# REPORT
# ON
# BASIC STUDIES FOR DEVELOPMENT
# OF HYDRAULIC POTENTIALS
# OF THE NAM SAI YAI
# KINGDOM OF THAILAND

JUNE 1965

OVERSEAS TECHNICAL COOPERATION AGENCY
GOVERNMENT OF JAPAN

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List of Errata

| Page | Line | | Corrected as |
|---|---|---|---|
| 6 | 15 | studies be | studies should be |
| " | 18 | forecost | forecast |
| 9 | 5 | gravels | gravel_ |
| 10 | 11 | indudtries | industries |
| 19 | 25 | trans formed | transformed |
| 20 | 14-15 | synchronous condensers and on load tap-changer installed at North-Bangkok substation | synchronous condensers installed at North-Bangkok substation and on load tap-changers |
| 21 | 7&11 | load factor curve | load curve |
| 24 | 14,15 & in table | Chal Buri | Chol Buri |
| 25 | 3 | littral | littoral |
| " | 9 | reprt | report |
| 33 | table | | |

| Catchment Area($km^2$) | Rainfall | | Rainfall | |
|---|---|---|---|---|
| | mm | $m^3$/sec-day | mm | $m^3$/sec-day |
| | | | | |

| Catchment Area($km^2$) | Rainfall | | Discharge | |
|---|---|---|---|---|
| | mm | $m^3$/sec-day | mm | $m^3$/sec-day |
| | | | | |

| Page | Line | | Corrected as |
|---|---|---|---|
| 34 | table | over 2000 mm | over 2001 mm |
| 40 | 21 | prohect | project |
| 42 | 3 | sandstone | sandstones |
| " | table | occures | occurs |
| 43 | 1 | distrubution | distribution |
| " | 6 | mountatin | mountain |
| " | 7 | bed | beds |
| 44 | 6 | tend | tends |
| " | 13 | preveailing | prevailing |
| " | 16 | disected | dissected |
| 45 | 19 | deposites | deposits |
| 46,47 | Fig 4-3-1 | (LEGEND)<br>Localy | Locally |
| 51 | 20 | date | data |
| 52 | table | 1963 \| 905.9 \| 17.0 | 1963 \| 905.9 \| 17.7<br>Mean \| 417.4 \| 19.7 |
| 63 | 15 | lenght | length |
| 64 | 1 | can not be expected | can be expected |

| Page | Line | | Corrected as |
|---|---|---|---|
| 65 | 8 | the upper-mostreser-voirand | the upper-most reser-voir and |
| " | 28 | Easire | Easier |
| 67~68 | 28 ~ 1 | feasible for the sites which in ordi-nary cases are econo-mically compatible with fill-type dams. | feasible for the sites, (dele) |
| 70 | 10 | with permeability of deep rock layers, as well as the possibi-lity of | with the possibility of |
| 72 | 6 | any channels | and any channels |
| 96 | Table | Prachin Bburi | Prachin Buri |
| " | Table | Kabin Bburi | Kabin Buri |
| 98 | 13 | tenacy | tenancy |
| 100 | 1 | embenkment | embankment |
| 100 | 6 | Huai Sai Noi | Nam Sai Noi |
| 109 | Fig-4-6-8-2 | Amphoe Prachin Buri | Amphur Prachin Buri |
| 114 | Table-3 | Jan.<br>1955 0.3 | Jan.<br>1955 0 |
| " | " | May.<br>Average 156.6 | May.<br>Average 156.0 |
| " | Table-4 | Jul.<br>1957 51.4 | Jul.<br>1957 57.4 |
| 115 | Table-6 | Jun.<br>1962 482.4 | Jun.<br>1962 480.4 |
| 117 | Table-11 | Jan. Feb.<br>1964 **24.8 19.8 | Jan. Feb.<br>1964 ※24.8 ※19.8 |
| 121 | Table-14 | %<br>Ban Sapan Hin 125 | %<br>Ban Sapan Hin 120 |

| Page | Line | | Corrected as |
|---|---|---|---|
| 123 | 1 | shows | show_ |
| 126 | 1 | dadat | data |
| " | 27 | Prochanta Kham | Prachanta Kham |
| " | 31 | comulative | cumulative |
| 128 | Fig-10 | Note; | Note; |
| | | ordinate and abscissa of fig 8-10 represent the cumulative rainfall and cumulative discharge of each station | ordinate and abscissa of fig 8-10 represent the cumulative rainfall of each station |
| 134 | 3 | considered this difference | considered about this difference |
| " | Fig-13 | (abscissa) | |
| | | cumulative discharge (mm) | cumulative rainfall (mm) |
| in the Report | | fall | falls |
| Photo-6 | | Ganging station | Gauging station |

# PREFACE

Submitted herewith as per the request of the Government of Thailand is an engineering report of basic studies and investigations which were conducted on the development of hydro-electricity potentials of the Nam Sai Yai River Basin by a Japanese mission which was organized and sent to Thailand by Overseas Technical Cooperation Agency of Japan

The six-member mission headed by Mr. Takeshi Tokuno of Electric Power Development Company Ltd , left Tokyo on February 11, 1965 in order to carry out field investigations for a period of about 45 days in Thailand

The Overseas Technical Cooperation Agency executive agency for the technical cooperation programs of the Government of Japan has been, since its establishment in June 1962, performing various activities including dispatching of technical experts, training of engineers from abroad, conducting preliminary survey relating to development projects in foreign countries

The happiness of the Agency will be unlimited, if the achievements of the mission contribute to the development of the said project economic interchange and mutual understandings between Thailand and Japan

The Agency hereby acknowledges hearty assistance and help extended by the administrative agencies of the Government of Thailand

June, 1965

Shinichi Shibusawa
Director General
Overseas Technical Cooperation Agency

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# 1. FOREWARD

1-1. Authority

1-2. Purposes

1-3. Acknowledgement

# 1. FORWARD

## 1-1. Authority

The Government of Thailand has established and been promoting its industrial development program with the objective of improving the living standards of its people

In the area of electric power development, several specific projects are under way based on the program, such as Yanhee multiple purpose dam and reservoir as well as ones in the lower basin of the Mekong River. However,, a rapid increase in power demand is further requiring new supply sources of electric power in addition to those projects.

Since December of 1958, when the first investigations was undertaken of the Lower Mekong Basin, the Government of Japan has sent its investigation missions at several occasions to Thailand and other coastal countries of the Mekong River, the assignment of which missions was to cooperate with the authorities concerned of the countries in planning out development projects primarily of electric power.

Recently, the Government of Thailand officially requested the Government of Japan to send an investigation mission to Thailand and to conduct basic studies on the development of the Nam Sai Yai river basin which is presumed as an important new source of electricity supply to Bangkok, the capital of Thailand, as well as to northeastern region of the country.

In response to the said request, the Government of Japann decided to cooperate with the Government of Thailand and assigned the Overseas Technical Cooperation Agency for the job.

The Overseas Technical Cooperation Agency organized and dispatched to Thailand an investigation mission consisting of engineers of Electric Power Development Comapany.

## 1-2. Purposes

The field studies, such as streamflow gauging and topographical survey of reservoir area have been conducted by the National Energy Authority of Thailand since several years ago, for the development of power potentials of the Nam Sai Yai river basin

The purposes of the investigation mission are to conduct onsite reconnaissance, to establish specific program for the investigation which is to be performed in the near future at the occasion of feasibility studies, and further to give basic ideas toward early realization of the development of the Nam Sai Yai river

In addition to the purposes as mentioned above, the mission reconnoitred the basin of the Khlong Tha Dan river, which is adjacent river basin of the Nam Sai Yai, according to the request of the National Energy Authority The results of the reconnaissance are given under separate volume as appendix to this report.

The members of the mission were as follows:

| | | |
|---|---|---|
| Chief Engineer | Takeshi Tokuno | Civil Engineer, Electric Power Development Co., Ltd. |
| | Norio Oshiki | Civil Engineer, Electric Power Development Co , Ltd |
| | Takao Toyoda | Geologist, Electric Power Development Co., Ltd |
| | Kei Yamamoto | Civil Engineer Electric Power Development Co., Ltd. |
| | Tsutomu Kidahashi | Electrical Engineer Electric Power Development Co., Ltd |
| | Azuma Tsunoda | Agricultural Engineer, Electric Power Development Co , Ltd |

The mission visited Thailand for a period of 45 days from February 11, 1965.

## 1-3 Acknowledgement

The Mission takes this occasion to express its deepest appreciation to the officials of the National Energy Authority, Ministry of National Development of the

Government of Thailand who were very willing to extend help and assistance to the Mission in the execution of its assignments Furthermore, the Mission appreciate the cordial facilities afforded by the particular engineers who accompanied the Mission to the field-sites and took charge of liaison and engineering advices

The Mission wishes to express its gratitude to the organizations and agencies of the Government of Thailand which provided the Mission with various convenience including furnishing of aerial photos, hydrological data and others

## 2. CONCLUSIONS AND RECOMMENDATIONS

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## 2. CONCLUSIONS AND RECOMMENDATIONS

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## 2-1 Introduction

The Mission conducted field investigations of the Nam Sai Yai river basin by the help of the basic data and informations including aerial photos, various maps and hydrological records which the National Energy Authority kindly provided to the Mission On the basis of the results of the investigations the Mission has reached and obtained a fundamental layout as regards the scale, econnomic feasibility and the timing of the Nam Sai Yai Project including electric power development and agricultural development The fundamental layout are described in section 2-2.

It must be pointed out that the fundamental lavout of the Mission were reached on the basis of data and informations which largely include assumed figures, so that elaboration is further required in the future of demand forecast, transmission system study, preparation of topographical maps, detailed studies of geology, and recording and compilation of hydrological data, before specific and concrete development plan is established according to the recommended fundamental idea. Details of such elaboration are given in Section 2-3

## 2-2. Conclusions and Recommendations on the Development of the Basin

### 2-2-1. Electric Power Development

Two favourable sites are available in the upstream reaches of the Nam Sai Yai river for the creation of two reservoirs with the high water level presumably at EL 730 m and 595 m respectively. It is proposed that two reservoirs of 150,000,000 $m^3$ effective storage capacity each shall be constructed on these sites and that four (4) power plants be constructed to utilize the stored water of the said reservoirs taking advantage of steep topography towards downstream to the point EL. 40 m The features of the proposed four (4) power plants are as follows:

| | Maximum discharge ($m^3$/sec) | Normal effective head (m) | Maximum output (kW) | Annual energy production ($10^6$kWh) |
|---|---|---|---|---|
| Sai Yai No. 1 | 8 0 | 111 | 7,500 | 24 |
| Sai Yai No. 2 | 20.0 | 81.5 | 13,700 | 43 |
| Sai Yai No. 3 | 20.0 | 248 | 41,700 | 132 |
| Sai Yai No. 4 | 20.0 | 185 | 31,100 | 110 |
| Total | | | 94,000 | 309 |

The total construction cost estimated of those power plants amounts to about \$44,600 × $10^3$. The power cost will be 474 \$ per Kilowatt and 0.144 \$ per Kilowatt-hour showing that this project is one of the most economical ones among several hydro-power projects under construction or at planning stage in this country.

The reservoirs can also supply irrigation water when paddyfield is newly devel-lped in the downstream area of the basin Then, in such case, the construction cost can be partially allocated to the agricultural sector resulting in the lowering of power cost

The power obtainable by this project shall be transmitted on 115 kv and 95 kv transmission lines to be constructed as far as Bangkok. The transmission lines shall be interconnected with the Yanhee transmission system at Chal Buri. In addition to this, 85 kv transmission line shall extend to Korat, which is the center of business activities in the northeastern region, to get interconnected there with the Nam Pong power system which is now under construction

The interconnection of the project system with the Lam Dom Noi power system may be a problem which shall be realized in the future depending upon the growth of power demand

Although construction schedule of a development program including various sites should be decided on the basis of a close analysis of the trend of power demand growth, availability of financing and other factors, it would in this project, be most suitable to choose No. 2 and No. 3 power plants as the first stage of construction in consideration of their size of power output and required financing.

2-2-2 Agricultural Development

By providing irrigation facilities including headwork, canal and other items, the two reservoirs proposed for electric power development will be utilized as a source of irrigation water supply enabling development of new arable land in the area downstream from the confluence of the Nam Sai Yai and Nam Sai Noi rivers. Then, in this area the cultivation of paddy rice, upland crops and fruit trees will be possible throughout the year not only in the wet season but in the dry season. The beneficiary arable land will amount to an approximation of 4,000 ha, which will show good effects of the development.

2-3. Recommendations on the Studies to follow the Mission's Inverstigations

In order to materialize the development of the Nam Sai Yai river basin as recommended in Section 2-2 and to evaluate its economic feasibility, it is recommended that the following investigations and studies be further executed.

The data which were made available to the Mission are also described in the following paragraphs.

2-3-1. Power demand forecost

In order to reach an accurate estimation of future power demand, the following data or informations shall be completed besides those records which are now available

(1) Data and informations as regards energy consumption by various field of industrial activities in the project area

(2) Records of outage in the existing power plants of the area by forced outage due to failure and scheduled maintenance outage (particulars should be analysed of cause and hour-duration of outage together with the kinds of equipment to which such outage has happened)

2-3-2. Interconnection of Transmission Lines

(1) In addition to the proposed interconnection of the transmission line of the Project with the Yanhee power system and the Nam Pong power system, the studies should immediately be started and elaborated of the timing and methods as regards system interconnection with the Lam Dom Noi power system which is under consideration.

(2) With the progress of interconnection of transmission line and expansion of power system, not only problems of technical nature in respect of equipment but also problems of economic nature, such as, standardization of plant equipment, determination of types and quantities of stand-by facilities and spare parts, etc. will necessarily arise. In order to cope with these problems, it would be of urgent necessity to prepare nationwide register on a standardized form recording equipment classified into generation plant, transmission line, sub-station and distribution line.

2-3-3. Power Generation

Sai Yai No. 1 and No. 2 Reservoirs

(1) Aerial map

The map on a scale of 1 to 50,000 which had been prepared by U.S. Army was made available to the Mission. No further investigation is required of this item.

(2) Topographical map

The following maps were made available to the Mission.

(a) Plan of No. 2 Reservoir area on a scale 1 to 10,000 prepared by the National Energy Authority based on actual measuring.

(b) Plan of No. 2 dam site area on a scale 1 to 2,000 prepared by the National Energy Authority based on actual measuring.

(c) Plan of No 1 dam site area on a scale 1 to 10,000 prepared based on U.S. Army's aerial photos.

As to this item, elaborations are further required of;

(a) Preparation of a plan of No. 1 Reservoir area on a scale of 1 to 10,000 based on actual measuring

(b) Modification or correction of the plan of No. 2 dam site area of a scale of 1 to 2,000, by carrying out actual measuring. The site of the proposed dam is shown in Fig. 4-5-7-9.

(3) Geology

Further investigations are required of the thickness and weathering of topsoil, and general conditions and permeability of the bedrock with regard to the both banks of the proposed dam site.

The method of the investigations including drilling and others are described in Section 4-3 together with locations of investigation sites.

Studies and tests should also be conducted of the embankment materials including analysis of characteristics, especially of specific gravity, of rock materials, and studies and tests of grading distribution, water contents and permeability of earth materials. The area to be investigated as regard the embankment materials is described in Section 4-3

Waterways and Powerstation

(1) Aerial Photos

The Aerial photos which was prepared by U S. Army on a scale of 1 to 40,000 was made available to the Mission

No further investigation is required of this item

(2) Topographical map

A plan which was prepared by U.S Army on a scale of 1 to 50,000 was made available to the Mission. Preparation of topographical maps on a scale 1 to 2,000 is necessary of intake site, surgetank-penstock-powerstation route for each proposed powerplant

(3) Geology

Geological investigations by means of drilling are required of the proposed sites of surgetanks, penstocks and powerhouses, in order to study the characteristics of bedrock and thickness of topsoil at the sites.

Aggregates

Investigations and explorations should be conducted in order to obtain pertinent data concering amount and quality of sand and gravels which are deposited and available at the proposed reservoir areas and other sites in the basins of the Sai Yai and Sai Noi rivers.

River Profil

Partial river profils of the Nam Sai Yai and the Nam Sai Noi rivers which were prepared by the National Energy Authority based on actual measuring are available.

River profils should be completed to include whole stretch of the project area.

Access Road

Such maps should be prepared on the basis of actual measuring which will help in the determination of the access road route and its cost estimation.

Streamflow and Rainfall

Measuring and observation of stremflow and rainfall should be continued into the future as elaborately as have been undertaken.

2-3-4. Agriculture

A plan on a scale of 1 to 50,000 which was prepared by the U.S. Army is abailable.

In addition to the said plan, the following data and investigations are necessitated of the project area ;

(1) Geographical map of the project area on a scale of 1 to 5,000 with 1.0 m contour interval.

(2) Soil investigation by means of about 90 holes of test pits to study the physical and chemical characteristics of the soil.

(3) Investigations of irrigation and drainage systems.

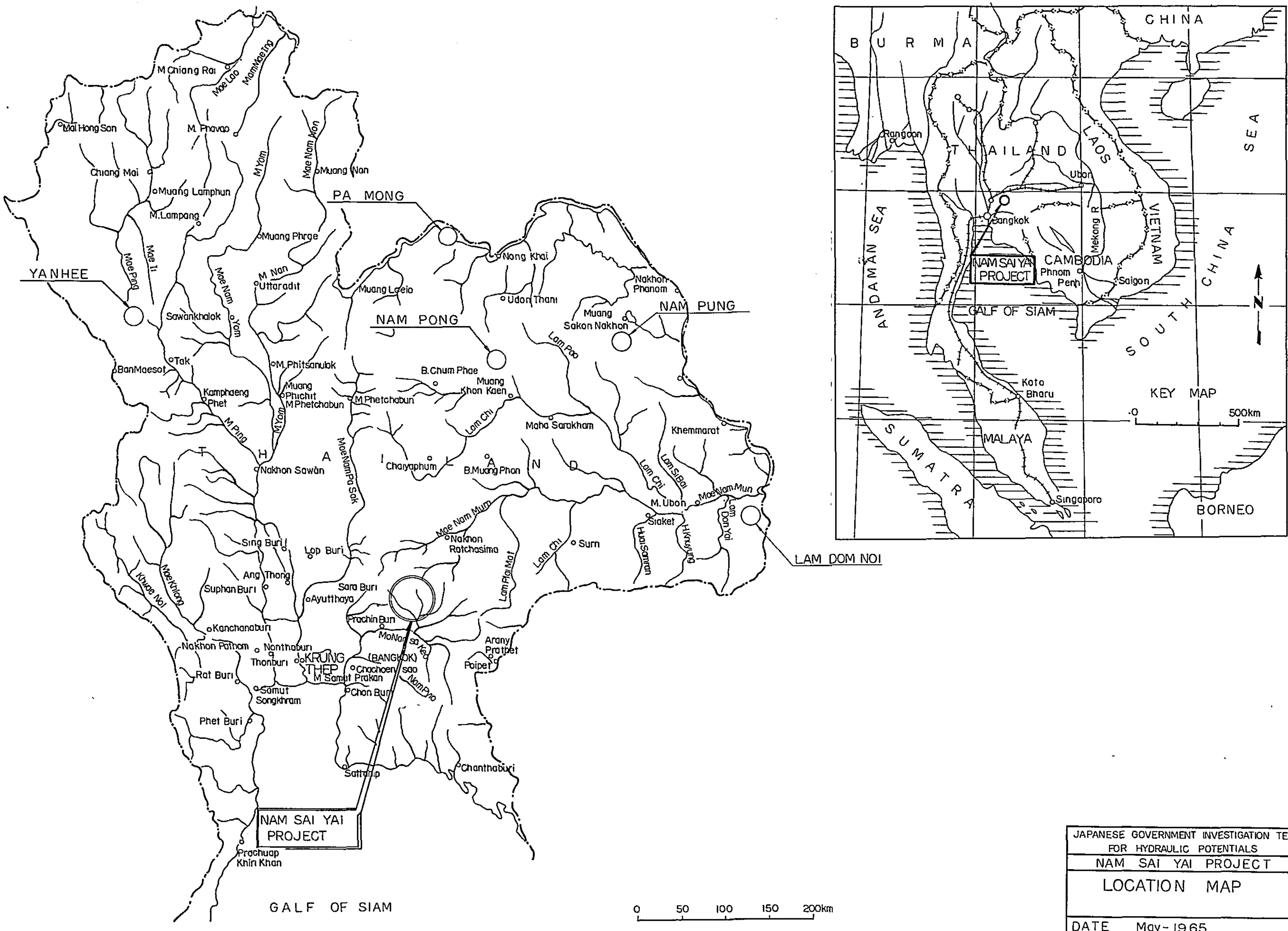
(4) River surveying around the intake site and topographical surveying around the pumping station.

(5) Basic soil studies including reconnaissance as well as tests of permissible soil pression and other characteristics of soil at about 20 sites.

(6) Studies of agricultural economy in the project area by means of hearing from the farmers.

(7) Long term observation at about 20 sites in connection with water requirement of crops and underground water.

(8) Collections of basic data with regard to hydrology, labour force, materials, general economy, geography, as well as effect of the project on related indudtries.




JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

LOCATION MAP

| | |
|---|---|
| DATE | May-1965 |
| NO | 2-1 |

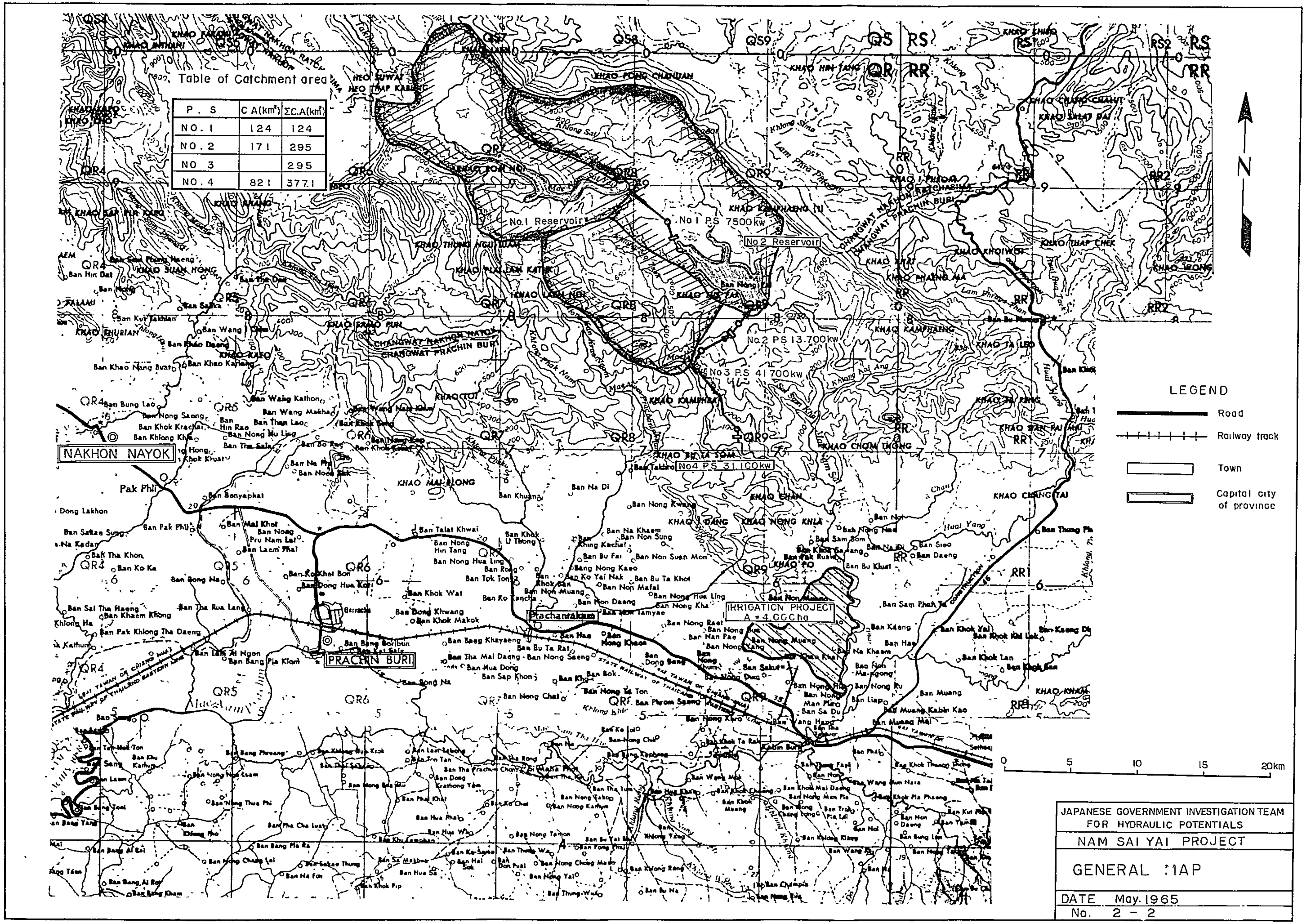
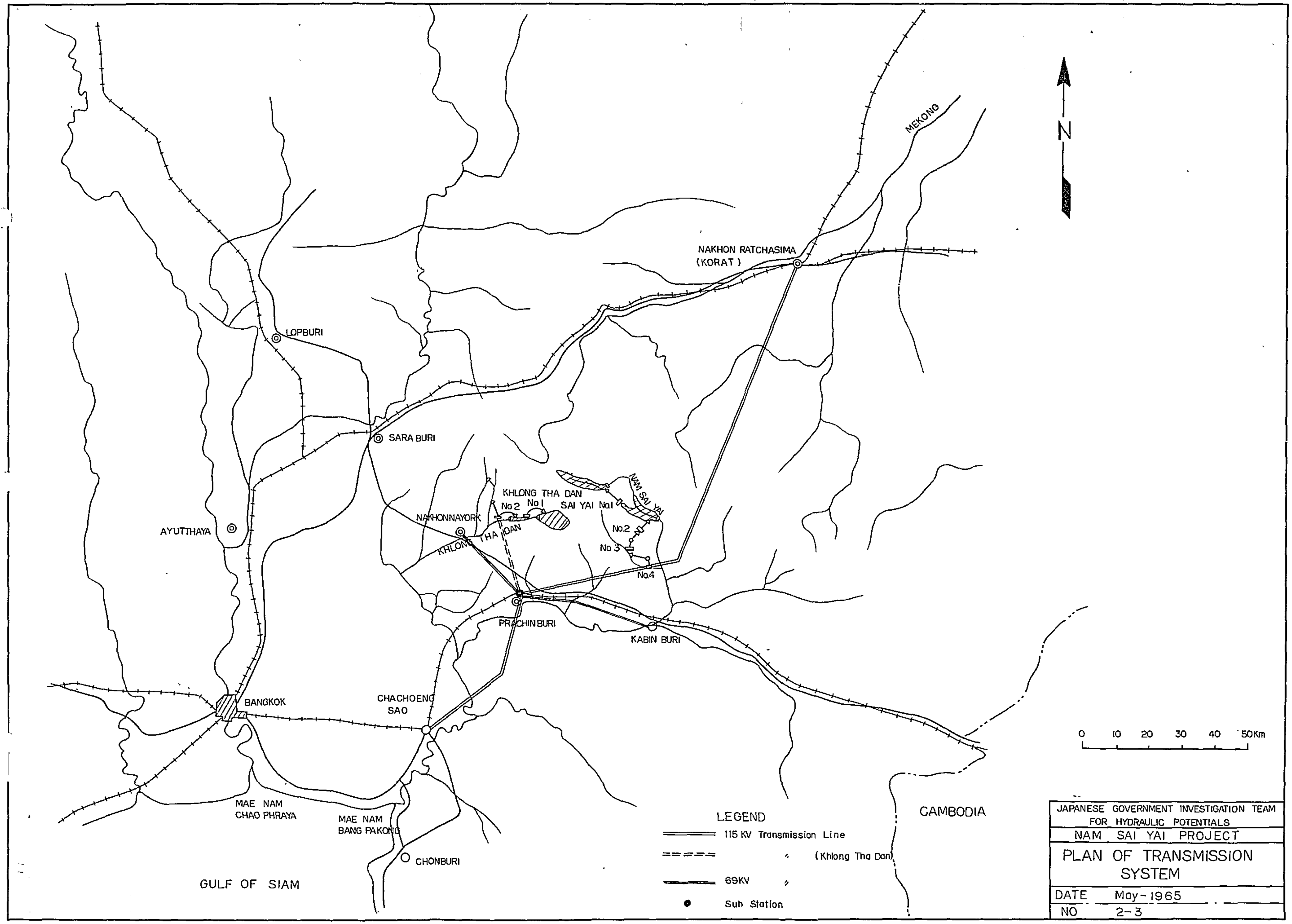


Table of Catchment area
P.S | C.A(km²) | ΣC.A(km²)
NO.1 | 124 | 124
NO.2 | 171 | 295
NO.3 | | 295
NO.4 | 821 | 377.1
No.1 Reservoir
No.1 P.S 7500kw
No.2 Reservoir
No.2 P.S 13 700kw
No.3 P.S 41 700kw
No.4 P.S 31 100kw
IRRIGATION PROJECT
A = 4,000ha
NAKHON NAYOK
PRACHIN BURI
Prachantakam
Kabin Buri
CHANGWAT NAKHON NAYOK
CHANGWAT PRACHIN BURI
CHANGWAT NAKHON RATCHASIMA
LEGEND
Road
Railway track
Town
Capital city of province
N
0 5 10 15 20km
JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS
NAM SAI YAI PROJECT
GENERAL MAP
DATE May. 1965
No. 2 - 2


N
MEKONG
NAKHON RATCHASIMA
(KORAT)
LOPBURI
SARA BURI
AYUTTHAYA
NAKHONNAYORK
KHLONG THA DAN
No 2
No 1
SAI YAI
No.1
No.2
No 3
No.4
NAM SAI YAI
KHLONG THA DAN
PRACHIN BURI
KABIN BURI
BANGKOK
CHACHOENG
SAO
MAE NAM
CHAO PHRAYA
MAE NAM
BANG PAKONG
CHONBURI
GULF OF SIAM
CAMBODIA
0 10 20 30 40 50Km
LEGEND
115 KV Transmission Line
" (Khlong Tha Dan)
69KV "
Sub Station
JAPANESE GOVERNMENT INVESTIGATION TEAM
FOR HYDRAULIC POTENTIALS
NAM SAI YAI PROJECT
PLAN OF TRANSMISSION
SYSTEM
DATE May-1965
NO 2-3

# 3. GENERAL FEATURES OF THE PROJECT AREA

## 3-1. General

## 3-2. Electric Power

(Table and Figures)

# 3 GENERAL FEATURES OF THE PROJECT AREA

## 3-1 General

Rice-crop is the very foundation of Thai economy Rice is mostly harvested in the central plain and the north-eastern plateau formed by serval rivers, such as, Chao Phraya, Me Khlong and Pakong. Especially the central plain produces about half of the total national production of rice which amounts to 7 million tons The Nam Sai Yai Project area is located nearly halfway between the above-stated plain and plateau At present, manufacturing industry plays only a minor role in comparison with agriculture in its economy, and main industrial products are cement, textiles, hempbags, papers and so on

The Government of Thailand started in 1961 the 6-Year Economic Development Plan and has been quite positive in industrialization of the country Bangkok-Thonoburi Area having a population of about 2 million, about 8% of her whole population of 29 7 million (UN statistics, 1964), is the most active center of industrialization of Thailand and the area is expected to be more and more industrialized along with the sea-side region around Chal Buri

## 3-2 Electric Power

The Nam Sai Yai Project area adjancent to the Central, the Northeastern and the East-Central Regions can occupy an important position in the power systems of Thailand (Refer to Fig 3-2-1)

### 3-2-1. The Central Region

Located in the central plain, this region which includes the major cities of Bangkok and Thonburi is a center of power industry as well as of commercial and industrial activities About 80% of generating facilities of power industry of the country is provided in this area, and about 85% of electricity is consumed in this Central Region

Electric power is currently supplied by the three authorities, that is, Yanhee Electricity Authority (YEA), Metropolitan Electricity Authority (MEA) and Provincial

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(Table and Figures)

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Electric power is currently supplied by the three authorities, that is, Yanhee Electricity Authority (YEA), Metropolitan Electricity Authority (MEA) and Provincial

Electricity Authority (PEA).

YEA owns main power facilities in this region such as Bhumibol hydro-electric power plant, North-Bangkok steam power plant, 230kv long distance transmission lines and 230 kv/69 kv primary substation. The authority supplies electricity to MEA and PEA on wholesale.

MEA is a power distribution authority which supplies electricity to Bangkok-Thonburi Area. The authority has no power generating facilities and receives electricity at secondary substations from YEA.

PEA is responsible for supplying electricity to provincial areas where MEA does not cover PEA generates power mostly by diesel generators installed in major provincial towns and supplies electricity to consumers together with one received from YEA.

Power system had been composed only of steam power plants and diesel power plants, but since Bhumibol hydro-electric plant was completed in 1964, the power system has been operated in a combination of hydro (140mW), steam (204.5mW) and diesel (36 5mW) power plants Frequency is 50 cycle.

Bhumibol hydro-electric power plant is located in Tak Province of northern part of the country, and the plant has a multi-purpose dam for irrigation, flood control and power generation. The power plant started power generation in May of 1964 with two 70mW units The total output of the plant will be 560mW with eight 70mW units at the final stage. The second stage construction is under preparation at present to meet a rapidly growing power demand. Under this program, two additional units will be installed by 1968.

There are three major steam power plants, that is, North-Bangkok (2 units x 75mW), Samsen (26.5mW) and Wat Lieb (23mW) power stations, of which the latter two are superannuated plants completed about 60 years ago with an extremely low thermal efficiency of only about 10%. Therefore, after the completion of North-Bangkok steam power plant in 1961, these old plants have been operated as only stand-by and are seldom operated at present

North-Bangkok oil fired steam power plant was constructed to meet with a rapidly growing power demand in Bangkok and its vicinity until Bhumibol hydro-electric plant would have started in operation. Constructin works of the first stage and the second stage were completed in 1961 and in 1963 respectively. Total generating capacity is 150mW at present. This power plant had been supplying about 90% of electricity consumption of this area before Bhumibol hydro-electric plant commenced its operation

Main diesel power plants are Samsen Diesel plant (5mW), Lumpini Diesel Plant (22.5mW) and Thonburi Diesel Plant (9mW), all of which are installed in the city of Bangkok or Thonburi. However, these plants are used today only as peak-load or stand-by stations due to surplus in power generating capacity which has been brought about by successive completion of large-scale hydro and steam power plants. Some of these diesel plants have been removed and transferred to provincial towns for the use in rural area. In brief, power system of this region is at present composed mainly of Bhumibol hydro and North-Bangkok steam power plants

The primary transmission line of this region is composed of two main transmission systems, that is, two circuits of 230 kv transmission line extending over a distance of 440 km from Yanhee to Bangkok (so-called Yanhee line), and 230kv transmission line passing and linking Bangkok Noi North-Bangkok and Bankapi primary substations located around Bangkok and Thonburi area. 69 kv secondary transmission lines are extending to PEA and MEA systems from these primary substations as well as from Nakorn Sawan and Angthorn substations which are provided on the said Yanhee transmission line. To these 69 kv lines are connected existing power plants around Bangkok.

For distribution purpose, power is trans formed from 69 kv to 11kv and 3.5kv in Bangkok-Thonburi area and to 33kv, 11kv and 3 5kv in other areas. As secondary distribution voltage for general consumers, single-phase 220v, three-phase three-wire 220v and three-phase four-wire 220V/380v are adopted. 110v distribution system which was prevailing formerly has been under alteration to 220v system by MEA in order to decrease transmission loss and keep good services to consumers. More than 50% of 110v system facilities has been changed for 220v.

There exists enough surplus in the Yanhee Power system with a supplying capacity of about 380mW against peak demand of about 160mW as of 1964. Therefore, North-Bangkok steam power plant is operated under a lowest load of 20 to 30mW with remaining power demand being supplied by Bhumibol hydro-electric power plant Output control of the system is undertaken by the hydro-power plant. Diesel power plants and superannuated steam power plants are operated as stand-by plants only when major power plants are in a failure or under repairing or regular inspection. (Refer to Fig. 3-2-2)

Frequency adjustment is done by governor-free operation of Bhumibol hydro-electric plant Voltage adjustment is done by generators in Bhumibol hydro-electric and North-Bangkok steam power stations, or by 60 mva synchronous condensers and onload tap-changer installed at North-Bangkok substation.

Classification of loads on this power system is as shown in the following table as of 1961. According to the table, the ratio of industrial use to total consumption is very large when compared with that of other areas, showing clearly that the Bangkok and Thonburi area is the center of commerce and industry.

Classification of Power Consumption

(Unit: $10^6$kWh)

| | Residential | Commercial | Industrial | Street lighting | Others | Total |
|---|---|---|---|---|---|---|
| Bangkok-Thomburi Area" | 131.4 (38%) | 75.2 (21.9%) | 130.6 (38%) | 5.2 (1.5%) | 1.4 (0.6%) | 343.9 (100%) |
| "Central Region excluding Bangkok-Thomburi Area" | 20.8 (45.6%) | 16.7 (36.6%) | 4.4 (9.6%) | 3.9 (8.2%) | - | 45.7 (100%) |

However, even in Bangkok-Thonburi area, power demand for industrial use is only 38% of total power demand, and the ratio of power demand for lighting is still quite high. Accordingly, load factor is low; 55% annual load factor and 65% daily load factor. But sizable increase is expectable of load factor due to increase of power demand for industrial use which is anticipated to arise along with the proceeding of industrialization of the area.

Fig. 3-2-3 shows the recent daily load factor curve of the YEA power system. As seen in the figure there appear three peaks in a day, that is, in the morning, in the afternoon and in the evening. The peak at daytime which is mainly due to industrial load demand is about 70% of the peak demand in the evening the larger part of which is lighting demand between 19:00 and 20:00 p.m. This load factor curve shows little variation throughout a year because of little climatic variations. Seasonal variations in energy consumption are scarcely recognized either.

Table 3-2-1 shows statistics of energy sold on wholesale from YEA to MEA during the period from 1961 to 1965. Growth of power demand recorded in this period may give the most reliable figures which can be used in the estimation of power demand of the near future, because after the North-Bangkok power plant was completed there has never been experienced in this area any such shortage of electricity that set restriction to a growing power demand.

Annual rate of growth of energy consumption was 19% in 1963 and 24.5% in 1964 and annual rate of growth of maximum peak demand was 12% in 1962, 21% in 1963 and 14% in 1964. Judging from present level of economic activities of Thailand, this remarkable growing trend may continue for the coming several years.

As for power rates, a demand depressing rate system was applied up to 1961 which charged higher rate on larger consumption of electricity; for lighting use 0.6 Bahts/kWh was charged on the first 50kWh and 0.95 Baht/kWh on that portion in excess of 50kWh; for industrial demand a rate of 0.5 Baht/kWh was applied.
An over-all averaged power rate was 0.73 Baht/kWh in 1961. This rate system was

on account of shortage of supplying capability in that period up to 1961.

However, after North-Bangkok and Bhumibol power plants started their operation, reductions were effectuated in power tariff in 1962 and 1964 and the said rates system was revised and a degressive rates system was introduced for lighting use and industrial use as well which charges smaller rates on the increasing portion of consumption Demand charge rate system as well as power-factor-correspondence rate system is introduced for industrial power use. It is expected that more electricity will be consumed in the future by dint of this revision of power rate system It is reported that wholesale power rates from YEA to MEA averaged 0.38 Baht/ kWh in 1963.

3-2-2. The Northeastern Region

In this Region PEA is supplying electricity to local towns and their vicinities. The power generating facilities in the area are all of them diesel power plants and neither hydro nor steam power plants are existing yet. Transmission lines are not interconnected between local towns. Total generating capacity in this region is only about 19,000kW of 108 diesel power plants. 99 plants belong to PEA and 9 plants to private enterprises. The average capacity per a plant is about 180kW. Electric power consumption in PEA system of this region and of Korat, a representative city in this Region, was as shown in the following table in 1963.

| | Installed capacity (kW) | Total power generation ($10^6$kWh) | Maximum load (kW) | Number of consumers | Power generation per consumer (kWh) |
|---|---|---|---|---|---|
| North-Eastern Region | 18,650 | 27.1 | 11,026 | 56,454 | 480 |
| Korat area | 3,736 | 6.1 | 1,890 | 6,227 | 980 |

The following table shows an outline of power industry of the city of Korat during the period from 1961 to 1963. According to the table, growth rate of power generation is 19%. Load is mainly lighting demand for residential and commercial use.

| Item / Year | Total power generation ($10^6$kWh) | Maximum load (kW) | Number of consumers | Population | Power generation per consumer (kWh) | Per capita generation (kWh) |
|---|---|---|---|---|---|---|
| 1961 | 4.3 | 1,520 | 5,129 | 135,300 | 840 | 31.7 |
| 1962 | 5.1 | 1,800 | 5,753 | 142,400 | 886 | 35.8 |
| 1963 | 6 1 | 1,960 | 6,118 | 148,000 | 1,000 | 41.2 |

In this region the Nam Pung hydro-electric power development project is under way at present by National Energy Authority (NEA). When completed in 1965, the power plant will produce 18,000,000 kWh annually with an installed capacity of 6mW. Electric power generated here will be transmitted to Nakhon Phanom via Sakol Nakorn on a 69kv transmission line to improve power supply situation around the boundary areas with Laos.

The Nam Pong hydro-electric power development project is also carried on as a part of a multi-purpose development program by North-East Electricity Authority (NEEA). When completed in 1966, the power plant will generate 70,000 000 kWh annually with an installed capacity of 25mW. About 450 km long transmission line of 115kv capaicty is also under construction from the power plant to Udon, Roi-et, and Korat. This transmission system will be interconnected with the above-stated Nam Pung Power system in the future as the second stage construction work of the project.

Furthermore the Lam Dom Noi hydro-electric power plant (15mW) near Ubol is under planning stage by NEA and when this project is realized a 69 kv transmission line will be extended to Surin.

Most of the diesel power plants located in this region are operated only for about 8 hours a day except the plants in major cities. Power rate for residential use is very high; 1.8 Bahts/kWh for the first 50kWh of consumption. However, when the above-mentioned hydro-electric plants be completed, and the transmission system of the projects be interconnected with that of the Sai Yai project, reliability of power supply and quality of electricity will be improved enormously. Such improvements will possibly enable supply of much cheaper electricity, and it may be natural to anticipate a rapid growth of power demand in this region.

3-2-3. The East-Cental Region

Electric power industry in this region is almost similar with that of the North-eastern Region. PEA is responsible for generation and distribution of electric power, and its service area is at present limited to some local towns and their vicinities As electric power is generated by small-scale diesel-engine generators at an expensive fuel cost, electric rate is considerably high. For power consumption by lighting use not exceeding 50kWh a month, it is mostly 1.8 Baht/kWh with exceptions of 1.7 Baht/kWh in Chacheongsao and 1.45 Baht/kWh in Chal Buri. Generating capacities and demand of power in this Region and Chal Buri are as shown in the following table.

| | Installed capacity (kW) | Total power generation (kWh) | Maximum Load (kW) | Number of consumers | Power generation per consumer (kWh) |
|---|---|---|---|---|---|
| East-Central Region | 10,695 | 15,900,000 | 7,413 | 30,733 | 517 |
| Chal Buri (Muang) | 3,019 | 6,400,000 | 2,470 | 5,751 | 1,110 |

There are existing 54 power plants in all, 27 plants of which belonging to PEA, 26 to private enterprises and 1 to other classification. Supply and demand of electric power in Prachinburi near the Sai Yai project area are as follows for the period from 1961 to 1963.

| | Installed capacity (kW) | Total power generation(1) (kWh) | Number of consumers(2) | Population(3) | $\frac{(1)}{(2)}$ | $\frac{(1)}{(3)}$ |
|---|---|---|---|---|---|---|
| 1961 | - | 717,000 | 1,420 | 50,400 | 505 | 142 |
| 1962 | - | 806,000 | 1,591 | 51,500 | 505 | 157 |
| 1963 | 863 | 1,116,000 | 1,749 | 49,000 | 636 | 227 |

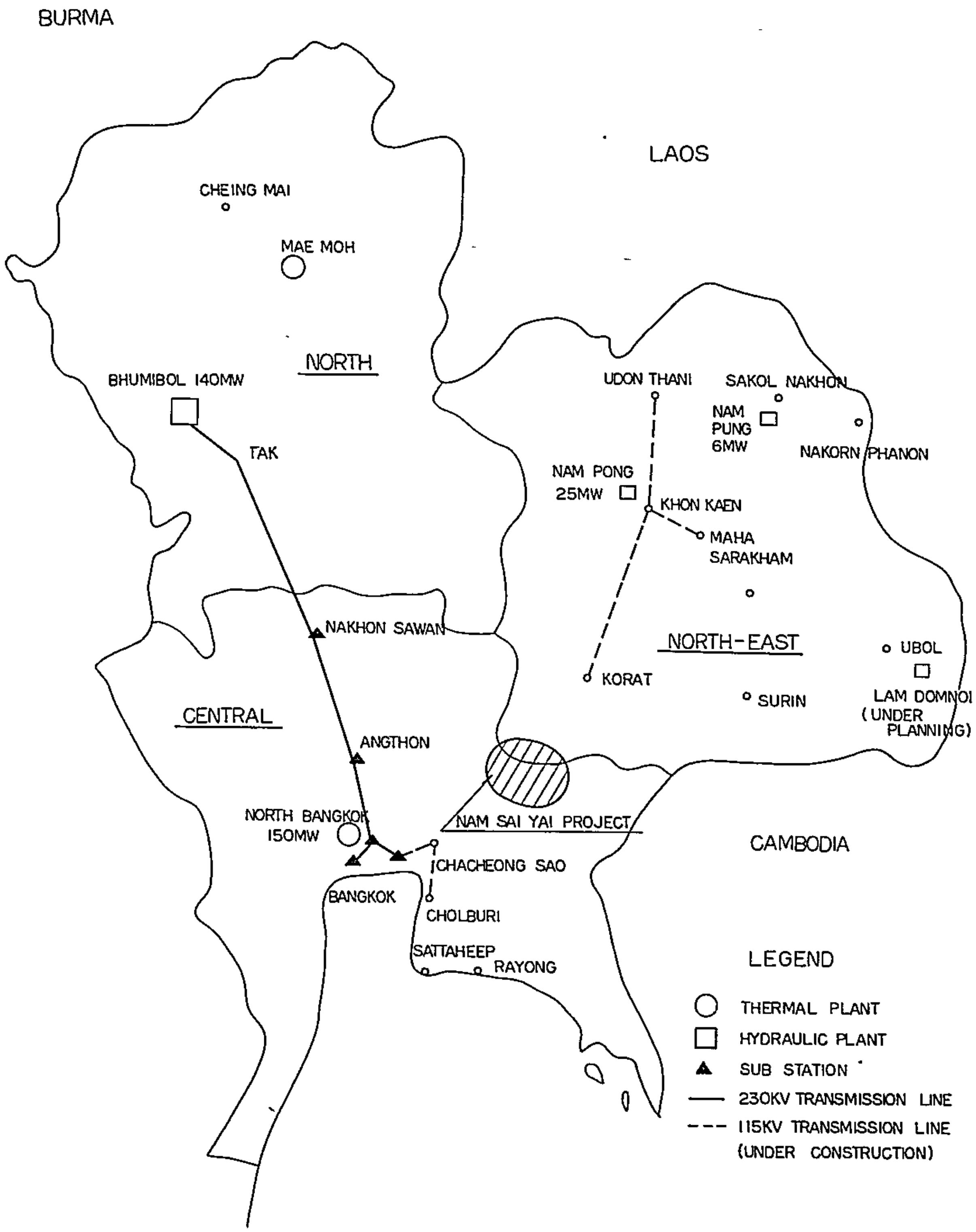
In the distribution system, the voltage of high-tension side is 3.5kv or 400v and low-tension side is 220v at which electricity is supplied to general consumers.

In this region the area facing the Gulf of Siam will be developed as a littral industrial center in the future. In the second stage Yanhee Project of YEA, a 115kv Transmission line will be extended from Bankapi substation to Chal Buri, Sataheep, and Rayong via Chacheongsao. A part of this transmission line is under construction.

As stated above, Bangkok area is considerably different from the other areas in power situation due to geographical and economic conditions. Therefore, in the latter part of this reprt, "Bangkok-Thonburi area" will be studied separately from "Rural areas" which include the northern part of the Thailand.

Table 3-2-1 Monthly Energy and Peak Demand Bangkok-Thonburi Area

| | 1961 | | 1962 | | 1963 | | 1964 | | 1965 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | mW | $10^6$kWh | mW | $10^6$kWh | mW | $10^6$kWh | mW | $10^6$kWh | mW | $10^6$kWh |
| 1 | | | 98.7 | 37.8 | 109.0 | 41.4 | 131.2 | 56.3 | 154.7 | 65.9 |
| 2 | | | 98.8 | 34.3 | 115.0 | 42.2 | 134.4 | 53.4 | 163.9 | 64.7 |
| 3 | | | 99.7 | 41.1 | 117.0 | 48.6 | 135.6 | 59.9 | | |
| 4 | | | 101.4 | 40.8 | 116.2 | 47.7 | 137.4 | 59.9 | | |
| 5 | | | 103.5 | 43.1 | 118.6 | 50.9 | 136.4 | 61.0 | | |
| 6 | | | 104.3 | 41.5 | 118.6 | 49.1 | 140.0 | 61.3 | | |
| 7 | 91.3 | 32.5 | 104.1 | 42.5 | 119.3 | 50.6 | 140.8 | 63.2 | | |
| 8 | 93.2 | 30.3 | 104.5 | 42.8 | 120.6 | 51.4 | 142.5 | 63.3 | | |
| 9 | 94.1 | 36.2 | 107.0 | 42.1 | 125.0 | 50.8 | 148.0 | 63.9 | | |
| 10 | 97.3 | 37.6 | 109.2 | 44.9 | 127.3 | 54.4 | 152.5 | 67.9 | | |
| 11 | 96.1 | 37.7 | 112.0 | 44.1 | 130.0 | 54.2 | 151.6 | 63.8 | | |
| 12 | 98.4 | 38.4 | 109.9 | 42.8 | 135.5 | 52.5 | 152.9 | 65.7 | | |
| Total | | | | 497.8 | | 593.6 | | 739.6 | | |
| % of Increase | | | 12% | | 21% | 19% | 14% | 24.5% | | |

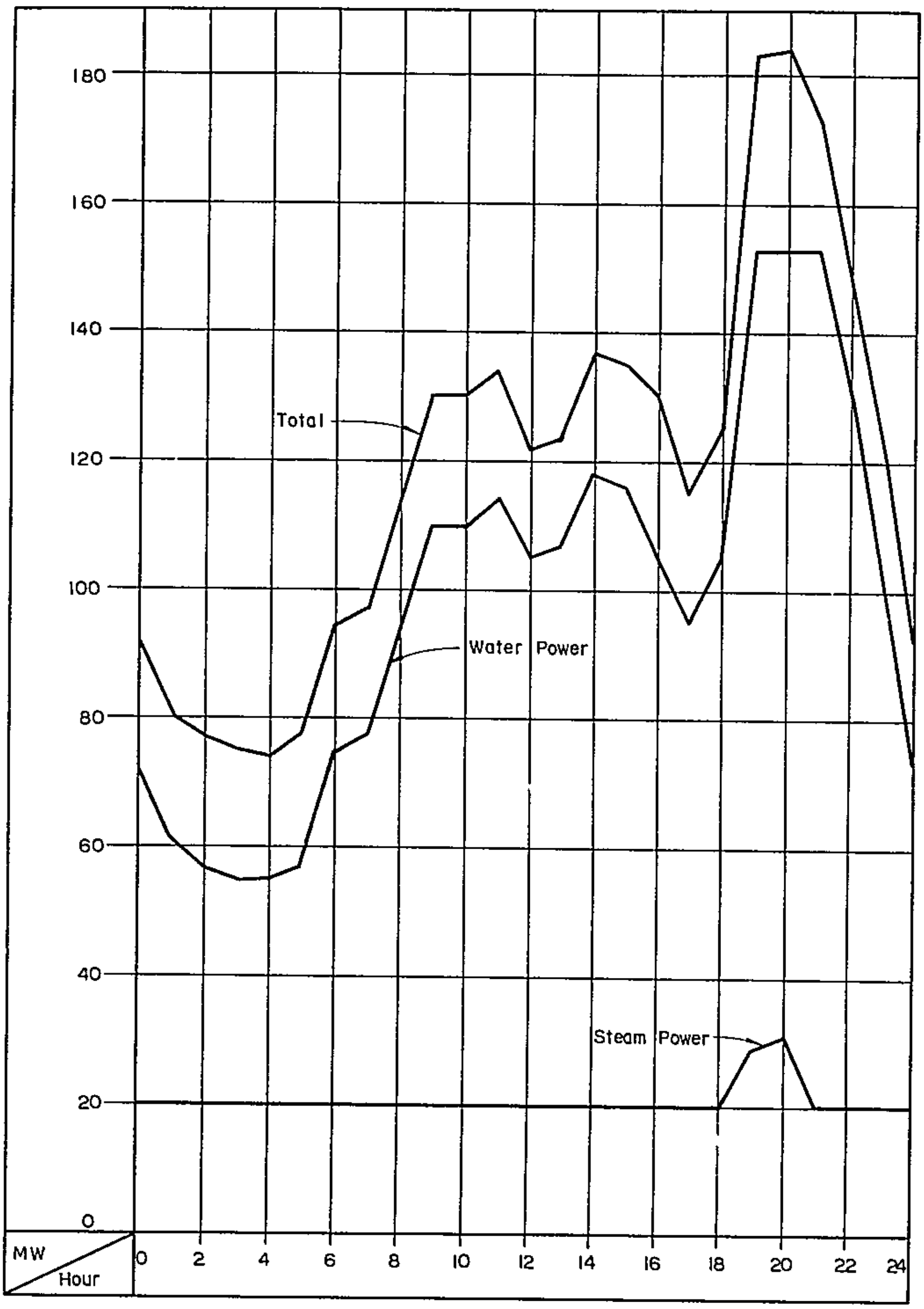



JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

MAIN TRANSMISSION SYSTEM OF THAILAND

| | |
|---|---|
| DATE | May - 1965 |
| NO. | 3-2-1 |




JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

DAILY LOAD CURVE OF BAN-GKOK~THONBURI AREA

DATE May-1965

NO 3-2-2

## 4. BASIC CONSIDERATIONS ON THE DEVELOPMENT OF THE PROJECT AREA

## 4. BASIC CONSIDERATIONS ON THE DEVELOPMENT OF THE PROJECT AREA

### 4-1 Location of the Project Area

The Dangrek mountain range which reaches a height of 1,000 m above mean sea level lies in the direction towards southeast by east halfway between Bngkok, the capital of Thailand, and Nakhon Ratchsima (Korat) which is the central city of the northeastern region where a larger part of rice crop of the country is produced.

There flows on the northeastern slope of the range called Korat plateau the river Nam Mune which drains into the Mekong River and flows the Nam Sai Yai river, a tributary of the Mae Nam Bang Pakong river on the opposite southeastern slope.

The Nam Sai Yai river flows meandering southward and takes turn westward near Kabin Buri, after which the river is called by the name of the Nae Nam Band Pakong finally flowing into the Gulf of Siam about 60 kilometers east to the city of Bangkok.

The project area is located in an upstream basin of the Sai Yai river and is about 150 kilometers northeast from Bangkok.

### 4-2. Hydrology

#### 4-2-1. Rainfall

Rainfall is very small from December to March all over Thailand excepting Isthmus of Kra and it is generally less than 25 mm in the plain areas. The rainy season starts abruptly at the end of April and continues until the middle of Novermber. This characteristic feature is largely due to location of mountain ranges and direction of winds.

During the monsoon season from Novermber to March, the monsoon does not bring rainfall being intercepted by the high mountain ranges in Vietnam and Laos to the project area.

Changing the direction southeasterly after April, the warm and humid monsoon invades into the Gulf of Siam and causes much rainfall all over the country, but rainfall differs by regions and this is most probably due to topographycal features.

Rainfall in the Me Nam plain and in the areas of Korat plateau at relatively low altitude is less than 1,500mm in general, but in the circumferential areas of the Korat plateau which are located at high altitude it amounts to 2,000 or 2,500 mm.

The Sai Yai project area is located at a southwest edge of the Korat plateau. As meteorological observation stations had not been installed in the catchment area until late 1963, it is rather difficult to make a precise analysis of rainfall characteristics.

However, judging from the rainfall records of several observation stations around the catchment area, for instance, 2,000 mm rainfall recorded at Nakon Nayork and Prachinburi near the foot of mountains, it is considered that the rainfall in the project area will be far much of plenty in comparison with that of Bangkok or Korat. This assumption will be further supported by the fact that rainfall records at Ban Sapan Hin and Kao Keep Samut observation stations, the latter of which is located in the catchment area, give considerably large figures for the year 1964 which was a dry year.

Rainfall records of the Kao Keep Samut station show rainfall of as much as 2,200 mm for the said year. The isohyet map of Thailand (Refer to Fig. 4-2-1) shows that this project area belongs to the richest rainfall area having rainfall of more than 2,000 mm.

Table 4-2-1. Regional Average Rainfall in Thailand

(mm)

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. |
|---|---|---|---|---|---|---|
| Chiengmay | 6.8 | 4.9 | 16.7 | 37.7 | 147.6 | 131.9 |
| Nakhon-Nayork | 13.1 | 28.6 | 50.2 | 90.1 | 218.2 | 340.2 |
| Nakhon-Rajasima | 9.1 | 38.2 | 41.6 | 80.4 | 178.4 | 133.7 |
| Bangkok | 9.2 | 19.5 | 37.8 | 66.5 | 145.5 | 151.7 |
| Nakhon panon | 2.7 | 31.0 | 27.4 | 95.3 | 236.2 | 392.6 |
| Pattani | 133.7 | 42.2 | 62.2 | 41.0 | 90.6 | 114.7 |

mm)

| | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual. |
|---|---|---|---|---|---|---|---|
| Chiengmay | 169.4 | 209.3 | 251.7 | 134.3 | 42.9 | 12.2 | 1,165.4 |
| Nakhon-Nayork | 406.4 | 409.8 | 455.8 | 189.0 | 38.3 | 11.1 | 2,250.8 |
| Nakhon-Rajasima | 121.0 | 155.1 | 233.9 | 168.5 | 38.0 | 6.3 | 1,204.2 |
| Bangkok | 165.1 | 172.9 | 305.4 | 229.5 | 65.2 | 9.5 | 1,377.8 |
| Nakhon-panon | 515.7 | 493.1 | 282 0 | 62.2 | 2.0 | 6.9 | 2.147.1 |
| Pattani | 94.6 | 105.5 | 122.1 | 245.8 | 572.6 | 439.0 | 2,064.0 |

Note :

Meteorological Dept. Royal Thai Navy B.K.K. Thiland

Monthly and Annual Rainfall of Thailand for 1951

(normal for 25 - 38 years)

Table 4-2-2. Rainfall Records at Gauging Stations Around the Project Area

(mm)

| | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kabin Buri | 7.3 | 17.8 | 40.0 | 88.5 | 156.0 | 184.4 | 219.1 | 284.9 | 291.5 | 160.1 | 28.1 | 0 | 1,477.7 |
| Prachin Buri | 4.2 | 34.1 | 72.8 | 101.6 | 194.3 | 278.1 | 326.9 | 328.7 | 421.7 | 209.0 | 34.8 | 2.2 | 2,008.4 |
| Nakhon Nayork | 10.0 | 27.5 | 66.9 | 93.2 | 209.3 | 343.7 | 305.6 | 412.6 | 411.3 | 221.4 | 39.3 | 1.7 | 2,142.5 |
| Prachanta kham | 5.1 | 12.9 | 60.2 | 83.5 | 166.4 | 241.9 | 239.2 | 236.7 | 274.8 | 150.1 | 27.8 | 1.1 | 1,499.7 |
| Pak Phli | 1.3 | 29.2 | 51.8 | 65.7 | 170.6 | 289.5 | 282.0 | 402.0 | 326.9 | 217.8 | 64.8 | 12.7 | 1.914.3 |

Note:

Based on NEA data (1951 - 1964)

Table 4-2-3. Montly Rainfall Records at Gauging Stations around the Project Atea (1964)

(mm)

| | Jan. | Feb | Mar. | Apr. | May. | Jun | Jul. |
|---|---|---|---|---|---|---|---|
| Kao Keep Samut | *7 | *133 | 7 | 74 | 658 | 216 | 229 |
| Ban Sapan Hin(Sai Yai) | 8 | 73 | 8 | 85 | 345 | 131 | 119 |
| Kabin Buri | *3.5 | *14.0 | *21.6 | 39.1 | 80.1 | 115 8 | 157.8 |
| Prachin Buri | 0 | 60.7 | 23 0 | 78.4 | 169.1 | 336.3 | 147 6 |
| Nakhon Nayork | 0 | 4.0 | 3.2 | 38.2 | 273.2 | 106.2 | 210.5 |
| Prachanta kham | 0 | 18 8 | 28.3 | 114.2 | 217.9 | 120.6 | 168 8 |
| Nakhon-Rajasima | 0 | 3.7 | 26.2 | 34.3 | 319.0 | 69 2 | 163 1 |

(mm)

| | Aug. | Sept | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|
| Kao Keep Samut | 310. | 349 | 287 | *3 | *0 | 2,273 |
| Ban Sapan Hin(Sai Yai) | 296 | 213 | 249 | 6 | 0 | 1,533 |
| Kabin Buri | 336.1 | 231.5 | 212.5 | *0 | *0 | 1,262.0 |
| Prachin Buri | 293.3 | 279.7 | 273.8 | 0 | 0 | 1,661.9 |
| Nakhon Nayork | 207.4 | 195 3 | 239.3 | 0.1 | 0 | 1,277 4 |
| Prachanta kham | 472.8 | 271.9 | 180 9 | 0 | 0 | 1,594.2 |
| Nakhon-Rajasima | 161.0 | 257.5 | 227.3 | 30.0 | 0 | 1,291.3 |

Note : * = Estimated Montly Rainfall

Based on NEA data

4-2-2. Streamflow

As stated before, gauging records of streamflow in the catchment area of the project cover only a very short period : only one year and six months at Ban Sapon Hin streamflow gauging station in the lower stream, and only ten months at Kao Keep Samut station in the upper stream. Accordingly, no year but 1964 in which gauging was conducted at the both of the said stations can give data which are necessitated for the study of relationship between rainfall and run-off of the river. The relationship established based on 1964 records only is as follows :

Relationship between rainfall and run-off (1964)

| Gauging Stations | Catchment Area ($km^2$) | Rainfall | | Rainfall | | Run-off co-efficient (%) |
|---|---|---|---|---|---|---|
| | | mm | $m^3$/sec-day | mm | $m^3$/sec-day | |
| Kao Keep Samut | 315.1 | 2,273 | 8.363 | 780 | 2.867 | 34.3 |
| Ban Sapan Hin | 636.0 | 1,532 | 11.379 | 916 | 6.804 | 59.8 |

Monthly average streamflow (1964, per 100 $km^2$) ($m^3$/sec)

| | Jan | Feb | Mar. | Apr. | May. | Jun. | Jul. |
|---|---|---|---|---|---|---|---|
| Kao Keep Samut | 0 25 | 0.22 | 0.10 | 0.10 | 2.23 | 2.12 | 4.32 |
| Ban Sapan Hin | 0 25 | 1.95 | 0.83 | 0.40 | 3.07 | 2.42 | 5.29 |

| | Aug | Sept. | Oct | Nov. | Dec. | Average |
|---|---|---|---|---|---|---|
| Kao Keep Samut | 3 38 | 5 57 | 9.83 | 3.02 | 1 31 | 2.49 |
| Ban Sapan Hin | 4 48 | 6.26 | 10.88 | 1.57 | 0.32 | 2.92 |

Note : Figures from Jan to Mar. and in Nov. and Dec are estimation.(Refer to appendix)

Determination of Design Streamflows

As evident in the table shown above, annual rainfall at the upstream observating station amounts to 150% equivalent of that at the downstream observating station. But, on the contrary, run-off per 100 $km^2$ of catchment area of the former station is only 85% of that of the latter station

The reason of this contradictive phenomenon could not be made clear without closer investigations of the catchment area.

Moreover the records of rainfall and run-off available are, as stated before, only for one year. Therefore, it is difficult to determine which station should be selected as giving more reliable data

However, in this study, streamflow records of Kao Keep Samut gauging station was tentatively adopted and resorted to, for safety's sake, in view that the station is situated closer to the center of the catchment area. The determination of representative streamflow was determined following steps.

(1) Based on the relationship between cumulated rainfall and cumulated run-off which was obtained on the basis of the Kao Keep Samut record of 1964, the run-off coefficient was determined as follows:

| Cumulated Rainfall | Run-off Co-efficient |
|---|---|
| Below 1,000 mm | 10% |
| 1,001 mm to 2,000 mm | 40% |
| over 2,000 mm | 85% |
| Average | 34.3% |

(2) To calculate long-term stream flow, rainfall of Kao Keep Samut observating station is assumed in the following way:

Firstly, the ratio of Kao Keep Samut rainfall to Kabin Buri rainfall is calculated on the basis of the data of 1964 as follows:

$$\frac{\text{Rainfall at Kao Keep Samut in 1964}}{\text{Rainfall at Kabin Buri in 1964}} = 1.801$$

Secondly, for safety's sake, this figure was made 10% smaller allowing for the scarcity of data, then

(Rainfall at Kao Keep Samut) = 1.621 x (Rainfall at Kabin Buri)

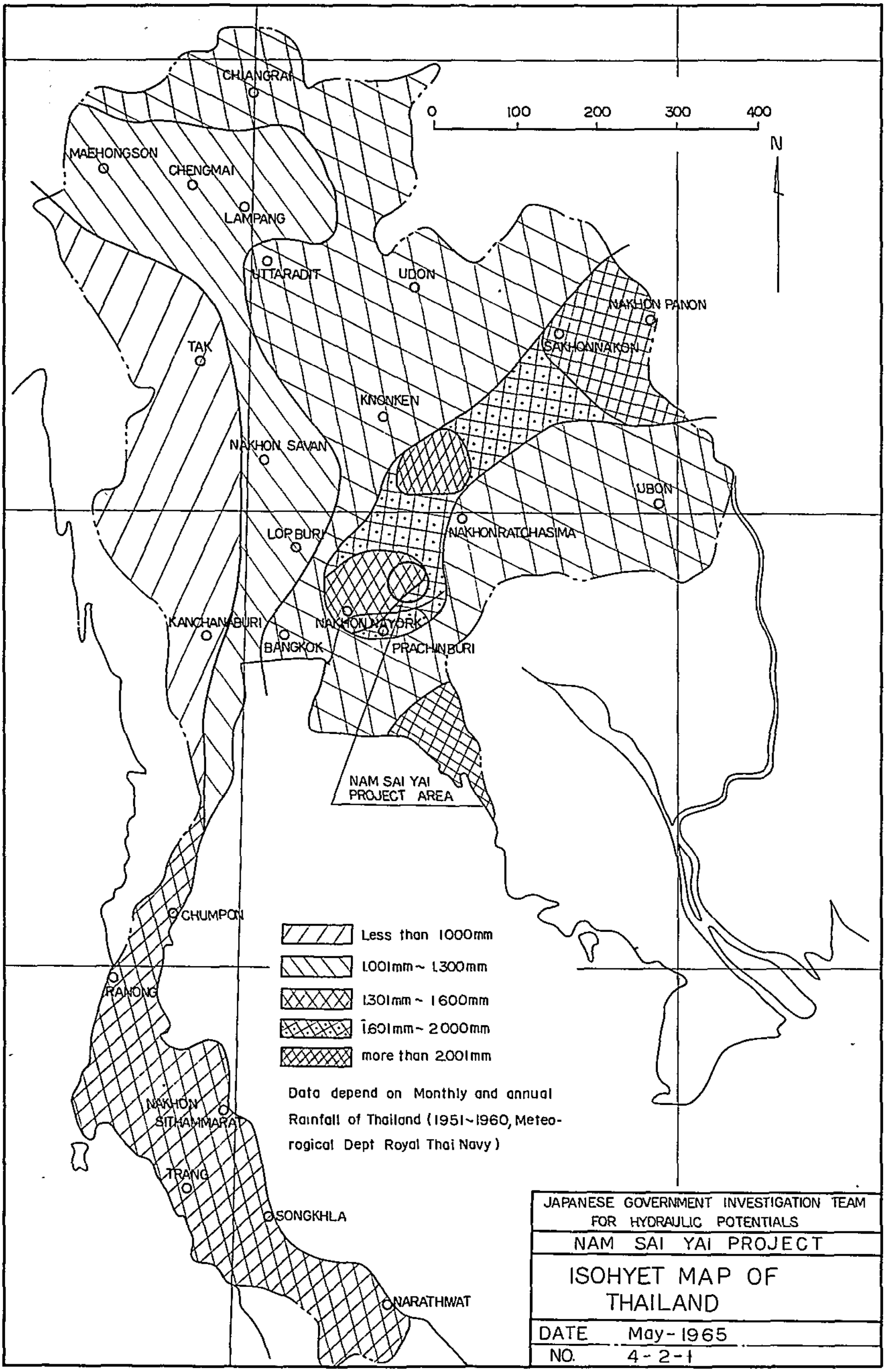
(3) Based on the formula as obtained above, monthly rainfall and monthly run-off at Kao Keep Samut are as shown in Table 4-2-4 for 14 years from 1951 to 1964. These figures are used as representative run-off in this report.

Table 4-2-4 Assumed Rainfall and Run-off at Kao Keep Samut Gauging Station

Catchment Area 315.1 $km^2$

| Item \ Month | Jan. | Feb. | Mar | Apr | May | Jun. | Jul. |
|---|---|---|---|---|---|---|---|
| Monthly Rainfall (mm) | 9 | 27 | 58 | 135 | 277 | 314 | 391 |
| Monthly Run-off ($m^3$/sec.-day) | 12 | 13 | 24 | 48 | 101 | 162 | 379 |
| Monthly Average Run-off ($m^3$/sec.) | 0.39 | 0.46 | 0.77 | 1.60 | 3.26 | 5.40 | 12.2 |
| Average Run-off per 100$km^2$ ($m^3$/sec.) | 0.12 | 0.15 | 0.24 | 0.51 | 1.03 | 1.71 | 3.87 |

| Item \ Month | Aug. | Sept | Oct | Nov | Dec | Annual | |
|---|---|---|---|---|---|---|---|
| Monthly Rainfall (mm) | 423 | 473 | 259 | 49 | 2 | 2,417 | |
| Monthly Run-off ($m^3$/sec.-day) | 578 | 924 | 658 | 156 | 15 | 3,070 | |
| Monthly Average Run-off ($m^3$/sec.) | 18.6 | 30.8 | 21.2 | 5.20 | 0.48 | 8.41 | |
| Average Run-off per 100$km^2$ ($m^3$/sec.) | 5.90 | 9.76 | 6.72 | 1.65 | 0.15 | 2.67 | |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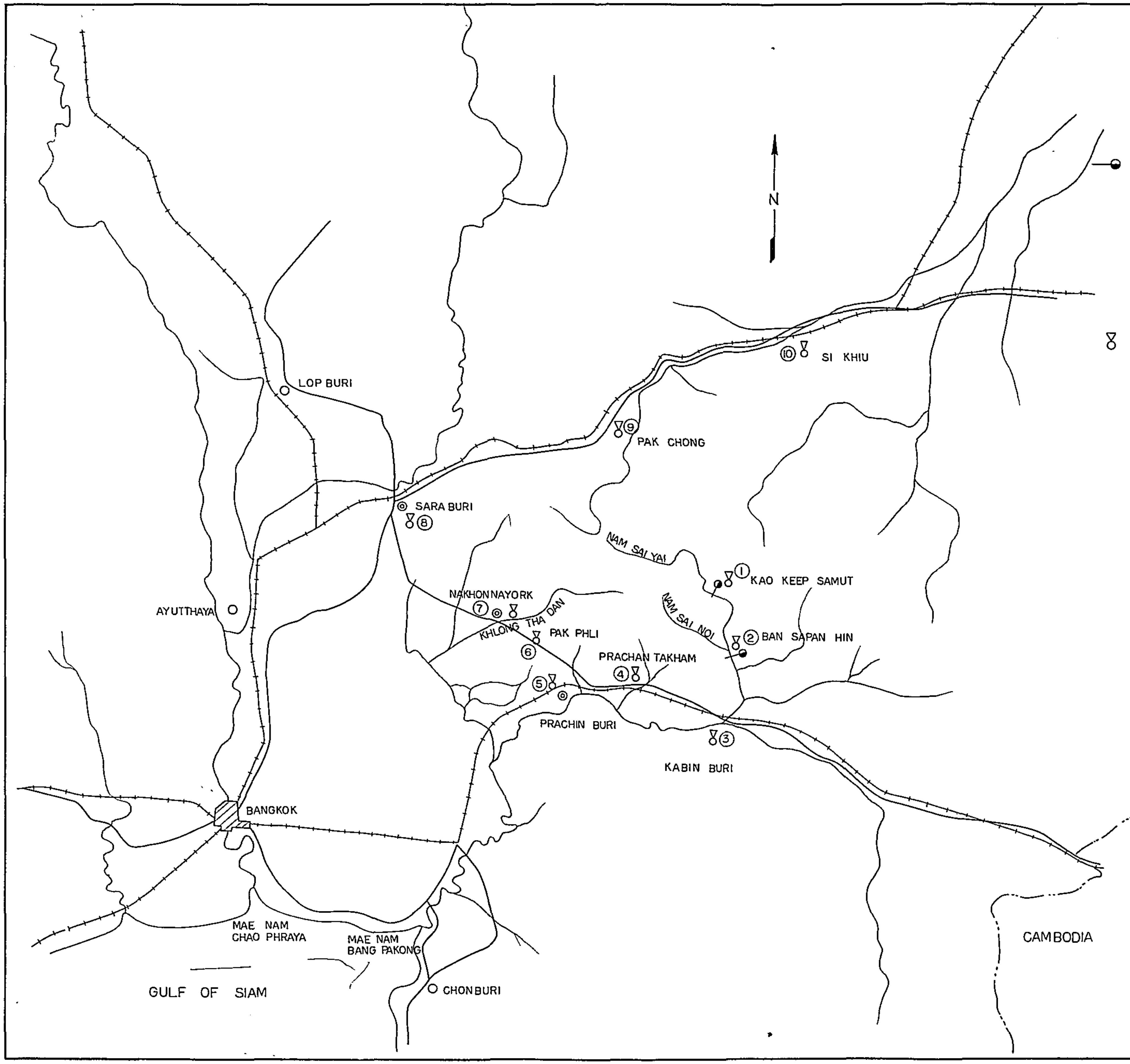
N
CHIANGRAI
MAEHONGSON
CHENGMAI
LAMPANG
UTTARADIT
UDON
NAKHON PANON
SAKHONNAKON
TAK
KHONKEN
NAKHON SAVAN
UBON
LOP BURI
NAKHONRATCHASIMA
KANCHANABURI
NAKHON NAYORK
BANGKOK
PRACHINBURI
NAM SAI YAI PROJECT AREA
CHUMPON
RANONG
NAKHON SITHAMMARAT
TRANG
SONGKHLA
NARATHIWAT
Less than 1000mm
1.001mm ~ 1.300mm
1.301mm ~ 1600mm
1.601mm ~ 2000mm
more than 2.001mm
Data depend on Monthly and annual Rainfall of Thailand (1951~1960, Meteorogical Dept Royal Thai Navy)
JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS
NAM SAI YAI PROJECT
ISOHYET MAP OF THAILAND
DATE May-1965
NO. 4-2-1




GAUGING STATION

| NO | NAME OF STATION | C A (KM ) | PERIOD OF DATA |
|---|---|---|---|
| ① | SAI YAI KAO KEEP SAMUT | 315 1 | March '64 ~ DEC. |
| ② | SAI YAI BAN SAPAN HIN | 636 | July '63 ~ DEC. |

METEOROLOGICAL OBSERVATING STATION

| NO | NAME OF STATION | PERIOD OF DATA |
|---|---|---|
| ① | KAO KEEP SAMUT | MARCH '64 ~ DEC '64 |
| ② | BAN SAPAN HIN | JULY '63 ~ DEC. '64 |
| ③ | KABIN BURI | '52 ~ 64 |
| ④ | PRACHAN TAKHAM | 〃 |
| ⑤ | PRACHIN BURI | '51 ~ '64 |
| ⑥ | PAK PHLI | 〃 |
| ⑦ | NAKHON NAYORK | 〃 |
| ⑧ | SARA BURI | 〃 |
| ⑨ | PAK CHONG | 〃 |
| ⑩ | SI KHIU | 〃 |

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

LOCATION MAP OF GAUGING STATIONS AND METEOROLOGICAL OBSERVATING STATIONS

DATE May - 1965

NO 4-2-2

## 4-3. Topography and Geology

### 4-3-1. Topography

The project area is located on a belt-like plateau at the southwest end of Korat plateau. This plateau is about 300 to 900 meters high above mean sea-level.

Around the project area, geography is relatively plain with mild undulation but at the northwestern and southern part of the plateau, the land is considerably eroded to show steep topographical features.

The southwestern and northwestern sides of the plateau are formed into cliffs with a height of hundred or several hundred meters.

From topographical viewpoint, the plateau can be considered of horst, but the details of geological structure is not clear yet

The Nam Sai Yai collects almost all the rainfall in the plateau It has a steep gradient both in the upper and the lower basins, but a very gentle gradient at the middle where a proposed reservoir is located. Route of the river is predominantly depending on geological structures, such as, strike and dip of formations and direction of joints.

Accessibility to the Project Area

Kabin Buri, an entrance to the project area located about 150 km from Bangkok, can be reached easily by driving along a highway which leads from Bangkok to the national boundary with Cambodia via Nakhon Nayork and Prachin Buri.

Access from Kabin Buri to the prohect site is towards north along the Nam Sai Yai river. Car-driving is possible for 35 km from Kabin Buri to Khok Kachang village in dry season, but with difficulties.

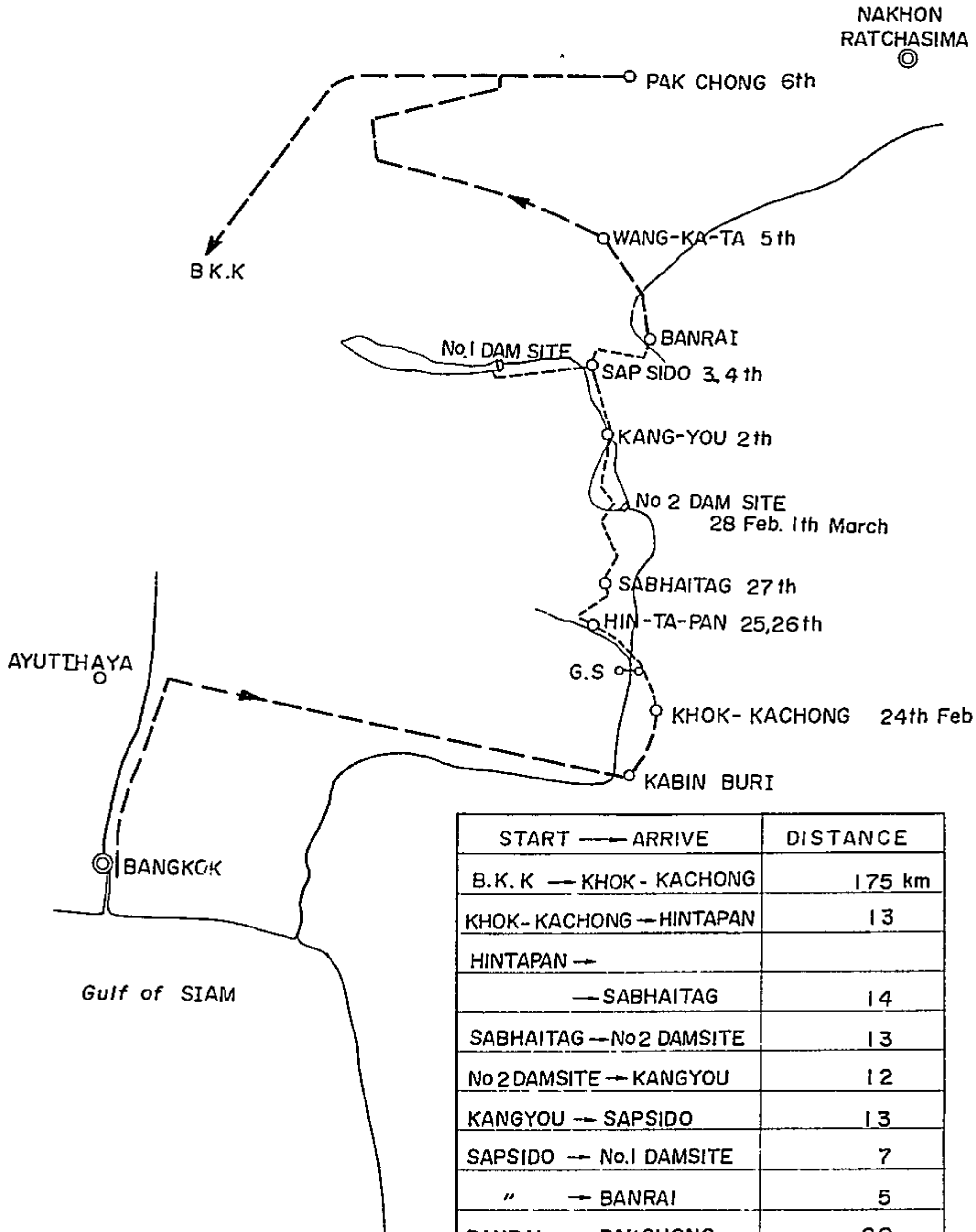
There is no road at present from the village to the proposed dam-site, tunnel-site and power station-site.

When the investigation mission visited the project-site, there was a very narrow pass opened by a surveying party of NEA. Thanks to this pass, the Mission could reconnoitered over a distance of about 100 km as far as No. 1 dam site.

However, the reconnasissance was limited to dam sites and their vicinities and a part of the reservoir area.

The proposed sites for tunnels and power stations are hidden in a dense jungle rejecting approach of human being. Onsite reconnaissance of these sites would be impossible until the jungle be cut over.

Rout of the reconnaissance on the Nam Sai Yai




| START → ARRIVE | DISTANCE |
|---|---|
| B.K.K → KHOK-KACHONG | 175 km |
| KHOK-KACHONG → HINTAPAN | 13 |
| HINTAPAN → | |
| → SABHAITAG | 14 |
| SABHAITAG → No2 DAMSITE | 13 |
| No 2 DAMSITE → KANGYOU | 12 |
| KANGYOU → SAPSIDO | 13 |
| SAPSIDO → No.1 DAMSITE | 7 |
| 〃 → BANRAI | 5 |
| BANRAI → PAKCHONG | 80 |
| PAKCHONG → B.K.K | 140 |

4-3-2. Geology

The bedrock of Korat plateau is Korat series which belongs to Mesozoic Era, and is mostly constituted of sandstone including the beds of conglomerate and red shale.

The formation and rock characters of the Korat plateau are as shown below.

| Age | Formation | | Thickness (Meters) | Character |
|---|---|---|---|---|
| | Series | Stage | | |
| Cretaceous, (?) Jurassic and Triassic | Korat | Phu Phan | | Arkosic sandstone and conglomerate Sandstone in the lower part is coarse grained and occures pebbles of conglomerate in lens. Toward the top of bed, it is fine to medium grained and shows ripple mark or cross bedding |
| | | Phra Wihan | 400 | Fine to medium grained sandstone with mica specks in band, includes some silicified woods and marly nodules; shows ripple mark in some parts. |
| | | Phukadung | 480 | Conglometate with pebbles of basalt and red shale, intercalates sandstone layers Red shale includes pebbles of quartzite derived from Kanchanaburi series |
| | Unconformity | | | |
| Permian and Carboniferous(?) | Rat Buri | | | Limestone interbedded with sandstone and shale. |
| | Unconformity | | | |
| Early Carboniferous (?) Devonian(?) and Silurian | Kanchanaburi | | | Shale, sandstone and sandy shale in many places metamorphosed to phyllite, argillite, quartzite and slate: thin beds of limestone, locally present |

Fig 4-3-2 represents the distrubution of formations which are classified by rock-facies and geological structure mainly by geological interpretation of aerial photos of the project area

Bed Rock

Outcrops of bedrock are often seen in river beds and in small dales but they are scarcely found in mountatin sides In the project area, the bedrock is mostly constituted of sandstones, thin bed of shale with very few conglomerates being inserted in the deposits locally

From observation of rock-facies, the formations seem to belong to the stages from the middle to the lower part of Korat series, i e. from Phra Wihan stage to Phukadung stage.

The formations thickness of which ranging from several centimeters to several meters, have different grain sizes, and in many cases they are not in close contact each other.

Strikes and dips of the formations show local varieties, but, as a whole, in the eastern area they have strike of NW-SE and dip of 5° - 15°SW. Whereas in the western area, they have strike of NE-SW with a gentle slope toward SE.

Distribution of the formations are, in appearance, upper formations in the eastern area and lower formations in the western area. Formations,are slightly undulating gently folded with no severe folding observed.

Although no large fault has been found so far, but geological interpretation of aerial photos reveals existence of weak lines as shown in Fig. 4-3-2. At the present stage, it is not possible to infer whether these lines represent faults, joints or fissures.

However, the line extending northwest from the north mountain side of Khao Khal (at the upper part of the Nam Sai Noi) to the north part of Ban Bu Bak Kung village can be recognized as a fault line

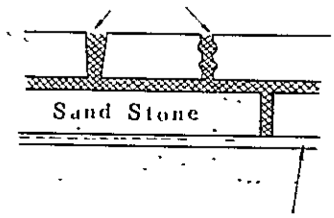
Sandstone

Sandstone is widely distributed within the project area. Generally, granularity of the sandstone ranges from fine to coarse, and occasionally to those of granular and conglomeratic nature. The fresh sandstone indicates gray or grayish blue and is compact suggesting little permeability. Weathered rock is contaminated in brown, or reddish-brown, and tend to decompose into laterite, loose and brittle.

This sandstone has medium hardness in general, but sometimes soft layers are alternated in the deposit. Therefore, even if an outcrop of sandstone seems hard, there may be soft rock in its deeper part The difference in their hardness seems to be due to difference in their grain size and matrix. Generally, the coarse grains seem to make the rock weak and brittle

Generally, in this sandstone, joints having a strike NW-SE and a vertical dip are preveailing, accompanied by many fissures These joints and fissures are often eroded to their deeper parts, and furthermore the erosion is also extended to horizontal beddings or soft formations Therefore, when both of them (vertical and horizontal erosion) exist, the resulting bedrock, being disected into many blocks, resembles to something like stone masonry, which is the phenomena often observed in the upper part of layers. The figure shown below is the characteristic representation of the phenomena

Erosion




Bedding or Loose layer

Major part of this sandstone may be broken into sand grains directly, without leaving a lot of gravels behind. Therefore, very little deposit of gravels are found in the river bed.

If the sandstone is blasted or crushed to get artificial concrete aggregates, they are likely to become fine sands, and this is not favourable for aggregates production.

Conglomerate

Since boulders of conglomerate have been often found in the southern part of the project area, it is presumed that the conglomerate is distributed in the southern area but as their outcrop has never been found actually, the real distrubution is not definite yet.

Pebbles in this rock are mainly quartzite and are generally in finger tip sizes. This rock is not well-cemented and easily broken due to weathering.

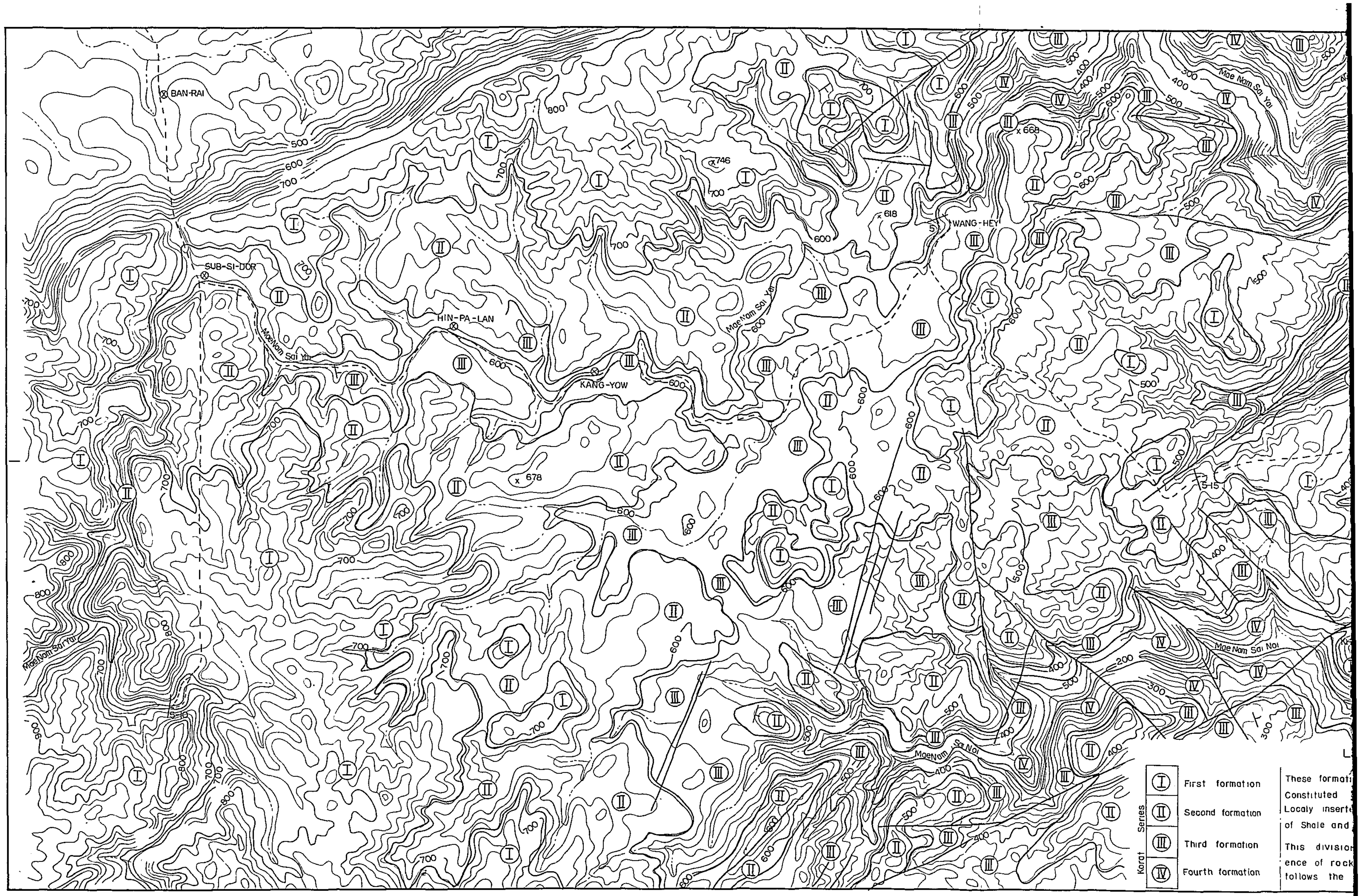
Shale

In a very rare case, boulders of shale are found, but since no outcrop of this rock has ever been found, no information has been obtained of their real distribution

Alluvial Deposit

Alluvial deposits are often found everywhere in the river basin of the project area. Almost all of them are made of fine sands, with very limited and poor deposites of gravels.

Therefore, there would be a lack of coarse portions in the natural aggregate obtainable in the area. In addition, the specific gravity of the deposits is very small, so that it may give arise to troubles to utilize the deposits as concrete aggregate


BAN-RAI
SUB-SI-DOR
HIN-PA-LAN
KANG-YOW
WANG-HEY
Mae Nam Sai Yai
Mae Nam Sai Noi
Korat Series
First formation
Second formation
Third formation
Fourth formation
These formati
Constituted
Localy inserte
of Shale and
This division
ence of rock
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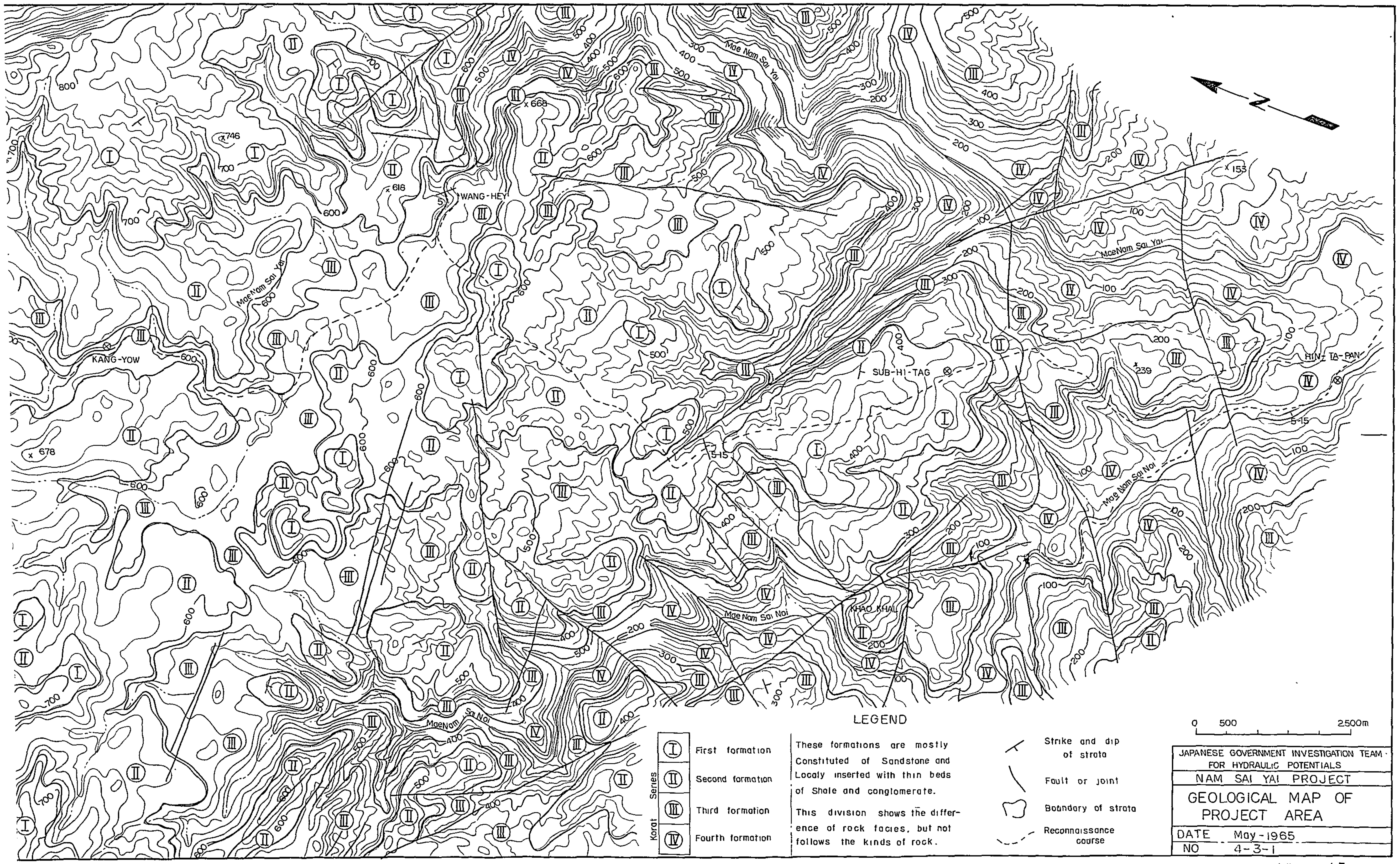
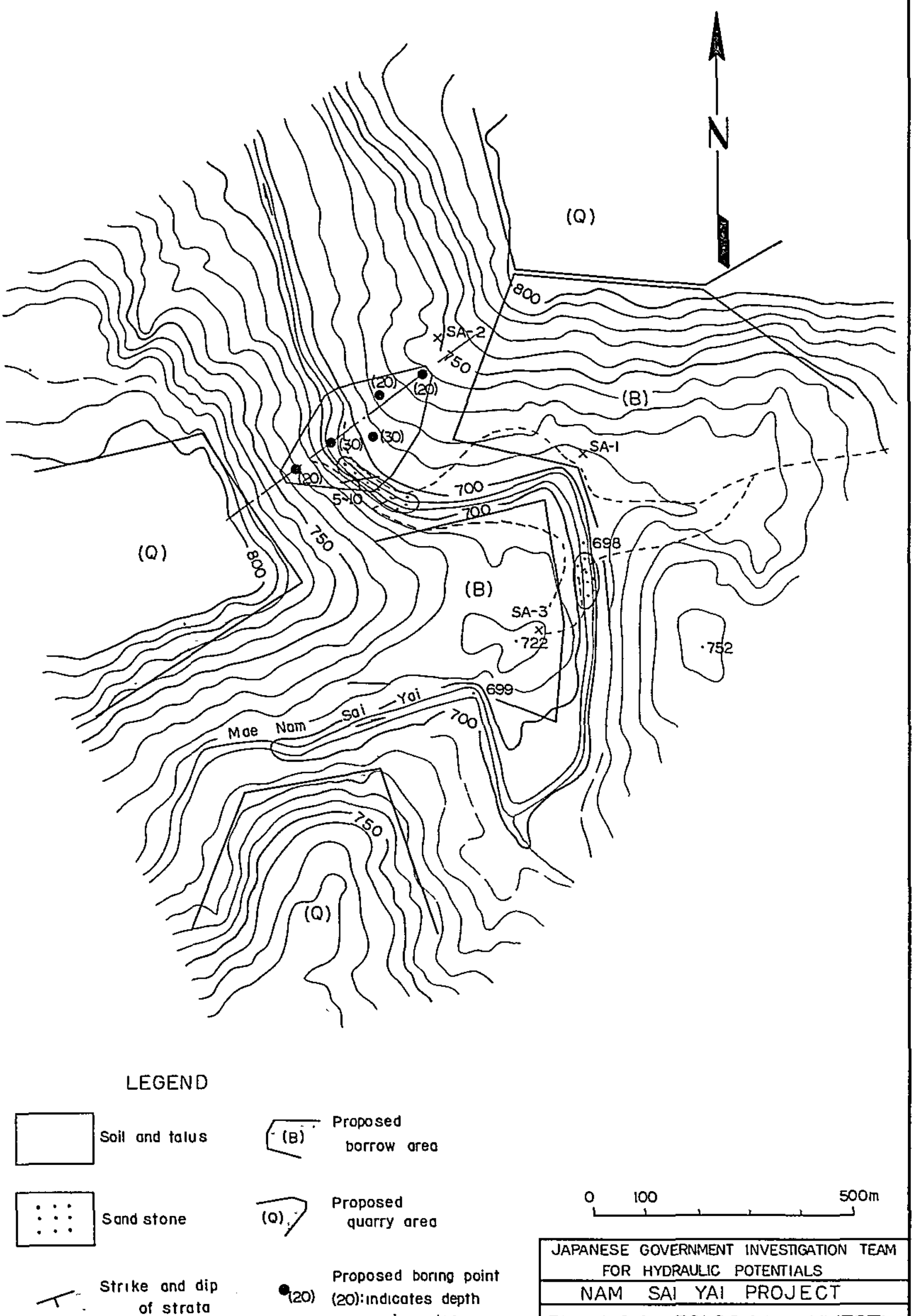


WANG-HEY
KANG-YOW
SUB-HI-TAG
HIN-TA-PAN
KHAO KHAU
Mae Nam Sai Yai
Mae Nam Sai Noi
Mae Nam Sai Yai
N
LEGEND
Korat Series
I First formation
II Second formation
III Third formation
IV Fourth formation
These formations are mostly Constituted of Sandstone and Localy inserted with thin beds of Shale and conglomerate.
This division shows the difference of rock facies, but not follows the kinds of rock.
Strike and dip of strata
Fault or joint
Boundary of strata
Reconnaissance course
0 500 2500m
JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS
NAM SAI YAI PROJECT
GEOLOGICAL MAP OF PROJECT AREA
DATE May-1965
NO 4-3-1



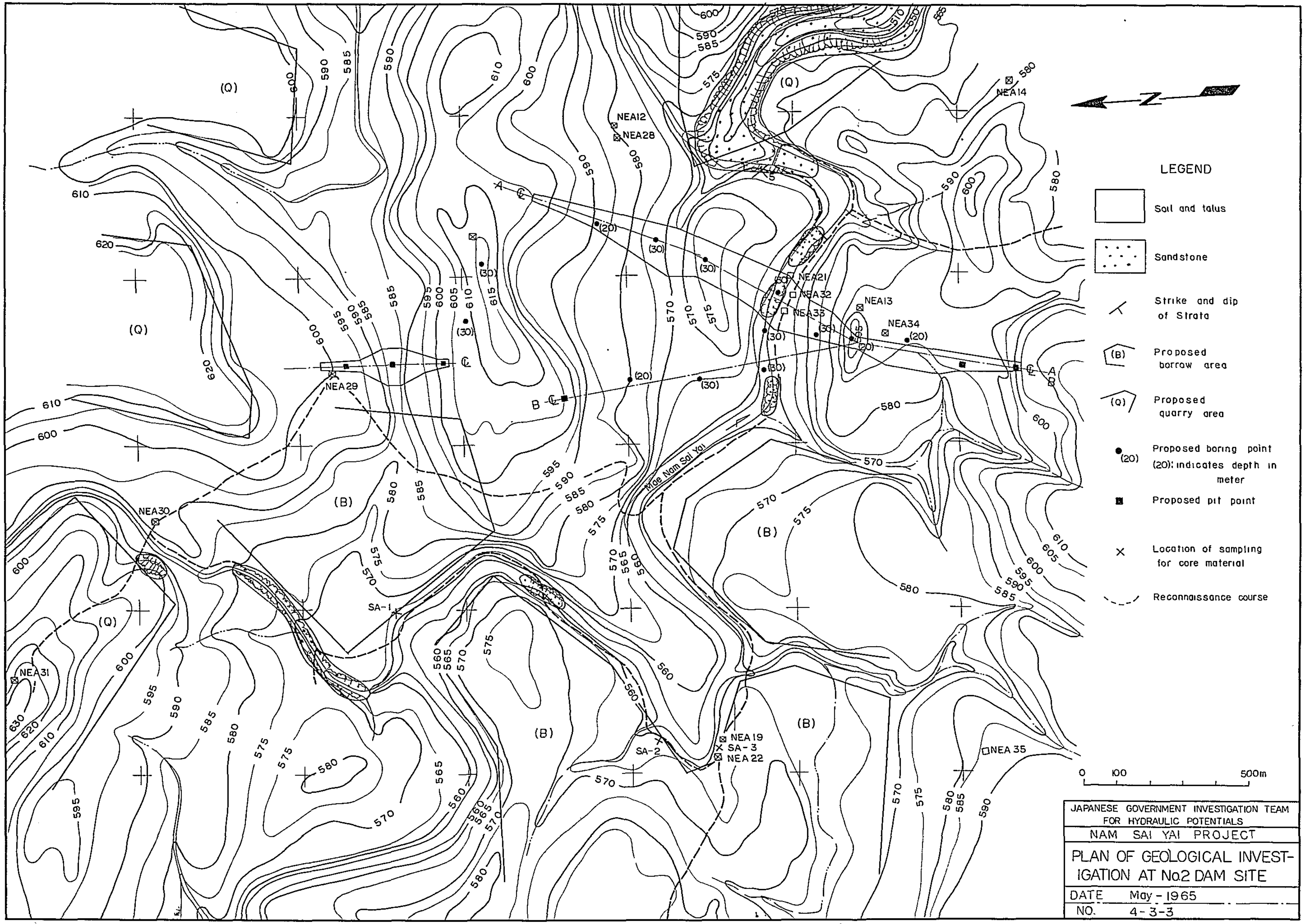

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PLAN OF GEOLOGICAL INVESTIGATION AT NO.1 DAM SITE

DATE May - 1965

NO. 4-3-2




JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PLAN OF GEOLOGICAL INVESTIGATION AT No.2 DAM SITE

DATE May - 1965

NO. 4-3-3

## 4-4. Estimate of Power Demand

### 4-4-1. Fundamental Considerations

Power demand which reflects the economic activities of national life and industry is very difficult to estimate exactly. Various methods have been introduced to estimate the future power demand in many advanced countries, but none of them has ever proved satisfactory and decisive.

From long experiences, it is said that the power demand has some correlation with the gross national products, population and production index of manufacturing industries But, in developing countries, where the economic situations is still in primary stages, development of electric resources sometimes stimulates national economy more strongly than in developed countries and the power demand often increases much rapidly. This must be taken into account in the demand forecast of a developing country.

In rural areas where the power demand is restrained due to higher power rate with lower supply capacities, a radical increase in demand may realize with the introduction of a new and low cost electric power supply, which fact needs carefull consideration.

The estimate of power demand in this report was made from a macroscopic point of view, being based on the following four facts and figures

(1) Statistical date in the past and forecast in the future, all obtained during the survey

(2) Electric energy consumption per capita of the inhabitants

(3) Tendencies of power demand in countries where social and economical conditions are quite alike with Thailand

(4) Present economic situations in Thailand.

Based on an assumption that the Sai Yai Project will be completed in 1972 (4 years of investigation, planning and design and 3 years of construction), the estimate was made for the coming 10 years period ending 1975.

All the regions of Thailand except the southern region were included to make the estimate, because these areas are expected to be interconnected by transmission lines in the near future, composing a unitary electric power system.

4-4-2. Annual Electric Energy Demand

Based on the NEA and ECAFE data, total electricity energy production in Thailand are as follows at the sending end.

| Year | Energy Generation ($10^6$ kWh) | Rate of Increase (%) |
|---|---|---|
| 1951 | 104.8 | - |
| 1952 | 128 0 | 22.2 |
| 1953 | 158.4 | 23.8 |
| 1954 | 223.6 | 41.2 |
| 1955 | 288.5 | 29.1 |
| 1956 | 328.1 | 13.7 |
| 1957 | 373.9 | 13.9 |
| 1958 | 408.1 | 9.1 |
| 1959 | 463.8 | 13.6 |
| 1960 | 593.8 | 28.0 |
| 1961 | 673.8 | 13.5 |
| 1962 | 775.2 | 15.0 |
| 1963 | 905.9 | 17.0 |

The said table contains the energy production not only by electric power enterprises but also by privately owned power stations. The table shows that average annual rate of increase is 19.7%, and the generated energy has increased to 8.6 times as much as that of 12 years ago.

Regional increase of electric power consumption is as shown in the following table. Average annual increase during the period from 1956 to 1962 were, 15.5% in Bangkok-Thonburi Area, 19.2% in the Central Region, 39.6% in the Northern Region, and 21.1% in the Northeastern Region.

Regional Electric Energy Production

| Year | Bangkok-Thonburi Area | | Central Region | | Northern Region | | North-Eastern Region | |
|---|---|---|---|---|---|---|---|---|
| | Energy Produced ($10^6$ kWh) | Annual Increase (%) | Energy Produced ($10^6$kWh) | Annual Increase (%) | Energy Produced ($10^6$kWh) | Annual Increase (%) | Energy Produced ($10^6$kWh) | Annual Increase (%) |
| 1956 | 223.3 | - | 24.2 | - | 8.6 | - | 7.3 | - |
| 1957 | 246.1 | 10.3 | 29.5 | 22 | 11.0 | 28.0 | 8.5 | 16.5 |
| 1958 | 286.0 | 16.5 | 34.2 | 16 | 12.0 | 9.0 | 9.9 | 16.5 |
| 1959 | 341.5 | 19.0 | 52.4 | 53 | 13.9 | 16.0 | 11.4 | 15 |
| 1960 | 387.4 | 13.5 | 62.3 | 19 | 17.3 | 24.5 | 13.9 | 22 |
| 1961 | 451.9 | 16.5 | 63.1 | 1 | 56.0 | 22.3 | 17.5 | 26 |
| 1962 | 531.4 | 18.0 | 69.5 | 10 | 60.9 | 8.8 | 23.1 | 32 |
| Average Increase | | 15.5 | | 19.2 | | 39.6 | | 21.2 |

The remarkable progress made in the Northern Region may be attributed to the completion of Mae Moh Lignite thermal power plant of the Lignite Authority (LA) in this period.

By the statistical data for the Bangkok-Thonburi Area for the period of 1961~1964, the average annual increase is 22% as is shown in Table 3-3-1.

The estimation of electric energy demand was made based on the following rate of annual increase which were assumed from the data referred above.

| | 1966-1970 | 1971-1975 |
|---|---|---|
| Bangkok-Thonburi Area | 20% | 18% |
| Rural Areas | 20% | 20% |

These figures are quite unusual compared with 7% of ordinary rate (or twice in every 10 years) in any advanced country, however, they are, as were shown, supported by the statistical data for more than 10 years, and trends of industrialization in Thailand and an expected reform in electric power rate systems in the near future. All these things are in support of the rapid increase in the electric energy demand.

Furthermore, in some ECAFE participant countries, where economic situations are alike with Thailand higher rates of increase have been reported as follows.

| | Average Annual Increase |
|---|---|
| Burma | 20.7% |
| Pakistan | 20.5% |
| Korea | 18.2% |

In the Rural Areas, the electric energy consumption per capita, is only 10% of that of Bangkok-Thonburi Area. But it can be easily assumed that the electric energy consumption in these areas may expand rapidly at the rate of the present increase, if low cost energy is supplied by hydro-electric power and if transmission and distribution systems are properly provided for.

4-4-3. Annual Maximum Power Demand

The annual maximum power demand was determined based on annual load factors in the past and increasing tendencies in load factor due to expanding demand for industrial use. For the Bangkok-Thonburi Area, the load factor was assumed to be 53-56% and for Rural Areas 30-40%.

The annual maximum power demand was calculated by adopting these load factors and the annual electric energy demand stated in the preceeding paragraph.

4-4-4. Gross Loss due to Transmission, Transforming and Distribution

The gross loss due to transmission, transforming and distribution obtained from past data were, 23.7% for 1961, 23.3% for 1962, and 23.2% for 1963. The loss is affected by various factors, such as;

(1) Location of power stations

(2) Hydro or thermal power

(3) Distribution of load demand

(4) Conditions of distribution net-work

The loss was assumed at 18-22% for Bangkok-Thonburi Area in view of the said statistical data and possible future improvement in substations and distribution networks in the Bangkok - Thonburi Area. For Rural Areas, 20-23% was assumed. These figures were used in the calculation of power demand at sending end from assumed demand at consuming.

4-4-5. Stand-by Capacity

Some stand-by capacity is necessitated to ensure a steady power supply even in the case of failures in power supply facilities, drought and fluctuations in demand, all of which are of an unexpectable nature. Therefore, it was determined that supplying capacity of the project should be a sum of maximum power demand and assumably necessitated stand-by capacity, and that the stand-by capacity of the total system should have a capacity equivalent to;

1. 75 mW which is the maximum unit output of generating equipments in the system, or
2. 10% of the total system installed output, whichever is larger,

in order mainly to be prepared for failures in supplying facilities.

4-4-6. Study on Balance of Supply and Demand

The electric power demand computed by the conditions stated above is tabulated in Table 4-4-1 for a period from 1965 to 1975. On the other hand, the supply capacity as of 1968 including existing power stations and hydro power plants under construction will be as shown in the following Table. The Nam Pung and the Nam Pong power plants, as well as No. 3 & No. 4 Units of Bhumibol Power Stations, which are under construction are included, but no other development project is included as their definite informations are not available.

Supply Capacity as of 1968

(Unit:mW & $10^6$kWh)

| | Hydro Power | | Thermal Power | | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | | | Steam Power | | Diesel Power | | | |
| | Installed Capacity (kW) | Annual Energy (kWh) | Installed Capacity (kW) | Annual Energy (kWh) | Installed Capacity (kW) | Annual Energy (kWh) | Installed Capacity (kW) | Annual Energy (kWh) |
| YEA | 280 | 1.080 | 150 | 1,110 | 36.5 | 128 | 466.5 | 2,318 |
| LA | | | 12.5 | 90 | | | 12.5 | 90 |
| PEA | | | | | 92 0 | 130 | 92.0 | 130 |
| NEA | 6 | 15 | | | | | 6.0 | 15 |
| NEEA | 25 | 57 | | | | | 25.0 | 57 |
| Total | 311 | 1 152 | 162 5 | 1,200 | 128.5 | 258 | 602.0 | 2,610 |

Note: (1) Annual energy for the hydro electric plants represents the firm energy

(2) The load factors for the thermal power are 85% for steam station and 40% for diesel station.

(3) Superannuated thermal power plant of YEA are neglected.

(4) Data for the PEA includes privately owned and other enterprises for the year of 1963.

From the said consideration, the supply of electricity in these areas as a whole will have an ample room over the demand until 1969, and shortage will be presumed to arise in 1970 or later.. However, since interconnection of transmission lines will not have been completed by the time, it is feared that shortages may arise in some local district much earlier.

On the other hand, the Sai Yai Project will not be completed earlier than 1972, since it requires 7 years of investigation and construction. Therefore, some measures have to be taken to prepare for the possible supply shortage of the intervening period.

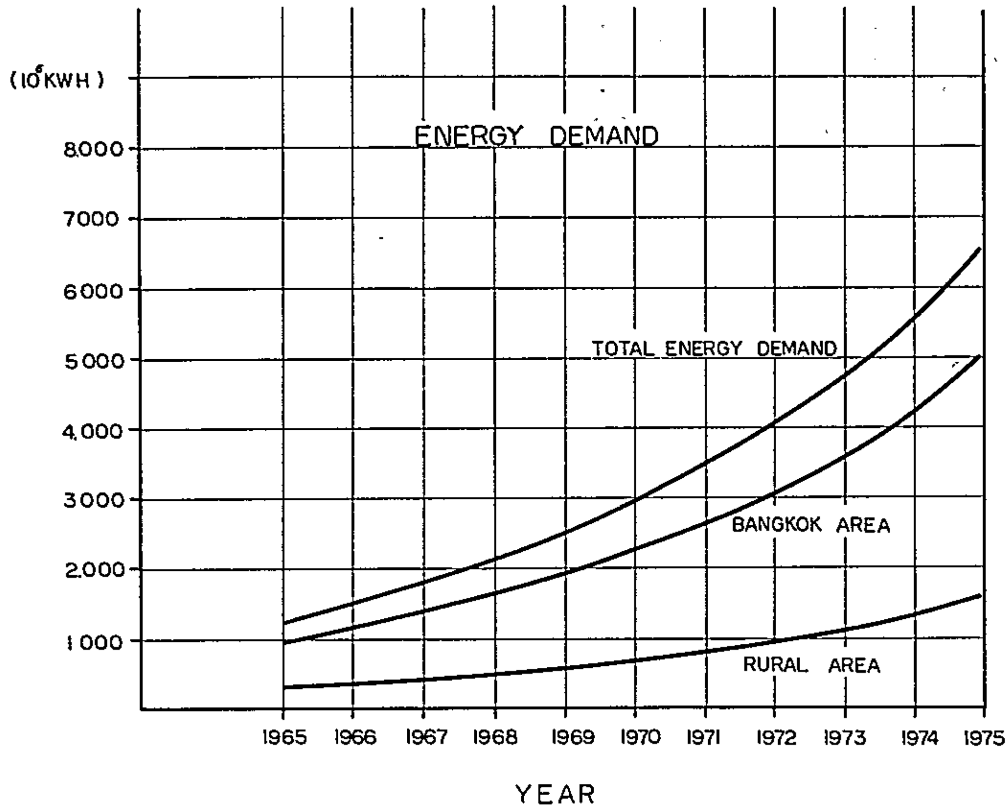
According to the demand estimation for the Northeastern region, which was conducted based on an assumption that peak power demand and annual energy demand of the region account for 15% and 20% of those of the Rural Area, peak power demand and annual energy demand of the region will be 40mW and 100,000,000 kWh in 1970, and 53mW and 142,000,000 kWh in 1972. While, supply capability will be 58mW of installed capacity and 112,000,000 kWh of annual energy production including the Nam Pung and the Nam Pong power plants, and PEA power plants as well. Therefore, though the supply capability will have an ample room over the demand in 1970, shortage is anticipated in annual energy supply in 1972.

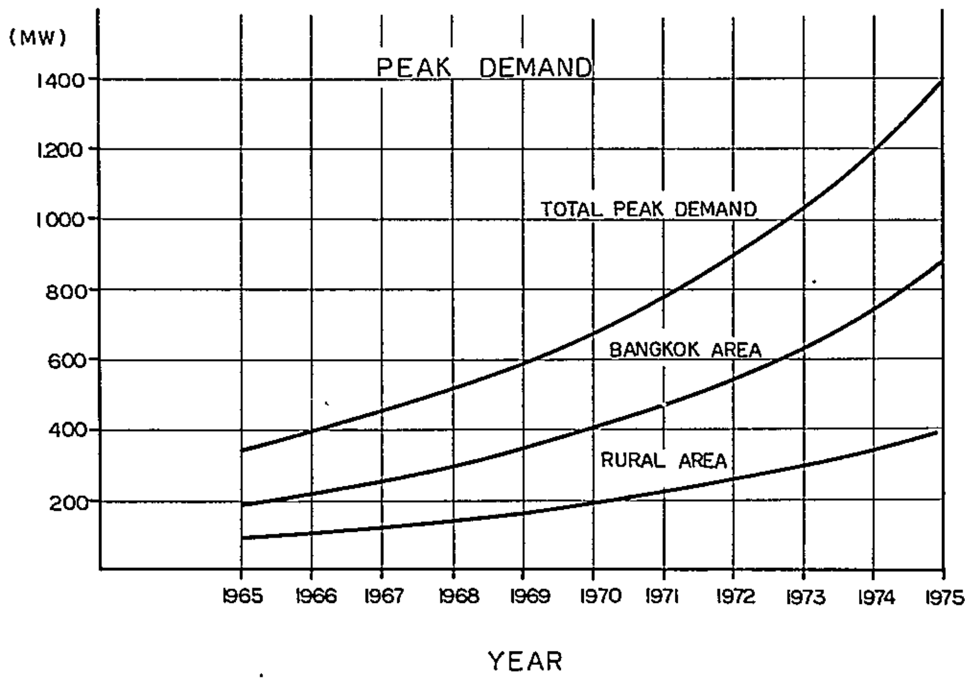
Even if the Lam Dom Noi hydro electric power station (15mW, 43.6 x $10^6$kWh) is to join in the supply system by that time shortage of power will probably arise in 1973. Therefore, it would be of absolute necessity for the Northeastern region to get interconnected with the Sai Yai system

Table 4-4-1. Load Forecast for the Year (1965~1975)

(Unit : mW, $10^6$kWh)

| | Item \ Year | 1965 | 1966 | 1967 | 1968 | 1969 | 1970 | 1971 | 1972 | 1973 | 1974 | 1975 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bangkok-Thonburi Area | Annual generation (at consuming end) | 715 | 855 | 1,030 | 1,230 | 1,480 | 1,775 | 2,095 | 2,470 | 2,915 | 3,440 | 4,060 |
| | Annual generation (at sending end) | 925 | 1,100 | 1,320 | 1.560 | 1,875 | 2,210 | 2,620 | 3,050 | 3,600 | 4,200 | 4,950 |
| | Annual maximum demand (mW) | 180 | 205 | 250 | 290 | 345 | 405 | 475 | 545 | 640 | 735 | 870 |
| | Annual increase rate (%) | 21 8 | 20 | 20 | 20 | 20 | 20 | 18 | 18 | 18 | 18 | 18 |
| | Gross loss rate (%) | 23 | 22 | 22 | 21 | 21 | 20 | 20 | 19 | 19 | 18 | 18 |
| | Annual load factor (%) | 52 | 53 | 53 | 54 | 54 | 55 | 55 | 56 | 56 | 57 | 57 |
| Rural Area | Annual generation (at consuming end) | 205 | 245 | 295 | 355 | 425 | 510 | 610 | 730 | 875 | 1,050 | 1,250 |
| | Annual generation (at sending end) | 270 | 320 | 385 | 460 | 545 | 655 | 780 | 925 | 1,100 | 1,330 | 1,560 |
| | Annual Maximum demand (mW) | 90 | 105 | 120 | 145 | 160 | 195 | 220 | 255 | 290 | 350 | 390 |
| | Annual increase rate (%) | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 | 20 |
| | Gross loss rate (%) | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 | 23 |
| | Annual load factor (%) | 30 | 30 | 32 | 32 | 34 | 34 | 36 | 36 | 38 | 38 | 40 |
| Total | Annual generation (at consuming end) | 920 | 1,100 | 1,325 | 1,585 | 1,905 | 2,285 | 2,705 | 3,200 | 3,790 | 4,490 | 5,310 |
| | Annual generation (at sending end) | 1,195 | 1,420 | 1,705 | 2,020 | 2,420 | 2,865 | 3,400 | 3,975 | 4,700 | 5,530 | 6,510 |
| | Annual maximum demand (mW) | 270 | 310 | 370 | 435 | 505 | 600 | 695 | 800 | 930 | 1,085 | 1,260 |
| | Required generating capacity | 345 | 385 | 445 | 510 | 580 | 675 | 770 | 880 | 1,025 | 1,195 | 1,385 |




| | |
|---|---|
| JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS | |
| NAM SAI YAI PROJECT | |
| LOAD FORECAST FOR THE YEAR (1965~1975) | |
| DATE | May -1965 |
| NO. | 4-4-1 |

## 4-5. Hydro Electric Development

### 4-5-1. General

This project area is very advantageous for hydro-electric power generation with its abundant rainfall and gentle river bed slope.

However, it is the characteristic of any river in Thailand that there is a distinct contrast between natural river flow in the wet and the dry seasons. According to 1964 record of Kao Keep Samut gauging station, for instance, the average river flow at the gauging station in the wet season from May to October is about 14 times as large as that in the dry season from November to April, and the maximum flood in the wet season reaches to 100 times as large as the minimum value in the dry season.

There is also a large difference between the quantities of annual total river flow in the wet and the dry years. Records of 14 years from 1951 to 1964 show that annual river flow in the wet years amounts 4 times as large as that in the dry years.

Furthermore, there is a tendency in which several consecutive years of drought sometimes happen.

All these natural river flow conditions lead to a conclusion that large scaled reservoirs are necessary to ensure steady and constant power supply.

### 4-5-2. Determination of Reservoir Location and Capacity

The Nam Sai Yai river joins to the Nam Sai Noi river in the vicinity of the Ban Sapan Hin gauging station. At a point about 28 km upstream from this confluence, the Nam Sai Yai river forms a fall which has a height of about 20 m. Downstream from the fall, there is no appropriate dam site. However, upstream from the fall, the valley is wide with gentle river bed slope.

In view of these topographical characteristics, the Sai Yai No. 2 dam is proposed at a site in a comparatively narrow valley some 350 m upstream from the fall. The dam is to be 45 m high and 1,500 m in the crest length.

About 10 km upstream from Sapsido near the upstream end of the No. 2 reservoir the river bed slope is steeper again up to a gorge above where the topography gets wider and flat with decreasing bed slope. The Sai Yai No. 1 dam which has a height of 45 m and a crest length of 330 m is proposed at the gorge.

Reservoir Capacity

The catchment area upstream from the No. 2 dam site, is about 300 $km^2$ and it is presumed that this area discharges annual flow of about 500 million $m^3$ in a wet year, 150 million $m^3$ in a drought year and 250 million $m^3$ in an average year.

Complete regulation over years and over months of the river flow will requires an effective storage capacity of about 400 million $m^3$, but it is not necessarily economical to obtain the required capacity by the two reservoirs. Therefore, the effective storage capacity of each reservoir has been determined to be 150 million $m^3$ totalling 300 million $m^3$ capacity.

By this effective storage capacity, regulated firm flow will be more than 90% of the natural average flow as shown in the following table.

Regulated Firm Flow*

| | (a) Natural Average Flow 1951-1964 | (b) Regulated Firm Flow* | (c) Ratio (b) / (a) |
|---|---|---|---|
| Sai Yai No. 1 Dam | 3.3 $m^3$/sec. | 3.1 $m^3$/sec. | 94% |
| Sai Yai No. 2 Dam | 7.9 $m^3$/sec. | 7.0 $m^3$/sec. | 90% |

*Regulated Firm Flow is the quantity of flow which can be expected during the successive drought years of 1957-1961.

Note: References:

1. Mass curves for the Sai Yai No. 1 and No. 2 dam sites.
2. Reservoir capacity curve for the Sai Yai No. 1 and No. 2 dam sites.

Determination of Maximum Discharge

Since the Sai Yai Project is located near Bangkok-Thonburi Area which is the center of consumption of electricity, the hydro power stations of the Sai Yai project had better be used as a peak power stations to meet the fluctuating demand.

The maximum discharges of the two power stations were determined in the following way, based on the said regulated firm flow and an assumed load factor of 33%.

No. 1 Power Station

| | |
|---|---|
| Firm Flow | 3.1 $m^3$/sec. |
| Evaporation* (in terms of flow) | 0.4 $m^3$/sec. |
| Net Flow | 2.7 $m^3$/sec. |

$\frac{100\%}{33\%} \times 2.7\ m^3/sec. \fallingdotseq 8.0\ m^3/sec.$

No. 2 Power Station

| | |
|---|---|
| Firm Flow | 7.0 $m^3$/sec. |
| Evaporation* (in terms of flow) | 0.4 $m^3$/sec. |
| Net Flow | 6.6 $m^3$/sec. |

$\frac{100\%}{33\%} \times 6.6\ m^3/sec. \fallingdotseq 20.0\ m^3/sec.$

*Evaporation is the quantity of water that evaporates from the reservoir surface. Total evaporation of 1,000 mm was assumed for a year.

4-5-3. General Outline of the Project

The normal water surface of the Sai Yai No. 1 reservoir is proposed at EL. 735m. The tail water level for the No. 4 power station (lower-most one) is determined to be EL. 40 m in view of river bed elevation of the Nam Sai Yai river and in view of necessary head for irrigation in the downstream areas.

The total head available is 695 m and the head will be completely utilized by 4 power stations resulting in total installed output of 94,000 kW and annual energy generation of 309,000 x $10^3$ kWh.

A few explanations is given below.

(1) The Sai Yai No. 1 power station receives water from No. 1 reservoir and

releases it into No. 2 reservoirs, to generate 7,500 kW of power.

The No. 1 reservoir water will reach No. 2 reservoir through 2,400 m long. Tunnel and 1,900 m long penstock which are proposed on a route connecting No. 1 and No. 2 reservoirs at the shortest distance taking advantage of the bending of the river course.

(2) The No. 2 reservoir water taken at an intake structure on the right bank of the No. 2 dam site will be diverted to the upper course of the Nam Sai Noi river.

The diversion shall be made in two stages for topographical reasons;

i) The water is firstly led to the Sai Yai No. 2 power station by means of a tunnel of 1,500 m length and a penstock of 800 m length to generate 13,700 kW at the station. The tail water elevation of the station is EL. 500 m.

ii) Then, the water discharged by the No. 2 station is led through a tunnel of 2,700 m length and a penstock of 1,500 m lenght, to a site at EL. 240 m in the upper stream of the Nam Sai Noi river, where the Sai Yai No. 3 power station generate power of 41,700 kW.installed capacity.

(3) An intake weir is to be constructed near the end of tailrace of the No. 3 power station to divert the flow of the Nam Sai Noi (82 $km^2$ in catchment area) which includes the discharge from the No. 3 power station as above-stated. The diversion will be by means of a tunnel of 6,800 m length on the left bank and a penstock of 1,450 m length which leads to the No. 4 power station. The No. 4 station discharges water at a site EL. 40 m, at about 10 km upstream from the confluence of the Nam Sai Yai and the Nam Sai Noi after producing power of 31,100 kW. Since the No. 4 power station receives a part of its discharge from the catchment basin of the Nam Sai Noi an energy increase can be expected by an increase of operation hours of the station, although this is only possible during the wet

season. No increase in kWh can not be expected in the dry season, the maximum discharge of the No. 4 power station is proposed to be of the same size as that of the No. 2 and No. 3 power stations, i.e., 20 $m^3$/sec.

(4) Equalizing Reservoir

In the lower stretch of the Nam Sai Yai, there is a broad irrigated land for agricultural cultivation where the river water has been in use. Therefore, from the irrigational purposes, it seems necessary to avoid river flow fluctuation which may arise due to the operation of the power stations as much as possible.

From this reason, an equalizing reservoir may be necessary so long as the power development aims at peak power generation.

And also, the Sai Yai Project has an object of reclaiming a new paddy-field in the lower reaches area of the river, and supplying irrigation water to the paddyfield from the Nam Sai Yai so that the field may yield crops even in the dry season. Therefore, by the time of this reclamation, at the latest, an equalizing reservoir will have to be constructed to obtain an even distribution of power station discharge throughout a day. However, the reclamation work is expected to start much later after the completion of the Nam Sai Yai Project. Although, it was also intended to attach to the equalizing reservoir dam, a low head power station, but since the cost of energy produced by this station is rather high, the development of this power station is later the better.

The equalizing reservoir and its appurtenant power station were excluded from this report, since their timing of construction is not definite yet, as stated above.

During the on-site reconnaissance, the mission searched along the Nam Sai Noi for possible dam site of the equalizing reservoir dam and found one or two favourable dam sites between the confluence with the Nam Sai Yai and the tailrace site of No. 4 power station. The height of the dam will most suitably be about 20 m, and the power station will have a capacity of about 3,000 to 4,000 kW

An Alternative Plan for the Power Development

The proposed Sai Yai Project is distinguished by the two characteristics, the one is almost complete river flow regulation by the two large scaled reservoirs, and the other is the development of large output under large heads.

The normal water surface of the upper-most reservoir and tail water surface at the lower most power station are, of course, determined by conditions in the upper-most dam site and those in the lower-most power station site. However, there may also be other alternatives for the passages of tunnels.

In the studies of the Mission, the passages of tunnels were selected based on aerial photos and topographic maps to a scale of 1/50,000, because on-site reconnaissance of tunnel passages were not conducted for several reasons.

As a result of these studies, the power project and the passages of tunnels as described before are proposed by the three reasons shown below to the exclusion of alternatives.

(1) The tunnel for the Sai Yai No. 2 power station is driven through the center of the left bank ridge to secure safety in the tunneling works. An alternative tunnel passage along the river on the right bank is conceivable, but in such case, due to its thinner rock cover, troubles in tunneling works and leakage of underground water are both anticipated to result inevitably in a higher construction cost.

(2) By the passages proposed for this project, comparatively shorter tunnels can lead water to the lower-most station, and furthermore, easier intake of water from the Nam Sai Noi can be expected at the tailrace of No. 3 power station.

(3) Easire access to the sites of construction works is expected by this project

than to have all the power station sites along the Nam Sai Yai river.

However, if the geological conditions in the tunnels and in the power station sites are favourable and no appreciable amount of underground water leakage is met, an underground power station may be conceivable as an alternative.

For instance, if No. 2 and No. 3 power stations are combined to form an underground power station, having a tunnel and a shaft and a tailrace tunnel, then a tunnel shorter than the proposed one can lead water to the Sai Noi intake site of No. 4 power station with smaller construction cost, provided that geological conditions are favourable.

4-5-4. Mission 's Opinion on the Dam Site

The No.1 and No. 2 dam sites are, except river bed, all covered with bushes including large trees more than 20m in height, and visibility is very bad at the sites. Therefore, it was very hard for the Mission to grasp general topographical features of the dam sites.

The Mission could obtain aerial photographic maps to a scale of 1/10,000 prepared by the U.S. Air Force for the No. 1 dam site, as well as topographic maps to a scale of 1/10,000 prepared by the National Energy Authority based on actual measuring. On the basis of these maps the Mission selected presumable dam sites before the reconnaissance. Simple surveying was carried out on these selected sites.

In the project area the dam sites were cleared of trees and bushes along the dam axis to have a geological observation from the ground surface. Soil samples were taken from some representative places for the studies of soil characteristics.

From the surveys shown above, following conclusions have been obtained.

(1) Fill-type dam is appropriate for both of the No. 1 and No. 2 dams.
The embankment materials will be similar to that of earth dam, from reasons shown below.

(2) The reasons of recommendation for fill-type dam are as follows;

(2)-(1) No deposit of natural gravel or sand which can be utilized as fine or coarse aggregates for concrete is observed at the sites. Explorations for natural deposit were conducted not only around the dam sites but even as far as the vicinity of Kabin Buri, but were found only a few deposits of fine sand and boulders in the Nam Sai Noi rejecting all possibilities of acquiring natural aggregates within economic transportation distance.

Then, if a concrete dam is to be constructed, aggregate should be produced from rocks by means of crushing, but rock outcrops in the river bed are suggesting that obtainable rocks are not hard engough to make good aggregate, and that crushing of the rock may result in too much fine grains. Thus, in any way, such aggregate may be unobtainable economically in the project area as is safely employed in the construction of a concrete dam. Concrete dams are not recommendable for the dam sites from viewpoint of aggregate procurement.

(2)-(2) Around the proposed dam sites, outcrops of bedrock are exposed in the river bed, but large trees are grown clustering on the banks of the river, which allows an inference that the earth cover on the banks are very deep. This fairly deep earth layers can be left unexcavated to some extent in case of a fill-type dam, so long as the layers are compact. But, in case of a concrete dam excavation will be necessary to the bottom of the layer in order to ensure direct contact of placed concrete with the bedrock. Therefore, both excavation and dam volume will be far larger for a concrete dam and construction cost is necessarily higher.

(2)-(3) Due to the topography, the dams will have a long crest length as compared with their height. Therefore, arch dams are not feasible for the sites which in ordinary cases are economically compatible with fill-type dams.

(2)-(4) When the rock conditions as stated in (2)-(1) are taken into consideration, a question may arise whether or not the large sized rock are available that are necessary for the construction of a fill-type dam, but it is believed, in view of the height and volume of the proposed dams, that large sized rock is obtainable in sufficient quantity within 1 km from the dam sites.

As to impervious core materials, soil materials that can be used for the core of the dams will be obtainable within about 1 km range from the dam sites, though they are not necessarily excellent in quality as they contain less clay than usual core materials.

(2)-(5) Magnitude of design flood for the No. 1 and No. 2 dams are about 300 $m^3$/sec. and 600 $m^3$/sec. respectively, which advantageously small in favour of fill-type dam design.

From the reasons as stated above, fill-type has been finally proposed and dam axes have tentatively been determined of the proposed dams based on the results of the on-site reconnaissance. At the No. 2 dam site, two dam axes, A and B, having almost equal dam volumes, are recommendable for choice between them. Unless no decisive superiority or inferiority is evaluated of the one to the other in future investigations, the axis A seems preferable to the axis B because dam volume will be a little smaller on the axis A.

Geology in the Dam Site, Quarry Sites and Borrow Areas.

No. 1 Dam site.

At the dam site, the river has a width of 20 m. The right bank of the valley is a slope of 27° and has complicated geography with many dales around the proposed dam axis. The left bank has a gentle slope of 7° to 10° up to higher elevations.

Though no outcrops of bedrock sandstone are seen in the river bed around the dam axis, but they are found at a site about 50m upstream from the axis. Therefore, it is believed that the bedrock lies close to the ground surface around the dam axis. The both banks of the river are covered with topsoil, with no trace of bedrock outcrops.

The layer of sandstone which exists in the river bed above the dam site is hard and has a strike of N 80°E and a dip of 5° - 10°SE. The sandstone is deeply eroded not only along its joints, but also along its almost horizontal beddings, and these eroded joints and beddings may have been interconnected together in deeper portions, disecting the rock masses into many and small blocks. Therefore, further investigations should be conducted of the depth of the erosion and the permeability of the layer.

Rock materials for the dam construction are believed to be available at higher elevations of the mountain slopes upon which the dam is to abuts.

It is believed that the said higher elevations are of sandstones.

Impervious core materials is believed obtainable in flat areas on the left bank, or in the right bank slope upstream from the dam site.

No. 2 Dam site.

The river bed has a width of 50 m on the proposed dam axis. The slope of the banks is gentle.

At about 350 m downstream from the dam axis, there is a fall 20 m in height around which an outcrop of sandstone is presented. For a distance of about 1 km downstream from the fall, there scattered numbers of large boulders of sandstone indicating gradual regression of the fall.

There is little deposit in the river bed around the dam site, and sandstone are exposed at many places in the river bed.

The banks are covered with topsoil and no outcrop of bedrock is presented in them. The layer of sandstone shows a strike of N 40° - 45° W, and a dip of 5° SW around the fall, though generally it has a strike of NW-SE and a dip of 5° - 10° SW.

The sandstone is hard and of medium to fine grains. Joints (strike, N-10°-W:

dip, vertical) as well as many fissures are developed in the layer and along which erosion is going on disecting the rock into many blocks. In addition, there are many pot-holes from several centimeters to several meters in diameter.

In view of all these facts, the bedrock is not excellent for a base of a dam. However, the river bed rocks around the dam axis are rather massive and favourable than those in other places.

Dissection of the sandstone layer into many blocks is clearly observed from downstream side of the fall; river-bed water is springing out of soft weathered layers.

Therefore, future investigations should be made in connection with permeability of deep rock layers, as well as the possibility of water seepage which, it is feared, may arise due to the facts

i) that the distance from the dam to the fall is rather short,

ii) that the Nam Sai Yai has its tributary in parallel with the main stream in the dam site area, and

iii) that there is only a thin redge between the left bank abutment of the main dam and the auxiliary dam.

As to the rock materials for the dam, boulders scattered upstream and downstream around the fall as well as sandstone rock masses found in the higher left bank area will serve the purpose.

Impervious core materials may be obtainable in the flat area which extends between 1.0 km and 1.5 km upstream from the dam site. Clay deposits are believed at that part of higher elevations of the flat area, while sand layers are widely found closer to the river course.

4-5-5. Transmission Programme

It would be most proper that the electric power generated in the Sai Yai power system be transmitted to the Bangkok-Thonburi Area which is the center of power demand. For this purpose, a 115 kv capacity transmission line shall be constructed over a distance of about 95 km from the project area to Chal Buri, where the line is to get interconnected with the Yanhee system.

On the other hand, for the purpose of lessening difficult supply situation in the North Eastern region, a transmission line shall be extended to Korat over a distance of 85 km to get interconnected with the Nam Pong system.

Furthermore, with the increase of demand in the Lam Dom Noi system, the necessity will arise of interconnection of the Sai Yai system with the said system at a proper time in the near future.

Transmission on 69 kv line is also proposed to Nakhon Nayrok, Prachin Burin and Kabin Buri in order to aim at the improvement of power supply situation in local cities and towns.

The electric supply for the Bangkok-Thonburi Area is now made by the Bhumibol hydro power station and the North Bangkok thermal power station. When the Sai Yai system is put into operation and interconnected with the Bangkok-Thonburi system, the reliability of the latter system will be much incerased. And since the Sai Yai system is very near to the Bangkok, transmission from the proposed power stations will be reasonably cheap.

The interconnection with the Nam Pong system will bring a similar stabilizing effect as above.

When all of these interconnections are realized, the electric power of the Yanhee, Sai Yai and Nam Pong system can be sent and received to and from each other, and the result will be an increase of reliability in supply capability, and curtailment of peak supply capacity due to possible pare-down of stand-by units as well as to divergence of peak hour in each system. And furthermore, by a combination of hydro and thermal power, the most economical operation of the whole system may also be realized.

4-5-6. Relation with Proposed Agricultural Development in Downstream Area.

As stated before, by the power development plan, two reservoirs with total effective storage capacity of 300 million $m^3$ will be developed in the upper stream area of the Nam Sai Yai river, and the discharge through the lower-most Sai Yai No. 4 power station is expected to be about 6.0 $m^3$/sec. throughout any season and any year.

Therefore, in case some intake structures (and equalizing reservoir, if necessary) any channels are provided in some location downstream from the tailrace of the No. 4 power station, about 4,000 ha of paddyfield may be reclaimed.

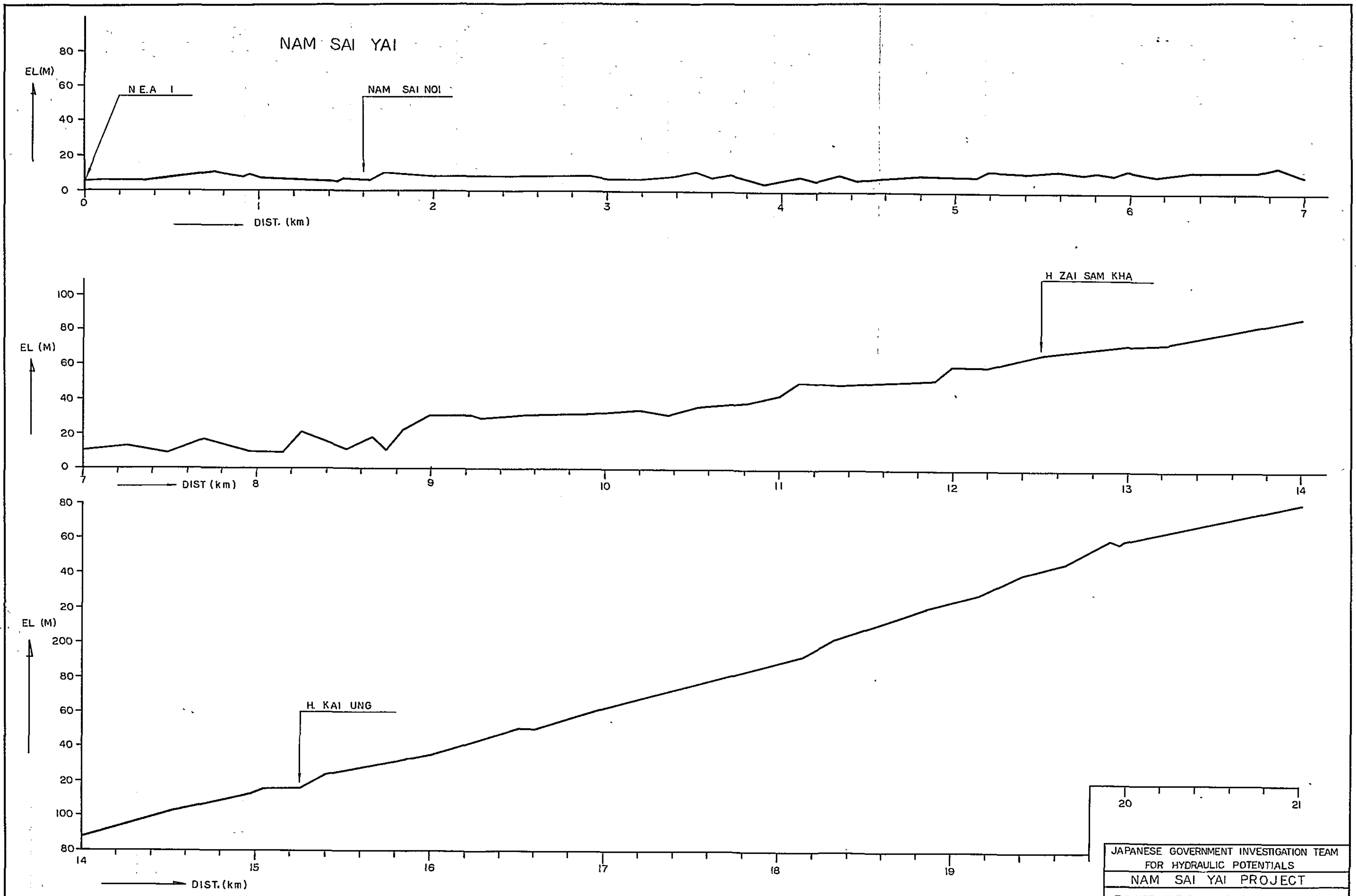
A part of construction cost of proposed dams may be allocated to this agricultural plan, the particulars of which are given in the following chapter.

4-5-7 Table and Figures

Table 4-5-7-1. General Features of the Nam Sai Yai Project

| Item \ Name of Station | Sai Yai No 1 | Sai Yai No2 | Sai Yai No3 | Sai Yai No4 | Total |
|---|---|---|---|---|---|
| Catchment Area | | | | | |
| Direct (km$^2$) | 124 | 171 | | 82.1 | |
| Indirect (km$^2$) | | 124 | | 295 | |
| Total (km$^2$) | 124 | 295 | 295 | 377.1 | |
| Reservoir | | | | | |
| Name | Sai Yai No1 | Sai Yai No2 | | | |
| High Water Surface (m) | 730 | 595 | | | |
| Surface Area (km$^2$) | 13.4 | 14.0 | | | |
| Effective Storage ($10^6 m^3$) | 150 | 140 | | | |
| Draw Down (m) | 15 | 14 | | | |
| Dam | | | | | |
| Type | Rock-fill | Rock-fill | | | |
| Height x Length (m) | 45 x 330 | 45 x 1,520 | | | |
| Volume of Dam (m) | 534,000 | 2,250,000 | | | |
| Headrace | | | | | |
| Main Tunnel (m) | ϕ2.5 2,400 | ϕ3.5 1,500 | ϕ3.5 2,700 | ϕ3.5 6,800 | |
| Sub-tunnel (m) | - | - | - | | |
| Tailrace (m) | ϕ2.5 600 | - | | ϕ3.5 100 | |
| Power Project | | | | | |
| Normal Intake Level (m) | 727.3 | 590.3 | 500 | 240 | |
| Tail Water Level (m) | 595 | 500 | 240 | 40 | |
| Rated Head (m) | 111 | 81.5 | 248 | 185 | 625.5 |
| Max. Discharge (m$^3$/sec) | 8 | 20 | 20 | 20 | |
| Installed Capcity (kW) | 7,500 | 13,700 | 41,700 | 31,100 | 94,000 |
| Annual Energy ($10^6$ kWh) Production | 24 | 43 | 132 | 110 | 309 |
| Construction Cost $10^3$$ | 7,400 | 18,100 | 8,810 | 10,300 | 44,600 |
| ($10^6$ Yen) | (2,670) | (6,530) | (3,180) | (3,720) | (16,100) |
| $/kW | 986 | 1,320 | 211 | 332 | 474 |
| (Yen/kW) | (356,000) | (477,000) | (76,000) | (120,000) | (171,000) |
| $/kW | 0.307 | 0.418 | 0.067 | 0.094 | 0.144 |
| (Yen/kW) | (111) | (151) | (24.1) | (33.8) | (52.1) |

Note : The construction cost does not include the cost of access road to the dam site, and transmission system.



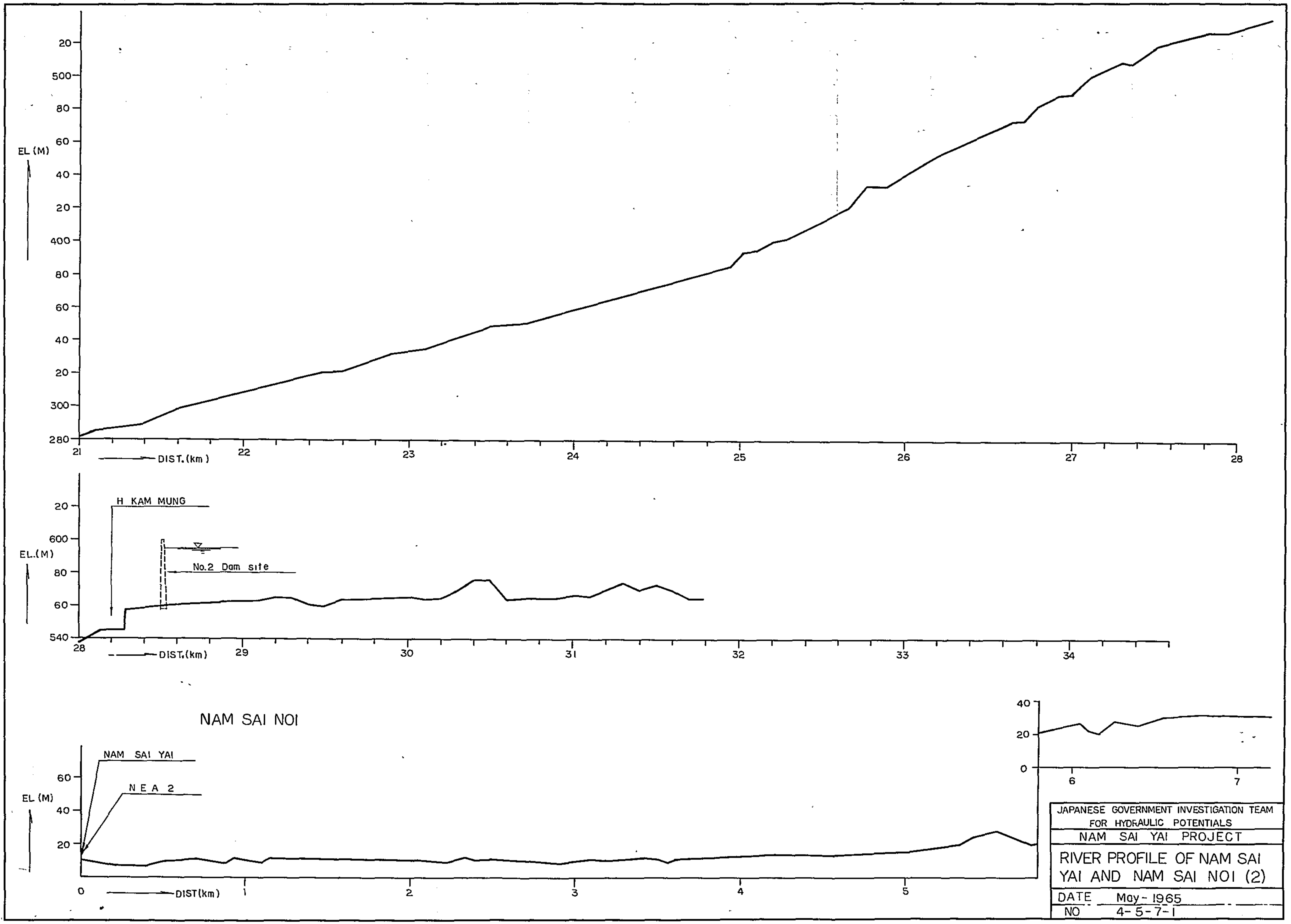

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

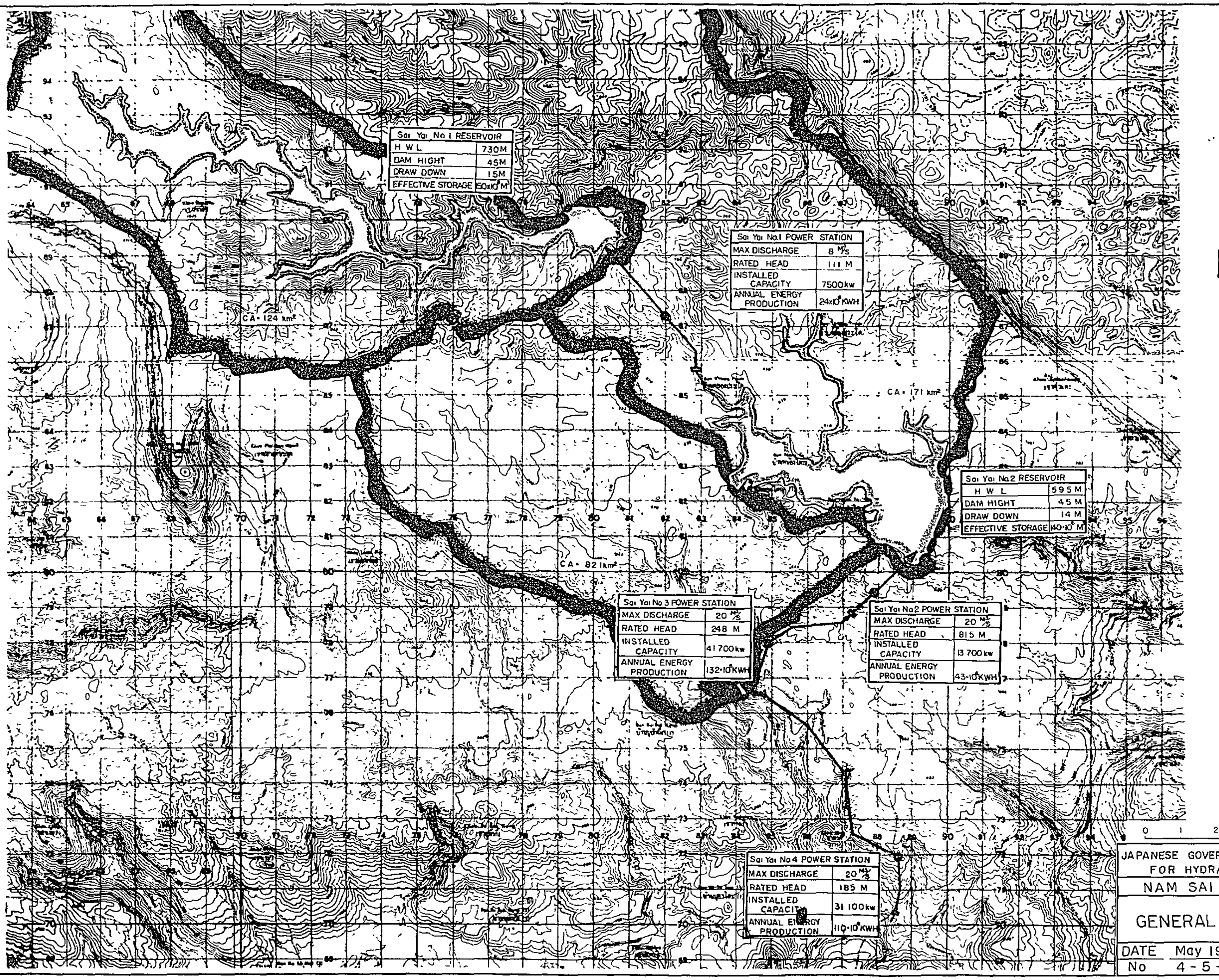
NAM SAI YAI PROJECT

RIVER PROFILE OF NAM SAI YAI AND NAM SAI NOI (I)

| | |
|---|---|
| DATE | May- 1965 |
| NO | 4-5-7-1 |

Note. The profile was surveyed by N.E.A.


EL (M)
DIST.(km)
H KAM MUNG
No.2 Dam site
EL.(M)
DIST.(km)
NAM SAI NOI
NAM SAI YAI
N E A 2
EL (M)
DIST(km)
JAPANESE GOVERNMENT INVESTIGATION TEAM
FOR HYDRAULIC POTENTIALS
NAM SAI YAI PROJECT
RIVER PROFILE OF NAM SAI
YAI AND NAM SAI NOI (2)
DATE May-1965
NO 4-5-7-1



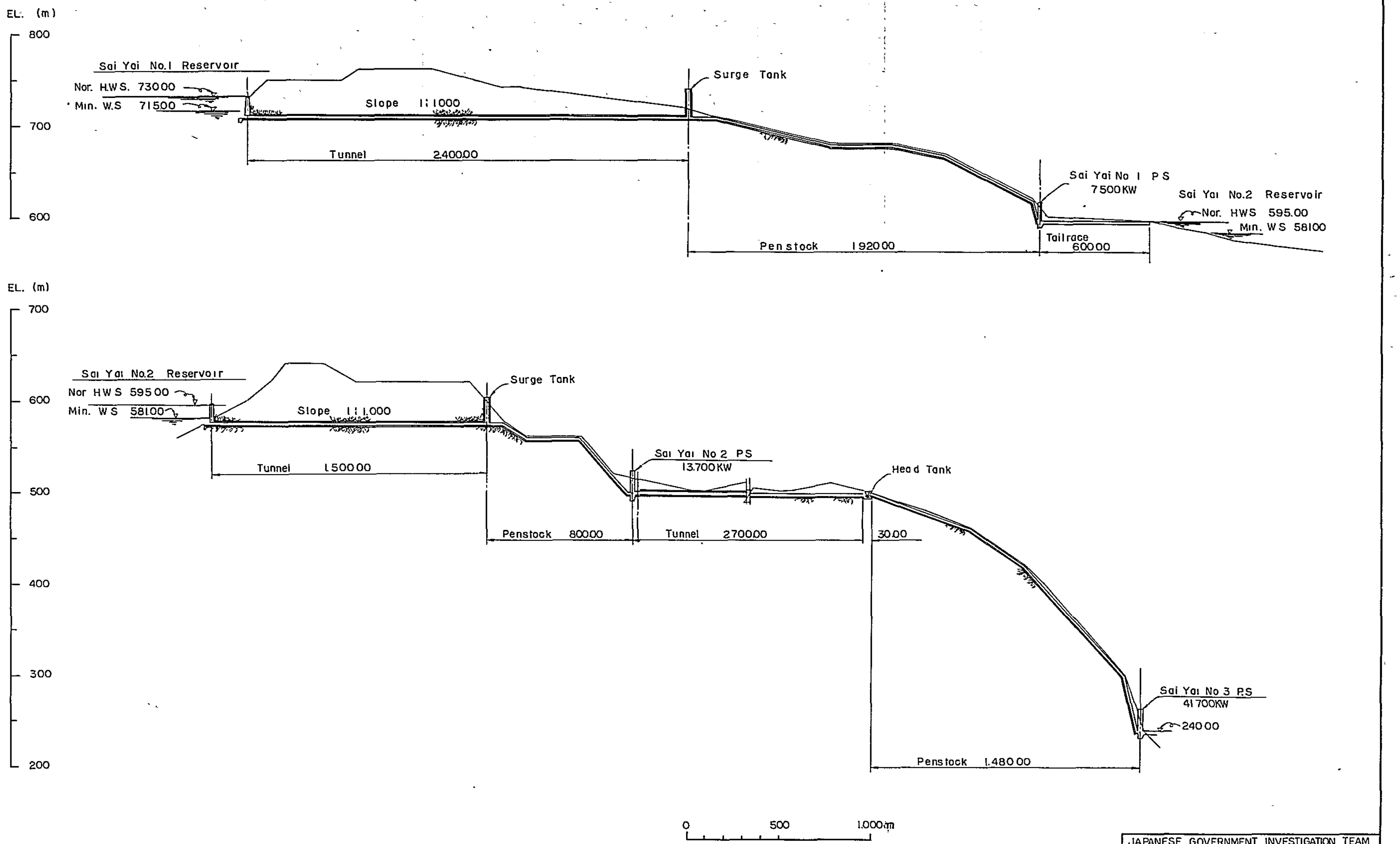

JAPANESE GOVERNMENT INVESTIGATION TEAM
FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

GENERAL PLAN

DATE May 1965

No 4-5-7-2



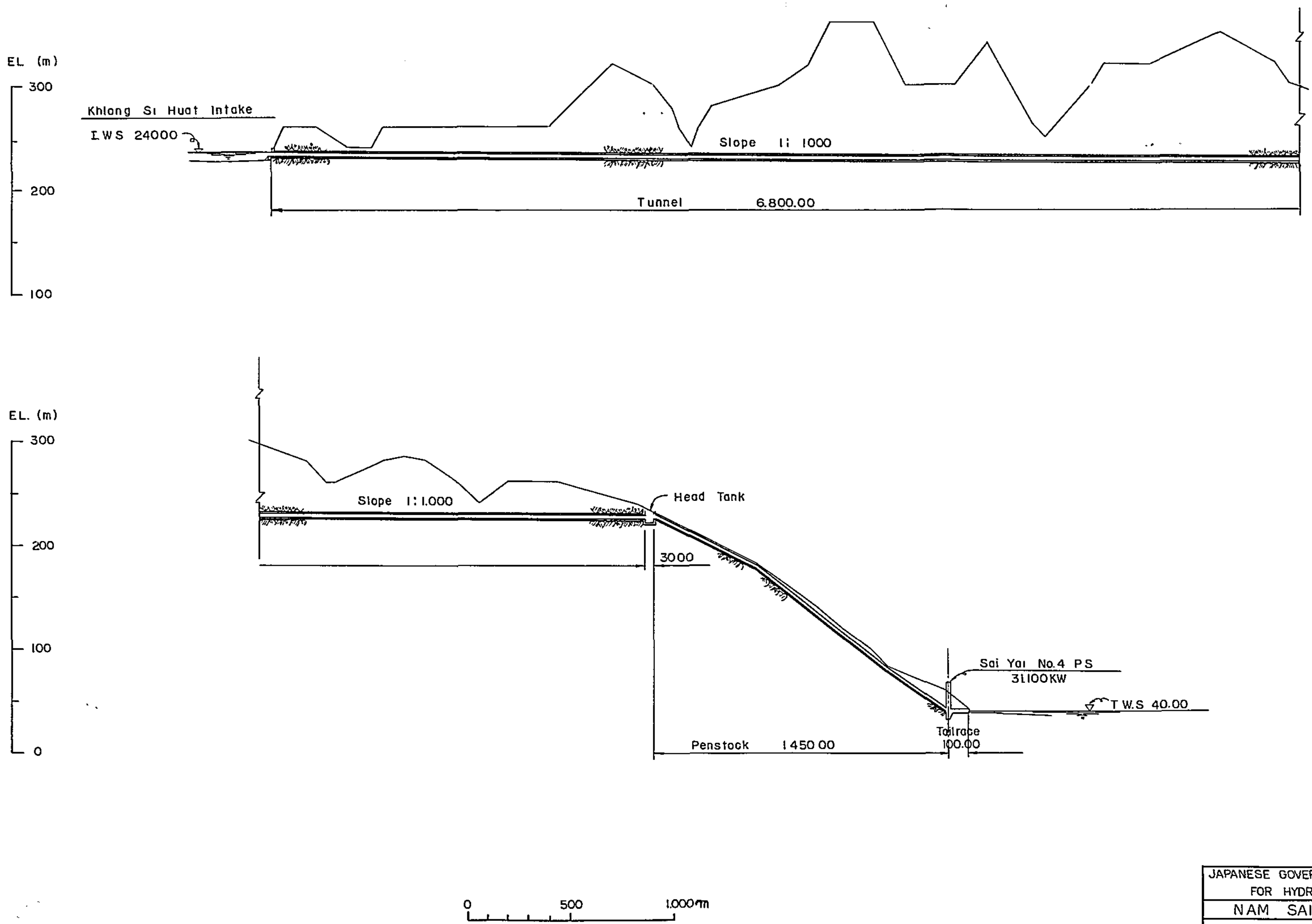

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PROFILE OF THE PROJECT (I)

DATE May-1965

NO 4-5-7-3



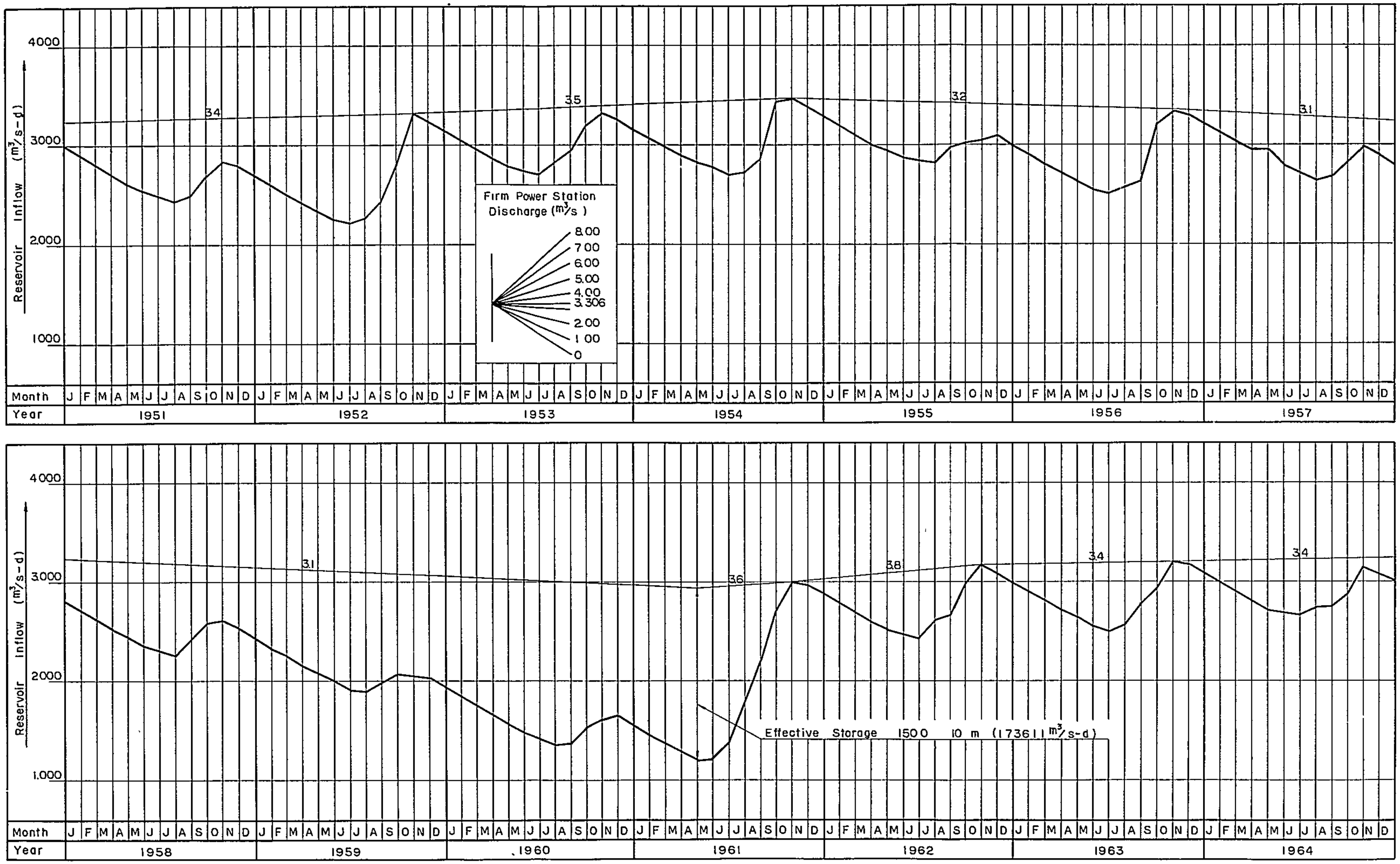

JAPANESE GOVERNMENT INVESTIGATION TEAM
FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PROFILE OF THE PROJECT (2)

DATE May- 1965

NO 4-5-7-3




Note.

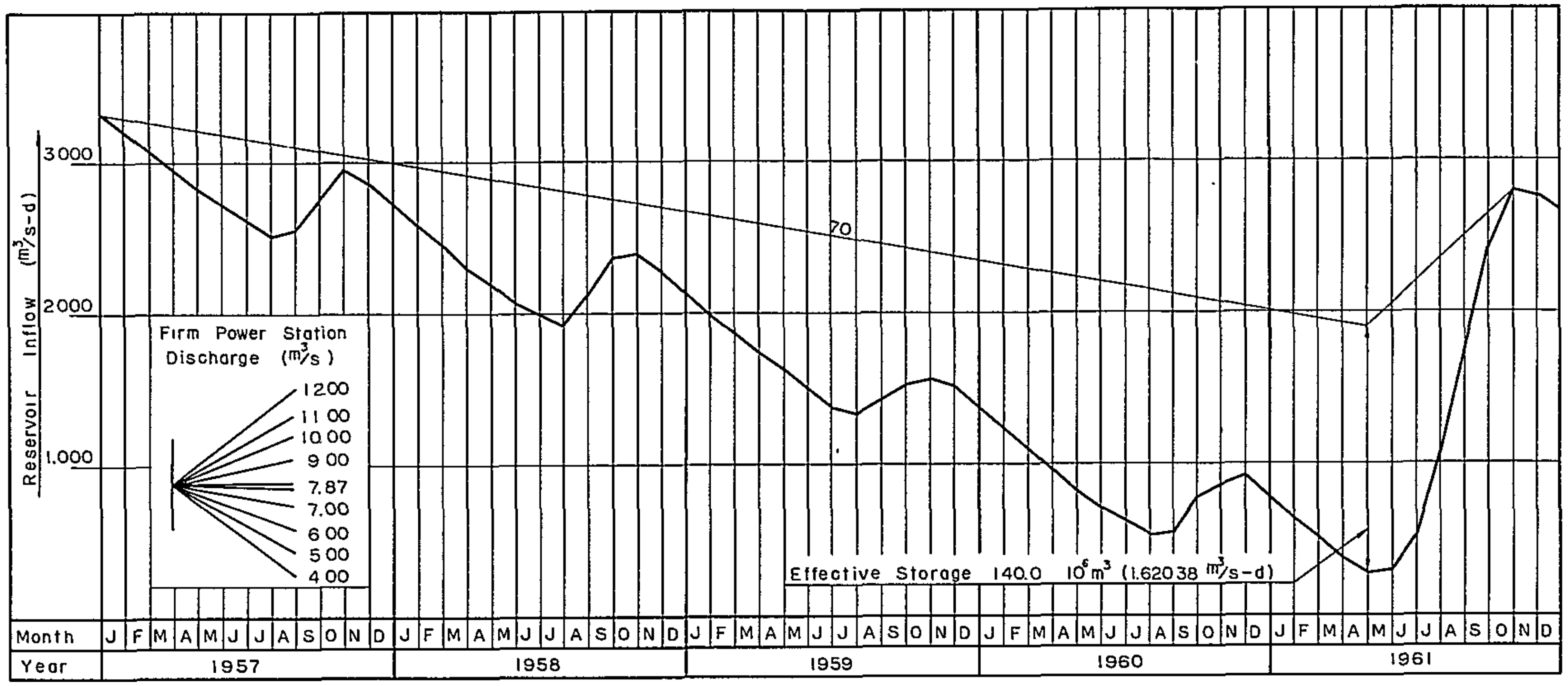
| | | |
|---|---|---|
| Nor. H. W. S | ---------- | 730.00 m |
| Min W S | ---------- | 715.00 m |
| Draw – down | ---------- | 15.00 m |
| Effective Storage | ---- | 150.000.000 m³ |
| | | ( 1736.11 m³/s-d ) |
| Catchment area | | 124 km² |

JAPANESE GOVERNMENT INVESTIGATION TEAM
FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PRESUMED MASS CURVE
AT No.1 RESERVOIR

DATE May-1965
NO 4-5-7-4




Note.

| | | |
|---|---|---|
| Nor H.W.S. | --------- | 595.00 m |
| Min W.S. | --------- | 581.00 m |
| Draw down | --------- | 14.00 m |
| Effective Storage | ------ | 140,000,000 $m^3$ (1,620.38 $m^3$/s-d) |

The mass curve shows inflow of reservoir after regulated by No.1 reservoir (Ve = 150 $10^6 m^3$)

Catchment area 295 $km^2$

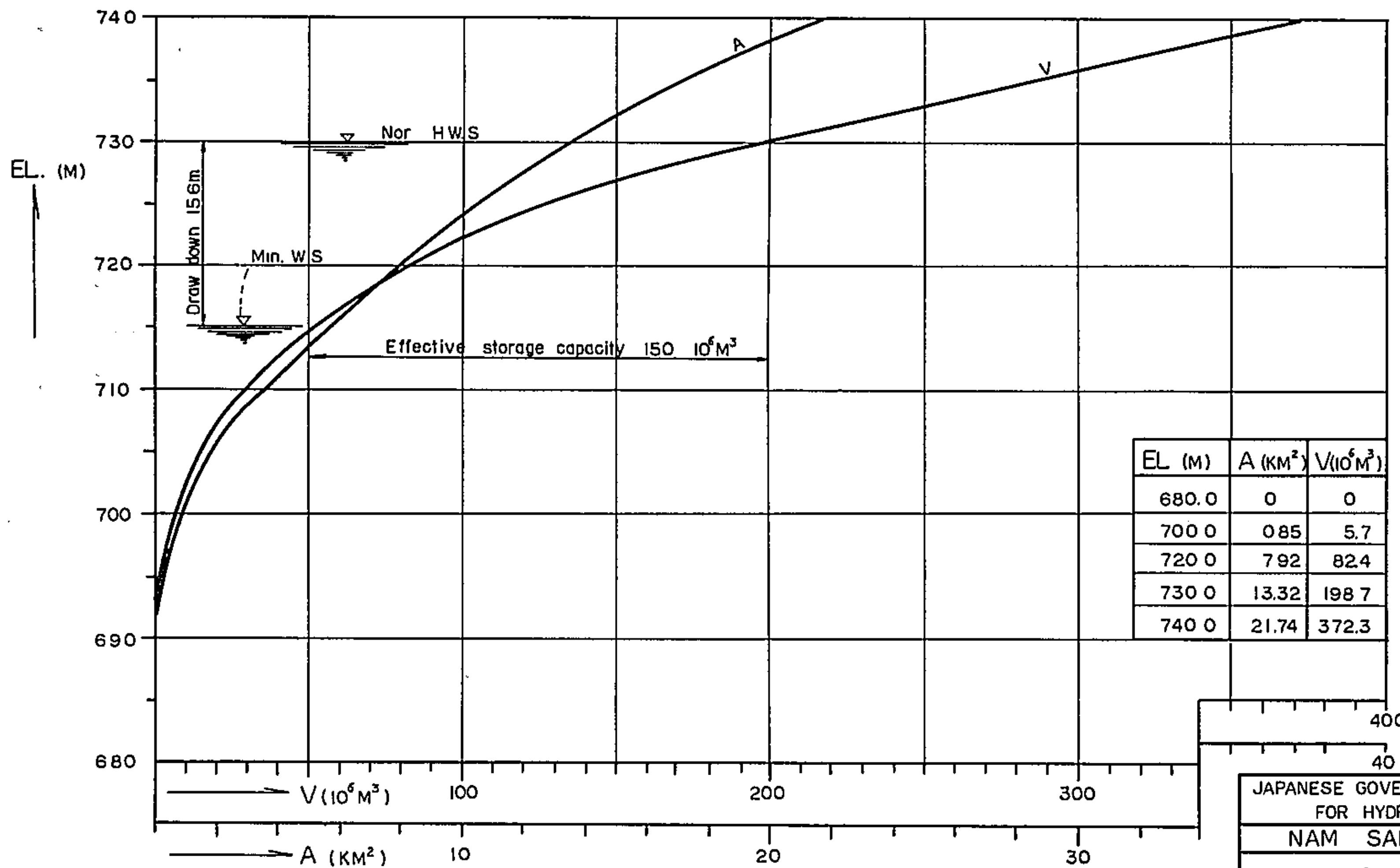
JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PRESUMED MASS CURVE AT No.2 RESERVOIR

DATE May-1965

NO 4-5-7-5




| EL. (M) | A ($KM^2$) | V ($10^6M^3$) |
|---|---|---|
| 680.0 | 0 | 0 |
| 700.0 | 0.85 | 5.7 |
| 720.0 | 7.92 | 82.4 |
| 730.0 | 13.32 | 198.7 |
| 740.0 | 21.74 | 372.3 |

Note. prepared using US Army Map Service map (S= 1/50000)

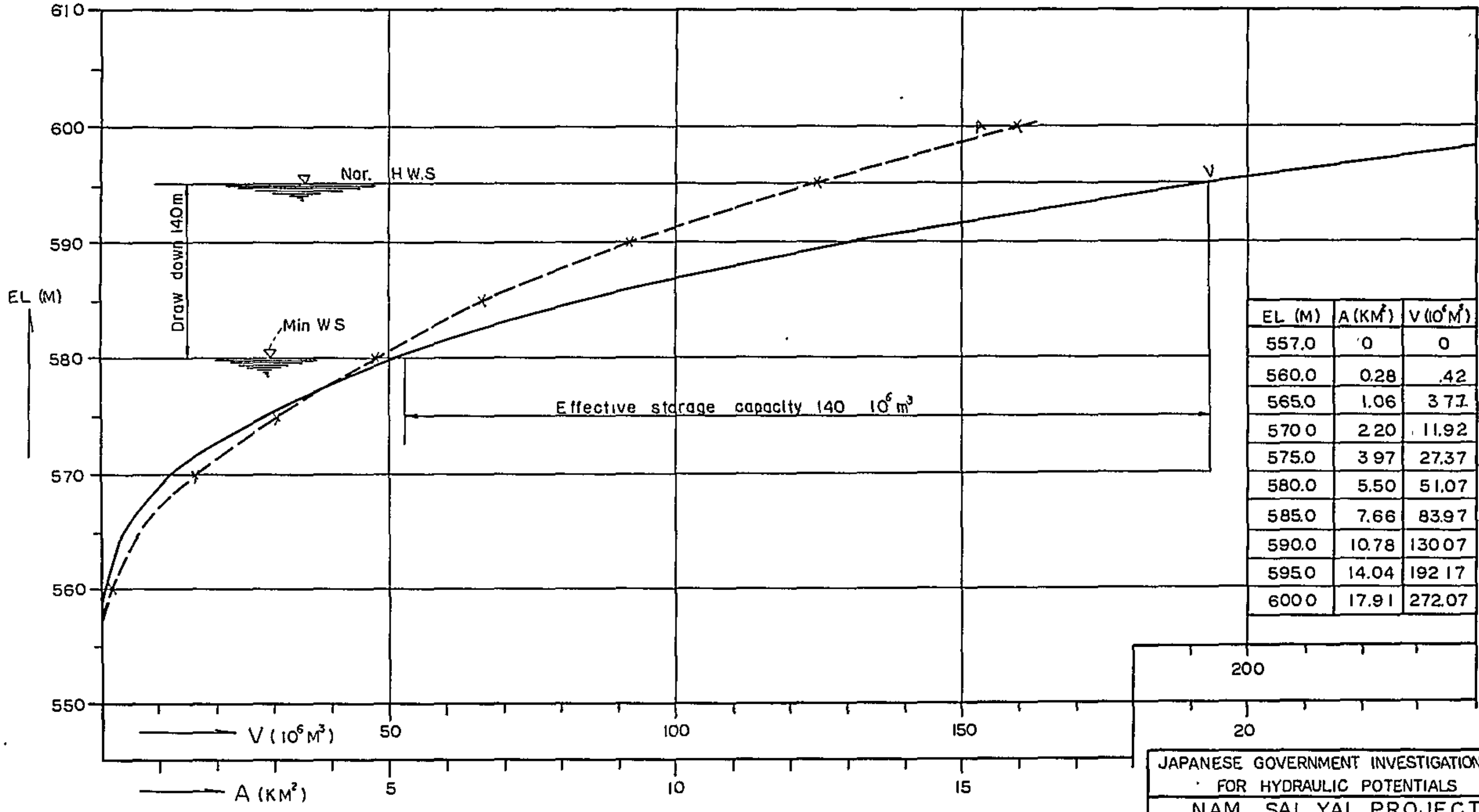
JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

SURFACE AREA AND STORAGE CAPACITY OF No1 RESERVOIR

DATE. May-1965

NO. 4-5-7-6




| EL (M) | A (KM²) | V (10⁶M³) |
|---|---|---|
| 557.0 | 0 | 0 |
| 560.0 | 0.28 | .42 |
| 565.0 | 1.06 | 3.77 |
| 570.0 | 2.20 | 11.92 |
| 575.0 | 3.97 | 27.37 |
| 580.0 | 5.50 | 51.07 |
| 585.0 | 7.66 | 83.97 |
| 590.0 | 10.78 | 130.07 |
| 595.0 | 14.04 | 192.17 |
| 600.0 | 17.91 | 272.07 |

Note. prepared using the plan of the reservoir (S=1/10000) surveyed by N.E.A

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

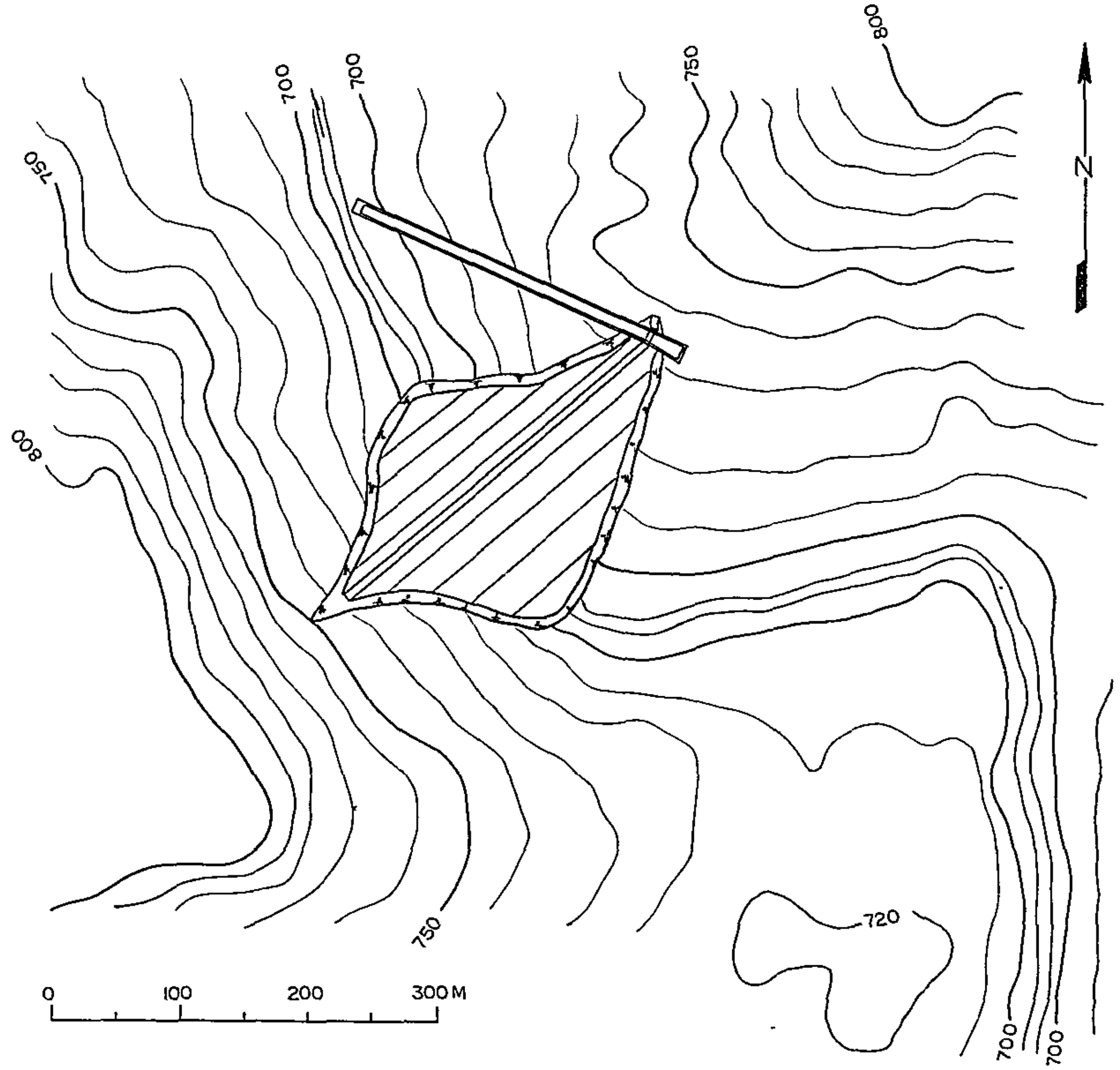
NAM SAI YAI PROJECT

SURFACE AREA AND STORAGE CAPACITY OF No2 RESERVOIR

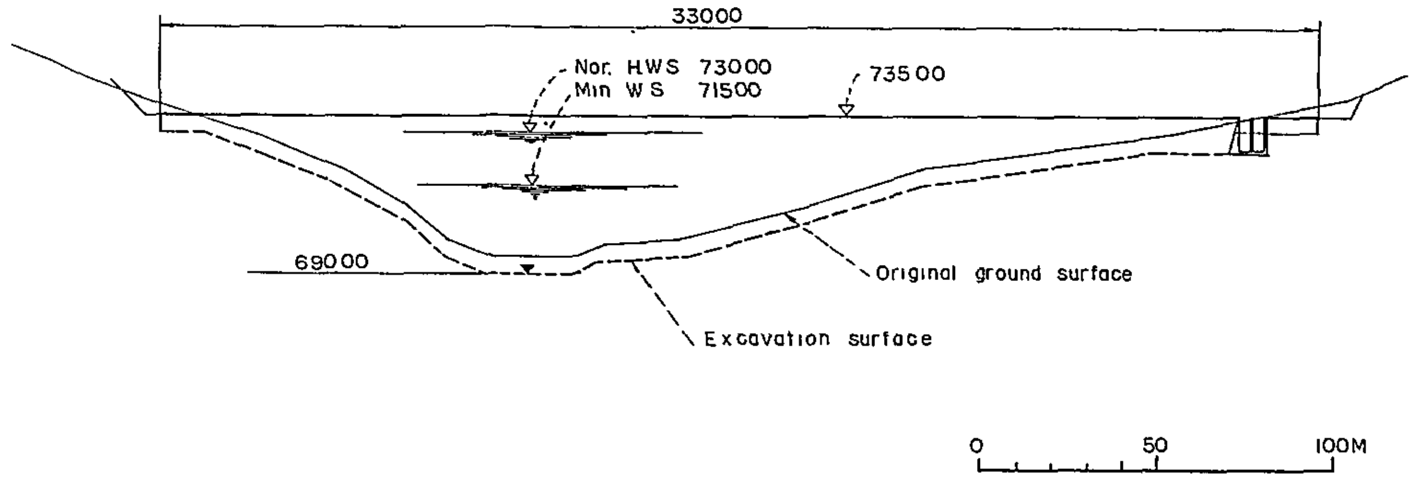
DATE May-1965

NO. 4-5-7-7

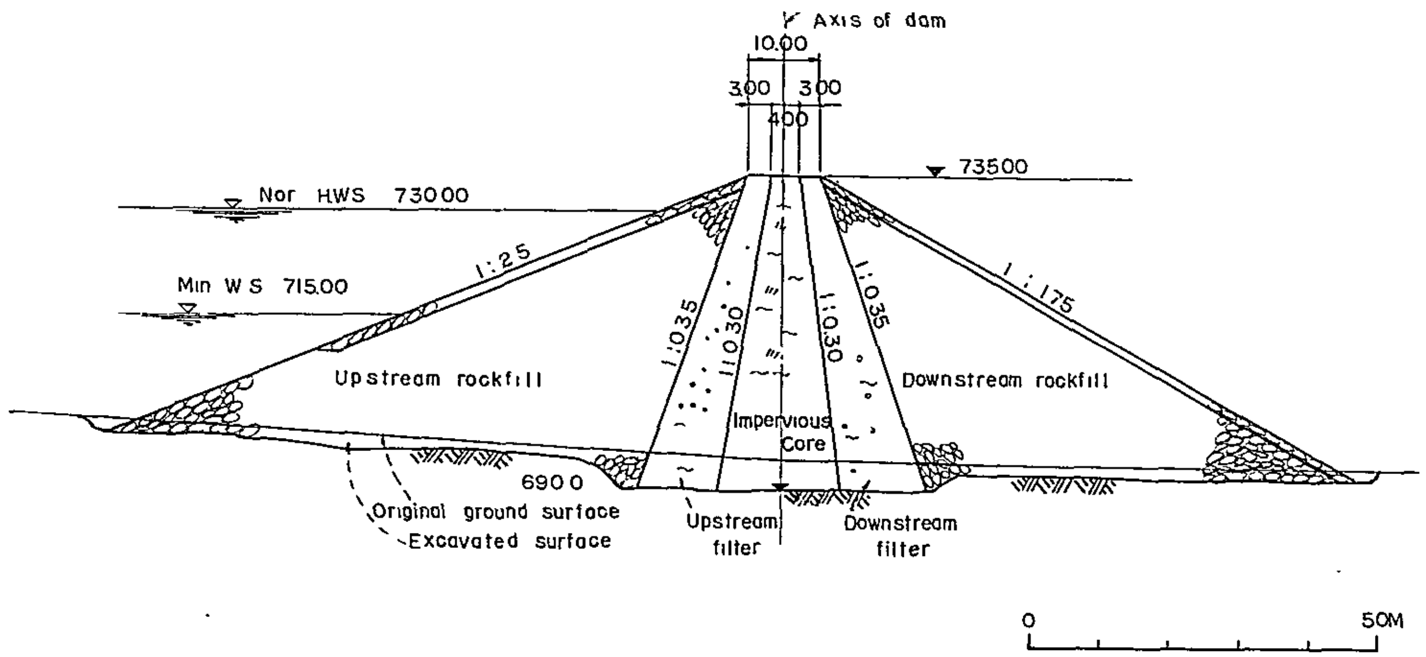
# PLAN




# UPSTREAM ELEVATION




# TYPICAL SECTION OF EMBANKMENT



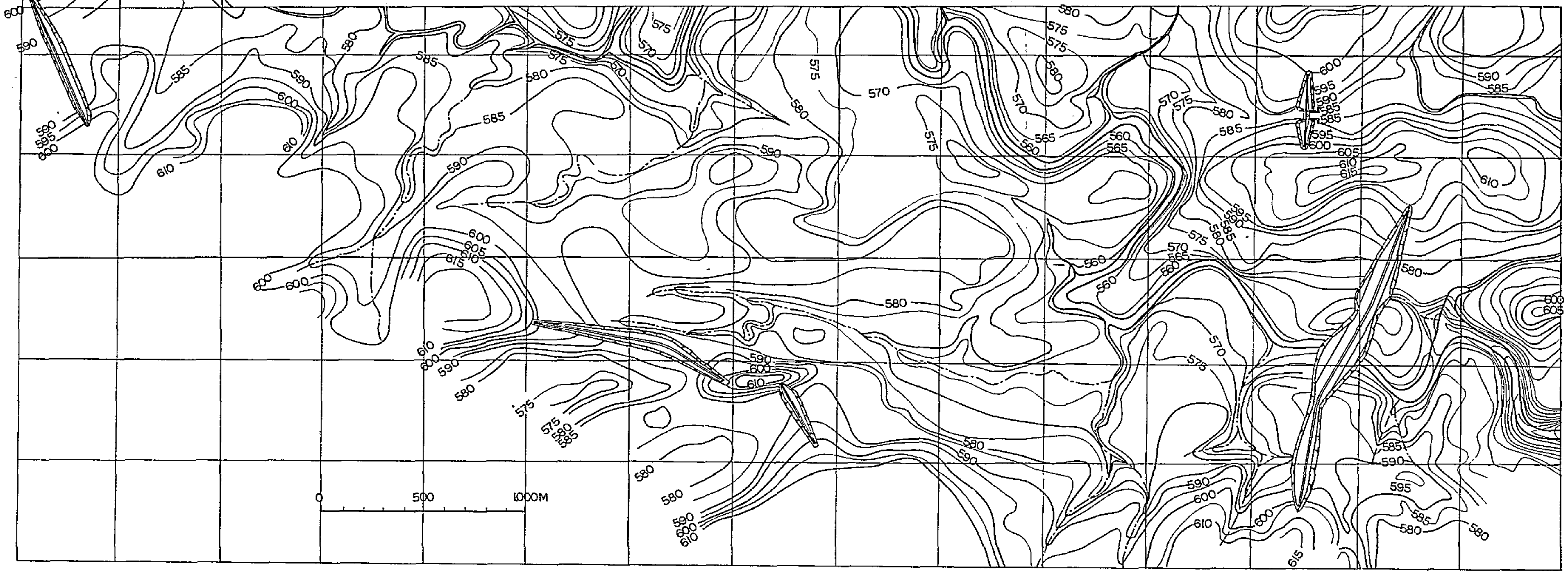

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

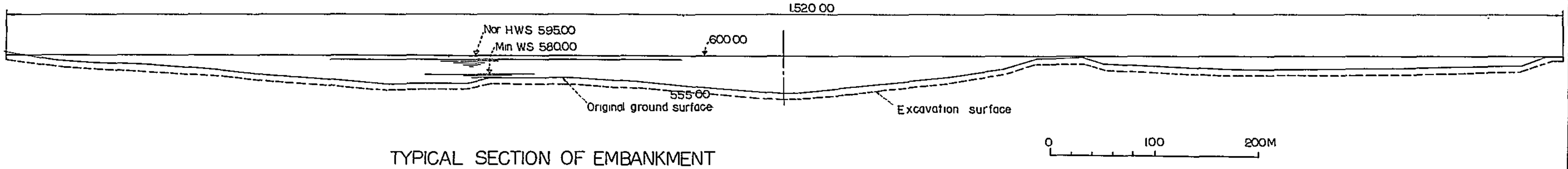
No.1 DAM GENERAL PLAN ELEVATION AND SECTION

| | |
|---|---|
| DATE | May-1965 |
| NO | 4-5-7-8 |

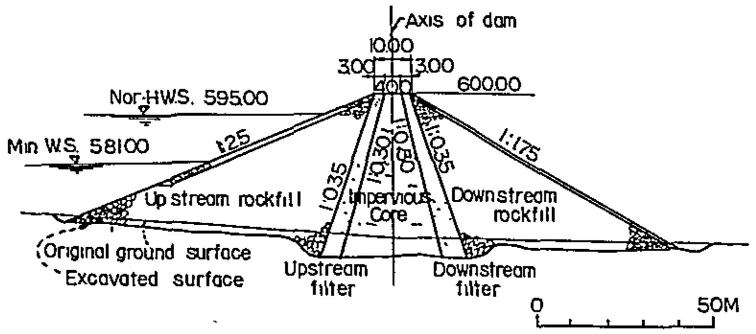
## PLAN




## UPSTREAM ELEVATION OF MAIN DAM




## TYPICAL SECTION OF EMBANKMENT




| JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS | |
|---|---|
| NAM SAI YAI PROJECT | |
| No 2 DAM GENERAL PLAN ELEVATION AND SECTION | |
| DATE | May-1965 |
| NO | 4-5-7-9 |

## 4-6. Agricultural Development

### 4-6-1. Introduction

The project area is situated in Ampur Kabin Buri of Prachin Buri Province about 210 km to the east-northeast of Bangkok which is the capital of Thailand, or in latitude 14° north and longitude 101°45' east belonging to the tropical zone.

The land around the project area may be devided and classified into two regions when viewed from topographical point, i.e., into the plain region and the mountain region. The plain region where the project is considered is such flat area with low elevation less than 40 m above mean sea level which is formed by the Prachin river and its tributaries and is forming the east part of the Bangkok Plain.

### 4-6-2. Climatic Conditions

As shown in the following tables, the annual mean temperature of the project area is 27.9°C with maximum monthly mean of 36°C of April and minimum of 18.8°C of December and January. The relative humidity is rather high averaging 75.7 per cent throughout the year. Annual average rainfall of Kabin Buri which is the closest to the project area is 1,480.3 mm for the recent 14 years. 89 per cent of annual rainfall occurs from May to October.

In view of these climatic conditions, crop cultivation will be practicable throughout the year if proper irrigation is introduced to the project area as well as advanced cultivation practice.

Temperature (Prachin Buri)

| Item \ Month | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Year | Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly Mean Temp. | ℃ 25.7 | 27.5 | 29.6 | 30.1 | 29.6 | 28.4 | 28.0 | 28.0 | 27.7 | 27.8 | 26.8 | 25.1 | 27.9 | 1952 - 1960 |
| Monthly Mean Max. Temp. | 32.6 | 33.8 | 35.1 | 36.0 | 34.5 | 32.7 | 32.0 | 31.7 | 31.4 | 31.8 | 31.9 | 31.7 | 32.9 | " |
| Monthly Mean Min. Temp. | 18.8 | 21.0 | 23.1 | 24.2 | 24.6 | 24.3 | 24.0 | 24.1 | 24.0 | 23.8 | 21.6 | 18.8 | 22.7 | " |
| Monthly Highest Temp. | 37.0 | 37.5 | 39.8 | 40.7 | 40.4 | 39.8 | 35.5 | 35.2 | 35.2 | 35.2 | 35.6 | 35.8 | 37.3 | " |
| Monthly Lowest Temp. | 10.2 | 15.1 | 16.9 | 19.8 | 22.0 | 21.0 | 20.6 | 21.6 | 21.4 | 20.0 | 13.8 | 10.8 | 17.8 | " |

Relative Humidity (Prachin Buri)

| Item \ Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Year | Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Monthly Mean Relative Humidity | % 63.9 | 66.4 | 70.2 | 73.2 | 77.4 | 81.9 | 83.6 | 83.7 | 85.6 | 88.2 | 71.0 | 63.3 | 75.7 | 1948 - 1960 |
| Monthly Mean Max. Relative Humidity | 86.6 | 90.3 | 92.7 | 93.3 | 94.0 | 95.3 | 96.8 | 96.9 | 97.1 | 93.4 | 87.5 | 84.6 | 92.4 | " |
| Monthly Mean Min. Relative Humidity | 49.5 | 50.6 | 53.4 | 57.1 | 64.6 | 69.7 | 72.6 | 72.8 | 74.1 | 69.6 | 58.9 | 52.1 | 62.1 | " |
| Monthly Highest Relative Humidity | 100.0 | 99.0 | 99.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 | 99.0 | 100.0 | " |
| Monthly Lowest Relative Humidity | 27.0 | 18.0 | 25.0 | 26.0 | 30.0 | 37.0 | 58.0 | 61.0 | 60.0 | 34.0 | 32.0 | 35.0 | 36.9 | " |

Annual Rainfall

| Item \ Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Year | Period |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Prachin Bburi | mm 4.2 | 34.1 | 72.8 | 101.6 | 194.3 | 278.1 | 326.9 | 328.7 | 421.7 | 209.0 | 34.8 | 2.2 | 2,008.4 | 1951 - 1964 |
| Kabin Bburi | 5.5 | 11.6 | 36.8 | 86.4 | 147.4 | 192.5 | 242.2 | 271.0 | 293.2 | 162.3 | 30.2 | 1.2 | 1,480.3 | 1951 - 1964 |

4-6-3. Soils and Underground Water

The soils of the project area are derived from sandstones of the Mesozoic Era and can be classified into 3 types as shown in Figure 4-6-8-2. The improvement of soils is most desired in the area because the soils are deficient in fertility or productive elements due to long year erosion which largely washed away organic and inorganic nutritive substances of soils. Soil samples were taken in the area during the investigation. In Figures 4-6-8-2, 4-6-8-3 and Table 4-6-8-1 are shown the results of physical and chemical analysis which were conducted on 22 typical soil samples. The sites of their sampling are also shown in Figure 4-6-8-2.

The soils of the area are mostly sandy loam with poor viscosity and water-holding capability. Reddish brown hard layer of laterite including stones and gravels is developed in the flat downstream area which is frequently inundated by flood discharge.

In the area around the sites where soil samples No. 16 and 18 were taken this hard layer of laterite is locally exposed and the depth of cultivatable topsoil which is covering unexposed part of the layer is only 10cm or less. However, crop cultivation is practiced on this poor topsoil taking advantage of relatively abundant source of irrigation water, though productivity is likely very low. According as the elevation decreases from the site of soil sample No. 16 sandy loam topsoil increases its depth offering more favourable land for cultivation. It is considered most important that further investigations be conducted in the area to clarify the conditions of the said hard layer of laterite and to establish means of improvement.

According to the results of chemical analysis the acidity of the soils is weak to normal suggesting the necessity of improvement depending upon the kinds of crops to be planted. Further investigations and studies are also necessitated.

In the rainy season the underground water of the area rises almost to reach the surface of the ground, while it goes down as deep as close to the bedrock in the dry season; the fluctuation of underground water level is very remarkable in the area.

4-6-4. Present Agricultural Management

The major item of the cultivated crops in and around the project area is paddy rice. Irrigation facilities are not enough provided in the area, and especially towards upstream from Kabin Buri there are none of such facilities existing. Single crop cultivation of paddy rice is prevailing by dint of rainfall of the rainy season but with poor yield. Secondary cropping is not practiced.

The acreage under paddy rice cultivation in the Province amounts to 1,046,730 rais which accounts for 79 per cent of the total area of 1,322,980 rais of the province or 92 per cent of the total cultivated land of 1,113,908 rais.

Land holding in and around the project area is as shown in Figure 4-6-8-4 and Table 4-6-8-2. Average land holding and cultivation acreage per farming family of the project area is about 32 rais which is 1.4 times the overall average size of the whole country. Classification of land by tenure and tenacy shows that more than 60 per cent of the cultivated land is managed by landowners.

The use of cultivating machines and tools, fertilizers and agricultural chemicals, which is considered a yardstick of advanced agricultural management, is not customary in the area. Animal force such as water buffaloes and cattle is major means of cultivation occupying 80 per cent of total force of cultivation. The use of machines account for only 1 per cent.

As for fertilizing practice, the amount of the chemical manure input slightly exceeds 1 per cent of the meagre total quantity of the used fertilizers including compost. Fertilizers are applied almost only to nursery seedbed. Little appliance is practiced of agricultural chemicals.

Under these unfavourable cultivating practice the yield per unit acreage of the paddyfield of the area is very low in comparison with that of neighburing provinces and resulting in remarkable fluctuation year to year. Annual average yield of rice of the area is as shown in Figure 4-6-8-5. This unstable and relatively meagre yield is considered attributable to such backward practice of cultivation prevailing in the area which is managed on the soils of rather sterility as mentioned before and without sizable systematized irrigation facilities and the use of fertilizers solely depending upon natural water supply of uncontrolable rainfall.

4-6-5. Present Conditions of Irrigation and Drainage

Of the cultivated land of 298,097 rais or 47,695 ha of Ampur Kabin Buri which is encompassed in or related to the project area only 66,496 rais or 10,639 ha, that is, 22.3 per cent against the former is provided with irrigation facilities. The remaining land of substantial acreage depends upon rainfall as supply source of water requirement. The shape and the size of unit section of the cultivated land varies largely according to the undulation of topography. No drainage facilities are provided.

4-6-6. Necessity of Agricultural Development

It is well and widely realized and requires no specific descriptions here that the increase of rice production is of absolute requisite for Thailand in order not only to supply annual increase of population growing at a rate of approximately 3 per cent but to further promote foreign trade export.

The agricultural production of the project area is at a low level and unstable due to unevenness of rainfall distribution, impoverished conditions of soils and lack of adequate water utilization facilities as previously referred. It is then of urgent necessity for the project area towards stable and larger production that irrigation and drainage facilities be completely provided, soils be improved, and advanced cultivating practice be introduced.

4-6-7. Proposed Idea Toward Agricultural Development

It is proposed that regulated water be supplied for irrigation purpose to the arable land in the downstream reaches of the Nam Sai Yai from the proposed two reservoirs which are to be developed at upstream sites on the river.

Two alternatives are considered of irrigation method as follows to make choice between them:

(1) A headwork or a small embenkment shall be constructed on the Nam Sai Noi. Irrigation water shall be taken and supplied therefrom to the arable land on the right bank of the Maenam Hanuman which is the downstream of Nam Sai Yai by means of gravity or pumping up system.

(2) A headwork or a small embankment shall be constructed at a site on the Nam Sai Yai downstream of the confluence with the Huai Sai Noi river. Water taken therefrom shall be supplied to the arable land on the right bank of the Maenam Hanuman by means of pumping up system.

Water supply will be possible to the left-bank area of the Maenam Hanuman. However, this area is not included in the supply area of the project on account that it seems likely more advantageous for the left-bank arable land to receive water from the Huai Yang under a separate project in future.

In either case of the alternatives 4,000 ha, as an approximation, of land including existing cultivated land will be brought under sufficient supply of irrigation water provided 35,000 $m^3$ of water be available per hectare of land from the reservoirs annually. Then, crop cultivation will be practicable throughout the year and two-crops farming will be ensured of paddy rice.

4-6-8. Tables and Figures

Physical and Chemical Characteristic of Soil Somples

Table 4-6-8-1

| Item \ Serial Number of Samples | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) Classification | Sandy Loam | Loam | Loam | * Sandy Loam | * Sandy Loam | Sandy Loam | Loam | Sandy Loam | Sandy Loam | Lomy Sand |
| (2) Colour | - | dark red | dark reddish brown | yellow reddish grey | - | greyish brown | dirty brown | greyish orange | dirty yellow-ish orange | dirty yellow-ish orange |
| (3) Sites of Samples | Paddy field (dry) | Forest (dry) | Paddy field (dry) | Paddy field (dry) | Paddy field (dry) | Forest (dry) | Paddy field (half wet) | Paddy field (half wet) | Paddy field (dry) | Paddy field (dry) |
| (4) PH Value | 5.0 | 4.0 ~ 4.5 | 5.5 ~ 6.0 | 5.5 | 5.5 | 4.5 | 4.5 | 4.5 | 4.5 ~ 5.0 | 6.5 |
| (5) mg of $P_2O_5$ per 100g Soil | 0.1 | 0.1 | 1.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| (6) Lime | deficit | deficit | abun-dant | slight | deficit | nearly abun-dant | deficit | deficit | deficit | deficit |
| (7) mg of $Al_2O_3$ per 100g soil | 10 | 10 | 5 | 5 | 5 | 5 | 15 | 10 | 15 | 5 |

Physical and Chemical Characteristic of Soil Somples

Table 4-6-8-1

| Item \ Serial Number of Samples | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| (1) Classification | Sandy Loam | Loam | Loam | * Sandy Loam | * Sandy Loam | Sandy Loam | Loam | Sandy Loam | Sandy Loam | Lomy Sand |
| (2) Colour | - | dark red | dark reddish brown | yellow reddish grey | - | greyish brown | dirty brown | greyish orange | dirty yellow-ish orange | dirty yellow-ish orange |
| (3) Sites of Samples | Paddy field (dry) | Forest (dry) | Paddy field (dry) | Paddy field (dry) | Paddy field (dry) | Forest (dry) | Paddy field (half wet) | Paddy field (half wet) | Paddy field (dry) | Paddy field (dry) |
| (4) PH Value | 5.0 | 4.0 ~ 4.5 | 5.5 ~ 6.0 | 5.5 | 5.5 | 4.5 | 4.5 | 4.5 | 4.5 ~ 5.0 | 6.5 |
| (5) mg of $P_2O_5$ per 100g Soil | 0.1 | 0.1 | 1.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| (6) Lime | deficit | deficit | abun-dant | slight | deficit | nearly abun-dant | deficit | deficit | deficit | deficit |
| (7) mg of $Al_2O_3$ per 100g soil | 10 | 10 | 5 | 5 | 5 | 5 | 15 | 10 | 15 | 5 |

| Item \ Serial Number of Samples | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Classification | Sandy Loam | Sandy Loam | Loam | Sandy Loam | Sandy Loam | * Loam | Loamy Sand | * Loam | Loamy Sand | * Sandy Loam | Loam | Sandy Loam |
| (2) Colour | - | - | yellow-ish orange grey | dirty yellow-ish brown | dirty yellow-ish brown | greyish orange | dirty yellow-ish orange | yellow-ish orange | dirty yellow-ish orange | dirty orange | dark greyish orange | - |
| (3) Sites of Samples | Paddy field (half wet) | Paddy field (dry) | Paddy field (dry) | Grass-land (dry) | Forest (dry) | Upland (dry) | Paddy field (dry) | Paddy field (dry) | Paddy field (dry) | Paddy field (dry) | Paddy field (wet) | Paddy field (dry) |
| (4) PH Value | 4.5 | 4.5 | 5.5 | 5.0 | 4.5 | 5.0 | 6.5 | 5.0 | 4.5 | 5.0 | 5.0 | 5.0 |
| (5) mg of $P_2O_5$ per 100g Soil | 1.0 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 0.1 | 1.0 | 0.1 |
| (6) Lime | abun-dant | deficit | nearly abun-dant | deficit | deficit | deficit | deficit | nearly abun-dant | deficit | deficit | nearly abun-dant | deficit |
| (7) mg of $Al_2O_3$ per 100g soil | 5 | 10 | 15 | 10 | 10 | 10 | 5 | 5 | 5 | 5 | 10 | 5 |

Note: 1/ Asterish showing existener of laterite in top soil and lower layer.

2/ Soil classification according to finger touch.

3/ Colour classification based on Japan Standard Soil Colour Table.

4/ Items (4) to (7) being measured by means of simplified soil tester.

Land Holdings and Cultivated Land of Changwat Prachin Buri

Table-4-6-8-2

| | | CHANGWAT TOTAL | MUANG PRACHIN-BURI | KABIN BURI | BANSANG | PRACHANTA-KHAM | WATTANANA-KHORN | TA-PHRAYA | SRI-MAHAPHOT | SRA-KAEO | ARAN-YAPRATHET |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Holdings | Number of farming family | (100.0%) 40,237 | 5,923 | 9,043 | 2,933 | 4,060 | 3,048 | 2,523 | 5,716 | 4,367 | 2,624 |
| | Land holdings and cultivated area | (100.0%) 1,322,980 Rai | 167,900 | 298,166 | 159,375 | 128,280 | 97,358 | 54,723 | 193,180 | 133,484 | 90,514 |
| | Average land holding and cultivation per farming family | 32.8 Rai | 28.3 | 32.9 | 54.3 | 31.5 | 31.9 | 21.6 | 33.7 | 30.5 | 34.4 |
| Owner | Number of farming family | (64.0%) 25,771 | 4,198 | 3,631 | 2,117 | 3,658 | 2,459 | 14 | 3,454 | 3,879 | 2,311 |
| | Land holdings | (70.8%) 936,772 Rai | 131,653 | 131,930 | 125,800 | 121,907 | 81,983 | 824 | 134,371 | 123,529 | 84,775 |
| | Average land holding per farming family | 36.3 Rai | 31.3 | 35.8 | 59.4 | 33.3 | 33.3 | 58.8 | 38.9 | 31.8 | 36.6 |
| Cash renter | Number of farming family | (0.8%) 350 | 152 | 9 | 82 | 12 | 2 | 1 | 80 | 5 | 7 |
| | Cultivated area | (0.3%) 5,010 Rai | 1,106 | 61 | 2,435 | 209 | 43 | 4 | 1,021 | 105 | 26 |
| | Average cultivation per farming family | 14.3 Rai | 7.2 | 6.7 | 29.6 | 17.4 | 21.5 | 4.0 | 12.7 | 21.0 | 3.7 |
| Crop renter | Number of farming family | (5.7%) 2,330 | 252 | 309 | 495 | 157 | 186 | 21 | 729 | 52 | 129 |
| | Cultivated area | (5.6%) 72,630 Rai | 10,396 | 6,409 | 22,645 | 3,374 | 4,997 | 157 | 21,202 | 1,287 | 2,163 |
| | Average cultivation per farming family | 31.1 Rai | 41.2 | 20.7 | 45.7 | 21.4 | 26.8 | 7.4 | 29.0 | 24.7 | 16.7 |
| Other | Number of farming family | (29.5%) 11,786 | 1,321 | 5,044 | 239 | 233 | 401 | 2,487 | 1,453 | 431 | 177 |
| | Cultivated area | (23.3%) 308,568 Rai | 24,745 | 159,766 | 8,495 | 2,790 | 10,335 | 53,738 | 36,586 | 8,563 | 3,550 |
| | Average cultivation per farming family | 26.1 Rai | 18.7 | 31.6 | 35.5 | 11.9 | 25.7 | 21.6 | 25.1 | 19.8 | 20.0 |

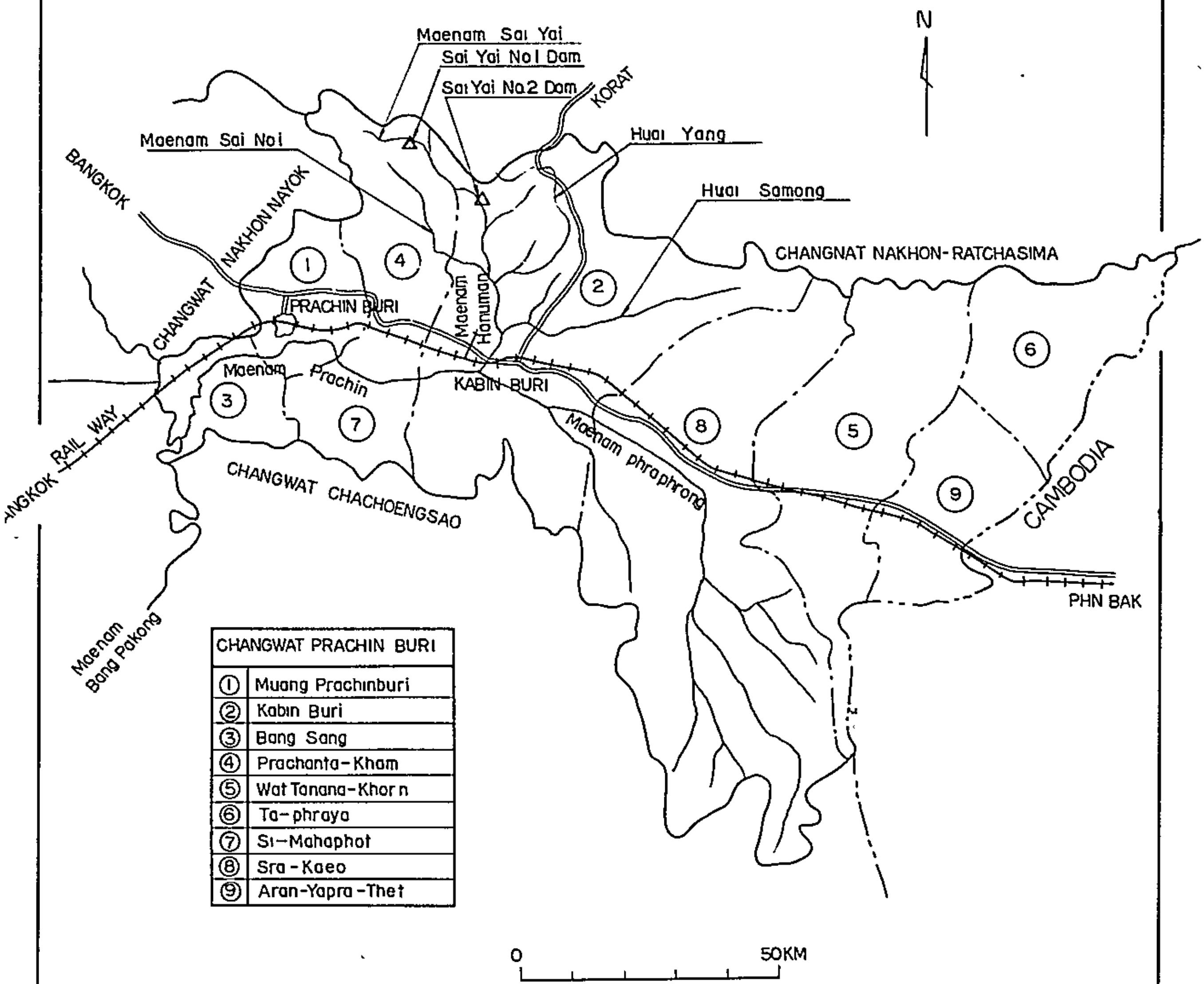
Note  Census of Agriculture 1963
(Changwat Prachin Buri)

TOTAL AREA OF HOLDINGS, BY LAND USE, BY AMPHUR

Table 4-6-8-3

| AMPHUR | TOTAL AREA OF HOLDINGS | ARABLE LAND: LAND IN CROPS: TOTAL AREA | % | IRRIGATED AREA | % | FALLOW AND OTHER ARABLE LAND AREA | % | LAND IN TREE CROPS AREA | % | PASTURE LAND AREA | % | WOODLAND AREA | % | OTHER LAND AREA | % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | RAI | RAI | | RAI | | RAI | | RAI | | RAI | | RAI | | RAI | |
| (1) MUANG PRACHIN-BURI | 167,788 | 140,968 | 84.0 | 113,000 | 67.3 | 3,812 | 2.3 | 14,645 | 8.7 | 325 | 0.2 | 2,626 | 1.6 | 5,412 | 3.2 |
| (2) KABIN-BURI | 298,097 | 217,865 | 73.1 | 66,496 | 22.3 | 12,975 | 4.4 | 9,348 | 3.1 | 2,182 | 0.7 | 50,129 | 16.8 | 5,598 | 1.9 |
| (3) BANSANG | 159,324 | 150,160 | 94.2 | 148,054 | 92.9 | 3,169 | 2.0 | 551 | 0.3 | 120 | 0.1 | 799 | 0.5 | 4,525 | 2.9 |
| (4) PRACHAN-TAKHAM | 128,245 | 114,377 | 89.2 | 48,435 | 37.8 | 3,692 | 2.9 | 2,529 | 2.0 | 124 | 0.1 | 2,044 | 1.6 | 5,479 | 4.2 |
| (5) WATTANA-NAKHORN | 97,343 | 67,499 | 69.3 | 49,331 | 50.7 | 5,478 | 5.6 | 1,397 | 1.4 | 1,603 | 1.6 | 20,491 | 21.2 | 875 | 0.9 |
| (6) TA-PHRAYA | 54,691 | 36,744 | 67.2 | 20,865 | 38.2 | 13,784 | 25.2 | 256 | 0.5 | 160 | 0.3 | 2,908 | 5.3 | 839 | 1.5 |
| (7) SI-MAHAPHOT | 193,087 | 170,108 | 88.1 | 16,900 | 8.8 | 7,887 | 4.1 | 4,254 | 2.2 | 115 | 0.1 | 4,991 | 2.6 | 5,732 | 2.9 |
| (8) SRA-KAEO | 133,422 | 91,272 | 68.4 | 4,235 | 3.2 | 6,672 | 5.0 | 1,105 | 0.8 | 3,703 | 2.8 | 25,341 | 19.0 | 5,329 | 4.0 |
| (9) ARAN-YAP-RATHET | 90,502 | 62,046 | 68.6 | 4,819 | 5.3 | 5,400 | 6.0 | 690 | 0.8 | 452 | 0.4 | 21,696 | 24.0 | 218 | 0.2 |
| TOTAL | 1,322,499 | (1,046,730) 1,051,039 | (79.1) 79.5 | 472,135 | 35.7 | 62,869 | 4.8 | 34,775 | 2.6 | 8,784 | 0.7 | 131,025 | 9.9 | 34,007 | 2.5 |

Note (1) AREA IN RAI (0.16HA)
(2) EXCLUDES HOLDING UNDER 2 RAI (481Rai)
(3) CENSUS OF AGRICULTURE 1963 (CHANGWAT PRACHIN BURI)
(4) ( ) is Area of Rice Field.

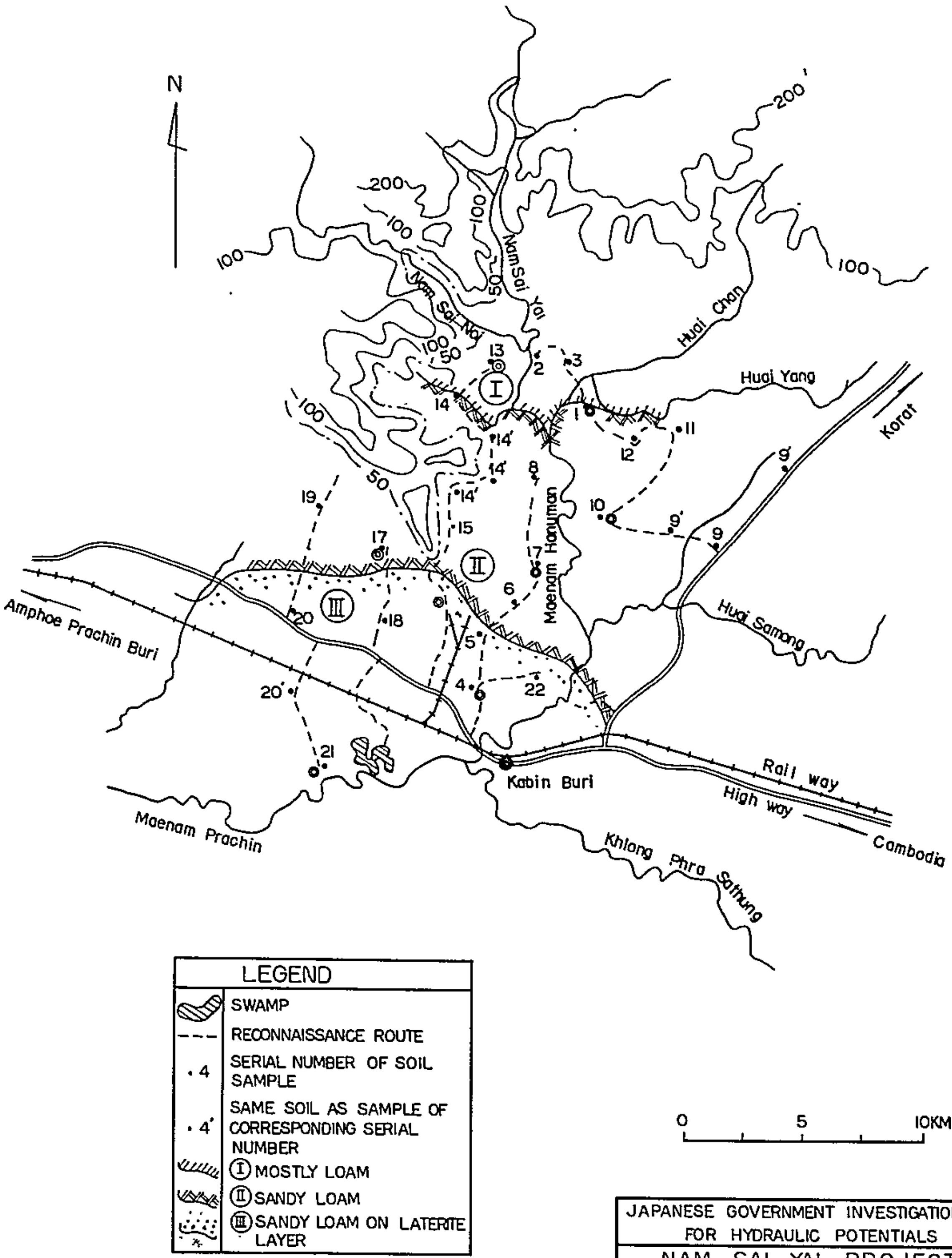



JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

PLAN OF CHANGWAT PRACHINBURI

| | |
|---|---|
| DATE | May-1965 |
| NO | 4-6-8-1 |



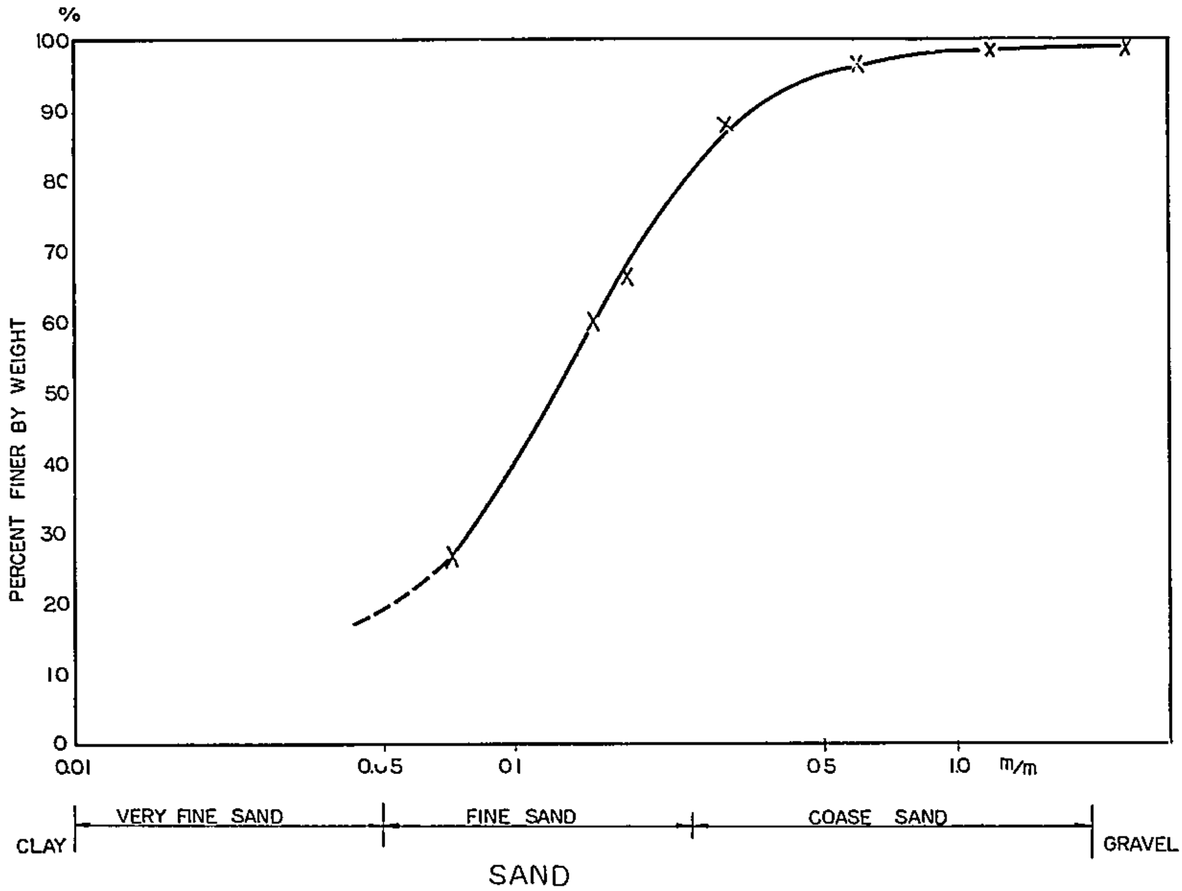

JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

MAP OF SOIL SAMPLES AND SOIL CLASSIFICATION

DATE May - 1965

NO 4-6-8-2




SOIL CLASSIFICATION

Note ------ is presumed value

| | |
|---|---|
| JAPANESE GOVERNMENT INVESTIGATION TEAM FOR HYDRAULIC POTENTIALS | |
| NAM SAI YAI PROJECT | |
| GRAIN SIZE DISTRIBUTION DIAGRAM | |
| DATE | May-1965 |
| NO | 4-6-8-3 |

Number of holdings by Tenure and Size

by Changwat Prachin Buri

Fig. 4-6-8-4

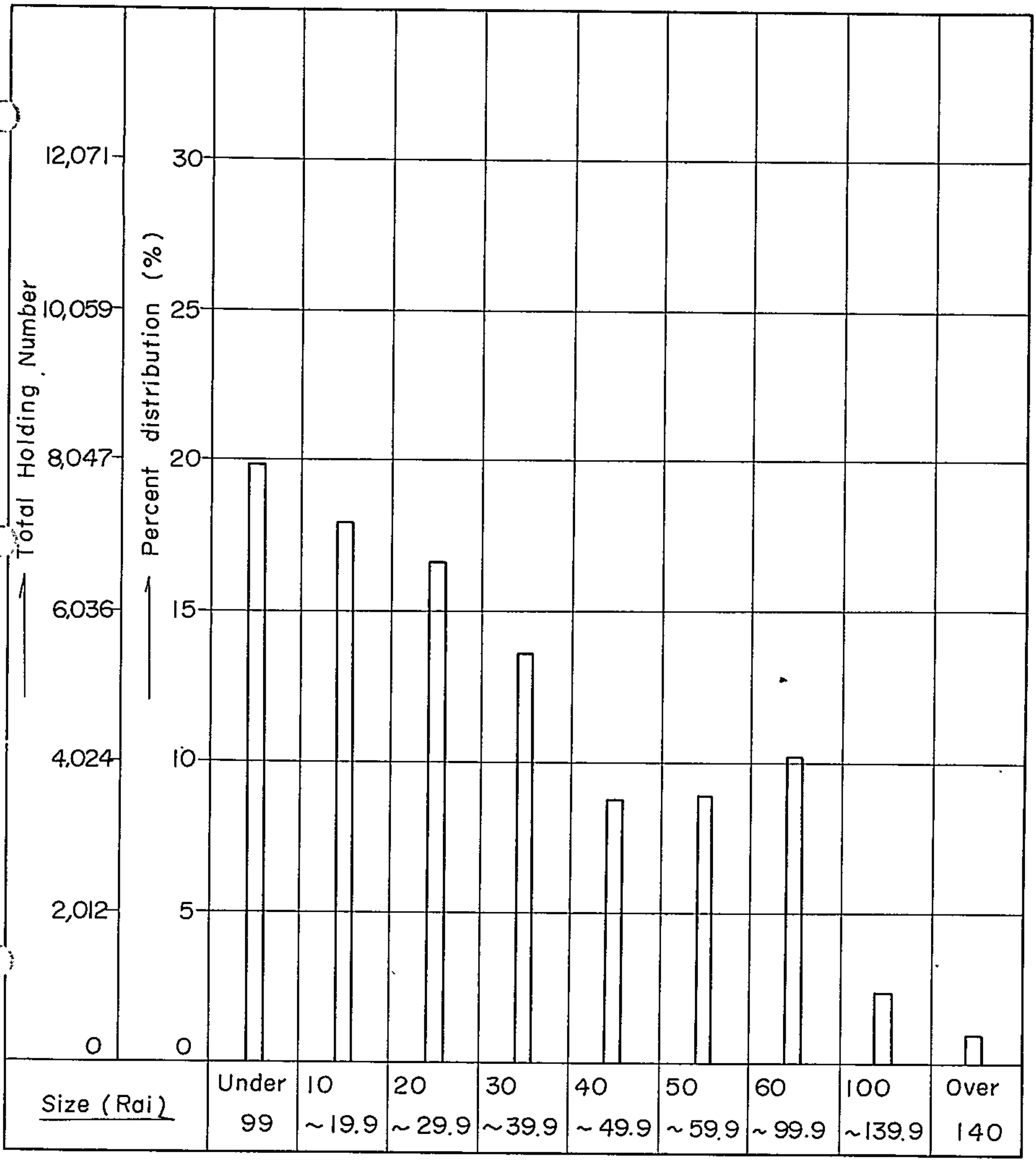
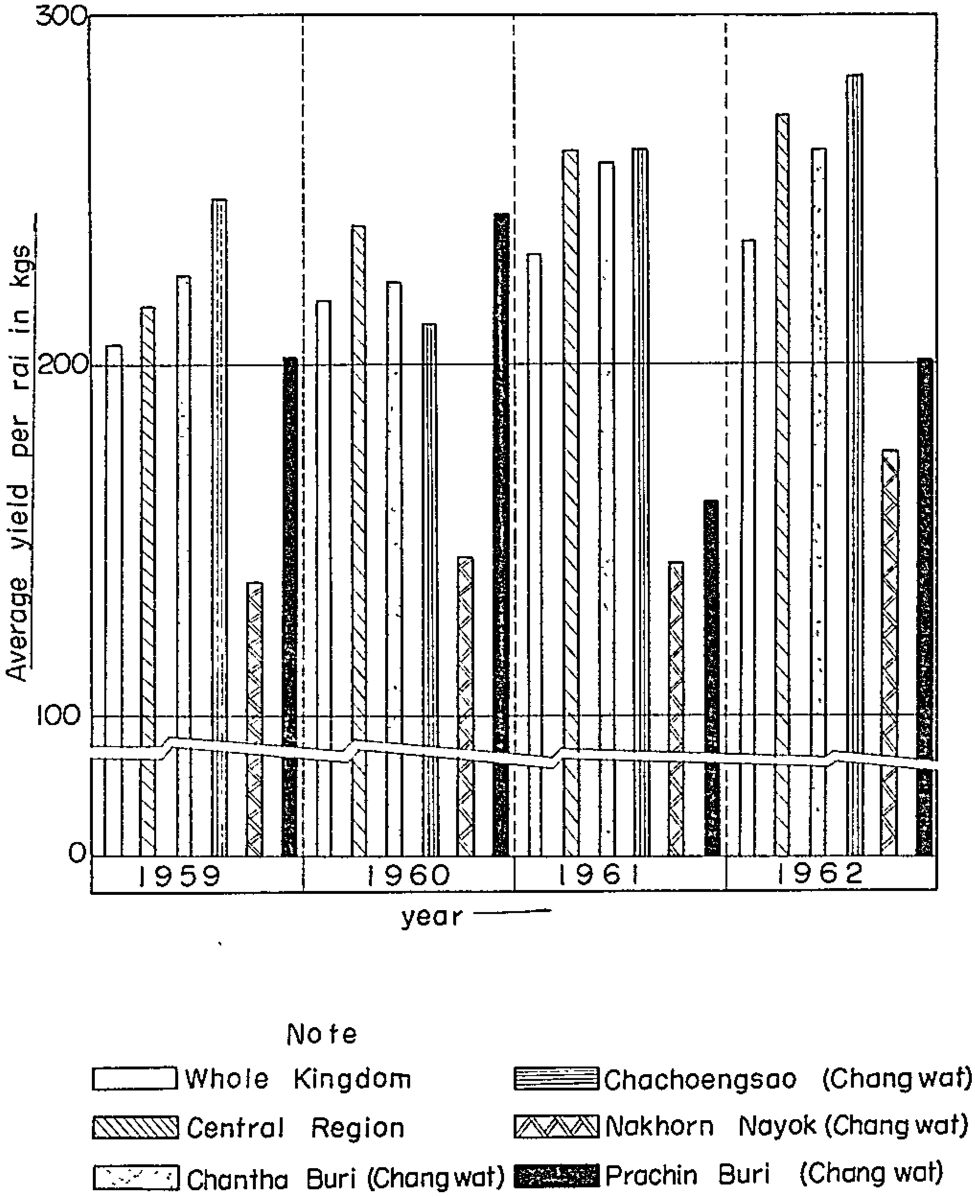


Fig.4-6-8-5 Averag yield of Rice

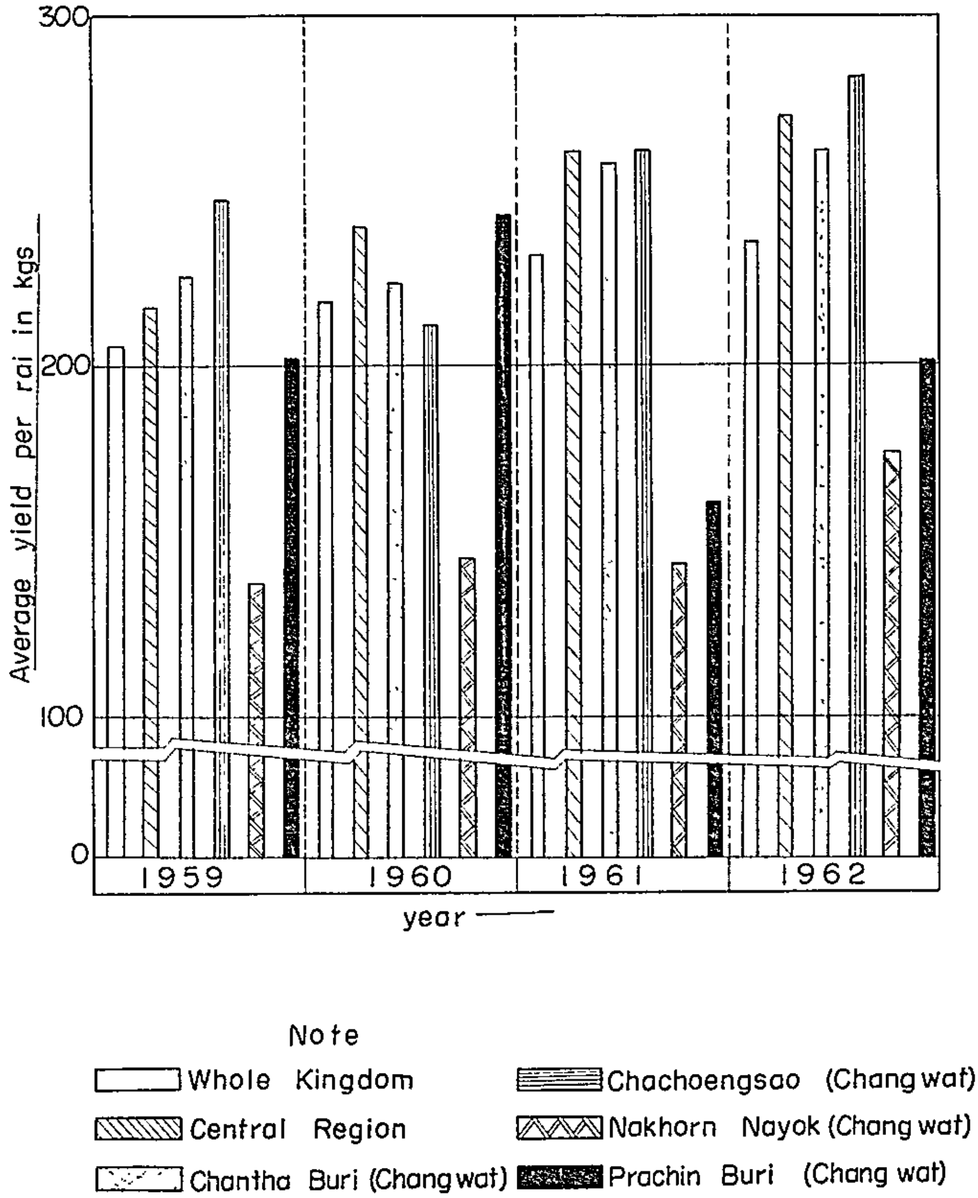


# APPENDIX

1. The Hydrology of the Nam Sai Yai Project area and its environs.

2. Photograph

Fig 4-6-8-5 Averag yield of Rice



## APPENDIX

1. The Hydrology of the Nam Sai Yai Project area and its environs.
2. Photograph

The Hydrology of the Nam Sai Yai Project Area and its environs

## 1. INTRODUCTION

There had been no gauging stations and meteorological observating stations in the Nam Sai Yai Project area before NEA started working in July, 1963.

As a result, only one or one and a half years of hydrologic data is available for the upper area of the Nam Sai Yai at present.

However, at many places near the Nam Sai Yai, rainfall has been observed for sometime. The rainfall data from these observating stations is considered to be usefull, though indirectry, for the project.

The following Tables 1, 2 and Fig 4-2-2 show the location of gauging stations and main meteorological stations for the project and the periods of observation.

Tables 3～11 show the monthly discharge at 2 gauging stations and the monthly rainfall at 7 meterological observating stations near the project area.

Table 1 Gauging Stations

| River | Name of Station | C.A. (km$^2$) | Period of observation |
|---|---|---|---|
| Nam Sai Yai | Kao Keep Samut | 315.1 | Mar. 1964 Dec. 64 |
| " | Ban Sapan Hin | 636 | Jul. 1963 Dec. 64 |

Table 2 Meteorological Observating Stations

| Name of Station | Period of Observation | | Note |
|---|---|---|---|
| Kao Keep Samut | Mar. 1964 | Dec 64 | |
| Ban Sapan Hin | Jul. 1963 | " | |
| Kabin Buri | Jun. 1952 | " | No data for 1962 |
| Prachanta Kham | " | " | " |
| Prachin Buri | Jun. 1951 | " | |
| Park Phli | " 1952 | " | No data for 1956 |
| Nakhon Nayork | Jun. 1951 | " | " |
| Saraburi | " | " | |
| Pak Chong | " | " | No data for 1958, 1960 |
| Si Khiu | " | " | |

1-1 Monthly Rainfall Data

Table 3. Kabin Buri

(mm)

| Month / Year | Jan. | Feb. | Mar. | Apr. | May. | Jun. | Jul. | Aug | Sept. | Oct. | Nov. | Dec | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 52 | 0.6 | 8.7 | 63.1 | 33.7 | 77.3 | 277.6 | 265.9 | 294.4 | 346.8 | 310.5 | 4.6 | 0 | 1,683.2 |
| 53 | 21.0 | 51.7 | 32.0 | 61.5 | 243.1 | 229.0 | 242.3 | 218.2 | 257.9 | 108.3 | 19.1 | 0 | 1,484.1 |
| 54 | 0 | 0 | 50.7 | 182.8 | 170.0 | 142.9 | 229.8 | 268.1 | 441.3 | 58.4 | 0 | 0 | 1,544.0 |
| 55 | 0.3 | 10.4 | 38.1 | 150.5 | 137.1 | 239.2 | 125.1 | 264.3 | 170.5 | 116.7 | 74.9 | 0 | 1,326.8 |
| 56 | 8.6 | 0 | 0 | 107.9 | 144.0 | 257.7 | 231.6 | 182.2 | 494.5 | 123.8 | 32.2 | 0 | 1,582.5 |
| 57 | 0 | 21.6 | 96.0 | 19.1 | 135.9 | 117.6 | 148.0 | 198.5 | 258.1 | 260.3 | 0 | 0 | 1,255.1 |
| 58 | 28.1 | 18.2 | 2.4 | 71.0 | 112.7 | 139.6 | 236.3 | 279.6 | 302.7 | 82.3 | 0 | 0 | 1,272.9 |
| 59 | 0 | 31.8 | 24.3 | 125.6 | 70.5 | 46.8 | 324.5 | 212.4 | 196.1 | 95.3 | 77.3 | 0 | 1,204.6 |
| 60 | - | - | 31.8 | 19.9 | 97.5 | 191.9 | 138.3 | 233.6 | 275.2 | 180.9 | - | - | - |
| 61 | - | - | 61.2 | 113.3 | 447.9 | 269.6 | 424.4 | 610.4 | 306.1 | 184.1 | - | - | - |
| 62 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 63 | - | - | - | - | - | 184.7 | - | 320.8 | 216.8 | 187.5 | 45.0 | 0 | - |
| 64 | - | - | - | - | 80.1 | 115.8 | 44.2 | 336.1 | 231.5 | 212.5 | - | - | - |
| Average | 7.3 | 17.8 | 40.0 | 88.5 | 156.6 | 184.4 | 219.1 | 284.9 | 291.5 | 160.1 | 28.1 | 0 | 1,477.7 |

Table 4. Prachanta Kham

(mm)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 52 | 2.2 | 19.8 | 86.9 | 49.8 | 132.4 | 454.5 | 293.0 | - | 519.4 | 215.5 | 32.2 | 0 | - |
| 53 | 0 | 85.2 | 125.3 | 74.3 | 138.1 | 227.7 | 215.7 | 154.3 | 343.9 | 77.3 | 0 | 0 | 1,441.8 |
| 54 | 0.3 | 0.2 | 62.9 | 186.7 | 119.9 | 69.3 | 192.4 | 194.3 | 190.2 | 60.0 | 3.0 | 0 | 1,079.2 |
| 55 | 0 | 16.8 | 27.2 | 77.3 | 212.5 | 375.8 | 301.8 | 274.8 | 198.3 | 124.5 | 96.1 | 0 | 1,700.1 |
| 56 | 55.2 | - | 35.6 | 89.9 | 207.5 | 177.8 | 319.0 | 101.4 | 408.8 | 107.4 | 38.5 | - | 1,541.1 |
| 57 | 0 | 0.9 | 135.7 | 19.2 | 194.5 | 356.7 | 51.4 | 212.4 | 199.2 | 143.6 | 0 | 0 | 1,319.6 |
| 58 | 3.2 | 3.3 | 6.8 | 8.3 | 47.7 | 97.0 | 143.6 | 99.0 | 167.9 | 11.6 | - | - | - |
| 59 | 0 | 10.5 | 37.4 | 126.5 | 109.8 | 136.0 | 400.6 | 103.7 | 201.1 | 168.7 | 5.9 | 2.3 | 1,302.5 |
| 60 | 0 | 0 | 54.3 | 44.5 | 217.2 | 389.7 | 241.9 | 386.6 | 348.3 | 428.5 | 71.9 | 0 | 2,182.9 |
| 61 | 0 | 0 | 36.2 | 109.9 | 321.3 | 379.0 | 161.8 | 389.3 | 198.6 | 165.4 | 25.0 | 6.3 | 1,792.8 |
| 62 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 63 | 0 | 0 | 86.3 | 101.2 | 77.5 | 118.6 | 374.7 | 214.8 | 250.5 | 118.3 | 32.9 | 2.1 | 1,376.9 |
| 64 | 0 | 18.8 | 28.3 | 114.2 | 217.9 | 120.6 | 168.8 | 472.8 | 271.9 | 180.9 | 0 | 0 | 1,594.2 |
| Average | 5.1 | 12.9 | 60.2 | 83.5 | 166.4 | 241.9 | 239.2 | 236.7 | 274.8 | 150.1 | 27.8 | 1.1 | 1,499.7 |

Table 5. Prachin Buri

(mm)

| Month / Year | Jan. | Feb. | Mar. | Apr. | May | Jun | Jul | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 0 | 0 | 39.0 | 82.4 | 125.9 | 212.8 | 305.5 | 277.1 | 429.9 | 281.4 | 45.1 | 12.0 | 1,811.1 |
| 52 | 5.9 | 0.1 | 111.8 | 97 4 | 135.3 | 232.6 | 215.0 | 373.8 | 393.1 | 313.2 | 14.8 | 0 | 1,892.9 |
| 53 | 1.6 | 178.4 | 152.0 | 50.9 | 240.6 | 243.8 | 205.8 | 283.7 | 428.6 | 66.2 | 8.7 | 1.8 | 1,862.1 |
| 54 | 6.6 | 3.6 | 51.2 | 55.0 | 244.4 | 220.5 | 338.1 | 493.5 | 361.4 | 77.2 | 1.2 | 0 | 1,852.7 |
| 55 | 0 | 40.9 | 68.7 | 117.1 | 323.9 | 481.9 | 398.7 | 246.7 | 259.3 | 128.3 | 124.9 | 6.7 | 2,197.1 |
| 56 | 36.8 | 0 | 59.4 | 102.8 | 252.5 | 263.6 | 371.8 | 340.0 | 742.1 | 157.6 | 37.5 | 0 | 2,364.1 |
| 57 | 5.4 | 23.1 | 125 2 | 56.3 | 60.6 | 335.4 | 265.1 | 352.3 | 590.5 | 337.9 | 72.8 | 0 | 2,224.6 |
| 58 | 0 | 91.5 | 8.7 | 59.3 | 269.9 | 254.7 | 372.4 | 312.7 | 432.0 | 176.1 | 0 | 0 | 1,977.3 |
| 59 | 0 | 53.5 | 77.9 | 68.7 | 119.0 | 156.9 | 518.1 | 257.8 | 350.7 | 195.8 | 9.6 | 0.6 | 1,808.6 |
| 60 | 0 | 0.5 | 49.6 | 80.9 | 118.1 | 174 3 | 145.8 | 273 0 | 382.4 | 235.1 | 69.3 | 0 | 1,529.0 |
| 61 | 2.2 | 18 2 | 79 5 | 121.3 | 275.2 | 326.7 | 414.6 | 440 7 | 410.5 | 265.3 | 33.1 | 0 | 2,387.3 |
| 62 | 0 | 3.4 | 74.3 | 343.6 | 281.1 | 382.9 | 551 3 | - | - | - | - | - | - |
| 63 | 0 | 3.6 | 99.0 | 108.4 | 104.5 | - | - | - | - | - | - | - | - |
| 64 | 0 | 60.7 | 23.0 | 78.4 | 169.1 | 336.3 | 147.6 | 293.3 | 279.7 | 273.8 | 0 | 0 | 1,661 9 |
| Average | 4.2 | 34.1 | 72.8 | 101.6 | 194.3 | 278.1 | 326.9 | 328.7 | 421.7 | 209.0 | 34.8 | 2.2 | 2,008.4 |

Table 6. Nakhon Nayork

(mm)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 51 | 0 | 0 | - | - | 97.9 | 276.7 | 182 2 | 253.8 | 409.2 | 201.2 | 53.1 | 5.4 | - |
| 52 | 0 | 25.9 | 138.7 | 43.2 | 229.2 | 329.4 | 374.0 | 420.1 | 443.9 | 264.9 | 28 7 | 0 | 2,298.0 |
| 53 | 29.7 | 79.4 | 114.2 | 67.1 | 278 0 | 343.9 | 361.0 | 296.6 | 339.0 | 147.7 | 85.5 | 9.4 | 2,151.5 |
| 54 | 60 3 | 2.5 | 109.7 | 169.0 | 249.0 | 416.4 | 364.7 | 899.7 | 577.1 | 81.1 | 0 | 0.6 | 2,930.1 |
| 55 | 0 | 31.1 | 50.8 | 140.9 | 377.1 | 494.0 | 281.8 | 231.7 | 356.8 | 172.5 | 78.6 | 0 | 2,215.3 |
| 56 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 57 | 5.3 | 3.6 | 32.2 | 98.3 | 159.9 | 307.4 | 318.5 | 658.2 | 660.4 | 527.8 | 52.6 | 0 | 2,824.2 |
| 58 | - | 109.3 | 4.0 | 109.3 | 54.6 | 379.2 | 282.4 | 243.9 | 446.4 | 180.0 | - | - | - |
| 59 | 24.9 | 49.4 | 196.6 | 127.1 | 136.4 | 397.9 | 284.7 | 441.3 | 238.0 | 18.4 | 7.8 | - | 1,922.5 |
| 60 | 0 | 0 | 57.6 | 18.6 | 144.0 | 442.4 | 323.1 | 314.0 | 434.6 | 306.0 | 94.1 | 0 | 2,134.4 |
| 61 | 0 | 21.4 | 59.3 | 119 9 | 358.1 | 315.6 | 246.0 | 681.2 | 450 7 | 322.2 | 26.5 | 0.9 | 2,600.9 |
| 62 | 0 | 8.9 | 0 | 142.4 | 286.1 | 482.4 | 424.1 | 239.0 | 409.8 | 201.9 | 1.3 | 0 | 2,193.9 |
| 63 | 0 | 22.4 | 35.9 | 44.4 | 77.9 | 178.0 | 319.8 | 485.4 | 385.7 | 214.7 | 42.8 | 1.9 | 1,608.9 |
| 64 | 0 | 4.0 | 3.2 | 38.2 | 273.2 | 106.2 | 210.5 | 207.4 | 195.3 | 239.3 | 0.1 | 0 | 1,277.4 |
| Average | 10.0 | 27.5 | 66.9 | 93.2 | 209.3 | 343.7 | 305.6 | 412.6 | 411.3 | 221.4 | 39.3 | 1.7 | 2,142.5 |

Table 7 Pak Phli

(mm)

| Month / Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 52 | 0 | 11.5 | 152.9 | 66.3 | 42.3 | 246.4 | 168.4 | 464.0 | 194.1 | 227.5 | 8.6 | 0 | 1,582.0 |
| 53 | 11.4 | 133.6 | 102.1 | 87.7 | 177.9 | 328.9 | 238.0 | 150.9 | 296.0 | 221.7 | 43.5 | 60.6 | 1,852.3 |
| 54 | 0 | 37.3 | 37.6 | 160.2 | 192.6 | 280.7 | 223.3 | 665.4 | 533.6 | 33.4 | 5.7 | 0 | 2,169.8 |
| 55 | 0 | 13.6 | 41.1 | 54.7 | 272.4 | 457.6 | 401.3 | 354.1 | 235.0 | 117.1 | 115.5 | 11.4 | 2,073.8 |
| 56 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 57 | 0.3 | 0 | 38.0 | 25.1 | 44.5 | 416.5 | 379.4 | 808.5 | 351.3 | 439.6 | 8.5 | 0 | 2,511.7 |
| 58 | - | - | 35.1 | - | 72.7 | 269.4 | 302.8 | 264.2 | 292.6 | 40.7 | - | - | - |
| 59 | 0 | 25.5 | 13.5 | 76.4 | 125.7 | 142.1 | 466.3 | 298.9 | 444.8 | 155.1 | 62.3 | 3.2 | 1,813.8 |
| 60 | 0 | 0 | 33.2 | 7.0 | 227.7 | 270.0 | 174.1 | 350.0 | 536.0 | 350.9 | 275.3 | 0 | 2,224.2 |
| 61 | - | 31.7 | 29.5 | 124.4 | 373.1 | 377.2 | 402.8 | 568.5 | 373.3 | 495.4 | 10.9 | - | - |
| 62 | - | 21.2 | - | - | 200.3 | 99.4 | 234.1 | 69.7 | 96.7 | 71.1 | - | - | - |
| 63 | 0 | 5.0 | 67.6 | 53.1 | 219.5 | 236.2 | 247.1 | 488.3 | 293.4 | 285.0 | 52.6 | 26.4 | 1,974.2 |
| 64 | 0 | 41.7 | 19.3 | 67.9 | 98.5 | - | 146.1 | 341.4 | 276.0 | 176.3 | - | - | - |
| Average | 1.3 | 29.2 | 51.8 | 65.7 | 170.6 | 289.5 | 282.0 | 402.0 | 326.9 | 217.8 | 64.8 | 12.7 | 1,914.3 |

Table 8 Ban Sapan Hin (at gauging station)

(mm)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1963 | - | - | - | - | - | - | 510.4 | 497.4 | 338.6 | 311.4 | 101.4 | 0 | - |
| 64 | 8.0 | 73.0 | 8.2 | 84.7 | 345.3 | 130.6 | 118.7 | 295.6 | 212.8 | 249.2 | 6.1 | 0 | 1,532.2 |

Table 9 Kao Keep Samut (at gauging station)

(mm)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | - | - | 7.4 | 73.6 | 657.7 | 215.6 | 229.2 | 310.4 | 348.6 | 287.2 | - | - | - |

1-2. Monthly Discharge Data

Table 10 Ban Sapan Hin G. S. C. A. = 636.0 km²

(m³/sec. -day)

| Month / Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1963 | - | - | - | - | - | - | 1,261.7 | 1,959.7 | 2,682.5 | 2,052.5 | 759.3 | 165.0 | - |
| 64 | 50.1 | 35.9 | 16.3 | 7.7 | 604.5 | 464.2 | 1,042.0 | 882.5 | 1,194.1 | 2,144.6 | 299.7 | 62.8 | 6,804.4 |

Table 11 Kao Keep Samut G. S. C. A. = 315.1 km²

(m³/sec. -day)

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1964 | ** 24.8 | 19.8 | 9.4 | 9.7 | 217.6 | 199.9 | 422.1 | 330.0 | 527.0 | 960.0 | ** 117.2 | ** 29.3 | 2,866.8 |

Note;

(1) Ban Sapan Hin G.S. was built in June, 1963. Belongs to NEA

Kao Keep Samut G.S. " in Feb. 1964 "

(2) * means estimated discharge ( see for Feg. 7)

** means modified discharge ( see for Fig. 7)

## 2. THE TENDENCY OF RAINFALL AND DISCHARGE OF THE NAM SAI YAI AND ITS ENVIRONS.

### 2-1. Rainfall

The Nam Sai Yai Project area and its environs are located in the mountain district which divides the central plain along the Mae Nam and the Korat plateau of eastern Thailand, this mountain area which has peaks of about 1,000m above sealevel, consists of a castle wall in the western and eastern parts of Thailand.

It also forms the watershed of the Mekong river side and smaller rivers such as the Nam Sai Yai and the Khlong Tha Dan all of which flow into the Gulf of Siam.

This area is located in the monsoon region of Southeast Asia and has two seasons, one dry (Nov.~Apr. ) and the other rainy (May~Oct.).

During the rainy season, these mountains have an annual recorded rainfall of more than 2,000 mm much of which comes by the monsoon from the south west. Therefore, this area is considered to be one of the heaviest rainfall districts in Thailand.

Table 12, Fig.1 show the average monthly rainfall of the Nam Sai Yai and its environs. The annual rainfall of 1964 in the same places is shown on Table 13, Fig. 2 and Fig. 3 shows the relation of rainfall between Kabin Buri and its environs.

Table 12 Average Monthly Rainfall

(mm)

| Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kao Keep Samut | 9 | 27 | 58 | 135 | 277 | 314 | 391 | 423 | 473 | 259 | 49 | 2 | 2,417 |
| Kabin Buri | 6 | 12 | 37 | 86 | 147 | 193 | 242 | 271 | 293 | 162 | 30 | 1 | 1,479 |
| Prachin Buri | 4 | 34 | 73 | 102 | 194 | 278 | 327 | 329 | 422 | 209 | 35 | 2 | 2,009 |
| Nakhon-Nayork | 10 | 28 | 67 | 93 | 209 | 344 | 306 | 413 | 411 | 221 | 39 | 2 | 2,143 |

Note: 1. Monthly rainfall is the average of the past 14 years (from 1951 to 1964)

2. Monthly rainfall at Kao Keep Samut is an estimated figure

Fig 1 Average monthly rainfall

(1951 ~ 1964)

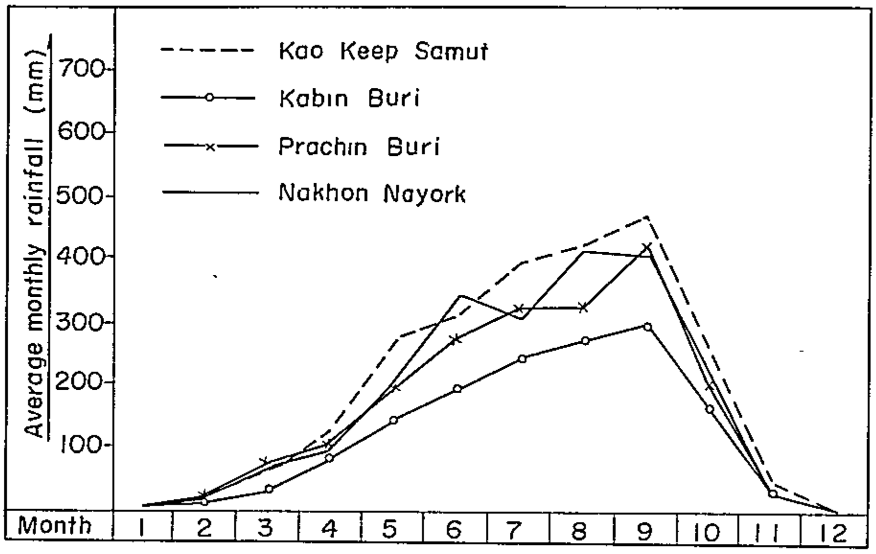



Table 13 Monthly Rainfall in 1964

| Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| KaoKeep Samut | 7 | 133 | 7 | 74 | 658 | 216 | 229 | 310 | 349 | 287 | 3 | 0 | 2,273 |
| Ban Sapan Hin | 8 | 73 | 8 | 85 | 345 | 131 | 119 | 296 | 213 | 249 | 6 | 0 | 1,533 |
| Kabin Buri | 4 | 14 | 22 | 89 | 80 | 116 | 158 | 336 | 232 | 213 | 0 | 0 | 1,264 |
| Prachin Buri | 0 | 61 | 23 | 78 | 169 | 336 | 148 | 293 | 280 | 274 | 0 | 0 | 1,662 |
| Nakhon-Nayork | 0 | 4 | 3 | 38 | 273 | 106 | 211 | 207 | 195 | 239 | 0 | 0 | 1,276 |

Fig 2 Monthly rainfall in 1964

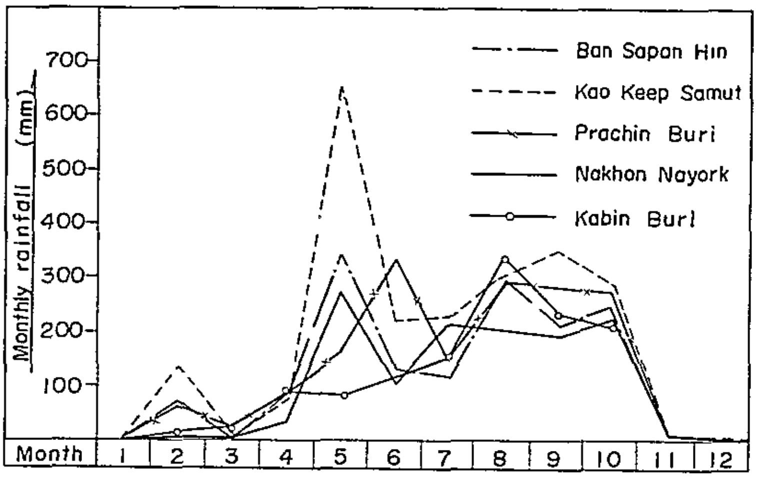
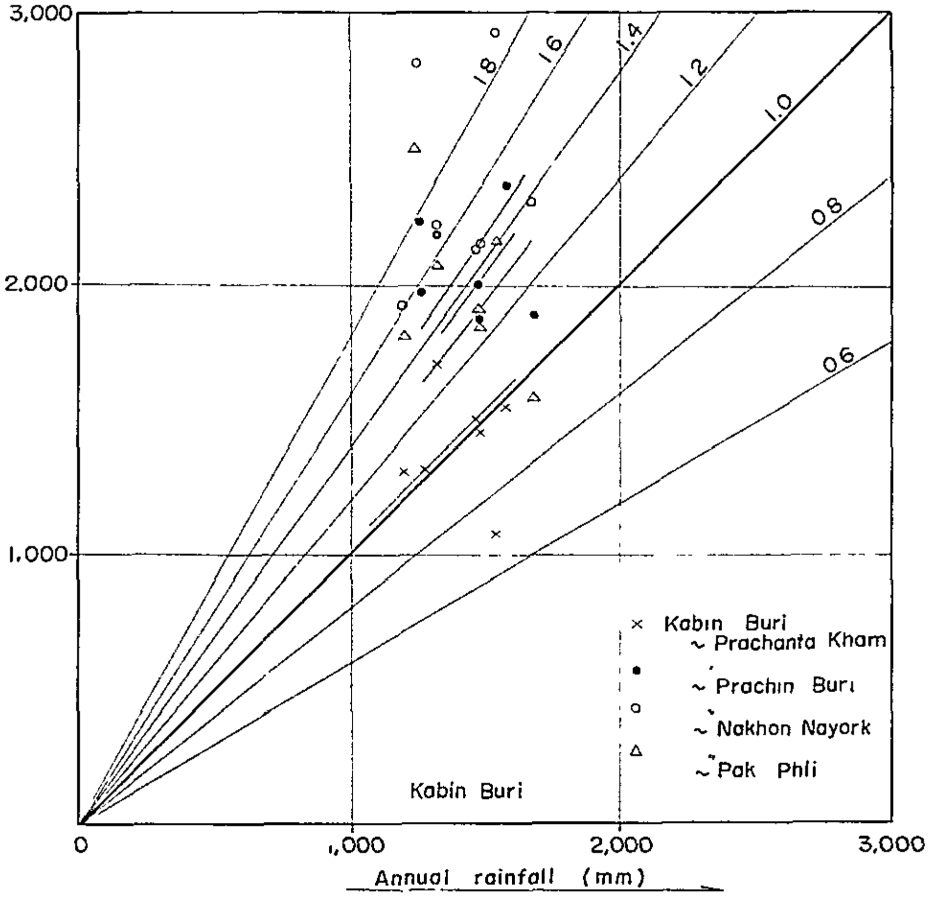



Fig 3 Relation of annual rainfall between
Kabin Buri and its environs



According to the above data, Kao Keep Samut which is located on the upper drainage area of the Nam Sai Yai has a greater abundance of rainfall than that of other places.

Especialy, annual observed rainfall in 1964 at Kao Keep Samut was 1.5 times as much as that of the lower drainage area (Ban Sapan Hin), and an estimated average annual rainfall for 14 years at Kao Keep Samut is considered to be about 1.3 times as much as that of the lower area.

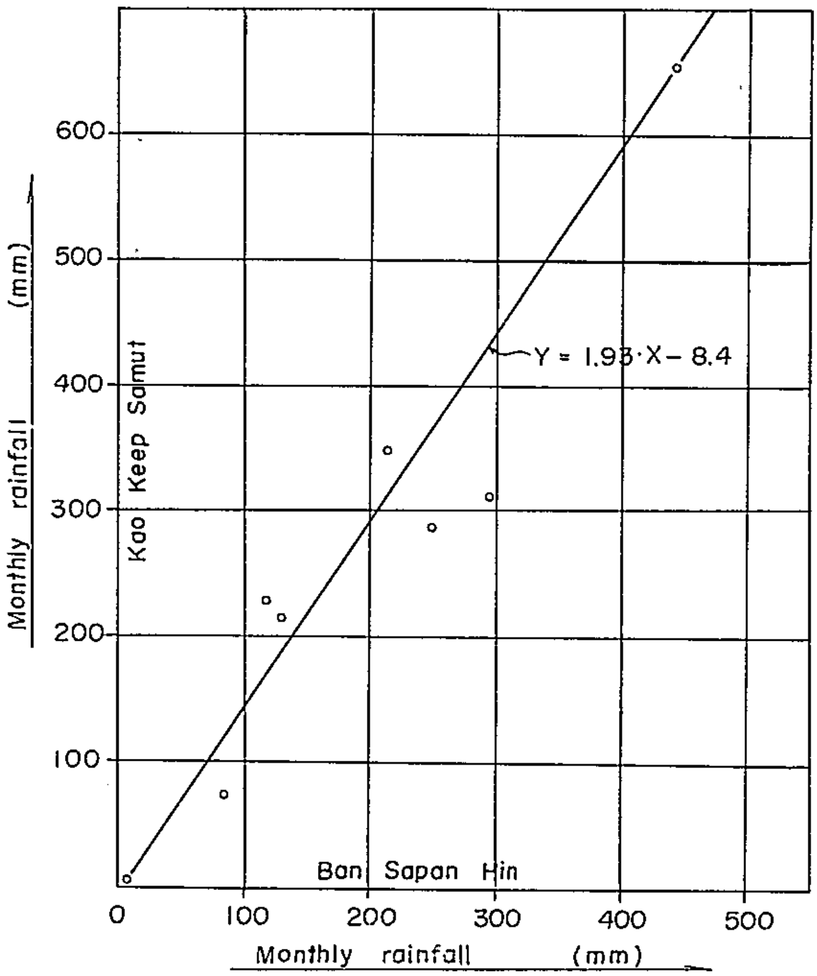
Table 14 shows annual rainfalls in 1964 at 3 observating stations within the Nam Sai Yai and their ratios to Kabin Buri.

Table 14 Annual Rainfull

| Station | Annual Rainfall (mm) | % | Note |
|---|---|---|---|
| Kabin Buri | 1,264 | 100 | Lowest drainage area |
| Ban Sapan Hin | 1,533 | 125 | Lower " |
| Kao Keep Samut | 2,273 | 180 | Upper " |

Fig.4 shows the relation of monthly rainfall in 1964 between Ban Sapan Hin and Kao Keep Samut stations which were recently built by the NEA.

Fig 4
Relation of monthly rainfall in 1964
between Ban Sapan Hin and Kao Keep Samut




2-2. Discharge

As mentioned in 1. no discharge or rainfall had been observed before 2 gauging stations were built on the Nam Sai Yai in July, 1963 and March, 1964. Therefore, discharge data of only one year or so which is obtainable at present is not sufficient to accurately calculate the hydrology of the Nam Sai Yai by usual means. Thus, it is necessary to estimate the long term discharge of the Nam Sai Yai by some other method.

Table 15, Fig. 5 and Fig. 6 shows the tendency of discharge of the Nam Sai Yai in 1964.

Table 15 Monthly Average Discharge per 100 $km^2$ in 1964

($m^3$/sec.)

| G. S. \ Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ban Sapan Hin | 0. 25 | 1. 95 | 0. 83 | 0. 40 | 3. 07 | 2. 42 | 5. 29 | 4. 48 | 6. 26 | 10.88 | 1. 57 | 0. 32 | 2. 92 |
| Kao Keep Samut | *0. 25 | *0. 22 | *0. 10 | 0. 10 | 2. 23 | 2. 12 | 4. 3 | 3. 38 | 5. 57 | 9. 83 | **3. 02 | **1. 31 | 2. 49 |

Note

(1) Ban Sapan Hin G. S. C. A. = 636. 0 $km^2$

Kao Keep Samut G. S. C. A. = 315. 1 $km^2$

(2) *Estimated discharge (see for Fig - 7 )

** Modified discharge (see for Fig - 7 )

Fig. 5 Monthly discharge and rainfall at Ban Sapan Hin in 1964 ($m^3/s/100\,km^2$, mm)

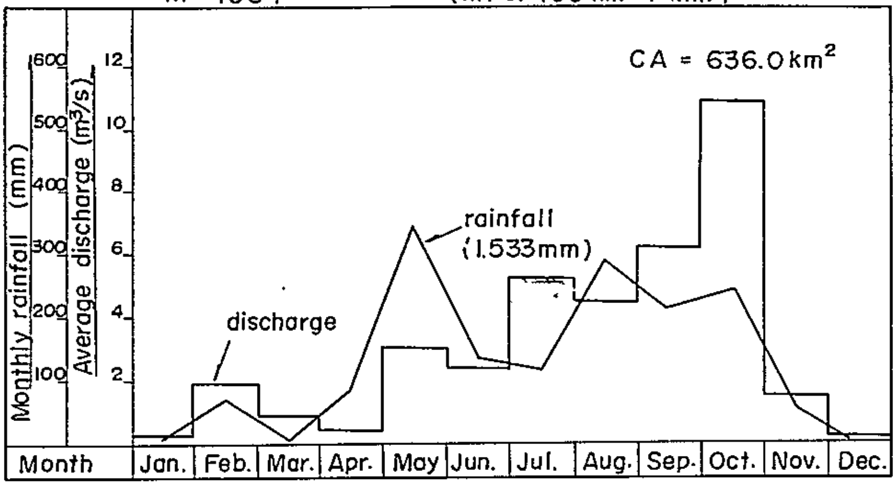



Fig. 6 Monthly discharge and rainfall at Kao Keep Samut in 1964 ($m^3/s/100\,km^2$, mm)

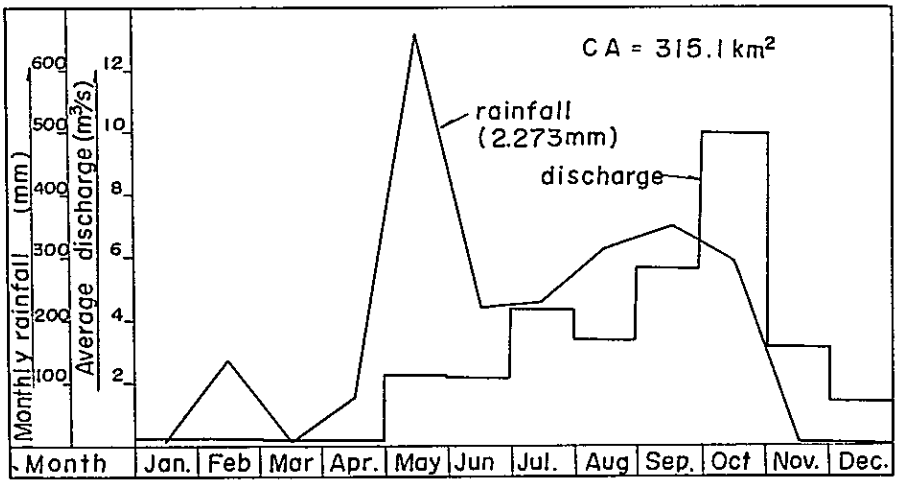
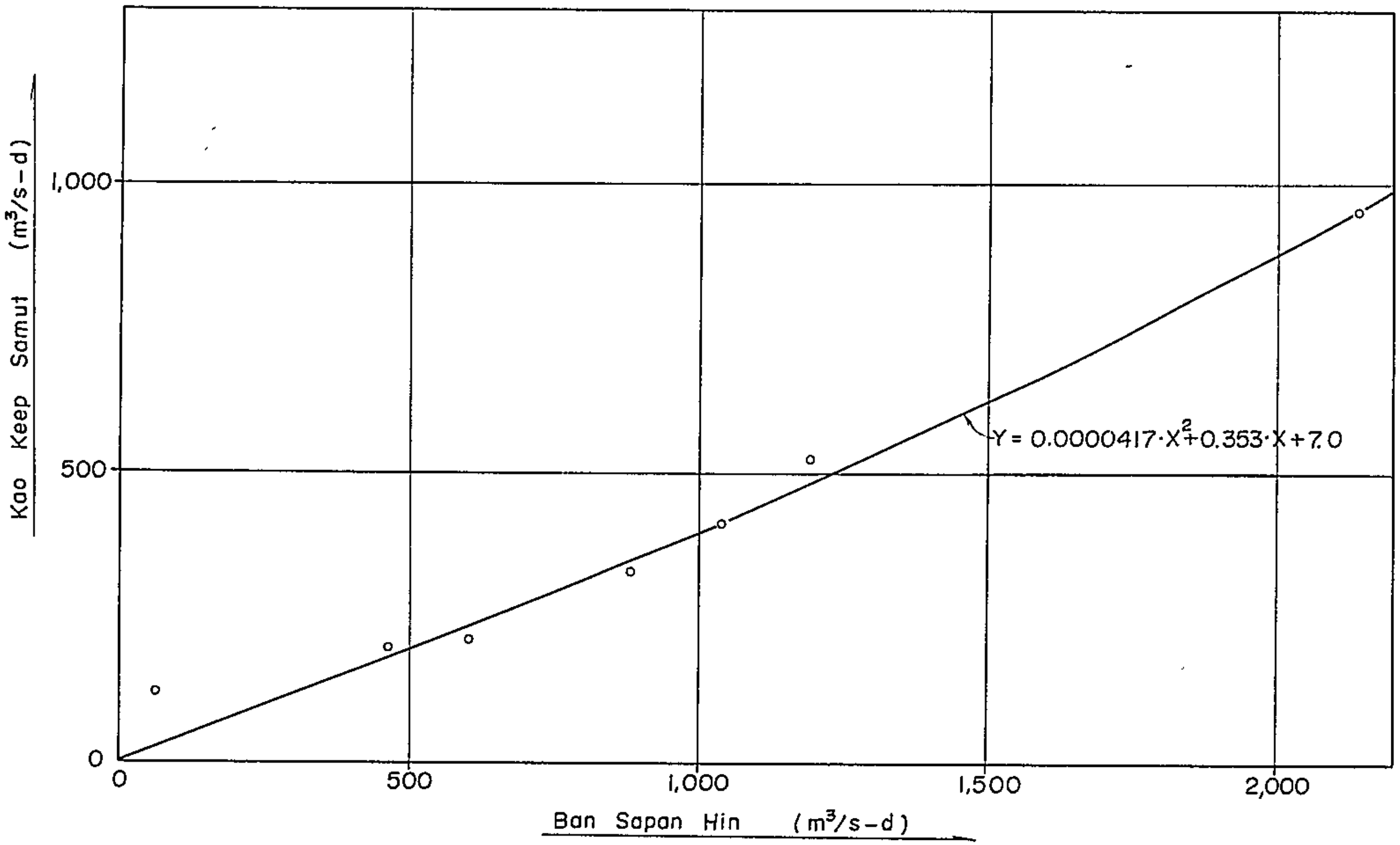


Fig. 7 Relation of monthly discharge between Ban Sapan Hin and Kao Keep Samut

CA = Ban Sapan Hin 636.0 km²
Kao Keep Samut 315.1 〃



According to the above hydraulic dadatof 1964, it can be seen that the annual discharge of the upper drainage area (Kao Keep Samut) is only 0.85 as much as that of the lower drainage area

(Ban Sapan Hin), even though the annual rainfall during the year at Kao Keep Samut was 1.5 times as much as that of Ban Sapan Hin. This means that the run-off coefficient of the upper drainage area is much smaller than that of the lower drainage area, (see for Table 19 for run-off coefficient of 34% for the upper drainage area, and 60% for the lower drainage area).

Although many reasons have been considered for this tendency, but only one year of hydrologic data is not enough to know the real hydrology of the Nam Sai Yai, the future investigation is desirable.

The specific discharge of the Nam Sai Yai in 1964, which is 2.7m$^3$/sec. is about twice as much as 1.3m$^3$/sec. of the Lam Ta Krong which is a tributary of the Mekong river closing to the. Nam Sai Yai.

Generally, aboundant discharge is expected in the upper drainage area of The Nam Sai Yai, from the above mentioned viewpoint.

## 3. ESTIMATION OF DISCHARGE FROM THE UPPER DRAINAGE AREA OF THE NAM SAI YAI

This estimation of discharge in the upper drainage area of the Nam Sai Yai is figured from the above mentioned data is as follows

### 3-1. Rainfall Data at Kabin Buri

Since Kabin Buri is located near the project area and has long term rainfall data, estimation of rainfall in the upper drainage area of the Nam Sai Yai should be done from this data.

2 years of no rainfall observation were filled up by the following process (1) (2) and (3).

(1) Relation of cumulative rainfall between Prochanta Kham and Kabin Buri (See for Fig. 8)

(2) Relation of cumulative rainfall between Prachin Buri and Kabin Buri (See for Fig. 9)

(3) Relation of comulative rainfall between Nakhon Nayork and Kabin Buri (See for Fig. 10)

Table 16 Shows the monthly rainfall for the past 14 years, after the blanks were filled up.

Fig 8 Relation of Cumulative rainfall between Prachanta Kham and Kabin Buri

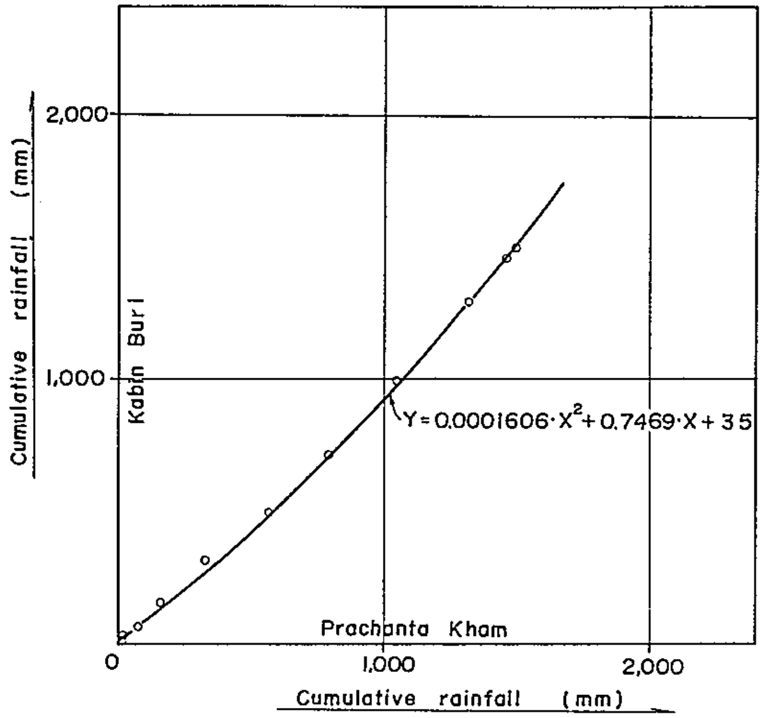



Fig 9 Relation of Cumulative rainfall between Prachin Buri and Kabin Buri

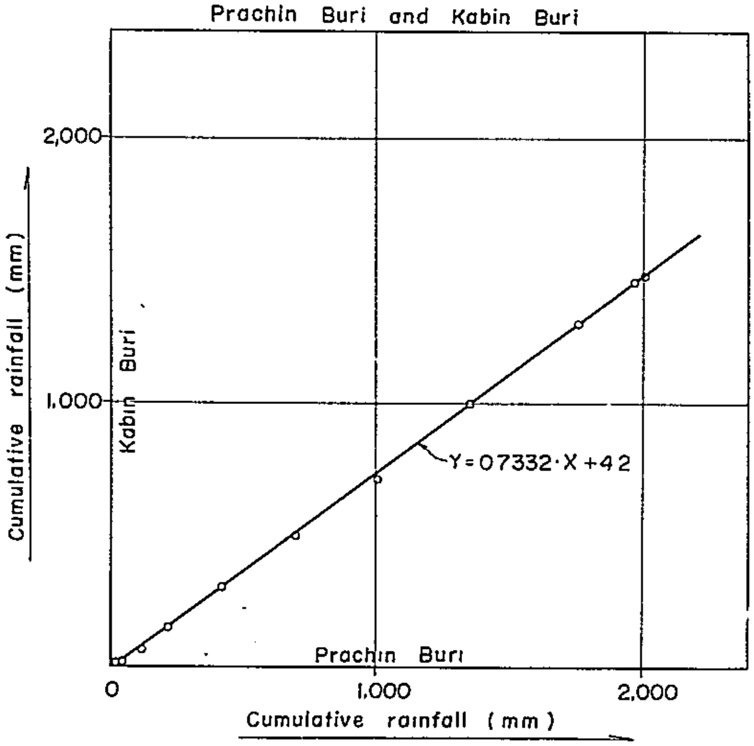
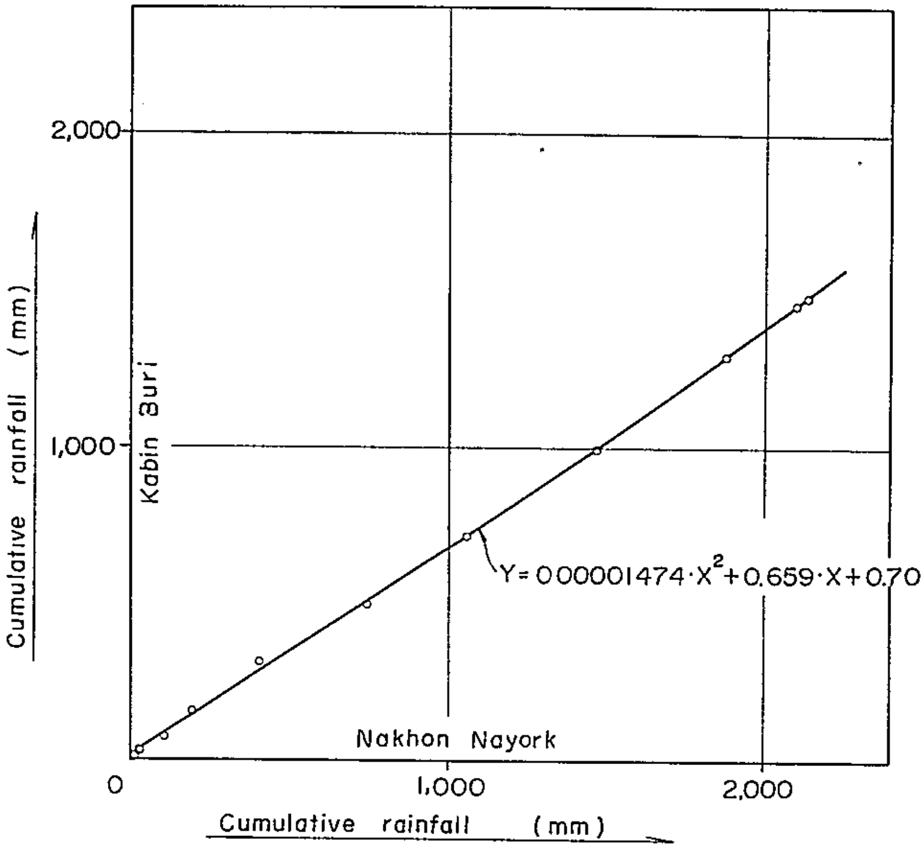


Fig 10 Relation of cumulative rainfall between Nakhon Nayork and Kabin Buri




Note; Ordinate and abscissa of fig. 8~10 represent the cumulative rainfall and cumulative discharge of each station.

Table 16 Monthly Kabin Buri Rainfall

| | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. |
|---|---|---|---|---|---|---|---|
| 1951 | 4.2** | 0** | 28.6** | 60.4** | 92.3** | 156.1** | 223.9** |
| 52 | 0.6 | 8.7 | 63.1 | 33.7 | 77.3 | 277.6 | 265.9 |
| 53 | 21.0 | 51.7 | 32.0 | 61.5 | 243.1 | 229.0 | 242.3 |
| 54 | 0 | 0 | 50.7 | 182.8 | 170.0 | 142.9 | 229.8 |
| 55 | 0 | 10.4 | 38.1 | 150.5 | 137.1 | 239.2 | 125.1 |
| 56 | 8.6 | 0 | 0 | 107.9 | 144.0 | 257.7 | 231.6 |
| 57 | 0 | 21.6 | 96.0 | 19.1 | 135.9 | 117.6 | 148.0 |
| 58 | 28.1 | 18.2 | 2.4 | 71.0 | 112.7 | 139.6 | 236.3 |
| 59 | 0 | 31.8 | 24.3 | 125.6 | 70.5 | 46.8 | 324.5 |
| 60 | 3.5* | 0* | 31.8 | 19.9 | 97.5 | 191.9 | 138.3 |
| 61 | 3.5* | 0* | 61.2 | 113.3 | 447.9 | 269.6 | 424.4 |
| 62 | 0.7*** | 5.9*** | 0*** | 94.1*** | 191.1*** | 326.1*** | 293.6*** |
| 63 | 3.5* | 0* | 65.7* | 80.0* | 63.5* | 184.7 | 348.7* |
| 64 | 3.5* | 14.0* | 21.6* | 89.1* | 80.1 | 115.8 | 157.8* |
| Average | 5.5 | 11.6 | 36.8 | 86.4 | 147.4 | 192.5 | 242.2 |

| | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|
| 1951 | 203.2** | 315.2** | 206.3** | 33.1** | 8.8** | 1,332.1 |
| 52 | 294.4 | 346.8 | 310.5 | 4.6 | 0 | 1,683.2 |
| 53 | 218.2 | 257.9 | 108.3 | 19.1 | 0 | 1,484.1 |
| 54 | 268.1 | 441.3 | 58.4 | 0 | 0 | 1,544.0 |
| 55 | 264.3 | 170.5 | 116.7 | 74.9 | 0 | 1,326.8 |
| 56 | 182.2 | 494.5 | 123.8 | 32.2 | 0 | 1,582.5 |
| 57 | 198.5 | 258.1 | 260.3 | 0 | 0 | 1,255.1 |
| 58 | 279.6 | 302.7 | 82.3 | 0 | 0 | 1,272.9 |
| 59 | 212.4 | 196.1 | 95.3 | 77.3 | 0 | 1,204.6 |
| 60 | 238.6 | 275.2 | 180.9 | 103.3* | 0* | 1,280.9 |
| 61 | 610.4 | 306.1 | 184.1 | 32.9 | 8.3 | 2,461.7 |
| 62 | 167.8*** | 291.7*** | 145.5*** | 1.0*** | 0*** | 1,517.5 |
| 63 | 320.8 | 216.8 | 187.5 | 45.0 | 0 | 1,516.2 |
| 64 | 336.1 | 231.5 | 212.5 | 0* | 0* | 1,262.0 |
| Average | 271.0 | 293.2 | 162.3 | 30.2 | 1.2 | 1,480.3 |

Note:

* ----- Monthly rainfall estimated by Fig-8 curve ($Y=0.0001606\,x^2 + 0.7469\,x + 3.5$)

** ----- Monthly rainfall estimated by Fig-9 curve ($Y=0.7332x+4.2$)

*** --- Monthly rainfall estimated by Fig-10 curve ($Y=0.00001474x^2 + 0.659\,x + 0.70$)

No Mark Monthly rainfall observed at Kabin Buri

3-2. Estimation of Rainfall at Kao Keep Samut

As mentioned above, no rainfall data of the upper drainage area of the Nam Sai Yai except data from one year at Kao Keep Samut and Ban Sapan Hin, has been taken the rainfall from 1951 to 1963 of Kao Keep Samut (Project area) must be estimated by the relation of rainfall in 1964 between Kabin Buri and Kao Keep Samut.

Table 17 shows the monthly rainfall in 1964 at Kao Keep Samut and Kabin Buri

Table 17 Monthly Rainfall at Kao Keep Samut

| Station \ Month | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Kao Keep Samut | ※ 7 | ※ 133 | 7 | 74 | 658 | 216 | 229 | 310 | 349 | 287 | ※ 3 | ※ 0 | 2,273 |
| Kabin Buri | 4 | 14 | 22 | 89 | 80 | 116 | 158 | 336 | 232 | 213 | 0 | 0 | 1,264 |

Note: ※ Estimated figures by the relation of rainfall between Kao Keep Samut and Ban Sapan Hin.

Following is an estimation of rainfall of Kao Keep Samut.

$$Rkao = Rkab \times \frac{2,273}{1,264} = Rkab \times 1.801 \times 0.9$$

Rkao; Monthly discharge at Kao Keep Samut ($m^3$/sec.-day)

Rkab. " at Kabin Buri ( " )

0.9. Safety factor due to lack of long term data

Table 18 shows the estimated rainfall from 1951-1964 (14 years) at Kao Keep Samut by the above method figures from July, 1963 to Dec, 1964 are observed ones at Kao Keep Samut).

Table 18 Estimated Rainfall at Kao Keep Samut G. S.

C. A. =315.1 $km^2$
(mm)

| Month / Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 7 | 0 | 46 | 98 | 150 | 253 | 363 | 329 | 511 | 334 | 54 | 14 | 2,159 |
| 52 | 1 | 14 | 102 | 55 | 125 | 450 | 431 | 477 | 562 | 503 | 8 | 0 | 2,728 |
| 53 | 34 | 84 | 52 | 100 | 394 | 371 | 393 | 354 | 418 | 176 | 31 | 0 | 2,407 |
| 54 | 0 | 0 | 82 | 295 | 276 | 232 | 373 | 435 | 715 | 95 | 0 | 0 | 2,503 |
| 55 | 0 | 17 | 62 | 244 | 222 | 388 | 203 | 428 | 276 | 189 | 121 | 0 | 2,150 |
| 56 | 14 | 0 | 0 | 175 | 233 | 418 | 375 | 295 | 802 | 201 | 52 | 0 | 2,565 |
| 57 | 0 | 35 | 156 | 31 | 220 | 191 | 240 | 322 | 418 | 422 | 0 | 0 | 2,035 |
| 58 | 46 | 30 | 4 | 115 | 183 | 226 | 383 | 453 | 491 | 133 | 0 | 0 | 2,064 |
| 59 | 0 | 52 | 39 | 204 | 114 | 76 | 526 | 344 | 318 | 155 | 125 | 0 | 1,953 |
| 60 | 6 | 0 | 52 | 32 | 158 | 311 | 224 | 387 | 446 | 293 | 168 | 0 | 2,077 |
| 61 | 6 | 0 | 99 | 184 | 726 | 437 | 688 | 990 | 496 | 298 | 53 | 14 | 3,991 |
| 62 | 1 | 10 | 0 | 153 | 310 | 529 | 476 | 272 | 473 | 236 | 2 | 0 | 2,462 |
| 63 | 6 | 0 | 107 | 130 | 103 | 299 | 565 | 520 | 351 | 304 | 73 | 0 | 2,458 |
| 64 | 7 | 133 | 7 | 74 | 658 | 216 | 229 | 310 | 349 | 287 | 3 | 0 | 2,273 |
| Average | 9 | 27 | 58 | 135 | 277 | 314 | 391 | 423 | 473 | 259 | 49 | 2 | 2,417 |

## 3-3. Estimation of Discharge at Kao Keep Samut

The following is an estimation of discharge at Kao Keep Samut by the estimated rainfall and run-off coefficient of the same place.

### 3-3-1. Estimation of the Run-off Coefficient

Table 19, Fig. 11 and Fig. 12 show the run-off coefficient on the Nam Sai Yai from observed rainfall and discharge in 1964.

Table 19 Run-off Coefficient (from data in 1964)

| Station | C. A. ($km^2$) | Rain fall (mm) | Rain fall ($m^3$/sec-day) | Discharge ($m^3$/sec-day) | Run-off Coefficient(%) |
|---|---|---|---|---|---|
| Kao Keep Samut | 315.1 | 2.273 | 8,363 | 2,867 | 34.3 |
| Ban Sapan Hin | 636.0 | 1,532 | 11,379 | 6,804 | 59.8 |

Fig 11 Relation between cumulative rainfall and cumulaive discharge at Ban Sapan Hin in 1964 (CA = 636.0km²)

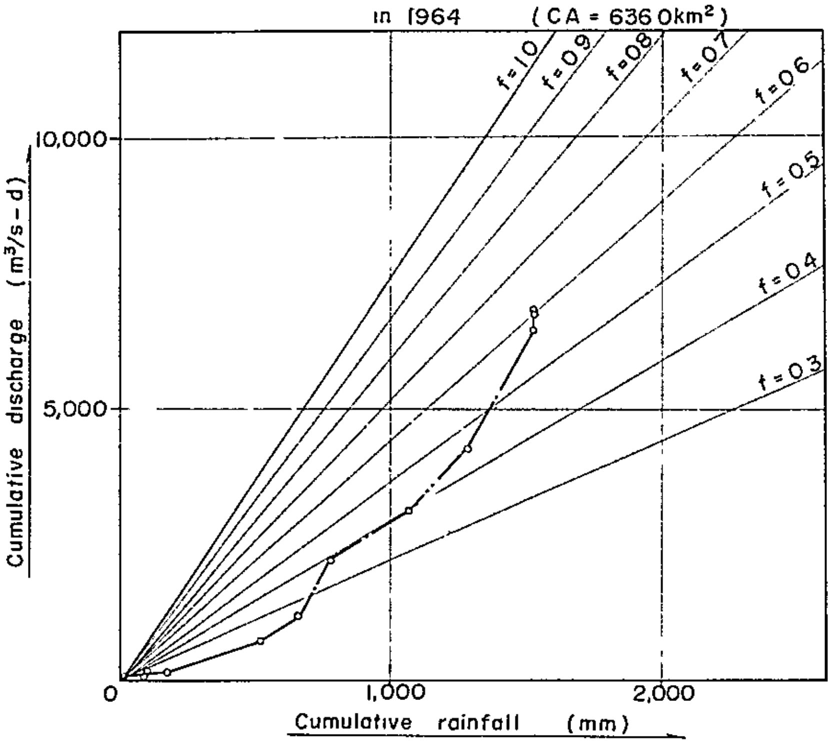
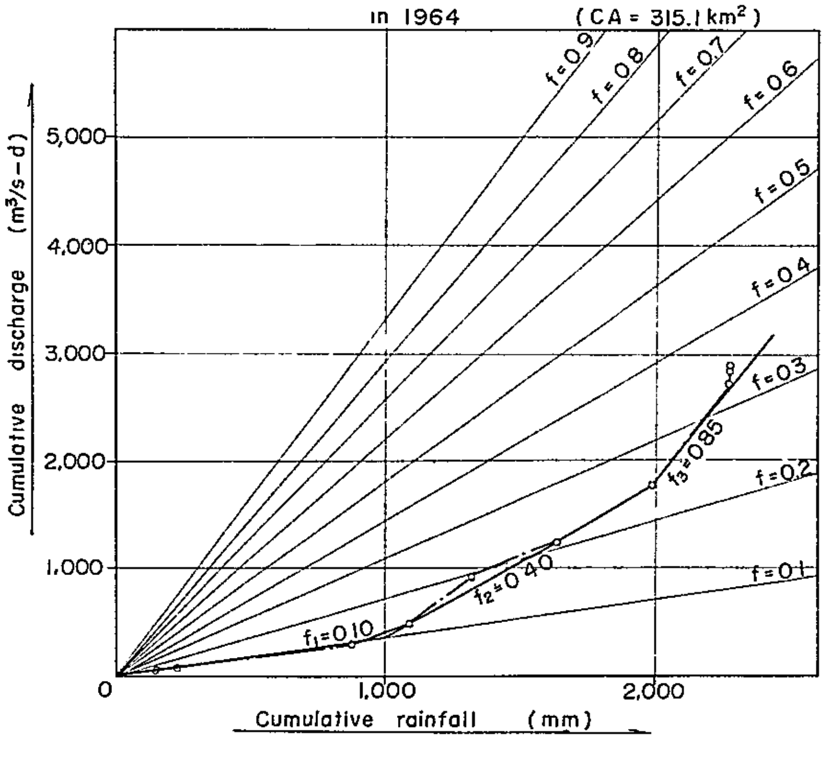


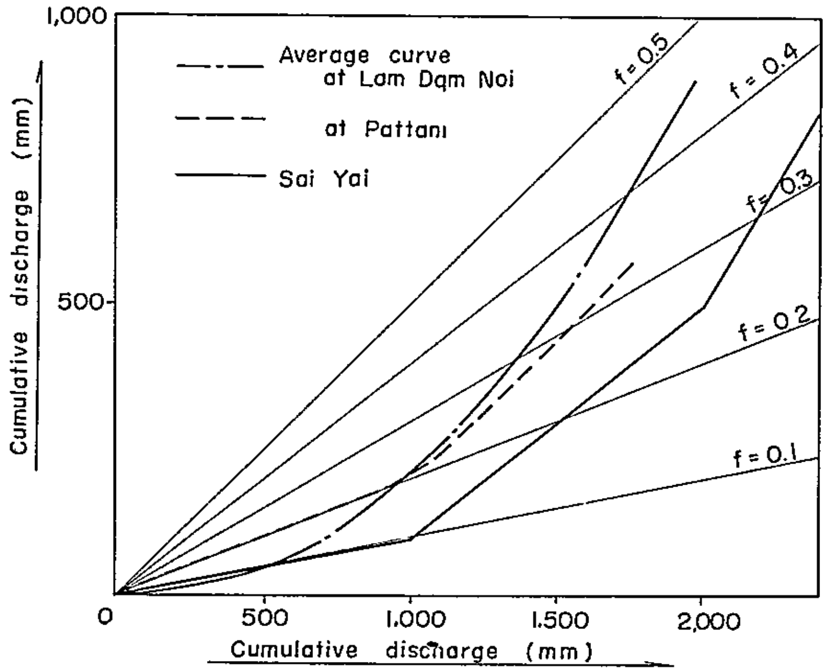

Fig 12 Relation between cumulative rainfall and cumulative discharge at Kao Keep Samut in 1964 (CA = 315.1 km²)



According to the above data, in 1964, the run-off coefficient of the upper drainage area of the Nam Sai Yai was smaller than that of the lower area. Many reasons have been considered this difference in the run-off coefficient between the upper area and lower area but hydrologic data of one year is not sufficient to determine run-off coefficients for the Nam Sai Yai, correct figures will depend much upon future investigation with long term hydrologic data.

Fig. 13 shows the run-off coefficient of other rivers in Thailand

Fig 13 Coefficient of runoff




Run-off coefficient for the Nam Sai Yai project is shown in the following table

Run-off Coefficient for the Nam Sai Yai Project

Table-20

| Cumulative Rainfall (mm) | Run-off Coefficient (%) |
|---|---|
| 0 ~ 1,000 | 10 |
| 1,001 ~ 2,000 | 40 |
| 2,001 ~ | 85 |
| Average | 34 |

3-3-2. Estimation of Discharge at Kao Keep Samut

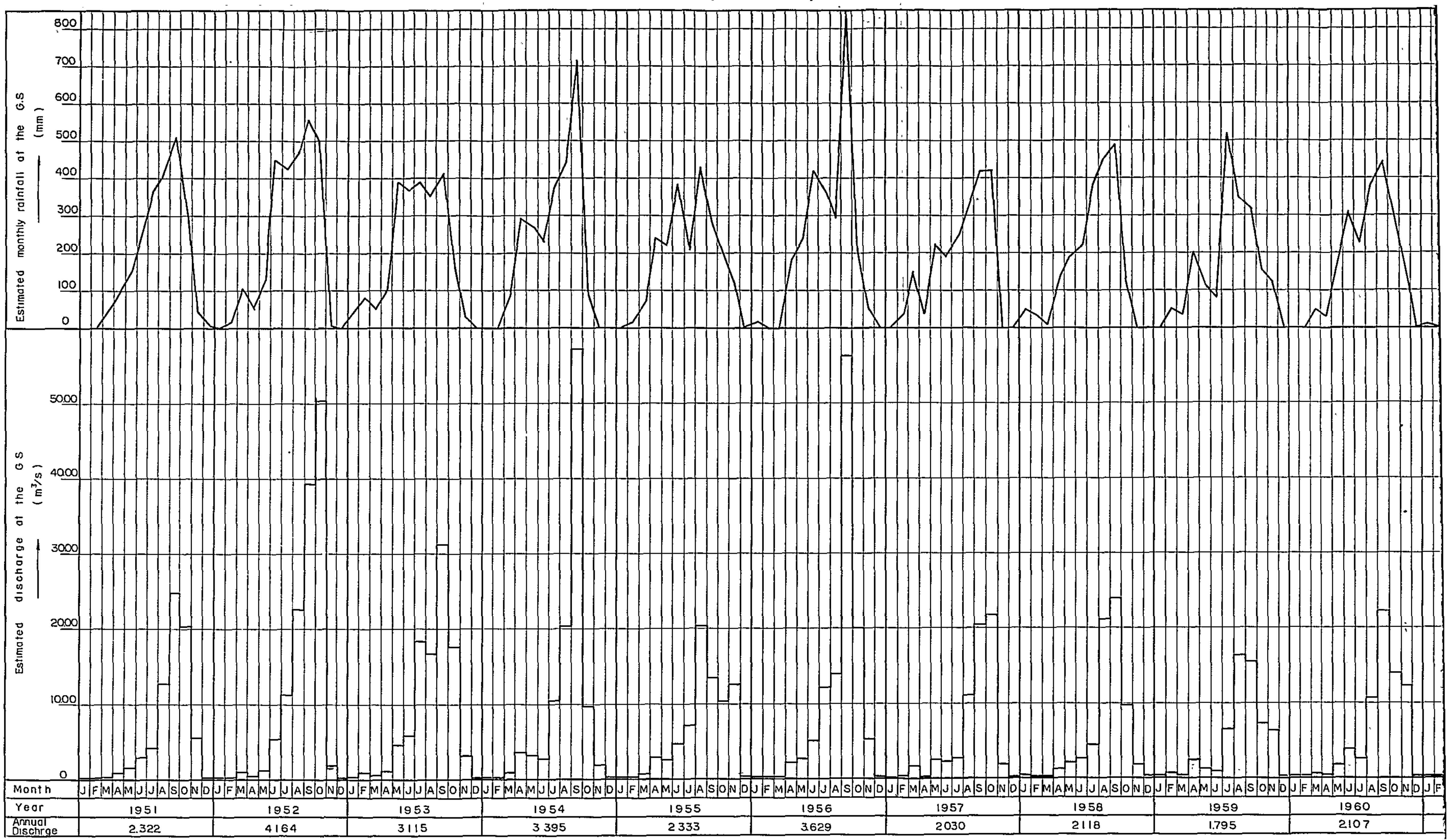
Table-21 shows the discharge of Kao Keep Samut which was estimated by the above method. The hydrograph is shown in Fig. 14

Table 21. Estimated Discharge of Kao Keep Sumut G.S.

C. A. = 315.1 $km^2$
($m^3$/sec-day)

| Month / Year | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1951 | 10 | 10 | 17 | 36 | 55 | 93 | 134 | 397 | 750 | 640 | 170 | 10 | 2,322 |
| 52 | 10 | 10 | 38 | 20 | 46 | 166 | 354 | 705 | 1,180 | 1,565 | 60 | 10 | 4,164 |
| 53 | 13 | 31 | 19 | 37 | 145 | 180 | 575 | 520 | 940 | 550 | 95 | 10 | 3,115 |
| 54 | 10 | 10 | 31 | 108 | 102 | 85 | 324 | 635 | 1,720 | 300 | 60 | 10 | 3,395 |
| 55 | 10 | 10 | 22 | 90 | 82 | 143 | 221 | 635 | 405 | 325 | 380 | 10 | 2,333 |
| 56 | 10 | 10 | 10 | 64 | 86 | 154 | 375 | 435 | 1,690 | 625 | 160 | 10 | 3,629 |
| 57 | 10 | 14 | 57 | 11 | 81 | 70 | 89 | 333 | 620 | 675 | 60 | 10 | 2,030 |
| 58 | 18 | 10 | 10 | 42 | 68 | 83 | 141 | 656 | 720 | 300 | 60 | 10 | 2,118 |
| 59 | 10 | 20 | 14 | 75 | 42 | 28 | 206 | 510 | 465 | 225 | 190 | 10 | 1,795 |
| 60 | 10 | 10 | 19 | 12 | 58 | 115 | 82 | 331 | 655 | 435 | 370 | 10 | 2,107 |
| 61 | 10 | 10 | 36 | 68 | 283 | 645 | 1,245 | 1,435 | 1,550 | 935 | 165 | 55 | 6,437 |
| 62 | 10 | 10 | 10 | 57 | 114 | 195 | 710 | 395 | 1,065 | 730 | 60 | 10 | 3,366 |
| 63 | 10 | 10 | 39 | 48 | 38 | 110 | 432 | 775 | 645 | 940 | 235 | 10 | 3,292 |
| 64 | 25 | 20 | 9 | 10 | 218 | 200 | 422 | 330 | 527 | 960 | 117 | 29 | 2,867 |
| Average | 12 | 13 | 24 | 48 | 101 | 162 | 379 | 578 | 924 | 658 | 156 | 15 | 3,070 |

Note : Figures from July 1963 to Dec. 1964 are observed ones at the G.S.



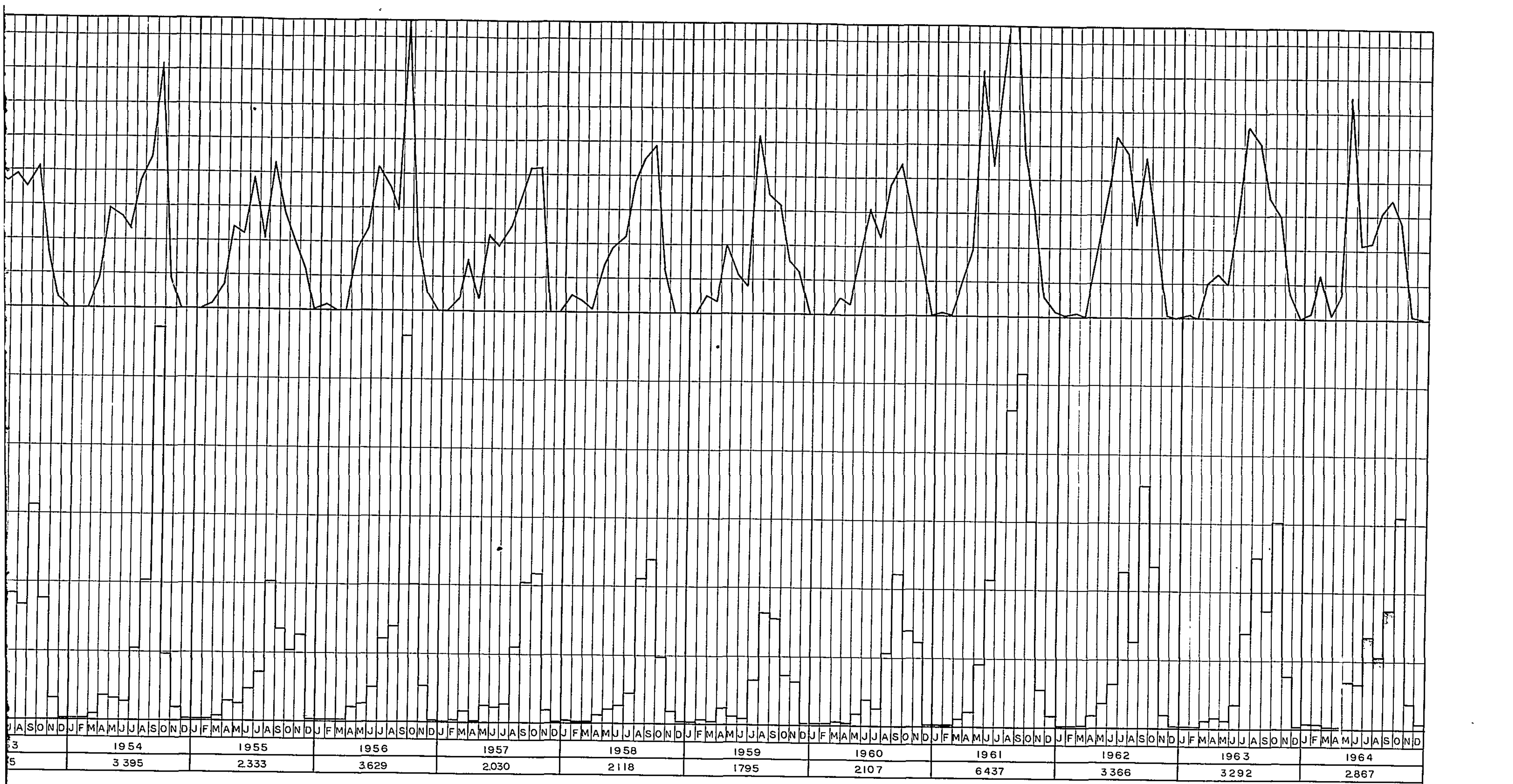

Note.

14 Years average

Rainfall ------ 2.417 mm

Discharge --------- 3 070 m³/s-d

Catchment area 315.1 km²




ge

------ 2.417 mm

-------- 3070 m³/s-d

315 l km²

JAPANESE GOVERNMENT INVESTIGATION TEAM
FOR HYDRAULIC POTENTIALS

NAM SAI YAI PROJECT

ESTIMATED DISCHARGE AND RAINFALL AT KAO KEEP SAMUT ON THE NAM SAI YAI

DATE May-1965

NO 14

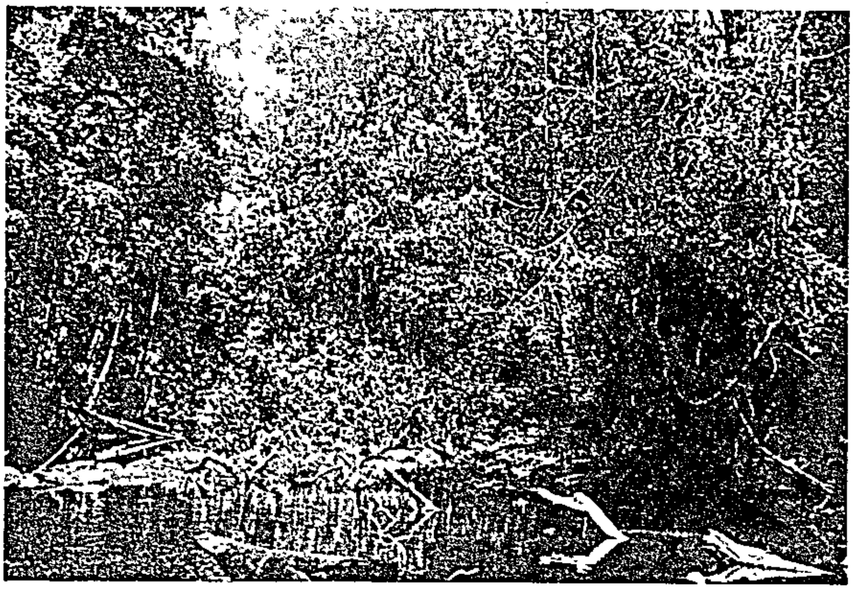


Photo - 1

Downstream view of Sai Yai No.1 Dam site (right bank)

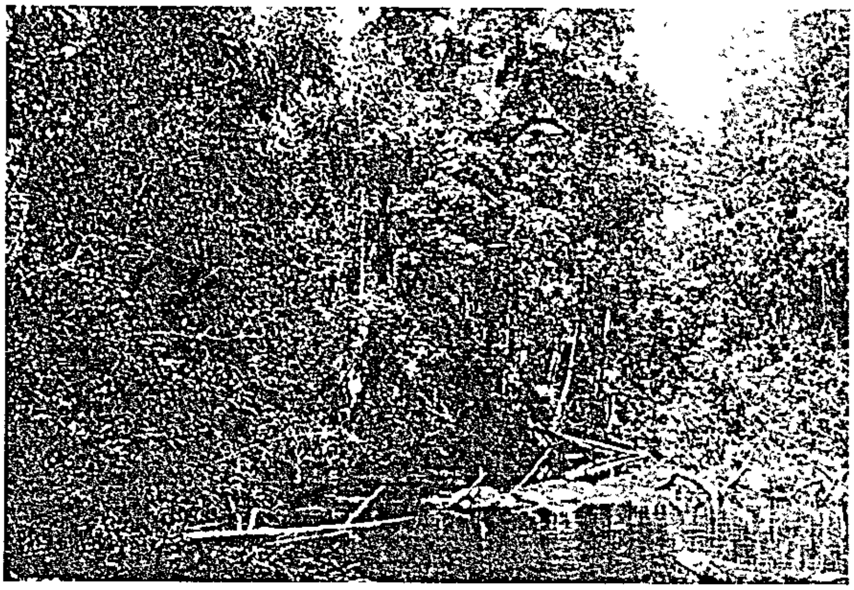


Photo - 2

Downstream view of Sai Yai No.1 Dam site (left bank)

Photo－3

Downstream view of Sai Yai No.2 Dam site (right bank)

Photo－4

Downstream view of Sai Yai No.2 Dam site (left bank)

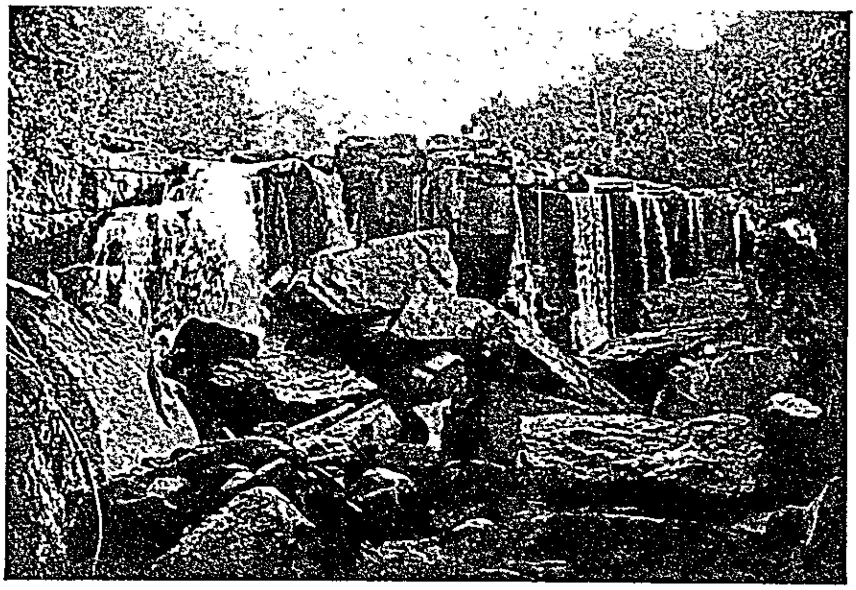


Photo - 5

Waterfall downstream of Sai Yai No.2 Dam site

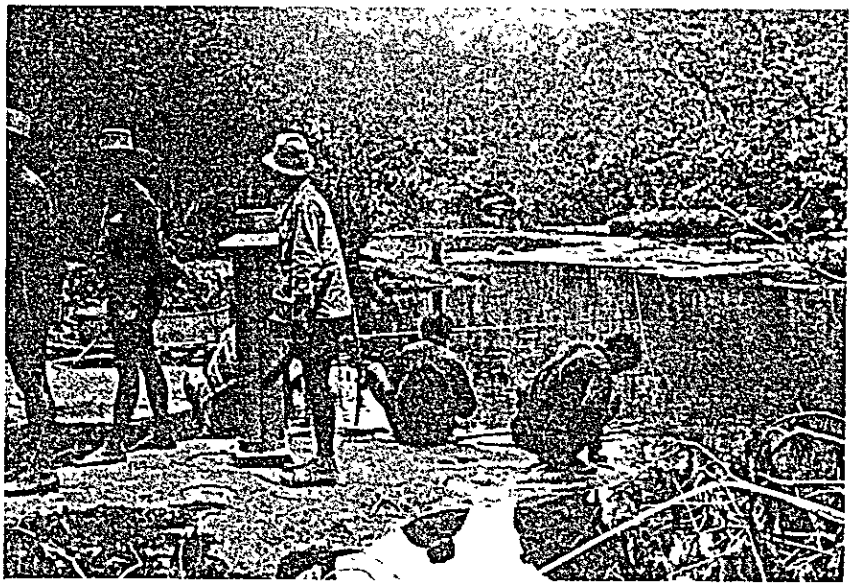


Photo - 6

Kao Keep Samut Ganging Station upstream of No.2 Dam site

Photo - 7

Nam Sai Yai river around the confluence with Nam Sai Noi river