THE SECOND PROGRESS REPORT
ON
INVESTIGATIONS OF THE SAMBOR PROJECT

SEPTEMBER 1964

OVERSEAS TECHNICAL COOPERATION AGENCY

TOKYO

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FOREWORD

In response to the request made by the Committee for Coordination of Investigations of the Lower Mekong Basin, the Government of Japan conducted in FY 1962 the First Phase Investigations on the Sambor Site on the main stream of the Mekong.

The Overseas Technical Cooperation Agency (OTCA) was entrusted by the Government of Japan with the execution of investigations, results of which were compiled in "The First Progress Report on Investigations of the Sambor Project" already submitted to the Committee.

The OTCA, in continuation of FY 1962, was entrusted by the Government of Japan with the execution of the Second Phase Investigations which were carried out during FY 1963. A Survey Team comprising 25 members was consequently despatched by the OTCA which engaged in the field survey during the period from the latter part of October 1963 to the beginning of January 1964.

The Second Phase Investigations were performed with particular emphasis placed upon hydro-electric power aspect of the Project. The results of the investigations were reviewed and compiled in relation to those of the First Phase Investigations, and are presented herewith as "The Second Progress Report on Investigations of the Sambor Project." My deepest gratitude is hereby expressed to the Committee, the Government of Cambodia and cooperating countries for their unlimited cooperation.

Mr. Goro Inoue, Chairman of the Board of Directors of Chubu Electric Power Co. and concurrently a member of OTCA's Board of Directors, who headed the Sambor Preliminary Survey Team, continued to assume the overall responsibilities of the investigations as Project Manager, and Mr. Motonaga Ohto, Director of OTCA, served successively as Leader of the Survey Team.

I avail myself of this opportunity to express my heartfelt gratitude to Mr. Inoue, and the Leader and members of the Survey Team for their elaborate efforts which made it possible to carry out the Second Phase Survey and produce this Report.

OVERSEAS TEACHNICAL COOPERATION AGENCY

Shinichi Shibusawa

Director General

TABLE OF CONTENTS

DRAWINGS

SAMBOR PROJECT	CONTOUR OF ROCK SURFACE IN VICINITY OF POWER-HOUSE & SPILLWAY	HO-0232	(SHEET NO. 4 OF 14)
" "	GEOLOGICAL SECTIONS OF SPILLWAY AND VICINITY 1-2	HO-0232	(SHEET NO. 5 OF 14)
" "	GEOLOGICAL SECTIONS OF SPILLWAY AND VICINITY 2-2	HO-0232	(SHEET NO. 6 OF 14)
" "	GEOLOGICAL SECTIONS I-I & J-J	HO-0232	(SHEET NO. 7 OF 14)
" "	GEOLOGICAL SECTIONS K-K, L-L, M-M, & N-N	HO-0232	(SHEET NO. 8 OF 14)
" "	GEOLOGICAL SECTIONS O-O, & P-P	HO-0232	(SHEET NO. 9 OF 14)
" "	GEOLOGICAL SECTIONS Q-Q & R-R	HO-0232	(SHEET NO. 10 OF 14)
" "	LOCATION OF EXPLORATIONS IN LQO QUARRY AREA	HO-0232	(SHEET NO. 11 OF 14)
" "	GEOLOGICAL SECTIONS OF LQO QUARRY AREA	HO-0232	(SHEET NO. 12 OF 14)
" "	LOCATION OF EXPLORATIONS AND GEOLOGICAL SECTIONS IN LQ2 QUARRY AREA	HO-0232	(SHEET NO. 13 OF 14)
" "	LOCATION OF EXPLORATIONS AND GEOLOGICAL SECTIONS IN LQ3 QUARRY AREA	HO-0232	(SHEET NO. 14 OF 14)
" "	CLASSIFICATION OF EARTH MATERIAL		

I. INTRODUCTION

1. BACKGROUND OF INVESTIGATIONS

2. OUTLINE OF DEVELOPMENT PROJECT

3. INVESTIGATION ITEMS, PARTICIPATING ORGANIZATIONS,

   AND FORMATION OF SURVEY TEAM

I. Introduction

1. Background of Investigations

The results of the First Phase Investigations on the Sambor Site on the main stream of the Mekong which had been conducted by the Government of Japan in compliance with the request of the Committee for Coordination of Investigations of the Lower Mekong Basin (hereinafter referred to as "the Committee") were submitted to the Committee in November 1963 as "The First Progress Report on Investigations of the Sambor Project." The Government of Japan further performed, in response to the request made by the Committee, the Second Phase Investigations covering the field survey as well as domestic works during the period from October 1963 to March 1964. The results of the Second Phase Investigations are compiled and presented herewith as "The Second Progress Report on Investigations of the Sambor Project."

The objective of the Investigations was to conduct detailed surveys relative to the technical and economic feasibility of the Project on the basis of the results of the Preliminary Investigations previously performed by the Government of Japan in accordance with the request of the Committee, and to prepare, based on such detailed surveys, a comprehensive feasibility report which should be substantial enough to be examined when submitted to international financial organizations.

With the view to preparing such a comprehensive report, the Government of Japan appropriated in the budget about ¥50 million each for the First and Second Phase Investigations, and entrusted the Overseas Technical Cooperation Agency (hereinafter referred as "the OTCA"), an executing agency of the Government of Japan, with the execution of the investigations.

In view of the significance of the objective and scale of the

Development Project of Sambor Site as well as of the anticipated economic and social effects upon riparian countries, the OTCA organized and despatched, for the First Phase Investigations, a Survey Team comprising 21 members specialized in hydro-electric power, inland navigation, agriculture, power market survey, and for the Second Phase Investigations which were carried out with emphasis placed on hydro-electric power, it despatched a Survey Team consisting of 25 members for the field survey during a period of 2.5 months from October 1963, with the cooperation of the competent Government authorities, affiliated organizations and engineering consulting firms. Results of the Second Phase Investigations are to form, together with those of the First, Third and following investigations, the basis for planning, preliminary designing and assessment of the proposed Development Project of the Sambor Site. On the occasion of presenting this progress report, the OTCA and the Survey Team wish to express their deep appreciation of the invaluable assistance and facilities extended by the Committee, the four riparian countries, particularly the central and provincial authorities of Cambodia, and further express their heartfelt gratitude to the governments of the cooperating countries for various data and materials made available by them.

2. Outline of Development Project

The outline of the Development Project of the Sambor Site, described in the Preliminary Survey Report, is briefly given hereunder.

A dam will be constructed at the downstream end of Samboc Rapids on the main stream of the Mekong. The dam will be 36 m in height with the crest length of about 29 km, and will have the maximum water level elevation of 40.00 m with the effective storage capacity of 1.7 billion m^3. With the resevoir water and head thus obtained, the maximum output of 625,000 KW and the annual energy output of 4.6 billion KWH will be available after completion of the first stage construction.

Simultaneously, navigation locks will be installed attached to the dam, thereby to improve the inland navigation. With regard to the agricultural development, irrigation by gravity flow utilizing the resevoir water is being contemplated. For flood control, however, no particular consideration is paid at present.

Further, dam axis lines Ⓒ and Ⓒ' (See Dwg. No. HO-0025) have been selected, but the final choice between the proposed two lines should await the results of the investigations and studies to be made in the future.

3. Investigation Items, Participaiting Organizations, and Formation of Surey Team

The Second Phase Investigations were conducted on items listed below with stress placed on hydro-electric power aspect of the Project. Expenses for carrying out the investigations were covered by the contribution of ¥50 million by the Government of Japan and the counter-part contribution by the Government of Cambodia amounting to ¥3 million equivallent.

(a) Geological Survey

Seismic prospecting, boring tests and test pit observation were conducted in continuation of FY 1962 on the proposed sites for the dam and other structures as well as in the proposed quarry areas. A general geological map covering the proposed dam axis line area was also prepared.

(b) Topographical Survey

Topographical survey was conducted on the alternative dam center line and on the proposed quarry areas, with the supplementary surveys and checking simultaneously performed for the investigations conducted in FY 1962.

(c) Material Investigations

Investigations were conducted, continuously from FY 1962, on materials for the dam body construction in the proposed dam center line area.

(d) Hydrological Investigations

In continuation of FY 1962, observation was made on the water level and discharge of the main stream of the Mekong. At the same time, efforts were made in collecting various hydrological data.

(e) Hydraulic Model Test

A reduced model of the Project Site was made to serve the purpose of conducting tests relative to the capacity and direction of the spillway, location of the navigation locks, as well as the length of the training wall.

(f) Tests on Materials for Dam Body

Different tests were conducted on rock - earth - sand specimens collected from the vicinity of the Project Site.

(g) Survey on Inland Navigation

Sounding was conducted on the main stream of the Mekong covering about 14 km downstream from the dam site.

(h) Agriculture

The Team requested the Committee for the preparation of a topographical map covering the irrigable areas.

(i) Power Market Survey

Analysis and compilation of data and materials collected during the field survey in FY 1962 were performed.

Organizations participating in each aspect of the investigations were as follows.

(a)	Hydro-Electric Power Aspect	:	Electric Power Development Co. (EPDC)
(b)	Inland Navigation Aspect (Sounding)	:	Ditto
(c)	Agricultural Aspect	:	Ministry of Agriculture and Forestry

(d) Power Market Aspect : Overaeas Electrical Industries Survey Inst., Inc.

As regards the geological surveys of the Hydro-Electric Power Aspect, seismic prospecting was conducted by Japan Geophisical Prospecting Co. and the boring tests and test pit observation were performed by Hazama Construction Co. under contract with Electric Power Development Co. These surveys were carried out under the technical guidance and supervision of Electric Power Development Co.

The OTCA undertook the coordination and accounting for the Survey Team. The formation of the Survey Team was as follows.

Name	Post	Assignment	Schedule
Mr. Motonaga Ohto (c)	Director, OTCA	Leader, Agricultural economy	Nov 3 - 28, 1963
Mr. Yutaka Kubota (a), (b) & (c)	President, Nihon Koei Co., Ltd.	Technical advisor, Civil engineering	Nov 3 - 17, 1963
Mr. Yoshio Niinomi (c)	Chief of Operation Sec., Development Survey Div., OTCA	Ass't Leader, Civil engineering	Oct 27 - Nov 30, 1963
Mr. Kazuo Yamada (a) & (c)	Staff of Development Div., OTCA	Liaison, accounting, Hydro-electric power	Oct 26, 1963 - Jan 13, 1964
Mr. Yoshisuke Arai (b) & (c)	Inspector, EPDC, Dr. of engineering	Controller of hydro-electric power aspect, Civil engineering	Oct 27 - Nov 25, 1963

Name	Post	Assignment	Schedule
Mr. Hiroshi Watanabe (b) & (c)	Ass't Chief, Hydro-Power Investigations Sec., EPDC	Civil engineering	Oct 27, 1963 - Jan 9, 1964
Mr. Akihiro Irie (b) & (c)	Staff of Hydro-Power Investigations Sec., EPDC	Civil engineering & hydrology	Ditto
Mr. Hiroshi Suetomi (b) & (c)	Staff of Geological Sec., EPDC	Geology	Ditto
Mr. Noboru Yamaguchi	Staff of Hydro-Power Planning Sec., EPDC	Earth materials	Ditto
Mr. Tokuro Kanda	Staff of Civil Engineering Laboratory, EPDC	Ditto	Ditto
Mr. Bunya Kanahara (b) & (c)	Staff of Hydro-Power Investigations Sec., EPDC	Geology & Hydrology	Ditto
Mr. Kiyoshi Tsunoda (b) & (c)	Ditto	Ditto	Ditto
Mr. Atsushi Ohdaira (b) & (c)	Ditto	Civil engineering	Ditto
Mr. Keisuke Kudo	Staff of Hydro-Power Planning Sec., EPDC	Ditto	Ditto
Mr. Gihei Fujiwara	Chief of Saigon Office, Hazama Construction Co.	Leader of boring test & test pit observation group	Jan 2 - 7, 1964

Name	Post	Assignment	Schedule
Mr. Kaneo Matsuyoshi (c)	Staff of Hazama Construction Co.	Chief engineer, boring test & test pit observation group	Oct 27, 1963 - Jan 17, 1964
Mr. Akira Izawa	Ditto	Civil engineering, boring test & test pit observation group	Ditto
Mr. Akio Akatsuka (c)	Ditto	Liaison & accounting, boring test & test pit observation group	Oct 26, 1963 - Jan 17, 1964
Mr. Yasuyuki Sasaki (c)	Ditto	Engineer, boring test & test pit observation group	Oct 27, 1963 - Jan 9, 1964
Mr. Kinichiro Tanaka (c)	Staff of Hazama Construction Co.	Ditto	Oct 27, 1963 - Jan 17, 1964
Mr. Nizo Okada (c)	Ditto	Ditto	Ditto
Mr. Takeo Suzuki (c)	Executive Director, Japan Geophisical Prospecting Co., Dr. of engineering	Leader of seismic prospecting group	Nov 7 - Dec 28, 1963
Mr. Hisatoshi Yoshida (c)	Deputy Chief, Prospecting Div., Japan Geophisical Prospecting Co.	Chief engineer, seismic prospecting group	Ditto

Name	Post	Assignment	Schedule
Mr. Yoshihiko Kadoyama	Staff of Japan Geo-phisical Prospecting Co.	Engineer, Seismic prospecting group	Nov 11 - Dec 28, 1963
Mr. Isao Kaneko	Ditto	Ditto	Ditto

Remarks: (a) indicates participation in the reconnaissance of major tributaries of the Mekong

(b) indicates participation in the Preliminary Survey on Sambor Site

(c) indicates participation in the First Phase Investigations on Sambor Site

Besides services of the above-listed Team members, cooperation was rendered by Mr. Hirobumi Shinozuka, Chief Representative of Phnom-Penh Office, Nichimen Co., Ltd., in relation to liaison works.

It is to be noted that in addition to the above-mentioned Survey Team which was despatched during the dry season, the following two experts were also despatched furing the period from August 24 to September 11, 1963 in order to observe general conditions in the wet season.

Name	Assignment and Post
Mr. Hiroshi Miyauchi	Flood control, Chief of Planning Sec., Kanto Regional Construction Bureau, Ministry of Construction
Mr. Tadao Haruta (c)	Inland navigation, Chief of Construction Div., Japan Ports Consultants, Ltd.

II. HYDRO-ELECTRIC POWER

1. INTRODUCTION

2. TOPOGRAPHICAL SURVEY

3. HYDROLOGICAL INVESTIGATIONS

4. INVESTIGATIONS ON GEOLOGY AND MATERIALS

5. MATERIAL TEST

6. HYDRAULIC MODEL TEST

7. OTHER DOMESTIC WORKS

II. HYDRO-ELECTRIC POWER

1. Introduction

In the second phase (FY 1963) investigations, the domestic works performed in Japan centered upon the crude analysis of the Project, soil test of earth and rock materials for dam enbankment as well as hydraulic model test, all of which were based on the results of the first phase investigations conducted with particular importance attached to Line Ⓒ' Plan.

Further, the field investigations covered for the most part topography, geology and materials for Line Ⓒ Plan, with such other investigations and surveys concurrently undertaken as supplementary investigations for Line Ⓒ' Plan, geological survey of Phnom Samboc Line 3.5 km downstream of Samboc Rapids. Sounding between Samboc Rapids and Kratie, and hydrological investigations were also performed.

2. Topographical Survey

2-1 Scope

Topographical survey was conducted relative to Line Ⓒ Plan with the object of preparing a plan (scale: 1/2,000), with supplementary survey on Line Ⓒ' Plan simultaneously performed.

With regard to the sounding downstream of Kratie, the Government of Cambodia had performed the necessary survey which resulted in the preparation of the relevant hydrographical map. In order to supplement this map, further sounding was conducted by the Japanese Team to prepare a map covering about 15 km between Kratie and Samboc Rapids.

2-2 Outline of Survey

Surveys conducted were triangulation, traversing, levelling, cross sectional survey and sounding. Locations of surveyed sites and particulars of the surveys are as indicated in the general plan. The field survey was conducted from November 11 to December 31, 1963.

(a) Ground Control Survey

To clarify the location and extension of Line Ⓒ and Phnom Samboc Line, and to transfer the control points for the downstream sounding from the left to the right bank, triangulation was performed on a newly established base line.

(b) Center Line Levelling of Line ③

The center line levelling of Line ③ was performed by means of traversing which was conducted along the road leading from Samboc village to Srechay starting from the established survey points. IP I was established on the center line of Line ③, whence the levelling was conducted along the center line and off the road. The traversing was performed after altering the center line proposed in the Preliminary Investigations Report in order to save the quantity of enbankment materials. The altered center line was plotted on the map and the azimuth and distance were determined prior to the traversing. Wooden piles were anchored on the center line at intervals of 50 m which served as survey points for alignment and chaining. The chaining was performed twice the duplicate by means of stadia survey, and the average value was recorded as the distance between the survey points. The traversing was extended up to an elevation of 50 m, and the levelling, which was performed in parallel with the traversing, was made twice the duplicate on the wooden piles with 50 m intervals on the center line. An error of closure $15\sqrt{S}$ mm or less was assumed as the limit of survey error. (S stands for the total length of the levelling route in km) The cross sectional survey was conducted for a width of 400 m perpendicular to the center line at traversing points located with intervals of about 300 m. Results of the survey were utilize in preparing the general plan (scale:1/2,000).

(c) Center Line Levelling of the Navigation Lock of the Spillway Dam on the Right Bank

Line Ⓒ Plan was reviewed on the basis of the results of geological investigations conducted in FY 1962, and the location and direction of the spillway were altered so that the navigation lock and the spillway may be located on a comparatively high level of the bedrock. Traversing and levelling were conducted on the center line of the lock. The order of the work was the same as that of center line levelling of line ③.

(d) Sounding

Prior to conducting the sounding, levelling of control points on the cross sectional line was performed. With △ 6 established in FY 1962 as the starting point, the traversing was conducted along the road on the left bank of the river. Since Kas Trong Island hinders the visibility downstream of survey point #22, control points were transferred to the right bank, and the traversing was conducted along the road on the right bank of the river, establishing control pointsat intervals of 500 m. After completion of the traversing of control points, levelling was conducted to determine their elevations. The direction of the cross sectional line was determined by previously plotting each control point with the fixed bearing on the topographical map and by surveying the bearing from the control points on either bank of the river. Then, reference points indicating the direction were set up on the opposite bank. A sounder loaded on the boat was utilized for the water depth survey. A transit-compass was installed at the control point on the left bank and the boat was guided by the portable wireless to travel straight. Cross sectional survey was conducted for the distance on land between the control point and the shore of the river.

(e) Installation of Bench Marks

No bench marks have yet been installed downstream of the proposed power house on the right bank, nor are they found installed on the left bank except on the bank of the Mekong. Levelling was conducted to install bench marks in the area where structures are expected to be constructed and at the proposed quarry site. On the right bank, 11 bench marks were installed on the road leading to the opposite side of Kratie, downstream of the power house site. On the left bank, 1 bench mark each was installed at 3 different points, i.e., at a point 2 km from the rotary on the road connecting Kratie and Phnom-Penh, and at 2 points 2 km and 5 km respectively from Sandon which is located at the end of the road leading to Stung Treng.

Bench mark 2BM - 6D which had been removed due to the road construction was replaced by a new one. Bench mark 2BM 2A-6 which had been placed in the rotary in Kratie city was taken away due to the partial reconstruction of the rotary. A new bench mark was therefore set up on the bank of the Mekong west to the rotary.

(f) Embedding of Bench Marks

After completion of the topographical survey, concrete bench marks were embedded at 5 IP's on the left bank, 3 IP's on the right bank and at 13 reference points. Regarding the bench marks mentioned in (e) above, 16 concrete bench marks were embedded at their respective points.

Kind and quantity of the survey are as listed in the next page.

	Triangulation	Traversing	Levelling	Plane Levelling	Sounding
Control Points Survey					
Line Ⓒ	1 point				
Phnom Samboc Line	1 point				
Cross sectional survey, point #22'	1 point				
Topographical Survey					
Line ③, left bank		17.1 km	17.1 km	6.8 km^2	
Spillway dam & training wall, right bank		3.8 km	3.8 km	1.5 km^2	
River Survey					
Setting up of control points (40 points)		24.6 km	24.6 km		
Cross sectional survey (32 sections)					64.0 km
Installation of Bench Marks					
Right bank (11 points)			18.8 km		
Left bank (5 points)			26.1 km		
TOTAL	3 points	45.5 km	90.4 km	8.3 km^2	64.0 km

3. Hydrological Investigations

Taking into consideration the outcome of the investigations conducted by Harza Engineering Co., U.S.A., which is compiled in their final report (4, 5, 6, 7, 8, 9, 10), investigations were conducted in FY 1962 on precipitation, evaporation as well as on water level between the dam site and Kratie with the view to supplementing the above report. In FY 1963, these investigations were continuously carried out, and in addition, recording of temperature and humidity was conducted so that it may contribute to the concrete works and dam enbankment plans.

(a) Precipitation and Evaporation

Observation by a rain-gauge and a vaporimeter installed by the Preliminary Investigation Team in the premises of the Ministry of Public Works in Kratie has been undertaken by the Ministry since the completion of the First Phase Investigations. The Team has requested the Ministry to continue the recording for FY 1963.

The recording of evaporation was planned to compute the amount of evaporation from the Sambor dam resevoir to be constructed, and that of precipitation to contribute to the dam enbankment and other plans.

(b) Water Level between Dam Site and Kratie

During the field survey, the water level was recorded 5 times at 10 points between the dam site and Kratie in order to obtain more data for the computation of the surface slope between the dam site and Kratie and for the preparation of the rating curve at the dam site, whereby to contribute to the determination of the water level at the tailrace as well as to the designing of the powerhouse, navigation lock, etc.

(c) Temperature and Humidity

2 each of thermometer and hygrometer were installed at the office of the Team and the recording of temperature and humidity was conducted at a fixed time (9:00 a.m.) daily during the field survey. Arrangements were made for the continuation of the recording after completion of the field survey.

4. Investigations on Geology and Materials

4-1 Sccpe

Geophisical methods were employed in conducting geological investigations in the area which should provide foundations for structures such as dam, power house, navigating channel, etc. Same methods were employed in peforming investigations on materials for the construction of the dam and appertunent structures.

In the Preliminary Investigations Report on the Sambor Project, it is suggested for Line Ⓒ Plan that the concrete dam, power house and spillway be constructed on the river bed, while for Line Ⓒ' Plan, it is suggested to construct the rock-fill dam on the river bed and the power house and spillway on land of the right bank. For both plans, it is assumed in the Report that both wings of the dam would be rock-fill dams.

Of these two Plans, stress was placed on Line Ⓒ' Plan in FY 1962. Emphasis was therefore put on Line Ⓒ Plan in the investigations of FY 1963 with due attention paid to Phnom Samboc Line Plan.

Geological investigations on foundations for structures conducted by means of surface exploration, seismic prospecting, boring test, test pits observation and permeability test, covered the river bed for dam - power house - spillway in Line Ⓒ' Plan, the river bed for dam in Line Ⓒ Plan, the river bed for dam in Phnom Samboc Line Plan, Line ① and ③ on the left bank, and the right bank for navigating channel.

Investigations on materials were conducted based on the following plans.

(1) For enbankment of both wings of the dam (18,000,000 - 20,000,000 m^3), materials available in the proximity of the dam axis will be utilized. The dam section will therefore be so designed as would be suitable for such materials.

(2) As regards the concrete for the dam, investigations will be made on each side of the river for concrete aggregate sufficient to meet with the concrete manufacture of 2,000,000 - 3,000,000 m^3.

(3) On the assumption that the cofferdam to be placed on the Mekong would be a rock-fill dam, investigation will be made on both banks for earth and rock materials which should amount to 10,000,000 m^3 on each bank.

In connection with the proposed quarries, investigations were conducted at LQ-O, LQ-2, LQ-3 and LQ-4 for rock materials, and in the area extending along the main stream, Line ① and ③ on the left bank, Line ④ on the right bank for earth materials. For concrete aggregate, investigations were conducted on the former river bed on the right bank, quarries downstream of Samboc Rapids, bars extending in the river downstream of Kratie. Methods employed for the quarry investigation were surface exploration, seismic prospecting, boring test and observation through test pits, soil test on the spot as well as laboratory soil test in Japan.

4-2 Outline of Investigations

(a) Course of Investigations

(1) Rock Foundations for Structures

Observations through test pits were performed on Line ① of the dam center line on the left bank. Simultaneously, boring tests were conducted in the area closer to the river with the elevation lower than the alternative line ③, while in the area with EL 20 m or more, observation through test pits was performed. On the right bank, seismic prospecting was conducted along the center line of the dam and training wall assuming that the spillway section of the dam in Line Ⓒ Plan would be on the lower reaches; and boring holes were drilled on its line of measurement at intervals of 500 m with test pits excavated in between the boring holes. Boring tests were conducted on the river bed to check the results of surface exploration and seismic prospecting conducted in FY 1962. The condition of the channel made by the erosion of water flow along the right bank was investigated by means of seismic prospecting and sounding. With regard to the foundations for navigation facilities, seismic prospecting and boring tests were conducted along the proposed route of the navigating channel on the right bank in order to confirm the condition of the surface layer and bedrock. Further, permeability test utilizing boring holes and test pits were performed in areas where such test was considered necessary from the standpoint of geology and designing of structures.

(2) Materials for Dam Body (Fill Type)

Investigations on rock materials were conducted within the area extending about 15 km from the proposed dam site, with due consideration paid to the following -

If a cofferdam is to be placed on the main stream of the Mekong as proposed in Line Ⓒ' Plan, close attention should be exercised in designing and construction since there will be the stream flow of about 2,000 m^3/s and the maximum water depth of 20 m (between the water surface and the bedrock) in the dry season. Since the rock materials for the cofferdam are required to be considerably bulky, following attention should be paid:

1. Quarries should be of good quality with sufficient quantity of rocks available.

2. Distance of transportation should preferably be short.

3. The quarry site should have the convenience of drainage, and the thickness of the surface layer should preferably be small since the surrounding area is flat and vast.

4. As regards the geological formation, the Project Site and its vicinity consists chiefly of shale and sand stone, or the alternated layer of the both, and partly of conglomerate. The quarries are preferred to be in the area where fresh sand stone is distributed in quantities.

Investigations on earth materials were conducted with the following taken into account -

1. As a result of the investigations and subsequent tests conducted twice in the past, the specimens collected in the vicinity of the Project Site can be classified into several kinds by their property.

2. Apart from the materials for the cofferdam on the main stream, earth materials for the dam on either bank should preferably be secured from the area close to the dam center axis.

3. Earth materials for the cofferdam on the main stream should preferably be secured from a limited range of area near the Project Site.

4. Investigations should be conducted on the natural water content ratio of the soil during the dry season so that the obtained data may be utilized for the dam designing and construction.

(3) Concrete Aggregate

Investigations on concrete aggregate and rock materials were conducted twice in the past by means of observation through test pits at RQ-1 and RQ-2 on the right bank, and at LQ-1 and LQ-2 on the left bank. These investigations revealed that the proposed quarries have the drawback of being covered by thick surface layer of soil or embodying an alternated layer of sand stone and clay-slate which would be easily weathered. As regards the fine aggregate, previous investigations conducted on the bars along the right bank downstream of Samboc Rapids revealed that though the sand is acceptable as the material, the unit quantity of cement would be required in larger amount because "the sand is too fine." This time, therefore, investigations for fine aggregate were conducted over a wider area.

(Coarse Aggregate)

According to the reconnaissance hitherto made, the natural coarse aggregate available near the dam site is found as rounded gravels of less than 30 mm diameter which are discovered in small quantities between the islands on the Rapids. It would be extremely difficult to secure substantial quantities of coarse aggregate near the dam site. The right bank near the Sambor dam site is geologically composed mainly of Tmor Moykbyk layer which consists of brittle shale or the alternated layer of silt stone and sand stone. In order to determine whether these rocks could be utilized as the materials for concrete aggregate, investigations were conducted in the area extending between the Mekong and the former river bed on the right bank by means of boring tests, observation through test pits and seismic prospecting. Further, 1.5 tons of the outcrop of shale found downstream of Samboc Rapids was collected.

(Fine Aggregate)

Results of reconnaissance conducted in the area near the Samboc Rapids and subsequent test results are as follows:

1. There are no bars upstream of Samboc Rapids that could provide fine aggregate materials.

2. Comparatively fine sands are discovered in the bars surrounding the island located opposite to Kratie, about 12 km downstream of the dam site.

3. In the vicinity of the point about 17 km downstream of Samboc Rapids, i.e., 3 km downstream of Kratie, there was found a bar along the left bank which extends for 2 km in length and 200 m in width (With EL 7.00 m, the bar protrudes above the water surface as shoal in the dry season). Since the quality of the sand was considered fairly good, 0.5 tons of sand was collected at 3 points of the bar as specimen for fine aggregate test.

(b) Quantity of Survey

(1) Outline

	Seismic prospecting		Boring test		Test pit		Permeability test		Auger boring	
	A	B (m)	C	D (m)	E	F (m)	G	H	I	J (m)
Main river bed										
Line Ⓒ'			3	104			1	3		
Line Ⓒ	1	2,140	1	10			1	2		
Phnom Samboc Line	1	2,880	7	112						
Right bank										
Power house	3	930	5	81						
Spillway	6	7,000	12	215	39	112.0	5	10		
Navigating channel	1	500	4	125	5	20.8				
Line ④					8	33.3			20	73.4
Left bank										
Line ①					19	43.5			9	21.8
Line ③			4	88	26	52.9	5	5	26	63.4
Quarry										
LQ-0	1	1,000	4	50	29	62.5				
LQ-2	1	1,000	1	10	26	46.9				
LQ-3	1	950	1	10	12	21.1				
LQ-4			1	15						
TOTAL:	15	16,400	43	820	164	393.0	12	20	55	158.6

Remarks: A: No. of line of measurement, B: Length of line of measurement
C, E, G, I: No. of bores D, F & J: Bore length
H: No. of tested cross sections

(2) Seismic prospecting

Line of Measurement	From	To	Length of line of Measurement (m)	No. of survey point	No. of Shot Points	No. of Shots
(Main river bed, Line ©)						
DH4100-DH4101	DH4100	DH4101+53	2,140	369	21	98
(Main river bed, Phnom Samboc Line)						
DH6344-DH6340	DH6344-110	DH6340+80	2,880	894	44	116
(Right bank, powerhouse)						
DH6310	DH6310-170	DH6310+200	370	133	10	19
DH6312	DH6312-110	DH1312+80	190	78	5	9
AT3	AT3-270	AT3+100	370	146	10	23
(Right bank, Spillway)						
DH6309-DH6316	DH6309	DH6316+100	1,700	121	24	73
RP4-DH6323	RP4	DH6323+180	1,950	784	25	76
DH6318-DH6319	DH6319	DH6318+220	1,050	424	15	44
DH6320	DH6320	DH6320+800	800	324	11	32
DH6323-H7	DH6323-700	DH6323+300	1,000	404	12	40
DH6325	DH6325-325	DH6325+175	500	204	7	20
(Right bank, Navigating channel)						
DH6326	DH6326-380	DH6326+120	500	220	9	26
(Quarry LQ-0)						
DH6348	DH6348-300	DH6348+700	1,000	404	12	40
(Quarry LQ-2)						
DH6331	DH6331-200	DH6331+800	1,000	404	12	40
(Quarry LQ-3)						
DH6332	DH6332-400	DH6332+550	950	404	12	40
TOTAL : 15			16,400	5,822	229	696

(3) Boring Test

No.	Bore length(m)	Surface ground (Elevation in m)	Weathered rocks (Elevation in m)	Sound rocks (Elevation in m)	Kind of rocks
Main river bed, Line Ⓒ'					
DH6301	44	12.92	-	10.54	Sandstone
6302	30	9.00	6.60	6.30	"
6304	30	11.17	-	8.87	Shale
3 Holes	104				
Main river bed, Line Ⓒ					
DH6303	10	9.80	7.40	7.10	Sandstone
1 Hole	10				
Main river bed, Phnom Samboc Line					
DH6305	15	10.00	-	0.80	Siltstone or Shale
6322	10	23.10	17.00	15.50	Sandstone
6324	20	21.35	13.35	9.85	Shale
6340	12	18.58	14.38	8.00	"
6341	15	22.96	13.26	10.70	Sandstone
6344	20	18.10	-	2.60	Shale or Siltstone
6345	20	20.34	16.74	12.34	Shale
7 Holes	112				
Right bank, power house					
DH6308	20	22.20	16.20	13.90	Sandstone
6309	20	21.91	15.21	10.91	Shale
6310	15	14.45	8.35	6.95	Sandstone
6311	11	11.33	-	7.03	Shale & Sandstone
6312	15	21.61	17.51	13.00	"
5 Holes	81				
Right bank, spillway					
DH6313	20	24.77	17.97	10.67	Shale & Sandstone
6315	20	26.60	21.20	18.30	Shale & Siltstone
6316	20	23.98	13.28	12.78	Sandstone
6317	20	21.96	13.66	10.66	Siltstone
6318	15	20.22	16.02	11.02	"
6319	15	23.57	21.97	13.27	Shale
6320	15	19.73	17.53	15.37	Sandstone
6321	20	20.69	-	7.29	Siltstone or Shale
6323	20	22.70	8.90	5.50	Sandstone
6327	15	21.51	14.80	9.11	Shale
6336	15	23.28	17.28	11.00	"
6337	20	23.78	19.48	3.70	Sandstone
12 Holes	215				

No.	Bore length(m)	Surface ground (Elevation in m)	Weathered rocks (Elevation in m)	Sound rocks (Elevation in m)	Kind of rocks
Right bank, navigating channel					
DH6325	40	21.88	-	-12.12	Sandstone
6326	35	22.20	-	-11.10	"
6338	20	21.99	-	2.79	"
6339	30	21.34	-	-5.06	"
4 Holes	125				
Left bank, Line③					
DH6342	25	21.49	4.69	1.89	Shale
6343	20	18.54	15.04	14.34	Siltstone
6346	23	21.26	-	3.76	Sandstone
6347	20	24.66	21.56	14.26	Siltstone
4 Holes	88				
Quarry LQ-⓪					
DH6328	10	34.79	31.00	-	-
6329	20	29.13	28.13	26.63	Sandstone
6330	10	30.56	26.96	24.76	"
6348	10	34.36	28.66	24.36	"
4 Holes	50				
Quarry LQ-②					
DH6331	10	29.47	28.97	21.67	Sandstone
1 Hole	10				
Quarry LQ-③					
DH6332	10	30.31	27.71	27.51	Sandstone
1 Hole	10				
Quarry LQ-④					
DH6333	15	38.90	35.70	34.30	Sandstone
1 Hole	15				
TOTAL					
43 Holes	820				

(4) Test Pit

No.	Elevation (m)	Bore length(m)	Sampling depth(m)
Right bank, spillway			
RP 1	21.20	3.9	
2	23.89	3.8	2.0
3	19.91	2.0	
4	23.37	5.0	1.0 - 3.0
5	22.85	4.8	1.0 - 3.0
6	21.23	1.2	
7	22.91	2.0	
8	24.46	4.5	
9	23.38	4.6	
10	23.20	5.0	
11	23.42	4.4	
12	23.60	2.9	1.2 - 2.0
13	23.30	2.5	1.0 - 2.0
14	20.00	1.5	1.0
15	24.62	2.8	
16	24.45	3.1	
17	23.04	3.2	
18	23.92	2.2	
19	21.78	1.0	
20	19.81	1.7	
21	24.18	3.5	
22	23.6	3.0	
23	21.0	1.2	0.3 - 1.0
24	20.0	2.9	
25	20.0	2.0	
26	23.0	5.0	3.5 - 4.0
27	25.0.	3.3	
28	21.0	1.6	
29	22.0	1.9	
30	24.5	1.2	
31	23.67	2.2	0 - 1.0, 1.0 - 2.0
32	21.5	1.8	1.0
33	22.5	1.8	
34	21.0	2.5	
35	23.5	5.1	
36	23.5	2.1	
37	22.0	2.3	1.0 - 2.0
38	20.0	1.2	
39	20.0	5.3	3.0
39 Holes		112.0	13 Specimens
Right bank, navigating channel			
RP40	21.0	5.0	2.0
41	20.0	5.0	2.0
42	19.5	4.2	
43	20.0	5.0	2.0
44	19.5	1.6	1.0
5 Holes		20.8	4 Specimens

No.	Elevation (m)	Bore length(m)	Sampling depth(m)
Right bank, Line ④			
RP50	32.0	5.3	
51	35.0	4.4	1.3 - 2.0, 2.0 - 3.8
52	30.0	4.1	1.5 - 2.0
53	30.0	2.0	
54	31.0	5.0	3.0
55	32.0	5.0	
56	35.0	5.0	1.0 - 3.0
57	40.0	2.5	0.9 - 2.5
8 Holes		33.3	6 Speciments
Left bank, Line ①			
LP 1	22.35	2.7	0.5 - 2.0
2	21.35	1.8	
3	27.15	4.4	1.4 - 2.9
4	27.6	3.4	
5	28.3	1.6	0.5 - 1.6
6	31.4	2.8	
7	35.3	2.8	1.0 - 2.5
8	42.9	3.5	
9	42.6	3.2	1.5 - 2.5
10	44.0	2.7	
11	42.3	1.8	0.4 - 1.5
12	41.2	1.5	
13	39.5	1.1	0.4 - 1.0
14	37.5	1.3	
15	37.0	2.3	0.5 - 2.0
16	36.0	1.2	
17	44.0	1.4	0.4 - 1.2
18	43.5	2.0	
19	43.0	2.0	1.2 - 2.0
19 Holes		43.5	10 Specimens
Left bank, Line ③			
LP25	25.5	1.5	
26	28.0	1.6	0.3 - 1.0
27	29.0	1.2	
28	31.0	0.9	0 - 0.7
29	36.0	2.5	1.4
30	26.0	1.8	
31	39.0	1.9	
32	39.7	1.8	
33	36.5	2.2	1.5
34	35.8	2.1	
35	38.5	2.3	
36	30.0	1.4	1.0
37	39.6	1.5	
38	37.5	2.9	1.9
39	40.65	3.6	1.3

No.	Elevation (m)	Bore length(m)	Sampling depth(m)
40	41.2	2.8	
41	37.6	2.4	
42	36.7	2.0	1.4
43	43.34	3.2	0.5 - 1.0
44	40.05	2.2	
45	48.8	1.5	
46	47.65	1.4	0.5 - 1.0
47	48.3	2.7	0.4 - 1.5
48	45.9	1.9	
49	42.9	1.8	
50	45.0	1.8	0.3 - 1.2
26 Holes		52.9	12 Specimens
Quarry LQ-⓪			
LQO-1	35.5	0.6	
2	34.0	4.0	
3	31.0	1.8	
4	34.5	2.4	
5	32.5	2.6	
6	29.0	2.2	
7	29.0	2.7	
8	30.0	1.3	
9	30.0	1.7	
10	27.0	1.7	
11	27.5	2.0	
12	35.5	3.6	
13	29.13	1.3	
14	31.0	0.6	
15	28.3	2.0	
16	35.4	1.3	
17	34.3	2.1	
18	29.5	1.4	
19	34.0	1.7	
20	35.2	3.3	
21	30.0	3.1	
22	30.0	2.4	
23	30.0	2.3	
24	28.0	2.5	
25	32.0	2.4	
26	29.0	1.9	
27	33.5	4.5	
28	32.0	2.1	
29	31.5	1.0	
29 Holes		62.5	-
Quarry LQ②			
LQ2 8	29.0	1.7	0.3 - 1.0
9	26.0	1.5	
10	25.0	1.9	0.3 - 1.5
11	20.0	4.3	
12	19.0	3.7	
13	29.0	1.9	
14	31.0	1.4	
15	27.0	1.4	
16	24.0	2.0	
17	29.0	1.1	0.2 - 1.0
18	24.0	1.6	0.4 - 1.0
19	28.0	1.2	
20	29.0	1.0	
21	27.0	1.7	
22	28.0	1.8	
23	25.0	3.0	
24	31.0	2.1	0.5 - 1.5
25	29.0	1.7	
26	28.0	1.2	
27	25.0	1.3	
28	30.0	2.3	
29	30.0	2.0	
30	27.0	2.1	
31	25.0	0.7	
32	26.0	1.0	
33	25.0	1.3	
26 Holes		46.9	5 Specimens
Quarry LQ③			
LQ3-1	30.1	1.8	
2	30.5	1.3	
3	33.5	0.8	
4	30.0	0.6	
5	35.0	1.5	
6	35.0	3.5	
8	40.0	1.5	
9	38.5	1.7	
10	36.8	2.9	
11	26.7	1.6	
13	29.5	0.8	
14	35.5	3.1	
12 Holes		21.1	-
TOTAL			
164 Holes		393.0	50 Specimens

(5) Permeability Test

No.	Depth of tested cross section (m)	Injection pressure (kg/cm^2)	Permeability Coefficient (cm/sec)	Test method
Main river bed, Line ©				
DH6302	2.5 - 5.0	0.8 - 0.5	$(3.3 - 9.3) \times 10^{-4}$	Injection at Fixed Pressure (Boring Hole)
"	10.0 - 15.0	0.9	3.3×10^{-3}	"
"	15.0 - 20.0	0.4	8.1×10^{-4}	"
1 Holes	3 Sections			
Main river bed, Line ©				
DH6303	4.0 - 10.0	0.5 - 0.8	$(3.3 - 4.4) \times 10^{-3}$	Injection at Fixed Pressure (Boring Hole)
"	5.0 - 10.0	1.0 - 2.6	$(1.6 - 4.5) \times 10^{-4}$	"
1 Hole	2 Sections			
Right bank, spillway				
DH6313	5.0 - 10.0	0.3	8.3×10^{-4}	Injection at Fixed Pressure (Boring Hole)
DH6315	15.0 - 20.0	0.5 - 5.0	$(0.7 - 1.1) \times 10^{-5}$	"
DH6316	11.0 - 15.0	0.5 - 1.0	$(2.2 - 2.6) \times 10^{-4}$	"
"	11.5 - 15.0	0.5	2.7×10^{-4}	"
"	11.5 - 15.4	1.0 - 2.0	$(2.8 - 3.1) \times 10^{-4}$	"
"	15.0 - 20.0	0.5 - 2.0	$(1.6 - 1.7) \times 10^{-4}$	"
DH6319	5.0 - 10.0	0.5 - 1.0	$(2.0 - 2.6) \times 10^{-4}$	"
"	10.0 - 15.0	0.5 - 3.0	$(0.9 - 1.5) \times 10^{-4}$	"
DH6336	6.0 - 11.0	0.5 - 2.0	$(0.6 - 1.8) \times 10^{-4}$	"
"	10.5 - 15.3	0.5 - 5.0	$(0.5 - 1.2) \times 10^{-4}$	"
5 Holes	10 Sections			
Left bank, Line③				
LP 25	0 - 1.5	-	$(0.8 - 1.3) \times 10^{-4}$	Feeding of Fixed Quantity of Water without pressure (Test Pit)
LP 26	0 - 1.6	-	$(0.7 - 1.0) \times 10^{-6}$	"
LP 30	0 - 1.8	-	$(1.4 - 4.0) \times 10^{-5}$	"
LP 31	0 - 1.9	-	$(2.0 - 4.5) \times 10^{-5}$	"
LP 32	0 - 1.8	-	$(3.3 - 5.6) \times 10^{-5}$	"
5 Holes	5 Sections			
TOTAL:				
12 Holes	20 Sections			

(6) Auger boring test

No.	Elevation (m)	Bore length (m)	Sampling depth (m)
Right bank, Line ④			
AH01	22.00	5.0	3.0
02	25.00	6.0	1.0, 2.0, 3.0, 4.0
03	30.50	1.9	1.5
04	31.00	4.8	1.0, 2.0, 3.0, 4.0
05	37.00	4.0	0.5, 2.0, 3.0, 4.0
06	20.00	3.7	1.0, 2.0, 3.0
07	25.00	5.0	1.0, 2.0, 3.0, 4.0, 5.0
08	25.00	4.5	1.0, 2.0, 3.0, 4.0
09	30.00	2.5	1.0, 2.0
10	30.50	1.7	0.5, 1.0, 1.7
11	25.00	2.8	1.0, 2.0, 2.5
12	22.00	2.3	1.0, 2.0
13	20.00	4.1	1.0, 2.0, 3.0, 4.0
14	32.00	4.3	1.0, 2.0, 3.0
15	32.00	3.5	1.0, 2.0, 3.0
16	30.50	2.8	1.0, 2.0
17	31.00	3.3	1.0, 2.0, 3.0
18	24.50	4.2	1.0, 2.0, 4.0
19 - 1	17.00	5.0	1.0, 2.0, 3.0, 4.0
19 - 2	25.50	2.0	1.0, 2.0
20 Holes		73.4	60 Specimens
Left bank, Line ①			
AH40	19.50	3.0	1.0, 2.0, 3.0
41	27.50	5.0	1.0, 2.0, 3.0, 4.0, 5.0,
42	42.00	2.4	1.0, 2.0
43	39.50	2.0	1.0, 2.0
44	35.00	1.2	0.5, 1.0
45	34.00	1.2	1.0
46	21.00	1.2	1.0
47	28.00	1.0	0.5, 1.0
52	20.00	4.8	1.0, 2.0, 3.0, 4.0
9 Holes		21.8	22 Specimens
Left bank, Line ③			
AH20	25.00	4.0	1.0, 2.0, 3.0, 4.0
21	21.50	2.5	1.0, 2.0
22	24.60	2.0	1.0, 2.0
23	31.90	1.1	1.0
24	34.30	1.6	1.0, 1.5
25	36.50	5.5	1.0, 2.0, 3.0
26	34.70	1.8	1.0, 1.8
27	35.20	1.8	1.0, 1.8
28	35.90	2.3	1.0, 2.0,
29	31.00	3.4	1.0, 2.0, 3.0
30	39.50	1.1	1.0
31	40.00	1.2	1.0
31'	39.00	2.0	1.0, 2.0
32	39.00	2.8	1.0, 2.0
33	39.00	2.0	1.0, 2.0
34	39.50	2.5	1.0, 2.0
35	48.00	2.5	1.0, 2.0
36	39.50	2.7	1.0, 2.0
37	35.00	1.6	1.0, 1.5
38	35.50	2.0	1.0, 2.0
39	33.00	0.8	0.8
48	28.00	1.2	1.0
49	27.00	1.0	1.0
50	21.50	3.5	1.0, 2.0, 3.0
51	21.00	5.0	1.0, 2.0
53	20.50	6.0	1.0, 2.0, 3.0
26 Holes		63.4	52 Specimens
TOTAL			
55 Holes		158.6	134 Specimens

(c) Method of Survey

(1) Seismic Prospecting

The seismic prospecting was conducted by Japan Geophisical Prospecting Co. from November 17 to December 23. The survey, which covered the line of measurement with a total length of 16.4 km, was performed with the use of twelve elements electromagnetic oscillograph.

For the survey in the river, Gimballed detectors and echo-sounders were used. Lines of measurement, number of survey points, number of shot points and shots are as shown in Table (b)-(2) under 4-2. Boring holes and test pits were drilled at one or more points on each line of measurement for the analysis of the seismic wave.

(2) Boring Test

The boring test was conducted by Hazama Construction Co. from November 11 to January 2, and 3 type UD-5 boring machines manufactured by Tone Boring Co. were utilized, with metal crown bits (NX size, 76.2 mm dia.) employed for drilling the surface layer and diamond bits (AX size, 49.2 mm dia.) for the bedrock. Number of bores and bore lengths are as shown in Table (b)-(3) under 4-2.

(3) Test Pit

Test pits were excavated by Hazama Construction Co. and the period required for the test was the same as that spent for the boring test. Test pits were excavated not only to clarify the condition of the foundations for structures and the bedrock, but also to investigate the earth materials and confirm the condition of the surface layer of the quarries. Hence the excavation was concentrated upon such points as may be deemed important from the standpoint of designing. To be specific, the supplementary investigations of Line (1) were conducted by excavating test pits downstream of the center line, and for Line ③ test pits were excavated on the center line and on its approximate parallel line about 500 m downstream of the center line. As to the spillway and quarries for rock materials in Line Ⓒ' Plan, grids with 200 - 500 m intervals were established and test pits were excavated at the intersections of the grids. In addition, a number of test pits were excavated for the purpose of supplementary investigation on earth materials for Line ④.

(4) Permeability Test

Permeability tests were performed when drilling boring holes and excavating test pits. The boring points were located in the river bed and spillway section of Line Ⓒ' Plan. The bore was of AX size, and the length of the tested cross sections averaged 5 m. Permeability of the bedrock was tested by varying the injection pressure. As regards the test pits, the test points were located in the area with EL below 35 m in Line ③, and the permeability of the ground was tested by means of injection method. Number of test points and tested cross sections are given in Table (b)-(5) under 4-2.

(5) Auger Boring Test

Investigations by auger boring test were conducted by the Team from November 15 to December 30 with the use of 2 sets each of hand auger, sampling set and cylinder type sampler. Specimens collected were immediately put into specimen containers, and after conducting water content test, transferred into vinyl bags which were packed in oil tins and sent to Japan.

4-3 Results of Investigations

(a) Main River Bed

(1) Supplementary Investigations on Line Ⓒ' Plan

Investigations were conducted by boring test at DH 6302 and DH 6304 on the dam center line △6 - △5 and at DH 6301 on the alternative dam center line △1 - △4. Further, the channel with the minimum elevation of -20 m near the right bank on Line △6 - △5 was surveyed with a sounder.

DH 6302 was a vertical bore with the bore length of 30 m, located in the layer which registered 6.0 km/sec of seismic wave velocity. Sand bed load extends from the ground surface down to the depth of about 2.40 m, underlain by fresh sand stone of medium grain which reaches the bottom of the bore. The sand stone embodied thin layers (0.70 - 1.30 m thick) of silt stone and shale, and the joints were at different intervals according to the depth, i.e., 3 - 10 cm at the depth ranging from 2.60 - 17.00 m, and 15 - 30 cm at the depth ranging from 17.00 m to the bottom of the bore.

DH 6304 was a vertical bore with the bore length of 30.00 m, drilled in the layer which registered 4.8 km/sec of seismic wave velocity. From the ground surface to the depth of 2.30 m, the sand bed load is found, and thence downward to the bottom of the bore extends very fresh shale with the joint registering intervals of 40-100 cm. In order to clarify the condition of the fault, boring test DH 4163 and DH 4112 on the above-mentioned dam center line had been conducted by the Australian Snowy Mountains Hydro-Electric Authority Team. The tests had confirmed that the bedrock is for the most part fresh and sound with extremely little permeability.

DH 6301 was an inclied bore (45°) drilled in the direction of △ 1, the bore length being 44.50 m. The boring at this point was performed to clarify the condition of Cha Sorowoo fault which forms the demarcation line between Tmor Moybyik layer and Sambor layers. Sand bed load extends from the ground surface down to the depth of 2.40 m, with sand stone of fine grain extending as main rock component between the depths of 2.40 m and 21.65 m, thence downward is found shale which reaches the bottom of the bore. Decomposition of rocks by weathering was scarcely noticed, and the joint intervals are small. Most of the rocks found below the depth of 30.60 m were distrubed , and those rocks which had not been affected by disturbance were found to have the core of debris with slip plane.

The water depth at the channel surveyed by the sounder almost corresponded to the depth from the water surface to the bedrock obtained from the delay time of time-distance curve of seismic prospecting. It can therefore be assumed that bedrocks are exposed at the river bed at this depth and are free from the surface deposit, excepting the sloping river bed leading to the right bank which was found covered by the bed load of several meters thickness.

(2) Line Ⓒ Plan

(See Dwg. No. HO-0232, Sheet No. 7-14)

With regard to this Plan, the Australian Snowy Mountains Hydro-Electric Authority Team has already conducted investigations and their outcome is contained in "Geological Investigations on Sambor Dam Site, Cambodia, Vol. 1 - 4." Taking into account the results of this Australian investigations, seismic prospecting was conducted with the line connecting DH 4100 and DH 4101 as the line of measurement. At the same time, boring test DH 6303 was performed on a vertical boring with the bore length of 10.00 m. These investigations revealed that the channel part, when compared with Line △6 - △5, comprises two channels which form the shape of non-symmetrical "W" and is slightly less in depth. The deepest elevation near the center line of the stream was -10 m, and that of the channel running beyond the protrusion with EL -1 m and leading to the right bank marked -7 m. No surface deposit was found on the river bed, and the distance between the shoulders of the channel was 130 m at the elevation of .0 m.

With regard to test boring DH 6303, sand bed load extends from the surface ground to the depth of 2.40 m, thence downward was found a layer of very fresh shale embodying in part sand stone. The layer of shale was found to be an excellent bedrock, registering 6 km/sec.

It was noted, however, that while the bedrock is widely exposed above the water surface in the river bed of Line (C'), most of the bedrock in Line (C) was found dipped under water. The bedrock of Line (C) has, for the most past, the elevation of 5 m, and is covered by surface deposit of some meters thickness. Further, eroded strips with EL .0 m or less were found.

(3) Investigations on Phnom Samboc Line Plan

(See Dwg. No. HO-0232, Sheet No. 7-14)

Center line investigations relative to this Plan were conducted by means of seismic prospecting, boring test, auger boring test and test pits observation, the last three having been performed by excavating several bores. Over the greater portion of this center line, i.e., between the western tip of Phnom Samboc and DH 6324 on the right bank, the elevation of the bedrock marked .0 m or less with few exceptions. The bedrock is covered by thick surface deposit which is as thick as 20 m or more at some points near the bank. The bedrock also has a number of channels with EL -10 m or less, the deepest of which is found on land close to the right bank, with its bottom bedrock marking EL deeper than -20 m.

(b) Left Bank

(See Dwg. No. HO-232, Sheet No. 9-14 & 10-14)

As the supplementary investigations for Line ①, 19 test pits were excavated downstream of the dam center line mainly for the purpose of material investigation. The observation through test pits revealed that the surface layer, except on the banks of the Mekong, is very thin as in the case of Line ①, generally marking about 2 m or less. The surface layer consists of solidified clay or silty clay. The clay was generally found to possess more cohesive property in the lower part of the layer than in the upper part, and is tightly stuck to the completely decomposed rocks.

As regards Line 3, investigations were conducted by boring test, auger boring test and test pits observation on the dam center line and within the area about 500 m downstream of the center line. Since it was expected that thick surface deposit would be found near the banks of the Mekong, investigations in areas close to the Mekong river banks were conducted mainly by boring test. Test pits were excavated on the dam center line at intervals of 1 km. Test pits were also excavated within the area downstream of the center line at points corresponding to the test pits on the center line, and auger boring holes were drilled at proper points between these test pits. As in the case of the dam center line of Line ①, permeability test was conducted utilizing test pits with EL 35 m or less.

Investigations revealed that in the area near the banks of the main stream of the Mekong, the bedrock is located deep under water marking a depth of more than 14 m. At DH 6326, the depth of the bedrock registered over 17 m. Save for this area, the thickness of the surface deposits did not show much difference when compared with Line ①. The permeability test utilizing test pits also indicated that the layer is highly water-tight as in Line ①.

(c) Right Bank

(1) Vicinity of Power House Site of Line Ⓒ' Plan

(See Dwg. No. 0232, Sheet No. 1-14 & 2-14)

Supplementary investigations on power house site of Line Ⓒ' Plan were conducted by means of boring test and seismic prospecting, results of which were compiled and utilized in preparing a contour map of the bedrock. The thickness of the weathered zone differed by place, and it was noted that in the river bed, the fresh bedrock exists immediately below the surface deposit, whereas in flat areas on land, the fresh bedrock is sometimes overlain by the weathered zone with thickness ranging from 3 - 4 m.

(2) Vicinity of Spillway of Line Ⓒ' Plan

(See Dwg. No. HO-232, Sheet No. 3-14, 4-14, 5-14 & 6-14)

Investigations on the spillway of Line Ⓒ' Plan were conducted mainly by boring test, test pits observation and seismic prospecting. Since uplands with EL 25 m or more and outcrops of weathered rocks are found downstream of the spillway, boring holes and test pits were drilled with due attention paid to the possibility of securing rock materials for enbankment and concrete aggregate. The seismic prospecting was performed along the center line of the proposed spillway dam and training wall and on 3 lines of measurement intersecting the training wall in an effort to clarify the geological condition of the downstream area as a whole. The seismic prospecting revealed that the bedrock is an alternated layer of chiefly shale and partly sand stone; the undulation of the bedrock including the weathered part is shown in the drawing of cross section and the contour map. The surface deposit was found generally thin on uplands excepting the eastern tip of the former river bed, which is nearly identical to the area where bedrocks with EL approx. 20 m are discovered.

On the east side of this fairly elevated area, however, the elevation of the bedrock located south of coordinates N. 1,391.2 km drops sharply. Drawing of geological cross section (D-D) was prepared along the center line of the spillway dam. According to the seismic prospecting, the marshy area of DH A-5 and DH 6315 is covered by the fairly thick layer (10 m thick) which marked 1.5 km/sec of seismic wave velocity. Judging from the geological conditions of the marshy area and its vicinity dam and the results of investigations conducted in FY 1962 on the spillw center line (See drawing of cross section E-E), this layer is considered to be weathered zone and not a stratum of surface deposit. However, further confirmation should be made in this respect.

Permeability test was conducted utilizing the boring holes drilled on the center line of the spillway dam and the training wall. The test revealed that the permeability coefficient is in the order of 1×10^{-4} m/sec - 1×10^{-5} m/sec, indicating a fairly high water-tightness.

Study of the geological structure of this area as a proposed quarry for rock materials and concrete aggregate for dam construction revealed that layers are steeply dipping and sharply folded, resulting in the foliation being developed in the order of several centimeters or less at a number of places. The thickness of the surface deposit generally exceeded 4 m even in areas where the deposit is comparatively thin. The formation of the rocks in this area, as assumed by the boring test, was 60% shale and 40% sand stone. It is therefore believed that rock materials of good quality could not be obtained from this area.

(3) Vicinity of Navigating Channel on Land

(See Dwg. No. HO-0232, Sheet No. 7-14 & 8-14)

Investigations were conducted chiefly by boring test with seismic prospecting as supplementary test on the navigating channel and navigation lock to be constructed from the end of the spillway in Line ©' Plan, along the right bank of the Mekong.

Towards the lower reaches of the river, the bedrock elevation drops remarkably in this area. This tendency is conspicuous south of Phnom Samboc Line (See drawing of cross section J-J), and the boring test DH 6326 revealed that the bedrock elevation in the vicinity of the proposed navigation lock site is deeper than -10 m, with the surface deposit marking about 33 m thickness. The boring test also revealed that the surface deposit is mainly greasy clay at DH 6323 and silty clay at DH 6324, whereas bores south of Phnom Samboc Line produced mostly sandy silt or sand of fine grain but no cohesive materials.

The seismic prospecting indicated the tendency that the bedrock elevation increases in proportion to the distance from the mainstream of the Mekong.

(d) Proposed Quarry Areas

(1) LQ-O

(See Dwg. No. HO-0232, Sheet No. 11-14 & 12-14)

This area extends along Highway #13 and surrounds a point about 3 km north-east to Sandon upstream of the dam site. The area has been recommended by the afore-mentioned Australian Team as a potential quarry to provide rock materials. Investigations in this area were conducted by 4 boring tests, 29 test pits and seismic prospecting over a length of 1 km of line of measurement. The area is geologically composed of chiefly sand stone of bluish-grey colour, and the surface deposit is so thin that the bedrock can be reached within 2 m below the ground surface. On the northern side of Highway #13, exposed rocks are seen in fairly wide range of area, while on the southern side, outcrops become scarce as the distance from the Highway increases, with the surface deposit getting thicker. As to the geological structure, this area is formed mainly by the layer of sand stone of medium grain which is almost horizontal with a very gentle dipping. The fresh sand stone presents dark bluish-grey colour and is very solid. 4 boring tests and seismic prospecting revealed that the thickness of the weathered zone was about 2 m. It is assumed by the geological survey conducted on the ground surface that layers which registered 0.8 km/sec and 1.2 km/sec of seismic wave velocity are comparatively fresh bedrocks that have been loosened and cracked. Ground water level is assumed to be about 15 m judging from the depth of wells in this area. The proposed quarry is promising and is presumed to extend over an area of 2 km^2 and to economically provide ample quantity of materials for the cofferdam to be placed on the main stream.

(2) LQ-2

(See Dwg. No. HO-0232, Sheet No. 13-14)

This area is located about 7.5 km on the straight line from Line Ⓒ' and extends along Line ③ about 1.5 km east of Samboc village. The area is the closest to the dam site among other areas on the left bank of the Mekong, with the quarry site assumed to extend over an area of about 1.5 km^2. Investigations were conducted by 1 boring test, 26 test pits and seismic prospecting on the line of measurement with the total length of 1 km.

The thickness of surface deposit in this area is small and marked about 1 m. Small outcrops of weathered rocks were observed here and there.

The bedrock on the west side of the line connecting test pit 25 - 6 - 13 - 2 consists of the alternated layer comprising chiefly shale and partly sand stone. On the contrary, the bedrock on the east side of this line is formed by the alternated layer comprising chiefly sand stone and partly shale. The strike of bed runs in the direction of S - N or with little deviation to the east. The layers are dipping almost vertically, and in the area where shale is found in quantities, foliation is found developed considerably. The thickness of the weathered zone is larger than in LQ-0 area due to the almost vertical dipping of layers and to the development of beddings and foliation. Judging from the results of the boring tests and seismic prospecting, the thickness ranges from 5 - 10 m in some parts and increases where shale is found in quantities.

The thickness of the layer rich in sand stone is presumed to be about 100 m. Quarrying has taken place at some of the outcrops of fresh rocks, but the distribution of sand stone is limited to a smaller area than in LQ-0. It is therefore presumed that the quantity of sand stone suitable for rock materials that could be economically extracted would not be sufficient for constructing the cofferdam.

(3) LQ-3

(See Dwg. No. HO-0232, Sheet No. 14-14)

This area lies about 14.4 km on the straight line from Line Ⓒ', extending over the upland south to Kalop village, and produces sand stone of light reddish colour. As in the case of LQ-0 area, fresh sand stone is found widely exposed, and quarrying is being conducted on a small scale near Highway #13. The thickness of the surface deposit is small, rarely exceeding 2 m, but becomes larger near the eastern end of the area. The area consists mainly of the sand stone layer with thin layers of shale embodied. In the area around the line of measurement of seismic prospecting, sand stone composes predominantly large portion of layers. At the eastern end of the area, rocks with gravels of small diameter are found, while at the western end, some parts are found rich in shale. Thus, rocks of fairly diversified kinds are found in this area. The layers generally show gentle dipping with sluggish undulation. The thickness of the weathered zone is assumed to be about 1 m but not more in the sand stone, whereas it is fairly thick in shale as in the case of LQ-2. The quarry is very widely distributed, extending over an area of 2.7 km^2 where the thickness of the surface deposit is about 2 m at maximum, which indicates that the area is one of the promising quarry sites.

(4) LQ-4

This area lies about 13.5 km on the straight line from Line Ⓒ', extending along Line ③ about 4 km east of Kalop village, and produces sand stone of reddish purple colour. The area extends over more than 3 km^2. The sand stone in this area is found partly exposed almost horizontally. The rocks in the surface layer are comparatively light with voids embodied. Test pits observation revealed that there exists residual soil caused by weathering. According to the boring test DH 6333, debris deposit extends from the ground surface to a depth of 3.20 m, with slightly weathered rocks extending between depths of 3.20 m and 4.60 m. From the depth of 4.60 m and downward, and with the exception of the bluish green sand stone of medium grain found between the depths of 9.80 m and 11.20 m, the main component is fresh sand stone of medium grain which presents reddish purple colour and embodies small coarse gravels. The area is considered to be a promising quarry site capable of economically providing sufficient rocks for the cofferdam.

(e) Earth Materials

(1) Earth Materials for Cofferdam to be Placed on the Main Stream

Investigations were conducted on earth materials for placing a rock-fill dam on the main stream. As to the right bank, investigations were conducted in the area near the spillway, around the jungle locat downstream as well as upstream of the dam axis, and in the vicinity of AH-09 -12. On the left bank, vicinity of the ridge near AH-44 - 4 and the area around AH-37 - 39 were investigated. In the area AH-09 12, materials found were clay silt or silty clay derived from the yellowish brown shale which is found westward of the jungle on the right bank. These materials lie under the laterite layer of about 0.5 m thick and reaches the shale bedrock at the depth ranging from 1.7 - 2.8 m.

In the area AH-44 - 47 and vicinity on the left bank, the layer of weathered conglomerate is presumed to extend for several meters. At AH-37, it was discovered that the heavily weathered conglomerate exis continuously from AH-44 - 47 area, and at AH-38, silty clay with debris of shale was found extending for about 2.0 m. At AH-39, no earth materials were observed.

(2) Vicinity of Line ① on the Left Bank

The area covering LP-1 - 3 located close to the river bank is covered by the surface soil of silt of fine grain ranging from 0.1 - 0.5 m, and the yellowish white silty clay underlies in moistened condition. At LP-2 where boulders of 1 m diameter were found, soft and weathered sand stone extends as main component below the depth of 1.5 - 3.0 m. Areas covering LP-4 are covered by laterite layer of 0.2 - 0.6 m thic and the underlying material is silty clay of 0.5 - 1.8 m thickness derived from yellowish brown shale. This silty clay was found desiccated and solidified. Underneath this silty clay layer lies the bedrock of weathered shale. In the area covering LP-8 - 9, calcareous clay which embodies calcareous lumps and patches are found about 3 m below the the ground surface. At LP-8, silty clay involving debris of shale and sand stone lies under the laterite layer of about 1 m thickness, while at LP-9, silty clay involving round gravels and debris of small and medium size was found together with the silty residual soil caused by the weathering in moistened condition. The round gravels are mostly quartz, clay-slate and sand stone, and the debris is mainly shale.

In the area covering LP-10 - 11, laterite layer of 0.2 - 0.7 m is followed by silty clay of about 1 m thickness which is derived from shale and exists in moistened condition. Underneath this silty clay lies soft shale.

Shale was found mostly exposed in the area covering LP-12 - 14 and LP-16, and no earth materials were found.

In the area covering LP-15 and LP-17 - 19, the laterite layer of 0.3 - 1.5 m thickness was found in the upper part, underlain by clay or silty clay, and the shale bedrock was found about 1.5 - 2.3 m below the ground surface. It is to be added that round gravels of conglomerate were observed at LP-17.

(3) Vicinity of Line ③ on the Left Bank

At AH-51 and AH-52 which are located near the river bank, silty clay or sandy silt of fine grain were discovered in moistened condition, with the ground water running at a depth of about 5 m under the ground surface.

The area covering AH-20 and AH-21 consists of silt of fine grain which lacks cohesiveness, with the soft weathered sand stone found at a depth of 2.0 - 2.5 m from the ground surface. At LP-25 and LP-26, bedrock of weathered sand stone lies under a poor laterized layer of 0.4 - 0.9 thickness.

Different degrees of laterization were noticed at bores in the area covering LP-26 - 38, followed by the residual soil of weathered shale. However, the shale bedrock is located at a depth of 1.2 - 2.3 m from the ground surface.

In the area covering AH-31' - 33, sandy silt of reddish colour, 2.0 - 2.8 m in thickness, was found. In the area covering AH-35 and AH-36, the laterite layer of 0.6 m thickness is underlain by silty clay derived from the weathered shale. This silty clay reaches the bedrock at a depth of 2.5 m.

(4) Vicinity of Line ④ on the Right Bank

In the area between the river bank and the jungle, silty clay of the colour ranging from bluish-white to yellow lies under the laterite layer. This silty clay, comparatively cohesive in its property, is underlain by the weathered sand stone or shale. The depth from the ground surface to the bedrock varies to an extent, marking 0.3 - 1.4 m, or more than 5 m at the deepest.

In the former river bed in the jungle expressed by RP-50, RP-54 and RP-55, silty sand of fine grain, light yellow in colour, exists at the depth of 1.3 - 1.6 m, underlain by laterite layer of about 0.5 m thickness which is further underlain by thick silty clay of fine grain of white and reddish colours.

At the western end of the jungle and in the plain extending farther in the west, the layer overlying the laterite is the same as that found in the above-mentioned river bed. Under the laterite layer, however, was found silty clay of fine grain with comparatively high cohesive property. At AH-02 and AH-07, ground water was reached by 5 m boring.

In the area around the dam axis west to AH-03 and RP-53, khaki coloured silty clay was found under the laterite layer of 0.4 - 1.0 m thickness. This silty clay was considerably solidified and becomes glossy when rubbed. It also has a comparatively high cohesiveness.

At AH-03 and RP-53, boulders or weathered sand stone of medium hardness were reached at a depth of 1.5 - 1.9 m. Westward from these two points, the bedrock becomes deeper and at some places it was at a depth of more than 40 m.

The area extending over AH-01, AH-06 and RP-31 downstream of the spillway is covered by silty sand of fine grain of 0.4 - 1.6 m thickness which presents reddish brown colour, underlain by laterite layer of 0.3 - 0.8 m and further by yellow silty clay or clay silt.

At RP-2, 12, 13, 23, 37, silty soil was found from the ground surface down to a depth of 0.3 m, underlain by yellow silty clay with high plasticity. The bedrock of weathered sand stone or weathered shale was reached at a depth of 2.2 - 2.8 m.

5. Material Test

5-1 Outline

Material tests were conducted in Japan by the Civil Engineering Laboratory, Electric Power Development Co. on earth materials and concrete aggregate collected during the field survey in FY 1962 and FY 1963.

Tests on materials collected in FY 1962 were performed during the period from May - July 1963, and materials collected in FY 1963 were tested during the period from February - June 1964.

Tests on earth materials were performed on specimens collected at test pits and auger boring holes in order to determine their physical properties whereby such materials may be utilized as water-tight earth materials for the rock-fill dam and for the construction of earth-fill dam body.

Testson concrete aggregate were carried out to examine the physical and crushing properties of rocks and sand to be used for concrete manufacture.

5-2 Tests on Earth Materials

(1) Specimens

In FY 1962, specimens were collected at test pits excavated mainly along the center of Line ④ on the right bank and also along the center line of Line ① on the left bank. In FY 1963, specimens were collected in the area extending along the right bank, at test pits and auger boring holes on Line ④ as well as at test pits and auger boring holes excavated on Lines ① and ③ at Quarry LQ-2.

	Bank	No. of Test pits	No. of Auger boring holes	Total
FY 62	Right bank	17	-	17
"	Left bank	11	-	11
"	Total	28 (850 kg)	-	28
FY 63	Right bank	23	60	83
"	Left bank	27	74	101
"	Total	50 (3,000 kg)	134 (480 kg)	184
TOTAL		78	134	212

(2) Tests Performed

Various tests were conducted on specimens collected at test pits in order to classify them into groups. Distribution by district of materials of similar quality and property was then obtained based on the results of the classification tests. Further, physical tests were performed on mixtures of major materials available within the same districts.

Classification Tests:

Water content ratio test

Specific gravity test of soil fraction

Mechanical analysis of soil

Atterberg's limit test

Stamping test

Physical tests:

Specific gravity and water absorption tests on materials of coarse grain

Permeability test

Triaxial compression test

As regards the specimens collected at auger boring holes, those presenting similar appearance were collected from the same district. Classification tests were then conducted on mixtures of such similar specimens.

Classification Tests:

Mechanical analysis of soil

Atterberg's limit test

Stamping test

These tests were conducted in accordance with JIS standards with partial amendment.

(3) Test Results

Properties and qualities of the soil as revealed by different tests are as follows.

1. Earth materials are found distributed as transported or residual soil by district. Distribution by district of similar earth materials is as shown in the attachment.

2. Excepting the flat area extending along the bank, the left bank side consists of ridge area where the weathered residul soil of shale

or of sand stone constitutes the main soil component. The soil is of relatively coarse grain belonging to SC or GC. In the inner districts, i.e., in districts A and G, however, clayey soil with high cohesive property belonging to CH is found.

Generally speaking, earth materials are found in smaller quantities near Line ① on the upper reaches than in the vicinity of Line ③ on the lower reaches.

3. The flat area along the left bank is formed by silty clay with medium plasticity or by clayey silt, both being fine grain materials belonging to CL.

4. The inner district located about 5 km from the right bank is formed by the weathered residual soil of mainly shale embodying sand stone in part. The soil is silty clay of fine grain with high cohesive property and belongs to CH.

Decomposition by weathering of the materials at AH-9 - 12 on the upper reaches in this district was noticed to be less heavy with comparatively little plasticity than that of the materials available on the lower reaches.

5. The former river bed, now forming a flat area, is evenly covered by silty clay containing sand of fine grain which is transported soil. The clay has high cohesive property and extends from the ground surface down to a considerable depth.

6. Districts N and P near the river banks are island-like districts located between the river and the former river bed. The districts are formed by clayey silt or silty clay. Materials in district N on the upper reaches of the river have medium plasticity, whereas those in district P on the lower reaches have high plasticity.

7. Transported soil consisting of silty clay of fine grain is distributed in districts S and T extendending along the river bank. While

the materials in district T belong to SM or CL with little plasticity, those in district S belong to CL or CH with medium or high plasticity. The latter are also found in the area extending along the opposite (left) bank.

8. Investigations in FY 1963 revealed that earth materials are found in limited quantities meeting the requirements on either bank, but no quarries to provide sufficient earth materials for dam body construction are available. It is therefore considered necessary to investigate in the vicinity of the ridge about 2 km from Line ① on the left bank.

5-3 Tests on Concrete Aggregate

(1) Specimens

In FY 1962, specimens were collected from the bars extending along the right bank of the Mekong about 5 km downstream of Sambor dam site. The sand collected was quartz sand of fine grain presenting reddish colour. In FY 1963, specimens were collected from the bar (2,000 m x 200 m) extending along the left bank about 17 km downstream of Samboc Rapids, i.e., about 3 km downstream of Kratie. Sample rocks were collected from the outcrops of slaty sand stone on the right bank downstream of Samboc Rapids.

	Kind of Specimen	Sampling Place	No. of Specimens	Weight
FY 62	River sand	About 5 km downstream of dam site	5	250 kg
FY 63	River sand	About 3 km downstream of Kratie	3	450 kg
"	Rocks	Right bank downstream of Samboc Rapids	1	1,500 kg

(2) Tests Performed

As regards the river sand, physical properties and grain size were tested.

Physical Properties:

Specific gravity and water absorption tests

Test on amount of material finer than #200 sieve

Organic impurities test

Stability test

Grain size.

As regards rocks, weathered rocks were separated with the use of hammers. Rocks which were not weathered were crushed by means of a jaw crusher, and tests were conducted for the flat degree, elongate degree and grain size of the crushed stones. Further, test on manufacturing sand was performed utilizing a rod mill. The physical properties of the crushed stones and sand were also tested, followed by the aggregate strength test which was conducted by manufacturing concrete.

The weathered rocks were crushed by a jaw crusher, and the physical properties of the crushed stones were tested.

Tests performed were:

Crushing test

Test on manufacturing sand

Tests on physical properties of crushed stone and sand

Aggregate strength test by manufacturing concrete

Tests for physical properties were performed in accordance with JIS standards. Concrete test was carried out utilizing ordinary Portland cement, with the proportions given below.

	Proportion #1	Proportion #2
Max. size of aggregate (mm)	150	150
Unit Q'ty of cement (kg)	240	180
Slump (cm)	3 ± 1	3 ± 1
Air content (%)	3 ± 1	3 ± 1

(3) Test Results

Tests for specific gravity, water absorption and stability revealed that the specimen sand collected in FY 1962 is quite suitable for fine aggregate. The test for organic impurities also showed satisfactory results.

It was noted, however, that if the tested sand is used, its extremely fine grain size would incur an increase in the unit quantity of water and consequently that of cement, rendering the concrete manufacture quite uneconomical. It is therefore considered necessary to find fine aggregate materials of coarser grain.

Results of tests conducted on specimens collected in FY 1963 are as follows.

The river sand is hard and its physical properties are satisfactory. Results of each test amply met with the specifications for dam concrete of the Society of Civil Engineering. It was generally noted that each specimen was short of sand of fine grain size (0.3 mm or less). Nevertheless, specimens collected from the central part and upstream extension of the bar were satisfactory with fineness modulus of less than 3.00. However, specimens collected from downstream extension of the bar marked fineness modulus of 3.28. Adjustment of grading is therefore desirable since this large fineness modulus is feared to disturb the workability when the unit quantity of cement is small (When the concrete aggregate size is 150 mm at maximum, the unit quantity of cement is less than 180 kg.)

The rocks were noticed to be distributed mixed with extremely weathered ones. Since the weathered rocks show exceedingly deteriorated physical properties, they have to be separated. Physical properties of rocks not affected by weathering were all found to meet with the specifications for dam concrete of the Society of Civil Engineering. However, stones crushed by a jaw crusher were noted to have the elongate degree which is a little too large, presumably because of the composition of the rocks. Test on manufacturing sand revealed that the specimens have comparatively little crushing resistence considering the fact that they are slaty sand stone. Strength test of concrete aggregate marked about 300 kg/cm^2 after 28 days of age, indicating that the rocks, excepting the weathered ones, are satisfactory as concrete aggregate. These aggregates, however, showed the tendency of absorbing more air-entraining agent than ordinary aggregate.

6. Hydraulic Model Test

In order to review the items listed below which are related chiefly to the partial alteration of the preliminary design of Line Ⓒ Plan, hydraulic model test was conducted at the Civil Engineering Laboratory, Electric Power Development Co. from September to December 1963.

1. Capacity of the spillway
2. Direction of the spillway and the effects of spilled water upon the opposite bank
3. Direction of the navigation lock and the length of the training wall
4. Water level and flow velocity when the cofferdam is placed on the main stream

The test was performed upon alteration on the axis line of the spillway section made due to the reason given in 2-2 (c). The test results were compiled in "Civil Engineering Test Report on the Spillway of Sambor Dam, Hydraulic Model Test[(11')]." As a result of the test, the following were revealed in connection with items given above.

6-1 Capacity of the Spillway

According to the resevoir water level ~ spillway discharge curve, the discharge is 72,100 m^3/s provided that the resevoir water level has EL 40.00 m. When the water discharge caused by an extraordinary flood marks 84,000 m^3/s, the resevoir water level would be EL 41.35 m.

In computing the spillway discharge, the spillway coefficient C=1.7 was adopted and 53 gates with 15 m width were assumed to be installed. In drafting the design which is based on the above assumption, the discharge Q=70,000 m^3/s was assumed to be possible with resevoir water level of EL 40.00 m. The test revealed that the presumed coefficient was almost accurate and safe.

With regard to the flow condition in the channel downstream of the spillway, the water flows over some points of the training wall when the basement of the downstream channel is on the existing ground surface line. If, however, the basement is reduced to the level of the bedrock line, no overflow occurs. It will therefore be necessary to excavate the surface ground down to the level of the bedrock when constructing the training wall based on the present design.

6-2 Direction of the Spillway and Effects of Spilled Water on the Opposite Bank

The test revealed that the spilled water runs generally along the river base in the direction of the spillway, with slight deviation in the running direction caused by the discharge volume, and reaches the opposite bank.

When the water flows from the channel downstream of the spillway into the river base, the direction of flow changes, and the flow shows the tendency of rushing towards the left bank. This rushing flow is considered to be the main cause of the effects imposed on the opposite bank.

The maximum wave-height caused by the discharge which runs down through the spillway is about 42 cm at the opposite bank. Effects of the wave are therefore considered almost negligible, but the energy of the rushing flow that collides against the bank is feared to cause damages. Shore protection works to safeguard private houses and roads should therefore be taken into consideration.

The spilled water flows in the approximate direction of the spillway after joining the main stream, and reaches the opposite bank with its energy gradually decreased.

It is presumed that the energy of the spilled water imposed on the opposite bank would not be decreased even if a slight change were made in the proposed location of the spillway.

6-3 Direction of Navigation Lock and Length of Training Wall

The navigating channel, as proposed by the present design, is to run in parallel with the training wall, and the navigation lock was assumed to be installed with 2 stages, i.e., at the end of the training wall where the river joins the canal, and at the right bank of the spillway where the channel enters into the resevoir. Effects that will be caused by the spillway are attributabl to the flow of water from the resevoir at the upper lock, while at the lower lock, such effects can be attributed to the flow of the spilled water as well as to the surface deposit on the river bed.

The effect of the water flow on the upper lock could be eliminated by installing a training wall for navigation. Attention should therefore be given to the location of the lower lock.

The test revealed that the flow velocity around the lower lock and its downstre right bank was not so high, but on the contrary counter-flow was observed. The wave-height in these sections of the stream was about 60 cm. In so far as the flow velocity and wave-height are concerned, the proposed location of the lower lock would not have to be changed.

6-4 Water Level and Flow Velocity When Cofferdam is Constructed

The condition of flow of the water from the diversion channel at the last stage of the cofferdam construction was reviewed on the basis of the records of water level and flow velocity.

From the chart showing upstream water level and discharge at the time of cofferd construction, the upstream water level corresponding to the elevation of the basement of the opening (EL 4.00 - 14.00 m) was clarified. If the basement of the opening exceeds EL 11.00 m, the discharge of less than 4,500 m^3/s would run through the diversion channel. If the basement of the opening is EL 4.00 m, the water level upstream of the cofferdam almost corresponds to the downstream water level. In case of EL 6.50 m and 9.00 m, the water level upstream of the cofferdam, as compared with the downstream level, shows an increase of 1.4 m and 2.0 m respectively. Difference in the water level after placing the cofferdam is about 1.8 m, 2.5 m and 2.9 m respectively for 2,500 m^3/s, 3,500 m^3/s and 4,500 m^3/s. These figures have been computed on the assumption that the coffering materials are entirely impermeable, and are therefore safe figures in placing the cofferdam. Further, it is reported in various data and materials relative to cofferdams that the coffering is possible when based on figures given above. It is therefore considered that the proposed construction is justifiable. When the cofferdam is actually to be constructed, however, studies should be made on designs relating to the coffering works inclusive of the proposed date of coffering, probable discharge, selection of coffering materials etc.

7. Other Domestic Works

In addition to the afore-mentioned hydraulic model test and material tests, such other domestic works as study and analysis of data, rough planning, a few preliminary designs were made based on the results obtained by the field investigations in FY 1962 as well as on materials relating to geology, topography and hydrology which had been made available by Australia, Canada, U.S.A. and other countries. Since the results of such domestic works were found needful of further studies and review, items with brief explanation are given in this report.

7-1 Review and Analysis of Hydrological Data, and Hydraulic Computation

Based on the hydrological surveys conducted in 1958 by Harza Engineering Co., U.S.A. and their final report as well as on the results of the supplementary surveys conducted by the Team on water level, evaporation and precipitation between the dam site and Kratie, study and analysis were made on hydrological and hydraulic data in relation to items given hereunder for the planning of Sambor Project.

(a) Preparation of Discharge-Duration Curve and Rating Curve at Kratie

Discharge curve at Kratie Gauging Station for 1960 and 1961 was prepared utilizing data of Harza Engineering Co., and the rating curve at the dam site was prepared on the basis of the recording of the water level conducted by the Team between Kratie and the dam site.

(b) Review of Estimated Flood Volume at Dam Site

On the basis of Harza Engineering Co.'s data complete for 24 years (1934 - 1961) recorded at Kratie Gauging Station, the estimated volume at the dam site was reviewed. Statistical study was made in some measure utilizing data on Vientiane, Stung Treng, etc. since the flood volumes actually recorded are available only for 3 years from 1959 - 1961.

(c) Preparation of Discharge Mass Curve at Vientiane and Kratie Gauging Stations

In order to review the plan for resevoir operation and the final plan for Sambor Project, discharge mass charts at Vientiane and Kratie and mass charts of residual discharge between Vientiane - Kratie and Stung Treng - Kratie were prepared by means of I.B.M. and the mass curves for them were also prepared.

(d) Review of Spillway Capacity

Hydraulic computation was made relative to the capacity.

(e) Computation of the Resevoir Back Water

Aerial map (1/20,000) and topographical map (1/250,000) presently available were utilized in computing the back water in an effort to confirm the back water condition upstream of the resevoir after its construction, particularly around Stung Treng.

(f) Review of Operation Plan of Resevoir

In order to review the discharge duration of the Mekong at the first and last stages of Sambor Project, study was made in connection with the operation of the resevoir at Pa Mong, Stung Treng and Sambor utilizing hydrological data of Harza Engineering Co. and the above-mentioned data which are the outcome of domestic works.

7-2 Calculation of Electricity to be Generated

On the basis of the hydrological data of Harza Engineering Co. and of the rating curve at the dam site mentioned in 7-1 (a) above, calculation was made for the electricity to be generated at the first stage of Sambor Project.

7-3 Crude Analysis and a Few Preliminary Designs

(a) Review of Rough Layout of Each Alternative Line, Particularly in Relation to Line Ⓒ' Plan

(b) A Few Preliminary Designs

Computation and review were made in relation to the dam, intake, water turbines of power house, capacity of generators, electrical apparatus, installation of machines and equipment, capacity of the diversion channel, coffering method for the main stream of the Mekong, and the structure of the navigating channel.

7-4 Estimation of Construction Cost

In order to obtain the general idea about the feasibility of the Project, rough computation of the quantity of construction work, review of unit cost, and rough estimation of the construction cost were made based on the layout given in 7-3 (a) above.

III. INLAND NAVIGATION

1. DOMESTIC TRANSPORT SYSTEM IN CAMBODIA

2. WATERWAY TRANSPORT ON THE MAIN STREAM OF THE MEKONG

III INLAND NAVIGATION

The second phase field investigations on inland navigation in regard to the Sambor Project for the development of the Mekong were conducted from Aug. 24th to Sept. 11th, during the wet season, with particular reference to the study of present facilites and flow of traffic.

1. Domestic Transport System in Cambodia

   1-1 Outline of the Transport System

   Goods transported to and from various centers in the country of Cambodia include agricultural products, livestock, forestry output, fish products, food commodities, daily commodities, and construction material, of which agricultural products occupy the larger part. Excluding domestic consumption in the production areas, local products are collected in their respective districts and sent forward to the urban districts, either in the original state, or upon some primary process of manufacturing. The main consumption centers are Phnom-Penh, the capital, and local towns in the various districts. Of these products, those to be exported to foreign countries are shipped largely from the port of Phnom-Penh, and partly from the ports of Sihanoukville and Kompong Cham. Different from the local products, food commodities, daily commodities, and construction material generally take a reverse course but the majority is consumed in urban districts, and the amount transported to rural districts may be considered to be of a relatively small portion.

   As means of transporting these goods to and from various centers, trucks, buses, three wheelers, and trains are used on land, as well as ox-carts and rams for short distance conveyance, while transport vessels, barges, rafts and ferry boats are active on waterways. The method of transporting various cargo depends on the type of cargo, and varies according to the district. Different types of cargo such as bulk cargo, heavy cargo, fresh products, valuable goods are handled by different transportation facilities. The transport system in areas around the main stream of the Mekong differs considerably from the network in areas around the Grand Lac and the south-west district of the country.

Transportation of passengers is handled by transport vessels and ferry boats on waterways, and buses, trucks, three wheelers, automobiles, and trains on overland routes, with rams and bicycles serving short distance transport in the rural districts.

As the transport system in areas along the main stream of the Mekong differs from that in other areas, passenger traffic depends on different transportation facilities.

1-2 Transportation of Various Cargo

Generally, waterway transport of cargo is more economical and secure than highway or railway transport, but certain types of cargo depend largely on overland transport.

Bulk cargo such as rice, corn and wheat, and heavy cargo such as iron, cement and timber depend on waterway transport where available, particularly in the case of long distance transportation.

Cargo liable to be damaged such as charcoal and chinaware are also transported by river routes. These goods are transported collectively by barges in most cases, and occasionally by vessels as well. However, even in the case of these goods, overland transport is often preferred as it offers a direct route between production and storage centers.

As most agricultural products are sent out in quantity in periods immediately after the respective harvests, the type of cargo loaded on trucks and barges varies considerably according to the month of the year, with convenience of direct communication with storages, markets and general consumers. Overland transport is favored for the transportation of fresh fish and vegetables demanding rapid transport, valuable daily commodities of small size as well as goods in small quantity. Imported goods also take advantage of direct communication by overland routes.

1-3 Transportation Facilities in Various Districts

Products of basic industries are generally collected from the producing areas to the urban centers in rural districts, from where a large portion is further transported to Phnom-Penh. Processed food stuffs and beverages, clothing, machinery, household articles, and construction material take a reverse course, from the urban centers to the rural districts.

In respect to the transport network, the country may be largely divided into the south-west district, the district around the Grand Lac, and the district along the main stream of the Mekong.

1-3-1 The South-West District

With hardly any navigable rivers in the district, the majority of cargo depend on highway transport by means of trucks, buses and three wheelers.

1-3-2 The Grand Lac District

Numerous tributaries flow into the Grand Lac, and the Grand Lac and the Mekong are connected by the Tonle Sap providing a network of waterway transport for a considerable amount of cargo in this district. However, inland navigation has not been so developed in this district as in areas along the main stream of the Mekong, and relatively heavy traffic is observed on overland routes. Though accurate statistics are not available for the present traffic flow, on the whole, overland transport probably exceeds waterway transport in volume. The following factors may be responsible for this situation.

(a) The features of the river in the section between Chhnok Trou and Kompong Chhnang at the outlet of the Grand Lac are quite variable, and particularly around Chhnok Trou the water is shallow with a depth of less than 1 m in the dry season, cutting off the Grand Lac and the Tonle Sap during this period.

(b) In the Grand Lac, as the bottom is undulated and the average depth of water is relatively shallow, navigation on the lake is confronted with difficulty in the dry season.

(c) The water level in the Grand Lac rises in the wet season with the inflow from the tributaries and the reverse flow from the Tonle Sap, accompanying a considerable expansion of the water surface. In contrast to the active inland navigation in the upper and lower reaches of the tributaries, waterway transport from one tributary to another, or the Tonle Sap, through the Grand Lac is seldom observed, even in the wet season. This may be attributed to the fact that the lower reaches of the river are of a variable nature with a river bed of a moderate slope following a sinuous course, dangerous for the navigation of vessels which may easily lose track of the navigable channel.

In the Grand Lac district, even in the wet season, inland navigation over a long distance is quite scarce, but in the tributaries, numerous small barges and vessels convey passengers and cargo up and down the rivers as means of communication between districts in the upper and lower reaches. Along the Tonle Sap River, downstream from Kompong Chhnang, the abundant water and sufficient depth of the river provide favorable conditions for waterway transport, and regular lines operate in six directions with Kompong Chhnang as the traffic center.

In the district on the north-east coast of the Grand Lac, a trunk highway serves as the long distance transport route of the district, while in the south-east district a trunk highway and railroad truck run roughly parallel to each other, playing important roles in the development of domestic industries.

1-3-3 Districts along the main stream of the Mekong

In the districts along the main stream of the Mekong, contrary to the other two districts, the Mekong plays the chief role in the transport system, and the transportation of various cargo and passenger traffic depend largely on the river navigation of the Mekong.

As the main highway deviates from the river course to escape the influence of overflow and inundation from the Mekong, the river route is of considerably shorter distance than the overland route.

Comparatively heavy traffic takes advantage of overland routes up to Kompong Cham, but in the section between Kompong Cham and Kratie, overland transport decreases considerably, with an extremely small traffic flow in areas further north from Kratie.

Agricultural products produced in areas at some distance from the banks of the Mekong are conveyed to urban centers along the river by means of ox-carts, three wheelers and trucks. The goods are collected in these centers and loaded on barges or shipped on transport vessels when the amount of products assembled does not call for particular barges. Transportation of cargo over a long distance, therefore, often takes the form of (overland transport + waterway transport).

Goods are transported to Phnom-Penh over routes connecting highway and waterway transport or direct highway routes, and a distance of approximately 50 - 60 km is considered to be the longest limit of distance for the transport of goods. However, as connecting roads leading to junctions on the river banks are not well developed, the choice of adequate transportation facilities varies according to the area and the season of the year.

1-4 Domestic Transport Vehicles

Vehicles registered with the authorities in Cambodia are as listed in Table 1-4.

Table 1-4 Number of Registered Vehicles

	1960	1961	1962	June 1963
Automobiles	10,198	11,625	13,416	14,433
Trucks (including small trucks)	6,223	6,924	7,410	7,621
Buses	542	611	674	700
Motor cycles & scooters	5,318	6,509	8,476	9,362
Motor bicycles	24,519	29,009	33,610	36,166

1-5 Domestic Transport Vessels

Vessels registered with the Authorities in Cambodia are as listed Table 1-5(a).

Table 1-5(a) Number of Registered Vessels

	1960		1961		1962	
	No.	tons	No.	tons	No.	tons
Junks over 16 tons	2,268	111,726	2,279	112,315	2,281	112,261
Steel barges	23	4,455	27	4,982	29	5,007
Steam boats	138	6,306	138	6,306	138	6,306
Self-propelled barges	7	167	7	167	9	209
Motor boats and others	511	4,768	556	5,995	581	6,145

The dimensions of typical transport vessels among those registered are given in Table 1-5(b).

Table 1-5(b) Dimensions of Vessels

Registration Number	Tonnage	Length m	Width m	Draught m	Free Board m
HF 2748 PP	300	39.45	7.91	3.70	1.0
HF 3024 PP	250	38.66	7.91	3.05	1.15
HF 1266 PP	122	32.50	6.60	2.75	0.95
HF 3208 PP	111.5	31.91	6.26	2.75	0.85
HF 1524 PP	52	28.26	5.12	1.70	0.75
HF 3572 PP	10.3	15.45	3.23	0.90	0.40

The majority of transport vessels in operation are of 50 - 100 tons, and small boats of less than 50 tons are engaged in short distance conveyance.

A far greater number of transport vessels of larger dimensions navigate the main stream of the Mekong as compared to the River Tonle Sap.

1-6 Overland Transport Costs

Approximate figures for cargo freight and passenger fare obtained from business firms engaged in the operation of bus lines and cargo transportation in Phnom-Penh are given in Table 1-6.

Table 1-6 Overland Transport Costs

Course		Bus			Truck
		passenger Fare	Freight for 1 - 100kg bag of rice	No. of trips per day	5 - 7 tons
Phnom-Penh	- Kompong Cham	50 R/per passenger	15 - 20 R/per bag	8	500 R/ton
"	- Kratie	120	40	2 - 3	6,000 R/per truck
"	- Neak Luong	20	15 - 20	20	
"	- Kompong Thom	60	20		5,000
"	- Siem Reap	120	40	8 - 9	6,000
"	- Svay Rieng	40	15	10	5,000
"	- Battambang	80 - 90	40	8	6,000
"	- Pursat	60			
"	- Takeo			15	
"	- Preg Veng			5	
"	- Kampot	40			

Note: R indicates Riel, the local currency.

In regard to the above freight and fare, the Travaux Publics, the ministry for public works and civil engineering of the Cambodian government gives the explanation that the standard rate for passenger fare is 0.5 Riel/km per passenger, and cargo freight for truck loads is 1.8 Riel/km per ton, but the charge is subject to change according to the distance involved.

2. Waterway Transport on the main stream of the Mekong

In districts along the Mekong, the river serves as the great artery of transportation, with a far larger volume of traffic on the waterway than on the highways and railways on land.

Though an accurate and detailed account cannot be easily obtained, the results of investigation on the existing traffic related to the river will be given in the following paragraphs.

2-1 Transport Vessels

Transport vessels are operated by small enterprises possessing 3 - 6 vessels, and even the larger companies possess around ten vessels. Therefore, the number of enterprises run into a large number, rendering it extremely difficult to gather correct information on all vessels engaged in domestic transportation particularly in regard to the number of vessels in operation. The number of vessels registered and the dimensions are as given in Table 1-5(a) and 1-5(b). The vessels are all of wooden structure between 100 - 150 tons, most of which are run by diesel engines with some boats run by engines with firewood as the fuel.

2-1-1 Navigating Routes and Time Required

Various companies operate vessels between different towns and the time required to navigate each course depends on the type of vessel, the season of the year, and the direction of the course in regard to the current of the river. Table 2-1-1 gives the approximate time required for vessels to navigate the respective courses on the river.

Table 2-1-1 Principal Lines of Transport Vessels

Course		Time Required		Note
		Journey downstream	Journey upstream	
Phnom-Penh	- Kompong Cham	6 - 9 hr.	9 - 10 hr.	Less time
"	- Kratie	12 - 14	14 - 16	required for
"	- Prek Po	3	4	night
"	- Krouchmar	8 - 10	15	navigation
Kompong Cham	- Kratie	7 - 9	11	
"	- Krouch mar	4	5	
"	- Chumnik	5	6	
"	- Prek Kak	3	4	
"	Prek Stek	2.5	3	
Neak Luong	- Border Line	14	15	

There are also numerous short distance courses with small boats in operation not included in Table 2-1-1. The time required for each course records a difference of 1 - 2 hours in the trips upstream and downstream due to the current velocity of the river, and a difference of 1 - 2 hours between the wet season and the dry season.

2-1-2 Arrival and Departure of Vessels

Table 2-1-2 shows the number of trips made by vessels leaving Kratie and Kompong Cham for various destinations. Compared to Kompong Chhnang on the Tonle Sap, with merely six routes, far more river routes are observed to be available between Kratie and Kompong Cham on the Mekong, with frequent arrival and departure of vessels.

Table 2-1-2 Arrival and Departure of Vessels

Kratie		Kompong Cham	
Destination	No. of trips	Destination	No. of trips
Phnom - Penh	2	Phnom-Penh	6
Kompong Cham	4	Kratie	4
Opposite bank of river	15 - 16	Krouchmar	1
		Chumnik	2
		Prek Po	1
		Chihe	2
		Other towns	4
Total	Approx. 20 - 25	Total	Approx. 20

2-1-3 Passenger Traffic

With numerous enterprises of small scale operating transport vessels, at the present stage, it is quite difficult to estimate the total number of passengers in the traffic flow. However, information gathered from representative operators shows a tendency of increase in the number of passengers handled, and in some cases the number has increased 1.5 - 3 times in the last five years. No marked difference may be observed in the traffic flow between the wet season and the dry season, though in some cases, the traffic increases somewhat in the dry season, and passengers crowd the vessels on holidays and the New Year season on the lunar calendar.

Though the number of passengers carried on one vessel depends on the size of vessel and the destination, small boats carry 20 - 50 passengers per day, and large vessels carry 150 - 300 passengers per day on a single trip. On the course between Phnom-Penh and Kratie, vessels of 60 - 100 tons convey 200 - 300 passengers per day on a single vessel, and between Phnom Penh and Kompong Cham, vessels of 50 tons convey 150 - 200 passengers per day on a single vessel.

2-1-4 Cargo Transportation

Cargo depending on transportation by transport vessels are of much smaller quantity but of a greater variety as compared to cargo conveyed by barges.

Vessels convey rice, wheat, rubber, corn, kapoc, bananas and fruits on the journey downstream, and processed foodstuffs and beverages, daily commodities, construction material and machinery parts on the journey upstream. Generally there is more cargo transport in the dry season than in the wet season.

Though the figures cannot be ascertained, these vessels reportedly convey around 3 - 5 tons per day on one vessel.

2-1-5 Transport Costs

Though a slight difference is observed among various shipping companies, the average cargo freight and passenger fares are as given in Table 2-1-5.

Table 2-1-5 Transport Costs

Course		Passenger Fare	Freight of 1-100kg package of rice or corn
Phnom-Penh	- Kompong Cham	20 R	3 - 6 R/per package
"	- Kratie	45	12 - 15
"	- Prek Po	10	
Kompong Cham	- Kratie	30	
"	- Krouchmar	10	Note: R indicates Riel
"	- Chumnik	15	
"	- Prek Kak	10	
"	- Prek Stek	12	

Between Phnom-Penh and Kratie freight charge for steel bars is about 220 R/ton, and about 250 - 300 R/ton for dry goods, while between Phnom-Penh and Kompong Cham, the charge is about 100 R/ton for steel bars and 150 R/ton for dry goods.

Comparing Tables 2-1-5 and 1-6, waterway transport costs are 1/2 - 1/3 of overland transport costs, and proves to be obviously cheaper.

2-1-6 Navigation in the Upper Reaches beyond Kratic

At present, regular lines for transport vessels have not been developed in the upper reaches of the river beyond Kratie. During the dry season, the water level falls and numerous islands and sand bars accumulate in the river. The current is divided into a branch-like form, running a sinuous course, and shoals protrude above the water surface, prohibiting the safe navigation of vessels.

Between Kratie and Stung Treng, a depth of over 10 m is maintained over a relatively long distance even during the dry season, but shallow spots are found at intervals. According to investigations made by Mr. Dooleage, spots of particular danger are found in sections around the Sambor Rapids, the narrow channel around Kas Pring, approximately 60 - 75 km from Kratie, and around the numerous small islands in the vicinities of Kas Senha and Kas Preas, approximately 100 - 115 km from Kratie.

On the other hand, though the water level rises during the wet season, rocks and fallen trees are found scattered on the bottom of the river, and the current being quite swift, difficulty in steering vessels accounts for the scarcity of traffic in these waters.

Considered from the economic point of view, the stretches upstream from Kratie are located far from the center of the country, with industries of small scale producing agricultural and forest products which do not amount to any substantial quantity. With a small population, the area is one of the districts in Cambodia which have not yet been much developed, without any appreciable more of cargo to call for the opening of regular lines of inland navigation.

Under such unfavorable natural conditions and economic background, the traffic flow merely consists of timber rafts and barges occasionally observed in these waters.

2-2 Timber Rafts

Timber logs are cut down in the deep forests, assembled near the tracks, and conveyed to the river banks by means of trailers, where they are fastened into rafts on a bamboo float, and carried down the river to Phnom-Penh. The logs are rafted at Se Kong, Se San in the upper stream, Stung Treng, Kratie and Tonle Bet, and trailers move toward these rafting centers, choosing the most economical routes.

The logs are of 60 - 140 cm in diameter, and cut in lengths of 7 - 12 meters for the convenience of transport by trailers and rafts. The volume of one log is 2 - 5 m^3. As the logs will not float on water due to their large specific gravity, bamboo poles are used to give buoyancy to the rafts. Logs are fastened into a platform 8 - 12 m in width and 10 - 15 m in length, and several platforms are further joined into fleets with total lengths of 50 - 90 m.

Rafts are floated down the river taking advantage of the river current as far as possible, but in the lower reaches of the river where the velocity of the current is very slow, or in the dry season, the rafts are towed with the aid of tug boats. Therefore, on the whole, the wet season is preferred for the flow of rafts down the river, while the dry season is more preferable for the chopping of trees in the forests.

Particularly in the upper reaches beyond Kratie, rafts are flowed down the river in the wet season, as the lack of sufficient water depths and the presence of obstacles to navigation in the river impose difficulties on the flow of rafts in the dry season.

The section between Siem Pang and Stung Treng, and Stung Treng and Kratie can be covered in one day, and the section between Kratie and Phnom-Penh is a two day course for the transport of rafts, but due to inspections on the way, actually a longer period is required.

2-3 Barges for the Transport of Charcoal

Barges carrying charcoal down the Mekong mostly load the cargo around Kratie and Krouchmar. Long distance transport of charcoal by trucks is seldom found in the Mekong basin, but in the south-west district, charcoal of superior quality is conveyed from the Kompong Som Bay district, the producing center, to Phnom-Penh, overland by trucks.

The barges, made of wood, are of about 50 - 100 tons, and the fleet makes a total of 50 - 60 trips a month to Phnom-Penh on the average.

Trucks capable of loading approximately 7 tons, carry about 70 bundles (each bundle weighing about 100 kg) of charcoal on one trip. Small barges carry 7 - 10 truck loads, while large vessels carry about 12 truck loads of charcoal. The barges are mostly non-propelling boats, and are tugged in tow in a group of 4 - 10 boats.

The majority of the barges are bound for Phnom-Penh with a freight charge of about 100 Riel per ton. The transport cost of a barge loaded with 70 tons of charcoal amounts to approximately 7,000 Riel, including the towing charge.

As 60 kg of charcoal is sold for 70 - 80 Riel in Kratie, and 100 Riel in Phnom Penh, the transport cost occupies about 6 % (about 6 Riel) of the selling price of charcoal in Phnom-Penh.

2-4 Barges for the Transport of Corn

Corn is widely cultivated in the Mekong main stream basin and ranks next to rice in agricultural production. It is cultivated mostly in the wet season from April to August, but in some areas they are grown from November to March. Hence, corn is carried out mostly during the period from August to October, the traffic being most active in the month of September.

Corn is loaded on barges in areas around Kratie and Kompong Cham, and carried to Phnom-Penh, or in areas around Neak Luong whence the barges run upstream often using the River Bassac as the transport route.

Excluding domestic consumption in the producing centers and rural towns, corn is collected in Phnom-Penh, and exported to foreign countries mostly in the months of August and September.

2-5 Kapoc

Kapoc is cultivated throughout the country and the harvest is reaped at the end of the dry season. The seeds are treated to obtain fibers and prepared for shipping around the month of August. Barges for the transport of Kapoc load approximately 400 packages of kapoc each weighing about 20 - 30 kg.

Along the Mekong River, kapoc is shipped mostly from the vicinity of Kompong Cham, and the transport cost from Kompong Cham to Phnom-Penh is approximately 10 Riel per package.

IV. POWER MARKET SURVEY

IV. Power Market Survey

The power market survey was not conducted in FY 1963. However, important data and materials collected during the field survey in FY 1962 were selected, translated and compiled.

Data and materials thus processed can be broadly classified into the following 2 groups.

(1) Data and materials relative to the present situation of, and outlock for, the supply and demand of electric power in Cambodia, Viet-Nam and Laos.

(2) Data relative to concessions for distribution of electricity by power companies in the above 4 countries.

(3) Data relative to electric rates in force in the above 4 countries.

Further, the following reviews were made in FY 1963 in addition to the compilation of data and materials.

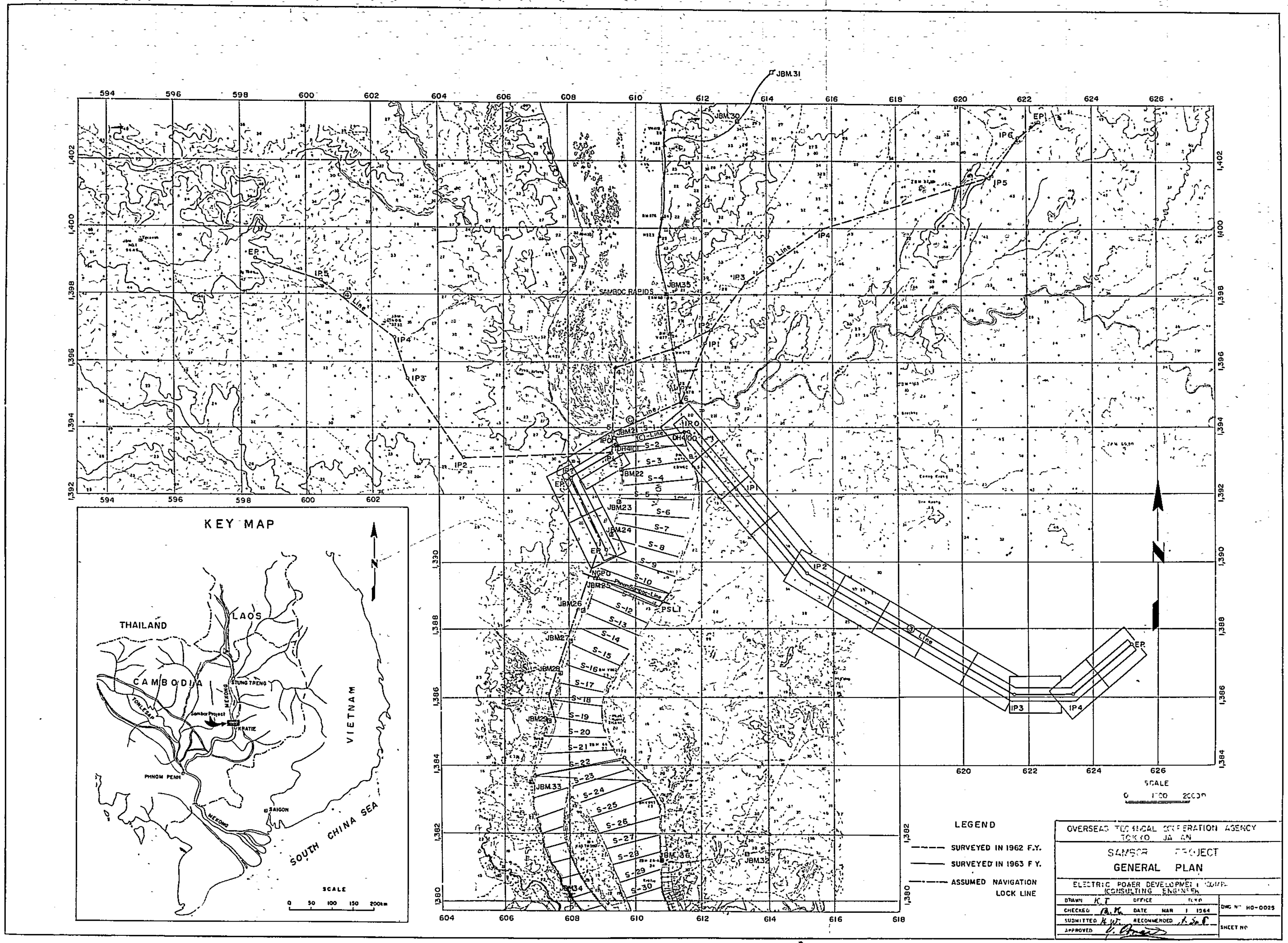
(1) Review of Methods for Assuming Long-Term Supply-Demand Situation

There are various methods by which to assume, over a long term, the supply-demand situation of electric power in developing countries.

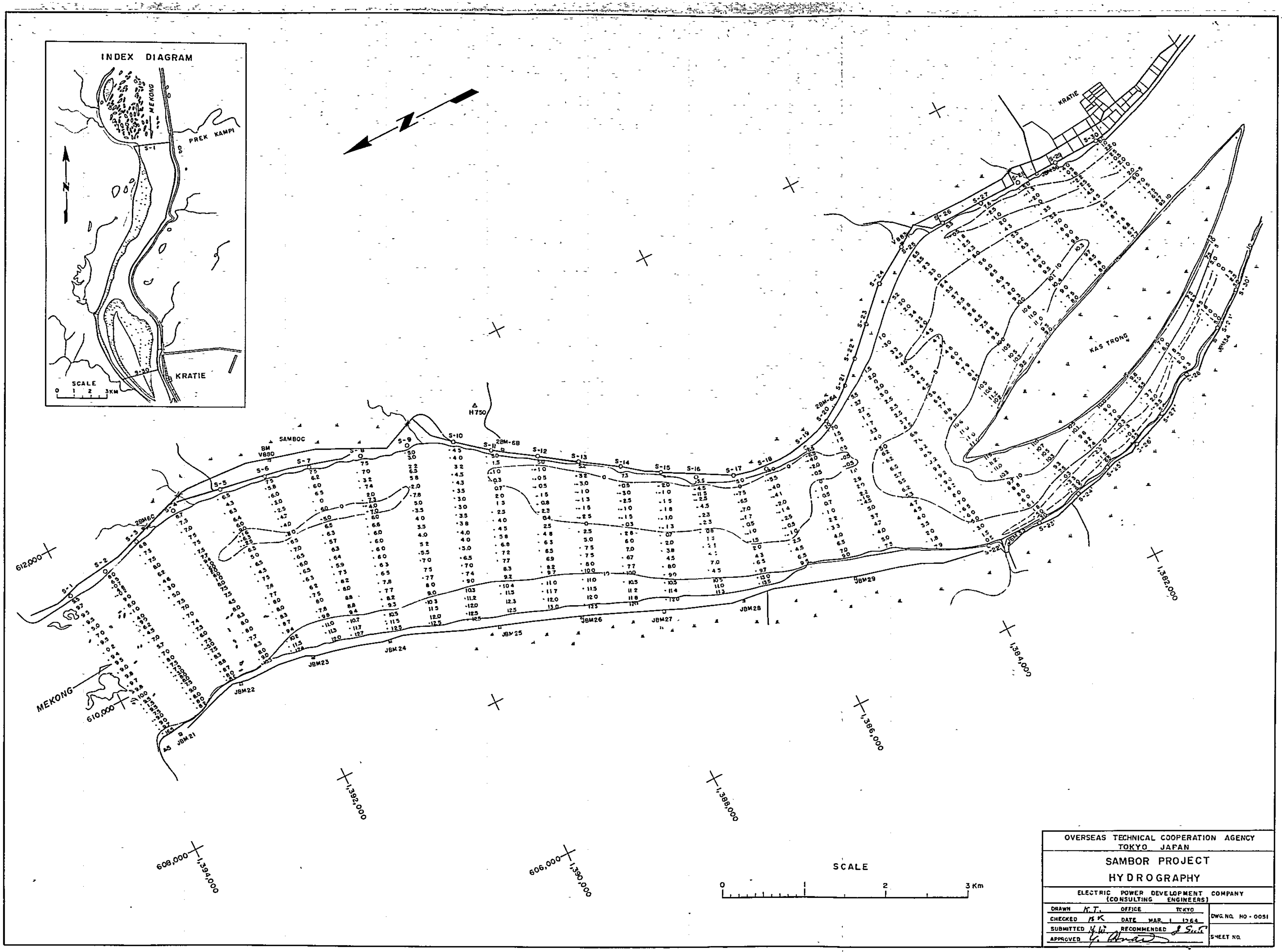
As regards the market survey relating to the Sambor Project, it is rather difficult to determine at present which method should be adopted as the major means of assuming the long-term supply-demand situation. It is intended, however, that the assumption will be reached on the basis of reviews and comparisons among as many different methods as possible.

(2) Basic Study Relating to Conditions for Establishing Heavy Electric Consuming Industries

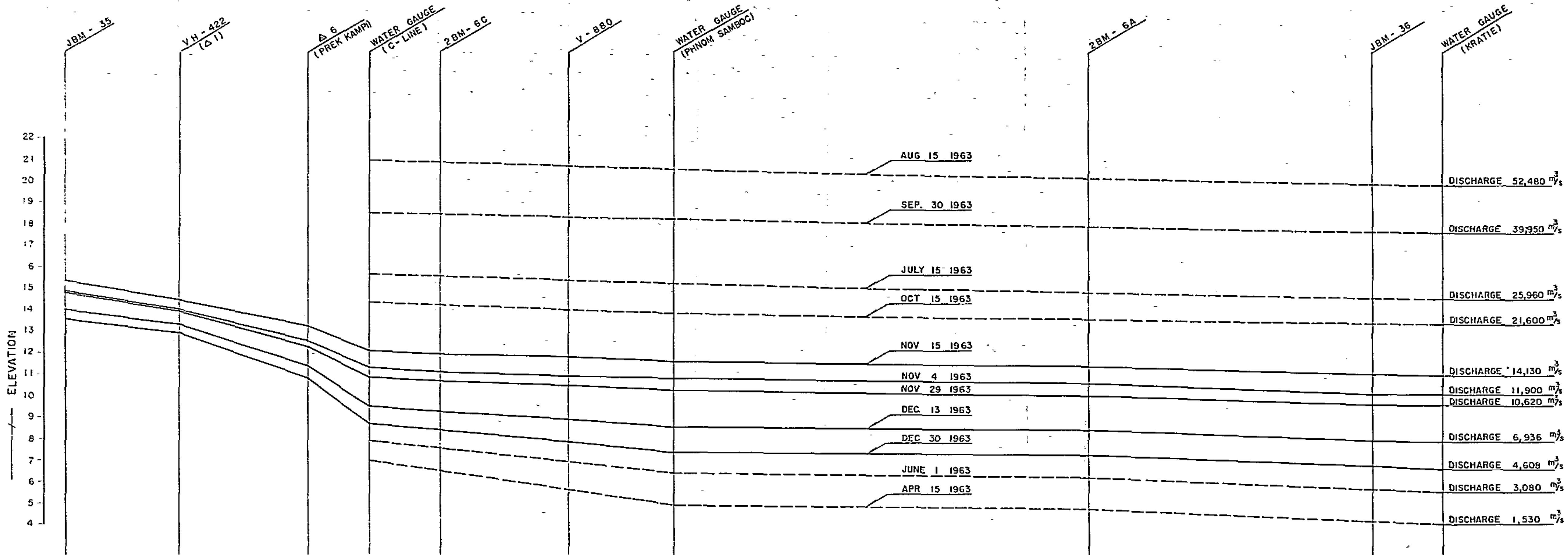
With regard to the selection of industries desired to be established for the purpose of consuming the electric power to be made available by the Sambor Project, no final decision has been made due to the fact that the quantity and quality of the electricity required by such industries are not yet clarified. However, studies were made tentatively relative to the general conditions for establishing such industries as electrolytic aluminium industry, vinyl chloride industry, carbide industry, carbide-acetylene chemical industry, and ferro-alloy industry.



KEY MAP
THAILAND
LAOS
CAMBODIA
VIETNAM
SOUTH CHINA SEA
MEKONG
TONLESAP
STUNG TRENG
KRATIE
PHNOM PENH
SAIGON
Sambor Project
SAMBOR RAPIDS
LEGEND
SURVEYED IN 1962 F.Y.
SURVEYED IN 1963 F.Y.
ASSUMED NAVIGATION LOCK LINE
SCALE
GENERAL PLAN
DATE MAR 1 1964
DWG No HO-0025



OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN		
SAMBOR PROJECT HYDROGRAPHY		
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)		
DRAWN K.T.	OFFICE TOKYO	DWG. NO. HO-0051
CHECKED	DATE MAR. 1 1964	
SUBMITTED	RECOMMENDED	
APPROVED		SHEET NO.



		1	2	3	4	5	6	7	8	9	10
EL 1963 (m)	12-30	13.54	12.94	10.79	8.69	8.40	7.85	7.34	7.23	6.72	6.55
	12-13	14.02	13.37		9.50	9.27	8.89	8.54	8.40	7.91	7.86
	11-29	14.79	13.94		10.86	10.67	10.48	10.23	10.01	9.60	9.54
	11-15	15.37	14.45		12.09	11.93	11.81	11.60	11.38	11.00	10.93
	11-4	14.85	14.00	12.57	11.28		10.93	10.80			10.07
TOTAL DISTANCE (Km)		-4.26	-2.66	-0.85	0	1.00	2.80	4.30	10.18	14.18	15.18
DISTANCE (Km)		-1.60	-1.81	-0.85	0	1.00	1.80	1.50	5.88	4.00	1.00
NO		1	2	3	4	5	6	7	8	9	10

LEGEND

- - - - - Observation by Water gauge
——— Observation in Nov & Dec. 1963

SCALE

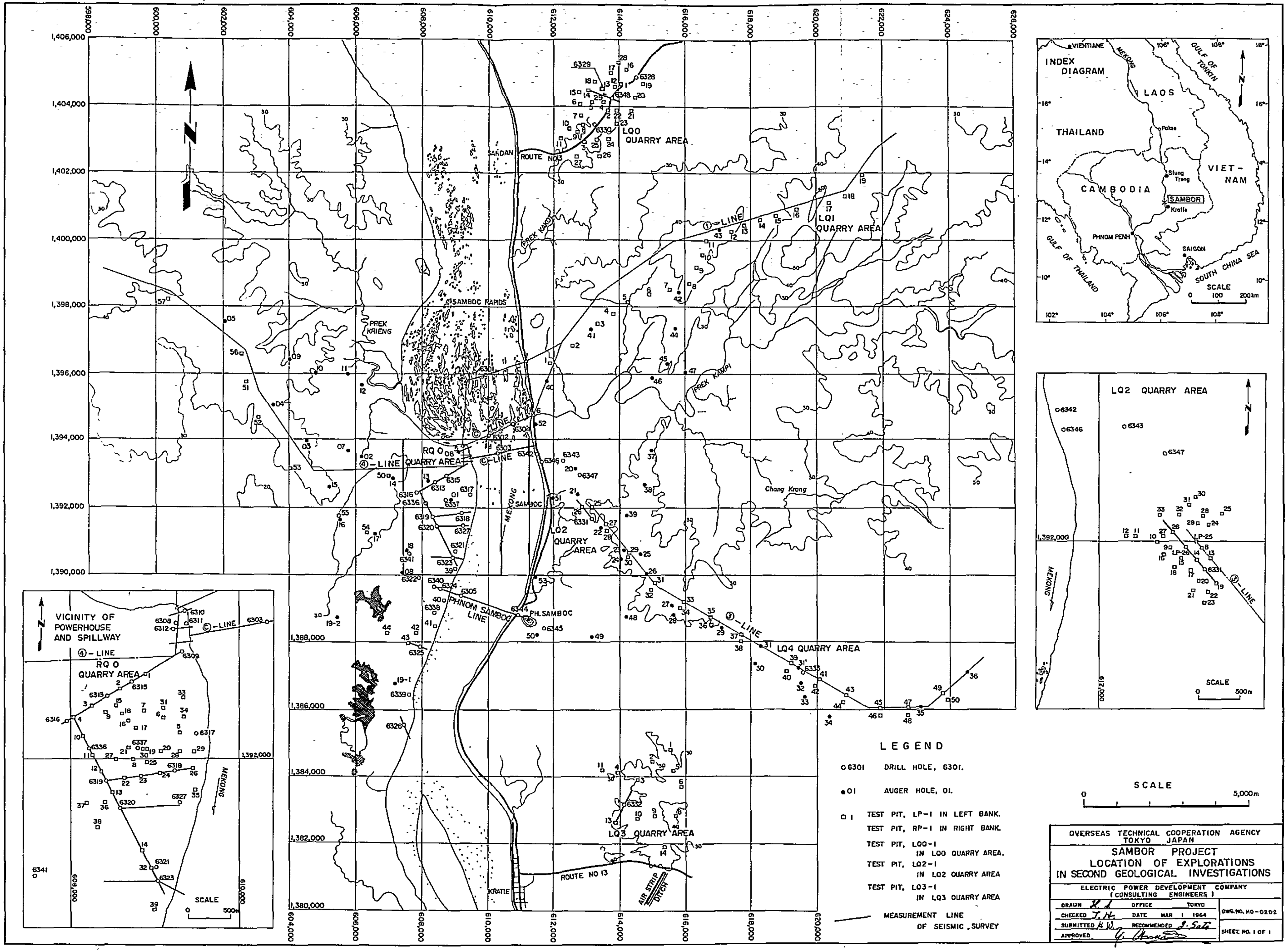
0 1000 2000 3000 4000 m

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
PROFILE OF MEKONG RIVER (SAMBOR-KRATIE)

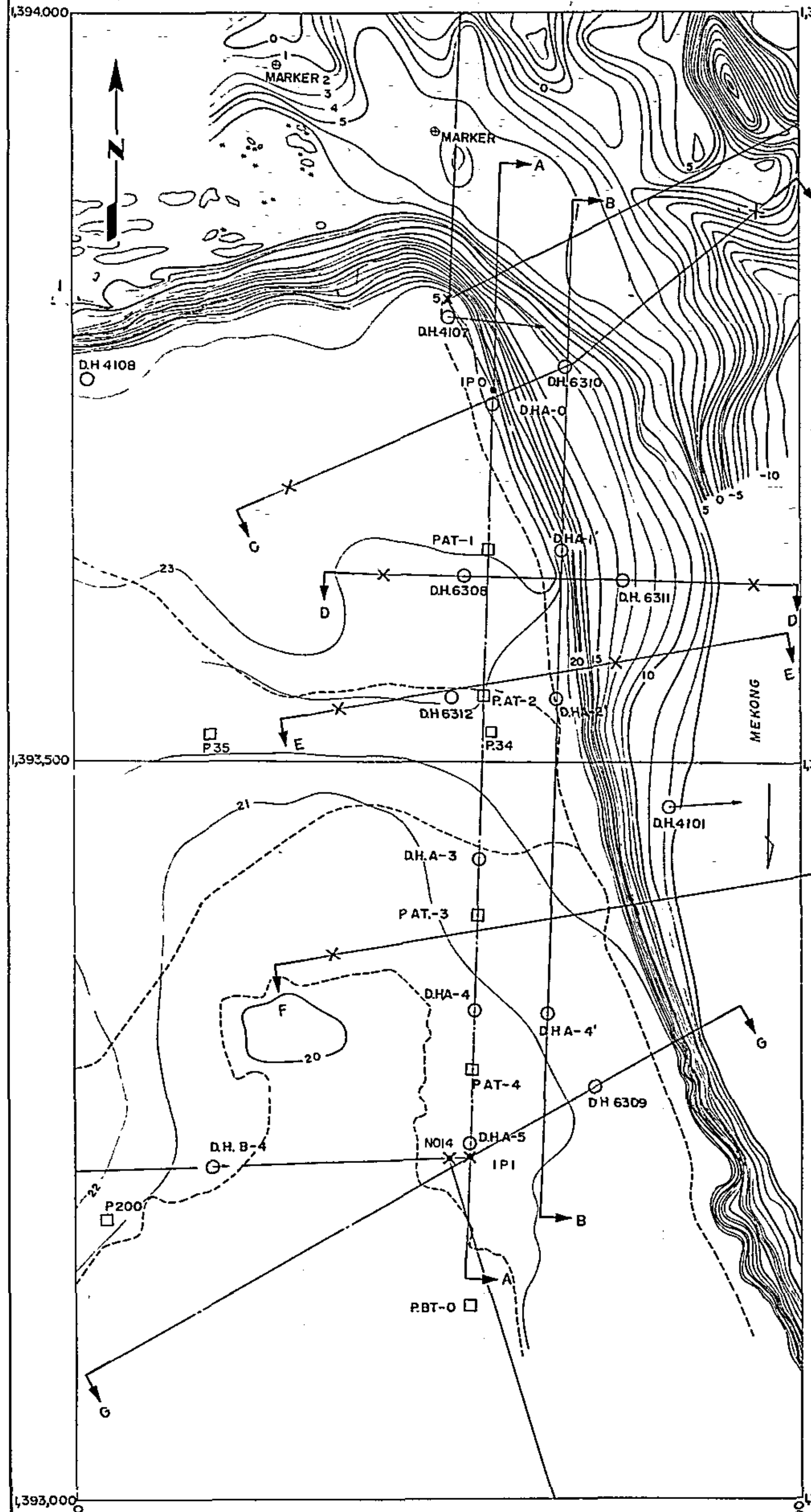
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN K. T	OFFICE TOKYO	DWG. NO HO-0028	
CHECKED B.	DATE MAR 1 1964		
SUBMITTED K.W.	RECOMMENDED I.S.		
APPROVED Y.		SHEET NO.	

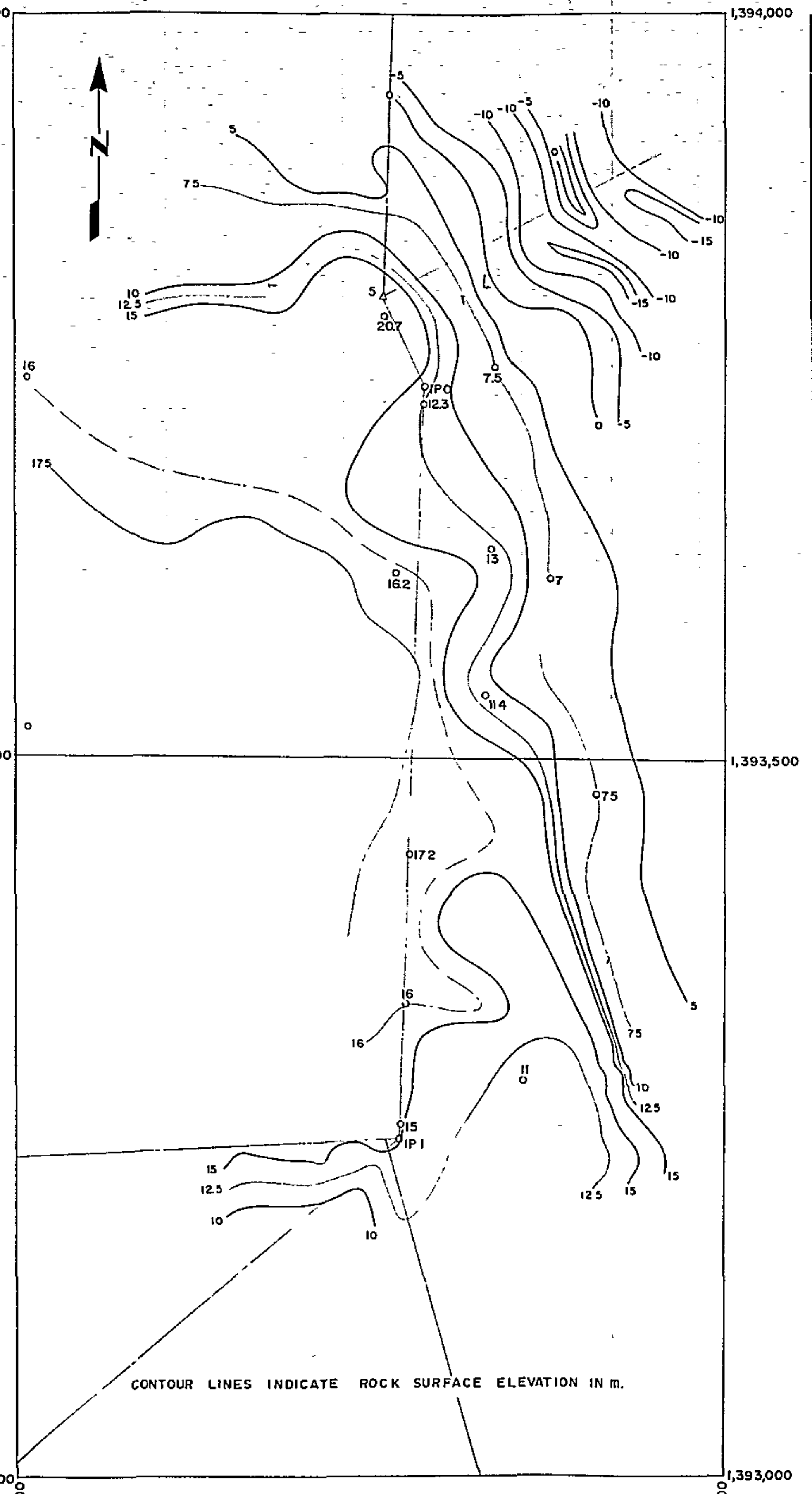


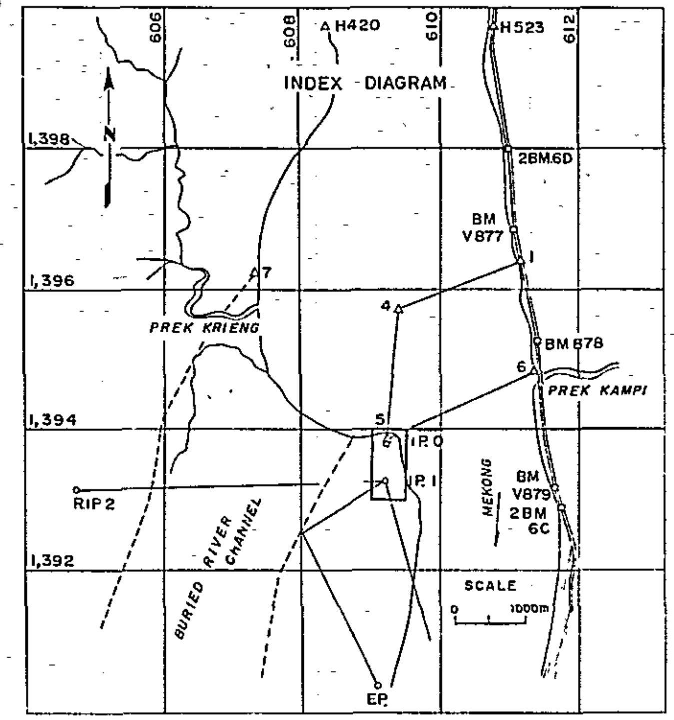
INDEX DIAGRAM
VIENTIANE
MEKONG
GULF OF TONKIN
LAOS
THAILAND
Pakse
CAMBODIA
Stung Treng
VIET-NAM
SAMBOR
Kratie
PHNOM PENH
GULF OF THAILAND
SAIGON
SOUTH CHINA SEA
SCALE
0 100 200km
LQ2 QUARRY AREA
MEKONG
LP-25
LP-26
SCALE 0 500m
VICINITY OF POWERHOUSE AND SPILLWAY
④-LINE
Ⓒ-LINE
RQ O QUARRY AREA
MEKONG
SCALE 0 500m
LQO QUARRY AREA
SANDAN
ROUTE NO13
PREK KAKOT
①-LINE
LQI QUARRY AREA
SAMBOC RAPIDS
PREK KRIENG
PREK KAMPI
Ⓒ-LINE
RQ O QUARRY AREA
④-LINE
SAMBOC
Chang Krong
LQ2 QUARRY AREA
PHNOM SAMBOC LINE
PH. SAMBOC
③-LINE
LQ4 QUARRY AREA
LQ3 QUARRY AREA
ROUTE NO 13
AIR STRIP DITCH
KRATIE
LEGEND
○6301 DRILL HOLE, 6301.
●01 AUGER HOLE, 01.
□1 TEST PIT, LP-1 IN LEFT BANK.
TEST PIT, RP-1 IN RIGHT BANK.
TEST PIT, LQ0-1 IN LQO QUARRY AREA.
TEST PIT, LQ2-1 IN LQ2 QUARRY AREA
TEST PIT, LQ3-1 IN LQ3 QUARRY AREA
MEASUREMENT LINE OF SEISMIC SURVEY
SCALE
0 5,000m
OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN
SAMBOR PROJECT
LOCATION OF EXPLORATIONS IN SECOND GEOLOGICAL INVESTIGATIONS
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)
DRAWN
OFFICE TOKYO
CHECKED
DATE MAR 1 1964
SUBMITTED
RECOMMENDED
APPROVED
DWG. NO. HO-0202
SHEET NO. 1 OF 1

LOCATION OF EXPLORATIONS



CONTOUR OF ROCK SURFACE





LEGEND

DH A-5 — VERTICAL DRILL HOLE, A-5

DH 4107 — INCLINED DRILL HOLE, 4107.

P.AT-4 — TEST PIT, AT-4.

MEASUREMENT LINE OF SEISMIC SURVEY.

A — A GEOLOGICAL SECTION, A-A.

SCALE

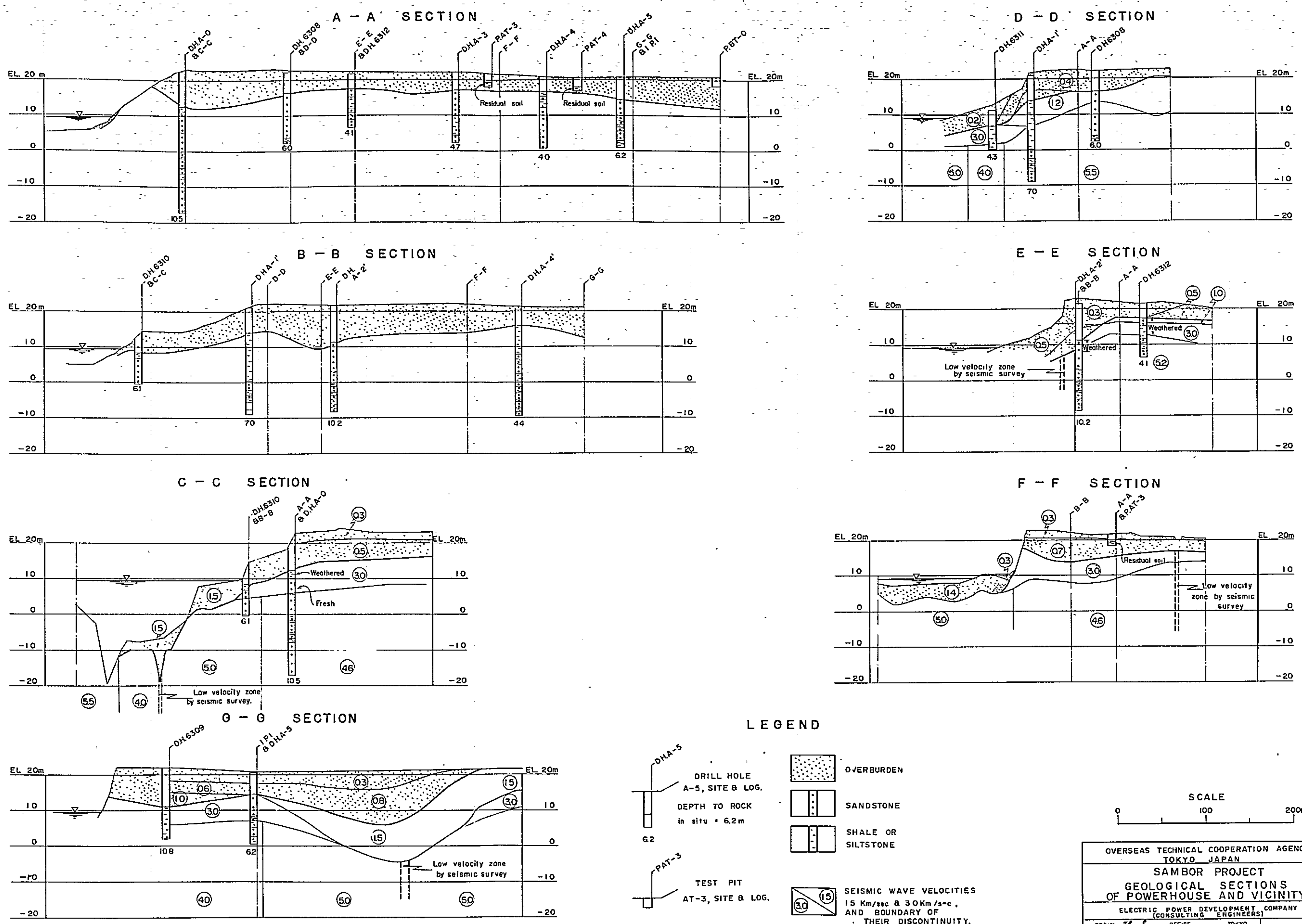
0 100 200 m

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
GEOLOGICAL MAP
OF POWERHOUSE AND VICINITY

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	K.S.	OFFICE	TOKYO	DWG NO HS-0232
CHECKED	J.H.	DATE	MAR 1 1964	
SUBMITTED	H.W.	RECOMMENDED	S. Sato	SHEET NO 1 OF 14
APPROVED	[signature]			



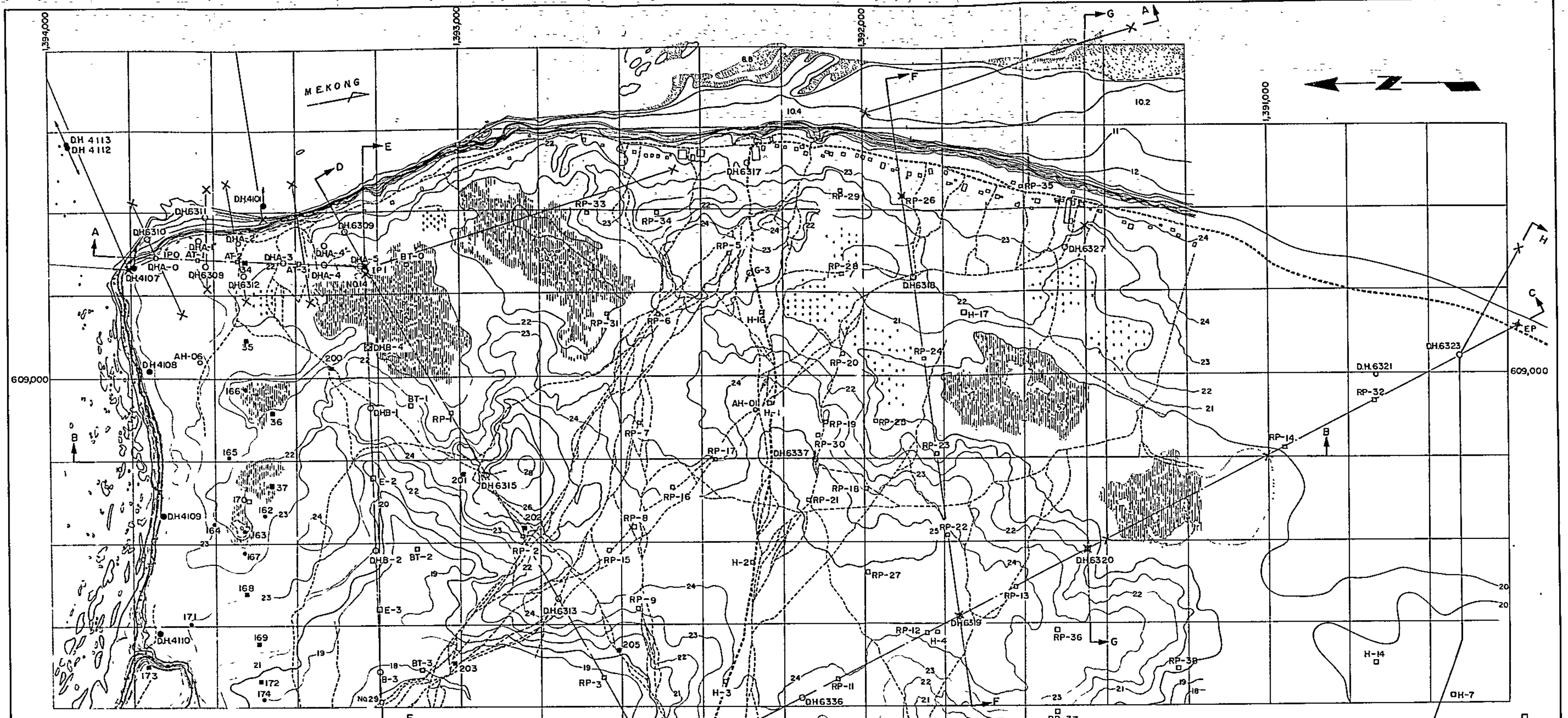
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

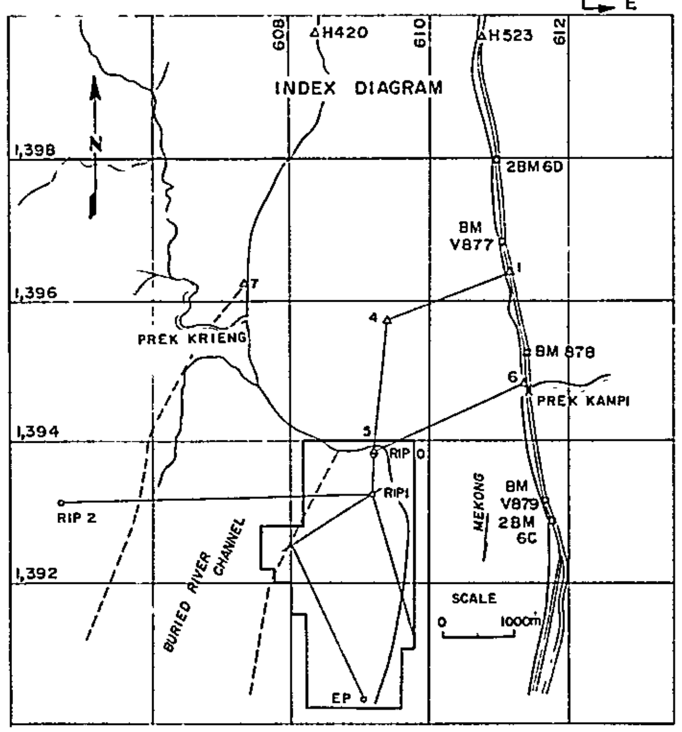
SAMBOR PROJECT

GEOLOGICAL SECTIONS OF POWERHOUSE AND VICINITY

ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)

DRAWN	OFFICE TOKYO		DWG. NO. HO-0232
CHECKED	DATE MAR 1 1964		
SUBMITTED	RECOMMENDED		SHEET NO. 2 OF 14
APPROVED			





LEGEND

○	VERTICAL AND INCLINED DRILL HOLE, in re JAPANESE TEAM.
●	VERTICAL AND INCLINED DRILL HOLE, in re AUSTRALIAN TEAM
∘	AUGER HOLE, in re JAPANESE TEAM.
•	AUGER HOLE, in re AUSTRALIAN TEAM.
□	TEST PIT, in re JAPANESE TEAM.
■	TEST PIT, in re AUSTRALIAN TEAM.
×—×	MEASUREMENT LINE OF SEISMIC SURVEY.
A — A	GEOLOGICAL SECTION, A — A.

SCALE

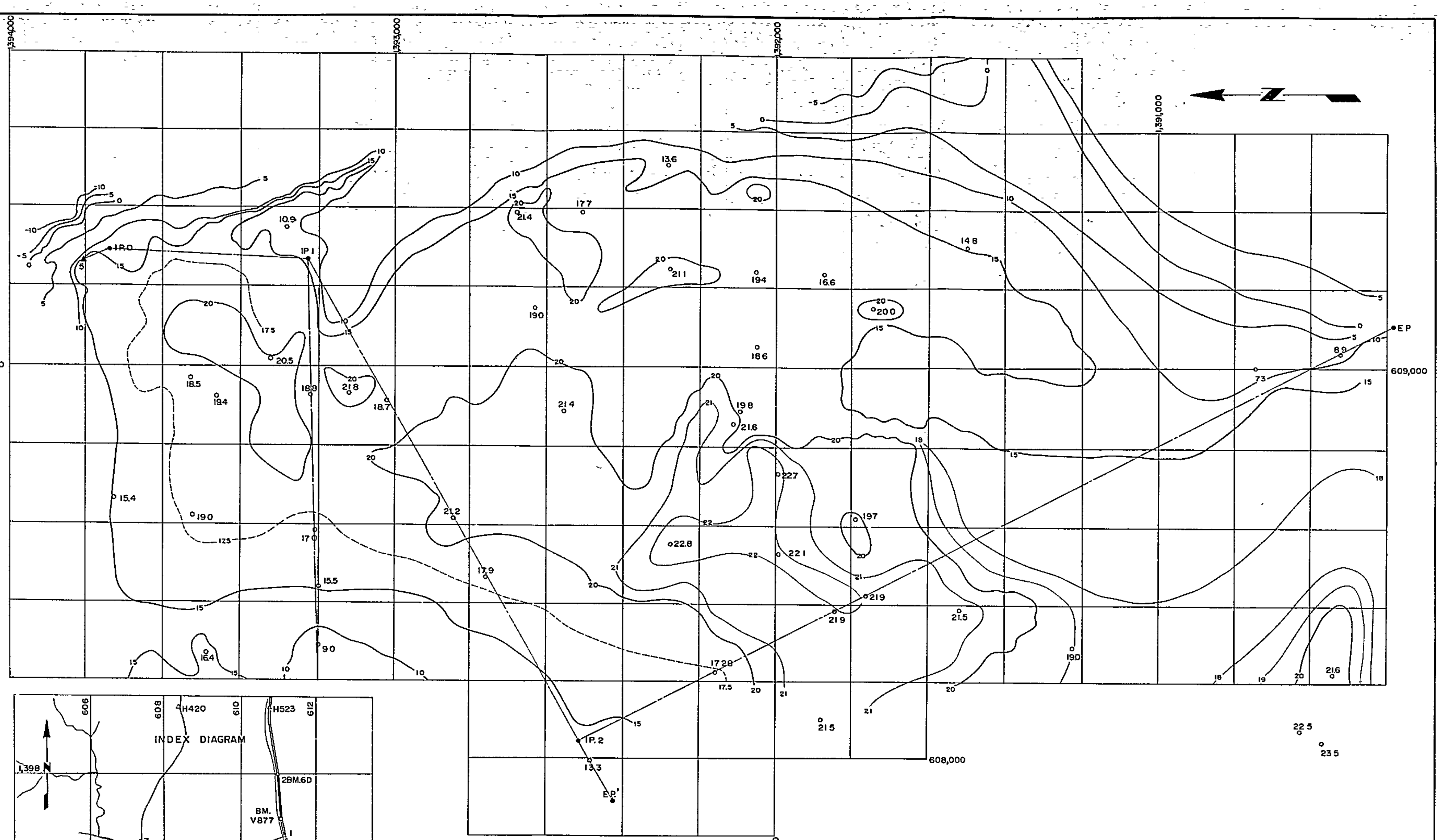
0 100 200 300 400 500m

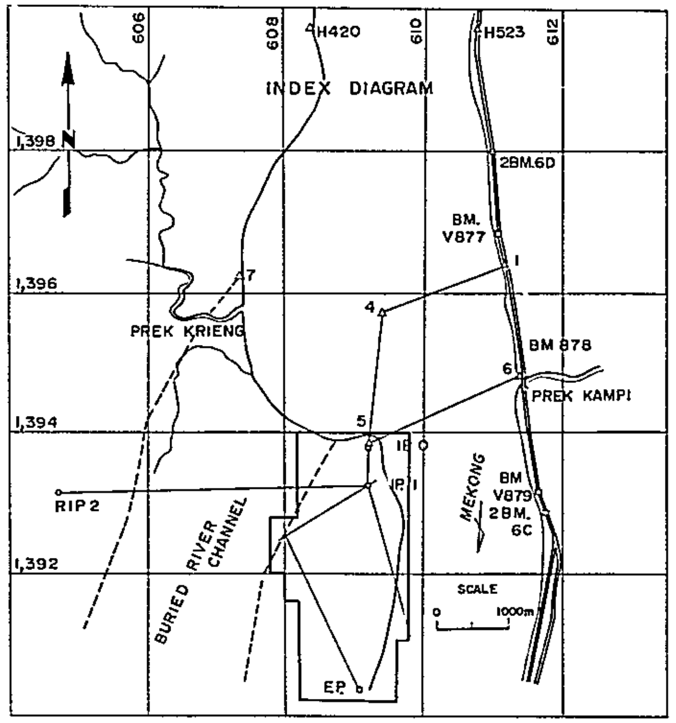
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
LOCATION OF EXPLORATIONS
IN VICINITY OF POWERHOUSE & SPILLWAY

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	K. I.	OFFICE	TOKYO	DWG.NO HO - 0232
CHECKED	T. H.	DATE	MAR 1 1964	
SUBMITTED	K.W.	RECOMMENDED	I. S.	SHEET NO 3 OF 14
APPROVED				





CONTOUR LINES INDICATE
ROCK SURFACE ELEVATION IN m

SCALE

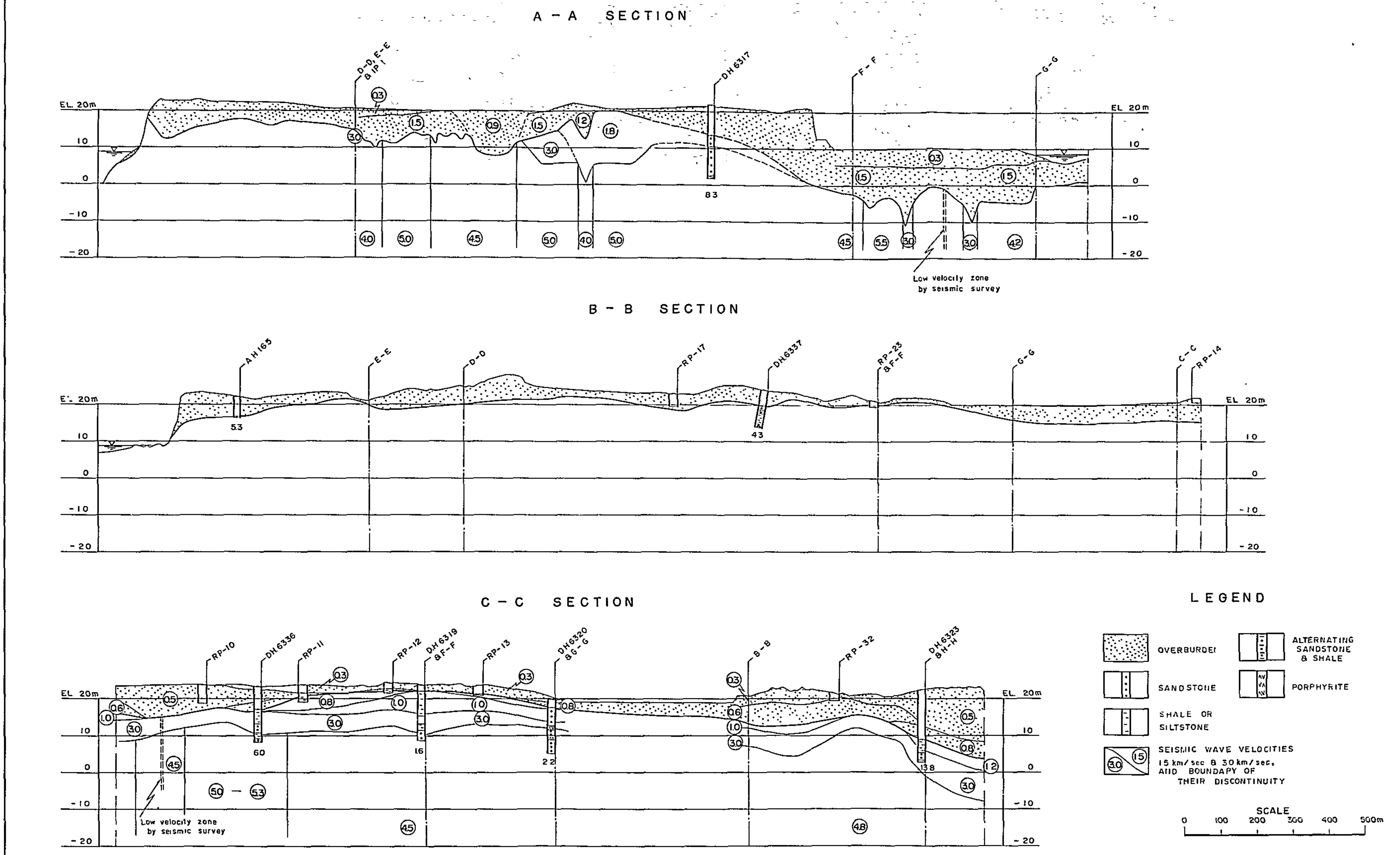
0 100 200 300 400 500m

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
CONTOUR OF ROCK SURFACE IN VICINITY OF POWERHOUSE & SPILLWAY

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	K. S.	OFFICE	TOKYO	DWG. NO. HO-023E
CHECKED	J. H.	DATE	MAR. 1 1964	
SUBMITTED	d.W.	RECOMMENDED	J. Sato	
APPROVED	Y. [illegible]			SHEET NO. 4 OF 14



A.H.165 — AUGER HOLE 165, SITE & LOG. DEPTH TO ROCK in situ = 5.3 m

DH 6317 — DRILL HOLE 6317, SITE & LOG. DEPTH TO ROCK in situ = 8.3 m

RP-23 — TEST PIT RP-23, SITE & LOG

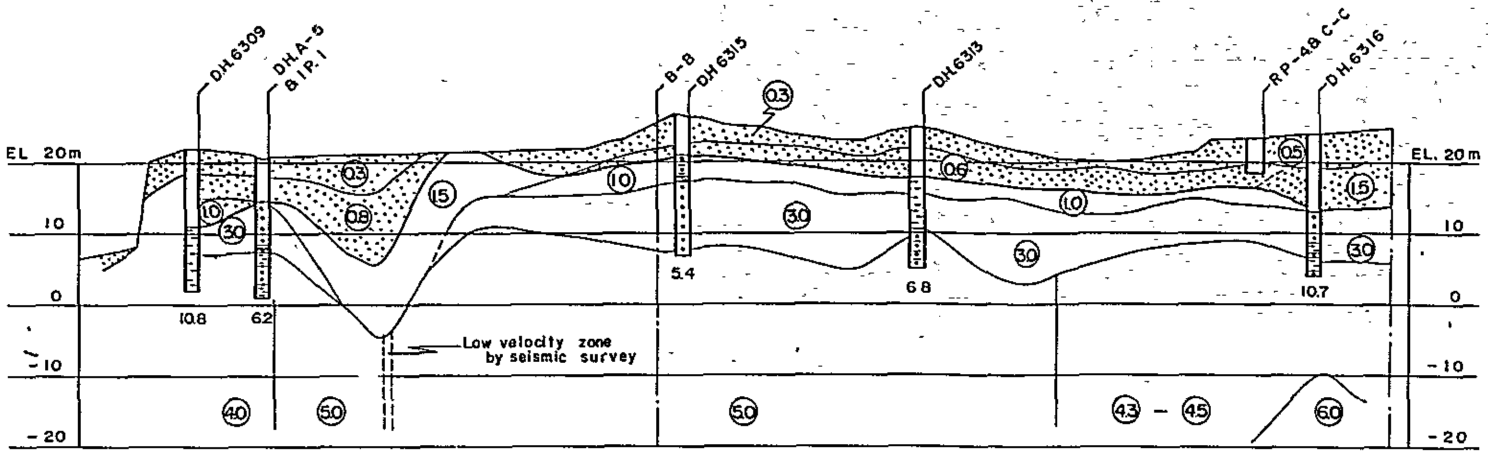
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
GEOLOGICAL SECTIONS OF SPILLWAY AND VICINITY 1-2

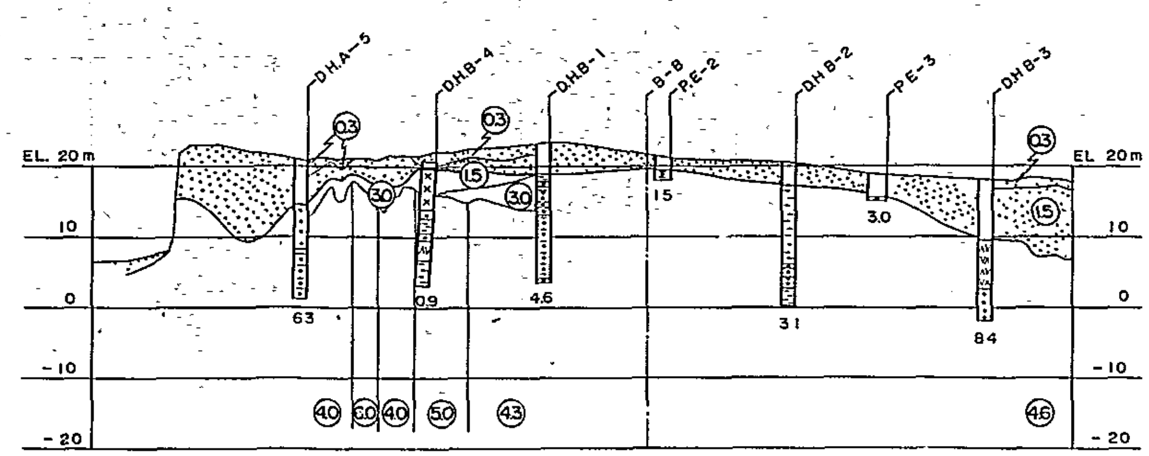
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN		OFFICE	TOKYO	DWG.NO. HO-0232
CHECKED		DATE	MAR 1 1964	
SUBMITTED		RECOMMENDED		SHEET NO. 5 OF 14
APPROVED				

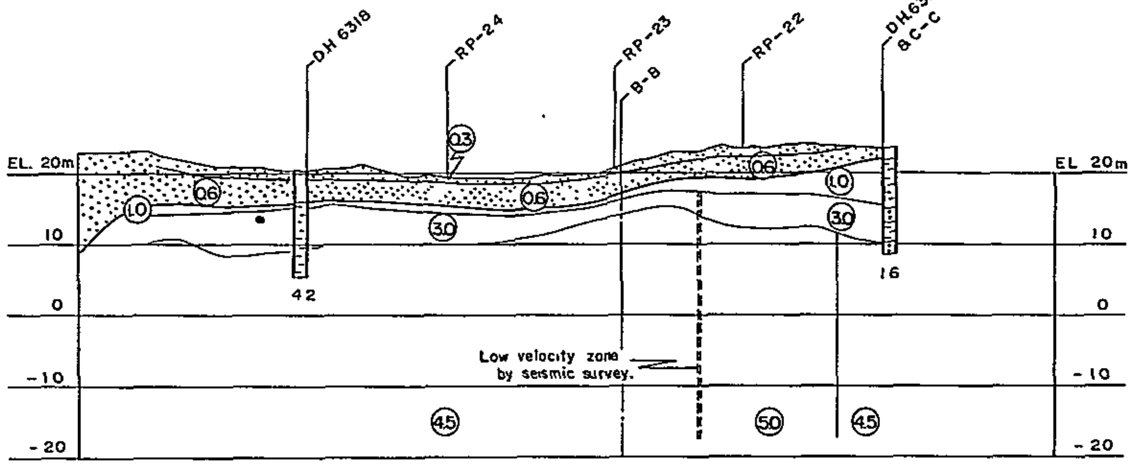
D - D SECTION



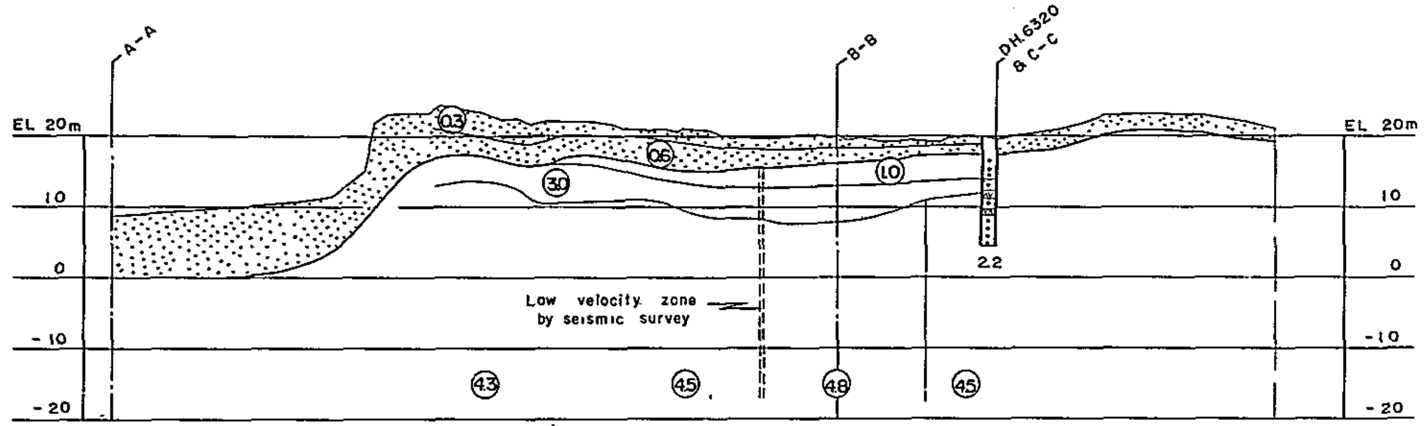
E - E SECTION



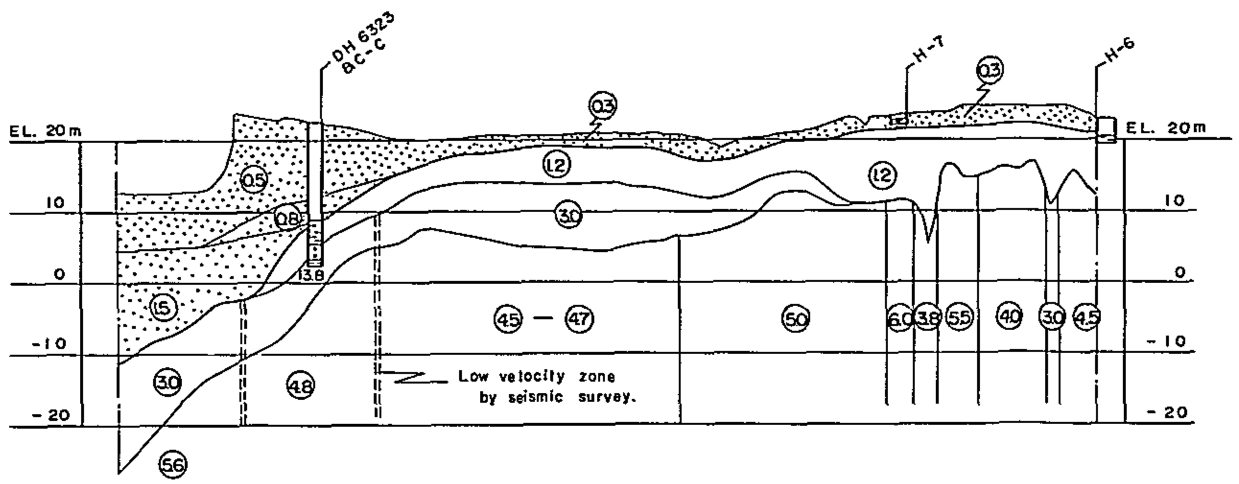
F - F SECTION



G - G SECTION



H - H SECTION



LEGEND

DH 6309 — DRILL HOLE 6309, SITE & LOG. DEPTH TO ROCK in situ = 10.8m

RP-4 — TEST PIT RP-4, SITE & LOG.

OVERBURDEN

SANDSTONE

SHALE OR SILTSTONE

ALTERNATING SANDSTONE & SHALE

DIORITE

PORPHYRITE

SEISMIC WAVE VELOCITIES 1.5 km/sec & 3.0 km/sec, AND BOUNDARY OF THEIR DISCONTINUITY.

SCALE

0 100 200 300 400 500m

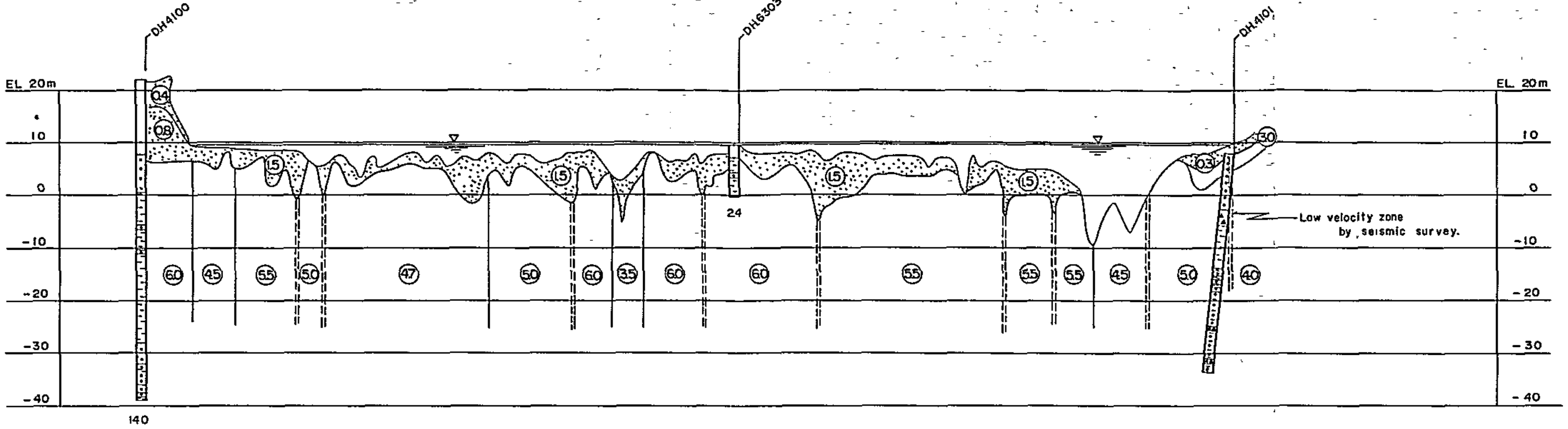
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

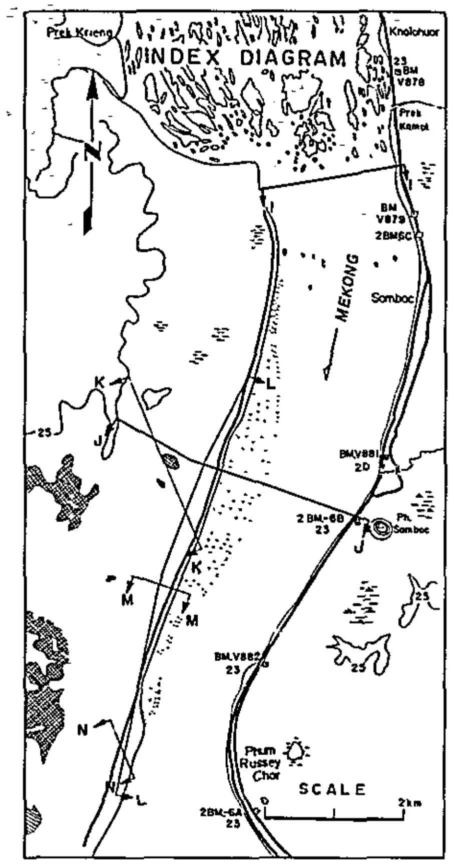
SAMBOR PROJECT
GEOLOGICAL SECTIONS OF SPILLWAY AND VICINITY 2-2

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

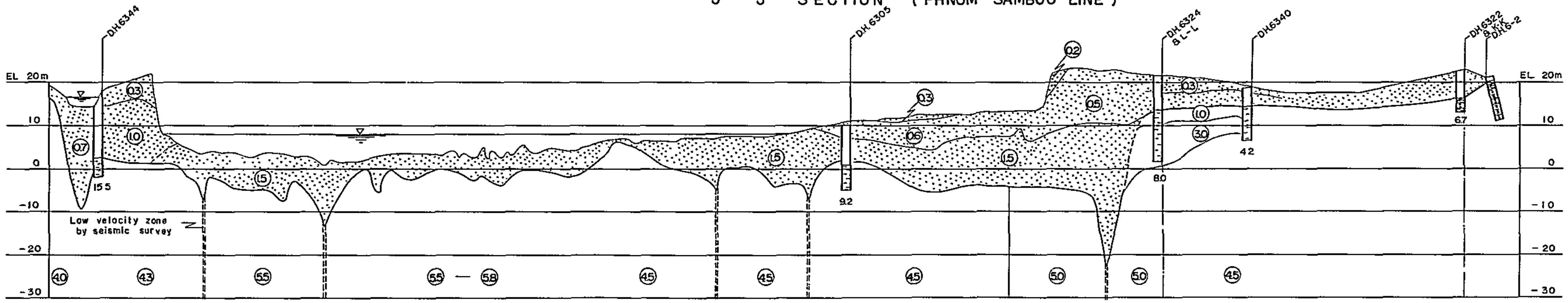
DRAWN		OFFICE	TOKYO	DWG. NO HD-0232
CHECKED		DATE	MAR 1 1964	
SUBMITTED		RECOMMENDED		
APPROVED				SHEET NO. 6 OF 14

I – I SECTION (℄ LINE)





J – J SECTION (PHNOM SAMBOC LINE)



LEGEND

DH 6303 — DRILL HOLE 6303, SITE & LOG.
DEPTH TO ROCK in situ = 2.4m
2.4

SEISMIC WAVE VELOCITIES 1.5 km/sec & 3.0 km/sec, AND BOUNDARY OF THEIR DISCONTINUITY.

OVERBURDEN

SANDSTONE

SHALE OR SILTSTONE

ALTERNATING SANDSTONE & SHALE

MYLONITE

SCALE

0 100 200 300 400 500m

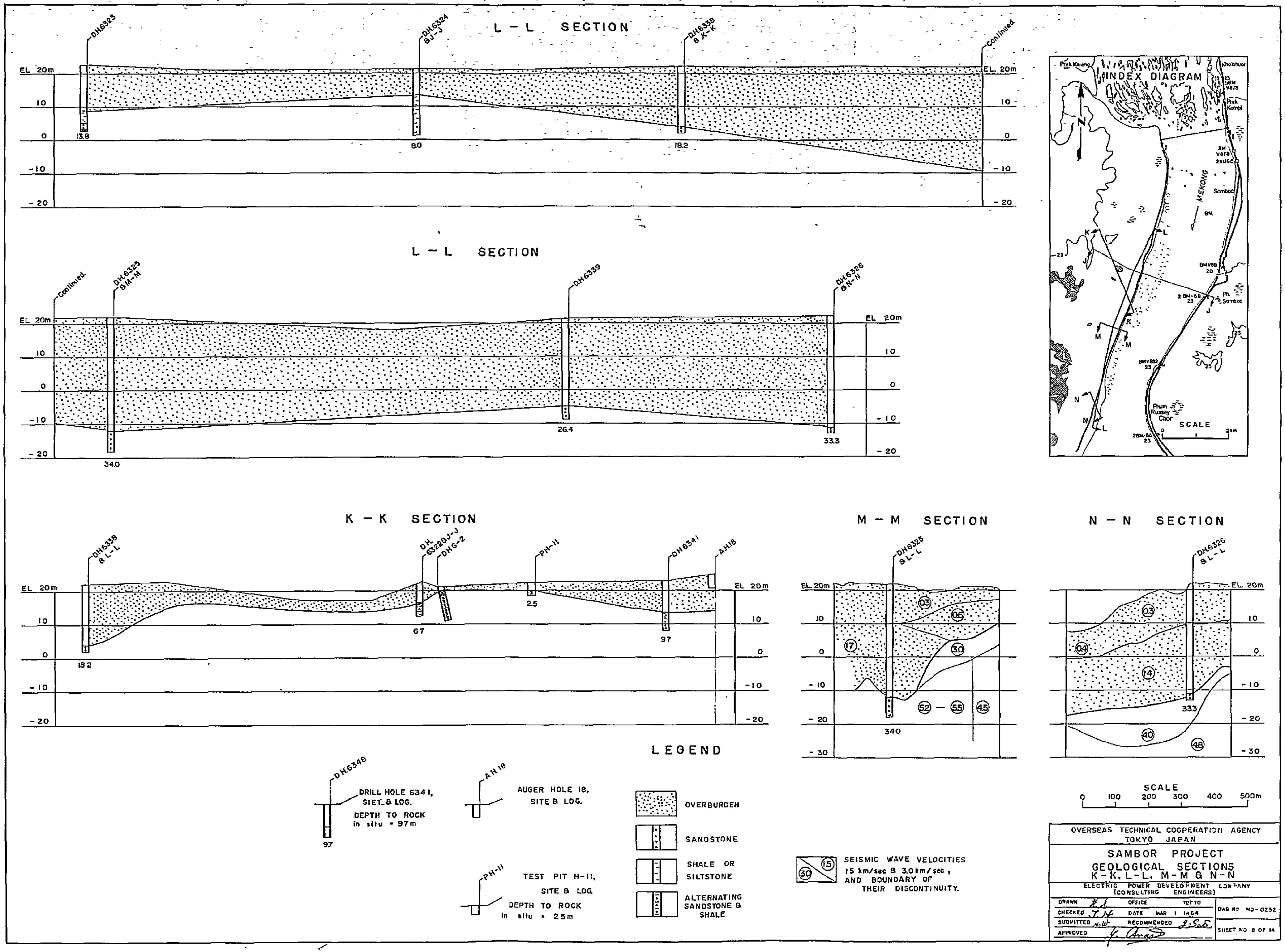
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT

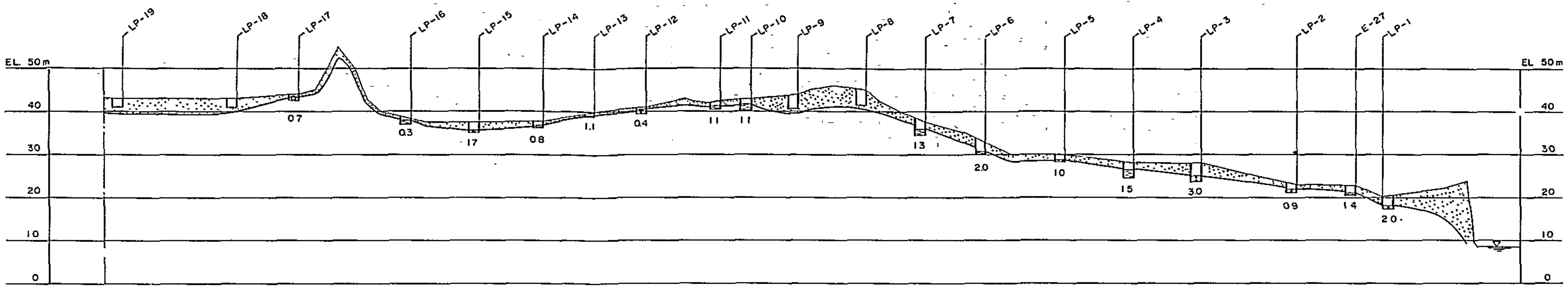
GEOLOGICAL SECTIONS I-I & J-J

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

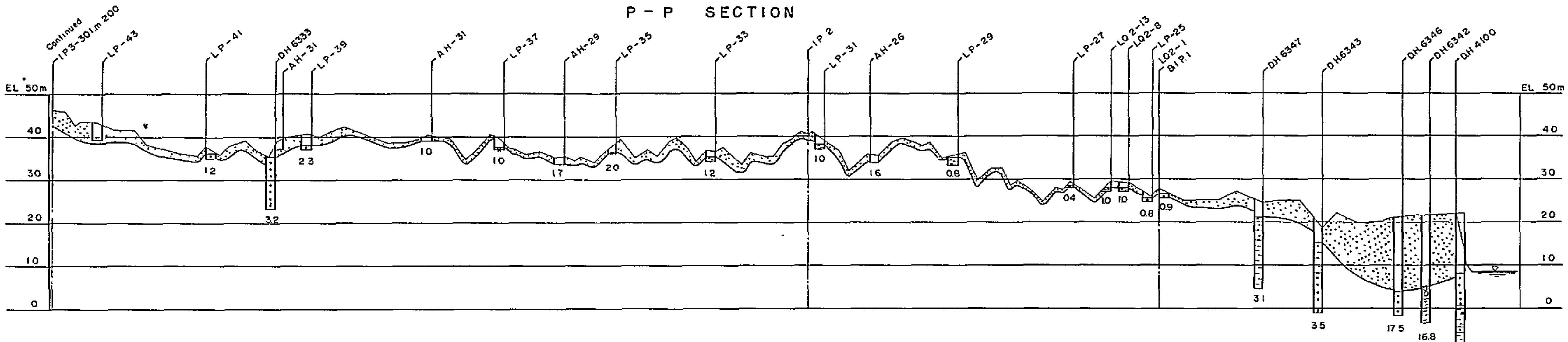
DRAWN	K.S.	OFFICE	TOKYO	DWG.NO. HO-0232
CHECKED	T.N.	DATE	MAR. 1 1964	
SUBMITTED	H.W.	RECOMMENDED	[illegible]	SHEET NO. 7 OF 14
APPROVED	[illegible]			

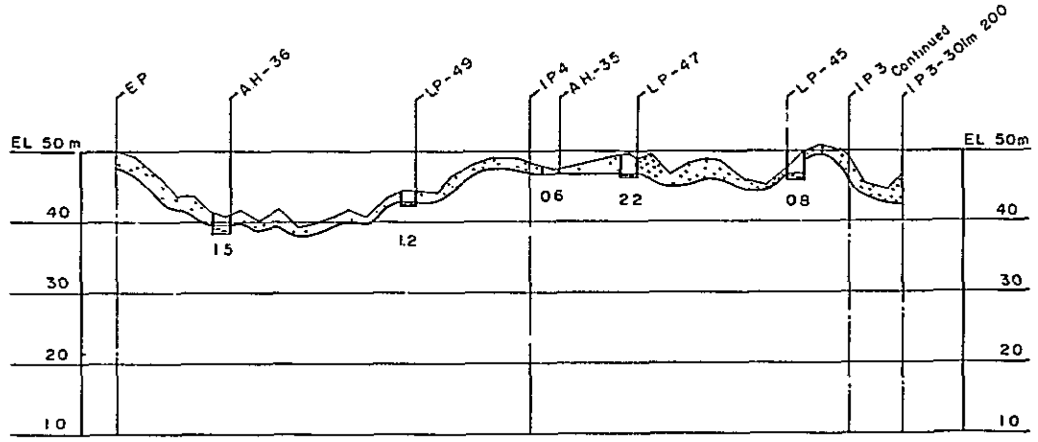

L – L SECTION
DH6323
DH6324 & J-J
DH6338 & K-K
Continued.
EL 20m
10
0
-10
-20
13.8
8.0
18.2
L – L SECTION
Continued.
DH6325 & M-M
DH6339
DH6326 & N-N
34.0
26.4
33.3
INDEX DIAGRAM
Prek Kriena
Kholohuor
Prek Kompi
MEKONG
Sambor
Ph. Sambor
Phum Russey Chor
SCALE
0
2km
K – K SECTION
DH6338 & L-L
DH 6322 & J-J
DHG-2
PH-11
DH6341
AH18
18.2
6.7
2.5
9.7
M – M SECTION
DH6325 & L-L
0.3
0.6
1.7
3.0
5.2 – 5.5
4.5
34.0
N – N SECTION
DH6326 & L-L
0.3
0.4
1.4
4.0
4.8
33.3
LEGEND
DH6348
DRILL HOLE 6341, SITE & LOG.
DEPTH TO ROCK in situ = 9.7m
9.7
AH.18
AUGER HOLE 18, SITE & LOG.
PH-11
TEST PIT H-11, SITE & LOG
DEPTH TO ROCK in situ = 2.5m
OVERBURDEN
SANDSTONE
SHALE OR SILTSTONE
ALTERNATING SANDSTONE & SHALE
SEISMIC WAVE VELOCITIES 1.5 km/sec & 3.0 km/sec, AND BOUNDARY OF THEIR DISCONTINUITY.
SCALE
0 100 200 300 400 500m
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN
SAMBOR PROJECT
GEOLOGICAL SECTIONS
K-K, L-L, M-M & N-N
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)
DRAWN
OFFICE TOKYO
CHECKED
DATE MAR 1 1964
SUBMITTED
RECOMMENDED
APPROVED
DWG NO HD-0232
SHEET NO 8 OF 14

O-O SECTION

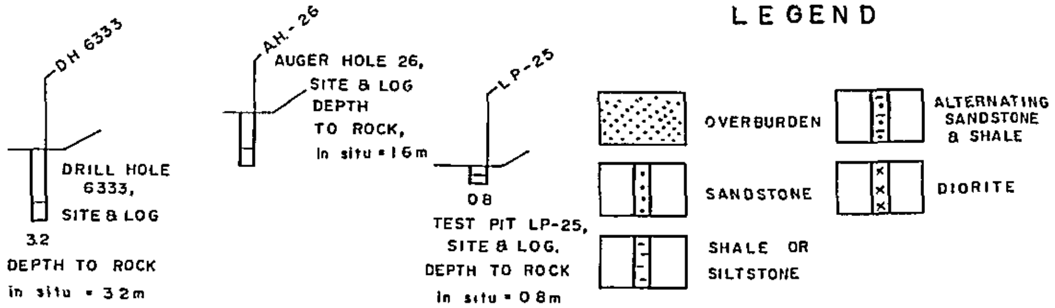


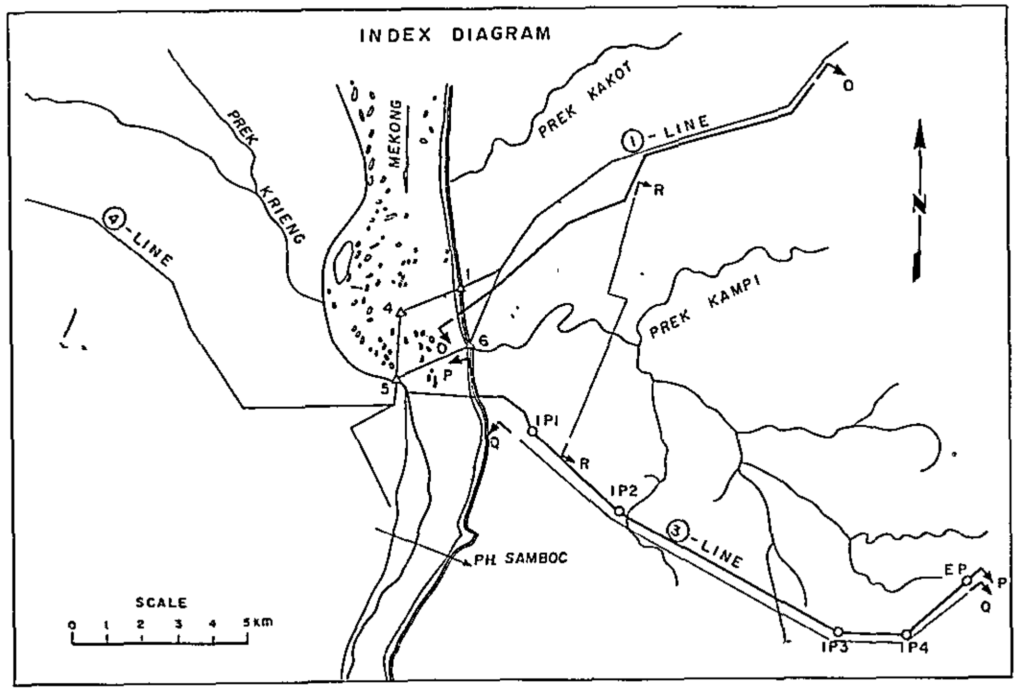
P-P SECTION

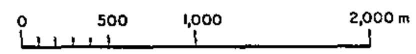




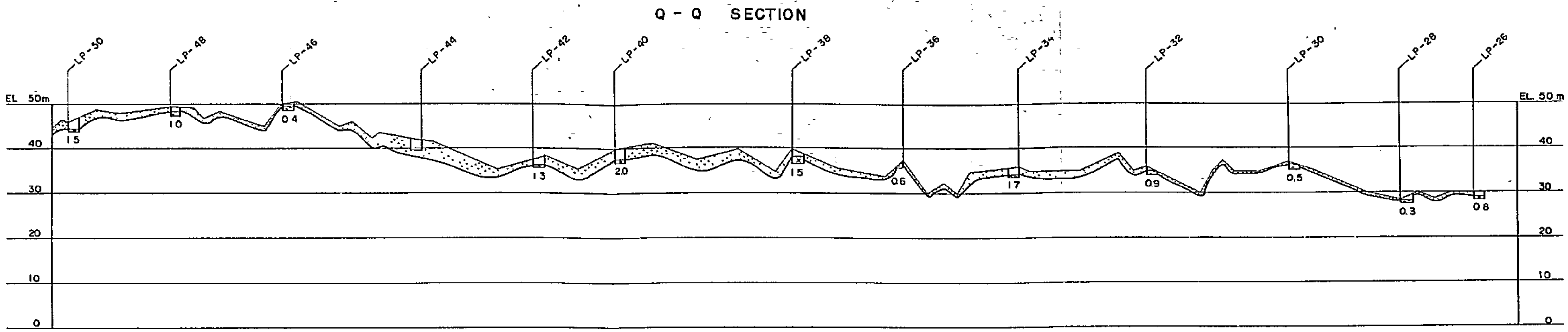
LEGEND

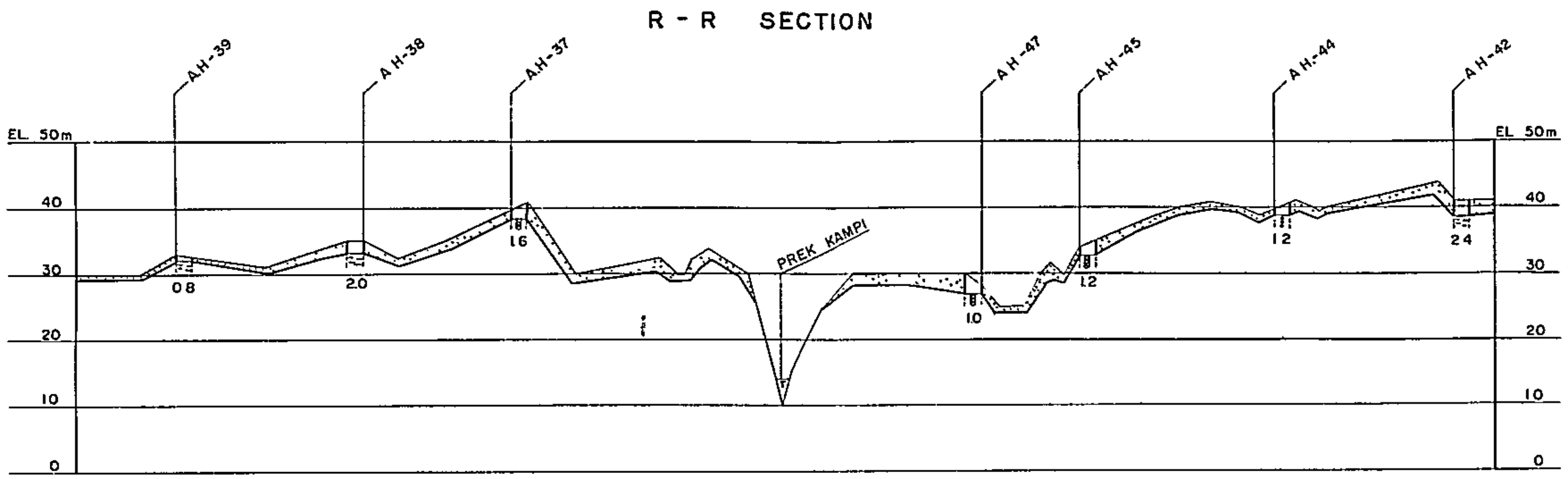


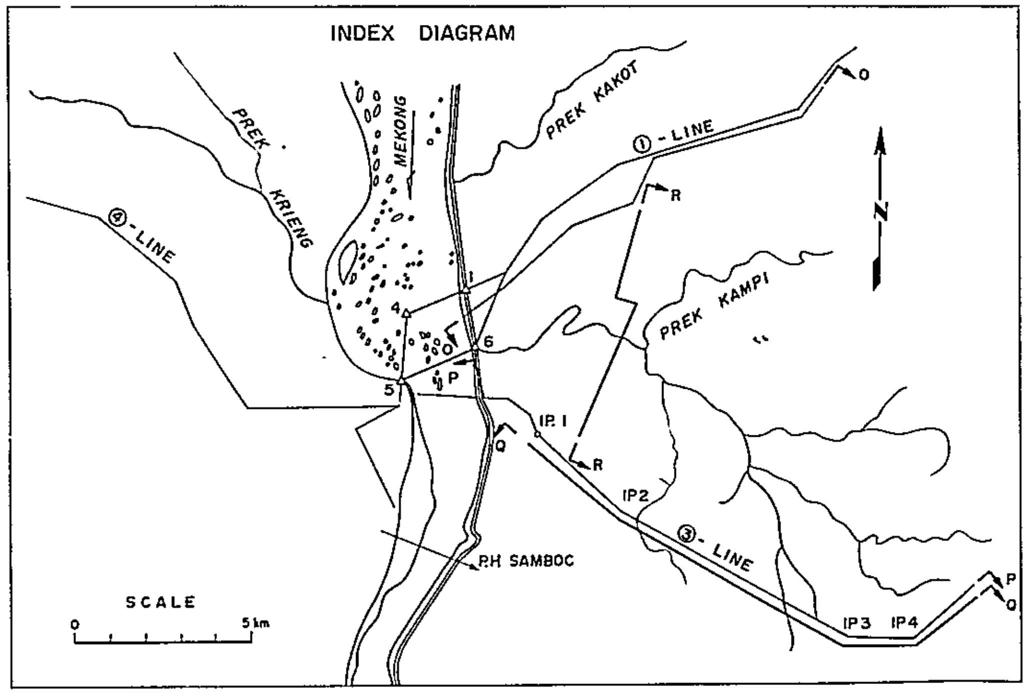




OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
SAMBOR PROJECT GEOLOGICAL SECTIONS O-O & P-P	
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)	
DRAWN H. S. — OFFICE TOKYO	DWG NO HO-0232
CHECKED T. K. — DATE MAR 1, 1964	
SUBMITTED H. W. — RECOMMENDED I. Sato	SHEET NO 9 OF 14
APPROVED Y. Arai	







LEGEND

AH-47 — AUGER HOLE, 47 SITE & LOG. DEPTH TO ROCK in situ = 1.0 m (1.0)

LP-26 — TEST PIT LP-26 SITE & LOG DEPTH TO ROCK in situ = 0.9 m (0.9)

- OVERBURDEN
- SANDSTONE
- SHALE OR SILTSTONE
- CONGLOMERATE
- ALTERNATING SANDSTONE & SHALE
- DIORITE

SCALE

0 500 1000 2000m

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

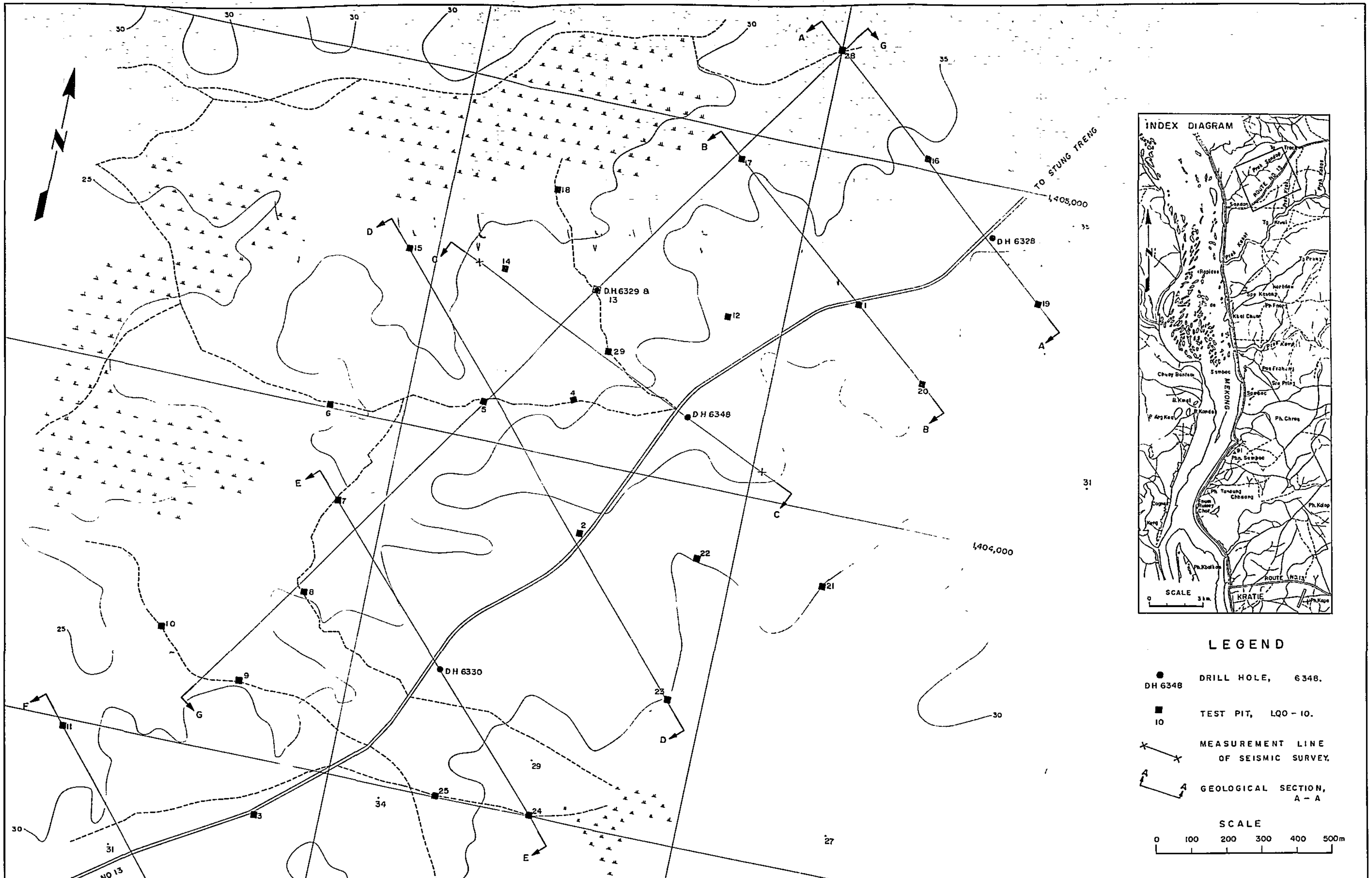
SAMBOR PROJECT
GEOLOGICAL SECTIONS Q-Q & R-R

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	[signature]	OFFICE	TOKYO
CHECKED	[signature]	DATE	MAR 1 1964
SUBMITTED	[signature]	RECOMMENDED	[signature]
APPROVED	[signature]		

DWG.NO. HD-0232

SHEET NO. 10 OF 14



OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
LOCATION OF EXPLORATIONS
IN LQO QUARRY AREA

ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	K. S.	OFFICE	TOKYO	DWG. NO. HO - 0232
CHECKED	J. N.	DATE	MAR. 1 1964	
SUBMITTED	K. U.	RECOMMENDED	[illegible]	SHEET NO. 11 OF 14
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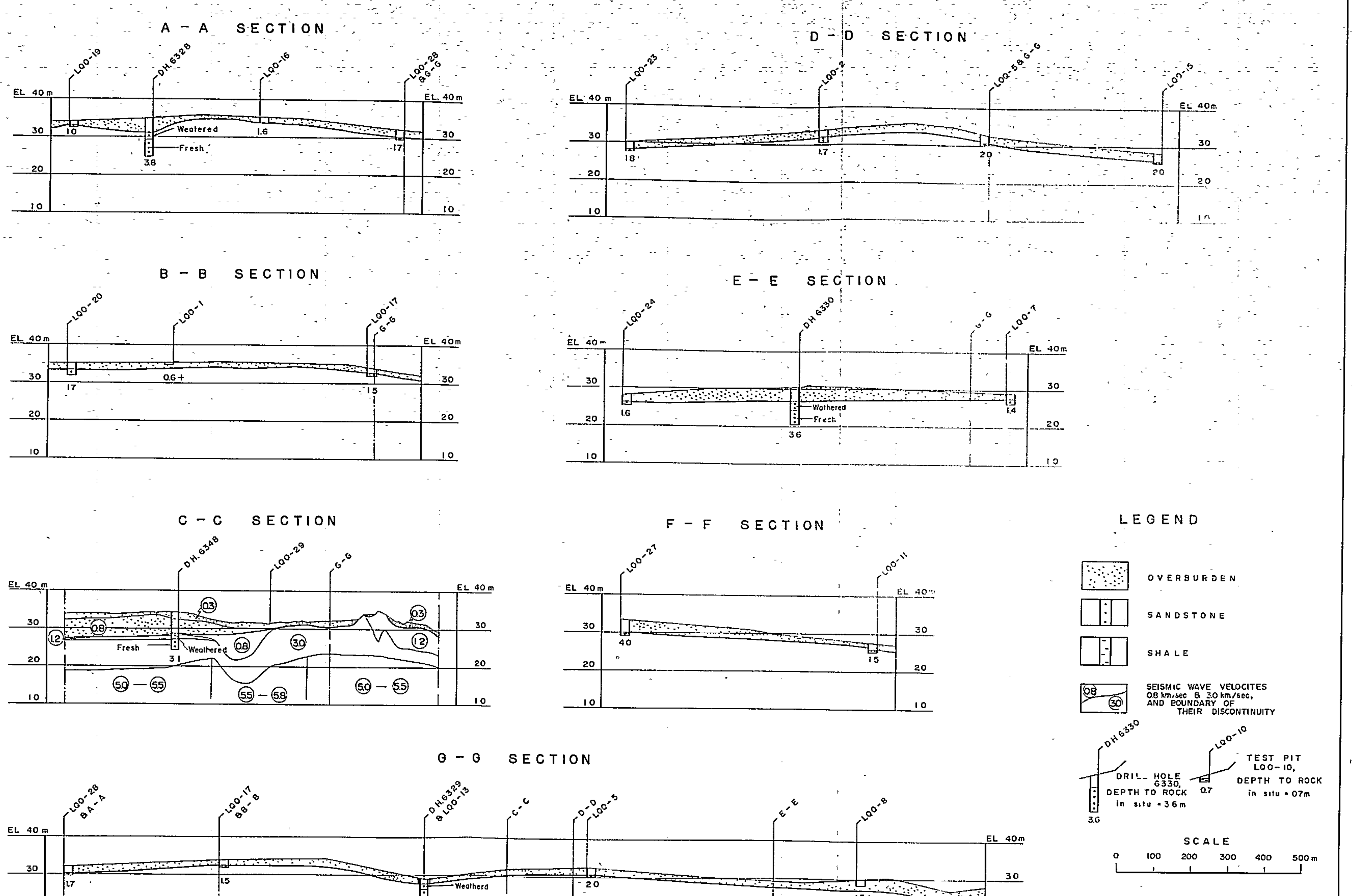


G – G SECTION

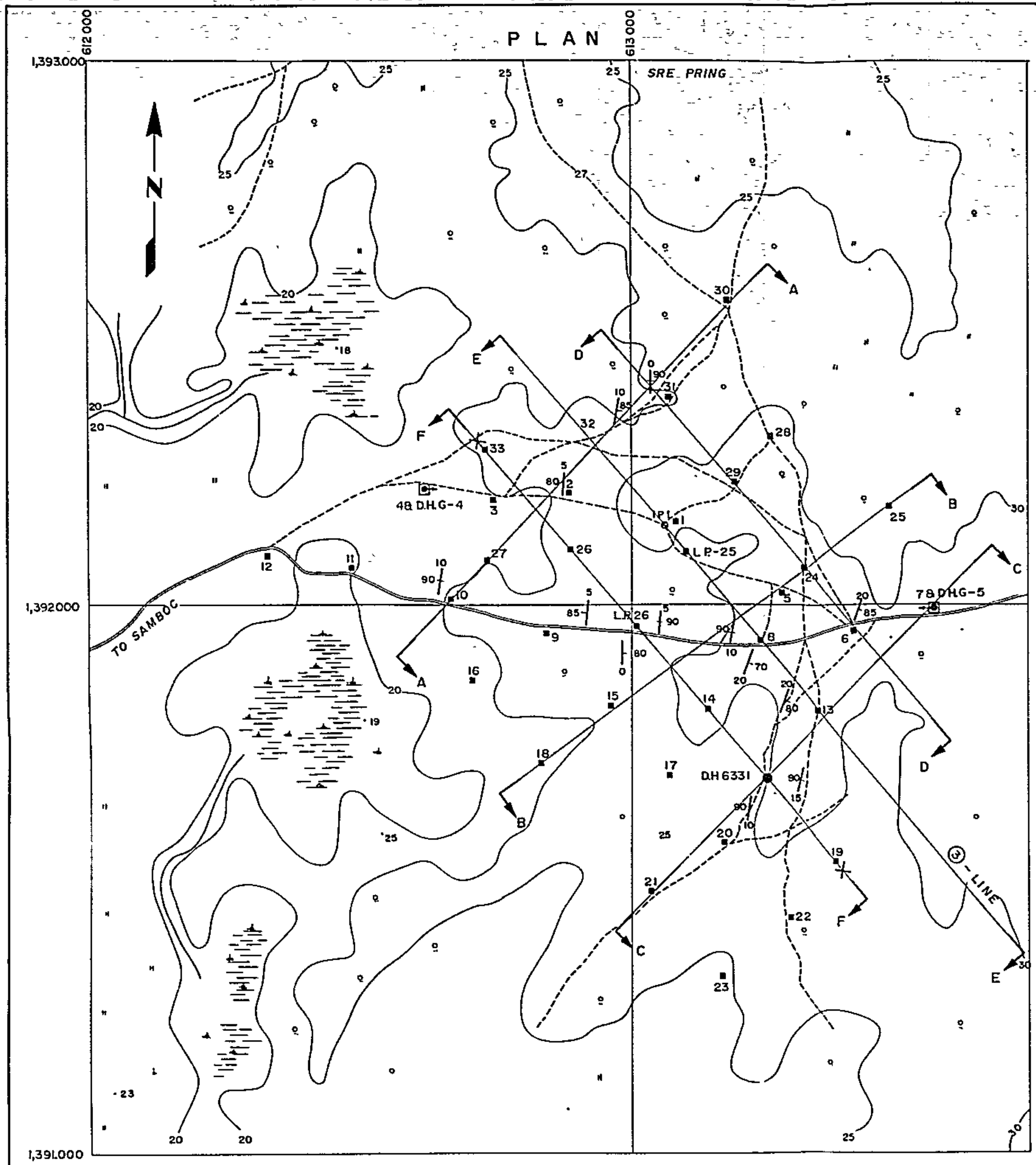
OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

SAMBOR PROJECT
GEOLOGICAL SECTIONS
OF LQO QUARRY AREA

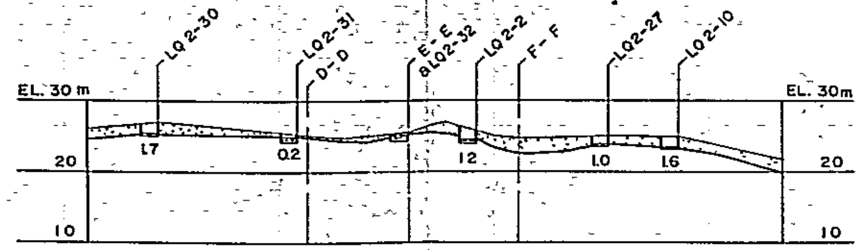
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	H.S.	OFFICE	TOKYO	DWG NO. HO-0232
CHECKED	T.H.	DATE	MAR 1 1964	
SUBMITTED	H.W.	RECOMMENDED	S. Sato	SHEET NO. 12 OF 14
APPROVED	Y. [signature]			

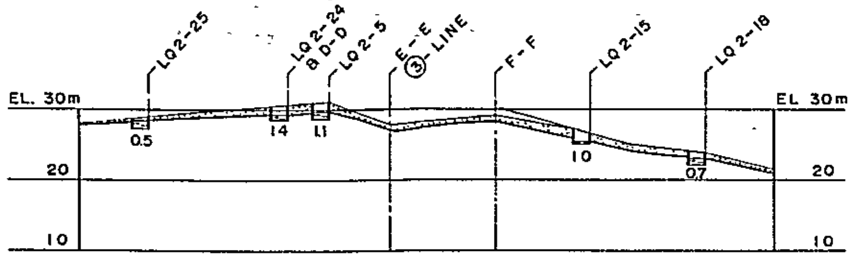
PLAN



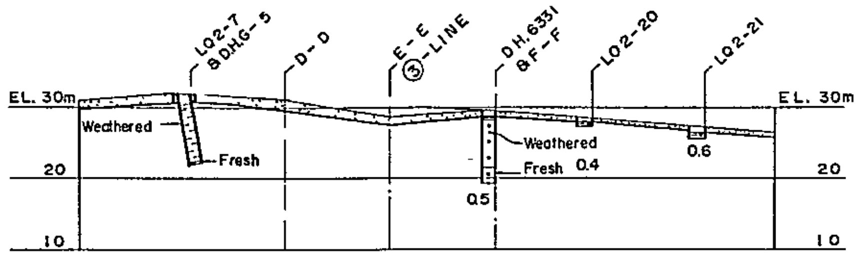
A – A SECTION



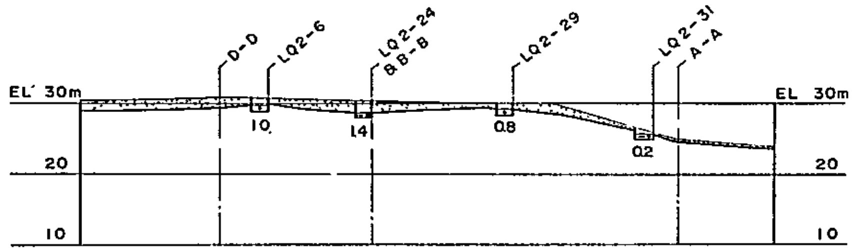
B – B SECTION



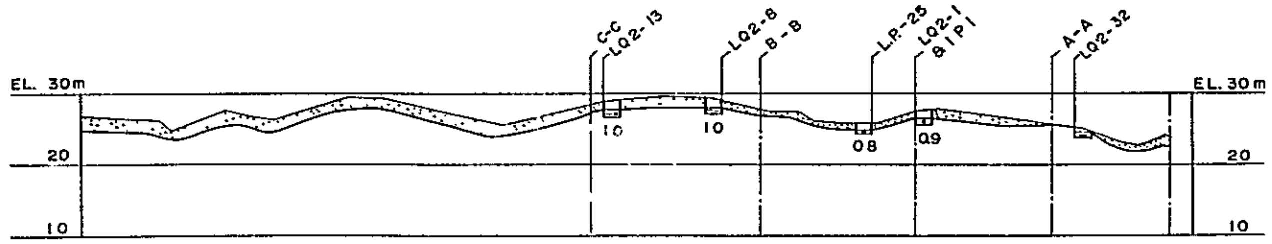
C – C SECTION

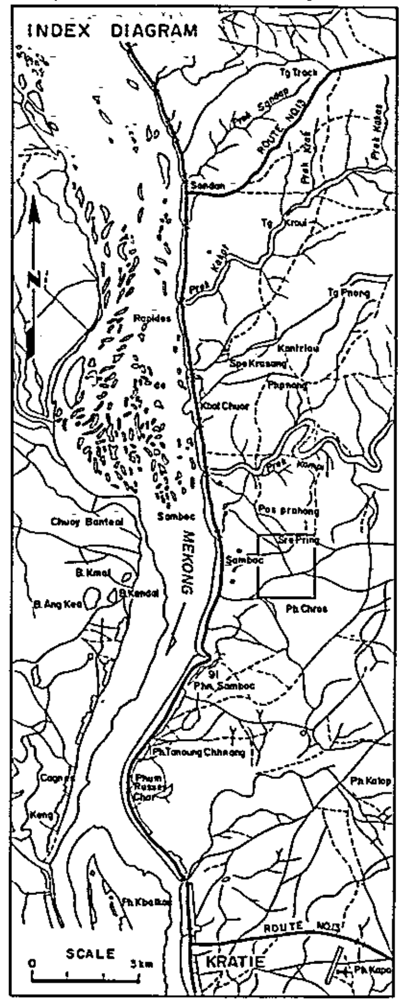


D – D SECTION

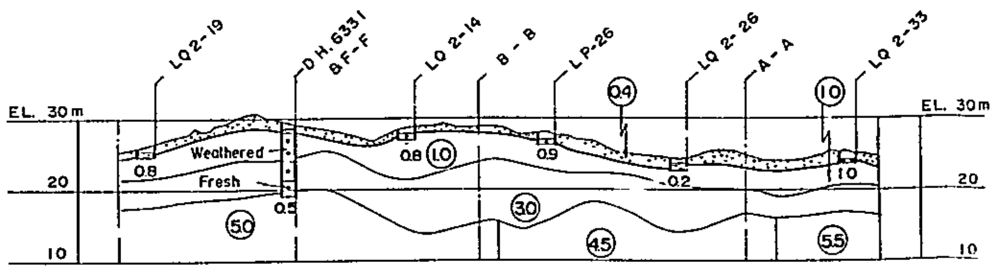


E – E SECTION

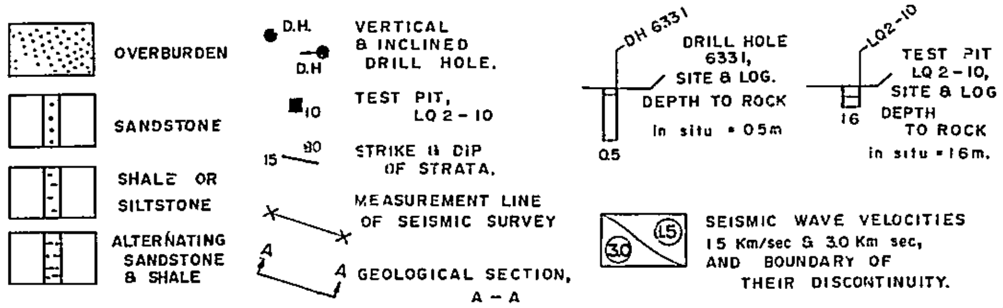




F – F SECTION



LEGEND



SCALE 0 – 500m

OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

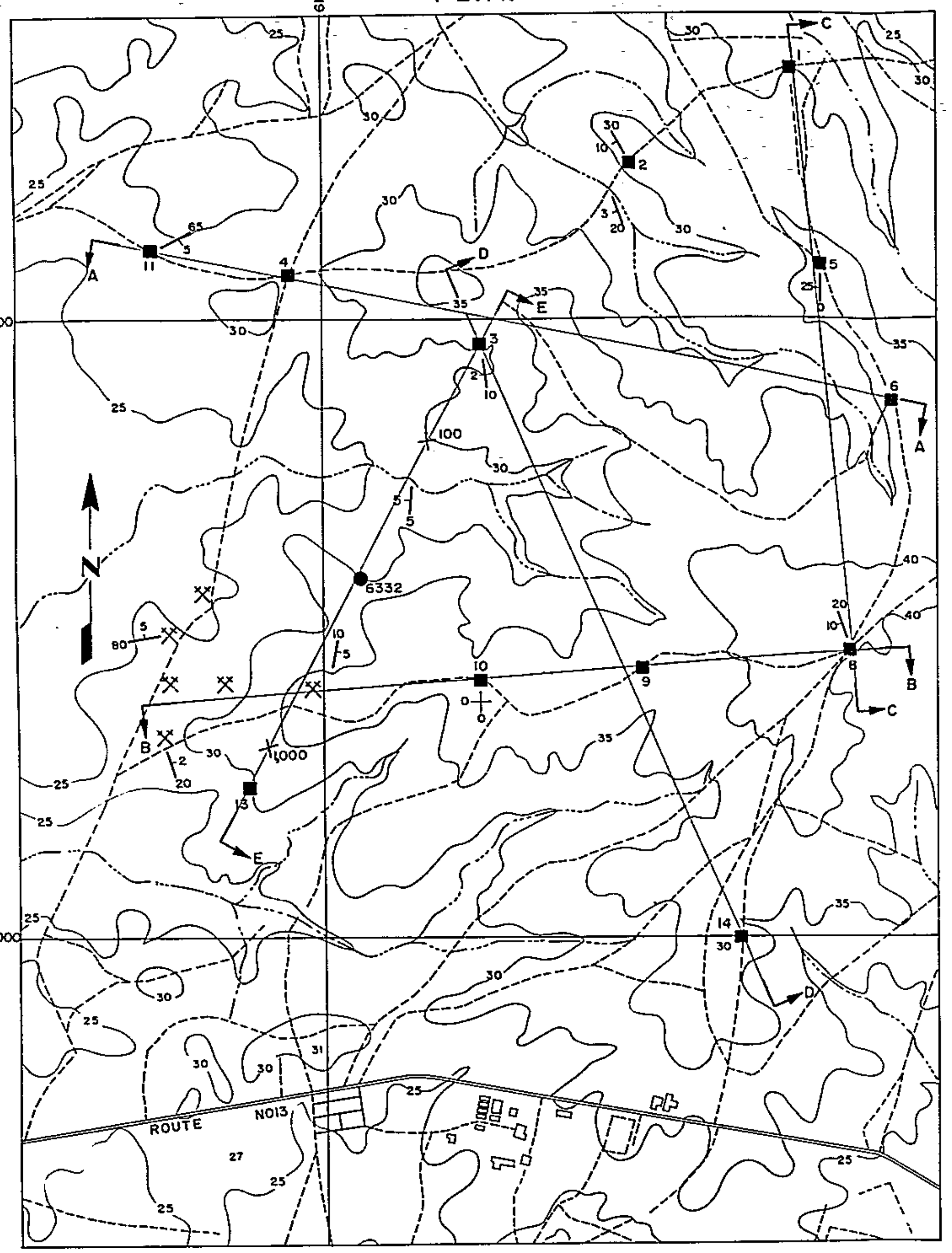
SAMBOR PROJECT

LOCATION OF EXPLORATIONS AND GEOLOGICAL SECTIONS IN LQ2 QUARRY AREA

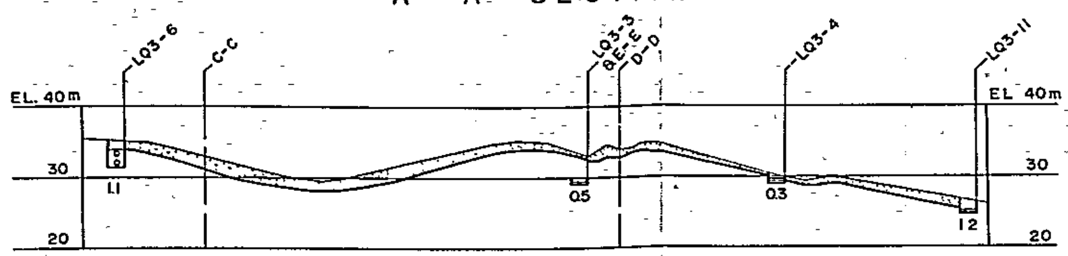
ELECTRIC POWER DEVELOPMENT COMPANY
(CONSULTING ENGINEERS)

DRAWN	H.S.	OFFICE	TOKYO	DWG. NO. HO-0232
CHECKED	T.N.	DATE	MAR 1 1964	
SUBMITTED	H.W.	RECOMMENDED	[signature]	SHEET NO. 13 OF 14
APPROVED	[signature]			

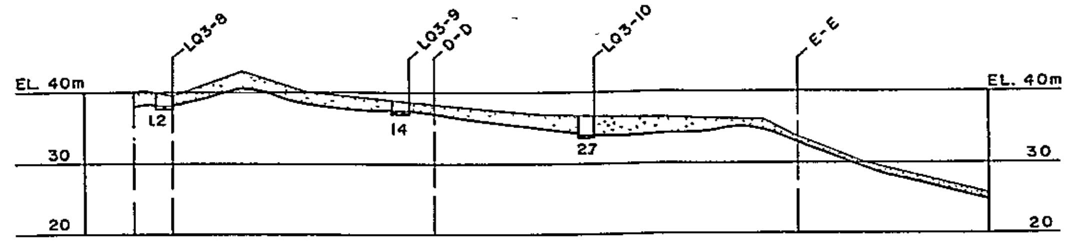
PLAN



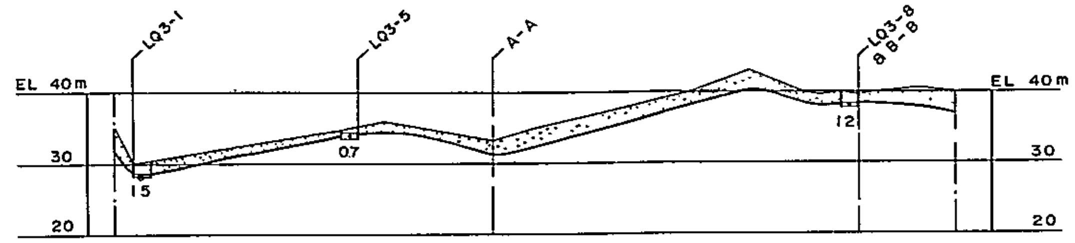
A – A SECTION



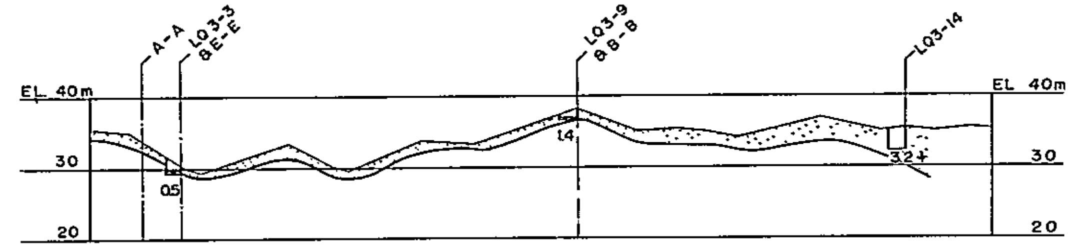
B – B SECTION

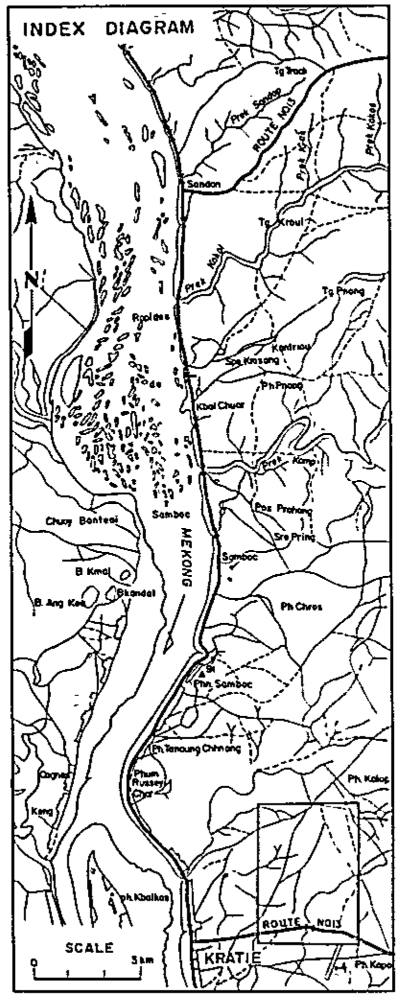


C – C SECTION



D – D SECTION





SEISMIC WAVE VELOCITIES 1.5 km/sec & 3.0 km/sec AND BOUNDARY OF THEIR DISCONTINUITY

LEGEND

STRIKE & DIP OF STRATA

HORIZONTAL STRATA

WORKED QUARRY FOR MACADAM

DRILL HOLE, D.H 6332, 6332.

TEST PIT, LQ3 - 10

MEASUREMENT LINE OF SEISMIC SURVEY

GEOLOGICAL SECTION, A-A.

OVERBURDEN

SANDSTONE

SHALE, SILTSTONE OR CLAYSTONE

CONGLOMERATE

TEST PIT LQ3-10, DEPTH TO ROCK In situ = 2.7 m

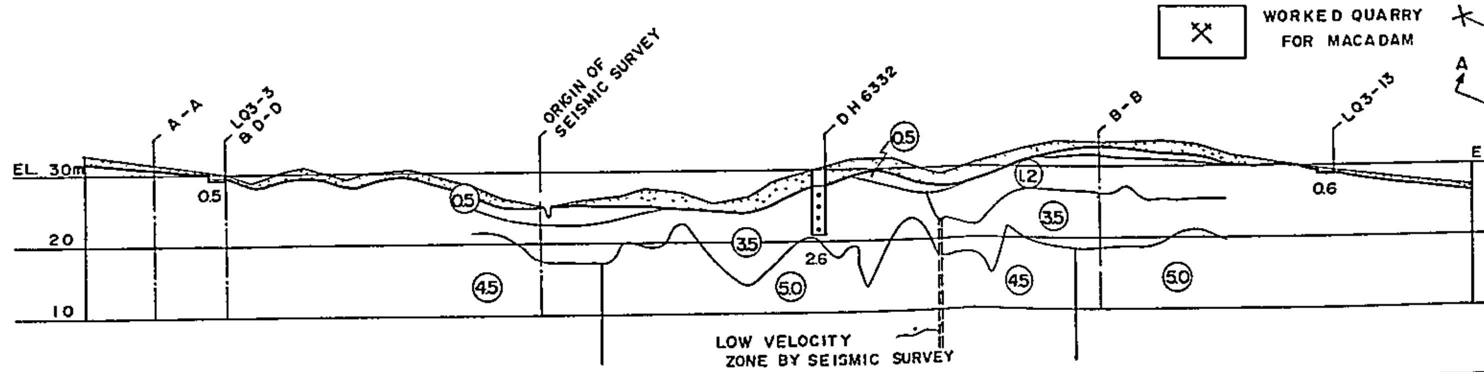
DRILL HOLE 6332, DEPTH TO ROCK in situ = 2.6 m

SCALE

FOR PLAN, A-A, B-B, C-C, & D-D SECTION: 0 – 1,000m

FOR E-E SECTION: 0, 100, 200, 300, 400, 500m

E – E SECTION



OVERSEAS TECHNICAL COOPERATION AGENCY
TOKYO JAPAN

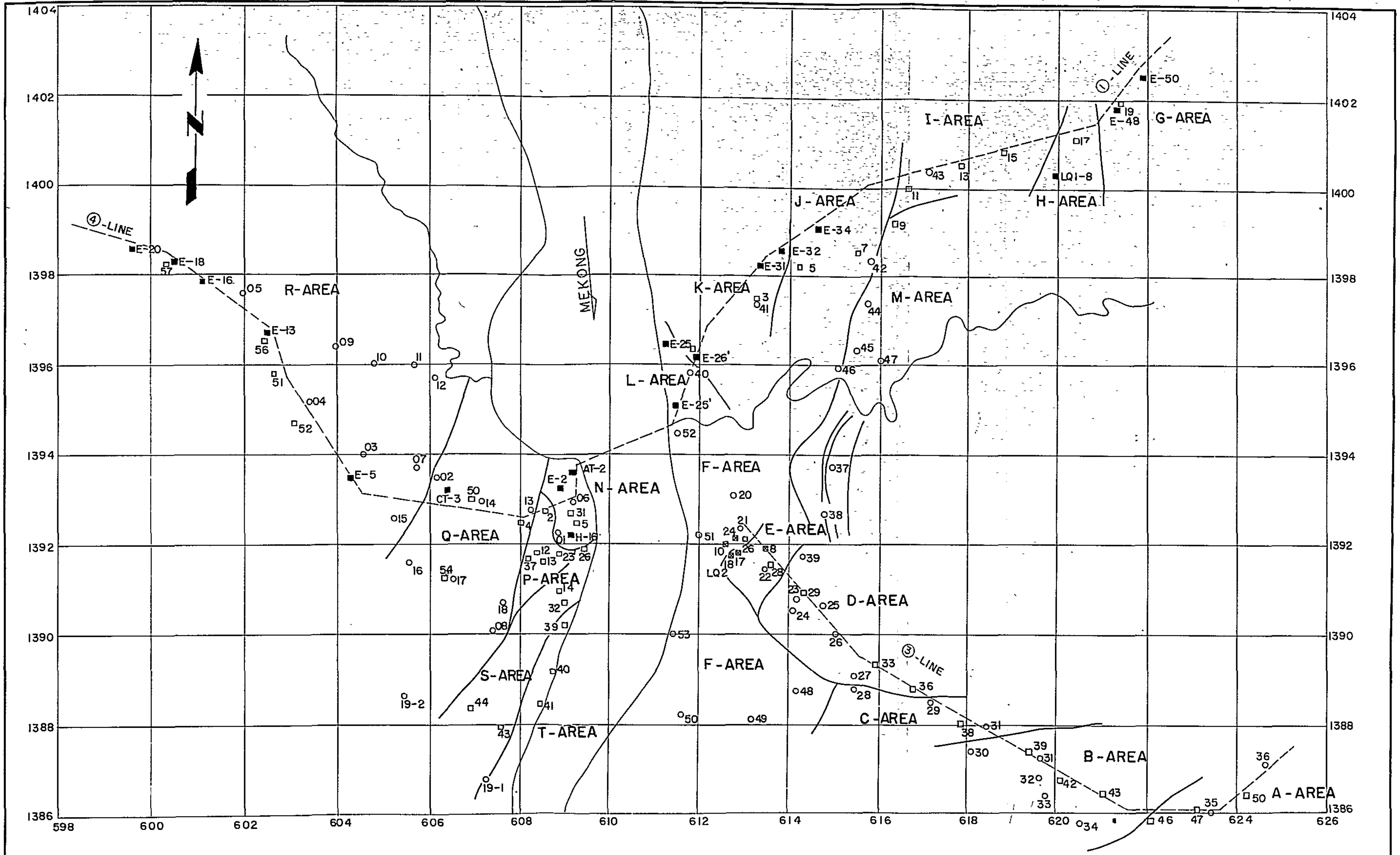
SAMBOR PROJECT
LOCATION OF EXPLORATIONS AND GEOLOGICAL SECTIONS IN LQ3 QUARRY AREA

ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)

DRAWN		OFFICE	TOKYO
CHECKED		DATE	MAR. 1. 1964
SUBMITTED		RECOMMENDED	
APPROVED			

DWG. NO. HO-0232

SHEET NO. 14 OF 14



LEGEND

- ■ TEST PIT (F.Y. 1962)
- □ TEST PIT (F.Y. 1963)
- ○ AUGER BORING HOLE

1000m 0 1 2 3km

OVERSEAS TECHNICAL COOPERATION AGENCY TOKYO JAPAN	
SAMBOR PROJECT	
CLASSIFICATION OF EARTH MATERIAL	
ELECTRIC POWER DEVELOPMENT COMPANY (CONSULTING ENGINEERS)	
DRAWN. OFFICE. TOKYO	DWG.NO
CHECKED. DATE. JULY 1.1964	
SUBMITTED. RECOMMENDED.	SHEET.NO.
APPROVED.	