CHAPTER - 2

GEOLOGICAL INVESTIGATION

NAM NGIEP-1 HYDROELECTRIC POWER PROJECT
FEASIBILITY STUDY (PHASE II)

GEOLOGICAL INVESTIGATION

FINAL REPORT

BPKP GROUP PHOUDOI GEO-MINING CO., LTD.

August, 2002

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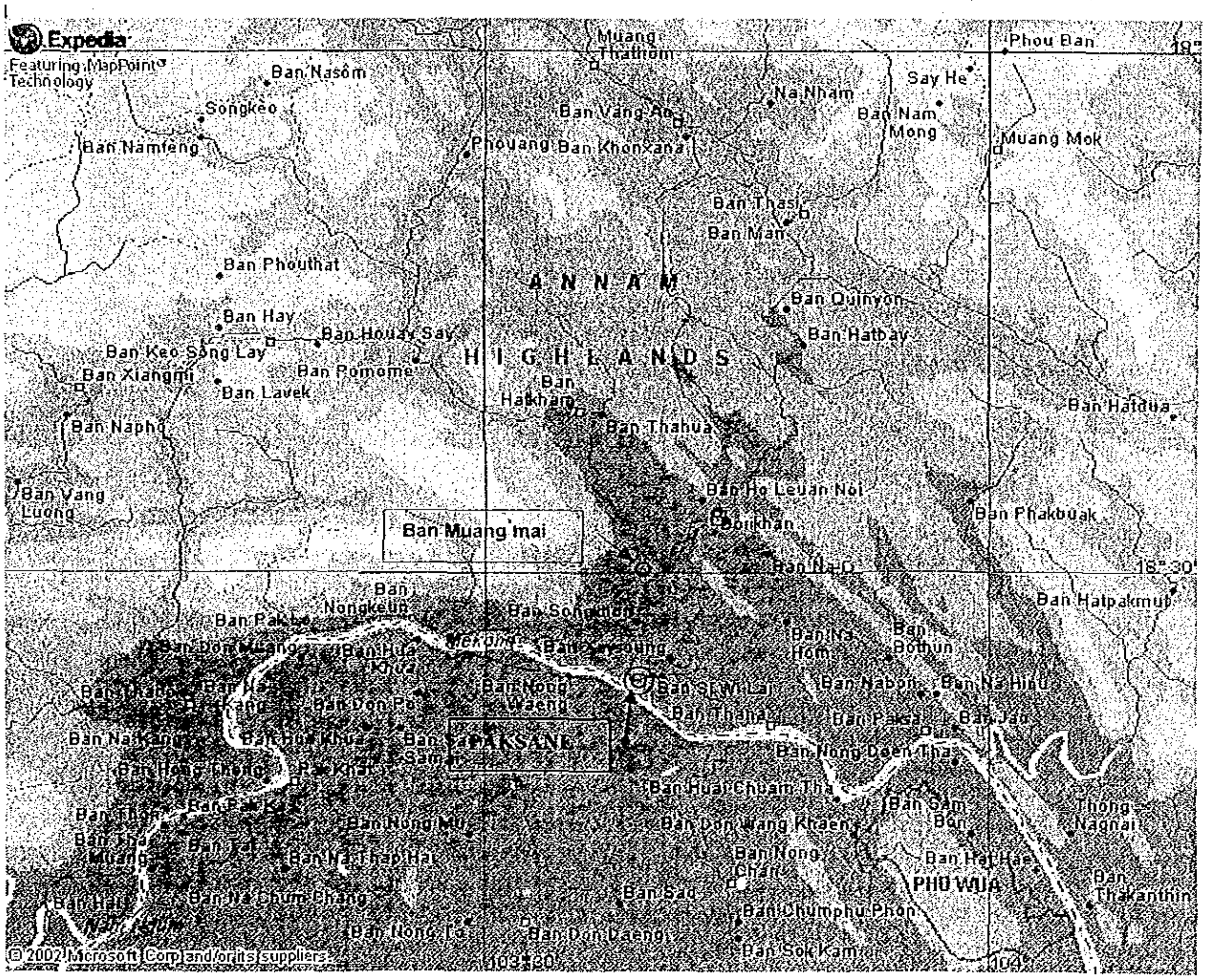
I. Summary of Investigation:

The geological investigation is a part attached to perform the feasibility study on The Nam Ngiep Hydroelectric Power Project (Phase II) in The Lao People's Democratic Republic.

a. Location:

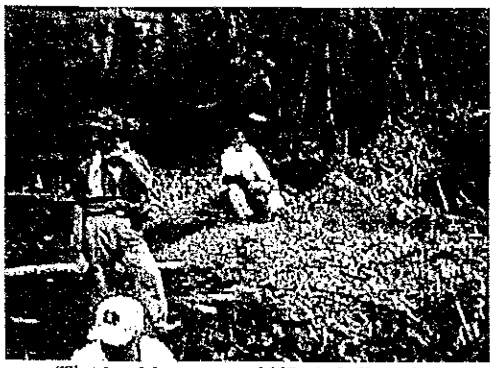
The study Project area is located in Ban Hatkham, Muang Borikhan District, Borikhamxay Province Lao PDR. The dam site area is located on a distance of around 32 km from the conjuction to the road Borikhan district or around 50 km from Paksane (Capital town of Borikhamxay District).



Access to the dam site by car is available only dry season and it took around 1 and half hour from Paksane or 3 to 3.5 hrs from Vientiane. In the rainy season have to access to Ban Muangmai (15 km from Paksane, it take about 20 to 30 minutes by car) and then by boat to Ban Hatkham it took around 2 hrs.
Access from Ban Hatkham to dam site took 25-30 minutes by car in the dry season by the constructed road. In rainy season have to travel by boat from Ban Hatkham to Hmong village (took around 15-20 minutes) then have to walk around 1.5 hrs by the construction road or stop the boat a little bit further at Vangtham area (around 2 km upper Hmong village) and walk along the river for 1 hrs.

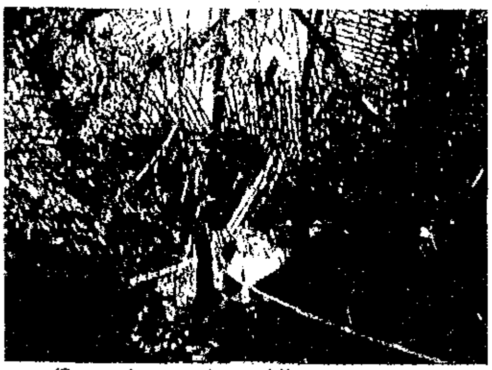
The geomorphology of dam site area is U-shape type with cliff of weathered sandstone in the form of big boulders. *(See photos below).*

(Big boulders on the upper part of left bank side)



(The boulders around ND-1 drill site)

(The boulders below ND-1 drill site)



(Steep slope at the middle part trap to river have to use the rope to climb up & go down)

b. <u>Objective of Investigation</u>:

The study area regionally is located in the Postmezozoic anti-clinory system, which called as Lao-Vietnam Fold System. As the generalized stratigraphic column hereunder and the real structure as above pictures, the geological structure and physic-mechanical properties and also hydro-geological features of the rock and soil should be determined by geological investigation.
The goal of investigation is to define the structure and texture of soil and rock and its geotechnical data such as: unit weight, specific gravity, compressive strength, water absorption, permeability and other required figures for design of the dam.

GENERALIZED STRATIGRAPHIC COLUMN

LAO - VIETNAM and NORTHERN THAILAND FOLD SYSTEMS

50 to 60 m	10-15 m	Reddish Clayey zone (Entirely Decomposed Bedrocks)	Lateritic Weathering crust with fracturing zone.
	5 to 10m	Debris zone: broken stone, size of 15 cm. Yellowish clay filling joints and opening.	
	20-30 m	Zone intensive external fracturing bedrocks.	Quaternary deposits.
300 to 500 m		Basalt (Quaternary period) — Conglomerate (Neogene period)	Neogene - Quaternary deposits
800 to 1500 m		Continental psephitic deposits; - locally include salt-bearing bed and coal bed intercalated.	Folding molasse Upper Triassic and Jurassic periods.
1.5 to 2.0 km		Limestone, Sandstone, Mudstone and Siltstone.	Upper Paleozoic Era and Lower Triassic period.
7 to 9 km		Shale, Slate stone, Sandstone and Limestone.	Lower and Middle Paleozoic Era.
		Facies of amphibolite rocks of metamorphism.	Precambrian period

II. Scope of Work:

The scope of work for geological investigation shall be as follows :

1. Road access repairing partially from the conjunction of main road to Borikhan District and construction new road access from Ban Hatkham (Local people call as "Hatyuun")
2. Set up temporary base camp, prepared each drilling sites and mobilization all drilling equipments by helicopter in each sites.
3. To execute core drilling including with water pressure test and Standard Penetration Test (SPT) in total of 9 boreholes.
4. To carry out seismic exploration work.
5. To carry out the laboratory test to purpose of confirming the basic physical, chemical and mechanical characteristics of the collected rock samples.
6. To prepare the geotechnical final report for all data that concern with the feasibility study in this project.

III. Methods of Investigation:

The geological investigation by core drilling, water pressure tests, seismic exploration and laboratory tests for the purpose of obtaining geotechnical data of the sub-surface condition of the sites proposed for dam, re-regulating weir, construction material resources and other important structures of the Nam Ngiep–I Hydropower Project

a. Drilling work:
Drilling work has been carried out by single core – dry drilling method in the overburden part with setting up casing diameter of HQ size (94 mm) and the core drilling work was carried out by 4 rotary drilling machines; 2 of model TONE THC-1, 1 of model TONE THS-88 and 1 PAT-201 model (for NQ1). Boreholes were penetrated by water circulation bits (NQ size or ID 60 millimeters, in approximately) attached to the bottom of the drill rod, cut and grind, then advance into the borehole. Water was forced down by mud pump (NA-60), through the drill rod and bit. Then the returned flow forced the cutting up to the surface. The core samples was collected by wire line core barrel method and placed in order in core boxes.

b. Field permeability:
Respecting to the technical specification and recommendation of project consultant 2 permeability testing method were applied.

a. Open-end constant-head test method:
For each 3 meters depth of unconsolidated strata. The quantity of the supplied water must be measured and recorded every minute for a duration of 20 minutes. The results presented in terms of coefficient of permeability, as calculated by the following formula ;

$$K = (Q/5.5rH) \times 60$$

Where,
K = Coefficient of permeability (cm/sec), r= Radius of casing (cm.)

H = Water head from the bottom of the hole up to constant water level. If groundwater table is higher than the bottom of hole, it is the height of the constant water level from the groundwater table (cm.)
Q = Rate of water supply (cm3/min).

b. Water pressure test (Lugeon test):

In the bedrock executed in the section of borehole passing through bedrock by 5 m. stage in descending order, by used of packer. Pumping water into the section through the injection pipe under a certain water pressure regulated constant, then measuring quantity of water injection rate every 1 minute during 10 minutes. This procedure must by repeated under varied pressure are 1 kgf/cm^2, 4 kgf/cm^2, 7 kgf/cm^2, 10 kgf/cm^2, 7 kgf/cm^2, 4 kgf/cm^2, 1 kgf/cm^2.

The results of this test presented in coefficient of permeability and Lugeon Unit, as calculated by the following formula:

$k = q \times 10^3 \times \ln (L/r) / (2LH \times 60)$ when $L > 10r$
$k = q \times 10^3 \times \mathrm{Smh}^{-1} (L/2r) (2LH \times 60)$ when $10r > L > r$
$Lu = (q/LH0 \times 10^6$

Where;
k = Coefficient of permeability (cm/sec), Lu : Lugeon Unit
L = Length of test section (cm.)
r = Radius of hole (cm.)
H = Water pressure in head (cm.), H = A+B+C – Hf
A = Pumping pressure head (cm)
B = Static water head from the middle part of the test section up to the top of hole. If the groundwater is higher than the middle part of the test section, this shall be the head from the water level to the top of the hole (cm.).
C = Height of the water pressure gage from the top of the hole (cm.).
Hf = Friction loss of energy in the injection pipe (cm.)
q = Water injection rate (litre/minute)

All collected data are recorded in the prepared form.

c. Standard penetration test:

This method describe the procedure for driving a split-barrel sampler to obtain a representative soil sample and a measure of the resistance of the soil to penetration of the sampler.

The penetration resistance of the soil N-Value, is represented by blow count. N-value, reported in blow/foot, equals the sum of the number of blows required to drive the sampler over the depth interval of 6 to 18 inches.

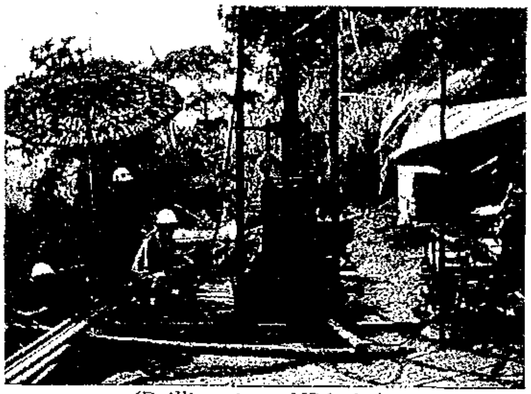
The results of testing were recorded as per attached documents.

d. Laboratory testing Method:
All selected samples were sent to analyze in Bangkok Laboratory.
The laboratory tests were carried out according to procedure recommended by ASTM Standard.

IV. Schedule/Progress of Investigation:

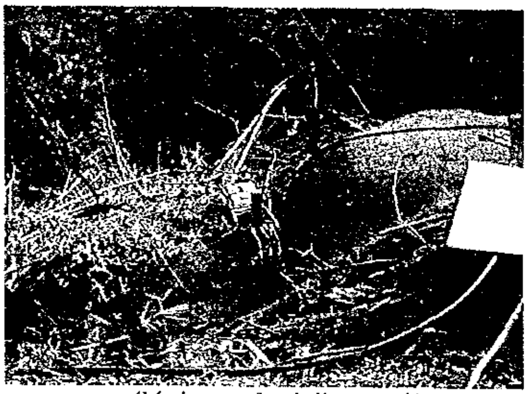
The drilling works has been carried out by 3 rigs. The actual progress schedule of work is as the following:

(Preparation drilling equipment at Ban Hatkham)



(Drilling rig on ND1 site)

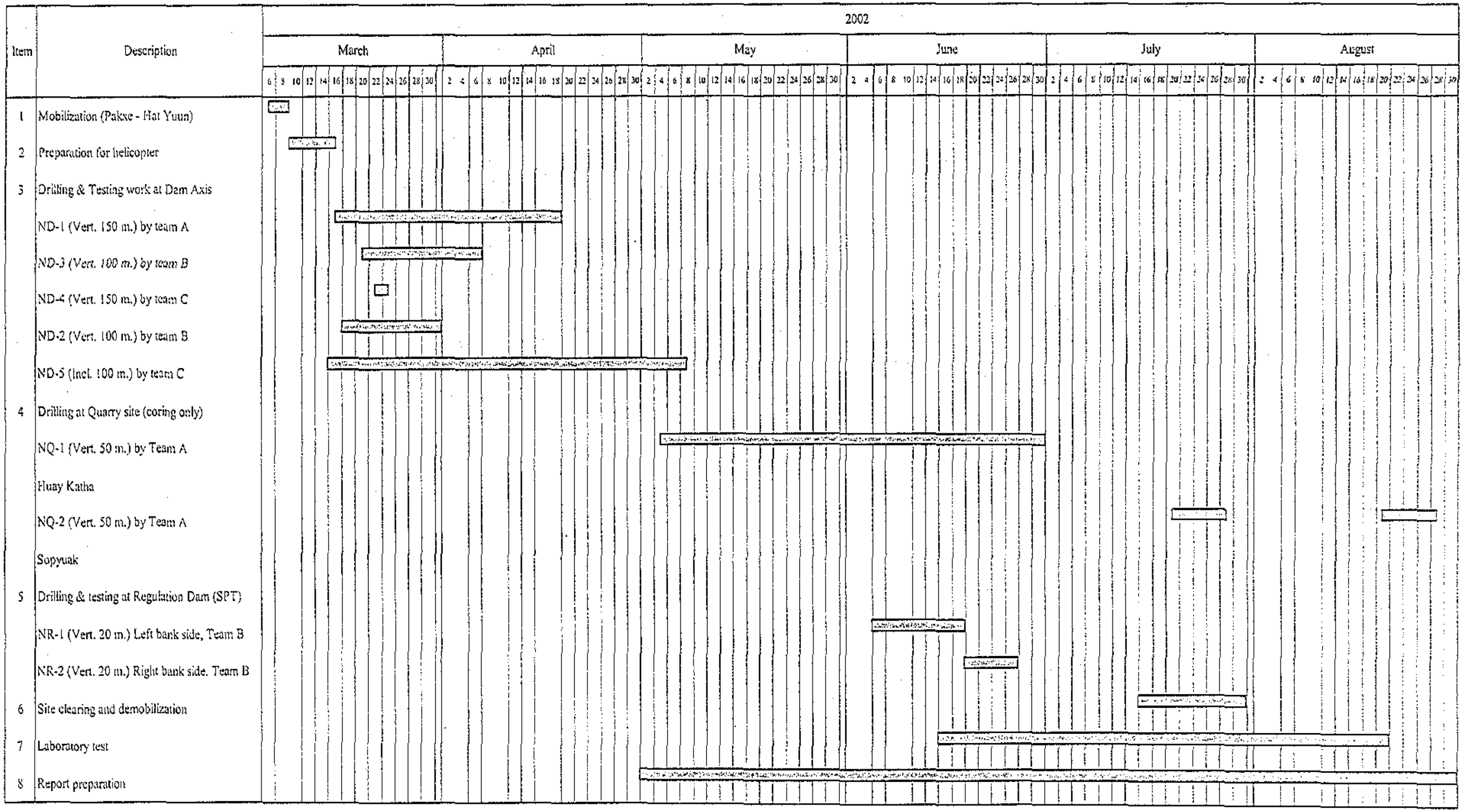
(DeliveryFuel-white, water-black by tube)



(Mud pump for drilling work)

ACTUAL WORKS FOR THE GEOLOGICAL INVESTIGATION FOR NAM NGIEP DAM PROJECT

Figure No.1



V. Implementation of Geological Investigation:

a. Access road Repairing & Construction:

The access road repairing has been carried out by using bulldozer TD-20 (equivalent to D8) from the conjunction of the road to Borikhan District Ban Nonsomboon to Ban Hatyuun (Ban Halkham on the map). Total distance of repairing part is 22 km.

The construction of new road access from Ban Hatyuun to the damsite was undertaken by using 1 bulldozer and 2 excavators. The difficulty is no survey work for the road alignment had been carried out. Nevertheless, base on the experiences of road engineer they has reached the top of the damsite axis with total length 10 km. Additionally the access road to Hmong village also has been constructed with the distance of 700 m and the access to the regulation weir site with a distance of 1,200 m. Total new constructed road distance is around 12 km.


(Contructing road at km 4+500)


(Contructed road at km 6+500)


(The end of road access at dam site axis)


(The end of road access at NR1 site)

The details are given in the attached map and profiles.

b. Field Exploration work:

The geological investigation work had been started since March 16, 2002 and was completed in July 20, 2002

1) Mobilization work:
All drilling equipment and accessories has arrived on March 7, 2002. All

equipment arrived Ban Hatkham and preparing for helicopter, which expected to be on site on March 8. However, the flight plan was changed by emergency work of high ranging officers. The drilling team prepared necessary equipment and packing work. Eventually on the March 15, 2002, K-32 helicopter has arrived and carried out mobilization of drilling equipment to the dam site.

2) Core drilling and testing Works:

Core drilling and testing works have been undertaken with co-operation of Siam-Tone Company, who mainly has mainly provided technical support to us. The works have been carried as follows:

1. Core Drilling Work:

The total of 9 boreholes was drilled. In according with the result of topographic survey and GPS measurement the locations of boreholes are shown in the following table:

Table No 1

Station	Easting	Northing	Elevation	Drilling depth	Remark
MBFr	344,240.79	2,062,393.11	212.094	French BM	For reference only
ND1	344,459.90	2,062,512.39	321.493	150 m	By EDM
ND2	344,251.46	2,062390.35	211.497	100 m	By EDM
ND3	344,230.12	2,062,278.90	205.044	100 m	By EDM
ND4	344,304.06	2,062,041.60	322.335	150 m	By EDM
ND5	344,230.00	2,062,280.30	205.040	100 m	By Comparing
NR1	349,340.69	2,062,541.71	172.442	20 m	By EDM
NR2	349,319.41	2,062454.84	167.565	20 m	By EDM
NQ1	341,800	2,061,960	325	50 m	By GPS
NQ2	329,863	2,071,591	464	50 m	By GPS

At the dam site 5 bore hole has been drilled with total depth of 600 m. In this 1 bore hole (ND5) is incline drilling of 100 m depth.

The details boring logs and daily reports are given in the attached documents.

2. Field Permeability Test:

a) Permeability test in unconsolidated deposits:

Permeability test by the open-end constant-head test method as above described.

Table No. 2

Station	Test number	Testing depth (m)	Average K (cm/s)	Remark
ND1	1	3.00	1.43×10^{-1}	
	2	6.00	7.22×10^{-2}	
	3	9.00	4.77×10^{-2}	
	4	12.75	3.17×10^{-2}	
	5	17.50	2.52×10^{-2}	
	6	20.5	2.07×10^{-2}	
ND2	1	3.00	0.00	
	2	6.00	1.45×10^{-3}	
	3	9.00	3.90×10^{-3}	
	4	12.00	4.12×10^{-3}	
	5	15.00	5.97×10^{-4}	
	6	18.00	2.03×10^{-3}	
	7	21.00	3.51×10^{-3}	

Table No. 2

Station	Test number	Testing depth (m)	Average K (cm/s)	Remark
ND3	1	3.00	1.03×10^{-1}	
	2	6.00	6.10×10^{-2}	
	3	9.00	2.83×10^{-2}	
	4	12.00	1.77×10^{-3}	
	5	15.00	1.62×10^{-2}	
	6	18.00	8.46×10^{-3}	
	7	21.00	7.94×10^{-3}	
ND4	1	3.00	1.63×10^{-1}	
	2	6.00	4.54×10^{-3}	
	3	9.00	4.62×10^{-3}	
ND5	1	3.00	1.21×10^{-2}	
	2	6.00	8.12×10^{-3}	
	3	9.00	1.55×10^{-2}	
	4	12.00	1.75×10^{-2}	
	5	15.00	4.46×10^{-3}	
	6	18.00	3.81×10^{-3}	
	7	21.00	5.13×10^{-2}	
NR1	1	5.00	1.35×10^{-2}	
	2	11.20	2.10×10^{-4}	
	3	16.10	0.00	
	4	20.00	0.00	
NR2	1	5.00	3.84×10^{-2}	
	2	10.50	0.00	
	3	15.00	0.00	
	4	20.00	0.00	
Total	38			*(Reference file: rp-nng-f.xls)*

b) Water Pressure test in Bedrock:

Water pressure test has been carried out in the 5 bore holes, which located in dam site area, where the bed rock was drilled. Total amount of test is 94.

Table No. 3

Station	Test amount	Testing Interval (m)	Remark
ND1	25	26.5 – 150.0	
ND2	14	30.0-100.0	
ND3	14	30.0-100.0	
ND4	26	20.0-150.0	
ND5	15	25.0-100.0	
Total	94		

The details of testing result are given in the attached documents.

3) Standard Penetration Test:

The Standard Penetration Test (SPT) has been tried to carry out at NR-1 and NR-2. But the formation of overburden deposits is alluvial formation with gravel, boulders and sand very loose, which did not be suitable for SPT testing.

4) Topographic Survey

Topographic survey was additionally planned. Previously, this work is deemed that topographic team will carried out. However the topo-survey team has finished their work before geotechnical investigation work. Nevertheless, we have to define the co-ordinate and elevation of boreholes and also seismic alignment.
The road alignment and profile has been also undertaken for all length of new constructed access road.

The results of survey works have illustrated in the form of profiles in the attachment documents.

3. Seismic Refraction Prospecting

Seismic Refraction Prospecting has been carried with technical support and co-operation of Siam Tone & GMT Company from Thailand.
The report of seismic work is given as attachment documents.

c. Laboratory Testing

The collected samples were sent to Laboratory in Bangkok, Thailand. Item and envisaged quantities of the laboratory test are as following.

1)	Water absorption and bulk density (ASTM C136)	20 samples
2)	Unconfined Compression and Poisson's Ratio(ASTM D2938)	20 samples
3)	Super-sonic wave velocity test	20 samples
4)	Chemical (alkali) reactivity test (ASTM C289)	20 samples

The results of laboratory test are summarized as shown in Table No 4 & 5.

Table No 4 Summary of Rock Testing for Nam Gniep - I Hydroelectric Power Project in Lao P.D.R. (Phase II)

Hole No.	Sample No.	Depth (m)	Total unit weight (ton/m³)	Specific Gravity	Max. Compressive Strength (ton/m²)	Water Absorption (%)	Colour	Rock Description
ND-1	R-1	53-54	2.61	2.62	20,326	0.71	Light Brownish Gray	Conglomeratic Sandstone
	R-2	41-42	2.58	2.62	9,969	0.79	Light Brownish Gray	Conglomerate
	R-3	36-37	2.61	2.61	15,523	0.87	Pale Red	Sandstone
	R-4	47-48	2.66	2.69	7,095	0.67	Grayish Red Purple	Sandstone
	R-5	69-70	2.70	2.73	5,062	0.93	Dark Reddish Brown	Mudstone
	R-8	107-108	2.62	2.61	19,254	0.96	Light Gray	Sandstone
ND-2	R-6	36-37	2.68	2.69	13,407	0.39	Grayish Red Purple	Sandstone
	R-9	28-29	2.70	2.64	3,798	1.68	Dark Reddish Brown	Mudstone
ND-3	R-10	45-46	2.71	2.69	4,545	1.05	Dark Reddish Brown	Mudstone
	R-13	52-53	2.58	2.64	5,986	0.48	Pale Red	Sandstone
	R-15	81-82	2.70	2.67	7,702	1.20	Dark Reddish Brown	Mudstone
ND-4	R-7	42-43	2.59	2.60	14,040	1.08	Very Light Gray	Sandstone
	R-12	68-69	2.72	2.69	2,519	1.24	Dark Reddish Brown	Mudstone
ND-5	R-11	70-71	2.61	2.59	5,540	2.50	Grayish Red Purple	Mudstone
	R-14	53-54	2.51	2.60	7,140	1.13	Grayish Red	Sandstone
	R-16	81-82	2.70	2.70	5,899	0.43	Grayish Red Purple	Mudstone
NQ-1	R-17	35.15-35.70	2.69	2.60	5,671	1.25	Dark Reddish Brown	Mudstone
	R-18	45.00-45.30	2.70	2.69	20,300	0.25	Pale Brown	Sandstone
NQ-2	R-19	38.00-42.60	2.54	2.64	2,218	0.65	Pinkish Gray	Highly Weathered Granite
	R-20	43.00-48.00	2.52	2.65	1,849	1.39	Medium Gray	Highly Weathered Granite

Table No. 5 Summary of Sonic Velocity Test on Rock Samples for Nam Gniep - I Hydroelectric Power Project in Lao P.D.R.

Hole No.	Sample No.	Depth (m)	Young's Modulus (GPa)	Modulus of Rigidity (GPa)	Poisson's Ratio	Lame's Constant (GPa)	Bulk Modulus (GPa)	Colour	Rock Description
ND-1	R-1	53-54	23.04	8.69	0.33	16.29	22.08	Light Brownish Gray	Conglomeratic Sandstone
	R-2	41-42	19.07	7.24	0.32	12.53	17.36	Light Brownish Gray	Conglomerate
	R-3	36-37	19.99	7.74	0.29	10.87	16.03	Pale Red	Sandstone
	R-4	47-48	28.10	10.07	0.39	37.87	44.58	Grayish Red Purple	Sandstone
	R-5	69-70	50.02	21.29	0.17	11.44	25.63	Dark Reddish Brown	Mudstone
	R-8	107-108	25.02	9.22	0.36	22.89	29.04	Light Gray	Sandstone
ND-2	R-6	36-37	31.03	11.07	0.40	45.12	52.50	Grayish Red Purple	Sandstone
	R-9	28-29	21.57	7.86	0.37	22.82	28.07	Dark Reddish Brown	Mudstone
ND-3	R-10	45-46	19.78	6.96	0.42	37.00	41.64	Dark Reddish Brown	Mudstone
	R-13	52-53	24.29	9.08	0.34	18.88	24.94	Pale Red	Sandstone
	R-15	81-82	22.05	7.75	0.42	42.65	47.82	Dark Reddish Brown	Mudstone
ND-4	R-7	42-43	22.65	8.45	0.34	18.01	23.64	Very Light Gray	Sandstone
	R-12	68-69	14.82	5.61	0.32	10.04	13.78	Dark Reddish Brown	Mudstone
ND-5	R-11	70-71	24.32	11.96	0.02	0.41	8.39	Grayish Red Purple	Mudstone
	R-14	53-54	22.47	8.55	0.31	14.37	20.07	Grayish Red	Sandstone
	R-16	81-82	31.51	11.15	0.41	52.96	60.39	Grayish Red Purple	Mudstone
NQ-1	R-17	35.15-35.70	19.94	7.55	0.32	13.54	18.57	Dark Reddish Brown	Mudstone
	R-18	45.00-45.30	21.10	7.57	0.39	27.82	32.87	Pale Brown	Sandstone
NQ-2	R-19	38.00-42.60	23.24	11.40	0.02	0.47	8.06	Pinkish Gray	Highly Weathered Granite
	R-20	43.00-48.00	22.90	10.96	0.04	1.08	8.39	Medium Gray	Highly Weathered Granite

VI. Conclusion:

Execution of geological investigation works of the above mentioned project was started in late dry season. The main difficulty is seasoning rain, which came earlier in this year. However, we have tried our best to complete the task.

Local people and governor were very happy. They have put some contribution such as clearing the bush along the road and help us to construct soil-wooden convert as they could do.

We highly appreciated the contribution of HPO staff and MOIH officers, who support us to accomplish the work.

We also acknowledge to of Siam Tone Co., Ltd. in technical support and dispatching STC staff engineer to carry out the work.

Very high appreciation of kindly giving recommendations and good suggestions of JICA staff & JICA study team.

We hope that, this project will go on smoothly and will achieve successfully.

ANNEX 7

FACTUAL REPORT
ON
SEISMIC REFRACTION PROSPECTING

Notes: Annexes 1 to 6 and 8 to 9 are not attached hereto.

CONTENTS

Factual Report on Geological Investigation
by Seismic Refraction Prospecting
Nam Ngiep-I Hydroelectric Power Project, Laos PDR

1. Introduction

At proposed dam axis, Nam Ngiep-I HydroelectricPower Project ,Boli Kham Xai, Loa People Democratic Republic as shown in ***Figure 1***. The approximate geographic coordinate of dam site is N 18° 38' 54.1" E 103° 31' 28.6" as shown in ***Figure 2.*** In order to obtain the subsurface foundation condition including depth of solid rock, location of weak zones, faults etc, the geological investigation by mean of seismic refraction prospecting was carried out. The classification of the subsurface substance based upon the difference in velocity of seismic wave propagation is the principal of the proposed investigation method.

2. Scope of Work

The seismic refraction prospecting was performed for two traverse line and some minor traverse lines diagonal from BH-2 to BH-4 and one spread line extend from BH-4 with the total length of 2,070 m. The seismic survey was performed during July 5-9, 2002. The traverse lines of seismic refraction prospecting were shown in ***Figure 3***.

3. Method of Investigation

3.1 Seismic Refraction Prospecting

3.1.1 Equipment

The system of seismic refraction is a set of portable signal enhancement engineering seismograph (24-channel). The system consists of the following:

Seismograph : McSeis 170f, OYO corporation, Japan

Geophone : Constant damping, 28 Hz, OYO Corporation, Japan

: Constant damping, 100 Hz, OYO Geospace Inc. USA

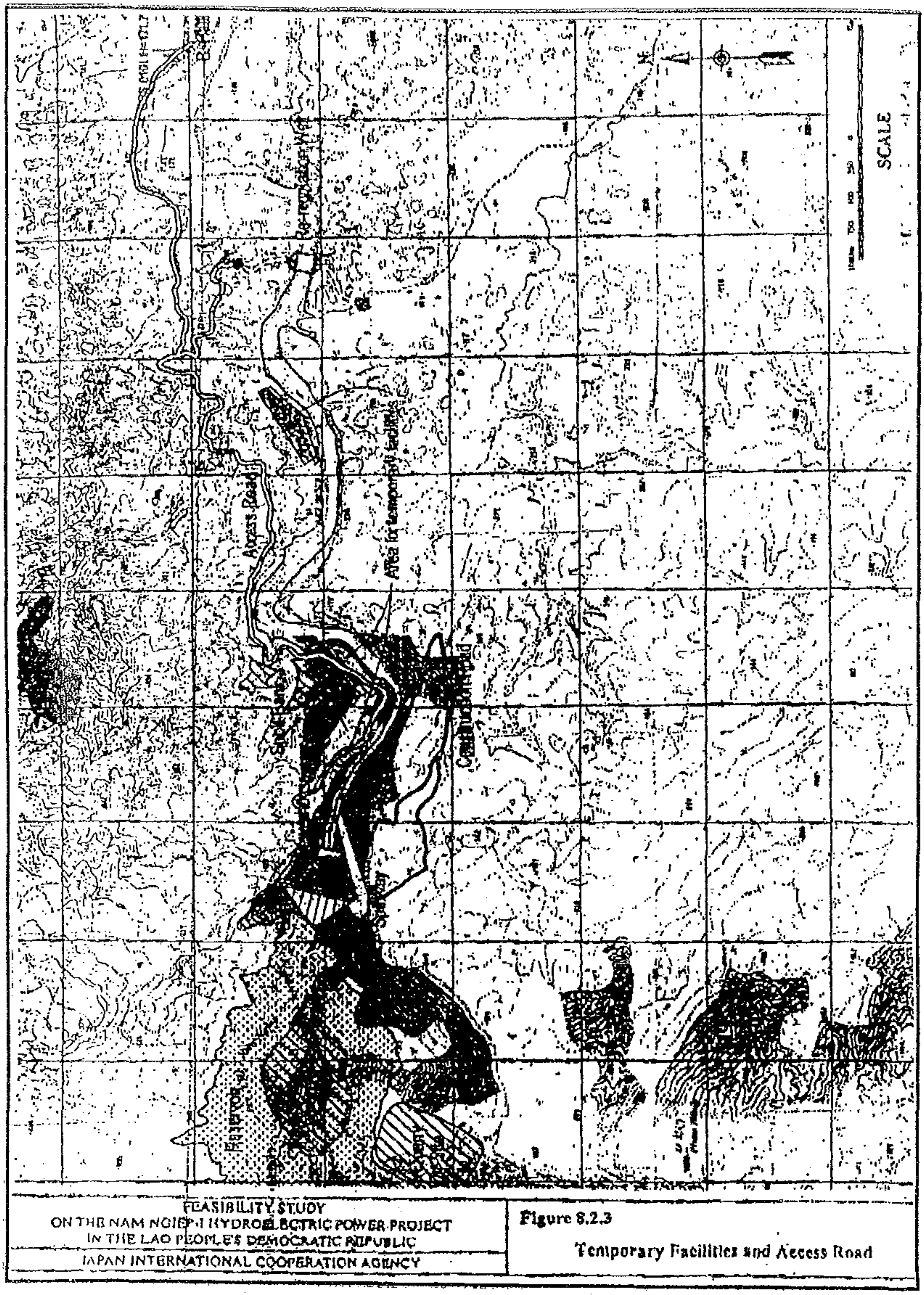


Figure 1 Project Area of Nam-Ngiep I Hydroelectric Power Project

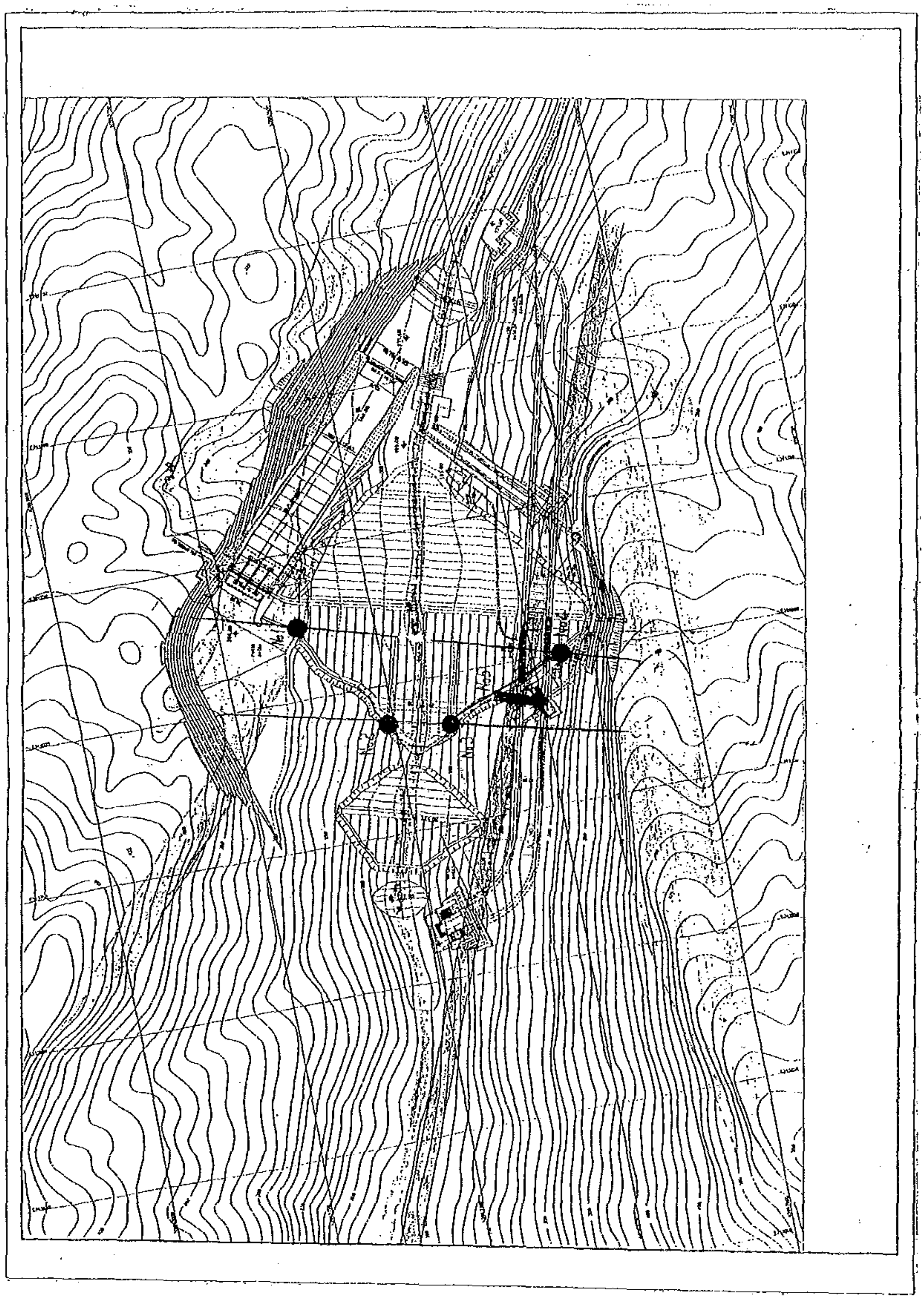


Figure 2 Topographic Map of Project Area

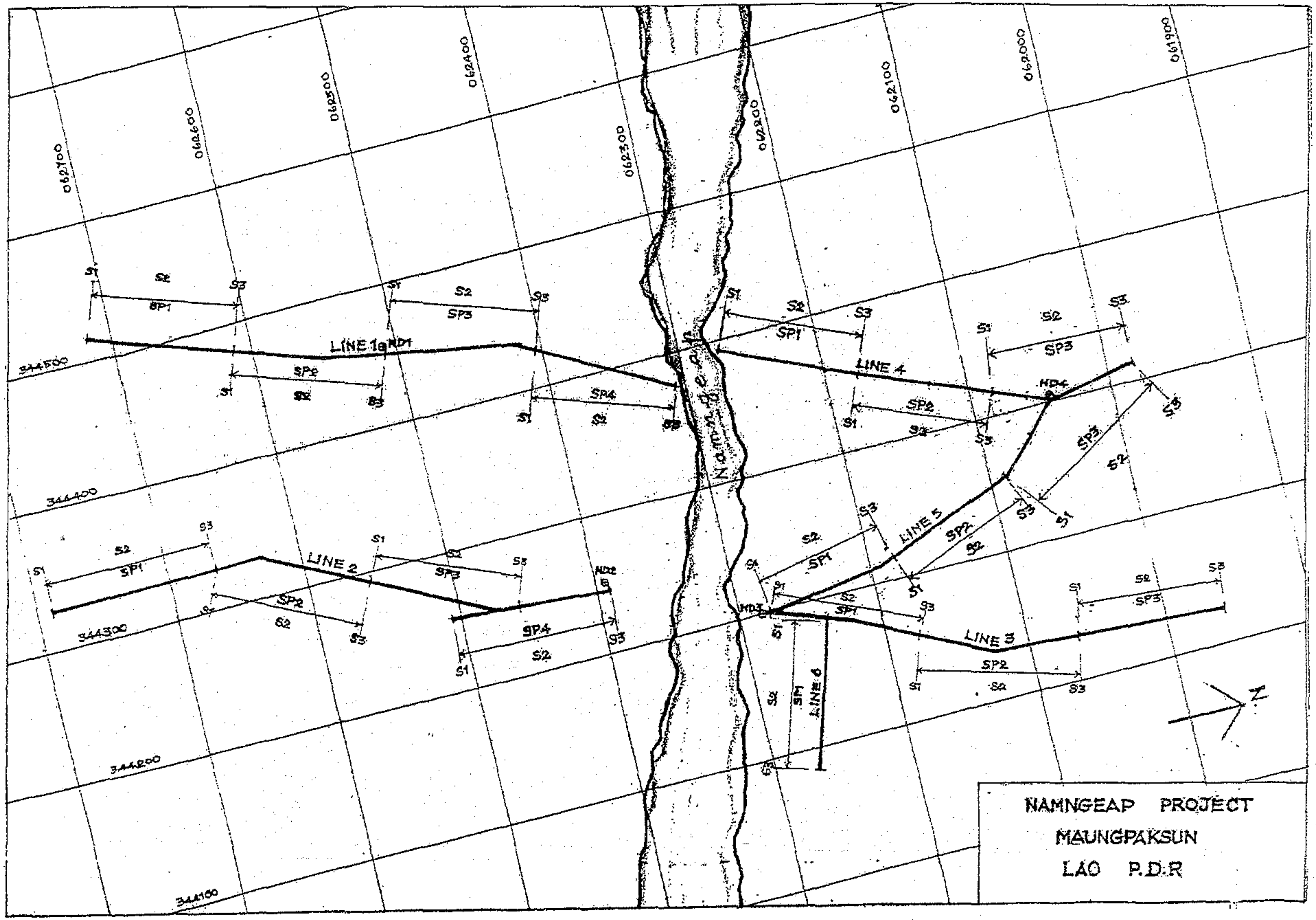


Figure 3 Traverse Line of Seismic Refraction Prospecting

Source : 2 - 35 kg weight drop, in-house made, 12-lb hammer for P wave

: 12-lb hammer and 20x20x200 cm. Wood plank for S wave

Cable : 2-12 take-out with 7.5 m spacing and 15 m lead in, OYO, Japan,

Trigger switch : piezoelectric type, or geophone.

3.1.2 Seismic Refraction Survey

a) Overview

The velocity of transmission of seismic waves varies with the material through which they are passing, and is dependent on the density, porosity, structure and elastic constant of the material. The seismic method of investigation may be considered if the subsurface strata and the boundaries between them fulfill the following requirements:-

- information not required below approximately 30 m. depth
- the interface between the strata approximate to inclined or horizontal planes
- each stratum is of sufficient thickness to reflect a change in velocity on time-distant plot
- the velocity of wave propagation increases with the depth of each succeeding formation

In the seismic refraction method, a shock wave is produced by mechanical means, and the primary, P wave (as opposed to surface and shear waves) are monitored at detecting stations (geophones), which normally equally spaced in a line across the area being investigated. Twenty four geophones would typically be spaced so that the total distant is three or four times the expected depth of the interface. Comparison waves from the source are refracted (and reflected) from the interface, and arrivals of the refracted waves are picked up by the geophones and relayed to a receiving station which records them against a time scale starting from the initiating pulse (shock moment). The time of the first P wave arrivals are plotted on a time - distant plot (T-X plot). A kink in the T-X plot occurs when the faster refracted waves overtake the direct wave arrivals. The velocities of transmission are calculated from the critical distant given by the change in gradient. The depth of an interface in the simple single boundary case is given by the time intercept or critical distance. In practice, the procedure is repeated, moving the geophone group each time along the line to be investigated. Moreover, reverse shooting, or shot points located at both ends of a spread, one at the middle point of the spread and the other two for remote shooting beyond the ends of the spread are also used in order to get better information.

b) Theory and interpretation technique

Physically, the seismic refraction method is based on the fact that differences occur between the velocity of elastic (sound) waves in different geologic formations. The velocity of seismic P wave in air is about 340 m/sec, in soil layer, between 250 - 1,800 m/sec and in igneous rocks some 4,000 - 6,000 m/sec. The refraction method makes use of the fact that when an elastic wave strikes a discontinuity or interface in the ground, the wave is refracted. If the underlying layer is more compact and has a higher velocity, the wave is refracted towards the horizontal, if the layer has a lower velocity, the wave is refracted towards the vertical. If the wave strikes the interface at the critical angle, it is refracted along the interface. The amount that the wave is refracted is determined by Snell's law, which states that

$$(\sin i / \sin r) = (V1/V2)$$

Where i is angle of incidence
r is angle of refraction
V1 is velocity of wave in incidence medium
V2 is velocity of wave in emergent medium

When r is 90 degree, $\sin i_{1,2} = V1/V2$. The refraction along and parallel to the interface is of vital importance in the seismic refraction method. It occurs when ever the incident wave strikes the interface at the critical angle. In ***Figure 4*** illustrates a simple two layer case with horizontal layering and constant velocities V! and V2. It is assumed that V2 is greater than V1. The cross-section (lower part of ***Figure 4***) shows the wave fronts ray paths in the layer. In the upper layer, the waves propagate from the impact point as hemispheres at a velocity of V1. When the elastic waves reach the second layer, they travel at the higher velocity of V2. It is evident that (for example) 0.04 second after the impact distant, the positions of the wave fronts on the ground and in the bedrock are considerably displaced horizontally. Due to oscillations at the interface between the two layers when the wave travel in the lower medium, ground vibrations are created in the upper layer. These vibrations return to the surface in the form of plane wave fronts which make and angle of $i_{1,2}$ with the interface ($\sin(i\ 1,2) = V1/V2$). That is to say, they are critically refracted.

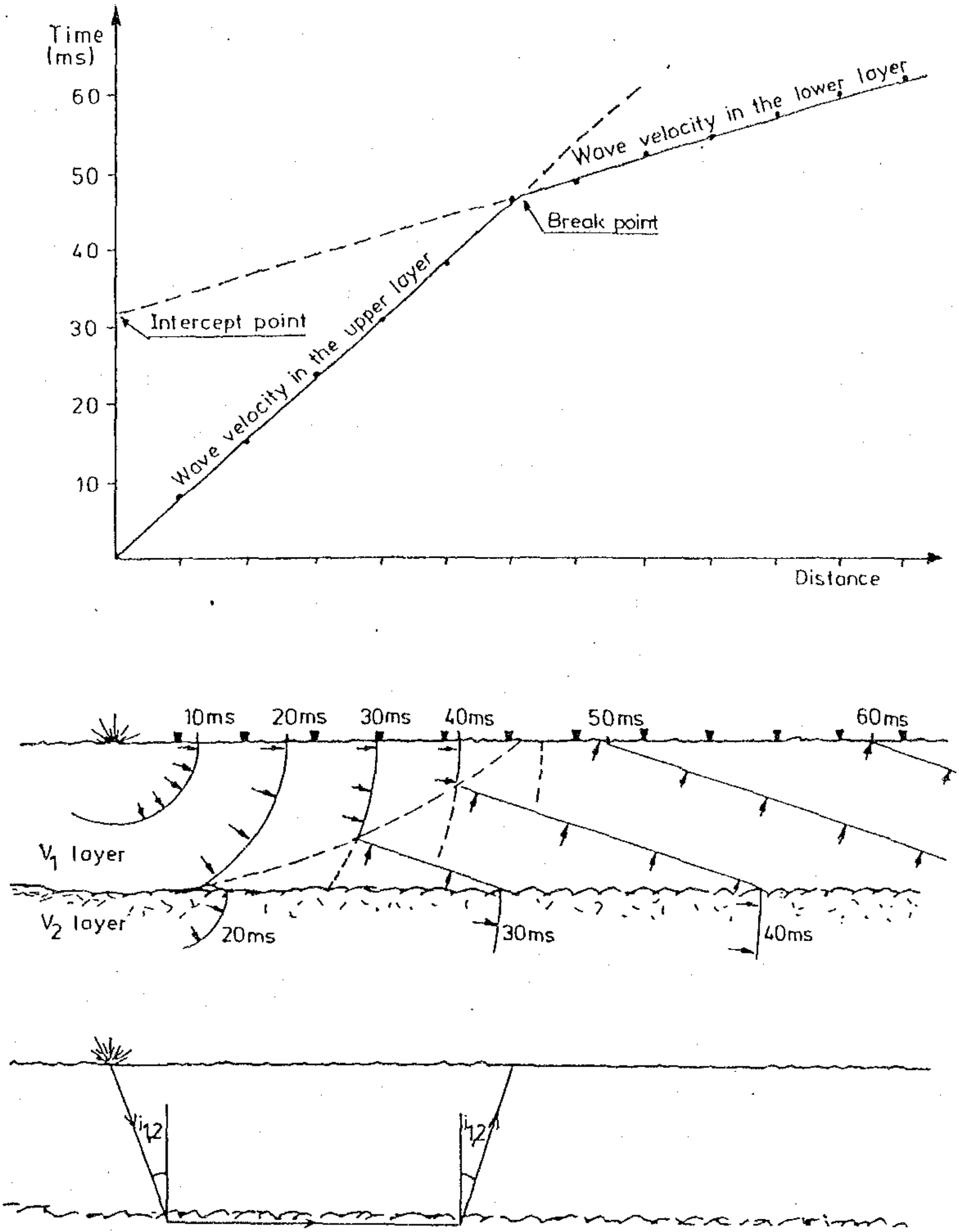


Figure 4 Time-Distance Curves, Wavefront Propagation and Raypath for Two-Layer Case

In the immediate vicinity of the impact point, the waves in the upper layer are the first to reach the geophones implanted on the ground surface. At a distance that is generally 3-5 times the depth to bedrock (interface, so far), the waves travelling the longer but faster route via the V2 - layer will overtake the others. The turning point is the outcropping on the ground surface of the wave front contact.

A corresponding T-X plot is presented in the upper part of ***Figure 4***. The conventional way to interpret and analyze the measured data is to plot the arrival times for each channel on a T-X graph in relation to distances between the geophones. Lines connecting the plotted arrival times indicate the velocities (inverse slopes) in the various subsurface layers. The intersection between these lines corresponds to the outcropping of the wave front contact.

The distance between the impact point and the intersection (breaking point) of the velocity lines can be used to calculate the depth at the impact point. This is called the critical distance method. The depth is obtained using the following equation:

$$h1 = (Xc/2).[(V2-V1)/(V2+V1)]^{1/2}$$

where h1 = depth

Xc = critical distance (impact to intersection of velocity lines)

V1, V2 = layer velocities computed from T-X plot.

Another method of calculating the depth at the impact point is to prolong the velocity line of the V2 - layer back to the vertical line through the impact point. The time from the impact instant to the intersection between the vertical line and the velocity line is then used to calculated the depth. This called the intercept time method. Thus,

$$h1 = (TiV1)/2(\cos i_{1,2})$$

where Ti = intercept time

The equations given above are only valid for two layer with horizontal bedding. For multi-layer case or when the layers are dipping, the equations are considerably more complicated. At present, there are numerous interpretation methods, ranging from the very simple like the two which illustrated above, to the complex. The interpretations based on the ray theory are developed into analytical and graphical methods. Computer programs have been developed for interpretation of refraction data based on the generalized reciprocal method (PALMER, 1980), ray tracing (SCOTT, 1973, ACKERMANN et. Al., 1980), wave equation modeling or finite difference method (KELLEY, et. Al., 1976). Use of analytical technique is sought for fast and accurate handling of refraction data as compared to the graphical technique which is very much time consuming. Our office developed a computer program for seismic refraction survey based on Reciprocal method. The detailed practical routine interpretation was described by HAWKINS, 1961.

4. Results

- Reading first arrival times and time-distance plots

The travel time recorded from the field for each spread is then readout for use as seismic data to draw travel time - distant plot. The velocity of each layer is then computed using time - distant plot. The thickness of the layer is also calculated for each geophone.

- Seismic wave velocity layer profiles

After T-X plot or time - distant plot is completed, the validity of reciprocity of the spread is also check. The number of layer, layer velocity and thickness are computed.

The results of this survey including reading first arrival time, T-X pot, layer velocities and interpreted profile are shown in the appendix

5. Technical Comments

The obtained results shown that there are 2 to 3 layers with vary in thickness, those can be recognized by seismic velocity. The loose overburden with velocity of not more than 700 m/sec. The weathered bedrock is 700- 1400 m/sec in velocity. The velocity of fresh bedrock is more or less higher than 2000 m/sec. The thickness of each layer is varied from about 1 m to more than 20 m.

Due to high relief, dense forest and rain, the noise condition in the survey area is very high. The seismic source used in this survey is a 5.5 kg. sledgehammer. The quality of seismic travel time is not so clear to get sharp value. To overcome this limitation, stronger seismic source and buried geophone for better signal should be considered. Moreover, field investigation period should be performed during dry season.

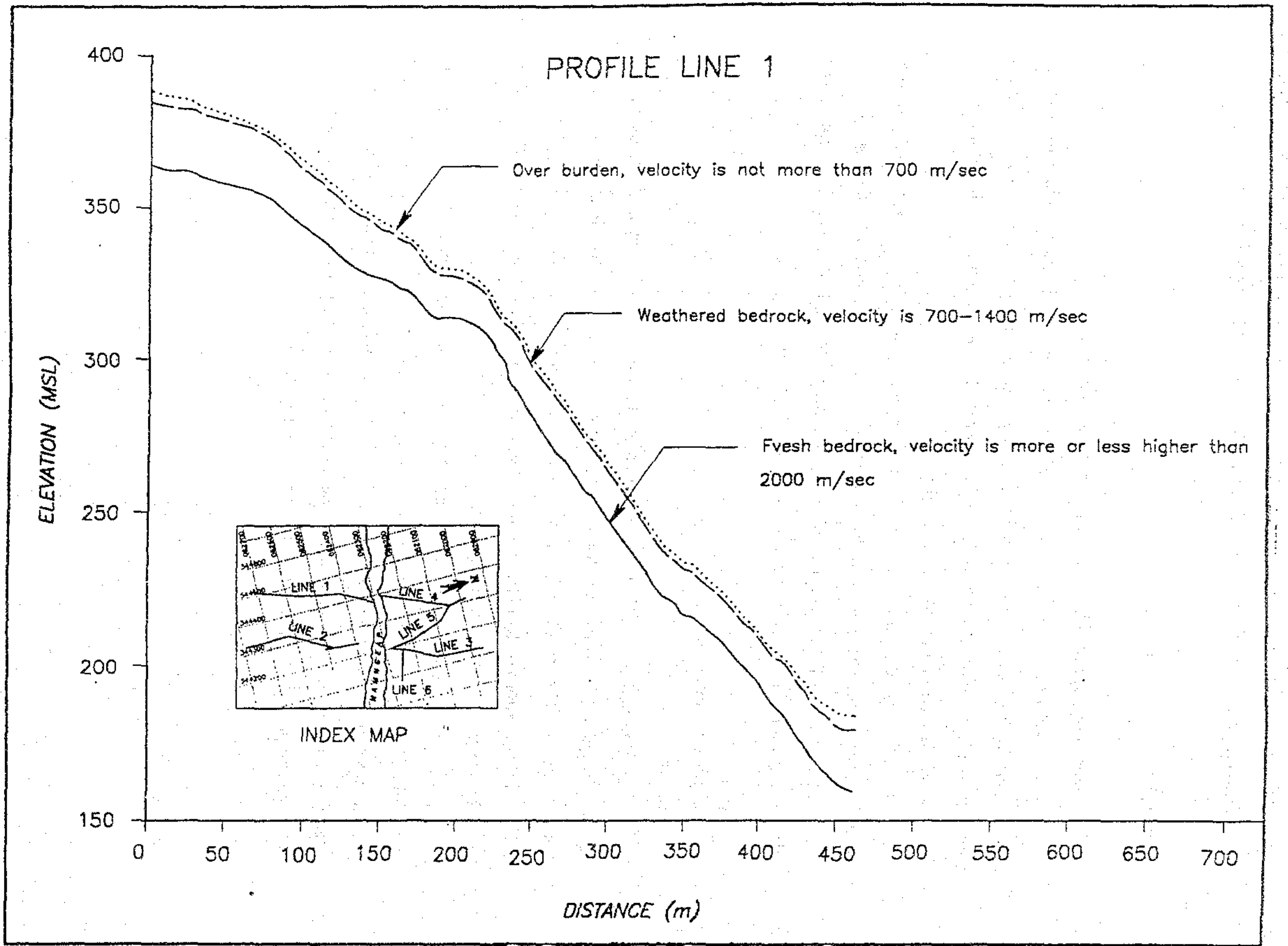


Figure 5 Profile of Subsurface Along Line No.1

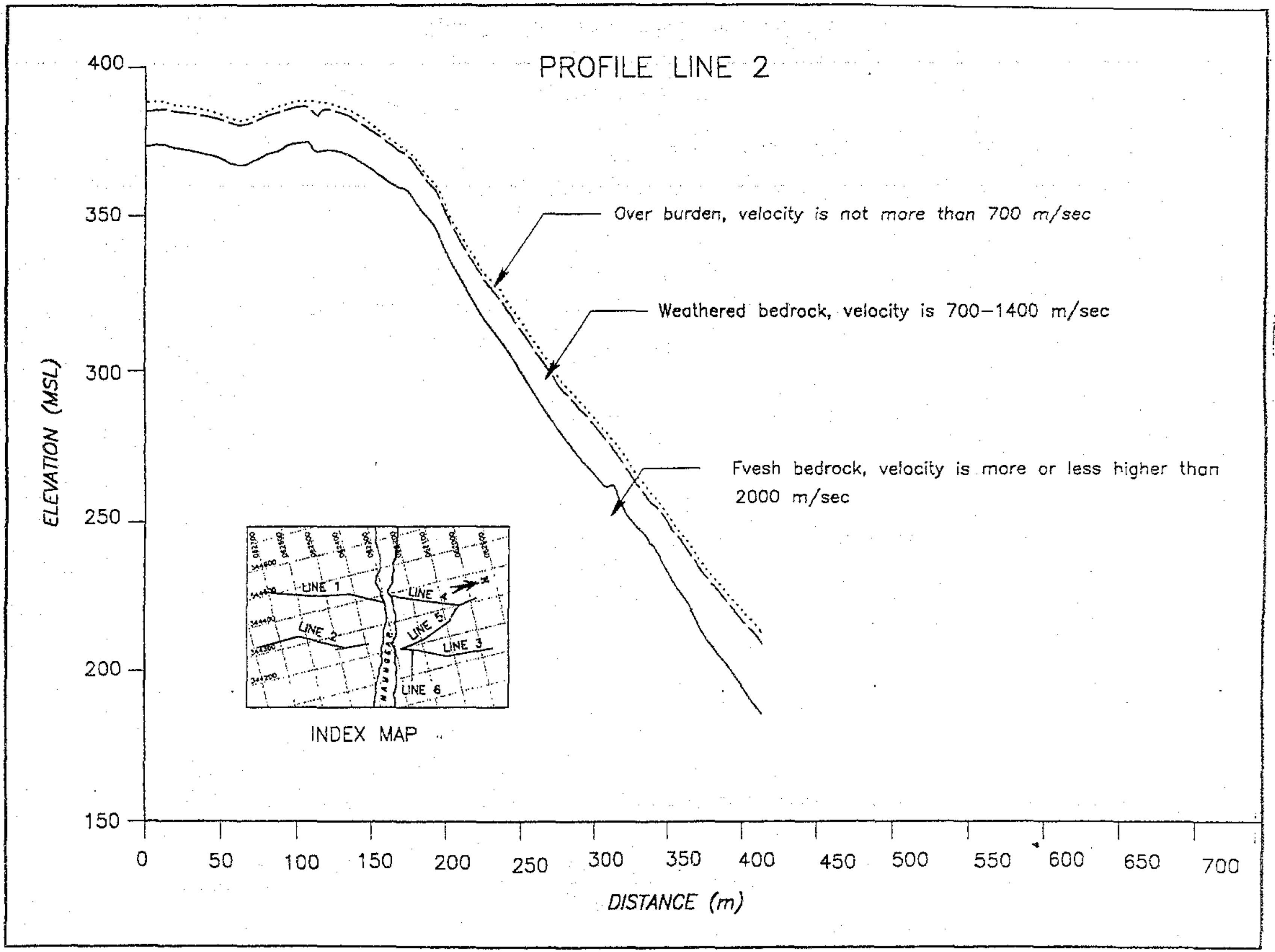


Figure 6 Profile of Subsurface Along Line No.2

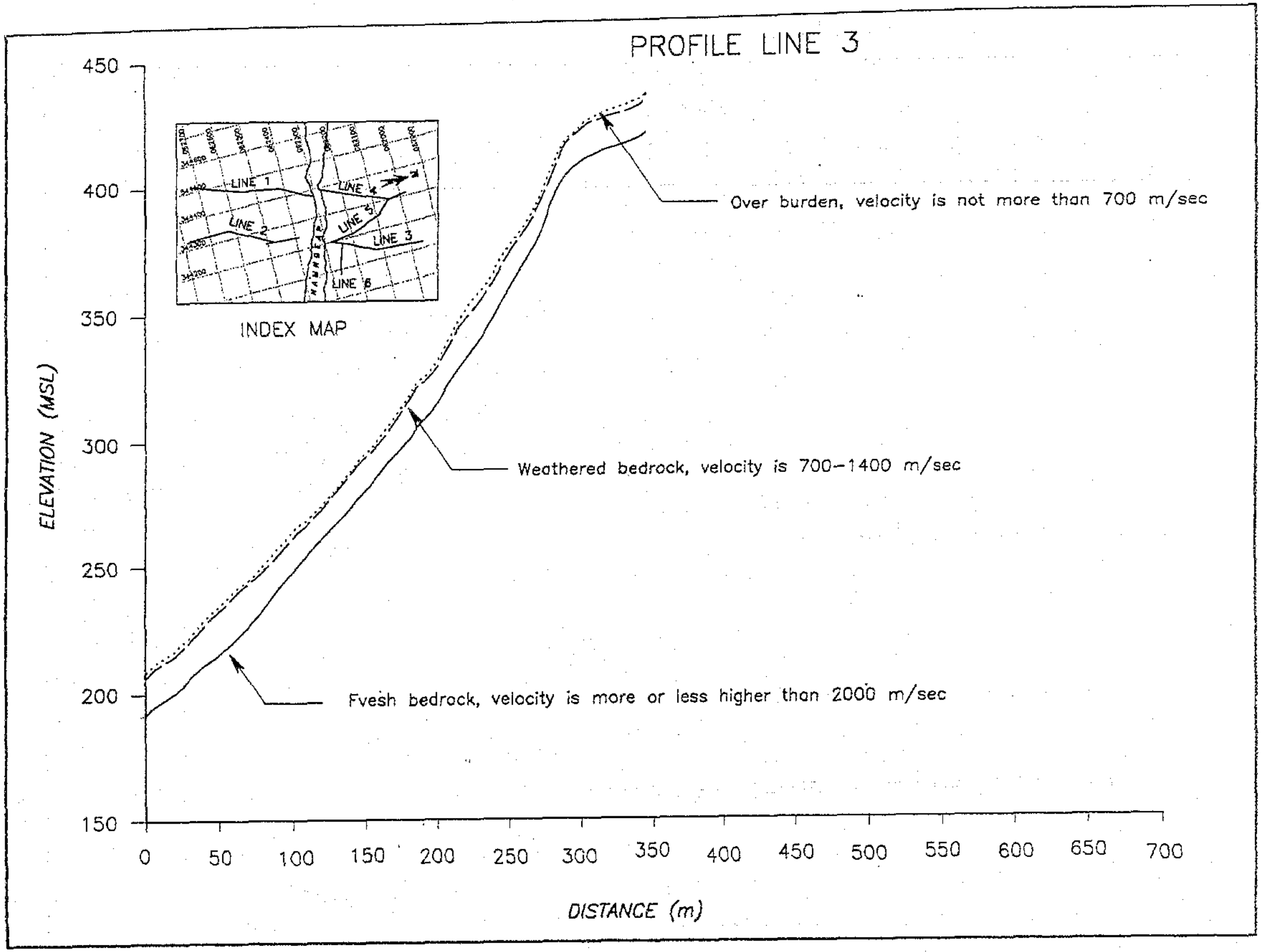


Figure 7 Profile of Subsurface Along Line No.3

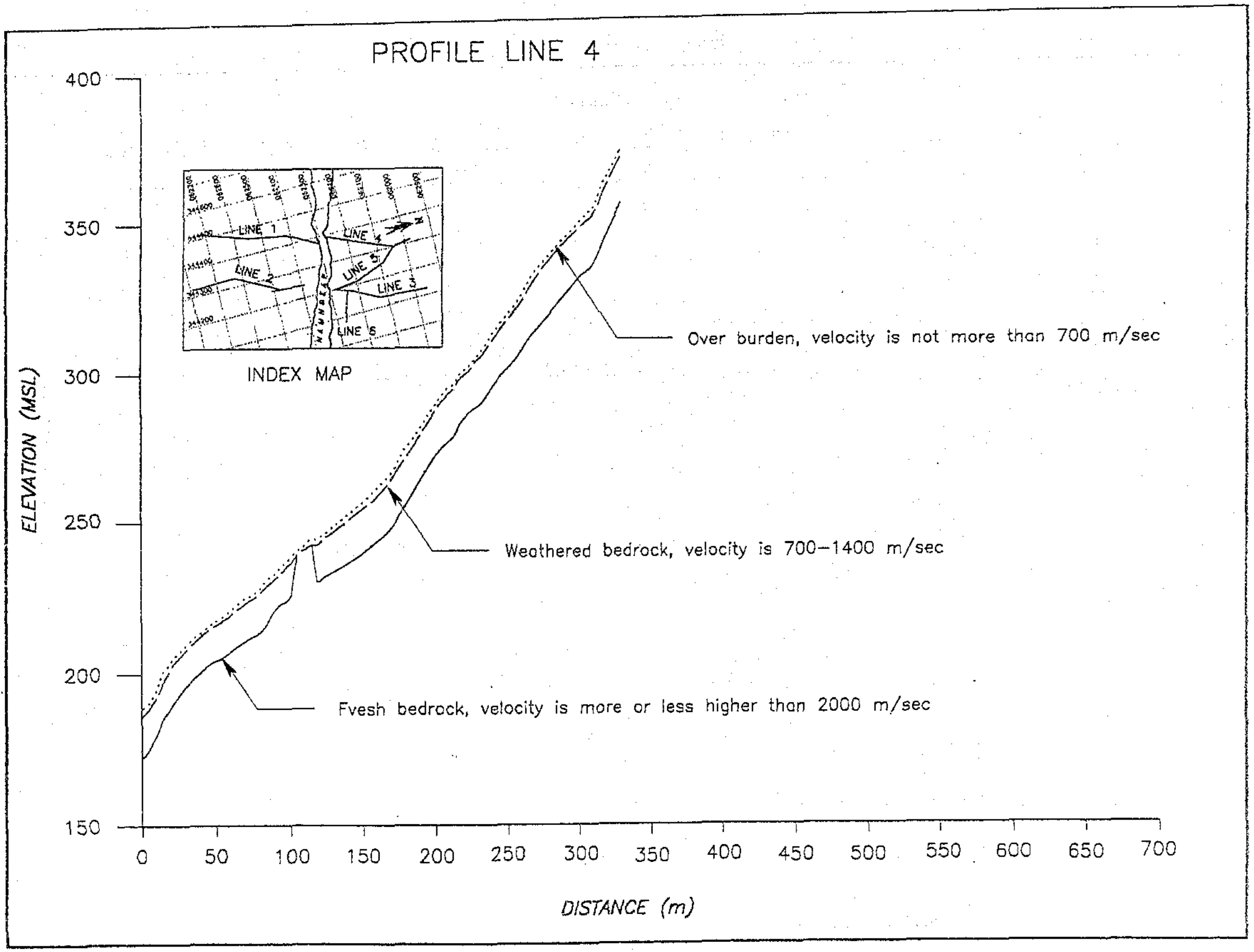


Figure 8 Profile of Subsurface Along Line No.4

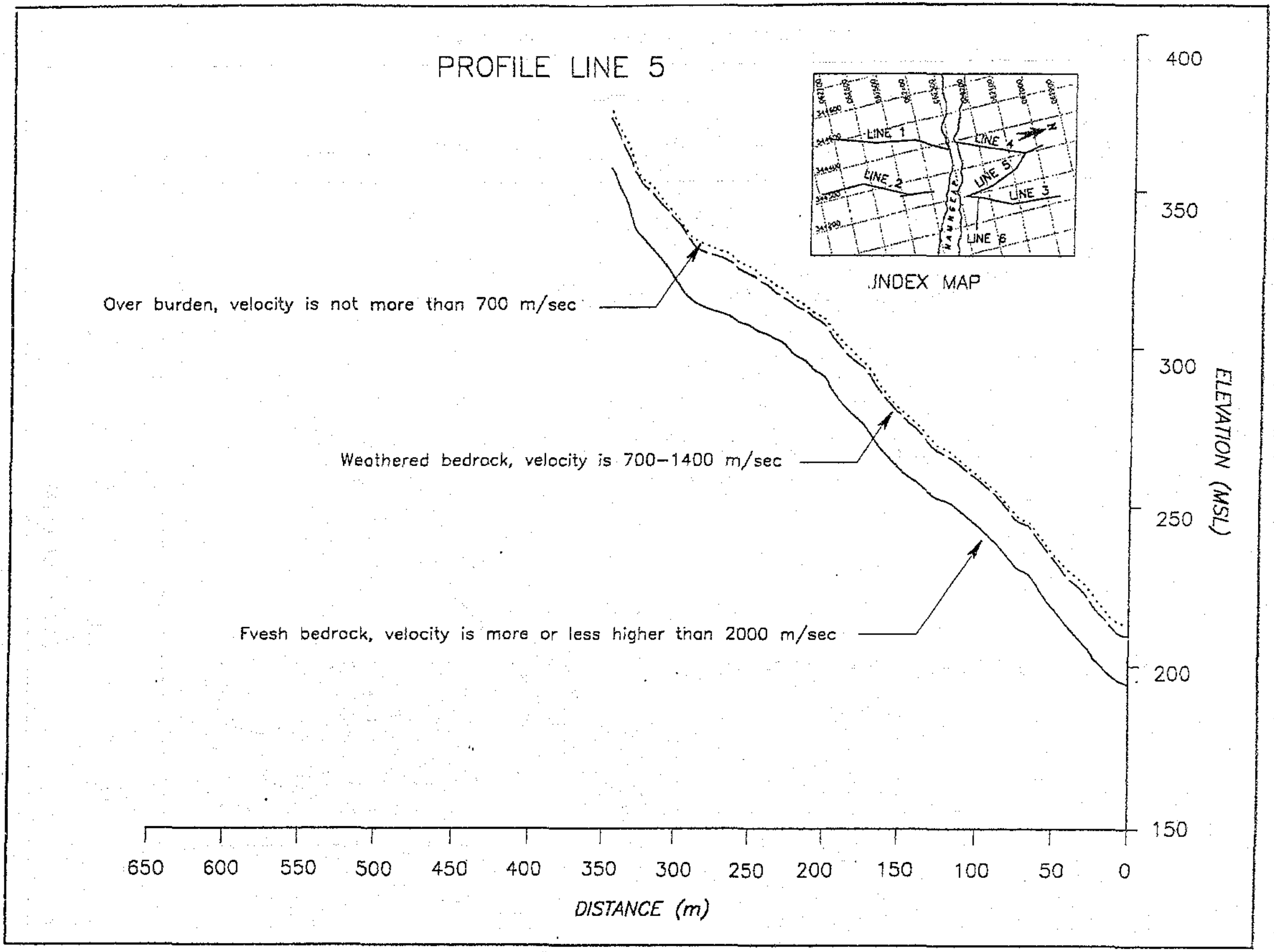


Figure 9 Profile of Subsurface Along Line No.5

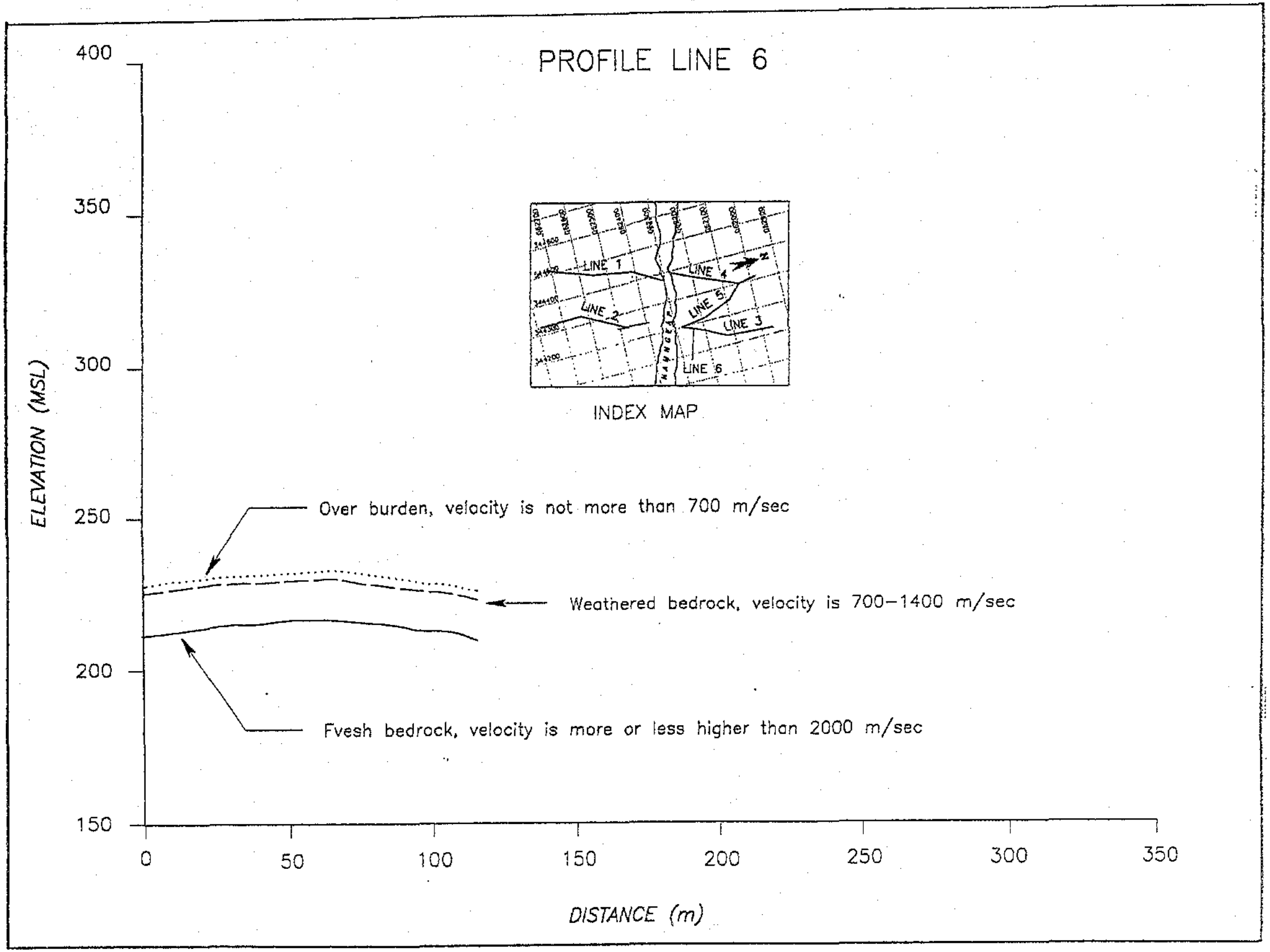


Figure 10 Profile of Subsurface Along Line No.6

CHAPTER - 3

STUDY ON THAILAND POWER SECTOR MARKET OUTLOOK (1997-2016)

FEASIBILITY STUDY
ON
THE NAM NGIEP-I HYDROELECTRIC POWER PROJECT (PHASE II)
IN
THE LAO PEOPLE'S DEMOCRATIC REPUBLIC

STUDY
ON
THAILAD POWER SECTOR
MARKET OUTLOOK (1997-2016)

FINAL REPORT

NOVEMBER 2001

NAVAPAT Construction & Consultant (NCC) Ltd. Partnership
Entrusted by
Nippon Koei Co., Ltd.

Glossary

AAM	Automatic Adjustment Mechanism (Ft)
ACSR	Aluminum Conductor Steel-Reinforced
ADB	Asian Development Bank
ASEAN	Association of South-East Asian Nations
BOI	Board of Investment
BOO	Build-Own-Operate, a scheme in which a private company is set up to plan, design, finance, construct and operate an infrastructure project (in this case a power generation facility) normally undertaken by the government.
BOT	Bank of Thailand
BOOT	Build-Own-Operate-Transfer, similar to BOO except that after an agreed period, usually 20-25 years, the project transferred to the government.
ckt-km	circuit kilometres
CO_2	Carbon Dioxide
COD	Commercial Operation Date
CP	Charoen Pokphand Co., Ltd.
DEDP	Department of Energy Development and Promotion
DR	Discount Rate
DSM	Demand-side management
DSMO	DSM Office
EC	European Community
EGAT	Electricity Generating Authority of Thailand
EGCO	Electricity Generating Co., Ltd.
EHV	Extra High Voltage
EIA	Environmental Impact Assessment
EPC	Engineering Procurement Construction
ESI	Electricity Supply Industry
FCM	Full Condensing Mode no steam export
FGD	Fuel Gas Desulphurisation
FPA	Fuel Purchase Agreement
GDP	Gross Domestic Product
GE	General Electric
GEF	Global Environmental Facility
GT	Gas Turbine
GWh	Gigawatt-Hour (Million Kilowatt-Hour)
HRSG	Heat Recovery Steam Generator
HV	High Voltage
HVDC	High Voltage Direct Current
IPP	Independent Power Producer
IRR	Internal Rate of Return
kJ	kilo-Joul
km	Kilometre
km^2	Square Kilometre
ktoe	thousand tons of oil equivalent
kV	Kilovolt
kVA	Kilovolt-Ampere
kW	kilo-Watt
kWh	Kilowatt-Hour
LNG	Liquefied Natural Gas
LOC	Letter of Confirmation
LPG	Liquefied Petroleum Gas
m	Meter
mbara	millibar absolute
MCM	Thousand Circular Mils
MCR	Maximum net electrical output
MEA	Metropolitan Electricity Authority
mm^2	Square millimeter
mmbtu	million British thermal unit
MMSCFD	Million Standard Cubic Feet Per Day
MOSTE	Ministry of Science, Technology and Environment
MOU	Memorandum of Understanding
m^3/s	Cubic Meter per Second
MTHB	Million Thai Baht
mtoe	million tons of oil equivalent
MVA	Megavolt-Ampere
MVAr	Megavolt-Ampere Reactive
MW	Megawatt
NEB	National Environmental Board
NEPC	National Energy Policy Council
NEPO	National Energy Policy Office
NEQA	National Environmental Quality Act
NESDB	National Economic and Social Development Board
NESDP	National Economic and Social Development Plan
NG	Natural Gas
NO_x	Nitrogen Dioxide
NPV	Net Present Value
OECD	Organization for Economic Development
OECF	Overseas Economic Co-operation Fund
OEPP	Office of Environmental Policy and Planning
O&M	Operation & Maintenance
p.a	per annum
PCC	Pollution Control Committee
PDP	Power Development Plan
PEA	Provincial Electricity Authority
PPA	Power Purchase Agreement
ppm	parts per million
PPP	polluter pays principle
PTT	Petroleum Authority of Thailand
PTTEP	PTT Exploration and Production, a subsidiary of PTT
PU	Private Utility
PWD	Public Works Department
REGCO	Rayong Electricity Generating Co
RFP	Request for Proposals
RHCO	Ratchaburi Holding Company
RYIP	Rayong Industrial Park
SET	Stock Exchange of Thailand
SO_x	Sulphur Dioxide
SPP	Small Power Producer
ST	Steam Turbine
TAMC	Thailand Asset Management Company
TDRI	Thailand Development Research Institute
t/h	ton/hour
THB	Thai Baht
TISI	Thailand Industrial Standards Institute
TLFS	Thailand Load Forecast Subcommittee
TLPC	Thai LNG Power Corporation Limited
TLP COGEN	TLP Cogeneration Company Limited
TNB	Tenaga Nasional Bhd of Malaysia
TOD	Time-of-Day
TOR	Terms of Reference
TOU	Time-of-Use
TOYO	TOYO Engineering Corporation
TWh	Terawatt hours or billion kilowatt hours, a unit of electrical energy
USD	United States Dollar
VAT	Value Added Tax
Yen	Japanese Yen

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Preface

The purpose of the study "Thailand Power Sector Market Outlook" is to learn the situation of power supply and demand in Thailand both in present and future. The structure and regulation of power sector, power development plan, restructuring of power sector as well as some tips for development of a medium hydropower project in Lao PDR, such Nam Ngiep-I HEPP when it intends to join in the Thai power market, are presented in this report.

The study "Thailand Power Sector Market Outlook" is divided into eight chapters:

Chapter 1 provides a socio-economic background and highlights the role of the electricity sector in the Thai economy. It explains the anatomy of the financial crisis during 1997-2000 and comments on electricity demand consumption growth in response to the crisis in the period.

Chapter 2 gives an overview of the country's energy situation by presenting of energy resources and supply as well as energy development target.

Chapter 3 focuses on the evolution of electricity supply and demand, including fuel consumption by the electricity sector and particulars of the transmission and distribution systems.

Chapter 4 reviews the structure of Electricity Structure Industry (ESI) and regulatory framework for the energy and power sector. Key players are identified and the roles of individual agencies presented. This chapter ends with a short discussion of the electricity pricing automatic adjustment mechanism (Ft) in Thailand.

Chapter 5 discusses in detail EGAT's Power Development Plan based on preliminary PDP 2002 (2001-2016) approved by the EGAT Board of Directors in September 2001. This chapter presents the generation and transmission expansion plan and the required capital investment. The activities outcome of demand side management is also presented.

Chapter 6 explains the role of private power generation in the generation expansion plan. The status of independent power producers are presented as well as the opportunities for IPPs as part of the new capacity in the PDP. The present and future contributions of SPPs are also included. This chapter also gives the status of the two challenges in the electricity sector in which private investment will play an important role: the formation of EGAT generation subsidiaries and EGAT's purchases from foreign power producers.

Chapter 7 discusses the power sector privatisation and restructuring power sector. A brief historical background leading to the present programme is provided. The final regulatory framework is presented as being worked out and the privatisation plan for PEA and MEA has yet to be finalized. Chapter 7 also addresses the privatisation of EGAT which is seen as being well under way.

Chapter 8 has given some suggestion for promotion of the Nam Ngiep-I HEPP and the opportunity to join in the Thai power market. This Chapter also recommends the timing for the project enter into the market as well as the mode of operation. The advantage and disadvantage between the PPA and power pool system in view of the developer are also presented. The impact of the ASEAN power grid development and the power pool on the Nam Ngiep-I are also mentioned.

Appendix 1 presents latest list of small power producers as of April 2001.
Appendix 2 presents Draft Energy Industry Act.
Appendix 3 presents Ft's calculation formula.
Appendix 4 presents Comparison of Thai Power Pool and International Transmission Pricing

Executive Summary

1. Introduction

Generally in Thailand, electricity consumption growth had always followed economic growth. After the years of 1995, 1996, 1997 the Thai economy suddenly fallen in crisis. In 1996, the annual growth rate of power demand fell to 8.50% from 14.56% or 6.06% decreased, while energy consumption has decreased 8.93% from 13.25% on yearly before. In 1997, the situation did a minor change in both of power demand and energy consumption, i.e. 0.50% increased and 1.01% decreased from the previous year respectively. However, power demand and energy consumption of the year 1998 and 1999 decreased figures, then reversed into a healthy recovery in 2000 and 2001. It is anticipated that the annual growth rate of power demand and energy consumption of Thailand for the period 2002-2006 (9th NESDP) will increase by 6.86% and 6.79% respectively while assumption on economic growth rate will be 4.2% for the period 2002-2006, and 4.3% period 2007-2011 (10th NESDP).

Economic experts, however, are optimistic and believed that Thailand is on the way to a gradually economic recovering, despite the gloomy global economic outlook, Thailand is highly likely to positive growth in 2001. Hence, electricity consumption growth rate then will be following economic growth.

2. Overall Energy Situation

Thailand is endowed with domestic energy resources. At present, its energy self-sufficiency rate is about 50 %. The estimated hydro potential is 15,155 MW, the natural gas reserve is about 12.2 trillion cubic feet, the lignite reserve is 1,390 million tons, the crude oil reserve 156.2 million barrels and the reserve for condensate is 212.7 million barrels. The hydropower, natural gas and lignite are used mostly for power production. After being discovered in the Gulf of Thailand some 20 years ago, natural gas has been used productively in the power sector. The domestic energy resources will be used to supply about half of the total energy need of the country in 2001. In the 9th NESDP period, the level of utilization of domestic resources will become a little less than 50 %. In the long run, however, the domestic resources will not be sufficient to meet the increasing demand and more energy will be imported. At the end of the 10th NESDP and 11th NESDP periods, the domestic supply will be able to meet only about 30 % and 20 % of the total country demand.

3. Electricity Demand and the Power Development Plan

The Thailand Load Forecast Sub-committee (TLFS) issued the latest load forecast in February 2001. The assumptions for the February 2001 forecast are based on those of the previous forecast issued in September 2000. The revision was only attempted to reflect the economic downturn in 1997-2000 to the new forecast in the macro picture. The TLFS has reviewed the economic condition in the year 2000 and early 2001 and has come up with the conclusion that the overall situation will remain more or less the same as before with expected faster recovery in the 9th NESDP. The TLFS has extended the forecast from 2011 to 2016. The major difference between the September 2000 forecast and the February 2001 forcast is summarized in Table S-1 below:

Table S-1 Comparison of the September 2000 Forecast and the February 2001 Forecast

Fiscal Year	September 2000 Forecast		February 2001 Forecast		Difference	
	MW	GWh	MW	GWh	MW	GWh
2001	16,214	103,685	16,184	103,496	-30	-189
2006	22,168	141,300	22,552	143,748	384	2,448
2011	30,587	194,930	30,587	194,930	-	-
2016	-	-	40,699	260,262	-	-

During the period of the 8th NESDP (1997-2001), the demand for electricity is expected to increase by 2,873 MW, or 3.99 % yearly. In the 9th NESDP (2002-2006), the peak demand is forecast to increase by 6,368 MW, with an annual average growth rate of 6.86 %. In the 10th NESDP, the demand projection is based on the estimated annual growth rate of 6.28 % which will make the capacity requirement to rise from 22,552 MW to 30,587 MW. For the next five year period of the 11th NESDP (2007-2011), the average increase of peak demand is projected to be 5.88 % yearly and the peak demand will increase from 30,587 MW in FY 2011 to 40,699 MW.in FY 2016.

At the end of September 2001, EGAT's total generating capacity includes purchased power of 24,321.4 MW. The purchased power consists of 4,976 MW that EGAT buys from its subsidiaries – EGCO, RATHCO and 3,808 MW from IPPs, SPPs, Lao PDR and Malaysia.

Gross annual energy generation in fiscal year 2000 totaled 96,781 GWh, of which EGAT's own power plants accounted for 77.2%.

As of August 2001, the total capacity of the Thailand system was 21,939.8 MW which comprises 2,886.264 MW of hydropower, 7,875 MW of conventional thermal power plants, 8,380.6 MW of combined cycle power plants, 340 MW of power purchase form Laos, 1,673.4 MW of SPPs and 784.0 MW of peaking capacity.

EGAT formulated a new Power Development Plan (PDP) which was referred to as the "PDP2002". The PDP2002 was approved by the EGAT Board of Directors in September 2001. The PDP is now being submitted to the National Energy Policy Office for review. At the end of 2016, the installed capacity of the EGAT system will be 48,271.5 MW which consists of 4,046 MW (8.4 %) of hydro power, 8,326 MW (17.2 %) of conventional thermal, 11,167 MW (23.1 %) of combined cycle, power purchases of 24,280 MW (50.3 %) and 453 MW (1 %) of peaking plants.

Thailand load forecast and generation development plan (2001-2016) are summarized in Table S-2 for installed capacity and in Table S-3 for energy generation.

The transmission lines of the Electricity Generating Authority of Thailand (EGAT) for the whole country, as of April 2001, extend 26,904 circuit-kilometers, connecting all the 5 regions of the EGAT system. There are 194 high-voltage substations currently in service with transformer capacity totaling 57,109 MVA.

The distribution voltages of the Provincial Electricity Authority (PEA) area are 115 kV, 69 kV, 33 kV, 22 kV, 19 kV, 3.5 kV and the 380/220 volts for household application. As of December 2000, the combined length of the 115/69 kV systems was 3,809.48 circuit-kms. The total length of the remaining high voltage systems was 243,824.03 circuit-kms. The low voltage system covered the highest length totaling 338,493.75 circuit-kms.

The distribution voltages of the Metropolitan Electricity Authority (MEA) are 230 kV, 115 kV, 69 kV, 24 kV, 12 kV and 380/220 volts for household application as of 2000, the combined length of 230, 115, 69 kVs was 1,161 circuit-kms, while the 12, 24 kVs was 13,303 vircuit-kms. The secondary lines or low voltage 380/220 volts was 23,356 circuit-kms.

The transmission system expansion and development to accommodate the power development program is also planned by EGAT. During the period up to 2016, EGAT will expand the transmission system by constructing the 500 kV transmission lines with a total length of 4,374.4 circuit-kms. At the same time, EGAT will also expand the 230 kV and 115 kV transmission lines for the distances of 1,271 circuit-kms and 368.2 circuit-kms, respectively.

Table S-2 Thailand (EGAT) Load Forecast and Generation Development Plan (Power)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Electricity Demand																	
Maximum Demand; MW	14,918	16,184	17,388	18,587	19,913	21,222	22,552	23,951	25,450	27,232	28,912	30,587	32,405	34,352	36,366	38,519	40,699
Annual Increase	14,918	1,266	1,204	1,199	1,326	1,309	1,330	1,399	1,499	1,782	1,680	1,675	1,818	1,947	2,014	2,153	2,180
Annual Load Factor	74.1	73.0	72.8	72.8	72.5	72.5	72.8	72.8	72.9	72.7	72.7	72.8	72.8	72.8	72.9	72.9	73.0
Energy Sent; GWh	96,781	103,496	110,945	118,540	126,449	134,794	143,748	152,743	162,438	173,532	184,213	194,930	206,660	219,134	232,106	245,948	260,262
Annual Increase	6,367	6,715	7,449	7,595	7,909	8,345	8,954	8,995	9,695	11,094	10,681	10,717	11,730	12,474	12,972	13,842	14,314
GDP Growth Rate	3.67	4.42	4.80	4.90	4.68	4.56	4.62	4.86	4.74	4.73	4.63	4.55					
GDP elasticity of electricity demand	2.40	1.92	1.55	1.41	1.52	1.44	1.36	1.28	1.32	1.48	1.33	1.27					
Installed Generating Capacity (end of year); MW																	
EGAT																	
Hydro Power Plant	2,880	2,886	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,386	3,826	4,046
Plant added (net)	0	0	500	0	0	0	0	0	0	0	0	0	0	0	0	440	220
Thermal Power Plant	7,238	6,255	5,855	6,155	5,845	5,845	5,225	5,225	5,225	5,075	5,075	5,075	5,000	5,000	4,450	3,600	3,300
Plant added (net)	0	-973	-400	300	-310	0	-620	0	0	-150	0	0	-75	0	-550	-850	-300
Combined Cycle Plant	5,075	5,075	5,075	5,075	5,075	5,075	5,075	5,632	5,632	6,325	7,207	7,207	7,207	6,852	6,852	6,162	5,855
Plant added (net)	0	0	0	0	0	0	0	557	0	693	882	0	0	-355	0	-690	-307
Gas Turbines	682	785	819	819	453	453	453	453	453	453	453	453	453	453	453	453	453
Plant added (net)	0	123	34	0	-366	0	0	0	0	0	0	0	0	0	0	0	0
Total Generation EGAT	15,845	15,001	15,135	15,435	14,759	14,759	14,139	14,696	14,695	15,239	16,121	16,121	16,046	15,691	15,141	14,041	13,654
Total Plant added (net)	0	-844	134	300	-676	0	-620	557	0	543	882	0	-75	-355	-550	-1,100	-387
Purchased Power																	
EGCO, IPP, RGCO																	
Thermal (Oil, Coal)	150	1,620	1,620	1,620	1,620	2,354	3,754	5,101	5,101	5,101	5,101	5,101	5,101	5,027	5,026	5,026	5,026
Plant added (net)																	
Combined Cycle	3,306	3,306	6,544	6,544	6,544	6,544	6,544	6,544	6,544	6,544	6,544	6,544	5,928	5,620	5,312	5,312	5,312
Plant added (net)																	
New Capacity	0	0	0	0	0	0	0	0	0	0	700	3,000	5,800	8,600	11,800	15,300	18,300
Plant added (net)											700	2,300	2,800	2,800	3,200	3,500	3,000
Total EGCO, IPP, RGCO	3,456	4,926	8,164	8,164	8,164	8,898	10,298	11,645	11,645	11,645	12,345	14,645	16,829	19,247	22,138	25,638	28,618
Plant added (net)	3,456	1,470	3,238	0	0	734	1,400	1,347	0	0	700	2,300	2,184	2,418	2,891	3,500	3,000
SPP	1,433	1,678	1,777	1,967	1,967	1,967	1,967	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057	2,057
Plant added (net)	90	245	99	190	0	0	0	0	0	0	0	0	0	0	0	0	0
Import from Laos																	
Theun-Hinboun	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214	214
Houay Ho	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126	126
Import 2007	0	0	0	0	0	0	0	1,903	1,903	1,903	1,903	1,903	1,903	1,903	1,903	1,903	1,903
Import 2008	0	0	0	0	0	0	0	0	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380	1,380
Total import from Laos added in year	340	340	340	340	340	340	340	2,243	3,623	3,623	3,623	3,623	3,623	3,623	3,623	3,623	3,623
Other (TNB, Malaysia)																	
TNB	0	0	300	300	300	300	300	300	300	300	300	300	300	300	300	300	300
Added in year (net)	0	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Power Purchased	5,229	6,944	10,581	10,771	10,771	11,505	12,905	16,245	17,625	17,625	18,325	20,625	22,809	25,227	28,118	31,618	34,618
Added in year (net)																	
Total Generating Capacity (end of year)	21,074	21,945	25,716	26,206	25,510	26,264	27,044	30,941	32,321	32,864	34,446	36,746	38,855	40,918	43,259	45,659	48,272
Total Capacity added in year (net)	1,974	872	3,771	450	-676	734	780	3,897	1,380	543	1,582	2,300	2,109	2,063	2,341	2,400	2,613
Dependable Generating Capacity at System Peak in Year	20,398	21,117	21,354	25,102	24,436	24,780	26,000	27,994	31,171	30,975	33,296	35,596	37,705	39,767	39,647	44,509	47,122
Reserve Margin (% of Peak Demand); target minimum is	36.73	30.48	32.23	35.05	22.97	18.28	15.29	16.88	22.48	15.31	15.16	16.38	16.36	15.76	13.61	15.55	15.78

Source : EGAT

Table S-3 Thailand Load Forecast and Generation Development Plan (Energy) (Moderate Economic Recovery Case)

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Electricity Demand																	
Maximum Demand (sent-out); MW	14,918	16,184	17,388	18,587	19,913	21,222	22,552	23,951	25,450	27,232	28,912	30,587	32,405	34,352	36,366	38,519	40,699
Annual Increase	14,918	1,266	1,204	1,199	1,326	1,309	1,330	1,399	1,499	1,782	1,680	1,675	1,818	1,947	2,014	2,153	2,180
Annual Load Factor	74.1	73.0	72.8	72.8	72.5	72.5	72.8	72.8	72.9	72.7	72.7	72.8	72.8	72.8	72.9	72.9	73.0
Energy Sent (sent-out); GWh	96,781	103,496	110,945	118,540	126,449	134,794	143,748	152,743	162,438	173,532	184,213	194,930	206,660	219,134	232,106	245,948	260,262
Annual Increase	6,367	6,715	7,449	7,595	7,909	8,345	8,954	8,995	9,695	11,094	10,681	10,717	11,730	12,474	12,972	13,842	14,314
GDP Growth Rate	3.67	4.42	4.80	4.90	4.68	4.56	4.62	4.86	4.74	4.73	4.63	4.55					
GDP elasticity of electricity demand	2.40	1.92	1.55	1.41	1.52	1.44	1.36	1.28	1.32	1.48	1.33	1.27					
Energy Generation (sent-out); GWh																	
EGAT																	
Hydro Power Plant	5,296	5,025	3,552	3,552	4,351	4,493	4,503	4,479	4,241	4,413	4,461	4,457	4,476	4,536	4,489	5,149	5,573
Average Plant Factor	20.99	19.98	11.98	11.98	14.67	15.15	15.18	15.10	14.30	14.88	15.04	15.03	15.09	15.29	15.13	15.36	15.72
Thermal Power Plant (Lignite; Oil, Gas)		37,090	31,853	33,764	16,640	19,181	19,082	16,883	15,389	14,583	14,575	14,109	13,431	13,014	12,932	9,755	6,784
Average Plant Factor		67.69	62.10	62.62	32.50	37.46	41.69	36.89	33.62	32.80	32.78	31.74	30.66	29.71	33.17	30.93	23.47
Combined Cycle Plant (Gas)		11,698	14,341	10,739	26,498	26,737	26,358	32,548	31,899	37,990	44,159	42,775	40,790	38,226	36,037	33,029	31,793
Average Plant Factor		26.31	32.26	24.16	59.60	60.14	59.29	65.97	64.66	68.57	69.95	67.75	64.61	63.69	60.04	61.19	61.99
Gas Turbines		1,210	1,359	1,382	1,310	1,400	1,404	1,395	1,329	1,385	1,417	1,384	1,388	1,326	1,240	1,093	543
Average Plant Factor		17.60	18.94	19.26	33.01	35.28	35.38	35.15	33.49	34.90	35.71	34.88	34.98	33.41	31.25	27.54	13.68
Total Generation EGAT	62,864	*55,050*	*51,105*	*49,437*	*48,799*	*51,811*	*51,347*	*55,305*	*52,858*	*58,371*	*64,612*	*62,725*	*60,085*	*57,102*	*54,698*	*49,026*	*44,693*
Average Plant Factor	45.29	14.89	38.55	36.56	37.74	40.07	41.46	42.96	41.06	43.73	45.75	44.42	42.75	41.54	41.24	39.86	37.37
Purchased Energy																	
EGCO, IPP, RGCO																	
Thermal (Oil, Coal, Gas)		10,846	10,880	11,084	10,136	15,286	25,023	31,585	31,338	32,822	32,761	31,776	31,406	30,811	30,452	30,625	31,123
Average Plant Factor		37.45	18.98	19.34	17.68	26.67	43.65	55.10	54.67	57.26	57.15	55.43	60.48	62.58	65.44	65.81	66.88
Combined Cycle		21,580	31,858	40,029	47,672	48,004	47,568	45,092	45,093	46,063	45,491	43,765	37,711	33,774	29,578	25,772	24,121
Average Plant Factor		74.52	55.57	69.83	83.16	83.74	82.98	78.66	78.66	80.35	79.36	76.34	72.62	68.60	63.56	55.38	51.84
New Capacity	0	0	0	0	0	0	0	0	0	0	5,190.0	20,742	41,460	61,599	81,513	105,555	125,933
Average Plant Factor											84.6	79	82	82	79	79	79
Total EGCO, IPP, RGCO	21,517	32,426	42,738	51,113	57,808	63,290	72,591	76,677	76,431	78,885	83,442	96,283	110,577	126,184	141,543	161,952	181,177
Average Plant Factor	71.07	75.14	59.76	71.47	80.83	81.20	80.47	75.17	74.92	77.33	77.16	75.05	75.01	74.84	72.99	72.11	72.22
SPP	9,409	10,215	11,232	12,057	13,786	13,786	13,786	14,417	14,417	14,417	14,417	14,417	14,417	14,417	14,417	14,417	14,417
Average Plant Factor	74.95	69.49	72.15	69.97	80.01	80.01	80.01	80.01	80.01	80.01	80.01	80.01	80.01	80.01	80.01	80.01	80.01
Import from Laos	2,991	2,631	2,690	2,640	2,921	2,918	2,875	3,330	15,332	18,835	18,787	18,722	18,699	18,635	18,585	18,535	18,499
Other (TNB, Malaysia)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Energy Purchased	33,917	45,272	56,660	65,810	74,515	79,994	89,252	94,424	106,180	112,137	116,646	129,422	143,693	159,236	174,545	194,904	214,093
Average Plant Factor	74.04	74.42	61.13	69.75	78.97	79.37	78.95	66.35	68.77	72.63	72.66	71.63	71.92	72.06	70.86	70.37	70.60
Total Electricity Supplied (sent-out)	**96,781**	**100,322**	**107,765**	**115,247**	**123,314**	**131,805**	**140,599**	**149,729**	**159,038**	**170,508**	**181,258**	**192,147**	**203,778**	**216,338**	**229,243**	**243,930**	**258,786**

Source : EGAT 2002

Source : EGAT

The capital requirements for all the projects whose construction periods are within 2002-2011 are estimated at 225,055.1 million Baht. The capital will be used for the investment of 11 transmission projects amounting to 169,955.1 million Baht, the hydro renovation project requiring an investment of 2,471.2 million Baht. The remaining expenditure will go to the repowering project for which EGAT will have to invest 52,626.8 million Baht.

4. Structure and Regulation of Power Sector

Power business in Thailand is supplied by three electricity utilities, i.e. the Electricity Generating Authority of Thailand (EGAT) is responsible for generation and transmission while the function of distribution is handled by the Metropolitan Electricity Authority (MEA) and the Provincial Electricity Authority (PEA). MEA services the Bangkok metropolis and two neighbouring provinces – Nonthaburi and Samut Prakarn with a total area of 3,115 km^2, while PEA supplies electricity to the rest of the country covering 73 provinces of 510,000 km^2.

Regulator body to regulate the above power supply agencies is National Energy Policy Committee which was established in 1992, and chaired by Prime Minister. The NEPC is the central authoritative body in the establishment of the national policies by virtue of its having Ministers from related Ministries as well as chiefs of concerned government agencies as its committee members.

The National Energy Policy Office (NEPO) serves as the secretariat to the NEPC. It formulates the NEPC directives and the commercial and operational requirements of the state energy enterprises, and disseminates them to the government agencies and state energy enterprises. It also coordinates activities among the state energy enterprises as well as between the enterprises and government agencies. Other than performing duties as mentioned. The NEPO still serves as secretary to the Energy Policy Committee (EPC) which EPC will be in charge of screening work related to energy management and development prior to submission to the NEPC for consideration.

5. Demand Side Management Program

EGAT started the demand side management program in 1993 to encourage the energy savings and efficiency improvement among the consumers. The funding for the program comes from

1) Grants from GEF (Global Environment Facility) and the Australian Government totaling 15.5 million USD,
2) Soft loan from JBIC for an amount of 25 million USD and,

3) Income from the electricity tariff through the Ft (Automatic Adjustment Mechanism).

The total budget for the DSM from the three sources amounted to 189 million USD.

At the end of December *2000*, the savings from the implementation of DSM activities were estimated at 597 MW in capacity saving and 3,325 GWh in energy saving. EGAT has planned to continue the DSM program in the next 5 year-period between 2001-2005 to achieve further savings of 521 MW and 2,203 GWh in power and energy respectively. In addition, EGAT will launch the public awareness in DSM program at the same time so as to create a better understanding in the DSM. The indirect benefit of the DSM program is in the reduction of harmful substances emitted to the environment such as CO_2, CH_4, N_2O, NO_x, SO_x, and PM_{10}. The estimated reduction of pollutants in 2005 is 1.6 million tons of CO_2, 56.2 tons of CH_4, 11.188 tons of N_2O, 4,016 tons of NO_X, 23 tons of SO_X and 18.5 thousand tons of PM_{10}, respectively.

6. Private Power Generation and International Power Purchase

Thai government has a policy to encourage the private sector participatation in the power generation business in the form of Independent Power Producer (IPP) and Small Power Producer (SPP). The IPPs generate bulk power from the fuels which are usually natural gas and coal. The SPPs generate power using the co-generation system or using renewable energy.

The government has approved the establishment of the two EGAT's subsidiaries: Electricity Generating Company (EGCO) and Ratchaburi Electricity Generating Holding Public Co., Ltd. (RHCO). Both of them have been listed in the Stock Exchange of Thailand (SET).

The neighboring countries of Thailand have large potential of hydropower and fossil fuels which can be used to generate electricity for export to Thailand. The Foreign Power Purchase Program was initiated in response to the Government Policy to promote greater role of private Power Producers in Thailand's power supply industry and also its policy to jointly develop energy resources with neighboring countries. The Thai government has entered into Memorandum of Understanding (MOU) with Lao PDR, the Union of Myanmar, and the People Republic of China. Also it has established the power exchange program with Malaysia. The interconnection of power systems planned for the power links from these countries to Thailand may be later become part of the ASEAN Power Grid.

As highlighted in the PDP2002, there will be the purchases of power from Lao PDR in September 2007 and March 2008 and that the capacity requirement from 2010 and afterward will all be supplied by IPPs or power purchases. The power import form Lao PDR in September 2007 will come from Nam Theun 2, Nam Ngum 2 and Nam Ngum 3 for the combined capacity of 1,903 MW. The purchase in March 2008 will consist of the power from Hongsa Lignite, Xekaman 1 and Xepian-XeNamnoi with capacity totaling 1,380 MW.

7. Privatization and Restructuring of Power Sector

The privatization and restructuring of the ESI in Thailand has systematically been implemented over a number of years. The cabinet resolution gave consent to the separation of generation, transmission and distribution businesses. To comply with this resolution, EGAT's thermal power plant will be separated into business unit (Bus) and then corporatized, registered and listed on the SET.

The future structure of the ESI and will be introduced the Power Pool. The Power Pool shall be established as an independent entity, separated from EGAT, comprising the System Operator (SO), Market Operator (MO) and Settlement Administrator (SA). The power generation sector will be participating in the power trade bidding in the Power Pool or will have individual bilateral contracts with major customers or DisCos. The power consumers will not have to buy electricity from single supplier; they can opt for any retailer to be their supplier. Such retailers can purchase power from various generators via the Power Pool or by bilateral contracts and deliver power using the transmission and distribution lines.

The Long-Term ESI Structure will commence around the year 2003 onwards. A competitive wholesale power pool will be established, separate from EGAT. Competition will be introduced at both wholesale and retail levels, as illustrated in Figure S-1. Generation companies (GenCos) will offer competitive bids to sell power via the Power Pool, using the transmission system of EGAT or the distribution systems of the MEA and PEA. The Regulator will regulate the transmission and distribution system activities to ensure access for the third party to the power system of the country with reasonable charges.

The Independent System Operator (ISO) will be responsible for the security of the power system. The ISO shall not be involved in power generation business in order to be independent and transparent in carrying out its operation. The ISO will be responsible for economic merit order dispatch and the development of the national power system plan.

Regulated Electricity Delivery Companies (REDCos), the future form of the MEA and PEA, will be responsible for power distribution within their respective customer franchise areas. Since the distribution system is a natural monopoly in nature, the Independent Regulator will regulate the criteria for distribution services and charges for delivery-related services. For retail customers, competitive Retail Companies (RetailCos) will be an alternative for consumers. RetailCos may offer value-added services (for example: give free advice on energy management system) to consumers together with their electricity delivery.

At this stage, EGAT still remains a state enterprise, responsible for the transmission system and hydro power plants, with shares in some power generation companies and other related businesses.

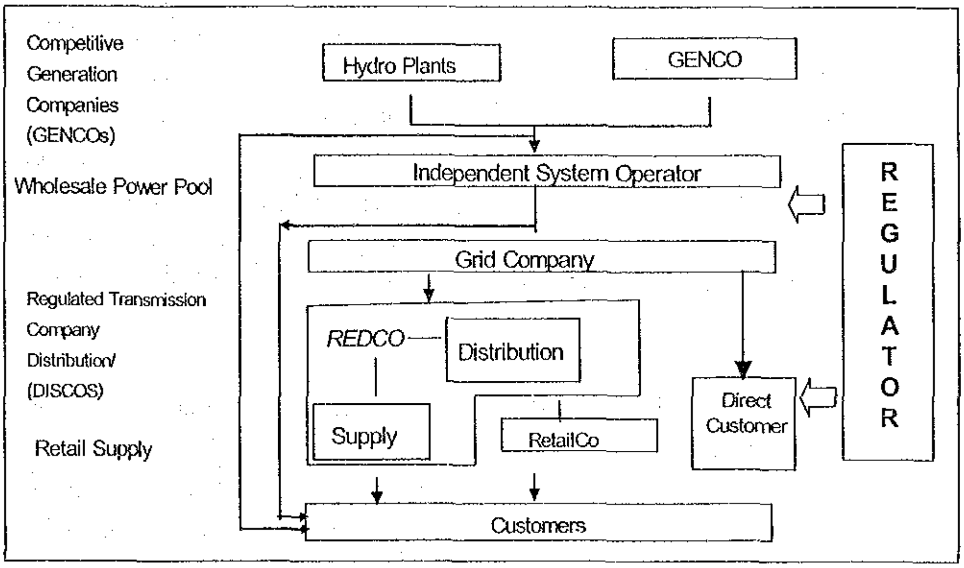


Figure S-1 Long-Term ESI Structure (2003/2004 onwards)

In order to accomplish the long-term ESI structure, extensive reform of the existing ESI structure are essential, namely:

- Power generation, formerly operated solely by EGAT, will have to be spun off into various groups of GenCos (with the exception of hydro power generation, because hydro power in Thailand is multipurpose project for: irrigation, transportation, and etc. It has many government agencies to concern.);
- A power pool shall be established as an independent entity, separated from EGAT, comprising the System Operator (SO), Market Operator (MO) and Settlement Administrator (SA). At the initial term, EGAT may carry out all or part of these functions of the Power Pool, but ultimately the SO/MO/SA will be transferred out of EGAT and the SO will become the Independent System Operator (ISO);

- The accounting system of the distribution system and that of the supply business shall be clearly separated so that competitive retailers could efficiently participate in the market; and
- The Independent Regulator will have an important role in regulating natural monopoly businesses and in promoting real competition in competitive activities, i.e. power generation and retail businesses.

The future structure of the ESI and the Power Pool at the final stage are discussed below:

In the power generation sector, there will be a number of generators, including power plants that will be split from EGAT, participating in power trade bidding in the Power Pool. For retail supply, there will be competition among retailers. As a result, power consumers will not have to buy electricity only from the PEA or MEA as they can opt for any retailer to be their supplier. Such retailers can purchase power from various generators via the Power Pool and deliver power using the lines of EGAT, PEA or MEA. This will enhance retail competition not only in terms of prices but also in terms of service quality. Hence, the future structure of the ESI in Thailand must suit and facilitate such business operation.

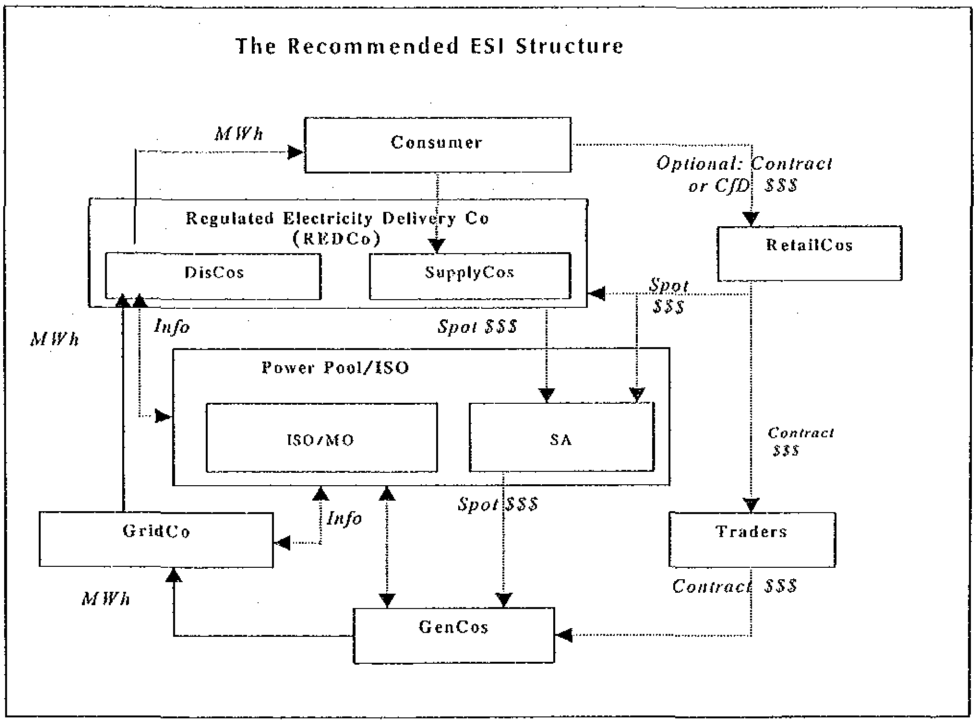
The structure of the ESI and the Power Pool have to properly accommodate both supply and distribution functions to consumers. Each generator will commence physical operation when a dispatch instruction, according to the generation cost merit order, is received. This is to ensure that the overall generation cost of the system is kept at the minimum. Then, the physical electricity (MWh) generated by each generator pursuant to the dispatching order will be delivered via a high-voltage transmission grid. The voltage of the electricity will be transformed and delivered to a low-voltage distribution system when it comes nearer to the consumption destination prior to being distributed to each customer.

Under the above process of power supply and distribution, final consumers will pay for their electricity to a retail service provider who usually buys electricity from generators through a combination of contract trading and spot trading.

GenCos can be competitive private generation entities. GridCo and DisCos still belong to the government, are subject to regulation, and are responsible for high-voltage transmission grid systems and low-voltage distribution systems respectively. RetailCos are unregulated private entities and are competitive providers of electricity and various delivery-related services for general customers. SupplyCos are regulated entities that supply electricity and provide related services to consumers who do not want to buy or are not allowed to choose to buy electricity from a competitive RetailCo so that power consumers under all categories could have access to the services.

Under the above structure if the existing IPPs agree to enter into in the Power Pool, Traders will negotiate and carry out the trading of contracts that were signed between EGAT and IPPs. And if any existing IPP does not agree to be in the Pool, he can still execute his PPA. In addition, there is a need to form an Independent System Operator (ISO) to monitor and control the power system operation in accordance with specified standards, a Market Operator (MO) to administer the Power Pool, and a Settlement Administrator (SA) to manage the billing and settlements among market participants. The ISO, MO and SA have to cooperate closely and be independent from any entity participating in the Power Pool; however, the functions of the ISO and MO may be handled by the same entity.

Given the basic functions and various functional entities concerned in the ESI, the recommended future ESI structure, from 2003 onwards, can be illustrated in Figure S-2.



Note: CfD stands for Contract for Difference.

Figure S-2 Recommended Future ESI Structure

Under the recommended structure, SupplyCo and DisCo functions are combined in a Regulated Electricity Delivery Company (REDCo) which is regulated by the Regulator. The REDCo will provide electricity to consumers **at spot prices** plus delivery-related costs (regulated by the Regulator). Competitive RetailCos will be able to offer to consumers such value-added services as electricity tariff risk-management (hedging) and energy conservation services.

The ISO, MO and SA functions are combined in the Power Pool. The ISO will be responsible for the economic merit order dispatch to generators, with close coordination with the MO, and will, control the operation of the GridCo. The SA, responsible for the billing and settlements among market participants, may be part of the Power Pool or be split off as a separate entity.

The GridCo owns, operates and carries out maintenance work of grid facilities under a contract made with the ISO. The GridCo must not have any affiliation with any competitive entities, especially those unregulated, and should be a different entity from the SO.

The recommended structure provides power consumers with options pertaining to retail services. Consumers can choose a competitive **RetailCo** to obtain risk-management against the fluctuating pool prices and other value-added services.

On the generation side, generation companies **(GenCos)** will compete in the bidding of electricity prices in the Power Pool. GenCos may be the existing power plants of EGAT, IPPs, SPPs, Ratchaburi Power Plant or power producers from neighboring countries.

Traders are entities that buy or sell energy without their own generation facilities. They will act as mediators between power producers and consumers or retailers, or as administrators of the existing Power Purchase Agreements (PPAs) made between EGAT and IPPs.

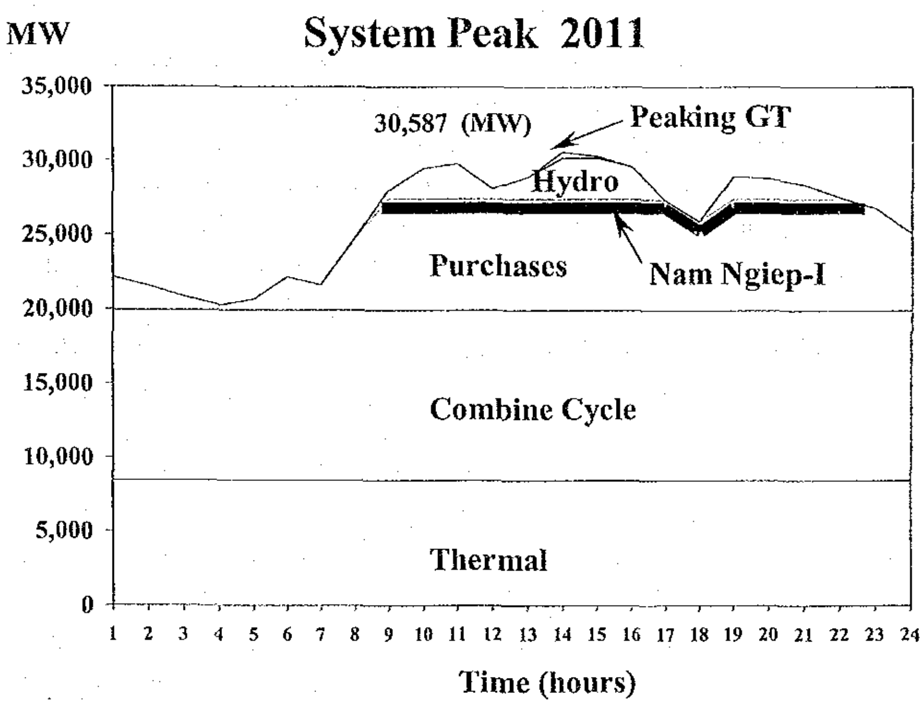
From the foregoing explanation, functional entities involved in the Power Pool can be categorized into regulated entities and competitive entities. Regulated entities are the **GridCo, REDCos and the Power Pool,** with well-defined duties and role, making them relatively easy to manage and regulate. Competitive entities are GenCos, RetailCos and Traders. They will compete in providing services to consumers, from generation to retailing levels. The establishment of RetailCos and Traders will be determined by the market forces. The SA, being responsible for the billing and settlements, may be part of the Power Pool or be split off as a separate entity.

8. Suggestion for Promotion of the Nam Ngiep-I HEPP

Based on the information from the new PDP (unofficial PDP 2002), the suggested timing for power import from the neighboring countries of Thailand could be from the year 2010. As for 2010, there will be a need of 700 MW of new capacity from IPP (either domestic or import). Afterwards, the system will require addition purchases of at least 2,000 MW yearly. Accordingly, the Nam Ngiep-I can bid to supply the power to Thailand as one of the projects in the year 2010 at the earliest. It is recommend that the Nam Ngiep-I should be operated at the plant factor of at least 50 %. Therefore, the Nam Ngiep-I should be running as an intermediate power plant with the operating duration of 12 hours per day at the minimum. If the Nam Ngiep would be generating at the plant factor lower than 50 %, the combined cycle plant would be more economical and EGAT would rather buy the power from the combined cycle IPPs. This recommended operation mode will also fit the demand characteristics of the EGAT system which possesses an annual load factor of over 72 %.

The possible position of Nam Ngiep-I in the load curve representing the system peak of 2011 is illustrated in Figure S-3 below.

Figure S-3 Position of the Nam Ngiep-I in the Daily Load Curve



The tariff for the Nam Ngiep-I project can be construed from the existing IPPs and the power purchases from the projects in Lao PDR. At present, there are two domestic IPPs, i.e., the Independent Power (700 MW) and the Tri Energy (700 MW) in operation. EGAT buys power from both projects under the two-part tariff structure consisting of the availability payment (AP) and the energy charge. The AP for the Independent Power is currently 0.491 Baht/kWh and the energy charge is 1.087 Baht/kWh (totaling 3.54 cents/kWh). The Tri Energy receives the AP at 0.666 Baht/kWh and the energy charge at 1.064 Baht/kWh (totaling 3.88 cents/kWh).

Thailand is currently importing power mainly form two sources, i.e. the Theun-Hinboun (187 MW) and the Houay Ho (126 MW) projects in Lao PDR. The purchase price from the Theun Hinboun is 1.734 Baht/kWh (3.88 cents/kWh) and from the Houay Ho is 2.0008 Baht/kWh (4.48 cents/kWh)

For comparison purpose, the tariff for the Nam Theun II is presented here. The developer of the Nam Theun II project proposed two options, i.e. a base load plant or an intermediate plant. The avoided cost for the base load plant was found to be about 4.1 cent/kWh and the avoided cost for the intermediate load operation was around 5.4 cent/kWh for the primary energy and 4.0 cent/kWh for the secondary energy.

9. Conclusion

In June 2001 NESDB has forecasted the GDP growth rate for the year 2001 to be 2-3%. According to "Economic Forum" held on September 26, 2001 in Bangkok (organized by Bangkok Post), hundreds of diplomats and business executives to the United Nation Conference Centre were attended to discuss the economic outlook for Thailand and neighboring region. The governor of the Bank of Thailand (BOT) addressed in his key note speech that despite the gloomy global economic outlook, Thailand was highly likely to positive growth this year (2001). The electricity demand, therefore, which usually grows faster than economy has been forecasted to increase at yearly average 6.86% for power demand and 6.79% for electric energy during 2002-2006 or the 9^{th} national plan.

Power supply situation, power development plan as well as restructuring of power sector are progressively. Only the power pool establishment which is planned to be completed by the end of 2002 would likely be delayed at least 5 years. This matter was released by EGAT's deputy governor, transmission system business in early October 2001. The main reason is that EGAT's transmission system still is not strong enough. However, whether the power pool establishment will be delayed or not, the followings are particular advices for power developers in case of Nam Ngiep-I HEPP will join in the Thai power market.

- **Impact of power market reform and liberalization on existing PPAs and future PPA**

The existing PPAs between EGAT and the IPP developers (including those in the Lao PDR) have been executed before the power pool will be in place. Therefore, the developers are provided an option whether they will keep the PPAs or they can switch to the bidding process in the power pool and cancel the PPAs. Since the existing PPAs are "front-end" as regard to the electricity payment, the developers may wish to switch to the bidding option after a certain period when their debts are almost or totally paid off, since the power pool price could be higher than the prices in the PPAs in the future.

After the introduction of the power pool in the future, it is unlikely that the developers of IPPs will be able to get the long-tem agreement with the PPA trader or with their customers. This is due to the fact that the electricity price in the power pool will fluctuate and the buyers may not want to fix their choice in case the power pool price is lower than the price in the PPA or the bilateral contract.

- **Bidding in power pool versus bilateral contracts**

If the developer can overcome the financing difficulty and can complete the project, bidding in the power pool may not be a bad idea. The customers will not get into any agreement unless they receive a good deal. This means that the prices they are offered should be lower than the anticipated power pool price. In this regard, the developer will be able to sale the power at higher value in the power pool.

If developers consider use of project financing then they may have to seek the bilateral contracts initially. In the long run, the power pool price can be expected to increase since the reserve margin in the free market may not be high enough to maintain reliable operation of the power system (as in California), resulting in the situation of over demand (in contrast to the over supply at the present). The developer may decide to bid in the power pool after the initial contracts expire, if under-supply is the case in the market.

- **Effective way for bidding**

Since the NNP-1 is a hydro project, it is capital intensive and need to be dispatched to earn enough income to recover the fixed cost. Contrary to the thermal plant, the hydro power plant has very little variable costs associated to its operation. Therefore, the earning received from the operation of the hydropower plant, no matter how low it is, will go towards the recovery of the capital investment. Under this circumstance, it may be advantageous for the NNP-1 to be able to bid at low bidding price to get dispatched due to its low operating costs. The price that the NNP-1 will be actually paid will be determined by the price setting bid which will can be expected to be sufficient for the NNP-1 to gain enough earning to recover the investment.

- **Contract price versus changing power pool price and contract condition**

It is possible that the contract price will be lower or higher than the power pool price. However, at the beginning of the contract period, the contract price will be lower than the power pool price otherwise the customer will not find it attractive and will not enter into the contract. Therefore, the developer may have to index the contract price with a reference, for example the pool price, so that the developer can adjust the contract price accordingly.

- **Future pricing of electricity, factors affecting electricity prices**

The pricing in the future will be determined by the market mechanism. The regulatory body will only make sure that the quality of the power system will be maintained.

- **Trend of electricity prices**

After the liberalization of the electricity market, the electricity price will be certainly higher than it has been in the monopoly market. At present, the electricity price in Thailand is the lowest in the ASEAN region (second to Indonesia because the electricity price has been subsidized by the Indonesian government). The private developers need higher return on their investments while EGAT only requires marginal profit to comply with the loan agreements made with the financial institutions. Furthermore, EGAT pays lower interests to the financial institution because the loans are guaranteed by the Thai government.

- **Impact of ASEAN power grid on pricing for NNP-1**

The ASEAN power grid will take very long time to be realized. The idea of the ASEAN power grid was initiated a long while ago. Until now, only two projects have been implemented, i.e. the Thailand-Malaysia and Malaysia-Singapore interconnections. There have been no progress seen on other projects. Therefore, it can be expected that it will take a lot more time (surely beyond 2011) for the ASEAN power grid to be realized. The ASEAN power grid can be considered as having virtually no impacts on the NNP-1 project what so ever.