3.6 Electricity Tariff

The electricity tariffs in Thailand can be roughly divided into the wholesale tariffs of the EGAT and retail tariffs of the MEA and the PEA.

The wholesale tariffs for the PEA have been set relatively lower than for the MEA. The reason is the political consideration in determining the electricity tariffs for the PEA because of its weak managerial basis.

The electricity tariffs contracted between the EGAT, the MEA and the PEA in 1989, are as follows for energy change:

MEA:	1.4777	฿/kWh
PEA:	1.0399	฿/kWh

The average unit tariffs for large users who directly contract with the EGAT are 1.25 B/kWh for energy charge, and 170 B/kW for demand charge, respectively.

On the other hand the retail rates of the MEA and the PEA consist of a tariff system organized by the type of use and by amount.

Table 3-7 shows the tariff structure of the electricity distributors (MEA, PEA). The time of day rate system was adopted for large manufacturing and mining (2,000 kW or over) in January 1990, aiming at encouraging industrial uses to avoid using power during the peak hours.

Table 3-7 Tariff Structure of Electric Distributors (MEA, PEA)

1. Residential

Energy Charge :	First 5 kWh or less	5.00	Baht
	Next 10 kWh	0.70	Baht/kWh
	Next 10 kWh	0.90	Baht/kWh
	Next 10 kWh	1.17	Baht/kWh
	Next 65 kWh	1.58	Baht/kWh
	Next 50 kWh	1.68	Baht/kWh
	Next 150 kWh	1.76	Baht/kWh
	Next 100 kWh	2.02	Baht/kWh
	Next 400 kWh	2.11	Baht/kWh
	Over 800 kWh	2.43	Baht/kWh

Minimum Charge: 5.00 Baht/month

2. Small Business

Energy Charge :	First 40 kWh or less	88.12	Baht
	Next 260 kWh	1.77	Baht/kWh
	Next 200 kWh	1.88	Baht/kWh
	Next 500 kWh	2.21	Baht/kWh
	Next 2,000 kWh	2.43	Baht/kWh
	Over 3,000 kWh	2.50	Baht/kWh

Minimum Charge: 88.12 Baht/month

3. Large Business (30 kW or over)

3.1 For below 12 kV
Demand Charge 239.00 Baht/kW
Energy Charge 1.28 Baht/kWh
3.2 For 12 kV or over
Demand Charge 229.00 Baht/kW
Energy Charge 1.23 Baht/kWh

4. Specific Business (Tourist Hotel)

4.1 For below 12 kV
Demand Charge 233.00 Baht/kW
Energy Charge 1.28 Baht/kWh
4.2 For 12 kV or over
Demand Charge 216.00 Baht/kW
Energy Charge 1.23 Baht/kWh

5. Small Manufacturing & Mining (30 - 499 kW)

All Voltage
Demand Charge 177.00 Baht/kW
Energy Charge 1.23 Baht/kWh
Dicount 4% from demand and energy charge

6. Medium Manufacturing & Mining (500 - 1,999 kW)

All Voltage
Demand Charge 174.00 Baht/kW
Energy Charge 1.23 Baht/kWh
Discount 4% from demand and energy charge

7. Large Manufacturing & Mining (2,000 kW or over)

All Voltage
Demand Charge
18:30-21:30 (Peak) 180 Baht/kW/Month
08:00-18:30 (Partial Peak) 90 Baht/kW/Month
21:30-08:00 (Off Peak) -
Energy Charge 1.22 Baht/kWh
Discount 4% from demand and energy charge

8. Electric Smelting/Fusing Industry or Electroysis Industry

All Voltage
Demand Charge 165.00 Baht/kW
Energy Charge 1.20 Baht/kWh
Discount 4% from demand and energy charge

9. Public Utility (Water Works)

9.1 A maximum 15 minute integrated demand of less than 30 kW
Energy Charge : First 10 kWh or less 18.20 Baht
Over 10 kWh 1.82 Baht/kWh
Minimum Charge: 18.20 Baht/month
9.2 A maximum 15-minute integrated of 30 kW or over
Demand Charge 167.00 Baht/kW
Energy Charge 1.23 Baht/kWh

10. Government Office

Energy Charge : First 10 kWh or less 18.20 Baht
Over 10 kWh 1.82 Baht/kWh
Minimun Charge: 18.20 Baht/month

11. Non-Profit Organization

Energy Charge : First 100 kWh or less 18.40 Baht
Over 100 kWh 1.84 Baht/kWh
Minimum Charge: 18.40 Baht/month

12. Agricultural Pumping

Energy Charge : First 10 kWh or less 117.00 Baht
Over 100 kWh 1.17 Baht/kWh
Minimum Charge: 117.00 Baht/month

Note: Effective June 1, 1987
Minimum charge for schedule 3, 4, 5, 6, 7, 8 and 9.2 are 30% of the highest billing demand occurring during the 12 months ended with the current month

CHAPTER 4

LOAD FORECAST

CHAPTER 4 LOAD FORECAST

CONTENTS

List of Tables

List of Figures

CHAPTER 4 LOAD FORECAST

4.1 The Present Situation and Trend of Power Demand in Thailand

The electric power demand in Thailand has been increasing substantially in recent years as a result of her favorable economy and incoming rush of foreign enterprises and factories.

Transition of power and energy generated in Thailand for the past ten years are shown in Table 4-1. Yearly average growth rates of power and energy generation during the last ten years are 10.7% and 10.07% respectively. Load factor at generating end has decreased gradually from approximate 0.7 to 0.67. On an average its decreasing rate was approximately 0.4% per year.

Transition of power and energy requirement from EGAT's customers, i.e. the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA) and other direct customers, is shown in Table 4-2.

MEA is the distributor of electric energy in the greater Bangkok area, Nonthaburi and Samut Prakan provinces, whereas PEA is that in all the provinces except those in the MEA's area.

About ten years ago (1979), ratios of power consumption among the three parties were MEA 61.5%, PEA 35.0% and the other direct customers 3.5%. However, the growth rate of power demand from PEA has surpassed that from MEA with a recent advance of the electrification programs in rural areas, and the energy demand (GWh) from PEA has become almost the same level as that from MEA.

For example, the actual result of 1988 shows ratios of the three parties' energy consumption as MEA 49.4%, PEA 46.4% and the other direct customers 4.0%. In respect of the maximum power demand, ratios of the three parties were as MEA 45.4%, PEA 51.3% and the other direct customers 3.6%, showing that power demand from PEA was larger than that from MEA.

Most part of the PEA demand comes from local cities, towns, and fishing and agrarian villages, and the demand is particularly high at the lighting peak time.

The load factor of PEA demand is about 0.56-0.57, which is considerably low in comparison with MEA's 0.68-0.70, and it is pushing down the load factor of the total load of Thailand year by year.

Table 4-1 Power (MW) and Energy (GWh) Generation in Thailand (1979-1989)

Fiscal Year	Peak Generation			Energy Generation			Load Factor
	MW	Increase		GWh	Increase		
		MW	%		GWh	%	%
1979	2,255.00	154.40	7.35	13,964.55	1,592.88	12.88	70.69
1980	2,417.40	162.40	7.20	14,753.73	789.18	5.65	69.67
1981	2,588.70	171.30	7.09	15,959.97	1,206.24	8.18	70.38
1982	2,838.00	249.30	9.63	16,881.95	921.98	5.78	67.91
1983	3,204.30	366.30	12.91	19,066.30	2,184.35	12.94	67.92
1984	3,547.30	343.00	10.70	21,066.44	2,000.00	10.49	67.79
1985	3,878.40	331.10	9.33	23,356.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.00	3,812.84	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,461.09	13.94	66.59
Average Growth 1980-1989	–	397.77	10.70	–	2,249.25	10.07	–

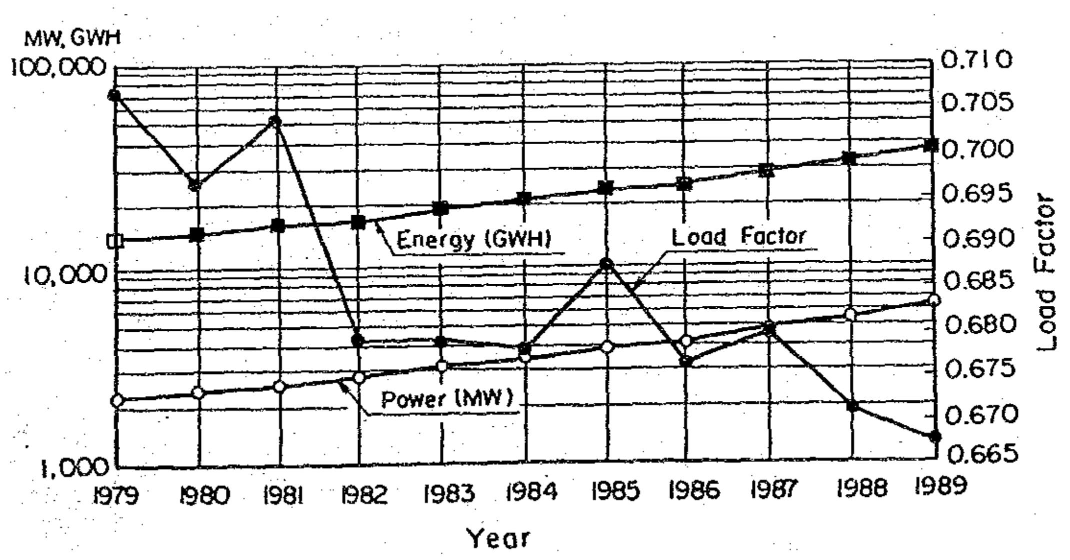


Table 4-2 Requirement of Power and Energy from EGAT

Fiscal Year	Power & Energy Generated by EGAT		Requirement from MEA		Requirement from PEA		Requirement from Other Customers	
	MW	GWH	MW	GWH	MW	GWH	MW	GWH
1979	2,255.00	13,964.55	1,268.00	7,970.27	889.40	4,542.20	87.50	452.67
1980	2,417.40	14,753.73	1,391.50	8,286.06	973.90	4,966.10	85.80	443.73
1981	2,588.70	15,959.97	1,388.40	8,495.98	1,115.40	5,569.20	100.20	500.61
1982	2,838.00	16,881.95	1,498.80	8,718.70	1,263.50	6,189.50	102.30	494.33
1983	3,204.30	19,066.30	1,630.60	9,665.67	1,493.40	7,287.30	124.60	637.03
1984	3,547.30	21,066.44	1,775.80	10,497.51	1,675.00	8,173.90	129.20	709.93
1985	3,878.40	23,356.57	1,822.90	10,909.59	1,917.60	9,391.00	162.30	963.08
1986	4,180.90	24,779.53	1,982.60	11,390.60	2,078.00	10,190.30	169.50	1,036.95
1987	4,733.90	28,193.16	1,178.10	12,929.71	2,375.20	11,792.10	166.90	1,123.03
1988	5,444.00	31,996.94	2,432.20	14,564.10	2,744.90	13,737.30	174.60	1,192.14
1989	6,232.70	36,457.09						
Annual Growth Rate (1979-88)	10.29%	9.65%	7.51%	6.93%	13.34%	13.08%	7.98%	11.36%

4.2 Load Forecast Formulated by Thai Organization

Load forecasts in Thailand have been prepared by a Load Forecast Working Group which is composed of the representatives of the National Economic and Social Development Board (NESDB), the National Energy Policy Office (NEPO), the National Energy Administration (NEA), the Electricity Generating Authority of Thailand (EGAT), the Provincial Electricity Authority (PEA), the Metropolitan Electricity Authority (MEA), the National Institute for Development Administration (NIDA) and the Thailand Development Research Institute (TDRI).

The load forecast which was made public in January 1990 was prepared for a Base Case, on the assumption of GDP growth rate from 1987 to 1996 at 8.0% per ann., and a High Case, on the assumption of 8.8% per ann.

According to the forecast of Base Case shown in Table 4-3, the predicted maximum power generation in 1990 was 6,980 MW, 11.99% higher than that in the previous year. However, 7,056 MW, recorded on 23 April 1990, surpassed the forecasted High Case value of 7,046 MW. There was a possibility of meeting with more higher value during 1990, then EGAT has hastily reviewed the said load forecast. Table 4-4 shows the reviewed forecast.

Table 4-3 Load Forecast by Thai Organization
(Base Case)

Fiscal Year	Peak Generation			Energy Generation			Load Factor
	MW	Increase MW	Increase %	GWh	Increase GWh	Increase %	%
			Actual				
1979	2,255.00	154.40	7.35	13,964.55	1,592.88	12.88	70.69
1980	2,417.40	162.40	7.20	14,753.73	789.18	5.65	69.67
1981	2,588.70	171.30	7.09	15,959.97	1,206.24	8.18	70.38
1982	2,838.00	249.30	9.63	16,881.95	921.98	5.78	67.91
1983	3,204.30	366.30	12.91	19,066.30	2,184.35	12.94	67.92
1984	3,547.30	343.00	10.70	21,066.44	2,000.00	10.49	67.79
1985	3,878.40	331.10	9.33	23,356.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.00	3,812.84	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,461.09	13.94	66.59
Average Growth 1980-1989	–	397.77	10.70	–	2,249.25	10.07	–
			Forecast				
1990	6,980.00	747.30	11.99	41,187.00	4,729.91	12.97	67.36
1991	7,760.00	780.00	11.17	46,311.00	5,124.00	12.44	68.13
1992	8,610.00	850.00	10.95	51,500.00	5,189.00	11.20	68.28
1993	9,489.00	879.00	10.21	56,976.00	5,476.00	10.63	68.54
1994	10,330.00	841.00	8.86	62,211.00	5,235.00	9.19	68.75
1995	11,054.00	724.00	7.01	66,865.00	4,654.00	7.48	69.05
1996	11,785.00	731.00	6.61	71,641.00	4,376.00	7.14	69.39
1997	12,508.00	723.00	6.13	76,274.00	4,633.00	6.47	69.61
1998	13,265.00	738.00	5.90	81,159.00	4,885.00	6.40	69.94
1999	14,007.00	761.00	5.75	86,310.00	5,151.00	6.35	70.34
2000	14,768.00	761.00	5.43	91,718.00	5,408.00	6.27	70.90
2001	15,565.00	797.00	5.40	97,377.00	5,659.00	6.17	71.42
2002	16,380.00	815.00	5.24	103,222.00	5,845.00	6.00	71.94
2003	17,212.00	832.00	5.08	109,289.00	6,067.00	5.88	72.48
2004	18,063.00	851.00	4.94	115,509.00	6,220.00	5.69	73.00
2005	18,932.00	869.00	4.81	121,066.00	5,557.00	4.81	73.00
2006	19,819.00	887.00	4.69	126,738.00	5,672.00	4.69	73.00
Average Growth							
1987-1991	–	715.82	13.17	–	4,306.29	13.32	–
1992-1996	–	805.00	8.72	–	4,986.00	9.12	–
1997-2001	–	756.00	5.72	–	5,147.20	6.33	–
2002-2006	–	850.00	4.95	–	5,872.00	5.41	–

Table 4-4 Load Forecast by Thai Organization
(High Case)

Fiscal Year	Peak Generation			Energy Generation			Load Factor
	MW	Increase		GWh	Increase		
		MW	%		GWh	%	%
			Actual				
1979	2,255.00	154.40	7.35	13,964.55	1,592.88	12.88	70.69
1980	2,417.40	162.40	7.20	14,753.73	789.18	5.65	69.67
1981	2,588.70	171.30	7.09	15,959.97	1,206.24	8.18	70.38
1982	2,838.00	249.30	9.63	16,881.95	921.98	5.78	67.91
1983	3,204.30	366.30	12.91	19,066.30	2,184.35	12.94	67.92
1984	3,547.30	343.00	10.70	21,066.44	2,000.00	10.49	67.79
1985	3,878.40	331.10	9.33	23,356.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.00	3,812.84	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,461.09	13.94	66.59
Average Growth 1980-1989	—	397.77	10.70	—	2,249.25	10.07	—
			Forecast				
1990	7,168.00	935.30	15.00	42,203.00	5,745.91	15.76	67.21
1991	8,028.00	860.00	12.00	48,013.00	5,810.00	13.77	68.27
1992	8,911.00	883.00	11.00	53,760.00	5,747.00	11.97	68.87
1993	9,802.00	891.00	10.00	59,470.00	5,710.00	10.62	69.26
1994	10,689.00	887.00	9.47	65,113.00	5,643.00	9.92	69.54
1995	11,498.00	809.00	7.57	70,505.00	5,392.00	8.28	70.00
1996	12,335.00	837.00	7.28	76,113.00	5,608.00	7.95	70.44
1997	13,190.00	855.00	6.93	81,674.00	5,561.00	7.31	70.69
1998	14,093.00	903.00	6.85	87,931.00	6,257.00	7.66	71.23
1999	15,009.00	916.00	6.50	94,167.00	6,236.00	7.09	71.62
2000	15,946.00	937.00	6.24	100,951.00	6,784.00	7.20	72.27
2001	16,916.00	970.00	6.04	108,041.00	7,090.00	7.02	72.91
2002	17,842.00	926.00	5.47	114,096.00	6,055.00	5.60	73.00
2003	18,777.00	935.00	5.24	120,075.00	5,979.00	5.24	73.00
2004	19,681.00	904.00	4.81	125,856.00	5,781.00	4.81	73.00
2005	20,593.00	912.00	4.63	131,688.00	5,832.00	4.63	73.00
2006	21,499.00	906.00	4.40	137,482.00	5,794.00	4.40	73.00
Average Growth							
1987-1991	—	769.42	13.94	—	4,646.69	14.14	—
1992-1996	—	861.40	8.97	—	5,620.00	9.65	—
1997-2001	—	916.20	6.52	—	6,385.60	7.26	—
2002-2006	—	916.60	4.91	—	5,960.20	4.94	—

4.3 Forecast of Power Demand Made by the JICA Team

4.3.1 Way of Prediction

The JICA Team forecasted the future values of energy consumption, energy demand and maximum power demand at sending end, based on such data of Thailand as actual energy consumption, past GDP, GDP and population in future predicted by the Thai government agencies.

Fig. 4-1 shows the way of predicting future power and energy demands.

(1) Past Energy Demand, Maximum Power Demand and Load Factor at Sending End

Past energy demands at sending end (h) were estimated from the actual past values of generated energy (c) and consumed energy at the power stations (d).

Past maximum power demands at sending end (i) were estimated from the actual past values of maximum generated power (e) and the KW station service rate (k) assumed as 90% of the kWh station service rate (d).

Load factors of the past power demands at sending end (j) were estimated from the energy demand at sending end (h) and the maximum power demand at sending end (i).

Energy demand at sending end (GWh)
= generated energy (GWh)
- energy for station service (GWh)

Maximum power demand at sending end (MW)
= Maximum generated power x (1 - kW station service rate)

Load factor at sending end
= energy demand at sending end (GWh) x 1,000/8,760
x 1/maximum power demand at sending end (MW)

(2) Past Transmission Losses

Past transmission losses (g) were acquired from the estimated past energy demand at sending end (h) and the actual past energy consumption (b). On an average the rate of transmission losses was 10.2% for the past ten years.

(3) Forecast of Energy Consumption in Future

Investigation of the actual past values of energy consumption and GDP of Thailand showed that the value of energy consumption per GDP Unit has increased approximately in straight line (Fig. 4-2).

Future energy consumption (r) was forecasted from the growth rate of the energy consumption per GDP Unit (m) and the forecasted future values of GDP (l) which were formulated by NESDB in Thailand.

On that occasion, 3.3%-the average growth rate during the past ten years-was adopted as the growth rate of the energy consumption per GDP Unit in 1990 over the previous year, but the growth rate from 1991 forward was assumed to be reducing at the rate of 0.1 - 0.2% yearly.

Fig. 4-3 shows the actual past values and estimated future values of the energy consumption and GDP, and Fig. 4-4 does the relation between the energy consumption and GDP.

The relation of the above two factors from 1980 to 2001 is expressed by the following mode formula;

$$\log y = -3.772487225 + 1.440643987 \log x$$

y = energy consumption (GWh)
x = GDP (Million Baht)
(correlation coefficient r = 0.99607371)

(4) Forecast of Transmission Losses and Energy Demand at Sending End

The energy demands at sending end (s) were forecasted from the following formula by taking the rate of transmission losses (n) into consideration to the future energy consumption (r) estimated in the above section (3).

Energy demand at sending end (GWh)
= Energy consumption (GWh) /
(1 - rate of transmission losses)

The rate of transmission losses increases in proportion to power demand, but in reality, the increase of it will be curbed by an investment which should be made in transmission and distribution systems with the increase of power demand.

Therefore, the rate of transmission losses will not change very much in future. The JICA Team used 10.2%, the average value for the last ten years, for 1990, and assumed 10.4 - 10.6% for the years after 1990.

(5) Forecast of annual Load Factor and Maximum Power Demand at Sending End

The maximum power demand at sending end (t) was calculated from the energy demand at sending end (s), which was calculated by the above mentioned way, using the following formula with the annual load factor at sending end.

Maximum power demand at sending end (MW)
= energy demand at sending end (GWh) x 1,000/8,760
x 100/annual load factor (%)

The forecast of the annual load factor at sending end was made in the section (1). The peak portion of the load curve has become acute with the increase of power demand, and the annual load factor showed a tendency to decrease.

The decrease of load factor is in part caused by an increase of the portion of PEA demand, whose load factor is quite low.

However, an annual load factor decreases in general, as seen in Japan, when demands with low load factor, e.g. demand from office buildings, department stores, hotels, schools, research institutes, stores, small scale factories, increase.

This phenomenon is also seen in Thailand, chiefly around the Metropolitan area.

Also, in Thailand, the percentages of industries such as the machine work, the assembling, the textile, the food, etc. are expected to increase in future.

The annual load factors of these industries are lower than those of the high energy consumption type industries, e.g. the steel and the chemical.

Moreover, it is predicted that a peaking portion of daily load curve will become sharper because of a substantial increase of livelihood demand due to rapid diffusion of various household electrical appliances and construction booms of large-sized stores, offices, apartment houses, etc.

Therefore unless some measures for a peak shift are taken, the tendency of decrease of annual load factor will advance as before. In the forecast, the annual load factor at sending end was assumed to be 66.3% for 1990, and to be decreased afterwards at the rate of 0.3% yearly.

Incidentally, the transition of an annual load factor in Japan and that in Taiwan are shown in Fig. 4-5 and in Fig. 4-6 respectively. The transition of power demand in Japan and that in Taiwan are shown in Table 4-5 and in Table 4-6 respectively.

(6) Forecast of Energy Demand and Maximum Power Demand at Generating End

The energy demand and the maximum power demand at generating end, (u) and (v), are predicted by adding the energy and power consumed for station service respectively to the energy and maximum power demand at sending end.

A station service rate, ratio of power and energy consumed at a power station to generated power and energy, depends on the type of power source. According to the actual records of power plant operation in 1988, the kWh station service rates are as follows;

Oil and gas fired plant	4 - 5%
Lignite fired plant	7 - 9%
Combined cycle	1.5%

The total energy consumed by all the power stations was about 4% of the total generated energy in the whole system.

A rate of energy to be consumed at generating end will be increased with an increase of a rate of the capacity of thermal power plants to the total generating capacity of a power system.

In EGAT power system, especially at the second half of the 1990s, the rate of the capacity of coal and lignite fired power plants is to be increased, so the rate of energy consumed for station use will be increased.

In this forecast the kWh station service rate to the total generated energy is set at 4.2% for 1990, the same rate as for 1989, and it is supposed to be increased at the rate of 0.04 - 0.05% per year after 1990. The kW station service rate is assumed at 90% of the kWh station service rate.

4.3.2 Result of Load Forecast

Power demand forecast presumed by the JICA Team are shown in Table 4-7 and Table 4-8.

(1) Energy Consumption

The GDP of Thailand in future is forecasted to grow at an average rate of 9.15% until 1991, 6.77% from 1992 to 1996, and 5.26% from 1997 to 2001.

Based on these data, the JICA Team predicted that the energy consumption will increase at the average growth rate of 13.01%

from about 31,500 GWh in 1989 to about 39,400 GWh in 1991, 9.52% from 1992 to 1996 and 7.36% from 1997 to 2001, and in 2000 it will be about 82,800 GWh, which is about 2.6 times as much as that in 1989.

Energy consumption per capita in 2000 is predicted to be 1286 kWh, which is about 2.26 times as much as 568 kWh at the present time.

(2) Energy Demand, Power Demand and Annual Load Factor at Sending End

The energy demand at sending end was calculated from above mentioned energy consumption by assuming that the transmission losses would be about 10.5%. It is predicted that the energy demand will increase at an average annual rate of about 8.87% from the present value of some 35,000 GWh and it will be about 92,500 GWh in 2000.

The power demand at sending end, on the other hand, is predicted to increase at an average annual rate of about 9.37% from the estimated present value of about 6,000 MW and reach some 16,700 MW in 2000.

The annual load factor at sending end is predicted to decrease at a rate of 0.3% per year from the present 66.5% (estimated value) and to be 63.3% in 2000.

(3) Energy Demand, Maximum Power Demand and Annual Load Factor at Generating End

Energy demand at generating end was acquired by adding energy consumption at power stations to the above-mentioned energy demand at sending end.

A rate of station service was estimated at 4.2 - 4.7% for the next ten years.

The energy demand at generating end is predicted to increase at an average rate of about 8.93% per year from the current about 36,500 GWh to about 97,000 GWh in 2000.

The maximum power demand at generating end is predicted to grow at a rate of 9.42% per year on average and to be about 17,400 MW in 2000.

The annual load factor at generating end is predicted to decrease gradually in future from current 68% to 63.3% in 2000.

Table 4-5 TRANSITION OF TOTAL POWER DEMANDS OF NINE ELECTRICAL POWER COMPANIES IN JAPAN

Year	Generated Energy (GWh)	Peak Demand (MW)	Load Factor (%)
1970	279,287	47,545	67.1
1971	295,390	51,989	64.9
1972	326,098	57,862	64.3
1973	358,649	66,971	61.1
1974	352,664	66,937	60.1
1975	370,944	70,540	60.0
1976	399,345	75,726	60.2
1977	415,511	80,195	59.1
1978	441,736	84,616	59.6
1979	466,575	87,226	61.1
1980	460,658	84,919	61.9
1981	472,434	90,855	59.4
1982	478,022	90,015	60.6
1983	508,633	98,886	58.7
1984	531,749	103,686	58.5
1985	551,279	106,566	59.1
1986	549,460	107,657	58.3
1987	584,078	111,485	59.8
1988	609,784	118,326	58.8
1989	646,025	124,172	59.4

Note : As per Japan Electric Power Survey Committee

Table 4-6 TRANSITION OF POWER DEMAND IN TAIWAN

Year	Energy Output (GWh)	Peak Demand (MW)	Load Factor (%)
1970	13,213	2,131	70.8
1971	15,171	2,399	72.2
1972	17,449	2,734	72.9
1973	18,805	3,134	72.1
1974	20,534	3,452	67.9
1975	22,894	3,765	69.4
1976	26,877	4,302	71.3
1977	29,724	4,818	70.4
1978	34,433	5,630	69.8
1979	37,896	6,070	71.3
1980	40,813	6,703	69.5
1981	40,150	6,797	67.4
1982	40,899	6,918	67.5
1983	45,517	7,808	66.5
1984	49,286	8,517	66.1
1985	52,556	8,716	68.8
1986	59,031	9,900	68.1
1987	65,515	11,113	67.3
1988	71,641	12,331	66.3
1989	76,909	13,422	65.4

Note : As per TAIPOWER 1979-1989

Table 4-7 POWER DEMAND FORECAST IN THILAND

Year	Generating End							Sending End			Transmission & Distribution Losses		Energy Consumption
	Energy	KWH Station Losses		Maximum Power	KW Station Losses		Load Factor	Energy	Maximum Power	Load Factor			
	(GWH)	(GWH)	(%)	(MW)	(MW)	(%)	(%)	(GWH)	(MW)	(%)	(GWH)	(%)	(GWH)
1980	14,753.73	590.45	4.00	2,417.40	87.0	3.60	69.7	14,163.28	2330.4	69.4	1,156.31	8.2	13,006.97
1981	15,959.97	612.29	3.84	2,588.70	89.4	3.45	70.4	15,347.68	2499.3	70.1	1,455.16	9.5	13,892.52
1982	16,881.95	602.49	3.57	2,838.00	91.2	3.21	67.9	16,279.46	2746.8	67.7	1,507.29	9.3	14,772.17
1983	19,066.30	659.05	3.46	3,204.30	99.7	3.11	67.9	18,407.25	3104.6	67.7	1,951.28	10.6	16,455.97
1984	21,066.44	830.10	3.94	3,547.30	125.8	3.55	67.8	20,236.34	3421.5	67.5	2,196.89	10.9	18,039.45
1985	23,356.57	1,022.81	4.38	3,878.40	152.9	3.94	68.7	22,333.76	3725.5	68.4	2,519.57	11.3	19,814.19
1986	24,779.53	1,010.03	4.08	4,180.90	153.4	3.67	67.7	23,769.50	4027.5	67.4	2,755.66	11.6	21,013.84
1987	28,193.16	1,154.68	4.10	4,733.90	174.5	3.69	68.0	27,038.48	4559.4	67.7	2,867.63	10.6	24,170.85
1988	31,996.00	1,265.89	3.96	5,444.00	193.8	3.56	67.1	30,730.11	5250.2	66.8	3,165.26	10.3	27,564.85
1989	36,457.09	1,532.22	4.20	6,232.70	235.8	3.78	66.8	34,924.87	5996.9	66.5	3,429.77	9.8	31,495.10
1990	41,256	1,735	4.20	7,074	268	3.78	66.6	39,522	6,806	66.3	4,190	10.2	35,332
1991	45,961	1,954	4.25	7,916	303	3.83	66.3	44,007	7,613	66.0	4,576	10.4	39,431
1992	50,953	2,189	4.30	8,815	341	3.87	66.0	48,764	8,474	65.7	5,116	10.5	43,648
1993	56,132	2,438	4.34	9,754	381	3.91	65.7	53,694	9,373	65.4	5,699	10.6	47,995
1994	61,476	2,698	4.39	10,731	424	3.95	65.4	58,778	10,307	65.1	6,240	10.6	52,538
1995	66,987	2,971	4.43	11,746	469	3.99	65.1	64,017	11,277	64.8	6,781	10.6	57,236
1996	72,699	3,257	4.48	12,805	516	4.03	64.8	69,441	12,289	64.5	7,307	10.5	62,134
1997	78,189	3,539	4.53	13,835	564	4.07	64.5	74,650	13,271	64.2	7,775	10.4	66,875
1998	84,118	3,846	4.57	14,952	615	4.12	64.2	80,272	14,337	63.9	8,346	10.4	71,926
1999	90,392	4,175	4.62	16,141	671	4.16	63.9	86,217	15,470	63.6	8,972	10.4	77,245
2000	97,012	4,525	4.66	17,404	731	4.20	63.6	92,487	16,673	63.3	9,679	10.5	82,808
2001	103,921	4,896	4.71	18,730	794	4.24	63.3	99,025	17,936	63.0	10,390	10.5	88,635
2002	110,571	5,260	4.76	19,940	854	4.28	63.3	105,312	19,087	63.0	11,059	10.5	94,253
2003	117,549	5,646	4.80	21,199	916	4.32	63.3	111,903	20,282	63.0	11,752	10.5	100,151
2004	124,933	6,058	4.85	22,530	983	4.36	63.3	118,875	21,547	63.0	12,471	10.5	106,404
2005	132,760	6,499	4.89	23,942	1055	4.41	63.3	126,261	22,887	63.0	13,230	10.5	113,031
2006	141,061	6,970	4.94	25,439	1131	4.45	63.3	134,091	24,308	63.0	14,036	10.5	120,055

Table 4-8 FORECAST OF ENERGY CONSUMPTION IN THAILAND

Year	Energy Consumption *1		GDP in 1972 Price *2		Energy Consumption Per GDP		Population *2	kWh Per Capita	
	GWh	Growth Rate	M Baht	Growth Rate	Wh/Baht	Growth Rate	Thousand	kWh	Growth Rate
1980	13,006.97	(%)	299,472	(%)	43.4	(%)	46,961	277.0	(%)
1981	13,892.52	6.8	318,440	6.3	43.6	0.4	47,875	290.2	4.8
1982	14,772.17	6.3	331,379	4.1	44.6	2.2	48,847	302.4	4.2
1983	16,455.97	11.4	355,411	7.3	46.3	3.9	49,515	332.3	9.9
1984	18,039.45	9.6	380,739	7.1	47.4	2.3	50,583	356.6	7.3
1985	19,814.19	9.8	394,113	3.5	50.3	6.1	51,796	382.5	7.3
1986	21,013.84	6.1	411,813	4.5	51.0	1.5	52,969	396.7	3.7
1987	24,170.85	15.0	446,361	8.4	54.2	6.1	53,973	447.8	12.9
1988	27,564.85	14.0	495,378	11.0	55.6	2.8	54,961	501.5	12.0
1989	31,495.10	14.3	542,706	9.6	58.0	4.3	55,448	568.0	13.3
1990	35,332	12.2	589,370	8.6	59.9	3.3	56,340	627.1	10.4
1991	39,431	11.6	637,964	8.2	61.8	3.1	57,199	689.4	9.9
1992	43,648	10.7	686,300	7.6	63.6	2.9	58,041	752.0	9.1
1993	47,995	10.0	734,802	7.1	65.3	2.7	58,876	815.2	8.4
1994	52,538	9.5	783,975	6.7	67.0	2.6	59,693	880.1	8.0
1995	57,236	8.9	834,063	6.4	68.6	2.4	60,508	945.9	7.5
1996	62,134	8.6	885,081	6.1	70.2	2.3	61,311	1013.4	7.1
1997	66,875	7.6	932,103	5.3	71.7	2.2	62,100	1076.9	6.3
1998	71,926	7.6	981,893	5.3	73.3	2.1	62,879	1143.9	6.2
1999	77,245	7.4	1,033,820	5.3	74.7	2.0	63,640	1213.8	6.1
2000	82,808	7.2	1,087,614	5.2	76.1	1.9	64,390	1286.0	6.0
2001	88,635	7.0	1,143,570	5.1	77.5	1.8	65,182	1359.8	5.7
2002	94,253	6.3	1,195,714	4.6	78.8	1.7	66,012	1427.8	5.0
2003	100,151	6.3	1,249,304	4.5	80.2	1.7	66,803	1499.2	5.0
2004	106,404	6.2	1,305,113	4.5	81.5	1.7	67,594	1574.2	5.0
2005	113,031	6.2	1,363,229	4.5	82.9	1.7	68,385	1652.9	5.0
2006	120,055	6.2	1,423,742	4.4	84.3	1.7	69,176	1735.5	5.0

Note : *1. The values for the year of 1990 onward were predicted by the JICA Team.

*2. The values for the year of 1990 onward were predicted by the Office of National Economic and Social Development Board, and National Energy Policy Office in Thailand.

Fig. 4-1 Way of Predicting Future Power and Energy Demand

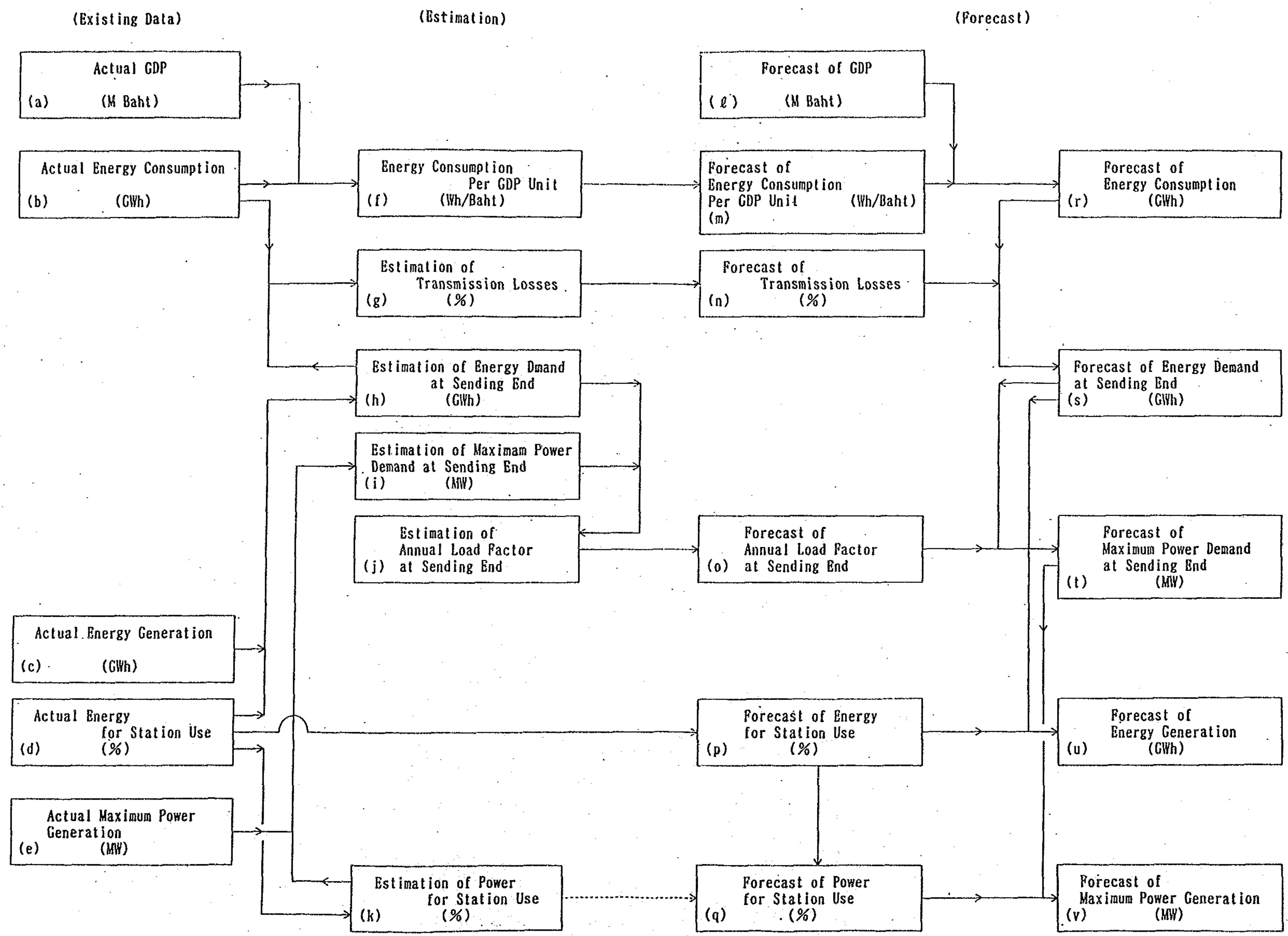


Fig. 4-2 ENERGY CONSUMPTION PER GDP UNIT

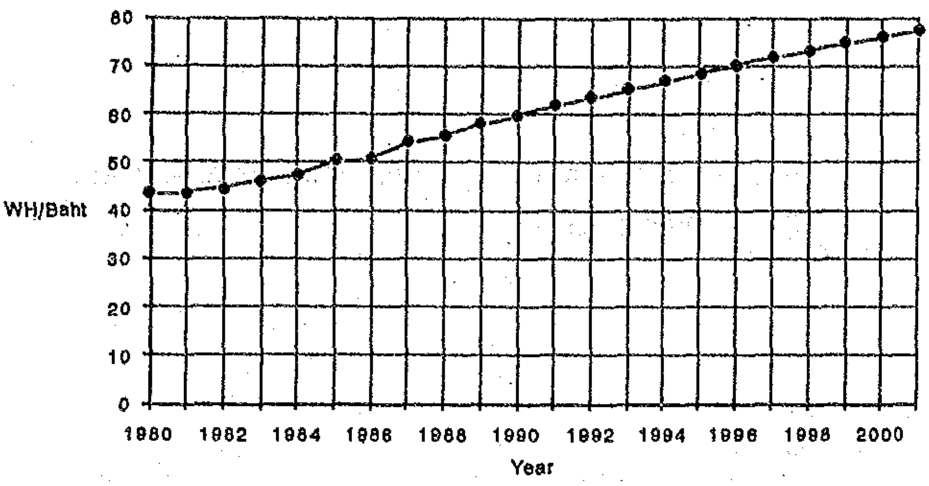


Fig. 4-3 Energy Consumption and GDP

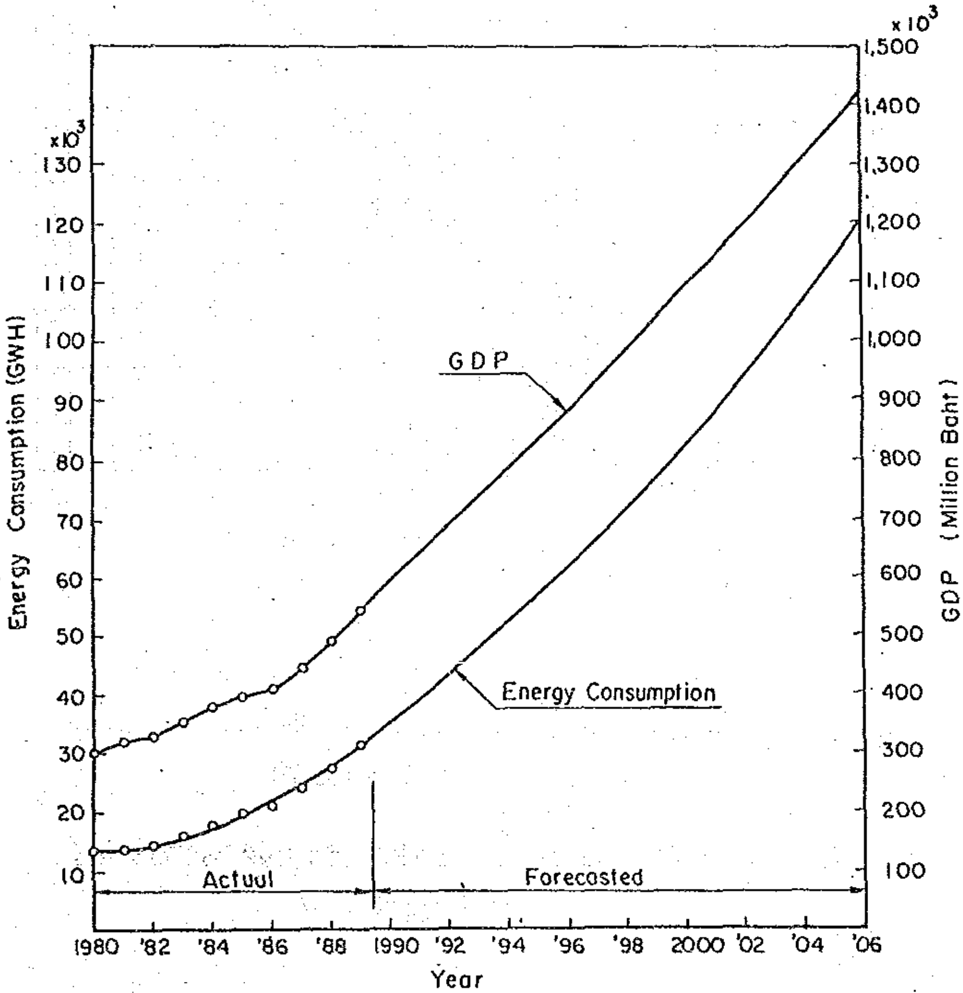
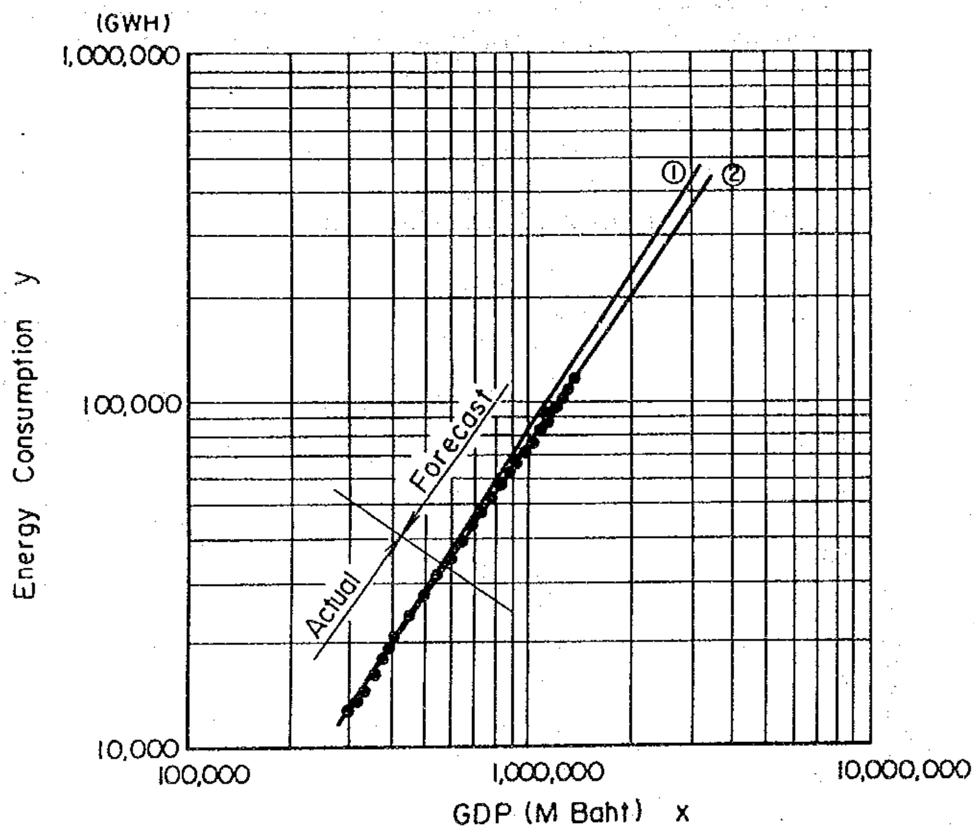


Fig. 4-4 Relation between Energy Consumption (GWH) and GDP (Million Baht)



① (1980 – 1989) $\log y = -4.304207758 + 1.535792455 \log x$

$r = 0.998543248$

② (1980 – 2001) $\log y = -3.772487225 + 1.440643987 \log x$

$r = 0.999607371$

Fig. 4-5 TRANSITION OF ANNUAL LOAD FACTOR IN JAPAN

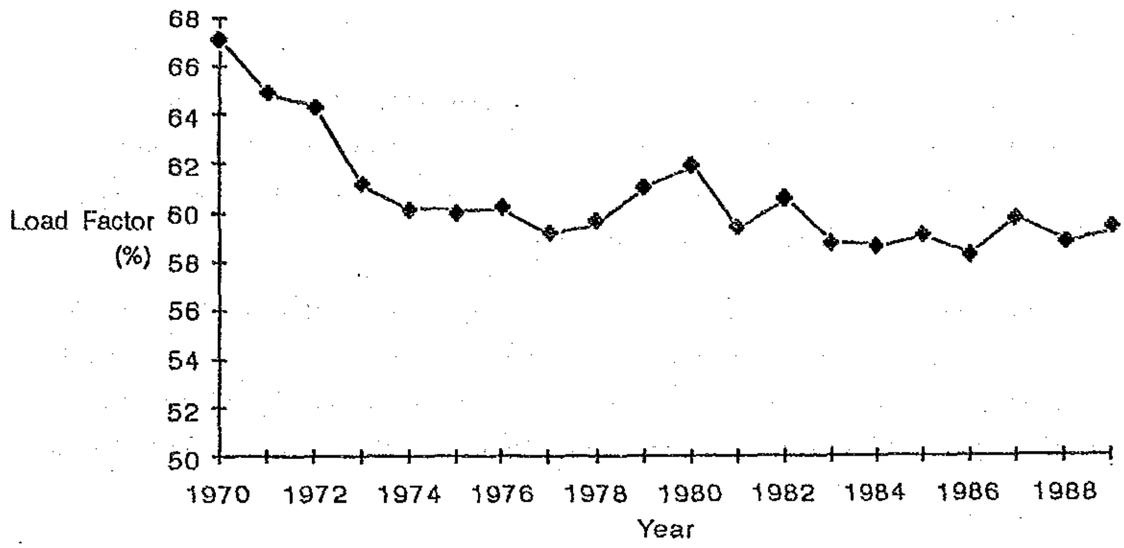
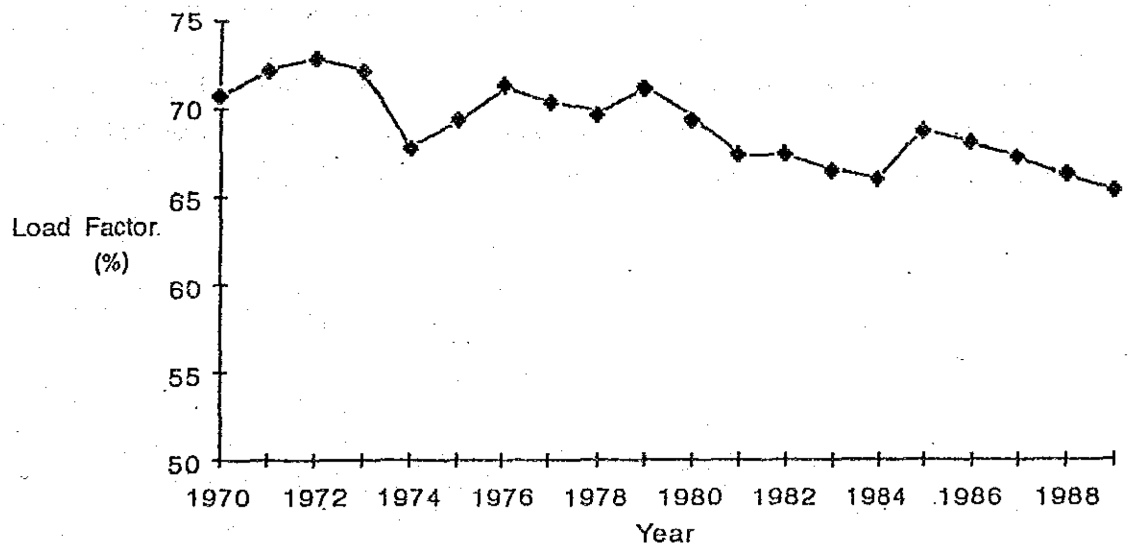


Fig. 4-6 TRANSITION OF ANNUAL LOAD FACTOR IN TAIWAN



4.4 Comparison between the Two Load Forecasts

Table 4-9, Fig. 4-7 and Fig. 4-8 show a comparison between the load forecast made by the JICA Team and the load forecast by Thai Organization.

The difference between the two is exceedingly small in the energy demand at generating end, although the JICA forecast is a little bit lower than the High Case forecast by the Thai Organization. They can be regarded as almost the same.

As for the maximum power demand, each forecast predicts that it will grow almost in the same way until 1995 or 1996, but after that the values predicted by the JICA Team will surpass those predicted by the Thai Organization and the difference between them will increase gradually.

This difference can be referred to the annual load factors differently predicted by both parties. The JICA Team predicted that the annual load factor will decrease gradually while the Thai Organization predicted that it will increase by degrees year by year.

In order to use facilities efficiently and not to make over-much investment in development of power resources, it is desirable to prevent the annual load factor from decreasing and to make it increase.

However, the current tendency of decrease in its value will continue for the time being as shown in the past records in Japan and Taiwan, unless some drastic measures to level the load are taken.

Table 4-9 COMPARISON OF LOAD FORECASTS MADE BY JICA TEAM & THAI ORGANIZATION

Fiscal Year	(A) Forecast by JICA Team			(B) Forecast by Thai Organization			Comparison of (A) & (B)	
	Generating End			Generating End			Energy	Max. Power
	Energy (1) (GWH)	Max. Power (2) (MW)	Load Factor (%)	Energy (3) (GWH)	Max. Power (4) (MW)	Load Factor (%)	((1)-(3))/(3) (%)	((2)-(4))/(4) (%)
1988	31,996.00	5,444.0	67.1	31996.00	5,444.0	67.1	-	-
1989	36,457.09	6,232.7	66.8	36457.09	6,232.7	66.8	-	-
1990	41,256	7,074	66.6	42,203	7,168	67.2	-2.2	-1.3
1991	45,961	7,916	66.3	48,013	8,028	68.3	-4.3	-1.4
1992	50,953	8,815	66.0	53,760	8,911	68.9	-5.2	-1.1
1993	56,132	9,754	65.7	59,470	9,802	69.3	-5.6	-0.5
1994	61,476	10,731	65.4	65,113	10,689	69.5	-5.6	0.4
1995	66,987	11,746	65.1	70,505	11,498	70.0	-5.0	2.2
1996	72,699	12,805	64.8	76,113	12,335	70.4	-4.5	3.8
1997	78,189	13,835	64.5	81,674	13,190	70.7	-4.3	4.9
1998	84,118	14,952	64.2	87,931	14,093	71.2	-4.3	6.1
1999	90,392	16,141	63.9	94,167	15,009	71.6	-4.0	7.5
2000	97,012	17,404	63.6	100,951	15,946	72.3	-3.9	9.1
2001	103,921	18,730	63.3	108,041	16,916	72.9	-3.8	10.7
2002	110,571	19,940	63.3	114,096	17,842	73.0	-3.1	11.8
2003	117,549	21,199	63.3	120,075	18,777	73.0	-2.1	12.9
2004	124,933	22,530	63.3	125,856	19,681	73.0	-0.7	14.5
2005	132,760	23,942	63.3	131,688	20,593	73.0	0.8	16.3
2006	141,061	25,439	63.3	137,482	21,499	73.0	2.6	18.3

Fig. 4-7 **Load Forecast (Energy Demand at Generating End)**

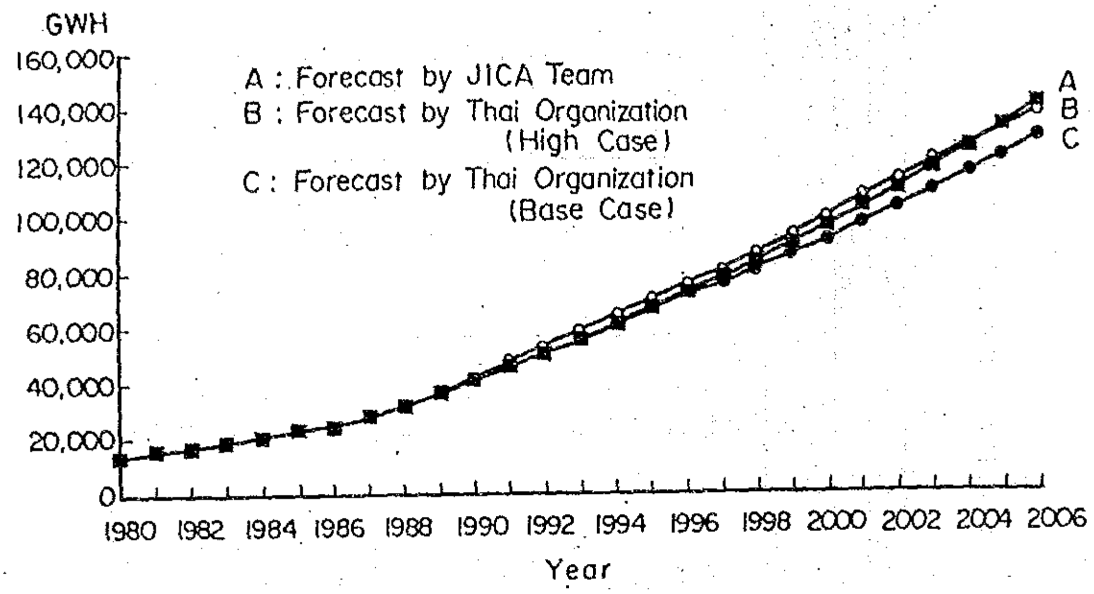
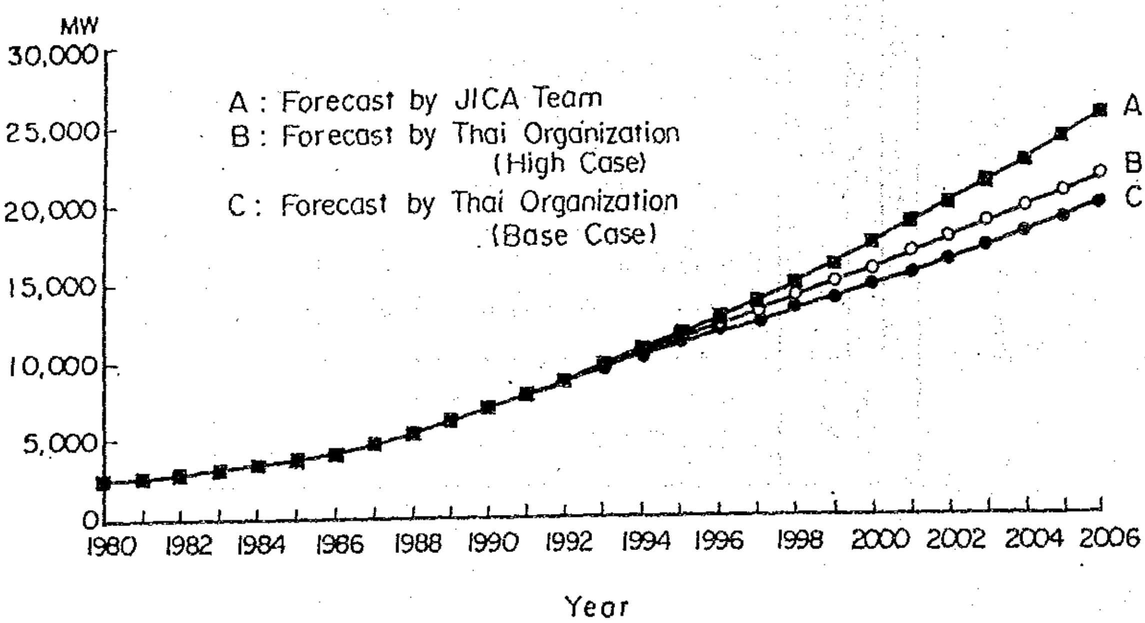


Fig. 4-8 **Load Forecast (Maximum Power Demand at Generating End)**



CHAPTER 5

POWER DEVELOPMENT PLAN

CHAPTER 5 POWER DEVELOPMENT PLAN

CONTENTS

List of Tables

CHAPTER 5 POWER DEVELOPMENT PLAN

5.1 Present Power Supply in Thailand

The power supply capacity of EGAT as of September, 1990 is shown in Table 5-1. The total installed capacity of the power generation facilities owned by EGAT is 7,970.3 MW and the total dependable capacity of each power source is 7,484.6 MW.

The dependable capacity is the maximum load of a power plant under adverse conditions. In steam, combined cycles and gas turbine plants, the dependable capacity is obtained from the rated capacity of units multiplied by the following coefficients:

Steam power	0.98
Combined cycles	0.98
Gas turbine (existing)	0.85

These coefficients are defined from the reserve criterion by EGAT, taking into consideration of several occasions incapable of generating power upto full rated capacity in the past years.

The dependable capacity of a hydro power plant is defined as the output of plant at the water level of a reservoir corresponding to 90 percent of the water level frequency, based on a long period reservoir simulation using past hydrological records. The average ratio of the dependable capacity to the installed capacity of all the existing hydro power plants is 0.85 though the ratio differs from plant to plant.

Table 5-1 EGAT EXISTING INSTALLED GENERATING CAPACITY
(As of September 1990)

Plants	Number of Units	Capacity (MW) Installed	Dependable
Hydro			
Bhumibol	7	535.0	480.0
Sirikit	3	375.0	285.0
Ubolratana	3	25.2	16.6
Sirindhorn	3	36.0	32.4
Chulabhorn	2	40.0	39.9
Krang Kracharn	1	17.5	11.0
Nam Pung	2	6.0	5.6
Srinagarind	4	540.0	540.0
Bang Lang	3	72.0	80.5
Tha Thung Na	2	38.0	38.0
Khao Laem	3	300.0	211.7
Huai Kum	1	1.06	-
Ban Santi	1	1.275	-
Mae Ngat	2	9.0	-
Kiridharn	2	12.7	12.2
Rajjaprabha	3	240.0	176.0
Miscellaneous	7	0.428	-
Total	49	2249.2	1908.9
Thermal			
North Bangkok	3	237.5	232.8
South Bangkok	5	1330.0	1303.4
Mae Moh	9	1425.0	1396.5
Krabi	2	34.0	33.3
Surat Thani	1	30.0	29.4
Khanom	2	150.0	147.0
Bang Pakong	2	1100.0	1078.0
Total	24	4306.5	4220.4
Combined Cycle			
Bang Pakong	14	1176.6	1153.0
Total	14	1176.6	1153.0
Gas Turbine			
Nakhon Ratchasima	1	14.0	11.9
Udon Thani	1	14.0	11.9
Hat Yai	3	42.0	35.7
Surat Thani	3	42.0	35.7
Lam Krabu	7	126.0	107.1
Total	15	238.0	202.3
Grand Total	102	7970.26	7484.6

5-2 Power Development Plan of EGAT

The main part of future power development of Thailand is supposed to be filled up by the development of thermal power as seen in Table 5-2.

For the present, the following projects are being proceeded.

Combined cycle:	Bang Pakong	Block 3-4 (307 MW each)
	Rayong	Block 1-3 (308 MW each)
	Nam Phong	Block 1 (355 MW)
Oil/Gas fired:	Bang Pakong	Units 3-4 (600 MW each)
Lignite fired:	Mae Moh	Units 10-11 (300 MW each)

Although there are a few hydro power projects to be developed, like Srinagarind Unit 5 (180 MW), Pak Mun (4 x 34 MW) and Sirikit Unit 4 (125 MW) but the capacity of thermal power to be developed are to be overwhelmingly great.

From the mid 1990s, there are some development plans of hydro power like Kaeng Krung (2x 40 MW), Bhumibol Unit 8 (175 MW) and Lam Ta Khong (600 MW as per EGAT's PDP), but a great part of the power development will be occupied by the thermal development of combined cycle, lignite fired and coal fired power plants.

The capacity of power sources which are planned to be developed sums up to 19,934 MW by the year 2006, but there are some plans of retirement of old gas turbines and thermal power plants (total: 2,930.1 MW), so the total generating capacity in 2006 will be 24,974.2 MW.

Table 5-2 Power Development Plan in Thailand (EGAT's PDP 90-03)

	Power Plant	Fuel Type	Unit Number	Rating (MW)	Total (MW)	Commissioning Date	
Under Construction	Rayong CC 1 (GT)	Gas	1-2	103	206	November	1990
	Nam Phong CC 1 (GT)	Gas	1-2	121	242	December	1990
	Rayong CC 2 (GT)	Gas	1-2	103	206	December	1990
	Rayong CC 3 (GT)	Gas	1-2	103	206	March	1991
	Srinagarind	Hydro	5	180	180	April	1991
	Bang Pakong CC 3 (ST)	-	1	99	99	March	1991
	Bang Pakong CC 4 (ST)	-	1	99	99	July	1991
	Rayong CC 1 (ST)	-	1	102	102	August	1991
	Rayong CC 2 (ST)	-	1	102	102	September	1991
	Nam Phong CC 1 (ST)	-	1	113	113	November	1991
	Mae Moh	Lignite	10	300	300	November	1991
	Rayong CC 3 (ST)	-	1	102	102	December	1991
	Bang Pakong Thermal	Oil/Gas	3	600	600	March	1992
	Mae Moh	Lignite	11	300	300	May	1992
	Bang Pakong Thermal	Oil/Gas	4	600	600	May	1993
	Pak Mun	Hydro	1-4	34	136	Jun 94 - Nov 94	
	Bhumibol Renovation	Hydro	1	(70)	(70)	June	1992
	Nam Phong CC 2 (GT)	Gas	1-2	121	242	January	1993
	Bhumibol Renovation	Hydro	2	(70)	(70)	January	1993
	Rayong CC 4 (GT)	Gas	1-2	100	200	March	1993
	South Bangkok CC 1 (GT)	Gas	1-2	100	200	April	1993
	Khanom CC1 (GT)	Gas	1-2	100	200	December	1993
	Nam Phong CC 2 (ST)	-	1	113	113	January	1994
	Sirikit	Hydro	4	125	125	February	1994
	Rayong CC 4 (ST)	Gas	1	100	100	March	1994
	South Bangkok CC 1 (ST)	-	1	100	100	April	1994
	Khanom CC 2 (GT)	Gas	1-2	100	200	April	1994
	Wang Noi Gas Turbine	Gas	1-2	100	200	November	1994
	Khanom CC 1 (ST)	-	1	100	100	December	1994
	Kaeng Krung	Hydro	1-2	40	80	December	1994
	Bhumibol	Hydro	8	175	175	January	1995
	Wang Noi Gas Turbine	Gas	3-4	100	200	April	1995
	Khanom CC 2 (ST)	-	1	100	100	April	1995
	Mae Moh	Lignite	12	300	300	April	1996
	Ao Phai	Coal	1	700	700	August	1996
	Mae Moh	Lignite	13	300	300	October	1996
	Lam Takhong	Hydro	1-4	150	600	Dec 96 - Jun 97	
	Ao Phai	Coal	2	700	700	April	1997
	Ao Phai	Coal	3	700	700	April	1998
	Mae Taeng	Hydro	1-2	18+8	26	June	1998
	Nam Khek	Hydro	1	50	50	December	1998
	Lampang	Lignite	1	300	300	January	1999
	Mae Lama Luang	Hydro	1-3	80	240	January	1999
	Lampang	Lignite	2	300	300	July	1999
	Nam Ngao	Hydro	1-2	70	140	January	2000
	Lampang	Lignite	3	300	300	January	2000
	Saba Yoi	Lignite	1	300	300	April	2000
	Lampang	Lignite	4	300	300	July	2000
	Saba Yoi	Lignite	2	300	300	October	2000
	Lampang	Lignite	5	450	450	January	2001
	New Gas Turbine	Gas	1-2	100	200	April	2001
	Lampang	Lignite	6	450	450	July	2001
	Ao Phai	Coal	4	700	700	October	2001
	Saba Yoi	Lignite	3	300	300	April	2002
	New Thermal	1/	1	1,000	1,000	October	2002
	New Thermal	1/	2	1,000	1,000	April	2003
	Sin Pun	Lignite	1	75	75	April	2003
	New Gas Turbine	Gas	3-4	100	200	May	2003
	New Thermal	1/	3	1,000	1,000	January	2004
	Sin Pun	Lignite	2	75	75	April	2004
	New Thermal	1/	4	1,000	1,000	January	2005
	New Thermal	1/	5	1,000	1,000	October	2005
	New Thermal	1/	6	1,000	1,000	April	2006

Existing Capacity by September 1990	=	7,970.3	MW
Total Added Capacity (Up to 2006)	=	19,934.0	MW
Plant Retirement	=	2,930.1	MW
Total Capacity by Year 2006	=	24,974.2	MW

Note : 1/ Type of fuel will be determined later on.

5.3 Balance of Power Supply and Demand

A supply and demand balance has been established by combining the power demand forecast prepared by the JICA Team with EGAT's power development plan as shown in Table 5-3.

The dependable capacity of the future projects was calculated from the rated capacity of each power source unit multiplied by the following coefficients in the same way mentioned before about the existing power plants.

Steam	0.98
Combined cycle	0.98
Gas turbine	0.98
General hydro	0.85
Pumped storage	1.00

The coefficients for steam and combined cycle plants are the same as those for the existing plants but for gas turbines a coefficient 0.98 is used instead of 0.85 which is used for the existing gas turbine plants, because some improvement will be taken on the design for the future projects.

A coefficient 0.85 which is an average value for the existing hydro power plants is applied to a general reservoir type hydro power plant, while a coefficient of 1.0 is used for pumping facilities.

The peak generation is the maximum power demand at the generating end which is described in Load Forecast of the previous chapter.

It is necessary to have operating reserve or extra generating capacity available for emergencies such as unexpected interruption of plant operation, decrease in output power due to shortage of water or unforeseen increase of demand.

This capacity of reserve margin should be studied in conjunction with power supply reliability.

The operating reserve comprises spinning reserve, hot reserve and cold reserve.

Spinning reserve is generating capacity connected to the system and ready to take load. It includes capacity available in generating units which are operating at less than their capability. Hot reserve is thermal generating capacity maintained at a temperature and condition which will permit it to be placed into service promptly.

Cold reserve is thermal generating capacity that takes several hours to get ready for taking load.

Reserve margin is the difference between dependable capacity and anticipated peak generation requirement. The whole reserve margin may be used as operating reserve unless there is a planned repair of the facility during the period in which the maximum demand is expected.

Table 5-3 SUPPLY AND DEMAND BALANCE

Fiscal Year	Power Plant	Fuel, Type	Installed Capacity Unit (MW)	Installed Capacity Accumulated (MW)	Dependable Capacity Unit (MW)	Dependable Capacity Accumulated (1)(MW)	Peak Generation (2)(MW)	Reserve Margin (1)-(2)(MW)	Reserve Margin (%)
1990	Existing (as of Sept.1990)	-	-	7,970.3	-	7,484.6	7,074.1	410.5	5.8
1991	Rayong cc Block 1 (GT)	Gas	206	8,176.3	201.9	7,686.5			
	Nam Phong cc Block1 (GT)	Gas	242	8,418.3	237.2	7,923.6			
	Rayong cc Block 2 (GT)	Gas	206	8,624.3	201.9	8,125.5			
	Rayong cc Block 3 (GT)	Gas	206	8,830.3	201.9	8,327.4			
	Srinagarind Unit 5	Hydro	180	9,010.3	180.0	8,507.4			
	Bang Pakong cc Block 3 (ST)	Gas	99	9,109.3	97.0	8,604.4			
	Bang Pakong cc Block 4 (ST)	Gas	99	9,208.3	97.0	8,701.4			
	Rayong cc Block 1 (ST)	Gas	102	9,310.3	100.0	8,801.4			
	Rayong cc Block 2 (ST)	Gas	102	9,412.3	100.0	8,901.4	7,915.7	985.7	12.5
1992	Nam Phong cc Block1 (ST)	Gas	113	9,525.3	110.7	9,012.1			
	Mae Moh Unit 10	Lignite	300	9,825.3	294.0	9,306.1			
	Rayong cc Block 3 (ST)	Gas	102	9,927.3	100.0	9,406.1			
	Bang Pakong Unit 3	Oil/Gas	600	10,527.3	588.0	9,994.1			
	Mae Moh Unit 11	Lignite	300	10,827.3	294.0	10,288.1	8,814.8	1,473.3	16.7
1993	Nam Phong cc Block2 (GT)	Gas	242	11,069.3	237.2	10,525.2			
	Rayong cc Block 4 (GT)	Gas	200	11,269.3	196.0	10,721.2			
	South Bangkok cc Block1(GT)	Gas	200	11,469.3	196.0	10,917.2			
	Bang Pakong Unit 4	Oil/Gas	600	12,069.3	588.0	11,505.2	9,754.1	1,751.1	18.0
1994	Khanom cc Block 1 (GT)	Gas	200	12,269.3	196.0	11,701.2			
	R2 Gas Turbine Retired	Gas	-28	12,241.3	-23.8	11,677.4			
	Nam Phong cc Block2 (ST)	Gas	113	12,354.3	110.7	11,788.2			
	Sirikit Unit 4	Hydro	125	12,479.3	106.3	11,894.4			
	Rayong cc Block 4 (ST)	Gas	100	12,579.3	98.0	11,992.4			
	South Bangkok cc Block1(ST)	Gas	100	12,679.3	98.0	12,090.4			
	Khanom cc Block 2 (GT)	Gas	200	12,879.3	196.0	12,286.4			
	Pak Mun Unit 1-4	Hydro	136	13,015.3	115.6	12,402.0	10,730.8	1,671.2	15.6
1995	Wang Noi Gas Turbine Unit 1-2	Gas	200	13,215.3	196.0	12,598.0			
	Khanom cc Block 1 (ST)	Gas	100	13,315.3	98.0	12,696.0			
	Kaeng Krung Unit 1-2	Hydro	80	13,395.3	68.0	12,764.0			
	Bhumibol Unit 8	Hydro	175	13,570.3	157.5	12,921.5			
	Wang Noi Gas Turbine Unit 3-4	Gas	200	13,770.3	196.0	13,117.5			
	Khanom cc Block 2 (ST)	Gas	100	13,870.3	98.0	13,215.5	11,745.7	1,469.8	12.5
1996	Krabi Retired	Lignite	-34	13,836.3	-33.3	13,182.2			
	Mae Moh Unit 12	Lignite	300	14,136.3	294.0	13,476.2			
	Ao Phai Unit 1	Coal	700	14,836.3	686.0	14,162.2	12,805.0	1,357.2	10.6
1997	Mae Moh Unit 13	Lignite	300	15,136.3	294.0	14,456.2			
	Lam Takhong Unit 1-4	Hydro	600	15,736.3	600.0	15,056.2			
	Ao Phai Unit 2	Coal	700	16,436.3	686.0	15,742.2	13,835.0	1,907.2	13.8
1998	Surat Thani Unit1 Retired	Oil	-30	16,406.3	-29.4	15,712.8			
	Ao Phai Unit 3	Coal	700	17,106.3	686.0	16,398.8			
	Mae Taeng Unit 1-2	Hydro	26	17,132.3	22.1	16,420.9	14,952.3	1,468.6	9.8
1999	R3 Gas Turbine Retired	Gas	-84	17,048.3	-71.4	16,349.5			
	Nam Khek	Hydro	50	17,098.3	42.5	16,392.0			
	Lampang Unit 1	Lignite	300	17,398.3	294.0	16,686.0			
	Mae Lama Luang Unit 1-3	Hydro	240	17,638.3	204.0	16,890.0			
	Lampang Unit 2	Lignite	300	17,938.3	294.0	17,184.0	16,141.4	1,042.6	6.5
2000	Nam Ngao	Hydro	140	18,078.3	119.0	17,303.0			
	Lampang Unit 3	Lignite	300	18,378.3	294.0	17,597.0			
	Lan Krabu Gas Turbine Retired	Gas	-126	18,252.3	-107.1	17,489.9			
	Saba Yoi Unit 1	Lignite	300	18,552.3	294.0	17,783.9			
	Lampang Unit 4	Lignite	300	18,852.3	294.0	18,077.9	17,403.8	674.1	3.9
2001	Saba Yoi Unit 2	Lignite	300	19,152.3	294.0	18,371.9			
	Lampang Unit 5	Lignite	450	19,602.3	441.0	18,812.9			
	New Gas Turbine Unit 1-2	Gas	200	19,802.3	196.0	19,008.9			
	Lampang Unit 6	Lignite	450	20,252.3	441.0	19,449.9	18,729.9	720.0	3.8
2002	Ao Phai Unit 4	Coal	700	20,952.3	686.0	20,135.9			
	Saba Yoi Unit 3	Lignite	300	21,252.3	294.0	20,429.9	19,940.4	489.5	2.5
2003	New Thermal Unit 1	*	1000	22,252.3	980.0	21,409.9			
	Bang Pakong cc Block 1 Retired	Gas	-380.3	21,872.0	-372.7	21,037.2			
	New Thermal Unit 2	*	1000	22,872.0	980.0	22,017.2			
	Sin Pun Unit 1	Lignite	75	22,947.0	73.5	22,090.7			
	New Gas Turbine Unit 3&4	Gas	200	23,147.0	170.0	22,260.7			
	Bang Pakong cc Block 2 Retired	Gas	-380.3	22,766.7	-372.7	21,888.0			
	North Bangkok Unit 1-3 Retired	Oil	-237.5	22,529.2	-232.8	21,655.3	21,198.8	456.5	2.2
2004	Mae Moh Unit 1-2 Retired	Lignite	-150	22,379.2	-147.0	21,508.3			
	New Thermal Unit 3	*	1000	23,379.2	980.0	22,488.3			
	Sin Pun Unit 2	Lignite	75	23,454.2	73.5	22,561.8	22,530.4	31.4	0.1
2005	New Thermal Unit 4	*	1000	24,454.2	980.0	23,541.8	23,941.9	-400.1	-1.7
2006	New Thermal Unit 5	*	1000	25,454.2	980.0	24,521.8			
	Khanom Unit 1 Retired	Oil	-75	25,379.2	-73.5	24,448.3			
	Mae Moh Unit 3 Retired	Lignite	-75	25,304.2	-73.5	24,374.8			
	New Thermal Unit 6	*	1000	26,304.2	980.0	25,354.8			
	South Bangkok Unit 1-5 Retired	Oil/Gas	-1330	24,974.2	-1,303.4	24,051.4	25,438.9	-1,387.5	-5.5

Note : * Type of fuel will be determined later on.

5.4 Necessity for Additional Development of Power Source

According to the present power development plan, as shown in Table 5-3, the reserve margin decreases gradually from 18 percent in 1993 to nearly zero in 2004. The actual percentage of operating reserve will be smaller than this figure, if scheduled outages for inspection of the thermal power plants are taken into account.

Power demand in Thailand increases from May to September in rainy season and slightly falls between November and January in dry season, but its seasonal fluctuation is not so great. (Table 5-4)
Therefore, maintenance inspection of thermal power plants must be performed throughout the year, not in any specific period of the year.

The appropriate amount of the operating reserve must be discussed in conjunction with power supply reliability. Insufficient operating reserve will cause frequent power shortages and vice versa. Larger operating reserve leads to higher reliability but requires larger investment to facilities.

Study of Japanese power systems reveals that capacity of about 10 percent of the peak load is required for the operating reserve to maintain the reliability level of 0.3 days per month for loss of load expectation (LOLE). Typical LOLP index (Loss of Load Probability) used by power companies is between 0.1 and 1.0 day per year which is said to be equivalent to having an operating reserve of 15 to 25 percent. In the United States, however, there is a study result for a certain power system in which the reliability level of 1.0 day per year LOLP requests an operating reserve of 25 percent.

The power system in Thailand will not assure the reliability level of LOLE 0.3 days per month, with the present power development plan, in and after 1998 when operating reserve becomes less than 10 percent.
The actual operating reserve will become five to six percent when scheduled outages of thermal power plants are taken into account, making the situation even more severe.

A reserve margin of at least 15 to 16 percent will be required if LOLE 0.3 days per month is set to reliability level, which means additional generating capability between 700 MW and 900 MW is required to the present power development plan in 1997 to 1998.

If the target for the reliability level is set at LOLP one day per year, an additional capacity of 2,000 MW or over may be required during the same period.

Table 5-4 MONTHLY DEPENDABLE CAPACITY, PEAK GENERATION AND RESERVE MARGIN IN FISCAL 2000

Month	Dependable Capacity				Peak Generation (2) (MW)	Reserve Margin	
	Hydro (MW)	Thermal (MW)	Gas Turbine (MW)	Total (1) (MW)		(3)=(1)-(2) (MW)	(3)/(2) (%)
Oct.	3,580.4	13,287.3	499.1	17,366.8	15,271.8	2,095.0	13.7
Nov.	3,641.4	13,287.3	499.1	17,427.8	15,510.3	1,917.5	12.4
Dec.	3,602.7	13,287.3	499.1	17,389.1	14,876.8	2,512.3	16.9
Jan.	3,617.7	13,581.3	392.0	17,591.0	15,827.0	1,764.0	11.1
Feb.	3,729.0	13,581.3	392.0	17,702.3	16,048.0	1,654.3	10.3
Mar.	3,697.1	13,581.3	392.0	17,670.4	16,716.3	954.1	5.7
Apr.	3,536.4	13,875.3	392.0	17,803.7	16,763.3	1,040.4	6.2
May	3,508.2	13,875.3	392.0	17,775.5	17,190.0	585.5	3.4
Jun.	3,460.7	13,875.3	392.0	17,728.0	16,836.4	891.6	5.3
Jul.	3,460.5	14,169.3	392.0	18,021.8	16,989.6	1,032.2	6.1
Aug.	3,667.6	14,169.3	392.0	18,228.9	17,085.3	1,143.6	6.7
Sep.	3,644.3	14,169.3	392.0	18,205.6	17,403.8	801.8	4.6

5.5 Significance of Development of Lam Ta Khong Pumping Power Station

Hydro power source is an important power supply which has a swift responsive performance for requirements from power system operation.

It is used as spinning reserve where the power can be called upon very rapidly in case of any unexpected loss of generating capability.
It also can meet sudden variations of load and requirements for frequency control, voltage control, and power flow control of the power system.

The total capacity of EGAT's hydro power generation facilities as of September 1990 was 2,249.16 MW which is 28 percent of the overall installed capacity of 7,970.26 MW.

The ratio of hydro power to the total generating capacity will be decreased from now on because of the following reasons.

Future development of hydro power will be greatly hampered by the lack of sites to be economically developed and troubles on environmental concerns.

Considering difficulties of the development of hydro power, future power source development in Thailand will be carried out with emphasis on power sources that take charge of the base portion of load curves such as lignite fired and/or coal fired thermal power plants.

Consequently, the ratio of power supply taking charge of the peak portion of load curve, such as hydro power, will decrease gradually, and a problem of how to meet peak demand will come up in future.

As sites for hydro power development becomes scarce, the development of pumped storage power will become a promising alternative.

Unlike general hydro power, the pumped storage power plant will not be influenced by the flow rate of the river, which provides more freedom in selecting sites and in deciding size of a facility to be developed.

In Japan, the appropriate development capacity of pumped storage power is said to be between 15 and 20 percent of increased demand, though it somewhat varies according to a power system. The appropriate development capacity mostly depends on the trend of construction cost of a pumped storage power plant and load curve. It also depends on types of power sources that take charge of the base load portion and their fuel cost, but it is said that they do not have much effect on the capacity of pumped storage to be developed.

As shown in the supply and demand balance on Table 5-3, the reserve margin in 1997 will be about 14 percent, if Lam Ta Khong (600 MW as per EGAT PDP 90-03) is put into service. But the increase of power demand will continue to reduce the reserve margin to about four percent in 2000, even if the power sources are developed according as the present power development plan.

If Lam Ta Khong project is developed for the demand increase from the year 1996 upto 2000 which is forecasted to be 4,384 MW at sending end and 15 to 20 percent of the above demand increase shall be the capacity of the pumped storage to be developed, it is conceivable that the scale of the project shall be 660 MW to 880 MW.

Therefore, the following three alternatives are compared to decide the development scale of Lam Ta Khong pumped storage.

Alternative 1	600 MW (150 MW x 4)
Alternative 2	800 MW (200 MW x 4)
Alternative 3	1,000 MW (250 MW x 4)

The feasibility of development is also examined for 1,200 MW.

5.6 Features of Pumped Storage Power Plant and its Use

A pumped storage power plant is a power source required all the time to supply electric power just like other power sources, but it differs from others in its characteristics, function and economic effect.

Features of the pumped storage power plant are as follows.

(1) Functional feature

(a) Like a general hydro power generation, it can reach the full power output in only several minutes from the starting. It also has a swift follow-up ability against load fluctuations.

(b) It can be treated as a general hydro power plant for system operation, but it must take power from power system for pumping water into the upper reservoir, and so consumes fuel like a thermal power plant.

(c) The duration of power generation is limited by the capacity of the water reservoir.

(d) Unlike a general hydro power plant, a pumped storage is not affected by the volume of flowing water of rivers, which provides flexibility and reliability in power generation.

(2) Features on system operation

(a) It is effectively used as operating reserve providing for failures of a power source or unexpected increase of power demand.

(b) It has superb characteristic of responding to load fluctuation and can be used for maintaining system frequency during peak time.

(c) The generating operation of the pumped storage power plant reduces the frequency of start-and-stop of the thermal power plants and consequently reduce their start up costs.

(d) The pumping operation of the pumped storage power plant makes the thermal power plants generate power with higher efficiency at off-peak hours. It is used to generate during peak hours taking place of the low efficiency thermal power plants and reduces their fuel expenses.

Because of the above features, the pumped storage power plant is used for the following purposes:

(1) Generation to meet supply and demand balance

It is used to keep supply and demand balance in an emergency such as an unanticipated outage of generating facility, water shortage of hydro power plant or sudden increase of power demand.

(2) Economical operation of power plants

It can be used to reduce total fuel cost by pumping during off-peak time using power generated by low-cost base load power plants and generating during peak time in place of high-cost thermal power plants or gas turbines.

(3) Control of power system frequency and voltage

It is used as operating reserve to hold the frequency of power system at a predetermined value. It is also used as a source of reactive power to control the system voltage.

The pumped storage power plant is used for the above purposes, but recently in order to hold reliable power supply capability and improve the quality of electric power, it is used more frequently for the purposes of (1) or (3) rather than for the purpose of (2) economical operation of power plants.

5.7 Commissioning Time of the Project

As mentioned above Lam Ta Khong project should be implemented as early as possible taking into account the drop of the reserve margin of the system in late nineteen-nineties.

Considering the detailed design and construction work period, the earliest possible timing of the project will be the first half of 1997.

CHAPTER 6

HYDROLOGY

CHAPTER 6 HYDROLOGY

CONTENTS

List of Tables

List of Figures

CHAPTER 6 HYDROLOGY

6.1 General

The Mekong River flows along the border between Thailand and Myanmar, and around the Khong Chian city 800 kilometers upstream from the estuary it joins the Mun River which flows in from the west. The Mun River basin is very wide covering almost the east part of Thailand.

The Lam Ta Khong River, about 170 kilometers in length, is one of the major tributaries of the Mun River. It flows generally north and eastward passing the city of Nakhon Ratchasima to its confluence with the Mun River at Ban Tha Chang about 20 kilometers east of the city.

The Lam Ta Khong River basin originates in the high mountainous area on the southwest corner of the Khorat Plateau and lies on the northern slopes of the divide between the provinces of Nakhon Nayok and Nakhon Ratchasima.

The rainy season due to the Southwest Monsoon begins normally in early May and ends in October. It is a time of frequent and heavy rainfall, high humidity, maximum cloudiness and tropical temperature. The heaviest rainfall generally occurs in the months of September and October.

The winter season due to the Northeast Monsoon normally starts from November and lasts until the end of February, and is characterized by relatively little rainfall, low humidity, clear skies and lower temperatures.

The summer season, March and April, starts from the cessation of the Northeast Monsoon. Temperatures are extremely high and humidity is low.

6.2 Meteorological Stations and Stream Flow Gauging Stations

6.2.1 Meteorological Station

There are five rainfall stations in and around the project basin, among which the longest data have been recorded at two stations, No. 25072 and No. 25132. Locations and period of the stations are shown in Table 6-2.

At the station of Nakhon Ratchasima about 65 km northeast from the Lam Ta Khong dam, rainfall, temperature, relative humidity, evaporation, sunshine duration, etc., have been observed since 1956.

The climatological data at the station of Nakhon Ratchasima is tabulated on Table 6-1.

6.2.2 Stream Flow Gauging Stations

Data on stream flows of the Lam Ta Khong River upstream of the Lam Ta Khong dam are available at five gauging stations. The station M38C near the Lam Ta Khong dam has recorded since 1962, but the flow data since July, 1968 are the outflows from the Lam Ta Khong dam. Locations, drainage areas, periods, etc., are shown in Table 6-3. Locations of rainfall stations and gauging stations are shown in Fig. 6-1.

Table 6-1 Climatological Data for the Period 1956 - 1985

Station: Nakhon Ratchasima (EL. 187 m)
Lat, 14°58'N, Long, 102°05'E

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rainfall (mm)													
Mean	4.8	22.7	43.9	68.3	145.2	111.6	132.6	130.4	261.5	154.1	30.0	3.6	1,108.7
Mean rainy days	1.0	2.9	5.6	8.0	13.4	14.1	13.4	16.4	19.7	12.3	4.0	0.9	115.7
Greatest in 24 hr.	71.2	59.7	57.3	91.5	73.8	114.8	104.1	72.3	143.7	136.0	84.3	20.6	143.7
Temperature (°C)													
Mean	23.0	25.9	28.3	29.2	28.5	28.2	27.7	27.4	26.7	26.0	24.4	22.7	26.5
Mean Max.	30.7	33.5	36.0	36.5	35.1	34.1	33.4	33.0	31.9	30.8	29.7	29.5	32.9
Mean Min.	16.3	19.7	22.2	23.8	24.2	24.1	23.7	23.6	23.2	22.4	19.9	16.9	21.7
Ext. Max.	37.8	40.6	42.3	42.7	41.4	40.1	40.0	38.1	38.0	35.3	35.3	35.8	42.7
Ext. Min.	6.7	11.4	11.6	16.9	20.7	21.1	21.1	20.5	19.7	16.2	9.1	6.2	6.2
Relative Humidity (%)													
Mean	65.8	63.6	62.8	66.8	74.4	74.5	75.8	77.0	82.4	80.3	75.3	67.6	72.2
Mean Max.	87.5	85.3	84.8	86.1	90.3	90.0	90.6	91.3	94.7	93.8	91.2	89.1	89.6
Mean Min.	41.7	40.2	38.3	43.4	52.3	54.0	55.7	57.8	63.2	62.0	55.6	47.3	51.0
Ext. Min.	22.0	14.0	12.0	19.0	23.0	23.0	35.0	35.0	41.0	31.0	27.0	20.0	12.0
Evaporation (mm)													
Mean - Pan	140.6	149.7	190.8	192.1	176.1	170.9	168.1	158.2	131.3	135.7	130.0	137.7	1,879.2
Cloudiness (0-10)													
Mean	3.4	4.2	4.6	5.5	7.1	7.9	8.5	8.5	8.1	6.5	4.9	3.9	6.1
Sunshine Duration (hr)													
Mean	283.0	244.5	249.0	245.0	244.5	207.2	194.2	185.4	165.1	225.1	257.8	276.0	2,776.8

Table 6-2 List of Rainfall Stations

Code	Station Name	Location		Period of Record	Annual Rainfall (mm)		
		Latitude	Longitude		Max.	Min.	Ave.
25072	A. Sikhiu	14°53'27"N	100°43'33"E	1952 ~ date	1307.4	647.7	1032.0
25132	Pak Chong Animal Food St.	14°38' N	101°18' E	1952 ~ date	1377.3	541.8	921.7
25272	Pak Chong Agrometeorolog. St.	14°42'48"N	101°25'16"E	1968 ~ date	1487.3	806.3	1096.5
25541	Lam Ta Khong (M38c)	14°52'06"N	101°33'53"E	1963 ~ date	1181.5	527.7	912.7
25550	Huai Sub Pra Du Tank	16°50'47"N	101°42'15"E	1972 ~ date	1298.0	713.4	965.9

Table 6-3 List of Gauging Stations

Code	Station Name	Location	Drainage Area (km^2)	Period of Record
M_{N2}	Khao Yai	Lat 14°-26.4'N Long 101°-22.2'E	60.7	1964 Sept. ~ 1976 Dec.
M_{43}	Ban Mu Si	Lat 14°31'40"N Long 101°24'09"E	235	1965 July ~ 1983 Mar.
M_{N1}	Ban Bung Toei	Lat 14°32.9'N Long 101°27.9'E	476	1963 May ~ 1976 Dec.
M_{89}	A. Pak Chong	Lat 14°41'46"N Long 101°25'07"E	699	1976 May ~ present (1986.12)
M_{38C}	Ban Khlong Pha	Lat 14°52'06"N Long 101°33'53"E	1292	1962 July ~ present (1988. 3)

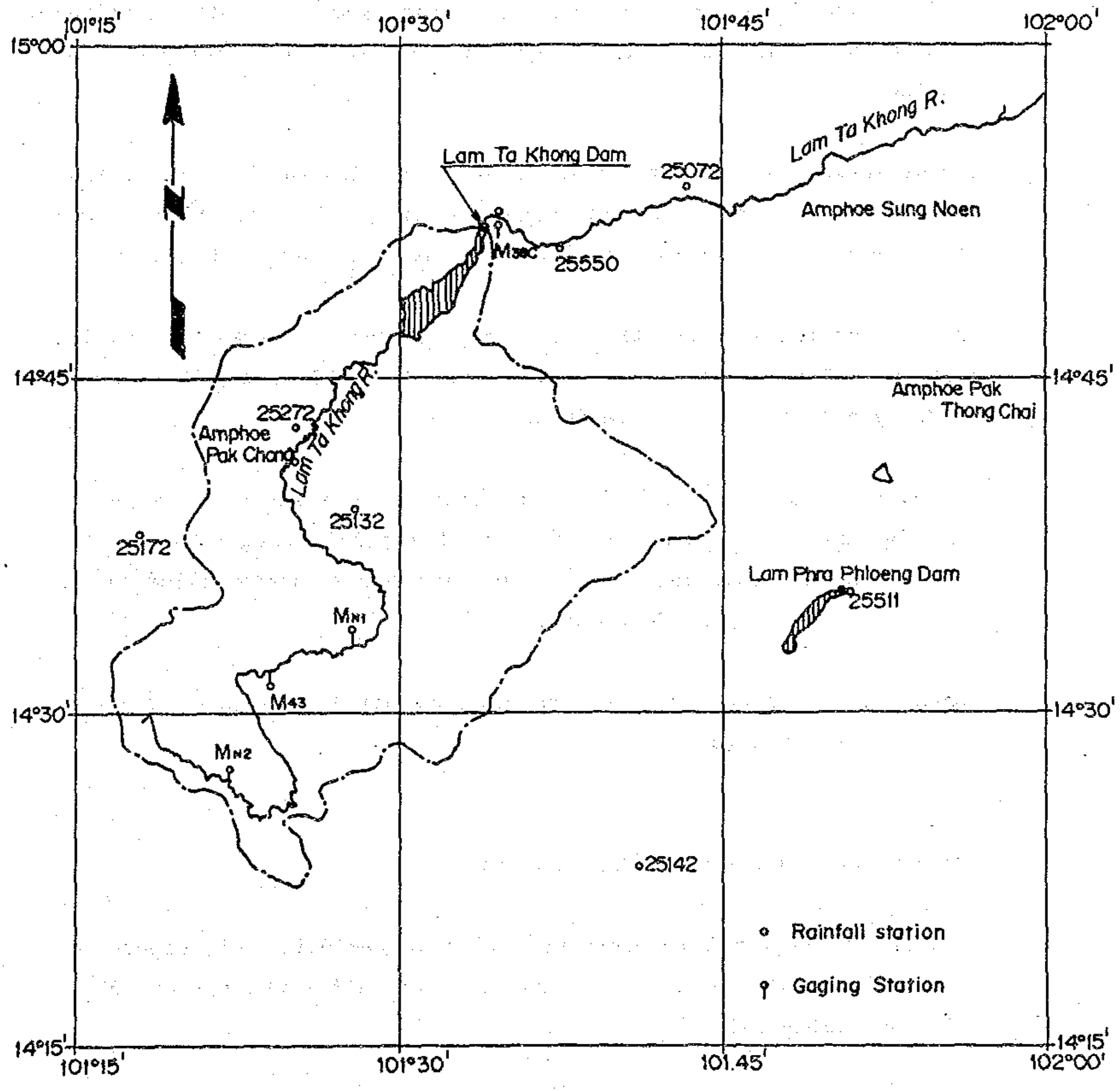


Fig.6-1 Location of Rainfall Station and Gauging Station

6.3 Hydrological Features of the Basin

6.3.1 Precipitation

The rainfall in the project area mainly depends on the Southwest Monsoon and the depression that originates from the South China Sea then passes through Vietnam and moves toward the northeast of Thailand.

The drainage basin of the Lam Ta Khong river lies in the area of less rainfall. This is because the mountain ranges along the western end of the Plateau act as high barriers against the Southwest Monsoon.

The average annual rainfall in the project area is between 900 mm and 1,100 mm. The annual rainfall as low as 500 ~ 600 mm may be expected in dry years, while 1,500 mm in wet years.

The average monthly rainfall at the stations are shown in Table 6-4 and Fig. 6-2. About 80% of the annual rainfall occurs during the months of May through October, and maximum monthly rainfall of 200 ~ 250 mm occurs in September.

Monthly rainfall data at the five stations are tabulated on Table 6-5 (1) ~ Table 6-5 (5).

6.3.2 Temperature, Humidity and Evaporation

Data on the regional temperature, relative humidity and evaporation are available at the Nakhon Ratchasima station for the period 1956 - 1985 (see Table 6-1).

The annual mean temperature is 26.5°C, and the extreme highest and lowest temperatures are recorded 42.7°C in April and 6.2°C in December.

The annual mean relative humidity is 72.2%, and the monthly mean relative humidity is as high as 94.7% in September and as low as 84.8% in March.

The annual evaporation is 1,879.2 mm, and the maximum is 192.1 mm in April.

Annual loss of the upper reservoir due to evaporation is estimated 0.045 - 0.09 MCM from annual rainfall and annual evaporation (pan coefficient = 0.70). The annual evaporation loss corresponds to 0.02 - 0.04% of annual reservoir inflow of 258.9 MCM.

6.3.3 Runoff

(1) General

The monthly average runoff at the five gauging stations along the Lam Ta Khong river are shown in Table 6-6. The runoff data at the Ban Khong Pha station has been recorded since July 1962, and the data from July 1968 is not natural flows but outflows from the Lam Ta Khong dam.

About 80% of the annual rainfall concentrates in the rainy season of May ~ October, and about 85% of annual runoff concentrates as well.

The specific runoff is 0.024 $m^3/sec/km^2$ in the upstream reaches and 0.010 $m^3/sec/km^2$ in the middle reaches.

The monthly average runoffs at the stations are tabulated on Table 6-7 (1) ~ Table 6-7 (5), and the annual flood peaks at the stations are shown in Table 6-8.

(2) Inflow, Outflow and Water Level of the Lam Ta Khong Dam

The reservoir inflow data are available at the Ban Khong Pha gauging station (M38c) from July 1962. This gauge is located approximately 500 m downstream from the Lam Ta Khong dam. The monthly reservoir inflows are tabulated on Table 6-9. The data of July 1962 ~ June 1968 are observed flows at the station. The data of July 1968 - date are total monthly reservoir inflow volumes computed based on a water balance of outflow and change in reservoir storage volume.

The natural annual reservoir inflow is 258.94 MCM (8.21 m^3/sec) on the average, 110.00 MCM in the driest year (1968) and 495.00 MCM in the wettest year (1972).

The reservoir water levels of the Lam Ta Khong dam are tabulated on Table 6-10 and illustrated in Fig. 6-3.

Table 6-4 Average Monthly Precipitation

(mm)

Station Name	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Ann.
A. Sikhiu (25072)	76.0	144.3	87.4	104.8	103.4	256.7	161.7	28.9	1.2	4.3	16.4	41.8	1032.0
Pak Chong Animal Food St. (25132)	106.3	117.3	82.5	83.0	100.1	197.5	139.0	22.9	2.7	5.3	26.6	60.2	921.7
Pak Chong Agrometeorolog St. (25272)	123.7	145.7	71.3	99.4	115.3	255.0	160.8	27.5	5.6	6.3	20.2	68.9	1096.5
Lam Ta Khong (M-38c)(25541)	85.8	117.5	64.0	81.0	99.1	245.0	148.0	33.9	2.5	7.3	22.5	36.5	912.7
Huai Sub Pra Du Tank (25550)	81.1	132.5	68.9	97.9	97.2	255.6	137.2	40.3	0.5	5.7	16.4	32.8	965.9

Table 6-5(1) Monthly Rainfall Data: Unit (mm)
Location: 25072 Name: Sikhiu

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1952	22.3	34.3	123.1	17.1	56.5	70.5	363.1	0.0	0.0	25.4	30.2	105.1	847.6
1953	208.1	225.3	166.2	137.1	228.4	299.9	146.4	34.2	0.0	41.9	16.6	15.6	1519.7
1954	63.9	250.5	97.0	79.5	106.2	294.4	50.7	0.0	0.0	0.0	25.9	0.0	968.1
1955	80.0	40.5	188.5	65.0	99.1	222.2	51.2	66.7	0.0	0.0	44.3	14.3	871.8
1956	49.1	117.5	70.9	270.6	81.4	264.0	161.8	0.0	0.0	0.0	7.9	54.8	1078.0
1957	110.6	106.9	109.0	108.6	152.2	206.4	205.1	0.0	0.0	0.0	26.0	102.9	1117.7
1958	24.7	99.5	147.3	78.7	143.0	325.2	85.8	0.0	0.0	0.0	46.2	49.3	999.7
1959	40.7	98.1	18.7	127.7	104.7	408.4	301.2	0.0	0.0	0.0	0.0	76.4	1175.9
1960	28.7	176.6	128.0	109.8	55.0	195.4	290.0	28.0	0.0	0.0	0.0	38.3	1049.8
1961	62.5	231.8	94.4	105.2	33.9	63.1	129.8	0.0	0.0	0.0	0.0	4.2	724.9
1962	187.6	107.2	47.6	69.1	95.2	560.0	175.3	0.0	0.0	0.0	0.0	14.7	1256.7
1963	54.1	134.0	112.4	62.1	137.6	271.5	185.6	136.6	0.0	0.0	0.0	34.6	1128.5
1964	48.8	251.7	17.9	140.3	101.4	204.7	217.0	22.7	0.0	0.0	15.9	60.1	1080.5
1965	141.1	274.3	9.7	82.5	176.2	257.8	69.5	35.7	0.0	0.0	19.3	7.4	1073.5
1966	51.1	235.8	-	116.7	26.0	89.1	254.3	9.3	19.2	14.2	8.6	28.1	-
1967	90.1	238.6	141.9	87.2	35.0	46.1	104.2	51.1	0.0	0.0	6.3	142.3	942.8
1968	197.3	138.3	122.3	119.6	12.8	219.1	42.5	0.0	0.0	7.5	28.6	46.4	934.4
1969	80.0	225.4	77.6	32.5	109.1	424.8	166.0	0.0	0.0	0.0	0.0	57.7	1173.1
1970	53.6	208.7	78.7	137.0	155.7	211.2	199.9	4.1	16.9	0.0	15.2	7.3	1088.3
1971	109.2	173.8	43.0	161.8	172.7	147.8	79.9	0.0	0.0	0.0	20.3	48.6	957.1
1972	32.8	20.5	114.0	39.2	109.1	583.0	196.9	100.4	0.0	0.0	0.0	17.3	1213.2
1973	93.4	78.0	55.0	98.0	125.7	406.1	200.5	100.4	0.0	0.0	66.6	83.7	1307.4
1974	94.8	155.3	79.0	152.2	156.6	215.7	173.0	54.3	0.0	0.0	46.5	68.8	1196.2
1975	14.0	140.3	100.5	98.8	70.5	253.8	106.9	24.0	0.0	0.0	53.7	87.5	950.0
1976	33.7	150.3	35.1	75.7	233.5	197.8	233.1	58.7	0.0	0.0	47.8	30.0	1095.7
1977	25.8	176.0	68.3	53.5	182.3	173.1	12.2	0.0	0.0	0.0	7.5	85.7	784.4
1978	141.4	214.4	101.5	143.3	47.5	424.7	53.2	10.5	0.0	0.0	11.0	0.0	1147.5
1979	61.0	212.0	172.0	92.2	61.8	392.1	14.5	0.0	0.0	0.0	0.0	0.0	1005.6
1980	15.7	0.0	73.6	142.0	26.8	285.3	129.3	0.0	0.0	0.0	19.5	16.0	708.2
1981	60.6	100.5	21.9	106.0	13.6	103.8	90.2	80.2	0.0	0.0	7.5	63.4	647.7
1982	91.8	84.9	71.0	141.4	105.2	314.7	156.6	104.9	0.0	15.3	1.2	0.0	1087.0
1983	0.0	88.1	43.3	96.4	203.5	226.1	275.1	27.0	0.0	0.0	28.2	73.5	1061.2
1984	168.7	63.4	117.7	124.6	100.4	190.9	217.5	14.3	0.0	55.4	0.0	42.7	1095.6
1985	83.1	80.2	30.0	81.2	20.4	186.7	271.5	22.6	0.0	0.0	0.0	0.0	775.7
1986	40.0	89.2	59.2	60.8	59.3	279.4	294.6	22.4	7.6	0.0	11.4	8.0	931.9
1987	59.3	105.1	110.3	116.8	87.0	298.4	113.0	60.8	0.0	0.0	6.2	21.2	978.1
1988	91.5	211.1	101.1	146.6	140.3	184.7	264.0	0.0	0.0	0.0	0.0	39.1	1178.4
TOTAL	2811.1	5338.1	3147.7	3876.8	3825.6	9497.9	5981.4	1068.9	43.7	159.7	608.4	1545.0	37151.9
NUMBER	37	37	36	37	37	37	37	37	37	37	37	37	36
AVERAGE	76.0	144.3	87.4	104.8	103.4	256.7	161.7	28.9	1.2	4.3	16.4	41.8	1032.0
MAX	208.1	274.3	188.5	270.6	233.5	583.0	363.1	136.6	19.2	55.4	66.6	142.3	1519.7
MIN	0.0	0.0	9.7	17.1	12.8	46.1	12.2	0.0	0.0	0.0	0.0	0.0	647.7

Table 6-5(2) Monthly Rainfall Data: Unit (mm)
Location: 25132 Name: Pak Chong Animal Food Station

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1952	-	-	122.7	57.8	81.2	90.0	280.1	0.0	0.0	14.1	91.7	97.2	-
1953	102.9	100.5	79.1	73.7	76.0	216.1	145.1	15.3	0.0	13.9	29.0	93.9	945.5
1954	60.2	236.6	119.5	104.4	82.4	203.0	44.1	0.0	0.0	0.0	29.5	90.6	970.3
1955	123.8	94.8	107.4	71.6	131.4	248.8	80.2	102.2	0.0	0.0	71.5	118.7	1150.4
1956	134.6	57.1	59.5	78.7	167.4	116.9	139.6	39.9	0.0	0.0	7.9	184.7	986.3
1957	69.6	45.6	184.3	104.6	162.5	298.2	282.1	37.4	0.0	30.5	1.5	99.0	1315.3
1958	38.6	-	-	-	-	163.4	80.3	0.0	0.0	0.0	57.9	49.9	-
1959	75.5	77.2	86.9	112.2	57.3	343.1	-	0.0	0.0	0.0	0.4	40.8	-
1960	79.6	67.4	40.9	122.6	54.8	194.6	163.8	36.0	0.0	7.2	65.0	40.3	872.2
1961	159.3	145.3	107.3	92.0	98.5	78.7	113.7	0.0	0.0	7.0	24.0	74.2	900.0
1962	74.3	62.5	96.6	226.4	100.8	320.5	52.8	25.2	0.0	0.0	12.7	95.6	1067.4
1963	118.7	134.5	100.5	95.6	104.2	215.0	208.8	19.5	0.0	0.0	35.0	25.0	1056.8
1964	160.6	308.8	-	59.6	172.5	326.4	131.9	32.8	0.0	0.0	115.9	72.6	-
1965	118.7	219.9	102.5	6.0	175.8	166.5	152.1	30.1	0.0	3.1	0.0	31.1	1005.8
1966	98.5	250.2	-	147.0	-	82.7	-	0.0	22.1	0.0	36.9	0.0	-
1967	169.0	125.6	71.0	102.3	31.0	147.0	117.0	0.0	0.0	0.8	30.0	34.5	828.2
1968	169.9	70.0	49.0	18.8	39.0	139.6	55.5	0.0	0.0	0.0	0.0	0.0	541.8
1969	83.3	95.0	59.5	62.5	59.0	279.1	98.5	0.0	0.0	0.0	2.0	52.1	791.0
1970	162.3	142.9	67.1	13.9	93.7	118.7	166.7	0.9	42.8	0.0	34.3	41.4	884.7
1971	91.5	134.7	45.0	59.3	141.7	57.2	102.3	0.0	0.0	0.0	23.2	205.1	860.0
1972	144.4	23.1	109.9	38.2	110.1	612.2	242.5	90.3	6.6	0.0	0.0	0.0	1377.3
1973	-	-	-	-	-	-	-	-	-	-	-	-	-
1974	-	-	-	-	-	-	-	-	-	30.6	61.6	21.2	-
1975	106.3	25.5	90.8	112.2	-	-	-	-	-	-	-	-	-
1976	-	-	-	-	-	-	-	-	-	-	11.1	65.6	-
1977	123.8	128.3	10.3	-	46.0	102.0	75.8	13.3	-	-	-	-	-
1978	56.6	122.1	33.1	127.0	34.1	241.9	25.8	0.0	0.0	0.0	14.1	8.3	663.0
1979	64.9	92.5	144.9	90.9	82.3	178.7	21.2	0.3	0.0	0.0	0.0	67.9	743.6
1980	44.3	94.7	77.3	10.5	37.8	175.9	150.1	28.3	0.0	0.0	10.4	45.8	675.1
1981	121.4	118.3	42.2	88.5	52.8	106.0	103.3	64.4	1.0	0.0	5.0	137.1	840.0
1982	85.1	128.8	74.2	71.7	79.5	171.8	131.7	64.2	2.3	11.1	0.0	0.0	820.4
1983	1.8	119.4	139.6	92.2	328.3	-	324.1	19.3	2.5	0.0	54.0	2.5	-
1984	133.0	72.6	29.5	62.1	156.5	173.8	198.2	39.9	0.0	40.2	0.0	38.5	944.3
1985	216.6	108.0	60.0	104.0	46.7	159.8	205.7	26.7	0.0	0.0	0.0	32.0	959.5
TOTAL	3189.1	3401.9	2310.6	2406.3	2803.3	5727.6	3893.0	686.0	77.3	158.5	824.2	1865.6	21198.9
NUMBER	30	29	28	29	28	29	28	30	29	30	31	31	23
AVERAGE	106.3	117.3	82.5	83.0	100.1	197.5	139.0	22.9	2.7	5.3	26.6	60.2	921.7
MAX	216.6	308.8	184.3	226.4	328.3	612.2	324.1	102.2	42.8	40.2	115.9	205.1	1377.3
MIN	1.8	23.1	10.3	6.0	31.0	57.2	21.2	0.0	0.0	0.0	0.0	0.0	541.8

Table 6-5(3) Monthly Rainfall Data: Unit (mm)
Location: 25272 Name: Pak Chong Agrometeorological Station

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1968	206.3	235.0	58.6	81.6	34.4	227.0	73.6	0.0	0.0	36.0	18.1	69.8	2040.4
1969	109.8	166.0	57.5	58.9	134.0	362.7	112.9	86.9	0.0	0.0	17.2	88.5	1194.4
1970	125.7	180.0	61.7	30.2	111.9	305.0	212.1	1.0	26.3	0.0	11.7	58.0	1123.6
1971	130.6	244.2	43.0	53.7	139.1	104.5	126.6	0.0	0.0	0.2	26.6	196.6	1065.1
1972	206.1	66.1	61.0	57.0	88.7	589.9	229.8	79.6	14.2	0.0	13.6	81.3	1487.3
1973	57.7	181.6	59.8	55.0	139.8	179.0	112.8	12.6	0.0	10.3	18.1	115.4	942.1
1974	113.7	80.8	31.3	117.8	91.0	126.8	197.3	95.2	9.6	41.0	39.4	37.0	980.9
1975	92.0	88.3	94.1	101.8	66.6	327.3	121.9	5.8	11.7	0.0	22.7	88.1	1020.3
1976	67.1	96.9	102.9	199.2	270.8	149.4	262.1	3.9	1.3	0.0	20.4	91.0	1265.0
1977	136.1	99.6	20.8	132.7	76.8	125.4	77.1	19.1	20.8	6.2	49.2	42.5	806.3
1978	94.2	219.4	61.2	200.2	75.8	302.6	14.2	1.7	0.0	4.3	11.7	0.0	985.3
1979	165.9	159.3	153.4	118.8	-	-	-	-	-	0.0	-	-	-
1980	-	-	-	-	-	-	-	-	-	0.0	21.7	0.0	-
1981	-	-	-	-	-	-	-	-	-	0.0	3.7	-	-
1982	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	-	-	-	-	-	-	-	-	-	-	-	-	-
1984	-	-	-	-	-	-	-	-	-	-	-	-	-
1985	154.6	111.2	64.9	159.8	59.3	158.7	180.5	22.6	0.0	0.0	3.1	49.5	965.2
1986	130.9	105.7	66.1	63.8	186.6	262.4	257.6	0.0	6.4	0.0	31.9	62.8	1174.2
1987	76.6	114.0	97.1	131.3	115.9	231.3	172.4	83.9	0.0	0.0	33.2	69.1	1124.8
1988	112.5	183.1	106.0	28.3	138.7	372.4	261.8	0.0	0.0	15.4	1.0	52.7	1271.9
TOTAL	1979.8	2331.2	1140.4	1590.1	1729.4	3824.4	2412.7	412.3	90.3	113.4	343.3	1102.3	16446.8
NUMBER	16	16	16	16	15	15	15	15	16	18	17	16	15
AVERAGE	123.7	145.7	71.3	99.4	115.3	255.0	160.8	27.5	5.6	6.3	20.2	68.9	1096.5
MAX	206.3	244.2	153.4	200.2	270.8	589.9	262.1	95.2	26.3	41.0	49.2	196.6	1487.3
MIN	57.7	66.1	20.8	28.3	34.4	104.5	14.2	0.0	0.0	0.0	1.0	0.0	806.3

Table 6-5(4) Monthly Rainfall Data: Unit (mm)
Location: 25541 Name: Lam Takhong (M-38C)

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1963	-	-	-	-	-	-	218.3	106.2	0.0	-	-	-	-
1964	-	-	-	-	29.5	246.4	189.1	115.7	0.0	0.0	41.2	19.1	-
1965	81.5	294.9	-	60.6	221.7	250.4	123.9	0.0	0.0	0.0	105.3	15.1	-
1966	164.3	-	-	-	-	-	-	-	10.9	17.7	9.9	24.7	-
1967	171.1	99.8	137.1	96.6	24.2	73.3	148.5	11.4	0.0	0.0	0.0	0.0	762.0
1968	170.4	89.4	53.0	78.9	50.8	177.2	45.8	0.0	0.0	40.2	5.5	132.5	843.7
1969	68.5	98.9	52.9	31.7	127.7	360.4	156.1	16.9	0.0	0.3	6.1	81.8	1001.3
1970	101.6	142.4	43.8	24.8	170.0	269.6	169.6	3.6	25.4	0.0	19.4	0.0	970.2
1971	41.0	48.7	18.6	49.6	296.2	95.2	78.4	0.0	0.0	0.0	0.0	0.0	527.7
1972	20.3	6.8	83.9	18.3	31.6	460.6	249.6	78.0	2.8	0.0	12.7	25.4	990.0
1973	84.3	187.3	105.0	123.8	143.3	242.5	135.3	9.5	0.0	0.0	17.9	51.8	1100.7
1974	80.4	109.3	43.2	69.8	68.0	178.5	185.5	68.3	1.3	5.2	29.2	68.0	906.7
1975	25.3	122.0	86.9	66.6	25.4	324.4	92.0	6.6	0.0	0.0	69.7	29.6	848.5
1976	80.3	73.3	27.7	120.9	172.9	194.1	266.7	32.8	4.4	0.4	1.0	33.3	1007.8
1977	67.6	175.5	9.5	60.2	78.7	190.9	68.3	12.8	7.3	9.8	32.6	45.9	759.1
1978	47.8	128.1	39.2	192.7	36.8	295.7	20.1	5.8	0.0	2.9	44.4	0.8	814.3
1979	58.0	122.7	96.2	119.7	89.4	313.7	21.9	6.2	0.0	0.0	3.5	103.8	935.1
1980	70.4	93.7	161.8	154.6	87.3	390.9	155.9	6.4	0.0	0.0	29.6	30.9	1181.5
1981	183.9	74.8	21.5	89.8	84.3	219.0	81.3	124.9	1.6	0.0	16.1	92.0	989.2
1982	37.0	96.9	71.9	43.9	108.9	278.7	132.7	27.0	1.6	10.7	0.0	0.0	809.3
1983	12.1	198.9	59.5	33.2	221.6	248.9	253.5	47.0	4.2	0.1	41.9	34.1	1155.0
1984	97.0	40.1	46.8	91.2	95.4	199.8	166.2	25.7	0.0	60.9	4.7	3.7	831.5
1985	105.4	174.7	46.4	145.6	35.0	227.3	236.2	20.9	0.0	0.0	0.0	46.4	1037.9
1986	55.0	81.4	22.3	36.7	103.0	119.9	249.4	24.1	4.6	0.0	0.0	11.4	707.8
1987	116.8	102.3	70.9	26.2	72.0	298.0	107.1	96.7	0.0	0.0	70.6	26.3	986.9
1988	118.6	139.8	110.6	127.3	104.2	223.6	-	0.0	0.0	35.2	0.0	-	-
TOTAL	2058.6	2701.7	1408.7	1862.7	2377.9	5879.0	3551.4	846.5	64.1	183.4	561.3	876.6	19166.2
NUMBER	24	23	22	23	24	24	24	25	26	25	25	24	21
AVERAGE	85.8	117.5	64.0	81.0	99.1	245.0	148.0	33.9	2.5	7.3	22.5	36.5	912.7
MAX	183.9	294.9	161.8	192.7	221.7	460.6	266.7	124.9	25.4	60.9	105.3	142.5	1181.5
MIN	12.1	6.8	9.5	18.3	24.2	73.3	20.1	0.0	0.0	0.0	0.0	0.0	527.7

Table 6-5(5) Monthly Rainfall Data: Unit (mm)
Location: 25550 Name: Huai Sub Pra Du Tank (THK-112)

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1972	-	25.9	119.0	21.5	17.4	490.7	149.0	50.6	0.0	0.0	0.0	13.4	-
1973	98.8	132.3	27.7	114.4	162.5	357.9	71.9	12.0	0.0	0.0	49.6	24.6	1051.7
1974	120.6	206.7	74.7	113.1	19.3	157.2	171.4	89.0	0.0	0.0	0.0	16.2	968.2
1975	46.6	129.1	141.4	206.8	135.6	291.2	60.8	0.0	0.0	0.0	46.5	55.6	1113.6
1976	26.3	128.3	34.0	79.1	145.4	153.7	171.1	35.0	0.0	0.0	27.4	3.0	803.3
1977	75.8	250.8	12.3	93.4	148.2	212.5	66.5	15.3	2.2	0.0	14.7	36.8	928.5
1978	71.9	139.8	57.6	132.7	43.4	345.4	41.1	15.2	0.0	3.4	7.4	8.7	866.6
1979	87.6	106.2	120.5	68.5	64.2	350.2	29.5	8.4	0.0	0.0	16.2	114.5	965.8
1980	143.8	151.0	131.1	79.5	91.4	290.0	154.1	8.3	0.0	0.0	24.8	35.8	1109.8
1981	49.6	126.3	22.8	101.6	47.1	81.4	73.5	139.7	0.0	0.0	25.1	46.3	713.4
1982	54.0	55.3	36.9	74.7	101.6	294.4	171.4	122.7	0.0	37.4	1.6	1.7	951.7
1983	5.8	86.2	51.7	74.1	211.5	321.1	264.3	37.3	0.0	0.0	5.2	8.2	1065.4
1984	202.5	109.1	49.6	106.4	109.6	161.4	138.8	26.6	0.0	38.5	11.7	25.6	979.8
1985	79.8	115.4	31.1	57.5	33.7	168.4	241.9	36.8	0.0	0.0	0.0	2.7	767.3
1986	87.1	119.0	32.6	74.8	124.5	192.9	219.5	0.0	7.0	0.0	26.8	59.9	944.1
1987	76.0	109.7	98.2	48.8	68.1	267.9	91.9	87.8	0.0	0.0	21.2	57.7	927.3
1988	70.6	261.1	130.2	218.1	129.2	208.5	215.2	0.0	0.0	17.5	0.0	47.6	1298.0
TOTAL	1296.8	2252.2	1171.4	1665.0	1652.7	4344.8	2331.9	684.7	9.2	96.8	278.2	558.3	15454.5
NUMBER	16	17	17	17	17	17	17	17	17	17	17	17	16
AVERAGE	81.0	132.5	68.9	97.9	97.2	255.6	137.2	40.3	0.5	5.7	16.4	32.8	965.9
MAX	202.5	261.1	141.1	218.1	211.5	490.7	264.3	139.7	7.0	38.5	49.6	114.5	1298.0
MIN	5.8	25.9	12.3	21.5	17.4	81.4	29.5	0.0	0.0	0.0	0.0	1.7	713.4

Table 6-6 Average Monthly Runoff

(MCM)

Name	Code	Period	A (km^2)	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual (MCM)	Annual (m^3/sec)	Specific Runoff ($m^3/s/km^2$)
Khao Yai	M_{N2}	1964 Sept. ~ 1976 Dec.	61	0.30	1.96	4.98	6.20	9.04	11.33	9.22	2.76	0.97	0.44	0.21	0.15	45.6	1.44	0.024
Ban Mu Si	M_{43}	1965 Jul. ~ 1983 Mar.	235	0.91	3.98	12.97	17.09	24.68	27.17	19.81	5.78	2.56	1.39	0.86	0.65	115.1	3.65	0.016
Ban Bung Toei	M_{N1}	1963 May ~ 1976 Dec.	476	2.18	7.28	16.26	19.06	25.13	38.79	29.77	11.42	4.94	2.87	2.03	1.94	149.8	4.75	0.010
A Pak Chong	M_{89}	1976 May ~ 1986 Dec.	699	5.60	8.93	16.27	20.33	25.28	43.74	51.44	17.09	9.74	6.90	5.00	5.00	224.7	7.12	0.010
Ban Khlong Pha	M_{38C}	1962 Jul. ~ 1988 Mar.	1292	7.24	13.79	18.61	27.13	27.22	28.31	33.25	15.80	6.89	7.34	9.26	8.30	201.4	6.38	0.005

Table 6-7(1) Monthly Runoff Data: Unit (MCM)
Lam Ta Khong At Khao Yai (M_{N2})

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1964	-	-	-	-	-	10.40	15.40	3.06	1.15	0.45	0.35	0.31	-
1965	0.28	1.74	12.00	6.81	17.60	15.70	13.40	4.39	1.5	0.49	0.30	0.22	74.44
1966	0.21	7.17	2.85	7.12	16.50	7.31	6.45	2.57	1.60	0.49	0.24	0.08	52.59
1967	1.00	3.26	3.36	3.11	5.45	8.07	8.94	1.94	0.73	0.19	0.12	0.13	36.30
1968	0.53	3.71	4.33	6.24	4.23	4.95	3.64	0.82	0.22	0.11	0.03	0.02	28.83
1969	0.0	0.25	6.12	10.80	9.40	17.30	5.85	2.50	0.89	0.37	0.17	0.07	53.72
1970	0.17	0.48	5.12	9.24	9.41	10.80	5.42	2.09	0.14	0.41	0.12	0.0	43.40
1971	0.11	1.75	2.97	7.55	3.60	6.15	3.56	1.22	0.51	0.16	0.06	0.0	27.64
1972	0.17	0.11	2.40	5.60	5.96	24.40	12.20	3.11	1.50	0.65	0.25	0.24	56.59
1973	0.06	0.20	2.46	5.35	6.26	8.75	8.93	1.65	0.52	0.26	0.09	0.11	34.64
1974	0.52	1.26	2.53	1.71	5.09	5.44	11.30	6.57	1.56	1.16	0.54	0.52	38.20
1975	0.47	1.23	10.50	5.19	11.00	12.80	9.72	1.99	1.03	0.49	0.28	0.15	54.85
1976	0.03	2.31	5.14	5.64	14.00	15.20	15.00	3.95	1.21	-	-	-	-
TOTAL	3.55	23.47	59.78	74.36	108.50	147.27	119.81	35.86	12.57	5.23	2.55	1.85	501.20
NUMBER	12	12	12	12	12	13	13	13	13	12	12	12	11
AVERAGE	0.30	1.96	4.98	6.20	9.04	11.33	9.22	2.76	0.97	0.44	0.21	0.15	45.56
MAX	1.00	7.17	12.00	10.80	17.60	24.40	15.40	6.57	1.60	1.16	0.54	0.52	74.44
MIN	0.0	0.11	2.40	1.71	3.60	4.95	3.56	0.82	0.14	0.11	0.03	0.0	27.64

Table 6-7(2) Monthly Runoff Data: Unit (MCM)
Lam Ta Khong At Ban Mu Si (M_{43})

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1965	-	-	-	15.200	54.200	39.600	25.800	6.770	1.840	0.705	0.486	0.235	-
1966	0.419	7.990	5.030	15.800	43.600	21.900	12.500	3.000	1.100	0.333	0.118	0.002	111.792
1967	2.580	7.930	12.600	14.100	21.300	19.600	21.900	3.870	1.570	0.561	0.227	0.238	106.476
1968	1.440	7.760	7.180	15.100	14.200	13.000	8.430	2.150	0.748	0.258	0.066	0.165	70.497
1969	0.007	0.770	19.100	36.300	25.600	34.700	14.600	6.170	1.910	0.149	0.154	0.012	139.472
1970	0.228	1.030	10.300	20.000	17.000	21.300	13.900	4.970	2.560	1.090	0.571	0.142	93.091
1971	0.672	4.660	7.720	22.200	8.420	11.200	7.860	2.630	0.795	0.234	0.235	0.003	66.629
1972	0.640	0.320	6.080	16.700	20.500	57.700	28.00	5.850	3.320	1.200	0.535	0.555	141.400
1973	0.550	1.010	8.010	10.600	15.500	19.300	17.800	3.320	1.940	1.160	0.762	0.902	80.854
1974	2.000	3.670	12.900	7.370	17.500	18.200	32.000	18.300	3.800	2.690	1.340	1.080	120.850
1975	0.570	2.960	32.000	19.700	25.300	36.700	25.300	4.410	2.550	1.230	0.860	0.760	152.340
1976	0.500	6.040	14.800	16.800	33.600	31.700	36.700	12.800	4.240	2.890	1.620	1.340	163.030
1977	1.180	3.690	-	-	-	-	12.700	4.620	3.290	2.240	1.490	1.080	-
1978	0.060	4.790	19.900	22.700	24.700	19.300	20.800	4.440	2.730	2.210	-	-	-
1979	0.010	3.380	13.400	14.900	24.400	32.100	11.900	3.540	2.260	1.320	1.020	1.190	109.420
1980	1.560	2.520	9.520	14.900	12.000	23.900	19.100	5.780	2.870	1.570	0.900	1.020	95.640
1981	1.760	7.590	22.800	21.100	29.000	27.500	18.900	9.020	3.790	2.160	1.180	0.650	145.450
1982	0.006	0.390	8.680	6.900	35.900	15.500	30.800	2.370	4.150	2.630	2.950	1.790	112.066
1983													
TOTAL	16.402	71.570	220.420	307.570	444.320	489.100	376.390	109.880	48.643	26.450	15.425	11.614	1841.028
NUMBER	18	18	17	18	18	18	19	19	19	19	18	18	16
AVERAGE	0.911	3.976	12.966	17.087	24.684	27.172	19.810	5.783	2.560	1.392	0.857	0.645	115.064
MAX	2.580	7.990	32.000	36.300	54.200	57.700	36.700	18.300	4.240	2.890	2.950	1.790	163.030
MIN	0.006	0.320	5.030	6.900	8.420	11.200	7.860	2.150	0.748	0.149	0.066	0.002	66.629

Table 6-7(3) Monthly Runoff Data: Unit (MCM)
Lam Ta Khong At Ban Bung Toei (M_{NI})

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1963	-	1.00	3.66	18.60	26.20	49.80	47.40	22.50	9.52	4.64	2.99	2.79	-
1964	2.47	31.40	29.20	21.40	18.00	38.10	55.20	10.60	6.51	-	-	-	-
1965	1.25	4.24	45.40	17.60	59.30	51.60	41.10	13.60	4.22	4.33	3.46	3.45	249.55
1966	3.44	17.50	10.70	20.00	49.10	26.00	17.80	7.97	5.52	2.76	1.89	1.70	164.38
1967	4.66	9.35	15.20	14.30	20.70	19.10	25.00	4.87	2.71	1.93	1.66	1.69	121.17
1968	2.40	10.90	7.56	14.60	14.80	13.90	11.20	3.32	1.80	0.97	0.95	1.14	83.54
1969	0.86	1.16	25.80	44.40	29.90	69.40	20.90	10.40	4.58	2.82	2.01	2.01	214.24
1970	2.08	2.80	10.60	22.20	17.40	22.90	17.20	7.75	4.69	2.23	1.35	1.45	112.65
1971	1.68	6.24	9.45	25.40	9.25	15.80	11.70	3.78	1.40	0.83	0.54	0.50	86.57
1972	0.58	0.61	5.64	17.50	21.50	75.00	21.20	11.50	7.19	3.67	2.04	1.82	168.25
1973	1.46	1.56	8.07	11.40	11.10	56.00	16.60	4.77	2.68	1.57	0.86	0.69	116.76
1974	1.82	3.91	11.70	7.07	15.20	21.20	46.20	30.90	5.70	4.64	3.35	2.87	154.56
1975	2.75	4.82	29.20	17.20	24.50	42.10	33.40	6.91	5.00	4.02	3.31	3.11	176.32
1976	2.85	6.44	15.40	15.10	34.80	42.20	51.90	21.00	7.70	-	-	-	-
TOTAL	28.30	101.93	227.58	266.77	351.75	543.10	416.80	159.87	69.22	34.41	24.41	23.22	1647.99
NUMBER	13	14	14	14	14	14	14	14	14	12	12	12	11
AVERAGE	2.18	7.28	16.26	19.05	25.12	38.79	29.77	11.42	4.94	2.87	2.03	1.93	149.82
MAX	4.66	31.40	45.40	44.40	59.30	75.00	55.20	30.90	9.52	4.64	3.46	3.45	249.55
MIN	0.58	0.61	3.66	7.07	9.25	13.90	11.20	3.32	1.40	0.83	0.54	0.50	83.54

Table 6-7(4) Monthly Runoff Data: Unit (MCM)
Lam Ta Khong At A. Pak Chong (M_{89})

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1970	-	4.73	10.80	22.60	26.00	21.80	12.20	8.19	-	3.97	3.90	-	
1971	4.88	8.49	9.20	24.90	10.90	23.30	17.70	7.04	5.06	4.41	3.40	3.64	122.92
1972	2.46	2.17	6.89	18.30	23.90	125.00	107.00	28.70	19.10	12.50	8.40	6.20	360.62
1973	4.96	5.63	10.70	11.40	17.50	38.10	32.70	10.00	6.58	4.71	3.52	6.47	152.27
1974	-	7.97	14.00	9.91	18.80	21.30	55.00	38.30	12.00	8.99	5.65	4.89	-
1975	4.39	6.38	38.60	28.80	36.00	72.10	72.50	18.70	10.90	6.78	5.11	4.42	304.68
1976	45.04	8.99	19.50	19.80	49.80	67.00	82.80	35.20	13.00	8.60	5.64	6.69	322.07
1977	-	11.20	10.80	29.20	15.00	28.00	19.00	8.67	7.34	5.34	4.31	4.16	-
1978	4.24	7.37	15.80	27.70	27.60	30.10	37.50	9.01	7.14	6.19	4.44	4.19	181.28
1979	6.52	7.73	10.30	21.60	24.70	61.30	27.90	0.49	7.87	6.01	5.64	6.06	186.12
1980	5.23	6.38	11.90	15.10	13.20	25.00	38.90	13.60	8.63	6.39	5.20	5.57	155.10
1981	6.90	13.40	25.10	23.40	31.20	36.40	25.70	15.50	8.59	6.01	4.30	4.99	201.49
1982	5.65	8.52	11.00	18.80	22.20	44.50	29.60	12.10	8.53	6.25	4.18	3.96	175.29
1983	3.48	4.94	10.50	8.08	47.80	47.00	140.00	33.60	14.70	10.70	10.20	8.68	339.68
1984	5.88	6.06	8.06	22.30	26.00	31.90	69.70	17.10	9.50	6.31	4.19	3.95	210.95
1985	9.18	20.70	33.60	26.00	35.40	41.30	30.90	17.10	10.60	6.38	3.82	3.58	238.56
1986	7.07	21.20	12.90	17.80	12.10	25.30	65.80	13.30	7.87	4.75	2.95	3.67	194.71
TOTAL	75.88	151.86	259.65	345.69	429.70	743.60	874.50	290.61	165.60	110.32	84.93	85.02	3145.74
NUMBER	17	17	17	17	17	17	17	17	17	17	17	17	14
AVERAGE	5.45	8.93	15.27	20.33	25.28	43.74	51.44	17.09	9.74	6.89	5.00	5.00	224.70
MAX	9.18	21.20	38.60	29.20	49.80	125.00	140.00	38.30	19.10	12.50	10.20	8.68	360.62
MIN	2.46	2.17	6.89	8.08	10.90	21.30	17.70	0.49	5.06	4.41	2.95	3.58	122.92

Table 6-7(5) Monthly Runoff Data: Unit (MCM)
Lam Ta Khong At Ban Khlong Pha (M_{38C})

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1962	-	-	-	36.70	20.40	72.60	55.60	10.30	5.06	3.21	2.47	2.57	-
1963	3.30	2.52	3.53	17.40	30.40	56.60	87.40	25.10	10.10	6.58	3.87	3.15	249.95
1964	3.32	52.50	18.60	25.20	22.80	50.40	112.00	23.00	9.27	6.27	5.54	5.64	334.54
1965	3.53	8.83	21.90	31.10	64.40	80.50	69.40	19.70	9.64	6.21	5.10	4.44	324.75
1966	4.61	25.80	14.00	22.00	48.90	33.90	18.80	9.89	5.78	4.44	3.83	3.60	195.55
1967	5.11	14.80	15.20	15.70	21.70	22.10	48.60	7.36	3.91	2.98	2.07	2.87	162.40
1968	4.01	23.10	7.72	12.80	3.28	5.49	4.15	10.60	4.15	3.18	2.66	4.99	86.13
1969	5.00	5.27	5.27	18.40	30.10	9.23	12.80	13.70	6.62	4.39	11.20	11.20	133.18
1970	8.58	11.50	17.40	33.10	17.80	13.30	9.56	8.87	2.90	5.63	8.09	7.10	143.83
1971	7.35	7.94	25.30	29.50	26.60	19.60	26.40	17.40	3.24	7.41	5.60	4.83	181.17
1972	5.80	16.90	18.90	21.60	18.60	7.68	49.40	28.70	8.42	11.30	15.50	19.00	221.80
1973	22.30	30.40	37.30	32.00	24.90	23.20	15.30	16.20	7.45	7.90	9.18	8.48	234.61
1974	6.89	12.80	17.90	29.60	25.30	23.40	19.50	9.96	3.88	3.94	5.83	4.64	163.64
1975	2.05	4.30	29.40	43.70	59.40	49.90	84.00	22.00	6.12	14.30	12.40	9.90	337.47
1976	-	-	-	-	-	-	-	-	-	-	-	-	-
1977	-	-	-	-	-	-	-	-	-	-	-	-	-
1978	-	-	-	-	-	-	-	-	-	-	-	-	-
1979	6.00	4.21	6.09	36.10	37.00	20.80	23.90	25.20	6.88	5.94	12.20	11.30	195.62
1980	7.12	6.66	7.67	26.80	27.90	20.70	8.27	17.40	6.18	8.03	12.10	16.30	165.13
1981	9.19	7.03	26.00	28.50	35.90	47.00	29.30	23.90	8.77	9.08	21.90	7.38	253.95
1982	-	-	-	-	-	-	-	-	-	-	-	-	-
1983	5.81	10.60	21.50	26.80	14.80	17.60	21.20	9.25	8.76	11.00	13.20	7.88	168.40
1984	2.70	7.39	14.60	14.00	17.40	7.03	9.03	7.44	6.68	12.50	7.89	5.94	112.60
1985	7.26	6.41	8.68	13.70	6.73	20.50	18.40	8.38	7.71	6.33	13.30	17.20	134.60
1986	15.20	17.40	36.10	39.90	22.00	22.40	22.10	24.90	13.80	11.90	19.30	16.90	261.90
1987	17.40	18.00	28.40	36.60	19.80	10.30	9.48	15.40	8.30	10.70	12.60	11.40	198.48
1988	14.00	9.00	28.00	32.70	29.90	17.00	10.10	8.75	4.71	5.60	7.12	4.24	171.12
TOTAL	166.53	303.36	409.46	623.90	626.01	651.23	764.69	363.40	158.43	168.82	212.95	190.95	4430.82
NUMBER	22	22	22	23	23	23	23	23	23	23	23	23	22
AVERAGE	7.57	13.79	18.61	27.13	27.22	28.31	33.25	15.80	6.89	7.34	9.27	8.30	201.40
MAX	22.30	52.50	37.30	43.70	64.40	80.50	112.00	28.70	13.80	14.30	21.90	19.00	337.47
MIN	2.05	2.52	3.53	12.80	3.28	5.49	4.15	7.36	2.90	2.98	2.07	2.57	86.13

Table 6-8 Annual Flood Peaks

(m^3/sec)

Year	M_{N2} (C.A=60.7km^2)		M_{43} (C.A=235km^2)		M_{N1} (C.A=476km^2)		M_{89} (C.A=699km^2)		M_{38C} (C.A=1292km^2)	
	Date	Qp	Date	Qp	Date	Qp	Date	Qp	Date	Qp
1962									Sep. 11	85
63									Oct. 6	122
64					Jul. 5	107			Oct. 2	110
65	Oct. 12	144			Jun. 29	159			Oct. 14	87
66	Aug. 18	76.4	Aug. 18	290	Aug. 18	174			Aug. 21	103
67	Oct. 2	55.4			Oct. 3	104				
68	Jul. 5	30.3	Aug. 16	37	May 7	39.2				
69	Jul. 12	109	Sep. 21	287	Jul. 13	134				
70	Sep. 8	32.9	Sep. 8	43	Jul. 19	35.7	Jul. 20	30		
71	May 29	27.8	Jul. 9	33	Jul. 19	33.0	Sep. 28	45		
72	Sep. 6	78.4	Sep. 6	217	Sep. 7	244	Sep. 19	215		
73	Oct. 4	37.7	Oct. 5	45	Sep. 21	55.3	Sep. 26	89		
74	Oct. 9	34.2	Oct. 9	72	Oct. 10	68.7	Oct. 10	90		
75	Jun. 10	39.5	Jun. 10	90	Jun. 7	42.6	Oct. 1	86		
76	Sep. 5	86.7	Oct. 20	274	Oct. 20	122	Oct. 21	181		
77							Jul. 30	89		
78			Oct. 1	91.2			Oct. 2	93.1		
79			Sep. 24	100			Sept. 30	122.6		
80			Sep. 30	87.6			Oct. 2	76.7		
81			Aug. 7	55.2			Jun. 22	43.3		
82			Sep. 8	109.5			Sep. 12	78.3		
83			Aug. 22	183.6			Oct. 20	145.1		
84							Oct. 20	152.4		
85							Apr. 18	53.4		
86							Oct. 3	163.6		

Table 6-9 Estimated Inflow At Lam Ta Khong Dam: Unit (MCM)

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	TOTAL
1962	-	-	-	37.00	20.00	73.00	56.00	10.00	5.00	3.00	2.00	3.00	-
1963	3.00	3.00	4.00	17.00	30.00	57.00	87.00	25.00	10.00	7.00	4.00	3.00	250.00
1964	3.00	53.00	19.00	25.00	23.00	50.00	112.00	23.00	9.00	6.00	6.00	6.00	335.00
1965	4.00	9.00	22.00	31.00	6.400	81.00	69.00	20.00	10.00	6.00	5.00	4.00	325.00
1966	5.00	26.00	14.00	22.00	49.00	34.00	19.00	10.00	6.00	4.00	4.00	4.00	197.00
1967	5.00	15.00	15.00	16.00	22.00	22.00	49.00	7.00	4.00	3.00	2.00	3.00	163.00
1968	4.00	24.00	8.00	11.00	12.00	16.00	18.00	5.00	2.00	4.00	2.00	4.00	110.00
1969	2.00	1.00	19.00	38.00	33.00	110.00	38.00	15.00	8.00	7.00	6.00	8.00	285.00
1970	8.00	7.00	14.00	22.00	17.00	36.00	40.00	9.00	9.00	5.00	5.00	4.00	176.00
1971	6.00	14.00	11.00	23.00	15.00	28.00	18.00	6.00	6.00	2.00	7.00	6.00	142.00
1972	5.00	0.0	6.00	17.00	24.00	192.00	168.00	33.00	15.00	13.00	13.00	9.00	495.00
1973	12.00	16.00	11.00	12.00	19.00	70.00	47.00	6.00	6.00	5.00	10.00	16.00	230.00
1974	15.00	18.00	18.00	19.00	22.00	32.00	75.00	46.00	13.00	11.00	10.00	11.00	290.00
1975	8.00	19.00	38.00	39.00	39.00	92.00	107.00	18.00	10.00	10.00	12.00	8.00	400.00
1976	13.00	20.00	24.00	30.00	59.00	82.00	99.00	43.00	15.00	6.00	6.00	10.00	407.00
1977	10.00	16.00	11.00	28.00	22.00	35.00	20.00	7.00	7.00	4.00	5.00	6.00	171.00
1978	14.00	10.00	19.00	35.00	36.00	39.00	57.00	8.00	4.00	5.00	3.00	2.00	232.00
1979	7.00	10.00	9.00	24.00	29.00	61.00	53.00	7.00	6.00	4.00	4.00	3.00	217.00
1980	5.90	5.50	24.80	19.60	18.10	41.90	84.80	17.40	5.70	4.40	3.80	2.00	233.90
1981	11.00	16.10	22.60	27.50	31.80	43.60	33.80	27.20	4.60	0.0	3.00	5.30	226.50
1982	4.40	6.40	8.80	21.70	28.70	70.20	38.90	11.40	4.80	4.20	2.30	0.60	202.40
1983	1.60	4.50	7.50	12.90	46.50	58.90	231.40	30.00	16.00	10.40	14.20	7.20	451.10
1984	11.70	8.20	8.40	24.50	32.10	41.50	83.60	15.80	7.50	8.50	4.20	1.50	247.50
1985	9.20	26.70	30.80	32.30	31.20	45.80	51.00	16.70	6.60	5.90	2.00	4.40	262.60
1986	11.10	24.30	10.20	15.00	14.60	29.90	77.90	11.00	5.60	1.80	3.70	1.80	206.90
1987	7.90	12.80	10.70	8.90	12.20	73.90	44.80	17.00	5.10	5.80	7.10	2.90	209.10
1988	5.50	22.60	16.60	14.30	29.70	87.40	105.80	15.60	9.70	7.50	4.90	7.40	327.00
1989	1.60	20.10	7.70	8.90	9.80	-	-	-	-	-	-	-	-
TOTAL	193.90	408.20	410.10	631.60	789.70	1603.10	1884.00	470.10	210.60	153.50	151.20	143.10	6792.00
NUMBER	27	27	27	28	28	27	27	27	27	27	27	27	28
AVERAGE	7.18	15.12	15.19	22.56	28.20	59.37	69.78	17.41	7.80	5.69	5.60	5.30	261.32
MAX	15.00	53.00	38.00	39.00	64.00	192.00	231.40	46.00	26.00	13.00	14.20	16.00	495.00
MIN	1.60	0.0	4.00	8.90	9.80	16.00	18.00	5.00	2.00	0.0	2.00	0.60	110.00

Table 6-10 Water Level of Lam Ta Khong Dam (1/2)

(Unit: m)

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1968				256.12	259.64	261.71	263.26	262.27	261.94	261.77	261.55	261.13
1969	260.53	259.83	262.18	264.71	264.92	271.48	272.43	272.37	272.32	272.29	271.89	271.60
1970	271.45	271.14	270.83	270.22	270.11	271.29	272.52	272.48	272.58	272.37	272.05	271.71
1971	271.48	271.65	270.96	270.79	270.18	270.71	270.23	269.49	269.47	268.99	268.71	268.62
1972	268.54	267.26	266.35	264.92	266.21	275.03	277.13	277.13	277.22	277.04	276.71	276.19
1973	276.71	275.02	275.14	273.38	273.09	274.1	275.74	275.40	275.25	274.96	274.79	274.73
1974	274.74	274.65	274.07	273.37	272.99	273.15	275.04	276.03	276.13	276.04	275.80	275.63
1975	275.29	275.02	275.13	274.99	274.47	275.99	276.46	276.01	275.93	275.70	275.46	275.09
1976	275.00	274.65	273.80	273.07	273.60	274.79	276.51	276.77	276.78	276.40	275.98	275.61
1977	275.32	275.06	273.79	282.99	271.82	271.94	271.65	270.66	270.60	270.05	269.23	267.77
1978	264.67	264.99	265.25	265.96	265.15	266.89	269.58	268.53	268.42	268.17	267.91	267.43
1979	267.39	267.75	267.97	267.21	266.70	269.67	270.71	269.76	269.68	269.50	268.90	268.54
1980	268.33	268.18	269.08	268.24	267.60	269.20	272.96	272.87	272.81	272.61	272.26	271.83
1981	271.86	272.23	272.16	271.82	271.62	271.61	271.89	272.11	271.95	271.65	270.92	270.74
1982	270.38	270.21	269.41	268.38	268.03	271.24	272.03	271.63	271.48	271.01	270.40	269.76
1983	269.18	268.40	267.41	266.20	268.56	270.90	277.17	277.15	277.24	277.10	276.81	276.61
1984	276.59	276.20	275.65	275.40	274.27	274.13	276.17	275.40	274.96	274.37	274.06	273.66
1985	273.51	274.09	274.36	273.89	273.43	274.27	275.21	274.95	274.77	274.51	273.67	273.12

Table 6-10 Water Level of Lam Ta Khong Dam (2/2)

(Unit: m)

Water Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.
1986	272.87	273.09	272.23	271.05	270.56	270.72	273.17	272.59	272.19	271.70	270.75	270.01
1987	269.76	269.60	268.60	266.50	265.66	270.01	271.61	271.53	271.28	270.89	270.50	269.93
1988	269.45	270.19	269.51	268.24	268.03	271.93	275.39	275.24	275.13	274.86	274.38	274.03
1989	273.59	273.67	272.82	271.98	270.73	270.51						

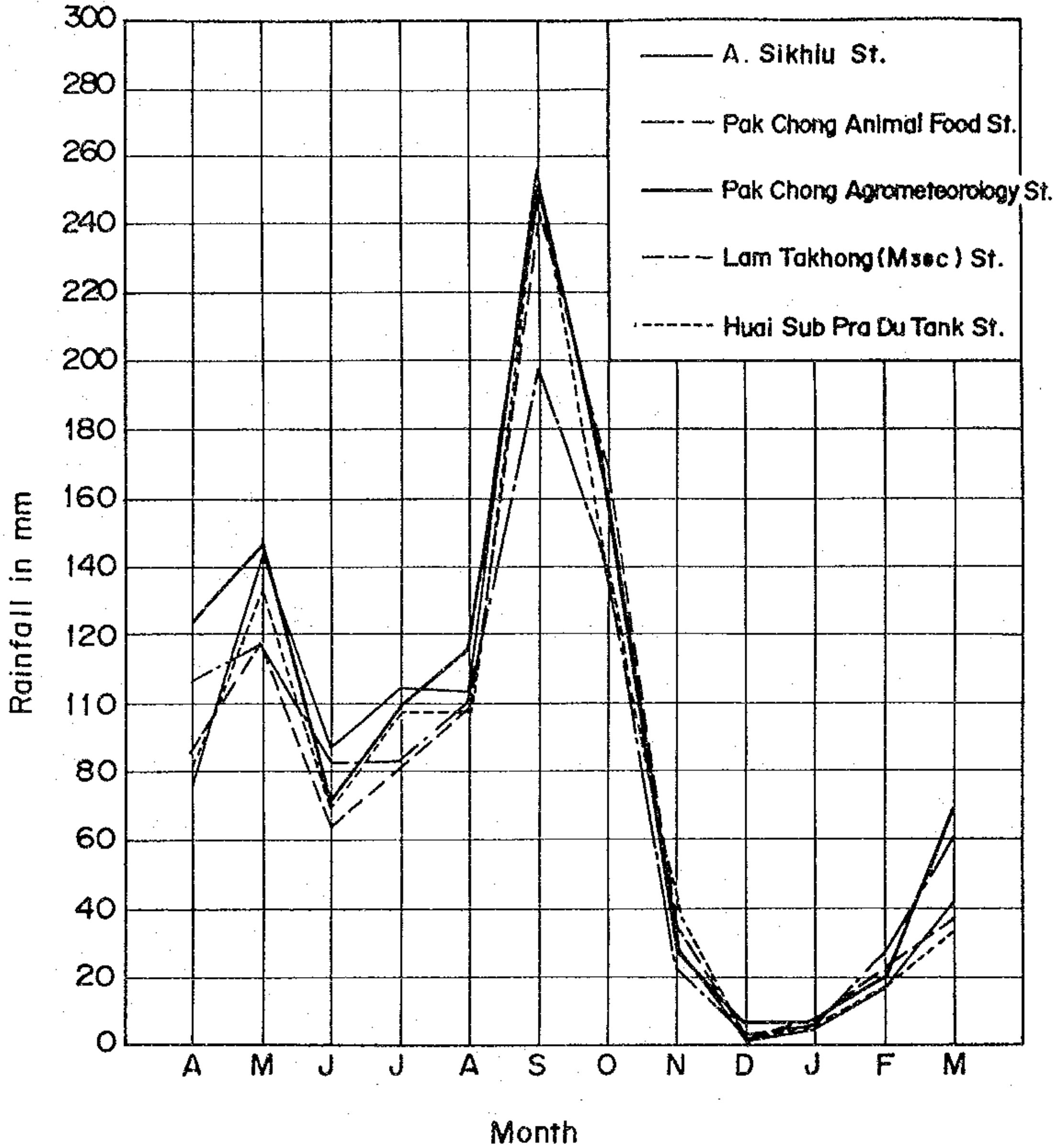


Fig.6-2 Monthly Rainfall

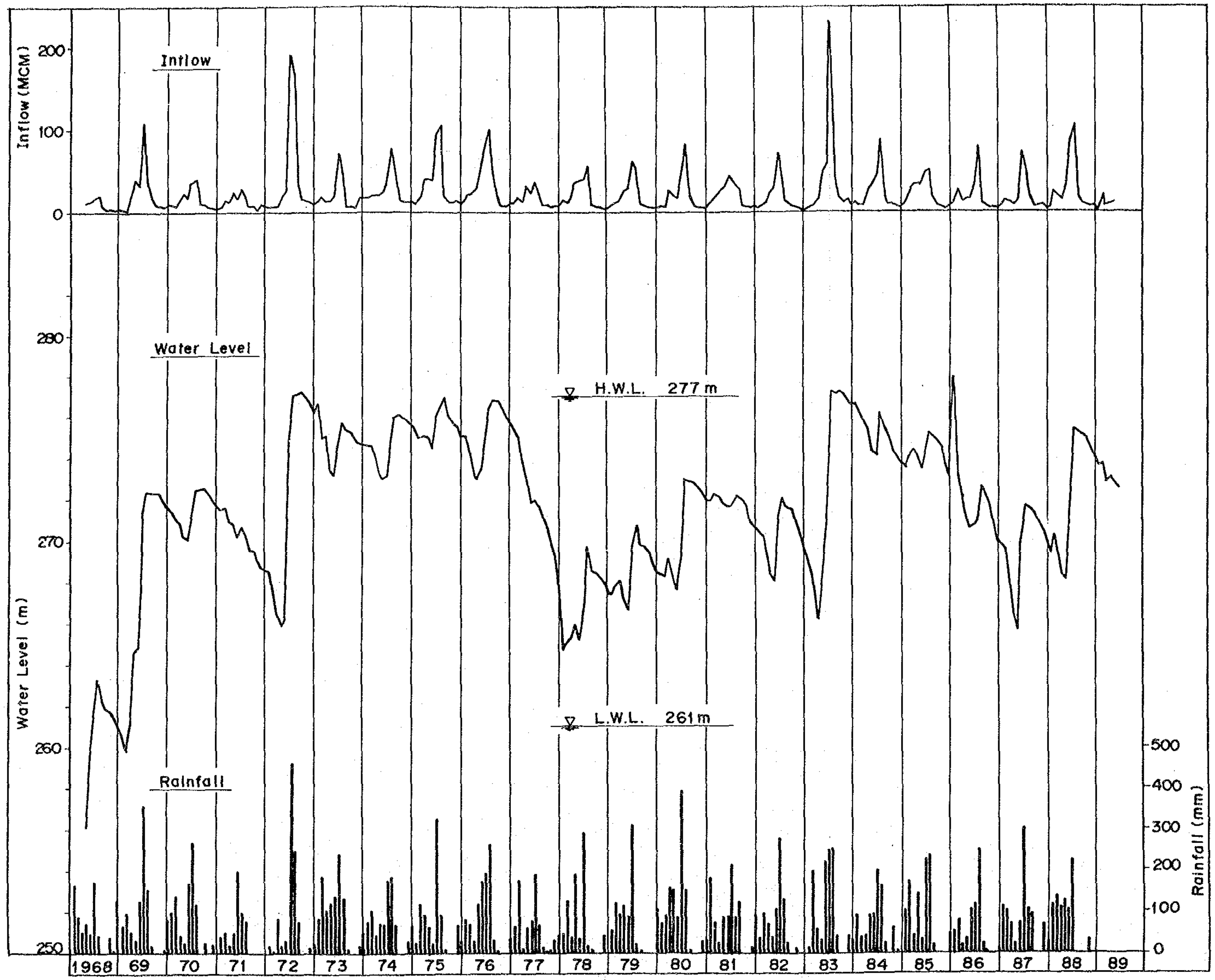


Fig.6-3 Inflow, Water Level and Rainfall of Lam Ta Khong Dam

6.4 Sedimentation

(1) General

The process of erosion, transportation and deposition of sediment are complex. Although considerable basic data have been collected and comprehensive research has been performed, generally much yet remains to be done before the prediction of rates and processes of reservoir sedimentation can achieve the degree of accuracy desired.

Sedimentation of a reservoir created by a dam constructed on a natural water course is inevitable. The problem of concern is the rapidity of sedimentation and the period of time which will elapse before the usefulness of the reservoir storage and the power structures are seriously impaired.

The Lam Ta Khong dam constructed by the RID in 1969 creates the reservoir with a capacity of 310 MCM at N.H.W.L. More than 20 years have passed through since the reservoir was impounded.

The RID carried out the hydrographical surveys twice in 1979 and 1984, and has measured suspended sediment loads and the character of sediment. In additon, the EGAT carried out the hydrographical survey in 1990.

Based on these survey data, a comprehensive study related to the reservoir sedimentation was performed.

(2) Character of Sediment

The RID carried out investigations of grain size of river bed materials in the Lam Ta Khong reservoir in 1984. The results of the investigations are summarized in Table 6-11.

The average contents of clay, silt, sand, coarse sand and gravel are 28.6%, 43.7%, 16.7%, 8.0% and 3.0% respectively. The river bed material is characterized to show a high content of fine particles;

contents of clay and silt is so high as 72.3%. These clay and silt are generally classified into "wash load". The wash load comes from watershed-erosion in the river basin.

(3) Sediment Yield

Suspended sediment loads have been measured at three gauging stations of the Lam Ta Khong river. Sediment data are shown in the following table, and a relation between catchment areas and annual suspended sediment loads is shown in Fig. 6-4.

Assuming the bed load to be 30% of the suspended sediment load, the annual sediment load at the Lam Ta Khong dam is estimated to be 52,000 tons/year (40,000 m^3/year) and the erosion depth is 0.028 mm - 0.030 mm over the watershed area. The erosion depths of other rivers in Thailand are shown in Fig. 6-5.

The erosion depth of the Lam Ta Khong river is relatively small compared with other rivers in Thailand. While in the feasibility study by the RID in October 1962, the erosion depth was set to be 0.16 mm which is about six times the observed data of 0.028 mm.

Suspended Sediment Data of the Lam Ta Khong River

Code of Station	Catchment Area (km^2)	Period	Annual Suspended Sediment Load (tons)	Erosion Depth (mm)
M_{N2}	61	1966-1976	1,720	0.028
M_{N1}	476	1965-1976	14,403	0.030
M_{38C}	1,292	1963-1967	39,253	0.030

(4) Sediment Volume

To grasp the accumulated sediment volume after the construction of the Lam Ta Khong dam, the reservoir capacities at N.H.W.L. 277.0 m were calculated and compared.

- Planimeter readings at elevations of the reservoir

- Cross-sectional areas in the reservoir

The reservoir capacities in 1969 (original), 1979, 1984 and 1990 are summarized in Table 6-12 (1) and Table 6-12 (2). The reservoir capacities at EL. 277 m by two methods are tabulated below.

Reservoir Capacities at N.H.W.L. (EL. 277 m)

	1969 (Original)	1979	1984	1990
Planimeter reading	310 MCM	321.8	325.3	311.9
Cross section	304.7 MCM	319.6	321.6	306.5

It is recognized that the reservoir capacity has been increased from 1969 to 1984, and that it has been decreased from 1984 to 1990. In other words, the accumulated sediment volume in the reservoir is negative for 1960 - 1984 and positive for 1984 - 1990.

However, it is judged from the following reasons that differences of reservoir capacities among 1969, 1979,1984 and 1990 are not significant.

- Difference of reservoir survey

The reservoir capacities in 1969, 1979, 1984 and 1990 are calculated from the following maps.

Year	Survey	Scale
1969 (RID)	Aerial survey	1:20,000
1979 (RID)	Hydrographic survey	1: 4,000
1984 (RID)	- ditto -	1: 4,000
1990 (EGAT)	- ditto -	1: 5,000

Reservoir sedimentation is generally obtained by surveying the reservoir with fixed sounding survey lines periodically, that is, changes of cross sections of the reservoir with time are investigated.

However, the above surveys for the Lam Ta Khong reservoir were not done with fixed survey lines.

Since the hydrographic surveys in 1979 and 1984 were carried out by the RID, and the survey in 1990 by the EGAT, the accuracy of surveys is considered substantially different. Also the topographical map by the aerial survey in 1969 is of different accuracy from the maps by the hydrographic survey in 1979, 1984 and 1990.

- Sediment yield

Judging from the observed data of suspended sediment, the accumulated sediment volume for 21 years of 1969 - 1990 is estimated to be less than 840,000 m^3, (= 40,000 m^3/year x 21 years) if the trap efficiency is considered.

The accumulated sediment volume is estimated so small for the total reservoir capacity of 310 MCM (in 1969) that they are within calculating errors.

(5) Distribution of Sediment

The distribution of sediment in a reservoir is dependent upon several interrelated factors, including nature of sediment, inflow-outflow relations, shape of reservoir and reservoir operation.

When the incoming sediment load contains coarse-grained materials or gravels, they are deposited first at headwaters of the reservoir, progressively fine materials being deposited as the transport capacity is further diminished by the silting effect of the reservoir. Silts, clays and colloids which remain in suspension for long periods of time are transported for greater distances into the reservoir, finally being deposited in the vicinity of the dam or being discharged with water to the downstream of the dam.

Generally sediment profiles of reservoirs are classified into 5 patterns depending on the above cited factors, as shown in Fig. 6-6.

In case of the Lam Ta Khong reservoir, profiles of average elevations of river beds in 1969, 1979, 1984 and 1990 are illustrated in Fig. 6-7 and Fig. 6-8.

In spite of the different accuracy of surveys, the followings are roughly evaluated in terms of changes in profiles of river beds of the Lam Ta Khong reservoir.

Distance from Dam	Change in Profile of River Beds
0 - 2 km	The river bed has been lowered after the completion of the Lam Ta Khong dam. There has been great changes of river bed elevation in respective years.
2 - 6 km	The differences of elevations of the river bed in respective years are as small as about 1 m excluding in 1984. There has been no tendency for river beds to be lowered or raised in course of time.
6 - 7 km (Refer to Fig. 6-8)	The outlet structure site corresponds to the cross section No. 11 in Fig. 6-8. For the far downstream stretches of the outlet site (No. 8 - No. 9), the river bed has been raised for 1969- 1984 and has been lowered for 1984 - 1990. To the contrary, for the far upstream stretches of the outlet site (No. 13 - No. 14), the river bed has been lowered for 1969 - 1984 and has been raised for 1984 - 1990. For the stretch near the outlet site (No. 9 - No. 13), there has been no tendency for river beds to be lowered or raised in course of time. Roughly speaking, the average river bed for 600 m (No. 9 - No. 13) has been unchanged as high as about EL 263 m - 264 m.
7 - 15 km	The river bed has been lowered as much as about 1.5 m for 1969 - 1984, and the river bed in 1990 has been raised at the approximate same elevation of the river bed in 1969.

The change of cross sections of river beds in the vicinity of the outlet site from 1979 to 1990 are shown in Fig. 6-9, where No. 11 section corresponds to the outlet site.

Fig. 6-9 indicates that the lower elevation part of the reservoir in the middle of cross sections has changed greatly in the course of time. This great change of river beds is considered due to floods' effects.

Although the hydrographical surveys in 1979, 1984 and 1990 were neither carried out with fixed sounding survey lines nor carried out in the same season, significant sedimentation except changes in river beds due to floods' effects have not been seen in the vicinity of the outlet site.

Table 6-11 Summary of Sediment Data Analysis (1984 Survey)

Sample No.	Clay	Silt	Sand	Coarse Sand.	Gravel	Unit Weight T/m^3
1	16	38	16	25	5	1.310
2	12	48	26	11	3	1.281
3	42	40	13	3	2	1.063
4	16	50	24	8	2	1.236
5	10	27	16	24	23	1.480
6	17	37	14	24	8	1.320
7	29	34	14	2	1	1.113
8	29	43	21	3	4	1.163
9	22	54	18	4	2	1.153
10	17	47	20	13	3	1.249
11	13	52	26	4	5	1.362
12	27	35	25	8	4	1.210
13	46	36	14	3	1	1.042
14	40	42	17	1	-	1.081
15	33	48	13	1	-	1.057
16	42	48	9	1	-	1.027
17	36	52	10	2	-	1.061
18	24	42	12	21	1	1.212
19	25	49	17	7	2	1.170
20	21	49	25	4	1	1.194
21	39	47	8	4	2	1.057
22	34	48	17	1	-	1.227
23	26	36	16	18	4	1.227
24	50	38	8	4	2	1.019
25	48	38	11	4	1	1.039
26	34	44	14	7	1	1.113
27	22	44	14	14	6	1.253
29	23	42	23	2	2	1.173
Total	801	1,224	467	223	83	
Average	23.61	43.71	16.68	7.36	3.04	1.185

Table 6-12 (1) Reservoir Capacity of Lam Ta Khong Dam
(By Planimeter Reading)

(Unit: MCM)

EL.	Original (1969)		1979		1984		1990	
	Volume	Accumu-lated Volume	Volume	Accumu-lated Volume	Volume	Accumu-lated Volume	Volume	Accumu-lated Volume
				(EL. 255)		(EL. 255)		(EL. 255)
254		0		4.9		5.9		5.1
	12		15.1		13.5		13.9	
260		12		20.0		19.4		19.0
	36		36.4		35.1		34.3	
265		48		56.4		54.5		53.3
	70		70.7		74.2		67.7	
270		118		127.1		128.7		121.0
	126		125.2		128.0		122.4	
275		244		252.3		256.7		243.4
	66		69.5		68.6		68.5	
277		310		321.8		325.3		311.9

Note: 1) Reservoir capacity is estimated on:

a scale of 1:10,000 (1969)
a scale of 1:4,000 (1979)
a scale of 1:4,000 (1984)
a scale of 1:5,000 (1990)

Table 6-12 (2) Reservoir Capacity of Lam Ta Khong Dam
(By Cross Sectional Area)

(Unit: MCM)

EL.	Original (1969)		1979		1984		1990	
	Volume	Accumu-lated Volume	Volume	Accumu-lated Volume	Volume	Accumu-lated Volume	Volume	Accumu-lated Volume
245		0		0		0		0
	13.3		18.4		18.3		18.5	
260		13.3		18.4		18.3		18.5
	32.4		37.0		34.7		34.1	
265		45.7		55.4		53.0		52.6
	68.3		72.1		76.2		68.2	
270		114.0		127.5		129.2		120.8
	121.8		123.1		124.7		120.3	
275		235.8		250.6		253.9		241.1
	68.9		69.0		67.7		65.4	
277		304.7		319.6		321.6		306.5

Note: 1) Reservoir capacity is estimated on:

a scale of 1:20,000 (1969)
a scale of 1:4,000 (1979)
a scale of 1:4,000 (1984)
a scale of 1:5,000 (1990)

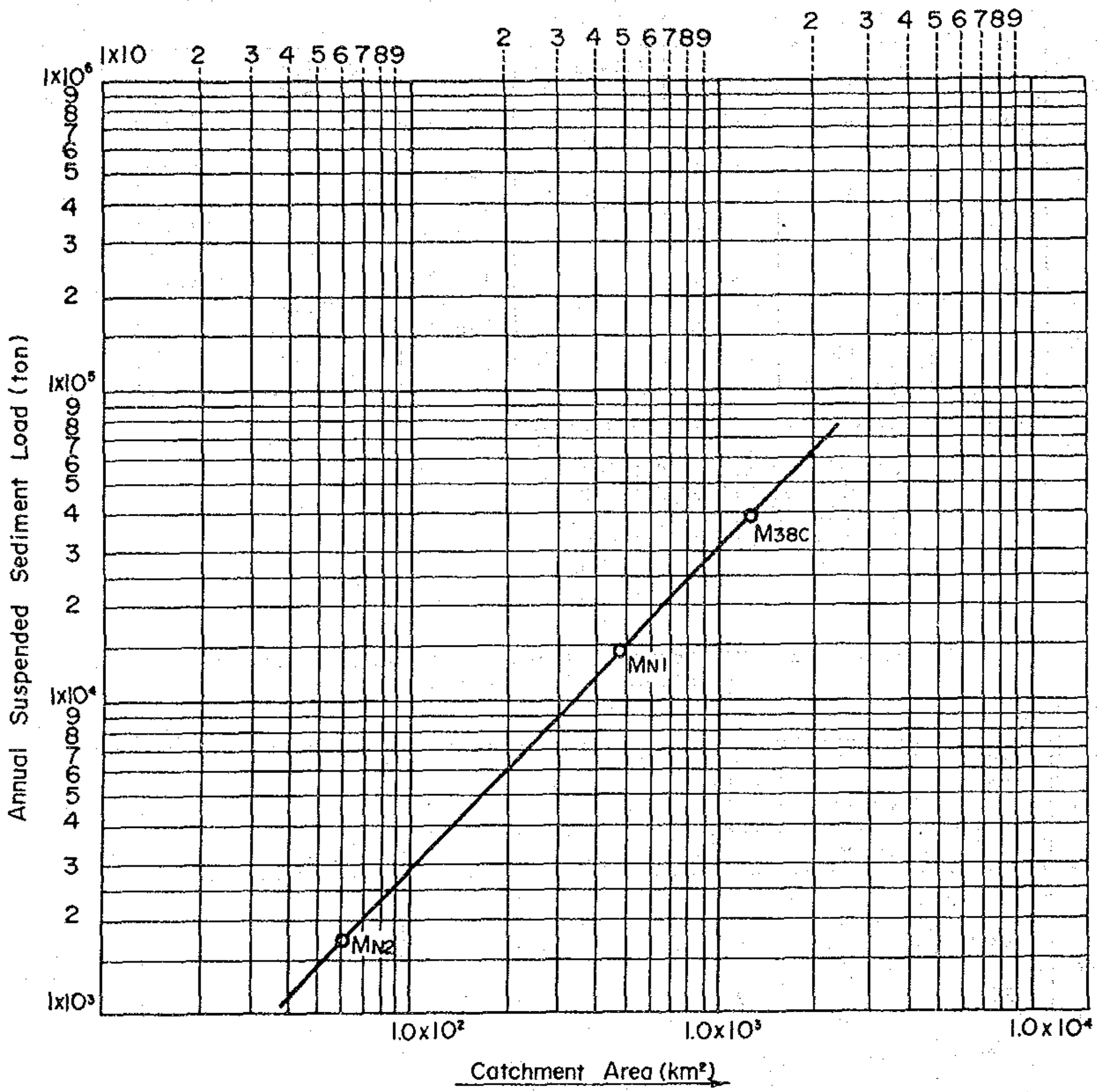


Fig.6-4 Relation between Catchment Area and Annual Suspended Sediment Load

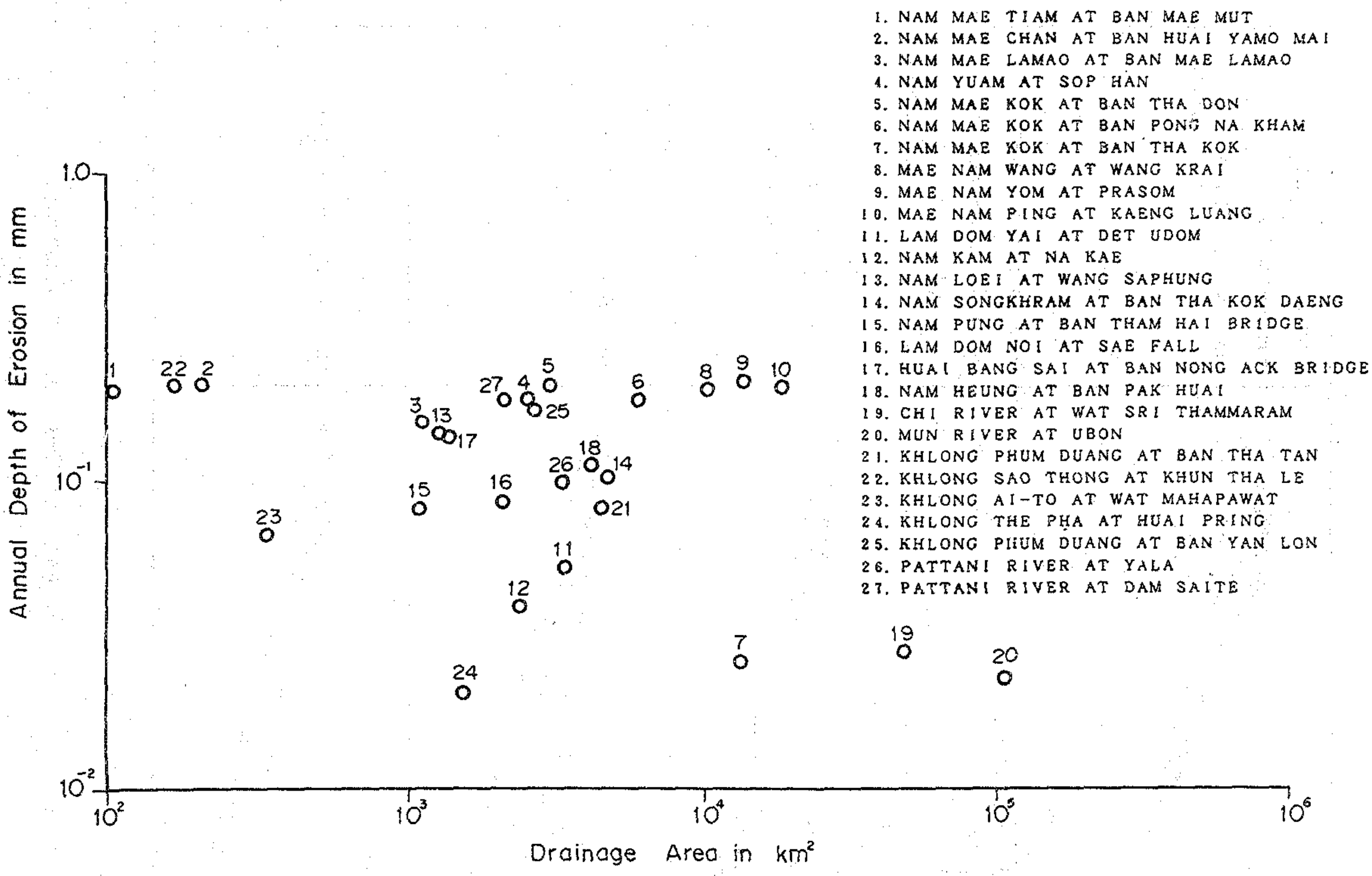


Fig.6-5 Annual Depth of Erosion in Thailand

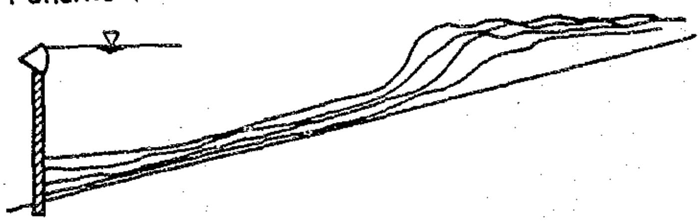
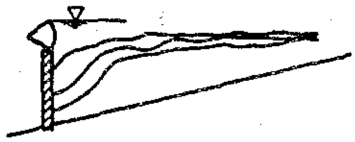
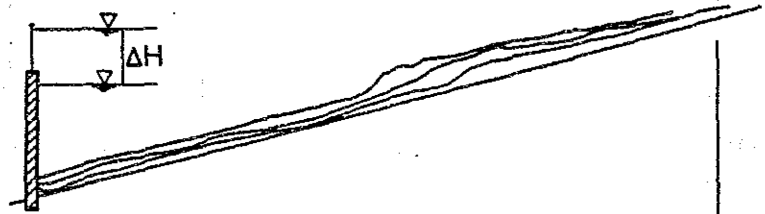
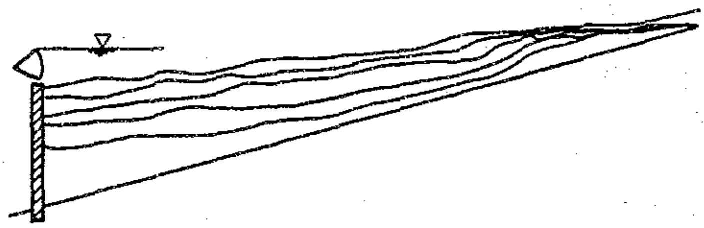
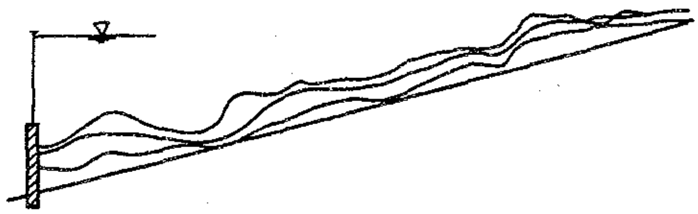
Pattern I-1 	gravel } much coarse-sand } fine particle-little
Pattern I-2 	- ditto - Dam is located most upstream , its capacity is small
Pattern I-3 	- ditto - Floods occur when water level is low
Pattern II 	fine particle. - much
Pattern III 	- ditto - Height of dam is low.

Fig.6-6 Profile Patterns of Sediment in Reservoir

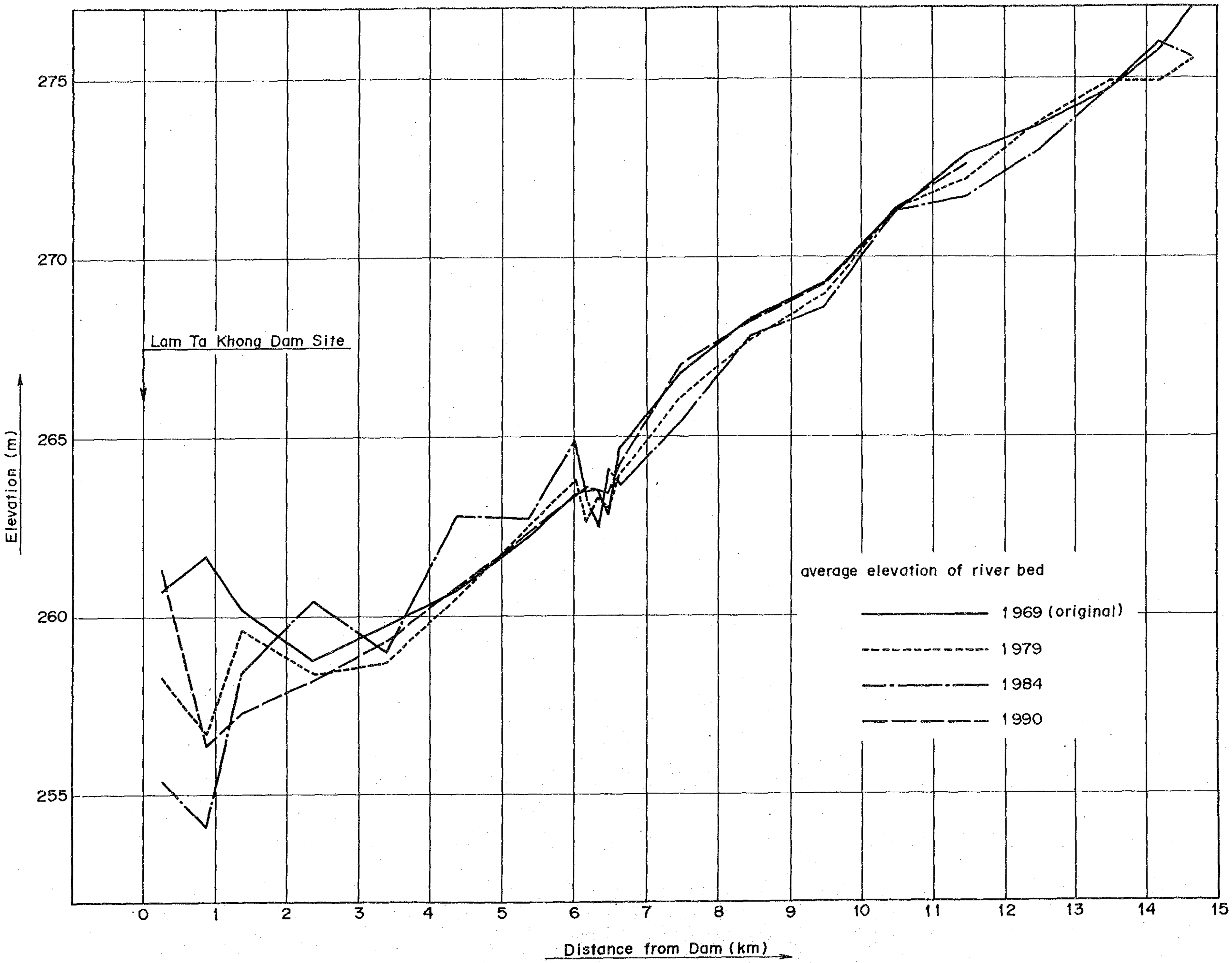


Fig.6-7 Profiles of River Beds

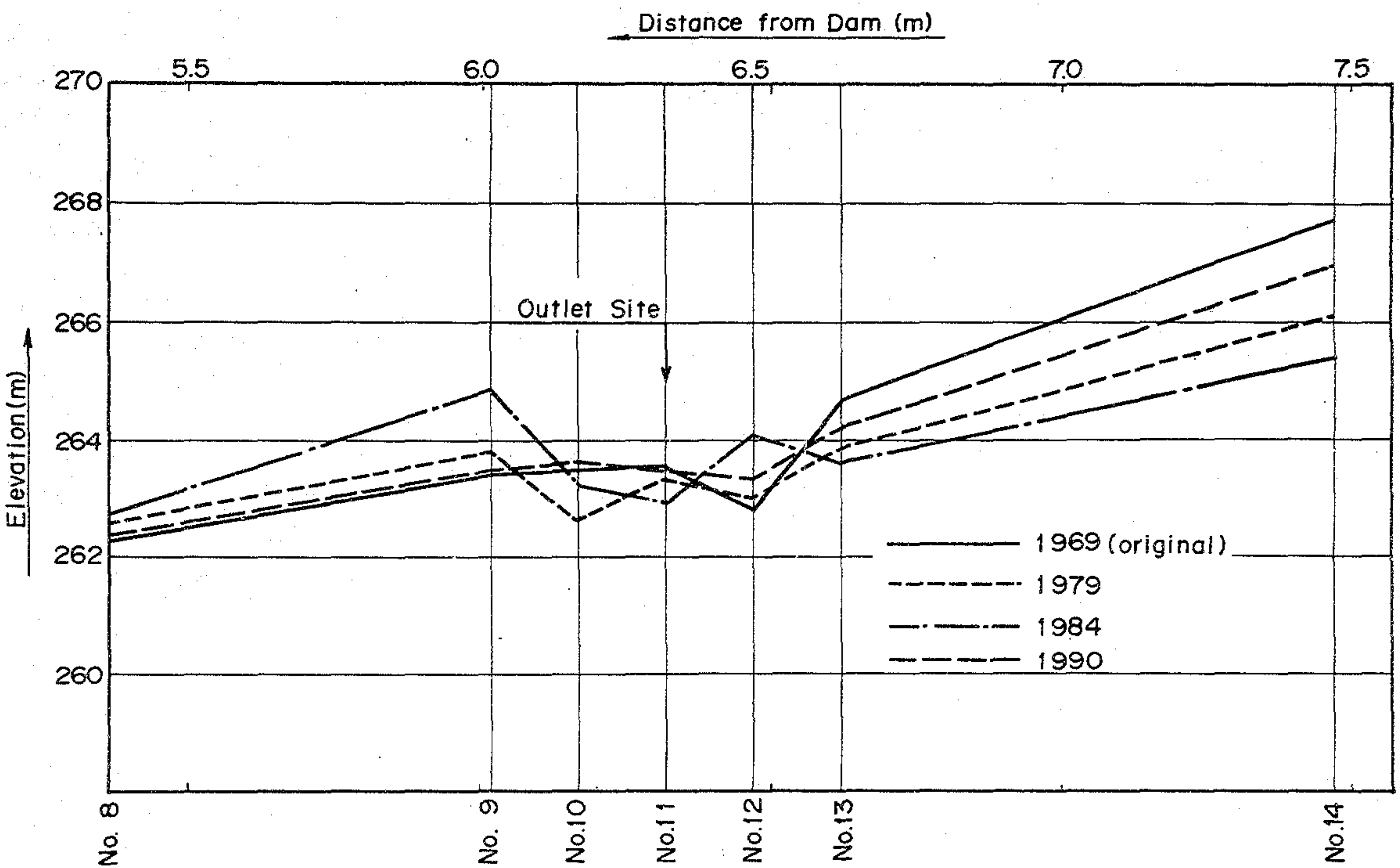


Fig. 6-8 Detailed Profiles of River Beds Near Outlet

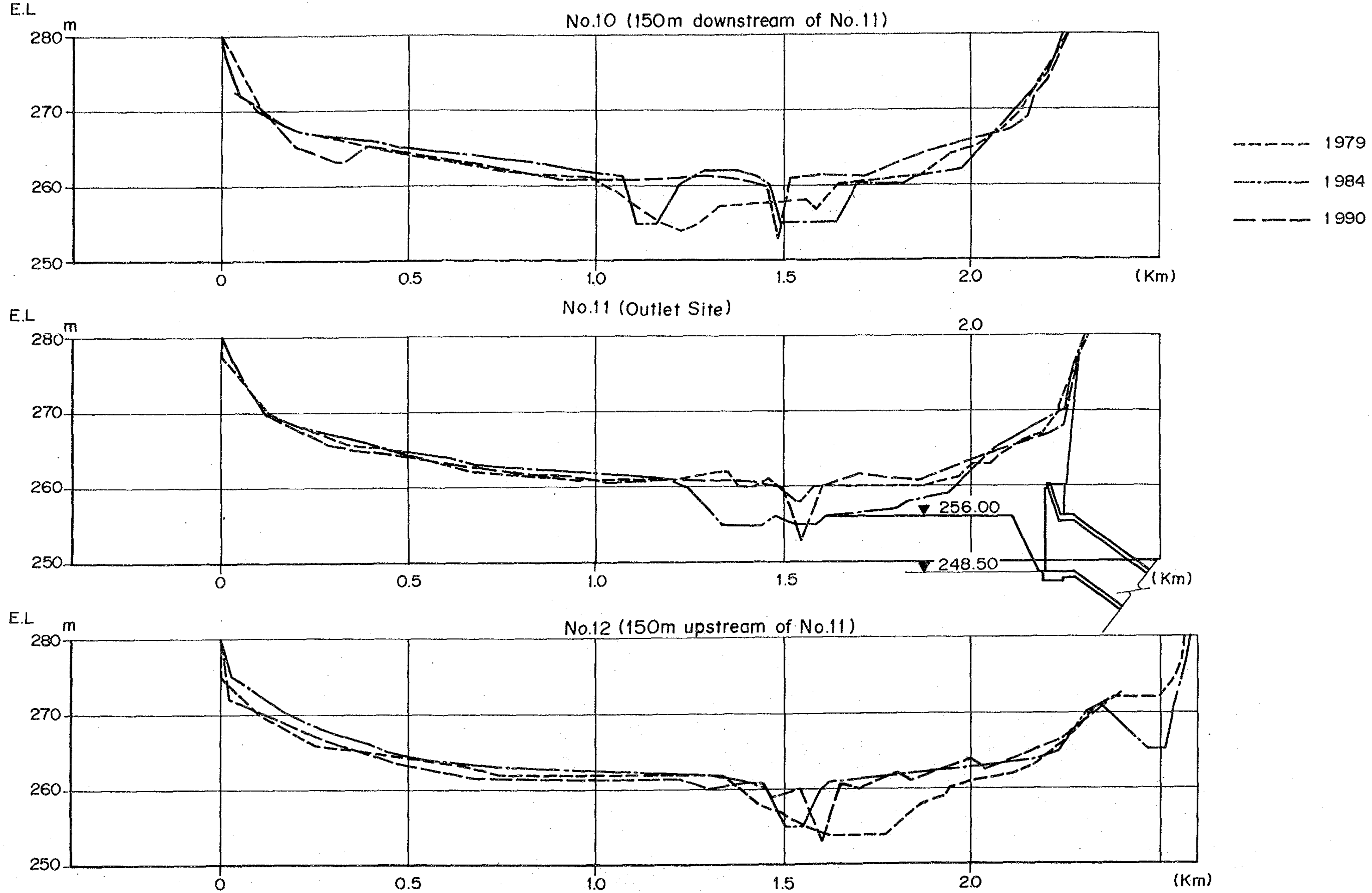


Fig.6-9 Reservoir Cross Sections near Outlet

CHAPTER 7

GEOLOGY & CONSTRUCTION MATERIALS

CHAPTER 7 GEOLOGY AND CONSTRUCTION MATERIALS

CONTENTS

Page

List of Tables

List of Figures

List of Drawings

CHAPTER 7 GEOLOGY AND CONSTRUCTION MATERIALS

7.1 Introduction

The geological investigation works concerning the LAM TA KHONG PUMPED STORAGE PROJECT were started by EGAT in May 1990. All of them in connection with the sites around the upper reservoir and the waterway route and proposed aggregate quarries had finished by January 1991.

This chapter describes the geological, hydrogeological and engineering-geological conditions of the project area and of main structure sites that have been revealed as a result of the field survey conducted by the JICA Survey Team as well as various investigation works and tests carried out by EGAT.

7.2 Outline of Topography and Geology of Project Area

7.2.1 Outline of Topography

The Lam Ta Khong River is one of the tributaries of the Mun River that runs eastward through the Korat Plateau in the east of Thailand and empties itself into the Mekong River at the Thai-Laos border. It originates in the steep mountains ranging in elevation from nearly 1000 to 1300 m located about 50 km to the southsouthwest of the project site and then runs northeastward through a flat basin located in the vicinity of Pak Chong about 30 km to the northeast of this mountains to the Lam Ta Khong reservoir where the project site is located. The river bed slope in this basin is gentle, averaging 2/1000 and there is not any landforms that is likely to cause a rapid accretion of sand, for example, a slope failure or a landslide, in any place including the area of its tributaries.

Close to the both banks of the river near the Lam Ta Khong reservoir there is a plateau having a maximum elevation of about 750 m which forms a valley. The southwestern (upstream) side of the this plateau forms a relatively steep slope of 10 to 25° which is similar to the both banks of the reservoir. The top of the plateau is inclined northeastward (downstream) at nearly 5° and the northeast side hardly presents any difference in elevation between the top of the plateau and the river bed at about 1 km downstream of the Lam Ta Khong dam to the northeast of which extends the flat and sprawling korat plateau with an elevation of nearly 200 m. The geologic formation forming the top of the plateau consists of a thick layer of sandstone with a high resistance to weathering and erosion whose inclination almost corresponds to that of the top of the plateau. The landform of this plateau can be called to be a "cuesta". On the top of the plateau valleys are ranging in depth from the top of the plateau from a few tens of meters to 100 m. They run northeastward, in the dip direction of the top of the plateau.

The upper reservoir is planned on the above-mentioned plateau on the right bank of the Lam Ta Khong reservoir and the gradient of the slope of the plateau under which the waterway route is planned will average nearly 12°.

7.2.2 Outline of Geology

DWG. 7-1 shows a geologic map of the vicinity of the project area. The vicinity of the project area is roughly divided into two areas according to the rock types that form the bedrock:

(1) Mountains in which the Lam Ta Khong River originates and the basin of Pak Chong district, where the Ratburi group of the Permian period of the Paleozoic era and igneous rocks of the Permian to the Triassic period are distributed.

(2) The periphery of the Lam Ta Khong reservoir and the Korat plateau to the northeast of the reservoir where the Korat group of the Triassic to Cretaceous period of the Mesozoic era are distributed.

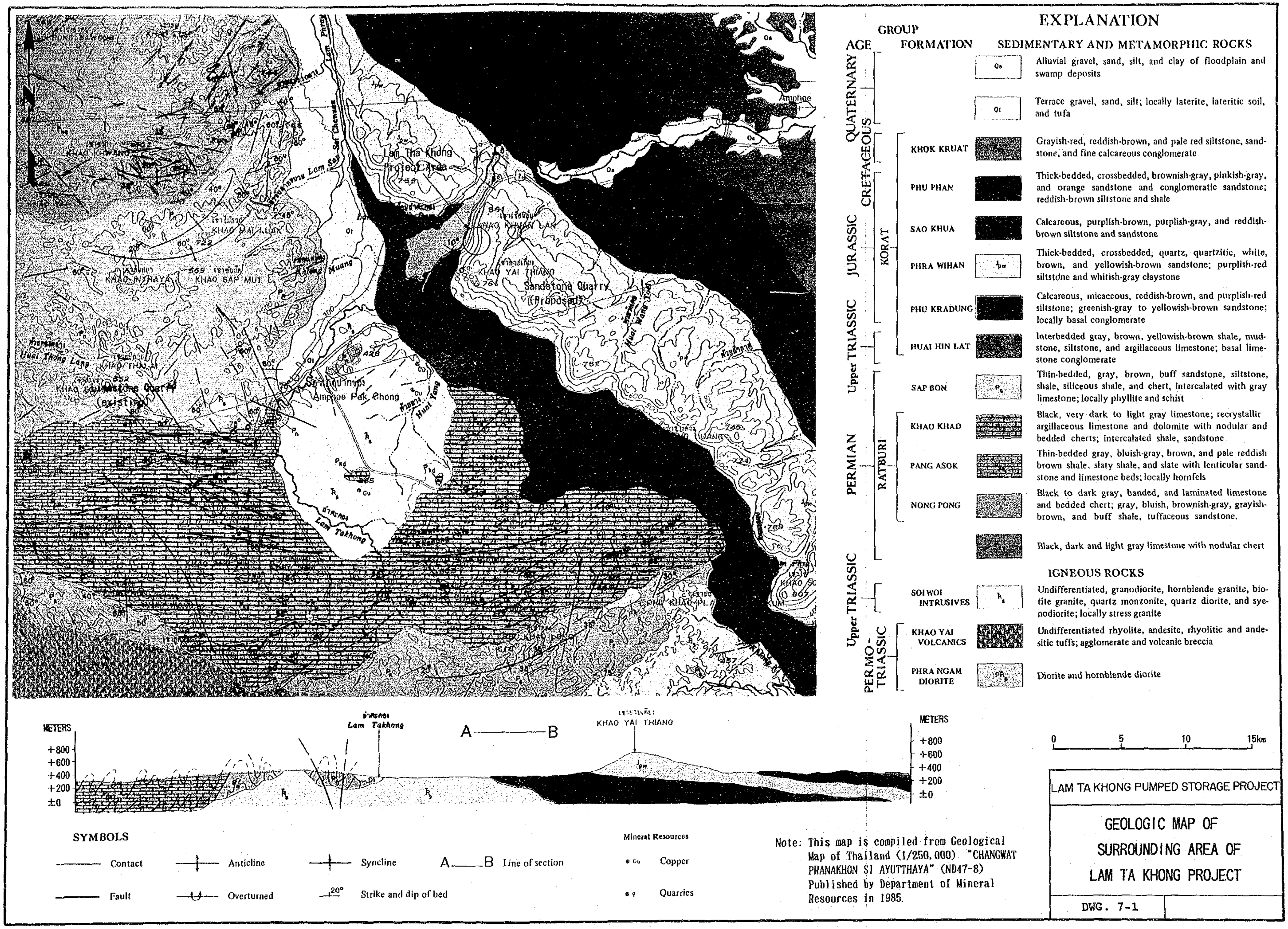
The Ratburi group in the (1) area is a marine deposit mainly consisting of limestone, chert, shale and sandstone and forms mountains around the basin. The igneous rocks are composed of the Soiwoi intrusive mainly consisting of granodiorite and granite and the Khao Yai volcanic mainly consisting of rhyolite and andesite. The former forms the basin of Pak Chong district and the latter forms the mountains. Along the valley to the north of Pak Chong is distributed terrace deposit consisting of conglomerate, sand and silt of the Quaternary period. The site proposed for a limestone aggregate quarry for the project is located about 12 km to the southeast of Pak Chong, namely in the area in which are distributed the Ratburi group.

The Ratburi group forming a number of small folds with east-to-west axes is mildly inclined southward as a whole, so that younger formations are distributed on the south side. In this area are found a number of high-angle faults with a length of the order of 10 km, however, there are not such faults as may affect the regional geologic structure.

The Korat group in the (2) area is a continental or shallow-sea sediment which unconformably covers the Ratburi group and igneous rocks and is composed mainly of sandstone, siltstone, shale and claystone and partly of limestone and conglomerate. Along the Lam Ta Khong River are also distributed alluvial deposit consisting of gravel, sand and silt of the Quaternary period. The Phu Kradung formation (siltstone, sandstone and partly conglomerate) and the Phra Wihan formation (sandstone, siltstone, claystone) which are the Jurassic strata and belong to the Korat group are distributed in the project area. The site proposed for a sandstone aggregate quarry is located in the area in which the Phra Wihan formation is distributed.

The Korat group does not form any fold but is simply inclined about 5 to 10° northeastward. In this area, although there are few faults, high-angle faults are found running from northwest to southeast and from northeast to southwest. In the vicinity of the project area there is a fault with a length of about 6 km (strike: northnorthwest to southsoutheast) at the western end of the plateau on the left bank of the Lam Ta Khong reservoir 7 km to the northwest of the project are. To the north of this fault there is another fault running continuously to the north which is a little large in scale and forms a boundary between the Korat group and the Ratburi group.

The faults in the areas (1) and (2) both are thought to have been formed in old ages and no report has been made on an active fault with the displacement in the Quaternary period.


EXPLANATION
AGE
GROUP
FORMATION
SEDIMENTARY AND METAMORPHIC ROCKS
QUATERNARY
Alluvial gravel, sand, silt, and clay of floodplain and swamp deposits
Terrace gravel, sand, silt; locally laterite, lateritic soil, and tufa
CRETACEOUS
KHOK KRUAT
Grayish-red, reddish-brown, and pale red siltstone, sandstone, and fine calcareous conglomerate
PHU PHAN
Thick-bedded, crossbedded, brownish-gray, pinkish-gray, and orange sandstone and conglomeratic sandstone; reddish-brown siltstone and shale
JURASSIC
KORAT
SAO KHUA
Calcareous, purplish-brown, purplish-gray, and reddish-brown siltstone and sandstone
PHRA WIHAN
Thick-bedded, crossbedded, quartz, quartzitic, white, brown, and yellowish-brown sandstone; purplish-red siltstone and whitish-gray claystone
TRIASSIC
PHU KRADUNG
Calcareous, micaceous, reddish-brown, and purplish-red siltstone; greenish-gray to yellowish-brown sandstone; locally basal conglomerate
Upper TRIASSIC
HUAI HIN LAT
Interbedded gray, brown, yellowish-brown shale, mudstone, siltstone, and argillaceous limestone; basal limestone conglomerate
SAP BON
Thin-bedded, gray, brown, buff sandstone, siltstone, shale, siliceous shale, and chert, intercalated with gray limestone; locally phyllite and schist
PERMIAN
RATBURI
KHAO KHAD
Black, very dark to light gray limestone; recrystallir argillaceous limestone and dolomite with nodular and bedded cherts; intercalated shale, sandstone
PANG ASOK
Thin-bedded gray, bluish-gray, brown, and pale reddish brown shale, slaty shale, and slate with lenticular sandstone and limestone beds; locally hornfels
NONG PONG
Black to dark gray, banded, and laminated limestone and bedded chert; gray, bluish, brownish-gray, grayish-brown, and buff shale, tuffaceous sandstone.
Black, dark and light gray limestone with nodular chert
IGNEOUS ROCKS
Upper TRIASSIC
SOIWOI INTRUSIVES
Undifferentiated, granodiorite, hornblende granite, biotite granite, quartz monzonite, quartz diorite, and syenodiorite; locally stress granite
PERMO-TRIASSIC
KHAO YAI VOLCANICS
Undifferentiated rhyolite, andesite, rhyolitic and andesitic tuffs; agglomerate and volcanic breccia
PHRA NGAM DIORITE
Diorite and hornblende diorite
Lam Tha Khong Project Area
KHAO KHWAN LAN
KHAO YAI THIANG
Sandstone Quarry (Proposed)
Amphoe Pak Chong
KHAO Limestone Quarry (existing)
KHAO MAI LOUK
KHAO INTHAYA
KHAO SAP MUT
KHAO KHWANG
Lam Sai Chanuan
Lam Takhong
Huai Thong Lang
Huai Wang Sai
Huai Yang
Amphoe
METERS
+800
+600
+400
+200
±0
Lam Takhong
A——B
KHAO YAI THIANG
0
5
10
15km
SYMBOLS
Contact
Fault
Anticline
Overturned
Syncline
Strike and dip of bed
A——B Line of section
Mineral Resources
Copper
Quarries
Note: This map is compiled from Geological Map of Thailand (1/250,000) "CHANGWAT PRANAKHON SI AYUTTHAYA" (ND47-8) Published by Department of Mineral Resources in 1985.
LAM TA KHONG PUMPED STORAGE PROJECT
GEOLOGIC MAP OF SURROUNDING AREA OF LAM TA KHONG PROJECT
DWG. 7-1

7.3 Outline of Investigation

7.3.1 Existing Data

Geological data used as references in writing the present chapter are listed in Table 7-1.

7.3.2 Geological Investigation Works

Geological investigation works were carried out at the project area on the plateau on the right bank of the Lam Ta Khong reservoir which upon previous examination was held to the most promising. They are summarized as follows:

(1) Geological Reconnaissance

Area of survey: The upper reservoir site and periphery of the waterway route

Scales of the maps used: 1/50,000, 1/5,000, 1/1,000

(2) Drilling

Area of survey: The upper reservoir site and the waterway route (see DWG. 7-2)

Quantity: 10 holes, 1,050.0 m (see Table 7-2)

Standard penetration test: 8 holes, 23 tests (see Table 7-2)

Permeability test: 10 holes, 173 tests (see Table 7-2)

(3) Pitting

Area of survey: The upper reservoir site (see DWG. 7-2)

Quantity: 4 pits, 17.3 m (see Table 7-2)

In situ permeability test: 2 pits x 2 tests/pit = 4 tests (see Table 7-3)

(4) Seismic Prospecting

Area of survey: The upper reservoir site (see DWG. 7-2)
Quantity: 4 survey lines x 900 m/line = 3,600 m

(5) Drill Hole Deformation Test

Test site: The upper reservoir site and the waterway route
Quantity: 7 holes, 41 tests (see Table 7-2)

(6) Drill Core Test

Sampling location: The upper reservoir site and the waterway route

Quantity: 35 samples (see Table 7-2, 7-4)

(7) Soil Material Test

Sampling location: The pits at the upper reservoir site
Quantity: 16 undisturbed samples, 10 disturbed samples (see Table 7-3, 7-4)

(8) Concrete Aggregate Test

Sampling location: sites proposed for limestone and sandstone quarries (see DWG.7-1)

Quantity: 2 samples (about 300 kg/sample, see Table 7-4)

(9) Rock and Soil Sample Analyses

Samples for analyses: drill cores of the upper reservoir site and the waterway route, the samples of limestone and sandstone proposed as aggregate
Quantity: 13 samples (see Table 7-5)

Table 7-1 List of Reference Data

No.	Items	Remarks
1	Geological Map of Thailand (1/250,000) "CHANGWAT PRANAKHON SI AYUTTHAYA" (ND47-8)	Department of Mineral Resources, 1985
2	Geology of Thailand	Department of Mineral Resources, 1969
3	Report of Lam Tha Khong Geological Investigation (Memo. No. G54)	Royal Irrigation Department, 1963
4	Interpretation Map of Aerial Photograph (1/15,000)	EGAT, Nov. 1990
5	Geologic Map of Project Area (1/50,000)	EGAT, Nov. 1990
6	Geologic Map of Project Area (1/5,000)	EGAT, Nov. 1990
7	Geologic Map of Project Area (1/1,000)	EGAT, Jan. 1991
8	Geologic Logs of Drill Holes	EGAT, Dec. 1991
9	Standard Penetration Test Data	EGAT, Nov. 1990
10	Permeability Test Data in Drill Holes	EGAT, Nov. 1990
11	Permeability Test Data in Test Pits	EGAT, Nov. 1990
12	Drill Hole Deformation Test Data	EGAT, Jan. 1991
13	Geologic Sketches of Test Pits	EGAT, Nov. 1990
14	Seismic Prospecting Data	EGAT, Dec. 1991
15	Laboratory Test Data for Drill Cores	EGAT, Jan. 1991
16	Laboratory Test Data for Samples of Test Pits	EGAT, Jan. 1991
17	Laboratory Test Data of Concrete Aggregate Samples	EGAT, Jan. 1991
18	Problems of Stratigraphic Classification and Environments of Khorat Group	Sangat Piyasin, 1985
19	Engineering Properties of Phra Wihan Sandstone	P. Nutalaya, Chung, 1985
20	Dynamic Elastic Properties of Phra Wihan Sandstone	P. Thanvarachorn et al., 1983

Table 7-2 Geological Investigation Works in Drill Holes

Drill Hole NO.	Location			Length	N-Value Test Qt.	Permea-bility Test Qt. <Depth>	Deforma-tion Test Qt.	Laboratory Test Sample Qt.
	Coordinate X(E)=	Y(N)=	Elevation (m)	(m)				
[Upper Reservoir]								
DHU-1	775,410.82	1,638,046.41	632.14	100.0	5	20 <0－100>	5	4
DHU-2	775,706.01	1,638,044.28	632.08	40.0	2	6 <0－40 >	0	1
DHU-3	775,699.85	1,637,744.42	660.93	50.0	3	10 <0－50 >	0	4
DHU-4	775,402.16	1,637,748.69	638.30	50.0	4	10 <0－50 >	4	2
DHU-5	775,572.42	1,637,894.61	646.38	30.0	1	7 <0－30 >	0	3
[Waterway, Powerhouse]								
DHW-1	775,199.66	1,638,095.07	631.05	230.0	2	37 <4.5-230>	11	2
DHW-2	774,561.61	1,638,283.56	422.83	250.0	4	32 <27.5-224>	2	9
[Tailrace]								
DHT-1	773,826.25	1,638,489.36	316.08	180.0	0	32 <4.5-180>	8	5
DHT-2	773,628.63	1,638,536.37	290.00	70.0	2	12 <4.5-70>	5	2
DHT-3	773,561.94	1,638,553.54	276.84	50.0	0	9 <5－50 >	6	3
Total				1050.0	23	175	41	35

Qt.= Quantity

Table 7-3 Geological Investigation Works in Test Pits

Test Pit No.	Location			Depth	Permea-bility Test	Undisturbed Sample		Disturbed Sample ##	
	Coordinate X=	Y=	EL. (m)	(m)	Qt.	Depth (m)	Sample Qt.	Depth (m)	Sample Qt.
PU-1	775,422.42	1,638,044.32	632.78	5.0	2 *	4.8	6 #	0.5-3.0 3.0-5.0	2
PU-2	775,706.61	1,638,036.02	633.05	2.3	0 **	—	0	0.3-1.2 1.2-1.8	2
PU-3	775,698.07	1,637,747.51	660.41	5.0	2 *	5.0	4 #	0.7-3.1 3.1-5.0	2
PU-4	775,406.86	1,637,737.94	638.42	5.0	0 **	4.9	6 #	0.6-3.1 3.1-4.4 4.4-5.0 0.6-5.0	4
Total				17.3	4		16		10

Qt. = Quantity

* : One is well permeameter test and the other is open-end pipe test.
** : The weathered rocks are too hard to dig the test holes.
# : ϕ = 4 inch, h = 10～20 cm
: Sample weight = 60～70 kg

Table 7-4 List of Laboratory Test

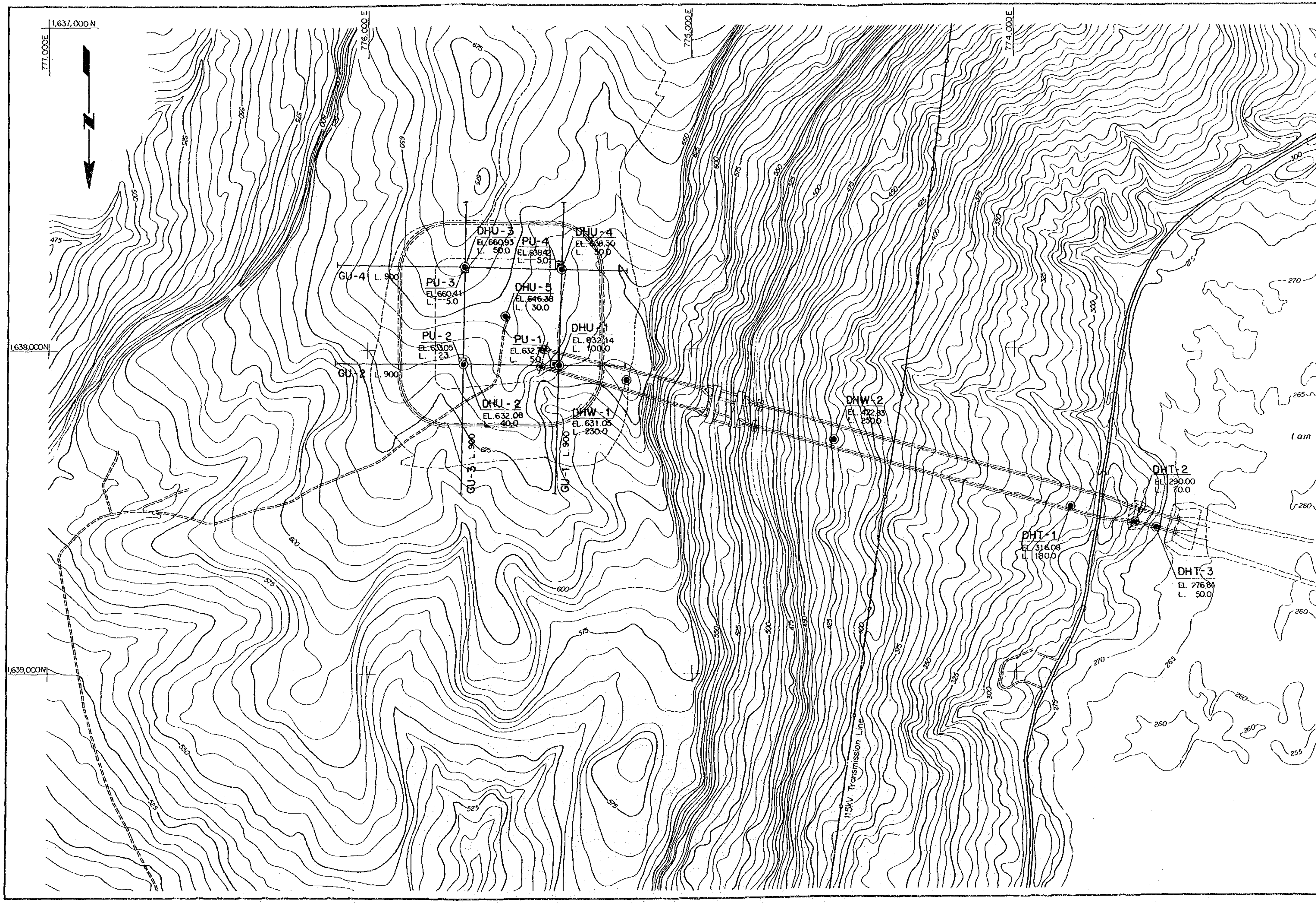
Test Item	Drilling	Test Pit		Quarry, Outcrop	Total
	Core Samples	Undisturbed Samples	Disturbed Samples	Block Samples	
Density, Absorption, Water Content etc.	35	3	10	2	50
Uniaxial Compression, P-Wave Velocity	35	—	—	—	35
Triaxial Compression	—	3	2	—	5
Particle Size Analysis	—	—	10	—	10
Atterberg Limits	—	—	10	—	10
Compaction, Permeability	—		10	—	10
Soundness	—			2	2
Abrasion Loss (Los Angels Machine)	—			2	2

Table 7-5 List of Chemical and Mineralogical Analyses

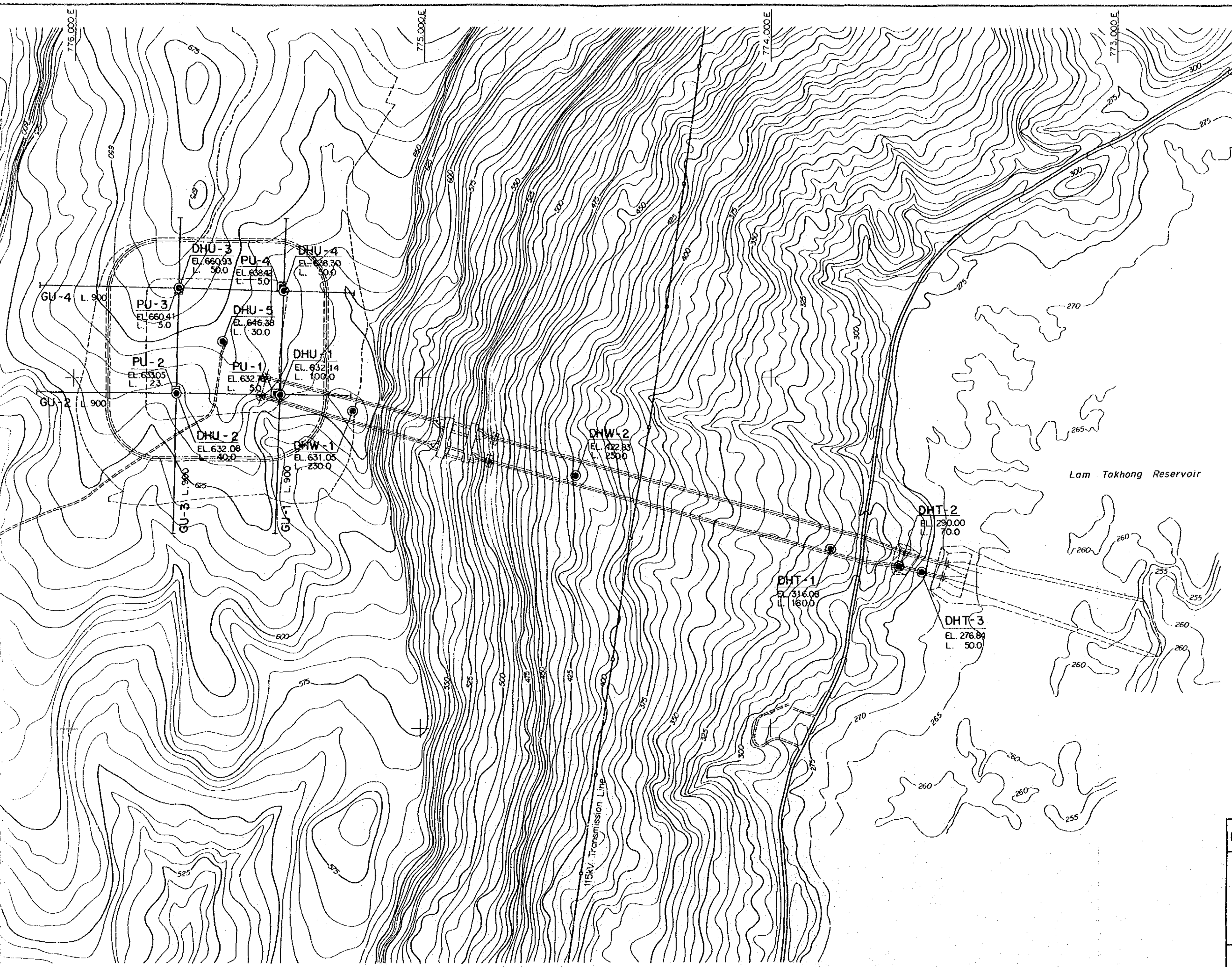
Item of Analysis		Drilling	Quarry, Outcrop	Total
		Core Samples	Block Samples	
Thin Section		4	2	6
X-ray Diffraction	balk analysis	10	2	12
	clay fraction analysis	7	1	8
Chemical Composition	13 components *	2	2	4
	3 components **	1	—	1

* : SiO_2, TiO , Al_2O , Fe_2O_3, FeO, MnO, MgO, CaO, Na_2O, K_2O, P_2O_5, H_2O^+ , H_2O^-

**: Fe_2O_3, FeO, MgO



1,637,000 N
777,000 E
776,000 E
775,000 E
774,000 E
1,638,000 N
1,639,000 N
N
DHU-3
EL. 660.93
L. 50.0
PU-4
EL. 638.42
L. 5.0
DHU-4
EL. 638.30
L. 30.0
GU-4 L. 900
PU-3
EL. 660.41
L. 5.0
DHU-5
EL. 646.38
L. 30.0
PU-2
EL. 633.05
L. 23
PU-1
EL. 632.78
L. 5.0
DHU-1
EL. 632.14
L. 100.0
GU-2 L. 900
DHU-2
EL. 632.08
L. 40.0
DHW-1
EL. 631.05
L. 230.0
GU-3 L. 900
GU-1 L. 900
DHW-2
EL. 422.83
L. 250.0
DHT-2
EL. 290.00
L. 70.0
DHT-1
EL. 316.08
L. 180.0
DHT-3
EL. 276.84
L. 50.0
115kV Transmission Line
Lam Ta



LEGEND

DHU - 1 / EL. 300.00 / L. 100.0 — Drill Hole
EL. : Elevation (m)
L. : Length (m)

PU - 1 / EL. 300.00 / L. 50.0 — Test Pit
EL. : Elevation (m)
L. : Length (m)

GU-1 L.900 — Geophysical Prospecting
L. : Length (m)

Drill Hole Name	Location			Length
	Coordinate		Elevation	
	X (E)=	Y (N)=	(m)	(m)
Upper Reservoir				
DHU-1	775,410.82	1,638,046.41	632.14	100.0
DHU-2	775,706.01	1,638,044.28	632.08	40.0
DHU-3	775,699.85	1,637,744.42	660.93	50.0
DHU-4	775,402.16	1,637,748.69	638.30	50.0
DHU-5	775,572.42	1,637,894.61	646.38	30.0
Waterway, Powerhouse				
DHW-1	775,199.66	1,638,095.07	631.05	230.0
DHW-2	774,561.61	1,638,283.56	422.83	250.0
Tailrace				
DHT-1	773,826.25	1,638,489.36	316.08	180.0
DHT-2	773,628.63	1,638,536.37	290.00	70.0
DHT-3	773,561.94	1,638,553.54	276.84	50.0
Total				1050.0

Test Pit Name	Location			Depth
	Coordinate		EL.	
	X=	Y=	(m)	(m)
PU-1	775,422.42	1,638,044.32	632.78	5.0
PU-2	775,706.61	1,638,036.02	633.05	2.3
PU-3	775,698.07	1,637,747.51	660.41	5.0
PU-4	775,406.86	1,637,737.94	638.42	5.0
Total				17.3

0 500m

LAM TA KHONG PUMPED STORAGE PROJECT

LOCATION MAP OF GEOLOGICAL INVESTIGATION WORKS

DWG. 7-2