3.3.2 Road Network in Lao PDR

Road network in Lao PDR is composed of primary road, secondary road, feeder road and special road. All national roads and most provincial roads are classified as primary roads. Other total length of road network in Lao PDR is about 13,094 Km, of which National Roads share 3,486 Km, Provincial Roads 6,149 Km and District Roads 3,456 Km as shown below. Road density in Lao PDR is about 0.055 Km/sq.Km (13,094 Km/236,800 sq.Km).

Category	Length(km)
National Road	3,486 km
	(3,356 km)/a
Provincial Road	6,149 km
District Road	3,459 km
Total	13,094 km

/a shows figure from CDRI's map.

Primary roads are numbered from 1 to 23. National roads consist of Route No.1, 2, 4, 6, 7, 8, 9, 10 and 13. The trunk route in the Lao PDR is Route No.13 which starts from the southern border of Cambodia, via Vientiane and ends in Luangprabang (road net work is shown in Figure 3.1). Several routes can not be found on the map because those are in schedule.

Length of national roads in 1990 are shown as below.

Route Number	Length(km)
Route No.1	633
Route No.2	85
Route No.4	332
Route No.6	241
Route No.7	279
Route No.8	132
Route No.9	243
Route No.10	40
Route No.13	1,371
Total	3,356 km

Source: Communication, Design, Research Institute

Source: Communication, Design, Research Institute

Generally Provincial roads are not numbered. The provincial road on which the Project bridge is located is, however, given serial number Route 10, although another National Route No.10 exists in Province Pakse.

Road lengths classified by the surface type are presented as follows. (refer to Table 3.2)

Category	Length
Paved	2,560 km
Lateritic/Gravel	3,750 km
Unpaved/Earth	6,790 km
Total	13,100 km

As it can be seen above, paved roads account for only about 2,500 Km or 19.6% of total road length. The remainder is classified as lateritic/gravel or unpaved/earth surface roads. Although there has been no accurate road and bridge inventory in Lao PDR, it is obliged to say on the basis of collected data by the Team, that only one or two hundred Kilometers(100-200Km) or less in total national road length are in "fair" condition. Those are a part of route 13 North, South and a few part of other routes. Thus remaining roads are belonging to a poor or bad category and can pass only with 20-30 Km/hr of travelling speed. This indicates that approximately 13,000 Km of national roads are in bad condition.

Under the circumstances, vehicles can use the roads mostly in dry season. Moreover, on several roads, vehicles can not pass the roads when rain comes, even in dry season.

Since the last decade, the Government of Lao PDR has intended to improve the existing road and develop new ones to facilitate commodity and passenger flow in the country. As a result, however, only few part of Route 13 is upgraded into a good condition, and other portions are still being constructed with ADB Loan, Swedish Government assistance(SIDA) and/or IDA.

A part of Route 10, the section between Ban Hai and Nam Ngum river was improved with ADB Loan (refer to Figure 3.2). Route 10 is consisting of two (2) three (3) meter lanes, one and a half (1.5) meter shoulders on both sides. Pavement consists of DBST (Double Bituminous Surface Treatment), prime-coat, base course (Laterite mixed with sand or aggregate), subbase course (Laterite) as shown in Figure 3.3. Lime stabilization or cement stabilization with a mix percentage of 1-1.5% is rarely used for base course in Lao PDR.

3.4 Bridges Over Nam Ngum River

Only two permanent bridges at Thinkeo and Ban Hai cross the Nam Ngum River within Vientiane Plain. The other bridges in Vientiane Plain crossing the rivers other than Nam Ngum mostly have a short span or they are one-lane bridge in use as temporary one. The existing conditions visually observed on these bridges give valuable information for selecting and planning the type of the Project bridge, which are summarized as follows.

3.4.1 Thinkeo Bridge

The bridge was completed in 1968 within 14 months of it's commencement. It is an 8 span simple P.C. girder bridge crossing the Nam Ngum River at Ban Thalat, approximately 80 kilometer of Ban Tha Ngon. (refer to map)

The bridge is 245 meter long with one lane. The carriageway width is 3.75 meter with 0.5 meter side walks on both sides. Substructure consists of R.C. piles and piers. 35 cm x 35 cm section R.C. piles were driven to base rock for pier foundation.

The live load adopted was 58 tons trailer without impact load or 35 ton trailer including 25% impact load, whichever is larger.

It appears that the superstructure of the bridge has not suffered serious damages in appearance in spite of no maintenance work. However, the following problems were found:

a. wearing of concert deck/slab
b. leaning the post about 10 cm from the top
c. fall on drain water on concrete beam

As for the substructures, a problem of riverbed scour had been a matter of concern. In this regard, riverbed sounding survey was conducted for 3 years towards April 1970 to observe the extent and periodical development of the scour around the piers.

The surveys revealed that the scour of the riverbed had been growingly taking place at the foundation areas of piers and it would further develop to a hazardous extent for the pier structures. Especially, the depth of scour at pier No.4 had reached the maximum of 1.5 meters.

A cause of the extensive scour, particular to this bridge, was turbulent flow in the area between piers No.3 and No.4 caused by exposed rocks and boulders existing in an area from pier No.3 to 100 meters upstream the bridge. The flow seemed to accelerate the scour particularly in the area of pier No.4. Local turbulent flow at each pier due to the existence of piles in the flow also caused the riverbed scour at the respective pier foundation.

Thus, it was recommended to provide scour protection work in the last dry season of the project period, i.e. the 1970/71 dry season.

A proposed scour protection work was to provide a protective layer of 50 centimeters minimum thickness with prefabricated concrete blocks, each weighing 40 Kg or more, covering an area of 14 meters by 17 meters at piers No.2, 3, 4 and 5 respectively. It is notified that these considerations paid for preventing the progressive scouring around the R.C. piles shall be taken into account for the determination of the type of foundation of the project bridge.

3.4.2 Ban Hai Bridge

This bridge is also located on the Nam Ngum River at Ban Hai 80 kilometers down stream from Tha Ngon. (Shown in Fig.3.2) The bridge was constructed in 1984 by USSR and its construction took 4 years.

It is a 254 meters long four (4) span steel girder bridge with two 4

meter lane carriageway (total of 8.0 meters) and 1.0 meter of side walks on both sides. According to an engineer who had been involved in construction work, cast-in-site piles (Benoto Method) were employed for the foundation of substructure.

Other than bridges on Nam Ngum River, Nam Kading bridge was being constructed last year by one of the state enterprise with USSR's Official Aid.

3.5 State Enterprises

Construction and maintenance works for roads and bridges are carried out mainly by the state enterprises. They are primarily established to cover the whole range of each main route. However, only 11 enterprises are active as of July 1990 according to the authorities concerned as below (see Table 3.3).

Name
1. Route No.10
2. Route No.13(South)
3. Route No.13/1
4. Route No.13/2
5. Route No.13/3
6. Route No.13/4
7. Route No.8
8. Route No.20
9. Pakse - Savannakhet
10. State enterprise for bridge construction (pakse)
11. Construction Communication Society

Other than those listed above, 9 maintenance brigades operate for road and bridge maintenance across the Lao PDR. Each brigade is obliged to maintain approximately 200 km of road annually with less amount of equipment compared with other state enterprises. Fundamentally these brigades are required at least for each province. Which means, six(6) or seven(7) more maintenance brigades are necessary in Lao PDR to carry out a sufficient maintenance work. Due to lack of maintenance work, erosion at pavement edges, heavy damages on the pavement (pot holes) in many places have occurred.

Table 3.1 Trend of Transport Charge

Year	Charge Kip/T.Km	Price of Gas. Kip/L
1985	10	45
1986	15	50
1987	17	75
1988	22	96
1989	26	145
1990	30	170

Source: Transport Company, Vientiane Municipality

Table 3.2 Road Length by Surface Type

Category	Length (Km)	Share (%)
Paved	2,560	19.6
Lateritic/Gravel	3,750	28.6
Unpaved/Earth	6,790	51.8
Total	13,100	100.0

Table 3.3 Name of State Enterprises and its Capability

Name of Enterprise	Capacity per Year
1. Route No.10	30 Km
2. Route No.13(South)	30 Km
3. Route No.13/1	
4. Route No.13/2	
5. Route No.13/3	
6. Route No.13/4	
7. Route No.8	20 Km
8. Route No.20	25 Km
9. Pakse - Savannakhet	
10. State enterprise for bridge construction (pakse)	
11. Construction Communication Society	

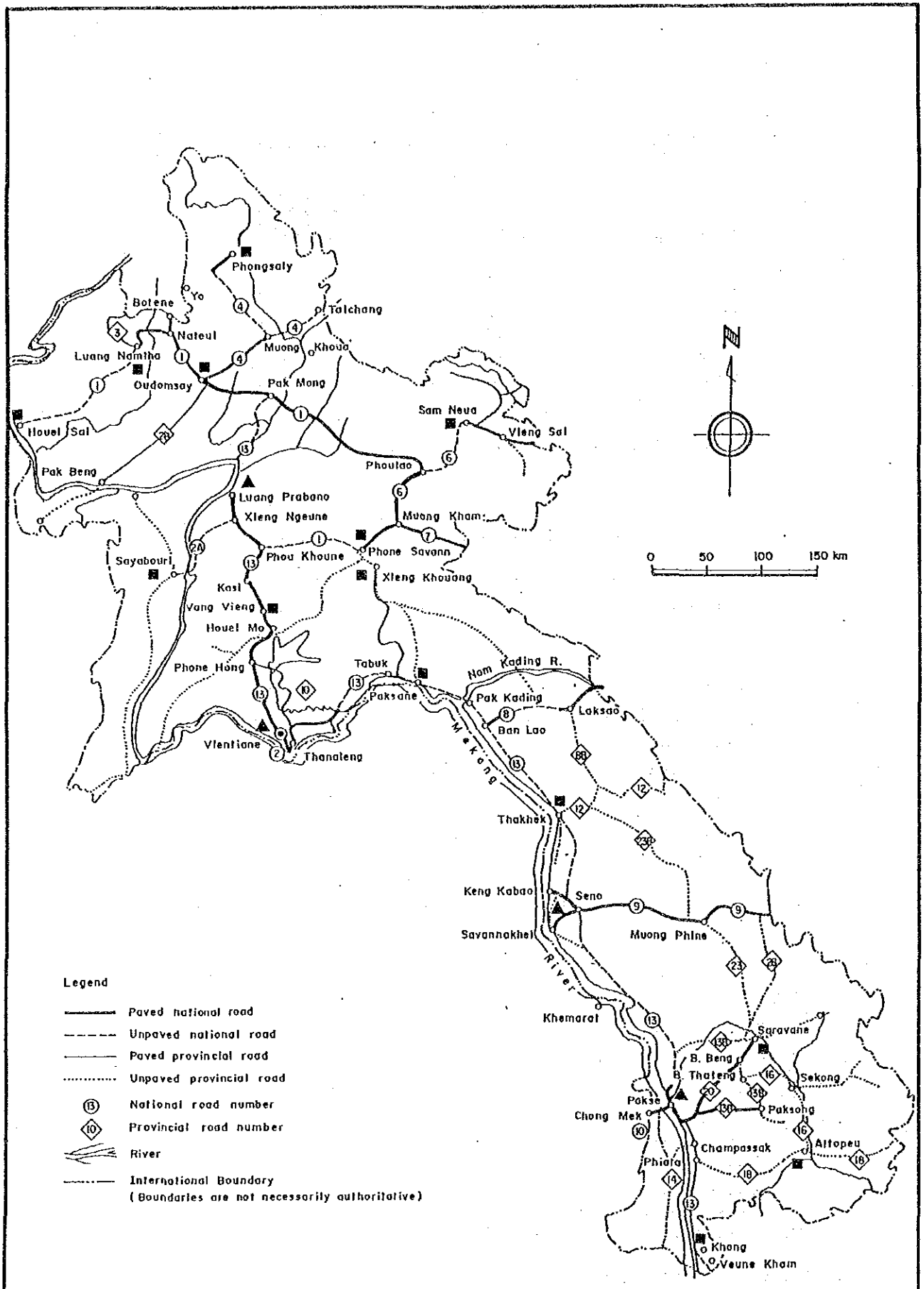


Figure 3.1 Road Network in Lao PDR

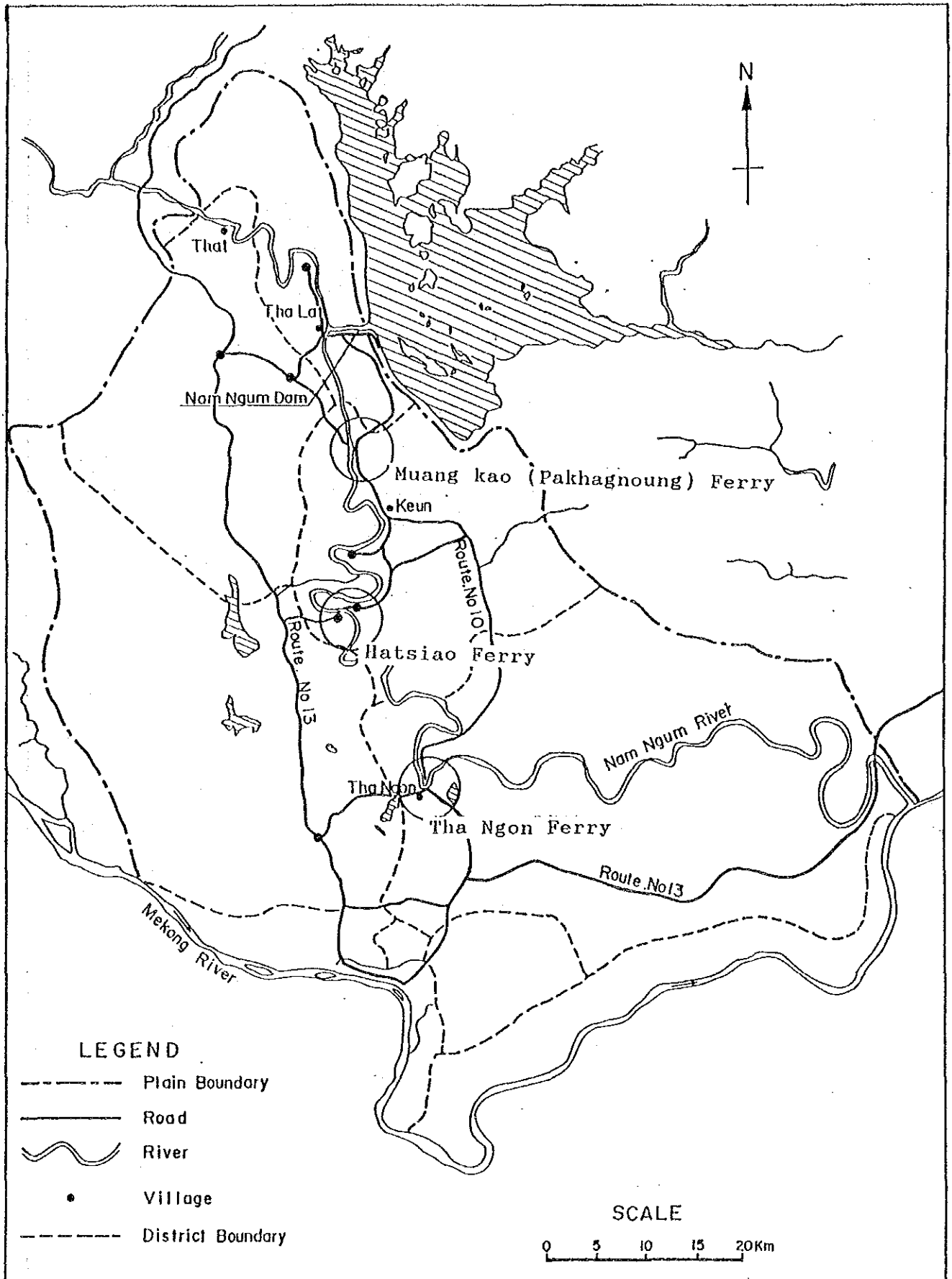


Figure 3.2 Road Network in Vientiane Plain

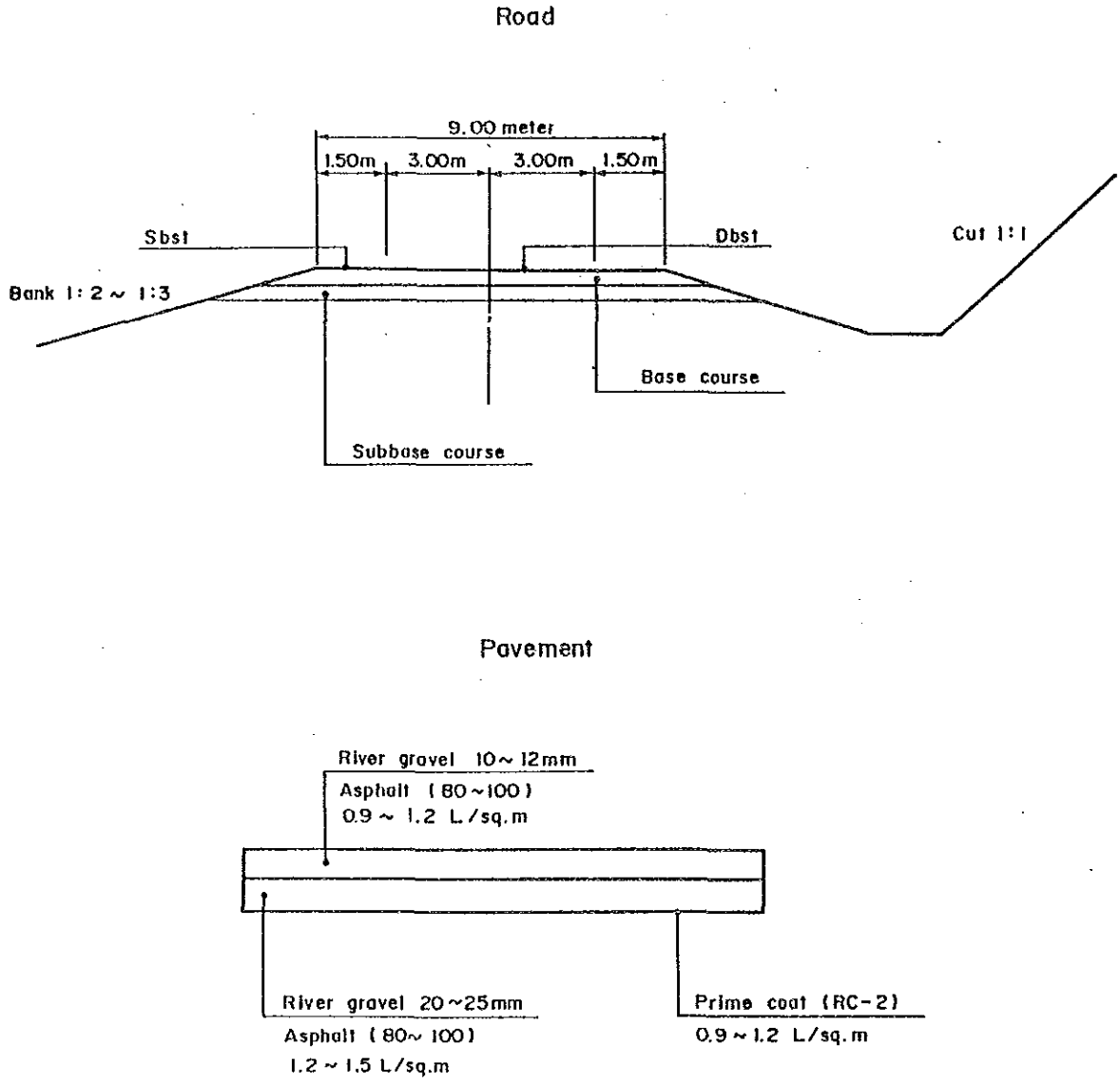


Figure 3.3 Road Structure of Existing Route No.10

CHAPTER IV

FERRY CROSSING NAM NGUM RIVER

CHAPTER IV FERRY CROSSING NAM NGUM RIVER

4. Ferry Crossing Nam Ngum River

There are three ferry crossing points along Nam Ngun River between Tha Ngon and Thinkeo as depicted in Figure 4.1. Tha Ngon ferry transports the largest volume among three ferries.

4.1 Tha Ngon Ferry

4.1.1 Operation

At Tha Ngon, a public ferry and several private ferries operate. Traffic between 10 pm and 6 am is almost none existing in accordance with the traffic survey conducted in February 1990. Nevertheless, at least one operator is on duty all night long even no vehicle comes to cross Nam Ngum River. There are about half hour breaks during the ferry operations between 7 and 8 am for breakfast, and 12 am and 1 pm for lunch.

The ferry has two sets of fares; day time and night time. According to vehicle type and size, the fares are set as follows:

Vehicle Type	Day Time	Night Time
Bicycle	25 Kip	35 Kip
Motorcycle	60 Kip	90 Kip
Passenger	200 Kip	300 Kip
Pick-up	350 Kip	525 Kip
Small bus/truck	420 Kip	530 Kip
Truck 5-8 tons	500 Kip	750 Kip
Truck 8-12 tons	600 Kip	900 Kip
Big bus/truck 12-14 tons	750 Kip	1,125 Kip
Truck 14-20 tons	1,000 Kip	1,500 Kip

The company submitted the plan of 20% increase in ferry fares for MCTPC's studying. Ferry charges at Tha Ngon, however, are relatively high, compared with rates of Chaopuraya River, Bangkok.

Two private ferries supplement the public ferry. They operate when the public ferry does not operate or when cyclists and pedestrians are in a hurry. The private ferries are made of two small wooden boats which are joined with boards, like a catamaran. The fare is 150 Kip for motorcycle, 50 Kip for bicycle, and 20 Kip for person (free for pupils and students).

Since January, 1990, ferry operation has been experiencing difficulties because the break down of spare parts mainly related ferry boat every night.

The numbers of operating days since the beginning of 1990 are as follows:

	days of operation	days of no operation
January	31 days	0
February	21	7
March	26	5
April	16	14
May	16	15
June	29	1

Average number of ferry trips was 58.5 times per day during the traffic survey in February. Based on the supplemental traffic survey in July, it is estimated that the ferry makes about 41 round trips per day during the rainy season.

The public ferry at Tha Ngon was constructed in December 1987. The ferry, which was financed by Asian Development Bank, cost 360,000 US$. The life of the ferry boat is some 10 years. It is installed with two 136 PS (horse-power) diesel engines normal loading capacity is 45 tons. The ferry can cross Nam Ngum River even during a flood.

According to the ferry company (State Enterprise Route No.10), the ferry operation makes some benefit every month.

4.1.2 Ferry Operating Costs

The operating costs of the ferry boat consist of the costs of diesel, engine oil, spare parts and maintenance, wages, and overhead. Depreciation will be considered separately for economic evaluation. According to an interview survey, monthly financial operating costs are estimated at 1.559 million Kip. Import taxes are 5% for diesel, 7% for engine oil, 10% for spare parts (two thirds of maintenance costs are assumed to be spent for spare parts) and income tax is 5%. Thus, the economic operating costs are estimated at 1.486 million Kip (2.196 US$) per month.

Item	Unit price	Quantity	Cost ('000) Financial	Economic
Diesel	170 Kip/l	6,000	1,020	969
Oil	675 Kip/l	40	27	25
Salary	30,000 Kip	9	270	257
Maintenance			100	93
Overhead			142	142
Total			1,559	1,486

According to a shipbuilding company, some 7% of the price should be spent for maintenance every year. This implies that maintenance cost should be 1.49 million Kip (2,100 US$) per month which is 15 times of actual spending for maintenance. Costs for overhauling the engines, which are required every two years, are included in this amount. Also, after 4 to 5 years, a ferry boat should be docked. Docking costs no more than 20% of the price.

Ramps on both sides of Nam Ngum River have deteriorated because of scouring. According to the ferry company, repairing cost of ramps is about 1 million Kip every year.

4.1.3 Transport Capacity

1) Observed Capacity

Tha Ngon ferry accommodates two heavy vehicles, or six small vehicles at maximum. Besides these vehicles, motorcycles, bicycles, and pedestrians are loaded near the landing flaps.

Including loading and unloading, it takes about three to five minutes for the ferry to cross Nam Ngum River during dry season and five to ten minutes during the rainy season. Naturally, the more loaded, longer the loading and unloading time. Theoretically, the ferry can transport 120 and 72 passenger car units at maximum during the dry and rainy seasons respectively.

According to the traffic survey carried out in February, 40 passenger car units (PCU) was the largest number which the ferry transported within one hour: At the end of this hour, some vehicles were still on the waiting line. Therefore, 80 PCU's seems to be close to the actual maximum transport capacity per hour for both directions during the dry season.

Crossing time including waiting time is 10.5 minutes in average during the dry season according to the traffic survey carried out in February. Looking at hourly traffic, most of the average crossing time falls into 6 to 12 minutes as illustrated in Figure 4.1. There is no relation between hourly traffic volume and crossing time(see Figure 4.2). This is because the range of present traffic volume is less than the maximum transport capacity of the ferry and crossing time is highly influenced by arriving amount of vehicles on both sides of Nam Ngum River.

2) Simulation of Nam Ngum Crossing Time

Increasing ratio of Ferry waiting time is bigger than that of traffic volume. Time to cross Nam Ngum River for future traffic can be estimated by simulation with a queuing model. Nam Ngum crossing time simulation is based on the following conditions and assumptions derived from observations of actual ferry operation:

a) Unit time is minute. Simulation period is one hour.

b) Traffic volume of both directions are equal.

c) Due to no traffic control in the vicinity of ferry ramps on both sides, vehicles arrive at the ferry ramp at random.

d) Traffic shares are 24% for passenger cars, 23% for pick-ups, 9% for medium trucks, 31.% for heavy trucks, 6% for light buses, and 7% for heavy buses, which are the results of the traffic survey in February 1990. Motorcycles are excluded from the simulation because their crossing time is independent from total traffic volume, with riding on private ferries which other types of vehicles cannot use. Each type of vehicles arrives at random.

e) It takes five minutes for the ferry to finish one-way trip, including loading and unloading.

f) The ferry boat accommodates six passenger can units at once. Conversion factors are one for passenger cars, pick-ups and light buses, two for medium trucks, and three for heavy trucks and heavy buses.

g) The service order is not necessary the same as the arrival order to minimize unloading space. For example, a smaller car like a passenger car arriving at the ferry ramp after a heavy truck rides on the ferry before the truck when unloading space on the ferry is not enough for the truck.

h) In order to operate in an economical manner, the ferry does not operate unless the sum of ferry charges of vehicles on board exceeds 500 Kip.

i) When the sum of ferry charges of vehicles waiting for the ferry on the other side exceeds 750 Kip, the ferry goes to other side even though the sum of ferry charges of vehicles on board is less than 500 Kip.

The simulation reveals that crossing time does not significantly change while traffic volume is less than 20 per hour for one direction. The present situation of Tha Ngon Ferry falls into this range of traffic volume.

Traffic volume per hour/a	Crossing time/b (min.)	Average queue length/b	Clearing time/b (min.)	No. of car loaded per hour/b
10	10.0	0.9	67.8	8.4
15	11.6	1.9	68.8	13.4
20	11.2	2.2	73.2	17.8
25	17.8	4.5	85.2	18.4
30	24.1	6.2	103.6	18.6
35	31.6	8.7	111.6	18.6
40	40.8	11.2	131.6	18.0

/a for one direction; excluding motorcycles
/b average of two directions, which is average of five times of simulation

The crossing time increases sharply beyond 25 cars per hour as shown in Figure 4.3. The curve of the crossing time significantly fits the following equation::

$$Y = 0.037X^2 - 0.793X + 14.293 \quad (R^2 = 0.991)$$

where, Y : crossing time
X : hourly traffic volume of one direction excluding motorcycles.

The average queue length increases along with increasing traffic volume. With more than 30 vehicles per hours, some vehicles waiting for the ferry are likely not to be able to get on the next ferry trip since average queue length is over six vehicles.

The clearing time which is required for the last vehicle within one hour to cross Nam Ngum River exceeds two hours when traffic volume of in direction is over 40 vehicles per hour. This means that every vehicle arriving at the ferry ramp during the following hour must wait for over two hours.

The ferry is estimated to be able to transport approximately 18 cars for one direction per hour. This implies that waiting queue becomes longer and longer when traffic volume of one direction is over 18 per hour. Nam Ngum crossing time exceeds one hour when traffic volume of two directions, exclud-

ing motorcycles, reaches 600 per day. If motorists are sure that it will take over one hour to cross Nam Ngum River at Tha Ngon, a part of traffic will divert form Route 10 to Route 13. This would occur when traffic volume is approaching 600 per day without the Project.

Hourly traffic volume (one direction)	20	21.5	25	30
Daily traffic volume (two directions)	560	603	700	840
Average crossing time (minute)	31	60	172	447

Note: Traffic volume does not include motorcycles.
Daily traffic volume is hourly traffic volume times 14 hours.

Briefly, Nam Ngum Crossing at Tha Ngon will be a bottleneck of economic development in the influence area when traffic volume reach 600 per day excluding motorcycles.

4.2 Hatsiao Ferry

The ferry boat at Hatsiao is made of seven iron boats. The operating hours are 8 to 12 am and 2 to 5 pm. Daily traffic is about 10 cars. The traffic increases when the Tha Ngon ferry does not operate. The ramps on both shores are not paved and require grading regularly. During the rainy season, the ferry crossing point on the left bank (Hatsiao) is not accessible from Route 10.

4.3 Muangkao (Pakhagnoung) Ferry

As of February 1990, a public ferry boat made of seven iron boats was operating between Muangkao and Pakhagnoung. Nevertheless, the boat was abandoned on May. Since then, no public boat has been in operation. However, some traffic demand for crossing the Nam Ngum River exists because there are offices of Vientiane Province at Muangkao.

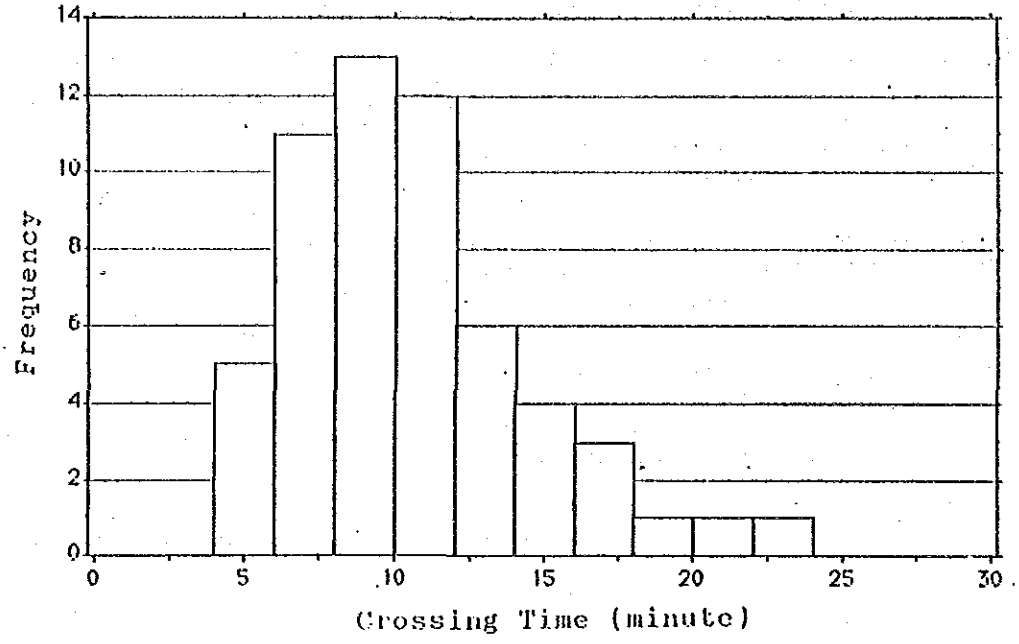


Figure 4.1 Distribution of Nam Ngum Crossing Time

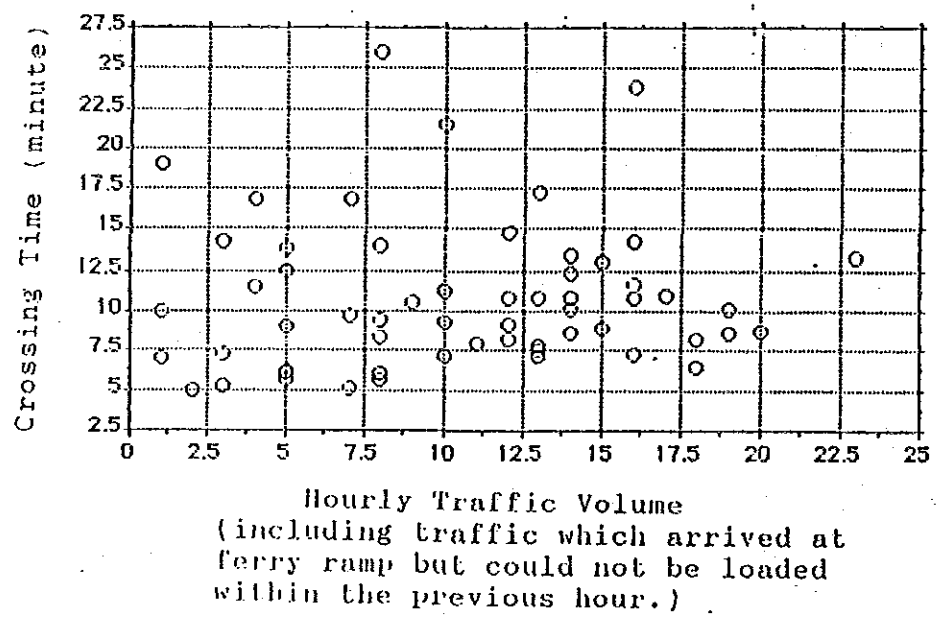


Figure 4.2 Traffic Volume and Nam Ngum Crossing Time

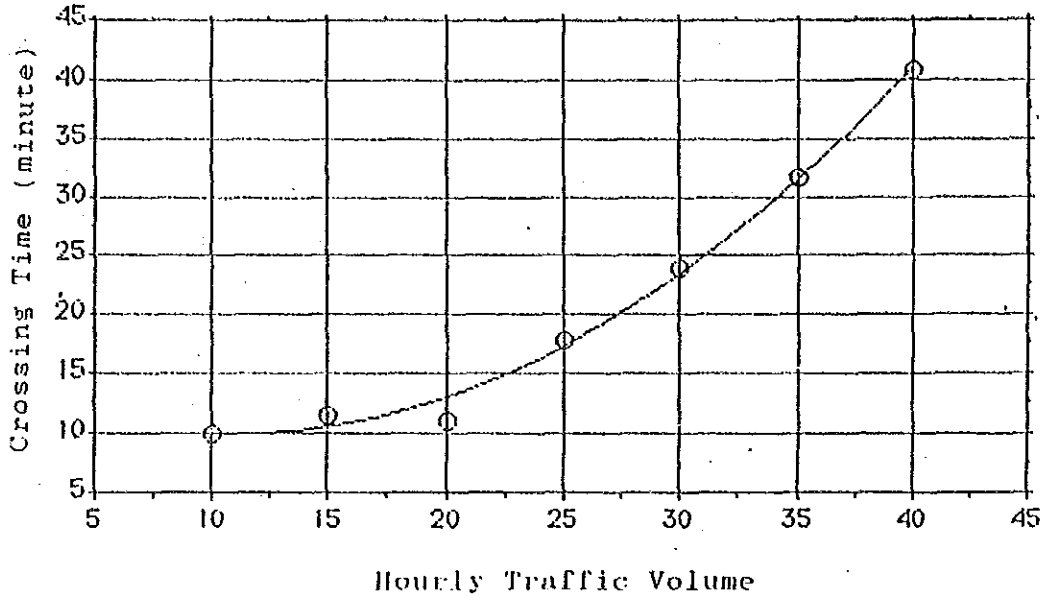


Figure 4.3 Simulated Nam Ngum Crossing Time

CHAPTER V

TRAFFIC SURVEY

CHAPTER V TRAFFIC SURVEY

5 Traffic Survey

5.1 General

Traffic survey consisting of cross-sectional traffic volume survey and O-D survey was conducted from February 21st to 28th, for a total of 7 days (1-week) at Ban Tha Ngon on route 10 and Naxaythong on route 13.

Cross-sectional traffic volume survey was carried out from cearly morning (5:00 AM) up to nine o'clock (9:00 PM) in night, except the 27th.

On the 25th of February, O-D was executed simultaneously with the cross-sectional traffic volume survey for a time period of 16 hours.

Besides above, 24 hours observation (O-D and Cross-sectional traffic volume survey) was done on 27th.

Summary of traffic survey carried out is as follows:

Date	Cross-sectional	O-D
21st(Wed)	Done 16-Hr(5am-9pm)	-
22nd(Thus)	Done 16-Hr(5am-9pm)	-
23rd(Fri)	Done 16-Hr(5am-9pm)	-
24th(Sat)	Done 16-Hr(5am-9pm)	-
25th(Sun)	Done 16-Hr(5am-9pm)	Done 16-Hr
26th(Mon)	Done 16-Hr(5am-9pm)	-
27th(Tue)	Done 24-Hr(5am,27th-5am,28th)	Done 24-Hr

5.2 Cross-sectional Traffic Volume

5.2.1 Traffic Volume on Route 10, at Tha Ngon

Ban Tha Ngon about 21 km north from Vientiane on route 10 has a ferry boat facility to cross over the Nam Ngum River. At Ban Tha Ngon, traffic volume, number of ferry crossings, alternative routes during no ferry operation and crossing time were surveyed.

Typical traffic at Tha Ngon on route 10 from 6 o'clock in the morning is coming from Ban Hai/Ban Keun.

As the result of cross-sectional traffic volume survey at Ban Tha Ngon, existing daily traffic is considered between 380 and 740 unit vehicles, including motor-cycles in both directions as indicted in Table 5.1.

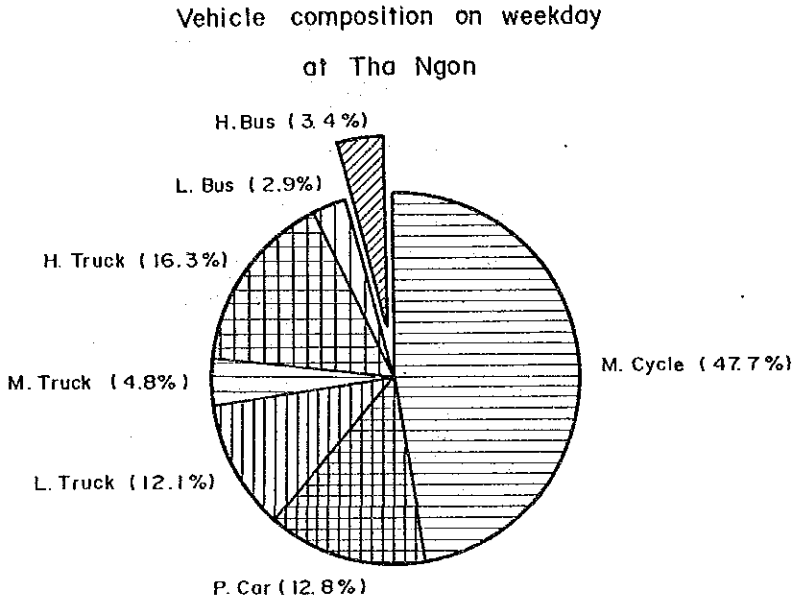
In the average, except Sundays and the days when ferry is not in operation, daily traffic volume (day time) is 515 units on both directions, which consists of 246 motorcycles, 64 passenger cars, 61 light trucks (pick-up), 25 medium trucks, 86 heavy trucks, 15 light buses, and 18 heavy buses as shown in Table 5.1.

If the night volume is considered, this daily traffic volume becomes 524 instead of 515 as shown in the Table 5.1, this is in accordance with the percentage of night traffic against day time traffic (Night/Day Ratio, 4% max. for passenger car).

The ferry is basically operated 24 hours. At night (10pm - 5am), however, the driver has to wake up ferry operator to ask operation. Moreover, night-time fare is 150% high than day-time fare. Night time traffic volume, therefore, is very small.

Existing Night/Day Ratio(NDR) at Tha Ngon is very small, when compared with the NDR of Naxaythong. Therefore, the NDR of Naxaythong, shall be used for future traffic volume forecast.

Existing component of vehicles at Ban Tha Ngon is as shown below;

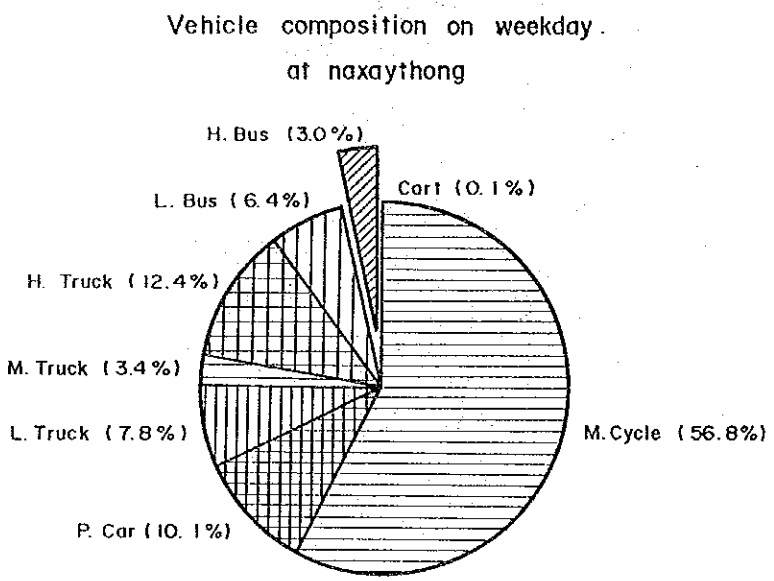


5.2.2 Traffic Volume on Route 13, at Naxaythong

Traffic volume at Ban Naxaythong was also observed in the same manner with Ban Tha Ngon.

Although vehicle component varies by day/date in a week, traffic volume was counted constantly at two thousands(2,000) which a half of these were motor-cycle(50~57%). Average daily traffic volume except Sundays was 2,013 consisting of 1,101 units of motor-cycles, 201 passenger cars, 163 light trucks(pick-ups), 74 medium trucks, 260 heavy trucks, 146 light buses, 62 heavy buses, and 2 ox-carts as in Table 5.2.

Component of vehicles at Ban Naxaythong is shown in the following Figure;



Typical traffic at Ban Naxaythong on route 13 starts for 5 am as commuting traffic and there are vehicles still moving to/from Vientiane after 10 pm. Volume of night time traffic is 3 to 20 percent of day-time traffic, depending on type of vehicle. When night traffic volume is considered, obtained daily traffic volume becomes 2,331 instead of 2,013 units as shown in the Table 5.2. Summary of Night/Day Ratio at Ban Naxaythong is also available from Table 5.2.

5.2.3 Cross-sectional Traffic Volume

As aforementioned, cross-sectional traffic volume survey was carried out on February 1990 at Naxaythong and Tha Ngon.

follows:

M.cycle	P.Car	P.up	M.Truck	H.Truck	L.Bus	H.Bus	Total
250	67	63	25	86	15	18	524

February belongs to dry season in Lao PDR, therefore additional traffic survey in rainy season was conducted on the 6th of July 1990 at Tha Ngon, from six(6) o'clock in the morning to five(5) o'clock in the evening.

Traffic volume was lower than dry season and it took six(6) to ten(10) minutes to cross the river. This means that crossing time is more than three(3) times that of dry season which is only two and half(2.5) minutes to cross the river.

Traffic volume however, was about 74% (not a half) that of dry season. Component of traffic was nearly same as in dry season. Following figures show observed traffic volume at Tha Ngon on the 6th of July 1990 by the Study Team, during an 11 hour survey.

M.cycle	P.Car	P.up	M.Truck	H.Truck	L.Bus	H.Bus	Total
136	40	28	19	57	16	16	312

Therefore daily traffic volume at Tha Ngon, which was observed in February 1990, shall be modified with scrutinized figures obtained through additional survey.

The influence area has a dry season of almost eight(8) months and a rainy season of remaining four(4) months. With above mentioned traffic volume and duration of rainy season, average daily traffic volume can be calculated as follows:

$$74\% \times (4/12) + 100\% \times (8/12) = 91.3\%$$

This figure shows that approximately 91% of traffic volume mentioned in

This figure shows that approximately 91% of traffic volume mentioned in the Interim Report (I) shall be the average daily traffic volume through a year.

Adjusted average daily traffic volumes are as follows:

M.cycle	P.Car	P.up	M.Truck	H.Truck	L.Bus	H.Bus	Total
224	60	55	24	81	17	18	479

5.3 O-D Survey

5.3.1 Zoning

As mentioned before, there are 8 administrative districts in Vientiane Municipality:

1) Chanthabouri
2) Sisattanak
3) Xaysettha
4) Sikhottabong
5) Hatxayfong
6) Xaythani
7) Nawaythong
8) Phialat

On the other hand, Vientiane Province has 9(nine) districts:

9) Xanakham
10) Muang Feuang
11) Phonehong
12) Kasi
13) Vangviang
14) Xaysomboun
15) Keo Oudom
16) Muang Hom
17) Thourakhom

Out of 17 districts, the project area spreads to the following districts;

1) Chanthabouri
2) Sisattanak
3) Xaysettha
4) Sikhottabong
5) Hatxayfong
6) Xaythani
7) Naxaythong
8) Phialat
9) Phonebong
10) Keo Oudom
11) Thourakhom

Before starting O-D Survey, the project area was divided into 12(twelve) zones with considering the existing road network, administrative districts, population and in accordance with the information concerning actual traffic flow in the area. Established and employed zones for the Study are shown in Figure 5.1.

5.3.2 O-D Survey Form

O-D survey from (attached hereafter including questionnaires to the drivers) was designed referring to the forms used in Japan and other similar countries (see Figure 5.2).

Items involved in O-D survey form were;

1) Time
2) Type of vehicle
3) Origin
4) Destination
5) Ownership
6) Aim of trip
7) Passenger/load
8) Kind of cargo
9) Possibility to use the proposed Tha Ngon Bridge

Note: Last item (No.9) was asked only on Sunday, 25th at Naxaythong

Roadside Origin-Destination Survey was carried out on Sunday, 25th (16 hour) and Tuesday, 27th (24 hour inspection, until 5 o'clock, 28th) of February 1990.

5.3.3 O-D Survey on Route 10

Aiming a 100 percent interview rate, O-D survey was carried out on both banks at Ban Tha Ngon Ferry crossing, for a period of 16 hrs on 25th and 24 hrs on 27th of February 1990. Traffic generates mainly from Vientiane (34%), Ban Keun(30%) and Hatkiang(18%) and concentrates to Vientiane(45%), Ban Keun(23%) and Hatkiang(17%).

From the viewpoint of Origin-Destination survey, trips from Ban Keun to Vientiane were 133, from Vientiane to Ban Keun were 103, from Hatkiang to Vientiane were 68 and Vientiane to Hatkiang were 55 units.

Results of O-D survey are shown in Table 5.3.

69% of total traffic passing through the Ban Tha Ngon falls into the Vientiane - Ban Keun route and Vientiane - Hatkiang route. This pattern fundamentally does not differ on week days or even on Sundays.

Aims of trip were also interviewed. Ordinary, aims of trips are;

Weekday	Sunday
i) commutation	recreation
ii) shopping	shopping
iii) on duty	commutation
v) others	others

5.3.4 O-D Survey on Route 13

O-D survey at Ban Naxaythong, having 2,300 units of daily traffic, was performed for a period of 16 hrs on 25th and 24 hrs on 27th of February 1990, same as Ban Tha Ngon, which showed 49% of traffic generated from Naxaythong, 33% from Vientiane and 11% Naxaythong(45%), to Vientiane(36%), to Phonehong(7%) and Thalat(5%).

Result of O-D survey at Ban Naxaythong shows that there is much intra-zone traffic(23%) which is mostly motor-cycles.

Regarding to Origin-Destination of the trips, Vientiane - Naxaythong has a share of 49%, Phonehong - Vientiane has 17%, in zone 23% and Talat - Vientiane has 11%.

Results of O-D survey are shown in Table 5.4.

5.3.5 Characteristic of the Traffic

1) Route No.10

Observed traffic at Tha Ngon has quite different character in number of passengers, kinds of loaded goods, between Sunday and weekdays.

It is found that person trip is much more on Sunday than weekday and smaller than that of Sunday. On the other hand, kinds of cargo loaded are mainly agricultural goods, wood/bamboo and ceramics, thus quite different from Sunday.

However, on weekday, person trip and rate of vehicle loaded are smaller than that of Sunday. On the other hand, kinds of cargo loaded are mainly agricultural goods, wood/bamboo and ceramics, thus quite different from Sunday.

Representative characteristics of traffic on Route 10 are shown as follows:

Weekday

	M/C	P/C	P/U	M/T	H/T	L/B	H/B
Passenger	1.45	3.72	3.34	2.50	4.67	16.00	28.69
Rate of vehicle loaded(%)			18.87	50.00	46.55		
Average weight of Load/cargo(ton)			1.90	2.00	4.89		
Kinds of Goods(%)							
Agricultural goods			100	0	0		
Fishery goods			0	0	0		
Wood/bamboo			0	100	28.00		
Mine			0	0	4.00		
Steel/Machine			0	0	0		
Chemical goods			0	0	0		
Food/paper			0	0	0		
Rubbish			0	0	0		
Daily goods			0	0	0		
Others			100	100	28.00		
Ceramics			0	0	40.00		

For economic evaluation, above mentioned figures are used in this study.

2) Route No.13

Various kinds of goods were transported on Route 13, compared with on Route 10. Person trip on Sunday, however, is almost same as weekday. Following table shows characteristic of traffic on Route 13.

Weekday

	M/C	P/C	P/U	M/T	H/T	L/B	H/B
Passenger	1.69	3.35	3.75	8.55	3.92	10.96	35.65
Rate of vehicle loaded(%)			8.26	63.64	64.54		
Average weight of Load/cargo(ton)			1.25	2.38	4.53		
Kinds of Goods(%)							
Agricultural products			15.00	0	9.78		
Fishery products			0	0	0		
Wood/bamboo			15.00	4.76	42.85		
Mine			5.00	4.77	4.51		
Steel/Machine			0	0	5.26		
Chemical goods			10.00	4.76	15.04		
Food/paper			5.00	0	0.76		
Rubbish			0	0	2.26		
Daily goods			40.00	85.71	12.03		
Others			10.00	0	7.51		
Ceramics			0	0	0		

Percentage of vehicle loaded is bigger than that of Rotue 10. Woods and planking are brought to Vientiane, mainly in the night. No ceramic and fishery products are found on this route.

5.4 Alternative Routes During No Ferry Operation

During the traffic survey, the ferry was out of operation from 5 pm, 21st of February to 7 pm, 23rd because of breakage in the shaft connected to propeller. While the ferry was out of order, alternative routes to destination were interviewed in parallel to traffic counting.

Because of poor telecommunication system in the Vientiane Plain, there is no way to know whether the ferry operates or not except in Tha Ngon. Thus, most of the vehicles must take alternative routes after arriving at Tha Ngon not at the origin of trip when the ferry is out of order.

Slightly more than half of the northbound traffic go back to Vientiane and take Route 13. About one third vehicles take the bypass of Route 13 starting from Dongdok. Some 10 percent answered that they drove the earth road between Tha Ngon and Naxaythong. Only during the dry season, these routes can be used by passenger cars and the earth road is heavily deteriorated. Heavy trucks are prophibited to go into Vientiane according to the MCTPC's decree and thus must take bypass.

As for the southbound traffic, about two thirds take the ferry at Hatsiao. Some 20 percent cross Nam Ngum River at Muang Kao. The vehicles which take Thinkeo Bridge was about 14 percent and half of them were heavy trucks. Hatsiao, however, is accessible only during the dry season. The ferry at Muang Kao was abandoned after the traffic survey. Hence, during the rainy season, the southbound traffic must take Thinkeo Bridge as an alternative route.

Alternative Route/Date	21st	22nd	23rd	Total	Percentage
Northbound					
Via Naxaythong	10	4	6	20	9.4%
Via Dongdog	4	31	40	75	35.2%
Via Vientiane	11	44	63	118	55.4%
Total	25	79	109	213	100.0%
Southbound					
Via Hatsiao	2	n.a.	35	37	66.1%
Via Muangkao	2	n.a.	9	11	19.6%
Via Thinkeo	3	n.a.	5	8	14.3%
Total	7	n.a.	49	56	100.0%

Note: Total is not equal to traffic volume. The ferry at Muang Kao was operating during the traffic survey.

Additional travel distance due to no ferry operation between one third of considerable zone pairs for the northbound and all the zone pairs for the southbound exceeds 100 km (see Table 5.5). Therefore, no ferry operation at Tha Ngon causes significant increase in vehicle operating costs. This economic loss can be deleted by the opening of the proposed bridge.

5.5 Vehicle Operating Costs

Vehicle operating costs (VOC) are used for estimation of generated traffic and benefits brought by the Project. First, VOC on a level tangent paved road is calculated. Then, it is adjusted to actual costs according to road surface conditions by vehicle type which is summarized below.

		Motorcycle M/C	Sedan P/C	Pick-up P/U	Med. truck M/T	Hvy truck H/T	Light bus L/B	Heavy bus H/B
typical model		Honda super cub	Mitsubishi Lancer	Toyota	Toyota Dyna	Fuso FM515F	Toyota	MMC BE434FL
no. of axle		2	2	2	2	3	2	2
no. of tire		2	4	4	4	6	4	4
price	US$	2,000	16,000	18,000	24,000	47,000	18,000	70,000
service life	year	6	12	12	10	10	7	7
annual travel distance	km	12,000	16,000	20,000	36,000	36,000	45,000	75,000
average speed	km/h	30	40	40	30	30	30	30
productive time	hour	400	400	500	1,200	1,200	1,500	2,500
life time distance	km	72,000	192,000	240,000	360,000	360,000	315,000	525,000

Vehicle operating costs are divided into two groups: distance related costs; and time related costs. The distance related costs are 1) fuel, 2) oil, 3) tires, and 4) maintenance. On the other hand, time related costs are 5) depreciation, 6) interest, 7) crew costs, and 8) overhead. Equations and discussions of these costs are attached to Appendix B.

It is considered that only road surface type affects VOC in the Vientiane Plain based on the geographical conditions and road alignment. Conversion factors of fuel, tire, and parts are assumed in reference to Jan de Weille, "Quantification of Road User Savings," and TRRL 723, "Tables for Estimating *Vehicle Operating Costs on Rural Roads in Developing Countries*" as follows:

	Rt. 10 & 13			laterite road		
	Fuel	Tire wear	Parts	Fuel	Tire wear	Parts
Heavy bus	1	1.07	1.55	1.3	1.35	3.55
Truck	1	1.07	1.2	1.3	1.35	1.92
Others	1	1.7	1.55	1.2	4.28	3.55

The calculated results are as follows:

VOC on a Tangent Paved Road

(US$/1,000km)

Speed	M/C	P/C	P/U	M/T	H/T	L/B	H/B
10	62.6	264.4	295.4	461.1	800.2	219.2	557.7
15	52.0	211.4	231.4	372.7	651.9	181.5	467.6
20	45.4	183.1	196.2	317.2	563.8	159.3	414.6
25	40.7	165.1	173.3	277.7	505.3	144.2	379.3
30	37.2	152.5	157.0	248.4	465.8	133.5	354.8
35	34.4	143.3	144.7	226.6	440.6	125.7	338.0
40	32.2	136.4	135.3	211.1	427.3	120.2	327.3
45	30.4	131.2	128.0	201.1	424.3	116.6	321.6
50	29.0	127.3	122.3	196.1	430.8	114.6	320.3
55	27.9	124.6	117.9	195.6	446.1	114.0	323.0
60	27.0	122.8	114.6	199.6	469.9	114.8	329.3
65	26.4	121.9	112.2	207.8	501.7	116.7	339.1
70	25.9	121.7	110.7	220.2	541.5	119.7	352.1
75	25.6	122.2	109.9	236.6	589.0	123.9	368.3
80	25.5	123.3	109.8	256.9	644.1	129.0	387.6
85	25.6	125.1	110.3	281.2	706.7	135.2	409.7
90	25.7	127.4	111.4	309.3	776.7	142.4	434.8

VOC on an Actual Paved Road

(US$/1,000km)

Speed	M/C	P/C	P/U	M/T	H/T	L/B	H/B
10	78.6	284.4	315.4	537.8	933.0	263.2	638.9
15	67.2	230.2	251.1	439.7	772.2	221.4	543.1
20	60.0	201.0	216.0	376.1	675.7	195.7	488.0
25	54.7	182.4	193.6	330.2	612.9	178.1	454.3
30	50.7	169.6	178.2	296.1	573.2	165.6	435.1
35	47.4	160.5	167.3	271.3	551.8	156.9	427.4
40	44.8	154.0	159.6	254.4	546.3	151.3	429.5
45	42.7	149.6	154.5	244.6	555.3	148.3	440.3
50	41.0	146.8	151.4	241.4	577.7	147.8	459.2
55	39.7	145.6	150.0	244.5	613.0	149.6	485.9
60	38.7	145.6	150.1	253.7	660.8	153.4	519.9
65	37.9	146.7	151.6	268.9	720.8	159.3	561.1
70	37.5	149.0	154.3	298.7	792.8	167.1	609.3
75	37.2	152.4	158.2	316.3	876.5	176.8	664.3
80	37.3	156.7	163.2	348.5	971.9	188.4	726.1
85	37.5	161.9	169.2	386.3	1078.8	201.8	794.6
90	37.9	168.1	176.2	429.6	1197.2	217.0	869.8

5.6 Future Traffic Forecast

Further traffic on Route 10 is divided into the following types of traffic for projection:

1) existing traffic on Route 10

2) diverted traffic from Route 13 to Route 10

3) generated traffic
   (mainly due to reduction of travel cost and improvement of traffic conditions)

4) developed traffic
   (mainly due to implementation of projects which are promoted by the project)

The last three kinds of traffic appear only when the Project is implemented.

5.6.1 Diverted Traffic from Route 13 to Route 10

From the results of the O-D survey at Naxaythong, a part of the traffic currently running on Route 13 between the following four zone pairs is expected to divert to Route 10 along with construction of the proposed bridge:

Zone 2 (Keo Oudom) - Zone 5 (Sikhottabong)
Zone 2 (Keo Oudom) - Zone 9 (Vientiane)
Zone 9 (Vientiane) - Zone 4 (Thourakhom)
Zone 9 (Vientiane) - Zone 7 (Northeast of Xaythani)

All the traffic between the last two zone pairs is assumed to divert from Route 13 to Route 10 because the distance via Route 10 is significantly shorter than via Route 13 as shown below.

Zone Pair	Distance (km)	
	Route 10	Route 13
2-5	93.2	90.4
2-9	87.3	84.5
4-9	61.7	107.8
7-9	55.4	136.3

A par of the traffic between the first three zone pairs is assumed to divert by the rate obtained from the following equation:

$$DR = (13 - 10 \times TS/TL)/6$$

where, DR : diversion rate
TS : travel time via Route 10
TL : travel time via Route 13

note: When $7/10 < TS/TL < 13/10$, the equation can be applied.

Although the distance between Zone 2 - Zone 5 and Zone 2 - Zone 9 via Route 13 is slightly shorter than via Route 10, travel time via Route 10 seems to be shorter than that via Route 13 because of better road alignment/surface and less housing along the Route 10. Buses are not likely to divert because current passengers get on and off any place between origin and destination. Diversion rates are about two thirds for all the vehicle types except buses (see Table 5.6).

Thus, the traffic diverted from Route 13 to Route 10 with the Project is estimated at about 265 per day in 1996 as follows (in detail, see Table 5.7):

Estimated Diverted Traffic (per day) in 1995

M/C	P/C	P/U	M/T	H/T	Total
100	40	37	25	63	265

5.6.2 Generated Traffic

Generated traffic is divided into day-time and night traffic. Since there are no data on person trip, buses are excluded from estimation of day-time generated traffic.

Addition to the physical benefits such as time-saving, reliability, etc., the proposed bridge psychologically connects the two sides of Nam Ngum River. The psychological distance to Vientiane from Thourakhom District will significantly reduce with the Project. Furthermore, the bridge is a smooth and reliable all day long connection between the two sides, while the current ferry is irregular, less reliable, and costly at night. Some traffic is expected to generate due to these factors.

Generated day-time traffic of each zone pair is estimated by the following equation:

$$\Delta T = \Delta P/P \times e \times T$$

where,
- e : price eleaticity
- ΔP : reduction of travel cost due to the Project (=ferry charge)
- P : present travel cost
- ΔT : generated day - time traffic volume
- T : existing traffic volume

Based on factors mentioned above, price elasticity is assumed at 0.4 for all the Vehicles, which is larger than that in the relevant past studies. Hence, it is estimated that the Project generates about vehicles during day time in 1995 as follows (in detail, see Table 5.8):

Generated Day-time Traffic (per day) in 1995

M/C	P/C	P/U	M/T	H/T	Total
17.7	2.7	3.8	1.6	2.7	28.6

Currently, traffic volume at Tha Ngon between 9 pm and 5 am is very small mainly because of high night time ferry charges. With construction of the proposed bridge, night traffic is likely to significantly increase. The ratios of night traffic over day traffic are assumed to become larger with reference to those at Naxaythong as follow:

Night/Day Ratio

	M/C	P/C	P/U	M/T	H/T	L/B	H/B
W/O Project	1.5%	4.8%	3.9%	3.9%	0%	0%	0%
W/ Project	15.0%	12.0%	6.0%	6.0%	6.0%	2.0%	8.0%

Hence, the Project generates night traffic of 92 vehicles in 1996 as follows:

Generated Night Traffic (per day) in 1996

M/C	P/C	P/U	M/T	H/T	L/B	H/B	Total
64.0	7.8	2.2	2.6	12.1	0.5	2.4	91.7

5.6.3 Developed Traffic

At present, vegetables and fruits are transported to Vientiane from Ban Keun by some 20 pick-ups and light buses every day. According to staff in Department of Agriculture, Thourakhom District, the number of the vehicles loaded with agricultural products will be double if the proposed bridge is constructed. The results of questionnaire survey to the farmers along Route 10 reveal their strong intention to increase products and trips to Vientiane.

Ministry of Agriculture and Forestry has a policy to give the first development priority to the areas with good infrastructure, especially road. Thus, the Ministry intends to implement further irrigation projects on the left side of Nam Ngum River along with the construction of the proposed bridge. There are four irrigation plans along Route 10 on the left side of Nam Ngum River. It is assumed that irrigation projects in Ban Keun (500ha) and Hatkiang (300ha) are completed around 2000 and those in Napeng (325ha) and Tanpia (600ha) around 2005.

In addition, Vientiane Municipality is now making a rural development plan of Pou Kao Khouay Area, which takes advantage of improvement of accessibility to the area due to the Project. The plan would consist of irrigation and cattle breeding and be completed around 2005.

In accordance with several projects on the left side of Nam Ngum River, the developed traffic per day due to the Project is estimated as follows:

Year	Pick up	Medium Truck	Heavy Truck	Total
2000	2	1	2	5
2005	2	1	2	5

5.6.4 Traffic Growth Rate

Traffic growth rates are estimated with growth rate of gross regional product times elasticity of traffic volume. It is estimated that GRP of Vientiane Municipality increases by 4.4% for 1989 - 1995, 6.3% for 1995 - 2000, and 5.2% for the following ten years according to the National Transport Study (NTS) (see Table 5.9). The estimated GRP growth rates of Vientiane Province are about 1% lower than those of Vientiane Municipality for each target year.

Agricultural sector in the influence area seems to be more prosperous than whole Vientiane Municipality and Vientiane Province. Thourakhom District, the influence area, is one of the leading districts in Vientiane Province in terms of economic development. Agricultural production in the influence area has been significantly increasing for the last five years. Initiation of an agricultural credit project in Thourakhom and Xaythani Districts will financially support increase in agricultural production.

Forestry sector is projected not to grow for the time being because of the government policy which prohibits logging in order to conserve forestry resources and to protect natural environment. Along with implementation of reforestation projects, planned logging may be restarted. The growth rates seem to be relatively low as estimated by the NTS.

In the influence area, except salt, there is no mining deposit. Since salt export is unlikely due to high import duty in Thailand, salt production seems to increase at the same pace with population increase. brick production in Thourakhom District seems to increase in parallel to growth of construction sector in the Vientiane Plan.

Regarding to service sector, tourism is the largest subsector in terms of traffic in the influence area. The tourism sub-sector is likely to rapidly grow along with increase in foreign tourists. Thus, the service sector in the influence area seems to grow faster than regional average.

Based on the above-mentioned projection of future economic situation in the influence are, growth rates by industrial origin are estimated as shown below:

Estimated GRP Growth Rate by Industrial Origin

Sector	1990-2000	2000-2010	2010-2020
agriculture	8.0%	7.0%	5.0%
forestry	0.0%	6.0%	2.0%
industry	6.0%	5.0%	5.0%
services	9.0%	8.0%	7.0%
total	7.2%	7.2%	5.4%

Note: The total growth rate is calculated with an assumption that sectoral GRP shares are 60% for agriculture, 10% for forestry, 10% for industry, .pm120% for service sector in 1990.

Vehicle types are reclassified into the following four groups for estimation of traffic growth rates due to data availability:

1) motorcycles
2) passenger cars and pick ups
3) medium and heavy trucks
4) light and heavy buses

By type of vehicle, elasticity between traffic volume and GRP is estimated in the following. Elasticity between freight transport in terms of ton and GDP for 1982-89 is 1.75 as mentioned Chapter III. That between passenger transport in terms of person and GDP for 1982-88 is 1.52. The influence area seems to have similar figure because the area is located close to Vientiane which is likely to have recorded one of the highest transport growth rates. In comparison, elasticities of freight and passenger transport in Bangladesh (1979-83) is about 2.1. Figures in Lao PDR, however, are partly results of introduction of the new economic mechanism. Hence, taking a safe side, elasticities of traffic volume of trucks and buses are estimated at 1.6 and 1.5, respectively.

Data on number of registered vehicles and GDP yield elasticity of 2.56 between amount of motorcycles and GDP. This figure is higher than that of Pakistan (1.85, for 1977-86) but lower than that of Bangladesh (3.77, for 1979-86). Again, taking a safe side, elasticity between traffic volume of motorcycles and GRP is assumed at 1.8. On the other hand, elasticity between passenger cars/pick ups and GDP is 0.92. This figure is relative low, compared with that in Bangladesh (1.70, for 1979-86). Furthermore, according to the household survey conducted for Vientiane development plan, income elasticity of passenger cars is 1.46. Taking these figures into consideration, elasticity between traffic volume of passenger cars/pick ups and GRP is assumed at 1.4. Also, data in Bangladesh and Pakistan show that elasticity of number of registered vehicles eventually decline. Thus, elasticities of traffic volume in the project area are also estimated to decrease in the long run as follows:

Estimated Elasticities between Traffic Volume and GRP

Period	M/C	P/C,P/U	M/T,H/T	L/B,H/B
1990-2000	1.8	1.4	1.6	1.5
2001-2010	1.5	1.2	1.4	1.3
2011-	1.2	1.1	1.2	1.2

Finally, growth rates of traffic volume by vehicle type at Tha Ngon are estimated as follows:

Estimated Growth Rates of Traffic Volume

Period	M/C	P/C,P/U	M/T,H/T	L/B,H/B	Total
1990-2000	13.0%	10.1%	11.5%	10.8%	11.1%
2001-2010	10.7%	8.6%	10.0%	9.3%	9.4%
2011-	6.5%	6.0%	6.5%	6.5%	6.4%

5.6.5 Future Traffic Volume

In accordance with the results of traffic count in February and July, and estimated volume of diverted, generated, and developed traffic and estimated growth rates, future traffic volume is forecasted at about 2,000 in 2000 and some 5,350 in 2010 as shown below.

Without the Project, Nam Ngum crossing time will increase and a part of traffic will switch from Route 10 to Route 13 as mentioned in the previous chapter. Motorcycles, however, can cross Nam Ngum River with private ferries without waiting for a long time. It is assumed that buses operate up to Nam Ngum River on both sides (no bus crosses Nam Ngum River) and that passengers must transfer to another bus on the other side of the River when the crossing time exceeds an hour. It is also assumed that traffic volume of passenger cars and trucks does not exceed the volume which yields average crossing time is 60 minutes. Hence, traffic volume crossing Nam Ngum River at Tha Ngon and the ratio of diversion from Route 10 to Route 13 without the Project are estimated as shown in Table 5.11.

It is estimated that GRP of Vientiane Municipality increases by 4.4% for 1989 - 1995, 6.3% for 1995 - 2000, and 5.2% for the following ten years according to the National Transport Study (NTS) (see Table 5.8). The estimated GRP growth rates of Vientiane Province are about 1% lower than those of Vientiane Municipality for each target year.

Table 5.1 Traffic Volume at Tha Ngon, by Day, by Type of Vehicle

DIRECTION: BOTH DATE: 21-27, FEB., 1990

DATE	M.CYCLE	P.CAR	PICKUP	M.TRUCK	H.TRUCK	L.BUS	H.BUS	CART	SUBTOTAL	PEDESTRIAN	BICYCLE	TOTAL
2/21	240	50	46	32	80	30	21	0	499	215	500	1,214
2/22	244	44	39	16	30	3	2	0	378	185	1,173	1,736
2/23	250	59	45	26	25	12	1	0	418	177	936	1,531
2/24	265	81	72	31	109	3	12	0	573	176	308	1,057
2/25	381	115	65	28	56	61	31	0	737	152	266	1,155
2/26	280	62	74	14	82	2	14	0	528	158	288	974
2/27	199	63	52	23	72	26	28	0	463	78	146	687
TOTAL	984	256	244	100	343	61	75	0	2,063	627	1,242	3,932
AVERAGE	246	64	61	25	86	15	18	0	515	156	310	983
(N/day)	1.51%	4.76%	3.85%	0.00%	0.00%	0.00%	0.00%	0.00%				
ADT	250	67	63	25	86	15	18	0	524	156	310	990

Table 5.2 Traffic Volume at Naxaythong, by Day, by Type of Vehicle

DIRECTION: BOTH DATE: 21-27, FEB., 1990

DATE	M.CYCLE	P.CAR	PICKUP	M.TRUCK	H.TRUCK	L.BUS	H.BUS	CART	SUBTOTAL	PEDESTRIAN	BICYCLE	TOTAL
2/21	1,090	208	174	87	293	137	55	-	2,044	-	-	2,044
2/22	1,039	204	188	70	287	161	45	3	1,997	-	-	1,997
2/23	1,174	214	192	60	230	145	56	-	2,071	-	-	2,071
2/24	1,052	204	111	148	240	110	103	-	1,968	-	-	1,968
2/25	1,094	51	538	44	135	228	86	-	2,176	-	-	2,176
2/26	977	181	130	34	254	184	67	8	1,835	-	-	1,835
2/27	1,278	195	188	47	260	144	48	5	2,165	-	-	2,165
TOTAL	6,610	1,206	983	446	1,564	881	374	16	12,080	-	-	12,080
AVERAGE	1,101	201	163	74	260	146	62	2	2,013	-	-	2,013
(N/day)	20.34%	16.92%	11.17%	8.51%	11.54%	2.78%	12.50%	0.00%				
ADT	1,324	235	181	80	290	150	69	2	2,331	-	-	2,331

Table 5.3(1) Origin Distination Survey

THA NGON (Motorcycle)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	1	0	0	0	1
2	0	0	0	0	0	0	0	0	4	0	0	0	4
3	0	1	0	0	0	0	0	0	0	0	0	0	1
4	0	0	1	0	0	0	0	12	60	1	0	0	74
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	14	37	0	0	0	51
7	0	0	0	0	0	0	0	3	5	0	0	0	8
8	0	0	0	7	0	18	0	0	0	0	0	0	25
9	0	3	0	35	0	41	1	0	0	0	0	0	80
10	0	0	0	4	0	1	0	0	0	0	0	0	5
11	0	0	0	0	0	1	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	4	1	46	0	61	1	29	107	1	0	0	250

THA NGON (Sedan)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	6	0	0	0	6
3	0	0	0	1	0	0	0	0	0	0	0	0	1
4	0	0	0	0	0	0	0	1	6	0	0	0	7
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	10	0	0	0	10
7	0	0	0	0	0	0	0	0	1	0	0	0	1
8	0	0	0	3	0	4	0	0	0	0	0	0	7
9	1	7	0	14	0	11	0	0	0	0	0	0	33
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	1	0	0	0	1	0	0	0	0	0	0	2
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	1	8	0	18	0	16	0	1	23	0	0	0	67

Table 5.3(2) Origin Distination Survey

THA NGON (Pickup)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	1	0	0	0	1
2	0	0	0	0	0	0	0	0	4	0	0	0	4
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	1	17	0	0	0	18
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	1	12	0	0	0	13
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	1	0	2	0	0	0	0	0	0	3
9	2	1	0	19	0	2	0	0	0	0	0	0	24
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	2	1	0	20	0	4	0	2	34	0	0	0	63

THA NGON (Medium Truck)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	3	0	0	0	3
2	0	0	0	0	0	0	0	0	3	0	0	0	3
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	2	0	0	0	0	3	3	3	0	0	11
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	4	4	0	0	0	8
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	2	0	0	0	0	7	13	3	0	0	25

Table 5.3(3) Origin Distination Survey

THA NGON (Heavy Truck)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	1	0	0	0	1
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	1	34	0	0	0	35
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	1	0	0	0	0	4	0	3	0	0	8
7	0	0	0	0	1	0	0	0	3	0	0	0	4
8	0	0	0	0	0	2	0	0	0	0	0	0	2
9	0	0	0	28	0	0	1	0	0	0	0	0	29
10	0	0	0	0	0	6	0	0	0	0	0	0	6
11	0	0	0	1	0	0	0	0	0	0	0	0	1
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	1	29	1	8	1	5	38	3	0	0	86

THA NGON (Light Bus)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	1	1	0	0	0	2
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	5	0	0	0	5
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	1	2	0	0	0	3
7	0	0	0	0	0	0	0	0	1	0	0	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	2	0	1	1	0	0	0	0	0	4
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	2	0	1	1	2	9	0	0	0	15

Table 5.3(4) Origin Distination Survey

THA NGON (Heavy Bus)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	8	0	0	0	8
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	3	0	0	0	3
7	0	0	0	0	0	0	0	0	1	0	0	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	5	0	0	1	0	0	0	0	0	6
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	5	0	0	1	0	12	0	0	0	18

Table 5.4(1) Origin Distination Survey

NAXAYTHONG (Motorcycle)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	18	0	2	0	0	0	69	0	0	0	89
2	0	0	4	0	4	0	0	0	34	0	0	0	42
3	0	0	471	0	97	0	4	0	301	0	2	0	875
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	20	0	0	0	0	0	0	0	0	0	20
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	34	28	230	2	0	0	4	0	0	0	0	0	298
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	34	28	743	2	103	0	8	0	404	0	2	0	1,324

NAXAYTHONG (Sedan)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	25	0	0	0	25
2	0	0	0	0	0	0	0	0	15	0	0	0	15
3	0	0	23	0	2	0	0	0	61	0	0	0	86
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	32	12	61	2	0	0	2	0	0	0	0	0	109
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	32	12	84	2	2	0	2	0	101	0	0	0	235

Table 5.4(2) Origin Distination Survey

NAXAYTHONG (Pickup)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	1	0	0	0	0	0	30	0	0	0	31
2	0	0	0	0	0	0	0	0	11	0	0	0	11
3	1	0	16	0	5	0	0	0	31	0	1	0	54
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	3	0	0	0	0	0	0	0	0	0	3
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	19	18	44	1	0	0	0	0	0	0	0	0	82
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	20	18	64	1	5	0	0	0	72	0	1	0	181

NAXAYTHONG (Medium Truck)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	5	0	0	0	5
2	0	0	0	0	0	0	0	0	3	0	0	0	3
3	0	0	3	0	0	0	0	0	8	0	0	0	11
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	3	0	0	0	0	0	0	0	0	0	3
9	15	17	26	0	0	0	0	0	0	0	0	0	58
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	15	17	32	0	0	0	0	0	16	0	0	0	80

Table 5.4(3) Origin Distination Survey

NAXAYTHONG (Heavy Truck)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	1	0	1	0	1	0	68	0	0	0	71
2	0	0	0	0	0	0	0	0	31	0	0	0	31
3	0	0	20	0	6	0	0	1	37	0	0	0	64
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	40	19	64	0	0	0	1	0	0	0	0	0	124
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	40	19	85	0	7	0	2	1	136	0	0	0	290

NAXAYTHONG (Light Bus)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	0	0	0	0	0	0	16	0	0	0	16
2	0	0	0	0	0	0	0	0	27	0	0	0	27
3	0	0	2	0	2	0	0	1	39	0	0	0	44
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	16	20	26	1	0	0	0	0	0	0	0	0	63
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	16	20	28	1	2	0	0	1	82	0	0	0	150

Table 5.4(4) Origin Distination Survey

NAXAYTHONG (Heavy Bus)

ZONE	1	2	3	4	5	6	7	8	9	10	11	12	Total
1	0	0	1	0	0	0	0	0	12	0	0	0	13
2	0	0	0	0	0	0	0	0	14	0	0	0	14
3	0	0	0	0	0	0	0	0	7	0	0	0	7
4	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0
9	12	13	6	4	0	0	0	0	0	0	0	0	35
10	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	12	13	7	4	0	0	0	0	33	0	0	0	69

Table 5.5(1) Additional Distance of Alternative Route

Northbound

O-D	Origin	Destination	Distance via Tha Ngon			Distance of Altenative route via Vientiane			Distance of Altenative route via Dongdok			Additional Distance v.VTE	Additional Distance v.Dongdok	
			Pav.	Lat.	Sum	Pav.	Lat.	Sum	Pav.	Lat.	Sum	pav.	Pav.	Lat.
3-2	Naxaythong	Tha Lat	85.6	9.0	94.6	na	na	0.0	133.3	18.0	151.3	na	47.7	9.0
3-4	Naxaythong	Keun	60.0	9.0	69.0	na	na	0.0	133.3	18.0	151.3	na	73.3	9.0
8-4	Tha Ngon	Keun	38.6		38.6	130.9		130.9	111.9	9.0	120.9	92.3	73.3	9.0
8-6	Tha Ngon	Hatkiang	7.8		7.8	161.7		161.7	142.7	9.0	151.7	153.7	153.9	9.0
9-2	Vientiane	Tha Lat	87.3		87.3	128.4		128.4	109.4	9.0	118.4	41.1	22.1	9.0
9-4	Vientiane	Keun	61.7		61.7	154.0		154.0	135.0	9.0	144.0	92.3	73.3	9.0
9-6	Vientiane	Hatkiang	30.9		30.9	184.8		184.8	165.8	9.0	174.8	153.9	134.9	9.0
9-7	Vientiane	Nakhanthoung	44.3	11.1	55.4	171.4	11.1	182.5	152.4	20.1	172.5	127.1	108.1	9.0
10-4	Dongdok	Keun	52.9		52.9	145.2		145.2	126.2	9.0	135.2	92.3	73.3	9.0
10-6	Dongdok	Hatkiang	22.1		22.1	176.0		176.0	157.0	9.0	166.0	153.9	134.9	9.0
11-2	Chompet	Tha Lat	93.7		93.7	134.8		134.8	115.8	9.0	124.8	41.1	22.1	9.0
11-4	Chompet	Keun	68.1		68.1	160.4		160.4	141.4	9.0	150.4	92.3	73.3	9.0
11-6	Chompet	Hatkiang	37.3		37.3	191.2		191.2	172.2	9.0	181.2	153.9	134.9	9.0
9-1	Vientiane	Phonehong(Keun)	101.2		101.2	154.0		154.0	135.0	9.0	144.0	52.8	33.8	9.0

Note : Pav. means paved road Lat. means Laterite

Table 5.5(2) Additional Distance of Alternative Route

Southbound

O-D	Origin	Destination	Distance via Tha Ngon			Distance of Altenative route via Hatsiao				Distance of Altenative route via Tha Lat			Additional Distance via Hatsiao			Additional Distance via Tha Lat	
			Pav.	Lat.	Sum	Pav.	Lat.	Earth	Sum	Pav.	Lat.	Sum	Pav.	Lat.	Earth	Pav.	Lat.
2-5	Tha Lat	Nonkeo	93.2		93.2	151.3	6.2	16.0	173.5	216.5		216.5	58.1	6.2	16.0	123.3	0.0
2-8	Tha Lat	Tha Ngon	64.2		64.2	149.5	13.3	16.0	178.8	214.7	9.0	223.7	85.3	13.3	16.0	150.5	9.0
2-9	Tha Lat	Vientiane	87.3		87.3	145.4	6.2	16.0	167.6	210.6		210.6	58.1	6.2	16.0	123.3	0.0
4-3	Keun	Naxaythong	60.0	9.0	69.0	102.5	6.2	16.0	124.7	167.7		167.7	42.5	-2.8	16.0	107.7	-9.0
4-8	Keun	Tha Ngon	38.6		38.6	123.9	13.3	16.0	153.2	189.1	9.0	198.1	85.3	13.3	16.0	150.5	9.0
4-9	Keun	Vientiane	61.7		61.7	119.8	6.2	16.0	142.0	185.0		185.0	58.1	6.2	16.0	123.3	0.0
4-10	Keun	Dongdok	52.9		52.9	109.6	13.3	16.0	138.9	174.8	9.0	183.8	56.7	13.3	16.0	121.9	9.0
6-3	Hatkiang	Naxaythong	29.2	9.0	38.2	71.7	6.2	16.0	93.9	136.9		136.9	42.5	-2.8	16.0	107.7	-9.0
6-8	Hatkiang	Tha Ngon	7.8		7.8	93.1	13.3	16.0	122.4	158.3	9.0	167.3	85.3	13.3	16.0	150.5	9.0
6-9	Hatkiang	Vientiane	30.9		30.9	89.0	6.2	16.0	111.2	154.2		154.2	58.1	6.2	16.0	123.3	0.0
6-10	Hatkiang	Dongdok	22.1		22.1	78.8	13.3	16.0	108.1	144.0	9.0	153.0	56.7	13.3	16.0	121.9	9.0
7-5	Nakhanthoung	Nankeo	50.2	11.1	61.3	108.3	6.2	16.0	130.5	173.5		173.5	58.1	-4.3	16.0	123.3	-11.1
7-7	Nakhanthoung	Tha Ngon	21.2	11.1	32.3	106.5	13.3	16.0	135.8	171.7	9.0	180.7	85.3	2.2	16.0	150.5	-2.1
7-9	Nakhanthoung	Vientiane	44.3	11.1	55.4	102.4	6.2	16.0	124.6	167.6		167.6	58.1	-4.9	16.0	123.3	-11.1
1-9	Phonehong	Vientiane	101.2		101.2	159.3	6.2	16.0	181.5	224.5		224.5	58.1	6.2	16.0	123.3	0.0

Note : Pav. means paved road Lat. means Laterite

Table 5.6 Diversion Rate

Zone Pair	Vehicle Type	Speed(km/h) Rt.10	Rt.13	Travel time(min) Rt.10	Rt.13	Diversion Rate
2-5	Motorcycle	45	40	124	136	63.9%
2-9	Motorcycle	45	40	117	127	63.6%
2-9	Sedan	70	60	75	85	69.1%
2-9	Pick up	70	60	75	85	69.1%
2-9	Med.truck	45	40	117	127	63.6%
2-9	Hev.truck	45	40	117	127	63.6%

Note: All the traffic between Zones 2 and 5 are motorcycles.

Table 5.7 Estimated Diverted Traffic (per day) in 1996

Zone Pair	Motor cycle	Sedan	Pick up	Medium truck	Heavy truck	Total
2-5	5.3	0	0	0	0	5.3
2-9	44.9	18.4	13.5	3.7	37.9	118.5
9-2	37.0	14.7	22.1	20.8	23.2	117.9
9-4	4.2	3.6	1.8	0	0	9.5
9-7	8.3	3.6	0	0	1.9	13.8
sum	99.7	40.3	37.4	24.5	63.1	265.0

Table 5.8 Generated Day-time Traffic (per day) in 1996

Zone Pair	M/C	P/C	P/U	M/T	H/T	Total
Northbound						
3-2	0.0	0.0	0.0	0.0	0.0	0.0
3-4	0.0	0.0	0.0	0.0	0.0	0.0
8-4	0.4	0.1	0.1	0.0	0.0	0.6
8-6	3.9	0.7	0.5	0.0	0.3	5.4
9-2	0.1	0.1	0.0	0.0	0.0	0.2
9-4	1.3	0.4	0.9	0.0	0.6	3.1
9-6	2.8	0.5	0.2	0.0	0.0	3.5
9-7	0.0	0.0	0.0	0.0	0.0	0.0
10-4	0.2	0.0	0.0	0.0	0.0	0.2
10-6	0.1	0.0	0.0	0.0	0.3	0.4
11-2	0.0	0.0	0.0	0.0	0.0	0.0
11-4	0.0	0.0	0.0	0.0	0.0	0.0
11-6	0.1	0.0	0.0	0.0	0.0	0.1
Southbound						
2-9	0.1	0.1	0.1	0.1	0.0	0.4
4-3	0.0	0.0	0.0	0.1	0.0	0.1
4-8	0.7	0.0	0.1	0.2	0.0	1.0
4-9	2.1	0.2	0.8	0.1	0.7	3.9
4-10	0.0	0.0	0.0	0.1	0.0	0.2
6-3	0.0	0.0	0.0	0.0	0.0	0.0
6-8	3.1	0.0	0.0	0.8	0.5	4.4
6-9	2.5	0.5	1.1	0.3	0.0	4.4
6-10	0.0	0.0	0.0	0.0	0.2	0.2
7-5	0.0	0.0	0.0	0.0	0.0	0.0
7-8	0.2	0.0	0.0	0.0	0.0	0.2
7-9	0.2	0.0	0.0	0.0	0.1	0.3
Total	17.7	2.7	3.8	1.6	2.7	28.6

Table 5.9 Estimated GDP by Industrial Origin (at 1989 prices)

		Vientiane Municipality			Vientiane Province			Nation		
		mil$	share rate	growth	mil$	share rate	growth	mil$	share rate	growth
Rice & Paddy	1989	13	15.3%		13	36.1%		134	24.2%	
	1995	17	15.5%	4.6%	13	30.2%	0.0%	151	21.5%	2.0%
	2000	22	14.7%	5.3%	15	26.8%	2.9%	171	18.2%	2.5%
	2010	32	12.9%	3.8%	20	23.5%	2.9%	231	14.9%	3.1%
Other agri-culture	1989	9	10.6%		9	25.0%		153	27.6%	
	1995	11	10.0%	3.4%	11	25.6%	3.4%	215	30.6%	5.8%
	2000	14	9.3%	4.9%	15	26.8%	6.4%	290	30.9%	6.2%
	2010	20	8.1%	3.6%	24	28.2%	4.8%	535	34.5%	6.3%
Forestry	1989	7	8.2%		4	11.1%		56	10.1%	
	1995	7	6.4%	0.0%	4	9.3%	0.0%	56	8.0%	0.0%
	2000	9	6.0%	5.2%	6	10.7%	8.4%	85	9.1%	8.7%
	2010	9	3.6%	0.0%	6	7.1%	0.0%	85	5.5%	0.0%
Mining & Manufac-turing	1989	19	22.4%		2	5.6%		54	9.7%	
	1995	26	23.6%	5.4%	5	11.6%	16.5%	72	10.2%	4.9%
	2000	38	25.3%	7.9%	6	10.7%	3.7%	102	10.9%	7.2%
	2010	60	24.2%	4.7%	10	11.8%	5.2%	164	10.6%	4.9%
Const-ruction	1989	5	5.9%		1	2.8%		22	4.0%	
	1995	7	6.4%	5.8%	2	4.7%	12.2%	28	4.0%	4.1%
	2000	8	5.3%	2.7%	2	3.6%	0.0%	35	3.7%	4.6%
	2010	13	5.2%	5.0%	4	4.7%	7.2%	57	3.7%	5.0%
Services	1989	32	37.6%		6	16.7%		135	24.4%	
	1995	43	39.1%	5.0%	8	18.6%	4.9%	180	25.6%	4.9%
	2000	60	40.0%	6.9%	12	21.4%	8.4%	255	27.2%	7.2%
	2010	113	45.6%	6.5%	22	25.9%	6.2%	479	30.9%	6.5%
Total	1989	85	100.0%		36	100.0%		554	100.0%	
	1995	110	100.0%	4.4%	43	100.0%	3.0%	703	100.0%	4.0%
	2000	150	100.0%	6.4%	56	100.0%	5.4%	938	100.0%	5.9%
	2010	248	100.0%	5.2%	85	100.0%	4.3%	1551	100.0%	5.2%

Source: SWECO, "National Transport Study, Interim Report III," April 1990.

Table 5.10 Forecasted Future Traffic Volume (with Project)

Year	M/C	P/C	P/U	M/T	H/T	L/B	H/B	Total	P.C.U.
1990	228	61	58	23	79	14	16	479	575
1991	258	67	63	25	88	15	18	535	641
1992	291	74	70	28	98	17	20	598	715
1993	329	82	77	32	109	19	22	669	798
1994	372	90	84	35	121	21	25	748	890
1995	420	99	93	39	135	23	27	837	993
1996	647	156	143	71	224	26	33	652	1,548
1997	731	172	157	79	249	29	36	1,453	1,727
1998	826	189	173	88	278	32	40	1,626	1,928
1999	933	208	190	98	310	35	45	1,819	2,152
2000	1,054	229	212	110	348	39	50	2,042	2,414
2001	1,167	249	230	121	383	43	54	2,247	2,653
2002	1,292	271	250	134	422	47	59	2,473	2,916
2003	1,431	294	271	147	464	51	65	2,722	3,205
2004	1,585	319	294	162	510	56	71	2,997	3,523
2005	1,755	346	322	179	564	61	77	3,304	3,883
2006	1,943	376	350	197	620	66	84	3,638	4,268
2007	2,152	409	380	217	682	73	92	4,005	4,693
2008	2,383	444	412	238	751	79	101	4,409	5,159
2009	2,639	482	448	262	826	87	110	4,854	5,673
2010	2,923	523	486	289	909	95	121	5,345	6,238
2011	3,113	554	515	307	968	101	128	5,688	6,637
2012	3,316	587	546	327	1,031	108	137	6,052	7,062
2013	3,532	623	579	349	1,098	115	146	6,440	7,514
2014	3,762	660	613	372	1,170	122	155	6,853	7,995
2015	4,006	699	650	396	1,246	130	165	7,292	8,507

P.C.U. : Traffic volume converted in passenger car unit,
Conversion fact : M/C=0.8, P/C=1, P/U=1.5, M/T=1.9, H/T=1.9, L/B=1.5, H/B=1.9

Table 5.11 Forecasted Future Traffic Volume without Project

Year	M/C	P/C	P/U	M/T	H/T	L/B	H/B	No Crossing L/B	No Crossing H/B	Daily ex.M/C	Hourly ex.M/C	Cross. Time (min.)	Traffic Rt. 10	Volume div. to Rt.13	Diver-tion Rate
1990	228	61	58	23	79	14	16			250	9		250	0	0.0%
1991	258	67	63	25	88	15	18			277	10		277	0	0.0%
1992	291	74	70	28	98	17	20			307	11		307	0	0.0%
1993	329	82	77	32	109	19	22			340	12		340	0	0.0%
1994	372	90	84	35	121	21	25			377	13	10	377	0	0.0%
1995	420	99	93	39	135	23	27	0	0	417	15	11	417	0	0.0%
1996	474	109	102	44	151	25	30	0	0	462	17	11	462	0	0.0%
1997	536	120	113	49	168	28	34	0	0	512	18	12	512	0	0.0%
1998	605	132	124	55	188	31	37	0	0	567	20	35	567	0	0.0%
1999	684	145	137	61	210	34	41	0	0	628	22	83	602	26	4.7%
2000	772	160	150	68	234	0	0	38	46	612	22	67	602	10	1.6%
2001	855	174	163	75	257	0	0	42	50	669	24	129	602	67	10.0%
2002	947	189	177	82	283	0	0	46	55	731	26	221	602	129	17.6%
2003	1,049	205	193	90	311	0	0	50	60	799	29	352	602	197	24.7%
2004	1,162	222	209	100	342	0	0	55	65	873	31	532	602	271	31.1%
2005	1,286	241	227	110	377	0	0	60	72	955	34	772	602	353	36.9%
2006	1,424	262	247	121	415	0	0	65	78	1,044	37	1,087	602	442	42.3%
2007	1,577	285	268	133	456	0	0	71	85	1,141	41	1,493	602	539	47.2%
2008	1,747	309	291	146	502	0	0	78	93	1,248	45	2,011	602	646	51.7%
2009	1,934	336	316	161	552	0	0	85	102	1,364	49	2,667	602	762	55.9%
2010	2,142	365	343	177	607	0	0	93	112	1,491	53	3,491	602	889	59.6%
2011	2,282	386	363	188	647	0	0	99	119	1,585	57	4,164	602	983	62.0%
2012	2,430	409	385	200	689	0	0	106	127	1,684	60		602	1,082	64.2%
2013	2,589	434	408	213	734	0	0	112	135	1,789	64		602	1,187	66.4%
2014	2,757	460	432	227	782	0	0	120	144	1,901	68		602	1,299	68.3%
2015	2,937	487	458	242	833	0	0	128	153	2,020	72		602	1,418	70.2%

Note : Total traffic volumes (Daily ex.M/C and Hourly ex.M/C) are number of vehicles corssing Nam Ngum River.

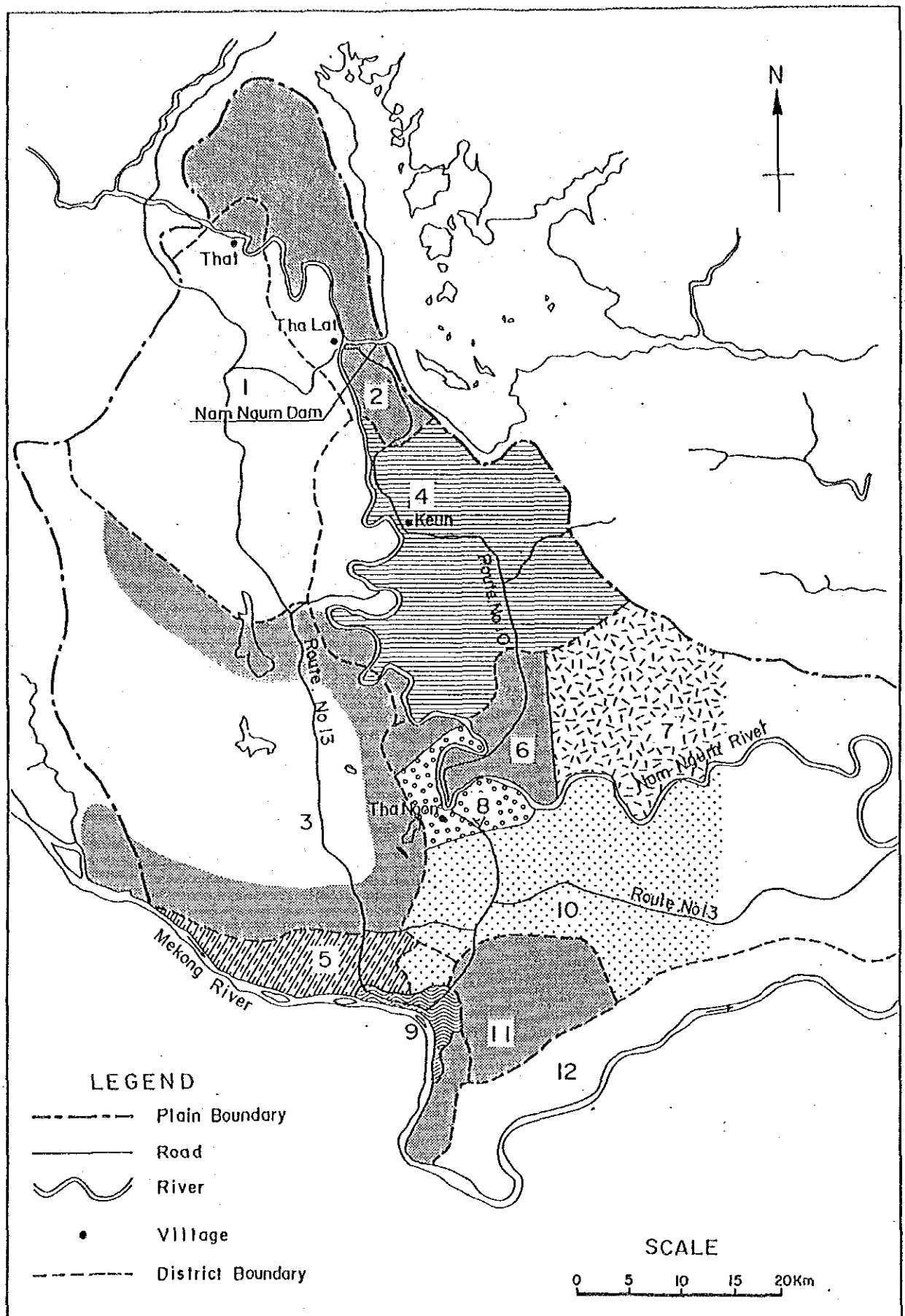


Figure 5.1 Zoing for O-D Survey

AT : BAN THA NGON ON ROUTE 10 No.

FOR: NORTH TO SOUTH (VIENTIANE) 27, FEB. 1990

1. TIME :

5	6	7	8	9	10	11	12	13	14	15	16
17	18	19	20	21	22	23	24	1	2	3	4

2. VEHICLE TYPE :

MOTOR CYCLE	SEDAN	LIGHT-BUS	BUS
LIGHT TRUCK	MEDIUM TRUCK	HEAVY TRUCK	OX CART
PASSENGER	BICYCLE		

3. FROM :

1	2	3	4	5	6	7	8	9	10	11	12

4. TO :

1	2	3	4	5	6	7	8	9	10	11	12

5. OWNERSHIP :

PRIVATE CAR		COMPANY OWNED	

6. OBJECT (Private Car only) :

TO OFFICE/WORK		TO SCHOOL		IN WORK,ON GOODS	
GO SHOPPING		RECREATION		BACK HOME	
IN WORK W/GOODS		BACK TO OFFICE			

7. LAOD :

PERSON W/DRIVER		TONS (WEIGHT)	

8. KINDS OF GOODS (Truck only)

UNLOADED/EMPTY		AGRICULTURAL P.		FISHERY PRODUCTS	
WOOD, BAMBOO ETC.		MINING PRODUCTS		METAL, MACHINE	
CHEMICAL PRODUCT		PAPER, FOOD, ETC		WAST, ETC,	
DAILY GOODS, ETC		OTHERS/UNKNOWN			

Figure 5.2 O-D Survey Form

CHAPTER VI

ROUTE AND BRIDGE TYPE SELECTION

CHAPTER VI ROUTE AND BRIDGE TYPE SELECTION

6 Route and Bridges Type Selection

6.1 Route Selection

From the technical point of view, alternative route selection was implemented and six (6) alternatives routes were established.

The alternative routes are;

Route No.1	On the existing ferry crossing with maximum use of existing road
Route No.2	To facilitate construction of substructure, 100 meter down stream of existing ferry crossing, use sandbar/holm
Route No.3	Eschew Weeping bend of the Nam Nugm River, Minimum bridge length
Route No.4	As the alternative to No.3, to shun the political school
Route No.5	Shift 600-700 to upstream of Route No.6 to avoid inundated area on Route No.6
Route No.6	Bypass the Tha Ngon Village, Pass-over the River through Tha Ngon Farm

6.1.1 Alternative Six Routes

Alternative 1

This route has been selected to cross approximately 100 meter upstream from the ferry crossing for immediate approach to existing road on both banks.

Water crossing would be approximately 180 m between top of the banks and the crossing is located at sweeping left hand bend, which appears to be causing scouring of riverbed on the right side as observed from the results to river sounding. Small collapse of river bank have also progressed on the right bank.

Approximately 100 m upstream from this crossing, there is a confluence of a tributary to the Nam Ngum river. This route will therefore have to be studied closely for the effects of stream on scouring of riverbed and erosion of bank together with the selection of bridge type. Total length of approach roads are approximately 800 m, which is minimal among the alternatives along with land compensation.

Alternative 2

The location of the crossing for this route is approximately 100 m down stream from ferry crossing. This route have been proposed for its easy foundation work which might be carried out on the dried riverbed or in shallow waters during dry season.

Water crossing, however, would be more than 260 m and approach road is passing through the densely populated areas of the old Ban Tha Ngon Village on the right bank side.

The crossing is also located at the sweeping bend and the riverbed on the right side appears to be scoured due to turbulent water flow. Total length of approach roads are approximately 1,100 m.

Alternative 3

The river crossing for this route is located just on the exit from the sweeping bend, forming the minimum width among the alternatives (approximately 170 m). This route have been so selected that the bridge length would be minimal.

The riverbed is V-shaped with a maximum water depth of 8.4 m at low water level. This is due to scouring by contraction of flow area at this point. Construction of piers under the water is very difficult due to high water depth and results in reduction in flow area, which cause further riverbed scouring.

Access road on the right bank passes very close to the political school, through the center of village over 900 m section. It appears to bring environmental problems. Total length of the approach roads are approximately 2,400 m.

Alternative 4

This route was selected as an alternative to Route 3, avoiding densely populated parts and the political school, and considering the stability of river flow during bridge construction.

Riverbed is flat with 3 m water depth and there has been no scouring observed from river sounding. Water crossing would be approximately 230 m. From the view point of construction work in water, this location appears to offer a suitable crossing for the proposed bridge.

This location is situated approximately 900 m away from the center of village, giving inconvenience to villagers. During the study, it has found that this route pass the narrow area between main pump station (for agricultural and rural development project) and cooperative school. A more detailed study is therefore required for the effect of bridge construction on pump operations, such as extent of scouring due to pier construction and river bank protection might be required.

It was also found that the approach road will pass too close to the proposed canal for the above project. Coordination of design with the project will be required. This route would require approximately 500 m of additional approach road compared with Route 3.

Alternative 5 and 6

Crossing for these routes are approximately 5 km and 6 km down stream from ferry crossing respectively. These routes were selected so as to shorten the existing road length running along the Nam Ngum river from the ferry crossing to Hatkiang Village. The main advantage would be a shortened road for vehicles passing through the village. River crossing would approximately be 190 m and riverbed is almost flat with 3.5 m of water depth.

Route 5 was chosen to avoid the inundated area on Route 6 and would involve a total of 6.8 km approach roads including embankment works on soft ground (flood prone area) and water-way works for irrigation facilities of Tha Ngon Farm.

Route 6 have also been chosen to shorten route 10 directly using the existing road and space in farm. However, approach roads would approximately be 1.3 km longer compared with Route 5.

These routes would have the highest construction cost among the alternatives and seems justified to construct in the future.

6.1.2 Final Candidate

To select the most suitable route among six (6) alternatives, the following check items were taken into account.

1. Stability of river bed and river banks
2. Length of bridge
3. Relation with township(Ban Tha Ngon and Ban Hai)
4. Existing land use
5. Length of approach roads
6. Erosion/scouring by water flow

The comparison study among alternatives was made mainly based on the technical assessments for suitable route selection.

Alternative 1 : on sweeping left hand bend
scouring of riverbed
erosion of right side bank
close to Ban Tha Ngon
bridge length may be 180 meter

Alternative 2 : mostly same as alternative 1
bridge length may be 260 m

Alternative 3 : V-shaped of riverbed
8 meter water depth(march)
close to the political school
bridge length may be 170 meter

Alternative 4 : 900 meter from Ban Tha Ngon
bridge length may be 230 meter

Alternative 5 : 6.8 km of approach road
passing through rice fields
bridge length may be 185 meter
as an option for alternative 6

Alternative 6 : 1.8 km longer than alternative 5
passing through rice field and
inundated area
bridge length may be 190 meter

From the view point of comparative merits and demerits among these alternatives, following were found by each alternative:

Large scale of shore protection works would be needed for alternatives No.1 and 2. Even though shore protection is provided, it is very risky for future stability by water flow. The approach road is poor in horizontal alignment and passing through residential areas of Tha Ngon. Longest bridge

length will be required for alternative No.2. Based upon these demerits, alternative Route No.1 and No.2 are found not suitable for new bride construction.

Being for close to political school is the problem for alternative No. 3. It will bring environmental difficulties during and after the construction, such as noise and air pollution. River bed is V-shaped and water depth is 8 meters during dry season. Bridge length will be 170 meters.

During the field work it was found that, no environmental problems would occur on alternative Route No.4. River bed is stable and water depth is only 3 to 4 meters in dry season. Gradient of road may be 3 to 4 percent on left bank. This will not cause any troubles for passing traffic in the future.

Alternative route No.5 pass through, rice fields of Tha Ngon Firm which is in good operation and has high productivity will be disturbed by embankment and mud. Same as alternative No.6, culverts and drainage facilities would be required. Approach roads would be 6,800 meters.

Alternative route No.6 is passing through an inundated area and crossing over the irrigation canal and feeder road. Large scale culverts and drainage facilities shall be needed. Approach roads are 8,100 meters.

Through these evaluations, as a conclusion the alternative Route No.4 appeared as the most suitable route for bridge construction, from both the technical aspect of bridge construction, and property likely to be affected by the Project and from the viewpoint of social and environmental impacts. However, more detailed examination and survey will be required to pin point exact bridge crossing site and route for approach roads for the detailed design.

6.1.3 Situations Along the Route

Detailed topogaphic survey was conducted during the second field survey in June, July and August 1990. Through this topogaphic survey and also several meetings among authorities concerned, the following circumstances were found (see Figure 6.1).

1) In Ban Tha Ngon Area

Two problems were found in Ban Tha Ngon area, which are:

a) Close to the propose road, approximately 400 meters from the starting point, there is an area which contains rice fields and an irrigation plan for the area.

b) The Km 6 irrigation project plans to set a pump station next to the bridge site and the distance between the planned pump station and bridge center is about 70 meters.

Therefore, road center line near the beginning point is obliged to be shifted several meters to west, in the same manner bridge site is also required to moved a little further upstream. No other problems were found in the area.

2) In Ban Hai area

Planned road runs into forest at Ban Hai area after crossing the river. During the topographic survey, it was also found that the forest have been used as a cemetery since 18th Century by the village community. Relocation of the route was required to avoid disturbing the spiritual life of local people.

6.1.4 Final Route Selection

Modification and shifting the selected route was made from the viewpoint of the followings:

1. to eliminate disturbances to the irrigation area (under planning)

2. to provide more distance between pump station for the irrigation project and the bridge; and

3. to avoid the cemetery in Ban Hai area.

Above mentioned conditions along the route caused the center line to move or shift from original planned location. In Ban Tha Ngon area, center line was move to west side and/or upstream side, in two places.

In Ban Hai area, two ideas were considered for shifting the center line:

a) moving the center line to northern edge of forest or,
b) moving to southern side of forest

Through several discussions with occupants of the village, DCTC and other authorities concerned, final route was decided as follows.

a) Fix the beginning point of road

b) Shift the center line about 100 meters to west, in the section near the starting point to avoid disturbance to the irrigation area

c) Shift center line to upstream about 20 meters from the original location, at river crossing point

d) Move center line to south-west side of forest to avoid the cemetery in Ban Hai area, and to facilitate access to new road from Ban Hai

Alignment of final route is shown on Figure 6.2.

6.2 Bridge Type Selection

6.2.1 Selection Flow

The flow chart in Figure 6.3 was used for choosing the optimum bridge type from the proposed possible alternatives.

In the figure, 11 types of superstructure are proposed for the evaluation mainly in terms of the split number of th spans with expression of the structural characteristics and materials of the bridge. Subsequently, 6 alternatives were entailed for selecting the type of substructure. After a comparative study on the superstructures of the alternatives, 4 bridge types were chosen for further detailed comparison. Consequently, one out of 4

alternatives was finally concluded for the basic design through the precise comparative studies on the basis of several evaluation criterions as indicated in the figure. As of the type of the substructure, one of the alternatives was chosen by direct comparison in order to cope with the requirements of the superstructure, and will be employed for the basic design.

6.2.2 Preliminary Selection

The influential factors to determine the physical type of the superstructure are; (1) range of split length and subsequent number of the spans; and (2) type of structure and materials.

The crossing length of the bridge over Nam Ngum is estimated at nearly 230 meters. In case of the size of bridge, the construction cost for the substructure will rise when the number of the spans increase because the work quantity of the substructure also increases, while the cost of the superstructure will drop because its structural volume is relatively reduced.

Figure 6.4 gives an attempt to show the specific relationships between the split number of the spans applied to the superstructure(varying from one to eight) and the cost levels(indices) estimated for both super and substructures. The cost level of the superstructure drops very rapidly between the cases of single and 3 spans and continues gradually to reduce between 3 and 8 spans. Although substructure cost decreases between the cases of single and 3 spans, it starts to increase between 3 and 8 spans. Consequently, the level of total cost will be extremely higher in both cases of single and 2 span bridges compared with 3 or more spans.

In general, a single span bridge is applied where valley crossing is very high and the construction of piers are extremely difficult, or if there is a need to allow free navigation beneath the superstructure. However, there is no such special requirements in this project. 2 span bridge type (average span length approximately 115 meters) can be adopted in case it is required to reduce the number of piers, however, there should not be such particular requirements in this case. In selecting the type of the bridge for basic design, priority shall be given preferably to the most economic designs, which are 3 or more span type bridge.

The discussion hitherto concludes to disregard the cases of single and 2 span bridges out of the possible alternatives. On the contrary, as the figure indicates, the cost level of 8 (or more) span bridge seems to be evaluated as low as those of 5, 6, or 7 span bridges, however it shall be disregarded as an objective of comparative studies, because too many pier construction in the river requires more construction period as the rainy seasons intervene, which is resulting in considerable increases on indirect construction costs. Furthermore, it facilitates the tendency to impede the flow of river when the number of the spans increases to 8 or more. Thus, the case of 8 or more span bridge is disregarded.

As a result, only 3 to 7 span bridge types are adopted for considering the normal ranges of span length by bridge type, as per Figure 6.5, thus as summarized in Figure 6.6, 11 alternative bride types have been subsequently proposed.

a) 3 span bridge type
   i) continuous pre-stressed concrete girder bridge(Type 1)
   ii) continuous steel box girder bridge(Type 2)
   iii) steel Langer girder bridge(Type 11)

b) 4 span bridge type
   i) continuous pre-stressed concrete box girder bridge(Type 3)
   ii) continuous steel box girder bridge(Type 4)

c) 5 span bridge type
   i) post tensioned concrete simple girder bridge (Type 5)
   ii) continuous steel girder bridge(Type 6)

d) 6 span bridge type
   i) post-tensioned concrete simple girder bridge (Type 7)
   ii) continuous steel girder bridge (Type 8)

e) 7 span bridge type
   i) post-tensioned concrete simple girder bridge (Type 9)
   ii) continuous steel girder bridge (Type 10)

Followings are detailed explanations by bridge type.

Type 1

Provides an attractive appearance with simple and clear lines. No disruption to the river flow due to few piers and no big construction risk for superstructure by employment of cantilever erection method. it needs a higher cost and longer construction period among the alternatives, but least maintenance is required. Employment opportunity is expected, but there is very little chance for technology transfer.

Type 2

Provides a comparatively attractive appearance. No disruption to the river flow due to few piers and no construction risk for superstructure by employment of launching erection method. It needs a bit higher cost but the least construction period among the alternatives. Periodic maintenance work is required. Technology transfer and employment opportunity are not expected.

Type 3

Provides a comparatively attractive appearance. A little construction difficulty exists due to the self launching erection method. Disruption to the river flow is comparatively little. The cost is moderate and the less construction period is necessary among the alternatives. The least maintenance is required. Employment opportunity and so chance for technology transfer is expected.

Type 4

Provides a comparatively attractive appearance, but less than Type 3. No construction difficulty for superstructure. Disruption to the river flow is comparatively little. The cost is adoptable and the least construction period is necessary among the alternatives. Periodic maintenance work is required. Technology transfer and employment opportunity are not expected.

Type 5

Provides a comparatively attractive appearance. Structure is simple. No construction difficulty for superstructure. Disruption to the river flow is comparatively small. The cost is the least and an average construction period is necessary among the alternatives. Less maintenance work is required. There is advantages on availability of technology transfer and employment opportunity.

Type 6

Provides a simple appearance. Structure is monotonous. No construction difficulty for superstructure. Disruption to the river flow is comparatively small. Construction cost is moderate and the period is average. Periodic maintenance work shall be required. Expected technology transfer and employment opportunity are low.

Type 7

Provides a monotonous appearance. No construction difficulty for superstructure. Reduction in flow area of river by many piers results possible scouring problem and swelling of water level. This type of bridge generally is of less direct costs, but requires longer period in construction of piers than Type 5. Less maintenance work is required, but maintenance cost is higher than Type 5. There is advantages on availability of technology transfer and employment opportunity.

Type 8

Provides a monotonous appearance. No construction difficulty for superstructure. Reduction in flow area of river by many piers results possible scouring problem and swelling of water level. The cost is average but require longer period for pier construction than Type 6. Periodic maintenance work is required. Expected technology transfer and employment opportunity are low.

Type 9

Provides a monotonous appearance. No construction difficulty for superstructure. Much disruption to the river flow, and reduction in flow area of river by many piers results possible scouring problem and swelling of water level. The cost is moderate but requires longer period for construction of piers than Type 7. Less maintenance work is required, but maintenance cost is higher than Type 7. There is advantages on availability of technology transfer and employment opportunity.

Type 10

Provides a monotonous appearance. No construction difficulty for superstructure. Much disruption to the river flow, and reduction in flow area of river by many piers results possible scouring problem and swelling of water level. The cost is average but fairly longer period is required for constructing the piers than Type 8. Periodic maintenance work is required. Technology transfer and employment opportunity are not expected.

Type 11

Provides an attractive appearance with simple and clear lines. No disruption to the river flow and no construction risk for superstructure. Requires large scale erection equipments which shall cause longer construction period. it needs the highest cost among the alternatives. Periodic maintenance work is absolutely required. Technology transfer and employment opportunity are not expected.

Among the considered eleven (11) type of bridges mentioned above, 4 final alternatives were taken up for final comparison as shown in Figure 6.7.

6.2.3 Type of Pier/Foundation

Considering that the both cost and construction period, several possible alternatives, with regards to the foundation, are proposed as follows(see Figure 6.8):

a) Spread foundation on dense gravels which requires the coffering work by double sheet piles in the river

b) Multi-column foundation by reinforced concrete piles or pre-stressed concrete piles

c) Multi-column foundation by reverse circulation drill method concrete piles, the foundation is constructed below the L.W.L.

d) Same as "b" but the foundation is constructed below the L.W.L., and requires coffering by single sheet piles

e) Same as "c" but the foundation is constructed below the L.W.L. and requires coffering by single sheet piles

f) Well using steel caisson

Method a)

Requires double coffering by sheet-piles, which shall cause extended construction period and difficulty on execution. Construction cost is moderate. Disruption to the river flow occurs during construction. Less maintenance work is required, and no scouring problem occurs. There is an advantage on availability of technology transfer and employment opportunity.

Method b)

Poor appearance of many piles plunging under the footing. Many piles disrupt the river flow and cause immediate scouring problem as was the case of Thinkeo bridge. Difficulty in driving piles is expected into the hard stratum sufficiently. Construction cost is low. Less construction period is expected, but longer than Method c). Maintenance work is required. Technology transfer and employment opportunity are expected.

Method c)

Considerably good and strong appearance by a few and large size piles supporting the footing concrete. Less disruption to the river flow and less scouring problem. Easier execution than Method b). Construction cost is the least and less construction period is expected than Method b). Maintenance work is not required. There is an advantage on availability of technology transfer and employment opportunity.

Method d)

Provides a good appearance. Requires coffering by the sheet-piles causes longer construction period and highest construction cost among the alternatives. Disruption to the river flow occurs during construction. Less maintenance work is required. No scouring problem takes place. There is advantages on availability of technology transfer and employment opportunity.

Method e)

Provides a good appearance. Coffering by the sheet piles causes longer construction period and higher construction cost among the alternatives. Disruption to the river flow takes place during construction term. Less maintenance work is required, and no scouring problem occurs. There is an advantage on availability of technology transfer and employment opportunity.

Method f)

Provides a monotonous appearance. Excavating in the water will be required. Shortest construction period is expected, but construction cost is the highest among the alternatives. Less impedance to the river flow. Less maintenance work is required, and no scouring problem occurs. Technology transfer and employment opportunity are not expected.

as above and the results are summarized in Table 6.1. After the comparison and examination of methods, it was decided to employ the Multicolumn Foundation by Reverse Circulation Drill Method Concrete Piles (Method C) for the foundation works.

6.2.4 Final Selection of Bridge Type

The 4 alternatives which are given higher marks in the preliminary selection are:

1) 5 span post-tensioned concrete simple girder bridge (Type 5)

2) 5 span continuous steel girder bridge (Type 6)

3) 6 span post-tensioned concrete simple girder bridge (Type 7), and

4) 6 span continuous pre-stressed concrete box girder bridge (Type 7.2)

A detailed evaluation of the 4 alternatives was further conducted on the basis of 15 criteria as indicated in Figure 6.3, which are summarized below:

Type 5

Provides a comparatively attractive appearance. Structure is very simple. No construction difficulty for superstructure. Disruption to the river flow is comparatively small and less than Type 7 and 7.2. The cost and construciton period are the least among 4 alternatives. A little maintenance work is required, and the maintenance cost is the least among the 4 alternatives. There is an advantage on availability of technology transfer, employment oppotunity and use of local materials. Smoothness of bridge surface gives comfort to drivers. Very easy to repair the bridge and widen its width when necessary in the future.

Type 6

Provides a comparatively more attractive appearance than Type 5 in simplicity of structure. Smoothness of bridge surface is expected. No construction difficulty of superstructure. Disruption to the river flow comparatively little and less than

Type 7 and 7.2. The cost is the highest among 4 alternatives. Construction period is less than Type 7 and Type 7.2. To reduce the maintenance work after completion, a maintenance-free steel shall be adopted, which causes the higher costs. Technology transfer, employment opportunity and use of local materials would not be expected. It is fairly easy to repair the bridge and widen its width in the future.

Type 7

Provides a monotonous appearance. No construction difficulty for super-structure. This type of bridge may belong to the least costly group, from figure 6.4 but requires a longer period of construction of piers than Type 5. Less maintenance work is required. The maintenance cost is higher than Type 5. There is an advantage on availability of technology transfer, employment opportunity and use of local materials. It is very easy to repair the bridge and widen its width in the future.

Type 7.2

Provides a comparatively more attractive appearance than type 5 in simplicity of structure. Smoothness of bridge surface. A little construction difficulty exists in the self launching erection method. Reduction in flow area of river by many piers results in possible scouring problem and swelling of water level compared with Type 5. The cost is higher than Type 5 and requires a longer period in construction of piers than Type 5. Very little maintenance work is required, and maintenance cost is the lowest among the 4 alternatives. There is an advantage on use of local materials. Availability of technology transfer and employment opportunity are expected but those are less than Type 5 and Type 7. It is very easy to repair bridge and widen it width.

As a result of the evaluation developed above, the type of 5 Span Post-tensioned Concrete Girder (Type 5) has been finally selected for the basic design.

Although there are some construction methods for the pre-stressed concrete bridge (especially in the manner of stressing the steel bar or wire), there will be no problems to adopt any of the methods currently used in Japan for post-tensioned simple girder construction.

Table 6.1 Comparison of Construction Method for Foundation

	1	2	3	4	5	6	7	8	9	Total Comparative Evaluation
1. Spread foundation on dense gravel with coffering by double sheet piles	○	△	△	◎	○	◎	○	△	◎	Requires double coffering by the sheet-piles to resist water and earth pressure, which shall cause extended construction period and difficulty on execution. Construction cost is moderate. Disruption of the river flow exists during construction term. Less maintenance work be required, and no scouring problem exists. There is advantages on availability of technical transfer and employment opportunity.
2. Multi-column foundation by reinforced concrete piles or prestressed concrete piles	◎	○	○	△	○	○	△	△	△	In dry season, provides poor appearance of many piles plunging under the footing. Many piles disrupt the river flow and cause immediate scouring problem. Difficulty in driving piles. Construction cost is less. Less construction period be expected, but longer than Method c) Maintenance work be required. Technical transfer and employment opportunity are expected.
3. Multi-column foundation by reverse circulation drill method concrete piles.	◎	○	◎	○	◎	○	○	○	○	Provides considerably good appearance by few piles under the footing. Less disruption of the river folw and scouring problem. Easier execution than Method b). Construction cost is least and less construction period be expected than Method b). Maintenance work not be required. There is advantages on availability of technical transfer and employment opportunity.
4. Reinforced concrete piles or prestressed concrete piles with coffering by single sheet piles	△	△	△	◎	○	◎	○	△	◎	Provides a monotonous appearance. Coffering by the sheet-piles causes longer construction period and higher construction cost among the alternatives. Disruption of the river flow exists during contruction term. Less maintenance work be required. No scouring problem exists. There is advantages on availability of technical transfer and employment opportunity.
5. Reverse circulation drill method concrete piles with coffering by single sheet piles	△	△	△	◎	◎	◎	○	△	◎	Provides a monotonous appearance. No scouring problem. Coffering by the sheet-piles causes longer construction period and higher construction cost among the alternatives. Disruption of the river flow exists during contruction term. Less maintenance work be required. No scouring problem exists. There is advantages on availability of technical transfer and employment opportunity.
6. Steel caisson	△	◎	◎	○	△	△	△	○	◎	Provides monotonous appearance. Excavating in the water be required. shortest construction period be expected, but construction cost is highest among the alternatives. Less impedence on the river flow exists. Less maintenance work be required, and no scouring problem exists. Technical transfer and employment opportunity not be expected.

1. Construction cost
2. Construction period
3. Easy construction
4. Bridge aesthetics
5. Technical transfer
6. Local employment opportunity
7. Maintenance aspect
8. Influence on river
9. Scouring

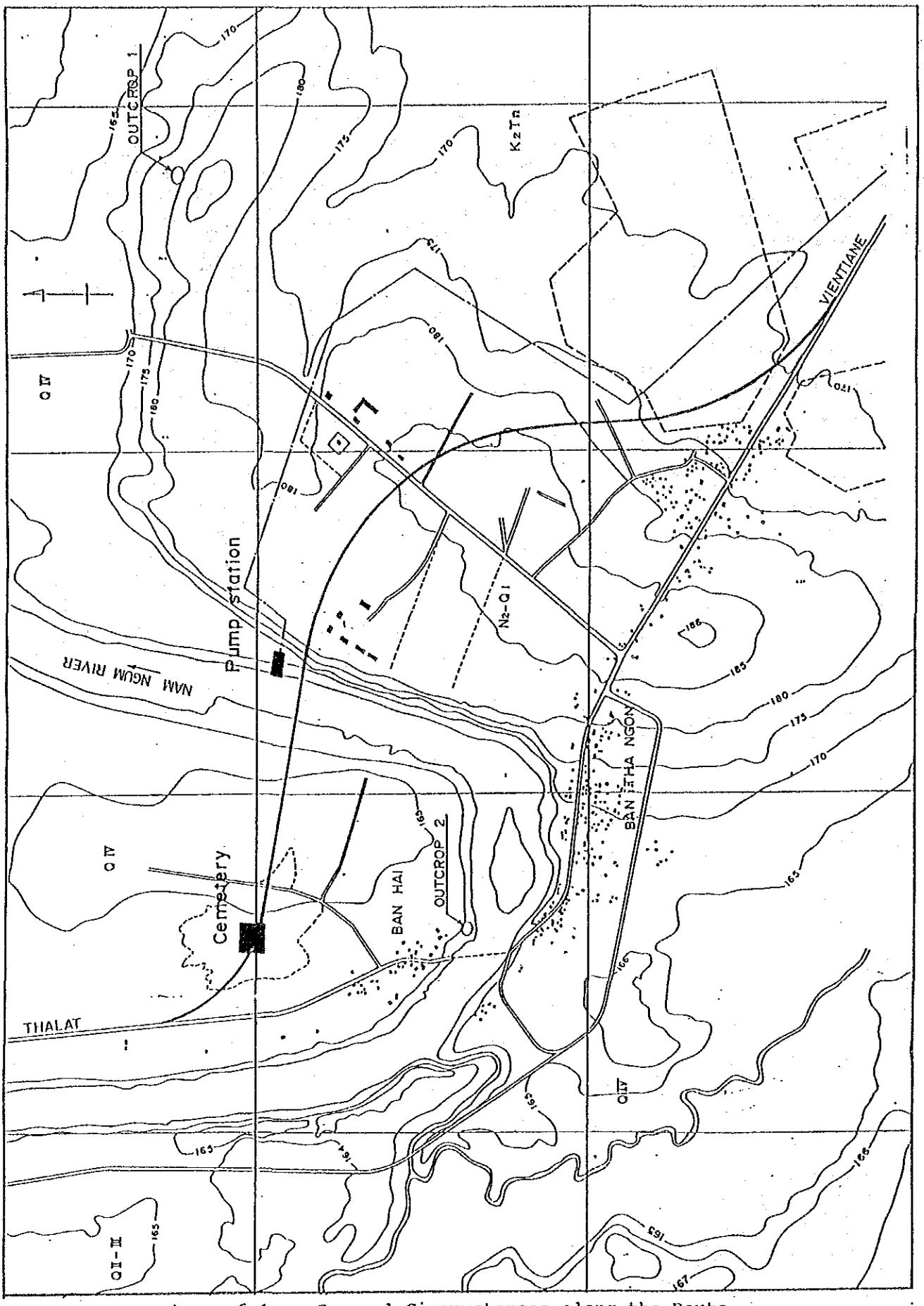


Figure 6.1 General Circumstances along the Route

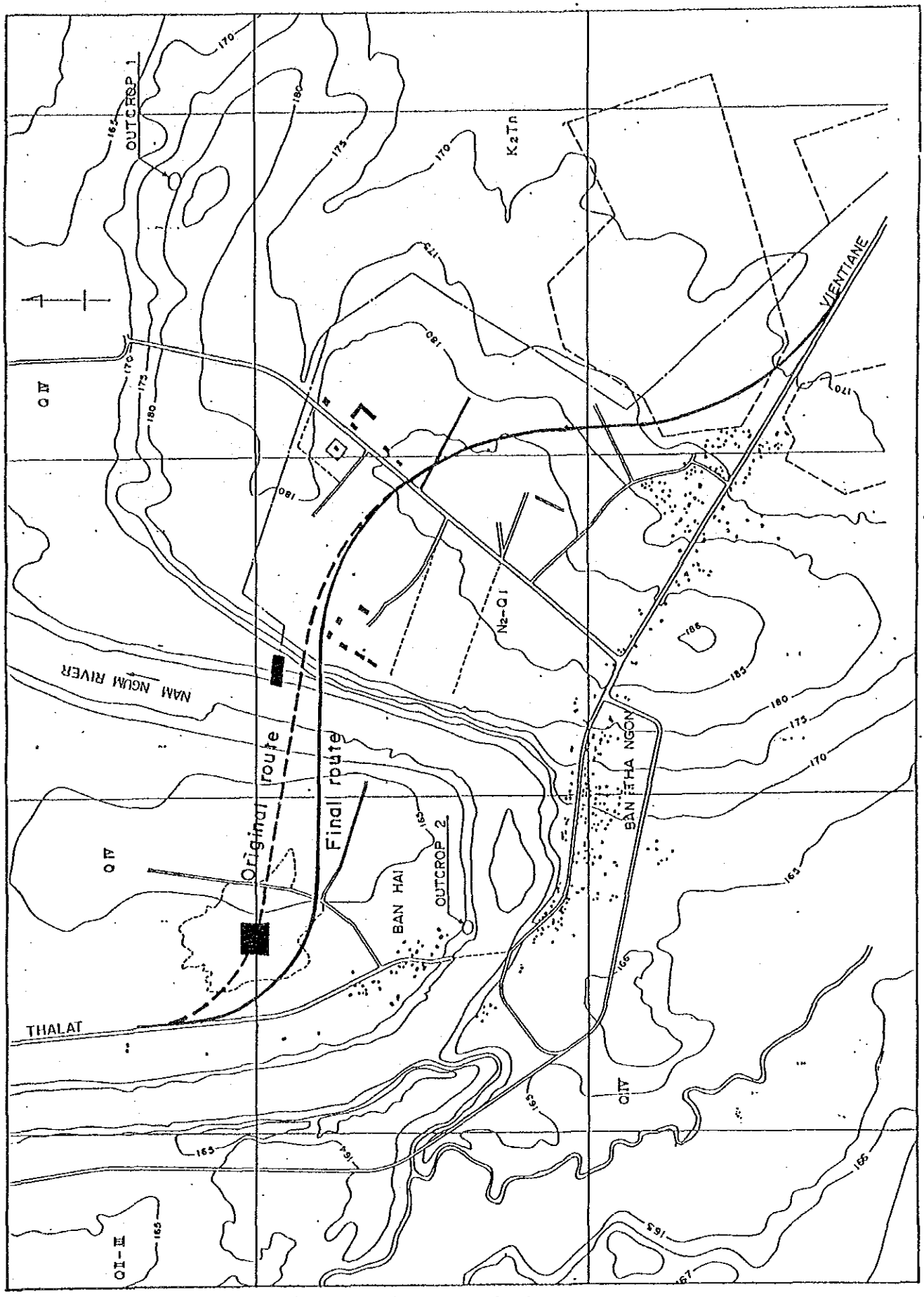


Figure 6.2 Alignment of Final Route

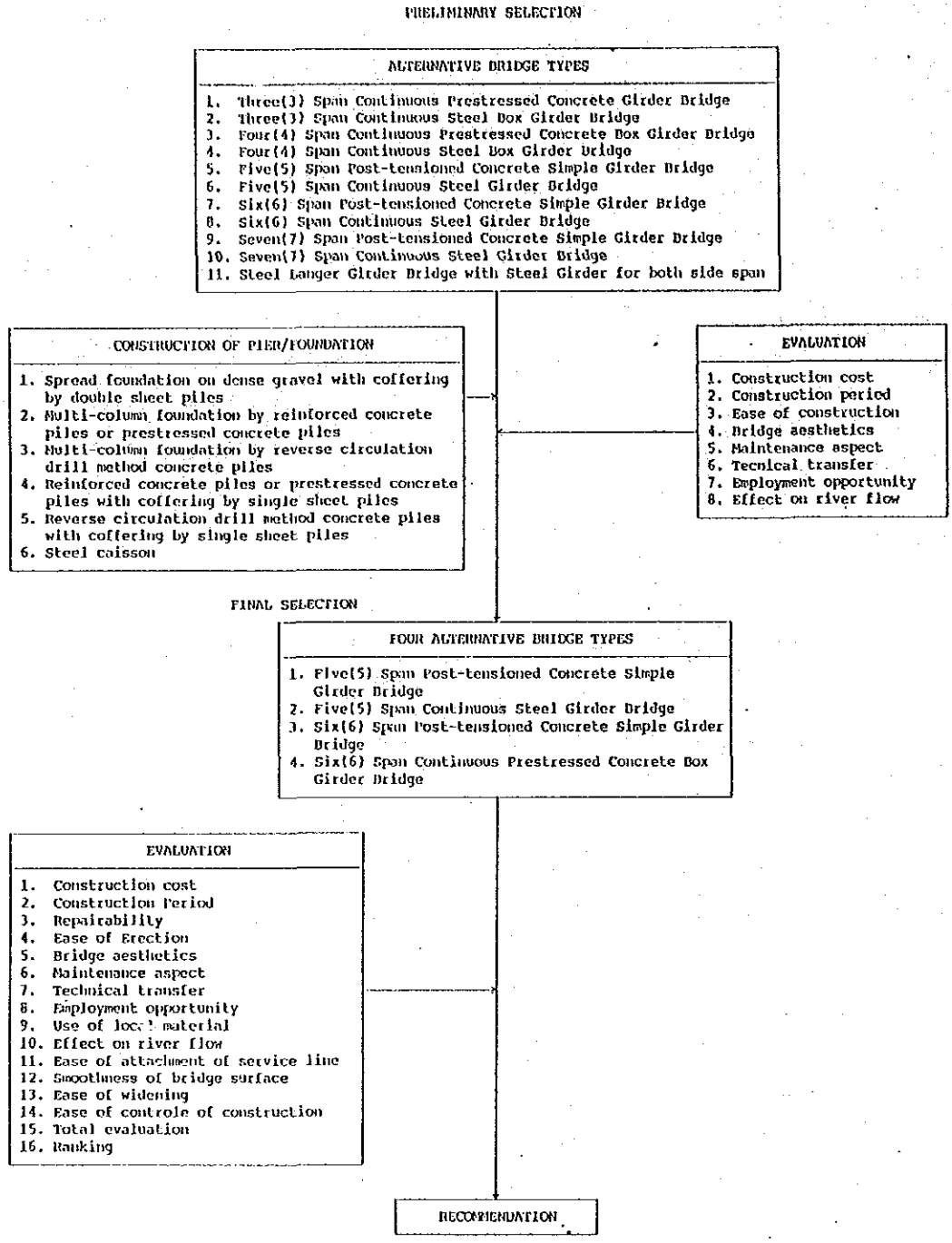


Figure 6.3 Flow Chart for Selection of the Bridge Type

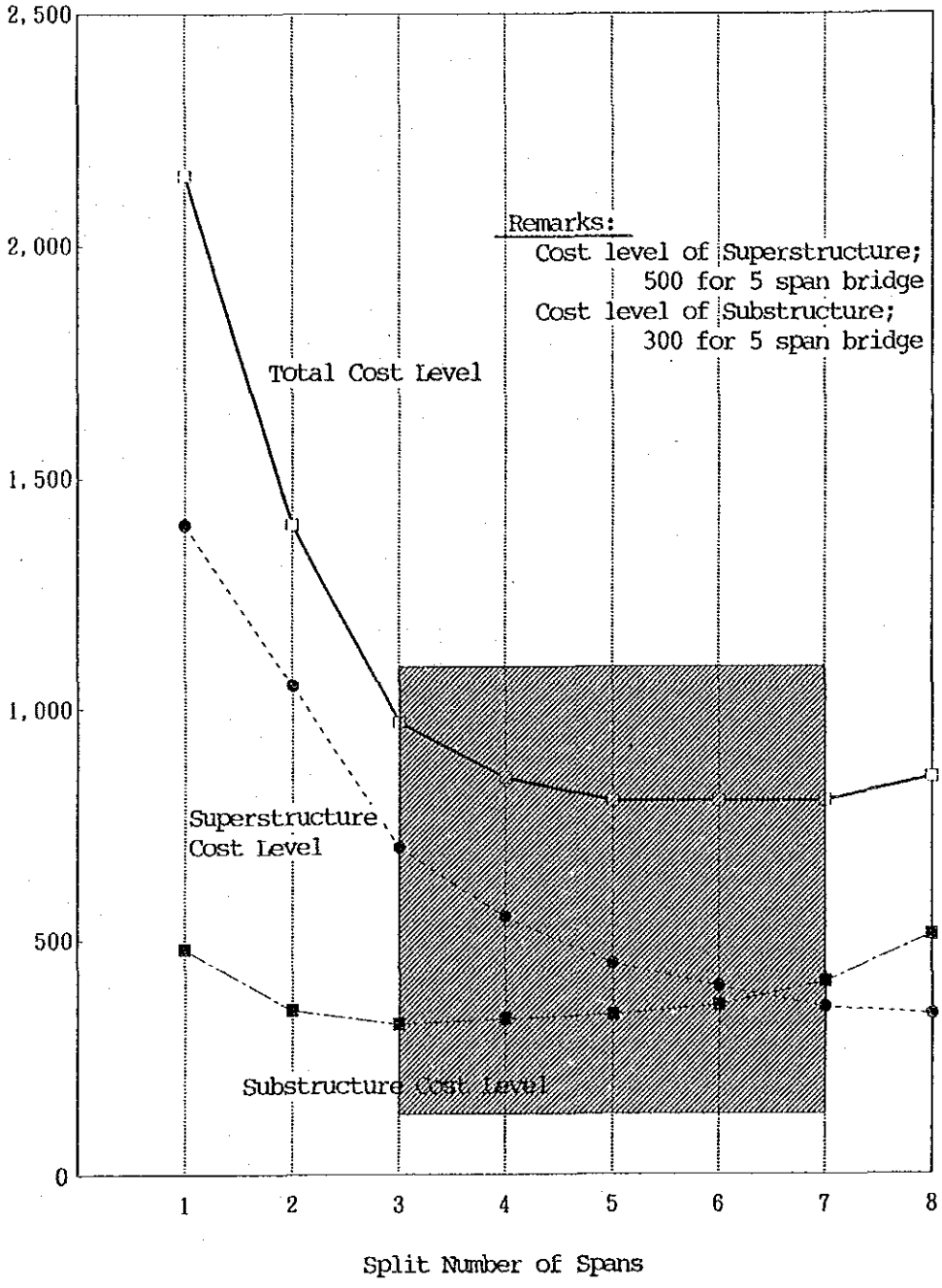


Figure 6.4 Level of Cost by Split Number of Spans

Normal range of span length by bridge type

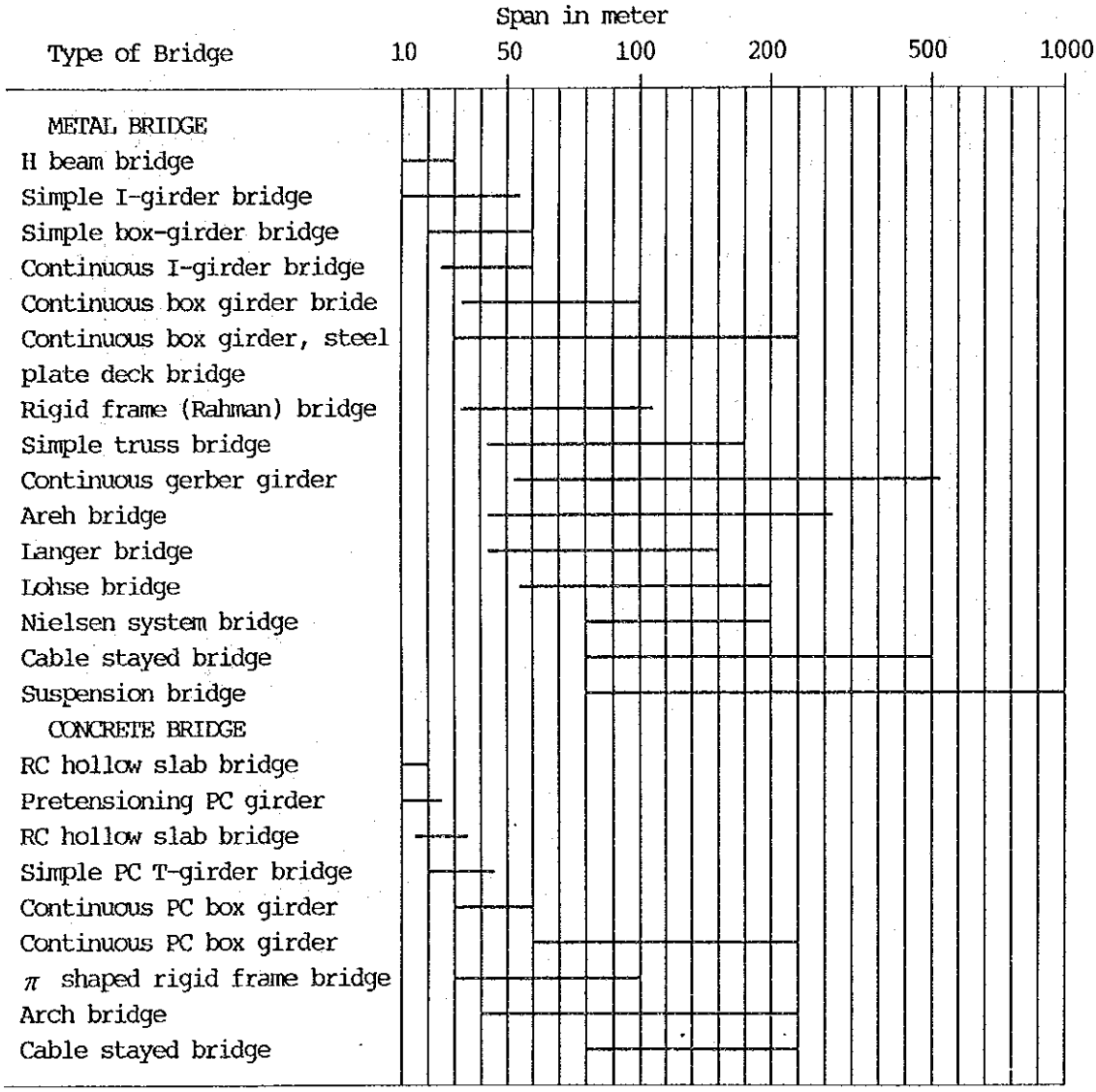


Figure 6.5 Normal Range of Span Length by Bridge Type

1. Construction Cost : 5. Maintenance Aspect :
2. Ease of Construction : 6. Technology Transfer :
3. Construction Period : 7. Employment Opportunity :
4. Bridge Aesthetics : 8. Effect on River Flow :

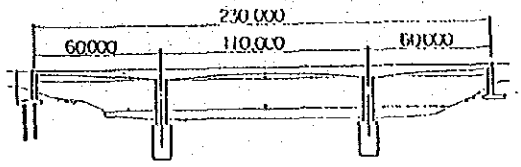
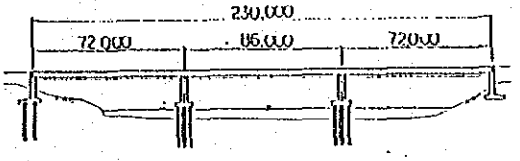
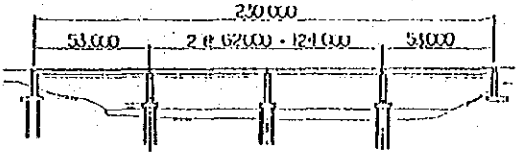
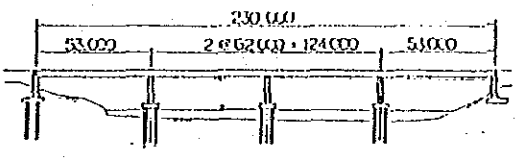
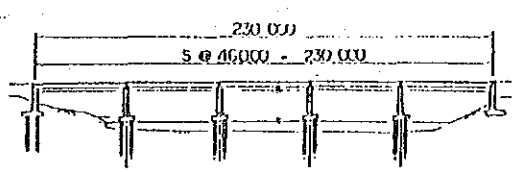
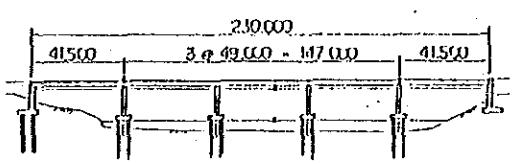
	ELEVATION OF BRIDGE	1	2	3	4	5	6	7	8	DESCRIPTION
1	3 Span Continuous P C Rigid Frame Bridge 	△	△	△	◎	◎	△	◎	◎	Provides an attractive appearance with simple and clear lines. No disruption of the river flow and no big construction risk for superstructure due to the few piers and employment of cantilever erection method. It needs a higher cost and longer construction period among the alternatives, but least maintenance be required. Employment opportunity is expected, but there is very few chance for technical transfer. △
2	3 Span Continuous Steel Box Girder Bridge 	△	○	◎	○	△	△	△	◎	Provides comparatively attractive appearance. No disruption of the river flow and no construction risk for superstructure due to the few piers and employment of launching erection method. It needs a bit higher cost but least construction period among the alternatives. Periodic maintenance work be required Technical transfer and employment opportunity not be expected. △
3	4 Span Continuous P C Box Girder Bridge 	○	△	◎	○	◎	△	◎	○	Provides a comparatively attractive appearance. A little construction difficulty exists due to self-launching erection method. Disruption of the river flow is comparatively little. The cost is average and less construction period is necessary among the alternatives. Least maintenance work be required. Employment opportunity and a few chance for technical transfer be expected. △
4	4 Span Continuous Steel Box Girder Bridge 	○	○	◎	○	△	△	△	○	Provides comparatively attractive appearance, but worse than type 3. No construction difficulty for superstructure. Disruption of the river flow comparatively little. The cost is adoptable and least construction period is necessary among the alternatives. Periodic maintenance work be required. Technical transfer and employment opportunity not be expected. △
5	5 span Simple P C Girder Bridge 	◎	○	○	○	◎	◎	◎	○	Provides a comparatively attractive apperance, on monumental point of view , it is simple. Structure is simple. No construction difficulty for superstructure. Disruption of the river flow comparatively little. The cost is least and an average construction period be necessary among the alternatives. Less maintenance work be required. There is advantages on availability of technical transfer and employment opportunity. ○
6	5 Span Continuous Steel Girder Bridge 	○	○	○	○	△	△	△	○	Provides a simple appearance. Structure is monotonous. No construction difficulty for superstructure. Disruption of the river flow comparativelly little. Construction cost and period are average. Periodic maintenance work shall be required. Technical transfer and employment opportunity not be so expected. ○

Figure 6.6(1) Summary of 11 Alternative Bridge Type

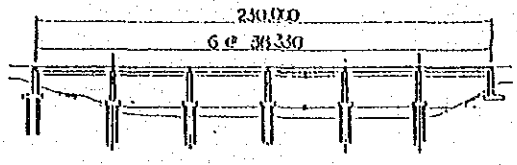
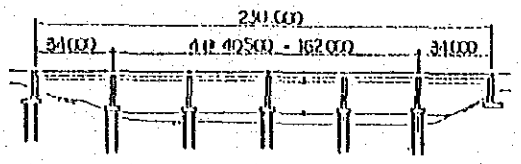
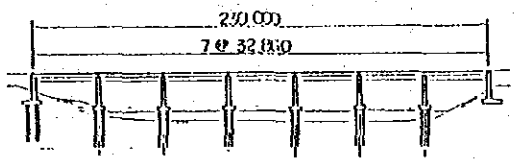
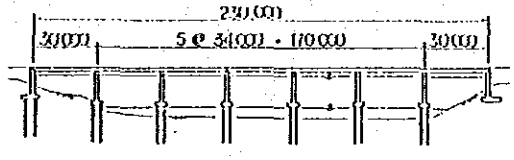
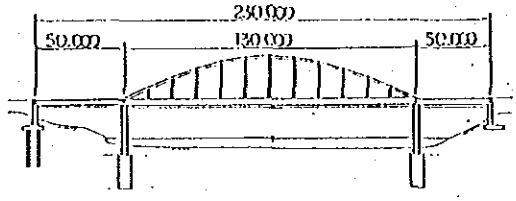
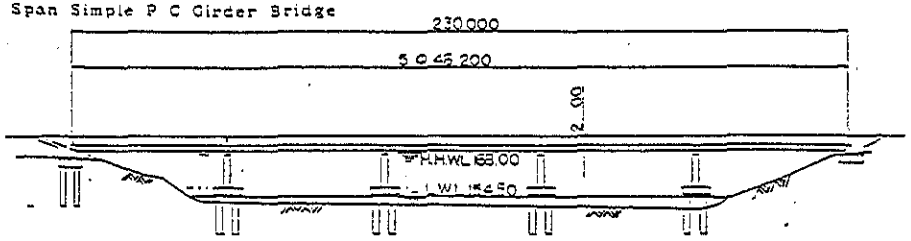
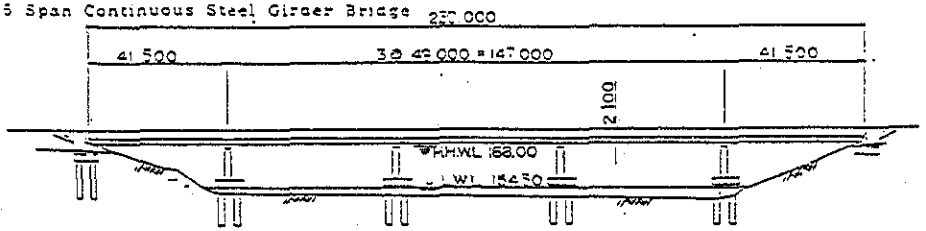
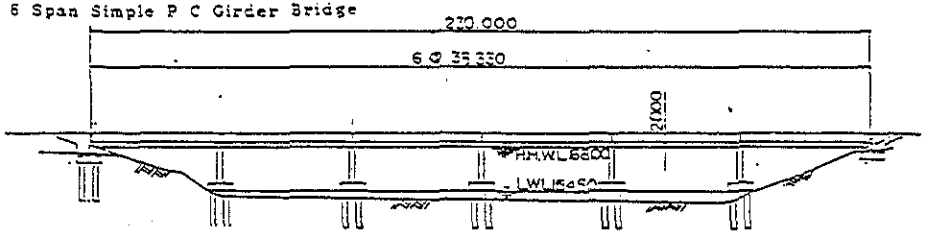
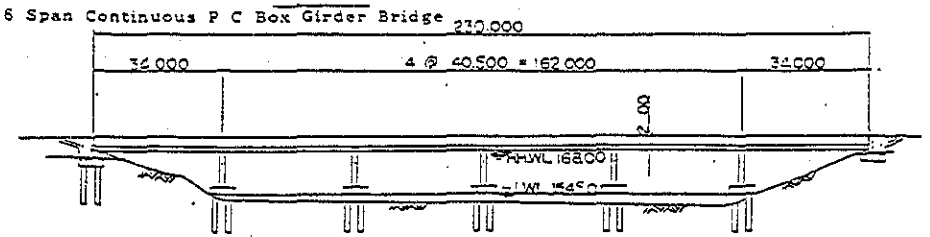
	ELEVATION OF BRIDGE	1	2	3	4	5	6	7	8	DESCRIPTION
7	6 Span Simple P C Girder Bridge 	◎	○	△	△	○	◎	◎	△	Provides a monotonous appearance. Structure is simple. No construction difficulty for super-structure. Reduction in flow area by many piers results possible scouring problem and swelling water level. *This type of bridge generally is of* less direct construction cost, but requires longer period in construction of piers than type 5. Less maintenance work be required,but maintenance cost is higher than type 5. There is advantages on availability of technical transfer and employment opportunity. ○
8	6 Span Continuous Steel Girder Bridge 	○	○	△	△	△	△	△	△	Provides monotonous appearance. Structure is simple. No construction difficulty for super-structure. Reduction in flow area by many piers results possible scouring problem and swelling water level. The cost is average but require longer *period in construction of piers* than type 8. Periodic maintenance work be required. Technical transfer and employment opportunity not be so expected. △
9	7 Span Simple P C Girder Bridge 	○	○	△	△	○	○	◎	△	Provides monotonous appearance. Structure is simple. No construction *difficulty for super-structure.* Much disruption of the river flow, and reduction in flow area by many piers results possible scouring problem and swelling water level. The cost is average but require longer period in construction of piers than type 7. Less maintenance work be required,but maintenance cost is higher than type 7. There is advantages on availability of technical transfer and employment opportunity. △
10	7 Span Continuous Steel Girder Bridge 	○	○	△	△	△	△	△	△	Structure is too monotonous and appearance is poor. No construction difficulty for superstructure. Much disruption to the river *flow. Reduction in flow area* by many piers results possible scouring problem and increased water level. Requires longer period in construction of piers than type 6. Periodic maintenance work is required. Technical transfer and employment opportunity would not be expected. △
11	Steel Longer Girder Bridge with Side Span 	△	△	△	◎	△	△	△	◎	Provides an attractive appearance with simple and clearlines. No disruption of the river flow and no constructionrisk for superstructure. Requires large-scale erection equipment which shall cause longer construction period. It needs highest cost among the alternatives. Periodic maintenance work be absolute ly required. Technical transfer and employment opportunity not be expected. △

Figure 6.6(2) Summary of 11 Alternative Bridge Type

	Elevation of Bridge	1	2	3	4	5	6	7	8	9	10	11	12	13	14		Overall Ranking
5	5 Span Simple P C Girder Bridge 	◎	◎	○	○	◎	◎	◎	◎	◎	○	◎	○	○	◎	The cost and period of construction are the least among the 4 alternative. Well-balanced type in evaluation items such as aesthetic, maintenance, technical transfer, employment opportunity, use of local material, less disruption to the river flow and any other evaluation items. Rates best.	1
6	5 Span Continuous Steel Girder Bridge 	△	◎	◎	◎	◎	○	△	△	△	○	◎	◎	○	○	Highest construction cost among 4 alternatives. More attractive appearance than type 5 above in simplicity of structure. Maintenance free steel shall be used. Technical transfer, employment opportunity, use of local material would not be expected. Rated as No.4	4
7	6 Span Simple P C Girder Bridge 	◎	○	○	○	○	◎	◎	◎	◎	△	◎	△	○	◎	Longer construction period is required than type 5 above. Scouring problem will occur by reduction of flow area of river by many piers. This type belongs the least costly group. Maintenance cost is higher than type 5. Rates as No.2	2
7-2	6 Span Continuous P C Box Girder Bridge 	○	○	◎	△	◎	◎	○	○	◎	△	◎	◎	◎	△	Comparatively more attractive appearance than type 5 in simplicity of structure. Smoothness of bridge surface. Construction difficulty exists in the self launching erection method. Reduction in flow area of river by many piers results in possible scouring problem. Cost is higher than type 5 and requires a longer period of construction.	3

Description
1. Construction cost
2. Construction period
3. Repairability
4. Ease of erection
5. Bridge aesthetic
6. Maintenance aspect
7. Technical transfer
8. Employment opportunity
9. Use of local material
10. Effect on river flow
11. Ease of attachment of service line
12. Smoothness of bridge surface
13. Ease of widening
14. Ease of control of construction

Figure 6.7 Final Alternative Bridge Type

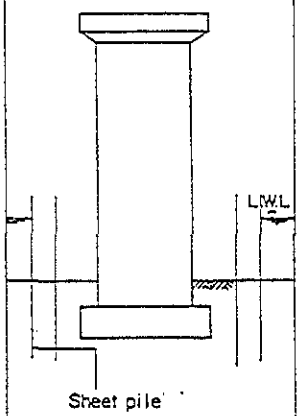
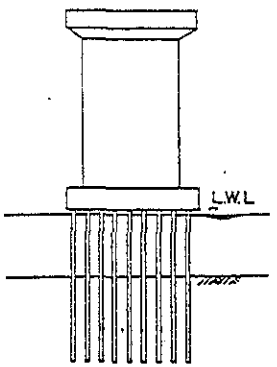
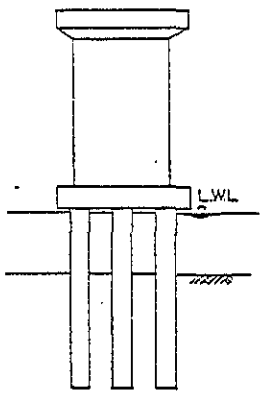
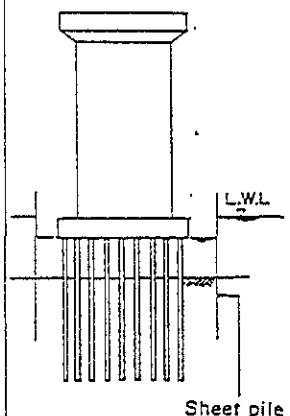
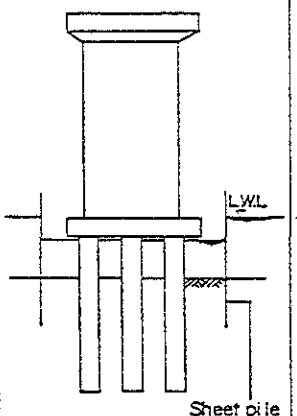
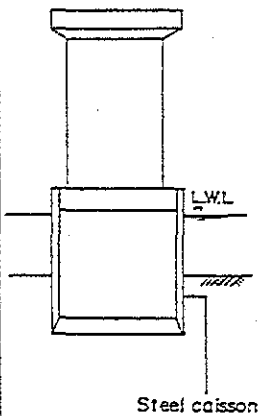
Method	a	b	c	d	e	f
Type	Spread foundation on dense gravel with Coffering by double Sheet piles	Multi column foundation by reinforced concrete piles or prestressed concrete piles	Multi-column foundation by reverse circulation dril method concrete piles	Reinforced concrete piles or prestressed concrete piles with coffering by single sheet piles	Reverse Circulation drill method concrete piles with coffering by single sheet piles	Steel Caisson
Section						

Figure 6.8 Comparison of Construction Method for Foundation

CHAPTER VII

PHYSICAL CONDITION SURVEY

CHAPTER VII PHYSICAL CONDITION SURVEY

7 Physical Condition Survey

7.1 Location

Lao PDR having a population of 3,940,000 (1989) and covering an area of 236,800 sq.Km, is located in the midland of Southeast Asia. The country is surrounded by China, Cambodia, Myanmar, Thailand and Vietnam. Two thirds of the land is categorized as mountainous terrain and contain only a few plains. Project site is located in the Xaythani district of the Vientiane Municipality, approximately 23 km north of the Vientiane city. Proposed bridge site is 1 km downstream from Tha Ngon ferry site in the Ngon village, crossing Nam Ngum river on the Prefectural Road No. 10.

7.2 Topography

Collection of topographic maps and aero-phtographs were a part of topographic survey as preliminary or preparation works. Sounding of the Nam Ngum River Bed was also conducted during the field work.

Through second field work, topographic survey was implemented on the selected route(Alternative Rote No.4 which was selected as the most suitable route) to identify detailed circumstances along the route, in a manner to employ a local surveying company.

7.2.1 Collected Maps and Aero-photographs

As a preliminary data and information collection, topographic maps in scales of 1/10,000, 1/50,000 and 1/100,000 were gathered from the Geographical Office in Vientiane. Topographic maps of scales 1/10,000 and 1/100,000 are complete. Maps in scale 1/50,000 were, however, collected only in part due to lack to stock in the mentioned office.

Together with the maps, aero-photographs in scale 1/30,000 were found in the office concerned. Photographs were taken in 1980 by USSR and by 1982 Lao PDR had the scale 1/100,000 maps prepared in France.

Topographic maps in various scales, which are available in Lao PDR at present were prepared from 1960 to 1982,and no nation wide surveying work have been conducted since 1960's.

It is difficult to get topographic map(s), even for the capital city of Lao PDR (Vientiane and surroundings) with recent situation or circumstances. Maps available in Lao PDR have been prepared on the basis of old data. Years of Maps by scale are as follows.

Topographic map in Scale

1 :	10,000	1967/68
1 :	50,000	1971
1 :	100,000	1982
1 :	500,000	Based on 1/200,000 of 1971
1 :	1,000,000	Based on 1/500,000 of 1971

7.2.2 Topographical Survey

The Survey and Design Institute of Vientiane Municipality was employed as the local survey team to carry out topographic survey on alternative route No.4. This topographic survey consisted of route survey, and site mapping as described in detail below:

a) route survey(1/2,000)
   traverse, centerline setting, longitudinal, cross section,
   bench mark setting

b) site mapping(1/300)
   bridge site survey consisting of plane, cross section,

Prior to all surveying work, traverse net was established form starting point up to route end in Ban Hai. Route surveying and centerline setting was carried out on each 20 meters as minimum distance with survey width of 200 meters along the centerline. Five(5) Bench Marks along the route, three(3) in Ban Tha Ngon side and Two(2) in Ban Hai side were also set.

Site mapping at bridge site was carried out for 200 meters x 100 meters (20,000 sq.meters or 2-ha) on each bank with a total survey area of 40,000 sq.meters(4-ha).

Total length of surveying ran into 3,700 linear meter including river crossing.

7.2.3 Sounding

Sounding of river bed where the bridge crosses Nam Ngum river was conducted wtih a total width of 100 meters both upstream and downstream side from road centerline. River crossing is approsimatley 250 meters.

7.3 Geology and Soil

7.3.1 General

Geology along the proposed route shows that the construction site is generally composed of the alluvial low lands and diluvial highlands. The basement complex is sandy rocks belonging to Neogene period. There is a firm strata of diluvial gravels from the Neogene period under the alluvial deposits at the both banks where the proposed bridge is crossing Nam Ngum. Most of the the access road on the right bank is passing through the diluvial highlands and will be constructed by cutting the diluvial deposits with a maximum cut slope of 5 meters deep. The materials to be excavated from the surface layer of about 5 meters is of sandy soils containing gravels, and can be used for fill works, however, those to be excavated from the deeper layers are swelling clays, which the use of such materials require cautions examinations.

All of the access road on the left bank will be constructed on the alluvial low lands composed of soft clays, and considerable consolidation characteristics shall be taken into consideration for the designs of fill works.

7.3.2 Soil Investigation and Tests

Project area is divided into two geological categories; the diluvial plateau formed on the Vientiane valley of the Neogene and alluvial deposits on the low lands belonging to the diluvial layers.

The soil profile on the bridge section presented in Figure 7.1 shows that the foundation of the abutments and piers will be established in the layer of alluvial gravels or the hard sandy rocks of Neogene period. The Maximum size of grender gravel is about 6 to 7 centimers.

It is observed that considerable extent of erosion have occurred due to repeated swelling of water on the right bank slopes of alluvial deposits around the elevation 158.0 meter.

Most of the access road on the right bank is located on alluvial plateau (expressed as "N-Q1" in the figure), where there are no ground water. The material of 4 to 5 meters thick surface layer is classified as laterites which is sandy soils containing gravels, while the lower layer is clayey soil containing the kaolinites.

The access road on the left bank will lie on an alluvial low land composed of soft calyey soil deposits, which gets inundated every two years.

Careful compaction control shall be essentially required for the use of the soils borrowed from side for embankment, and selected material should be borrowed from outside.

The bore hold investigation shows that the following problems will be expected to occur during the construction of the abutment on the left bank.

a) Settlement of the embankment
b) Lateral flow f the abutment
c) Negative frictions on the pile foundations
d) Deformation of the bank due to the change of river water level

Annex D describs the soil examination of the above.

7.3.3 Bridge Foundations

Piers

Bore hole investigations show that piles should be established in the sandy gravel stratum approximately 5 meters below the riverbed. Soil bearing capacity on this stratum, with N value of more than 30, empirically provide about 300t/sq.m of ultimate bearing capacity.

On the other hand, it should be ensured that the foundation depth is below the level of eroded riverbed by scour during floods. Therefore, it is recommended to provide a means of protection for the pile footing such as gabion or concrete blocks.

Abutment

Left bank abutment should be founded in the same stratum with the piers, approximately 14 meters below the existing ground level.

For right bank abutment, the bearing capacity of the soil at 6 meters below the existing ground level is expected to be 40ton/sq.m from Table 7.1. This abutment is envisaged to impose ground pressures of $24t/m^2$ on 7 meters x 11 meters foundation. However, the abutment height would be approximately 15 meters when foundation on the level described above is employed, which will cause a higher construction cost. So as to decrease the construction cost, it is effective to reduce the abutment height. Therefore, the abutment should be ensured above the foundation level with lean concrete 3.5 meters.

7.4 Material Investigation

7.4.1 General

River sand and gravel, available from the Nam Ngum river, have been used for construction material in the project area. However, these materials are not suitable for the use of bridge construction due to poor quality and limited quantity.

River gravel and sand from Mekong river in Vientiane city is also commonly used as building material but the gravel is produced unscreened without quality control. It is not recommended to use these materials for bridge structure which requires a high strength concrete. No crushed stones are produced around the project area. Figure 7.2 show the quarry sites around Vientiane city and project site. However, only one enterprise have been producing with a screen plant.

7.4.2 *Material for Concrete*

Khoaydeng river gravel 3

This site is located approximately 35 km east from the center of Vientiane city. State enterprise under MCTPC produces 5-10mm and 10-20mm size screened gravel from the Mekong river. So far these materials are the only source of good quality gravel for high grade concrete.

Vientiane river sand 1

This site is located in the center of the city and widely used to provide building material. The material contains high amount of mud and is too fine to produce high strength concrete.

Thinton river sand 2

This quarry site is located approximately 28 km east from the Vientiane City Center. The material is river sand from the Mekong River, consisting coarse material with no mud and no salt which affects the durability of PC concrete. So far, this quarry site is the only source of suitable material for bridge structure.

7.4.3 Material for Road Pavement

1) Subbase Material

Lateritic soil available near the project site can be used alone or mixed with river gravel. Quarry sites 5, 6 and 7 shown on Figure 7.2. are available for the subbase material.

2) Base Course Material

River gravel from the Nam Ngum river (unscreened gravel) at Tanpiao, around 30 km from the project site, mixed with lateritic soil can be used fro base course material.

3) Surfacing

There are two alternative material sources, screened river gravel at Tanpiao which was used in the rehabilitation for Road No.10 of Ban Hai - Tha Lat section constructed few years ago, and screened river gravel at Khoaydeng.

7.5 Meteorology

7.5.1 Temperature

The annual mean temperature is around 26 degree Celsius, it is dry and cool from October to may. The highest temperatures are usually recorded in April before the start of the monsoon, while the lowest temperatures are normally recorded in December and January. The project area lies in humid subtropical area with monthly mean relative humidity of 70%.

7.5.2 Rainfall

The project area is in a humid subtropical zone. Dry and wet seasons are the two distinct seasons, with dry season lasting from October to May and the wet season from June to September. Monsoon season starts in June and ends in September. Annual average rainfall is approximately 1,640 mm, of which 70% is concentrated during June and September. monthly mean rainfalls are as follows:

Monthly mean rainfall (1970-1989)

Month	Rainfall(mm)	Month	Rainfall(mm)
Jan.	7.1	July	271.4
Feb.	12.5	Aug.	326.9
Mar.	35.1	Sep.	283.2
Apr.	81.5	Oct.	98.6
May	244.7	Nov.	8.8
Jun.	268.6	Dec.	3.8

Years Total : 1642.2-mm

7.5.3 Wind

Strong winds with heavy rains occur during summer monsoon which comes in June and ends in September. Annual mean instantaneous maximum wind velocity is 20.3m/sec as show in Table 7.2.

7.5.4 Earthquake

Project area is located in the western edge of the earthquake belt referred as the Burma arc, frontal structures of the Trans-Asiatic zone in Asia. Intermediate shocks are frequent near the north of Burma (24 degree North, 93 degree East) as shown on Figure 7.3. One of the mountain ranges of the Burma arc extends to northern part of Laos. Shallow earthquakes have occurred on this mountainous area with the magnitudes from 3.4 to 4.4 as shown on Table 7.3.

7.6 River Hydrology

7.6.1 River Conditions

The Nam Ngum River is one of the major tributaries to the Mekong (main stream for Lao PDR). It takes its origin in the plateau of Xiangkhoang at 1,000 to 1,500 meters above mean sea level. It flows down about 240 km to reach Nam Ngum Reservoir, which was constructed in 1971. The Nam Lik river, the largest tributary to the Nam Ngum with a catchment area of 5,115 sq. km at Hinhoup gauging station, flows into the Nam Ngum river at Tha Lat about 4 km downstream from the Nam Ngum dam. After joining with the Nam Lik, the Nam Ngum river meanders through Vientiane Plain for about 80 km southerly to reach Tha Ngon and another 80 km easterly until it flows into the Mekong river at Pak Ngum.

1) Catchment area

The surface water catchment area of the Nam Ngum river at the Nam Ngum Dam is 8,460 sq.km. It increases to 14,200 sq.km after joining with Nam Lik at Tha Lat. At Tha Ngon, the catchment area is 16,500 sq.km and 17,340 sq.km at Pak Ngum confluence with the Mekong as shown of Figure 7.4.

2) Discharge data at Tha Ngon gauging station

The monthly mean discharge is summarized in Figure 7.5 and Table 7.4. The discharge varies with the seasons. The maximum discharge occurs during August and September, mostly in September as 1,840 qu.m/sec in 1972 and 2,960 qu.m/sec in 1973 with the corresponding water level of 162.3 meter and 165.8 meter respectively while the minimum discharge occurs from December to May with mean water level of 154.5 meters for the period.

Table 7.5 shows the annual maximum discharge from the period 1960 to 1989, with a maximum discharge of 4,110 qu.m/sec in September 1981. As shown in the similar table the absolute gauge height of 168.50 meters was observed in September, 1966 (the largest flood since 1960). However the maximum discharge was only 3,700 qu.m/sec because the back water effect from the Mekong river. Recorded maximum water level of the Mekong at that time was 170.0 meters at Thanaleng in Vientiane.

The minimum discharge was recorded as 59 qu.m/sec with a water level of 152.3 meters in May 1972 as shown in Table 7.6.

3) Flood Frequency Analysis

The peak discharge for different return periods at Tha Ngon gauging station have been analyzed by Gumbel method form the annual flood records for past 18 years, since completion of Nam Ngum Dam (see Annex C).

The results are as follows:

Return Period (year)

	2	5	10	25	50	100
Discharge (qu.m/sec)	2,460	3,180	3,670	4,280	4,730	5,180
Flood Level(m)	164.5	166.4	167.3	167.5	167.6	167.7

7.6.2 Design Discharge and High Water Level

The following have been considered in determining the design discharge.

a) More increased discharge would be expected in future due to development of logging, cultivation, etc. in the catchment area

b) There is a backwater effect from the Mekong river

c) Maximum recorded water level was 167.62 meter in 1981

From these factors it is recommended that the design flood level is to be taken 168.0 meters, which is associated with approximately 100-years return period.

7.6.3 Scouring

River sounding conducted at the proposed bridge site shows that cross section of the river bed is triangular with the greatest depth at the right bank side. It seems to be eroded due to the effect of sharp upstream bed. The proposed piers on the right bank would be inducing more scour than the ones on the left bank.

River bed consists very loose fine sand to a depth of 3 to 4 meters. This layer is underlain by gravel which is likely to resist scouring.

It is considered that this loose fine sand of river bed would be scoured when piers are constructed. Thus, the pier foundation should be established on the hard layer below the loose fine sand and protection against excessive scouring be provided around piers.

Table 7.1 Empirical Guide Values for Allowable Bearing Capacity

CONSISTENCY		'N' BLOWS	S TONS PER	ϕ	COHESION Qu	Qa(TONS/SQ.M.) (SF)SAFETY FACTOR 3		GUIDE FOR ESTIMATING REQUIRED PILE LENGTH 40 TONS (Ld), SF=3	
GRANULAR	COHESIVE	PER FT.	SQ. M.	(SAND)	TONS/SQ.M.	GRANULAR	COHESIVE	GRANULAR	COHESIVE
VERY LOOSE	VERY SOFT	0 To 5	0 To 3.0	<28°	0 To 5.5	0 To 5.5	NONE	$Pl=\frac{Ld-3S(At)}{0.33S(Ap)}$ = 44.0 M.+	$Pl=\frac{Ld-3S(At)}{0.33S(Ap)}$ = 46.0 M.+
LOOSE	SOFT	5 To 10	3.0 To 5.5	28° -30°	5.5 To 10.0	5.5 To 10.0	RARELY USED	$Pl=\frac{Ld-3.5S(At)}{0.4S(Ap)}$ = 16.0 M.+	$Pl=\frac{Ld-3S(At)}{0.33S(Ap)}$ = 22.0 M.+
SLIGHILY COMPACT	STIFF	10 To 20	5.5 To 10.0	30° -33°	10.0 To 20.0	10.0 To 20.0	10.0 To 20.0	$Pl=\frac{Ld-4S(At)}{0.45S(Ap)}$ = 8.0 M.+	$Pl=\frac{Ld-3S(At)}{0.3S(Ap)}$ = 12.0 M.+
COMPACT	VERY STIFF	20 To 35	10.0 To 20.0	33° -37°	20.0 To 40.0	20.0 To 40.0	20.0 To 40.0	$Pl=\frac{Ld-4.5S(At)}{0.5S(Ap)}$ = 3.6 M.+	$Pl=\frac{Ld-3.5S(At)}{0.25S(Ap)}$ = 7.0 M.+
DENSE	HARD	35 To 70	20.0 To 40.0	37° -44°	40.0 To 75.0	40.0 To 75.0	40.0 To 75.0	$Pl=\frac{Ld-5S(At)}{0.55S(Ap)}$ = 1.5 M.+	$Pl=\frac{Ld-4S(At)}{0.2S(Ap)}$ = 4.0 M.+
VERY DENSE	VERY HARD	70+	40.0+	44°+	75.0+	75.0+	75.0+	$Pl=\frac{Ld-5.5S(At)}{0.60S(Ap)}$ = 0 to 1.5 M.	$Pl=\frac{Ld-4.5S(At)}{0.15S(Ap)}$ = 0 to 4.0 M.

NOTATIONS:

N: BLOWS PER 0.3 M(60 .HAMMER, 75 DROP, 5 D.D. SAMPLER)
S: SHEARING RESISTANCE OF SOIL(TONS/SQ.M.)
ϕ: ANGLE OF INTERNAL FRICTION
Qu: UNCONFINED COMPRESSIVE STSRENGTH(TONS/SQ.M.)
Qa: SAFE ALLOWABLE DESIGN LOAD
Ld: DESIGN LOAD(TONS); COMPUTAITON FOR PILE LENGTH BASED ON 40 TON DESISGN LOAD, AVE. TIP DIA.= 0.25M AVE PILE DIA.=0.3M

Pl: PILE LENGTH PENETRAITON INTO STRATUM FROM WHICH CALCULATED BEARING IS DERIVED.
Ap: AVERAGE AREA OF PILE IN SQ.M. PER M. OF PENETRATION IN BEARING STRATUM.
At: AREA OF PILE TIP IN SQ.M.
NOTE: PILE LENGTH COMPUTATIONS ARE BASED UPON DISPLACEMENT OR COMPACTION TYPE PILES

SOURCE: BUREAU OF PUBLIC ROADS

TABLE 7.2 INSTANTANEOUS MAXIMUM WIND VELOCITY AT VIENTIANE

(Unit : m/sec)

No.	Year	Z (m)	Velocity at height Z m (m/sec)	Velocity at height 10 m (m/sec)
1	1960	12	14	13.64
2	1961		12	11.69
3	1962		10	9.74
4	1963		9	8.77
5	1964		6	5.85
6	1965		20	19.50
7	1966		10	9.94
8	1967		9	8.77
9	1968		29	28.25
10	1969		17	16.60
11	1970		30	29.20
12	1971	14	11	10.47
13	1972		25	23.80
14	1973		16	15.20
15	1974		30	28.60
16	1975		29	27.60
17	1976		27	25.70
18	1977		20	19.00
19	1978		22	20.96
20	1979	18	20	18.40
21	1980		30	27.60
22	1981		55	30.30
23	1982		19	17.50
24	1983		37	34.00
25	1984		25	22.90
26	1985		35	32.20
27	1986		30	27.60
28	1987		30	27.60
29	1988		20	18.40
30	1989		20	18.40

Source: Meteorological Department Average 20.27 m/sec

TABLE 7.3 RECORD OF EARTHQUAKE AROUND LAOS

No.	Date	Scale (magnitude)	Epicenter	Remarks
1	17 Feb. 1975	5.6-6.0	Andaman	
2	1 Sep. 1978	4.9	20°4 N/100°5 E	Lao-Burma border
3	3 Oct. 1979	4.5	18°1 N/ 94°8 E	
4	21 Feb. 1980	4.4	18°2 N/ 95°1 E	
5	4 Sep. 1980	5.1	21°4 N/ 93°9 E	
6	25 Aug. 1980	5.4	15°8 N/ 94°7 E	
7	18 Aug. 1981	4.2	19°4 N/101°6 E	
8	|	4.2		
9	|	3.9		
10	|	3.6		
11	25 Aug. 1981	3.4	19°3 N/101°6 E	
12	|	3.5	19°2 N/101°6 E	
13	|	4.7	23°4 N/ 94°6 E	
14	25 Aug. 1981	4.0	19°4 N/101°8 E	
15		3.8	19°2 N/101°5 E	
16	20 Mar. 1985	5.5	20°5 N/101°4 E	
17	18 Jul. 1985	5.3	18°1 N/104°7 E	
18	26 Jul. 1985	4.3	19°8 N/102°0 E	
19		3.5	19°9 N/101°8 E	
20	18 Nov. 1985	3.4	19°2 N/101°8 E	
21	12 Oct. 1986	4.4	19°5 N/102°3 E	

Source: Meteorological Department

Table 7.4 Monthly Mean Discharge at Tha Ngon Gauging Station

No.	Month / year	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1	1972				144	122	291	835	2,260	1,840	1,000	525	329
2	1973	202	165	199	129	157	363	1,280	1,630	2,960	1,240	425	247
3	1974	168	139	130	136	168	331	647	1,340	1,770	835	431	216
4	1975	153	132	120	124	185	791	1,500	2,247	2,790	1,290	515	284
5	1976	191	157	135	932	174	465	705	1,480	1,524	1,270	705	290
6	1977	155	142	450	398	235	216	728	1,170	1,400	469	260	149
7	1978	128	110	114	124	327	816	1,910	2,770	2,010	793	278	138
8	1979	293	333	322	326	430	642	762	1,060	1,600	603	369	282
9	1980	256	261	267	274	365	799	1,270	1,910	2,210	796	428	357
10	1981	347	351	333	259	450	835	2,200	2,470	2,410	1,410	514	378
11	1982	327	299	335	371	343	535	882	1,600	1,560	1,410	471	370
12	1983	339	324	330	326	280	388	936	1,670	1,600	852	510	363
13	1984	343	330	257	255	379	526	1,500	1,990	1,340	884	473	432
14	1985	445	404	390	113	166	596	1,074	1,170	2,210	1,052	808	985
15	1986	277	178	132	125	330	490	924	1,460	1,240	1,011	562	308
16	1987	269	234	185	177	194	450	445	1,012	1,024	768	424	392
17	1988	365	362	294	255	355	475	600	1,100	800	460	200	180
18	1988	218	210	210									
Mean Discharge		263	243	247	263	274	530	1,070	1,667	1,781	949	464	335

Table 7.5 Annual Floods Data at Tha Ngon Gauging Station

No.	Year	Maximum Gauge Reading (m)	Maximum Discharge (m^3/sec)	Remarks
	1960	165.56	2,650	
	1961	167.14	3,240	
	1962	163.90	2,260	
	1963	167.43	3,330	
	1964	165.29	2,680	
	1965	165.74	2,810	
	1966	168.50	3,700	6.Aug
	1967	165.49	2,740	
	1968	167.30	3,520	
	1969	167.65	4,590	18.Aug
	1970	167.20	4,100	
	1971	166.36	3,070	Nam Ngum Dam completed
1	1972	165.12	2,870	28.Aug
2	1973	166.68	3,370	12.Sep
3	1974	163.54	2,170	10.Sep
4	1975	167.06	3,620	7.Sep
5	1976	164.40	2,440	24.Sep
6	1977	161.90	1,730	25.Sep
7	1978	166.36	3,200	6.Aug
8	1979	164.24	2,380	9.Sep
9	1980	165.96	3,010	1.Aug
10	1981	167.62	4,110	11.Sep
11	1982	165.47	2,810	3.Oct
12	1983	163.99	2,310	15.Sep
13	1984	164.01	2,310	16.Jul
14	1985	161.93	1,750	27.Aug
15	1986	*165.00	2,328	27.Jul
16	1987	162.96	1,900	26.Aug
17	1988	162.11	1,800	20.Aug
18	1989	**162.98	1,872	25.Sep

Note: Zero of gauge elevation = 150.0m above M.S.L Ko Lak datum.
* by extrapolation from Thalat
** by extrapolation from Pakkagnoung Station

Table 7.6 Annual Minimum Discharge at Tha Ngon Gauging Station

No.	Year	Maximum Gauge Reading (m)	Maximum Discharge (m^3/sec)	Remarks
1	1972	152.30	59	3.May.
2	1973	153.10	115	26.Apr.
3	1974	-	-	
4	1975	152.80	88	28.Mar.
5	1976	152.68	80	17.Apr.
6	1977	-	-	
7	1978	152.56	73	23.Feb.
8	1979	152.98	103	4.Jan.
9	1980	153.68	173	10.Apr.
10	1981	154.12	222	30.Apr.
11	1982	154.02	215	21.May.
12	1983	-	-	
13	1984	154.06	215	22.Apr.
14	1985	-	-	
15	1986	-	-	
16	1987	153.45	146	4.apr.
17	1988	153.12	50	21-24 Apr.
Average		153.15	128	

Note: - Data not available

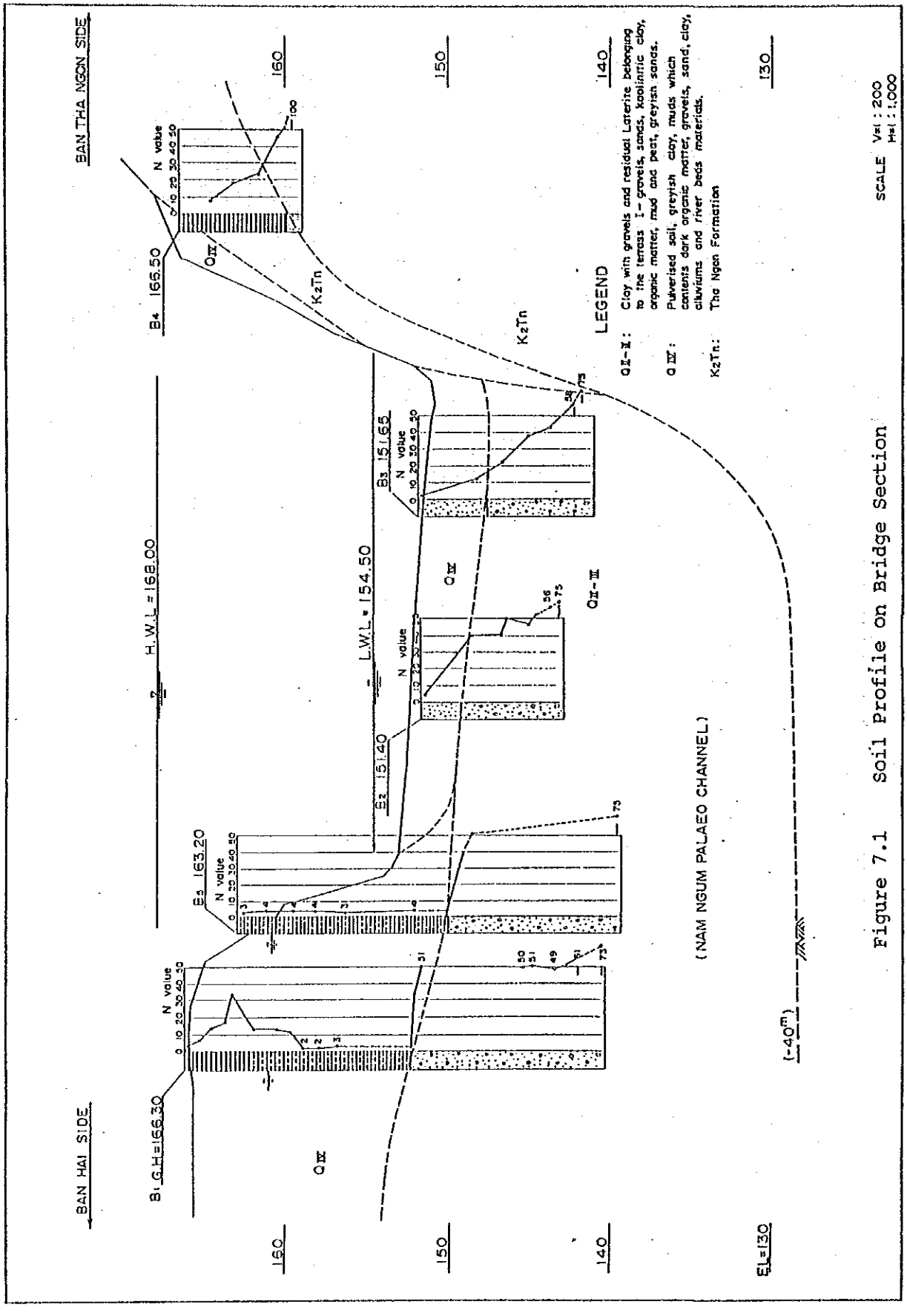


Figure 7.1 Soil Profile on Bridge Section

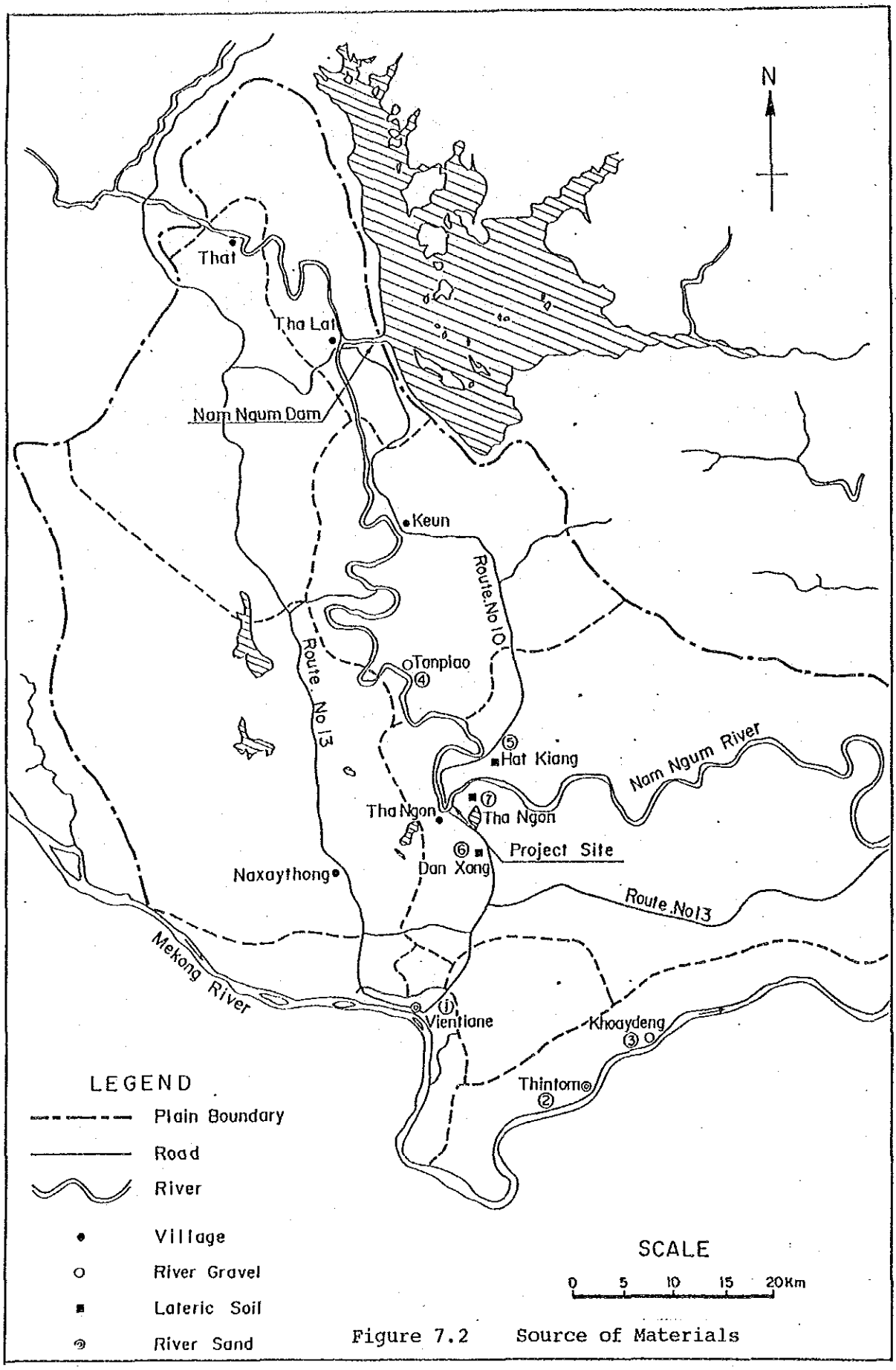
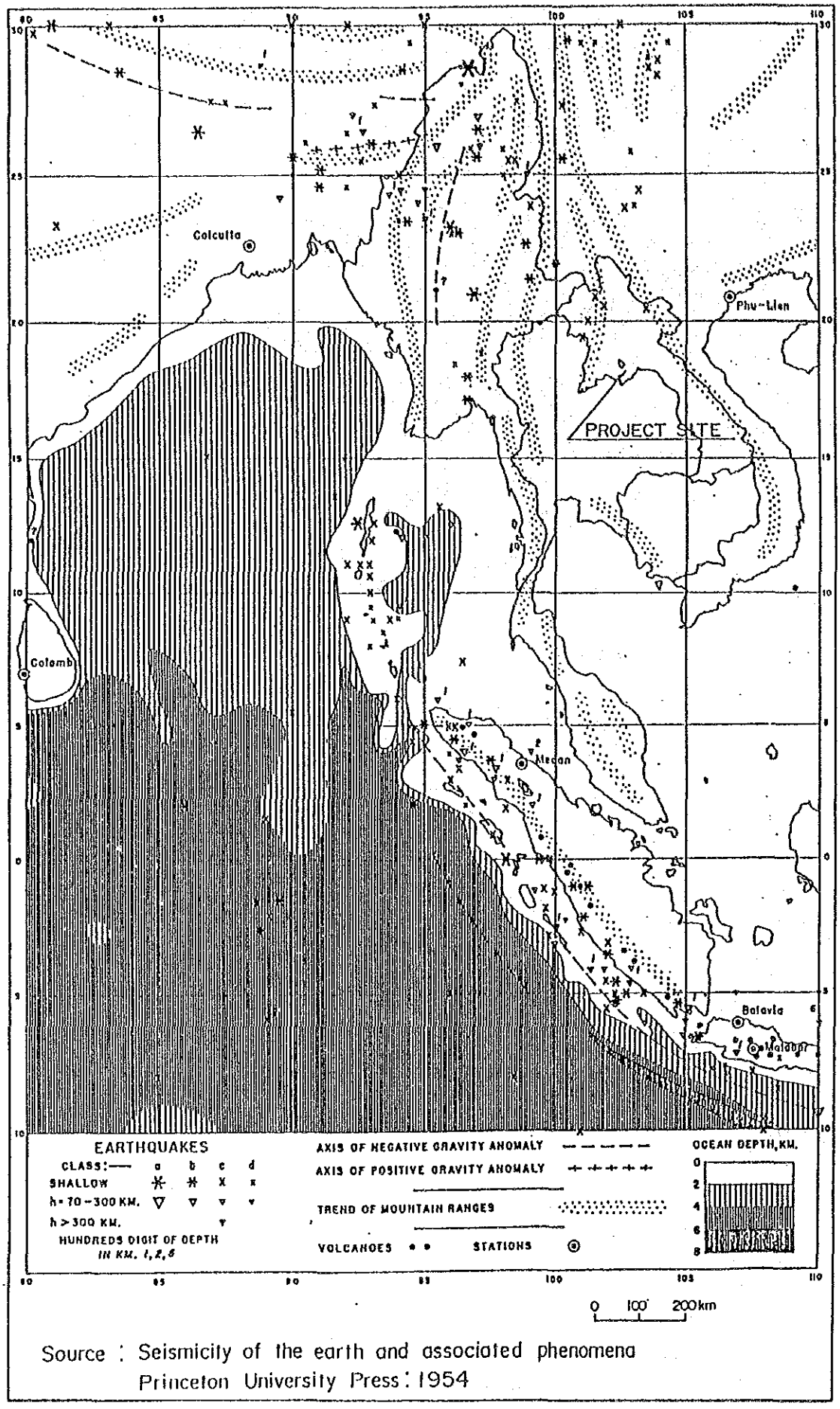


Figure 7.2 Source of Materials



Source : Seismicity of the earth and associated phenomena
Princeton University Press: 1954

Figure 7.3 Seismological Data in Sumatra-Burma

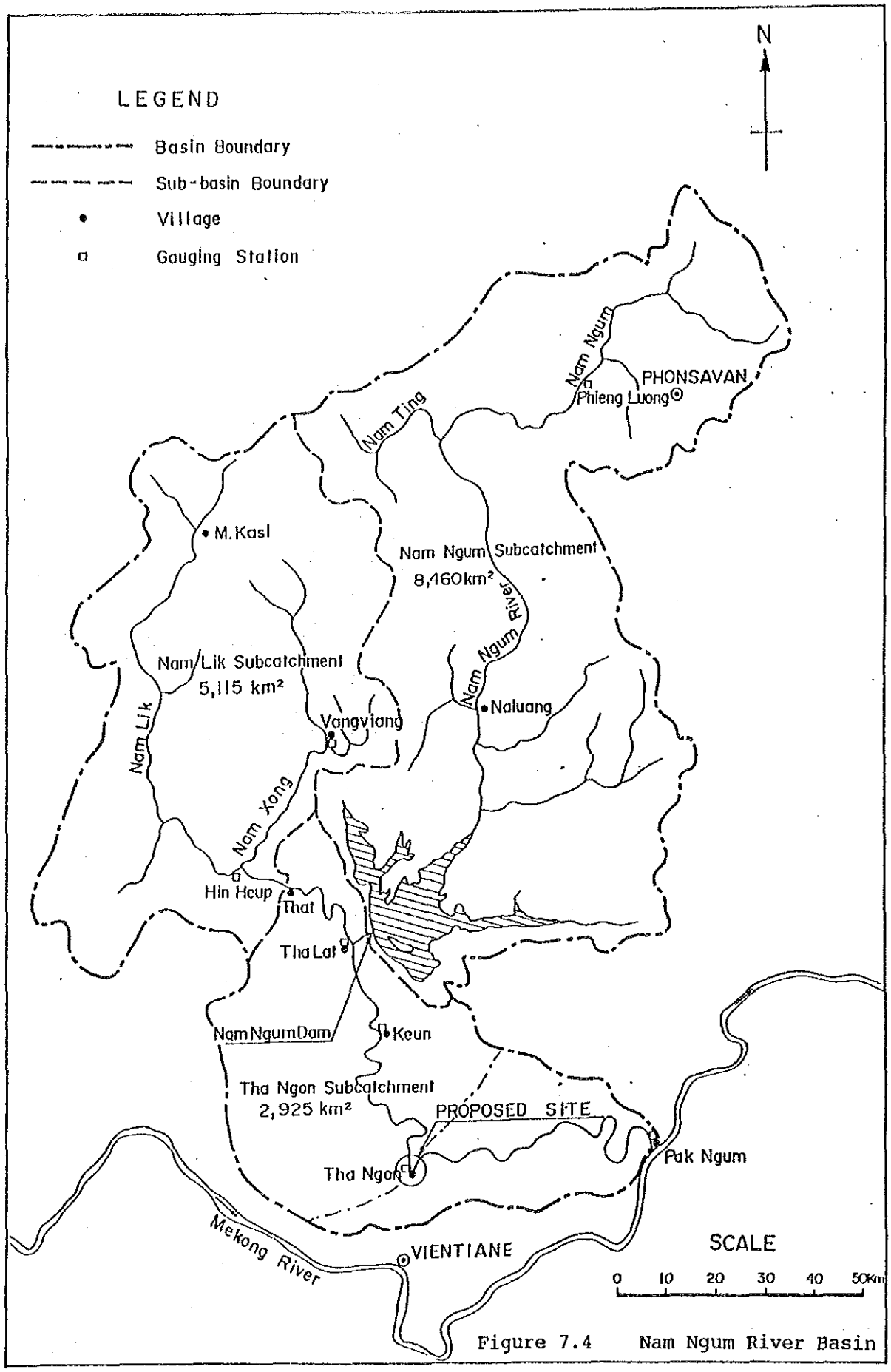


Figure 7.4 Nam Ngum River Basin

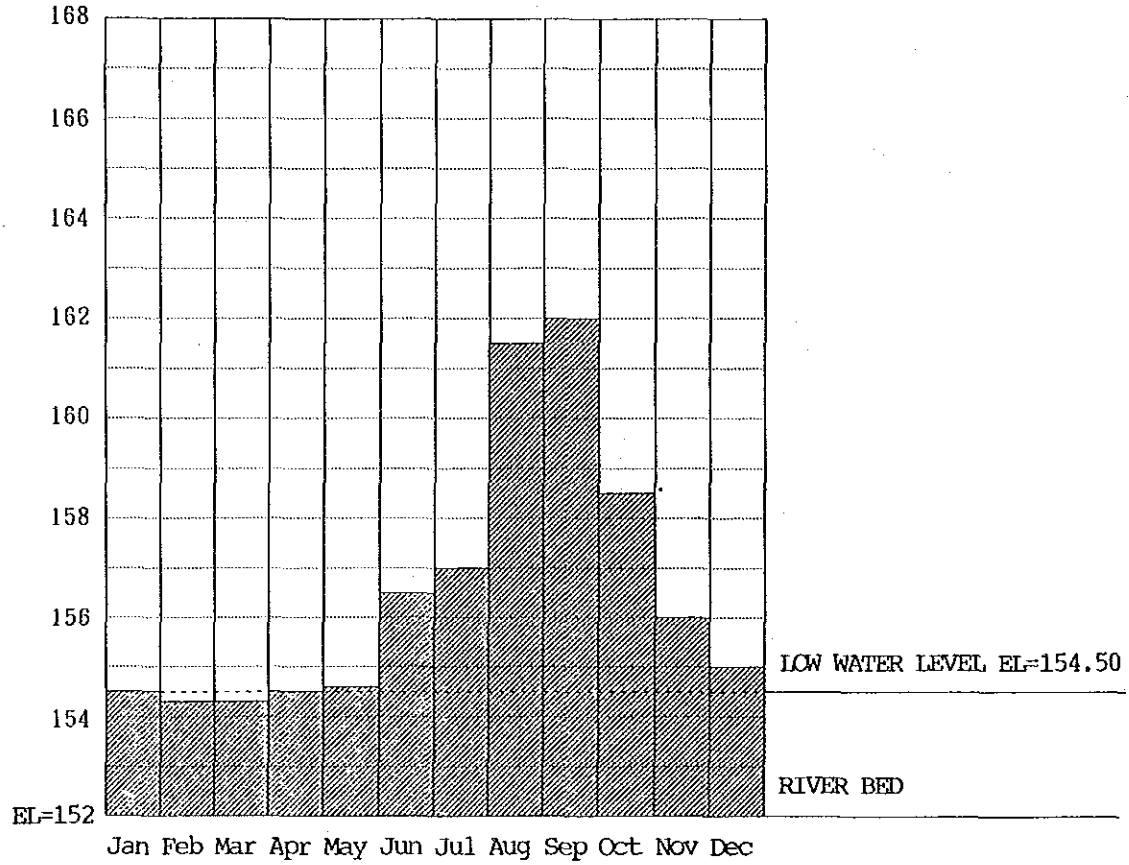


Figure 7.5 Monthly Mean Water Level (1972-1989)

CHAPTER VIII

PRELIMINARY DESIGN

CHAPTER VIII PRELIMINARY DESIGN

8 Preliminary Design

8.1 Design Policy

As a design policy for the Project, following matters shall be taken into consideration:

a) use of Lao's design standards as much as possible
b) provide countermeasures for scouring
c) ease of maintenance in the future
d) technology transfer

Other than above, there are some environmental aspects to be considered both the construction stage and post construction.

Construction Stage(during construction work)

a) Silt runoff into river from cut section of approach roads and bored pile construction might affect the pump operation which has been planned downstream of the Project

b) Silt runoff from fill sections into paddy fields

Post Construction

Borrow pits left without a proper resurfacing or replacement would result in continuous excessive erosion.

Above mentioned fundamental matters should be considered for the policy of design work in the Project.

8.2 Design Requirement

Standards for previous projects in Lao PDR shall be studied for the maximum sue of Lao standards.

The first ADB aid project for Lao PDR was "Vientiane Plain Road Improvement Project(called as ADB-1)" which aimed at widening and asphalt sealing(DBST) the Road No.10 from Tha Ngon to Tha Lat.

At present, several road and bridge projects are going on in Lao PDR with the loans of ADB, IDA, SIDA and USSR as follows:

Road Projects

a)	Pakse-Paksong-Saravane	135Km (ADB-2)
b)	Vientiane-Vangvieng	165Km (ADB-3)
c)	Vangvieng-Luangprabang	240Km (ADB-4)
d)	Pakse-Savannakhet	270Km (IDA-1)
e)	Savannakhet-Pakkading	270Km (IDA-2)
f)	Vientiane-Thabuk	93Km (SIDA-1)
g)	Thabuk-Pakkading	105Km (SIDA-2)

Bridge Project

a)	Sedon bridge	(USSR-3)

Design standards used for road construction in Lao PDR are established by modifying the Lao standards with foreign countries' standards. They differ by the project above and engineer. No definite standards, therefore, is yet provided.

For the Project, design standards used for Road No.10 improvement project will be employed as basic standard with several modifications based o the Japanese standards. The standards used for Road No.10 and Road No.13N were established following the Lao design standards and modified by SMEC, and these standards are still being used for Road No.13 improvement project.

Meanwhile, Lao PDR has no design standards for bridges. Thus Japanese bridge standards will be applied.

From the maintenance point of view, bridge shall be designed as a maintenance free type. Lack or difficulties of maintenance will make same problems as Ban Hai and Thinkeo bridges, aforementioned.

Moreover, extreme attention shall be given for foundation design to provide protection against the scouring around piers. This matter could be found at Thinkeo bridge, near Tha Lat.

8.3 Road Design Standard

8.3.1 Standards for Road Design

Initially, classification of the road should be determined in accordance with the actual and proposed function for the view point of economic activity, technical and political effects and other related elements.

In Lao PDR, several design standards are being used on different projects. Provisional guidelines have been used for the design of roads issued by MTP(no MCTPC) in 1981. In 1984, Snowy Mountain Engineering Corporation(SMEC) recommended the revised standards based on AASHTO(see Table 8.1), which has been used in road constructions in Vientiane Province. However, this standard is relatively brief and is not sufficiently comprehensive for a detailed design. Hence, various standards have been used in Lao PDR such as Australian, British, Swedish and others.

Therefore, a comparison study was necessary to establish a suitable design standard for this road, among the Japanese standards and other standards being employed in Lao PDR or previously was recommended by/for any other projects, such as National Transport Study(by SWECO) and Vientiane Plain Road Improvement Project(SMEC). Table 8.2 shows Japanese Standards (Grade 3-1 and 3-2) and Lao Standards (IV and V).

8.3.2 Proposed Road Design Standard

For the project road, modified Lao PDR standard Grade IV will basically be used with a few additional or modified figures based upon the Japanese Standard Grade 3.3 because, Grade III or IV is being applied for most of the road construction/development projects with few modifications in Lao PDR. For instance, in accordance with the Progress Report on "Third Road Improvement Project between Vientiane and Vangvieng on Route 13 North in February 1989(SMEC)", Grade III is being used for National Road Route 13 North and South near Vientiane and, Grade IV is applied for south of Phonehong on Route 13 North and southern part of Route 13.

To minimize the construction cost in a manner to provide safe driving facilities, and to prevent pedestrians and cyclists getting involved in accidents, Grade 3-3 of Japanese standards and Grade IV of Lao standards will be applied with combination.

1) Design Speed

Design speed is one of the most important factors. it has an influence over the geometric design standards such as minimum radius of curves, super-elevation, maximum grades, curve lengths, etc.

Design speed is the speed for determining the geometric shape which has an influence on vehicles operating on the road. And it is the SPEED which the average capable driver can comfortably drive his car under the proper functions of the road.

Design Standard IV for Provincial Road shows 80 Km/hr design speed in flat terrain, while Grade 3-3 of Japanese Standards requires a design speed of 60 Km/hr. Considering the flat terrain at the project site, 80 Km/hr of design speed will be employed for the Project.

2) Width of Carriageway

Capacity of traffic volume on the road mainly depends on the width of carriageway and the number of lanes. Carriageway widths in several design standards vary between 2.75 meters sand 3.5 meters for one lane, depending o the estimated volume of future traffic.

Both Grade IV and Japanese standard 3-3 requires a carriageway width of 3.0 meters for one lane.

Carriageway for the project road will be two (2) three meter lanes. The calculated capacity with the above mentioned carriageway width therefore, will be sufficient of the project road at present and also for the next 20 years.

3) Shoulder

Width of shoulder, as before-mentioned, has an influence on traffic capacity of road as lateral clearance. There are three (3) kind of shoulders, in the classifications with regards to shoulder width, i.e. ;

i) full-width shoulder,
2.5 to 3.25 meter width, which can accommodate any type of vehicles

ii) half-width shoulder,
1.25 to 1.75 meter width, which can accommodate passenger cars

iii) narrow-width shoulder
0.5 to 0.75 meter width, which is minimum lateral clearance

Usually for the same kind of project road as rural and/or provincial road, one(1) to one and a half(1.5) meter is applied as shoulder width. Actual number of pedestrians and cyclists on Route 10 around Tha Ngon show a necessity of 1.5 meter width shoulders on the project road.

In general, three(3) type of shoulder are being used in Lao PDR, such as ordinary soft shoulders, hard shoulders which are usually constructed with the mixture of soil and aggregates or medium size aggregates, and sealed shoulders. Among the three(3) type of shoulders, sealed shoulders are being used on Route 13.

From the view point of water proofing the road body/subgrade/base-course, sealed shoulders may be recommended. Hard shoulders, however, shall be recommended for the areas where many vehicles park on road sides or locations of heavy pedestrian/bicycle traffic exists. Both type of shoulders (hard shoulder and sealed shoulder), therefore, will be taken into consideration for the design of the project road.

4) Minimum Radius of Curve

In Japanese Road Design Standard, there are two minimum radius of curve such as Applicable Minimum and Recommended Minimum when considering driver's confort. In case Grade 3-3 road with design speed of 60Km/Hr, applicable minimum radius of curve is 200 meter and recommended minimum is 400 meter.

Recommended minimum and applicable minimum radius of curvature by design speeds are as follows as reference;

Design Speed(Km/hr)	Recommended Minimum(m)	Applicable Minimum(m)
100		700
80		400
60		200
50		150

For the Project, more big figure (450-m) than Recommended Minimum (400-m) for 80Km/Hr design speed was employed.

5) Maximum Gradient

As aforementioned, design speed has an influence over maximum gradients. In the Lao PDR Standard, 6% is to be used for Grade IV, as maximum gradient while in Japanese Standard 4% is employed for Grade 3-3 as maximum gradient.

In accordance with the actual observations, heavy truck with full load(cargo) runs with speed of 20-30 Km/hr on approximately 5 to 6% up-hill gradient along the Route 10.

Because the difficulty of overtaking slow moving vehicles by hghspeed one, such as passenger car or light truck, steep gradient causes disturbance to the smooth traffic flow. 4% as maximum gradient for 80Km/hr design speed, therefore, would be employed in the Project.

6) Super-elevation

Based upon the aforementioned conditions such as design speed, minimum radius of curve and other circumstances, 10% of superelevation is applied for the Project.

7) Design Standard to be Used for the Project

Based on the above mentioned study, design standards to be used for the access roads are summarized as follows.

Item	Figure
Average Daily Traffic(for Design)	500 - 4,000
Terrain	Flat
Design Class	Grade 3-1 & IV
Design Speed(Km/hr)	80
WIDTH	
One Lane(m)	3.00
Shoulder(m)	L=1.50
	R=1.50
Roadway(m)	9.00
Minimum Radius(m)	450.00
Maximum Gradient(%)	4.00
SIGHT DISTANCE	
Passing(m)	500
Stopping(m)	160