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LAO PEOPLE'S DEMOCRATIC REPUBLIC

FEASIBILITY STUDY
ON
THA NGON BRIDGE CONSTRUCTION PROJECT

FINAL REPORT

ANNEX

FEBRUARY 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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ANNEX A SIMULATION OF NAM NGUM CROSSING TIME

A.1 Assumptions

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

b) Traffic volume on both directions are equal.

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

d) Traffic shares are 23.9% for passenger cars, 22.8% for pick-ups, 9.3% for medium trucks, 31.7% for heavy trucks, 5.6% for light buses, and 6.7% 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 type of vehicles cannot use. Each type of vehicle arrives at random.

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

f) The ferry accommodates six passenger car 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 same as the arrival order to minimize unloaded 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 unloaded 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.

A.2 Traffic Component

Based on the above assumptions, traffic component by traffic volume of on direction is as follows:

Traffic Volume	P/C	P/U	M/T	H/T	L/B	H/B
15	4	3	1	5	1	1
20	5	5	2	6	1	1
25	6	6	2	8	1	2
30	7	7	3	10	1	2
35	9	8	3	11	2	2
40	9	9	4	13	2	3

A.3 Number of Simulation

For each case, Nam Ngum crossing simulated 5 times.

A.4 Results of Simulation

Result of simulation of each case is shown in the following pages.

A.5 Simulation in Case of Two Ferry Boats

Operation of two ferry boats at Tha Ngon can be considered as and alternative of the proposed bridge. Putting technical feasibility aside, the two-boat case is simulated based on the same assumptions and procedure as the one boat case.

The results of the simulation are summarized below. While one-direction traffic volume does not exceed 35 cars per hour, the average crossing time is less than 10 minutes.

Hourly Traffic Volume /a	Crossing Time /b (Min.)	No. of Car Loaded /b (car/hr)
20	6.6	18.7
25	6.7	23.7
30	7.2	27.4
35	7.9	32.2
40	10.7	33.9
45	11.8	38.2
50	14.6	38.3
55	18.4	37.2
60	21.3	38.5

Note : /a :for one direction
/b :average of two direction, which is average of five times of simulation

From above table, the following equation to estimate average crossing time is derived:

$$Y = 10.01X^2 - 0.434X + 11.17 (R^2=0.996)$$

Where, Y : average crossing time
X : hourly traffic volume of one direction

Also from the table, the transport capacity of two boats is estimated at around 38 cars for one direction. In other words, waiting queue becomes longer and longer when traffic volume of one direction is more 38 per hour. Considering a whole day, when daily traffic volume of two direction is over 1,256 cars, the average crossing time becomes more than one hour.

With the equation of crossing time, the average crossing time is estimated to exceed one hour in 2007 as shown in Table A.1. Therefore, in any case, the proposed bridge is required to provide transport capacity for the increasing traffic volume crossing Nam Ngum River at Tha Ngon in near future.

Table A.1 Traffic Volume without Project(2 Ferry Boats)

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 (Min)	Cross. Time	Traffic Rt.10	Volume div.to Rt. 13	Diver-tion Rate
1990	228	61	58	23	79	14	16	0	0	251	9.0	0	251	0	0.0%
1991	258	67	64	26	88	16	18	0	0	279	10.0	0	279	0	0.0%
1992	292	74	70	29	98	16	20	0	0	309	11.0	0	309	0	0.0%
1993	330	81	77	32	109	20	22	0	0	341	12.2	0	341	0	0.0%
1994	373	89	85	36	122	22	24	0	0	378	13.5	0	378	0	0.0%
1995	421	98	94	40	136	24	27	0	0	419	15.0	7	419	0	0.0%
1996	476	108	103	45	152	27	30	0	0	465	16.6	7	465	0	0.0%
1997	538	119	113	50	169	30	33	0	0	514	18.4	7	514	0	0.0%
1998	608	131	124	56	188	33	37	0	0	569	20.3	6	569	0	0.0%
1999	687	144	137	62	210	37	41	0	0	631	22.5	6	631	0	0.0%
2000	776	159	151	69	234	41	45	0	0	699	25.0	7	699	0	0.0%
2001	860	173	164	76	258	45	49	0	0	765	27.3	7	765	0	0.0%
2002	953	188	178	84	284	49	54	0	0	837	29.9	7	837	0	0.0%
2003	1056	204	193	92	313	54	59	0	0	915	32.7	8	915	0	0.0%
2004	1170	222	210	101	345	59	65	0	0	1002	35.8	8	1002	0	0.0%
2005	1296	241	228	111	380	65	71	0	0	1096	39.1	9	1096	0	0.0%
2006	1436	262	248	122	418	71	78	0	0	1199	42.8	38	1199	0	0.0%
2007	1591	285	269	134	460	78	85	0	0	1311	46.8	87	1256	55	4.8%
2008	1763	310	292	148	506	0	0	85	93	1256	44.9	61	1256	0	0.0%
2009	1953	337	317	163	557	0	0	93	102	1374	49.1	126	1256	118	8.6%
2010	2164	366	344	179	613	0	0	102	112	1502	53.6	224	1256	246	16.4%
2011	2302	387	364	190	652	0	0	109	119	1593	56.9	314	1256	337	21.2%
2012	2449	409	385	202	694	0	0	116	127	1690	60.4	428	1256	434	25.7%
2013	2606	433	407	215	738	0	0	123	135	1793	64.0	563	1256	537	29.9%
2014	2773	458	431	229	785	0	0	131	144	1903	68.0	735	1256	647	34.0%
2015	2950	485	456	244	835	0	0	139	153	2020	72.1	936	1256	764	37.8%

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 15
Case 15-1

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
4	3	1	5	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	6	15	9	1	P/U	3	20	17
2	P/U	11	15	4	2	P/C	9	20	11
3	H/T	17	25	8	3	H/T	13	20	7
4	H/B	23	35	12	4	M/T	18	30	12
5	H/T	30	35	5	5	H/T	21	30	9
6	L/B	31	45	14	6	P/C	23	30	7
7	H/T	33	45	12	7	P/C	27	40	13
8	P/C	35	45	10	8	P/U	32	40	8
9	P/C	37	45	8	9	P/U	34	40	6
10	P/U	37	55	18	10	H/T	40	50	10
11	H/T	42	55	13	11	H/B	44	50	6
12	M/T	48	55	7	12	H/T	49	60	11
13	P/U	48	65	17	13	L/B	53	60	7
14	H/T	54	65	11	14	P/C	57	70	13
15	P/C	60	65	5	15	H/T	60	70	10
avg				10.2	avg				9.8

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 15
Case 15-2

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
4	3	1	5	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	5	13	8	1	P/U	5	18	13
2	H/T	9	13	4	2	H/T	9	18	9
3	M/T	13	23	10	3	P/C	15	28	13
4	H/T	20	33	13	4	H/T	17	28	11
5	H/T	24	33	9	5	H/T	20	38	18
6	H/T	29	43	14	6	P/U	23	28	5
7	H/T	30	43	13	7	H/T	27	38	11
8	P/C	33	53	20	8	L/B	29	48	19
9	P/C	38	53	15	9	H/B	30	48	18
10	L/B	38	53	15	10	H/T	32	58	26
11	P/U	45	53	8	11	M/T	37	48	11
12	H/B	48	63	15	12	P/C	40	58	18
13	P/U	52	63	11	13	P/C	47	58	11
14	P/C	56	63	7	14	P/U	53	58	5
15	P/C	60	73	13	15	P/C	60	68	8
avg				11.7	avg				13.1

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 15

Case 15-3

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
4	3	1	5	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	7	18	11	1	P/U	1	13	12
2	P/C	10	18	8	2	H/B	4	13	9
3	P/U	14	18	4	3	H/T	5	23	18
4	H/T	17	28	11	4	P/C	10	23	13
5	P/C	22	28	6	5	H/T	11	33	22
6	H/T	25	38	13	6	H/T	14	33	19
7	H/B	27	38	11	7	H/T	20	43	23
8	H/T	31	48	17	8	P/U	20	43	23
9	P/U	34	48	14	9	P/C	26	43	17
10	P/C	36	48	12	10	P/C	34	43	9
11	P/U	42	48	6	11	P/U	35	53	18
12	M/T	47	58	11	12	P/C	38	53	15
13	P/C	53	58	5	13	H/T	46	53	7
14	H/T	54	58	4	14	M/T	53	63	10
15	L/B	60	68	8	15	H/B	60	73	13
avg				9.4	avg				15.2

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 15
Case 15-4

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
4	3	1	5	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	6	13	7	1	P/C	7	18	11
2	P/C	7	13	6	2	H/T	12	18	6
3	H/T	9	13	4	3	P/C	17	28	11
4	H/T	10	23	13	4	M/T	21	28	7
5	H/B	18	23	5	5	H/B	27	38	11
6	M/T	23	33	10	6	P/U	31	38	7
7	P/U	31	43	12	7	P/U	32	38	6
8	P/U	40	53	13	8	P/C	36	48	12
9	P/U	44	53	9	9	H/T	37	48	11
10	P/C	50	63	13	10	P/C	38	48	10
11	H/T	51	63	12	11	H/T	39	58	19
12	L/B	52	63	11	12	H/T	42	58	16
13	H/T	54	73	19	13	P/U	48	68	20
14	H/T	58	73	15	14	L/B	57	68	11
15	P/C	60	83	23	15	H/T	60	68	8
avg				11.5	avg				11.1

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 15
Case 15-5

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
4	3	1	5	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	4	8	4	1	H/T	1	13	12
2	L/B	5	18	13	2	P/U	6	13	7
3	P/C	10	18	8	3	M/T	9	13	4
4	H/B	17	28	11	4	P/C	10	23	13
5	P/U	19	28	9	5	H/T	11	23	12
6	P/C	27	38	11	6	H/B	18	33	15
7	P/U	34	38	4	7	P/C	19	23	4
8	H/T	40	50	10	8	P/C	25	33	8
9	P/C	45	50	5	9	P/U	26	33	7
10	H/T	45	60	15	10	P/U	33	45	12
11	P/C	49	60	11	11	P/C	41	45	4
12	M/T	49	60	11	12	H/T	47	55	8
13	H/T	51	70	19	13	H/T	48	55	7
14	H/T	57	70	13	14	H/T	50	65	15
15	P/U	60	80	20	15	L/B	60	65	5
avg				10.9	avg				8.9

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 20
Case 20-1

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
5	5	2	6	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	L/B	5	11	6	1	P/U	3	16	13
2	H/T	7	11	4	2	P/U	3	16	13
3	H/T	11	21	10	3	L/B	9	16	7
4	P/U	14	21	7	4	P/C	14	26	12
5	M/T	15	21	6	5	M/T	14	26	12
6	P/U	20	31	11	6	P/C	18	26	8
7	P/C	20	31	11	7	H/T	22	36	14
8	H/B	21	31	10	8	H/T	24	36	12
9	H/T	25	41	16	9	P/C	27	46	19
10	H/T	26	41	15	10	P/C	29	46	17
11	P/U	30	51	21	11	P/C	31	46	15
12	H/T	34	51	17	12	H/T	36	46	10
13	P/U	36	51	15	13	P/U	39	56	17
14	P/C	40	51	11	14	H/T	40	56	16
15	P/C	42	61	19	15	M/T	46	56	10
16	P/U	47	61	14	16	P/U	48	66	18
17	H/T	51	61	10	17	H/T	53	66	13
18	P/C	52	61	9	18	H/T	53	76	23
19	P/C	55	71	16	19	P/U	58	66	8
20	M/T	60	71	11	20	H/B	60	76	16
avg				12.0	avg				13.7

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 20
Case 20-2

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
5	5	2	6	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	0	4	4	1	H/T	0	9	9
2	M/T	3	14	11	2	P/C	5	9	4
3	P/U	6	14	8	3	H/T	6	19	13
4	H/T	7	14	7	4	M/T	8	19	11
5	M/T	7	24	17	5	P/C	15	19	4
6	H/T	8	24	16	6	P/U	17	29	12
7	L/B	12	24	12	7	H/T	19	29	10
8	P/C	15	34	19	8	P/C	20	29	9
9	P/U	20	34	14	9	P/U	26	39	13
10	H/B	22	34	12	10	H/B	32	39	7
11	P/U	29	34	5	11	H/T	34	49	15
12	P/U	36	44	8	12	P/U	36	49	13
13	P/C	36	44	8	13	P/C	36	49	13
14	H/T	42	54	12	14	L/B	41	49	8
15	P/C	44	54	10	15	H/T	44	59	15
16	H/T	50	64	14	16	P/C	48	59	11
17	H/T	56	64	8	17	P/U	50	59	9
18	P/C	58	74	16	18	M/T	53	69	16
19	P/C	59	74	15	19	P/U	55	59	4
20	P/U	60	74	14	20	H/T	60	69	9
avg				11.5	avg				10.3

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 20

Case 20-3

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
5	5	2	6	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	2	7	5	1	M/T	0	13	13
2	P/U	7	18	11	2	P/C	1	13	12
3	P/U	11	18	7	3	P/C	3	13	10
4	H/T	12	18	6	4	H/T	4	23	19
5	P/U	13	18	5	5	M/T	6	13	7
6	P/C	17	28	11	6	P/U	6	23	17
7	P/U	19	28	9	7	P/U	10	23	13
8	P/C	20	28	8	8	L/B	12	23	11
9	H/T	22	28	6	9	P/U	18	33	15
10	P/U	23	38	15	10	P/C	19	33	14
11	P/C	29	38	9	11	H/T	22	33	11
12	H/T	34	38	4	12	P/C	25	33	8
13	M/T	39	48	9	13	H/B	31	43	12
14	M/T	40	48	8	14	H/T	37	43	6
15	H/T	45	58	13	15	H/T	43	53	10
16	H/T	50	58	8	16	P/U	43	53	10
17	P/C	53	68	15	17	P/U	47	53	6
18	H/T	56	68	12	18	H/T	52	63	11
19	L/B	60	68	8	19	H/T	58	63	5
20	H/B	60	78	18	20	P/C	60	73	13
avg				9.4	avg				11.2

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 20
Case 20-4

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
5	5	2	6	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	0	9	9	1	P/U	5	14	9
2	P/C	5	9	4	2	H/T	8	14	6
3	H/T	7	19	12	3	P/U	13	24	11
4	P/C	8	19	11	4	P/C	14	24	10
5	P/C	13	19	6	5	H/T	19	24	5
6	P/U	18	29	11	6	H/T	24	34	10
7	L/B	21	29	8	7	H/T	25	34	9
8	P/U	27	39	12	8	P/C	29	44	15
9	H/B	31	39	8	9	H/T	34	44	10
10	H/T	38	49	11	10	H/T	38	54	16
11	P/U	44	49	5	11	L/B	39	44	5
12	P/U	46	59	13	12	P/U	43	54	11
13	H/T	46	59	13	13	M/T	46	54	8
14	M/T	50	59	9	14	P/C	49	64	15
15	M/T	52	69	17	15	P/C	50	64	14
16	P/C	52	69	17	16	M/T	51	64	13
17	H/T	53	69	16	17	P/C	53	64	11
18	P/C	58	79	21	18	P/U	57	64	7
19	H/T	59	79	20	19	P/U	58	74	16
20	H/T	60	89	29	20	H/B	60	74	14
avg				12.6	avg				10.8

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 20

Case 20-5

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
5	5	2	6	1	1

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	5	9	4	1	P/U	3	14	11
2	H/T	8	19	11	2	P/C	3	14	11
3	H/T	10	19	9	3	H/T	7	14	7
4	P/C	14	29	15	4	P/C	12	24	12
5	P/U	15	29	14	5	P/U	13	24	11
6	P/C	21	29	8	6	P/C	15	24	9
7	P/C	26	39	13	7	H/T	19	24	5
8	L/B	28	39	11	8	M/T	21	34	13
9	M/T	33	39	6	9	P/U	23	34	11
10	P/C	38	49	11	10	H/B	28	34	6
11	P/C	38	49	11	11	P/C	30	44	14
12	P/U	43	49	6	12	M/T	34	44	10
13	M/T	48	59	11	13	L/B	36	44	8
14	H/B	53	59	6	14	P/U	39	44	5
15	H/T	53	69	16	15	H/T	42	54	12
16	P/U	53	59	6	16	H/T	47	54	7
17	P/U	53	69	16	17	H/T	51	64	13
18	H/T	56	79	23	18	P/C	53	64	11
19	H/T	57	79	22	19	H/T	55	74	19
20	P/U	60	69	9	20	P/U	60	64	4
avg				11.4	avg				10.0

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 25
Case 25-1

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
6	6	2	8	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	3	14	11	1	H/B	0	9	9
2	P/C	6	14	8	2	L/B	4	9	5
3	M/T	9	14	5	3	P/U	8	19	11
4	P/U	14	24	10	4	H/T	9	19	10
5	M/T	14	24	10	5	H/T	10	29	19
6	H/T	18	24	6	6	H/B	15	29	14
7	P/C	19	34	15	7	H/T	16	39	23
8	P/C	23	34	11	8	P/C	16	39	23
9	P/U	24	34	10	9	P/U	19	39	20
10	H/T	26	34	8	10	P/C	24	39	15
11	H/B	30	44	14	11	P/C	28	49	21
12	L/B	30	44	14	12	M/T	29	49	20
13	P/U	30	44	14	13	M/T	32	49	17
14	H/T	32	54	22	14	P/C	32	49	17
15	P/C	34	44	10	15	H/T	36	59	23
16	P/U	39	54	15	16	H/T	37	59	22
17	H/T	39	64	25	17	P/U	41	69	28
18	H/T	42	64	22	18	P/U	42	69	27
19	H/T	46	74	28	19	H/T	45	69	24
20	P/U	49	54	5	20	P/C	46	69	23
21	P/C	51	74	23	21	P/C	49	79	30
22	H/B	53	84	31	22	P/U	50	79	29
23	P/C	53	74	21	23	H/T	52	79	27
24	H/T	56	84	28	24	P/U	57	79	22
25	H/T	60	94	34	25	H/T	60	89	29
avg				16.0	avg				20.3

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 25
Case 25-2

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
6	6	2	8	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	4	8	4	1	P/C	1	13	12
2	H/B	6	18	12	2	H/T	4	13	9
3	P/U	6	18	12	3	H/T	4	23	19
4	P/C	7	18	11	4	H/T	8	23	15
5	H/T	12	28	16	5	M/T	11	33	22
6	H/T	13	28	15	6	P/U	11	33	22
7	H/T	14	38	24	7	H/B	16	33	17
8	P/C	19	38	19	8	P/C	21	43	22
9	P/C	22	38	16	9	H/T	24	43	19
10	L/B	23	38	15	10	P/U	25	43	18
11	H/T	27	48	21	11	M/T	25	53	28
12	H/T	31	48	17	12	P/C	29	43	14
13	P/U	33	58	25	13	P/U	31	53	22
14	H/T	33	58	25	14	H/B	35	53	18
15	P/C	34	58	24	15	L/B	35	63	28
16	P/U	39	58	19	16	H/T	38	63	25
17	P/C	43	68	25	17	P/U	40	63	23
18	P/U	46	68	22	18	P/C	44	63	19
19	H/B	48	68	20	19	P/C	47	73	26
20	M/T	49	78	29	20	H/T	49	73	24
21	H/T	50	78	28	21	P/U	50	73	23
22	P/U	52	68	16	22	H/T	52	83	31
23	P/C	52	78	26	23	H/T	55	83	28
24	H/T	57	88	31	24	P/U	57	73	16
25	M/T	60	88	28	25	P/C	60	93	33
avg				20.0	avg				21.3

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 25

Case 25-3

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
6	6	2	8	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/B	1	5	4	1	H/T	2	10	8
2	P/U	3	15	12	2	H/B	4	10	6
3	H/T	5	15	10	3	H/T	6	20	14
4	H/T	8	25	17	4	P/U	9	20	11
5	M/T	12	25	13	5	M/T	12	20	8
6	P/U	13	25	12	6	P/U	15	30	15
7	P/C	15	35	20	7	H/T	15	30	15
8	H/T	18	35	17	8	M/T	18	30	12
9	M/T	21	35	14	9	P/U	18	40	22
10	P/U	21	45	24	10	L/B	21	40	19
11	H/T	22	45	23	11	H/T	23	40	17
12	H/T	25	55	30	12	P/C	27	40	13
13	P/C	28	45	17	13	H/T	31	50	19
14	P/C	32	45	13	14	P/C	35	50	15
15	H/T	36	55	19	15	P/C	39	50	11
16	P/C	39	65	26	16	P/C	39	50	11
17	H/T	43	65	22	17	P/U	40	60	20
18	H/T	43	75	32	18	P/U	44	60	16
19	P/U	47	65	18	19	H/B	48	60	12
20	P/U	49	65	16	20	P/C	51	60	9
21	P/C	52	75	23	21	H/T	51	70	19
22	P/C	53	75	22	22	H/T	53	70	17
23	H/B	56	85	29	23	P/U	54	80	26
24	L/B	58	75	17	24	H/T	57	80	23
25	P/U	60	85	25	25	P/C	60	80	20
avg				19.0	avg				15.1

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 25
Case 25-4

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
6	6	2	8	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	4	17	13	1	H/T	0	12	12
2	P/C	5	17	12	2	H/T	3	12	9
3	P/C	7	17	10	3	P/U	5	22	17
4	P/U	11	17	6	4	P/U	7	22	15
5	H/T	13	27	14	5	P/C	11	22	11
6	P/U	17	27	10	6	H/T	11	22	11
7	L/B	20	27	7	7	H/B	15	32	17
8	P/C	23	27	4	8	P/C	16	32	16
9	P/C	27	37	10	9	H/T	20	42	22
10	H/T	29	37	8	10	P/C	22	32	10
11	H/B	33	47	14	11	P/U	23	32	9
12	H/B	35	47	12	12	P/C	26	42	16
13	P/U	35	57	22	13	P/U	30	42	12
14	H/T	38	57	19	14	P/U	31	42	11
15	P/U	40	57	17	15	P/C	32	52	20
16	H/T	43	67	24	16	H/B	36	52	16
17	M/T	43	67	24	17	P/C	38	52	14
18	H/T	46	77	31	18	H/T	40	62	22
19	P/C	49	57	8	19	L/B	44	52	8
20	H/T	51	77	26	20	H/T	47	62	15
21	P/C	54	67	13	21	M/T	51	72	21
22	P/U	55	87	32	22	H/T	53	72	19
23	M/T	56	87	31	23	M/T	54	82	28
24	H/T	58	87	29	24	P/U	56	72	16
25	P/U	60	97	37	25	H/T	60	82	22
avg				17.3	avg				15.6

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 25
Case 25-5

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
6	6	2	8	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	1	7	6	1	P/C	2	12	10
2	P/C	5	17	12	2	L/B	2	12	10
3	H/T	7	17	10	3	H/T	3	12	9
4	P/C	7	17	10	4	P/C	8	12	4
5	P/C	7	17	10	5	H/T	9	22	13
6	M/T	11	27	16	6	H/T	9	22	13
7	H/T	14	27	13	7	P/C	12	32	20
8	L/B	16	27	11	8	H/B	14	32	18
9	P/U	18	37	19	9	P/U	19	32	13
10	P/C	18	37	19	10	P/U	20	32	12
11	H/B	22	37	15	11	M/T	23	42	19
12	H/T	22	47	25	12	P/U	23	42	19
13	P/U	25	37	12	13	P/U	28	42	14
14	H/T	29	47	18	14	P/C	32	42	10
15	M/T	31	57	26	15	H/B	33	52	19
16	P/U	33	57	24	16	H/T	35	52	17
17	H/T	36	57	21	17	H/T	39	62	23
18	H/B	38	67	29	18	H/T	42	62	20
19	H/T	40	67	27	19	P/U	46	72	26
20	H/T	43	77	34	20	M/T	50	72	22
21	P/C	47	77	30	21	H/T	52	72	20
22	P/U	50	77	27	22	P/C	55	82	27
23	P/U	54	77	23	23	P/C	57	82	25
24	P/U	56	87	31	24	P/U	58	82	24
25	H/T	60	87	27	25	H/T	60	82	22
avg				19.8	avg				17.2

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 30
Case 30-1

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
7	7	3	10	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	1	8	7	1	L/B	1	13	12
2	H/T	4	8	4	2	H/T	5	13	8
3	P/U	7	18	11	3	H/T	8	23	15
4	H/T	11	18	7	4	H/T	8	23	15
5	H/B	11	28	17	5	P/U	11	33	22
6	M/T	12	28	16	6	P/U	14	33	19
7	P/U	13	28	15	7	P/C	17	33	16
8	P/U	16	38	22	8	H/T	18	33	15
9	P/C	18	38	20	9	H/T	19	43	24
10	M/T	21	38	17	10	P/U	22	43	21
11	P/C	21	38	17	11	P/C	25	43	18
12	H/T	22	48	26	12	P/C	27	43	16
13	P/U	26	38	12	13	H/B	27	53	26
14	P/C	30	48	18	14	H/T	29	53	24
15	P/U	31	48	17	15	H/B	32	63	31
16	H/T	31	58	27	16	H/T	32	63	31
17	L/B	34	48	14	17	M/T	34	73	39
18	H/T	34	58	24	18	H/T	37	73	36
19	P/C	36	68	32	19	M/T	40	83	43
20	H/T	39	68	29	20	P/U	41	73	32
21	H/T	43	78	35	21	H/T	43	83	40
22	P/U	45	68	23	22	P/C	43	83	40
23	P/C	47	68	21	23	P/C	44	93	49
24	P/C	49	78	29	24	M/T	47	93	46
25	H/T	50	88	38	25	P/C	51	93	42
26	H/T	53	88	35	26	H/T	52	103	51
27	H/B	54	98	44	27	P/C	55	93	38
28	M/T	56	78	22	28	P/U	57	93	36
29	P/U	60	98	38	29	P/U	57	103	46
30	H/T	60	108	48	30	P/U	60	103	43
avg				22.8	avg				29.8

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 30
Case 30-2

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
7	7	3	10	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	2	6	4	1	H/T	2	11	9
2	H/T	2	6	4	2	P/C	4	11	7
3	H/T	6	16	10	3	P/U	6	11	5
4	L/B	8	16	8	4	H/T	10	21	11
5	M/T	9	16	7	5	M/T	10	21	11
6	P/C	9	26	17	6	H/T	12	31	19
7	P/C	10	26	16	7	P/C	15	21	6
8	P/C	12	26	14	8	P/U	18	31	13
9	H/T	12	26	14	9	H/T	19	41	22
10	H/T	16	36	20	10	H/T	22	41	19
11	P/U	20	36	16	11	P/U	22	31	9
12	P/C	22	36	14	12	H/T	25	51	26
13	P/U	25	36	11	13	P/C	26	31	5
14	H/B	29	46	17	14	H/T	29	51	22
15	P/C	31	46	15	15	H/T	30	61	31
16	M/T	32	46	14	16	P/C	33	61	28
17	H/T	37	56	19	17	H/B	35	71	36
18	M/T	39	56	17	18	P/C	38	61	23
19	P/C	39	56	17	19	M/T	40	71	31
20	P/U	43	66	23	20	P/U	42	61	19
21	P/C	48	66	18	21	P/C	43	71	28
22	P/U	50	66	16	22	H/B	45	81	36
23	H/T	53	66	13	23	L/B	45	81	36
24	P/U	54	76	22	24	P/U	48	81	33
25	H/T	54	76	22	25	P/U	51	81	30
26	H/T	55	86	31	26	H/T	53	91	38
27	H/T	57	86	29	27	P/U	54	91	37
28	P/U	59	76	17	28	M/T	57	91	34
29	H/B	59	96	37	29	P/C	57	101	44
30	H/T	60	96	36	30	H/T	60	101	41
avg				17.3	avg				23.6

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 30
Case 30-3

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
7	7	3	10	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	1	6	5	1	H/B	2	11	9
2	M/T	4	16	12	2	H/T	3	11	8
3	H/T	6	16	10	3	P/C	6	21	15
4	H/T	8	26	18	4	H/T	8	21	13
5	P/C	11	16	5	5	P/C	10	21	11
6	M/T	14	26	12	6	L/B	12	21	9
7	P/U	15	26	11	7	P/U	15	31	16
8	P/U	16	36	20	8	P/C	15	31	16
9	P/U	18	36	18	9	M/T	15	31	16
10	P/C	21	36	15	10	H/T	16	41	25
11	P/U	23	36	13	11	P/U	19	31	12
12	P/C	23	36	13	12	M/T	21	41	20
13	P/U	27	36	9	13	P/C	23	31	8
14	P/C	30	46	16	14	M/T	26	51	25
15	P/C	33	46	13	15	P/U	27	41	14
16	H/T	35	46	11	16	P/C	31	51	20
17	H/T	39	56	17	17	P/U	33	51	18
18	H/B	42	56	14	18	H/T	34	61	27
19	H/T	45	66	21	19	H/T	35	61	26
20	L/B	47	66	19	20	P/C	36	51	15
21	M/T	47	66	19	21	P/U	39	51	12
22	H/T	48	76	28	22	P/C	43	71	28
23	H/T	51	76	25	23	H/T	44	71	27
24	H/B	53	86	33	24	P/U	48	71	23
25	H/T	54	86	32	25	H/T	50	81	31
26	P/C	54	96	42	26	H/T	54	81	27
27	P/U	54	96	42	27	H/B	54	91	37
28	P/U	58	96	38	28	H/T	57	91	34
29	H/T	60	96	36	29	P/U	59	71	12
30	H/T	60	106	46	30	H/T	60	101	41
avg				20.4	avg				19.8

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 30
Case 30-4

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
7	7	3	10	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	1	7	6	1	P/U	1	12	11
2	P/C	4	17	13	2	P/C	2	12	10
3	P/U	5	17	12	3	H/T	3	12	9
4	P/C	8	17	9	4	P/U	3	12	9
5	P/C	8	17	9	5	P/U	6	22	16
6	H/T	11	27	16	6	H/T	6	22	16
7	P/C	12	17	5	7	P/C	8	22	14
8	P/C	14	27	13	8	H/T	12	32	20
9	H/T	17	37	20	9	H/T	13	32	19
10	H/B	20	37	17	10	P/U	17	22	5
11	P/C	23	27	4	11	P/C	20	42	22
12	P/U	26	47	21	12	P/C	23	42	19
13	H/T	26	47	21	13	P/C	26	42	16
14	P/U	30	47	17	14	M/T	27	42	15
15	H/T	33	57	24	15	H/T	27	52	25
16	H/T	34	57	23	16	H/T	30	52	22
17	H/T	36	67	31	17	H/T	34	62	28
18	P/U	36	47	11	18	L/B	36	42	6
19	H/B	38	67	29	19	M/T	37	62	25
20	L/B	38	77	39	20	P/C	37	62	25
21	H/T	40	77	37	21	M/T	39	72	33
22	H/T	41	87	46	22	P/U	43	72	29
23	M/T	42	77	35	23	P/U	43	72	29
24	P/U	44	87	43	24	H/T	47	82	35
25	P/C	47	87	40	25	P/C	51	72	21
26	H/T	50	97	47	26	P/U	54	72	18
27	M/T	52	97	45	27	H/B	56	82	26
28	H/T	55	107	52	28	H/B	59	92	33
29	M/T	58	107	49	29	H/T	60	92	32
30	P/U	60	87	27	30	H/T	60	102	42
avg				25.4	avg				21.0

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 30
Case 30-5

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
7	7	3	10	1	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	1	6	5	1	P/C	3	11	8
2	P/U	2	6	4	2	P/U	6	11	5
3	H/T	4	16	12	3	P/U	9	21	12
4	P/C	6	16	10	4	H/T	11	21	10
5	H/T	10	26	16	5	H/T	15	31	16
6	P/U	10	16	6	6	P/C	17	21	4
7	P/C	13	26	13	7	M/T	19	31	12
8	H/T	16	36	20	8	L/B	21	31	10
9	P/C	17	26	9	9	P/U	22	41	19
10	P/C	19	26	7	10	P/U	23	41	18
11	M/T	23	36	13	11	H/B	25	41	16
12	H/T	23	46	23	12	P/C	26	41	15
13	P/C	25	36	11	13	P/U	28	51	23
14	H/T	27	46	19	14	H/T	30	51	21
15	H/T	27	56	29	15	P/C	32	51	19
16	H/T	31	56	25	16	H/T	36	61	25
17	M/T	33	66	33	17	H/T	36	61	25
18	P/U	33	66	33	18	P/C	37	51	14
19	H/T	36	66	30	19	H/T	38	71	33
20	H/B	39	76	37	20	H/T	39	71	32
21	P/U	43	76	33	21	H/B	40	81	41
22	H/T	45	86	41	22	H/T	41	81	40
23	P/U	48	76	28	23	H/T	42	91	49
24	H/T	49	86	37	24	P/C	43	91	48
25	L/B	50	76	26	25	P/C	46	91	45
26	H/B	51	96	45	26	P/U	49	91	42
27	M/T	54	96	42	27	H/T	51	101	50
28	P/C	56	96	40	28	M/T	53	101	48
29	P/C	58	106	48	29	M/T	57	111	54
30	P/U	60	106	46	30	P/U	60	101	41
avg				24.7	avg				26.5

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 35
Case 35-1

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	8	3	11	2	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	3	15	12	1	H/T	0	10	10
2	P/U	4	15	11	2	H/B	0	10	10
3	P/C	7	15	8	3	H/T	2	20	18
4	M/T	10	25	15	4	P/U	5	20	15
5	P/C	11	15	4	5	H/B	6	30	24
6	P/U	13	25	12	6	H/T	8	30	22
7	P/U	16	25	9	7	H/T	8	40	32
8	M/T	16	25	9	8	P/C	9	20	11
9	H/T	18	35	17	9	P/U	11	20	9
10	P/U	19	35	16	10	P/C	13	40	27
11	P/C	21	35	14	11	H/T	16	50	34
12	P/U	21	35	14	12	P/C	19	40	21
13	H/T	23	45	22	13	P/U	22	40	18
14	P/C	26	45	19	14	H/T	24	50	26
15	H/T	27	55	28	15	H/T	27	60	33
16	H/T	29	55	26	16	P/C	29	60	31
17	H/T	30	65	35	17	P/U	30	60	30
18	H/T	30	65	35	18	P/C	32	60	28
19	H/T	32	75	43	19	H/T	34	70	36
20	H/B	33	75	42	20	H/T	35	70	35
21	M/T	34	45	11	21	L/B	37	80	43
22	P/C	37	85	48	22	H/T	40	80	40
23	P/U	40	85	45	23	P/U	40	80	40
24	P/C	43	85	42	24	L/B	41	80	39
25	P/U	43	85	42	25	M/T	43	90	47
26	L/B	45	85	40	26	P/U	46	90	44
27	H/T	46	95	49	27	P/U	49	90	41
28	H/B	47	95	48	28	H/T	49	100	51
29	L/B	49	85	36	29	P/C	52	90	38
30	P/C	49	105	56	30	P/U	54	90	36
31	H/T	51	105	54	31	P/C	56	100	44
32	P/C	54	105	51	32	P/C	58	100	42
33	H/T	56	115	59	33	P/C	60	100	40
34	P/U	57	105	48	34	M/T	60	110	50
35	P/C	60	115	55	35	M/T	60	110	50
avg				30.7	avg				31.9

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 35
Case 35-2

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	8	3	11	2	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	3	8	5	1	P/C	1	13	12
2	H/T	5	18	13	2	P/C	2	13	11
3	P/U	5	18	13	3	P/U	4	13	9
4	H/T	7	28	21	4	M/T	6	13	7
5	H/T	9	28	19	5	H/T	9	23	14
6	P/U	10	18	8	6	H/T	11	23	12
7	H/T	12	38	26	7	H/B	13	33	20
8	P/C	14	18	4	8	P/C	15	33	18
9	P/U	16	38	22	9	H/T	16	43	27
10	P/C	18	38	20	10	H/T	16	43	27
11	H/T	19	48	29	11	H/T	16	53	37
12	P/U	19	38	19	12	H/T	18	53	35
13	L/B	20	48	28	13	H/T	19	63	44
14	P/U	23	48	25	14	P/C	22	33	11
15	P/C	25	48	23	15	P/C	25	33	8
16	M/T	27	58	31	16	H/T	25	63	38
17	H/T	29	58	29	17	H/T	26	73	47
18	P/U	29	58	29	18	P/U	28	73	45
19	H/T	30	68	38	19	P/U	32	73	41
20	M/T	31	68	37	20	H/T	34	83	49
21	P/C	32	68	36	21	H/T	37	83	46
22	L/B	33	78	45	22	H/B	38	93	55
23	H/T	35	78	43	23	P/C	40	73	33
24	H/B	36	88	52	24	P/C	42	93	51
25	P/C	37	78	41	25	P/U	45	93	48
26	P/U	39	78	39	26	L/B	46	93	47
27	H/B	41	88	47	27	M/T	46	103	57
28	P/U	44	98	54	28	P/U	46	103	57
29	H/T	46	98	52	29	P/C	49	103	54
30	P/C	49	98	49	30	P/U	52	103	51
31	P/C	51	98	47	31	P/U	54	103	49
32	H/T	53	108	55	32	P/U	56	113	57
33	P/C	55	108	53	33	M/T	59	113	54
34	M/T	57	108	51	34	L/B	60	113	53
35	H/T	60	118	58	35	P/C	60	113	53
avg				33.2	avg				36.5

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 35
Case 35-3

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	8	3	11	2	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	3	8	5	1	H/T	1	13	12
2	P/C	6	18	12	2	P/U	4	13	9
3	P/C	9	18	9	3	P/U	6	13	7
4	P/U	9	18	9	4	P/C	7	13	6
5	H/T	12	18	6	5	L/B	10	23	13
6	H/T	13	28	15	6	P/U	11	23	12
7	H/T	13	28	15	7	H/T	14	23	9
8	L/B	16	38	22	8	H/T	14	33	19
9	H/B	18	38	20	9	H/T	17	33	16
10	H/T	21	48	27	10	P/U	19	23	4
11	M/T	21	38	17	11	H/T	20	43	23
12	H/T	23	48	25	12	P/C	22	43	21
13	P/U	25	58	33	13	P/C	24	43	19
14	P/C	27	58	31	14	H/T	25	53	28
15	H/T	30	58	28	15	H/B	28	53	25
16	P/U	30	58	28	16	P/U	31	43	12
17	H/T	31	68	37	17	M/T	34	63	29
18	P/U	33	68	35	18	H/T	36	63	27
19	P/C	35	68	33	19	P/U	36	63	27
20	L/B	37	68	31	20	L/B	38	73	35
21	P/C	39	78	39	21	P/C	39	73	34
22	H/T	41	78	37	22	H/T	41	73	32
23	P/U	45	78	33	23	P/C	43	73	30
24	P/C	47	78	31	24	H/B	44	83	39
25	H/T	50	88	38	25	H/T	45	83	38
26	P/C	51	88	37	26	P/C	45	93	48
27	H/T	52	98	46	27	M/T	47	93	46
28	P/U	54	88	34	28	P/C	47	93	46
29	M/T	57	98	41	29	P/U	50	93	43
30	P/C	57	88	31	30	P/C	50	93	43
31	P/C	57	98	41	31	H/T	52	103	51
32	P/U	57	108	51	32	P/C	54	103	49
33	M/T	58	108	50	33	H/T	57	113	56
34	H/B	60	108	48	34	M/T	60	103	43
35	P/U	60	118	58	35	P/U	60	113	53
avg				30.1	avg				28.7

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 35
Case 35-4

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	8	3	11	2	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	2	6	4	1	H/T	2	11	9
2	P/C	2	6	4	2	P/C	6	11	5
3	P/C	3	16	13	3	P/U	7	11	4
4	H/T	5	16	11	4	H/T	10	21	11
5	H/T	7	26	19	5	P/C	10	21	11
6	H/T	7	26	19	6	P/C	13	21	8
7	M/T	11	16	5	7	P/C	13	21	8
8	P/U	11	36	25	8	M/T	15	31	16
9	P/C	13	36	23	9	P/C	15	31	16
10	L/B	13	36	23	10	P/U	15	31	16
11	H/T	16	36	20	11	H/B	18	41	23
12	M/T	16	46	30	12	H/T	19	41	22
13	P/C	16	46	30	13	P/C	21	31	10
14	L/B	19	46	27	14	H/T	21	51	30
15	P/U	20	46	26	15	P/U	25	31	6
16	P/U	22	46	24	16	H/B	25	51	26
17	P/C	25	56	31	17	H/T	27	61	34
18	P/U	27	56	29	18	L/B	30	61	31
19	H/T	28	56	28	19	M/T	31	61	30
20	P/U	30	56	26	20	M/T	34	71	37
21	M/T	30	66	36	21	H/T	35	71	36
22	H/T	33	66	33	22	H/T	37	81	44
23	P/U	35	66	31	23	P/U	39	71	32
24	P/C	38	76	38	24	H/T	41	81	40
25	P/U	41	76	35	25	H/T	44	91	47
26	H/T	45	76	31	26	P/U	45	91	46
27	H/T	45	86	41	27	P/U	48	91	43
28	P/C	48	76	28	28	P/C	50	91	41
29	P/C	49	86	37	29	P/C	53	101	48
30	H/B	52	96	44	30	H/T	55	101	46
31	H/T	55	96	41	31	P/U	55	101	46
32	H/T	55	106	51	32	P/U	56	101	45
33	P/C	58	86	28	33	H/T	57	111	54
34	H/T	59	106	47	34	L/B	58	111	53
35	H/B	60	116	56	35	P/C	60	111	51
avg				28.4	avg				29.3

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 35

Case 35-5

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	8	3	11	2	2

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/C	1	6	5	1	P/C	1	11	10
2	H/B	2	6	4	2	H/B	4	11	7
3	H/T	2	16	14	3	H/T	5	21	16
4	H/T	4	16	12	4	P/U	7	11	4
5	H/B	5	26	21	5	P/U	7	11	4
6	P/C	6	26	20	6	H/T	7	21	14
7	P/U	8	26	18	7	M/T	9	31	22
8	M/T	12	36	24	8	H/T	11	31	20
9	P/U	13	26	13	9	H/T	11	41	30
10	P/C	14	36	22	10	H/T	14	41	27
11	H/T	16	36	20	11	P/C	17	31	14
12	P/U	17	46	29	12	M/T	19	51	32
13	P/C	20	46	26	13	H/T	22	51	29
14	H/T	22	46	24	14	L/B	24	51	27
15	P/C	24	46	22	15	M/T	24	61	37
16	M/T	27	56	29	16	P/C	27	61	34
17	P/U	28	56	28	17	L/B	29	61	32
18	P/C	31	56	25	18	H/B	32	71	39
19	P/C	32	56	24	19	P/C	33	61	28
20	P/C	33	56	23	20	P/C	34	61	27
21	P/U	35	66	31	21	H/T	34	71	37
22	M/T	36	66	30	22	P/C	36	81	45
23	H/T	40	66	26	23	P/C	39	81	42
24	L/B	40	76	36	24	P/C	39	81	42
25	H/T	40	76	36	25	P/U	42	81	39
26	H/T	43	86	43	26	P/U	43	81	38
27	P/U	46	76	30	27	H/T	45	91	46
28	H/T	49	86	37	28	H/T	46	91	45
29	P/U	53	76	23	29	P/U	47	81	34
30	L/B	53	96	43	30	P/U	50	101	51
31	H/T	54	96	42	31	H/T	52	101	49
32	H/T	54	106	52	32	P/C	54	101	47
33	P/C	55	96	41	33	P/U	56	101	45
34	P/U	57	96	39	34	H/T	58	111	53
35	H/T	60	106	46	35	P/U	60	111	51
avg				27.4	avg				31.9

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 40
Case 40-1

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	9	4	13	2	3

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	3	7	4	1	P/C	2	12	10
2	H/T	5	17	12	2	H/B	3	12	9
3	M/T	8	17	9	3	P/C	4	12	8
4	P/C	9	17	8	4	H/T	6	22	16
5	H/T	11	27	16	5	P/C	7	12	5
6	P/U	13	27	14	6	P/C	9	22	13
7	H/T	15	37	22	7	P/U	12	22	10
8	P/U	15	27	12	8	P/C	14	22	8
9	P/C	16	27	11	9	H/B	15	32	17
10	P/C	16	37	21	10	H/T	17	32	15
11	P/U	18	37	19	11	H/B	19	42	23
12	P/U	21	37	16	12	H/T	19	42	23
13	P/C	22	47	25	13	H/T	22	52	30
14	P/U	23	47	24	14	H/T	24	52	28
15	H/T	24	47	23	15	P/U	25	62	37
16	P/U	26	47	21	16	M/T	27	62	35
17	M/T	29	57	28	17	P/U	28	62	34
18	L/B	30	57	27	18	P/U	29	62	33
19	P/C	31	57	26	19	H/T	31	72	41
20	H/T	32	67	35	20	M/T	33	72	39
21	M/T	33	57	24	21	H/T	35	82	47
22	H/T	34	67	33	22	P/C	35	62	27
23	P/C	35	77	42	23	P/U	35	72	37
24	P/U	38	77	39	24	P/U	36	82	46
25	H/B	40	77	37	25	M/T	37	82	45
26	H/T	41	87	46	26	P/C	38	92	54
27	H/T	42	87	45	27	P/U	40	92	52
28	H/T	43	97	54	28	P/U	42	92	50
29	P/C	45	77	32	29	H/T	44	92	48
30	P/C	46	97	51	30	P/C	46	102	56
31	H/B	48	107	59	31	H/T	48	102	54
32	H/T	49	107	58	32	P/C	50	102	52
33	P/C	52	97	45	33	H/T	51	112	61
34	H/T	53	117	64	34	H/T	52	112	60
35	M/T	53	117	64	35	H/T	54	122	68
36	P/U	56	97	41	36	H/T	55	122	67
37	H/T	56	127	71	37	L/B	55	102	47
38	H/B	56	127	71	38	L/B	57	132	75
39	L/B	57	117	60	39	P/U	58	132	74
40	P/U	60	137	77	40	M/T	60	132	72
avg				34.7	avg				38.2

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 40
Case 40-2

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	9	4	13	2	3

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	P/U	3	7	4	1	M/T	0	12	12
2	M/T	5	17	12	2	L/B	3	12	9
3	P/C	7	17	10	3	P/U	4	12	8
4	P/U	10	17	7	4	H/B	5	22	17
5	H/T	11	27	16	5	P/C	7	12	5
6	H/T	13	27	14	6	H/T	10	22	12
7	P/C	16	37	21	7	H/T	13	32	19
8	M/T	19	37	18	8	L/B	16	32	16
9	P/C	19	37	18	9	H/T	16	42	26
10	H/T	20	47	27	10	P/U	19	32	13
11	P/U	20	37	17	11	H/T	21	42	21
12	P/U	23	37	14	12	P/U	22	32	10
13	P/C	24	47	23	13	M/T	24	52	28
14	H/T	25	57	32	14	P/C	26	52	26
15	H/T	26	57	31	15	P/C	28	52	24
16	H/T	27	67	40	16	H/T	29	62	33
17	P/C	28	47	19	17	P/C	30	52	22
18	P/U	30	47	17	18	P/C	30	52	22
19	P/C	31	67	36	19	H/T	30	62	32
20	L/B	32	67	35	20	M/T	32	72	40
21	H/T	32	77	45	21	H/T	33	72	39
22	H/T	35	77	42	22	P/U	34	72	38
23	H/B	36	87	51	23	H/B	37	82	45
24	H/T	36	87	51	24	M/T	40	82	42
25	H/B	36	97	61	25	H/T	40	92	52
26	P/U	37	67	30	26	H/T	42	92	50
27	P/U	40	97	57	27	H/B	45	102	57
28	P/C	40	97	57	28	P/U	46	82	36
29	M/T	42	107	65	29	P/C	46	102	56
30	H/T	43	107	64	30	P/C	50	102	52
31	P/C	45	97	52	31	P/U	50	102	52
32	M/T	48	117	69	32	P/U	50	112	62
33	P/U	51	107	56	33	H/T	51	112	61
34	P/C	52	117	65	34	H/T	51	122	71
35	H/T	54	117	63	35	H/T	52	122	70
36	H/T	55	127	72	36	P/U	53	112	59
37	H/T	55	127	72	37	H/T	56	132	76
38	L/B	57	137	80	38	P/U	57	112	55
39	P/U	60	137	77	39	P/C	57	132	75
40	H/B	60	137	77	40	P/C	60	132	72
avg				40.4	avg				37.9

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 40
Case 40-3

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	9	4	13	2	3

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	L/B	3	8	5	1	P/C	2	13	11
2	H/T	4	8	4	2	H/T	4	13	9
3	H/T	4	18	14	3	H/T	6	23	17
4	H/T	5	18	13	4	P/U	7	13	6
5	H/B	7	28	21	5	P/C	8	13	5
6	P/C	9	28	19	6	P/U	10	23	13
7	P/C	9	28	19	7	M/T	12	23	11
8	P/C	10	28	18	8	H/T	14	33	19
9	M/T	13	38	25	9	H/T	17	33	16
10	P/C	16	38	22	10	H/T	18	43	25
11	P/C	16	38	22	11	P/C	19	43	24
12	P/U	17	38	21	12	L/B	21	43	22
13	P/U	18	38	20	13	P/U	23	43	20
14	P/C	20	48	28	14	H/T	24	53	29
15	H/T	20	48	28	15	H/T	27	53	26
16	H/T	22	58	36	16	H/T	29	63	34
17	M/T	22	48	26	17	L/B	30	63	33
18	M/T	24	58	34	18	H/T	33	73	40
19	P/U	24	58	34	19	M/T	35	63	28
20	H/T	26	68	42	20	H/T	36	73	37
21	P/C	27	68	41	21	H/B	38	83	45
22	H/T	29	78	49	22	P/C	38	83	45
23	P/C	31	68	37	23	M/T	40	83	43
24	L/B	32	68	36	24	H/B	40	93	53
25	H/T	34	78	44	25	P/U	42	93	51
26	P/U	36	88	52	26	P/C	42	93	51
27	P/U	40	88	48	27	P/C	43	93	50
28	H/T	40	88	48	28	H/T	45	103	58
29	P/U	43	88	45	29	P/C	45	103	58
30	H/T	45	98	53	30	H/T	45	113	68
31	P/C	47	98	51	31	P/U	45	103	58
32	H/T	48	108	60	32	P/U	46	103	57
33	H/T	50	108	58	33	H/T	47	113	66
34	P/U	52	98	46	34	P/U	49	123	74
35	P/U	53	98	45	35	P/C	52	123	71
36	P/U	53	118	65	36	H/B	53	123	70
37	M/T	54	118	64	37	P/U	55	123	68
38	H/B	57	118	61	38	P/C	58	133	75
39	H/B	59	128	69	39	P/U	58	133	75
40	H/T	60	128	68	40	M/T	60	133	73
avg				37.3	avg				40.9

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 40
Case 40-4

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	9	4	13	2	3

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	L/B	1	6	5	1	H/T	2	11	9
2	H/T	2	6	4	2	P/U	4	11	7
3	P/C	4	16	12	3	P/C	6	11	5
4	H/T	7	16	9	4	P/U	7	11	4
5	M/T	8	16	8	5	H/T	8	21	13
6	H/T	10	26	16	6	H/T	8	21	13
7	H/T	12	26	14	7	P/U	11	31	20
8	L/B	13	36	23	8	P/C	12	31	19
9	H/T	16	36	20	9	H/T	13	31	18
10	P/C	17	36	19	10	H/T	13	41	28
11	H/T	18	46	28	11	H/T	14	41	27
12	P/U	20	36	16	12	H/B	16	51	35
13	H/T	23	46	23	13	P/U	18	31	13
14	P/C	23	56	33	14	P/U	19	51	32
15	M/T	24	56	32	15	H/T	20	61	41
16	H/T	26	56	30	16	H/T	22	61	39
17	P/U	28	66	38	17	H/B	24	71	47
18	P/U	31	66	35	18	M/T	25	51	26
19	H/B	33	66	33	19	P/C	27	71	44
20	P/C	35	66	31	20	P/U	29	71	42
21	M/T	37	76	39	21	M/T	32	81	49
22	H/T	37	76	39	22	P/U	33	71	38
23	H/B	38	86	48	23	M/T	34	81	47
24	P/C	39	76	37	24	H/T	34	91	57
25	P/C	41	86	45	25	H/T	35	91	56
26	P/U	42	86	44	26	H/T	36	101	65
27	H/T	43	96	53	27	P/C	38	81	43
28	H/B	44	96	52	28	H/T	40	101	61
29	M/T	45	106	61	29	H/B	42	111	69
30	P/U	46	86	40	30	H/T	44	111	67
31	P/U	48	106	58	31	P/C	46	81	35
32	P/U	51	106	55	32	L/B	46	121	75
33	P/U	51	106	55	33	M/T	47	121	74
34	H/T	52	116	64	34	P/C	49	121	72
35	P/C	54	106	52	35	P/U	49	121	72
36	H/T	55	116	61	36	P/C	51	121	70
37	P/C	57	126	69	37	P/C	53	131	78
38	P/U	59	126	67	38	P/U	56	131	75
39	H/T	60	126	66	39	L/B	58	131	73
40	P/C	60	126	66	40	P/C	60	131	71
avg				37.5	avg				43.2

SIMULATION OF NAM NGUM CROSSING

Hourly Traffic Volume = 40
Case 40-5

Traffic Component

P/C	P/U	M/T	H/T	L/B	H/B
9	9	4	13	2	3

No.	Vehicle type	Arr. time ThaNgon	Arr. time BanHai	Cross time	No.	Vehicle type	Arr. time BanHai	Arr. time ThaNgon	Cross time
Northbound					Southbound				
1	H/T	2	15	13	1	H/T	0	10	10
2	L/B	3	15	12	2	H/T	1	10	9
3	P/C	3	15	12	3	H/T	1	20	19
4	P/U	5	15	10	4	P/C	3	20	17
5	P/U	8	25	17	5	P/C	5	20	15
6	H/T	10	25	15	6	P/C	5	20	15
7	H/T	11	35	24	7	H/T	6	30	24
8	H/T	12	35	23	8	H/T	7	30	23
9	L/B	12	25	13	9	P/U	9	40	31
10	M/T	13	45	32	10	H/B	11	40	29
11	P/C	15	25	10	11	H/T	11	50	39
12	H/T	18	45	27	12	P/U	14	40	26
13	P/C	19	45	26	13	H/B	14	50	36
14	H/T	21	55	34	14	H/T	16	60	44
15	H/B	21	55	34	15	M/T	17	60	43
16	H/T	22	65	43	16	H/T	18	70	52
17	P/C	23	65	42	17	P/U	21	40	19
18	P/C	26	65	39	18	P/C	23	60	37
19	P/U	26	65	39	19	P/C	23	70	47
20	M/T	27	75	48	20	P/C	25	70	45
21	P/C	28	75	47	21	M/T	28	80	52
22	H/T	30	75	45	22	M/T	30	80	50
23	M/T	33	85	52	23	H/T	31	90	59
24	H/B	34	85	51	24	P/U	32	70	38
25	H/B	35	95	60	25	M/T	33	80	47
26	P/C	37	85	48	26	P/U	35	90	55
27	P/U	38	95	57	27	H/T	38	100	62
28	L/B	39	95	56	28	P/U	39	90	51
29	P/C	41	95	54	29	H/T	41	100	59
30	H/T	43	105	62	30	P/C	42	90	48
31	P/U	45	105	60	31	H/T	45	110	65
32	H/T	46	115	69	32	H/T	47	110	63
33	P/U	48	105	57	33	P/C	51	120	69
34	P/U	50	105	55	34	L/B	52	120	68
35	H/T	51	115	64	35	P/U	54	120	66
36	P/U	53	125	72	36	L/B	57	120	63
37	P/U	54	125	71	37	H/B	58	130	72
38	H/T	55	125	70	38	P/U	58	120	62
39	M/T	58	135	77	39	P/C	60	120	60
40	P/C	60	125	65	40	P/U	60	130	70
avg				42.6	avg				44.0

ANNEX B

VEHICLE OPERATING COST

ANNEX B

VEHICLE OPERATING COST

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ANNEX B VEHICLE OPERATING COST

B.1 General

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.

B.2 Component of Vehicle Operating Costs

B.2.1 Fuel

It is assumed that fuel consumption is obtained from the following equations:

Motorcycle	$Y_1 = 0.0077S^2 - 0.582S + 29.41$
Passenger car	$Y_1 = 0.0281S^2 - 2.186S + 107.3$
Pick-up	$Y_1 = 0.0227S^2 - 2.261S + 129.1$
Medium truck	$Y_1 = 0.2378S^2 - 24.00S + 803.9$
Heavy truck	$Y_1 = 0.2853S^2 - 28.80S + 964.7$
Light bus	$Y_1 = 0.0393S^2 - 3.472S + 176.6$
Heavy bus	$Y_1 = 0.0786S^2 - 6.943S + 353.3$

Where, Y_1 : volume of fuel consumption(litter per 1000 km)
S : running speed (Km/hr)

Regular gasoline is used for motorcycles, passenger cars, pick-ups, and light buses. Diesel is used for trucks and heavy buses. Price and import duty on fuel are:

Type of Fuel	Price	Import Duty
super gasoline	195 Kip/l	20%
regular gasoline	170 Kip/l	15%
diesel	170 Kip/l	5%

B.2.2 Oil

Import duty on oil is 7% at present. The price of oil is 3 US$ per litter for passenger cars, pick-ups, and motorcycles, and 4 US$ for the other type of vehicles. Oil consumption is assumed to obtain with the following formula:

Motorcycle	$Y_2 = 0.0008S^2 - 0.013S + 1.474$
Passenger car	$Y_2 = 0.0004S^2 - 0.039S + 2.141$
Pick-up	$Y_2 = 0.0004S^2 - 0.039S + 2.141$
Medium truck	$Y_2 = 0.0013S^2 - 0.153S + 8.309$
Heavy truck	$Y_2 = 0.0016S^2 - 0.183S + 9.970$
Light bus	$Y_2 = 0.00062^2 - 0.069S + 3.770$
Heavy bus	$Y_2 = 0.0012S^2 - 0.138S + 7.541$

Where, Y_2 : volume of oil consumption(litter per 1000 km)
S : running speed (Km/hr)

B.2.3 Tires

Tire wear is calculated with the following equations:

Motorcycle	$Y_3 = 0.0001S^2 - 0.0130S + 0.0625$
Passenger car	$Y_3 = 0.0005S^2 - 0.0411S + 0.2501$
Pick-up	$Y_3 = 0.0005S^2 - 0.0411S + 0.2501$
Medium truck	$Y_3 = 0.0025S^2 - 0.0730S + 3.6520$
Heavy truck	$Y_3 = 0.0043S^2 - 0.1240S + 6.2090$
Light bus	$Y_3 = 0.0013S^2 - 0.0360S + 1.8209$
Heavy bus	$Y_3 = 0.0025S^2 - 0.0730S + 1.8260$

Where, Y_3 : volume of Tire consumption(litter per 1000 km)
S : running speed (Km/hr)

Price of tire including 20% of import duty and number of tires by vehicle type are as follows:

vehicle type	price of tire	No. of tires
Motorcycle	10US$	2
Passenger car	50	4
Pick-up	80	4
Medium truck	120	4
Heavy truck	260	6
Light bus	80	4
Heavy bus	180	6

B.2.4 Maintenance

It is assumed that spar parts cost 0.05% of economic value of a new car per 1,00Km. Import duty on spare parts is 20% for passenger car, 10% for motorcycle, and 5% to 20% for other types of vehicles.

Maintenance hours of labour per 1,000 Km are assumed at 2 hours for motorcycles, 3 hours for passenger cars and pick ups, 18 hours for light buses, and 22 hours for trucks and heavy buses based on a similar study. According to interview survey to private repair shops, wage of maintenance workers is 3 US$ per day.

B.2.5 Depreciation

The financial cost of a new car by vehicle type is shown below. Import duty depends upon vehicle type. Before the end of 1990, all the import duties will be raised. The economic cost of a new car is different from the financial cost by import duty as follows:

Type		financial cost	import duty	economic cost
M/C	Honda super cub	2,000 US$	15%	1,740 US$
P/C	Mitsubishi Lancer	16,000	50	10,670
P/U	Toyota	18,000	15	15,300
M/T	Toyota Dyna	24,000	2	23,530
H/T	Fuso FM515F	47,000	2	46,080
L/B	Toyota	18,000	15	15,650
H/B	MMC BE434FL	70,000	5	66,670

The depreciation costs are obtained from the following equations:

Motorcycle	$Y_4 = 1/(1.2S + 36)$
Passenger car	$Y_4 = 1/(2.4S + 96)$
Pick-up	$Y_4 = 1/(3.0S + 120)$
Medium/Heavy truck	$Y_4 = 1/(6.0S + 180)$
Light bus	$Y_4 = 1/(5.25S + 157.5)$
Heavy bus	$Y_4 = 1/(8.75S + 262.5)$

Where, Y_4 : percentage of depreciation per 1000 km, equated as the depreciable value of vehicle(90% of economic cost of a new vehicle)

S : running speed (Km/hr)

B.2.6 Interest

Interests rates of loans are set based on costs of capital in Lao PDR. Interest rate of industrial credit financed by International Development Association is 7 to 8%. That of commercial loan financed by regular deposits is 28% or higher. A part of industrial credit may be utilized for purchase of vehicles. Due to the high interest rate of regular commercial loan, it is likely that a small percentage of vehicle are purchased with the commercial loan. Hence, interest rate is assumed at 10 percent per annum for all the type of vehicles. In addition, it is assumed that half of the vehicles need interest payment, as similar studies do. The interest costs in relation to running speed are calculated as follows:

Motorcycle	$Y_5 = 1/400S$
Passenger car	$Y_5 = 1/400S$
Pick-up	$Y_5 = 1/500S$
Medium truck	$Y_5 = 1/1{,}200S$
Heavy truck	$Y_5 = 1/1{,}200S$
Light bus	$Y_5 = 1/1{,}500S$
Heavy bus	$Y_5 = 1/2{,}500S$

Where, Y_5 : interest as % per 1,000Km, equated at the depreciable value of vehicle

S : running speed (Km/hr)

B.2.7 Crew Costs

An equation of traveling hours for wages is simply

$$Y_6 = 1{,}000/S$$

where, Y_6 : traveling hours per 1,000 Km

Number of crew by vehicle type is assumed as follows:

Medium truck	:	driver 1
Heavy truck	:	driver 1, assistant 1
Light bus	:	driver 1
Heavy bus	:	driver 1, conductor 1

In accordance with interviews to private transport companies and a public bus company, wage rates of crew are

truck driver	5.0US$/day
truck assistant	3.0US$/day
bus driver	2.0US$/day
bus conductor	1.8US$/day

Income tax for crew is 5%.

B.2.8 Insurance

Only vehicles owned by international organizations like UNDP and embassies are insured. Also, only relatively new vehicles whose residual value is more than 70% of sales price can be insured according to the policy of the insurance company. Thus, insured ratios of motorcycles, buses, trucks are considered at zero. Those of passenger cars and pick-ups are assumed at 10% with reference to the ratio of passenger cars and pick-ups owned by international organizations and embassies against all the registered ones. Tariff of comprehensive insurance is 6% of value of vehicles. Thus, formula of insurance are;

passenger car $Y_7 = 0.06 \times 1000/400S$

pick-up $Y_7 = 0.06 \times 1000/500S$

where, Y_7 : insurance as % per 1,000 Km, equated as the financial value of a new vehicle

B.2.9 Registration Fee

Every vehicle has to be registered every year. Registration fees are fairly low, compared to the other vehicle operating costs, as follows:

Motorcycle : 520Kip car and truck : 1,470Kip

Hence, registration fees are excluded from calculation of vehicle operation costs.

B.2.10 Overhead

According to studies in other countries, overhead costs are assumed at about 10% of the total direct costs for trucks and buses.

B.3 Vehicle Operating Costs on a Level Tangent Paved Road

With the estimation equations and assumptions mentioned above, vehicle operating costs on a level tangent paved road by vehicle type shows in the following pages.

Table B.1 Vehicle Operation Cost on a Level Tangent Paved Road
Motorcycle (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Dprec.	Interes	Insur.	wage	O.head	Total
10	4.63	3.79	0.03	0.79	0.75	32.61	19.57	0.00	0.00	0.00	62.16
15	4.26	3.63	0.04	0.79	0.75	28.99	13.04	0.00	0.00	0.00	51.50
20	3.96	3.49	0.05	0.79	0.75	26.09	9.78	0.00	0.00	0.00	44.91
25	3.74	3.35	0.07	0.79	0.75	23.72	7.83	0.00	0.00	0.00	40.24
30	3.59	3.23	0.08	0.79	0.75	21.74	6.52	0.00	0.00	0.00	36.70
35	3.51	3.12	0.09	0.79	0.75	20.07	5.59	0.00	0.00	0.00	33.93
40	3.51	3.02	0.11	0.79	0.75	18.63	4.89	0.00	0.00	0.00	31.71
45	3.58	2.93	0.13	0.79	0.75	17.39	4.35	0.00	0.00	0.00	29.92
50	3.73	2.85	0.14	0.79	0.75	16.30	3.91	0.00	0.00	0.00	28.49
55	3.95	2.79	0.16	0.79	0.75	15.35	3.56	0.00	0.00	0.00	27.34
60	4.24	2.73	0.18	0.79	0.75	14.49	3.26	0.00	0.00	0.00	26.45
65	4.61	2.69	0.20	0.79	0.75	13.73	3.01	0.00	0.00	0.00	25.78
70	5.05	2.66	0.22	0.79	0.75	13.04	2.80	0.00	0.00	0.00	25.31
75	5.56	2.64	0.25	0.79	0.75	12.42	2.61	0.00	0.00	0.00	25.01
80	6.14	2.63	0.27	0.79	0.75	11.86	2.45	0.00	0.00	0.00	24.88
85	6.80	2.63	0.30	0.79	0.75	11.34	2.30	0.00	0.00	0.00	24.91
90	7.54	2.64	0.32	0.79	0.75	10.87	2.17	0.00	0.00	0.00	25.08

Table B.2 Vehicle Operation Cost on a Level Tangent Paved Road
Passenger car (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Dprec.	Interes	Insur.	wage	O.head	Total
10	16.77	5.01	1.18	4.44	1.13	88.56	120.00	24.00	0.00	0.00	261.08
15	15.36	4.59	1.62	4.44	1.13	84.66	80.00	16.00	0.00	0.00	207.79
20	14.22	4.22	2.10	4.44	1.13	81.08	60.00	12.00	0.00	0.00	179.18
25	13.34	3.90	2.61	4.44	1.13	77.80	48.00	9.60	0.00	0.00	160.82
30	12.73	3.63	3.17	4.44	1.13	74.77	40.00	8.00	0.00	0.00	147.87
35	12.39	3.41	3.76	4.44	1.13	71.96	34.29	6.86	0.00	0.00	138.24
40	12.32	3.25	4.39	4.44	1.13	69.36	30.00	6.00	0.00	0.00	130.89
45	12.51	3.13	5.06	4.44	1.13	66.95	26.67	5.33	0.00	0.00	125.22
50	12.97	3.06	5.77	4.44	1.13	64.69	24.00	4.80	0.00	0.00	120.86
55	13.69	3.05	6.52	4.44	1.13	62.58	21.82	4.36	0.00	0.00	117.59
60	14.69	3.08	7.31	4.44	1.13	60.61	20.00	4.00	0.00	0.00	115.25
65	15.94	3.16	8.14	4.44	1.13	58.75	18.46	3.69	0.00	0.00	113.72
70	17.47	3.30	9.00	4.44	1.13	57.01	17.14	3.43	0.00	0.00	112.92
75	19.26	3.48	9.90	4.44	1.13	55.36	16.00	3.20	0.00	0.00	112.78
80	21.32	3.72	10.85	4.44	1.13	53.81	15.00	3.00	0.00	0.00	113.27
85	23.65	4.01	11.83	4.44	1.13	52.34	14.12	2.82	0.00	0.00	114.34
90	26.24	4.34	12.85	4.44	1.13	50.96	13.33	2.67	0.00	0.00	115.96

Table B.3 Vehicle Operation Cost on a Level Tangent Paved Road
Pick up (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Dprec.	Interes	Insur.	wage	O.head	Total
10	20.66	5.01	1.89	7.11	1.13	93.91	140.87	21.60	0.00	0.00	292.18
15	19.05	4.59	2.59	7.11	1.13	85.38	93.91	14.40	0.00	0.00	228.16
20	17.66	4.22	3.35	7.11	1.13	78.26	70.43	10.80	0.00	0.00	192.97
25	16.49	3.90	4.18	7.11	1.13	72.24	56.35	8.64	0.00	0.00	170.03
30	15.53	3.63	5.07	7.11	1.13	67.08	46.96	7.20	0.00	0.00	153.70
35	14.78	3.41	6.02	7.11	1.13	62.61	40.25	6.17	0.00	0.00	141.48
40	14.26	3.25	7.03	7.11	1.13	58.70	35.22	5.40	0.00	0.00	132.08
45	13.94	3.13	8.10	7.11	1.13	55.24	31.30	4.80	0.00	0.00	124.76
50	13.85	3.06	9.24	7.11	1.13	52.17	28.17	4.32	0.00	0.00	119.06
55	13.97	3.05	10.44	7.11	1.13	49.43	25.61	3.93	0.00	0.00	114.66
60	14.31	3.08	11.70	7.11	1.13	46.96	23.48	3.60	0.00	0.00	111.35
65	14.86	3.16	13.02	7.11	1.13	44.72	21.67	3.32	0.00	0.00	108.99
70	15.63	3.30	14.40	7.11	1.13	42.69	20.12	3.09	0.00	0.00	107.46
75	16.61	3.48	15.85	7.11	1.13	40.83	18.78	2.88	0.00	0.00	106.67
80	17.81	3.72	17.35	7.11	1.13	39.13	17.61	2.70	0.00	0.00	106.56
85	19.23	4.01	18.92	7.11	1.13	37.57	16.57	2.54	0.00	0.00	107.07
90	20.86	4.34	20.55	7.11	1.13	36.12	15.65	2.40	0.00	0.00	108.17

Table B.4 Vehicle Operation Cost on a Level Tangent Paved Road
Medium Truck (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Dprec.	Interes	Insur.	wage	O.head	Total
10	122.78	25.85	12.71	10.70	8.25	88.24	88.24	0.00	59.38	41.61	457.75
15	103.92	23.61	12.53	10.70	8.25	78.43	58.82	0.00	39.58	33.58	369.43
20	87.54	21.61	12.86	10.70	8.25	70.59	44.12	0.00	29.69	28.53	313.88
25	73.65	19.86	13.69	10.70	8.25	64.17	35.29	0.00	23.75	24.94	274.30
30	62.23	18.36	15.04	10.70	8.25	58.82	29.41	0.00	19.79	22.26	244.86
35	53.30	17.10	16.89	10.70	8.25	54.30	25.21	0.00	16.96	20.27	222.98
40	46.86	16.08	19.26	10.70	8.25	50.42	22.06	0.00	14.84	18.85	207.31
45	42.90	15.31	22.13	10.70	8.25	47.06	19.61	0.00	13.19	17.91	197.06
50	41.42	14.79	25.51	10.70	8.25	44.12	17.65	0.00	11.88	17.43	191.74
55	42.43	14.51	29.41	10.70	8.25	41.52	16.04	0.00	10.80	17.36	191.01
60	45.92	14.47	33.81	10.70	8.25	39.22	14.71	0.00	9.90	17.70	194.66
65	51.89	14.68	38.72	10.70	8.25	37.15	13.57	0.00	9.13	18.41	202.51
70	60.35	15.13	44.14	10.70	8.25	35.29	12.61	0.00	8.48	19.50	214.45
75	71.29	15.83	50.07	10.70	8.25	33.61	11.76	0.00	7.92	20.94	230.38
80	84.72	16.77	56.51	10.70	8.25	32.09	11.03	0.00	7.42	22.75	250.23
85	100.62	17.96	63.46	10.70	8.25	30.69	10.38	0.00	6.99	24.91	273.96
90	119.02	19.40	70.92	10.70	8.25	29.41	9.80	0.00	6.60	27.41	301.50

Table B.5 Vehicle Operation Cost on a Level Tangent Paved Road
Heavy Truck (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Depre.	Interes	Insur.	wage	O.head	Total
10	147.34	31.02	70.24	20.94	8.25	172.79	172.79	0.00	95.00	71.84	790.22
15	124.70	28.33	69.23	20.94	8.25	153.59	115.20	0.00	63.33	58.36	641.94
20	105.05	25.93	71.03	20.94	8.25	138.24	86.40	0.00	47.50	50.33	553.68
25	88.37	23.83	75.65	20.94	8.25	125.67	69.12	0.00	38.00	44.98	494.83
30	74.68	22.03	83.09	20.94	8.25	115.20	57.60	0.00	31.67	41.34	454.79
35	63.97	20.52	93.33	20.94	8.25	106.33	49.37	0.00	27.14	38.99	428.84
40	56.23	19.30	106.40	20.94	8.25	98.74	43.20	0.00	23.75	37.68	414.49
45	51.48	18.37	122.27	20.94	8.25	92.16	38.40	0.00	21.11	37.30	410.29
50	49.71	17.74	140.97	20.94	8.25	86.40	34.56	0.00	19.00	37.76	415.32
55	50.91	17.41	162.47	20.94	8.25	81.31	31.42	0.00	17.27	39.00	428.99
60	55.10	17.36	186.80	20.94	8.25	76.80	28.80	0.00	15.83	40.99	450.88
65	62.27	17.61	213.94	20.94	8.25	72.76	26.58	0.00	14.62	43.70	480.67
70	72.42	18.16	243.89	20.94	8.25	69.12	24.68	0.00	13.57	47.10	518.14
75	85.55	19.00	276.66	20.94	8.25	65.83	23.04	0.00	12.67	51.19	563.12
80	101.66	20.13	312.24	20.94	8.25	62.83	21.60	0.00	11.88	55.95	615.49
85	120.75	21.56	350.64	20.94	8.25	60.10	20.33	0.00	11.18	61.37	675.12
90	142.82	23.28	391.85	20.94	8.25	57.60	19.20	0.00	10.56	67.45	741.95

Table B.6 Vehicle Operation Cost on a Level Tangent Paved Road
Light bus (pick up) (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Depre.	Interes	Insur.	wage	O.head	Total
10	27.70	8.81	4.24	7.11	6.75	67.08	46.96	0.00	23.75	19.24	211.63
15	25.33	8.05	4.18	7.11	6.75	59.63	31.30	0.00	15.83	15.82	174.01
20	23.34	7.37	4.29	7.11	6.75	53.66	23.48	0.00	11.88	13.79	151.67
25	21.73	6.78	4.56	7.11	6.75	48.79	18.78	0.00	9.50	12.40	136.40
30	20.48	6.27	5.01	7.11	6.75	44.72	15.65	0.00	7.92	11.39	125.31
35	19.61	5.84	5.63	7.11	6.75	41.28	13.42	0.00	6.79	10.64	117.07
40	19.11	5.50	6.42	7.11	6.75	38.33	11.74	0.00	5.94	10.09	110.99
45	18.99	5.23	7.38	7.11	6.75	35.78	10.43	0.00	5.28	9.70	106.65
50	19.23	5.05	8.50	7.11	6.75	33.54	9.39	0.00	4.75	9.43	103.77
55	19.85	4.96	9.80	7.11	6.75	31.57	8.54	0.00	4.32	9.29	102.19
60	20.85	4.94	11.27	7.11	6.75	29.81	7.83	0.00	3.96	9.25	101.78
65	22.21	5.01	12.91	7.11	6.75	28.24	7.22	0.00	3.65	9.31	102.43
70	23.95	5.16	14.71	7.11	6.75	26.83	6.71	0.00	3.39	9.46	104.09
75	26.07	5.40	16.69	7.11	6.75	25.55	6.26	0.00	3.17	9.70	106.70
80	28.55	5.72	18.84	7.11	6.75	24.39	5.87	0.00	2.97	10.02	110.22
85	31.41	6.11	21.15	7.11	6.75	23.33	5.52	0.00	2.79	10.42	114.62
90	34.64	6.60	23.64	7.11	6.75	22.36	5.22	0.00	2.64	10.90	119.86

Table B.7 Vehicle Operation Cost on a Level Tangent Paved Road
Heavy bus (per 1000km, in US$)

Speed	Fuel	Oil	Tire	Parts	Labor	Depre.	Interes	Insur.	wage	O.head	Total
10	60.95	23.48	28.61	30.30	8.25	171.43	120.00	0.00	45.13	48.81	536.96
15	55.75	21.46	28.19	30.30	8.25	152.38	80.00	0.00	30.08	40.64	447.06
20	51.37	19.66	28.93	30.30	8.25	137.14	60.00	0.00	22.56	35.82	394.03
25	47.81	18.08	30.81	30.30	8.25	124.68	48.00	0.00	18.05	32.60	358.57
30	45.07	16.72	33.84	30.30	8.25	114.29	40.00	0.00	15.04	30.35	333.85
35	43.15	15.58	38.01	30.30	8.25	105.49	34.29	0.00	12.89	28.80	316.76
40	42.05	14.66	43.33	30.30	8.25	97.96	30.00	0.00	11.28	27.78	305.62
45	41.78	13.96	49.79	30.30	8.25	91.43	26.67	0.00	10.03	27.22	299.43
50	42.32	13.48	57.41	30.30	8.25	85.71	24.00	0.00	9.03	27.05	297.55
55	43.69	13.22	66.17	30.30	8.25	80.67	21.82	0.00	8.20	27.23	299.56
60	45.88	13.18	76.07	30.30	8.25	76.19	20.00	0.00	7.52	27.74	305.13
65	48.88	13.37	87.12	30.30	8.25	72.18	18.46	0.00	6.94	28.55	314.06
70	52.71	13.77	99.32	30.30	8.25	68.57	17.14	0.00	6.45	29.65	326.17
75	57.36	14.40	112.67	30.30	8.25	65.31	16.00	0.00	6.02	31.03	341.33
80	62.83	15.24	127.16	30.30	8.25	62.34	15.00	0.00	5.64	32.68	359.43
85	69.12	16.31	142.79	30.30	8.25	59.63	14.12	0.00	5.31	34.58	380.41
90	76.23	17.59	159.58	30.30	8.25	57.14	13.33	0.00	5.01	36.74	404.19

ANNEX C

METEOROLOGY AND HYDROGY

ANNEX C
METEOROLOGY AND HYDROGY

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ANNEX C METEOROLOGY

C.1 Meteorology

C.1.1 Rainfall

Table C.1 shows the monthly mean rainfall from the period 1970 to 1989 in Vientiane. 70% of annual rainfall is concentrated during June and September.

C.1.2 Wind

Strong wind occurs by summer monsoon which comes in June and ends in September with heavy rains. Annual mean instantaneous maximum wind velocity is 20.3 m/sec at Vientiane as shown in Table C.2.

Wind speeds have been analyzed for different return periods by Gumbel method. The results are as follows.

Return Period (Year)	30	50	100
Wind Velocity (m/sec)	40	44	49

C.1.3 Earthquake

Project area is located in the western edge of the earthquake belt referred to 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 C.1. One of the mountain range of the Burma arc extends to northern part of Laos. Shallow earthquakes have occurred on this mountainous area with the magnitude from 3.4 to 4.4 as shown on Table C.3.

Ground Acceleration due to Earthquake

Ground acceleration on the epicenter at northern mountain in Laos have been applied for design purpose using Gutenberg-Richter's formula, expressed as:

$$\text{Log } a_o = -2.1 + 0.8M - 0.07 \text{ m}^2$$

Where a_o = maximum acceleration in cm/sec^2

M = magnitude of the earthquake (Assumed to be 4.4)

Therefore: $a_o = 8$ cm/sec^2

The largest magnitude of the earthquake experienced in Vientiane is about 30 gal (3 cm/sec^2 by human sensation).

C.2 Hydrogy

C.2.1 Flood frequency analysis

The peak discharge for different return periods at Tha Ngon gauging station have been analyzed by Gumbel method from the annual flood record for past 18 years, since completion of the Nam Ngum dam (see Table C.4 and Figure C.4).

The results are given 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

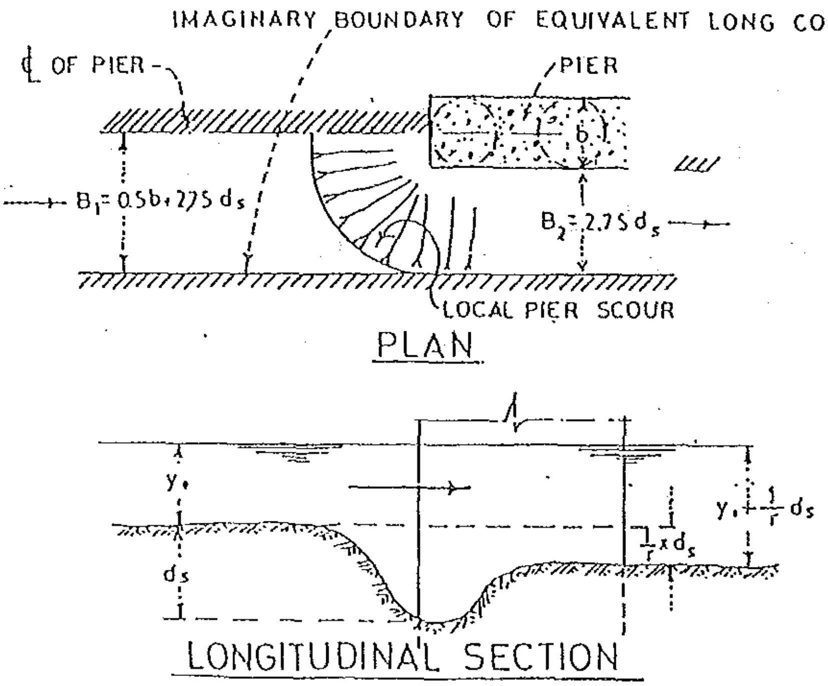
C.2.2 Water level

Monthly mean discharge at Tha Ngon gauging station for the period 1972 to 1989 shows that low water level occurs during dry season from December to May (see Table C.5). Average discharge for the period is 270m3/sec, which corresponds to water level of 155.0m. Recorded minimum water level was 152.12m in 1988 as shown in Table C.6.

C.3 SCOUR DEPTH

C.3.1 Scour Depth by Formula

There have been various formulas recommended for estimating local scour depth causing by construction of piers in river water. Laursen's formula among them will be used for checking scour depth as follows.



$$\frac{b}{Yo} = 5.5 \frac{ds}{Yo} \left[\left(1 + \frac{1}{r} \frac{ds}{Yo}\right)^{1/m} - 1 \right]$$

m=0.59, r=11.5

where Yo = Mean water depth
b = Pier width
ds = Scour depth

Assuming mean water depth "Yo" to be 5.5m (EL=157.0m) and pier width "d" is 1.5m, local scour depth: "ds" will be 3.2.

C.3.2 Scour Depth Observed

"Thinkeo Bridge Construction Report" describes that maximum scour depth of 1.5 m have developed around piers and scour protection work had been carried out after completion. 23,500 pieces of concrete block (48 kg per piece) had been dumped around piers by hand.

Bore hole investigation shows that river bed consists of very loose fine sand(having N-value of 1 to 6 to 3 to 4m depth). This layer is underlain by gravel which is likely to resist scouring.

It is considered that this loose fine sand would be scoured when pier constructed. The foundation should be based in hard layer of sandy gravel below the loose find sand. River bed protection work however would be necessitated to prevent possible excessive scour during flooding.

Table C.1 Monthly Mean Rainfall at Vientiane

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1970	0.5	-	31.2	56.9	306.4	377.2	215.8	624.9	420.5	53.8	T	0.1	2,087.3
1971	-	7.3	13.9	34.1	294.0	274.8	289.4	226.4	163.4	103.5	0.8	18.2	1,425.8
1972	-	6.8	36.8	167.6	115.6	312.8	246.1	306.7	166.3	148.4	8.2	5.8	1,521.1
1973	-	-	37.0	36.4	308.3	200.7	298.6	263.9	361.3	25.7	T	-	1,531.9
1974	T	1.6	36.7	97.4	100.5	159.2	255.7	368.4	187.1	92.6	29.7	0.2	1,329.1
1975	23.5	26.3	13.2	21.8	347.0	473.0	177.5	430.4	289.7	194.4	8.5	-	2,006.2
1976	-	23.0	111.9	126.9	121.7	167.3	167.3	403.1	416.7	76.7	-	-	1,614.9
1977	15.2	-	35.1	69.0	151.9	231.0	211.1	174.8	190.3	26.5	16.5	22.8	1,144.2
1978	1.6	17.8	51.1	145.9	328.4	254.9	354.6	293.6	381.4	128.9	28.5	-	1,986.7
1979	-	21.0	0.1	61.8	344.7	333.3	150.1	117.8	253.1	19.2	-	-	1,301.1
1980	-	18.6	68.8	61.0	319.5	611.0	461.5	342.9	353.4	54.7	T	-	2,291.4
1981	-	0.3	19.6	124.2	311.1	238.5	635.0	210.0	224.8	117.8	40.5	T	1,921.8
1982	-	6.1	60.8	69.6	239.3	95.4	253.8	484.0	319.5	90.2	22.2	0.6	1,641.5
1983	53.1	5.7	9.0	58.1	97.6	243.8	217.9	360.8	247.1	67.9	-	7.2	1,368.2
1984	-	10.6	3.4	88.9	148.3	148.1	421.0	388.9	267.1	142.1	17.3	-	1,635.7
1985	24.8	64.7	4.9	10.8	135.3	223.5	257.4	191.9	258.8	81.4	-	-	1,253.5
1986	-	3.2	1.5	118.8	383.4	256.2	308.9	318.3	275.3	66.7	-	21.0	1,753.3
1987	T	13.9	100.6	127.0	63.6	473.8	175.0	356.0	260.7	93.4	3.2	-	1,667.2
1988		23.4	2.8	68.5	576.6	131.5	199.4	253.0	171.0	192.9	-	-	1,619.1
1989	23.6	-	63.0	85.6	200.6	165.1	132.5	421.4	458.1	195.4	-	-	1,745.2
Average	7.1	12.5	35.1	81.5	244.7	268.6	271.4	326.9	283.2	98.6	8.8	3.8	1,642.2
%	0.4	0.8	2.2	5.0	14.9	16.4	16.5	19.9	17.2	6.0	0.5	0.2	100.0

T trace

\- no rain

Sources: Meteorological Department

Table C.2 Instantanous Maximum Wind Velocity at Vientiane

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 C.3 Record of Earthquake around Laos

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

Source: Meteorological Department

Table C.4 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.1 Ko Lak datum.
* by extrapolation from Thalat
** by extrapolation from Pakkagnoung Station

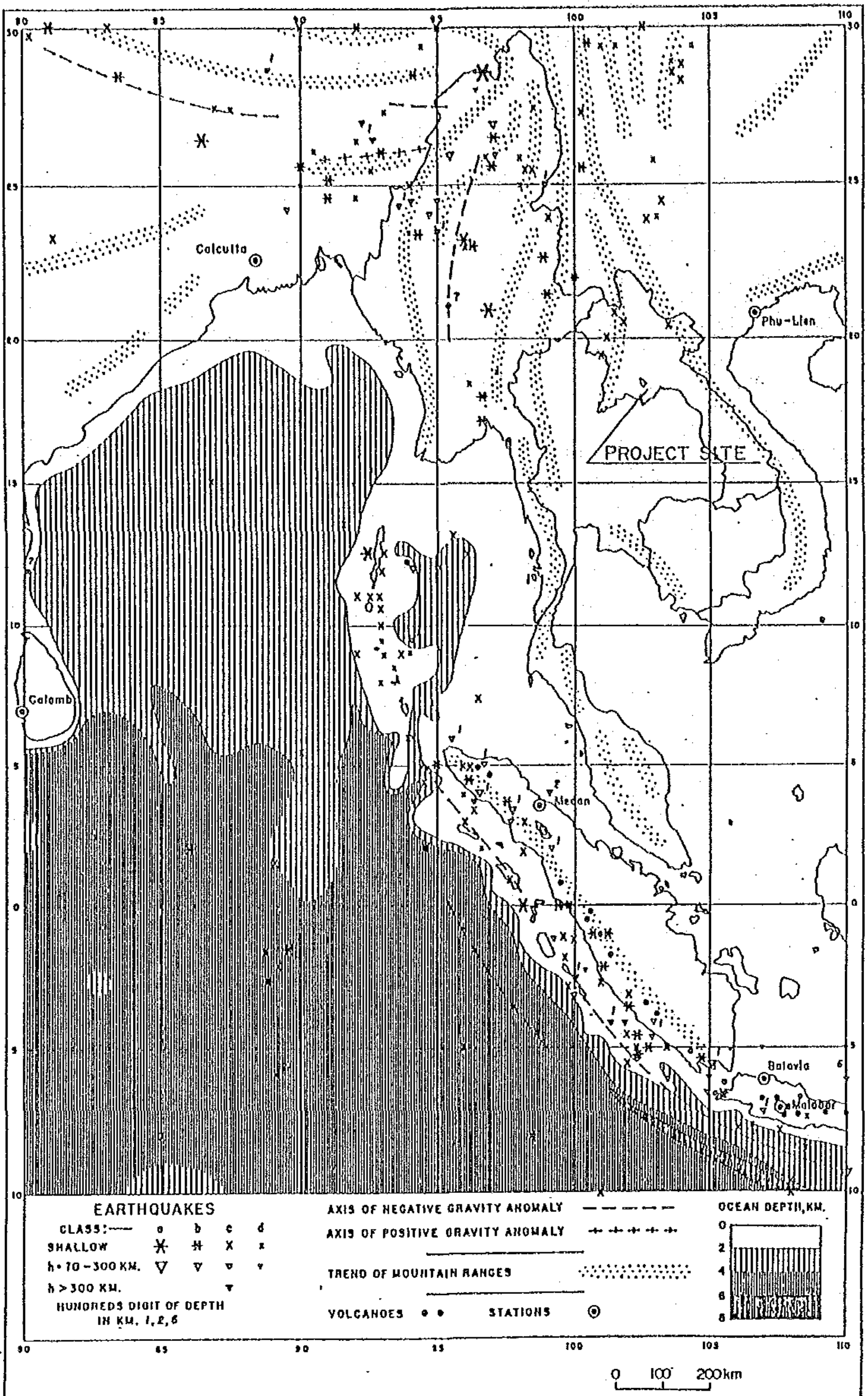
Table C.5 Monthly Mean Discharge at Tha Ngon Gauging Station

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	193	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 C.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



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

Figure C.1 Seismological Data in Sumatra-Burma

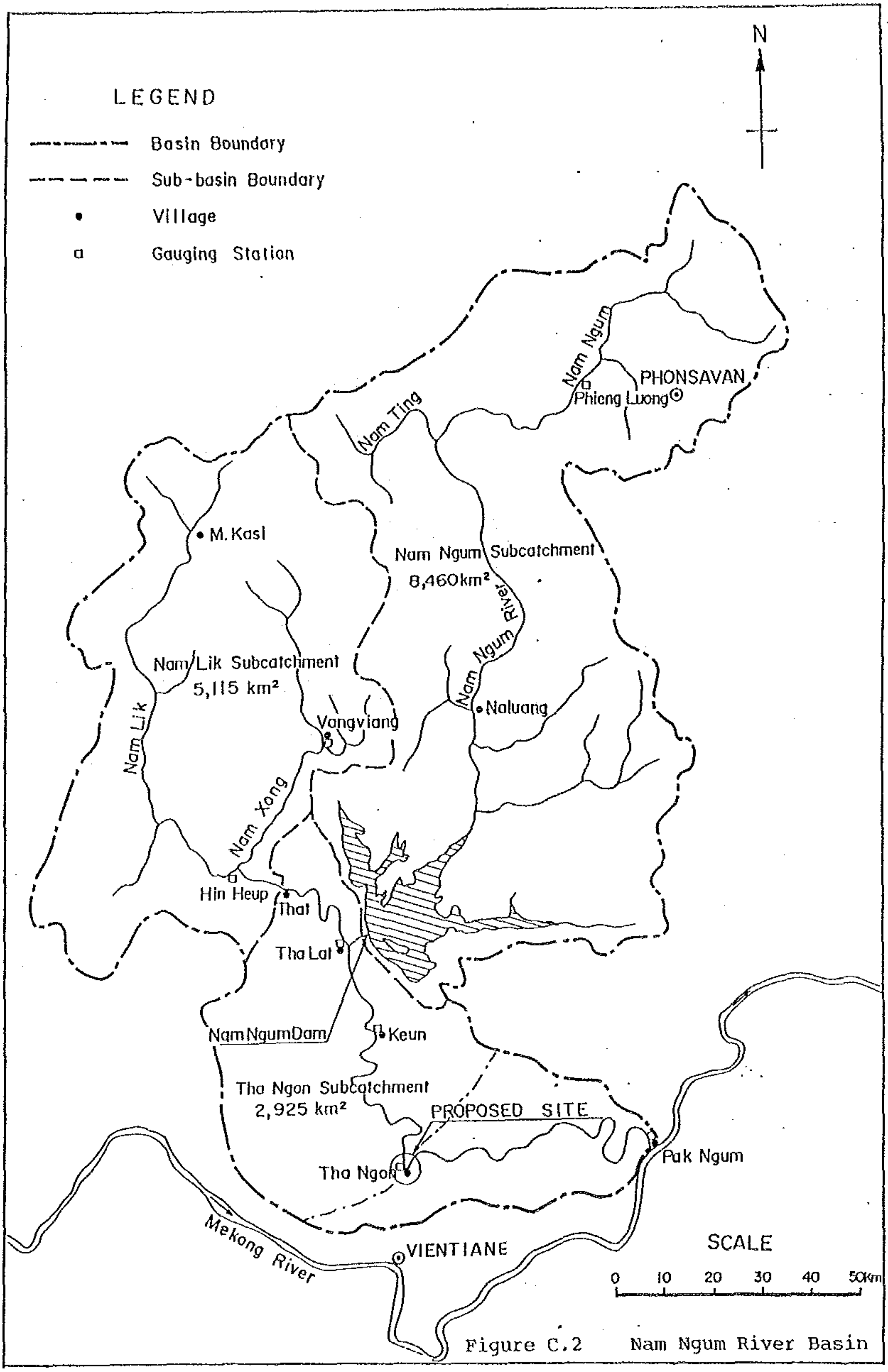


Figure C.2 Nam Ngum River Basin

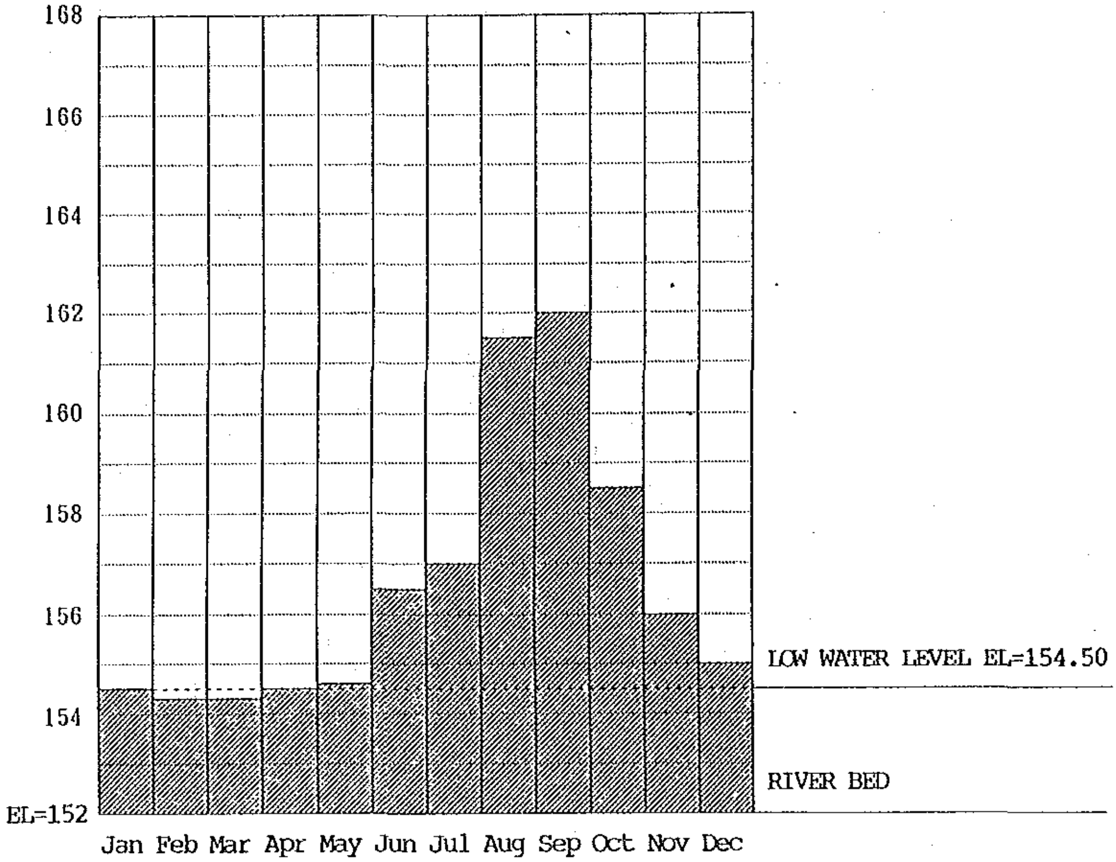


Figure C.3 Monthly Mean Water Level (1972-1989)

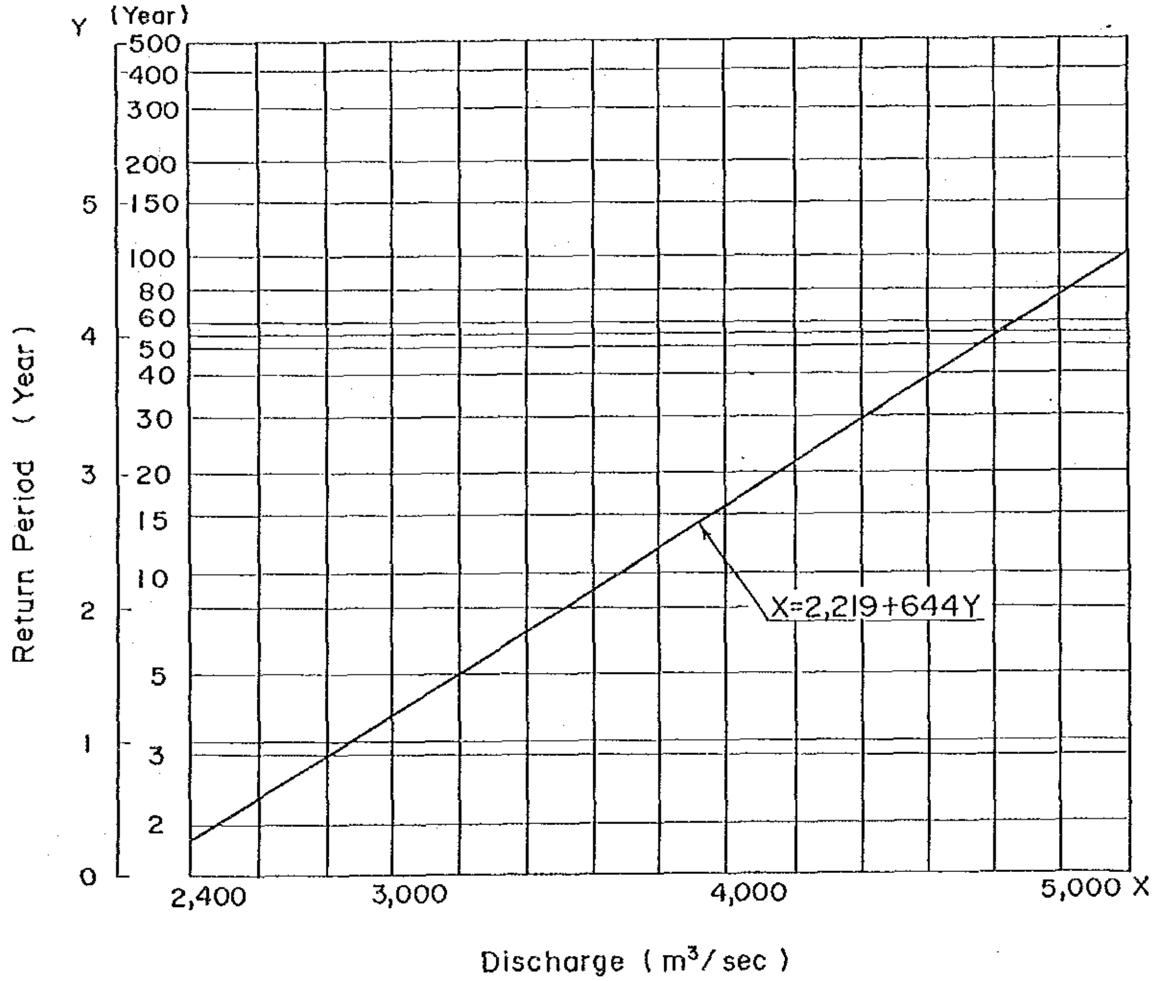
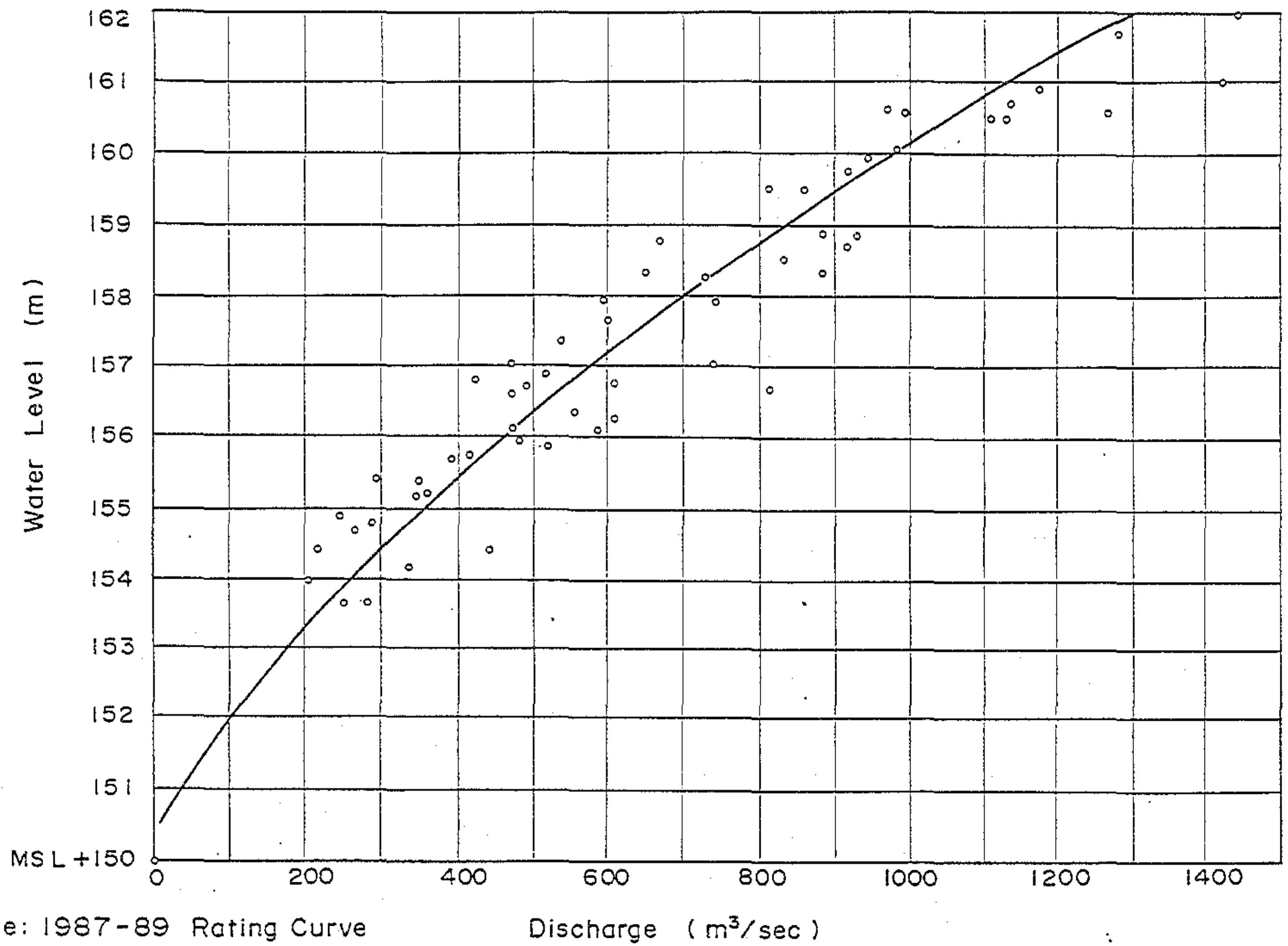


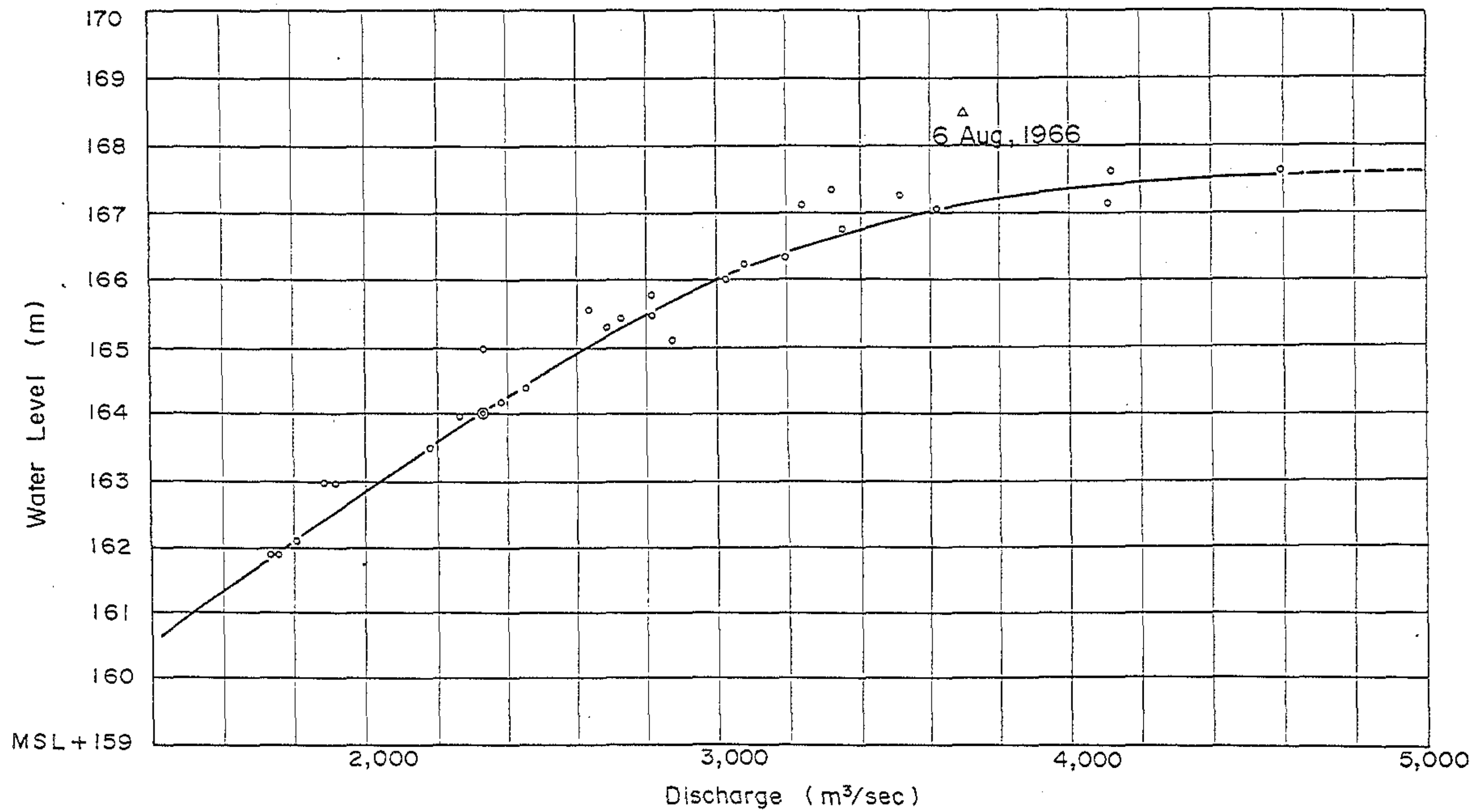
Figure C.4 Gumbel Distribution



Note: 1987-89 Rating Curve
∘ Recorded flood level (1960 - 1989)

Source:

Figure C.5 Rating Curve at Tha Ngon Gauging Station (1/2)



Note : Prepared from 1973 Rating Table
∘ Recorded flood level (1960-1989)

Source :

Figure C.6 Rating Curve at Tha Ngon Gauging Station (2/2)

ANNEX D

GEOLOGY AND MATERIAL INVESTIGATION

ANNEX D

GEOLOGY AND MATERIAL INVESTIGATION

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ANNEX D GEOLOGY AND MATERIAL INVESTIGATION

D.1 Soil Investigation

General geological maps at the site are shown in Figure D.1, D.2 with boring data(Figure D.3) previously executed by the Ministry of Agriculture & Forestry, Department of Geology and Mines.

The surface soil investigation was conducted in the Project along the proposed route, and subsoil investigation by boring was carried out at the bridge site, results of which are shown on Figure D.7 and Table D.1. The geology of the ground surface along the route is schematically shown in Figure D.4.

The Figure D.5 shows outline of stratigraphy of the project site, which area is divided into 2 geological categories; the diluvial plateau formed on the Vientiane valley of the Neogene and alluvial deposites of the eroded low lands belonging to the diluvial layers.

Profile of the soils are given on Figure D.1 along the whole sections on the basis of the ground surface investigation and some borings at the specific points.

The description of the soil classification in the Figure are as follows.

Legend

QIV Thickness : 0.5 meter

pulverized soil, greyish clay, muds which contains dark organic matter, gravel, sand, clay, alluviums and river bed materials,

QII-III Thickness : 20-25 meters

clay with gravel and residual laterite belonging to the terrace I - gravels, sand, kaolonitic clay, organic matters, mud and peat, greyish sand.

N2-QI VC Vientiane Formation Thickness : 70 meters

gravel, sand, clay, kaolon, light grey in colour, belonging to the terrace II and comprised of weathered laterite beds and yellowish sands.

K2 Tn Tha Ngon Formation Thickness : 550 meters

comprised of fine to medium grained sodium salts, white and associated with anhydrite of dark grey in colour, at places thin bed of gypsum can be obseved. Mainly comprised of dark brown sandstone intercalated by potassium and magnesium salt beds. The upper part is comprised of compacted clay mixed with agglomeratic soil of dark brown and reddish colour and bedded clay with fine lenses of brown limestone. Finer beds of rhyolitic tuff with compacted dark clay.

K2 Cp Champa Formation Thickness : 400 meters

mainly comprised of sandstones and quartzites, angular clastic elements, greyish-brown in colour, compacted soil intercalated by fine to medium size bed of medium grained sandstone, coloured in greyish-brown which contains polymictic gravels. At the upper part: comprised of light colour of sandstones, intercalated of polymictic conglomerates.

J-K Pn Dhanang Formation Thickness : 350 meters

micaceous and greyish sandstone interbedded with finer bed of siltstone, medium grained and light coloured sandstone having thicker bed and angular clastic materials. At the upper part: light coloured sandstone, interbedded with polymictic conglomerate.

D.2 Examination of Left Bank Abutment

D.2.1 Settlement of the backfill

The calculative assumption for the settlement analysis was estimated by N-value as shown in Figure D.16. Only QIV-2 layer was considered for calculating the settlement, because N-value of other layers are bigger than 4 thus it was concluded that those settlements could be neglected.

The settlement analysis is based on the equation below:

$$Sc = ((eo - e)/(1+eo)) \times H$$

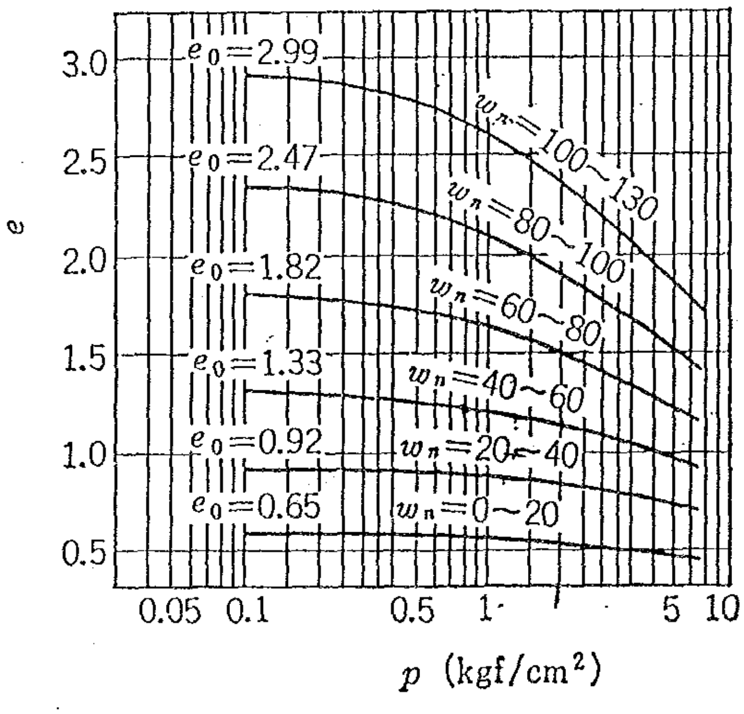
where Sc : settlement of soft clay(cm)

eo : primary void ratio

e : final void ratio

H : thickness of soft clay(cm)

The e-log p curve of soft clay which was established and proposed by the Japan Highway Public Corporation is as follows.



e - logp Curve of Soft Clay

The e-log curve was used for the settlement analysis when natural water content is 40 to 60% in Figure D.16. While the primary vertical stress (po) and the final vertical stress (po + ^p) were calculated respectively by ostergelg's method. The results are as follows.

Po and Po + ^P(t/m^2)

Layer	Po	Po + ^P
QIV	2.8	12.4
QIV-1	6.1	15.7
QIV-2	8.1	17.7

eo and e were separately found on the e-log p curve(Wb=40- 60%) and the po and the po+^p from above.

Thus,

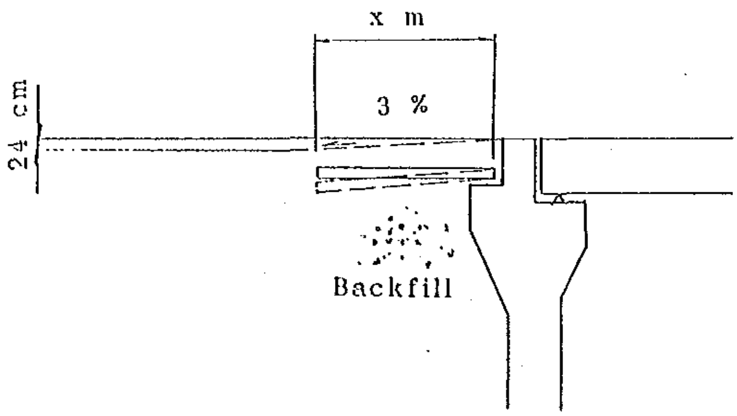
po = 8.1 ton/sq.m
eo = 1.15 - 1.20
po+^p = 12.9 ton/sq.m
e = 1.00 - 1.10

Therefore,

Sc=((1.15-1.20)-(1.00-1.10)/(1+1.15~1.20)))x750
= 52~34 cm(43cm in average)

This settlement will occur when the fill work is concluded at the back of the abutment on the left bank. The time-settlement curve is formulated as in Figure 1.7 with the pre-load speed of 10 cm/day in vertical direction, and the estimated vertical consolidational coefficient(Cv) of 3 x 10^{-2} cm/sec.

This time-settlement curve of backfill by the pre-load is indicated by the broken line in Figure 1.7. By this curve, it is estimated that the residual settlement will be about 24cm after the pavement works are completed, as shown below.

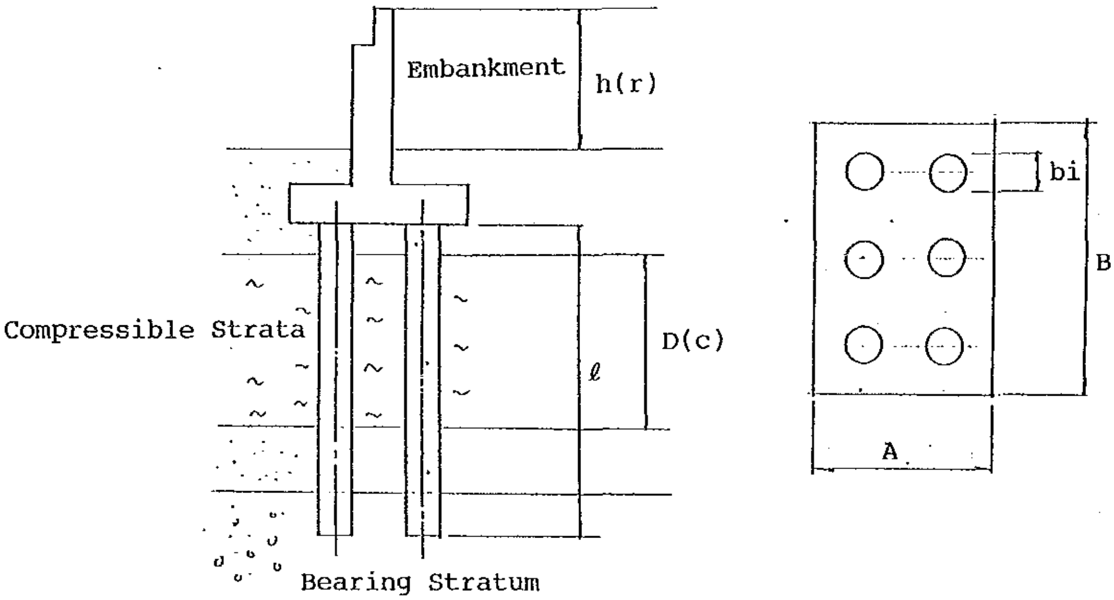


x = 24/0.03=800cm

Hence, the installment of an approach slab of about 8 meters long will be requied to cope with the possible settlement of such magnitude.

D.2.2 Lateral flow around the left bank abutment

The problem of lateral flow was examined for the left bank abutment by the method described in the "Specifications for Highway Bridges Substructure" published by Japan Road Association a shown below.



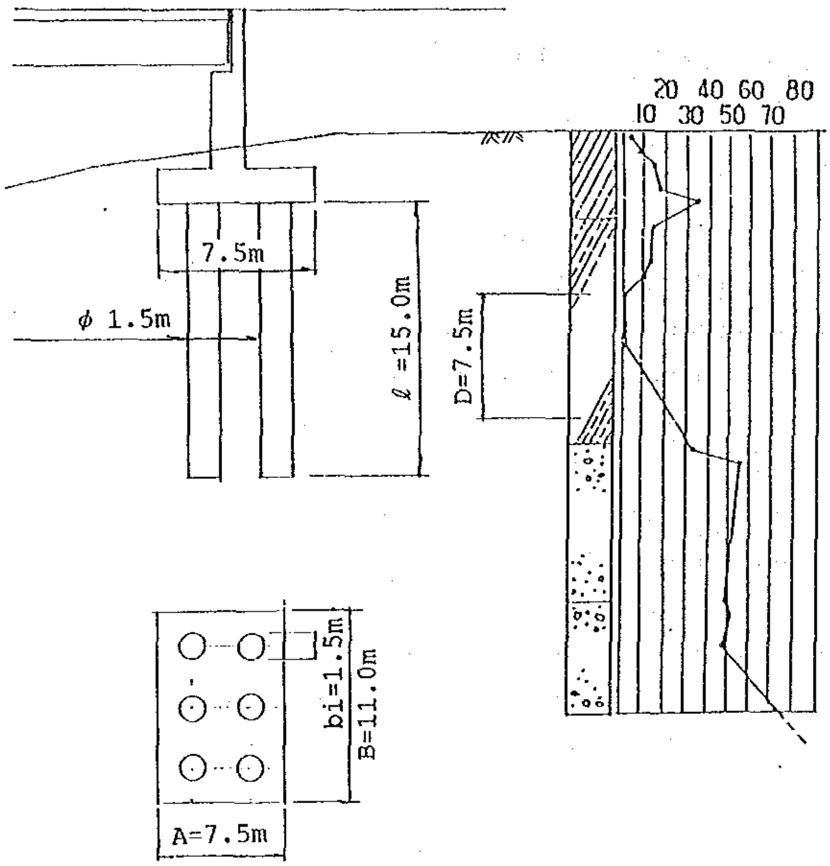
This method gives judgment equations below.

I = u1 x u2 x u3 x (rh/c)

where,

I = I-value, judgment index
u1 = coefficient of the soft ground thickness(u1=D1)
u2 = coefficient of the pile foundation(u2=b/B)
u3 = coefficient of the abutment(u3=D/A3.0)
r = unit density of the backfill(t/qu.m)
h = height of the backfill(m)
c = average cohesion of the soft ground(t/sq.m)
D = soft ground thickness(m)
A = length of abutment footing(m)
B = width of the abutment footing(m)
b = sum of each width of pile foundation(m)
1 = length of pile(m)

The I value is used to judge whether the lateral flow may occur or not. If the value becomes bigger than 1.20, the lateral flow pressure should be considered on the pile foundation. In this case the shape of the abutment is assumed as shown in below.



The average cohesion of the soft ground is estimated from the N-value of the layer as follows.

c = qu/2 qu = N/8 = 3/8 = 0.376 kg/sq.m

c = 0.376/2 = 0.188 kg/sq.m = 1.88 ton/sq.m

Therefore,

I = u1 x u2 x u3 x (rh/c) = 0.47 x 0.41 x 1.00 x (1.60 x 6.0)/1.88 = 0.98 < 1.20

Thus, it is not necessary to consider the lateral flow for the design of the abutment foundation.

D.2.3 Negative friction on the pile foundation

It is confirmed that the soft ground will settle by the fill works. The negative friction thereby shall act on the pile foundation. It is essential to consider such negative friction for the structural design of the pile foundation as follows.

a) In the case of steel piles, negative friction will be cut by coating thin tar film on the surface of steel piles.

b) In the case of cast-in-place concrete piles, as the above negative friction cut method can not be applied, it is required to design the pile foundations to bear the force acting due to negative friction.

D.2.4 Deformation of the left bank due to changes in the water level of Nam Ngum River

The difference between the high water and law water level reaches 13.0 meters. As left river bank is composed of soft ground with very small N-values it is anticipated that the difference of the river water level may case deformation of the river bank. Therefore, the magnitude of the deformation was analyzed by FEM method. (Figure D.18)

Figure D.19 gives the displacement of the ground under the abutment. From these analysis, the maximum deformation was estimated about 4 cm, then it is necessary to consider the magnitude of deformation for the structural design of the shoe on this abutment.

D.2.5 Examination of the pre-loading method for the left bank abutment

As the pre-load method has been recommended as one of the most efficient counter measures for the soft ground at the back of the abutment, future examination will be made on the assumption that the slopes of the pre-loading embankment be 1:1.8 and the fill height be 6.0 meters.

Stability of the pre-load embankment during the execution has been checked by the circular arc method. The results are given in Figure D.20, D.21 and D.22. The Figure D.20 gives the result of analysis made at the location of abutment, and Figure D.21 and Figure D.22 show those at 5 and 15 meters off the abutment respectively. From the examinations, safety factor(Fs) will become 1.0 or more at the location 15 meters off the abutment, which does not necessarily coincide with the results obtained from the analysis of lateral flow of the soft ground.

After analyzing the result above, it is provisionally concluded that the lateral flow may occur if the abutment be constructed within 15 meters from the top of slope of the bank, since there are no extra sectional area on the slope of the channel as it is the case in Japan.

Hence, the following alternative measures will be proposed for preventing the lateral flow of the soft ground at the back of abutment;

i) Application of vertical drains
ii) Application of the light fill materials
iii) Installation of reinforcing mattress(galvanized wire net)

Among these possible alternatives, i) seems to be a bit difficult for driving the drains into the upper clay layers on the left bank. And the cost of ii) appears to be 2 or 3 times expensive compared to iii), then iii) will finally be recommended as a counter measure for preventing the lateral flow accompanying the pre-load method.

D.2.6 Recommendation on earthwork

The recommendations for the earthwork design are summarized as follows:

a) The fill work at the back of the abutment shall be as low as possible taking into consideration that the possible lowest height of the fill be the design high water level plus 50 cm.

b) It is recommended to apply the pre-load method for the surcharge on the soft ground to reduce the residual settlement and to increase the strength of the soil.

D.3 Material Test Result

D.3.1 CBR Test

Proposed quarry sites for base course material and subgrade are shown on Figure D.5. Four samples from these sites have been tested for CBR test.

Test results show that base course material of river gravel (from Thanpiao) mixed with lateritic soil (from Tha Ngon) have sufficient bearing strength as shown on Table D.4–D.7.

Test results also indicate that both lateritic soil and river gravel are suitable for subbase course material.

D.3.2 Concrete strength

River gravel from Koay Deng and sand from Thington have been used for trial mix of concrete, mix proportion is shown on Table D.3. Crushing strengths on table D.3 show that concrete will meet the requirement for the specified strengths, but careful quality control of sand would be required for Class A concrete.

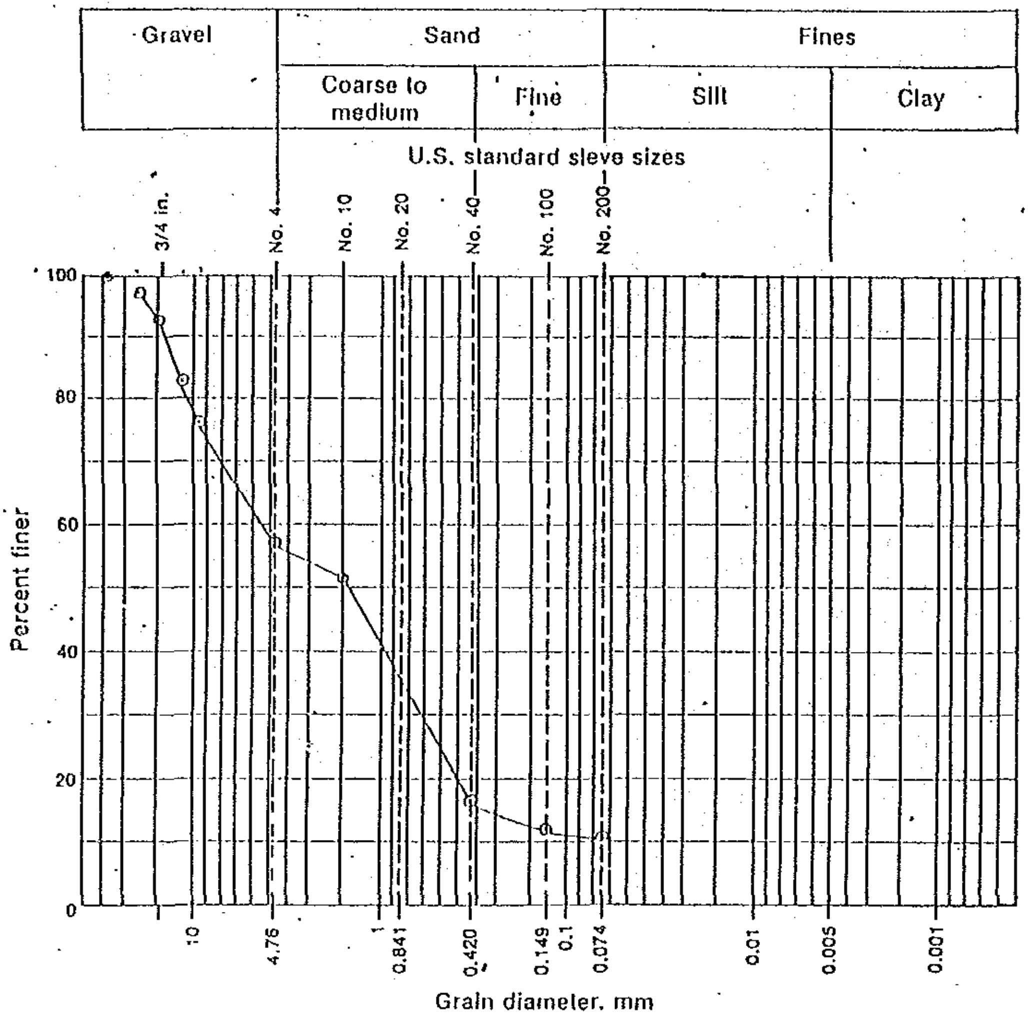
Table D.1 Summary of Test Results on Borehole Samples

Sample No.	Bore-hole No.	Depth (m)	% by weight passing U.S. standard sieve (mm)								Type of material	Liquid limit	Plastic limit	Natural moisture content	Plastic
			9.5	4.75	2.38	1.19	0.59	0.297	0.149	0.074					
1	1	0.6–1.2				100	99.8	98.9	97.4	95.4	Clay	37.1	22.1	22.1	15.0
2	1	1.8–2.7		100	99.6	99.3	98.4	95.7	91.7	88.5	Clay	36.5	22.1	25.7	14.4
3	1	2.7–3.3		100	99.9	99.8	99.7	99.7	74.0	60.6	Clay	36.2	23.2	19.2	13.0
4	1	4.3–4.6				100	99.8	97.9	61.6	47.9	Sandy clay loam	18.2	11.1	15.6	7.1
5	1	4.6–6.1				100	98.9	99.2	80.4	60.6	Sandy clay loam	32.0	20.7	26.6	11.3
6	1	6.1–6.7				100	99.9	99.6	90.8	73.4	Sandy clay loam	30.1	20.0	–	10.1
7	1	6.7–7.6				100	99.8	99.3	85.5	64.3	Sandy clay loam	25.5	16.2	29.0	9.3
8	1	8.8–9.8				100	99.9	99.7	85.2	54.2	Sandy clay loam	37.1	23.2	27.4	13.9
9	1	15.2–21.9	100	99.5	95.4	73.5	32.6	16.2	5.9	2.5	Sandy gravel	–	–	19.5	–
10	1	24.7–25.9	71.5	66.4	63.3	51.1	29.2	14.8	5.6	1.7	Sandy gravel	–	–	21.1	–
1	4	1.5–2.1			100	99.7	99.4	96.2	91.4	85.5	Clay	37.2	22.1	24.6	15.1
2	4	3.1–3.7			100	99.9	99.8	99.1	97.7	94.4	Clay	38.0	22.1	30.2	15.9
3	4	4.6–5.2			100	99.5	98.9	97.2	94.6	87.73	Clay	42.1	25.0	29.2	17.1
4	4	5.8–6.4			100	99.7	99.5	99.2	98.9	94.3	Clay	39.8	23.7	23.9	16.1
1	5	1.5–2.1				100	99.1	98.7	90.5	72.5	Sandy clay loam	26.5	16.9	16.7	9.6
2	5	10.7–11.3				100	99.9	98.0	70.0	50.0	Sandy clay loam	19.3	11.7	23.4	7.6
3	5	13.7–14.3	100	99.3	96.0	76.2	25.0	18.1	5.7	2.6	Sandy gravel	–	–	19.7	–

Table D.2 CBR Test Results (1/4)

Material: Gravel and sand(50%) + Clay laterite(50%)
Source: Gravel and sand (River gravel), Taupiao
Lateritic soil, Danxang

Particle size distribution

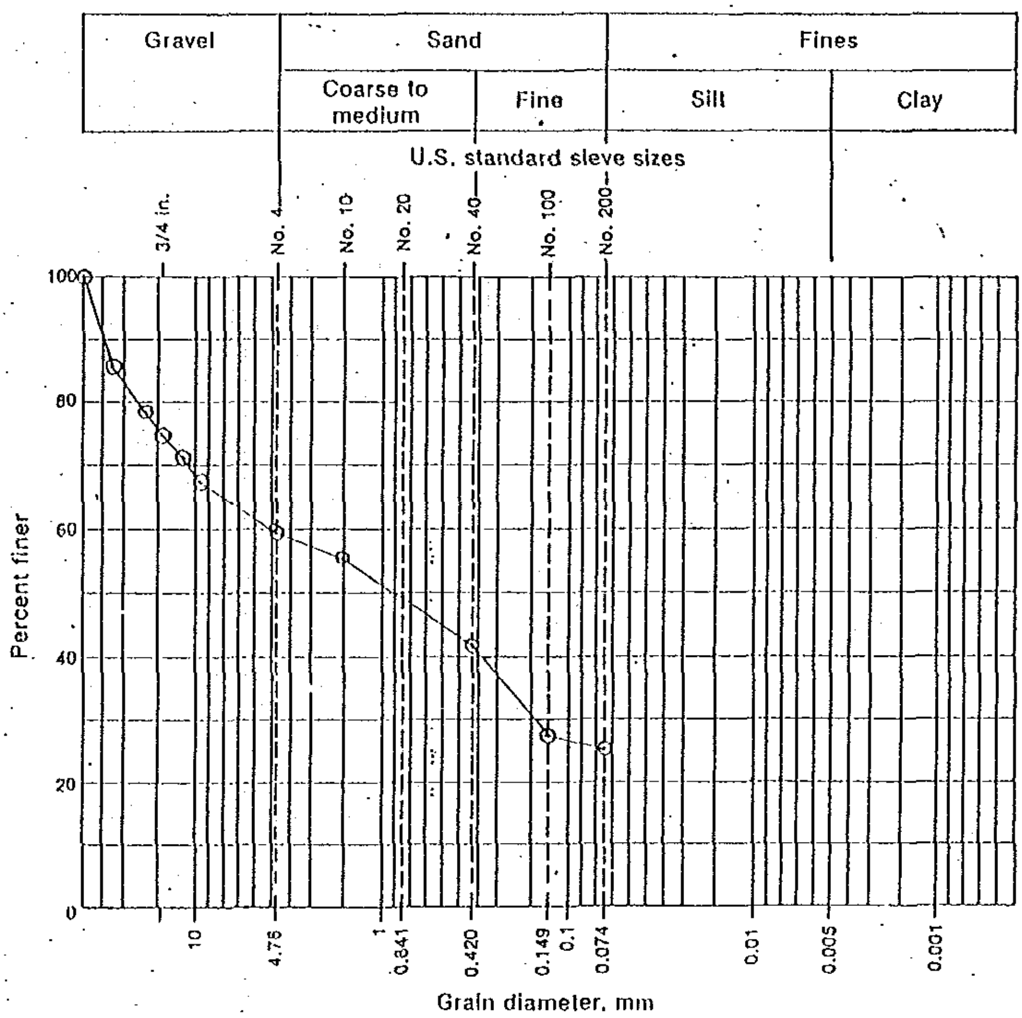


Classification: AASHO A-2-4
Atterberg Limit
Liquid limit : 24.5
Plastic limit : 17.7
Plastic index : 6.8
CBR value : 135% (42 blows, 3 layers)
Optimum moisture content: 8.5%
Maximum dry density : 2.17 g/cm^3

Table D.3 CBR Test Results (2/4)

Material: Clay gravel (lateritic soil)
Source: Tha Ngon

Particle size distribution

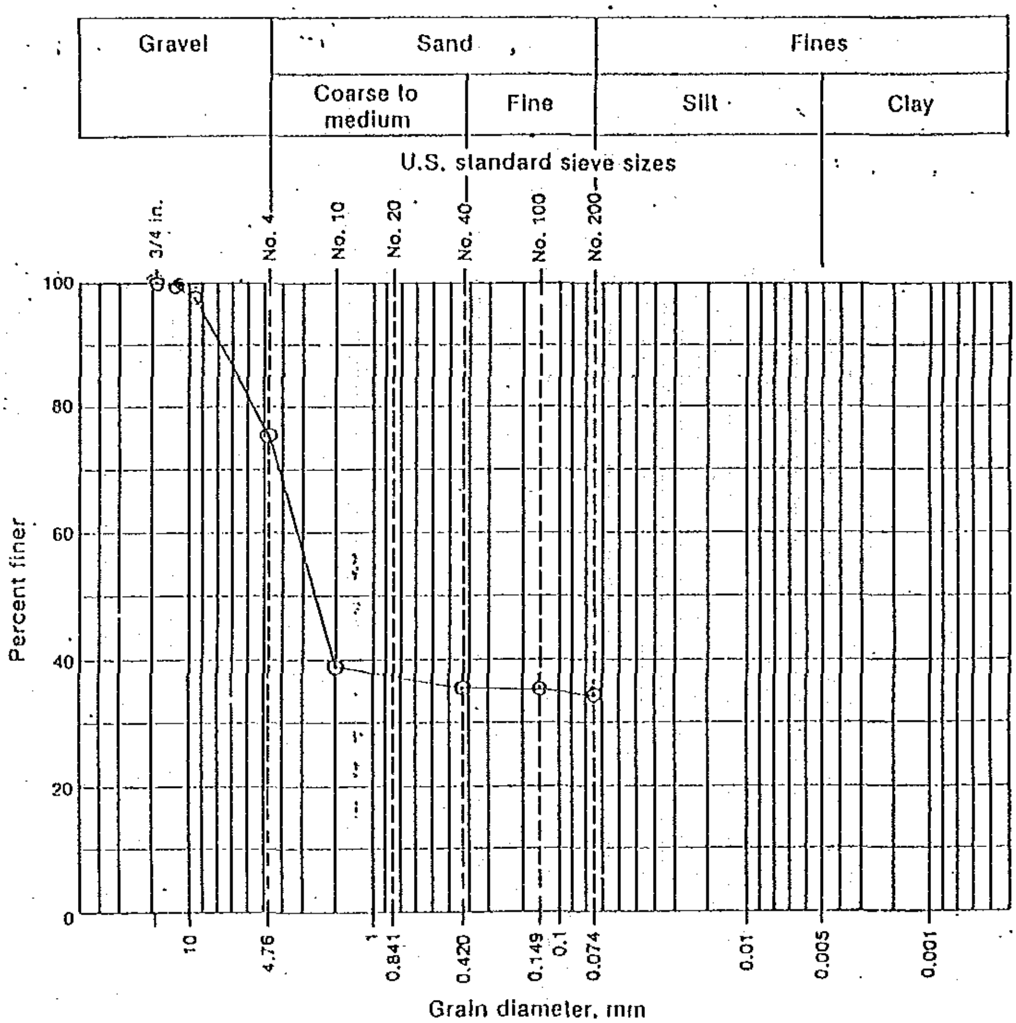


Classification: AASHO A-2-6
Atterberg Limit
  Liquid limit : 35.0
  Plastic limit : 22.1
  Plastic index : 12.9
CBR value : 124% (42 blows, 3 layers)
Optimum moisture content: 11.5%
Maximum dry density : 1.98 g/cm^3

Table D.4 CBR Test Results (3/4)

Material: Clay laterite
Source: Danxang

Particle size distribution

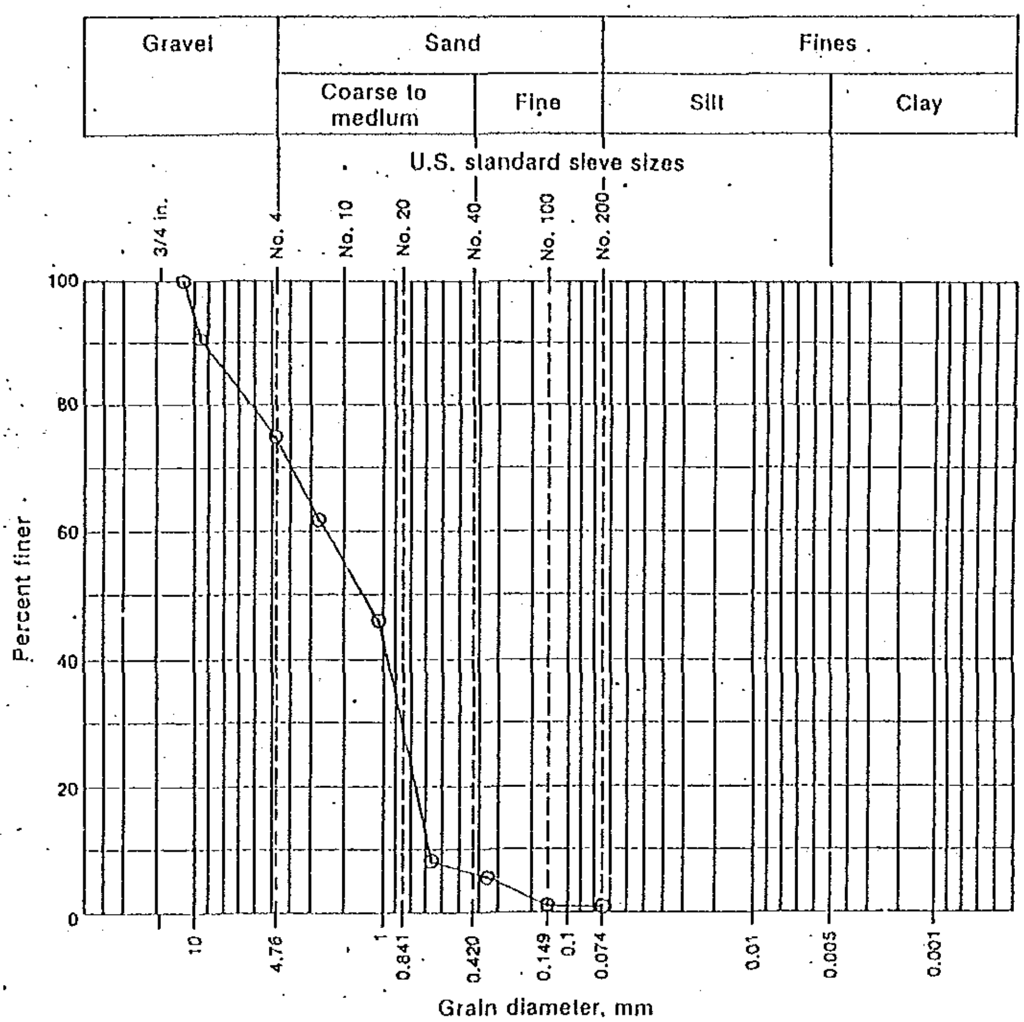


Classification: AASHO A-2-6
Atterberg Limit
  Liquid limit : 31.2
  Plastic limit : 20.2
  Plastic index : 11.0
CBR value : 137% (42 blows, 3 layers)
Optimum moisture content: 14.0%
Maximum dry density : 2.20 g/cm^3

Table D.5 CBR Test Results (4/4)

Material: Gravel + Sand
Source: River gravel, Tanpiao

Particle size distribution



Classification:
Atterberg Limit
Liquid limit : —
Plastic limit : —
Plastic index : —
CBR value : 126% (42 blows, 3 layers)
Optimum moisture content: 13.9%
Maximum dry density : 2.02 g/cm^3

Table D.6 Test Results of Aggregate for Concrete

River gravel at Khoaydeng 3

Physical Properties

	10-20 mm	5-10 mm
Specific Gravity	2.58	2.56
Absorption(%)	1.4	1.8
Abrasion Test(%)	27.0	30.5

Sieve Analysis

10-20 mm

Sieve Size	38.0	25.0	19.0	12.5	9.5	FM
Passing(%)	100	80.6	16.8	4.6	0.03	7.83

5-10 mm

Sieve Size	25.0	19.0	12.5	9.5	FM
Passing(%)	100	80.8	9.1	0.04	7.19

River sand at Thinton

Physical Properties

Specific Gravity 2.49

Absorption(%) 1.4

Sieve Analysis

Sieve Size(mm)	12.5	9.5	4.75	2.38	1.19	0.6	0.3	0.149	0.074
Passing (%)	100	99.3	98.1	95.1	90.7	22.4	5.5	3.0	0.7

Table D.7 Test Results of Concrete Mix

	Mix Proportion per Cubic Meter							Test Results			
Concrete Class	W (kg)	C (kg)	S (kg)	G (kg)	Ad (kg)	S/a (%)	W/C (%)	Air (%)	Slump (cm)	Compressive Strength (kg/cm²) 67	628
A	157	449	596	1,098	1.122	31.9	35		7	210	450
B	158	343	820	960	0.857	45.9	46		14	159	385
C	157	317	740	1,062	0.792	40.9	49		7	115	307

Specified strength of concrete Class A 628 = 350 kg/cm^2
B 628 = 300 kg/cm^2
C 628 = 240 kg/cm^2

"Pozolith 300-R" have been used for water-reducing agent.
Portland cement conform to AST-150 to be used.

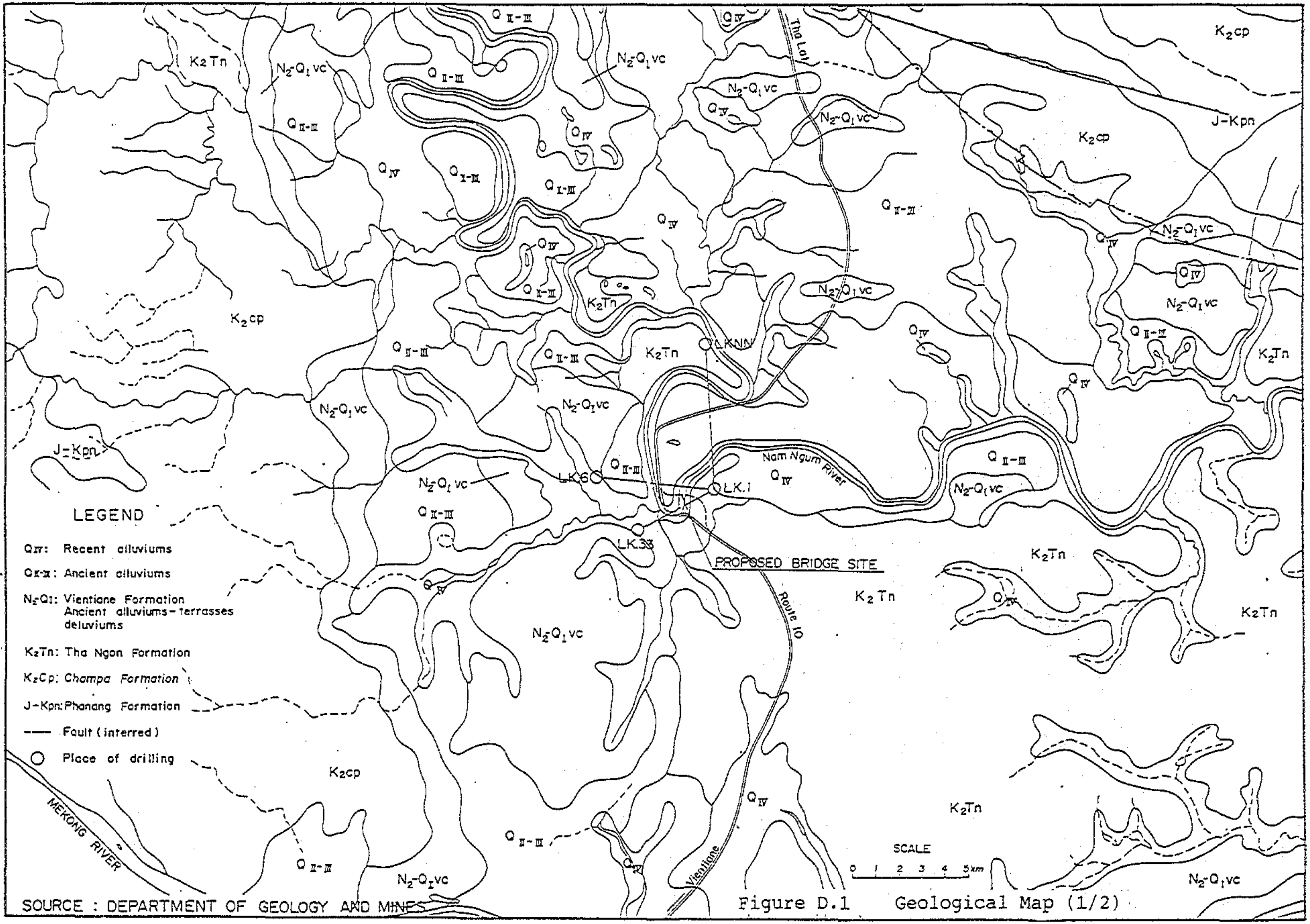


Figure D.1 Geological Map (1/2)

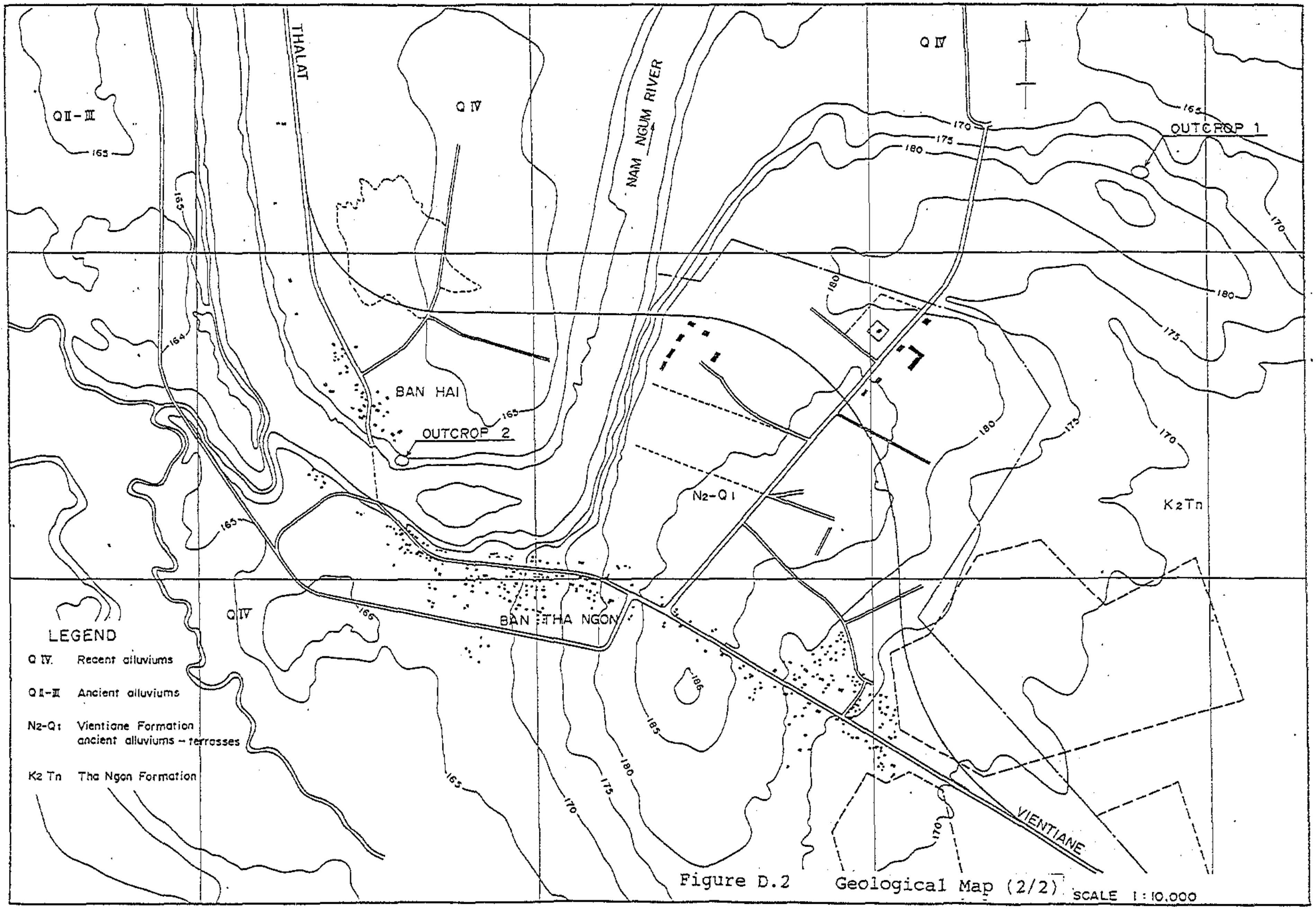
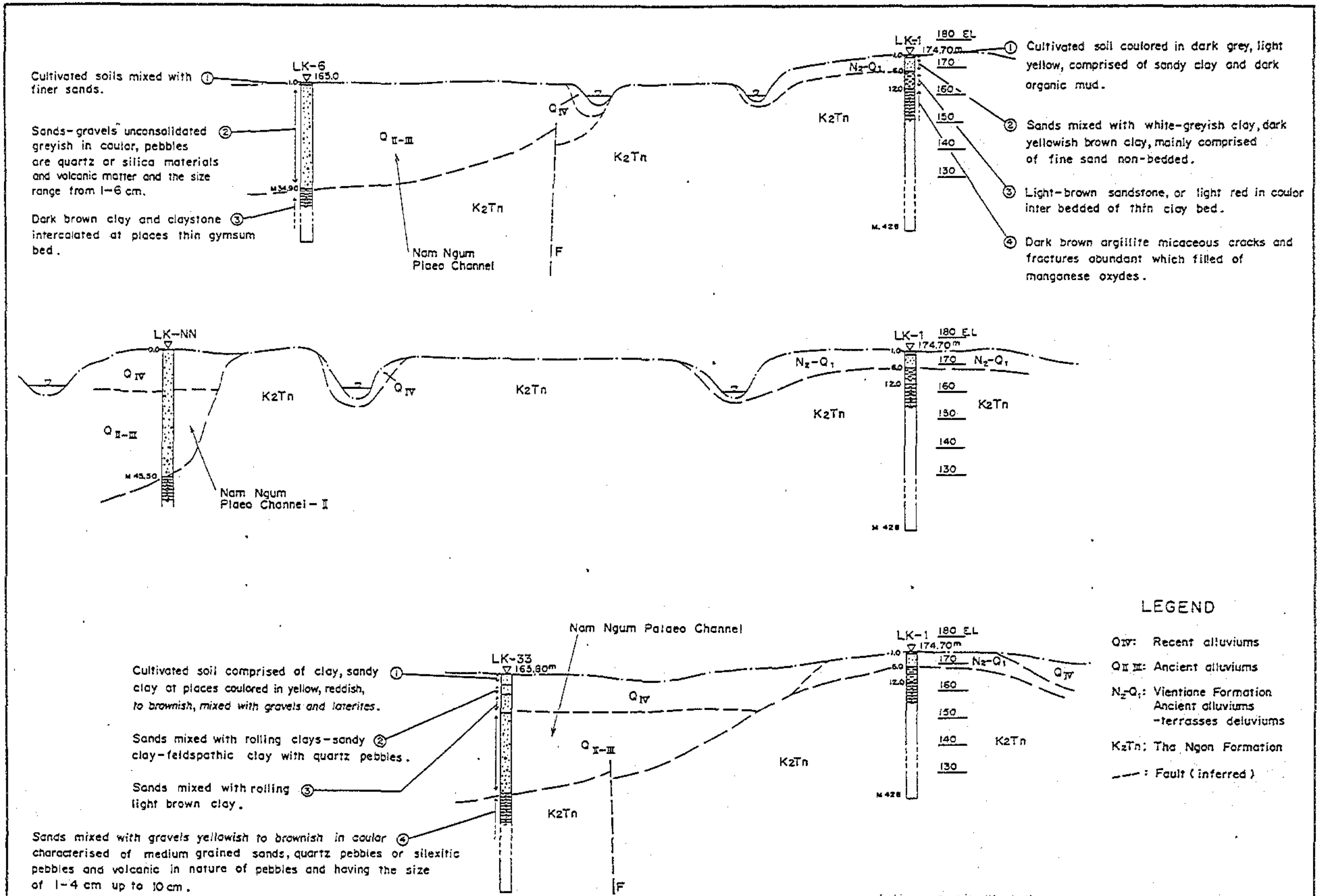


Figure D.2 Geological Map (2/2)



SOURCE : DEPARTMENT OF GEOLOGY AND MINES

Figure D.3 Cross Sections along the Drills Line

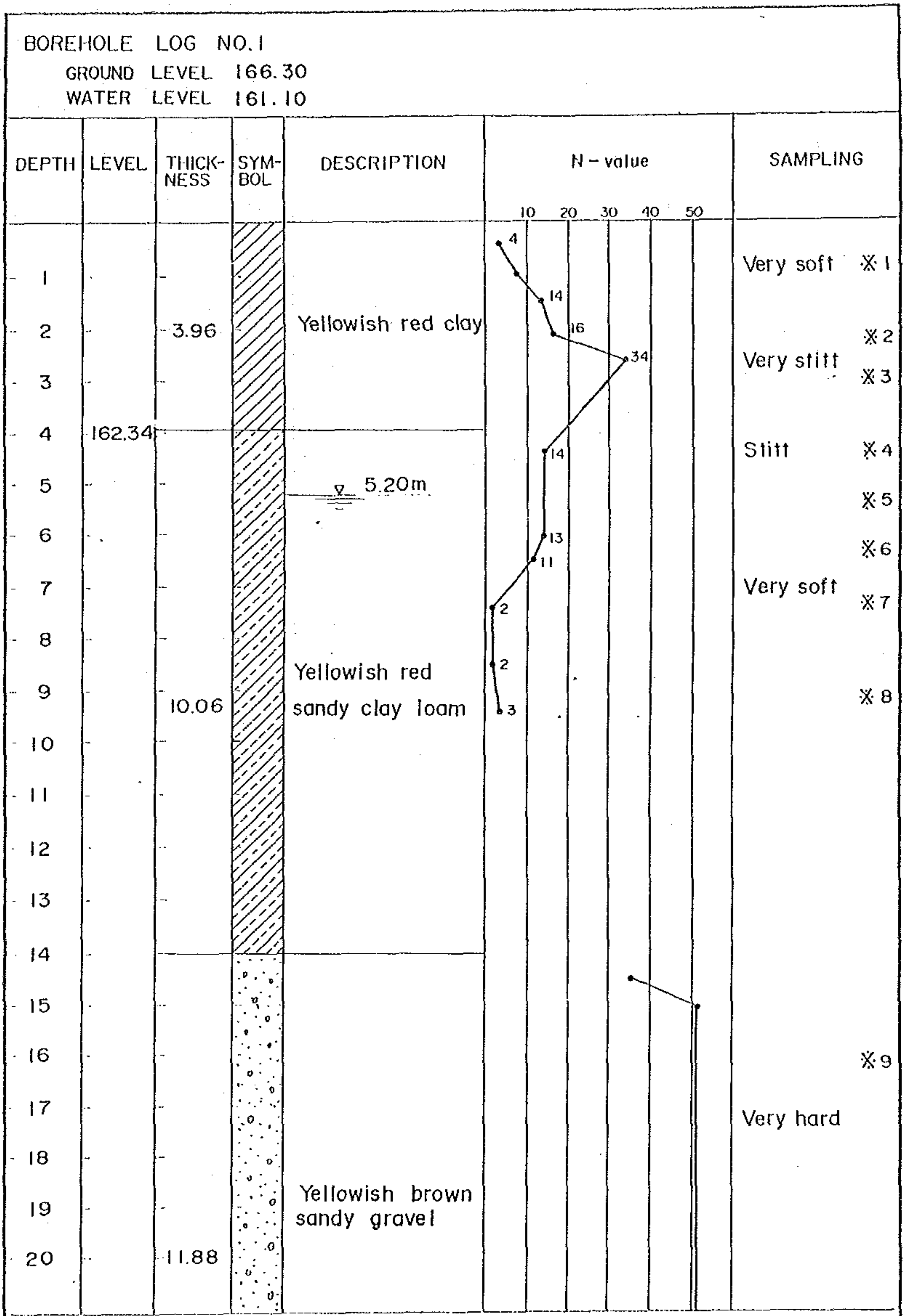


Figure D.4 Borehole Log (1/7)

BOREHOLE LOG NO.1

GROUND LEVEL 166.30

WATER LEVEL 161.00

DEPTH	LEVEL	THICKNESS	SYMBOL	DESCRIPTION	N - value	SAMPLING
22						Hard
23				Yellowish brown sandy gravel		
24						
25						Very hard
26	140.40					※10

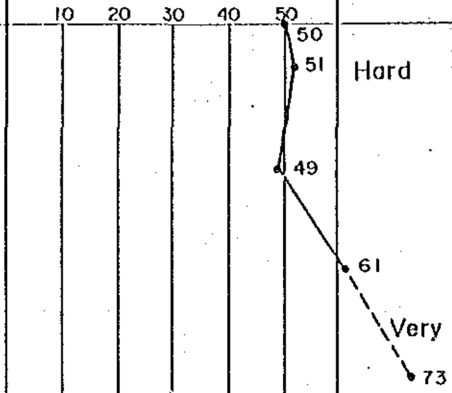


Figure D.5 Borehole Log (2/7)

BOREHOLE LOG NO. 2 (50m from Ban Hai side)

GROUND LEVEL 151.4 m

WATER LEVEL 154.4 m

DEPTH	LEVEL	THICK-NESS	SYM-BOL	DESCRIPTION	N – value	SAMPLING
1 2	148.90	2.50		Medium yellowish brown fine sand (Very loose)	4, 5, 2, 4	※
3 4 5 6 7 8	143.10	5.80		Olive yellow dense sandy gravel Max. size 20mm Gravel > 60 % Yellowish brown very dense gravel with little sand Max size 40mm	25, 29, 40, 42, 40, 48, 45, 50, 56, 75<	※ ※ ※

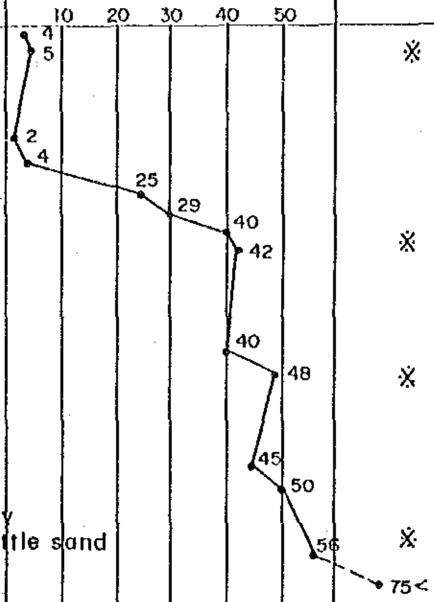


Figure D.6 Borehole Log (3/7)

BOREHOLE LOG NO. 3 (50m from Ban Tha Ngon side)

GROUND LEVEL 151.65 m

WATER LEVEL 154.4 m

DEPTH	LEVEL	THICKNESS	SYMBOL	DESCRIPTION	SAMPLING
0 – 4.25	147.40	4.25		Yellowish brown medium fine sand (Very loose) ↓ loose	※ (approx. 2 m), ※ (approx. 4 m)
4.25 – 10.05	141.60	5.80		Olieve yellow medium sandy gravel Max. size 20 mm Gravel > 60 % Olieve yellow dense sandy gravel Yellowish brown gravel with little sand Max. size 40 mm ↓ Very dense	※ (approx. 5 m), ※ (approx. 8 m), ※ (approx. 10.5 m)

N – value

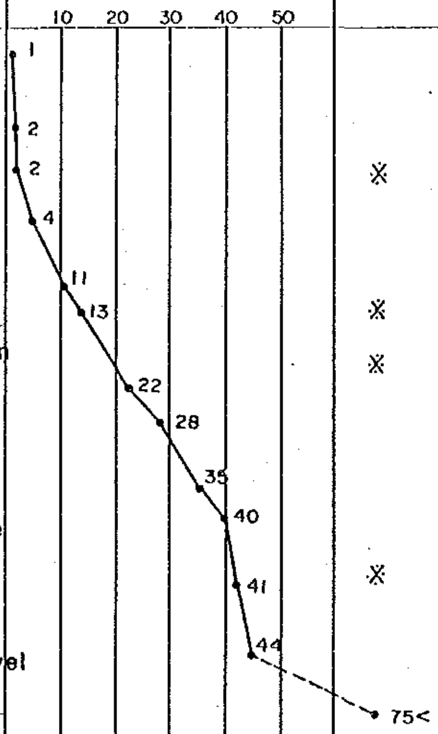


Figure D.7 Borehole Log (4/7)

BOREHOLE LOG NO.4

GROUND LEVEL 166.50 m

WATER LEVEL

DEPTH	LEVEL	THICKNESS	SYMBOL	DESCRIPTION	N – value	SAMPLING
	165.90	0.60		Clay + gravel		
1						
2						※ 1
3		5.19		Reddish brown and white clay	17	※ 2
4						
5	160.71				24	※ 3
6	160.10	0.61		Red and white hard clay	45	Hard ※ 4

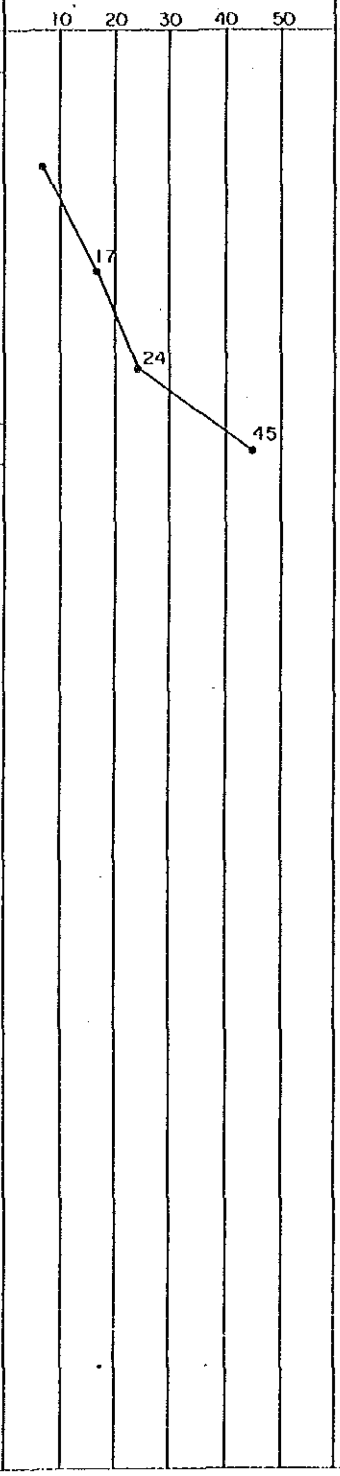


Figure D.8 Borehole Log (5/7)

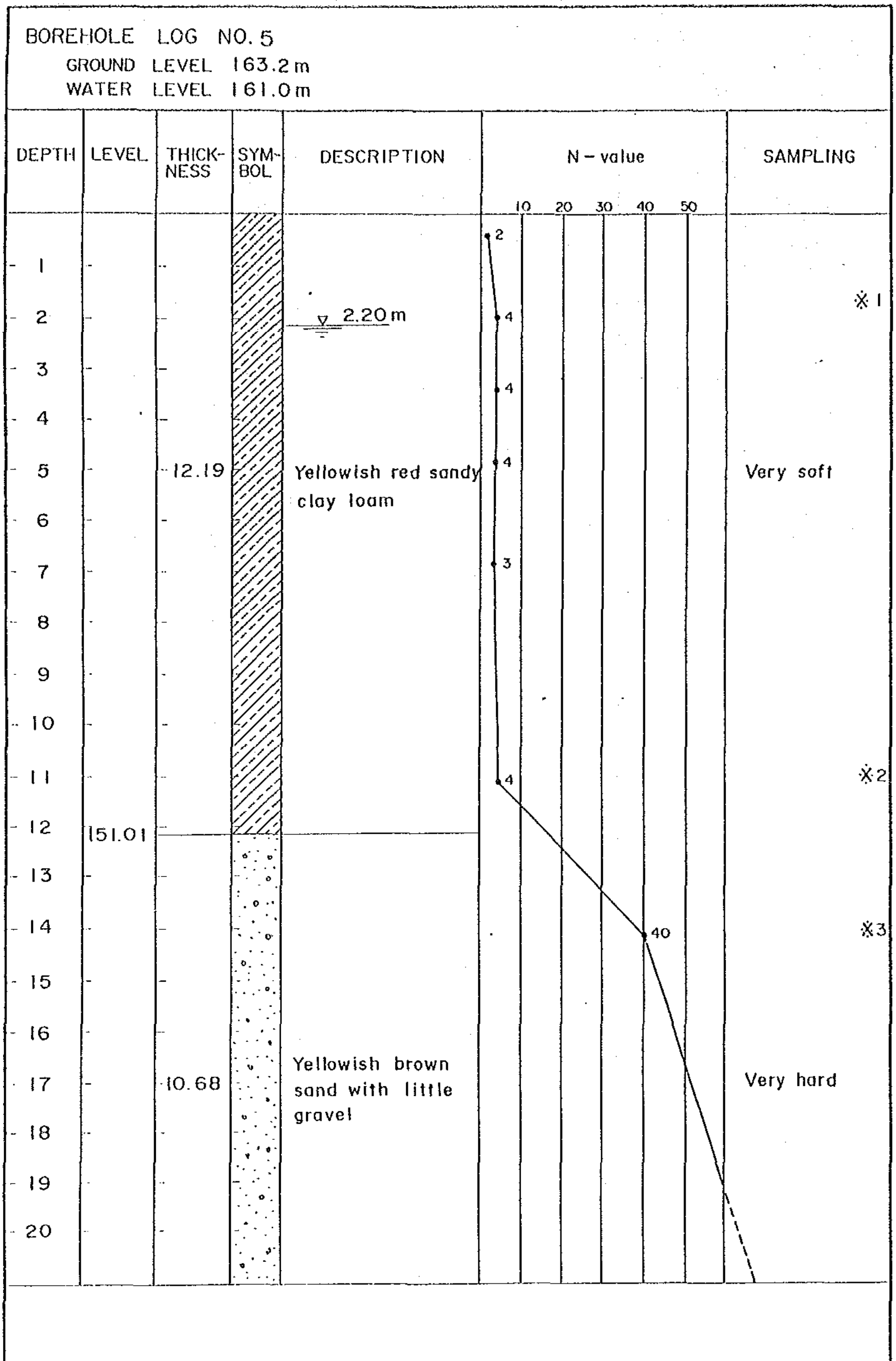


Figure D.9 Borehole Log (6/7)

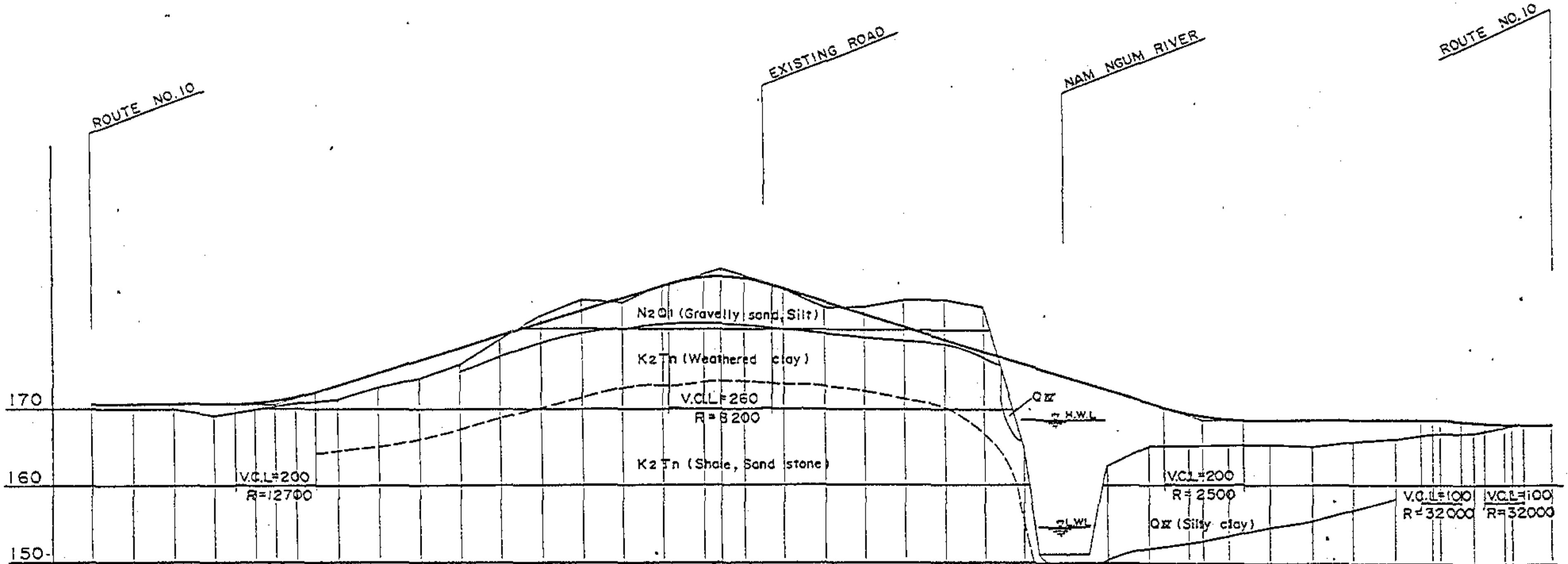
BOREHOLE LOG NO. 5

GROUND LEVEL 163.2m

WATER LEVEL 161.0m

DEPTH	LEVEL	THICKNESS	SYMBOL	DESCRIPTION	N-value (10 20 30 40 50)	SAMPLING
22						
23	140.33	0.61		Yellowish brown sandy gravel	>75	※
	139.72					

Figure D.10 Borehole Log (7/7)



GRADE: LEVEL — 170.500 — i=1.5759 % L=1090m — 187.677 — i=1.6000 % L=1198.563 — 168.500 — QII, III (Gravel) LEVEL L=581.437 — 168.500 — i=0.3125% L=16.000 — 168.000 — LEVEL

CHAINAGE	GROUND HEIGHT	ROAD HEIGHT
NO. 0	170.451	170.500
NO. 5	170.314	170.500
NO. 10	169.894	170.500
NO. 15	169.000	170.500
NO. 20	169.950	170.598
NO.22+10		170.894
NO. 25	170.750	171.386
NO. 30	171.190	172.864
NO. 35	172.800	174.440
NO. 40	173.900	176.016
NO. 45	175.750	177.591
NO. 50	178.950	179.167
NO. 55	181.700	180.743
NO. 60	183.600	180.319
NO. 65	183.400	183.895
NO. 70	185.700	185.471
NO. 75	186.800	186.552
NO.77+00		186.645
NO. 80	186.650	186.418
NO. 85	185.080	185.117
NO. 90	182.750	183.517
NO. 95	182.900	181.917
NO.100	183.800	180.317
NO.105	183.800	178.717
NO.110	182.900	177.117
NO.115	165.000	175.517
NO.120	151.900	173.917
NO.125	162.600	172.317
NO.130	165.000	170.717
NO.135	165.074	169.268
NO.136 +18.563		
NO.140	165.215	168.559
NO.145	165.380	168.514
NO.150	165.100	168.500
NO.155	165.700	168.500
NO.160	166.100	168.500
NO.165	166.700	168.486
NO.166+00		
NO.170	166.900	168.250
NO.174+00		
NO.175	167.915	168.014
NO.179 +8.542	167.915	168.000

Figure D.11 Soil Profile on Proposed Road

SCALE V=1:500 H=1:10,000

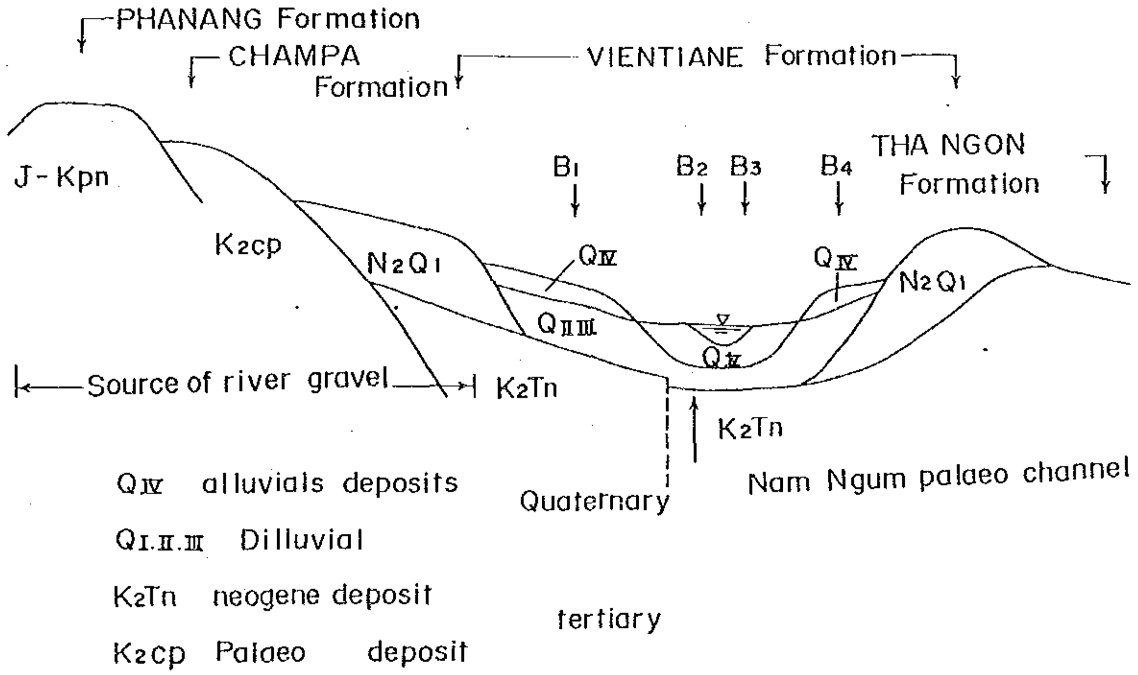


Figure D.12 Geological Profile

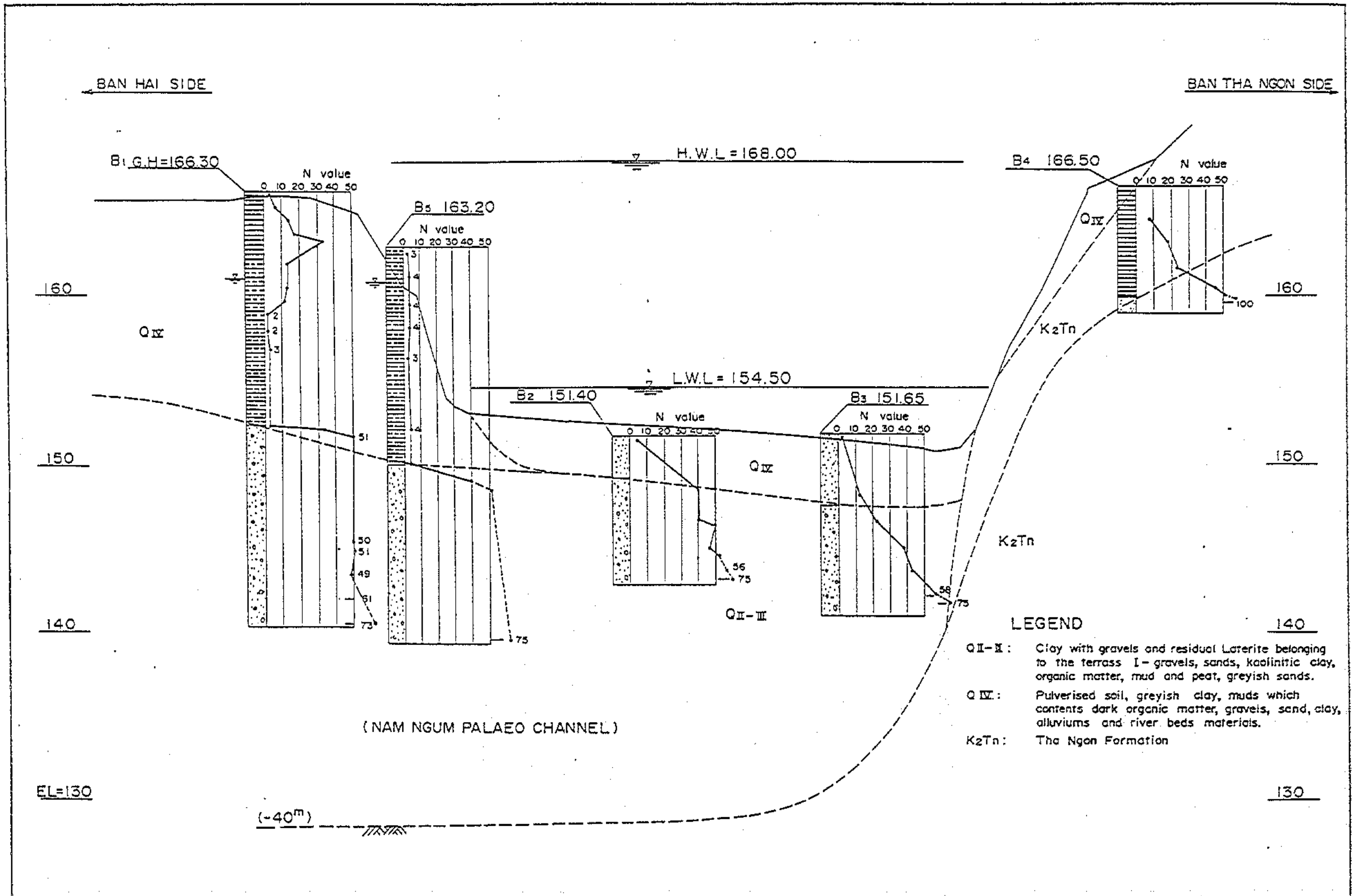


Figure D.13 Soil Profile on Bridge Section

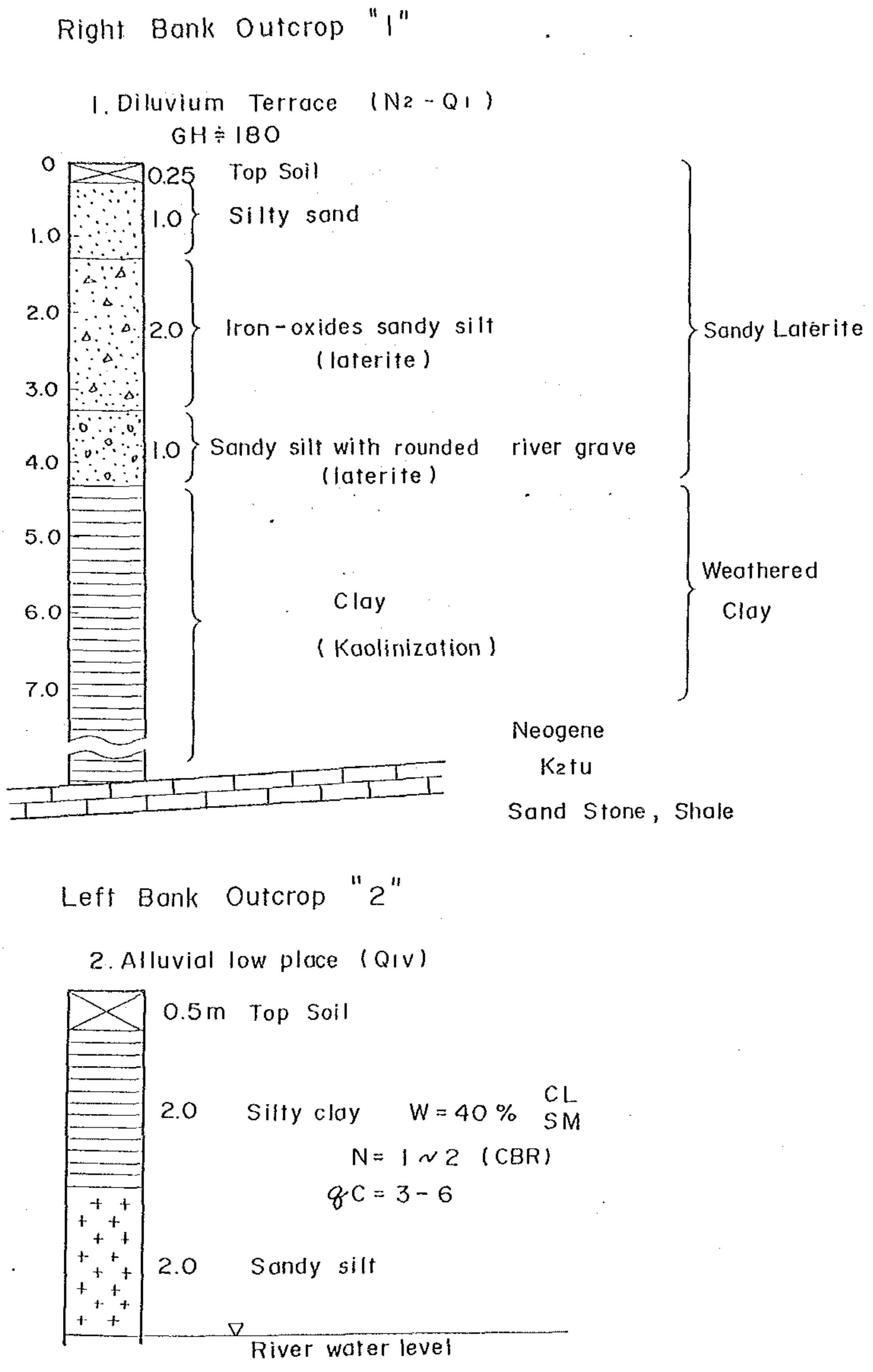


Figure D.14 Soil Profile on Cut Crop

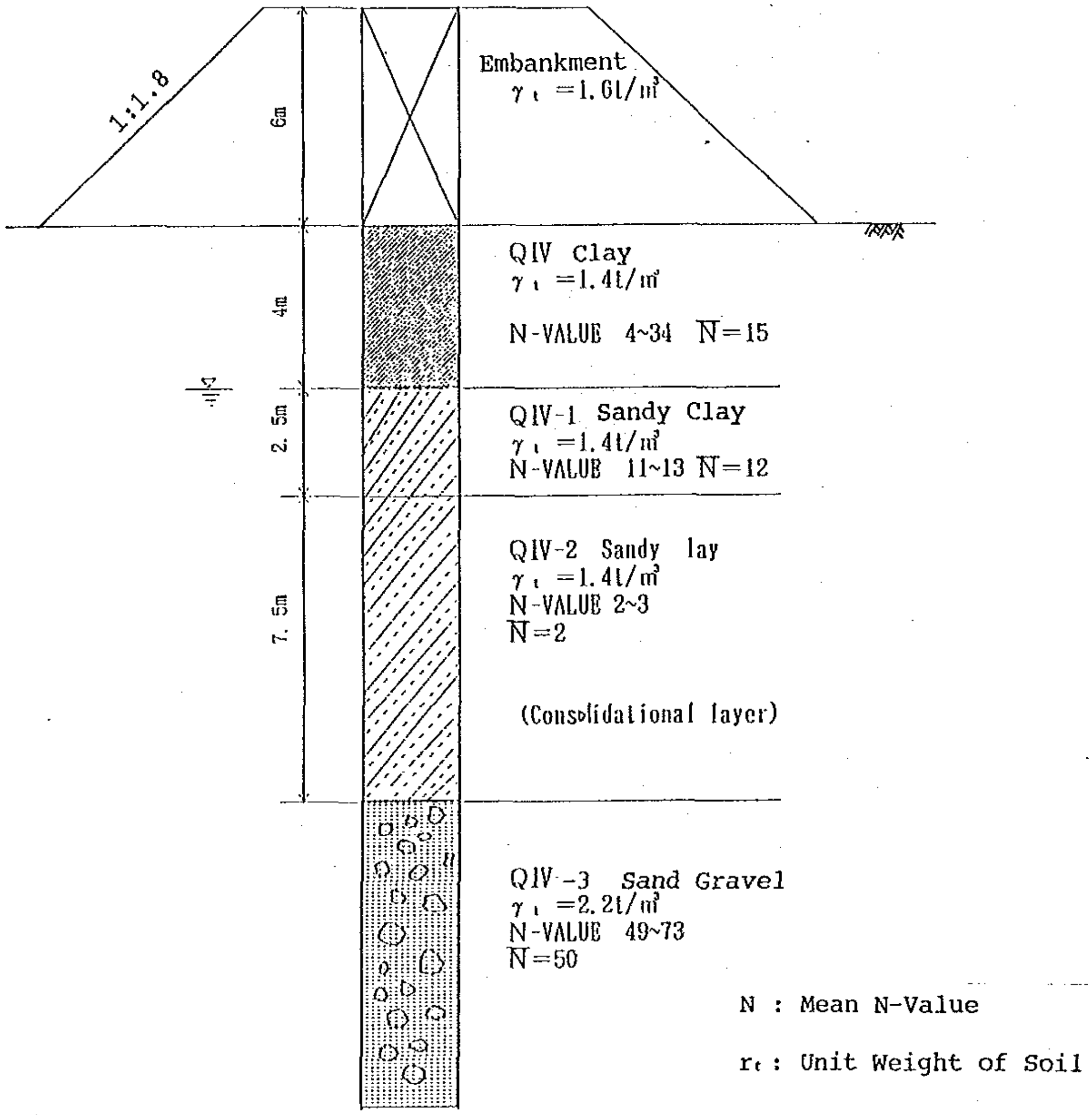


Figure D.15 Soil Profile

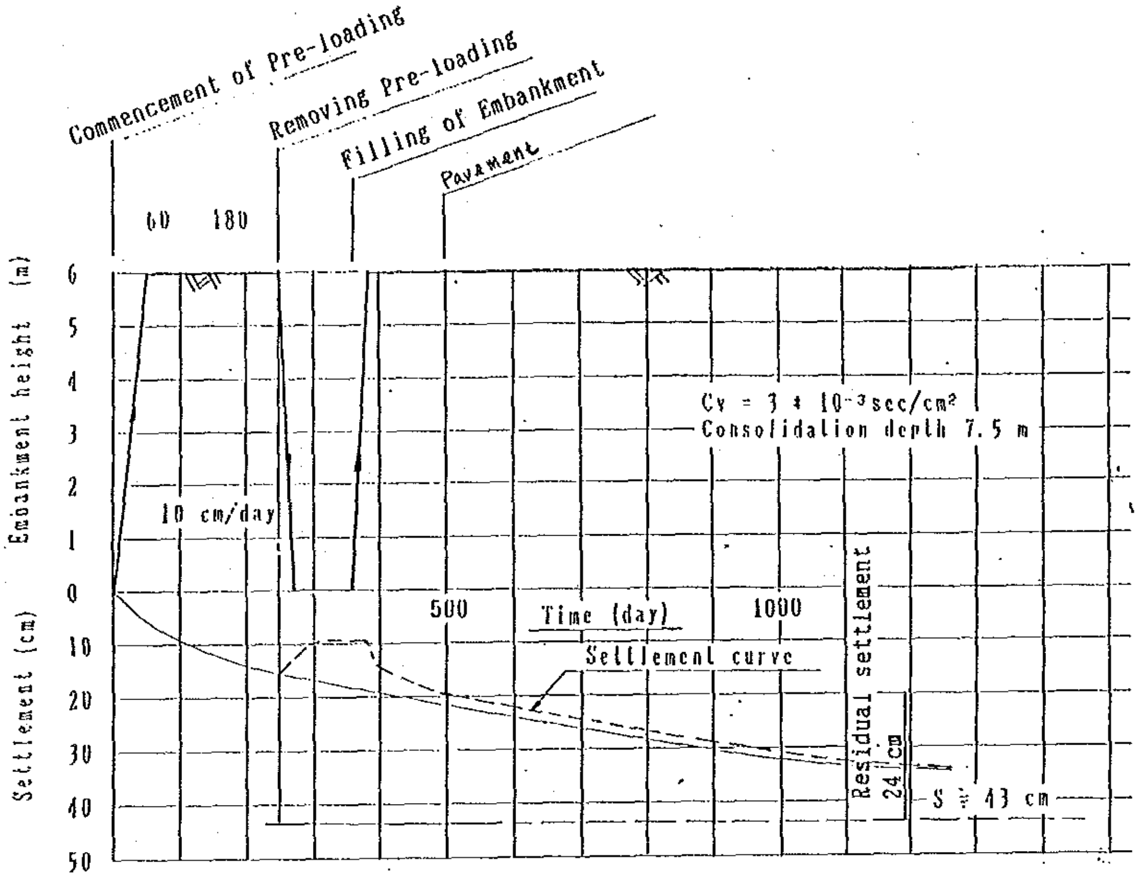


Figure D.16 Settlement-Time Curve for Backfill Due to Pre-Loading

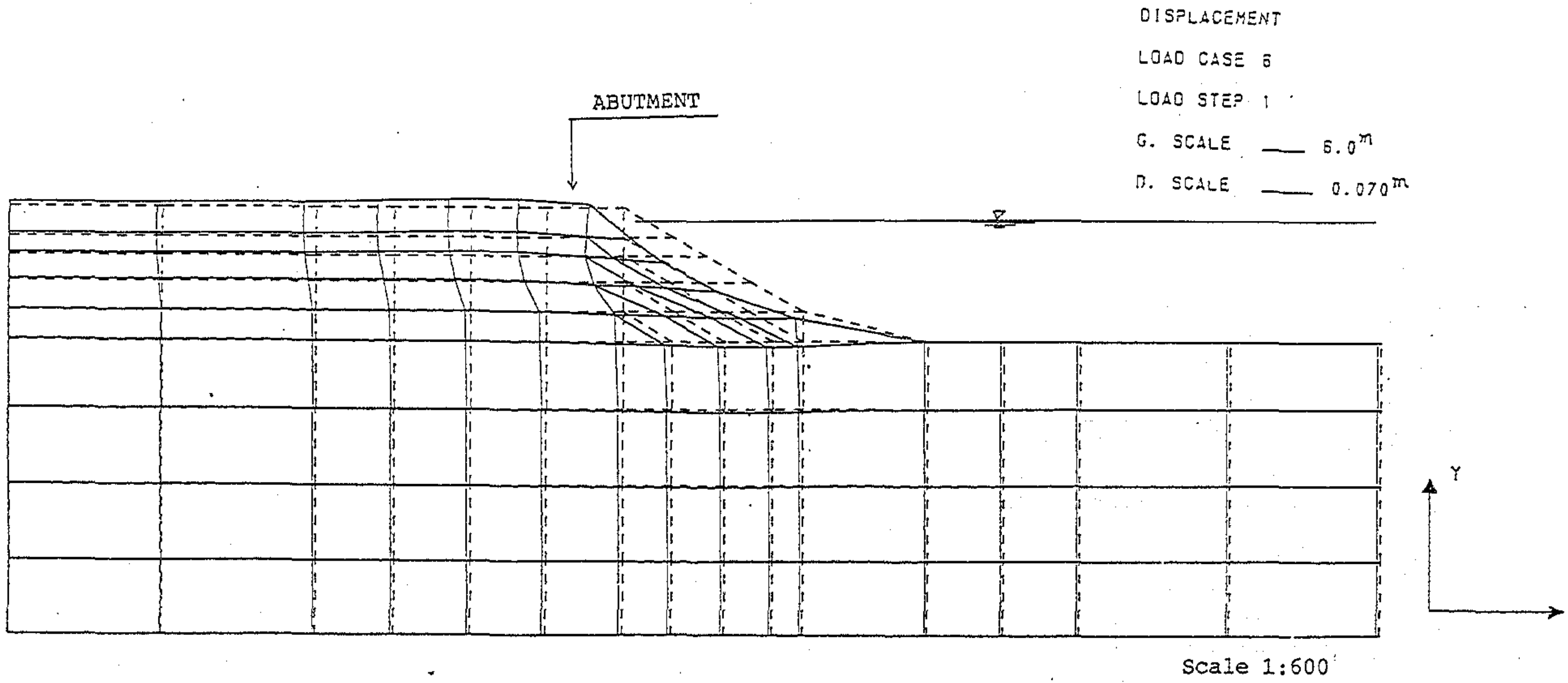


Figure D.17 Displacement of Ground (1/2)

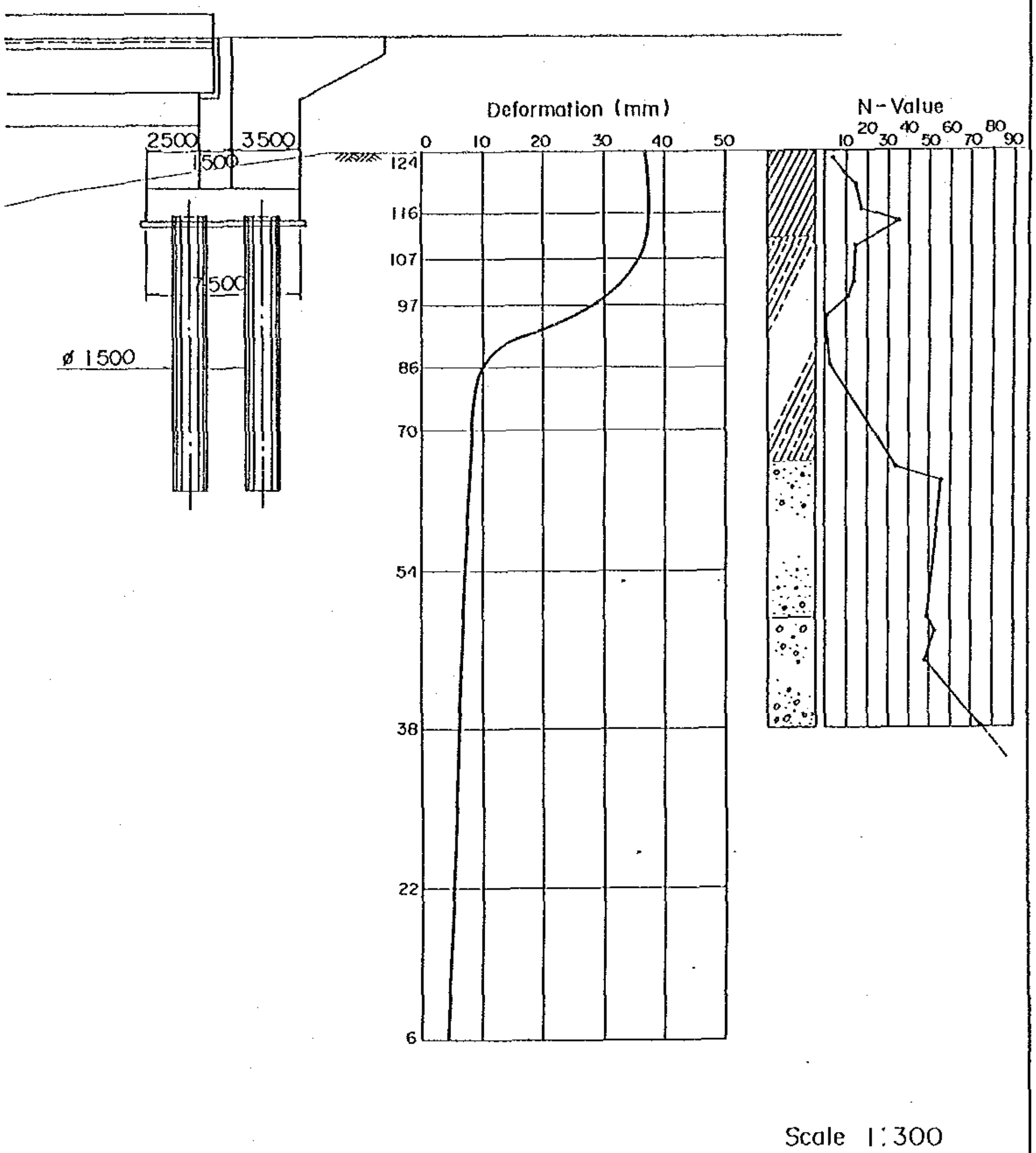


Figure D.18 Displacement of Ground (2/2)

	X (M)	Y (M)	R (M)	FS	MR (T.M/M)	MS (T.M/M)
1	31.00	55.00	44.00	0.924	8913.00	9643.56

• SOIL CONDITION & SEISMIC COEFFICIENT

	GAMMAT (T/M³)	GAMMAS (T/M³)	GAMMA (T/M³)	PHAI	CO (T/M²)	K	YO (M)	KH	KV
1	2.200	2.200	2.200	35.00	2.000	0.000	0.0		
2	18.000	18.000	18.000	20.00	0.000	0.000	0.0		
3	1.400	1.400	1.400	0.00	1.880	0.000	0.0		
4	1.400	1.400	1.400	0.00	7.500	0.000	0.0		
5	1.400	1.400	1.400	0.00	9.380	0.000	0.0		
6	1.600	1.600	1.600	0.00	3.000	0.000	0.0		

* C = CO + K (YO−Y)

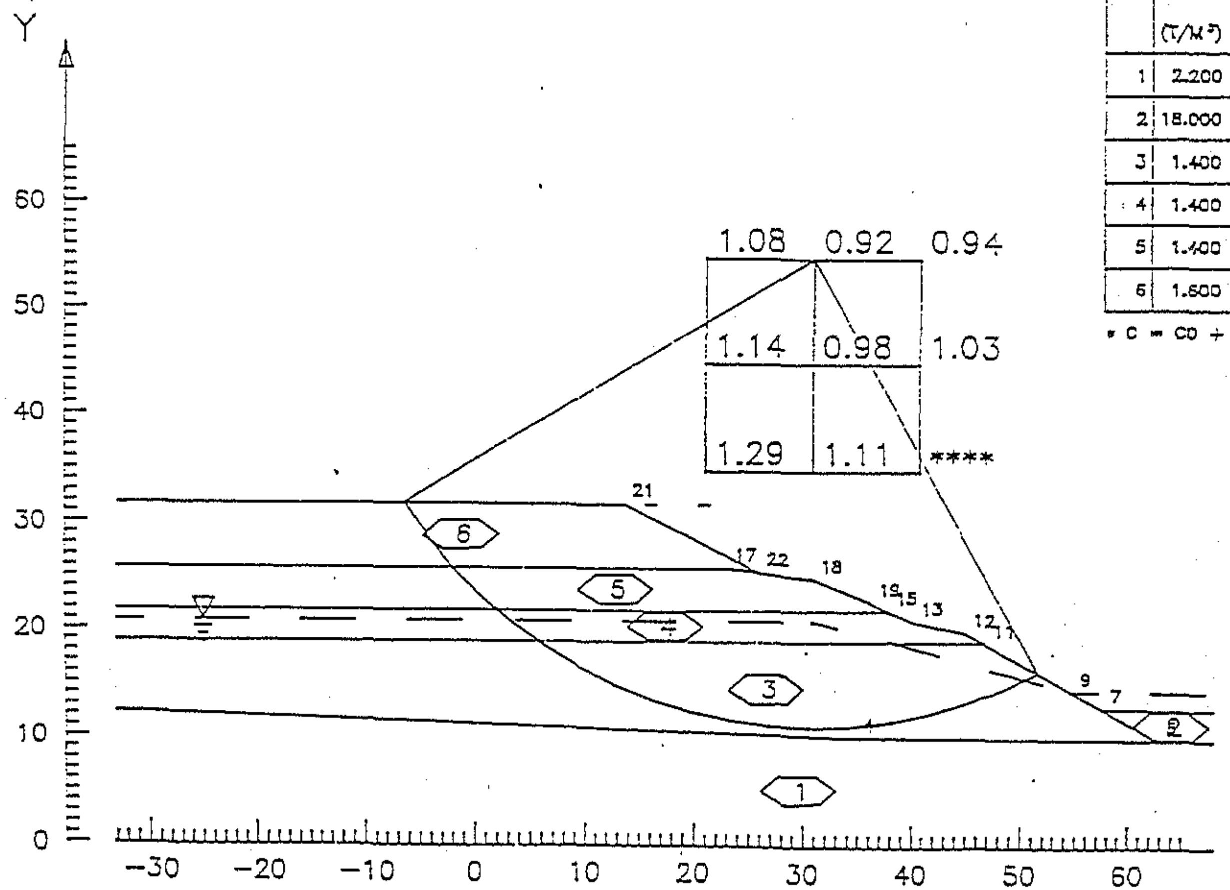
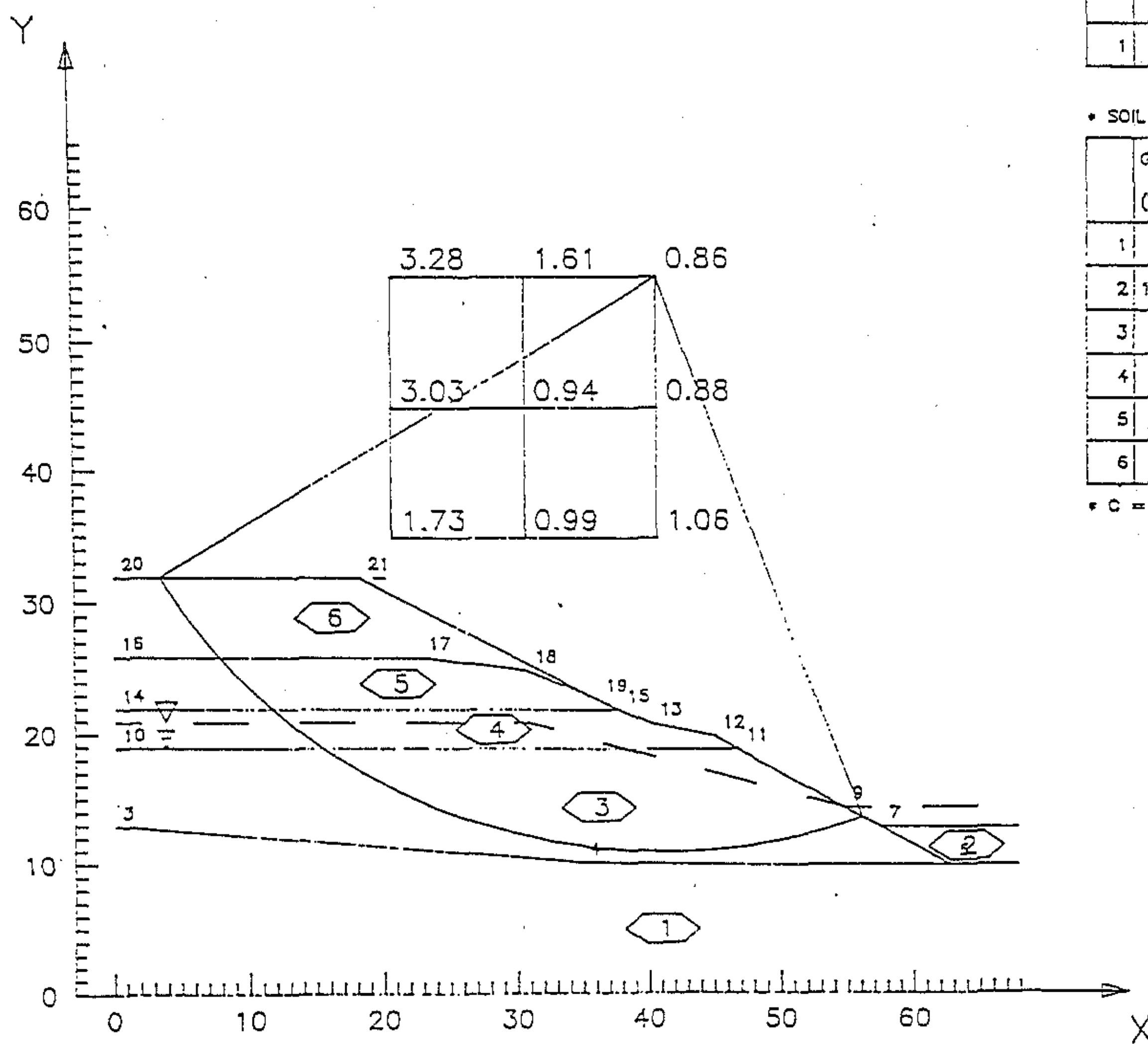


Figure D.19 Stability Analysis of Bank Slide (1/3)



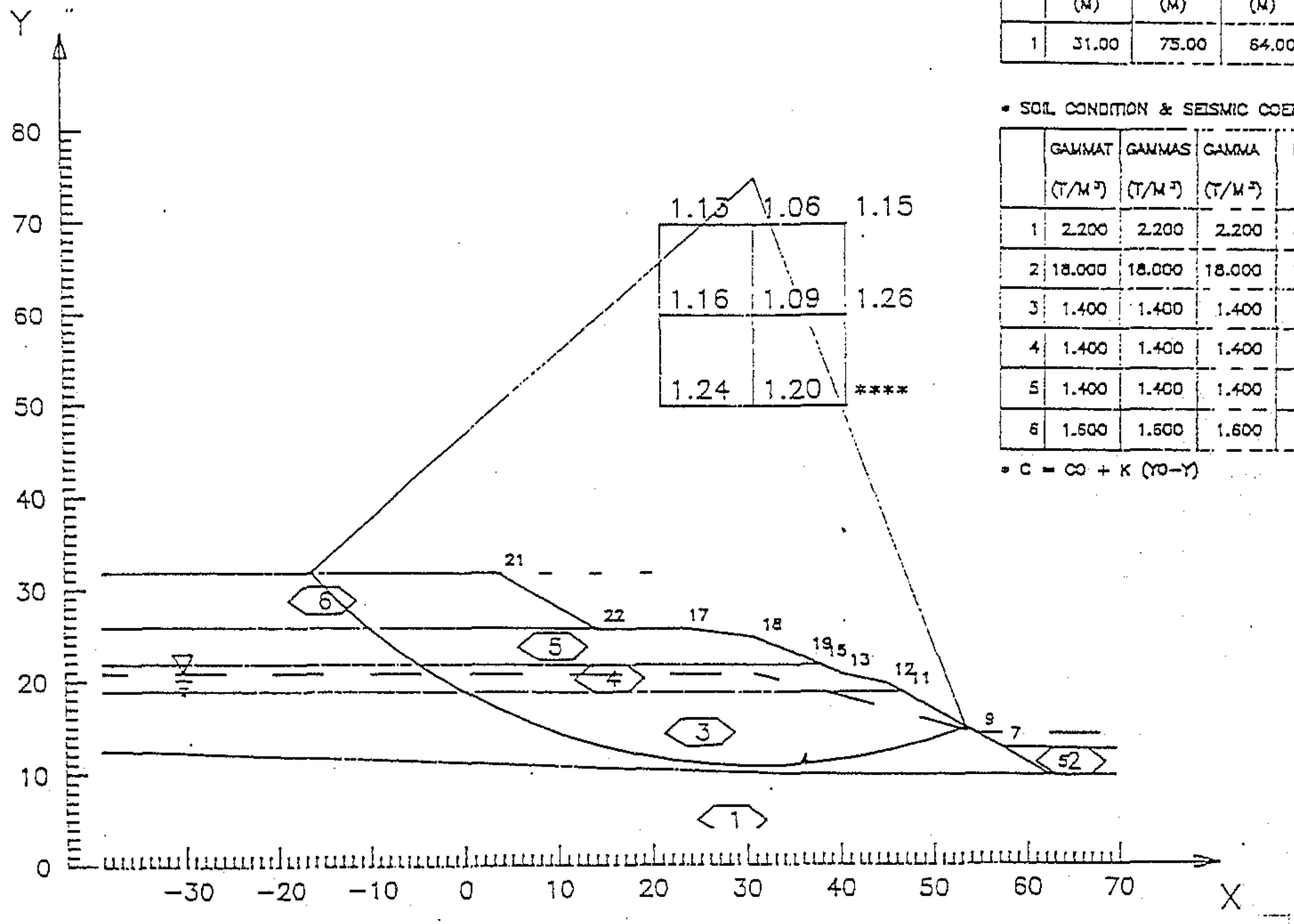
	X (M)	Y (M)	R (M)	FS	MR (T.M/M)	MS (T.M/M)
1	41.00	55.00	44.00	0.856	8499.95	9934.42

• SOIL CONDITION & SEISMIC COEFFICIENT

	GAMMAT (T/M³)	GAMMAS (T/M³)	GAMMA (T/M³)	PHAI	CO (T/M²)	K	YO (M)	KH	KV
1	2.200	2.200	2.200	35.00	2.000	0.000	0.0		
2	18.000	18.000	18.000	20.00	0.000	0.000	0.0		
3	1.400	1.400	1.400	0.00	1.880	0.000	0.0		
4	1.400	1.400	1.400	0.00	7.500	0.000	0.0		
5	1.400	1.400	1.400	0.00	9.380	0.000	0.0		
6	1.600	1.600	1.600	0.00	3.000	0.000	0.0		

• C = CO + K (YO−Y)

Figure D.20 Stability Analysis of Bank Slide (2/3)



	X (M)	Y (M)	R (M)	FS	MR (T.M/M)	MS (T.M/M)
1	31.00	75.00	64.00	1.054	14987.07	14220.37

* SOIL CONDITION & SEISMIC COEFFICIENT

	GAMMAT (T/M^3)	GAMMAS (T/M^3)	GAMMA (T/M^3)	PHAI	CO (T/M^2)	K	YO (M)	KH	KV
1	2.200	2.200	2.200	35.00	2.000	0.000	0.0		
2	18.000	18.000	18.000	20.00	0.000	0.000	0.0		
3	1.400	1.400	1.400	0.00	1.880	0.000	0.0		
4	1.400	1.400	1.400	0.00	7.500	0.000	0.0		
5	1.400	1.400	1.400	0.00	9.380	0.000	0.0		
6	1.600	1.600	1.600	0.00	3.000	0.000	0.0		

* C = CO + K (YO-Y)

Figure D.21 Stability Analysis of Bank Slide (3/3)

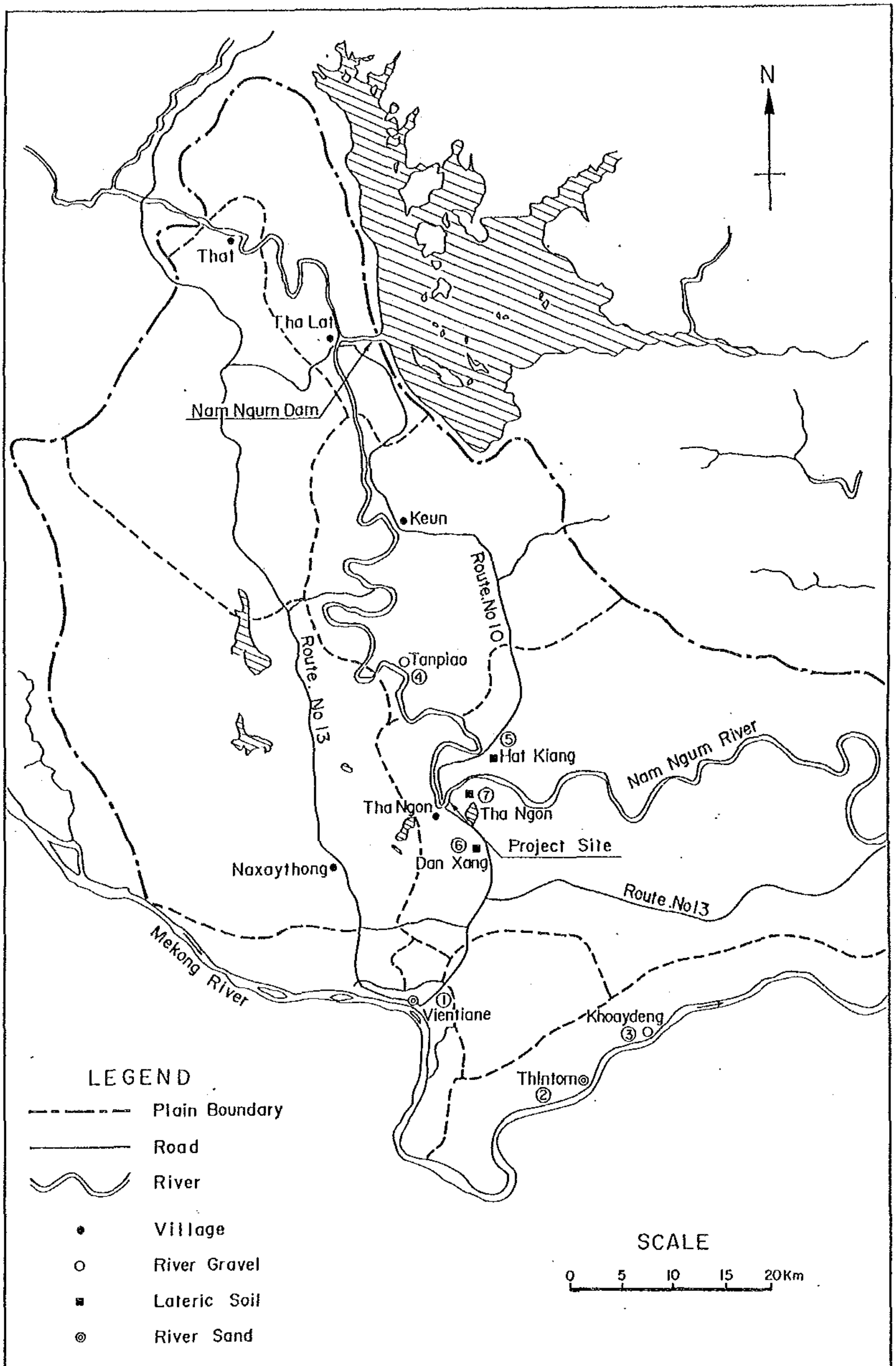


Figure D.22 Source of Materials

ANNEX E

BRIDGE DESIGN STANDARD

ANNEX E

BRIDGE DESIGN STANDARD

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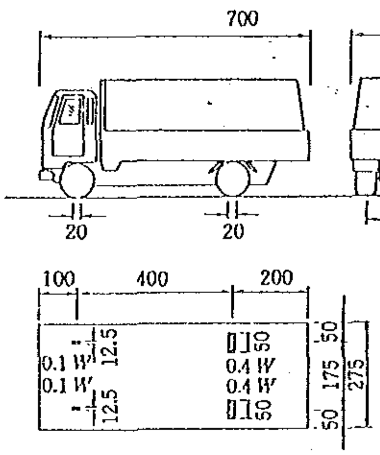
ANNEX E BRIDGE DESIGN STANDARD

E.1 Live Load

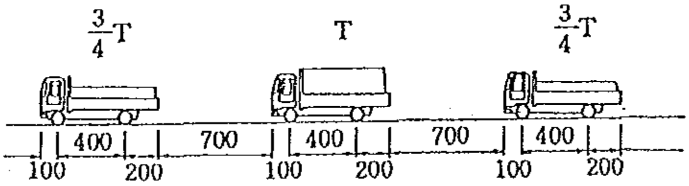
Japanese live load was originally based on AASHTO code, which comprises two loadings referred to as T and L loadings. T loadings consist of two-axle truck representing a standard truck and loadings to which the bridge might be subject under actual traffic conditions, as shown below.



Dimensions in cm

Total weight of truck and load W = 20 ton

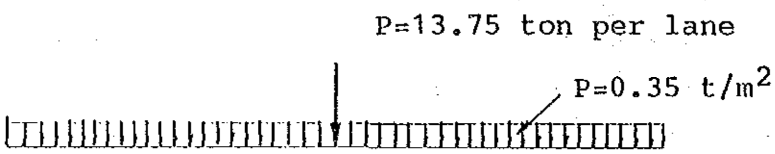
L loadings consist of two type of loadings, single concentrated load from T loadings and uniform load as caused by trucks by three-third the T loading with a spacing of about 7 meters between successive vehicles as shown below.



Dimensions in cm

E.2 Lane Loadings (L-loading)

Lane loadings corresponding to truck train are shown below:



The following is the comparison for or live loads (lane loads) from AASHTO HS 20-44, HS 25-44 with Japanese L-20 loads for one lane design load.

	L-20	HS 20-44	HS 25-44
Uniform Load(p)	$0.35 t/m^2$	$0.31 t/m^2$	$0.39 t/m^2$
Concentrated Load(p)	13.75 ton	* 8.10 ton ** 11.75 ton	* 10.13 ton ** 14.69 ton
Design Lane Width	2.75 meters	3.03 meters	3.03 meters

Note: * for moment calculation
** for shear calculation

E.3 Worked Example of Moment Calculation due to L-loadings

L loadings shall be assumed to occupy a width of 2.75 meter of one design traffic lane. Fractional part of design traffic lane shall be applied for an half the L loadings as illustrated as below. 45.06 m of span will be considered.

Loads per one traffic lane by L-loading are;

$$P = 0.35\ t/m^2 \times 2.75 = 0.96\ t/m$$

$$P = 5\ t/m \times 2.75 = 13.75\ t$$

Impact loading;

$$i = \frac{10}{25 + L} = \frac{10}{25 + 45.06} = 0.167$$

where i = fraction of live load

Then, the maximum bending moment caused by L-loading will be

$$Mp = \frac{PL^2}{8} = \frac{0.96 \times 45.06^2}{8} = 243.6\ t\text{-}m$$

$$Mp = \frac{PL}{4} = \frac{0.96 \times 45.06}{4} = 154.9\ t\text{-}m$$

$$Mi = (234.6 + 154.9) \times 0.167 = 66.5\ t\text{-}m$$

Total 465.0 t-m

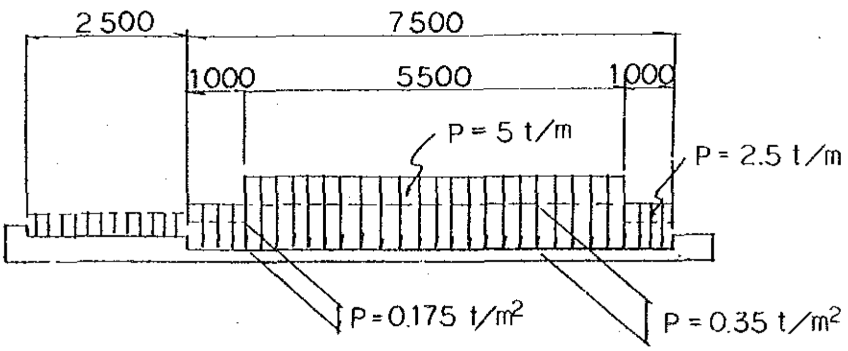
The maximum shear force is

$$Sp = \frac{PL}{2} = \frac{0.96 \times 45.06}{2} = 21.6\ t$$

$$S^P = P = 13.8\ t$$

$$Si = (21.6 + 13.8) \times 0.167 = 5.9\ t$$

Total 41.3 t



ANNEX F

BRIDGE RAILING

ANNEX F

BRIDGE RAILING

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ANNEX F BRIDGE RAILING

F.1 Bridge Railing

The following railings have been selected for comparison study(refer Figure F.1).

Type 1	:	Concrete parapet with curb
Type 2	:	Open type metal rail with curb base
Type 3	:	Concrete parapet with metal top rail

Comparison study was made to select the most suitable type of bridge rail, from view point of 1) pedestrian's safety, 2) landscape, 3) ease of maintenance and 4) cost for construction and maintenance.

From these point of view, explanation of each type are mentioned as follows:

Type 1 presents an obstructed view and bad appearance. This type is only sturdy and lowest cost among the alternatives.

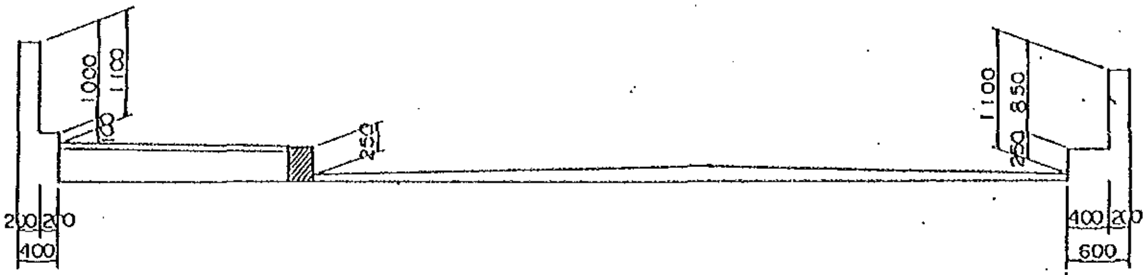
Type 2 offers enough strength for pedestrians and traffic with best appearance and full view, among the alternatives. From view point of landscape, this type of railing is recommended. Construction and repair cost, however, are relatively high.

Type 3 has relatively good appearance, but this still presents obstructed view. However, this needs low construction cost. Maintenance and repair costs are also middle level among the alternatives.

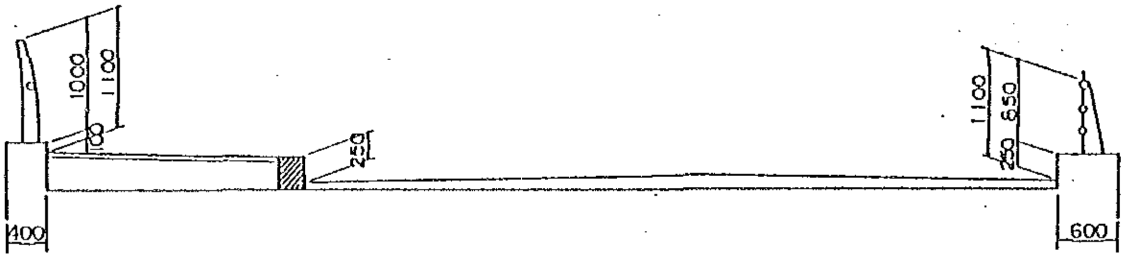
In accordance with above comparison study on bridge railing structure type, the second type(Type 2: metal rail with curb bed) was selected to employ in the Project. Rail shall be of ductile cost-iron pipe.

Comparison of Bridge Rail Type

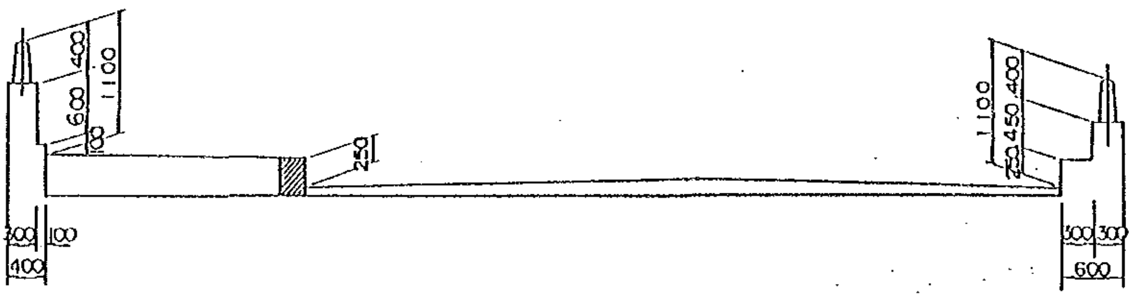
Type	Description	Rating
Type 1	- Presents an obstructed view and bad appearance	X
	- Low construction and repair costs	◎
	- Maintenance free and easy for repairing when damaged	◎
	- Structural strength is very sturdy	◎
Type 2	- Presents an best appearance and view among the alternatives	○
	- High construction and repair cost among the alternatives	△
	- No maintenance is required	○
	- Structural strength is relatively frail	○
Type 3	- Obstructed view and middle rank appearance	△
	- Relatively low construction and maintenance cost	○
	- Na maintenance cost is required	○
	- Very sturdy in structural strength	○



TYPE-1 (Concrete Parapet with Curb)



TYPE-2 (Open-Type Metal Rail with Curb Base)



TYPE-3 (Concrete Parapet with Metal Top Rail)

Figure F.1 Bridge Railing Structures

ANNEX G

ECONOMIC EVALUATION

ANNEX G

ECONOMIC EVALUATION

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ANNEX G ECONOMIC EVALUATION

G.1 General

The Project is evaluated from the viewpoint of the national economy based on the following assumptions:

a) The project life is 20 years after completion of construction.

b) All prices are expressed at constant 1990 prices.

c) The exchange rates as of August 1990 are applied :

US$ 1.00 = 715 Kip = 153 Yen.

d) The Project initiates in 1992 and the proposed bridge opens at the beginning of 1996.

The economic benefits can be classified into 1) saving of economic costs without the Project and 2) economic benefits derived from the Project. The major economic benefits are saving of vehicle operation costs(VOC) and time costs. VOC and time costs without the Project are calculated based on the forecasted traffic volume without the Project, while saving of VOC and time cost with the Project is obtained according to the forecasted traffic volume with the Project.

G.2 Future Traffic Volume

G.2.1 Future Traffic Volume without Project

The average time to cross Nam Ngum at Tha Ngon is estimated with the following equation obtained in chapter IV:

$$Y = 0.37X^2 - 0.793X + 14.293$$

where, Y : average crossing time

X : traffic volume of one direction

Thus, the ferry waiting time for the present traffic on Route 10 eventually becomes longer as traffic volume increases.

The future traffic volume without the Project was forecasted as shown in Table G.1 based on the following assumptions:

a) From the following year when the average crossing time becomes over one hour, bus routes ends at the ferry crossing points: passengers are obliged to get off buses at the crossing points, cross Nam Ngum River by the ferry and transfer to another bus.

b) A part of passenger cars, pick-ups, and trucks will divert from Route 10 to Route 13 when the average crossing time exceed one hour. the diversion rate is the same among these types of vehicles.

c) Motorcycles will not divert from Route 10 to Route 13 because they can cross the River also by private ferries.

d) Once a part of traffic starts to divert from Route 10 to Route 13, traffic volume crossing the River at Tha Ngon is constant in such that average crossing time is one hour.

In accordance with the forecasted traffic, crossing time by vehicle is assumed in the following:

a) The average crossing time of motorcycles is constant at 10 minutes.

b) The crossing time of passenger cars, pick-ups and trucks is obtained by the equation aforementioned before 1998 and constant at one hour after 1999.

c) That of buses is also calculated by the equation before 1998 and one hour in 1999. Transfer time including Nam Ngum crossing for passengers is 30 minutes after 2000.

G.2.2 Forcast Future Traffic with Project

Due to the open of the proposed bridge, some traffic on Route 13 will divert to Route 10 and some traffic will generated on Route 10. Also, the proposed bridge will promote development projects in the influence area and thus create some traffic. Taking these types of traffic into consideration, the future traffic with the Project is forecasted as shown in Table G.2.

G.3 Economic Costs Without Project

G.3.1 Time Cost of Passengers Crossing Nam Ngum River at Tha Ngon

The opportunity cost is assumed at US$ 0.035 per hour, referring to the National Transport Study of Lao PDR(NTS): time value is US$ 0.08 for duty and US$ 0.02 for other trip, and share of duty trip is assumed at 25% according to the person trip survey conducted by the NTS. Time costs of passengers of motorcycles, passenger cars, and buses are calculated as economic benefit.

Based on the O-D survey, average number of passengers at Tha Ngon is assumed as follows:

M/C	P/C	L/B	H/B
1.5	3.7	16.0	28.7

Number of days per year subject to generation of extra time cost is as follows:

	M/C	P/C	L/B	H/B
1995 - 1998	365	355	355	355
1999 - 2114	365	355	365	365

As a result, time cost of passengers crossing Nam Ngum River at Tha Ngon is obtained as shown in Table G.3. Time cost of passenger cars declines after 2000 due to diversion from Route 10 to Route 13.

G.3.2 Economic Loss Due to No Ferry Operation

It is assumed that the boat does not operate for 10 days a year due to out of order. Passenger cars, pick-ups, and trucks have to take alternative roads. Additional distance is shown in Table G.4. Shares of alternative ways are as follows:

	P/C	P/U	M/T	H/T
Northbound Traffic				
via Vientiane	0.9	0.7	0.0	0.0
via Dong Dok	0.1	0.3	1.0	1.0
Southbound Traffic				
via Hatsiao Ferry	0.1	0.2	0.0	0.0
via Thinkeo Bridge	0.9	0.8	1.0	1.0

Motorcycles can cross the River with private ferries. Buses stop at the ferry crossing points, Hence, additional VOC and time costs are generated for passenger cars, pick-ups, and trucks. VOC is shown in Table G.5. Running speed on Route 10 and 13, and a laterite road by vehicle type are assumed as follows:

	M/C	P/C	P/U	M/T	H/T
Route 10	45Km/h	70Km/hr	45Km/hr	45Km/hr	45Km/hr
Route 13	40	60	60	40	40
Laterite	20	30	30	20	20

For the calculation of extra VOC and time cost on paved roads, the average running speed on Routes 10 and 13 is applied.

It is assumed that it takes one hour for bus passengers to cross the River and transfer to a bus on the other side of the River when the ferry does not operated before 2000.

According to the assumptions above-mentioned, economic loss due to no ferry operation is obtained as shown in Table G.5. Total of economic loss is almost constant after 2000 because traffic component except motorcycles and buses does not change so much. Time cost of bus passengers is zero after 2000 since no bus crossing Nam Ngum River at Tha Ngon.

G.3.3 Extra VOC and Time Cost due to Diversion from Route 10 to Route 13

When the average waiting time exceeds one hour, a part of traffic is expected to divert from Route 10 to Route 13. The traffic is expected to divert from Route 10 to Route 13. The traffic switching the routes has to take a burden of extra VOC and time cost.

As shown in Table G.6, the extra VOC and time cost increase after 2001 significantly. These costs are the largest benefit diverted from the Project.

G.3.4 Extra VOC and Time Cost of Diverted Traffic from Route 13 to Route 10

The proposed bridge will result in diversion of a part of traffic from Route 13 to route 10. Without the Project, this diverted traffic from Route 13 to Route 10 will continue to run on route 13 with extra VOC and time costs.

Estimate diverted traffic per day in 1996 is as follows:

Zone pair	M/C	P/C	P/U	M/T	H/T	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

The travel distance of the diverted traffic by zone pair is as follows:

Zone	Distance(Km)	
pair	via Rt. 10	via Rt.13
2 - 5	90.4	93.2
2 - 9	84.5	87.3
9 - 2	84.5	87.3
9 - 4	93.9	61.7
9 - 7	122.4	55.4

Hence, some diverted traffic needs additional VOC with diversion from route 13 to Route 10 in the following:

Zone pair	M/C	P/C	P/U	M/T	H/T	Total
2 - 5	150	0	0	0	0	150
2 - 9	1,098	-1,668	97	378	-12,939	-13,033
9 - 2	905	-1,334	158	2,140	-7,930	-6,061
9 - 4	1,741	5,224	2,553	0	0	9,518
9 - 7	6,846	10,766	0	0	20,218	37,830
Sum	10,740	12,989	2,808	2,518	-651	28,403

Note : US$: total VOC via route 12 minus that via Route 10 in 1996

From the assumed running speed mentioned before, difference in travel time between Route 13 and 10 is in the followings:

Zone pair	M/C	P/C	P/U	M/T	H/T
2 - 5	11.3	10.5	10.5	11.3	11.3
2 - 9	10.4	9.7	9.7	10.4	10.4
9 - 2	10.4	9.7	9.7	10.4	10.4
9 - 4	58.6	41.0	41.0	58.6	58.6
9 - 7	109.7	74.9	74.9	109.7	109.7

Note : minute : travel time via route 13 minus that via Route 10

Based on the O-D survey, average number of passengers at Naxaythong is assumed as follows:

M/C	P/C	P/U
1.7	4.4	4.2

As result, VOC and time saving of diverted traffic from Route 13 to Route 10 is shown in Table G.7.

G.3.5 Ferry Operation and Maintenance Cost

Monthly economic operation cost is US$ 2,100 as estimated in Chapter IV. After 5 years from the start of operation, the ferry boat has to be docked. Its cost is assumed at 20% of the price of the boat. Also, it costs US$ 1,400 to maintain the landing slopes on the both sides of the River annually.

G.3.6 Replacement of Ferry

Every ten years, the ferry boat has to be replaced by a new one. The price of a new boat is estimated at US$ 400,000 based on the interview to a shipbuilding company.

G.4 Economic Benefits with Project

G.4.1 *VOC Saving of Generated and Developed Traffic*

With the Project, some traffic are generated and developed as discussed in Chapter V. In accordance with the concept of the consumer surplus, a half of VOC of the generated and induced traffic can be considered as economic benefits derived from the Project.

G.4.2 Salvage Value of the Ferry Boat

The existing ferry boat will be not needed at Tha Ngon any more, with the Project. The ferry will be used at a different site where economic benefits will be generated. The salvage value of the existing ferry is considered as economic benefit derived from the Project. Assuming that the ferry boat depreciates along a straight line, the salvage value of the ferry is estimated at US$ 36,000 in 1996.

G.4.3 Residual Value of the Proposed Bridge and Approach Roads

The residual value of the proposed bridge and approach roads at the end of the project life is assumed at the sum of 10% of the construction cost.

G.5 Economic Costs

Estimated project costs are converted into economic costs based on the following conditions and assumptions:

a) Direct transfer payments such as taxes and subsidies are deleted.

b) 5% of the foreign portion costs are considered as import taxes and thus excluded.

c) To adjust the distortion of domestic market prices, costs of local materials, equipment, and labor are multiplied by a standard conversion factor of 0.9, referring to the appraisal of the rural Credit Project by the IFAD in 1987.

d) A shadow wage rate for construction labor is assumed at 0.4, referring to past studies concerned.

G.6 Results of Economic Evaluation

Benefit and cost stream during the project life are summarized in Table G.8. the economic rate of return (EIRR) is calculated at 11.90%.

In order to study sensitivity of the Project, the following cases are examined:

Case 1-1 : The initial investment costs increase by 10% due to unexpected inflation.

Case 1-2 : The initial investment increase by 25% due to unexpected inflation.

Case 2 : The traffic volume grows at 90% of the estimated growth rate due to unexpected delay of economic development in the region. namely, the traffic growth rate are:

	M/C	P/C,P/U	M/T,H/T	L/B,H/B	Total
1990-2000	11.7%	9.1%	10.4%	9.7%	10.0%
2001-2010	9.7%	7.7%	9.0%	8.4%	8.5%
2011-	5.9%	5.4%	5.9%	5.9%	5.7%

Case 3 : The rapid construction method (2 yeras) is applied.

Benefit and cost stream of the four cases are shown in Table G.9, G.10, G.11, and G.12. The results of the sensitivity analysis are:

Case		EIRR	NPV(US$1,000)
Base Case	:	11.90%	8,345
Case 1-1	:	11.17%	7,164
Case 1-2	:	10.22%	5,392
Case 2	:	9.35%	2,494
Case 3	:	11.25%	6,602

These results tell that the Project is relatively sensitive to future traffic volume. In addition, the three-year construction plan(base case) is superior to the two-year construction plan(case-3) also from the viewpoint of the national economy.

Table G.1 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.

Table G.2 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 G.3 Time Cost of Passengers Crossing Nam Ngum River at Tha Ngon

(in US$)

Year	M/C	P/C	L/B	H/B	Total
1995	1,341	810	810	1,744	4,706
1996	1,515	941	948	2,040	5,444
1997	1,711	1,117	1,132	2,436	6,396
1998	1,933	3,506	3,576	7,698	16,713
1999	2,184	6,361	6,855	14,755	30,154
2000	2,467	7,232	3,905	8,405	22,007
2001	2,732	7,185	4,268	9,187	23,371
2002	3,025	7,138	4,665	10,042	24,871
2003	3,350	7,092	5,100	10,977	26,518
2004	3,710	7,045	5,574	11,998	28,327
2005	4,108	6,998	6,093	13,115	30,315
2006	4,549	6,951	6,660	14,336	32,497
2007	5,038	6,905	7,280	15,671	34,893
2008	5,579	6,858	7,958	17,129	37,524
2009	6,178	6,811	8,699	18,724	40,412
2010	6,842	6,765	9,508	20,466	43,581
2011	7,287	6,747	10,127	21,799	45,960
2012	7,762	6,729	10,787	23,218	48,495
2013	8,267	6,710	11,489	24,730	51,196
2014	8,805	6,692	12,237	26,340	54,074
2015	9,379	6,674	13,034	28,055	57,141

Table G. 4 (1) Forecasted Future Traffic Volume without Project

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 G.4(2) Forecasted Future Traffic Volume without Project

Southbound

O-D	Origin	Destination	Distance via Tha Ngon			Distance of Altenative route							Additional Distance				
						via Hatsiao				via Tha Lat			via Hatsiao			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 G.5 Economic Loss due to No Ferry Operation

(US$ / one no-operation day)

Year	Extra Vehicle Operation Cost					Extra Time Cost				Total
	P/C	P/U	M/T	H/T	Sum	P/C	L/B	H/B	Sum	
1995	827	818	571	4,965	7,182	19	13	28	59	7,242
1996	911	901	637	5,538	7,986	21	14	31	66	8,052
1997	1,002	991	711	6,175	8,880	23	16	34	73	8,952
1998	1,103	1,091	793	6,887	9,874	25	17	38	80	9,954
1999	1,157	1,144	842	7,317	10,460	27	19	42	87	10,548
2000	1,315	1,301	970	8,427	12,014	30	0	0	30	12,044
2001	1,307	1,293	976	8,483	12,059	30	0	0	30	12,089
2002	1,298	1,284	983	8,539	12,105	30	0	0	30	12,134
2003	1,290	1,276	989	8,595	12,150	30	0	0	30	12,180
2004	1,281	1,267	996	8,651	12,196	29	0	0	29	12,225
2005	1,273	1,259	1,002	8,707	12,241	29	0	0	29	12,270
2006	1,264	1,251	1,009	8,763	12,287	29	0	0	29	12,316
2007	1,256	1,242	1,015	8,819	12,332	29	0	0	29	12,361
2008	1,247	1,234	1,021	8,875	12,378	29	0	0	29	12,406
2009	1,239	1,225	1,028	8,931	12,423	28	0	0	28	12,452
2010	1,231	1,217	1,034	8,987	12,469	28	0	0	28	12,497
2011	1,227	1,214	1,037	9,008	12,486	28	0	0	28	12,514
2012	1,224	1,211	1,039	9,030	12,504	28	0	0	28	12,532
2013	1,221	1,207	1,042	9,052	12,522	28	0	0	28	12,550
2014	1,217	1,204	1,044	9,074	12,539	28	0	0	28	12,567
2015	1,214	1,201	1,047	9,095	12,557	28	0	0	28	12,585

Table G.6 Additional VOC due to Diversion from Route 10 to Route 13

(US$)

Year	Vehicle Operation Cost					Time Cost	Total
	P/C	P/U	M/T	H/T	sum	P/C	
1995	0	0	0	0	0	0	0
1996	0	0	0	0	0	0	0
1997	0	0	0	0	0	0	0
1998	0	0	0	0	0	0	0
1999	26,488	18,505	13,946	117,597	176,535	432	176,967
2000	9,913	6,925	5,287	44,585	66,711	162	66,872
2001	66,764	46,643	36,080	304,248	453,735	1,089	454,825
2002	128,163	89,539	70,175	591,754	879,632	2,091	881,723
2003	194,502	135,886	107,902	909,896	1,348,187	3,173	1,351,360
2004	266,205	185,979	149,628	1,261,746	1,863,558	4,343	1,867,901
2005	343,730	240,142	195,751	1,650,685	2,430,309	5,608	2,435,917
2006	427,580	298,722	246,714	2,080,433	3,053,449	6,976	3,060,425
2007	518,297	362,100	303,001	2,555,080	3,738,478	8,456	3,746,935
2008	616,471	430,687	365,147	3,079,129	4,491,434	10,058	4,501,492
2009	722,741	504,932	433,738	3,657,533	5,318,944	11,792	5,330,737
2010	837,805	585,319	509,422	4,295,741	6,228,287	13,670	6,241,957
2011	923,168	644,956	564,201	4,757,664	6,889,989	15,062	6,905,051
2012	1,013,535	708,089	622,600	5,250,121	7,594,345	16,537	7,610,881
2013	1,109,203	774,926	684,856	5,775,100	8,344,085	18,098	8,362,182
2014	1,210,489	845,688	751,220	6,334,718	9,142,115	19,750	9,161,865
2015	1,317,729	920,610	821,959	6,931,230	9,991,527	21,500	10,013,027

Table G.7 VOC and Time Saving of Diverted Traffic From Route 13 to Route 10

(US$)

Year	Vehicle Operation Cost						Time Cost			Total
	M/C	P/C	P/U	M/T	H/T	Sum	M/C	P/C	Sum	
1995	9,508	11,799	2,551	2,258	-584	25,532	458	488	945	26,477
1996	10,740	12,989	2,808	2,518	-651	28,403	554	575	1,130	29,533
1997	12,132	14,298	3,091	2,808	-726	31,602	671	679	1,350	32,953
1998	13,704	15,739	3,402	3,132	-810	35,167	813	801	1,614	36,781
1999	15,480	17,325	3,745	3,493	-903	39,140	984	946	1,930	41,070
2000	17,487	19,072	4,123	3,895	-1,007	43,569	1,192	1,116	2,308	45,876
2001	19,365	20,711	4,477	4,285	-1,108	47,729	1,414	1,298	2,713	50,442
2002	21,444	22,490	4,862	4,715	-1,219	52,292	1,678	1,511	3,189	55,481
2003	23,748	24,422	5,279	5,188	-1,342	57,295	1,992	1,758	3,750	61,045
2004	26,298	26,521	5,733	5,708	-1,476	62,784	2,364	2,046	4,410	67,193
2005	29,123	28,800	6,225	6,280	-1,624	68,804	2,805	2,381	5,186	73,989
2006	32,251	31,274	6,760	6,909	-1,787	75,408	3,328	2,771	6,099	81,507
2007	35,714	33,961	7,341	7,602	-1,966	82,653	3,950	3,224	7,174	89,827
2008	39,550	36,879	7,972	8,364	-2,163	90,603	4,687	3,752	8,439	99,042
2009	43,798	40,048	8,657	9,202	-2,380	99,326	5,562	4,366	9,928	109,254
2010	48,502	43,489	9,401	10,125	-2,618	108,899	6,601	5,080	11,681	120,580
2011	51,660	46,085	9,962	10,784	-2,789	115,701	7,412	5,676	13,088	128,789
2012	55,023	48,835	10,556	11,486	-2,970	122,930	8,323	6,341	14,664	137,594
2013	58,605	51,749	11,186	12,234	-3,164	130,611	9,346	7,084	16,429	147,041
2014	62,421	54,838	11,854	13,030	-3,370	138,773	10,494	7,914	18,408	157,181
2015	66,485	58,110	12,561	13,879	-3,589	147,446	11,784	8,841	20,625	168,071

Table G.8 Stream of Economic Cost and Benefit : Base Case

(in US$ 1,000)

	COST			BENEFIT Normal Traffic			Diverted Traffic		Ferry Operation		Generated Traffic	Salvage Value		
Year	Construc -tion	Mainte -nance	Sum	Time Save	Loss by no Ferry	Diversion to Rt.13	VOC Save	Time Save	O/M Cost	New Ferrty	VOC Save	Ferry	Bridge & Road	Sum
1992	375.7		375.7											0.0
1993	4,670.5		4,670.5											0.0
1994	5,225.4		5,225.4											0.0
1995	3,615.8		3,615.8											0.0
1996		4.4	4.4	5.4	80.5	0.0	28.4	1.1	26.3		6.6	36.0		184.3
1997		4.4	4.4	6.4	89.5	0.0	31.6	1.4	26.3	400.0	7.3			562.5
1998		4.4	4.4	16.7	99.5	0.0	35.2	1.6	26.3		8.2			187.5
1999		4.4	4.4	30.2	105.5	177.0	39.1	1.9	26.3		9.1			389.1
2000		4.4	4.4	22.0	120.4	66.9	43.6	2.3	26.3		10.2			291.7
2001		4.4	4.4	23.4	120.9	454.8	47.7	2.7	26.3		11.2			687.0
2002		77.9	77.9	24.9	121.3	881.7	52.3	3.2	106.3		12.3			1,202.0
2003		4.4	4.4	26.5	121.8	1,351.4	57.3	3.7	26.3		13.5			1,600.5
2004		4.4	4.4	28.3	122.3	1,867.9	62.8	4.4	26.3		14.9			2,126.9
2005		4.4	4.4	30.3	122.7	2,435.9	68.8	5.2	26.3		16.4			2,705.6
2006		4.4	4.4	32.5	123.2	3,060.4	75.4	6.1	26.3		18.0			3,341.9
2007		4.4	4.4	34.9	123.6	3,746.9	82.7	7.2	26.3	400.0	19.8			4,441.4
2008		4.4	4.4	37.5	124.1	4,501.5	90.6	8.4	26.3		21.7			4,810.1
2009		77.9	77.9	40.4	124.5	5,330.7	99.3	9.9	26.3		23.9			5,655.0
2010		4.4	4.4	43.6	125.0	6,242.0	108.9	11.7	26.3		26.3			6,583.8
2011		4.4	4.4	46.0	125.1	6,905.1	115.7	13.1	26.3		28.0			7,259.3
2012		4.4	4.4	48.5	125.3	7,610.9	122.9	14.7	106.3		29.8			8,058.4
2013		4.4	4.4	51.2	125.5	8,362.2	130.6	16.4	26.3		31.7			8,743.9
2014		4.4	4.4	54.1	125.7	9,161.9	138.8	18.4	26.3		33.7			9,558.9
2015		4.4	4.4	57.1	125.8	10,013.0	147.4	20.6	26.3		35.9		1,388.7	11,814.8
Sum	13,887.4	235.0	14,122.4	659.9	2,352.2	72,170.2	1,579.1	154.0	686.0	800.0	378.5	36.0	1,388.7	80,204.6

Table G.9 Stream of Economic Cost and Benefit : Case 1-1 (Construction Cost 10% up)

(in US$ 1,000)

	COST			BENEFIT Normal Traffic			Diverted Traffic		Ferry Operation		Generated Traffic	Salvage Value		
Year	Construc -tion	Mainte -nance	Sum	Time Save	Loss by no Ferry	Diversion to Rt.13	VOC Save	Time Save	O/M Cost	New Ferrty	VOC Save	Ferry	Bridge & Road	Sum
1992	413.3		413.3											0.0
1993	5,137.6		5,137.6											0.0
1994	5,747.9		5,747.9											0.0
1995	3,977.4		3,977.4											0.0
1996		4.4	4.4	5.4	80.5	0.0	28.4	1.1	26.3		6.6	36.0		184.3
1997		4.4	4.4	6.4	89.5	0.0	31.6	1.4	26.3	400.0	7.3			562.5
1998		4.4	4.4	16.7	99.5	0.0	35.2	1.6	26.3		8.2			187.5
1999		4.4	4.4	30.2	105.5	177.0	39.1	1.9	26.3		9.1			389.1
2000		4.4	4.4	22.0	120.4	66.9	43.6	2.3	26.3		10.2			291.7
2001		4.4	4.4	23.4	120.9	454.8	47.7	2.7	26.3		11.2			687.0
2002		77.9	77.9	24.9	121.3	881.7	52.3	3.2	106.3		12.3			1,202.0
2003		4.4	4.4	26.5	121.8	1,351.4	57.3	3.7	26.3		13.5			1,600.5
2004		4.4	4.4	28.3	122.3	1,867.9	62.8	4.4	26.3		14.9			2,126.9
2005		4.4	4.4	30.3	122.7	2,435.9	68.8	5.2	26.3		16.4			2,705.6
2006		4.4	4.4	32.5	123.2	3,060.4	75.4	6.1	26.3		18.0			3,341.9
2007		4.4	4.4	34.9	123.6	3,746.9	82.7	7.2	26.3	400.0	19.8			4,441.4
2008		4.4	4.4	37.5	124.1	4,501.5	90.6	8.4	26.3		21.7			4,810.1
2009		77.9	77.9	40.4	124.5	5,330.7	99.3	9.9	26.3		23.9			5,655.0
2010		4.4	4.4	43.6	125.0	6,242.0	108.9	11.7	26.3		26.3			6,583.8
2011		4.4	4.4	46.0	125.1	6,905.1	115.7	13.1	26.3		28.0			7,259.3
2012		4.4	4.4	48.5	125.3	7,610.9	122.9	14.7	106.3		29.8			8,058.4
2013		4.4	4.4	51.2	125.5	8,362.2	130.6	16.4	26.3		31.7			8,743.9
2014		4.4	4.4	54.1	125.7	9,161.9	138.8	18.4	26.3		33.7			9,558.9
2015		4.4	4.4	57.1	125.8	10,013.0	147.4	20.6	26.3		35.9		1,527.6	11,953.7
Sum	15,276.2	235.0	15,511.2	659.9	2,352.2	72,170.2	1,579.1	154.0	686.0	800.0	378.5	36.0	1,527.6	80,343.5

Table G.10 Stream of Economic Cost and Benefit : Case 1-2 (Construction Cost 25% up)

(in US$ 1,000)

	COST			BENEFIT											
				Normal Traffic			Diverted Traffic		Ferry Operation		Generated Traffic	Salvage Value		
Year	Construc -tion	Mainte -nance	Sum	Time Save	Loss by no Ferry	Diversion to Rt.13	VOC Save	Time Save	O/M Cost	New Ferrty	VOC Save	Ferry	Bridge & Road	Sum
1992	469.6		469.6											0.0
1993	5,838.1		5,838.1											0.0
1994	6,531.8		6,531.8											0.0
1995	4,519.8		4,519.8											0.0
1996		4.4	4.4	5.4	80.5	0.0	28.4	1.1	26.3		6.6	36.0		184.3
1997		4.4	4.4	6.4	89.5	0.0	31.6	1.4	26.3	400.0	7.3			562.5
1998		4.4	4.4	16.7	99.5	0.0	35.2	1.6	26.3		8.2			187.5
1999		4.4	4.4	30.2	105.5	177.0	39.1	1.9	26.3		9.1			389.1
2000		4.4	4.4	22.0	120.4	66.9	43.6	2.3	26.3		10.2			291.7
2001		4.4	4.4	23.4	120.9	454.8	47.7	2.7	26.3		11.2			687.0
2002		77.9	77.9	24.9	121.3	881.7	52.3	3.2	106.3		12.3			1,202.0
2003		4.4	4.4	26.5	121.8	1,351.4	57.3	3.7	26.3		13.5			1,600.5
2004		4.4	4.4	28.3	122.3	1,867.9	62.8	4.4	26.3		14.9			2,126.9
2005		4.4	4.4	30.3	122.7	2,435.9	68.8	5.2	26.3		16.4			2,705.6
2006		4.4	4.4	32.5	123.2	3,060.4	75.4	6.1	26.3		18.0			3,341.9
2007		4.4	4.4	34.9	123.6	3,746.9	82.7	7.2	26.3	400.0	19.8			4,441.4
2008		4.4	4.4	37.5	124.1	4,501.5	90.6	8.4	26.3		21.7			4,810.1
2009		77.9	77.9	40.4	124.5	5,330.7	99.3	9.9	26.3		23.9			5,655.0
2010		4.4	4.4	43.6	125.0	6,242.0	108.9	11.7	26.3		26.3			6,583.8
2011		4.4	4.4	46.0	125.1	6,905.1	115.7	13.1	26.3		28.0			7,259.3
2012		4.4	4.4	48.5	125.3	7,610.9	122.9	14.7	106.3		29.8			8,058.4
2013		4.4	4.4	51.2	125.5	8,362.2	130.6	16.4	26.3		31.7			8,743.9
2014		4.4	4.4	54.1	125.7	9,161.9	138.8	18.4	26.3		33.7			9,558.9
2015		4.4	4.4	57.1	125.8	10,013.0	147.4	20.6	26.3		35.9		1,735.9	12,162.0
Sum	17,359.3	235.0	17,594.3	659.9	2,352.2	72,170.2	1,579.1	154.0	686.0	800.0	378.5	36.0	1,735.9	80,551.8

Table G.11 Stream of Economic Cost and Benefit : Case 2 (Traffic Growth Rate 10% down)

(in US$ 1,000)

	COST			BENEFIT Normal Traffic			Diverted Traffic		Ferry Operation		Generated Traffic	Salvage Value		
Year	Construc -tion	Mainte -nance	Sum	Time Save	Loss by no Ferry	Diversion to Rt.13	VOC Save	Time Save	O/M Cost	New Ferrty	VOC Save	Ferry	Bridge & Road	Sum
1992	375.7		375.7											0.0
1993	4,670.5		4,670.5											0.0
1994	5,225.4		5,225.4											0.0
1995	3,615.8		3,615.8											0.0
1996		4.4	4.4	5.0	75.8	0.0	26.7	1.1	26.3		6.1	36.0		177.0
1997		4.4	4.4	5.7	83.4	0.0	29.4	1.3	26.3	400.0	6.8			552.9
1998		4.4	4.4	8.2	91.8	0.0	32.4	1.5	26.3		7.5			167.7
1999		4.4	4.4	19.1	101.1	0.0	35.7	1.8	26.3		8.3			192.3
2000		4.4	4.4	30.3	105.4	196.7	39.3	2.1	26.3		9.1			409.2
2001		4.4	4.4	21.5	120.3	.0	42.7	2.4	26.3		10.0			223.2
2002		77.9	77.9	22.9	120.9	337.6	46.4	2.8	106.3		10.9			647.8
2003		4.4	4.4	24.3	121.3	711.4	50.4	3.3	26.3		11.8			948.8
2004		4.4	4.4	25.7	121.7	1,118.9	54.7	3.8	26.3		12.9			1,364.0
2005		4.4	4.4	27.2	122.1	1,563.1	59.4	4.5	26.3		14.0			1,816.6
2006		4.4	4.4	28.9	122.5	2,047.2	64.6	5.2	26.3		15.3			2,310.0
2007		4.4	4.4	30.8	122.9	2,574.7	70.1	6.1	26.3	400.0	16.7			3,247.6
2008		4.4	4.4	32.8	123.3	3,149.3	76.2	7.1	26.3		18.2			3,433.2
2009		77.9	77.9	35.0	123.7	3,775.3	82.8	8.2	26.3		19.8			4,071.1
2010		4.4	4.4	37.3	124.1	4,457.2	89.9	9.6	26.3		21.6			4,766.0
2011		4.4	4.4	39.1	124.3	4,949.8	95.0	10.7	26.3		22.8			5,268.0
2012		4.4	4.4	41.0	124.5	5,471.0	100.3	11.9	106.3		24.1			5,879.1
2013		4.4	4.4	43.0	124.6	6,022.4	106.0	13.3	26.3		25.5			6,361.1
2014		4.4	4.4	45.1	124.8	6,605.9	111.9	14.8	26.3		27.0			6,955.8
2015		4.4	4.4	47.3	124.9	7,223.2	118.2	16.5	26.3		28.6		1,388.7	8,973.7
Sum	13,887.4	235.0	14,122.4	570.2	2,303.4	50,203.7	1,332.1	128.0	686.0	800.0	317.0	36.0	1,388.7	57,765.1

Table G.12 Stream of Economic Cost and Benefit : Case 3 (2 year construction)

(in US$ 1,000)

	COST			BENEFIT Normal Traffic			Diverted Traffic		Ferry Operation		Generated Traffic	Salvage Value		
Year	Construc -tion	Maintain -ance	Sum	Time Sav	Loss by no Ferry	Diversion to Rt.13	VOC Sav	Time Sav	O/M Cost	New Ferry	VOC Sav	Ferry	Bridge & Road	Sum
1992	375.7		375.7											0.0
1993	6,451.9		6,451.9											0.0
1994	6,764.3		6,764.3											0.0
1995		4.4	4.4	4.7	72.4	0.0	25.5	0.9	26.3		5.9	54.0		189.8
1996		4.4	4.4	5.4	80.5	0.0	28.4	1.1	26.3		6.6			148.4
1997		4.4	4.4	6.4	89.5	0.0	31.6	1.4	26.3	400.0	7.3			562.5
1998		4.4	4.4	16.7	99.5	0.0	35.2	1.6	26.3		8.2			187.5
1999		4.4	4.4	30.2	105.5	177.0	39.1	1.9	26.3		9.1			389.1
2000		4.4	4.4	22.0	120.4	66.9	43.6	2.3	26.3		10.2			291.7
2001		77.9	77.9	23.4	120.9	454.8	47.7	2.7	26.3		11.2			687.1
2002		4.4	4.4	24.9	121.3	881.7	52.3	3.2	106.3		12.3			1,202.1
2003		4.4	4.4	26.5	121.8	1,351.4	57.3	3.7	26.3		13.5			1,600.6
2004		4.4	4.4	28.3	122.3	1,867.9	62.8	4.4	26.3		14.9			2,126.9
2005		4.4	4.4	30.3	122.7	2,435.9	68.8	5.2	26.3		16.4			2,705.6
2006		4.4	4.4	32.5	123.2	3,060.4	75.4	6.1	26.3		18.0			3,341.9
2007		4.4	4.4	34.9	123.6	3,746.9	82.7	7.2	26.3	400.0	19.8			4,441.4
2008		77.9	77.9	37.5	124.1	4,501.5	90.6	8.4	26.3		21.7			4,810.2
2009		4.4	4.4	40.4	124.5	5,330.7	99.3	9.9	26.3		23.9			5,655.2
2010		4.4	4.4	43.6	125.0	6,242.0	108.9	11.7	26.3		26.3			6,583.7
2011		4.4	4.4	46.0	125.1	6,905.1	115.7	13.1	26.3		28.0			7,259.3
2012		4.4	4.4	48.5	125.3	7,610.9	122.9	14.7	106.3		29.8			8,058.4
2013		4.4	4.4	51.2	125.5	8,362.2	130.6	16.4	26.3		31.7			8,743.9
2014		4.4	4.4	54.1	125.7	9,161.9	138.8	18.4	26.3		33.7		1,359.2	10,918.0
Sum	13,591.9	235.0	13,826.9	607.5	2,298.8	62,157.1	1,457.2	134.4	686.8	800.0	348.4	54.0	1,359.2	69,903.4