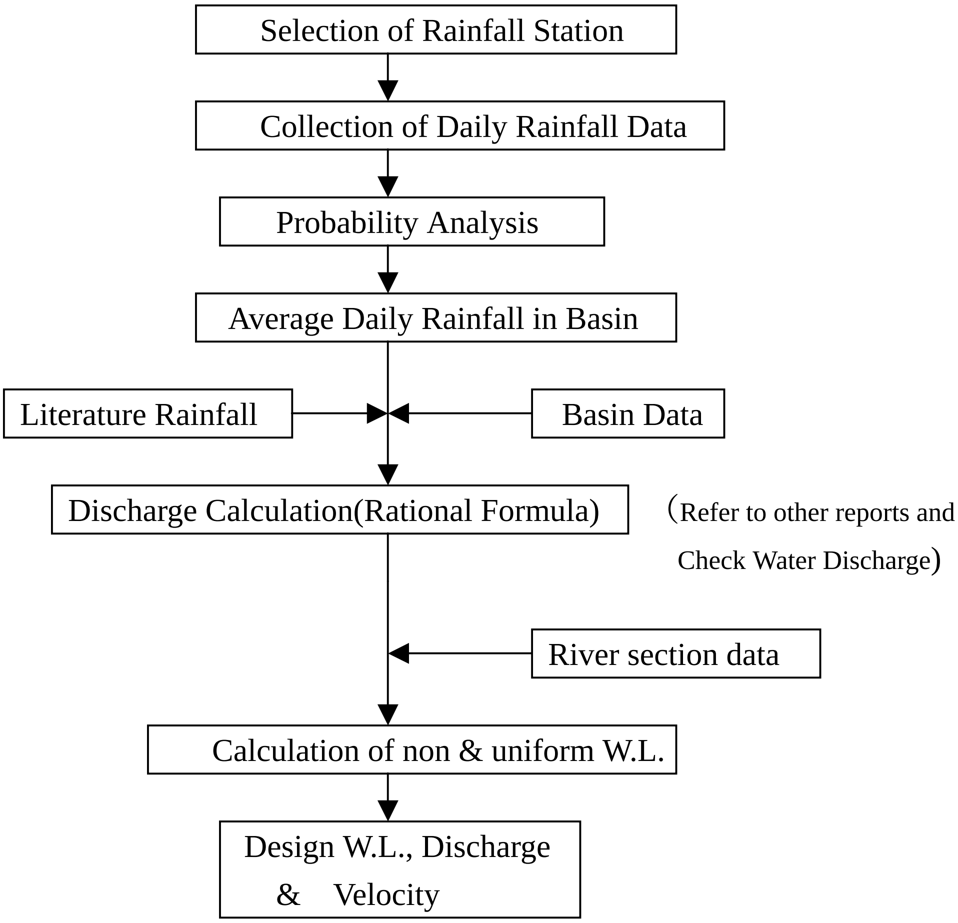
Ⅳ FEASIBLITY STUDY

CHAPTER 3

HYDROLOGOICAL ANALYSIS OF PROJECT AREA

(2) Route 16A For Xe Namnoy Basin



3.3.2 Selection of Hydrological Station

The location of the hydrological observation stations, which the data were obtained for this study, is indicated in Figure 3.3.1.

(1) Route 14A

As for the water level of Mekong River, there are three observatories near the route; namely Pakse, Phaphin and Channoy. The location of each observatory is indicated in Figure 3.3.1. In addition, the availability of water level data is indicated in Table 3.3.1.
The each data in detail are shown in ANNEX F-10.

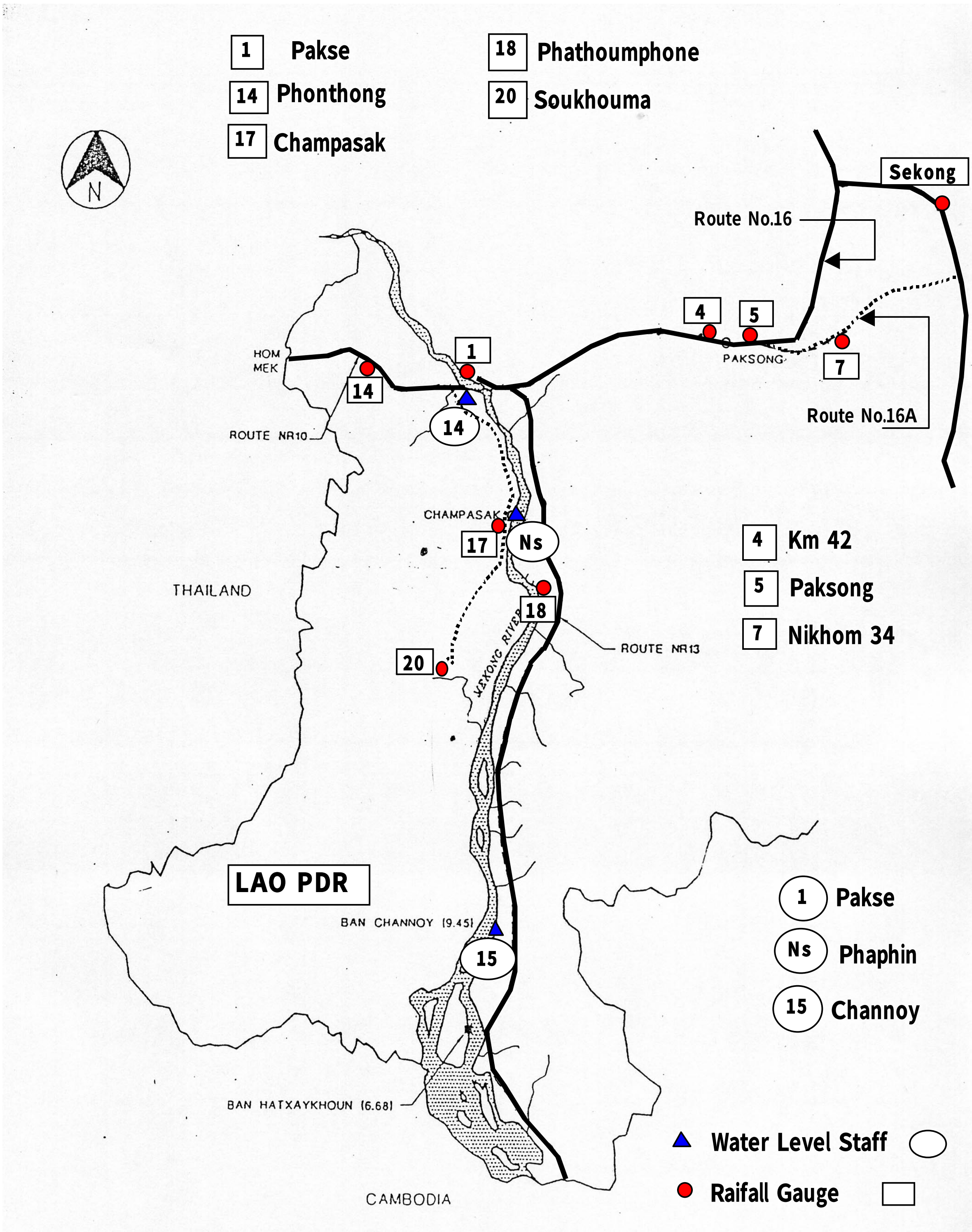


Figure 3.3.1 Location of Observatory Station

Table 3.3.1 Water Level (Mekong River) Observatory and Data Availability

No.	Station Name	Cord No.	Location		Drainage Area(km^2)	Data Available	Agency
			Lat.	Long.			
14	Pakse	013901	15-07N	105-48E	545,000	1902-2000	DCTPC
NS	Phaphin	-	-	-	-	1969-2001	DCTPC
15	Channoy	014301	14-19.5N	105-53.2E	549,000	1965-2001	DCTPC

(Note) lack of data for 3 years at No.14 Pakse, 18 years at Phaphin, 13 years at No.15 Channoy.

As for the rainfall data, 5 observatories are chosen to obtain necessary rainfall data for Route 14A.

Table 3.3.2 Rainfall Observatory and Data Availability

No.	Station No.	Station Name	Location		Altitude (m)	Data Available	Agency
			Lat.	Long.			
1	150504	Pakse	15-07N	105-47E	168.0	1960-2001	DHM
14	140510	Phonthong	15-06N	105-39E		1983-2001	DHM
17	140507	Champasack	15-54N	105-53E	95.0	1979-2001	DHM
18	140505	Phathoumphone	14-48N	105-56E		1965-2001	DHM
20	14506	Sukhuma	14-39N	105-49E	96.0	1979-2001	DHM

***(Note)** lack of data for 5 years at No14 Phonthong ,2 years at No.17 Champasack, and 12 years at No 18 Pathoomphone.*

(2) Route 16A

There is no water level observatory to cover the Xe Namnoy River basin. However, there are 3 rainfall observatories near Route 16A.

Table 3.3.3 Rainfall Station and Availability Data

No.	Station No.	Station Name	Location		Altitude (m)	Data Available	Agency
			Lat.	Long.			
4	150603	Km 42	15-11N	106-26E	1160	1977-2001	DHM
5	140511	Paksong	15-11N	106-14E		1987-2001	DHM
7	150607	Nikom34	15-12N	106-34E	1060	1984-2001	DHM

Note: Lack of data for one year at No.7 Nikom 34 station during available period

The data in detail are shown in ANNEX F-10.

3.3.3 Probability Analysis on River Water Level and Daily Rainfall

(1) Probability Analysis for Water Level of Mekong River

The probability analysis for the water level of Mekong River is carried out by employing Thomas plotting method based on observatory data at Pakse. The water level data at Pakse are available for past about 100 years, i.e., from 1902 to 2000 but for 15 years and 24 years at Phaphin and Channoy respectively. Those periods of data seems insufficient to execute 100 year probability from the viewpoint of statistics. Consequently, the Study Team decided that the probability analysis Mekong River is undertaken by only utilizing Pakse data. The analysis results are shown in Table 3.3.4. The plotting result is indicated in Figure 3.3.2.

Table3.3.4 Result of Probability of Max. W. L. for Mekong River at Pakse

Probability	Water Level (m)	Note
1/100	100.50	
1/50	100.30	Almost same as year 1929 flood level (2nd)
1/20	100.00	Almost same as year 1965and 2000 flood level (3 th and 4th)
1/10	99.70	
1/5	99.40	

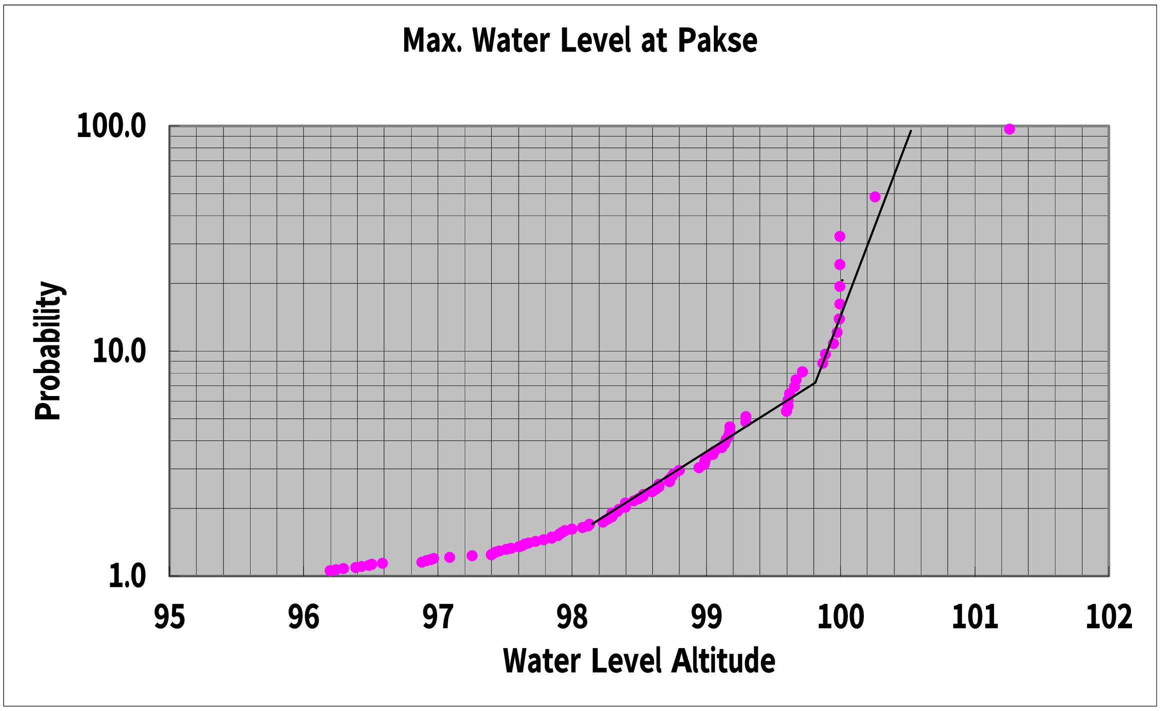


Figure 3.3.2 Estimated High Water Level at Each Probability at Pakse

The historical high water levels during the observation period at Pakse are listed below. As a result of the probability analysis, it can be said that whereas the water level at the year 2000 flood is equivalent to one at the 20-year probability level, the water level at the year 1929 flood is almost equivalent to one at the 50 years probability level. Furthermore, it was found that the flood water level in 1978 was extremely high on statistics and at more than 500 years probability level.

Order	Year	Water Level (m)
1st	1978	101.26(14.63)
2nd	1929	100.26(13.61)
3rd	1961	100.00(13.35)
4th	2000	99.99(13.36)

(Note)

Before 1971 ; Zero of gauge elevation was 86.507 m. above M.S.L. Ko Lak datum.
After 1972 to present ; Zero of gauge elevation was 86.49 m. above M.S.L. Ko Lak datum.
Mean Sea Level South China Sea Datum is approximately below Mean Sea Level Ko Lak Datum by 0.140 m.
Figures in parentheses indicate the gauge reading in Pakse

(2) Probability Analysis on Daily Rainfall

Based on the rainfall data from the selected observatories, the probability analysis was undertaken. The results are shown in Table 3.3.5(details be referred to ANNEX F-10).

Table 3.3.5 Probability for Max. Daily Rainfall (mm)

Prob.	Route 14 A					16 A		
	No.1	No.14	No.17	No.18	No20	No.4	No.5	No.7
1/50	390	250	260	260	250	540	340	320
1/20	290	200	230	220	210	450	290	230
1/10	210	185	210	200	180	380	250	190
1/5	160	150	200	180	150	310	210	150

3.3.4 Average Daily Rainfall of Each River Basin for Design at Each Probability

The design daily rainfall of each study river basin is estimated on the basis of the averaged value of the adjacent observatory. As for Route 14A, whereas the average value of the rainfall station No.1, No.14 and No.17 is applied to the A group waterways comprising from the river No.1 to No.19, the average one of the rainfall station No.17, No.18 and No.20 is applied to the B group waterways consisting of the river No.20 to No.23. The average daily rainfall of each river basin for design is indicated in Table 3.3.6.

As for Route 16A, the average daily rainfall of the rainfall station No.4, No.5, No.7 is applied to No.1&No.2 river sites on Route 16A. The rainfall applied to others is decreased from the 3 station's average taking account of their locations.

Table 3.3.6 Average Daily Rainfall of the Basin for Design at Each Probability (mm)

Probability	Route 14A		Route16A	
	A(No.1～No19 River)	B(No20～No.23 River)	A(No.1～No2 River)	B(No3～No.7 River)
1/50	300	260	400	360
1/20	240	220	320	290
1/10	200	200	270	240
1/5	170	180	220	200

The validity of the design daily rainfall mentioned above could be proved comparing with the one-day rainfall from Typhoon "SARAH" at Champasack Province (1983 June). (Source : F/S on Construction of Mekong Bridge, Final Report Volume Ⅱ Annexes Fig. A3-15)

3.3.5 Water Discharge

(1) Application of Rational Formula

The water discharge is calculated with the rational formula, which is introduced popularly. This formula can ensure its accuracy when the basin area is small enough, less than 200 km^2. Since the basin area of all rivers, except for No.3, No.4 and No.5 rivers on Route 16A, fulfills this requirement, its application is can be judged appropriate.

The formula is:

$$Q = 1 / 3.6 * f * I A$$

Where

Qp : Maximum Flood Discharge (m^3/s)

f : Runoff Coefficient, Mountain Area=0.75 , Plain Area=0.5

R : Hourly Rainfall Intensity for duration equal to the Time of Concentration (mm/h)

A : Catchment Area (km^2)

(2) Time of Flood Concentration

Although several formulas are proposed to calculate the time of flood concentration, the Study Team adopts the following formulas:

Road Design Manual (MCTPC)

Public Works Institute of Japan.

As for the Inflow time, 15 minutes shall be added to the time in case of the small basin and 30 minute to the middle class basin.

$Tc = (0.87 L^3 / H)^{0.385} + t$ ------------------(Formula introduced in the Road Manual)

Tc :Time of flood concentration (h)

L: River length (km)

H: Difference in elevation (m)

t : Inflow time

$T = 1.67 \times 10^{-3} (L / S)^{0.7} + t$ --------------(PWI Formula)

T : Time of flood concentration(h)

S : Average slope = H / L

$Tav = (Tc + T) / 2$

The calculation results at each river basin are shown in ANNEX F-10.

(3) Rainfall Intensity for Time Period Corresponding to "T"

The Monobe formula is applied to calculate the rainfall intensity for time period corresponding to T as follows.

$Rt = R_{24} (Tav / 24)^{K}$

Where :

Rt : Rainfall Intensity for time period corresponding to "T"

R_{24} : daily rainfall in Average basin (mm)

Tav : Flood Time of Concentration (h)

K : Coefficient =0.37 use

$R = Rt / Tav$ (mm/h)

0.37 of K value is applied to the existing rainfall intensity curve at the suburban area.

The calculation results of rainfall intensity at each probability are shown in Table 3.3.7 and 3.3.8.

(4) Calculation of Discharge

The results of water discharges for each river by calculation using rational formula are shown in Table 3.3.7 and 3.3.8. F values, the runoff coefficient, are determined according to the proportions of the mountain area and plain area.

River No.	Prob.	Tav(h)	R24	I(mm/h)	C.A(km2)	f	Q(m3/s)	Qd(m3/s)	Note
1	1/50	1.7	300	66.26	9.6	0.75	132.52	130	
	1/20	1.7	240	53.01	9.6	0.75	106.02	110	
	1/5	1.7	170	37.55	9.6	0.75	75.10	75	
2	1/50	0.6	300	127.70	0.8	0.75	21.28	21	
	1/20	0.6	240	102.16	0.8	0.75	17.03	17	
	1/5	0.6	170	72.37	0.8	0.75	12.06	12	
3	1/50								
	1/20								
	1/5								
4	1/50	0.6	300	127.70	0.9	0.75	23.94	24	
	1/20	0.6	240	102.16	0.9	0.75	19.16	19	
	1/5	0.6	170	72.37	0.9	0.75	13.57	14	
5	1/50	0.6	300	127.70	1.6	0.75	42.57	43	
	1/20	0.6	240	102.16	1.6	0.75	34.05	34	
	1/5	0.6	170	72.37	1.6	0.75	24.12	24	
6	1/50	0.5	300	143.25	1.2	0.75	35.81	36	
	1/20	0.5	240	114.60	1.2	0.75	28.65	29	
	1/5	0.5	170	81.17	1.2	0.75	20.29	20	
7	1/50	0.6	300	127.70	1.1	0.75	29.27	29	
	1/20	0.6	240	102.16	1.1	0.75	23.41	23	
	1/5	0.6	170	72.37	1.1	0.75	16.58	17	
8	1/50	0.7	300	115.89	4.6	0.75	111.06	110	
	1/20	0.7	240	92.71	4.6	0.75	88.85	89	
	1/5	0.7	170	65.67	4.6	0.75	62.93	63	
9	1/50								
	1/20								
	1/5								
10	1/50								
	1/20								
	1/5								
11	1/50	0.8	300	106.54	4.6	0.75	102.10	100	
	1/20	0.8	240	85.23	4.6	0.75	81.68	82	
	1/5	0.8	170	60.37	4.6	0.75	57.85	58	

Table 3.3.7 Calculation for Rainfall Intensity & Discharge for Route 14A

The river No.3, No.9, No.10 has less than 0.5 km2 of catchment area (small volume of discharge) and Box Culvert is sufficient.

No.	Prob.	Tav(h)	R24	I(mm/h)	C.A(km2)	f	Q(m3/s)	Qd	Note
12	1/50	0.7	300	115.89	3.5	0.75	84.50	85	
	1/20	0.7	240	92.71	3.5	0.75	67.60	68	
	1/5	0.7	170	65.67	3.5	0.75	47.88	48	
13	1/50	0.7	300	115.89	1.5	0.75	36.21	36	
	1/20	0.7	240	92.71	1.5	0.75	28.97	29	
	1/5	0.7	170	65.67	1.5	0.75	20.52	21	
14	1/50	0.7	300	115.89	3.2	0.75	77.26	77	
	1/20	0.7	240	92.71	3.2	0.75	61.81	62	
	1/5	0.7	170	65.67	3.2	0.75	43.78	44	
15	1/50	0.7	300	115.89	3.4	0.75	82.09	82	
	1/20	0.7	240	92.71	3.4	0.75	65.67	66	
	1/5	0.7	170	65.67	3.4	0.75	46.52	47	
16	1/50	0.7	300	115.89	3.1	0.75	74.84	75	
	1/20	0.7	240	92.71	3.1	0.75	59.87	60	
	1/5	0.7	170	65.67	3.1	0.75	42.41	42	
17	1/50	0.4	300	164.87	0.8	0.75	27.48	27	
	1/20	0.4	240	131.90	0.8	0.75	21.98	22	
	1/5	0.4	170	93.43	0.8	0.75	15.57	16	
18	1/50	1.0	300	92.56	6.6	0.75	127.28	130	
	1/20	1.0	240	74.05	6.6	0.75	101.82	120	
	1/5	1.0	170	52.45	6.6	0.75	72.12	72	
19	1/50	1.1	300	87.17	6.0	0.75	108.96	110	
	1/20	1.1	240	69.74	6.0	0.63	73.22	73	
	1/5	1.1	170	49.40	6.0	0.63	51.87	52	
20	1/50	2.4	260	46.21	22.5	0.53	153.08	150	
	1/20	2.4	220	39.10	22.5	0.53	129.53	130	
	1/5	2.4	180	31.99	22.5	0.53	105.98	110	
21_1	1/50	2.0	260	51.84	20.0	0.7	201.59	200	
	1/20	2.0	220	43.86	20.0	0.7	170.58	170	
	1/5	2.0	180	35.89	20.0	0.7	139.56	140	
21_2	1/50	2.2	260	48.82	6.4	0.63	54.67	55	
	1/20	2.2	220	41.31	6.4	0.63	46.26	46	
	1/5	2.2	180	33.80	6.4	0.63	37.85	38	
22	1/50	2.9	260	41.02	11.5	0.58	76.00	76	
	1/20	2.9	220	34.71	11.5	0.58	64.31	64	
	1/5	2.9	180	28.40	11.5	0.58	52.61	53	
23	1/50	9.0	260	20.10	15.0	0.53	44.38	44	
	1/20	9.0	220	17.00	15.0	0.53	37.55	38	
	1/5	9.0	180	13.91	15.0	0.53	30.72	31	

Table 3.3.8 Calculation for Rainfall Intensity & Discharge for Route 16A

No.	Prob.	Tav(h)	R24	I(mm/h)	C.A(km2)	f	Q (m3/s)	Qd (m3/s)	Note
1	1/50	4.4	400	48.53	33	0.75	333.6	330	
	1/20	4.4	320	38.82	33	0.75	266.9	270	
2	1/50	6.1	400	39.50	56	0.75	460.9	460	
	1/20	6.1	320	31.60	56	0.75	368.7	370	
3	1/50	10.0	400	28.93	296	0.75	1784.2	1780	-1730
	1/20	10.0	320	23.15	296	0.75	1427.3	1430	
4	1/50				1170			2800	
5	1/50							330	Fig.AN 8.6(1)
6	1/50	4.3	400	49.24	71	0.75	728.3	730	
	1/20	4.3	320	39.39	71	0.75	582.6	580	
7	1/50	1.6	400	91.79	4.2	0.75	80.3	80	
	1/20	1.6	320	73.43	4.2	0.75	64.3	60	

Note: No.4/5 shall refer to Clause 3.3.6

3.3.6 Discharge Calculation for Bridge No.3, No.4 & No.5 on Route 16A

The rational formula is not applicable to the discharge calculation at the bridge No.4 and No.5 sites, which both bridges are on the same river, because its basin area is more than the application limitation of 200 km^2. The basin area of this site is 1,170 km^2, although deducting the basin area 250km^2 of Kalak-Tok Dam. (The bridge No.3 basin area of this site is 296 km^2.)

In this discharge calculation, the Unit Graph Method, which was applied to the discharge calculation for Xe Namnoy Bridge on Route 1I in Six Road Improvement Project by ADB in 1994, can be applied for. As a result of the calculation, 3,130m^3/s of the discharge at 50 years probability for the No.4 bridge site is obtained (Refer to ANEX). The validity of calculation could be proved comparing with the discharge at Xe Namnoy Bridge on Route 1I, which is estimated 3,860 m^3/s at 50 years probability with 1,530km^2 of the basin area. In addition, the accuracy was confirmed on site investigations such as interview of the high water level to local people, observation of slop and flow velocity.

On the other hand, bridge No.5 river point has unique river characteristics. This is a detour river route of Xe Namnoy River (bridge No.4 river). It starts carrying the water overflowed from a mainstream of Xe Namnoy River at the right bank about 100m upstream from the No.4 bridge when the water level reaches to about elevation 260-261m (refer to Figure 3.3.3). As a result of the interview to villagers, the over flowing water spreads more than 1.0 m in water depth and about 50 m in length at the water diverting point. The discharge is estimated about 300 m^3/s from these site investigation results (Refer to ANNEX F-10). In addition to this, around 1 km^2 of the river basin area should be considered for additional discharge.

The Study Team concludes that 3,000m^3/s for the No. 4 bridge and 150m^3/s for No. 5 bridge at probability for 50 years are applied for discharge water on the bridge design.

As for the discharge of bridge No.3 river, the discharge water is 1,610m^3/s which is estimated with rational formula. The detail calculation process is shown in ANNEX F-10.

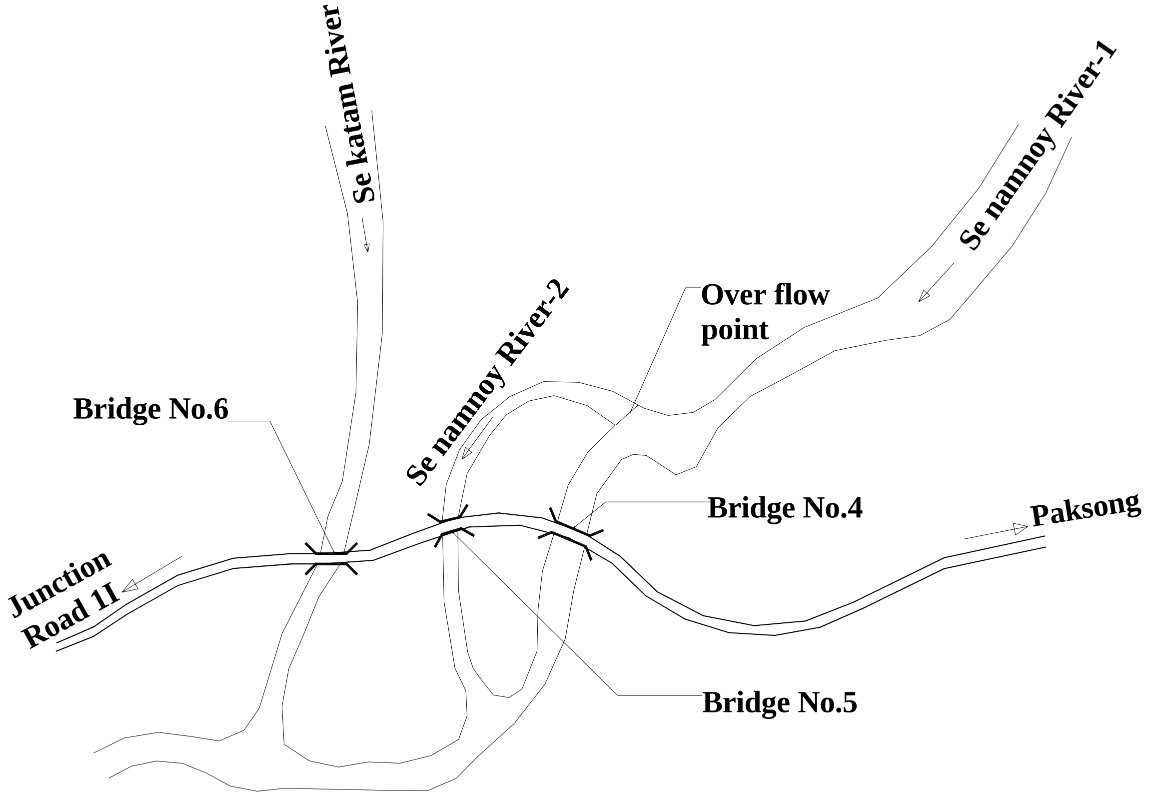


Figure 3.3.3 Plan Sketch of Bridge No.4, No.5 & No.6

3.3.7 Design Water Level for Bridge and Road on Route 14A

(1) Design Water Level for Each River Mouth

As a result of the site investigation of the rivers on Route 14A, it was found that the water level of Mekong River influences majority of the rivers during rainy season, i.e., backwater from the Mekong River. Since there are only three observatory along the Mekong River in the study area, the first one at Pakse, the second at Phaphin in Champasack Towm 26 km downstream from Pakse and the third at Channoy 97 km downstream from Pakse, it is an essential issue how to estimate the water level of Mekong River at river mouths located between three stations.

There are several methods to estimate. The following two steps procedure is appropriate to determine the water level at the mouth of each tributary river of the Mekong River.

Step 1

Both case of high water level at 100.50 and case of 20 years return periods are calculated employing the water level of the Mekong River at Pakse. On the one hand, the average slope of the Mekong water level shall be calculated from the past water level records at the same time and date at the Pakse, Phaphin and Channoy observatory. Based on the above, the high water level at the mouth of each branch river could be estimated.

Step 2

To simplify the analysis, The Study Team has assumed that the slope of the Mekong water level between both Pakse and Phaphin, and Phaphin and Channoy is constant.

By using the high water level record of the Mekong in 1978 (the highest from 1902) and another record in 2000(the highest in last 10years) at Pakse, Phaphin and B. Channoy station, the average water level slop can be calculated. The water level at each river mouth is estimated by using the slope obtained. Those water levels estimated can be compared with the ones obtained by villagers' interviews on the record of 1978 and 2000.

As a result of this procedure, it is found that the almost all interviewed are slightly below the one estimated by the average slope of the water level.

The result of this analysis is shown in Table 3.3.9 and Figure 3.3.4. The detail process is described in ANNEX F-10.

(2) Design Water Level for Road

As a result of the road inventory survey, there are several inundation areas on Route 14A due to the high water level of the Mekong River, i.e., the missing section and Champasack Town section. In order to determine the appropriate road surface elevation against the flood, the flood water levels of the Mekong River at each return period are required. The estimation method is as same as one described the above.

Since the distances indicated in Table 3.3.9 are the one based on along the Mekong River not road, some modification is necessary and the following figures are applied for design of road elevation.

Rd. Station	Flood Water Level (m)			Gradient (%)	
25+000	1/20	1/50	1/100	Pakse-Phaphin	Phaphin-Channoy
	97.11	97.41	97.61	0.011	0.008

Table 3.3.9 Analysis of Water Level for Mekong River – Route 14A

No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Distance from Pakse (Km)	0	6.8	7.5	14.6	14.9	18.1	22.8	26.1	26.3	30.2	33.2	40.2	49.0	54.5	97.0
W.L 1978	101.26	100.51	100.43	99.65	99.62	99.26	98.75	98.38	98.36	98.02	97.76	97.14	96.37	95.89	92.17
W.L 2000	99.99	99.21	99.13	98.32	98.28	97.92	97.38	97.00	96.98	96.66	96.41	95.84	95.11	94.66	91.17
Adjusted 1/100	100.50	99.73	99.65	98.89	98.86	98.51	97.99	97.63	97.61	97.30	97.06	96.50	95.79	95.35	91.95
Adjusted 1/50	100.30	99.53	99.45	98.69	98.66	98.31	97.79	97.43	97.41	97.10	96.86	96.30	95.59	95.15	91.75
Adjusted 1/20	100.00	99.23	99.15	98.39	98.36	98.01	97.49	97.13	97.11	96.80	96.56	96.00	95.29	94.85	91.45
Iterview 1978	(101.26)	100.99	(101.08)	99.29	99.8	99.22	98.1	98.01		97.94	96.92				
Iterview 2000	(99.99)	99.28	(98.81)	98.57	98.16	98.14	96.9	96.59	96.69	96.59	96.23	(100.44)			

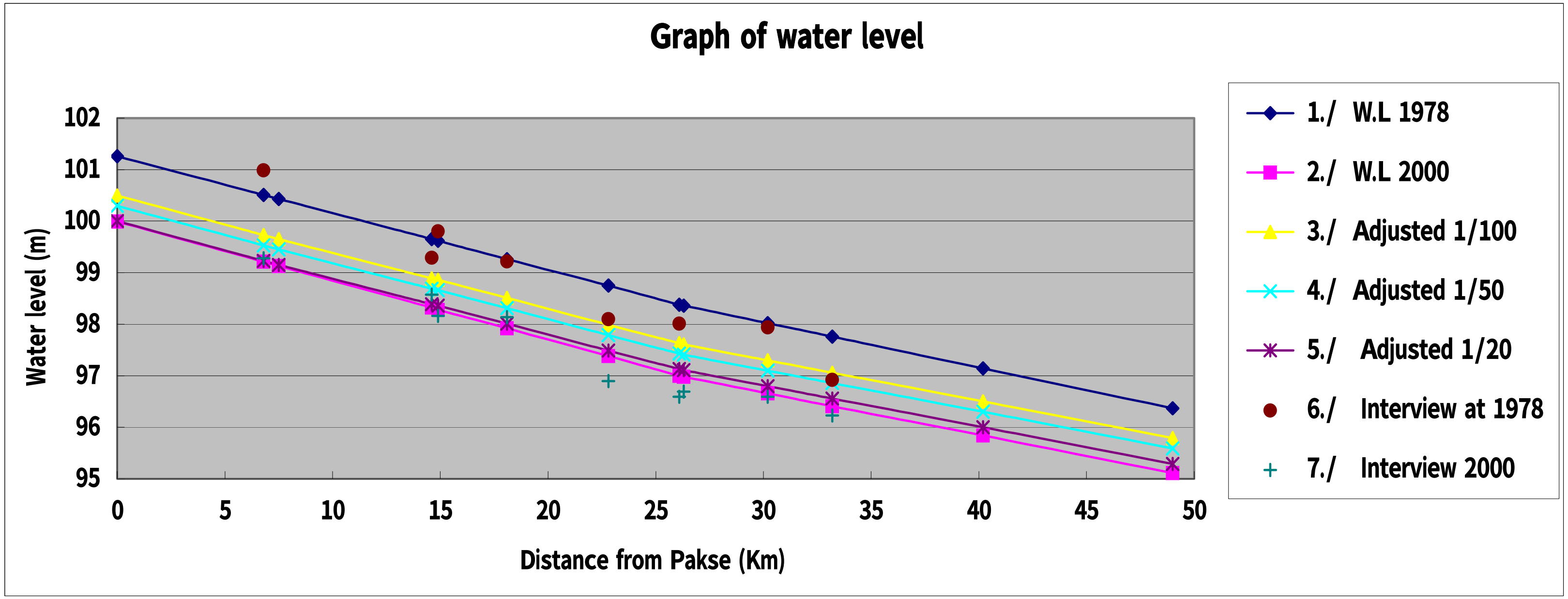


Figure 3.3.4 Estimation of Water Level for Mekong River

(3) Calculation Method of Design Water Level for Bridge

50 years return period is basically adopted to estimate the design water level for bridges in this study. Since the rivers on Route 14A shows complicated river phenomenon and have small catchment area with less than $20km^2$, the following three cases should be considered to determine the design high water level for bridges.

Case-1

The water level is determined by a backwater of the Mekong River at 50 years return period, which is equivalent to the water level of the Mekong River at 50 years return period at the mouth of each river coming across Mekong River. There is no consideration of the discharge from upstream in this case. This case maybe happen in the peak of rainy season.

Case-2

The backwater of the Mekong Rive has no affect on the water level at bridge site. The design water level at each bridge site is determined on the basis of the discharge by rainfall at probability for 50 years. 20 years probability is applied to a box culvert. The case maybe occurred in the beginning or end of rainy season.

Case-3

This case may happen on the branch rivers of the Mekong that have a backwater affect of the Mekong at the proposed bridge site. It is a case when the water level of Mekong River is relatively high and a large discharge by torrential rain in the catchment area flows the river. Each probability shall be set 20 years for Mekong River and 5 years for the study river. Since the peak water level of Mekong River continues for a few days, the probability of this case can be regarded as approximately 50 years.

For rivers on Route 14A, the highest water level among three cases should be adopted as the design water level for the bridge design. Case-1 is the highest for almost all rivers except for No.22 and 23 rivers. It is confirmed that the water level of Case-3 is lower than other two cases at the proposed bridge sites.

For rivers on Route 16A, the water level estimated in Case 2 is adopted as the design water level for bridge design.

(4) Design Water Level for Bridge

According to the procedure mentioned above, the design water level of each river is calculated. The discharge is calculated with Manning Formula and assumption of the river

conditions necessary for the calculation is as follows;
Used of each discharge calculated with condition mentioned above.

Roughness coefficient: n=0.03 for Route 14A and 0.035 for Route 16A.

The calculation results on Route 14A and 16 are shown in Table 3.3.10 and 3.3.11 respectively.

Table 3.3.10 Design Water Level & Velocity at Each Bridge for Route 14A

No.	River Name	Bridge Span	Qdat1/20 Or 1/50 (m3)	R.Bed EL.(m)	River Slope	Case-1 Mekong W.L.1/50	Case-2 R.W.L. 1/50(m)	Design W.L. (m)	Velo. (m/s)
1	Thok	22	130	88.90		99.55	92.90	99.60	2.1
2	Maknao	Box	17			99.53		99.50	
3	Namxan	Box	---			99.48		99.50	
4		Box	19			99.39		99.40	
5		Box	34			99.34		99.30	
6	Gnang	Box	29			99.27		99.30	
7		Box	23			99.18		99.20	
8	Imet	22.0	90	97.26	0.005	99.05	99.32	99.30	2.9
9	Kaunam	Box	---			98.99		99.00	
10	K. dam	Box	---			98.94		98.90	
11	Thakhong	22.0	100	91.41		98.77	94.63	98.80	3.2
12	Thapxang	30.0	85	90.85		98.67	93.17	98.70	2.0
13	K. Iiao	Box	29	91.09		98.54		98.50	
14	Khonken	25.0	80	90.13		98.36	93.43	98.40	3.3
15	Hong	25	80	89.54	0.005	98.23	92.89	98.20	3.0
16	He	30	75	90.24		98.12	92.71	98.10	3.1
17	Dua	Box	22			97.94		97.90	
18	Sai	30	130	89.35		97.71	92.09	97.70	3.8
19	Phaphin	15	110	90.08		97.45	92.95	97.50	3.5
20	Phabang	50	150	87.10		97.03	90.59	97.00	2.0
21	Sahoua	30	200	90.45		96.83	95.31	96.80	2.1
22	Kok	Box	55			96.83		96.80	
23	Thateng	22	80	98.08	0.003	96.22	100.51	100.50	2.3
24	Manpa	25	44	95.74		95.14	98.35	98.40	1.5

As a result of the comparison of Case-1 and 2, there are some findings on the Route 14 bridges as follows:

- The water levels of bridge No.1 to No.21-1 are determined by the high water level of Mekong River.
- The water level of the bridge No.22 is almost the same as the interviewed water level.
- As for the design water level of bridge No.23, the interview water leveled is the similar.
- The size of box culvert should be decided from the 1/20 probability discharge mentioned above with 0.5%of slope.

Table 3.3.11 Design Water Level & Velocity at Each Bridge for Route16A

No.	Name	Bridge Span	Discharge At 1/50	R.Bed EL.(m)	River Slope	Cal.W.L. 1/50(m3)	Design W.L.	Velocity (m)
1	Makchan	25	330	1140.21		1143.26	1143.30	5.2
2	Namtang	30	460	814.64		818.70	818.70	5.6
3	Xe Katam	50	1,610	490.10		496.42	496.40	6.9
4	Namnoy-1	60	3,000	254.78		262.51	262.50	8.0
5	Namnoy-2	25	150	255.57		257.56	257.60	4.1
6	Houay Ho	30	660	262.84		266.82	266.80	6.5
7	--------		70					

There are also the following findings on the Rt.16A bridges:

- **Bridge No.1 Makchan**: The water level elevation calculated at 1/50 probability is 1143.30 m (water depth is about 3.1m). On the other hand, the interviewed water level from inhabitants nearby is about 1143.10m. The difference only 0.2m and it can be judged that the calculation water level is appropriate as the design water level for this bridge.
- **Bridge No.2 Namtang**: The water level elevation calculated at 1/50 probability is 818.70m (water depth is about 4.1 m) and the interviewed water depth is about 2.0m. The difference is 2.1m. Although there is a large difference in the depth between two figures, it is assumed that the interviewed result is not so accurate because nobody lives near the site. Accordingly, the water level calculated at 1/50 probability can be adopted as the high water level for the bridge design. In addition, due to the topographic condition, the proposed bridge elevation will be set higher than this design high water level..
- **Bridge No.3 Xe Katam**: The water level elevation calculated at 1/50 probability is 496.40 m (water depth is about 6.60 m) and the interviewed water level elevation is almost similar. The catchment area at the site is about 296 km^2, it is too large to apply the Rational Formula Method and it is said that this method results in a large value than other method generally. On the other hand, the existing bridge surface elevation is about 498.5 m. and a bridge beam height and slab thickness in total is 1.05 m. Therefore, the elevation of the beam bottom is assumed 497.45m. The existing bridge freeboard is only 0.75 m and it may not enough design freeboard, i.e.,1.0 m.
- **Bridge No.4 Namnoy-1**: The water level elevation calculated at 1/50 probability is 262.50 m (water depth is about 7.4 m) and the interviewed water level elevation is almost similar. The existing bridge surface elevation is about 263.60m. and a bridge beam height and slab thickness in total is 1.05 m. Therefore, the elevation of the beam bottom is

assumed 262.95 m. The existing bridge freeboard is only 0.05 m and it may not enough design freeboard, i.e.,1.0 m.

- **Bridge No.5 Namnoy-2**: The water level elevation calculated at 1/50 probability is 257.60 m (water depth is about 3.1 m). The existing bridge surface elevation is about 261.80 m. and a bridge beam height and slab thickness in total is 1.05 m. Therefore, the elevation of the beam bottom is 260.80 m. The elevation of the beam bottom can be secured its safety against the design high water level. (freeboard is 3.20m)
- **Bridge No.6 Houay Ho :**The water level elevation calculated at 1/50 probability is 266.80 m (water depth is about 4.0 m). The design discharge(660m^3/s) is much bigger than the water flow capacity at under the existing bridge.