Hydrology Report Delivery History

Item/No	Status/Reason	Date
1	Draft	
2	Update Design HWL and Scouring Depth - Add summary table of HWL including: Interview data, calculation data based on Road Design Manual and calculation data based on back flood from Mekong River. - Add summary table of scouring depth.	06.Oct.2023

CONTENTS

PART 01: HYDROLOGY REPORT

PART 02: CALCULATION SHEETS

PART 01

HYDROLOGY REPORT

I. Introduction

This report has described the hydro-hydraulics and stormwater drainage system prepared by Lao Transport Engineering Consultant (LTEC) to provide the detailed design for 14 bridges improvement project on NR13 South from km 71 to km 346 included 4 packages, here only for the package no.1 would be considered.

Which Package 2 was included five bridges as followed: Nam Kap Bridge, Nam Thouay Bridge, Houay Dong Kam Bridge, Nam Ngiap Bridge and Nam Xan Bridge.

The main tasks of hydro-hydraulic calculation are analysis of hydrology in the project road in accordance with climate resilient; hydraulic design to support drainage design to prevent flooding and damage to road infrastructure (especially the new bridges design) due to climate change.

II. Basic data

To serve hydro-hydraulic analysis for works transportation in the project, the following basic data and documents had been collected:

- Mapping for carrying out pertinent hydrologic and hydraulic analysis, corresponding to the catchment that the drainage for Project Road necessarily entails. The topo sheets from which calculations of catchment areas are prepared with the help of Watershed Modeling System (WMS) software by using WGS_1984 UTM Zone 48N database for DEM file for those particular locations of all bridge.

- Intensity duration frequency curves (IDF curves) of Paksane hydro-meteorological gauge stations.

- Actual data on water level measured at 03 hydro-meteorological gauge stations: Vientiane, Paksane and Thakhek on Mekong River (*), including annual highest water level of 26 years; for package 2 (Paksane Station) average daily water levels of the years with heavy floods occurred in 2008.

(*) 03 national hydro-meteorological gauge stations on the Mekong River from upstream to downstream are Vientiane, Paksane, Thakhek respectively. According to the length of the river, from Vientiane station to Paksane station is 186604 m "Applied to this package" and from Paksane station to Thakhek station is 180670 m.

III. Standards and documentation applied for the project

In the process of calculating hydro-hydraulics and stormwater drainage for the project road, the main documents of Road Design Manual issued by Department of Roads under Ministry of Public Works and Transport was applied. In addition, some other hydro-hydraulic documents and manuals used in Laos were also applied.

IV. Analysis and calculation.

IV.1. Design flood frequency.

The designs criteria have been applied to its analysis as follows:

- Bridges flood frequency of 100 years.

IV.2. Climate change.

Climate change is a macroscopic and global issue. Because of its complexity, as indicated in the Road Design Manual. In addition, 14 Bridges in the project will be considered of climate resilience in the pattern of precipitation. Which will be increased 15% into the new IDF Curve according to the assessment of precipitation percent change. More details please refer to climate adaptation report.

The following measures are applied for dealing with the issue of climate change for road drainage design: (1) Adding a 15 % increase to calculated 100-year return storm events in order to react to increases in short duration rainfall intensities; (2) The new IDF curves are used, these curves are constructed through a series of rainfall measurements from 1989 to 2018 only.

IV.3. Hydrological analysis for the bridges.

a) Estimating flood flow

The flood flow shall be calculated by the following Modified Rational Method as specified in Road Design Manual (MPWT).

- **Calculation using Modified Rational Method**

The "Rational Method" (RM) including WMS software (Rational Model) is used for estimation of the maximum water discharge for a specific run-off area, formula of the Rational Method as follows:

$$Q_{P\%} = 0.278\ C.I.\ A\ \ (ARF) \qquad (1)$$

Where:

$Q_{P\%}$ = design flood flow, m^3/s.

0.278 = a constant conversion to express discharge in the required units.

C = run-off coefficient, expressing the fraction of the rainfall that is assumed to become direct run-off.

A = the drainage catchment area in km^2.

I = intensity of rainfall in mm/hour, for the duration corresponding to the time of concentration (Tc) of each catchment area.

Tc, in hours, the time of concentration is the time period (duration) required for the rain water to reach the outlet from the most remote point of the area. The formula used is:

$$Tc = (0.87(1/H).\ L\text{^}3)\text{^}0.385 \qquad (2)$$

Where:

L = the stream flow length of the catchment area in km.

H = the corresponding level difference in meter.

Regarding the rainfall intensity, within the project road there are one meteorological station with actual rainfall data, they are Paksane. Therefore, the IDF curves of these stations will be used in calculating the design flood flow.

The equation for determining the rainfall intensity with P = 1% (or return period N = 100 years) of Paksane station is written as follows:

$$I = 570.90\ Tc\text{^}(-0.5) \qquad (3)$$

Since the five bridges in package 2 are located in Bolikhamxay Province (Paksane Station). So, the designed flood flows for these bridges were same calculated using the rainfall intensity Equation (3).

(ARF) = Area Reduction Factor from Table 01 below.

The remaining parameters in the formula were introduced above.

Table 01. Area Reduction Factor (ARF)

Area (km^2)	(ARF)	Remarks
0 - 25	1.00	
> 25 - 50	0.95	
> 50 - 100	0.90	
> 100 - 150	0.85	
> 150 - 200	0.80	

Table 02. Design flood flow for the bridges

No.	Station (km)	Bridge name	A (km^2)	$Q_{max.1\%}$ (m^3/s) used	Remarks
1	117+032	Nam Kap	36.28	211.86	
2	121+959	Nam Thoay	165.85	475.79	
3	123+850	Houay Dong Kham	4.20	24.51	
4	140+200	Nam Ngiap	1463.33	1659.35	
5	146+642	Nam Xan	7537.27	3396.52	

b) Estimating design flood water level

Estimating the design flood levels for river sections without actual measurements are very difficult. To solve this problem, HEC RAS software to conceptual approaches have been followed to justify the definition of a unique relation between the stage and discharge for an open channel: (1) treating the discharge as open-channel flow with a constant slope for a given stage namely uniform (or normal) flow; (2) treating the discharge as flow over a weir (where critical flow conditions occur, with a single value relation between stage and discharge). Based on these assumptions, in an approximate way, the design flood water levels of the bridges were estimated mainly based on the results of field surveys and the stage-discharge relation (rating curve) conducted for an open channel. Accordingly, the flow rate is determined by Area-velocity method. The volume of flow is calculated using the formula:

$$Q = A.V \qquad (5)$$

Where:

Q = Volume of flow, m^3/s

A = Wetted cross-sectional area, m^2

V = Mean velocity of the water, m/s, is given by Manning's formula.

$V = (1/n)\ (A/P)^{\wedge 2/3}.S^{\wedge 0.5}$

Where:

n = Manning's rugosity coefficient investigated at the site

P = Wetted perimeter below the calculated water level, m

S = Gradient of the water or average bed gradient investigated at the site.

Based on the stage-discharge relation conducted, from the obtained design flood flow $Q_{max.1\%}$ (Table 02), a design flood water level ($H_{max.des.}$) will be specified.

The results of calculating design flood water levels for bridges are summarized as follows.

Table 03. Design flood water level for the bridges

No.	Station (km)	Bridge name	$Q_{max.1\%}$ (m^3/s)	Free Board required (m)	$H_{max.des.}$ (m)	$Ele._{soffit}$ (m)	ΔH (m)	Remarks
1	117+032	Nam Kap	211.86	0.80	157.640	158.440	0.80	ΔH (m) = $Ele._{soffit}$ (m) – $H_{max.des.}$(m)
2	121+959	Nam Thoay	475.79	0.80	157.340	158.140	0.80	$Ele._{soffit}$ (m) = Elevation of soffit
3	123+850	Houay Dong Kham	420.24	0.80	157.180	157.980	0.80	$H_{max.des.}$(m) = Elevation of design flood water level.
4	140+200	Nam Ngiap	1659.35	1.00	156.123	157.123	1.00	ΔH <0 meaning that the bottom of the girder will be submerged when design flood occurs.
5	146+642	Nam Xan	3396.52	1.20	155.632	156.832	1.20	

Regarding soffit elevations and design flood water levels of the bridges, the clearance under the bridge with ΔH ≥ the free board value as table 3 above should still be arranged to ensure safety height for the bridges themselves.

Opening area calculation

The discharge values obtained from the above table can also be used to check drainage structures by performing "Opening Area" calculations. Accordingly, it is necessary to estimate drainage opening (required drainage opening area = $A_{req.ope.}$, m^2) and drainage structures (actual drainage opening area = $A_{act.ope.}$, m^2). The results of analyzing drainage opening areas of bridges (through the "Safety Factor" = "FS" as instructed in the Road Design Manual, Chapter 5 – Hydraulic Design) are summarized as follows.

Table 04. Results of analyzing drainage opening areas of the bridges

No.	Station (km)	Bridge name	$A_{req.ope.}$ m^2	$A_{act.ope}$ m^2	FS	Remarks
1	117+032	Nam Kap	380.88	595.51	1.63	
2	121+959	Nam Thoay	488.88	691.45	1.41	
3	123+850	Houay Dong Kham	27.64	150.43	5.44	
4	140+200	Nam Ngiap	659.47	1196.96	1.81	
5	146+642	Nam Xan	849.76	1254.91	1.48	

The determined FS values shown in the table above show that all of the bridges have enough drainage areas as required (FS > 1). Therefore, hydraulically, it is not necessary to widen the drainage aperture of bridges in project road.

However, it should be noted that, generally, the drainage aperture parameter is only one of the elements that affect the total bridge length. Therefore, when establishing a new bridge layout, if any, it is necessary to consider more about the height and side slope of the riverbank, where the abutments will be located to ensure long-term stability for the bridge. From there, a solution can be made to lengthen the bridge to ensure that the height of the abutment is not too high, and the side slope of the abutment is not too steep, if necessary. This issue will be considered by bridge engineers combined with road engineers rather than hydrologists.

The lowest water level at bridge site

The lowest water levels at the bridge sites were estimated through field investigation. The results are summarized as follows.

Table 05. The lowest water levels investigated at the bridge sites

No.	Station (km)	Bridge name	$H_{min.}$ (m)	Remarks
1	117+032	Nam Kap	147.500	
2	121+959	Nam Thoay	143.500	
3	123+850	Houay Dong Kham	153.500	
4	140+200	Nam Ngiap	142.000	
5	146+642	Nam Xan	143.000	

The lowest water values at the bridge sites shown in the above table can be used in the design of abutments and pier foundations, and also serve the arrangement of work items during

construction.

a) Determination of design flood water level

- **For the segment of inundated due to floods rising from the Mekong River**

Field hydrographic investigation results and measured water levels for 26 years (from 1993 to 2018) at 3 hydrological stations of Vientiane, Paksane, and Thakhek on the Mekong River are basic input data to estimate the design flood level. The results of analyzing statistical method of the annual highest water level frequency in 26 years at the 03 stations show that the slope of flood water surface from Vientiane to Paksane is approximately S ≈ 0.000072 (Package 2 only 2 stations will be considered).

IV.4. Bridges

Table 06. Hydrological parameters for the bridges

No.	Station (km)	Bridge name	A (km^2)	$Q_{max.1\%}$ (m^3/s)	$H_{max.des.}$ (m)	$H_{min.}$ (m)	FS	Remarks
1	117+032	Nam Kap	36.28	211.86	157.64	147.500		
2	121+959	Nam Thoay	165.85	475.791	157.34	143.500		
3	123+850	HouayDong Kham	4.20	24.51	157.18	153.500		
4	140+200	Nam Ngiap	1463.33	1659.35	156.12	142.000		
5	146+642	Nam Xan	7537.27	3396.52	155.63	143.000		

Hydro-hydraulic analysis for DED upgrading 14 Bridges along the NR 13 South from km71 to km 346 (New Design of 14 Bridges) have been carried out on the basis of field investigation documents, actual meteor-hydrological data measured at 03 National gauge stations, including the consideration of climate change. During the reporting process, the requirements of specific standards and Road Design Manual were strictly followed.

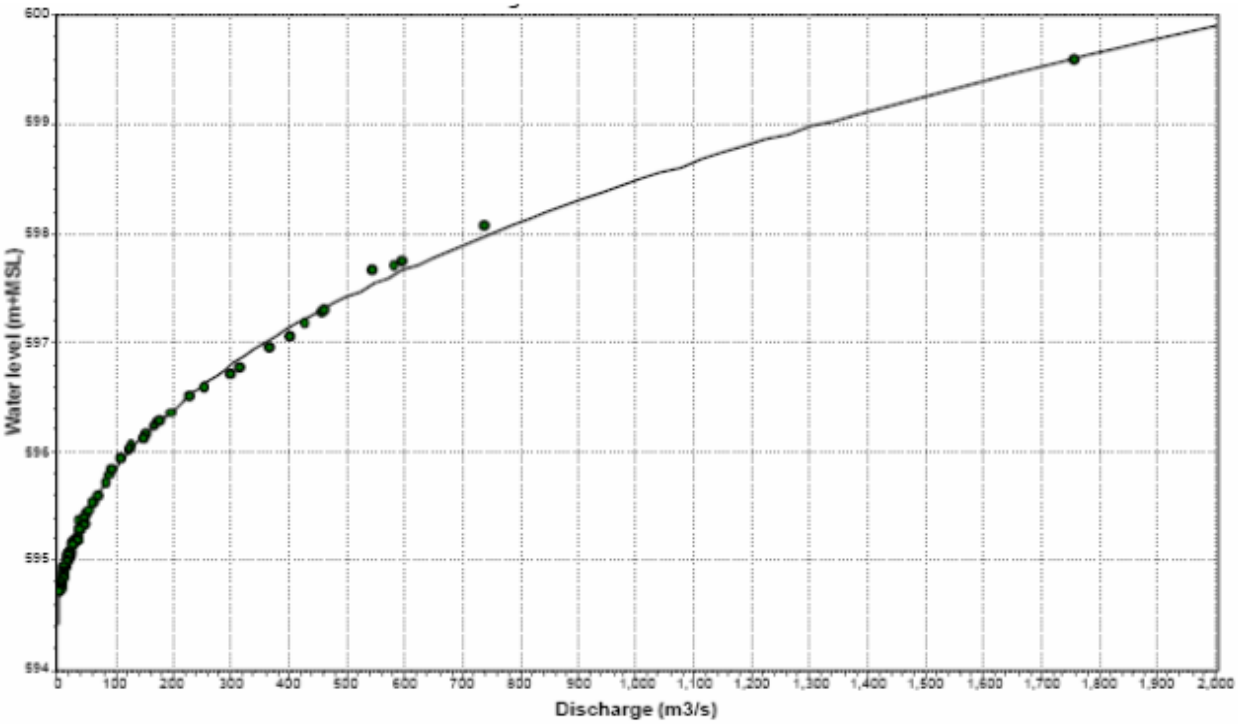
However, as is known, for many reasons, some of the input data for hydro-hydraulic calculations are still incomplete, such as:

- **For bridges**

In addition to the results of the investigation of the flood traces left in the field, so far there has not been any actual measurement of water level and flood flow on the river sections where the existing bridges located.

In the subsequent research steps, if possible, project management agencies should allow to carry out measurement of some hydrological parameters during the flood season to create the stage-discharge relation and some others; including charts that correlate with actual hydrological data measured by the national gauge stations on the Mekong River. Especially the rating curve (as described in Figure 01) has been and is extensively used tool in hydrology to estimate discharge or water level in natural rivers.

Figure 01: Example of a typical simple stage-discharge relation



The results determined by analyzing those relationships should be more realistic basis for adjusting the parameters analyzed from this DED Stage, if any.

Procedure for calculating the high-water level for the bridge

High flood level for the bridge had three methods to compare as follows:

1. Analysis as per manual is followed Rational Method at 100-year return period for Hydrology Assessment and using Manning equation Hydraulic Calculation. (Hereinafter called $H_{cal.1\%}$). More details please see Part 2 Calculation Sheet.

2. High-water level which is directly influenced by the Mekong River. Back flood analysis or flood frequency analysis conducted from various stations such as: Vientiane, Paksane and

Thakhek. (Hereinafter Called H_{back})

ESTIMATION OF THE DESIGNED HIGHT FLOOD WATER LEVEL FOR BRIDGES

No.	Station (km)	Name of Bridge	Paksane station			$I_{cal.}$	$Dl_{riv.}$ (m) from Paks. to Brid.	DH (m)	$H_{max.1\%}$ (m) at river mouth	**$H_{max.Inv.}$ (m) at the Brid. site**	Dl (m) from Bri. to Mekong River
			Altitude (m)	$h_{max.}$ (m)	$H_{max.}$ (m)						
1	117+032	Nam Kap	140.7	14.80	155.5	0.0000071	29888	2.12	157.64	156.918	390
2	121+959	Nam thuay					25647	1.82	157.34	156.681	396
3	123+850	Nam H Dong Kam					23421	1.66	157.18	155.632	**705**
4	140+200	Nam Ngiap					7021	0.50	156.02	156.123	1068
5	146+642	Nam Xan					414	0.03	155.55	155.632	2116

When:

$h_{max.}$is the water level in the Mekong River at the monitoring station.

$H_{max\ 1\%}$ Is High Flood Level (back flood)

$H_{max\ Inv}$ Is High Flood Level (Resident interview)

ΔL is distance

I_{cal} is slope

3. Based on a field observation conducted on 7 to 8 September 2023, a team consisting of PMU staff or project coordinators and consultants interviewed residents to take the historical high-water level.

HIGH FLOOD LEVEL OF EACH ITEH

After considering the results of hydraulic and hydrological modelling, Back flood from Mekong River, and historical flood levels, the maximum value will be chosen for designing the high-water level of the bridges. By selecting the highest value as below.

SUMMARY OF HWL RECHECK FOR 14 BRIDGES ON NR13S (LAO PDR)
UPDATED ON 18,SEPTEMBER 2023.

Sl. No.	Station	Bridge Name	No. of Span	Span Arrangement (m)	$H_{cal\ 1\%}$ (Updated)	$H_{back\text{-}MK}$	HWL (Recent-Interviews dated on 7-8,Sept.2023-PMU agreed)	HWL Consider to design	Existing FRL
					(m)	(m)	(m)	(m)	(m)
1	2	3	4	5	6	7	8	9	10
1	106+460	Nam ching	3	20.30+26.50+20.30=67.10	156.52	158.370	159.206	159.206	161.040
2	109+890	Nam Lo	3	26.30+26.30+26.30=78.90	152.44	158.160	157.897	158.160	160.569
3	117+038	Nam Kap	3	26.50+26.50+26.50=79.50	156.25	157.640	156.918	157.640	160.382
4	121+952	Nam Thoay	3	20.30+26.30+26.30=72.90	155.96	157.340	156.681	157.340	160.103
5	123+850	Houay dong kham	1	28.00	154.93	157.180	155.632	157.180	159.474
6	140+200	Nam Ngiap	5	20.40+26.40+26.40+26.40+20.40=120	152.76	156.020	156.123	156.123	158.914
7	146+642	Nam Xan	5	20.40+20.40+26.40+26.40+20.40=114	154.86	155.550	155.632	155.632	158.699
8	204+400	Houay Xamboungnai	1	25.4	152.56		155.127	155.127	158.120
9	217+578	Houay Deua2	3	20.30+20.30+20.30=60.90	152.88		153.281	153.281	156.000
10	231+199	Nam Sang	1	20.3	157.42		157.628	157.628	159.620
11	239+051	Nam Thone	3	26.00+26.40+26.00=78.40	156.13		157.406	157.406	159.200
12	288+400	Nam Hinboun	3	39.00+46.00+39.00=124.00	143.71		145.270	145.270	151.181
13	306+570	Houay Aek	1	25.60	146.91		146.880	146.910	151.179
14	325+800	Nam Done	3	26.00+26.50+26.00=78.50	142.42	143.040	143.750	143.750	147.072

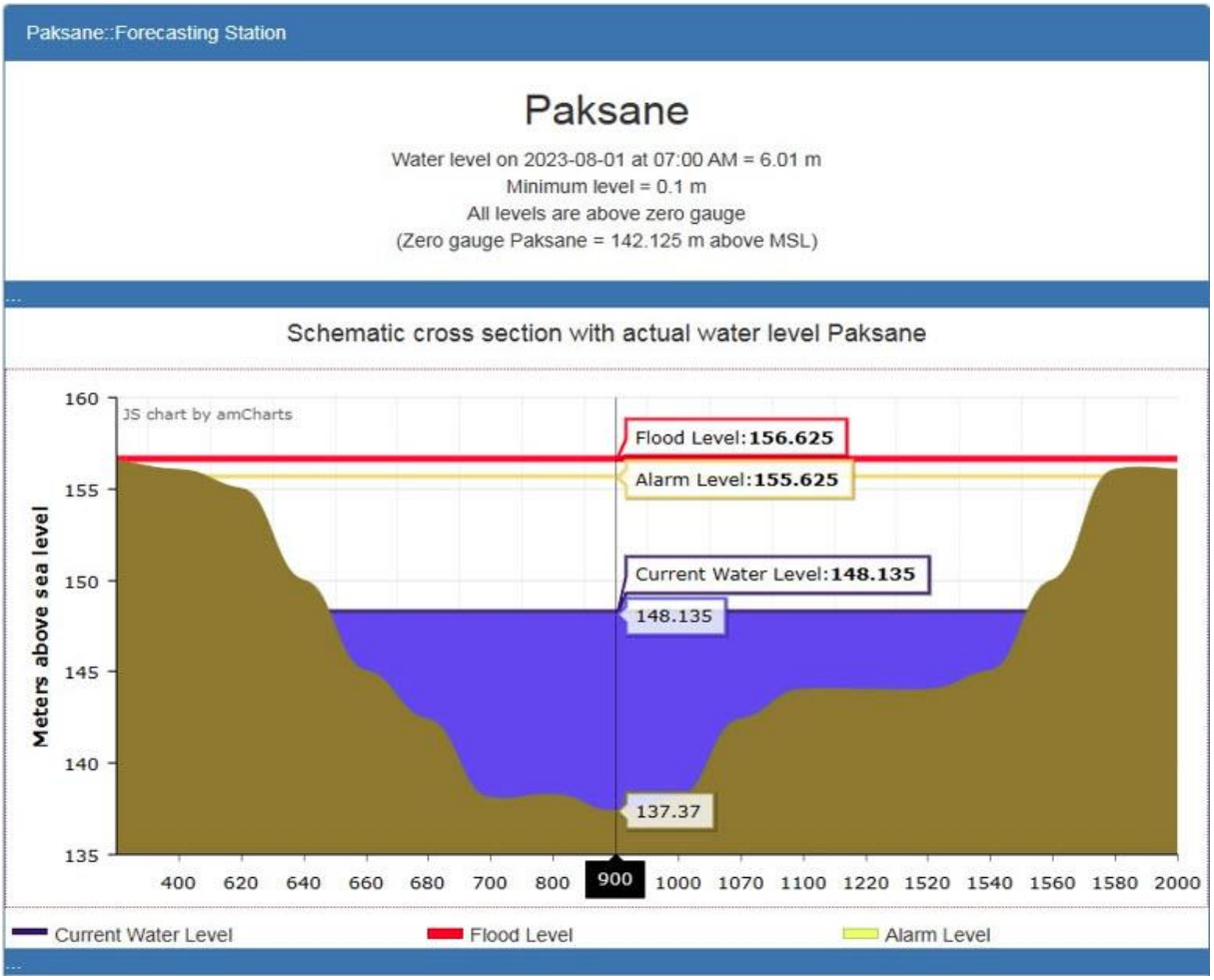
Notes:
- Hcal 1% (Updated) in column 6 is HWL calculation update.
- H(back-MK) in column 7 is HWL of water back of Mekong river calculated from meteorological measurement gauge datas of each stations in normal.
- HWL in column 9 is Highest water level considered for design, which they are selected from the maximum levels of Hcal 1% in column 6, H back-MK in column 7 and HWL recent interviewed in column 8 and they are also assured from PMU or project coordinators.

For LTEC
Phoutsavanh PHIMMAVONG
Sonexay PHOMCHAMPA

For LASA
S.K.Rusta

For PMU/Project Coordinators
VATTHANA

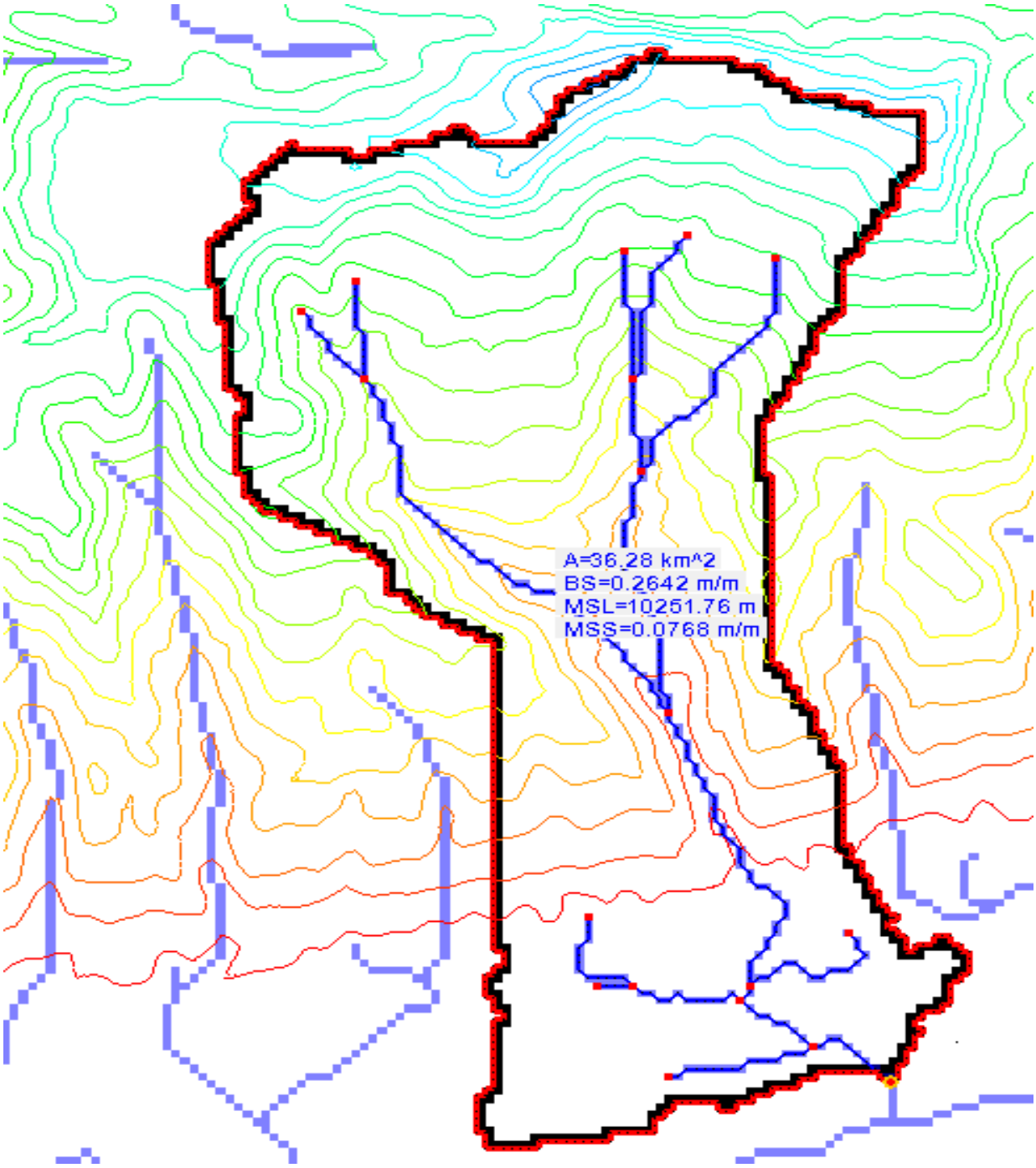
According to the calculation data of the highest water level for the bridges at the river branches close with the Mekong, we observed that there is an appropriate with the data information of the Mekong River Commission website at Pakxan hydrological station. So, we can assume the highest water level analysis for the bridges are to correct and enable to apply for the bridges designing.


Paksane::Forecasting Station
Paksane
Water level on 2023-08-01 at 07:00 AM = 6.01 m
Minimum level = 0.1 m
All levels are above zero gauge
(Zero gauge Paksane = 142.125 m above MSL)
Schematic cross section with actual water level Paksane
JS chart by amCharts
Flood Level:156.625
Alarm Level:155.625
Current Water Level:148.135
148.135
137.37
Meters above sea level
160
155
150
145
140
135
400
620
640
660
680
700
800
900
1000
1070
1100
1220
1520
1540
1560
1580
2000
Current Water Level
Flood Level
Alarm Level

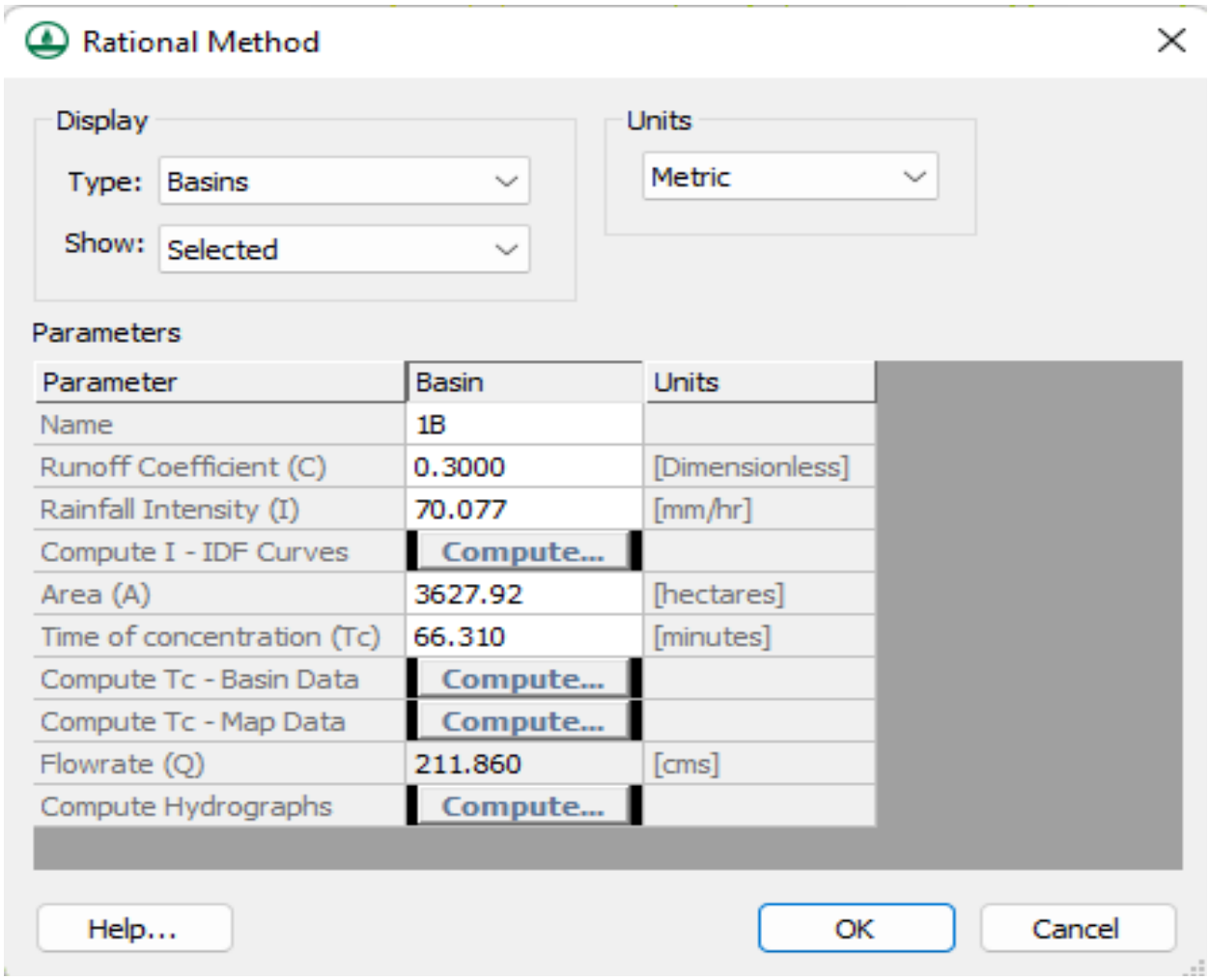
PART 2

CALCULATION SHEETS

2.1.1. Bridge 01: Nam Kap



2) Rational Model



3) Cross Section output of bridge station

Cross Section Output

File Type Options Help

River: Nam Kap Profile: 100 Years

Reach 1 RS: 100 BR U Plan: Plan 01

Plan: Plan 01 Nam Kap 1 RS: 100 BR U Profile: 100 Years

		Element	Left OB	Channel	Right OB
E.G. Elev (m)	156.26	Wt. n-Val.	0.150	0.100	0.150
Vel Head (m)	0.02	Reach Len. (m)	10.80	10.80	10.80
W.S. Elev (m)	156.24	Flow Area (m2)	62.68	278.17	40.03
Crit W.S. (m)	146.78	Area (m2)	62.68	278.17	40.03
E.G. Slope (m/m)	0.000488	Flow (m3/s)	17.08	185.30	9.48
Q Total (m3/s)	211.86	Top Width (m)	18.33	26.47	19.05
Top Width (m)	63.85	Avg. Vel. (m/s)	0.27	0.67	0.24
Vel Total (m/s)	0.56	Hydr. Depth (m)	3.42	10.51	2.10
Max Chl Dpth (m)	13.51	Conv. (m3/s)	773.0	8388.6	429.3
Conv. Total (m3/s)	9590.9	Wetted Per. (m)	24.91	53.12	19.62
Length Wtd. (m)	10.80	Shear (N/m2)	12.04	25.06	9.76
Min Ch El (m)	142.74	Stream Power (N/m s)	3.28	16.69	2.31
Alpha	1.28	Cum Volume (1000 m3)	10.87	38.43	6.51
Frctn Loss (m)	0.01	Cum SA (1000 m2)	3.10	3.77	2.39
C & E Loss (m)	0.00				

4) Profile output table

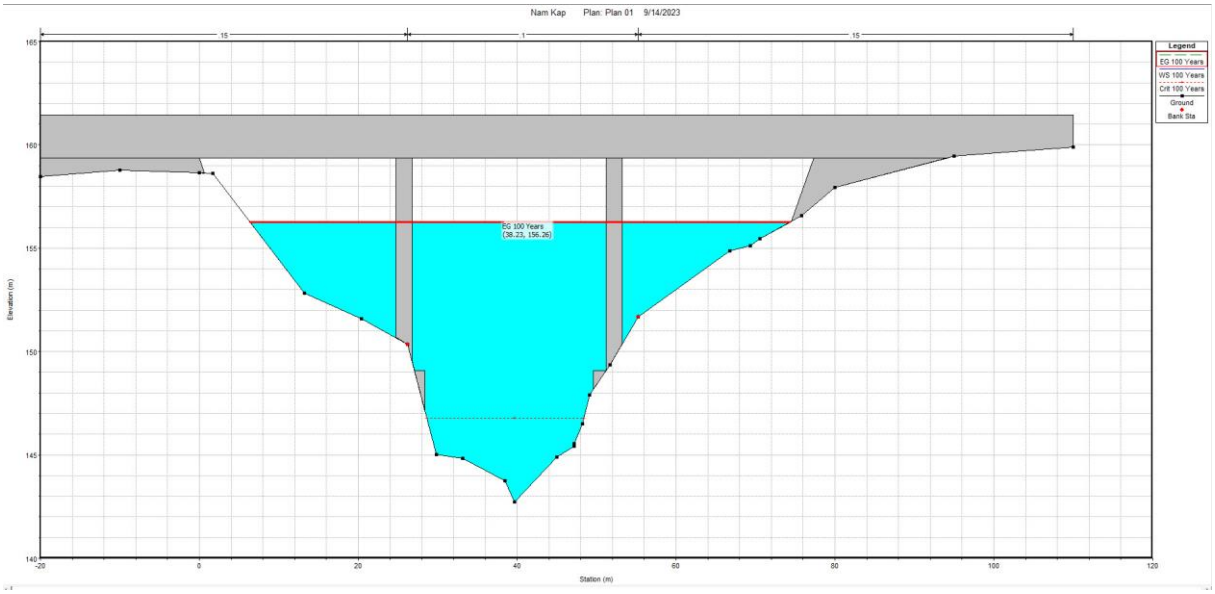
Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

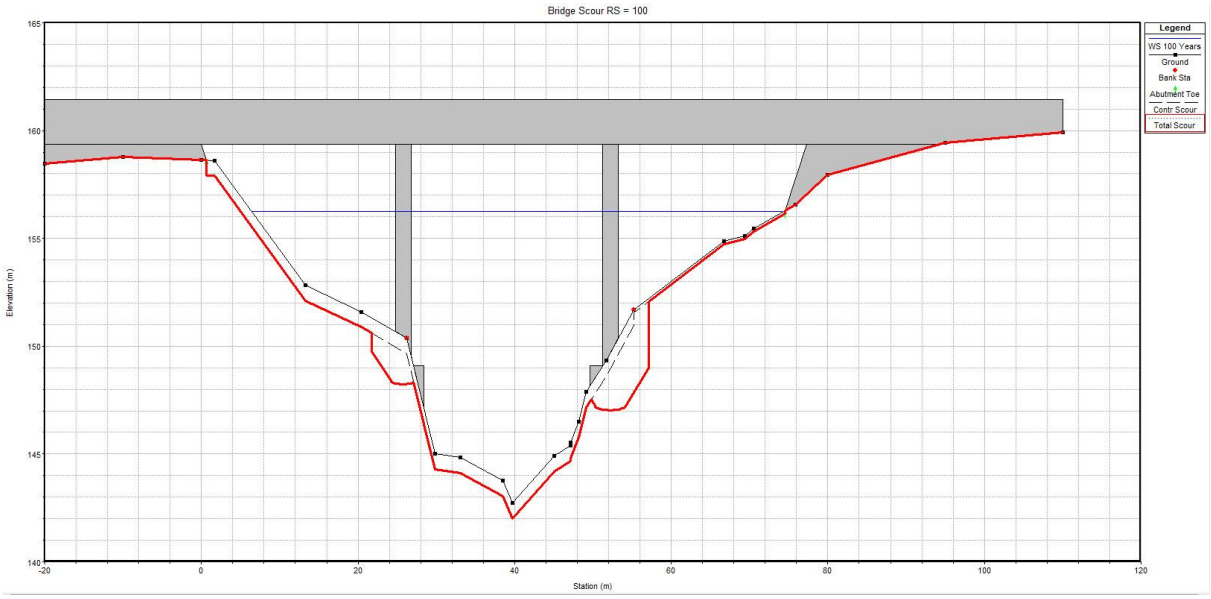
HEC-RAS Plan: Plan 01 River: Nam Kap Reach: 1 Profile: 100 Years

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	200	100 Years	211.86	143.41	156.29		156.30	0.000153	0.53	490.30	80.00	0.05
1	150	100 Years	211.86	143.85	156.28		156.29	0.000189	0.63	484.64	80.00	0.06
1	110	100 Years	211.86	142.74	156.25	146.78	156.27	0.000235	0.64	408.35	67.91	0.06
1	100		Bridge									
1	90	100 Years	211.86	142.74	156.23		156.25	0.000237	0.64	407.02	67.78	0.06
1	50	100 Years	211.86	142.78	156.22		156.24	0.000187	0.59	453.30	73.38	0.06
1	0	100 Years	211.86	142.65	156.21	146.84	156.23	0.000200	0.63	451.70	77.93	0.06

5) Cross Section of Bridge



6) Bridge Scour



Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (m):	3.88	10.81	4.20
	Approach Velocity (m/s):	0.21	0.63	0.22
	Br Average Depth (m):	3.42	10.51	2.10
	BR Opening Flow (m3/s):	17.08	185.30	9.48
	BR Top WD (m):	18.33	26.47	19.05
	Grain Size D50 (mm):	0.21	0.53	0.37
	Approach Flow (m3/s):	20.83	162.21	28.82
	Approach Top WD (m):	25.62	23.73	30.65
	K1 Coefficient:	0.690	0.690	0.690
Results				
	Scour Depth Ys (m):	0.70	0.73	0.15
	Critical Velocity (m/s):			
	Equation:	Live	Live	Live

Pier Scour

Pier: #1 (CL = 25.75)

Input Data

Pier Shape:	Circular cylinder
Pier Width (m):	2.00
Grain Size D50 (mm):	0.70000
Depth Upstream (m):	5.79
Velocity Upstream (m/s):	0.27
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (m):	10.80
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	7.56000
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (m):	1.52
Froude #:	0.04
Equation:	CSU equation

Pier: #2 (CL = 52.24)

Input Data

Pier Shape:	Circular cylinder
Pier Width (m):	2.00
Grain Size D50 (mm):	0.37000
Depth Upstream (m):	6.55
Velocity Upstream (m/s):	0.45
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (m):	10.80
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	4.76000
K4 Armouring Coef:	1.00

Results

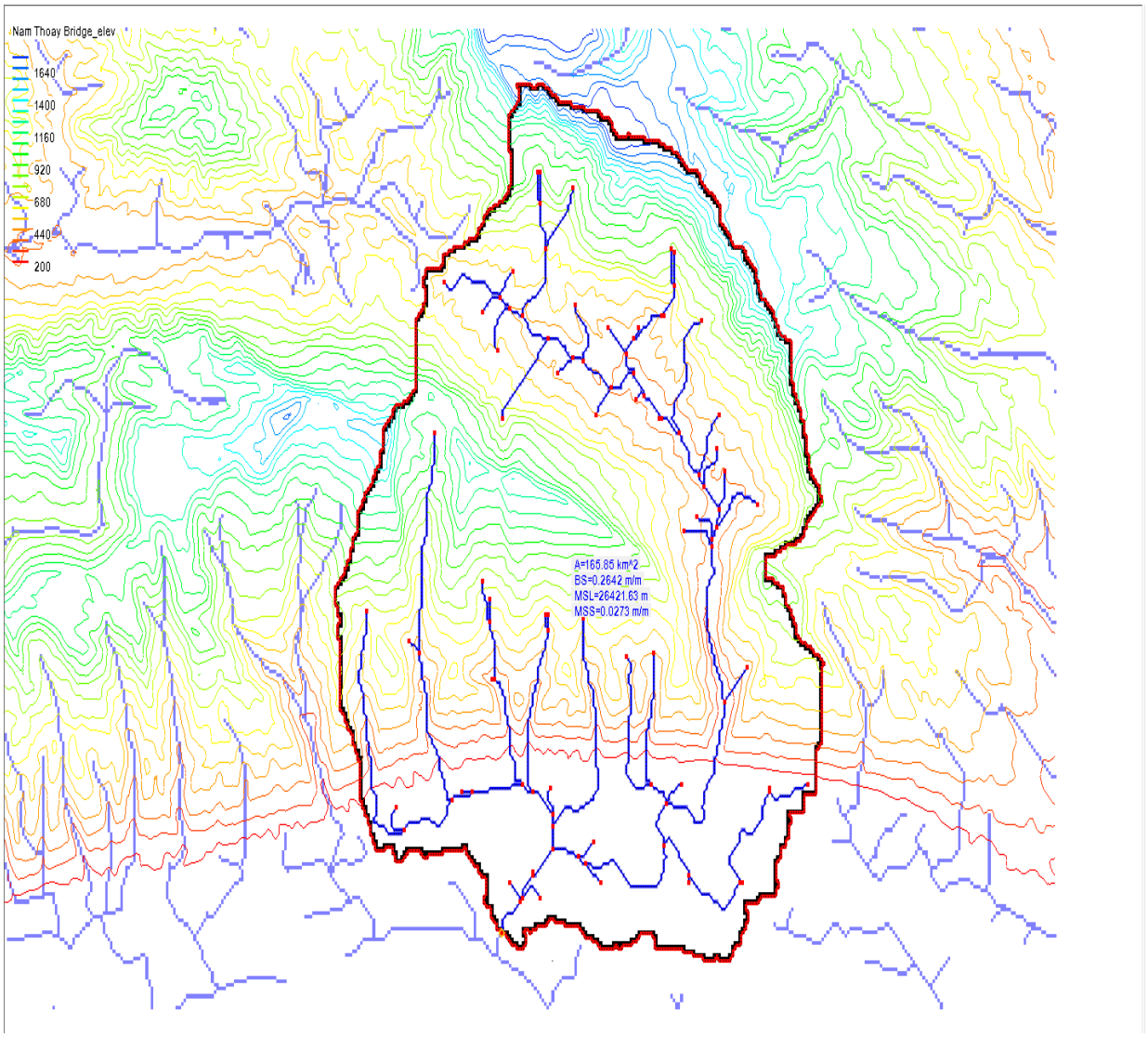
Scour Depth Ys (m):	1.94
Froude #:	0.06
Equation:	CSU equation

Combined Scour Depths

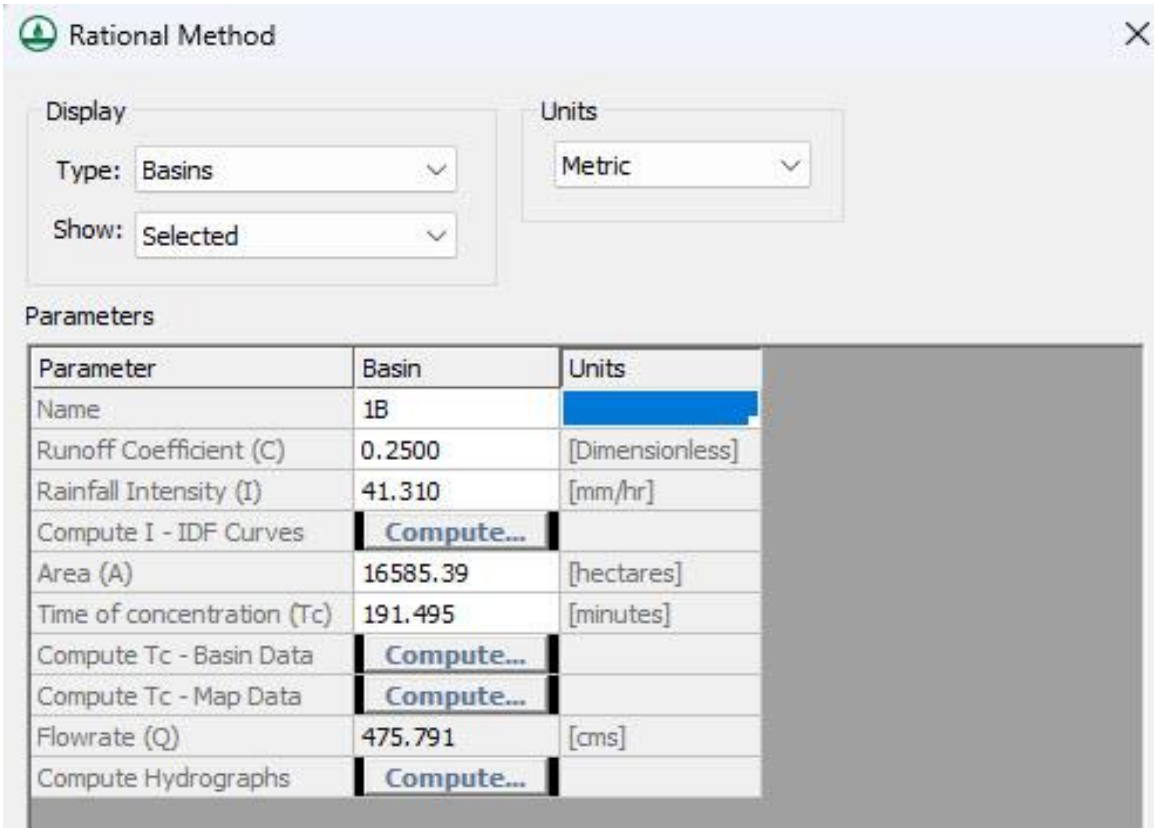
Pier : #1 (CL = 25.75) (Contr + Pier) (m):	2.22
Pier : #2 (CL = 52.24) (Contr + Pier) (m):	2.67

2.1.2. Bridge 04: Nam Thouay

1) Catchment area



2) Rational Model



3) Cross Section output of bridge station

Cross Section Output

File Type Options Help

River: Nam Thoay Profile: 100 Years

Reach 1 RS: 100 BR U Plan: Plan 01

Plan: Plan 01 Nam Thoay 1 RS: 100 BR U Profile: 100 Years

		Element	Left OB	Channel	Right OB
E.G. Elev (m)	155.99	Wt. n-Val.	0.100	0.100	0.100
Vel Head (m)	0.05	Reach Len. (m)	10.80	10.80	10.80
W.S. Elev (m)	155.94	Flow Area (m2)	60.70	386.67	41.51
Crit W.S. (m)	147.37	Area (m2)	60.70	386.67	41.51
E.G. Slope (m/m)	0.001224	Flow (m3/s)	50.83	394.69	30.27
Q Total (m3/s)	475.79	Top Width (m)	14.16	35.72	12.24
Top Width (m)	62.12	Avg. Vel. (m/s)	0.84	1.02	0.73
Vel Total (m/s)	0.97	Hydr. Depth (m)	4.29	10.82	3.39
Max Chl Dpth (m)	14.32	Conv. (m3/s)	1453.2	11283.1	865.3
Conv. Total (m3/s)	13601.7	Wetted Per. (m)	16.39	77.57	13.80
Length Wtd. (m)	10.80	Shear (N/m2)	44.45	59.81	36.11
Min Ch El (m)	141.61	Stream Power (N/m s)	37.23	61.05	26.33
Alpha	1.03	Cum Volume (1000 m3)	6.82	52.42	7.20
Frctn Loss (m)	0.01	Cum SA (1000 m2)	2.60	4.92	1.98
C & E Loss (m)	0.00				

4) Profile output table

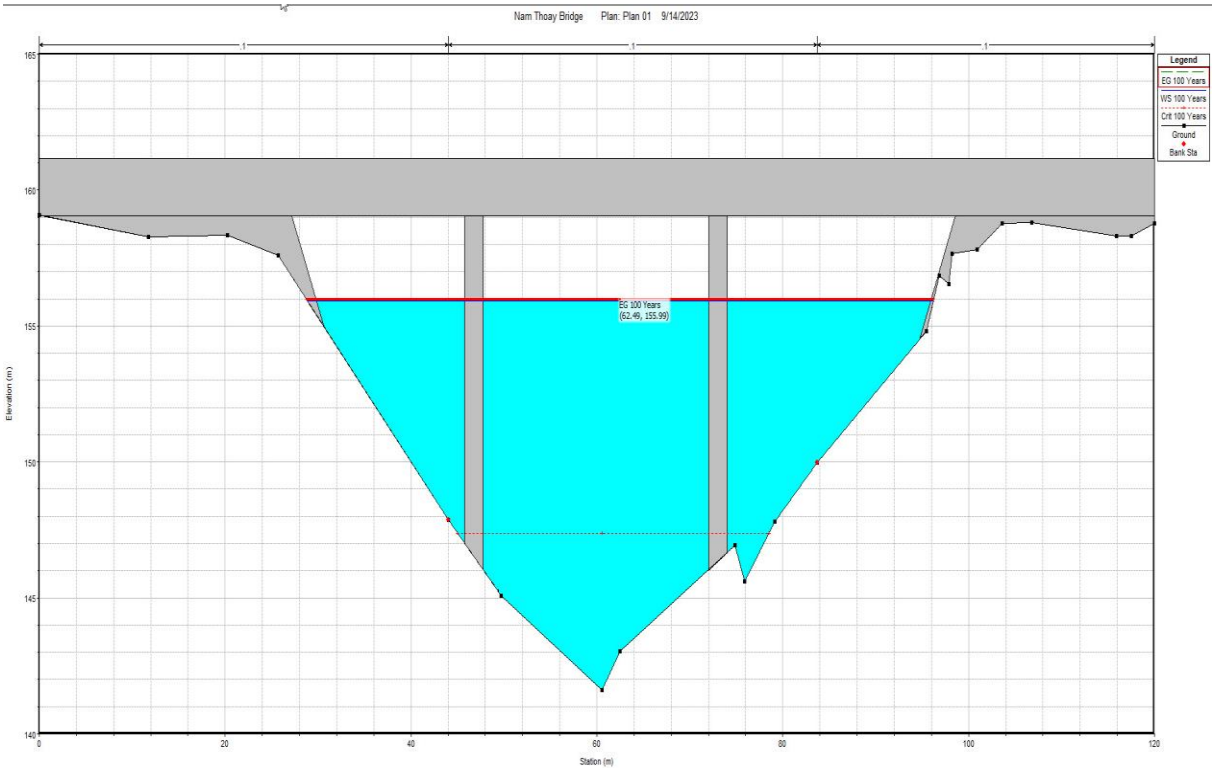
Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

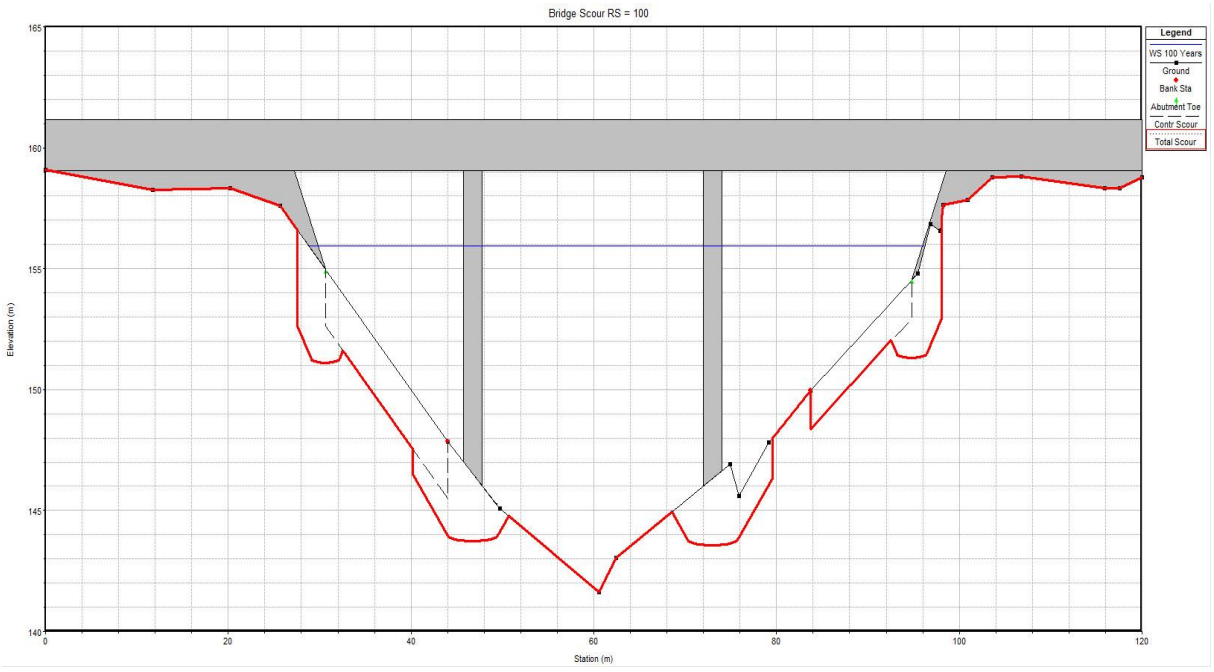
HEC-RAS Plan: Plan 01 River: Nam Thoay Reach: 1 Profile: 100 Years

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	200	100 Years	475.79	140.90	156.03		156.10	0.000683	1.28	472.80	79.22	0.12
1	150	100 Years	475.79	141.68	156.01		156.06	0.000618	1.07	498.59	80.48	0.11
1	110	100 Years	475.79	141.61	155.96	147.37	156.00	0.000482	1.00	529.05	67.40	0.10
1	100		Bridge									
1	90	100 Years	475.79	141.61	155.91		155.96	0.000489	1.00	526.05	67.28	0.10
1	50	100 Years	475.79	141.53	155.88		155.93	0.000524	1.05	517.58	81.71	0.10
1	0	100 Years	475.79	141.76	155.85	147.45	155.90	0.000570	1.10	495.71	72.78	0.11

5) Cross Section of Bridge



6) Bridge Scour



Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (m):	3.07	9.80	1.90
	Approach Velocity (m/s):	0.49	1.07	0.36
	Br Average Depth (m):	4.29	10.82	3.39
	BR Opening Flow (m3/s):	50.83	394.69	30.27
	BR Top WD (m):	14.16	35.72	12.24
	Grain Size D50 (mm):	1.87	0.93	0.07
	Approach Flow (m3/s):	18.92	438.89	17.99
	Approach Top WD (m):	12.58	41.89	26.01
	K1 Coefficient:	0.640	0.690	0.690
Results				
	Scour Depth Ys (m):	2.35	0.00	1.60
	Critical Velocity (m/s):			
	Equation:	Live	Live	Live

Pier Scour

Pier: #1 (CL = 46.76)

Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	1.26000
	Depth Upstream (m):	9.44
	Velocity Upstream (m/s):	0.94
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (m):	10.80
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	12.70000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	2.78
	Froude #:	0.10
	Equation:	CSU equation

Pier: #2 (CL = 73)

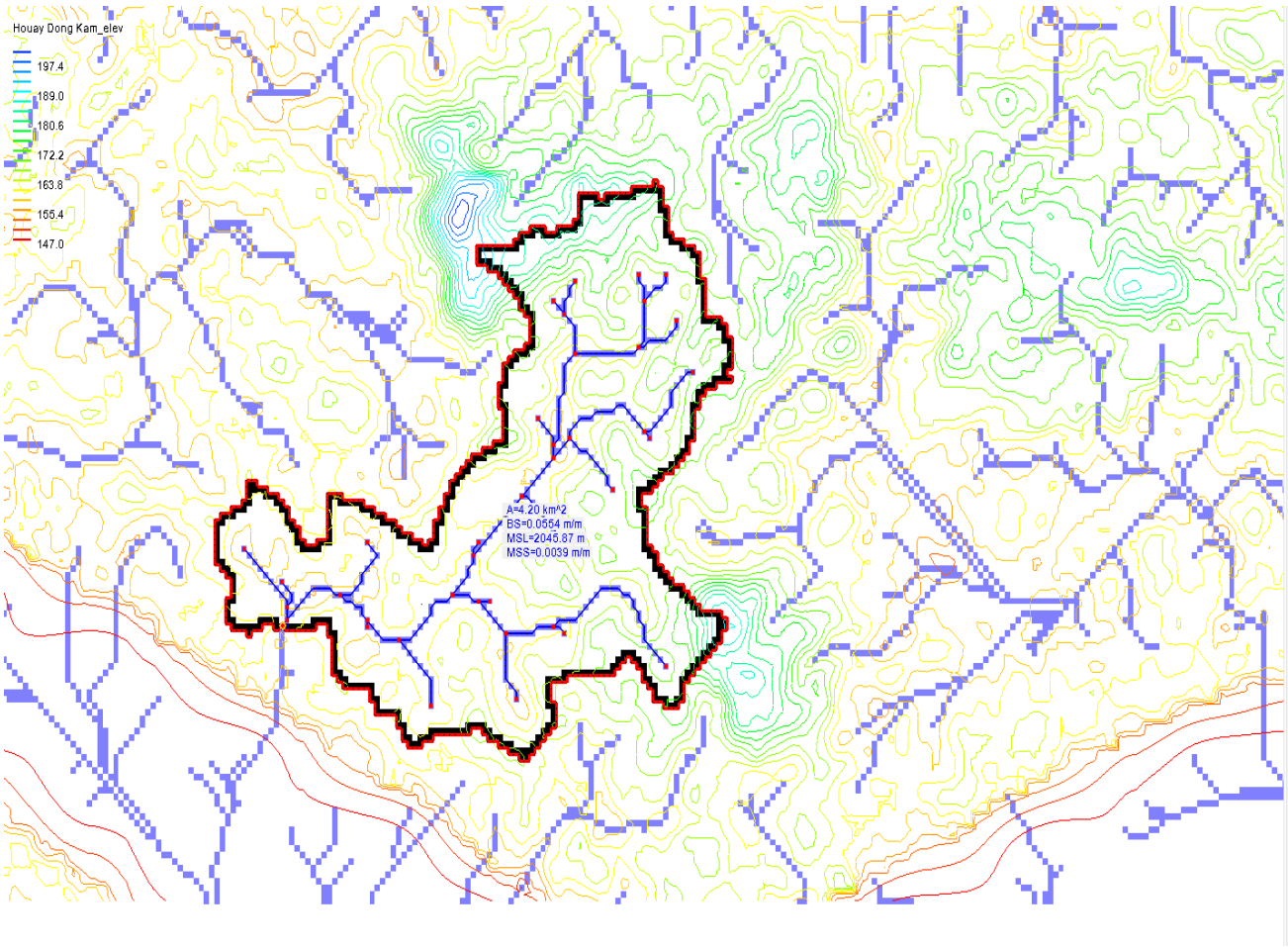
Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	0.59000
	Depth Upstream (m):	9.62
	Velocity Upstream (m/s):	0.93
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (m):	10.80
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	7.45000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	2.78
	Froude #:	0.10
	Equation:	CSU equation

Abutment Scour

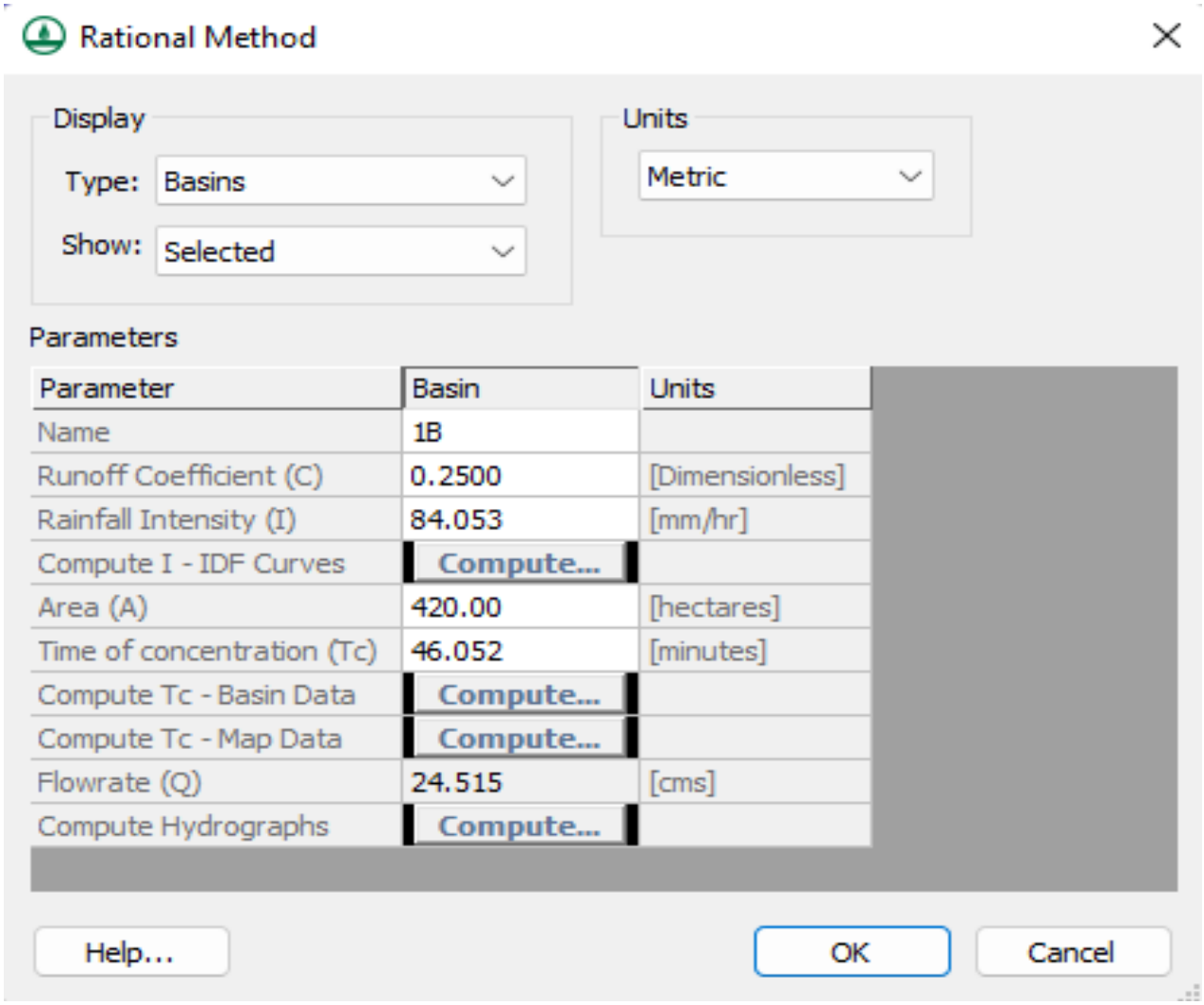
		Left	Right
Input Data			
	Station at Toe (m):	30.64	94.79
	Toe Sta at appr (m):	18.74	85.06
	Abutment Length (m):	2.29	1.23
	Depth at Toe (m):	0.97	1.41
	K1 Shape Coef:	0.55 - Spill-through abutment	
	Degree of Skew (degrees):	90.00	90.00
	K2 Skew Coef:	1.00	1.00
	Projected Length L' (m):	1.98	1.23
	Avg Depth Obstructed Ya (m):	1.01	1.24
	Flow Obstructed Qe (m3/s):	0.90	0.55
	Area Obstructed Ae (m2):	2.00	1.53
Results			
	Scour Depth Ys (m):	1.52	1.63
	Qe/Ae = Ve:	0.45	0.36
	Froude #:	0.14	0.10
	Equation:	Froehlich	Froehlich

2.1.3. Bridge 05: Houay Dong Kham

1) Catchment area



2) Rational Model



3) Cross Section output of bridge station

Cross Section Output

File Type Options Help

River: Houay Dong Kham Profile: 100 Years

Reach 1 RS: 100 BR U Plan: Plan 01

Plan: Plan 01 Houay Dong Kham 1 RS: 100 BR U Profile: 100 Years

		Element	Left OB	Channel	Right OB
E.G. Elev (m)	154.38				
Vel Head (m)	0.00	Wt. n-Val.	0.150	0.100	
W.S. Elev (m)	154.38	Reach Len. (m)	10.80	10.80	10.80
Crit W.S. (m)	152.49	Flow Area (m2)	1.14	26.50	
E.G. Slope (m/m)	0.000368	Area (m2)	1.14	26.50	
Q Total (m3/s)	7.14	Flow (m3/s)	0.08	7.06	
Top Width (m)	17.65	Top Width (m)	2.42	15.23	
Vel Total (m/s)	0.26	Avg. Vel. (m/s)	0.07	0.27	
Max Chl Dpth (m)	2.74	Hydr. Depth (m)	0.47	1.74	
Conv. Total (m3/s)	372.2	Conv. (m3/s)	4.4	367.8	
Length Wtd. (m)	10.80	Wetted Per. (m)	2.60	16.21	
Min Ch El (m)	151.63	Shear (N/m2)	1.59	5.90	
Alpha	1.05	Stream Power (N/m s)	0.12	1.57	
Frctn Loss (m)	0.00	Cum Volume (1000 m3)	0.15	3.54	0.05
C & E Loss (m)	0.00	Cum SA (1000 m2)	0.29	2.04	0.16

4) Profile output table

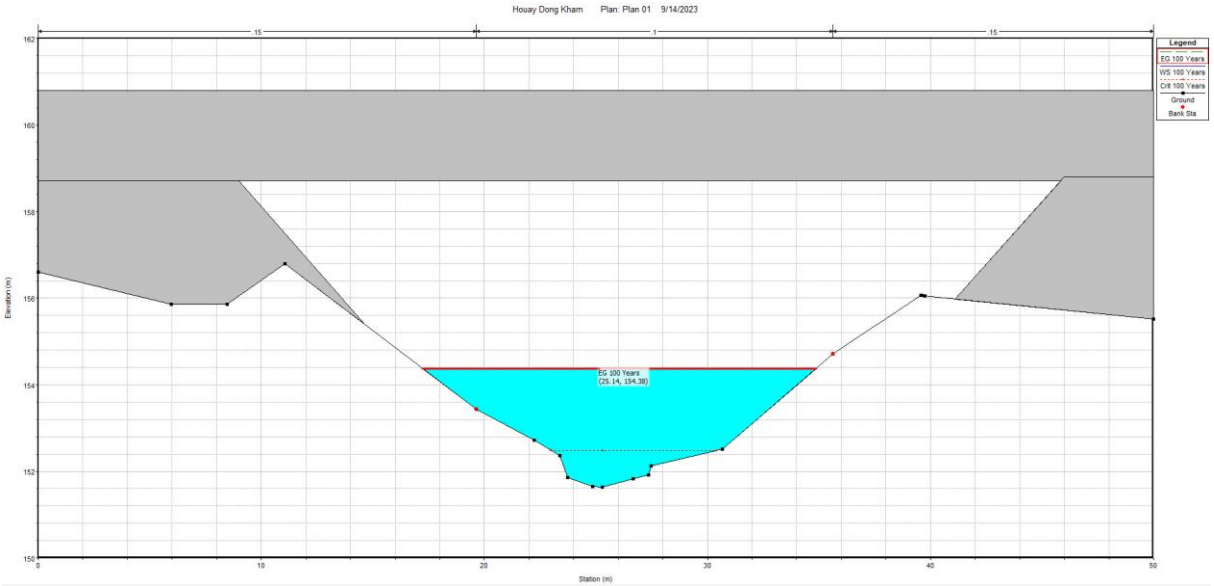
Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

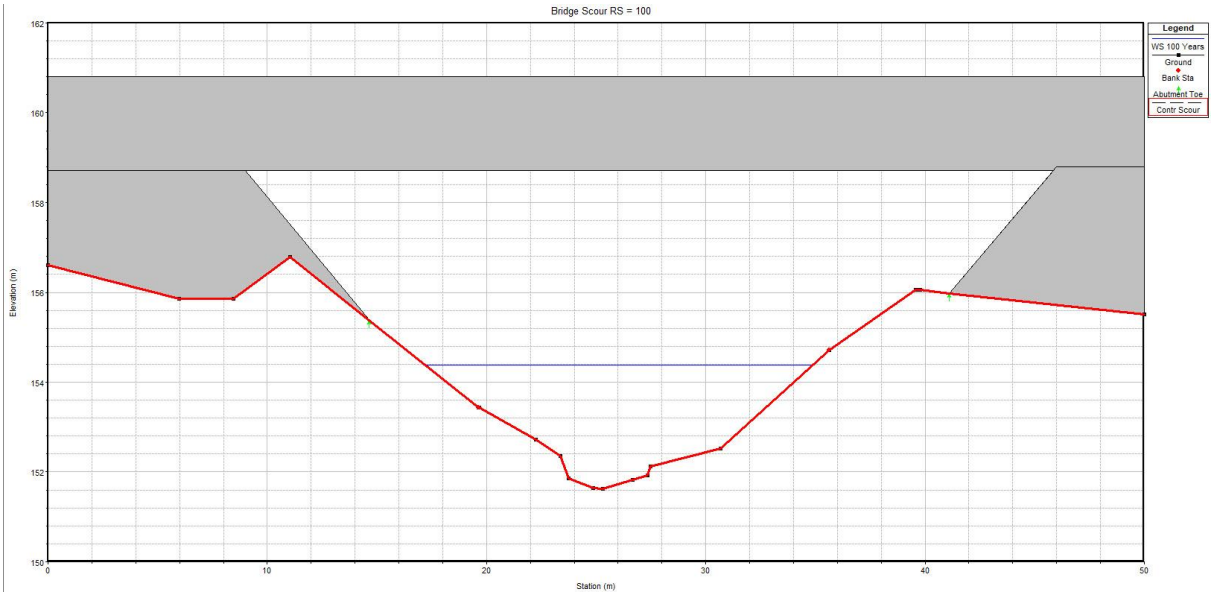
HEC-RAS Plan: Plan 01 River: Houay Dong Kham Reach: 1 Profile: 100 Years

Reach	River Sta	Profile	Q Total (m3/s)	Min Ch El (m)	W.S. Elev (m)	Crit W.S. (m)	E.G. Elev (m)	E.G. Slope (m/m)	Vel Chnl (m/s)	Flow Area (m2)	Top Width (m)	Froude # Chl
1	200	100 Years	7.14	151.41	154.42		154.43	0.000280	0.26	30.74	22.17	0.06
1	150	100 Years	7.14	151.79	154.40		154.41	0.000500	0.35	26.66	20.70	0.08
1	110	100 Years	7.14	151.63	154.38	152.48	154.39	0.000363	0.27	27.78	17.68	0.06
1	100		Bridge									
1	90	100 Years	7.14	151.63	154.36		154.37	0.000375	0.27	27.45	17.59	0.07
1	50	100 Years	7.14	151.55	154.35		154.35	0.000347	0.25	29.04	18.69	0.06
1	0	100 Years	7.14	151.12	154.33	152.06	154.33	0.000290	0.26	31.00	23.55	0.06

5) Cross Section of Bridge



6) Bridge Scour

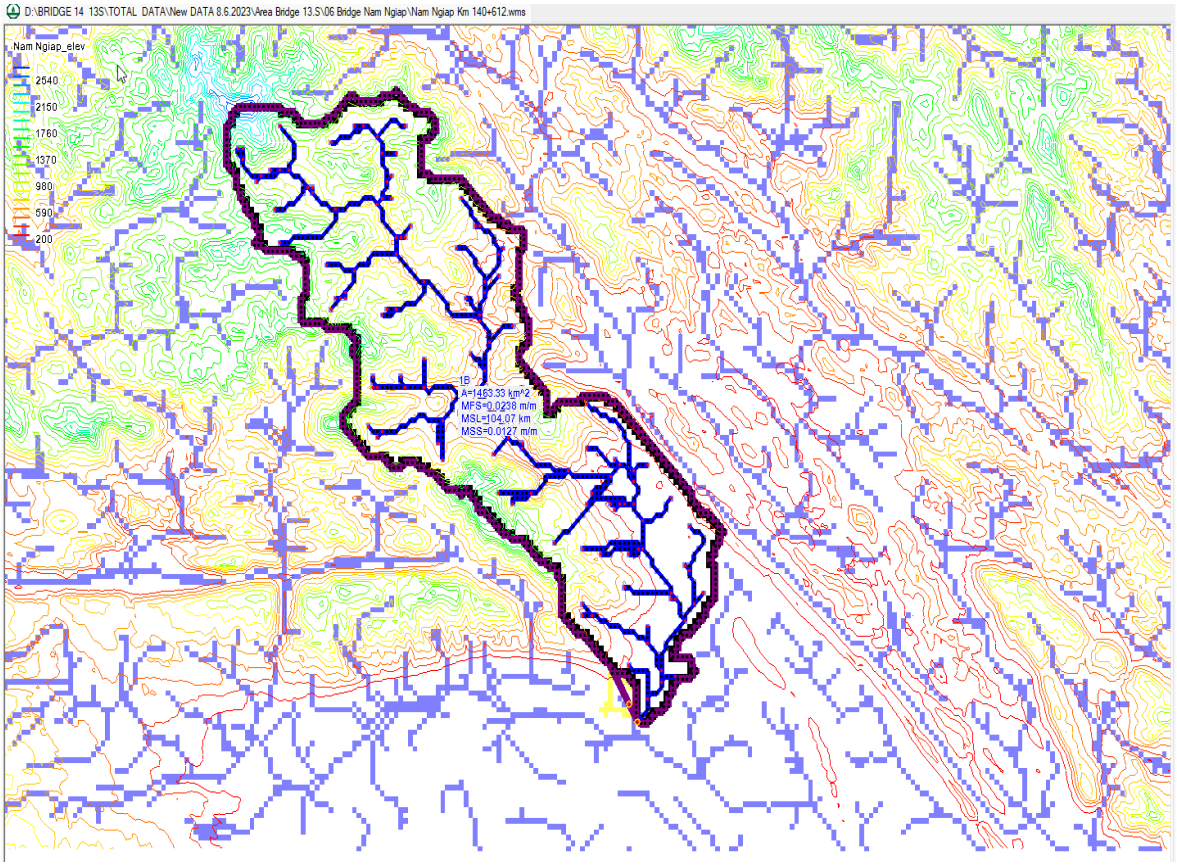


Contraction Scour

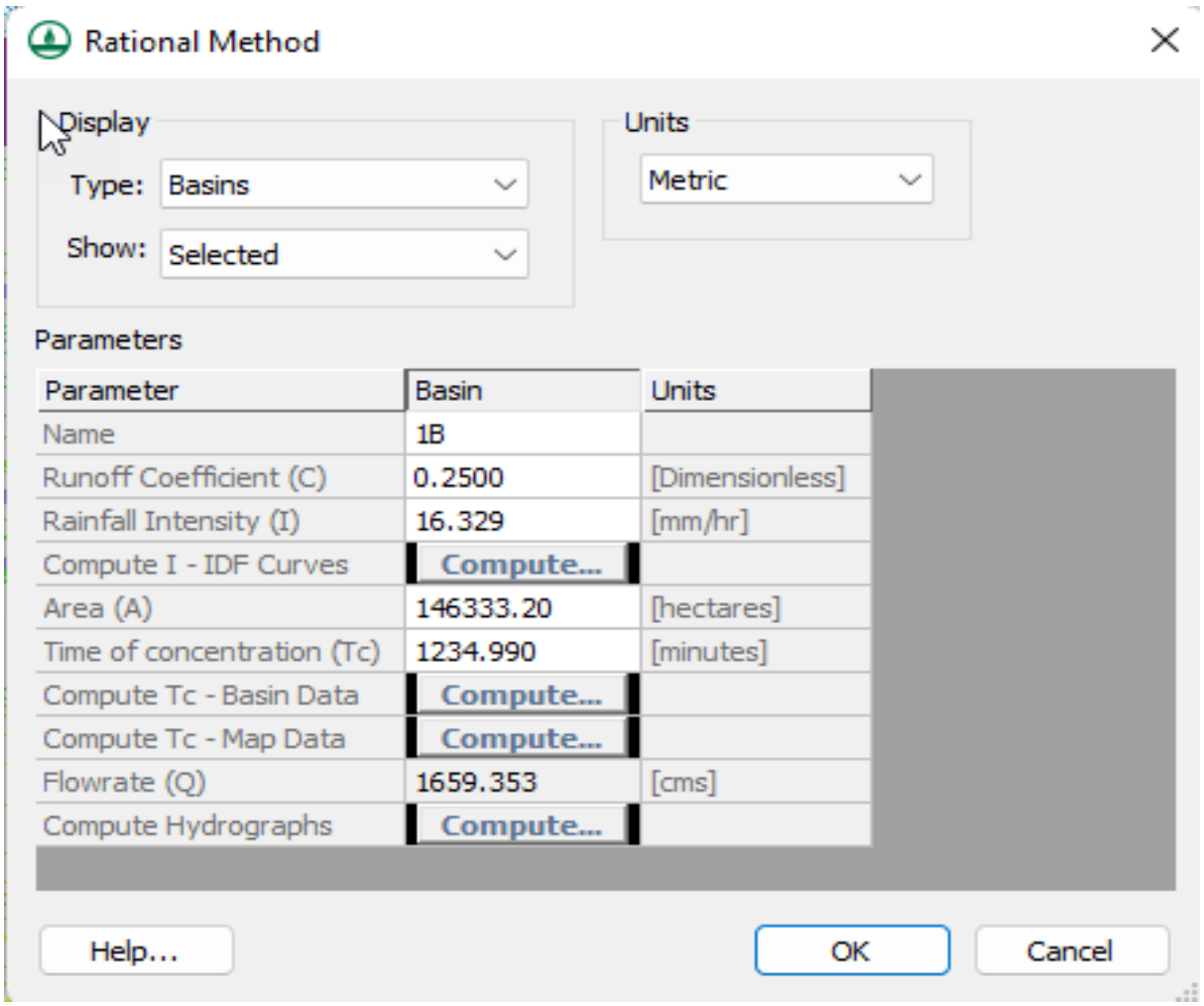
		Left	Channel	Right
Input Data				
	Average Depth (m):	0.79	2.12	0.59
	Approach Velocity (m/s):	0.13	0.35	0.09
	Br Average Depth (m):	0.47	1.74	
	BR Opening Flow (m3/s):	0.08	7.06	
	BR Top WD (m):	2.42	15.23	
	Grain Size D50 (mm):	0.39	0.41	0.43
	Approach Flow (m3/s):	1.11	5.94	0.09
	Approach Top WD (m):	11.05	8.00	1.65
	K1 Coefficient:	0.640	0.640	0.590
Results				
	Scour Depth Ys (m):	0.00	0.00	
	Critical Velocity (m/s):	0.43	0.52	
	Equation:	Clear	Clear	

2.1.4. Bridge 04: Nam Ngiap

1) Catchment area



2) Rational Model



3) Cross Section output of bridge station

Cross Section Output

File Type Options Help

River: Nam Ngiap Profile: 100 Years

Reach 1 RS: 100 BR U Plan: Plan 01

Plan: Plan 01 Nam Ngiap 1 RS: 100 BR U Profile: 100 Years

		Element	Left OB	Channel	Right OB
E.G. Elev (m)	152.93	Wt. n-Val.	0.150	0.100	0.150
Vel Head (m)	0.33	Reach Len. (m)	10.80	10.80	10.80
W.S. Elev (m)	152.60	Flow Area (m2)	6.16	649.52	3.79
Crit W.S. (m)	147.18	Area (m2)	6.16	649.52	3.79
E.G. Slope (m/m)	0.007437	Flow (m3/s)	2.96	1654.22	2.15
Q Total (m3/s)	1659.33	Top Width (m)	7.47	74.35	2.83
Top Width (m)	84.65	Avg. Vel. (m/s)	0.48	2.55	0.57
Vel Total (m/s)	2.52	Hydr. Depth (m)	0.82	8.74	1.34
Max Chl Dpth (m)	11.26	Conv. (m3/s)	34.3	19182.5	24.9
Conv. Total (m3/s)	19241.7	Wetted Per. (m)	8.07	127.97	3.86
Length Wtd. (m)	10.80	Shear (N/m2)	55.68	370.14	71.55
Min Ch El (m)	141.33	Stream Power (N/m s)	26.74	942.68	40.61
Alpha	1.02	Cum Volume (1000 m3)	1.10	86.99	0.68
Frctn Loss (m)	0.08	Cum SA (1000 m2)	1.03	10.15	0.44
C & E Loss (m)	0.00				

4) Profile output table

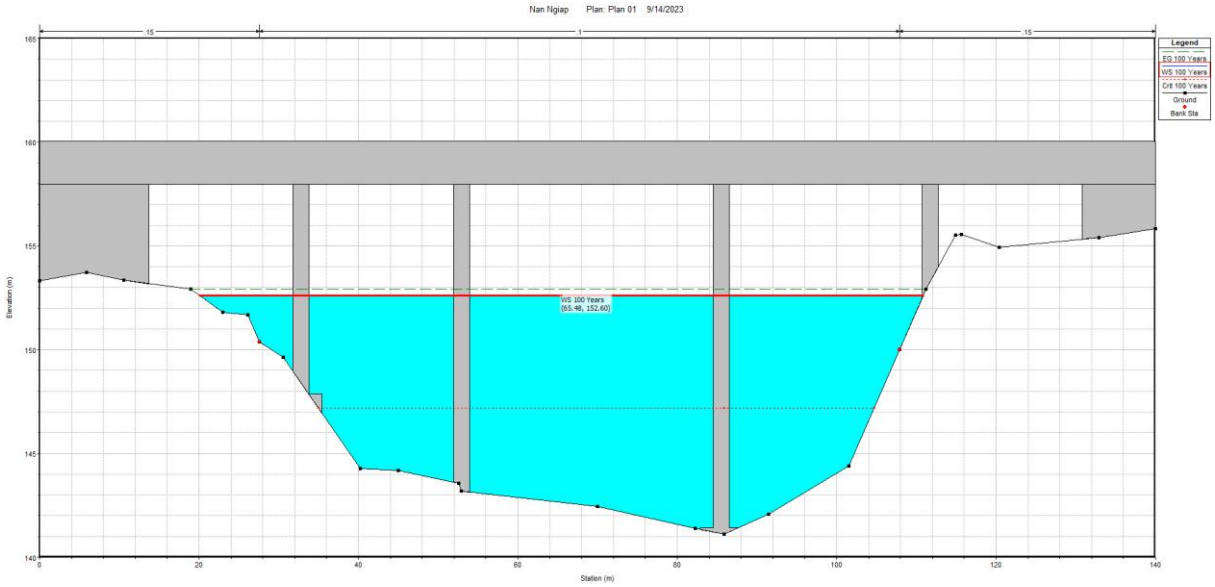
Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

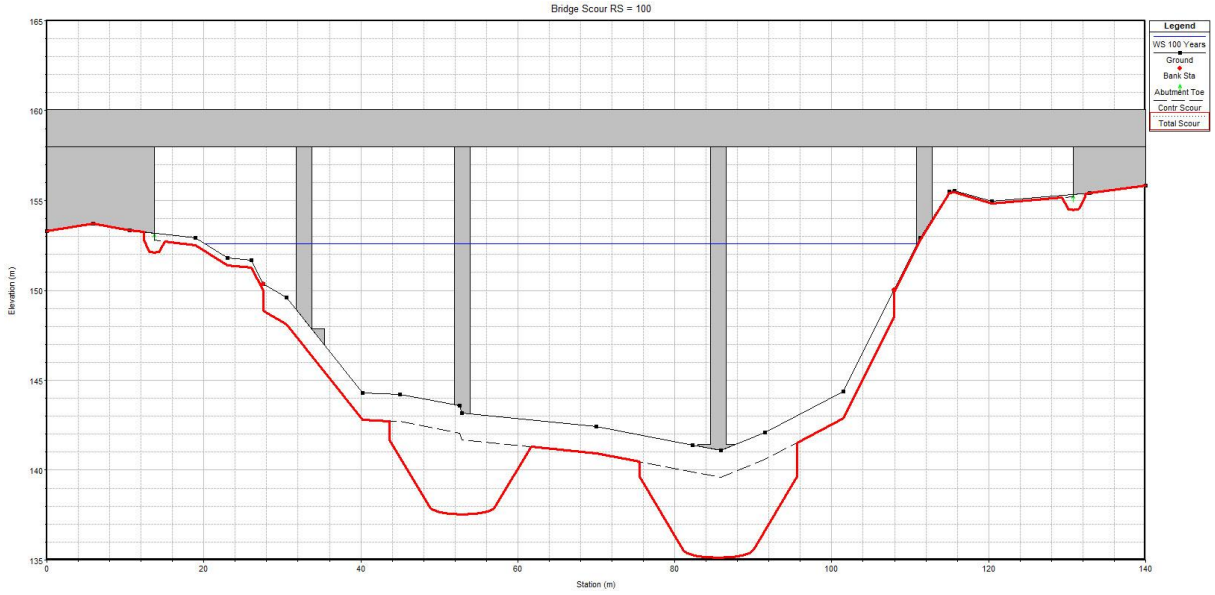
HEC-RAS Plan: Plan 01 River: Nam Ngiap Reach: 1 Profile: 100 Years

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
1	200	100 Years	1659.33	142.42	153.15		153.31	0.001783	1.78	941.61	113.47	0.19
1	150	100 Years	1659.33	141.21	152.98		153.19	0.002398	2.04	836.47	118.55	0.22
1	110	100 Years	1659.33	141.12	152.76	146.94	153.04	0.003129	2.32	725.47	91.55	0.25
1	100		Bridge									
1	90	100 Years	1659.33	141.12	152.43		152.73	0.003559	2.41	695.31	89.97	0.26
1	50	100 Years	1659.33	141.12	152.22		152.54	0.003739	2.51	676.33	88.96	0.27
1	0	100 Years	1659.33	142.59	152.05	147.01	152.34	0.003607	2.41	702.39	93.66	0.27

5) Cross Section of Bridge



6) Bridge Scour



Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (m):	0.79	8.89	1.19
	Approach Velocity (m/s):	0.28	2.04	0.36
	Br Average Depth (m):	0.82	8.74	1.34
	BR Opening Flow (m3/s):	2.96	1654.22	2.15
	BR Top WD (m):	7.47	74.35	2.83
	Grain Size D50 (mm):	0.06	0.99	0.13
	Approach Flow (m3/s):	2.64	1650.00	6.69
	Approach Top WD (m):	12.11	90.94	15.49
	K1 Coefficient:	0.690	0.690	0.690
Results				
	Scour Depth Ys (m):	0.40	1.50	0.11
	Critical Velocity (m/s):			
	Equation:	Live	Live	Live

Pier Scour

Pier: #1 (CL = 32.77)

Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	0.00000
	Depth Upstream (m):	4.36
	Velocity Upstream (m/s):	1.65
	K1 Nose Shape:	0.00
	Pier Angle:	0.00
	Pier Length (m):	2.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.00000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	0.00
	Froude #:	0.25
	Equation:	CSU equation

Pier: #2 (CL = 52.97)

Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	0.80000
	Depth Upstream (m):	9.58
	Velocity Upstream (m/s):	2.35
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (m):	2.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	3.40000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	4.14
	Froude #:	0.24
	Equation:	CSU equation

Pier: #3 (CL = 85.55)

Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	0.89000
	Depth Upstream (m):	11.62
	Velocity Upstream (m/s):	2.69
	K1 Nose Shape:	1.00
	Pier Angle:	0.00
	Pier Length (m):	2.00
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	6.60000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	4.50
	Froude #:	0.25
	Equation:	CSU equation

Pier: #4 (CL = 111.762)

Input Data

Pier Shape:	Circular cylinder
Pier Width (m):	2.00
Grain Size D50 (mm):	0.30000
Depth Upstream (m):	-0.52
Velocity Upstream (m/s):	0.38
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (m):	2.00
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	1.10000
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (m):	
Froude #:	
Equation:	CSU equation

Abutment Scour

Input Data

	Left	Right
Station at Toe (m):	13.73	130.80
Toe Sta at appr (m):	5.59	133.26
Abutment Length (m):	1.20	1.20
Depth at Toe (m):	1.00	-2.56
K1 Shape Coef:	0.55 - Spill-through abutment	
Degree of Skew (degrees):	90.00	90.00
K2 Skew Coef:	1.00	1.00
Projected Length L' (m):	1.20	1.20
Avg Depth Obstructed Ya (m):	0.35	0.36
Flow Obstructed Qe (m3/s):	0.20	0.26
Area Obstructed Ae (m2):	0.42	0.44

Results

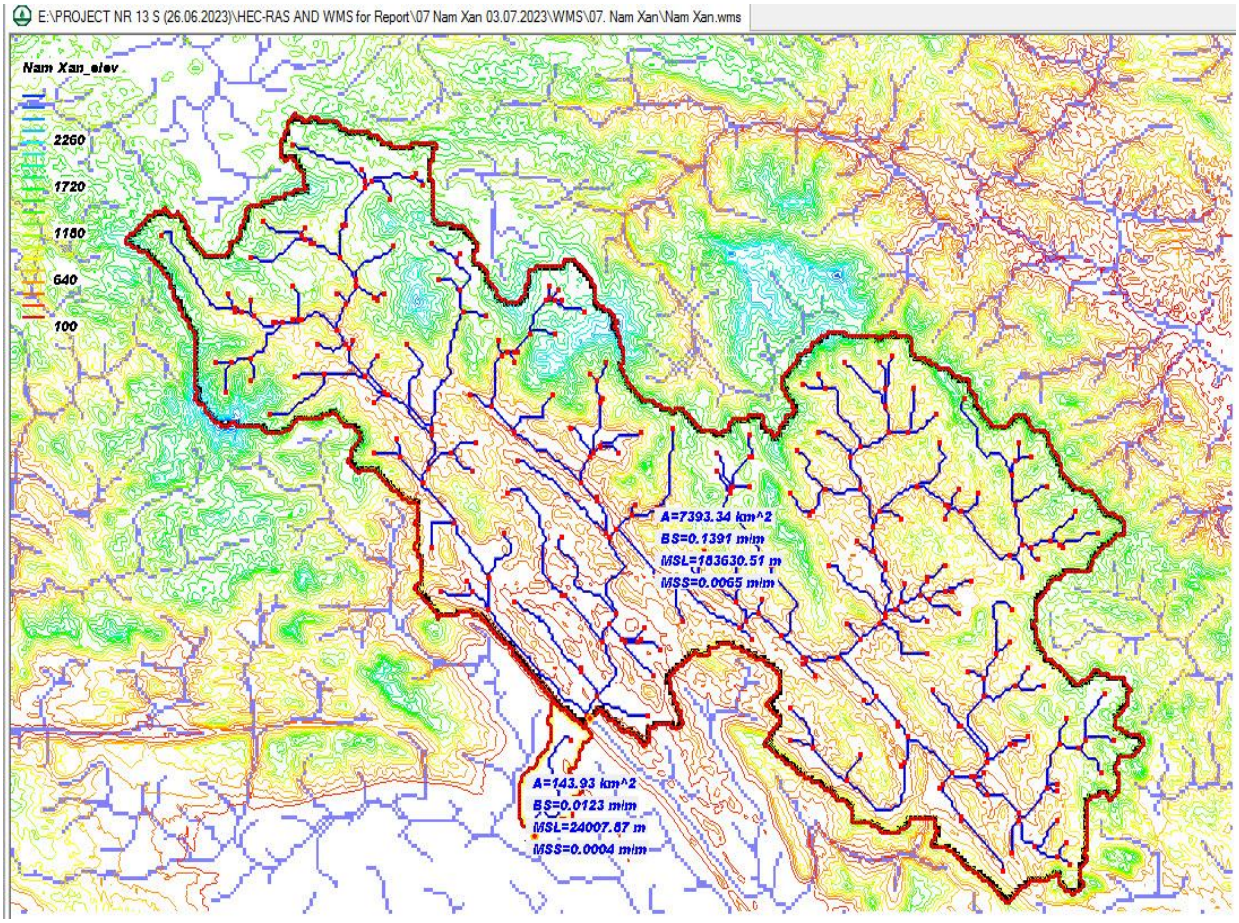
Scour Depth Ys (m):	0.67	0.73
Qe/Ae = Ve:	0.48	0.59
Froude #:	0.26	0.31
Equation:	Froehlich	Froehlich

Combined Scour Depths

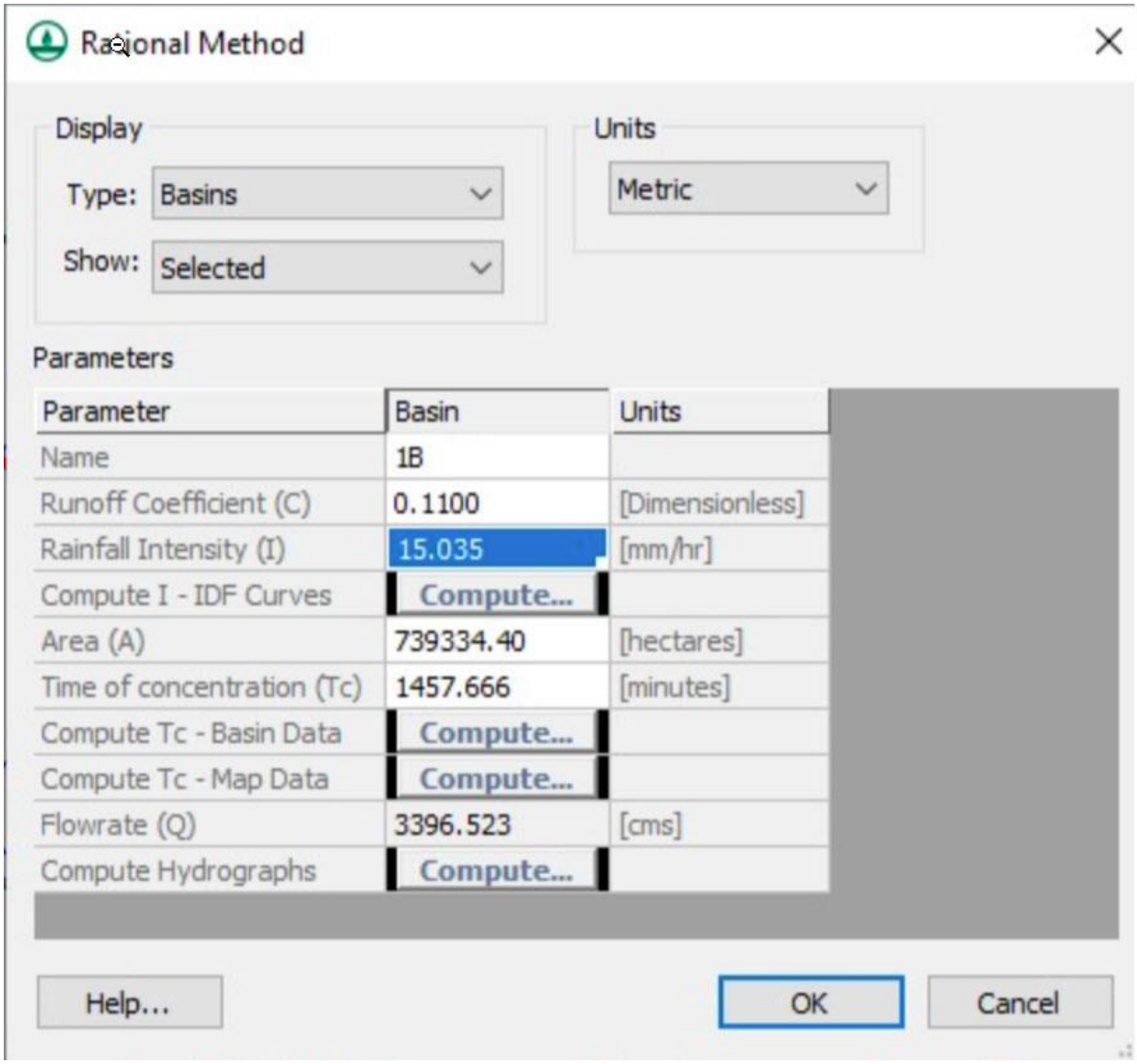
Pier : #1 (CL = 32.77) (Contr + Pier) (m):	1.50
Pier : #2 (CL = 52.97) (Contr + Pier) (m):	5.64
Pier : #3 (CL = 85.55) (Contr + Pier) (m):	6.00
Pier : #4 (CL = 111.762) (Contr + Pier) (m):	
Left abutment scour + contraction scour (m):	1.07
Right abutment scour + contraction scour (m):	0.85

2.1.5. Bridge 05: Nam Xan

1) Catchment area



2) Rational Model



3) Cross Section output of bridge station

Cross Section Output

File Type Options Help

River: ALIME_CROS Profile: 100 years

Reach XANN11 RS: 345 BR U Plan: Plan 01

Plan: Plan 01 ALIME_CROS XANN11 RS: 345 BR U Profile: 100 years

		Element	Left OB	Channel	Right OB
E.G. Elev (m)	155.32				
Vel Head (m)	0.83	Wt. n-Val.	0.070	0.080	0.070
W.S. Elev (m)	154.50	Reach Len. (m)	10.80	10.80	10.80
Crit W.S. (m)	150.43	Flow Area (m2)	10.82	825.17	13.75
E.G. Slope (m/m)	0.012432	Area (m2)	10.82	825.17	13.75
Q Total (m3/s)	3396.68	Flow (m3/s)	22.29	3342.59	31.80
Top Width (m)	102.36	Top Width (m)	6.59	88.93	6.84
Vel Total (m/s)	4.00	Avg. Vel. (m/s)	2.06	4.05	2.31
Max Chl Dpth (m)	13.33	Hydr. Depth (m)	1.64	9.28	2.01
Conv. Total (m3/s)	30463.5	Conv. (m3/s)	199.9	29978.3	285.2
Length Wtd. (m)	10.80	Wetted Per. (m)	7.36	166.54	7.86
Min Ch El (m)	141.16	Shear (N/m2)	179.22	604.08	213.36
Alpha	1.02	Stream Power (N/m s)	369.09	2446.97	493.53
Frctn Loss (m)	0.14	Cum Volume (1000 m3)	9.14	364.04	36.31
C & E Loss (m)	0.01	Cum SA (1000 m2)	2.98	37.88	16.22

4) Profile output table

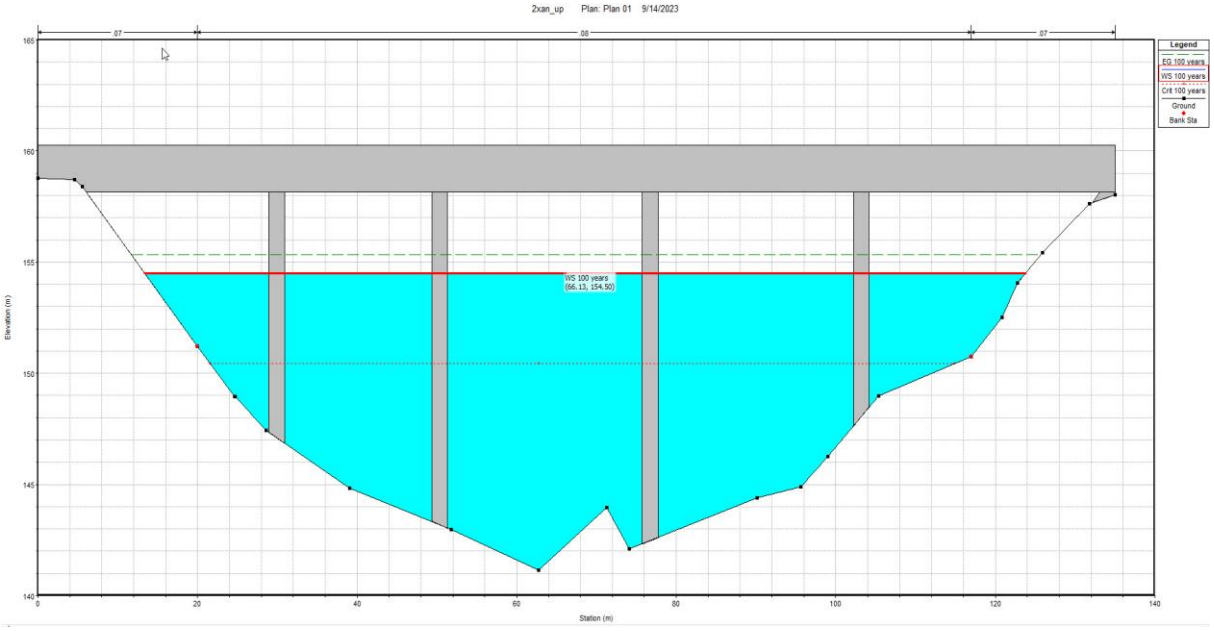
Profile Output Table - Standard Table 1

File Options Std. Tables Locations Help

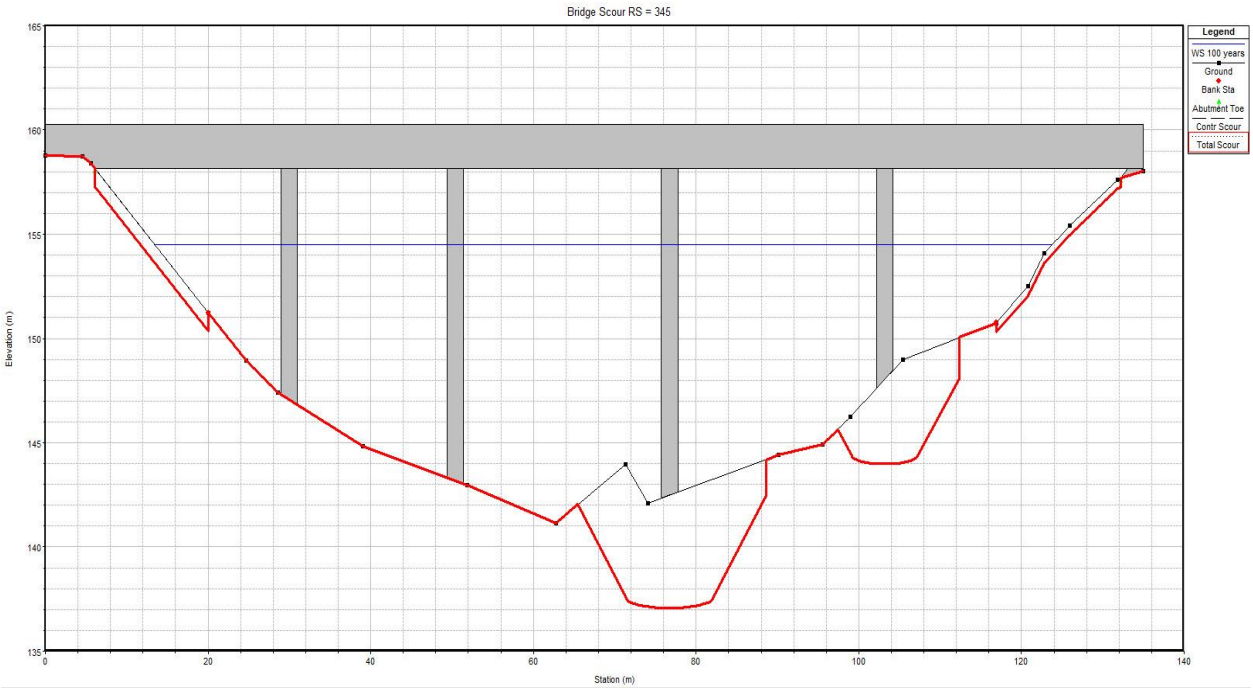
HEC-RAS Plan: Plan 01 River: ALIME_CROS Reach: XANN11 Profile: 100 years

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
			(m3/s)	(m)	(m)	(m)	(m)	(m/m)	(m/s)	(m2)	(m)	
XANN11	600	100 years	3396.68	142.65	156.33		156.59	0.001436	2.29	1573.71	194.94	0.22
XANN11	450	100 years	3396.68	141.25	156.02		156.33	0.001793	2.55	1452.51	200.00	0.25
XANN11	355	100 years	3396.68	141.16	154.86	150.05	155.51	0.004216	3.59	964.59	111.94	0.37
XANN11	345		Bridge									
XANN11	335	100 years	3396.68	141.16	153.69		154.55	0.006563	4.11	836.48	107.21	0.45
XANN11	250	100 years	3396.68	139.97	153.34		153.94	0.003746	3.49	1018.12	134.36	0.35
XANN11	150	100 years	3396.68	141.54	152.99		153.56	0.003581	3.48	1084.82	155.58	0.35
XANN11	0	100 years	3396.68	140.07	151.87	148.23	152.76	0.006312	4.30	865.37	142.45	0.45

5) Cross Section of Bridge



6) Bridge Scour



Contraction Scour

		Left	Channel	Right
Input Data				
	Average Depth (m):	1.75	11.02	2.68
	Approach Velocity (m/s):	0.86	2.55	1.13
	Br Average Depth (m):	1.64	9.28	2.01
	BR Opening Flow (m3/s):	22.29	3342.59	31.80
	BR Top WD (m):	6.59	88.93	6.84
	Grain Size D50 (mm):	0.81	0.00	0.50
	Approach Flow (m3/s):	46.37	3182.11	168.20
	Approach Top WD (m):	30.81	113.42	55.77
	K1 Coefficient:	0.640	0.590	0.640
Results				
	Scour Depth Ys (m):	0.87		0.45
	Critical Velocity (m/s):	0.63		0.58
	Equation:	Live		Live

Pier Scour

Pier: #1 (CL = 29.945)		
Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	0.00000
	Depth Upstream (m):	7.77
	Velocity Upstream (m/s):	2.85
	K1 Nose Shape:	0.00
	Pier Angle:	0.00
	Pier Length (m):	10.80
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.00000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	0.00
	Froude #:	0.33
	Equation:	CSU equation
Pier: #2 (CL = 50.345)		
Input Data		
	Pier Shape:	Circular cylinder
	Pier Width (m):	2.00
	Grain Size D50 (mm):	0.00000
	Depth Upstream (m):	11.67
	Velocity Upstream (m/s):	3.95
	K1 Nose Shape:	0.00
	Pier Angle:	0.00
	Pier Length (m):	10.80
	K2 Angle Coef:	1.00
	K3 Bed Cond Coef:	1.10
	Grain Size D90 (mm):	0.00000
	K4 Armouring Coef:	1.00
Results		
	Scour Depth Ys (m):	0.00
	Froude #:	0.37
	Equation:	CSU equation

Pier: #3 (CL = 76.743)

Input Data

Pier Shape:	Circular cylinder
Pier Width (m):	2.00
Grain Size D50 (mm):	0.01500
Depth Upstream (m):	12.39
Velocity Upstream (m/s):	4.05
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (m):	10.80
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	0.21000
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (m):	5.41
Froude #:	0.37
Equation:	CSU equation

Pier: #4 (CL = 103.19)

Input Data

Pier Shape:	Circular cylinder
Pier Width (m):	2.00
Grain Size D50 (mm):	0.49000
Depth Upstream (m):	6.80
Velocity Upstream (m/s):	2.51
K1 Nose Shape:	1.00
Pier Angle:	0.00
Pier Length (m):	10.80
K2 Angle Coef:	1.00
K3 Bed Cond Coef:	1.10
Grain Size D90 (mm):	5.11000
K4 Armouring Coef:	1.00

Results

Scour Depth Ys (m):	4.07
Froude #:	0.31
Equation:	CSU equation

Combined Scour Depths

Pier : #1 (CL = 29.945) (Contr + Pier) (m):	0.00
Pier : #2 (CL = 50.345) (Contr + Pier) (m):	0.00
Pier : #3 (CL = 76.743) (Contr + Pier) (m):	5.41
Pier : #4 (CL = 103.19) (Contr + Pier) (m):	4.07

SUMMARY OF HIGHEST WATER LEVEL FOR 14 BRIDGES ON NR 13 (LAO PDR)

SUMMARY OF HIGHEST WATER LEVEL FOR 14 BRIDGES ON NR13S (LAO PDR) Finalized on 4 October 2023.

Sl. No.	Station	Bridge Name	No. of Span	Span Arrangement (m)	$H_{cal\ 1\%}$ (Updated) (m)	V_{Flow} velocity (m/s)	Discharge (m3/s)	$H_{back\text{-}MK}$ (m)	HWL (Recent-Interviews dated on 7-8,Sept.2023-PMU agreed) (m)	HWL Consider to design (m)	Proposed FRL (m)	Existing FRL (m)	Difference Existing-Proposed (m) (m)	Proposed Bridge Site	Pkg.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	106+460	Nam ching	3	20.30+26.50+20.30=67.10	156.52	1.29	251.91	158.37	159.206	159.206	162.111	161.040	-1.071	RHS(Down Stream)	1
2	109+890	Nam Lo	3	26.30+26.30+26.30=78.90	152.44	1.57	429.31	158.16	157.897	158.160	161.065	160.569	-0.496	LHS(Up Stream)	
3	117+038	Nam Kap	3	26.50+26.50+26.50=79.50	156.25	0.67	211.86	157.64	156.918	157.640	160.545	160.382	-0.163	RHS(Down Stream)	2
4	121+952	Nam Thoay	3	20.30+26.30+26.30=72.90	155.96	1.02	475.79	157.34	156.681	157.340	160.245	160.103	-0.142	RHS(Down Stream)	
5	123+850	Houay dong kham	1	28.00	154.93	0.27	24.51	157.18	155.632	157.180	159.985	159.474	-0.511	LHS(Up Stream)	
6	140+200	Nam Ngiap	5	20.40+26.40+26.40+26.40+20.40=120	152.76	2.55	1659.35	156.02	156.123	156.123	159.228	158.914	-0.314	RHS(Down Stream)	
7	146+642	Nam Xan	5	20.40+20.40+26.40+26.40+20.40=114	154.86	4.05	3396.52	155.55	155.632	155.632	158.937	158.699	-0.238	RHS(Down Stream)	
8	204+400	Houay Xamboungnai	1	25.4	152.56	0.57	15.26		155.127	155.127	158.120	158.120	0.000	LHS(Up Stream)	3
9	217+578	Houay Deua2	3	20.30+20.30+20.30=60.90	152.86	1.19	347.25		153.281	153.281	156.050	156.000	-0.050	LHS(Up Stream)	
10	231+199	Nam Sang	1	20.3	157.42	2.91	105.44		157.628	157.628	160.083	159.620	-0.463	LHS(Up Stream)	
11	239+051	Nam Thone	3	26.00+26.40+26.00=78.40	156.14	1.28	649.73		157.406	157.406	160.511	159.200	-1.311	LHS(Up Stream)	
12	288+400	Nam Hinboun	3	39.00+46.00+39.00=124.00	143.86	2.11	1883.57		145.270	145.270	151.200	151.181	-0.019	LHS(Up Stream)	4
13	306+570	Houay Aek	1	25.60	146.91	2.67	77.66		146.880	146.910	151.180	151.179	-0.001	LHS(Up Stream)	
14	325+800	Nam Done	3	26.00+26.50+26.00=78.50	142.65	3.5	1571.66	143.04	143.750	143.750	147.105	147.072	-0.033	LHS(Up Stream)	

SUMMARY OF TOTAL SCOURING DEPTHS FOR 14 BRIDGES

Summary of Total Scouring Depths for 14 Bridges

Updated on 6.10.2023

No.	Station (Km)	Bridge name	Total Scouring Depths (m)					
			A	P1	P2	P3	P4	B
1	106+460	Nam Ching Bridge	1.40	1.74	2.57			NO
2	109+890	Nam Lo Bridge	0.44	4.45	3.77			0.60
3	117+032	Nam Kap Bridge	0.70	2.22	2.67			0.15
4	121+959	Nam Thoay Bridge	1.52	2.78	2.78			1.63
5	123+850	Houay Dong Kham Bridge	NO					
6	140+200	Nam Ngiap Bridge	1.07	1.50	5.64	6.00	NO	0.85
7	146+642	Nam Xan Bridge	0.87	NO	NO	5.41	4.07	0.45
8	204+400	Houay Xam boun Gnai Bridge	1.40					1.22
9	217+578	Houay Deua2 Bridge	2.57	2.57	3.00			3.02
10	231+199	Nam Sang Bridge	3.42					4.59
11	239+051	Nam Thone Bridge	1.70	4.56	5.03			2.97
12	288+400	Nam Hin Boun Bridge	2.87	4.13	NO			0.62
13	306+570	Houay Aek Bridge	0.02					NO
14	325+800	Nam Don Bridge	0.34	4.10	NO			3.07

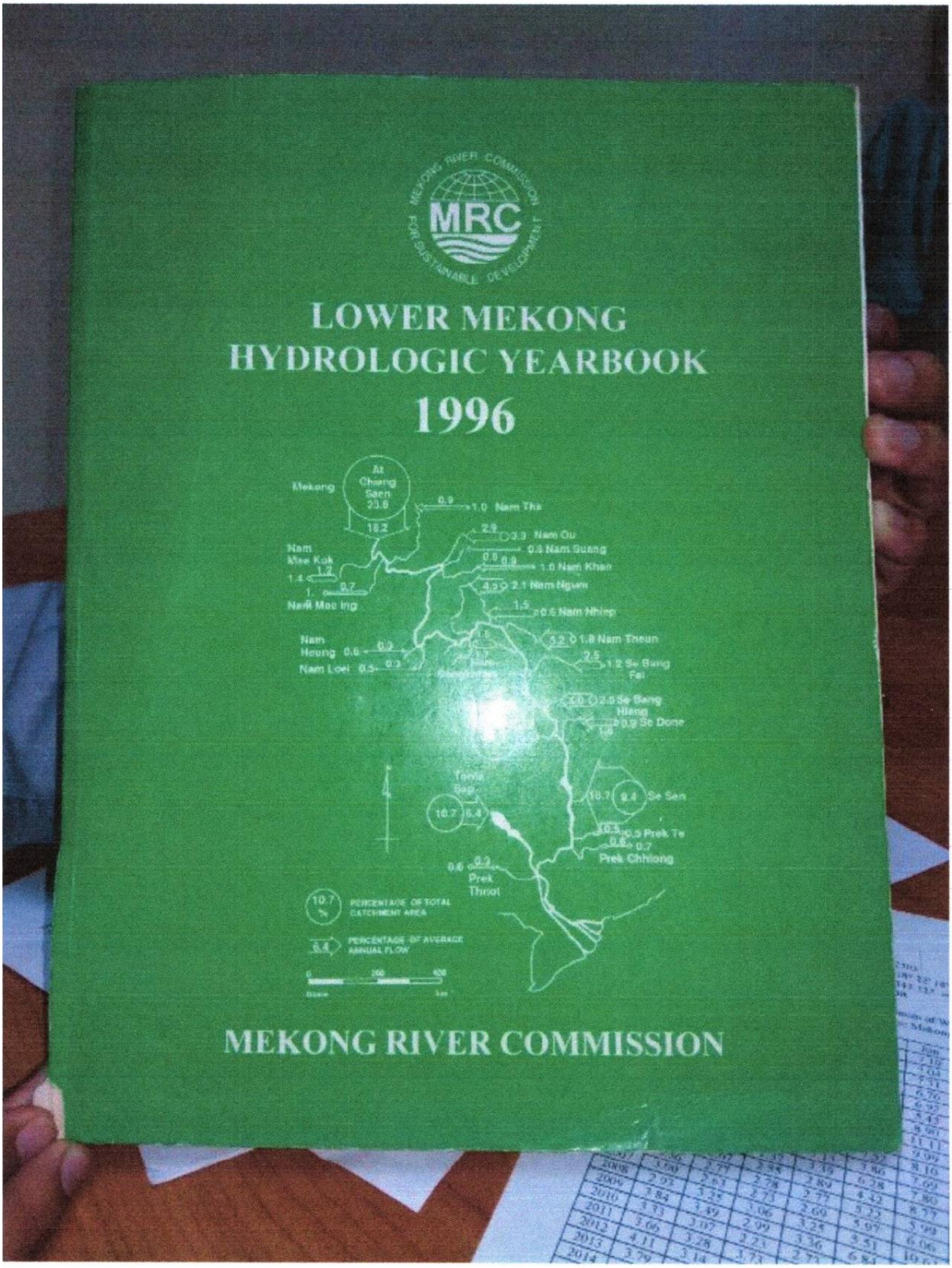
Notes:

- A or B is for Abutment.
- P 1,2,3,4 is for Pier.
- NO is without scouring depth.

3.1. The highest water level in months and years of Vientiane, Paksane and Thakhek

hydrological gauge stations

The source of meteorological and hydrological data for the project



Station Characteristics of station : 011901

Station name : Vientiane Km-4 Latitude : 17° 55' 42" North Longitude : 102° 37' 12" East
River : Mekong Altitude : 158.04 m Catchment area : 299000.000 km2
Province : Vientiane Capital Country : Lao PDR Agency : dmh

Somphanh VITHAYA

Vientiane Km-4

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Max
1993	2.40	1.02	1.02	0.90	1.88	2.60	7.76	9.26	9.78	6.38	5.32	2.65	9.78
1994	1.69	1.20	1.10	1.93	3.02	7.77	9.87	10.74	11.14	8.12	4.23	3.80	11.14
1995	2.75	1.40	1.24	1.72	3.29	5.85	8.20	11.95	11.22	8.48	5.06	3.96	11.95
1996	2.29	1.53	1.52	1.90	3.03	4.64	10.21	11.84	9.26	7.48	5.30	3.14	11.84
1997	2.32	1.70	1.07	1.50	1.98	3.55	9.44	9.03	11.34	8.98	5.18	3.02	11.34
1998	2.02	1.52	1.11	1.90	2.87	3.60	8.64	8.77	10.38	5.46	4.30	2.40	10.38
1999	1.84	1.28	1.00	1.15	3.23	4.78	6.82	10.28	10.88	8.50	7.40	3.77	10.88
2000	2.36	1.92	2.05	1.78	6.36	7.74	10.38	9.66	11.53	7.37	5.35	3.07	11.53
2001	2.21	1.53	1.71	1.42	4.54	7.94	10.16	11.56	10.87	7.82	8.36	4.12	11.56
2002	2.40	1.40	1.32	5.44	5.25	11.15	12.60	10.26	7.29	5.10	5.47	4.24	12.60
2003	4.24	2.33	1.69	1.44	1.76	4.36	6.12	8.22	9.63	6.60	3.52	2.23	9.63
2004	1.15	0.90	0.35	1.74	5.06	6.50	9.02	10.13	11.04	7.83	4.12	2.73	11.04
2005	1.72	1.18	1.30	1.67	1.90	4.82	8.15	11.08	10.67	8.02	5.70	3.02	11.08
2006	2.19	1.25	0.90	0.84	3.60	4.78	8.22	10.68	10.83	10.78	5.20	2.78	10.83
2007	1.65	1.08	0.74	1.67	4.86	3.75	8.08	9.60	10.16	8.82	5.64	2.78	10.16
2008	1.74	1.91	1.10	1.33	3.17	6.32	10.83	13.66	11.17	9.67	8.59	3.70	13.66
2009	2.41	1.80	1.18	1.63	3.00	3.80	9.21	8.46	8.42	6.90	3.97	1.95	9.21
2010	1.50	1.17	0.43	1.05	1.33	2.74	7.67	10.11	10.18	7.68	4.97	2.30	10.18
2011	1.63	1.09	1.79	1.28	3.70	7.70	9.20	10.09	10.64	9.58	4.69	2.46	10.64
2012	2.10	0.94	0.59	0.70	2.26	3.49	8.62	10.20	7.85	5.61	4.19	2.69	10.20
2013	1.75	1.68	1.37	1.49	2.02	4.08	7.22	9.62	9.62	6.27	5.32	7.25	9.62
2014	3.08	2.19	2.54	2.34	3.00	3.16	7.08	7.79	9.29	7.14	4.16	3.22	9.29
2015	2.63	1.47	2.68	2.85	2.85	3.93	7.57	10.25	8.55	5.53	3.26	2.20	10.25
2016	2.68	3.21	2.45	2.28	2.04	2.70	4.95	10.93	9.29	5.72	5.61	3.43	10.93
2017	2.89	2.93	2.92	3.19	5.45	3.33	8.81	8.80	9.01	6.34	5.72	4.59	9.01
2018	2.83	1.75	1.80	3.17	3.88	6.64	10.14	11.64	11.64	6.24	4.93	2.54	11.64

Station Characteristics of station : 012703

Station name : Paksane Latitude : 18° 22' 18" North Longitude : 103°40' 00" East
River : Mekong Altitude : 142.125 m Catchment area : .000 km2
Province : Borikhamxay Country : Lao PDR Agency : Hydro-met of Lao PDR

Maximum of Water Level in m
Station: Mekong Pakxan

Somphanh VITHAYA

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maxi
1993	2.98	2.00	1.94	1.94	3.21	7.10	12.69	11.15	11.67	9.77	6.00	3.96	12.69
1994	3.17	2.33	2.07	1.95	2.03	5.04	6.35	11.88	10.28	9.51	5.80	4.39	11.88
1995	3.52	2.46	2.17	2.63	5.23	7.31	11.00	14.17	14.77	10.26	6.44	5.67	14.77
1996	3.62	3.10	3.04	3.14	4.49	6.76	12.61	14.20	12.56	10.78	7.15	4.99	14.20
1997	3.94	2.51	2.21	2.93	4.03	6.92	13.41	13.12	14.74	9.42	6.35	4.63	14.74
1998	3.61	2.35	1.93	2.19	4.38	5.45	11.20	11.56	12.71	7.17	5.26	3.84	12.71
1999	3.23	2.89	2.50	2.78	6.94	8.90	9.48	12.31	13.08	12.23	8.18	5.83	13.08
2000	4.50	3.20	2.71	2.63	8.45	11.11	13.30	12.86	14.53	7.53	7.12	4.93	14.53
2001	4.26	3.00	2.67	3.26	6.93	9.99	13.04	14.76	13.90	10.18	9.89	5.92	14.76
2002	4.64	3.99	3.20	2.66	7.52	8.10	13.08	14.42	12.82	9.72	7.49	7.00	14.42
2003	5.68	3.96	3.21	3.13	3.86	7.69	9.36	10.92	12.58	8.78	5.11	3.86	12.58
2004	2.63	2.71	2.37	3.39	6.28	7.80	11.32	12.18	13.53	10.23	6.41	4.31	13.53
2005	3.98	2.67	2.55	2.89	4.42	8.77	11.37	13.93	13.06	12.38	5.91	4.48	13.93
2006	3.36	2.77	2.78	2.77	5.22	5.99	10.82	12.59	12.74	11.25	8.03	3.90	12.74
2007	3.00	2.63	2.73	2.69	5.97	6.06	9.30	11.30	12.47	11.33	6.55	4.06	12.47
2008	2.93	3.25	3.06	3.25	5.51	10.61	12.86	14.80	12.51	10.68	9.80	5.26	14.80
2009	3.84	3.49	2.99	3.36	6.84	6.82	11.52	11.12	10.18	9.23	5.48	3.64	11.52
2010	3.33	3.07	2.23	2.73	3.32	5.08	10.02	12.08	12.63	10.14	6.87	4.31	12.63
2011	3.66	3.28	3.73	3.21	6.07	10.96	11.94	13.28	13.41	13.04	6.63	4.52	13.41
2012	4.11	3.14	2.94	2.92	4.85	7.08	9.59	12.37	11.18	7.74	5.97	4.59	12.37
2013	3.79	3.80	3.48	3.72	4.23	6.94	10.98	12.94	11.84	8.72	8.39	8.35	12.94
2014	4.69	4.14	4.39	4.27	4.90	6.47	10.09	10.93	11.61	9.80	6.09	5.05	11.61
2015	4.44	3.50	4.55	4.80	4.92	6.00	11.15	12.84	11.54	7.95	4.64	3.38	12.84
2016	2.83	2.84	2.94	3.50	4.38	4.41	7.80	12.60	11.52	7.55	6.55	4.40	12.60
2017	3.88	3.94	4.69	4.01	6.72	6.20	11.10	10.74	11.50	8.69	7.89	6.25	11.50
2018	5.19	3.35	3.42	5.24	6.13	6.67	12.63	14.09	14.53	8.89	7.13	5.65	14.53

Station Characteristics of station :

Station name : Thakhek Latitude : 17° 23' 55" North Longitude : 104° 48' 05" East
River : Mekong Altitude : 129.63 m Catchment area : 373.000 km2
Province : Khammouan Country : Lao PDR Agency : Hydro-met of Lao PDR

Maximum of Water Level in m
Station: Mekong Thakhek

Somphanh VITTHAYA

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Maxi
1993	3.35	2.46	2.32	2.32	4.40	7.55	12.70	11.39	11.14	7.90	5.82	3.80	12.70
1994	2.78	2.58	2.18	2.87	4.09	10.35	12.87	13.49	12.85	9.99	5.67	4.37	13.49
1995	3.79	2.56	2.38	2.90	4.05	7.42	10.75	13.71	14.85	9.59	5.70	4.70	14.85
1996	3.49	2.87	2.84	2.88	3.99	7.00	11.97	13.27	13.71	12.20	6.78	4.60	13.71
1997	3.90	3.03	2.75	3.01	3.87	7.15	12.82	12.80	13.79	9.78	5.70	4.20	13.79
1998	3.40	2.84	2.54	2.89	3.65	5.54	10.43	10.38	11.72	7.74	4.94	3.41	11.72
1999	2.80	2.70	2.29	2.61	7.00	8.80	9.95	10.98	12.23	11.23	7.72	4.80	12.23
2000	3.60	2.90	3.05	3.12	7.72	10.60	12.33	12.14	14.35	9.90	6.37	4.18	14.35
2001	3.35	2.90	2.82	2.80	4.00	0.00	11.73	13.75	12.98	9.58	8.48	4.92	13.75
2002	3.67	3.10	2.70	2.57	6.08	8.81	12.13	13.47	12.10	8.78	5.96	5.60	13.47
2003	4.61	2.90	2.50	2.48	3.10	6.96	8.95	10.52	11.72	8.38	4.40	3.00	11.72
2004	2.19	2.10	1.62	2.49	5.75	7.65	10.33	11.56	13.26	9.70	5.32	3.72	13.26
2005	2.78	2.38	2.48	2.65	2.84	8.24	11.50	14.00	12.70	11.80	6.09	4.09	14.00
2006	3.10	2.60	2.45	2.34	4.65	5.10	10.32	11.67	11.65	9.99	5.90	3.66	11.67
2007	2.77	2.35	2.25	2.62	4.67	6.26	7.94	10.94	11.50	10.95	6.57	3.79	11.50
2008	2.98	3.00	2.42	2.80	4.59	10.52	11.95	13.76	11.09	10.11	8.04	4.53	13.76
2009	3.08	2.22	1.80	1.80	5.65	7.08	10.45	11.09	9.39	8.97	4.60	2.99	11.09
2010	2.56	2.67	1.72	2.08	3.06	4.42	9.03	11.45	11.78	9.33	6.03	3.54	11.78
2011	3.01	2.69	2.95	2.89	5.07	9.72	11.27	13.31	13.01	12.55	5.79	3.85	13.31
2012	3.30	2.60	2.48	2.50	4.27	6.66	8.26	11.31	10.57	6.62	4.85	3.75	11.31
2013	3.17	3.22	2.95	2.81	3.95	7.28	11.48	11.78	10.57	8.13	6.49	6.36	11.78
2014	4.00	3.56	3.62	3.48	3.92	7.57	10.36	11.37	10.16	9.01	5.16	4.11	11.37
2015	3.53	2.89	3.62	3.79	3.92	4.60	11.39	12.13	10.97	7.81	4.62	3.52	12.13
2016	3.31	3.99	3.42	3.45	3.86	5.69	8.65	11.24	10.83	7.75	6.06	4.26	11.24
2017	3.86	3.83	3.81	3.90	6.31	6.81	11.09	11.08	10.94	8.72	6.53	5.42	11.09
2018	4.09	3.59	3.16	3.95	4.84	7.43	12.90	13.83	13.80	8.25	5.83	4.09	13.83

3.2. The process of peak water level occurred at Paksane and Thakhek stations in 2008

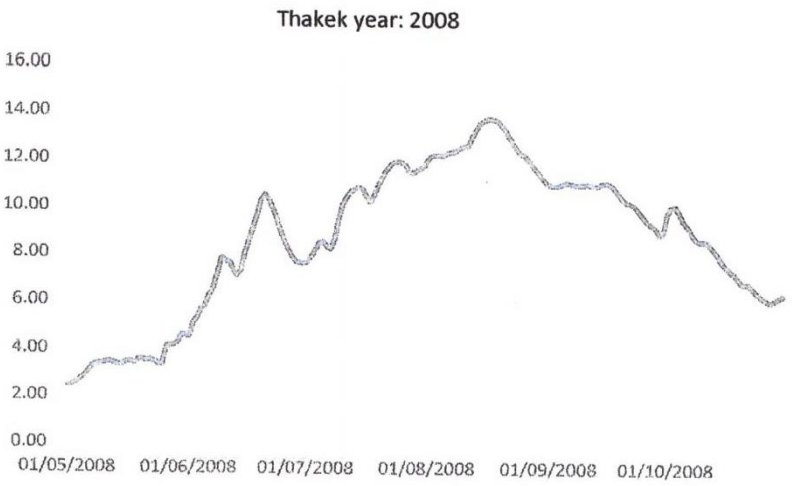
15/06/2008	8.61
16/06/2008	8.8
17/06/2008	9.11
18/06/2008	9.75
19/06/2008	10.51
20/06/2008	10.61
21/06/2008	9.85
22/06/2008	9.3
23/06/2008	8.81
24/06/2008	8.44
25/06/2008	8.26
26/06/2008	8.12
27/06/2008	8.01
28/06/2008	7.84
29/06/2008	7.55
30/06/2008	7.44
01/07/2008	7.7
02/07/2008	8.15
03/07/2008	8.9
04/07/2008	9.1
05/07/2008	8.83
06/07/2008	8.59
07/07/2008	8.63
08/07/2008	8.88
09/07/2008	9.31
10/07/2008	9.9
11/07/2008	10.69
12/07/2008	10.93
13/07/2008	11.2
14/07/2008	11.15
15/07/2008	10.77
16/07/2008	10.34
17/07/2008	10.29
18/07/2008	10.86
19/07/2008	11.31
20/07/2008	11.99
21/07/2008	12.55
22/07/2008	12.77
23/07/2008	12.83
24/07/2008	12.78
25/07/2008	12.64
26/07/2008	12.38
27/07/2008	12.3
28/07/2008	12.45
29/07/2008	12.58
30/07/2008	12.62
31/07/2008	12.86
09/06/2008	7.86
10/06/2008	7.72
11/06/2008	7.49
12/06/2008	7.36
13/06/2008	7.46
14/06/2008	8.2

01/08/2008	13.08
02/08/2008	13.09
03/08/2008	13.05
04/08/2008	13
05/08/2008	13.06
06/08/2008	13.1
07/08/2008	13.06
08/08/2008	13.06
09/08/2008	13.18
10/08/2008	13.18
11/08/2008	13.42
12/08/2008	13.95
13/08/2008	14.35
14/08/2008	14.64
15/08/2008	14.75
16/08/2008	14.8
17/08/2008	14.77
18/08/2008	14.6
19/08/2008	14.3
20/08/2008	14.03
21/08/2008	13.78
22/08/2008	13.56
23/08/2008	13.43
24/08/2008	13.33
25/08/2008	13.2
26/08/2008	12.97
27/08/2008	12.74
28/08/2008	12.52
29/08/2008	12.25
30/08/2008	12.06
31/08/2008	11.98
01/09/2008	11.96
02/09/2008	11.99
03/09/2008	12.13
04/09/2008	12.23
05/09/2008	12.23
06/09/2008	12.14
07/09/2008	12.17
08/09/2008	12.33
09/09/2008	12.46
10/09/2008	12.51
11/09/2008	12.47
12/09/2008	12.42
13/09/2008	12.37
14/09/2008	12.25
15/09/2008	12.08
16/09/2008	12.01

17/09/2008	11.72
18/09/2008	11.67
19/09/2008	11.32
20/09/2008	11.33
21/09/2008	11.22
22/09/2008	11.01
23/09/2008	10.78
24/09/2008	10.53
25/09/2008	10.38
26/09/2008	10.25
27/09/2008	10.13
28/09/2008	10.03
29/09/2008	9.87
30/09/2008	10.15
01/10/2008	10.68
02/10/2008	10.26
03/10/2008	10.28
04/10/2008	10.18
05/10/2008	10.08
06/10/2008	9.98
07/10/2008	9.74
08/10/2008	9.54
09/10/2008	9.75
10/10/2008	9.83
11/10/2008	9.67
12/10/2008	9.68
13/10/2008	9.55
14/10/2008	9.35
15/10/2008	9.23
16/10/2008	8.85
17/10/2008	8.41
18/10/2008	8.07
19/10/2008	7.94
20/10/2008	7.78
21/10/2008	7.7
22/10/2008	7.53
23/10/2008	7.43
24/10/2008	7.28
25/10/2008	7.22
26/10/2008	7.06
27/10/2008	7.03
28/10/2008	7.29
29/10/2008	7.44
30/10/2008	7.47
31/10/2008	7.45

15/06/2008	8.07
16/06/2008	8.60
17/06/2008	9.15
18/06/2008	9.67
19/06/2008	10.29
20/06/2008	10.52
21/06/2008	10.33
22/06/2008	9.91
23/06/2008	9.43
24/06/2008	8.89
25/06/2008	8.50
26/06/2008	8.18
27/06/2008	7.89
28/06/2008	7.69
29/06/2008	7.64
30/06/2008	7.60
01/07/2008	7.63
02/07/2008	7.86
03/07/2008	8.14
04/07/2008	8.47
05/07/2008	8.52
06/07/2008	8.31
07/07/2008	8.19
08/07/2008	8.66
09/07/2008	9.50
10/07/2008	10.09
11/07/2008	10.42
12/07/2008	10.65
13/07/2008	10.74
14/07/2008	10.86
15/07/2008	10.76
16/07/2008	10.48
17/07/2008	10.21
18/07/2008	10.50
19/07/2008	10.92
20/07/2008	11.23
21/07/2008	11.54
22/07/2008	11.77
23/07/2008	11.92
24/07/2008	11.95
25/07/2008	11.92
26/07/2008	11.79
27/07/2008	11.54
28/07/2008	11.47
29/07/2008	11.55
30/07/2008	11.64
31/07/2008	11.76

01/05/2008	2.46
02/05/2008	2.47
03/05/2008	2.56
04/05/2008	2.71
05/05/2008	2.83
06/05/2008	3.03
07/05/2008	3.23
08/05/2008	3.33
09/05/2008	3.39
10/05/2008	3.41
11/05/2008	3.45
12/05/2008	3.45
13/05/2008	3.38
14/05/2008	3.34
15/05/2008	3.39
16/05/2008	3.46
17/05/2008	3.48
18/05/2008	3.42
19/05/2008	3.56
20/05/2008	3.57
21/05/2008	3.51
22/05/2008	3.55
23/05/2008	3.49
24/05/2008	3.36
25/05/2008	3.38
26/05/2008	4.13
27/05/2008	4.15
28/05/2008	4.17
29/05/2008	4.27
30/05/2008	4.59
31/05/2008	4.58
01/06/2008	4.55
02/06/2008	5.07
03/06/2008	5.29
04/06/2008	5.67
05/06/2008	5.80
06/06/2008	6.25
07/06/2008	6.54
08/06/2008	7.15
09/06/2008	7.83
10/06/2008	7.71
11/06/2008	7.65
12/06/2008	7.29
13/06/2008	7.07
14/06/2008	7.33



01/08/2008	12.03
02/08/2008	12.18
03/08/2008	12.22
04/08/2008	12.20
05/08/2008	12.19
06/08/2008	12.30
07/08/2008	12.35
08/08/2008	12.38
09/08/2008	12.52
10/08/2008	12.58
11/08/2008	12.58
12/08/2008	13.01
13/08/2008	13.33
14/08/2008	13.57
15/08/2008	13.69
16/08/2008	13.75
17/08/2008	13.76
18/08/2008	13.70
19/08/2008	13.56
20/08/2008	13.33
21/08/2008	13.07
22/08/2008	12.79
23/08/2008	12.56
24/08/2008	12.36
25/08/2008	12.25
26/08/2008	12.11
27/08/2008	11.93
28/08/2008	11.70
29/08/2008	11.45
30/08/2008	11.23
31/08/2008	11.06
01/09/2008	10.96
02/09/2008	10.91
03/09/2008	10.94
04/09/2008	10.98
05/09/2008	11.09
06/09/2008	11.03
07/09/2008	11.00
08/09/2008	10.94
09/09/2008	10.96
10/09/2008	10.99
11/09/2008	10.99
12/09/2008	10.94
13/09/2008	10.91
14/09/2008	11.02
15/09/2008	11.08
16/09/2008	11.02

17/09/2008	10.88
18/09/2008	10.69
19/09/2008	10.45
20/09/2008	10.29
21/09/2008	10.24
22/09/2008	10.14
23/09/2008	9.97
24/09/2008	9.76
25/09/2008	9.54
26/09/2008	9.39
27/09/2008	9.27
28/09/2008	9.08
29/09/2008	8.87
30/09/2008	8.98
01/10/2008	9.79
02/10/2008	10.05
03/10/2008	10.11
04/10/2008	9.80
05/10/2008	9.45
06/10/2008	9.23
07/10/2008	8.98
08/10/2008	8.74
09/10/2008	8.61
10/10/2008	8.61
11/10/2008	8.58
12/10/2008	8.39
13/10/2008	8.22
14/10/2008	8.01
15/10/2008	7.71
16/10/2008	7.55
17/10/2008	7.37
18/10/2008	7.24
19/10/2008	7.05
20/10/2008	6.86
21/10/2008	6.83
22/10/2008	6.84
23/10/2008	6.63
24/10/2008	6.48
25/10/2008	6.34
26/10/2008	6.22
27/10/2008	6.12
28/10/2008	6.07
29/10/2008	6.15
30/10/2008	6.26
31/10/2008	6.32

3.3. Rainfall intensity-duration-frequency (IDF) curve of Paksane and Thakhek stations, from 1989 to 2018

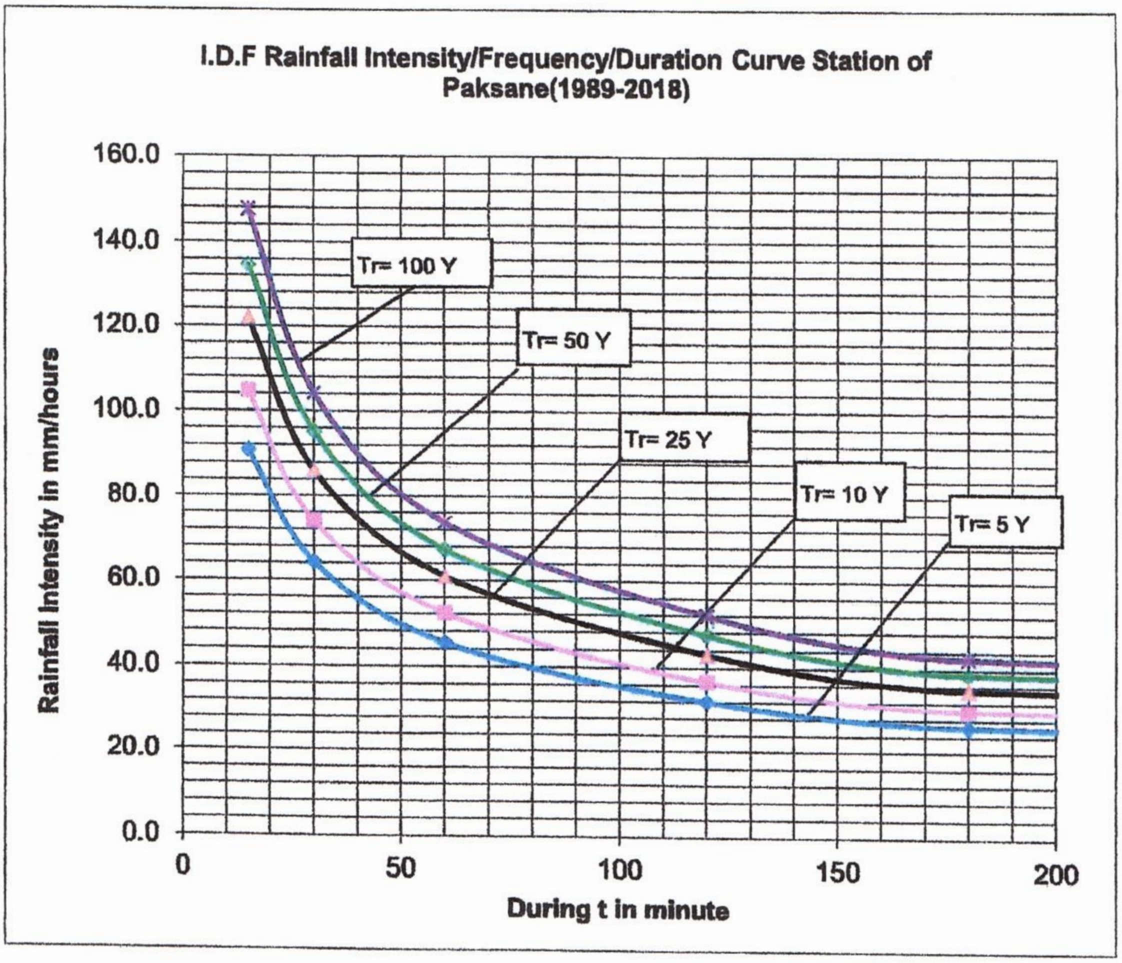
ແສງດາວເດືອນ ພຸດທະໂນໄຊ

Station: Paksane

	15'	30'	60'	120'	180'	1440'
Tr=5	79.1	56.0	39.6	28.0	22.8	8.1
Tr=10	91.0	64.4	45.5	32.2	26.3	9.3
Tr=25	106.1	75.0	53.0	37.5	30.6	10.8
Tr=50	117.2	82.9	58.6	41.4	33.8	12.0
Tr=100	128.3	90.7	64.1	45.3	37.0	13.1

+15%

	15	30	60	120	180	1440
Tr=5	91.0	64.4	45.5	32.2	26.3	9.3
Tr=10	104.7	74.0	52.3	37.0	30.2	10.7
Tr=25	122.0	86.2	61.0	43.1	35.2	12.4
Tr=50	134.8	95.3	67.4	47.7	38.9	13.8
Tr=100	147.5	104.3	73.8	52.2	42.6	15.1

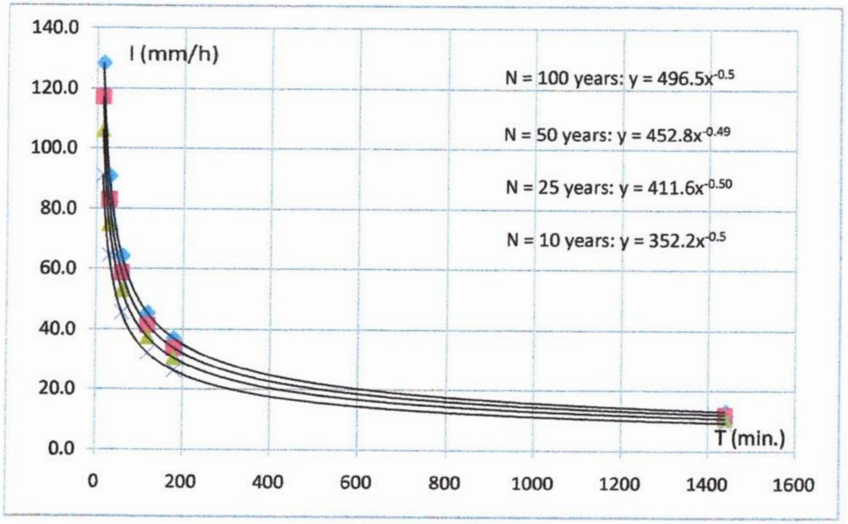


Sheet:

PAKSANE STATION
I.D.F - RAINFALL INTENSITY - DURATION - FREQUENCY CURVES

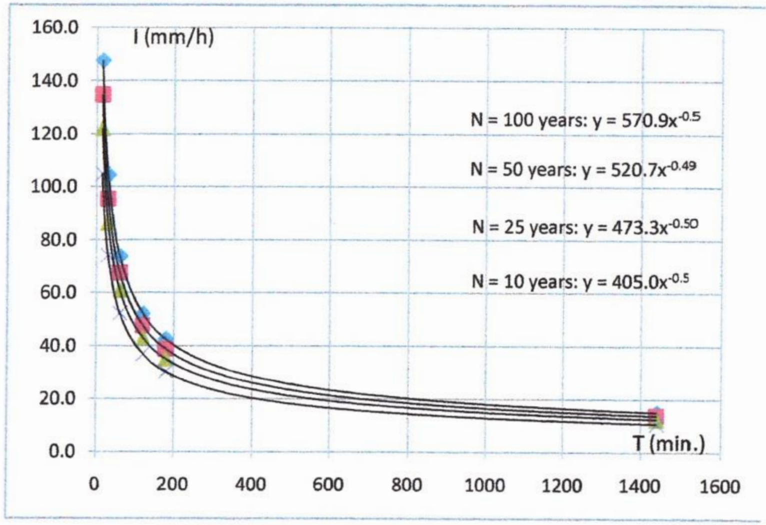
Normal condition

T (min.)	X (mm/h) = f(T min.; N years)			
	N = 100	N = 50	N = 25	N = 10
15	128.3	117.2	106.1	91.0
30	90.7	82.9	75.0	64.4
60	64.1	58.6	53.0	45.5
120	45.3	41.4	37.5	32.2
180	37.0	33.8	30.6	26.3
1440	13.1	12.0	10.8	9.3



Climate change condition (+15%)

T (min.)	X (mm/h) = f(T min.; N years)			
	N = 100	N = 50	N = 25	N = 10
15	147.5	134.8	122.0	104.7
30	104.3	95.3	86.3	74.1
60	73.7	67.4	61.0	52.3
120	52.1	47.6	43.1	37.0
180	42.6	38.9	35.2	30.2
1440	15.1	13.8	12.4	10.7



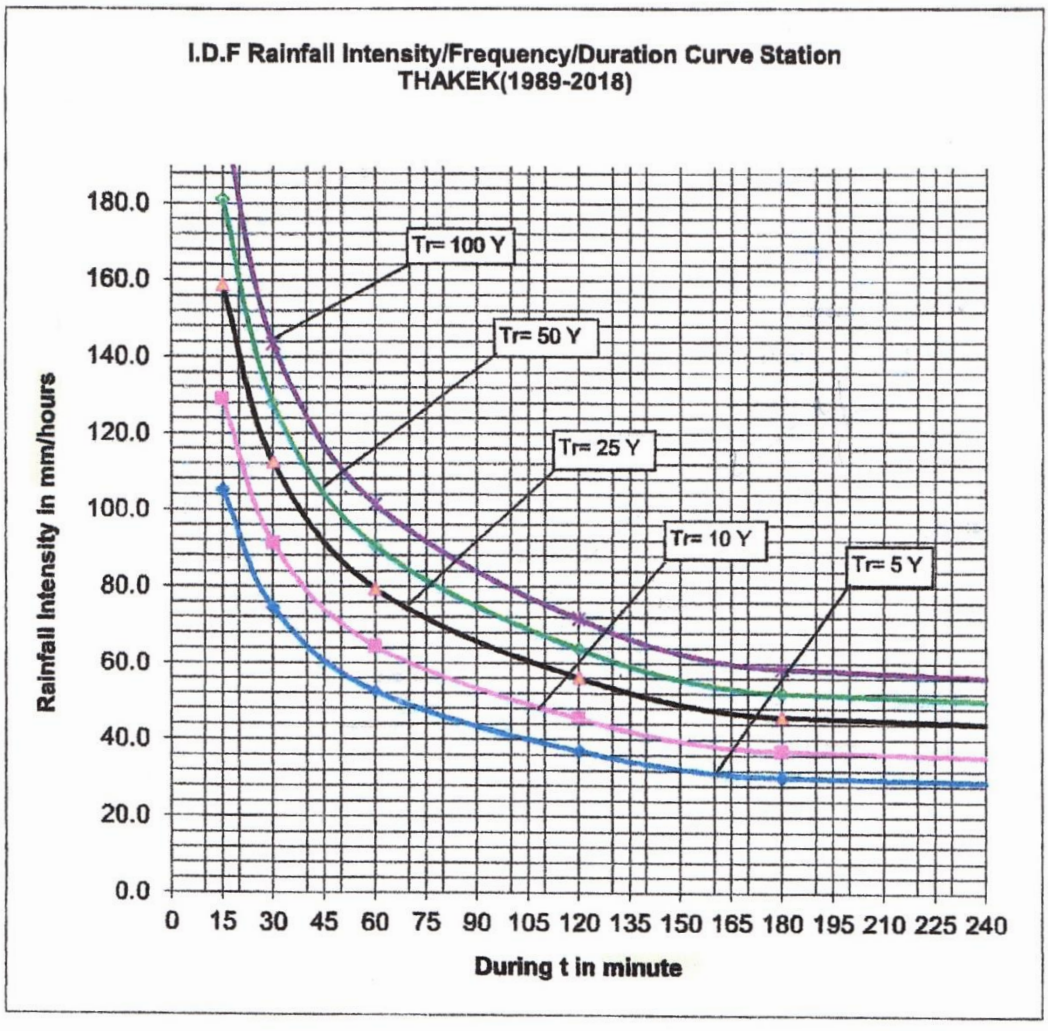
ແສງດວງເດືອນ ພຸດທະໂນໄຊ

Station: THAKEK

	15'	30'	60'	120'	180'	1440'
Tr=5	91.7	64.8	45.8	32.4	26.5	9.4
Tr=10	112.2	79.4	56.1	39.7	32.4	11.5
Tr=25	138.3	97.8	69.1	48.9	39.9	14.1
Tr=50	157.5	111.4	78.8	55.7	45.5	16.1
Tr=100	176.7	124.9	88.3	62.5	51.0	18.0

+15%

	15	30	60	120	180	1440
Tr=5	105.4	74.5	52.7	37.3	30.4	10.8
Tr=10	129.1	91.3	64.5	45.6	37.3	13.2
Tr=25	159.0	112.4	79.5	56.2	45.9	16.2
Tr=50	181.2	128.1	90.6	64.1	52.3	18.5
Tr=100	203.2	143.7	101.6	71.8	58.7	20.7

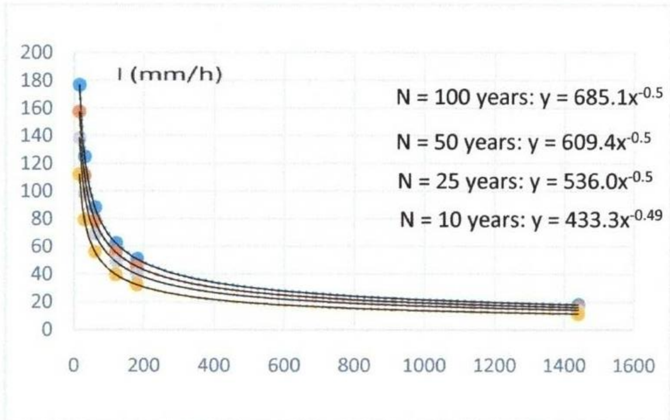


Sheet:

THAKHEK STATION
I.D.F - RAINFALL INTENSITY - DURATION - FREQUENCY CURVES

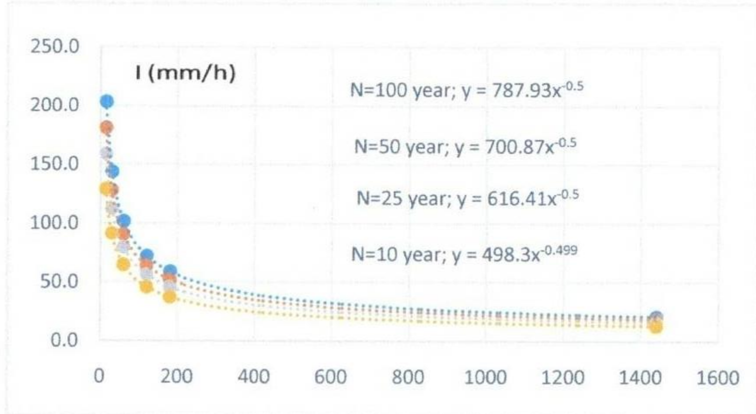
Normal condition

T(min.)	X(mm/h) = f(Tmin.; N years)			
	N=100	N=50	N=25	N=10
15	176.7	157.5	138.3	112.2
30	124.9	111.4	97.8	79.4
60	88.3	78.8	69.1	56.1
120	62.5	55.7	48.9	39.7
180	51	45.5	39.9	32.4
1440	18	16.1	14.1	11.5



Climate change condition (+15%)

T(min.)	X(mm/h) = f(Tmin.; N years)			
	N=100	N=50	N=25	N=10
15	203.2	181.1	159.0	129.0
30	143.6	128.1	112.5	91.3
60	101.5	90.6	79.5	64.5
120	71.9	64.1	56.2	45.7
180	58.7	52.3	45.9	37.3
1440	20.7	18.5	16.2	13.2



Flooding Level Site Observations on 7-8 September 2023

3. Nam Kap Bridge, KM 117+038.

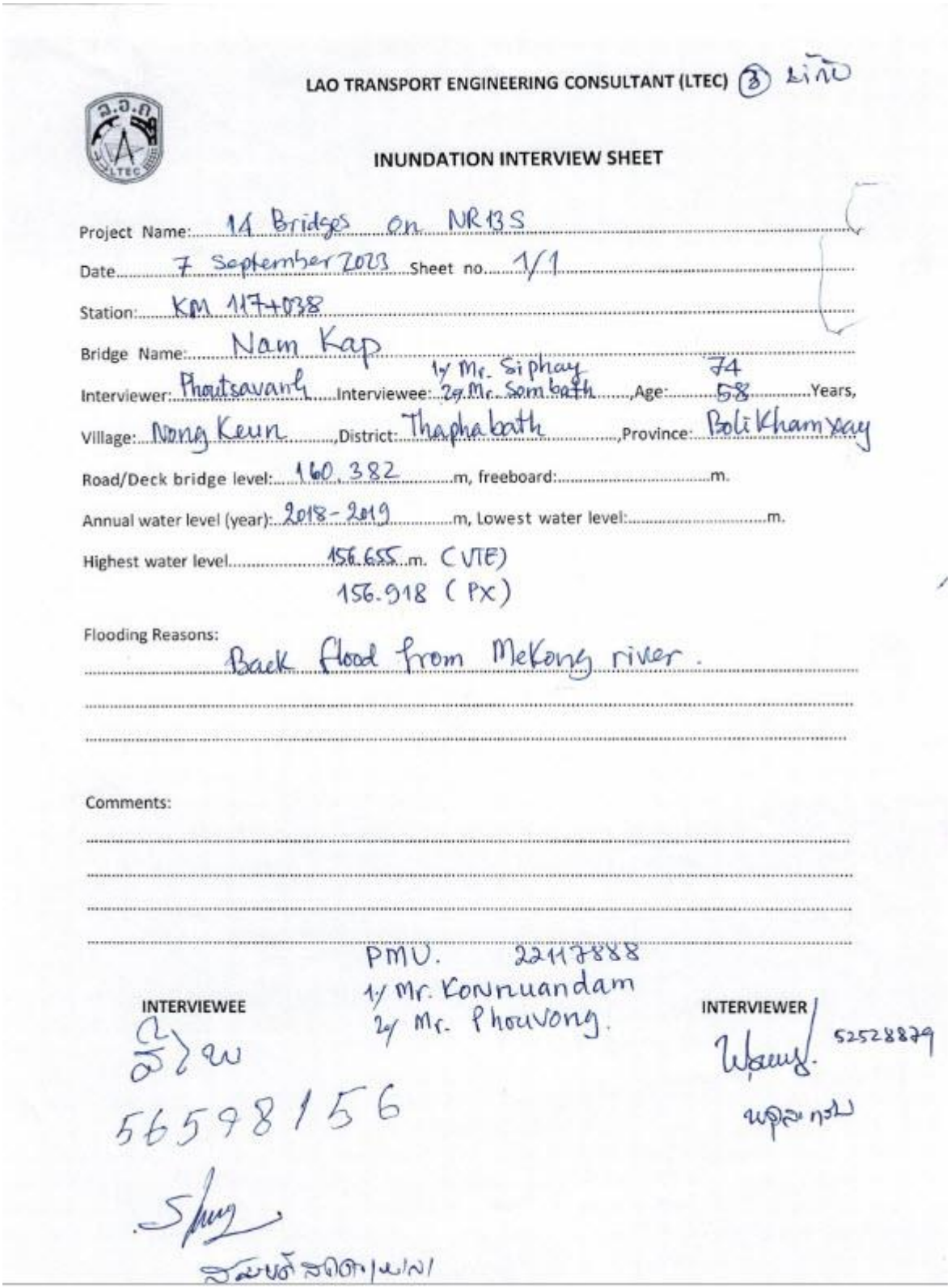
- Vientiane / A side.

- Interviewee: Mr. Sombath Southduangmala; age: 58 years, Phone no: 020 9960 5950
- Village: Nong keun; District: Thaphabath; Province: Bolikhamxay.
- HWL: 156.655 m (VTE / A side). Flooding year: 2018-2019.

- Pakxan / B side.

- Interviewee: Mr. Siphay; age: 74 years, Phone no: 020 5659 8156
- Village: Nong keun; District: Thaphabath; Province: Bolikhamxay.
- HWL: 156.918 m (PX / B side). Flooding year: 2018-2019.



LAO TRANSPORT ENGINEERING CONSULTANT (LTEC) (3) ลิเวน

INUNDATION INTERVIEW SHEET

Project Name: 14 Bridges on NR13S

Date: 7 September 2023 Sheet no. 1/1

Station: KM 117+038

Bridge Name: Nam Kap

Interviewer: Phoutsavanh Interviewee: 1/ Mr. Siphay 2/ Mr. Sombath Age: 74 58 Years,

Village: Nong Keun District: Thaphabath Province: Bolikhamxay

Road/Deck bridge level: 160.382 m, freeboard: m.

Annual water level (year): 2018-2019 m, Lowest water level: m.

Highest water level 156.655 m. (VTE)
156.918 (PX)

Flooding Reasons:
Back flood from Mekong river.

Comments:

PMU. 22117888
1/ Mr. Kounxuandam
2/ Mr. Phouvong.

INTERVIEWEE

56598156

INTERVIEWER

52528879

4. Nam Thoay Bridge, KM 121+952.

- Vientiane / A side.

- Interviewee: Mr. Phou nguen; age: 67 years, Phone no: (no have)
- Village: Pak Thoay; District: Pakxan; Province: Bolikhamxay.
- HWL: 156.333 m (VTE / A side). Flooding year: 2018-2019.

Pakxan / B side.

- Interviewee: Mr. Khamkhong Chanthavongsa; age: 58 years, Phone no: 020 5508 3818
- Village: Pak Thoay; District: Pakxan; Province: Bolikhamxay.
- HWL: 156.681 m (PX / B side). Flooding year: 2018-2019.

LAO TRANSPORT ENGINEERING CONSULTANT (LTEC)

INUNDATION INTERVIEW SHEET

Project Name: 14 Bridges on NR13S

Date: 7 September 2023 Sheet no. 1/1

Station: KM 121+952

Bridge Name: Nam Thoay

Interviewer: Phoutsavanh Interviewee: 1/ Mr. KhamKhong 2/ Mr. Phoungeun Age: 58 / 67 Years,

Village: Pakthoay, District: Pakxan, Province: Bolikhamxay

Road/Deck bridge level: 160.103 m, freeboard: m.

Annual water level (year): 2018-2019 m, Lowest water level: m.

Highest water level 156.333 m. (VTE)
156.681 (PX)

Flooding Reasons:
Back flood from Mekong River.

Comments:

PM.U. 22117888
1/ Mr. Konnuandam
2/ Mr. Phouvong.

INTERVIEWEE

55083818

INTERVIEWER

Phoutsavanh
52528879

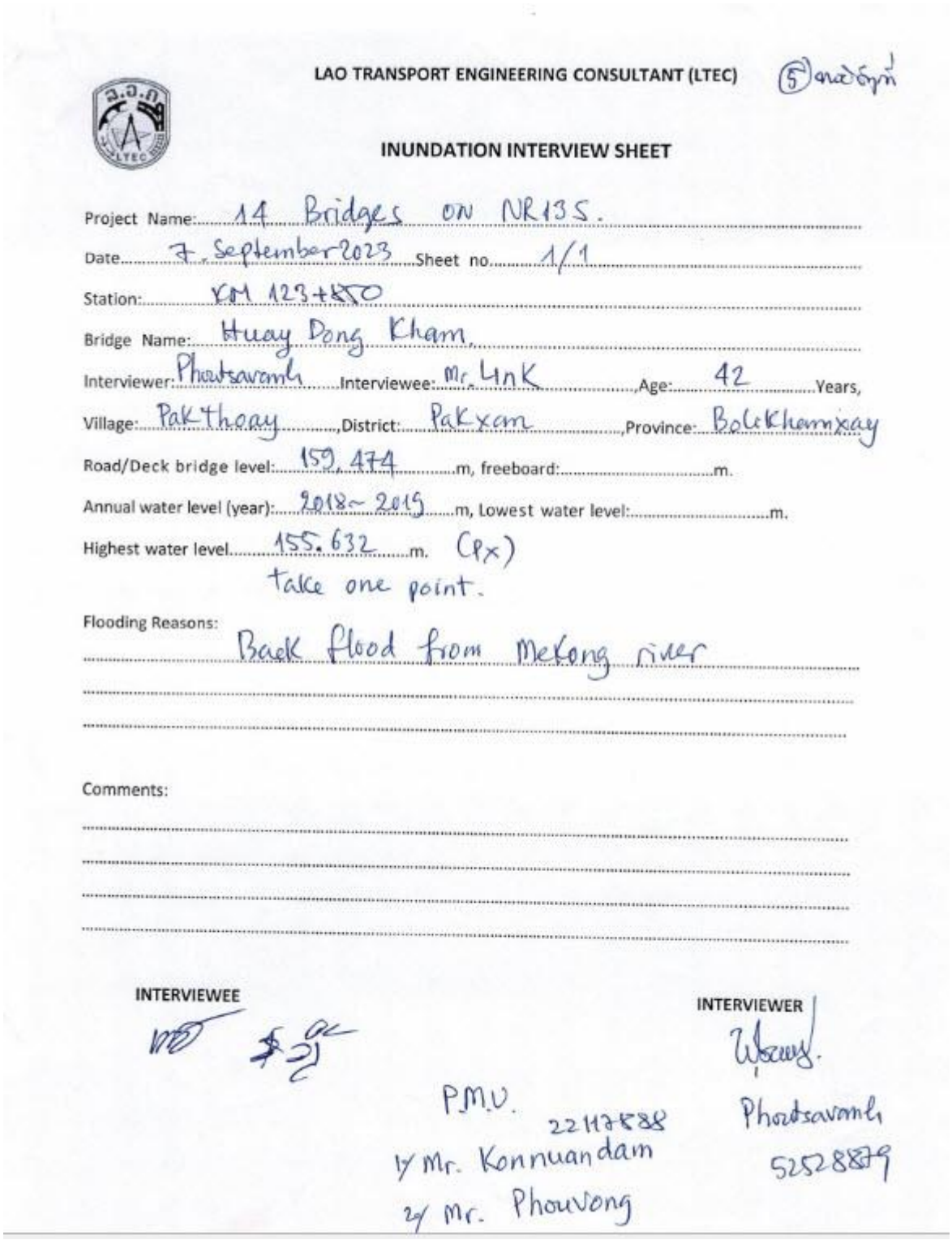
5. Huay Dong kam Bridge, KM 123+850.

- This bridge was a minor bridge, we took only one at B side.

- Interviewee: Mr. Link; age: 42 years, Phone no: (no have)

- Village: Pak Thoay; District: Pakxan; Province: Bolikhamxay.

- HWL: 155.632 m (PX / B side). Flooding year: 2018-2019.



LAO TRANSPORT ENGINEERING CONSULTANT (LTEC) (5) ตอนจบ

INUNDATION INTERVIEW SHEET

Project Name: 14 Bridges on NR13S.

Date: 7. September 2023 Sheet no. 1/1

Station: KM 123+850

Bridge Name: Huay Dong Kham

Interviewer: Phoutsavanh Interviewee: Mr. Link Age: 42 Years,

Village: Pak Thoay, District: Pakxan, Province: Bolikhamxay

Road/Deck bridge level: 159.474 m, freeboard: m.

Annual water level (year): 2018~2019 m, Lowest water level: m.

Highest water level 155.632 m. (Px)
take one point.

Flooding Reasons:
Back flood from Mekong river

Comments:

INTERVIEWEE

INTERVIEWER

PMU. 22117588
by Mr. Konnuandam
by Mr. Phouvong

Phoutsavanh
52528879

6. Nam Ngiap Bridge, KM 121+952.

- Vientiane / A side.

- Interviewee: Mr. Phet Luanglatbandith; age: 59 years, Phone no: 020 5585 2021
  Mr. Sithpaserth Luanglatbandith; age: 50 years, Phone no: 020 2303 1947
- Village: Koay oudom; District: Pakxan; Province: Bolikhamxay.
- HWL: 156.123 m (VTE / A side). Flooding year: 2018-2019.

- Pakxan / B side.

- Interviewee: Mrs. Khamkong ; age: 64 years, Phone no: 020 2927 9856
- Village: Koay oudom; District: Pakxan; Province: Bolikhamxay.
- HWL: 156.085 m (PX / B side). Flooding year: 2018-2019.

LAO TRANSPORT ENGINEERING CONSULTANT (LTEC)

6 ภาพ

INUNDATION INTERVIEW SHEET

Project Name: 14 Bridges on NR13S

Date: 7 September 2023 Sheet no. 1/1

Station: 140+200

Bridge Name: Nam Ngiap

Interviewer: Phoutsavanh Interviewee: 1/ Mr. Phet 59 2/ Mrs. Kham Kong 64 3/ Mr. Sithpaseut 50 Age: Years,

Village: Kaoyoudom District: Pakxan Province: Bolikhamxay

Road/Deck bridge level: 158.914 m, freeboard: m.

Annual water level (year): 2018-2019 m, Lowest water level: m.

Highest water level 156.123 m. (VTE)
156.085 (PX)

Flooding Reasons:
Back flood from Mekong River

Comments:

INTERVIEWEE

20/9/2021

55852021

23031947

INTERVIEWER

Phoutsavanh

02052528879

PM.U

1/ Mr. Konnuandam 22117888

2/ Mr. Phouvong.

7. Nam Xan Bridge, KM 146+642.

- Vientiane / A side.

- Interviewee: Mr. Phuangkeo Manivong; age: 73 years, Phone no: 030 913 8769.
- Village: Phonxay Neua; District: Pakxan; Province: Bolikhamxay.
- HWL: 155.166 m (VTE / A side). Flooding year: 2018-2019.

- Pakxan / B side.

- Interviewee: Mr. Sivixay ; age: 64 years, Phone no: 020 9803 9126
- Village: Phonxay Neua; District: Pakxan; Province: Bolikhamxay.
- HWL: 155.632 m (PX / B side). Flooding year: 2018-2019.

LAO TRANSPORT ENGINEERING CONSULTANT (LTEC) (7) 2ii 72

INUNDATION INTERVIEW SHEET

Project Name: National Road 13S Improvementation Support and Work Supervision

Date: 7 September 2023 Sheet no. 1

Station: 146+642

Bridge Name: Nam Xan bridge

Interviewer: Phoutsavanh Interviewee: 1/ Sivixay 2/ Phuangkeo 73 Age: 64 Years,

Village: Phon Xay District: Pa Kxan Province: Bolikhamxay

Road/Deck bridge level: 158.699 m, freeboard: m.

Annual water level (year): 2018-2019 m, Lowest water level: m.

Highest water level 155.166 m. (VTE)
155.632 (PX)

Flooding Reasons:

Back flood from Mekong river

Comments:

P.M.U. 22117888
1/ Mr. Konnuandam
2/ Mr. Phouvong

INTERVIEWEE

98039126.

030.9138769.

INTERVIEWER

Phoutsavanh
52528879