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IMPLEMENTATION AGENCY:

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CONCESSIONAIRE :



SHELADIA ASSOCIATES INC., USA

PROJECT : DRAFT DETAILED DESIGN FOR INDO MYANMAR ROAD SECTION PROJECT (IMPHAL TO MOREH : AH-01)

JOB No.

TOTAL NO. OF PAGES				TITLE :	
	NAME	SIGN	DATE		
DSGN	DY		12.03.14	APPENDIX 1.1 TO VOLUME II - PART II - CHAPTER I	
CHKD	UD		12.03.14	HYDROLOGY AND DRAINAGE REPORT	
APPD	SB		12.03.14		

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Discharge calculations for Bridges

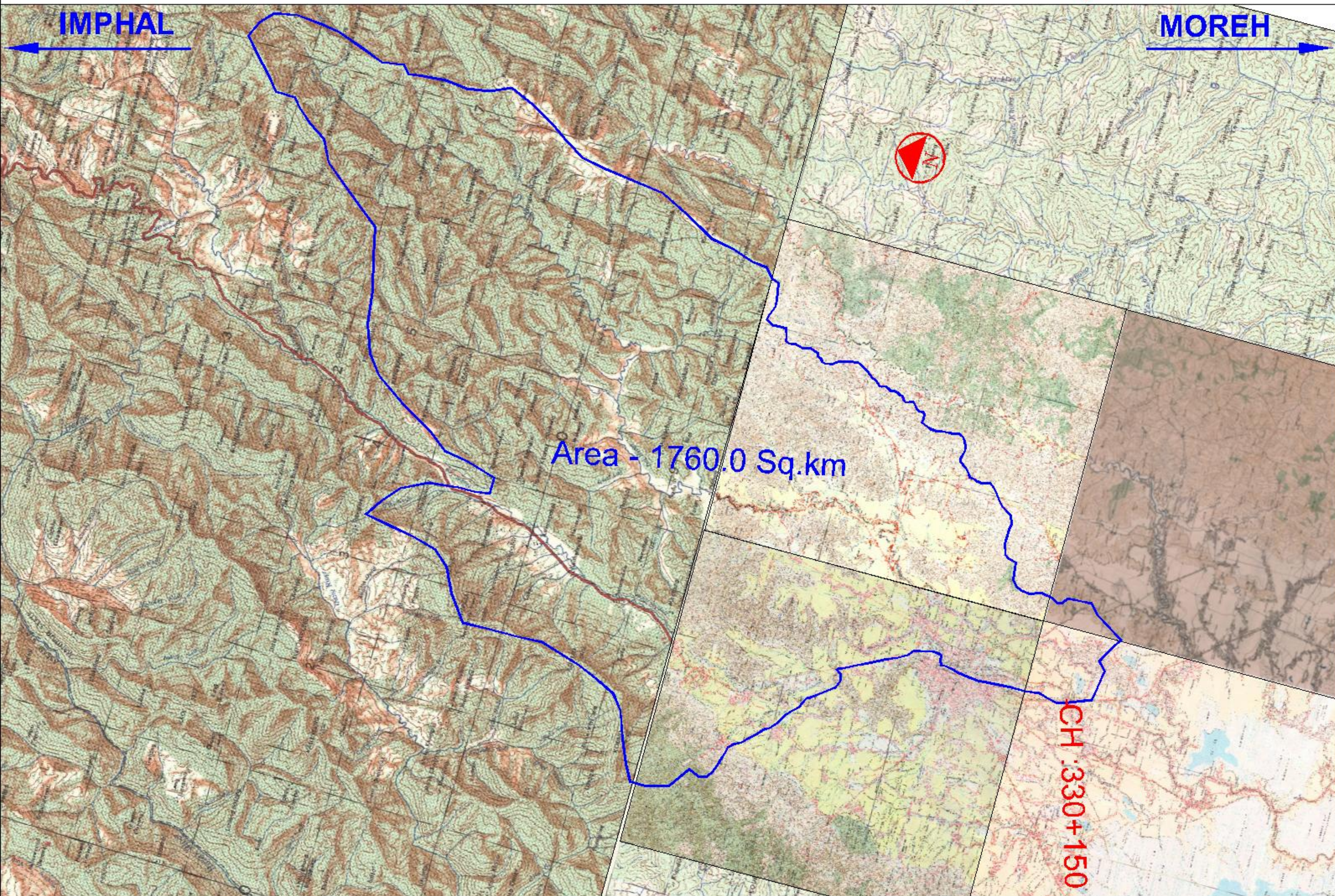
Summary of Hydraulic data for bridges :

Si.No	Chainage	Design Chainage	Name of the Bridge	Existing Span Arrangement (m)	Proposed Span Arrangement	Direction of Flow	Designed HFL in m	Designed Slab bottom in m	Designed Discharge in cumec	Designed Velocity in m/sec	Remarks
Minor Bridges											
1	334+330	334+640	Ushoipokpi Bridge	5.6 + 5.9 + 5.6	3 X 6.0	L-R	774.720	775.660	175.000	5.560	
2	336+100	336+315	Waithou Bridge	3 X 13.2	2 X 20.0	L-R	774.480	775.700	408.000	3.560	
3	344+150	344+130	Arong Bridge	3 X 10.5	3 X 10	L-R					It is a canal
4	347+600	347+790	Khabakong Bridge	2 X 7.0	2 X 7.0	L-R					It is a canal
5	348+150	348+355	Wangjing Bridge	3 X 8.8	3 X 8.0 / 1 X 25.0	L-R	775.750	776.670	204.000	3.470	
6	349+900	349+773	Unikhong Bridge	2 X 5.8	2 X 5.8	L-R					It is a canal
7	352+800	352+758	Khongjom Bridge	2 X 5.8	2 X 5.8	L-R	775.500	776.420	123.000	4.360	
8	407+450	404+435	Lokchav Bridge	1X30.5		L-R					DPR already submitted by others
9	409+000	405+495		1 X 10.3	1 X 10	L-R	396.150	397.170	169.000	9.970	
10	412+230	408+440		1 X 10.3	1 X 10	L-R	499.650	500.800	172.000	11.590	
11	428+180	423+492	Khujairok Bridge	1 X 16.0	1 X 16.0	R-L	182.660	183.700	239.000	6.980	
12	430+400		Border Bridge	1 X 44.0		R-L					Not our scope
Major bridges											
1	330+150	330+380	Lilong bridge	45+1.5+47.6	2 x 48.5	L-R	779.270	780.470	2166.000	3.170	
2	341+780	341+755	Thoubal Bridge	32.42+34.5	2 x 34.5	L-R	781.010	782.220	1741.000	3.800	
3	365+550	365+260	Parallel Bridge	3 x 24	3 x 24	L-R	786.140	787.370	1078.000	4.500	

MAJOR BRIDGE
(Existing CH: 330+150)
(Design CH: 330+380)

Catchment Details

CATCHMENT FOR MAJOR BRIDGE AT CH : 330+150 (DESIGN)



Discharge Calculations as per Rational Formula :

$$Q = 0.028 P \cdot f \cdot A \cdot I_c$$

Where Q = Maximum run-off in cu.m / sec

$$A = \text{Area of catchment in hectares} = 176000$$

$$P = \text{Percentage coefficient of runoff for the catchment characteristics (vide Table 4.1, SP-13-2004, pg 13)} = 0.7$$

$$f = \text{fraction depending on the catchment area from f curve (Sp-13, pg 14)} = 0.615$$

I_c = Critical Intensity of rainfall in cm per hour

$$= I_o \left[\frac{2}{t_c + 1} \right] \quad I_o = \text{one hour rainfall}$$

$$\text{Where } I_o = \frac{F}{2} \left[1 + \frac{1}{T} \right] = 16.67 \text{ cm/hr}$$

$$F = \text{Precipitation of the storm in cm} = 32 \text{ cm}$$

$$T = \text{Duration in hours} = 24 \text{ hrs}$$

t_c = Concentration time of Catchment in hours

$$= 0.870 \left[\frac{L^3}{H} \right]^{0.385} = 15.331 \text{ hrs}$$

$$L = \text{The distance from the critical point to the culvert in km.} = 137.70$$

$$H = \text{The fall in level from the critical point to the culvert in metre.} = 1514.6$$

$$\therefore Q = A \cdot I_o \cdot \lambda$$

$$\lambda = \frac{0.056 f \cdot P}{t_c + 1} = \frac{0.056 \times 0.62 \times 0.7}{15.331 + 1} = 0.0015$$

$$Q = 2E+05 \times 16.667 \times 0.001 = 4330 \text{ cumec}$$

After extensive study of catchment, it has been found that the stream is originated at different ranges of hills and at the toes of hills are thickly populated along both sides of banks. Maximum discharge of stream is vanished through irrigation canals for the domestic and agricultural requirements of local people.

Therefore, 50% of the calculated discharge only has been considered as designed discharge.

$$\text{So, Design discharge by SUH} = 2165.09 \text{ cumec}$$

Discharge Calculations as per AV method :

FRL in m	=	784.380
GL in m	=	768.800
HFL as per inventory	=	779.000

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	772.00	0.000			
2	37.000	780.00	37.000	8.00	8.00	296.00
3	55.200	800.00	18.200	28.00	36.00	655.20
4	114.200	914.63	59.000	142.63	170.63	10067.41
5	124.900	1067.07	10.700	295.07	437.71	4683.47
6	130.700	1219.51	5.800	447.51	742.59	4307.00
7	135.500	1371.95	4.800	599.95	1047.46	5027.82
8	135.800	1524.39	0.300	752.39	1352.34	405.70
9	136.300	1676.83	0.500	904.83	1657.22	828.61
10	136.500	1829.27	0.200	1057.27	1962.10	392.42
11	136.900	1981.71	0.400	1209.71	2266.98	906.79
12	137.300	2134.15	0.400	1362.15	2571.85	1028.74
13	137.700	2286.59	0.400	1514.59	2876.73	1150.69

S 29749.86

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 1.569 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W=	Width in m	=	97
h=	Depth of water in m	=	10.20 (from inventory)
n=	Rugosity coefficient	=	0.045
S=	Slope	=	0.0016

A= Cross sectional area in sq m = 665.40
(Area of chord, where L= width of stream & h = depth of water)

P = Wetted Perimeter = 99.84

R= Hydraulic mean depth = A/P
= 6.665

V= Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$
= 3.12

Q= Discharge in cum / sec = 2075

Discharge calculation by Synthetic Unit Hydrograph Method**1 Description**

Name and Number of Subzone = South Brahmaputra Subzone - 2(b)
 Location at Site = km. 330+150
 Name of Stream =

2 Design data

Catchment Area (A) = 1760.00 sqkm *from Toposheet*
 Length of Longest Stream (L) = 137.70 km *from Toposheet*
 Length of Longest Stream from cg to site (L) = 68.60 km *from Toposheet*
 Unit Duration of Unitgraph (t_r) = 1.0 hr
 Loss Rate = 0.35 cm/hr *From CWC report*

3 Computation of Equivalent Stream Slope (S)

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	772.00	0.000		-	-
2	37.000	780.00	37.000	8.00	8.00	296.00
3	55.200	800.00	18.200	28.00	36.00	655.20
4	114.200	914.63	59.000	142.63	170.63	10067.41
5	124.900	1067.07	10.700	295.07	437.71	4683.47
6	130.700	1219.51	5.800	447.51	742.59	4307.00
7	135.500	1371.95	4.800	599.95	1047.46	5027.82
8	135.800	1524.39	0.300	752.39	1352.34	405.70
9	136.300	1676.83	0.500	904.83	1657.22	828.61
10	136.500	1829.27	0.200	1057.27	1962.10	392.42
11	136.900	1981.71	0.400	1209.71	2266.98	906.79
12	137.300	2134.15	0.400	1362.15	2571.85	1028.74
13	137.700	2286.59	0.400	1514.59	2876.73	1150.69

S 29749.86

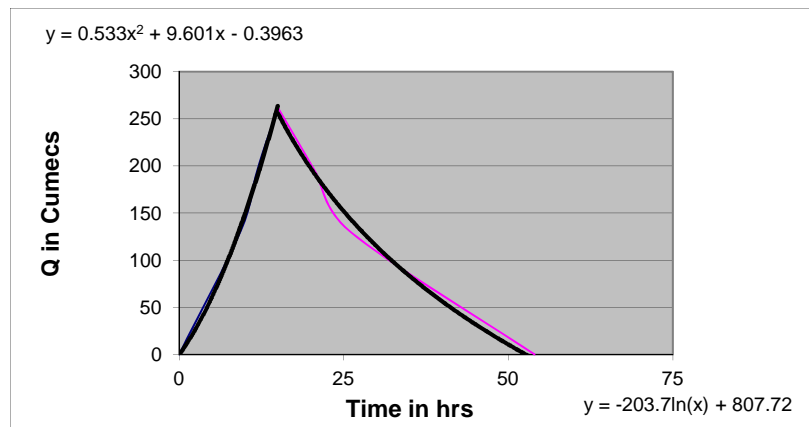
$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 1.5690 \text{ m/km}$$

4 Determination of Synthetic 1-hr Unitgraph Parameters

t_r = 1.0 hr
 $t_p = 2.87(q_p)^{-0.839}$ = 14.230 hrs 14.50 say
 Peak of the Unit Hydrograph $Q_p = 0.905 * (A)^{0.758}$ = 261.065 cumec/sqkm
 $q_p = Q_p/A$ = 0.148
 $W_{50} = 2.304 * (q_p)^{-1.035}$ = 16.61 hrs
 $W_{75} = 1.339 * (q_p)^{-0.978}$ = 8.66 hrs
 $W_{R50} = 0.814 * (q_p)^{-1.018}$ = 5.68 hrs
 $W_{R75} = 0.494 * (q_p)^{-0.966}$ = 3.12 hrs
 Base width $T_B = 2.447 * (t_p)^{1.157}$ = 53.99 hrs 54.00 say
 $t_m = t_p + t_r/2$ = 15.00 hrs
 $Q_p = q_p * A$ = 261.07 cumec

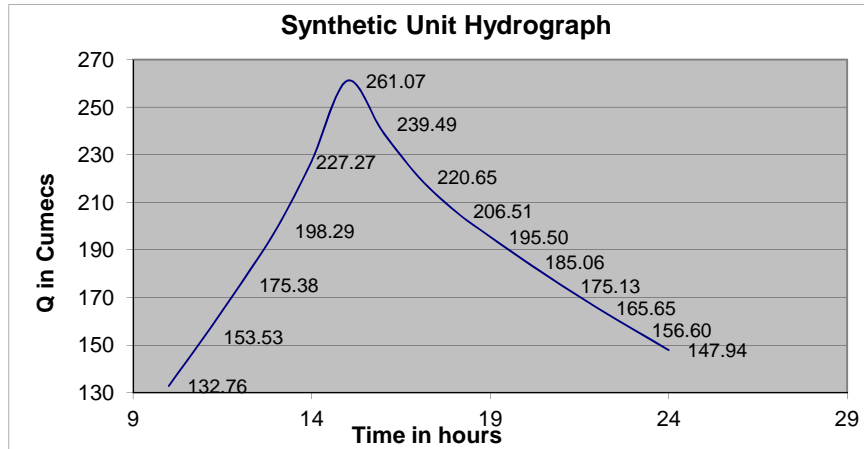
UG Ordinates from above formulae

X-value		Y-value	
0	0.00	0	0.00
$t_m - W_{R50}$	9.32	$Q_p * 0.5$	130.53
$t_m - W_{R75}$	11.88	$Q_p * 0.75$	195.80
t_m	15.00	$Q_p * 1.0$	261.07
$t_m + W_{75} - W_{R75}$	20.53	$Q_p * 0.75$	195.80
$t_m + W_{50} - W_{R50}$	25.93	$Q_p * 0.5$	130.53
T_B	54.00	0	0.00

**UG Ordinates from graph(from equation for rising and recession limb)**

Abcissa	values from the first equation	values from the Second equation	Adjusted values
10	148.91	148.91	132.76
11	169.71	169.71	153.53
12	191.57	191.57	175.38
13	214.49	214.49	198.29
14	238.49	238.49	227.27
15	263.54	263.54	261.07
16	242.94	242.94	239.49
17	230.59	230.59	220.65
18	218.95	218.95	206.51
19	207.94	207.94	195.50
20	197.49	197.49	185.06
21	187.55	187.55	175.13
22	178.07	178.07	165.65
23	169.02	169.02	156.60
24	160.35	160.35	147.94
25	152.03	152.03	139.63
	3171.66	3171.66	2980.46
	0.65	0.65	0.61

$$\Sigma Q_i = A * d / 0.36 * t_r = 4888.89$$

**5 Design Storm Rainfall***As per the steps followed in Page No.23*

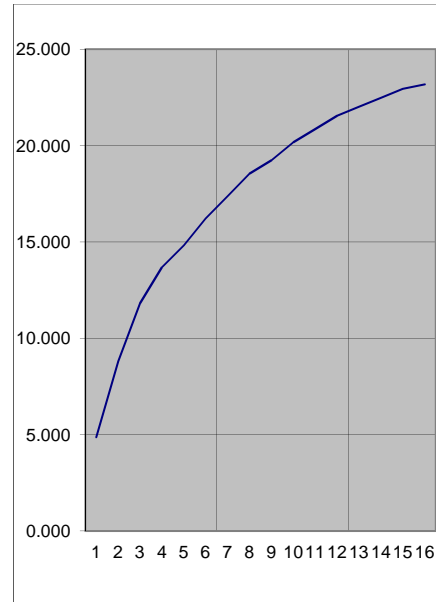
$$\begin{aligned}
 \text{Design Storm Duration (T}_D\text{)} &= 1.1 \times t_p &= 1.1 \times 14.5 &= \mathbf{16.00 \text{ say}} \\
 \text{50 year-24hour Point rainfall} &&= &= \mathbf{32.0 \text{ cm, from plate 10 (Step 1)}} \\
 \text{Conversion factor for T}_D\text{-hour i.e. 16.00} &&= &= \mathbf{0.923 \text{ from fig.10 (Step 2)}} \\
 \therefore \text{50 Year T}_D\text{ - Hour Point Rainfall} &&= &= \mathbf{29.55 \text{ cm}}
 \end{aligned}$$

Storm Areal Rainfall*Areal reduction factors for point to areal rainfall from Annexure 4.3, Page A-16 -step-3*

$$\begin{aligned}
 \text{Areal reduction factor corresponding to storm duration T}_D \text{ i.e hours } 16.0 & \\
 \text{and C.A } 1760.0 \text{ sq.km} & \\
 &= \mathbf{0.785} \\
 \therefore \text{50 year TD hour Areal Rainfall} &= \mathbf{23.182 \text{ cm}}
 \end{aligned}$$

Time Distribution coefficients from Annexure 4.4, Page A-17 - step4

Time	Distribution coefficient from Table T-2	Storm rainfall in Cm	Rainfall Increment Cms
1	0.21	4.868	4.87
2	0.38	8.809	3.94
3	0.51	11.823	3.01
4	0.59	13.678	1.85
5	0.64	14.837	1.16
6	0.70	16.228	1.39
7	0.75	17.387	1.16
8	0.80	18.546	1.16
9	0.83	19.241	0.70
10	0.87	20.169	0.93
11	0.90	20.864	0.70
12	0.93	21.560	0.70
13	0.95	22.023	0.46
14	0.97	22.487	0.46
15	0.99	22.950	0.46
16	1.00	23.182	0.23



$$\text{Base flow} = \mathbf{0.05} \text{ cumecs / sqkm} \quad \text{As per Cl. 3.7 Page No. 18}$$

$$\therefore \text{Total Base flow for C.A} = 0.05 \times 1760 = \mathbf{88.000 \text{ Cumec}}$$

50 year flood peak :

Time in hours	SUG ordinates	Gross rainfall Increments	Loss rate	Rainfall Excess	Rainfall Excess ordinates Arrangement	Direct Runoff (cumec)
10	132.76	4.87	0.35	4.518	0.000	0.00
11	153.53	3.94	0.35	3.591	0.114	17.45
12	175.38	3.01	0.35	2.664	0.577	101.25
13	198.29	1.85	0.35	1.505	0.809	160.44
14	227.27	1.16	0.35	0.809	2.664	605.38
15	261.07	1.39	0.35	1.041	4.518	1179.59
16	239.49	1.16	0.35	0.809	3.591	860.01
17	220.65	1.16	0.35	0.809	1.505	331.98
18	206.51	0.70	0.35	0.345	1.041	214.96
19	195.50	0.93	0.35	0.577	0.809	158.18
20	185.06	0.70	0.35	0.345	0.809	149.73
21	175.13	0.70	0.35	0.345	0.345	60.50
22	165.65	0.46	0.35	0.114	0.345	57.23
23	156.60	0.46	0.35	0.114	0.345	54.10
24	147.94	0.46	0.35	0.114	0.114	16.81
25	139.63	0.23	0.35	0.000	0.114	15.87

50 year Flood peak = 3983.49 cumec

Add Base flow = 88.00 cumec

Total = 4071.49 cumec

After extensive study of catchment, it has been found that the stream is originated at different ranges of hills and at the toes of hills are thickly populated along both sides of banks. Maximum discharge of stream is vanished through irrigation canals for the domestic and agricultural requirements of local people.

Therefore, 50% of the calculated discharge only has been considered as designed discharge.

So, Design discharge by SUH = 2035.74 cumec

Design Discharge :-**Design discharges by various methods :**

Method	Discharge	Units
Rational Method	2165.09	Cumecs
Area velocity Method	2075.00	Cumecs
SUH	2035.75	Cumecs

As per IRC-5 Design discharge = 2165.09

Hence Design discharge = **2165.09 Cumecs**

Design discharge for foundation design :

As per cl. 703.1.1 of IRC 78: 2000

Catchment area (in km ²)		Increase over design discharge in percent
0 -	3000	30 %
3000 -	10000	30 - 20
10000 -	40000	20 - 10
>40000		10 %

Design discharge for foundation = 1.3 x 2165.09
2815.00 Cumecs

Calculation of Designed HFL :

100 yr. max. flood discharge in cumec	=	2165.09
FRL in m	=	784.380
GL in m	=	768.800
HFL in m	=	779.269

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	772.00	0.000			
2	37.000	780.00	37.000	8.00	8.00	296.00
3	55.200	800.00	18.200	28.00	36.00	655.20
4	114.200	914.63	59.000	142.63	170.63	10067.41
5	124.900	1067.07	10.700	295.07	437.71	4683.47
6	130.700	1219.51	5.800	447.51	742.59	4307.00
7	135.500	1371.95	4.800	599.95	1047.46	5027.82
8	135.800	1524.39	0.300	752.39	1352.34	405.70
9	136.300	1676.83	0.500	904.83	1657.22	828.61
10	136.500	1829.27	0.200	1057.27	1962.10	392.42
11	136.900	1981.71	0.400	1209.71	2266.98	906.79
12	137.300	2134.15	0.400	1362.15	2571.85	1028.74
13	137.700	2286.59	0.400	1514.59	2876.73	1150.69

S 29749.86

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 1.569 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W=	Width of stream in m	=	97.0
h=	Depth of water in m (HFL - GL)	=	10.47
n=	Rugosity coefficient	=	0.045
S=	Slope	=	0.0016

A= Cross sectional area in sq m = 683.26
(Area of chord, where L= width of stream & h = depth of water)

P = Wetted Perimeter = 99.99

R= Hydraulic mean depth = A/P
= 6.834

V= Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$
= 3.17

Q= A*V = 2166 o.k

Hence, adopt HFL = 779.270 m

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	2166.00 m ³ /s	
Unobstructed Velocity of river	=	3.17 m/s	
HFL	=	779.270 m	
Bed level	=	768.800 m	
Depth of water (u/s)	=	10.47 m	
Afflux from Molesworth	=	0.000 m	
Velocity of approach	=	3.17 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	0.51 m	
Total head	=	0.51 m	
Velocity through vent (2gh)	=	3.17 m/s	
Linear water way required	=	91.91 m	
Proposed vent way (2 x 48.5 - 1 x 1.8 - 2 x 1.1)	=	93.00 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	3.17 m/sec
Unobstructed area, Au	=	683.26 m ²
Effective vent area, Ae	=	681.48 m ²
Afflux	=	0.000 m

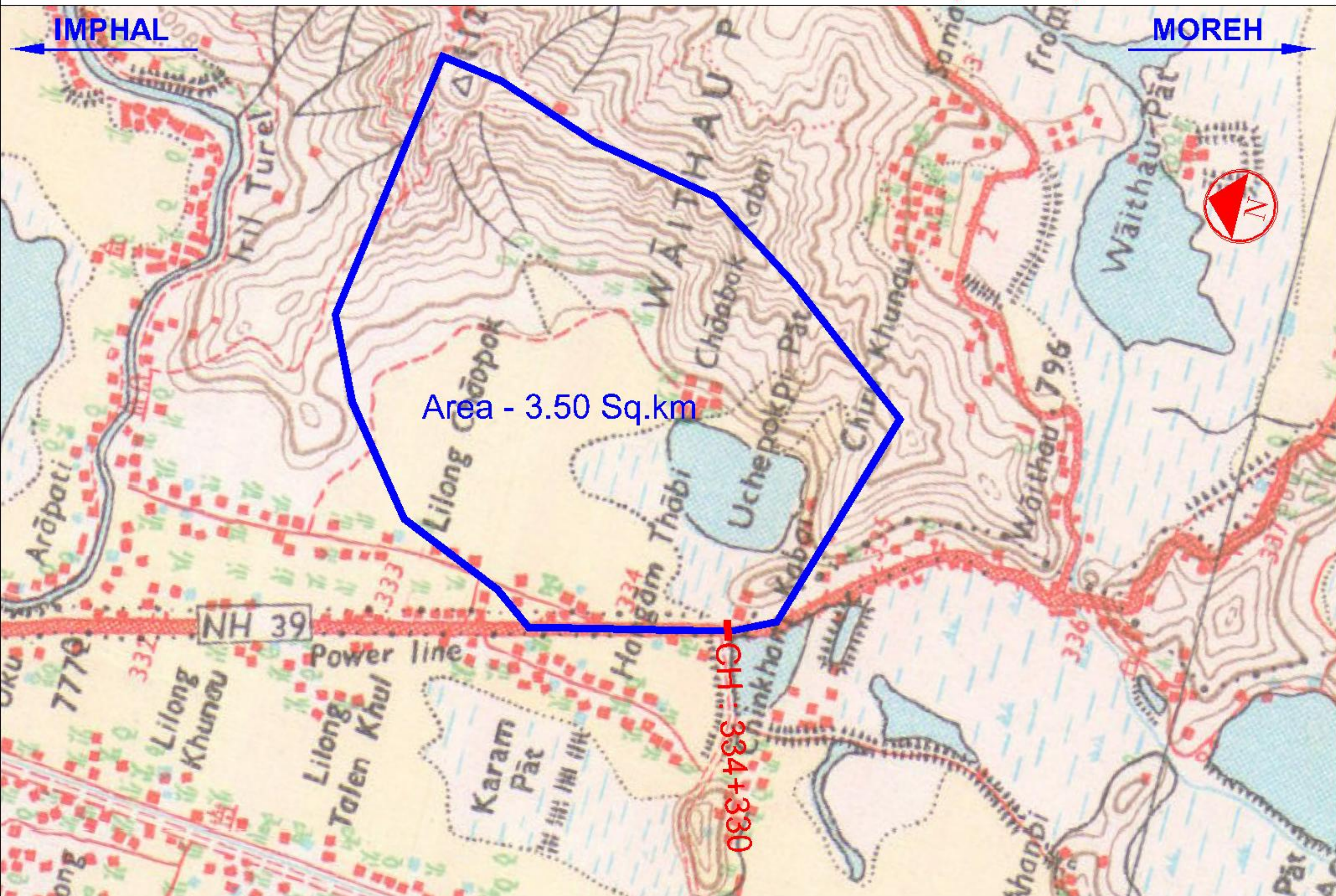
3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	1.20 m
Bottom of deck level to be provided	=	780.470 m

MINOR BRIDGE
(Existing CH: 334+330)
(Design CH: 334+640)

Catchment Details

CATCHMENT FOR MINOR BRIDGE AT CH : 334+330 (DESIGN)



Discharge Calculations by Dicken's Formula:-

Preparation of Catchment Area Plan:

A catchment plan showing the river/stream , contours and spot levels was prepared for determining the physiographic parameters as follow:

Physiographic Parameters:

Catchment Area (M) = 3.500 sq km

Discharge Calculations :

Discharge $Q = CM^{3/4}$, As per Dickens Formula

Where

Q = The Peak run-off in cum/sec

C = 17

M = 3.5 Sq.km

C, As per IRC SP13,pg No.07

11 - 14 , if the annual rainfall is 60-120 cm

14 - 19 , more than 120 cm

22 in Western Ghats

$$\therefore Q = 17 \times 3.5^{3/4} \\ = 43.501 \text{ cu.m/sec}$$

Discharge Calculations as per Rational Formula :

$$Q = 0.028 P \cdot f \cdot A \cdot I_c$$

Where Q = Maximum run-off in cu.m / sec

$$A = \text{Area of catchment in hectares} = 350$$

$$P = \text{Percentage coefficient of runoff for the catchment characteristics (vide Table 4.1, SP-13-2004, pg 13)} = 0.7$$

$$f = \text{fraction depending on the catchment area from f curve (Sp-13, pg 14)} = 0.990$$

I_c = Critical Intensity of rainfall in cm per hour

$$= I_o \left[\frac{2}{t_c + 1} \right] \quad I_o = \text{one hour rainfall}$$

$$\text{Where } I_o = \frac{F}{2} \left[1 + \frac{1}{T} \right] = 16.67 \text{ cm/hr}$$

$$F = \text{Precipitation of the storm in cm} = 32 \text{ cm}$$

$$T = \text{Duration in hours} = 24 \text{ hrs}$$

t_c = Concentration time of Catchment in hours

$$= 0.870 \left[\frac{L^3}{H} \right]^{0.385} = 0.296 \text{ hrs}$$

$$L = \text{The distance from the critical point to the culvert in km.} = 2.40$$

$$H = \text{The fall in level from the critical point to the culvert in metre.} = 227.4$$

$$\therefore Q = A \cdot I_o \cdot \lambda$$

$$\lambda = \frac{0.056 f \cdot P}{t_c + 1} = \frac{0.056 \times 0.99 \times 0.7}{0.296 + 1} = 0.0300$$

$$Q = 350 \times 16.667 \times 0.030 = 174.74 \text{ cu.m/sec}$$

Discharge Calculations as per AV method :

FRL in m = 776.482
 GL in m = 772.604
 HFL as per inventory = 774.400

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	772.60	0.000			
2	1.730	800.00	1.730	27.40	27.40	47.40
3	2.200	900.00	0.470	127.40	154.79	72.75
4	2.400	1000.00	0.200	227.40	354.79	70.96

S 191.11

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 33.178 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 18.0
 h= Depth of water in m = 1.796 (from inventory)
 n= Rugosity coefficient = 0.045
 S= Slope = 0.033

Assuming cross sectional slope of stream = 1 : 1.5

A= Cross sectional area in sq m = 27.490
 P = Wetted Perimeter = 19.088
 R= Hydraulic mean depth = $\frac{A}{P}$
 = 1.440

V= Velocity in m/sec = $\frac{1}{n} \cdot (R)^{2/3} \cdot S^{1/2}$
 = 5.16

Q= Discharge in cum / sec = 142.0

Design Discharge :-**Design discharges by various methods :**

Method	Discharge	Units
Dickens	43.50	Cumecs
Rational Method	174.74	Cumecs
Area velocity Method	142.00	Cumecs

As per IRC-5 Design discharge = 174.74

Hence Design discharge = **174.74 Cumecs**

Design discharge for foundation design :

As per cl. 703.1.1 of IRC 78: 2000

Catchment area (in km ²)		Increase over design discharge in percent
0 -	3000	30 %
3000 -	10000	30 - 20
10000 -	40000	20 - 10
>40000		10 %

Design discharge for foundation = 1.3 x 174.74
228.00 Cumecs

Calculation of Designed HFL :

100 yr. max. flood discharge in cumec	=	174.74
FRL in m	=	776.482
GL in m	=	772.604
HFL in m	=	774.714

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance (km)	Reduced levels (m)	L_i (km)	D_i (m)	$D_{i-1} + D_i$ (m)	$L_i(D_{i-1} + D_i)$ (mxkm)
1	2	3	4	5	6	7
1	0.000	772.604	0.000			
2	1.730	800.000	1.730	27.40	27.40	47.40
3	2.200	900.000	0.470	127.40	154.79	72.75
4	2.400	1000.000	0.200	227.40	354.79	70.96

S 191.11

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 33.178 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W=	Width of stream in m	=	18.0
h=	Depth of water in m (HFL - GL)	=	2.11
n=	Rugosity coefficient	=	0.045
S=	Slope	=	0.0332

Assuming cross sectional slope of stream = 1 : 1.5

A=	Cross sectional area in sq m	=	31.30
P =	Wetted Perimeter	=	19.28
R=	Hydraulic mean depth	=	A/P
		=	1.624
V=	Velocity in m/sec	=	$1/n \cdot (R)^{2/3} \cdot S^{1/2}$
		=	5.59
Q=	A * V in cumec	=	175.00 o.k

Hence, adopt HFL = 774.720 m

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	175.00 m ³ /s	
Unobstructed Velocity of river	=	5.59 m/s	
HFL	=	774.720 m	
Bed level	=	772.604 m	
Depth of water (u/s)	=	2.12 m	
Afflux from Molesworth	=	0.040 m	
Velocity of approach	=	5.49 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	1.53 m	
Total head	=	1.57 m	
Velocity through vent (2gh)	=	5.56 m/s	
Linear water way required	=	16.53 m	
Proposed vent way (3 x 6 - 2 x 0.4 - 2 x 0.3)	=	16.60 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	5.59 m/sec
Unobstructed area, Au	=	31.30 m ²
Effective vent area, Ae	=	30.97 m ²
Afflux	=	0.040 m

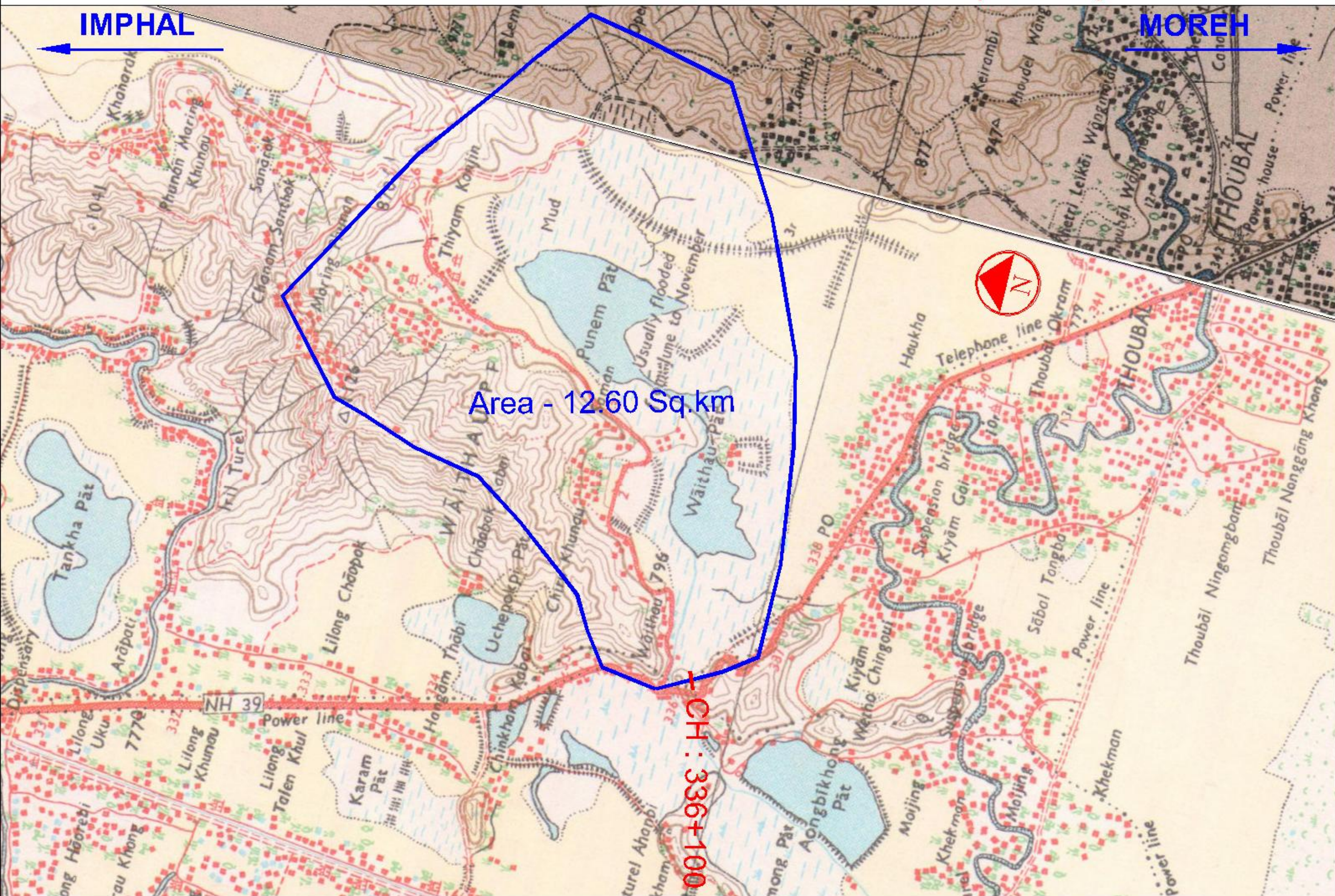
3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	0.90 m
Bottom of deck level to be provided	=	775.660 m

MINOR BRIDGE
(Existing CH: 336+100)
(Design CH: 336+315)

Catchment Details

CATCHMENT FOR MINOR BRIDGE AT CH : 336+100 (DESIGN)



Discharge Calculations by Dicken's Formula:-

Preparation of Catchment Area Plan:

A catchment plan showing the river/stream , contours and spot levels was prepared for determining the physiographic parameters as follow:

Physiographic Parameters:

Catchment Area (M) = 12.600 sq km

Discharge Calculations :

Discharge $Q = CM^{3/4}$, As per Dickens Formula

Where

Q = The Peak run-off in cum/sec

C = 17

M = 12.6 Sq.km

C, As per IRC SP13,pg No.07

11 - 14 , if the annual rainfall is 60-120 cm

14 - 19 , more than 120 cm

22 in Western Ghats

$$\therefore Q = 17 \times 12.6^{3/4} \\ = 113.691 \text{ cu.m/sec}$$

Discharge Calculations as per Rational Formula :

$$Q = 0.028 P \cdot f \cdot A \cdot I_c$$

Where Q = Maximum run-off in cu.m / sec

$$A = \text{Area of catchment in hectares} = 1260$$

$$P = \text{Percentage coefficient of runoff for the catchment characteristics (vide Table 4.1, SP-13-2004, pg 13)} = 0.6$$

$$f = \text{fraction depending on the catchment area from f curve (Sp-13, pg 14)} = 0.965$$

I_c = Critical Intensity of rainfall in cm per hour

$$= I_o \left(\frac{2}{t_c + 1} \right) \quad I_o = \text{one hour rainfall}$$

$$\text{Where } I_o = \frac{F}{2} \left(1 + \frac{1}{T} \right) = 16.67 \text{ cm/hr}$$

$$F = \text{Precipitation of the storm in cm} = 32 \text{ cm}$$

$$T = \text{Duration in hours} = 24 \text{ hrs}$$

t_c = Concentration time of Catchment in hours

$$= 0.870 \left(\frac{L^3}{H} \right)^{0.385} = 0.867 \text{ hrs}$$

$$L = \text{The distance from the critical point to the culvert in km.} = 6.10$$

$$H = \text{The fall in level from the critical point to the culvert in metre.} = 228.8$$

$$\therefore Q = A \cdot I_o \cdot \lambda$$

$$\lambda = \frac{0.056 f \cdot P}{t_c + 1} = \frac{0.056 \times 0.97 \times 0.6}{0.867 + 1} = 0.0174$$

$$Q = 1260 \times 16.667 \times 0.017 = 364.8 \text{ cu.m/sec}$$

Discharge Calculations as per AV method :

FRL in m = 778.780
 GL in m = 771.180
 HFL as per inventory = 774.480

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	771.18	0.000			
2	5.400	800.00	5.400	28.82	28.82	155.63
3	5.800	900.00	0.400	128.82	157.64	63.06

S 218.68

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 6.501 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 40
 h= Depth of water in m = 3.30 (from inventory)
 n= Rugosity coefficient = 0.045
 S= Slope = 0.0065

Assuming cross sectional slope of stream = 1 : 1.5

A= Cross sectional area in sq m = 115.66
 P = Wetted Perimeter = 42.00
 R= Hydraulic mean depth = A/P
 = 2.754

V= Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$
 = 3.52

Q= Discharge in cum / sec = 408.0

Design Discharge :-**Design discharges by various methods :**

Method	Discharge	Units
Dickens	113.69	Cumecs
Rational Method	364.78	Cumecs
Area velocity Method	408.00	Cumecs

As per IRC-5 Design discharge = 408.00

Hence Design discharge = **408.00 Cumecs**

Design discharge for foundation design :

As per cl. 703.1.1 of IRC 78: 2000

Catchment area (in km ²)		Increase over design discharge in percent
0 -	3000	30 %
3000 -	10000	30 - 20
10000 -	40000	20 - 10
>40000		10 %

Design discharge for foundation = 1.3 x 408.00
531.00 Cumecs

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	408.00 m ³ /s	
Unobstructed Velocity of river	=	3.53 m/s	
HFL	=	774.480 m	
Bed level	=	771.180 m	
Depth of water (u/s)	=	3.30 m	
Afflux from Molesworth	=	0.020 m	
Velocity of approach	=	3.51 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	0.63 m	
Total head	=	0.65 m	
Velocity through vent (2gh)	=	3.56 m/s	
Linear water way required	=	36.54 m	
Proposed vent way (2 x 20 - 1 x 1.2 - 2 x 1.1)	=	36.60 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	3.53 m/sec
Unobstructed area, Au	=	115.66 m ²
Effective vent area, Ae	=	113.74 m ²
Afflux	=	0.020 m

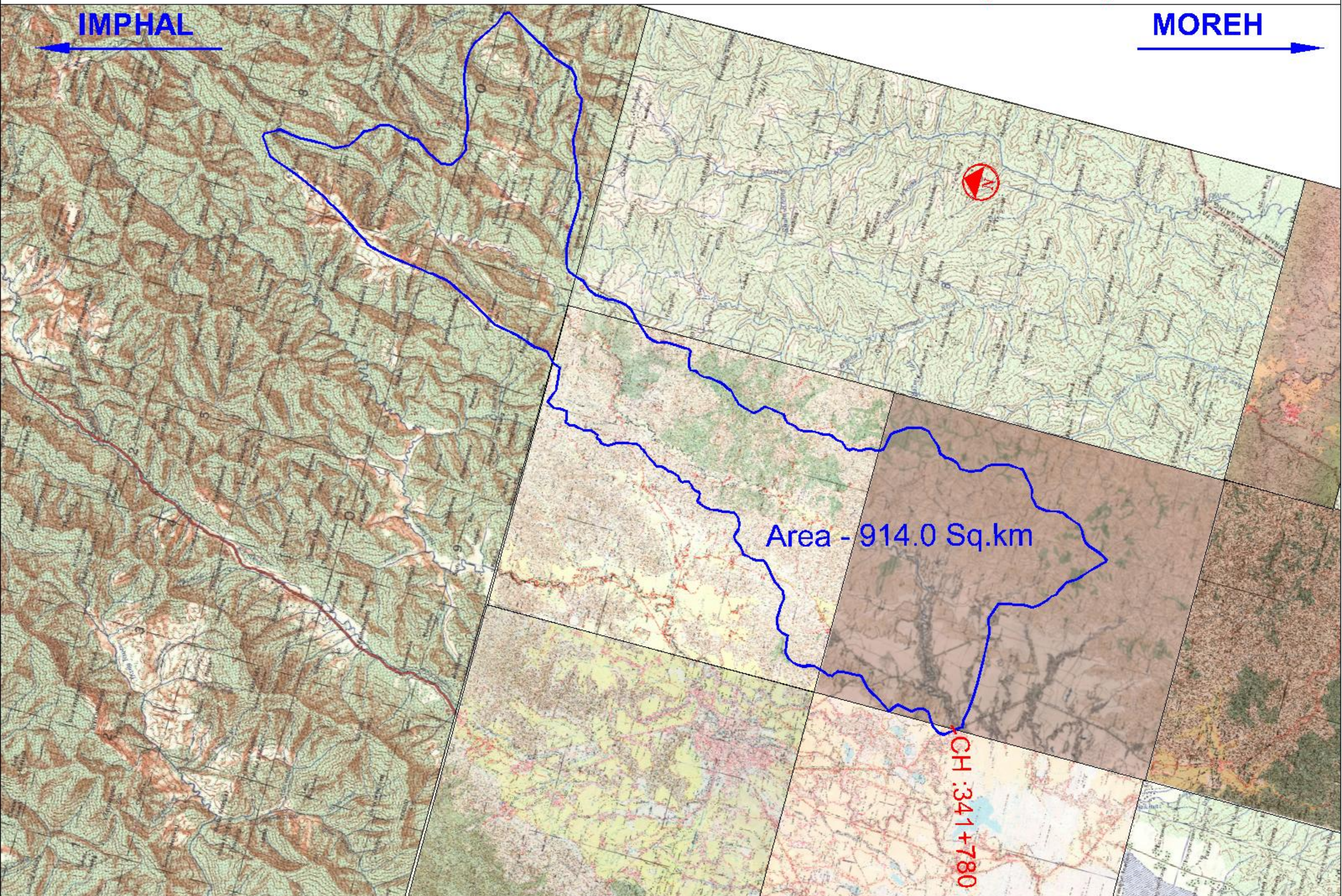
3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	1.20 m
Bottom of deck level to be provided	=	775.700 m

MAJOR BRIDGE
(Existing CH: 341+780)
(Design CH: 341+755)

Catchment Details

CATCHMENT FOR MAJOR BRIDGE AT CH : 341+780 (DESIGN)



Discharge Calculations as per Rational Formula :

$$Q = 0.028 P \cdot f \cdot A \cdot I_c$$

Where Q = Maximum run-off in cu.m / sec

$$A = \text{Area of catchment in hectares} = 91400$$

$$P = \text{Percentage coefficient of runoff for the catchment characteristics (vide Table 4.1, SP-13-2004, pg 13)} = 0.7$$

$$f = \text{fraction depending on the catchment area from f curve (Sp-13, pg 14)} = 0.615$$

I_c = Critical Intensity of rainfall in cm per hour

$$= I_o \left[\frac{2}{t_c + 1} \right] \quad I_o = \text{one hour rainfall}$$

$$\text{Where } I_o = \frac{F}{2} \left[1 + \frac{1}{T} \right] = 16.67 \text{ cm/hr}$$

$$F = \text{Precipitation of the storm in cm} = 32 \text{ cm}$$

$$T = \text{Duration in hours} = 24 \text{ hrs}$$

t_c = Concentration time of Catchment in hours

$$= 0.870 \left[\frac{L^3}{H} \right]^{0.385} = 19.179 \text{ hrs}$$

$$L = \text{The distance from the critical point to the culvert in km.} = 122.00$$

$$H = \text{The fall in level from the critical point to the culvert in metre.} = 588.8$$

$$\therefore Q = A \cdot I_o \cdot \lambda$$

$$\lambda = \frac{0.056 f \cdot P}{t_c + 1} = \frac{0.056 \times 0.62 \times 0.7}{19.179 + 1} = 0.0012$$

$$Q = 91400 \times 16.667 \times 0.001 = 1820 \text{ cumec}$$

After extensive study of catchment, it has been found that the stream is originated at different ranges of hills and at the toes of hills are thickly populated along both sides of banks. Maximum discharge of stream is vanished through irrigation canals for the domestic and agricultural requirements of local people.

Therefore, 30% of the calculated discharge has been considered as designed discharge.

$$\text{So, Design discharge by SUH} = 1273.98 \text{ cumec}$$

Discharge Calculations as per AV method :

FRL in m	=	784.660
GL in m	=	771.160
HFL as per inventory	=	780.900

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	778.00	0.000			
2	11.800	780.00	11.800	2.00	2.00	23.60
3	26.900	800.00	15.100	22.00	24.00	362.40
4	45.300	820.00	18.400	42.00	64.00	1177.60
5	64.200	840.00	18.900	62.00	104.00	1965.60
6	67.700	880.00	3.500	102.00	164.00	574.00
7	78.400	980.00	10.700	202.00	304.00	3252.80
8	97.300	1100.00	18.900	322.00	524.00	9903.60
9	111.000	1120.00	13.700	342.00	664.00	9096.80
10	117.800	1300.00	6.800	522.00	864.00	5875.20
11	121.900	1360.00	4.100	582.00	1104.00	4526.40

S 36758.00

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 2.474 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W=	Width in m	=	69
h=	Depth of water in m	=	9.74 (from inventory)
n=	Rugosity coefficient	=	0.045
S=	Slope	=	0.0025
A=	Cross sectional area in sq m	=	455.1
	(Area of chord, where L= width of stream & h = depth of water)		
P =	Wetted Perimeter	=	72.61
R=	Hydraulic mean depth	=	A/P
		=	6.268
V=	Velocity in m/sec	=	$\frac{1}{n} \cdot (R)^{2/3} \cdot S^{1/2}$
		=	3.76
Q=	Discharge in cum / sec	=	1710

Discharge calculation by Synthetic Unit Hydrograph Method**1 Description**

Name and Number of Subzone = South Brahmaputra Subzone - 2(b)
 Location at Site = km. 341+780
 Name of Stream =

2 Design data

Catchment Area (A) = 914.00 sqkm *from Toposheet*
 Length of Longest Stream (L) = 121.90 km *from Toposheet*
 Length of Longest Stream from cg to site (l) = 58.600 km *from Toposheet*
 Unit Duration of Unitgraph (t_r) = 1.0 hr
 Loss Rate = 0.35 cm/hr *From CWC report*

3 Computation of Equivalent Stream Slope (S)

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	778.00	0.000		-	-
2	11.800	780.00	11.800	2.00	2.00	23.60
3	26.900	800.00	15.100	22.00	24.00	362.40
4	45.300	820.00	18.400	42.00	64.00	1177.60
5	64.200	840.00	18.900	62.00	104.00	1965.60
6	67.700	880.00	3.500	102.00	164.00	574.00
7	78.400	980.00	10.700	202.00	304.00	3252.80
8	97.300	1100.00	18.900	322.00	524.00	9903.60
9	111.000	1120.00	13.700	342.00	664.00	9096.80
10	117.800	1300.00	6.800	522.00	864.00	5875.20
11	121.900	1360.00	4.100	582.00	1104.00	4526.40

S 36758.00

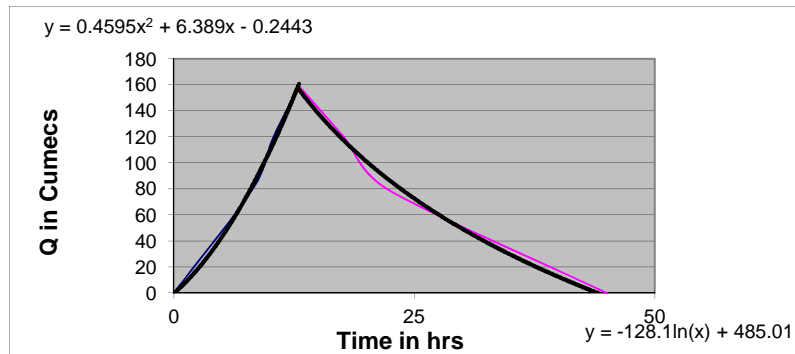
$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 2.474 \text{ m/km}$$

4 Determination of Synthetic 1-hr Unitgraph Parameters

t_r = 1.0 hr
 $t_p = 2.87(q_p)^{-0.839}$ = 12.458 hrs 12.50 say
 Peak of the Unit Hydrograph $Q_p = 0.905 * (A)^{0.758}$ = 158.872 cumec/sqkm
 $q_p = Q_p/A$ = 0.174
 $W_{50} = 2.304 * (q_p)^{-1.035}$ = 14.09 hrs
 $W_{75} = 1.339 * (q_p)^{-0.978}$ = 7.41 hrs
 $W_{R50} = 0.814 * (q_p)^{-1.018}$ = 4.83 hrs
 $W_{R75} = 0.494 * (q_p)^{-0.966}$ = 2.68 hrs
 Base width $T_B = 2.447 * (t_p)^{1.157}$ = 45.47 hrs 45.00 say
 $t_m = t_p + t_r/2$ = 13.00 hrs
 $Q_p = q_p * A$ = 158.87 cumec

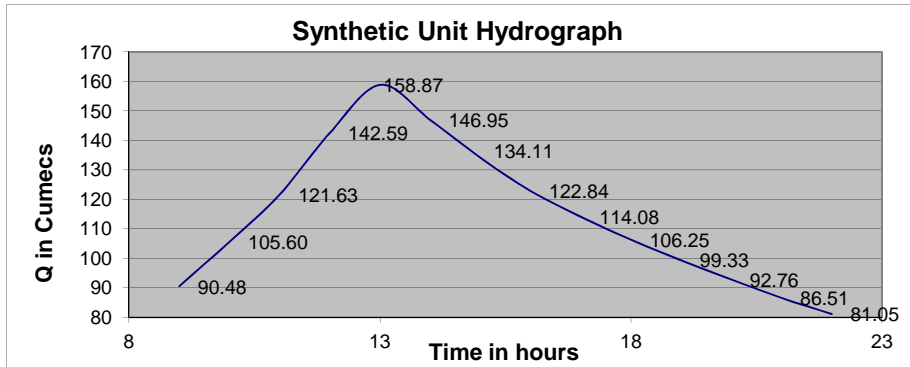
UG Ordinates from above formulae

X-value		Y-value	
0	0.00	0	0.00
$t_m - W_{R50}$	8.17	$Q_p * 0.5$	79.44
$t_m - W_{R75}$	10.32	$Q_p * 0.75$	119.15
t_m	13.00	$Q_p * 1.0$	158.87
$t_m + W_{75} - W_{R75}$	17.73	$Q_p * 0.75$	119.15
$t_m + W_{50} - W_{R50}$	22.26	$Q_p * 0.5$	79.44
T_B	45.00	0	0.00

**UG Ordinates from graph(from equation for rising and recession limb)**

Abcissa	values from the first equation	values from the Second equation	Adjusted values
9	94.48	94.48	90.48
10	109.60	109.60	105.60
11	125.63	125.63	121.63
12	142.59	142.59	142.59
13	160.47	160.47	158.87
14	146.95	146.95	146.95
15	138.11	138.11	134.11
16	129.84	129.84	122.84
17	122.08	122.08	114.08
18	114.75	114.75	106.25
19	107.83	107.83	99.33
20	101.26	101.26	92.76
21	95.01	95.01	86.51
22	89.05	89.05	81.05
	1677.63	1677.63	1603.03
	0.66	0.66	0.63

$$\Sigma Q_i = A * d / 0.36 * t_r = 2538.89$$

**5 Design Storm Rainfall***As per the steps followed in Page No.23*

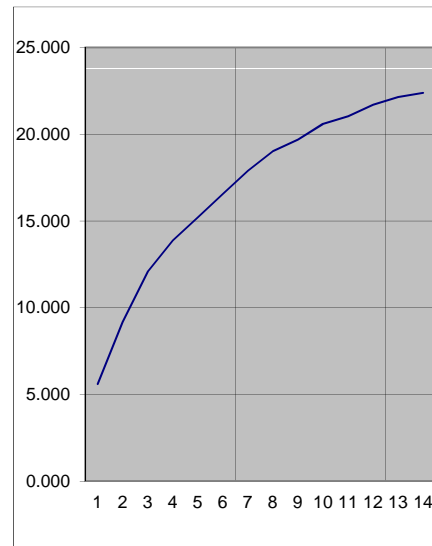
$$\begin{aligned}
 \text{Design Storm Duration (T}_D\text{)} &= 1.1 \times t_p &= 1.1 \times 12.5 &= \mathbf{14.00 \text{ say}} \\
 \text{50 year-24hour Point rainfall} &&= &= \mathbf{32.0 \text{ cm, from plate 10 (Step 1)}} \\
 \text{Conversion factor for T}_D\text{-hour i.e } 14.00 &&= &= \mathbf{0.897 \text{ from fig.10 (Step 2)}} \\
 \therefore \text{50 Year T}_D\text{- Hour Point Rainfall} &&= &= \mathbf{28.69 \text{ cm}}
 \end{aligned}$$

Storm Areal Rainfall*Areal reduction factors for point to areal rainfall from Annexure 4.3, Page A-16 -step-3*

$$\begin{aligned}
 \text{Areal reduction factor corresponding to storm duration T}_D \text{ i.e hours } 14.0 & \\
 \text{and C.A } 914.0 \text{ sq.km} & \\
 &= \mathbf{0.780} \\
 \therefore \text{50 year TD hour Areal Rainfall} &= \mathbf{22.378 \text{ cm}}
 \end{aligned}$$

Time Distribution coefficients from Annexure 4.4, Page A-17 - step4

Time	Distribution coefficient from Table T-2	Storm rainfall in Cm	Rainfall Increment Cms
1	0.25	5.595	5.59
2	0.41	9.175	3.58
3	0.54	12.084	2.91
4	0.62	13.874	1.79
5	0.68	15.217	1.34
6	0.74	16.560	1.34
7	0.80	17.903	1.34
8	0.85	19.021	1.12
9	0.88	19.693	0.67
10	0.92	20.588	0.90
11	0.94	21.035	0.45
12	0.97	21.707	0.67
13	0.99	22.154	0.45
14	1.00	22.378	0.22



$$\text{Base flow} = \mathbf{0.05} \text{ cumecs / sqkm} \quad \text{As per Cl. 3.7 Page No. 18}$$

$$\therefore \text{Total Base flow for C.A} = 0.05 \times 914 = \mathbf{45.700 \text{ Cumec}}$$

50 year flood peak :

Time in hours	SUG ordinates	Gross rainfall Increments	Loss rate	Rainfall Excess	Rainfall Excess ordinates Arrangement	Direct Runoff (cumec)
9	90.48	5.59	0.35	5.245	0.098	8.83
10	105.60	3.58	0.35	3.231	0.545	57.56
11	121.63	2.91	0.35	2.559	0.993	120.75
12	142.59	1.79	0.35	1.440	2.559	364.92
13	158.87	1.34	0.35	0.993	5.245	833.20
14	146.95	1.34	0.35	0.993	3.231	474.71
15	134.11	1.34	0.35	0.993	1.440	193.15
16	122.84	1.12	0.35	0.769	0.993	121.94
17	114.08	0.67	0.35	0.321	0.993	113.24
18	106.25	0.90	0.35	0.545	0.769	81.70
19	99.33	0.45	0.35	0.098	0.321	31.92
20	92.76	0.67	0.35	0.321	0.321	29.81
21	86.51	0.45	0.35	0.098	0.098	8.44
22	81.05	0.22	0.35	0.000	0.000	0.00

50 year Flood peak = 2440.16 cumec

Add Base flow = 45.70 cumec

Total = 2485.86 cumec

After extensive study of catchment, it has been found that the stream is originated at different ranges of hills and at the toes of hills are thickly populated along both sides of banks. Maximum discharge of stream is vanished through irrigation canals for the domestic and agricultural requirements of local people.

Therefore, 30% of the calculated discharge has been considered as designed discharge.

So, Design discharge by SUH = 1740.10 cumec

Design Discharge :-**Design discharges by various methods :**

Method	Discharge	Units
Rational Method	1273.98	Cumecs
Area velocity Method	1710.00	Cumecs
SUH	1740.12	Cumecs

As per IRC-5 Design discharge = 1740.12

Hence Design discharge = **1740.12 Cumecs**

Design discharge for foundation design :

As per cl. 703.1.1 of IRC 78: 2000

Catchment area (in km ²)		Increase over design discharge in percent
0 -	3000	30 %
3000 -	10000	30 - 20
10000 -	40000	20 - 10
>40000		10 %

Design discharge for foundation = 1.3 x 1740.12
2263.00 Cumecs

Calculation of Designed HFL :

100 yr. max. flood discharge in cumec	=	1740.12
FRL in m	=	784.660
GL in m	=	771.160
HFL in m	=	781.007

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	778.00	0.000			
2	11.800	780.00	11.800	2.00	2.00	23.60
3	26.900	800.00	15.100	22.00	24.00	362.40
4	45.300	820.00	18.400	42.00	64.00	1177.60
5	64.200	840.00	18.900	62.00	104.00	1965.60
6	67.700	880.00	3.500	102.00	164.00	574.00
7	78.400	980.00	10.700	202.00	304.00	3252.80
8	97.300	1100.00	18.900	322.00	524.00	9903.60
9	111.000	1120.00	13.700	342.00	664.00	9096.80
10	117.800	1300.00	6.800	522.00	864.00	5875.20
11	121.900	1360.00	4.100	582.00	1104.00	4526.40

S 36758.00

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 2.474 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W = Width of stream in m = 69.0

h = Depth of water in m (HFL - GL) = 9.85

n = Rugosity coefficient = 0.045

S = Slope = 0.0025

A = Cross sectional area in sq m = 460.24
(Area of chord, where L = width of stream & h = depth of water)

P = Wetted Perimeter = 72.69

R = Hydraulic mean depth = A/P

= 6.332

V = Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$

= 3.78

Q = A*V = 1741 o.k

Hence, adopt HFL = 781.010 m

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	1741.00 m ³ /s	
Unobstructed Velocity of river	=	3.78 m/s	
HFL	=	781.010 m	
Bed level	=	771.160 m	
Depth of water (u/s)	=	9.85 m	
Afflux from Molesworth	=	0.010 m	
Velocity of approach	=	3.78 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	0.73 m	
Total head	=	0.74 m	
Velocity through vent (2gh)	=	3.80 m/s	
Linear water way required	=	64.52 m	
Proposed vent way (2 x 34.5 - 1 x 1.5 - 2 x 1.1)	=	65.30 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	3.78 m/sec
Unobstructed area, Au	=	460.24 m ²
Effective vent area, Ae	=	458.17 m ²
Afflux	=	0.010 m

3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	1.20 m
Bottom of deck level to be provided	=	782.220 m

MINOR BRIDGE
(Existing CH: 348+150)
(Design CH: 348+355)

Discharge Calculations as per AV method :

FRL in m = 778.000
 GL in m = 772.950
 HFL as per inventory = 775.750

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	772.95	0.000			
2	4.800	780.00	4.800	7.05	7.05	33.84
3	7.200	800.00	2.400	27.05	34.10	81.84
4	11.300	820.00	4.100	47.05	74.10	303.81
5	12.800	860.00	1.500	87.05	134.10	201.15
6	16.700	880.00	3.900	107.05	194.10	756.99
7	18.300	900.00	1.600	127.05	234.10	374.56
8	20.000	960.00	1.700	187.05	314.10	533.97
9	20.600	1000.00	0.600	227.05	414.10	248.46
10	21.350	1100.00	0.750	327.05	554.10	415.58
11	21.700	1200.00	0.350	427.05	754.10	263.93
12	22.120	1300.00	0.420	527.05	954.10	400.72
13	22.400	1400.00	0.280	627.05	1154.10	323.15
14	22.500	1500.00	0.100	727.05	1354.10	135.41

S 4073.41

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 8.046 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 24
 h= Depth of water in m = 2.80 (from inventory)
 n= Rugosity coefficient = 0.045
 S= Slope = 0.0080

Assuming cross sectional slope of stream = 1:1

A= Cross sectional area in sq m = 59.36
 P = Wetted Perimeter = 26.32
 R= Hydraulic mean depth = A/P
 = 2.255

V= Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$
 = 3.43

Q= Discharge in cum / sec = 204.0

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	204.00 m ³ /s	
Unobstructed Velocity of river	=	3.44 m/s	
HFL	=	775.750 m	
Bed level	=	772.950 m	
Depth of water (u/s)	=	2.80 m	
Afflux from Molesworth	=	0.020 m	
Velocity of approach	=	3.41 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	0.59 m	
Total head	=	0.61 m	
Velocity through vent (2gh)	=	3.47 m/s	
Linear water way required	=	21.88 m	
Proposed vent way (3 x 8 - 2 x 0.6 - 2 x 0.4)	=	22.00 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	3.44 m/sec
Unobstructed area, Au	=	59.36 m ²
Effective vent area, Ae	=	58.36 m ²
Afflux	=	0.020 m

3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	0.90 m
Bottom of deck level to be provided	=	776.670 m

MINOR BRIDGE
(Existing CH: 352+800)
(Design CH: 352+758)

Discharge Calculations as per AV method :

FRL in m = 777.000
 GL in m = 772.000
 HFL as per inventory = 775.500

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	772.00	0.000			
2	0.090	780.00	0.090	8.00	8.00	0.72
3	4.840	800.00	4.750	28.00	36.00	171.00
4	6.500	820.00	1.660	48.00	76.00	126.16
5	8.000	840.00	1.500	68.00	116.00	174.00
6	9.100	860.00	1.100	88.00	156.00	171.60
7	9.900	900.00	0.800	128.00	216.00	172.80
8	11.200	1000.00	1.300	228.00	356.00	462.80
9	12.000	1100.00	0.800	328.00	556.00	444.80
10	12.800	1480.00	0.800	708.00	1036.00	828.80

S 2552.68

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 15.580 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 11.6
 h= Depth of water in m = 3.50 (from inventory)
 n= Rugosity coefficient = 0.045
 S= Slope = 0.0156

Assuming cross sectional slope of stream = 1 : 1

A= Cross sectional area in sq m = 28.35
 P = Wetted Perimeter = 14.50
 R= Hydraulic mean depth = A/P
 = 1.955

V= Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$
 = 4.34

Q= Discharge in cum / sec = 123.0

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	123.00 m ³ /s	
Unobstructed Velocity of river	=	4.34 m/s	
HFL	=	775.500 m	
Bed level	=	772.000 m	
Depth of water (u/s)	=	3.50 m	
Afflux from Molesworth	=	0.020 m	
Velocity of approach	=	4.31 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	0.95 m	
Total head	=	0.97 m	
Velocity through vent (2gh)	=	4.36 m/s	
Linear water way required	=	10.08 m	
Proposed vent way (2 x 5.8 - 1 x 0.4 - 2 x 0.3)	=	10.60 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	4.34 m/sec
Unobstructed area, Au	=	28.35 m ²
Effective vent area, Ae	=	28.10 m ²
Afflux	=	0.020 m

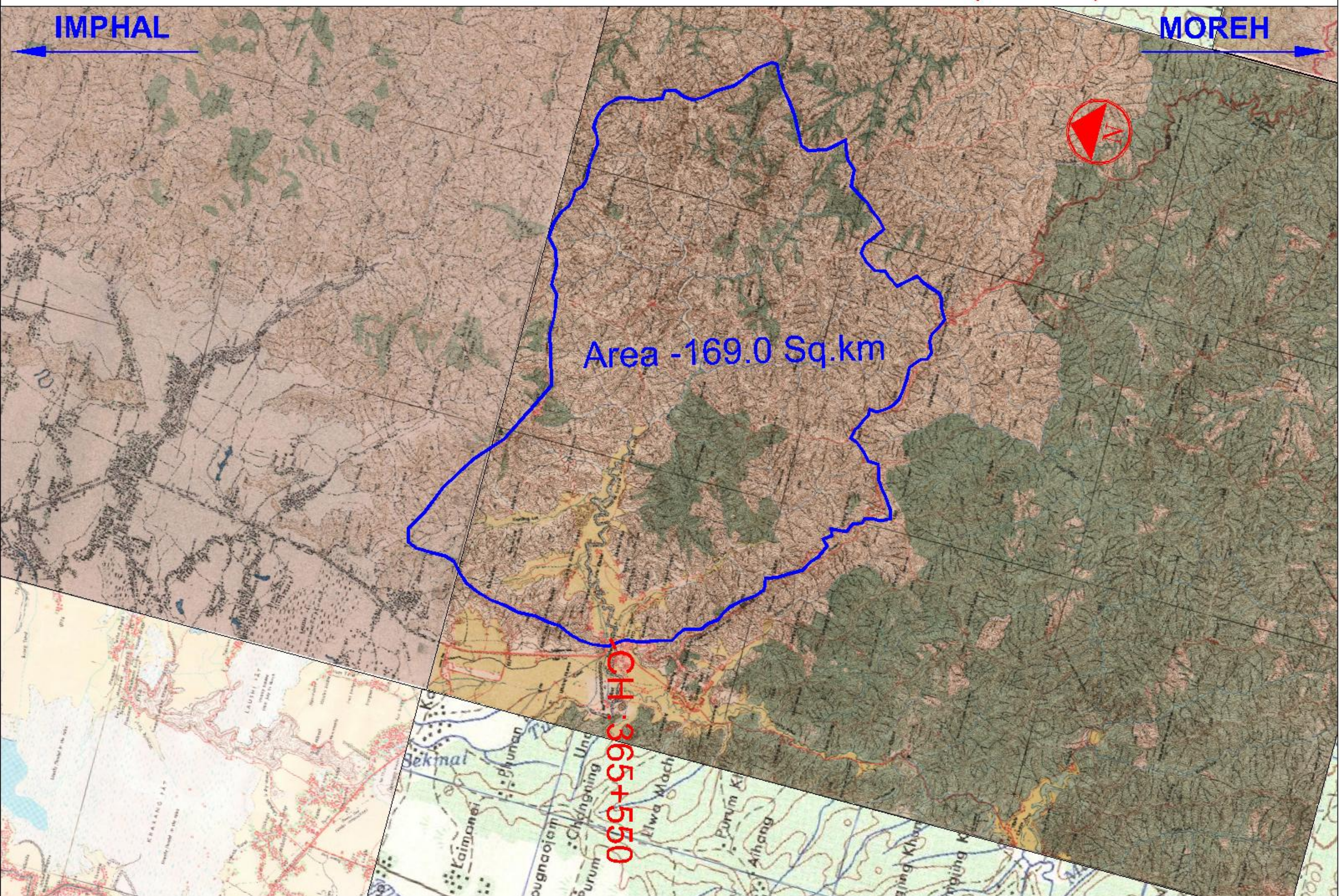
3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	0.90 m
Bottom of deck level to be provided	=	776.420 m

MAJOR BRIDGE
(Existing CH: 365+550)
(Design CH: 365+260)

Catchment Details

CATCHMENT FOR MAJOR BRIDGE AT CH : 365+550 (DESIGN)



Discharge Calculations as per Rational Formula :

$$Q = 0.028 P \cdot f \cdot A \cdot I_c$$

Where Q = Maximum run-off in cu.m / sec

$$A = \text{Area of catchment in hectares} = 16900$$

$$P = \text{Percentage coefficient of runoff for the catchment characteristics (vide Table 4.1, SP-13-2004, pg 13)} = 0.3$$

$$f = \text{fraction depending on the catchment area from f curve (Sp-13, pg 14)} = 0.673$$

I_c = Critical Intensity of rainfall in cm per hour

$$= I_o \left[\frac{2}{t_c + 1} \right] \quad I_o = \text{one hour rainfall}$$

$$\text{Where } I_o = \frac{F}{2} \left[1 + \frac{1}{T} \right] = 16.67 \text{ cm/hr}$$

$$F = \text{Precipitation of the storm in cm} = 32 \text{ cm}$$

$$T = \text{Duration in hours} = 24 \text{ hrs}$$

t_c = Concentration time of Catchment in hours

$$= 0.870 \left[\frac{L^3}{H} \right]^{0.385} = 3.121 \text{ hrs}$$

$$L = \text{The distance from the critical point to the culvert in km.} = 27.50$$

$$H = \text{The fall in level from the critical point to the culvert in metre.} = 753.6$$

$$\therefore Q = A \cdot I_o \cdot \lambda$$

$$\lambda = \frac{0.056 f \cdot P}{t_c + 1} = \frac{0.056 \times 0.67 \times 0.3}{3.121 + 1} = 0.0027$$

$$Q = 16900 \times 16.667 \times 0.003 = 773.1 \text{ cu.m/sec}$$

Discharge Calculations as per AV method :

FRL in m	=	790.678
GL in m	=	782.400
HFL as per inventory	=	786.140

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	788.00	0.000			
2	1.827	800.00	1.827	12.00	12.00	21.92
3	4.908	820.00	3.081	32.00	44.00	135.56
4	13.153	840.00	8.245	52.00	84.00	692.58
5	15.333	860.00	2.180	72.00	124.00	270.32
6	18.881	880.00	3.548	92.00	164.00	581.87
7	19.881	900.00	1.000	112.00	204.00	204.00
8	20.483	920.00	0.602	132.00	244.00	146.89
9	21.595	960.00	1.112	172.00	304.00	338.05
10	22.542	980.00	0.947	192.00	364.00	344.71
11	22.745	1000.00	0.203	212.00	404.00	82.01
12	23.324	1020.00	0.579	232.00	444.00	257.08
12	24.786	1080.00	1.462	292.00	524.00	766.09
14	25.223	1120.00	0.437	332.00	624.00	272.69
15	25.917	1180.00	0.694	392.00	724.00	502.46
16	26.420	1260.00	0.503	472.00	864.00	434.59
17	26.461	1280.00	0.041	492.00	964.00	39.52
18	27.047	1360.00	0.586	572.00	1064.00	623.50
19	27.322	1420.00	0.275	632.00	1204.00	331.10
20	27.500	1536.00	0.178	748.00	1380.00	245.64

S 6290.58

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 8.318 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W=	Width in m	=	72
h=	Depth of water in m	=	3.74 (from inventory)
n=	Rugosity coefficient	=	0.045
S=	Slope	=	0.0083

Assuming cross sectional slope of stream

A=	Cross sectional area in sq m	=	1 : 2
P=	Wetted Perimeter	=	241.3
R=	Hydraulic mean depth	=	73.77
		=	A/P
		=	3.27
V=	Velocity in m/sec	=	$1/n \cdot (R)^{2/3} \cdot S^{1/2}$
		=	4.47
Q=	Discharge in cum / sec	=	1078

Discharge calculation by Synthetic Unit Hydrograph Method**1 Description**

Name and Number of Subzone = South Brahmaputra Subzone - 2(b)
 Location at Site = km. 365+550
 Name of Stream =

2 Design data

Catchment Area (A) = 169.00 sqkm *from Toposheet*
 Length of Longest Stream (L) = 27.50 km *from Toposheet*
 Length of Longest Stream from cg to site (L) = 14.200 km *from Toposheet*
 Unit Duration of Unitgraph (t_r) = 1.0 hr
 Loss Rate = 0.35 cm/hr *From CWC report*

3 Computation of Equivalent Stream Slope (S)

Sl. No.	Reduced distance	Reduced levels	L _i	D _i	D _{i-1} + D _i	L _i (D _{i-1} + D _i)
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	788.00	0.000		-	-
2	1.827	800.00	1.827	12.00	12.00	21.92
3	4.908	820.00	3.081	32.00	44.00	135.56
4	13.153	840.00	8.245	52.00	84.00	692.58
5	15.333	860.00	2.180	72.00	124.00	270.32
6	18.881	880.00	3.548	92.00	164.00	581.87
7	19.881	900.00	1.000	112.00	204.00	204.00
8	20.483	920.00	0.602	132.00	244.00	146.89
9	21.595	960.00	1.112	172.00	304.00	338.05
10	22.542	980.00	0.947	192.00	364.00	344.71
11	22.745	1000.00	0.203	212.00	404.00	82.01
12	23.324	1020.00	0.579	232.00	444.00	257.08
13	24.786	1080.00	1.462	292.00	524.00	766.09
14	25.223	1120.00	0.437	332.00	624.00	272.69
15	25.917	1180.00	0.694	392.00	724.00	502.46
16	26.420	1260.00	0.503	472.00	864.00	434.59
17	26.461	1280.00	0.041	492.00	964.00	39.52
18	27.047	1360.00	0.586	572.00	1064.00	623.50
19	27.322	1420.00	0.275	632.00	1204.00	331.10
20	27.500	1536.00	0.178	748.00	1380.00	245.64

S 6290.58

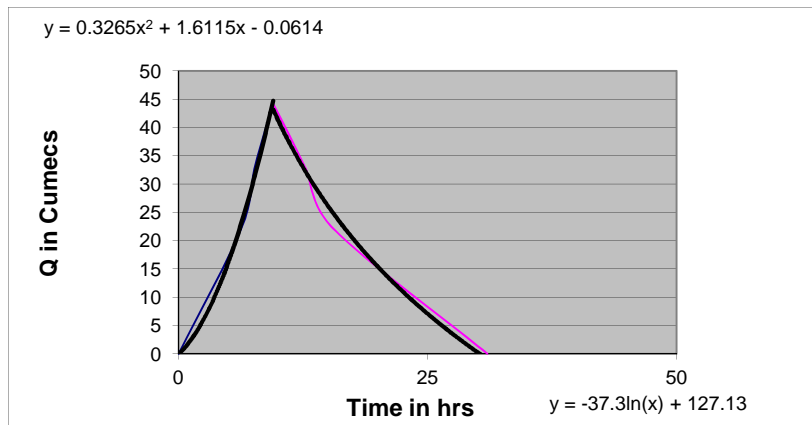
$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 8.318 \text{ m/km}$$

4 Determination of Synthetic 1-hr Unitgraph Parameters

$$\begin{aligned}
 t_r &= 1.0 \text{ hr} \\
 t_p &= 2.87(q_p)^{-0.839} = 8.843 \text{ hrs} & 9.00 \text{ say} \\
 \text{Peak of the Unit Hydrograph } Q_p &= 0.905 * (A)^{0.758} = 44.197 \text{ cumec/sqkm} \\
 q_p &= Q_p/A = 0.262 \\
 W_{50} &= 2.304 * (q_p)^{-1.035} = 9.23 \text{ hrs} \\
 W_{75} &= 1.339 * (q_p)^{-0.978} = 4.97 \text{ hrs} \\
 W_{R50} &= 0.814 * (q_p)^{-1.018} = 3.19 \text{ hrs} \\
 W_{R75} &= 0.494 * (q_p)^{-0.966} = 1.80 \text{ hrs} \\
 \text{Base width } T_B &= 2.447 * (t_p)^{1.157} = 31.10 \text{ hrs} & 31.00 \text{ say} \\
 t_m &= t_p + t_r/2 = 9.50 \text{ hrs} \\
 Q_p &= q_p * A = 44.20 \text{ cumec}
 \end{aligned}$$

UG Ordinates from above formulae

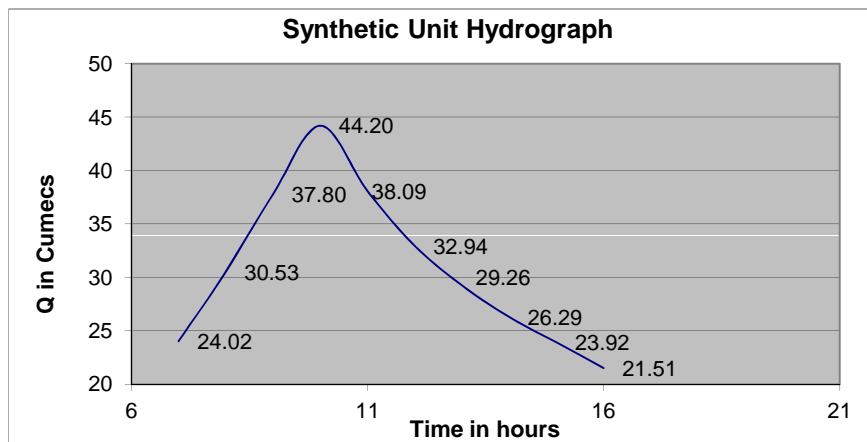
X-value		Y-value	
0	0.00	0	0.00
$t_m - W_{R50}$	6.31	$Q_p * 0.5$	22.10
$t_m - W_{R75}$	7.70	$Q_p * 0.75$	33.15
t_m	9.50	$Q_p * 1.0$	44.20
$t_m + W_{75} - W_{R75}$	12.67	$Q_p * 0.75$	33.15
$t_m + W_{50} - W_{R50}$	15.54	$Q_p * 0.5$	22.10
T_B	31.00	0	0.00



UG Ordinates from graph(from equation for rising and recession limb)

Abcissa	values from the first equation	values from the Second equation	Adjusted values
7	27.22	27.22	24.02
8	33.73	33.73	30.53
9	40.89	40.89	37.80
10	48.70	48.70	44.20
11	37.69	37.69	38.09
12	34.44	34.44	32.94
13	31.46	31.46	29.26
14	28.69	28.69	26.29
15	26.12	26.12	23.92
16	23.71	23.71	21.51
	332.65	332.65	308.56
	0.71	0.71	0.66

$$\Sigma Q_i = A \cdot d / 0.36 \cdot t_r = 469.44$$

**5 Design Storm Rainfall***As per the steps followed in Page No.23*

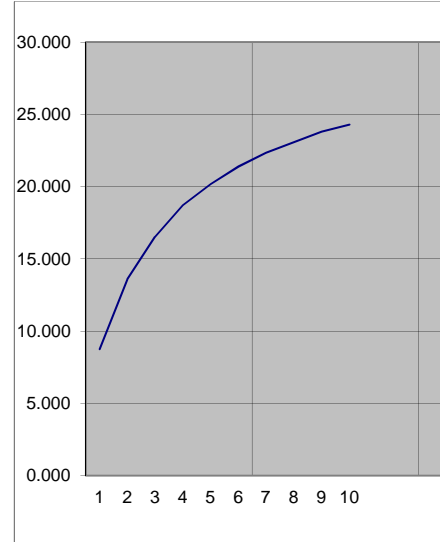
$$\begin{aligned}
 \text{Design Storm Duration (T}_D\text{)} &= 1.1 \cdot t_p &= 1.1 \times 9.0 &= \mathbf{10.00 \text{ say}} \\
 \text{50 year-24hour Point rainfall} & &= &= \mathbf{32.0 \text{ cm, from plate 10 (Step 1)}} \\
 \text{Conversion factor for T}_D\text{-hour i.e. } 10.00 & &= &= \mathbf{0.843 \text{ from fig.10 (Step 2)}} \\
 \therefore \text{50 Year T}_D\text{ - Hour Point Rainfall} & &= &= \mathbf{26.99 \text{ cm}}
 \end{aligned}$$

Storm Areal Rainfall*Areal reduction factors for point to areal rainfall from Annexure 4.3, Page A-16 -step-3*

$$\begin{aligned}
 \text{Areal reduction factor corresponding to storm duration T}_D \text{ i.e hours } 10.0 & & & \\
 \text{and C.A } 169.0 \text{ sq.km} & & & \\
 &= &= \mathbf{0.901} & \\
 \therefore \text{50 year TD hour Areal Rainfall} &= &= \mathbf{24.301 \text{ cm}} &
 \end{aligned}$$

Time Distribution coefficients from Annexure 4.4, Page A-17 - step4

Time	Distribution coefficient from Table T-2	Storm rainfall in Cm	Rainfall Increment Cms
1	0.36	8.749	8.75
2	0.56	13.609	4.86
3	0.68	16.525	2.92
4	0.77	18.712	2.19
5	0.83	20.170	1.46
6	0.88	21.385	1.22
7	0.92	22.357	0.97
8	0.95	23.086	0.73
9	0.98	23.815	0.73
10	1.00	24.301	0.49



Base flow = 0.05 cumecs / sqkm As per Cl. 3.7 Page No. 18

∴ Total Base flow for C.A = 0.05 x 169 = 8.450 Cumec

50 year flood peak :

Time in hours	SUG ordinates	Gross rainfall Increments	Loss rate	Rainfall Excess	Rainfall Excess ordinates Arrangement	Direct Runoff (cumec)
7	24.02	8.75	0.35	8.399	0.379	9.10
8	30.53	4.86	0.35	4.510	1.108	33.83
9	37.80	2.92	0.35	2.566	2.566	97.00
10	44.20	2.19	0.35	1.837	8.399	371.22
11	38.09	1.46	0.35	1.108	4.510	171.79
12	32.94	1.22	0.35	0.865	1.837	60.52
13	29.26	0.97	0.35	0.622	0.865	25.31
14	26.29	0.73	0.35	0.379	0.622	16.36
15	23.92	0.73	0.35	0.379	0.379	9.07
16	21.51	0.49	0.35	0.136	0.136	2.93

50 year Flood peak = 797.12 cumec

Add Base flow = 8.45 cumec

Total = 805.57 cumec

Design Discharge :-**Design discharges by various methods :**

Method	Discharge	Units
Rational Method	773.13	Cumecs
Area velocity Method	1078.00	Cumecs
SUH	805.57	Cumecs

As per IRC-5 Design discharge = 1078.00

Hence Design discharge = **1078.00 Cumecs**

Design discharge for foundation design :

As per cl. 703.1.1 of IRC 78: 2000

Catchment area (in km ²)		Increase over design discharge in percent
0 -	3000	30 %
3000 -	10000	30 - 20
10000 -	40000	20 - 10
>40000		10 %

Design discharge for foundation = 1.3 x 1078.00
1402.00 Cumecs

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	1078.00 m ³ /s	
Unobstructed Velocity of river	=	4.47 m/s	
HFL	=	786.140 m	
Bed level	=	782.400 m	
Depth of water (u/s)	=	3.74 m	
Afflux from Molesworth	=	0.030 m	
Velocity of approach	=	4.43 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	1.00 m	
Total head	=	1.03 m	
Velocity through vent (2gh)	=	4.50 m/s	
Linear water way required	=	66.77 m	
Proposed vent way (3 x 24 - 2 x 1.2 - 2 x 1.1)	=	67.40 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	4.47 m/sec
Unobstructed area, Au	=	241.30 m ²
Effective vent area, Ae	=	238.66 m ²
Afflux	=	0.030 m

3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	1.20 m
Bottom of deck level to be provided	=	787.370 m

MINOR BRIDGE
(Existing CH: 409+000)
(Design CH: 405+495)

Discharge Calculations as per AV method :

FRL in m = 404.000
 GL in m = 393.650
 HFL as per inventory = 396.150

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	393.65	0.000			
2	0.140	460.00	0.140	66.35	66.35	9.29
3	0.300	480.00	0.160	86.35	152.70	24.43
4	0.460	500.00	0.160	106.35	192.70	30.83
5	1.060	600.00	0.600	206.35	312.70	187.62
6	1.570	700.00	0.510	306.35	512.70	261.48
7	1.900	800.00	0.330	406.35	712.70	235.19

S 748.84

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 207.435 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 10.3
 h= Depth of water in m = 2.50 (from inventory)
 n= Rugosity coefficient = 0.055
 S= Slope = 0.2074

Assuming cross sectional slope of stream = 1 : 1.5

A= Cross sectional area in sq m = 16.38
 P = Wetted Perimeter = 11.81
 R= Hydraulic mean depth = A/P
 = 1.386
 V= Velocity in m/sec = $\frac{1}{n} \cdot (R)^{2/3} \cdot S^{1/2}$
 = 10.29
 Q= Discharge in cum / sec = 169.0

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	169.00 m ³ /s	
Unobstructed Velocity of river	=	10.32 m/s	
HFL	=	396.150 m	
Bed level	=	393.650 m	
Depth of water (u/s)	=	2.50 m	
Afflux from Molesworth	=	0.120 m	
Velocity of approach	=	9.85 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	4.94 m	
Total head	=	5.06 m	
Velocity through vent (2gh)	=	9.97 m/s	
Linear water way required	=	9.29 m	
Proposed vent way (1 x 10.3 - 0 x 0.6 - 2 x 0.5)	=	9.30 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	10.32 m/sec
Unobstructed area, Au	=	16.38 m ²
Effective vent area, Ae	=	16.21 m ²
Afflux	=	0.120 m

3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	0.90 m
Bottom of deck level to be provided	=	397.170 m

MINOR BRIDGE
(Existing CH: 412+230)
(Design CH: 408+440)

Discharge Calculations as per AV method :

FRL in m = 506.500
 GL in m = 497.950
 HFL as per inventory = 499.650

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	497.95	0.000			
2	0.060	560.00	0.060	62.05	62.05	3.72
3	0.200	600.00	0.140	102.05	164.10	22.97
4	0.500	700.00	0.300	202.05	304.10	91.23
5	0.800	800.00	0.300	302.05	504.10	151.23

S 269.16

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 420.558 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 10.3
 h= Depth of water in m = 1.70 (from inventory)
 n= Rugosity coefficient = 0.055
 S= Slope = 0.4206

Assuming cross sectional slope of stream = 1 : 1.5

A= Cross sectional area in sq m = 13.17
 P = Wetted Perimeter = 11.33
 R= Hydraulic mean depth = A/P
 = 1.163
 V= Velocity in m/sec = $1/n \cdot (R)^{2/3} \cdot S^{1/2}$
 = 13.04
 Q= Discharge in cum / sec = 172.0

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	172.00 m ³ /s	
Unobstructed Velocity of river	=	13.06 m/s	
HFL	=	499.650 m	
Bed level	=	497.950 m	
Depth of water (u/s)	=	1.70 m	
Afflux from Molesworth	=	0.250 m	
Velocity of approach	=	11.38 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	6.60 m	
Total head	=	6.85 m	
Velocity through vent (2gh)	=	11.59 m/s	
Linear water way required	=	9.19 m	
Proposed vent way (1 x 10.3 - 0 x 0.6 - 2 x 0.5)	=	9.30 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	13.06 m/sec
Unobstructed area, Au	=	13.17 m ²
Effective vent area, Ae	=	13.01 m ²
Afflux	=	0.250 m

3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	0.90 m
Bottom of deck level to be provided	=	500.800 m

MINOR BRIDGE
(Existing CH: 428+180)
(Design CH: 423+492)

Discharge Calculations as per AV method :

FRL in m = 186.660
 GL in m = 179.786
 HFL as per inventory = 182.660

Computation of Equivalent Stream Slope (S) :

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(km)	(m)	(km)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	179.79	0.000			
2	1.470	220.00	1.470	40.21	40.21	59.11
3	1.850	240.00	0.380	60.21	100.43	38.16
4	2.300	260.00	0.450	80.21	140.43	63.19
5	3.000	300.00	0.700	120.21	200.43	140.30
6	3.800	340.00	0.800	160.21	280.43	224.34
7	4.200	360.00	0.400	180.21	340.43	136.17
8	4.700	380.00	0.500	200.21	380.43	190.21
9	5.200	400.00	0.500	220.21	420.43	210.21
10	6.130	440.00	0.930	260.21	480.43	446.80
11	6.700	460.00	0.570	280.21	540.43	308.04
12	7.100	500.00	0.400	320.21	600.43	240.17
13	7.560	540.00	0.460	360.21	680.43	313.00
14	7.900	600.00	0.340	420.21	780.43	265.35
15	8.300	700.00	0.400	520.21	940.43	376.17

S 3011.24

$$\text{Slope (S)} = \frac{\sum L_i(D_{i-1} + D_i)}{L^2} = 43.711 \text{ m/km}$$

Where Q = Maximum run-off in cu.m / sec

W= Width in m = 16
 h= Depth of water in m = 2.87 (from inventory)
 n= Rugosity coefficient = 0.045
 S= Slope = 0.0437

Assuming cross sectional slope of stream = 1 : 1.5

A= Cross sectional area in sq m = 33.59
 P = Wetted Perimeter = 17.74
 R= Hydraulic mean depth = A/P
 = 1.894

V= Velocity in m/sec = $\frac{1}{n} \cdot (R)^{2/3} \cdot S^{1/2}$
 = 7.11

Q= Discharge in cum / sec = 239.0

Linear water way & Afflux :-**1. Linear Water Way:**

Design discharge	=	239.00 m ³ /s	
Unobstructed Velocity of river	=	7.11 m/s	
HFL	=	182.660 m	
Bed level	=	179.786 m	
Depth of water (u/s)	=	2.87 m	
Afflux from Molesworth	=	0.140 m	
Velocity of approach	=	6.78 m/s	
Head due to velocity of approach ($V^2 / 2g$)	=	2.35 m	
Total head	=	2.49 m	
Velocity through vent (2gh)	=	6.98 m/s	
Linear water way required	=	13.23 m	
Proposed vent way (1 x 16 - 0 x 1.2 - 2 x 1.1)	=	13.80 m	o.k

2. Check for Afflux

As per Cl. 2.2.5.2 of Pocket Book for Bridge Engineers published by Indian Road Congress, New Delhi

By Molesworth formula

$$\text{Afflux} = \left[\frac{V^2}{17.89} + 0.015 \right] \times \left[\left(\frac{Au}{Ae} \right)^2 - 1 \right]$$

Velocity, V	=	7.11 m/sec
Unobstructed area, Au	=	33.59 m ²
Effective vent area, Ae	=	32.79 m ²
Afflux	=	0.140 m

3. Fixing of RCL (As per table 12.1 of IRC: SP - 13)

Vertical clearance (V_c) required	=	0.90 m
Bottom of deck level to be provided	=	183.700 m

(Scour depth calculations)

SCOUR DEPTH CALCULATIONS FOR MAJOR AND MINOR BRIDGES

Si.No	Chainage	Proposed Span Arrangement	Location	HFL (m)	Discharge (Cumecs)	Velocity (m/sec)	Design Discharge 1.3xQ (Cumec)	Silt Factor	Eff. Linear Waterway (m)	Discharge per m width (Cumecs/	Mean Scour Depth Dsm(m)	Scour depth below HFL(m)	Borehole Level (m)	Theoretic al Scour level (m)	Seismic Scour Level (m)	Actual Scour level (m)	Scour depth below BH (m)
Minor bridges																	
1	334+330	1 x 18	A1	774.720	175	5.56	227.5	2.5	15.6	14.583	5.893	7.485	773.720	767.235	767.9839	767.235	6.485
	Ushoipokpi																
2	336+100	2 X 20.0	A1	774.480	408	3.56	530.4	2.5	36.4	14.571	5.890	7.480	773.480	767.000		767.000	6.480
	(Waithou)		P	774.480	408	3.56	530.4	2.5	36.4	14.571	5.890	11.780	770.480	762.700	765.980	765.980	4.500
3	344+150	1 x 33	A1	Irrigation Canal		-	-	-	94.2	-	-	-	772.990	-	-	-	-
	(Arong)																
4	347+600	2 X 7.0	A1	Irrigation Canal		-	-	-		-	-	-	773.315	-	-	-	-
	(Khabakong)		P	-	-	-	-	-		-	-	-	771.815	-	-	-	-
5	348+150	8.8+8.0+8.8	A1	775.750	204	3.47	265.2	3.0	22	12.055	4.885	6.203	774.000	769.547	770.167	769.547	4.453
	(Wangjing)		P	775.750	204	3.47	265.2	3.0	22	12.055	4.885	9.769	772.000	765.981	766.958	765.981	6.019
6	349+900	2 X 5.8	A1	Irrigation Canal		-	-	-	-	-	-	-	770.275	-	-	-	-
7	352+800	2 X 5.8	A1	775.500	123	4.36	159.9	2.5	11.6	13.784	5.676	7.209	773.596	768.291	769.012	768.291	5.305
Major bridges																	
1	330+150	2 x 48.5	A1	779.270	2166	3.17	2815.8	3.0	93.4	30.148	9.000	11.430	779.270	767.840	768.983	768.983	10.287
	(Lilong)		P	779.270	2166	3.17	2815.8	3.0	93.4	30.148	9.000	18.000	768.870	761.270	763.070	763.070	5.800
			A2	779.270	2166	3.17	2815.8	3.0	93.4	30.148	9.000	11.430	780.070	767.840	768.983	768.983	11.087
2	341+780	2 x 34.5	A1	781.010	1741	3.8	2263.3	3.0	65.4	34.607	9.867	12.531	776.267	768.479	769.732	769.732	6.535
	(Thoubal)		P	781.010	1741	3.8	2263.3	3.0	65.4	34.607	9.867	19.733	771.267	761.277	763.250	763.250	8.017
3	365+550	3 x 24	A1	786.140	1078	4.5	1401.4	3.0	67.2	20.854	7.039	8.940	783.179	777.200	778.094	777.200	5.979
	(Pallel)		P	786.140	1078	4.5	1401.4	3.0	67.2	20.854	7.039	14.078	781.179	772.062	773.469	772.062	9.117

List of Proposed and Existing Culverts

LIST OF SLAB/BOX/ARCH CULVERTS IN MAIN ALIGNMENT :

Sl. No.	Location in (kM)	Location in (kM)(Design)	Type of structure Arch/ Box/ Slab	Span arrangement No.x WxH (m)	Proposal		
					Type of structure	Span (m)	Remarks
1	334+590	335+113	Slab	1 x 1.8 x 1.8	Box	1 X 2 X 2.5	Reconstruction to 4 lane
2	334+765	335+144	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2.5	Reconstruction to 4 lane
3	334+790	335+517	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 4 lane
4	334+820	335+528	Slab	1 x 1 x 0.8	Box	1 X 1.5 X 2	Reconstruction to 4 lane
5	335+005	335+571	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2	Reconstruction to 4 lane
6	335+215	335+644	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2	Reconstruction to 4 lane
7	335+430	335+724	Slab	1 x 1.5 x 1	Box	1 X 1.5 X 1.5	Reconstruction to 4 lane
8	335+710	336+106	Slab	1 x 2 x 1	Box	1 X 2 X 2.5	Reconstruction to 4 lane
9	336+000	336+392	Slab	1 x 2 x 1.3	Box	1 X 2 X 1.5	Reconstruction to 4 lane
10	336+180	336+577	Slab	1 x 2 x 1.8	Box	1 X 2 X 2	Reconstruction to 4 lane
11	336+330	337+000	Slab	1 x 2 x 1.5	Box	1 X 2 X 3.5	Reconstruction to 4 lane
12	336+550	337+160	Slab	1 x 2 x 0.8	Box	1 X 2 X 1.5	Reconstruction to 4 lane
13	337+100	337+576	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 4 lane
14	337+230	337+721	Slab	1 x 2 x 1.5	Box	1 X 2 X 2.5	Reconstruction to 4 lane
15	337+450	337+974	Slab	1 x 6 x 2	Box	1 X 6 X 3	Reconstruction to 4 lane
16	338+125	338+576	Slab	1 x 1.8 x 2	Box	1 X 2 X 2.5	Reconstruction to 4 lane
17	338+250	338+587	Slab	1 x 1 x 0.8	Box	1 X 1.5 X 2	Reconstruction to 4 lane
18	338+600	338+908	Slab	1 x 1 x 0.8	Box	1 X 1.5 X 2	Reconstruction to 4 lane
19	338+782	339+103	Slab	1 x 1 x 0.8	Box	1 X 1.5 X 2.5	Reconstruction to 4 lane
20	339+050	339+391	Slab	1 x 1 x 1.2	Box	1 X 1.5 X 1.5	Reconstruction to 4 lane
21	339+700	340+376	Slab	1 x 6.0 x 3.5	Box	1 X 6 X 3.5	Reconstruction to 4 lane
22	342+360	342+564	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2	Existing 4 lane
23	343+110	343+131	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2.5	Reconstruction to 4 lane
24	343+410	343+433	Slab	1 x 1 x 1.5	Box	1 X 1.5 X 3	Reconstruction to 4 lane
25	343+900	343+949	Slab	1 x 1 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 4 lane
26	344+960	345+097	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 4 lane
27	345+350	345+515	Slab	1 x 1 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 4 lane
28	346+050	346+267	Slab	1 x 2 x 1.2	Box	1 X 2 X 2	Reconstruction to 4 lane
29	346+350	346+492	Slab	1 x 2.1 x 1.3	Box	1 X 2.5 X 2	Reconstruction to 4 lane
30	346+900	346+729	Box	2 x 2.5 x 1.2	Box		Retained
31	350+453	350+371	Slab	1 x 1 x 1.2	Box	1 X 1.5 X 1.5	Reconstruction to 4 lane

LIST OF SLAB/BOX/ARCH CULVERTS IN MAIN ALIGNMENT :

Sl. No.	Location in (kM)	Location in (kM)(Design)	Type of structure Arch/ Box/ Slab	Span arrangement No.x WxH (m)	Proposal		
					Type of structure	Span (m)	Remarks
32	350+990	351+194	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 4 lane
33	351+250	351+742	Slab	1 x 1 x 1	Box	1 X 1.5 X 2.5	Reconstruction to 4 lane
34	351+582	352+135	Slab	1 x 1 x NV	Box	1 X 1.5 X 2.5	Reconstruction to 4 lane
35	351+725	352+622	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 4 lane
36	352+050	352+681	Slab	1 x 2 x 1	Box	1 X 2 X 1.5	Reconstruction to 4 lane
37	352+450	352+831	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 4 lane
38	352+600	353+511	Slab	1 x 1 x NV	Box	1 X 1.5 X 1.5	Reconstruction to 4 lane
39	352+723	353+715	Slab	1 x 2 x 1.5	Box	1 X 2 X 3.5	Reconstruction to 4 lane
40	353+600	354+365	Slab	1 x 2 x 1.5	Box	1 X 2 X 2.5	Reconstruction to 4 lane
41	354+380	355+145	Slab	1 x 4 x 2.5	Box	1 X 4 X 3	Reconstruction to 4 lane
42	354+900	355+983	Slab	1 x 5.1 x 1.8	Box	1 X 5.5 X 3.5	Reconstruction to 4 lane
43	355+940	357+023	Slab	1 x 2 x 2	Box	1 X 2 X 2.5	Reconstruction to 4 lane
44	356+670	357+808	Slab	1 x 4.5 x 2.5	Box	1 X 4.5 X 3	Reconstruction to 4 lane
45	357+350	358+548	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 3.5	Reconstruction to 4 lane
46	358+150	359+290	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2.5	Reconstruction to 4 lane
47	360+240	360+357	Slab	1 x 1 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 4 lane
48	360+250	361+465	Slab	1 x 2 x 1	Box	1 X 2 X 1.5	Reconstruction to 4 lane
49	360+800	362+015	Slab	1 x 2 x 1	Box	1 X 2 X 1.5	Reconstruction to 4 lane
50	362+700	363+297	Slab	1 x 3 x 1	Box	1 X 3 X 2.5	Reconstruction to 4 lane
51	363+300	363+962	Slab	1 x 2 x 1.2	Box	1 X 2 X 2	Reconstruction to 4 lane
52	363+900	364+925	Slab	1 x NV x NV	Box	1 X 3 X 3	Reconstruction to 4 lane
53	364+890	365+263	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 4	Reconstruction to 4 lane
54	365+350	365+302	Slab	1 x 5 x NV	Box	1 X 5 X 3.5	Reconstruction to 4 lane
55	365+370	365+840	Slab	1 x NV x NV	Box	1 X 3 X 3	Reconstruction to 4 lane
56	365+890	366+254	Slab	1 x 1 x 0.8	Box	1 X 1.5 X 1.5	Reconstruction to 4 lane
57	366+300	366+605	Slab	1 x 2 x 1	Box	1 X 2 X 1.5	Reconstruction to 4 lane
58	366+380	366+685	Slab	1 x 1.5 x 3	Box	1 X 2 X 3.5	Reconstruction to 4 lane
59	368+445	368+068	Slab	1 x 1.5 x NV	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
60	368+900	368+520	Slab	1 x 2 x 1.8	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
61	369+013	368+860	Slab	1 x NV x NV	Box	1 X 3 X 3	Reconstruction to 2 lane with Paved shoulder
62	369+250	368+872	Slab	1 x 2 x 2	Box	1 X 2 X 2.5	Reconstruction to 2 lane with Paved shoulder

LIST OF SLAB/BOX/ARCH CULVERTS IN MAIN ALIGNMENT :

Sl. No.	Location in (kM)	Location in (kM)(Design)	Type of structure Arch/ Box/ Slab	Span arrangement No.x WxH (m)	Proposal		
					Type of structure	Span (m)	Remarks
63	370+400	369+960	Slab	1 x 1.5 x 1	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
64	371+625	371+238	Slab	1 x 1.5 x 2	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder
65	374+200	373+552	Slab	1 x 1.5 x 2	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder
66	375+270	374+617	Slab	1 x 1.2 x 1	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
67	376+550	375+896	Slab	1 x 2 x 1	Box	1 X 2 X 1.5	Reconstruction to 2 lane with Paved shoulder
68	377+050	376+396	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
69	377+250	376+597	Slab	1 x 1.5 x 1	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
70	378+500	377+784	Slab	1 x 1.8 x 1	Box	1 X 2 X 1.5	Reconstruction to 2 lane with Paved shoulder
71	379+350	378+741	Slab	1 x 1 x 1	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
72	379+375	378+849	Slab	1 x 1 x NV	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
73	380+560	379+543	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
74	380+330	379+804	Slab	1 x 1.5 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
75	382+160	380+903	Slab	1 x 2 x 1	Box	1 X 2 X 1.5	Reconstruction to 2 lane with Paved shoulder
76	383+220	381+931	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
77	386+230	384+631	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
78	388+900	387+046	Slab	1 x 2 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
79	390+000	388+218	Slab	1 x 2 x 2	Box	1 X 2 X 2.5	Reconstruction to 2 lane with Paved shoulder
80	390+630	388+849	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
81	392+100	390+240	Slab	1 x 1.5 x 0.8	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
82	393+280	391+456	Slab	1 x 1.8 x 4	Box	1 X 2 X 4.5	Reconstruction to 2 lane with Paved shoulder
83	393+530	391+782	Slab	1 x 1 x 3	Box	1 X 2 X 3.5	Reconstruction to 2 lane with Paved shoulder
84	394+050	392+191	Slab	1 x 1 x 2.1	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder
85	394+210	392+351	Slab	1 x 2.2 x 1.8	Box	1 X 2.5 X 2	Reconstruction to 2 lane with Paved shoulder
86	394+380	392+568	Slab	1 x 1.2 x 2	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder
87	394+444	392+692	Slab	1 x 1.2 x 1.8	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
88	396+280	394+228	Slab	1 x 1.8 x 1	Box	1 X 2 X 1.5	Reconstruction to 2 lane with Paved shoulder
89	398+300	395+951	Slab	1 x 1.8 x 1	Box	1 X 2 X 1.5	Reconstruction to 2 lane with Paved shoulder
90	399+010	396+770	Slab	1 x 1.5 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
91	403+270	400+871	Slab	1 x 3 x 5	Box	1 X 3 X 5.5	Reconstruction to 2 lane with Paved shoulder
92	403+600	401+238	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
93	403+990	401+400	Slab	1 x 1.3 x 1.4	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder

LIST OF SLAB/BOX/ARCH CULVERTS IN MAIN ALIGNMENT :

Sl. No.	Location in (kM)	Location in (kM)(Design)	Type of structure Arch/ Box/ Slab	Span arrangement No.x WxH (m)	Proposal		
					Type of structure	Span (m)	Remarks
94	404+600	401+972	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
95	405+200	402+519	Slab	1 x 1.8 x 1.5	Box	1 X 2 X 2	Reconstruction to 2 lane with Paved shoulder
96	405+300	402+619	Slab	1 x 3.5 x 3	Box	1 X 3.5 X 3.5	Reconstruction to 2 lane with Paved shoulder
97	405+310	402+673	Slab	1 x 1.5 x 2	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder
98	405+330	402+715	Slab	1 x 1 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
99	405+600	402+897	Slab	1 x 1 x 3	Box	1 X 2 X 3.5	Reconstruction to 2 lane with Paved shoulder
100	405+700	402+950	Slab	1 x 1 x 3	Box	1 X 2 X 3.5	Reconstruction to 2 lane with Paved shoulder
101	407+135	404+325	Slab	1 x 4 x 4.5	Box	1 X 4 X 5	Reconstruction to 2 lane with Paved shoulder
102	407+900	404+708	Slab	1 x 4 x 4.5	Box	1 X 4 X 5	Reconstruction to 2 lane with Paved shoulder
103	408+300	404+971	Slab	1 x 3 x 3	Box	1 X 3 X 3.5	Reconstruction to 2 lane with Paved shoulder
104	409+250	405+780	Slab	1 x 5 x 4	Box	1 X 5 X 4.5	Reconstruction to 2 lane with Paved shoulder
105	409+950	406+323	Slab	1 x 3.5 x 3.5	Box	1 X 3.5 X 4	Reconstruction to 2 lane with Paved shoulder
106	410+500	407+155	Slab	1 x 3 x 1	Box	1 X 3 X 2	Reconstruction to 2 lane with Paved shoulder
107	411+690	408+362	Slab	1 x 3.3 x 1	Box	1 X 3.5 X 2	Reconstruction to 2 lane with Paved shoulder
108	413+400	409+757	Slab	1 x 4 x 3.5	Box	1 X 4 X 4	Reconstruction to 2 lane with Paved shoulder
109	417+300	413+073	Slab	1 x 1.4 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
110	417+750	413+711	Slab	1 x 1.2 x 2.5	Box	1 X 2 X 3	Reconstruction to 2 lane with Paved shoulder
111	419+080	414+748	Slab	1 x 1 x 3.5	Box	1 X 2 X 4	Reconstruction to 2 lane with Paved shoulder
112	419+100	414+768	Slab	1 x 1 x 3.5	Box	1 X 2 X 4	Reconstruction to 2 lane with Paved shoulder
113	420+330	416+102	Slab	1 x 1 x 1	Box	1 X 1.5 X 1.5	Reconstruction to 2 lane with Paved shoulder
114	421+200	416+902	Slab	1 x 1.5 x 2.5	Box	1 X 2 X 3	Reconstruction to 2 lane with Paved shoulder
115	424+500	419+814	Slab	1 x 1.5 x 2.2	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder
116	424+600	419+914	Slab	1 x 1 x 1.5	Box	1 X 1.5 X 2	Reconstruction to 2 lane with Paved shoulder
117	429+030	423+999	Slab	1 x 1.5 x 2	Box	1 X 1.5 X 2.5	Reconstruction to 2 lane with Paved shoulder

LIST OF BOX CULVERTS IN ALTERNATE ALIGNMENT :

Sl. No.	Location in (kM)	Type of structure Arch/ Box/ Slab	Proposal	
			Span (m)	Remarks
1	4+123	Box	1x6.0x3.0	Reconstruction
2	6+625	Box	1x1.5X1.5	New Proposal
3	7+002	Box	1x6.0x3.0	Reconstruction
4	7+464	Box	1x6.0x3.0	Reconstruction
5	7+570	Box	1x1.5X1.5	New Proposal
6	7+700	Box	1x1.5X1.5	New Proposal
7	8+690	Box	1x1.5X1.5	New Proposal
8	9+560	Box	1x1.5X1.5	New Proposal
9	11+250	Box	1x1.5X1.5	New Proposal
10	11+520	Box	1x1.5X1.5	New Proposal
11	12+640	Box	1x1.5X1.5	New Proposal
12	13+650	Box	1x1.5X1.5	New Proposal
13	17+620	Box	1x1.5X1.5	New Proposal
14	18+435	Box	1x1.5X1.5	New Proposal
15	22+800	Box	1x1.5X1.5	New Proposal
16	23+650	Box	1x1.5X1.5	New Proposal
17	27+520	Box	1x1.5X1.5	New Proposal
18	32+570	Box	1x1.5X1.5	New Proposal
19	35+500	Box	1x1.5X1.5	New Proposal
20	35+770	Box	1x1.5X1.5	New Proposal
21	36+880	Box	1x1.5X1.5	New Proposal
22	36+980	Box	1x1.5X1.5	New Proposal
23	37+380	Box	1x1.5X1.5	New Proposal
24	39+055	Box	1x1.5X1.5	New Proposal
25	40+315	Box	1x1.5X1.5	New Proposal
26	41+365	Box	1x1.5X1.5	New Proposal
27	42+090	Box	1x1.5X1.5	New Proposal
28	42+250	Box	1x1.5X1.5	New Proposal
29	44+535	Box	1x1.5X1.5	New Proposal
30	45+955	Box	1x1.5X1.5	New Proposal

LIST OF BOX CULVERTS IN ALTERNATE ALIGNMENT :

Sl. No.	Location in (kM)	Type of structure Arch/ Box/ Slab	Proposal	
			Span (m)	Remarks
31	46+260	Box	1x1.5X1.5	New Proposal
32	46+576	Box	1x6.0x3.0	Reconstruction
33	46+630	Box	1x1.5X1.5	New Proposal
34	47+650	Box	1x1.5X1.5	New Proposal
35	48+970	Box	1x1.5X1.5	New Proposal
36	49+770	Box	1x1.5X1.5	New Proposal
37	53+200	Box	1x1.5X1.5	New Proposal
38	53+400	Box	1x1.5X1.5	New Proposal
39	59+535	Box	1x1.5X1.5	New Proposal
40	59+535	Box	1x1.5X1.5	New Proposal