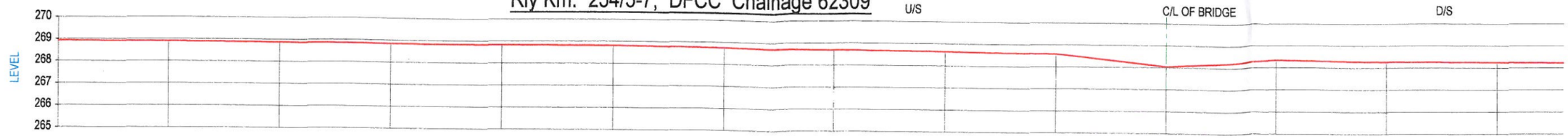
CATCHMENT AREA PLAN

Bridge no	292
A	0.427 sq km
L	0.478 km

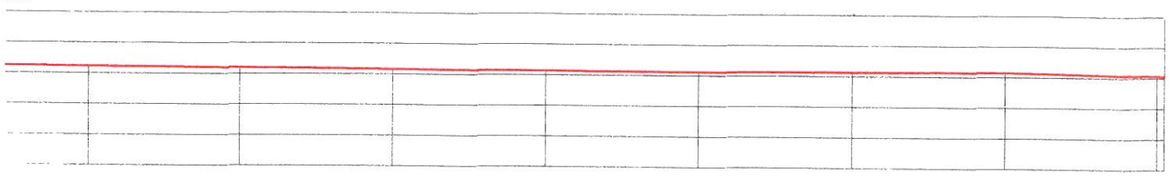
PROPOSED BRIDGE NO. BR. 005 (PRL_292)

Rly Km. 254/5-7, DFCC Chainage 62309

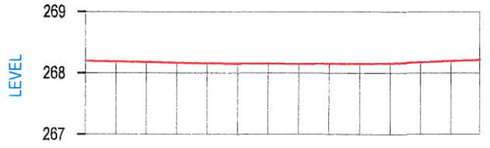


ELEVATION	268.915	268.887	268.857	268.832	268.814	268.786	268.726	268.668	268.629	268.571	268.025	268.315	268.251	268.227
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00

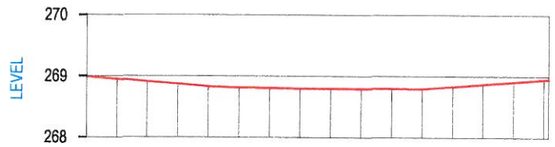
D/S



268.227	268.198	268.156	268.124	268.106	268.125	268.136	268.058	268.052
150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	502.434

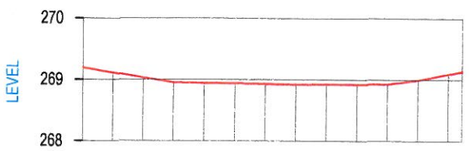


LONGITUDINAL SECTION



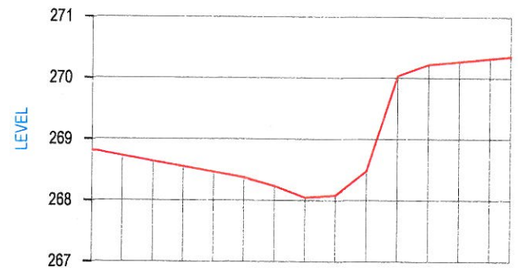
ELEVATION	268.989	268.949	268.909	268.869	268.829	268.809	268.804	268.799	268.796	268.796	268.795	268.795	268.832	268.871	268.909	268.948	268.954
CHAINAGE	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	14.311

(Upstream at 250m)



ELEVATION	269.186	269.105	269.024	268.944	268.936	268.929	268.922	268.915	268.917	268.919	268.921	268.990	269.088	269.132
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	10.886

(Upstream at 500m)



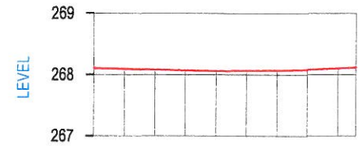
ELEVATION	268.809	268.721	268.633	268.545	268.457	268.369	268.231	268.043	268.081	268.475	270.033	270.217	270.267	270.317	270.351
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	13.353

(Bridge site)

CROSS SECTION

ELEVATION	268.192	268.182	268.171	268.161	268.151	268.148	268.146	268.144	268.146	268.148	268.152	268.170	268.188	268.205
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	11.874

(Downstream at 250m)



ELEVATION	268.098	268.086	268.074	268.064	268.052	268.056	268.061	268.075	268.096	268.109
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	9.195

(Downstream at 500m)

0091

Existing Bridge No – 293
Location – KM 256/5-7

Proposed Bridge No – 006
Location – CH: 64372

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	293
Name of Nallah / Stream / River :	Choa Nala
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	256/5-7
Latitude :	$30^0$18'13"
Longitude :	$76^0$52'18"

Catchment Area ,	**A**	=	19.093 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	9.558 Km
Height of Farthest Point ,	**H1**	=	279.23 m
Height of Point of Interest ,	**H2**	=	271.03 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	8.20 m
Average Bed Level		=	271.03 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where ,

Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0092

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **5.005 Hr**

= **300.307 Mins**

(a) t_c h Ratio = 0.54 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.574**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **12.84 cm**

= **128.40 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **25.65 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **54.468 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	19.093 Sq. Km	1909.35 Hectares
Length of path from Toposheet,	L	=	9.558 Km	
Difference in Levels from Toposheet,	H	=	8.20 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		5.72 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	37.22 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	1909.35 Hectares
I_c = Critical Intensity of Rainfall	3.722 cm / Hr
Q = Maximum Discharge	**77.992 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16 (adopted in present case)
M	=	19.093 Sq Km

Hence, **Q = 146.145 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	54.468 Cumecs
Discharge by Rational Formula (IRC approach)	77.992 Cumecs
Discharge by Dicken's Formula	146.145 Cumecs
Maximum Discharge	146.145 Cumecs
Next Maximum Discharge	77.992 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = 116.988 Cumecs

5 Linear Waterway :

Average Bed Level		=	271.03 m
HFL as per site condition & local inquiry		=	272.03 m
So, Total Depth of Water,	H	=	1.00 m

Provide 1 span of 30.5 m at Prosed bridge site location.

Clear Waterway (provided),	L	=	30.50 m
Total Area,	A	=	30.500 m2
Velocity ,	V	=	Q / A
		=	**3.836 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	116.988 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.900 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.792 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **272.930 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **152.084 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 4.99 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **3.91 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

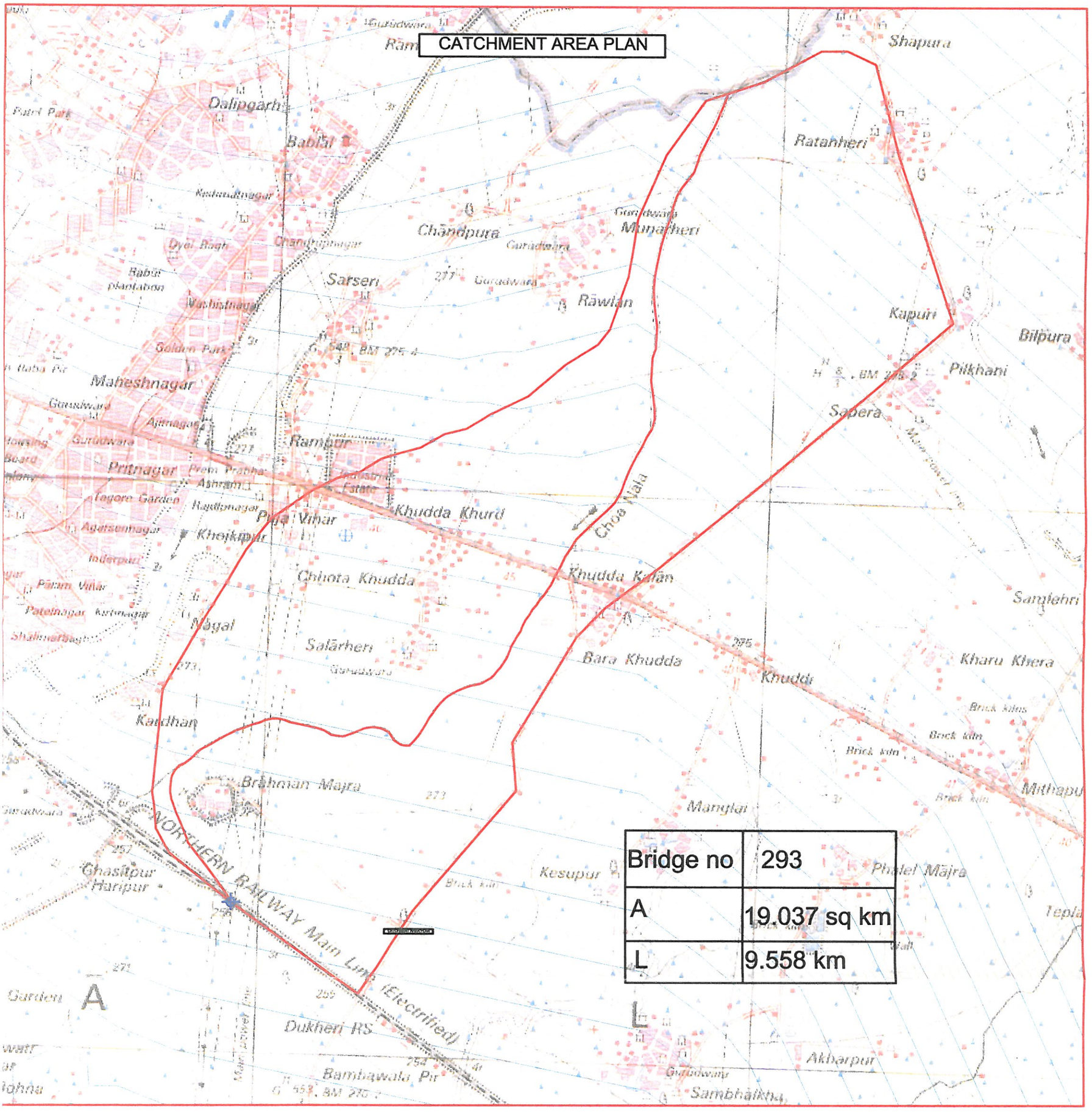
So, **Maximum Scour Depth** = **5.867 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.16 m**

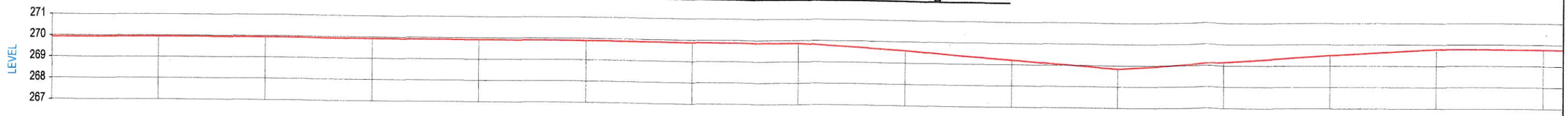
CATCHMENT AREA PLAN



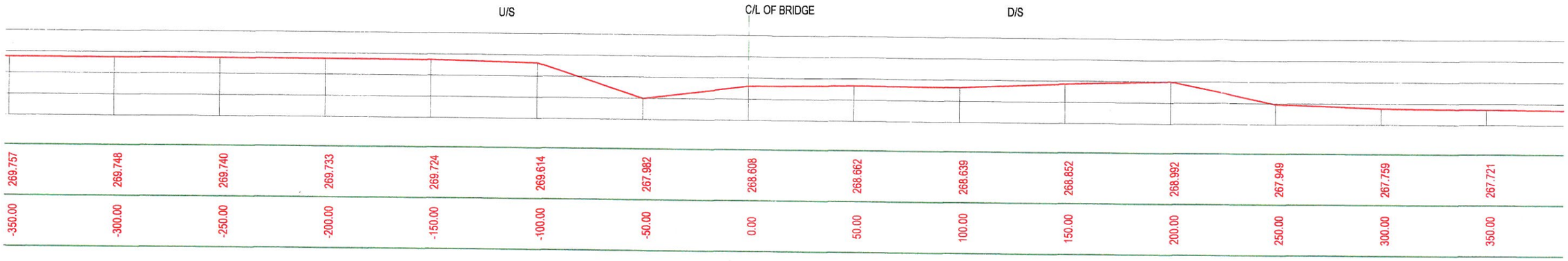
Bridge no	293
A	19.037 sq km
L	9.558 km

PROPOSED BRIDGE NO. BR. 006 (PRL_293)

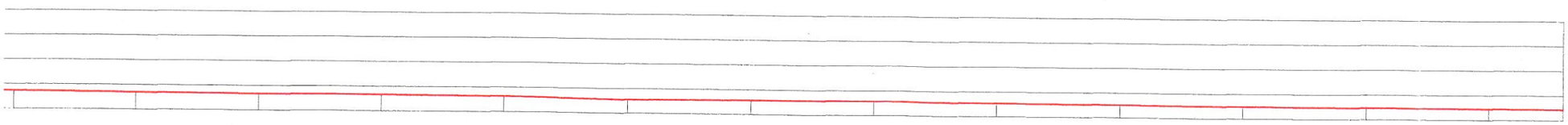
Rly Km. 256/5-7, DFCC Chainage 64372



ELEVATION	269.928	269.935	269.928	269.917	269.903	269.887	269.870	269.853	269.571	269.198	268.825	269.143	269.472	269.765	269.757
CHAINAGE	-1050.00	-1000.00	-950.00	-900.00	-850.00	-800.00	-750.00	-700.00	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00



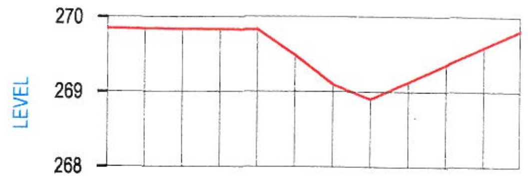
269.757	269.748	269.740	269.733	269.724	269.614	267.982	268.608	268.662	268.639	268.852	268.992	267.949	267.759	267.721
-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00



267.721	267.684	267.659	267.656	267.622	267.538	267.558	267.562	267.524	267.502	267.478	267.460	267.442	267.422
350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	980.127

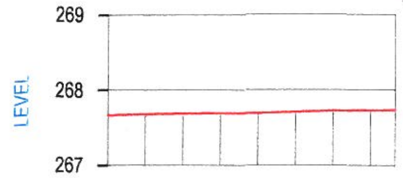
LONGITUDINAL SECTION

0097



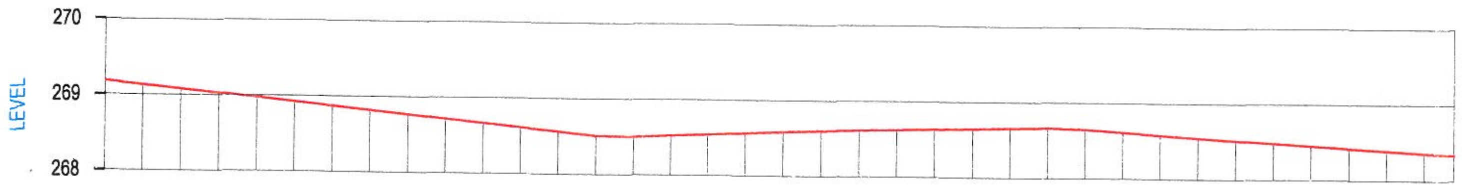
ELEVATION	269.832	269.828	269.823	269.819	269.815	269.478	269.087	268.892	269.123	269.354	269.585	269.806
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	7.909

(Upstream at 550m)



ELEVATION	267.655	267.665	267.676	267.681	267.679	267.697	267.715	267.719	267.722
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	7.301

(Downstream at 475m)

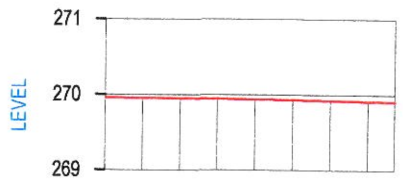


ELEVATION	269.172	269.121	269.069	269.018	268.967	268.915	268.864	268.813	268.761	268.710	268.658	268.607	268.556
CHAINAGE	-38.00	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00

ELEVATION	268.504	268.496	268.516	268.536	268.556	268.575	268.595	268.606	268.616	268.627	268.637	268.648
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00

ELEVATION	268.658	268.641	268.606	268.572	268.538	268.507	268.477	268.447	268.417	268.387	268.357	268.333
CHAINAGE	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	33.595

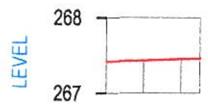
(Bridge site)



ELEVATION	269.951	269.947	269.942	269.937	269.932	269.926	269.918	269.910	269.905
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	5.422

(Upstream at 1050m)

CROSS SECTION



ELEVATION	267.412	267.425	267.449	267.453
CHAINAGE	-2.00	0.00	2.00	2.989

(Downstream at 970m)

0098

Existing Bridge No – 294
Location – KM 257/5-13

Proposed Bridge No – 007
Location – CH: 65481

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	294
Name of Nallah / Stream / River :	Tangri River
River Sub - Zone :	Upper Indo - Ganga Plains, 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	Km 257 / 5 -13
Latitude :	$30^0$18'32"
Longitude :	$76^0$51'43"

1 Discharge by Manning's Formula :

HFL with Afflux (HFL) taken at Bridge site for Existing Span = **272.552 m**

HFL at Bridge site without Afflux (HFL') for Existing Span = **272.522 m**

The Hydrological Calculations has been done at three sections i.e. at Upstream side, Downstream side and near Proposed Bridge location.

(i) At U/S location : (Distance from Proposed Bridge = 500 m)

HFL (Annexure - 1 & 6)		=	272.97 m
Cross - Sectional Area of Flow,	A	=	141.57 Sq.m
Width of Flow,	W	=	90.00 m
Wetted Perimeter (perpendicular to direction of flow) ,	P	=	90.15 m
Hydraulic Mean Radius,	R = A / P	=	1.57 m
Longitudinal Slope (as calculated),	S	=	0.0009 m per m

Velocity by Manning's Formula,

$V = 1/n\ R^{2/3}\ S^{1/2}$ (Refer IRC - SP : 13 - 1998, Clause : 5.4)

For " n " value (IRC-SP:13-1998, clause : 5.4, Table - 3)

Co-efficient of Rugosity,	n	=	0.035
Velocity,	V	=	1.158 m/s
Discharge,	Q = A x V	=	**163.943 Cumecs**

(ii) At Existing Bridge location :

HFL (Annexure - 2 & 6)		=	272.52 m
Cross - Sectional Area of Flow,	A	=	245.87 Sq.m
Width of Flow,	W	=	120.00 m
Wetted Perimeter (perpendicular to direction of flow) ,	P	=	120.27 m
Hydraulic Mean Radius,	R = A / P	=	2.04 m
Longitudinal Slope (as calculated),	S	=	0.0009 m per m

Velocity by Manning's Formula,

$V = 1/n\ R^{2/3}\ S^{1/2}$ (Refer IRC - SP : 13 - 1998, Clause : 5.4)

For " n " value (IRC-SP:13-1998, clause : 5.4, Table - 3)

Co-efficient of Rugosity,	n	=	0.035
Velocity,	V	=	1.381 m/s
Discharge,	Q = A x V	=	**339.469 Cumecs**

(iii) **At D/S location :** (Distance from Proposed Bridge = 600 m)			
HFL (Annexure - 3 & 6)		=	271.02 m
Cross - Sectional Area of Flow,	A	=	119.07 Sq.m
Width of Flow,	W	=	90.00 m
Wetted Perimeter (perpendicular to direction of flow) ,	P	=	90.44 m
Hydraulic Mean Radius,	R = A / P	=	1.32 m
Longitudinal Slope (as calculated),	S	=	0.0025 m per m
Velocity by Manning's Formula,			
$V = 1/n\ R^{2/3}\ S^{1/2}$ (Refer IRC - SP : 13 - 1998, Clause : 5.4)			
For " n " value (IRC-SP:13-1998, clause : 5.4, Table - 3)			
Co-efficient of Rugosity,	n	=	0.035
Velocity,	V	=	1.716 m/s
Discharge,	Q = A x V	=	**204.338 Cumecs**

Discharge at U/S location		=	163.94 Cumecs
Discharge at Proposed Bridges location		=	339.47 Cumecs
Discharge at D/S location		=	204.34 Cumecs
By comparision of U/S, D/S and Proposed Bridge location, the Design Discharge may be taken as ,			
Design Discharge,	Q	=	**339.469 Cumecs**

2 Linear Waterway :

Regime Width, $W = 4.8 \times Q^{1/2}$ = 88.438 m

In accordances with Para - 4.5.3 with a value of C = 2.67 of IRS - Code of Practice for the Design of Sub-structures & Foundations of Bridges, also IRC - SP : 13 - 1998, Clause : 8.5 & Clause : 104.3 of IRC : 5 - 1998

Minimum waterway provided = (2 / 3) of Regime Width = **58.959 m**

3 Afflux Calculations :

(i) Afflux Calculation for Existing Span

Cross - Sectional Area of Flow,	A	=	245.87 Sq. m
Width of Flow,	W	=	120.00 m
Existing Span Arrangement at Bridge location		=	3 x 47.5 m
Effective Span for passing the water at site		=	3 x 47.5 m
Total Water Way provided,	L	=	95.00 m
Design Discharge,	Q	=	339.47 Cumecs
Depth of Flow at D/S of Bridge,	Dd = A / W	=	2.049 m
(a / A) or (L / W)		=	0.8
(Refer IRC - SP : 13 - 1998, clause : 17.3)	Cofficient " e "	=	0.85
	Cofficient " C_o "	=	0.867
	g	=	9.81 m/s^2

If the Afflux, h < Dd/4, the Orifice Formula is applicable.

By Orifice Formula, the Discharge is given as,

$$Q = C_o\ (2g)^{0.5}\ L\ D_d\ \{h+(1+e)u^2/2g\}^{0.5}$$

or, $$\{h+(1+e)u^2/2g\}^{0.5} = Q / \{C_o\ (2g)^{0.5}\ L\ D_d\}$$

or, $$\{h+(1+e)u^2/2g\} = [Q / \{C_o\ (2g)^{0.5}\ L\ D_d\}]^2$$

Substituting values, we have

$$h + 0.094\ u^2 = 0.206 \quad \text{(i)}$$

Also at U/S of the Bridge,

$Q = W (D_d+h) u$ or, $h = Q / Wu - D_d$

Substituting values, we have

$h = (2.829 / u) - 2.049$ (ii)

Combining (i) & (ii) ,

$u - 0.04181 u^3 = 1.254$ (iii)

u (by trial & error) = 1.360

LHS Equation = 1.255

Substituting " **u** " in equation (i), we get

h = 0.030 m

The Afflux as per Orifice Formula , h = 0.030 m

h < Dd/4, OK

By Weir Formula, the Discharge is given as

Q = 1.706 Cw L H3/2

H = {Q/(1.706 Cw L)}2/3

(Refer IRC - SP : 13 - 1998, Page - 99)

Cw for Narrow Bridge Opening = 0.98

H = 1.659 m

Also, Du = H - u2/2g

Assume, Du = H = 1.659 m

u = Q/Wdu = 1.705 m/s

Now, Du = H - u2/2g = 1.511 m

Dd (as above) = 2.049 m

Afflux, h = Du - Dd = -0.538 m

Since h < Dd/4, Orifice formula will be applicable

The Afflux as per Weir Formula, h = -0.538 m

The Afflux adopted, h = **0.030 m**

(ii) <u>Afflux Calculation for Proposed Span</u>

Cross - Sectional Area of Flow,	A	=	249.52 Sq. m
Width of Flow,	W	=	120.00 m
Proposed Span Arrangement at Bridge location		=	3 x 47.5 m
Effective Span for passing the water at site		=	3 x 47.5 m
Total Water Way provided,	L	=	95.00 m
Design Discharge,	Q	=	339.47 Cumecs
Depth of Flow at D/S of Bridge,	Dd = A / W	=	2.079 m
(a / A) or (L / W)		=	0.75
(Refer IRC - SP : 13 - 1998, clause : 17.3)	Cofficient " e "	=	0.85
	Cofficient " C_o "	=	0.867
	g	=	9.81 m/s^2

If the Afflux, h < Dd/4, the Orifice Formula is applicable.

By Orifice Formula, the Discharge is given as,

$$Q = C_0 (2g)^{0.5} \; L \; D_d \; \{h+(1+e)u^2/2g\}^{0.5}$$

or, $$\{h+(1+e)u^2/2g\}^{0.5} = Q / \{C_0 (2g)^{0.5} \; L \; D_d\}$$

or, $$\{h+(1+e)u^2/2g\} = [Q / \{C_0 (2g)^{0.5} \; L \; D_d\}]^2$$

Substituting values, we have

$$h + 0.094 \; u^2 = 0.200 \qquad \text{(i)}$$

Also at U/S of the Bridge,

$$Q = W (D_d+h) u \qquad \text{or,} \qquad h = Q / Wu - D_d$$

Substituting values, we have

$$h = (2.829 / u) - 2.079 \qquad \text{(ii)}$$

Combining (I) & (ii) ,

$$u - 0.04136 \; u^3 = 1.241 \qquad \text{(iii)}$$

u (by trial & error) = 1.341

LHS Equation = 1.241

Substituting " u " in equation (i), we get

h = 0.030 m

The Afflux as per Orifice Formula , h = 0.030 m

h < Dd/4, OK

By Weir Formula, the Discharge is given as

Q = 1.706 Cw L H3/2

H = {Q/(1.706 Cw L)}2/3

(Refer IRC - SP : 13 - 1998, Page - 99)

Cw for Narrow Bridge Opening	=	0.98
H	=	1.659 m
Also, Du = H - u2/2g		
Assume, Du = H	=	1.659 m
u = Q/Wdu	=	1.705 m/s
Now, Du = H - u2/2g	=	1.511 m
Dd (as above)	=	2.079 m
Afflux, h = Du - Dd	=	-0.568 m

Since h < Dd/4, Orifice formula will be applicable

The Afflux as per Weir Formula, h = -0.568 m

The Afflux adopted, h = **0.030 m**

HFL at Bridge site for Proposed Span Arrangement = 272.552 m

So, Afflux adopted = 0.030 m

4 Vertical Clearance :

Design Discharge,	Q	=	339.469 Cumecs
(i) Vertical Clearance as per IRC : 5 - 1998, Clause : 106.2.1		=	1.20 m
(ii) Vertical Clearance as per Railway Code for Sub-structure, Clause : 4.8		=	1.50 m
So, Vertical Clearance adopted		=	1.50 m

Minimum Soffit Level of Deck Slab = **HFL + Afflux + Vertical Clearance**

= **274.052 m**

5 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **441.310 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width 4.645 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **3.731 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = $1.5 \times d_{sm}$

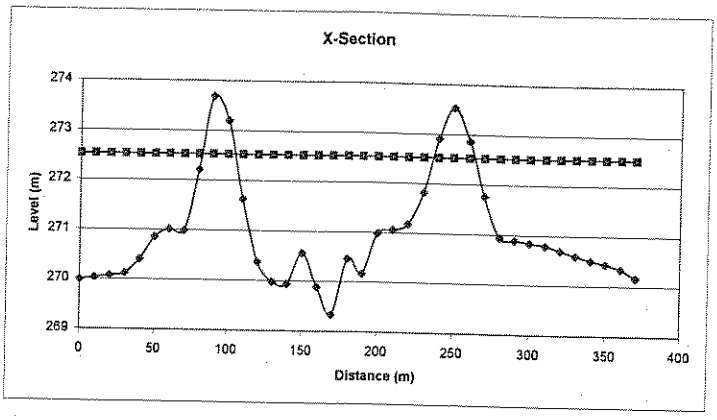
So, **Maximum Scour Depth** = **5.596 m**

6 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.926 m**

Annexure - 2

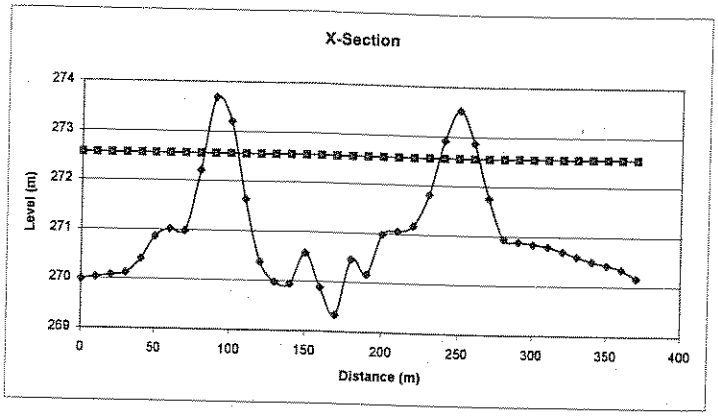


Cross - Sectional Area of River / Nallah at Existing Bridge Site is as follows :

HFL = without Afflux for existing span

Total			1.953		245.87	120.27	120.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	269.995	272.522	2.527				
10	270.038	272.522	2.484	2.506	25.055	10.000	10.000
20	270.081	272.522	2.441	2.463	24.625	10.000	10.000
30	270.124	272.522	2.398	2.420	24.195	10.000	10.000
40	270.410	272.522	2.112	2.255	22.550	10.004	10.000
50	270.859	272.522	1.663	1.888	18.875	10.010	10.000
60	271.015	272.522	1.507	1.585	15.850	10.001	10.000
70	270.984	272.522	1.538	1.523	15.225	10.000	10.000
80	272.212	272.522	0.310	0.924	9.240	10.075	10.000
90	273.690	272.522					
100	273.205	272.522					
110	271.634	272.522	0.888				
120	270.378	272.522	2.144	1.516	15.160	10.079	10.000
130	269.985	272.522	2.537	2.341	23.405	10.008	10.000
140	269.942	272.522	2.580	2.559	25.585	10.000	10.000
150	270.568	272.522	1.954	2.267	22.670	10.020	10.000
160	269.888	272.522	2.634	2.294	22.940	10.023	10.000
170	269.339	272.522	3.183	2.909	29.085	10.015	10.000
180	270.465	272.522	2.057	2.620	26.200	10.063	10.000
190	270.167	272.522	2.355	2.206	22.060	10.004	10.000
200	270.987	272.522	1.535	1.945	19.450	10.034	10.000
210	271.055	272.522	1.467	1.501	15.010	10.000	10.000
220	271.177	272.522	1.345	1.406	14.060	10.001	10.000
230	271.818	272.522	0.704	1.025	10.245	10.021	10.000
240	272.916	272.522					
250	273.534	272.522					
260	272.884	272.522					
270	271.761	272.522	0.761				
280	270.938	272.522	1.584	1.173	11.725	10.034	10.000
290	270.890	272.522	1.632	1.608	16.080	10.000	10.000
300	270.842	272.522	1.680	1.656	16.560	10.000	10.000
310	270.794	272.522	1.728	1.704	17.040	10.000	10.000
320	270.697	272.522	1.825	1.777	17.765	10.000	10.000
330	270.599	272.522	1.923	1.874	18.740	10.000	10.000
340	270.505	272.522	2.017	1.970	19.700	10.000	10.000
350	270.435	272.522	2.087	2.052	20.520	10.000	10.000
360	270.348	272.522	2.174	2.131	21.305	10.000	10.000
370	270.172	272.522	2.350	2.262	22.620	10.002	10.000

Annexure - 4

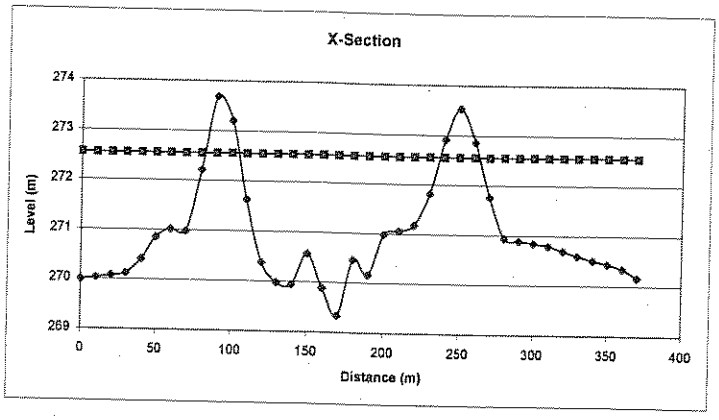


Cross - Sectional Area of River / Nallah at Existing Bridge Site is as follows :

HFL = with Afflux for existing span

Total			1.983		249.47	120.27	120.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	269.995	272.552	2.557				
10	270.038	272.552	2.514	2.536	25.355	10.000	10.000
20	270.081	272.552	2.471	2.493	24.925	10.000	10.000
30	270.124	272.552	2.428	2.450	24.495	10.000	10.000
40	270.410	272.552	2.142	2.285	22.850	10.004	10.000
50	270.859	272.552	1.693	1.917	19.175	10.010	10.000
60	271.015	272.552	1.537	1.615	16.150	10.001	10.000
70	270.984	272.552	1.568	1.553	15.525	10.000	10.000
80	272.212	272.552	0.340	0.954	9.540	10.075	10.000
90	273.690	272.552					
100	273.205	272.552					
110	271.634	272.552	0.918				
120	270.378	272.552	2.174	1.546	15.460	10.079	10.000
130	269.985	272.552	2.567	2.370	23.705	10.008	10.000
140	269.942	272.552	2.610	2.589	25.885	10.000	10.000
150	270.568	272.552	1.984	2.297	22.970	10.020	10.000
160	269.888	272.552	2.664	2.324	23.240	10.023	10.000
170	269.339	272.552	3.213	2.939	29.385	10.015	10.000
180	270.465	272.552	2.087	2.650	26.500	10.063	10.000
190	270.167	272.552	2.385	2.236	22.360	10.004	10.000
200	270.987	272.552	1.565	1.975	19.750	10.034	10.000
210	271.055	272.552	1.497	1.531	15.310	10.000	10.000
220	271.177	272.552	1.375	1.436	14.360	10.001	10.000
230	271.818	272.552	0.734	1.054	10.545	10.021	10.000
240	272.916	272.552					
250	273.534	272.552					
260	272.884	272.552					
270	271.761	272.552	0.791				
280	270.938	272.552	1.614	1.202	12.025	10.034	10.000
290	270.890	272.552	1.662	1.638	16.380	10.000	10.000
300	270.842	272.552	1.710	1.686	16.860	10.000	10.000
310	270.794	272.552	1.758	1.734	17.340	10.000	10.000
320	270.697	272.552	1.855	1.807	18.065	10.000	10.000
330	270.599	272.552	1.953	1.904	19.040	10.000	10.000
340	270.505	272.552	2.047	2.000	20.000	10.000	10.000
350	270.435	272.552	2.117	2.082	20.820	10.000	10.000
360	270.348	272.552	2.204	2.161	21.605	10.000	10.000
370	270.172	272.552	2.380	2.292	22.920	10.002	10.000

Annexure - 5

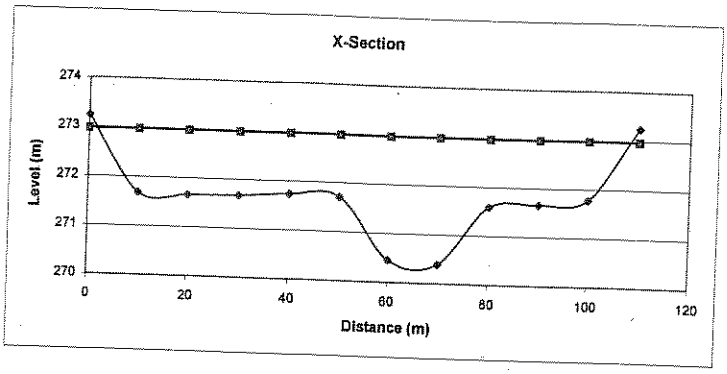


Cross - Sectional Area of River / Nallah at Proposed Bridge Site is as follows :

HFL = with Afflux for proposed span

Total			1.983		249.52	120.27	120.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	269.995	272.552	2.557				
10	270.038	272.552	2.514	2.536	25.360	10.000	10.000
20	270.081	272.552	2.471	2.493	24.930	10.000	10.000
30	270.124	272.552	2.428	2.450	24.500	10.000	10.000
40	270.410	272.552	2.142	2.285	22.855	10.004	10.000
50	270.859	272.552	1.693	1.918	19.180	10.010	10.000
60	271.015	272.552	1.537	1.615	16.155	10.001	10.000
70	270.984	272.552	1.568	1.553	15.530	10.000	10.000
80	272.212	272.552	0.340	0.954	9.545	10.075	10.000
90	273.690	272.552					
100	273.205	272.552					
110	271.634	272.552	0.918				
120	270.378	272.552	2.174	1.546	15.465	10.079	10.000
130	269.985	272.552	2.567	2.371	23.710	10.008	10.000
140	269.942	272.552	2.610	2.589	25.890	10.000	10.000
150	270.568	272.552	1.984	2.297	22.975	10.020	10.000
160	269.888	272.552	2.664	2.324	23.245	10.023	10.000
170	269.339	272.552	3.213	2.939	29.390	10.015	10.000
180	270.465	272.552	2.087	2.650	26.505	10.063	10.000
190	270.167	272.552	2.385	2.236	22.365	10.004	10.000
200	270.987	272.552	1.565	1.975	19.755	10.034	10.000
210	271.055	272.552	1.497	1.531	15.315	10.000	10.000
220	271.177	272.552	1.375	1.436	14.365	10.001	10.000
230	271.818	272.552	0.734	1.055	10.550	10.021	10.000
240	272.916	272.552					
250	273.534	272.552					
260	272.864	272.552					
270	271.761	272.552	0.791				
280	270.938	272.552	1.614	1.203	12.030	10.034	10.000
290	270.890	272.552	1.662	1.638	16.385	10.000	10.000
300	270.842	272.552	1.710	1.686	16.865	10.000	10.000
310	270.794	272.552	1.758	1.734	17.345	10.000	10.000
320	270.697	272.552	1.855	1.807	18.070	10.000	10.000
330	270.599	272.552	1.953	1.904	19.045	10.000	10.000
340	270.505	272.552	2.047	2.000	20.005	10.000	10.000
350	270.435	272.552	2.117	2.082	20.825	10.000	10.000
360	270.348	272.552	2.204	2.161	21.610	10.000	10.000
370	270.172	272.552	2.380	2.292	22.925	10.002	10.000

Annexure - 1



Cross - Sectional Area of River / Nallah at U/S of the Proposed Bridge is as follows :

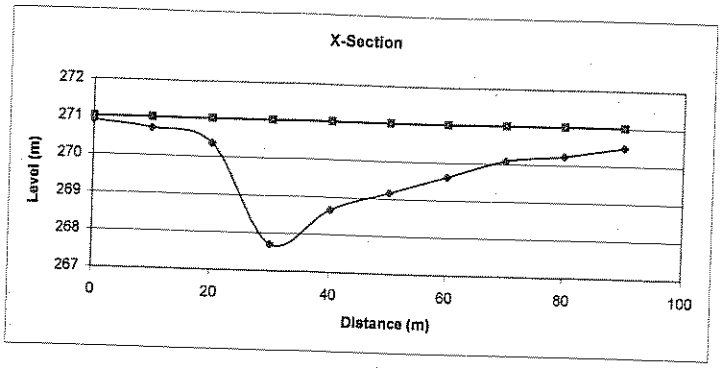
Distance from Proposed Bridge 500 m

Longitudinal Slope at U/S side 0.0009

HFL at this location 272.972 m

Total			1.540		141.57	90.15	90.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	273.240	272.972					
10	271.683	272.972	1.289				
20	271.654	272.972	1.318	1.304	13.035	10.000	10.000
30	271.676	272.972	1.296	1.307	13.070	10.000	10.000
40	271.735	272.972	1.237	1.267	12.665	10.000	10.000
50	271.707	272.972	1.265	1.251	12.510	10.000	10.000
60	270.454	272.972	2.518	1.892	18.915	10.078	10.000
70	270.392	272.972	2.580	2.549	25.490	10.000	10.000
80	271.591	272.972	1.381	1.981	19.805	10.072	10.000
90	271.654	272.972	1.318	1.350	13.495	10.000	10.000
100	271.773	272.972	1.199	1.259	12.585	10.001	10.000
110	273.253	272.972					

Annexure - 3



Cross - Sectional Area of River / Nallah at D/S of the Proposed Bridge is as follows :

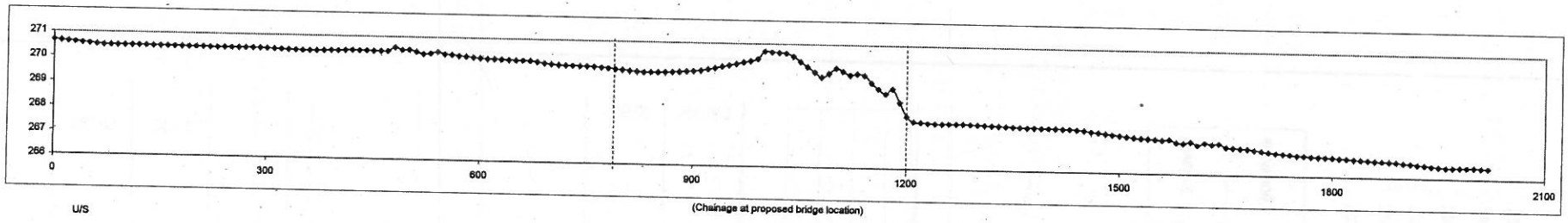
Distance from Proposed Bridge 600 m

Longitudinal Slope at D/S side 0.0025

HFL at this location 271.022 m

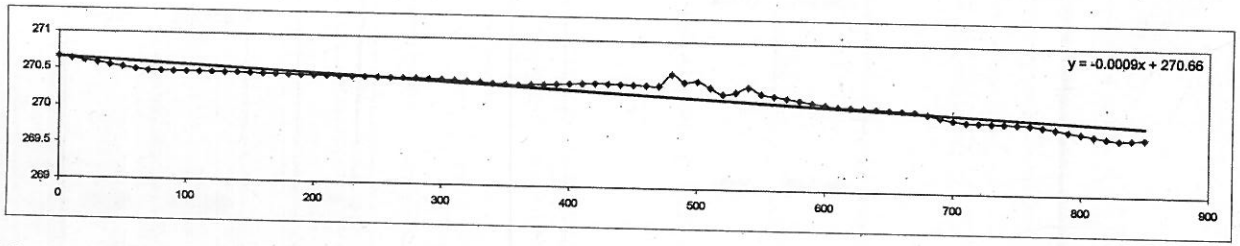
Total			1.223		119.07	90.44	90.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	270.915	271.022	0.107				
10	270.732	271.022	0.290	0.199	1.985	10.002	10.000
20	270.360	271.022	0.662	0.476	4.760	10.007	10.000
30	267.715	271.022	3.307	1.985	19.845	10.344	10.000
40	268.668	271.022	2.354	2.831	28.305	10.045	10.000
50	269.159	271.022	1.863	2.109	21.085	10.012	10.000
60	269.626	271.022	1.396	1.630	16.295	10.011	10.000
70	270.084	271.022	0.938	1.167	11.670	10.010	10.000
80	270.246	271.022	0.776	0.857	8.570	10.001	10.000
90	270.487	271.022	0.535	0.656	6.555	10.003	10.000

Annexure - 6

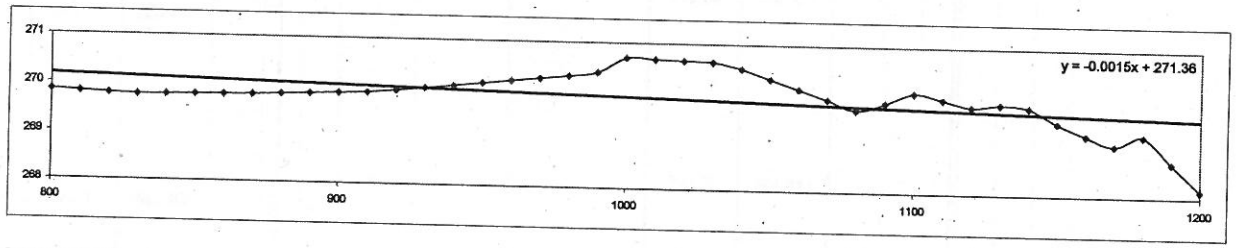


L-Section of River / Nallah

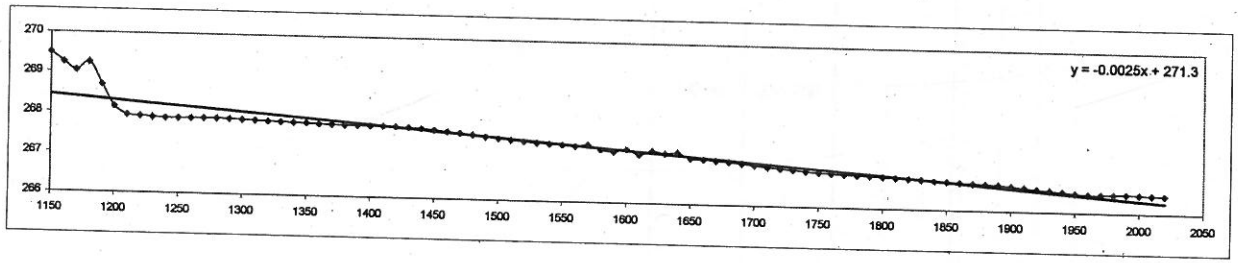
L-Section at U/S : Slope = 0.0009



L-Section at Existing Bridge Site : Slope = 0.0015



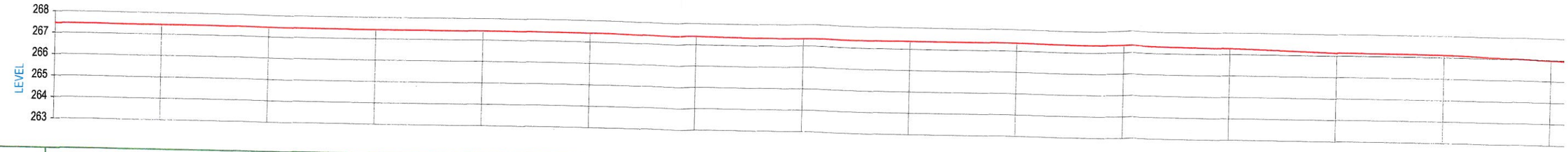
L-Section at D/S : Slope = 0.0025



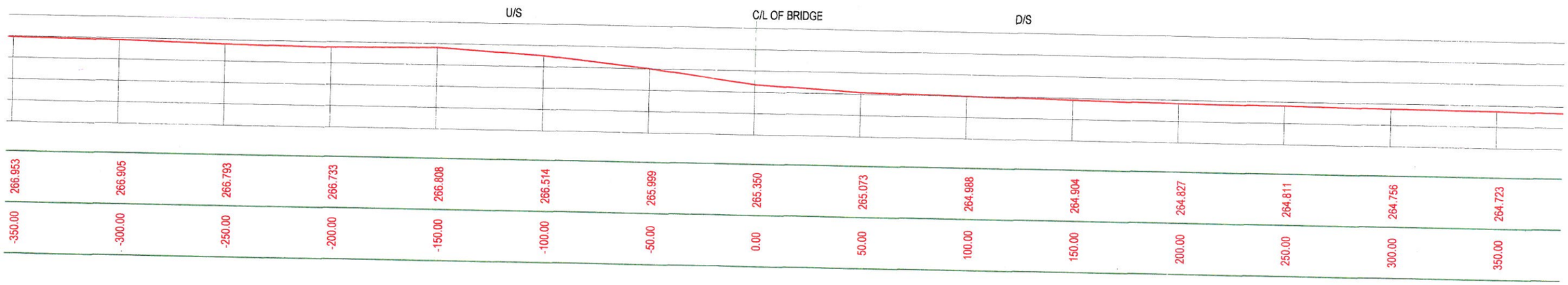
0108A

PROPOSED BRIDGE NO. BR. 007 (PRL_294)

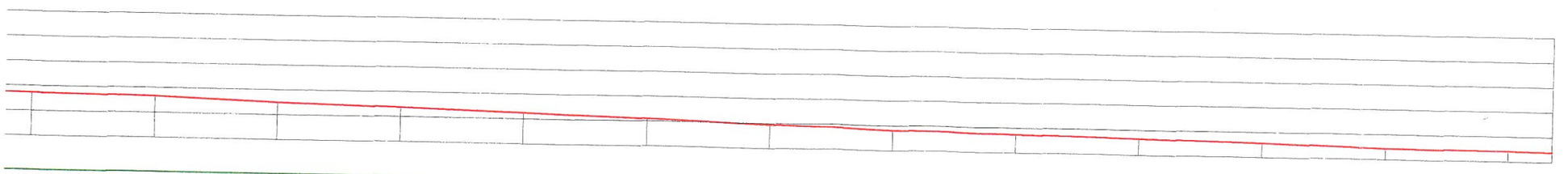
Rly Km. 257/1-13, DFCC Chainage 65481



ELEVATION	267.442	267.435	267.428	267.418	267.404	267.395	267.384	267.332	267.352	267.354	267.325	267.264	267.128	267.112	266.953
CHAINAGE	-1050.00	-1000.00	-950.00	-900.00	-850.00	-800.00	-750.00	-700.00	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00



266.953	266.905	266.793	266.733	266.808	266.514	265.999	265.350	265.073	264.988	264.904	264.827	264.811	264.756	264.723
-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00

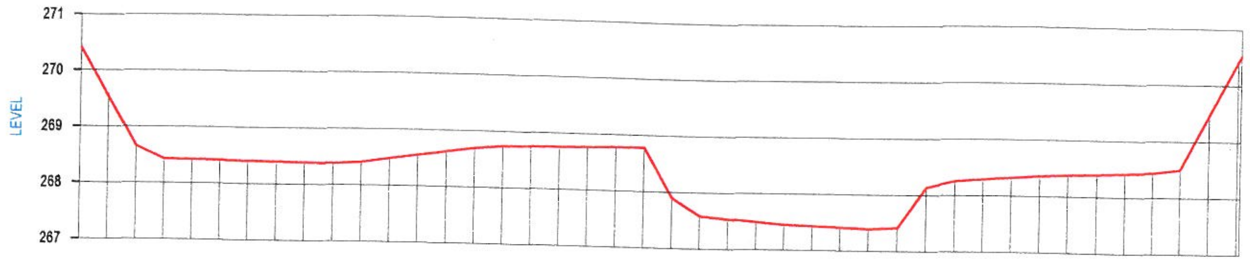


264.723	264.656	264.489	264.362	264.242	264.084	263.944	263.802	263.729	263.641	263.556	263.419	263.405	263.382
350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	967.765

LONGITUDINAL SECTION

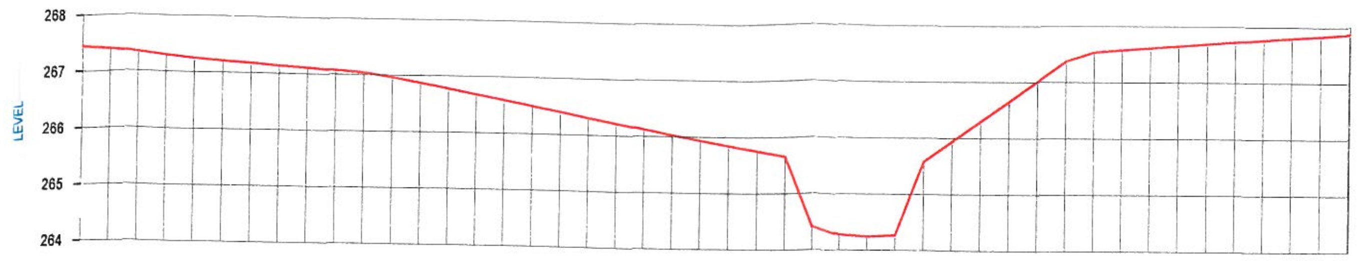
0109

SHEET NO. 1 TO 2



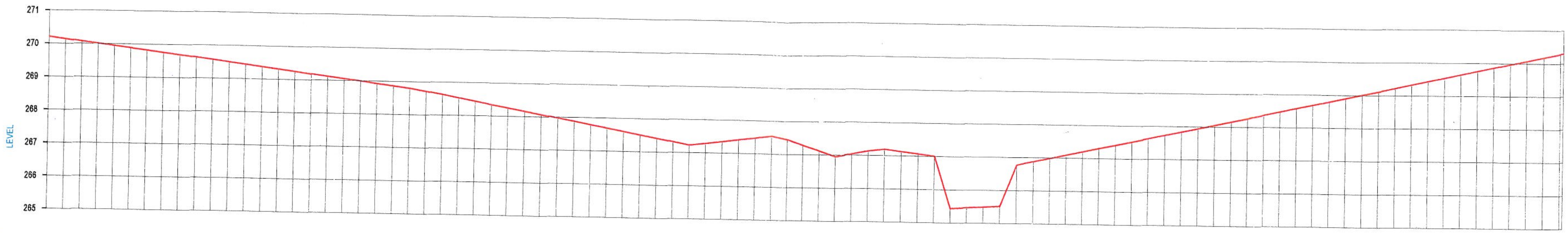
CHAINAGE	ELEVATION
-52.00	270.396
-50.00	269.519
-48.00	268.643
-46.00	268.416
-44.00	268.408
-42.00	268.400
-40.00	268.393
-38.00	268.385
-36.00	268.377
-34.00	268.369
-32.00	268.398
-30.00	268.469
-28.00	268.540
-26.00	268.611
-24.00	268.682
-22.00	268.728
-20.00	268.737
-18.00	268.746
-16.00	268.755
-14.00	268.763
-12.00	268.772
-10.00	267.887
-8.00	267.577
-6.00	267.531
-4.00	267.485
-2.00	267.441
0.00	267.422
2.00	267.402
4.00	267.383
6.00	267.402
8.00	268.131
10.00	268.244
12.00	268.278
14.00	268.312
16.00	268.345
18.00	268.369
20.00	268.387
22.00	268.406
24.00	268.425
26.00	268.490
28.00	269.449
30.00	270.409
30.223	270.516

(Upstream at 990m)



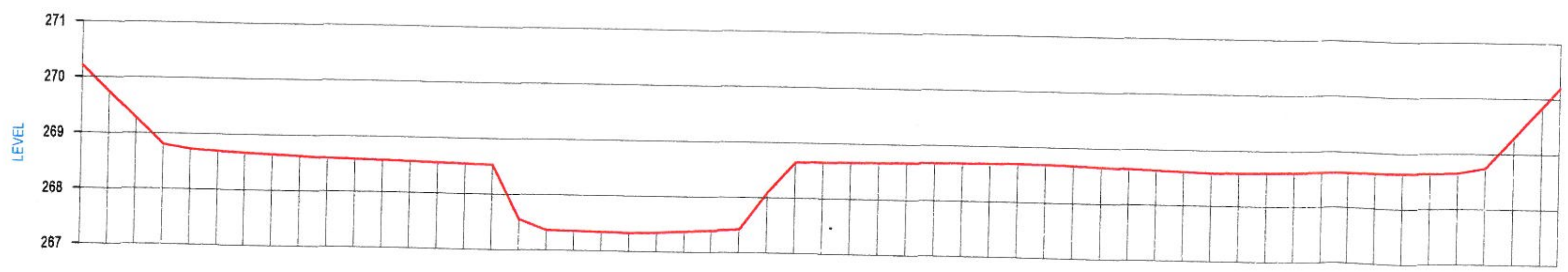
CHAINAGE	ELEVATION
-56.00	267.436
-54.00	267.386
-52.00	267.336
-50.00	267.286
-48.00	267.235
-46.00	267.195
-44.00	267.162
-42.00	267.130
-40.00	267.097
-38.00	267.065
-36.00	267.032
-34.00	266.953
-32.00	266.859
-30.00	266.765
-28.00	266.670
-26.00	266.576
-24.00	266.482
-22.00	266.387
-20.00	266.293
-18.00	266.201
-16.00	266.109
-14.00	266.017
-12.00	265.925
-10.00	265.833
-8.00	265.740
-6.00	265.648
-4.00	264.401
-2.00	264.269
0.00	264.234
2.00	264.257
4.00	265.565
6.00	265.924
8.00	266.282
10.00	266.641
12.00	267.000
14.00	267.359
16.00	267.525
18.00	267.563
20.00	267.602
22.00	267.640
24.00	267.679
26.00	267.717
28.00	267.753
30.00	267.790
32.00	267.826
34.00	267.862
34.063	267.863

(Downstream at 565m)



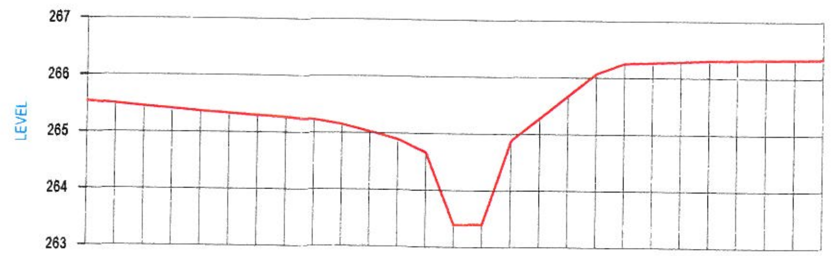
CHAINAGE	ELEVATION
-112.00	270.196
-110.00	270.132
-108.00	270.069
-106.00	270.005
-104.00	269.941
-102.00	269.878
-100.00	269.814
-98.00	269.750
-96.00	269.687
-94.00	269.623
-92.00	269.560
-90.00	269.496
-88.00	269.432
-86.00	269.369
-84.00	269.305
-82.00	269.241
-80.00	269.178
-78.00	269.114
-76.00	269.050
-74.00	268.987
-72.00	268.923
-70.00	268.859
-68.00	268.796
-66.00	268.710
-64.00	268.617
-62.00	268.524
-60.00	268.431
-58.00	268.338
-56.00	268.246
-54.00	268.153
-52.00	268.060
-50.00	267.967
-48.00	267.874
-46.00	267.781
-44.00	267.689
-42.00	267.596
-40.00	267.503
-38.00	267.410
-36.00	267.317
-34.00	267.225
-32.00	267.280
-30.00	267.345
-28.00	267.410
-26.00	267.474
-24.00	267.539
-22.00	267.450
-20.00	267.282
-18.00	267.115
-16.00	266.947
-14.00	267.036
-12.00	267.134
-10.00	267.190
-8.00	267.128
-6.00	267.086
-4.00	267.004
-2.00	265.432
0.00	265.458
2.00	265.484
4.00	265.510
6.00	266.769
8.00	266.876
10.00	266.982
12.00	267.088
14.00	267.195
16.00	267.301
18.00	267.408
20.00	267.514
22.00	267.620
24.00	267.727
26.00	267.833
28.00	267.939
30.00	268.046
32.00	268.152
34.00	268.259
36.00	268.365
38.00	268.471
40.00	268.578
42.00	268.684
44.00	268.791
46.00	268.897
48.00	269.003
50.00	269.110
52.00	269.216
54.00	269.323
56.00	269.429
58.00	269.535
60.00	269.642
62.00	269.748
64.00	269.855
66.00	269.961
68.00	270.067
70.00	270.174
72.00	270.280
72.373	270.300

(Bridge site)



CHAINAGE	ELEVATION
-40.00	270.201
-38.00	269.733
-36.00	269.265
-34.00	268.797
-32.00	268.712
-30.00	268.688
-28.00	268.664
-26.00	268.641
-24.00	268.617
-22.00	268.593
-20.00	268.578
-18.00	268.567
-16.00	268.557
-14.00	268.546
-12.00	268.535
-10.00	268.524
-8.00	267.540
-6.00	267.356
-4.00	267.346
-2.00	267.336
0.00	267.326
2.00	267.337
4.00	267.362
6.00	267.387
8.00	267.412
10.00	268.083
12.00	268.640
14.00	268.645
16.00	268.651
18.00	268.657
20.00	268.662
22.00	268.668
24.00	268.674
26.00	268.680
28.00	268.685
30.00	268.683
32.00	268.667
34.00	268.651
36.00	268.634
38.00	268.618
40.00	268.601
42.00	268.586
44.00	268.592
46.00	268.599
48.00	268.605
50.00	268.611
52.00	268.616
54.00	268.622
56.00	268.627
58.00	268.633
60.00	268.638
62.00	268.730
64.00	269.286
66.00	269.841
67.249	270.188

(Upstream at 500m)



CHAINAGE	ELEVATION
-26.00	265.527
-24.00	265.484
-22.00	265.442
-20.00	265.399
-18.00	265.356
-16.00	265.320
-14.00	265.289
-12.00	265.258
-10.00	265.228
-8.00	265.143
-6.00	265.015
-4.00	264.887
-2.00	264.658
0.00	263.387
2.00	263.394
4.00	264.873
6.00	265.270
8.00	265.667
10.00	266.064
12.00	266.245
14.00	266.264
16.00	266.282
18.00	266.301
20.00	266.315
22.00	266.320
24.00	266.326
25.980	266.332

(Downstream at 970m)

0110

CROSS SECTION

SHEET NO. 2 TO 2

Existing Bridge No – 299
Location – KM 263/21-23

Proposed Bridge No – 016
Location – CH: 72637

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	299
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	263/21-23
Latitude :	$30^0$20'49"
Longitude :	$76^0$48'46"

Catchment Area ,	**A**	=	1.618 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.807 Km
Height of Farthest Point ,	**H1**	=	272.15 m
Height of Point of Interest ,	**H2**	=	269.95 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	2.20 m
Average Bed Level		=	269.95 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.405 Hr**

= **84.327 Mins**

(a) t_c h Ratio = 0.40 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.176**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **9.60 cm**

= **95.97 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **68.28 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **12.289 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.618 Sq. Km	161.84 Hectares
Length of path from Toposheet,	L	=	1.807 Km	
Difference in Levels from Toposheet,	H	=	2.20 m	

Maximum Rainfall, F = 240.00 mm

Duration of Storm, T = 24 Hrs

One Hour Rainfall, $I_o = (F / T) \times (T + 1) / (1 + 1)$ = 125.00 mm / Hr

Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7) $t_c = (0.87 \times L^3 / H)^{0.385}$ = 1.39 Hrs

Critical Rainfall Intensity, $I_c = I_o \times [2 / (1 + t_c)]$ = 104.79 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	161.84 Hectares
I_c = Critical Intensity of Rainfall	10.479 cm / Hr
Q = Maximum Discharge	**18.615 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q = the peak run-off in Cumecs

M = the catchment area in Sq Km

C = 11 - 14, where the annual rainfall is 60 - 120 cm
14 - 19 in Madhya Pradesh
22 in Western Ghats

C = 16 (adopted in present case)

M = 1.618 Sq Km

Hence, Q = **22.958 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	12.289 Cumecs
Discharge by Rational Formula (IRC approach)	18.615 Cumecs
Discharge by Dicken's Formula	22.958 Cumecs
Maximum Discharge	22.958 Cumecs
Next Maximum Discharge	18.615 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **22.958 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.95 m
HFL as per site condition & local inquiry		=	270.85 m
So, Total Depth of Water,	H	=	0.90 m

Provide 3 spans of 6.1 m at proposed site location.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	16.470 m2
Velocity ,	V	=	Q / A
		=	**1.394 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	22.958 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **271.452 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **29.846 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.63 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.86 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **2.785 m**

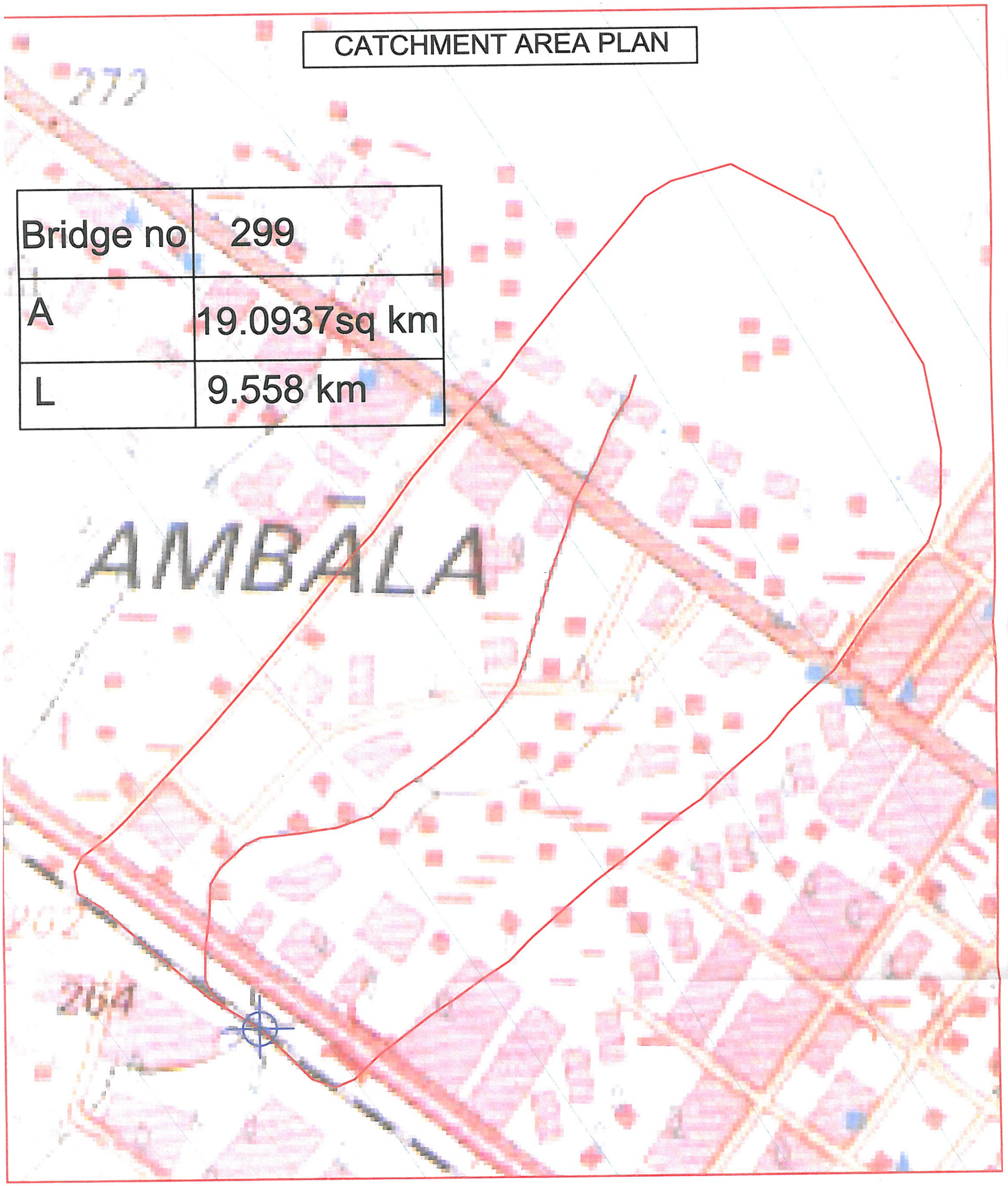
8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **268.07 m**

CATCHMENT AREA PLAN

Bridge no	299
A	19.0937sq km
L	9.558 km



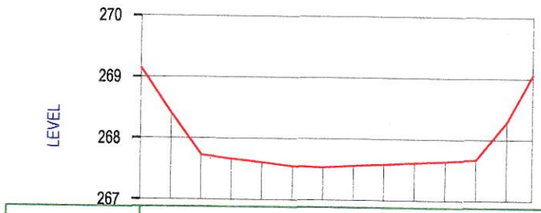
0115

PROPOSED BRIDGE NO. BR. 016 (PRL_299)

Rly Km. 263/21-23, DFCC Chainage 72637

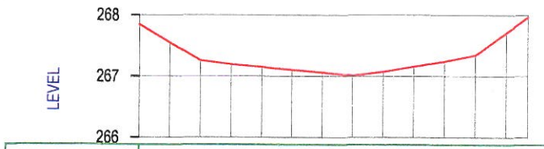
ELEVATION	267.593	267.573	267.527	267.464	267.398	267.335	267.335	267.306	267.010	266.990	266.832	267.135
CHAINAGE	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	292.405

LONGITUDINAL SECTION



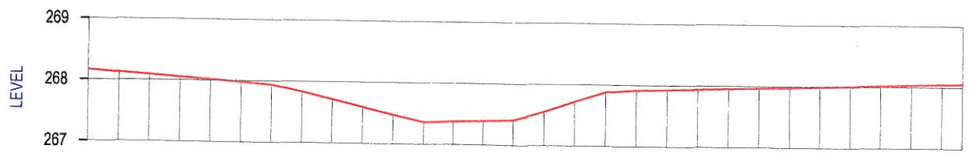
ELEVATION	269.134	268.401	267.718	267.660	267.602	267.544	267.528	267.556	267.583	267.611	267.638	267.665	268.281	269.057
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	13.667

(Upstream at 150m)



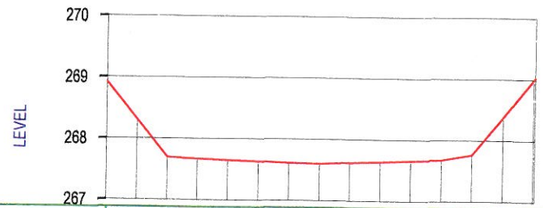
ELEVATION	267.842	267.547	267.252	267.190	267.145	267.100	267.055	267.010	267.088	267.154	267.240	267.341	267.706	267.962
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.403

(Downstream at 170m)



ELEVATION	268.157	268.121	268.084	268.048	268.011	267.975	267.939	267.829	267.710	267.592	267.473	267.357	267.372	267.388	267.403	267.548	267.713	267.879	267.909	267.922	267.936	267.949	267.963	267.976	267.990	268.004	268.017	268.031	268.044	268.053
CHAINAGE	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	35.332

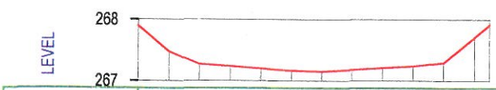
(Bridge site)



ELEVATION	268.911	268.298	267.686	267.663	267.644	267.626	267.607	267.598	267.617	267.637	267.656	267.675	267.761	268.377	268.994	269.022
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.000	14.090

(Upstream at 260m)

CROSS SECTION



ELEVATION	267.892	267.471	267.266	267.230	267.194	267.157	267.146	267.176	267.206	267.235	267.290	267.709	267.911
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.965

(Downstream at 280m)

Existing Bridge No – 300
Location – KM 264/21-23

Proposed Bridge No – 017
Location – CH: 73445

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	300
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	264/21-23
Latitude :	$30^0$21'2"
Longitude :	$76^0$48'25"

Catchment Area ,	**A**	=	1.019 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.501 Km
Height of Farthest Point ,	**H1**	=	272.53 m
Height of Point of Interest ,	**H2**	=	270.53 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	2.00 m
Average Bed Level		=	270.53 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.199 Hr**

= **71.920 Mins**

(a) t_c h Ratio = 0.37 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.087**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **8.87 cm**

= **88.74 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **74.03 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **8.387 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.019 Sq. Km	101.89 Hectares
Length of path from Toposheet,	L	=	1.501 Km	
Difference in Levels from Toposheet,	H	=	2.00 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.16 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	115.73 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	101.89 Hectares
I_c = Critical Intensity of Rainfall	11.573 cm / Hr
Q = Maximum Discharge	**12.942 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16 (adopted in present case)
M	=	1.019 Sq Km

Hence, Q = **16.226 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	8.387 Cumecs
Discharge by Rational Formula (IRC approach)	12.942 Cumecs
Discharge by Dicken's Formula	16.226 Cumecs

Maximum Discharge	16.226 Cumecs
Next Maximum Discharge	12.942 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **16.226 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.53 m
HFL as per site condition & local inquiry		=	271.69 m
So, Total Depth of Water,	H	=	1.16 m

Provide 3 spans of 6.1 m at proposed site location.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	21.277 m2
Velocity ,	V	=	Q / A
		=	**0.763 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	16.226 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **272.290 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **21.094 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width 1.15 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.47 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

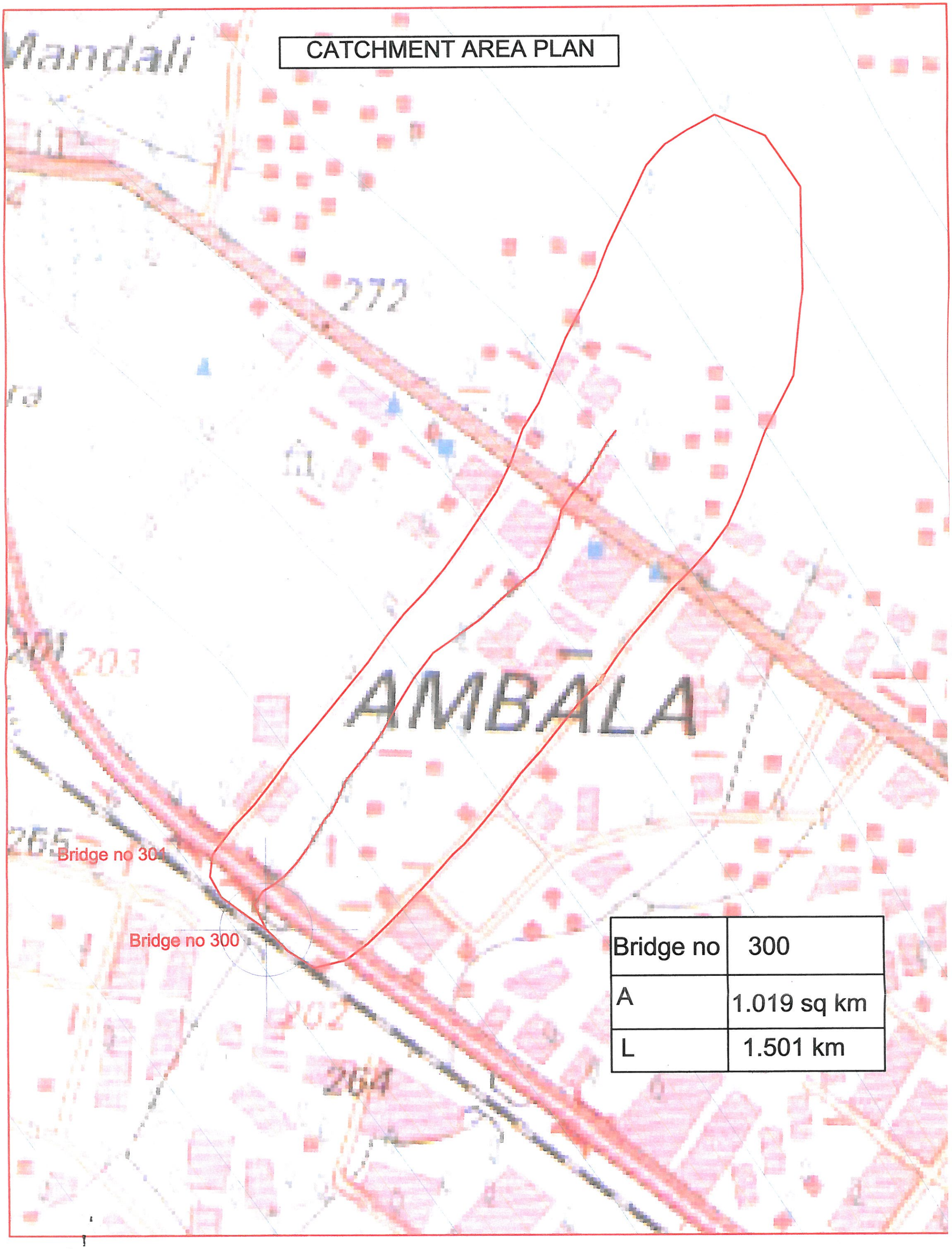
So, **Maximum Scour Depth** = **2.210 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

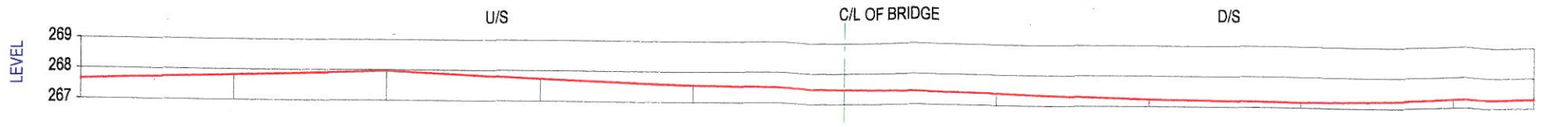
= **269.48 m**

CATCHMENT AREA PLAN



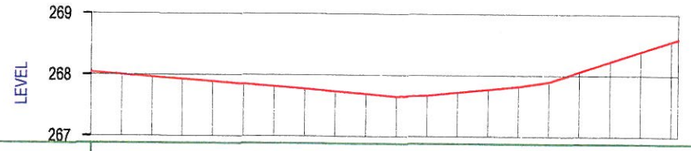
Bridge no	300
A	1.019 sq km
L	1.501 km

PROPOSED BRIDGE NO. BR. 017 (PRL_300)
Rly Km. 264/21-24, DFCC Chainage 73445



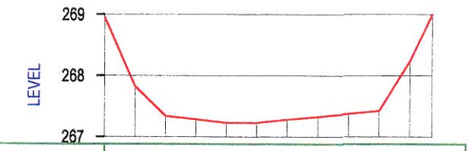
ELEVATION	267.638	267.805	267.950	267.708	267.539	267.456	267.372	267.207	267.156	267.259	267.279
CHAINAGE	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	226.898

LONGITUDINAL SECTION



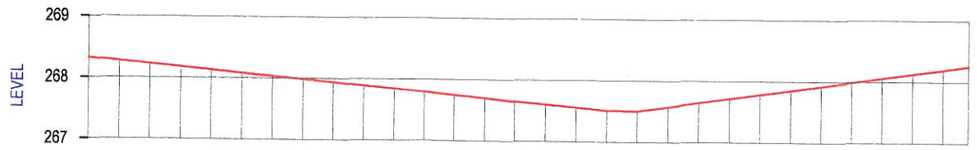
ELEVATION	268.032	267.995	267.958	267.921	267.885	267.848	267.810	267.769	267.729	267.689	267.648	267.668	267.717	267.767	267.816	267.895	268.060	268.225	268.391	268.556	268.593		
CHAINAGE	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	18.445		

(Upstream at 100m)



ELEVATION	268.942	267.817	267.334	267.279	267.225	267.227	267.275	267.324	267.372	267.421	268.233	268.994											
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	11.470											

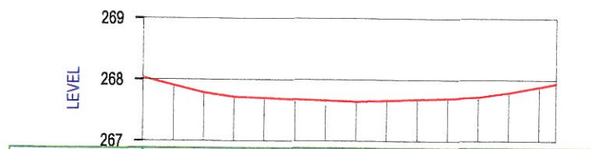
(Downstream at 90m)



ELEVATION	268.315	268.267	268.220	268.172	268.124	268.077	268.029	267.981	267.933	267.886	267.838	267.790	267.743	267.695	267.647	267.600	267.552	267.504	267.502	267.571	267.640	267.708	267.777
CHAINAGE	-36.00	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00

ELEVATION	267.846	267.915	267.984	268.053	268.122	268.190	268.248																
CHAINAGE	10.00	12.00	14.00	16.00	18.00	20.00	21.672																

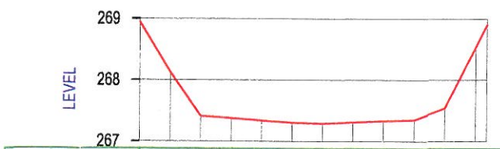
(Bridge site)



ELEVATION	268.022	267.901	267.780	267.712	267.694	267.675	267.657	267.638	267.657	267.677	267.696	267.716	267.788	267.884	267.937								
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	13.103								

(Upstream at 260m)

CROSS SECTION



ELEVATION	268.939	268.123	267.407	267.371	267.335	267.298	267.288	267.308	267.328	267.348	267.537	268.533	268.899										
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.734										

(Downstream at 210m)

0122

Existing Bridge No – 301
Location – KM 264/33-35

Proposed Bridge No – 018
Location – CH: 73695

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	301
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	264/33-35
Latitude :	$30^0$21'13"
Longitude :	$76^0$48'3"

Catchment Area ,	**A**	=	0.751 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.285 Km
Height of Farthest Point ,	**H1**	=	272.65 m
Height of Point of Interest ,	**H2**	=	271.05 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	1.60 m
Average Bed Level		=	271.05 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where ,

Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **1.102 Hr**

= **66.137 Mins**

(a) t_c h Ratio = 0.36 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.045**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = K x R_{50} (1)

= **8.53 cm**

= **85.25 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **77.34 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **6.460 Cumecs**

0124

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.751 Sq. Km	75.11 Hectares
Length of path from Toposheet,	L	=	1.285 Km	
Difference in Levels from Toposheet,	H	=	1.60 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.06 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	121.56 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	75.11 Hectares
I_c = Critical Intensity of Rainfall	12.156 cm / Hr
Q = Maximum Discharge	**10.021 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm 14 - 19 in Madhya Pradesh 22 in Western Ghats

C	=	16 (adopted in present case)
M	=	0.751 Sq Km

Hence, Q = **12.909 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	6.460 Cumecs
Discharge by Rational Formula (IRC approach)	10.021 Cumecs
Discharge by Dicken's Formula	12.909 Cumecs
Maximum Discharge	12.909 Cumecs
Next Maximum Discharge	10.021 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **12.909 Cumecs**

5 Linear Waterway :

Average Bed Level		=	271.05 m
HFL as per site condition & local inquiry		=	272.00 m
So, Total Depth of Water,	H	=	0.95 m

Provide 2 spans of 6.1 m at proposed site location.

Clear Waterway (provided),	L	=	12.20 m
Total Area,	A	=	11.566 m2
Velocity ,	V	=	Q / A
		=	**1.116 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	12.909 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.600 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.600 m
	So, Vertical Clearance adopted		=	0.600 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **272.600 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **16.782 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 1.38 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.66 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = $1.5 \times d_{sm}$

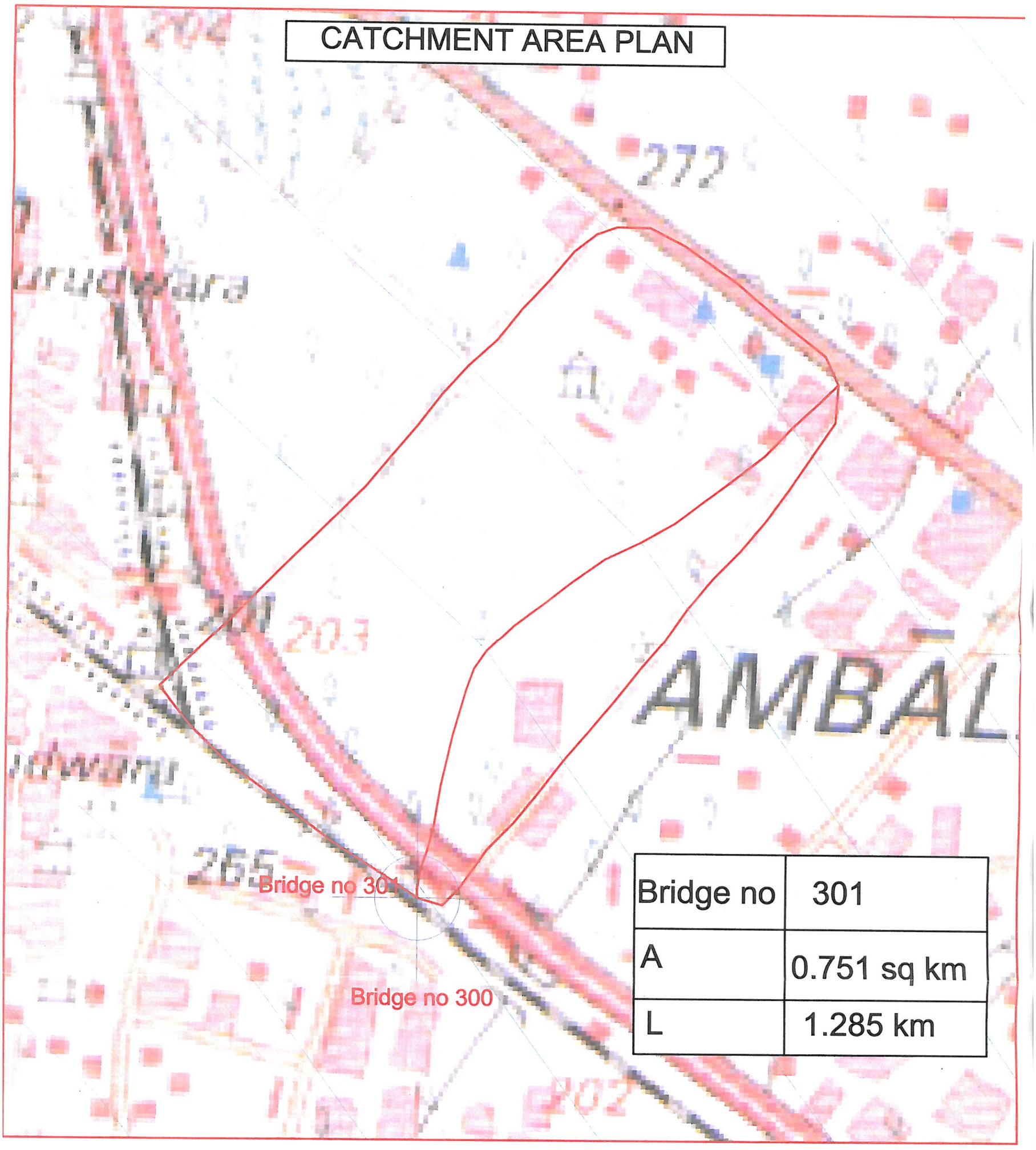
So, **Maximum Scour Depth** = **2.486 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **269.51 m**

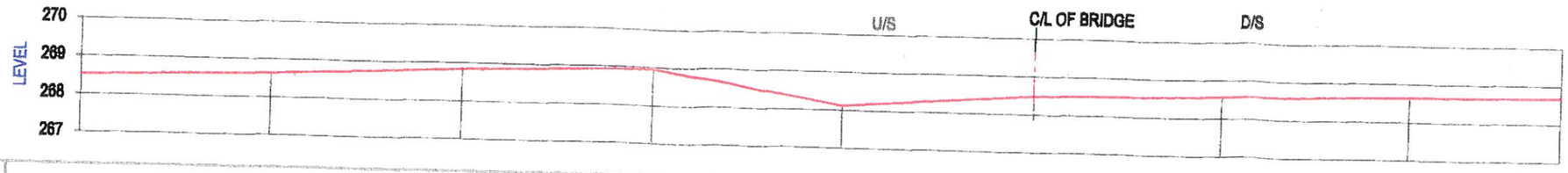
CATCHMENT AREA PLAN



Bridge no	301
A	0.751 sq km
L	1.285 km

PROPOSED BRIDGE NO. BR. 018 (PRL_301)

Rly Km. 264/33-36, DFCC Chainage 73695

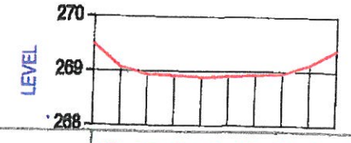


ELEVATION	268.505	268.624	268.827	268.955	268.110	268.466	268.550	268.631	268.668
CHAINAGE	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	140.444

LONGITUDINAL SECTION

ELEVATION	268.623	268.584	268.545	268.505	268.527	268.549	268.571	268.592	268.596
CHAINAGE	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	8.324

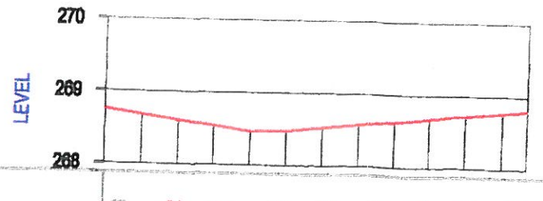
(Upstream at 250m)



ELEVATION	269.489	269.061	268.928	268.903	268.878	268.896	268.920	268.945	269.111	269.380	269.382
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	10.018

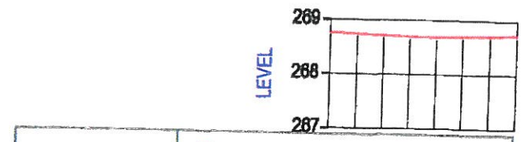
(Upstream at 100m)

CROSS SECTION



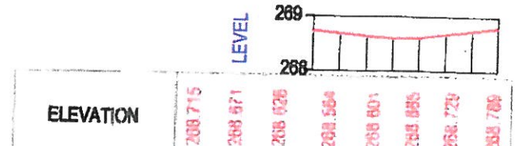
ELEVATION	268.743	268.672	268.601	268.529	268.458	268.471	268.520	268.568	268.616	268.665	268.713	268.762	268.795
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	15.374

(Bridge site)



ELEVATION	268.740	268.721	268.702	268.683	268.671	268.686	268.701	268.715
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	5.956

(Downstream at 150m)



ELEVATION	268.715	268.671	268.626	268.584	268.601	268.665	268.729	268.789
CHAINAGE	-6.00	-4.00	2.00	0.000	2.00	4.00	6.00	7.857

(Downstream at 81m)

0128

SHEET NO. 1 TO 1

Existing Bridge No – 302
Location – KM 266/19-21

Proposed Bridge No – 019
Location – CH: 75644

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	302
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	266/19-21
Latitude :	$30^0$21'42"
Longitude :	$76^0$47'21"

Catchment Area ,	A	=	3.888 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	2.513 Km
Height of Farthest Point ,	H1	=	272.95 m
Height of Point of Interest ,	H2	=	270.35 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	2.60 m
Average Bed Level		=	270.35 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0129

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.867 Hr**

= **111.991 Mins**

(a) t_c h Ratio = 0.46 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.340**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **10.94 cm**

= **109.36 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **58.59 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **25.331 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	3.888 Sq. Km	388.80 Hectares
Length of path from Toposheet,	L	=	2.513 Km	
Difference in Levels from Toposheet,	H	=	2.60 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.90 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	86.15 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	388.80 Hectares
I_c = Critical Intensity of Rainfall	8.615 cm / Hr
Q = Maximum Discharge	**36.765 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16 (adopted in present case)
M	=	3.888 Sq Km

Hence, Q = **44.301 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	25.331 Cumecs
Discharge by Rational Formula (IRC approach)	36.765 Cumecs
Discharge by Dicken's Formula	44.301 Cumecs

Maximum Discharge	44.301 Cumecs
Next Maximum Discharge	36.765 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **44.301 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.35 m
HFL as per site condition & local inquiry		=	271.70 m
So, Total Depth of Water,	H	=	1.35 m

Provide 2 spans of 12.2 m and 2 Spans of 9.15 at proposed site location.

Clear Waterway (provided),	L	=	42.70 m
Total Area,	A	=	57.560 m2
Velocity ,	V	=	Q / A
		=	**0.770 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	44.301 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.900 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.630 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **272.600 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **57.591 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.35 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.64 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **2.454 m**

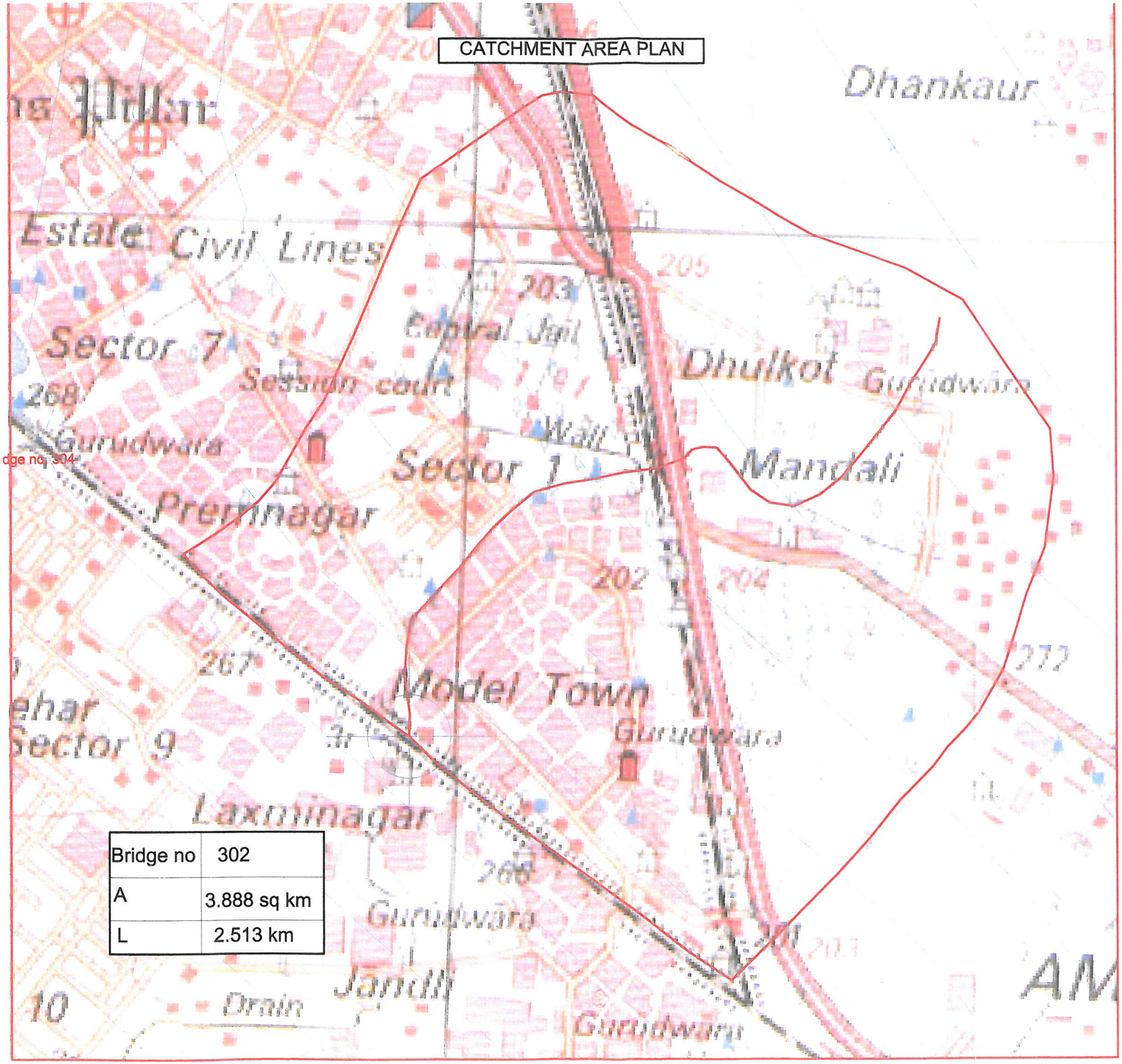
8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **269.25 m**

0131 A

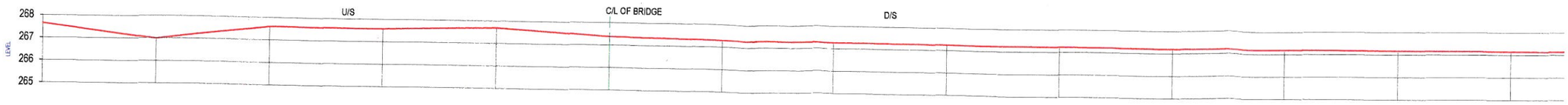
CATCHMENT AREA PLAN



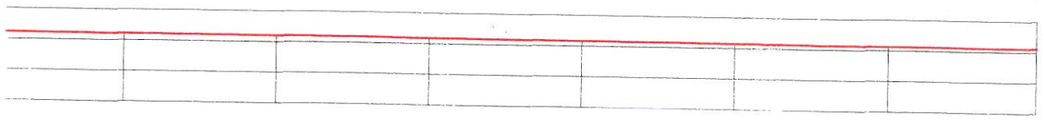
Bridge no	302
A	3.888 sq km
L	2.513 km

PROPOSED BRIDGE NO. BR. 019 (PRL_302)

Rly Km. 266/19-22, DFCC Chainage 75644

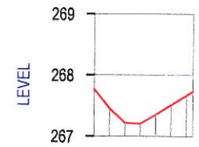


ELEVATION	267.632	266.981	267.583	267.567	267.678	267.364	267.284	267.256	267.235	267.212	267.191	267.177	267.160	267.139
CHAINAGE	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00



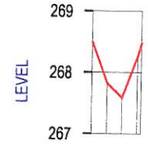
	267.212	267.191	267.177	267.160	267.139	267.114	267.105
	200.00	250.00	300.00	350.00	400.00	450.00	498.519

LONGITUDINAL SECTION



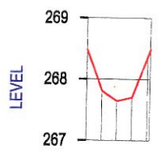
ELEVATION	267.762	267.450	267.212	267.203	267.345	267.503	267.661	267.729
CHAINAGE	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	3.432

(Downstream at 220m)



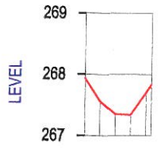
ELEVATION	268.489	267.817	267.582	268.267	268.476
CHAINAGE	-2.000	-1.000	0.000	1.000	1.239

(Upstream at 180m)



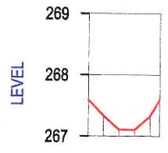
ELEVATION	268.474	267.804	267.639	267.699	268.370	268.485
CHAINAGE	-2.000	-1.000	0.00	1.000	2.000	2.172

(Upstream at 235m)



ELEVATION	267.929	267.557	267.349	267.330	267.697	267.828
CHAINAGE	-2.000	-1.000	0.000	1.000	2.000	2.330

(Bridge site)



ELEVATION	267.585	267.327	267.103	267.092	267.314	267.592
CHAINAGE	-3.000	-2.000	-1.000	0.000	1.000	1.636

(Downstream at 500m)

CROSS SECTION

0133

SHEET NO. 1 TO 1

Existing Bridge No – 304
Location – KM 267/25-27

Proposed Bridge No – 021
Location – CH: 76908

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			304
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 15
Scale :			1 : 50,000
Location :			267/25-27
Latitude :			$30^0$22'9"
Longitude :			$76^0$46'42"
Catchment Area ,	**A**	=	2.507 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	2.040 Km
Height of Farthest Point ,	**H1**	=	272.15 m
Height of Point of Interest ,	**H2**	=	269.85 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	2.30 m
Average Bed Level		=	269.85 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

0134

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.569 Hr**

= **94.150 Mins**

(a) t_c h Ratio = 0.42 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.242**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **10.14 cm**

= **101.35 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **64.59 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **18.006 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	2.507 Sq. Km	250.70 Hectares
Length of path from Toposheet,	L	=	2.040 Km	
Difference in Levels from Toposheet,	H	=	2.30 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.57 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	97.39 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	250.70 Hectares
I_c = Critical Intensity of Rainfall	9.739 cm / Hr
Q = Maximum Discharge	**26.798 Cumecs**

3 Discharge by Dicken's Formula :

$$Q = C \times M^{3/4}$$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	2.507	Sq Km

Hence, Q = **31.877 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	18.006 Cumecs
Discharge by Rational Formula (IRC approach)	26.798 Cumecs
Discharge by Dicken's Formula	31.877 Cumecs
Maximum Discharge	31.877 Cumecs
Next Maximum Discharge	26.798 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **31.877 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.85 m
HFL as per site condition & local inquiry		=	271.45 m
So, Total Depth of Water,	H	=	1.60 m

Provide 3 spans of 6.1 m at proposed site location.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	29.280 m2
Velocity ,	V	=	Q / A
		=	**1.089 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	31.877 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.900 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.602 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **272.352 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **41.441 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width	2.26 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.31 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **1.5 x d_{sm}**

So, **Maximum Scour Depth** = **3.466 m**

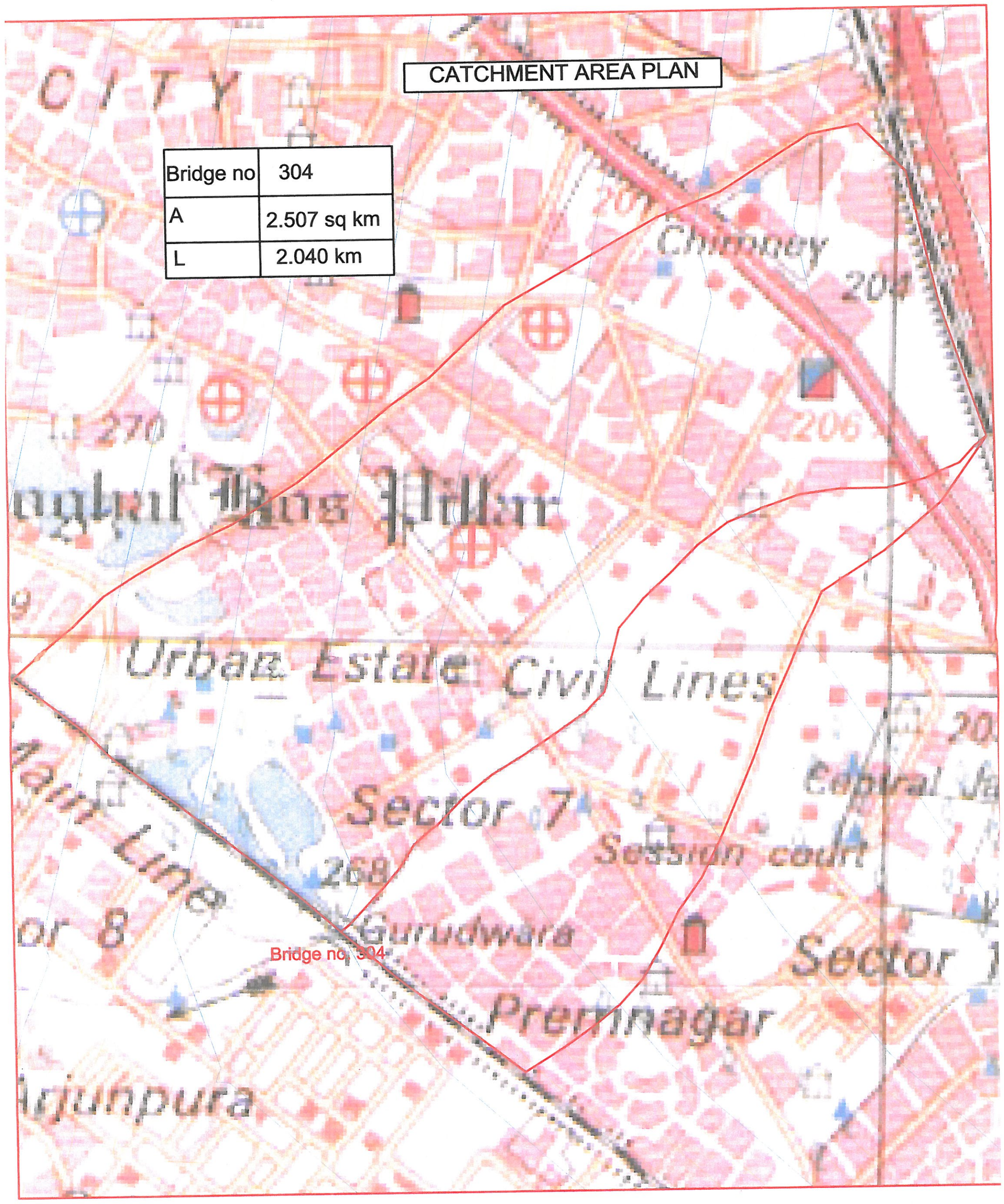
8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **267.99 m**

CATCHMENT AREA PLAN

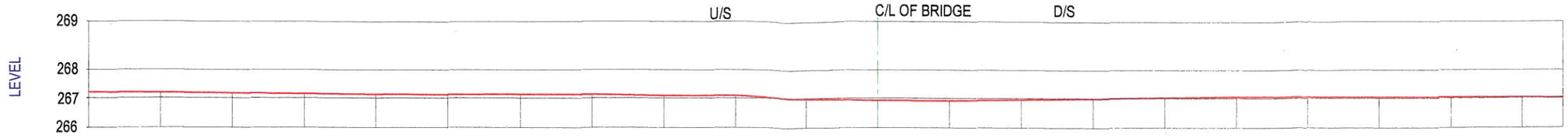
Bridge no	304
A	2.507 sq km
L	2.040 km



0138

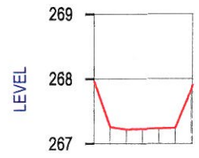
PROPOSED BRIDGE NO. BR. 021 (PRL_304)

Rly Km. 267/25-27, DFCC Chainage 76908



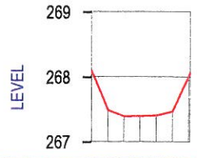
ELEVATION	267.378	267.347	267.316	267.281	267.237	267.216	267.235	267.239	267.154	267.159	266.916	266.823	266.797	266.874	266.963	267.013	267.094	267.079	267.064	267.047	267.030	267.020
CHAINAGE	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	478.519

LONGITUDINAL SECTION



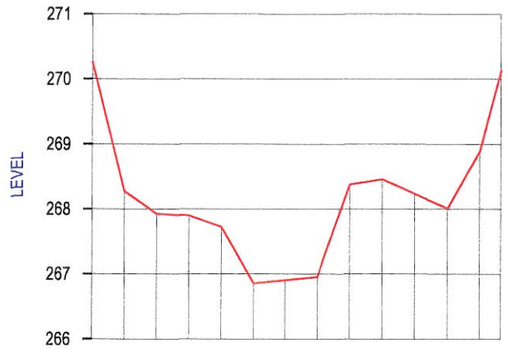
ELEVATION	267.959	267.253	267.217	267.226	267.234	267.243	267.831	267.898
CHAINAGE	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	3.084

(Upstream at 270m)



ELEVATION	268.082	267.482	267.384	267.391	267.398	267.457	268.001	268.046
CHAINAGE	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	3.082

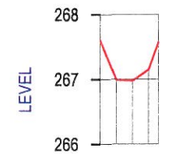
(Upstream at 500m)



ELEVATION	270.262	268.271	267.925	267.896	267.722	266.852	266.902	266.952	268.371	268.453	268.228	268.004	268.881	270.125
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	13.296

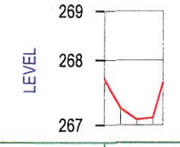
(Bridge site)

CROSS SECTION



ELEVATION	267.595	266.982	266.973	267.144	267.562
CHAINAGE	-2.000	-1.000	0.000	1.000	1.609

(Downstream at 220m)



ELEVATION	267.698	267.252	267.082	267.110	267.649
CHAINAGE	-2.000	-1.000	0.000	1.000	2.630

(Downstream at 515m)

0139

SHEET NO. 1 TO 1

Existing Bridge No –309
Location – KM 269/35-37

Proposed Bridge No – 025
Location – CH: 78984

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			309
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 15
Scale :			1 : 50,000
Location :			269/35-37
Latitude :			$30^0$22'50"
Longitude :			$76^0$45'41"
Catchment Area ,	A	=	0.073 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.363 Km
Height of Farthest Point ,	H1	=	270.05 m
Height of Point of Interest ,	H2	=	269.55 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.50 m
Average Bed Level		=	269.55 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where ,

Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient,** C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

$= 0.445$ Hr

$= 26.700$ Mins

(a) t_c h Ratio = 0.21 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K $= \dfrac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

$= 0.628$

(d)

(I) R_{50} (24) = 24.00 cm

(II) R_{50} (1) = $0.34 \times R_{50}$ (24) [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

$= 8.16$ cm

(III) R_{50} (t_c) = $K \times R_{50}$ (1)

$= 5.12$ cm

$= 51.24$ mm

(Iv) Rainfall Intensity, $I = \dfrac{R_{50}(t_c)}{t_c}$

$= 115.15$ mm / Hr

(iv) Design Flood Discharge :

$Q_{50} = 0.278 \times C \times I \times A$

$Q_{50} = 0.929$ Cumecs

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.073 Sq. Km	7.26 Hectares
Length of path from Toposheet,	L	=	0.363 Km	
Difference in Levels from Toposheet,	H	=	0.50 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.38 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	180.64 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4	
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95	
A = Catchment Area in Hectares	7.26	Hectares
I_c = Critical Intensity of Rainfall	18.064	cm / Hr
Q = Maximum Discharge	**1.395**	**Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.073	Sq Km
Hence, Q	=	**2.237**	**Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	0.929 Cumecs
Discharge by Rational Formula (IRC approach)	1.395 Cumecs
Discharge by Dicken's Formula	2.237 Cumecs
Maximum Discharge	2.237 Cumecs
Next Maximum Discharge	1.395 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **2.092 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.55 m
HFL as per site condition & local inquiry		=	270.35 m
So, Total Depth of Water,	H	=	0.80 m

Provided One RCC BOX of 3 x 2m span at proposed bridge site location.

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	2.400 m2
Velocity ,	V	=	Q / A
		=	**0.872 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **2.720 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	0.91 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.26 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

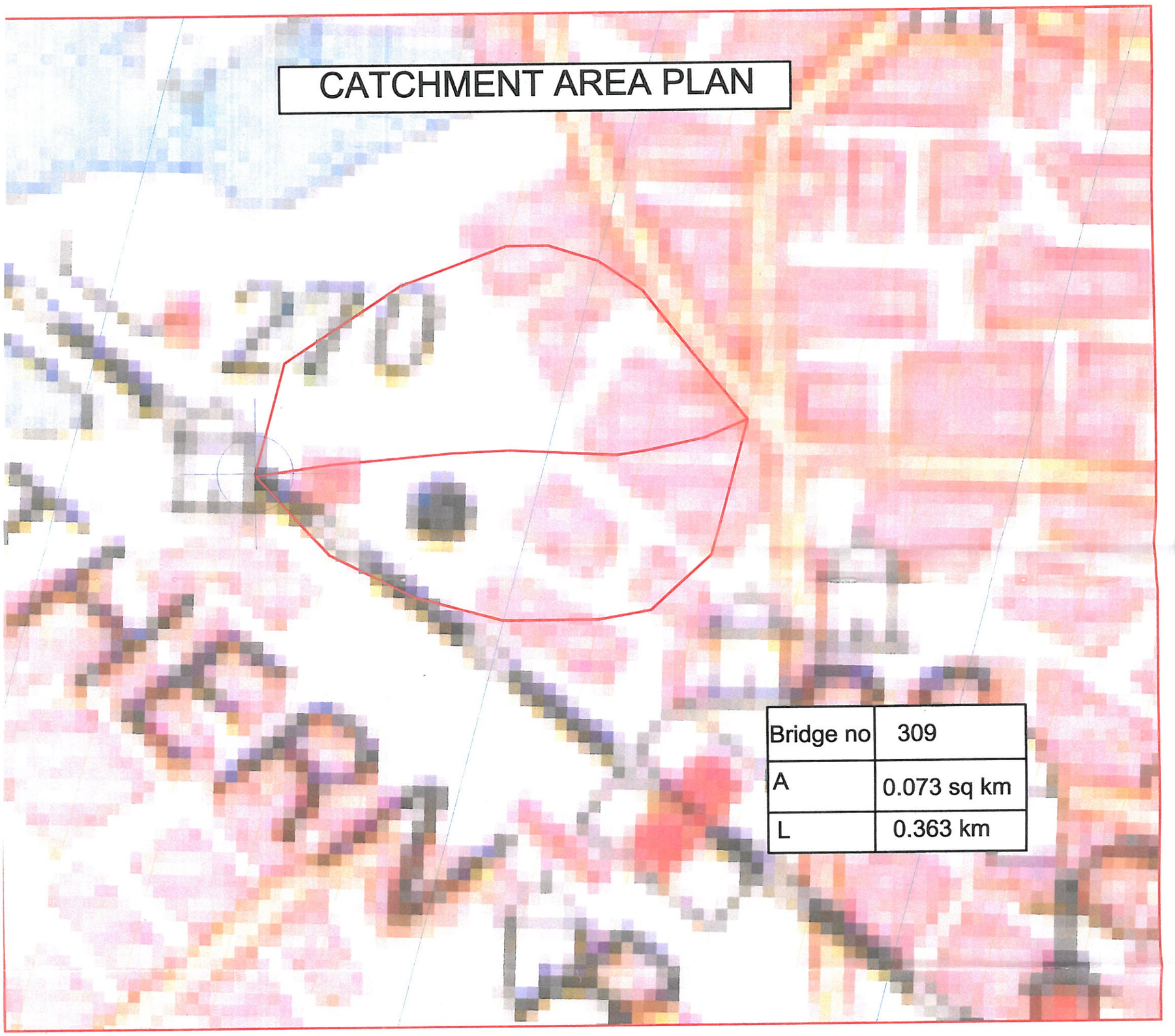
So, **Maximum Scour Depth** = **1.883 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **268.47 m**

CATCHMENT AREA PLAN



Bridge no	309
A	0.073 sq km
L	0.363 km

Existing Bridge No – 311
Location – KM 270/27-29

Proposed Bridge No – 028
Location – CH: 79952

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	311
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 6
Scale :	1 : 50,000
Location :	270/27-29
Latitude :	$30^0$34'5'
Longitude :	$76^0$28'12"

Catchment Area ,	A	=	0.179 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.810 Km
Height of Farthest Point ,	H1	=	269.45 m
Height of Point of Interest ,	H2	=	268.35 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.10 m
Average Bed Level		=	268.35 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, Runoff Coefficient, C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **0.778 Hr**

= **46.682 Mins**

(a) t_c h Ratio = 0.29 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **0.866**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **7.07 cm**

= **70.68 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **90.84 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **1.813 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.179 Sq. Km	17.95 Hectares
Length of path from Toposheet,	L	=	0.810 Km	
Difference in Levels from Toposheet,	H	=	1.10 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.72 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	145.66 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	17.95 Hectares
I_c = Critical Intensity of Rainfall	14.566 cm / Hr
Q = Maximum Discharge	**2.869 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.179 Sq Km	

Hence, Q = **4.412 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	1.813 Cumecs
Discharge by Rational Formula (IRC approach)	2.869 Cumecs
Discharge by Dicken's Formula	4.412 Cumecs

Maximum Discharge	4.412 Cumecs
Next Maximum Discharge	2.869 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **4.304 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.35 m
HFL as per site condition & local inquiry		=	270.27 m
So, Total Depth of Water,	H	=	1.92 m

Provided One RCC BOX of 3 x 3 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	5.760 m2
Velocity ,	V	=	Q / A
		=	**0.747 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **5.595 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	1.87 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.03 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

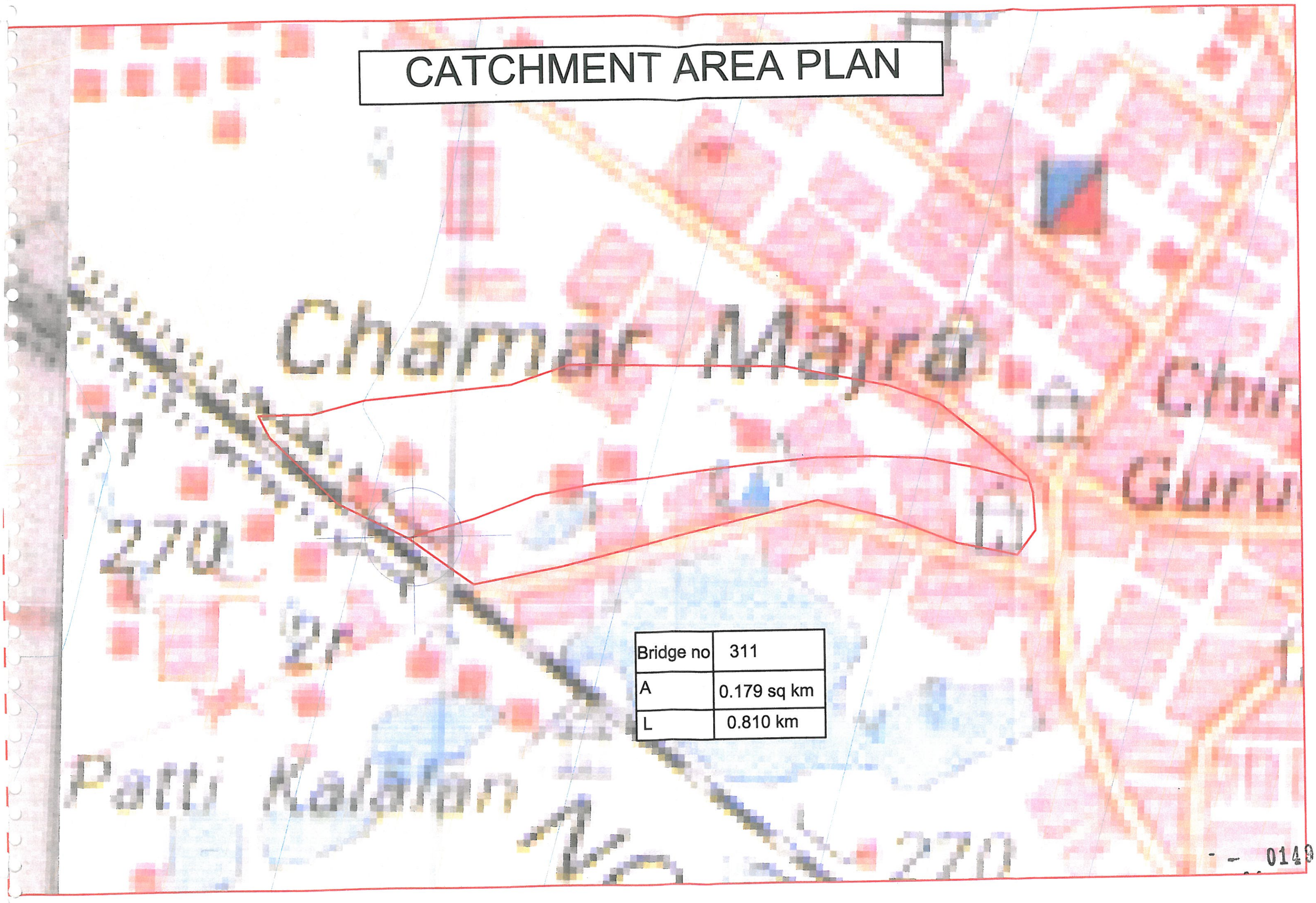
So, **Maximum Scour Depth** = **3.046 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **267.23 m**

CATCHMENT AREA PLAN



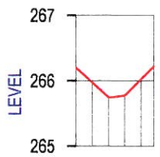
Bridge no	311
A	0.179 sq km
L	0.810 km

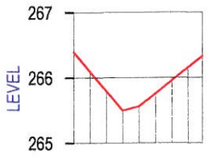
PROPOSED BRIDGE NO. BR. 028 (PRL_311)

Rly Km. 270/27-30, DFCC Chainage 79952

ELEVATION	265.272	265.315	265.364	265.434	265.523	265.621	265.674	265.644	265.618	265.314	265.208	265.082	265.513	265.447	265.412	265.420	265.416	265.435	265.428	265.377	265.367	265.356	265.329	265.303	265.276	265.258
CHAINAGE	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.000	600.000	650.000	684.136

LONGITUDINAL SECTION



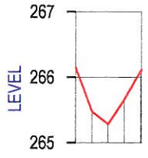


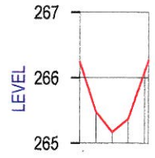
ELEVATION	266.193	265.966	265.739	265.770	266.020	266.215
CHAINAGE	-2.000	-1.000	0.000	1.000	2.000	2.782

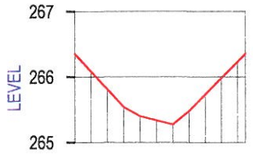
(Upstream at 260m)

ELEVATION	266.386	266.088	265.790	265.492	265.554	265.752	265.950	266.148	266.325
CHAINAGE	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	4.000	4.892

(Downstream at 240m)







ELEVATION	266.135	265.472	265.276	265.655	266.087	266.113
CHAINAGE	-2.000	-1.000	0.000	1.000	2.000	2.060

(Upstream at 520m)

ELEVATION	266.240	265.477	265.163	265.368	266.093	266.265
CHAINAGE	-2.000	-1.000	0.000	1.000	2.000	2.238

(Bridge site)

CROSS SECTION

ELEVATION	266.345	266.074	265.803	265.533	265.392	265.329	265.266	265.475	265.725	265.976	266.226	266.351
CHAINAGE	-6.000	-5.000	-4.000	-3.000	-2.000	-1.000	0.000	1.000	2.000	3.000	4.000	4.500

(Downstream at 680m)

0150

Existing Bridge No – 312
Location – KM 271/19-21

Proposed Bridge No – 029
Location – CH: 80744

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			312
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 15
Scale :			1 : 50,000
Location :			271/19-21
Latitude :			$30^0$23'16"
Longitude :			$76^0$45'
Catchment Area ,	A	=	0.256 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.580 Km
Height of Farthest Point ,	H1	=	268.65 m
Height of Point of Interest ,	H2	=	268.15 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.50 m
Average Bed Level		=	268.15 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, Runoff Coefficient, C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **0.723 Hr**

= **43.367 Mins**

(a) t_c h Ratio = 0.28 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **0.829**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **6.76 cm**

= **67.64 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **93.58 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **2.663 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.256 Sq. Km	25.59 Hectares
Length of path from Toposheet,	L	=	0.580 Km	
Difference in Levels from Toposheet,	H	=	0.50 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.66 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	150.63 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	25.59 Hectares
I_c = Critical Intensity of Rainfall	15.063 cm / Hr
Q = Maximum Discharge	**4.102 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	0.256	Sq Km

Hence, Q = **5.757 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	2.663 Cumecs
Discharge by Rational Formula (IRC approach)	4.102 Cumecs
Discharge by Dicken's Formula	5.757 Cumecs
Maximum Discharge	5.757 Cumecs
Next Maximum Discharge	4.102 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **5.757 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.15 m
HFL as per site condition & local inquiry		=	270.17 m
So, Total Depth of Water,	H	=	2.02 m

Provided One RCC BOX of 3 x 3 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	6.054 m2
Velocity ,	V	=	Q / A
		=	**0.951 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **7.485 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width	2.49 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.46 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

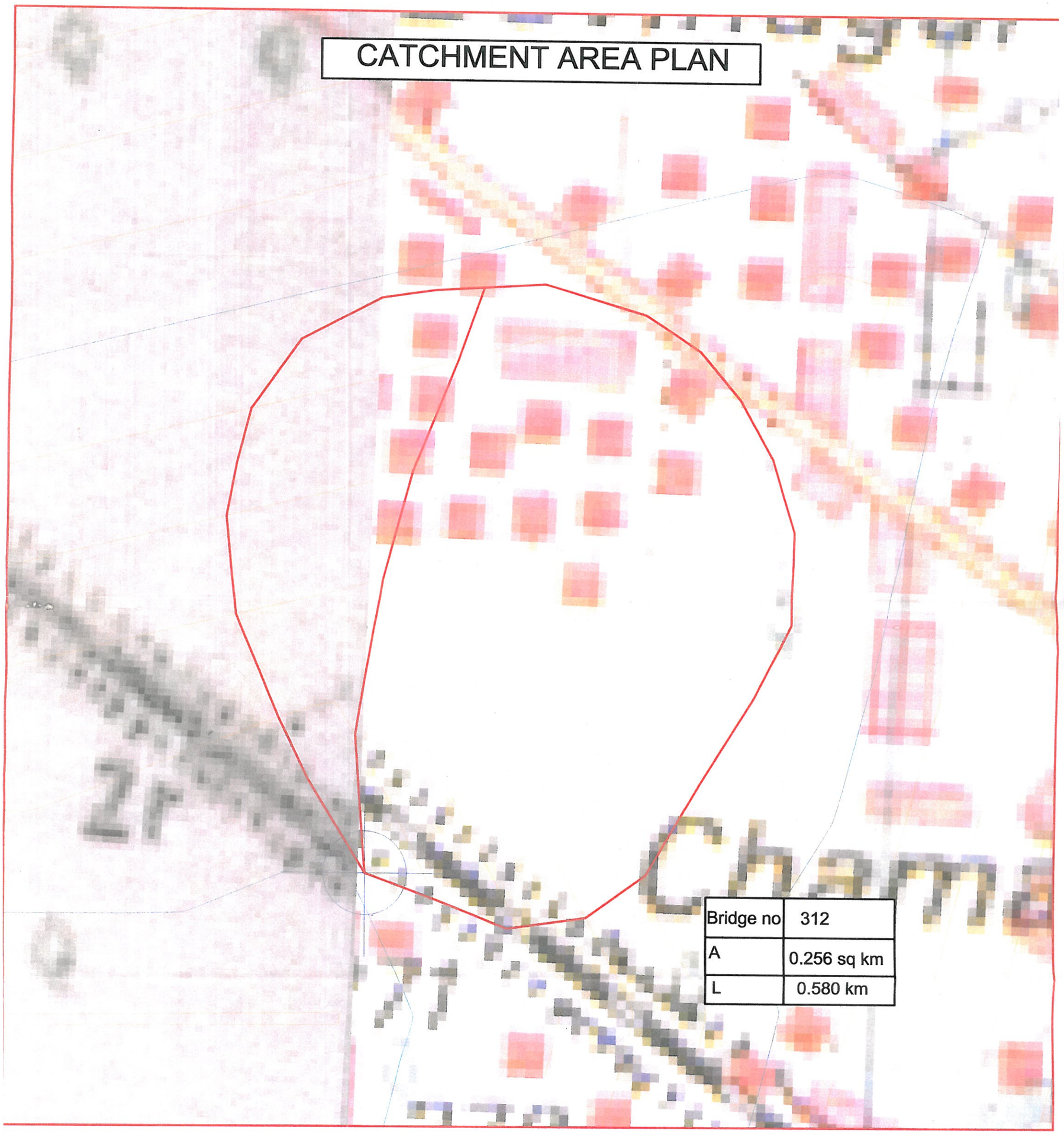
So, **Maximum Scour Depth** = **3.697 m**

7 Maximum Scour Level :

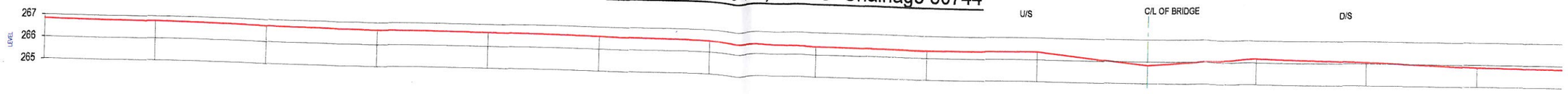
Maximum Scour Level = HFL - Maximum Scour Depth

= **266.47 m**

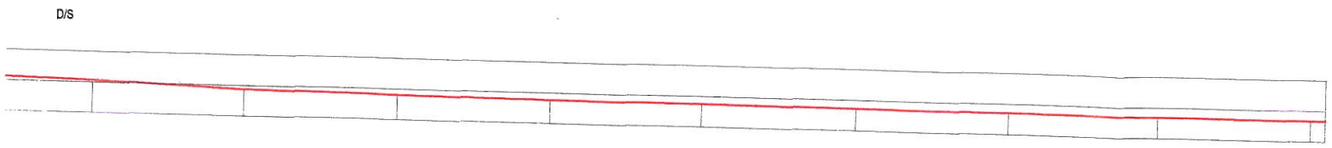
CATCHMENT AREA PLAN



PROPOSED BRIDGE NO. BR. 029 (PRL_312)
Rly Km. 271/19-22, DFCC Chainage 80744

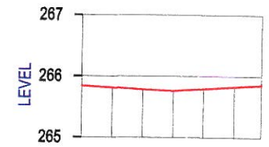


ELEVATION	266.815	266.776	266.708	266.645	266.619	266.556	266.480	266.345	266.323	266.344	265.816	266.165	266.054	265.866
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00



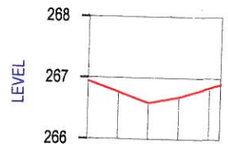
266.054	265.866	265.801	265.760	265.739	265.716	265.697	265.674	265.664	265.663	
100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	504.863	

LONGITUDINAL SECTION



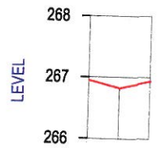
ELEVATION	265.832	265.806	265.781	265.757	265.791	265.826	265.856
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.000	4.000	5.775

(Downstream at 230m)



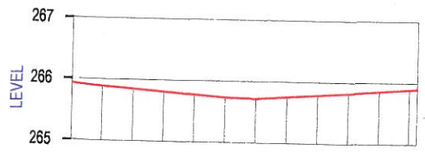
ELEVATION	266.935	266.761	266.587	266.686	266.842	266.897
CHAINAGE	-4.000	-2.000	0.000	2.000	4.000	4.709

(Upstream at 230m)



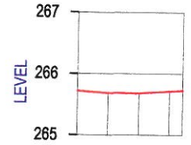
ELEVATION	266.942	266.817	266.935
CHAINAGE	-2.000	0.000	1.958

(Upstream at 480m)



ELEVATION	265.922	265.883	265.844	265.805	265.766	265.728	265.716	265.750	265.785	265.819	265.854	265.888	265.897
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	10.507

(Bridge site)



ELEVATION	265.708	265.681	265.674	265.708	265.722
CHAINAGE	-4.000	-2.000	0.000	2.000	2.862

(Downstream at 480m)

CROSS SECTION

0156

Existing Bridge No – 312 New
Location – KM 271/19-21

Proposed Bridge No – 030
Location – CH: 80763

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :	312 New
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	271/19-21
Latitude :	$30^0$23'16"
Longitude :	$76^0$45'

Catchment Area ,	A	=	2.929 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	1.675 Km
Height of Farthest Point ,	H1	=	269.16 m
Height of Point of Interest ,	H2	=	268.16 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	1.00 m
Average Bed Level		=	268.16 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, Runoff Coefficient, C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **1.706 Hr**

= **102.331 Mins**

(a) t_c h Ratio = 0.44 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.291**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = K x R_{50} (1)

= **10.53 cm**

= **105.31 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **61.74 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **20.107 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	2.929 Sq. Km	292.86 Hectares
Length of path from Toposheet,	L	=	1.675 Km	
Difference in Levels from Toposheet,	H	=	1.00 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.72 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	91.92 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	292.86 Hectares
I_c = Critical Intensity of Rainfall	9.192 cm / Hr
Q = Maximum Discharge	**28.643 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	2.929 Sq Km	

Hence, Q = **35.819 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	20.107 Cumecs
Discharge by Rational Formula (IRC approach)	28.643 Cumecs
Discharge by Dicken's Formula	35.819 Cumecs
Maximum Discharge	35.819 Cumecs
Next Maximum Discharge	28.643 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **35.819 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.16 m
HFL as per site condition & local inquiry		=	270.16 m
So, Total Depth of Water,	H	=	2.00 m

Provided Four RCC BOX of 4 x 2 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	16.00 m
Total Area,	A	=	32.000 m2
Velocity ,	V	=	Q / A
		=	**1.119 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **46.565 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	2.91 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.73 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

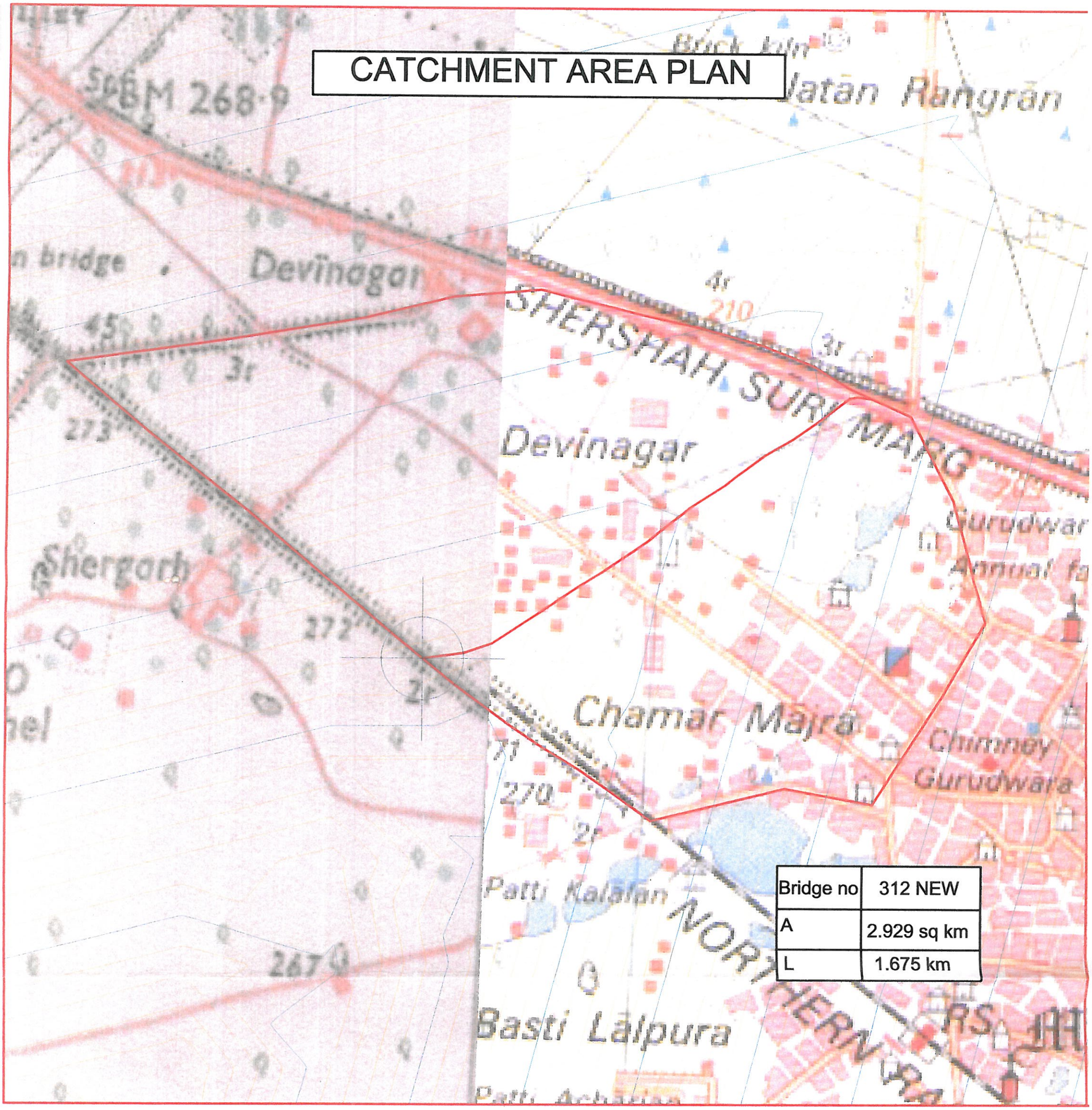
So, **Maximum Scour Depth** = **4.097 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.06 m**

CATCHMENT AREA PLAN



Bridge no	312 NEW
A	2.929 sq km
L	1.675 km

1910 - 0151

Existing Bridge No – 313
Location – KM 273/22-30

Proposed Bridge No – 031
Location – CH: 82722

(Hydrology Details)

Hydraulic Calculation for Bridges of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No of Bridge	:	313
Name of Nallah / Stream / River	:	Ghaggar River
River Sub - Zone	:	Upper Indo - Ganga Plains, 1 (e)
G.T Sheet No	:	53 B / 11, 13, 14, 15 & 53 F / 1, 2
Scale	:	1 : 50,000
Location	:	Km 273/22-30
Latitude	:	300 24' 00"
Longitude	:	760 43' 53"
Type of Catchment	:	Fern Elongated

1 Discharge by Dicken's Formula :

Discharge as per Dicken's Formula, (Refer IRC - SP : 13 - 1998, Clause : 3.2)

$Q = C M^{3/4}$

C = 14 - 19 where annual rainfall is more than 120 cm
= 11 - 14 where annual rainfall is 60-120 cm
= 22 in Western Ghats

Value of " C " adopted in the present case =			11
Catchment Area,	M	=	901.560 Sq. Km
Discharge,	Q	=	**1809.834 Cumecs**

2 Discharge by Ryve's Formula :

Discharge as per Ryve's Formula (Refer IRC - SP : 13 - 1998, Clause : 3.3)

$Q = C M^{2/3}$

	C	=	10
Catchment Area,	M	=	901.560 Sq. Km
Discharge,	Q	=	**933.247 Cumecs**

3 Discharge by Rational Formula :

Catchment Area,	A	=	901.560 Sq. Km	90156.00 Hectares
Length of path from Toposheet,	L	=	76.350 Km	
Difference in Levels from Toposheet,	H	=	731.75 m	
(Ref: Index Map / G.T.Sheet)				

Maximum Rainfall, F		=	194.4 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1$	=	101.25 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause :	$tc = (0.87 \times L^3 / H)^{0.385}$	=	11.18 Hrs
Critical Rainfall Intensity,	$Ic = Io \times (2 / (1 + tc)$	=	16.62 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times Ic$

P = Coefficient of Runoff	0.600
f = Fraction of maximum point intensity at centre of storm, depends on area	0.70
A = Catchment Area in Hectares	90156.00 Hectares
I_c = Critical Intensity of Rainfall	1.662 cm / Hr
Q = Maximum Discharge	**1762.192 Cumecs**

4 Discharge by Flood Estimation Report - SUG :

Name of Railway Section	Kesri to Sahnewal		
Name of River/Nallah/Stream	GHAGGAR RIVER		
Name of nearest Village/Town			
RD/Location	273/22-30	Base flow =	0.05 Cumecs/Sq.km.
Longitude	: 76° 43' 53"E	45.08 Cumecs	
Latitude	:30° 24' 00"N		
GT Sheet No.	53B/10,53B/14 , 53B/13,53B/15,53F/1 & 53F/2		
Sub-Zone	Upper Ganga Plains Sub-Zone-1(e)	G.T Sheet scale	1:50000
Shape of catchment	Fern Elongated		

Estimation of Equivalent stream slope

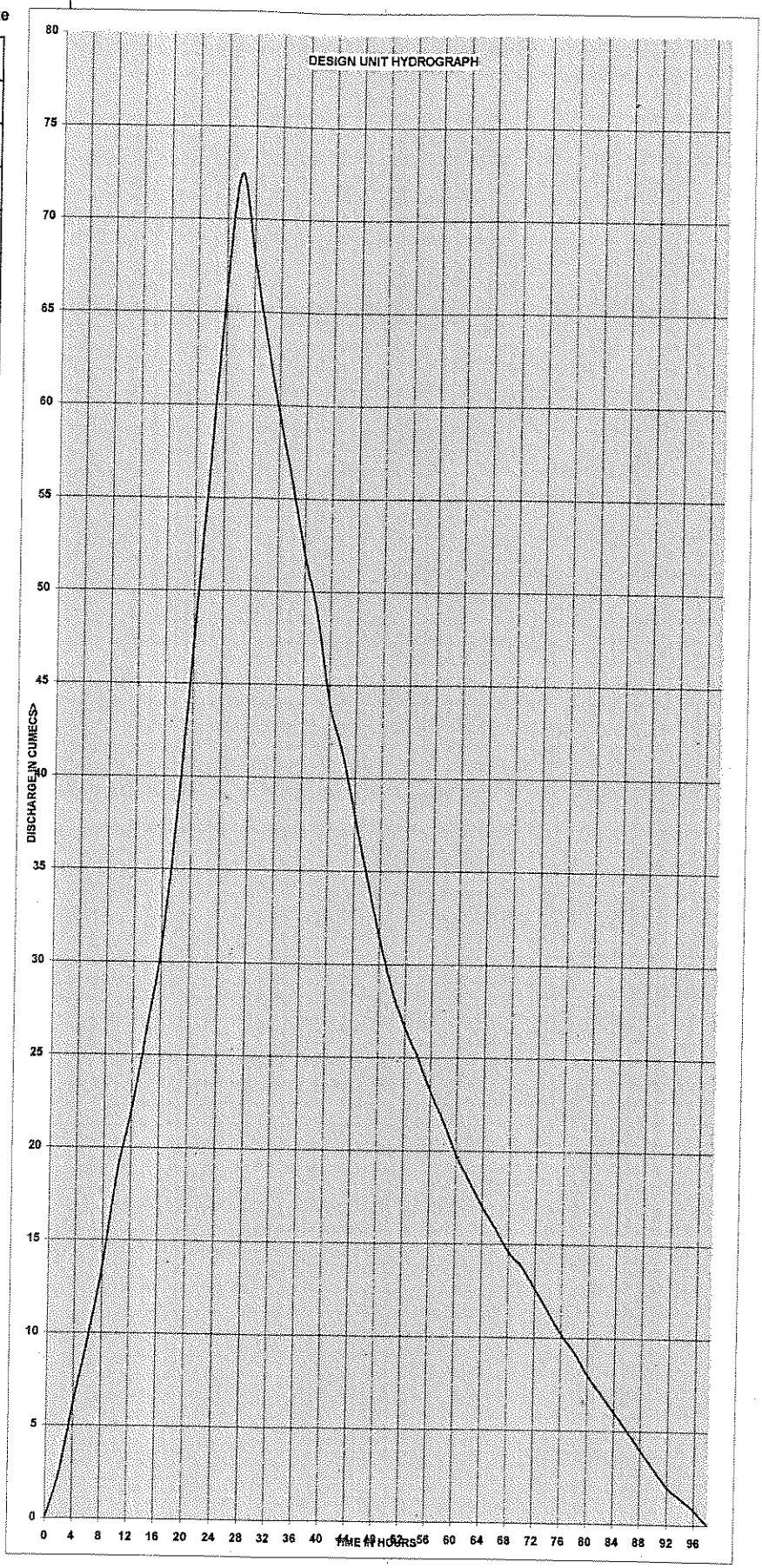
S. No.	Reduced Distance Starting from Point of Study (kms)	Reduced Levels of River/stream/nallah Bed (m)	Length of each Segment L_i (km)	Height Above Datum *(D_i Difference Between the Datum and the ith R.L. (m)	$(D_{i-1} + D_i)$	$L_i (D_{i-1} + D_i)$ (4) x (6) (m x km)
1	2	3	4	5	6	7
1	0.000	268.250	0	0	0	0.000
2	0.766	268.900	0.77	0.65	0.65	0.500
3	3.898	270.500	3.132	2.25	2.9	9.080
4	7.013	272.200	3.115	3.95	6.2	19.310
5	9.548	276.000	2.535	7.75	11.7	29.660
6	19.508	280.000	9.96	11.75	19.50	194.220
7	28.894	289.000	9.39	20.75	32.50	305.050
8	37.531	300.000	8.64	31.75	52.50	453.440
9	41.055	320.000	3.52	51.75	83.50	294.250
10	43.600	340.000	2.55	71.75	123.50	314.310
11	46.037	360.000	2.44	91.75	163.50	398.450
12	49.567	400.000	3.53	131.75	223.50	788.960
13	56.667	460.000	7.10	191.75	323.50	2296.850
14	58.255	500.000	1.59	231.75	423.50	672.520
15	62.000	600.000	3.75	331.75	563.50	2110.310
16	63.500	700.000	1.50	431.75	763.50	1145.250
17	69.000	800.000	5.50	531.75	963.50	5299.250
18	73.000	900.000	4.00	631.75	1163.50	4654.000
19	76.353	1000.000	3.35	731.75	1363.50	4571.820
					$\Sigma L_i (D_{i-1} + D_i)$ =	1619.820

$$S = \frac{\Sigma L_i (D_{i-1} + D_i)}{L^2} = 0.278 \text{ m/km}$$

Synthetic Unitgraph Parameters:

Catchment area A =	901.56	Sq.Km.
d =	1.0	cm depth
$t_i = t_r$ (the unit duration of the UG) =	2.0	hr
$\Sigma Q_i t_i = A \times d / (0.36 \times t_r)$ =	1252.167	Cumec./sec.
L =	76.353	km
Lc =	40.36	km
L/(sqrt(s)) =	144.85	
$t_p = 1.858*(qp)^{-1.038}$=	25.44	hrs
Say	26.0	hrs
$q_p = 2.030* (L/\sqrt{S})-0.649$ =	0.08	Cumec/Sq.Km.
Q_p = Catchment area x q_p =	72.45	cumecs
$W_{50} = 2.217* (q_p)-0.990$ =	26.90	hrs
$W_{75} = 1.477* (q_p)-0.876$ =	13.44	hrs
$W_{R50} = 0.812* (q_p)-0.907$ =	7.99	hrs
$W_{R75} = 0.606 (q_p)-0.791$ =	4.45	hrs
$Q_{50} = 0.5 \times Q_p$ =	36.23	cumecs
$Q_{75} = 0.75 \times Q_p$ =	54.34	cumecs
$T_B = 7.744* (t_p)0.779$ =	98.00	hrs
Say	98.0	hrs
$T_m = t_p + t_r/2 = t_p + 2/2$ =	27.0	hrs

Unit Graph(1 cm 1 hour)		
S.No.	Time	Ordinate
0	0	0
1	2	2.4
2	4	6.20
3	6	9.60
4	8	13.6
5	10	18.6
6	12	22
7	14	26.2
8	16	30.8
9	18	38
10	20	47
11	22	56.8
12	24	66
13	26	72.45
14	28	68
15	30	63.6
16	32	59.6
17	34	56
18	36	52
19	38	48.8
20	40	44.06
21	42	41.4
22	44	38
23	46	34.6
24	48	31.4
25	50	28.6
26	52	26.6
27	54	25
28	56	23.2
29	58	21.6
30	60	19.8
31	62	18.4
32	64	17
33	66	15.8
34	68	14.6



35	70	13.8	
36	72	12.6	
37	74	11.4	
38	76	10.2	
39	78	9.2	
40	80	8	
41	82	7	
42	84	6	
43	86	5	
44	88	4	
45	90	3	
46	92	2	
47	94	1.4	
48	96	0.8	
49	98	0	
		1252.1	10.00

Strom duration=1.1*tp T_D= 27.99 Say 24.00 Hours **(Maximum)**

From Plate,the 50 -Year return period,24 hour point rainfall=240 mm 240 mm Based on Longi.&Lati.of Bridge site

Convertion factor,Areal Rainfall =100 % of Point Rainfall 100 240 mm Based on storm duration Td hrs.

Areal reduction factor,for TD=24.0hr &C.A.=903.56 Sq.km.= 81 194.40 mm Based on C.A.& Storm duration

Hourly rainfall increments Design Loss rate = 0.30 cm / hour 6.0 $mm^2/hr.$

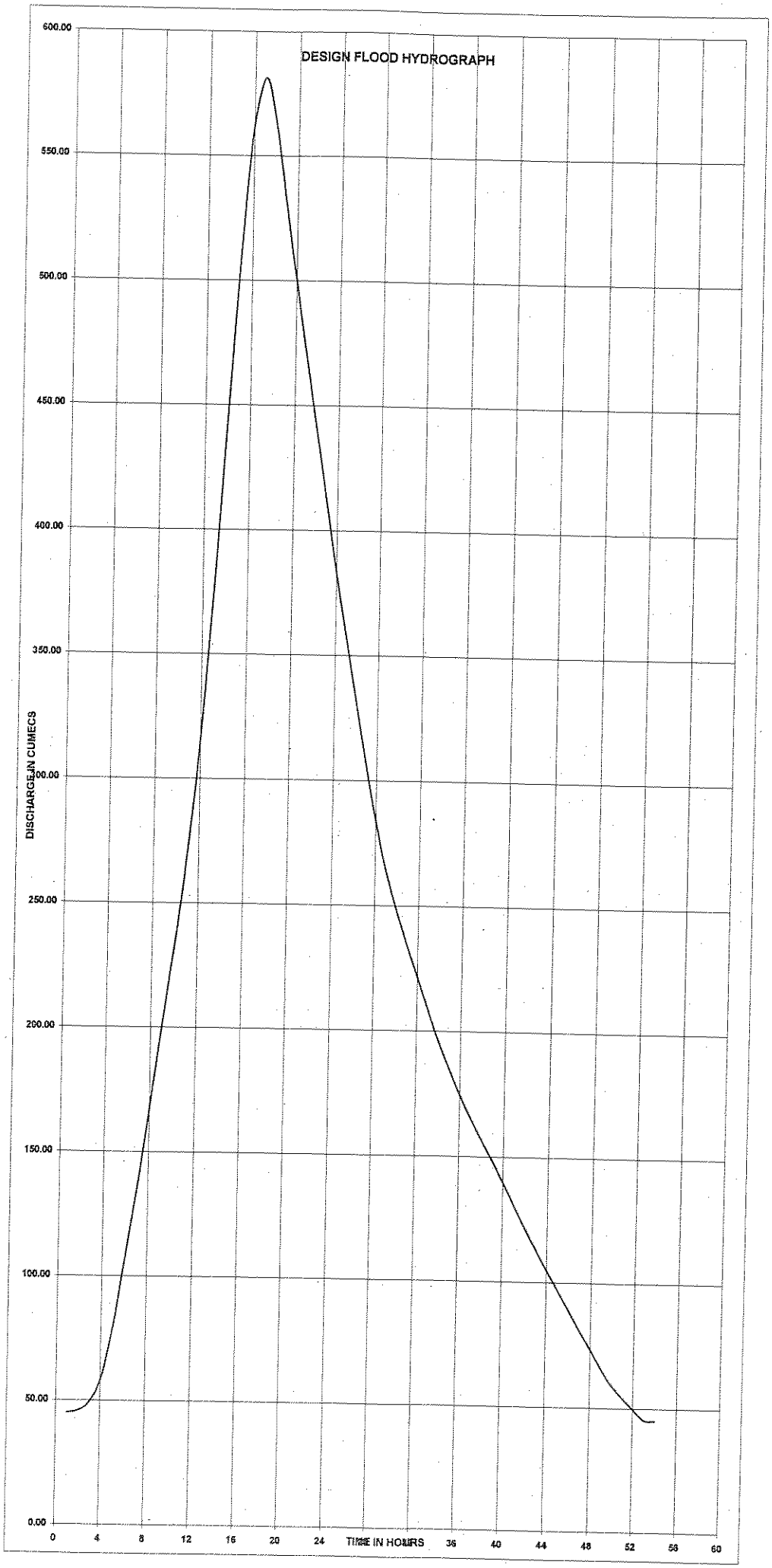
Hours	Storm Percentage	Storm Rainfall	Excess Rainfall	Incremental R.E.
0	0	0	0	0
2	20	38.88	32.88	32.88
4	34	66.10	54.10	21.22
6	46	89.42	65.42	11.33
8	56	108.86	72.86	7.44
10	64	124.42	76.42	3.55
12	71	138.02	78.02	1.61
14	77	149.69	77.69	-0.34
16	83	161.35	77.35	-0.34
18	88	171.07	75.07	-2.28
20	93	180.79	72.79	-2.28
22	97	188.57	68.57	-4.22
24	100	194.4	62.40	-6.17

50-Year and T_D (24.0 hr.)areal rainfall has been split into 2-hr. rainfall increments using time distribution coefficients

Estimation of Design Flood Hydrograph

Unit Graph(1 cm 2 hour)			R.E.	R.E.							Base Flow		Total Discharge (Cum)
S. NO.	Time	Ordinate	Peak to Peak	Reverse order	0.355	0.744	2.144	3.288	1.133	0.161	0.744		
0	0	0			0						45.078		45.08
1	2	2.4			0.852	0					45.078		45.93
2	4	6.2			2.201	1.7856	0				45.078		49.06
3	6	9.6			3.408	4.6128	5.1456	0			45.078		58.24
4	8	13.6			4.828	7.1424	13.293	7.8912	0		45.078		78.23
5	10	18.6			6.603	10.118	20.582	20.386	2.7192	0	45.078		105.49
6	12	22			7.81	13.838	29.158	31.565	7.0246	0.3864	45.078		134.86
7	14	26.2			9.301	16.368	39.878	44.717	10.877	0.9982	45.078		167.22
8	16	30.8			10.934	19.493	47.168	61.157	15.409	1.5456	45.078		200.78
9	18	38			13.49	22.915	56.173	72.336	21.074	2.1896	45.078		233.26
10	20	47			16.685	28.272	66.035	86.146	24.926	2.9946	45.078		270.14
11	22	56.8	1.61	3.55	20.164	34.968	81.472	101.27	29.685	3.542	45.078		316.18
12	24	66	11.33	7.44	23.43	42.259	100.77	124.94	34.896	4.2182	45.078		375.59
13	26	72.45	32.88	21.44	25.72	49.104	121.78	154.54	43.054	4.9588	45.078		444.23
14	28	68	21.22	32.88	24.14	53.903	141.5	186.76	53.251	6.118	45.078		510.75
15	30	63.6	7.44	11.33	22.578	50.592	155.33	217.01	64.354	7.567	45.078		562.51
16	32	59.6	3.55	1.61	21.158	47.318	145.79	238.22	74.778	9.1448	45.078		**581.48**
17	34	56			19.88	44.342	136.36	223.58	82.086	10.626	45.078		561.95
18	36	52			18.46	41.664	127.78	209.12	77.044	11.664	45.078		530.81
19	38	48.8			17.324	38.688	120.06	195.96	72.059	10.948	45.078		500.13
20	40	44.06			15.641	36.307	111.49	184.13	67.527	10.24	45.078		470.41
21	42	41.4			14.697	32.781	104.63	170.98	63.448	9.5956	45.078		441.20
22	44	38			13.49	30.802	94.465	160.45	58.916	9.016	45.078		412.22
23	46	34.6			12.283	28.272	88.762	144.87	55.29	8.372	45.078		382.93
24	48	31.4			11.147	25.742	81.472	136.12	49.92	7.8568	45.078		357.34
25	50	28.6			10.153	23.362	74.182	124.94	46.906	7.0937	45.078		331.72
26	52	26.6			9.443	21.278	67.322	113.76	43.054	6.6654	45.078		306.61

27	54	25			8.875	19.79	61.318	103.24	39.202	6.118	45.078		283.62
28	56	23.2			8.236	18.6	57.03	94.037	35.576	5.5706	45.078		264.13
29	58	21.6			7.668	17.261	53.6	87.461	32.404	5.0554	45.078		248.53
30.00	60	19.8			7.029	16.07	49.741	82.2	30.138	4.6046	45.078		234.86
31.00	62	18.4			6.532	14.731	46.31	76.282	28.325	4.2826	45.078		221.54
32.00	64	17			6.035	13.69	42.451	71.021	26.286	4.025	45.078		208.59
33.00	66	15.8			5.609	12.648	39.45	65.102	24.473	3.7352	45.078		196.10
34.00	68	14.6			5.183	11.755	36.448	60.499	22.433	3.4776	45.078		184.87
35.00	70	13.8			4.899	10.862	33.875	55.896	20.847	3.1878	45.078		174.65
36.00	72	12.6			4.473	10.267	31.302	51.95	19.261	2.9624	45.078		165.29
37.00	74	11.4			4.047	9.3744	29.587	48.005	17.901	2.737	45.078		156.73
38.00	76	10.2			3.621	8.4816	27.014	45.374	16.542	2.5438	45.078		148.66
39.00	78	9.2			3.266	7.5888	24.442	41.429	15.635	2.3506	45.078		139.79
40.00	80	8			2.84	6.8448	21.869	37.483	14.276	2.2218	45.078		130.61
41.00	82	7			2.485	5.952	19.725	33.538	12.916	2.0286	45.078		121.72
42.00	84	6			2.13	5.208	17.152	30.25	11.557	1.8354	45.078		113.21
43.00	86	5			1.775	4.464	15.008	26.304	10.424	1.6422	45.078		104.69
44.00	88	4			1.42	3.72	12.864	23.016	9.064	1.4812	45.078		96.64
45.00	90	3			1.065	2.976	10.72	19.728	7.931	1.288	45.078		88.79
46.00	92	2			0.71	2.232	8.576	16.44	6.798	1.127	45.078		80.96
47.00	94	1.4			0.497	1.488	6.432	13.152	5.665	0.966	45.078		73.28
48.00	96	0.8			0.284	1.0416	4.288	9.864	4.532	0.805	45.078		65.89
49.00	98	0			0	0.5952	3.0016	6.576	3.399	0.644	45.078		59.29
50.00	100						1.7152	4.6032	2.266	0.483	45.078		54.15
51.00	102							2.6304	1.5862	0.322	45.078		49.62
52.00	104									0.2254	45.078		45.30
53.00	106										45.078		45.08
	Qp =	**581**	**Cumecs**										


DESIGN FLOOD HYDROGRAPH
DISCHARGE IN CUMECS
600.00
550.00
500.00
450.00
400.00
350.00
300.00
250.00
200.00
150.00
100.00
50.00
0.00
0
4
8
12
16
20
24
TIME IN HOURS
36
40
44
48
52
56
60

5 Discharge by Manning's Formula :

HFL **with Afflux** (HFL) taken at Bridge site for Existing Span = **271.752 m**

HFL at Bridge site **without Afflux** (HFL') for Existing Span = **271.558 m**

The Hydrological Calculations has been done at three sections i.e. at Upstream side, Downstream side and near Proposed Bridge location.

(i) At U/S location : (Distance from Proposed Bridge = 1000 m)

HFL (Annexure - 1 & 6)		=	272.16 m
Cross - Sectional Area of Flow,	**A**	=	429.34 Sq.m
Width of Flow,	**W**	=	100.00 m
Wetted Perimeter (perpendicular to direction of flow) ,	**P**	=	100.74 m
Hydraulic Mean Radius,	**R = A / P**	=	4.26 m
Longitudinal Slope (as calculated),	**S**	=	0.0006 m per m

Velocity by Manning's Formula,

$V = 1/n\ R^{2/3}\ S^{1/2}$ (Refer IRC - SP : 13 - 1998, Clause : 5.4)

For " **n** " value (IRC-SP:13-1998, clause : 5.4, Table - 3)

Co-efficient of Rugosity,	**n**	=	0.035
Velocity,	**V**	=	1.840 m/s
Discharge,	**Q = A x V**	=	**789.854 Cumecs**

(ii) At Existing Bridge location :

HFL (Annexure - 2 & 6)		=	271.56 m
Cross - Sectional Area of Flow,	**A**	=	756.59 Sq.m
Width of Flow,	**W**	=	280.00 m
Wetted Perimeter (perpendicular to direction of flow) ,	**P**	=	280.38 m
Hydraulic Mean Radius,	**R = A / P**	=	2.70 m
Longitudinal Slope (as calculated),	**S**	=	0.0006 m per m

Velocity by Manning's Formula,

$V = 1/n\ R^{2/3}\ S^{1/2}$ (Refer IRC - SP : 13 - 1998, Clause : 5.4)

For " **n** " value (IRC-SP:13-1998, clause : 5.4, Table - 3)

Co-efficient of Rugosity,	**n**	=	0.035
Velocity,	**V**	=	1.356 m/s
Discharge,	**Q = A x V**	=	**1026.287 Cumecs**

(iii) At D/S location : (Distance from Proposed Bridge = 1000 m)

HFL (Annexure - 3 & 6)		=	270.66 m
Cross - Sectional Area of Flow,	**A**	=	540.43 Sq.m
Width of Flow,	**W**	=	120.00 m
Wetted Perimeter (perpendicular to direction of flow) ,	**P**	=	120.70 m
Hydraulic Mean Radius,	**R = A / P**	=	4.48 m
Longitudinal Slope (as calculated),	**S**	=	0.0009 m per m

Velocity by Manning's Formula,

$V = 1/n\ R^{2/3}\ S^{1/2}$ (Refer IRC - SP : 13 - 1998, Clause : 5.4)

For " **n** " value (IRC-SP:13-1998, clause : 5.4, Table - 3)

Co-efficient of Rugosity,	**n**	=	0.035
Velocity,	**V**	=	2.328 m/s
Discharge,	**Q = A x V**	=	**1258.359 Cumecs**

Discharge at U/S location	=	789.85 Cumecs
Discharge at Proposed Bridges location	=	1026.29 Cumecs
Discharge at D/S location	=	1258.36 Cumecs

By comparision of U/S, D/S and Proposed Bridge location, the Design Discharge may be taken as ,

Design Discharge, **Q** = **1258.359 Cumecs**

6 **Design Discharge :**

(Refer IRC - SP : 13 - 1998, Clause : 7.1)

Discharge by Dicken's Formula	=	1809.834 Cumecs
Discharge by Ryve's Formula	=	933.247 Cumecs
Discharge by Rational Formula	=	1762.192 Cumecs
Discharge by Flood Estimation Report - SUG	=	581.000 Cumecs
Discharge by Manning's Formula	=	1258.359 Cumecs
Maximum Discharge	=	1809.834 Cumecs
Next Maximum Discharge	=	1762.192 Cumecs
The difference is within 50% of the next maximum discharge		
Hence, **Design Discharge**	=	**1809.83 Cum/sec**

Design Discharge adopted = **1809.834 Cumecs**

7 **Linear Waterway :**

In accordance with Para - 4.2 & 4.3 of IRS - Code of Practice for the Design of Sub-structures & Foundations of Bridges

Regime Width, $W = 4.8 \times Q^{1/2}$ = **204.202 m**

In accordances with Para - 4.5.3 with a value of C = 2.67 of IRS - Code of Practice for the Design of Sub-structures & Foundations of Bridges, also IRC - SP : 13 - 1998, Clause : 8.5 & Clause : 104.3 of IRC : 5 - 1998

Minimum waterway provided = (2 / 3) of Regime Width = **136.135 m**

8 Afflux Calculations :

(i) Afflux Calculation for Existing Span

Cross - Sectional Area of Flow,	A	=	756.59 Sq. m
Width of Flow,	W	=	280.00 m
Existing Span Arrangement at Bridge location		=	6 x 30.5 m
Effective Span for passing the water at site		=	6 x 30.5 m
Total Water Way provided,	L	=	183.00 m
Design Discharge,	Q	=	1258.36 Cumecs
Depth of Flow at D/S of Bridge,	Dd = A / W	=	2.702 m
(a / A) or (L / W)		=	0.6
(Refer IRC - SP : 13 - 1998, clause : 17.3)	Cofficient " e "	=	0.989
	Cofficient " C_O -	=	0.8676
	g	=	9.81 m/s^2

If the Afflux, h < Dd/4, the Orifice Formula is applicable.

By Orifice Formula, the Discharge is given as,

$$Q = C_0 (2g)^{0.5} L D_d \{h+(1+e)u^2/2g\}^{0.5}$$

or, $$\{h+(1+e)u^2/2g\}^{0.5} = Q / \{C_0 (2g)^{0.5} L D_d\}$$

or, $$\{h+(1+e)u^2/2g\} = [Q / \{C_0 (2g)^{0.5} L D_d\}]^2$$

Substituting values, we have

$$h + 0.101\ u^2 = 0.438 \qquad \text{(i)}$$

Also at U/S of the Bridge,

$$Q = W (D_d+h) u \qquad \text{or,} \quad h = Q / Wu - D_d$$

Substituting values, we have

$$h = (4.494 / u) - 2.702 \qquad \text{(ii)}$$

Combining (i) & (ii),

$$u - 0.03228\ u^3 = 1.431 \qquad \text{(iii)}$$

u (by trial & error) = 1.552

LHS Equation = 1.431

Substituting " **u** " in equation (i), we get

h = 0.194 m

The Afflux as per Orifice Formula, h = 0.194 m

h < Dd/4, OK

By Weir Formula, the Discharge is given as

$Q = 1.706\ Cw\ L\ H3/2$

$H = \{Q/(1.706\ Cw\ L)\}2/3$

(Refer IRC - SP : 13 - 1998, Page - 99)

Cw for Narrow Bridge Opening	=	0.98
H	=	2.567 m
Also, Du = H - u2/2g		
Assume, Du = H	=	2.567 m
u = Q/Wdu	=	1.751 m/s
Now, Du = H - u2/2g	=	2.411 m
Dd (as above)	=	2.702 m
Afflux, h = Du - Dd	=	-0.291 m

Since h < Dd/4, Orifice formula will be applicable

The Afflux as per Weir Formula, h = -0.291 m

The Afflux adopted, h = **0.194 m**

(ii) Afflux Calculation for Proposed Span

Cross - Sectional Area of Flow,	A	=	803.57 Sq. m
Width of Flow,	W	=	280.00 m
Proposed Span Arrangement at Bridge location		=	6 x 30.5 m
Effective Span for passing the water at site		=	6 x 30.5 m
Total Water Way provided,	L	=	183.00 m
Design Discharge,	Q	=	1258.36 Cumecs
Depth of Flow at D/S of Bridge,	Dd = A / W	=	2.870 m
(a / A) or (L / W)		=	0.63
(Refer IRC - SP : 13 - 1998, clause : 17.3)	Cofficient " e "	=	0.989
	Cofficient " C_0 "	=	0.8676
	g	=	9.81 m/s^2

If the Afflux, h < Dd/4, the Orifice Formula is applicable.

By Orifice Formula, the Discharge is given as,

$$Q = C_0 (2g)^{0.5} \; L \; D_d \{h+(1+e)u^2/2g\}^{0.5}$$

or, $$\{h+(1+e)u^2/2g\}^{0.5} = Q / \{C_0 (2g)^{0.5} \; L \; D_d\}$$

or, $$\{h+(1+e)u^2/2g\} = [Q / \{C_0 (2g)^{0.5} \; L \; D_d\}]^2$$

Substituting values, we have

$$h + 0.101 \; u^2 = 0.389 \qquad \textbf{(i)}$$

Also at U/S of the Bridge,

$$Q = W (D_d+h) u \qquad \text{or,} \qquad h = Q / Wu - D_d$$

Substituting values, we have

$$h = (4.494 / u) - 2.870 \qquad \textbf{(ii)}$$

Combining (I) & (ii),

$$u - 0.03111 \; u^3 = 1.379 \qquad \textbf{(iii)}$$

u (by trial & error)		=	1.479
LHS Equation		=	1.379
Substituting " **u** " in equation (i), we get			
h		=	0.168 m
The Afflux as per Orifice Formula ,	h	=	0.168 m

h < Dd/4, OK

By Weir Formula, the Discharge is given as

$$Q = 1.706 \; Cw \; L \; H3/2$$

$$H = \{Q/(1.706 \; Cw \; L)\}2/3$$

(Refer IRC - SP : 13 - 1998, Page - 99)

Cw for Narrow Bridge Opening		=	0.98
H		=	2.567 m
Also, Du = H - u2/2g			
Assume, Du = H		=	2.567 m
u = Q/Wdu		=	1.751 m/s
Now, Du = H - u2/2g		=	2.411 m
Dd (as above)		=	2.870 m
Afflux, h = Du - Dd		=	-0.459 m

Since h < Dd/4, Orifice formula will be applicable

The Afflux as per Weir Formula,	h	=	-0.459 m
The Afflux adopted,	h	=	**0.168 m**
HFL at Bridge site for Proposed Span Arrangement		=	271.726 m

So, Afflux adopted = 0.194 m

9 **Vertical Clearance :**

Design Discharge, Q = 1809.834 Cumecs

(i) Vertical Clearance as per IRC : 5 - 1998, Clause : 106.2.1 = 1.20 m

(ii) Vertical Clearance as per Railway Code for Sub-structure, Clause : 4.8 = 1.50 m

So, Vertical Clearance adopted = 1.50 m

Minimum Soffit Level of Deck Slab = HFL + Afflux + Vertical Clearance

= 273.252 m

10 **Scour Depth :**

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **2352.784 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width 19.285 Cumecs / m

K_{sf} = Silt factor 0.83

d_{sm} = **10.238 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(for moderate bend) = $1.5 \times d_{sm}$

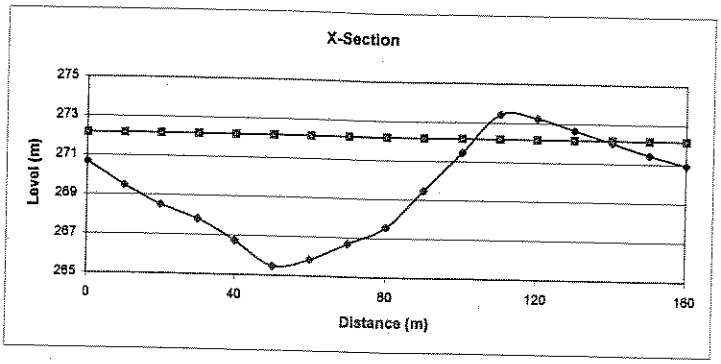
So, **Maximum Scour Depth** = **15.356 m**

11 **Maximum Scour Level :**

Maximum Scour Level = HFL - Maximum Scour Depth

= **256.202 m**

Annexure - 1



Cross - Sectional Area of River / Nallah at U/S of the Proposed Bridge is as follows :

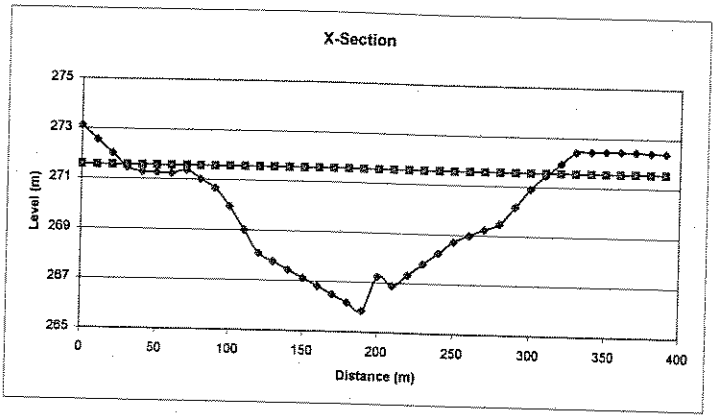
Distance from Proposed Bridge 1000 m

Longitudinal Slope at U/S side 0.0006

HFL at this location 272.158 m

Total			4.002		429.34	100.74	100.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimetar (m)	Top width of Flow (m)
0	270.687	272.158	1.471				
10	269.481	272.158	2.677	2.074	20.745	10.072	10.000
20	268.513	272.158	3.645	3.161	31.615	10.047	10.000
30	267.803	272.158	4.355	4.000	40.005	10.025	10.000
40	266.743	272.158	5.415	4.885	48.855	10.056	10.000
50	265.474	272.158	6.684	6.050	60.500	10.080	10.000
60	265.835	272.158	6.323	6.504	65.040	10.007	10.000
70	266.698	272.158	5.460	5.892	58.920	10.037	10.000
80	267.561	272.158	4.597	5.029	50.290	10.037	10.000
90	269.471	272.158	2.687	3.642	36.425	10.181	10.000
100	271.457	272.158	0.701	1.694	16.945	10.195	10.000
110	273.444	272.158					
120	273.245	272.158					
130	272.645	272.158					
140	272.044	272.158	0.114				
150	271.444	272.158	0.714	0.414	4.145	10.018	10.000
160	270.947	272.158	1.211	0.963	9.630	10.012	10.000

Annexure - 2

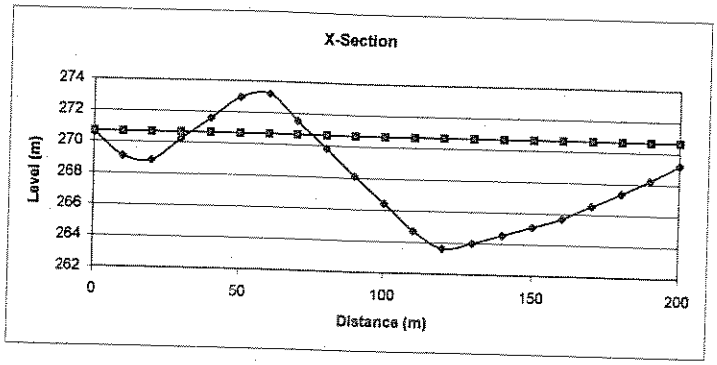


Cross - Sectional Area of River / Nallah at Existing Bridge Site is as follows :

HFL = without Afflux for existing span

Total			2.612		756.59	280.38	280.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	273.116	271.558					
10	272.561	271.558					
20	272.006	271.558					
30	271.451	271.558	0.107				
40	271.281	271.558	0.277	0.192	1.925	10.001	10.000
50	271.255	271.558	0.303	0.290	2.905	10.000	10.000
60	271.231	271.558	0.327	0.315	3.155	10.000	10.000
70	271.363	271.558	0.195	0.261	2.615	10.001	10.000
80	271.012	271.558	0.546	0.371	3.710	10.006	10.000
90	270.662	271.558	0.896	0.721	7.215	10.006	10.000
100	269.941	271.558	1.617	1.257	12.570	10.026	10.000
110	269.005	271.558	2.553	2.085	20.855	10.044	10.000
120	268.083	271.558	3.475	3.014	30.145	10.042	10.000
130	267.785	271.558	3.793	3.634	36.345	10.005	10.000
140	267.446	271.558	4.112	3.953	39.530	10.005	10.000
150	267.127	271.558	4.431	4.272	42.720	10.005	10.000
160	266.809	271.558	4.749	4.590	45.905	10.005	10.000
170	266.49	271.558	5.068	4.909	49.090	10.005	10.000
180	266.171	271.558	5.387	5.228	52.280	10.005	10.000
190	265.852	271.558	5.706	5.547	55.470	10.005	10.000
200	267.251	271.558	4.307	5.007	50.070	10.097	10.000
210	266.891	271.558	4.667	4.487	44.875	10.008	10.000
220	267.328	271.558	4.230	4.449	44.490	10.010	10.000
230	267.791	271.558	3.767	3.999	39.990	10.011	10.000
240	268.253	271.558	3.305	3.536	35.365	10.011	10.000
250	268.715	271.558	2.843	3.074	30.745	10.011	10.000
260	268.987	271.558	2.571	2.707	27.075	10.004	10.000
270	269.234	271.558	2.324	2.448	24.480	10.003	10.000
280	269.481	271.558	2.077	2.201	22.010	10.003	10.000
290	270.178	271.558	1.380	1.729	17.290	10.024	10.000
300	270.915	271.558	0.643	1.012	10.120	10.027	10.000
310	271.473	271.558	0.085	0.364	3.645	10.018	10.000
320	271.948	271.558					
330	272.424	271.558					
340	272.456	271.558					
350	272.482	271.558					
360	272.466	271.558					
370	272.447	271.558					
380	272.427	271.558					
390	272.413	271.558					

Annexure - 3



Cross - Sectional Area of River / Nallah at D/S of the Proposed Bridge is as follows :

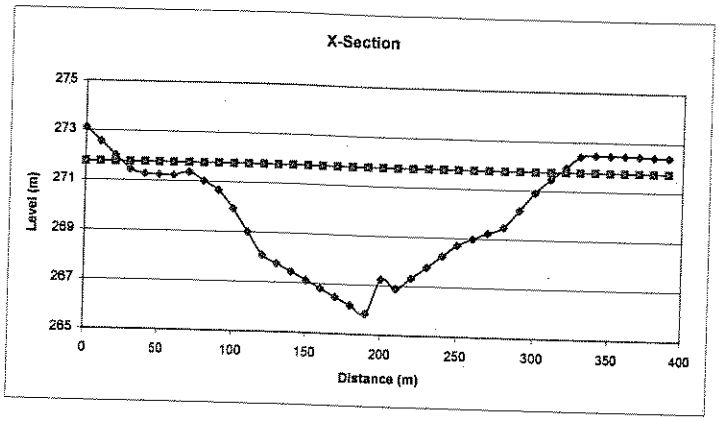
Distance from Proposed Bridge 1000 m

Longitudinal Slope at D/S side 0.0009

HFL at this location 270.658 m

Total			4.244		540.43	120.70	120.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	270.584	270.658	0.074				
10	269.107	270.658	1.551	0.813	8.130	10.108	10.000
20	268.854	270.658	1.804	1.678	16.780	10.003	10.000
30	270.223	270.658	0.435	1.120	11.200	10.093	10.000
40	271.592	270.658					
50	272.961	270.658					
60	273.222	270.658					
70	271.52	270.658					
80	269.819	270.658	0.839				
90	268.118	270.658	2.540	1.690	16.900	10.144	10.000
100	266.417	270.658	4.241	3.391	33.910	10.144	10.000
110	264.716	270.658	5.942	5.092	50.920	10.144	10.000
120	263.618	270.658	7.040	6.491	64.915	10.060	10.000
130	264.001	270.658	6.657	6.849	68.490	10.007	10.000
140	264.557	270.658	6.101	6.379	63.795	10.015	10.000
150	265.112	270.658	5.546	5.824	58.240	10.015	10.000
160	265.691	270.658	4.967	5.257	52.570	10.017	10.000
170	266.521	270.658	4.137	4.552	45.525	10.034	10.000
180	267.351	270.658	3.307	3.722	37.225	10.034	10.000
190	268.233	270.658	2.425	2.866	28.665	10.039	10.000
200	269.229	270.658	1.429	1.927	19.275	10.049	10.000

Annexure - 4

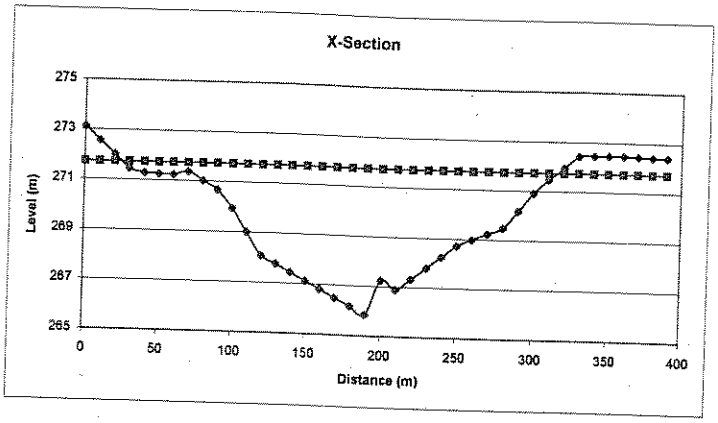


Cross - Sectional Area of River / Nallah at Existing Bridge Site is as follows :

HFL = with Afflux for existing span

Total			2.806		810.77	280.38	280.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	273.116	271.752					
10	272.561	271.752					
20	272.008	271.752					
30	271.451	271.752	0.301				
40	271.281	271.752	0.471	0.386	3.860	10.001	10.000
50	271.255	271.752	0.497	0.484	4.840	10.000	10.000
60	271.231	271.752	0.521	0.509	5.090	10.000	10.000
70	271.363	271.752	0.389	0.455	4.550	10.001	10.000
80	271.012	271.752	0.740	0.565	5.645	10.006	10.000
90	270.662	271.752	1.090	0.915	9.150	10.006	10.000
100	269.941	271.752	1.811	1.451	14.505	10.026	10.000
110	269.005	271.752	2.747	2.279	22.790	10.044	10.000
120	268.083	271.752	3.669	3.208	32.080	10.042	10.000
130	267.765	271.752	3.987	3.828	38.280	10.005	10.000
140	267.446	271.752	4.306	4.147	41.465	10.005	10.000
150	267.127	271.752	4.625	4.465	44.655	10.005	10.000
160	266.809	271.752	4.943	4.784	47.840	10.005	10.000
170	266.49	271.752	5.262	5.102	51.025	10.005	10.000
180	266.171	271.752	5.581	5.422	54.215	10.005	10.000
190	265.852	271.752	5.900	5.741	57.405	10.005	10.000
200	267.251	271.752	4.501	5.201	52.005	10.097	10.000
210	268.891	271.752	4.861	4.881	48.810	10.006	10.000
220	267.328	271.752	4.424	4.643	46.425	10.010	10.000
230	267.791	271.752	3.961	4.193	41.925	10.011	10.000
240	268.253	271.752	3.499	3.730	37.300	10.011	10.000
250	268.715	271.752	3.037	3.268	32.680	10.011	10.000
260	268.987	271.752	2.765	2.901	29.010	10.004	10.000
270	269.234	271.752	2.518	2.642	26.415	10.003	10.000
280	269.481	271.752	2.271	2.395	23.945	10.003	10.000
290	270.178	271.752	1.574	1.923	19.225	10.024	10.000
300	270.915	271.752	0.837	1.206	12.055	10.027	10.000
310	271.473	271.752	0.279	0.558	5.580	10.018	10.000
320	271.948	271.752					
330	272.424	271.752					
340	272.456	271.752					
350	272.462	271.752					
360	272.468	271.752					
370	272.447	271.752					
380	272.427	271.752					
390	272.413	271.752					

Annexure - 5

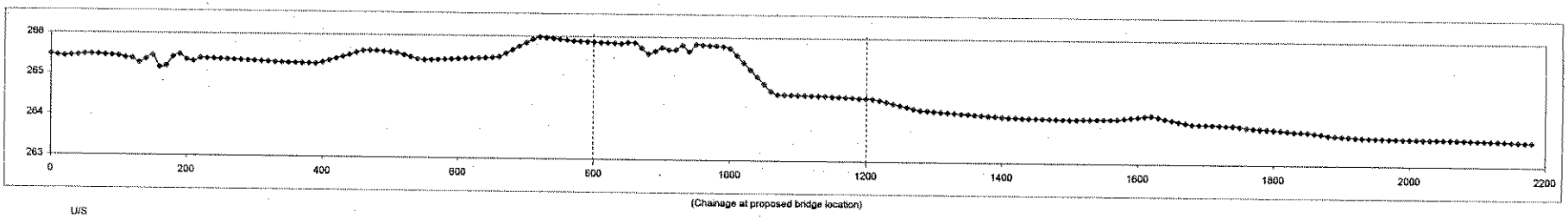


Cross - Sectional Area of River / Nallah at Proposed Bridge Site is as follows :

HFL = with Afflux for proposed span

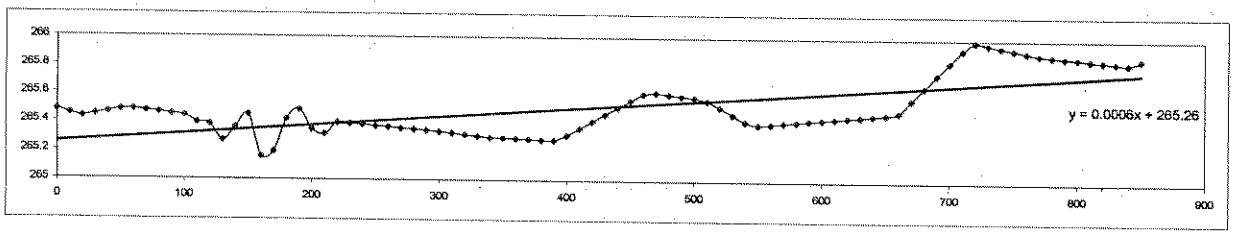
Total			2.780		803.57	280.38	280.00
Distance (m)	Bed Level (m)	HFL (m)	Depth (m)	Average Depth (m)	Area (Sq. m)	Perimeter (m)	Top width of Flow (m)
0	273.116	271.726					
10	272.561	271.726					
20	272.006	271.726					
30	271.451	271.726	0.275				
40	271.281	271.726	0.445	0.360	3.603	10.001	10.000
50	271.255	271.726	0.471	0.458	4.583	10.000	10.000
60	271.231	271.726	0.495	0.483	4.833	10.000	10.000
70	271.363	271.726	0.363	0.429	4.293	10.001	10.000
80	271.012	271.726	0.714	0.539	5.388	10.006	10.000
90	270.662	271.726	1.064	0.889	8.893	10.006	10.000
100	269.941	271.726	1.785	1.425	14.248	10.026	10.000
110	269.005	271.726	2.721	2.253	22.533	10.044	10.000
120	268.083	271.726	3.643	3.182	31.823	10.042	10.000
130	267.765	271.726	3.961	3.802	38.023	10.005	10.000
140	267.448	271.726	4.280	4.121	41.208	10.005	10.000
150	267.127	271.726	4.599	4.440	44.398	10.005	10.000
160	266.809	271.726	4.917	4.758	47.583	10.005	10.000
170	266.49	271.726	5.238	5.077	50.768	10.005	10.000
180	266.171	271.726	5.555	5.396	53.958	10.005	10.000
190	265.852	271.726	5.874	5.715	57.148	10.005	10.000
200	267.251	271.726	4.475	5.175	51.748	10.097	10.000
210	266.891	271.726	4.835	4.655	46.553	10.006	10.000
220	267.328	271.726	4.398	4.617	46.168	10.010	10.000
230	267.791	271.726	3.935	4.167	41.668	10.011	10.000
240	268.253	271.726	3.473	3.704	37.043	10.011	10.000
250	268.715	271.726	3.011	3.242	32.423	10.011	10.000
260	268.987	271.726	2.739	2.875	28.753	10.004	10.000
270	269.234	271.726	2.492	2.616	26.158	10.003	10.000
280	269.481	271.726	2.245	2.369	23.688	10.003	10.000
290	270.178	271.726	1.548	1.897	18.968	10.024	10.000
300	270.915	271.726	0.811	1.180	11.798	10.027	10.000
310	271.473	271.726	0.253	0.532	5.323	10.016	10.000
320	271.948	271.726					
330	272.424	271.726					
340	272.456	271.726					
350	272.462	271.726					
360	272.466	271.726					
370	272.447	271.726					
380	272.427	271.726					
390	272.413	271.726					

Annexure - 6

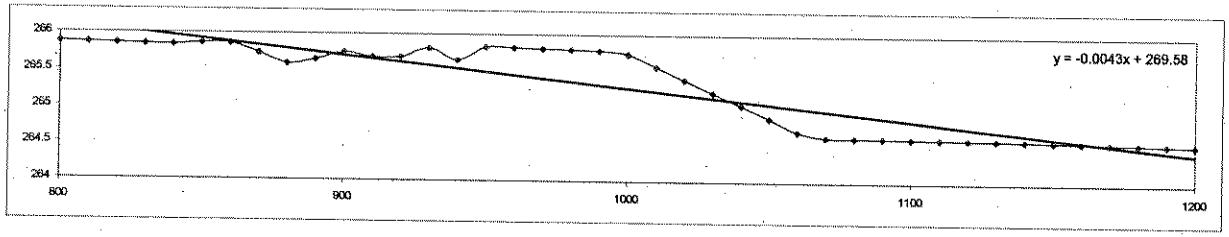


L-Section of River / Nallah

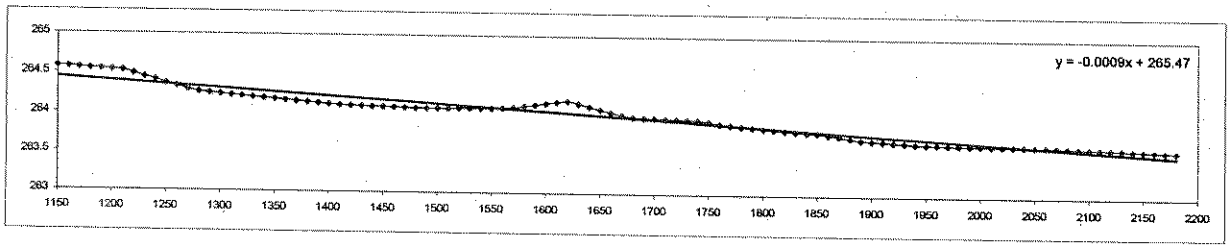
L-Section at U/S : Slope = 0.0006

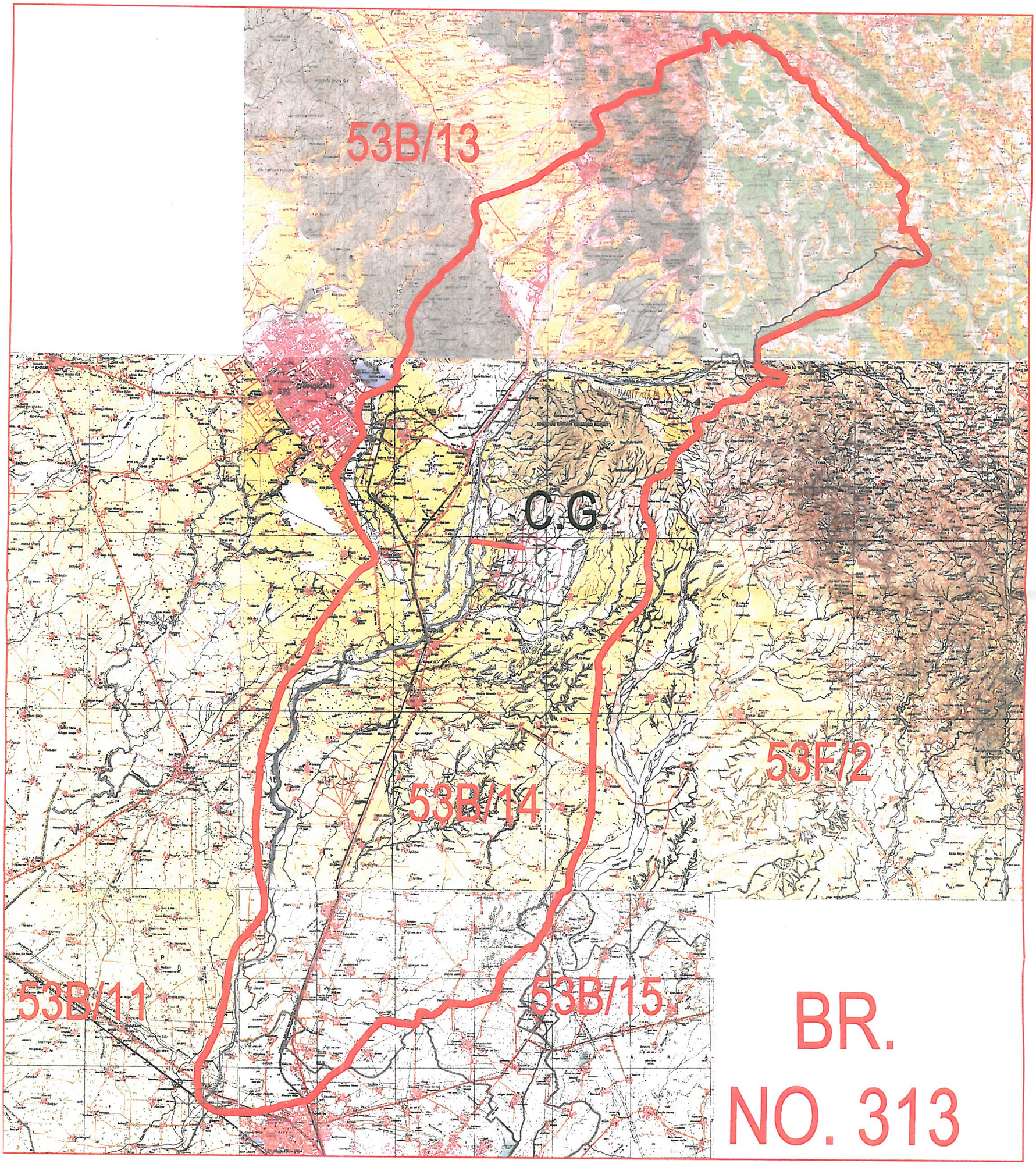


L-Section at Existing Bridge Site : Slope = 0.0043



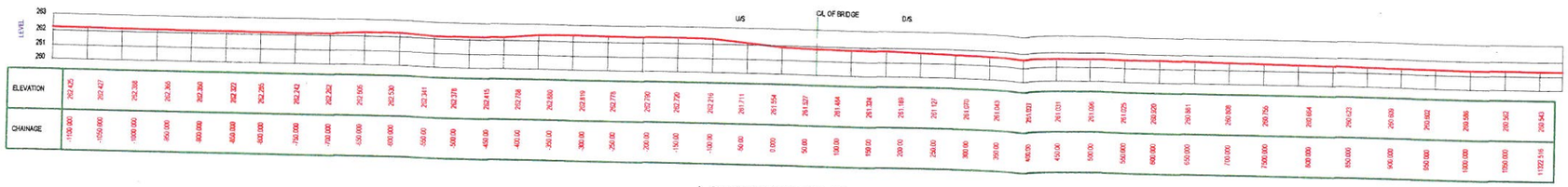
L-Section at D/S : Slope = 0.0009



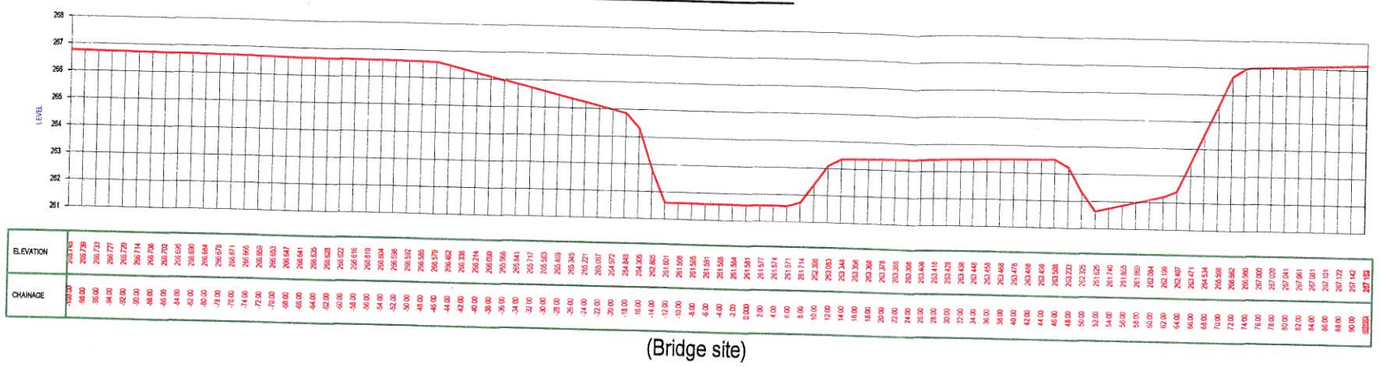


PROPOSED BRIDGE NO. BR. 031 (PRL_313)

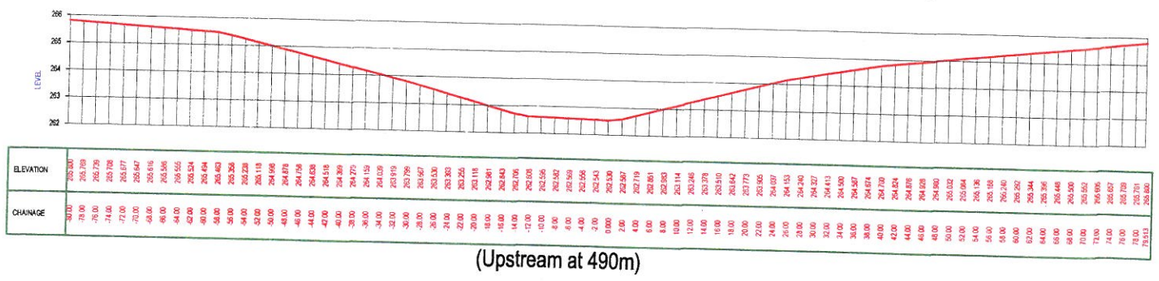
Rly Km. 273/22-30, DFCC Chainage 82722



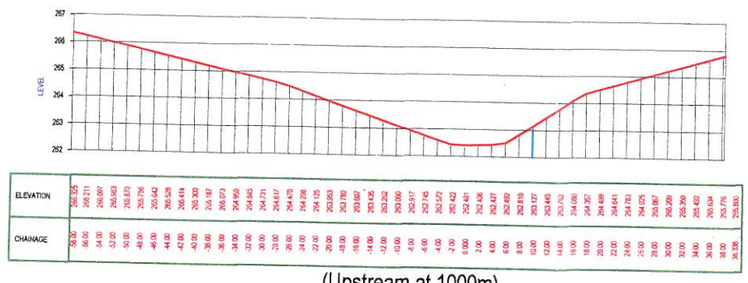
LONGITUDINAL SECTION



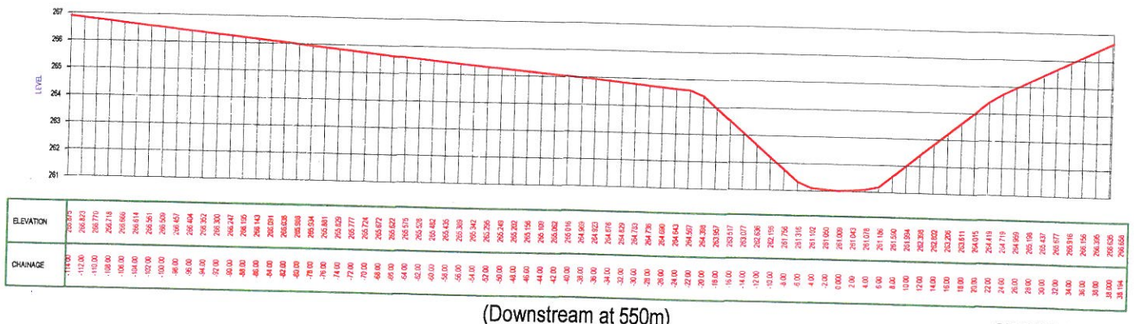
(Bridge site)



(Upstream at 490m)

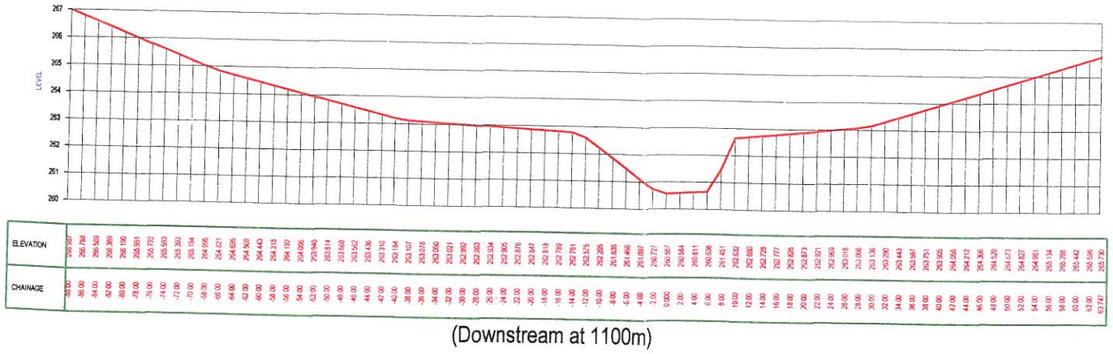


(Upstream at 1000m)



(Downstream at 550m)

CROSS SECTION



(Downstream at 1100m)

0182

SHEET NO. 1 TO 1

Existing Bridge No – 314A
Location – KM 275/3-5

Proposed Bridge No – 032
Location – CH: 84206

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :		314A	
Name of Nallah / Stream / River :		Local Stream	
River Sub - Zone :		Upper Indo- Ganga Plains 1 (e)	
G.T Sheet No :		53 B / 11	
Scale :		1 : 50,000	
Location :		275/3-5	
Latitude :		$30^0$24'34"	Approx.
Longitude :		$76^0$43'1"	Approx.
Catchment Area ,	A	=	7.830 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	9.591 Km
Height of Farthest Point ,	H1	=	274.55 m
Height of Point of Interest ,	H2	=	268.05 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	6.50 m
Average Bed Level		=	268.05 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient,** C = 0.4

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **5.442 Hr**

= **326.532 Mins**

(a) t_c h Ratio = 0.54 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.574**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **12.84 cm**

= **128.40 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **23.59 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **20.544 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	7.830 Sq. Km	783.04 Hectares
Length of path from Toposheet,	L	=	9.591 Km	
Difference in Levels from Toposheet,	H	=	6.50 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		6.28 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	34.35 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4	
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95	
A = Catchment Area in Hectares	783.04	Hectares
I_c = Critical Intensity of Rainfall	3.435	cm / Hr
Q = Maximum Discharge	**28.620**	**Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	7.830	Sq Km

Hence, Q = **74.896 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	20.544 Cumecs
Discharge by Rational Formula (IRC approach)	28.620 Cumecs
Discharge by Dicken's Formula	74.896 Cumecs
Maximum Discharge	74.896 Cumecs
Next Maximum Discharge	28.620 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **42.930 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.05 m
HFL as per site condition & local inquiry		=	269.57 m
So, Total Depth of Water,	H	=	1.52 m

Provided 8 RCC BOX of (2 x 4 x 3) m span at proposed bridge site location.

Clear Waterway (provided),	L	=	64.00 m
Total Area,	A	=	97.280 m2
Velocity ,	V	=	Q / A
		=	**0.441 m/sec**

6 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **55.809 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^2 / K_{sf})^{1/3}$

D_b = Design discharge per metre width	0.87 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.22 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

So, **Maximum Scour Depth** = **1.835 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

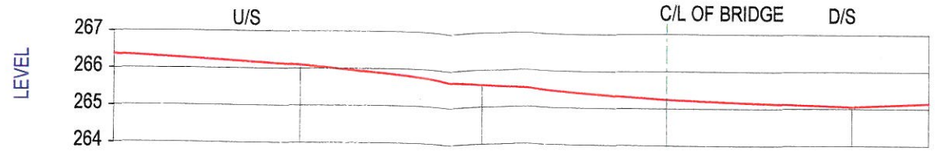
= **267.74 m**

CATCHMENT AREA PLAN

Bridge no	314-A
A	7.830 sq km
L	9.591 km

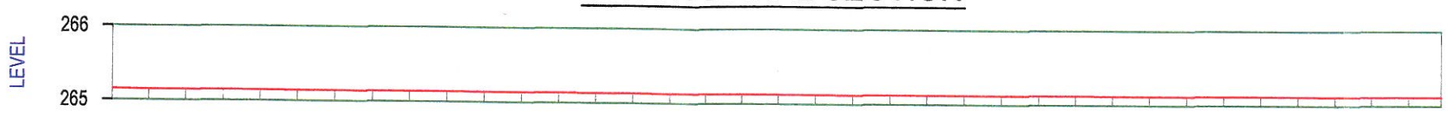
PROPOSED BRIDGE NO. BR. 033 (PRL_314A)

Rly Km. 275/7-10, DFCC Chainage 84355



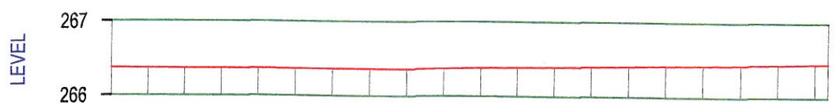
ELEVATION	266.364	266.080	265.587	265.237	265.041	265.137
CHAINAGE	-150.00	-100.00	-50.00	0.000	50.000	70.713

LONGITUDINAL SECTION



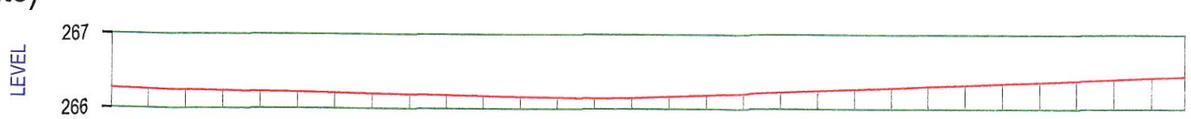
ELEVATION	265.145	265.144	265.142	265.141	265.140	265.139	265.137	265.136	265.135	265.134	265.132	265.131	265.130	265.129	265.127	265.126	265.125	265.124	265.124	265.123	265.123	265.122	265.122	265.121	265.121	265.120	265.119	265.119	265.118	265.118	265.117	265.117	265.116	265.116	265.115	265.114	265.114
CHAINAGE	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	39.745

(Bridge site)



ELEVATION	266.365	266.364	266.363	266.362	266.361	266.360	266.360	266.359	266.360	266.368	266.375	266.383	266.391	266.399	266.406	266.414	266.422	266.430	266.438	266.445	266.448
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	24.687

(Upstream at 72m)



ELEVATION	265.265	265.256	265.246	265.237	265.227	265.218	265.208	265.199	265.189	265.180	265.170	265.161	265.151	265.142	265.146	265.166	265.185	265.205	265.224	265.243	265.263	265.282	265.301
CHAINAGE	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00

ELEVATION	265.321	265.340	265.360	265.379	265.398	265.418	265.435																
CHAINAGE	20.00	22.00	24.00	26.00	28.00	30.00	31.789																

(Downstream at 70m)

CROSS SECTION

0188

Existing Bridge No – 314
Location – KM 275/7-9

Proposed Bridge No – 033
Location – CH: 84355

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :			314
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 11
Scale :			1 : 50,000
Location :			275/7-9
Latitude :			$30^0$24'34"
Longitude :			$76^0$43'1"
Catchment Area ,	**A**	=	21.736 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	11.791 Km
Height of Farthest Point ,	**H1**	=	274.35 m
Height of Point of Interest ,	**H2**	=	266.65 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	7.70 m
Average Bed Level		=	266.65 m

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

t_c = $[L^3 / H]^{0.345}$

= **6.356 Hr**

= **381.388 Mins**

(a) t_c h Ratio = 0.54 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.574**

(d)

(i) R_{50} (24) = 24.00 cm

(ii) R_{50} (1) = **0.34 x R_{50} (24)** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) R_{50} (t_c) = **K x R_{50} (1)**

= **12.84 cm**

= **128.40 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **20.20 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **48.824 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	21.736 Sq. Km	2173.61 Hectares
Length of path from Toposheet,	L	=	11.791 Km	
Difference in Levels from Toposheet,	H	=	7.70 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		7.47 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	29.53 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	2173.61 Hectares
I_c = Critical Intensity of Rainfall	2.953 cm / Hr
Q = Maximum Discharge	**70.455 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	11 - 14, where the annual rainfall is 60 - 120 cm
		14 - 19 in Madhya Pradesh
		22 in Western Ghats

C	=	16 (adopted in present case)
M	=	21.736 Sq Km

Hence, Q = **161.067 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	48.824 Cumecs
Discharge by Rational Formula (IRC approach)	70.455 Cumecs
Discharge by Dicken's Formula	161.067 Cumecs
Maximum Discharge	161.067 Cumecs
Next Maximum Discharge	70.455 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **105.683 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.65 m
HFL as per site condition & local inquiry		=	268.55 m
So, Total Depth of Water,	H	=	1.90 m

Provide Span arrangement of ((2 x 12.2) + (2 x 9.15) + 6.1) m at proposed bridge site location.

Clear Waterway (provided),	L	=	48.80 m
Total Area,	A	=	92.720 m2
Velocity ,	V	=	Q / A
		=	**1.140 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	105.683 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.900 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.767 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = **HFL + Vertical Clearance**

= **269.452 m**

7 Scour Depth :

Increase in Design Discharge (as per IRC : 78 - 2000, Clause : 703.1.1 & Clause : 4.4, IRS Code of Practices for Design of Substructure & Foundation of Bridges) **30%**

Increased Design Discharge **137.388 Cumecs**

Depth of Scour in accordance with Clause 4.6 of I.R.S. Code of Practices for Design of Substructure & Foundation of Bridges & IRC - 78 : 2000, Clause : 703.2 ,

Mean Depth of Scour, $d_{sm} = 1.34 \times (D_b^{\,2} / K_{sf})^{1/3}$

D_b = Design discharge per metre width 2.82 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **2.67 m**

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)

(For moderate bend) = **$1.5 \times d_{sm}$**

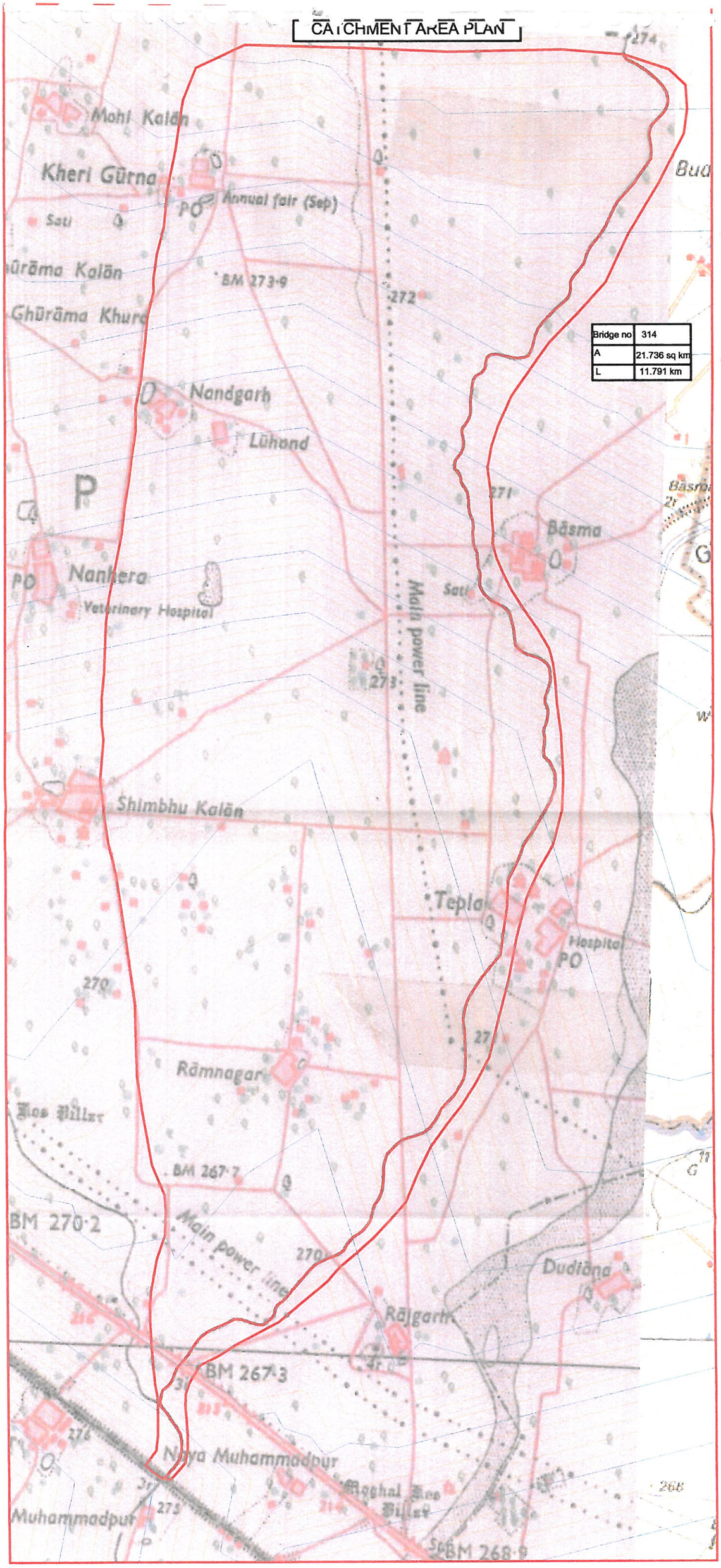
So, **Maximum Scour Depth** = **4.008 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **264.54 m**

CATCHMENT AREA PLAN

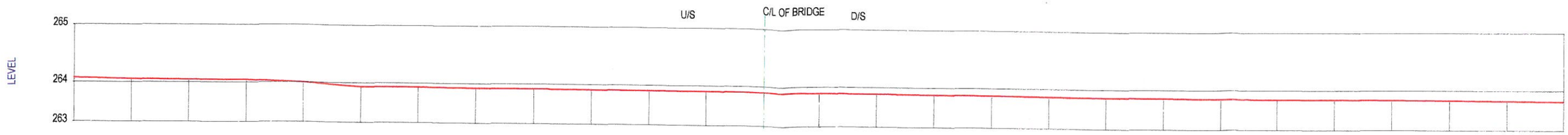


Bridge no	314
A	21.736 sq km
L	11.791 km

0193

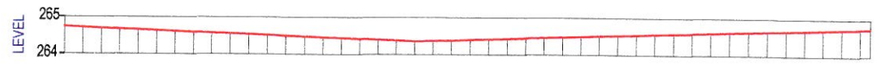
PROPOSED BRIDGE NO. BR. 032 (PRL_314)

Rly Km. 275/1-8, DFCC Chainage 84206



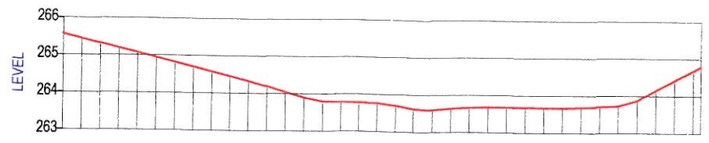
CHAINAGE	ELEVATION
-250.00	264.348
-200.00	264.264
-150.00	264.206
-100.00	264.187
-50.00	263.990
0.000	263.642
50.00	263.637
100.00	263.590
150.00	263.560
200.00	263.530
250.00	263.515
300.00	263.492
350.00	263.465
400.00	263.440
450.00	263.411
500.00	263.379
550.000	263.350
600.000	263.308
650.000	263.277
700.000	263.257
750.000	263.215
800.000	263.200
850.000	263.188
900.000	263.162
950.000	263.130
1000.000	263.102
1049.479	263.057

LONGITUDINAL SECTION



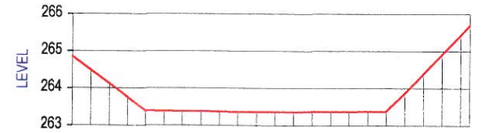
CHAINAGE	ELEVATION
-38.00	264.730
-36.00	264.710
-34.00	264.690
-32.00	264.671
-30.00	264.651
-28.00	264.631
-26.00	264.611
-24.00	264.591
-22.00	264.572
-20.00	264.552
-18.00	264.532
-16.00	264.512
-14.00	264.492
-12.00	264.473
-10.00	264.453
-8.00	264.433
-6.00	264.413
-4.00	264.393
-2.00	264.374
0.000	264.354
2.00	264.359
4.00	264.376
6.00	264.392
8.00	264.408
10.00	264.424
12.00	264.440
14.00	264.456
16.00	264.472
18.00	264.488
20.00	264.504
22.00	264.520
24.00	264.536
26.00	264.552
28.00	264.568
30.00	264.585
32.00	264.601
34.00	264.617
36.00	264.633
38.00	264.649
40.00	264.665
42.00	264.681
44.00	264.697
46.00	264.713
48.00	264.729
49.087	264.738

(Upstream at 270m)



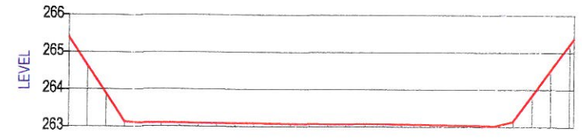
CHAINAGE	ELEVATION
-40.00	265.556
-38.00	265.433
-36.00	265.310
-34.00	265.186
-32.00	265.063
-30.00	264.940
-28.00	264.817
-26.00	264.694
-24.00	264.570
-22.00	264.447
-20.00	264.324
-18.00	264.180
-16.00	264.036
-14.00	263.892
-12.00	263.784
-10.00	263.775
-8.00	263.766
-6.00	263.756
-4.00	263.694
-2.00	263.616
0.000	263.585
2.00	263.631
4.00	263.658
6.00	263.669
8.00	263.674
10.00	263.668
12.00	263.663
14.00	263.662
16.00	263.681
18.00	263.699
20.00	263.718
22.00	263.871
24.00	264.138
26.00	264.405
28.00	264.672
28.843	264.785

(Bridge site)



CHAINAGE	ELEVATION
-20.00	264.847
-18.00	264.482
-16.00	264.117
-14.00	263.752
-12.00	263.387
-10.00	263.381
-8.00	263.375
-6.00	263.370
-4.00	263.365
-2.00	263.359
0.000	263.357
2.00	263.358
4.00	263.360
6.00	263.363
8.00	263.365
10.00	263.368
12.00	263.371
14.00	263.374
16.00	263.848
18.00	264.371
20.00	264.894
22.00	265.418
23.010	265.682

(Downstream at 500m)



CHAINAGE	ELEVATION
-28.00	265.382
-26.00	264.629
-24.00	263.876
-22.00	263.123
-20.00	263.085
-18.00	263.084
-16.00	263.082
-14.00	263.081
-12.00	263.079
-10.00	263.078
-8.00	263.076
-6.00	263.071
-4.00	263.066
-2.00	263.062
0.000	263.057
2.00	263.059
4.00	263.061
6.00	263.063
8.00	263.057
10.00	263.049
12.00	263.041
14.00	263.034
16.00	263.026
18.00	263.018
20.00	263.135
22.00	263.823
24.00	264.511
26.00	265.198
26.462	265.357

(Downstream at 1000m)

CROSS SECTION

Existing Bridge No – 314B
Location – KM 275/13-15

Proposed Bridge No – 034
Location – CH: 84550

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Kesri to Sanehwal

Name / No. of Proposed Bridge :		314B	
Name of Nallah / Stream / River :		Local Stream	
River Sub - Zone :		Upper Indo- Ganga Plains 1 (e)	
G.T Sheet No :		53 B / 11	
Scale :		1 : 50,000	
Location :		275/13-15	
Latitude :		$30^0$24'34"	Approx.
Longitude :		$76^0$43'1"	Approx.
Catchment Area ,	**A** =	14.133 Sq Km	
Length of Longest Stream course from source to the bridge site ,	**L** =	10.161 Km	
Height of Farthest Point ,	**H1** =	273.20 m	
Height of Point of Interest ,	**H2** =	267.20 m	
Height of the Farthest Point above Point of Interest along the river ,	**H** =	6.00 m	
Average Bed Level	=	267.20 m	

1 Discharge by Rational Formula (Bridges & Flood Wing Report No. RBF - 16) :

(i) $Q_{50} = 0.278 \times C \times I \times A$

where , Q_{50} = 50 years Design Flood Discharge (Cumecs)

C = Runoff Coefficient

I = 50 Years Rainfall Intensity (mm / Hr) lasting for tc hour duration where tc is the time of concentration

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

According to Report of the Committee of Engineers (Khosla), Annexure - 5.1.1 (a), Bridges & Floods Wing Report No. RBF - 16, March - 1990

S. No.	Description	" C " Value
1	Steep, bare rock, city pavements	0.9
2	Rock, Steep but wooded	0.8
3	Plateaus , Lightly covered	0.7
4	Clavey soils, Stiff & bare	0.6
5	Clavey soils, Lightly covered	0.5
6	Loam, Lightly cultivated or covered	0.4
7	Loam, largely cultivated	0.3
8	Sandy Soil, Light growth	0.2
9	Sandy Soil, covered, heavy brush	0.1

In present case, **Runoff Coefficient, C = 0.4**

(iii) Calculation of Intensity of Rainfall, I :

For estimating the time of concentration (tc) as per Bhatnagar's formula :

$t_c = [L^3 / H]^{0.345}$

= **5.939 Hr**

= **356.343 Mins**

(a) t_c h Ratio = 0.54 (from Fig. 4 of RBF - 16)

(b) 1 h Ratio = 0.34 (from Fig. 4 of RBF - 16)

(c) Coefficient, K = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.574**

(d)

(i) $R_{50}(24)$ = 24.00 cm

(ii) $R_{50}(1)$ = **0.34 x $R_{50}(24)$** [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= **8.16 cm**

(iii) $R_{50}(t_c)$ = K x $R_{50}(1)$

= **12.84 cm**

= **128.40 mm**

(iv) Rainfall Intensity, I = $\frac{R_{50}(t_c)}{t_c}$

= **21.62 mm / Hr**

(iv) Design Flood Discharge :

Q_{50} = 0.278 x C x I x A

Q_{50} = **33.977 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	14.133 Sq. Km	1413.28 Hectares
Length of path from Toposheet,	L	=	10.161 Km	
Difference in Levels from Toposheet,	H	=	6.00 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		6.92 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	31.56 mm / Hr

Discharge, $Q = 0.028 \times P \times f \times A \times I_c$

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95
A = Catchment Area in Hectares	1413.28 Hectares
I_c = Critical Intensity of Rainfall	3.156 cm / Hr
Q = Maximum Discharge	**47.463 Cumecs**

3 Discharge by Dicken's Formula :

$Q = C \times M^{3/4}$

where,
- Q = the peak run-off in Cumecs
- M = the catchment area in Sq Km
- C = 11 - 14, where the annual rainfall is 60 - 120 cm
  14 - 19 in Madhya Pradesh
  22 in Western Ghats

C	=	16	(adopted in present case)
M	=	14.133 Sq Km	

Hence, Q = **116.625 Cumecs**

4 Design Discharge :

(As per IRC - SP : 13 - 1998, Clause - 7.1 & Clause - 4.2 and 4.3 of I.R.S. Code of Practices for the Design of Substructure & Foundation of Bridges)

Discharge by Rational Formula (RBF - 16 Report)	33.977 Cumecs
Discharge by Rational Formula (IRC approach)	47.463 Cumecs
Discharge by Dicken's Formula	116.625 Cumecs
Maximum Discharge	116.625 Cumecs
Next Maximum Discharge	47.463 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **71.195 Cumecs**