(iii) Calculation of Intensity of Rainfall, I :

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

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

= **1.606 Hr**

= **96.388 Mins**

(a) t_c h Ratio = 0.43 (from Fig. 4 of RBF - 16)

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

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

= **1.254**

(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)**

= **10.24 cm**

= **102.36 mm**

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

= **63.72 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **3.890 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.549 Sq. Km	54.90 Hectares
Length of path from Toposheet,	L	=	1.703 Km	
Difference in Levels from Toposheet,	H	=	1.25 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.61 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	95.84 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	54.90	Hectares
I_c = Critical Intensity of Rainfall	9.584	cm / Hr
Q = Maximum Discharge	**5.598**	**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	=	0.549 Sq Km	

Hence, Q = **10.205 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)	3.890 Cumecs
Discharge by Rational Formula (IRC approach)	5.598 Cumecs
Discharge by Dicken's Formula	10.205 Cumecs
Maximum Discharge	10.205 Cumecs
Next Maximum Discharge	5.598 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **8.397 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.45 m
HFL as per site condition & local inquiry		=	268.20 m
So, Total Depth of Water,	H	=	1.75 m

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

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	10.500 m2
Velocity ,	V	=	Q / A
		=	**0.800 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 **10.916 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	1.82 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.00 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** = **2.996 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

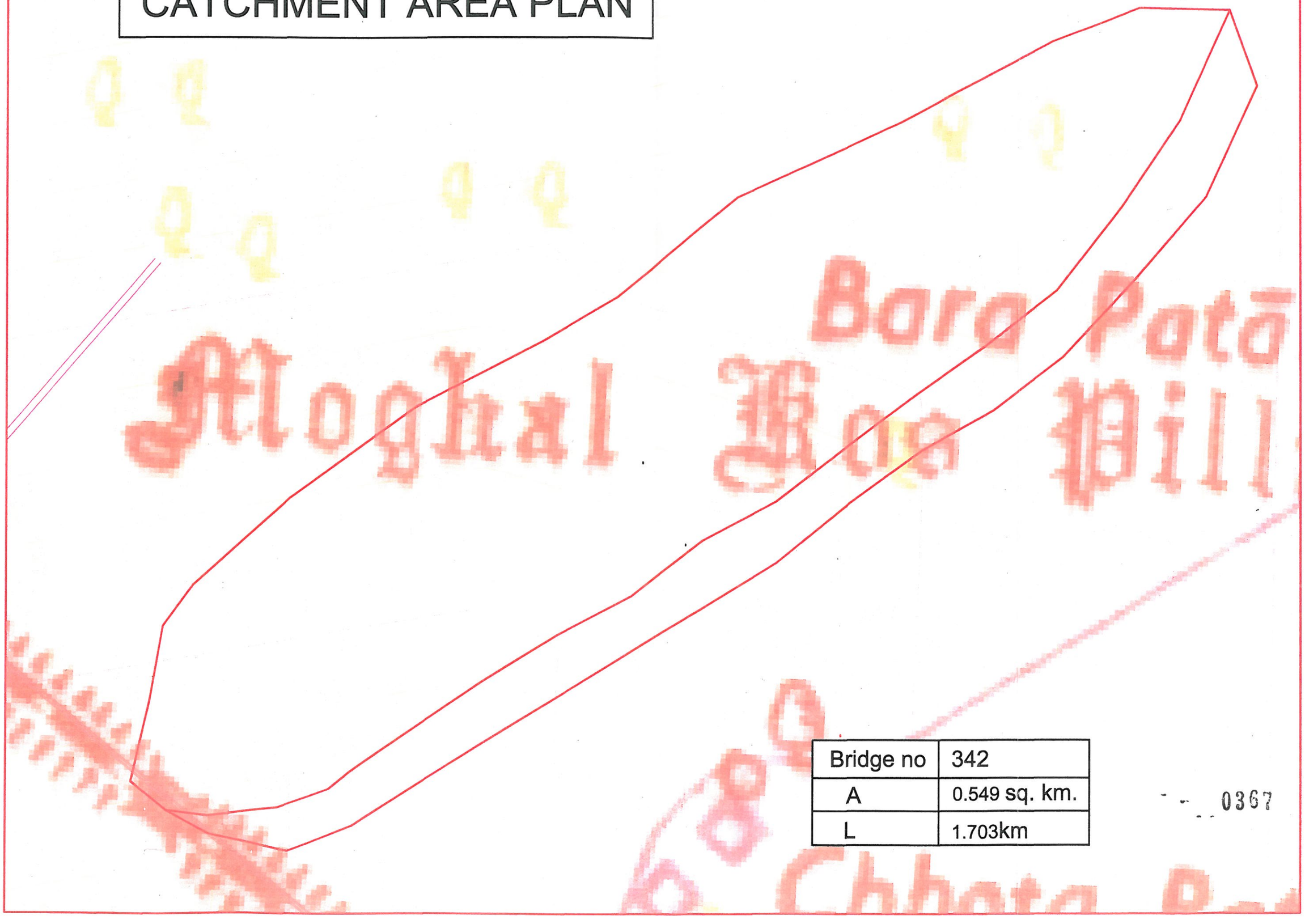
= **265.21 m**

Existing Bridge No – 343
Location – KM 303/25-27

Proposed Bridge No – 078
Location – CH: 112930

(Hydrology Details)

CATCHMENT AREA PLAN



Bridge no	342
A	0.549 sq. km.
L	1.703km

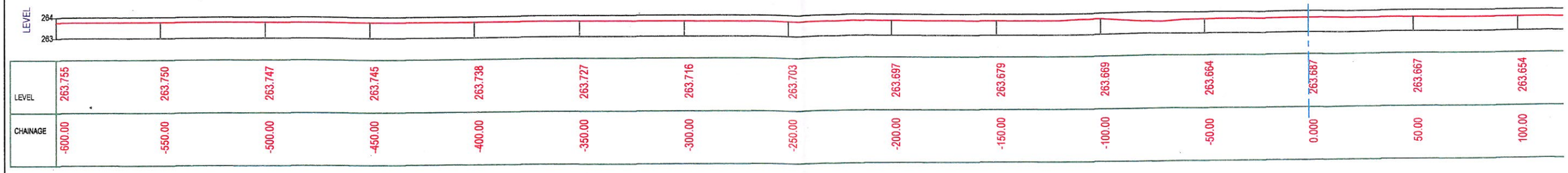
0367

PROPOSED BRIDGE NO. BR.077(PRL_342)

Rly Km. 303/12-14, DFCC Chainage 112435

U/S

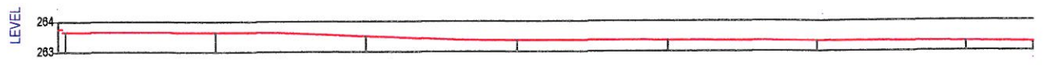
C/L OF BRIDGE



LEVEL	263.755	263.750	263.747	263.745	263.738	263.727	263.716	263.703	263.697	263.679	263.669	263.664	263.687	263.667	263.654
CHAINAGE	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00

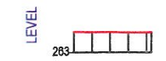
LONGITUDINAL SECTION

D/S



LEVEL	263.654	263.648	263.512	263.374	263.366	263.342	263.310	263.289
CHAINAGE	100.00	150.00	200.00	250.00	300.00	350.00	400.00	422.337

LONGITUDINAL SECTION

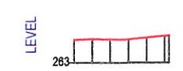


LEVEL	263.684	263.682	263.680	263.681
CHAINAGE	-4.00	-2.00	0.000	2.00

(Bridge site)

LEVEL	263.731	263.730	263.729	263.739	263.755
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.000

(Upstream at 250m)

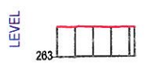


LEVEL	263.767	263.761	263.795	263.823	263.841
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.000

(Upstream at 510m)

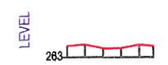
LEVEL	263.465	263.445	263.430	263.431	263.452
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	4.797

(Downstream at 00m)



LEVEL	263.659	263.658	263.651	263.646	263.661
CHAINAGE	-4.00	2.00	0.000	2.00	4.00	4.979

(Downstream at 250m)



LEVEL	263.245	263.278	263.142	263.146	263.277
CHAINAGE	0.000	2.000	4.000	6.000	8.000	9.546

(Downstream at 500m)

CROSS SECTION

CROSS SECTION

0368

SHEET NO.-1

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

Name / No. of Proposed Bridge :	343
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 :	303/25-27
Latitude :	$30^0$33'47"
Longitude :	$76^0$28'44"

Catchment Area ,	**A**	=	0.658 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.669 Km
Height of Farthest Point ,	**H1**	=	267.47 m
Height of Point of Interest ,	**H2**	=	266.37 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	1.10 m
Average Bed Level		=	266.37 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 :

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

= **1.644 Hr**

= **98.654 Mins**

(a) t_c h Ratio = 0.43 (from Fig. 4 of RBF - 16)

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

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

= **1.263**

(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)**

= **10.31 cm**

= **103.09 mm**

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

= **62.70 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **4.586 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.658 Sq. Km	65.78 Hectares
Length of path from Toposheet,	L	=	1.669 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.65 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	94.31 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	65.78 Hectares
I_c = Critical Intensity of Rainfall	9.431 cm / Hr
Q = Maximum Discharge	**6.600 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	=	0.658 Sq Km
Hence,	Q	=	**11.686 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)	4.586 Cumecs
Discharge by Rational Formula (IRC approach)	6.600 Cumecs
Discharge by Dicken's Formula	11.686 Cumecs
Maximum Discharge	11.686 Cumecs
Next Maximum Discharge	6.600 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **9.901 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.37 m
HFL as per site condition & local inquiry		=	268.77 m
So, Total Depth of Water,	H	=	2.40 m

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

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	14.400 m2
Velocity ,	V	=	Q / A
		=	**0.688 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 **12.871 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	2.15 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.23 m**

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

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

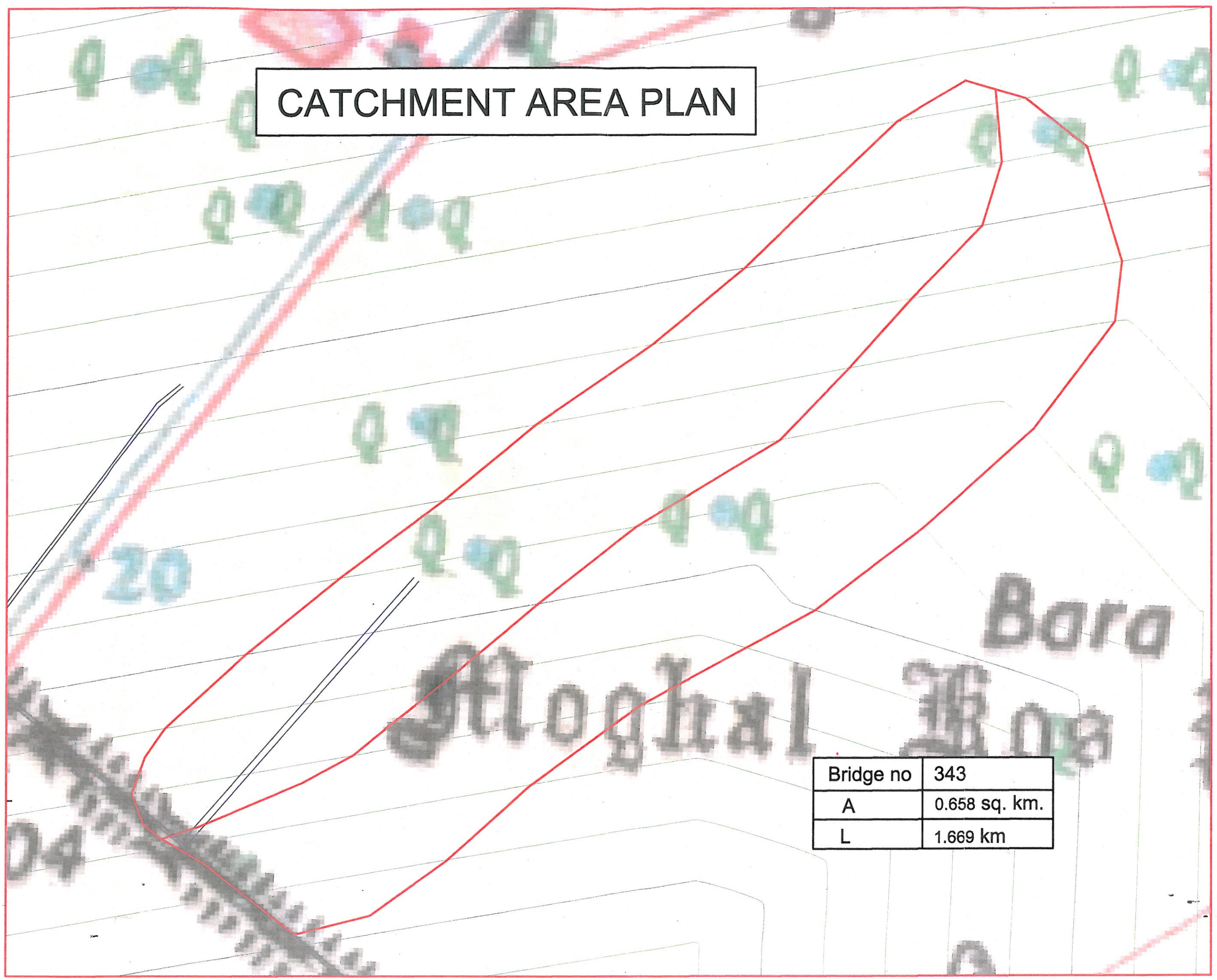
So, **Maximum Scour Depth** = **3.343 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.43 m**

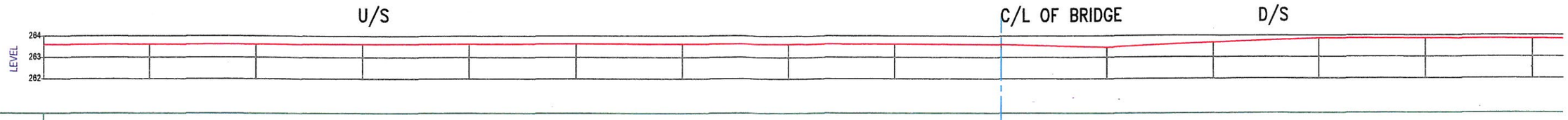
CATCHMENT AREA PLAN



Bridge no	343
A	0.658 sq. km.
L	1.669 km

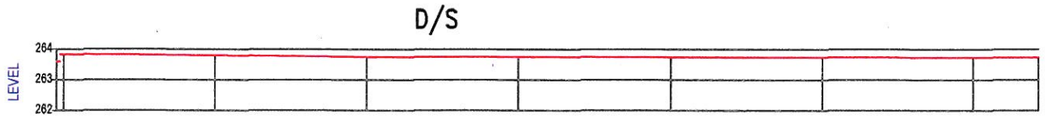
0373

PROPOSED BRIDGE NO. BR.078(PRL_343)
Rly Km. 303/25-28, DFCC Chainage 112930



LEVEL	263.598	263.603	263.611	263.616	263.620	263.628	263.622	263.617	263.610	263.599	263.467	263.682	263.856	263.846	263.830
CHAINAGE	-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

LONGITUDINAL SECTION

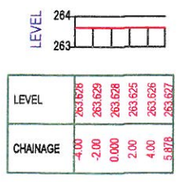


LEVEL	263.830	263.807	263.754	263.749	263.746	263.743	263.738	263.735
CHAINAGE	250.00	300.00	350.00	400.00	450.00	500.00	550.000	521.397

LONGITUDINAL SECTION

LEVEL	263.497	263.363	263.361	263.352	263.489
CHAINAGE	-4.00	-2.00	0.000	2.00	3.841

(Bridge site)



LEVEL	263.626	263.629	263.628	263.625	263.626	263.627
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.878

(Upstream at 250m)

LEVEL	263.589	263.594	263.598	263.600	263.606	263.610
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.017

(Upstream at 500m)

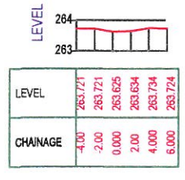
CROSS SECTION

LEVEL	263.297	263.223	263.226	263.218	263.310
CHAINAGE	-4.00	-2.00	0.000	2.00	5.534

(Downstream at 00m)

LEVEL	263.796	263.797	263.698	263.650	263.696	263.793
CHAINAGE	-4.00	-2.00	0.000	2.00	4.000	5.751

(Downstream at 255m)



LEVEL	263.721	263.721	263.625	263.634	263.734	263.724
CHAINAGE	-4.00	-2.00	0.000	2.00	4.000	6.000

(Downstream at 515m)

CROSS SECTION

- 0374

SHEET NO.-1

Existing Bridge No – 344
Location – KM 304/1-3

Proposed Bridge No – 079
Location – CH: 113176

(Hydrology Details)

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

Name / No. of Proposed Bridge :	344
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 :	304/1-3
Latitude :	$30^0$33'51"
Longitude :	$76^0$28'37"

Catchment Area ,	**A**	=	15.543 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	7.382 Km
Height of Farthest Point ,	**H1**	=	273.44 m
Height of Point of Interest ,	**H2**	=	267.44 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	6.00 m
Average Bed Level		=	267.44 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 = $[L^3 / H]^{0.345}$

= **4.267 Hr**

= **256.005 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 = $\frac{R_{50}(t_c)}{t_c}$

= **30.09 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **52.013 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	15.543 Sq. Km	1554.31 Hectares
Length of path from Toposheet,	L	=	7.382 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		4.78 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	43.22 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	1554.31	Hectares
I_c = Critical Intensity of Rainfall	4.322	cm / Hr
Q = Maximum Discharge	**73.728**	**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	=	15.543	Sq Km

Hence, Q = **125.249 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)	52.013 Cumecs
Discharge by Rational Formula (IRC approach)	73.728 Cumecs
Discharge by Dicken's Formula	125.249 Cumecs
Maximum Discharge	125.249 Cumecs
Next Maximum Discharge	73.728 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **110.592 Cumecs**

5 Linear Waterway :

Average Bed Level		=	267.44 m
HFL as per site condition & local inquiry		=	268.64 m
So, Total Depth of Water,	H	=	1.20 m

Provide 8 spans of 6.1 m at bridge site location.

Clear Waterway (provided),	L	=	48.80 m
Total Area,	A	=	58.658 m2
Velocity ,	V	=	Q / A
		=	**1.885 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	110.592 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		=	0.778 m
	So, Vertical Clearance adopted		=	0.900 m

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

= **269.542 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 **143.769 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 2.95 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **2.75 m**

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

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

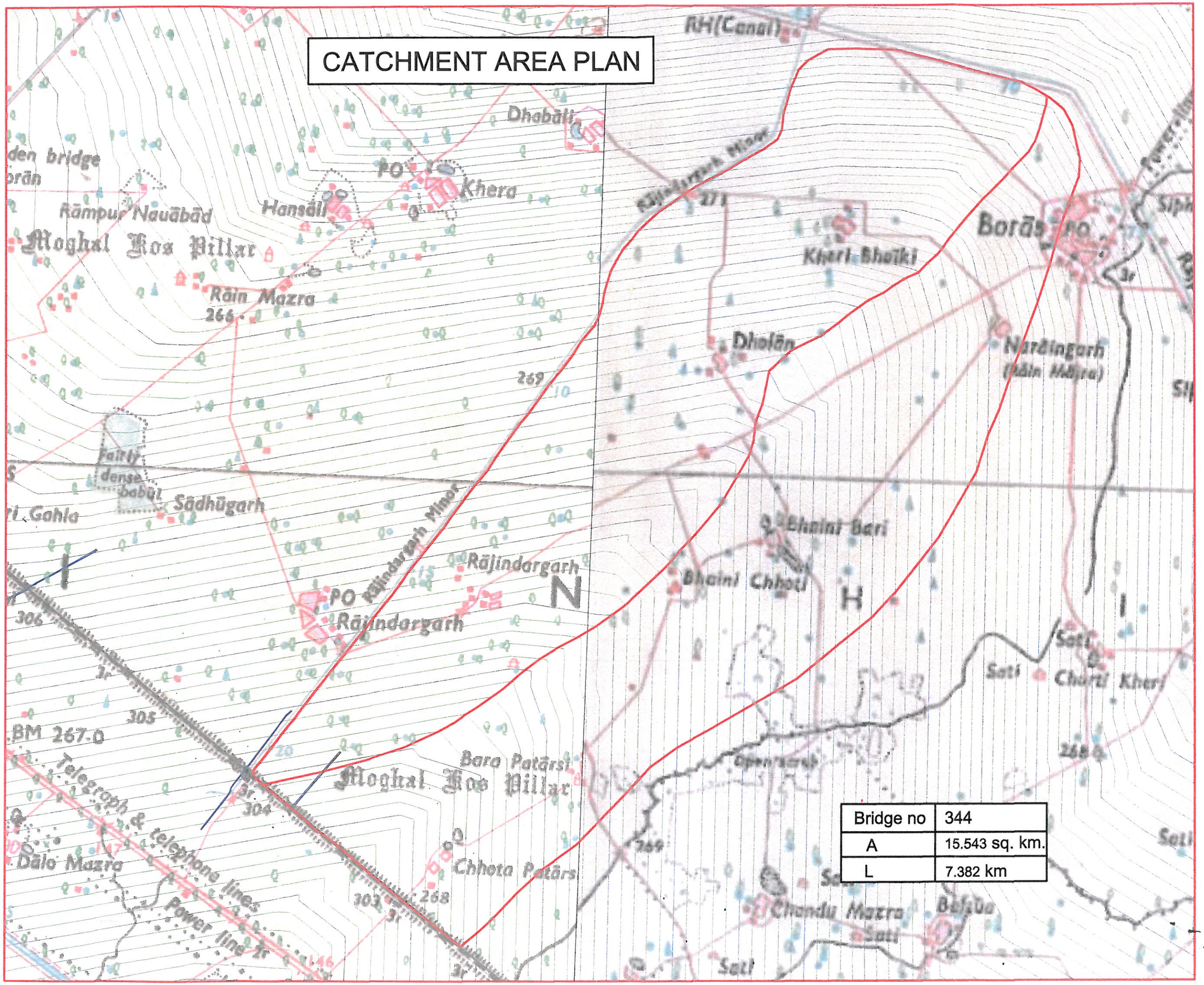
So, **Maximum Scour Depth** = **4.131 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

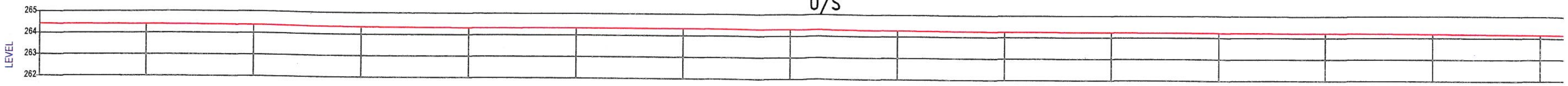
= **264.51 m**

CATCHMENT AREA PLAN



Bridge no	344
A	15.543 sq. km.
L	7.382 km

0379

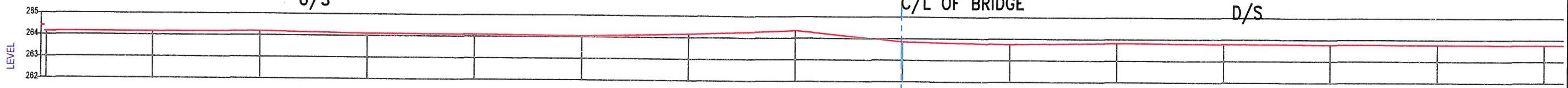


LEVEL	264.415	264.387	264.360	264.337	264.315	264.319	264.323	264.306	264.272	264.247	264.233	264.220	264.206	264.180	264.150
CHAINAGE	-1100.00	-1050.00	-1000.00	-950.00	-900.00	-850.00	-800.00	-750.00	-700.00	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00

LONGITUDINAL SECTION

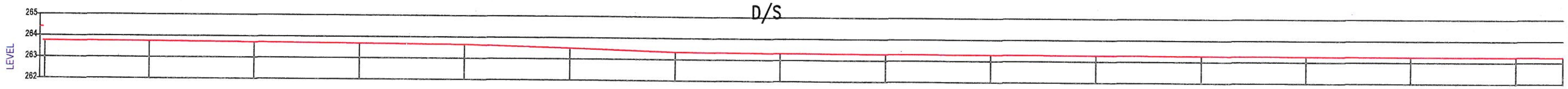
PROPOSED BRIDGE NO. BR.079(PRL_344)

Rly Km. 304/2-4, DFCC Chainage 113176



LEVEL	264.150	264.149	264.182	264.103	264.090	264.034	264.159	264.352	263.848	263.757	263.818	263.794	263.774	263.765	263.758
CHAINAGE	-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

LONGITUDINAL SECTION



LEVEL	263.758	263.751	263.715	263.682	263.651	263.501	263.346	263.321	263.307	263.297	263.291	263.281	263.264	263.255	263.251	263.249
CHAINAGE	300.00	350.00	400.00	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	1022.140

LONGITUDINAL SECTION

LEVEL	264.950	264.848	264.745	264.643	264.540	264.438	264.335	264.233	264.130	264.127	264.152	264.177	264.202	264.227	264.252	264.277	264.302	264.327	264.352	264.377	264.401	264.426	264.469	264.515	264.560	264.606	264.651	264.697	264.742	264.788	264.830
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	20.00	22.00	24.00	26.00	28.00	30.000	32.000	33.854

(Bridge site)

LEVEL	264.200	264.204	264.208	264.212	264.216	264.220	264.224	264.224	264.223	264.222	264.221	264.220	264.219	264.218	264.217	264.217	264.216	264.215	264.216	264.216	264.216	264.217	264.217	264.217	264.218	264.218	264.219	264.219 [illegible]
CHAINAGE	-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	30.000 [illegible]

(Upstream at 500m)

LEVEL	264.425	264.424	264.423	264.422	264.421	264.420	264.419	264.418	264.417	264.416	264.415	264.413	264.411	264.409	264.407	264.405	264.403	264.401	264.401	264.405	264.409	264.413	264.417	264.420	264.424	264.428	264.432
CHAINAGE	-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	28.000

(Upstream at 1020m)

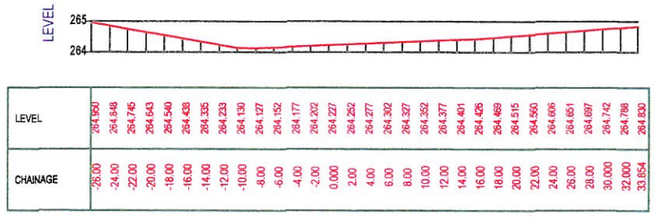
CROSS SECTION

0380

SHEET NO.-1

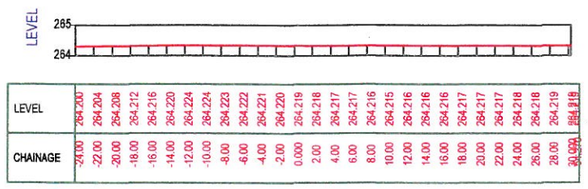
PROPOSED BRIDGE NO. BR.079(PRL_344)

Rly Km. 304/2-4, DFCC Chainage 113176



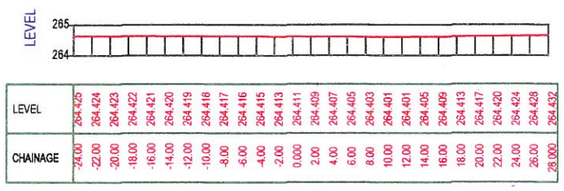
CHAINAGE	LEVEL
-26.00	264.950
-24.00	264.848
-22.00	264.745
-20.00	264.643
-18.00	264.540
-16.00	264.438
-14.00	264.335
-12.00	264.233
-10.00	264.130
-8.00	264.127
-6.00	264.152
-4.00	264.177
-2.00	264.202
0.000	264.227
2.00	264.252
4.00	264.277
6.00	264.302
8.00	264.327
10.00	264.352
12.00	264.377
14.00	264.401
16.00	264.426
18.00	264.469
20.00	264.515
22.00	264.560
24.00	264.606
26.00	264.651
28.00	264.697
30.000	264.742
32.000	264.788
33.854	264.830

(Bridge site)



CHAINAGE	LEVEL
-24.00	264.200
-22.00	264.204
-20.00	264.208
-18.00	264.212
-16.00	264.216
-14.00	264.220
-12.00	264.224
-10.00	264.224
-8.00	264.223
-6.00	264.222
-4.00	264.221
-2.00	264.220
0.000	264.219
2.00	264.218
4.00	264.217
6.00	264.217
8.00	264.216
10.00	264.215
12.00	264.216
14.00	264.216
16.00	264.216
18.00	264.217
20.00	264.217
22.00	264.217
24.00	264.218
26.00	264.218
28.00	264.219
30.000	264.218

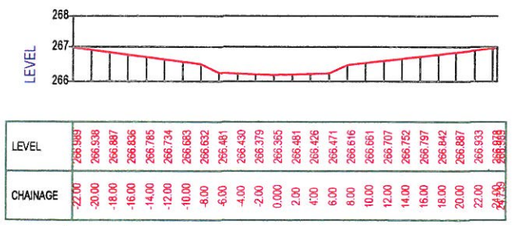
(Upstream at 500m)



CHAINAGE	LEVEL
-24.00	264.425
-22.00	264.424
-20.00	264.423
-18.00	264.422
-16.00	264.421
-14.00	264.420
-12.00	264.419
-10.00	264.418
-8.00	264.417
-6.00	264.416
-4.00	264.415
-2.00	264.413
0.000	264.411
2.00	264.409
4.00	264.407
6.00	264.405
8.00	264.403
10.00	264.401
12.00	264.405
14.00	264.409
16.00	264.413
18.00	264.417
20.00	264.420
22.00	264.424
24.00	264.428
26.00	264.432
28.000	264.432

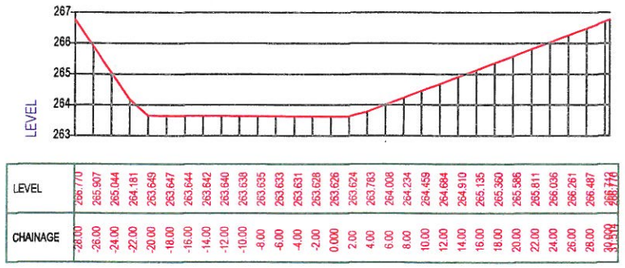
(Upstream at 1020m)

CROSS SECTION



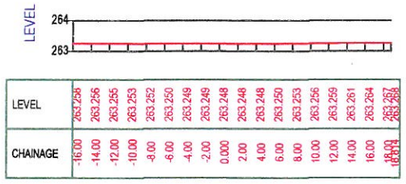
CHAINAGE	LEVEL
-22.00	266.969
-20.00	266.938
-18.00	266.887
-16.00	266.836
-14.00	266.785
-12.00	266.734
-10.00	266.683
-8.00	266.632
-6.00	266.481
-4.00	266.430
-2.00	266.379
0.000	266.365
2.00	266.481
4.00	266.426
6.00	266.471
8.00	266.616
10.00	266.661
12.00	266.707
14.00	266.752
16.00	266.797
18.00	266.842
20.00	266.887
22.00	266.933
24.00	266.978
24.155	266.978

(Downstream at 00m)



CHAINAGE	LEVEL
-28.00	266.770
-26.00	265.907
-24.00	265.044
-22.00	264.181
-20.00	263.649
-18.00	263.647
-16.00	263.644
-14.00	263.642
-12.00	263.640
-10.00	263.638
-8.00	263.635
-6.00	263.633
-4.00	263.631
-2.00	263.628
0.000	263.626
2.00	263.624
4.00	263.753
6.00	264.008
8.00	264.234
10.00	264.459
12.00	264.684
14.00	264.910
16.00	265.135
18.00	265.360
20.00	265.586
22.00	265.811
24.00	266.036
26.00	266.261
28.00	266.487
30.000	266.712
31.919	266.712

(Downstream at 550m)



CHAINAGE	LEVEL
-16.00	263.259
-14.00	263.256
-12.00	263.255
-10.00	263.253
-8.00	263.252
-6.00	263.250
-4.00	263.249
-2.00	263.249
0.000	263.248
2.00	263.248
4.00	263.248
6.00	263.250
8.00	263.253
10.00	263.256
12.00	263.259
14.00	263.261
16.00	263.264
18.00	263.268
18.000	263.268

(Downstream at 1040m)

CROSS SECTION

0381

Existing Bridge No – 345
Location – KM 304/10-12

Proposed Bridge No – 081
Location – CH: 113413

(Hydrology Details)

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

Name / No. of Proposed Bridge :	345
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 :	304/10-12
Latitude :	$30^0 33'57"$
Longitude :	$76^0 28'29"$

Catchment Area ,	**A**	=	0.376 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.121 Km
Height of Farthest Point ,	**H1**	=	267.98 m
Height of Point of Interest ,	**H2**	=	266.83 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	1.15 m
Average Bed Level		=	266.83 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 = $[L^3 / H]^{0.345}$

= **1.073 Hr**

= **64.351 Mins**

(a) t_c h Ratio = 0.35 (from Fig. 4 of RBF - 16)

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

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

= **1.033**

(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)**

= **8.43 cm**

= **84.28 mm**

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

= **78.58 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **3.284 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.376 Sq. Km	37.59 Hectares
Length of path from Toposheet,	L	=	1.121 Km	
Difference in Levels from Toposheet,	H	=	1.15 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.02 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	123.47 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	37.59 Hectares
I_c = Critical Intensity of Rainfall	12.347 cm / Hr
Q = Maximum Discharge	**5.094 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	=	0.376 Sq Km

Hence, **Q = 7.680 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)	3.284 Cumecs
Discharge by Rational Formula (IRC approach)	5.094 Cumecs
Discharge by Dicken's Formula	7.680 Cumecs
Maximum Discharge	7.680 Cumecs
Next Maximum Discharge	5.094 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **7.640 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.83 m
HFL as per site condition & local inquiry		=	268.73 m
So, Total Depth of Water,	H	=	1.90 m

Provided Two RCC BOX of 4 x 3 m span at proposed bridge site location.

Clear Waterway (provided),	L	=	8.00 m
Total Area,	A	=	15.200 m2
Velocity ,	V	=	Q / A
		=	**0.503 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 **9.932 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	1.24 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.55 m**

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

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

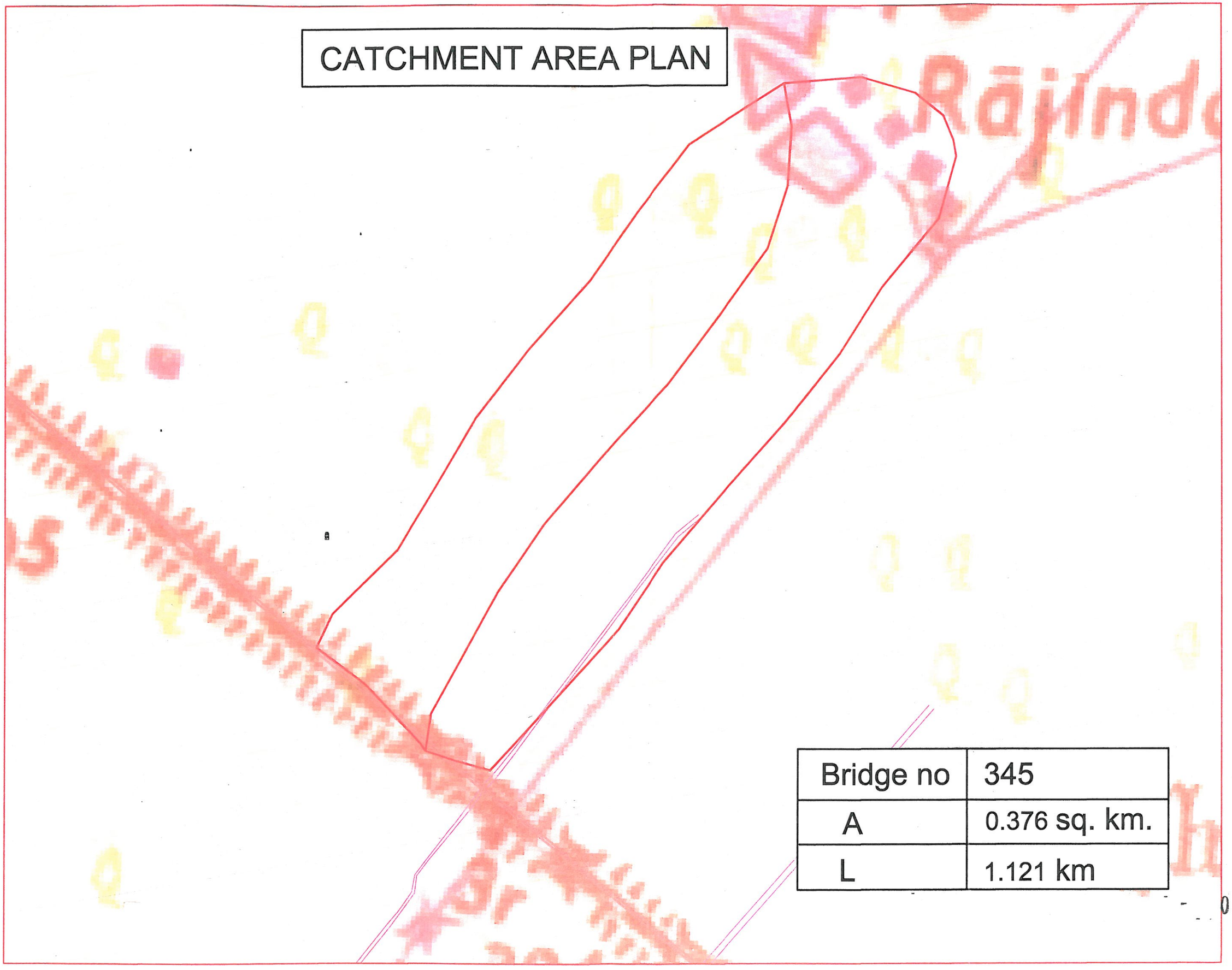
So, **Maximum Scour Depth** = **2.322 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.41 m**

CATCHMENT AREA PLAN



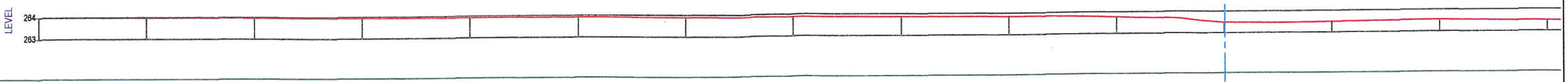
Bridge no	345
A	0.376 sq. km.
L	1.121 km

0386

PROPOSED BRIDGE NO. BR.081(PRL_345)

Rly Km. 304/10-12, DFCC Chainage 113413

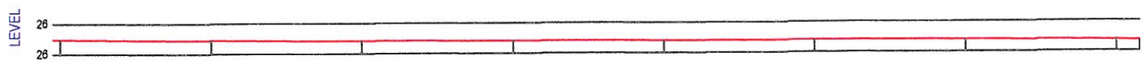
U/S C/L OF BRIDGE D/S



LEVEL	263.993	263.973	263.957	263.935	263.920	263.909	263.885	263.865	263.851	263.834	263.752	263.484	263.480	263.531	263.482
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

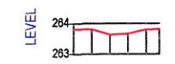
LONGITUDINAL SECTION

D/S



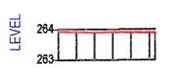
LEVEL	263.482	263.443	263.420	263.413	263.408	263.404	263.397	263.371 263.365
CHAINAGE	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00 557.732

LONGITUDINAL SECTION



LEVEL	263.910	263.914	263.624	263.247	263.773	263.611
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.465

(Bridge site)



LEVEL	263.919	263.910	263.906	263.910	263.909	263.892
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.000

(Upstream at 260m)

LEVEL	263.989	263.886	263.966	263.992	263.992	263.891
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.869

(Upstream at 535m)

CROSS SECTION

LEVEL	263.529	263.522	263.494	263.499	263.517	263.521
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	4.486

(Downstream at 00m)

LEVEL	263.435	263.425	263.421	263.420	263.442	263.466
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.567

(Downstream at 260m)

LEVEL	263.347	263.356	263.364	263.354	263.349	263.354	263.357
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.000	7.295

(Downstream at 515m)

CROSS SECTION

0387

SHEET NO.-1

Existing Bridge No – 346
Location – KM 304/18-20

Proposed Bridge No – 082
Location – CH: 113741

(Hydrology Details)

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

Name / No. of Proposed Bridge :	346
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 :	304/18-20
Latitude :	$30^0$34'5'
Longitude :	$76^0$28'12"

Catchment Area ,	A	=	0.243 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.574 Km
Height of Farthest Point ,	H1	=	267.47 m
Height of Point of Interest ,	H2	=	266.87 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.60 m
Average Bed Level		=	266.87 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 = $[L^3 / H]^{0.345}$

= **0.671 Hr**

= **40.287 Mins**

(a) t_c h Ratio = 0.27 (from Fig. 4 of RBF - 16)

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

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

= **0.792**

(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)**

= **6.46 cm**

= **64.63 mm**

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

= **96.25 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **2.604 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.243 Sq. Km	24.32 Hectares
Length of path from Toposheet,	L	=	0.574 Km	
Difference in Levels from Toposheet,	H	=	0.60 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.61 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	155.50 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	24.32 Hectares
I_c = Critical Intensity of Rainfall	15.550 cm / Hr
Q = Maximum Discharge	**4.025 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	=	0.243 Sq Km	

Hence, Q = **5.542 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)	2.604 Cumecs
Discharge by Rational Formula (IRC approach)	4.025 Cumecs
Discharge by Dicken's Formula	5.542 Cumecs
Maximum Discharge	5.542 Cumecs
Next Maximum Discharge	4.025 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **5.542 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.87 m
HFL as per site condition & local inquiry		=	268.67 m
So, Total Depth of Water,	H	=	1.80 m

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

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	5.394 m2
Velocity ,	V	=	Q / A
		=	**1.027 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 **7.204 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	2.40 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.40 m**

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

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

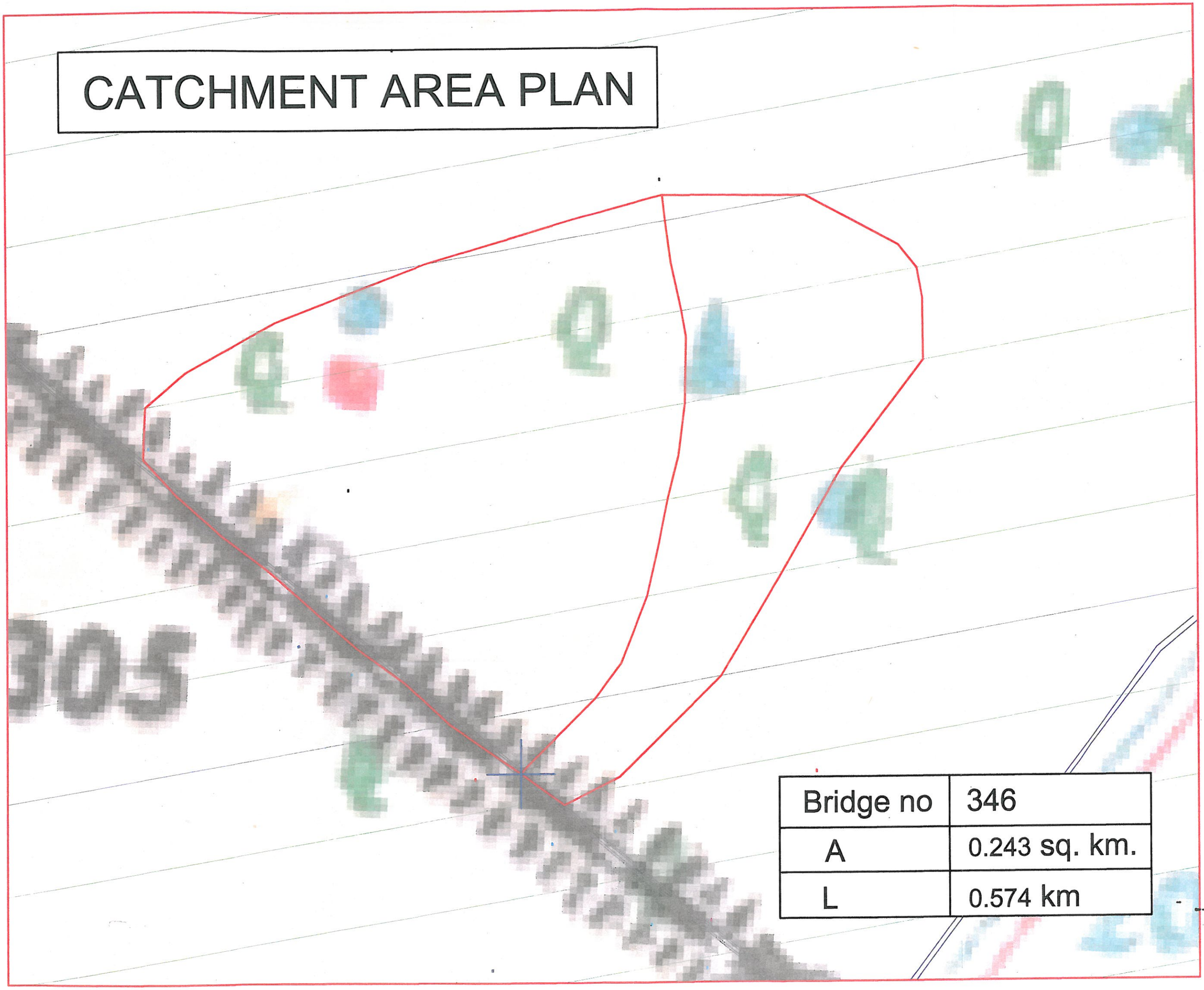
So, **Maximum Scour Depth** = **3.605 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.07 m**

CATCHMENT AREA PLAN



Bridge no	346
A	0.243 sq. km.
L	0.574 km

0392

Existing Bridge No – 347
Location – KM 305/8-10

Proposed Bridge No – 083
Location – CH: 114341

(Hydrology Details)

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

Name / No. of Proposed Bridge :	347
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 :	305/8-10
Latitude :	$30^0$34'15"
Longitude :	$76^0$28'1"

Catchment Area ,	**A**	=	0.146 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.611 Km
Height of Farthest Point ,	**H1**	=	267.03 m
Height of Point of Interest ,	**H2**	=	266.73 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.30 m
Average Bed Level		=	266.73 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 = $[L^3 / H]^{0.345}$

= **0.910 Hr**

= **54.588 Mins**

(a) t_c h Ratio = 0.32 (from Fig. 4 of RBF - 16)

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

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

= **0.942**

(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)**

= **7.69 cm**

= **76.88 mm**

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

= **84.51 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **1.372 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.146 Sq. Km	14.60 Hectares
Length of path from Toposheet,	L	=	0.611 Km	
Difference in Levels from Toposheet,	H	=	0.30 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.85 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	134.92 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	14.60 Hectares
I_c = Critical Intensity of Rainfall	13.492 cm / Hr
Q = Maximum Discharge	**2.096 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 = 0.146 Sq Km

Hence, Q = **3.779 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)	1.372 Cumecs
Discharge by Rational Formula (IRC approach)	2.096 Cumecs
Discharge by Dicken's Formula	3.779 Cumecs
Maximum Discharge	3.779 Cumecs
Next Maximum Discharge	2.096 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **3.144 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.73 m
HFL as per site condition & local inquiry		=	268.72 m
So, Total Depth of Water,	H	=	2.00 m

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

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	5.988 m2
Velocity ,	V	=	Q / A
		=	**0.525 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 **4.087 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	1.36 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.65 m**

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

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

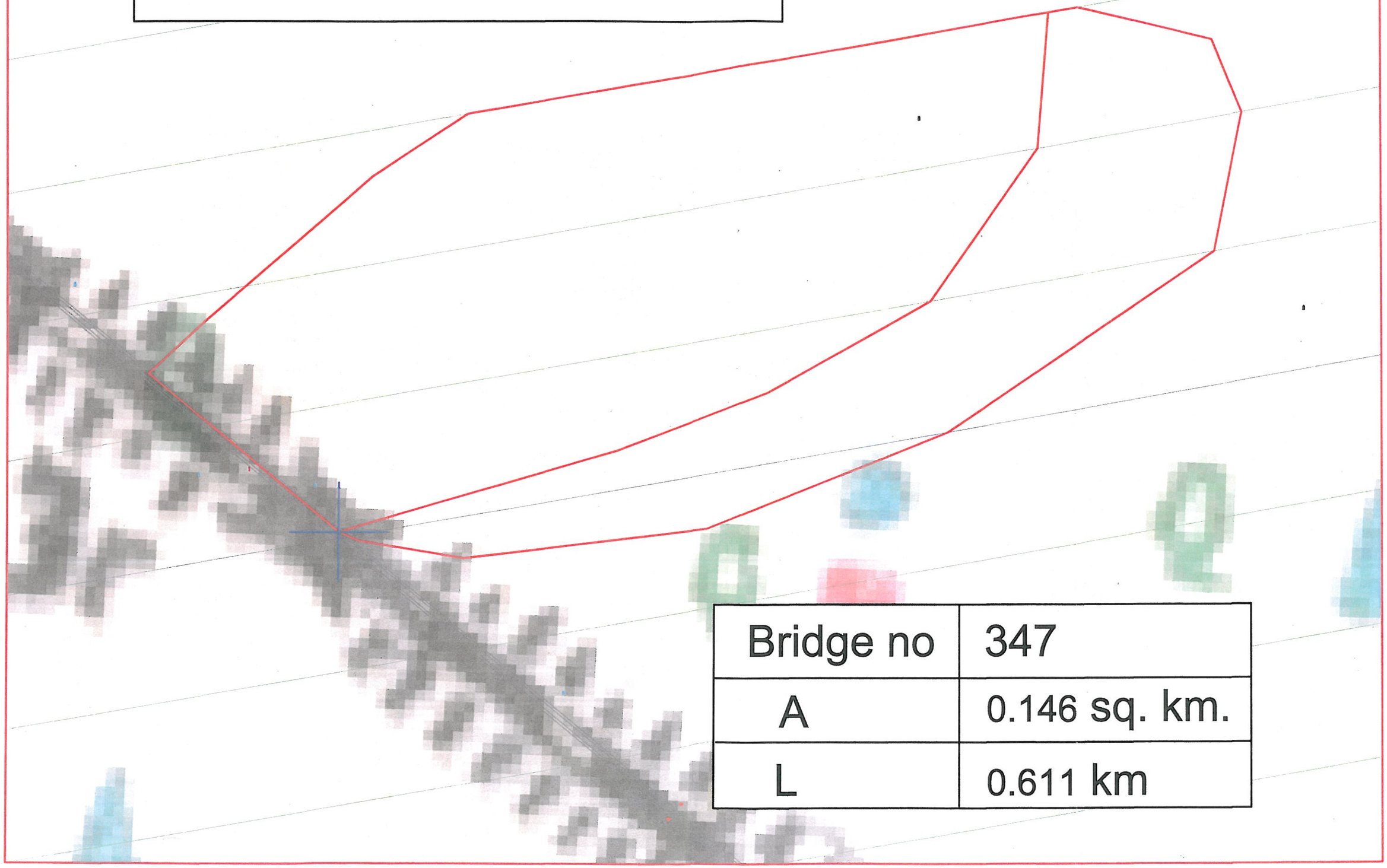
So, **Maximum Scour Depth** = **2.470 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.25 m**

CATCHMENT AREA PLAN



Bridge no	347
A	0.146 sq. km.
L	0.611 km

Existing Bridge No – 348
Location – KM 305/15-17

Proposed Bridge No – 084
Location – CH: 114637

(Hydrology Details)

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

Name / No. of Proposed Bridge :	348
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 :	305/15-17
Latitude :	$30^0$34'20"
Longitude :	$76^0$27'53"

Catchment Area ,	**A**	=	1.380 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.381 Km
Height of Farthest Point ,	**H1**	=	267.59 m
Height of Point of Interest ,	**H2**	=	266.39 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	1.20 m
Average Bed Level		=	266.39 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 = $[L^3 / H]^{0.345}$

= **1.312 Hr**

= **78.693 Mins**

(a) t_c h Ratio = 0.39 (from Fig. 4 of RBF - 16)

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

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

= **1.136**

(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)**

= **9.27 cm**

= **92.68 mm**

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

= **70.66 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **10.844 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.380 Sq. Km	138.00 Hectares
Length of path from Toposheet,	L	=	1.381 Km	
Difference in Levels from Toposheet,	H	=	1.20 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.28 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	109.52 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	138.00	Hectares
I_c = Critical Intensity of Rainfall	10.952	cm / Hr
Q = Maximum Discharge	**16.588**	**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	=	1.380	Sq Km

Hence, **Q = 20.372 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)	10.844 Cumecs
Discharge by Rational Formula (IRC approach)	16.588 Cumecs
Discharge by Dicken's Formula	20.372 Cumecs
Maximum Discharge	20.372 Cumecs
Next Maximum Discharge	16.588 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = 20.372 Cumecs

5 Linear Waterway :

Average Bed Level		=	266.39 m
HFL as per site condition & local inquiry		=	268.15 m
So, Total Depth of Water,	H	=	1.76 m

Provide 2 spans of 9.15 m at proposed site location.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	32.299 m2
Velocity ,	V	=	Q / A
		=	**0.631 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	20.372 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**

= **268.752 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 **26.483 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	1.45 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.71 m**

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

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

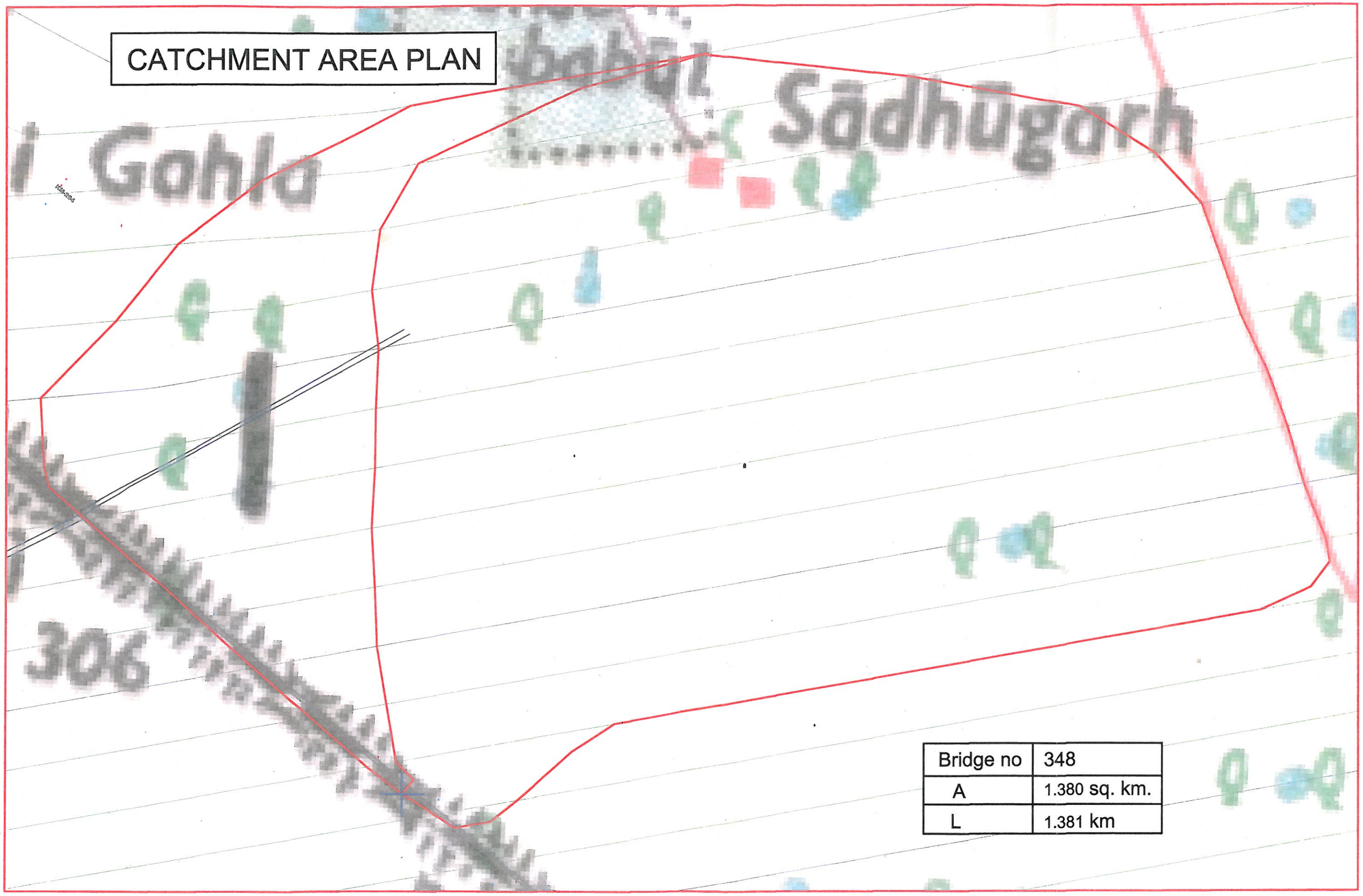
So, **Maximum Scour Depth** = **2.572 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.58 m**

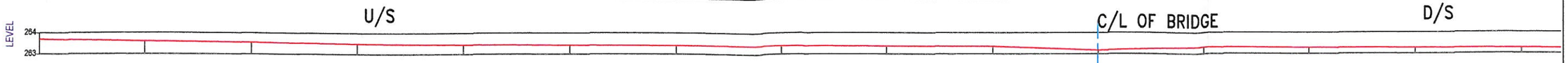
CATCHMENT AREA PLAN



Bridge no	348
A	1.380 sq. km.
L	1.381 km

PROPOSED BRIDGE NO. BR.084(PRL_348)

Rly Km. 305/15-17, DFCC Chainage 114637

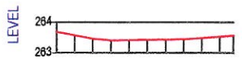


LEVEL	263.689	263.587	263.544	263.487	263.438	263.415	263.397	263.381	263.358	263.348	263.168	263.308	263.286	263.265	263.248
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00

LONGITUDINAL SECTION

LEVEL	263.248	263.220	263.148	263.100	263.096	263.070	263.052 263.049
CHAINAGE	200.00	250.00	300.00	350.00	400.00	450.00	500.00 507.116

LONGITUDINAL SECTION

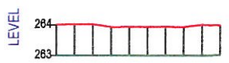


LEVEL	263.438	263.382	263.306	263.271	263.278	263.285	263.292	263.299	263.325	263.354 263.376
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00 9.524

(Bridge site)

LEVEL	263.433	263.429	263.425	263.421	263.416	263.416	263.418	263.421	263.429 263.433
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00 8.291

(Upstream at 250m)



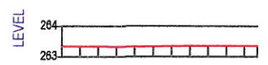
LEVEL	263.674	263.678	263.682	263.686	263.686	263.689	263.688	263.686	263.666	263.647
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.695

(Upstream at 500m)

CROSS SECTION

LEVEL	263.359	263.358	263.356	263.353	263.354	263.357	263.360	263.358	263.351	263.347
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	8.722

(Upstream at 00m)



LEVEL	263.225	263.222	263.220	263.217	263.217	263.222	263.227	263.232	263.236	263.236 263.235
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00 10.00 11.414

(Upstream at 250m)

LEVEL	263.044	263.045	263.047	263.048	263.049	263.049	263.050	263.050	263.049	263.049	263.048 263.048
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 11.180

(Upstream at 500m)

CROSS SECTION

0403

SHEET NO.-1

Existing Bridge No – 349
Location – KM 305/21-23

Proposed Bridge No – 085
Location – CH: 114840

(Hydrology Details)

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

Name / No. of Proposed Bridge :			349
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 :			305/21-23
Latitude :			$30^0$34'24"
Longitude :			$76^0$27'47"
Catchment Area ,	A	=	0.313 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.970 Km
Height of Farthest Point ,	H1	=	267.05 m
Height of Point of Interest ,	H2	=	266.35 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.70 m
Average Bed Level		=	266.35 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 = $[L^3 / H]^{0.345}$

= **1.096 Hr**

= **65.751 Mins**

(a) t_c h Ratio = 0.35 (from Fig. 4 of RBF - 16)

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

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

= **1.042**

(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)**

= **8.51 cm**

= **85.06 mm**

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

= **77.62 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **2.702 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.313 Sq. Km	31.30 Hectares
Length of path from Toposheet,	L	=	0.970 Km	
Difference in Levels from Toposheet,	H	=	0.70 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.05 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	121.97 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	31.30 Hectares
I_c = Critical Intensity of Rainfall	12.197 cm / Hr
Q = Maximum Discharge	**4.062 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	=	0.313 Sq Km

Hence, Q = **6.695 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)	2.702 Cumecs
Discharge by Rational Formula (IRC approach)	4.062 Cumecs
Discharge by Dicken's Formula	6.695 Cumecs
Maximum Discharge	6.695 Cumecs
Next Maximum Discharge	4.062 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **6.093 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.35 m
HFL as per site condition & local inquiry		=	268.55 m
So, Total Depth of Water,	H	=	2.20 m

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

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	13.200 m2
Velocity ,	V	=	Q / A
		=	**0.462 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 **7.921 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	1.32 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.61 m**

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

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

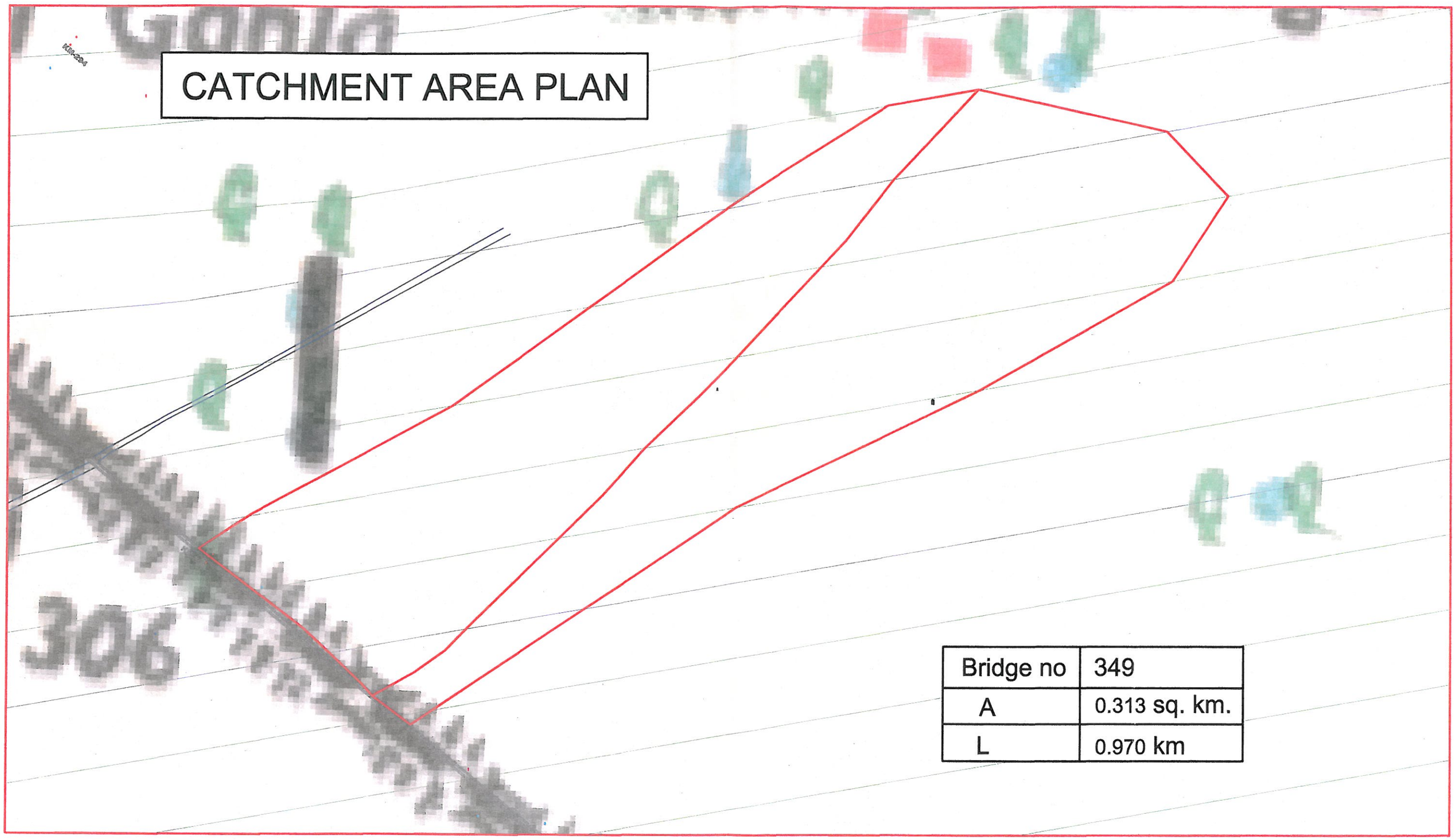
So, **Maximum Scour Depth** = **2.419 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.13 m**

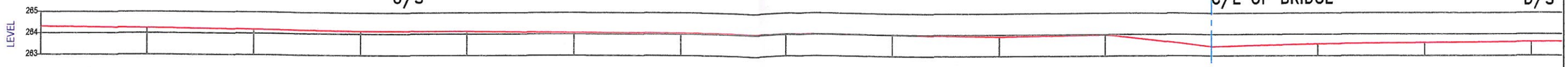
CATCHMENT AREA PLAN



Bridge no	349
A	0.313 sq. km.
L	0.970 km

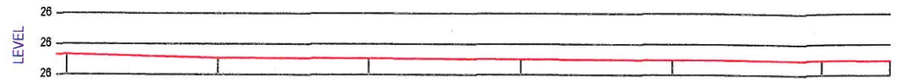
PROPOSED BRIDGE NO. BR.085(PRL_349)

Rly Km. 305/21-24, DFCC Chainage 114840



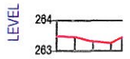
LEVEL	264.300	264.232	264.181	264.134	264.126	264.065	264.049	264.016	264.000	263.961	263.985	263.433	263.546	263.597	263.643
CHAINAGE	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00

LONGITUDINAL SECTION



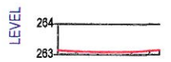
LEVEL	263.659	263.545	263.528	263.504	263.483	263.471	263.466
CHAINAGE	200.00	250.00	300.00	350.00	400.00	450.00	472.729

LONGITUDINAL SECTION



LEVEL	263.313	263.310	263.205	263.176	263.300
CHAINAGE	-4.00	-2.00	0.000	2.00	5.295

(Bridge site)



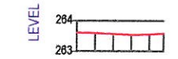
LEVEL	264.089	264.074	264.060	264.061	264.066	264.086
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00

(Upstream at 250m)

LEVEL	264.347	264.330	264.311	264.317
CHAINAGE	-4.00	-2.00	0.000	2.00

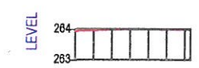
(Upstream at 500m)

CROSS SECTION



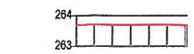
LEVEL	263.400	263.391	263.375	263.356	263.362	263.387
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.587

(Downstream at 00m)



LEVEL	263.625	263.640	263.654	263.657	263.658	263.659
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00

(Downstream at 250m)



LEVEL	263.463	263.464	263.465	263.466	263.465	263.464	263.463
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.000

(Downstream at 515m)

CROSS SECTION

0409

SHEET NO.-1

Existing Bridge No – 350
Location – KM 306/3-5

Proposed Bridge No – 086
Location – CH: 115254

(Hydrology Details)

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

Name / No. of Proposed Bridge :	350
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 :	306/3-5
Latitude :	$30^0$34'33"
Longitude :	$76^0$27'34"

Catchment Area ,	**A**	=	0.364 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.953 Km
Height of Farthest Point ,	**H1**	=	267.17 m
Height of Point of Interest ,	**H2**	=	266.57 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.60 m
Average Bed Level		=	266.57 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

0410

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

= **1.135 Hr**

= **68.085 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 = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.054**

(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)**

= **8.60 cm**

= **86.03 mm**

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

= **75.82 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **3.069 Cumecs**

0411

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.364 Sq. Km	36.40 Hectares
Length of path from Toposheet,	L	=	0.953 Km	
Difference in Levels from Toposheet,	H	=	0.60 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.09 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	119.54 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	36.40 Hectares
I_c = Critical Intensity of Rainfall	11.954 cm / Hr
Q = Maximum Discharge	**4.630 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	=	0.364	Sq Km

Hence, **Q = 7.498 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)	3.069 Cumecs
Discharge by Rational Formula (IRC approach)	4.630 Cumecs
Discharge by Dicken's Formula	7.498 Cumecs
Maximum Discharge	7.498 Cumecs
Next Maximum Discharge	4.630 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **6.944 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.57 m
HFL as per site condition & local inquiry		=	268.57 m
So, Total Depth of Water,	H	=	2.00 m

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

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	12.000 m2
Velocity ,	V	=	Q / A
		=	**0.579 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 **9.028 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	1.50 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.76 m**

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

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

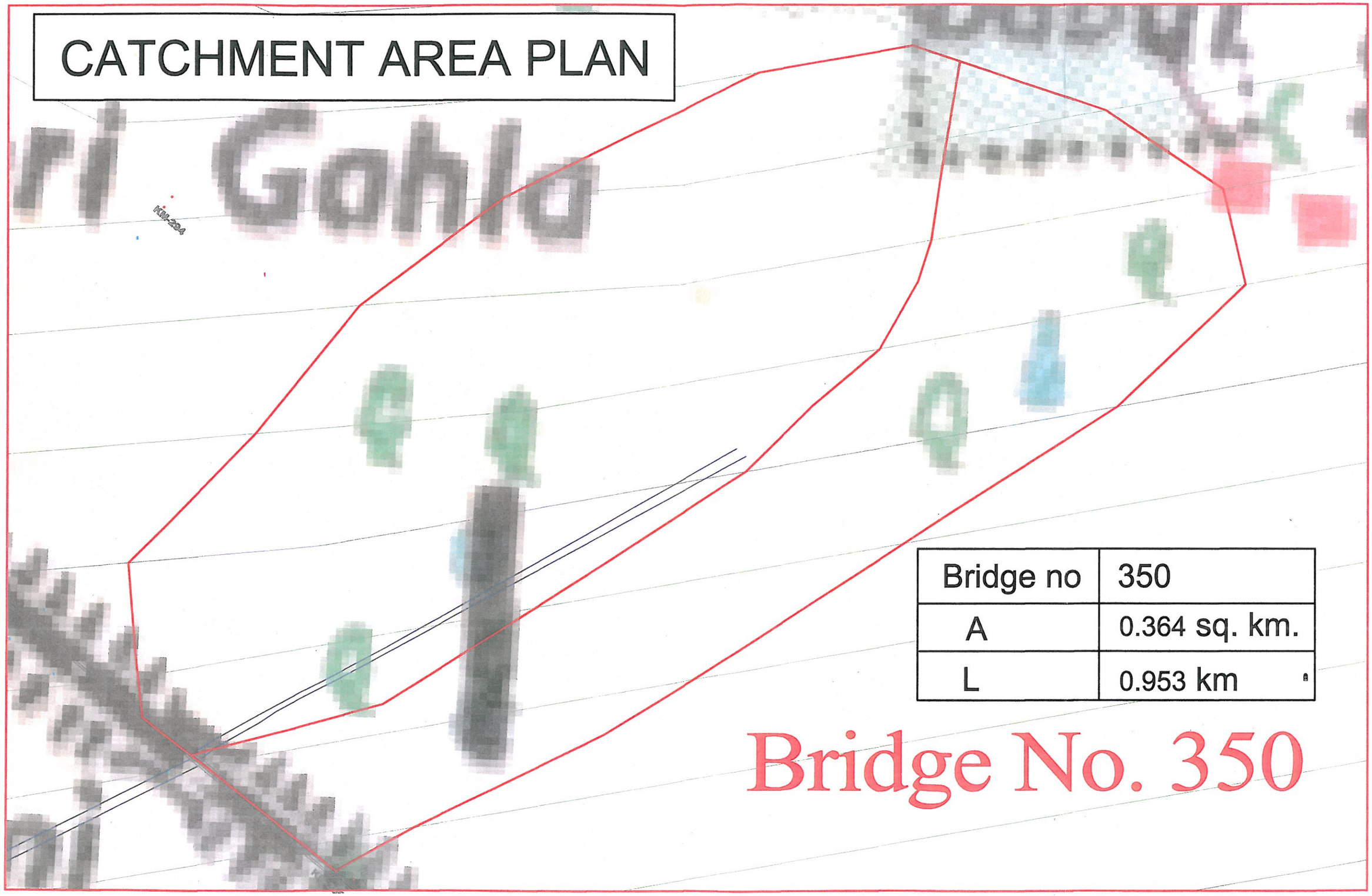
So, **Maximum Scour Depth** = **2.639 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.93 m**

CATCHMENT AREA PLAN



Bridge no	350
A	0.364 sq. km.
L	0.953 km

Bridge No. 350

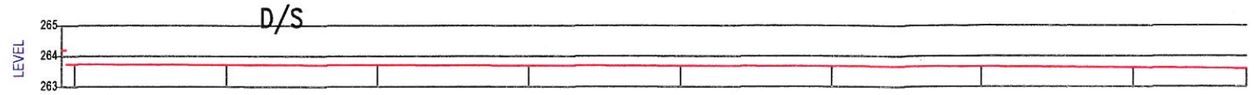
0414

PROPOSED BRIDGE NO. BR.086(PRL_350)

Rly Km. 306/3-5, DFCC Chainage 115254

LEVEL	264.206	264.252	264.311	264.363	264.375	264.363	264.275	264.175	264.057	263.989	264.071	264.014	263.800	263.740	263.731
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	200.00

LONGITUDINAL SECTION



LEVEL	263.731	263.720	263.704	263.689	263.680	263.673	263.658	263.626	263.588
CHAINAGE	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.00	587.595

LONGITUDINAL SECTION

LEVEL	264.135	263.632	263.591
CHAINAGE	-4.00	-2.00	0.000

(Bridge site)

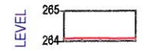
LEVEL	264.340	264.335	264.337
CHAINAGE	-4.00	-2.00	0.000

(Upstream at 250m)

LEVEL	264.236	264.200	264.203	264.205	264.209	264.213
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00

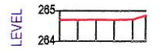
(Upstream at 520m)

CROSS SECTION



LEVEL	264.059	264.065	264.065	264.060
CHAINAGE	-4.00	-2.00	0.000	2.00

(Downstream at 00m)



LEVEL	263.693	263.696	263.700	263.694	263.709
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00

(Downstream at 270m)

LEVEL	263.582	263.584	263.587	263.585
CHAINAGE	-6.00	-4.00	-2.00	0.000

(Downstream at 545m)

CROSS SECTION

0415

SHEET NO.-1

Existing Bridge No – 351
Location – KM 306/11-13

Proposed Bridge No – 087
Location – CH: 115550

(Hydrology Details)

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

Name / No. of Proposed Bridge :	351
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 :	306/11-13
Latitude :	$30^0$34'37"
Longitude :	$76^0$27'26"

Catchment Area ,	**A**	=	4.042 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	3.539 Km
Height of Farthest Point ,	**H1**	=	269.95 m
Height of Point of Interest ,	**H2**	=	266.95 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	3.00 m
Average Bed Level		=	266.95 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 = $[L^3 / H]^{0.345}$

= **2.532 Hr**

= **151.927 Mins**

(a) t_c h Ratio = 0.51 (from Fig. 4 of RBF - 16)

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

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

= **1.495**

(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)**

= **12.20 cm**

= **121.99 mm**

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

= **48.18 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **21.654 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	4.042 Sq. Km	404.20 Hectares
Length of path from Toposheet,	L	=	3.539 Km	
Difference in Levels from Toposheet,	H	=	3.00 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		2.67 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	68.07 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	404.20	Hectares
I_c = Critical Intensity of Rainfall	6.807	cm / Hr
Q = Maximum Discharge	**30.198**	**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	=	4.042	Sq Km

Hence, **Q = 45.611 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)	21.654 Cumecs
Discharge by Rational Formula (IRC approach)	30.198 Cumecs
Discharge by Dicken's Formula	45.611 Cumecs
Maximum Discharge	45.611 Cumecs
Next Maximum Discharge	30.198 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **45.296 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.95 m
HFL as per site condition & local inquiry		=	268.50
So, Total Depth of Water,	H	=	1.55 m

Provide 5 spans of 6.1 m at proposed bridge site location.

Clear Waterway (provided),	L	=	30.50 m
Total Area,	A	=	47.275 m2
Velocity ,	V	=	Q / A
		=	**0.958 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	45.296 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		=	0.632 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = HFL + Vertical Clearance

= **269.402 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 **58.885 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	1.93 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.08 m**

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

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

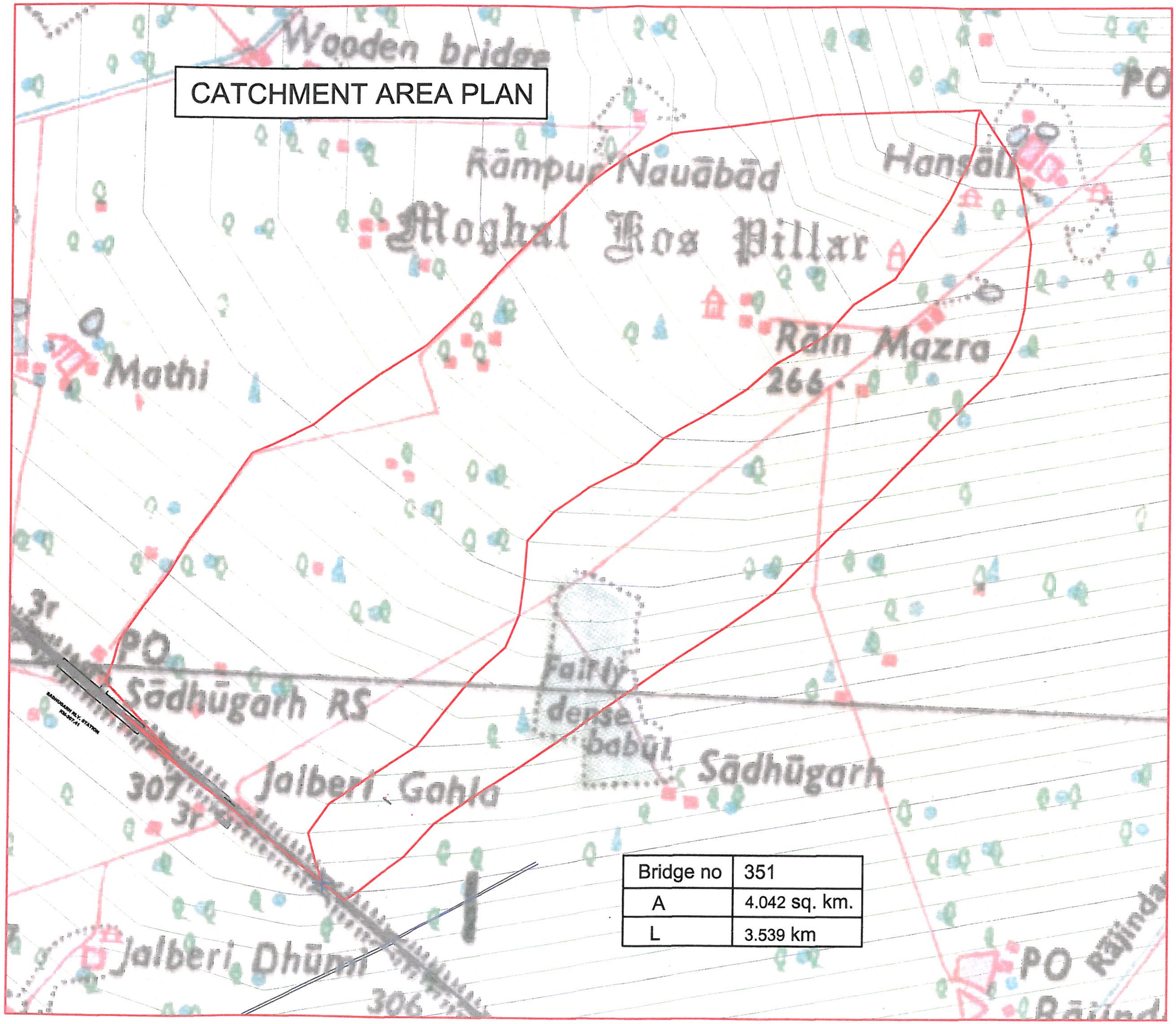
So, **Maximum Scour Depth** = **3.117 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.39 m**

CATCHMENT AREA PLAN



Bridge no	351
A	4.042 sq. km.
L	3.539 km

0420

PROPOSED BRIDGE NO. BR.087(PRL_351)
Rly Km. 306/12-14, DFCC Chainage 115550

U/S

U/S

	263.660	263.676	263.682	263.688	263.695	263.700	263.701	263.702	263.705	263.709	263.723	263.729	263.742	263.760	263.777
	-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	-300.00

LONGITUDINAL SECTION

U/S C/L OF BRIDGE D/S

LEVEL 26 26

LEVEL	263.827	263.906	263.867	263.896	263.791	263.620	263.613	263.590	263.578	263.560	263.534	263.514	263.501	263.486	263.469
CHAINAGE	-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

LONGITUDINAL SECTION

D/S

LEVEL 26 26

LEVEL	263.467	263.465	263.463	263.461	263.460	263.458	263.455	263.450	263.448
CHAINAGE	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000

LONGITUDINAL SECTION

LEVEL 264

LEVEL	264.436	264.267	264.078	264.042	264.044	264.046	264.048	264.045	264.041	264.037	264.032	264.028	264.051	264.149	264.248	264.345
CHAINAGE	-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	13.960

(Bridge site)

LEVEL 264 263

LEVEL	263.745	263.737	263.729	263.721	263.714	263.711	263.711	263.712	263.713	263.714	263.715	263.714	263.714	263.713	263.713	263.712
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	16.000

(Upstream at 500m)

LEVEL 264 263

LEVEL	263.645	263.645	263.644	263.644	263.643	263.643	263.642	263.641	263.640	263.640	263.642	263.643	263.644	263.644	263.644	263.644
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	13.887		

(Upstream at 1000m)

CROSS SECTION

LEVEL 284 263

LEVEL	263.917	263.924	263.930	263.937	263.942	263.943	263.945	263.947	263.948	263.950	263.952	263.955	263.959	263.962	263.960	263.960
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	16.000

(Downstream at 00m)

LEVEL 264 263

LEVEL	263.478	263.476	263.475	263.473	263.471	263.470	263.471	263.473	263.474	263.475	263.475	263.476	263.477	263.478	263.478	263.478
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	16.000

(Downstream at 510m)

LEVEL 264 263

LEVEL	263.451	263.451	263.450	263.450	263.449	263.449	263.448	263.448	263.448	263.448	263.448	263.447	263.447	263.447	263.447	263.446
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	16.000

(Downstream at 1030m)

CROSS SECTION

0421

SHEET NO.-1

Existing Bridge No – 352
Location – KM 307/5-7

Proposed Bridge No – 088
Location – CH: 116215

(Hydrology Details)

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

Name / No. of Proposed Bridge :	352
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 :	307/5-7
Latitude :	$30^0$34'52"
Longitude :	$76^0$27'5"

Catchment Area ,	A	=	0.235 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.675 Km
Height of Farthest Point ,	H1	=	267.00 m
Height of Point of Interest ,	H2	=	266.50 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.50 m
Average Bed Level		=	266.50 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 = $[L^3 / H]^{0.345}$

= **0.846 Hr**

= **50.735 Mins**

(a) t_c h Ratio = 0.31 (from Fig. 4 of RBF - 16)

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

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

= **0.909**

(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)**

= **7.41 cm**

= **74.15 mm**

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

= **87.69 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **2.293 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.235 Sq. Km	23.51 Hectares
Length of path from Toposheet,	L	=	0.675 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.79 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	139.98 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	23.51 Hectares
I_c = Critical Intensity of Rainfall	13.998 cm / Hr
Q = Maximum Discharge	**3.502 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	=	0.235 Sq Km

Hence, **Q = 5.403 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)	2.293 Cumecs
Discharge by Rational Formula (IRC approach)	3.502 Cumecs
Discharge by Dicken's Formula	5.403 Cumecs
Maximum Discharge	5.403 Cumecs
Next Maximum Discharge	3.502 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **5.253 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.50 m
HFL as per site condition & local inquiry		=	268.00 m
So, Total Depth of Water,	H	=	1.50 m

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

Clear Waterway (provided),	L	=	3.00 m
Total Area,	A	=	9.000 m2
Velocity ,	V	=	Q / A
		=	**0.584 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 **6.829 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	2.28 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.32 m**

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

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

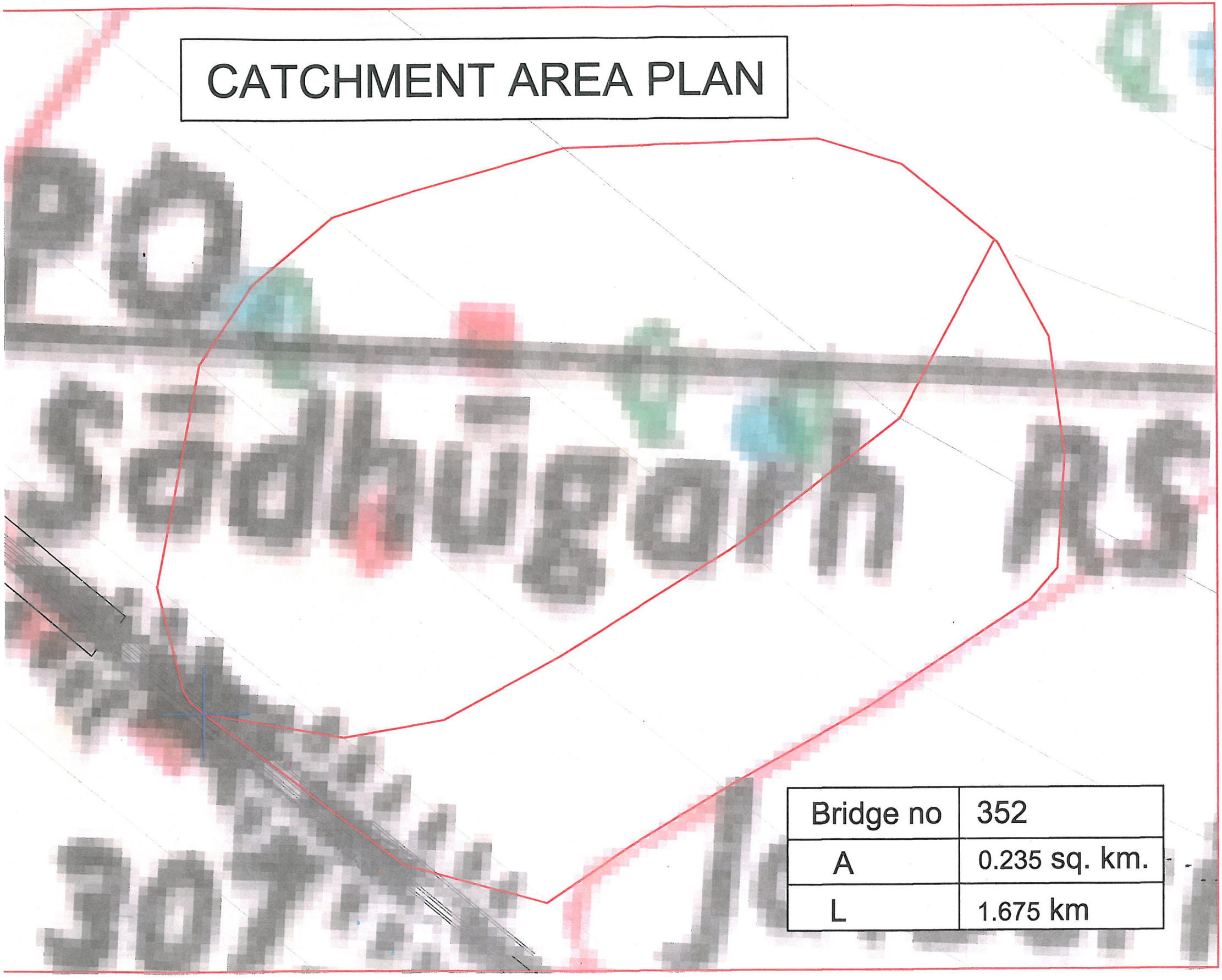
So, **Maximum Scour Depth** = **3.478 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **264.52 m**

CATCHMENT AREA PLAN



Bridge no	352
A	0.235 sq. km.
L	1.675 km

0426

Existing Bridge No – 353
Location – KM 307/24-26

Proposed Bridge No – 089
Location – CH: 116770

(Hydrology Details)

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

Name / No. of Proposed Bridge :	353
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 :	307/24-26
Latitude :	$30^0$35'3"
Longitude :	$76^0$26'48"

Catchment Area ,	**A**	=	0.240 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.556 Km
Height of Farthest Point ,	**H1**	=	267.05 m
Height of Point of Interest ,	**H2**	=	266.65 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.40 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

0427

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 :

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

= **0.747 Hr**

= **44.833 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 = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **0.850**

(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)**

= **6.94 cm**

= **69.40 mm**

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

= **92.88 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **2.476 Cumecs**

0428

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.240 Sq. Km	23.97 Hectares
Length of path from Toposheet,	L	=	0.556 Km	
Difference in Levels from Toposheet,	H	=	0.40 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.68 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	148.40 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	23.97 Hectares
I_c = Critical Intensity of Rainfall	14.840 cm / Hr
Q = Maximum Discharge	**3.905 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	=	0.240	Sq Km

Hence, Q = **5.482 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)	2.476 Cumecs
Discharge by Rational Formula (IRC approach)	3.905 Cumecs
Discharge by Dicken's Formula	5.482 Cumecs
Maximum Discharge	5.482 Cumecs
Next Maximum Discharge	3.905 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **5.482 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.65 m
HFL as per site condition & local inquiry		=	267.45 m
So, Total Depth of Water,	H	=	0.80 m

Provide 2 spans of 3.66 m at bridge site location.

Clear Waterway (provided),	L	=	7.32 m
Total Area,	A	=	5.856 m2
Velocity ,	V	=	Q / A
		=	**0.936 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	5.482 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**

= **268.052 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 **7.126 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	0.97 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.32 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}**

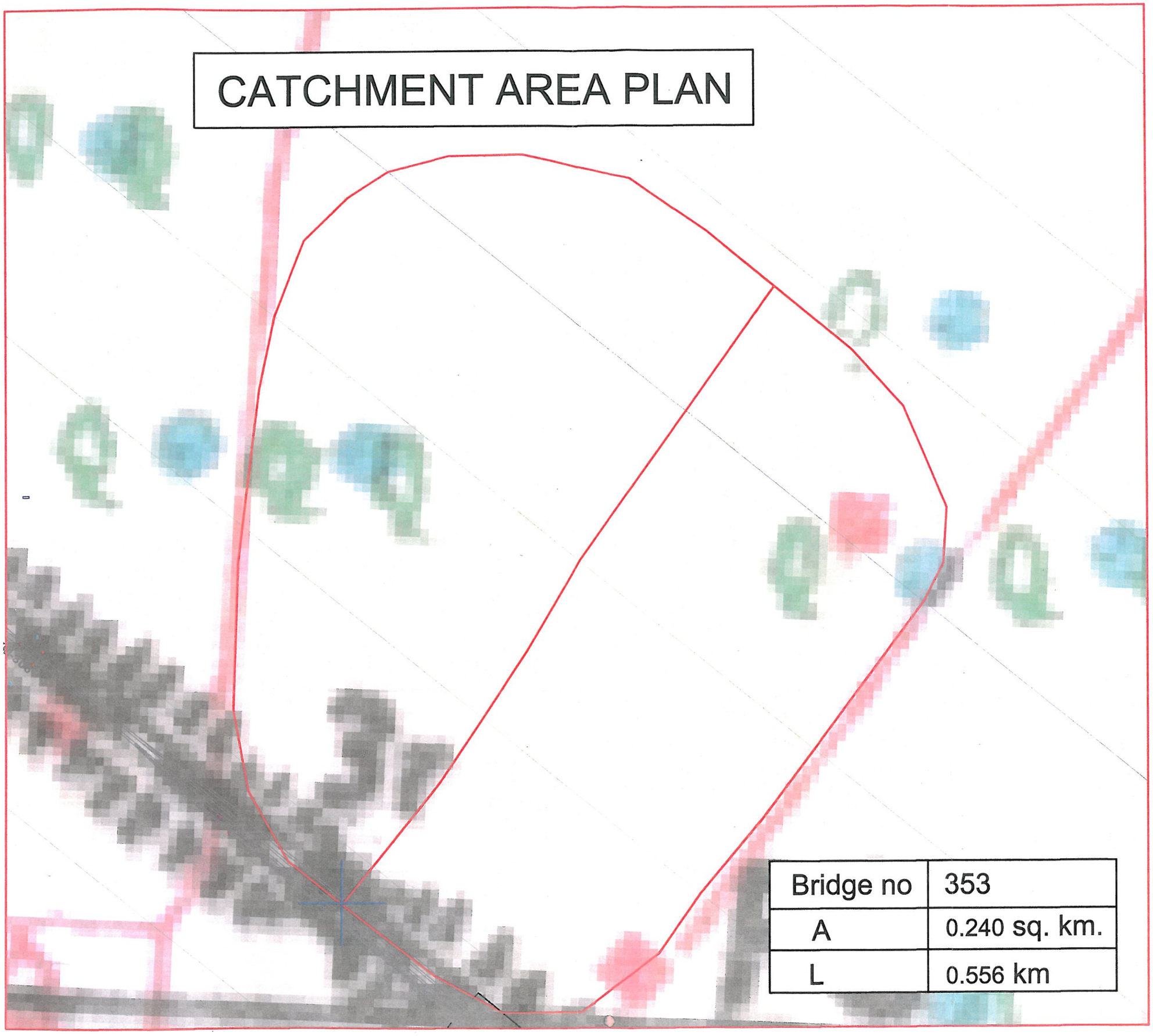
So, **Maximum Scour Depth** = **1.974 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.48 m**

CATCHMENT AREA PLAN



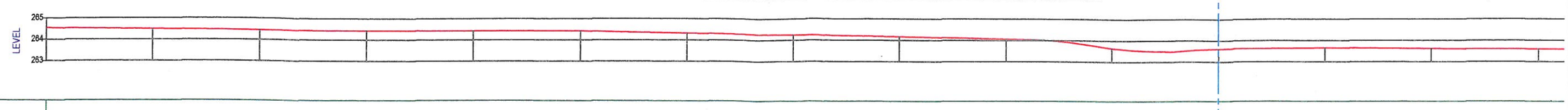
Bridge no	353
A	0.240 sq. km.
L	0.556 km

0431

PROPOSED BRIDGE NO. BR.089(PRL_353)

Rly Km. 307/24-26, DFCC Chainage 116770

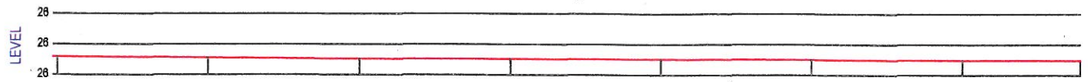
U/S C/L OF BRIDGE D/S



LEVEL	264.538	264.482	264.437	264.428	264.419	264.415	264.319	264.242	264.165	264.047	263.637	263.605	263.644	263.611	263.589
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

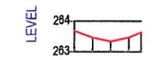
LONGITUDINAL SECTION

D/S



LEVEL	263.589	263.555	263.519	263.520	263.518	263.500	263.488	263.487
CHAINAGE	150.00	200.00	250.00	300.00	350.00	400.00	450.00	490.422

LONGITUDINAL SECTION



LEVEL	263.458	263.395	263.220	263.314	263.421
CHAINAGE	-4.00	-2.00	0.000	2.00	3.352

(Bridge site)

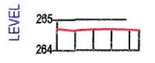
LEVEL	264.413	264.414	264.415	264.408	264.407	264.410
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.559

(Upstream at 260m)

LEVEL	264.548	264.550	264.538	264.538	264.538
CHAINAGE	-4.00	-2.00	0.000	2.00	3.559

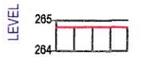
(Upstream at 510m)

CROSS SECTION



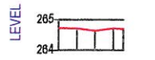
LEVEL	263.468	263.430	263.453	263.458	263.442	263.433
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.008

(Downstream at 00m)



LEVEL	263.520	263.518	263.524	263.524	263.515
CHAINAGE	-4.00	-2.00	0.000	2.00	3.674

(Downstream at 260m)



LEVEL	263.476	263.469	263.466	263.468	263.468
CHAINAGE	-4.00	-2.00	0.000	2.00	4.115

(Downstream at 510m)

CROSS SECTION

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SHEET NO.-1