डेडीकेटेड फ्रेट कोरीडोर

DESIGN AND CONSTRUCTION OF CIVIL, STRUCTURES AND TRACK WORKS FOR SINGLE LINE RAILWAY INVOLVING FORMATION IN EMBANKMENTS/CUTTINGS, BALLAST ON FORMATION, TRACK WORKS, BRIDGES, STRUCTURES, BUILDINGS, YARDS, INTEGRATION WITH IR EXISTING RAILWAY SYSTEM AND TESTING & COMMISSIONING ON DESIGN-BUILD LUMP SUM BASIS FOR SAHNEWAL - PILKHANI SECTION OF EASTERN DEDICATED FREIGHT CORRIDOR

Contract Package: 301

ICB No. HQ/EN/EC/D-B/SAHNEWAL - PILKHANI

PART - 4 - REFERENCE DOCUMENT

HYDRAULIC DATA - VOLUME - 4

SAHNEWAL TO PILKHANI

From Km. 360.200 to Km. 187.500

HYDRAULIC DATA

Vol. 2/2

EMPLOYER
DEDICATED FREIGHT CORRIDOR CORPORATION OF INDIA LIMITED
(A GOVERNMENT OF INDIA ENTERPRISES)
MINISTRY OF RAILWAYS
COUNTRY : INDIA

Hydraulic Data for Contract Package 301					
Sr. No.	Chainage	Exist. No.	IR KM	Prop. No.	Page Numbers
1	Methodology				0001-0008
2	119330	237	190/11-13	5	0009-0012
3	4030.336	241	195/29 - 196/1	9	0013-0016
4	5866.009	242	197/23-25	10	0017-0020
5	21013.359	253	212/33-35	23	0021-0024
6	27676.071	259	219/17-19	31	0025-0029
7	29000	260	221/5-7	32	0030-0034
8	32467.577	263	224/9-11	35	0035-0039
9	36864.174	268	228/25-29	40	0040-0049
10	44086.609	276	235/29-31	48	0050-0054
11	46669.462	279	238/15-17	51	0055-0058
12	56653	287	248/15-17	59	0059-0064
13	59410	289	251/5-7	60	0065-0071
14	61240	290	253/1-3	61	0072-0078
15	62017	291	253/23-25	62	0079-0085
16	62309	292	254/5-7	63	0086-0091
17	64372	293	256/5-9	64	0092-0098
18	65481	294	257/7-13	65	0099-0110
19	72637	299	263/21-23	74	0111-0116
20	73445	300	264/21-23	75	0117-0122
21	73695	301	264/33-35	76	0123-0128
22	75644	302	266/19-21	77	0129-0133
23	76908	304	267/25-27	79	0134-0139
24	78984	309	269/29-31	83	0140-0144
25	79952	311	270/33-35	87	0145-0150
26	80744	312	271/19-21	89	0151-0156
27	80763	312 New	271/19-21	90	0157-0161
28	82722	313	273/21-29	91	0162-0182
29	84355	314 A	275/1-7	92	0183-0188
30	84206	314	275/7-9	93	0189-0194
31	84550	314 B	275/13-15	94	0195-0200
32	86275	315	277/7-9	95	0201-0207
33	87150	316	278/3-5	96	0208-0214
34	89680	319	280/17-19	99	0215-0220
35	90105	320	281/1-3	100	0221-0226
36	92000	322	282/27-283/1	102	0227-0232
37	94473	323	285/13-15	104	0233-0237B
38	94850	324	285/25-27	107	0238-0242
39	96263	324 A	287/5-7	111	0243-0248
40	96433	324 B	287/11-13	112	0249-0254
41	96688	325 (2-D-7)	287/17-25	114	0255-0266
42	100564	326	291/16-18	121	0267-0272
43	100835	327	291/24-26	122	0273-0278
44	101086	328	291/32-292/2	123	0279-0284
45	102518	329	293/12-14	124	0285-0291
46	103190	330	294/4-6	125	0292-0297
47	103563	331	294/14-18	126	0298-0303
48	104372	332	295/8-10	127	0305-0310
49	104574	333	295/14-16	128	0311-0316
50	106823	334	297/22-24	130	0317-0323
51	108072	335	298/34-36	131	0324-0329
52	109307	337	300/7-9		0330-0335
53	109654	338	300/18-20	134	0336-0343
54	110723	339	301/20-22	135	0344-0350
55	110979	340	301/28-30	136	0351-0356
56	111543	341	302/14-16	137	0357-0362
57	112435	342	303/12-14	138	0363-068
58	112930	343	303/26-28	139	0369-0374
59	113176	344	304/2-4	140	0375-0381
60	113413	345	304/10-12	142	0382-0387
61	113741	346	304/18-20	143	0388-0392
62	114341	347	305/8-10	144	0393-0397

Hydraulic Data for Contract Package 301					
Sr. No.	Chainage	Exist. No.	IR KM	Prop. No.	Page Numbers
63	114637	348	305/16-18	145	0398-0403
64	114840	349	305/22-24	146	0404-0409
65	115254	350	306/4-6	147	0410-0415
66	115550	351	306/12-14	148	0416-0421
67	116215	352	307/6-8	149	0422-0426
68	116770	353	307/24-26	150	0427-0432
69	118668	354	309/18-20	152	0433-0438
70	119243	355	310/4-6	154	0439-0444
71	119841	355 A	310/22-24	153	0445-0450
72	120688	356	311/18-20	155	0451-0456
73	121275	356 A	312/6-8	156	0457-0462
74	122090	357	312/30-32	157	0463-0468
75	122805	358	313/20-22	158	0469-0474
76	125700	Detour (3-D-4)	Sirhind Detour	163	0475-0485
77	131393	362	320/26-28	171	0486-0491
78	132402	363	321/28-30	172	0492-0497
79	139140	366	328/15-17	176	0498-0503
80	147247	370	336/19-21	183	0504-0508
81	148704	371	338/3-5	184	0509-0514
82	150823	372	340/7-9	185	0515-0520
83	151200	373	340/17-19	186	0521-0526
84	152014	375	341/13-15	188	0527-0532
85	159390	377	348/25-27	191	0533-0538
86	159595	378	348/31-349/1	192	0539-0543
87	163211	383	352/21-23	197	0544-0548
88	164481	384	353/33-35	198	0549-0554

Existing Bridge No – 331
Location – KM 294/13-17

Proposed Bridge No – 064
Location – CH: 103563

(Hydrology Details)

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

Name / No. of Proposed Bridge :		331	
Name of Nallah / Stream / River :		Local Stream	
River Sub - Zone :		Upper Indo- Ganga Plains 1 (e)	
G.T Sheet No :		53 B / 10	
Scale :		1 : 50,000	
Location :		294/13-17	
Latitude :		$30^0 30' 58''$	Approx.
Longitude :		$76^0 32' 57''$	Approx.
Catchment Area ,	**A**	=	20.241 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	6.692 Km
Height of Farthest Point ,	**H1**	=	275.95 m
Height of Point of Interest ,	**H2**	=	267.55 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	8.40 m
Average Bed Level		=	267.55 m

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

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

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

0298

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 :

$t_c = [L^3/H]^{0.385}$

= 3.432 Hr

= 205.933 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 $R_{50}(1)$

= 12.64 cm

= 128.40 mm

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

= 37.41 mm / Hr

(iv) Design Flood Discharge :

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

Q_{50} = 84.201 Cumecs

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	20.241 Sq. Km	2024.06 Hectares
Length of path from Toposheet,	L	=	6.692 Km	
Difference in Levels from Toposheet,	H	=	8.40 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)	$t_c = (0.87 \times L^3/H)^{0.385}$		3.75 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2/(1+t_c)]$	=	52.60 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	2024.06 Hectares
I_c = Critical Intensity of Rainfall	5.260 cm / Hr
Q = Maximum Discharge	116.852 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	=	20.241 Sq Km

Hence, Q = 152.682 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)	84.201 Cumecs
Discharge by Rational Formula (IRC approach)	116.852 Cumecs
Discharge by Dicken's Formula	152.682 Cumecs
Maximum Discharge	152.682 Cumecs
Next Maximum Discharge	116.852 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = 152.682 Cumecs

5 Linear Waterway :

Average Bed Level		=	267.55 m
HFL as per site condition & local inquiry		=	269.05 m
So, Total Depth of Water,	H	=	1.50 m

Provide 15 spans of 6.1 m at proposed brisge site location.

Clear Waterway (provided),	L	=	91.50 m
Total Area,	A	=	137.250 m2
Velocity ,	V	=	Q / A
		=	1.112 m/sec

6 Vertical Clearance :

	Design Discharge	Q	=	152.682 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		=	0.671 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = HFL + Vertical Clearance

= **269.952 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 **198.486 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	2.17 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	2.25 m

Maximum Scour Depth (as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.)
(For moderate bend) = $1.5 \times d_{sm}$

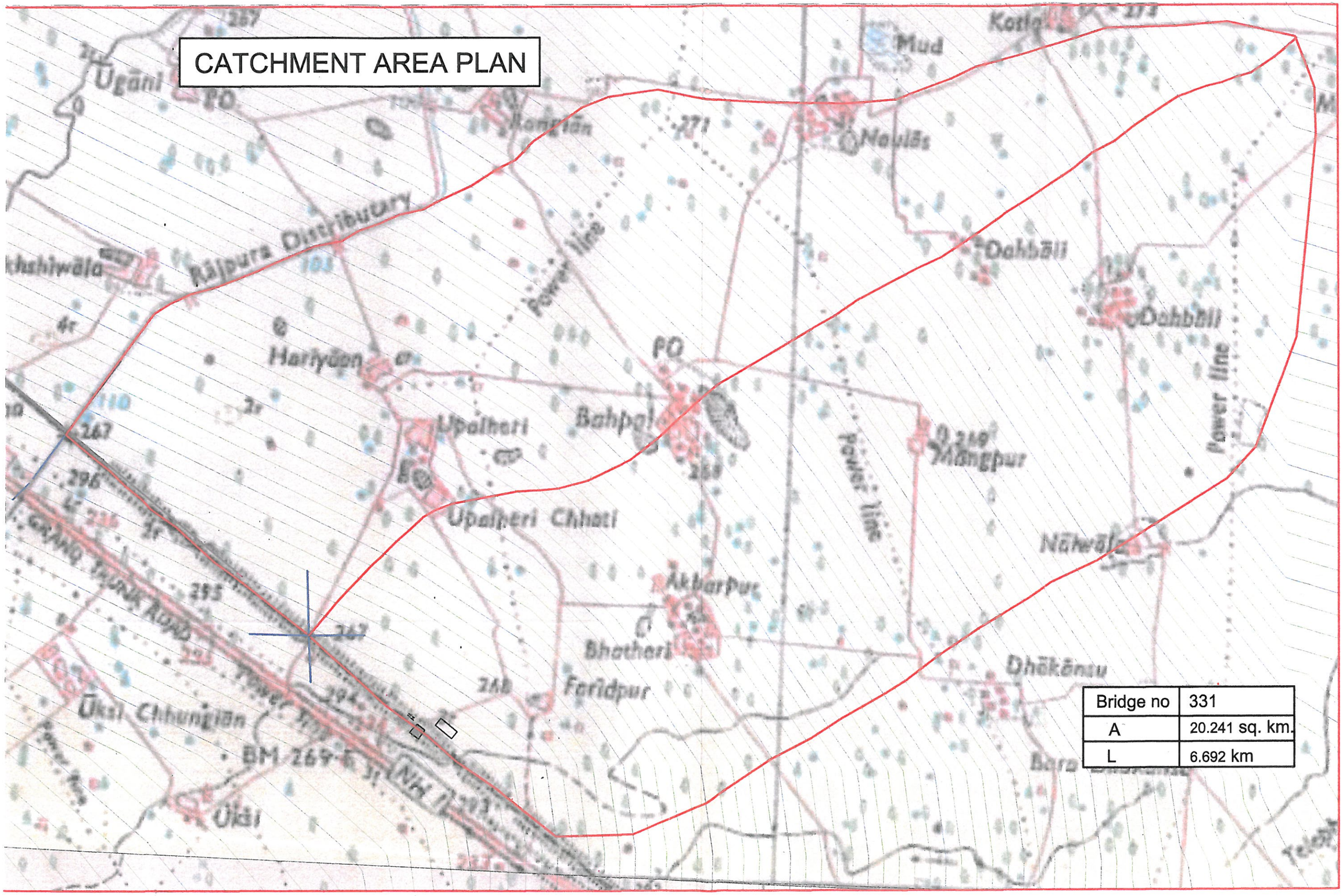
So, Maximum Scour Depth = **3.368 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.68 m**

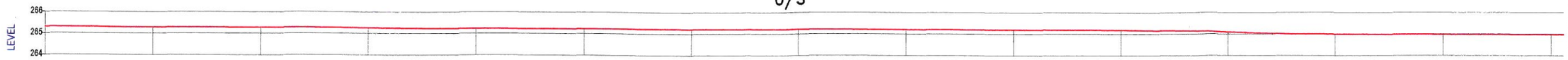
CATCHMENT AREA PLAN



0302

PROPOSED BRIDGE NO. BR.064 (PRL_331)
Rly Km. 294/14-18, DFCC Chainage 103563

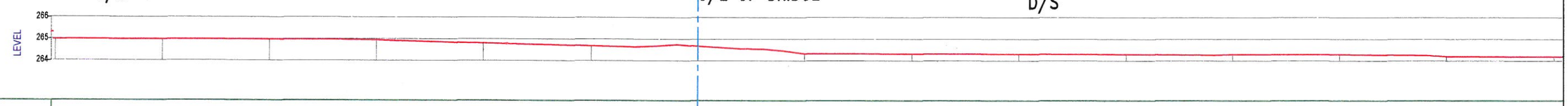
U/S



LEVEL	265.298	265.275	265.266	265.250	265.222	265.214	265.209	265.204	265.197	265.189	265.176	265.089	264.986	264.971	264.968
CHAINAGE	-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

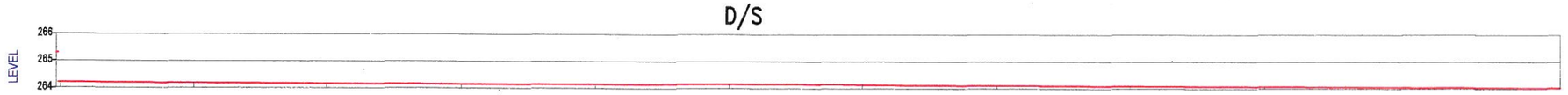
U/S C/L OF BRIDGE D/S



LEVEL	264.968	264.971	264.969	264.937	264.799	264.684	264.665	264.329	264.319	264.308	264.293	264.292	264.293	264.198	264.197
CHAINAGE	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00

LONGITUDINAL SECTION

D/S



LEVEL	264.197	264.180	264.158	264.148	264.147	264.153	264.139	264.112	264.093	264.071	264.050	264.030	264.025
CHAINAGE	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	1010.824

0303

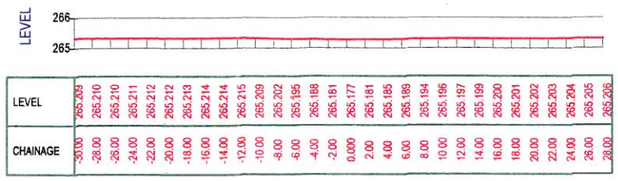
LONGITUDINAL SECTION

SHEET NO.-1 TO 2

PROPOSED BRIDGE NO. BR.064 (PRL_331)
Rly Km. 294/14-18, DFCC Chainage 103563

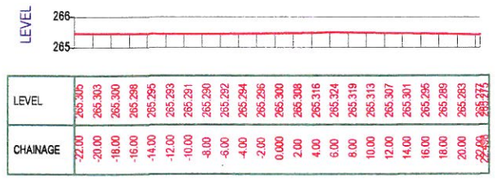
CHAINAGE	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	28.152
LEVEL	264.732	264.725	264.718	264.710	264.703	264.696	264.689	264.682	264.674	264.667	264.660	264.653	264.646	264.639	264.631	264.624	264.620	264.632	264.645	264.658	264.670	264.683	264.695	264.708	264.720	264.733	264.746	264.758	264.771	264.783	264.788

(Bridge site)



CHAINAGE	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00
LEVEL	265.205	265.210	265.210	265.211	265.212	265.212	265.213	265.214	265.214	265.215	265.209	265.202	265.195	265.188	265.181	265.177	265.181	265.185	265.189	265.194	265.196	265.197	265.199	265.200	265.201	265.202	265.203	265.204	265.205	265.206

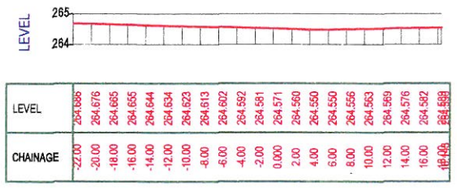
(Upstream at 475m)



CHAINAGE	-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
LEVEL	265.305	265.303	265.300	265.298	265.295	265.293	265.291	265.290	265.292	265.294	265.296	265.300	265.308	265.316	265.324	265.319	265.313	265.307	265.301	265.295	265.289	265.283	265.277	265.272

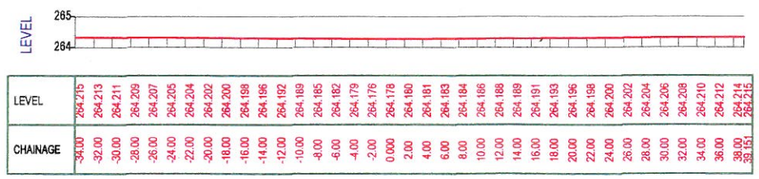
(Upstream at 975m)

CROSS SECTION



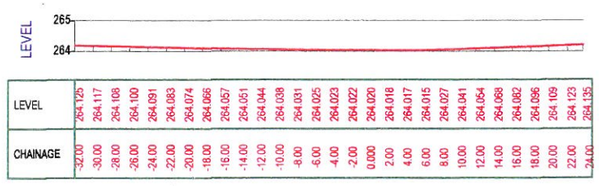
CHAINAGE	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00
LEVEL	264.686	264.676	264.665	264.655	264.644	264.634	264.623	264.613	264.602	264.592	264.581	264.571	264.560	264.550	264.550	264.556	264.563	264.569	264.576	264.582	264.588

(Downstream at 15m)



CHAINAGE	-34.00	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.00	32.00	34.00	36.00	38.00	39.151
LEVEL	264.215	264.213	264.211	264.209	264.207	264.205	264.204	264.202	264.200	264.198	264.196	264.192	264.189	264.185	264.182	264.179	264.176	264.178	264.180	264.181	264.183	264.184	264.186	264.188	264.189	264.191	264.193	264.196	264.198	264.200	264.202	264.204	264.206	264.208	264.210	264.212	264.214	264.215

(Downstream at 486m)



CHAINAGE	-32.00	-30.00	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00
LEVEL	264.125	264.117	264.108	264.100	264.091	264.083	264.074	264.066	264.057	264.051	264.044	264.038	264.031	264.025	264.023	264.022	264.020	264.018	264.017	264.015	264.027	264.041	264.054	264.068	264.082	264.096	264.109	264.123	264.135

(Downstream at 990m)

CROSS SECTION

0304

SHEET NO.-2 TO 2

Existing Bridge No – 332
Location – KM 295/8-10

Proposed Bridge No – 065
Location – CH: 104372

(Hydrology Details)

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

Name / No. of Proposed Bridge :	332
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 10
Scale :	1 : 50,000
Location :	295/8-10
Latitude :	$30^0$30'58"
Longitude :	$76^0$32'57"

Catchment Area ,	**A**	=	0.191 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.873 Km
Height of Farthest Point ,	**H1**	=	268.95 m
Height of Point of Interest ,	**H2**	=	268.05 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.90 m
Average Bed Level		=	268.05 m

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

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

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

0305

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 :

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

$= 0.901$ Hr

$= 54.061$ 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 = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

$= 0.936$

(d)

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

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

$= 8.16$ cm

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

$= 7.64$ cm

$= 76.38$ mm

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

$= 84.77$ mm / Hr

(iv) Design Flood Discharge :

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

$Q_{50} = 1.796$ Cumecs

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.191 Sq. Km	19.05 Hectares
Length of path from Toposheet,	L	=	0.873 Km	
Difference in Levels from Toposheet,	H	=	0.90 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.84 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	135.59 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	19.05 Hectares
I_c = Critical Intensity of Rainfall	13.559 cm / Hr
Q = Maximum Discharge	**2.749 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	=	0.191 Sq Km	

Hence, Q = **4.614 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)	1.796 Cumecs
Discharge by Rational Formula (IRC approach)	2.749 Cumecs
Discharge by Dicken's Formula	4.614 Cumecs

Maximum Discharge	4.614 Cumecs
Next Maximum Discharge	2.749 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **4.123 Cumecs**

5 Linear Waterway :

Average Bed Level		=	268.05 m
HFL as per site condition & local inquiry		=	269.83 m
So, Total Depth of Water,	H	=	1.78 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	=	5.340 m2
Velocity ,	V	=	Q / A
		=	**0.772 m/sec**

6 Scour Depth :

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

Increased Design Discharge **5.360 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	1.79 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.97 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** = **2.960 m**

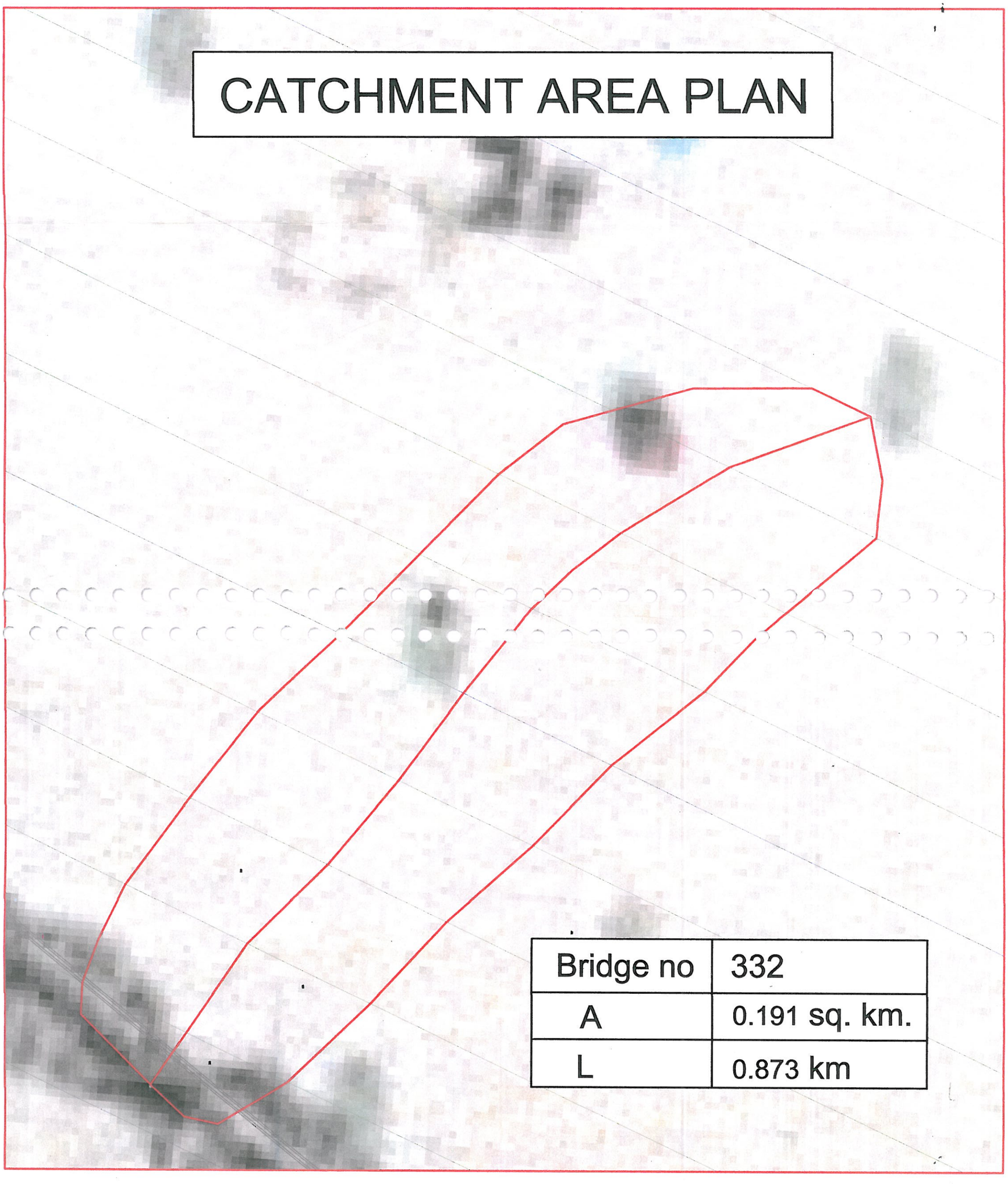
7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.87 m**

0309

CATCHMENT AREA PLAN

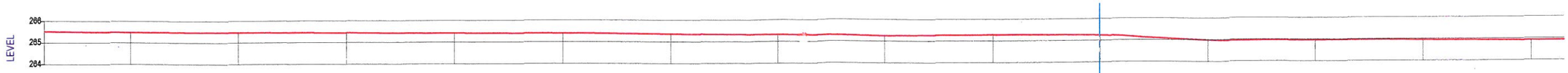


Bridge no	332
A	0.191 sq. km.
L	0.873 km

PROPOSED BRIDGE NO. BR.065(PRL_332)

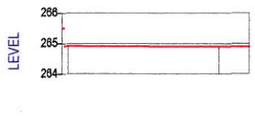
Rly Km. 295/7-10, DFCC Chainage 104372

U/S C/L OF BRIDGE D/S



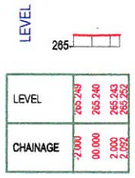
LEVEL	265.506	265.475	265.456	265.434	265.411	265.388	265.350	265.310	265.244	265.277	265.235	264.975	264.962	264.941	264.910
CHAINAGE	-490.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00

LONGITUDINAL SECTION



LEVEL	264.910	264.891	264.887
CHAINAGE	200.00	250.00	260.00

LONGITUDINAL SECTION

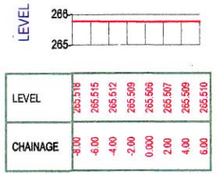


LEVEL	265.249	265.240	265.243	265.252						
CHAINAGE	-2.000	00.000	2.000	2.092						

(Bridge site)

LEVEL	265.397	265.388	265.384	265.373	265.377					
CHAINAGE	-4.000	-2.000	00.000	2.000	2.288					

(Upstream at 245m)



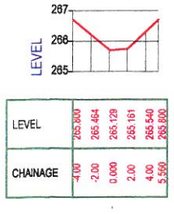
LEVEL	265.518	265.515	265.512	265.509	265.508	265.507	265.509	265.510		
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00		

(Upstream at 490m)

CROSS SECTION

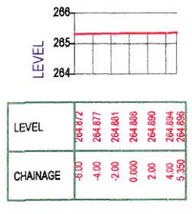
LEVEL	265.215	265.160	265.139	265.136						
CHAINAGE	-2.000	00.000	2.000	2.750						

(Downstream at 00m)



LEVEL	265.200	265.464	265.129	265.161	265.540	265.600				
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	5.550				

(Downstream at 100m)



LEVEL	264.872	264.877	264.881	264.886	264.890	264.894	264.895			
CHAINAGE	-8.00	-4.00	-2.00	0.000	2.00	4.00	5.350			

(Downstream at 250m)

CROSS SECTION

0310

Existing Bridge No – 333
Location – KM 295/13-15

Proposed Bridge No – 066
Location – CH: 104574

(Hydrology Details)

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

Name / No. of Proposed Bridge :	333
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 10
Scale :	1 : 50,000
Location :	295/13-15
Latitude :	$30^0$31'2"
Longitude :	$76^0$32'8"

Catchment Area ,	**A**	=	0.406 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.427 Km
Height of Farthest Point ,	**H1**	=	269.00 m
Height of Point of Interest ,	**H2**	=	267.95 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	1.05 m
Average Bed Level		=	267.95 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

0311

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 :

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

= **0.408 Hr**

= **24.453 Mins**

(a) t_c h Ratio = 0.20 (from Fig. 4 of RBF - 16)

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

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

= **0.595**

(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)**

= **4.85 cm**

= **48.54 mm**

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

= **119.11 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **5.378 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.406 Sq. Km	40.60 Hectares
Length of path from Toposheet,	L	=	0.427 Km	
Difference in Levels from Toposheet,	H	=	1.05 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.35 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	185.45 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	40.60 Hectares
I_c = Critical Intensity of Rainfall	18.545 cm / Hr
Q = Maximum Discharge	**8.264 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	=	0.406 Sq Km

Hence, **Q** = **8.138 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)	5.378 Cumecs
Discharge by Rational Formula (IRC approach)	8.264 Cumecs
Discharge by Dicken's Formula	8.138 Cumecs
Maximum Discharge	8.264 Cumecs
Next Maximum Discharge	8.264 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted **Q** = **8.264 Cumecs**

5 Linear Waterway :

Average Bed Level		=	267.95 m
HFL as per site condition & local inquiry		=	269.35 m
So, Total Depth of Water,	H	=	1.40 m

Provide 2 spans of 3.05 m at bridge site location.

Clear Waterway (provided),	L	=	6.10 m
Total Area,	A	=	8.540 m2
Velocity ,	V	=	Q / A
		=	**0.968 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	8.264 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**

= **269.952 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 **10.743 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	1.76 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.95 m**

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

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

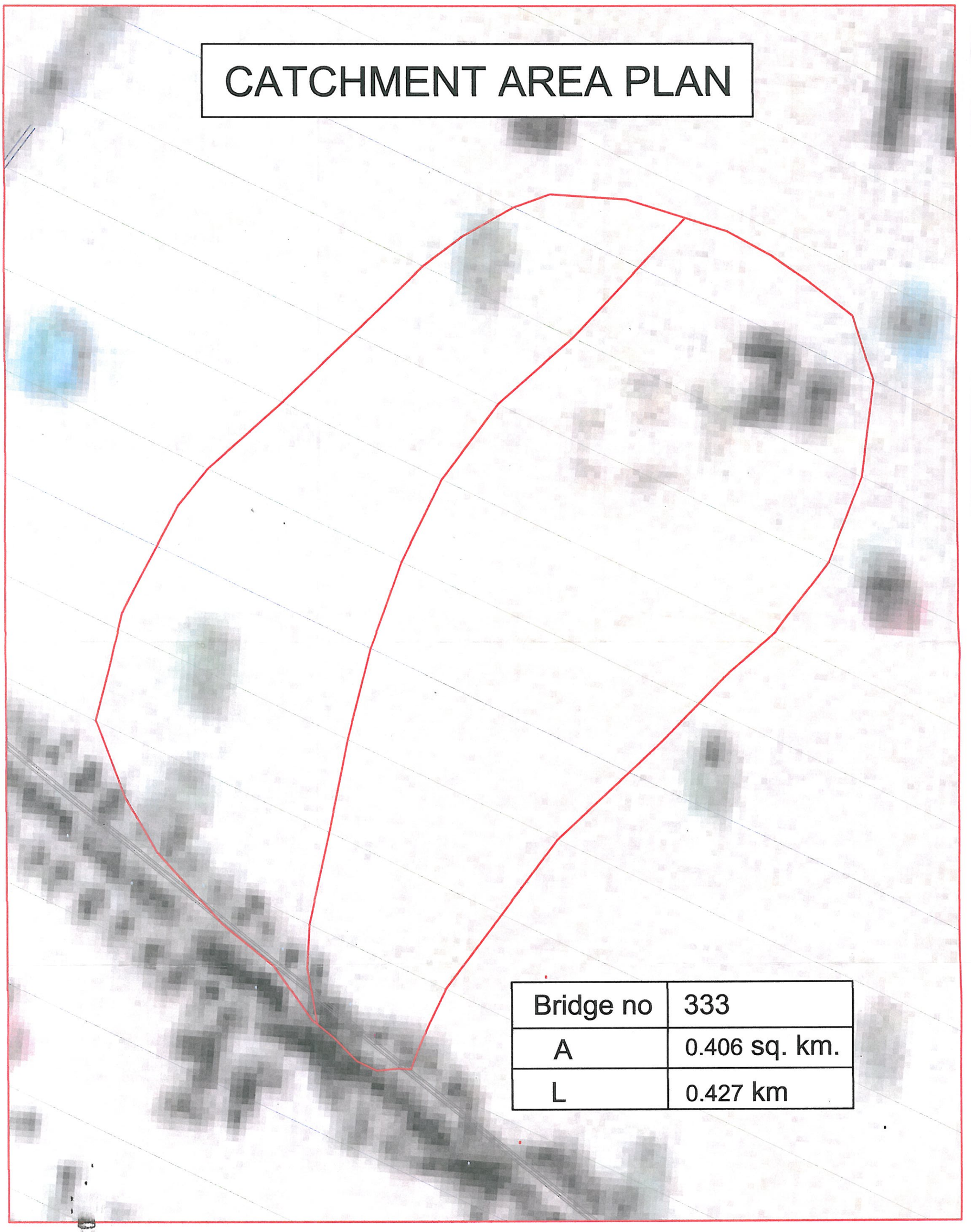
So, **Maximum Scour Depth** = **2.931 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **266.42 m**

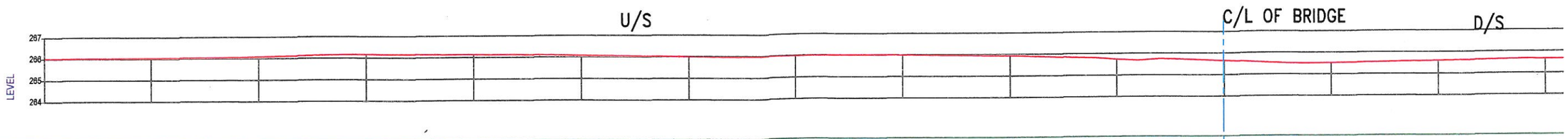
CATCHMENT AREA PLAN



Bridge no	333
A	0.406 sq. km.
L	0.427 km

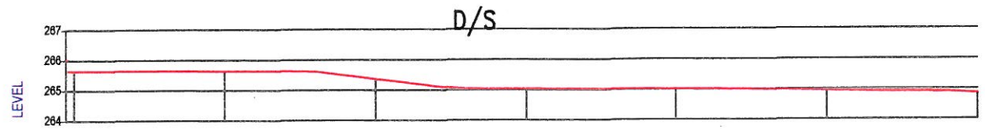
PROPOSED BRIDGE NO. BR.066(PRL_333)

Rly Km. 296/14-16, DFCC Chainage 104574



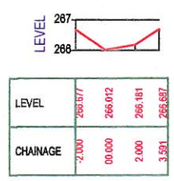
LEVEL	266.010	266.032	266.078	266.156	266.130	266.076	265.991	265.988	265.998	265.930	265.731	265.641	265.516	265.589	265.645
CHAINAGE	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00

LONGITUDINAL SECTION



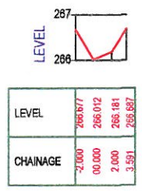
LEVEL	265.645	265.639	265.369	265.030	265.010	264.950	264.843
CHAINAGE	150.00	200.00	250.00	300.00	350.00	400.00	450.00

LONGITUDINAL SECTION



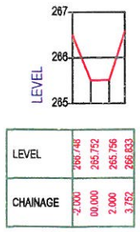
(Bridge site)

(Upstream at 250m)

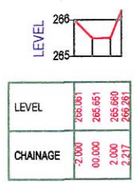


(Upstream at 505m)

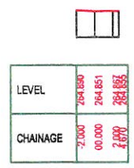
CROSS SECTION



(Downstream at 00m)



(Downstream at 95m)



(Downstream at 250m)

CROSS SECTION

0316

SHEET NO.-1

Existing Bridge No – 334
Location – KM 297/21-23

Proposed Bridge No – 068
Location – CH: 106823

(Hydrology Details)

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

Name / No. of Proposed Bridge :			334
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 10
Scale :			1 : 50,000
Location :			297/21-23
Latitude :			$30^0$31'47"
Longitude :			$76^0$31'45"
Catchment Area ,	**A**	=	1.768 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	4.018 Km
Height of Farthest Point ,	**H1**	=	269.15 m
Height of Point of Interest ,	**H2**	=	265.85 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	3.30 m
Average Bed Level		=	265.85 m

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

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

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

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 :

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

= **2.794 Hr**

= **167.654 Mins**

(a) t_c h Ratio = 0.52 (from Fig. 4 of RBF - 16)

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

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

= **1.535**

(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)**

= **12.52 cm**

= **125.22 mm**

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

= **44.82 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **8.810 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	1.768 Sq. Km	176.78 Hectares
Length of path from Toposheet,	L	=	4.018 Km	
Difference in Levels from Toposheet,	H	=	3.30 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		2.98 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	62.76 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	176.78 Hectares
I_c = Critical Intensity of Rainfall	6.276 cm / Hr
Q = Maximum Discharge	**12.177 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	=	1.768	Sq Km

Hence, Q = **24.530 Cumecs**

4 Design Discharge :

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

Discharge by Rational Formula (RBF - 16 Report)	8.810 Cumecs
Discharge by Rational Formula (IRC approach)	12.177 Cumecs
Discharge by Dicken's Formula	24.530 Cumecs
Maximum Discharge	24.530 Cumecs
Next Maximum Discharge	12.177 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **18.266 Cumecs**

5 Linear Waterway :

Average Bed Level		=	265.85 m
HFL as per site condition & local inquiry		=	268.50 m
So, Total Depth of Water,	H	=	2.65 m

Provide 4 spans of 3.05 m at bridge site location.

Clear Waterway (provided),	L	=	12.20 m
Total Area,	A	=	32.330 m2
Velocity ,	V	=	Q / A
		=	**0.565 m/sec**

6 Vertical Clearance :

	Design Discharge	Q =	18.266 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**

= **269.102 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 **23.746 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 1.95 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **2.09 m**

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

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

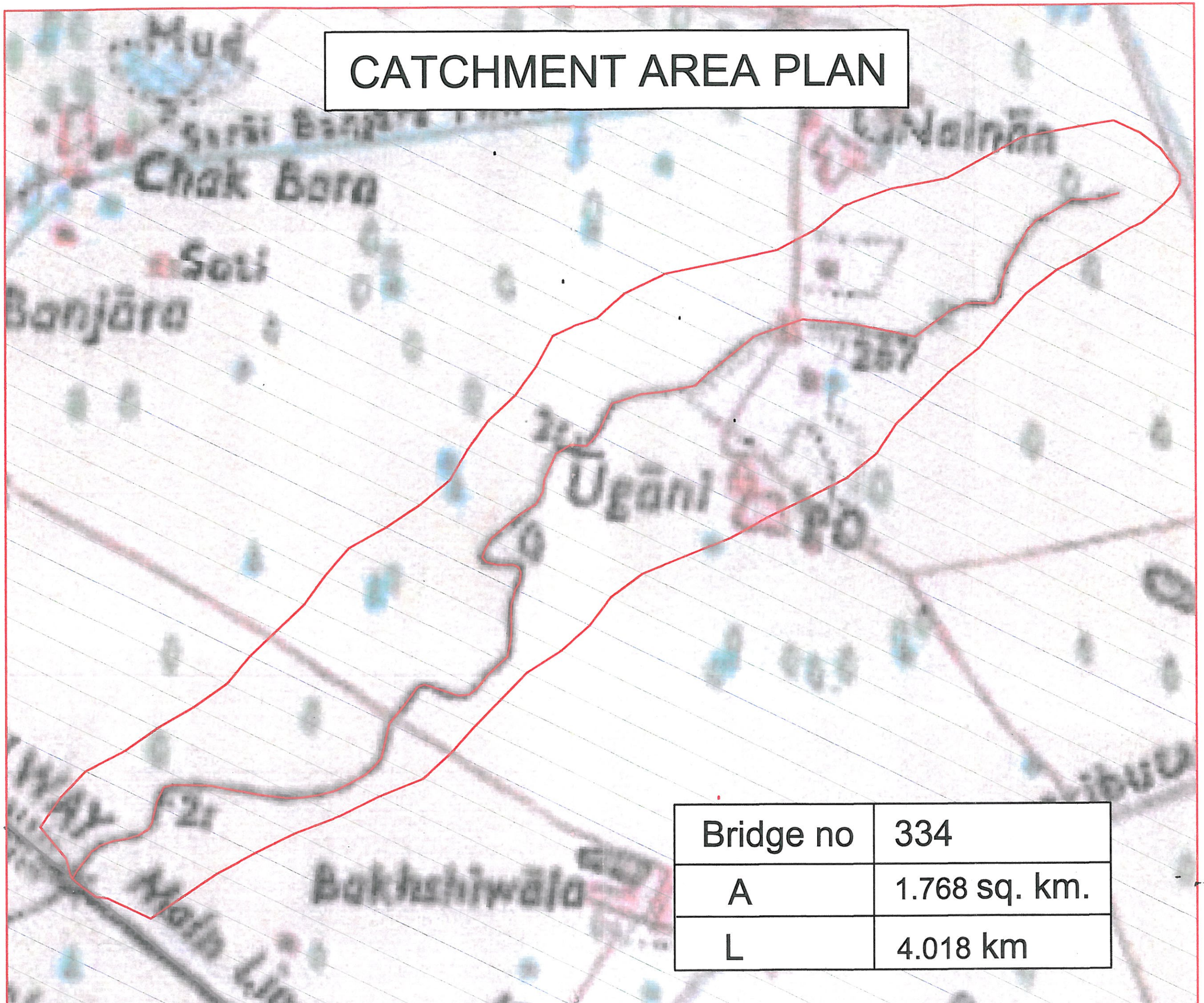
So, **Maximum Scour Depth** = **3.133 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

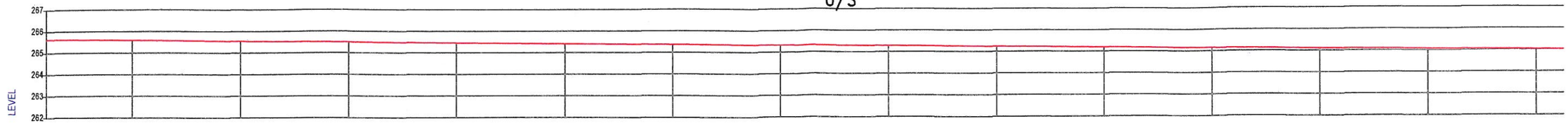
= **265.37 m**

CATCHMENT AREA PLAN



Bridge no	334
A	1.768 sq. km.
L	4.018 km

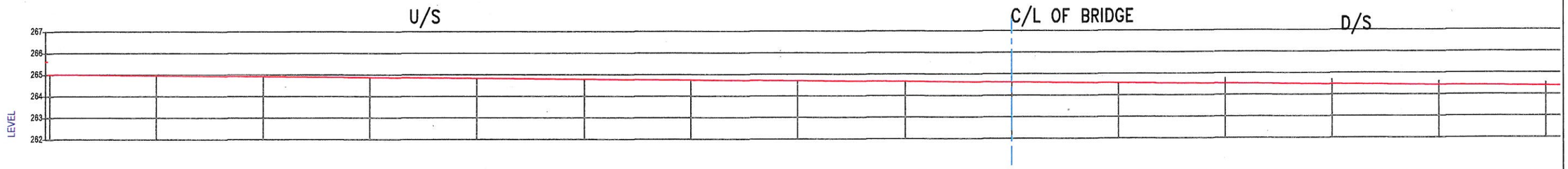
0321



LEVEL	265.62	265.58	265.55	265.51	265.48	265.44	265.41	265.38	265.34	265.31	265.27	265.24	265.21	265.17	265.14
CHAINAGE	-1140.00	-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

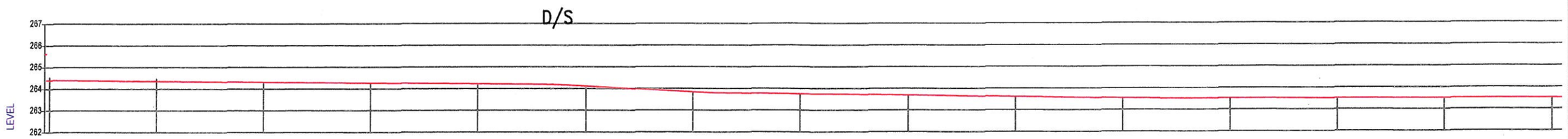
LONGITUDINAL SECTION

PROPOSED BRIDGE NO. BR.068(PRL_334)
Rly Km. 297/22-24, DFCC Chainage 106823



LEVEL	265.14	265.10	265.07	265.04	265.00	264.97	264.93	264.90	264.86	264.83	264.80	264.76	264.73	264.69	264.66
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



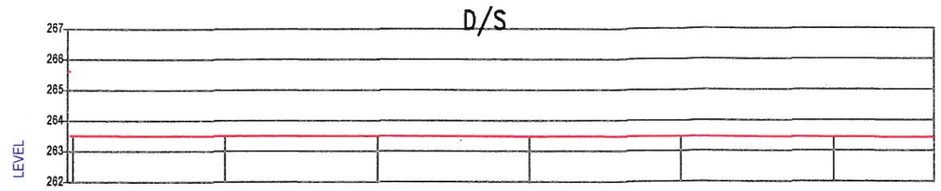
LEVEL	264.66	264.63	264.59	264.22	264.219	263.112	263.833	263.750	263.686	263.608	263.541	263.510	263.507	263.503	263.499
CHAINAGE	250.00	300.00	350.00	400.00	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000

LONGITUDINAL SECTION

0322

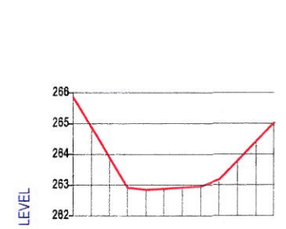
SHEET NO.-1 TO 2

PROPOSED BRIDGE NO. BR.068(PRL_334)
Rly Km. 297/22-24, DFCC Chainage 106823



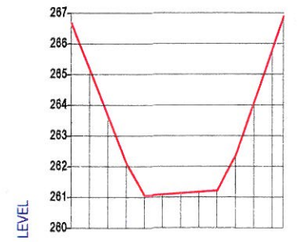
LEVEL	263.499	263.495	263.490	263.480	263.466	263.447	263.432
CHAINAGE	950.000	1000.000	1050.000	1100.000	1150.000	1200.000	1232.986

LONGITUDINAL SECTION



LEVEL	264.886	264.214	263.562	262.910	262.865	262.688	262.913	262.937	263.084	263.500	263.917	264.315	
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	21.913	

(Bridge site)



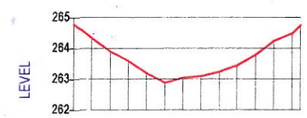
LEVEL	264.440	263.426	262.412	261.398	260.697	260.724	260.752	260.779	260.806	261.571	262.729	263.887	264.567
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	11.628

(Upstream at 510m)

LEVEL	265.975	265.733	265.619	265.616	265.729	265.870
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.00

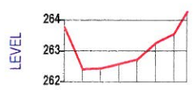
(Upstream at 1130m)

CROSS SECTION



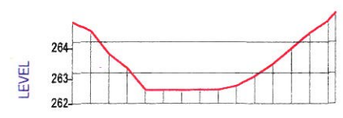
LEVEL	264.111	264.341	263.970	263.600	263.230	262.860	262.970	263.119	263.269	263.418	263.701	264.078	264.455
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	12.000

(Downstream at 00m)



LEVEL	263.972	262.366	262.563	262.759	262.955	263.152	263.599
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00

(Downstream at 450m)



LEVEL	264.977	264.263	263.589	262.896	262.423	262.425	262.427	262.428	262.430	262.516	262.975	263.435	263.894
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	12.000

(Downstream at 1135m)

CROSS SECTION

0323

SHEET NO.2 TO 2

Existing Bridge No – 335
Location – KM 298/33-34

Proposed Bridge No – 069
Location – CH: 108102

(Hydrology Details)

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

Name / No. of Proposed Bridge :	335
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 10
Scale :	1 : 50,000
Location :	298/33-34
Latitude :	$30^0$32'11"
Longitude :	$76^0$31'8"

Catchment Area ,	**A**	=	0.232 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.971 Km
Height of Farthest Point ,	**H1**	=	268.05 m
Height of Point of Interest ,	**H2**	=	267.45 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.60 m
Average Bed Level		=	267.45 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 = $[L^3 / H]^{0.345}$

= **1.157 Hr**

= **69.416 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 = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.063**

(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)**

= **8.67 cm**

= **86.73 mm**

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

= **74.97 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **1.934 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.232 Sq. Km	23.20 Hectares
Length of path from Toposheet,	L	=	0.971 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		1.12 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	118.19 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	23.20	Hectares
I_c = Critical Intensity of Rainfall	11.819	cm / Hr
Q = Maximum Discharge	**3.010**	**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	=	0.232	Sq Km

Hence, Q = **5.349 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)	1.934 Cumecs
Discharge by Rational Formula (IRC approach)	3.010 Cumecs
Discharge by Dicken's Formula	5.349 Cumecs
Maximum Discharge	5.349 Cumecs
Next Maximum Discharge	3.010 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **4.514 Cumecs**

- **Linear Waterway :**

Average Bed Level = 267.45 m

HFL as per site condition & local inquiry = 268.04 m

So, Total Depth of Water, H = 0.59 m

Provide 2 spans of 3.05 m at bridge site location.

Clear Waterway (provided), L = 6.10 m

Total Area, A = 3.587 m2

Velocity , V = Q / A

= **1.259 m/sec**

6 Vertical Clearance :

Design Discharge Q = 4.514 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**

= **268.640 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)

Increased Design Discharge **30%**

5.869 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 0.96 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **1.31 m**

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

= **$1.5 \times d_{sm}$**

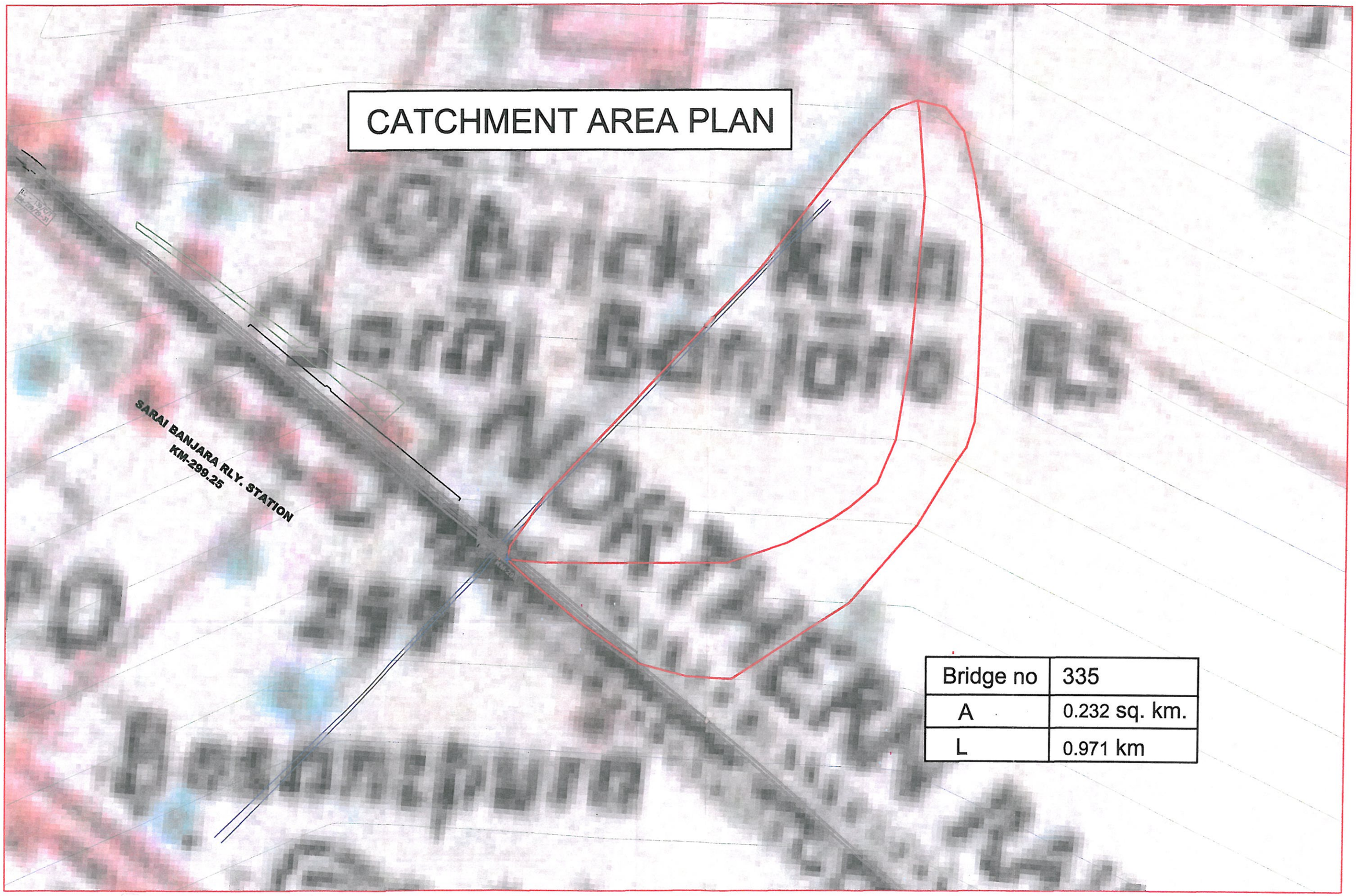
So, **Maximum Scour Depth** = **1.959 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

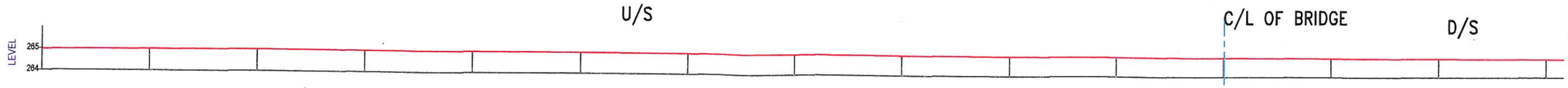
= **266.08 m**

CATCHMENT AREA PLAN



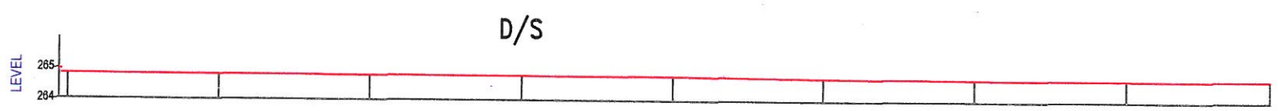
Bridge no	335
A	0.232 sq. km.
L	0.971 km

PROPOSED BRIDGE NO. BR.069(PRL_335)
Rly Km. 298/33-35, DFCC Chainage 108102



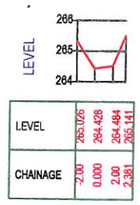
LEVEL	264.965	264.983	264.95	264.93	264.91	264.89	264.87	264.85	264.82	264.80	264.78	264.76	264.74	264.72	264.70
CHAINAGE	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00

LONGITUDINAL SECTION



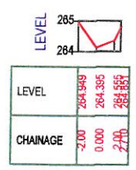
LEVEL	264.70	264.68	264.65	264.619	264.793	264.743	264.715	264.699	264.697
CHAINAGE	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	547.768

LONGITUDINAL SECTION



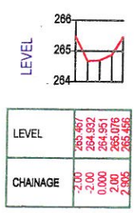
LEVEL	263.126	264.428	264.484	265.141
CHAINAGE	-2.00	0.000	2.00	2.381

(Bridge site)



LEVEL	264.949	264.385	264.555	264.857
CHAINAGE	-2.00	0.000	2.00	2.710

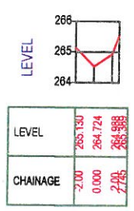
(Upstream at 255m)



LEVEL	265.467	264.932	264.951	265.076
CHAINAGE	-2.00	0.000	2.00	2.365

(Upstream at 580m)

CROSS SECTION

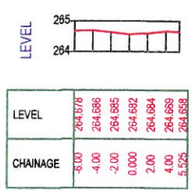


LEVEL	263.130	264.724	264.988	265.389
CHAINAGE	-2.00	0.000	2.00	2.750

(Downstream at 00m)

LEVEL	264.854	264.532	264.816
CHAINAGE	-2.00	0.000	2.00

(Downstream at 225m)



LEVEL	264.578	264.686	264.685	264.682	264.684	264.669	264.668
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	5.525

(Downstream at 450m)

CROSS SECTION

0329

SHEET NO.-1

Existing Bridge No – 337
Location – KM 300/7-9

Proposed Bridge No – 072
Location – CH: 109307

(Hydrology Details)

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

Name / No. of Proposed Bridge :			337
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 10
Scale :			1 : 50,000
Location :			300/7-9
Latitude :			$30^0$32'35"
Longitude :			$76^0$30'32"
Catchment Area ,	**A**	=	2.399 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	6.830 Km
Height of Farthest Point ,	**H1**	=	269.95 m
Height of Point of Interest ,	**H2**	=	266.05 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	3.90 m
Average Bed Level		=	266.05 m

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

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

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

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

(iii) Calculation of Intensity of Rainfall, I :

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

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

= **4.568 Hr**

= **274.069 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 = $\frac{R_{50}(t_c)}{t_c}$

= **28.11 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **7.497 Cumecs**

0331

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	2.399 Sq. Km	239.85 Hectares
Length of path from Toposheet,	L	=	6.830 Km	
Difference in Levels from Toposheet,	H	=	3.90 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		5.16 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	40.56 mm / Hr

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

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	239.85 Hectares
I_c = Critical Intensity of Rainfall	4.056 cm / Hr
Q = Maximum Discharge	**10.679 Cumecs**

3 Discharge by Dicken's Formula :

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

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

C	=	16	(adopted in present case)
M	=	2.399 Sq Km	

Hence, Q = **30.837 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)	7.497 Cumecs
Discharge by Rational Formula (IRC approach)	10.679 Cumecs
Discharge by Dicken's Formula	30.837 Cumecs
Maximum Discharge	30.837 Cumecs
Next Maximum Discharge	10.679 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **16.018 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.05 m
HFL as per site condition & local inquiry		=	268.37 m
So, Total Depth of Water,	H	=	2.32 m

Provide 2 spans of 3.05 m at bridge site location.

Clear Waterway (provided),	L	=	6.10 m
Total Area,	A	=	14.140 m2
Velocity ,	V	=	Q / A
		=	**1.133 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	16.018 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**

= **268.970 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 **20.824 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	3.41 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**3.04 m**

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

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

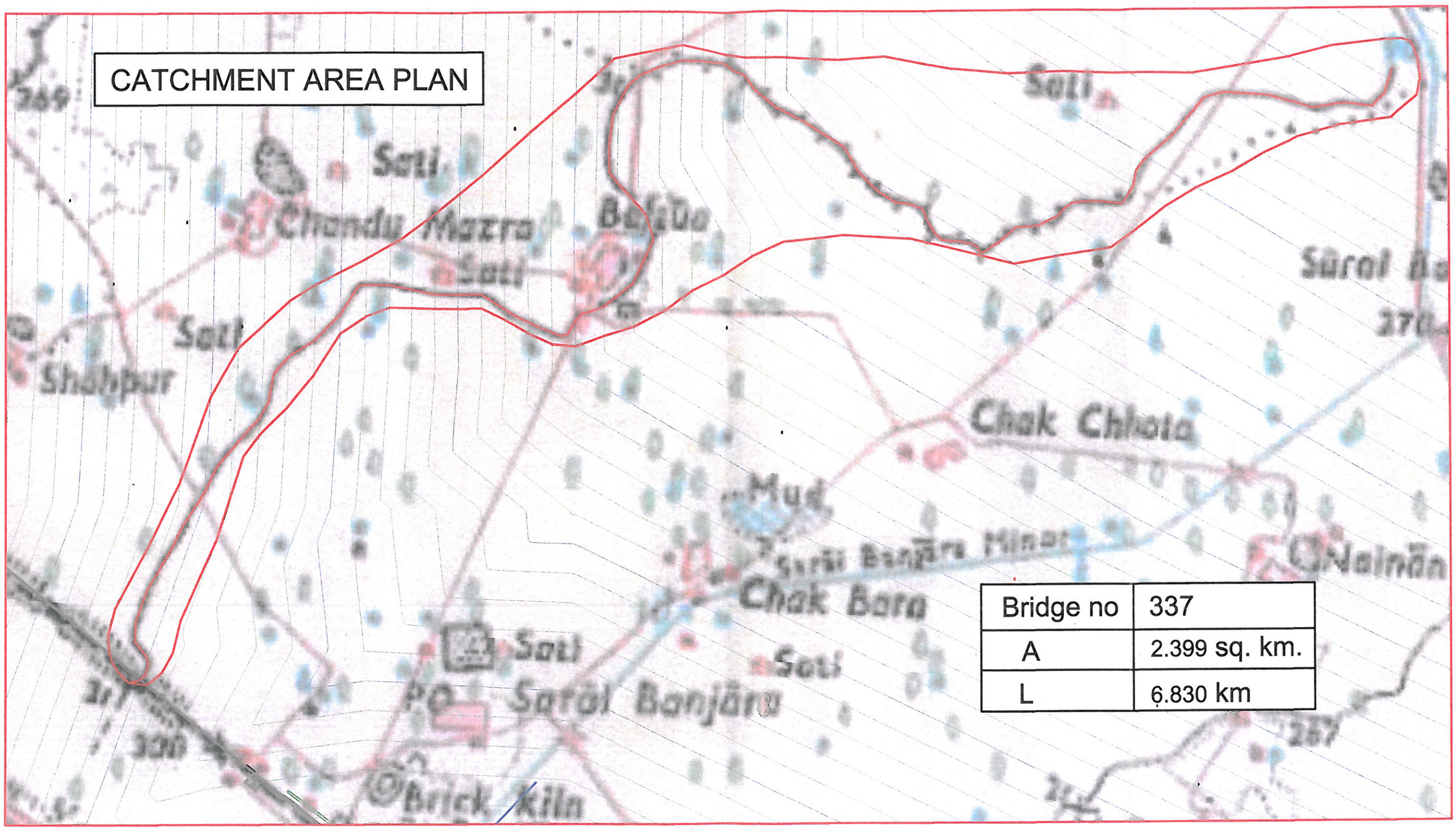
So, **Maximum Scour Depth** = **4.557 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **263.81 m**

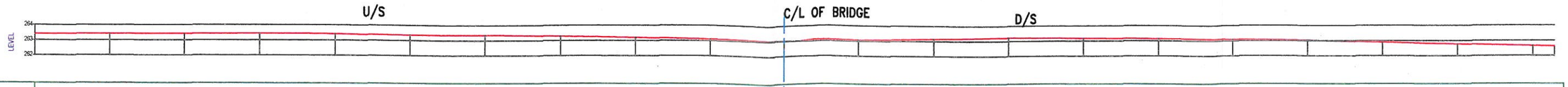
CATCHMENT AREA PLAN



Bridge no	337
A	2.399 sq. km.
L	6.830 km

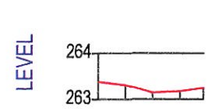
PROPOSED BRIDGE NO.BR.072(PRL_337)

Rly Km. 300/8-10, DFCC Chainage 109307



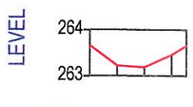
LEVEL	263.400	263.405	263.410	263.416	263.398	263.347	263.350	263.273	263.184	263.095	263.008	263.051	263.239	263.209	263.171	263.132	263.076	263.015	262.886	262.759	262.647	262.615
CHAINAGE	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	514.292

LONGITUDINAL SECTION



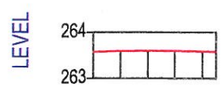
LEVEL	263.038	263.031	263.015	263.018	263.025
CHAINAGE	-4.00	-2.00	0.000	2.00	3.748

(Bridge site)



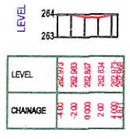
LEVEL	263.660	263.370	263.347	263.530	263.660
CHAINAGE	-4.00	-2.00	0.000	2.00	3.073

(Upstream at 250m)

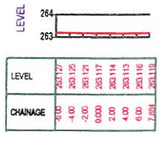


LEVEL	263.384	263.397	263.399	263.398	263.391
CHAINAGE	-4.00	-2.00	0.000	2.00	4.000

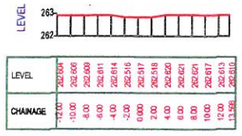
(Upstream at 495m)



(Downstream at 00m)



(Downstream at 255m)



(Downstream at 510m)

CROSS SECTION

0335

SHEET NO.-1

Existing Bridge No – 338
Location – KM 300/18-20

Proposed Bridge No – 073
Location – CH: 109654

(Hydrology Details)

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

Name / No. of Proposed Bridge :	338
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 10
Scale :	1 : 50,000
Location :	300/18-20
Latitude :	$30^0 32'43"$
Longitude :	$76^0 30'21"$

Catchment Area ,	**A**	=	9.647 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	5.674 Km
Height of Farthest Point ,	**H1**	=	271.38 m
Height of Point of Interest ,	**H2**	=	266.35 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	5.03 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

0336

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

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

Name / No. of Proposed Bridge :	338
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 10
Scale :	1 : 50,000
Location :	300/18-20
Latitude :	$30^0 32'43"$
Longitude :	$76^0 30'21"$

Catchment Area ,	**A**	=	9.647 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	5.674 Km
Height of Farthest Point ,	**H1**	=	271.38 m
Height of Point of Interest ,	**H2**	=	266.35 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	5.03 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 = $[L^3 / H]^{0.345}$

= **3.453 Hr**

= **207.198 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 = $\frac{R_{50}(t_c)}{t_c}$

= **37.18 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **39.886 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	9.647 Sq. Km	964.69 Hectares
Length of path from Toposheet,	L	=	5.674 Km	
Difference in Levels from Toposheet,	H	=	5.03 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		3.78 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	52.31 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)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	964.69 Hectares
I_c = Critical Intensity of Rainfall	5.231 cm / Hr
Q = Maximum Discharge	**55.393 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	=	9.647 Sq Km

Hence, Q = **87.581 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)	39.886 Cumecs
Discharge by Rational Formula (IRC approach)	55.393 Cumecs
Discharge by Dicken's Formula	87.581 Cumecs

Maximum Discharge	87.581 Cumecs
Next Maximum Discharge	55.393 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **83.090 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.35 m
HFL as per site condition & local inquiry		=	268.20 m
So, Total Depth of Water,	H	=	1.85 m

Provide 8 spans of 6.1 m at bridge site location.

Clear Waterway (provided),	L	=	48.80 m
Total Area,	A	=	90.182 m2
Velocity ,	V	=	Q / A
		=	**0.921 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	83.090 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		=	0.716 m
	So, Vertical Clearance adopted		=	0.900 m

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

= **269.100 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 **108.016 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	2.21 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.28 m**

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

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

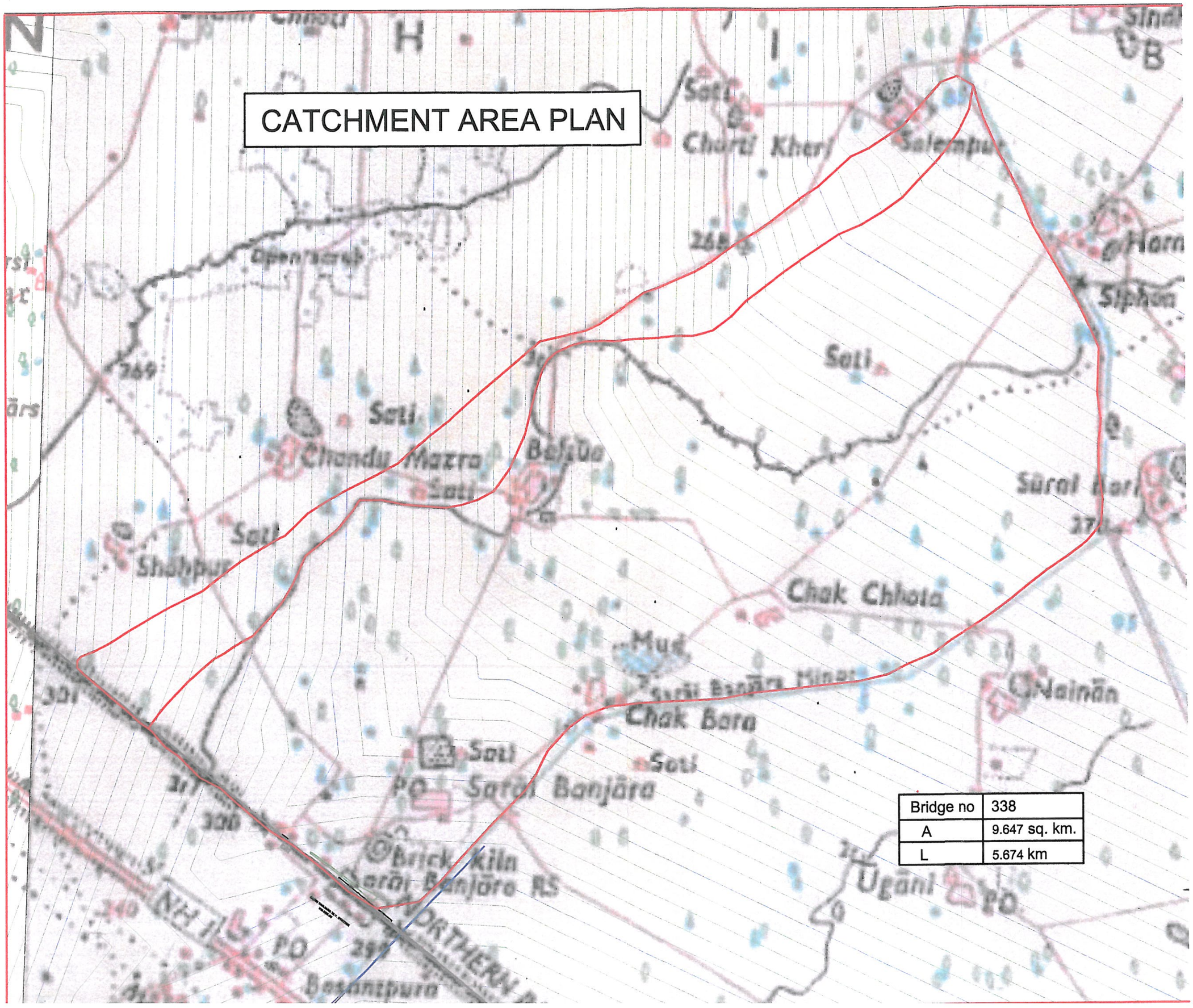
So, **Maximum Scour Depth** = **3.414 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **264.79 m**

CATCHMENT AREA PLAN

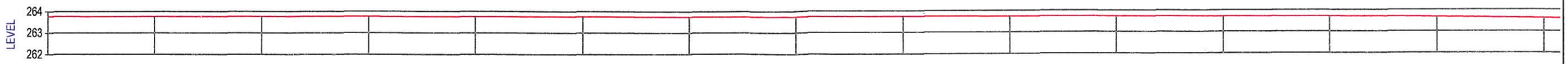


Bridge no	338
A	9.647 sq. km.
L	5.674 km

0341

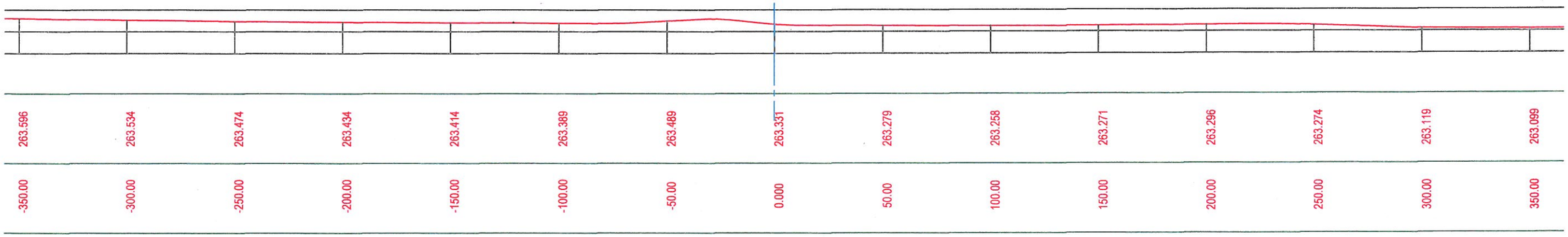
PROPOSED BRIDGE NO. BR. 073 (PRL_338)
Rly Km. 300/17-20, DFCC Chainage 109654

U/S

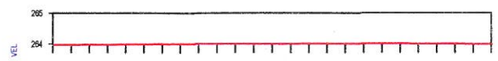


LEVEL	263.763	263.761	263.758	263.755	263.751	263.747	263.741	263.736	263.732	263.727	263.719	263.709	263.697	263.658	263.596
CHAINAGE	-1050.00	-1000.00	-950.00	-900.00	-850.00	-800.00	-750.00	-700.00	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00

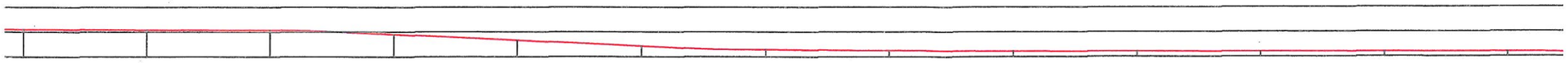
U/S C/L OF BRIDGE D/S



263.596	263.534	263.474	263.434	263.414	263.389	263.489	263.331	263.279	263.258	263.271	263.296	263.274	263.119	263.099
-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00



D/S

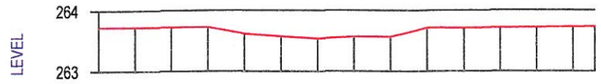


263.099	263.082	263.065	262.898	262.661	262.425	262.284	262.250	262.217	262.210	262.202	262.195	262.187
350.00	400.00	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000

0342

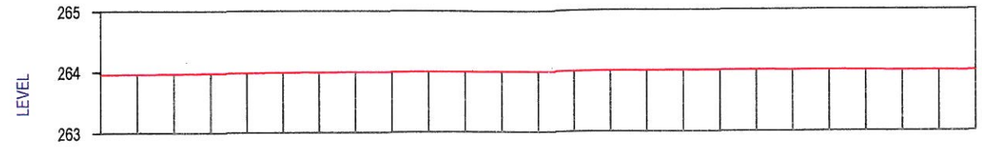
LONGITUDINAL SECTION

SHEET NO. 1 TO 2



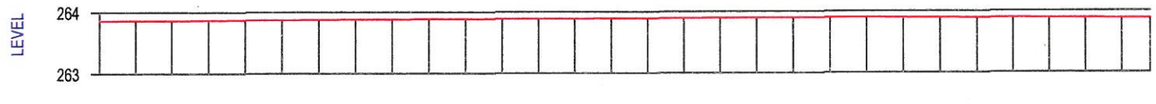
LEVEL	263.720	263.720	263.720	263.719	263.619	263.568	263.548	263.566	263.565	263.714	263.713	263.715	263.719	263.723	263.725
CHAINAGE	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	13.189

(Upstream at 495m)



LEVEL	263.956	263.959	263.962	263.965	263.968	263.972	263.975	263.978	263.979	263.980	263.980	263.981	263.982	263.983	263.984	263.985	263.985	263.986	263.987	263.985	263.983	263.981	263.979	263.977	263.975
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

(Downstream at 00m)

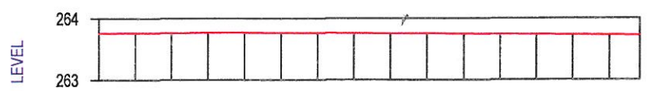


LEVEL	263.573	263.575	263.577	263.579	263.580	263.582	263.584	263.586	263.588	263.589	263.590	263.591	263.592	263.594	263.595	263.596	263.597	263.598	263.599	263.600	263.599	263.598	263.596	263.595	263.594	263.592	263.591	263.589	263.588	263.587
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	29.561

(Bridge site)

LEVEL	262.947	262.951	262.951	262.943	262.938	262.941	262.944	262.947
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00

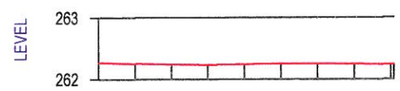
(Downstream at 490m)



LEVEL	263.758	263.759	263.760	263.762	263.763	263.761	263.759	263.757	263.755	263.753	263.750	263.747	263.744	263.741	263.738	263.735
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	15.673

(Upstream at 1020m)

CROSS SECTION



LEVEL	262.179	262.170	262.161	262.154	262.160	262.167	262.165	262.162	262.158
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00

(Downstream at 1005m)

0343

SHEET NO. 2 TO 2

Existing Bridge No – 339
Location – KM 301/18-20

Proposed Bridge No – 074
Location – CH: 110979

(Hydrology Details)

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

Name / No. of Proposed Bridge :			339
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 :			301/18-20
Latitude :			$30^0 33'3"$
Longitude :			$76^0 28'51"$
Catchment Area ,	**A**	=	11.066 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	7.518 Km
Height of Farthest Point ,	**H1**	=	271.71 m
Height of Point of Interest ,	**H2**	=	266.25 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	5.46 m
Average Bed Level		=	266.25 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 = $[L^3 / H]^{0.345}$

= **4.492 Hr**

= **269.517 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 = $\frac{R_{50}(t_c)}{t_c}$

= **28.58 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **35.174 Cumecs**

0345

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	11.066 Sq. Km	1106.60 Hectares
Length of path from Toposheet,	L	=	7.518 Km	
Difference in Levels from Toposheet,	H	=	5.46 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		5.07 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	41.20 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	1106.60 Hectares
I_c = Critical Intensity of Rainfall	4.120 cm / Hr
Q = Maximum Discharge	**50.045 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	=	11.066 Sq Km	

Hence, **Q = 97.076 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)	35.174 Cumecs
Discharge by Rational Formula (IRC approach)	50.045 Cumecs
Discharge by Dicken's Formula	97.076 Cumecs

Maximum Discharge	97.076 Cumecs
Next Maximum Discharge	50.045 Cumecs
The difference is beyond 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **75.068 Cumecs**

5 Linear Waterway :

Average Bed Level		=	266.25 m
HFL as per site condition & local inquiry		=	268.20 m
So, Total Depth of Water,	H	=	1.95 m

Provide 8 spans of 6.1 m at bridge site location.

Clear Waterway (provided),	L	=	48.80 m
Total Area,	A	=	95.062 m2
Velocity ,	V	=	Q / A
		=	**0.790 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	75.068 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		=	0.698 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = HFL + Vertical Clearance

= **269.100 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 **97.589 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 2.00 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **2.13 m**

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

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

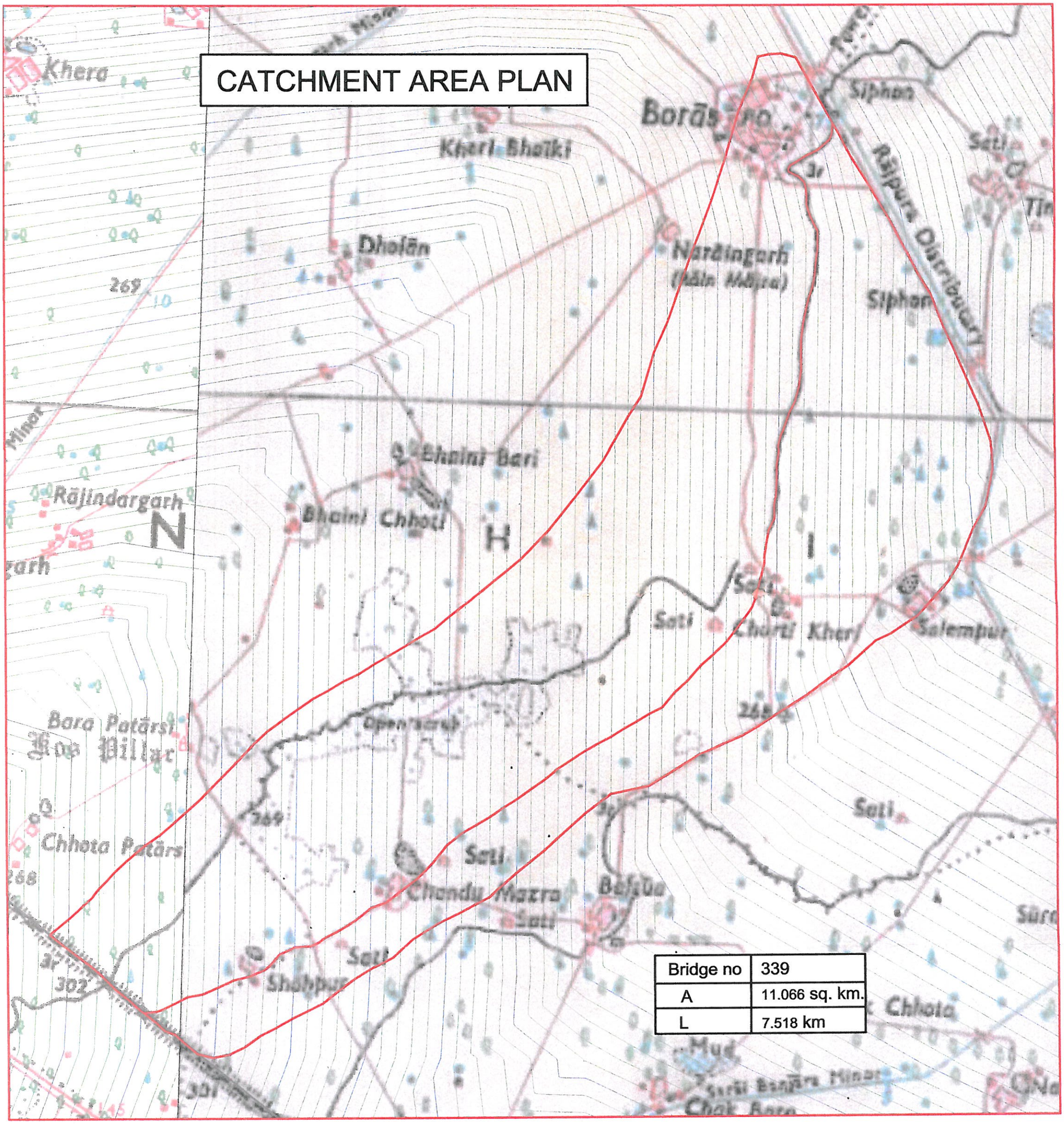
So, **Maximum Scour Depth** = **3.190 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.01 m**

CATCHMENT AREA PLAN



Bridge no	339
A	11.066 sq. km.
L	7.518 km

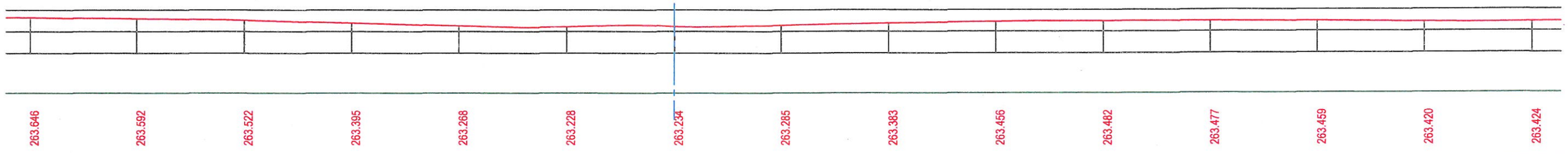
0348

PROPOSED BRIDGE NO. BR. 074 (PRL_339)
Rly Km. 301/18-21, DFCC Chainage 110723

U/S

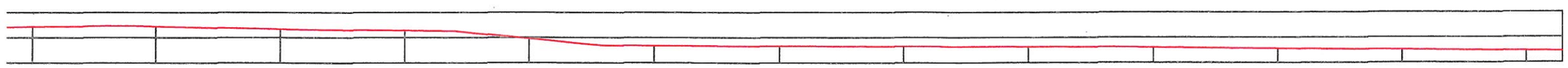
LEVEL	263.847	263.829	263.807	263.776	263.746	263.714	263.682	263.649	263.639	263.635	263.630	263.676	263.725	263.700	263.646
CHAINAGE	-1000.00	-950.00	-900.00	-850.00	-800.00	-750.00	-700.00	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00

U/S C/L OF BRIDGE D/S



263.646	263.592	263.522	263.395	263.268	263.228	263.234	263.285	263.383	263.456	263.482	263.477	263.459	263.420	263.424
-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00

D/S

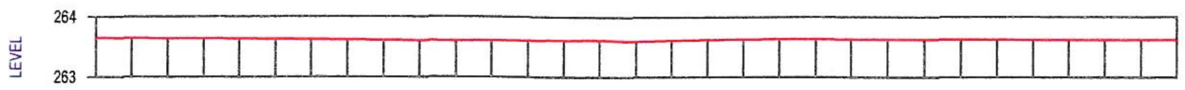


263.424	263.438	263.335	263.279	262.959	262.672	262.659	262.644	262.627	262.622	262.619	262.613	262.599	262.589
400.00	450.00	500.00	550.000	600.000	650.000	700.000	750.000	800.000	850.000	900.000	950.000	1000.000	1014.617

0349

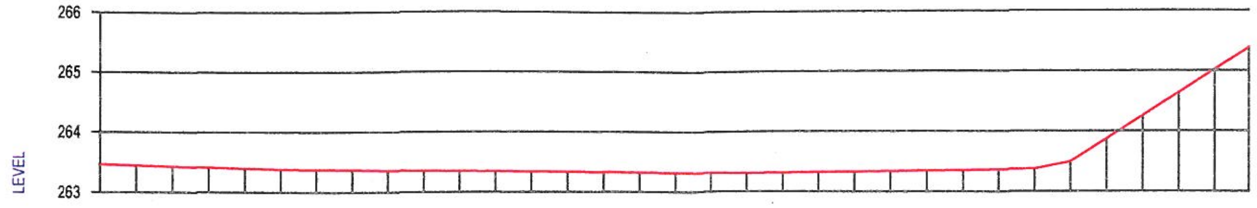
LONGITUDINAL SECTION

SHEET NO. 1 TO 2



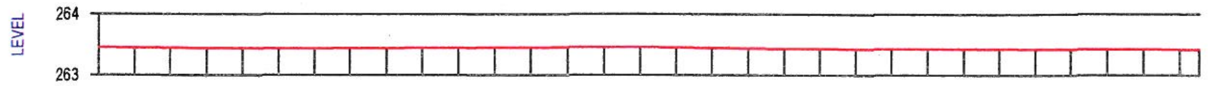
LEVEL	263.658	263.655	263.652	263.648	263.645	263.642	263.639	263.636	263.632	263.629	263.626	263.627	263.630	263.633	263.637	263.640	263.643	263.646	263.647	263.646	263.645	263.644	263.644	263.643	263.642	263.642	263.641	263.640	263.639	263.639	263.638
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000

(Upstream at 495m)



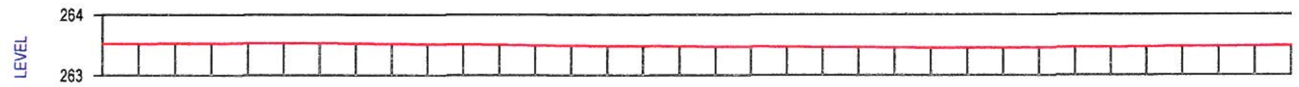
LEVEL	263.305	263.294	263.283	263.273	263.262	263.252	263.247	263.242	263.237	263.232	263.228	263.225	263.221	263.218	263.214	263.211	263.207	263.204	263.201	263.205	263.211	263.217	263.222	263.228	263.234	263.240	263.246	263.324	263.579	263.833	264.088	264.343	264.585
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000	34.000	35.900

(Downstream at 00m)



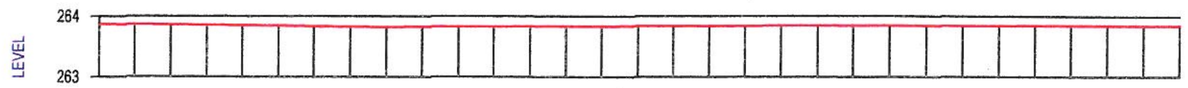
LEVEL	263.300	263.298	263.296	263.294	263.292	263.290	263.290	263.292	263.294	263.296	263.298	263.300	263.302	263.303	263.305	263.304	263.300	263.297	263.294	263.290	263.289	263.288	263.287	263.286	263.285	263.284	263.[illegible]	263.283	263.282	263.281	263.280 263.280
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000 33.071

(Bridge site)



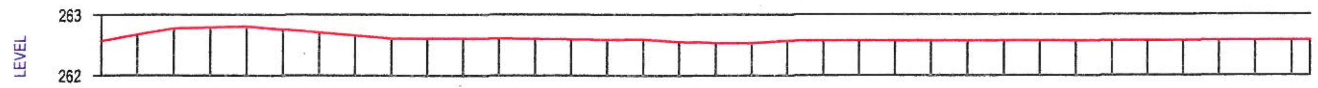
LEVEL	263.347	263.349	263.350	263.352	263.353	263.355	263.354	263.351	263.347	263.343	263.339	263.335	263.331	263.327	263.324	263.321	263.319	263.317	263.314	263.312	263.309	263.307	263.304	263.302	263.300	263.303	263.305	263.307	263.309	263.312	263.314	263.316	263.318	263.321
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000	34.000	36.000	38.000

(Downstream at 495m)



LEVEL	263.865	263.861	263.858	263.854	263.851	263.847	263.844	263.840	263.836	263.837	263.838	263.839	263.840	263.841	263.843	263.844	263.845	263.846	263.847	263.847	263.848	263.848	263.849	263.849	263.850	263.850	263.851	263.851	263.852	263.852	263.853
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000

(Upstream at 990m)



LEVEL	262.635	262.704	262.773	262.725	262.702	262.689	262.665	262.635	262.620	262.618	262.617	262.616	262.614	262.613	262.608	262.611	262.613	262.615	262.618	262.621	262.625	262.632	262.635	262.636	262.636	262.636	262.637	262.637	262.638	262.638	262.639	262.639	262.639	262.640	262.640
CHAINAGE	-28.00	-26.00	-24.00	-22.00	-20.00	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	20.00	22.00	24.00	26.00	28.00	30.000	32.000	34.000	36.000	38.000	39.006

(Downstream at 10005m)

CROSS SECTION

0350

SHEET NO. 2 TO 2

Existing Bridge No – 340
Location – KM 301/27-29

Proposed Bridge No – 075
Location – CH: 110979

(Hydrology Details)

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

Name / No. of Proposed Bridge :	340
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 :	301/27-29
Latitude :	$30^0$33'8"
Longitude :	$76^0$28'42"

Catchment Area ,	**A**	=	2.472 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	5.261 Km
Height of Farthest Point ,	**H1**	=	270.04 m
Height of Point of Interest ,	**H2**	=	265.44 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	4.60 m
Average Bed Level		=	265.44 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

0351

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

= **3.293 Hr**

= **197.608 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 = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.588**

(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)**

= **12.96 cm**

= **129.60 mm**

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

= **39.35 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **10.816 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	2.472 Sq. Km	247.17 Hectares
Length of path from Toposheet,	L	=	5.261 Km	
Difference in Levels from Toposheet,	H	=	4.60 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		3.58 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	54.54 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)	0.400
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98
A = Catchment Area in Hectares	247.17 Hectares
I_c = Critical Intensity of Rainfall	5.454 cm / Hr
Q = Maximum Discharge	**14.795 Cumecs**

3 Discharge by Dicken's Formula :

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

where,

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

C	=	16	(adopted in present case)
M	=	2.472	Sq Km

Hence, Q = **31.541 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)	10.816 Cumecs
Discharge by Rational Formula (IRC approach)	14.795 Cumecs
Discharge by Dicken's Formula	31.541 Cumecs
Maximum Discharge	31.541 Cumecs
Next Maximum Discharge	14.795 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **22.193 Cumecs**

5 Linear Waterway :

Average Bed Level		=	265.44 m
HFL as per site condition & local inquiry		=	267.85 m
So, Total Depth of Water,	H	=	2.41 m

Provide 2 spans of 9.15m at proposed site location.

Clear Waterway (provided),	L	=	18.30 m
Total Area,	A	=	44.030 m2
Velocity ,	V	=	Q / A
		=	**0.504 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	22.193 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**

= **268.450 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 **28.851 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	1.58 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.82 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}**

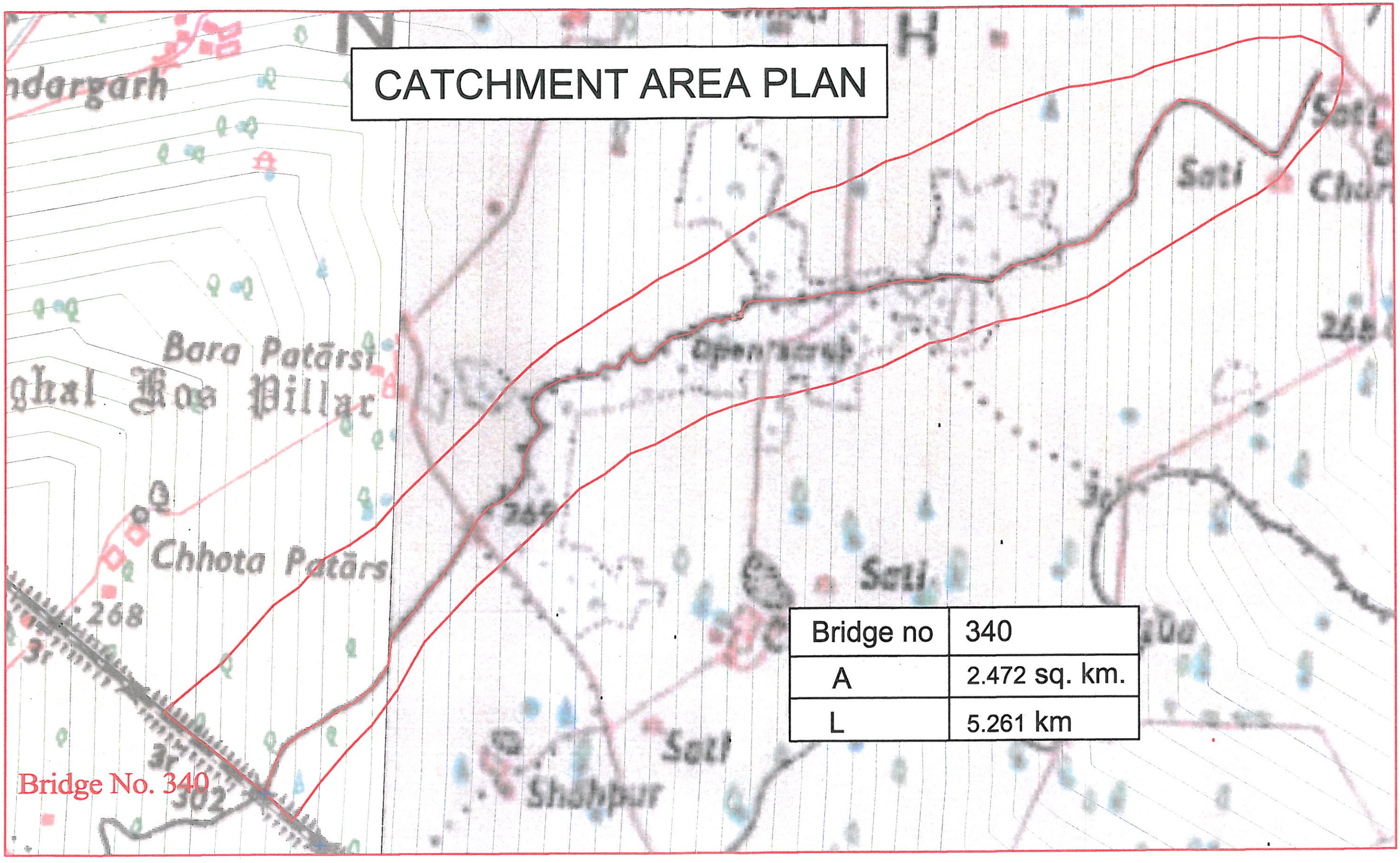
So, **Maximum Scour Depth** = **2.723 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **265.13 m**

CATCHMENT AREA PLAN



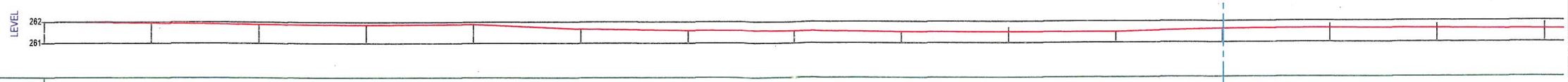
Bridge no	340
A	2.472 sq. km.
L	5.261 km

PROPOSED BRIDGE NO. BR.075(PRL_340)
Rly Km. 301/27-30, DFCC Chainage 110979

U/S

C/L OF BRIDGE

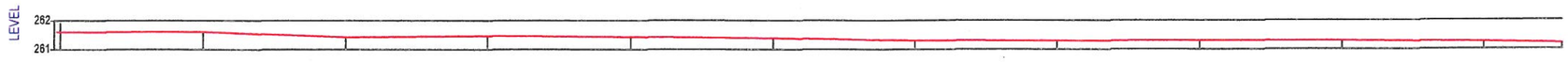
D/S



LEVEL	261.998	261.939	261.880	261.865	261.875	261.660	261.593	261.568	261.516	261.676	261.494	261.628	261.647	261.631	261.599
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

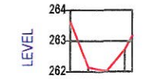
LONGITUDINAL SECTION

D/S



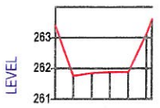
LEVEL	261.599	261.607	261.426	261.468	261.429	261.386	261.302	261.297	261.303	261.299	261.249	261.221
CHAINAGE	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.000	600.000	650.000	677.524

LONGITUDINAL SECTION



LEVEL	263.622	262.141	262.020	263.178
CHAINAGE	-4.00	-2.00	0.000	2.00

(Bridge site)



LEVEL	263.401	261.753	261.845	261.880	261.880	263.130
CHAINAGE	-4.00	-2.00	0.000	2.00	4.00	6.00

(Upstream at 350m)

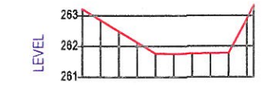
LEVEL	262.391	262.391	262.392	262.396	262.399	262.419	262.470	262.556
CHAINAGE	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	6.386

(Upstream at 550m)

LEVEL	263.264	263.248	263.233	263.217	263.207	263.200	263.192	263.200	263.262	263.363	263.433
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.726

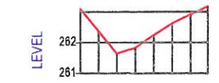
(Downstream at 00m)

CROSS SECTION



LEVEL	263.213	262.851	262.489	262.127	261.765	261.757	261.765	261.772	261.780	262.131	262.481
CHAINAGE	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	9.742	11.48

(Downstream at 275m)



LEVEL	263.096	262.364	261.632	261.833	262.238	262.623	262.913	263.178	
CHAINAGE	-8.00	-4.00	-2.00	0.000	2.00	4.00	6.00	7.830	

(Downstream at 410m)

CROSS SECTION

0356

SHEET NO.-1

Existing Bridge No – 341
Location – KM 302/13-15

Proposed Bridge No – 076
Location – CH: 111543

(Hydrology Details)

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

Name / No. of Proposed Bridge :			341
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 :			302/13-15
Latitude :			$30^0$33'20"
Longitude :			$76^0$28'25"
Catchment Area ,	**A**	=	2.626 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	3.455 Km
Height of Farthest Point ,	**H1**	=	267.95 m
Height of Point of Interest ,	**H2**	=	265.05 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	2.90 m
Average Bed Level		=	265.05 m

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

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

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

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

(iii) Calculation of Intensity of Rainfall, I :

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

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

= **2.499 Hr**

= **149.940 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 = $\frac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

= **1.491**

(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)**

= **12.17 cm**

= **121.66 mm**

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

= **48.68 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **14.214 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	2.626 Sq. Km	262.56 Hectares
Length of path from Toposheet,	L	=	3.455 Km	
Difference in Levels from Toposheet,	H	=	2.90 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		2.63 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	68.80 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	262.56	Hectares
I_c = Critical Intensity of Rainfall	6.880	cm / Hr
Q = Maximum Discharge	**19.826**	**Cumecs**

3 Discharge by Dicken's Formula :

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

where,

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

C	=	16 (adopted in present case)
M	=	2.626 Sq Km

Hence, Q = **33.002 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)	14.214 Cumecs
Discharge by Rational Formula (IRC approach)	19.826 Cumecs
Discharge by Dicken's Formula	33.002 Cumecs
Maximum Discharge	33.002 Cumecs
Next Maximum Discharge	19.826 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **29.739 Cumecs**

5 Linear Waterway :

Average Bed Level		=	265.05 m
HFL as per site condition & local inquiry		=	267.55 m
So, Total Depth of Water,	H	=	2.50 m

Provide 5 spans of 3.05 m RCC SLAB at proposed bridge site location.

Clear Waterway (provided),	L	=	15.25 m
Total Area,	A	=	38.125 m2
Velocity ,	V	=	Q / A
		=	**0.780 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	29.739 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**

= **268.152 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 **38.660 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 2.54 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = **2.49 m**

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

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

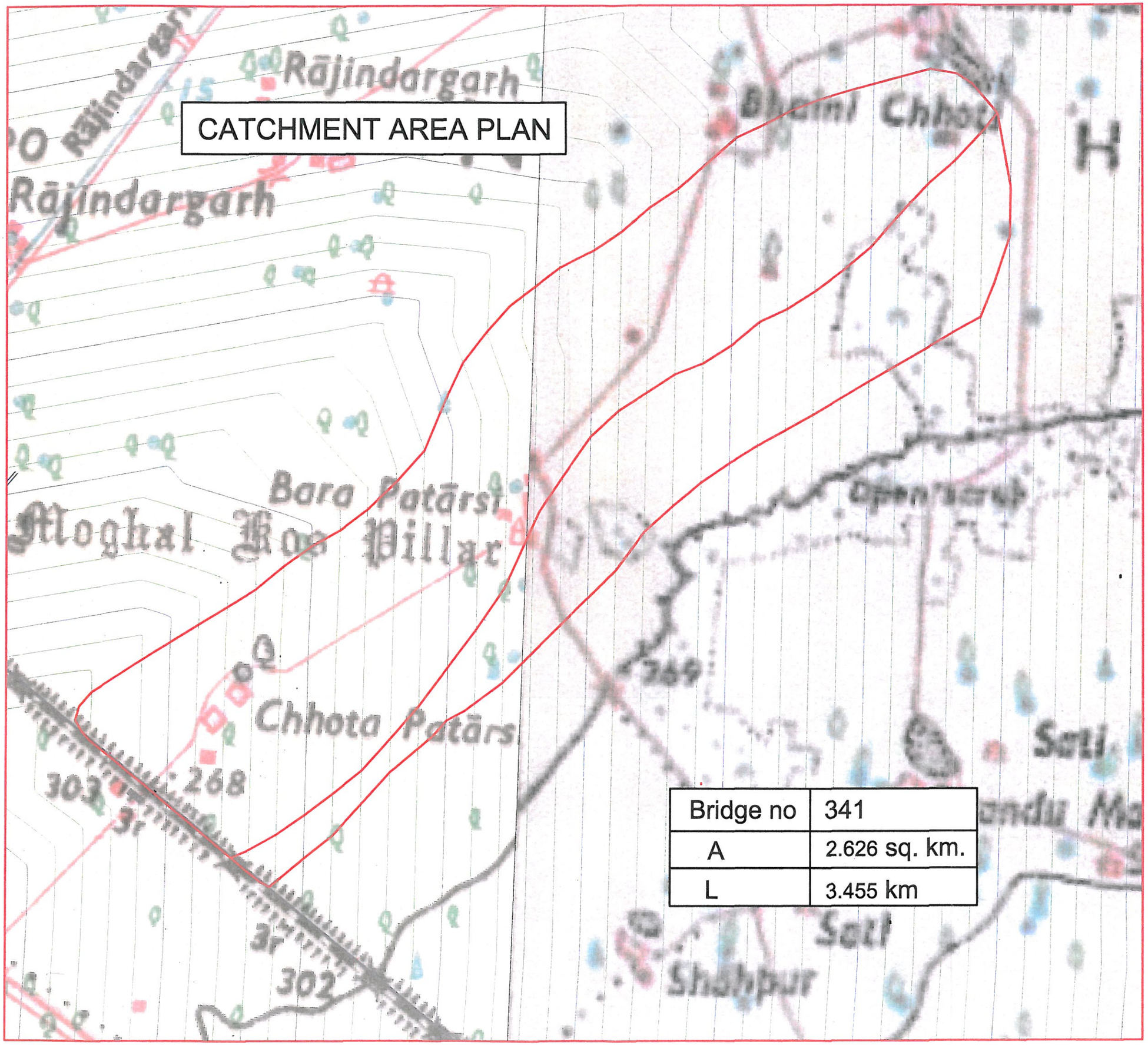
So, **Maximum Scour Depth** = **3.737 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **263.81 m**

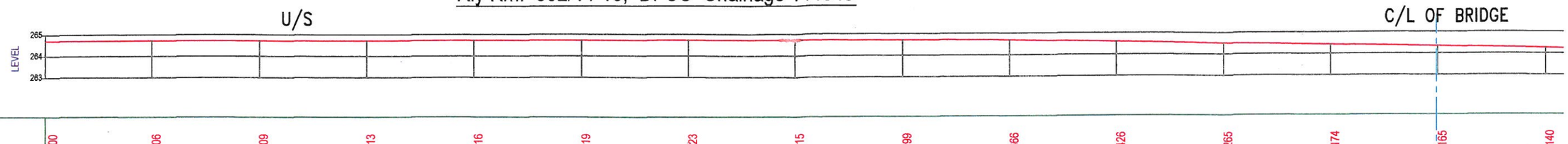
CATCHMENT AREA PLAN



Bridge no	341
A	2.626 sq. km.
L	3.455 km

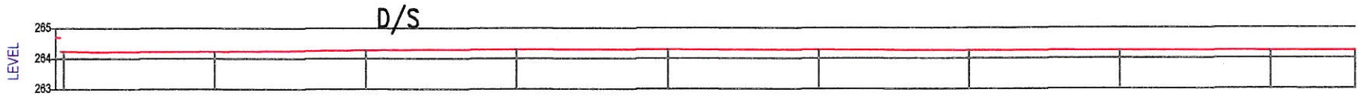
0361

PROPOSED BRIDGE NO. BR.076(PRL_341)
Rly Km. 302/14-16, DFCC Chainage 111543



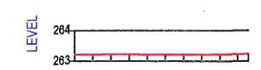
LEVEL	263.700	263.706	263.709	263.713	263.716	263.719	263.723	263.715	263.699	263.666	263.426	263.265	263.174	263.165	263.140
CHAINAGE	-650.00	-600.00	-550.00	-500.00	-450.00	-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.000	50.00

LONGITUDINAL SECTION



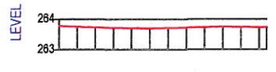
LEVEL	263.140	263.236	263.280	263.298	263.292	263.283	263.265	263.254	263.248	263.245
CHAINAGE	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	477.780

LONGITUDINAL SECTION



LEVEL	263.140	263.143	263.146	263.146	263.144	263.142	263.140	263.140	263.147	263.154
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00

(Bridge site)



LEVEL	263.776	263.760	263.744	263.738	263.731	263.725	263.733	263.740	263.748	263.756
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00

(Upstream at 300m)

LEVEL	263.676	263.681	263.685	263.688	263.692	263.670	263.665	263.673	263.675	263.682
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00

(Upstream at 620m)

CROSS SECTION

LEVEL	262.058	262.056	262.058	262.057	262.057	262.057	262.059	262.061	262.062	262.061	262.060	262.059	262.058
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	11.677

(Downstream at 00m)

LEVEL	263.297	263.297	263.296	263.286	263.295	263.293	263.292	263.290	263.292	263.295	263.297	263.300	263.300
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	10.000

(Downstream at 250m)

LEVEL	263.228	263.254	263.250	263.246	263.244	263.244	263.243	263.247	263.250	263.254	263.257	263.258
CHAINAGE	-10.00	-8.00	-6.00	-4.00	-2.00	0.000	2.00	4.00	6.00	8.00	10.000	10.677

(Downstream at 490m)

CROSS SECTION

0362

SHEET NO.-1

Existing Bridge No – 342
Location – KM 303/12-14

Proposed Bridge No – 077
Location – CH: 112435

(Hydrology Details)

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

Name / No. of Proposed Bridge :	342
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 :	303/12-14
Latitude :	$30^0$33'37"
Longitude :	$76^0$28'58"

Catchment Area ,	**A**	=	0.549 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	1.703 Km
Height of Farthest Point ,	**H1**	=	267.70 m
Height of Point of Interest ,	**H2**	=	266.45 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	1.25 m
Average Bed Level		=	266.45 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**