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. 1/2

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

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Hydraulic Data for Contract Package 301					
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METHODOLOGY

METHODOLOGY FOR HYDROLOGICAL CALCULATIONS

Physiographic parameters of various structure sites have assessed on the basis of G.T. sheets of the area as available on scale 1: 50,000. Inputs in the study include the field surveys data, road inventory records, geo-technical investigations and information gathered during field visit. Design discharge at each structure site shall be estimated through various available approaches.

Study on topography (topographic maps), storm duration, rainfall statistics, top soil characteristics, vegetation cover etc were done so as to assess the catchments areas and hydraulic parameters for all existing and proposed drainage provisions. The findings of the desk study have been further supplemented and augmented by a reconnaissance along the area. All important hydrological features were noted during this field reconnaissance.

Information on high flood level (HFL), low water levels (LWL), discharge, velocity etc. were collected from available past records, local inquiries and visible signs, on the structural components and embankments. Local inquiries were also made with regard to the road sections getting overtopped during heavy rains. The maximum Scour level has been calculated based on Lacey's theory and comparable with unscourable strata as per geotechnical report and final maximum scour level has been calculated for design purpose.

For the theoretical computation of Design Discharge, following methods shall be used.

1. Empirical Formula
2. Rational Method
3. Manning Formula

1. Empirical Formula

During the past decade, numbers of inventers / scientists have evolved many empirical formulae, to be utilized in different zones across the world. IRC-SP: 13, though has recommended using empirical formulae like Dicken's, Ryves and Inglis. Wherever hydrological records are inadequate, empirical formulae developed for the region is used. The common type of formula makes the flow function of catchment area i.e. C * (M) ^ n. The important formulae used in India are Dicken's, Ryve and Inglis. The exponent 'n' assigned the value of 3/4, 2/3 and1/2 respectively in Dicken, Ryve and Inglis formulae. Most popular formula in the region is **Dicken's Formula** and is adopted for catchment area up to 25 - 30 sq. Km.

$$Q = C * (M)^{3/4}$$

Where, Q = Peak runoff in cumecs
M = Catchment area in Sq.km.
C = Dicken's constant
= 11-14 where the annual rainfall is 600 mm to 1200 mm

= 14 -19 where the annual rainfall is more than 1200 mm
= 22 in Western Ghats

2. Rational Formula

The rational formula for assessment of peak discharge from project catchment takes into account rainfall, runoff under various circumstances, time of concentration and critical intensity of rainfall. For small size catchment (less than 25 Sq. Km), design discharge is estimated using the techniques described in **RDSO Report No: RBF - 16, titled as "Flood Estimation Methods for Catchments Less Than 25 Sq. Km in Area" and "IRC Approach".**

(I) RBF Method

Rational Formula is proposed with suggested improvements in the values of C and I.

$$Q_{50} = 0.278\ C^{*}\ I^{*}\ A$$

Where, Q_{50} = 50 year design flood discharge (m^3 / s)
C = Runoff coefficient
I = 50 year rainfall intensity (mm / h) lasting for t_c hour duration where t_c is the time of concentration
A = Catchment area (Sq Km)

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

Rainfall Intensity, I :

- By using Bhatnagar's formula, the time of concentration t_c is calculated as

$$t_c\ (\text{in hrs}) = [L^3 / H]^{0.345}$$

- Obtain 50 year 1 hour rainfall value using the rainfall map for the catchment lying in the sub-zone as attached with the Annexure.

- Method for computing R_{50} (t_c)

  Step 1: Read the ratio for t_c h (from Fig. 4)

  Step 2: Read the ratio for 1 h (from Fig. 4)

  Step 3: Obtain Coefficient, K

$$K = \frac{t_c \text{ h ratio}}{1 \text{ h ratio}}$$

  Step 4: $R_{50}(t_c) = K.\ R_{50}(1)$

  Step 5: Rainfall Intensity is calculated as

$$I = \frac{R_{50}(t_c)}{t_c}$$

Now, having obtained values of C, I and A, the 50 year design flood discharge can be computed using the formula as stated above.

(ii) IRC Approach

Rational Formula for Peak Run-off is given as

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

Where, Q = Maximum discharge (m^3 / s)
P = Coefficient of Runoff for the Catchment characteristics
f = Fraction of maximum point intensity at centre of storm, depends on area
A = Catchment Area in Hectares
I_c = Critical intensity of Rainfall in cm/hours

Critical Intensity I_c:

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

Time of concentration can be calculated as $t_c = (\,0.87 \times L^3 / H\,)^{0.385}$

I_o is One Hour Rainfall intensity is calculated as $I_o = (F / T) \times (T + 1) / (1 + 1)$

Here F = Maximum Rainfall in cm
T = Duration of Storm in hours

Coefficient of Runoff, P:

Steep, bare rock, city pavements	0.9
Rock, Steep but wooded	0.8
Plateaus , Lightly covered	0.7
Clavey soils, Stiff & bare	0.6
Clavey soils, Lightly covered	0.5
Loam, Lightly cultivated or covered	0.4
Loam, largely cultivated	0.3
Sandy Soil, Light growth	0.2
Sandy Soil, covered, heavy brush	0.1

(iii) Synthetic Unit Hydrograph

This method is applicable For Catchment area greater than 25 Sq. Km. some parameter are use in this method which are computed as listed below.

$t_p = 0.257 * A^{0.409} S^{0.432}$

$q_p = 2.165 * (t_p)^{-0.893}$

$W_{50} = 2.654 * (q_p)^{-0.921}$

$W_{75} = 1.672 * (q_p)^{-0.816}$

$W_{R50} = 1.245 * (q_p)^{-0.571}$

$W_{R50} = 1.245 * (q_p)^{-0.571}$

$T_B = 6.299 * (tp)^{0.612}$

$T_m = (t_p + t_r)/2$

$Q_p = q_p \times A$

By using these parameters unit hydrograph is plotted on graph paper and discharge can calculated.

3. Manning's Formula

For estimation of design flood based on field data, knowing the slope of the stream (S), Velocity as per Manning's Formula is given by the relation,

Velocity of flow in a channel

$$V = 1 / \eta * (R)^{2/3} * (S)^{1/2}$$

Where, V = Mean velocity of flow in m/sec.
R = Hydraulic Radius in meter = A/P,
A = Water area i.e. area of flow in Sq.m.
P = Wetted perimeter in meter
S = Slope of the energy line (when flow is uniform, energy slope gradient may become parallel to the water surface slope and bed of the channel)
η = Coefficient of Roughness

Discharge, Q = A* V (in cumecs)

$$= A * 1 / \eta * (R)^{2/3} * (S)^{1/2}$$

$$= 1 / \eta * W * (R)^{2/3} * (S)^{1/2}$$

$$Q = A * (A/P)^{2/3} * [1 / \eta * (S)^{1/2}] \qquad (R = A/P)$$

$$Or, Q = 1 / \eta * (S)^{1/2} * [(A)^5 / (P)^2]^{1/3}$$

Knowing Q, W and S, D can be calculated.

Note: In this portion, Manning's formula can't be adopted for Hydrological calculations of Minor Bridges and Major Bridges, as the terrain is not well defined (partially flat & partially undulating). So in the present case only Empirical and Rational methods are applicable.

4. Design Discharge

Design discharge can be fixed 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. The values of peak discharge calculated as per above methods should be compared. The highest of these values should be adopted as design discharge, provided it does not exceed the next highest discharge by more than 50%. If it does, restrict it to that limit.

5. Linear Waterway

Regime width can be calculated for the design discharge determined above as per provisions in IRC-5 & IRC: SP-13. Linear waterway may be kept normally equal to the regime width for alluvial streams or equal to the natural width for streams with rigid banks. From the economy point of view, the linear waterway may be contracted leaving shallow depths.

Regime width as per IRC: 5-1998, Clause – 104.3; IRC-SP: 13-1998, Clause – 8.5 & Clause – 4.5, IRS - Code of Practice for the Design of Sub-structures & Foundations of Bridges:

$$W = 4.8 \times (Q)^{\wedge}(½)$$

Where, W = Regime Width
Q = Design Discharge (m^3/sec)

6. Vertical Clearance

Vertical Clearance as per IRC – 5: 1998, Clause – 106.2.1 is given as under :

Discharge (m^3/sec)	Minimum Vertical Clearance (mm)
Up to 0.3	150
Above 0.3 & up to 3.0	450
Above 3.0 & up to 30.0	600
Above 30.0 & up to 300	900
Above 300 & up to 3000	1200
Above 3000	1500

Vertical Clearance as per Railway Code for sub-structure, Clause – 4.8 is given as under :

Discharge (m^3/sec)	Minimum Vertical Clearance (mm)
0 - 30	600
31 – 300	600 – 1200 (Pro-rata)
301 – 3000	1500
Above 3000	1800

7. Scour Depth

Determination of scour depth is important factor for deciding depth of foundation. As per Clause 703.1, IRC : 78 – 2000 & Clause 4.4, IRS - Code of Practices for Design of Substructure & Foundation of Bridges, to provide for an adequate margin of safety, the scour for the foundations has been calculated for a larger discharge over the design discharge calculated above.

Increase in Design Discharge as per IRC : 78 - 2000, Clause : 703.1.1 is given as under :

Catchment Area (Sq. Km)	Increase over Design Discharge (%)
0 - 3000	30
3000 - 10000	30 - 20
10000 - 40000	20 - 10
Above 40000	10

Increase in Design Discharge as per Clause: 4.4, IRS - Code of Practices for Design of Substructure & Foundation of Bridges is given as under:

Catchment Area (Sq. Km)	Increase over Design Discharge (%)
0 - 500	30
500 - 5000	30 - 20
5000 - 25000	20 - 10
Above 25000	10

The mean depth of scour can be calculated as per Clause 703.2, IRC: 78 – 2000 & Clause 4.6, IRS - Code of Practices for Design of Substructure & Foundation of Bridges

$$d_{sm} = 1.34 \times (D_b^2 / K_{ef})^{1/3}$$

Where, d_{sm} = Mean Depth of Scour
D_b = Design Discharge per metre width of effective waterway
K_{ef} = Silt factor of bed material

Maximum Scour Depth below the highest flood level (HFL) for the design of foundations, protection works may be taken as per Clause 4.6.6, IRS Code of Practices for Design of Substructure & Foundation of Bridges.

Nature of the River	Depth of Scour
In a straight reach	1.25 D
At the moderate bend	1.5 D
At a severe bend	1.75 D
At a right angle bend	2.0 D
In severe swirls	2.5 to 2.75 D

Existing Bridge No – 237
Location – KM 190/11-13

Proposed Bridge No – 01
Location – CH: 119330

(Hydrology Details)

Hydrological Calculations for Bridge of Dedicated Freight Corridor - Sarsawa to Tapri

Name / No. of Proposed Bridge :			237
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo - Ganga Plains, 1 (e)
G.T Sheet No :			53 F / 8
Scale :			1 : 50,000
Location :			KM 190 / 11 - 13
Latitude :			30° 0' 22.61"
Longitude :			77° 27' 25.26"
Catchment Area ,	A	=	0.151 Sq Km
Length of Longest Stream course from source to the bridge site ,	L	=	0.495 Km
Height of Farthest Point ,	H1	=	273.11 m
Height of Point of Interest ,	H2	=	272.26 m
Height of the Farthest Point above Point of Interest along the river ,	H	=	0.85 m
Average Bed Level		=	272.26 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 = $[L^3 / H]^{0.385}$

= 0.511 Hr

= 30.648 Mins

(a) t_c h Ratio = 0.23 (from Fig. 4 of RBF - 16)

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

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

= 0.672

(d)

(i) R_{60} (24) = 28.00 cm

(ii) R_{60} (1) = 0.34 x R_{60} (24) [as per Clause : 2.1.3, RBF - 16, for River Sub - Zone : 1 (e)]

= 9.52 cm

(iii) R_{60} (t_c) = K x R_{60} (1)

= 6.40 cm

= 64.01 mm

(iv) Rainfall Intensity, I = $\frac{R_{60}(t_c)}{t_c}$

= 125.30 mm / Hr

(iv) Design Flood Discharge :

Q_{100} = 0.278 x C x I x A

Q_{100} = 2.104 Cumecs

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.151 Sq. Km	15.10 Hectares
Length of path from Toposheet,	L	=	0.495 Km	
Difference in Levels from Toposheet,	H	=	0.85 m	

Maximum Rainfall, F		=	280.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T_t) \times (T + 1) / (1 + 1)$	=	145.83 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.45 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	201.45 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	15.10 Hectares
I_c = Critical Intensity of Rainfall	20.145 cm / Hr
Q = Maximum Discharge	3.339 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	=	14 (adopted in present case)
M	=	0.151 Sq Km

Hence, Q = **3.391 Cumecs**

4 Discharge by Ryve's Formula :

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

where,

Q	=	the peak run-off in Cumecs
M	=	the catchment area in Sq Km
C	=	6.8 for areas within 25 Km of the coast 8.5 for areas between 25 & 160 Km of the coast 10.0 for limited areas near the hills

C	=	10 (adopted in present case)
M	=	0.151 Sq Km

Hence, Q = **2.836 Cumecs**

5 Design Discharge :

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

Discharge by Rational Formula (RBF - 16 Report)	2.104 Cumecs
Discharge by Rational Formula (IRC approach)	3.339 Cumecs
Discharge by Dicken's Formula	3.391 Cumecs
Discharge by Ryve's Formula	2.836 Cumecs
Maximum Discharge	3.391 Cumecs
Next Maximum Discharge	3.339 Cumecs
The difference is within 50% of the next maximum discharge	

Hence, Design Discharge adopted Q = **3.391 Cumecs**

0011

6 Linear Waterway :

Average Bed Level		=	272.26 m
HFL as per site condition & local inquiry		=	273.96 m
So, Total Depth of Water,	H	=	1.70 m

Provide 1 span of 6.10 m at bridge site location.

Clear Waterway (provided),	L	=	6.10 m
Total Area,	A	=	10.358 m2
Velocity ,	V	=	Q / A
		=	0.327 m/sec

7 Vertical Clearance :

Design Discharge	Q	=		3.391 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

= 274.560 m

8 Scour Depth :

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

Increased Design Discharge 4.409 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 0.72 Cumecs / m

K_{sf} = Silt factor 1.00

d_{sm} = 1.08 m

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

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

So, Maximum Scour Depth = 1.619 m

9 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= 272.34 m

0012

Existing Bridge No – 241
Location –Km 195/29 - 196/1

Proposed Bridge No – 9
Location – CH: 4030.336

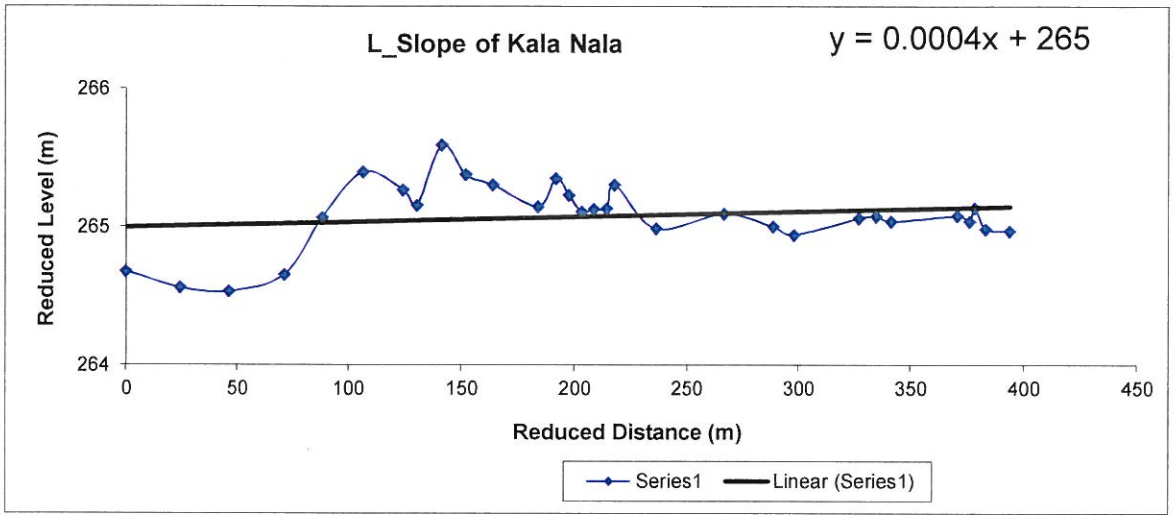
(Hydrology Details)

Br. No. 241
Nala/River Crossing Kala Nala
Proposed Chainage Indian Railways Ch:196/29-1 RITES CH:4/30.336
Type of STR Composite Girder(1 x 24.4)
Skew Angle 0 Degree

(A) FLOOD ESTIMATION

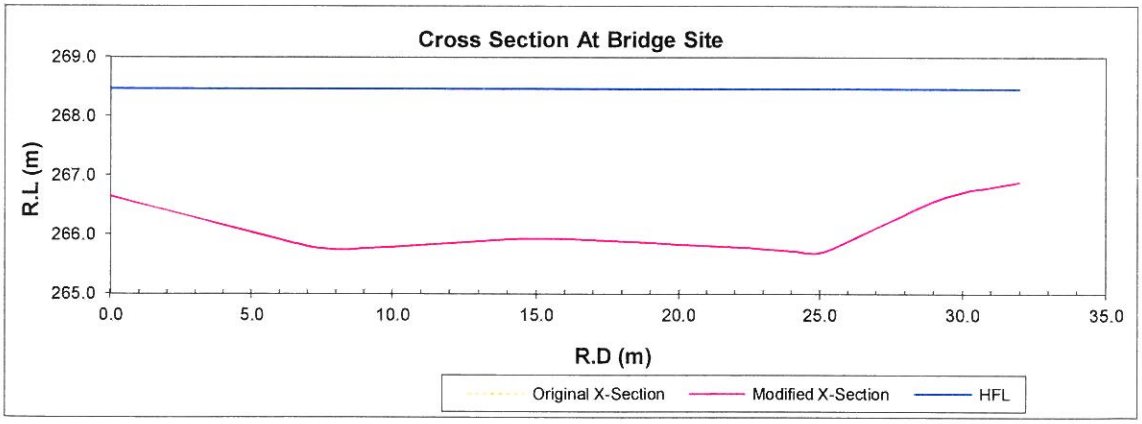
By Slope Area Method

HFL(by local enquiry) = 268.460 m



Average Bed Slope of River, S = 0.0004
Manning's Coefficient,n = 0.025 (in main channel)
= 0.03 (in flood plains)

At Bridge Site



Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	depth, d
0.00	266.643	266.643	268.460	-	-	-	-	-
1.00	266.523	266.523		1.877	1.007	1.864	2.2744	1.9372
2.00	266.403	266.403		1.997	1.007	1.983	2.5220	2.0573
3.00	266.283	266.283		2.117	1.007	2.102	2.7798	2.1774
4.00	266.162	266.162		2.237	1.007	2.222	3.0475	2.2975
5.00	266.042	266.042		2.358	1.007	2.341	3.3250	2.4176
6.00	265.922	265.922		2.478	1.007	2.460	3.6121	2.5377
7.00	265.802	265.802		2.598	1.007	2.579	3.9085	2.6578
8.00	265.745	265.745		2.686	1.002	2.682	4.1486	2.7150
9.00	265.762	265.762		2.707	1.000	2.706	4.2053	2.6985

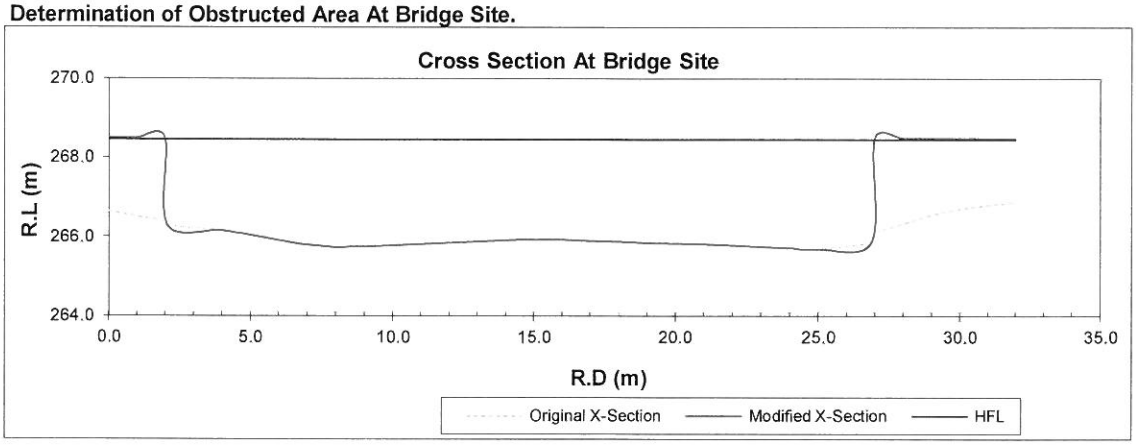
0013

10.00	265.794	265.794		2.682	1.001	2.681	4.1416	2.6664
11.00	265.826	265.826		2.650	1.001	2.649	4.0595	2.6345
12.00	265.857	265.857		2.619	1.001	2.617	3.9783	2.6025
13.00	265.889	265.889		2.587	1.001	2.585	3.8978	2.5706
14.00	265.916	265.916		2.557	1.000	2.557	3.8253	2.5442
15.00	265.933	265.933		2.536	1.000	2.535	3.7714	2.5269
16.00	265.931	265.931		2.528	1.000	2.528	3.7527	2.5288
17.00	265.907	265.907		2.541	1.000	2.540	3.7838	2.5526
18.00	265.884	265.884		2.564	1.000	2.564	3.8429	2.5763
19.00	265.860	265.860		2.588	1.000	2.587	3.9024	2.6001
20.00	265.836	265.836		2.612	1.000	2.611	3.9623	2.6238
21.00	265.812	265.812		2.636	1.000	2.635	4.0225	2.6475
22.00	265.790	265.790		2.659	1.000	2.658	4.0817	2.6702
23.00	265.756	265.756		2.687	1.001	2.686	4.1533	2.7040
24.00	265.724	265.724		2.720	1.001	2.719	4.2390	2.7363
25.00	265.691	265.691		2.752	1.001	2.751	4.3232	2.7686
26.00	265.882	265.882		2.673	1.018	2.626	4.0710	2.5781
27.00	266.108	266.108		2.465	1.025	2.404	3.5388	2.3517
28.00	266.335	266.335		2.239	1.025	2.183	3.0138	2.1253
29.00	266.561	266.561		2.012	1.025	1.962	2.5231	1.8989
30.00	266.716	266.716		1.821	1.012	1.800	2.1556	1.7435
31.00	266.803	266.803		1.700	1.004	1.694	1.9334	1.6575
32.00	266.889	266.889		1.614	1.004	1.608	1.7730	1.5714

An1=	77.499	Q=	112.570

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	266.643	268.500	268.460	-	-	-	-
1.00	266.523	268.500					
2.00	266.403	268.500					
2.10	266.283	266.283		0.107	2.220	0.048	2.1774
4.00	266.162	266.162		4.251	1.904	2.233	2.2975
5.00	266.042	266.042		2.358	1.007	2.341	2.4176
6.00	265.922	265.922		2.478	1.007	2.460	2.5377
7.00	265.802	265.802		2.598	1.007	2.579	2.6578
8.00	265.745	265.745		2.686	1.002	2.682	2.7150
9.00	265.762	265.762		2.707	1.000	2.706	2.6985
10.00	265.794	265.794		2.682	1.001	2.681	2.6664
11.00	265.826	265.826		2.650	1.001	2.649	2.6345
12.00	265.857	265.857		2.619	1.001	2.617	2.6025
13.00	265.889	265.889		2.587	1.001	2.585	2.5706
14.00	265.916	265.916		2.557	1.000	2.557	2.5442
15.00	265.933	265.933		2.536	1.000	2.535	2.5269
16.00	265.931	265.931		2.528	1.000	2.528	2.5288
17.00	265.907	265.907		2.541	1.000	2.540	2.5526
18.00	265.884	265.884		2.564	1.000	2.564	2.5763

19.00	265.860	265.860		2.588	1.000	2.587	2.6001
20.00	265.836	265.836		2.612	1.000	2.611	2.6238
21.00	265.812	265.812		2.636	1.000	2.635	2.6475
22.00	265.790	265.790		2.659	1.000	2.658	2.6702
23.00	265.756	265.756		2.687	1.001	2.686	2.7040
24.00	265.724	265.724		2.720	1.001	2.719	2.7363
25.00	265.691	265.691		2.752	1.001	2.751	2.7686
26.90	265.882	265.882		5.079	1.910	2.660	2.5781
27.00	266.108	268.500		0.127	2.620	0.048	
28.00	266.335	268.500					
29.00	266.561	268.500					
30.00	266.716	268.500					
31.00	266.803	268.500					
32.00	266.889	268.500					

An2*=	64.309

Therefore,

Discharge, Q	=	112.570	cumec
HFL (Without Afflux)	=	268.460	m
Average Depth, d	=	2.585	m
Lowest bed level	=	265.691	m

Area before constriction

An1	=	77.499	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	1.453	m/s

Area before constriction(excluding piers)

An2*	=	64.309	sq m

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	64.309	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	1.750	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.060	m

(D) Recommendation

Design Discharge, Q	=	112.570	cumecs
Design Affluxed HFL	=	268.520	m
Average Velocity, Vn2	=	1.750	m/sec

Check			
Formation Level	=	272.444	m
Slab Thickness	=	2.6	m
Sofit level	=	269.8	m
Available vertical clearance	=	1.780	m
Required vertical clearance	=	1.50	m
Adequacy	=	Adequate	
Required Freeboard	=	1.000	m

(E) CALCULATION OF SCOUR DEPTH

(Ref:IRS Sub-structure & Foundation Code)

Chainage (km)	196/29-1	
Str No.		
HFL (m)	268.460	
Q (cumecs)	112.570	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	146.341	
Effective Linear Waterway Provided (Le) (m)	24.400	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	58.494	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	2.582	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	4.575	(Cl.4.6.4)
Lowest Bed level(m)	265.691	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	4.465	m
Maximum Scour depth below HFL, Dmax	=	8.930	m
Maximum scour depth level	=	259.530	m

0016

Existing Bridge No – 242
Location – Km 197/23-25

Proposed Bridge No – 10
Location – CH: 197/23-25

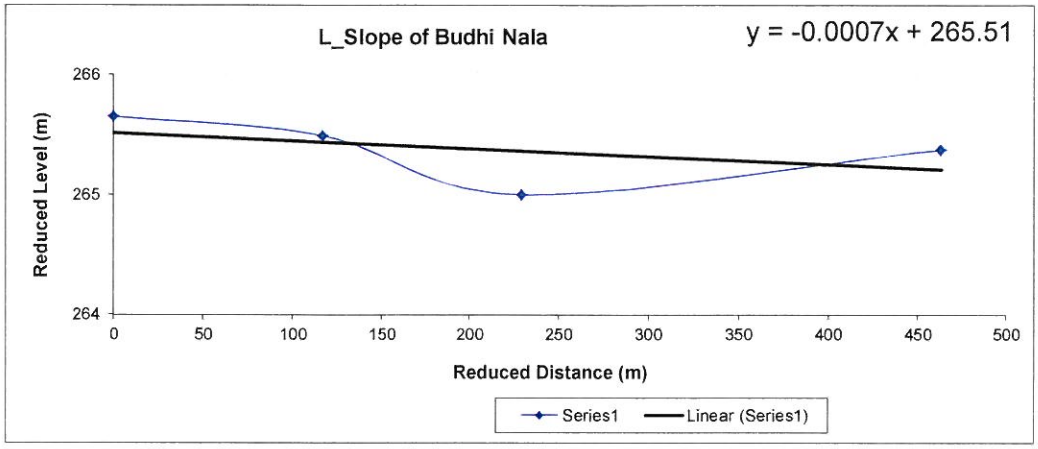
(Hydrology Details)

Br.No	242		
Nala/River Crossing	Budhi Nala		
Proposed Chainage	Indian railways:197/22-23		RITES Chainage:5/866.009
Type of STR	Steel Girder(2x 30.5)		
Skew Angle	0	Degree	

(A) **FLOOD ESTIMATION**

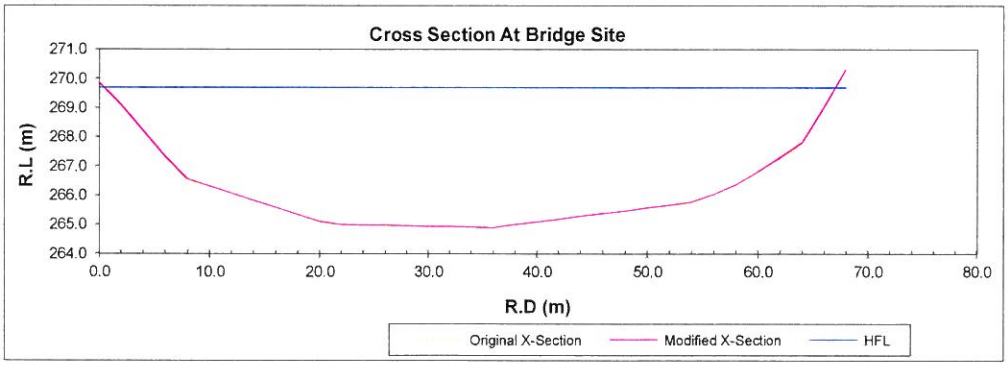
By Slope Area Method

HFL(by local enquiry) = 269.704 m



Average Bed Slope of River, S	=	0.0007	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site

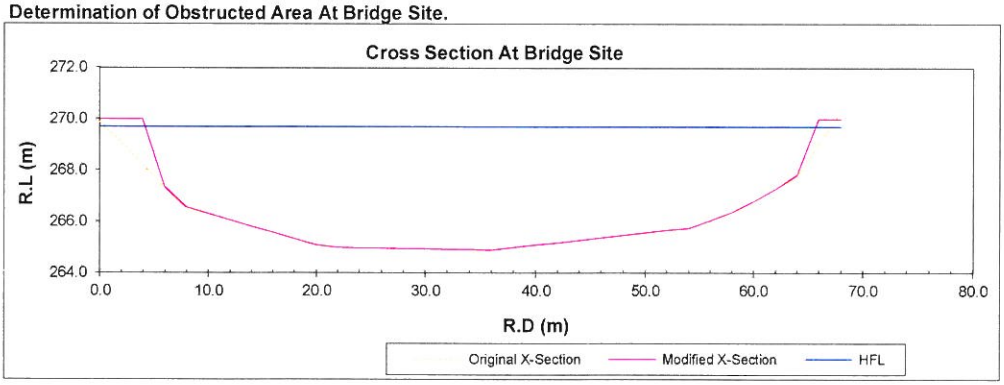


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	depth, d
0.00	269.881	269.881	269.704	-	-	-	-	-
2.00	269.119	269.119		0.408	2.140	0.190	0.1428	0.5850
4.00	268.237	268.237		2.052	2.186	0.939	2.0814	1.4665
6.00	267.356	267.356		3.815	2.186	1.745	5.8520	2.3481
8.00	266.571	266.571		5.481	2.148	2.551	10.8295	3.1328
10.00	266.326	266.326		6.511	2.015	3.231	15.0603	3.3782
12.00	266.081	266.081		7.002	2.015	3.475	16.9992	3.6235
14.00	265.835	265.835		7.492	2.015	3.718	19.0308	3.8689
16.00	265.590	265.590		7.983	2.015	3.962	21.1531	4.1142
18.00	265.344	265.344		8.474	2.015	4.205	23.3643	4.3596
20.00	265.099	265.099		8.964	2.015	4.449	25.6625	4.6049
22.00	264.998	264.998		9.311	2.003	4.650	27.4505	4.7061
24.00	264.984	264.984		9.426	2.000	4.713	28.0430	4.7202
26.00	264.969	264.969		9.455	2.000	4.727	28.1856	4.7349
28.00	264.955	264.955		9.484	2.000	4.742	28.3299	4.7493
30.00	264.940	264.940		9.513	2.000	4.756	28.4732	4.7636
32.00	264.926	264.926		9.542	2.000	4.771	28.6166	4.7780
34.00	264.912	264.912		9.570	2.000	4.785	28.7604	4.7924
36.00	264.897	264.897		9.599	2.000	4.799	28.9045	4.8067
38.00	264.993	264.993		9.517	2.002	4.753	28.4747	4.7108
40.00	265.089	265.089		9.326	2.002	4.657	27.5240	4.6148
42.00	265.185	265.185		9.134	2.002	4.562	26.5863	4.5188
44.00	265.279	265.279		8.943	2.002	4.467	25.6711	4.4247
46.00	265.377	265.377		8.752	2.002	4.371	24.7580	4.3269
48.00	265.473	265.473		8.558	2.002	4.274	23.8517	4.2309
50.00	265.569	265.569		8.366	2.002	4.178	22.9667	4.1349
52.00	265.665	265.665		8.174	2.002	4.082	22.0951	4.0389
54.00	265.761	265.761		7.982	2.002	3.986	21.2371	3.9429
56.00	266.045	266.045		7.602	2.020	3.763	19.4659	3.6593
58.00	266.369	266.369		6.995	2.026	3.452	16.9095	3.3355
60.00	266.798	266.798		6.241	2.046	3.051	13.8941	2.9057
62.00	267.286	267.286		5.323	2.059	2.586	10.6139	2.4178
64.00	267.821	267.821		4.301	2.070	2.077	7.4096	1.8828
66.00	269.039	269.039		2.548	2.342	1.088	2.8527	0.6651
68.00	270.307	270.307		0.062	2.368	0.026	0.0057	

An1=	245.904	Q=	661.256

(C) **Afflux Calculation**

Determination of Obstructed Area At Bridge Site.



0018

Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	269.881	270.000	269.704	-	-	-	-
2.00	269.119	270.000					
4.00	268.237	270.000					
6.00	267.356	267.356		2.052	3.315	0.619	2.3481
8.00	266.571	266.571		5.481	2.148	2.551	3.1328
10.00	266.326	266.326		6.511	2.015	3.231	3.3782
12.00	266.081	266.081		7.002	2.015	3.475	3.6235
14.00	265.835	265.835		7.492	2.015	3.718	3.8689
16.00	265.590	265.590		7.983	2.015	3.962	4.1142
18.00	265.344	265.344		8.474	2.015	4.205	4.3596
20.00	265.099	265.099		8.964	2.015	4.449	4.6049
22.00	264.998	264.998		9.311	2.003	4.650	4.7061
24.00	264.984	264.984		9.426	2.000	4.713	4.7202
26.00	264.969	264.969		9.455	2.000	4.727	4.7349
28.00	264.955	264.955		9.484	2.000	4.742	4.7493
30.00	264.940	264.940		9.513	2.000	4.756	4.7636
32.00	264.926	264.926		9.542	2.000	4.771	4.7780
34.00	264.912	264.912		9.570	2.000	4.785	4.7924
36.00	264.897	264.897		9.599	2.000	4.799	4.8067
38.00	264.993	264.993		9.517	2.002	4.753	4.7108
40.00	265.089	265.089		9.326	2.002	4.657	4.6148
42.00	265.185	265.185		9.134	2.002	4.562	4.5188
44.00	265.279	265.279		8.943	2.002	4.467	4.4247
46.00	265.377	265.377		8.752	2.002	4.371	4.3269
48.00	265.473	265.473		8.558	2.002	4.274	4.2309
50.00	265.569	265.569		8.366	2.002	4.178	4.1349
52.00	265.665	265.665		8.174	2.002	4.082	4.0389
54.00	265.761	265.761		7.982	2.002	3.986	3.9429
56.00	266.045	266.045		7.602	2.020	3.763	3.6593
58.00	266.369	266.369		6.995	2.026	3.452	3.3355
60.00	266.798	266.798		6.241	2.046	3.051	2.9057
62.00	267.286	267.286		5.323	2.059	2.586	2.4178
64.00	267.821	267.821		4.301	2.070	2.077	1.8828
66.00	269.039	270.000		1.587	2.958	0.537	
68.00	270.307	270.000					

An2*=	240.660

Therefore,

Discharge, Q	=	661.256	cumec
HFL (Without Afflux)	=	269.704	m
Average Depth, d	=	4.021	m
Lowest bed level	=	264.897	m

Area before constriction

An1	=	245.904	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	2.689	m/s

Area before constriction(excluding piers)

An2*	=	240.660	sq m

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	232.618	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	2.843	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.049	m

(D) Recommendation

Design Discharge, Q	=	661.256	cumecs
Design Affluxed HFL	=	269.753	m
Average Velocity, Vn2	=	2.843	m/sec

Check			
Formation Level	=	273.604	m
Slab Thickness	=	2.4	m
Sofit level	=	271.20	m
Proposed vertical clearance	=	1.780	m
Required vertical clearance	=	1.50	m
Adequacy	=	Adequate	
Required Freeboard	=	1.000	m

0019

(E) CALCULATION OF SCOUR DEPTH

(Ref:IRS Sub-structure & Foundation Code)

Chainage (km)	railways:197/22-23	
Str No.		
HFL (m)	269.704	
Q (cumecs)	661.256	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	859.632	
Effective Linear Waterway Provided (Le) (m)	61.000	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	141.771	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	4.658	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	8.085	(Cl.4.6.4)
Lowest Bed level(m)	264.770	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	8.085	m
Maximum Scour depth below HFL, Dmax	=	16.171	m
Maximum scour depth level	=	259.530	m

0020

Existing Bridge No – 253
Location – Km 212/33-35

Proposed Bridge No – 23
Location – CH: 21013.359

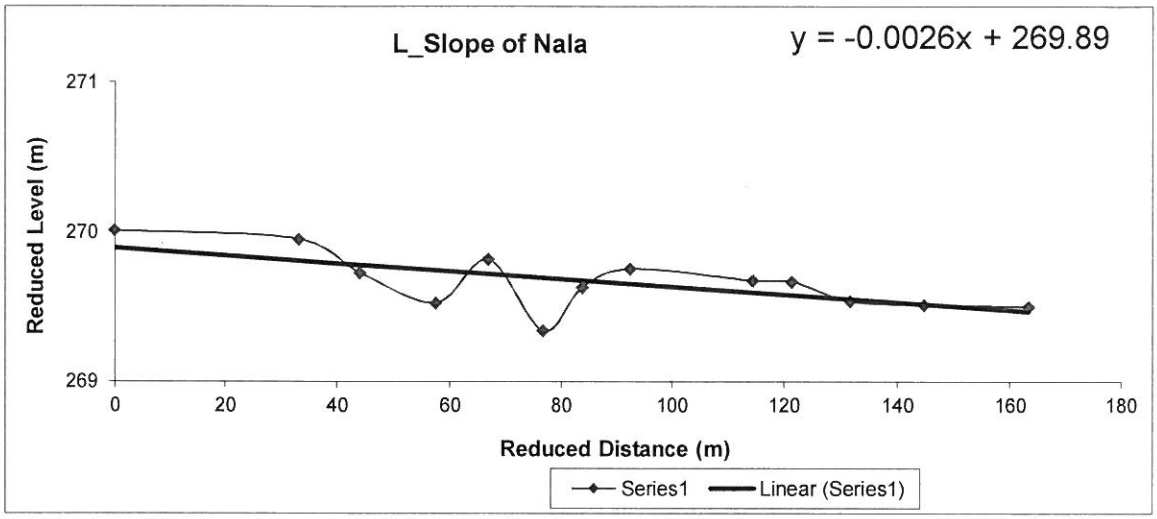
(Hydrology Details)

Br. No.	253		
Nala/River Crossing	**Drain**		
Proposed Chainage	**Indian Railways ch:212/33-35**		RITES Chainage21/13.359
Type of STR	RCC Box		
Skew Angle	0	Degree	

(A) FLOOD ESTIMATION

(1) By Slope Area Method

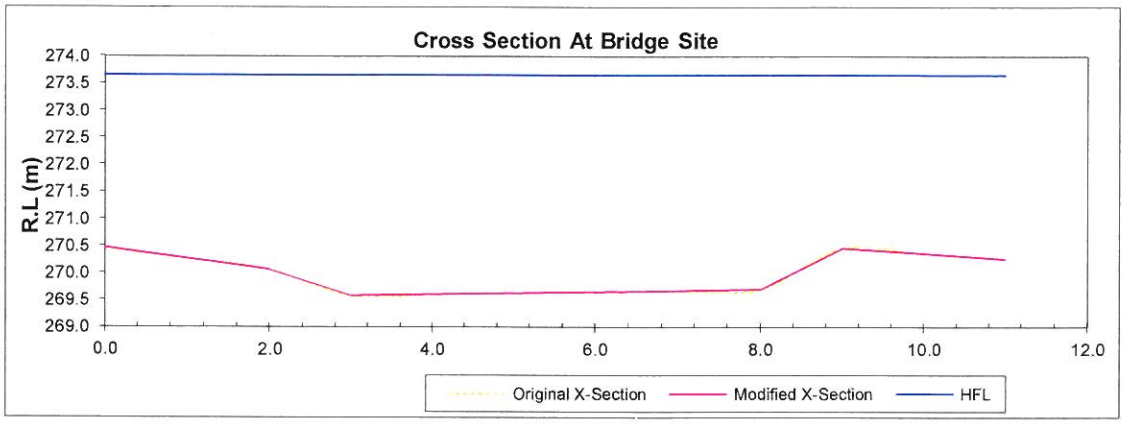
HFL(by local enquiry) = 273.65 m



Average Bed Slope of River, S	=	0.0026	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

0021

At Bridge Site

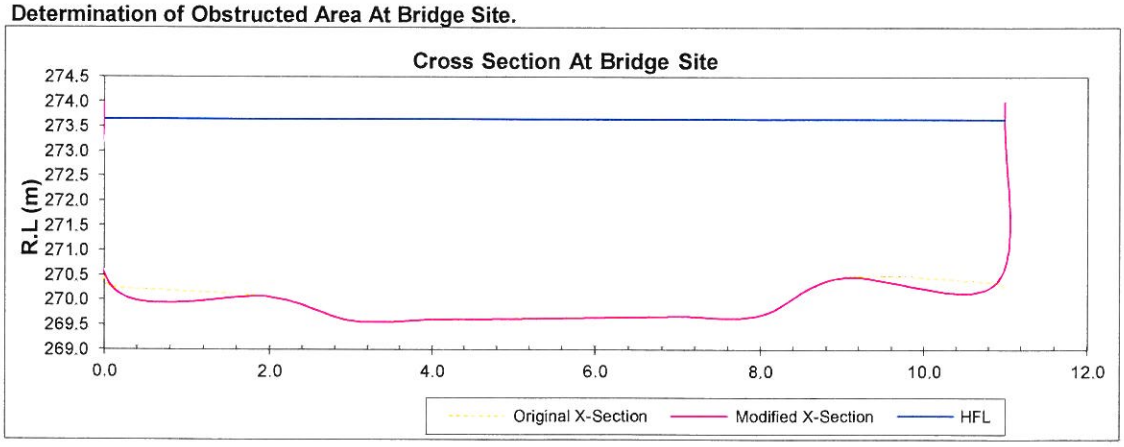


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	270.463	270.463	273.650	-	-	-	-	
1.00	270.261	270.261		3.288	1.020	3.223	14.6341	
2.00	270.060	270.060		3.490	1.020	3.421	16.1585	
3.00	269.582	269.582		3.829	1.108	3.455	17.8496	
4.00	269.605	269.605		4.057	1.000	4.056	21.0423	
5.00	269.627	269.627		4.034	1.000	4.033	20.8469	
6.00	269.650	269.650		4.011	1.000	4.010	20.6522	
7.00	269.673	269.673		3.989	1.000	3.988	20.4586	
8.00	269.695	269.695		3.966	1.000	3.965	20.2653	
9.00	270.455	270.455		3.575	1.256	2.847	14.6456	
10.00	270.356	270.356		3.245	1.005	3.229	14.4573	
11.00	270.257	270.257		3.344	1.005	3.328	15.2014	

An1=	40.827		Q=	196.212

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



0022

Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	270.463	274.000	273.650	-	-	-	-
0.10	270.261	270.261		0.152	3.740	0.041	3.3888
2.00	270.060	270.060		6.630	1.911	3.470	3.5903
3.00	269.582	269.582		3.829	1.108	3.455	4.0680
4.00	269.605	269.605		4.057	1.000	4.056	4.0454
5.00	269.627	269.627		4.034	1.000	4.033	4.0227
6.00	269.650	269.650		4.011	1.000	4.010	4.0001
7.00	269.673	269.673		3.989	1.000	3.988	3.9775
8.00	269.695	269.695		3.966	1.000	3.965	3.9548
9.00	270.455	270.455		3.575	1.256	2.847	3.1951
10.90	270.356	270.356		6.165	1.903	3.240	3.2943
11.00	270.257	274.000		0.147	3.646	0.040	

An2*=	40.555

Therefore,

Discharge, Q	=	196.212	cumec
HFL (Without Afflux)	=	273.650	m
Average Depth, d	=	3.754	m
Lowest Bed level	=	269.582	m

Area before constriction

An1	=	40.827	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	4.806	m/s

Area after constriction(excluding piers)

An2*	=	40.555	

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	35.300	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	5.558	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.441	m

(D) Recommendation

Design Discharge, Q	=	196.212	cumecs
Design Affluxed HFL	=	273.650	m
Average Velocity, Vn2	=	5.558	m/sec

Check			
Formation Level	=	274.65	m
Slab Thickness	=	0.5	m
Sofit level	=	274.15	m
Available vertical clearance	=	0.500	m
Required vertical clearance	=	-	m
Adequacy	=	Adequate.	

0023

(E) CALCULATION OF SCOUR DEPTH

Chainage (km)	Railways ch:212/33-35	
Str No.		
HFL (m)	273.650	
Q (cumecs)	154.500	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	200.850	
Effective Linear Waterway Provided (Le) (m)	8.000	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	68.528	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	2.869	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	12.325	(Cl.4.6.4)
Lowest Bed level(m)	271.973	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	12.325	m
Maximum Scour depth below HFL, Dmax	=	24.650	m
Maximum scour depth level	=	249.400	m

0024

Existing Bridge No – 259
Location – Km 219/17-19

Proposed Bridge No – 31
Location – CH:27676.071

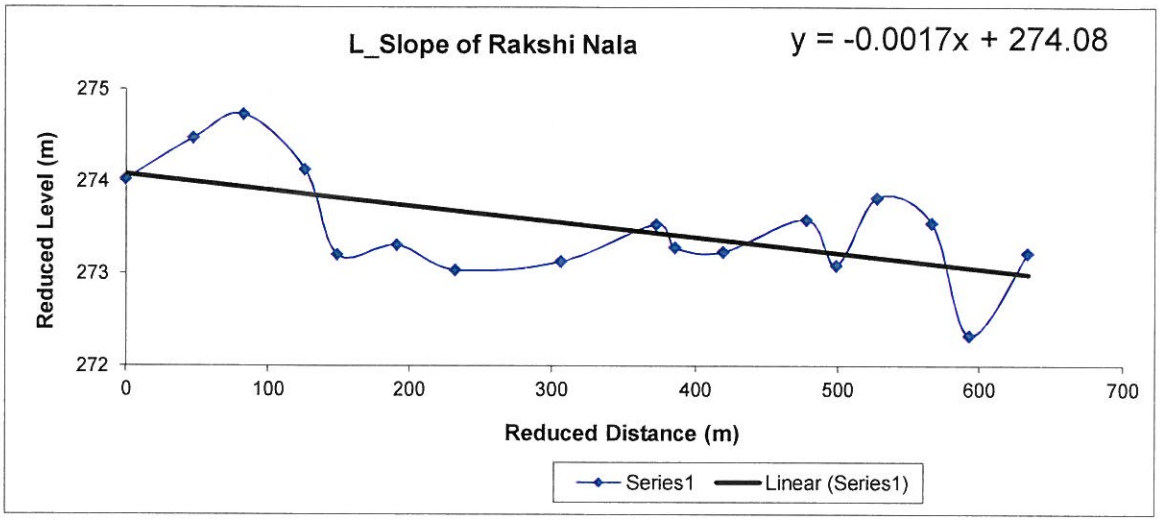
(Hydrology Details)

Br No.	259	
Nala/River Crossing	Rakshi Nala	
Proposed Chainage	Indian railways:219/17-19	RITES Ch:27/676.071
Type of STR	Composite Girder(1x 24.4)	
Skew Angle	0 Degree	

(A) FLOOD ESTIMATION

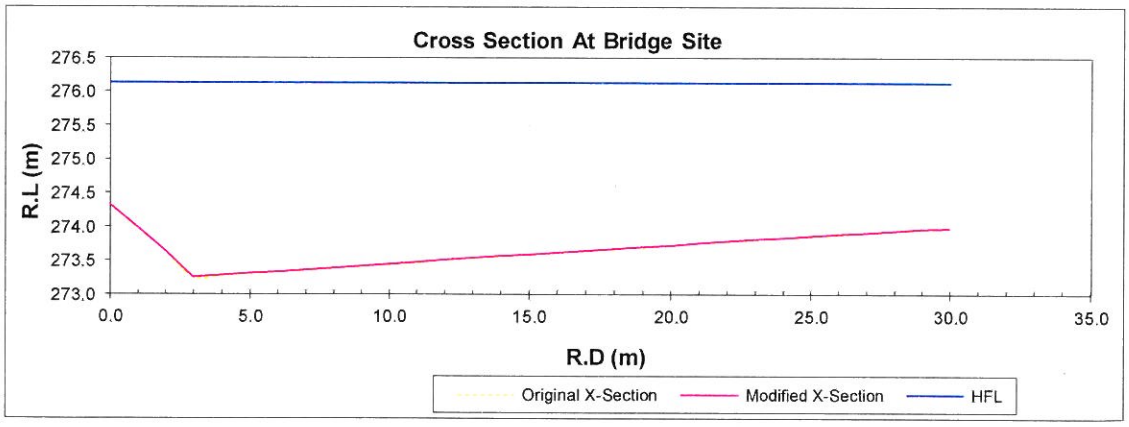
By Slope Area Method

HFL(by local enquiry) = 276.130 m



Average Bed Slope of River, S	=	0.0017	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site

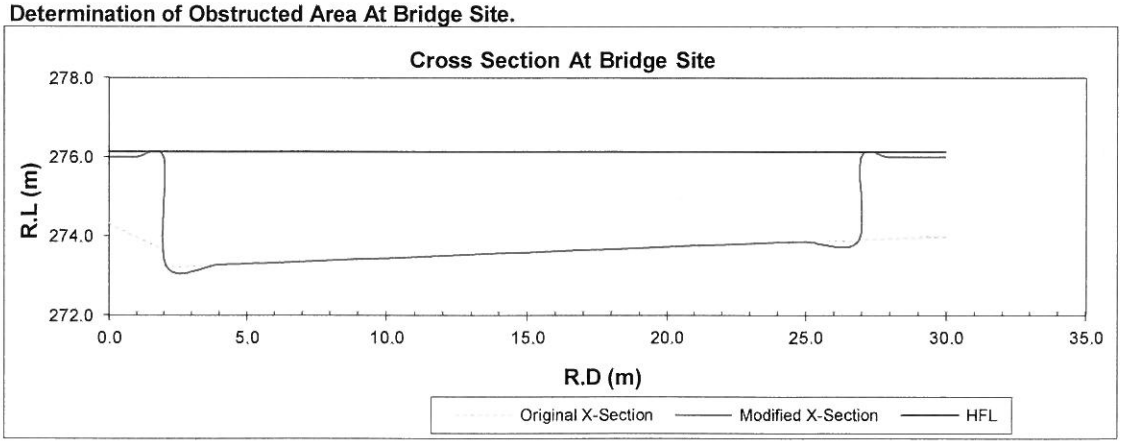


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	depth, d
0.00	274.329	274.329	276.130	-	-	-	-	-
1.00	273.985	273.985		1.973	1.057	1.866	4.9322	2.1446
2.00	273.642	273.642		2.316	1.057	2.191	6.4436	2.4878
3.00	273.254	273.254		2.682	1.073	2.500	8.1479	2.8761
4.00	273.281	273.281		2.862	1.000	2.861	9.5152	2.8489
5.00	273.308	273.308		2.835	1.000	2.834	9.3649	2.8217
6.00	273.336	273.336		2.808	1.000	2.807	9.2156	2.7945
7.00	273.363	273.363		2.781	1.000	2.780	9.0672	2.7672
8.00	273.390	273.390		2.754	1.000	2.753	8.9198	2.7400
9.00	273.417	273.417		2.726	1.000	2.725	8.7734	2.7128
10.00	273.444	273.444		2.699	1.000	2.698	8.6280	2.6856
11.00	273.472	273.472		2.672	1.000	2.671	8.4835	2.6584
12.00	273.513	273.513		2.638	1.001	2.636	8.3007	2.6172
13.00	273.539	273.539		2.604	1.000	2.603	8.1263	2.5906
14.00	273.566	273.566		2.577	1.000	2.576	7.9885	2.5640
15.00	273.593	273.593		2.551	1.000	2.550	7.8517	2.5375
16.00	273.619	273.619		2.524	1.000	2.523	7.7158	2.5109
17.00	273.646	273.646		2.498	1.000	2.497	7.5808	2.4843
18.00	273.672	273.672		2.471	1.000	2.470	7.4469	2.4577
19.00	273.699	273.699		2.444	1.000	2.444	7.3138	2.4311
20.00	273.725	273.725		2.418	1.000	2.417	7.1818	2.4046
21.00	273.762	273.762		2.386	1.001	2.385	7.0258	2.3684
22.00	273.788	273.788		2.355	1.000	2.354	6.8740	2.3419
23.00	273.813	273.813		2.329	1.000	2.328	6.7484	2.3165
24.00	273.839	273.839		2.304	1.000	2.303	6.6264	2.2912
25.00	273.864	273.864		2.278	1.000	2.278	6.5052	2.2658
26.00	273.890	273.890		2.253	1.000	2.252	6.3850	2.2404
27.00	273.915	273.915		2.228	1.000	2.227	6.2656	2.2151
28.00	273.940	273.940		2.202	1.000	2.202	6.1472	2.1897
29.00	273.966	273.966		2.177	1.000	2.176	6.0296	2.1643
30.00	273.983	273.983		2.156	1.000	2.156	5.9330	2.1474

An1=	74.503	Q=	225.538

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	274.329	276.000	276.130	-	-	-	-
1.00	273.985	276.000		0.130	1.000	0.130	0.1300
2.00	273.642	276.000		0.130	1.000	0.130	0.1300
2.10	273.254	273.254		0.150	2.748	0.055	2.8761
4.00	273.281	273.281		5.439	1.900	2.862	2.8489
5.00	273.308	273.308		2.835	1.000	2.834	2.8217
6.00	273.336	273.336		2.808	1.000	2.807	2.7945
7.00	273.363	273.363		2.781	1.000	2.780	2.7672
8.00	273.390	273.390		2.754	1.000	2.753	2.7400
9.00	273.417	273.417		2.726	1.000	2.725	2.7128
10.00	273.444	273.444		2.699	1.000	2.698	2.6856
11.00	273.472	273.472		2.672	1.000	2.671	2.6584
12.00	273.513	273.513		2.638	1.001	2.636	2.6172
13.00	273.539	273.539		2.604	1.000	2.603	2.5906
14.00	273.566	273.566		2.577	1.000	2.576	2.5640
15.00	273.593	273.593		2.551	1.000	2.550	2.5375
16.00	273.619	273.619		2.524	1.000	2.523	2.5109
17.00	273.646	273.646		2.498	1.000	2.497	2.4843
18.00	273.672	273.672		2.471	1.000	2.470	2.4577
19.00	273.699	273.699		2.444	1.000	2.444	2.4311
20.00	273.725	273.725		2.418	1.000	2.417	2.4046
21.00	273.762	273.762		2.386	1.001	2.385	2.3684
22.00	273.788	273.788		2.355	1.000	2.354	2.3419
23.00	273.813	273.813		2.329	1.000	2.328	2.3165
24.00	273.839	273.839		2.304	1.000	2.303	2.2912
25.00	273.864	273.864		2.278	1.000	2.278	2.2658
26.90	273.890	273.890		4.281	1.900	2.253	2.2404
27.00	273.915	276.000		0.119	2.113	0.056	0.1300
28.00	273.940	276.000		0.130	1.000	0.130	0.1300
29.00	273.966	276.000		0.130	1.000	0.130	0.1300
30.00	273.983	276.000		0.130	1.000	0.130	0.1300

An2*=	64.292

Therefore,

Discharge, Q	=	225.538	cumec
HFL (Without Afflux)	=	276.130	m
Average Depth, d	=	2.070	m
Lowest bed level	=	273.254	m

Area before constriction

An1	=	74.503	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	3.027	m/s

Area before constriction(excluding piers)

An2*	=	64.292	sq m

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	64.292	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	3.508	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.181	m

(D) Recommendation

Design Discharge, Q	=	199.110	cumecs
Design Affluxed HFL	=	276.130	m
Average Velocity, Vn2	=	3.508	m/sec

Check			
Formation Level	=	280.13	m
Slab Thickness	=	2.6	m
Sofit level	=	277.5	m
Proposed vertical clearance	=	1.220	m
Required vertical clearance	=	1.0	m
Adequacy	=	Adequate	
Required Freeboard	=	1.000	m

(E) CALCULATION OF SCOUR DEPTH

(Ref:IRS Sub-structure & Foundation Code)

Chainage (km)	railways:219/17-19	
Str No.		
HFL (m)	276.130	
Q (cumecs)	199.110	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	258.843	
Effective Linear Waterway Provided (Le) (m)	24.400	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	77.794	
Factor for increase in depth of scour,y	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	3.122	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	6.691	(Cl.4.6.4)
Lowest Bed level(m)	273.504	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	8.565	m
Maximum Scour depth below HFL, Dmax	=	17.130	m
Maximum scour depth level	=	259.300	m

Existing Bridge No – 260
Location – Km 221/5-7

Proposed Bridge No – 32
Location – CH: 29000

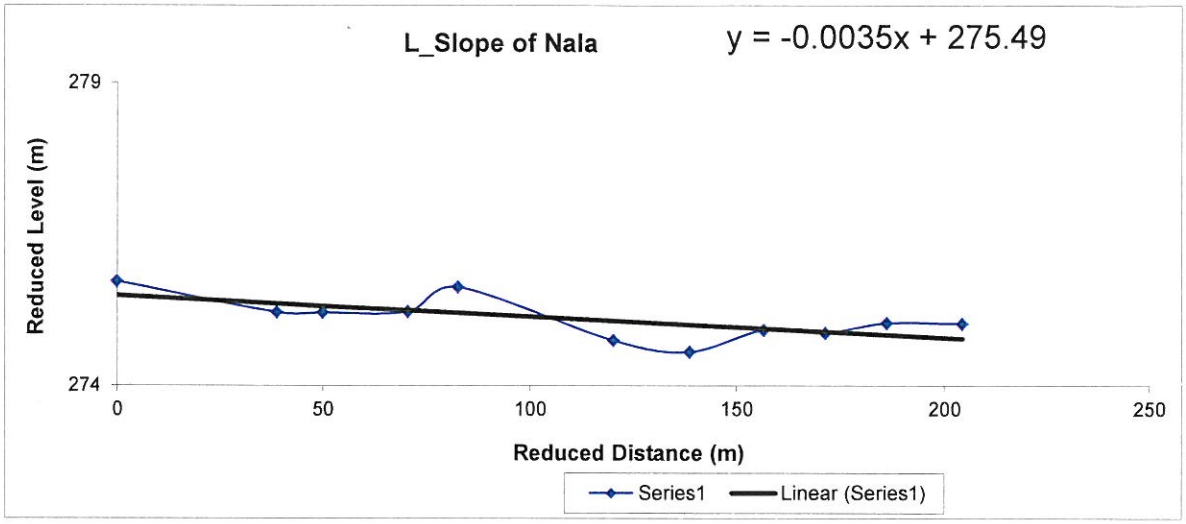
(Hydrology Details)

Br.No	260	
Nala/River Crossing	**Nala**	**221/5-7**
Proposed Chainage		
Type of STR		
Skew Angle	0	Degree

(A) FLOOD ESTIMATION

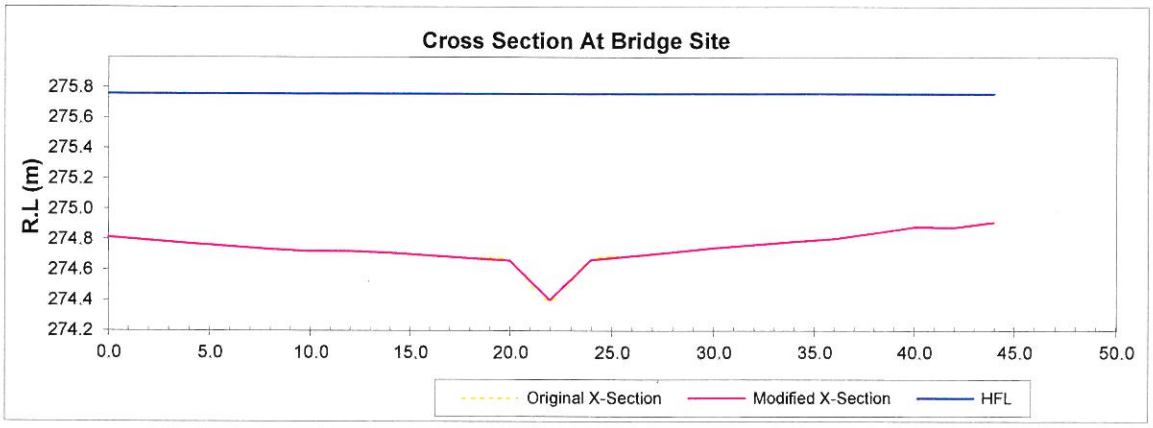
(1) By Slope Area Method

HFL(by local enquiry) = 275.76 m



Average Bed Slope of River, S	=	0.0035	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site

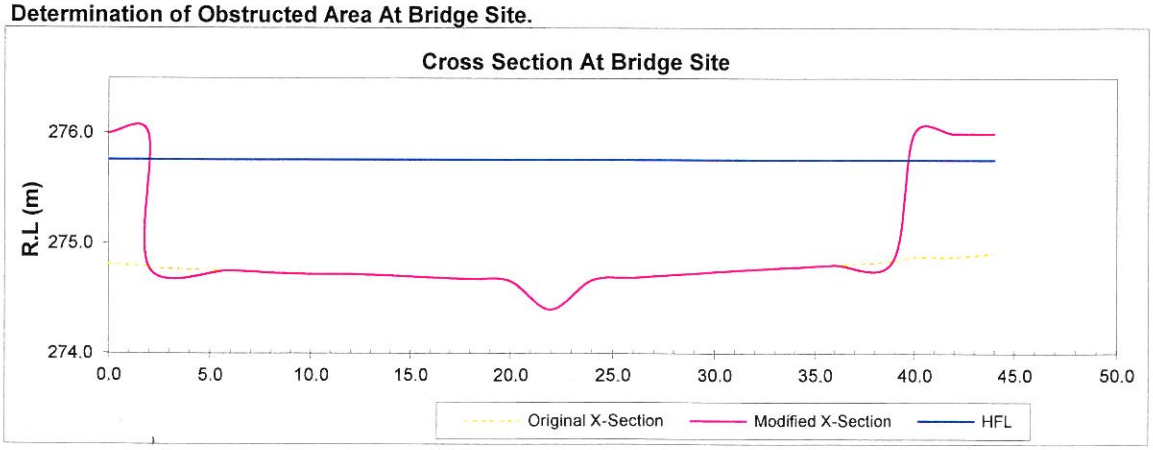


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	274.814	274.814	275.760	-	-	-	-	
2.00	274.793	274.793		1.913	2.000	0.957	4.3952	
4.00	274.774	274.774		1.953	2.000	0.976	4.5483	
6.00	274.754	274.754		1.992	2.000	0.996	4.7005	
8.00	274.735	274.735		2.031	2.000	1.015	4.8547	
10.00	274.722	274.722		2.063	2.000	1.031	4.9825	
12.00	274.721	274.721		2.076	2.000	1.038	5.0366	
14.00	274.711	274.711		2.088	2.000	1.044	5.0838	
16.00	274.694	274.694		2.115	2.000	1.057	5.1944	
18.00	274.678	274.678		2.148	2.000	1.074	5.3303	
20.00	274.661	274.661		2.181	2.000	1.090	5.4677	
22.00	274.401	274.401		2.458	2.017	1.219	6.6354	
24.00	274.665	274.665		2.454	2.017	1.216	6.6166	
26.00	274.690	274.690		2.164	2.000	1.082	5.3988	
28.00	274.716	274.716		2.114	2.000	1.057	5.1912	
30.00	274.743	274.743		2.062	2.000	1.031	4.9784	
32.00	274.765	274.765		2.012	2.000	1.006	4.7811	
34.00	274.785	274.785		1.970	2.000	0.985	4.6144	
36.00	274.805	274.805		1.929	2.000	0.965	4.4574	
38.00	274.842	274.842		1.872	2.000	0.936	4.2399	
40.00	274.882	274.882		1.796	2.000	0.898	3.9560	
42.00	274.881	274.881		1.758	2.000	0.879	3.8158	
44.00	274.915	274.915		1.724	2.000	0.862	3.6950	

An1=	44.872		Q=	107.974

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	274.814	276.000	275.760	-	-	-	-
2.00	274.793	276.000					
2.05	274.774	274.774		0.019	1.227	0.015	0.9862
6.00	274.754	274.754		3.934	3.950	0.996	1.0056
8.00	274.735	274.735		2.031	2.000	1.015	1.0251
10.00	274.722	274.722		2.063	2.000	1.031	1.0375
12.00	274.721	274.721		2.076	2.000	1.038	1.0385
14.00	274.711	274.711		2.088	2.000	1.044	1.0492
16.00	274.694	274.694		2.115	2.000	1.057	1.0657
18.00	274.678	274.678		2.148	2.000	1.074	1.0822
20.00	274.661	274.661		2.181	2.000	1.090	1.0987
22.00	274.401	274.401		2.458	2.017	1.219	1.3590
24.00	274.665	274.665		2.454	2.017	1.216	1.0948
26.00	274.690	274.690		2.164	2.000	1.082	1.0696
28.00	274.716	274.716		2.114	2.000	1.057	1.0445
30.00	274.743	274.743		2.062	2.000	1.031	1.0172
32.00	274.765	274.765		2.012	2.000	1.006	0.9950
34.00	274.785	274.785		1.970	2.000	0.985	0.9748
36.00	274.805	274.805		1.929	2.000	0.965	0.9545
38.95	274.842	274.842		2.762	2.950	0.936	0.9179
40.00	274.882	276.000		0.356	1.563	0.228	
42.00	274.881	276.000					
44.00	274.915	276.000					

An2*=	38.934

Therefore,

Discharge, Q	=	107.974	cumecs
HFL (Without Afflux)	=	275.760	m
Average Depth, d	=	1.045	m
Lowest Bed level	=	274.401	m

Area before constriction

An1 = 44.872 sq m

Average velocity prior to constriction

Vn1 = Q/An1

= 2.406 m/s

Area after constriction(excluding piers)

An2* = 38.934

Area after constriction

An2 = An2* - no's of piers * average width of piers * average depth (d)

= 34.753 sq m

Average Velocity after constriction

Vn2 = Q/An2

= 3.107 m/s

Afflux due to constriction (By Molesworth Formula)

h = [(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]

= 0.226 m

(D) Recommendation

Design Discharge, Q	=	107.974	cumecs
Design Affluxed HFL	=	275.986	m
Average Velocity, Vn2	=	3.107	m/sec

Check

Formation Level	=	276.768	m
Slab Thickness	=	1	m
Sofit level	=	275.768	m
Available vertical clearance	=	-0.22	m
Required vertical clearance	=	0.77	m
Adequacy	=	Not Adequate	

(F) CALCULATION OF SCOUR DEPTH

Chainage (km)	0.000	
Str No.		
HFL (m)	275.760	
Q (cumecs)	107.974	
Silt Factor (K_{sf} or f)	0.900	
#REF!	#REF!	
Effective Linear Waterway Provided (Le) (m)	36.120	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	#REF!	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	#REF!	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	#REF!	(Cl.4.6.4)
Lowest Bed level(m)	274.401	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	#REF!	m
Maximum Scour depth below HFL, Dmax	=	#REF!	m
Maximum scour depth level	=	#REF!	m

Existing Bridge No – 263
Location – Km 224/9-11

Proposed Bridge No – 35
Location – CH: 32467.577

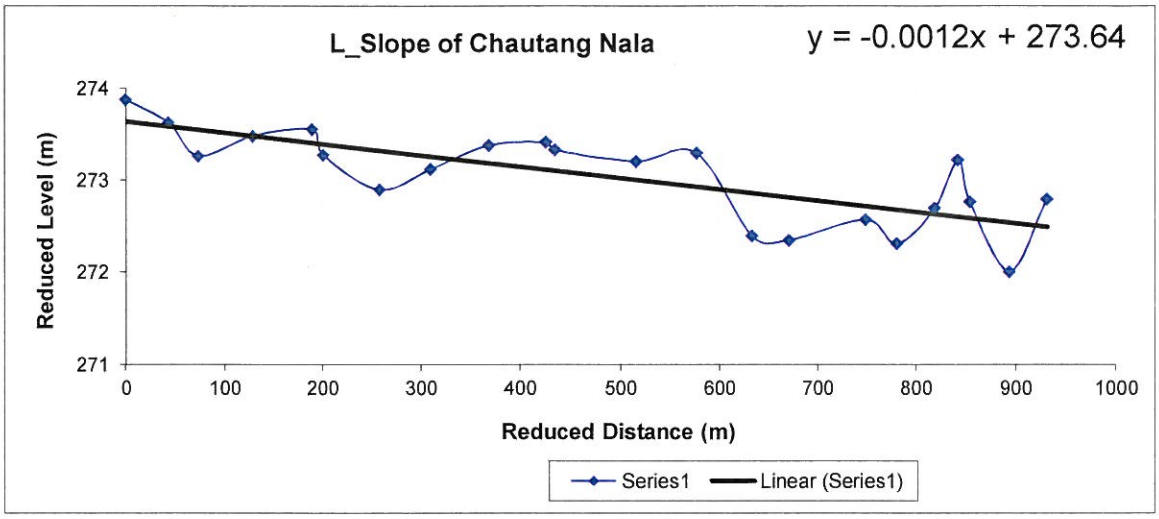
(Hydrology Details)

Br No.	263		
Nala/River Crossing	Chautang Nala		
Proposed Chainage	Indian railways:224/10-12	RITES Chainage:32/467.577	
Type of STR			
Skew Angle	0	Degree	

(A) FLOOD ESTIMATION

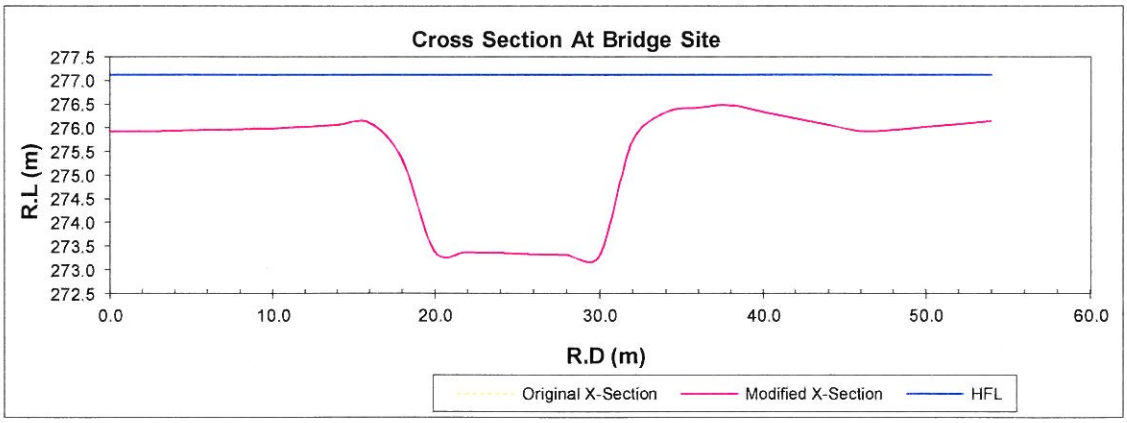
By Slope Area Method

HFL(by local enquiry) = 277.120 m



Average Bed Slope of River, S	=	0.0012	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site



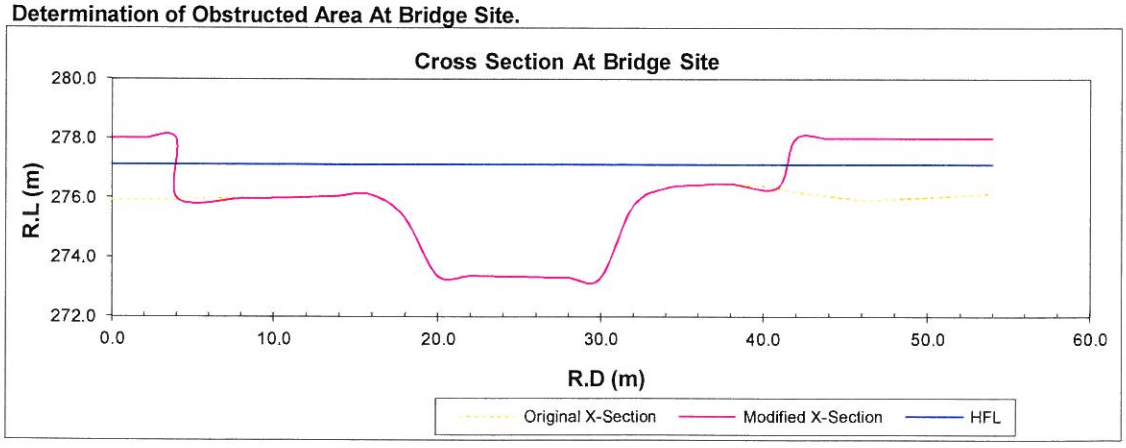
Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	275.928	275.928	277.120	-	-	-	-	
2.00	275.929	275.929		2.383	2.000	1.192	3.7114	
4.00	275.943	275.943		2.368	2.000	1.184	3.6722	
6.00	275.956	275.956		2.341	2.000	1.171	3.6035	
8.00	275.969	275.969		2.315	2.000	1.157	3.5352	
10.00	275.988	275.988		2.282	2.000	1.141	3.4531	
12.00	276.029	276.029		2.223	2.000	1.111	3.3042	
14.00	276.069	276.069		2.142	2.000	1.071	3.1063	
16.00	276.110	276.110		2.061	2.000	1.030	2.9129	
18.00	275.349	275.349		2.781	2.140	1.300	4.5888	
20.00	273.396	273.396		5.495	2.796	1.965	11.9463	
22.00	273.377	273.377		7.467	2.000	3.734	24.9025	
24.00	273.358	273.358		7.506	2.000	3.753	25.1157	
26.00	273.338	273.338		7.544	2.000	3.772	25.3302	
28.00	273.319	273.319		7.582	2.000	3.791	25.5449	
30.00	273.300	273.300		7.621	2.000	3.810	25.7603	
32.00	275.716	275.716		5.224	3.137	1.665	10.1696	
34.00	276.329	276.329		2.195	2.092	1.049	3.1395	
36.00	276.428	276.428		1.482	2.002	0.740	1.6809	
38.00	276.479	276.479		1.333	2.001	0.666	1.4090	
40.00	276.342	276.342		1.419	2.005	0.708	1.5624	
42.00	276.205	276.205		1.693	2.005	0.844	2.0951	
44.00	276.069	276.069		1.966	2.005	0.981	2.6886	
46.00	275.932	275.932		2.239	2.005	1.117	3.3397	
48.00	275.959	275.959		2.348	2.000	1.174	3.6215	
50.00	276.022	276.022		2.259	2.001	1.129	3.3933	
52.00	276.084	276.084		2.134	2.001	1.066	3.0864	
54.00	276.147	276.147		2.009	2.001	1.004	2.7912	

An1=	90.412

Q=	209.465

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



0036

Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	275.928	278.000	277.120	-	-	-	-
2.00	275.929	278.000					
4.00	275.943	278.000					
4.10	275.956	275.956		0.014	2.046	0.007	1.1640
8.00	275.969	275.969		4.513	3.900	1.157	1.1506
10.00	275.988	275.988		2.282	2.000	1.141	1.1316
12.00	276.029	276.029		2.223	2.000	1.111	1.0912
14.00	276.069	276.069		2.142	2.000	1.071	1.0507
16.00	276.110	276.110		2.061	2.000	1.030	1.0102
18.00	275.349	275.349		2.781	2.140	1.300	1.7706
20.00	273.396	273.396		5.495	2.796	1.965	3.7242
22.00	273.377	273.377		7.467	2.000	3.734	3.7433
24.00	273.358	273.358		7.506	2.000	3.753	3.7625
26.00	273.338	273.338		7.544	2.000	3.772	3.7817
28.00	273.319	273.319		7.582	2.000	3.791	3.8008
30.00	273.300	273.300		7.621	2.000	3.810	3.8200
32.00	275.716	275.716		5.224	3.137	1.665	1.4037
34.00	276.329	276.329		2.195	2.092	1.049	0.7908
36.00	276.428	276.428		1.482	2.002	0.740	0.6916
38.00	276.479	276.479		1.333	2.001	0.666	0.6414
40.90	276.342	276.342		2.058	2.903	0.709	0.7780
42.00	276.205	278.000					
44.00	276.069	278.000					
46.00	275.932	278.000					
48.00	275.959	278.000					
50.00	276.022	278.000					
52.00	276.084	278.000					
54.00	276.147	278.000					

An2*=	71.524

Therefore,

Discharge, Q	=	209.465	cumec
HFL (Without Afflux)	=	277.120	m
Average Depth, d	=	1.961	m
Lowest bed level	=	273.300	m

Area before constriction

An1	=	90.412	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	2.317	m/s

Area before constriction(excluding piers)

An2*	=	71.524	sq m

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	63.678	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	3.289	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.320	m

(D) Recommendation

Design Discharge, Q	=	209.465	cumecs
Design Affluxed HFL	=	277.120	m
Average Velocity, Vn2	=	3.289	m/sec

Check			
Formation Level	=	280.85	m
Slab Thickness	=	1.8	m
Sofit level	=	279.1	m
Available vertical clearance	=	1.900	m
Required vertical clearance	=	1.0	m
Adequacy	=	Adequate	

(E) CALCULATION OF SCOUR DEPTH

(Ref:IRS Sub-structure & Foundation Code)

Chainage (km)	railways:224/10-12	
Str No.		
HFL (m)	277.120	
Q (cumecs)	209.465	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	272.304	
Effective Linear Waterway Provided (Le) (m)	36.600	
Lacey's Wetted perimeter , P_w = 1.811 x C x$\sqrt{(Q_f)}$(m)	79.792	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),Dn=0.473*$(Q_f/f)^{1/3}$	3.175	(Cl.4.6.3)
Constricted Scour Depth(m),Dc=1.338*$(q_f^2/f)^{1/3}$	5.282	(Cl.4.6.4)
Lowest Bed level(m)	276.164	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	5.282	m
Maximum Scour depth below HFL, Dmax	=	10.563	m
Maximum scour depth level	=	266.557	m

Existing Bridge No – 268
Location – Km 228/25-29

Proposed Bridge No – 40
Location – CH: 36864.174

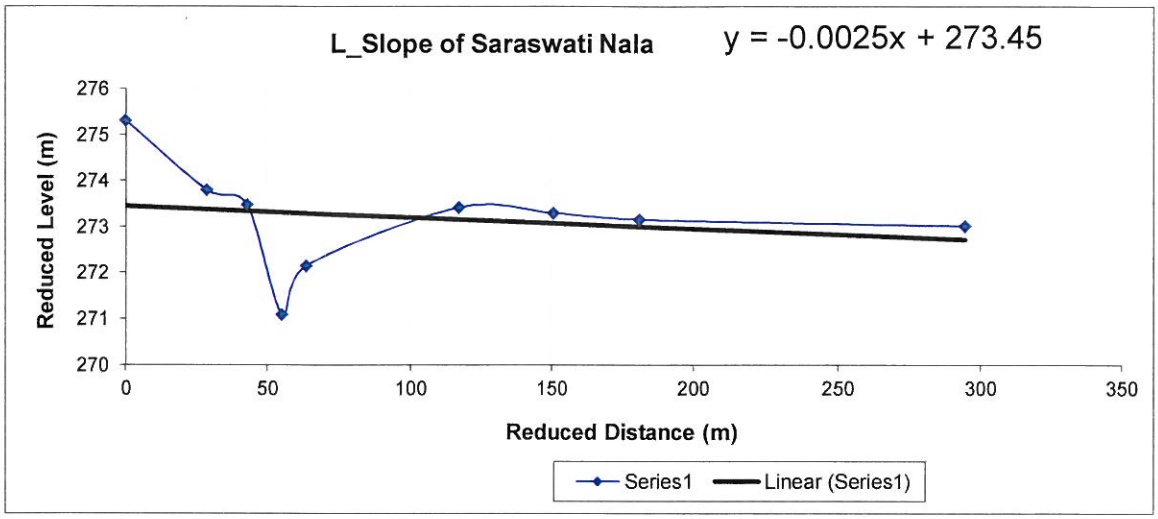
(Hydrology Details)

Br. No.	268	
Nala/River Crossing	Saraswati Nala	
Proposed Chainage	Indian railways:228/25-27	RITES Ch:36/864.174
Type of STR	Composite Girder(2 x 24.4)	
Skew Angle	0 Degree	

(A) FLOOD ESTIMATION

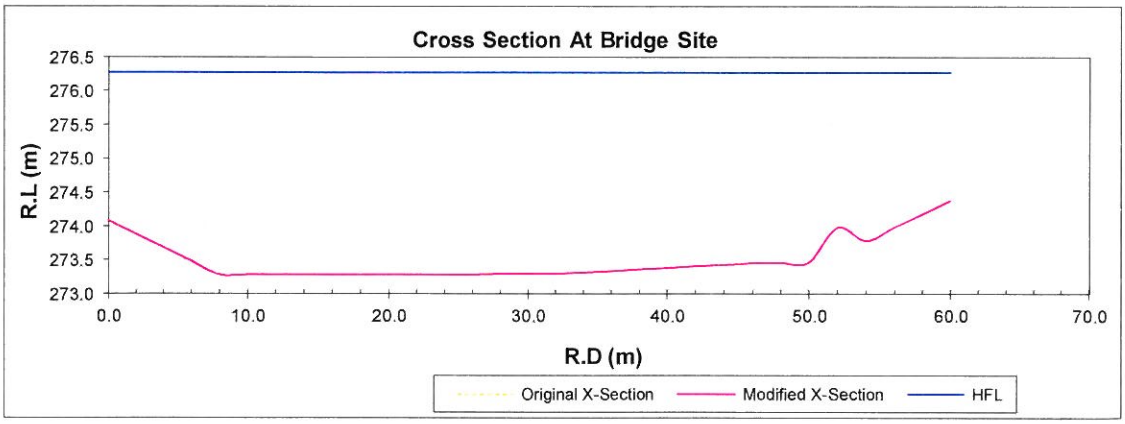
By Slope Area Method

HFL(by local enquiry) = 276.280 m



Average Bed Slope of River, S	=	0.0025	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site



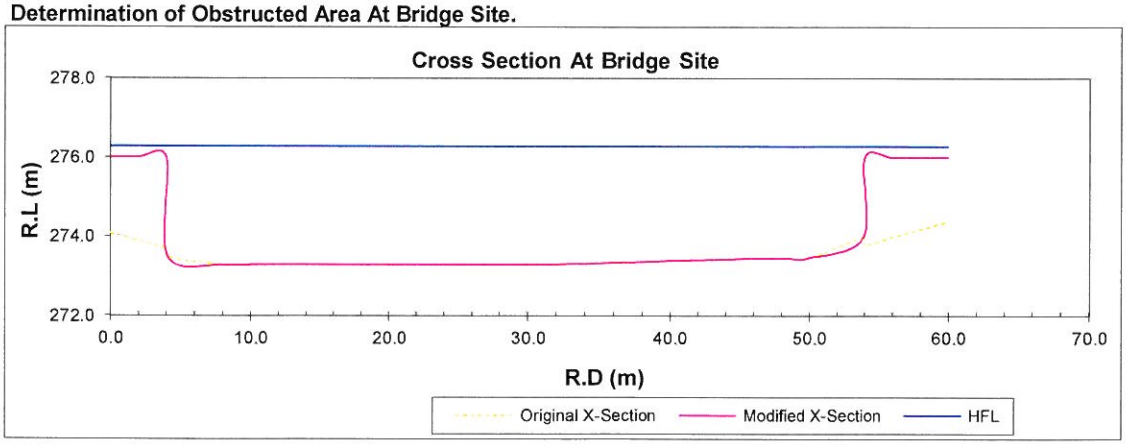
Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	274.091	274.091	276.280	-	-	-	-	
2.00	273.890	273.890		4.580	2.010	2.278	15.8600	
4.00	273.689	273.689		4.981	2.010	2.478	18.2456	
6.00	273.488	273.488		5.383	2.010	2.678	20.7630	
8.00	273.287	273.287		5.785	2.010	2.878	23.4090	
10.00	273.288	273.288		5.985	2.000	2.993	24.8575	
12.00	273.288	273.288		5.984	2.000	2.992	24.8482	
14.00	273.289	273.289		5.982	2.000	2.991	24.8388	
16.00	273.290	273.290		5.981	2.000	2.991	24.8295	
18.00	273.291	273.291		5.980	2.000	2.990	24.8201	
20.00	273.291	273.291		5.978	2.000	2.989	24.8108	
22.00	273.292	273.292		5.977	2.000	2.988	24.8015	
24.00	273.293	273.293		5.976	2.000	2.988	24.7921	
26.00	273.293	273.293		5.974	2.000	2.987	24.7828	
28.00	273.294	273.294		5.973	2.000	2.986	24.7735	
30.00	273.295	273.295		5.972	2.000	2.986	24.7641	
32.00	273.295	273.295		5.970	2.000	2.985	24.7548	
34.00	273.318	273.318		5.947	2.000	2.973	24.5947	
36.00	273.341	273.341		5.902	2.000	2.951	24.2826	
38.00	273.364	273.364		5.856	2.000	2.928	23.9677	
40.00	273.387	273.387		5.810	2.000	2.905	23.6546	
42.00	273.410	273.410		5.764	2.000	2.882	23.3431	
44.00	273.433	273.433		5.718	2.000	2.859	23.0333	
46.00	273.456	273.456		5.672	2.000	2.836	22.7251	
48.00	273.464	273.464		5.641	2.000	2.820	22.5205	
50.00	273.469	273.469		5.627	2.000	2.814	22.4302	
52.00	273.984	273.984		5.106	2.065	2.472	18.6733	
54.00	273.789	273.789		4.787	2.010	2.382	17.0757	
56.00	273.987	273.987		4.784	2.010	2.380	17.0561	
58.00	274.186	274.186		4.386	2.010	2.182	14.7604	
60.00	274.385	274.385		3.989	2.010	1.985	12.5994	

An1=	167.449

Q=	666.668

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	274.091	276.000	276.280	-	-	-	-
2.00	273.890	276.000		0.560	2.000	0.280	0.2800
4.00	273.689	276.000		0.560	2.000	0.280	0.2800
4.10	273.488	273.488		0.154	2.514	0.061	2.7920
8.00	273.287	273.287		11.281	3.905	2.889	2.9929
10.00	273.288	273.288		5.985	2.000	2.993	2.9922
12.00	273.288	273.288		5.984	2.000	2.992	2.9915
14.00	273.289	273.289		5.982	2.000	2.991	2.9908
16.00	273.290	273.290		5.981	2.000	2.991	2.9902
18.00	273.291	273.291		5.980	2.000	2.990	2.9895
20.00	273.291	273.291		5.978	2.000	2.989	2.9888
22.00	273.292	273.292		5.977	2.000	2.988	2.9881
24.00	273.293	273.293		5.976	2.000	2.988	2.9875
26.00	273.293	273.293		5.974	2.000	2.987	2.9868
28.00	273.294	273.294		5.973	2.000	2.986	2.9861
30.00	273.295	273.295		5.972	2.000	2.986	2.9854
32.00	273.295	273.295		5.970	2.000	2.985	2.9848
34.00	273.318	273.318		5.947	2.000	2.973	2.9624
36.00	273.341	273.341		5.902	2.000	2.951	2.9394
38.00	273.364	273.364		5.856	2.000	2.928	2.9164
40.00	273.387	273.387		5.810	2.000	2.905	2.8933
42.00	273.410	273.410		5.764	2.000	2.882	2.8703
44.00	273.433	273.433		5.718	2.000	2.859	2.8473
46.00	273.456	273.456		5.672	2.000	2.836	2.8243
48.00	273.464	273.464		5.641	2.000	2.820	2.8165
50.00	273.469	273.469		5.627	2.000	2.814	2.8107
53.90	273.984	273.984		9.957	3.934	2.531	2.2956
54.00	273.789	276.000		0.129	2.018	0.064	0.2800
56.00	273.987	276.000		0.560	2.000	0.280	0.2800
58.00	274.186	276.000		0.560	2.000	0.280	0.2800
60.00	274.385	276.000		0.560	2.000	0.280	0.2800

An2*=	147.987

Therefore,

Discharge, Q	=	666.668	cumec
HFL (Without Afflux)	=	276.280	m
Average Depth, d	=	2.383	m
Lowest bed level	=	273.287	m

Area before constriction

An1	=	167.449	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	3.981	m/s

Area before constriction(excluding piers)

An2*	=	147.987	sq m

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	143.220	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	4.655	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.331	m

(D) Recommendation

Design Discharge, Q	=	541.000	cumecs
Design Affluxed HFL	=	276.280	m
Average Velocity, Vn2	=	4.655	m/sec

Check			
Formation Level	=	280.48	m
Slab Thickness	=	2.6	m
Sofit level	=	277.9	m
Available vertical clearance	=	1.420	m
Required vertical clearance	=	1.2	m
Adequacy	=	Adequate	
Required Freeboard	=	1.000	m

(E) CALCULATION OF SCOUR DEPTH

(Ref:IRS Sub-structure & Foundation Code)

Chainage (km)	railways:228/25-27	
Str No.		
HFL (m)	276.280	
Q (cumecs)	541.000	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	703.300	
Effective Linear Waterway Provided (Le) (m)	48.800	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	128.233	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	4.357	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	8.207	(Cl.4.6.4)
Lowest Bed level(m)	273.287	

RECOMMENDATIONS

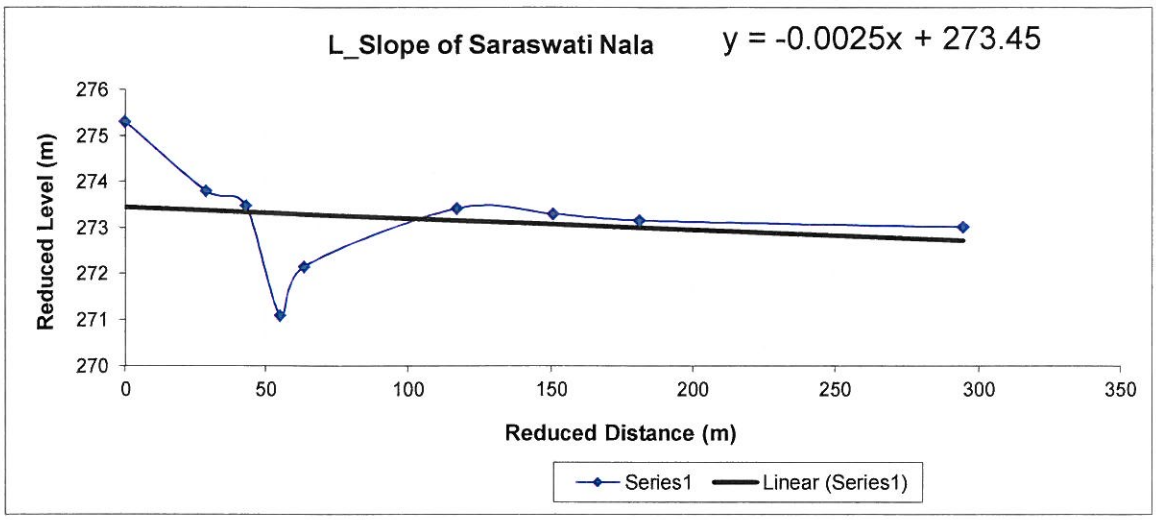
Final Recommended Scour depth below HFL, D	=	4.860	m
Maximum Scour depth below HFL, Dmax	=	9.720	m
Maximum scour depth level	=	266.560	m

Br. No.	268	
Nala/River Crossing	Saraswati Nala	
Proposed Chainage	Indian railways:228/25-27	RITES Ch:36/864.174
Type of STR	Composite Girder(2 x 24.4)	
Skew Angle	0 Degree	

(A) FLOOD ESTIMATION

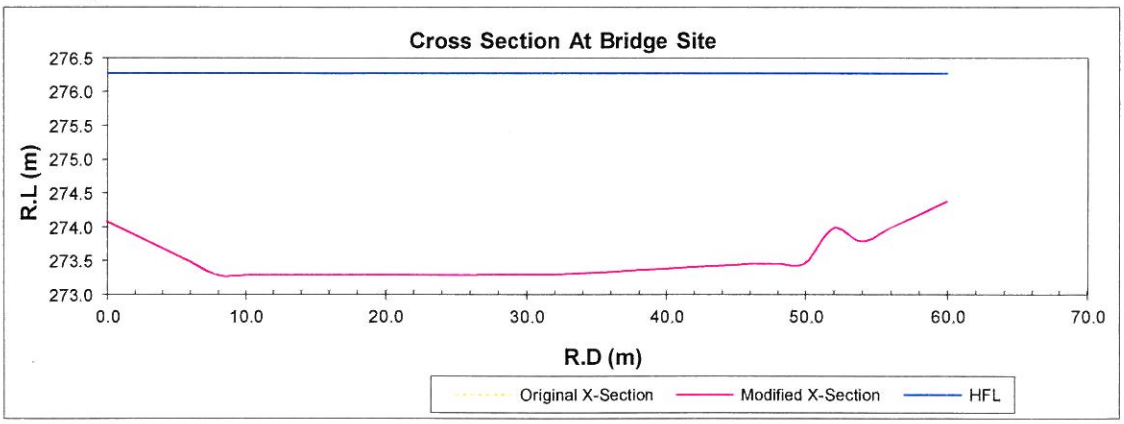
By Slope Area Method

HFL(by local enquiry) = 276.280 m



Average Bed Slope of River, S	=	0.0025	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site

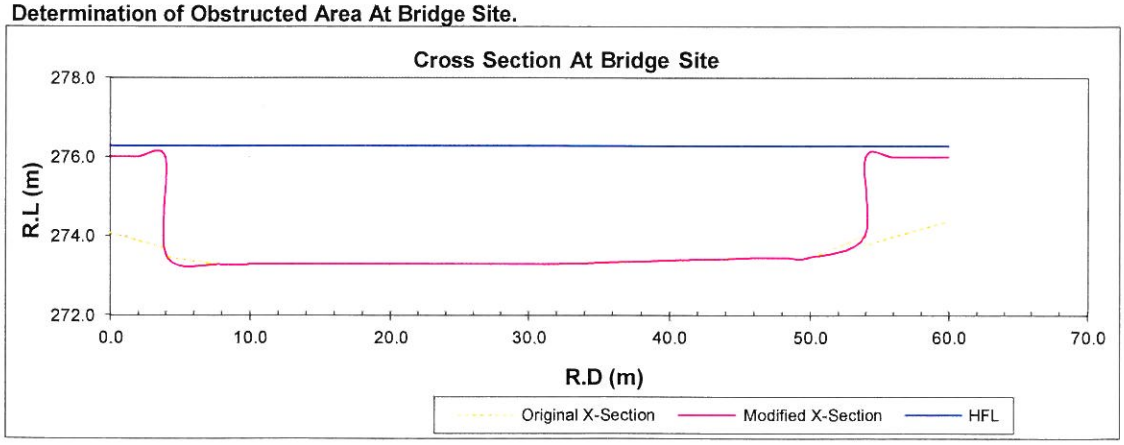


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	274.091	274.091	276.280	-	-	-	-	
2.00	273.890	273.890		4.580	2.010	2.278	15.8600	
4.00	273.689	273.689		4.981	2.010	2.478	18.2456	
6.00	273.488	273.488		5.383	2.010	2.678	20.7630	
8.00	273.287	273.287		5.785	2.010	2.878	23.4090	
10.00	273.288	273.288		5.985	2.000	2.993	24.8575	
12.00	273.288	273.288		5.984	2.000	2.992	24.8482	
14.00	273.289	273.289		5.982	2.000	2.991	24.8388	
16.00	273.290	273.290		5.981	2.000	2.991	24.8295	
18.00	273.291	273.291		5.980	2.000	2.990	24.8201	
20.00	273.291	273.291		5.978	2.000	2.989	24.8108	
22.00	273.292	273.292		5.977	2.000	2.988	24.8015	
24.00	273.293	273.293		5.976	2.000	2.988	24.7921	
26.00	273.293	273.293		5.974	2.000	2.987	24.7828	
28.00	273.294	273.294		5.973	2.000	2.986	24.7735	
30.00	273.295	273.295		5.972	2.000	2.986	24.7641	
32.00	273.295	273.295		5.970	2.000	2.985	24.7548	
34.00	273.318	273.318		5.947	2.000	2.973	24.5947	
36.00	273.341	273.341		5.902	2.000	2.951	24.2826	
38.00	273.364	273.364		5.856	2.000	2.928	23.9677	
40.00	273.387	273.387		5.810	2.000	2.905	23.6546	
42.00	273.410	273.410		5.764	2.000	2.882	23.3431	
44.00	273.433	273.433		5.718	2.000	2.859	23.0333	
46.00	273.456	273.456		5.672	2.000	2.836	22.7251	
48.00	273.464	273.464		5.641	2.000	2.820	22.5205	
50.00	273.469	273.469		5.627	2.000	2.814	22.4302	
52.00	273.984	273.984		5.106	2.065	2.472	18.6733	
54.00	273.789	273.789		4.787	2.010	2.382	17.0757	
56.00	273.987	273.987		4.784	2.010	2.380	17.0561	
58.00	274.186	274.186		4.386	2.010	2.182	14.7604	
60.00	274.385	274.385		3.989	2.010	1.985	12.5994	

An1=	167.449	Q=	666.668

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	274.091	276.000	276.280	-	-	-	-
2.00	273.890	276.000		0.560	2.000	0.280	0.2800
4.00	273.689	276.000		0.560	2.000	0.280	0.2800
4.10	273.488	273.488		0.154	2.514	0.061	2.7920
8.00	273.287	273.287		11.281	3.905	2.889	2.9929
10.00	273.288	273.288		5.985	2.000	2.993	2.9922
12.00	273.288	273.288		5.984	2.000	2.992	2.9915
14.00	273.289	273.289		5.982	2.000	2.991	2.9908
16.00	273.290	273.290		5.981	2.000	2.991	2.9902
18.00	273.291	273.291		5.980	2.000	2.990	2.9895
20.00	273.291	273.291		5.978	2.000	2.989	2.9888
22.00	273.292	273.292		5.977	2.000	2.988	2.9881
24.00	273.293	273.293		5.976	2.000	2.988	2.9875
26.00	273.293	273.293		5.974	2.000	2.987	2.9868
28.00	273.294	273.294		5.973	2.000	2.986	2.9861
30.00	273.295	273.295		5.972	2.000	2.986	2.9854
32.00	273.295	273.295		5.970	2.000	2.985	2.9848
34.00	273.318	273.318		5.947	2.000	2.973	2.9624
36.00	273.341	273.341		5.902	2.000	2.951	2.9394
38.00	273.364	273.364		5.856	2.000	2.928	2.9164
40.00	273.387	273.387		5.810	2.000	2.905	2.8933
42.00	273.410	273.410		5.764	2.000	2.882	2.8703
44.00	273.433	273.433		5.718	2.000	2.859	2.8473
46.00	273.456	273.456		5.672	2.000	2.836	2.8243
48.00	273.464	273.464		5.641	2.000	2.820	2.8165
50.00	273.469	273.469		5.627	2.000	2.814	2.8107
53.90	273.984	273.984		9.957	3.934	2.531	2.2956
54.00	273.789	276.000		0.129	2.018	0.064	0.2800
56.00	273.987	276.000		0.560	2.000	0.280	0.2800
58.00	274.186	276.000		0.560	2.000	0.280	0.2800
60.00	274.385	276.000		0.560	2.000	0.280	0.2800

An2*=	147.987

Therefore,

Discharge, Q	=	666.668	cumec
HFL (Without Afflux)	=	276.280	m
Average Depth, d	=	2.383	m
Lowest bed level	=	273.287	m

Area before constriction

An1	=	167.449	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	3.981	m/s

Area before constriction(excluding piers)

An2*	=	147.987	sq m

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	143.220	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	4.655	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.331	m

(D) Recommendation

Design Discharge, Q	=	541.000	cumecs
Design Affluxed HFL	=	276.280	m
Average Velocity, Vn2	=	4.655	m/sec

Check			
Formation Level	=	280.48	m
Slab Thickness	=	2.6	m
Sofit level	=	277.9	m
Available vertical clearance	=	1.420	m
Required vertical clearance	=	1.2	m
Adequacy	=	Adequate	
Required Freeboard	=	1.000	m

(E) CALCULATION OF SCOUR DEPTH

(Ref:IRS Sub-structure & Foundation Code)

Chainage (km)	railways:228/25-27	
Str No.		
HFL (m)	276.280	
Q (cumecs)	541.000	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	703.300	
Effective Linear Waterway Provided (Le) (m)	48.800	
Lacey's Wetted perimeter , P_w = 1.811 x C x$\sqrt{(Q_f)}$(m)	128.233	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),Dn=0.473*$(Q_f/f)^{1/3}$	4.357	(Cl.4.6.3)
Constricted Scour Depth(m),Dc=1.338*$(q_f^2/f)^{1/3}$	8.207	(Cl.4.6.4)
Lowest Bed level(m)	273.287	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	4.860	m
Maximum Scour depth below HFL, Dmax	=	9.720	m
Maximum scour depth level	=	266.560	m

Existing Bridge No – 276
Location – Km 235/29-31

Proposed Bridge No – 48
Location – CH: 44086.609

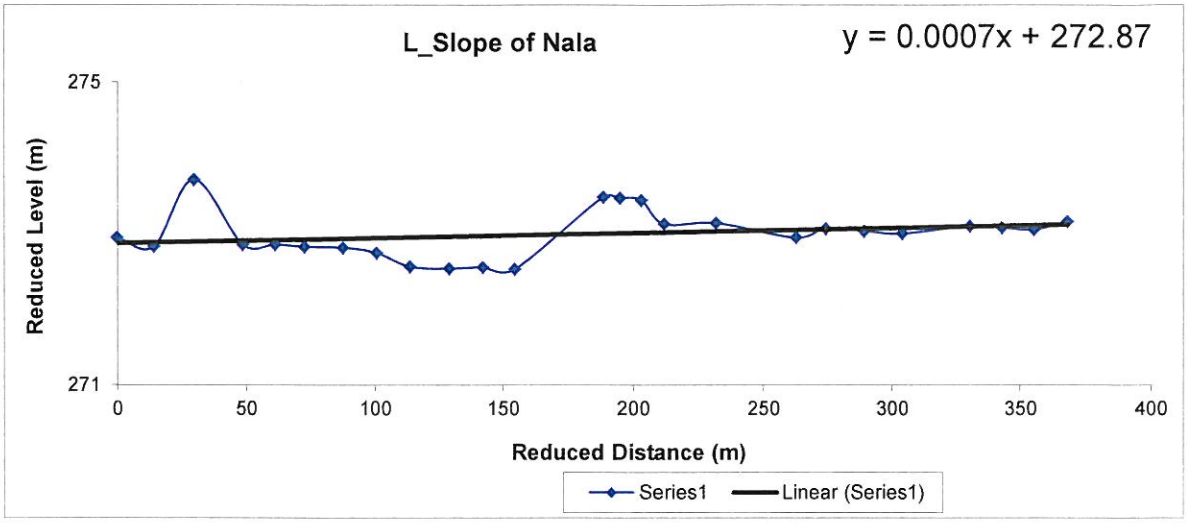
(Hydrology Details)

Br No.	276		
Nala/River Crossing	Drain		
Proposed Chainage	**Indian railways:235/28-30**		**RITES Ch:44/86.609**
Type of STR	RCC Box.		
Skew Angle	0	Degree	

(A) FLOOD ESTIMATION

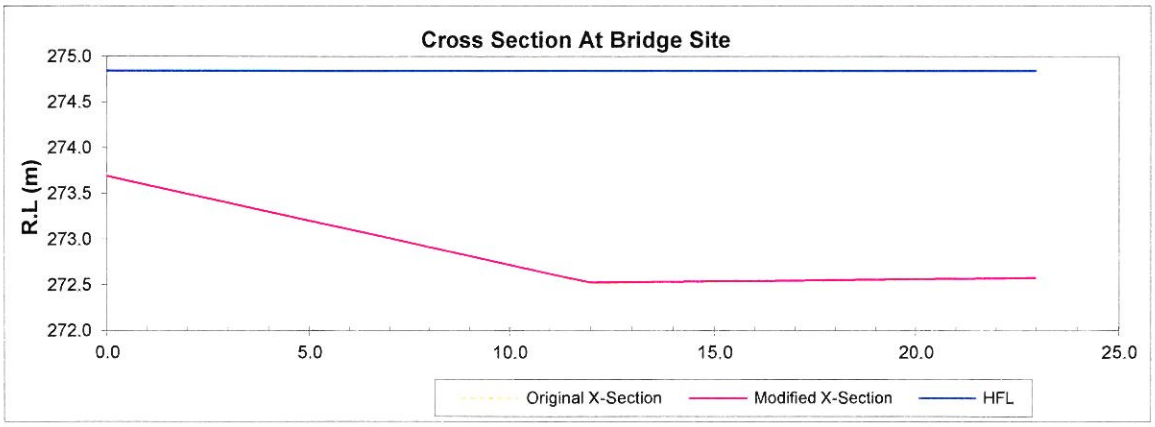
(1) By Slope AreaMethod

HFL(By local enquiry) = 274.84 m



Average Bed Slope of River, S	=	0.0007	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site

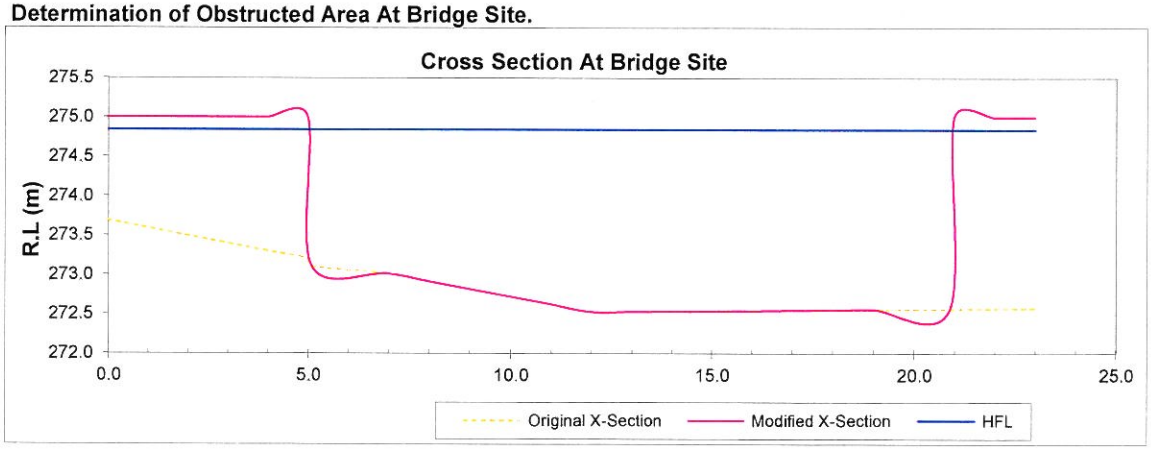


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	273.692	273.692	274.840	-	-	-	-	
1.00	273.595	273.595		1.197	1.005	1.191	1.4230	
2.00	273.498	273.498		1.294	1.005	1.288	1.6209	
3.00	273.400	273.400		1.391	1.005	1.385	1.8289	
4.00	273.303	273.303		1.488	1.005	1.481	2.0470	
5.00	273.206	273.206		1.586	1.005	1.578	2.2747	
6.00	273.109	273.109		1.683	1.005	1.675	2.5120	
7.00	273.011	273.011		1.780	1.005	1.772	2.7585	
8.00	272.914	272.914		1.877	1.005	1.869	3.0142	
9.00	272.817	272.817		1.975	1.005	1.965	3.2789	
10.00	272.720	272.720		2.072	1.005	2.062	3.5525	
11.00	272.622	272.622		2.169	1.005	2.159	3.8347	
12.00	272.525	272.525		2.266	1.005	2.256	4.1255	
13.00	272.530	272.530		2.313	1.000	2.313	4.2800	
14.00	272.535	272.535		2.308	1.000	2.308	4.2652	
15.00	272.539	272.539		2.303	1.000	2.303	4.2505	
16.00	272.544	272.544		2.298	1.000	2.298	4.2359	
17.00	272.549	272.549		2.293	1.000	2.293	4.2212	
18.00	272.554	272.554		2.289	1.000	2.289	4.2065	
19.00	272.559	272.559		2.284	1.000	2.284	4.1918	
20.00	272.563	272.563		2.279	1.000	2.279	4.1773	
21.00	272.568	272.568		2.274	1.000	2.274	4.1628	
22.00	272.573	272.573		2.270	1.000	2.270	4.1482	
23.00	272.578	272.578		2.265	1.000	2.265	4.1335	

An1=	45.954		Q=	78.54

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



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Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	273.692	275.000	274.840	-	-	-	-
1.00	273.595	275.000					
2.00	273.498	275.000					
3.00	273.400	275.000					
4.00	273.303	275.000					
5.00	273.206	275.000					
5.10	273.109	273.109		0.079	1.894	0.041	1.7315
7.00	273.011	273.011		3.382	1.902	1.778	1.8288
8.00	272.914	272.914		1.877	1.005	1.869	1.9260
9.00	272.817	272.817		1.975	1.005	1.965	2.0233
10.00	272.720	272.720		2.072	1.005	2.062	2.1205
11.00	272.622	272.622		2.169	1.005	2.159	2.2178
12.00	272.525	272.525		2.266	1.005	2.256	2.3150
13.00	272.530	272.530		2.313	1.000	2.313	2.3102
14.00	272.535	272.535		2.308	1.000	2.308	2.3054
15.00	272.539	272.539		2.303	1.000	2.303	2.3007
16.00	272.544	272.544		2.298	1.000	2.298	2.2959
17.00	272.549	272.549		2.293	1.000	2.293	2.2911
18.00	272.554	272.554		2.289	1.000	2.289	2.2863
19.00	272.559	272.559		2.284	1.000	2.284	2.2815
20.90	272.563	272.563		4.330	1.900	2.279	2.2768
21.00	272.568	275.000		0.106	2.439	0.043	
22.00	272.573	275.000					
23.00	272.578	275.000					

An2*=	34.344

Therefore,

Discharge, Q	=	78.54	cumec
HFL (Without Afflux)	=	274.840	m
Average Depth, d	=	2.167	m
Lowest Bed level	=	272.525	m

Area before constriction

An1 = 45.954 sq m

Average velocity prior to constriction

Vn1 = Q/An1

= 1.709 m/s

Area after constriction(excluding piers)

An2* = 34.344

Area after constriction

An2 = An2* - no's of piers * average width of piers * average depth (d)

= 31.960 sq m

Average Velocity after constriction

Vn2 = Q/An2

= 2.458 m/s

Afflux due to constriction (By Molesworth Formula)

h = [(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]

= 0.190 m

(D) Recommendation

Design Discharge, Q	=	78.544	cumecs
Design Affluxed HFL	=	274.840	m
Average Velocity, Vn2	=	2.458	m/sec

Check

Formation Level	=	275.84	m
Slab Thickness	=	0.75	m
Sofit level	=	275.09	m
Available vertical clearance	=	0.250	m
Required vertical clearance	=	-	m
Adequacy	=	Adequate	

(E) CALCULATION OF SCOUR DEPTH

Chainage (km)	h railways:235/28-30	
Str No.		
HFL (m)	274.840	
Q (cumecs)	78.544	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	102.107	
Effective Linear Waterway Provided (Le) (m)	15.000	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	48.860	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	2.290	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	4.978	(Cl.4.6.4)
Lowest Bed level(m)	273.213	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	4.978	m
Maximum Scour depth below HFL, Dmax	=	9.955	m
Maximum scour depth level	=	264.885	m

Existing Bridge No – 279
Location – Km 238/15-17

Proposed Bridge No – 51
Location – CH: 46669.462

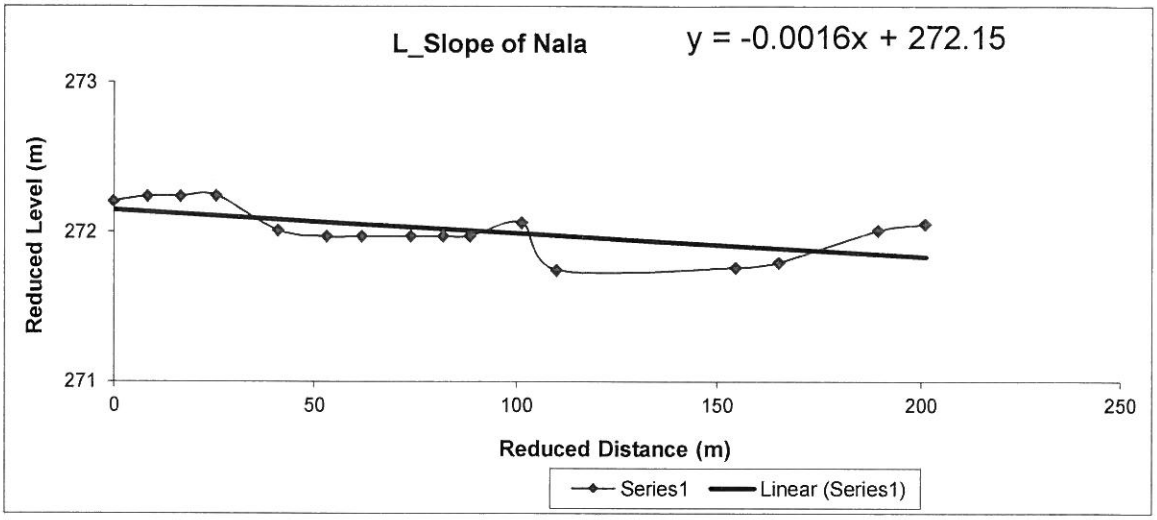
(Hydrology Details)

Br. No.	279		
Nala/River Crossing	**Drain**		
Proposed Chainage	**Indian railways: 238/15-17**		**RITES Ch:46/669.462**
Type of STR			
Skew Angle	0	Degree	

(A) FLOOD ESTIMATION

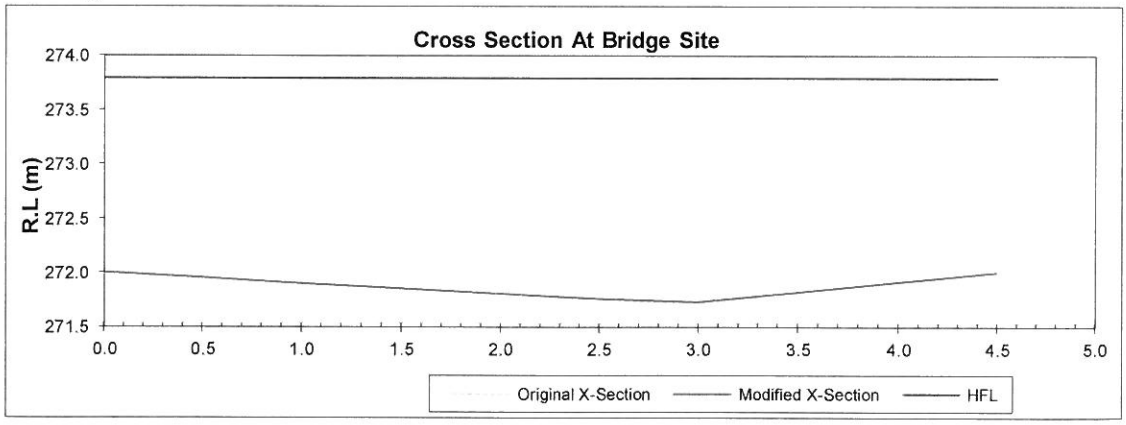
(1) By Slope Area Method

HFL(By local enquiry) = 273.793 m



Average Bed Slope of River, S	=	0.0016	
Manning's Coefficient,n	=	0.025	(in main channel)
	=	0.03	(in flood plains)

At Bridge Site

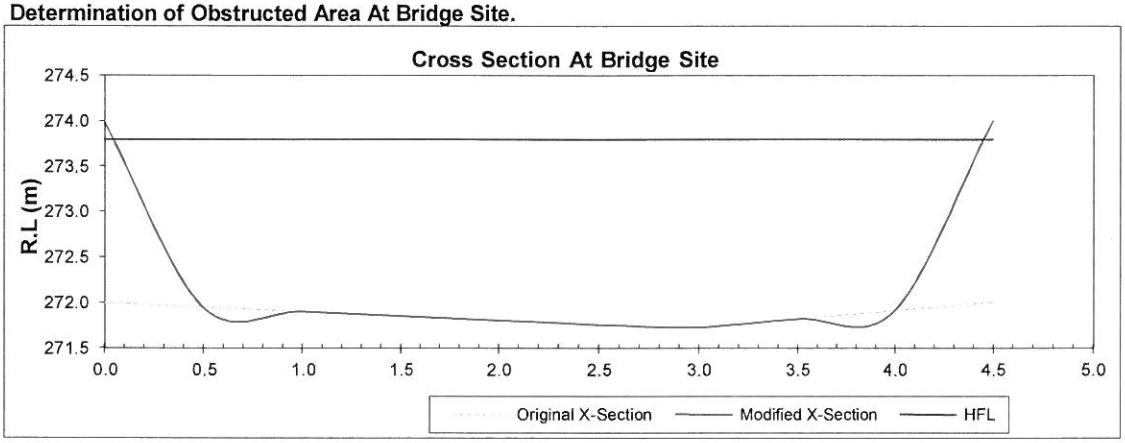


Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	q	
0.00	272.000	272.000	273.793	-	-	-	-	
0.50	271.952	271.952		0.909	0.502	1.809	2.1580	
1.00	271.903	271.903		0.933	0.502	1.857	2.2548	
1.50	271.855	271.855		0.957	0.502	1.905	2.3533	
2.00	271.806	271.806		0.981	0.502	1.953	2.4534	
2.50	271.757	271.757		1.006	0.502	2.002	2.5556	
3.00	271.729	271.729		1.025	0.501	2.047	2.6433	
3.50	271.820	271.820		1.009	0.508	1.986	2.5507	
4.00	271.911	271.911		0.964	0.508	1.896	2.3618	
4.50	272.002	272.002		0.918	0.508	1.806	2.1788	

An1=	8.701		Q=	21.51

(C) Afflux Calculation

Determination of Obstructed Area At Bridge Site.



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Distance	RL of Existing GL	RL of Modified GL	HFL	a	p	r=a/p	depth, d
0.00	272.000	274.000	273.793	-	-	-	-
0.50	271.952	271.952		0.409	2.109	0.194	1.8414
1.00	271.903	271.903		0.933	0.502	1.857	1.8899
1.50	271.855	271.855		0.957	0.502	1.905	1.9383
2.00	271.806	271.806		0.981	0.502	1.953	1.9868
2.50	271.757	271.757		1.006	0.502	2.002	2.0358
3.00	271.729	271.729		1.025	0.501	2.047	2.0638
3.50	271.820	271.820		1.009	0.508	1.986	1.9727
4.00	271.911	271.911		0.964	0.508	1.896	1.8817
4.50	272.002	274.000		0.419	2.148	0.195	

An2*=	7.702

Therefore,

Discharge, Q	=	21.51	cumec
HFL (Without Afflux)	=	273.793	m
Average Depth, d	=	1.951	m
Lowest Bed level	=	271.729	m

Area before constriction

An1	=	8.701	sq m

Average velocity prior to constriction

Vn1	=	Q/An1	
	=	2.472	m/s

Area after constriction(excluding piers)

An2*	=	7.702	

Area after constriction

An2	=	An2* - no's of piers * average width of piers * average depth (d)	
	=	7.702	sq m

Average Velocity after constriction

Vn2	=	Q/An2	
	=	2.793	m/s

Afflux due to constriction (By Molesworth Formula)

h	=	[(Vn1^2)/17.88+0.015] [(An1/An2)^2-1]	
	=	0.099	m

(D) Recommendation

Design Discharge, Q	=	21.510	cumecs
Design Affluxed HFL	=	273.892	m
Average Velocity, Vn2	=	2.793	m/sec

Check			
Formation Level	=	274.093	m
Slab Thickness	=	0.55	m
Sofit level	=	273.543	m
Proposed vertical clearance	=	-0.349	m
Required vertical clearance	=	0.60	m
Adequacy	=	Not Adequate	

(E) CALCULATION OF SCOUR DEPTH

Chainage (km)	railways: 238/15-17	
Str No.		
HFL (m)	273.793	
Q (cumecs)	21.510	
Silt Factor (K_{sf} or f)	0.900	
Qf=1.3xQ (As per Cl.4.4)	27.963	
Effective Linear Waterway Provided (Le) (m)	3.000	
Lacey's Wetted perimeter , $P_w = 1.811 \times C \times \sqrt{(Q_f)}$(m)	25.569	
Factor for increase in depth of scour,γ	2.000	(Cl.4.6.6)
Normal Scour Depth(m),$Dn=0.473*(Q_f/f)^{1/3}$	1.487	(Cl.4.6.3)
Constricted Scour Depth(m),$Dc=1.338*(q_f^2/f)^{1/3}$	6.138	(Cl.4.6.4)
Lowest Bed level(m)	271.72921	

RECOMMENDATIONS

Final Recommended Scour depth below HFL, D	=	6.138	m
Maximum Scour depth below HFL, Dmax	=	12.276	m
Maximum scour depth level	=	261.517	m

Existing Bridge No – 287
Location – KM 248/15-17

Proposed Bridge No – 001
Location – CH: 56653

(Hydrology Details)

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

Name / No. of Proposed Bridge :	287
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	248/15-17
Latitude :	$30^0 15'46"$
Longitude :	$76^0 56'15"$

Catchment Area ,	**A**	=	0.146 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.451 Km
Height of Farthest Point ,	**H1**	=	272.70 m
Height of Point of Interest ,	**H2**	=	272.50 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.20 m
Average Bed Level		=	272.50 m

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

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

where ,

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

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

(iii) Calculation of Intensity of Rainfall, I :

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

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

= **0.764 Hr**

= **45.853 Mins**

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

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

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

= **0.860**

(d)

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

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

= **8.16 cm**

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

= **7.01 cm**

= **70.15 mm**

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

= **91.79 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **1.487 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.146 Sq. Km	14.57 Hectares
Length of path from Toposheet,	L	=	0.451 Km	
Difference in Levels from Toposheet,	H	=	0.20 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.70 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	146.88 mm / Hr

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

P = Coefficient of Runoff (For clayey soils, lightly cultivated or covered)	0.4	
f = Fraction of maximum point intensity at centre of storm, depends on area	0.95	
A = Catchment Area in Hectares	14.57	Hectares
I_c = Critical Intensity of Rainfall	14.688	cm / Hr
Q = Maximum Discharge	**2.277**	**Cumecs**

3 Discharge by Dicken's Formula :

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

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

C	=	16	(adopted in present case)
M	=	0.146	Sq Km

Hence, Q = **3.773 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)	1.487 Cumecs
Discharge by Rational Formula (IRC approach)	2.277 Cumecs
Discharge by Dicken's Formula	3.773 Cumecs
Maximum Discharge	3.773 Cumecs
Next Maximum Discharge	2.277 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **3.415 Cumecs**

5 Linear Waterway :

Average Bed Level		=	272.50 m
HFL as per site condition & local inquiry		=	273.42 m
So, Total Depth of Water,	H	=	0.92 m

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

Clear Waterway (provided),	L	=	6.00 m
Total Area,	A	=	5.502 m2
Velocity ,	V	=	Q / A
		=	**0.621 m/sec**

6 Scour Depth :

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

Increased Design Discharge **4.439 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	0.74 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**1.10 m**

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

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

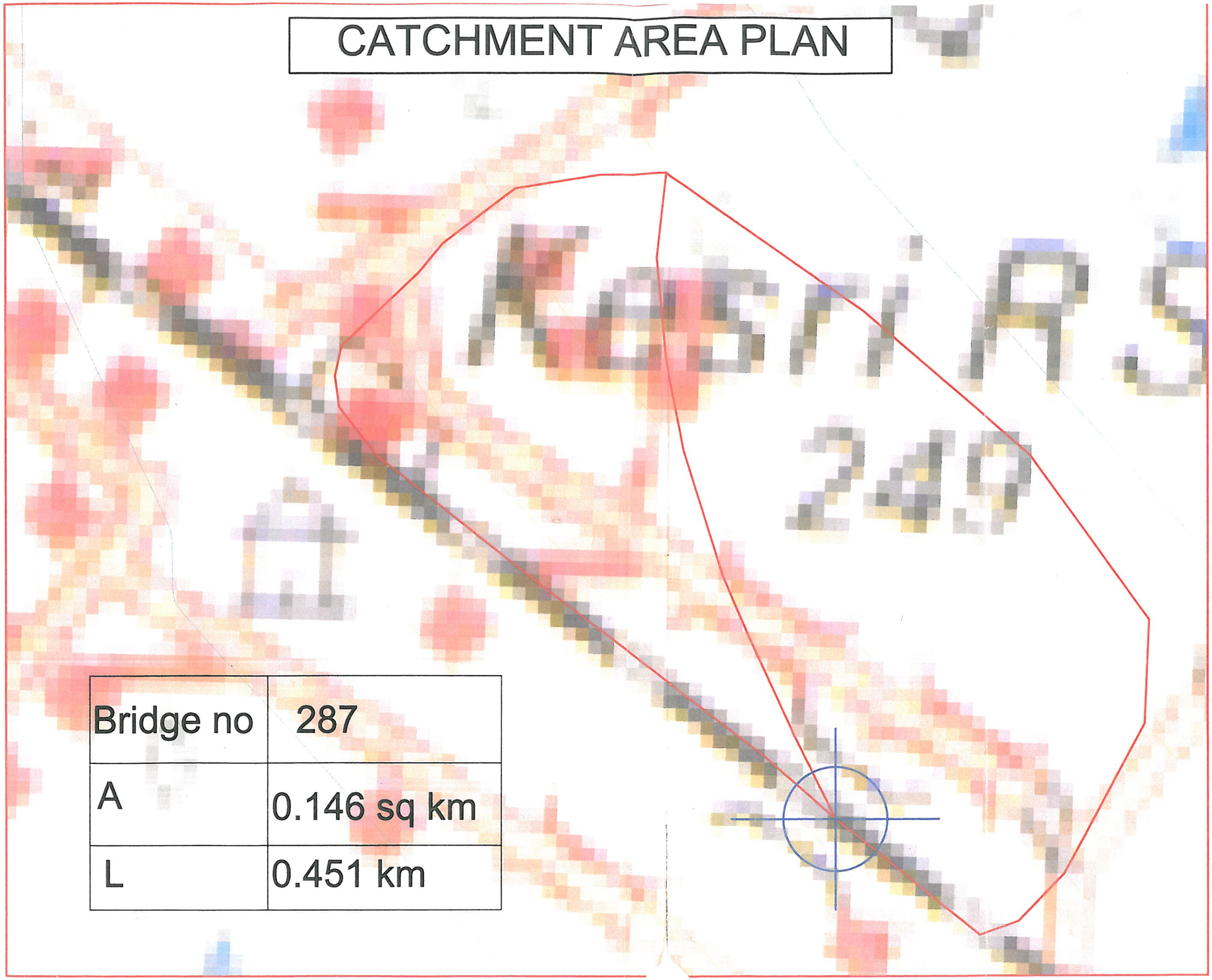
So, **Maximum Scour Depth** = **1.644 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **271.77 m**

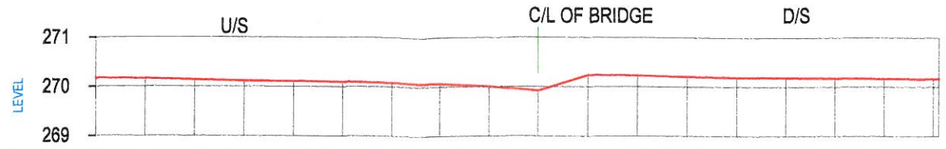
CATCHMENT AREA PLAN



Bridge no	287
A	0.146 sq km
L	0.451 km

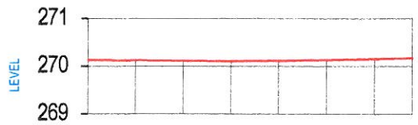
PROPOSED BRIDGE NO. BR. 001 (PRL_287)

Rly Km. 248/15-18, DFCC Chainage 56653



LEVEL	270.165	270.153	270.127	270.107	270.098	270.092	270.075	270.058	269.998	269.913	270.232	270.219	270.200	270.184	270.177	270.168	270.158	270.154	270.153
CHAINAGE	-90.00	-80.00	-70.00	-60.00	-50.00	-40.00	-30.00	-20.00	-10.00	0.00	10.00	20.00	30.00	40.00	50.00	60.00	70.00	80.00	81.125

LONGITUDINAL SECTION



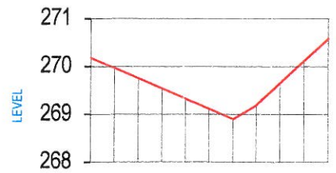
ELEVATION	270.126	270.118	270.109	270.101	270.113	270.131	270.150	270.165
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	67.978

(Upstream at 60m)

ELEVATION	270.189	270.184	270.180	270.175	270.170	270.165	270.115	270.062	270.118	270.181
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	80.000	88.292

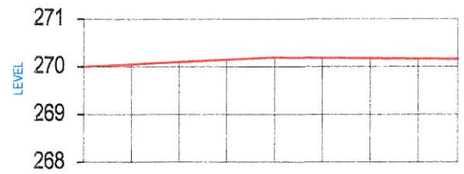
(Upstream at 95m)

CROSS SECTION



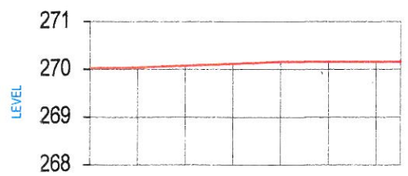
ELEVATION	271.174	270.962	270.740	270.537	270.324	270.112	269.900	270.192	270.655	271.118	271.582
CHAINAGE	-30.00	-25.00	-20.00	-15.00	-10.00	-5.00	0.00	5.00	10.00	15.00	20.00

(Bridge site)



ELEVATION	269.998	270.047	270.095	270.144	270.186	270.178	270.170	270.163	270.156
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	70.000	78.295

(Downstream at 33m)



ELEVATION	270.018	270.033	270.073	270.114	270.153	270.153	270.154	270.154
CHAINAGE	0.000	10.000	20.000	30.000	40.000	50.000	60.000	65.112

(Downstream at 78m)

Existing Bridge No – 289
Location – KM 251/5-7

Proposed Bridge No – 002
Location – CH: 59410

(Hydrology Details)

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

Name / No. of Proposed Bridge :			289
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 15
Scale :			1 : 50,000
Location :			251/5-7
Latitude :			$30^0$16'38"
Longitude :			$76^0$54'50"
Catchment Area ,	**A**	=	14.196 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	6.086 Km
Height of Farthest Point ,	**H1**	=	276.35 m
Height of Point of Interest ,	**H2**	=	270.05 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	6.30 m
Average Bed Level		=	270.05 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 = $[L^3 / H]^{0.345}$

= **3.436 Hr**

= **206.140 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 = $\frac{R_{50}(t_c)}{t_c}$

= **37.37 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **58.996 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	14.196 Sq. Km	1419.59 Hectares
Length of path from Toposheet,	L	=	6.086 Km	
Difference in Levels from Toposheet,	H	=	6.30 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		3.76 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	52.55 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	1419.59 Hectares
I_c = Critical Intensity of Rainfall	5.255 cm / Hr
Q = Maximum Discharge	**81.882 Cumecs**

3 Discharge by Dicken's Formula :

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

where,

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

C	=	16 (adopted in present case)
M	=	14.196 Sq Km

Hence, Q = **117.015 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)	58.996 Cumecs
Discharge by Rational Formula (IRC approach)	81.882 Cumecs
Discharge by Dicken's Formula	117.015 Cumecs
Maximum Discharge	117.015 Cumecs
Next Maximum Discharge	81.882 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **117.015 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.05 m
HFL as per site condition & local inquiry		=	272.55 m
So, Total Depth of Water,	H	=	2.50 m

Provide 5 spans of 6.1 m at proposed bridge site.

Clear Waterway (provided),	L	=	30.50 m
Total Area,	A	=	76.250 m2
Velocity ,	V	=	Q / A
		=	**1.535 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	117.015 Cumecs
(i)	Vertical Clearance as per IRC 5 - 1998 Cl. 106.2.1		=	0.900 m
(ii)	Vertical Clearance as per Railway Code for sub-structure Cl. 4.8		=	0.792 m
	So, Vertical Clearance adopted		=	0.900 m

Minimum Soffit Level = HFL + Vertical Clearance

= **273.452 m**

7 Scour Depth :

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

Increased Design Discharge **152.120 Cumecs**

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

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

D_b = Design discharge per metre width	4.99 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**3.91 m**

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

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

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

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

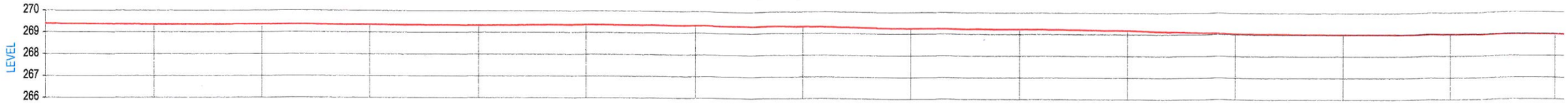
= **266.68 m**

CATCHMENT AREA PLAN

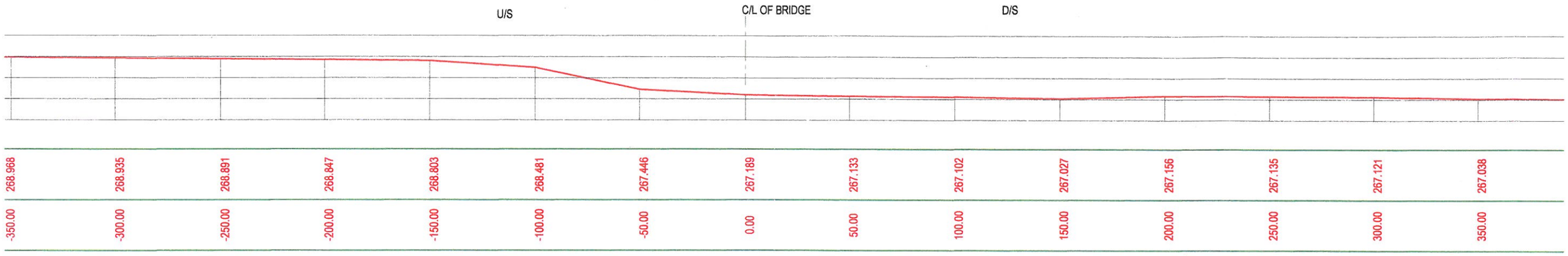
Bridge no	289
A	14.196 sq km
L	6.086 km

PROPOSED BRIDGE NO. BR. 002 (PRL_289)

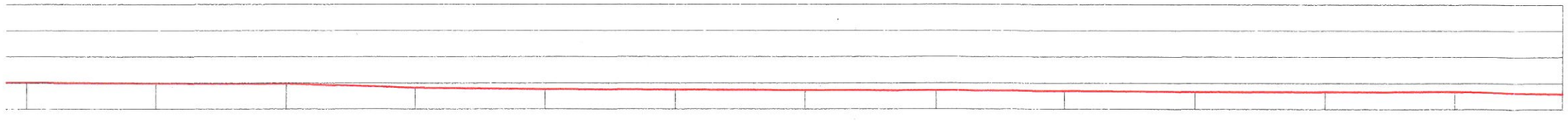
Rly Km. 251/5-8, DFCC Chainage 59410



ELEVATION	269.382	269.348	269.354	269.341	269.321	269.355	269.330	269.309	269.238	269.220	269.171	269.016	268.995	268.989	268.968
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



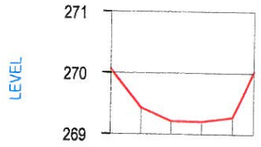
268.968	268.935	268.891	268.847	268.803	268.481	267.446	267.189	267.133	267.102	267.027	267.156	267.135	267.121	267.038
-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00



267.001	266.981	266.958	266.813	266.753	266.729	266.716	266.704	266.691	266.660	266.654	266.665	266.582
400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	991.467

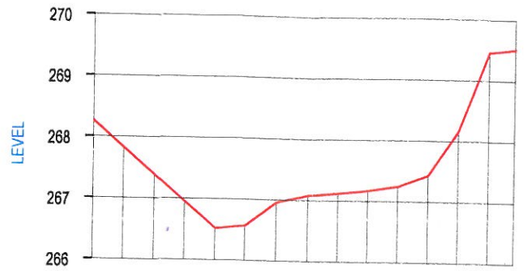
0070

LONGITUDINAL SECTION



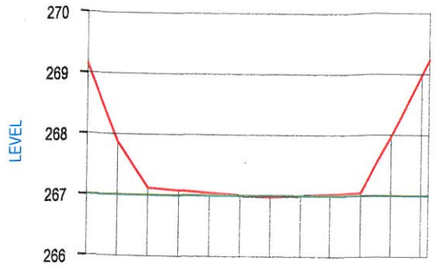
ELEVATION	270.047	269.419	269.204	269.198	269.268	270.013
CHAINAGE	-3.00	-2.00	-1.00	0.00	1.00	1.701

(Upstream at 540m)



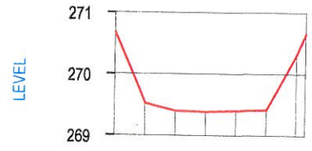
ELEVATION	268.253	267.817	267.382	266.946	266.511	266.563	266.956	267.078	267.118	267.170	267.244	267.426	268.158	269.457	269.509
CHAINAGE	-20.00	-15.00	-10.00	-5.00	0.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	49.22

(Bridge site)



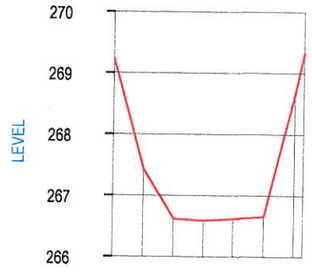
ELEVATION	269.137	267.863	267.116	267.077	267.039	267.001	266.976	266.998	267.021	267.043	267.969	268.971	269.215
CHAINAGE	-6.00	-5.00	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.00	5.00	5.243

(Downstream at 490m)



ELEVATION	270.668	269.519	269.394	269.383	269.397	269.413	270.311	270.658
CHAINAGE	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	3.296

(Upstream at 1050m)



ELEVATION	269.217	267.422	266.613	266.585	266.617	266.649	268.647	269.325
CHAINAGE	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	4.290

(Downstream at 1000m)

CROSS SECTION

0071

Existing Bridge No – 290
Location – KM 253/1-3

Proposed Bridge No – 003
Location – CH: 61240

(Hydrology Details)

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

Name / No. of Proposed Bridge :			290
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 15
Scale :			1 : 50,000
Location :			253/1-3
Latitude :			$30^0$17'13"
Longitude :			$76^0$53'54"
Catchment Area ,	**A**	=	5.517 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	7.930 Km
Height of Farthest Point ,	**H1**	=	279.85 m
Height of Point of Interest ,	**H2**	=	269.75 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	10.10 m
Average Bed Level		=	269.75 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

0072

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 :

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

$= 3.839$ Hr

$= 230.361$ 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 $= \dfrac{t_c \text{ h Ratio}}{1 \text{ h Ratio}}$

$= 1.588$

(d)

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

(ii) R_{50} (1) = **$0.34 \times R_{50}$ (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)**

= **12.96 cm**

= **129.60 mm**

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

= **33.76 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **20.708 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	5.517 Sq. Km	551.69 Hectares
Length of path from Toposheet,	L	=	7.930 Km	
Difference in Levels from Toposheet,	H	=	10.10 m	

Maximum Rainfall, F		=	240.00 mm
Duration of Storm, T		=	24 Hrs
One Hour Rainfall,	$I_o = (F / T) \times (T + 1) / (1 + 1)$	=	125.00 mm / Hr
Time of Concentration (IRC - SP : 13 - 1998, Clause : 4.7)	$t_c = (0.87 \times L^3 / H)^{0.385}$		4.25 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	47.59 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)	0.400	
f = Fraction of maximum point intensity at centre of storm, depends on area	0.98	
A = Catchment Area in Hectares	551.69	Hectares
I_c = Critical Intensity of Rainfall	4.759	cm / Hr
Q = Maximum Discharge	**28.818**	**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	=	5.517	Sq Km

Hence, Q = **57.596 Cumecs**

4 Design Discharge :

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

Discharge by Rational Formula (RBF - 16 Report)	20.708 Cumecs
Discharge by Rational Formula (IRC approach)	28.818 Cumecs
Discharge by Dicken's Formula	57.596 Cumecs

Maximum Discharge	57.596 Cumecs
Next Maximum Discharge	28.818 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **43.226 Cumecs**

5 Linear Waterway :

Average Bed Level		=	269.75 m
HFL as per site condition & local inquiry		=	270.30 m
So, Total Depth of Water,	H	=	0.55 m

Provide 1 span of 24.4 m at bridge site location.

Clear Waterway (provided),	L	=	24.40 m
Total Area,	A	=	13.371 m2
Velocity ,	V	=	Q / A
		=	**3.233 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	43.226 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		=	0.627 m
	So, Vertical Clearance adopted		=	0.900 m

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

= **271.200 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 **56.194 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	2.30 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**2.34 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** = **3.505 m**

8 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

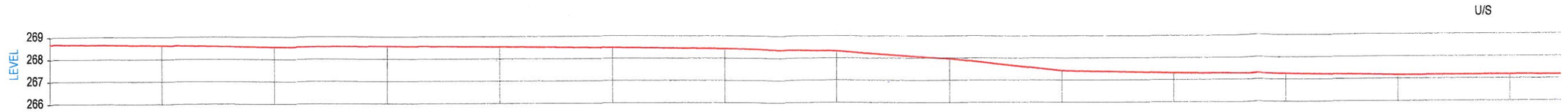
= **266.79 m**

CATCHMENT AREA PLAN

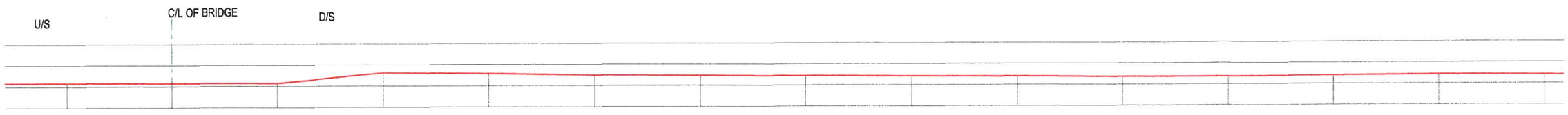
Bridge no	290
A	5.517 sq km
L	7.930 km

PROPOSED BRIDGE NO. BR. 003 (PRL_290)

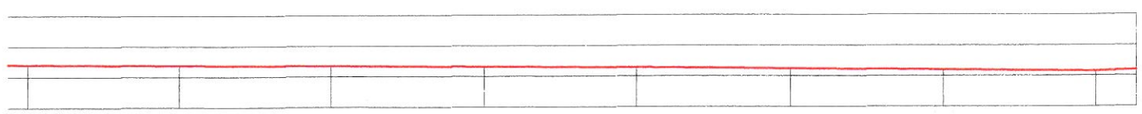
Rly Km. 253/1-3, DFCC Chainage 61240



ELEVATION	268.649	268.614	268.534	268.557	268.522	268.461	268.412	268.298	267.946	267.407	267.302	267.240	267.147	267.162
CHAINAGE	-700.00	-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



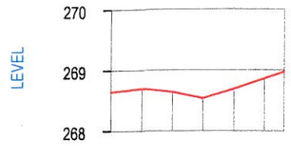
	267.162	267.140	267.143	267.624	267.568	267.482	267.459	267.429	267.408	267.388	267.354	267.344	267.378	267.421	267.396
	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00



267.396	267.370	267.340	267.311	267.272	267.232	267.189	267.136	267.182
650.00	700.00	750.00	800.00	850.00	900.00	950.00	1000.00	1013.327

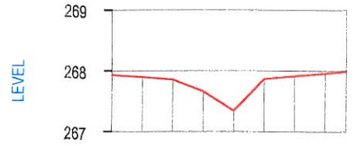
LONGITUDINAL SECTION

0077



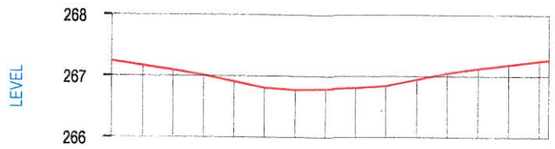
ELEVATION	268.639	268.689	268.631	268.528	268.680	268.850	268.963
CHAINAGE	-6.00	-4.00	-2.00	0.00	2.00	4.00	5.277

(Upstream at 520m)



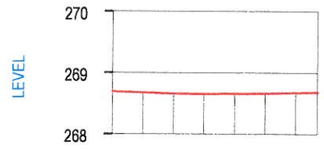
ELEVATION	267.923	267.887	267.852	267.654	267.334	267.858	267.905	267.952	267.984
CHAINAGE	-4.00	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	3.68

(Downstream at 490m)



ELEVATION	267.236	267.163	267.090	267.005	266.903	266.800	266.772	266.789	266.805	266.838	266.942	267.046	267.124	267.186	267.248	267.267
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	16.621

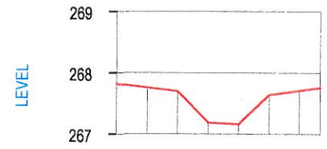
(Bridge site)



ELEVATION	268.688	268.672	268.655	268.651	268.653	268.659	268.671	268.679
CHAINAGE	-6.00	-4.00	-2.00	0.0	2.00	4.00	6.00	7.429

(Upstream at 720m)

CROSS SECTION



ELEVATION	267.814	267.754	267.695	267.184	267.158	267.640	267.707	267.753
CHAINAGE	-3.00	-2.00	-1.00	0.00	1.00	2.00	3.00	3.677

(Downstream at 1000m)

0078

Existing Bridge No – 291
Location – KM 253/23-25

Proposed Bridge No – 004
Location – CH: 62017

(Hydrology Details)

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

Name / No. of Proposed Bridge :			291
Name of Nallah / Stream / River :			Local Stream
River Sub - Zone :			Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :			53 B / 15
Scale :			1 : 50,000
Location :			253/23-25
Latitude :			$30^0$17'27"
Longitude :			$76^0$53'31"
Catchment Area ,	**A**	=	19.647 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	19.532 Km
Height of Farthest Point ,	**H1**	=	283.95 m
Height of Point of Interest ,	**H2**	=	267.55 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	16.40 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

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

= **8.257 Hr**

= **495.397 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 = $\frac{R_{50}(t_c)}{t_c}$

= **15.70 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **34.292 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	19.647 Sq. Km	1964.66 Hectares
Length of path from Toposheet,	L	=	19.532 Km	
Difference in Levels from Toposheet,	H	=	16.40 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		10.00 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	22.74 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	1964.66	Hectares
I_c = Critical Intensity of Rainfall	2.274	cm / Hr
Q = Maximum Discharge	**49.029**	**Cumecs**

3 Discharge by Dicken's Formula :

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

where,

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

C	=	16	(adopted in present case)
M	=	19.647	Sq Km

Hence, Q = **149.309 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)	34.292 Cumecs
Discharge by Rational Formula (IRC approach)	49.029 Cumecs
Discharge by Dicken's Formula	149.309 Cumecs
Maximum Discharge	149.309 Cumecs
Next Maximum Discharge	49.029 Cumecs

The difference is beyond 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **73.543 Cumecs**

5 Linear Waterway :

Average Bed Level		=	267.55 m
HFL as per site condition & local inquiry		=	270.05 m
So, Total Depth of Water,	H	=	2.50 m

Provide 1 span of 24.4 m at bridge site location.

Clear Waterway (provided),	L	=	24.40 m
Total Area,	A	=	61.000 m2
Velocity ,	V	=	Q / A
		=	**1.206 m/sec**

6 Vertical Clearance :

	Design Discharge	Q	=	73.543 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		=	0.695 m
	So, Vertical Clearance adopted		=	0.900 m

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

= **270.952 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 **95.606 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	3.92 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**3.33 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** = **4.996 m**

8 Maximum Scour Level :

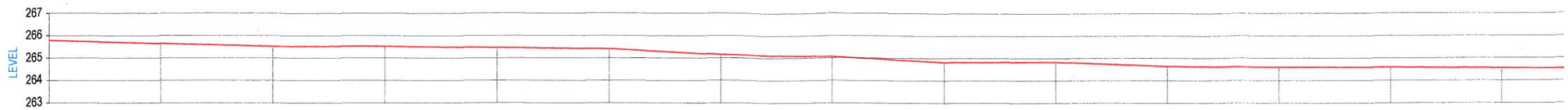
Maximum Scour Level = HFL - Maximum Scour Depth

= **265.06 m**

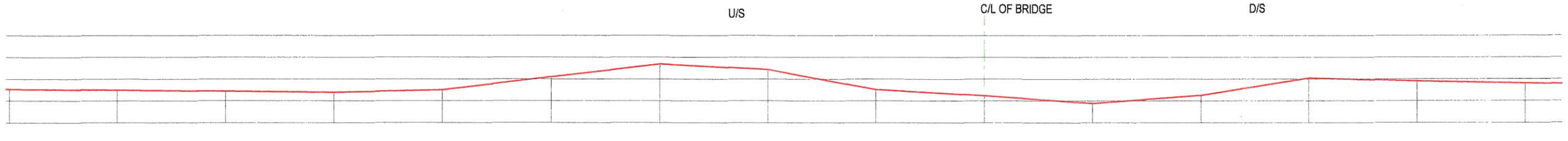
CATCHMENT AREA PLAN

Bridge no	291
A	19.647 sq km
L	19.532 km

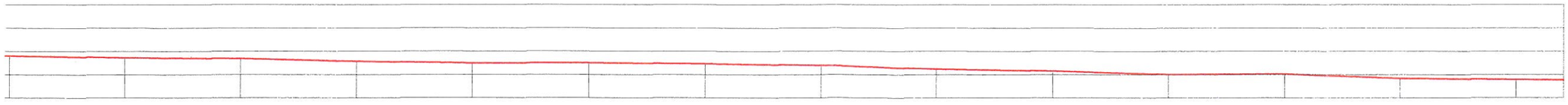
PROPOSED BRIDGE NO. BR. 004 (PRL_291)
Rly Km. 253/23-25, DFCC Chainage 62017



ELEVATION	265.782	265.633	265.506	265.515	265.458	265.393	265.136	265.055	264.808	264.813	264.618	264.585	264.580	264.535
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



264.535	264.488	264.440	264.384	264.495	265.090	265.684	265.436	264.518	264.232	263.872	264.251	265.039	264.900	264.792
-400.00	-350.00	-300.00	-250.00	-200.00	-150.00	-100.00	-50.00	0.00	50.00	100.00	150.00	200.00	250.00	300.00

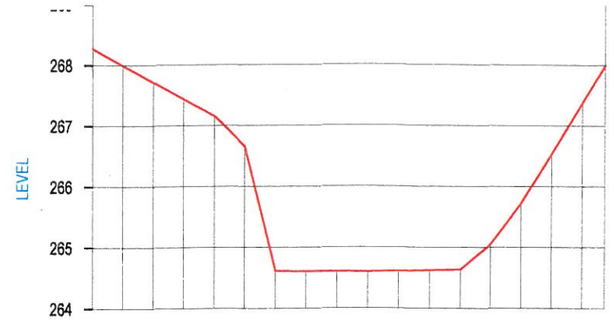


264.792	264.723	264.680	264.558	264.481	264.489	264.459	264.390	264.227	264.143	263.995	264.017	263.826	263.775	263.755
300.00	350.00	400.00	450.00	500.00	550.00	600.00	650.00	700.00	750.00	800.00	850.00	900.00	950.00	970.727

LONGITUDINAL SECTION

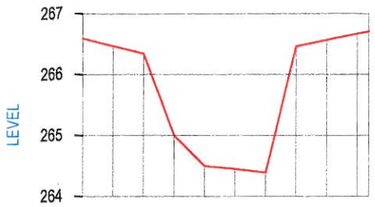
0084

SHEET NO. 1TO 2



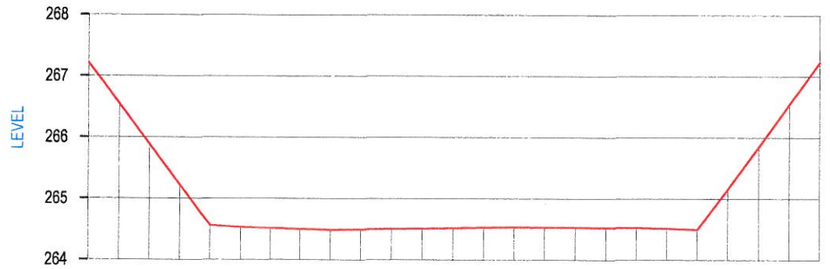
ELEVATION	268.264	267.984	267.705	267.425	267.145	266.652	264.604	264.601	264.597	264.593	264.604	264.616	264.628	265.044	265.716	266.530	267.371	267.985
CHAINAGE	-18.00	-16.00	-14.00	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	15.458

(Upstream at 500m)



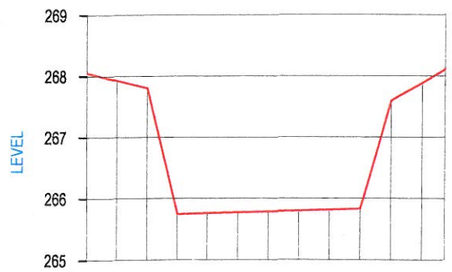
ELEVATION	266.587	266.461	266.335	264.993	264.489	264.445	264.381	266.452	266.556	266.659	266.698
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	6.742

(Downstream at 490m)



ELEVATION	267.203	266.542	265.880	265.219	264.558	264.528	264.513	264.499	264.485	264.494	264.502	264.510	264.518	264.526	264.532	264.530	264.528	264.526	264.524	264.511	264.497	265.152	265.847	266.542	267.225
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	0.00	2.00	4.00	6.00	8.00	10.00	12.00	14.00	16.00	18.00	19.968

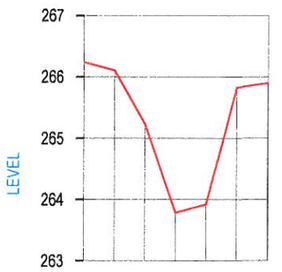
(Bridge site)



ELEVATION	268.047	267.925	267.803	265.739	265.754	265.768	265.782	265.796	265.810	265.829	267.591	267.882	268.106
CHAINAGE	-12.00	-10.00	-8.00	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00	8.00	10.00	11.543

(Upstream at 1010m)

CROSS SECTION



ELEVATION	266.234	266.098	265.223	263.780	263.914	265.820	265.892
CHAINAGE	-6.00	-4.00	-2.00	0.00	2.00	4.00	6.00

(Downstream at 1010m)

0085

Existing Bridge No – 292
Location – KM 254/5-7

Proposed Bridge No – 005
Location – CH: 62309

(Hydrology Details)

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

Name / No. of Proposed Bridge :	292
Name of Nallah / Stream / River :	Local Stream
River Sub - Zone :	Upper Indo- Ganga Plains 1 (e)
G.T Sheet No :	53 B / 15
Scale :	1 : 50,000
Location :	254/5-7
Latitude :	$30^0$17'36"
Longitude :	$76^0$53'16"

Catchment Area ,	**A**	=	0.427 Sq Km
Length of Longest Stream course from source to the bridge site ,	**L**	=	0.748 Km
Height of Farthest Point ,	**H1**	=	271.70 m
Height of Point of Interest ,	**H2**	=	270.95 m
Height of the Farthest Point above Point of Interest along the river ,	**H**	=	0.75 m
Average Bed Level		=	270.95 m

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

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

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

C = Runoff Coefficient

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

A = Catchment Area (Sq Km)

(ii) Runoff Coefficient , C :

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

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

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

(iii) Calculation of Intensity of Rainfall, I :

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

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

= **0.818 Hr**

= **49.062 Mins**

(a) t_c h Ratio = 0.30 (from Fig. 4 of RBF - 16)

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

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

= **0.889**

(d)

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

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

= **8.16 cm**

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

= **7.25 cm**

= **72.54 mm**

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

= **88.71 mm / Hr**

(iv) Design Flood Discharge :

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

Q_{50} = **4.217 Cumecs**

2 Discharge by Rational Formula (IRC approach) :

Catchment Area,	A	=	0.427 Sq. Km	42.74 Hectares
Length of path from Toposheet,	L	=	0.748 Km	
Difference in Levels from Toposheet,	H	=	0.75 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)	$t_c = (0.87 \times L^3 / H)^{0.385}$		0.76 Hrs
Critical Rainfall Intensity,	$I_c = I_o \times [2 / (1 + t_c)]$	=	142.28 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	42.74	Hectares
I_c = Critical Intensity of Rainfall	14.228	cm / Hr
Q = Maximum Discharge	**6.471**	**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	=	0.427 Sq Km	

Hence, Q = **8.458 Cumecs**

4 Design Discharge :

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

Discharge by Rational Formula (RBF - 16 Report)	4.217 Cumecs
Discharge by Rational Formula (IRC approach)	6.471 Cumecs
Discharge by Dicken's Formula	8.458 Cumecs
Maximum Discharge	8.458 Cumecs
Next Maximum Discharge	6.471 Cumecs

The difference is within 50% of the next maximum discharge

Hence, Design Discharge adopted Q = **8.458 Cumecs**

5 Linear Waterway :

Average Bed Level		=	270.95 m
HFL as per site condition & local inquiry		=	272.61 m
So, Total Depth of Water,	H	=	1.66 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	=	4.986 m2
Velocity ,	V	=	Q / A
		=	**1.696 m/sec**

6 Scour Depth :

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

Increased Design Discharge **10.996 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	3.67 Cumecs / m
K_{sf} = Silt factor	1.00
d_{sm} =	**3.19 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** = **4.778 m**

7 Maximum Scour Level :

Maximum Scour Level = HFL - Maximum Scour Depth

= **267.84 m**