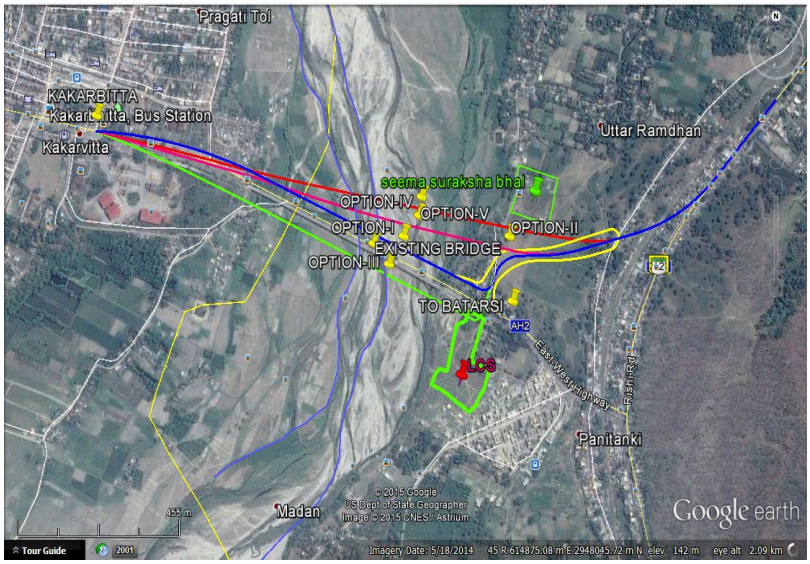
ADB TA No. 8116-IND

TA SUBPROJECT NO. 25

DETAILED DESIGN OF THE SASEC SUBREGIONAL ROAD CONNECTIVITY PROJECT



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DETAILED PROJECT REPORT FOR MECHI BRIDGE

Volume-III
Hydrological and Hydraulic Report

Sheladia Associates Inc (ADB TA Consultant)

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SHELADIA ASSOCIATES, INC.

CONTENTS

DRAINAGE DESIGN REPORT OF MAJOR BRIDGE ACROSS MECHI RIVER AT KM: 0+885

1.1 Introduction

Mechi Bridge is an important link connecting India and Nepal, serving immensely, both the countries in trans-border trade, Industrial, social and cultural exchange and development in the region. The existing bridge connecting Nepal to India is located at about 150m from Kakarbhitta junction in Nepal, towards India side; connecting Panitaki in India.

Existing Mechi Bridge consists of 20 spans of each 29.3m, with cast-in-place, concrete T-girder and slab superstructure, resting on solid wall type concrete substructures and well foundations. The bridge is built in the early1970 s and is about 45 years old now. The bridge is also in reasonably Fair condition, so far as the overall structural integrity is concerned, except for the requirement of spalling and some surface repairs etc., which may be dealt addressed in the structural report.

The carriageway width of the bridge is to cater for maximum of 2 lane width without paved shoulder but it is also being used by numerous autos, paddle operated rickshaws and other slow moving hand pulling carts as well, along with the pedestrian traffic. The capacity of the bridge has far exceeded to take care of present day mixed traffic volume. Therefore, it is proposed construction a new 4-lane bridge, with independent structure in each direction of traffic. The span arrangement shall be 15 x 45.0m. The existing bridge will continue to be used by pedestrians and slow moving vehicles.

1.2 General Hydrology and Physiography

Mechi is a typical Himalayan river. The project road, AH-2, crosses the river in its sub-mountainous reach. This reach is known as the Duars and the Terai region which is relatively flat with respect to the immediate upper reach of Mechi and the river is characterized by its braided and interlaced system of independent channels/ branches. These braided channels are meandering between relatively large khadir of the Mechi River. The courses of the braided channels are unstable, i.e., during one season some of the channels remain almost dead but in the next season can get active and vice versa. The channels are separated by the shallow

sandy beach which is in fact bed of the Mechi itself. At the end of the Khadir, there are banks which on the upstream side of the existing bridge are stabilized by the high bund roads, both on India and Nepal side. The downstream Indian side has natural high bank with a significant deep gorge, hugging on the India side with a large bend. But on the Nepal side, it is quite undefined on the downstream. The braided channels generally carry perennial flow. Three distinct such braided channels are found in active stage on the upstream side, during investigation, with mean width of flow of 10 to 20m concentrated drainage path meandering between the khadir. As these channels meander, unpredictably. Each of these channels has the potential of getting ferocious and can also combine with the other few, during peak flow. Each of these has high velocity. So, it is best to avoid obstructing these or blocking partially, which may result in many consequences, like deep scouring and even outflanking. The existing is also bank to bank. So, the waterway has to be liberal and recommended to bridge the entire khadir, i.e. high bank to high bank. These streams join together at little downstream of the existing bridge and the combined flow found to be quite mighty with high current, not less than 2.0 to 2.5m/sec even during ordinary flow situation.

The river has a sharp bend at existing bridge location and further downstream. As it hugs India side bank, deep erosion and high natural bank is found all along the sharp bend downstream. The bank is protected by series of spurs which are in fair to good condition and found to be serving well and can be retained with minor repair.

During high flood which is never more than 2.0m from the low bed, as per the local information collected from the senior and informed citizen. During high flood the river flow widens to almost bank to bank. The rest of the year the flow of Mechi remains divided and restricted within the shallow braided channels. The flash floods are characterized by high velocity and contribute to deep erosion on the concave side of the bank and silting on Nepal side.

Each of these channels is potential of getting ferocious and can also combine with the other few, during peak flow. So, it is best to avoid tampering with these or

blocking partially, which may result in many consequences, like deep scouring and even outflanking.

Relevant photographs are attached with captions, which are self explanatory to illustrate the objects of interest, vide Annexure-12.

1.3 The Proposed Bridge

It is observed that the existing bridge as a whole is sited on a bend and the river hugs on Indian side. The flow also in skew and the piers and abutments are subject to oblique attack of the channel flows, vide attached google imagery. So in the choice of the siting of the new bridge, the follwing are considered:

1. Because of the curvature of the river sharply increases and the three channels combine at little downstream of the existing bridge and hug intensely the India side bank with great current and so the downstream option is not recommendable. Besides, it has immense social impact and conflict with the existing well functioning series of groins also.
2. However, towards the upstream of the bridge, the curvature reduces abruptly, in a short distance. So, it is safer and pragmatic to move away from India side existing abutment little on the upstream side. This side at presently is relative uninhabited with some agricultural land use. This will also reduce the oblique attack of the streamlines to the substructures of the new bridge. Nepal side A1, abutment necessarily cannot be shifted much due to the permanency of the channel and thick settlement all around. So, A1 will be close and next to the existing A1 side abutment, on upstream side.
3. The new bridge being bank to bank, covering the entire khadir and therefore no deficiency due to constriction and possibility of rise of the back water phenomena is eliminated.

1.4 Hydrological and hydraulic Recommendations:

1. The new 2x2 lane bridge shall be on the upstream side.
2. A1 abutment for the proposed bridge shall be next to the existing bridge, whereas, A2 of the proposed bridge shall be away from the existing A2, as far as practicable, to minimize the oblique attack due

to curvature. At present the approved alignment Option-V, makes A2, about 100 m away from the existing A2, towards upstream side.

3. The bank between the existing and the proposed shall be heavily armoured, (may be increased further towards upstream, if needed as per site condition). This is because, for A2, chance of oblique attack of flow at high floods cannot be eliminated due to the geometry of the river bend on India side. Pitching is proposed of 825 mm thk, with 300 mm thick filter underlying, for the embankment. Free board shall be 1.5m above HFL. The length of Apron shall be 6.0m. Thickness shall be 1.55m. The length may however vary as per site condition, at the discretion of the Engineer in charge.
4. The bed between the existing and the proposed shall be completely protected, in accordance with the provisions of IRC: 89, as provided in article 10, i.e. over a compacted bed, 150 mm M-10 PCC, followed by 300 mm thick M-15, grade of PCC, followed by 150 thick flat stone, grouted in 1:3 mortar. The top of flooring shall match with the top of Pile or well cap or as per site condition.
5. The launching Apron shall be 6.0m on downstream of the existing bridge and 3.0m on the upstream of the proposed bridge, throughout the bed and thickness shall be 1.0m. The length may however vary as per site condition, at the discretion of the Engineer in charge.
6. The weight of an individual boulder shall not be less than 40 Kg.

1.5 Calculation of design discharge

1.5.1 SUH Method:

As mechi river is having considerably larger catchment of 210 Sqkm, SUH method is carried out to calculate the design discharge. For the catchments having more than 25 sqkm SUH method is applicable to calculate discharge as per IRC: 5-1998. Calculations of SUH discharge is done in accordance with the recommendation of CWC Manual. This region falls under North Brahmaputra subzone-2(a). SUH calculations are carried out accordingly. 100 year peak discharge obtained from SUH method is 1835 cumec. The calculations are presented in Annexure-1.

1.5.2 Area Velocity calculations:

From extensive local inquiry, the HFL is adopted at existing bridge location. Three cross-sections are chosen, one at the proposed bridge and another two are at 250m and 500m, upstream, from the survey data. Slope calculated from the survey data, vide procedure explained under chapter 1.5.4, is applied to the HFL obtained from local inquiry, at the existing bridge locations to work out HFLs at the three cross-sections. Discharge then is calculated at each of the cross-sections and the highest is adopted for finalization of design discharge. The value of rugosity coefficient "n", adopted for the design = 0.03. This method has yielded maximum discharge of 1730 cumec at bridge site cross-section. The calculations are presented in Annexure-3.

1.5.3.1 Rational Method

Though this method is not recommended for large catchments more than 50 Sq. Km., but still worked out as one more method to compare and adopt the most severe discharge. This method has yielded a discharge of 1456 cumec. The calculations are provided in the Annexure-4.

1.5.3.2 Other Empirical Methods

Empirical methods are extreme simplification, as they have only one factor and that is the catchment area; overlooking many other factors of run-off. The accuracy of the discharge therefore remains doubtful, vide Clause 4.5 and 4.6 of IRC:SP-13-2004 and also the pocket Book of Bridge Engineers, Cl. 1.4 and 1.5 of Appendix-1. Therefore, it is avoided and not presented in this report as more reliable three methods to compare, are available and above all CWC manual for this sub-zone, recommended by IRC:5-1998, is available and that always predominates, vide Cl. 103.2.

1.5.3.3 Design Discharge

Mechi is extremely important trans international border 4-lane bridge on AH-2. Therefore, flood frequency of 100 years minimum is adopted for design, vide Cl. 2.2.5.1 of Pocket Book for Bridge Engineers and IRC: SP-84-2014, Cl. 7.5. Comparing discharges obtained from various methods the maximum discharge is obtained by SUH method. The value of this discharge is 1835 cumec. Since no topo-sheet is available, may be due to Survey of India's restrictive policy in and around international boundary. Also, no data of the catchment from the utility Department or CWC could be made available, even after best efforts of the

Consultants. Therefore, extra 33.33% discharge is further considered necessary, looking at into the importance of the crossing. Therefore the Design Discharge = 1835*1.33 = 2440 cumec, say 2500 cumec.

1.5.4 Slope Calculation:

In Mechi River there are predominantly three braided channels meandering through the khadir only. Longitudinal slopes, along the deepest bed for individual channels have been worked out from the topographic survey data and the simple mean of the three slopes is taken as longitudinal slope for the design calculation, vide Annexure-**2**.

Longitudinal slope for channel 1(S1) = 0.0038

Longitudinal slope for channel 2(S2) = 0.004

Longitudinal slope for channel 3(S3) = 0.00396

Therefore, longitudinal slope adopted for Mechi bridge = 0.004

1.5.5 HFL Calculations, vertical clearances, general hydraulics and scour

1.5.5.1 Design HFL

The HFL is assumed to be of 100 year frequency, based on the assumption that the 100 year flood will yield be give rise to 100 year HFL too, in accordance with the provisions of CWC Manual. The design HFL of the proposed bridge is then computed from the proposed bridge site cross section obtained from survey data, and applying the same boundary conditions, e.g. local slope, n value. By equating the discharge obtained from SUH method HFL is being fixed. The calculation of design HFL and design velocity are provided in the Annexure-**6**. The procedure is in accordance with CWC and IRC recommendations and as follows:

$A \times [1/nR^{2/3}S^{1/2}] = Q$ design

n=Rugosity coefficient (from IRC SP: 13-2004). For the purpose of calculation, it is adopted n = 0.03.

R=Hydraulic mean depth=A/P, A = Wetted cross section at HFL and P= Wetted perimeter.

S=Longitudinal slope, as explained, under chapter 1.5.4.

1.5.5.2 Vertical Clearance

Vertical clearance is adopted, in accordance with IRC: 5-1998, clause No. 106.2.1. For the relevant discharge, it is 1.2m. No navigational clearance requirement is reported for this bridge.

1.5.5.3 General hydraulics

No afflux is anticipated as the vent of the proposed is more than the existing and the bridge is also bank to bank, which exceeds actual linear waterway and Lacey's regime width requirement. The same is reflected in the calculation also, vide work-sheet "LWW", vide Annexure 7. However, a back water due to unforeseen eventualities, e.g. sudden obstruction of vent due to choking by floating debris and bushes etc., a 150 mm, back water rise is considered and added to the HFL value, in order to arrive at Design HFL. A complete hydrological and hydraulic design parameters of the river is provided in the Annexure-8.

1.5.5.4 Scour calculations for the foundations

Scour calculations are necessary to ascertain the founding levels or the pile capacities for pile foundations. Scour shall be calculated in accordance with IRC: 78-2014, Clause 702.2 and 702.3 and may also be referred to the chapter No. 110 of IRC: 5-1998. But it demands a physical index or property of the bed material known as Silt Factor. At present, geotechnical investigation is in progress at site and therefore, Silt Factors, as a necessary ingredient to prepare scour table for abutment and piers are not available. The Silt Factors, in case of granular bed materials (bouldery, sandy or silty), are generally calculated in accordance with the mean diameter of the particle size of the bed materials, obtained from the sieve analysis, upto the anticipated depth of scour. Ksf = 1.76 x (d_m)^0.5, where d_m is the mean dia. of the particles as explained above and needs to be calculated as per Appendix-2 of IRC:5-1998.

However, for clayey/very fine grained colloidal particles, the above procedure does not hold good and it needs to be calculated as per Appendix-1 of IRC:78-2014, on the basis of geotechnical report.

The scour table therefore shall be presented in the geotechnical report based on the local scour as per unit discharge d_b (cumec/m), provided in the table of Annexure 7, under col. 5, applying the appropriate Silt Factors to be obtained from the geotechnical investigation.

Since, the khadir is large with meandering braided active channels and therefore due to some possibility of outflanking, it is recommended to design the Abutments as abutment piers safely with the provision for all-round scour.

1.5.6. Codes of Practice and publications used in the report are as follow:

1. CWC Manual - Flood estimation report, of North Brahmaputra basin sub-zone 2(a).
2. IRC: 5-1998 – General features of Design for road bridges.
3. IRC: 78-2014 – Code of practice for substructures and foundations of road bridges.
4. IRC: SP-84-2014 – 4- Lane Manual.
5. Pocket Book for Bridge Engineers
6. IRC: 89-1995 – Guidelines for design and construction of river training and control works for road bridges.
7. IRC: SP-13-2004 – Guidelines for the design of small bridges and culverts.

1.5.7. Analysis and study of the partial flow pattern of Mechi discharge due to the braided channels, q1, q2 and q3; their flow concentration

As the River Mechi also consists of braided and interlaced system of channels, particularly 3 such channels found to carry a significant flow concentration within the bed, which is much higher than that of the average flow pattern of the bed outside these concentrated flow lines, therefore, a separate and exclusive hydraulic analysis became imperative to understand the these flow

concentration. These are particularly important in view of the excessive and much deeper local scour around the piers, it will necessarily attract, during peak design flow. The piers which will fall within these concentrated flow lines need to designed with the provision of additional scour. The piers are identified and earmarked in the Annexure-10. The discharges in each of these three channels are calculated and presented in Annexure-9. The scour and foundation designs for the piers and abutments, need to be done as recommended based on concentrated unit discharge (d_b), in the table, vide Annexure-10.

1.5.8 Maps and drawings

Maps and drawings are appended in the Annexure-11. The following maps and drawings are used in the analysis and hydraulic design calculations:

1. Topographical survey drawing.
2. Cross-section and Long section drawing.
3. Google imagery showing the catchment boundary and the River Mechi, with catchment area marked.
4. A blow up version map showing plans of the proposed and existing bridges, together with other important hydraulic features.
5. General Arrangement Drawing.

ANNEXURE - 1

CALCULATION OF DISCHARGE OF MECHI RIVER BY SYNTHETIC UNIT HYDROGRAPH METHOD

Discharge calculation by Synthetic Unit Hydrograph Method

1 Description

Name and Number of Subzone	-	North Bhramaputra Subzone - 2(a), CWC Manual	
Location at Site	-	Km : 0+884	
Name of Place	-	Panitanki-Kakrabhitta	
Name of River	-	Mechi	
Shape of the Catchment	-		
Topography	-	Sub-montaneous	

2 Design data

Catchment Area	(A) =	210.000	sqkm	from Google-Pro
Length of Longest Stream	(L) =	43.300	km	from Google-Pro-Map, vide attached
Length of Longest Stream from cg to site	(L_c) =	22.600	km	from Toposheet
Unit Duration of Unitgraph	(t_r) =	1.0	hr	
Loss Rate	=	0.24	cm/hr	

3 Computation of Equivalent Stream Slope (S)

Sl. No.	Reduced distance	Reduced levels	L_i	D_i	$D_{i-1} + D_i$	$L_i(D_{i-1} + D_i)$
	(kms)	(m)	(kms)	(m)	(m)	(mxkm)
1	2	3	4	5	6	7
1	0.000	127.000	0.000		-	-
2	1.090	132.000	1.090	5.00	5.00	5.45
3	3.280	144.000	2.190	17.00	22.00	48.18
4	7.660	177.000	4.380	50.00	67.00	293.46
5	13.820	246.000	6.160	119.00	169.00	1041.04
6	16.660	332.000	2.840	205.00	324.00	920.16
7	19.390	360.000	2.730	233.00	438.00	1195.74
8	21.180	418.000	1.790	291.00	524.00	937.96
9	22.800	478.000	1.620	351.00	642.00	1040.04
9	25.800	645.000	3.000	518.00	869.00	2607.00
10	28.300	817.000	2.500	690.00	1208.00	3020.00
11	30.800	947.000	2.500	820.00	1510.00	3775.00
12	33.300	1058.000	2.500	931.00	1751.00	4377.50
13	35.800	1197.000	2.500	1070.00	2001.00	5002.50
14	38.300	1255.000	2.500	1128.00	2198.00	5495.00
15	40.800	1457.000	2.500	1330.00	2458.00	6145.00
16	43.300	1898.000	2.500	1771.00	3101.00	7752.50
					S	43656.53

Slope (S) = $\frac{\sum Li(Di\text{-}1+Di)}{L^2}$ = **23.285** m/km

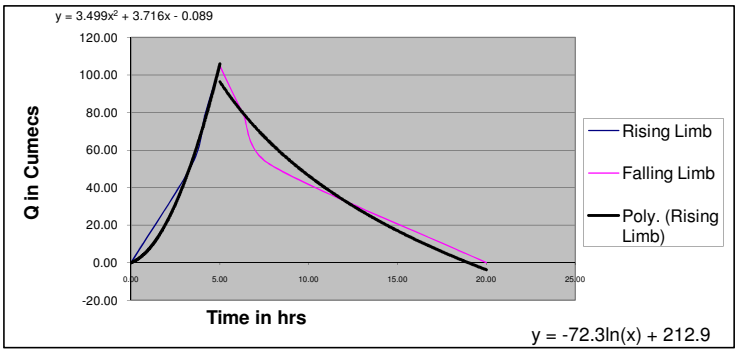
4 Determination of Synthetic 1-hr Unitgraph Parameters

tr		=	1.0 hr		
Basin Lag	$t_p = 2.164(q_p)^{-0.940}$	=	4.152 hrs	~	4.500 say
Peak of the Unit Hydrograph	$q_p = 2.272 * (LLc/S)^{-0.409}$	=	0.500 cumec/sqkm		
$W_{50} = 2.084 * (q_p)^{-1.065}$		=	4.36 hrs		
$W_{75} = 1.028* (q_p)^{-1.071}$		=	2.16 hrs		
$W_{R50} = 0.856 * (q_p)^{-0.865}$		=	1.56 hrs		
$W_{R75} = 0.440 * (q_p)^{-0.918}$		=	0.83 hrs		
Base width	$T_B = 5.428 *(t_p)^{0.852}$	=	19.55 hrs		20.000 say
$t_m = t_p + t_r/2$		=	5.00 hrs		
$Q_p = q_p$ x A		=	105.00 cumec		

UG Ordinates from above formulae

X-value		Y-value	
0	0.00	0	0.00
t_m-W_{R50}	3.44	Q_p*0.5	52.50
t_m-W_{R75}	4.17	Q_p*0.75	78.75
t_m	5.00	Q_p*1.0	105.00
t_m+W_{75}-W_{R75}	6.33	Q_p*0.75	78.75
t_m+W_{50}-W_{R50}	7.80	Q_p*0.5	52.50
T_B	20.00	0	0.00

Major bridge across Mechi river at Km. 0+885



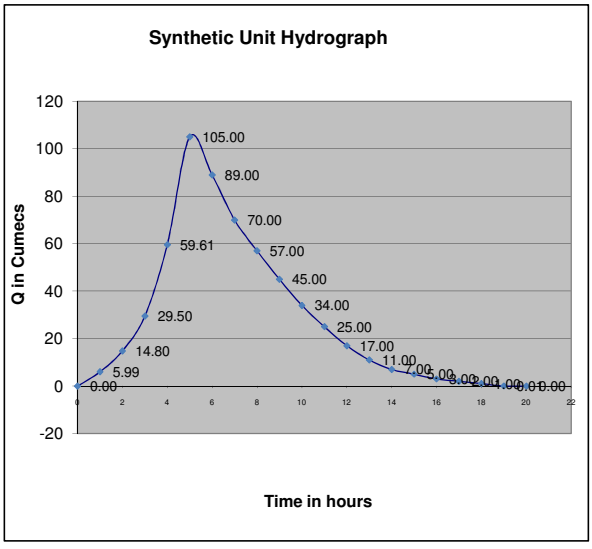
UG Ordinates from graph(from equation for rising and recession limb)

Abcissa	values from the first equation	values from the Second equation	Adjusted values
0	0.00	0.00	0.00
1	7.13	7.13	5.99
2	17.62	17.62	14.80
3	35.12	35.12	29.50
4	59.61	59.61	59.61
5	96.54	96.54	105.00
6	83.36	83.36	89.00
7	72.21	72.21	70.00
8	62.56	62.56	57.00
9	54.04	54.04	45.00
10	46.42	46.42	34.00
11	39.53	39.53	25.00
12	33.24	33.24	17.00
13	27.45	27.45	11.00
14	22.10	22.10	7.00
15	17.11	17.11	5.00
16	12.44	12.44	3.00
17	8.06	8.06	2.00
18	3.93	3.93	1.00
19	0.02	0.02	0.01
20	-3.69	-3.69	0.00
	694.79	694.79	580.91
	1.19	1.19	1.00

ΣQ_i = A*d /0.36* tr = 583.33

UG Ordinates from graph

Time in hours	Adjusted values of UG ordinates (Cumec)	UG Ordinates rearranged
0	0.00	
1	5.99	105.00
2	14.80	89.00
3	29.50	70.00
4	59.61	59.61
5	105.00	57.00
6	89.00	45.00
7	70.00	34.00
8	57.00	29.50
9	45.00	25.00
10	34.00	17.00
11	25.00	14.80
12	17.00	11.00
13	11.00	7.00
14	7.00	5.99
15	5.00	5.00
16	3.00	3.00
17	2.00	2.00
18	1.00	1.00
19	0.01	0.01
20	0.00	0.00



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

Design Storm Duration (T_D)= T_B, for this sub-zone = **20.00 hrs**

100 year-24hour Point rainfall = 44.0 cm from plate 10 (Step 1)

Conversion factor for T_D-hour i.e 20.00 = 0.960 from fig.10 (Step 2)

.'. 100 Year T_D - Hour Point Rainfall = 42.24 cm

Storm Areal Rainfall

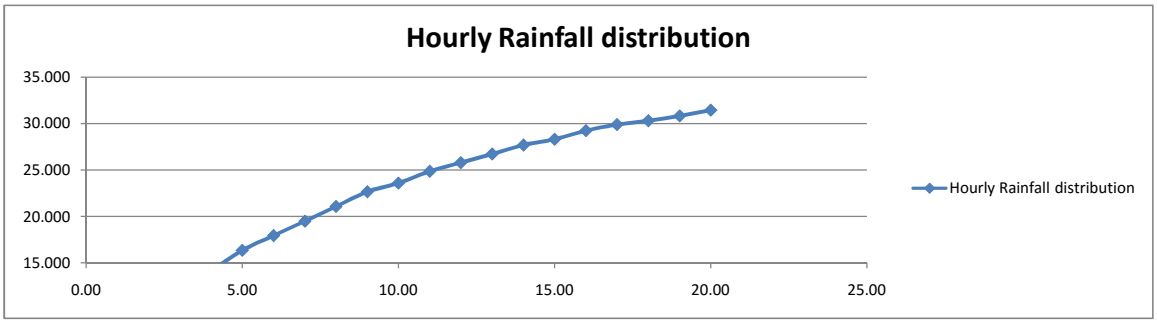
From Table 6 of CWC Publication for sub zone 2(a) - step 3, Fig. 11-b

Areal reduction factor corresponding to storm duration T_D i.e hours 20.0 and C.A of sq.km 210.0

= 0.910

.'. 100 year TD hour Areal Rainfall = 38.438 cm

Time Distribution of input storm Step 4



Time (Hr)	Distribution coefficient from Table T-2	Areal rainfall in Cm	Hourly rainfall Increment (cm)	Design Loss Rate (Cm/hr	Effective /Excess Rainfall (Cm)	Effective rainfall rearranged (largest to smallest)	Direct runoff (Cumec)
1	2	3					
1.00	0.15	5.766	5.77	0.24	5.526	5.526	580.20
2.00	0.27	10.378	4.61	0.24	4.373	4.373	389.16
3.00	0.38	14.607	4.23	0.24	3.988	3.988	279.18
4.00	0.45	17.297	2.69	0.24	2.451	2.451	146.09
5.00	0.52	19.988	2.69	0.24	2.451	2.451	139.69
6.00	0.57	21.910	1.92	0.24	1.682	1.682	75.69
7.00	0.62	23.832	1.92	0.24	1.682	1.682	57.19
8.00	0.67	25.754	1.92	0.24	1.682	1.682	49.62
9.00	0.72	27.676	1.92	0.24	1.682	1.682	42.05
10.00	0.75	28.829	1.15	0.24	0.913	1.298	22.06
11.00	0.79	30.366	1.54	0.24	1.298	0.913	13.52
12.00	0.82	31.519	1.15	0.24	0.913	0.913	10.04
13.00	0.85	32.673	1.15	0.24	0.913	0.913	6.39
14.00	0.88	33.826	1.15	0.24	0.913	0.913	5.47
15.00	0.90	34.595	0.77	0.24	0.529	0.913	4.57
16.00	0.93	35.748	1.15	0.24	0.913	0.529	1.59
17.00	0.95	36.516	0.77	0.24	0.529	0.529	1.06
18.00	0.96	37.016	0.50	0.24	0.260	0.529	0.53
19.00	0.98	37.670	0.65	0.24	0.413	0.413	0.01
20.00	1.00	38.438	0.77	0.24	0.529	0.260	0.00

Base flow = 0.05 cumecs / sqkm As per Cl. 3.6 Page No. 17

.'. Total Base flow for C.A = 0.05 x 210.0 = 10.500 Cumecs

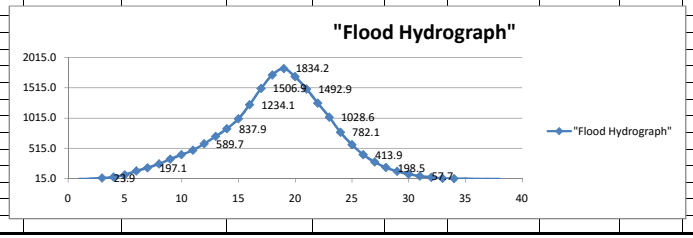
100 year Peak run-off 1824.08 Cumecs

Therefore, gross 100 year peak flood 1835 Cumec

Major bridge across Mechi river at Km. 0+885

Computation of design flood hdrograph

Time (Hours)	UG Ordinates (Cumec)	Effective Rainfall unit																				Total direct runoff (Cumec)	Base Flow (Cumec)	Total Flood flow (Cumecs)
		0	0.1	0.529	0.529	0.529	0.913	0.913	0.913	1.298	1.682	1.682	1.682	2.451	3.988	4.373	5.526	2.451	1.682	0.913	0.913			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20			
1	6	0																						
2	15	0	0.60																			0.60	10	10.6
3	29	0	1.48	3.17																		4.65	10	14.6
4	60	0	2.95	7.83	3.17																	13.95	10	23.9
5	105	0	5.96	15.61	7.83	3.17																32.56	10	42.6
6	89	0	10.50	31.53	15.61	7.83	5.47															70.94	10	80.9
7	70	0	8.90	55.55	31.53	15.61	13.52	5.47														130.56	10	140.6
8	57	0	7.00	47.08	55.55	31.53	26.93	13.52	5.47													187.07	10	197.1
9	45	0	5.70	37.03	47.08	55.55	54.42	26.93	13.52	7.77												248.00	10	258.0
10	34	0	4.50	30.15	37.03	47.08	95.87	54.42	26.93	19.21	10.07											325.27	10	335.3
11	25	0	3.40	23.81	30.15	37.03	81.26	95.87	54.42	38.29	24.90	10.07										399.19	10	409.2
12	17	0	2.50	17.99	23.81	30.15	63.91	81.26	95.87	77.38	49.62	24.90	10.07									477.44	10	487.4
13	11	0	1.70	13.23	17.99	23.81	52.04	63.91	81.26	136.29	100.27	49.62	24.90	14.67								579.67	10	589.7
14	7	0	1.10	8.99	13.23	17.99	41.09	52.04	63.91	115.52	176.61	100.27	49.62	36.28	23.87							700.51	10	710.5
15	5	0	0.70	5.82	8.99	13.23	31.04	41.09	52.04	90.86	149.70	176.61	100.27	72.30	59.04	26.18						827.85	10	837.9
16	3	0	0.50	3.70	5.82	8.99	22.83	31.04	41.09	73.99	117.74	149.70	176.61	146.11	117.64	64.73	33.08					993.56	10	1003.6
17	2	0	0.30	2.65	3.70	5.82	15.52	22.83	31.04	58.41	95.87	117.74	149.70	257.36	237.73	129.00	81.80	14.67				1224.13	10	1234.1
18	1	0	0.20	1.59	2.65	3.70	10.04	15.52	22.83	44.13	75.69	95.87	117.74	218.139	418.74	260.6789	163.01214	36.282937	10.068183			1496.88	10	1506.9
19	0	0	0.10	1.06	1.59	2.65	6.39	10.04	15.52	32.45	57.19	75.69	95.874	171.57	354.932	459.165	329.41039	72.302343	24.899184	5.4650719		1716.29	10	1726.3
20	0	0	0.00	0.53	1.06	1.59	4.57	6.39	10.04	22.07	42.05	57.19	75.69	139.71	279.16	389.20	580.23	146.11	49.62	13.52	5.47	**1824.17**	**10**	**1834.2**
21			0.00	0.01	0.53	1.06	2.74	4.57	6.39	14.28	28.59	42.05	57.19	110.30	227.32	306.11	491.81	257.36	100.27	26.93	13.52	1691.00	10	1701.0
22				0.00	0.01	0.53	1.83	2.74	4.57	9.09	18.50	28.59	42.05	83.33	179.46	249.26	386.82	218.14	176.61	54.42	26.93	1482.88	10	1492.9
23					0.00	0.01	0.91	1.83	2.74	6.49	11.77	18.50	28.59	61.28	135.59	196.79	314.98	171.57	149.70	95.87	54.42	1251.04	10	1261.0
24						0.00	0.01	0.91	1.83	3.89	8.41	11.77	18.50	41.67	99.70	148.68	248.67	139.71	117.74	81.26	95.87	1018.62	10	1028.6
25							0.00	0.01	0.91	2.60	5.05	8.41	11.77	26.96	67.80	109.33	187.88	110.30	95.87	63.91	81.26	772.05	10	782.1
26								0.00	0.01	1.30	3.36	5.05	8.41	17.16	43.87	74.34	138.15	83.33	75.69	52.04	63.91	566.62	10	576.6
27									0.00	0.02	1.68	3.36	5.05	12.26	27.92	48.10	93.94	61.28	57.19	41.09	52.04	403.91	10	413.9
28										0.00	0.02	1.68	3.36	7.35	19.94	30.61	60.79	41.67	42.05	31.04	41.09	279.60	10	289.6
29											0.00	0.02	1.68	4.90	11.96	21.87	38.68	26.96	28.59	22.83	31.04	188.54	10	198.5
30												0.00	0.02	2.45	7.98	13.12	27.63	17.16	18.50	15.52	22.83	125.20	10	135.2
31													0.00	0.03	3.99	8.75	16.58	12.26	11.77	10.04	15.52	78.94	10	88.9
32														0.00	0.05	4.37	11.05	7.35	8.41	6.39	10.04	47.68	10	57.7
33															0.00	0.06	5.53	4.90	5.05	4.57	6.39	26.49	10	36.5
34																0.00	0.08	2.45	3.36	2.74	4.57	13.19	10	23.2
35																	0.00	0.03	1.68	1.83	2.74	6.28	10	16.3
36																		0.00	0.02	0.91	1.83	2.76	10	12.8
37																			0.00	0.01	0.91	0.93	10	10.9
38																				0.00	0.01	0.01	10	10.0
39																					0	0	10	10.0



ANNEXURE - 2

LONGITUDINAL SLOPE CALCULATIONS OF MECHI RIVER

Major bridge across Mechi river at km: 0+885

Slope for Channel 1

Bed Slope / Longitudinal Slope of River Bed :

S. No.	length	LBL
1	0	127.155
2	8.843	126.981
3	20.88	126.922
4	33.912	126.852
5	47.009	126.874
6	59.945	126.897
7	70.96	126.881
8	86.038	126.874
9	94.353	126.867
10	106.377	126.819
11	114.433	126.832
12	128.798	126.742
13	139.453	126.735
14	151.125	126.816
15	161.341	126.781
16	174.55	126.542
17	186.694	126.353
18	197.935	126.372
19	207.976	126.276
20	219.642	126.211
21	230.814	126.283
22	243.935	126.238
23	255.442	126.29
24	284.966	126.103
25	295.501	125.965
26	306.46	125.797
27	317.815	125.715
28	327.674	125.708
29	340.509	125.727
30	352.301	125.676
31	363.642	125.659
32	375.835	125.656
33	384.477	125.639
34	391.583	125.677
35	402.649	125.692
36	416.874	125.68
37	428.021	125.653
38	436.697	125.612
39	447.943	125.616
40	460.403	125.45
41	474.58	125.404
42	484.25	125.303
43	493.933	125.191
44	502.163	125.186
45	511.64	125.067
46	524.182	124.947
47	534.089	125.001
48	546.677	125.058
49	557.314	125.008
50	565.436	124.925
51	576.847	124.951
52	583.432	124.935
53	596.855	124.846
54	604.657	124.822
55	615.262	124.733
56	627.856	124.652
57	637.791	124.648
58	652.672	124.661
59	662.111	124.655
60	681.452	124.7
61	689.396	124.722
62	702.478	124.619
63	713.572	124.576
64	723.781	124.567
65	736.515	124.544
66	744.581	124.527
67	754.867	124.494
68	774.72	124.309
69	795.552	124.015
70	809.841	123.978
71	820.209	123.967
72	826.017	123.942
73	863.07	123.725
74	896.186	123.573
75	909.617	123.639

Major bridge across Mechi river at km: 0+885

Slope for Channel 1

Bed Slope / Longitudinal Slope of River Bed :

	76	921.904	123.563
	77	927.392	123.596
	78	944.038	123.499
	79	957.145	123.54
	80	973.84	123.668
	81	983.757	123.616
	82	994.108	123.622
	83	1002.26	123.533
	84	1011.407	123.461
	85	1019.789	123.415
	86	1028.234	123.256
	87	1037.351	123.196
	88	1045.293	123.146
	89	1050.998	122.986
	90	1060.159	122.986
	91	1067.806	122.996
	92	1090.142	122.873
	93	1102.07	122.902
	94	1116.049	122.825
	95	1130.927	122.726
	96	1140.975	122.845
	97	1149.952	122.786
	98	1161.363	122.7
	99	1174.26	122.759
	100	1182.495	122.695
	101	1193.827	122.665
	102	1200.929	122.741
	103	1214.956	122.572
	104	1224.442	122.431
	105	1234.614	122.225
	106	1245.645	122.223
	107	1258.932	122.213
	108	1270.214	122.205
	109	1282.433	122.315
	110	1293.505	122.349
	111	1304.797	122.283
	112	1327.339	122.039
	113	1339.502	122.114
	114	1352.811	122.044
	115	1383.63	122.155
	116	1419.735	121.966
	117	1444.236	121.932
	118	1468.545	121.868
	119	1477.758	121.85
	120	1494.523	121.769
	121	1510.836	121.214
	122	1528.774	121.293
	123	1543.283	121.305
	124	1557.951	121.036
	125	1577.282	121.067
	126	1592.733	120.755
	127	1634.013	120.686
	128	1657.147	120.595
	129	1665.503	120.409
	130	1678.41	120.217
	131	1692.554	120.313
	132	1702.345	120.387
	133	1721.137	120.425
	134	1730.694	120.442
	135	1749.475	120.258
	136	1762.836	120.106
	137	1779.763	119.987
	138	1800.771	119.937
	139	1824.259	119.92
	140	1843.948	119.82
	141	1873.809	119.704
	142	1907.928	119.407
	143	1951.238	119.442
	144	1982.475	119.406
	145	2030.867	119.177
	146	2068.541	118.903
	147	2098.66	118.674
	148	2121.721	118.896
	149	2149.589	118.719
	150	2165.848	118.632
	151	2182.675	118.431
	152	2207.073	118.375
	153	2216.395	118.461
	154	2236.919	118.387

Major bridge across Mechi river at km: 0+885

Slope for Channel 1

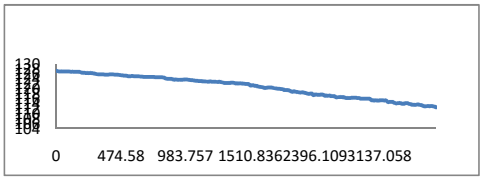
Bed Slope / Longitudinal Slope of River Bed :

155	2267.931	118.234
156	2301.258	118.013
157	2339.407	117.882
158	2353.793	117.956
159	2368.776	117.985
160	2378.979	117.319
161	2396.109	117.58
162	2420.489	117.546
163	2434.684	117.453
164	2443.978	117.487
165	2469.563	117.61
166	2488.395	117.51
167	2513.315	117.101
168	2540.626	117.158
169	2562.771	117.085
170	2587.624	117.168
171	2606.41	116.913
172	2632.596	116.898
173	2651.388	116.912
174	2666.443	116.468
175	2679.596	116.489
176	2694.962	116.518
177	2710.192	116.5
178	2727.235	116.583
179	2744.291	116.406
180	2762.27	116.216
181	2778.705	116.127
182	2790.775	116.185
183	2810.423	116.225
184	2840.304	116.316
185	2861.498	116.3
186	2883.818	116.297
187	2906.612	116.205
188	2921.879	116.181
189	2931.865	115.925
190	2949.723	115.928
191	2967.303	115.918
192	2986.612	115.881
193	3011.139	115.915
194	3031.843	115.905
195	3050.4	115.816
196	3075.074	115.245
197	3082.47	115.299
198	3100.337	115.184
199	3114.272	115.205
200	3124.332	115.086
201	3137.058	115.286
202	3158.115	115.254
203	3178.91	115.22
204	3209.047	115.169
205	3217.431	115.167
206	3245.272	114.59
207	3272.382	114.559
208	3289.136	114.582
209	3312.514	114.636
210	3338.149	114.244
211	3348.49	114.028
212	3369.595	114.034
213	3391.843	114.166
214	3406.188	114.054
215	3429.322	113.87
216	3450.521	113.865
217	3472.144	114.072
218	3483.039	114.15
219	3498.343	113.849
220	3515.747	113.665
221	3526.98	113.465
222	3538.876	113.465
223	3548.144	113.369
224	3567.395	113.516
225	3585.371	113.528
226	3611.802	113.385
227	3623.584	113.27
228	3653.019	112.944
229	3671.05	112.787
230	3688.54	112.87
231	3711.787	112.93
232	3730.883	112.849
233	3749.207	112.905
234	3779.095	112.846
235	3811.868	112.647
236	3835.621	112.412

Major bridge across Mechi river at km: 0+885

Slope for Channel 1

Bed Slope / Longitudinal Slope of River Bed :



Weighted average Bed slope = 0.0038

Major bridge across Mechi river at km: 0+885

Slope for Channel 2

Bed Slope / Longitudinal Slope of River Bed :

S. No.	length	LBL
1	0	128.14
2	14.26	128.06
3	28.32	128.05
4	51.18	127.81
5	65.52	127.64
6	70	127.45
7	89.88	127.46
8	112.81	127.42
9	122.57	127.36
10	147.36	127.1
11	152.31	127.27
12	175.32	127.12
13	182.86	127.03
14	210.81	127.13
15	220.33	127.1
16	248.7	126.88
17	258.77	126.78
18	308.5	126.66
19	326.97	126.68
20	360.01	126.12
21	388.41	125.85
22	432.55	125.68
23	461.84	125.89
24	502.37	125.49
25	529.74	125.69
26	562.3	125.46
27	644.31	124.99
28	685.69	124.8
29	721.98	124.69
30	756.53	124.62
31	788.63	124.56
32	821.54	124.16
33	854.42	124.33
34	875.19	124.27
35	917.23	124.07
36	944.29	123.88
37	980.44	123.35
38	1015.84	123.26
39	1080.63	122.96
40	1116.42	122.73
41	1139.1	122.69
42	1146.42	122.46
43	1174.74	122.52
44	1197.05	122.51
45	1221.89	122.26
46	1262.21	121.95
47	1306.32	121.93
48	1352.76	122.01
49	1412.71	121.63
50	1472.98	121.29
51	1510.7	121.31
52	1563.5	120.91
53	1598.04	120.88
54	1628.96	120.4
55	1673.52	120.26
56	1714.09	120.29
57	1775.73	119.83
58	1810.51	119.83
59	1846.36	119.54
60	1878.51	119.48

Major bridge across Mechi river at km: 0+885

Slope for Channel 2

Bed Slope / Longitudinal Slope of River Bed :

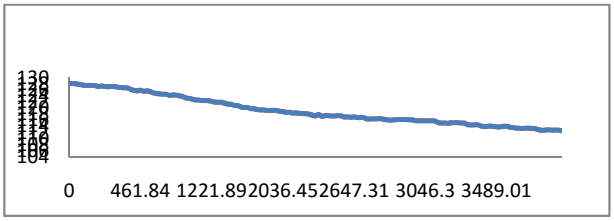
	61	1898.87	119.5
	62	1923.55	119.29
	63	1933.47	119.26
	64	1952.8	119.32
	65	1975.94	119.23
	66	2008.05	119.04
	67	2036.45	118.89
	68	2071.51	118.6
	69	2102.75	118.68
	70	2138.82	118.44
	71	2175.26	118.47
	72	2204.33	118.33
	73	2243.26	118.34
	74	2284.89	118.24
	75	2307.35	118.1
	76	2343.35	117.73
	77	2410.75	117.49
	78	2428.46	117.99
	79	2438.67	117.32
	80	2455.8	117.58
	81	2480.18	117.55
	82	2494.37	117.45
	83	2503.67	117.49
	84	2529.25	117.61
	85	2548.08	117.51
	86	2573	117.1
	87	2600.31	117.16
	88	2622.46	117.09
	89	2647.31	117.17
	90	2666.1	116.91
	91	2692.28	116.9
	92	2711.08	116.91
	93	2726.13	116.47
	94	2739.28	116.49
	95	2754.65	116.52
	96	2769.88	116.5
	97	2786.92	116.58
	98	2803.98	116.41
	99	2821.96	116.22
	100	2838.39	116.13
	101	2850.46	116.19
	102	2870.11	116.23
	103	2899.99	116.32
	104	2921.18	116.3
	105	2943.5	116.3
	106	2966.3	116.21
	107	2981.57	116.18
	108	2991.55	115.93
	109	3009.41	115.93
	110	3026.99	115.92
	111	3046.3	115.88
	112	3070.83	115.92
	113	3091.53	115.91
	114	3110.09	115.82
	115	3134.76	115.25
	116	3160.02	115.18
	117	3173.96	115.21
	118	3184.02	115.09
	119	3196.74	115.29
	120	3217.8	115.25
	121	3238.6	115.22
	122	3268.73	115.17
	123	3277.12	115.17
	124	3304.96	114.59

Major bridge across Mechi river at km: 0+885

Slope for Channel 2

Bed Slope / Longitudinal Slope of River Bed :

125	3332.07	114.56
126	3348.82	114.58
127	3372.2	114.64
128	3397.84	114.24
129	3408.18	114.03
130	3429.28	114.03
131	3451.53	114.17
132	3465.87	114.05
133	3489.01	113.87
134	3510.21	113.87
135	3531.83	114.07
136	3542.73	114.15
137	3558.03	113.85
138	3575.43	113.67
139	3586.67	113.47
140	3598.56	113.47
141	3607.83	113.37
142	3627.08	113.52
143	3645.06	113.53
144	3671.49	113.39
145	3683.27	113.27
146	3712.71	112.94
147	3730.74	112.79
148	3748.23	112.87
149	3771.47	112.93
150	3790.57	112.85
151	3808.89	112.91
152	3838.78	112.85
153	3871.55	112.65



Weighted average Bed slope = 0.004001

Major bridge across Mechi river at km: 0+885

Slope for Channel 3

Bed Slope / Longitudinal Slope of River Bed :

S. No.	length	LBL
1	0	125.28
2	14.9	125.22
3	33.67	125.14
4	76.14	124.58
5	108.11	124.46
6	135.96	124.5
7	225.87	123.81
8	254.34	123.65
9	288.26	123.51
10	327.89	123.22
11	363.64	123.1
12	380.29	122.91
13	402.16	122.73
14	487.58	122.8
15	512.85	122.65
16	536.25	122.54
17	567.55	122.38
18	606.79	122.25
19	653.88	121.7
20	703.19	121.9
21	719.53	121.81
22	765.84	121.76
23	804.35	121.41
24	890.61	121.04
25	930.82	120.88
26	987.65	120.77
27	1033.43	120.67
28	1069.1	120.45
29	1100.11	120.34
30	1112.36	120.42
31	1131.03	120.25
32	1155.45	119.76
33	1187.99	119.97
34	1218.95	119.54
35	1256.32	119.14
36	1277.02	119.29
37	1286.94	119.26
38	1306.27	119.32
39	1329.41	119.23
40	1361.52	119.04
41	1389.92	118.89
42	1424.98	118.6
43	1456.22	118.68
44	1492.29	118.44
45	1528.74	118.47
46	1557.8	118.33
47	1596.73	118.34
48	1638.37	118.24
49	1660.82	118.1
50	1696.82	117.73
51	1764.22	117.49
52	1781.93	117.99
53	1792.14	117.32
54	1809.27	117.58
55	1833.65	117.55
56	1847.84	117.45
57	1857.14	117.49
58	1882.72	117.61

Major bridge across Mechi river at km: 0+885

Slope for Channel 2

Bed Slope / Longitudinal Slope of River Bed :

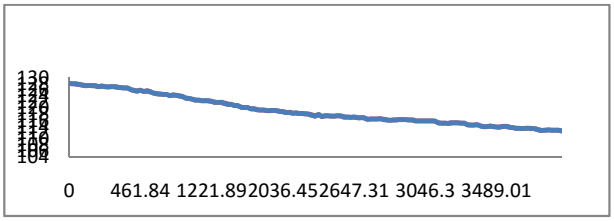
	59	1901.55	117.51
	60	1926.47	117.1
	61	1953.78	117.16
	62	1975.93	117.09
	63	2000.78	117.17
	64	2019.57	116.91
	65	2045.75	116.9
	66	2064.55	116.91
	67	2079.6	116.47
	68	2092.75	116.49
	69	2108.12	116.52
	70	2123.35	116.5
	71	2140.39	116.58
	72	2157.45	116.41
	73	2175.43	116.22
	74	2191.86	116.13
	75	2203.93	116.19
	76	2223.58	116.23
	77	2253.46	116.32
	78	2274.66	116.3
	79	2296.98	116.3
	80	2319.77	116.21
	81	2335.04	116.18
	82	2345.02	115.93
	83	2362.88	115.93
	84	2380.46	115.92
	85	2399.77	115.88
	86	2424.3	115.92
	87	2445	115.91
	88	2463.56	115.82
	89	2488.23	115.25
	90	2513.49	115.18
	91	2527.43	115.21
	92	2537.49	115.09
	93	2550.22	115.29
	94	2571.27	115.25
	95	2592.07	115.22
	96	2622.2	115.17
	97	2630.59	115.17
	98	2658.43	114.59
	99	2685.54	114.56
	100	2702.29	114.58
	101	2725.67	114.64
	102	2751.31	114.24
	103	2761.65	114.03
	104	2782.75	114.03
	105	2805	114.17
	106	2819.35	114.05
	107	2842.48	113.87
	108	2863.68	113.87
	109	2885.3	114.07
	110	2896.2	114.15
	111	2911.5	113.85
	112	2928.91	113.67
	113	2940.14	113.47
	114	2952.03	113.47
	115	2961.3	113.37
	116	2980.55	113.52
	117	2998.53	113.53
	118	3024.96	113.39
	119	3036.74	113.27
	120	3066.18	112.94
	121	3084.21	112.79
	122	3101.7	112.87

Major bridge across Mechi river at km: 0+885

Slope for Channel 2

Bed Slope / Longitudinal Slope of River Bed :

123	3124.94	112.93
124	3144.04	112.85
125	3162.36	112.91
126	3192.25	112.85
127	3225.03	112.65
128	3248.78	112.41



Weighted average Bed slope = 0.00396

ANNEXURE - 3

AREA VELOCITY CALCULATIONS FOR MECHI RIVER DISCHARGE AT PROPOSED BRIDGE LOCATION, 250M AND 500M UPSTREAM SIDE

Calculation of discharge for MJB @ 0+884: across Mechi

Cross-section at bridge site

Bed slope from survey data = 0.004

Local inquiry HFL = 122.650 m

Serl. No.	Ch.	Mod. Ch	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
		-7.250		122.650	130.297					
		0.135		122.650	122.650		0.000			
1	49.839	0.000	-0.135	122.650	122.790	0.140	-0.140	0.195	-0.070	0.009
2	73.852	24.013	24.013	122.650	122.774	-0.016	-0.124	24.013	-0.132	-3.170
3	84.510	34.671	10.658	122.650	122.742	-0.032	-0.092	10.658	-0.108	-1.151
4	95.577	45.738	11.067	122.650	122.682	-0.060	-0.032	11.067	-0.062	-0.686
5	106.790	56.951	11.213	122.650	122.652	-0.030	-0.002	11.213	-0.017	-0.191
6	114.482	64.643	7.692	122.650	122.292	-0.360	0.358	7.700	0.178	1.369
7	124.964	75.125	10.482	122.650	122.111	-0.181	0.539	10.484	0.449	4.701
8	145.548	95.709	20.584	122.650	121.894	-0.217	0.756	20.585	0.648	13.328
9	167.443	117.604	21.895	122.650	121.936	0.042	0.714	21.895	0.735	16.093
10	214.759	164.920	47.316	122.650	122.155	0.219	0.495	47.317	0.605	28.603
11	227.451	177.612	12.692	122.650	122.223	0.068	0.427	12.692	0.461	5.851
12	244.336	194.497	16.885	122.650	122.106	-0.117	0.544	16.885	0.486	8.198
13	257.641	207.802	13.305	122.650	121.942	-0.164	0.708	13.306	0.626	8.329
14	268.307	218.468	10.666	122.650	121.783	-0.159	0.867	10.667	0.788	8.399
15	299.302	249.463	30.995	122.650	121.901	0.118	0.749	30.995	0.808	25.044
16	304.825	254.986	5.523	122.650	121.755	-0.146	0.895	5.525	0.822	4.540
17	312.358	262.519	7.533	122.650	121.734	-0.021	0.916	7.533	0.906	6.821
18	319.797	269.958	7.439	122.650	121.713	-0.021	0.937	7.439	0.927	6.892
19	329.580	279.741	9.783	122.650	121.757	0.044	0.893	9.783	0.915	8.951
20	336.425	286.586	6.845	122.650	120.628	-1.129	2.022	6.937	1.458	9.977
21	341.411	291.572	4.986	122.650	120.571	-0.057	2.079	4.986	2.051	10.224
22	356.882	307.043	15.471	122.650	120.386	-0.185	2.264	15.472	2.172	33.595
23	366.304	316.465	9.422	122.650	120.545	0.159	2.105	9.423	2.185	20.582
24	375.467	325.628	9.163	122.650	121.334	0.789	1.316	9.197	1.711	15.673
25	385.214	335.375	9.747	122.650	121.256	-0.078	1.394	9.747	1.355	13.207
26	394.195	344.356	8.981	122.650	121.513	0.257	1.137	8.985	1.266	11.365
27	404.241	354.402	10.046	122.650	121.413	-0.100	1.237	10.046	1.187	11.925
28	413.688	363.849	9.447	122.650	121.533	0.120	1.117	9.448	1.177	11.119
29	424.544	374.705	10.856	122.650	121.488	-0.045	1.162	10.856	1.140	12.370
30	434.362	384.523	9.818	122.650	120.781	-0.707	1.869	9.843	1.516	14.879
31	443.623	393.784	9.261	122.650	120.929	0.148	1.721	9.262	1.795	16.623
32	453.212	403.373	9.589	122.650	120.788	-0.141	1.862	9.590	1.792	17.179
33	481.627	431.788	28.415	122.650	120.167	-0.621	2.483	28.422	2.173	61.732
34	487.805	437.966	6.178	122.650	120.368	0.201	2.282	6.181	2.383	14.719
35	505.752	455.913	17.947	122.650	120.602	0.234	2.048	17.949	2.165	38.855
36	516.922	467.083	11.170	122.650	121.071	0.469	1.579	11.180	1.814	20.257
37	528.540	478.701	11.618	122.650	120.536	-0.535	2.114	11.630	1.847	21.453
38	564.482	514.643	35.942	122.650	120.576	0.040	2.074	35.942	2.094	75.263
39	587.204	537.365	22.722	122.650	120.895	0.319	1.755	22.724	1.915	43.501
40	611.913	562.074	24.709	122.650	121.283	0.388	1.367	24.712	1.561	38.571
41	618.974	569.135	7.061	122.650	121.250	-0.033	1.400	7.061	1.384	9.769
42	671.955	622.116	52.981	122.650	120.672	-0.578	1.978	52.984	1.689	89.485
43		627.313	5.197	122.650	122.650	1.978	0.000	5.561	0.989	5.140
	693.172	643.333		122.650	128.747					
							Total	628.093		759.395

12.2992

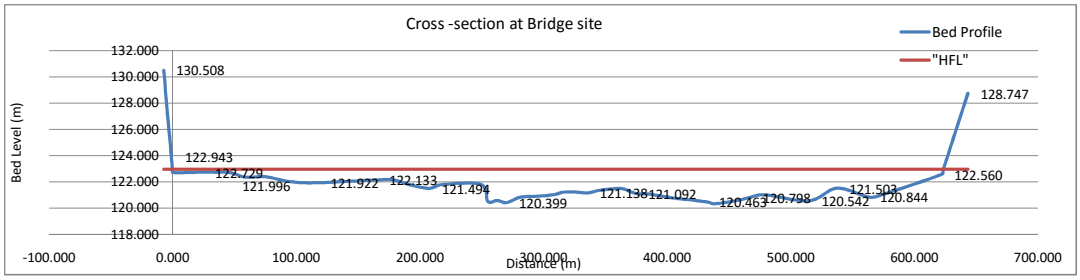
R = 1.209 m

S = 0.004

n = 0.03

V = 2.393 m/sec

Q = 1817 cumec



Major bridge across Mechi at Km:0+885

Calculation of discharge for MJB @ 0+884: across Mechi

Cross-section at 250m u/s;

Bed slope from survey data = 0.004

Local inquiry HFL = 123.650 m

Serl. No.	Ch.	Mod. Ch	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
		-7.250		123.650	130.297					
		0.000		123.650	124.200		-0.550			
1	75.772	0.000	0.000	123.650	123.650	-0.550	0.000	0.550	-0.275	0.000
2	122.407	46.635	46.635	123.650	123.843	0.193	-0.193	46.635	-0.096	-4.500
3	147.486	71.714	25.079	123.650	123.746	-0.097	-0.096	25.079	-0.144	-3.624
4	175.426	99.654	27.940	123.650	124.067	0.321	-0.417	27.942	-0.256	-7.167
5	196.245	120.473	20.819	123.650	123.976	-0.091	-0.326	20.819	-0.371	-7.734
6	222.936	147.164	26.691	123.650	123.460	-0.516	0.190	26.696	-0.068	-1.815
7	225.404	149.632	2.468	123.650	122.476	-0.984	1.174	2.657	0.682	1.683
8	230.563	154.791	5.159	123.650	122.220	-0.256	1.430	5.165	1.302	6.717
9	235.680	159.908	5.117	123.650	122.411	0.191	1.239	5.121	1.335	6.829
10	246.390	170.618	10.710	123.650	122.696	0.285	0.954	10.714	1.097	11.744
11	266.927	191.155	20.537	123.650	122.654	-0.042	0.996	20.537	0.975	20.024
12	289.623	213.851	22.696	123.650	122.461	-0.193	1.189	22.697	1.093	24.795
13	313.320	237.548	23.697	123.650	122.639	0.178	1.011	23.698	1.100	26.067
14	341.901	266.129	28.581	123.650	122.155	-0.484	1.495	28.585	1.253	35.812
15	368.112	292.340	26.211	123.650	122.071	-0.084	1.579	26.211	1.537	40.286
16	393.377	317.605	25.265	123.650	121.983	-0.088	1.667	25.265	1.623	41.005
17	419.469	343.697	26.092	123.650	122.132	0.149	1.518	26.092	1.593	41.552
18	444.840	369.068	25.371	123.650	122.584	0.452	1.066	25.375	1.292	32.779
19	467.147	391.375	22.307	123.650	122.100	-0.484	1.550	22.312	1.308	29.178
20	499.330	423.558	32.183	123.650	122.094	-0.006	1.556	32.183	1.553	49.980
21	502.600	426.828	3.270	123.650	121.821	-0.273	1.829	3.281	1.693	5.534
22	506.075	430.303	3.475	123.650	121.642	-0.179	2.008	3.480	1.919	6.667
23	510.592	434.820	4.517	123.650	121.818	0.176	1.832	4.520	1.920	8.673
24	516.012	440.240	5.420	123.650	122.786	0.968	0.864	5.506	1.348	7.306
25	527.342	451.570	11.330	123.650	122.727	-0.059	0.923	11.330	0.894	10.123
26	543.800	468.028	16.458	123.650	122.557	-0.170	1.093	16.459	1.008	16.590
27	565.184	489.412	21.384	123.650	122.715	0.158	0.935	21.385	1.014	21.683
28	586.802	511.030	21.618	123.650	122.388	-0.327	1.262	21.620	1.099	23.747
29	612.060	536.288	25.258	123.650	122.503	0.115	1.147	25.258	1.205	30.423
30	632.738	556.966	20.678	123.650	122.207	-0.296	1.443	20.680	1.295	26.778
31	662.080	586.308	29.342	123.650	122.729	0.522	0.921	29.347	1.182	34.682
32	689.693	613.921	27.613	123.650	122.429	-0.300	1.221	27.615	1.071	29.574
33	696.752	620.980	7.059	123.650	121.771	-0.658	1.879	7.090	1.550	10.941
34	699.817	624.045	3.065	123.650	121.560	-0.211	2.090	3.072	1.985	6.082
35		625.754	1.709	123.650	123.650	2.090	0.000	2.700	1.045	1.786
	702.630	626.858		123.650	125.000					
							Total	627.676		584.201

12.2992

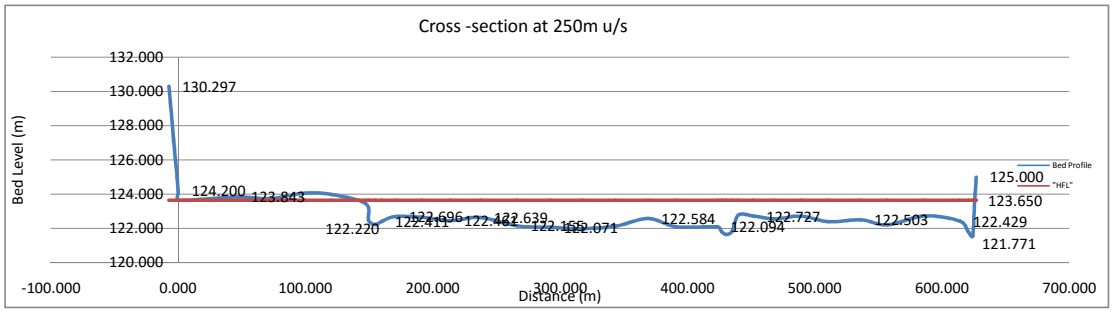
R = 0.931 m

S = 0.004

n = 0.03

V = 2.010 m/sec

Q = 1174 cumec



Major bridge across Mechi at Km:0+885

Calculation of discharge for MJB @ 0+884; across Mechi

Cross-section at 500m u/s;

Bed slope from survey data = 0.004

Local inquiry HFL = 124.650 m

Serl. No.	Ch.	Mod. Ch	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
		-7.250		124.650	130.297					
		0.000		124.650	125.200		-0.550			
1	16.640	0.000	0.000	124.650	124.650	-0.550	0.000	0.550	-0.275	0.000
2	31.218	14.578	14.578	124.650	124.409	-0.241	0.241	14.580	0.121	1.757
3	55.034	38.394	23.816	124.650	124.390	-0.019	0.260	23.816	0.251	5.966
4	71.877	55.237	16.843	124.650	124.400	0.010	0.250	16.843	0.255	4.295
5	83.683	67.043	11.806	124.650	123.297	-1.103	1.353	11.857	0.802	9.463
6	105.457	88.817	21.774	124.650	122.986	-0.311	1.664	21.776	1.509	32.846
7	107.900	91.260	2.443	124.650	123.274	0.288	1.376	2.460	1.520	3.713
8	115.443	98.803	7.543	124.650	123.830	0.556	0.820	7.563	1.098	8.282
9	123.809	107.169	8.366	124.650	124.085	0.255	0.565	8.370	0.693	5.793
10	132.251	115.611	8.442	124.650	123.593	-0.492	1.057	8.456	0.811	6.846
11	154.638	137.998	22.387	124.650	123.749	0.156	0.901	22.388	0.979	21.917
12	167.583	150.943	12.945	124.650	123.584	-0.165	1.066	12.946	0.984	12.731
13	189.330	172.690	21.747	124.650	123.419	-0.165	1.231	21.748	1.149	24.976
14	207.809	191.169	18.479	124.650	123.518	0.099	1.132	18.479	1.182	21.833
15	231.689	215.049	23.880	124.650	123.093	-0.425	1.557	23.884	1.345	32.107
16	252.289	235.649	20.600	124.650	122.770	-0.323	1.880	20.603	1.719	35.401
17	268.535	251.895	16.246	124.650	122.682	-0.088	1.968	16.246	1.924	31.257
18	274.592	257.952	6.057	124.650	122.760	0.078	1.890	6.058	1.929	11.684
19	287.226	270.586	12.634	124.650	123.267	0.507	1.383	12.644	1.637	20.676
20	301.022	284.382	13.796	124.650	123.341	0.074	1.309	13.796	1.346	18.569
21	309.122	292.482	8.100	124.650	123.630	0.289	1.020	8.105	1.165	9.432
22	321.354	304.714	12.232	124.650	122.855	-0.775	1.795	12.257	1.408	17.217
23	333.136	316.496	11.782	124.650	122.729	-0.126	1.921	11.783	1.858	21.891
24	344.014	327.374	10.878	124.650	122.856	0.127	1.794	10.879	1.858	20.206
25	346.075	329.435	2.061	124.650	123.623	0.767	1.027	2.199	1.411	2.907
26	347.728	331.088	1.653	124.650	123.250	-0.373	1.400	1.695	1.214	2.006
27	363.806	347.166	16.078	124.650	124.296	1.046	0.354	16.112	0.877	14.100
28	382.699	366.059	18.893	124.650	124.121	-0.175	0.529	18.894	0.442	8.341
29	401.239	384.599	18.540	124.650	123.980	-0.141	0.670	18.541	0.600	11.115
30	419.487	402.847	18.248	124.650	124.139	0.159	0.511	18.249	0.591	10.775
31	451.456	434.816	31.969	124.650	124.102	-0.037	0.548	31.969	0.530	16.928
32	471.404	454.764	19.948	124.650	124.197	0.095	0.453	19.948	0.501	9.984
33	491.189	474.549	19.785	124.650	123.904	-0.293	0.746	19.787	0.600	11.861
34	512.948	496.308	21.759	124.650	124.226	0.322	0.424	21.761	0.585	12.729
35	534.555	517.915	21.607	124.650	124.298	0.072	0.352	21.607	0.388	8.384
36	556.091	539.451	21.536	124.650	123.359	-0.939	1.291	21.556	0.822	17.692
37	578.008	561.368	21.917	124.650	122.808	-0.551	1.842	21.924	1.567	34.333
38	596.010	579.370	18.002	124.650	122.537	-0.271	2.113	18.004	1.978	35.599
39	602.308	585.668	6.298	124.650	122.781	0.244	1.869	6.303	1.991	12.539
40	604.199	587.559	1.891	124.650	123.371	0.590	1.279	1.981	1.574	2.976
41	609.848	593.208	5.649	124.650	122.745	-0.626	1.905	5.684	1.592	8.993
42	617.304	600.664	7.456	124.650	122.981	0.236	1.669	7.460	1.787	13.324
43	630.533	613.893	13.229	124.650	123.958	0.977	0.692	13.265	1.181	15.617
44	654.643	638.003	24.110	124.650	124.224	0.266	0.426	24.111	0.559	13.477
45	673.317	656.677	18.674	124.650	124.425	0.201	0.225	18.675	0.326	6.078
46	689.939	673.299	16.622	124.650	124.197	-0.228	0.453	16.624	0.339	5.635
47	707.255	690.615	17.316	124.650	124.223	0.026	0.427	17.316	0.440	7.619
48	724.161	707.521	16.906	124.650	124.320	0.097	0.330	16.906	0.379	6.399
49		714.863	7.342	124.650	124.650	0.330	0.000	7.349	0.165	1.211
	744.852	728.212		124.650	125.250					
							Total	716.006		669.483

12.2992

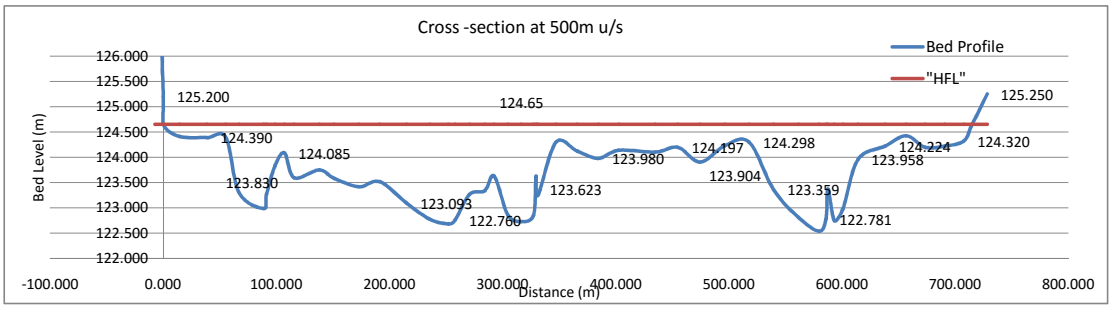
R = 0.935 m

S = 0.004

n = 0.03

V = 2.016 m/sec

Q = 1350 cumec



ANNEXURE - 4

DISCHARGE CALCULATION OF MECHI RIVER BY RATIONAL METHOD

Discharge Calculations as per Rational Formula :

Q = 0.028 P. f . A . Ic

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

A = Area of catchment in hectares = 21000

P = Percentage coefficient of runoff for the catchment characteristics (vide Table 4.1, SP-13-2004, pg 13) = 0.4

f = fraction depending on the catchment area from f curve(Sp-13,pg 14) = 0.648

Ic = Critical Intensity of rainfall in cm per hour

$= Io \left(\frac{2}{tc + 1} \right)$ Io = one hour rainfall

Where $Io = \frac{F}{2} \left(1 + \frac{1}{T} \right)$ = 22.92 cm/hr

F = Precipitation of the storm in cm = 44 cm

T = Duration in hours = 24 hrs

tc = Concentration time of Catchment in hours

$= 0.870 \left(\frac{L^3}{H} \right)^{0.385}$ = 3.794 hrs

L = The distance from the critical point to the culvert in km. = 43.30

H = The fall in level from the critical point to the culvert in metre. = 1771.0

∴ Q = A.Io.λ

$\lambda = \frac{0.056 f. P}{tc + 1} = \frac{0.056 \times 0.65}{3.794 + 1} \times 0.4$ = 0.0030

Q = 21000 x 22.917 x 0.003 = **1455.9936 cu.m/sec**

However, rational formula is generally avoided for such large catchments

ANNEXURE - 5

ABSTRACT OF DISCHARGES BY DIFFERENT METHODS AND DESIGN DISCHARGE (Q)

Major bridge across Mechi river at km: 0+885

Abstract of discharges by different methods and adoption of Design Discharge (Q),

Sl. No.	Method adopted	Discharge in cumec	Reference in the Report
1	SUH-CWC Manual	1835	Annexure-1
2	Area-velocity	1730	Annexure-3
3	Rational	1456	Annexure-5

Therefore, the maximum discharge is obtained by SUH method and the value is 1835 cumec.

However, due to lack of topo sheet and any authenticated data from PWD, Irrigation or CWC, vide discussions in the article 1.5.3.3 of this report. So, looking at into the importance of the bridge, the above discharge is further enhanced little conservatively by 33% and adopted as the Design Discharge (Q) of Mechi River.

Therefore, Design Discharge Q = 1.33x1835 = 2440 cumec, **say 2500 Cumec.**

ANNEXURE - 6

DESIGN HFL CALCULATION AT PROPOSED BRIDGE ALIGNMENT

Major bridge across Mechi bridge at km:0+885

Calculation of HFL for MJB @ 0+885, across Mechi

Cross-section at bridge site; Cross-section 1-1

Discharge from SUH = 2500 cumec, at the crossing of the river

Bed slope from survey data = 0.004

100 year HFL = 123.070 m Back water (considered) = 150

Serl. No.	Ch.	Mod. Ch	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
		-7.250		123.070	130.297					
		-0.270		123.070	123.070		0.000			
1	41.490	0.000	0.270	123.070	122.790	-0.280	0.280	0.389	0.140	0.038
2	52.770	11.280	11.280	123.070	122.774	-0.016	0.296	11.280	0.288	3.249
3	63.049	21.559	10.279	123.070	122.742	-0.032	0.328	10.279	0.312	3.207
4	107.699	66.209	44.650	123.070	122.682	-0.060	0.388	44.650	0.358	15.985
5	117.285	75.795	9.586	123.070	122.652	-0.030	0.418	9.586	0.403	3.863
6	127.939	86.449	10.654	123.070	122.292	-0.360	0.778	10.660	0.598	6.371
7	137.686	96.196	9.747	123.070	122.111	-0.181	0.959	9.749	0.868	8.465
8	149.082	107.592	11.396	123.070	121.894	-0.217	1.176	11.398	1.068	12.165
9	155.716	114.226	6.634	123.070	121.936	0.042	1.134	6.634	1.155	7.662
10	166.188	124.698	10.472	123.070	122.155	0.219	0.915	10.474	1.025	10.729
11	188.192	146.702	22.004	123.070	122.223	0.068	0.847	22.004	0.881	19.386
12	198.888	157.398	10.696	123.070	122.106	-0.117	0.964	10.697	0.905	9.685
13	210.140	168.650	11.252	123.070	121.942	-0.164	1.128	11.253	1.046	11.770
14	218.861	177.371	8.721	123.070	121.783	-0.159	1.287	8.722	1.208	10.531
15	231.252	189.762	12.391	123.070	121.901	0.118	1.169	12.392	1.228	15.216
16	241.916	200.426	10.664	123.070	121.755	-0.146	1.315	10.665	1.242	13.245
17	253.339	211.849	11.423	123.070	121.734	-0.021	1.336	11.423	1.326	15.141
18	263.842	222.352	10.503	123.070	121.713	-0.021	1.357	10.503	1.347	14.142
19	280.768	239.278	16.926	123.070	121.757	0.044	1.313	16.926	1.335	22.596
20	288.354	246.864	7.586	123.070	120.628	-1.129	2.442	7.670	1.878	14.243
21	294.477	252.987	6.123	123.070	120.571	-0.057	2.499	6.123	2.470	15.127
22	299.798	258.308	5.321	123.070	120.386	-0.185	2.684	5.324	2.592	13.789
23	306.547	265.057	6.749	123.070	120.545	0.159	2.525	6.751	2.604	17.578
24	353.427	311.937	46.880	123.070	121.334	0.789	1.736	46.887	2.130	99.878
25	362.572	321.082	9.145	123.070	121.256	-0.078	1.814	9.145	1.775	16.232
26	373.010	331.520	10.438	123.070	121.513	0.257	1.557	10.441	1.686	17.593
27	377.662	336.172	4.652	123.070	121.413	-0.100	1.657	4.653	1.607	7.476
28	385.113	343.623	7.451	123.070	121.533	0.120	1.537	7.452	1.597	11.899
29	393.068	351.578	7.955	123.070	121.488	-0.045	1.582	7.955	1.559	12.406
30	419.669	378.179	26.601	123.070	120.781	-0.707	2.289	26.610	1.936	51.486
31	429.161	387.671	9.492	123.070	120.929	0.148	2.141	9.493	2.215	21.025
32	438.544	397.054	9.383	123.070	120.788	-0.141	2.282	9.384	2.211	20.751
33	455.512	414.022	16.968	123.070	120.167	-0.621	2.903	16.979	2.592	43.990
34	463.714	422.224	8.202	123.070	120.368	0.201	2.702	8.204	2.802	22.986
35	470.760	429.270	7.046	123.070	120.602	0.234	2.468	7.050	2.585	18.214
36	499.295	457.805	28.535	123.070	121.071	0.469	1.999	28.539	2.233	63.733
37	511.946	470.456	12.651	123.070	120.536	-0.535	2.534	12.662	2.266	28.673
38	519.214	477.724	7.268	123.070	120.576	0.040	2.494	7.268	2.514	18.272
39	532.959	491.469	13.745	123.070	120.895	0.319	2.175	13.749	2.335	32.088
40	568.829	527.339	35.870	123.070	121.283	0.388	1.787	35.872	1.981	71.058
41	575.653	534.163	6.824	123.070	121.250	-0.033	1.820	6.824	1.803	12.307
42	592.410	550.920	16.757	123.070	120.672	-0.578	2.398	16.767	2.109	35.341
43		553.245	19.082	123.070	123.070	1.820	0.000	19.169	0.910	17.365
	654.256	612.766		123.070	128.747					
							Total	570.657		886.954

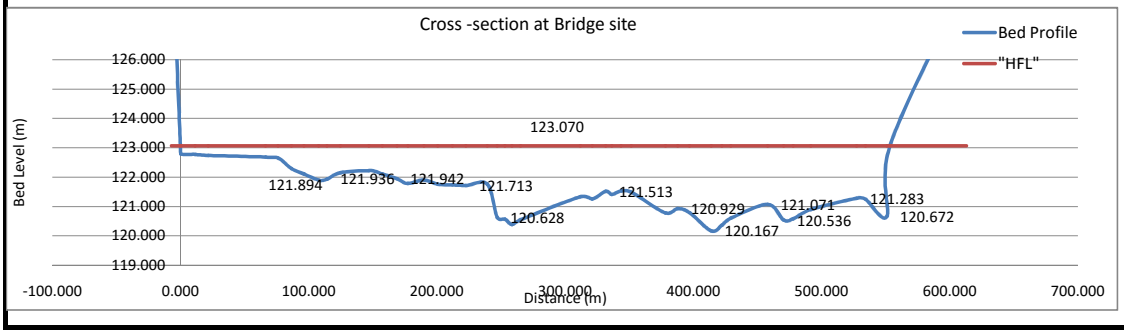
R = 1.554 m

S = 0.004

n = 0.03

V = 2.829 m/sec

Q = 2509 cumec



ANNEXURE - 7

CALCULATION OF LINEAR WATERWAY, AFFLUX AND OTHER HYDRAULICS OF MECHI RIVER

Linear water way & Afflux :-

1. **Linear Water Way:**

Design discharge	=	2500.00	m^3/s
Unobstructed Velocity of river	=	2.82	m/s
HFL	=	123.070	m
Bed level	=	120.167	m
Depth of water (u/s)	=	2.90	m
Afflux from Molesworth	=	0.000	m
Velocity of approach	=	2.82	m/s
Head due to velocity of approach (V^2 / 2g)	=	0.40	m
Total head	=	0.40	m
Velocity through vent (2gh)	=	2.82	m/s
Linear water way required	=	305.53	m
Proposed clear vent way (Bank to Bank decided)	=	546.00	m o.k

Note: Effective linear waterway of downstream existing bridge is considered as the value is less than that of the proposed

2. **Check for Afflux**

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

By Molesworth formula

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

Velocity, V	=	2.82	m/sec
Unobstructed area, Au	=	886.95	m^2
Effective vent area, Ae	=	1585.04	m^2
Afflux	=	0.000	m

3. **Fixing of RCL** (As per table 12.1 of IRC: 5-1998)

Vertical clearance (V_c) required = 1.20 m

Bottom of deck level to be provided = 124.270 m

ANNEXURE - 8

TABLE SHOWING HYDROLOGICAL AND HYDRAULIC PARAMETERS OF MECHI RIVER

Hydrological and hydraulic design parameters of Mechi River and its braided channels on Project Road, AH-2

0	1	2	3	4	5		7	8	9	10	11	12	13	14	15
S. No	**Type**	**Location**	**Span arrangement (m)**	**Name of River/ Stream**	**Local inquiry HFL (m)**	**Catchment Area (Sq. Km.)**	**Design Discharge (cumec)**	**Design HFL (m)**	**Design velocity (m/sec)**	**Linear waterway required (Square) (m)**	**Effective Linear waterway (Square) (m)**	**Afflux (mm)**	**Affluxed HFL (m)**	**Vertical clearance (mm)**	**Remarks**
1	MJB	0+800	15x45	Mechi	122.65	210	2500	123.1	2.83	306	546	150 (consid-ered)	123.25	1200	No navigation clearance required as per Irrigation Department. Linear waterway is kept High bank to high bank due to meandering characteristics of the River
2	-	0+800	2x16	Channel-1	-	-	210	123.1	4.02	-	18.55	150	123.25	900	Braided channels of Main river
3	-	0+800	2x16.0	Channel-2	-	-	211	123.1	3.88	-	21.62	150	123.25	900	Braided channels of Main river
4	-	0+800	2x14	Channel-3	-	-	91	123.1	3.86	-	11.16	150	123.25	900	Braided channels of Main river

Notes:

1. Affluxed HFLs are to be indicated in the bridge GAD
2. Bridge details under 2, 3 and 4 are the braided channels within the same khadir of Mechi. It is part of the same river.

ANNEXURE - 9

DISCHARGES OF BRAIDED CHANNELS (CHANNEL-1, 2 &3) WITH IN MECHI RIVER BED

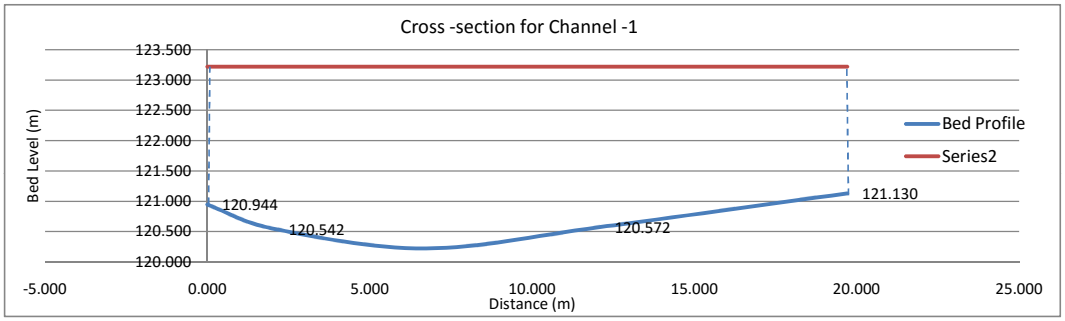
Calculation of design discharge, in Channel-1, at HFL flow

The total design discharge of Mechi is worked out to be 2500 Cumec. However, this discharge is not uniform throughout the bed and there are flow concentration in the three braided channels, flowing within Mechi River bed. As per river hydraulics, these channels will carry more concentrated discharges than the average discharge. This calculation is for the design discharge at channel 1, (vide map showing the river and channels) at peak flow, i.e. when the river Mechi is carrying its design discharge at HFL = 123.22

Bed slope for the for the river from the survey data = 0.004

Serl. No.	Mod. Ch	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
1	0.000		123.220	123.250		-0.030			
2	0.000	0.000	123.220	120.944	-2.306	2.276		1.123	0.000
3	2.060	2.060	123.220	120.542	-0.402	2.678	2.099	2.477	5.103
4	6.740	4.680	123.220	120.217	-0.325	3.003	4.691	2.841	13.294
5	12.100	5.360	123.220	120.572	0.355	2.648	5.372	2.826	15.145
6	19.710	7.610	123.220	121.130	0.558	2.090	7.630	2.369	18.028
7	19.71	0.000	123.220	123.250	2.120	-0.030		1.030	0.000
							19.792		51.569

R = 2.606 m
S = 0.004
n = 0.03
V = 3.993 m/sec
Q = 206 cumec



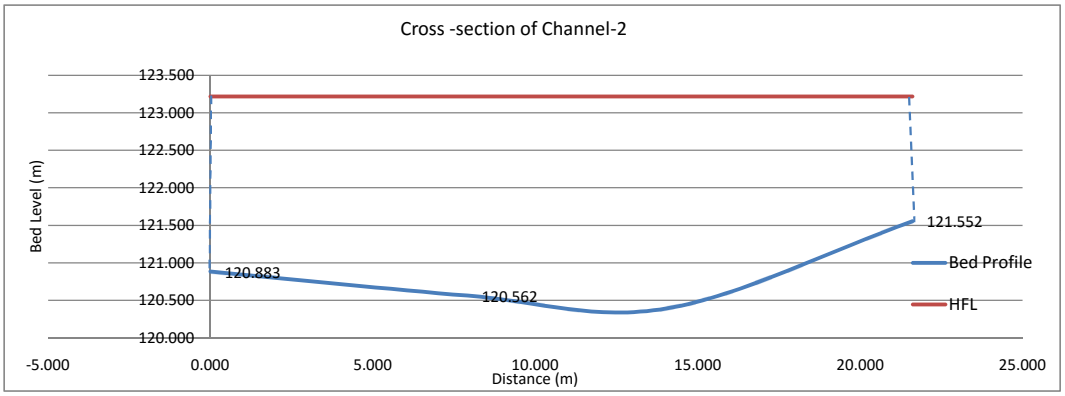
Calculation of design discharge, in Channel-2, at HFL flow

The total design discharge of Mechi is worked out to be 2500 Cumec. However, this discharge is not uniform throughout the bed and there are flow concentration in the three braided channels, flowing within Mechi River bed. As per river hydraulics, these channels will carry more concentrated discharges than the average discharge. This calculation is for the design discharge at channel 2, (vide map showing the river and channels) at peak flow, i.e. when the river Mechi is carrying its design discharge at HFL = 123.22

Bed slope for the for the river from the survey data = 0.004

Serl. No.	Ch (m)	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
1	0.000		123.220	123.250		-0.030			
1	0.000	0.000	123.220	120.883	-2.367	2.337		1.154	0.000
2	7.910	7.910	123.220	120.562	-0.321	2.658	7.917	2.498	19.755
3	14.051	6.141	123.220	120.392	-0.170	2.828	6.143	2.743	16.845
4	21.607	7.556	123.220	121.552	1.160	1.668	7.645	2.248	16.986
5	21.607	0.000	123.220	123.25	1.698	-0.030		0.819	0.000
							21.704		53.586

R = 2.469 m
S = 0.004
n = 0.03
V = 3.852 m/sec
Q = 206 cumec



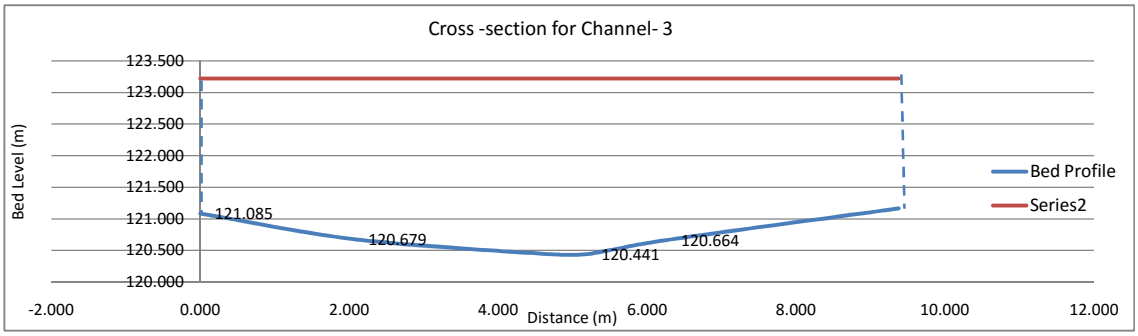
Calculation of design discharge, in Channel-3, at HFL flow

The total design discharge of Mechi is worked out to be 2500 Cumec. However, this discharge is not uniform throughout the bed and there are flow concentration in the three braided channels, flowing within Mechi River bed. As per river hydraulics, these channels will carry more concentrated discharges than the average discharge. This calculation is for the design discharge at channel 3, (vide map showing the river and channels) at peak flow, i.e. when the river Mechi is carrying its design discharge at HFL = 123.22

Bed slope for the for the river from the survey data = 0.004

Serl. No.	Mod. Ch	Dist(m)	HFL(m)	GL(m)	Fall(m)	Ht of water(m)	Wet Per(m)	Avg water Ht. (m)	Wetted Area(m^2)
	0.000		123.220	123.250		-0.030			
1	0.000	0.000	123.220	121.085	-2.165	2.135		1.053	0.000
2	2.060	2.060	123.220	120.679	-0.406	2.541	2.100	2.338	4.816
3	4.560	2.500	123.220	120.450	-0.229	2.770	2.510	2.656	6.639
	5.190	0.630	123.220	120.441	-0.009	2.779	0.630	2.775	1.748
4	6.260	1.070	123.220	120.664	0.223	2.556	1.093	2.668	2.854
	9.380	3.120	123.220	121.165	0.501	2.055	3.160	2.305	7.193
	9.380	0.000	123.220	123.250	2.085	-0.030		1.013	0.000
							9.493		23.250

R = 2.449 m
S = 0.004
n = 0.03
V = 3.832 m/sec
Q = 89 cumec



ANNEXURE - 10

TABLE SHOWING UNIT DISCHARGES OF MECHI RIVER AND ITS BRAIDED CHANNELS

DESIGN DISCHARGE, HFL AND VELOCITIES OF MECHI AND ITS BRAIDED CHANNELS WITHIN THE BED

CHANNELS MKD.	DISCHARGE (CUMEC)	HFL (m)	WIDTH OF THE CHANNEL (M)/LINEAR WATERWAY	DISCHARGE PER UNIT WIDTH d_b (Cumec/m)	DISCHARGE PER UNIT WIDTH d_b, FOR FOUNDATIONS DESIGN (Cumec/m)	Velocities (m/sec)	SUPPORTS INFLUENCED
1	2		3	4	5	6	7
MAIN RIVER	2500	123.25	546	4.579	5.952380952	2.83	ALL OTHER PIERS AND ABUTMENTS
CHANNEL-1	210		18.55	11.321	14.71698113	4.02	P-5, P-6 & P-7
CHANNEL-2	211		21.62	9.759	12.68732655	3.88	P-9 & P-10
CHANNEL-3	91		11.145	8.165	10.61462539	3.86	P-11 & P-12

NOTES:

1. DISCHARGES ARE INCREASED BY 30% FOR DESIGN OF FOUNDATION IN ACCORDANCE WITH CL.NO:703.1.1 OF IRC:78-2014

2. THE SCOUR DESIGN OF THE SUPPORT FOUNDATIONS UNDER COL. 7 SHALL BE DONE WITH THE UNIT DISCHARGES UNDER COL. 5

3.EFFECTIVE LINEAR WATERWAY IS ADOPTED AS THAT OF THE EXISTING BRIDGE AS THAT IS LESS AND AT CLOSE DOWNSTREAM

4. THE EFFECTIVE LINEAR WATERWAY IS CALCULATED ASSUMING THE THICKNESS OF PIER IS 2.0M. IT WILL CHANGE IF THE THICKNESS VARIES.

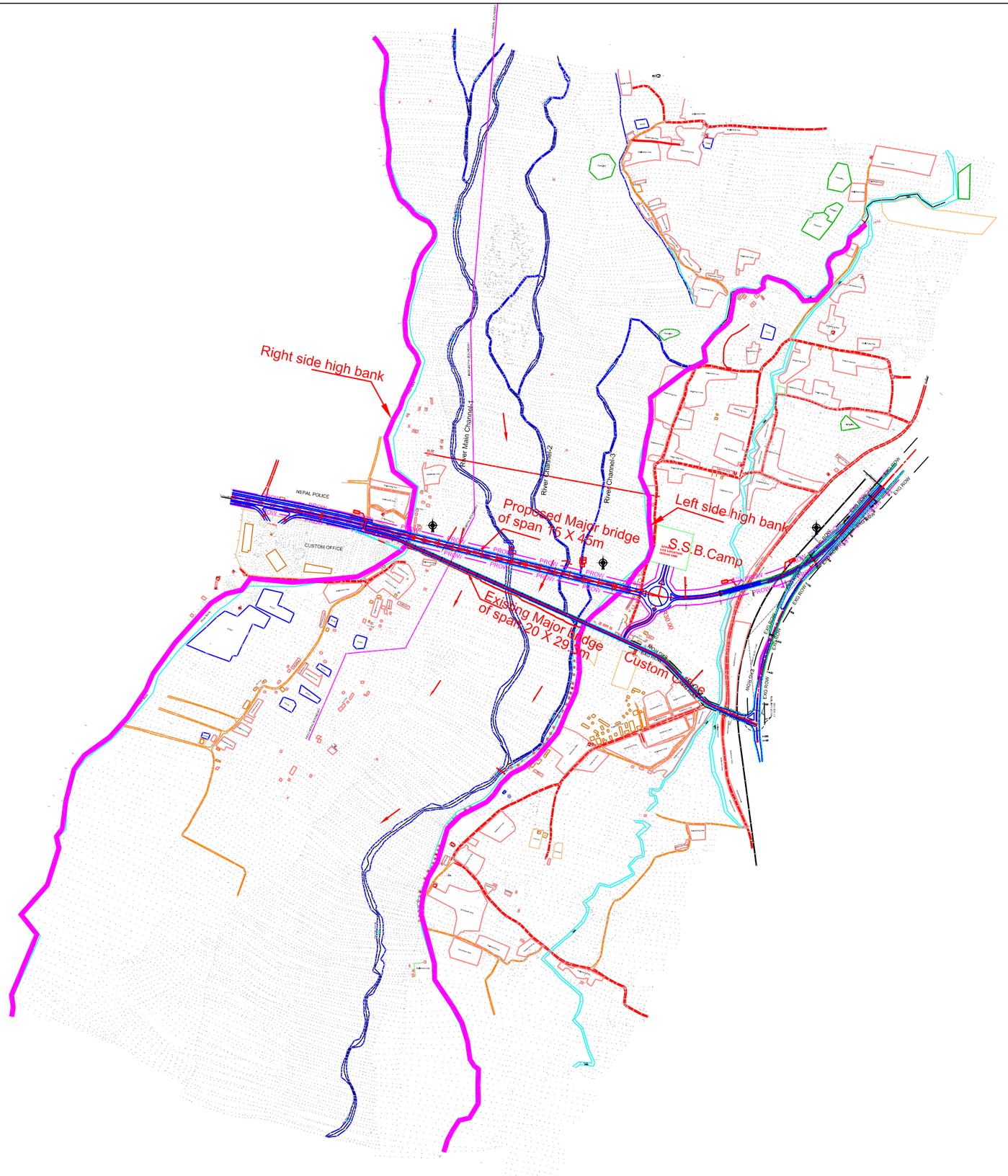
ANNEXURE - 11

MAPS AND DRAWINGS OF MECHI RIVER

TOPOGRAPHICAL SURVEY DRAWING

Nepal

India



REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHECKED	APPROVED

OWNER : PWRD/MoRT&H/ SJDA

PROJECT : DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT : ASIAN DEVELOPMENT BANK

JOB No. :		
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
DATE	SCALE:	

TITLE :

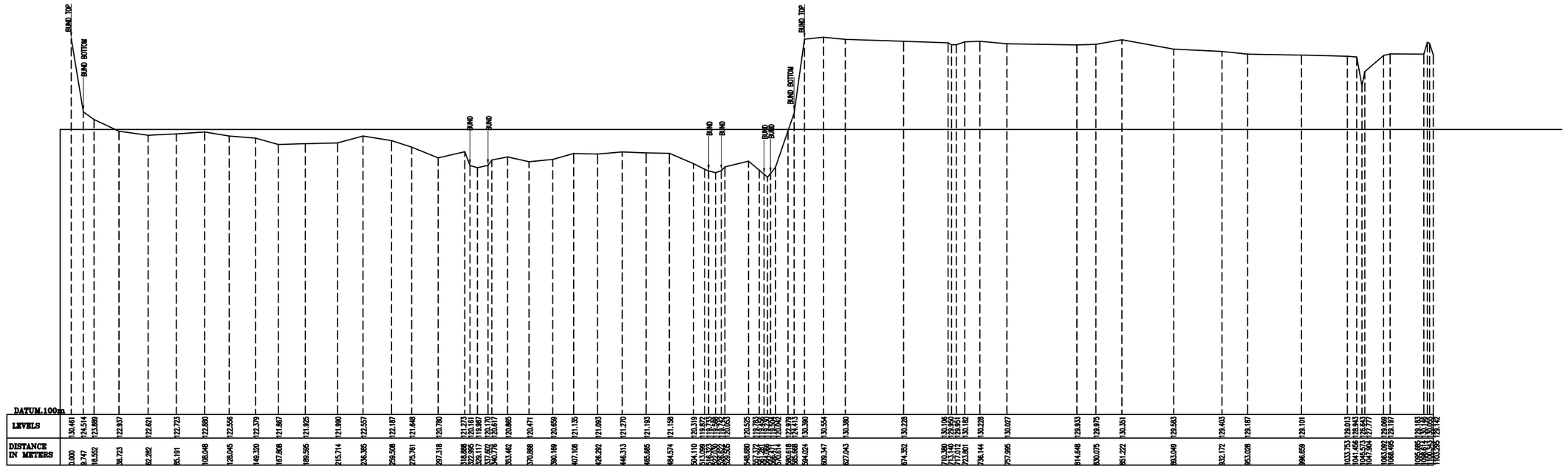
REV.

SIZE A2

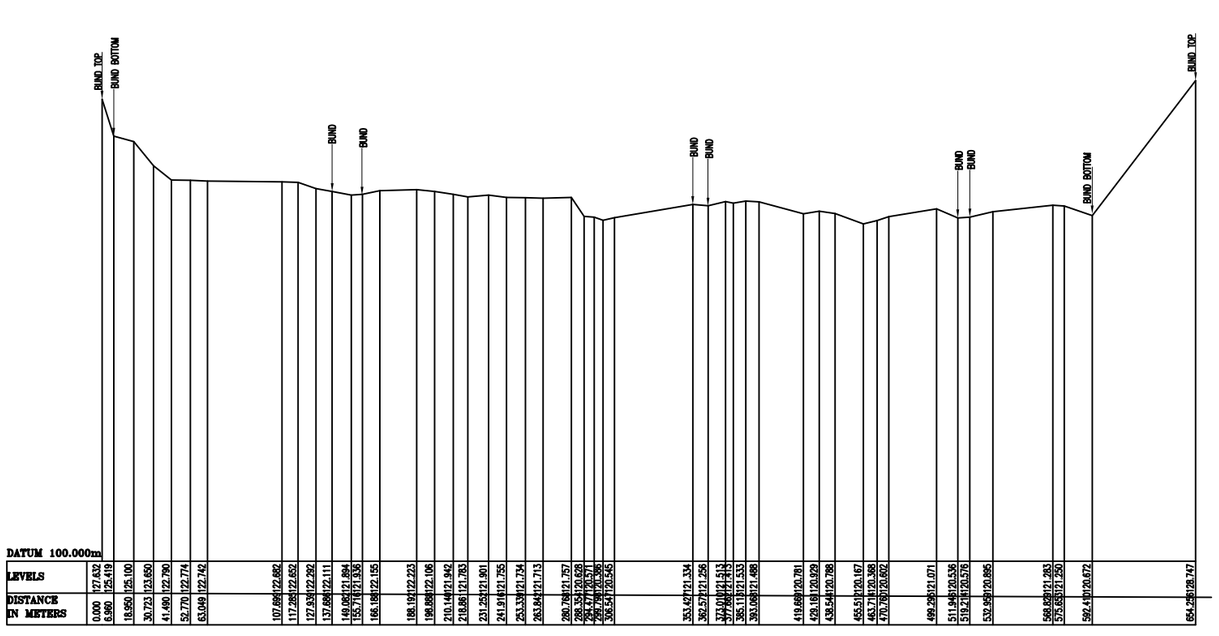
DRAWING NO : 49

SHEET OF

CROSS SECTION AND LONG SECTION DRAWING



CROSS SECTION AT EXISTING MECHI BRIDGE



CROSS SECTION AT PROPOSED MECHI BRIDGE

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PWRD/MoRT&H/ SJDA

PROJECT :
DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT :
ADB ASIAN DEVELOPMENT BANK

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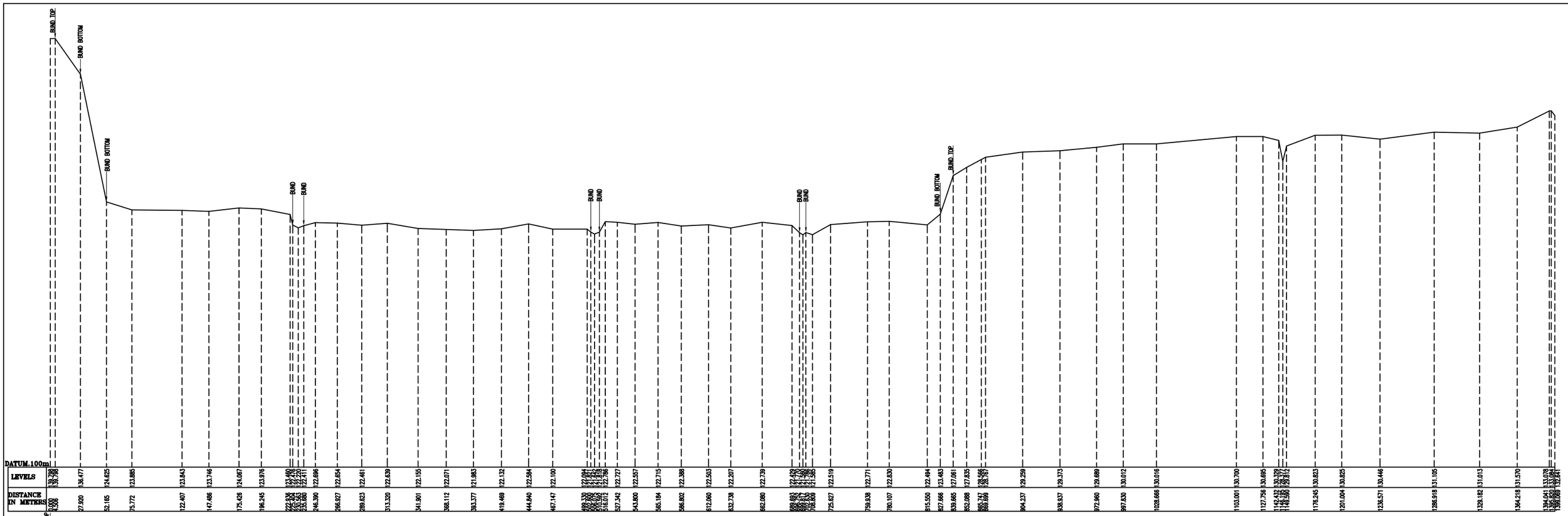
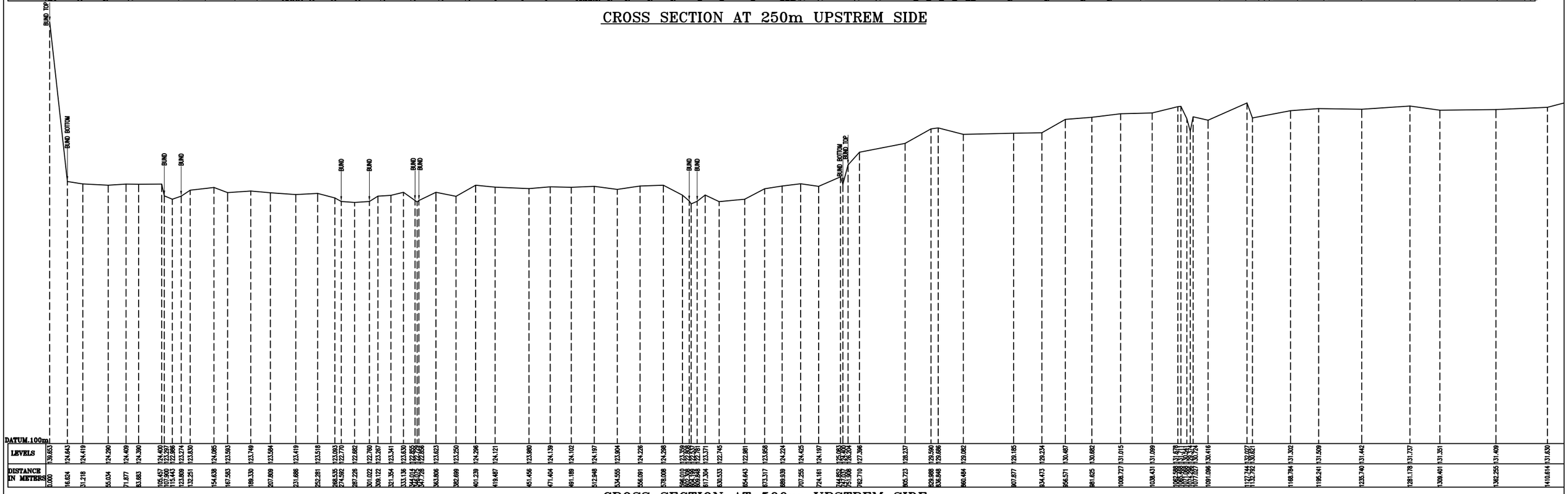


CROSS SECTION AT 250m UPSTREM SIDE



CROSS SECTION AT 500m UPSTREM SIDE

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PWRD/MoRT&H/ SJDA

PROJECT :
DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT :
ADB
ASIAN DEVELOPMENT BANK

JOB No. :		
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
DATE	SCALE:	

TITLE :

REV.

SIZE A2

DRAWING NO :

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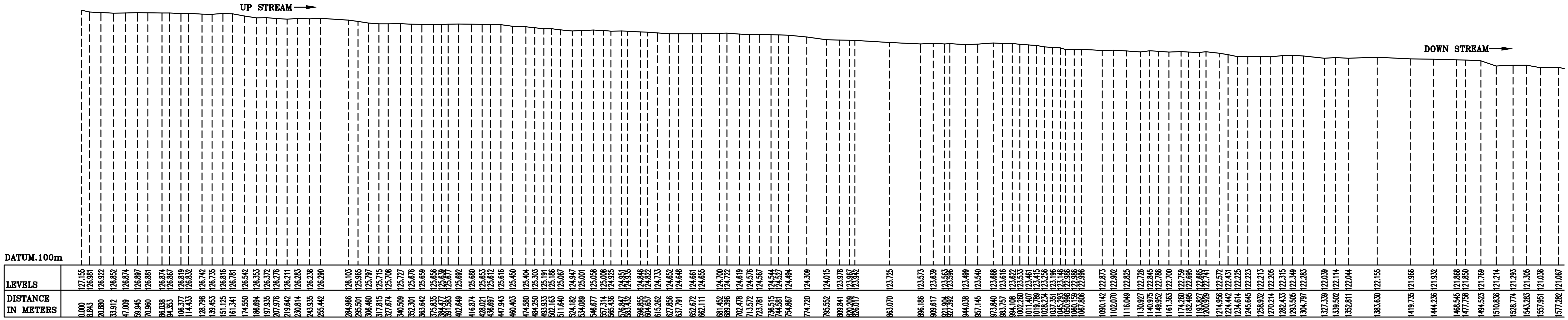
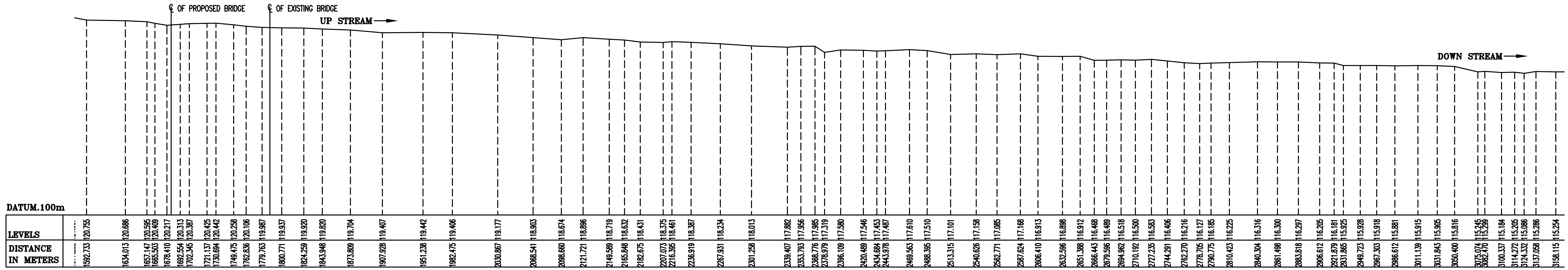


STREAM -1



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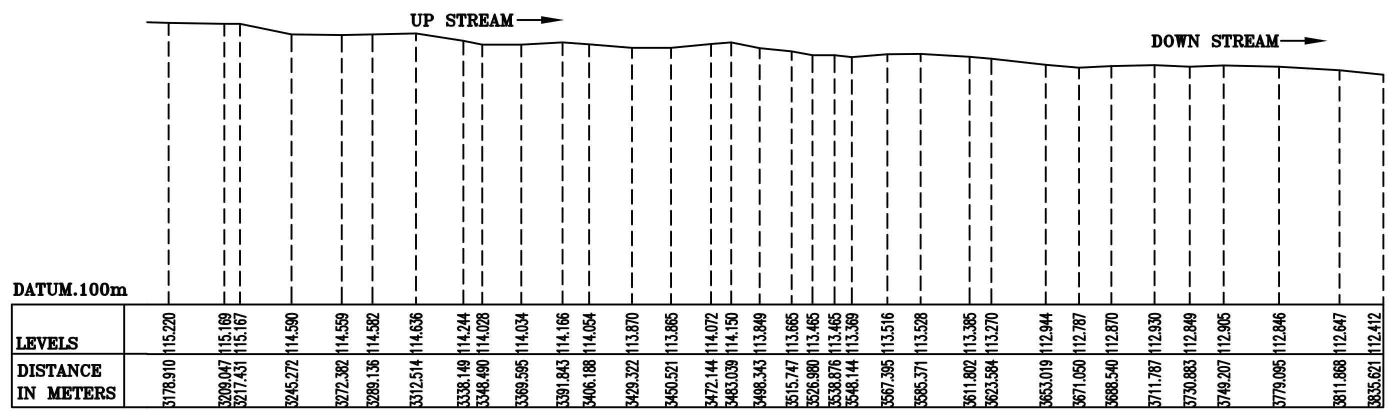


STREAM -1

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHECKED	APPROVED

OWNER : PWRD/MoRT&H/ SJDA

PROJECT : DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT : ASIAN DEVELOPMENT BANK

JOB No. :
DESIGNED
DRAWN
CHECKED
APPROVED
DATE SCALE:

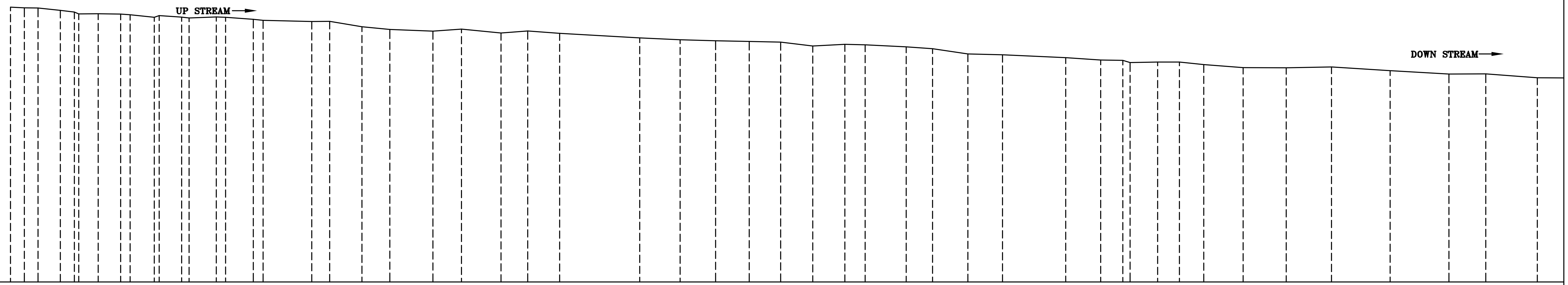
TITLE :

REV.

SIZE A2

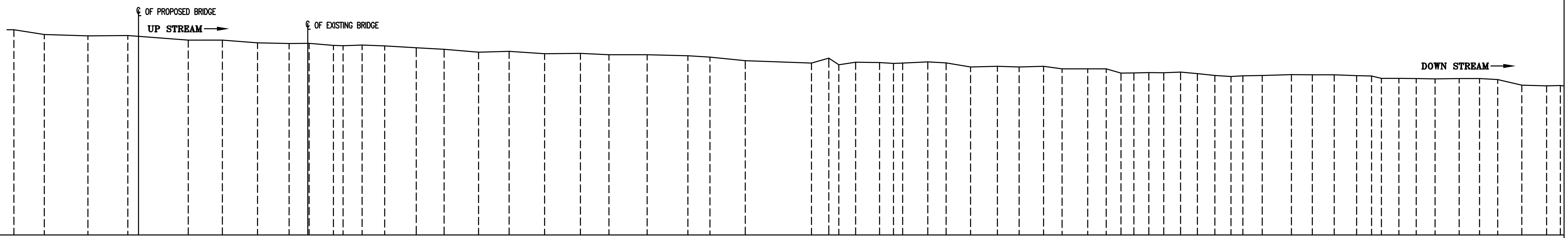
DRAWING NO :

SHEET OF



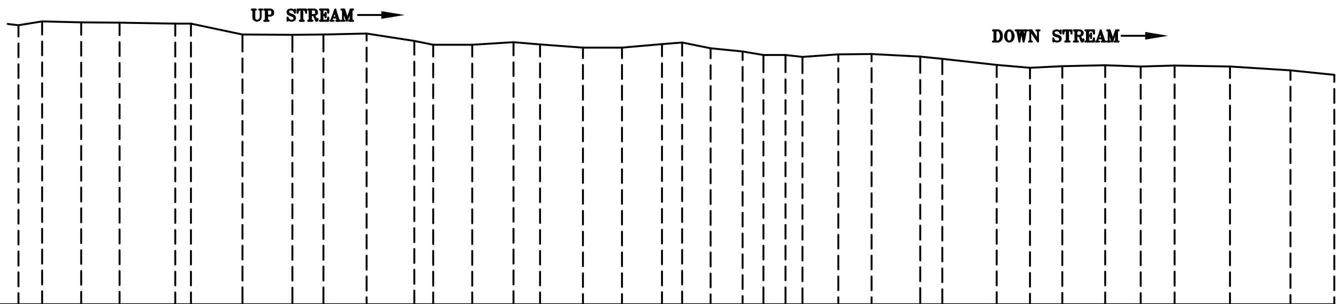
DISTANCE IN METERS	LEVELS
0.000	128.140
14.260	128.060
28.320	128.050
51.180	127.810
65.520	127.640
70.000	127.450
89.880	127.460
112.810	127.420
122.570	127.360
147.360	127.100
152.310	127.270
175.320	127.120
182.860	127.030
210.810	127.130
220.330	127.100
248.700	126.880
258.770	126.780
308.500	126.660
326.970	126.680
360.010	126.120
388.410	125.850
432.550	125.680
461.840	125.890
502.370	125.490
529.740	125.690
562.300	125.460
644.310	124.990
685.690	124.800
721.980	124.690
756.530	124.620
788.630	124.560
821.540	124.160
854.420	124.330
875.190	124.270
917.230	124.070
944.290	123.880
980.440	123.350
1015.840	123.260
1080.630	122.960
1116.420	122.730
1139.100	122.690
1146.420	122.460
1174.740	122.520
1197.050	122.510
1221.890	122.260
1262.210	121.950
1306.320	121.930
1352.760	122.010
1412.710	121.630
1472.980	121.290
1510.700	121.310
1563.500	120.910

STREAM -2



DISTANCE IN METERS	LEVELS
1598.040	120.880
1628.960	120.400
1673.520	120.260
1714.090	120.290
1775.730	119.830
1810.510	119.830
1846.360	119.540
1878.510	119.480
1898.870	119.500
1923.550	119.290
1933.470	119.260
1952.800	119.320
1975.940	119.230
2008.050	119.040
2036.450	118.890
2071.510	118.600
2102.750	118.680
2138.820	118.440
2175.260	118.470
2204.330	118.330
2243.260	118.340
2284.890	118.240
2307.350	118.100
2343.350	117.730
2410.750	117.490
2428.460	117.990
2438.670	117.320
2455.800	117.580
2480.180	117.550
2494.370	117.450
2503.670	117.490
2529.250	117.610
2548.080	117.510
2573.000	117.100
2600.310	117.160
2622.460	117.090
2647.310	117.170
2666.100	116.910
2692.280	116.900
2711.080	116.910
2726.130	116.470
2739.280	116.490
2754.650	116.520
2769.880	116.500
2786.920	116.580
2803.980	116.410
2821.960	116.220
2838.390	116.130
2850.460	116.190
2870.110	116.230
2899.990	116.320
2921.180	116.300
2943.500	116.300
2966.300	116.210
2981.570	116.180
2991.550	115.930
3009.410	115.930
3026.990	115.920
3046.300	115.880
3070.830	115.920
3091.530	115.910
3110.090	115.820
3134.760	115.250
3160.020	115.180
3173.960	115.210

STREAM -2



DISTANCE IN METERS	LEVELS
3184.020	115.090
3196.740	115.290
3217.800	115.250
3238.600	115.220
3268.730	115.170
3277.120	115.170
3304.960	114.590
3332.070	114.560
3348.820	114.580
3372.200	114.640
3397.840	114.240
3408.180	114.030
3429.280	114.030
3451.530	114.170
3465.870	114.050
3489.010	113.870
3510.210	113.870
3531.830	114.070
3542.730	114.150
3558.030	113.850
3575.430	113.670
3586.670	113.470
3598.560	113.470
3607.830	113.370
3627.080	113.520
3645.060	113.530
3671.490	113.390
3683.270	113.270
3712.710	112.940
3730.740	112.790
3748.230	112.870
3771.470	112.930
3790.570	112.850
3808.890	112.910
3838.780	112.850
3871.550	112.650
3895.310	112.410

STREAM -2

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHECKED	APPROVED

OWNER : PWRD/MoRT&H/ SJDA

PROJECT : DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT : ASIAN DEVELOPMENT BANK

JOB No. :
DESIGNED
DRAWN
CHECKED
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DATE
SCALE:

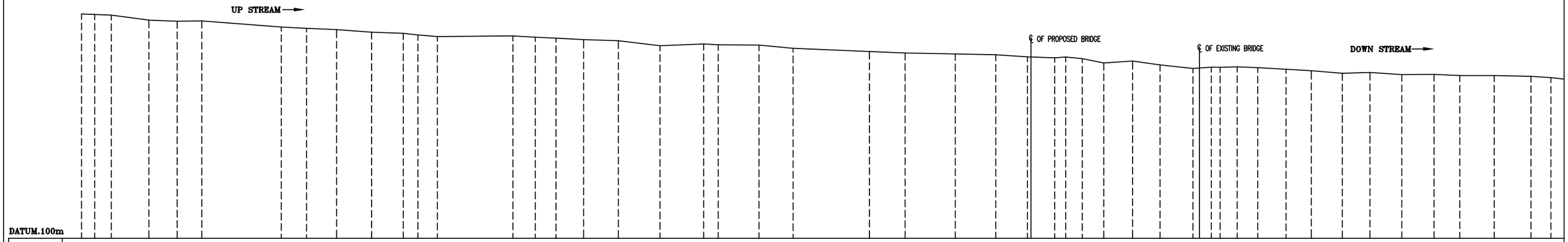
TITLE :

REV.

SIZE A2

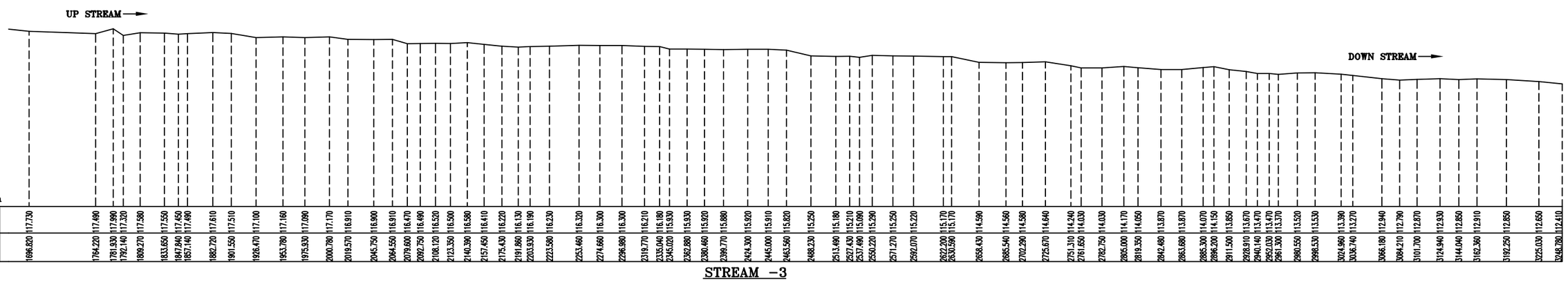
DRAWING NO :

SHEET OF



DISTANCE IN METERS	LEVELS
0.000	125.280
14.900	125.220
33.670	125.140
76.140	124.580
108.110	124.460
135.960	124.500
225.870	123.810
254.340	123.650
288.260	123.510
327.890	123.220
363.640	123.100
380.290	122.910
402.160	122.730
487.580	122.800
512.850	122.650
536.250	122.540
567.550	122.380
606.790	122.250
653.880	121.700
703.190	121.900
719.530	121.810
765.840	121.760
804.350	121.410
890.610	121.040
930.820	120.880
987.650	120.770
1033.430	120.670
1069.100	120.450
1100.110	120.340
1112.360	120.420
1131.030	120.250
1155.450	119.760
1187.980	119.970
1218.950	119.540
1256.320	119.140
1277.020	119.290
1286.940	119.260
1306.270	119.320
1329.410	119.230
1361.520	119.040
1389.920	118.890
1424.980	118.600
1456.220	118.680
1492.290	118.440
1528.740	118.470
1557.800	118.330
1596.730	118.340
1638.370	118.240
1660.820	118.100

STREAM –3



DISTANCE IN METERS	LEVELS
1696.820	117.730
1764.220	117.480
1781.930	117.990
1792.140	117.320
1809.270	117.580
1833.650	117.550
1847.840	117.450
1857.140	117.490
1882.720	117.610
1901.550	117.510
1926.470	117.100
1953.780	117.160
1975.930	117.090
2000.780	117.170
2019.570	116.910
2045.750	116.900
2064.550	116.910
2079.600	116.470
2092.750	116.490
2108.120	116.520
2123.350	116.500
2140.390	116.580
2157.450	116.410
2175.430	116.220
2191.860	116.130
2203.930	116.190
2223.580	116.230
2253.460	116.320
2274.660	116.300
2296.960	116.300
2319.770	116.210
2335.040	116.180
2345.020	115.930
2362.880	115.930
2380.460	115.920
2399.770	115.880
2424.300	115.920
2445.000	115.910
2463.560	115.820
2488.230	115.250
2513.490	115.180
2527.430	115.210
2537.490	115.090
2550.220	115.290
2571.270	115.250
2592.070	115.220
2622.200	115.170
2630.590	115.170
2658.430	114.590
2685.540	114.560
2702.290	114.580
2725.670	114.640
2751.310	114.240
2761.650	114.030
2782.750	114.030
2805.000	114.170
2819.350	114.050
2842.490	113.870
2863.680	113.870
2885.300	114.070
2896.200	114.150
2911.500	113.850
2928.910	113.670
2940.140	113.470
2952.030	113.470
2961.300	113.370
2980.550	113.520
2998.530	113.530
3024.960	113.390
3036.740	113.270
3066.180	112.940
3084.210	112.790
3101.700	112.870
3124.940	112.930
3144.040	112.850
3162.360	112.910
3192.250	112.850
3225.030	112.650
3248.780	112.410

STREAM –3

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	CHECKED	APPROVED

OWNER : PWRD/MoRT&H/ SJDA

PROJECT : DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT : ASIAN DEVELOPMENT BANK

JOB No. :		
DESIGNED		
DRAWN		
CHECKED		
APPROVED		
DATE	SCALE:	

TITLE :

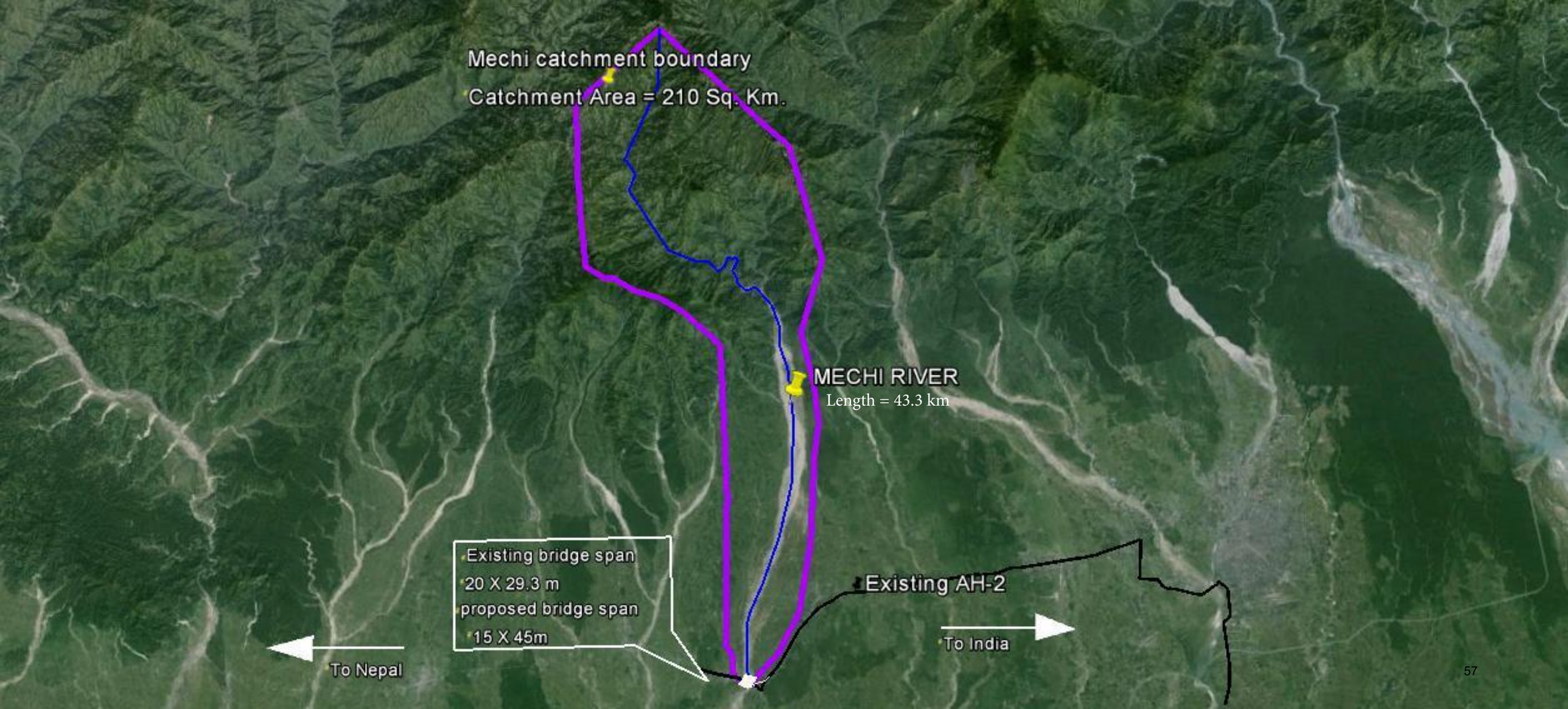
REV.

SIZE A2

DRAWING NO :

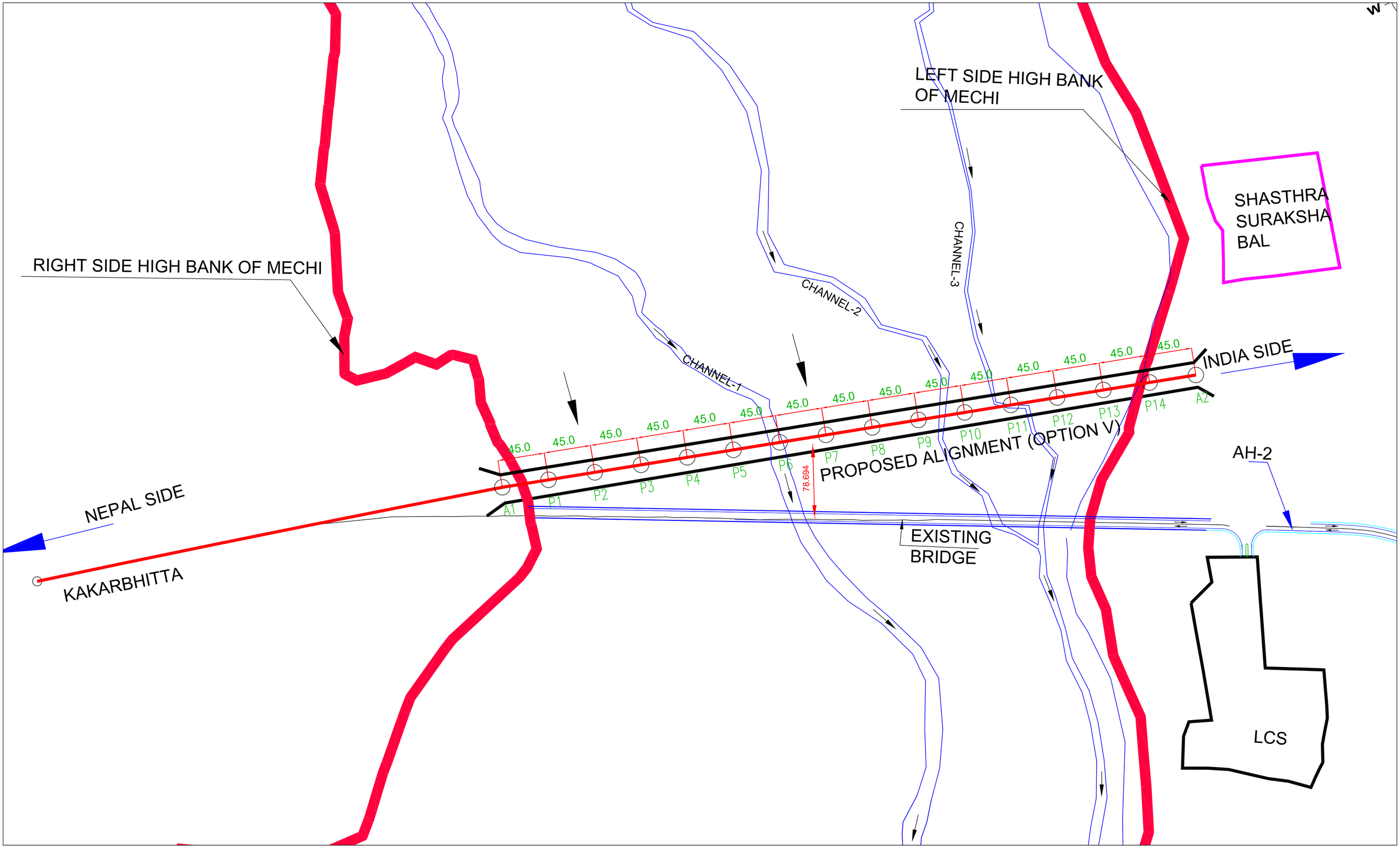
SHEET OF

GOOGLE IMAGERY SHOWING MECHI CATCHMENT AREA AND OTHER SALIENT FEATURES

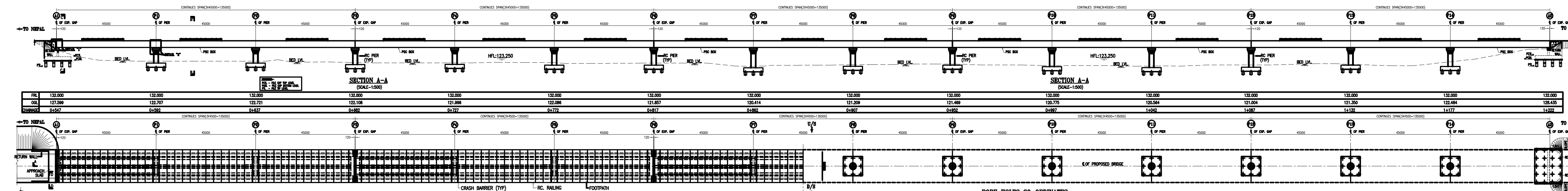

Mechi catchment boundary
Catchment Area = 210 Sq. Km.
MECHI RIVER
Length = 43.3 km
Existing bridge span
20 X 29.3 m
proposed bridge span
15 X 45m
Existing AH-2
To India
To Nepal

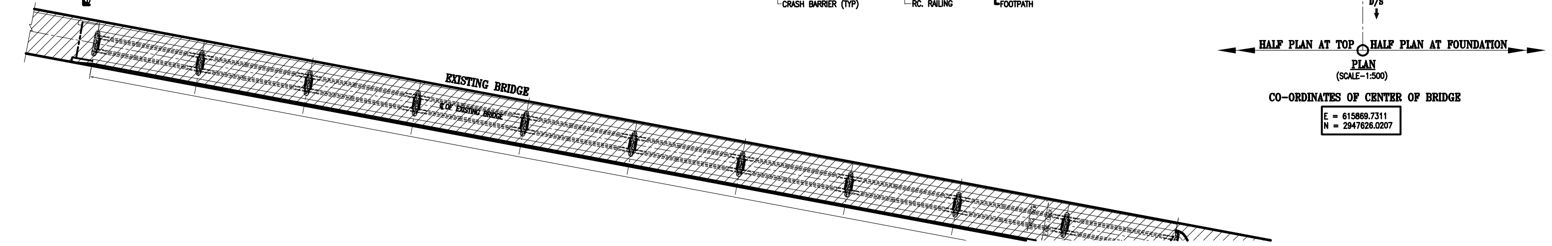
PLAN OF MECHI SHOWING BRAIDED CHANNELS, EXISTING BRIDGE AND PROPOSED BRIDGE ALIGNMENT

PLAN OF MECHI RIVER WITH BRAIDED CHANNELS , EXISTING AND PROPOSED BRIDGE



GENERAL ARRANGEMENT DRAWING



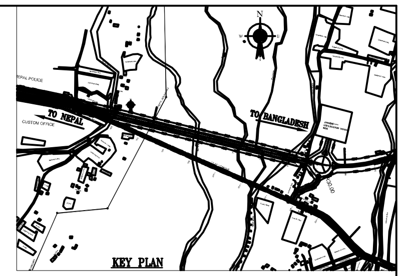


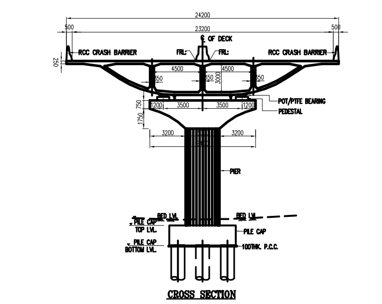
BORE HOLES CO-ORDINATES

SPAN 15X45m		
Sl.No	Easting	Northing
A1	615541.892	2947706.193
P1	615585.604	2947695.503
P2	615629.316	2947684.814
P3	615673.028	2947674.124
P4	615716.740	2947663.435
P5	615760.452	2947652.745
P6	615804.163	2947642.055
P7	615847.875	2947631.366
P8	615891.587	2947620.676
P9	615935.299	2947609.986
P10	615979.011	2947599.297
P11	616022.723	2947588.607
P12	616066.435	2947577.917
P13	616110.147	2947567.228
P14	616153.859	2947556.538
A2	616197.571	2947545.849

NOTES:

1. ALL DIMENSIONS ARE IN mm. UNLESS OTHERWISE MENTIONED. ONLY WRITTEN DIMENSIONS ARE TO BE FOLLOWED.NO DIMENSION IS TO BE SCALED.
2. THE BRIDGE HAS BEEN DESIGNED FOR COMBINATION OF LOADING AS PER TABLE 2 OF IRC-6.
3. THE CONCRETE SHALL BE DESIGN MIX AND 28 DAYS CHARACTERISTIC STRENGTH FOR VARIOUS COMPONENTS SHALL BE AS UNDER.
   * PSC BOX GIRDER – M55
   * SUBSTRUCTURE & PILE FOUNDATION – M40
   * CRASH BARRIER – M40
   * APPROACH SLAB – M30
   * PCC LEVELLING COURSE – M15
4. ALL UNTENSIONED REINFORCEMENT SHALL BE GRADE DESIGNATION Fe-500D HAVING YIELD STRENGTH OF 500 Mpa, CONFORMING TO IS:1786 STANDARD.
5. CLEAR COVER TO OUTERMOST REINFORCEMENT SHALL BE 75mm FOR FOOTING ANS 45mm FOR SUBSTRUCTURE.
6. NOT MORE THAN 50% OF REINFORCEMENT SHALL BE LAPPED AT ANY SECTION. LAP LENGTH SHALL BE 56 TIMES THE DIA OF THE BAR.
7. BACK FILLING SHALL CONSIST OF SELECTED EARTH CONFORMING TO APPENDIX: 6 OF IRC:78-2014 HAVING PROPERTIES C=0, ϕ = 30° & d = 20KN/Cum.
8. 600mm THICK FILTER MEDIA SHALL BE PROVIDED.
9. HYDRAULIC DATA FOR DESIGN OF BRIDGE.
   DESIGN DISCHARGE 2500 cumecs
   HFL 123.250 m
   VELOCITY 2.484 m/Sec.
10. 65mm THICK WEARING COURSE SHALL BE PROVIDED.
11. THIS STRUCTURE LIES IN SEISMIC ZONE-IV.
12. FOR CRASH BARRIER, FOOTPATH, DRAINAGE SPOUT, WEARING COAT AND EXPANSION JOINT DETAILS REFER MISCELLANEOUS DRAWING.
13. THE DIMENSIONS AND LEVELS SHOWN IN THIS DRAWING SHALL BE VERIFIED WITH FINALISED STRUCTURAL & HIGHWAY DRAWINGS.
14. PILE CAPACITY:
   VERTICAL ---- 600 T/M2
   HORIZONTAL ---- 20 T/M2
   THE SAME SHALL BE VERIFIED BY CONFIRMATORY BORING.





OWNER : PWRD/MoRT&H/ SJDA

PROJECT : DETAILED DESIGN FOR THE SUBREGIONAL ROAD CONNECTIVITY PROJECT - DETAILED ENGINEERING DESIGN AND FINALIZATION OF SAFEGUARD DOCUMENTS

CLIENT : ASIAN DEVELOPMENT BANK

JOB No. :

TITLE : MAJOR BRIDGE ACROSS RIVER MECHI AT CH: 0+884.5 (DESIGN) GENERAL ARRANGEMENT DRAWING

REV. R0

SIZE A2

DRAWING NO : ADB/MB/STR/MJB/0+884.5/DD/101

SHEET 1 OF 1

ANNEXURE – 12

ILLUSTRATIVE PHOTOGRAPHS OF MECHI RIVER

Illustrative Photographs

Photo-1: Showing u/s side of the river bed with braided channels

Photo-2: Showing d/s side of the river bed and braided channels

Photo-3: General elevation of the bridge from downstream and Combined interlaced channels and piers vulnerable to concentrated flow line

Photo-4: Showing downstream bend and deep erosion

Photo-5: Showing groins constructed to resist erosion of fragile India side downstream bank.

Photo-6: Partly Eroded abutment spill due to attack of active channel

Photo-7: Showing eroded India side abutment spill on the left side

Photo-8: End of bridge on India side, at about 130.0m from the existing bridge along the Bund road below; and 150 m from the "Sasastra Suraksha Bal", campus, visible in the photo