REPORT

ON

"Assessment of extractable River Bed Material (RBM) from River KOSI –Dabka II during year 2021-22"

FOR

Uttarakhand Forest Developmet Corporation
Ramnagar, Nainital (Uttarakhand)

BY

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Dr. P R Ojasvi
Er. S.K. Sharma
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Er. Amit Chauhan

ICAR-Indian Institute of Soil and Water Conservation,
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
218, KAULAGARH ROAD, DEHRADUN-248 195 (UTTARAKHAND)
(December, 2021)

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Executive Summary

A study on consultancy basis was undertaken by ICAR-IISWC (formerly CSWCRTI), Dehradun during 2021 entitled "Assessment of extractable river bed material from river Kosi -DabkaII for the year 2021-22" for the UKFDC, Ramnagar, Nainital (Uttarakhand). The study area was river Kosi Dabka II downstream to the bridge on Ramnagar – Haldwani highway about 06 km from Ramnagar under jurisdiction of RM, UKFDC covering a length of 6.85 km. The area was critically examined for the entire length and the cross-sections were taken at the locations mentioned in the Fig. 2. Survey was carried out for the length of 6.85km **of** the defined river reach.

Based on the survey conducted and volume calculation for permissible extraction of deposited RBM is worked out as **574291.57 cum**. It is also suggested that for estimation of RBM in the following year, a reassessment study will be required to be conducted during the post monsoon period.

It is recommended to confine the extraction of RBM from middle half of the river width in order to channelize the flow and for protecting the adjoining land from flood damages. The various depths of cut at different distance from the bank of the river have been mentioned in Table 2, which is strictly required to be followed for safe passage of river flow.

Hence, it is strongly recommended that extraction of RBM should be undertaken in a scientific and regulated manner by marking the extraction boundaries in order to improve the safe passage of flow and protect the adjoining river ecosystem.

Assessment of extractable river bed material from river KOSi Dabka-II for the year 2021-2022

Introduction

The mountain Rivers of Himalayas bring down huge quantity of sediment (sand, bajri, gravel and stones) from hilly catchments while flowing with high velocity on steep slopes. The riverbed material (RBM) rolls over the surface and is deposited while coming to the foothills with mild slopes due to reduction in flow velocity.

The RBM deposited on the river bed in the form of mounds/islands causes braiding of flow (i.e flowing through several streams instead of confined one) and meandering of the river course. This process continues and the river erodes adjoining lands thus increasing the total width of the river, though the required width for actual flow is much less. Further, the encroachment of river along the banks damages valuable property, agricultural lands and forests during the monsoon period.

The extraction/removal of this erratic deposited material, therefore, needs to be done periodically from the river bed in order to channelize the flow and consequently prevent bank erosion and flood damages along the banks.

On request from UKFDC, Ramnagar, Nainital (Uttarakhand) consultancy project was undertaken by IISWC (formerly CSWCRTI), Dehradun to conduct a study on river Kosi -Dabka II with following objectives

Objectives

1. Study the morphological profile (Cross section) of river Kosi -DabkaII for defined river reach.
2. Estimation of permissible limit of extraction of river bed material to improve the river flow.

River Kosi - Dabka II

The river reach under study Kosi- DabkaII originates at 29°16’22.41”N & 79°6’17.60”E and terminate at 29°12’51.13”N & 79°5’25.46”E The Catchment delineated start from the hills of Nainital district of Uttarakhand and flows down to the foothills near Ramnagar, district Nainital (Fig. 1) The river carries with it sediment/river bed material (RBM) consisting of sand, bajri, gravel and stones during every monsoon season.

Extraction of RBM in river Kosi Dabka II:

The Study Area

The study area is located at river Kosi -Dabka II, under jurisdiction of UKFDC, Ramnagar, district Nainital, Uttarakhand (Fig.1). River reach 6.85 km downstream of Kosi I away from Ramnagar crossing the Ramnagar – Haldwani highway.

Methodology

A team from ICAR-IISWC, Dehradun consisting of Dr. P.R. Ojasvi, Pr. Scientist & Head (H&E), Er. S.S. Shrimali, Sr. Scientist, Er. S.K. Sharma, Chief Technical Officer, Shri H.S. Bhatia, Technical Officer and Er. Amit Chauhan, Senior Technical Officer analyzed the data and studied the project site. The site was visited and surveyed on 12 and 13 July 2021 with the help of DLM, Ramnagar and other staff of UKFDC. Cross section survey at the marked locations (Fig. 2) was carried out for the estimation of the RBM.

To protect the land adjoining the river banks 25 per cent of the river bed width along each bank of river would be left undisturbed for extraction. Therefore, volume of extractable sediment within the middle 50 per cent of river width was worked out based on the average width of the segment and required shape (Fig 3 & 4) for safe passage of flow.

Analysis, Results and Recommendations

1. The cross-sections of river Kosi -DabkaII at different locations are shown in Fig. 5. It is seen from the cross-sections sediment deposits are occurring in the middle portion of the river (shown by hatched portion between $M_R - M_L$). Thus, it is suggested that these deposits may be removed in order to channelize the river flow.
2. The permissible quantity of RBM that can be extracted in different segments of the river is shown in Table 1. The estimated total scientifically extractable material is **574291.57 cum** as shown in Table 1.
3. The recommended depths in respect of different locations as mentioned in Table 2 should be strictly monitored during extraction of RBM.
4. It is observed that rainfall in this region and therefore discharge of river in the past few years has reduced. Therefore, the quantity of RBM deposition in this reach of the river is reducing over the years and in the river reach under study/ proposed for extraction of RBM..
5. Suitable river training measures need to be taken for prevention of bank erosion and protection of adjoining lands from flood damages.

Acknowledgements

The project team is grateful to, Director, IISWC, Dehradun for approving this project and providing necessary support and facilities.

The team is thankful to Regional Manager, Kumaon Region for sponsoring this project and providing all help and facilities for timely completion of this study. The logistics and field assistance provided by the officers and staff of Uttarakhand Forest Corporation is thankfully acknowledged.

The help rendered by the Division of Hydrology & Engineering officers and staff on preparation of the project report is duly acknowledged.

PI and Consultants
ICAR-IISWC, Dehradun (Uttarakhand)

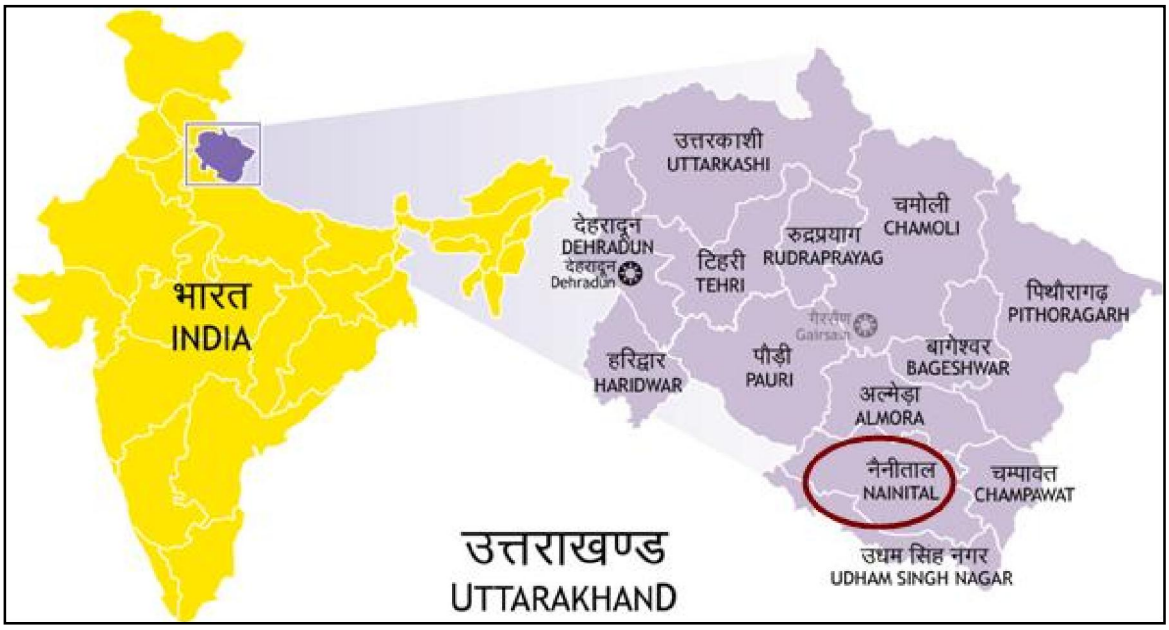
Table 1: Estimation of the extractable RBM for the marked river reach of Kosi -Dabka II River.

Volume of safely extractable RBM from River Kosi-Dabka-2 for the year 2021-22								
Location	**Length Segment (m)**	**Width of the river (m)**	**Extractable width (m)**	**Average Depth of Extraction**	**Cross Section (m^2)**	**Average Cross section (m^2)**	**Volume (m3)**	**Cumulative Volume (m^3)**
CS1	0.00	557.86	206.13	0.60	123.68	0.00	0.00	0.00
CS2	438.00	480.53	240.27	0.50	120.14	121.91	53395.05	53395.05
CS3	495.00	569.24	205.29	0.64	131.39	125.76	62251.35	115646.40
CS4	490.00	541.22	171.60	0.64	109.82	120.60	59096.35	174742.75
CS5	598.00	652.12	208.09	0.51	106.13	107.97	64569.02	239311.77
CS6	498.00	699.42	332.18	0.40	132.87	119.50	59510.48	298822.24
CS7	666.00	489.58	235.32	0.39	91.77	112.32	74807.38	373629.63
CS8	460.00	292.16	110.50	0.57	62.99	77.38	35594.75	409224.38
CS9	434.00	377.77	91.78	0.90	82.60	72.79	31592.38	440816.76
CS10	741.00	653.70	326.85	0.53	173.23	127.92	94785.94	535602.70
CS11	412.00	450.76	137.58	0.40	55.03	114.13	47022.08	582624.78
CS12	480.00	463.73	147.94	0.55	81.37	68.20	32735.76	615360.54
CS13	437.00	463.76	139.69	0.80	111.75	96.56	42196.50	657557.04
CS14	703.00	356.64	175.94	0.34	59.82	85.79	60307.42	717864.46
	6852.00				**Total Volume**			717864.46
	Recommended volume of extraction (80% of total volume)							**574291.57**

Total Volume : **574291.57 Cum**

Table2 : Distance and extraction depth across width

CS1	**Distance**	212.26	228.40	238.92	255.34	278.93	282.73	301.77	317.89	330.71	365.28	418.39							**206.13**
	Av. Depth	0.00	1.11	0.94	0.80	1.04	1.06	0.20	0.18	0.80	0.48	0.00							**0.60**
CS2	**Distance**	120.13	134.62	146.55	160.04	170.97	183.82	205.50	228.34	240.27	244.58	257.92	268.70	309.62	360.40				**240.27**
	Av. Depth	0.00	0.50	0.92	0.11	0.13	1.01	0.84	0.71	0.53	0.50	0.24	1.09	0.35	0.00				**0.50**
CS3	**Distance**	221.64	238.45	255.68	278.41	284.62	297.27	328.63	383.47	421.62	426.93								**205.29**
	Av. Depth	0.00	0.57	0.96	0.94	0.92	0.86	0.82	1.05	0.29	0.00								**0.64**
CS4	**Distance**	234.32	249.30	268.82	270.61	297.42	322.07	353.62	394.35	405.92									**171.60**
	Av. Depth	0.00	0.79	1.26	1.29	0.93	0.78	0.47	0.24	0.00									**0.64**
CS5	**Distance**	249.49	263.44	286.18	321.00	326.06	352.05	386.55	415.24	457.58									**208.09**
	Av. Depth	0.00	0.82	0.86	0.71	0.71	0.71	0.52	0.24	0.00									**0.51**
CS6	**Distance**	192.39	202.57	217.86	239.75	256.32	278.58	295.00	317.15	320.95	349.71	351.59	359.61	365.48	415.01	443.83	486.72	524.57	**332.18**
	Av. Depth	0.00	0.22	0.89	0.32	0.20	0.15	0.25	0.17	0.40	0.60	0.64	0.63	0.64	0.86	0.28	0.51	0.00	**0.40**
CS7	**Distance**	123.86	169.89	192.64	216.50	244.79	247.26	263.30	275.25	285.62	302.97	327.04	345.20	359.19					**235.32**
	Av. Depth	0.00	0.49	0.20	0.78	0.81	0.79	0.71	0.32	0.33	0.10	0.32	0.23	0.00					**0.39**
CS8	**Distance**	73.04	99.71	136.44	146.08	165.18	183.54												**110.50**
	Av. Depth	0.00	0.59	1.04	1.00	0.82	0.00												**0.57**
CS9	**Distance**	156.96	180.81	188.88	196.61	211.96	230.62	248.74											**91.78**
	Av. Depth	0.00	1.40	1.23	1.06	1.39	1.20	0.00											**0.90**
CS10	**Distance**	163.43	177.53	204.10	220.68	244.60	264.72	296.07	323.07	326.85	364.54	381.53	393.79	461.64	484.69	490.28			**326.85**
	Av. Depth	0.00	0.71	0.93	0.66	0.78	0.56	0.84	0.77	0.73	0.14	0.73	0.56	0.35	0.15	0.00			**0.53**
CS11	**Distance**	194.11	225.38	233.13	252.14	276.75	302.99	331.69											**137.58**
	Av. Depth	0.00	0.45	0.45	0.89	0.82	0.22	0.00											**0.40**
CS12	**Distance**	133.12	143.85	170.36	193.41	212.84	231.87	247.08	263.42	281.06									**147.94**
	Av. Depth	0.00	0.42	0.77	1.33	1.13	0.78	0.38	0.14	0.00									**0.55**
CS13	**Distance**	115.94	132.34	148.13	154.32	180.52	202.49	223.28	231.88	255.63									**139.69**
	Av. Depth	0.00	1.40	0.25	0.86	1.04	1.20	1.38	1.03	0.00									**0.80**
CS14	**Distance**	89.16	106.44	150.37	163.29	165.30	178.32	191.20	212.11	234.32	265.10								**175.94**
	Av. Depth	0.00	0.14	0.62	0.59	0.21	0.31	0.22	0.27	1.04	0.00								**0.34**



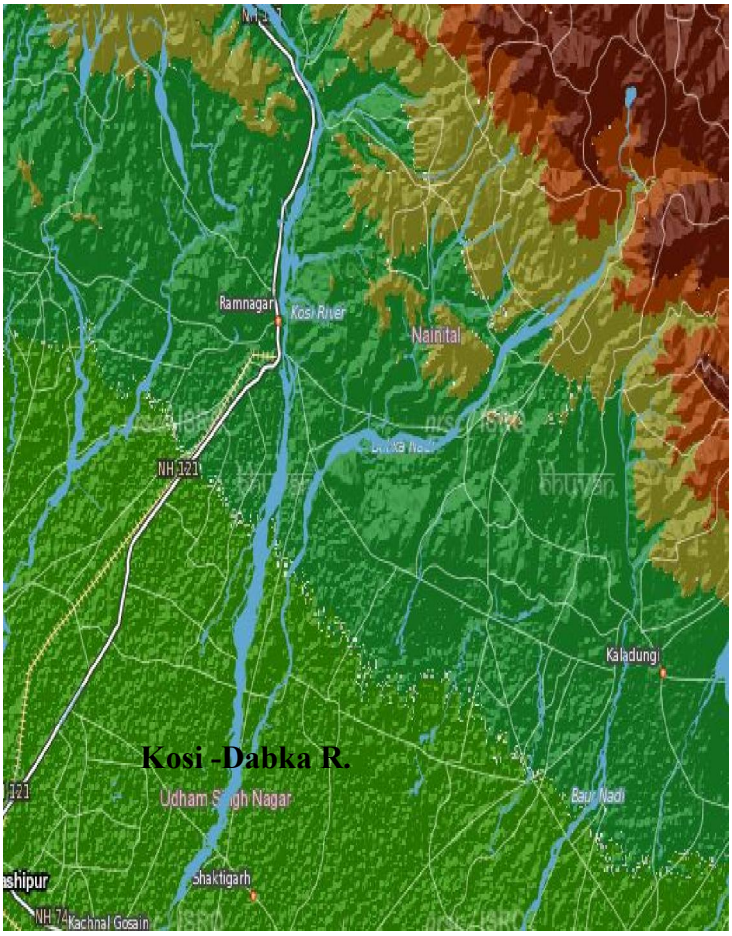
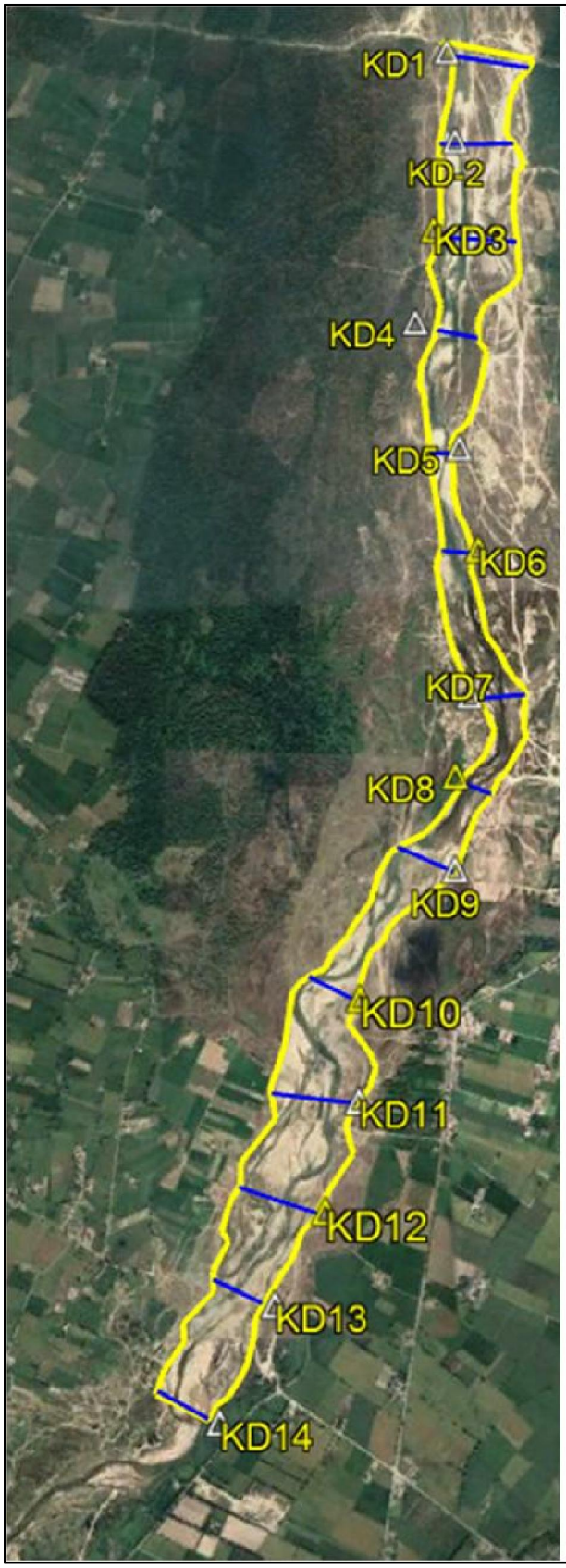


Fig.1: Location of the study area



Section No.	Northing	Easting
KD-1	29°16'20.23"N	79° 6'18.40"E
KD-2	29°16'5.17"N	79° 6'16.12"E
KD-3	29°15'49.65"N	79° 6'14.73"E
KD-4	29°15'34.62"N	79° 6'13.10"E
KD-5	29°15'14.41"N	79° 6'15.45"E
KD-6	29°14'57.77"N	79° 6'18.61"E
KD-7	29°14'35.18"N	79° 6'26.62"E
KD-8	29°14'19.98"N	79° 6'19.49"E
KD-9	29°14'8.42"N	79° 6'11.62"E
KD-10	29°13'50.11"N	79° 5'54.07"E
KD-11	29°13'34.93"N	79° 5'53.05"E
KD-12	29°13'19.45"N	79° 5'45.71"E
KD-13	29°13'7.20"N	79° 5'35.75"E
KD-14	29°12'50.21"N	79° 5'27.31"E

Fig. 2: Cross-section of river Kosi -DabkaII, Ramnagar at different kilometers showing the extractable RBM

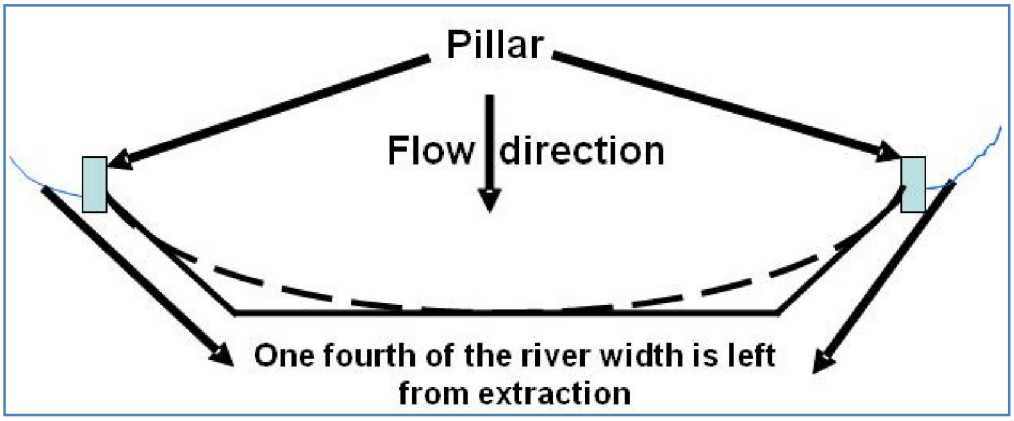


Fig: 3. Procedure of extraction of river bed material

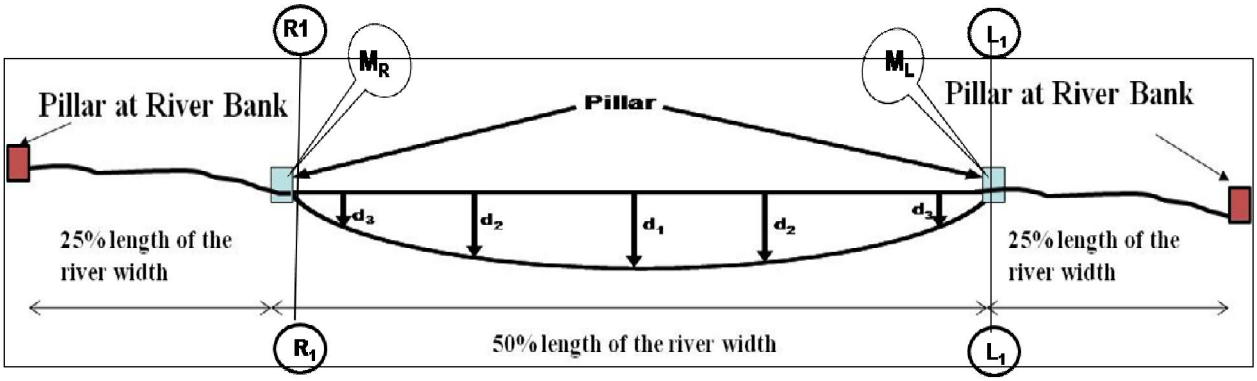


Fig . 4 Anticipated shape of the river after proper extraction of river bed material

Table3: Details of cross-sections

Cross-section 1			Cross-section 2		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
874.13	1009.96	256.57	1205.01	1101.27	255.64
876.99	1007.42	254.71	1189.46	1097.67	251.85
918.44	1008.20	254.85	1168.50	1086.68	251.98
1007.13	1008.95	254.33	1124.77	1048.73	252.00
1016.13	1014.18	253.31	1109.71	1041.24	252.14
1026.11	1019.26	252.60	1087.82	1035.01	251.50
1043.97	1017.06	252.86	1080.89	1023.34	251.52
1052.72	1019.22	252.91	1068.29	1018.08	250.41
1063.52	1022.24	253.02	1058.67	1012.86	250.33
1074.63	1025.93	252.97	1045.82	1009.36	251.61
1085.56	1028.71	252.49	1025.10	1001.95	252.14
1101.66	1029.95	254.01	1008.37	985.20	251.71
1111.99	1032.41	254.54	1000.28	967.47	251.00
1128.58	1031.32	254.80	996.06	950.06	250.94
1155.35	1039.17	255.06	992.77	936.49	252.09
1173.87	1044.84	254.50	980.29	888.28	251.85
1189.62	1048.93	255.78	914.59	834.59	253.26
1202.12	1052.23	256.38	890.02	802.84	253.76
1234.97	1066.74	256.28	872.22	754.62	253.38
1321.01	1084.07	256.91			
1362.46	1095.20	256.36			
1407.09	1104.98	257.47			
1431.97	1013.49	259.91			

Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

Cross-section 3			Cross-section 4		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
1245.37	1052.85	251.88	1265.55	1028.64	251.00
1223.32	1051.26	248.78	1240.26	1028.05	247.25
1195.85	1043.85	248.74	1209.53	1022.43	247.12
1151.67	1022.30	248.85	1165.12	1009.08	247.28
1134.27	1018.35	248.88	1146.55	1006.91	247.25
1113.96	1014.79	248.83	1127.03	1004.68	247.29
1099.41	1009.45	248.65	1108.68	1002.50	247.24
1082.65	1005.72	248.67	1089.83	999.54	247.10
1066.75	1002.67	247.97	1070.80	997.58	246.35
1053.39	999.70	247.53	1057.17	994.87	245.83
1030.82	997.27	247.67	1033.67	994.94	246.53
1015.43	989.73	248.27	1018.96	991.99	247.24
1000.00	980.97	248.66	999.87	987.73	247.96
980.78	966.26	248.64	973.13	974.36	247.38
963.68	957.90	248.56	949.13	968.60	247.33
940.39	930.42	248.52	920.45	951.49	247.22
893.40	900.64	249.05	882.81	933.66	247.34
860.17	881.45	248.89	845.24	920.76	247.13
844.91	859.83	249.17	831.26	912.44	248.29
844.91	860.23	249.31	795.74	907.83	248.45
825.53	870.32	249.50	763.31	904.07	252.62
805.09	870.33	249.67	739.42	901.72	254.86
785.17	870.63	249.84			
765.26	880.13	250.01			
745.34	860.35	250.36			
725.26	875.37	250.25			
705.45	872.52	254.50			

Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

Cross-section 5			Cross-section 6		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
1285.74	1004.43	248.13		1204.89	246.02
1257.19	1004.84	245.72	1115.89	1180.44	244.71
1223.20	1001.02	245.49	1100.06	1151.63	244.42
1178.57	995.86	245.71	1078.41	1138.82	244.43
1158.83	995.46	245.62	1071.43	1115.47	244.40
1140.09	994.57	245.74	1062.20	1103.65	244.22
1117.94	995.56	245.82	1050.79	1092.22	244.40
1097.01	993.36	245.54	1042.49	1075.73	244.17
1074.84	992.49	244.73	1031.53	1067.27	243.72
1060.96	990.04	244.14	1026.69	1060.10	243.23
1036.53	992.60	245.39	1014.15	1056.18	243.86
1022.49	994.25	246.22	1007.65	1048.35	244.12
999.73	994.48	247.26	998.03	1036.47	244.89
965.49	982.46	246.11	981.90	1021.40	244.42
934.58	979.31	246.11	966.48	1012.83	244.40
900.50	972.57	245.92	949.31	998.31	244.55
872.22	966.69	245.64	937.57	986.79	244.75
830.31	960.06	245.36	919.71	973.14	245.02
817.61	965.05	247.41	918.60	968.99	245.35
746.57	955.42	247.59	884.85	959.07	246.04
701.10	937.82	247.94	882.67	949.88	247.43
637.76	931.11	250.87	876.02	948.24	247.04
			825.02	930.32	247.26
			800.12	915.02	247.68
			756.32	900.62	248.01
			645.32	850.23	248.32
			615.33	830.53	248.63
			580.63	820.15	248.96
			560.32	807.98	249.00

Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

Cross-section 7			Cross-section 8		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
986.70	1405.35	248.78	942.66	1371.82	246.19
974.60	1356.04	243.71	942.45	1344.31	241.97
976.91	1302.24	243.35	946.31	1306.08	241.71
978.25	1281.77	243.16	952.18	1272.57	241.79
984.02	1235.48	243.19	959.87	1236.47	241.74
984.30	1212.72	242.70	965.28	1208.20	241.62
983.64	1188.87	242.98	968.84	1190.17	240.88
987.97	1158.09	242.79	974.58	1163.38	241.70
988.22	1142.05	242.71	974.82	1147.02	241.48
992.41	1130.16	242.32	977.64	1133.24	241.60
991.78	1119.77	242.33	979.06	1118.81	241.36
992.80	1102.44	242.03	981.28	1101.20	243.24
996.32	1078.45	242.52	984.65	1082.70	244.00
998.32	1060.34	242.73			
998.38	1046.35	242.69			
998.12	1024.06	243.18			
1002.93	1006.90	243.85			
1009.10	986.22	244.67			
1019.60	972.93	243.29			
1023.12	962.72	244.49			
1064.23	921.95	246.93			

Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

Cross-section 9			Cross-section 10		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
898.62	1338.30	243.61	1139.07	819.30	242.89
910.30	1332.57	240.24	1123.21	842.07	241.59
915.70	1309.93	240.07	1112.96	854.08	239.50
926.11	1263.36	240.41	1104.62	875.75	238.20
935.71	1237.47	240.29	1097.72	872.26	237.58
946.26	1203.69	240.53	1087.47	903.78	238.21
954.05	1191.46	238.78	1078.93	922.00	237.62
961.18	1168.66	240.60	1069.37	939.42	238.23
961.42	1152.00	240.26	1059.88	958.36	237.26
962.87	1136.32	240.89	1054.34	975.30	238.01
966.33	1117.84	240.40	1042.13	998.91	238.13
969.77	1099.95	239.14	1035.21	1014.02	237.81
972.97	1086.95	239.75	1024.36	1035.33	237.83
977.86	1067.86	240.31	1012.17	1051.62	237.56
985.34	1046.75	239.65	997.28	1079.22	237.84
982.87	1024.97	240.30	983.02	1102.18	237.77
993.99	1014.75	240.13	967.02	1140.68	237.34
1002.91	1006.54	243.07	960.39	1156.40	238.53
1014.91	978.88	242.79	950.88	1165.21	238.51
			910.23	1220.23	238.65
			890.23	1235.23	238.85
			875.33	1255.33	239.26
			830.65	1302.55	240.12
			801.55	1335.22	241.32
			780.66	1365.99	241.98

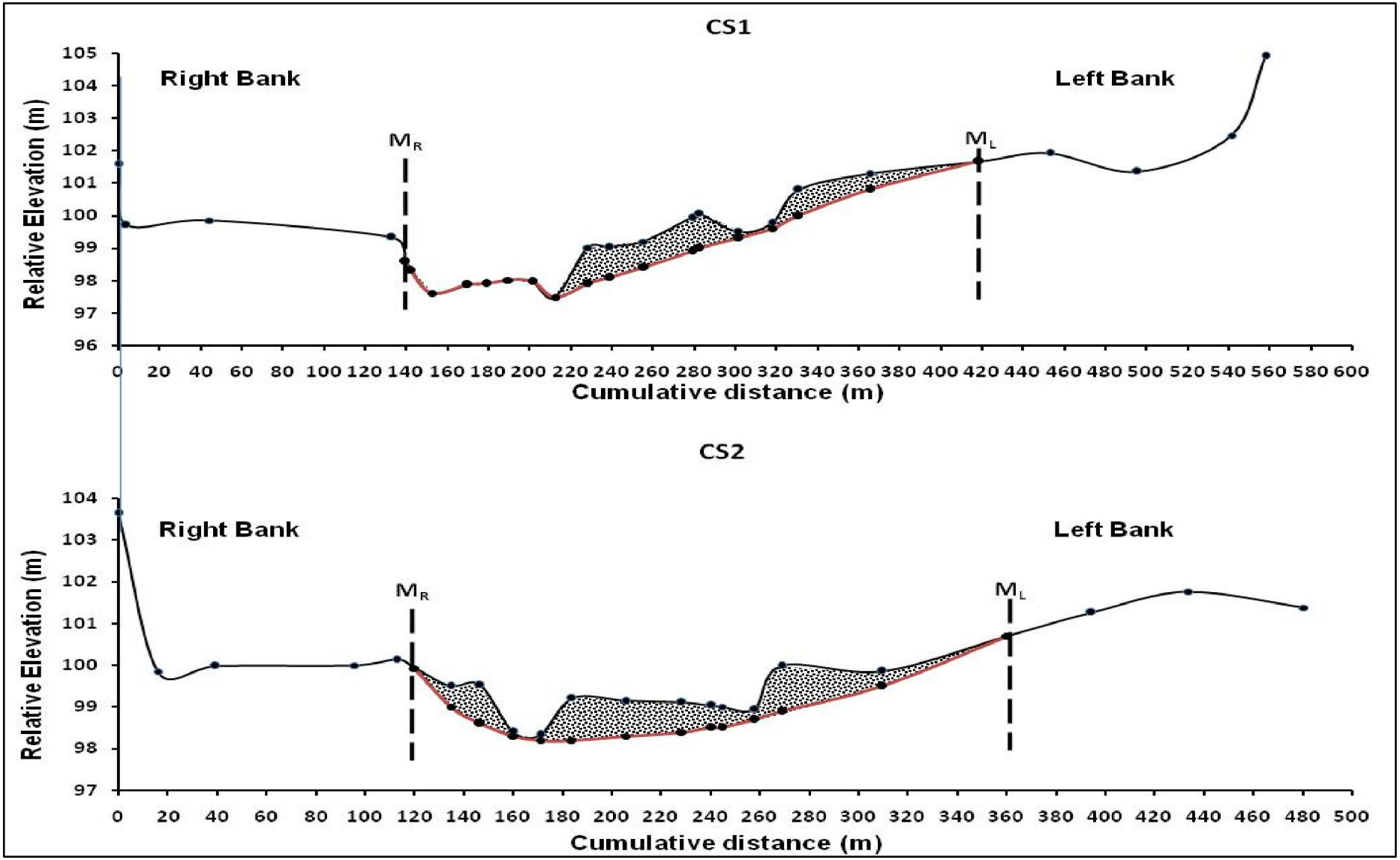
Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

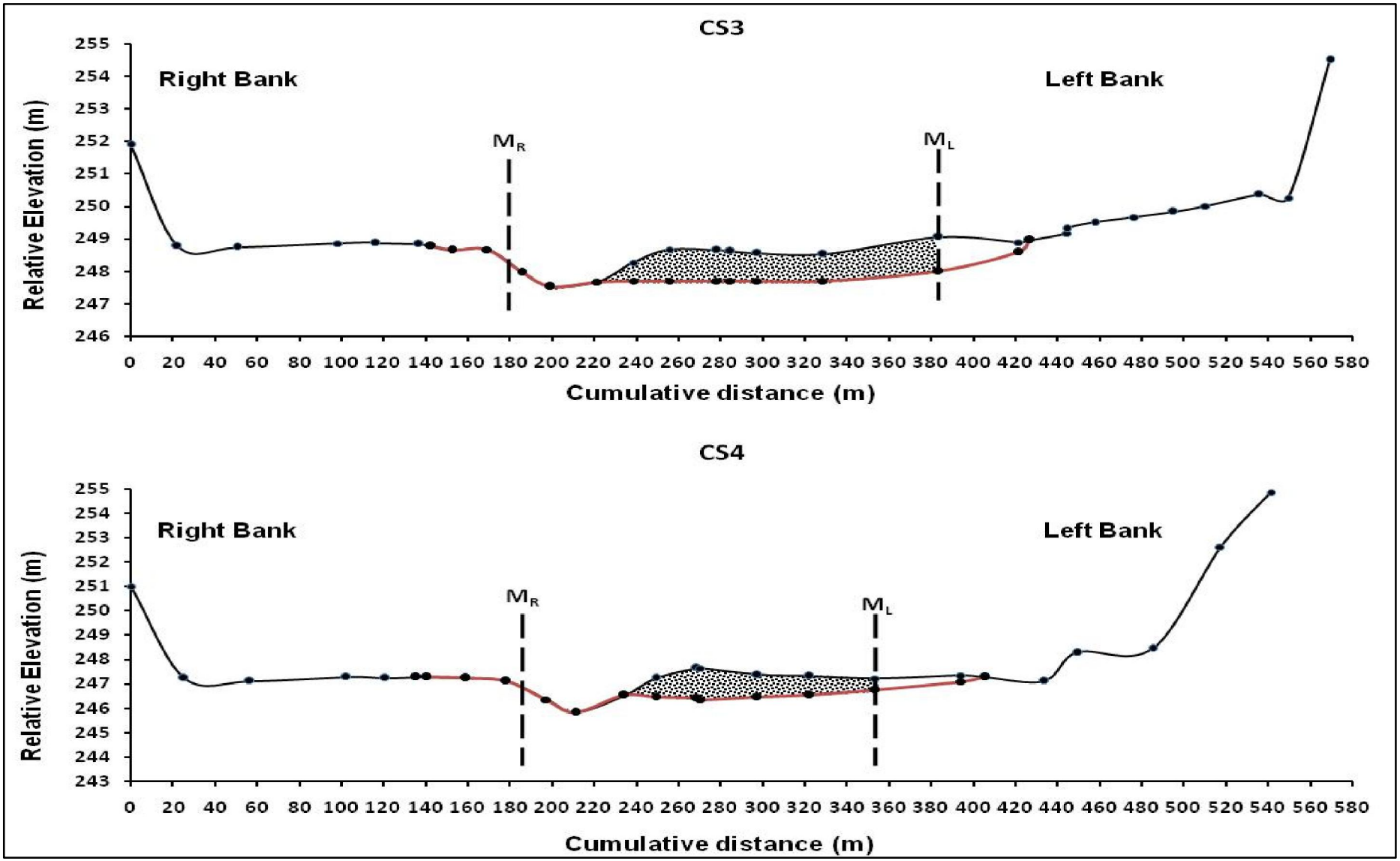
Cross-section 11			Cross-section 12		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
1263.24	659.72	239.57	1150.79	630.72	238.65
1243.50	677.60	236.76	1131.16	648.76	233.18
1231.92	693.41	235.08	1109.14	679.32	232.77
1223.90	704.76	236.00	1094.74	692.08	232.92
1212.57	719.55	234.95	1073.16	714.65	232.98
1197.09	739.69	235.93	1056.26	724.45	232.01
1184.88	757.04	235.74	1044.65	727.82	232.22
1168.97	778.88	235.41	1028.24	749.06	231.97
1153.42	798.88	236.00	1012.93	766.38	232.13
1145.81	814.29	234.73	1002.00	782.92	231.83
1122.83	845.82	235.25	976.54	805.89	231.38
1109.25	859.37	235.99	965.29	817.76	231.34
1094.67	879.21	235.92	945.94	823.15	231.53
1078.08	899.55	235.22	931.67	841.39	231.19
1058.86	920.96	235.03	916.87	859.28	231.10
1039.93	941.00	236.76	903.23	886.80	235.48
1018.34	971.43	236.89	850.37	950.25	237.63
1010.47	980.22	237.17	840.75	975.57	238.13
1003.14	992.11	239.86			
973.68	1005.18	239.91			

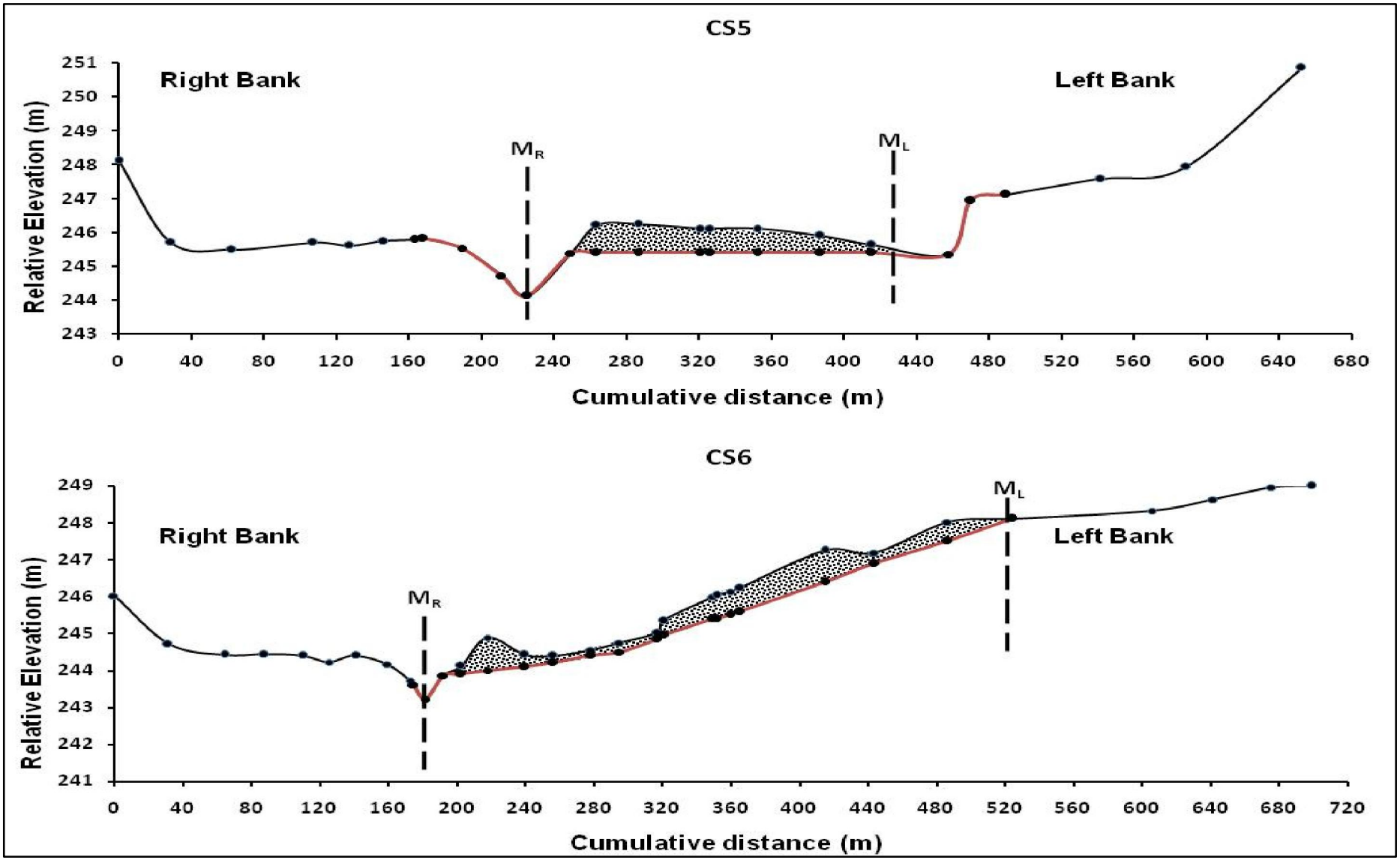
Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

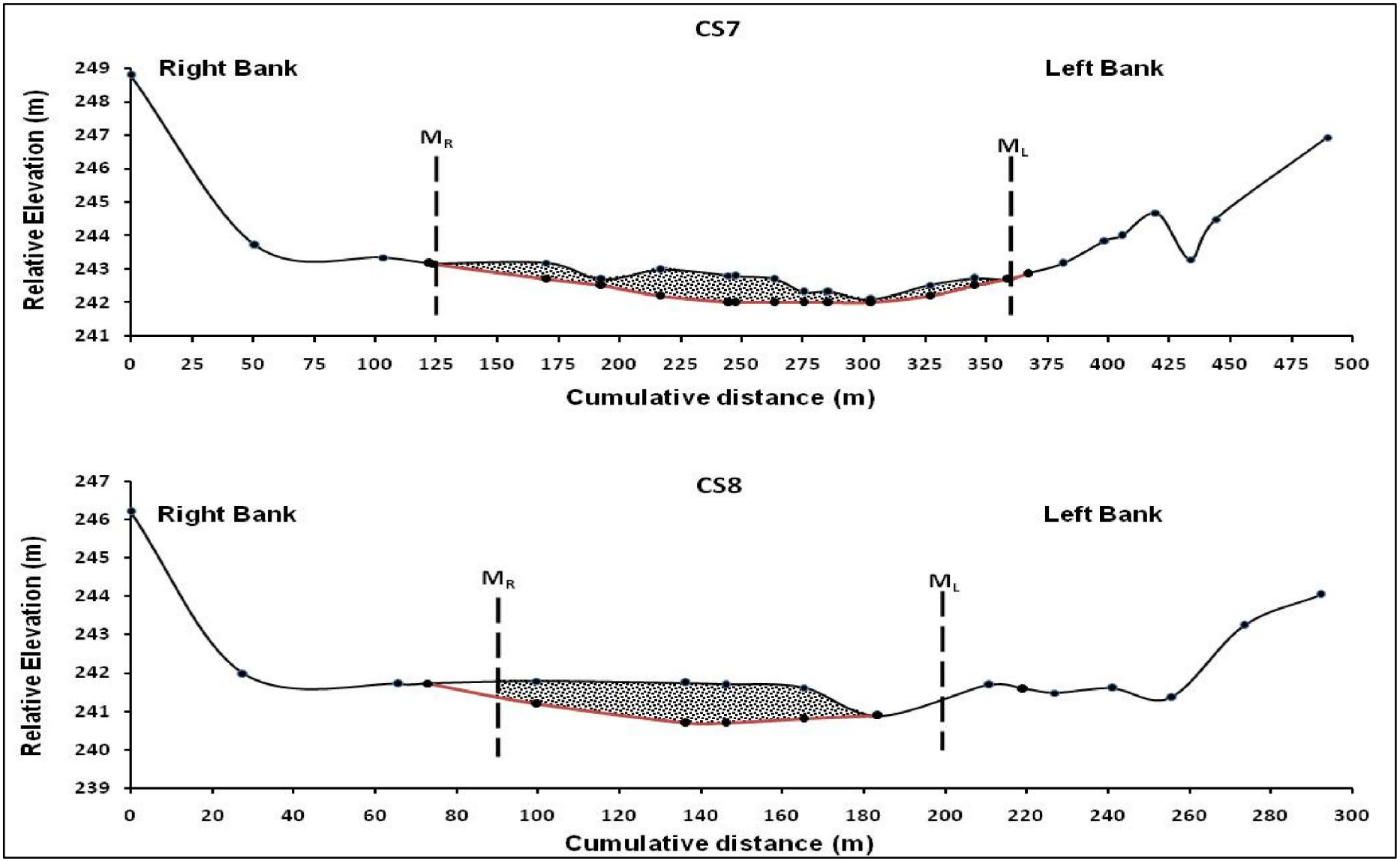
Cross-section 13			Cross-section 14		
Northing	**Easting**	**Elevation**	**Northing**	**Easting**	**Elevation**
1094.57	616.22	237.60	1038.35	601.72	232.12
1074.99	634.34	235.39	1018.82	619.92	229.60
1047.74	672.28	231.62	986.35	665.23	230.46
1030.15	685.74	231.38	965.57	679.40	229.84
1003.46	712.21	232.00	933.76	709.76	231.02
985.84	716.83	230.05	915.43	709.21	228.09
974.53	713.20	230.46	904.41	698.59	228.71
957.88	734.14	230.24	887.52	719.23	228.52
942.69	750.14	230.20	872.45	733.89	228.27
930.10	767.23	230.38	858.19	751.55	228.94
903.39	785.92	229.44	830.24	765.95	227.51
893.32	796.95	229.02	821.34	776.14	226.70
871.57	795.12	229.34	797.20	767.09	227.14
858.47	812.31	229.18	785.26	783.23	227.17
845.88	828.45	229.14	774.89	797.61	227.18
834.87	859.70	234.83	766.52	832.60	234.19
800.65	910.26	235.63			
780.57	920.66	237.57			
758.36	935.66	238.63			

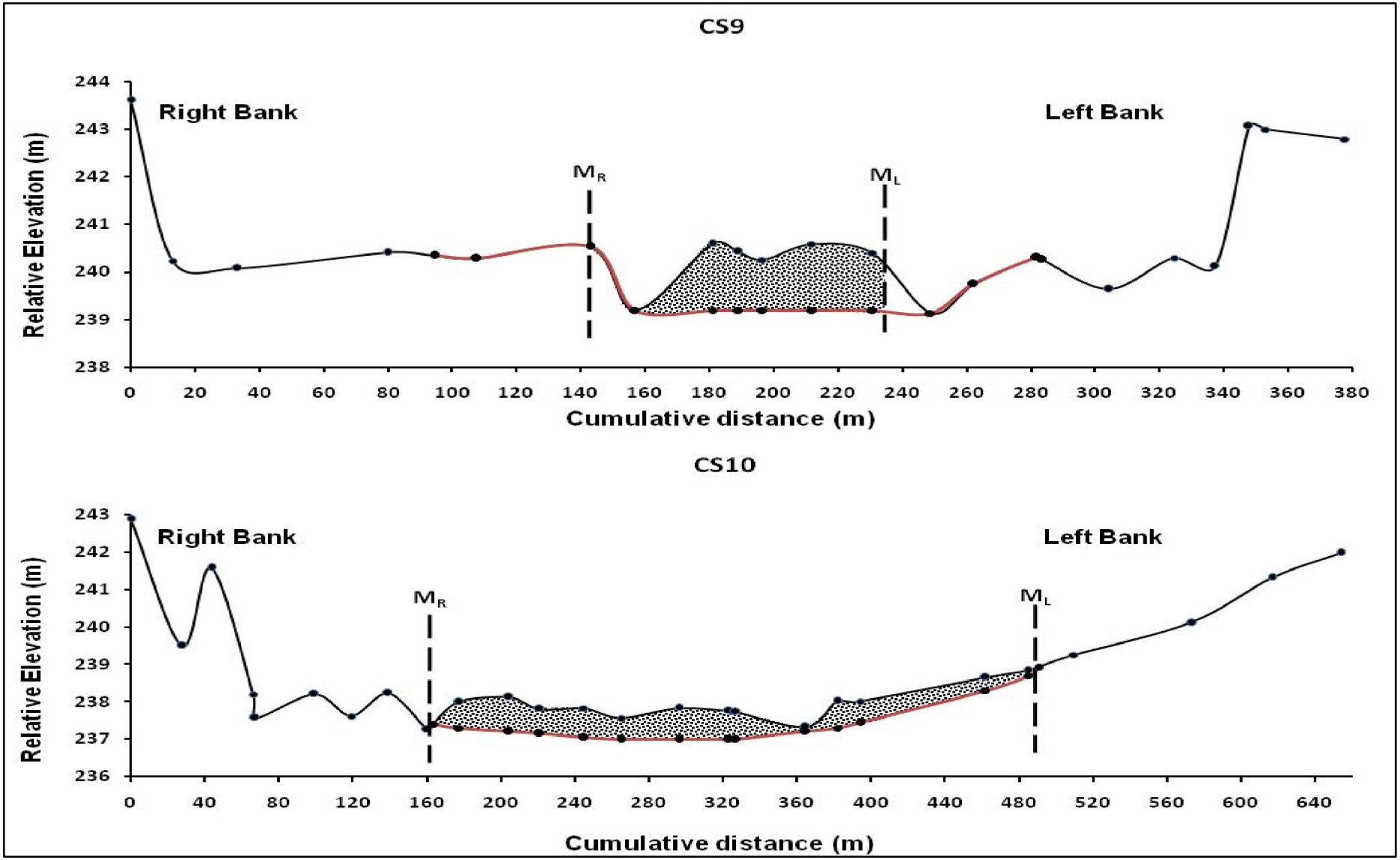
Note: All X & Y Coordinates are arbitrary **(with Inst at 1000,1000)** while Z coordinate is as per GPS at Inst station

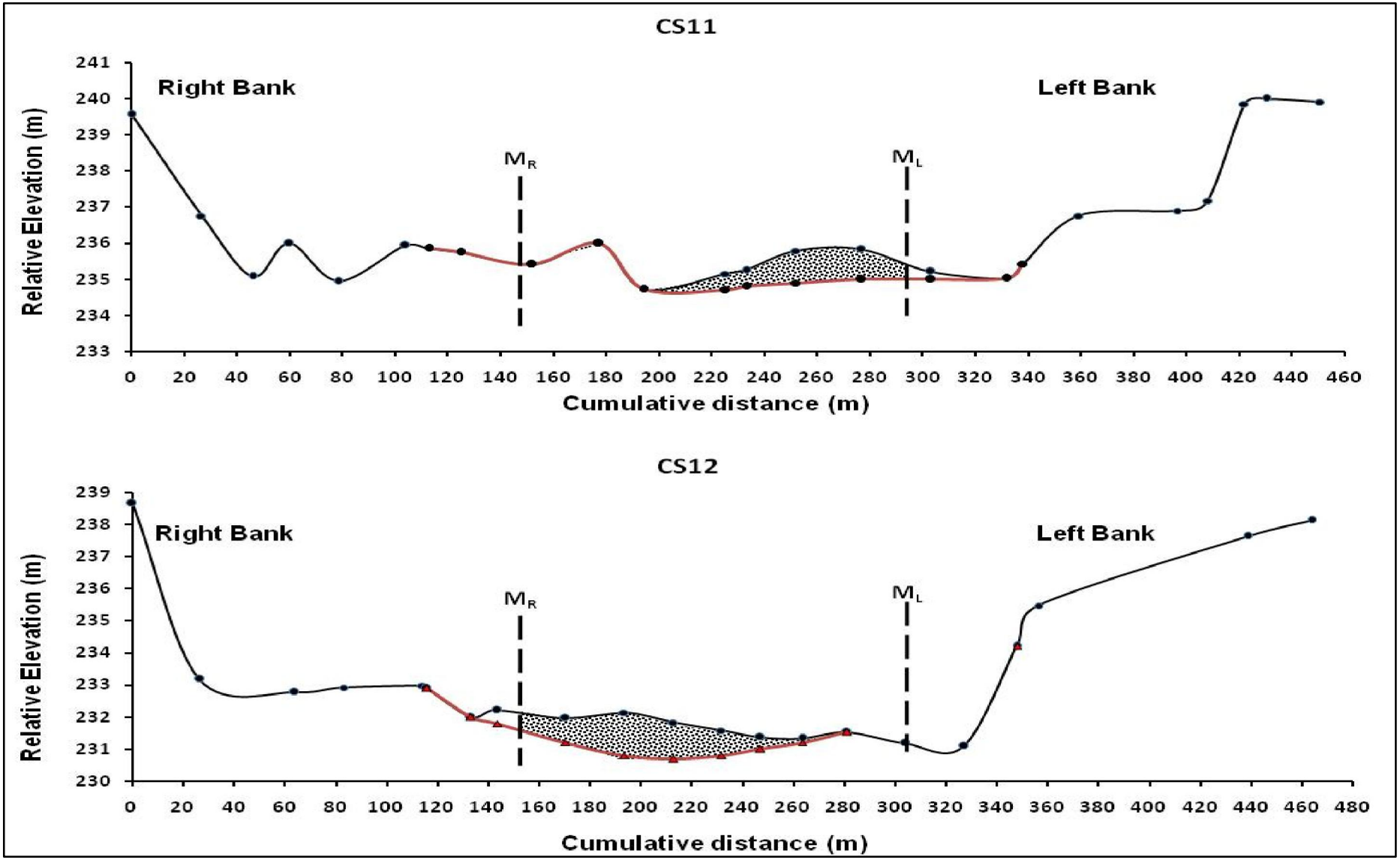

CS1
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
105
104
103
102
101
100
99
98
97
96
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580 600
Cumulative distance (m)
CS2
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
104
103
102
101
100
99
98
97
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500
Cumulative distance (m)


CS3
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
255
254
253
252
251
250
249
248
247
246
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580
Cumulative distance (m)
CS4
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
255
254
253
252
251
250
249
248
247
246
245
244
243
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480 500 520 540 560 580
Cumulative distance (m)


CS5
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
251
250
249
248
247
246
245
244
243
0 40 80 120 160 200 240 280 320 360 400 440 480 520 560 600 640 680
Cumulative distance (m)
CS6
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
249
248
247
246
245
244
243
242
241
0 40 80 120 160 200 240 280 320 360 400 440 480 520 560 600 640 680 720
Cumulative distance (m)


CS7
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
249
248
247
246
245
244
243
242
241
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350 375 400 425 450 475 500
Cumulative distance (m)
CS8
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
247
246
245
244
243
242
241
240
239
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300
Cumulative distance (m)


CS9
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
Cumulative distance (m)
CS10
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
Cumulative distance (m)


CS11
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
241
240
239
238
237
236
235
234
233
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460
Cumulative distance (m)
CS12
Right Bank
Left Bank
M_R
M_L
Relative Elevation (m)
239
238
237
236
235
234
233
232
231
230
0 20 40 60 80 100 120 140 160 180 200 220 240 260 280 300 320 340 360 380 400 420 440 460 480
Cumulative distance (m)

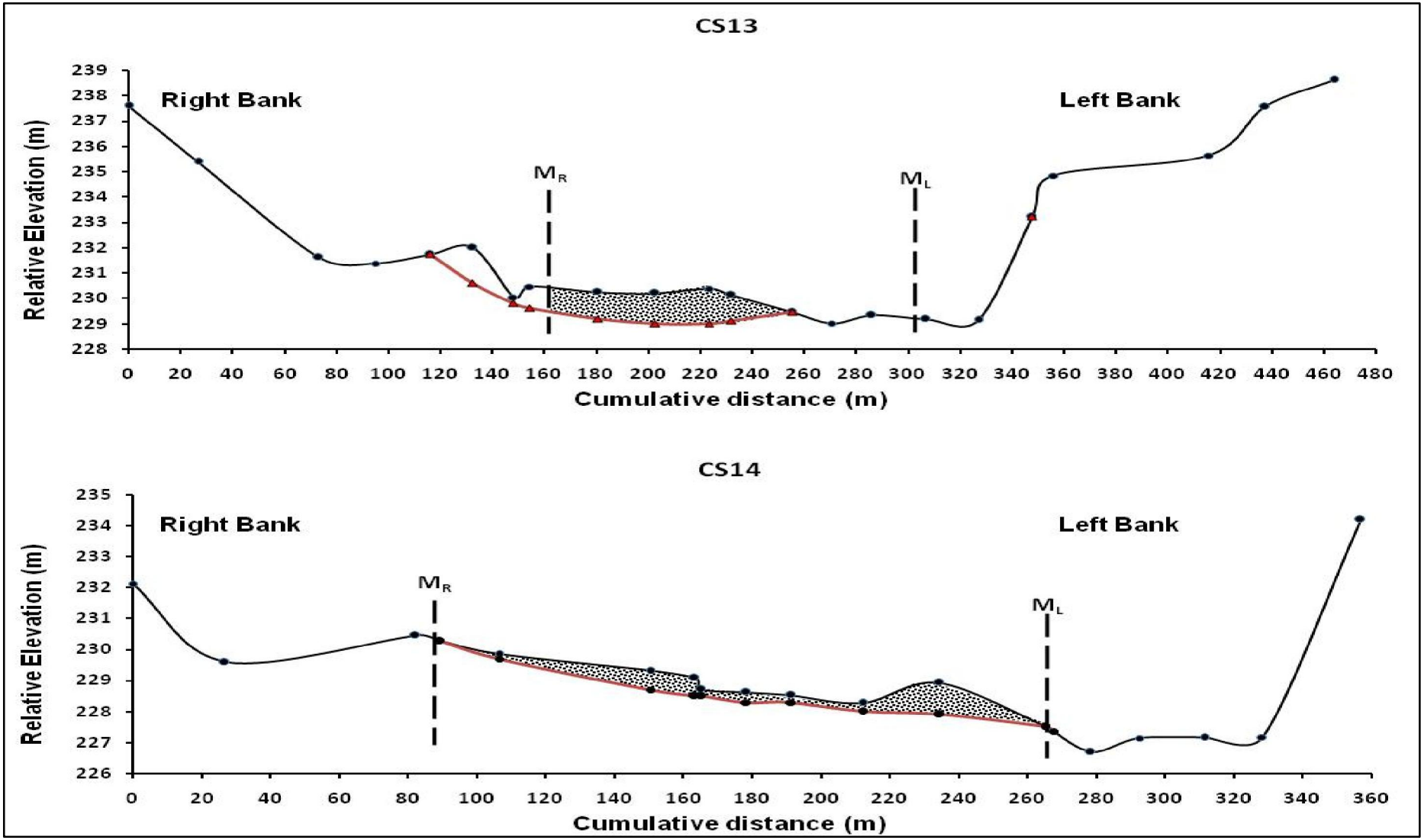


Fig. 5: Cross-section of river Kosi -DabkaII, Ramnagar at different locations showing the extractable RBM

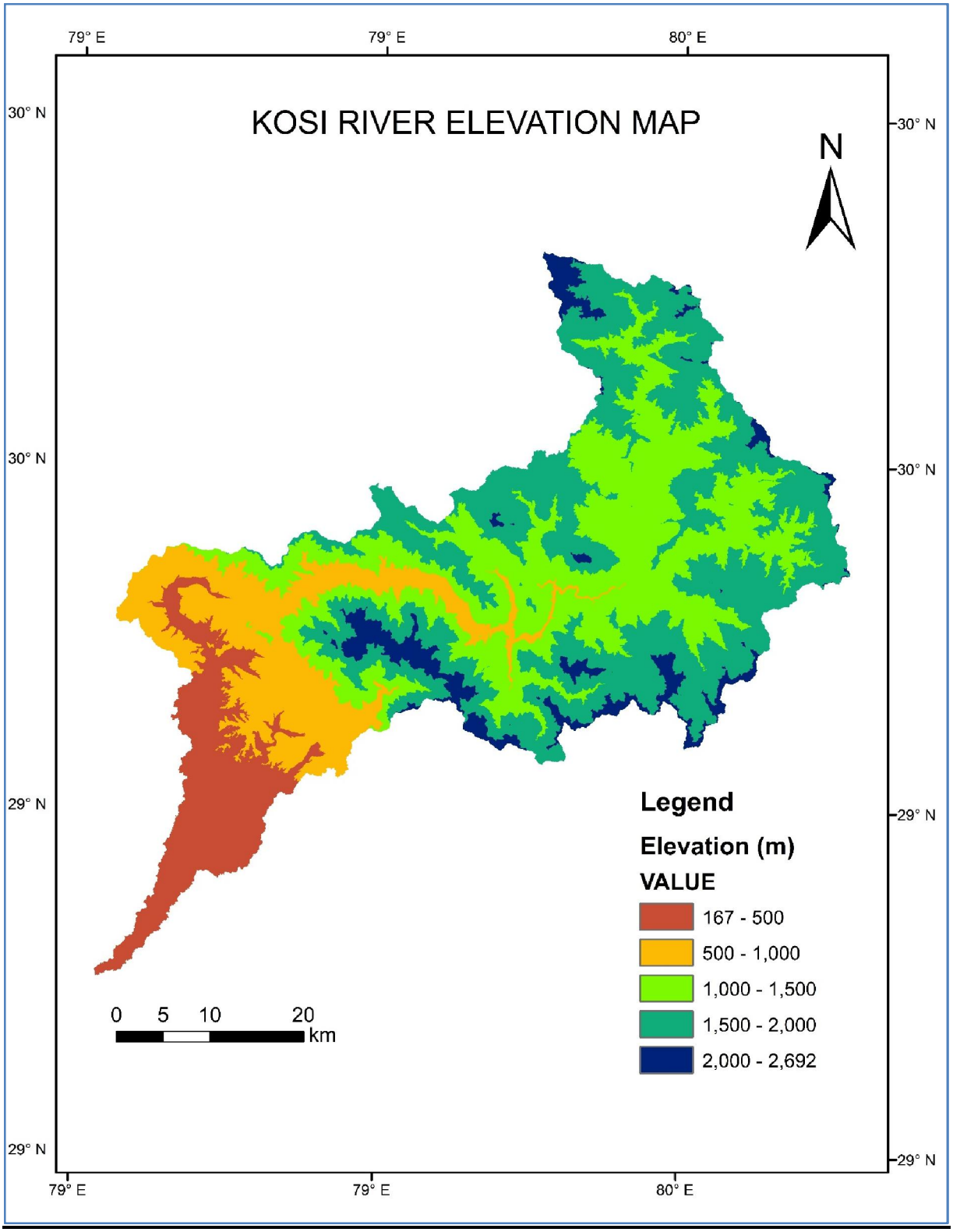
KOSI RIVER BASIN MAPPING DETAILS

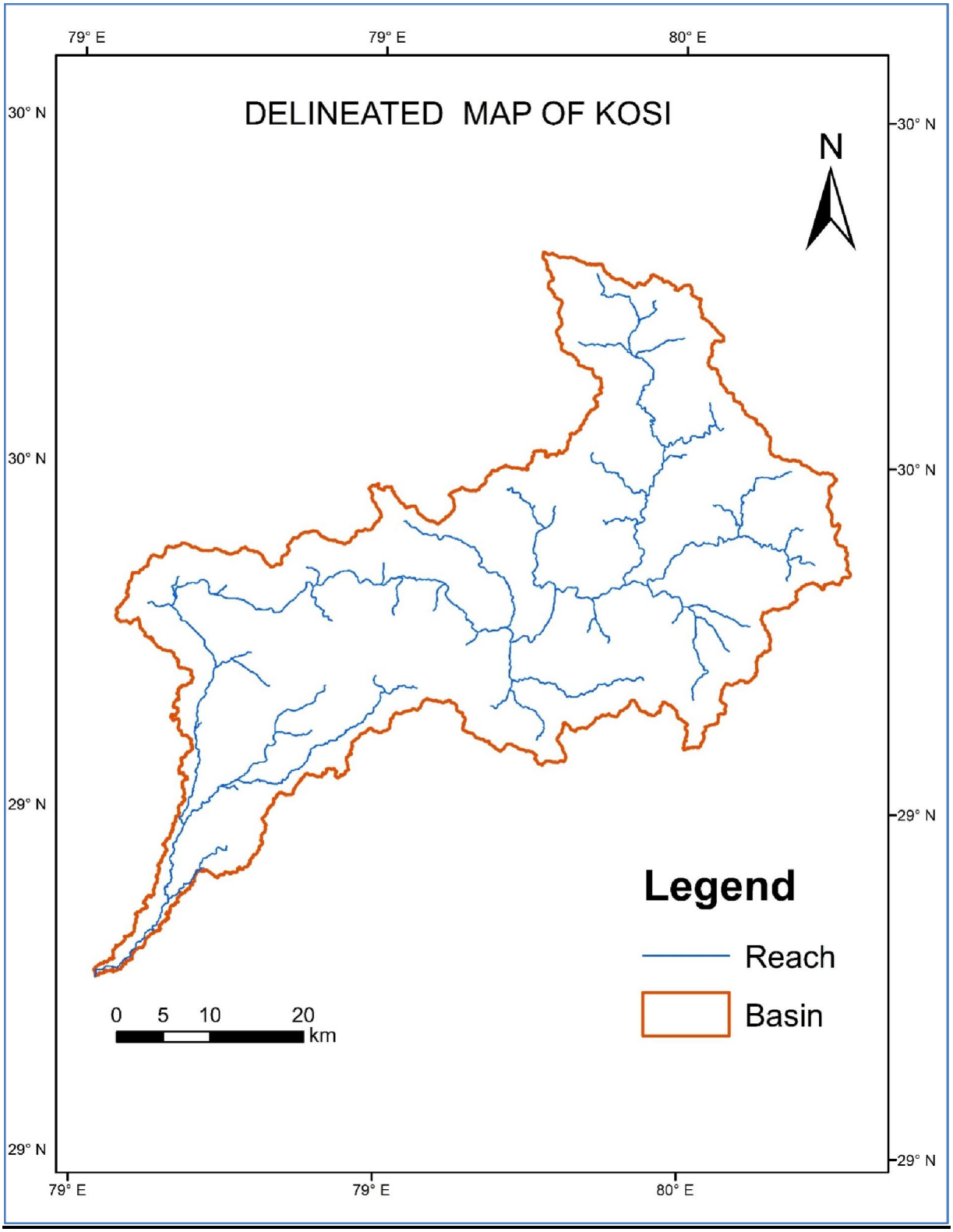
BASIN DETAILS:

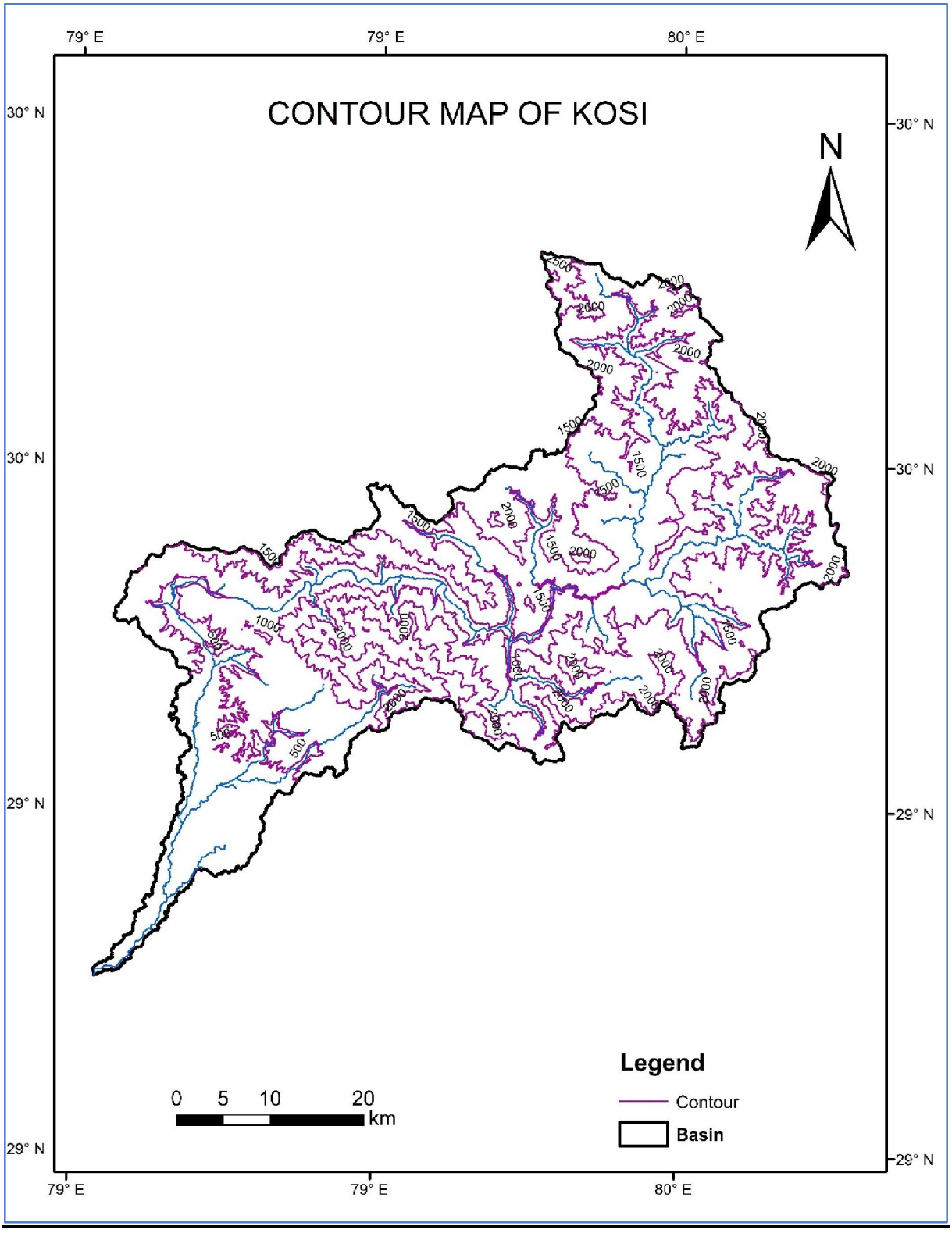
BASIN AREA, ha	222572.46875
BASIN PERIMETER, km	514.025
Longitude	79.026 E to 79.854 E
Lattitude	29.168 N to29.873 N

AREA (ha) UNDER DIFFERENT ELEVATION RANGE:

1. 167-500 m	25248.05 ha
2. 500.01- 1000 m	34003.23ha
3. 1000.01-1500 m	69873.56ha
4. 1500.01-2000 m	81190.08ha
5. 2000.01-2692 m	12256.52ha


KOSI RIVER ELEVATION MAP
N
79° E
79° E
80° E
30° N
30° N
29° N
29° N
0 5 10 20
km
Legend
Elevation (m)
VALUE
167 - 500
500 - 1,000
1,000 - 1,500
1,500 - 2,000
2,000 - 2,692


DELINEATED MAP OF KOSI
N
79° E
79° E
80° E
30° N
30° N
29° N
29° N
Legend
Reach
Basin
0 5 10 20
km


CONTOUR MAP OF KOSI
N
79° E
80° E
30° N
29° N
0 5 10 20
km
Legend
Contour
Basin

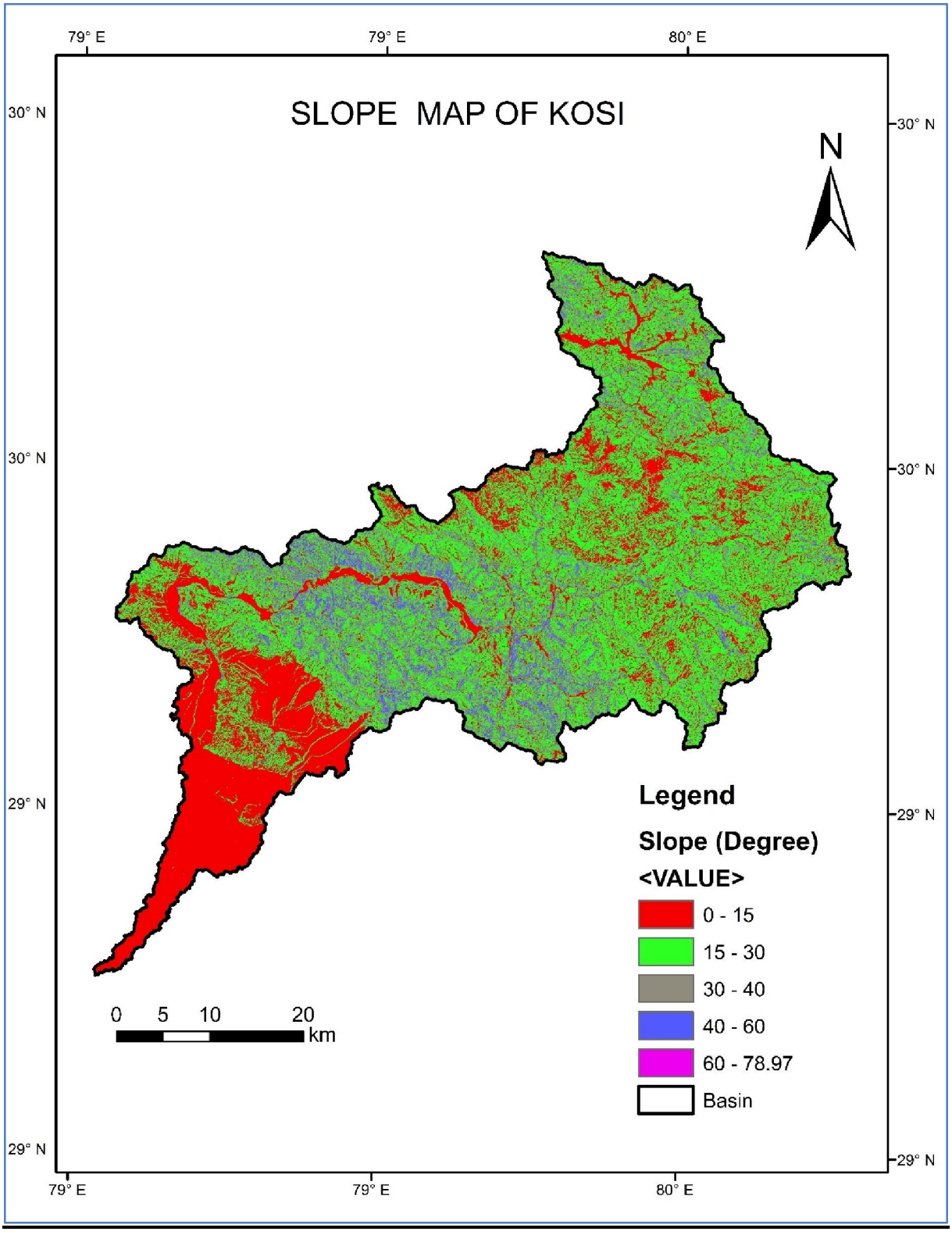
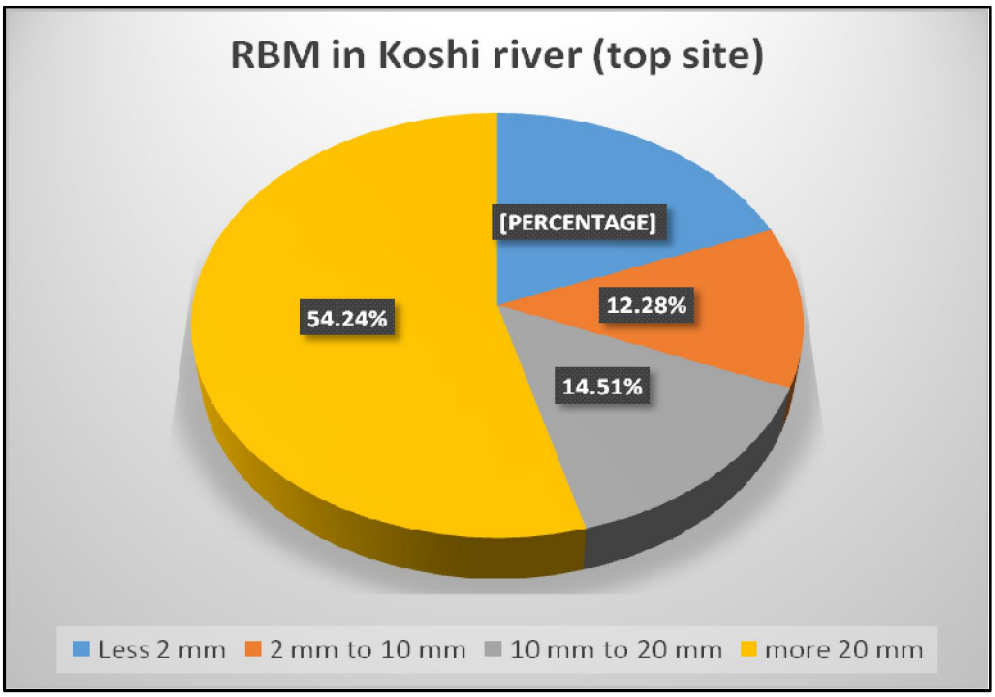
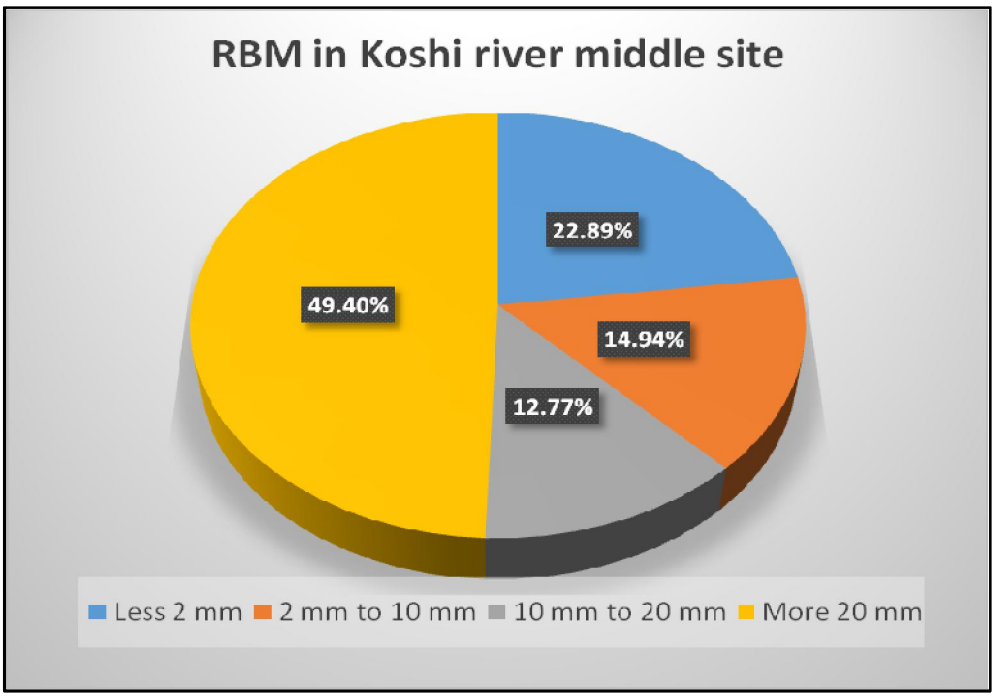

SLOPE MAP OF KOSI
N
79° E
80° E
30° N
29° N
0 5 10 20
km
Legend
Slope (Degree)
<VALUE>
0 - 15
15 - 30
30 - 40
40 - 60
60 - 78.97
Basin

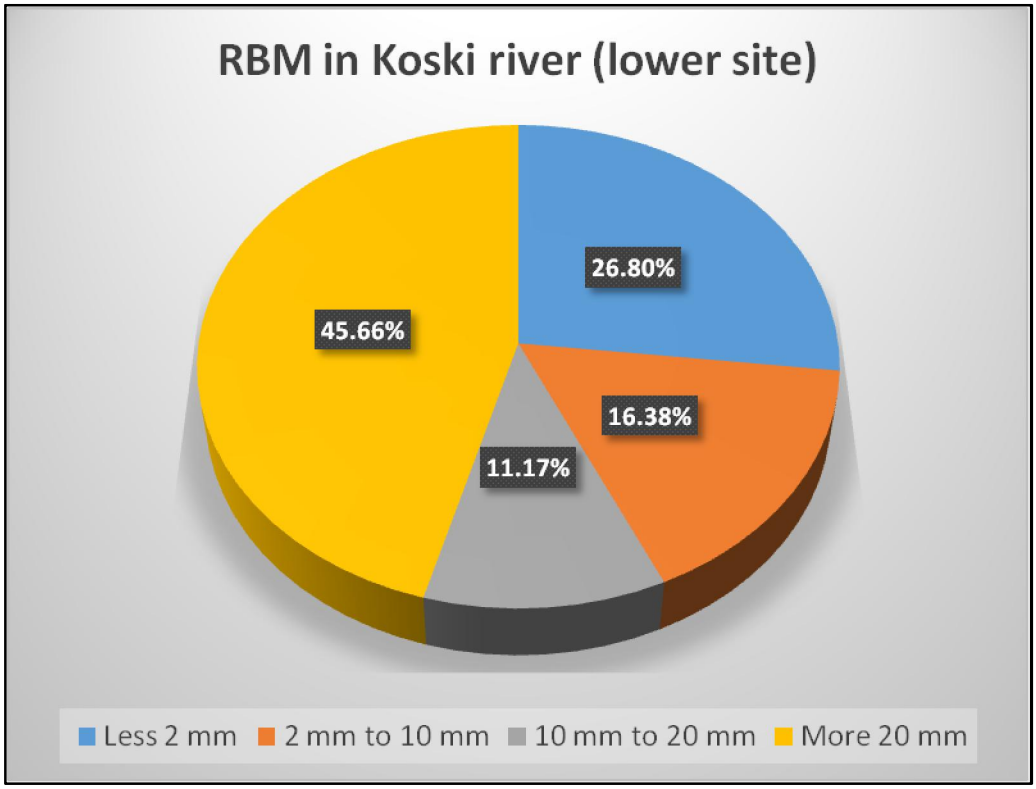
Photo : Survey of river Kosi - DabkaII for RBM estimation

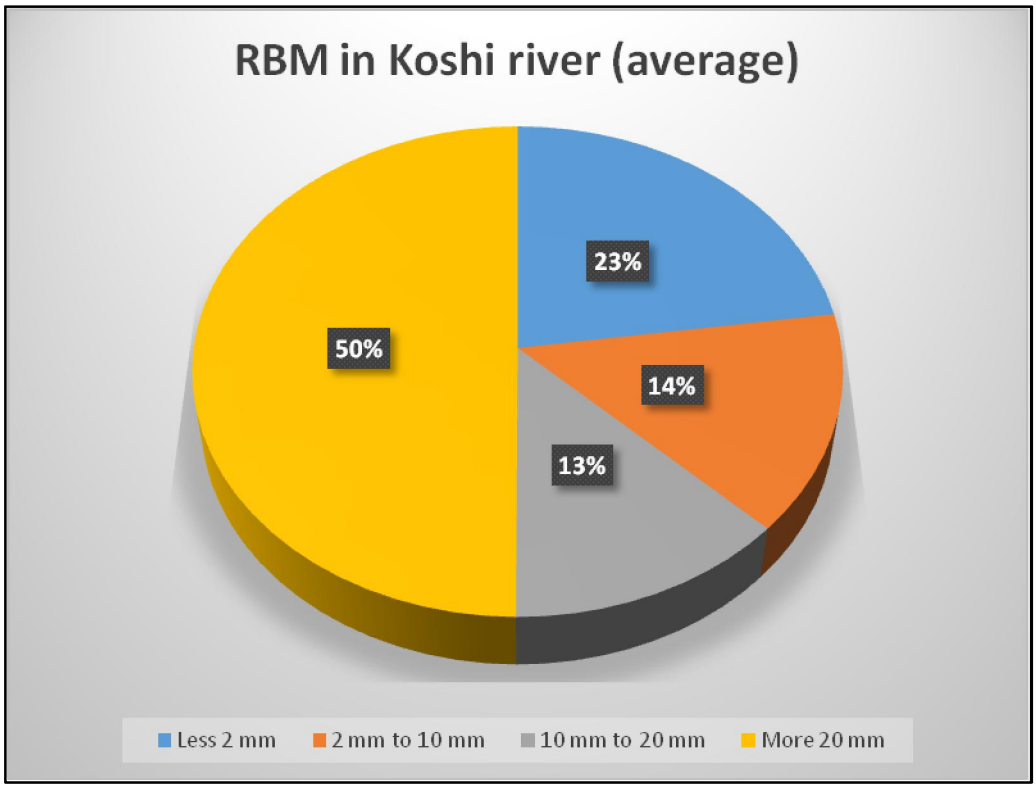
Photo ; Deposition of RBM in the surveyed river reach

Photo : Constituents of RBM


RBM in Koshi river (top site)
[PERCENTAGE]
12.28%
14.51%
54.24%
Less 2 mm
2 mm to 10 mm
10 mm to 20 mm
more 20 mm


RBM in Koshi river middle site
22.89%
14.94%
12.77%
49.40%
Less 2 mm
2 mm to 10 mm
10 mm to 20 mm
More 20 mm


RBM in Koski river (lower site)
26.80%
16.38%
11.17%
45.66%
Less 2 mm
2 mm to 10 mm
10 mm to 20 mm
More 20 mm


RBM in Koshi river (average)
23%
14%
13%
50%
Less 2 mm
2 mm to 10 mm
10 mm to 20 mm
More 20 mm