



REPORT

ON



ASSESSMENT OF EXTRACTABLE RIVER BED MATERIAL FROM RIVER CHANDRABHAGA AT TEHRI DISTRICT FOR THE YEAR 2019-20

FOR

**Divisional Logging Manager (Khanan), Uttarakhand Forest
Development Corporation, Dehradun (Uttarakhand)**



BY

**Er. S S Shrimali
Dr. P R Ojasvi
Er. S.K. Sharma
Er. C.S. Tiwari
Sh H S Bhatia
Er. Amit Chauhan
Sh. Ashok Kumar**

ICAR-Indian Institute of Soil and Water Conservation,
(INDIAN COUNCIL OF AGRICULTURAL RESEARCH)
218, KAULAGARH ROAD, DEHRADUN-248 195 (UTTARAKHAND)
(June, 2020)



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EXECUTIVE SUMMARY

A study was undertaken by ICAR- Indian Institute of Soil and Water Conservation (Formerly CSWCRTI), Dehradun (Uttarakhand) under a consultancy project sponsored by Divisional Logging Manager (Khanan), Uttarakhand Forest Development Corporation, Dehradun (Uttarakhand) on “**Assessment of extractable river bed material from river Chandrabhaga at Tehri District for the year 2019-20**” in the defined reach of the river.

Based on the survey, assessment of the sediment deposits it is assessed that the safe limit for extraction / removal of deposited river material from Chandrabhaga is **462375.97m³**. This quantity has been arrived upon considering that hydrological profile of the river flow is guided to the centre of the river so as to minimize risk of stream bank erosion.

The following recommendations for future are also made for the assessment of permissible quantity of RBM to be made from the river and the methodology of extraction to be followed so as to maintain the hydrological profile of the river along with the extraction of the RBM.

1. As the method and depth of extraction of RBM to be made will depend upon the pattern and quantity of RBM deposited during the monsoon, hence the quantity of RBM extraction is to be estimated by surveying the river preferably before the monsoon (after extraction of RBM is over i.e. in the month of June) and after the monsoon is over (before the extraction of RBM starts i.e. in the month of November/ December).
2. The extraction duration of RBM in the seasonal river **Chandrabhaga** may be kept from January to May.
3. The very big boulders in the river should not be removed from the junction of the hilly area and plain area as these big boulders serve for dissipating the energy of the flowing water.
4. The extraction may be carried out as per the methodology explained in the report and the concerned authorities responsible for extraction may please be communicated accordingly.
5. As explained to the staff present during survey, permanent pillars on both sides of the river at every one kilometer of length may be erected as permanent bench post. Further the pillars constructed to demarcate width of extraction leaving 25 % of river width from the bank may be erected with a depth of 1.5 m below the ground and 1.2 m above

the ground. Probably this may not be carried over by river during monsoon and hence reduce the periodical construction of pillar every year. However this year only 5-6 such pillars may be erected to observe its stability. While erecting the pillar, the corner of the pillar may face upstream.

6. The four pillars are to be constructed to help in confining the extraction of RBM may please be marked from the right hand side of the river to the left hand side of the river as 1/1, 1/2, 1/3, and 1/4 starting from zero length of the river and then at the interval of about 1 Km distance in the river length till the last of the river reach up to which the extraction of RBM is made. These will serve as the permanent bench mark for the survey of the cross section.

Consultancy Project

on

“Assessment of extractable river bed material from river Chandrabhaga Tehri District for the year 2019-20”

Under Divisional Logging Manager (Khanan), Uttarakhand Forest Development Corporation, Dehradun (Uttarakhand)

Introduction

The mountain river, specially of Himalayas, bring down huge quantity of land mass broken into clay, silt, sand and boulders of various sizes (small gravels to very big stones weighing in tones) while traveling with high velocity on the steep slopes of the stream/river. The heavy material (small gravels and stones) roll over the stream surface and get deposited while coming to the foot hills with mild slope due to reduction in the velocity. The coarse / fine particle like sand, silt and clay are further carried and get deposited in mild slopping areas where the velocity further reduces. The very fine clay particle, which remain in suspension are further carried to the sea through river and get deposited in the plains during overflowing of the river.

The heavy and coarse material when gets deposited in the foothills (plain river bed with mild slope), it obstructs the subsequent flow of water carrying more land mass material. This results in change of river course to the sides. This process continues and the river encroaches to either side of the river thus increasing the total width of the river though the actual flow width is much less. Further the encroachment on either side also damages/destroys the valuable property/plantation/agriculture lying there and hence needs some management practices to avoid such phenomena. Sometimes the river flows full of its width also thus accelerating the erosion of weak bank.

The extraction/removal of this erratic deposited material from these river beds periodically may maintain the course of river within prescribed banks/boundaries. However if the extraction/removal, is not carried out properly, may further aggravate the problem. The proper way to prevent a river from damaging the banks is to channelize/centralize the flow at the centre of the river bed. Hence a proper methodology needs to be followed while extracting/removing the deposited river bed material (RBM) from the river bed. In view of

the source of construction material for various civil works and revenue to the Government it is not advisable to promote the excessive & unscientific extraction from the river.

The ICAR-IISWC (Formerly CSWCRTI), Dehradun had undertaken a consultancy project during the year 2019-20 on “**Assessment of extractable river bed material from river Chandrabhaga at Tehri District for the year 2019-20**” at the request of the Divisional Logging Manager (Khanan), Uttarakhand Forest Development Corporation, Dehradun (Uttarakhand).

The river site was visited and surveyed during May, 2020 after post monsoon survey by Er. S S Shrimali, Sr. Scientist, Er. S.K Sharma, Chief Technical Officer, Er. C. S. Tiwari, Asst. Chief Technical Officer, Sh. HS Bhatia, Technical Officer and Mr. Ashok Kumar, Chief Technical Officer of ICAR-IISWC, Dehradun along with the officials of Forest Corporation, for detailed field survey.

Objectives of the study

The study has been conducted with the following objectives:

1. Study of the hydrological profile of River Chandrabhaga (for the defined river reach) with respect to the extraction of river bed material
2. Estimation of permissible extraction of river bed material (RBM) for the year 2019-20

Description of River Chandrabhaga

The geographic location of the Chandrabhaga River Catchment extends from 30.11°N to 30.26°N Latitude and 78.14°E to 78.24°E longitude. A total area of the watershed is about 6832.89ha (Fig. 3) Topography of the area exhibits distinct variation and contains moderate slope to surround by steep hills and rugged land features. Thus, catchment can be divided into a narrow steep upper catchment draining the flanks of Mount Himalayas range, and the remainder on relatively flat plateau sloping gently..Elevation ranges between 314m and 2078m The nature of the topographical features has made the area very liable to heavy gully formation and extensive soil erosion. Chandrabhaga river is a tributary of the Ganga River meeting near *Triveni ghat* at *Rishikesh*..

Collection and analysis of basic information

A. Preparation of watershed map

Assessment of drainage pattern and their quantitative analysis provides background information about the hydrological conditions and nature of rock formation exposed within the watershed. To carry out the present work, Alos Polarsar (12.5 m spatial resolution) satellite dem (digital elevation model) data is used.

The extracted data was filled for avoiding any gap in the existing data by using fill tool in ARC GIS Platform. Further flow accumulation and flow direction raster were prepared. Using ARC SWAT automatic delineation tool and by the defined outlet, the whole watershed was delineated. The stream network and sub watershed boundary were demarcated. Area, perimeter, maximum and minimum elevation, latitude and longitude of each sub watershed and Chandrabhaga watershed were found out. Area of Chandrabhaga watershed is 6832.891 ha and it has 23 sub-watersheds (Fig 4 to 7).

B. Preparation of Slope map

Slope is the measure of change in surface value over distance and can be expressed in degrees or as a percentage. In a raster format, the Digital Elevation Model (DEM) is a grid where each cell is a value referenced to a common datum. For extraction of elevation from remote sensing dedicated software packages are required but most GIS packages have routines for point or contour line interpolation. Any two points on the grid will be sufficient to ascertain a slope. Once the slopes have been calculated, then the maximum difference can be found and the gradient can be determined. In the present write-up topographical elevation map for the study area was developed by Digital Elevation Model (DEM) extracted from the POLSAR data. For this, the DEM was subjected to two directional gradient filters (one in x-direction and another in y direction). The resultant maps were used to generate a slope map of the study area using ArcGIS Spatial Analyst tools (Fig. 8 & 9). The highest topographic elevations exist in the northeastern portions of the area which induces highest runoff and hence less possibility of rainfall infiltration. Further longitudinal section has been drawn after surveying the entire river reach under study using Total Station and GPS and observed a uniform slope of 1.2 percent (fig, 10). The contour map also indicates that the slope in the river width is almost gentle and flow pattern is also uniformly spreading in full width of the river (Fig.11).

Table 1a: Distribution of elevation into different classes

Sl. No.	Elevation (m)	Area (ha)
1	314-500	1265.414
2	500- 1000	2962.304
3	1000-1500	2207.96
4	1500-2000	393.027
5	2000-2078	3.962866

In the given watershed, maximum area is under 20-30 degree slope, followed by 30-40 degree slope and minimum area is under above 40 degree slope.

Table1b: Distribution of elevation into different classes

Sl. No.	Slope (°)	Area (ha)	Area (%)
1	0-10	1298.10	19.0
2	10-20	1132.01	16.6
3	20-30	2036.20	29.8
4	30-40	1774.81	26.0
5	40-74	590.88	8.6
Total		6832.00	

The RBM brought down from slopes of the catchment and getting deposited In order to channelize the river and keep the banks protected, the removal of the RBM is required. Further the RBM is also a very good construction material and fetches revenue. Hence instead of using the word removal the use of word extraction of RBM is more relevant. The river when coming down to mild slopes (along with RBM) from steep slopes dissipates its energy and thus deposits the RBM brought along with it. The heavy materials (boulders) are deposited first followed by small material (bajari and sand). The finer soil particles (slit and clay) are carried over further down.

Pits of 100*100*100/150 cm were got made at upper, middle and lower reaches for computing the constituents of boulders, bajari and sand at different reaches of the river. The proportions of the RBM recorded during the inspection are reported in Fig. 2 as Pie chart. The longitudinal and cross section survey of the River **Chandrabhaga** were carried out (Fig. 10) and the survey included the pre and post monsoon at the predefined grid points on the locations mentioned as the positional coordinates (UTM coordinates) 2019-2020 mentioned in the tables (Fig. 3)) cross sections taken at various locations. The total width of the river,

middle 50 percent of the width and the width from where the extraction can be made along with the depth of extraction of RBM is presented in Table 1-5 and Fig 1 (a&b).

Procedure of extraction of the RBM

It is recommended that the extraction may be undertaken of the portion shown between L_1L_1 and R_1R_1 within the middle half portion indicated between M_R & M_L in Fig. 1 (a). The depth of extraction may also be limited as shown in the cross section at different segments in Fig. 1(b). Further, the extraction may not be started just from the pillar constructed at right hand side leaving 25 percent from the river bank.

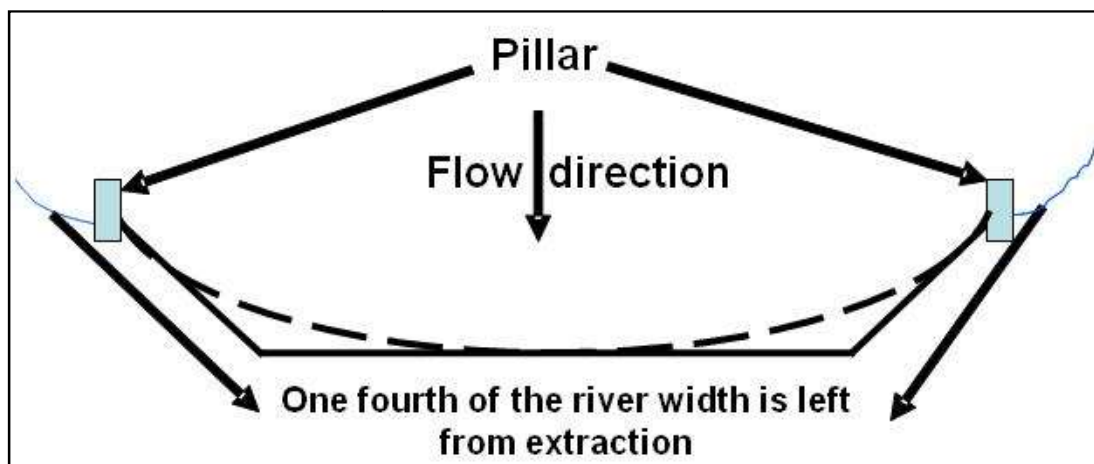


Fig. 1 (a): Procedure of extraction of river bed material

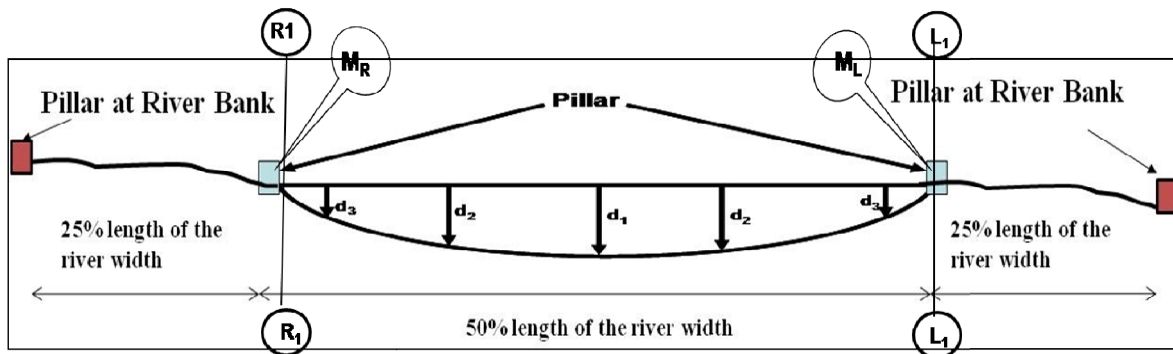


Fig1 (b): Anticipated shape of the river after proper extraction of river bed material

Methodology for assessment of cross section of extraction of RBM

It was suggested by the ICAR-IISWC, Dehradun through previous reports that the extraction / removal of the deposited RBM from these rivers be made leaving 25 % width of the river on either side of the river (Fig.1). The recommendation to restrict the flow to the middle half of the river was to ensure the stability of the river bank and also to rehabilitate the reclaimed area by suitable plantation etc. This would help in channelization and centralization of the river which is very much relevant from river training point of view. In absence of the periodically channelization / centralization of the river material deposited-foothills-river, the tendency of periodical flooding of the adjoining area on the river bank exists. It further accelerates the stream bank cutting also.

The extraction / removal of the deposited river material should be executed in a scientific manner which will help in channelization / centralization of the river flow. The maximum depth of cut should be from the middle of the river course and it should be nil at the boundary of the middle half of the river (Fig.1 (a)).

If this method is adopted, the river is likely to take a parabolic shape (Fig.1 (b)). It will not happen in a year or two but the extraction/removal like this for years may lead to this ideal situation. However the river material brought due to a heavy discharge in a particular year of long duration probability may hamper this. But this is what we need to do.

Recommendations

1. As the method and depth of extraction of RBM to be made will depend upon the pattern and quantity of RBM deposited during the monsoon, hence the quantity of RBM extraction will be estimated by surveying the river before the monsoon (after extraction of RBM is over i.e. in the month of June) and after the monsoon is over (before the extraction of RBM starts i.e. in the month of November/ December).
2. The extraction duration of RBM in the seasonal river Chandrabhaga may be kept from January to May.
3. The very big boulders in the river should not be removed from the junction of the hilly area and plain area as these big boulders serve for dissipating the energy of the flowing water.
4. The extraction may be carried out as per the methodology explained in the report and the concerned authorities responsible for extraction may please be communicated accordingly.
5. As explained to the staff present during survey and communicated in the earlier report and in this report as well, permanent pillars on both sides of the river at every one kilometer of length may be erected as permanent bench post. Further the pillars constructed to demarcate width of extraction leaving 25 % of river width from the bank may be erected with a depth of 1.5 m below the ground and 1.2 m above the ground. Probably this may not be carried over by river during monsoon and hence reduce the periodical construction of pillar every year. However this year only 5-6 such pillars may be erected to observe its stability. While erecting the pillar, the corner of the pillar may face upstream.
6. The four pillars constructed to help for confining the extraction of RBM may please be marked from the right hand side of the river to the left hand side of the river as 1/1, 1/2, 1/3, and 1/4 starting from zero length of the river and then at the interval of about 1 Km distance in the river length till the last of the river reach up to which the extraction of RBM is made. These will serve as the permanent bench mark for the survey of the cross section.

Acknowledgements

The project team is grateful to Dr. P.R. Ojasvi, Director, ICAR-IISWC, Dehradun for approving this project and providing necessary support and facilities. The team is thankful to Divisional Logging Manager (Khanan), Uttarakhand Forest Development Corporation, Dehradun (Uttarakhand) 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 Forest Corporation are thankfully acknowledged. The help rendered by Er Chandan Roy Technical Assistant, during survey and analysis is also appreciated.



(S.S. Shrimali)
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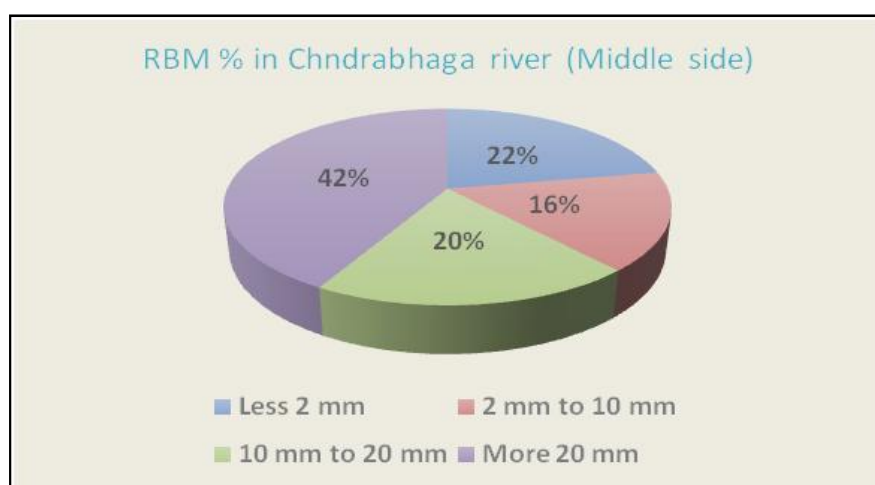
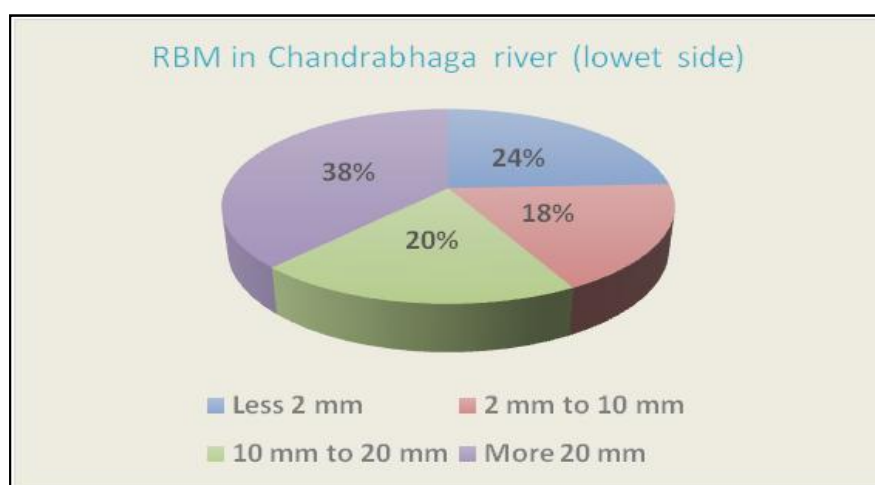
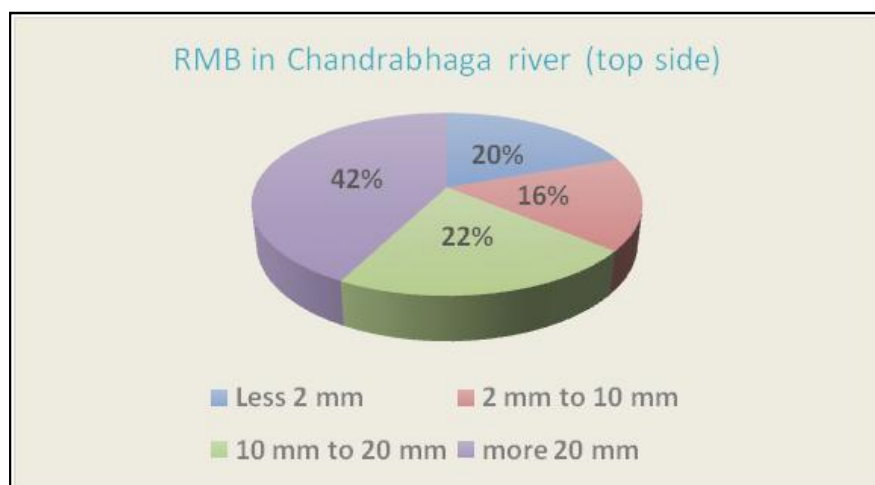


Fig. 2: RBM Constituents in river Chandrabahga



Fig. 3: Location of various cross-sections along the river Chandrabhaga

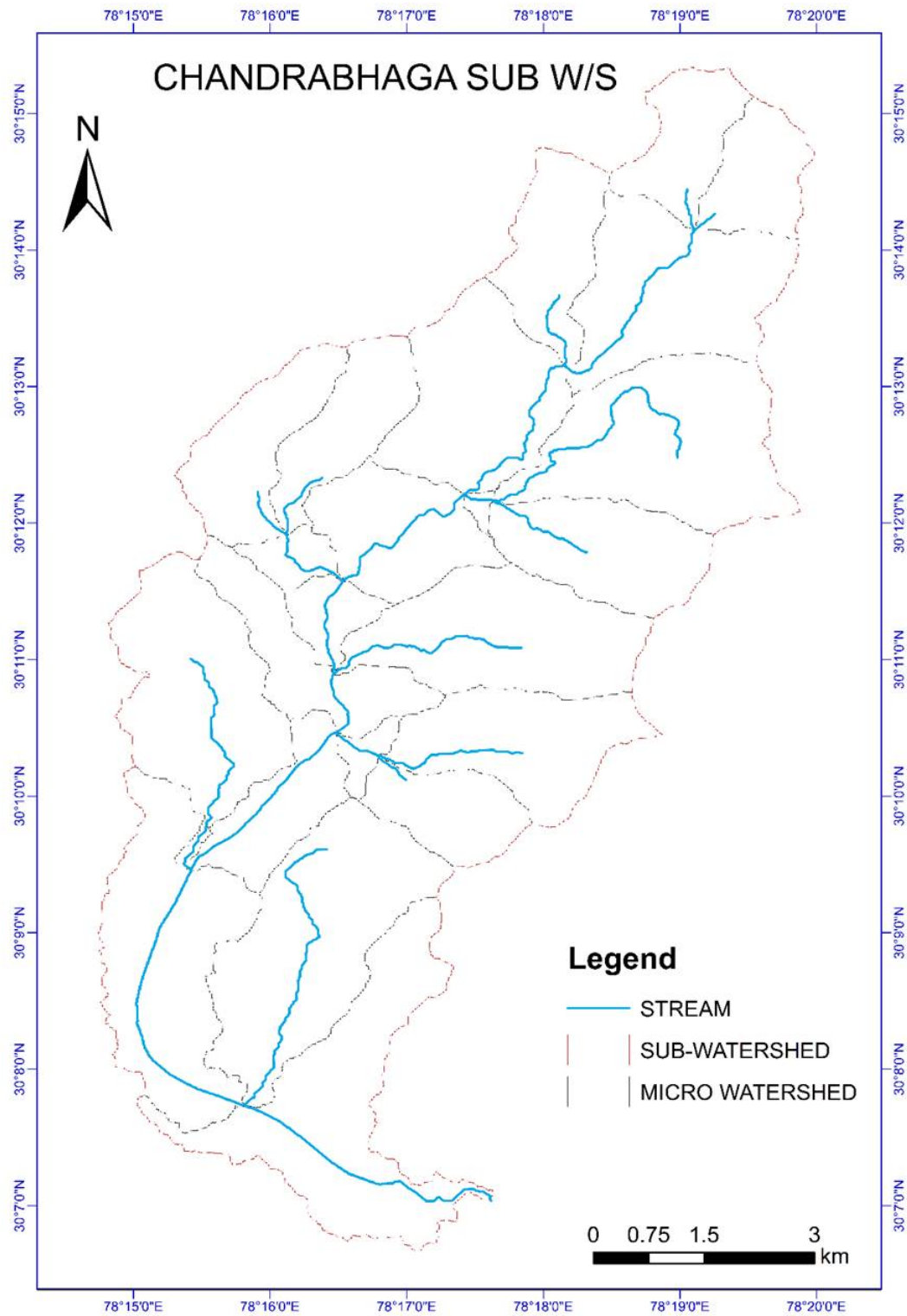


Fig. 4: Delineated boundary with stream network of Chandrabhaga sub watershed

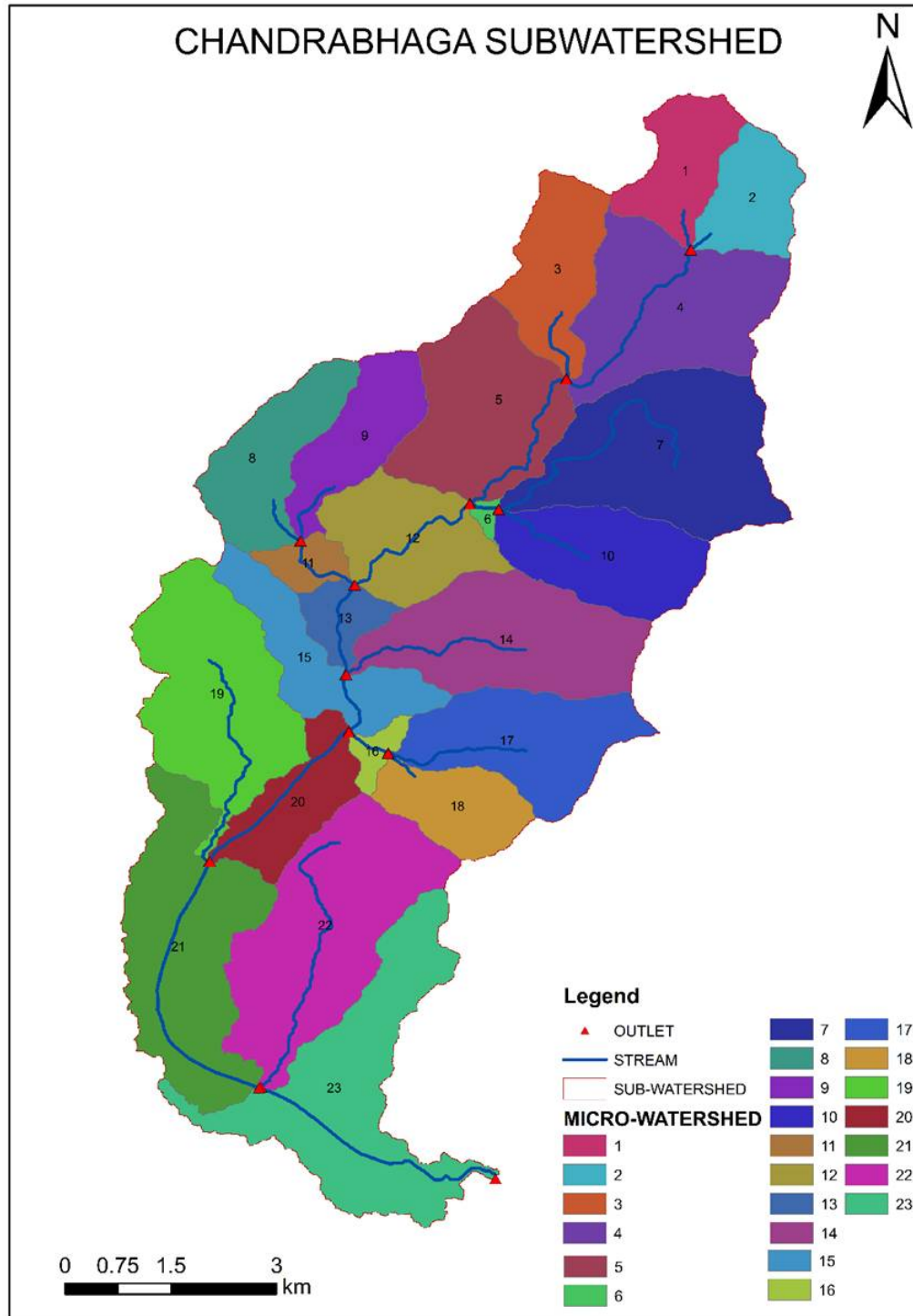


Fig. 5: Sub watershed details with outlet and stream network of Chandrabhaga sub watershed

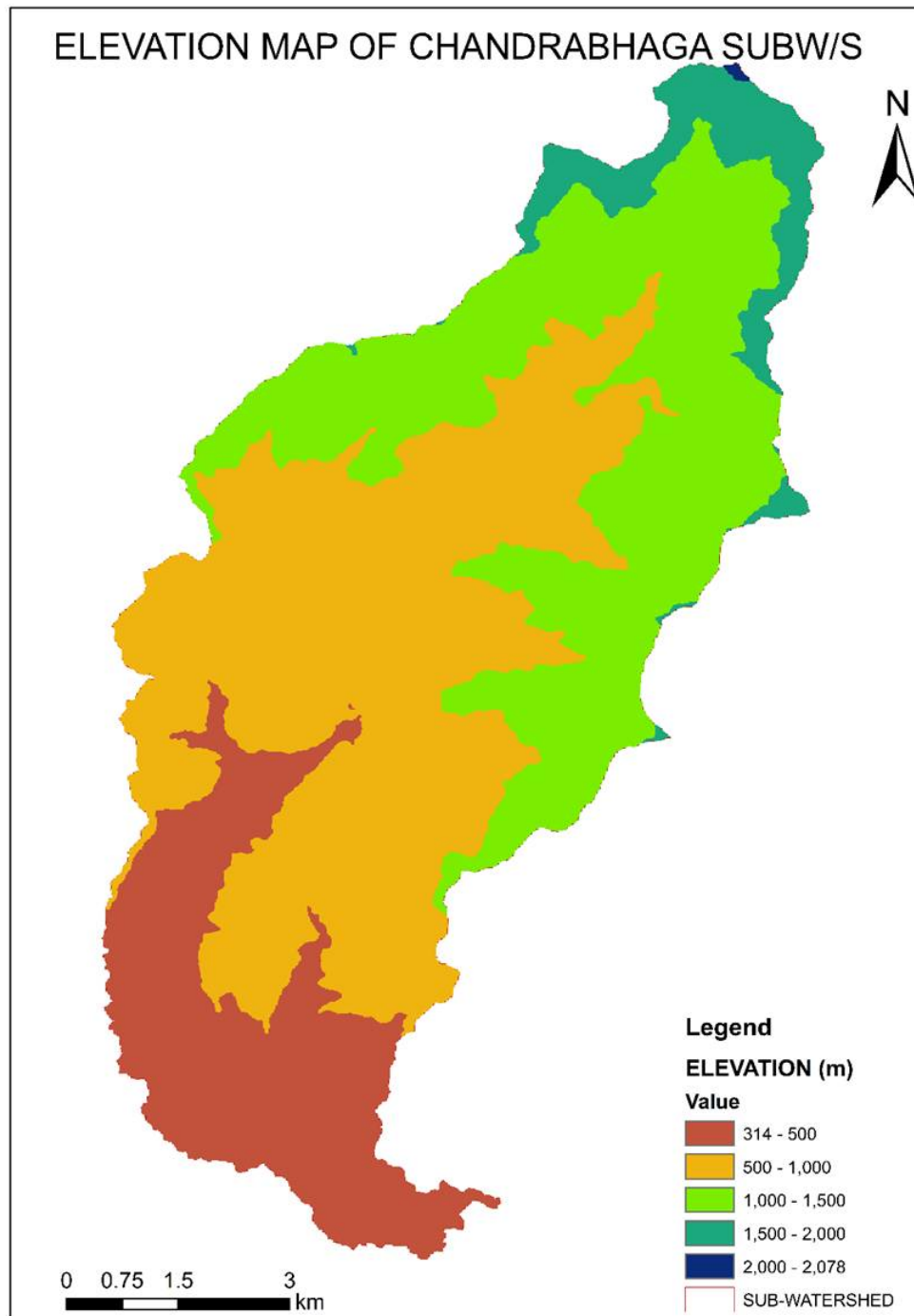


Fig. 6: Elevation map of Chandrabhaga sub watershed

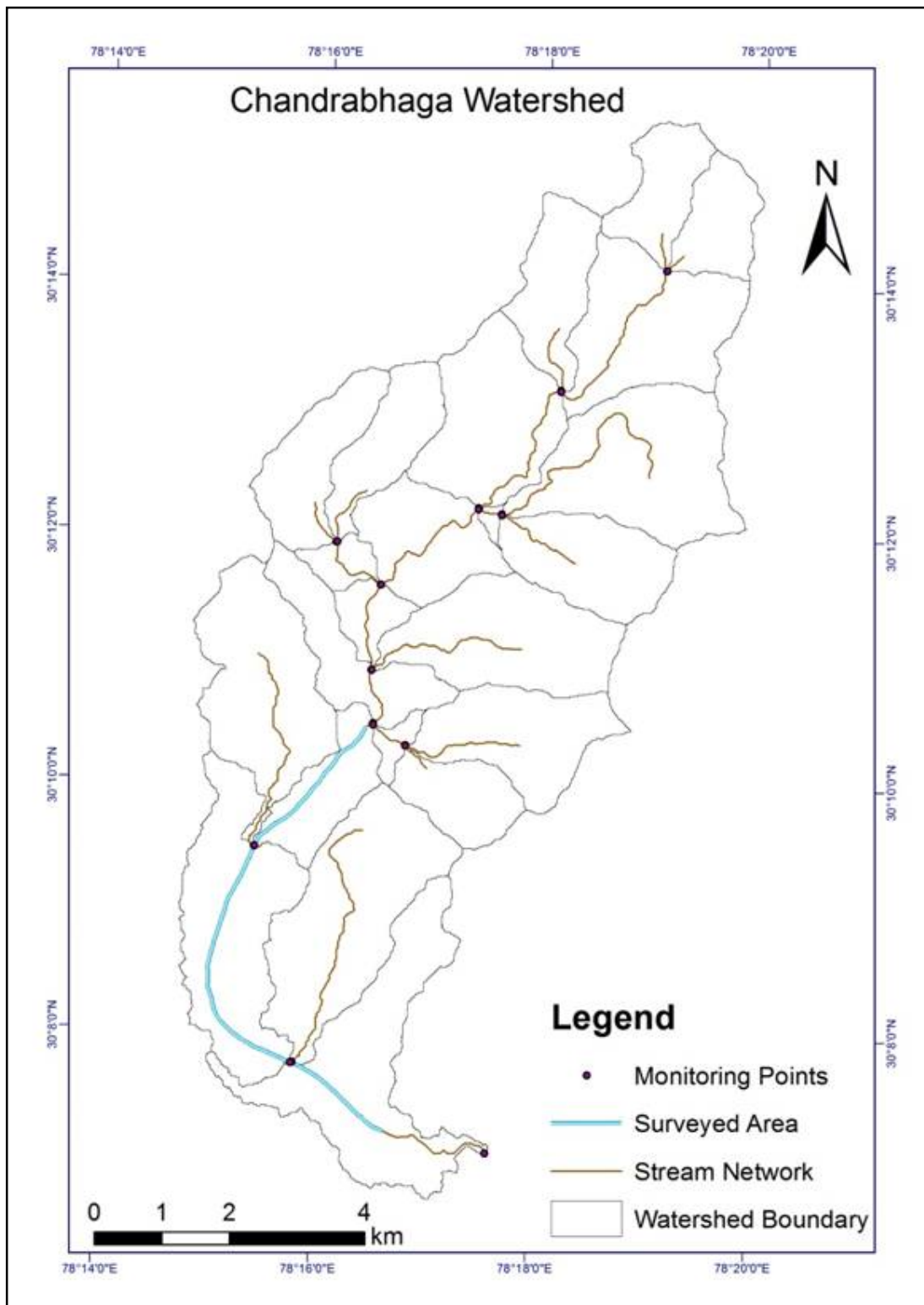


Fig. 7. Surveyed area for mining activity in Chandrabhaga sub watershed

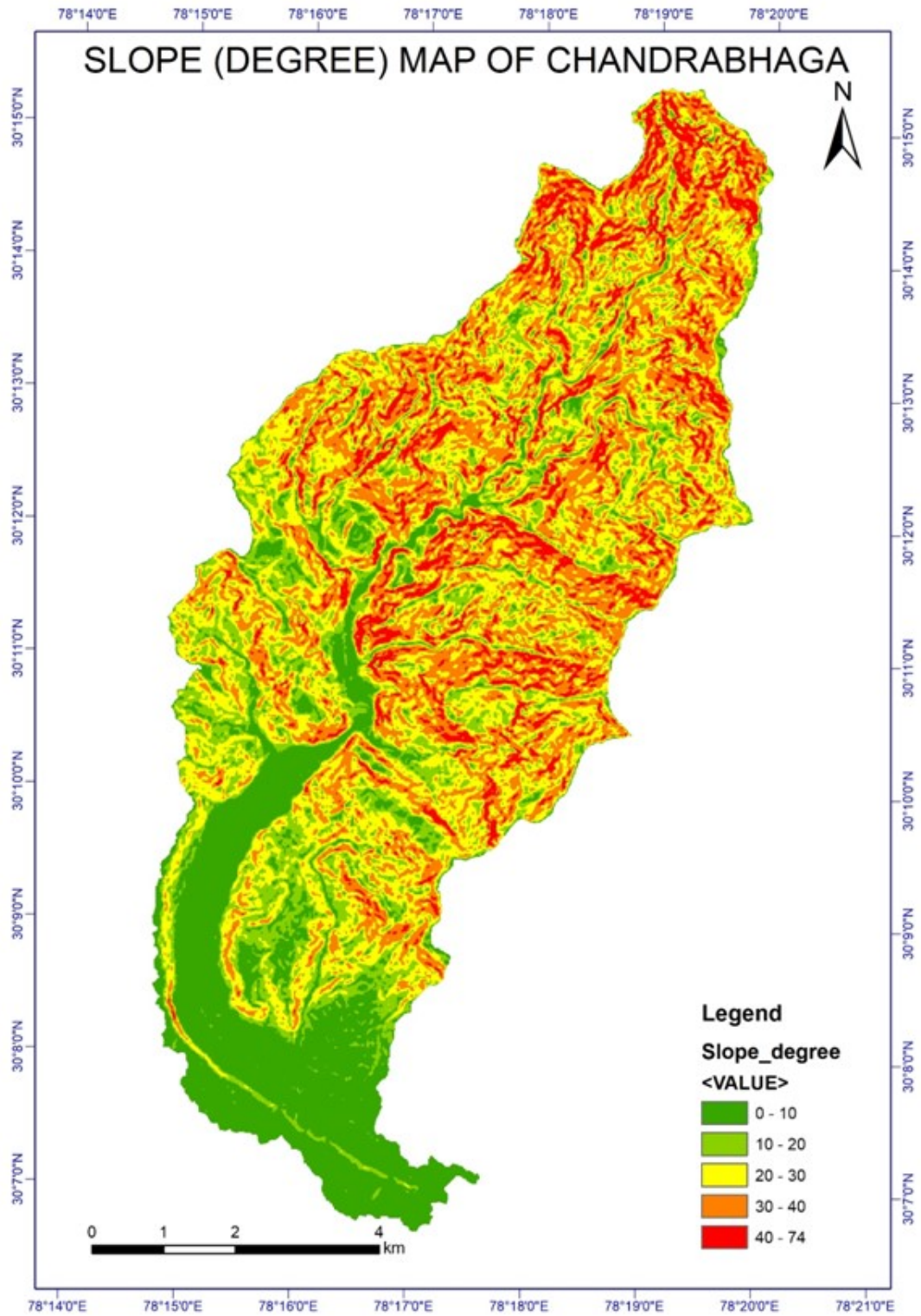


Fig. 8: Slope (in degree) map of Chandrabhaga

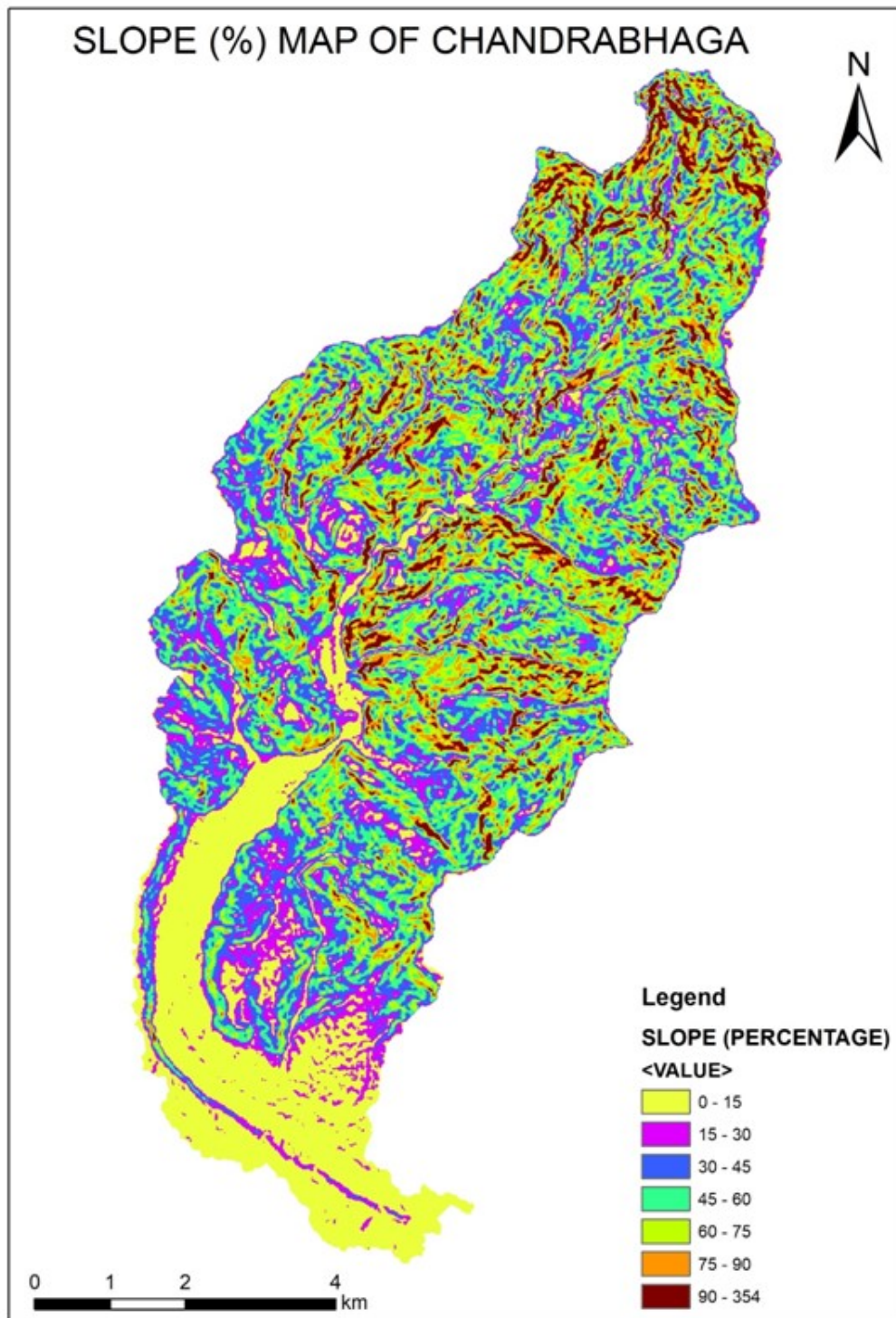


Fig. 9: Slope (in percentage) map of Chandrabhaga

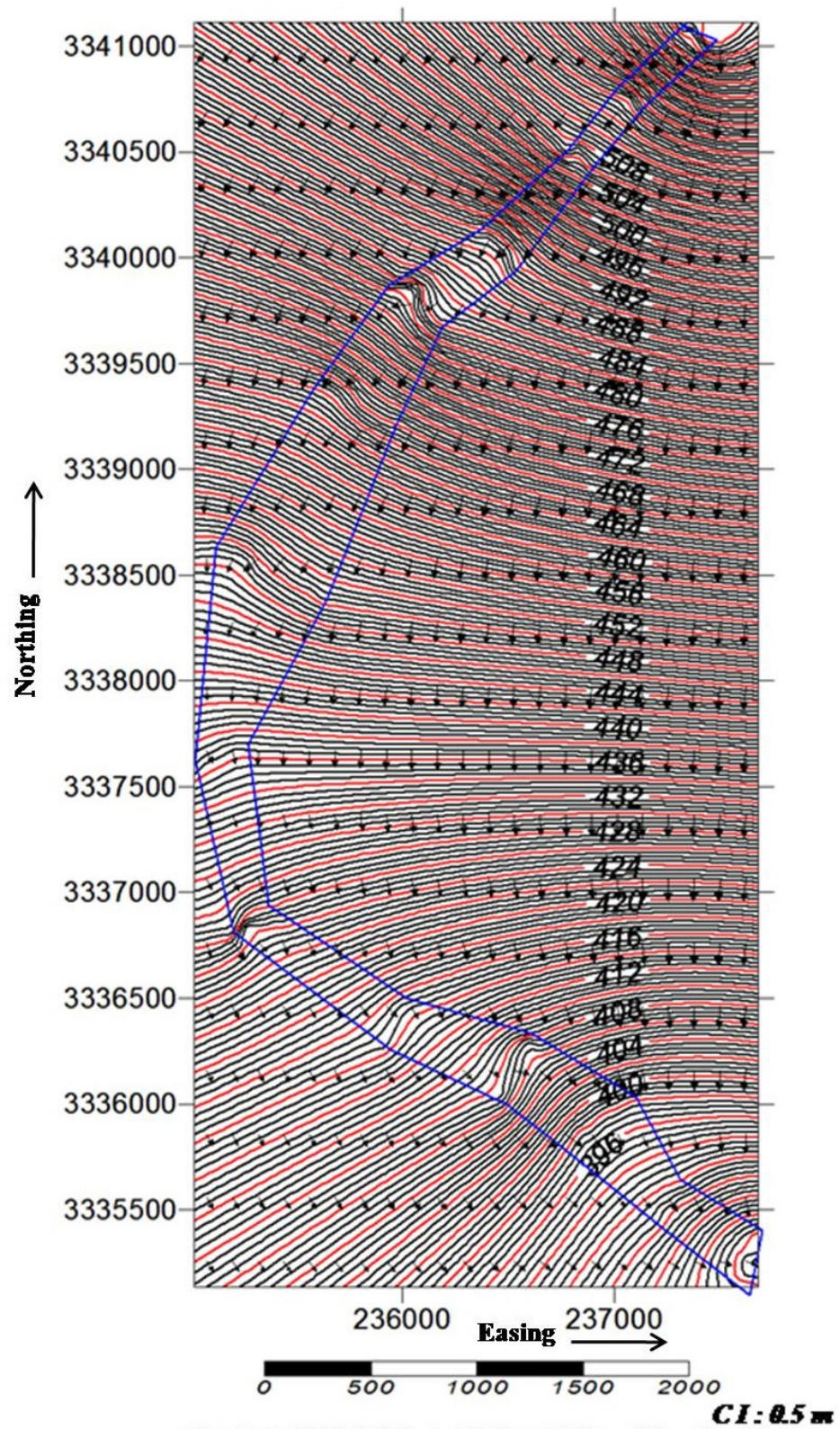


Fig. 10: Contour & Grid Vector Map of River Chandrabhaga

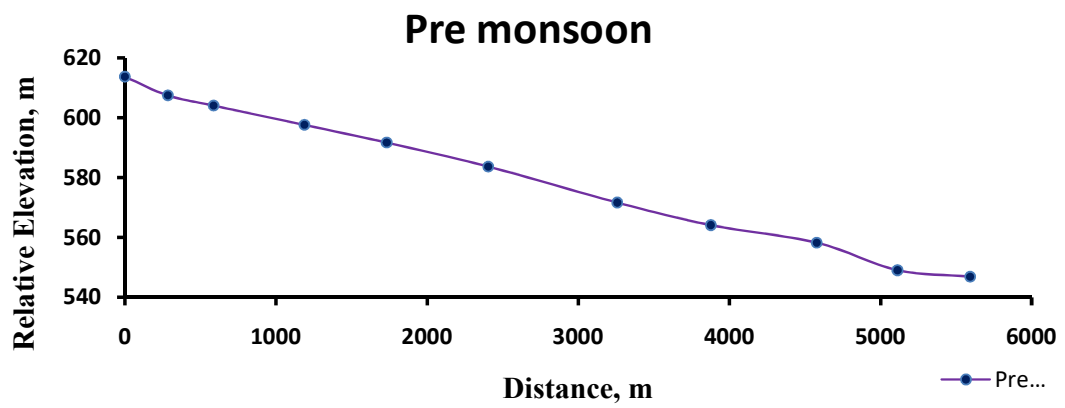
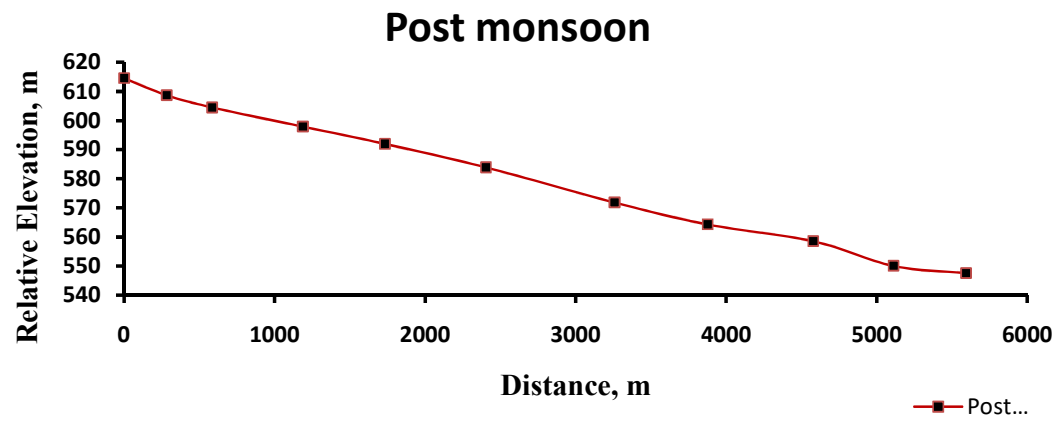


Fig. 11: Longitudinal Section of River Chandrabhaga

Table 2: Sub watershed characteristics of Chandrabhaga rivers

Sub basin	Area (ha)	Perimeter (m)	Lat	Long	Elev. (m)	Elev. Min (m)	Elev. Max (m)
1	186.0781	8475	30.24663	78.31728	1601.994	1099	2078
2	170.9375	7250	30.24239	78.32618	1548.495	1101	1956
3	238.5156	9750	30.2333	78.30134	1352.702	823	1964
4	449.1094	12800	30.22839	78.31576	1239.989	823	1731
5	410.7813	11225	30.21531	78.29202	1008.136	622	1510
6	13.01563	2450	30.20181	78.29233	701.9088	617	984
7	533	13275	30.20955	78.31504	1155.522	638	1655
8	252.4375	10300	30.20919	78.26507	1068.456	711	1511
9	213.5156	9650	30.21206	78.27599	1121.632	712	1510
10	297.8281	9000	30.19665	78.30751	1108.988	641	1534
11	62.64063	4625	30.1958	78.2695	767.8967	556	964
12	277.7031	9200	30.19899	78.28222	780.8061	556	1150
13	87.40625	5650	30.18879	78.27404	636.3588	513	914
14	448.1406	12275	30.18608	78.29523	988.4307	516	1514
15	240.375	12600	30.18381	78.27132	709.5001	489	1069
16	39.17188	4325	30.17182	78.27838	624.296	490	827
17	336.3438	11125	30.17318	78.2973	1082.667	540	1601
18	180.9219	7375	30.16483	78.28845	897.0538	542	1343
19	493.8594	15600	30.17915	78.25779	610.1173	425	981
20	198.75	9725	30.16538	78.26791	549.2507	425	819
21	545.4844	18300	30.14695	78.25451	444.7462	360	717
22	576.4063	15700	30.14891	78.27196	599.5549	357	1098
23	580.4688	24175	30.12894	78.27605	438.6647	314	1054
Total	6832.891					314	2078

Table 3: Location and relative elevation of various cross- sections in river Chandrabhaga (UTM Zone 44R)

Cross Section I

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3341110.00	237350.83	530.25	3341110.22	237351.03	530.25
3341106.34	237355.95	529.75	3341106.05	237356.22	529.75
3341101.21	237364.09	529.62	3341101.24	237364.14	529.62
3341095.95	237370.78	529.30	3341096.15	237371.05	529.30
3341093.13	237375.99	528.69	3341093.36	237376.25	528.69
3341090.19	237381.50	528.25	3341090.22	237381.21	528.25
3341086.05	237386.46	528.07	3341086.36	237386.30	528.07
3341083.17	237391.95	527.58	3341083.47	237392.02	527.58
3341079.14	237397.07	527.85	3341079.31	237397.10	527.85
3341076.48	237402.24	528.07	3341076.40	237402.21	528.07
3341072.74	237406.99	528.05	3341072.42	237407.06	528.05
3341069.19	237413.05	528.33	3341069.52	237413.25	528.33
3341065.06	237418.29	529.02	3341065.25	237418.39	529.02
3341062.56	237422.00	529.72	3341062.54	237422.21	529.72
3341058.04	237427.89	530.29	3341058.35	237428.15	530.29
3341054.25	237434.61	530.81	3341054.32	237434.36	530.81
3341051.32	237440.46	530.96	3341051.25	237440.37	530.96
3341045.95	237445.86	531.44	3341046.26	237446.14	531.44

Cross Section II

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3340734.00	237110.00	515.60	3340734.00	237110.00	515.60
3340750.05	237089.76	513.96	3340749.96	237089.82	513.96
3340753.28	237085.05	514.90	3340753.20	237085.07	514.90
3340757.61	237080.75	514.57	3340757.51	237080.53	514.57
3340762.21	237075.95	514.54	3340762.18	237075.66	514.04
3340767.08	237072.27	514.47	3340767.02	237072.07	514.17
3340768.90	237066.91	514.39	3340769.08	237067.14	514.09
3340772.88	237059.42	514.44	3340773.05	237059.82	514.04
3340777.38	237055.26	514.20	3340777.20	237055.10	513.80
3340781.10	237048.40	514.48	3340781.01	237048.28	514.08
3340781.61	237045.63	514.08	3340781.55	237046.03	514.08
3340783.55	237040.24	514.08	3340783.42	237040.55	514.08
3340785.33	237035.13	514.48	3340785.30	237035.14	514.48
3340788.06	237028.60	514.08	3340788.10	237028.72	514.08
3340791.45	237022.46	514.40	3340791.34	237022.60	514.40
3340793.82	237017.17	515.04	3340793.70	237017.38	515.04

Cross Section III

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3340439.09	236876.41	506.50	3340439.15	236876.51	506.50
3340441.74	236872.73	505.93	3340441.42	236872.47	505.93
3340444.23	236867.64	505.80	3340444.56	236867.84	505.80
3340447.46	236862.92	506.04	3340447.72	236862.99	506.04
3340451.41	236862.04	506.25	3340451.59	236862.03	506.25
3340454.48	236857.89	506.26	3340454.51	236857.63	506.26
3340458.11	236854.01	506.06	3340458.30	236853.72	506.06
3340462.17	236848.56	505.81	3340462.25	236848.87	505.81
3340467.26	236842.89	505.89	3340467.15	236843.04	505.29
3340470.74	236836.83	505.45	3340470.72	236836.61	505.05
3340474.05	236831.57	505.57	3340474.25	236831.66	504.97
3340476.59	236826.97	505.70	3340476.76	236826.87	504.90
3340479.61	236821.59	505.30	3340479.77	236821.63	505.10
3340482.16	236815.10	505.21	3340482.26	236815.36	505.21
3340485.56	236809.79	505.54	3340485.39	236809.86	505.54
3340489.40	236805.97	505.70	3340489.40	236805.74	505.70
3340491.12	236801.68	506.54	3340491.32	236801.40	506.54
3340490.89	236799.22	507.11	3340490.59	236799.33	507.11
3340490.92	236800.23	507.11	3340490.59	236800.14	507.11
3340499.92	236795.23	507.20	3340499.25	236795.25	507.20
3340503.92	236788.23	507.31	3340503.22	236788.15	507.31

Cross Section IV

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3339969.39	236503.14	489.62	3339969.43	236502.96	489.618
3339979.10	236496.10	487.99	3339979.13	236496.37	487.9859
3339988.02	236490.38	488.24	3339987.88	236490.32	488.2395
3339996.09	236485.41	488.14	3339996.35	236485.62	488.1433
3340000.87	236482.08	488.30	3340001.11	236481.88	488.301
3340005.26	236478.89	488.24	3340005.44	236479.22	488.3371
3340010.52	236475.84	488.38	3340010.44	236476.02	488.0447
3340014.83	236473.10	488.14	3340015.04	236472.93	488.0619
3340020.30	236469.45	488.26	3340020.25	236469.14	488.1013
3340026.08	236466.02	488.40	3340025.83	236465.99	488.088
3340032.55	236461.58	488.29	3340032.55	236461.78	488.0609
3340038.41	236457.98	488.46	3340038.17	236458.23	488.1994
3340044.24	236453.88	488.90	3340044.47	236454.12	488.312
3340052.33	236449.18	488.51	3340052.59	236449.51	488.2229
3340059.66	236444.61	489.02	3340059.50	236444.53	488.243
3340066.13	236440.26	488.54	3340065.86	236440.16	488.4728
3340071.68	236435.43	488.77	3340071.51	236435.23	488.6059
3340083.49	236428.72	488.61	3340083.61	236428.57	488.8004
3340096.21	236420.90	488.80	3340096.25	236420.83	489.1896
3340110.00	236411.53	489.19	3340109.81	236411.85	489.2081
3340120.94	236410.39	489.21	3340120.77	236410.48	489.3423
3340128.50	236403.21	489.34	3340128.19	236403.16	490.2591
3340134.44	236395.41	490.26	3340134.37	236395.61	489.34

Cross Section V

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3339708.15	236163.30	482.55	3339708.38	236163.51	482.55
3339716.20	236153.84	482.10	3339716.04	236153.61	482.10
3339724.25	236145.68	482.18	3339724.40	236145.44	482.18
3339732.67	236141.20	482.20	3339732.67	236141.29	482.20
3339743.32	236136.67	482.13	3339743.42	236136.81	482.13
3339749.61	236128.46	481.81	3339749.60	236128.78	481.81
3339756.12	236121.23	482.08	3339756.42	236120.95	482.08
3339765.17	236113.65	482.15	3339765.44	236113.42	482.15
3339772.09	236103.07	481.28	3339772.30	236102.99	481.28
3339780.26	236096.13	481.29	3339780.07	236096.24	481.29
3339788.60	236089.62	480.81	3339788.50	236089.35	480.81
3339798.55	236084.06	480.79	3339798.46	236083.75	480.79
3339812.38	236073.50	481.02	3339812.58	236073.59	481.02
3339824.77	236061.96	480.42	3339825.04	236061.90	480.42
3339834.54	236053.69	480.15	3339834.30	236053.91	480.15
3339842.36	236047.37	480.29	3339842.23	236047.25	480.29
3339853.26	236038.29	480.13	3339853.17	236038.14	480.13
3339864.21	236028.57	479.86	3339863.89	236028.49	479.86
3339870.43	236018.73	479.49	3339870.29	236018.54	479.49
3339881.82	236011.28	482.41	3339881.71	236011.06	482.41

Cross Section VI

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
235952.38	3339237.85	468.23	235952.66	3339237.98	468.23
235945.46	3339240.77	468.45	235945.57	3339240.78	468.45
235937.66	3339244.65	468.47	235937.56	3339244.38	468.47
235927.56	3339248.66	468.43	235927.51	3339248.81	468.43
235916.09	3339253.86	468.60	235915.77	3339253.55	468.60
235906.29	3339259.96	468.28	235906.50	3339259.97	468.28
235892.63	3339266.65	468.22	235892.50	3339266.62	468.22
235883.55	3339272.98	468.20	235883.65	3339272.79	468.20
235874.05	3339277.60	468.17	235874.00	3339277.44	468.47
235858.93	3339283.71	467.78	235858.77	3339283.90	467.78
235842.37	3339290.57	468.06	235842.64	3339290.40	467.66
235826.13	3339297.57	467.43	235826.04	3339297.29	467.43
235813.43	3339304.12	467.53	235813.58	3339303.88	467.13
235799.79	3339308.95	467.73	235800.07	3339308.97	466.83
235788.85	3339313.97	467.73	235789.01	3339314.18	466.73
235778.31	3339321.29	467.36	235778.37	3339321.02	466.66
235764.52	3339327.10	467.55	235764.80	3339327.40	466.55
235750.46	3339334.57	466.58	235750.53	3339334.41	466.18
235739.04	3339343.38	466.79	235738.81	3339343.27	466.09
235726.14	3339347.06	466.62	235726.41	3339347.22	466.12
235701.16	3339355.52	466.36	235701.08	3339355.52	466.36
235684.59	3339362.19	466.55	235684.82	3339361.96	466.55
235666.35	3339371.54	466.65	235666.41	3339371.82	466.65
235647.40	3339381.52	466.58	235647.69	3339381.61	466.58
235615.80	3339395.21	466.39	235615.54	3339394.90	466.39
		468.10			468.10

Cross Section VII

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3338384.63	235607.23	450.39	3338384.67	235607.07	450.39
3338387.39	235599.15	450.31	3338387.57	235599.25	450.32
3338393.74	235587.26	450.19	3338393.70	235587.22	450.21
3338400.09	235575.41	450.23	3338400.04	235575.42	450.17
3338408.73	235557.23	449.89	3338408.49	235557.23	449.97
3338419.29	235537.99	449.91	3338419.54	235537.78	449.99
3338426.93	235521.80	449.95	3338427.08	235521.80	449.82
3338431.60	235513.67	450.00	3338431.36	235513.85	450.05
3338439.39	235496.07	450.08	3338439.18	235495.91	450.09
3338447.24	235481.43	450.02	3338447.40	235481.40	450.25
3338455.55	235464.96	449.30	3338455.63	235465.12	450.14
3338462.86	235450.50	449.56	3338463.10	235450.68	449.83
3338474.56	235435.87	449.71	3338474.38	235435.56	450.06
3338485.06	235412.32	449.20	3338484.97	235412.13	449.98
3338493.24	235388.20	449.46	3338493.34	235388.40	449.58
3338503.57	235367.49	449.45	3338503.28	235367.37	449.71
3338516.67	235344.43	448.81	3338516.46	235344.13	449.57
3338533.57	235322.07	449.15	3338533.83	235322.39	449.60
3338544.82	235299.04	449.15	3338544.95	235299.33	449.33
3338550.30	235284.52	449.03	3338550.47	235284.63	449.16
3338558.40	235266.06	448.52	3338558.33	235266.21	448.74
3338572.80	235241.73	448.22	3338572.47	235241.72	448.66
3338583.38	235217.14	448.58	3338583.27	235217.44	448.68
3338594.74	235192.26	448.80	3338594.84	235192.34	448.82
3338621.87	235141.39	448.91	3338621.62	235141.47	448.91
		450.12			450.02

Cross Section VIII

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3337663.99	235239.82	436.36	3337663.89	235239.70	436.36
3337663.22	235232.59	436.12	3337662.89	235232.75	436.12
3337659.99	235227.27	436.09	3337659.77	235226.97	436.09
3337657.05	235217.42	436.24	3337657.09	235217.12	436.24
3337655.00	235216.67	436.05	3337654.94	235216.92	436.21
3337651.36	235209.75	436.09	3337651.58	235209.60	436.16
3337648.31	235200.72	436.12	3337648.08	235200.95	436.16
3337646.37	235191.17	435.96	3337646.62	235190.99	436.00
3337643.38	235180.99	435.91	3337643.13	235181.17	436.30
3337639.52	235171.52	435.93	3337639.79	235171.47	436.14
3337636.37	235162.07	435.74	3337636.05	235162.32	436.35
3337633.02	235152.29	435.70	3337632.94	235152.46	436.33
3337629.43	235141.09	435.29	3337629.46	235141.35	436.32
3337626.47	235131.61	435.33	3337626.74	235131.88	436.40
3337623.44	235122.29	436.31	3337623.64	235122.09	436.49
3337620.18	235111.30	436.22	3337620.36	235111.19	436.58
3337617.05	235098.40	435.98	3337616.84	235098.13	436.42
3337612.64	235087.49	436.43	3337612.84	235087.36	436.56
3337607.01	235071.62	435.95	3337606.99	235071.57	436.41
3337601.87	235057.56	436.37	3337602.12	235057.26	436.53
3337596.32	235039.72	436.38	3337596.65	235039.78	436.64
3337593.51	235026.39	436.78	3337593.22	235026.13	436.85
3337590.57	235016.19	437.05	3337590.25	235016.05	437.05
		437.81			437.81

Cross Section IX

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3336920.14	235359.90	425.98	3336920.00	235359.63	425.98
3336914.08	235352.23	425.64	3336913.99	235352.07	425.64
3336909.17	235345.21	425.20	3336909.17	235345.01	425.29
3336905.20	235338.79	425.04	3336905.04	235338.53	425.18
3336899.78	235333.04	424.85	3336900.03	235333.33	425.03
3336895.48	235328.03	424.45	3336895.20	235328.04	425.07
3336889.51	235320.25	424.86	3336889.48	235320.02	425.49
3336881.86	235310.83	425.30	3336882.13	235310.66	425.40
3336875.58	235301.39	424.55	3336875.33	235301.13	425.10
3336871.64	235295.37	423.54	3336871.75	235295.59	424.27
3336865.72	235286.83	424.75	3336866.04	235286.70	424.78
3336860.23	235279.08	424.32	3336860.34	235279.06	424.91
3336855.06	235269.69	425.12	3336855.13	235269.40	425.43
3336849.32	235262.32	424.95	3336849.31	235262.39	424.86
3336842.81	235253.95	424.53	3336842.52	235253.64	424.51
3336839.25	235248.64	424.26	3336839.18	235248.80	424.31
3336837.58	235243.99	425.07	3336837.83	235243.94	424.98
3336835.13	235238.80	424.57	3336835.18	235238.94	424.68
3336835.73	235237.36	425.97	3336835.76	235237.31	426.08
3336830.81	235229.94	426.64	3336830.54	235230.05	426.64

Cross Section X

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3336468.80	236030.55	414.79	3336468.93	236030.76	414.79
3336462.00	236028.01	414.58	3336461.88	236028.03	414.64
3336451.88	236022.95	414.13	3336451.86	236023.12	414.28
3336443.52	236019.38	414.40	3336443.42	236019.44	414.53
3336437.04	236016.18	414.26	3336436.76	236016.37	414.25
3336427.23	236011.11	414.01	3336427.12	236011.33	414.27
3336419.15	236007.24	414.08	3336419.11	236007.40	414.29
3336411.68	236004.87	413.72	3336411.45	236004.90	414.07
3336402.92	236001.34	413.81	3336403.16	236001.42	414.58
3336392.57	235994.83	414.21	3336392.68	235994.97	414.33
3336385.62	235990.69	413.49	3336385.33	235990.77	414.29
3336377.09	235985.06	413.88	3336376.87	235985.39	414.45
3336367.54	235978.47	414.04	3336367.75	235978.60	414.44
3336358.40	235972.07	413.77	3336358.15	235972.00	414.60
3336346.55	235964.97	414.07	3336346.40	235964.84	414.46
3336336.64	235958.14	414.07	3336336.94	235958.26	414.44
3336328.14	235952.41	414.08	3336327.88	235952.42	414.40
3336318.88	235946.28	414.28	3336318.78	235946.45	414.39
3336308.52	235939.23	414.28	3336308.50	235939.54	414.45
3336301.26	235934.45	414.71	3336301.13	235934.19	414.73
3336290.84	235927.99	414.15	3336290.60	235928.01	414.24
3336286.67	235925.80	414.63	3336286.62	235925.92	414.63

Cross Section XI

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3336304.65	236617.71	408.02	3336304.68	236617.69	408.02
3336299.87	236610.91	408.06	3336300.27	236611.37	408.09
3336290.11	236604.83	407.39	3336289.68	236604.87	407.47
3336282.10	236598.38	406.63	3336282.31	236598.14	406.79
3336271.03	236587.96	406.29	3336270.82	236587.74	406.33
3336260.08	236580.04	406.48	3336260.24	236579.85	406.53
3336252.45	236573.05	406.44	3336252.08	236573.55	406.58
3336245.65	236570.08	406.53	3336245.64	236569.65	406.58
3336232.38	236561.90	406.06	3336232.76	236561.85	406.62
3336225.00	236557.17	406.05	3336224.77	236557.57	406.51
3336215.79	236552.37	406.04	3336215.35	236552.54	406.66
3336203.06	236546.96	406.22	3336203.26	236547.37	406.88
3336193.66	236542.60	406.56	3336193.77	236542.13	407.04
3336185.06	236537.79	406.58	3336185.08	236537.77	407.02
3336176.67	236532.92	406.85	3336177.07	236532.78	407.21
3336165.16	236526.71	406.40	3336164.80	236527.17	406.95
3336152.30	236520.91	406.46	3336152.09	236520.59	407.05
3336138.97	236515.60	406.39	3336139.45	236515.55	406.97
3336127.85	236510.77	406.80	3336127.68	236510.54	407.28
3336114.20	236502.97	406.78	3336113.74	236502.94	407.21
3336113.75	236503.78	406.95	3336113.33	236503.39	407.21
3336102.97	236497.75	407.37	3336102.73	236497.80	407.36
3336092.20	236492.73	407.22	3336092.63	236492.60	407.27
3336085.28	236487.75	407.31	3336085.43	236488.16	407.31
3336071.04	236481.16	407.41	3336070.90	236481.06	407.25
3336058.69	236474.67	407.10	3336058.72	236475.06	407.22
3336049.25	236469.13	407.41	3336048.75	236469.07	407.41
3336038.50	236464.76	407.60	3336038.58	236464.81	407.60

Cross Section XII

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3335991.84	237072.71	397.59	3335992.22	237072.62	397.50
3335984.09	237060.41	397.59	3335983.95	237060.55	397.58
3335978.41	237051.41	397.77	3335978.36	237051.16	397.73
3335968.97	237036.79	397.81	3335969.22	237036.81	397.92
3335963.59	237028.88	396.95	3335963.65	237028.91	397.04
3335960.35	237025.53	397.61	3335960.75	237025.33	397.57
3335952.80	237012.85	397.64	3335953.18	237013.21	397.81
3335947.38	237004.15	397.02	3335947.39	237004.16	397.52
3335938.60	236991.44	397.04	3335938.74	236991.66	397.43
3335931.19	236979.53	396.27	3335930.72	236979.04	396.87
3335918.85	236961.99	396.36	3335918.63	236961.78	397.30
3335912.60	236950.50	396.75	3335912.72	236950.75	397.31
3335901.86	236935.24	397.11	3335901.82	236934.85	397.43
3335894.47	236923.83	397.70	3335894.12	236924.07	397.88
3335884.71	236911.20	397.07	3335884.95	236911.23	397.30
3335872.26	236894.91	396.50	3335872.64	236894.67	397.04
3335864.37	236882.33	397.07	3335864.44	236881.89	397.73
3335854.94	236867.06	397.34	3335854.79	236867.46	397.43
3335849.07	236855.35	397.35	3335848.62	236855.77	397.45
3335839.99	236842.62	397.16	3335840.25	236842.27	397.31
3335829.58	236827.22	397.21	3335829.83	236827.36	397.34
3335822.50	236814.62	397.53	3335822.51	236814.99	397.52
3335816.75	236805.47	397.13	3335816.76	236805.79	397.15
3335815.21	236803.28	398.57	3335815.45	236803.74	398.55
3335808.23	236791.47	397.86	3335808.15	236791.03	397.95

Cross Section XIII

Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3335606.54	237312.22	391.65	3335606.25	237312.05	391.65
3335589.76	237302.84	391.17	3335589.86	237302.90	391.19
3335581.89	237297.87	391.12	3335581.92	237297.50	391.09
3335574.07	237293.08	390.85	3335574.55	237293.29	390.83
3335567.47	237285.78	390.06	3335567.47	237285.98	390.77
3335555.64	237277.11	389.93	3335555.71	237277.27	390.87
3335549.28	237272.98	390.64	3335549.59	237273.42	390.89
3335542.57	237273.93	389.95	3335542.89	237273.64	390.75
3335535.08	237269.91	390.14	3335535.36	237269.68	390.57
3335531.69	237269.86	390.32	3335531.48	237269.59	390.52
3335526.77	237263.15	389.97	3335527.23	237262.88	390.86
3335520.44	237259.07	389.95	3335520.25	237259.28	390.67
3335514.51	237255.09	390.08	3335514.03	237255.40	390.87
3335507.51	237251.49	389.63	3335507.20	237251.27	390.24
3335498.82	237246.35	389.76	3335498.89	237246.19	390.26
3335492.90	237242.45	389.97	3335492.52	237242.36	390.56
3335486.59	237239.63	390.37	3335486.16	237239.50	390.56
3335483.95	237236.27	390.58	3335483.61	237236.36	390.40
3335477.26	237233.41	390.47	3335477.27	237233.71	390.49
3335470.11	237230.15	390.43	3335470.52	237230.03	390.43
3335463.38	237225.44	390.17	3335463.53	237225.23	390.09
3335457.95	237221.66	390.10	3335457.61	237221.50	390.19
3335450.42	237216.97	390.54	3335450.21	237217.37	390.53

Cross Section XIV

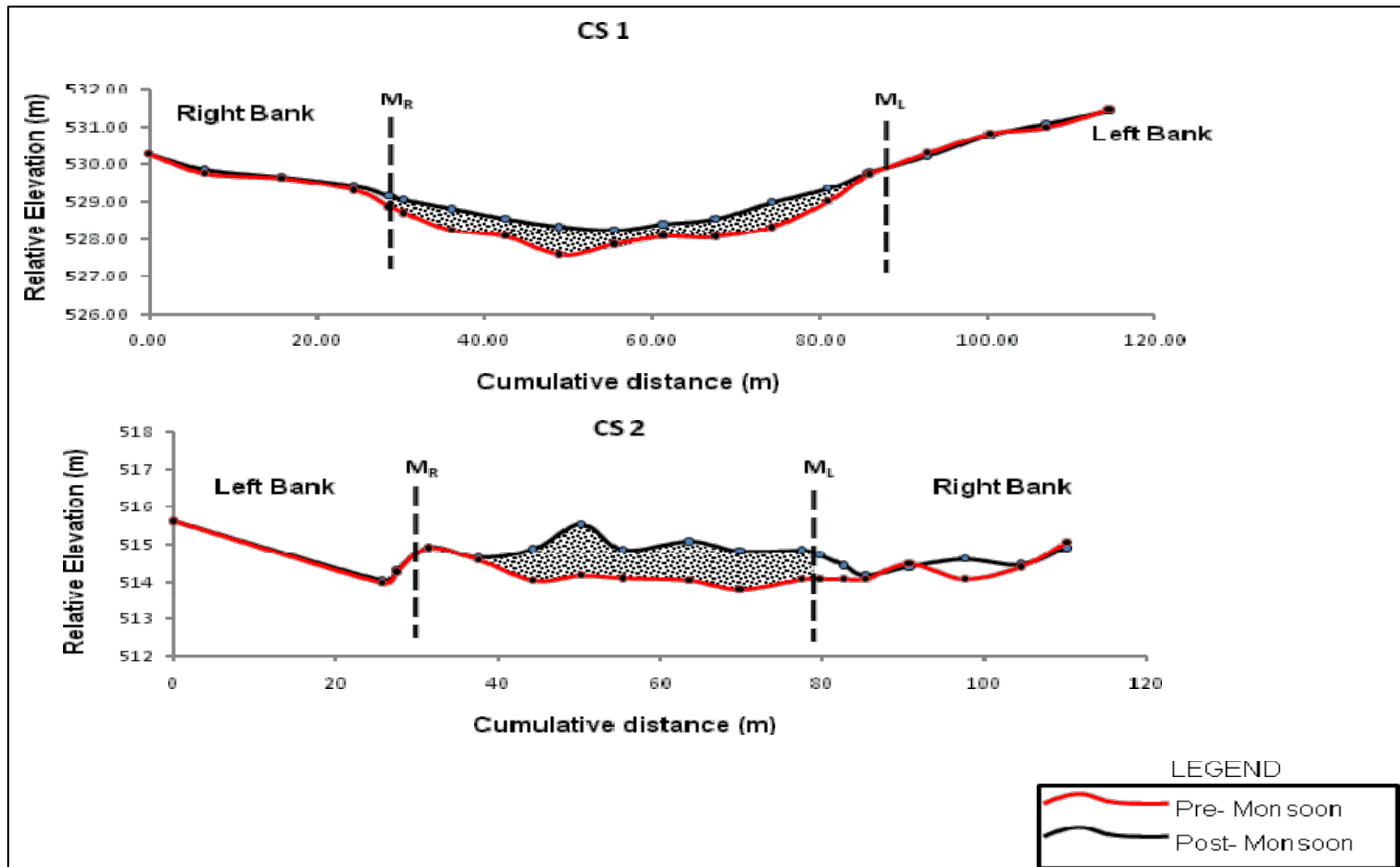
Pre-monsoon data			Post-monsoon data		
Northing	Easting	Relative elevation	Northing	Easting	Relative elevation
3335370.70	237674.67	383.48	3335370.85	237674.68	383.48
3335363.10	237673.40	383.53	3335363.45	237672.99	383.66
3335354.74	237672.99	383.64	3335354.70	237673.36	383.65
3335347.73	237676.60	383.43	3335347.85	237676.16	383.52
3335339.46	237675.58	383.58	3335339.18	237675.47	383.39
3335329.13	237673.21	384.06	3335329.21	237672.72	383.93
3335319.56	237671.68	384.04	3335319.93	237671.69	383.95
3335306.39	237669.94	383.38	3335306.71	237669.50	383.72
3335298.28	237667.37	383.59	3335298.19	237667.54	384.00
3335288.06	237664.32	383.07	3335287.68	237664.67	383.22
3335271.86	237662.39	382.25	3335272.08	237662.01	383.17
3335258.08	237659.27	381.86	3335258.19	237659.12	382.10
3335253.11	237657.37	381.87	3335252.61	237657.56	383.14
3335247.24	237656.18	381.92	3335247.38	237655.86	383.31
3335235.72	237656.53	381.80	3335235.53	237656.24	382.06
3335222.15	237651.81	382.01	3335222.31	237651.98	382.49
3335213.76	237653.40	382.37	3335213.49	237653.48	383.31
3335199.54	237650.17	382.61	3335199.44	237650.03	383.44
3335186.93	237648.15	383.34	3335187.06	237648.50	383.45
3335172.09	237644.86	383.18	3335172.53	237645.04	383.15
3335156.27	237640.44	383.35	3335156.75	237640.52	383.38
3335152.66	237640.58	384.20	3335152.22	237640.76	384.24
3335134.82	237638.41	384.63	3335134.94	237638.32	384.63

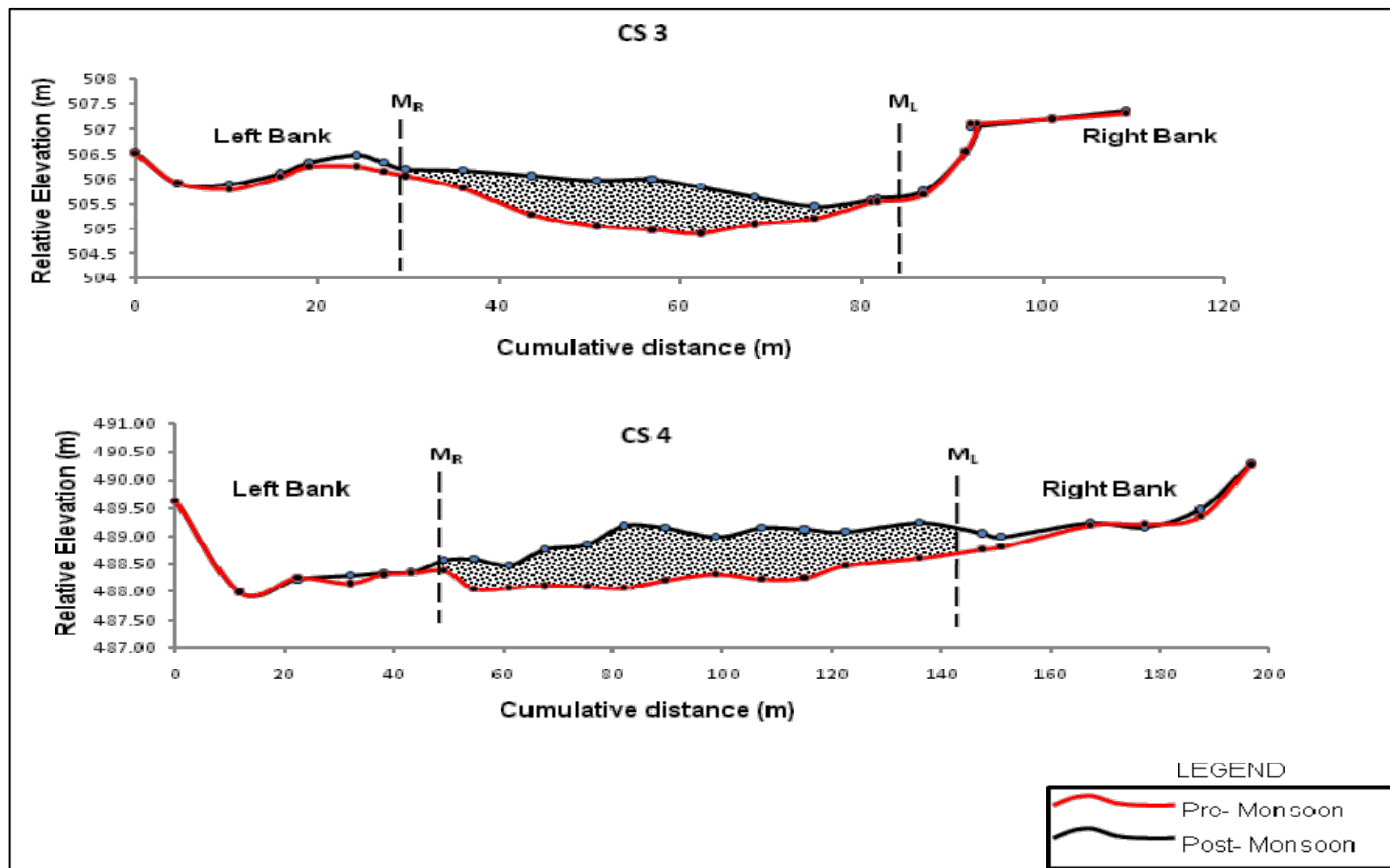
Table 4: Volume of safely extractable RBM from River Chandrabhaga

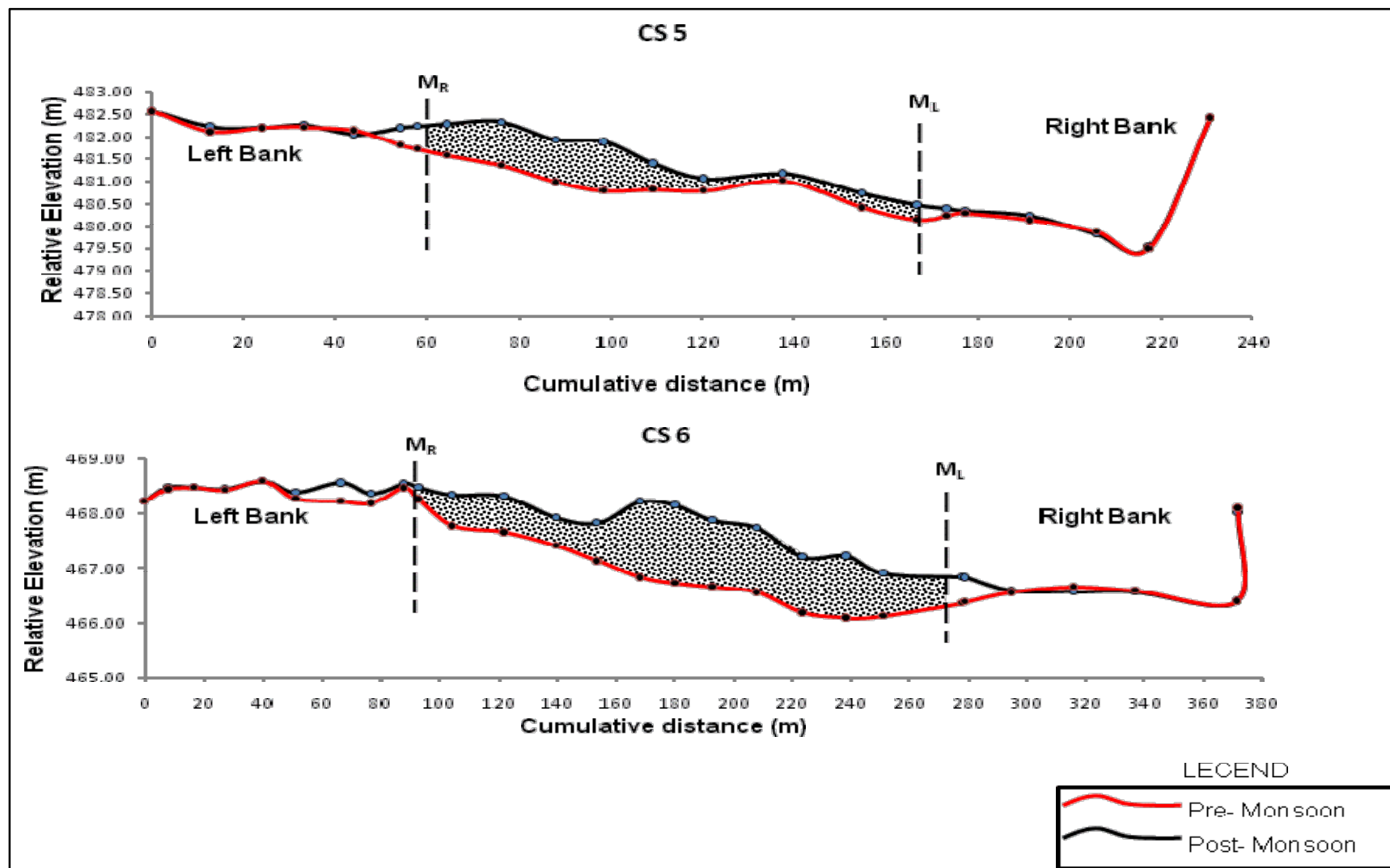
Location	Length Segment(m)	Width of the river (m)	Extractable width (m)	Average Depth of Extraction	Cross Section (m²)	Average Cross section (m²)	Volume (m³)	Cumulative Volume (m³)
CS1	0	114.60	57.31	0.39	0.00	0	0	0
CS2	450	110.19	55.09	0.62	34.16	17.08	7685.06	7685.06
CS3	380	109.14	54.57	0.48	26.19	30.17	11466.37	19151.42
CS4	570	196.80	98.53	0.66	65.03	45.61	25999.33	45150.75
CS5	440	230.84	115.42	0.54	62.33	63.68	28018.89	73169.64
CS6	560	372.00	185.93	0.84	156.18	109.25	61181.39	134351.03
CS7	900	523.00	261.21	0.36	93.65	124.91	112423.09	246774.12
CS8	890	236.00	117.73	0.48	56.66	75.15	66887.48	313661.60
CS9	770	157.46	74.00	0.44	32.83	44.74	34452.04	348113.64
CS10	850	210.30	105.15	0.45	46.84	39.83	33858.27	381971.91
CS11	575	306.89	154.05	0.44	67.94	57.39	32999.00	414970.92
CS12	490	321.79	160.89	0.47	75.63	71.79	35175.49	450146.40
CS13	500	182.52	91.26	0.63	57.63	66.63	33317.01	483463.42
CS14	465	238.70	119.35	0.61	72.63	65.13	30287.66	513751.08
Total Volume								513751.08
Recommended volume of extraction (90% of total volume)								462375.97

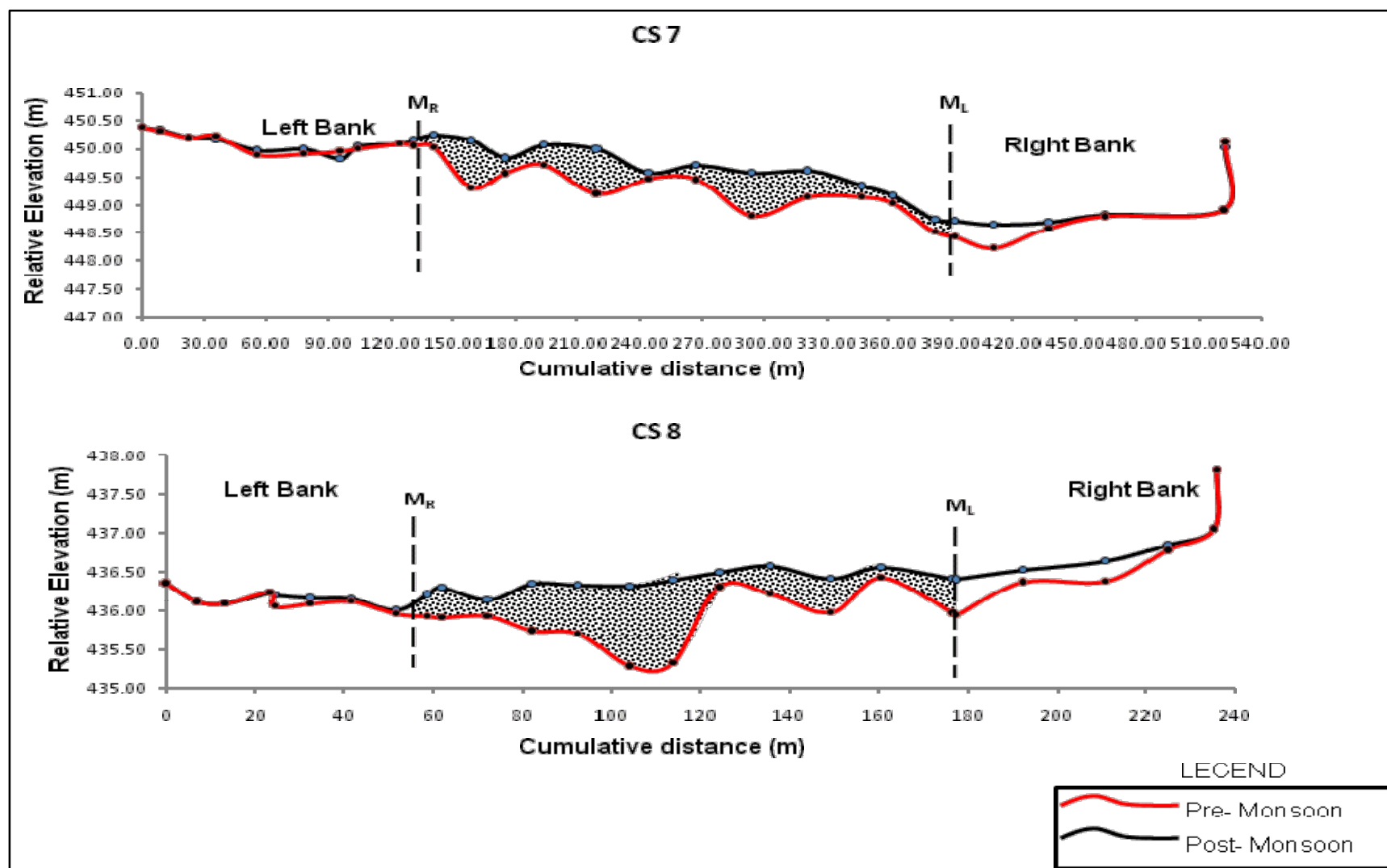
Table 5: Distance and depth of extraction river Chandrabhaga

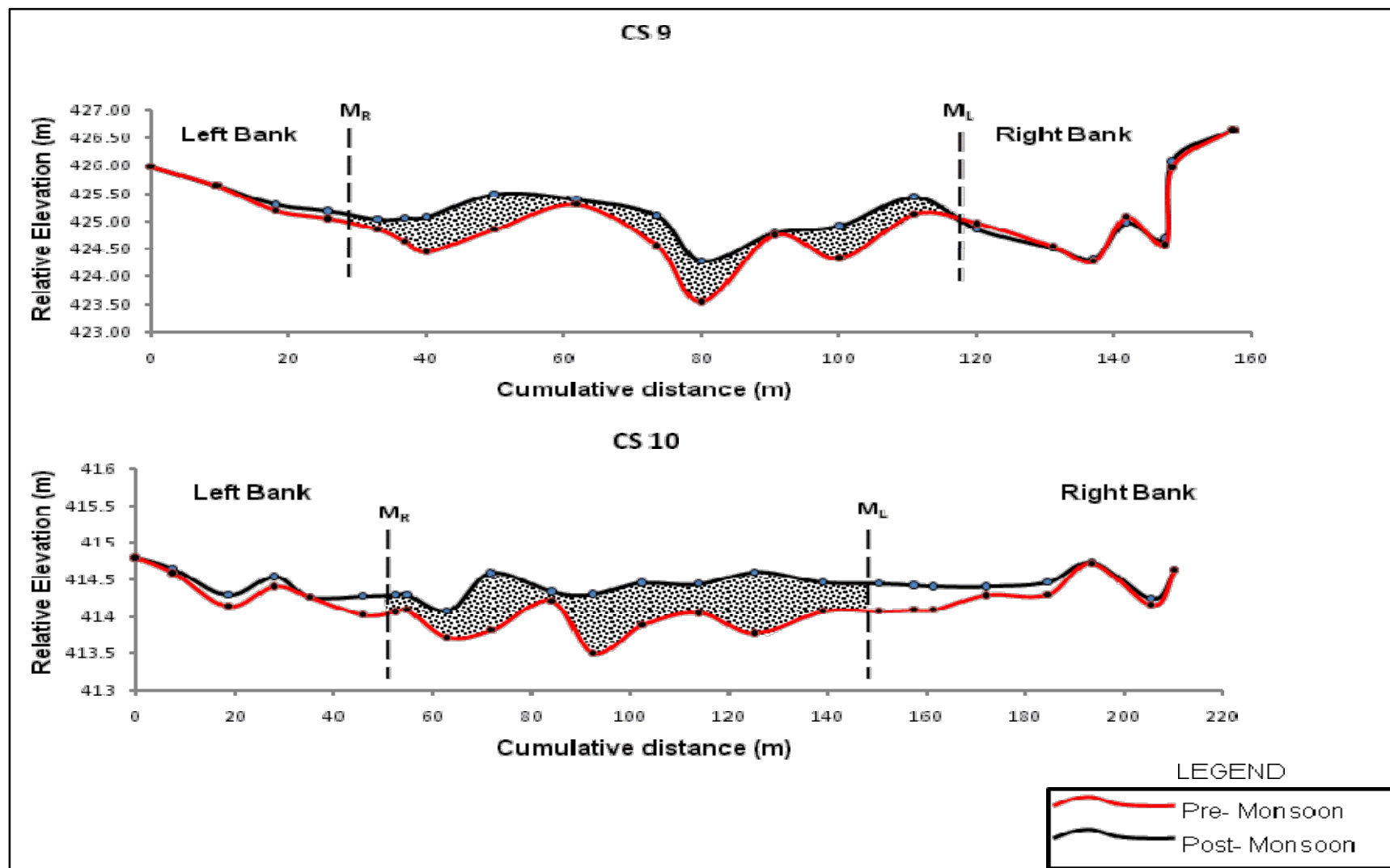
Distance	CS1	28.65	30.34	36.21	42.59	48.95	55.48	61.34	67.59	74.35	81.00	85.67	85.96				57.31
Depth		0.29	0.37	0.55	0.47	0.75	0.38	0.33	0.49	0.65	0.34	0.03	0.03				0.39
Distance	CS2	27.55	31.47	37.70	44.42	50.29	55.39	63.59	69.86	77.59	79.71	82.64					55.09
Depth		0.05	0.01	0.08	0.82	1.36	0.75	1.03	1.01	0.75	0.63	0.34					0.62
Distance	CS3	27.28	29.77	36.02	43.64	50.88	56.95	62.28	68.28	74.82	81.12	81.85					54.57
Depth		0.17	0.14	0.36	0.77	0.92	1.02	0.95	0.54	0.24	0.06	0.06					0.48
Distance	CS4	49.07	54.61	61.05	67.44	75.37	82.02	89.54	98.86	107.37	115.08	122.51	136.28	147.60			98.53
Depth		0.19	0.53	0.42	0.66	0.76	1.12	0.94	0.68	0.92	0.87	0.60	0.63	0.28			0.66
Distance	CS5	57.71	64.18	75.92	88.02	98.30	109.17	120.31	137.63	154.70	166.94	173.13					115.42
Depth		0.49	0.69	0.96	0.94	1.09	0.58	0.27	0.15	0.31	0.31	0.15					0.54
Distance	CS6	92.96	104.51	121.87	139.82	153.91	168.30	180.52	193.06	208.05	223.95	238.37	251.25	277.68	278.89		185.93
Depth		0.22	0.56	0.67	0.50	0.70	1.39	1.44	1.22	1.19	1.02	1.14	0.79	0.49	0.45		0.84
Distance	CS7	130.60	140.45	158.69	174.95	193.55	219.23	244.18	267.44	294.12	321.38	346.97	362.57	382.54	391.81		261.21
Depth		0.10	0.23	0.85	0.27	0.36	0.78	0.12	0.26	0.76	0.45	0.19	0.13	0.23	0.29		0.36
Distance	CS8	58.86	62.09	72.36	82.23	92.57	104.19	114.03	124.30	135.68	149.18	160.66	176.59				117.73
Depth		0.28	0.39	0.21	0.61	0.63	1.03	1.07	0.18	0.36	0.44	0.13	0.44				0.48
Distance	CS9	37.13	40.17	50.00	61.91	73.60	80.18	90.72	100.25	111.13							74.00
Depth		0.43	0.62	0.63	0.10	0.56	0.74	0.02	0.58	0.31							0.44
Distance	CS10	52.57	55.02	63.03	72.01	84.23	92.67	102.63	113.83	125.40	139.13	150.58	157.72				105.15
Depth		0.22	0.21	0.36	0.77	0.12	0.80	0.56	0.39	0.82	0.38	0.37	0.33				0.45
Distance	CS11	76.11	91.05	100.00	110.56	123.41	134.20	143.84	153.27	166.62	180.86	194.25	206.91	222.76	222.89	230.16	154.05
Depth		0.05	0.56	0.46	0.62	0.66	0.48	0.44	0.36	0.56	0.58	0.58	0.48	0.43	0.26	0.10	0.44
Distance	CS12	80.45	81.84	97.03	111.98	133.05	145.51	164.78	178.02	193.79	214.40	229.58	241.34				160.89
Depth		0.45	0.49	0.39	0.60	0.94	0.56	0.32	0.18	0.23	0.55	0.66	0.27				0.47
Distance	CS13	45.63	46.73	61.35	68.58	74.10	82.60	85.99	93.08	100.91	108.24	116.21	125.95	133.39	136.89		91.26
Depth		0.63	0.71	0.94	0.25	0.80	0.43	0.21	0.89	0.72	0.79	0.61	0.50	0.59	0.78		0.63
Distance	CS14	59.67	64.35	73.02	83.77	99.58	113.73	119.47	124.90	136.58	150.27	158.79	173.18	179.02			119.35
Depth		0.19	0.34	0.41	0.15	0.92	0.24	1.27	1.39	0.26	0.48	0.94	0.83	0.49			0.61

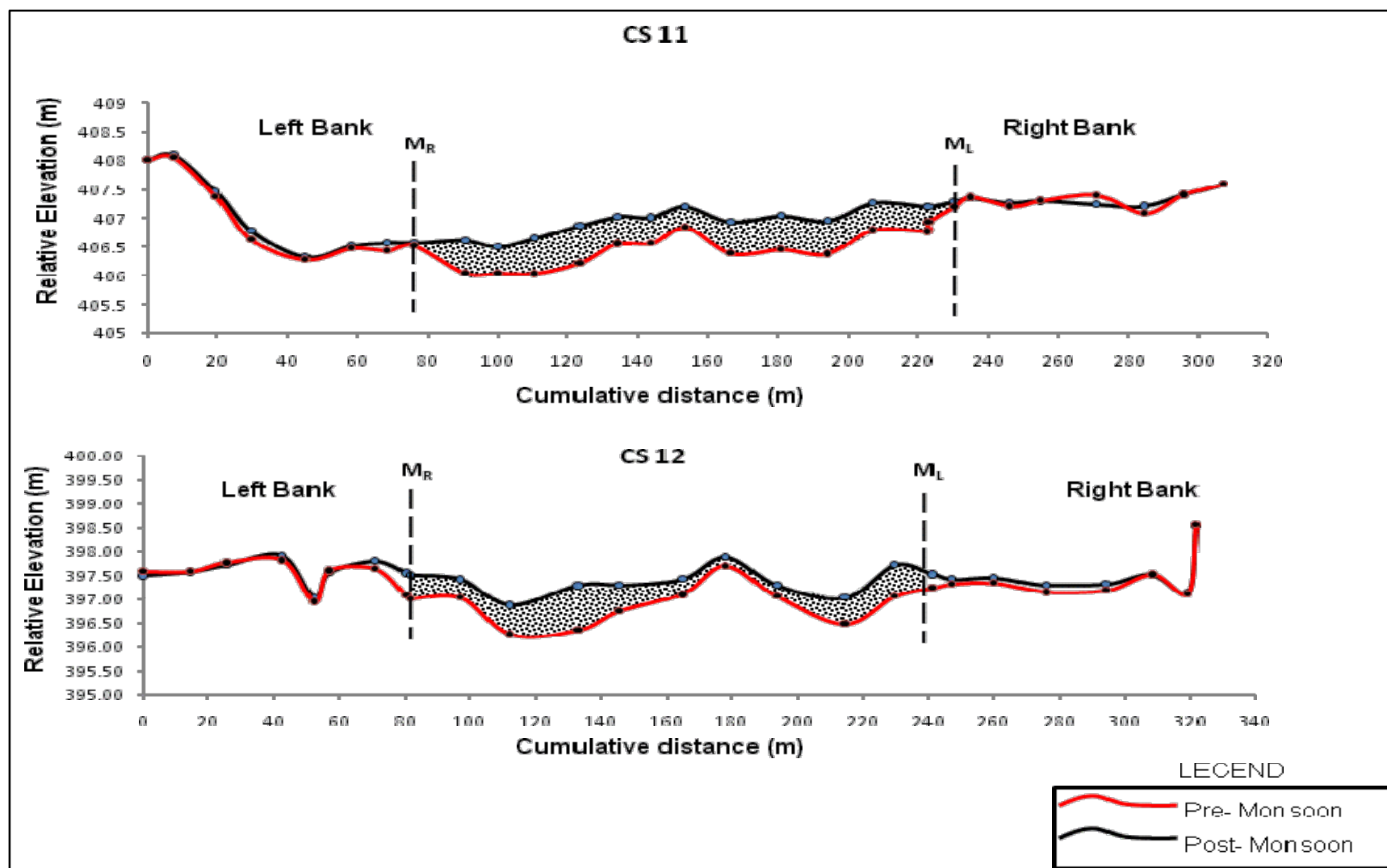












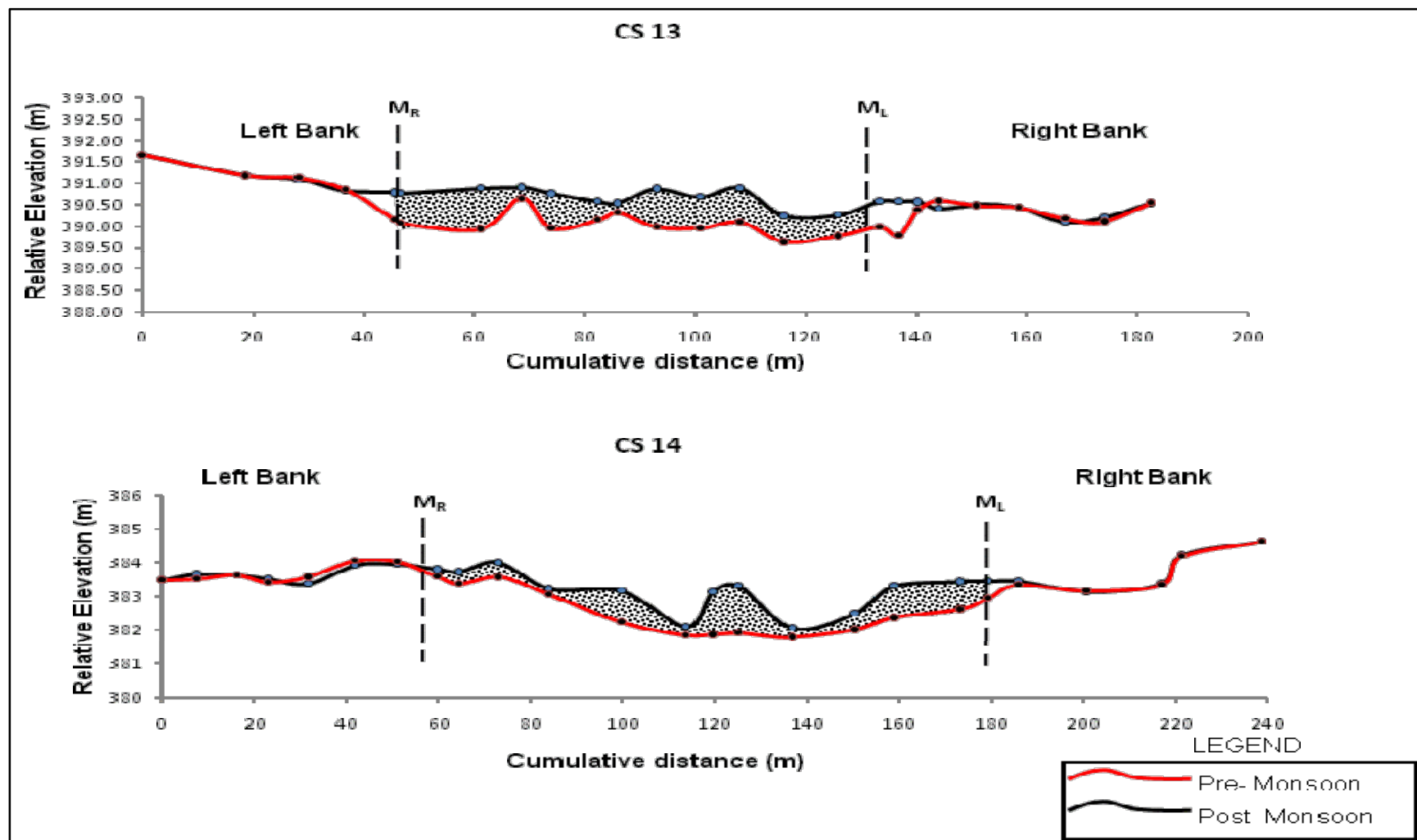


Fig. 12: Cross Sections at different reach of the River Chandrabhaga



Plate: Sampling of RBM in River Chandrabhaga



Plate: Survey of river Chandrabhaga