

1.3 Topographic Survey (on river)

Topographic survey has been carried out to understand the river bed profile and to develop numerical model for each river. Survey lines are decided from the hydraulic point of view, which are also close to past survey line so that a comparative study can be easily carried out. The schematic diagram of survey lines is shown in Figure 1.3.2 and Figure 1.3.3 for Meghna Bridge and Gumti Bridge, respectively.

As there are no survey results/ survey records for Kanchpur Bridge, therefore, the survey lines have been selected at 200 m intervals in u/s and d/s of existing bridges, which are shown in Figure 1.3.4.

Survey type

- River Bathymetric Survey (under the river flow, water)
- Using Echo- Sounding device (Figure 1.3.1)
- River Topographic Survey (on the land)

The above survey results will be formulated soon.



(GPS)

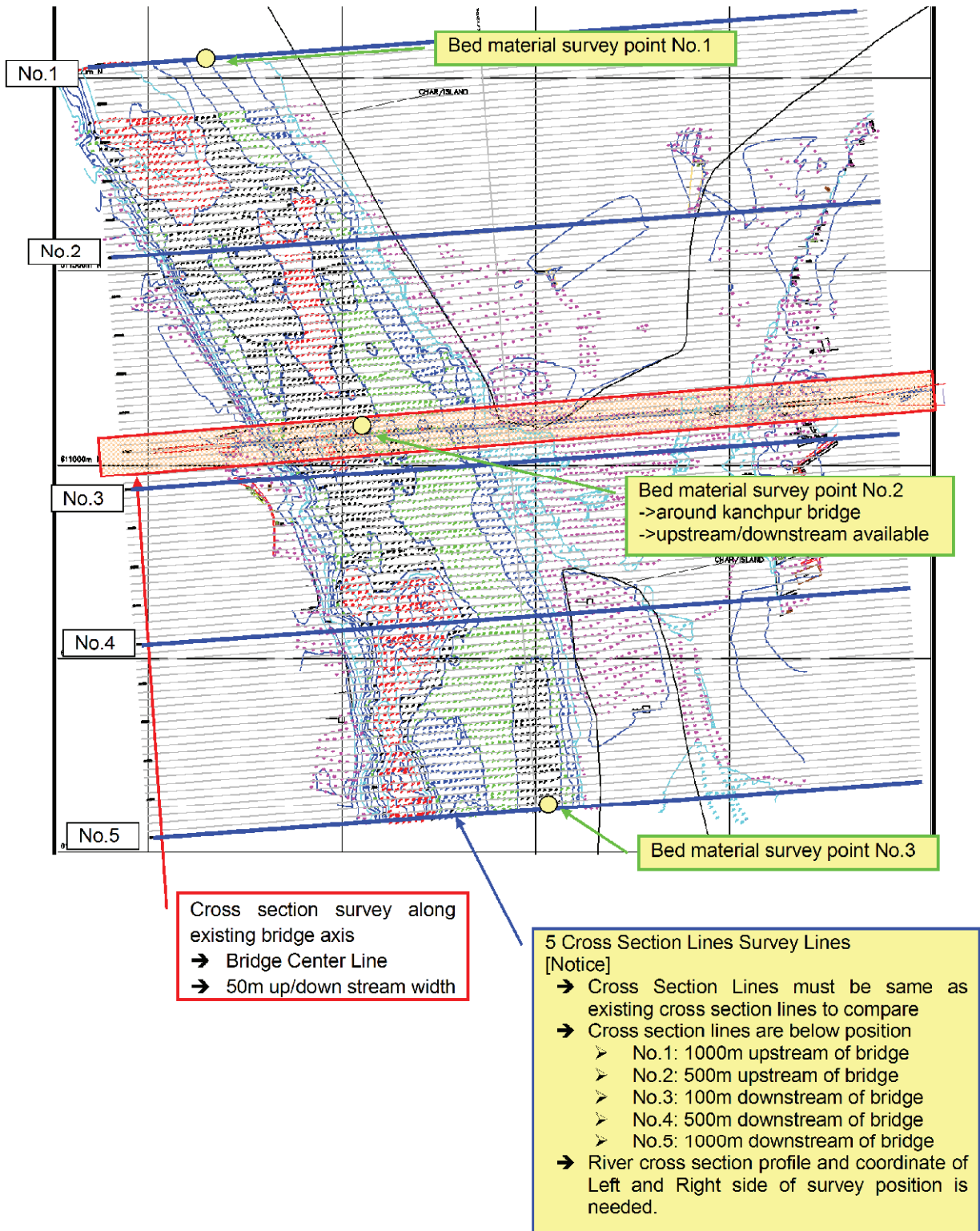


Echo-sounding device -Echotrac DF3200 MKII
Odom Hydrographical Systems Inc.)

Figure 1.3.1 bathymetric survey device.

Meghna-Gumti Bridge

Meghna-Gumti River Bathymetry by Sounding Surveyby JPZ in 2010

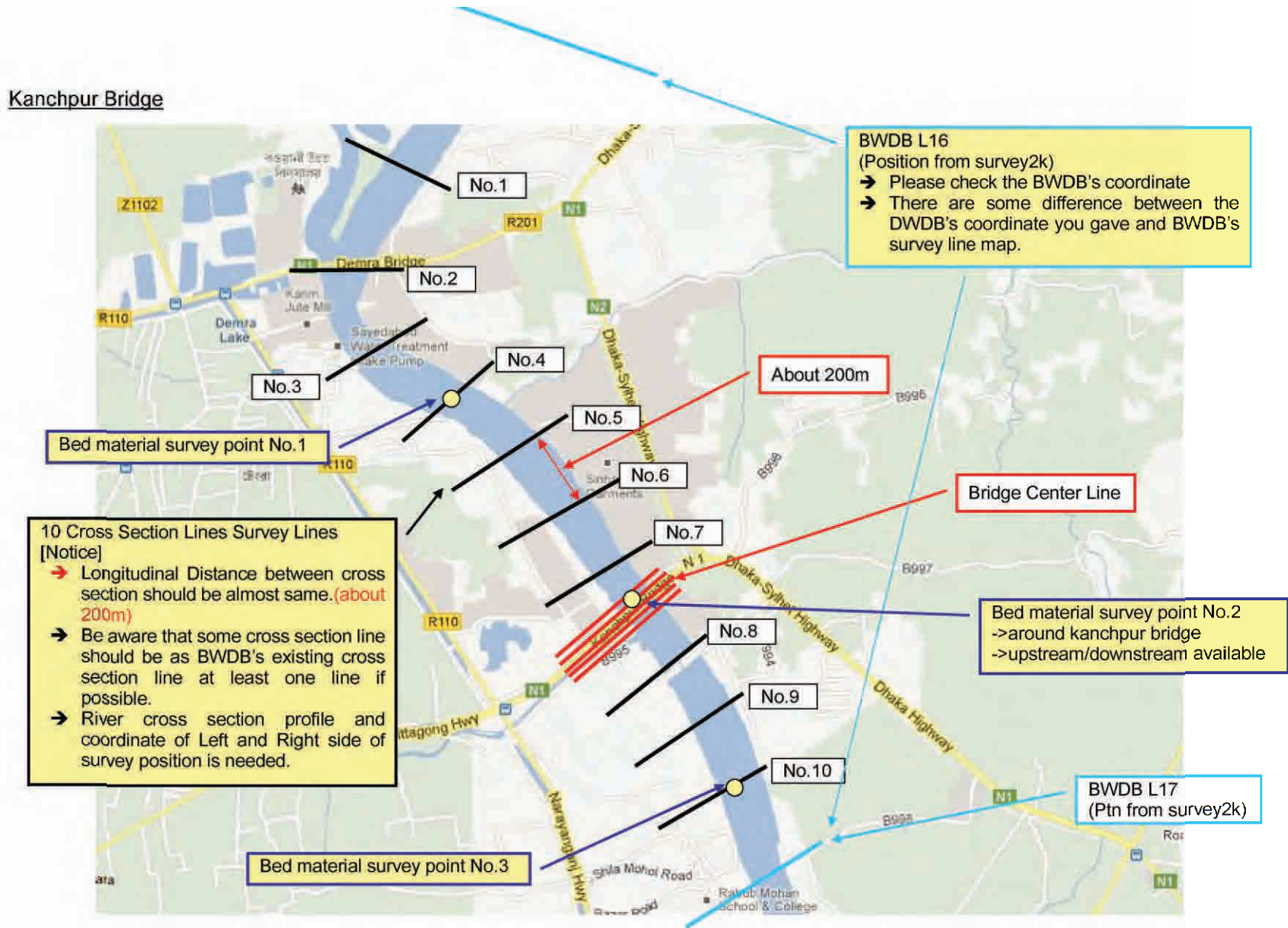


Source :Edited RHD Report³ by JICA Team

Figure 1.3.3 Topographic Survey Line at Gumti Bridge

³ Rehabilitation of Existing Meghna Bridge & Gumti Bridge Protective Works of Pier Foundation Design Report, Roads & Highways Department, Feb 2011

Figure 1.3.4 Topographic Survey Line at Kanchpur Bridge



1.3.1 Kanchpur Bridge

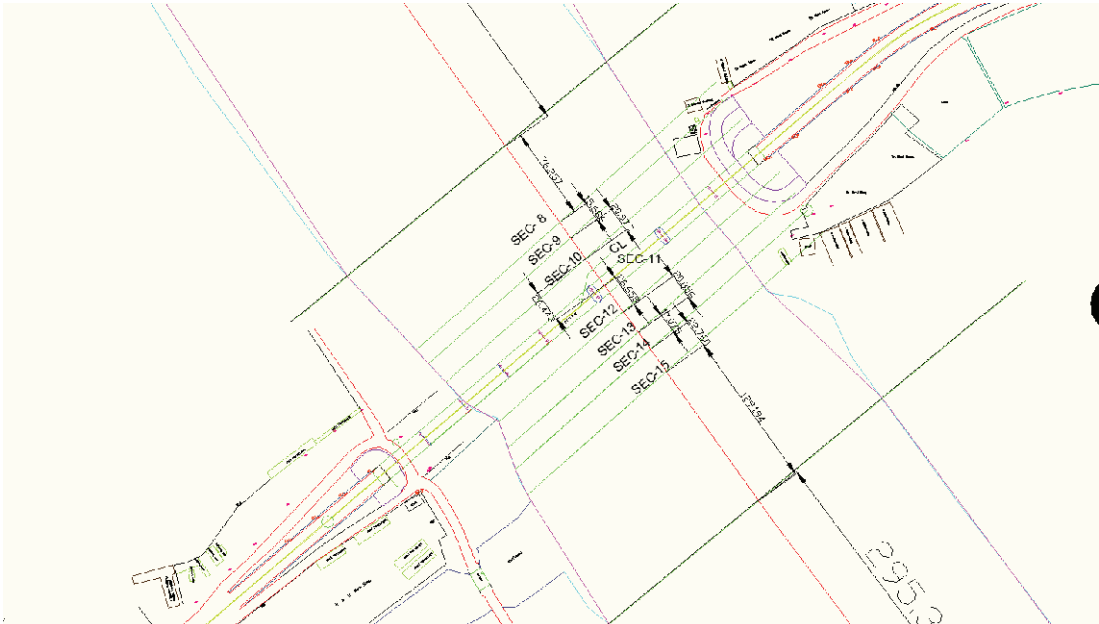
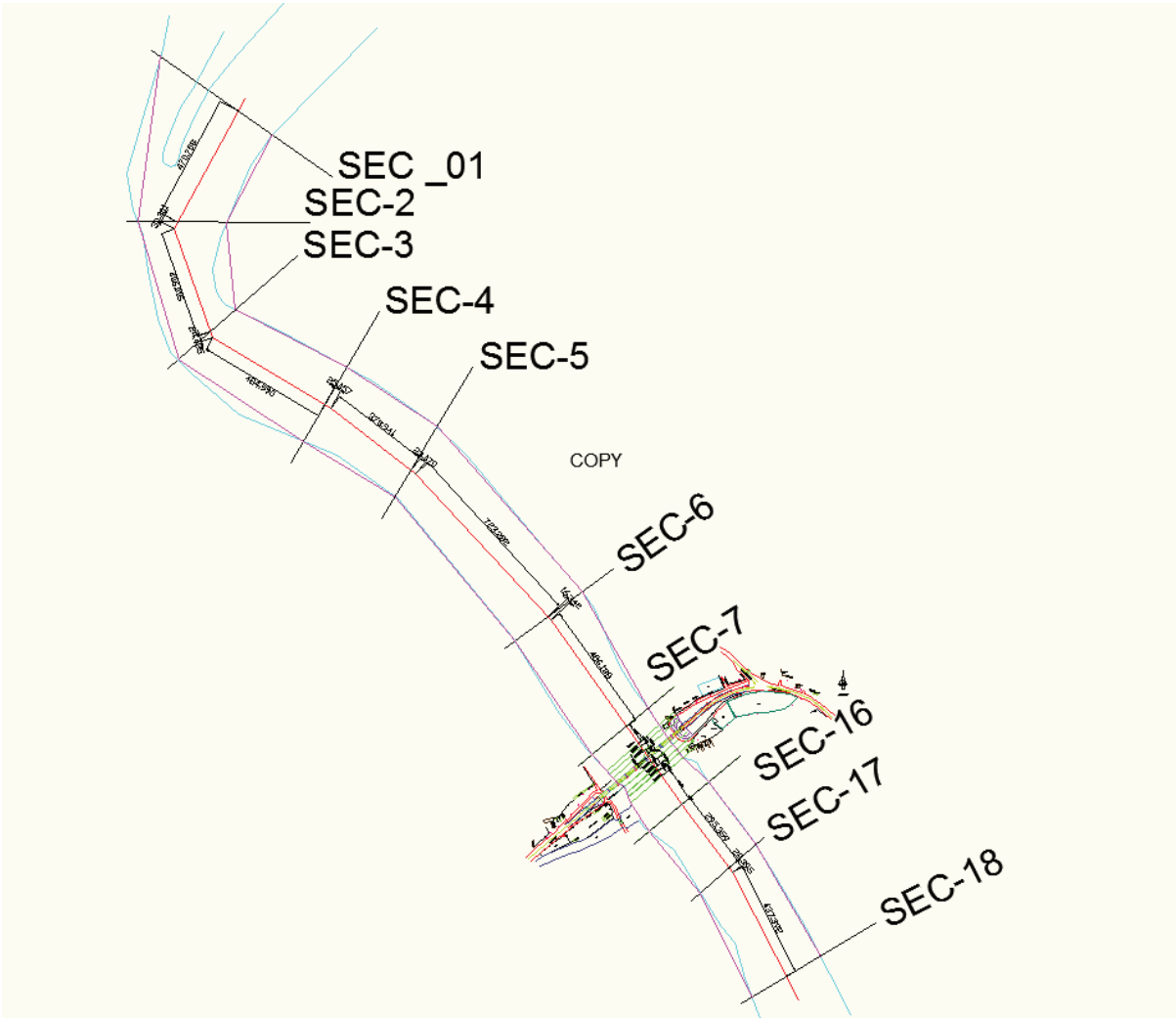


Figure 1.3.5 Topographic Survey Line at Kanchpur Bridge

Table 1.3.1 Longitudinal River Bed Profile of Lahkya River

Sec No.	Distance Between Cross section (m)	Distance from Cross Sec18 (m)	Lowest Bed Level	Average Bed Level
			R.L.m	R.L.m
SEC18	-	0.0	-8.85	-5.36
SEC17	459.8	459.8	-9.39	-5.97
SEC16	295.4	755.1	-10.20	-5.81
SEC15	129.2	884.3	-11.56	-7.31
SEC14	22.8	907.1	-11.81	-7.89
SEC13	17.1	924.2	-13.40	-8.08
SEC12	20.9	945.0	-12.95	-8.09
SEC11	26.7	971.7	-11.11	-7.27
SEC10	26.4	998.1	-11.42	-7.12
SEC9	21.0	1,019.1	-11.22	-7.33
SEC8	15.7	1,034.8	-10.37	-7.20
SEC7	76.3	1,111.0	-9.87	-5.60
SEC6	502.5	1,613.6	-9.71	-5.52
SEC5	746.4	2,359.9	-14.93	-7.50
SEC4	404.0	2,763.9	-8.07	-4.59
SEC3	509.5	3,273.4	-11.59	-6.91
SEC2	436.3	3,709.7	-14.08	-5.88
SEC1	470.8	4,180.5	-6.97	-3.26

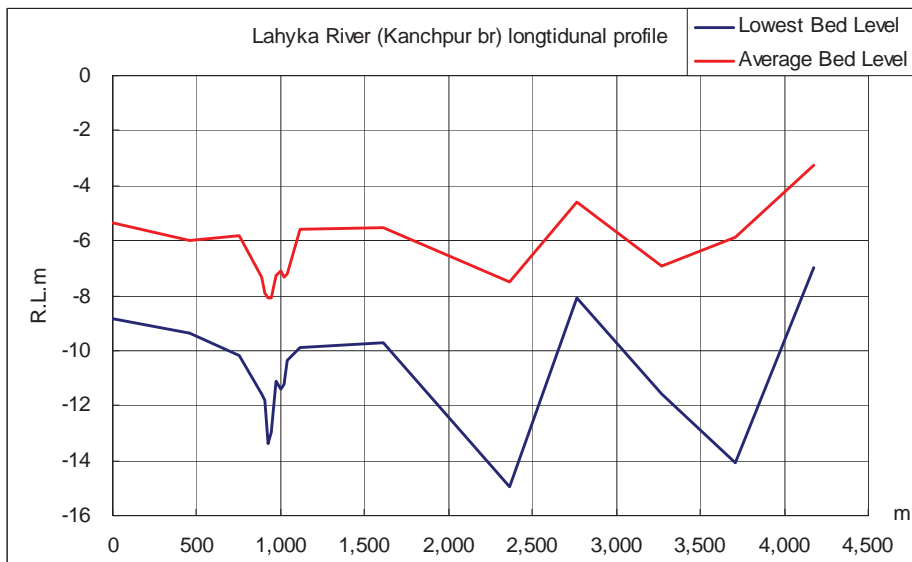


Figure 1.3.6 Longitudinal River Bed Profile of Lahkya River

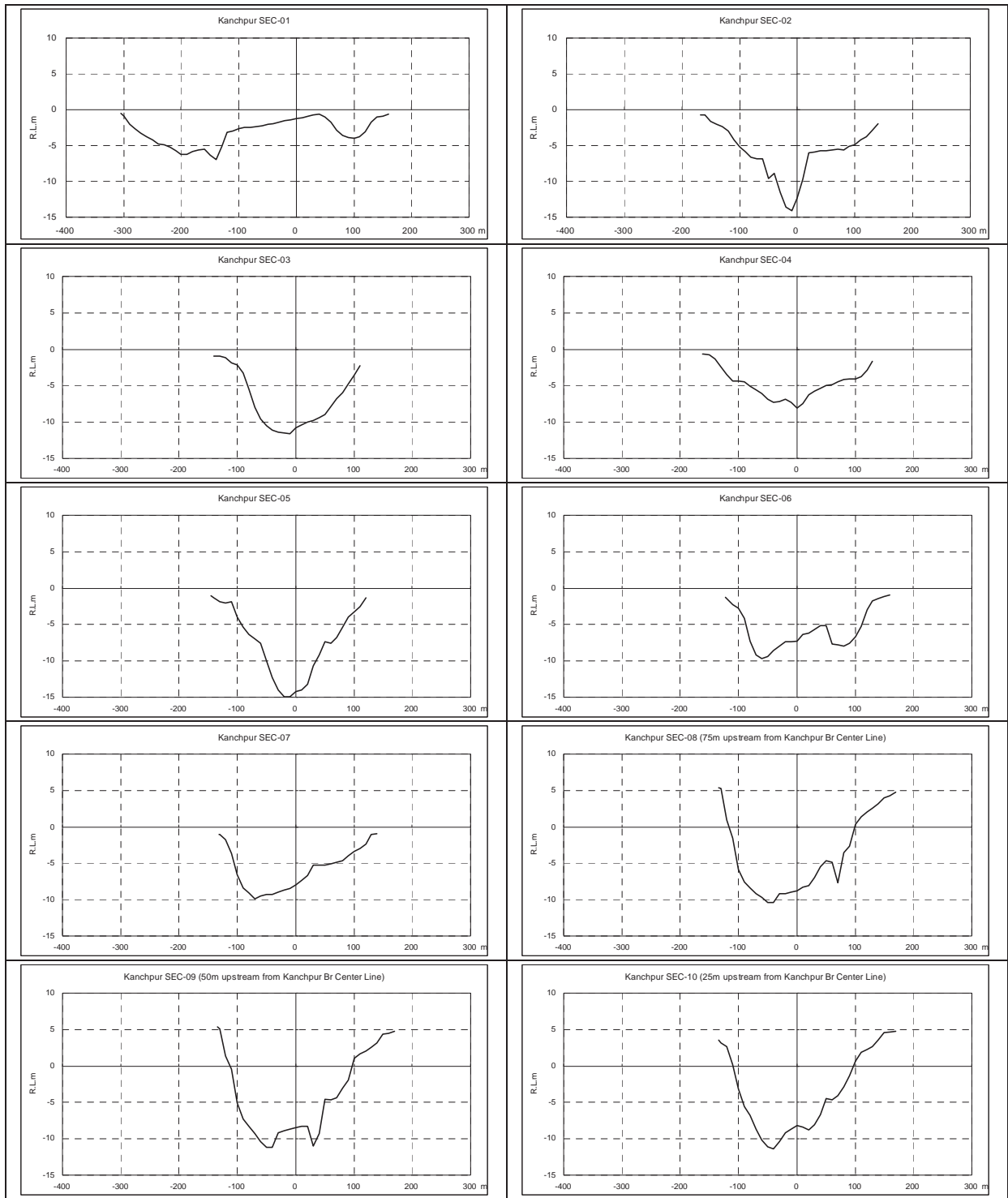


Figure 1.3.7 Cross Section Profile of Lahkya River(1/2)

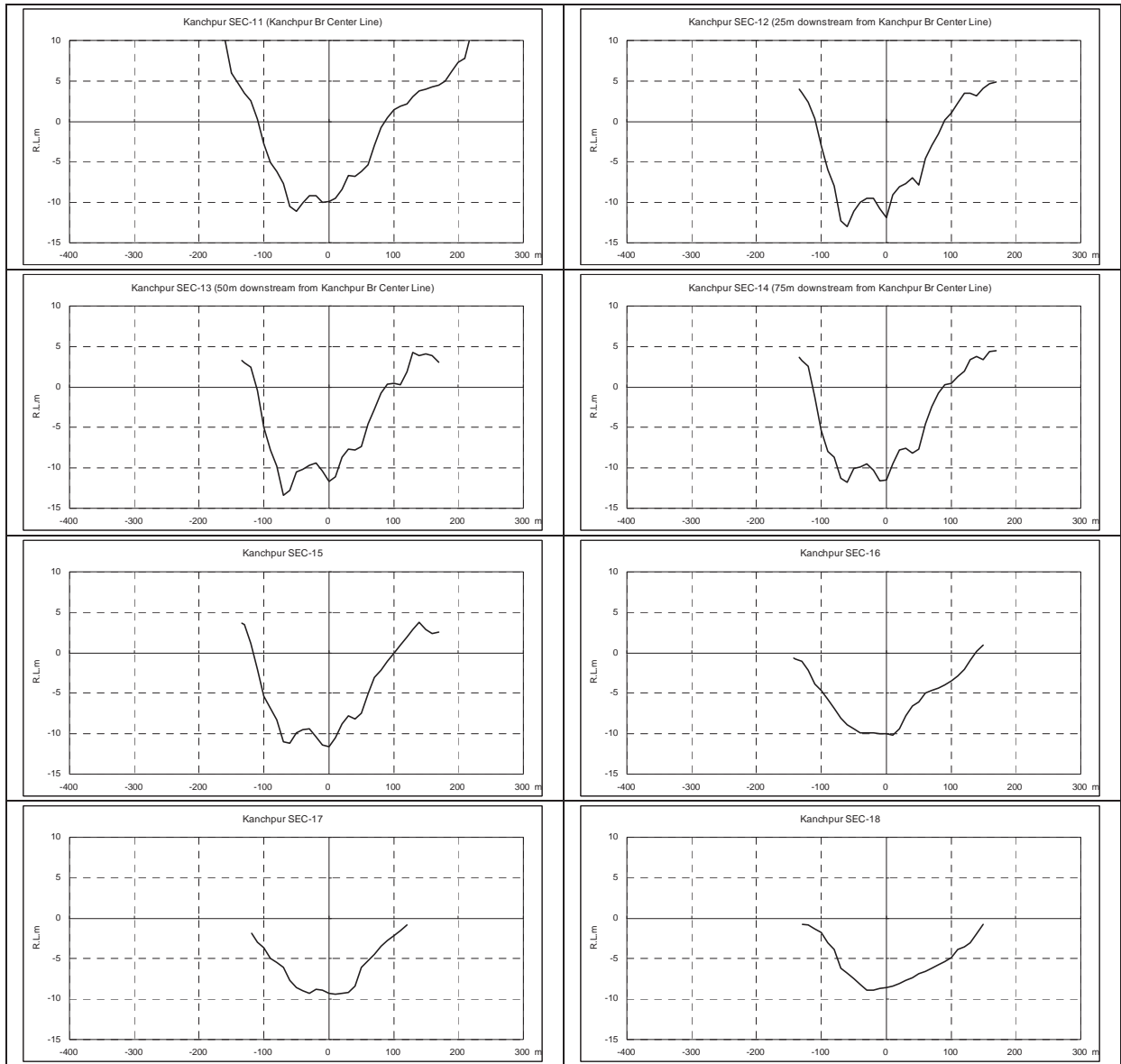


Figure 1.3.8 Cross Section Profile of Lahkya River(2/2)

1.3.2 Meghna Bridge (Meghna River)

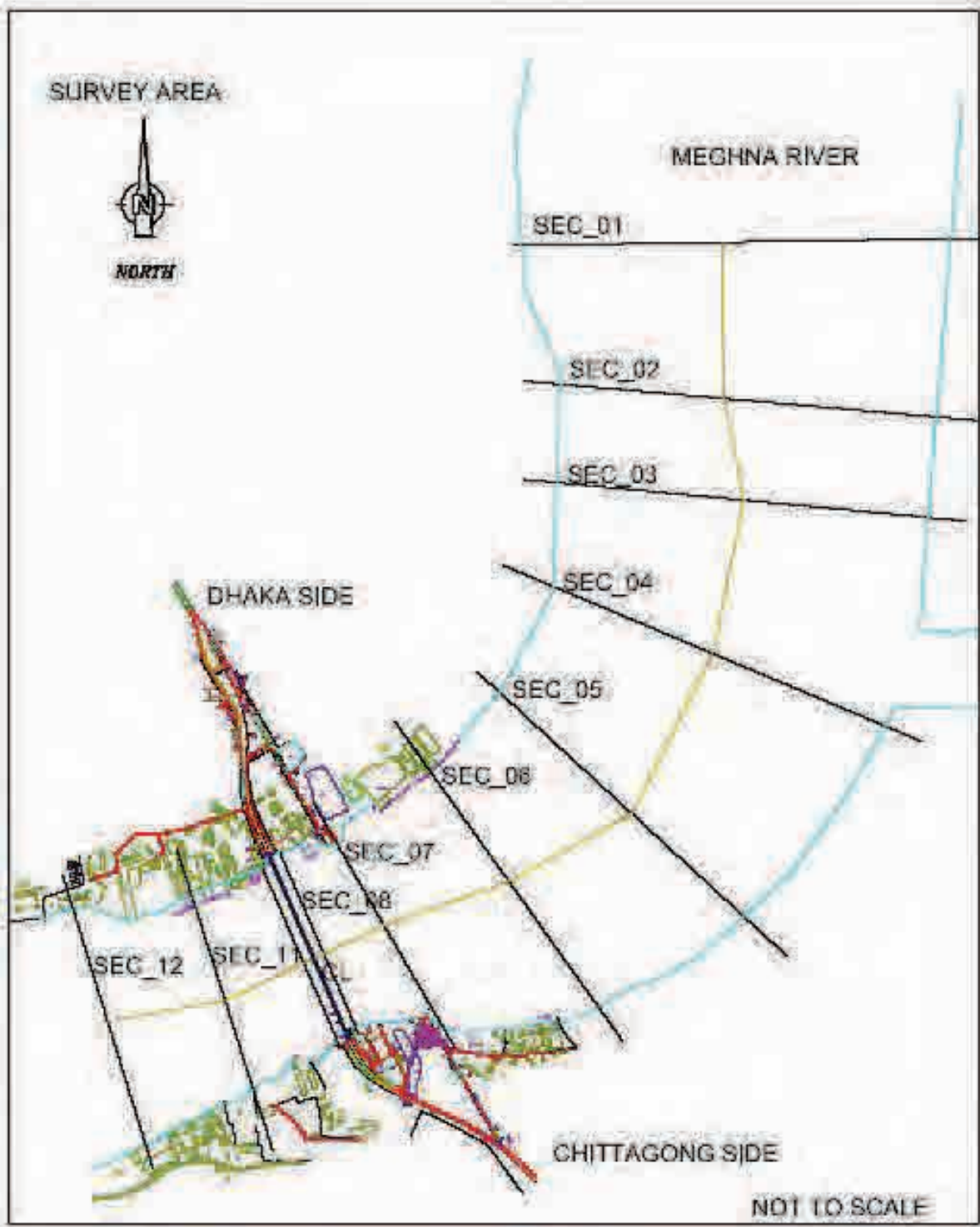


Figure 1.3.9 Topographic Survey Line at Meghna Bridge

Table 1.3.2 Longitudinal River Bed Profile of Meghna River

Sec No.	Distance Between Cross section (m)	Distance from CrossSec12 (m)	Lowest Bed Level R.L.m	Average Bed Level R.L.m
SEC12	-	0.0	-20.68	-14.98
SEC11	538.4	538.4	-22.19	-14.31
SEC10	316.1	854.6	-27.50	-13.92
SEC9	139.4	994.0	-23.02	-12.40
SEC8	63.9	1,057.8	-22.17	-11.92
SEC7	274.1	1,331.9	-25.82	-13.41
SEC6	597.4	1,929.4	-23.61	-15.79
SEC5	634.2	2,563.6	-23.66	-15.78
SEC4	810.9	3,374.5	-21.57	-15.91
SEC3	707.2	4,081.7	-20.05	-14.44
SEC2	468.5	4,550.2	-22.05	-16.48
SEC1	706.2	5,256.4	-22.49	-13.34

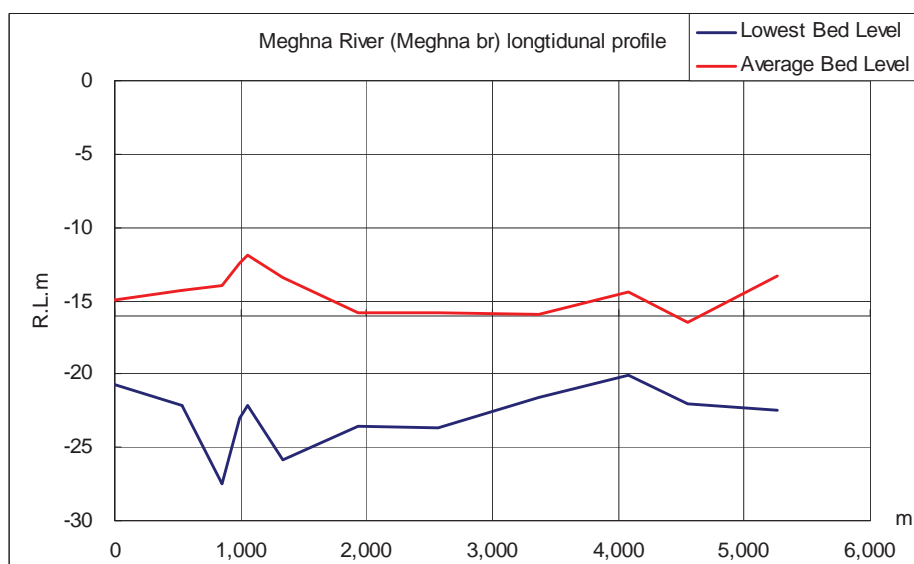


Figure 1.3.10 Longitudinal River Bed Profile of Meghna River

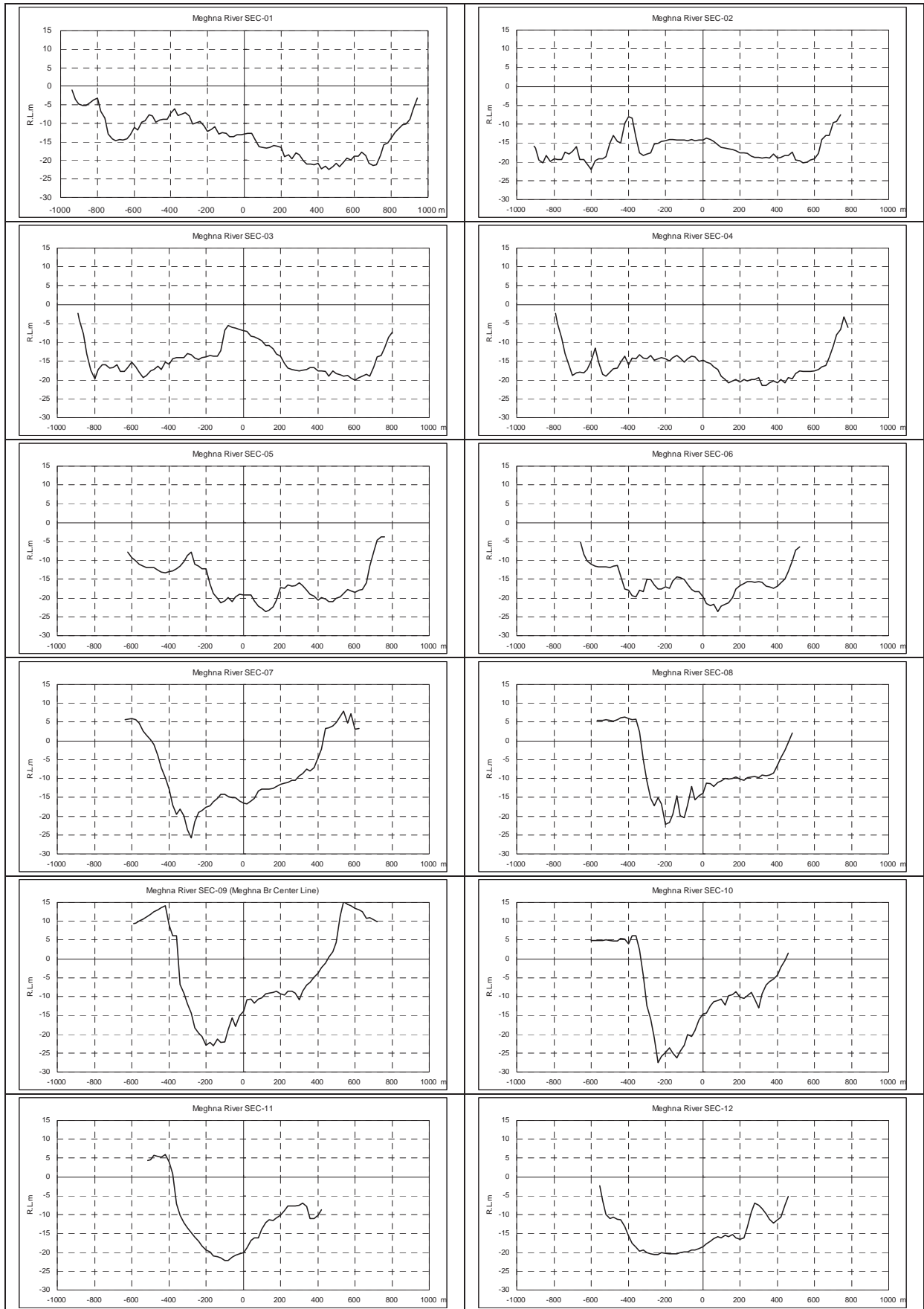


Figure 1.3.11 Cross Section Profile of Meghna River

1.3.3 Gumti Bridge

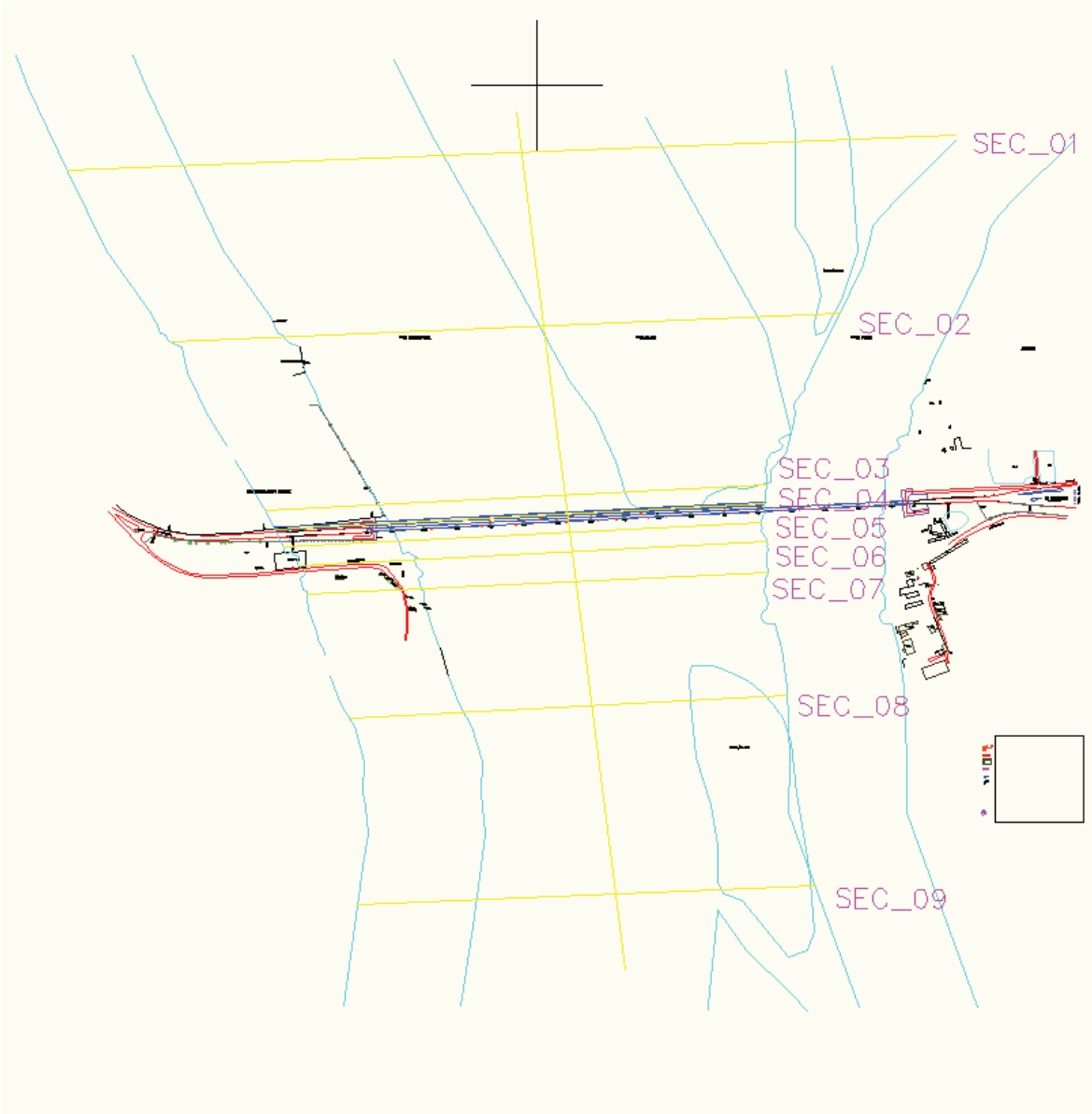


Figure 1.3.12 Topographic Survey Line at Gumti Bridge

Table 1.3.3 Longitudinal River Bed Profile of Gumit River

Sec No.	Distance Between Cross section (m)	Distance from Cross Sec9 (m)	Lowest Bed Level R.L.m	Average Bed Level R.L.m
SEC9	-	0.0	-13.64	-6.99
SEC8	496.4	496.4	-16.32	-8.88
SEC7	328.5	824.9	-9.11	-5.09
SEC6	78.7	903.6	-9.85	-5.20
SEC5	50.1	953.8	-8.57	-4.36
SEC4	50.1	1,003.9	-9.80	-6.09
SEC3	50.1	1,054.0	-7.73	-5.38
SEC2	445.6	1,499.6	-9.23	-6.82
SEC1	458.9	1,958.6	-21.71	-12.28

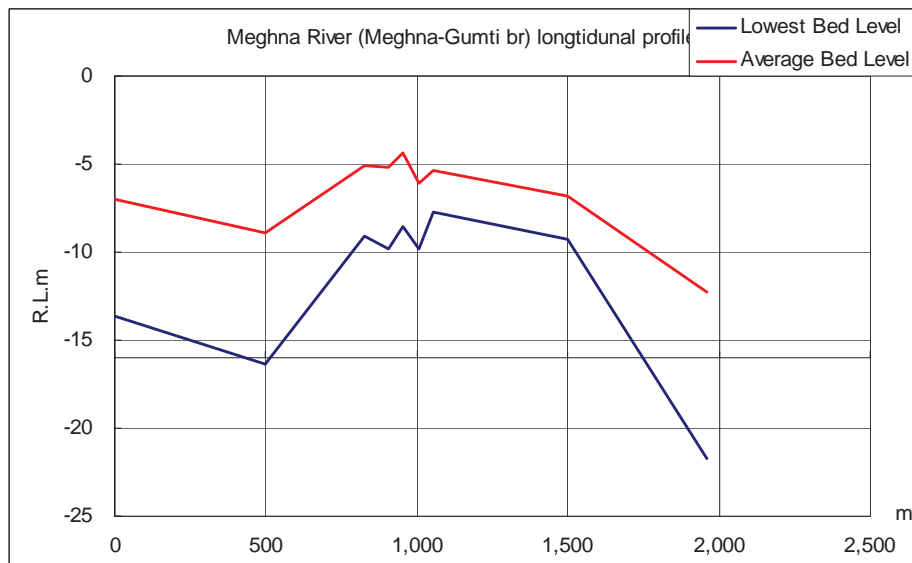


Figure 1.3.13 Longitudinal River Bed Profile of Gumti River

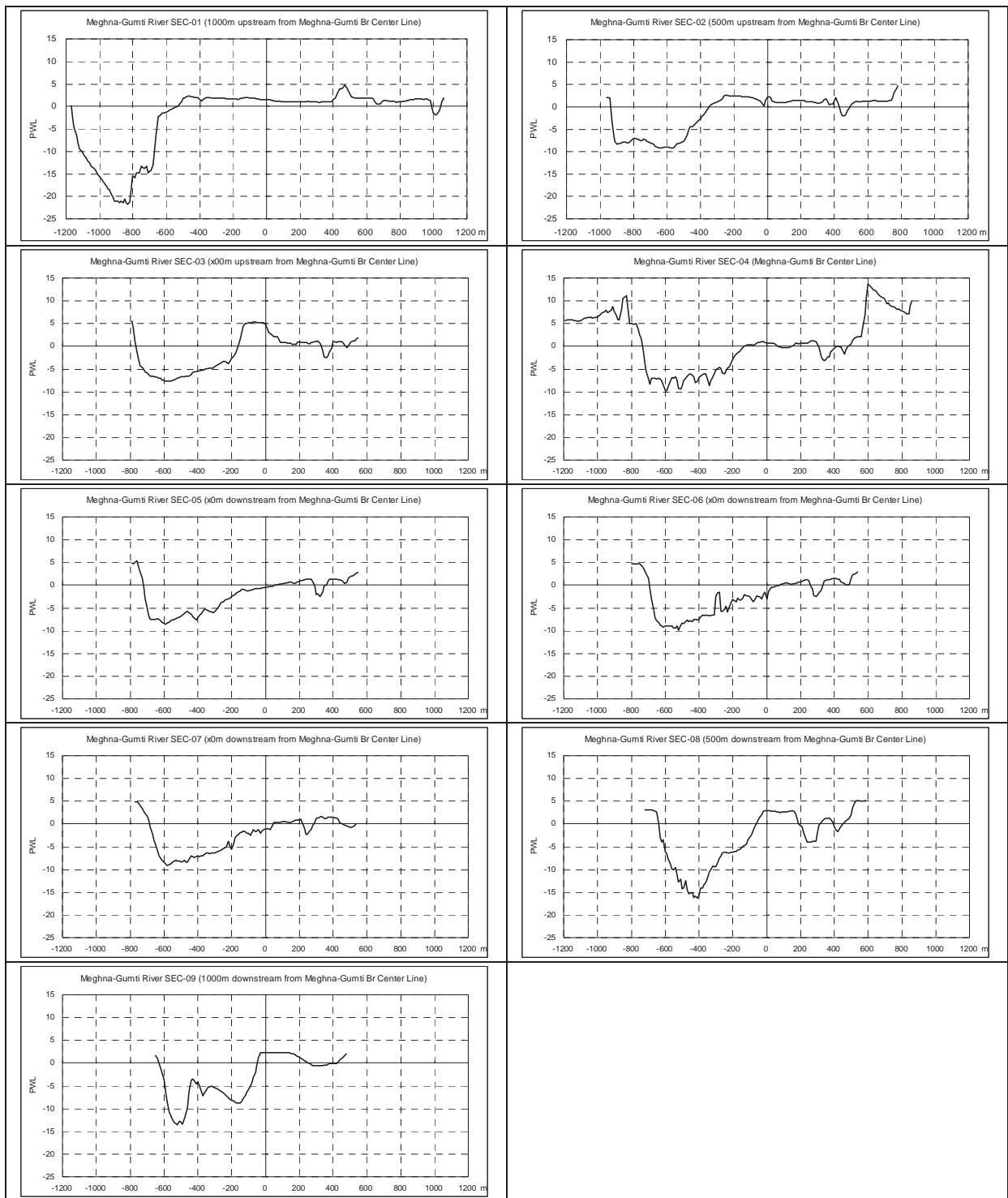


Figure 1.3.14 Cross Section Profile of Gumti River

1.4 River Current Velocity Survey

1.4.1 Overall

In order to protect the existing bridge and new bridge from scouring around piers, it is necessary to predict current velocity in design flood event. River current velocity survey is held to collect the basic hydrological data of the river, and data measured will be used to check the numerical analysis.

River current velocity survey is carried out from July 30th 2012 by ADCP device which can measure river current velocity, flow direction and total discharge measurement along the cross section of the river.

1.4.2 Method

Discharge measurement has been conducted at Kanchpur, Megnha and Meghna-gumti Rivers using Acoustic Doppler Current Profiler (ADCP) and DGPS System on 30th July 2012.

The R D Instruments state-of-the earth Workhorse Rio-grande ADCP (600 Khz) with bottom tracking option has been used for the survey. The instrument is capable of velocity profiling upto 45m depth. The measurement has been done following WinRiver User Guide supplied by the manufacturer of the instrument. The instrument is used for measuring velocity at a fixed time interval (known as ensemble) without anchoring at desired transects location (moving boat condition). It measures flow velocity at each ensemble (around 2.5 second intervals) at 50cm interval throughout the water column.

Thus a series of velocity data is recorded along the whole transect line. However, it estimates the discharge of unmeasured areas (the top of instrument face, near bottom part and at edges). The river flow is calculated online by the WinRiverII Software adding discharge of each ensemble as it moves along the transect line. As the river carries considerable amount of sediment and have a higher velocity, the bias bottom tracking condition was observed. To overcome this, GPS (GGA) has been used as reference for velocity and discharge computation. Necessary compass calibration has been made earlier as per guidelines set in the User Manual supplied by RD Instruments. The observed data has been found very consistent. The discharge data provides good indication of the distribution of flow. It also provides velocity distribution across the full channel.

Table 1.4.1 Instruments and Software on Current Velocity Survey

	Supplier
ADCP Device	Workhouse Rio Grande 600 khz
RTK GPS Device	Trimble 5700
Software	Winriver II

1.4.3 Survey Result

(1) Overall

Total discharge , average flow area and average velocity of three bridges by ADCP survey are shown in Table 1.4.2.

In this result, discharge at Meghna bridge is about 10 times more than discharge at Gumti bridge,. Both river flow originally one channel at upstream of the bridges, and after Bhairab Bazar, station, both river channel are separated. Hence it seems that the discharge at Bhairab Bazar almost flows along Main Meghna river through Meghna Bridge.

Table 1.4.2 Measurement Result at Meghna Bridge

	Unit	Meghna	Meghna-Gumti	Kanchpur
Water Level	M.S.L	3.72	3.69	3.96
Total Discharge	m ³ /s	11637.0	1063.5	1248.4
Average Flow Area	m ²	13245.9	7416.0	2267.5
Average Velocity	m/s	0.892	0.143	0.554

Table 1.4.3 Cross Section Current Velocity Survey Result

Transact	Start Bank	# Ene	Start Time	Total Q m ³ /s	Delta Q %	Top Q m ³ /s	Misc. Q m ³ /s	Bottom Q m ³ /s	Left Q m ³ /s	Left Dist m	Right Q m ³ /s	Right Dist m	Width m	Total Area m ²	Q/Area m/s	Boat Speed m/s	Flow Speed m/s	Flow Dir °	End Time	Duration s	Start Ene	End Ene	Velocity Ref	Depth Ref
02002	Right	112	14:31:49	11911.817	0.88	742.091	9892.908	1248.764	18.980	3.00	5.075	5.00	820.86	13234.59	0.902	1.451	0.966	274.87	14:41:06	556.87	5	106	Ref: BT	ADCP
02003	Left	69	14:41:45	11744.835	-0.63	754.469	9894.460	1065.979	21.915	4.00	6.012	5.00	784.04	12895.27	0.904	2.121	0.924	239.94	14:48:00	374.92	112	181	Ref: BT	ADCP
02004	Right	87	14:50:01	11967.754	1.38	630.246	10064.747	1165.131	15.300	5.00	47.240	29.00	799.76	13641.26	0.878	1.614	0.920	268.13	14:57:05	474.17	203	289	Ref: BT	ADCP
02005	Left	72	14:58:23	11636.357	-1.95	682.008	9619.204	1253.304	24.693	5.00	57.748	29.00	731.02	13142.33	0.885	1.641	0.923	238.38	15:04:54	391.46	294	365	Ref: BT	ADCP
Average		82		11619.343	-0.00	718.703	9867.705	1183.294	20.372	4.25	29.519	12.50	713.82	13245.86	0.892	1.757	0.933							
Std. Dev.		13		157.531	1.33	37.896	164.149	88.092	3.785	0.96	26.861	6.65	38.08	277.65	0.013	0.290	0.022							
Std. Dev.		0.18		0.01	0.00	0.05	0.02	0.07	0.19	0.23	0.51	0.69	0.05	0.02	0.01	0.16	0.02							

Transact	Start Bank	# Ene	Start Time	Total Q m ³ /s	Delta Q %	Top Q m ³ /s	Misc. Q m ³ /s	Bottom Q m ³ /s	Left Q m ³ /s	Left Dist m	Right Q m ³ /s	Right Dist m	Width m	Total Area m ²	Q/Area m/s	Boat Speed m/s	Flow Speed m/s	Flow Dir °	End Time	Duration s	Start Ene	End Ene	Velocity Ref	Depth Ref
03003	Right	179	17:21:51	966.523	7.24	110.395	761.996	119.188	0.501	6.00	0.864	3.00	1105.69	7310.03	0.135	1.763	0.185	166.16	17:33:44	712.62	7	184	Ref: BT	ADCP
03004	Left	146	17:34:08	1146.554	7.24	122.045	875.583	136.582	0.287	7.00	5.129	5.00	1146.26	7521.52	0.152	1.546	0.293	133.25	17:43:57	582.67	191	338	Ref: BT	ADCP
Average		163		1063.539	0.00	116.220	820.640	123.514	0.107	6.50	2.997	4.00	1141.88	7415.03	0.143	1.654	0.195							
Std. Dev.		22		108.517	10.24	8.239	79.257	18.962	0.557	0.71	3.016	1.41	9.03	148.19	0.012	0.130	0.010							
Std. Dev.		0.13		0.10	0.00	0.07	4.10	0.15	5.28	0.11	1.01	0.35	0.01	0.02	0.00	0.02	0.05							

Transact	Start Bank	# Ene	Start Time	Total Q m ³ /s	Delta Q %	Top Q m ³ /s	Misc. Q m ³ /s	Bottom Q m ³ /s	Left Q m ³ /s	Left Dist m	Right Q m ³ /s	Right Dist m	Width m	Total Area m ²	Q/Area m/s	Boat Speed m/s	Flow Speed m/s	Flow Dir °	End Time	Duration s	Start Ene	End Ene	Velocity Ref	Depth Ref
1001	Right	47	11:52:37	1369.360	4.88	138.324	1019.343	141.808	7.882	4.00	1.000	5.00	248.86	2469.34	0.530	1.341	0.351	154.06	11:58:42	184.72	162	208	Ref: BT	ADCP
1003	Right	41	11:59:06	1214.728	-2.70	137.662	927.600	139.271	5.370	4.00	0.910	5.00	233.14	2324.49	0.523	1.435	0.344	163.36	12:01:46	160.20	259	298	Ref: BT	ADCP
1005	Right	39	12:12:37	1221.106	-2.16	142.531	925.724	149.050	11.524	4.00	1.350	5.00	211.37	2099.00	0.600	1.494	0.095	151.04	12:15:09	152.10	30	76	Ref: BT	ADCP
Average		42		1248.428	0.00	139.839	957.623	140.378	9.497	4.00	1.089	5.00	234.13	2267.49	0.554	1.429	0.567							
Std. Dev.		1		52.867	4.23	2.412	52.463	1.299	1.862	0.00	0.229	0.00	18.83	293.57	0.017	0.073	0.033							
Std. Dev.		0.10		0.04	0.00	0.03	0.06	0.01	0.20	0.00	0.29	0.50	0.08	0.10	0.05	0.05	0.06							

Meghna

Meghna-Gumti

Kanchpur

(2) Meghna Bridge (Meghna River)

Table 1.4.4 Measurement Result at Meghna Bridge

	Unit	Result
Water Level	M.S.L	3.72
Total Discharge	m ³ /s	11637.0
Average Velocity	m/s	0.892

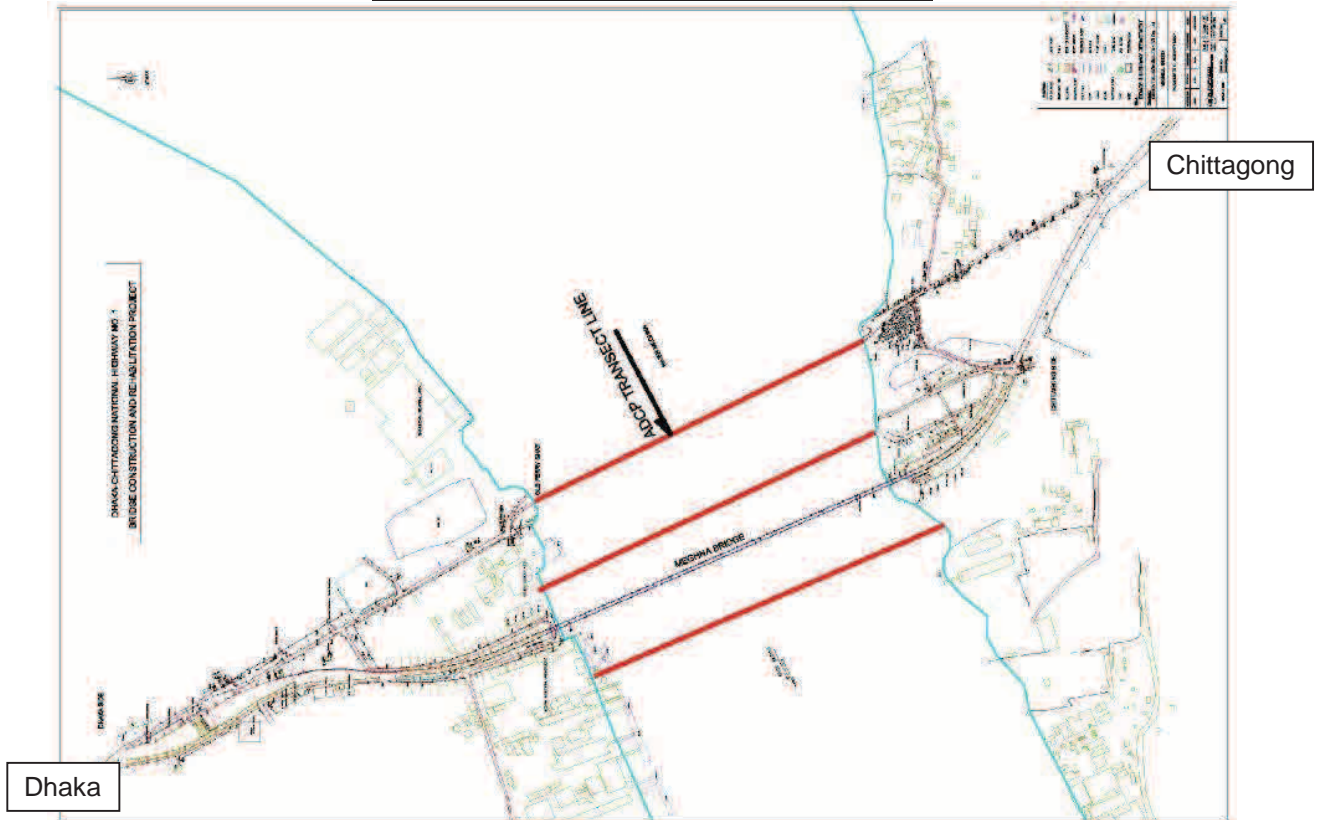


Figure 1.4.3 Transect Lines at Meghna Bridge Site

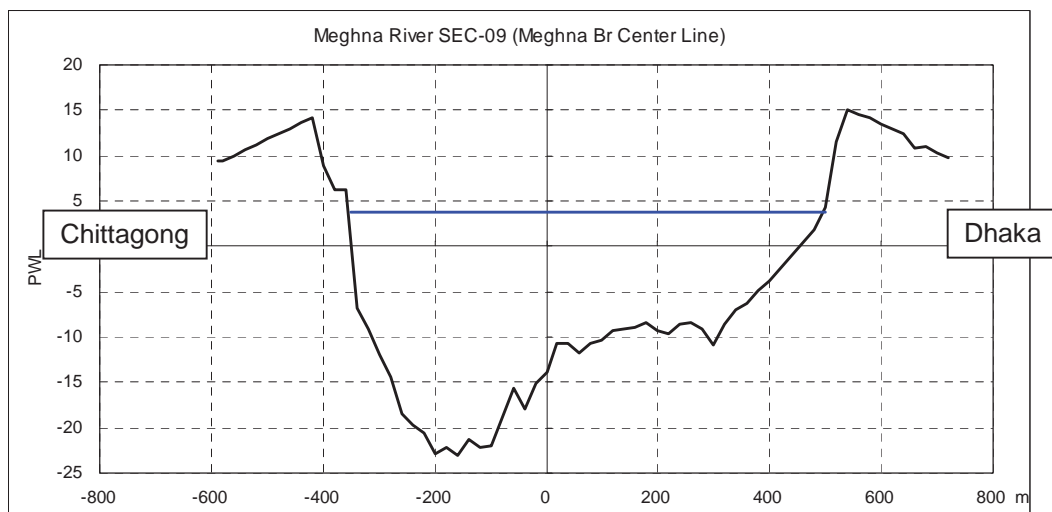


Figure 1.4.4 Water Level on the Measured Period (July 30th 2012)

(3) Gumti Bridge

Table 1.4.5 Measurement Result at Gumti Bridge

	Unit	Result
Water Level	M.S.L	3.69
Total Discharge	m ³ /s	1063.5
Average Velocity	m/s	0.143

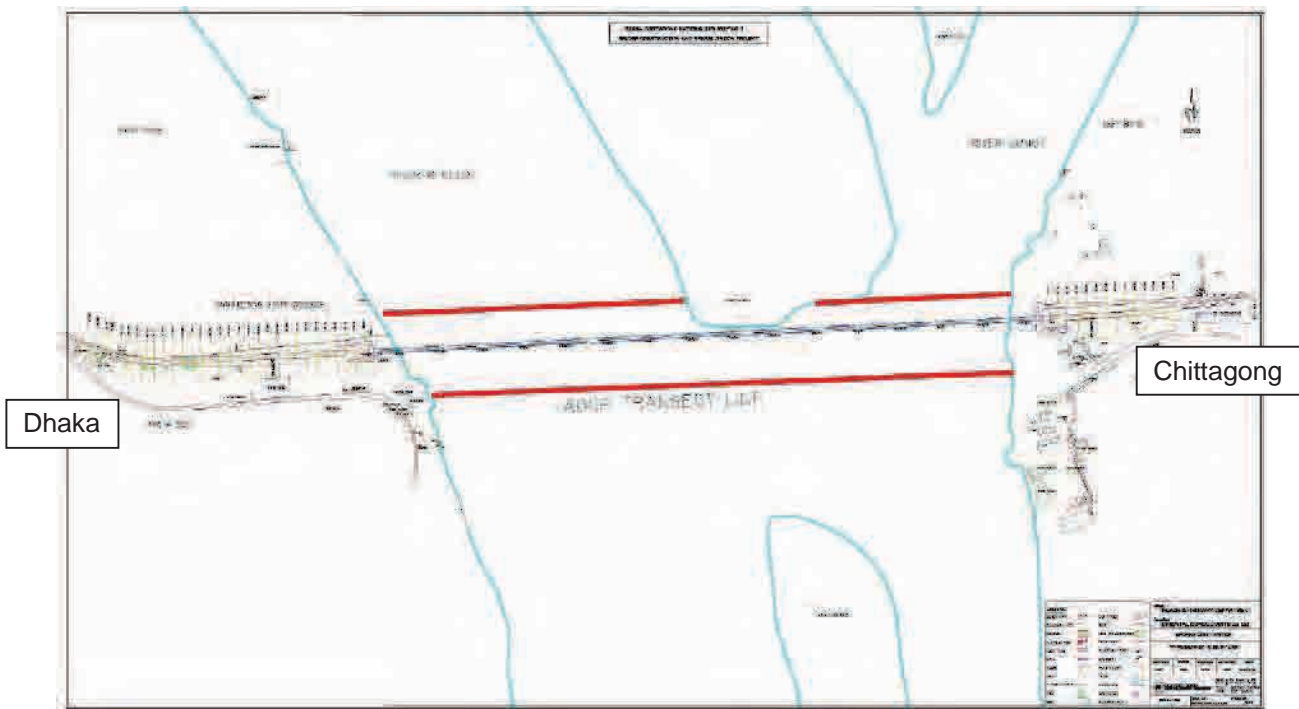


Figure 1.4.7 Transect Lines at Gumti Bridge Site

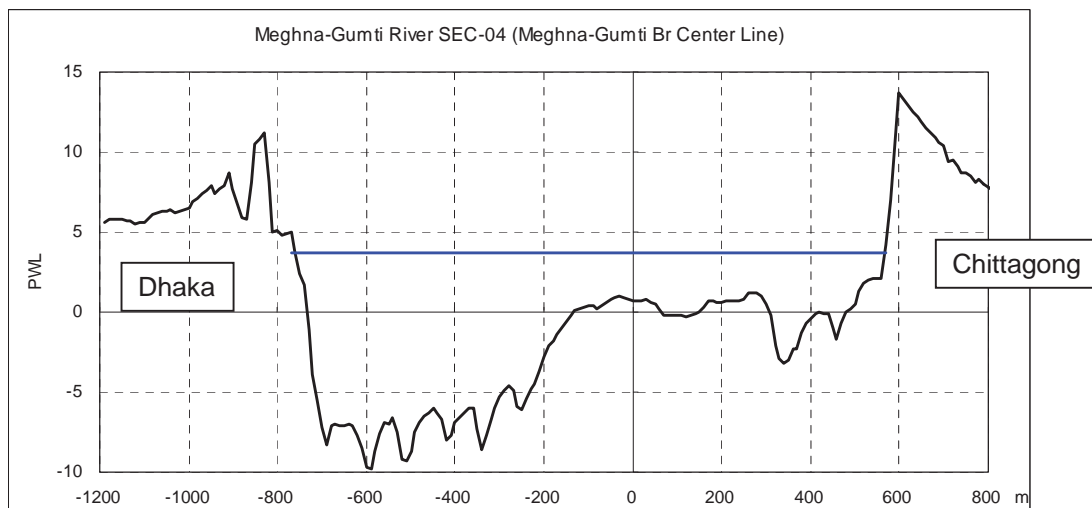


Figure 1.4.8 Water Level on the Measured Period (July 30th 2012)

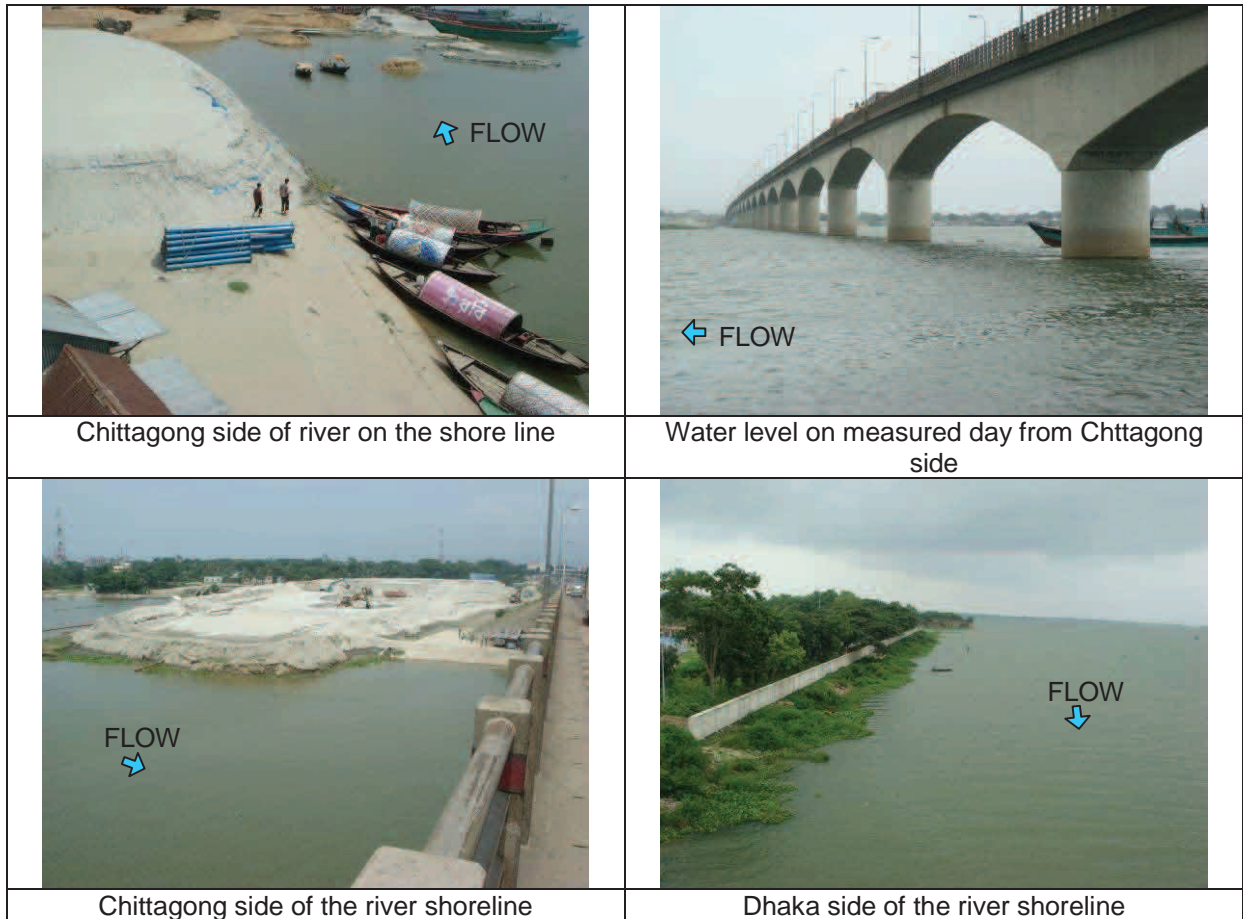


Figure 1.4.9 Water Level on the Measured Day at Gumti Bridge (July 30th 2012)

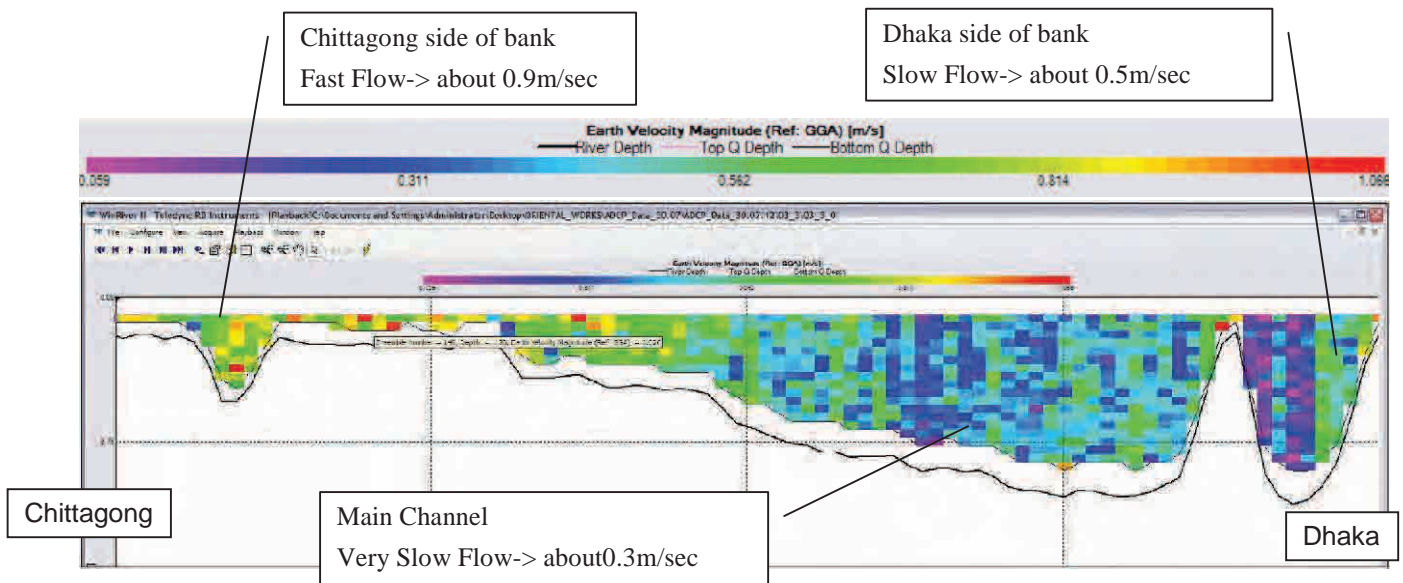


Figure 1.4.10 Cross Section Velocity Contour at Gumti Bridge

(4) Kanchpur Bridge

Table 1.4.6 Measurement Result at Kanchpur Bridge

	Unit	Result
Water Level	M.S.L	3.96
Total Discharge	m ³ /s	1248.4
Average Velocity	m/s	0.554

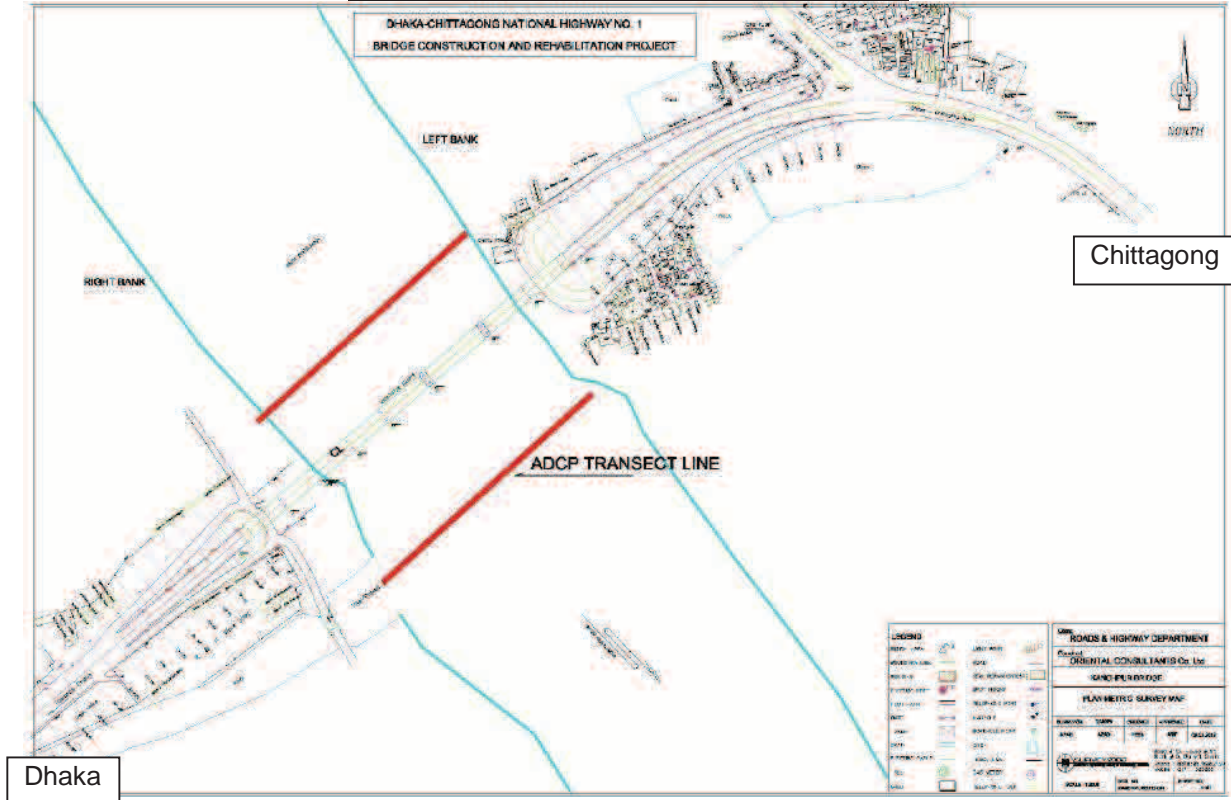


Figure 1.4.11 Transect Lines at Kanchpur Bridge Site

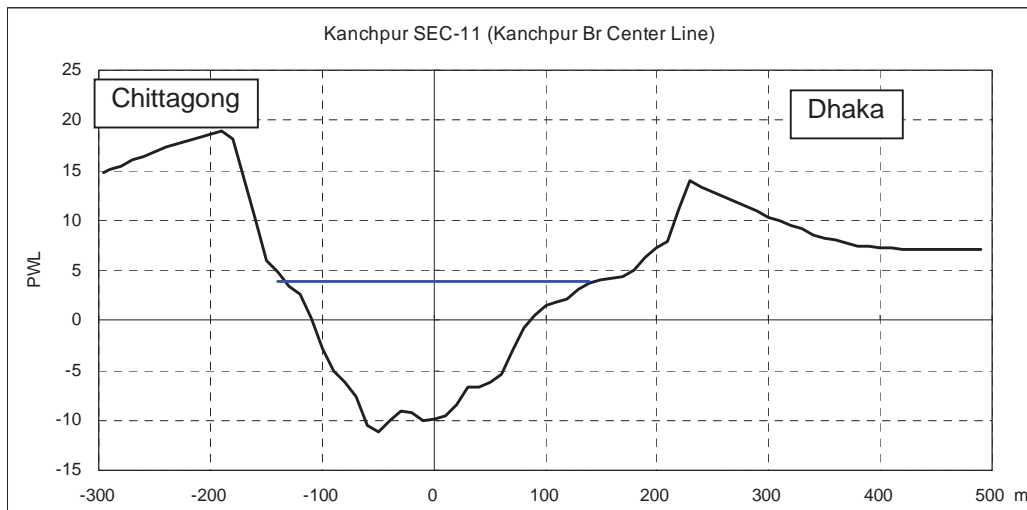


Figure 1.4.12 Water Level on the Measured Period (July 30th 2012)



Figure 1.4.13 Water Level on the Measured Day at Kanchpur Bridge (July 30th 2012)

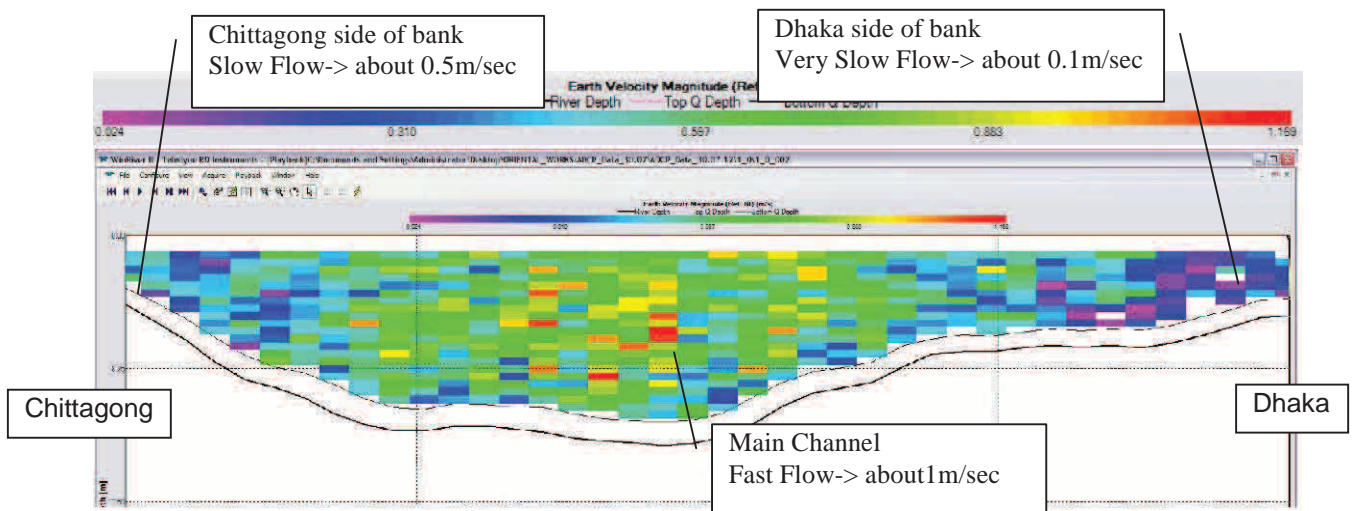


Figure 1.4.14 Cross Section Velocity Contour at Kanchpur Bridge

2. HYDROLOGICAL AND HYDRAULIC ANALYSIS

2.1 Design Criteria

Bridge: Design water level is 100-year return period water level + 2.0m freeboard (minimum) up to the bottom of bridge girders, in reference to Japanese "Government ordinance for structural standards for river administration facilities".

Motorway Alignment: The elevation at the bottom of sub base level is to be above the 100-year return period of high water level.

Protection of Road Embankment: It is provided for inundated areas except reaches where flow velocity is low. The elevation of protection level is 1.0m above 100-year return period flood level.

2.2 Hydrological Analysis

Hydrological analysis was carried out to estimate the design discharges of streams at motorway crossing points which are required to estimate the hydraulic design outputs at bridges and also water levels. The corresponding catchment area of stream was measured using topographic maps or/and referring the data from nearby gauging stations.

In this section, the discharge around three bridges are re-examined by discharge data which is collected in chapter 4.

2.2.1 Kanchpur Bridge

There is no existing river plan at Kanchpur Bridge and Lahkya river, hence the discharge value for Kanchpur Bridge is estimated in this study by using recently collected reference data.

There are two water level and discharge measuring station, Demra at Lahkya river and Demra at Balu river which is maintained by BWBD. The discharge at Kanchpur Bridge is sum of discharge of Lahkya and Balu river.

100-year return period discharge at Demra(Lahkya) and Demra(Balu) is estimated according to Japanese Government's technical standard shown in Table 2.2.2 and Table 2.2.3, and the 100-year return period discharge at Kanchpur Bridge is 3480 [m³/s] , shown in Table 2.2.1 and Figure 2.2.1.

Table 2.2.1 100-year return period discharge at Kanchpur Bridge

	Demra(Lahyka) [m3/s]	Demra(Balu) [m3/s]	Kanchpur Bridge [m3/s]
100-year discharge	2596	884	3480

Table 2.2.2 Occurrence Probability for Discharge at Demra(Lahyka) St.

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	Ishihara Takase	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM
Return Period in year	2	1705	1776	1772	—	1893	1879	—	—	—	—	—	—
	3	1891	1953	2019	—	2066	2056	—	—	—	—	—	—
	5	2125	2151	2311	—	2208	2209	—	—	—	—	—	—
	10	2443	2399	2703	—	2333	2351	—	—	—	—	—	—
	20	2761	2638	3106	—	2415	2452	—	—	—	—	—	—
	30	2947	2775	3349	—	2450	2497	—	—	—	—	—	—
	50	3182	2946	3665	—	2485	2545	—	—	—	—	—	—
	80	3397	3103	3965	—	2511	2581	—	—	—	—	—	—
	100	3500	3177	4112	—	2521	2596	—	—	—	—	—	—
	150	3686	3312	4383	—	2536	2620	—	—	—	—	—	—
200	3818	3407	4581	—	2546	2635	—	—	—	—	—	—	
400	4136	3637	5072	—	2564	2665	—	—	—	—	—	—	
SLSC(99%)	0.099	0.066	0.084	—	0.038	0.038	—	—	—	—	—	—	—
Error of Estimation	224	181	266	—	238	216	—	—	—	—	—	—	—

Source: Estimated by the study team according to Japanese Government technical standard

Table 2.2.3 Occurrence Probability for Discharge at Demra(Balu) St

	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	Ishihara Takase	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM
Return Period in year	2	337	363	360	378	392	—	—	380	—	—	—	—
	3	406	429	455	446	460	—	—	445	—	—	—	—
	5	493	503	571	515	520	—	—	511	—	—	—	—
	10	611	595	734	592	577	—	—	585	—	—	—	—
	20	730	684	906	657	616	—	—	649	—	—	—	—
	30	799	735	1012	691	634	—	—	684	—	—	—	—
	50	886	798	1153	731	652	—	—	725	—	—	—	—
	80	966	856	1288	764	665	—	—	761	—	—	—	—
	100	1004	884	1355	779	671	—	—	778	—	—	—	—
	150	1073	934	1479	804	680	—	—	807	—	—	—	—
200	1122	970	1571	821	685	—	—	828	—	—	—	—	
400	1240	1055	1801	859	695	—	—	875	—	—	—	—	
SLSC(99%)	0.068	0.052	0.072	0.061	0.086	—	—	0.058	—	—	—	—	—
Error of Estimation	203	167	479	279	642	—	—	78	—	—	—	—	—

Source: Estimated by the study team according to Japanese Government technical standard

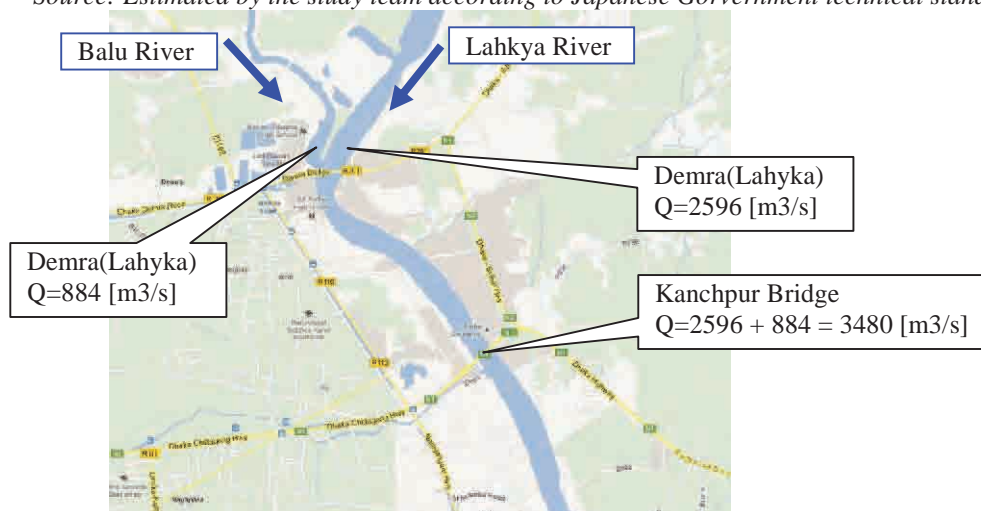
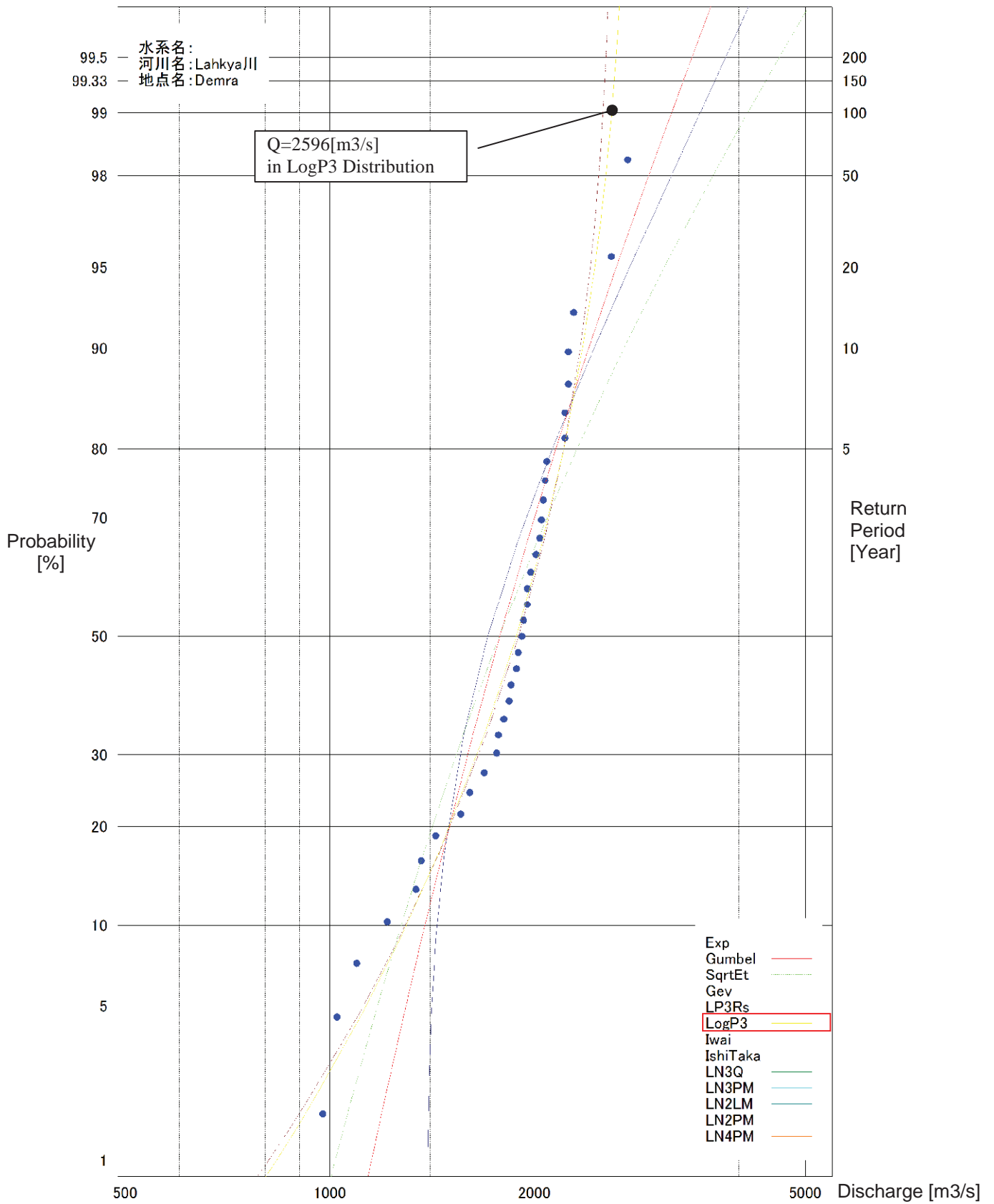
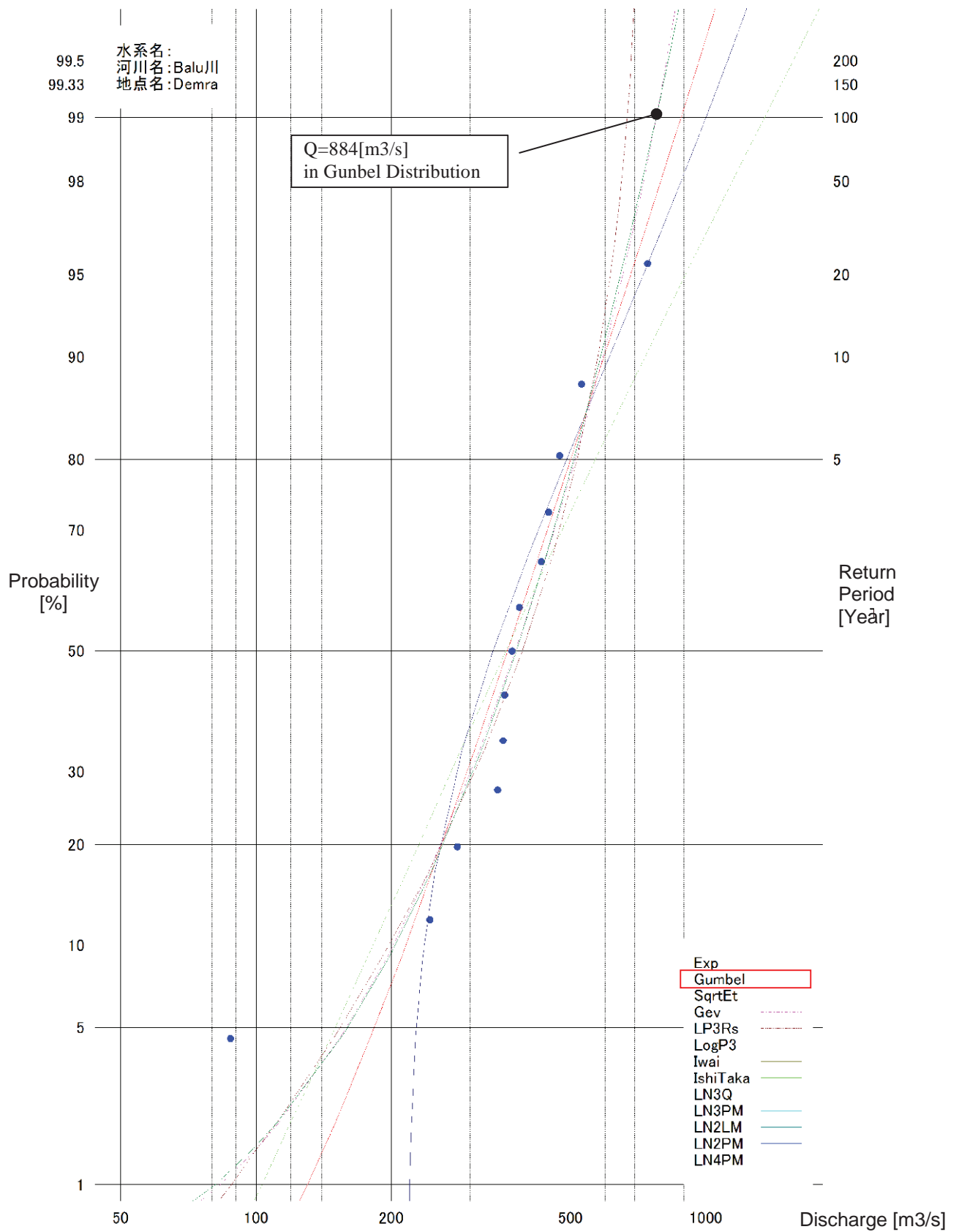


Figure 2.2.1 Discharge measuring station map around Kanchpur Bridge



Source: Estimated by the study team according to Japanese Government technical standard

Figure 2.2.2 Frequency Curve for Design Discharge (W=1/100) at Demra(Lahkya) St.



Source: Estimated by the study team according to Japanese Government technical standard

Figure 2.2.3 Frequency Curve for Design Discharge (W=1/100) at Demra(Balu) St.

2.2.2 Meghna & Gumti Bridge

The design discharge should be determined by the maximum number considering the former plan discharge and latest discharge data.

In upper Meghna river, there is only one discharge measuring station at Bhairab Bazar which is maintained by BWBD. Hence, the discharge is estimated according to the "Feasibility study on Meghna, Gumti Bridges construction project - final report (1985), JICA". In this report, discharge at Bhairab Bazar is estimated at first, then discharge at Meghna and Gumti Bridge is estimated by considering the flow distribution to main channel and branch of Meghna river and rest of catchment area after Bhairab Bazar Station.

100-year return period discharge at Bhairab Bazar Station is estimated by three methods in Table 2.2.4, the maximum discharge is 23700[m³/s] in 1985's JICA Report.

100-year return period discharge at Bridge is estimated below, relationship between discharge and catchment area, discharge distribution is shown in Figure 2.2.5.

- ◆ 100 year return period discharge of Meghna Bridge $Q = 15,200\text{m}^3/\text{sec}$.
- ◆ 100 year return period discharge of Gumti Bridge $Q = 12,400\text{m}^3/\text{sec}$.

Table 2.2.4 100-year return period discharge at Bhairab Bazar

	Discharge at Bhairab Bazar [m ³ /s]	Remarks
1985 JICA report	23,700	Adaption in this research
1992 FAP9B	20,300	
Estimated using by collected data	22,848	See Table 2.2.5 and Figure 2.2.4

Table 2.2.5 Occurrence Probability for Discharge at Bhairab Bazar (Estimated)

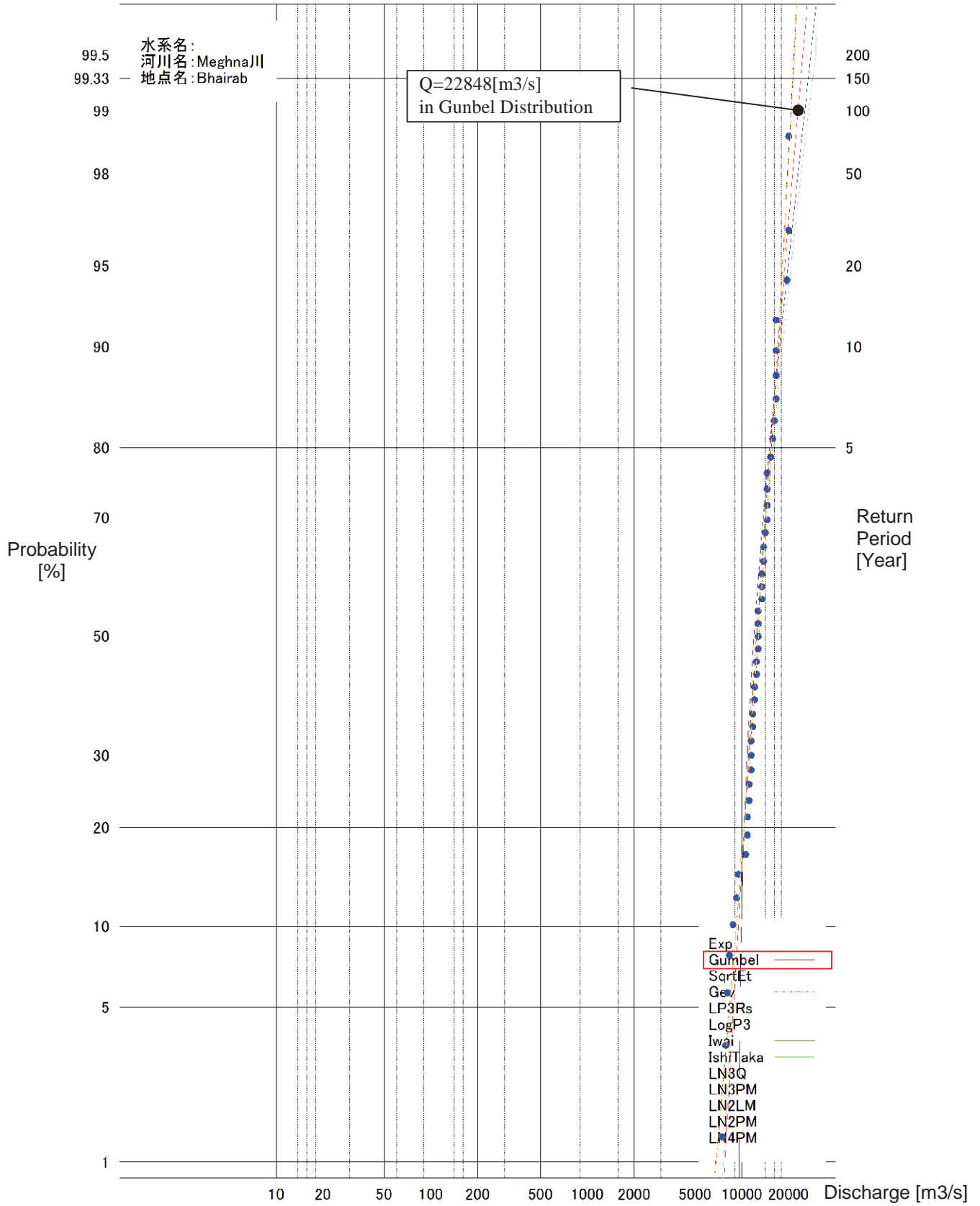
	Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	Ishihara Takase	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM
Return Period in year	2	11888	12417	12348	12715	12771	12739	—	—	—	—	—	—
	3	13273	13738	13892	14072	14111	14080	—	—	—	—	—	—
	5	15017	15209	15709	15448	15445	15429	—	—	—	—	—	—
	10	17385	17058	18136	16994	16924	16943	—	—	—	—	—	—
	20	19753	18832	20615	18307	18179	18246	—	—	—	—	—	—
	30	21138	19852	22107	18994	18843	18941	—	—	—	—	—	—
	50	22882	21128	24040	19789	19621	19763	—	—	—	—	—	—
	80	24488	22295	25875	20459	20291	20477	—	—	—	—	—	—
	100	25250	22848	26766	20758	20596	20803	—	—	—	—	—	—
	150	26635	23851	28419	21274	21129	21378	—	—	—	—	—	—
	200	27618	24562	29618	21619	21494	21773	—	—	—	—	—	—
400	29985	26273	30000	22384	22330	22685	—	—	—	—	—	—	
SLSC(99%)	0.069	0.037	0.053	0.033	0.028	0.028	—	—	—	—	—	—	
Error of Estimation	1617	1349	1694	1723	1359	1587	—	—	—	—	—	—	

Source: Estimated by the study team according to Japanese Government technical standard

Table 2.2.6 Catchment Area of the Meghna River

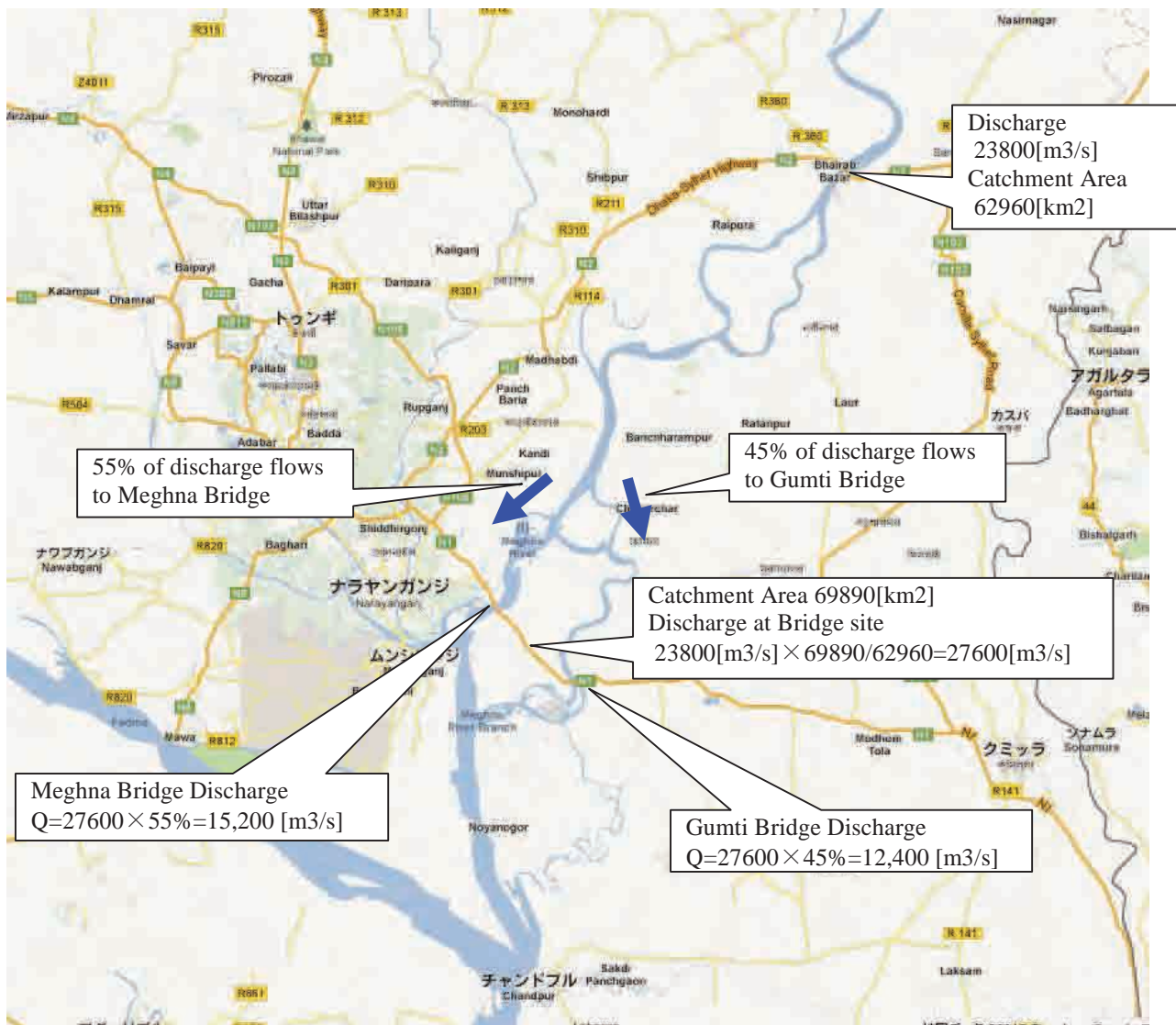
	Outside of Bangladesh[km2]	Inside of Bangladesh[km2]	Total [km2]
Catchment Area at Bhairab Bazar St.	41,390	21,570	62,960
Rest of Catchment Area Between Bridge Site And Bhairab Bazar St.	2,760	4,170	6,930
Catchment Area at Bridge Sites	44,150	25,740	6,9890

Source: 1985's JICA report



Source: Estimated by the study team according to Japanese Government technical standard

Figure 2.2.4 Frequency Curve for Design Discharge (W=1/100) at Bhairab Bazar St.



Source: Estimated by the study team according to 1985's JICA report

Figure 2.2.5 Relationship Between 100-year period Discharge and Catchment Area

2.3 High-Water Level Calculation

2.3.1 Method

Hydraulic design was carried out to obtain the design outputs at the three bridges using Nays2D on i-Ric software platform developed by Professor Yasuyuki SHIMIZU of Hokkaido University(Japan). Nays2D is free software, which is capable of calculating unsteady horizontal two-dimensional river flows and riverbed variation / lateral erosion. The software can be downloaded from website: [http:// http://i-ric.org/en/](http://http://i-ric.org/en/)

Water surface profiles are computed from horizontal two-dimensional lattice by solving the 2d-unsteady equation of motion. Energy losses are evaluated by friction (Manning's equation) and contraction/expansion coefficients. Nays2D requires inputs for boundary conditions of upstream discharge and either downstream water level.

The following procedure was adopted in the modelling.

- ◆ River profile is set up in the model using the river cross-sections taken at upstream and downstream. Cross section data is used (will be updated by using new survey results)
- ◆ Channel roughness “Manning’s n” is adopted according to the bed material diameter $d=0.167$ [mm]. Manning's n value for $d=0.167$ [mm] is $n=0.020$ according to Japanese Government's Technical Standard, that number is applied for main river and flood plain.
- ◆ The upstream boundary condition is applied for 100-year return period discharge for each bridges.
- ◆ The downstream boundary condition is applied for 100-year return period water level for each bridges which is estimated according to Japanese Government's Technical Standard, shown in Table 2.3.2 to Table 2.3.4 and Figure 2.3.2 to Figure 2.3.4.

The boundary condition for numerical model simulation is summarized in Table 2.3.1. Water Level measured at BWDB's station is transformed from PWD.m to R.L.m by relationship shown in Figure 2.3.1.

Table 2.3.1 Boundary Condition for Hydraulic Analysis at Each Bridge (100-Year Return Period)

Bridge Site	Discharge (m ³ /s)		Water Level						
	Measured Station	Upstream Discharge [m ³ /s]	Measured Station	[PWD.m]	[MSL.m]	Bed slope	Distance from station [m]	Downstream Water Level [MSL.m]	
Kanchpur	Demra(Lahkya)	2596	3,480	Demra(Lahkya)	7.47	7.01	0.0001	4,180	6.59
	Demra(Balu)	884							
Meghna	Bhirab bazar	23700	15,200	Meghna Ferryghat	6.98	6.52	0.0001	1,332	6.39
Gumti		12,400	Daudkandi	7.36	6.90	0.0001	900	6.81	

Source: Estimated by the study team according to Japanese Government technical standard

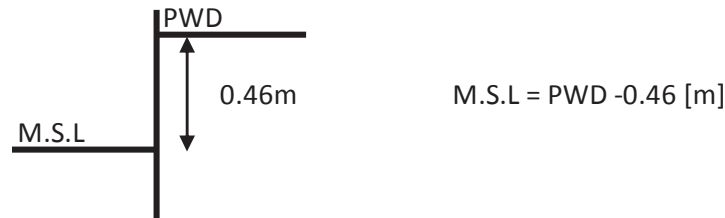


Figure 2.3.1 Relationship between BWDB's PWD.m and M.S.L.m

Table 2.3.2 Occurrence Probability for Water Level at Meghna Ferryghat St. (unit:PWD.m)

		Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	Ishihara Takase	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM
Return Period in year	2	5478	5549	5544	5551	—	5546	—	5546	5545	5547	—	—	—
	3	5664	5727	5718	5729	—	5724	—	5721	5721	5722	—	—	—
	5	5898	5924	5914	5926	—	5923	—	5916	5919	5918	—	—	—
	10	6216	6172	6165	6172	—	6171	—	6162	6167	6163	—	—	—
	20	6534	6410	6410	6407	—	6406	—	6399	6407	6398	—	—	—
	30	6720	6547	6554	6542	—	6542	—	6535	6545	6533	—	—	—
	50	6954	6719	6735	6709	—	6710	—	6706	6719	6702	—	—	—
	80	7170	6875	6903	6862	—	6865	—	6864	6880	6859	—	—	—
	100	7272	6949	6984	6934	—	6939	—	6939	6956	6933	—	—	—
	150	7458	7084	7131	7064	—	7073	—	7077	7096	7068	—	—	—
	200	7590	7180	7236	7156	—	7168	—	7175	7196	7165	—	—	—
400	7907	7409	7492	7378	—	7399	—	7413	7440	7400	—	—	—	
SLSC(99%)	0.046	0.030	0.029	0.030	—	0.030	—	0.029	0.028	0.028	—	—	—	
Error of Estimation	284	239	215	391	—	285	—	266	304	265	—	—	—	

Source: Estimated by the study team according to Japanese Government technical standard

Table 2.3.3 Occurrence Probability for Water Level at Daudkandi St. (unit:PWD.m)

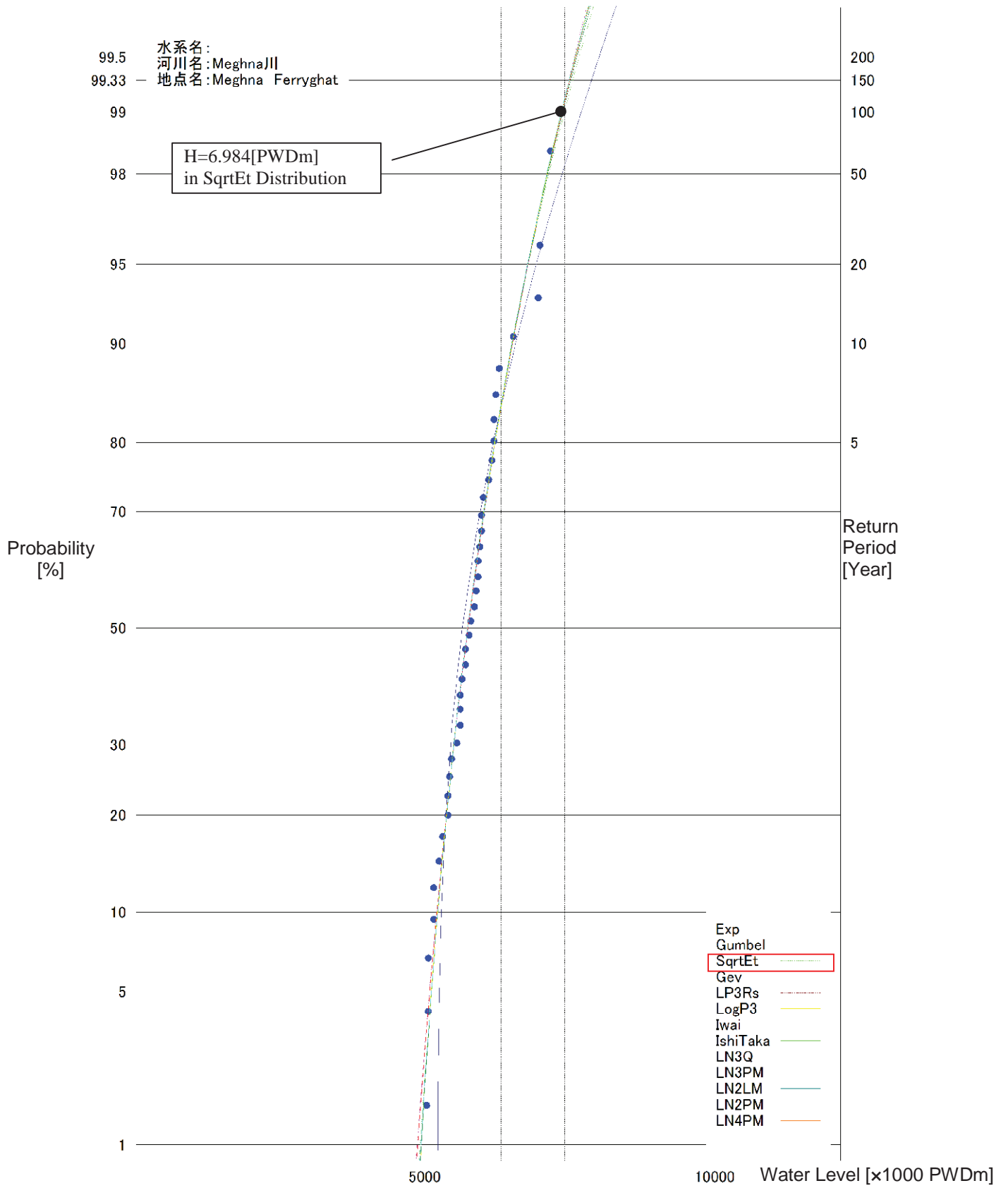
		Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	Ishihara Takase	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM
Return Period in year	2	5360	5456	5459	5500	—	—	5520	5512	5530	5512	5524	5524	—
	3	5612	5697	5731	5747	—	—	5760	5752	5766	5753	5765	5763	—
	5	5930	5964	6042	6001	—	—	6000	5996	5998	5996	6004	6001	—
	10	6361	6301	6444	6293	—	—	6270	6273	6255	6273	6272	6267	—
	20	6792	6624	6841	6547	—	—	6503	6516	6474	6515	6501	6495	—
	30	7044	6810	7074	6682	—	—	6628	6647	6590	6646	6624	6617	—
	50	7361	7042	7371	6841	—	—	6778	6804	6728	6802	6770	6762	—
	80	7654	7254	7649	6977	—	—	6908	6942	6847	6939	6897	6888	—
	100	7792	7355	7782	7039	—	—	6968	7006	6901	7003	6955	6945	—
	150	8045	7538	8026	7146	—	—	7074	7119	6997	7115	7058	7048	—
	200	8223	7667	8201	7218	—	—	7147	7198	7063	7194	7129	7118	—
400	8655	7979	8630	7381	—	—	7318	7382	7216	7376	7294	7282	—	
SLSC(99%)	0.068	0.036	0.046	0.029	—	—	0.024	0.024	0.026	0.024	0.024	0.025	—	
Error of Estimation	288	241	331	290	—	—	186	205	197	203	214	200	—	

Source: Estimated by the study team according to Japanese Government technical standard

Table 2.3.4 Occurrence Probability for Water Level at Demra(Lahkya) St (unit:PWD.m)

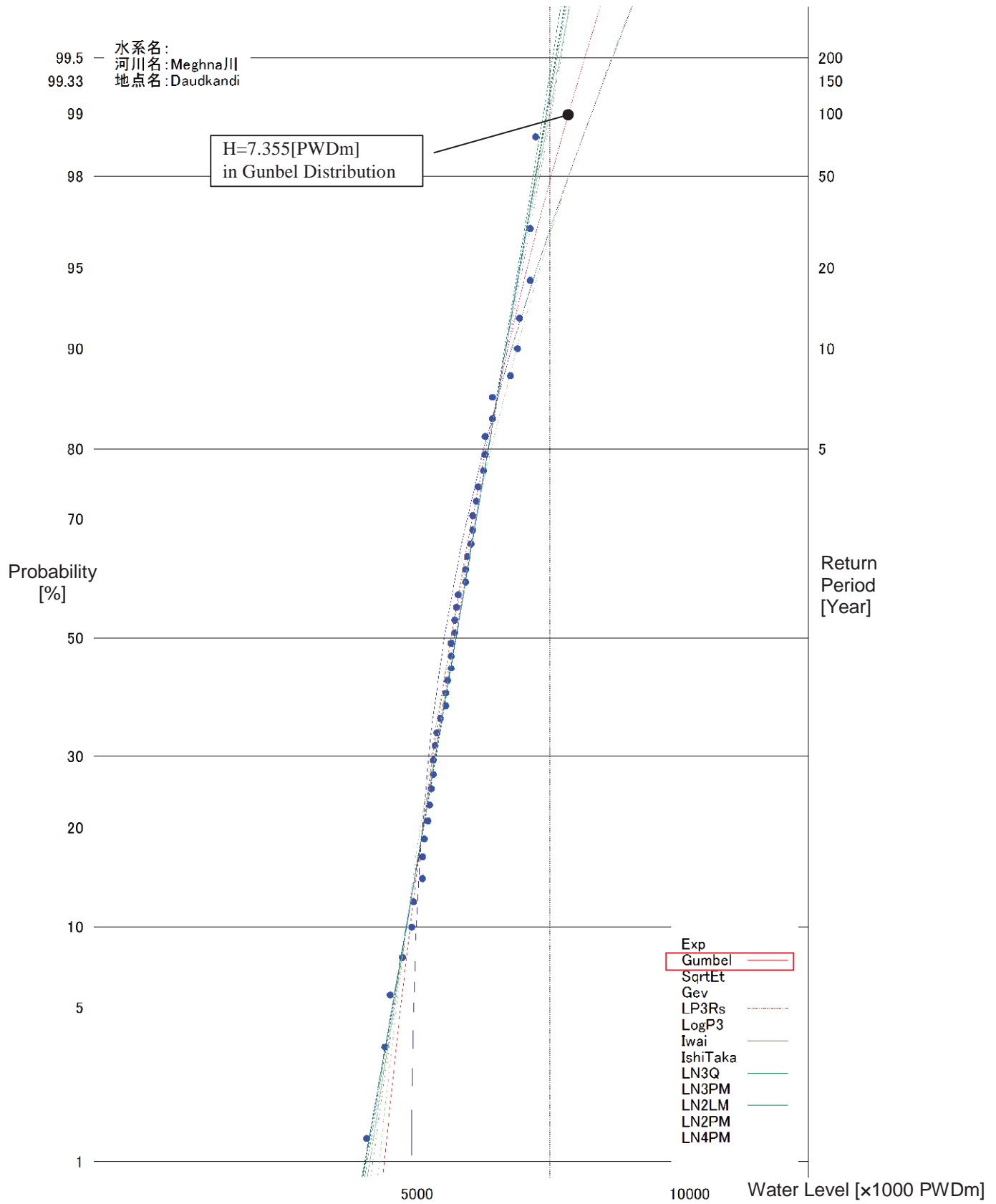
		Exp	Gumbel	SqrtEt	Gev	LP3Rs	LogP3	Iwai	Ishihara Takase	LN3Q	LN3PM	LN2LM	LN2PM	LN4PM
Return Period in year	2	5663	5745	5740	5761	—	5757	5765	5755	5766	5757	—	—	—
	3	5877	5949	5947	5968	—	5962	5969	5959	5968	5961	—	—	—
	5	6146	6176	6181	6191	—	6185	6188	6180	6182	6182	—	—	—
	10	6512	6461	6482	6460	—	6455	6450	6450	6439	6450	—	—	—
	20	6878	6735	6777	6707	—	6706	6691	6702	6675	6700	—	—	—
	30	7091	6893	6950	6844	—	6848	6826	6844	6806	6841	—	—	—
	50	7361	7090	7169	7010	—	7023	6992	7021	6967	7016	—	—	—
	80	7609	7270	7372	7158	—	7182	7141	7181	7113	7174	—	—	—
	100	7727	7356	7469	7227	—	7257	7211	7257	7181	7249	—	—	—
	150	7940	7511	7647	7349	—	7392	7338	7394	7303	7384	—	—	—
	200	8092	7620	7774	7434	—	7488	7427	7491	7390	7479	—	—	—
400	8458	7885	8085	7632	—	7718	7640	7724	7596	7709	—	—	—	
SLSC(99%)	0.052	0.028	0.029	0.030	—	0.028	0.026	0.026	0.027	0.026	—	—	—	
Error of Estimation	291	244	237	390	—	290	399	274	276	271	—	—	—	

Source: Estimated by the study team according to Japanese Government technical standard



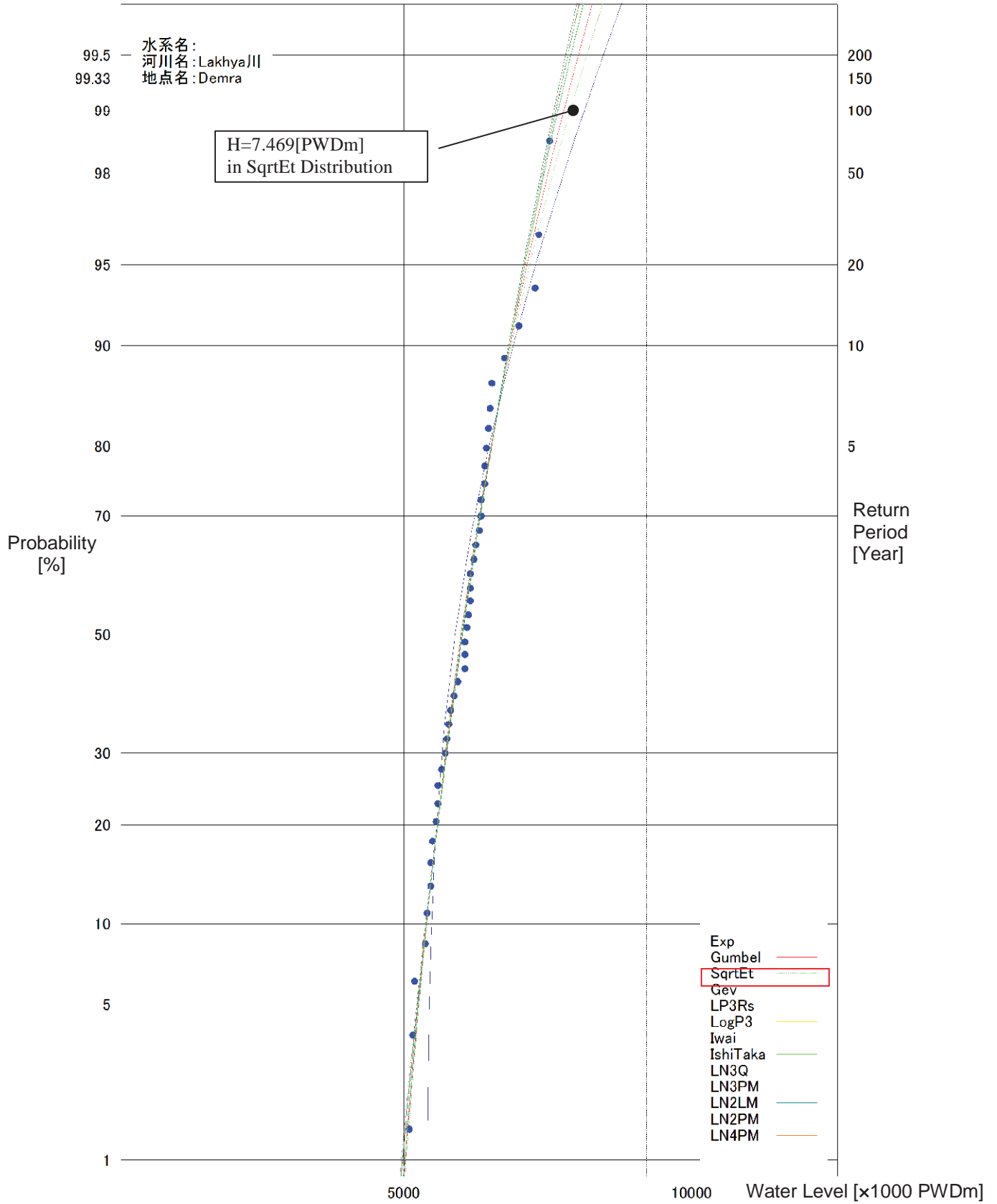
Source: Estimated by the study team according to Japanese Government technical standard

Figure 2.3.2 Frequency Curve for Design Water Level (W=1/100) at Meghna Ferryghat St.



Source: Estimated by the study team according to Japanese Government technical standard

Figure 2.3.3 Frequency Curve for Design Water Level (W=1/100) at Daudkandi St.



Source: Estimated by the study team according to Japanese Government technical standard

Figure 2.3.4 Frequency Curve for Design Water Level (W=1/100) at Demra(Lahkya) St.

2.3.2 Numerical Simulation Results in 100-year return period condition

To estimate scour around new bridge pier, hydraulic values in 100-year return period flood is calculated by Nays2D software for each bridges.

(1) Kanchpur Bridge

The hydraulic value of numerical analysis results at bridge center line in 100-year return period discharge is shown in Table 2.3.5, and cross section bed profile, water level, current velocity and water depth at same line is shown in Figure 2.3.5.

Contour map of bed elevation, current velocity, water depth, and water surface level in 100-year return period flood in this model is shown in *Source: Estimated by the study team* Figure 2.3.6 and *Source: Estimated by the study team*

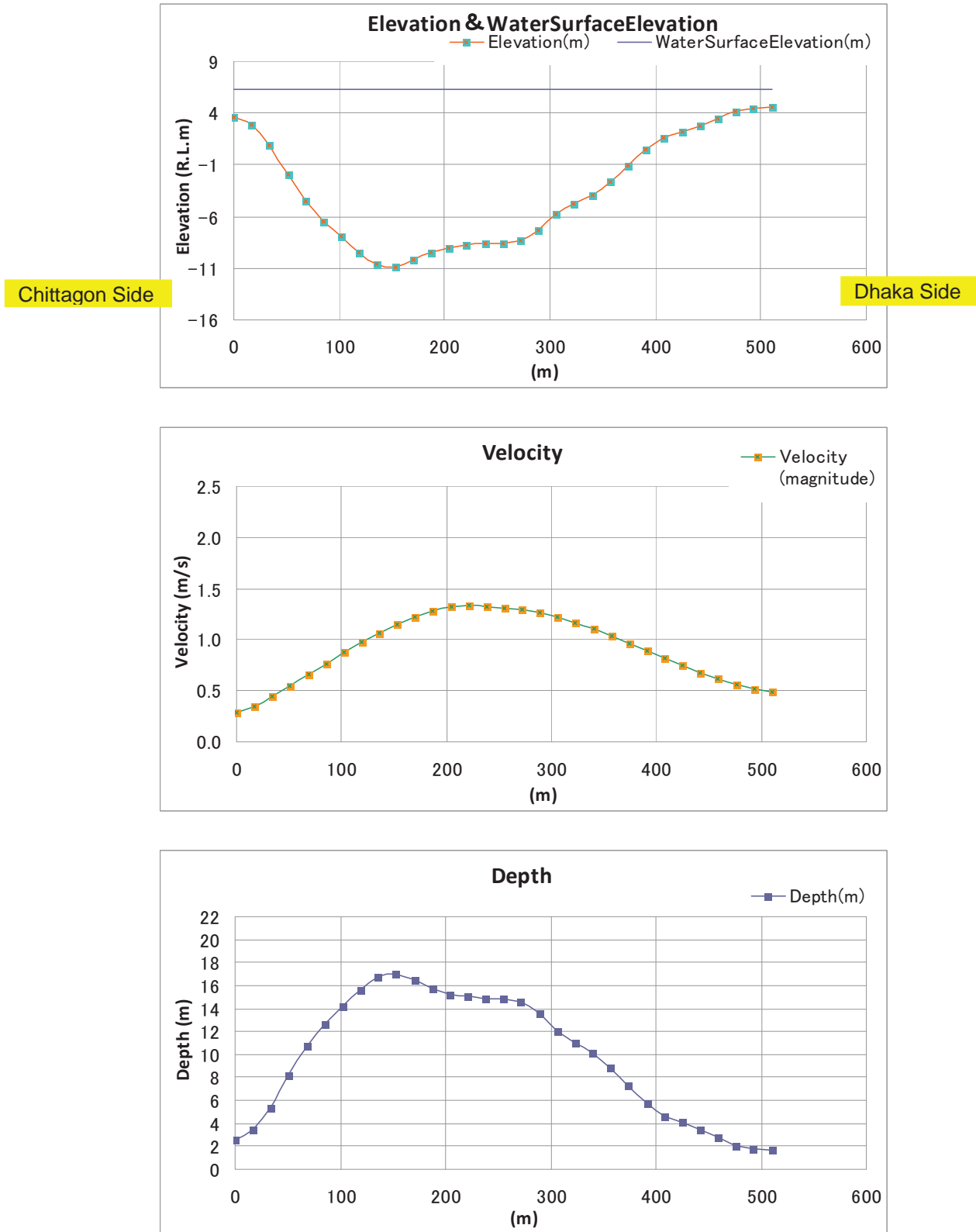
Figure 2.3.7.

The hydraulic value shown in Table 2.3.5 will be used to estimate the local scouring around each pier at Kanchpur Bridge.

Table 2.3.5 Numerical Analysis Result in 100-year return period at Kanchpur Bridge

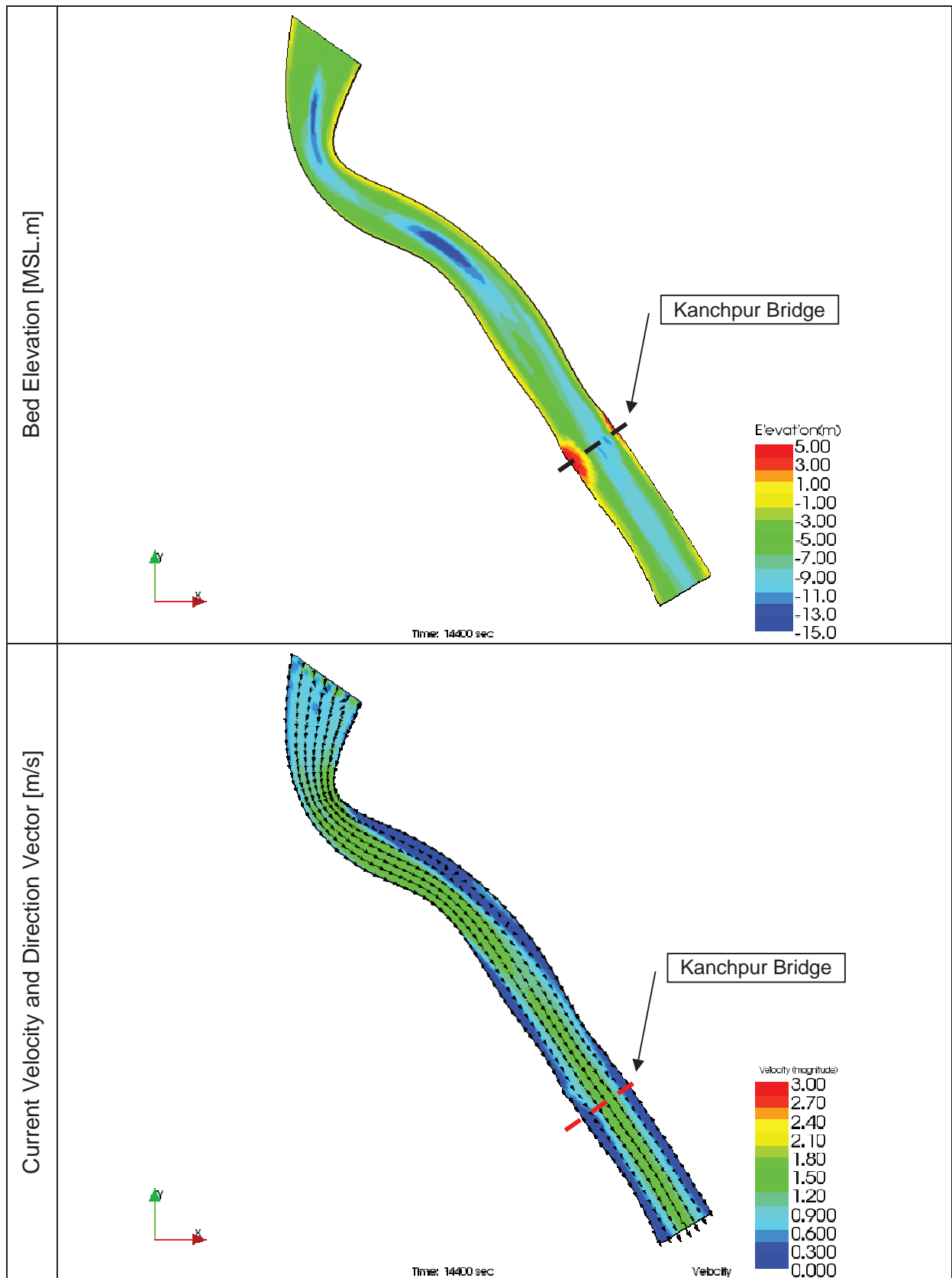
Pier No	Water Depth [MSL.m]	Bed Elevation [MSL.m]	Water Elevation [MSL.m]	Current Velocity [m/s]
A1	1.65	4.60	6.25	0.49
P1	2.76	3.49	6.25	0.62
P2	5.76	0.48	6.24	0.89
P3	12.04	-5.80	6.24	1.22
P4	14.90	-8.66	6.23	1.33
P5	16.44	-10.20	6.24	1.23
P6	12.67	-6.42	6.25	0.77
P7	2.61	3.65	6.26	0.28
A2	2.61	3.65	6.26	0.28

Source: Estimated by the study team



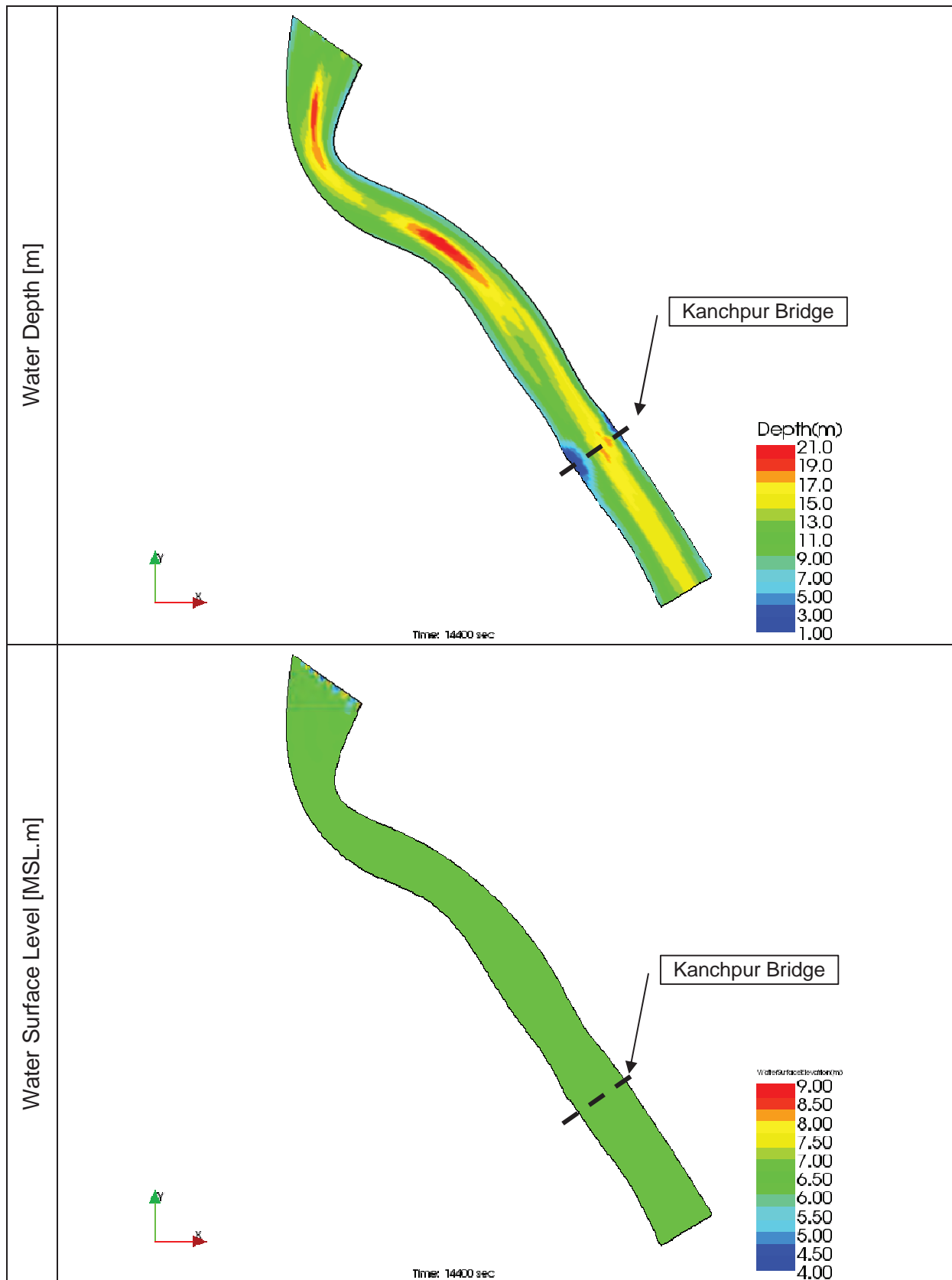
Source: Estimated by the study team

Figure 2.3.5 Numerical Analysis Result along Bridge Axis at Kanchpur Bridge (100-year)



Source: Estimated by the study team

Figure 2.3.6 Bed Elevation and Current Velocity Contour around Kanchpur Bridge (100-year)



Source: Estimated by the study team

Figure 2.3.7 Water Depth and Water Surface Level around Kanchpur Bridge (100-year)

(2) Meghna Bridge

The hydraulic value of numerical analysis results at bridge center line in 100-year return period discharge is shown in Table 2.3.6, and cross section bed profile, water level, current velocity and water depth at same line is shown in Figure 2.3.8.

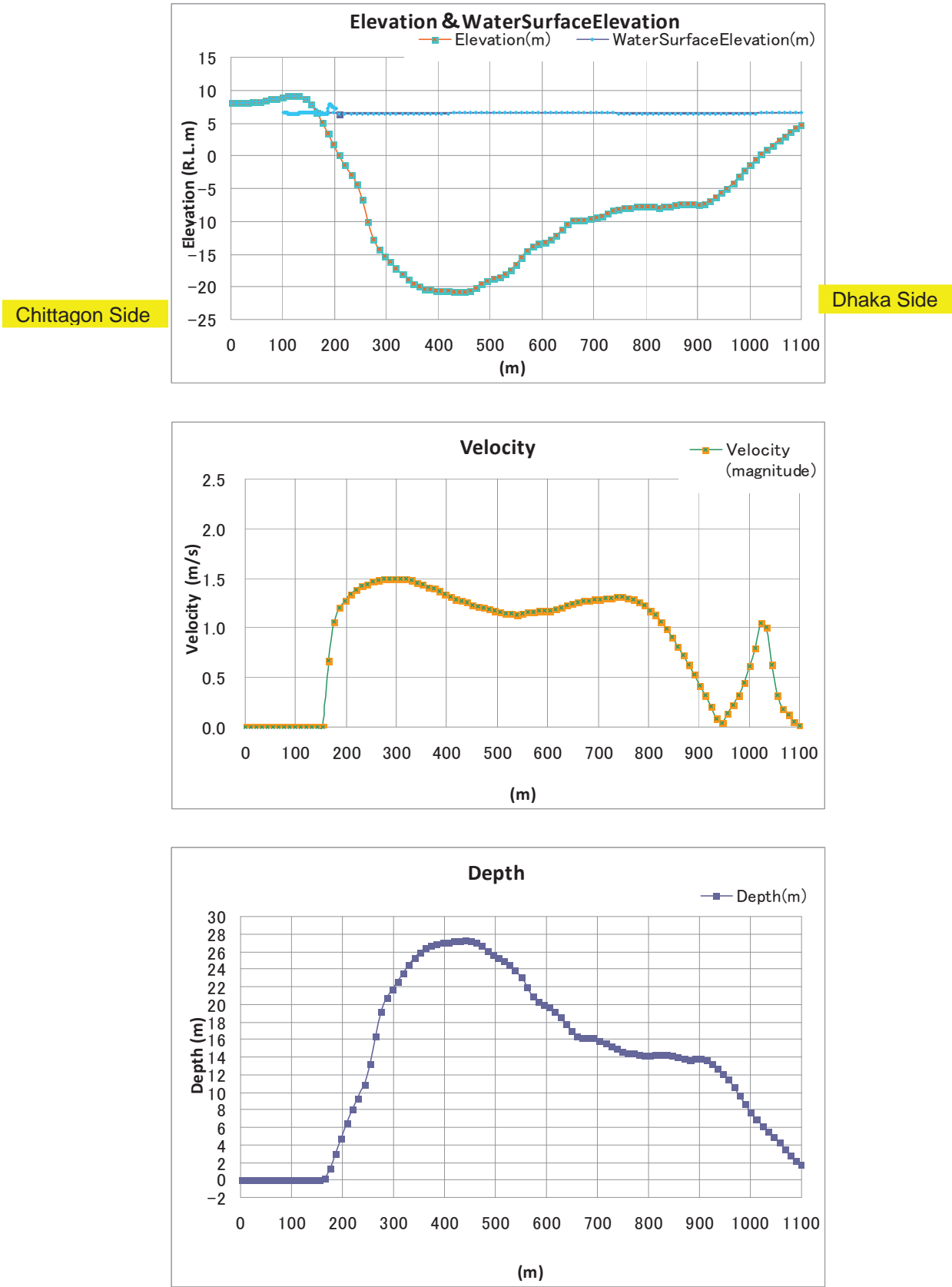
Contour map of bed elevation, current velocity, water depth, and water surface level in 100-year return period flood in this model is shown in Figure 2.3.9 and Figure 2.3.10.

The hydraulic value shown in Table 2.3.6 will be used to estimate the local scouring around each pier at Meghna Bridge.

Table 2.3.6 Numerical Analysis Result in 100-year return period at Meghna Bridge

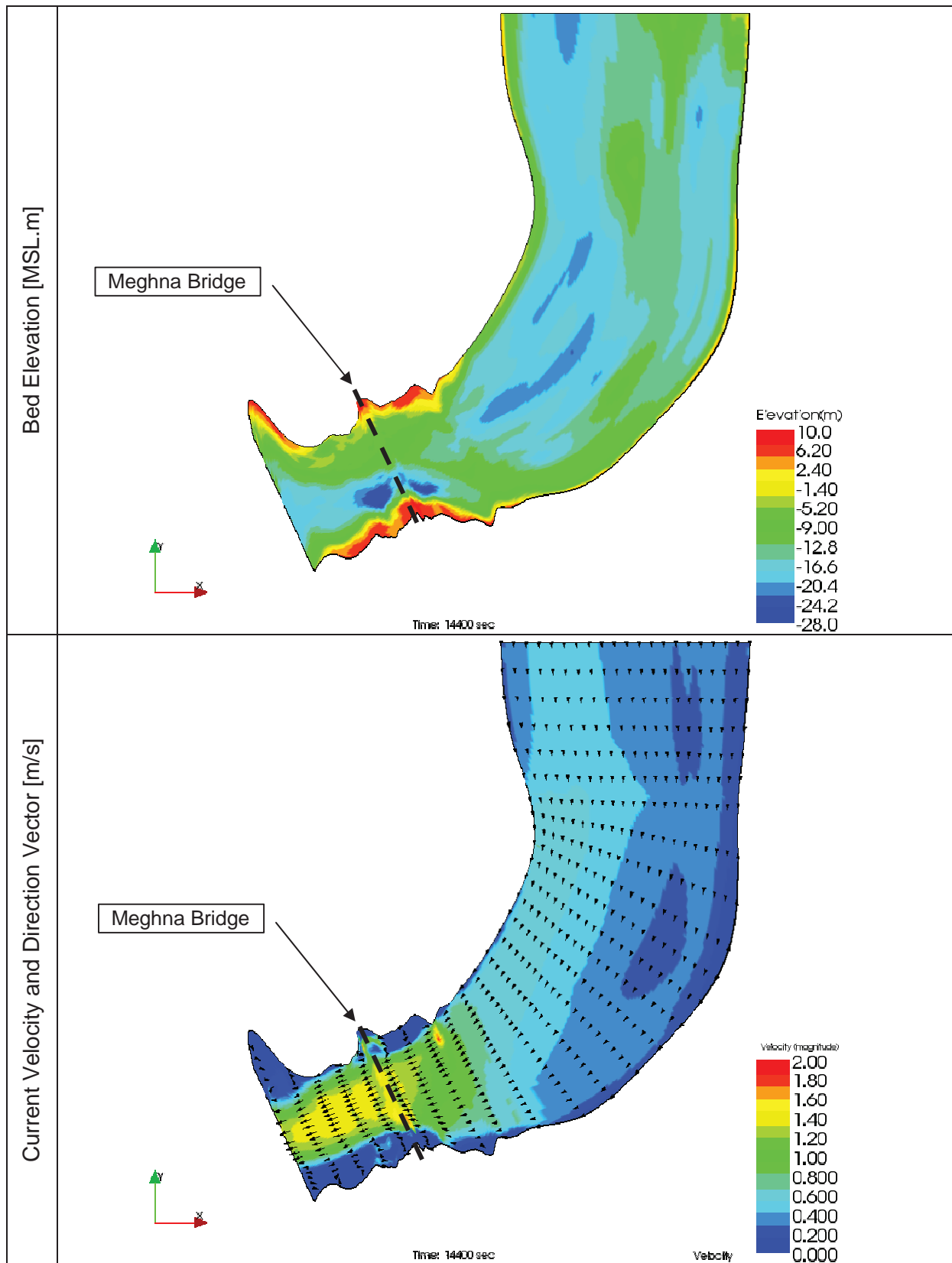
Pier No	Water Depth [MSL.m]	Bed Elevation [MSL.m]	Water Elevation [MSL.m]	Current Velocity [m/s]
A1	1.80	4.69	6.50	0.02
P1	2.87	3.62	6.50	0.13
P2	4.86	1.63	6.49	0.62
P3	7.78	-1.33	6.46	0.61
P4	13.91	-7.45	6.45	0.42
P5	14.27	-7.81	6.47	1.13
P6	15.23	-8.76	6.48	1.30
P7	18.54	-12.05	6.48	1.21
P8	23.89	-17.40	6.49	1.14
P9	27.23	-20.76	6.48	1.23
P10	25.97	-19.51	6.46	1.44
P11	16.41	-9.95	6.46	1.47
P12	1.36	5.11	6.48	1.07
A2	0.00	9.13	9.13	0.00

Source: Estimated by the study team



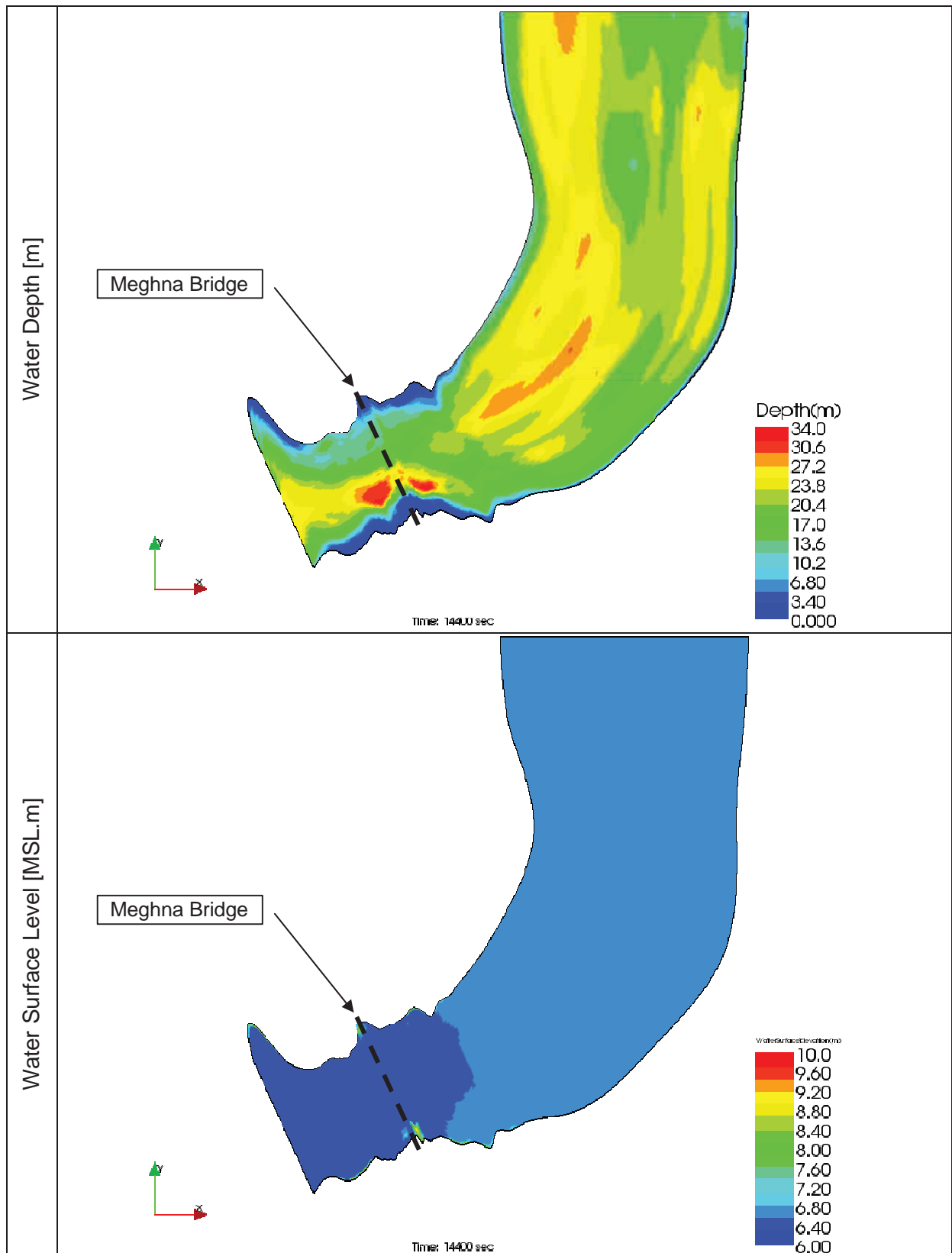
Source: Estimated by the study team

Figure 2.3.8 Numerical Analysis Result along Bridge Axis at Meghna Bridge (100-year)



Source: Estimated by the study team

Figure 2.3.9 Bed Elevation and Current Velocity Contour around Meghna Bridge (100-year)



Source: Estimated by the study team

Figure 2.3.10 Water Depth and Water Surface Level around Meghna Bridge (100-year)