FAP24

Government of the People's Republic of Bangladesh

Water Resources Planning Organization

European Commission

Delft Hydraulics

Danish Hydraulic Institute

Hydroland

Approtech

Osiris

RIVER SURVEY PROJECT

Special Report No.22

River Data Book January 1993 - March 1995

Part A: Text

October 1996

Special Report 22

River Data Book
January 1993 - March 1995

Part A: Text volume

October 1996

Contents

Part A: Text volume

Part B: Routine gauging January 1993 - March 1995

Part C: Special surveys June 1994 - March 1995

Figures

Tables

Data presentations

Acronyms, abbreviations and symbols

ADCP	:	Acoustic Doppler current profiler
AWLR	:	Automatic water level recorder
BM	:	Bench mark
BTM	:	Bangladesh Transverse Mercator (a geodetic grid)
BWDB	:	Bangladesh Water Development Board
DELFT	:	Delft Hydraulics
DGPS	:	Differential Global Positioning System
DHI	:	Danish Hydraulic Institute
EMF	:	Electromagnetic flow meter
FAP	:	Flood Action Plan
FAP24	:	FAP project 24 = The River Survey Project
FPCO	:	Flood Plan Coordination Organization (today merged with WARPO)
h	:	Stage (m +PWD)
HYMOS	:	Name of a hydrological software package, and of the RSP data base for water level recordings
MBM	:	Moving boat method (by ADCP/EMF/DGPS survey spread)
MEX	:	Brand name of a turbidity meter
PSD24	:	Processed Survey Data of FAP24 (an RSP data base)
PWD	:	Public Works Department datum (a reference level)
Q	:	Flow rate (m^3/s)
RSP	:	The River Survey Project = FAP24
S	:	Sediment transport rate (kg/s) (please refer to Figure 5)
SB	:	Survey Bulletin (the basic RSP data report)
SLW	:	Standard Low Water (a reference level)
S4	:	Brand name of an EMF
US BM-54	:	Brand name of a bed material sampler
TBM	:	Temporary bench mark
VAM	:	Velocity-area method
WARPO	:	Water Resources Planning Organization

1 Introduction

1.1 The River Survey Project

The River Survey Project (RSP, or FAP24) started in June, 1992, and continued for a period of four years. The project was executed by the Flood Plan Coordination Organisation (FPCO), later merged with the Water Resources Planning Organization (WARPO), under the present Ministry of Water Resources. Funding was granted by the Commission of the European Communities, presently the European Commission. The Consultant was DELFT-DHI Joint Venture in association with Osiris, Hydroland and Approtech. Project supervision was undertaken by a Project Management Unit with participation by WARPO, a Project Adviser, and a Resident Project Adviser.

The objective of the project was to establish the availability of detailed and accurate field data as a part of the basis for the FAP projects, as well as adding to the basis for any other planning, impact evaluation and design activities within national water resources and river engineering activities.

The project consisted of three categories of activities:

- A survey component, comprising development, implementation, and execution of a comprehensive field survey programme of river hydrology, sediment transport, and morphology;
- a study component, comprising investigations of processes and effects within river hydrology, sediment transport and morphology; and
- a training component.

The field programme was a quantitative and qualitative supplement to the comprehensive permanent registration of flow and water level which has been carried out by Bangladesh Water Development Board (BWDB) for many years all over Bangladesh. By application of advanced technology, such as accurate DGPS positioning and high-capacity ADCP flow measurements, the programme has added to the general data coverage and has provided a new insight into the time and space variation of the flow and sediment transport processes.

1.2 Use of this Data Book

The aim of the present River Data Book is to give an outline of the data collected during the routine programme of the River Survey Project. Brief data summaries are presented, and catalogue entries are listed for the period from January, 1993, and until March, 1995. For the subsequent data collection, until the completion of the Project, please refer to the 1995/96 River Data Book (RSP Special Report 23).

The book is divided into

- The present *Part A,* which describes the data collection and coverage and presents summary tables of water levels, flow and sediment transport
- *Part B,* with details about the completed measurements, together with summary presentations of flow and sediment transport from the individual surveys. Also, this part contains a full catalogue listing of the collected data and their storage
- *Part C,* with short information about the special surveys

The activities described in the present Data Book have produced several giga-bytes of raw data, and only a very superficial presentation of the findings has been made here. For an in-depth information

about the results, the user is referred to the underlying data bases of the River Survey Project: HYMOS (for water level data) and PSD24 (for flow and sediment transport data).

1.3 Summary of survey programme

The survey programme comprises the following activities:

a. Water level recordings at 12 stations, plus a number of temporary gauge locations;
b. dry season routine transect gauging covering 11 locations (November through May);
c. flood season routine transect gauging covering 11 locations (June through October);
d. special surveys and monitoring programmes with specific, individual objectives; and
e. bathymetry surveys at selected locations.

The present Data Book deals with activities a, b, c, and d. Activity e is reported in *RSP Special Report 3: 'Bathymetric surveys'*.

1.4 Positioning and datum

Positions are relative to the BTM grid. Stages are referred to PWD datum. Water depths are relative to the stage. Bed contours in bathymetry charts and bed contour maps are relative to SLW datum.

2 Summary of collected data

Year	1993				1994
Quarter	J-M	A-J	J-S	O-D	J-M
Hydrological year					
Flood season					
Lean season					
Water level gauging					
1 Bahadurabad					
1 Gabgachi					
1 Char Parul					
1 Thantania Para					
1 North Katiamari					
1 North Horindhara					
1 Belgacha					
1 Kabilpur					
1 Shanki Bhanga					
1 Bhagir Chao					
2 Bhuyanpur					
3 Aricha (Teota)					
4 Hardinge Bridge					
5 Baruria					
6 Mawa					
7 Mymensingh					
8 Tilly					
9 Gorai					
10 Arial Khan					
11 Bhairab Bazar					
12 Mir Char					
Routine transect gauging					
1 Bahadurabad					
2 Sirajganj					
3 Aricha (Teota)					
4 Hardinge Bridge					
5 Baruria					
6 Mawa					
7 Mymensingh					
8 Tilly					
9 Gorai					
10 Arial Khan					
11 Bhairab Bazar					
Special surveys					
• Flow at Bahadurabad					
• Bedform inventory					
• Other special surveys					
Bathymetric surveys					

Figure 1: Summary of data collection (continued)

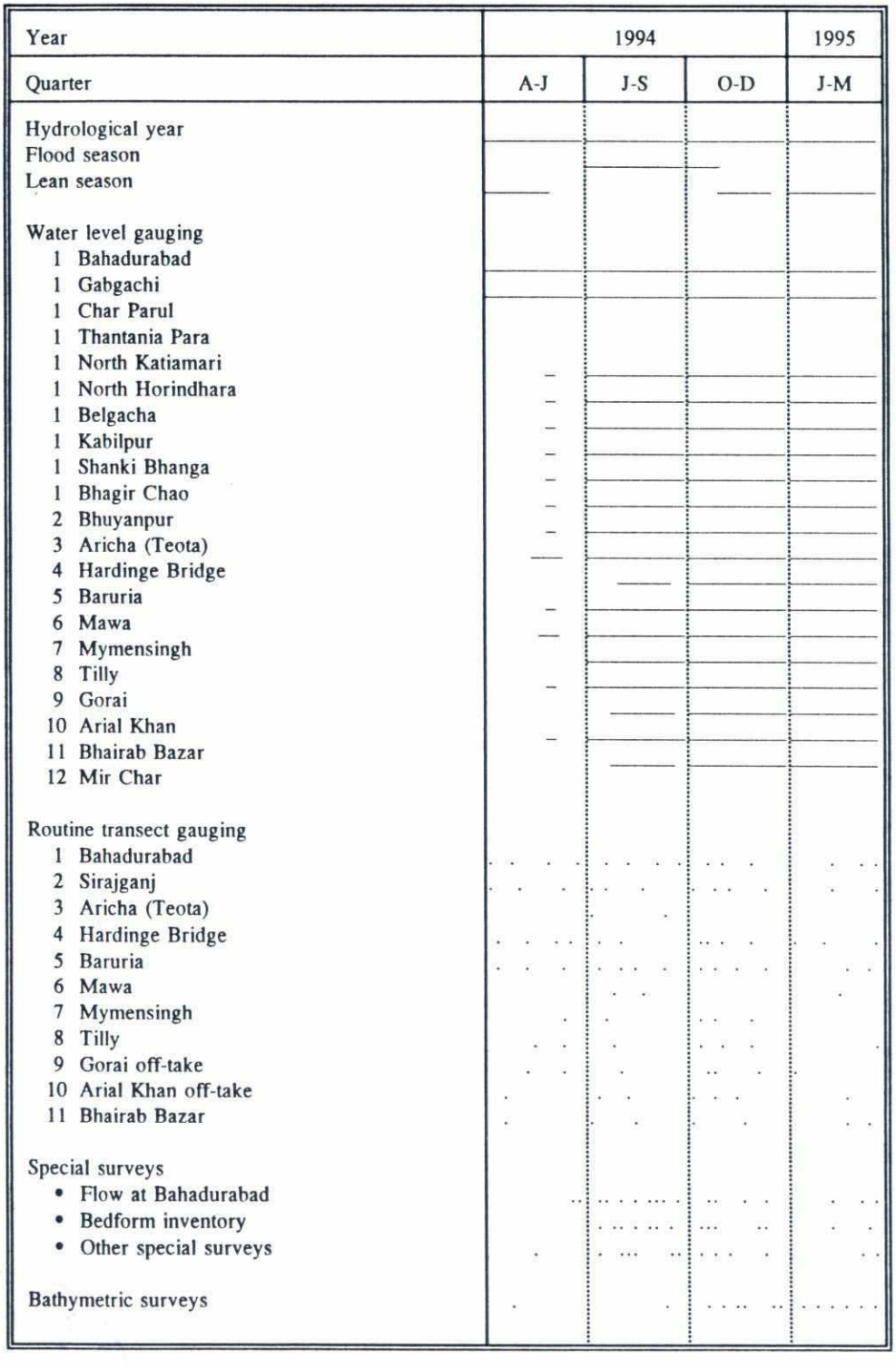


Figure 1 (continued): Summary of data collection

No.	Place	Date	No.	Place	Date
1	Bahadurabad	14-16/1 93	56	Baruria	3-5/5 94
2	Bahadurabad	13-15/2 93	57	Gorai	10-11/5 94
3	Bahadurabad	13-16/3 93	58	Hardinge Bridge	12/5 94
5	Bhairab Bazar	27-28/4 93	59	Tilly	15/5 94
6	Bahadurabad	6-9/6 93	60	Bahadurabad	2-8/6 94
7	Bahadurabad	15-17/7 93	61	Hardinge Bridge	5-6/6 94
8	Sirajganj	23-29/7 93	62	Sirajganj	8-12/6 94
9	Baruria	4-8/8 93	63	Baruria	12-15/6 94
10	Bahadurabad	23-24/8 93	64	Mymensingh	15/6 94
11	Bahadurabad	11/9 93	65	Tilly	16/6 94
12	Sirajganj	17/9 93	66	Gorai off-take	19/6 94
13	Aricha	19/9 93	67	Hardinge Bridge	20-21/6 94
14	Baruria	19/9 93	69	Bahadurabad	24-26/6 94
15	Hardinge Bridge	26-29/9 93	72	Sirajganj	1-3/7 94
16	Gorai off-take	29-30/9 93	73	Bhairab Bazar	4-5/7 94
17	Baruria	1/10 93	74	Aricha	6-8/7 94
18	Mawa	3-7/10 93	75	Arial Khan	8/7 94
19	Arial Khan off-take	8/10 93	77	Baruria	9-10/7 94
20	Bhairab Bazar	12/10 93	79	Hardinge Bridge	14-15/7 94
21	Tilly	16/10 93	80	Bahadurabad	14-16/7 94
22	Baruria	19-22/10 93	82	Sirajganj	18-20/7 94
23	Sirajganj	24-27/10 93	83	Mymensingh	19-20/7 94
24	Bahadurabad	2-3/11 93	84	Mawa	24-25/7 94
25	Baruria	4-5/12 93	85	Tilly	25/7 94
26	Sirajganj	7-8/12 93	86	Baruria	29-30/7 94
27	Bahadurabad	11-12/12 93	87	Hardinge Bridge	1/8 94
28	Bahadurabad	29/1-1/2 94	88	Gorai	3/8 94
29	Mymensingh	30-31/1 94	89	Bahadurabad	6-9/8 94
30	Sirajganj	3/2 94	90	Arial Khan	10/8 94
31	Baruria	5-6/2 94	91	Bhairab Bazar	13/8 94
32	Tilly	5-7/2 94	92	Baruria	21-23/8 94
33	Arial Khan off-take	9/2 94	93	Mawa	25-26/8 94
34	Bhairab Bazar	10/2 94	94	Sirajganj	25-31/8 94
35	Gorai off-take	15/2 94	95	Bahadurabad	1-6/9 94
36	Hardinge Bridge	16-18/2 94	96	Baruria	9-10/9 94
37	Mymensingh	23/2 94	97	Aricha	11-13/9 94
38	Gorai off-take	5-6/3 94	98	Bahadurabad	21-28/9 94
39	Hardinge Bridge	7/3 94	99	Sirajganj	2-5/10 94
40	Bahadurabad	15-17/3 94	100	Bhairab Bazar	5/10 94
41	Sirajganj	19/3 94	101	Arial Khan	7/10 94
42	Mymensingh	20/3 94	102	Baruria	8-10/10 94
43	Baruria	21/3 94	103	Mymensingh	11/10 94
44	Tilly	22/3 94	104	Hardinge Bridge	11-12/10 94
45	Bhairab Bazar	24/3 94	105	Tilly	13/10 94
46	Arial Khan off-take	24/3 94	106	Kushtia/Gorai	16/10 94
47	Hardinge Bridge	28-29/3 94	107	Bahadurabad	18-22/10 94
48	Bahadurabad	2-4/4 94	108	Hardinge Bridge	20/10 94
49	Sirajganj	5-7/4 94	109	Kushtia/Gorai	24/10 94
50	Hardinge Bridge	8/4 94	110	Arial Khan	25/10 94
51	Baruria	9-10/4 94	111	Sirajganj	26-29/10 94
52	Bhairab Bazar	16/4 94	112	Mymensingh	27/10 94
53	Arial Khan off-take	18-19/4 94	113	Tilly	28/10 94
54	Bahadurabad	26-28/4 94	114	Baruria	28-29/10 94
55	Sirajganj	29/4-1/5 94			

Table 1: Key index of routine transect gauging (continued)

22

No.	Place	Date	No.	Place	Date
115	Hardinge Bridge	31/10-1/11 94	131	Hardinge Bridge	3-4/2 95
117	Bahadurabad	7-8/11 94	132	Bahadurabad	8-10/2 95
118	Sirajganj	10-12/11 94	133	Sirajganj	11-13/2 95
119	Baruria	14-15/11 94	134	Mawa	17-18/2 95
120	Arial Khan off-take	17/11 94	135	Bhairab Bazar	21/2 95
121	Bhairab Bazar	20/11 94	136	Arial Khan	23/2 95
122	Bahadurabad	26-28/11 94	137	Baruria	25/2 95
123	Tilly	28/11 94	138	Bahadurabad	11-12/3 95
124	Mymensingh	30/11 94	139	Bhairab Bazar	17-20/3 95
125	Hardinge Bridge	2-4/12 94	140	Baruria	22/3 95
126	Kushtia/Gorai	5/12 94	141	Tilly	24/3 95
127	Sirajganj	15-16/12 94	142	Sirajganj	24-25/3 95
128	Baruria	18/12 94	143	Hardinge Bridge	27-30/3 95
129	Hardinge Bridge	3-4/1 95	144	Bahadurabad	28-29/3 95
130	Gorai off-take	5/1 95			

Table 1 (Continued) : Key index of routine transect gauging

No.	Place	Date	No.	Place	Date
8001	Bahadurabad	20/6-3/7 93	9038	Karmarjani	10-20/11 94
8002	Bahadurabad	23/8-9/9 93	8011	Dhaleshwari	24/11-11/12 94
8003	Ganges/Jamuna confluence	15-31/10 93	8012	Ganges/Jamuna confluence	13-25/12 94
8004	Bahadurabad	10-18/11 93	8013	Hurasagar	25-29/12 94
8005	Hurasagar	23-30/11 93	8014	Gorai off-take	6-20/1 95
8006	Arial Khan	1-10/1 94	9044	Gorai off-take	15/1-14/2 95
8007	Ganges/Jamuna confluence	19/4-5/5 94	8015	Arial Khan	4-13/2 95
8008	Karmarjani	1-26/9 94	8016	Bahadurabad	24-27/2 95
8009	Gorai off-take	13-23/10 94	8017	Karmarjani	6-13/3 95
8010	Bahadurabad	1-11/11 94	8018	Dhaleshwari	29/3-4/4 95

Table 2: Key index of bathymetric surveys

No.	Place	Date	No.	Place	Date
9001	Bahadurabad	23/6 94	9027	Bahadurabad	28/9 94
9002	Bahadurabad	27/6 94	9028	Bahadurabad	29-30/9 94
9003	Bahadurabad	28/6 94	9029	Baha → Aricha	1-6/10 94
9004	Arial Khan	8/7 94	9030	Aricha → Sira	15/10 94
9006	Bahadurabad	13/7 94	9031	Sira → Baha	16/10 94
9007	Bahadurabad	16/7 94	9032	Bahadurabad	17/10 94
9010	Hardinge Bridge	2/8 94	9033	Hardinge Bridge	19/10 94
9011	Bahadurabad	2/8 94	9034	Hardinge Bridge	21/10 94
9012	Bahadurabad	2-4/8 94	9035	Bahadurabad	23/10 94
9013	Kushtia/Gorai	4-5/8 94	9036	Baha → Sira	25/10 94
9014	Kushtia → Aricha	6/8 94	9037	Bahadurabad	4/11 94
9015	Bahadurabad	5/8 94	9037B	Bahadurabad	6/11 94
9016	Old Brahmaputra	9-20/8 94	9039	Bahadurabad	26/11 94
9017	Bahadurabad	10-14/8 94	9040	Bahadurabad	4-12/12 94
9018	Bahadurabad	14-18/8 94	9041	Bahadurabad	13/12 94
9019	Bahadurabad	18/8 94	9042	Baha → Sira	14/12 94
9020	Bahadurabad → Aricha	19-20/8 94	9043	Sira → Aricha	17/12 94
9021	Aricha → Bahadurabad	28-29/8 94	9045	Bahadurabad	8/2 95
9022	Bahadurabad	30/8 94	9046	Baha → Sira	11/2 95
9022B	Bahadurabad	31/8-1/9 94	9047	Sira → Aricha	14/2 95
9023	Bahadurabad	6/9 94	9048	Bahadurabad	6-10/3 95
9024	Bahadurabad → Aricha	7-8/9 94	9049	Bahadurabad	11/3 95
9025	Siranganj → Baha	16/9 94	9050	Baha → Sira	14/3 95
9026	Bahadurabad	17/9 94	9051	Bahadurabad	24-27/3 95
9026B	Bahadurabad	18/9 94	9052	Bahadurabad	27/3 95
9026C	Bahadurabad	19-20/9 94	9053	Bahadurabad	31/3-4/4 95

Table 3: Key index of special surveys

3 Water levels

3.1 Measuring stations

Water level gauge locations are shown on Figure 2 (for the entire investigation area) and Figure 3 (for the Bahadurabad area).

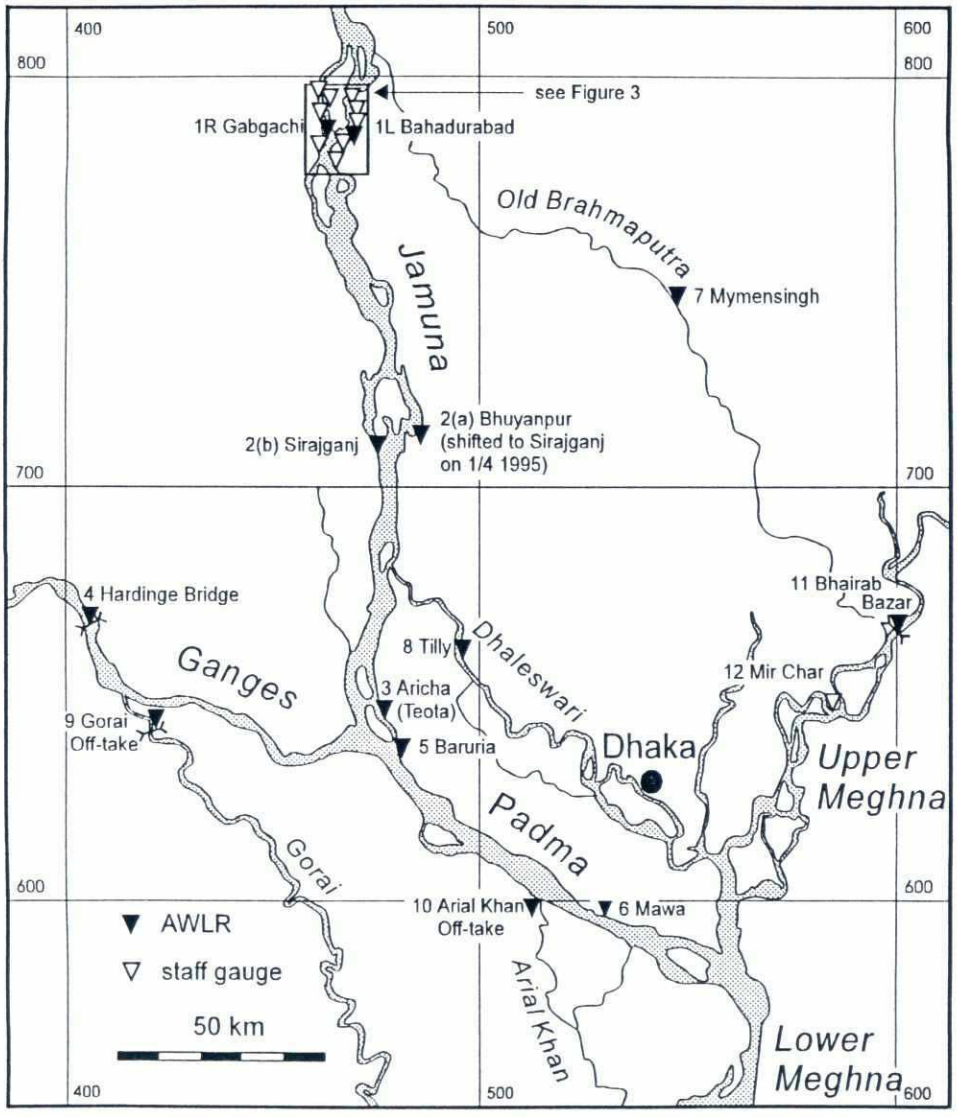


Figure 2: Location of water level gauges

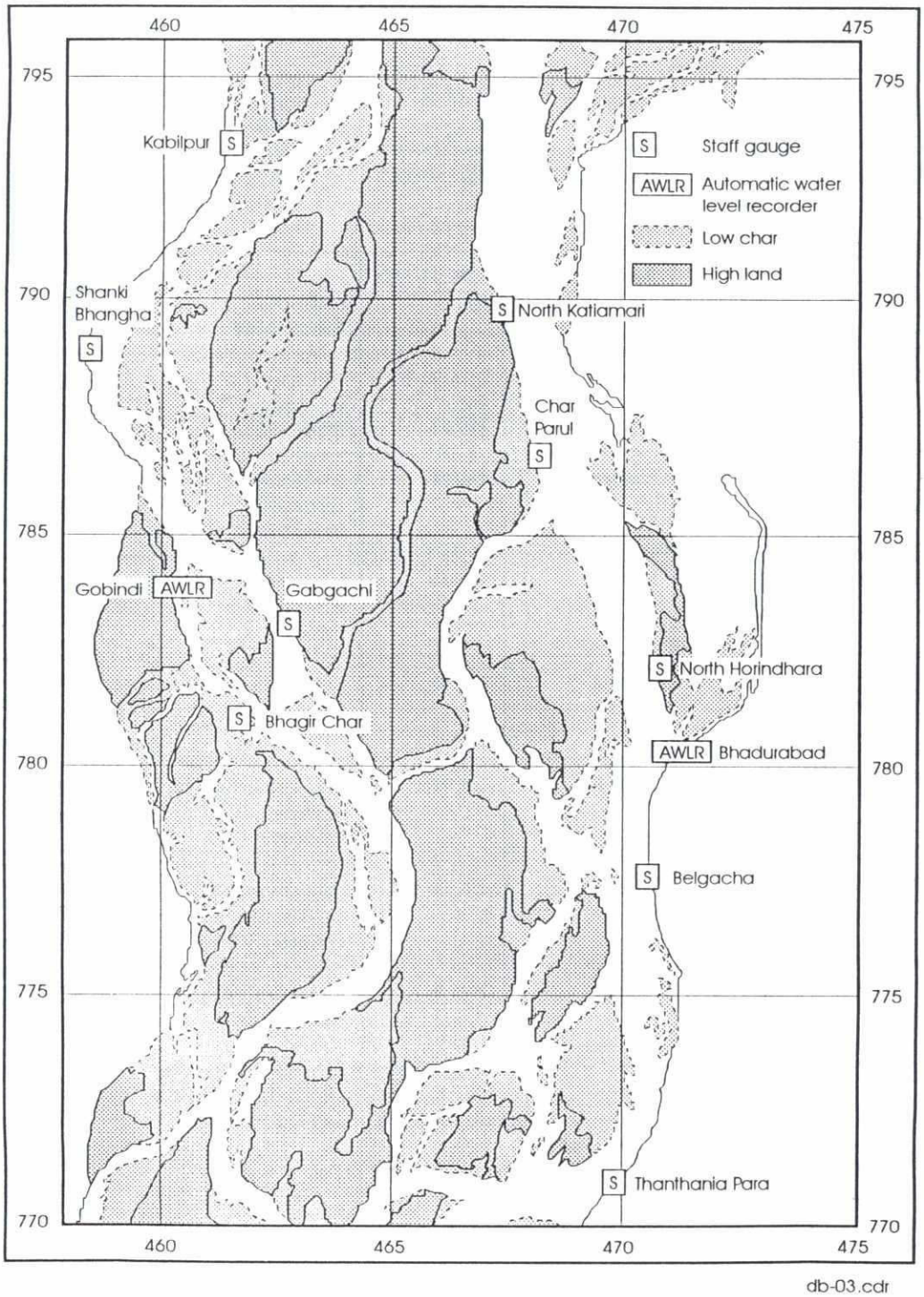


Figure 3: Water level gauges at Bahadurabad

Station	Type 1)	River	Period	Location	Benchmark and benchmark datum (m +PWD) 2)
1L Bahadurabad	P, S 3)	Jamuna	6/6 93-	700 m upstream of ghat	FAP24 TBM O1 21.999 m
1R Gabgachi	P, A, S	Jamuna	15/7 93- 3)	mid char opposite of Fulchari	FAP24 C_2RE 19.998 m
B) Char Parul	S	Jamuna	15/6 93-12/2 94	mid char opposite of Fulchari	FAP24 TBM 20.075 m
B) Thantania Para	S	Jamuna	22/6 93-11/2 94	left channel, 10 km downstream of Bahadurabad	FAP24 TBM 19.306 m
B) N. Katiamari	S	Jamuna	21/6 93-11/2 94, 1/6 94-	left channel, 7.5 km upstream of Bahadurabad	FAP24 TBM 21.316 m
B) N. Horindhara	S	Jamuna	1/6 94-	left channel, 1.5 km upstream of Bahadurabad	FAP24 TBM 21.561 m
B) Belgacha	S	Jamuna	1/6 94-	left channel, 3.5 km downstream of Bahadurabad	FAP24 TBM 19.636 m
B) Kabilpur (Ratanpur)	S	Jamuna	1/6 94-	right channel, 7.5 km upstream of Fulchari	FAP24 TBM 21.883 m
B) Shanki Bhanga	S	Jamuna	1/6 94-	right channel, 1 km upstream of Fulchari	FAP24 TBM 22.289 m
B) Bhagir Chaw	S	Jamuna	1/6 94-	right channel, 4.5 km downstream of Fulchari	FAP24 TBM 20.388 m
2 Bhuyanpur	P, S	Jamuna	29/5 94-	left channel, opposite of Sirajganj	FAP24 TBM 14.249 m

1): P = pressure cell gauge, A = acoustic (ultrasonic) gauge, S = staff gauge
2): All recordings are referred to PWD datum
3): AWLR has been substituted by a staff gauge for a part of the period
B): Bahadurabad area (see Figure 3)

Table 4: Water level gauges (continued)

Station	Type 1)	River	Period	Location	Benchmark and benchmark datum (m +PWD) 2)
3 Aricha (Teota) B)	P, S	Jamuna	13/5 94-	2 km upstream of Aricha	FMBM 8122 10.202 m
4 Hardinge Bridge	A, S	Ganges	21/7 94-	at bridge	FAP24 TBM 15.633 m
5 Baruria T)	P, S 3)	Padma	25/5 94-	6 km downstream of Aricha	BWDB BM 91.9L 7.793 m
6 Mawa T)	P, S	Padma	10/5 94-	near ferry ghat	FAP24 TBM 1708 6.314 m
7 Mymensingh	A, S	Old Brahmaputra	29/6 94-	railway bridge	FAP24 TBM 14.358 m
8 Tilly	P, S 3)	Dhaleswari	28/5 94-	10 km upstream of bridge	BWDB BM 10.466 m
9 Gorai	A, S	Gorai (near Ganges)	22/7 94-	railway bridge at off-take	FAP24 TBM 13.756 m
10 Arial Khan T)	P, S	Arial Khan	3/6 94-	Koshabhaya, 3 km from off-take	BWDB TBM 6.145 m
11 Bhairab Bazar B), T)	A, S	Meghna	24/7 94-	railway bridge	FAP24 TBM 9.140 m
12 Mir Char	S	Meghna	31/5 95-	20 km downstream of Bhairab Bazar	FAP24 TBM 7.154 m

1): P = pressure cell gauge, A = acoustic (ultrasonic) gauge, S = staff gauge
2): All recordings are referred to PWD datum
3): AWLR has been substituted by a staff gauge for a part of the period
B): Influenced by back-water
T): Tidal effect can occur; please refer to Section 4.3

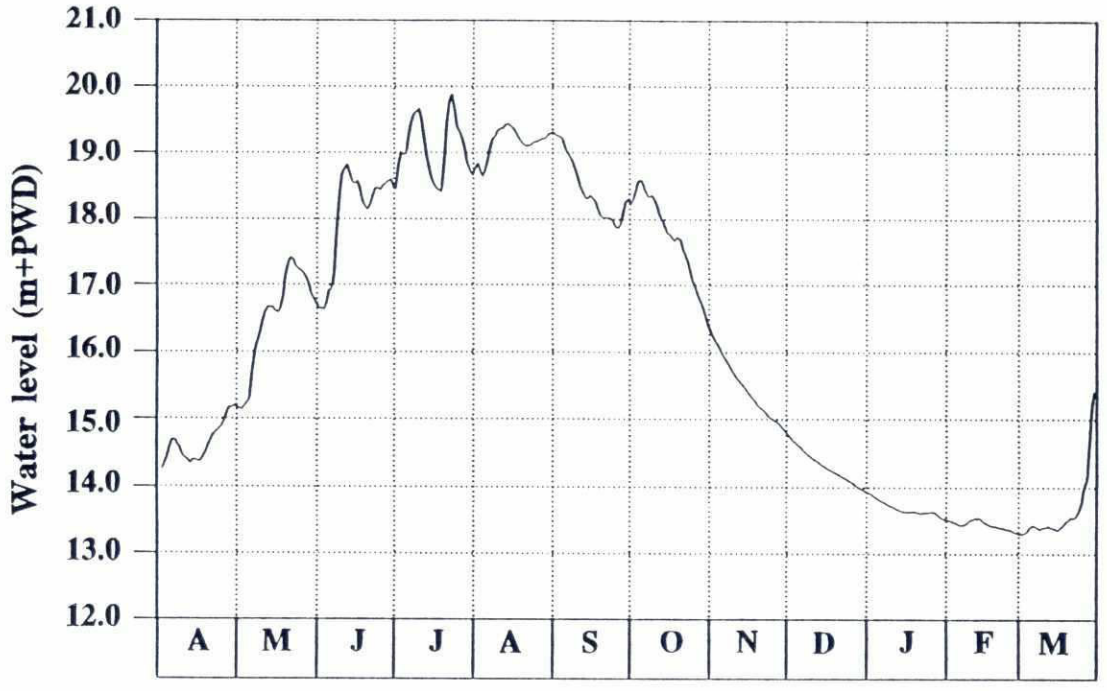
Table 4 (continued): Water level gauges

3.2 Hydrographs

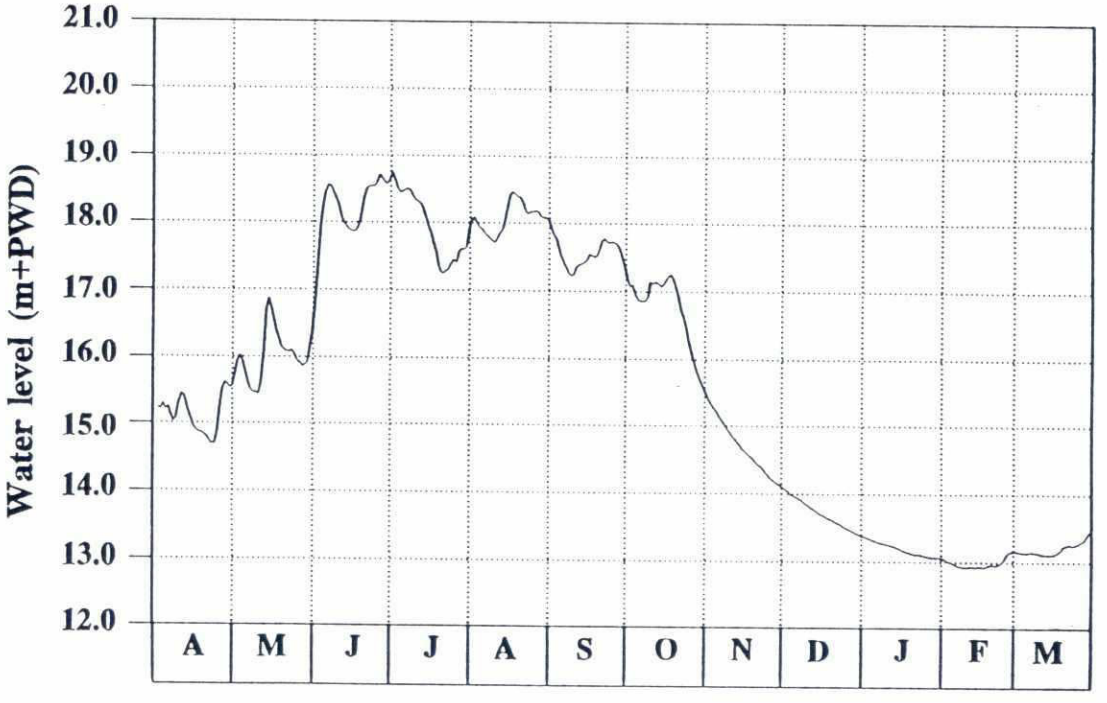
On the following pages are shown hydrographs for the AWLR and FAP24 staff gauge stations for the hydrological years 1993/94 (5 stations) and 1994/95 (18 stations).

79

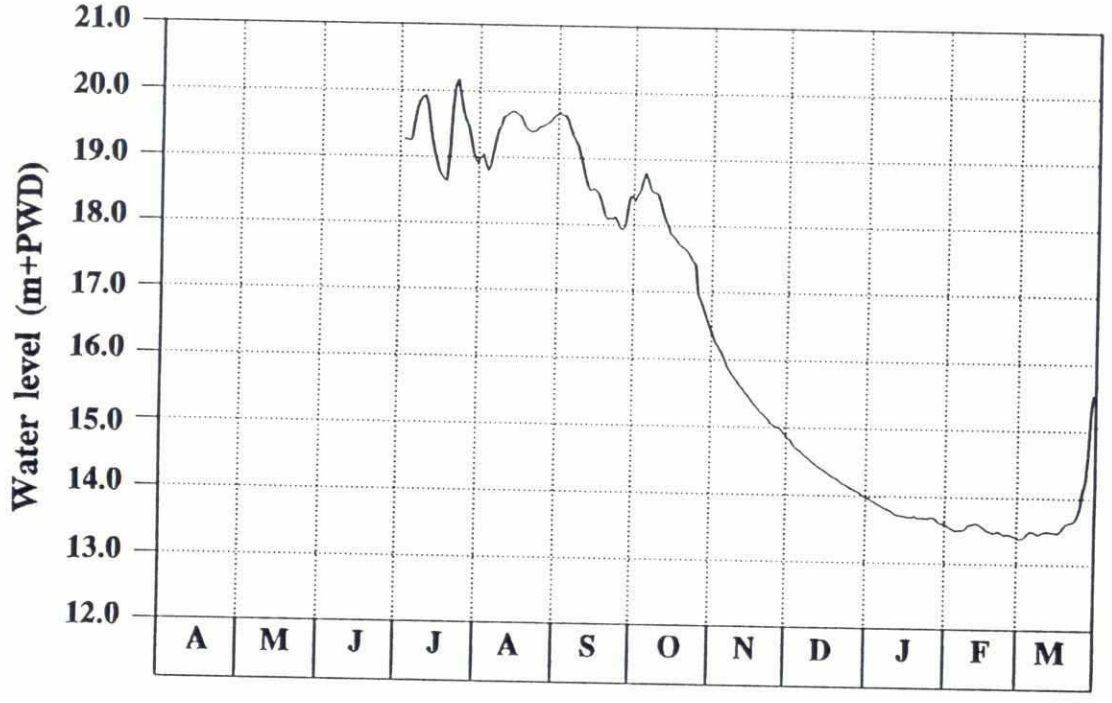
1L Bahadurabad
April 1993 - March 1994



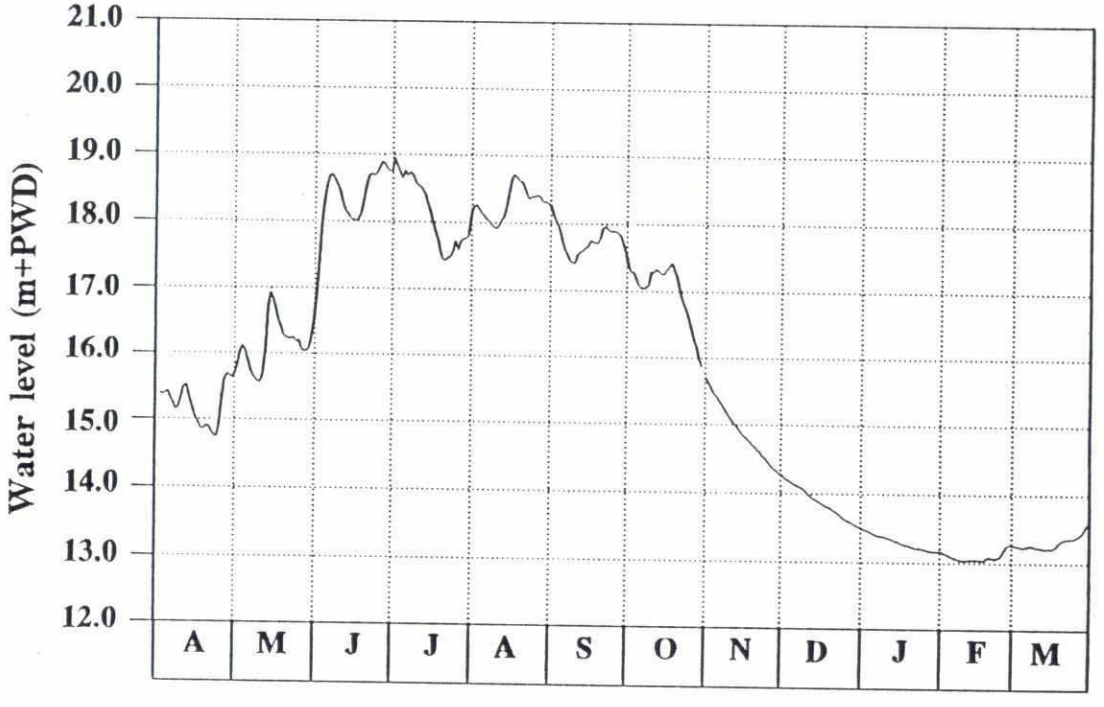
1L Bahadurabad
April 1994 - March 1995



1R Gabgachi
April 1993 - March 1994

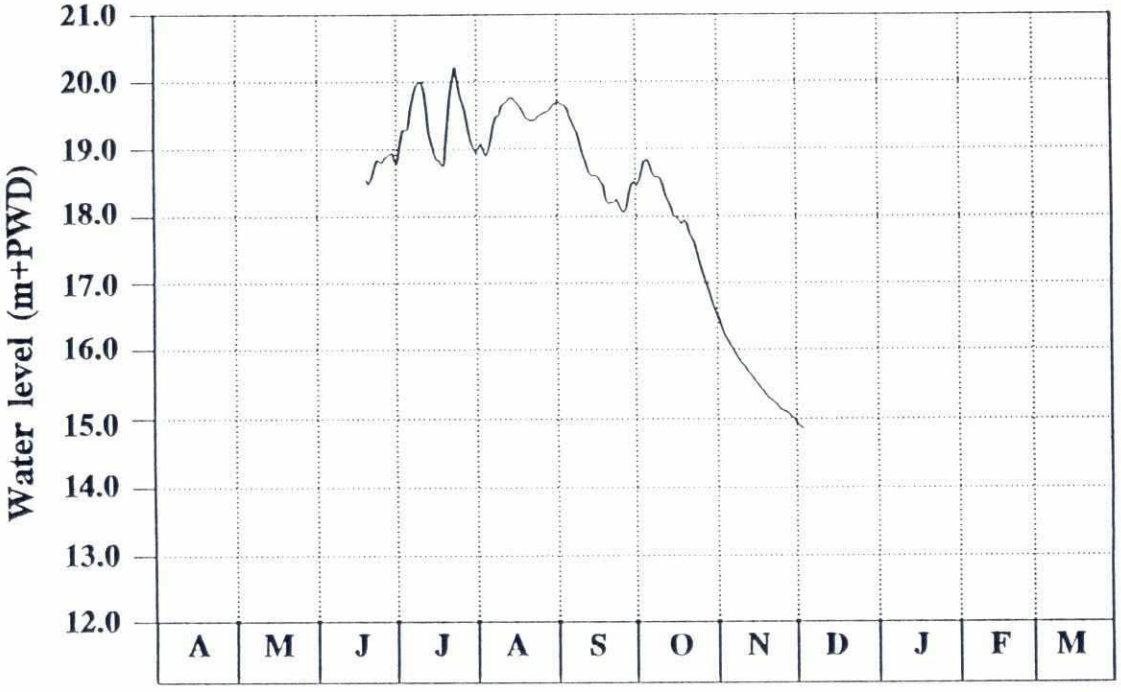


1R Gabgachi
April 1994 - March 1995

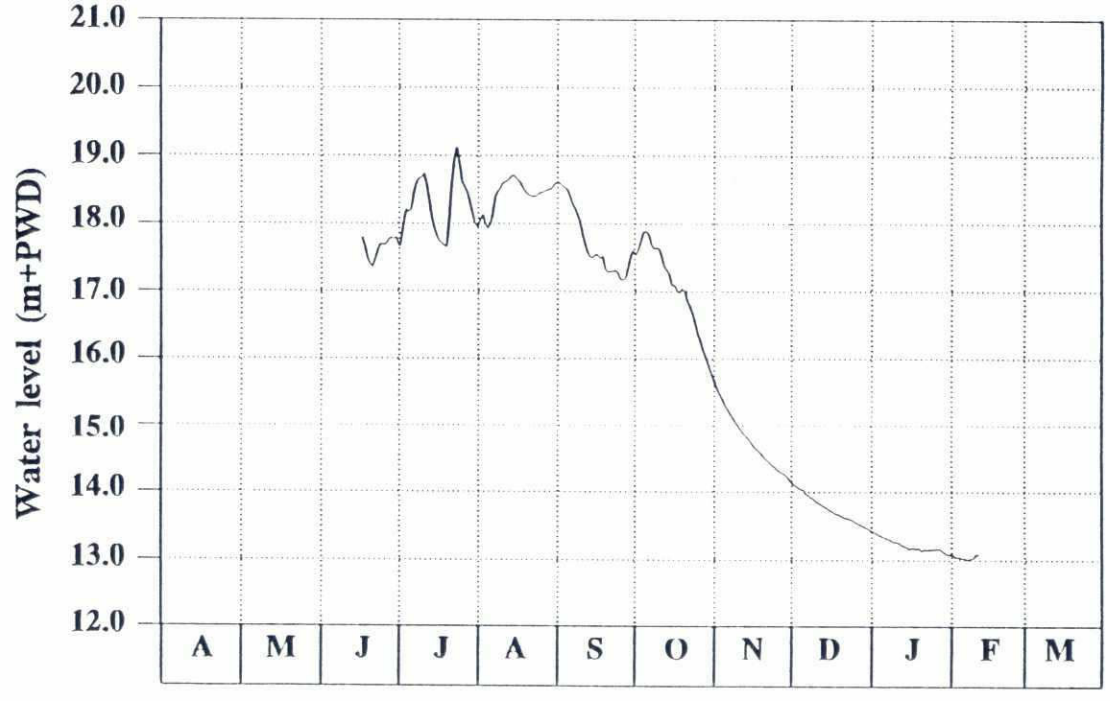


32

B) Char Parul
April 1993 - March 1994

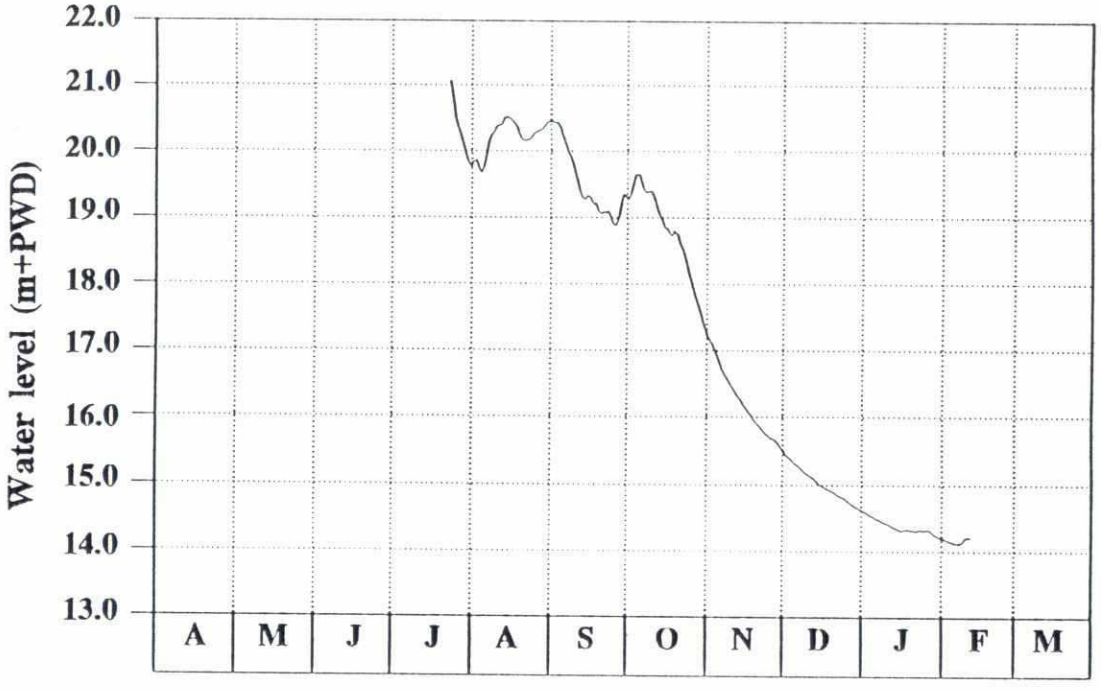


B) Thantania Para
April 1993 - March 1994

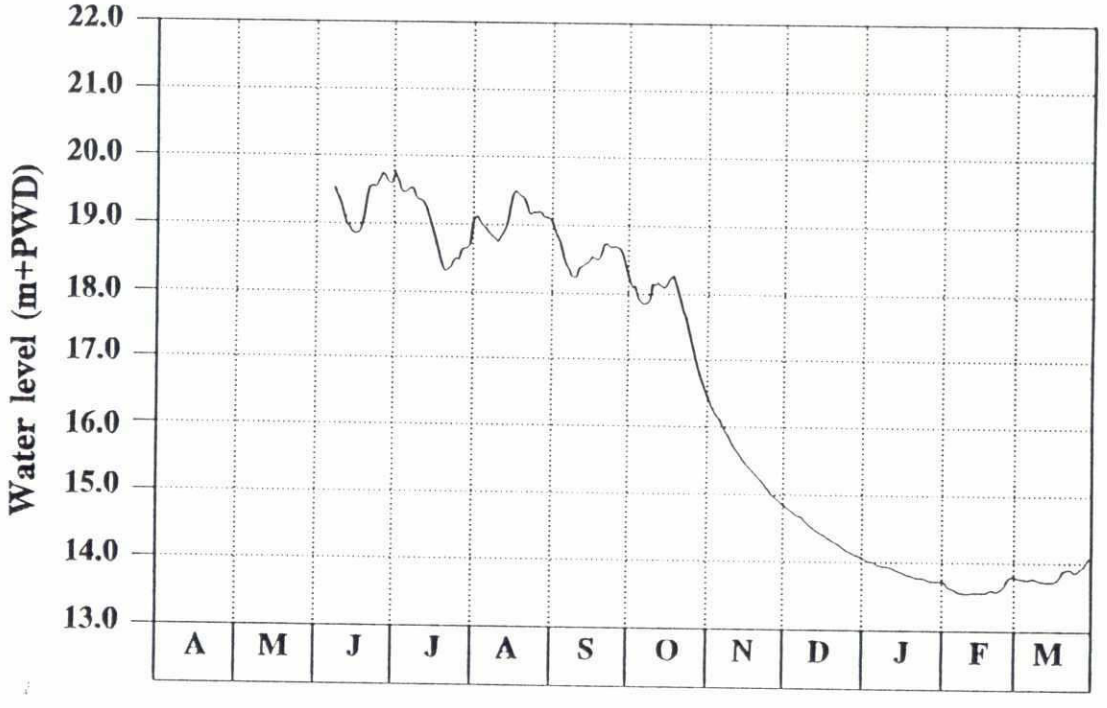


20

B) North Katiamari
April 1993 - March 1994

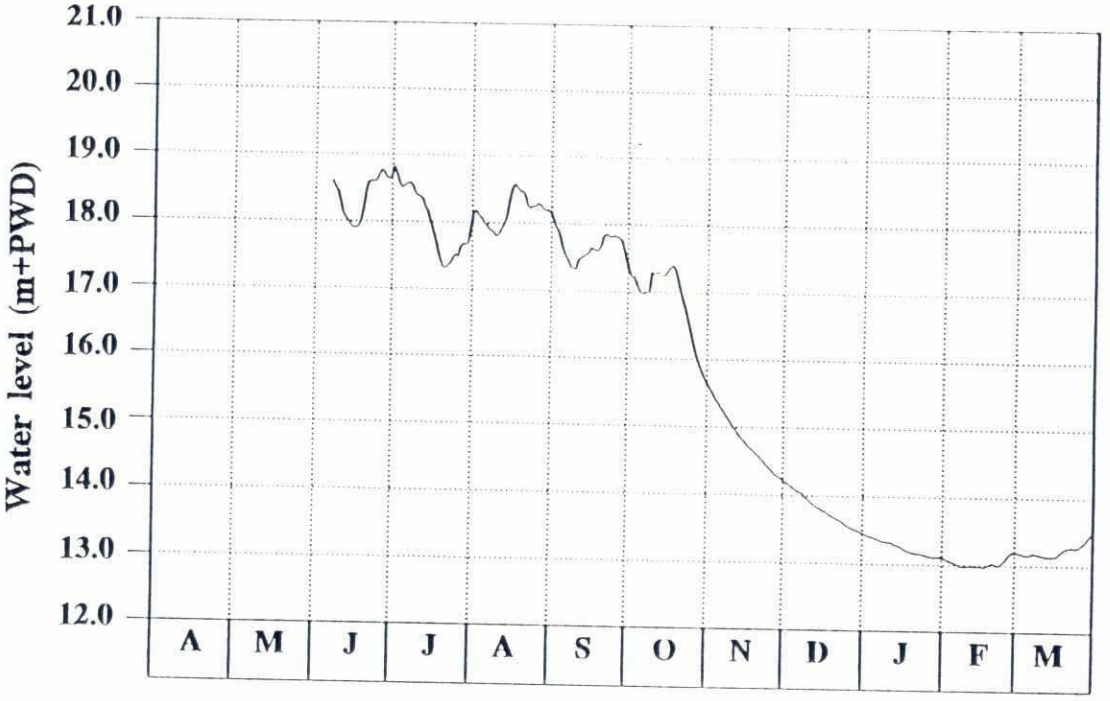


B) North Katiamari
April 1994 - March 1995

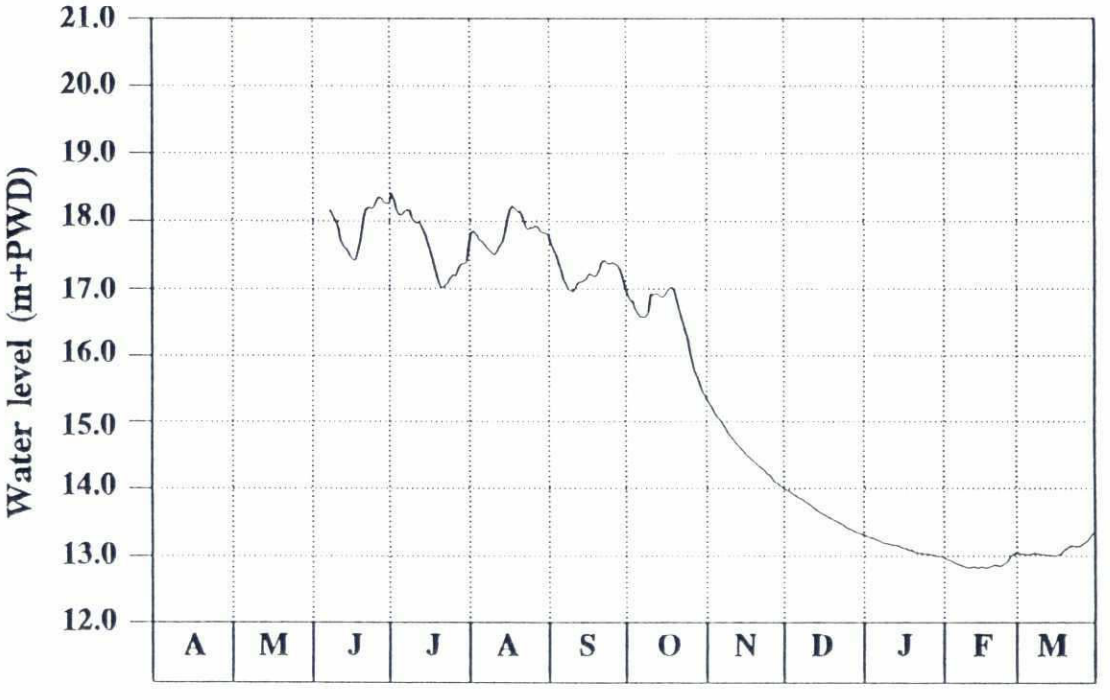


P2

B) North Horindhara
April 1994 - March 1995

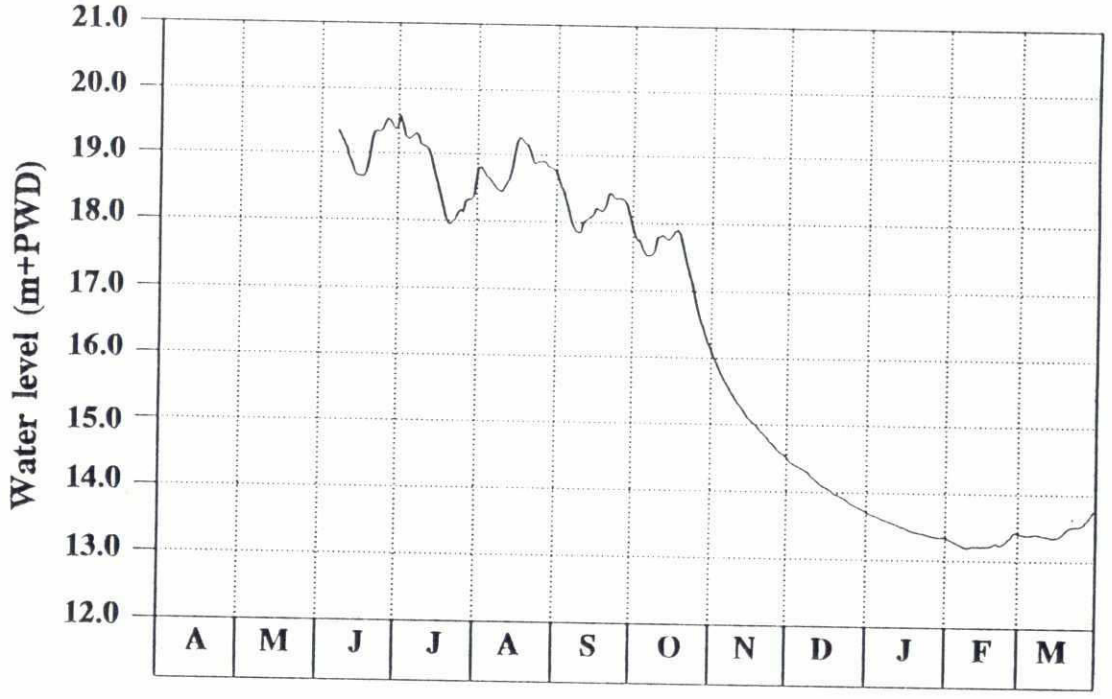


B) Belgacha
April 1994 - March 1995

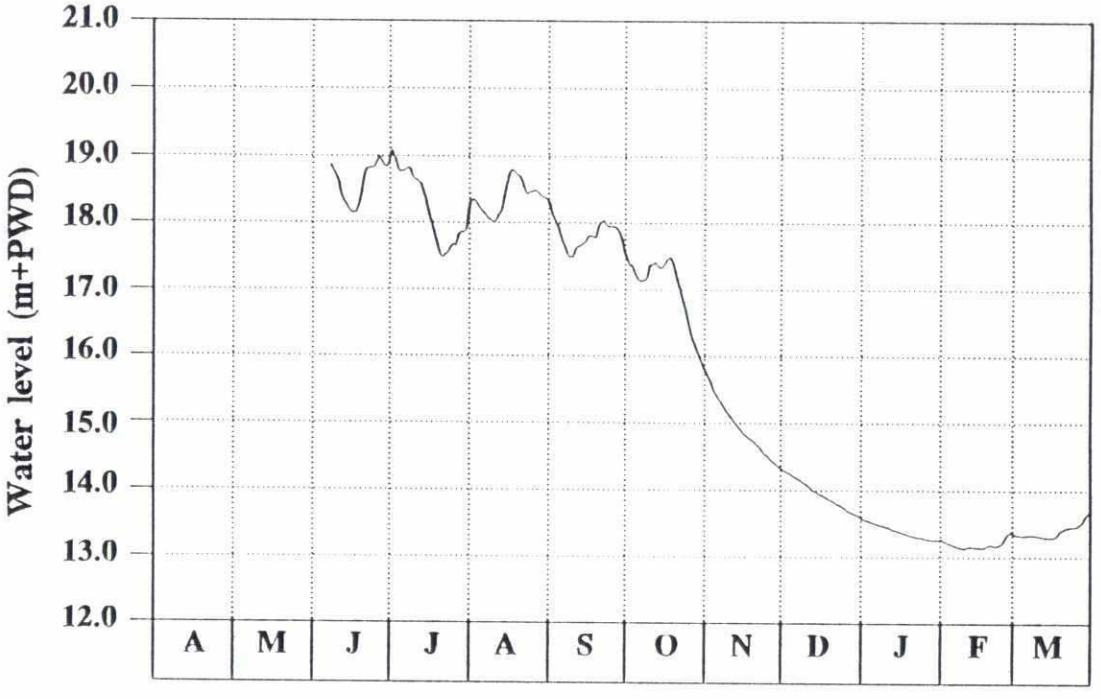


22

B) Kabilpur
April 1994 - March 1995

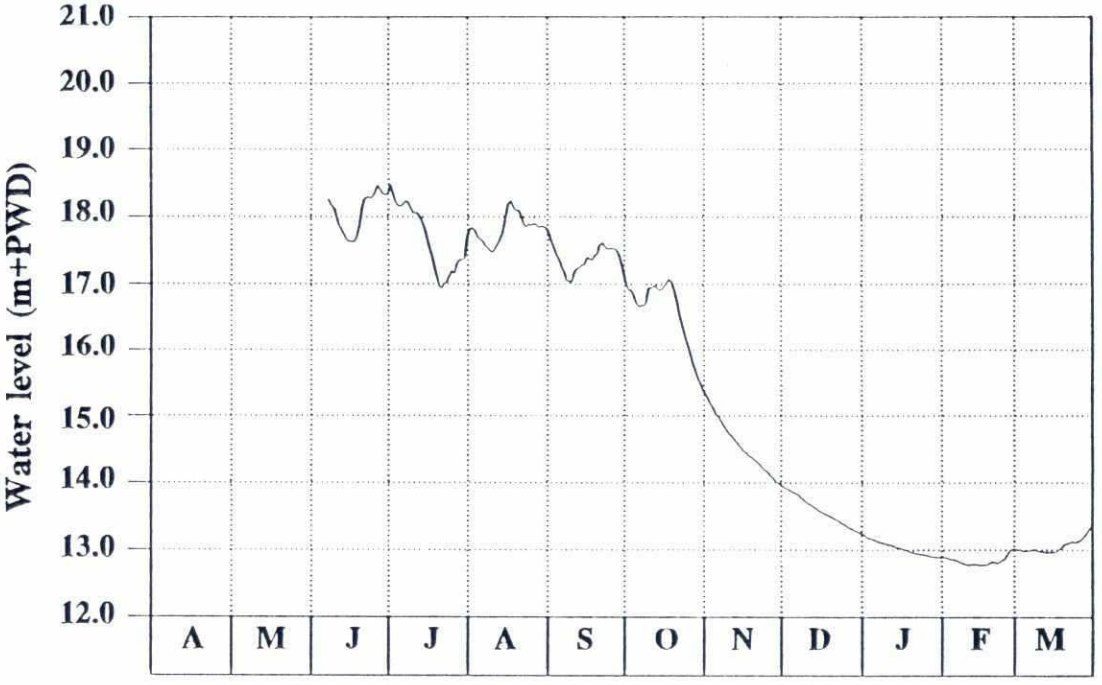


B) Shanki Bhanga
April 1994 - March 1995

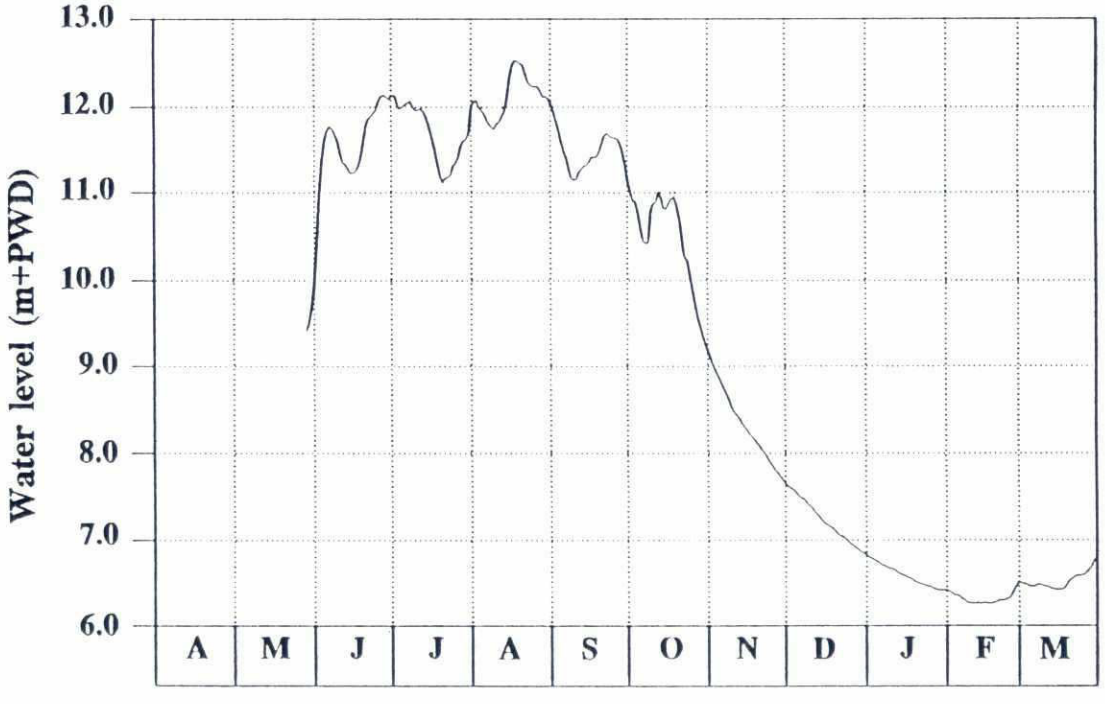


26

B) Bhagir Chaw
April 1994 - March 1995

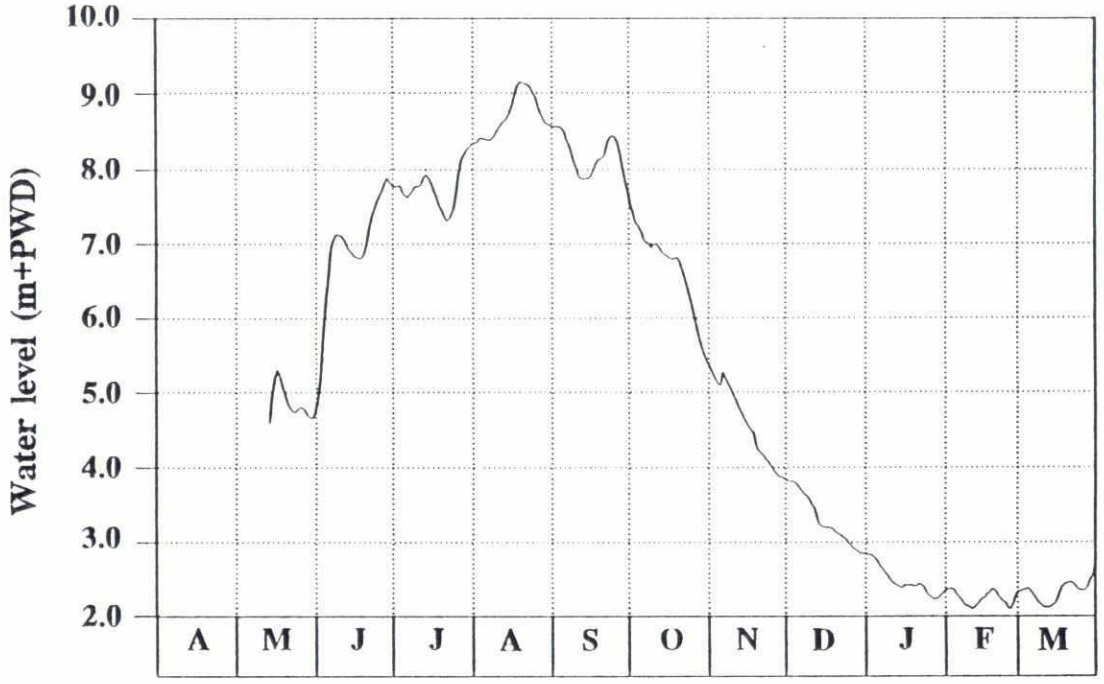


2 Bhuyanpur
April 1994 - March 1995

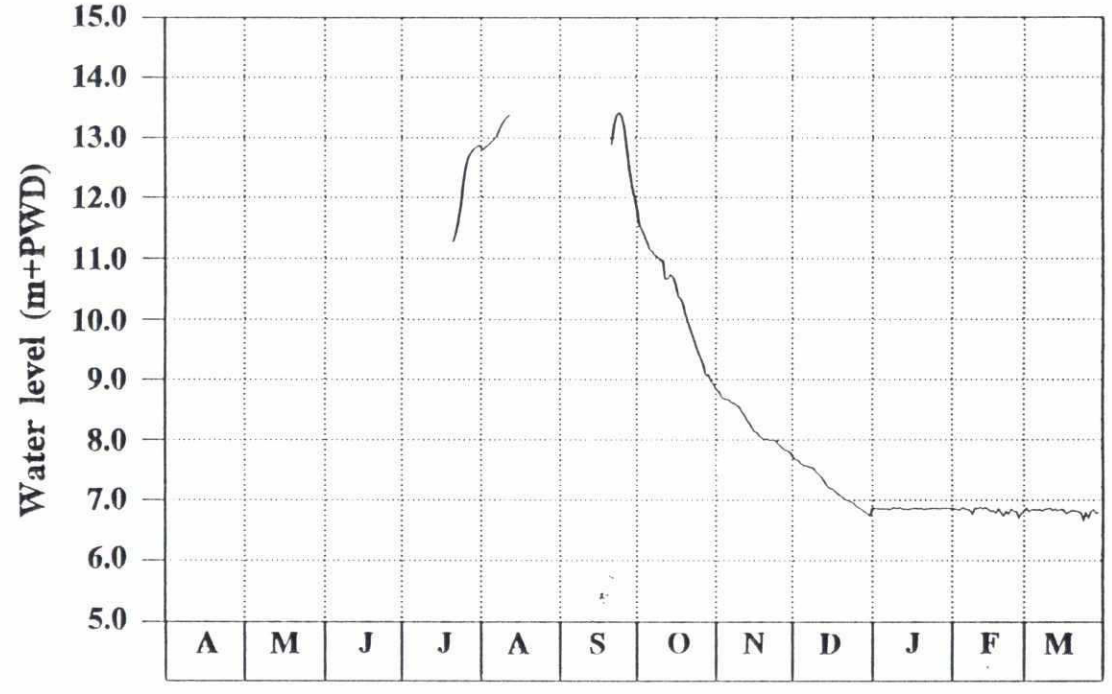


28

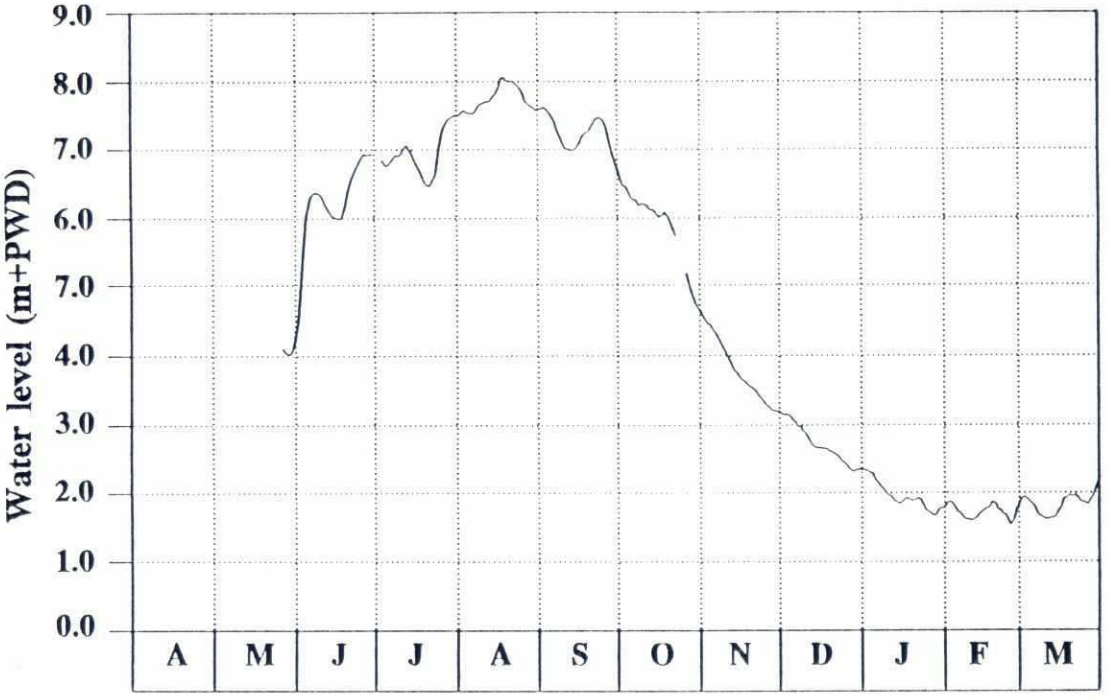
3 Aricha
April 1994 - March 1995



4 Hardinge Bridge
April 1994 - March 1995

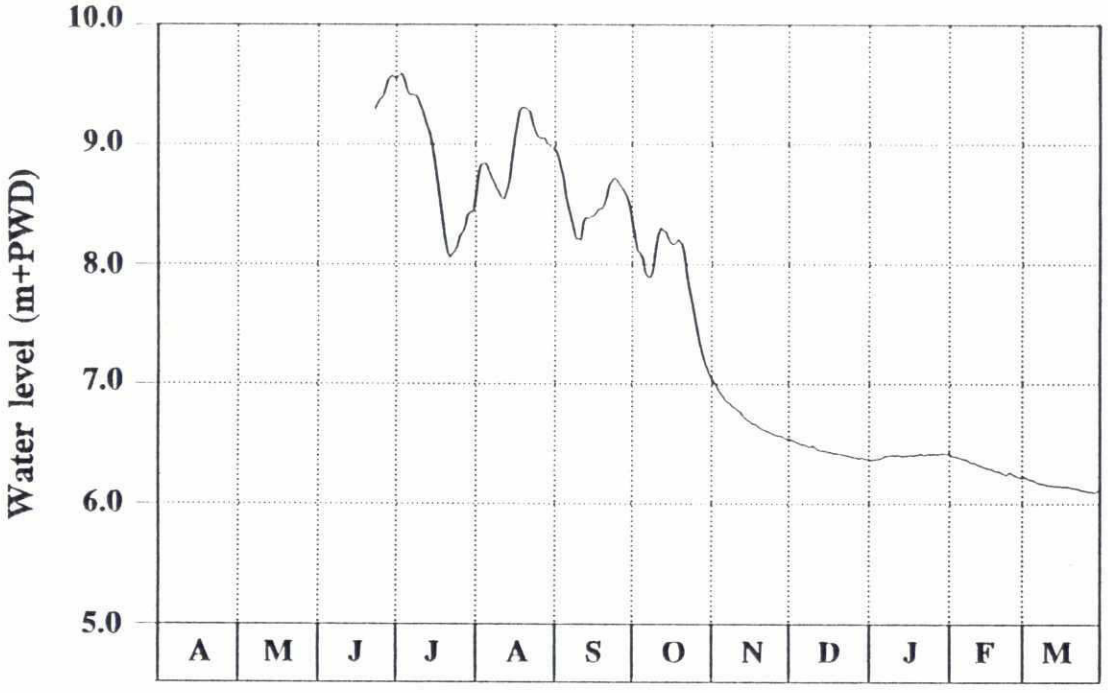


5 Baruria
April 1994 - March 1995

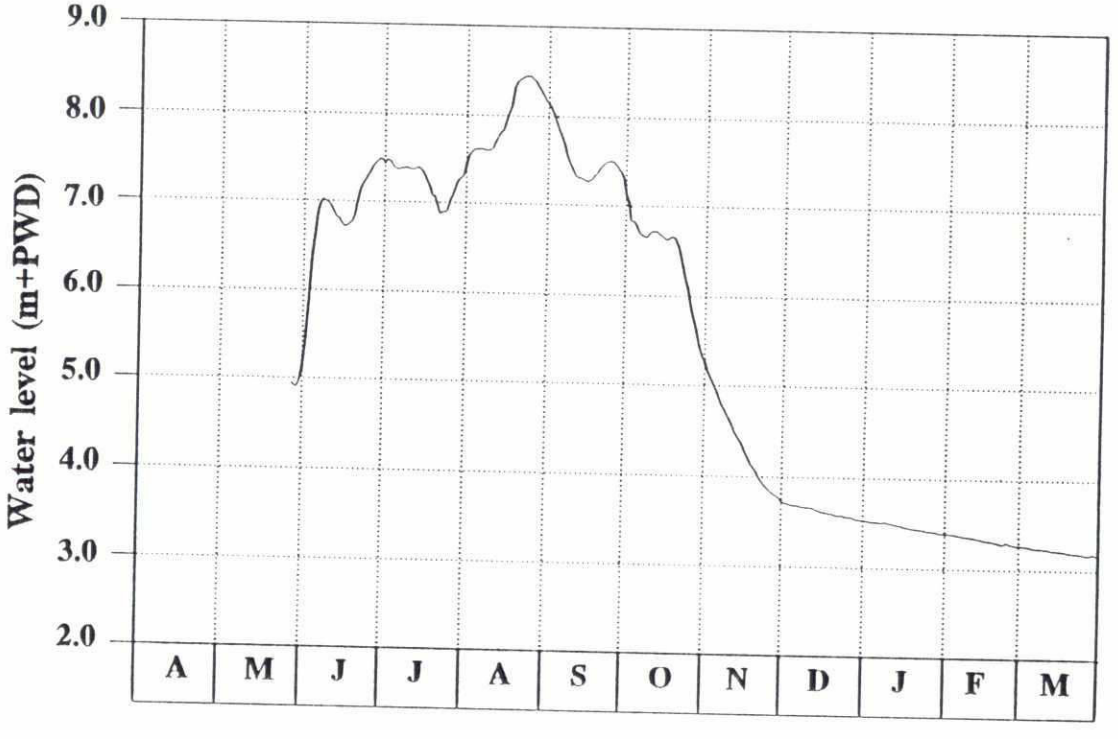


6 Mawa
April 1994 - March 1995

7 Mymensingh
April 1994 - March 1995

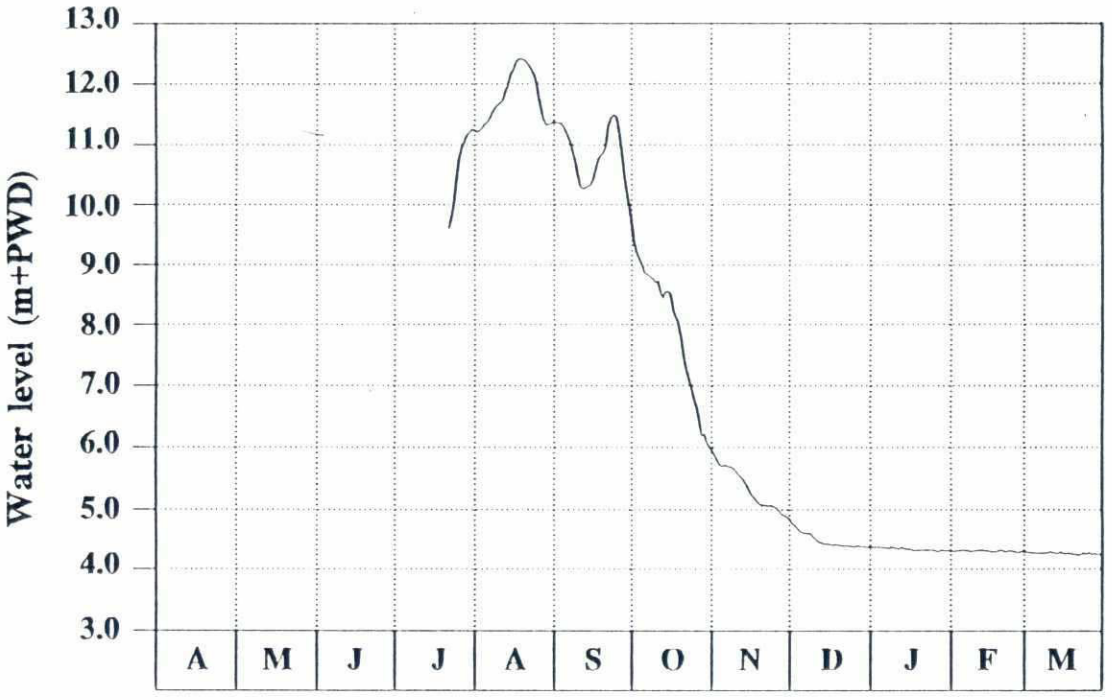


8 Tilly
April 1994 - March 1995

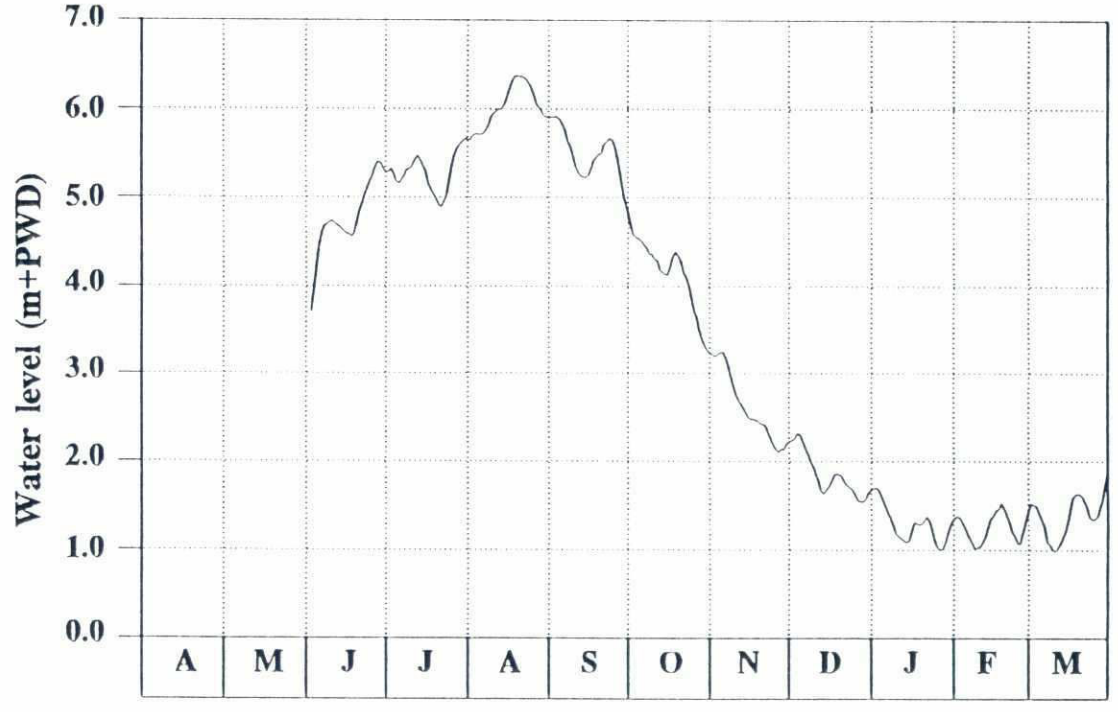


29

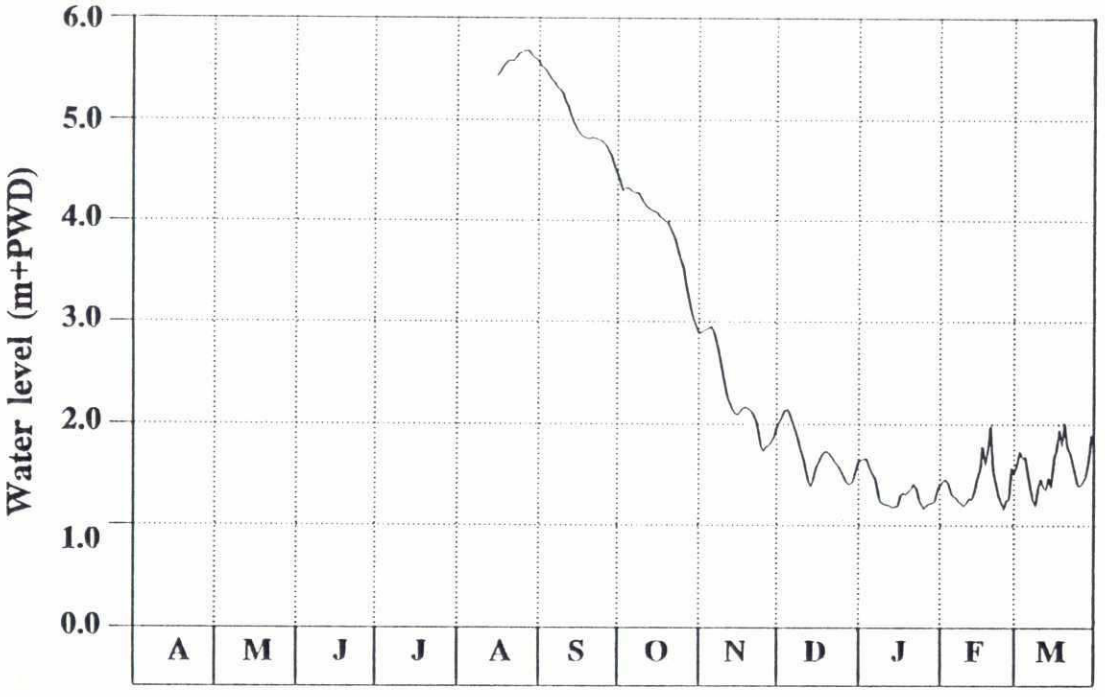
9 Gorai
April 1994 - March 1995



10 Arial Khan
April 1994 - March 1995

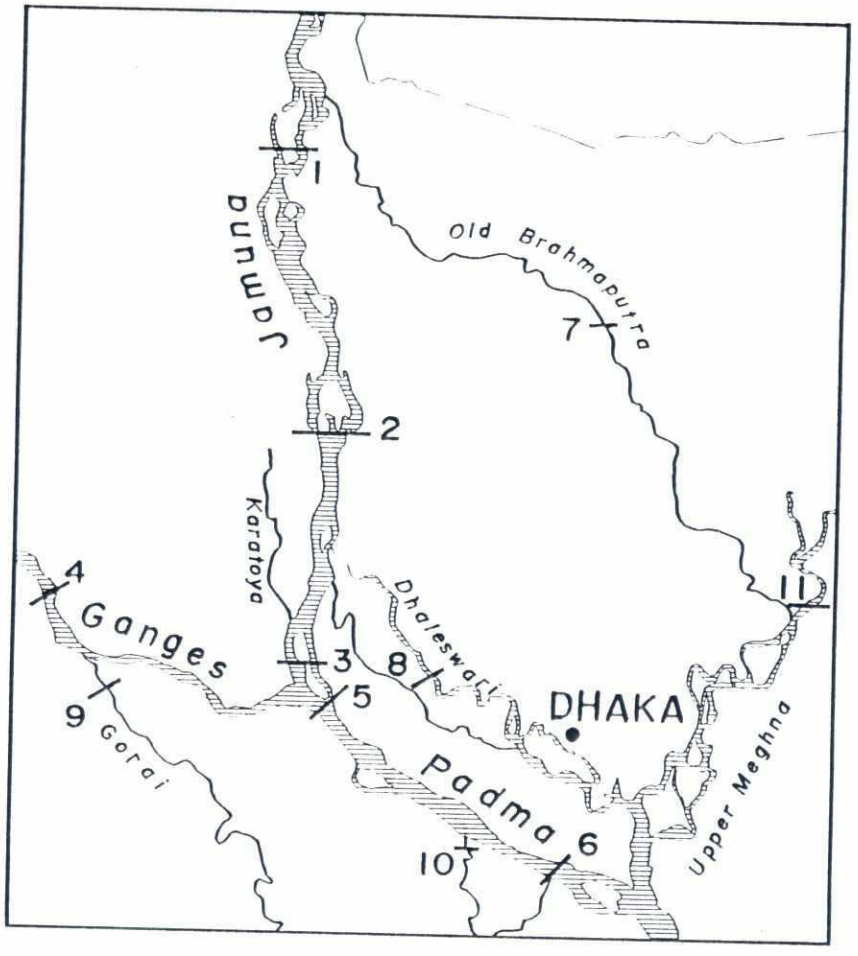


11 Bhairab Bazar
April 1994 - March 1995



4 Routine transect gauging

4.1 Location of transects



LEGEND

1	Bahadurabad	Jamuna	7	Mymensingh	Old Brahmaputra
2	Sirajganj	Jamuna	8	Tilly	Dhaleswari
3	Aricha (Teota)	Jamuna	9	Gorai off-take	Gorai
4	Hardinge Bridge	Ganges	10	Arial Khan off-take	Arial Khan
5	Baruria	Padma	11	Bhairab Bazar	Megna
6	Mawa	Padma			

Figure 4: Location of transects for routine gauging

4.2 Description of the measurements

A routine survey consists of some combination of components as listed in Table 5. The actual combination applied in each survey is given in Part B of the present Data Book. A short characteristic of some of the instruments applied in the routine programme is given in Table 6.

Discharge calculations are based on the moving boat method (MBM) or on the velocity-area method (VAM). The methods are explained in First Interim Report Volume II, Appendix 1, February 1993.

Sediment analyses are carried out by standard methods in the sediment laboratory of the River Survey Project.

For details about procedures, instrumentation, and analyses, please refer to the reports listed as references at the end of the present Data Book.

1	Longitudinal echo sounder reconnaissance of river bed features
2	Initial transects in each direction by ADCP, EMF, and echo sounder
3	Vertical profiles: (a) Current by ADCP and/or S4 (b) sediment concentration by pump bottle, turbidity meter, integrated bottle, and/or collapsible bag (c) pump bottle sampling for settling velocity
4	Bed load: (a) Helley-Smith sampler (b) Delft Bottle (c) dune tracking (where practical)
5	Bed material by US BM-54 sampler and/or van Veen sampler (Since June, 1995, a drag sampler has been applied from the smallest RSP vessels and from country boats)
6	Concluding transects in each direction by ADCP, EMF, and echo sounder
Note:	Not all components were included in each case. Please refer to Part B of this Data Book for information about the actual extent of each routine gauging

Table 5: Components of the recommended method

Instrument		accuracy 1)	resolution 2)	sampling duration/ averaging period	sampling interval
DGPS		3 - 5 m	< 1 m	< 1 s / < 1 s	1 s
AWLR (pressure cell)	3)	1 cm	< 1 cm	< 1 s / 1 min	30 min
AWLR (acoustic)	3)	1 cm	< 1 cm	< 1 s / 1 min	30 min
Echo sounder		5 cm + 1 %	< 1 cm	<< 1 s / << 1 s	1 s
ADCP		5 - 10 cm/s	5 - 10 cm/s	<< 1 s / 6 s	1 s 4)
EMF	5)	2 %	1 cm/s	<< 1 s / 6 s	1 s 4)
S4	6)	2 %	1 cm/s	<< 1 s / 3 x 50 s	-
Ott current meter		3 - 10 % 7)	1 - 2 cm/s	50 s / 3 x 50 s	-

Note: All values are approximate. The values relate to the specific deployment, procedures, and application conditions during the River Survey Project, and do not directly reflect the potential capability of each instrument. The over-all accuracy of a recording can be different from the listed values due to for example repeated measurements (which can improve the over-all accuracy), or validity and time scale effects (which can reduce the over-all accuracy)

< = 'less than', << = 'much less than'

1): Standard deviation between true value and registered value
2): Smallest increment of the true value that can be registered by the instrument
3): 1 sample every 5 s, average for 12 samples (1 min) is stored
4): 6 s average value is updated every s
5): When used for cross-sectional transects or 'moving boat method'
6): When used for individual vertical current profiles
7): Mainly depending on the mooring of the vessel

Table 6: Characteristics of some instruments applied by the project

4.3 Tidal effects and backwater

Some stations are influenced by the astronomical tide in the lean season, most pronouncedly at spring tide, while in the flood season, tidal effects are insignificant at all stations covered by the project.

In Table 4 (Section 3.1), some stations are pointed out where the astronomical tide or backwater are of some practical significance. Seasonal backwater occurs at Aricha during peak flow in Ganges River, and at Bhairab Bazar during peak flow in Old Brahmaputra.

4.4 Sediment properties and sediment transport

In addition to the flow recordings, the routine transect surveys comprise determination of suspended sediment transport and bed load transport, as well as sediment grain size distributions, and vertical distributions of sediment concentration and settling velocity.

The different types of samples are analyzed in the sediment laboratory of the River Survey Project, which has equipment for standard analyses of concentration, settling velocity distribution, and grain size distribution. Some of the samples are analyzed for physical and chemical characteristics by an external laboratory.

Results are digitized, whereafter transport rates are calculated by application of the flow data from the survey. Data files are generated, checked, and stored in separate data files in the PSD24.

The sediment transport terms applied are summarised in Figure 5. Wash load is characterised by a grain size diameter less than 0.063 mm.

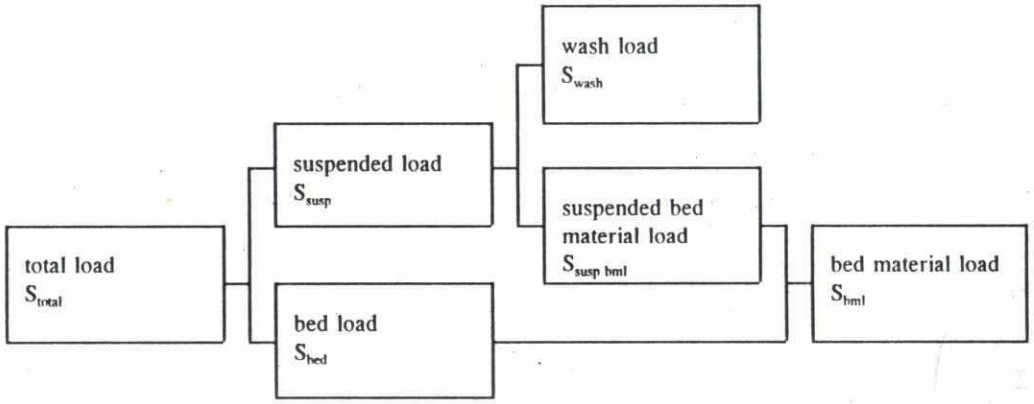


Figure 5: Sediment transport terms

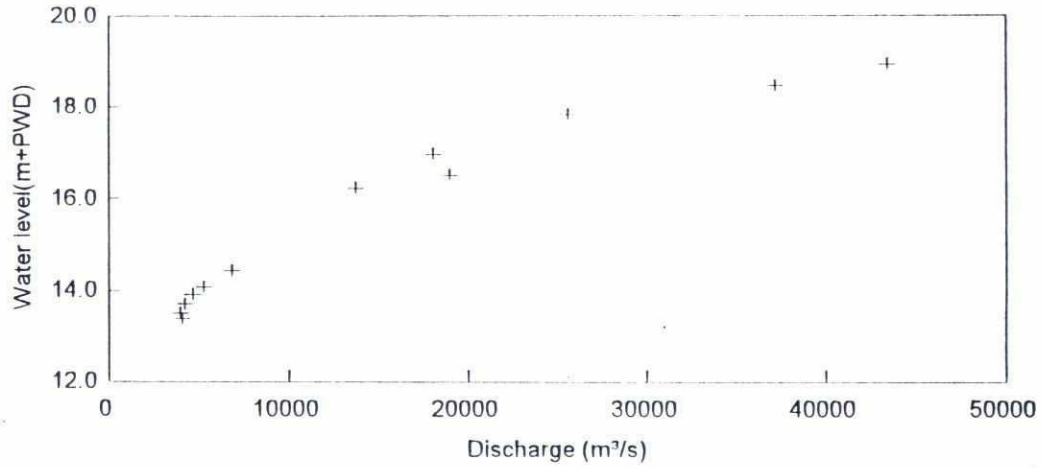
4.5 Rating curves

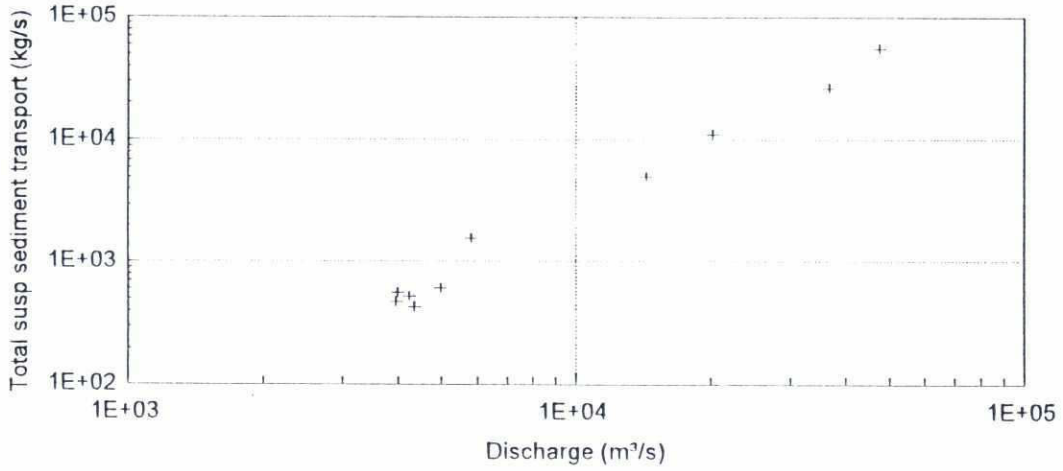
Rating curves for the transect stations are shown on the following pages. Q_{MBM} and Q_{VAM} are the discharges calculated by means of the moving boat method and the velocity-area method respectively.

Please note that, for compatibility reasons, these rating curves are based on water level data produced by BWDB (and not by the River Survey Project).

1L Bahadurabad

January 1993 - March 1994



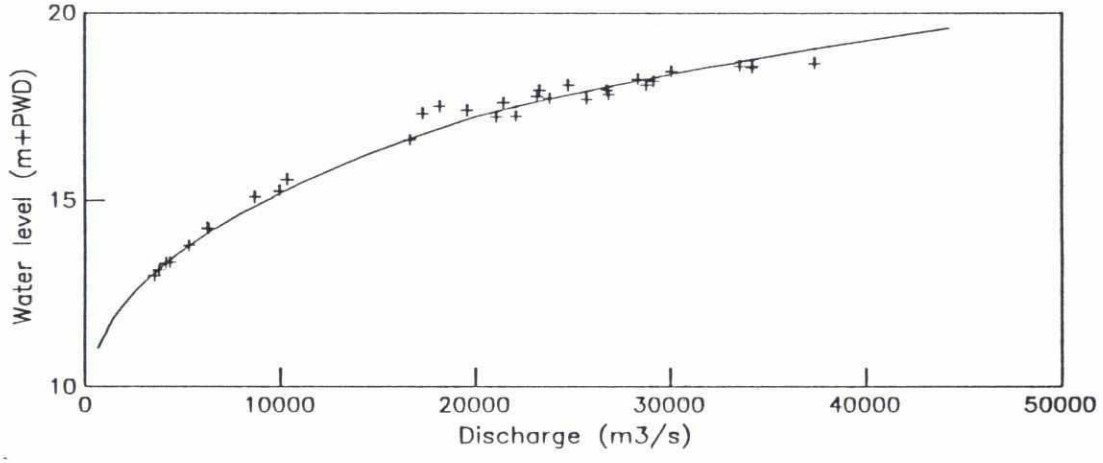


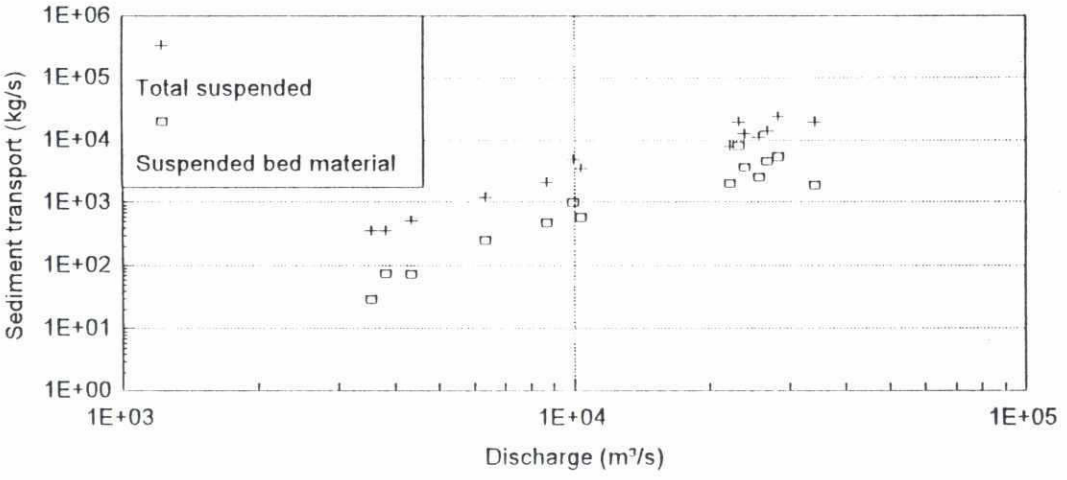
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
15-16/9 92	17.82	25600					
27-29/10 92	16.50	19000					
14-15/1 93	14.07	*5300	4982				606
13-15/2 93	13.70	*4250	4237				516
13-16/3 93	13.92	*4700	4352				425
6/6 93	16.95	*18100	20264				11072
13/7 93	18.94	*43400	47766				55604
11/9 93	18.47	*37200	36857				26070
3/11 93	16.23	*13768	14401				5039
10/12 93	14.43	*6873	5845				1564
31/1 93	13.51	*3998	3994	308	174	6	557
17/3 93	13.38	*4104	3968				467

* not used for calculation of sediment transport

1L Bahadurabad

April 1994 - March 1995

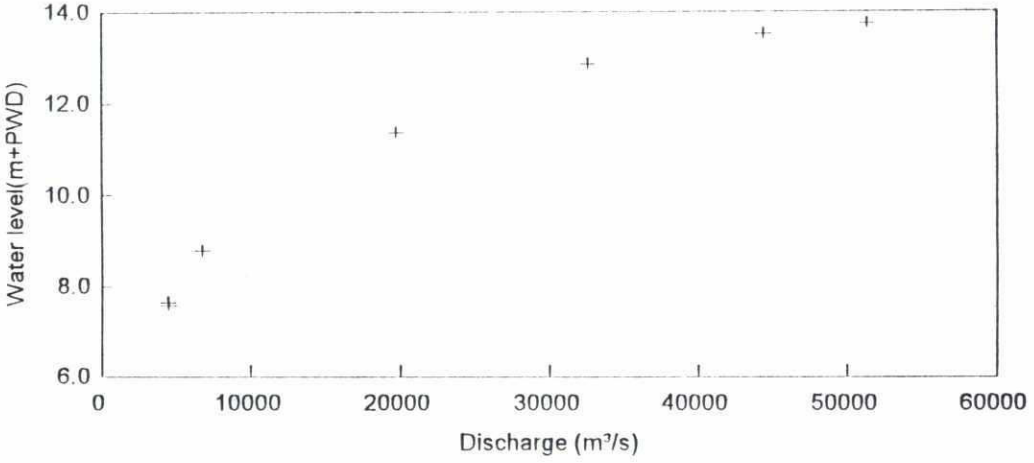


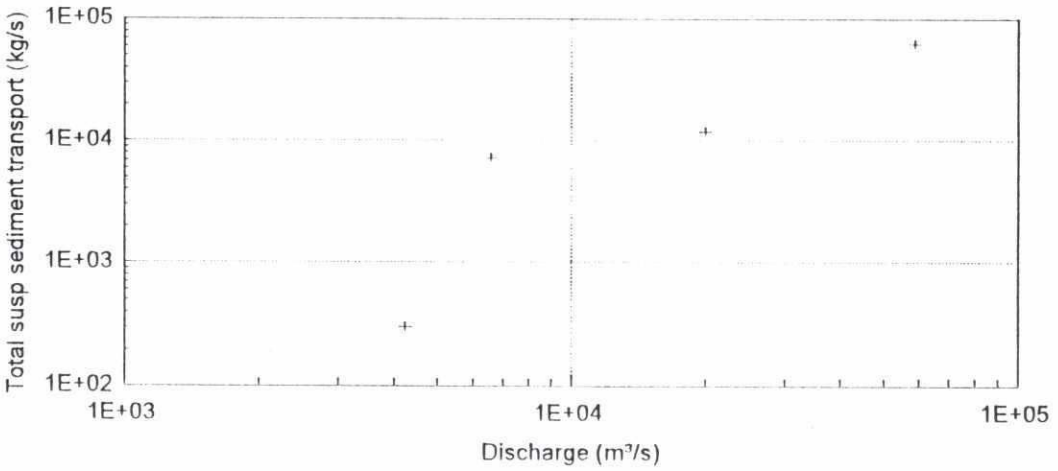


date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
2-4/4 94	15.25	9952		3899	990	36	4925
26-28/4 94	15.55	10360		2879	580	31	3490
3-5/6 94	18.24	28329		17897	5480	489	23866
23/6 94	18.53	34166					
24-26/6 94	18.57	34200		17154	1835	487	19476
27/6 94	18.65	37352					
28/6 94	18.58	33548					
13/7 94	18.19	29143					
14-16/7 94	17.96	26738		9467	4498	290	14255
16/7 94	17.84	26838					
2/8 94	18.09	28749					
6-9/8 94	17.80	23144		11306	8064	146	19516
18/8 94	18.44	30051					
30/8 94	18.09	24763					
1/9 94	17.96	23285					
1-5/9 94	17.74	23812		9092	3646	224	12962
6/9 94	17.42	19577					
17/9 94	17.52	18156					
21-28/9 94	17.72	25706		8608	2473	220	11301
28/9 94	17.62	21437					
30/9 94	17.33	17278					
17/10 94	17.24	21061					
18-21/10 94	17.26	22089		5841	1988	158	7987
23/10 94	16.61	16644					
7-8/11 94	15.09	8707		1576	474	35	2085
26/11 94	14.25	6280					
26-27/11 94	14.22	6342		960	252	4	1216
13/12 94	13.77	5351					
8/2 95	12.95	3583					
9/2 95	12.94	3562		324	29	1	354
11/3 95	13.10	3818		276	74	3	353
12/3 95	13.10	3812					
27-28/3 95	13.30	4153					
28-29/3 95	13.32	4344		437	73	3	513

2 Sirajganj

January 1993 - March 1994



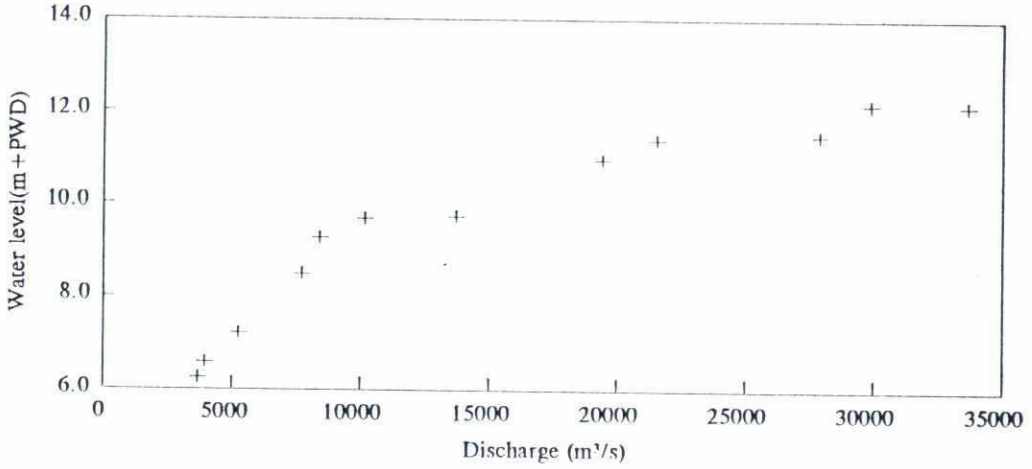


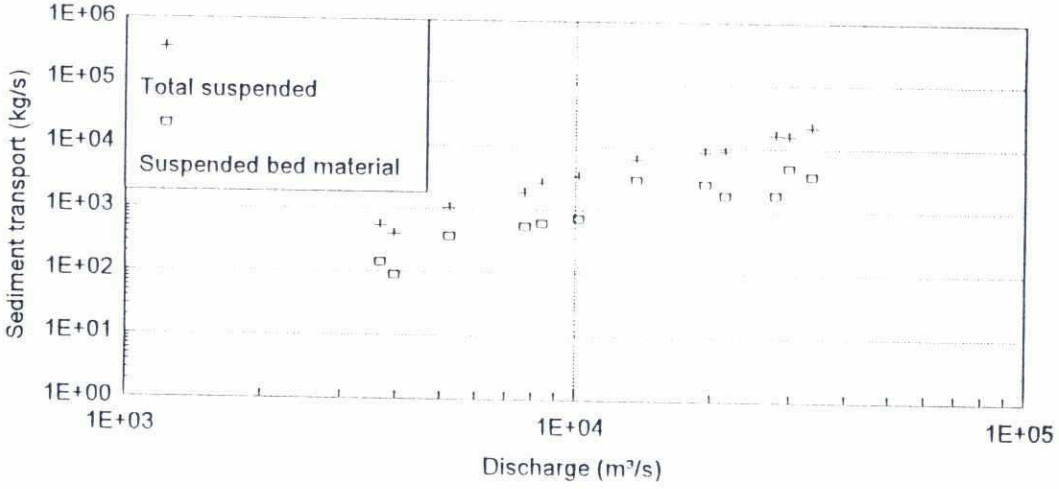
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
23/7 93	13.73	51360					
26/7 93	13.50	*44422	58957				62570
17/9 93	12.84	32605					
24-27/10 93	11.36	*19689	20044				11967
7-8/12 93	8.78	*6761	6621	571	4798	29	7160
3/2 94	7.65	4431					
19/3 94	7.58	*4496	4234				303

* not used for calculation of sediment transport

2 Sirajganj

April 1994 - March 1995

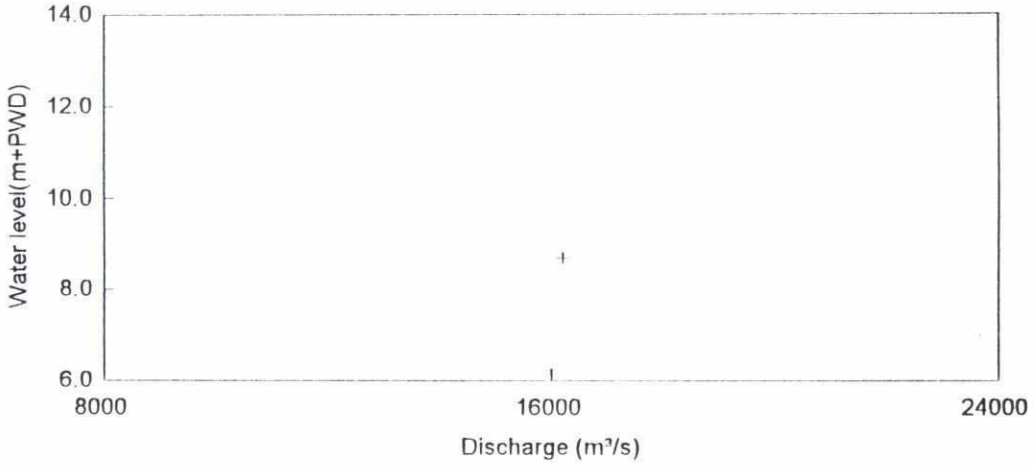




date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
6-7/4 94	9.28	8426		2044	606	53	2703
30/4 94	9.69	10180		2623	734	70	2428
10-11/6 94	11.49	27925		14413	1836	220	16469
1-2/7 94	12.14	33670		17752	3756	221	21729
18-19/7 94	11.40	21588		7271	1782	114	9167
25-29/8 94	12.17	29910		10615	5070	166	15851
2-3/10 94	10.95	19451		5872	2744	222	8838
26-28/10 94	9.74	13737		3445	3088	120	6653
11/11 94	8.49	7729		1280	542	63	1885
15/12 94	7.23	5260		668	373	8	1049
13/2 95	6.27	3683		399	145	7	551
25/3 95	6.59	3966		307	91	7	405

3 Aricha

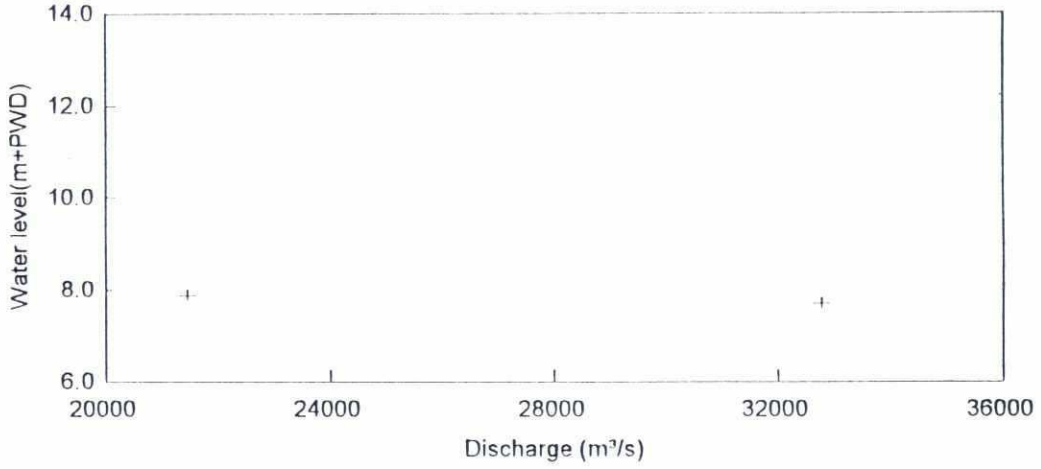
January 1993 - March 1994

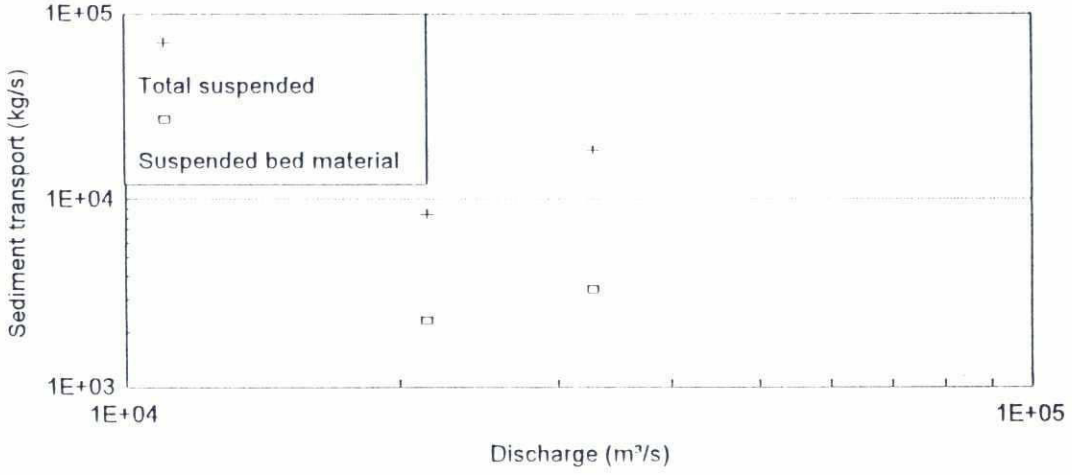


date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
19/9 93	8.68	16215					

3 Aricha

April 1994 - March 1995



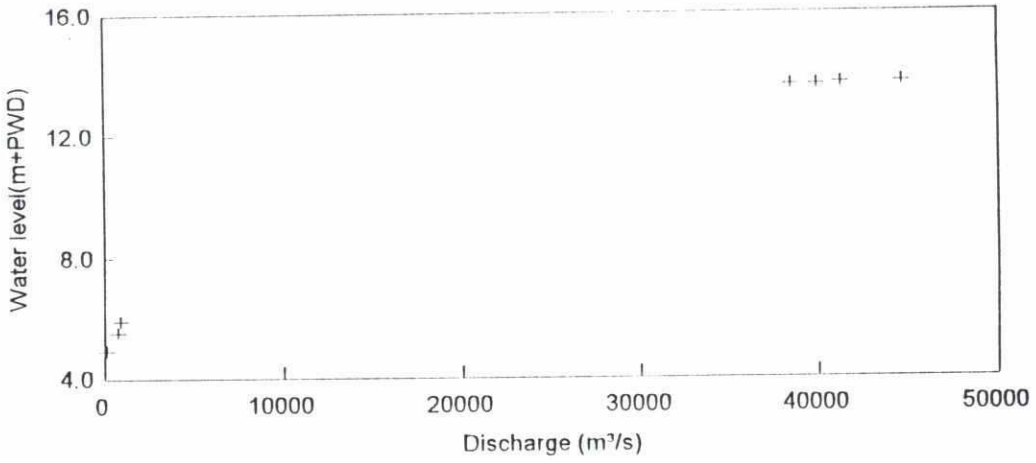


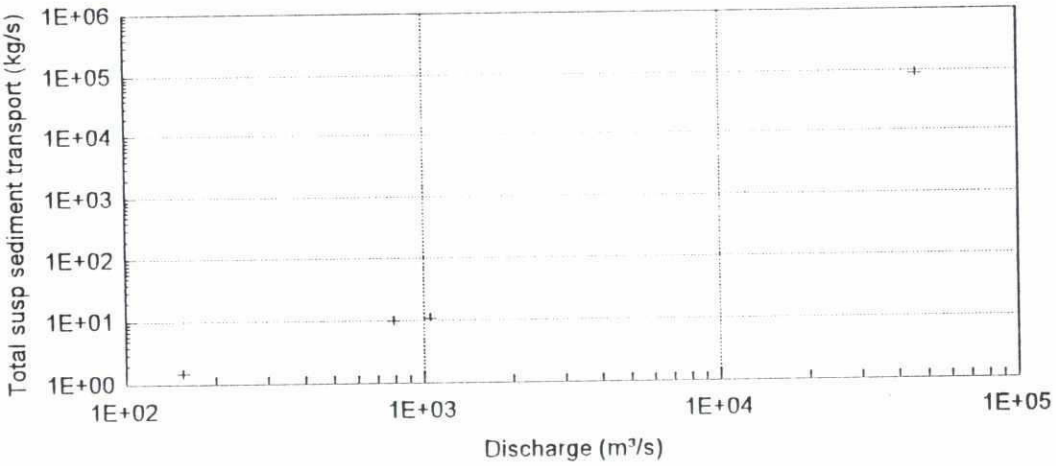
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
6-8/7 94	7.69	32779		14845	3392	208	18445
11-13/9 94	7.87	21467		6022	2313	27	8362

80

4 Hardinge Bridge

January 1993 - March 1994



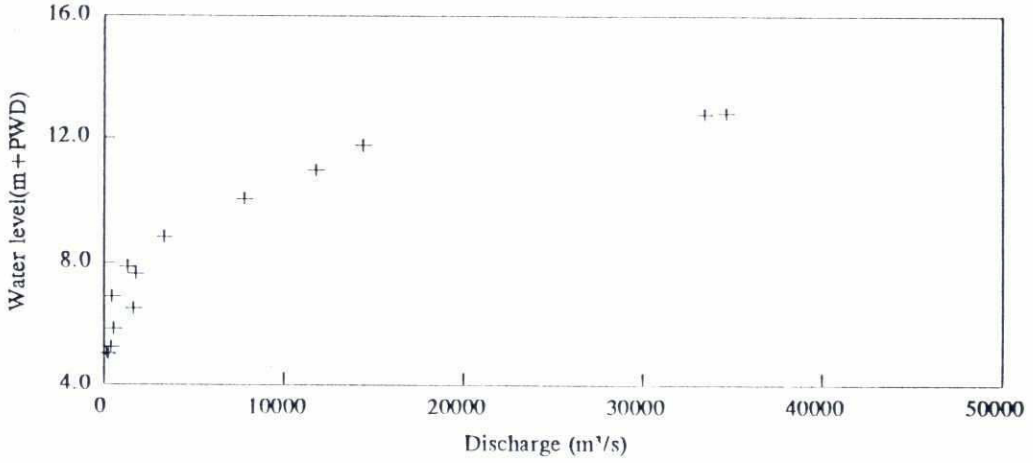


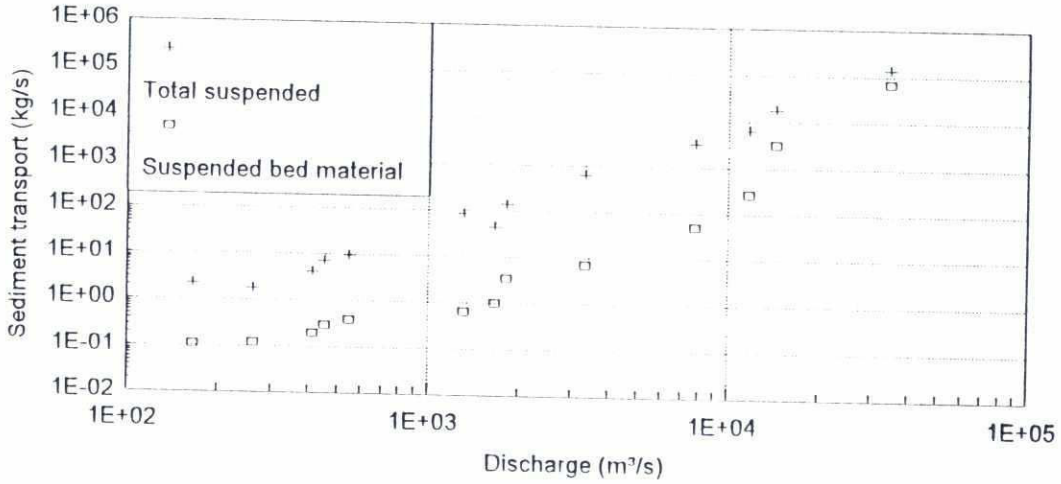
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
26/9 93	13.66	39945					
27/9 93	13.66	*38491	46103				89341
28/9 93	13.71	41294					
29/9 93	13.74	44677					
16/2 94	5.94		1057				11
7/3 94	5.57		792				9
28/3 94	4.95		156				1

* not used for calculation of sediment transport

4 Hardinge Bridge

April 1994 - March 1995



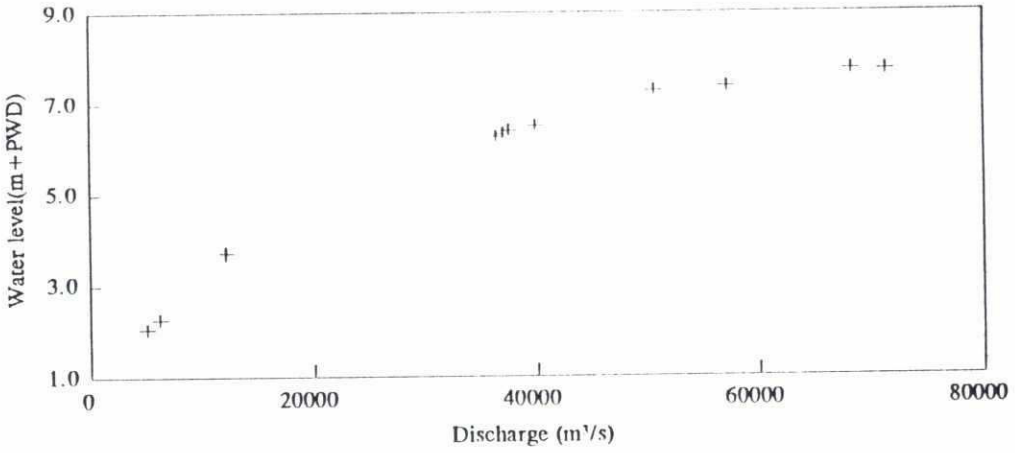


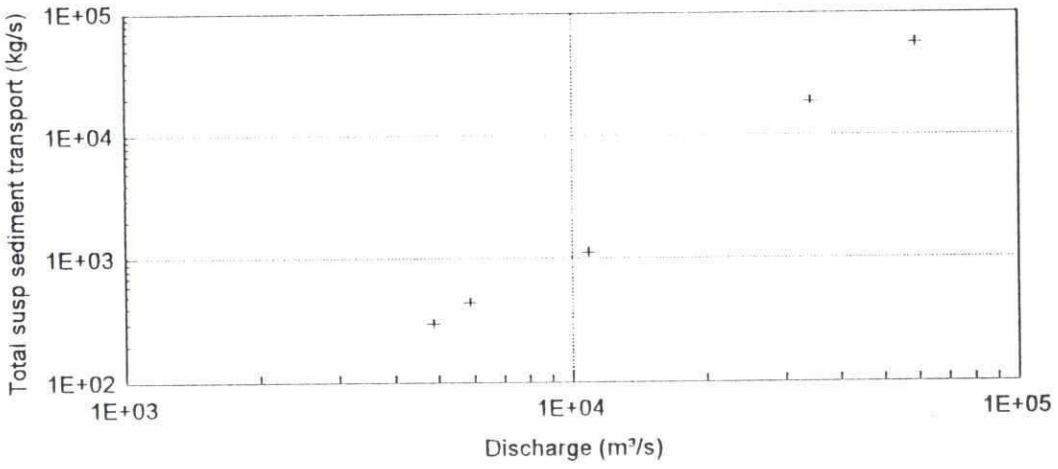
date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
8/4 94	5.02	263		2	0	0	2
12/5 94	5.09	*237	167	2	0	0	2
5/6 94	6.91	455		7	0	0	7
20/6 94	7.88	1326		84	1	0	85
14/7 94	11.77	14411		14998	3198	7	18203
1/8 94	12.84	34667		69849	68877	119	138845
2/8 94	12.80	33510					
11/10 94	10.98	11786		5939	265	2	6206
20/10 94	10.05	7810		3101	51	2	3154
1/11 94	8.82	3370		645	7	0	652
3/12 94	7.66	1839		136	3	0	139
3/1 95	6.52	1679		44	1	0	45
3/2 95	5.87	548		9	0	0	9
28/3 94	5.29	417		4	0	0	4

* not used for calculation of sediment transport

5 Baruria

January 1993 - March 1994



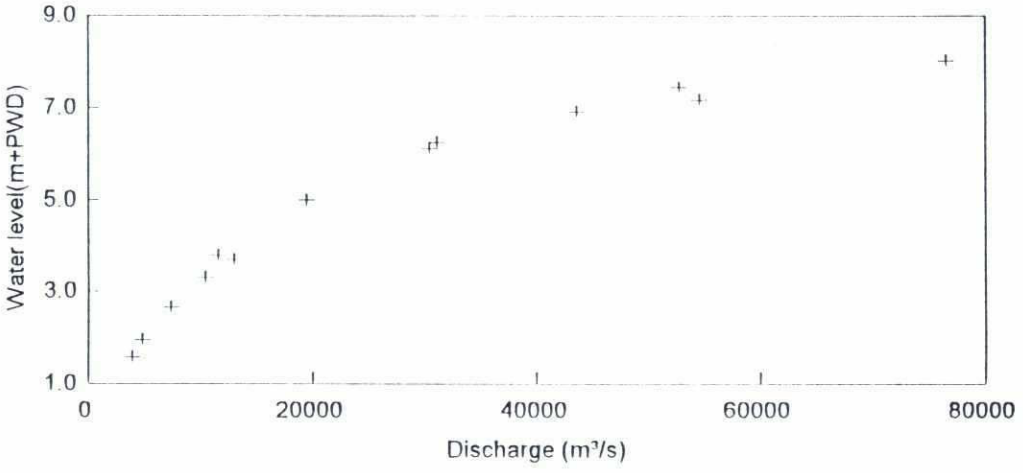


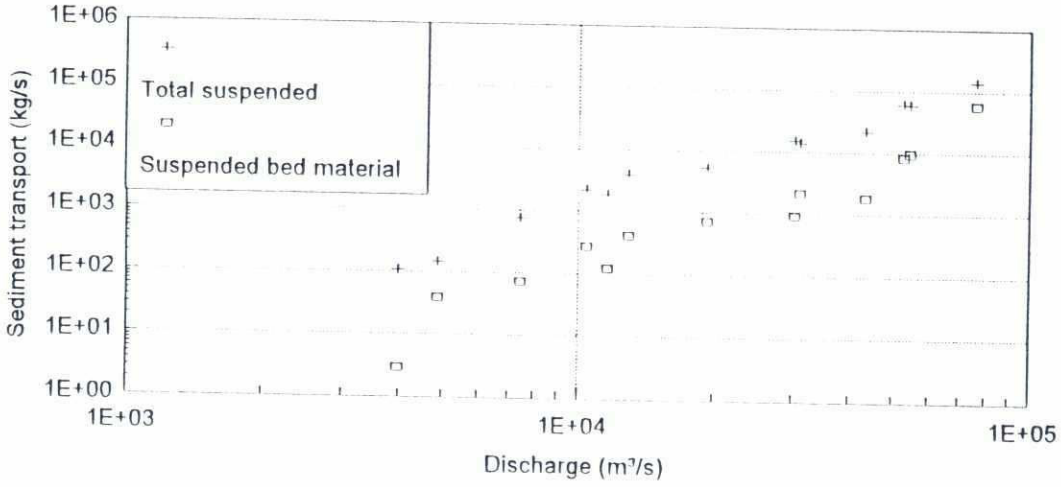
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
5/8 93	7.28	50606					
7/8 93	7.36	*57135	59305		56392		56392
19/9 93	7.73	68288					
1/10 93	7.72	71382					
19/10 93	6.50	39960					
20/10 93	6.40	*37595	34341				18837
21/10 93	6.33	37068					
22/10 93	6.27	36409					
5/12 93	3.56	*11315	10898				1119
5/2 94	2.27	*6242	5882				446
21/3 94	2.06	*5107	4882				302

* not used for calculation of sediment transport

5 Baruria

April 1994 - March 1995



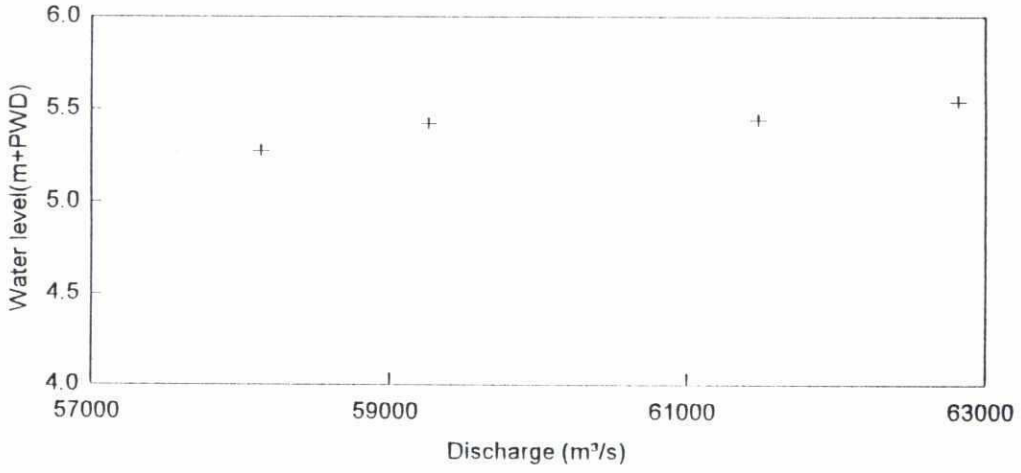


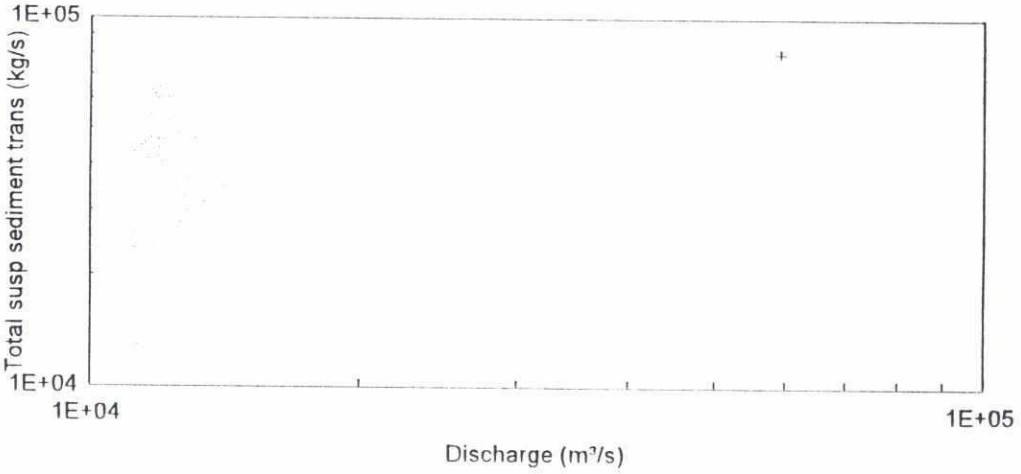
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
9/4 94	3.30	10483		1976	280	1	2257
3/5 94	3.71	13016		3629	417	1	4047
14/6 94	6.11	30393		14159	954	25	15138
9/7 94	6.92	43585		19934	1834	42	21810
29/7 94	7.45	52769		52443	8343	240	61026
21-23/8 94	8.03	76553		81168	59121	523	140812
9/9 94	7.18	54603		50694	9699	-	60393
8/10 94	6.26	31135		11578	2165	110	13853
28/10 94	5.01	19443		4516	735	21	5272
14/11 94	3.80	11661		1773	124	5	1902
18/12 94	2.66	7477		685	74	1	760
25/2 95	1.59	4001		104	3	0	107
22/3 95	1.96	4901		108	39	0	147

88

6 Mawa

January 1993 - March 1994



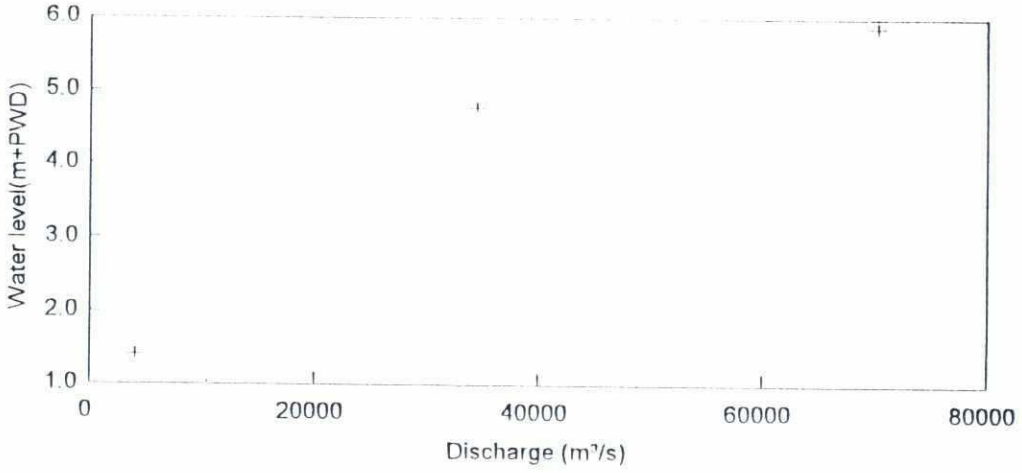


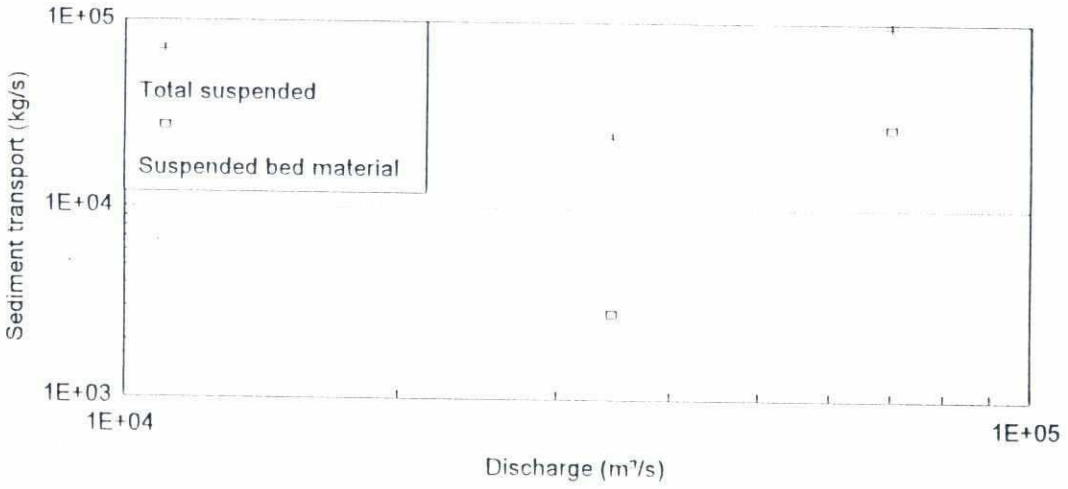
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
3/10 93	5.54	62821					
4/10 93	5.44	61480					
6/10 93	5.42	*59267	63884				86227
7/10 93	5.27	58141					

* not used for calculation of sediment transport

6 Mawa

April 1994 - March 1995

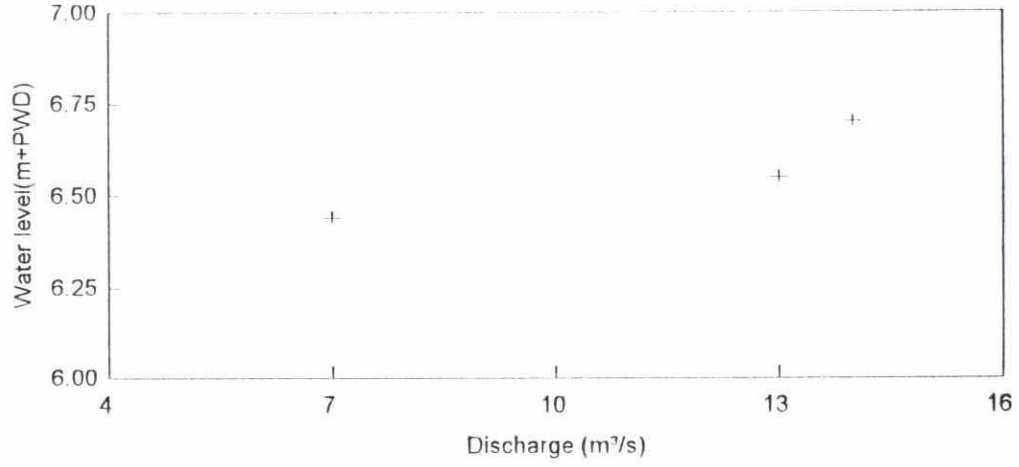


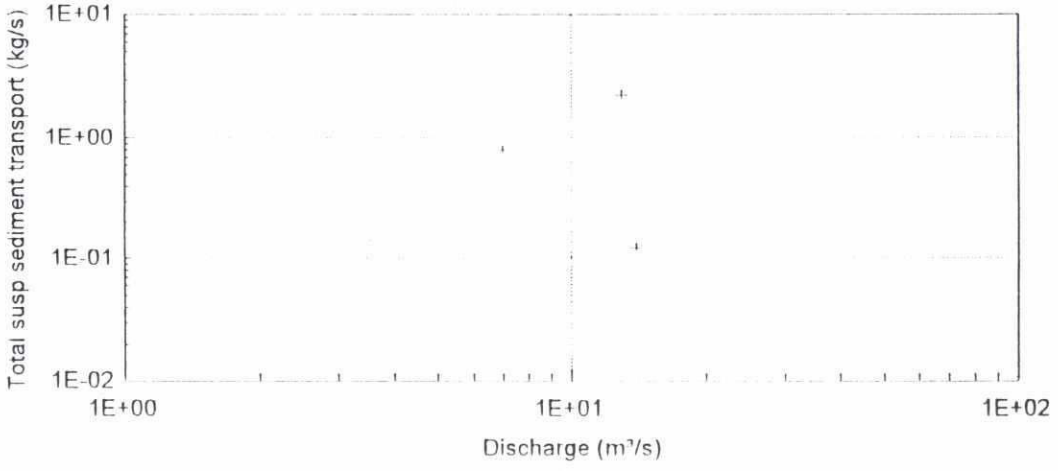


date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
25/7 94	4.77	34550		21025	2796	152	23973
25/8 94	5.87	70291		68040	27079	449	95568
17-18/2 95	1.41	4107					

7 Mymensingh

January 1993 - March 1994

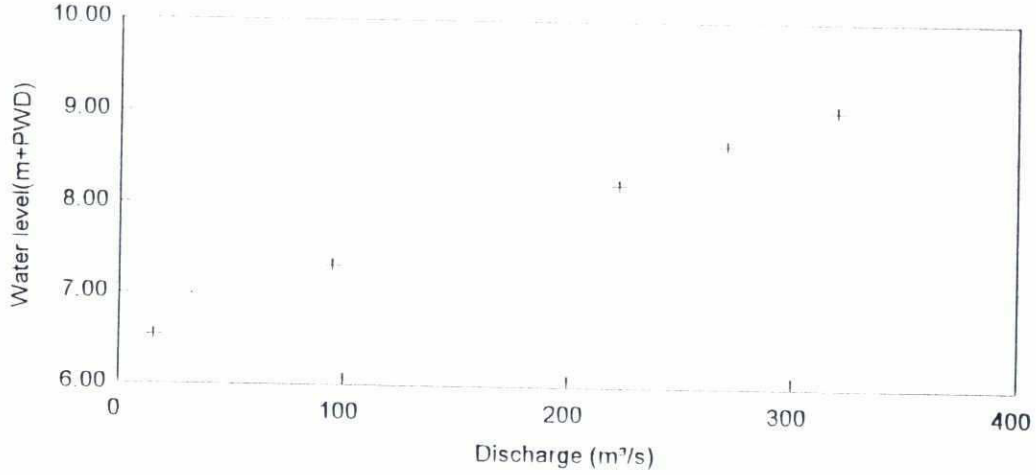


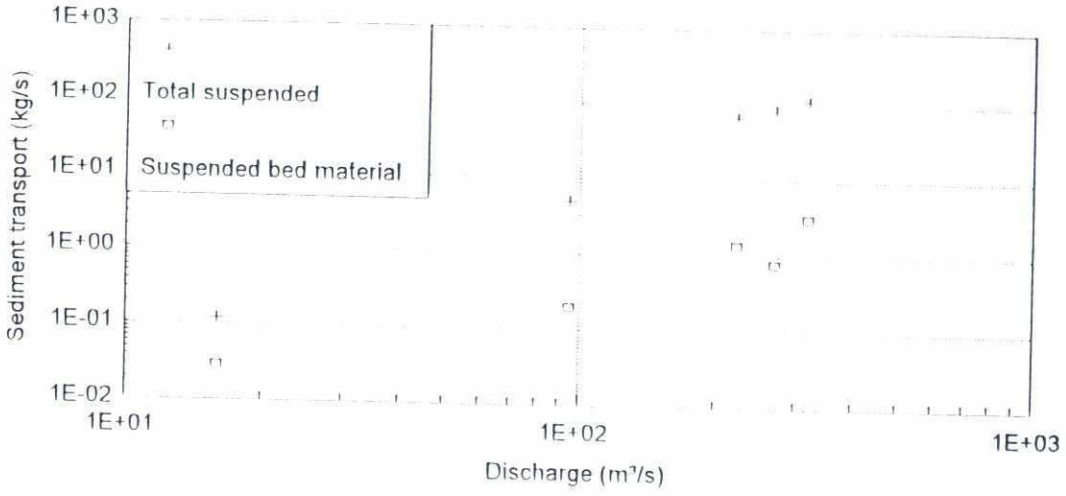


date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{ash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
31/1 94	6.70		14				0
23/2 94	6.55		13				2
20/3 94	6.44		7				0

7 Mymensingh

April 1994 - March 1995

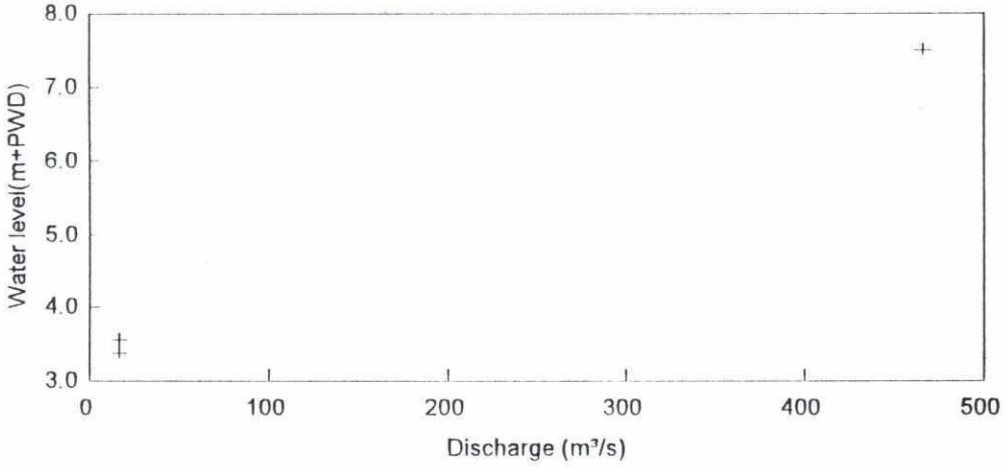


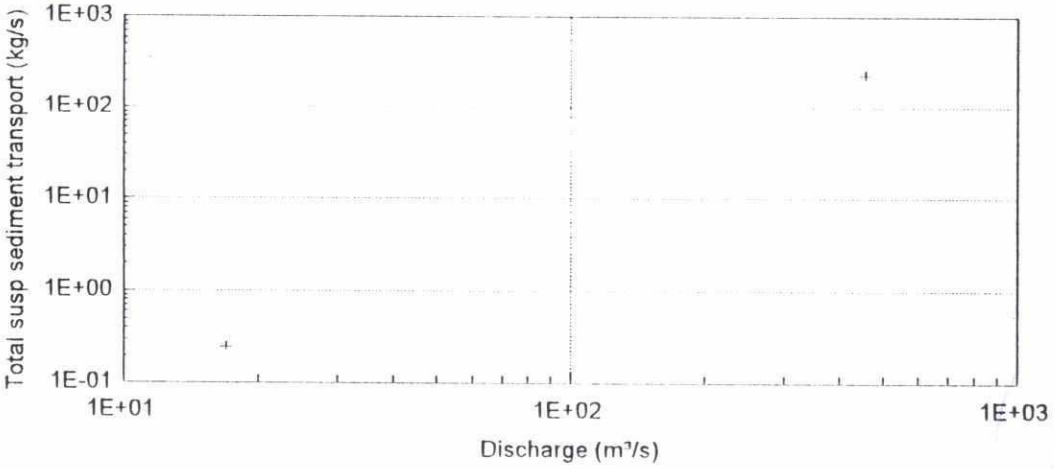


date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
15/6 94	9.04		320	112	3	0	115
19/7 94	8.65		271	82	1	2	85
11/10 94	8.22		223	67	1	0	68
27/10 94	7.32		95	5	0	0	5
30/11 94	6.54		16	0	0	0	0

8 Tilly

January 1993 - March 1994

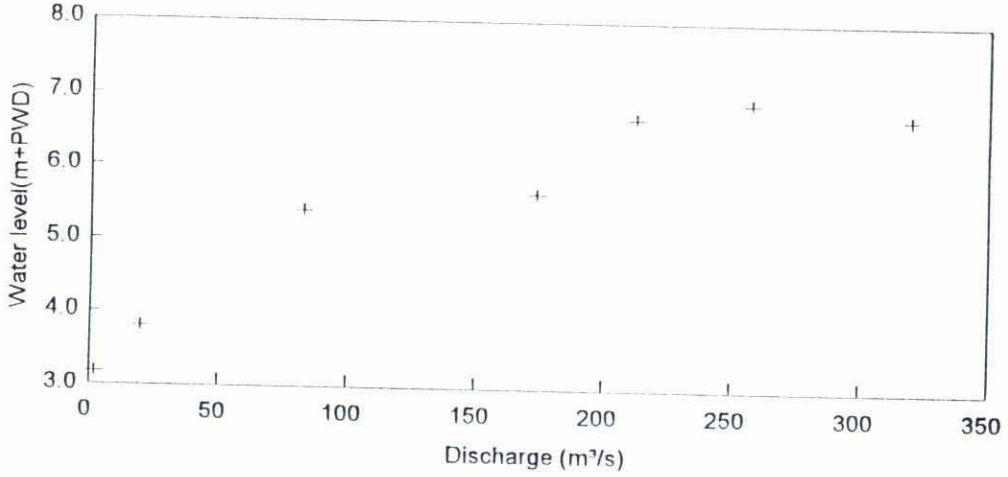


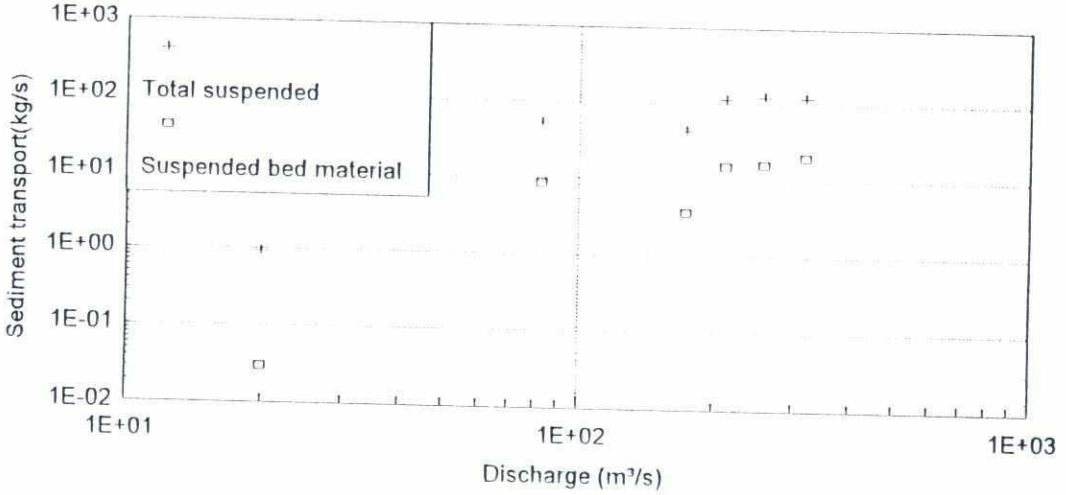


date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
16/10 93	7.50		458				229
7/2 94	3.56		17				
22/3 94	3.38		17				0

8 Tilly

April 1994 - March 1995

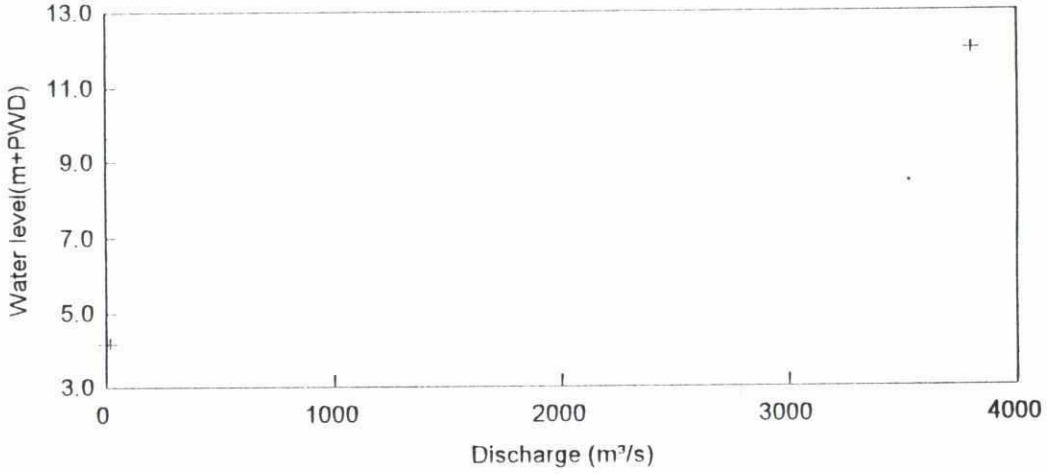


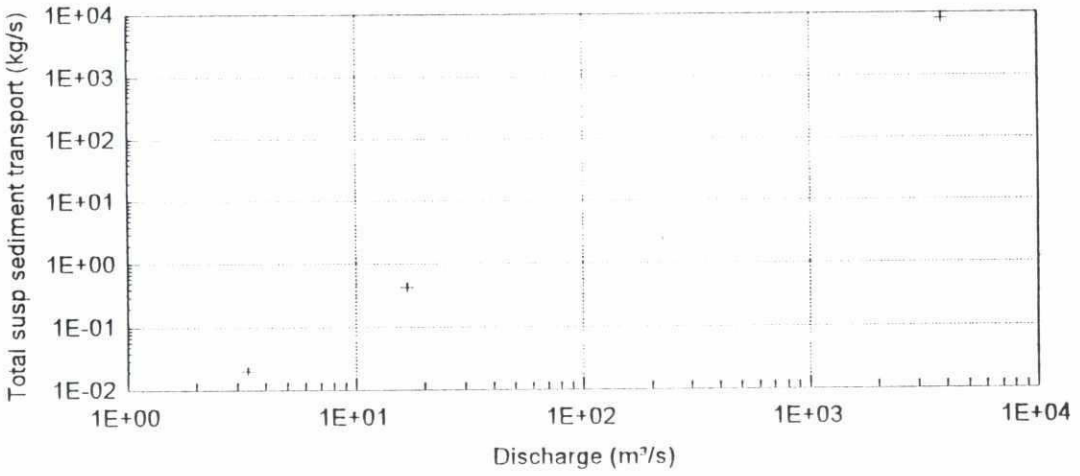


date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
15/5 94	5.41		83	45	8	0	53
16/6 94	6.70		213	98	15	0	114
25/7 94	6.91		258	105	16	4	125
13/10 94	6.72		320	103	20	0	123
28/10 94	5.66		174	40	3	0	43
28/11 94	3.81		20	1	0	0	1
24/3 95	3.18		2	0	0	0	0

9 Gorai Railway Bridge

January 1993 - March 1994



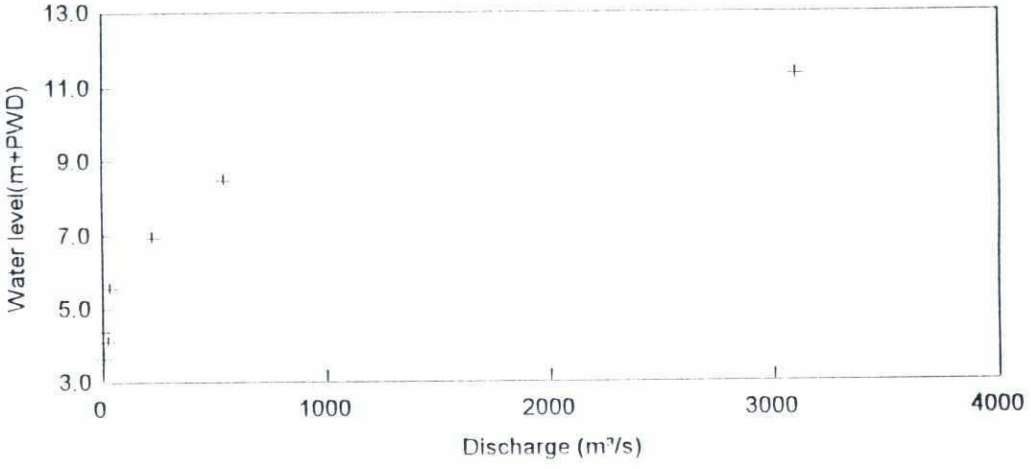


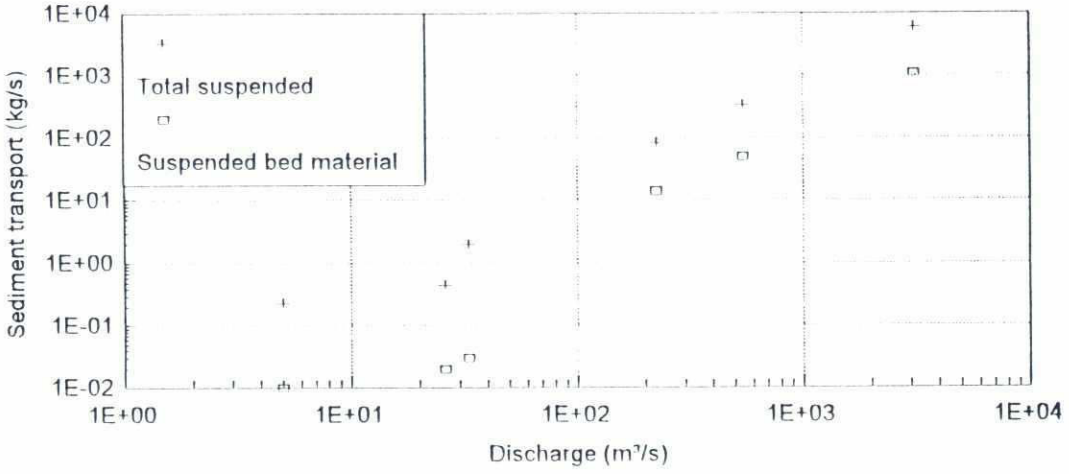
date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
30/9 93	11.98	*3802	3092				6521
15/2 94	4.19		16				0
6/3 94	4.18		3				0

* not used for calculation of sediment transport

9 Gorai Railway Bridge

April 1994 - March 1995



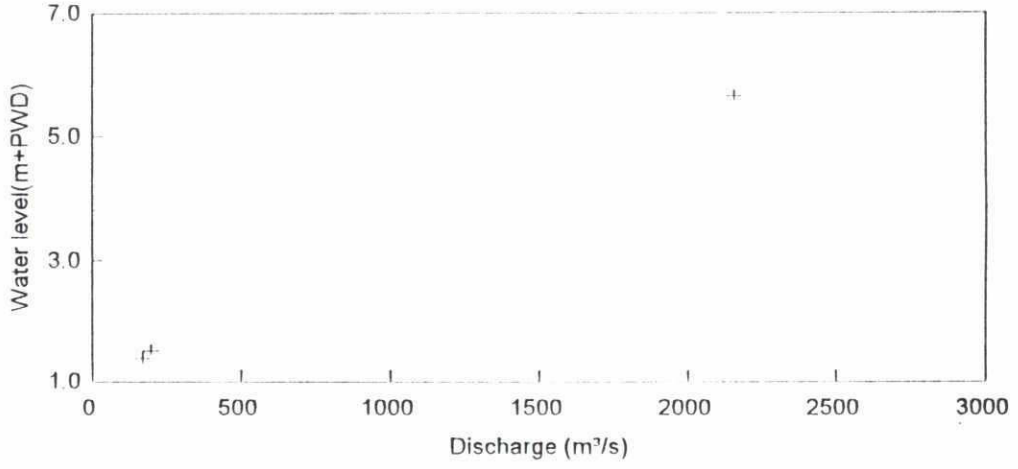


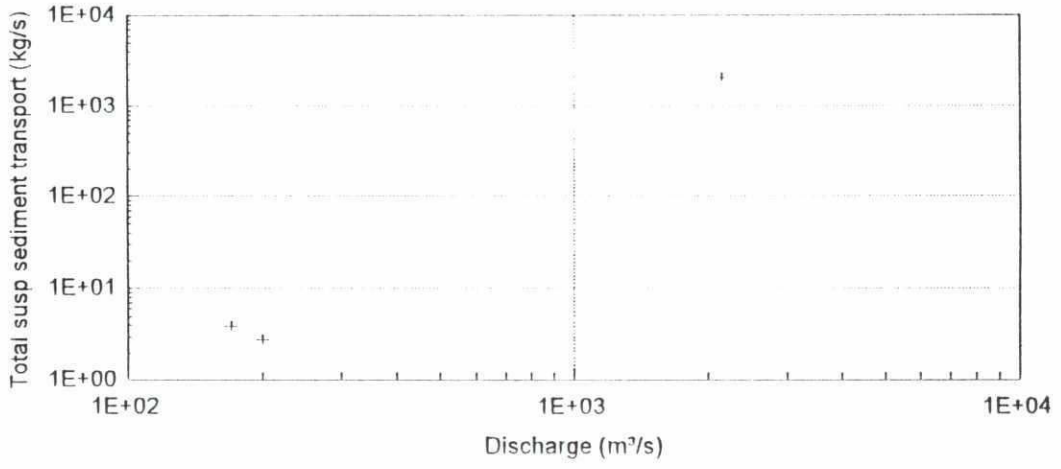
date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
11/5 94	4.11		26	0	0	0	0
19/6 94	5.56		33	2	0	0	2
3/8 94	11.34	3103		4918	1101	33	6052
16/10 94	8.50		544	283	50	1	334
24/10 94	6.95		225	68	14	0	82
5/12 94	3.66		5	0	0	0	0
5/1 95	4.38		0	0	0	0	0

92

10 Arial Khan

January 1993 - March 1994

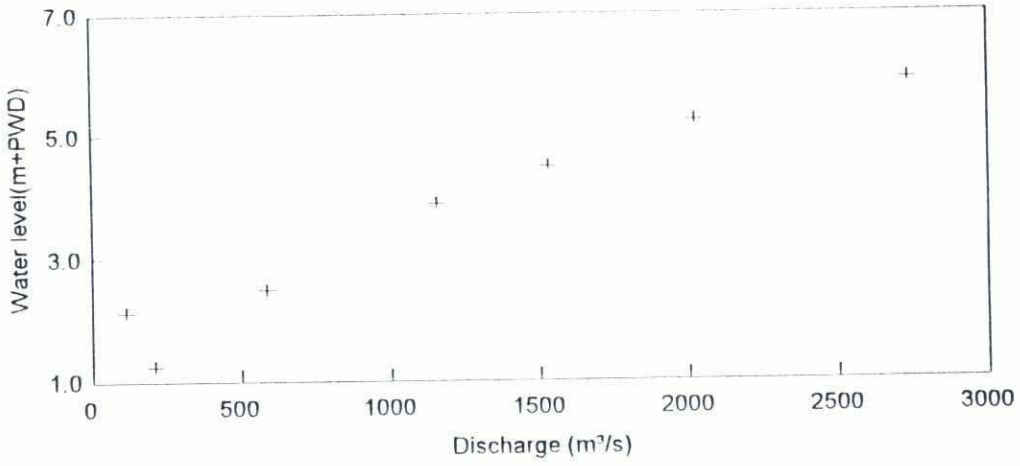


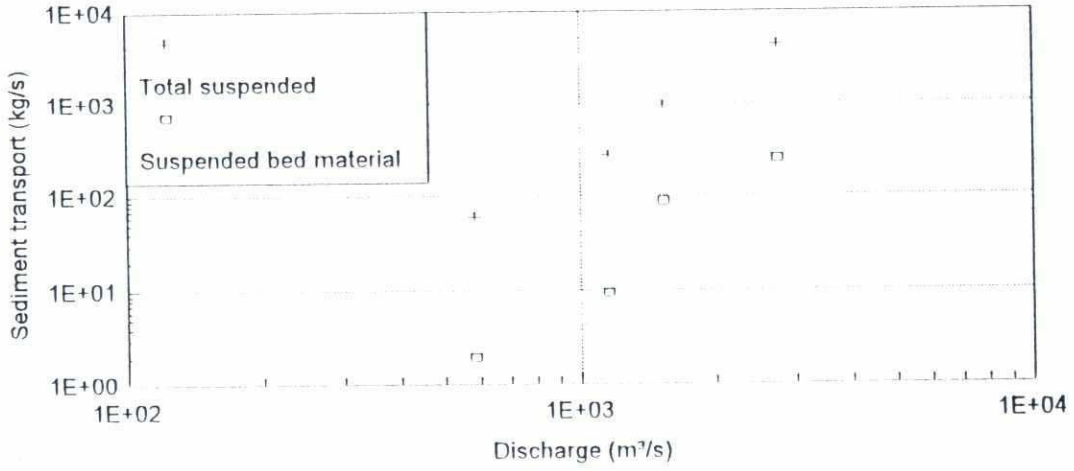


date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
8/10 93	5.65	2157					2044
9/2 94	1.39		171				4
24/3 94	1.52		201				3

10 Arial Khan

April 1994 - March 1995

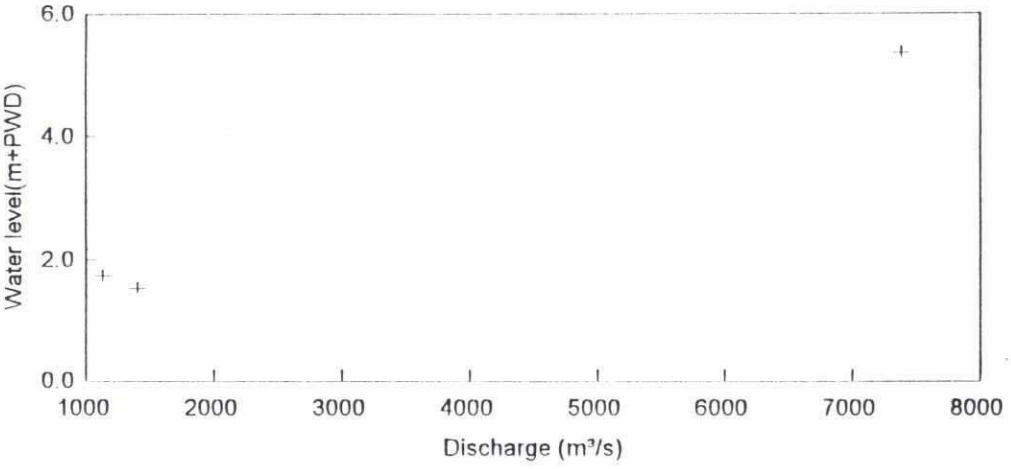


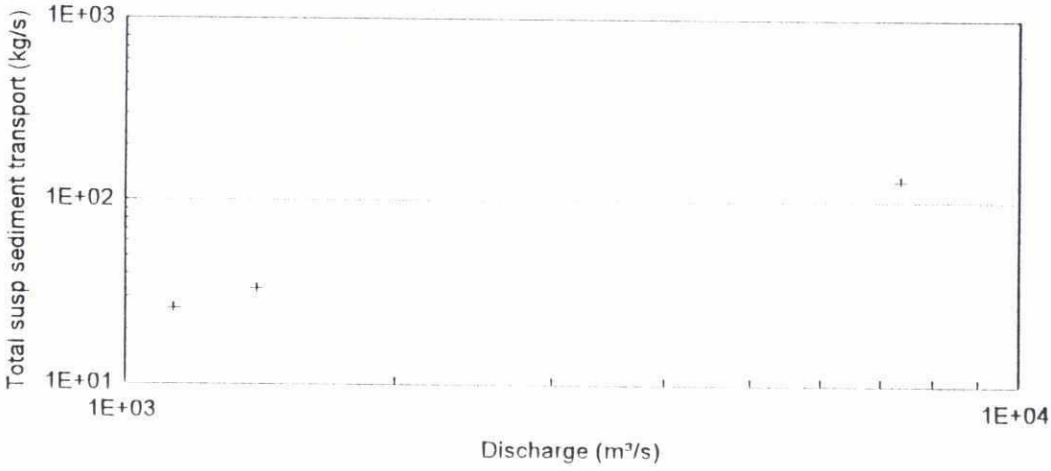


date	h (m +PWD)	Q_{MBM} (m³/s)	Q_{VAM} (m³/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
18-19/4 94	2.13		115				
8/7 94	5.23	2026					
10/8 94	5.89	2738		4135	246	7	4388
7/10 94	4.48	1534		856	87	0	943
25/10 94	3.89	1156		260	9	0	269
17/11 94	2.49	585		58	2	0	60
23/2 95	1.25		210				

11 Bhairab Bazar

January 1993 - March 1994

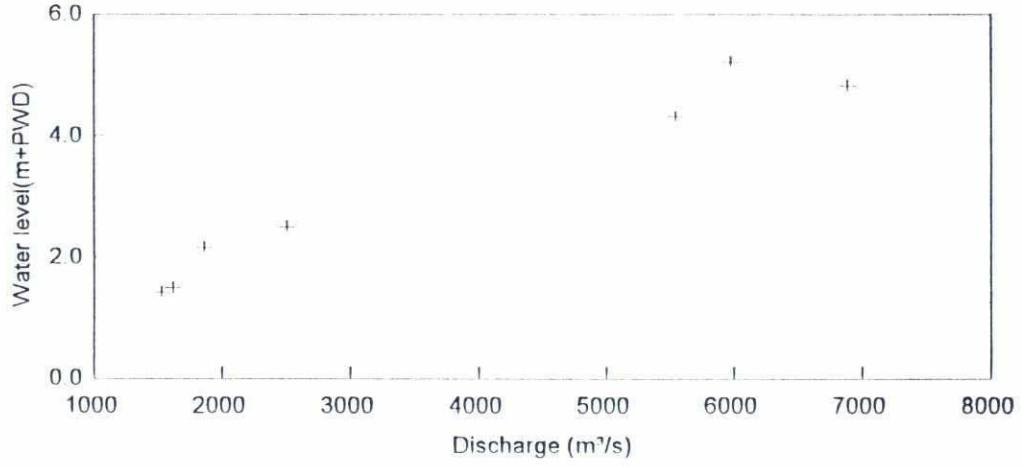


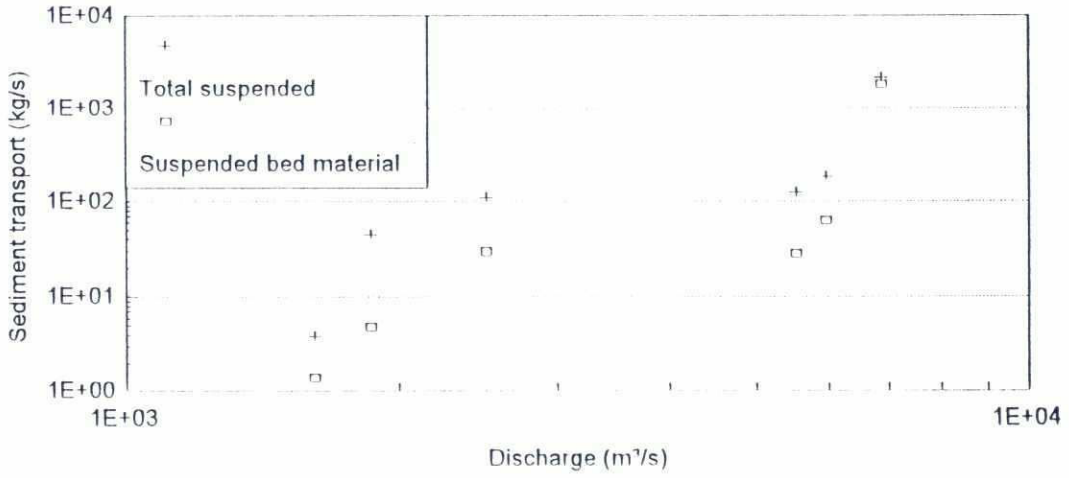


date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
12/10 93	5.36	7390					130
10/2 94	1.53	1403					33
24/3 94	1.74	1133					26

11 Bhairab Bazar

April 1994 - March 1995

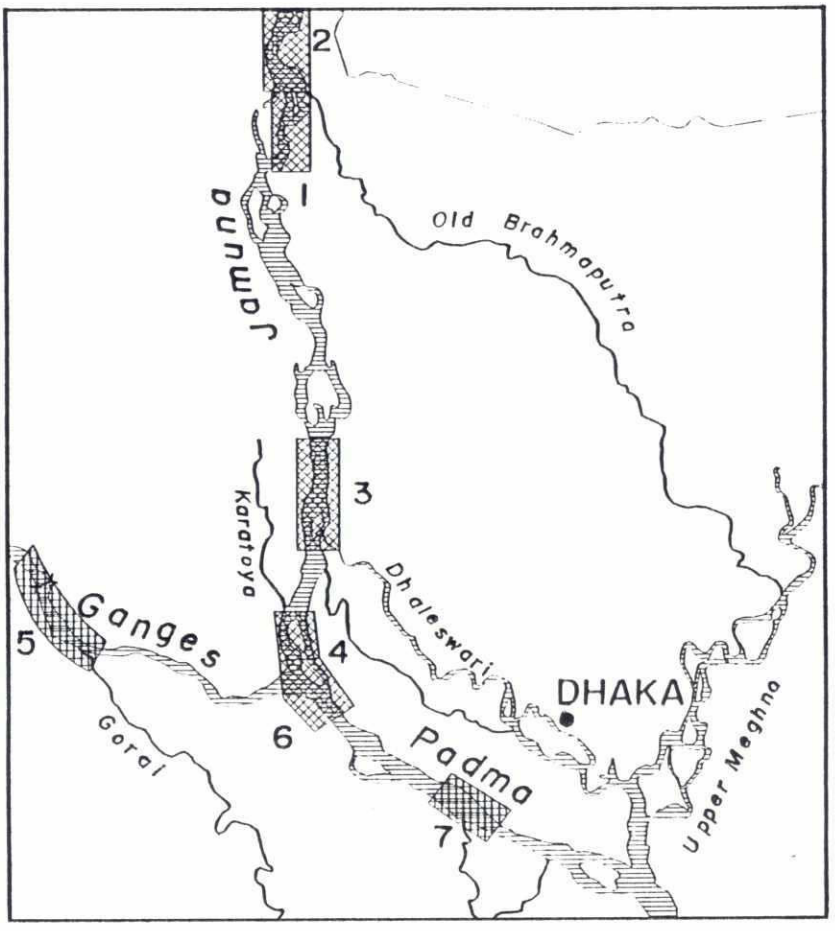




date	h (m +PWD)	Q_{MBM} (m^3/s)	Q_{VAM} (m^3/s)	S_{wash} (kg/s)	$S_{susp\ bml}$ (kg/s)	S_{bed} (kg/s)	S_{total} (kg/s)
16/4 94	2.51	2506		82	29	0	111
5/7 94	4.83	6889		349	1833	0	2182
13/8 94	5.22	5980		121	63	0	184
5/10 94	4.32	5543		97	28	0	125
20/11 94	2.16	1865		39	5	0	44
21/2 95	1.49	1618		2	1	0	3
18-19/3 95	1.42	1534					

5 Bathymetric surveys

The bathymetric survey areas are shown in Figure 6. The survey programme is shown in Table 2 (Chapter 2). The bathymetric maps are submitted separately to WARPO. The surveys are described in *RSP Special Report 3: 'Bathymetric surveys'*.



LEGEND

1	Bahadurabad	Jamuna	4	Hurasagar outlet	Jamuna
2	Karmarjani (extension of the Bahadurabad survey area)	Jamuna	5	Gorai off-take	Ganges
3	Dhaleswari off-take	Jamuna	6	Jamuna/Ganges confluence	Padma
			7	Arial Khan off-take	Padma

Figure 6: Bathymetry survey areas

6 Special surveys

The special surveys serve a variety of specific purposes that are identified in connection with the study activities. They may be divided into three categories:

- Additional flow measurements at Bahadurabad;
- a so-called bedform inventory programme, comprising repeated recordings of longitudinal depth contour profiles; and
- a variety of other purposes.

6.1 Flow measurements at Bahadurabad

The objective of the additional flow measurements at Bahadurabad is to improve the data coverage of the routine gauging, for several good reasons, one being to allow for a detailed inter-calibration and a mutual validation of the BWDB and the FAP 24 rating curves at that key location.

These flow recordings are being carried out by the same procedure as that of the routine gauging, except that sediment transport measurements are omitted.

The programme of additional flow recordings at Bahadurabad is shown in Table 7.

Date	Survey bulletin	Date	Survey Bulletin
23 Jun 94	9001	28 Sep 94	9027
28 Jun 94	9003	17 Okt 94	9032
13 Jul 94	9006	23 Okt 94	9035
16 Jul 94	9007	26 Nov 94	9039
2 Aug 94	9011	13 Dec 94	9041
18 Aug 94	9019	8 Feb 95	9045
30 Aug 94	9022	11 Mar 95	9049
6 Sep 94	9023	27 Mar 95	9052
17 Sep 94	9026		

Table 7: Additional flow measurements at Bahadurabad

6.2 Bedform inventory programme

The bedform inventory programme comprises repeated recordings of longitudinal depth contour profiles, mainly in Jamuna River. Hereby, a supplement is provided to the information about the time and space variation of bedforms that is produced by the bathymetry surveys. As compared with these surveys, the bedform inventory programme covers the entire reach between Bahadurabad and Aricha, and the measurements are more frequent, but only one longitudinal line is recorded, and the positioning (by ordinary, or 'non-differential' GPS) is less accurate than for the bathymetry surveys.

The recordings are listed in Table 8.

Date	Reach	Survey Bulletin
19-20 Aug 94	Bahadurabad → Aricha	9020
28-29 Aug 94	Aricha → Bahadurabad	9021
7-8 Sep 94	Bahadurabad → Aricha	9024
16 Sep 94	Siranganj → Bahadurabad	9025
1-6 Oct 94	Bahadurabad → Aricha	9029
15 Oct 94	Aricha → Siranganj	9030
16 Oct 94	Siranganj → Bahadurabad	9031
25 Oct 94	Bahadurabad → Siranganj	9036
14 Dec 94	Bahadurabad → Siranganj	9042
17 Dec 94	Siranganj → Aricha	9043
11 Feb 95	Bahadurabad → Siranganj	9046
14 Feb 95	Siranganj → Aricha	9047
14 Mar 95	Bahadurabad → Siranganj	9050

Table 8: Bedform inventory programme

6.3 Other special surveys

The programme of special surveys, in addition to the activities mentioned above, is described in Table 9 below. In this table, the scope of each activity is given by a few key words only, together with a reference to the related Survey Bulletin, while a short outline of the scope of each survey is given in Table 10.

Date	Place	Scope	Survey Bulletin
27 Jun 94	Bahadurabad	Slope determination	9002
8 Jul 94	Arial Khan	Off-take dynamics	9004
2 Aug 94	Upstr. of Hardinge Bridge	Effect of contraction	9010
3-4 Aug 94	Bahadurabad	Near bed transport	9012
4-5 Aug 94	Kushtia/Gorai	Off-take dynamics	9013
6 Aug 94	Kushtia → Aricha	Bed material	9014
5 Aug 94	Bahadurabad	Slope determination	9015
9-20 Aug 94	Old Brahmaputra	Bed material	9016
10-14 Aug 94	Bahadurabad	Bifurcation flow	9017
15-18 Aug 94	Bahadurabad	Flow near bedforms	9018
31 Aug-1 Sep 94	Bahadurabad	Slope determination	9022B
18 Sep 94	Bahadurabad	Bifurcation flow	9026B
19-20 Sep 94	Bahadurabad	Flow near bedforms	9026C
29-30 Sep 94	Bahadurabad	Slope determination	9028
1-6 Oct 94	Bahadurabad → Aricha	Bedform inventory, detailed flow near bedforms	9029
19 Oct 94	Hardinge Bridge	Bridge constriction	9033
21 Oct 94	Hardinge Bridge	Bridge constriction	9034
4 Nov 94	Bahadurabad	Bifurcation flow	9037
6 Nov 94	Bahadurabad	Turbulence measurement	9037B
4-12 Dec 94	Bahadurabad	Sediment transport and morphology	9040
6-10 Mar 95	Bahadurabad	Char topography	9048
24-27 Mar 95	Bahadurabad	Joint measurements with BWDB	9051
31 Mar-4 Apr 95	Bahadurabad	Optimization of survey methods	9053

Table 9: Other special surveys

9002
Discharge rating curve by slope-area method. Measurements of local water level slopes and discharges

9004
Seasonal variation of bed forms. Measurements around Jim's Bar of bed forms and flow, and (a few) suspended sediment measurements

9010
Effect of constriction on sediment transport and discharge rating curve. Measurements at a cross-section upstream of the Hardinge Bridge constriction

9012
Near-bed sediment transport over dunes. Measurements of flow and sediment transport over stoss, crest, and trough of selected dunes

9013
(same as 9004)

9014
Bed material sampling in Jamuna in order to study the variability of bed material composition

Table 10: Scope of special surveys (continued)

9015
(same as 9002)
9016
Bed material sampling in Old Brahmaputra in order to study the variability of bed material composition

9017
Bifurcation flow patterns. Measurement of the flow division at a bar in order to determine secondary flow patterns

9022B
(same as 9002)

9026B
(same as 9017)

9026C
Seasonal variation of bed forms/bar topography. Measurements around Jim's bar of bed forms, flow, and (a few) suspended sediment measurements. Longitudinal profile of bed levels between Sirajganj and Aricha. Also, over-bar measurements of flow and bed levels

9028
(same as 9002)

9029
Bedform inventory. Measurements of bed levels in order to map the spatial distribution of bars

9033
Effect of a constriction on the sediment transport and discharge rating curves. Measurements at a cross-section at the upstream end of the Ganges bathymetric survey area

9034
Sediment transport and discharge at the downstream boundary of the Ganges bathymetric survey area, and near Gorai mouth

9037
(same as 9017 and 9026B)

9037B
Time series measurements of flow profile, for optimization of the flow measuring period based on analysis of the turbulent flow structure. This special survey is used in the study topic "optimization of hydraulic measurements" and is not documented in a survey bulletin or PSD24.

9040
Optimization of sediment measuring techniques, and bar topography and dune inventory. Measurements of sediment transport near eroding banks, and mapping of bed levels

9048
Bar topography. Land survey of bar, and bed level survey of dunes. Also flow measurements. Side scan sonar survey of bed form variation across the channel

9051
Cross-section survey. Joint measurements with BWDB-Morphology of one cross-section in Jamuna (J13-1). Echo soundings and topographical survey

9053
Optimization of number of verticals in a cross-section and number of measuring points in a vertical. Flow and sediment profiles

Table 10 (continued): Scope of special surveys

References

The following reports among the ones prepared by the River Survey Project provide details or general background information about the survey routines, data collection and data management. For a complete list of rsp reports, please refer to the Main Volume of the Final Report.

General project reports

Final Report : Main Volume
Annex 1 : Surveys
Annex 2 : Sustainable survey techniques
Annex 3 : Hydrology
Annex 4 : Sediment transport
Annex 5 : Morphology

Special reports

1 : Validation of staff gauge bench marks
2 : Water level gauging stations
3 : Bathymetric surveys
4 : Stage-discharge relationship for the Jamuna at Bahadurabad
8 : Bed material sampling
11 : Optimization of hydraulic measurements
12 : Optimization of sediment measurements
14 : Mineralogical and physical properties of river sediments
19 : Joint BWDB/RSP measurements, hydrology
20 : Joint BWDB/RSP measurements, morphology
21 : Guide to RSP databases
22 : River Data Book January 1993 - March 1995
23 : River Data Book April 1995 - March 1996