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JANUARY 1993

CONSULTING CONSORTIUM FAP 21/22

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DRAFT FINAL REPORT

ANNEX 5

HYDROLOGIC DATA

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ANNEX 5

HYDROLOGIC DATA

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1 INTRODUCTION

Characteristic hydrologic data of the Jamuna river are required for the design of bank protection structures in the selected test areas and for the study of the effectiveness of recurrent river training measures. These hydrologic data are collected and analysed in an hydrologic study, which was executed directly after a first selection of the location of possible test areas. This means that hydrologic data for the test areas near Kamarjani with the Manos regulator, Bahadurabad, Chandanbaisa and Nakalia. In a later stage of this study phase Kamarjani and Bahadurabad were selected as the most promising test areas and the designs were made for these two locations.

The final results of run 6 from the Flood Hydrology Study FAP 25 have been stored in the data base of the project, and an updating of this data base is to be considered during the next years.

The objectives of the hydrology study is to provide hydrologic boundary conditions in conjunction with FAP 25 for the selected test areas along the Jamuna river. These objectives include the analysis of a kind of construction window during low water periods and the analysis of quick rises and falls in the water level as a boundary for the study of groundwater flow near the test sites. It is mentioned that the hydrologic study does not include the results of the field surveys near the selected test areas.

The Jamuna river is the name of the stretch of the Brahmaputra river in Bangladesh from the border with India to the confluence with the Ganges river. From the Himalaya mountains to the Bay of Bengal the combination of Brahmaputra river, Jamuna river, Padma river and Lower Meghna river has a length of 2700 km and drains an area of 580,000 km^2, of which less than 10 percent is within the borders of Bangladesh. Snowmelt in the Himalaya mountains accounts for most of the discharge of the Brahmaputra river, also the rainfaal in Assam and in the northern part of Bangladesh contributes significantly. Consequently the river discharge has a high seasonal variability. The major tributaries of the Jamuna river are the Teesta river, the Dudhkumar and the Dharla rivers. The source of the tributaries of the Jamuna river is the Himalaya mountains. These tributaries enter Bangladesh in its north-west region. The Old Brahmaputra river and the Dhaleswari river are the most important distributaries of the Jamuna river, which divert a relatively small part of the discharge from the Jamuna river. During the monsoon period a considerable part of the total discharge is spilling into an extensive floodplain. The jamuna river meets the Ganges river near Aricha and from this confluence the river is called Padma river up to the next confluence with the Upper Meghna river. Further downstream the river is called Lower Meghna river and flows towards the Bay of Bengal.

The hydrologic study started with the collection of hydrologic data (Chapter 2). From the available hydrologic data the interesting data for the various test areas were selected (Chapter

3). Maximum water levels and maximum discharges were determined for the test areas as a function of the return period (Chapter 4). Next periods with low water levels during the winter season and the quick rises and falls of the water level in the Jamuna river during a few days were analyzed (Chapters 5 and 6).

2 DATA COLLECTION

A satisfactory network of hydrologic stations in the Jamuna river catchment in Bangladesh has been established by the Bangladesh Water Development Board (BWDB), which is the main source of hydrologic data for this Project. In general hydrologic data related to the Jamuna River catchment within Bangladesh are available from the early 1960's (EPWAPDA, FAO, ITAL CONSULT and SOGREAH, 1966, EPIWTA and NEDECO, 1967). A data availability directory has been produced by FAP 25 (Krüger Consult, BCEOM and FPCO, 1992).

The hydrologic data of interest for the hydrologic study of this Project were collected from several sources and stored in a computer database in the Consultant's office. The emphasis was given on available computerized data, and some additional data were stored manually.

The rainfall data has been stored in a database and these data can be used as input for the rainfall-runoff module of the 1-dimensional model (NAM module) to run together with the general model or with one of the regional models. Location map of BWDB rainfall stations in the region of the Jamuna river is shown in Fig. A.5-1 and an overview of the collected data is shown in Table 2-1.

An extensive network of water level gauging stations on the Jamuna river and its distributaries has been established also by the BWDB, see Fig. A.5-2 and Table 2-2. The data of some secondary stations have been collected mainly with the purpose to improve, if necessary the 1-dimensional model. Thus additional data collection was kept to a minimum level.

The accurate location of these gauging stations has been determined recently by various teams using Global Positioning Systems, see Table 2-3. From the comparison with the results of the previous applied methods it is shown that a more accurate determination of the location of these stations is obtained with a GPS .

The reliability of the zero datum of these stations, especially between right bank and left bank of the Jamuna river is still pending. The preliminary results of the second order bench marks checks indicate a vertical difference of about 0.20 m between the bench marks on the left bank and the bench marks on the right bank.

STN. NO.	STATION NAME	DATE INSTALLED OR RE-INSTALLED	DAILY DATA PERIOD ENTERED ON COMPUTER	MISSING DATA (Water Years)	RAIN GAUGE POSITION	
					Longitude deg min N	Longitude deg min E
R.001	Atghoria	1961-11-19	1961 - 1990		24 6.0 N	89 15.0 E
R.002	Atia (Tangail)	1960-12-01	1954 - 1989	59/60 60/61	24 13.0 N	89 55.0 E
R.003	Atrai	1962-02-18	1962 - 1990		24 38.0 N	88 58.0 E
R.004	Bera	1961-12-03	1962 - 1990	82/83 83/84 84/85	24 4.5 N	89 38.0 E
R.005	Bhaluka	1962-07-13	1962 - 1990	86/87	24 23.5 N	90 24.0 E
R.006	Bogra	1961-02-01	1954 - 1989		24 51.8 N	89 21.3 E
R.007	Chatmohar	1963-07-15	1963 - 1990	84/85	24 13.0 N	89 16.0 E
R.008	Chaugram	1961-05-21	1954 - 1979	59/60 60/61	24 33.0 N	89 10.0 E
R.010	Daulatpur	1961-11-14	1961 - 1990		23 58.3 N	89 50.4 E
R.011	Dhunot	1962-01-06	1962 - 1990	81/82	24 41.2 N	89 33.0 E
R.012	Faridpur (Banwarinagar)	1961-11-23	1961 - 1990		24 10.0 N	89 27.0 E
R.013	Gopalpur	1961-09-01	1961 - 1990	88/82	24 33.5 N	89 58.2 E
R.014	Gurudaspur	1961-12-21	1961 - 1990		24 21.0 N	89 12.0 E
R.015	Ishurdi	1961-02-01	1954 - 1990	59/60 60/61	24 8.0 N	89 2.5 E
R.016	Joari	1962-01-09	1954 - 1990	59/60 60/61 61/62	24 18.0 N	89 8.0 E
R.018	Kalihati	1962-02-26	1962 - 1990		24 23.0 N	89 59.5 E
R.019	Kushtia	1061-01-01	1954 - 1989	59/60 60/61	23 58.0 N	89 2.0 E
R.020	Manikganj	1961-01-24	1954 - 1990	59/60 60/61	23 51.0 N	90 0.0 E
R.021	Mirzapur	1961-08-31	1961 - 1990	68/69 76/77 77/78 79/80 80/81	24 6.0 N	90 5.0 E
R.022	Nandigram	1962-01-08	1962 - 1990		24 38.0 N	89 16.0 E
R.024	Nawkhila	1961-01-01	1954 - 1990	59/60 60/61 86/87	24 48.0 N	89 37.3 E
R.025	Pabna	1961-02-08	1954 - 1990	59/60 60/61	24 0.0 N	89 15.6 E
R.026	Pangsa	1961-02-01	1954 - 1979	59/60 60/61	23 48.0 N	89 23.3 E
R.027	Phulbaria	1962-06-02	1962 - 1990		24 37.5 N	90 16.0 E
R.028	Pingna	1961-02-25	1954 - 1979	59/60 60/61	24 40.0 N	89 54.0 E
R.029	Raiganj	1962-02-20	1962 - 1990		24 30.0 N	89 33.8 E
R.030	Rajbari	1960-11-27	1954 - 1989	59/60 60/61	23 46.0 N	89 40.3 E
R.031	Savar	1961-11-23	1961 - 1990	88/89	23 51.0 N	90 16.2 E
R.032	Sarishabari	1961-02-24	1954 - 1990	59/60 60/61 83/84 87/88	24 44.3 N	89 49.5 E
R.033	Sherpur (Bogra)	1961-03-15	1954 - 1990	59/60 60/61	24 41.2 N	89 23.0 E
R.034	Serajganj	1961-03-01	1954 - 1990	59/60 60/61	24 27.5 N	89 43.3 E
R.035	Shahzadpur	1961-02-15	1954 - 1990	59/60 60/61	24 10.5 N	89 38.0 E
R.036	Singra	1962-01-25	1962 - 1989		24 30.0 N	89 8.0 E
R.038	Sujanagar	1963-12-24	1963 - 1990		23 56.0 N	89 24.5 E
R.039	Taras	1963-10-13	1964 - 1990		24 25.0 N	89 23.0 E
R.040	Ullapara	1961-02-14	1954 - 1990	59/60 60/61	24 18.5 N	89 34.3 E
R.041	Bheramara	1960-10-01	1961 - 1990		24 1.0 N	89 0.2 E
R.062	Dewanganj	1961-03-09	1954 - 1990	59/60 60/61	25 8.5 N	89 45.7 E
R.066	Islampur	1961-09-01	1961 - 1979		25 3.8 N	89 47.0 E
R.067	Jamalpur	1961-02-25	1954 - 1990	59/60 60/61	24 56.0 N	89 55.5 E
R.072	Muktagacha	1961-09-21	1961 - 1990	87/88	24 4.5 N	90 16.0 E
R.073	Mymensingh	1960-12-18	1954 - 1990	59/60 60/61	24 46.0 N	90 24.0 E
R.074	Nalitabari (Taragani)	1961-02-28	1961 - 1990	76/77-79/80 81/82-83/84	25 4.5 N	90 11.0 E
R.077	Phulpur	1962-06-11	1962 - 1990	59/60 60/61	24 58.0 N	90 22.0 E
R.078	Sherpur (Town)	1961-04-14	1954 - 1990	59/60 60/61 68/69 76/77	25 0.0 N	90 0.8 E
R.151	Adamdighi	1961-06-02	1954 - 1979	82/83	24 50.4 N	89 3.0 E
R.153	Badarganj	1962-05-28	1962 - 1989	59/60 60/61 86/87 88/89	25 42.0 N	89 2.0 E
R.156	Bhawaniganj (Gaibandha)	1961-06-02	1954 - 1988	71/72 75/76	25 19.7 N	89 33.0 E
R.159	Bhurungamari	1963-05-20	1963 - 1990		26 6.8 N	89 41. E
R.163	Chilmari	1962-12-20	1962 - 1990	82/83 88/89	25 32.3 N	89 42.6 E
R.164	Ghoraghat	1963-05-26	1963 - 1988	59/60 60/61	25 14.6 N	89 16.4 E
R.169	Dubchanchia	1961-06-05	1954 - 1990		24 51.8 N	89 10.5 E
R.171	Gobindaganj	1961-06-06	1961 - 1990	75/76 82/83	25 8.3 N	89 22.5 E
R.174	Hatibandha	1962-06-14	1962 - 1990		26 7.4 N	89 8.7 E
R.175	Hilli (Hakimpur)	1963-01-01	1963 - 1989	68/69	25 16.1 N	89 0.0 E
R.176	Mohasthan	1967-07-06	1967 - 1979	88/89	24 57.5 N	89 21.7 E
R.177	Kaliganj	1961-01-01	1961 - 1990		25 58.6 N	89 12.6 E
R.178	Kaunia	1962-03-22	1962 - 1990	59/60 60/61	25 46.1 N	89 24.8 E
R.181	Khetlal	1961-06-11	1954 - 1990	59/60 60/61	25 2.2 N	89 7.5 E
R.182	Kurigram	1961-05-21	1954 - 1990	88/89	25 47.7 N	89 39.0 E
R.183	Lalmonirhat	1962-04-18	1962 - 1990		25 54.4 N	89 26. E
R.184	Lalpur	1961-07-14	1954 - 1990	59/60 60/61	24 0.0 N	88 57.5 E
R.186	Mithapukur	1962-12-23	1962 - 1988	68/69 88/89	25 35.2 N	89 15.9 E
R.188	Mahipur	1962-10-29	1962 - 1990		25 52.0 N	89 15.0 E
R.189	Mohanpuir	1962-08-19	1962 - 1982		25 31.0 N	89 43.8 E
R.191	Naogaon	1961-07-23	1954 - 1990	59/60 60/61	24 48.0 N	88 56.0 E
R.196	Nawabganj	1961-06-01	1954 - 1990	59/60 60/61 82/83 84/85 88/89	25 24.0 N	89 4.7 E
R.198	Panchbibi	1961-05-22	1954 - 1979	59/60 60/61 71/72	25 11.5 N	89 2.3 E
R.199	Parbatipur	1961-05-17	1954 - 1979	59/60 60/61	25 44.7 N	88 59.6 E
R.201	Phulbari	1962-01-18	1962 - 1989		25 30.0 N	88 58.0 E
R.202	Pirgacha	1962-05-27	1962 - 1990	82/83	25 39.8 N	89 25.1 E
R.203	Pirganj	1962-05-08	1954 - 1989	59/60 60/61 87/88	25 25.6 N	89 19.1 E
R.206	Rangpur	1961-03-01	1954 - 1989	59/60 60/61	25 44.2 N	89 15.8 E
R.216	Shibganj (Dinajpur)	1962-07-17	1962 - 1990		25 0.7 N	89 18.5 E
R.218	Sundarganj	1961-09-06	1954 - 1989	59/60 60/61 81/82 82/83	25 33.4 N	89 31.9 E
R.222	Ulipur	1961-05-21	1954 - 1989	59/60 60/61 71/72	25 38.9 N	89 36.7 E
R.452	Alamdanga	1962-09-18	1962 - 1990		23 47.0 N	88 57.0 E

Source : North West Hydraulics

Table 2-1: Status of data collection - BWDB rain gauges

River Name	BWDB No.	Station Name	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Arialkhan	5	Madaripur										L							L	L	L	L															
Jamuna	15J	Mathurpara																													H	H	H	H	H	H		
Jamuna	45	Nunkhawa								L	-	L							L																			
Jamuna	45.5	Chilmari	•																L																			
Jamuna	46	Kamarjani			H	H				H		H	H	H	H	H	H		H			H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Old Brahmaputra	46.7L	Kholabarichar																	-	L																		
Jamuna	46.7R	Kirstomonichar										H	H	H	H	H	H	H	-	H	H	H	H	H	H	H	H	H	-	H	H	H	H					
Jamuna	46.9R	Fulchari										L	L	L	L	L	L	L	-	-	L	L	L	L	L	L	-	-	-	L	L	L	L	-	L			
Jamuna	46.9L	Bahadurabad Transmiter	L1	L1	L1	L1	L1	L1	L1	L1		L							-																			
Jamuna	47	Bahadurabad								H	-	H	H	H	H	H	H	-	H	H	H	H	H	-	H	H	-	H	H	H	H	H	H	H	H	H	H	L
Jamuna	47.3L	Jognaichar											H	H	H	H	H	H	H	H	H	H	-	H	H	H	H	H	H	H	H	H						
Jamuna	47.3R	Patbaricher											H	H	H			H	H	H	H	H	-	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Jamuna	48	Jaganathganj										H	-	H	H	H	H	H	H	H	H	H	H	H	H	H	H	-	-	H	H	H	H	H	H	H	H	H
Jamuna	49	Serajganj			L1	L1	L1	L1	L1	L1	L1	L							-																			
Jamuna	49A	Kazipur																	-																			
Jamuna	50	Porabari										L	L	L	L	L	L	L	-		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Jamuna	50.3	Mathura												L	L	L	L	L		L		L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Jamuna	50.6	Teota										H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Deonai	65	Bogra						H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Koratoa	66	Ullapara						H	H	H	H	H	H	H	-	H	H	H	H	H	H	H	H	H	H	H	-	H	-	H	H	H	H	H	H	H	H	H
Dharla	77	Kurigram						H	-	H	-	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Dudh Kumar	81	Pateswari								H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Ganges	90	Harding Bridge										L							-																			
Ganges	91.9R	Goalundo Transit											L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L
Ganges	91.9L	Barurla Transit											L						-																			
Ganges	93.5L	Mawa																	-																			
Ganges	97	Galbanda																H	H	-	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Modhumati	99	Goral Riv. Bridge	L	L	L	L	L	L	L	L	L	L	L							-																	
Kaliganga	137A	Taraghat										L								-																		
Koratoa-atrai	151	Baghabari																		-																		
Old Brahmaputra	225	Jamalpur										L							L																			
Meghna	273	Bhairab Bazar										L							-																			
Meghna	277	Chandpur																	-																			
Teesta	294	Kaunia			L	L	L	L	L	L	L	L	L	L	L	L	L	L	-	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	-

L : Lotus file (from FAP 25)
L1 : Lotus file (from FAP 1)
H : Hardcopy
[redacted] In MIKE 11 database (to be checked)

Table 2-2: Status of data collection - daily water level

For the secondary stations the quality of the data was checked by visual inspection of the daily data, computation of the water level difference between 2 sequential days (one day gradient) and comparison with the other stations.

The water levels, which were calculated by the 1-D model during the 25 year period, can be used to determine design conditions near the test areas. These water levels are stored in a database.

Station No.	Name of Station	Latitude	Longitude	Sources
15J	Mathurapara	24°51'32"	89°36'10"	FAP, GPS
45	Nunkhawa	25°54'36"	89°46'12"	BWDB(*)
45.5	Chilmari	25°34'26"	89°41'41"	FAP1, GPS
46	Kamarjani	25°20'05"	89°37'42"	FAP22, GPS
46.7L	Kholabarichar	24°13'33"	89°45'10"	SWMC, GPS
46.7R	Kirstomonichar	25°13'30"	89°39'00"	BWDB(*)
469.R	Fulchari	25°11'24"	89°35'56"	FAP1, GPS
46.9L	Bahadurabad Tr	25°08'00"	89°42'30"	FAP1, GPS
47	Bahadurabad	25°8'30"	89°41'00"	BWDB(*)
47.3L	Jognaichar	25°5'12"	89°40'00"	BWDB(*)
47.3R	Patilbarichar	25°5'18"	89°38'00"	BWDB(*)
48	Jaganathganj	24°39'00"	89°51'00"	BWDB(*)
49	Sirajganj	24°27'45"	89°43'57"	FAP1, GPS
49A	Kazipur	24°37'18"	89°40'39"	FAP1, GPS
50	Porabari	24°17'21"	89°48'45"	SWMC, GPS
50.3	Mathura	23°57'00"	89°39'14"	FAP1, GPS
50.6	Teota	23°50'07"	89°46'59"	FAP1, GPS

(*) = Approximate Location
GPS = Global Positioning System
SWMC = Surface Water Modelling Centre

Table 2-3: Global coordinates of water level stations on the Jamuna river

Discharge data of different stations along the main rivers of Bangladesh have been collected, see the overview of the available data in Table 2-4. The station in Bahadurabad is the most important station along the Jamuna river, because it is the only station where the discharge is currently being measured regularly by the BWDB.

It should be mentioned that the accuracy of the discharge measurements has been estimated at some 20-30 %, especially for the estimation of the maximum discharge. Under the present conditions it is difficult, if not impossible, to do discharge measurements in the Jamuna river during the monsoon period.

Therefore the peak-discharge data is often based on an extrapolation of stage-discharge relationship. These extrapolations do not have high degree of accuracy. In the Flood Hydrology Study discharges were calculated by using a set of improved rating curves with consistent extrapolation characteristics. These discharge data have also been collected for the Project database and will be used instead of the uncorrected daily data. For locations, other than Bahadurabad the discharges, which were calculated by the 1-D model for the 25 year period, have been used to determine design conditions near the test areas. These discharges are stored in a database and an example of a stage discharge relationship and the variation of the discharge in Bahadurabad during one year is given in Fig. A.5-3.

The General Model (GM) is a hydrodynamic model of the main rivers in Bangladesh. This model has been developed at the Surface Water Modelling Centre (SWMC) in recent years. Based on the hydrodynamic module of Mike 11 Software, the FAP 25-GM model is a reduced version of the GM with runs for a long period from 1965 to 1989 with a fixed bed.

The so called run 6 of FAP 25-GM is considered in this study as the final run for the existing situation with a recalibrated model. It is mentioned that the "BRTS Chainage" has been used for run 6 instead of the "GM" chainage used for run 5, see Table 2-5. To avoid any confusion, only the "BRTS" chainage has been used in this study (Halcrow, DHI, EPC, DIG and BWDB, 1991).

The collected hydrologic data have been stored logically into several databases:

Lotus files: Some BWDB data are available in data files, which have been made with a spreadsheet programme, Lotus, with 16 water levels gauge stations and 2 discharge stations along the Jamuna river.

General Model database : Data used or calculated by this hydrodynamic model are available in two kinds of databases, which are part of the Mike II software package, which has been developed by the DANISH HYDRAULIC INSTITUTE.

Table 2-4: Status of data collection - daily discharge

River Name	BWDB no.	Station name	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Jamuna	46.9L	Bahadurabad Transit								L	L	L	L	L	–	L	L	L	L	L	L	L	–	L	–	L	L	L	L	L	L	L	L	L
Dharla	77	Kurigram															H	H	H	H	H	H	H	H	H	H	H	–	–	H	H	H		
Ganges	90	Hardinge Bridge		L	L	L	L	L	L	L	L	L	L	L	–	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L		
Ganges	91.9L	Baruria Transit								L	L	L	L	L	–	L	L	L	L	L	L	L	–	L	L	L	L	L	L	L	L	L	L		
Ganges	93.5L	Mawa							L	L	L	L	L	L	–	L	L	L	–	L	L	L	L	L	L	L	L	L	L	L	L	L			
Ghagot	97	Galbandah										H	–	–	H	H	H	H	H	–	H	H	H	H	H										
Ganges	99	Goral Rly Bridge						L	L	L	L	L	L	L	–	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L		
Kalliganga	137A	Taraghat										L	L	L	–	L	L	L	L	L	–	L	L	L	L	–	L	L	L	L	L	L	L		
Meghna	273	Bhairab Bazar						L	L	L	L	L	L	L	–	L	L	L	L	L	–	–	–	–	–	L	L	L	L	L	L	L	L		
Teesta	294	Kaunia	L	L	L	L	L	–	–	L	L	L	L	L	–	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L	L			

L : Lotus file (from FAP25)
H : Hardcopy
: in MIKE11 database

Observed discharge

River Name	BWDB no.	Station name	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Jamuna	46.9L	Bahadurabad								L	L	L	L	L	–	L	L	L	L	L	L	L	–	L	–	L	L	L	L	L	L	L	L	L

Computed discharge (FAP25)

River Name	BWDB no.	Station name	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
Jamuna	46.9L	Bahadurabad Transit																																
Ganges	90	Hardinge Bridge																																
Teesta	294	Kaunia																																

: in MIKE11 database

HYMOS database: A hydrologic database using HYMOS software has been built and checked to facilitate data interpretation. This software programme is a hydrologic data management and processing software package developed by DELFT HYDRAULICS. It is pointed out that all the basic data into HYMOS have been introduced from the Lotus files or the Mike 11 databases.

TOPO BWDB Name	CHAINAGE Km	HYMOS name	DATABASE		FAP 1 DATABASE		Remarks
			Latitude Degrees	Longitude Degrees	Latitude Degrees	Longitude Degrees	
J-17	25.0		25.40	89.45	25.670	89.745	
J-16-1	31.4		25.37	89.44	25.615	89.735	
J-16	37.1		25.34	89.44	25.564	89.726	
J-15-1	44.3		25.30	89.40	25.504	89.669	
J-15	55.7	J56	25.24	89.41	25.401	89.679	
J-14-1	63.3	J63 Q67	25.20	89.40	25.331	89.670	Manos regulator
J-14	71.2	J71	25.15	89.40	25.254	89.663	
J-13-1	81.7	J82 Q83	25.09	89.39	25.158	89.658	
J-13	84.7	J85	25.08	89.39	25.129	89.656	Bahadurabad gauge(46.9L)
Interpolate	92.6	J92					
J-12	100.5		25.00	89.38	25.000	89.629	
J-11-1	108.9	J109 Q113	24.55	89.38	24.929	89.630	
******	114.6		24.52	89.39	24.873	89.643	Mathurapara(15J)
J-11	117.8	J118	24.51	89.39	24.846	89.655	Chandanbaisa
J-10-1	126.5	J126	24.46	89.41	24.769	89.675	
J-10	134.3		24.42	89.42	24.706	89.708	
J-9-1	139.0		24.40	89.44	24.669	89.732	
J-9	142.5		24.38	89.45	24.640	89.744	
J-8-1	145.4		24.37	89.45	24.615	89.752	
J-8	149.5		24.35	89.46	24.587	89.761	
J-7-1	156.6		24.31	89.46	24.514	89.768	
J-7	162.4		24.28	89.46	24.464	89.765	Sirjganj(49)
J-6-1	170.8		24.23	89.46	24.387	89.764	
J-6	177.7		24.19	89.46	24.324	89.760	
J-5-1	180.6		24.18	89.45	24.299	89.756	
J-5	188.2		24.14	89.45	24.230	89.745	
J-4-1	195.8		24.10	89.44	24.162	89.739	
J-4	201.3		24.07	89.44	24.113	89.730	
J-3-1	205.2	J205	24.05	89.43	24.079	89.724	
J-3	213.2		24.00	89.43	24.005	89.711	Nakalia
Interpolate	213.4	J214 Q217					
******	218.9		23.57	89.43	23.956	89.710	Mathura gauge(50.3)
J-2-1	220.0	J220	23.57	89.42	23.946	89.707	
J-2	223.2		23.55	89.43	23.917	89.711	
J-1-1	229.4		23.52	89.44	23.863	89.730	
J--1	230.8		23.49	89.44	23.814	89.737	
J-0-1	235.4		23.50	89.45	23.838	89.752	Teota gauge

****** Cross-sections not used in the FAP 25-GM model

Selected test sites

Table 2.5: Cross-sections used in FAP 25-GM model

Although the systematic errors between measured and calculated time series at a station will be assessed in detail by FAP 25 in their final report, some quick checks have already been done in this hydrologic study.

Additional analyses (like rating curves or any other data interpretation) can be carried out easily with this HYMOS database.

3 TEST AREAS

For an hydrologic analysis per test area it was decided to use the calculated hydrologic data from the FAP 25-GM model. But because of the results of run 6 were not finalized at the beginning of the study and BWDB guage station is located in the vicinity of each test area, an analysis of the most suitable data has been done site by site, keeping in mind that for the modelling activities, to be consistent, the results of the FAP 25-GM model will always be used as boundaries conditions for the determination of the decisive data for design parameters.

From the initially 5 selected test areas the test area near Betil was disregarded as less promising test area in an early stage and only the following 4 locations are considered in this study, see also Fig. A.5-4.

Kamarjani

This test area starts from Kamarjani on the right bank of the Jamuna river up to the Manos regulator as southern boundary, see Fig. A.5-5. The data of BWDB water level station just upstream of the Manos regulator was collected and analyzed. The monthly maximum, minimum and average water level have been compared with the results of the General Model for the chainage 63 km (J63) but the differences between observed and computed water level are too big to be easily explained: an average difference of 0.56 m in the water level in a period of several years, but up to 1.4 m in annual average. The field measurements of this station cannot be used without a complete investigation of these differences in the water level. Therefore the computed water level for the chainage 56 km and 63 km have been used. The computed discharge has been taken from the chainage 67 km (Q67).

Chandanbaisa

This test area is on the right bank of the Jamuna river and about 10 km south of Sariakandi. The length of this test area is about 8 km along a more or less straight channel, see Fig.A.5-6.

The BWDB station 15J Mathurapara is located 3 kilometer upstream of the test area near Chandanbaisa. After the finalization of the second order bench marks check a more accurate zero datum of this station can be determined probably. Because only eight years of water level data of this station are available, and to be consistent with the Flood Hydrology Study, the calculated water levels of FAP 25-GM have been used.

Nakalia

This test area is on the right bank of the Jamuna river south of the mouth of the Atrai river and north of Nagabari. The test area is more than 10 km long, see Fig. A.5-7.

The BWDB station Mathura (50.3) is located downstream of the test area and the readings of this station have been compared with the computed water levels in cross-section J220.

Although the results of the two stations generally match well, this means only a small difference of 0.05 m in average, the differences in yearly average ranges from -0.70 to 0.65 m. The statistical analysis of the observed data may be more accurate than the computed data.

Bahadurabad

The northern boundary of this test area is Bahadurabad at the left bank and the test area reaches along an outflanking channel up to about 10 km south of that place, see Fig. A.5-8. In Bahadurabad the water levels and the discharges are measured regularly.

The observed data has been compared with the computed water levels at the station J85, see for example the Fig. A.5-9 to A.5-13 with observed and computed water levels for the years 1986 to 1989. The difference between observed and computed water levels (J85) is very small in average, 0.06 m, but with a range from -0.36 m to 0.57 m for the annual average difference.

4 FLOOD FREQUENCY ANALYSIS

With a frequency analysis of the available data the design water levels and the design discharges have been established. For this analysis HYMOS software has been used. The recommendations, which were made by FAP 25 (Krüger Consult, BCEOM and FPCO, 1992) for the selection of probability distributions, have been used as guideline.

The 3 parameter log-normal distribution has been selected for the statistical analysis of the maximum annual water levels, and the seasonal discharges, see the distribution of the yearly maximum water levels in the different test areas in Fig. A.5-14 to A.5-19. The maximum water levels for a selected return period of 2, 5, 10, 25, 50 and 100 year are given for the cross sections near the test areas in Table 4-1. These results were used to determine the standard low water and standard high water levels (Interconsult and BIWTA, 1990).

Station Name	HYMOS Code	Return Period					
		2	5	10	25	50	100
		Water Level (in m PWD)					
Kamarjani	J63	21.60	22.01	22.25	22.52	22.71	22.89
Bahadurabad	J85	19.82	20.21	20.43	20.67	20.83	20.98
Bahadurabad transit	BWDB 46.9L	19.78	20.04	20.20	20.42	20.57	20.72
Chandanbaisa	J118	16.78	17.18	17.43	17.71	17.91	18.11
Nakalia	J205	10.99	11.40	11.64	11.93	12.13	12.32
Mathura	BWDB50.3	10.01	10.46	10.76	11.14	11.41	11.69
Mathura	J220	9.77	10.13	10.38	10.71	10.96	11.22

Table 4-1: Maximum water level for selected return periods

The distance between the Jamuna river and the Bangali river is very small near Sariakandi and therefore the water levels of both rivers were analyzed.The differences between the water level in the Jamuna river and the Bangali river near Sariakandi can be maximum +1.5 m and -1.5 m during the rising limb and the falling limb of the flood hydrograph.

The design water levels should include a safety margin. Safety margins, accounting for the effects of random morphological processes, for model errors, and the likely underestimation of extreme events, due to the shortness of available records of observations, have been proposed by FAP 25 for the determination of the design water level. Safety margins varying from 0.45 m for the 100 years maximum flood level to 0.30 m for the 10 years maximum flood level were proposed for the major rivers. These safety margins have to be added to the free board of the bank protections, accounting for wind set-up, wave run-up and other possible safety factors.

From a frequency analysis of the calculated daily discharges during a period of 25 years the magnitude of the discharges corresponding to a selected return period has been determined. A Gumbel distribution has been fitted to the annual maximum discharges, see Figs. A.5-20 to A.5-23 and (RPT,NEDECO, BCL and GOB, 1989). From the graphs it can be seen that the Gumbel distribution fits very well the 24 data points, because 1971 is missing. The maximum discharges for a selected return period of 2, 5, 10, 25, 50 and 100 year are given for the test areas, see Table 4-2.

Station Name	Return Period					
	2	5	10	25	50	100
	Maximum discharge (in m^3/s)					
Kamarjani	70,251	82,722	90,979	101,412	109,151	116,834
Bahadurabad	67,621	79,144	86,774	96,413	103,565	110,663
Bahadurabad transit	64,267	75,670	83,220	92,759	99,836	106,861
Nakalia	56,435	64,002	69,012	75,342	80,038	84,700

Table 4-2: Maximum discharge for selected return periods

Only one parameter, as the maximum annual discharge, is not necessarily sufficient to characterize the flood discharge and the morphologic consequences of a flood discharge. As an alternative parameter the average discharge during the months July, August and September has been chosen. For the station in Bahadurabad this parameter has been determined from the calculated daily discharges during the 25 year period, see Fig. A.5-24. The log normal distribution fits best to these data of the average discharge during the flood season. Mean of 3 months maximum discharge for selected return period in given in Table 4-3.

Station Name	Return Period						Type of distribution
	2	5	10	25	50	100	
	Mean maximum discharge (in m^3/s)						
Bahadurabad transit	41,966	47,142	50,467	54,576	57,581	60,548	Log normal
	41,663	46,983	50,739	55,768	59,715	63,825	EVT 2

Table 4-3: Mean of 3 months maximum discharge for selected return period

A return period means that the considered event will be observed on an average n times in a given period, in which n is equal to the given period divided by the return period. For a good understanding of the hydrologic behaviour of the peak water level and the peak discharge the relative meaning of a return period is essential, or more specific it means that a return period of a flood depends on the parameters, which are chosen and on the selected locations.

From the analysis it can be seen that in 1988 the maximum discharge had a return period of 100 year, but the maximum water level was not so extreme: a return period of only 60 years. The selection of a return period of one parameter in one location is not sufficient to characterize a hydrologic event as a typical design event. This is a reason for FAP 25 to recommend a long-term simulation with the regional models and the General Model for the period 1965-1989. The statistical representativeness of the period 1965-1989 for the whole century has been assessed by the Flood Hydrology Study and this analysis indicates that the period 1965-1989 can be considered to be typical for this century and so designs can be based on the statistical analysis of the output of a simulation of that period.

5 LOW WATER ANALYSIS

A construction window has been defined by the number of days during which the water level is below a certain level with a certain probability.

From the duration curve, the level not surpassed during periods of 60, 90, 120 and 180 days can be extracted for the 10%, 50%, 90% frequencies. The 90% value for 90 days indicates that in 9 years of a period of 10 years, one can expect during at least 90 days per year a water level below the mentioned value, see Table 5-1 to 5-5 and see also the frequency curves and the duration curves for the different test areas in Fig. A.5-25 to A.5-36. With this data a construction window regarding the water level can be determined for each test area.

The small variations in the water level during the receding limb of the hydrograph in the dry season are remarkable, therefore the differences between the 10%, 50 % and 90% water level is relatively small. As soon as the monsoon period starts the variation in the water level at a certain date increases from year to year.

Duration in days	Low Water Level (in m PWD) for the frequency			Date of occurence of the 90 % low water level	
	10 %	50 %	90 %	Start date and 90 % range	End date and 90 % range
60 days	15.14	15.51	15.96	355 (337 - 15)	101 (72 - 109)
90 days	15.34	15.76	16.29	341 (329 - 362)	106 (86 - 119)
120 days	15.73	16.10	16.84	326 (316 - 345)	113 (101 - 128)
180 days	16.90	17.45	18.31	299 (286 - 308)	145 (122 - 168)

Day number 1 = 1st January

Table 5-1: Low water analysis at Chainage 63 km (Kamarjani)

Duration in days	Low Water Level (in m PWD) for the frequency			Date of occurence of the 90 % low water level	
	10 %	50 %	90 %	Start date and 90 % range	End date and 90 % range
60 days	13.21	13.54	13.89	362 (351 - 13)	93 (72 - 106)
90 days	13.48	13.81	14.19	347 (340 - 362)	106 (86 - 114)
120 days	13.89	14.20	14.74	329 (318 - 342)	112 (97 - 127)
180 days	14.88	15.43	16.33	300 (287 - 307)	149 (121 - 165)

Day number 1 = 1st January

Table 5-2: Low water analysis at Bahadurabad (BWDB 46.9L)

Duration in days	Low Water Level (in m PWD) for the frequency			Date of occurence of the 90 % low water level	
	10 %	50 %	90 %	Start date and 90 % range	End date and 90 % range
60 days	10.06	10.60	11.25	356 (338 - 16)	102 (83 - 110)
90 days	10.35	10.95	11.64	341 (330 - 362)	107 (87 - 120)
120 days	10.91	11.44	12.23	326 (316 - 345)	114 (101 - 129)
180 days	12.27	12.75	13.55	298 (286 - 308)	146 (122 - 168)

Day number 1 = 1st January

Table 5-3: Low water analysis at Chainage 118 km (Chandanbaisa)

Duration in days	Low Water Level (in m PWD) for the frequency			Date of occurence of the 90 % low water level	
	10 %	50 %	90 %	Start date and 90 % range	End date and 90 % range
60 days	2.88	3.47	3.92	1 (343 - 26)	104 (82 - 119)
90 days	3.21	3.73	4.22	354 (334 - 9)	108 (98 - 129)
120 days	3.66	4.23	4.79	338 (322 - 352)	122 (106 - 142)
180 days	4.63	5.40	6.25	307 (293 - 318)	151 (131 - 172)

Day number 1 = 1st January

Table 5-4: Low water analysis at Mathura (BWDB 50.3)

Duration in days	Low Water Level (in m PWD) for the frequency			Date of occurence of the 90 % low water level	
	10 %	50 %	90 %	Start date and 90 % range	End date and 90 % range
60 days	3.60	3.91	4.34	364 (355 - 22)	103 (79 - 110)
90 days	3.88	4.19	4.70	349 (339 - 1)	108 (93 - 122)
120 days	4.32	4.61	5.21	333 (324 - 348)	116 (101 - 129)
180 days	5.44	5.84	6.56	306 (293 - 311)	147 (125 - 169)

Day number 1 = 1st January

Table 5-5: Low water analysis at Chainage 214 km (Nakalia)

6 SHORT WATER LEVEL RISE AND FALL ANALYSIS

Relatively short rises and falls in the water level can be observed in all water level stations along the Jamuna river during the rising limb of the hydrograph, that is during the start of the monsoon period, see for example the water level in Bahadurabad during 1989 in Fig. A.5-12.

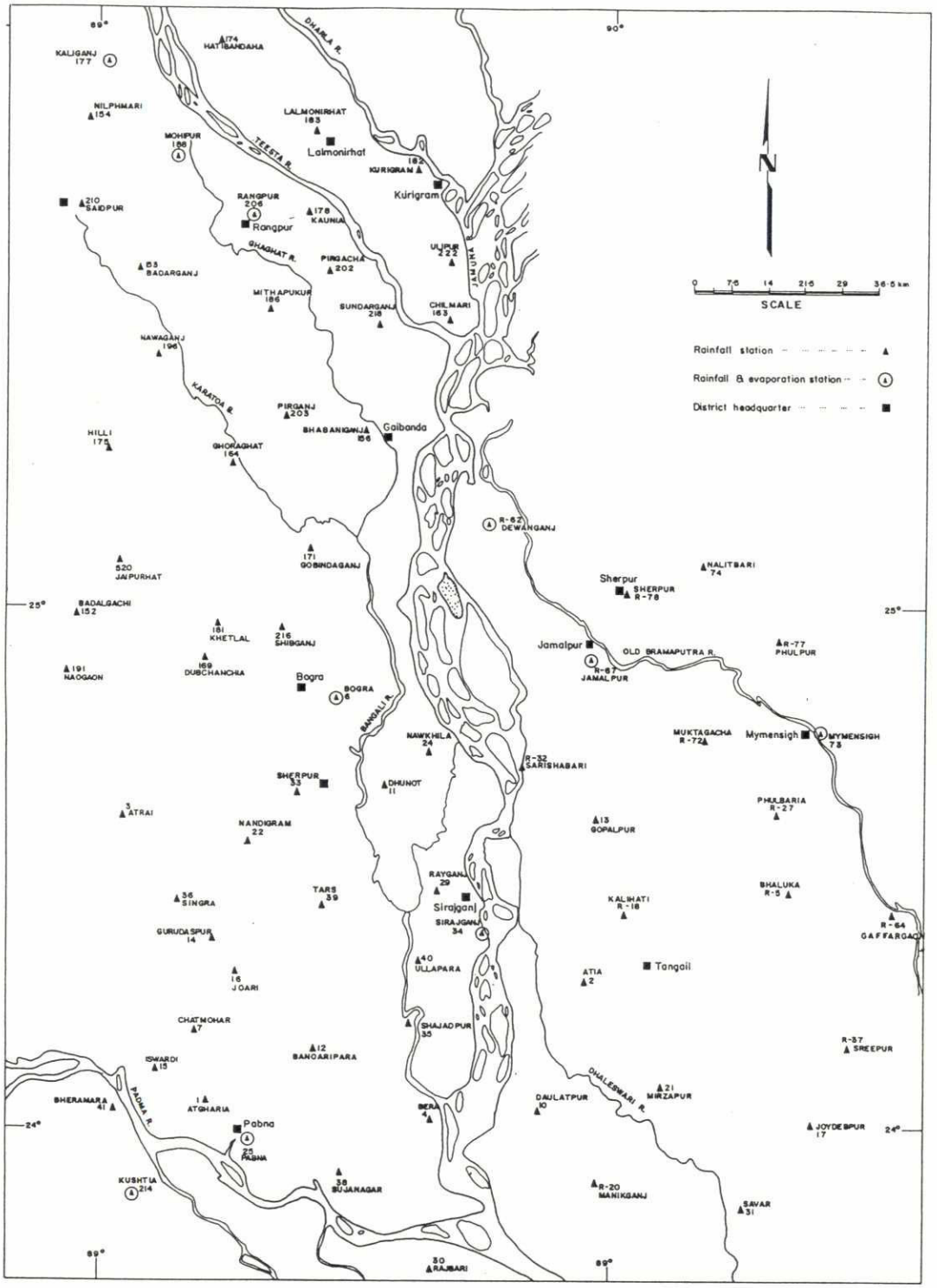
The differences of water levels between 1, 2, 3, 5 and 7 sequential days have been computed with a frequency analysis from the daily water levels in the 25 year period and the extreme positive and negative values for each day of a year have been calculated, see for example the results for Bahadurabad in Fig. A.5-37 to A.5-41 for the different time steps. In these gradients per day of a year two different periods can be distinguished:

* From November to February the water level is changing very slowly with a few centimeter per day without exception.
* And from April to October the water level can rise or fall suddenly with a few decimeters per day.

During the rising limb of the hydrograph in April to October the positive gradient is 0.25 to 0.5 m per day. This celerity in rising waterlevels can continue for days with a total rise of 0.5 to 1.0 m. In a period of 5 sequential days the water level can rise with an average celerity of 0.2 to 0.5 m per day.

During the rising limb of the hydrograph the negative gradient is 0.1 to 0.25 m per day, the celerity of the falling water level continues for a second day and a third sequential day with a total negative gradient of 0.3 to 0.75 m per period of 3 sequential days. For longer periods the average rate of the falling water levels is reduced.

The variation in the results is very small between different locations along the Jamuna river and therefore the graphs for Bahadurabad are representative for the whole Jamuna river.

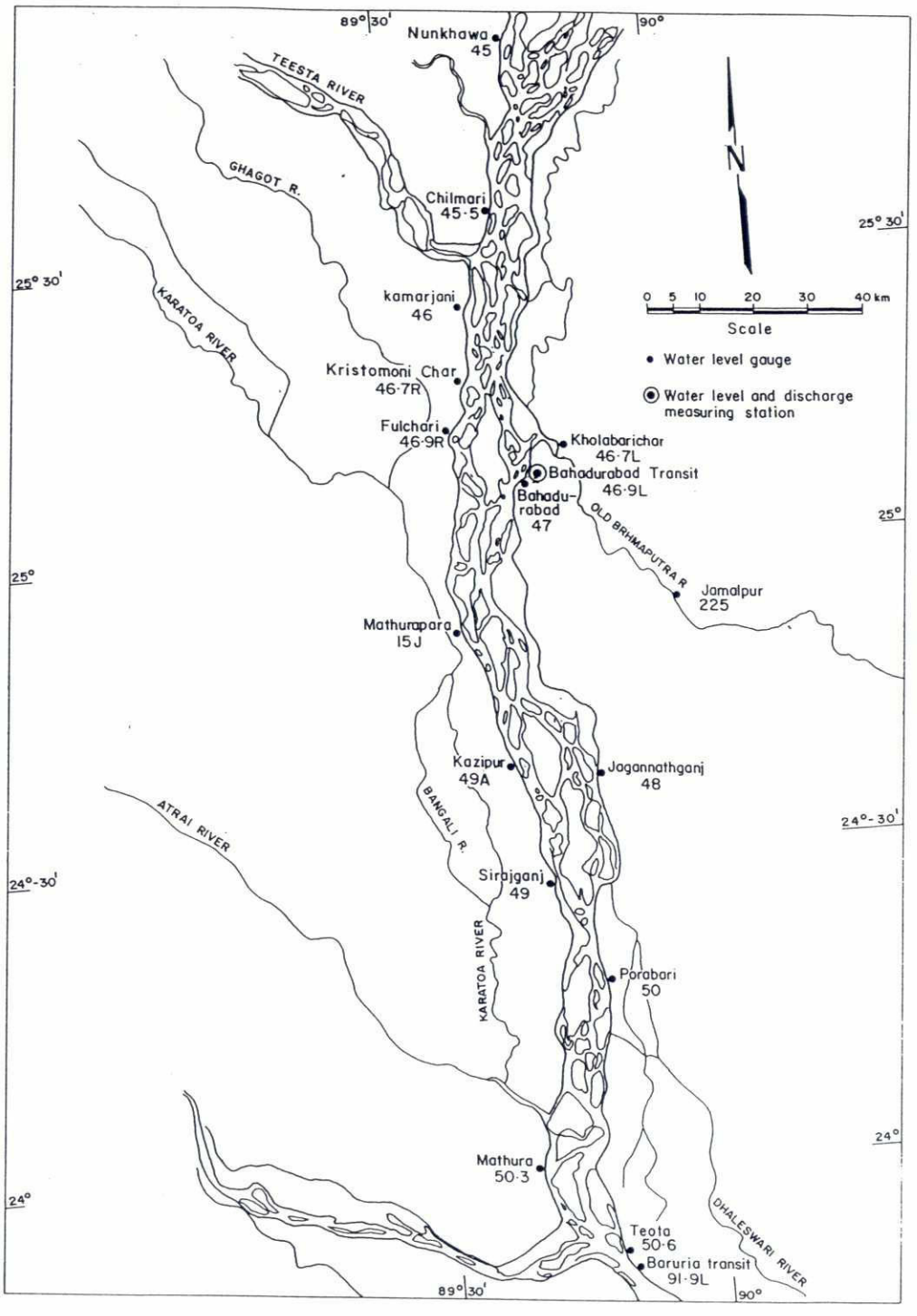


Location map of BWDB rainfall stations

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT	FIG. A.5 – 1

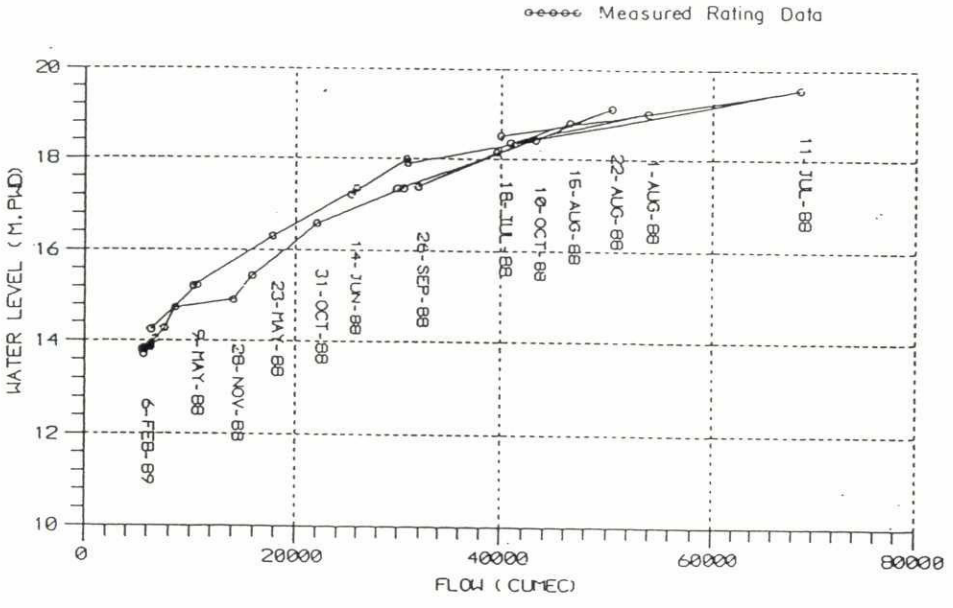


BWDB hydrometric stations on Brahmaputra - Jamuna river

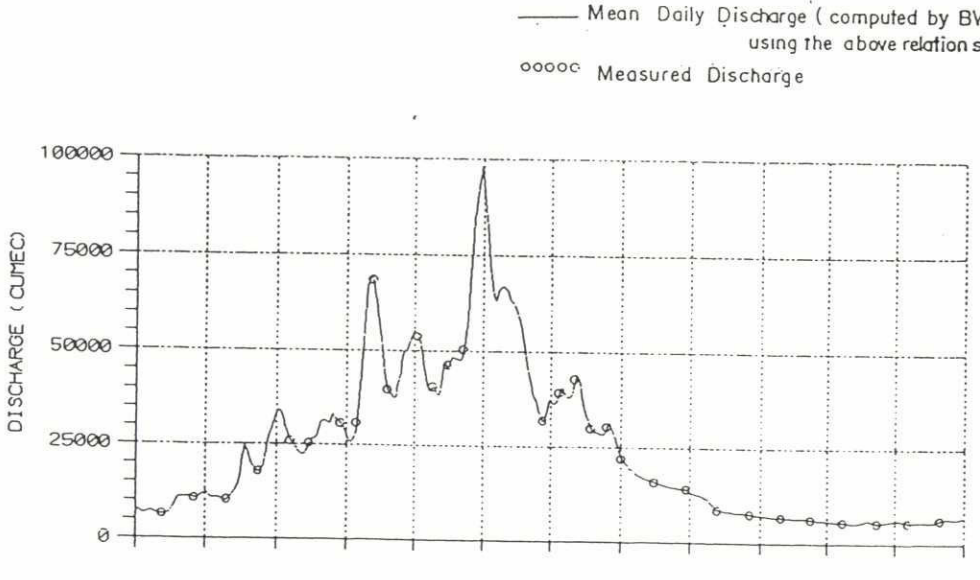
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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 — 2



(a) 1988-89 Stage-Discharge Relationship

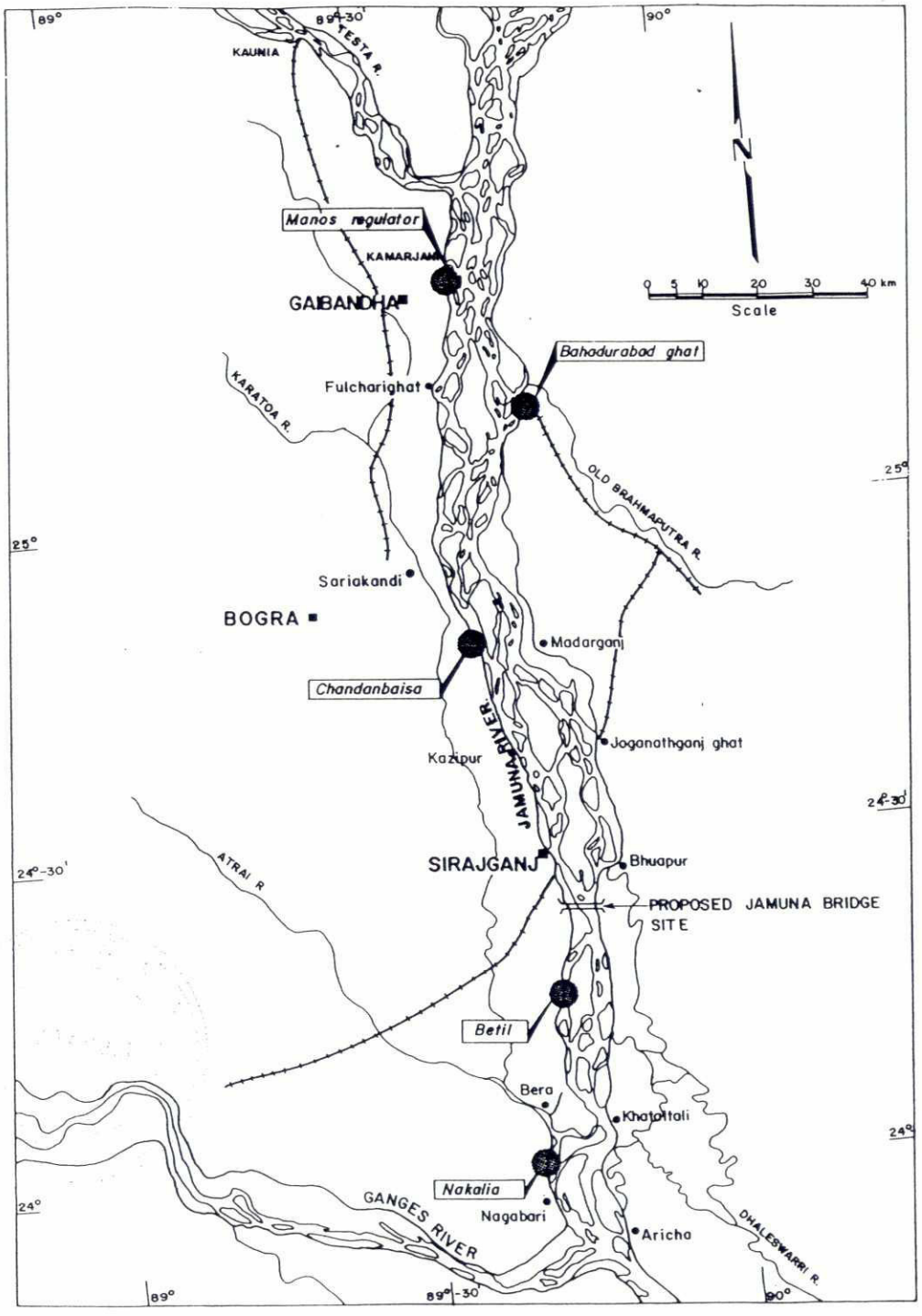


(b) Measured and Computed Discharges

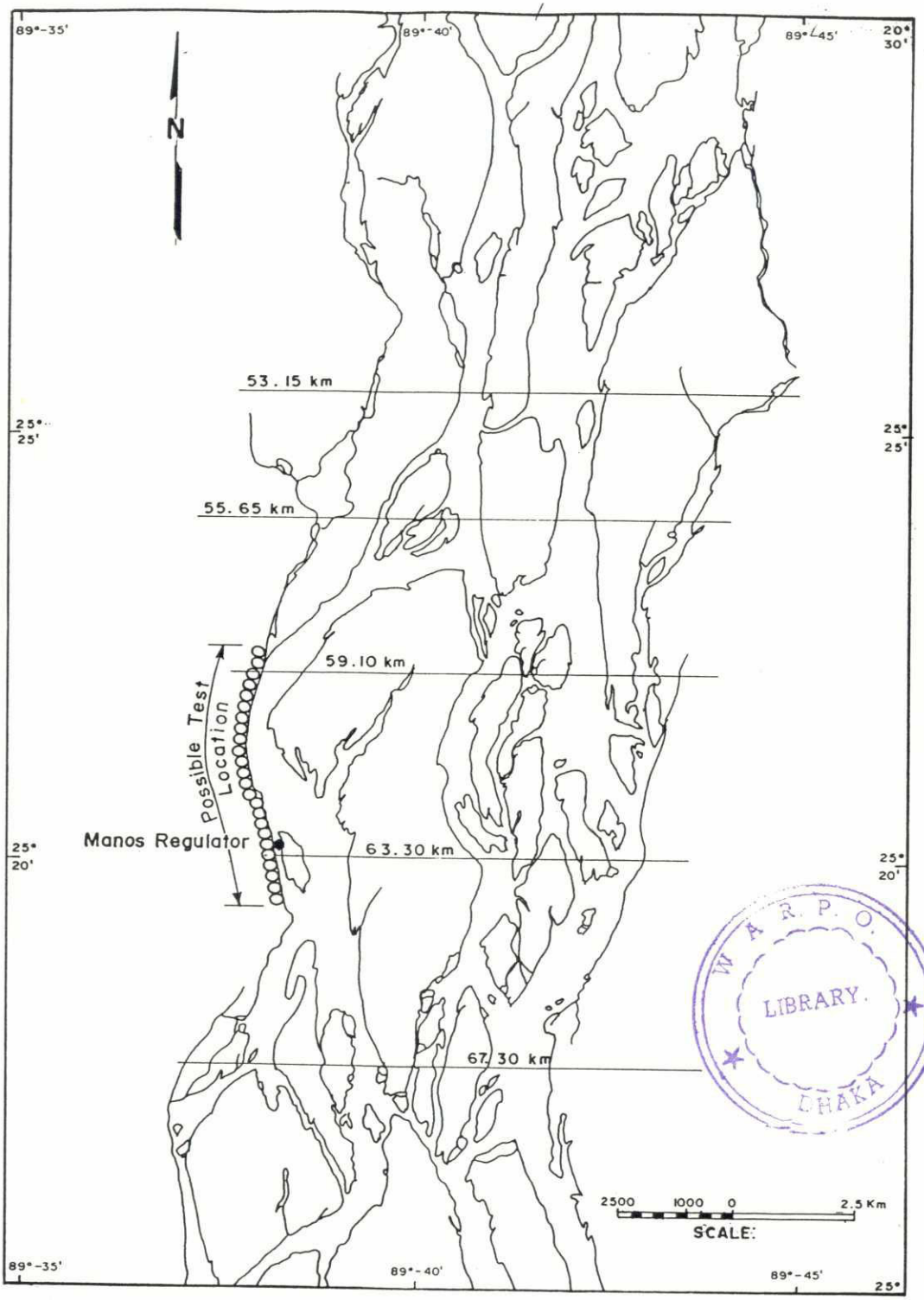
Example of discharge measurement data at Bahadurabad transit

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FINAL REPORT | **FIG. A.5-3**



Preselected test areas	**FAP – 21/22** **BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT**
	FINAL REPORT | **FIG. A.5 – 4**



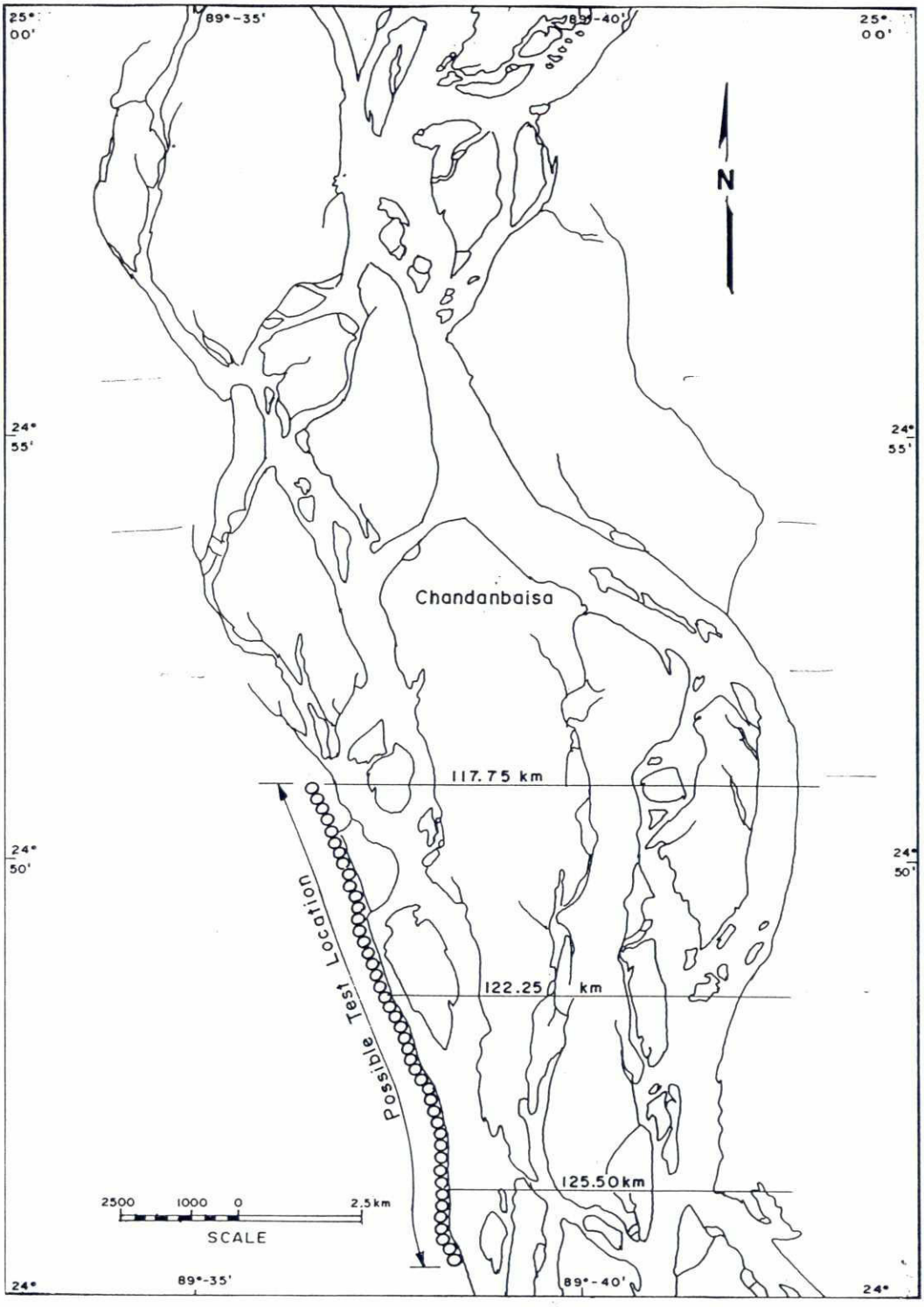
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Test site - Manos regulator

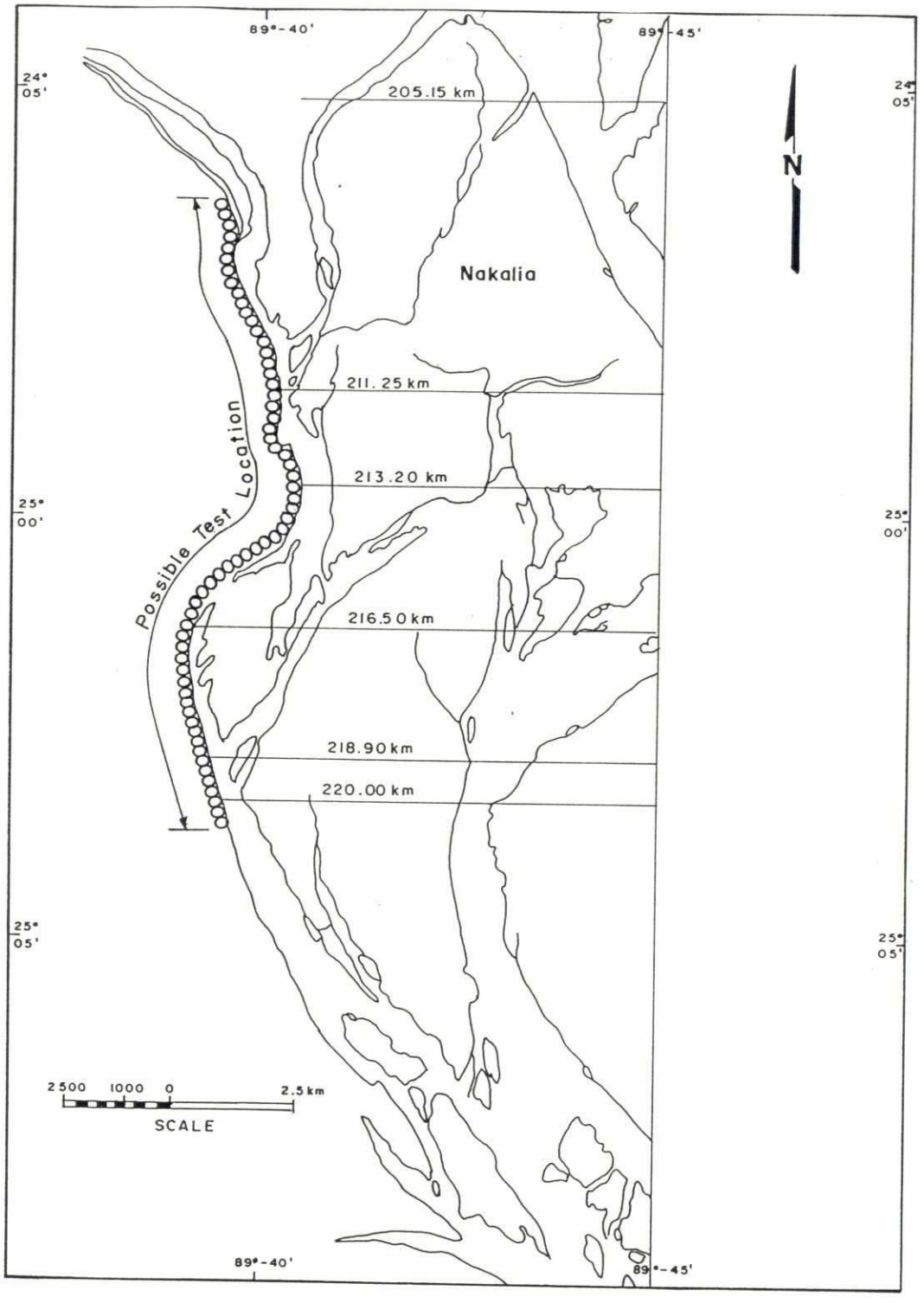
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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 5



Test site - Chandanbaisa	FAP -21/22 BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT	
	FINAL REPORT	FIG. A . 5 — 6

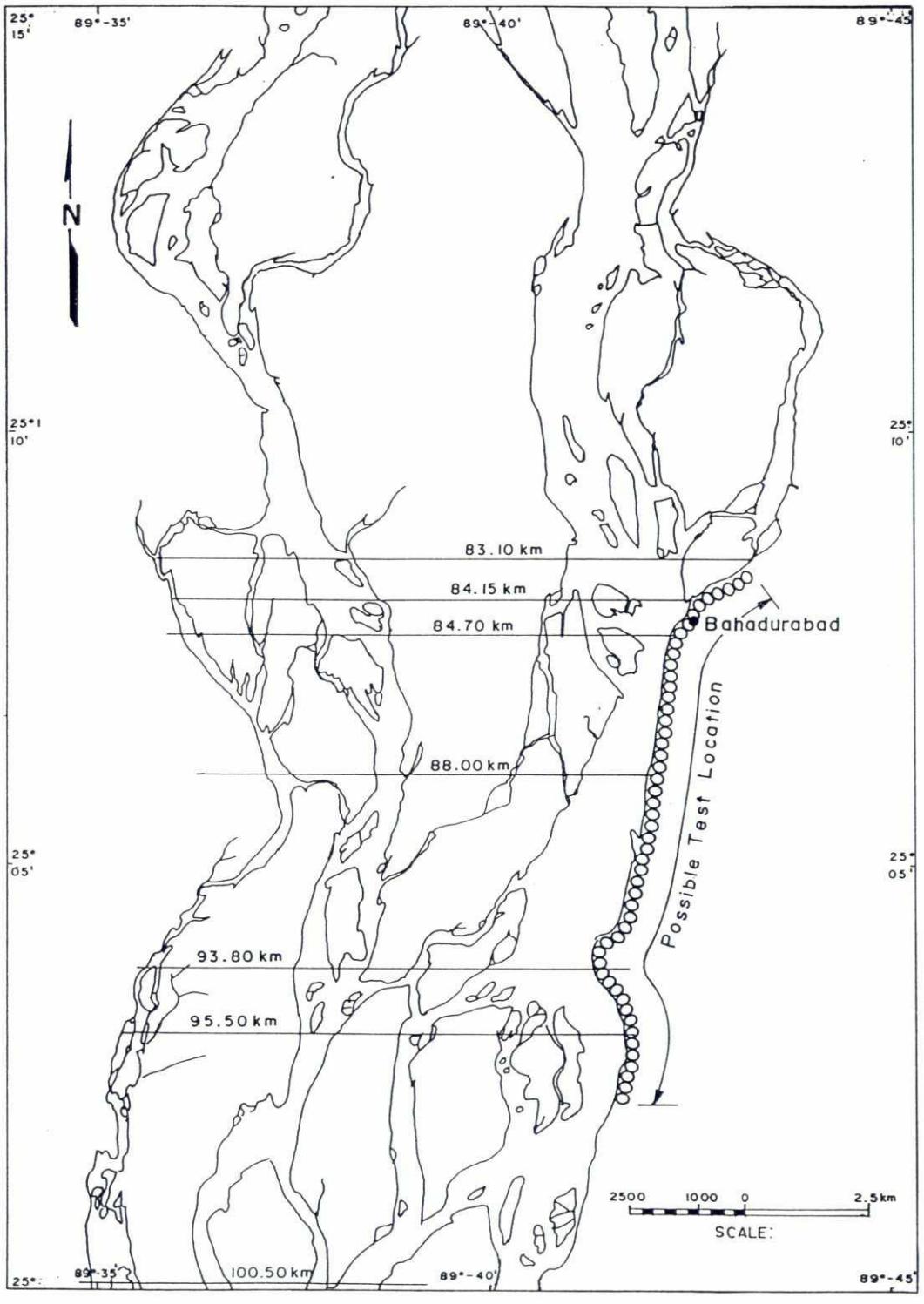


Test site - Nakalia

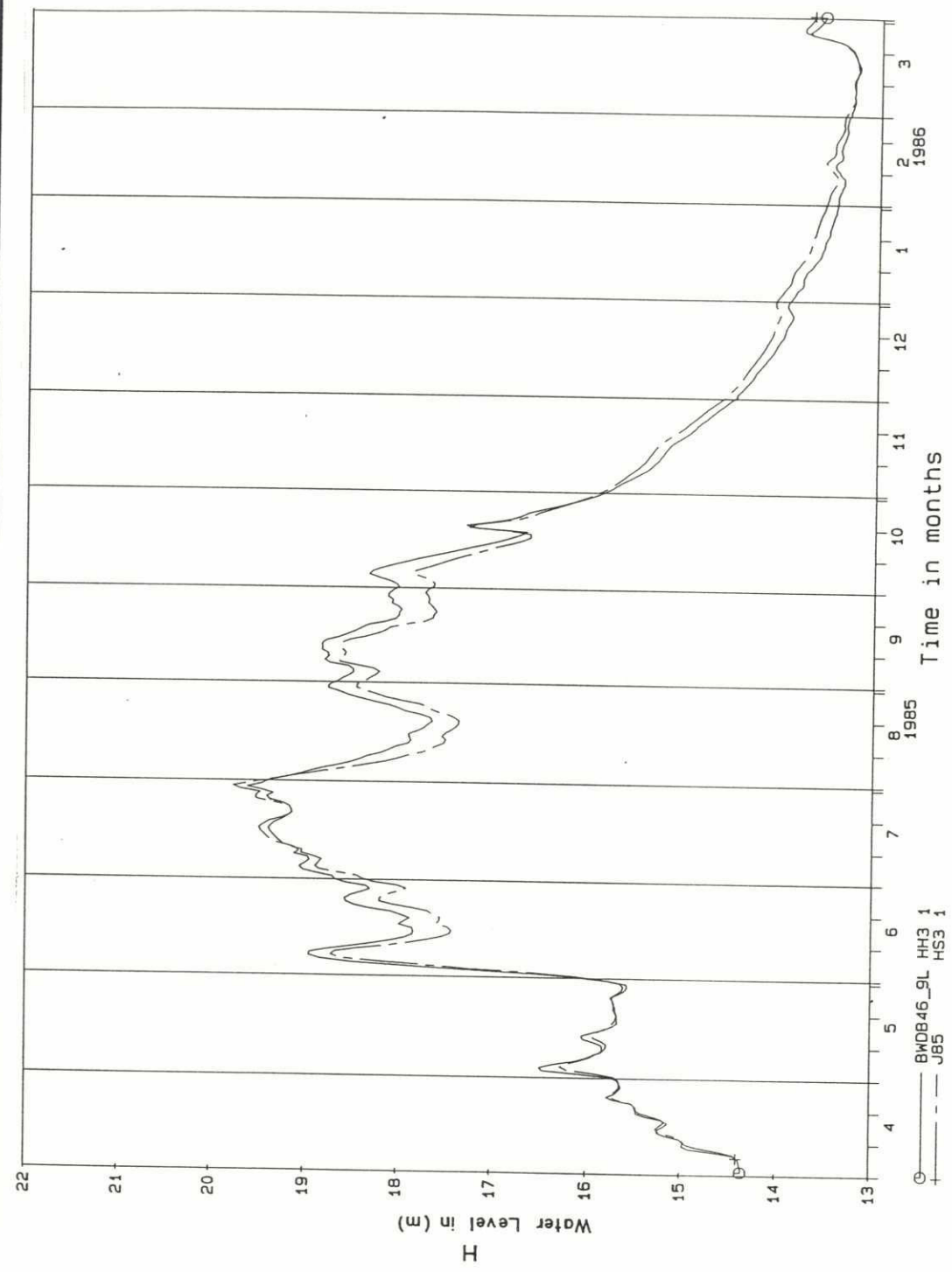
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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A. 5 — 7



Test site - Bahadurabad	FAP – 21/22 BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT	
	FINAL REPORT	FIG. A.5 — 8

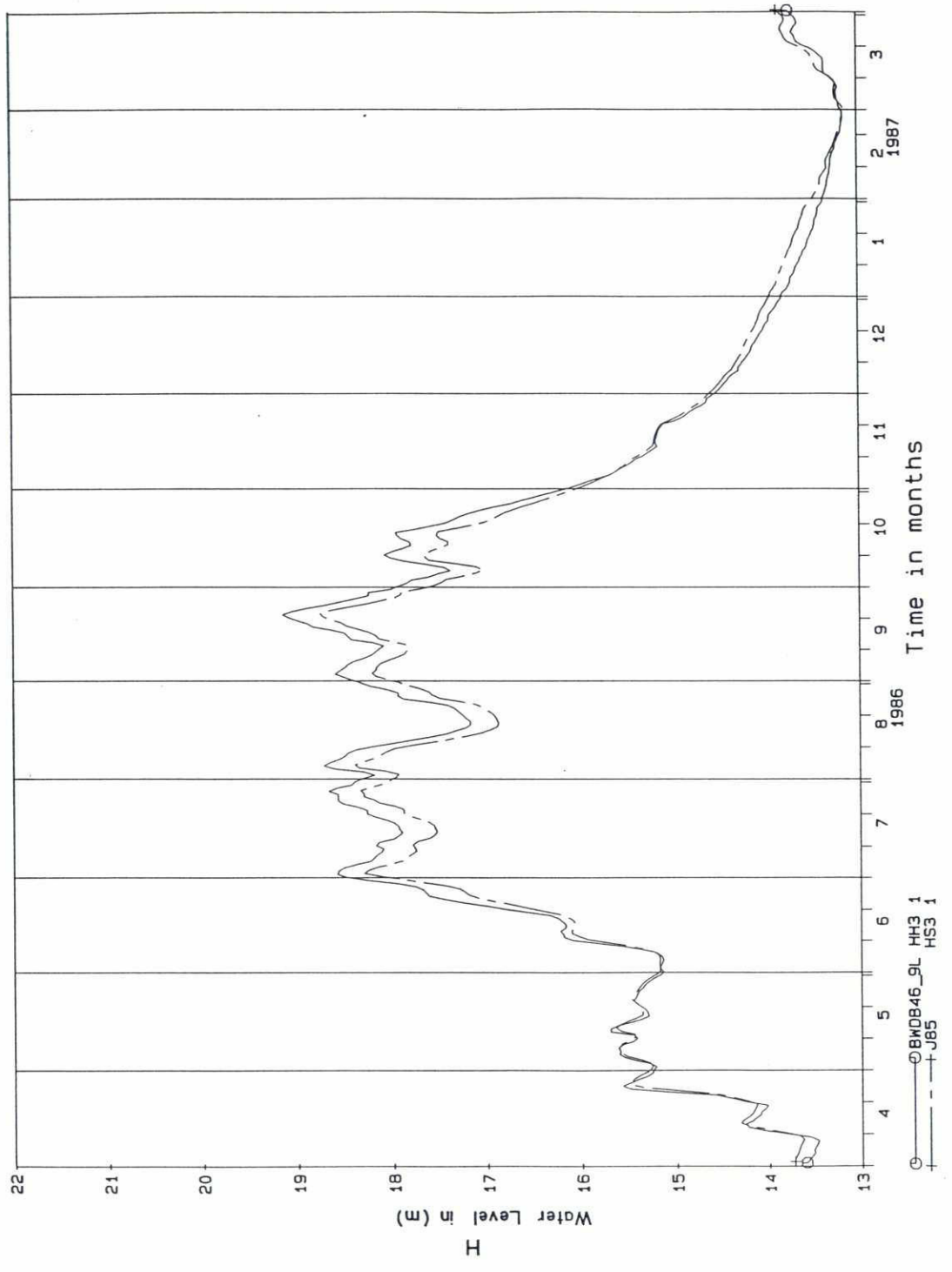


Comparison curves between observed and computed water level at Bahadurabad (1985-86)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 9

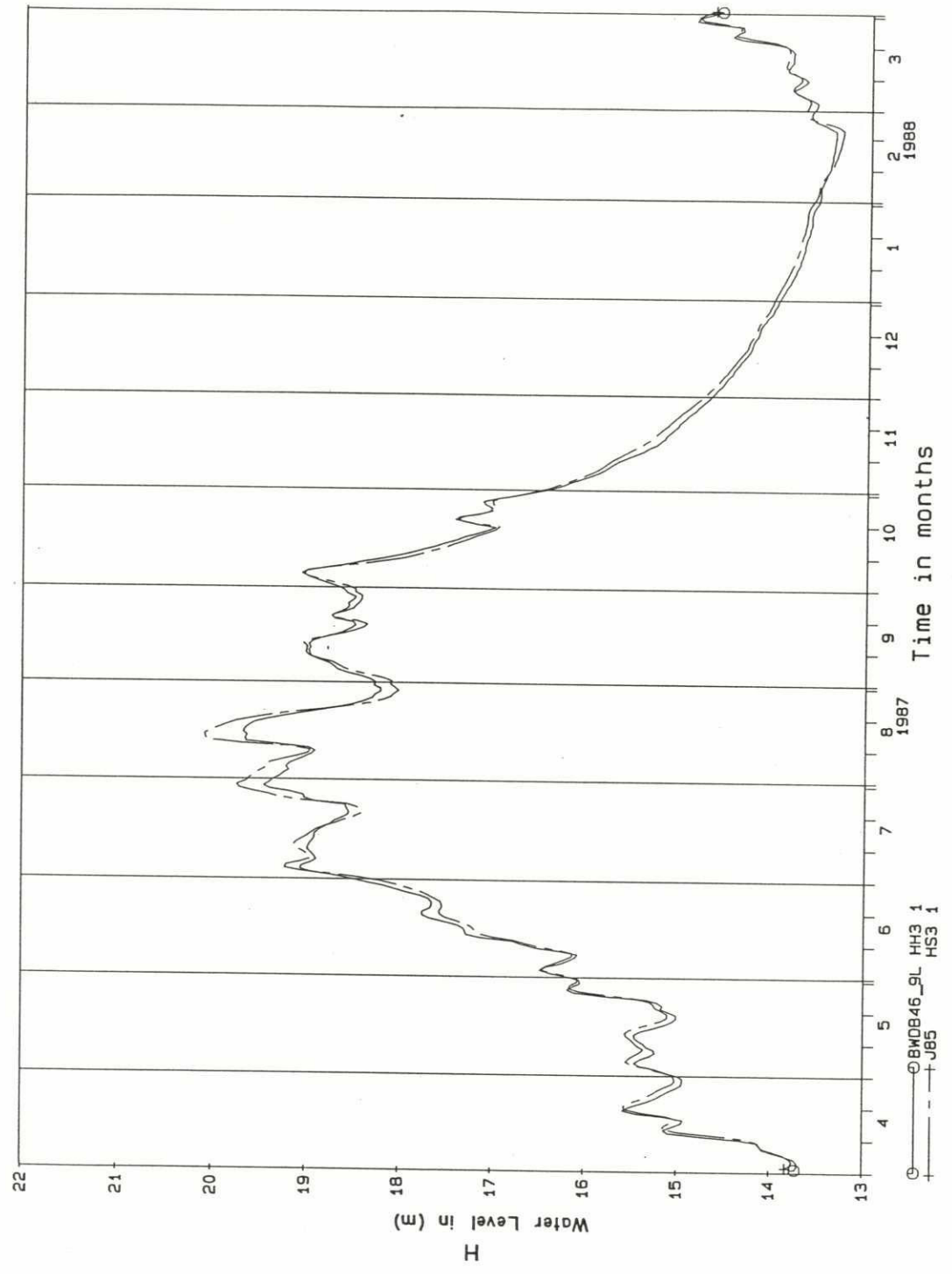


Comparison curves between observed and computed water level at Bahadurabad (1986-87)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 10

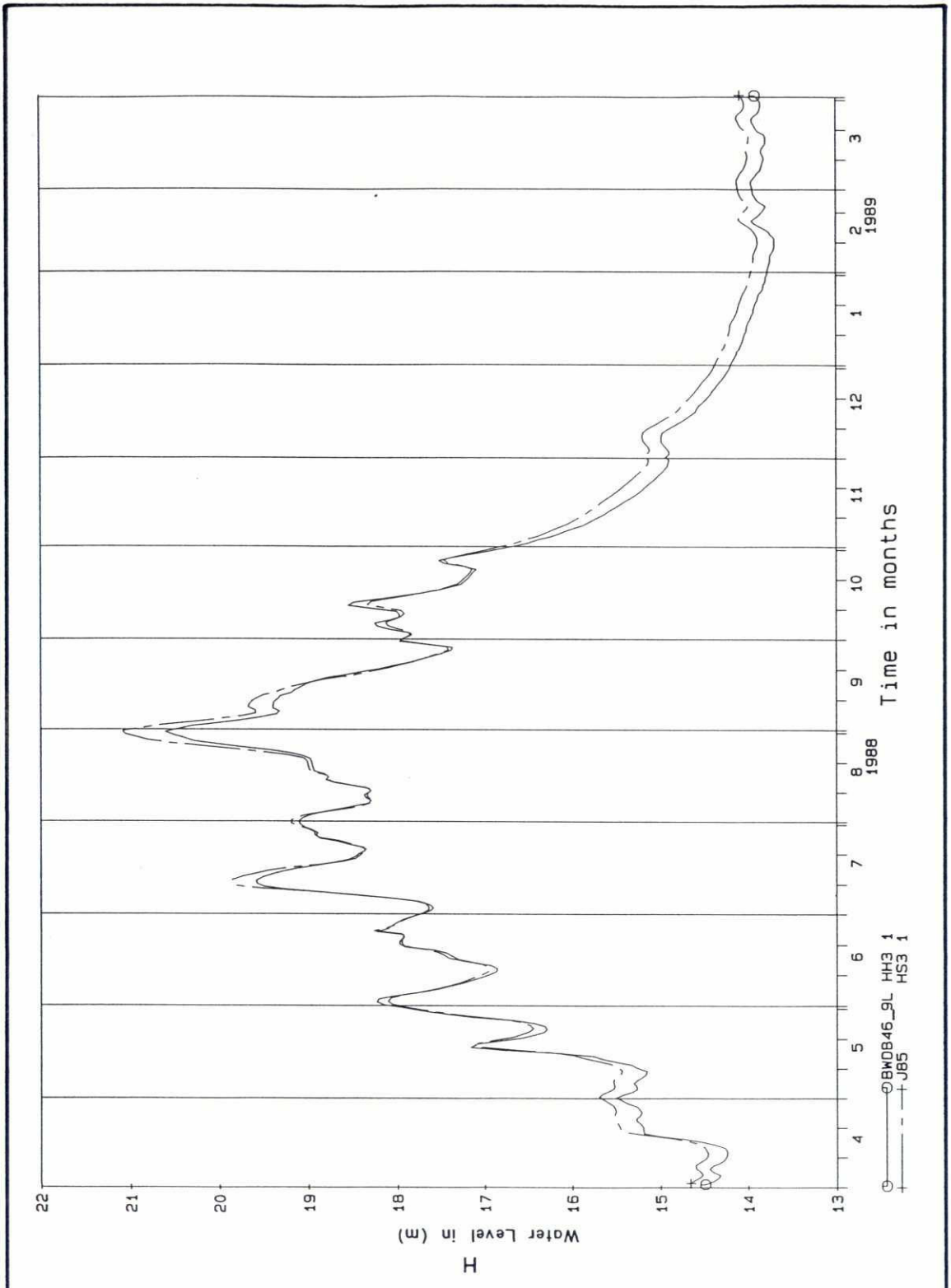


Comparison curves between observed and computed waterlevel at Bahadurabad (1987-88)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 11

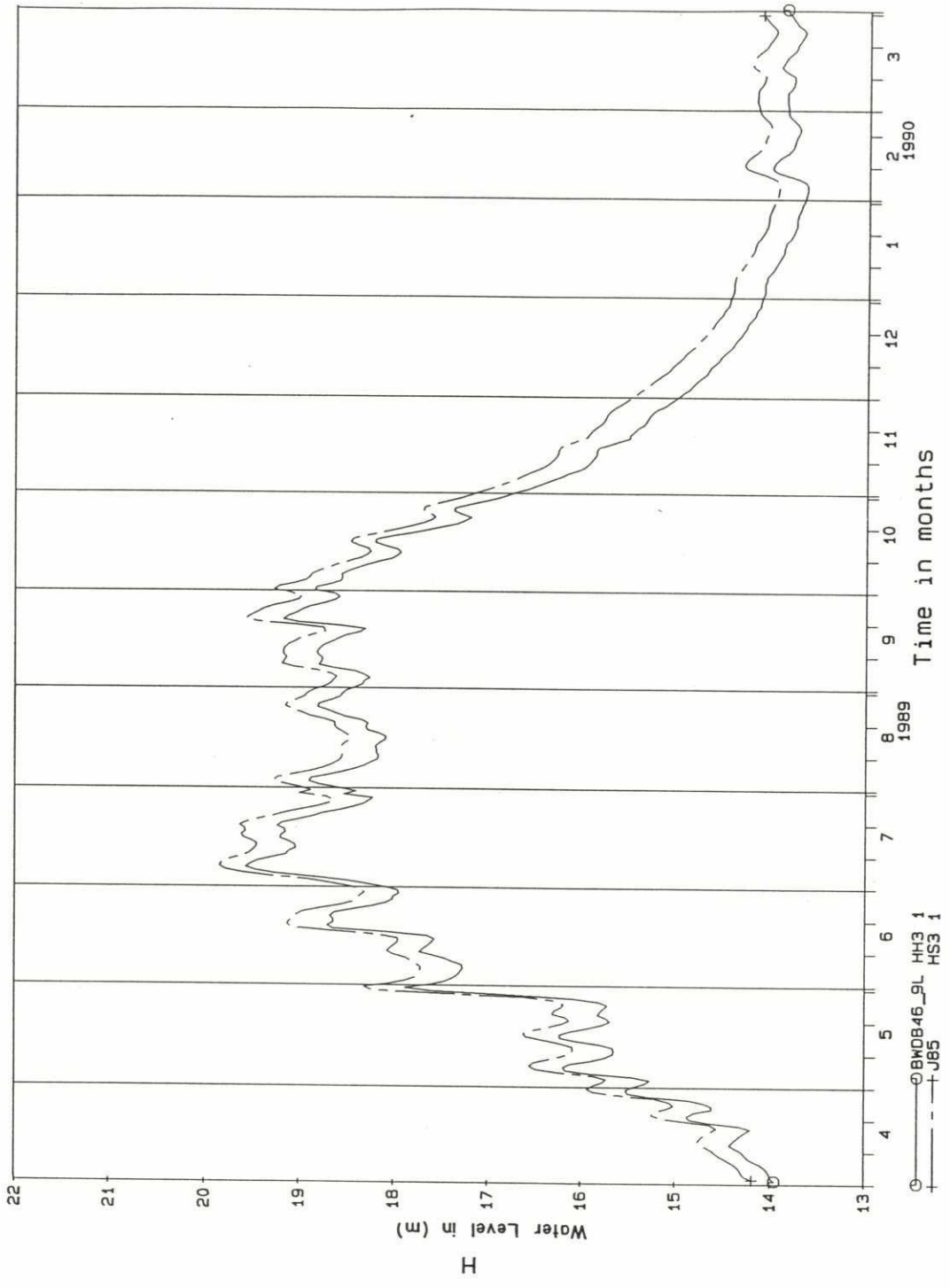


Comparison curves between observed and computed water level at Bahadurabad (1988-89)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 12

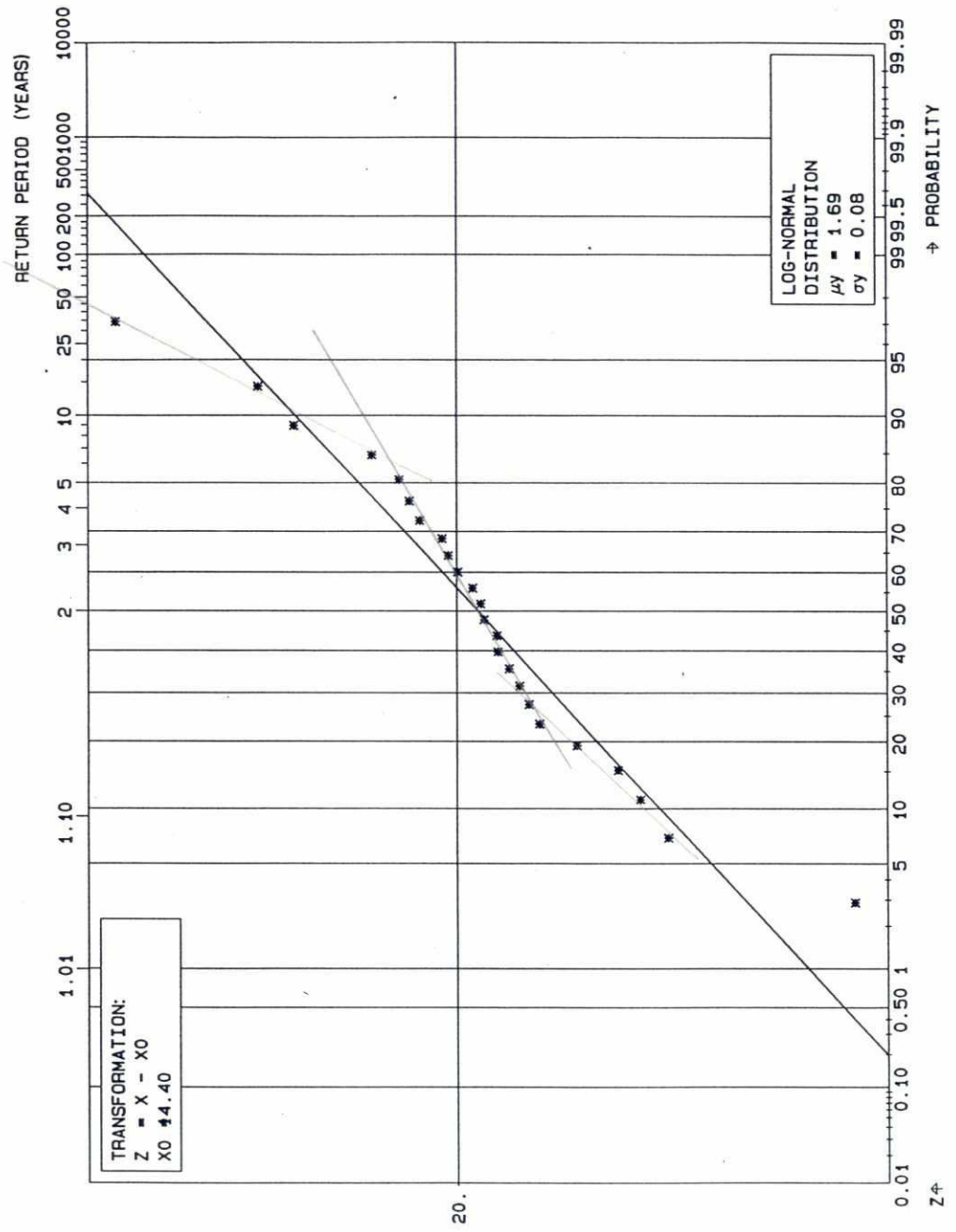


Comparison curves between observed and computed water level at Bahadurabad (1989-90)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A . 5 – 13



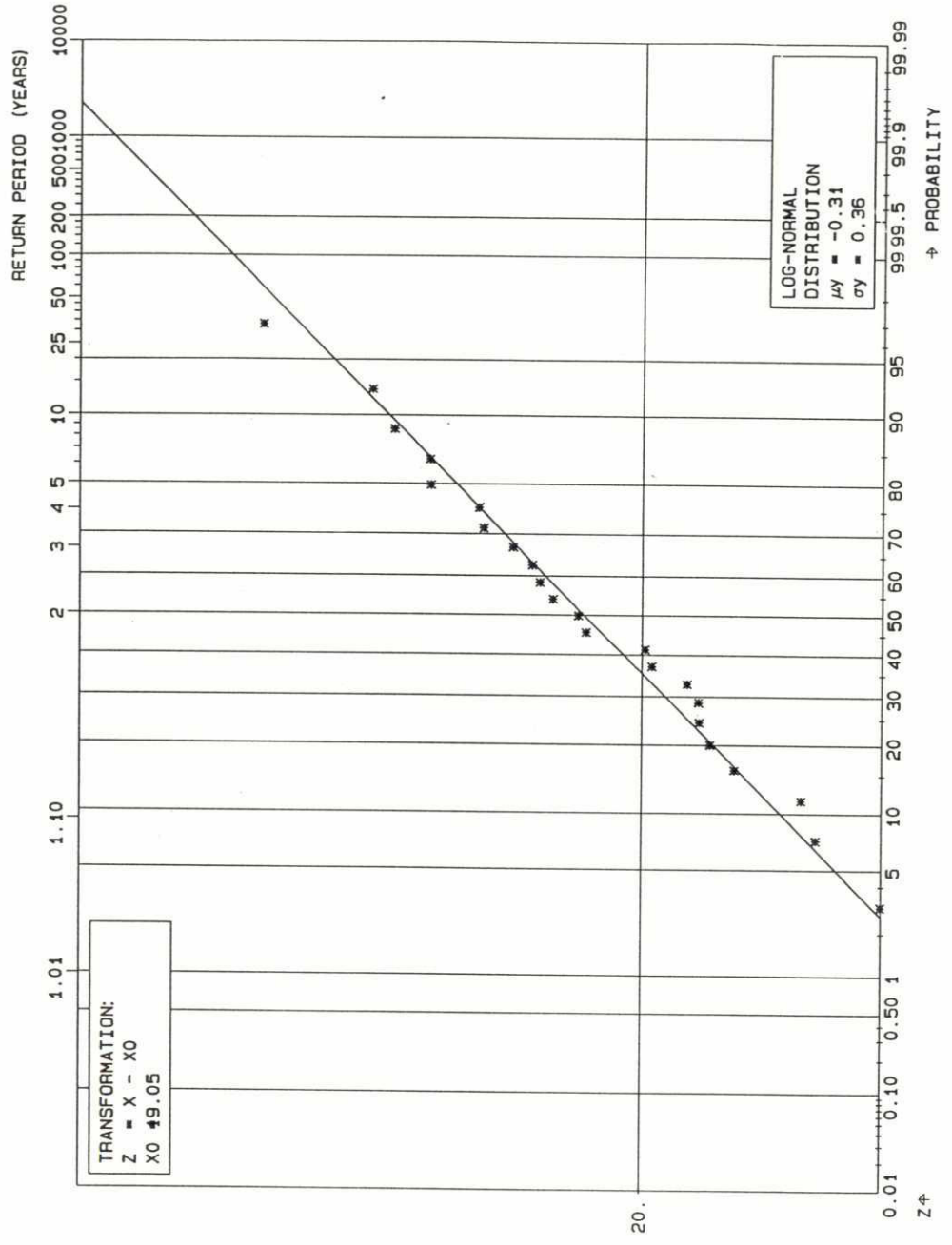
Maximum water level distribution at chainage 85 km near Bahadurabad

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 -14

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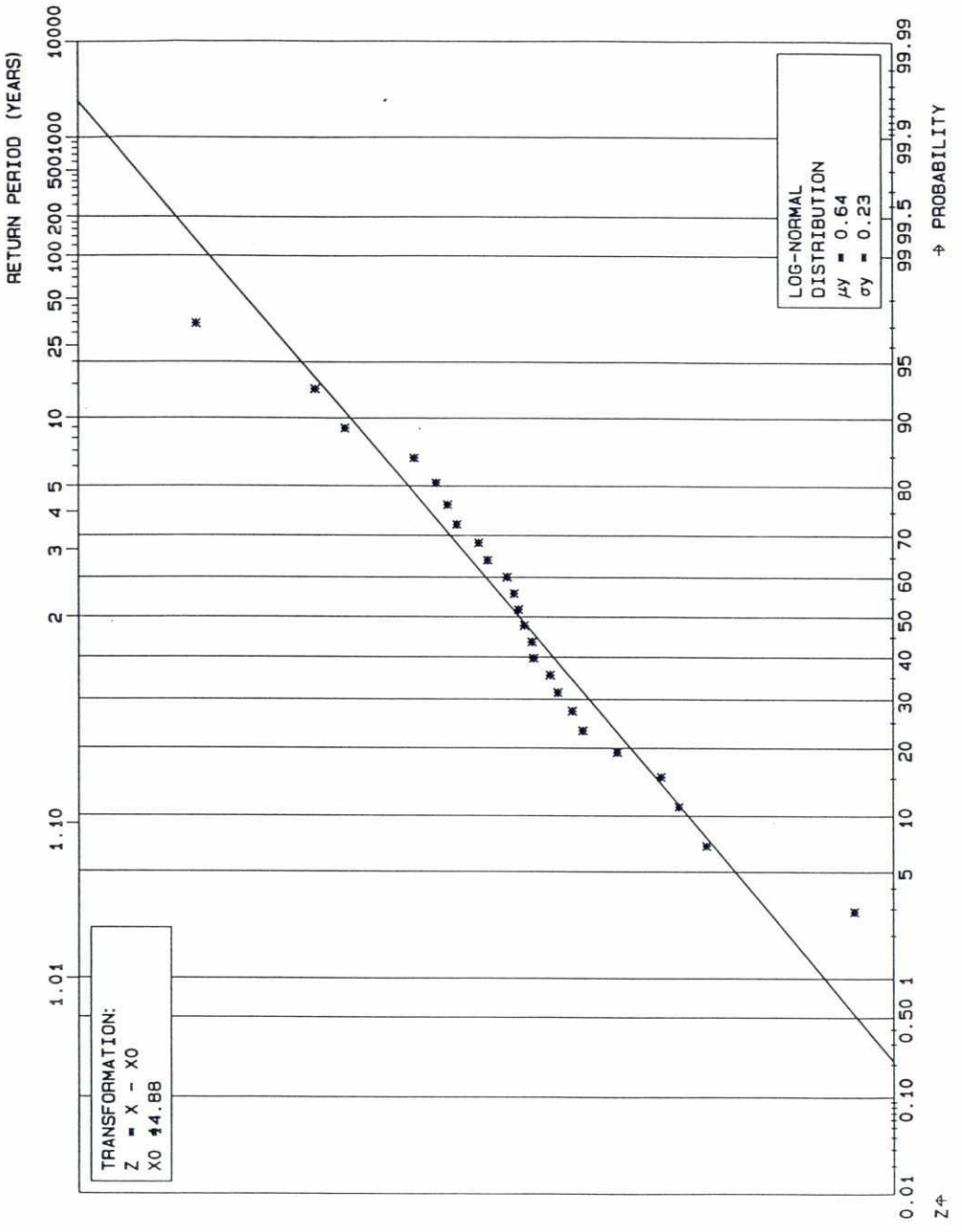


Maximum water level distribution at Bahadurabad

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 15

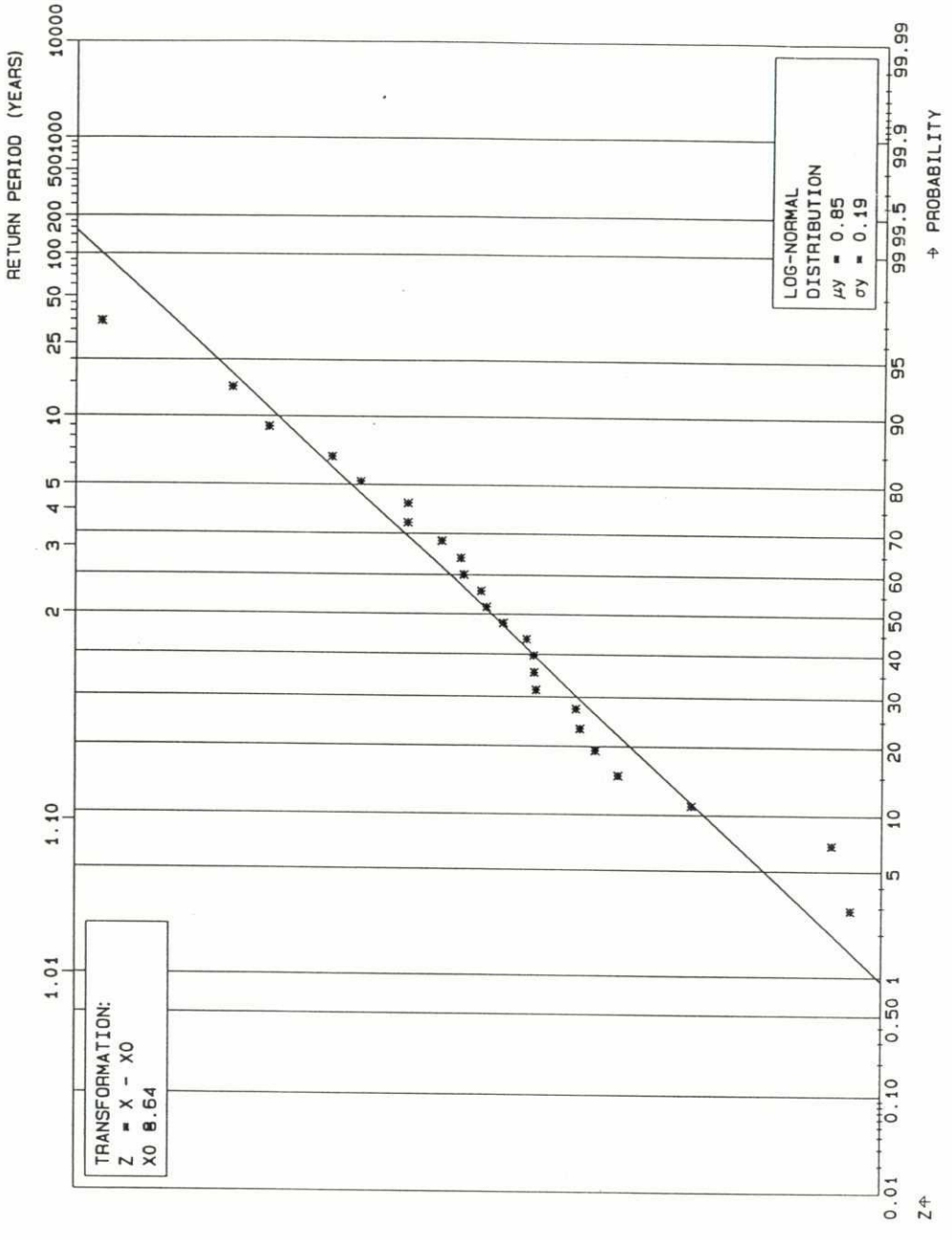


Maximum water level distribution at Chandanbaisa

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 16



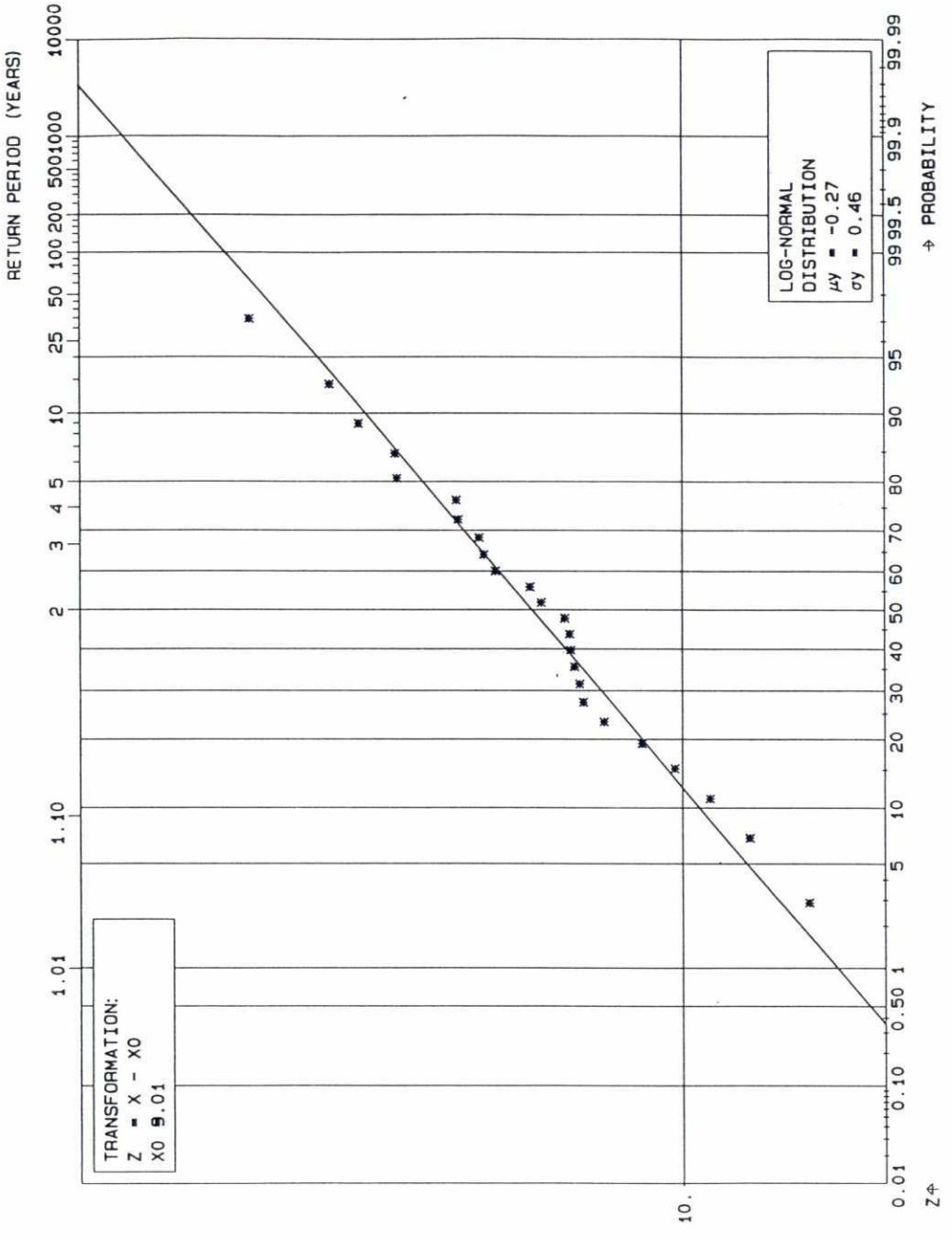
Maximum water level distribution at Nakalia

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT

FIG. A.5 - 17

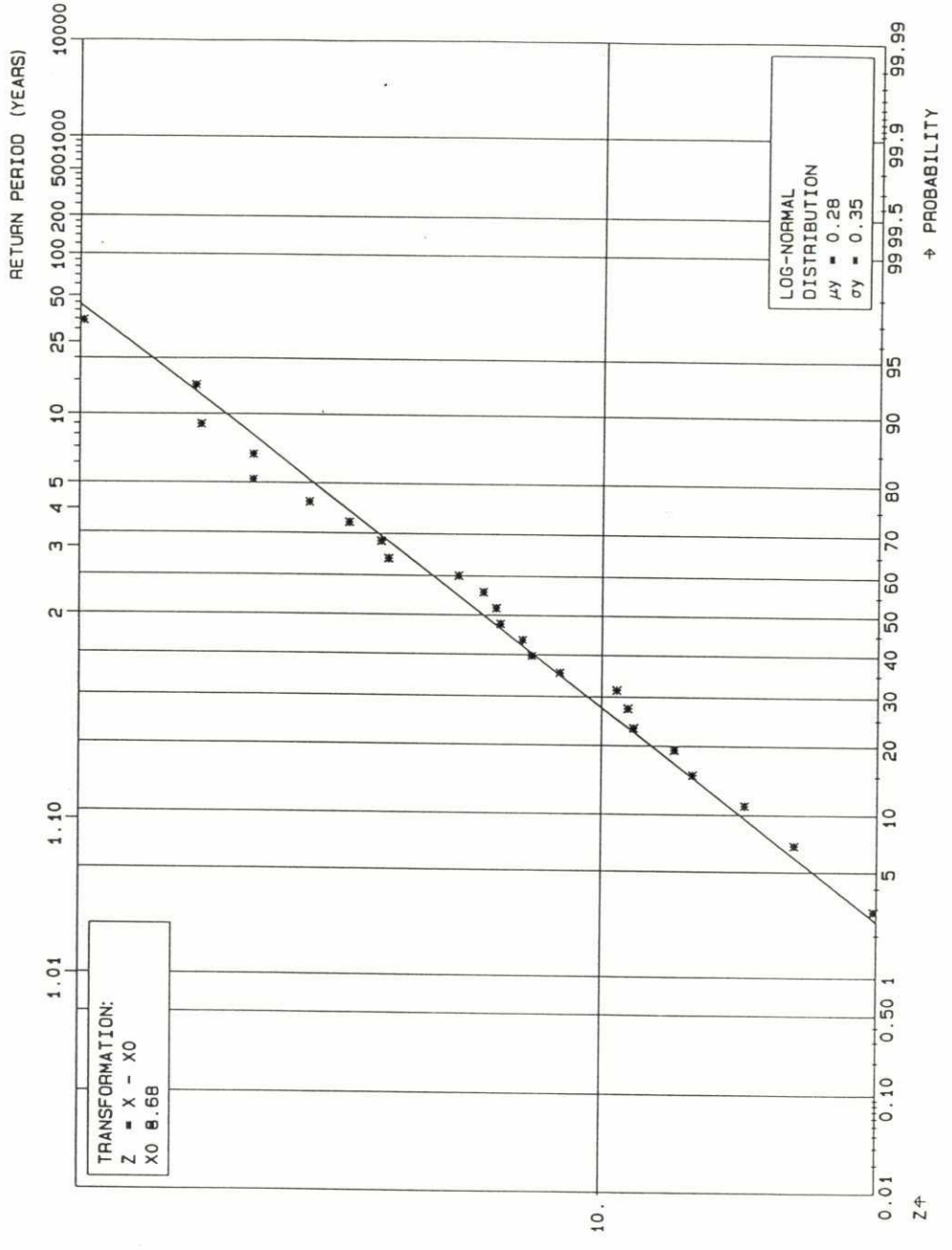


Maximum water level distribution at chainage 220 km near Nakalia

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5-18

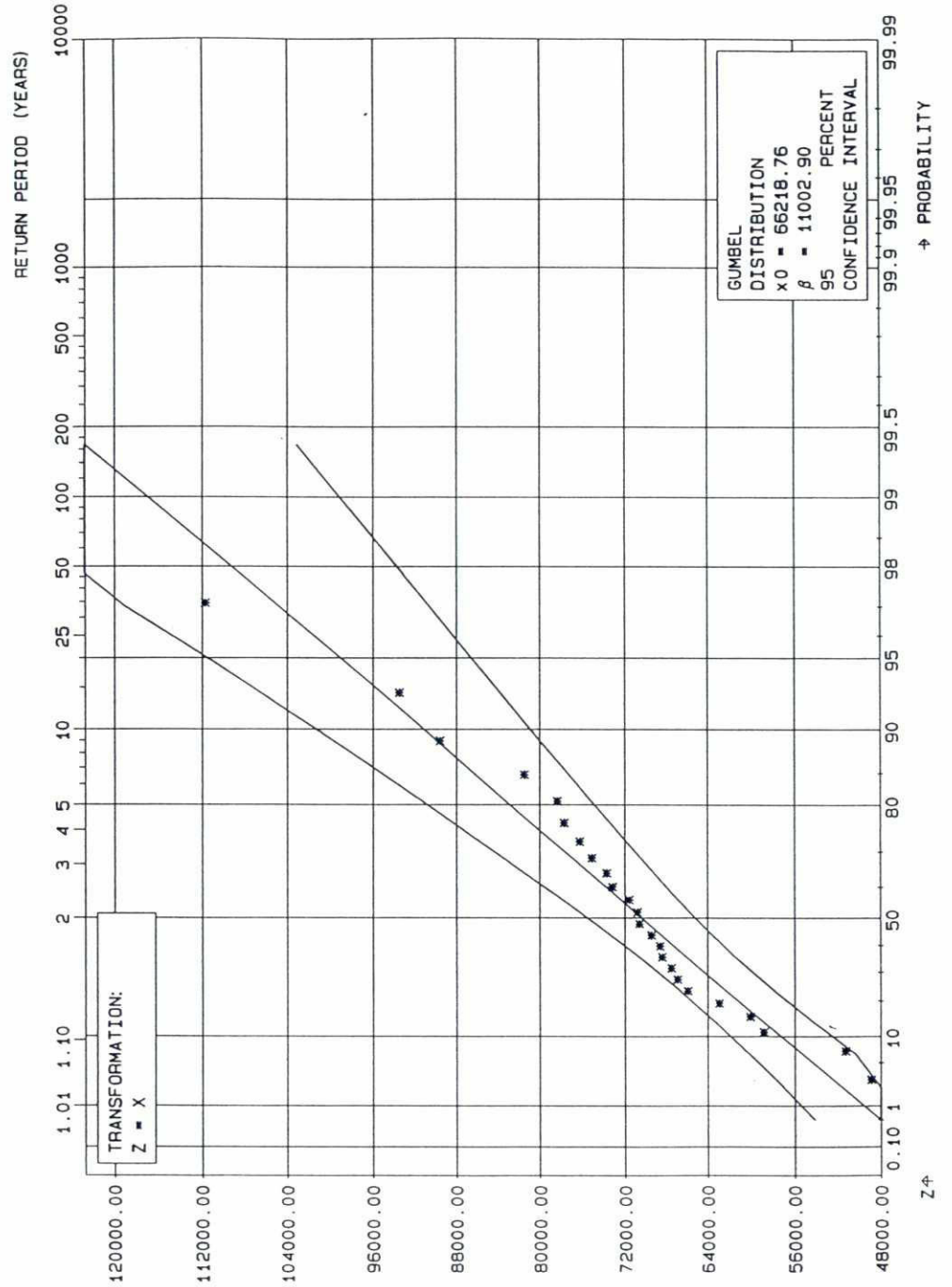


Maximum water level distribution at Mathura

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 -19

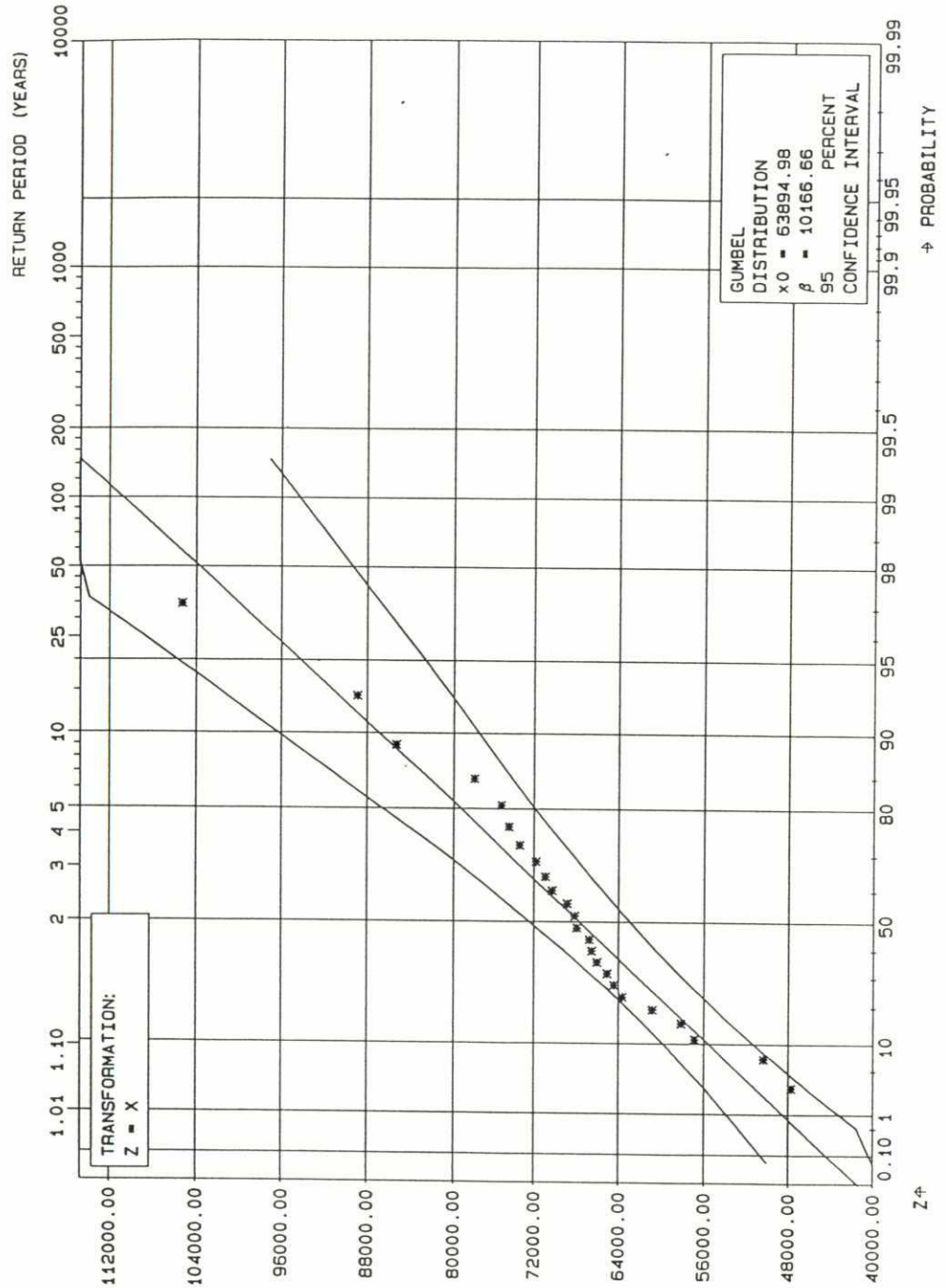


Annual maximum discharges near Manos regulator at Kamarjani

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 20

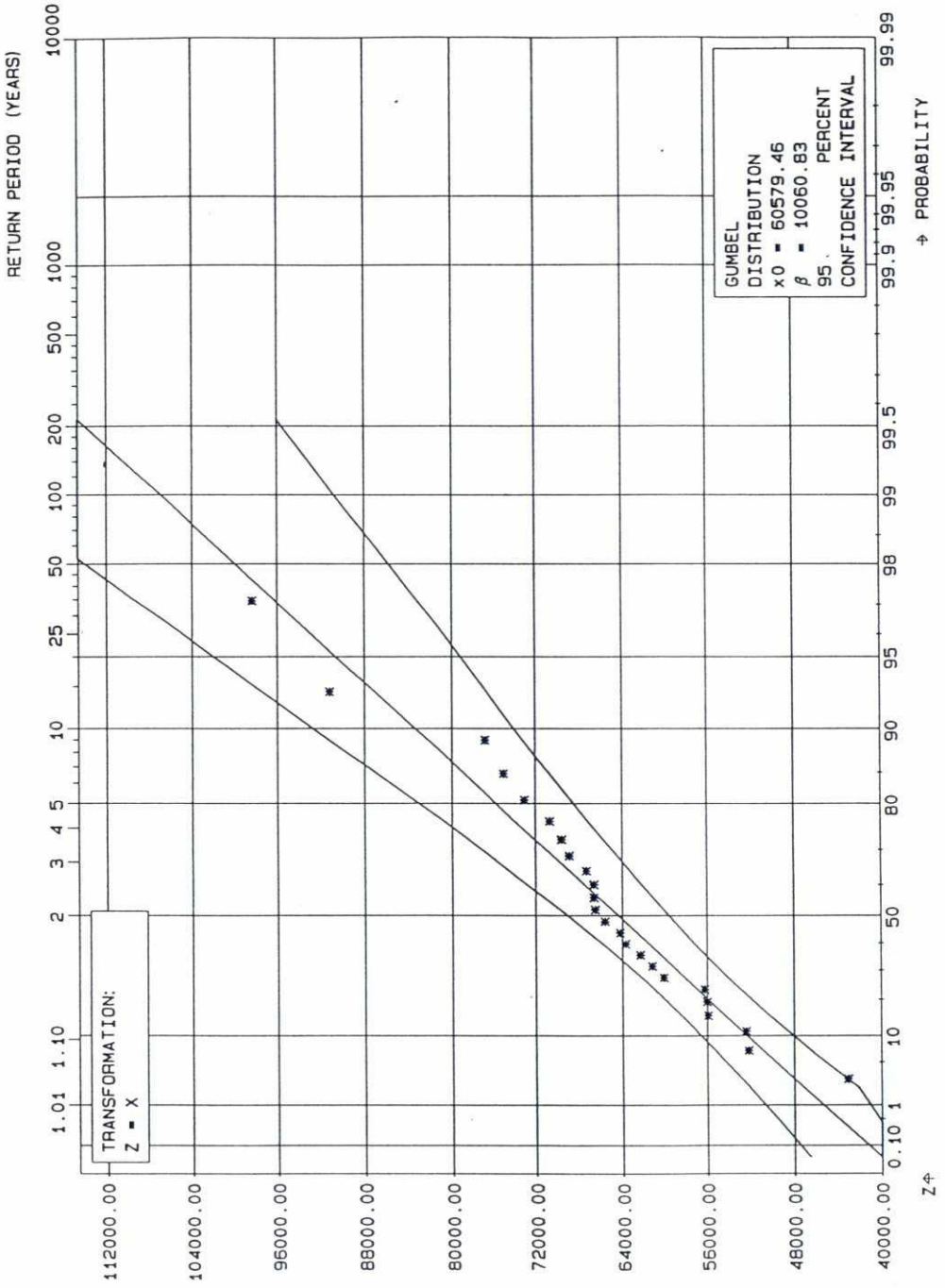


Annual maximum discharges at chainage 83 km near Bahadurabad

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 21

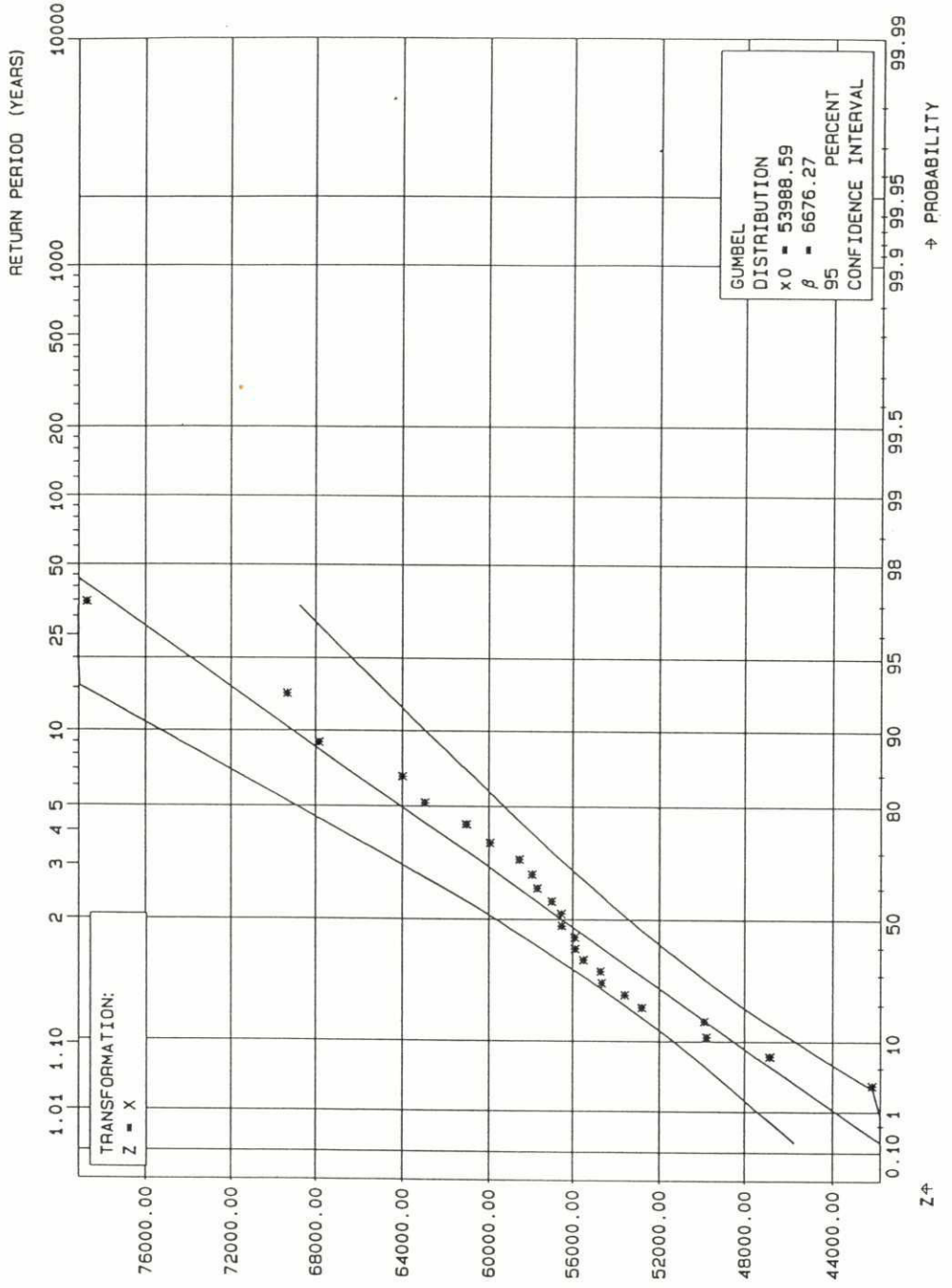


Annual maximum discharges at Bahadurabad

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 22

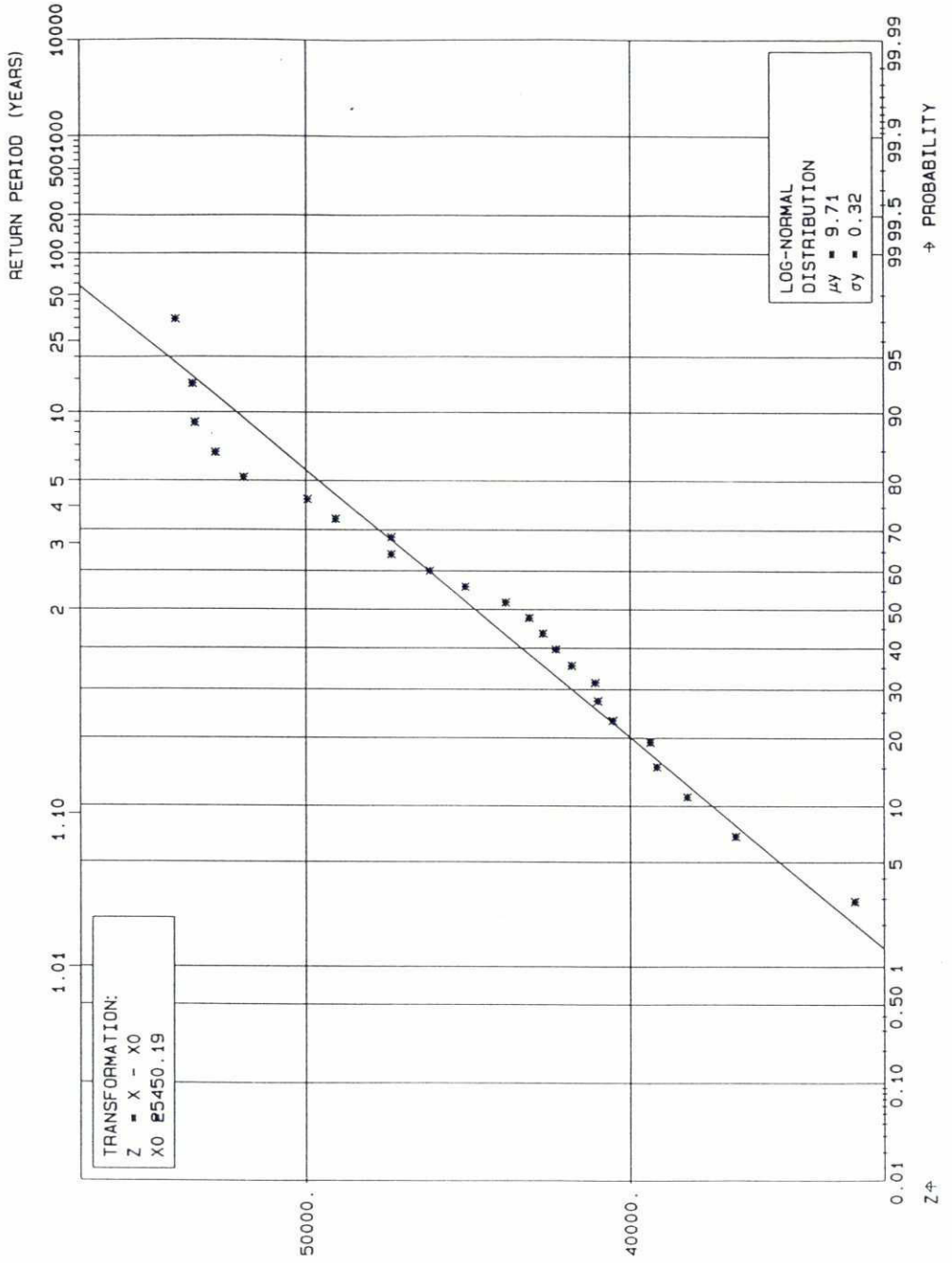


Annual maximum discharges at Mathura

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 23

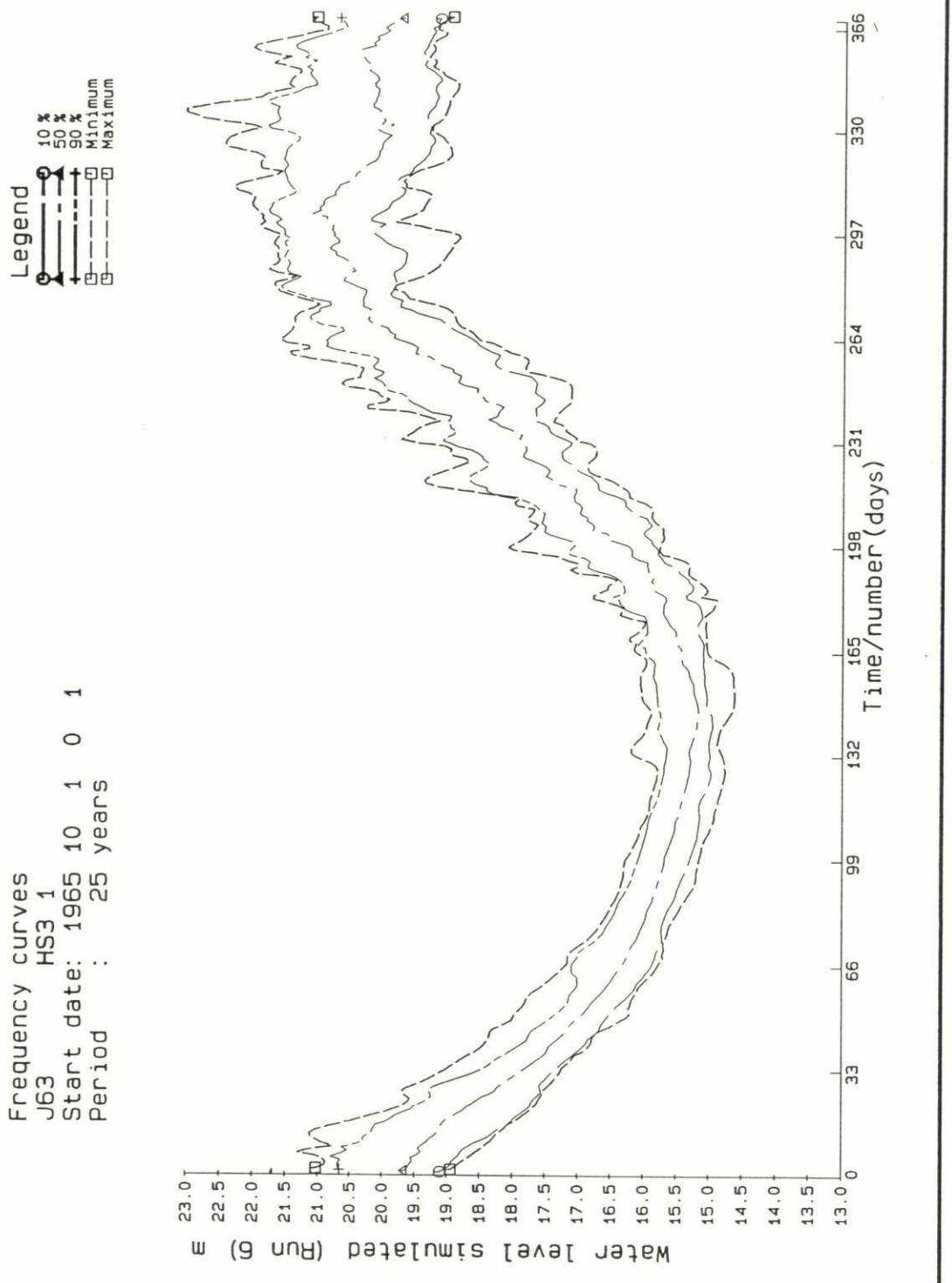


Seasonal (July - Sept.) mean discharge at Bahadurabad

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 24

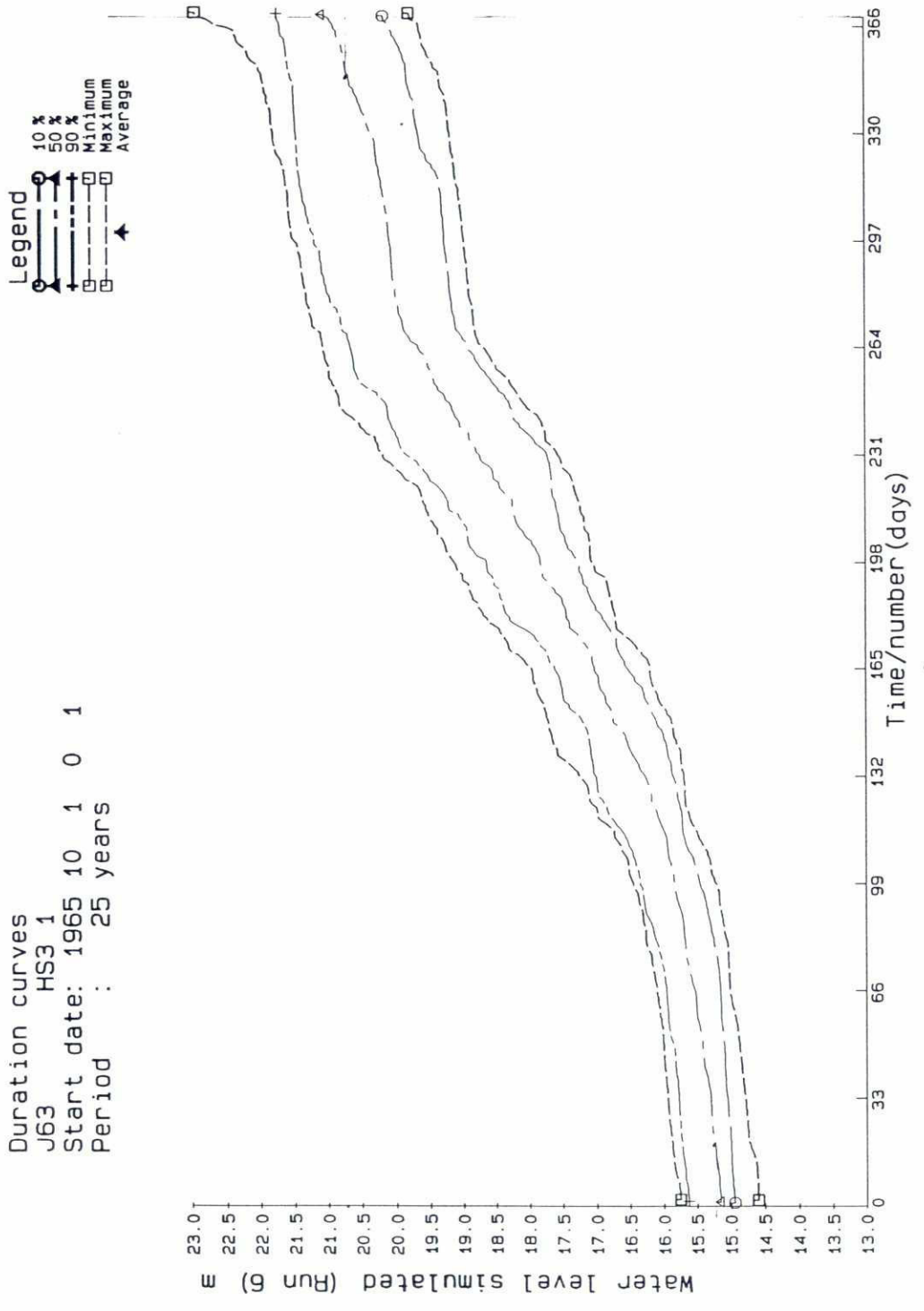


Frequency analysis of the water level at Kamarjani

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 25

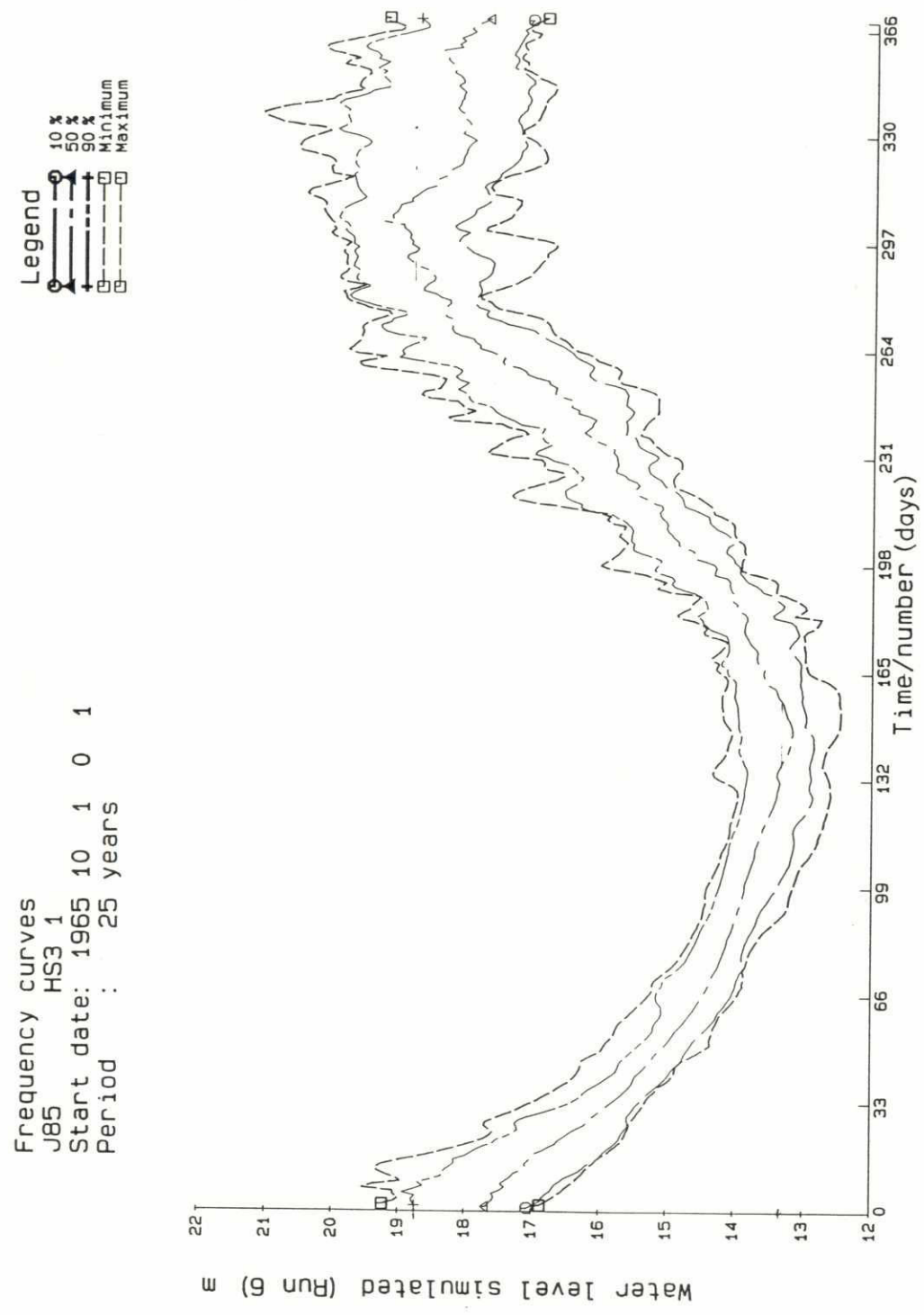


Duration curves of the water level at Kamarjani

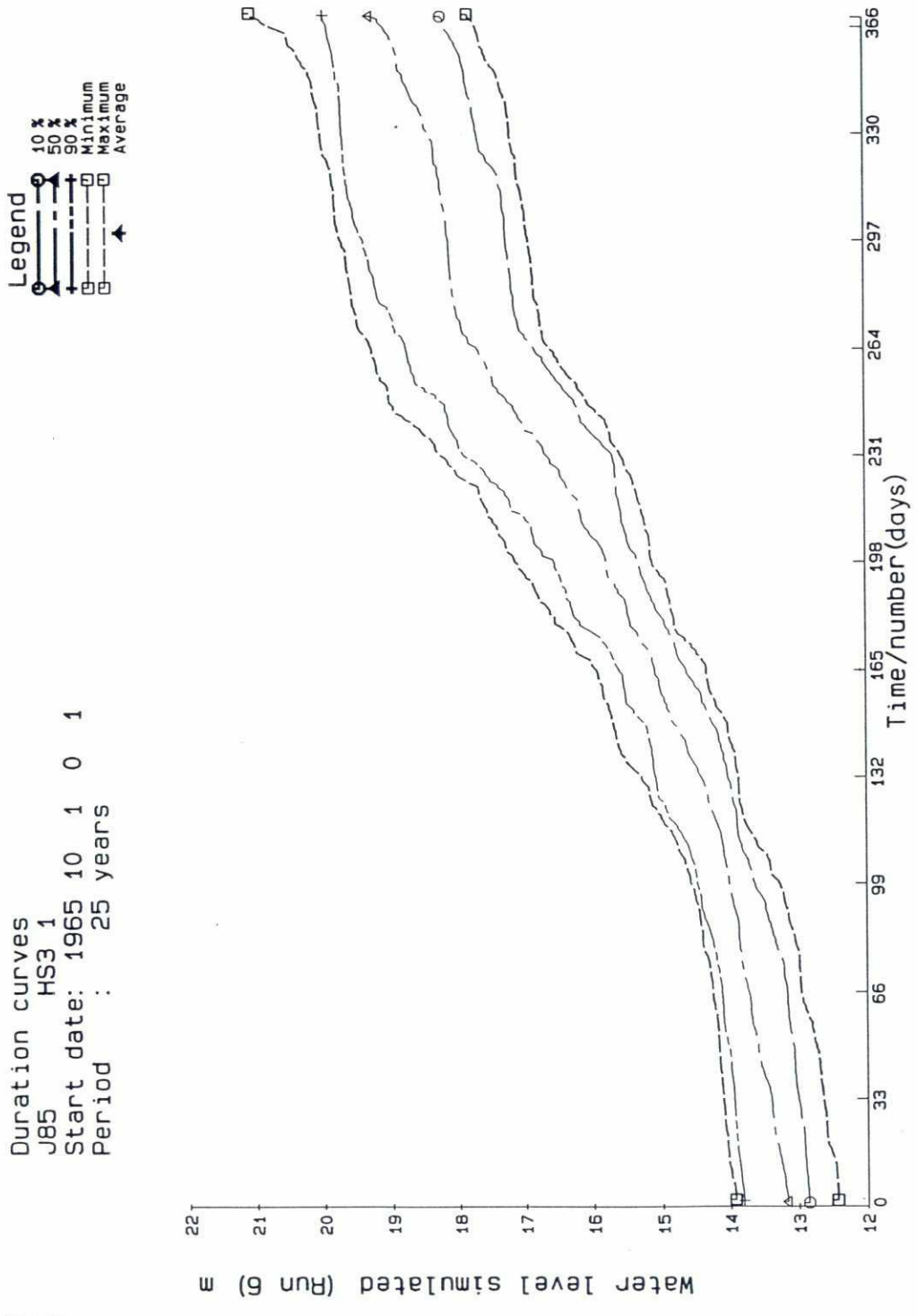
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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 26



Frequency analysis of the water level at chainage 85 km near Bahadurabad	FAP -21/22 BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT	
	FINAL REPORT	FIG. A.5-27



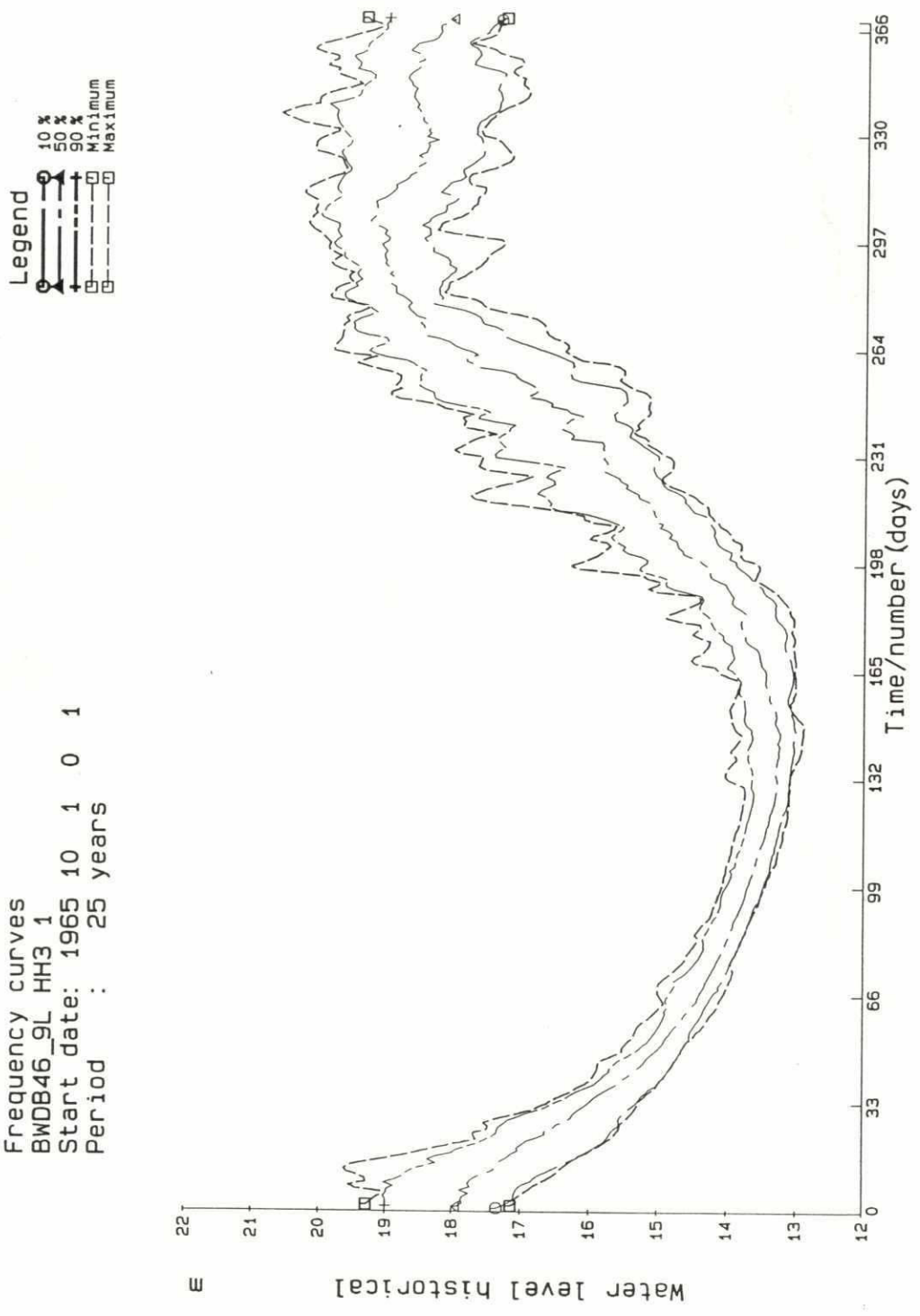
Duration curves of the water level at chainage 85 km near Bahadurabad

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5-28

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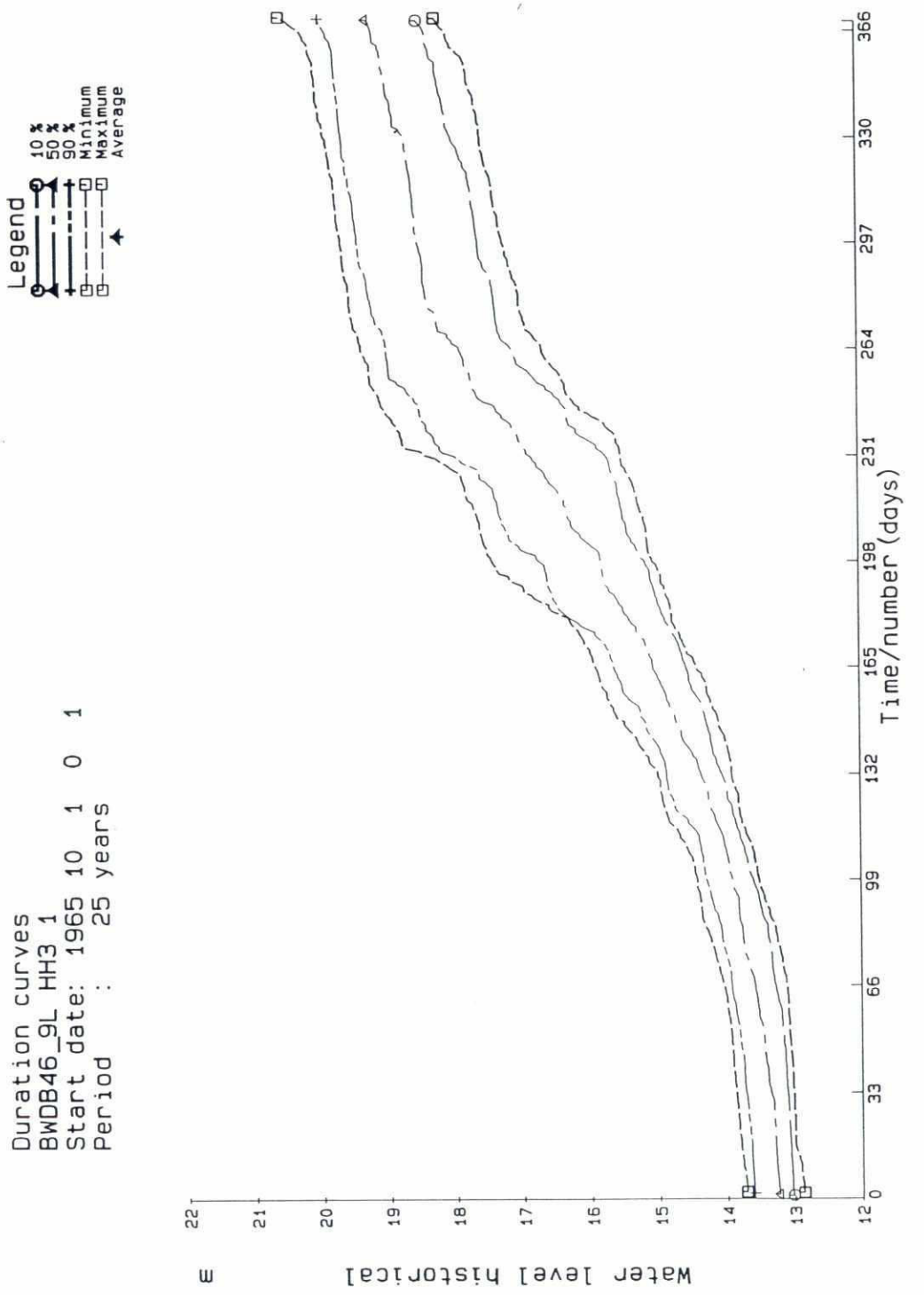
Frequency analysis of the water level at Bahadurabad

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 - 29

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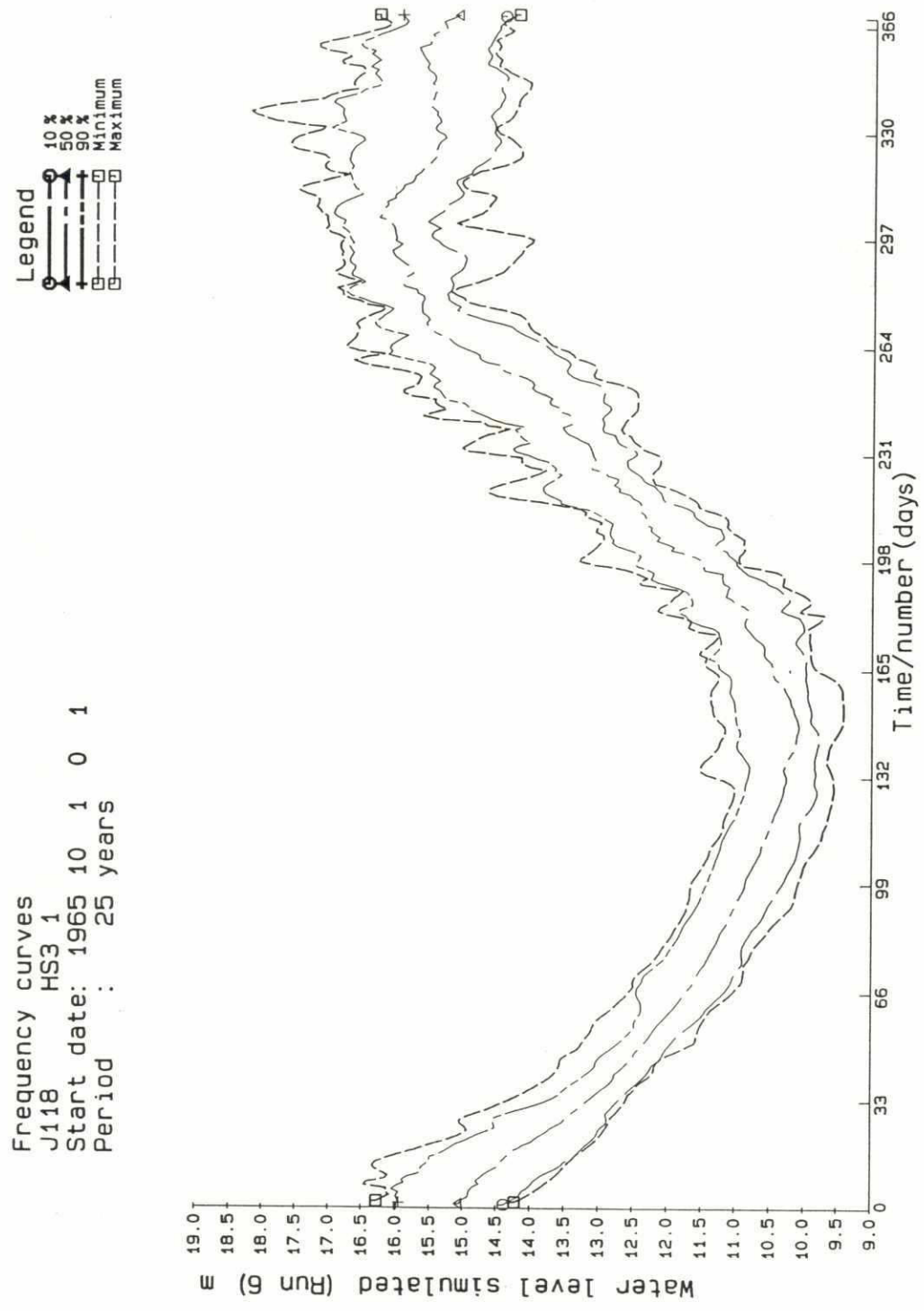
Duration curves of the water level at Bahadurabad

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 30

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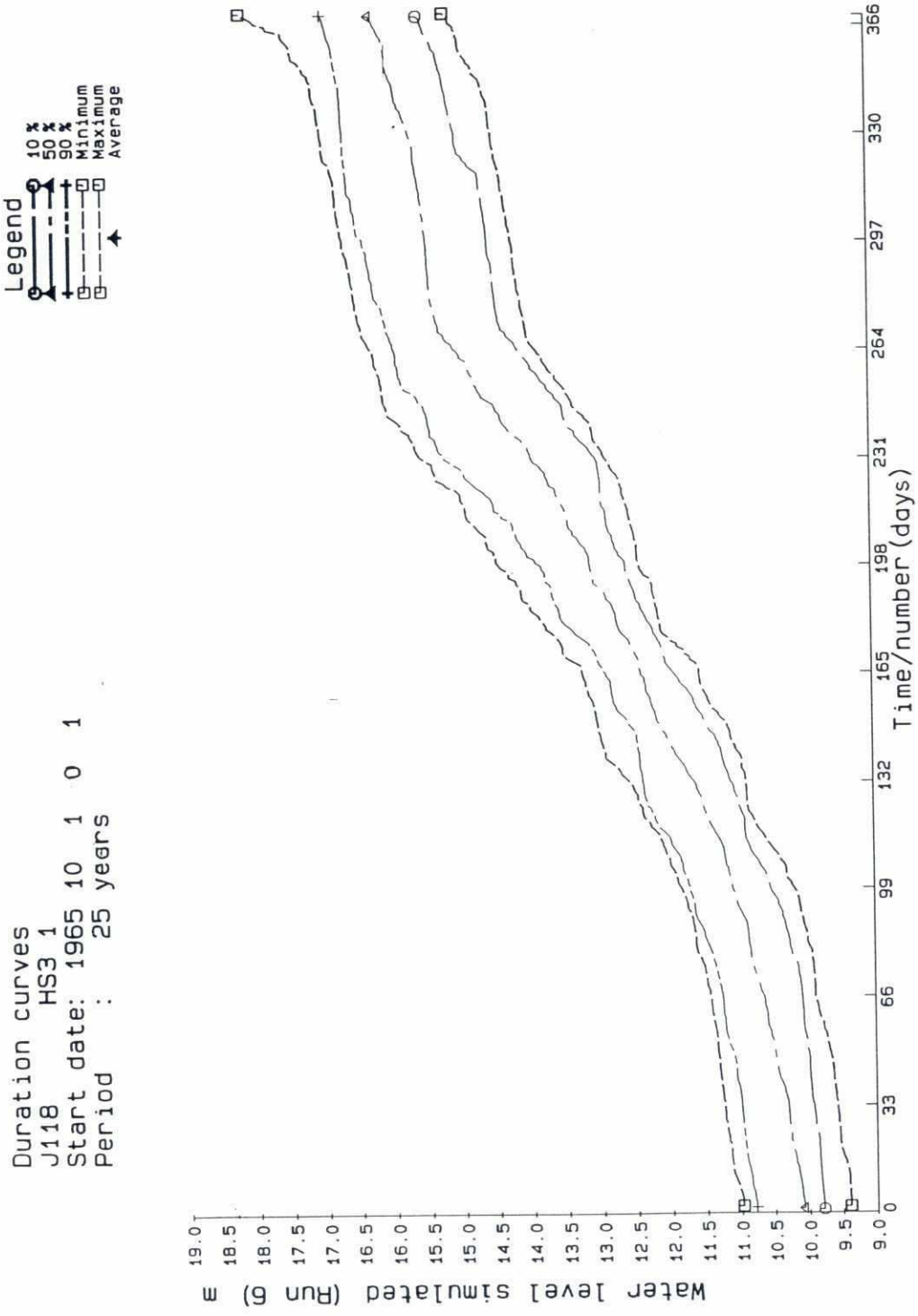


Frequency analysis of the water level at Chandanbaisa

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 31



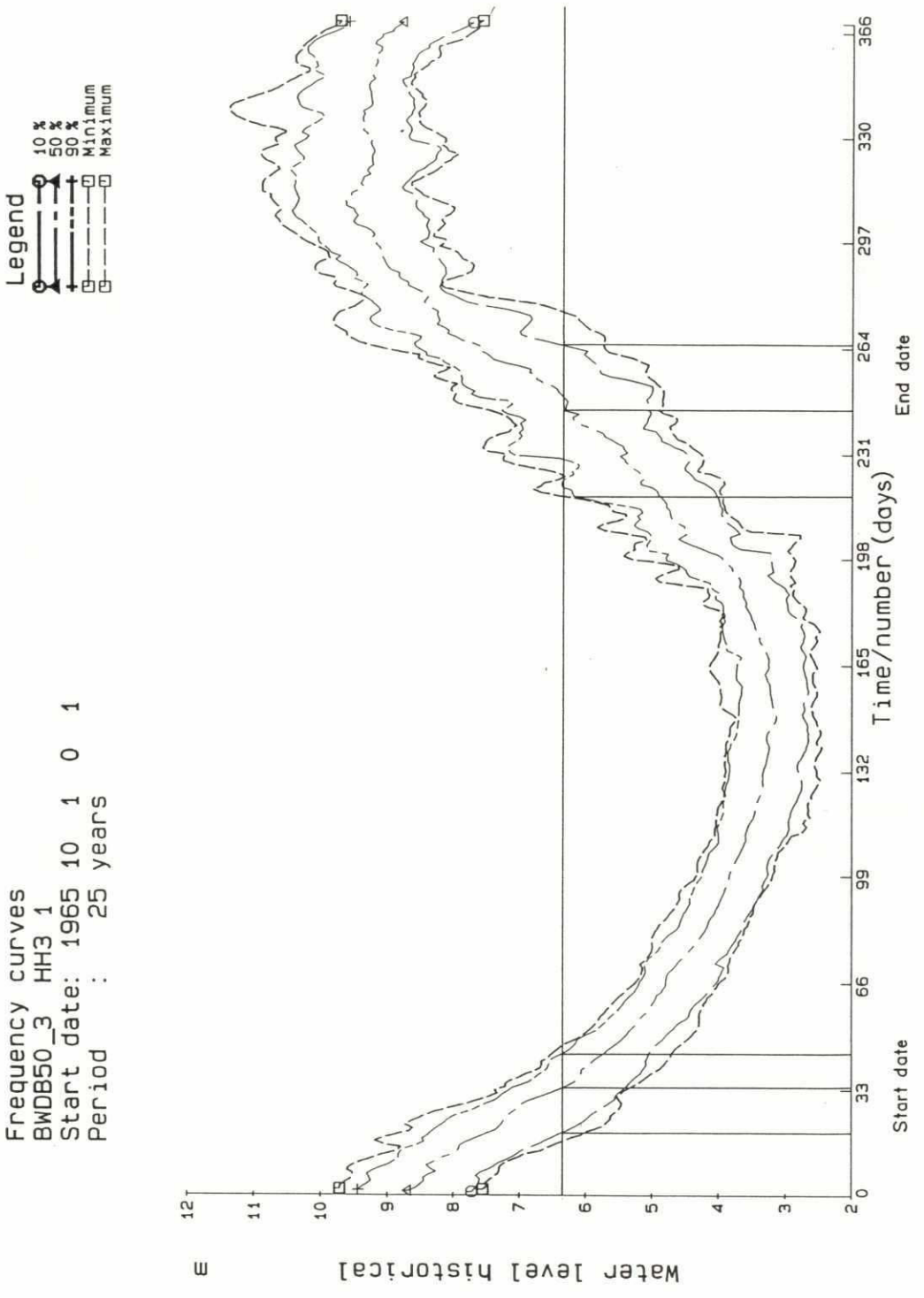
Duration curves of the water level at Chandanbaisa

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A . 5 – 32

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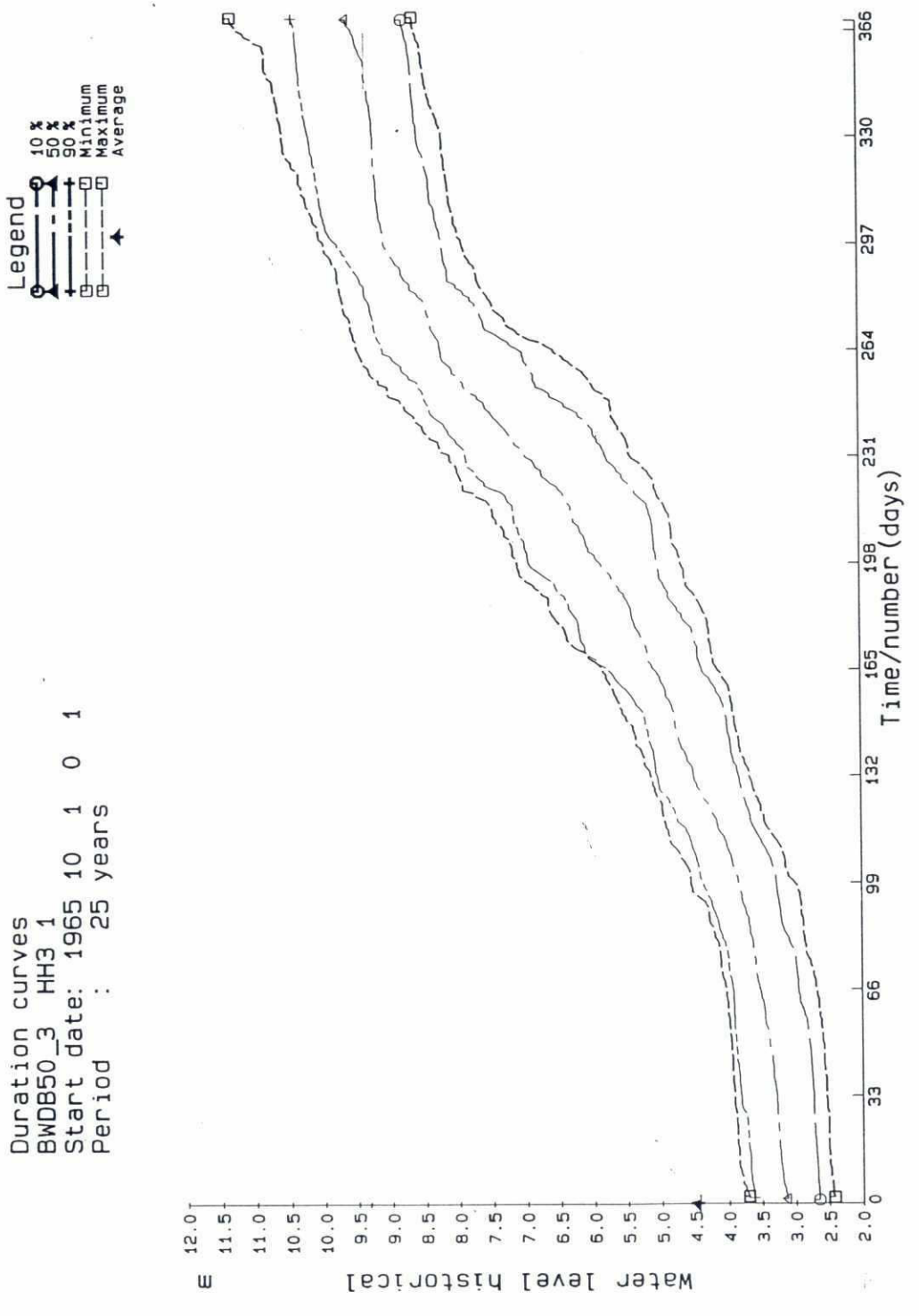


Frequency analysis of the water level at Mathura

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 33



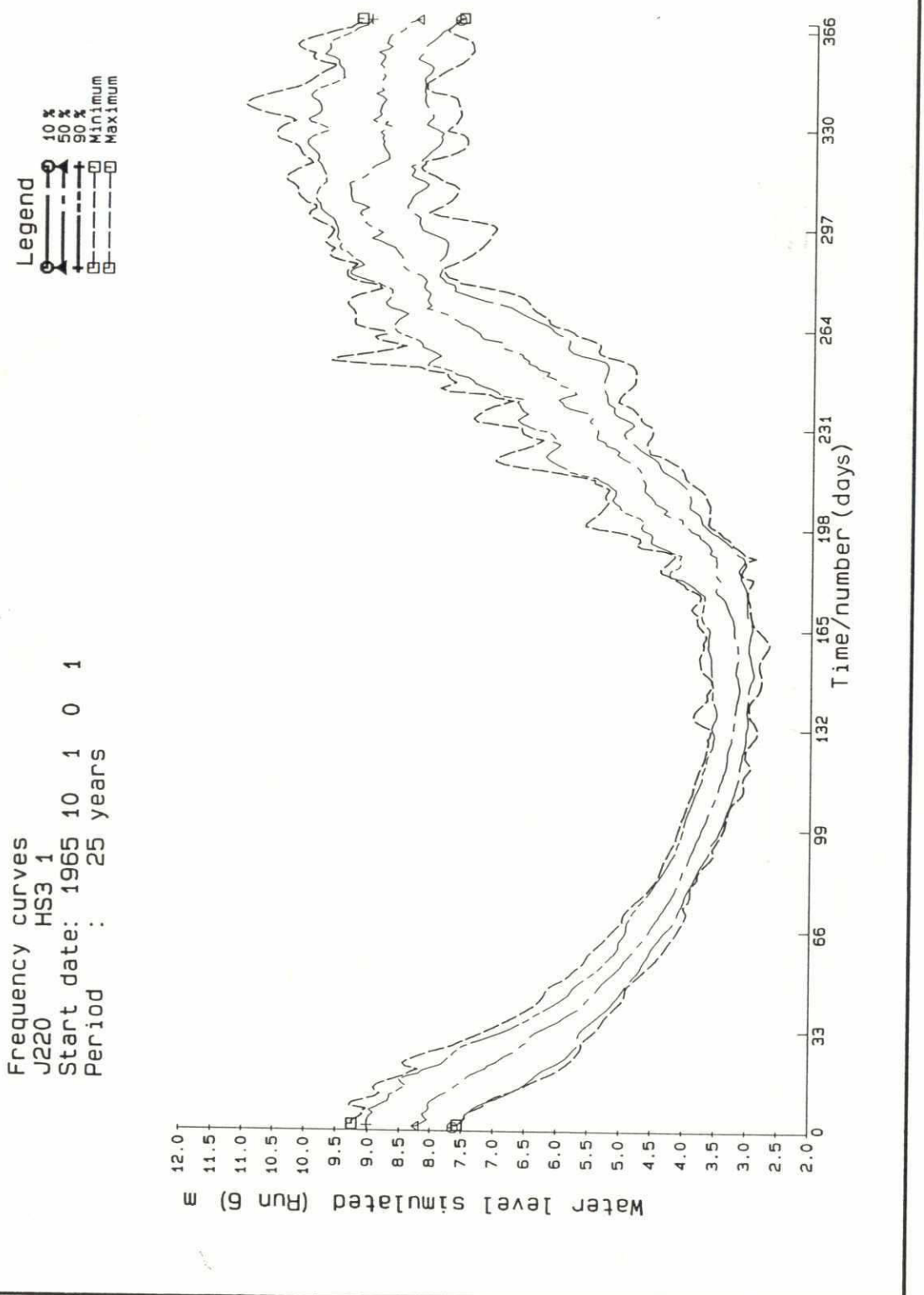
Duration curves of the water level at Mathura

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 34

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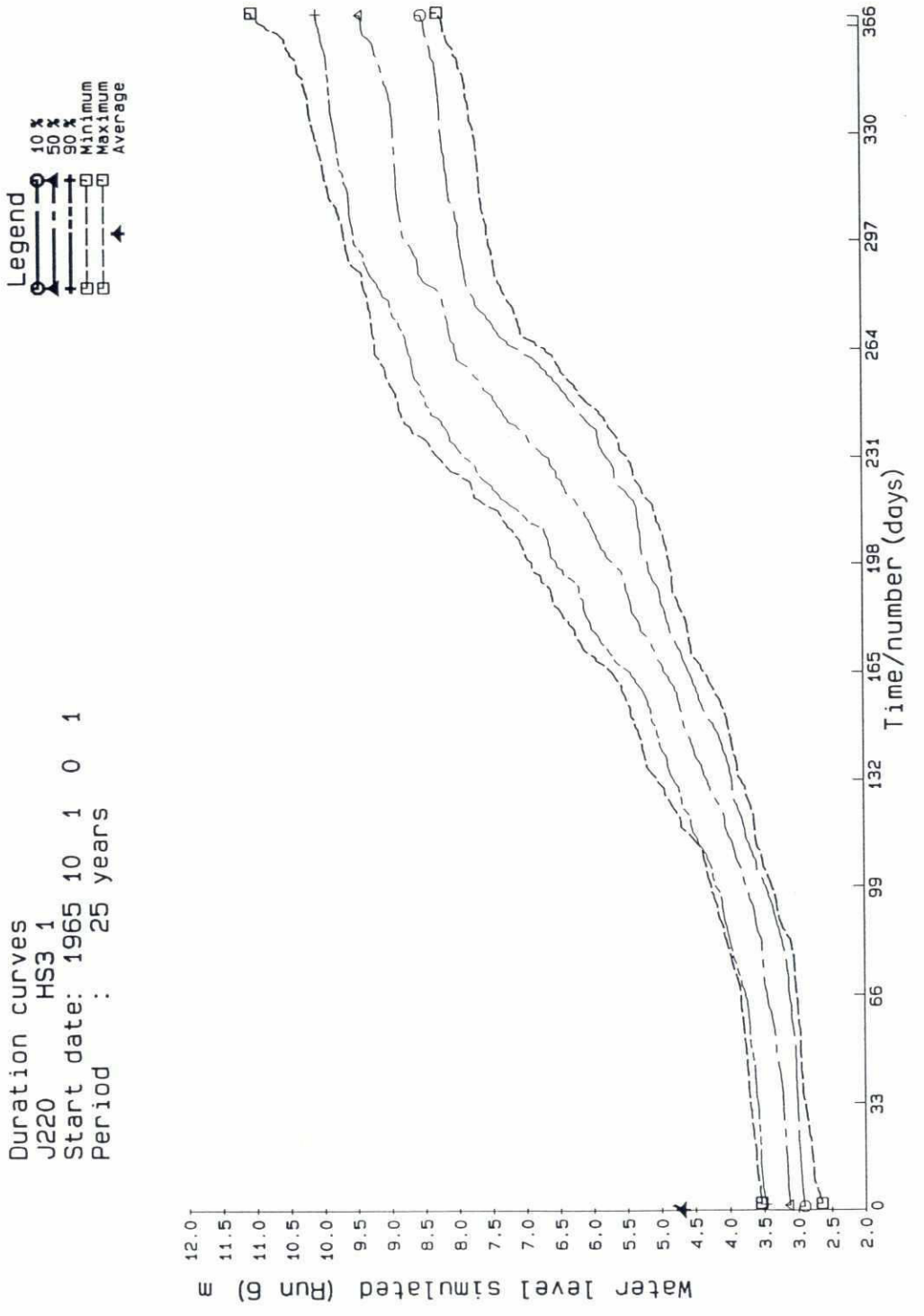


Frequency analysis of the water level at chainage 220 km near Nakalia

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 35

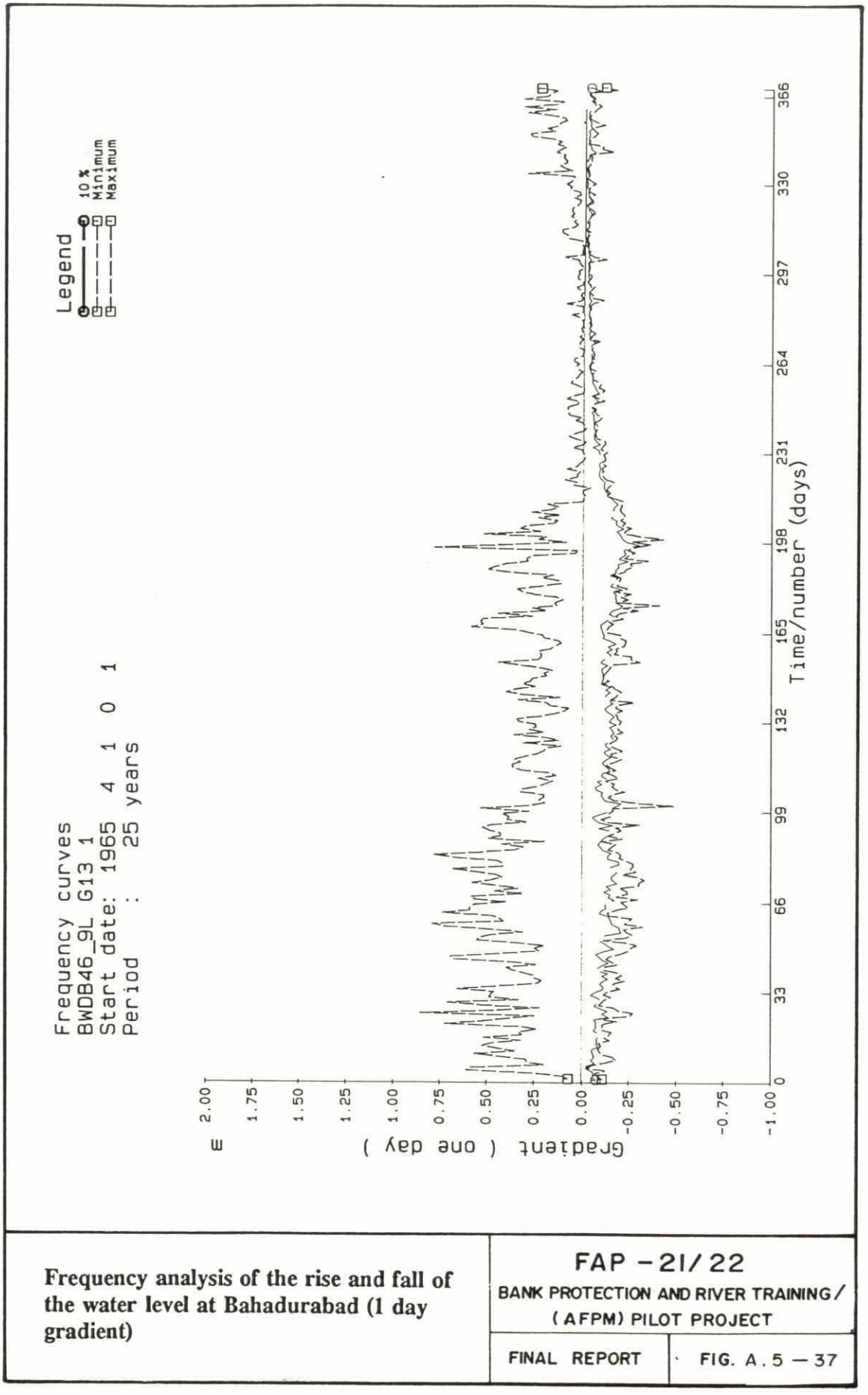


Duration curves of the water level at chainage 220 km near Nakalia

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5–36

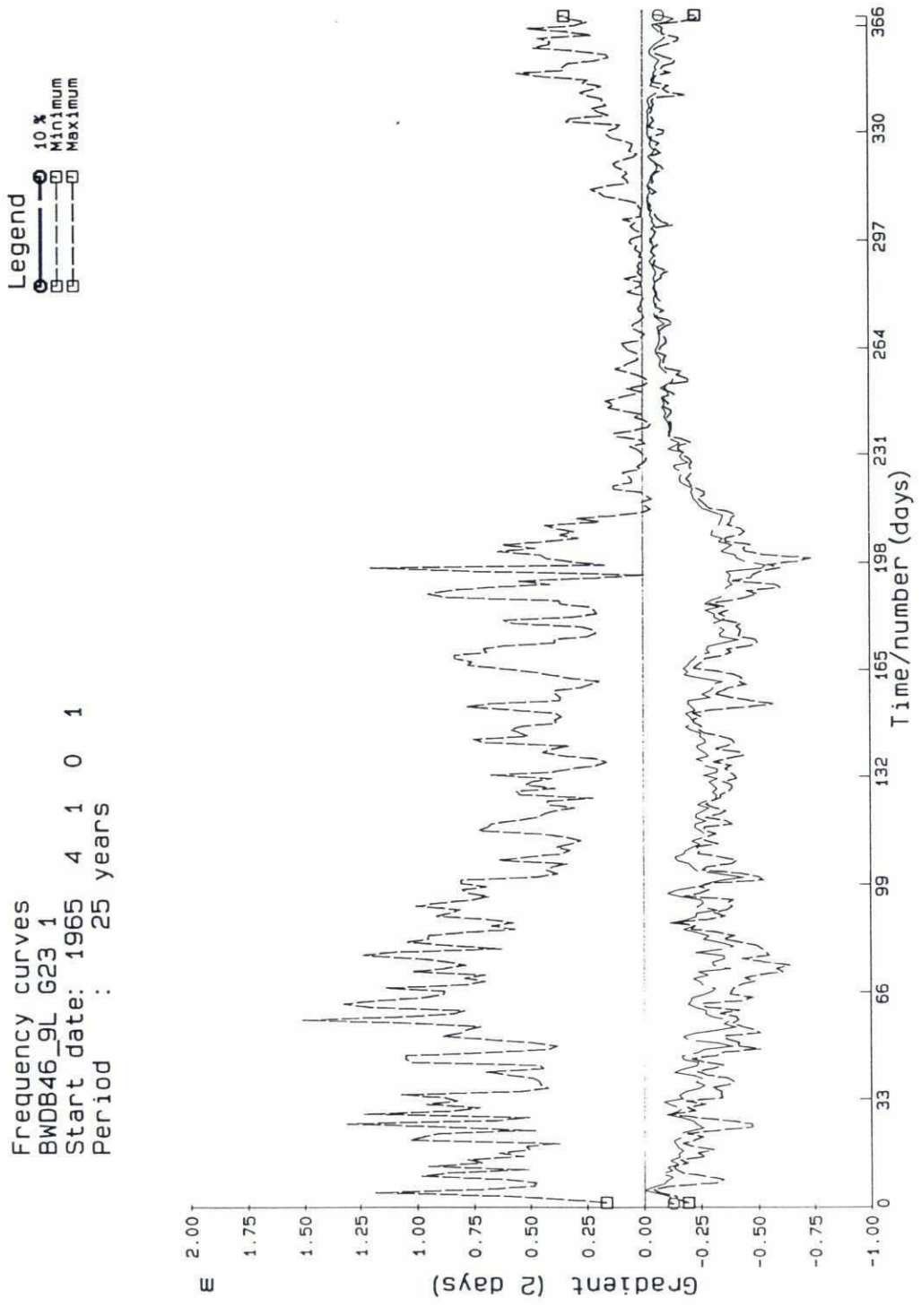


Frequency analysis of the rise and fall of the water level at Bahadurabad (1 day gradient)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 37

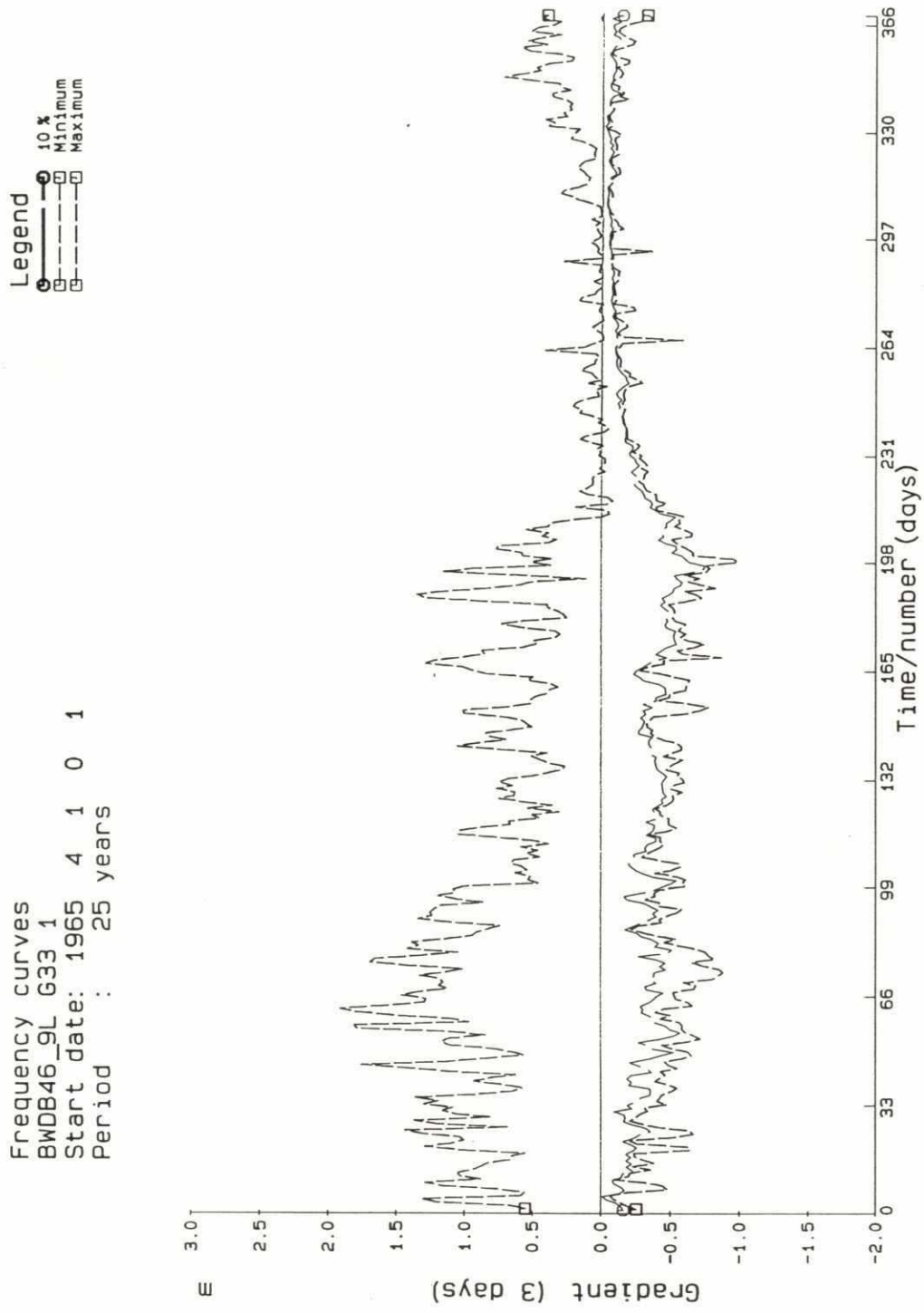


Frequency analysis of the rise and fall of the water level at Bahadurabad (2 days gradient)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A . 5 – 38

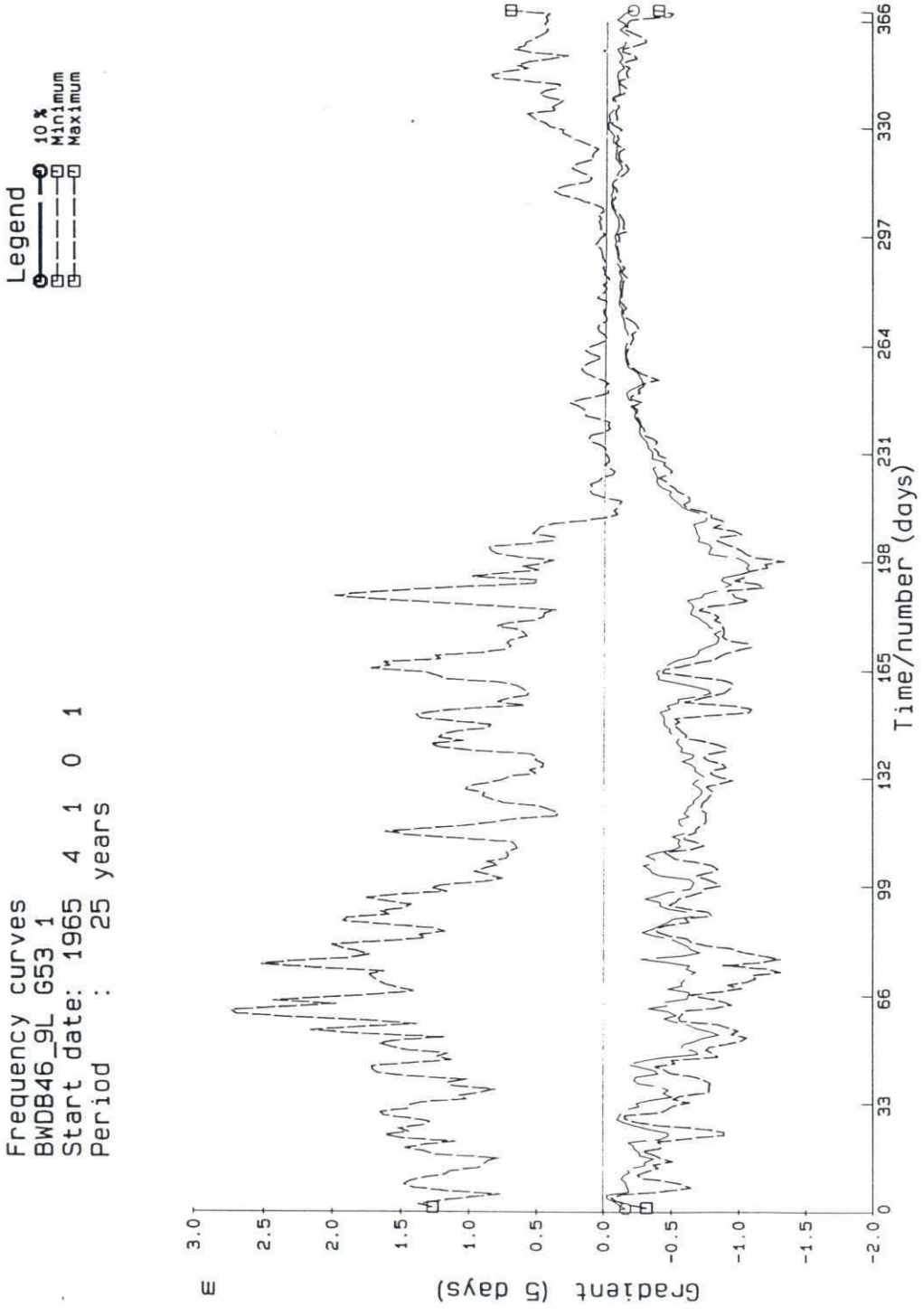


Frequency analysis of the rise and fall of the water level at Bahdurabad (3 days gradient)

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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 39



Frequency analysis of the rise and fall of the water level at Bahdurabad (5 days gradient)

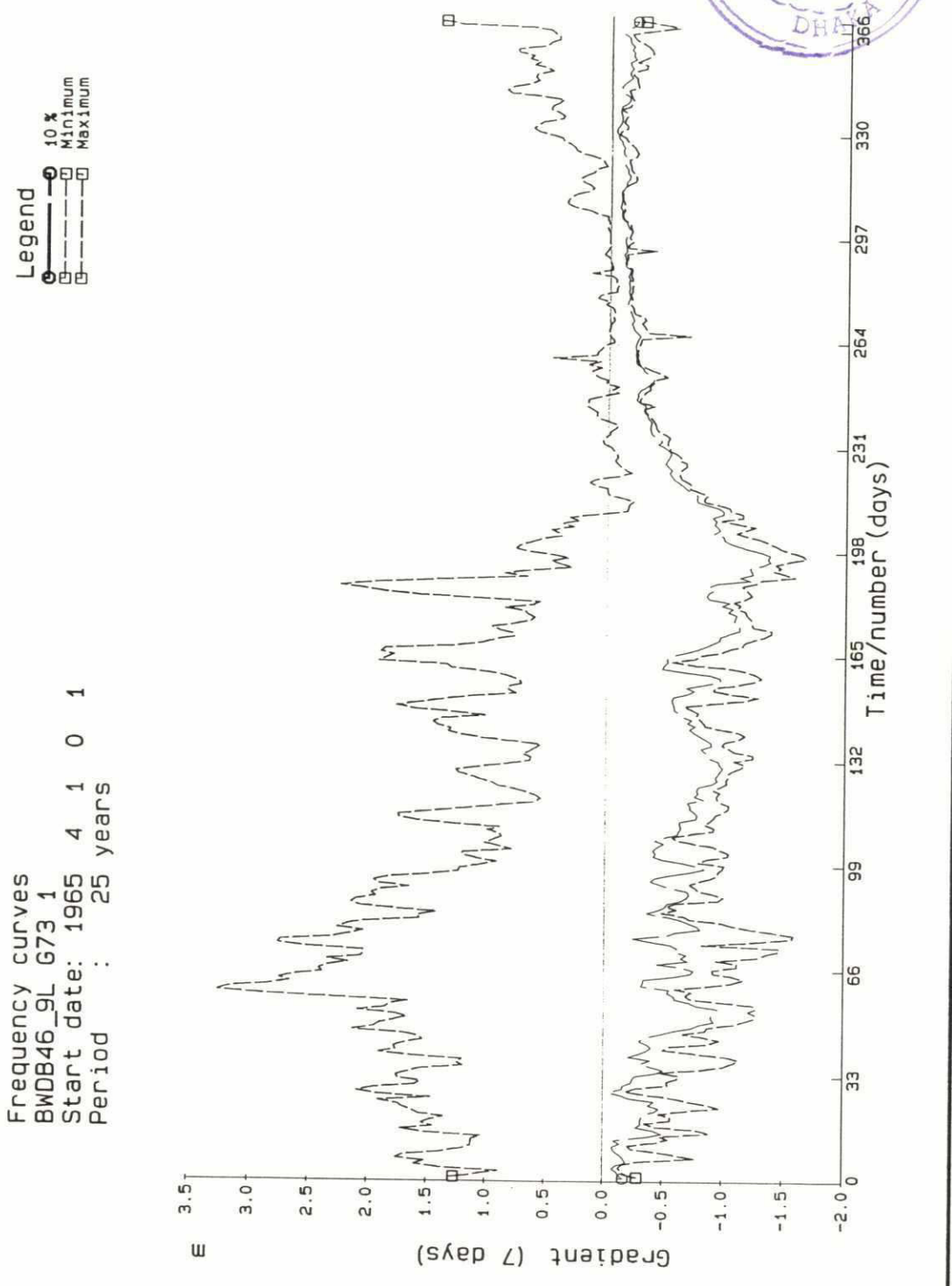
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BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.5 – 40

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Frequency analysis of the rise and fall of the water level at Bahdurabad (7 days gradient)

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FINAL REPORT | FIG. A.5 - 41

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(AFPM) PILOT PROJECT
FAP 21/22

DRAFT FINAL REPORT

ANNEX 6

MATHEMATICAL MODEL TESTS

JANUARY 1993

ANNEX 6

MATHEMATICAL MODEL TESTS

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(Presented with Draft Final Report, FAP 22)

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4 INTRODUCTION

The probable flow fields near the test structures are computed with a two-dimensional mathematical model. The computed flow velocities are used to determine the design flow velocities which are decisive for the design of these test structures. The computations are also used for the determination of the boundary conditions of the physical models of the test structures. The discharge distribution at the inflow of the physical models and the lateral boundary which should follow a flow line are compared with the computed flow field.

After a description of the characteristics of the mathematical model in Section 5 the schematization for the model and the computed flow field test structure near Kamarjani (Section 6) and the test structure near Bahadurabad (Section 7) are discussed.

5 THE TRISULA PROGRAMME

The mathematical model TRISULA can simulate three dimensional flow based on a hydrostatic approach. These three dimensional flows are, for example, non-steady and wind driven flow fields, which can include the effects of density differences due to non-uniform heat and salt concentration distributions in estuaries and in rivers. The programme was developed by DELFT HYDRAULICS in cooperation with the Netherlands Ministry of Public Works and the Rand Corporation (see Delft Hydraulics, 1991).

A hydrostatic approach means that the effects of vertical accelerations and sudden variations in the bottom topography can not be reproduced properly. These limitations are known as the shallow water assumption under which the vertical momentum equation is reduced to the hydrostatic pressure relation. The fluid is taken as incompressible and density variations are neglected in the equations of motion except in the buoyancy term. This assumption is known as the Boussinesq Approximation. In the numerical method the model area is covered by a two-dimensional, curvilinear orthogonal grid of variable size. This enables an accurate schematization of complicated geometries and increases the computational efficiency. For the water level, the depth and the flow velocity components are defined in different grids which are staggered by half a grid space in one or both directions. The flow velocity is computed in a water level point using the averaged flow velocity components entering and leaving the box which is defined by the curvilinear grid.

A simulation with the TRISULA programme is prepared in the following steps:

- determination of the model area,
- the generation of a curvi-linear grid within this model area,
- the definition of the bed level at the grid points,

- the estimation of the hydraulic roughness of the model, if no accurate data are available from the field,
- the selection of the boundary conditions,
- the specification of the required output.

These steps are explained in more details in the following chapters.

The model boundaries were determined by the minimum grid size for the schematization of the test structures, the maximum number of grid points with respect to the available computing time, and the character of the flow field in the area of interest. For steady flow calculations with river models in general two boundary conditions, one at the upstream side and one at the downstream side of the model, should be defined. At the downstream boundary the water level is given as a function of a return period which is determined in the Section 2.2 Hydrologic Study, Draft Main Report FAP 21. The discharge distribution at the upstream boundary of the model is estimated assuming an average value of the hydraulic roughness and an estimated value for the water level gradient.

In the simulations a constant and uniform roughness Manning coefficient was applied. The assumed value of the uniform horizontal eddy viscosity of 1 m^2/s is based on experiences with previous mathematical models.

In the present study the depth averaged flow conditions were calculated for a steady flow situation at the model boundaries. For these conditions the calculations were started with a constant water level and zero velocities in both directions in the whole model. The calculations with time steps of 15 seconds were terminated when equilibrium conditions had been reached, i.e. steady flow situation. The TRISULA programme solves the depth-averaged shallow water equations with an implicit finite difference method (ADI) on the staggered curvilinear grid.

The resulting equations, which are based on vertically averaged force components, and a more detailed description of the TRISULA programme are presented in Appendix 1 for the curvilinear case.

6 KAMARJANI TEST SITE (GROYNES)

The area of the mathematical model is sketched in a detailed map of the planform 1992 of the Jamuna river, see Fig. 6-1. The discharge through the left boundary of the model is very small, because of the high char. The right boundary follows more or less the predicted future bank line after the flood in 1993. The downstream boundary is just downstream of the Manos regulator.

The curvilinear grid was chosen to follow as good as possible the estimated bankline III'94, that is the predicted bank line after the flood of 1993. The grid spacing varies

from 50 m in the area of interest to 350 m in the inner bend which forms the left boundary at the char. In the model a series of three groynes are simulated and in the mathematical grid the length of a groyne is two boxes and the spacing between the groynes is three boxes, see Fig. A.6-2. The grid point locations are referred to a system of coordinates with x-axis varying from 804000 to 811500 and the y-axis from 461000 to 467000. This y-axis coincides with the y-axis used in the field survey, but this x-axis has a different sense as the x-axis used in the field survey starting from x= 806000 as a common point. In the graphs A.6-1 to A.6-18 both x-axis are shown.

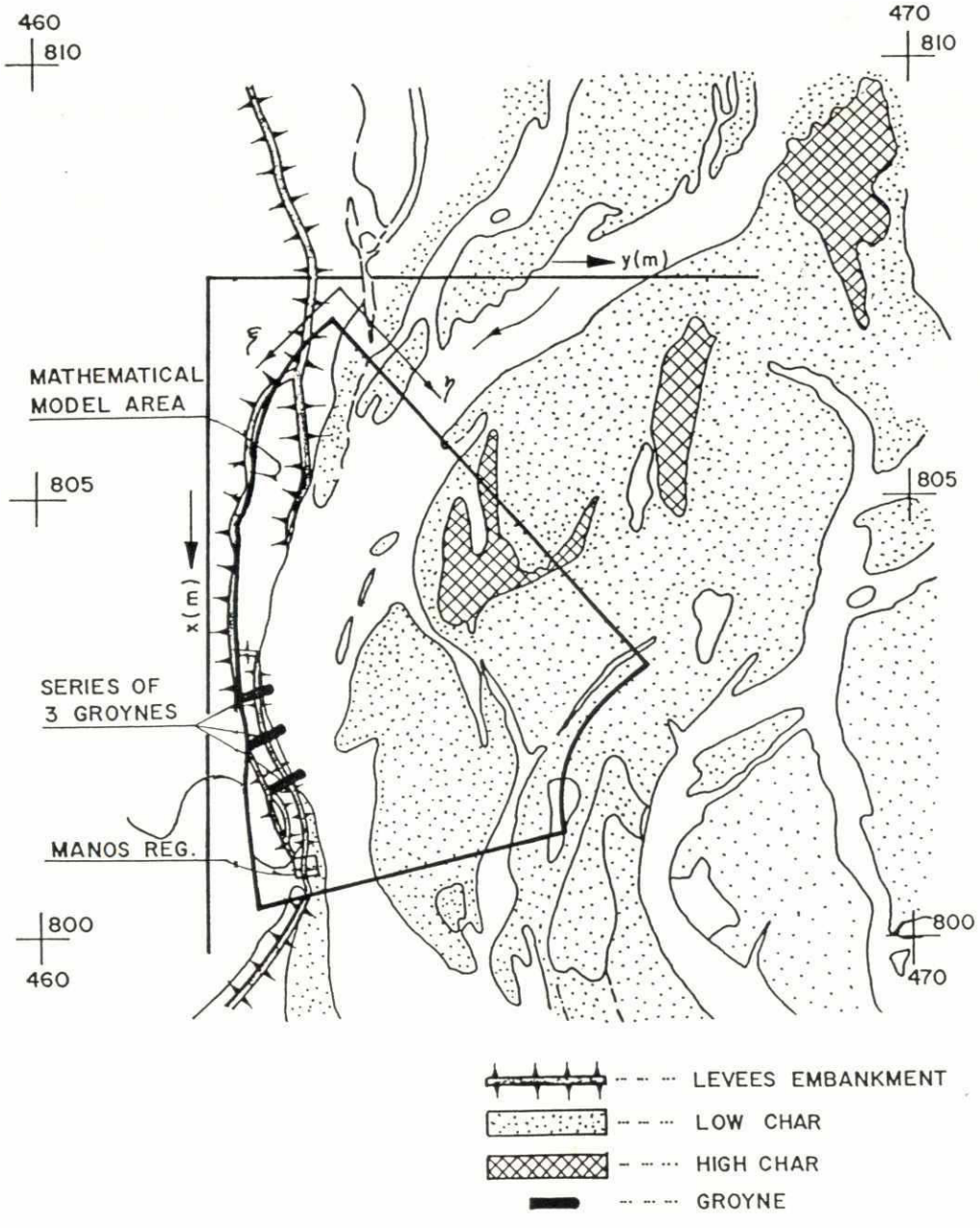


Fig. 6-1: **Area of the mathematical model in the planform 1992 of the Jamuna river**

After the generation of the curvilinear grid the bed level of the model is defined in the grid points. The river bed geometry which was measured during the field survey was combined with the future bank lines by shifting the whole geometry to the new bank line after the flood of 1993 (this bank line is indicated by III'94) and after the flood of 1994 (indicated by III'95). The shape of the impermeable groyne was introduced in the bathymetry in those grid points where their slope levels are higher than the existing bed levels. Permeable groynes are not simulated. The bank line between the groynes is the same as the assumed bank lines in the physical model. As part of the output of the programme graphs with isolines of the bed geometry are made with the levels referring to PWD-datum. In the graphs the river bed below this datum is positive and the char land above this datum negative.

The reduction of the bank erosion by a series of groynes can result in deeper bed levels in front of the groynes. The comparison of the equilibrium cross-sections of a channel with a constant discharge and without bank erosion with the equilibrium cross-sections of a similar channel with bank erosion shows that the water depth in the cross-sections with bank erosion are smaller than the water depth in a cross-section without bank erosion. Both channels have the same constant widths. This increase of the water depth is estimated according to Mosselman, 1992:

$$h_{new} = \bar{h} + \left(1 + \frac{h_{old}}{h_{max}} \right) . \left(h_{old} - \bar{h} \right) \qquad (6\text{-}1)$$

in which:

h_{old}	=	existing water depth without a series of groynes	(m)
h_{new}	=	estimated water depth above the eroded bed because of the series of groynes	(m)
$\bar{h}$	=	averaged water depth over the cross-section before construction of the series of groynes	(m)
h_{max}	=	maximum water depth in the cross-section before construction of the series of groynes	(m)

On these bed levels the local scour which is induced by the groynes should be superimposed. Up to now no general rule for the superposition of local scour on the scour by a interrupted bank erosion is available. Also in the physical model the effect of the interuption of the bank erosion on the local scour depths is not taken into account separately. This lowering of the bed level in front of the groynes was included in the bed geometry of the model.

The computations with the predicted bank line after the flood of 1993 were made for a return period of 2, 10 and 100 years, see Table 6-1. A flow field with a return period of 2 and 10 years can be expected during the monitoring phase of the project and the flow field with a return period of 100 years represents the design condition for a permanent

structure. A part of the test structure will be designed as a permanent structure with the possibility that some minor parts should show some damage during the monitoring phase. For the bank line after the flood of 1994 the extreme flow field is calculated with a return period of 100 years.

No	Layout Bank Line	Return Period (Years)	Downstream Water Level (m + PWD)	Channel Discharge (m^3/s)
1	III'94	2	21.60	20800
2	III'94	10	22.25	27400
3	III'94	100	22.90	41900
4	III'95	100	22.90	41900

Table 6-1: Programme for mathematical simulations for groynes

A simple method was applied to estimate the discharge in the area represented by the mathematical model because no precise information about the discharge distribution in a complete cross-section of the Jamuna river is available.

The discharge in the model area was estimated by means of the Manning equation, applied at the downstream end where the water level (see Table 6-1) and the cross-sectional bathometry are given. The roughness coefficient and surface water level gradient were estimated according to the local conditions. The general Chézy coefficient was replaced by a Manning coefficient, see Table 6-2.

	Tr=2 Years	Tr=10 Years	Tr=100 Years
Chézy coefficient C ($m^{1/2}/s$)	60 - 70	60 - 70	80 - 90
Manning coefficient n ($s/m^{1/3}$)	0.022	0.021	0.017
Water level gradient (-)	$7*10^{-5}$	$8*10^{-5}$	$9*10^{-5}$

Tr = Return period (years)

Table 6-2: Estimated values of the Chézy, Manning coefficient and the water level gradient

The discharges in the model area were distributed along the cross-section of the upstream model boundary according to the capacity given by the local bathymetry. This capacity was estimated with the same simple method as explained for the downstream end.

The boundary conditions are the water level at the downstream boundary of the model which is given in Table 6-1, and the estimated discharge distribution at the upstream

boundary of the model.

Results

The bed topography with isolines of the depth is given for the III'94 bankline in Fig. A.6-1 and a detail of this topography around the series of groynes is presented in Fig. A.6-2. The approach channel can be recognised easily between the char areas with a rather deep channel in front of the groynes including the confluence scour holes. This bed topography is typical for a strong flow attack on the bank.

For each return period of 2, 10 and 100 years 4 graphs are presented of the model area with flow velocity isolines see Figs. A.6-3 to A.6-20, flow velocity arrows indicating direction and magnitude of the flow velocities, flow lines and water level isolines. These graphs provide a good impression of the flow field in the whole model area but no clear information close to the series of groynes for the bank line III'94.

Detailed information is also given about flow fields around the series of groynes in separate figures. The figures related to a return period of 2 years show the following tendencies:

- in the approach channel the flow velocities increase from about 1.0 m/s to more than 2.0 m/s downstream of the series of groynes;
- the flow velocities above the left char are around 1.0 m/s. Above the right char, which is attached to the embankment, the flow velocities are very small, less then 0.5 m/s;
- perpendicular to the flow direction, the gradients in the flow velocity are gradual, only near the groyne, sharp gradients were calculated;
- the flow lines tend to concentrate along the right bank and at the location of the groynes the flow starts to attack the bank, and
- the water level isolines are perpendicular to the direction of the flow velocities.

The differences between the flow fields with return periods 2, 10 and 100 years are with an increase of the return period:

- an increase in the flow velocities, and
- a slightly less strong concentration of the flow lines along the right bank.

The computed flow lines were used to verify the selected left boundary of the model and the differences between the flow lines and the model boundary are rather small. These small differences did not influence the results of the physical model and are mainly caused by differences in bed geometries. This bed geometry in the mathematical model refers to the situation with a strong attack on the bank with confluence scour holes in front of it. However in the physical model a moderate attack on the bank line III'94 was simulated and therefore the bed geometry in the model deviated from the bed geometry in the mathematical model. The computed flow velocities (magnitude and direction) in the neighbourhood of the groynes were used to define the maximum approach flow velocity.

The flow velocities close to the groynes are lower than the maximum flow velocities found in the physical model because the flow velocities in the mathematical model are the average flow velocity in a box and in the physical models the maximum flow velocity is measured at a point, and because of the mentioned different bed geometries in the mathematical and physical model.

The discharge distribution along the line $\xi = 12$ in the mathematical grid is shown in Tables 6-3 and 6-4 for the bank line III'94 and the bank line III'95 repectively. The grid discharges were computed only along the main flow direction (in this case the u velocity component) perpendicular to the line $\xi = 12$. This discharge distribution refers to the situation with a strong attack on the bank with confluence scour holes in front of it. However in the physical model a moderate attack on the bank line III'94 was simulated and therefore the discharge distribution in the model deviated slightly form the calculated distribution.

Row η	Grid Coordinates		Distance along η axis	Discharge (m^3/s) III'94 with protections		
	x	y		Tr=100	Tr=10	Tr=2
18	807288	462520	51.8	76	36	17
19	807315	462558	46.1	61	27	13
20	807340	462595	44.8	273	67	55
21	807364	462632	43.9	236	186	161
22	807388	462668	43.4	310	254	217
23	807410	462701	39.3	320	261	221
24	807431	462734	39.6	414	334	285
25	807453	462769	40.9	498	391	331
26	807476	462805	43.2	541	410	346
27	807499	462843	44.0	517	382	319
28	807522	462882	45.4	546	400	334
29	807546	462921	46.2	584	426	357
30	807568	462957	42.1	579	425	360
31	807590	462994	43.0	687	512	441
32	807615	463039	51.3	913	691	600
33	807645	463094	62.5	1236	942	816
34	807679	463156	71.2	1486	1115	955
35	807721	463231	85.8	1803	1319	1118

Remark: The discharge allocated, for example, to row 11 corresponds to the section between rows 17 and 18.
Tr = Return period.

Table 6-3: Kamarjani area. Bank line III'94 with protections. Suggested discharge (m^3/s) distribution at the upstream boundary of the physical model ($\xi = 12$) in case of a strong attack on the bank

Row η	Grid coordinates		Distance along η axis (m)	Discharge (m/s^3) III'95 with protections Return Period 100 Years
	x	y		
18	807288	462520	51.8	112
19	807315	462558	46.1	102
20	807340	462595	44.8	95
21	807364	462632	43.9	105
22	807388	462668	43.4	147
23	807410	462701	39.3	201
24	807431	462734	39.6	308
25	807453	462769	40.9	427
26	807476	462805	43.2	557
27	807499	462843	44.0	622
28	807522	462882	45.4	638
29	807546	462921	46.2	609
30	807568	462957	42.1	517
31	807590	462994	43.0	534
32	807615	463039	51.3	646
33	807645	463094	62.5	832
34	807679	463156	71.2	1070
35	807721	463231	85.8	1461

Table 6-4: Kamarjani area. Bank line III'95 with protections. Suggested discharge (m^3/s) distribution at the upstream boundary of the physical model ($\xi = 12$) in case of a strong attack on the bank

7 BAHADURABAD TEST SITE (REVETMENT)

The mathematical model covers the outflanking channel over a length of about 3.5 km south of Bahadurabad. This area is drawn in a detailed map of the planform of the Jamuna river in 1992, see Fig. 7-1. The left boundary with the revetment includes some reserved area for future bank erosion. The right boundary is on the char where the discharge and the water depths are small and therefore the results of the computations are not sensitive for an accurate alignment of this right boundary. The upstream and the downstream boundary of the model area were designed to be perpendicular to the expected flow direction.

The morphological analysis of the channels showed that the thalweg of this channel can follow different courses in the future. The development of these courses are probably influenced by complex, temporary phenomena, for example retarded scour. The extreme courses near the revetment are selected as alignments A, B and C, see Fig. 7-2. Of these three A and C are the most extreme aligments which were built in the mathematical model.

The computations with the predicted bankline after the flood of 1994 are made for the alignments A and C and with up- and downstream boundaries which have a return period of 2, 10 and 100 years, see Table 7-1. The total discharge is the discharge of the Jamuna river in a complete cross-section the from the right to the left embankment. The discharge in the channel which is modelled in the mathematical model is only a part of the total discharge and this discharge is called channel discharge. In the programme 3 simulations with alignment A are included and only 2 simulations with alignment C, because for the design alignment A is proabably more important then alignment C. In these simulations the length and the layout of the revetment was not changed.

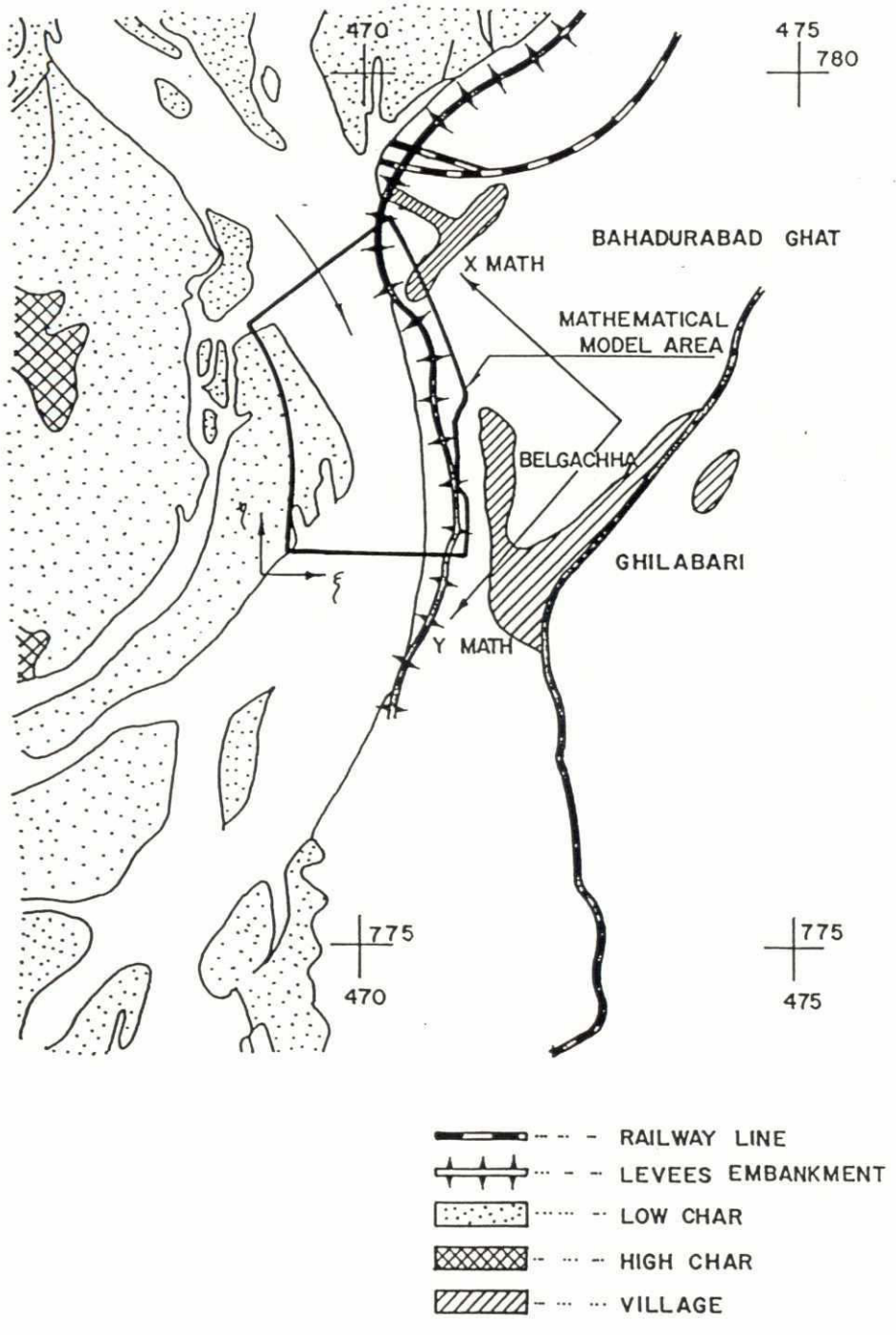


Fig. 7-1: Area of the mathematical model in the planform of the Jamuna river south of Bahadurabad

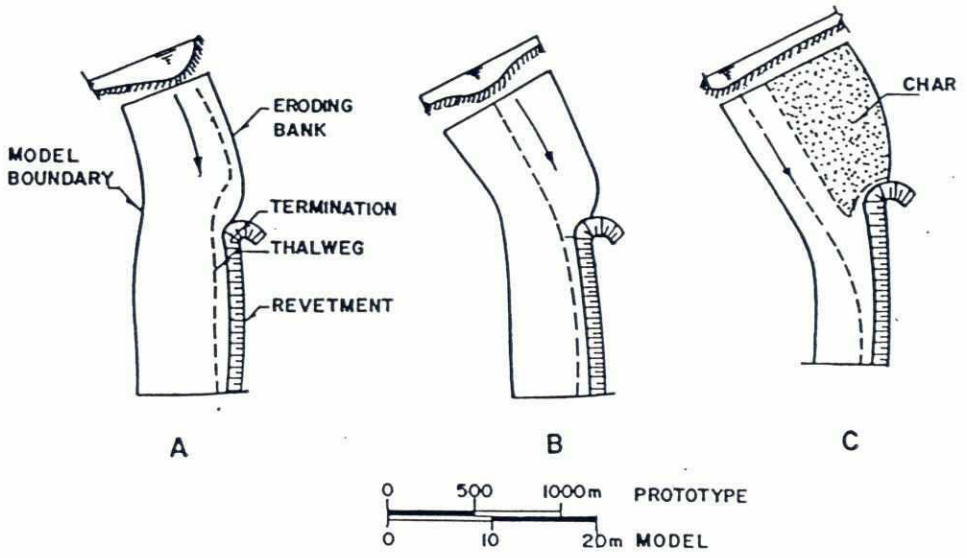


Fig. 7-2: Characteristic channel alignments A, B and C

No	Channel alignment and bankline	Return period (Years)	Downstream water level (m + PWD)	Total discharge (m^3/s)	Channel discharge (m^3/s)
1	A, III'94	2	19.80	64000	22395
2	A, III'94	10	20.20	83000	26080
3	A, III'94	100	20.70	107000	38975
4	C, III'95	2	19.80	64000	18205
5	C, III'95	100	20.70	107000	32200

Table 7-1: Programme of mathematical simulations of the flow field near a revetment

The curvilinear grid was chosen to follow as good as possible the predicted bank line III'95, that is the bank line after the flood of 1994. The grid spacing varies from 30 m in the area of interest to 200 m along the right boundary which is located at a char. In the model the revetment is simulated as a part of the bankline, see for example Fig. A.6-21 in which the mathematical grid represents a small embayment upstream of the revetment. The approximation of the upstream termination with a radius of 50 m in the mathematical grid is a rough schematization but this detail has only a small influence on the flow field very close to this termination. The grid point locations are referred to a grid system of coordinate system of the field survey with the x-axis varying from 468500 to 471500 and the y-axis from 774500 to 778500. In the graphs A.6-21 to A.6-46 also a local grid system is shown with the x-axis from 0 to 4000 m and the y-axis from 750 to 4750 m.

After the generation of the curvilinear grid the bed level of the model is defined in the grid points. The river bed geometry is schematized in a number of cross-sections which were measured during the field survey. These cross-sections were averaged to eliminate the effects of non-permanent retarded scour phenomena, which are not representative of the bed geometry during flood conditions. In alignment A this averaged cross-section was shifted to the bank line III'95 to give the model the typical shape of a river bend with the maximum water depth along the outer bend, see graph with isolines of the depth in Fig. A.6-21. In alignment C the centre line of the approach channel makes a maximum angle with the alignment of the revetment and this results in a strong attack of the revetment just near the upstream termination of the revetment. This approach channel is allmost uniform and has a symmetric cross-section, see also Fig. A.6-34. In this type of figures the level of the riverbed is expressed in meters relative to PWD-datum and the levels above PWD have a negative value.

The increased bed erosion by the reduced bank erosion in front of the banks is not included in the bed geometry of the mathematical model.

The discharge entering the mathematical model was estimated using the same method as described in the foregoing section for Kamarjani test structures. These estimated discharges are presented in the last column of Table 6-6.

Return period	Years	2	10	100
Chézy coeff. C	$m^{1/2}/s$	60 - 70	60 - 70	80 - 90
Manning coeff. n	$s/m^{1/3}$	0.021	0.021	0.0165
Surface slope	-	$7*10^{-5}$	$8*10^{-5}$	$9*10^{-5}$

Table 7-2: Estimated values of the Chézy and Manning coefficient and the water level gradient

The boundary conditions are the water level, which is given in Table 7-1, at the downstream boundary of the model and the estimated discharge distribution at the upstream boundary of the model.

Results

For each return period of 2, 10 and 100 years 4 graphs are presented of the model area with flow velocity isolines, flow velocity arrows indicating direction and magnitude of the flow velocities, flow lines and water level isolines, see Fig. A.6-22 to A.6-46. These graphs provide a good impression of the flow field in the whole model area for a selected channel alignment. For detail information close to the revetment some enlargements of these graphs are included.

These graphs related to a return period of 2 years show the following tendencies for alignment A:

- Upstream of the revetment the highest flow velocities are calculated close to the outer bend, as is the normal pattern in bend flow. Along the left bank upstream of the revetment the flow velocities gradually decrease, resulting in a reduced flow attack on the bank from upstream boundary towards the revetment.
- In front of the revetment small flow velocities of about 0.1 m/s indicate that a long eddy can be expected in front of the revetment. Such an eddy was not calculated because of the rough schematization of the revetment in the mathematical grid.
- The arrow presentation has the disadvantege of the overlapping arrows, only a general impression of the flow field is obtained.
- The water level gradients are perpendicular to the flow direction as expected, but near the upstream and downstream termination the flow lines are curved and this results in a relatively strong transverse water level gradient along the radius of the curvature.
- These curvatures are also shown by the flow lines. The flow lines are concentrated along the left bank.

These graphs related to a return period of 2 years show the following tendencies for alignment C which can be compared with the tendencies for alignment A:

- The flow velocities are high in the approach channel and in front of the revetment. Along the revetment rather high flow velocities are calculated: 1.0 to 1.7 m/s and at some distance from the revetment the flow velocity is more than 2 m/s. The transverse gradient in the flow velocities is more than in alignment A.
- The flow lines are allmost parallel with a small disturbance near the revetment. The flow lines are concentrated along the revetment and at the downstream termination the flow separates and an eddy is generated in the same way as in alignment A.

The differences between the flow fields with a return period of 2, 1 and 100 years are the following tendencies with an increasing return period:

Alignment A:

A return period of 100 years results in an increase of the flow velocities of roughly 1 m/s if compared with the flow velocities with a return period of 2 years. In a small area near the upstream termination maximum flow velocities of 3.3 to 3.5 m/s are calculated for a return period of 100 years.

Alignment C:

A return period of 100 years results in an increase of the flow velocities with about 1 m/s if compared with the flow velocities with a return period of 2 years and in front of the downstream half of the revetment maximum flow velocities between 3 to 3.5 m/s are calculated. The patern of the flow lines is allmost the same for both return periods.

The maximum flow velocities are the same in both extreme alignments but they are observed in different locations.

The results of these simulations were used to verify the selected right boundary of the model and the differences between the calculated flow lines and the measured flow lines in the physical model are rather small, see Fig. 7-3. These small differences did not influence the results of the physical model.

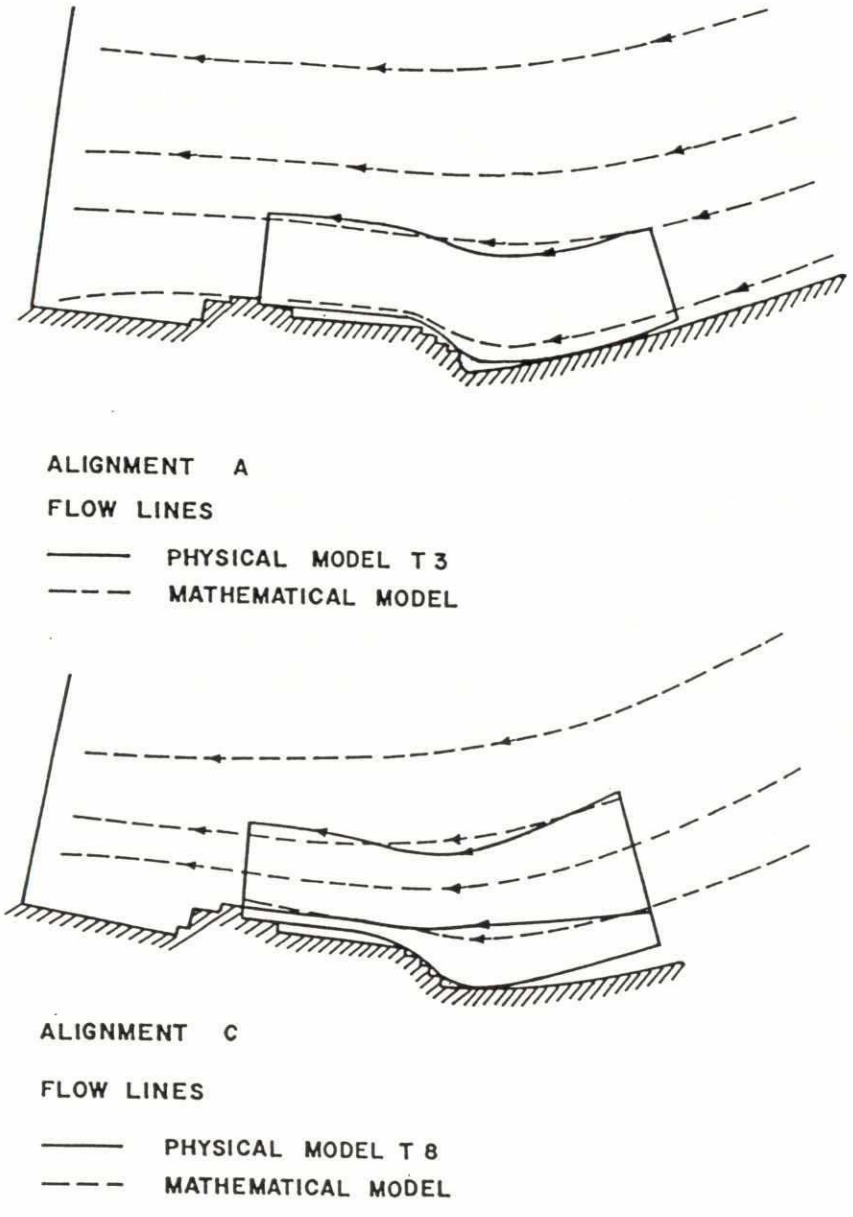


Fig. 7-3 : Comparison of the computed flow lines with the measured flow lines in the physical model

Row ξ	Grid Coordinates		Distance along ξ axis	Discharge (m^3/s) III'95 with protections (Alignment A)		
	x	y		Tr=100	Tr=10	Tr=2
1	3141	3130				
2	3045	2969	187.6	1702	1006	782
3	2943	2802	195.9	2318	1434	1160
4	2843	2635	194.0	2822	1806	1499
5	2755	2489	171.1	2939	1920	1621
6	2682	2368	140.7	2714	1803	1538
7	2622	2268	117.7	2381	1599	1371
8	2568	2178	104.5	2089	1411	1213
8	2517	2094	97.6	1890	1283	1103
10	2467	2010	98.1	1850	1264	1087
11	2427	1943	78.1	1459	998	858
12	2392	1882	70.1	1344	911	784
13	2361	1828	62.3	1286	868	749
14	2334	1783	52.6	1182	802	695
15	2312	1745	44.0	1055	720	627
16	2292	1709	41.1	1039	712	622
17	2272	1676	39.2	1041	716	628
18	2252	1641	39.4	1091	753	663
19	2232	1607	39.6	1143	791	698
20	2213	1573	39.8	1193	829	732
21	2193	1538	40.0	1244	866	767
22	2177	1509	32.9	1049	734	650
23	2161	1480	32.9	1043	733	651
24	2145	1451	33.3	1013	717	640
25	2129	1422	33.1	919	657	590
26	2113	1393	33.1	753	541	487
27	2087	1344	55.9	363	231	191

Remark: The discharge allocated to row 2 corresponds to the section between rows 1 and 2 and so on.

Table 7-3: Bahadurabad area. Bank line III'95 with protections, alignment A. Suggested discharge (m^3/s) distribution at the upstream boundary of the physical model (η=47)

Row ξ	Grid coordinates		Distance along ξ axis	Discharge (m^3/s) III'95 with protections (Alignment C)		
	x	y		Tr=100	Tr=10	Tr=2
1	3141	3130				
2	3045	2969	187.6	1665		715
3	2943	2802	195.9	1873		814
4	2843	2635	194.0	2156		990
5	2755	2489	171.1	2340		1122
6	2682	2368	140.7	2295		1144
7	2622	2268	117.7	2221		1164
8	2568	2178	104.5	2247		1247
8	2517	2094	97.6	2327		1361
10	2467	2010	98.1	2484		1523
11	2427	1943	78.1	2008		1273
12	2392	1882	70.1	1732		1119
13	2361	1828	62.3	1458		949
14	2334	1783	52.6	1177		768
15	2312	1745	44.0	933		610
16	2292	1709	41.1	806		528
17	2272	1676	39.2	704		463
18	2252	1641	39.4	641		423
19	2232	1607	39.6	578		382
20	2213	1573	39.8	521		342
21	2193	1538	40.0	475		307
22	2177	1509	32.9	360		230
23	2161	1480	32.9	331		209
24	2145	1451	33.3	298		188
25	2129	1422	33.1	259		164
26	2113	1393	33.1	214		134
27	2087	1344	55.9	88		33

Table 7-4: **Bahadurabad area. Bank line III'95 with protections, alignment C. Suggested discharge (m^3/s) distribution at the upstream boundary of the physical model (η=47)**

8 CONCLUSIONS

The future flow fields around the planned test structures near Kamarjani and Bahadurabad were computed with the two-dimensional mathematical mode of the TRISULA model. The test structure near Kamarjani is a series of groynes and the test structure near Bahadurabad is a revetment. The model area near Kamarjani covers an area of 6 km long and 5 km in width. A surveyed bed geometry and predicted future bank lines have been built in the model. The model area near Bahadurabad has a length of about 3.5 km and a width of about 2 km. In this model area a schematized bed geometry based on two extreme channel alignments and predicted future bank lines have been built.

The results are computed flow fields which are presented in graphs with isolines of the flow velocities, isolines of the water levels, flow lines and an arrow presentation which indicates the magnitude and the direction of the flow.

The maximum flow velocities near the series of groynes are 2.0 m/s in III'94 increasing to 2.5 m/s in III'95.

The maximum flow near the revetment is almost the same for the selected extreme channel alignments, 3.3 to 3.5 m/s, however the location where this maximum flow velocity is observed is different: near the upstream termination of the revetment and along the downstream half of the revetment.

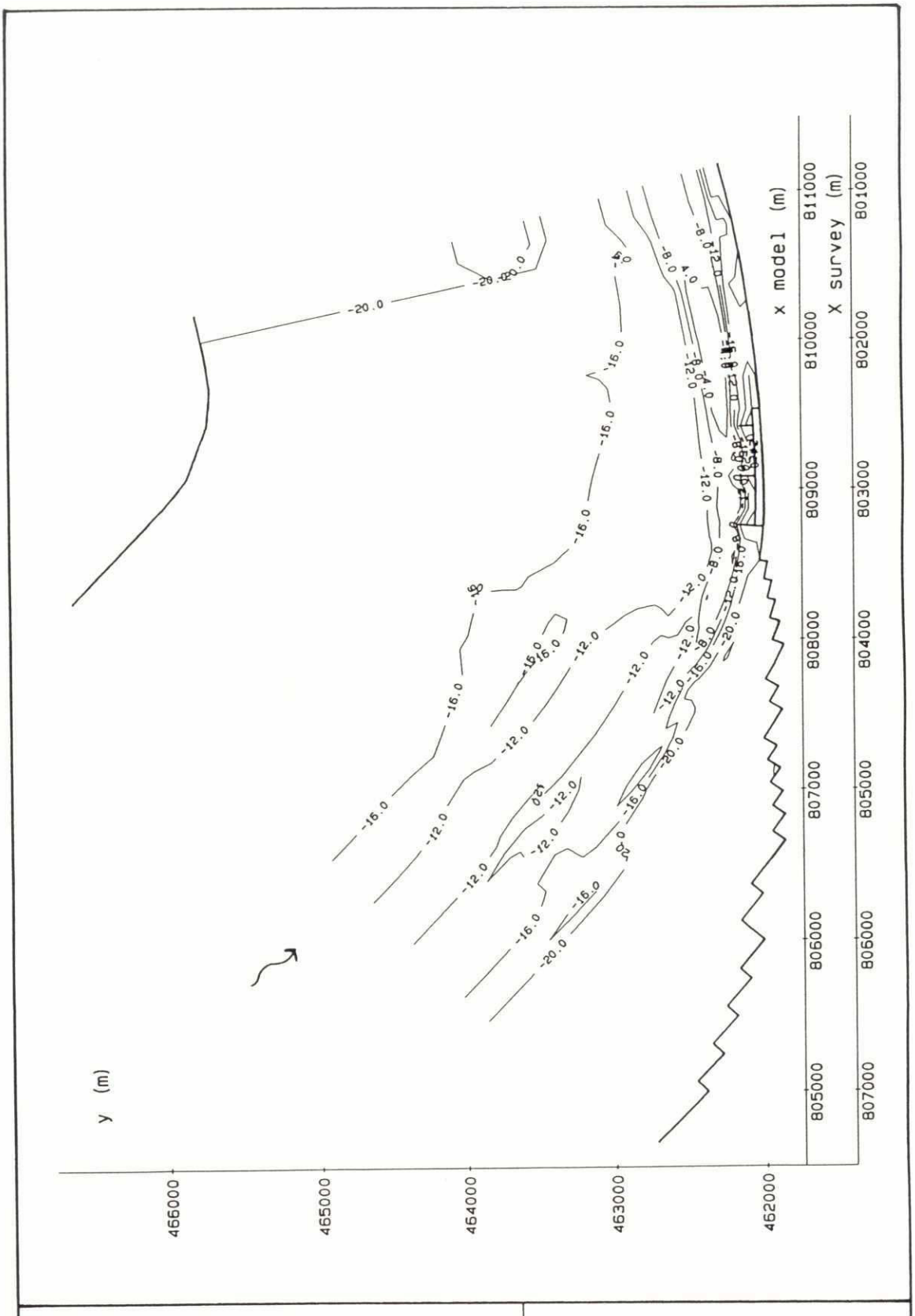
The series of groynes were tested in the physical model under conditions which represent a moderate attack of the flow on the bank. This was different from the strong attack of the flow on the bank in the mathematical simulations. Therefore the discharge distribution and the flow lines in the physical and the mathematical model show some differences.

The revetment has been tested under the same conditions in the mathematical model and in the physical model and the comparison of the flow lines showed a good similarity.

REFERENCES

REFERENCES

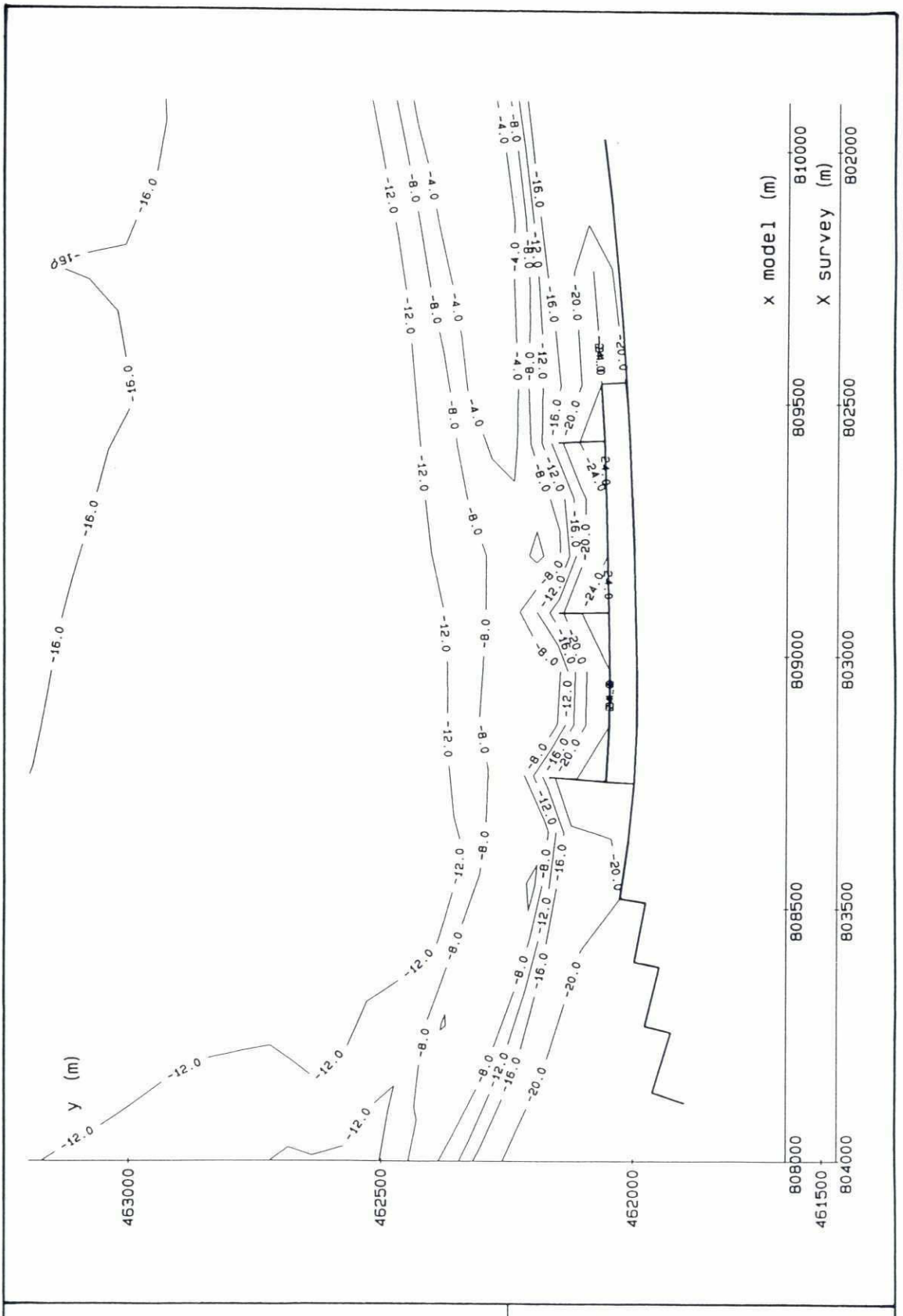
AUTHOR/DATE		TITLE/PUBLISHER
Delft Hydraulics (1991)	:	TRISULA: A simulation programme for hydrodynamic flows and transports in 2 and 3 dimensions - User Guide, release 1.
Mosselman, E. (1992)	:	Mathematical modelling of morphological processes in rivers with erodible cohesive banks, Communications on Hydraulic and Geotechnical Engineering, Faculty of Civil Engineering, Delft University of Technology; also personal communication.



Kamarjani area - Manos Regulator
Bank line III'94 with protections
Bed level isolines [-(+m PWD)]

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FINAL REPORT | FIG. A.6 – 1

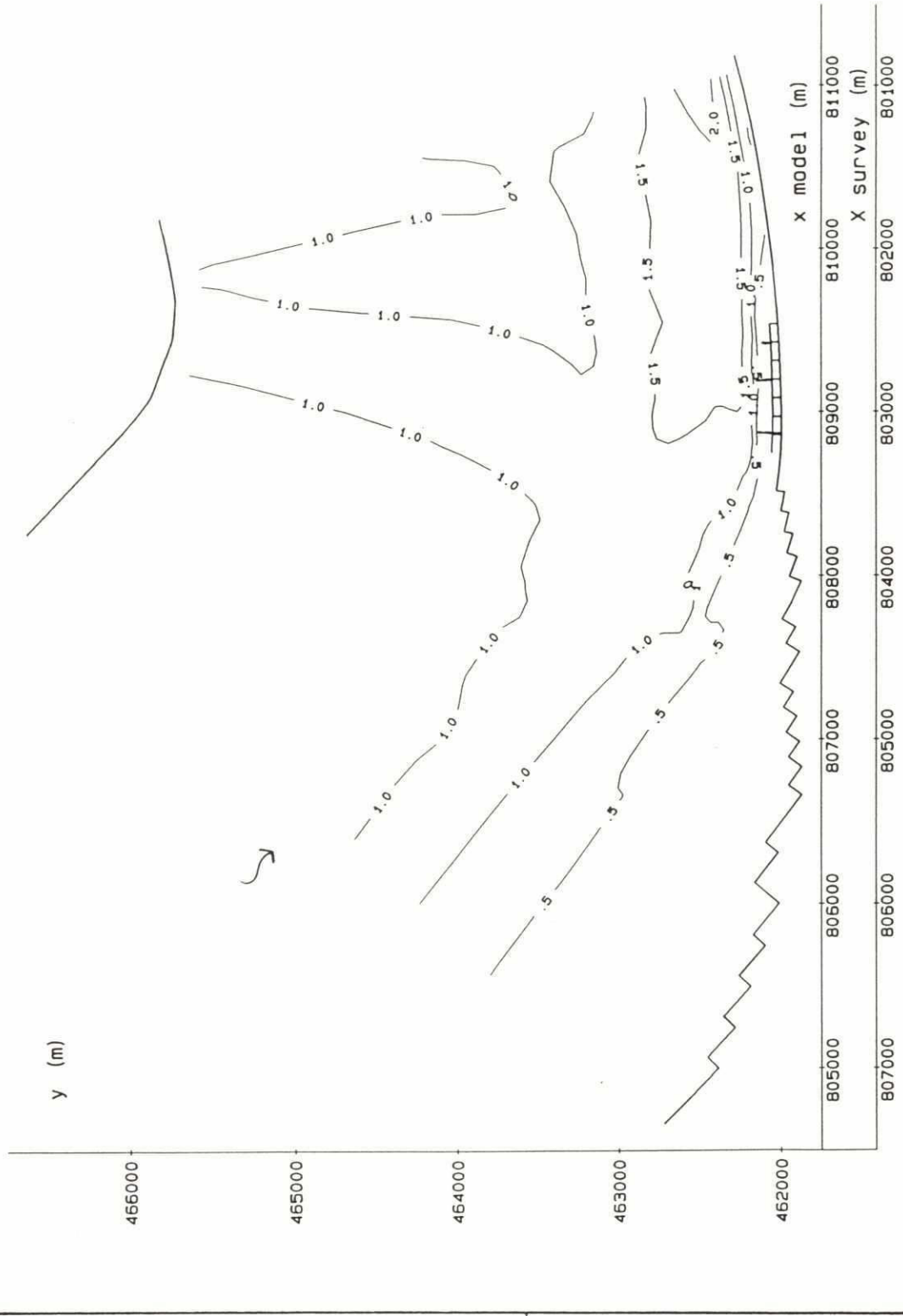


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Bed level isolines [-(+m PWD)] Detail

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FINAL REPORT | FIG. A.6 – 2

92

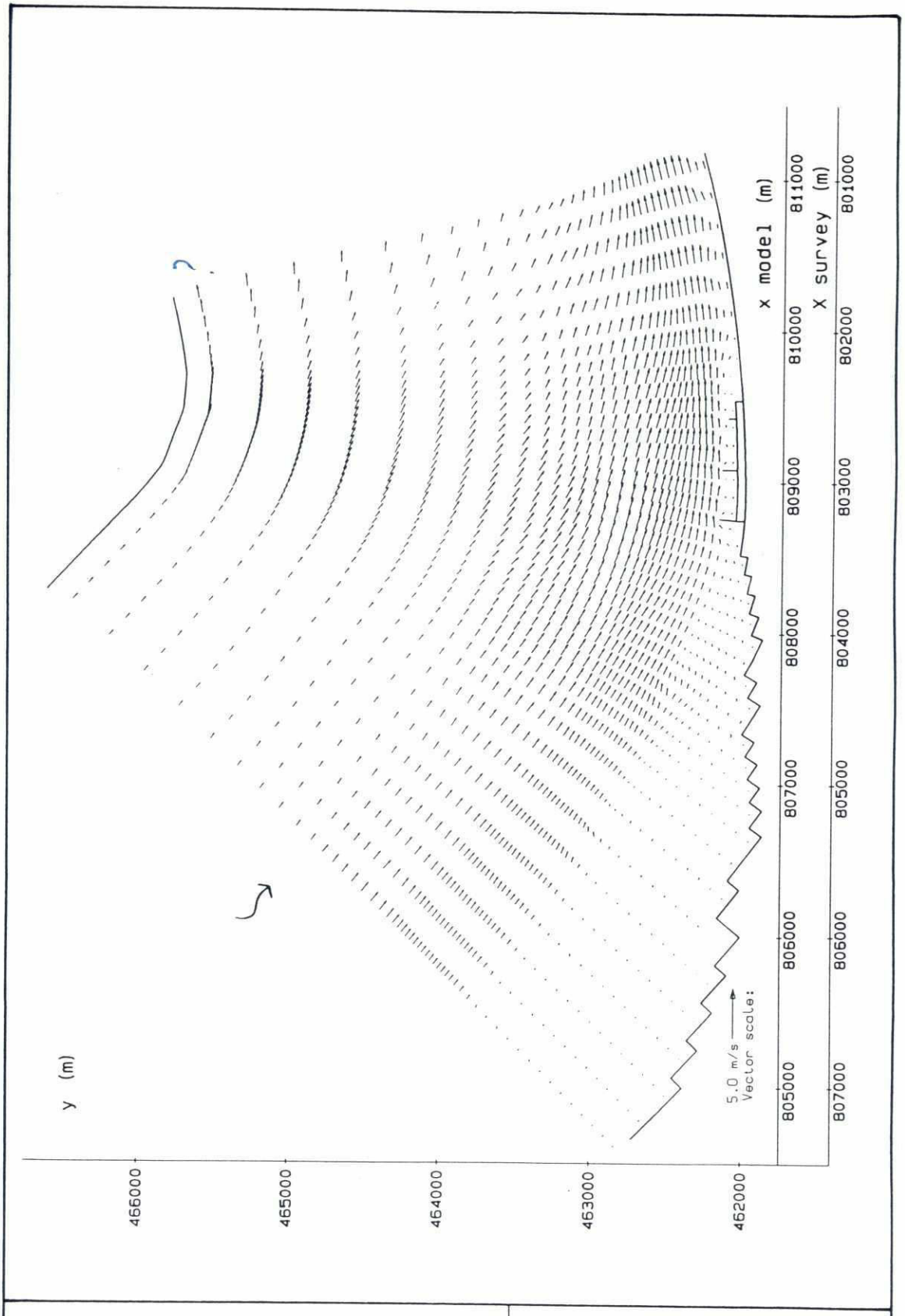


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 2 years - Velocity isolines (m/s)

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FINAL REPORT | FIG. A.6 – 3

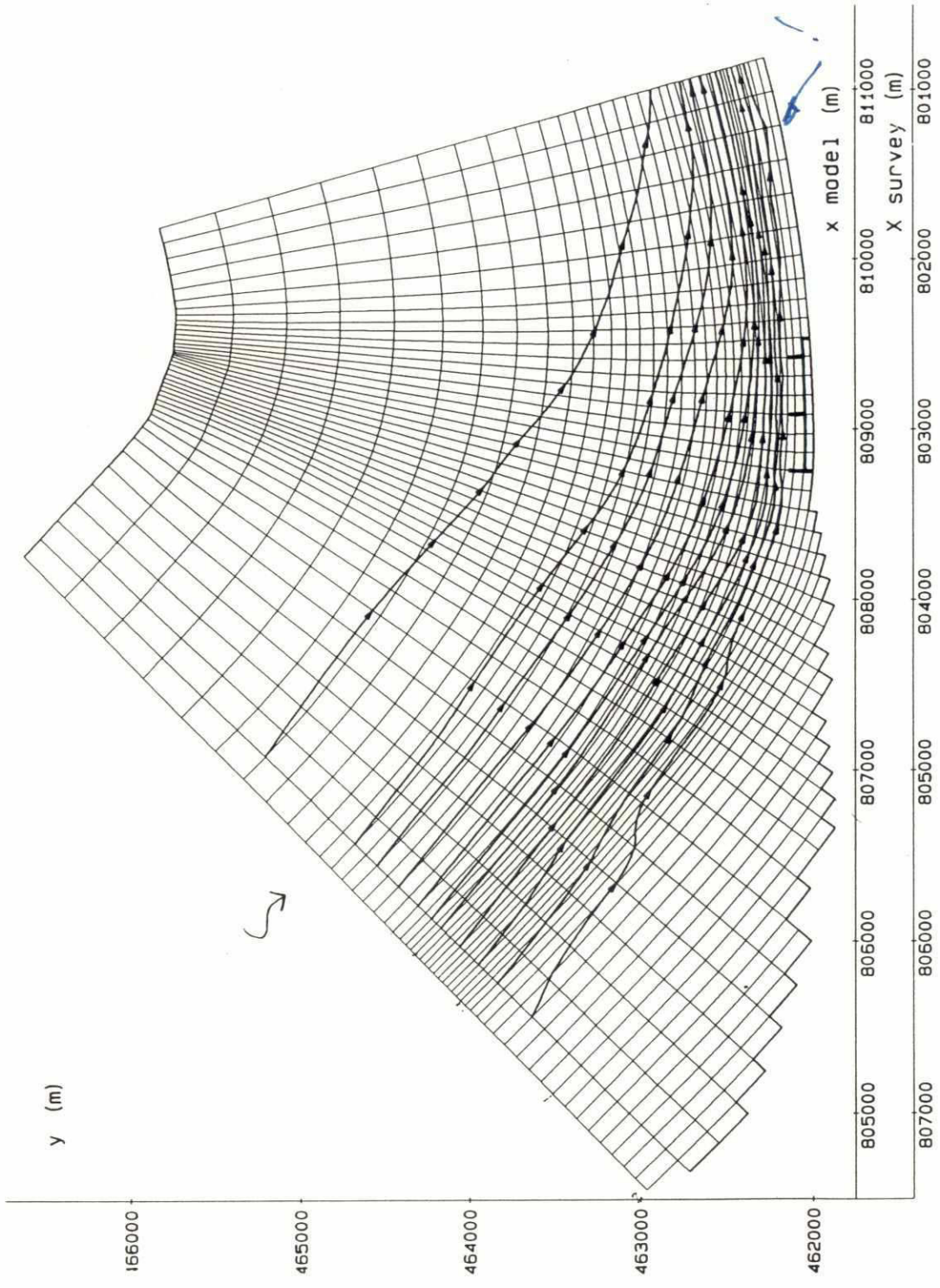


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 2 years - Flow field

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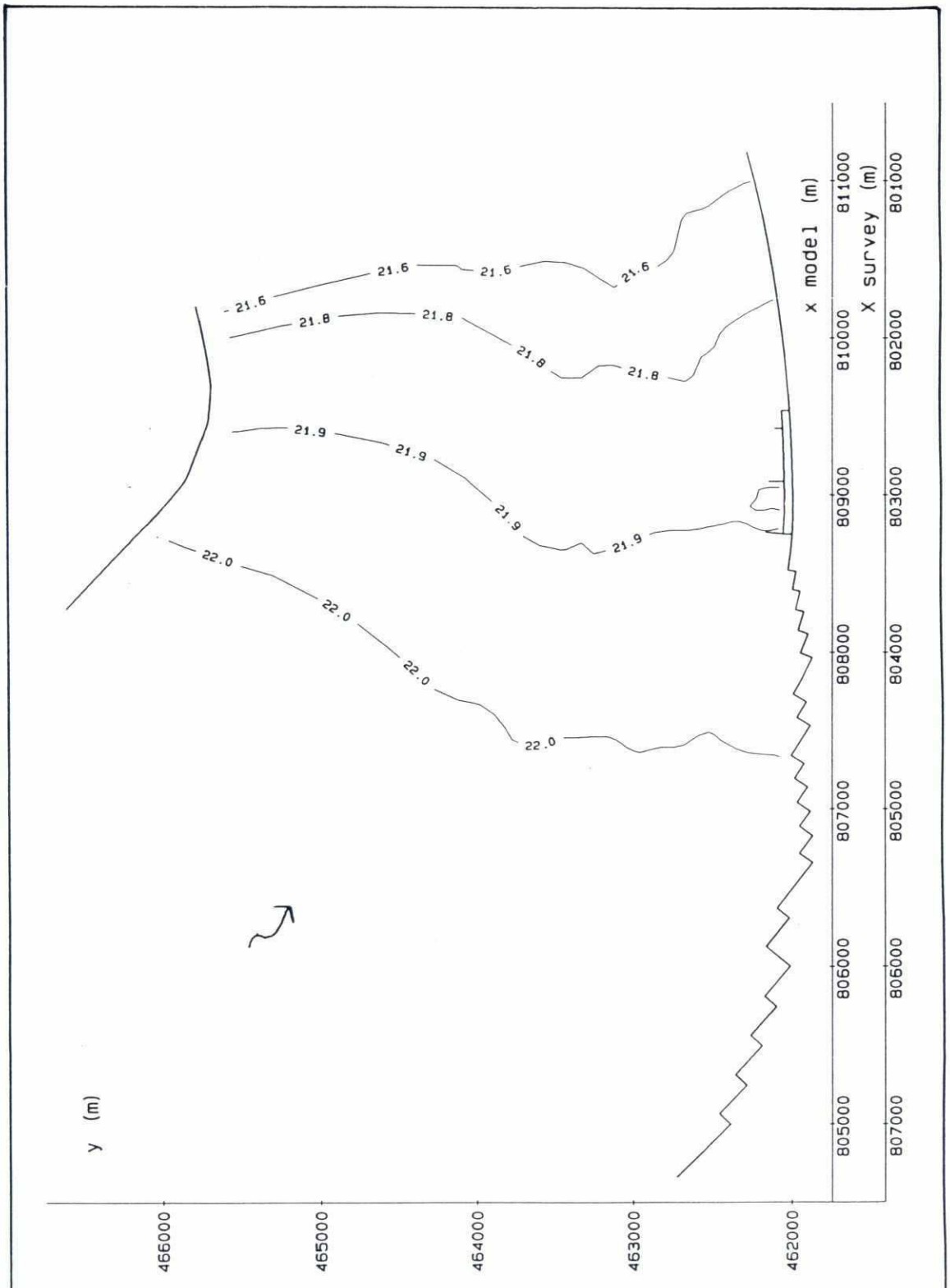
FINAL REPORT | FIG. A.6 - 4



Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 2 years - Stream lines

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FINAL REPORT | FIG. A.6 – 5

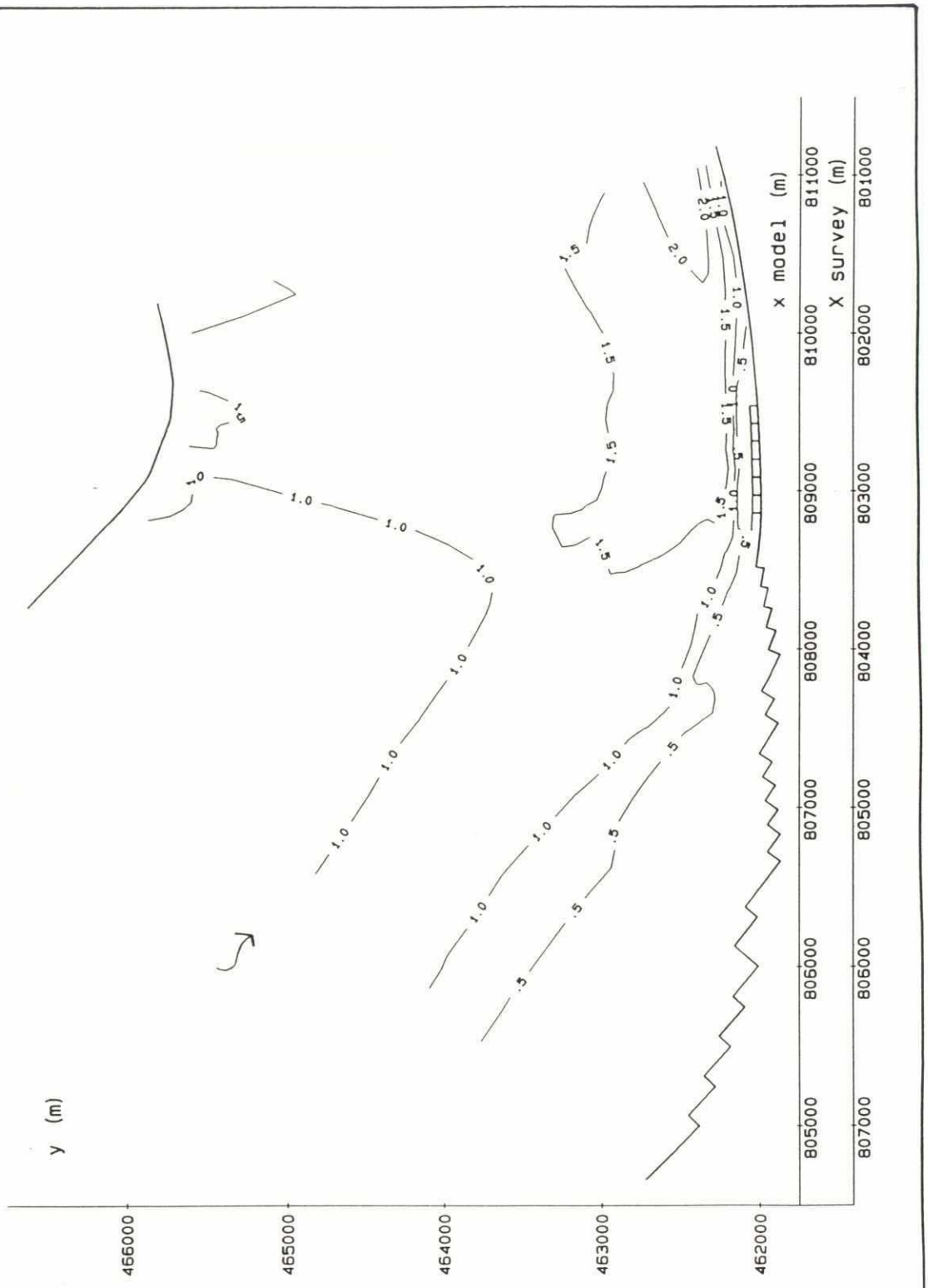


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 2 years - Water level isolines (m)

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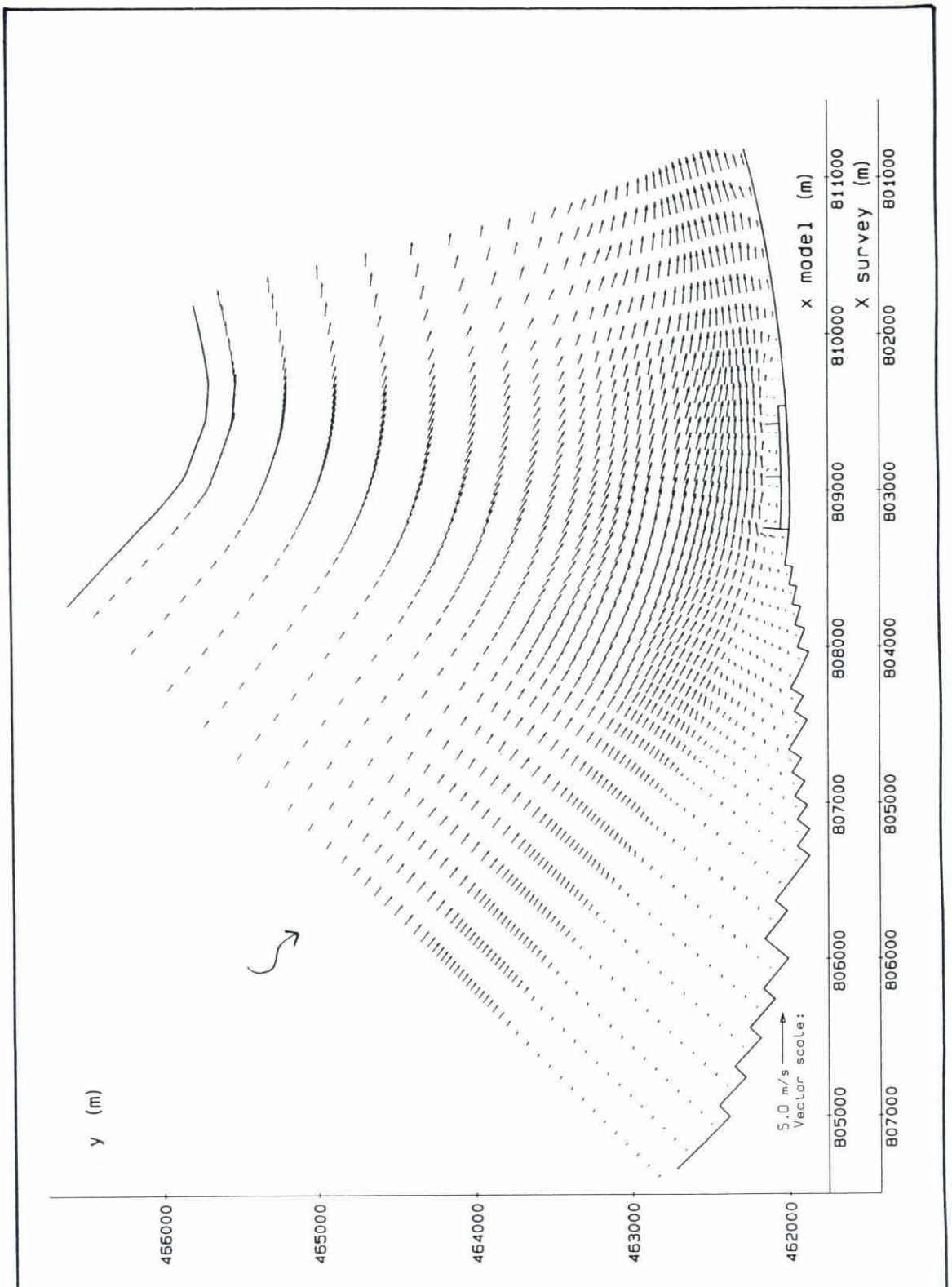
FINAL REPORT | FIG. A.6 – 6



Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 10 years - Velocity isolines (m/s)

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FINAL REPORT	FIG. A.6 – 7

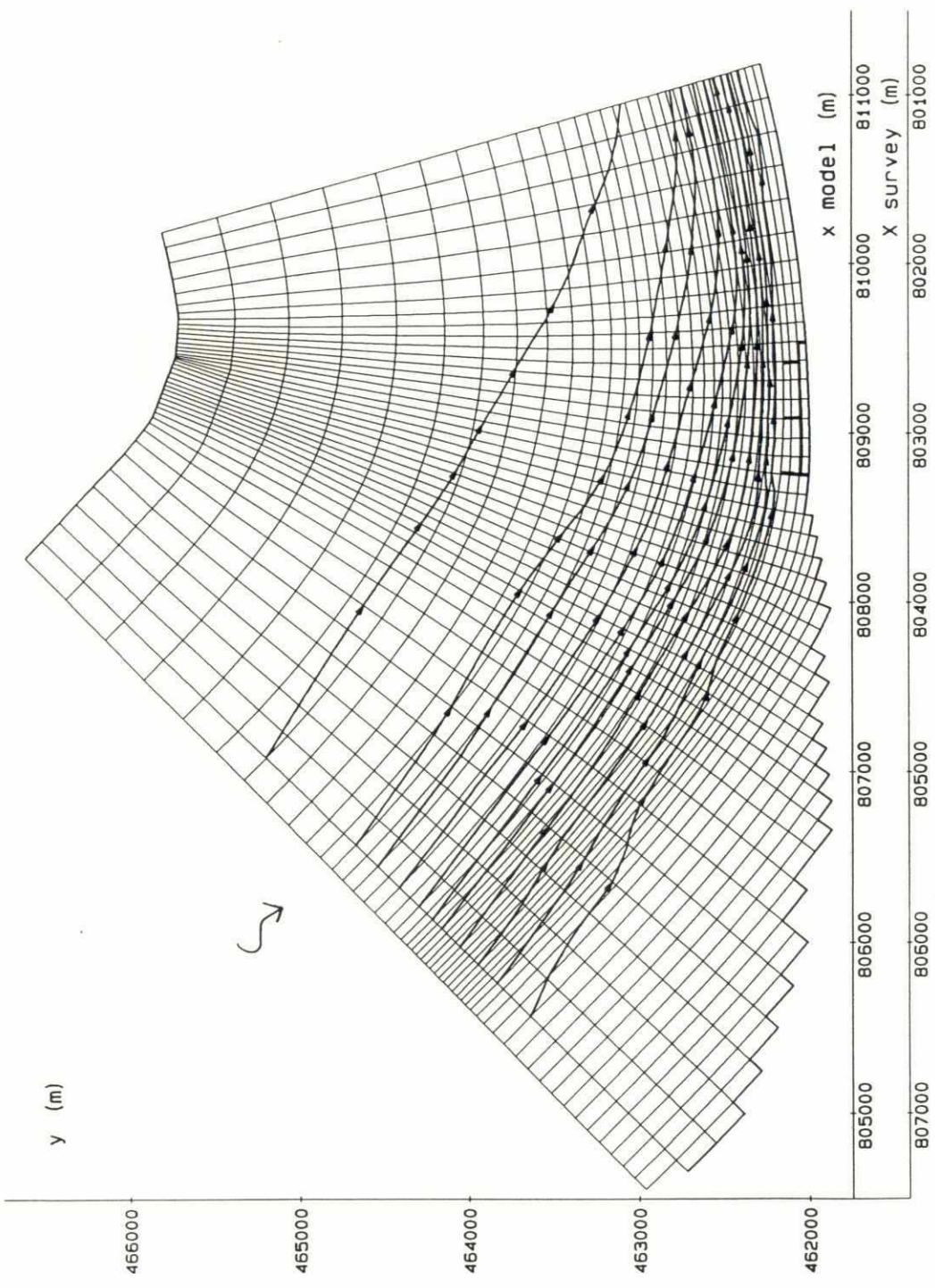


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 10 years - Flow field

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FINAL REPORT	FIG. A.6 – 8

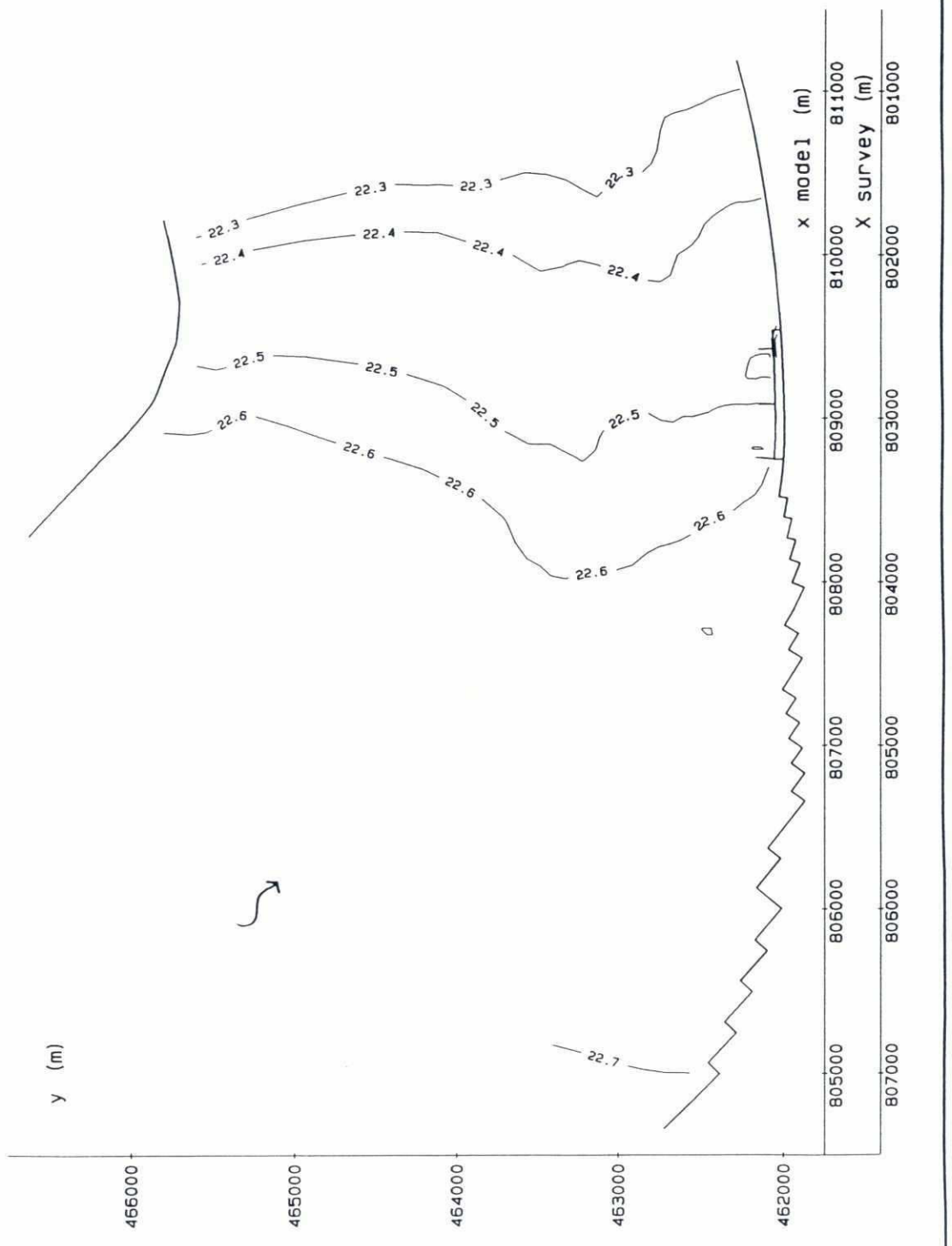
98



Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 10 years - stream lines

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FINAL REPORT	FIG. A.6 – 9



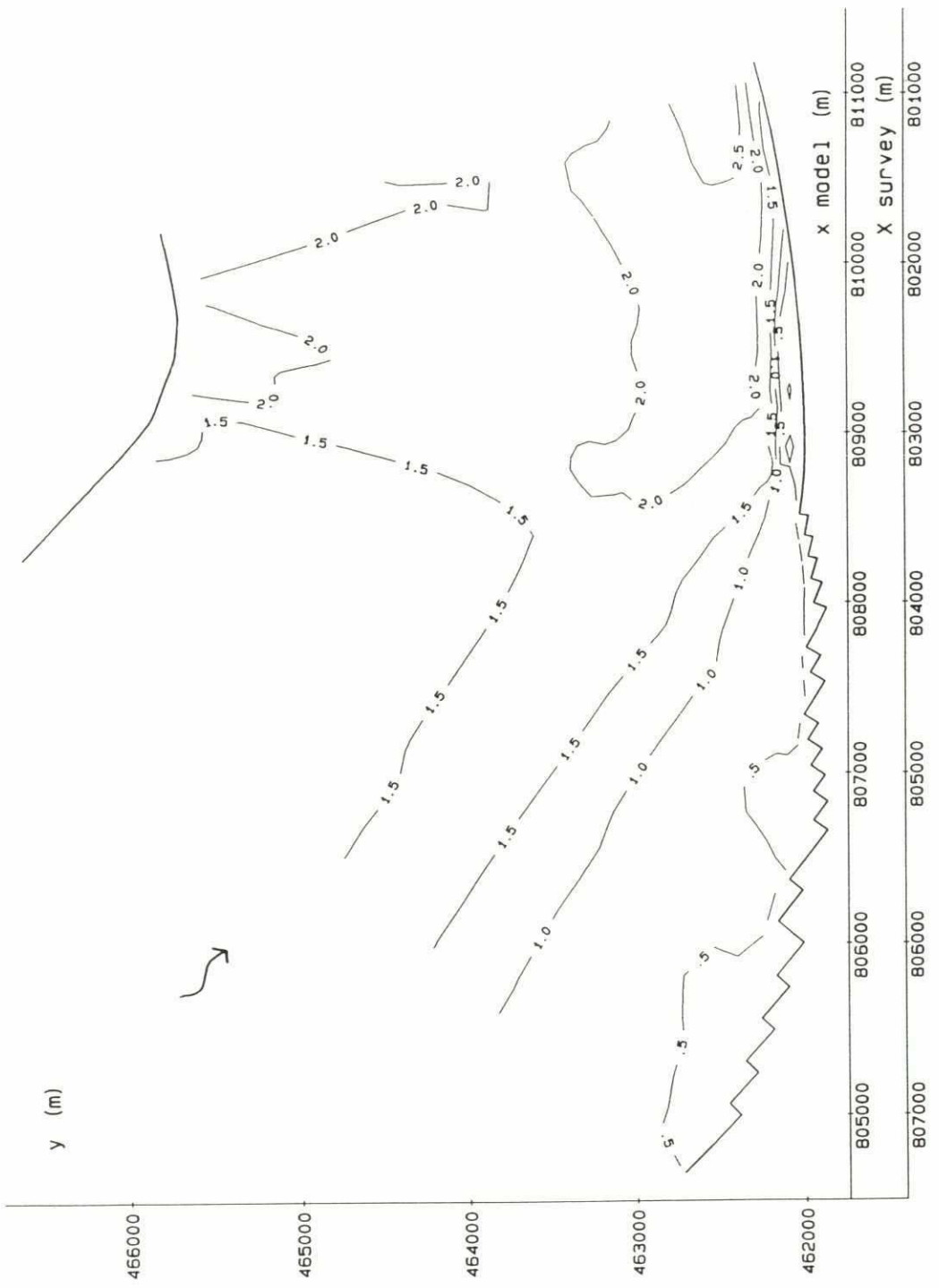
Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 10 years - Water level isolines (m)

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FINAL REPORT | FIG. A.6 – 10

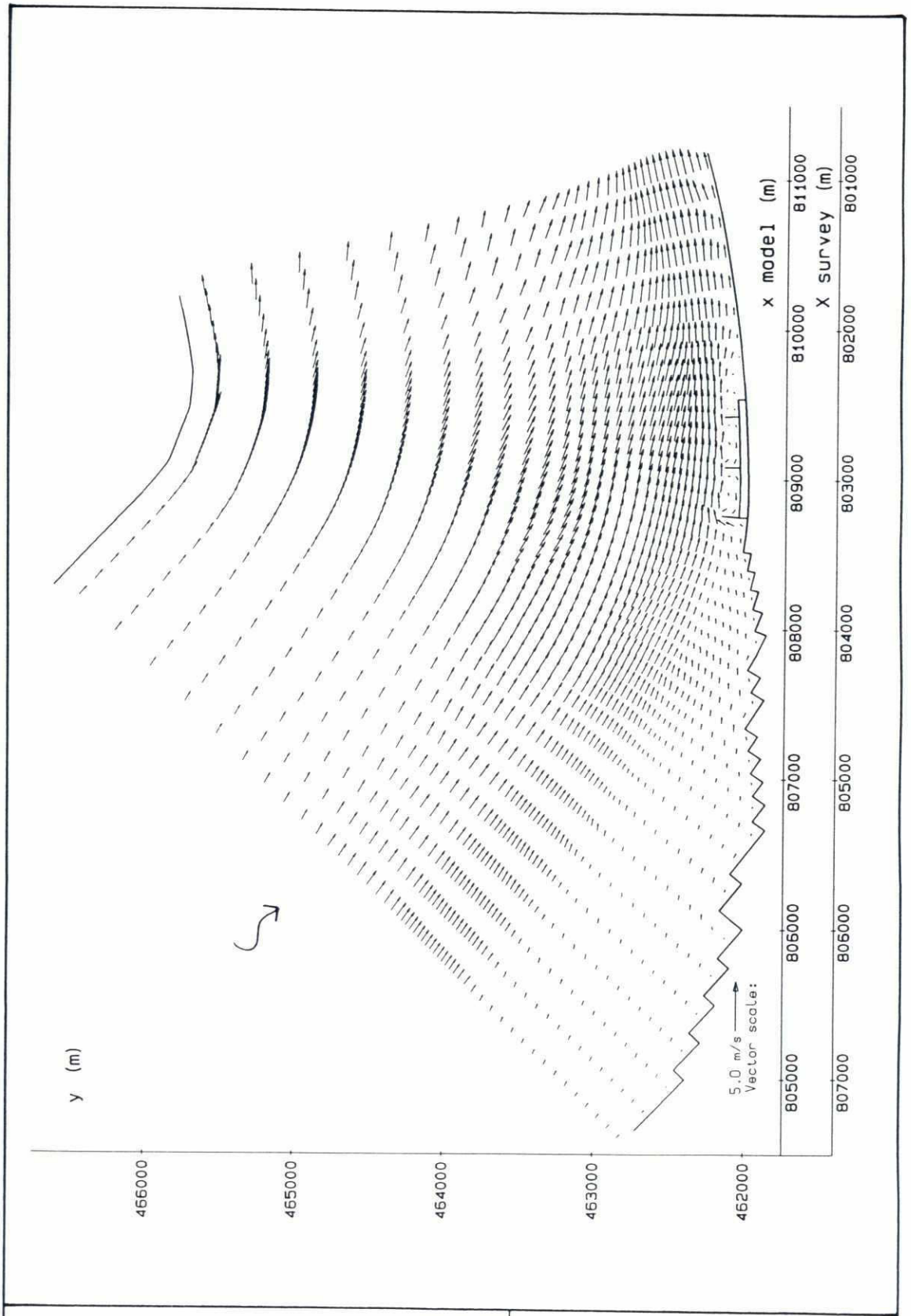
100



Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 100 years - Velocity isolines (m/s)

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FINAL REPORT | FIG. A.6 – 11

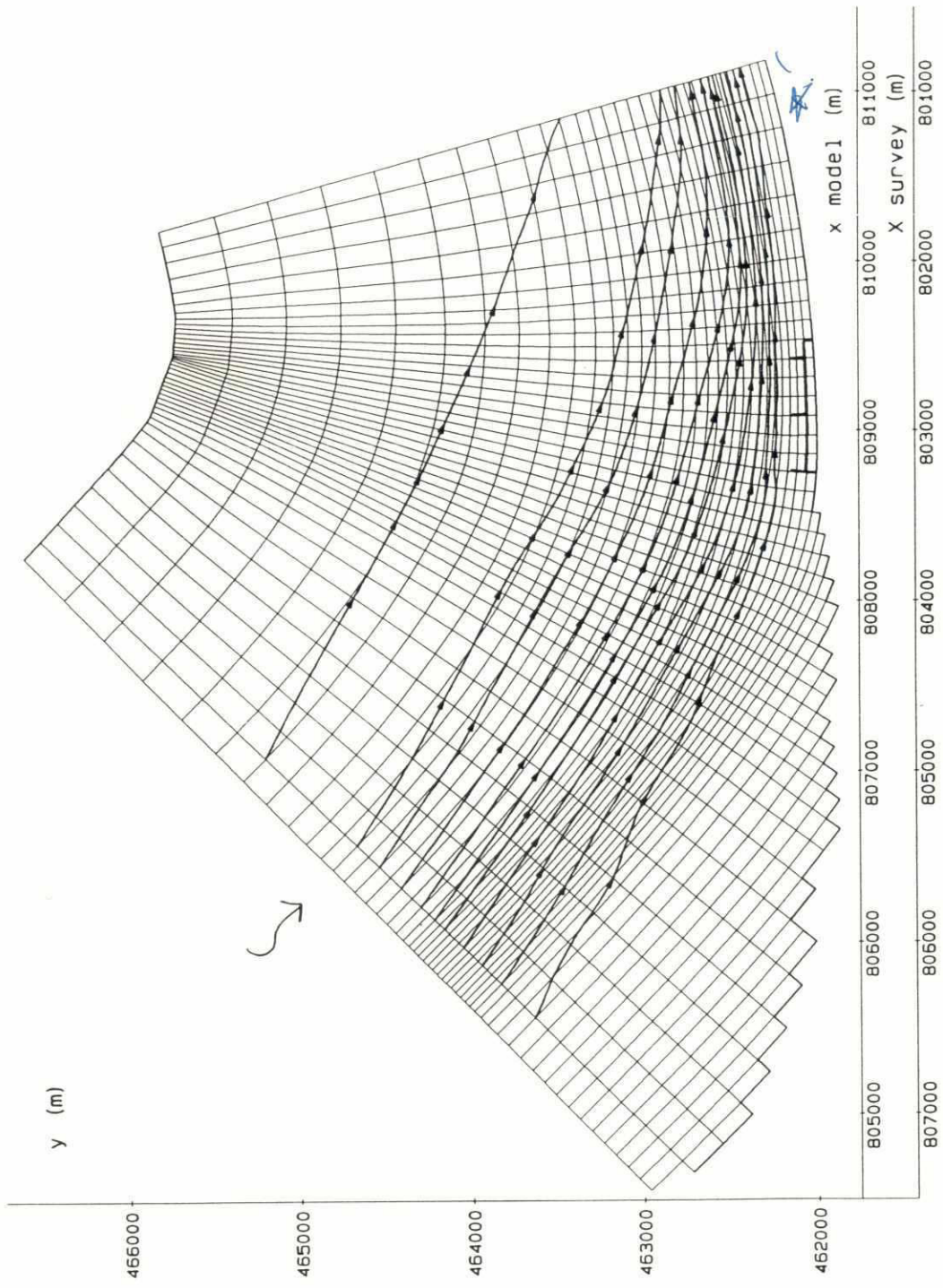


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 100 years - Flow field

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FINAL REPORT | FIG. A.6 – 12

102

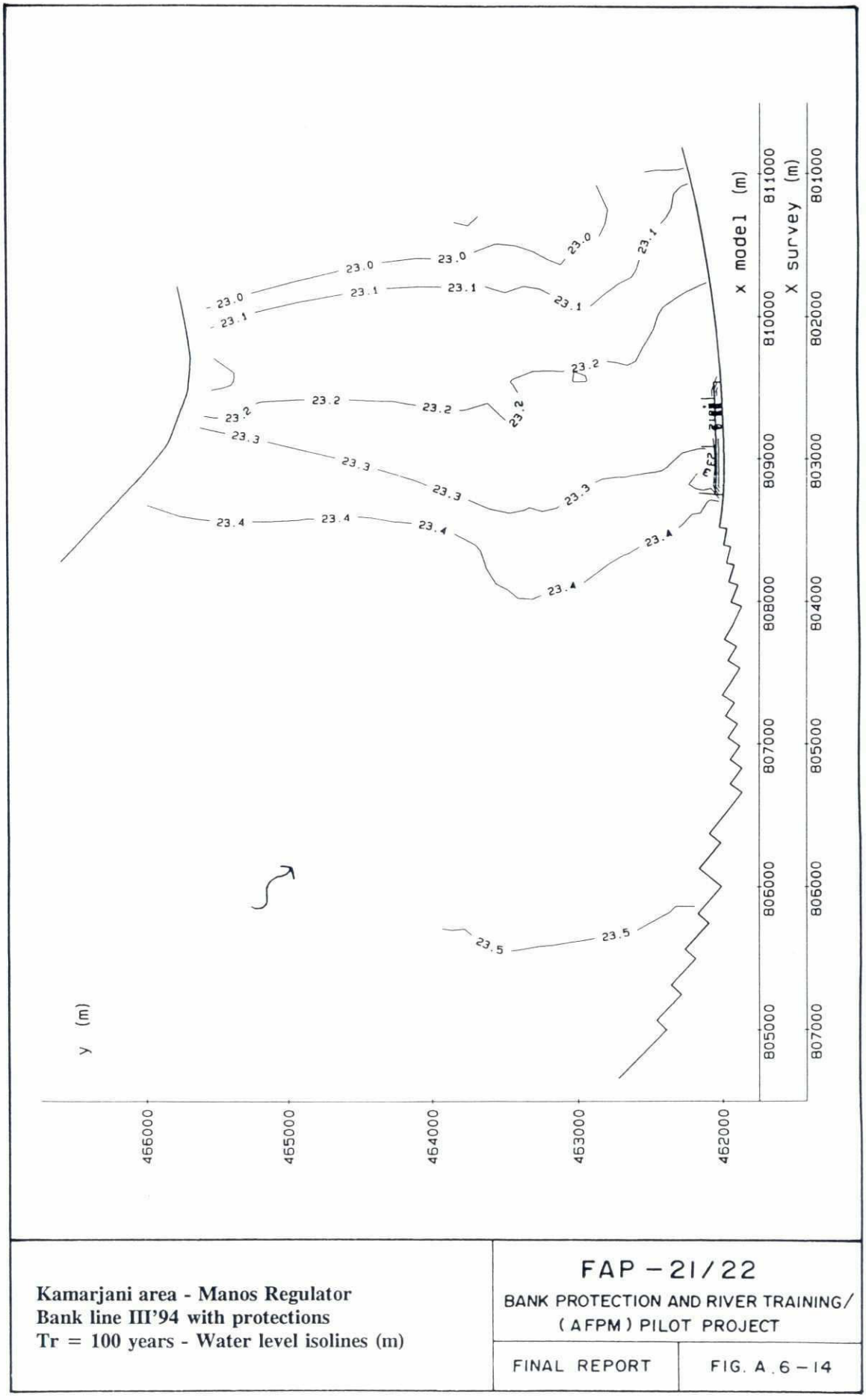


Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 100 years - Stream lines

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FINAL REPORT | FIG. A.6 – 13



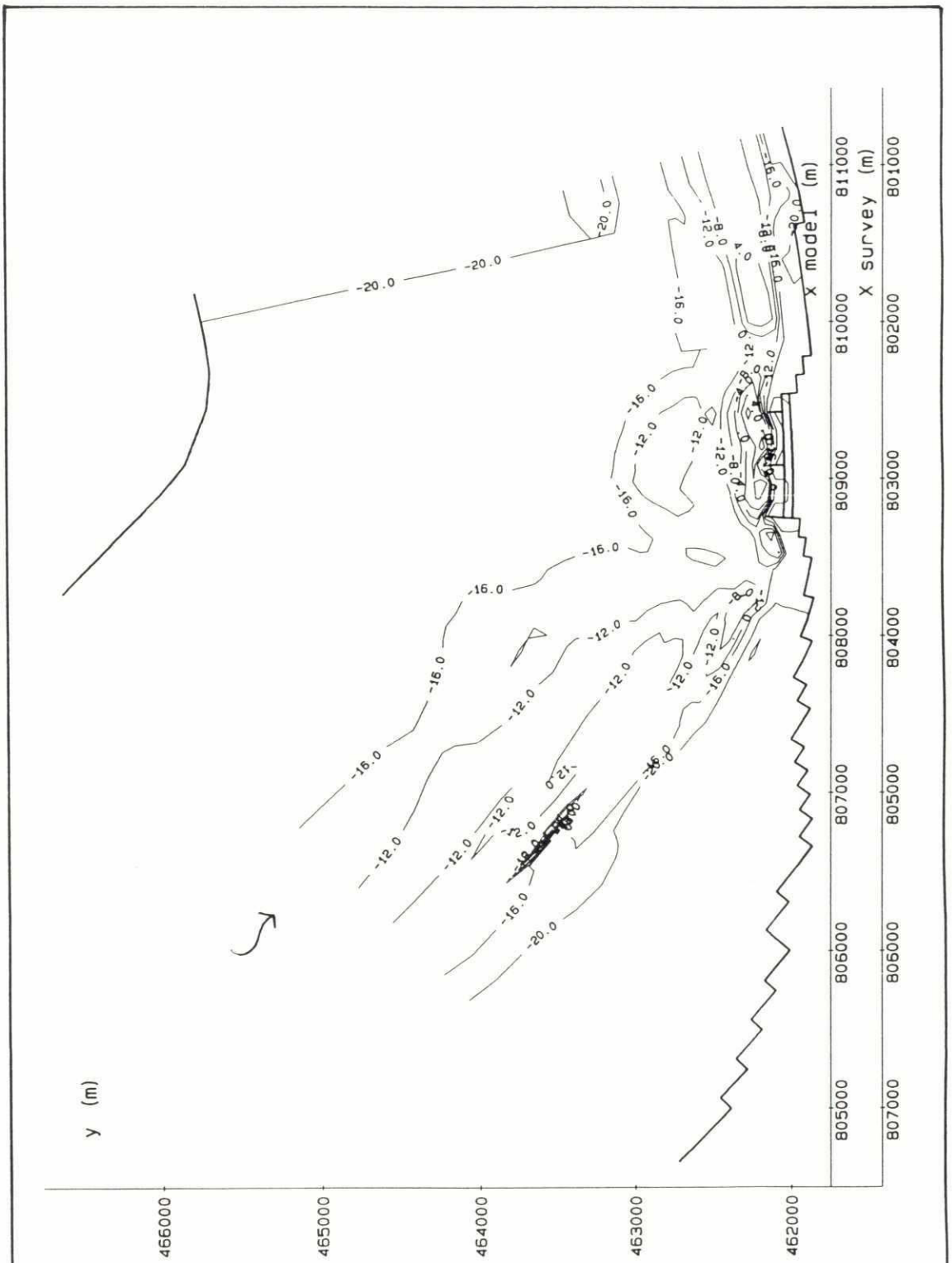
Kamarjani area - Manos Regulator
Bank line III'94 with protections
Tr = 100 years - Water level isolines (m)

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FINAL REPORT | FIG. A.6 – 14

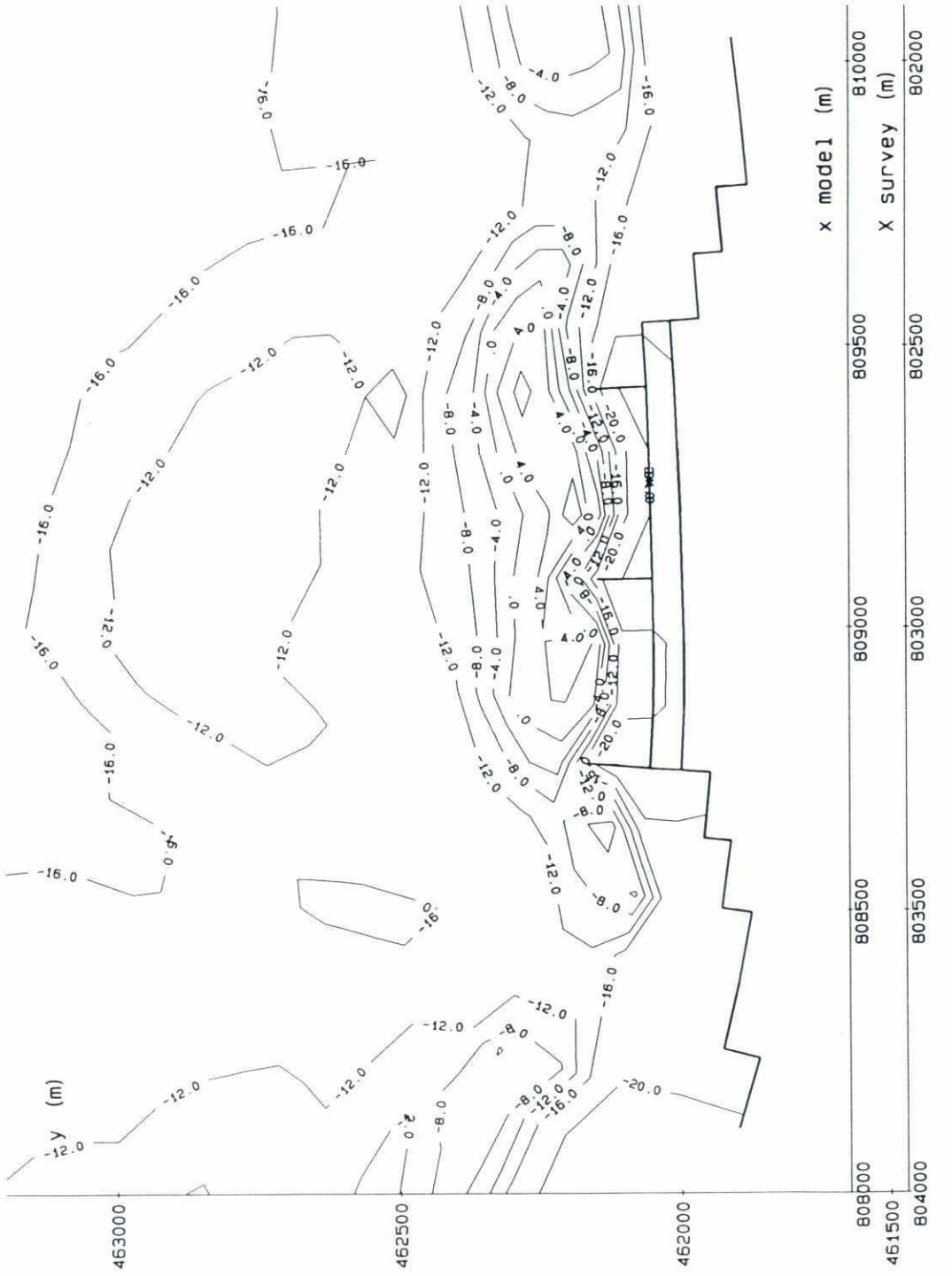
104



Kamarjani area - Manos Regulator
Bank line III'95 with protections
Bed level isolines [-(+m PWD)]

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FINAL REPORT | FIG. A.6 – 15



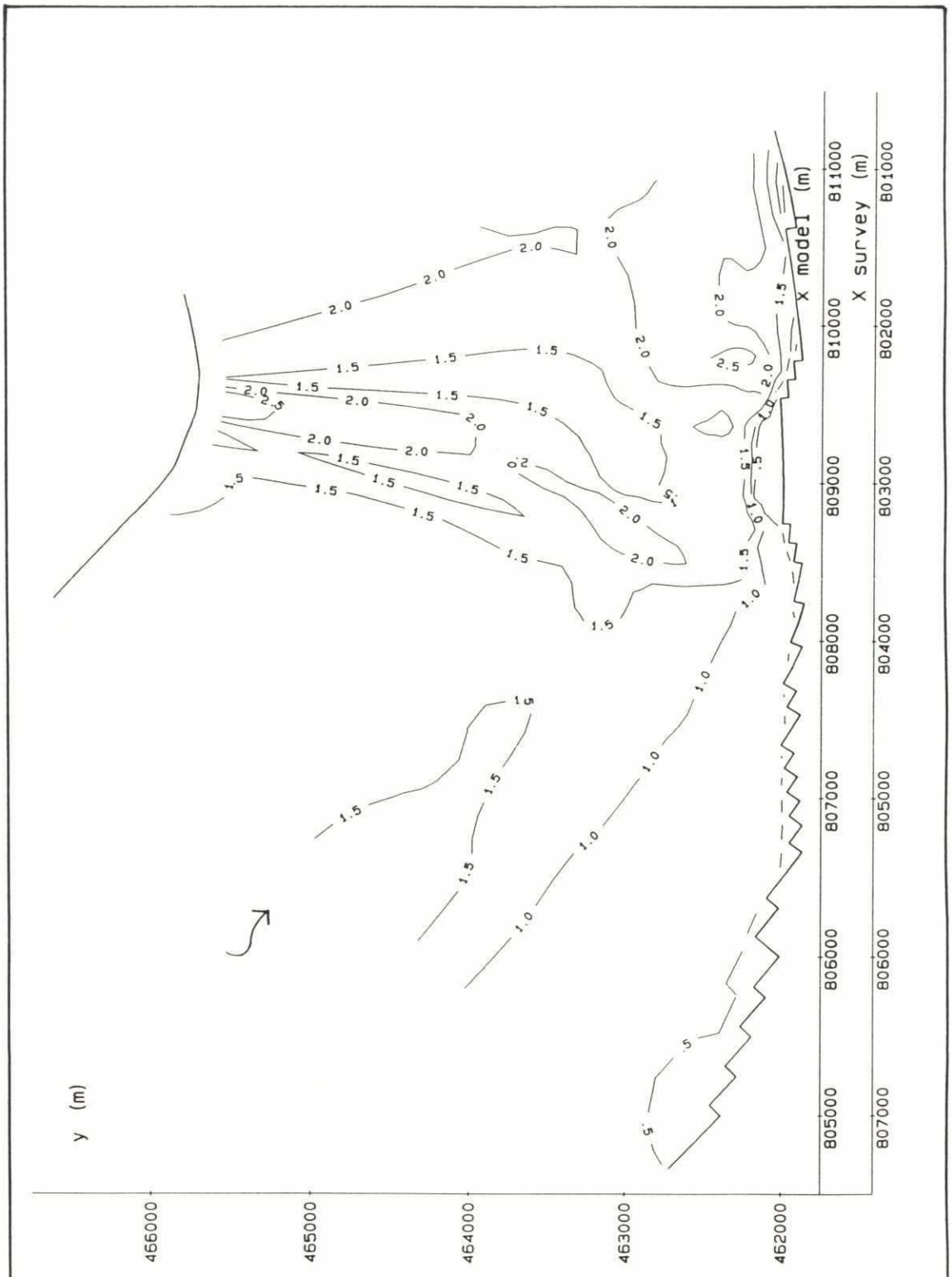
Kamarjani area - Manos Regulator
Bank line III'95 with protections
Bed level isolines [-(+m PWD)] Detail

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 16

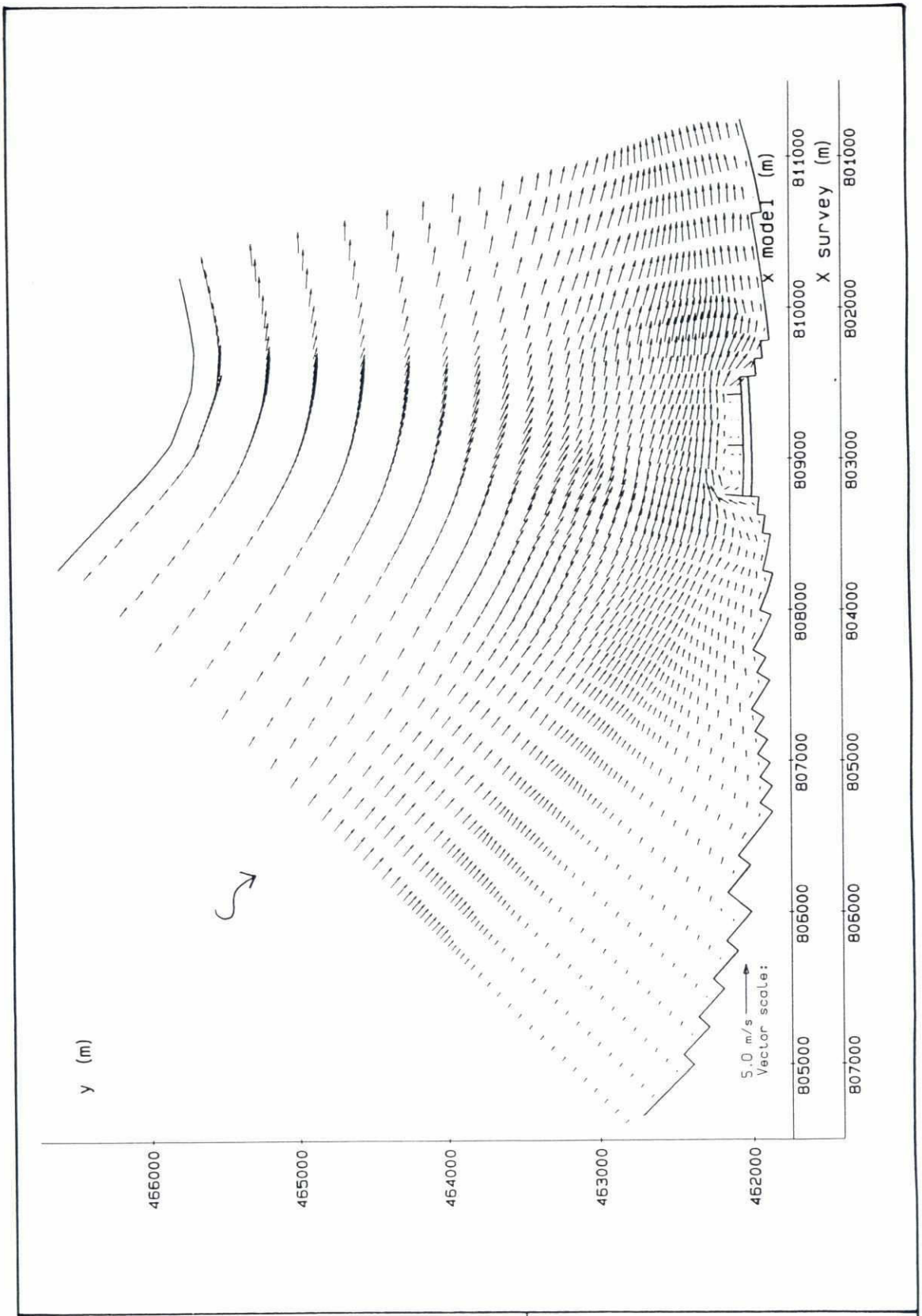
106



Kamarjani area - Manos Regulator
Bank line III'95 with protections
Tr = 100 years - Velocity isolines (m/s)

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 17

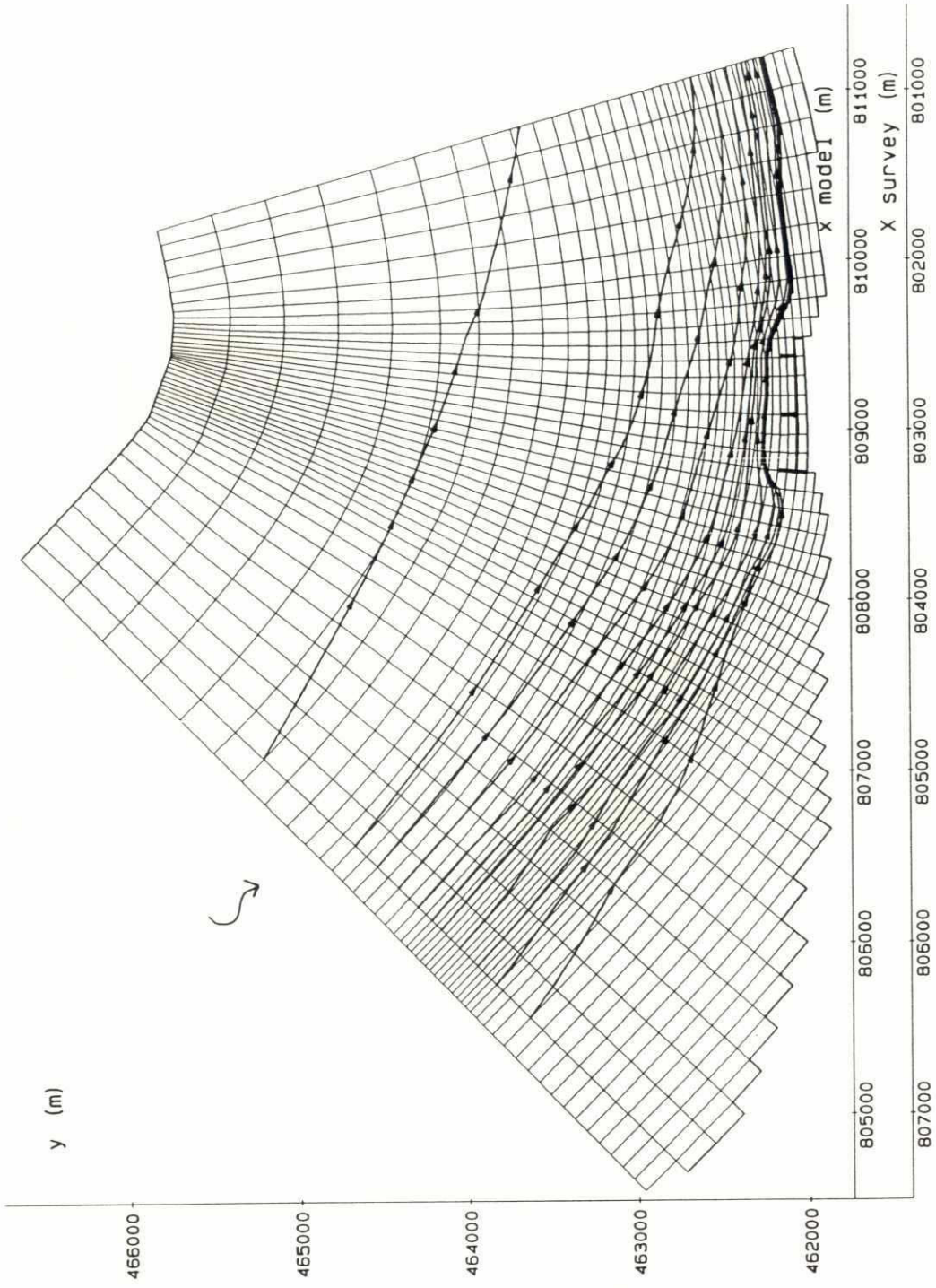


Kamarjani area - Manos Regulator
Bank line III'95 with protections
Tr = 100 years - Flow field

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

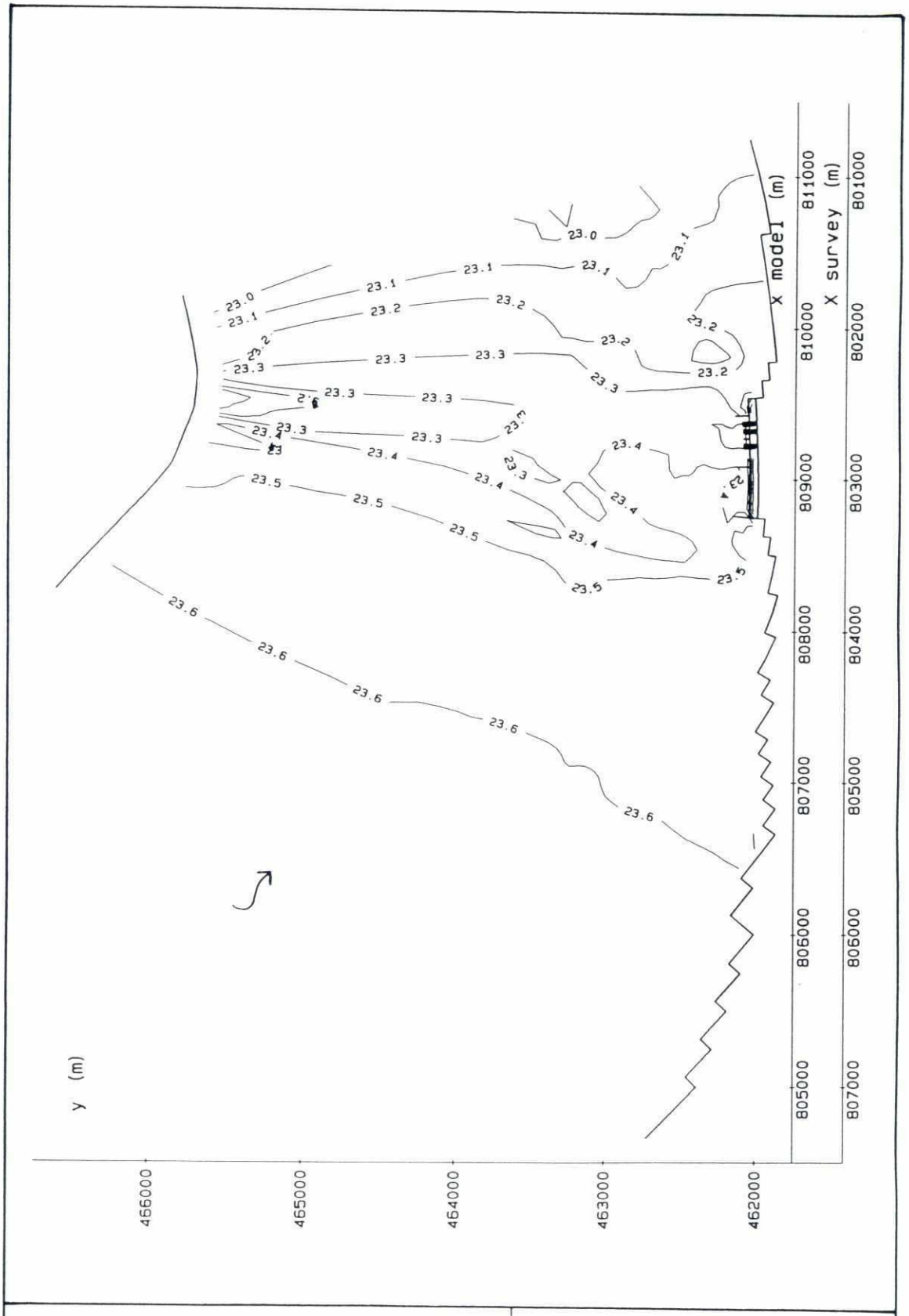
FINAL REPORT | FIG. A.6 – 18



Bahadurabad area
Bank line III'95 with protections
Tr = 100 years - Stream lines

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

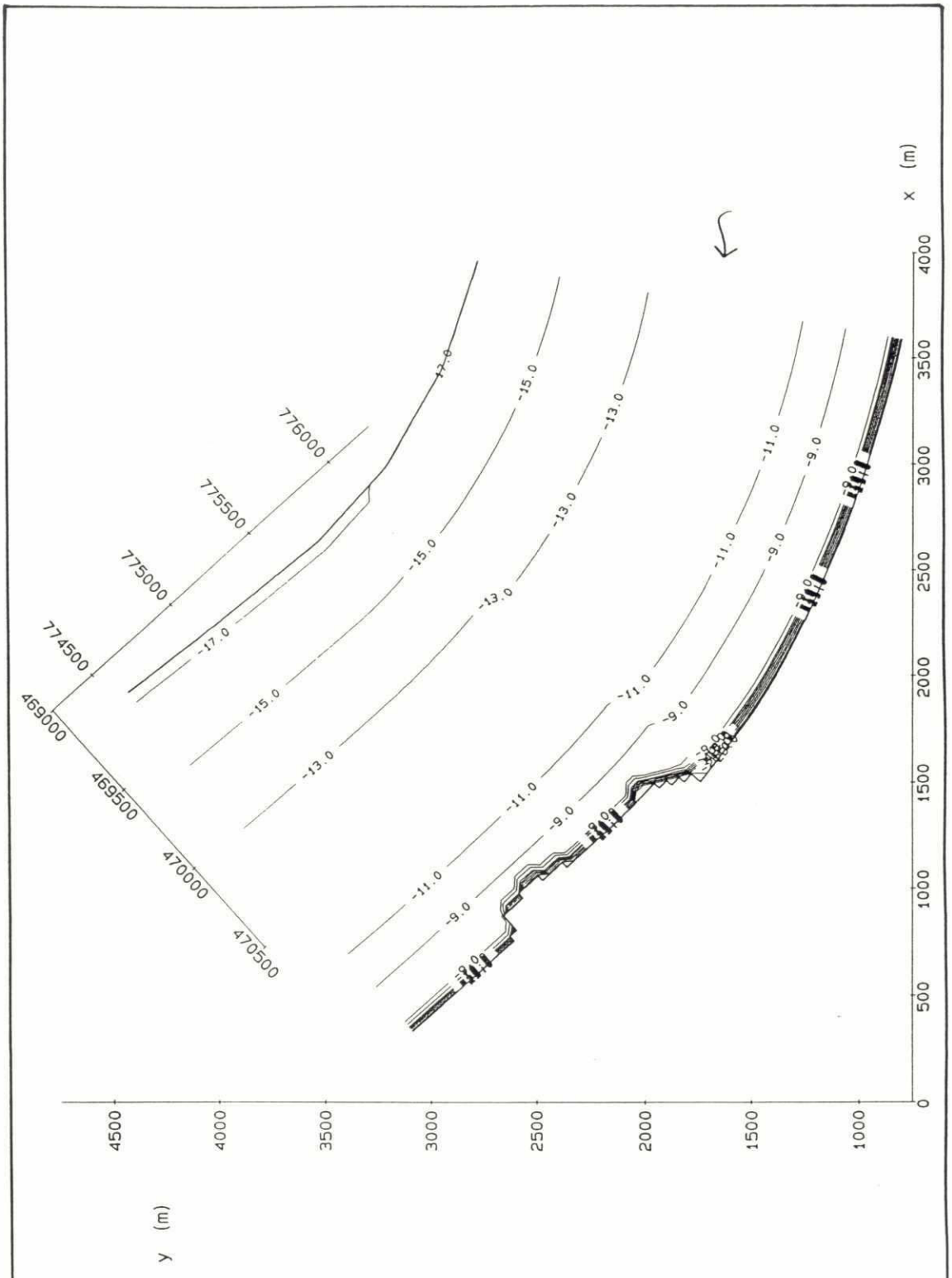
FINAL REPORT | FIG. A.6 – 19



Bahadurabad area
Bank line III'95 with protections
Tr = 100 years - Water level isolines (m)

FAP – 21/22
BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

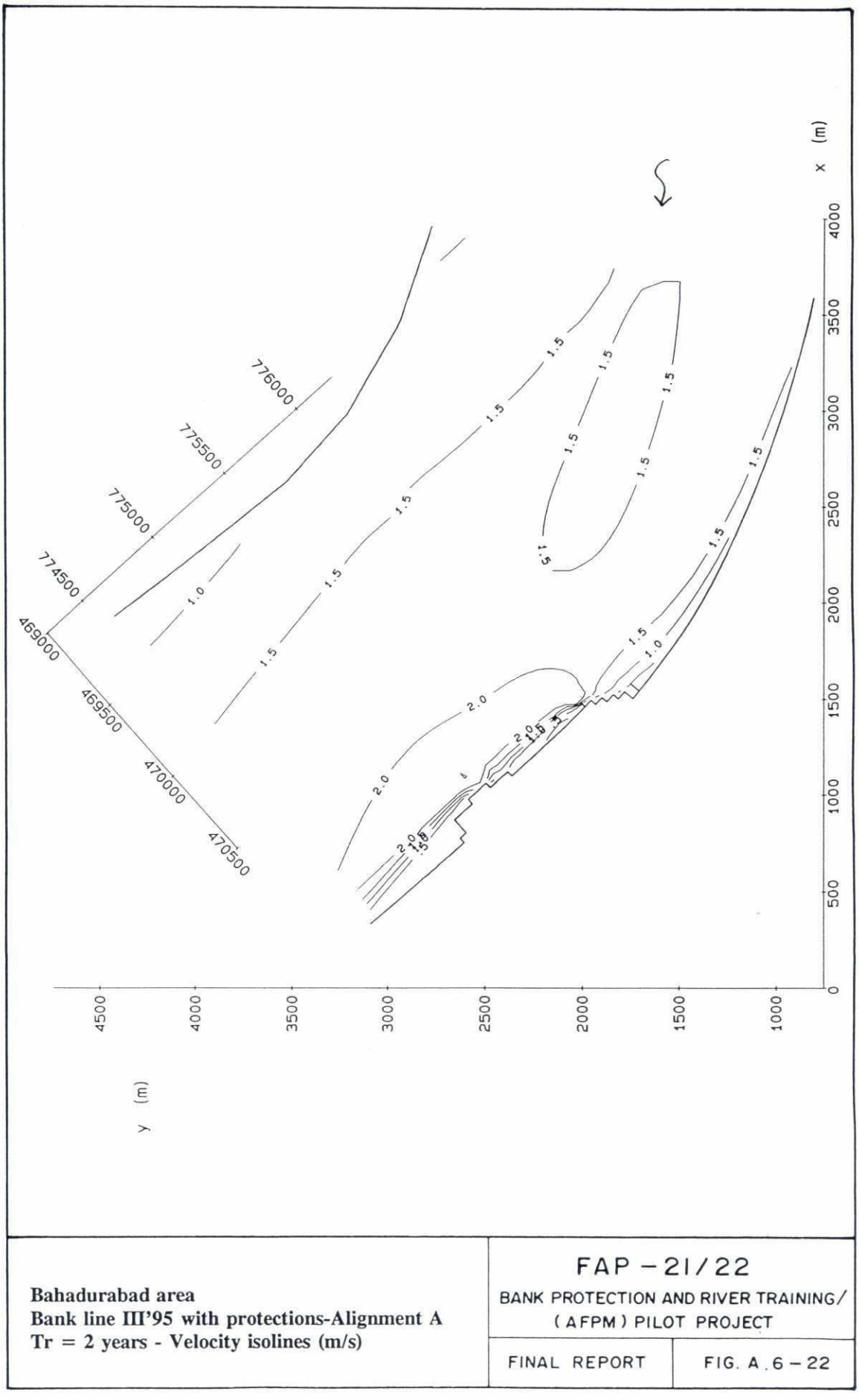
FINAL REPORT | FIG. A.6 – 20



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 100 years - Bed level isolines (-1)*(m+PWD)

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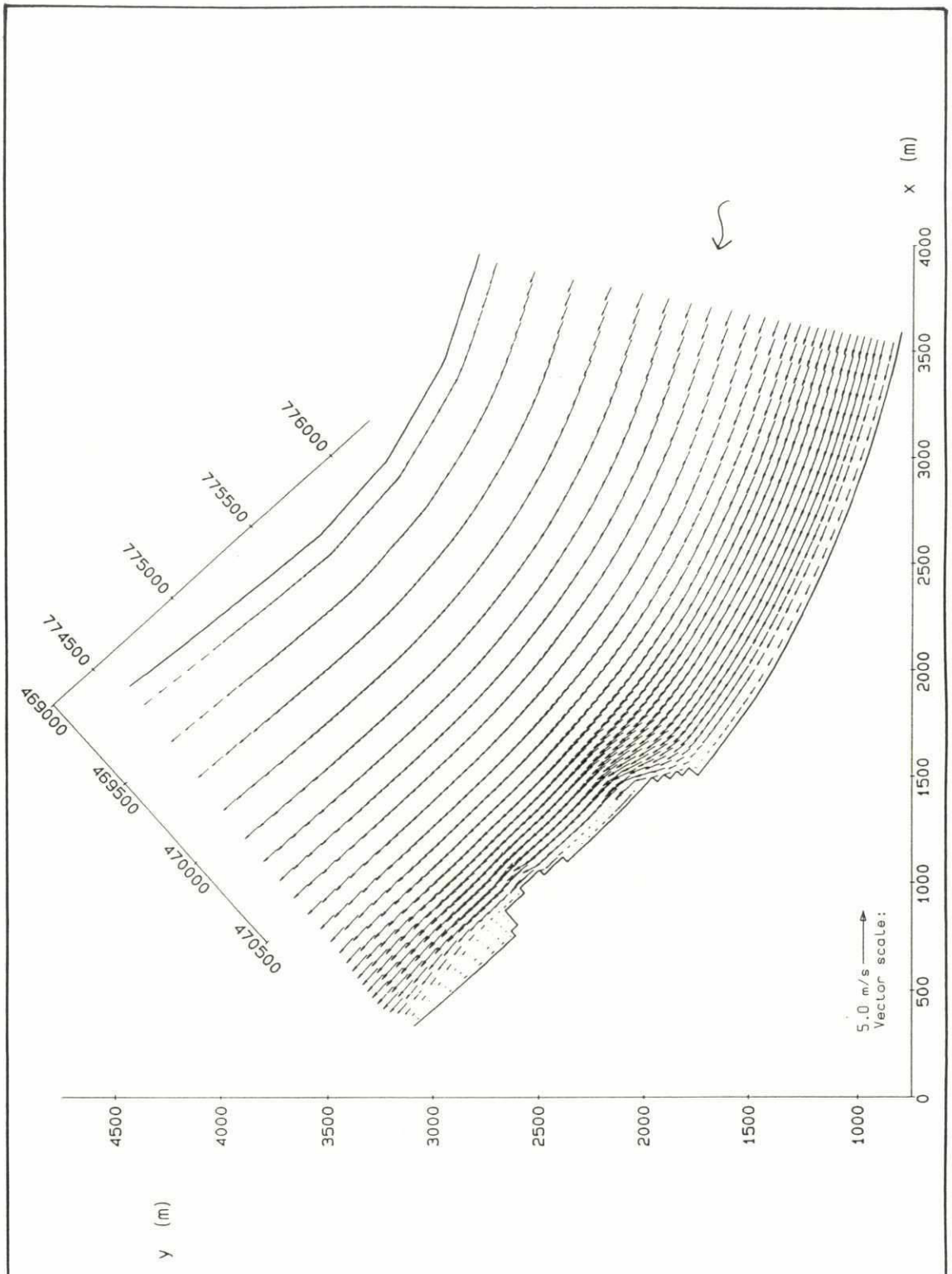
FINAL REPORT | FIG. A.6 - 21



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 2 years - Velocity isolines (m/s)

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

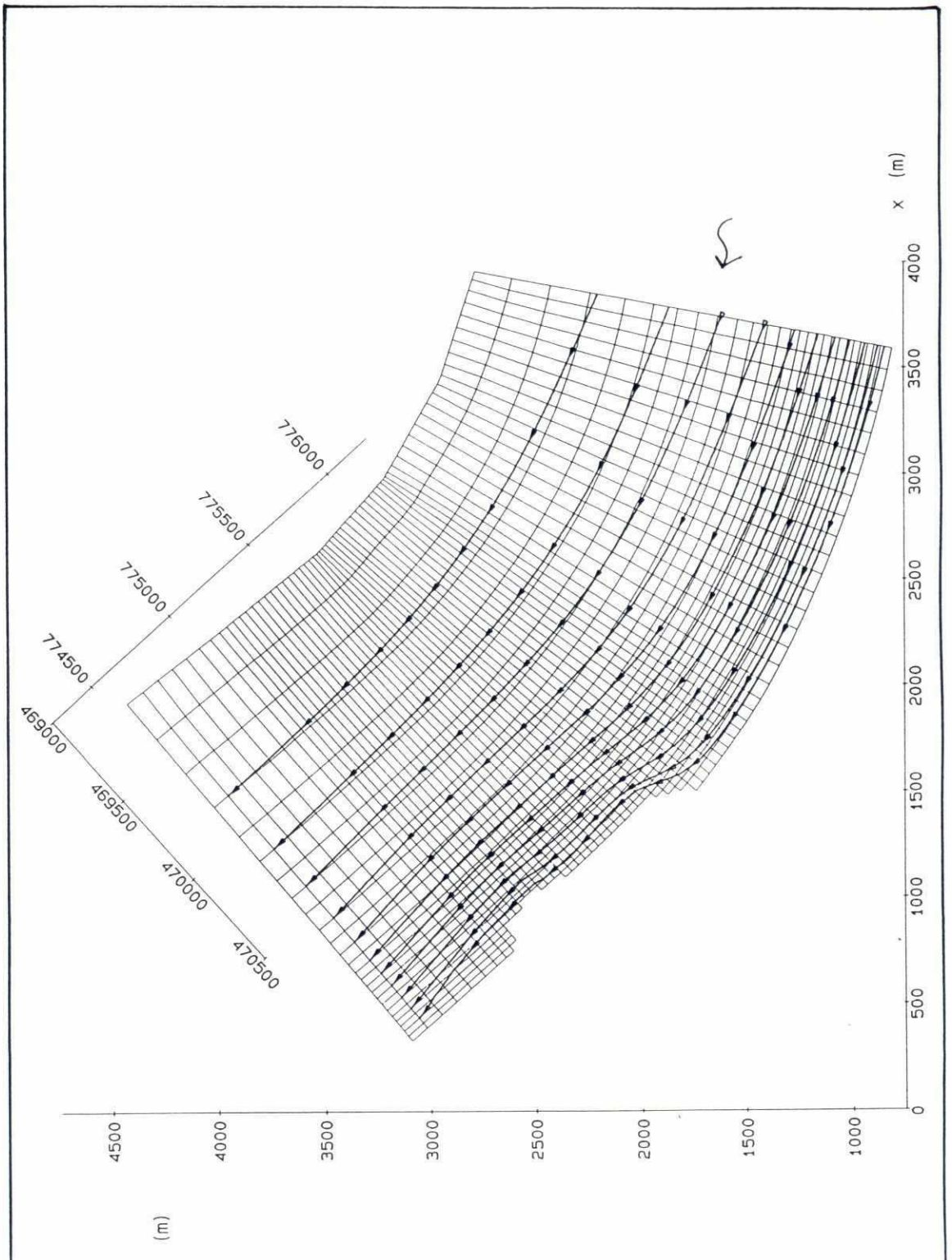
FINAL REPORT | FIG. A.6 – 22



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 2 years - Flow field

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BANK PROTECTION AND RIVER TRAINING/
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FINAL REPORT | FIG. A.6 – 23



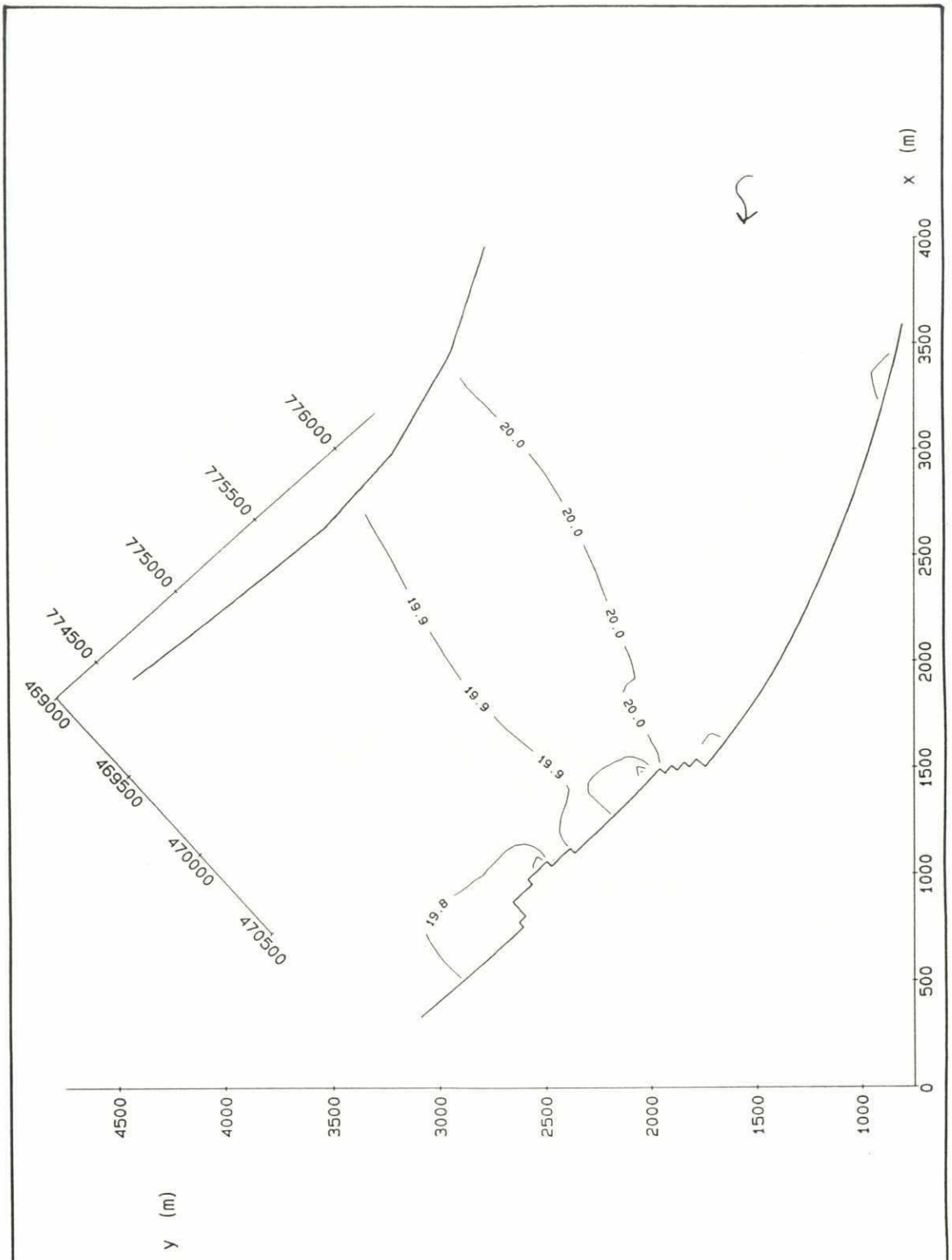
Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 2 years - Stream lines

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 24

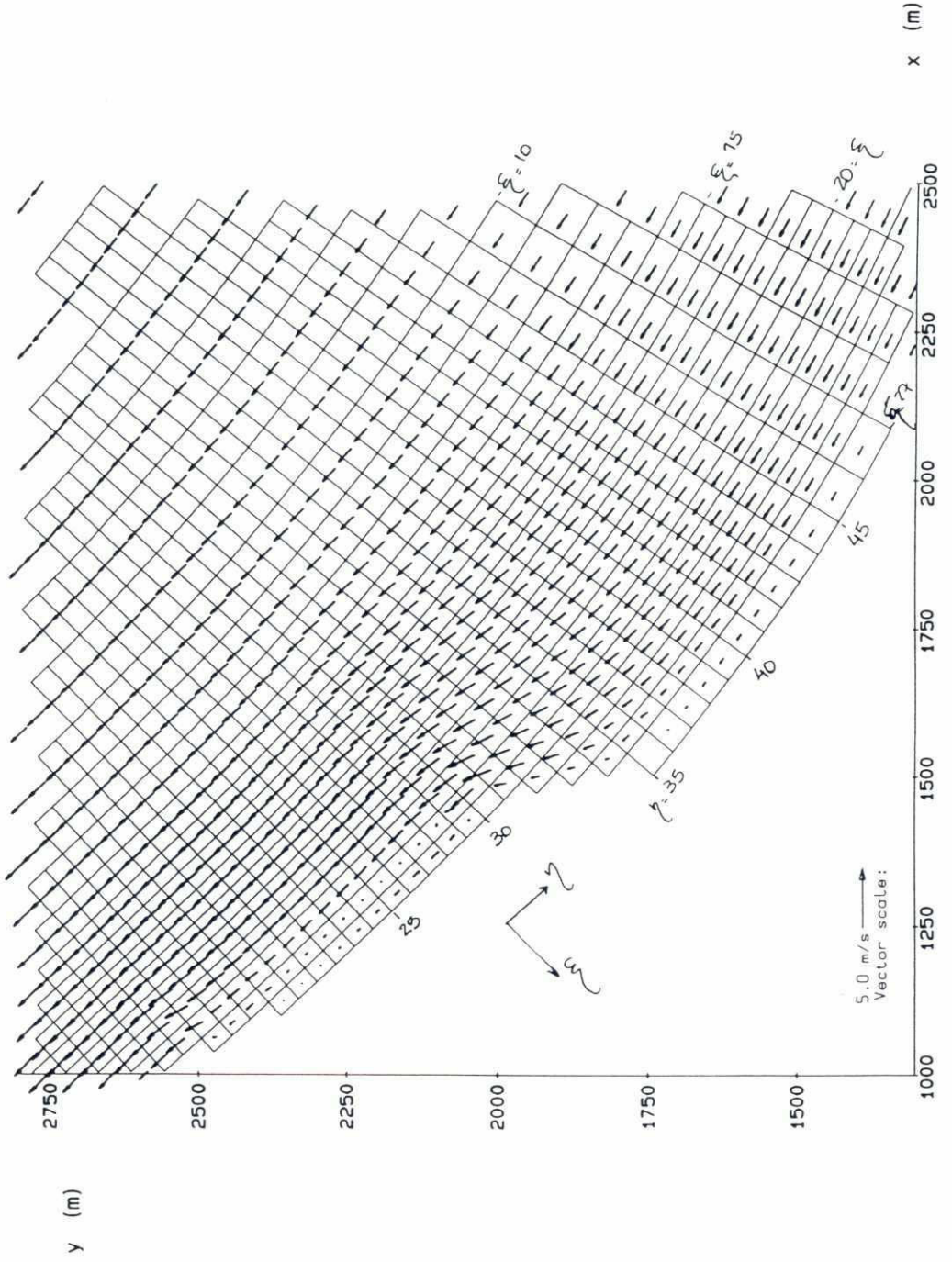
114



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 2 years - Water level isolines (+m PWD)

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(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 25

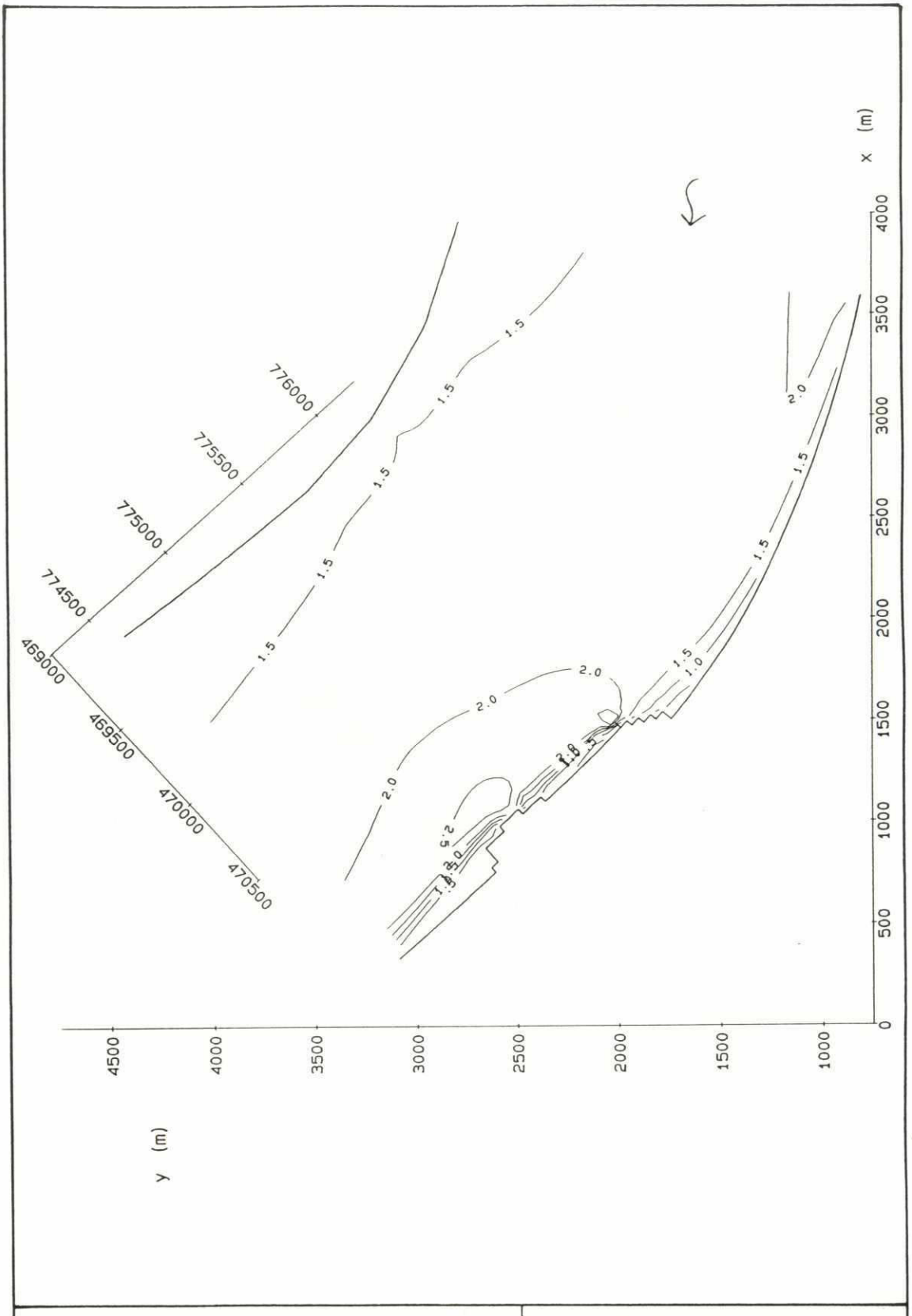


Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 2 years - Flow field (detail)

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(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 26

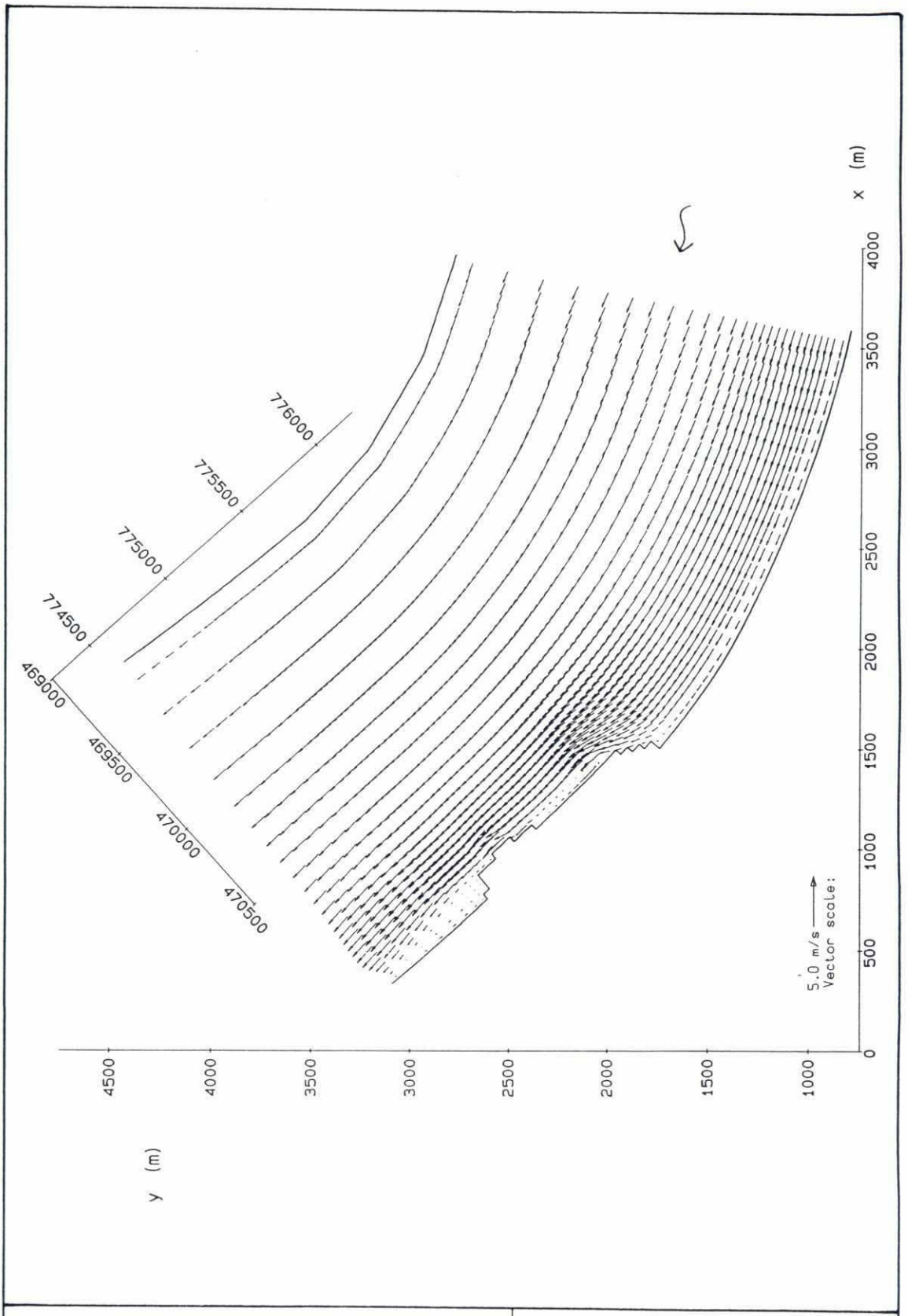
116



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 10 years - Velocity isolines (m/s)

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 27



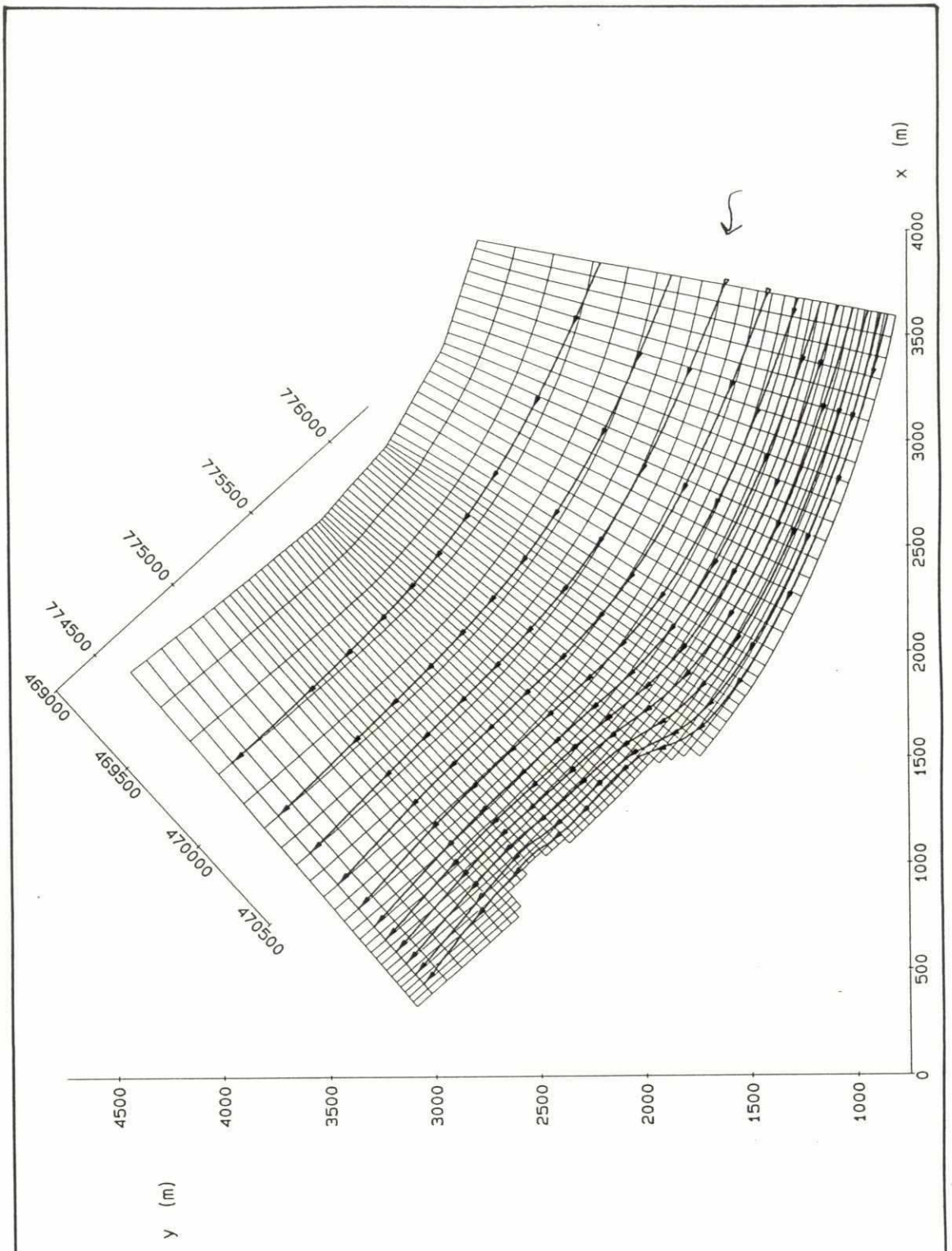
Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 10 years - Flow field

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 28

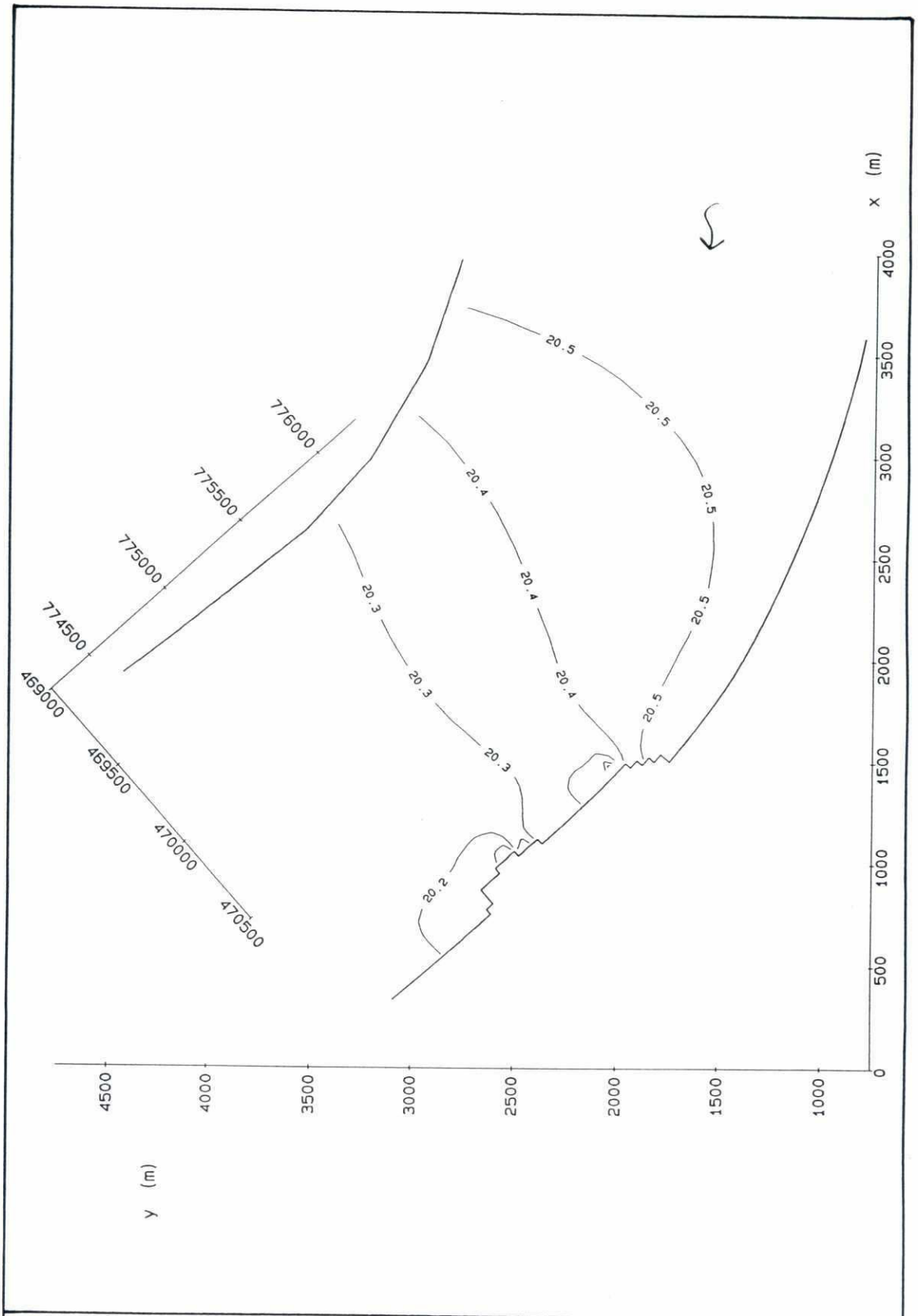
118



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 10 years - Stream lines

FAP – 21/22
BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT	FIG. A.6 – 29



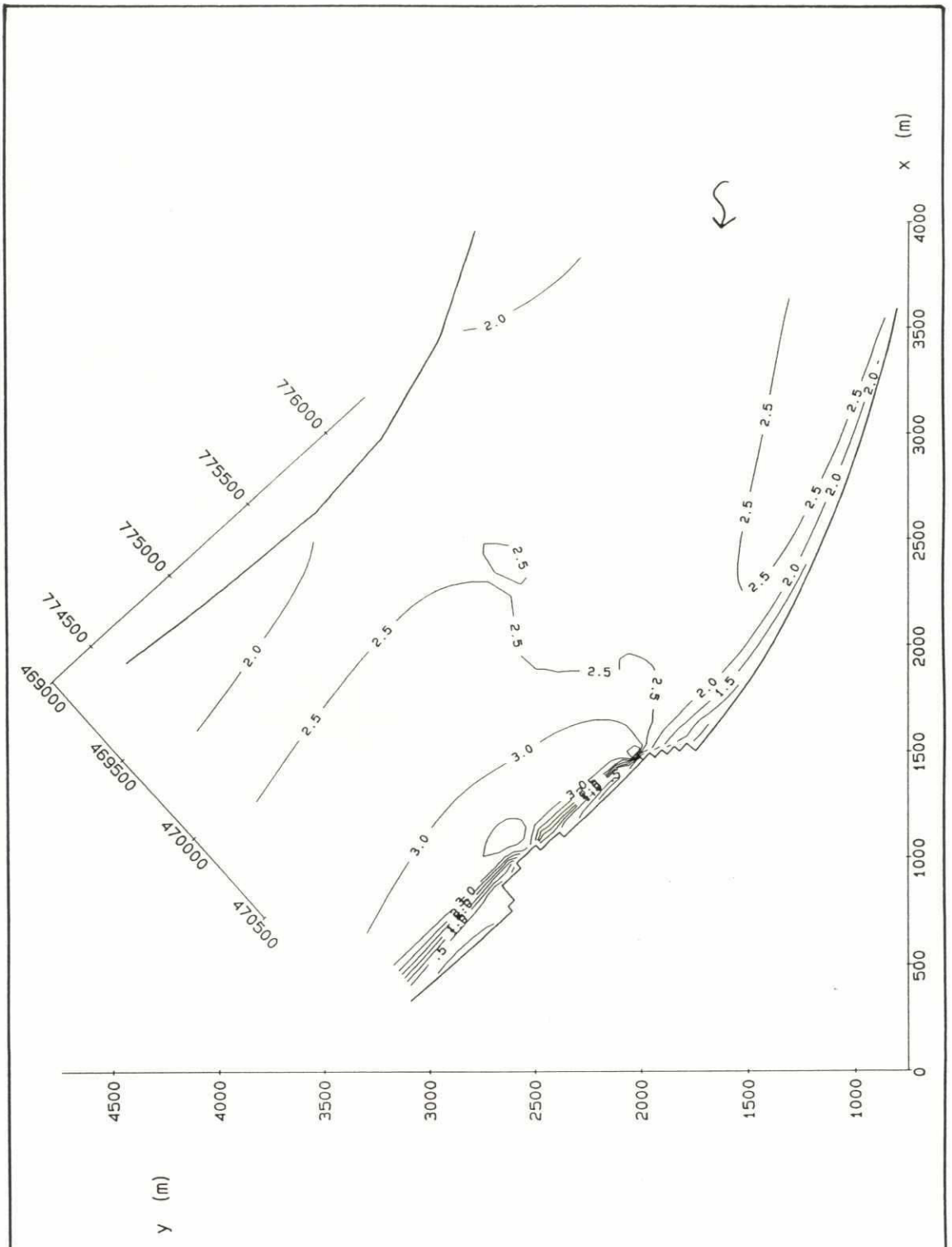
Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 10 years - Water level isolines (+m PWD)

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 30

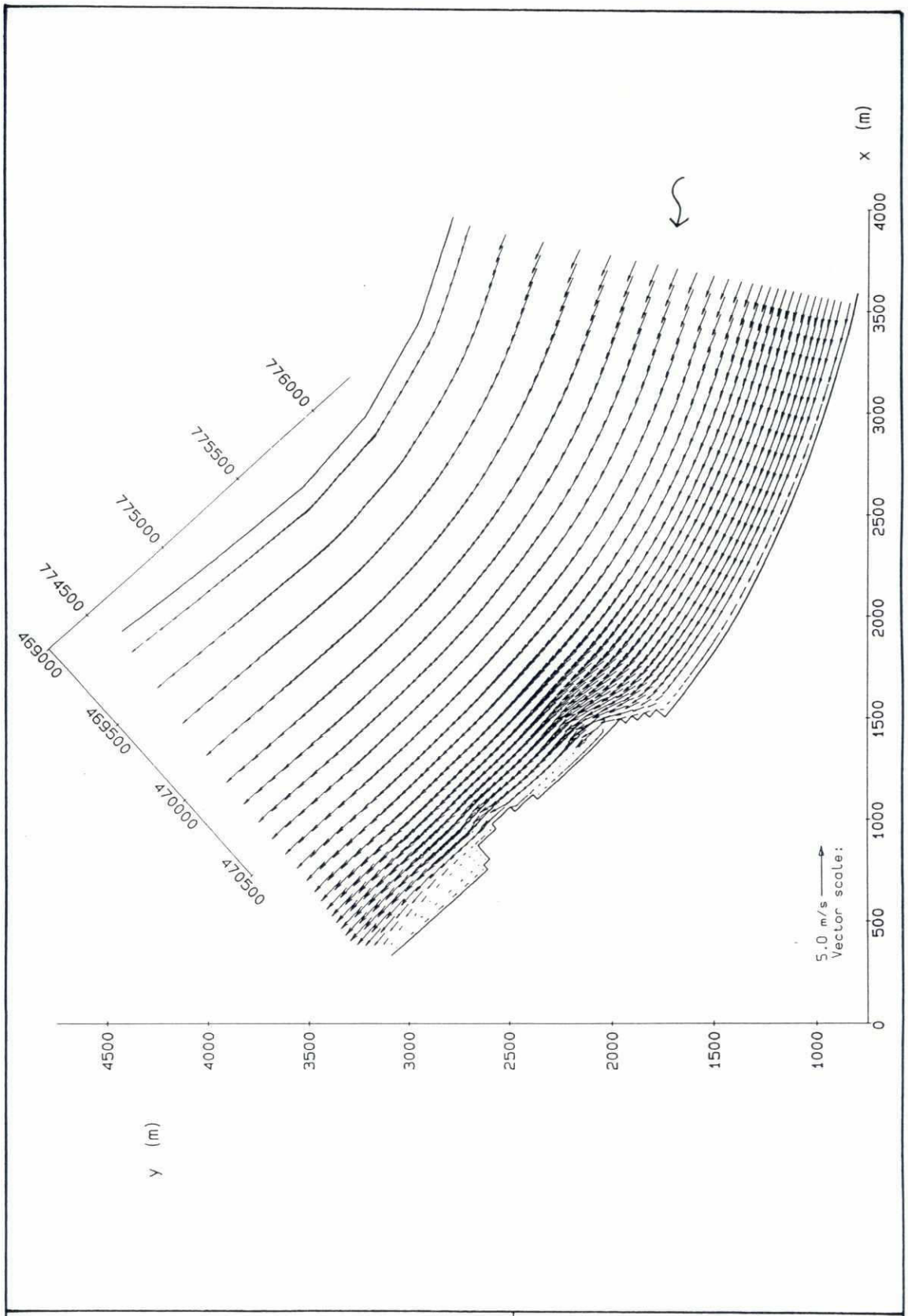
120



Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 100 years - Velocity isolines (m/s)

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 31



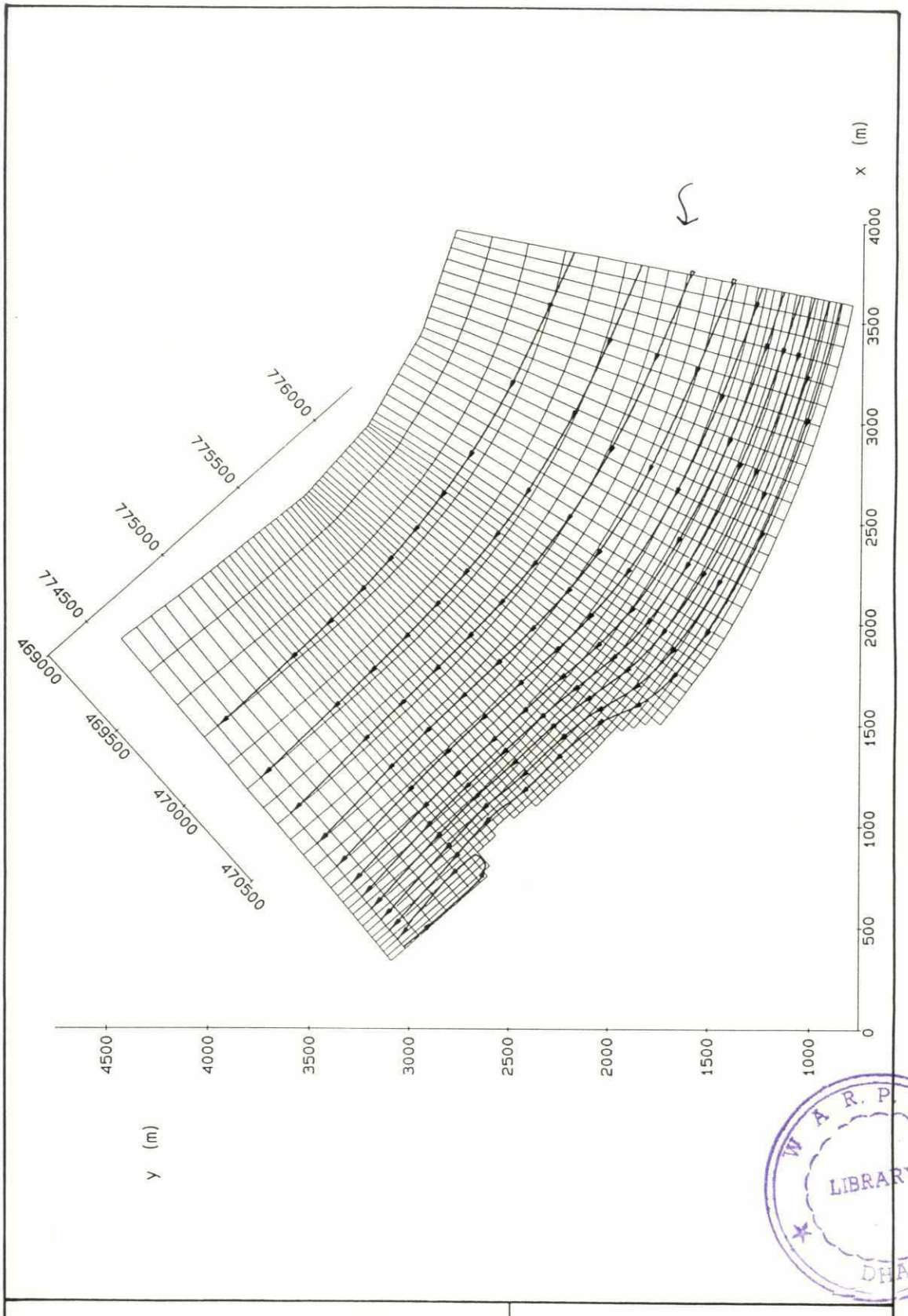
Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 100 years - Flow field

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 32

122

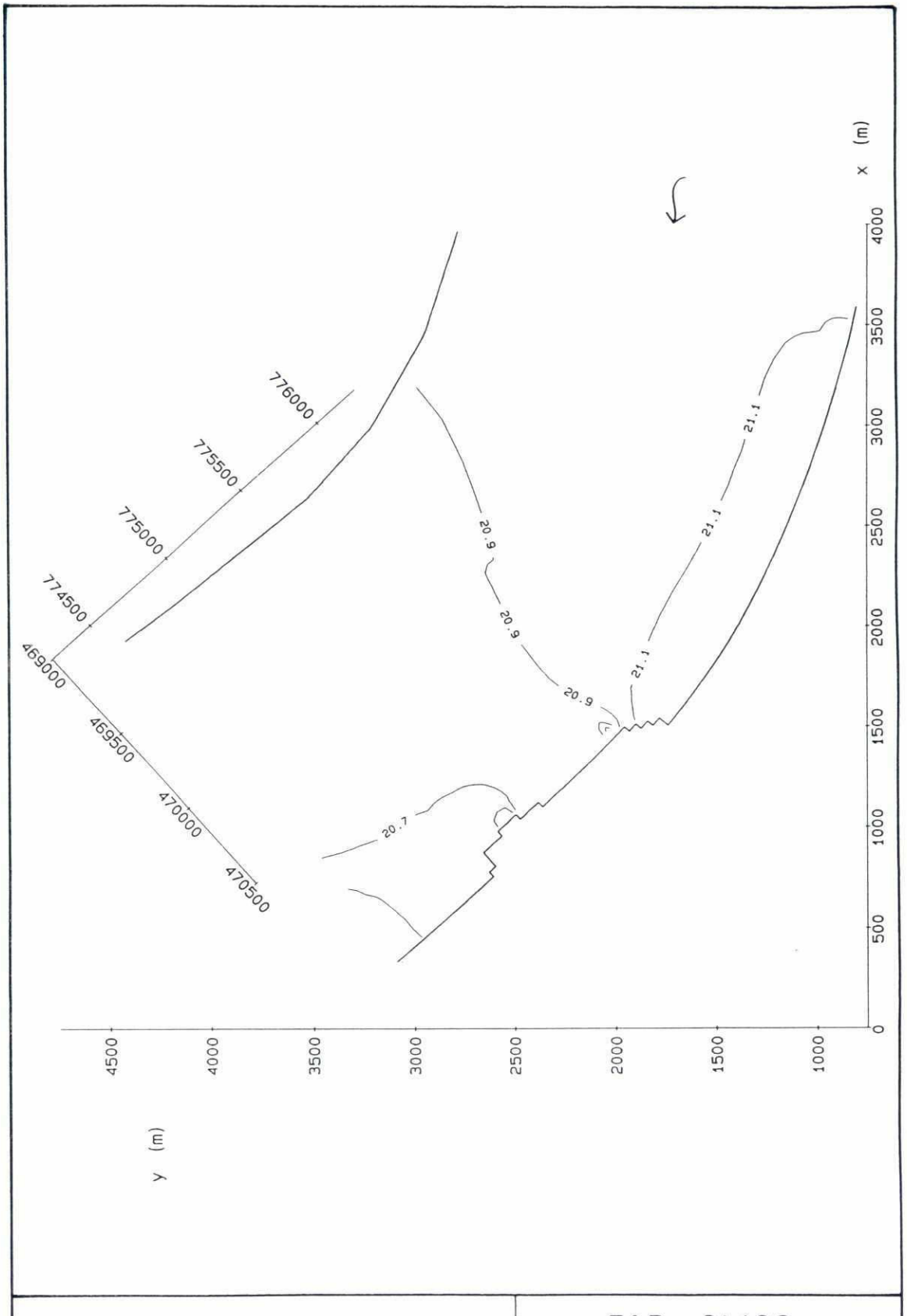


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Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 100 years - Stream lines

FAP – 21/22
BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 33



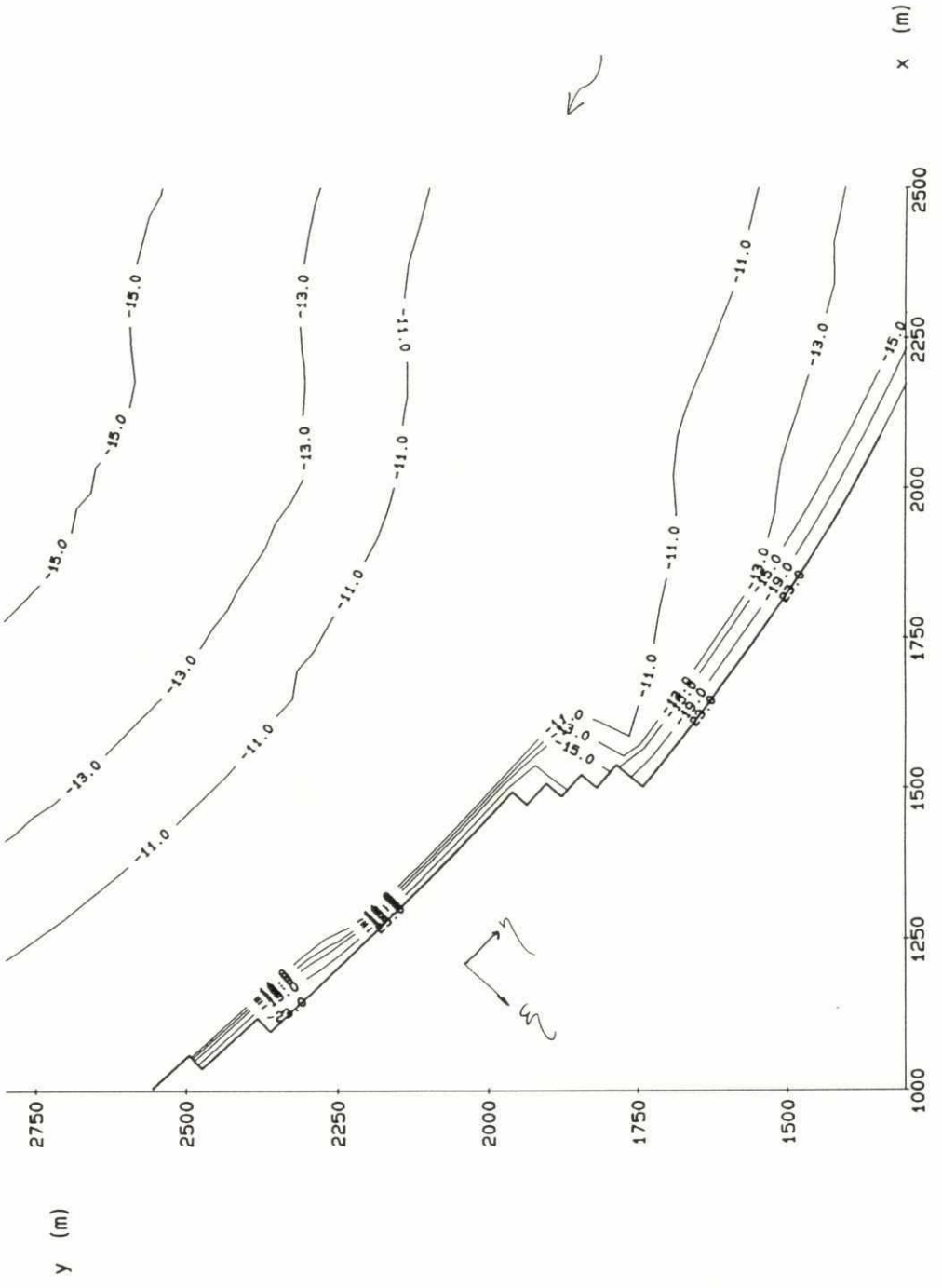
Bahadurabad area
Bank line III'95 with protections-Alignment A
Tr = 100 years - Water level isolines (+m PWD)

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 34

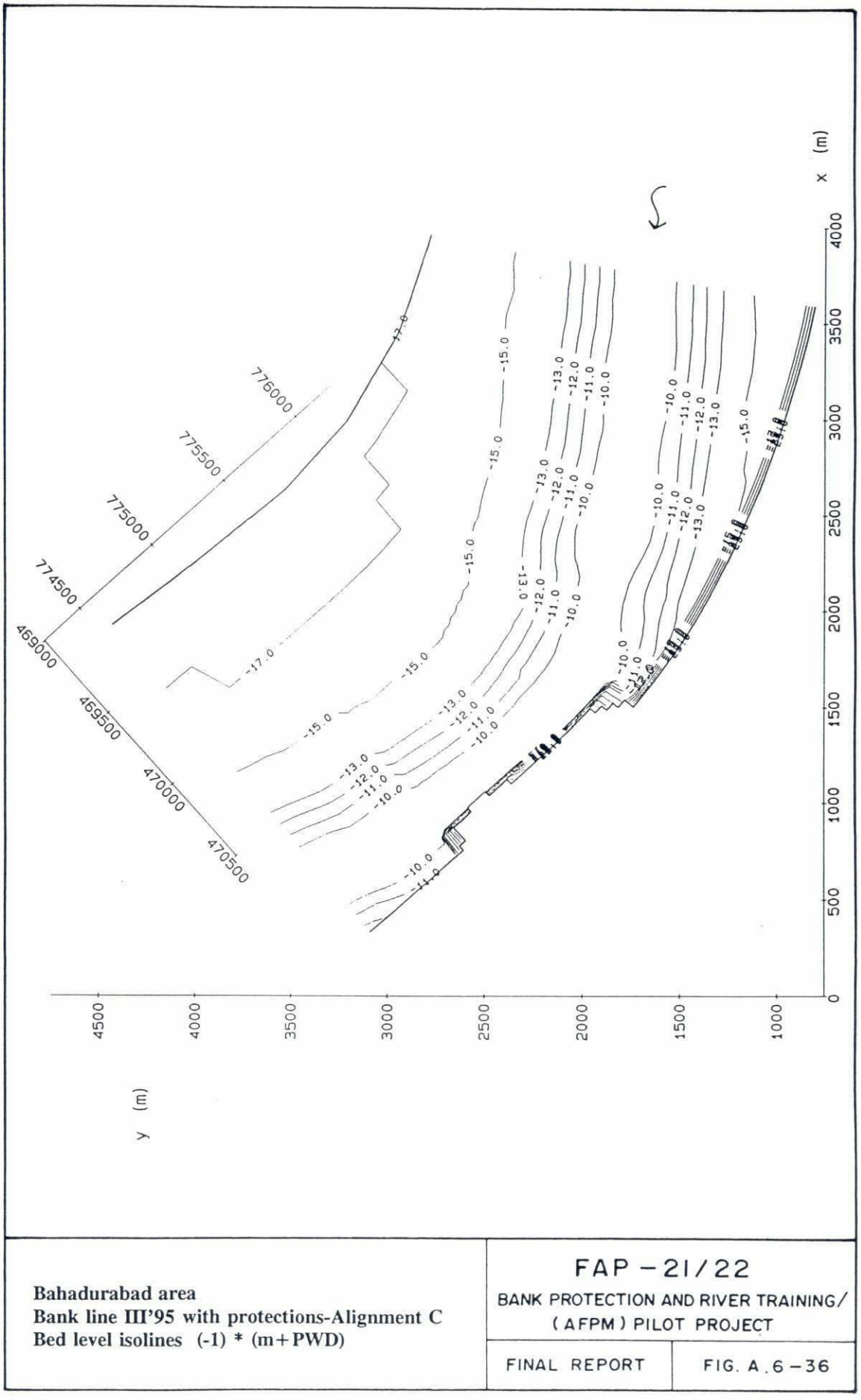
124



Bahadurabad area
Bank line III'95 with protections-Alignment C
Bed level isolines (-1) * (m+PWD)

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 35

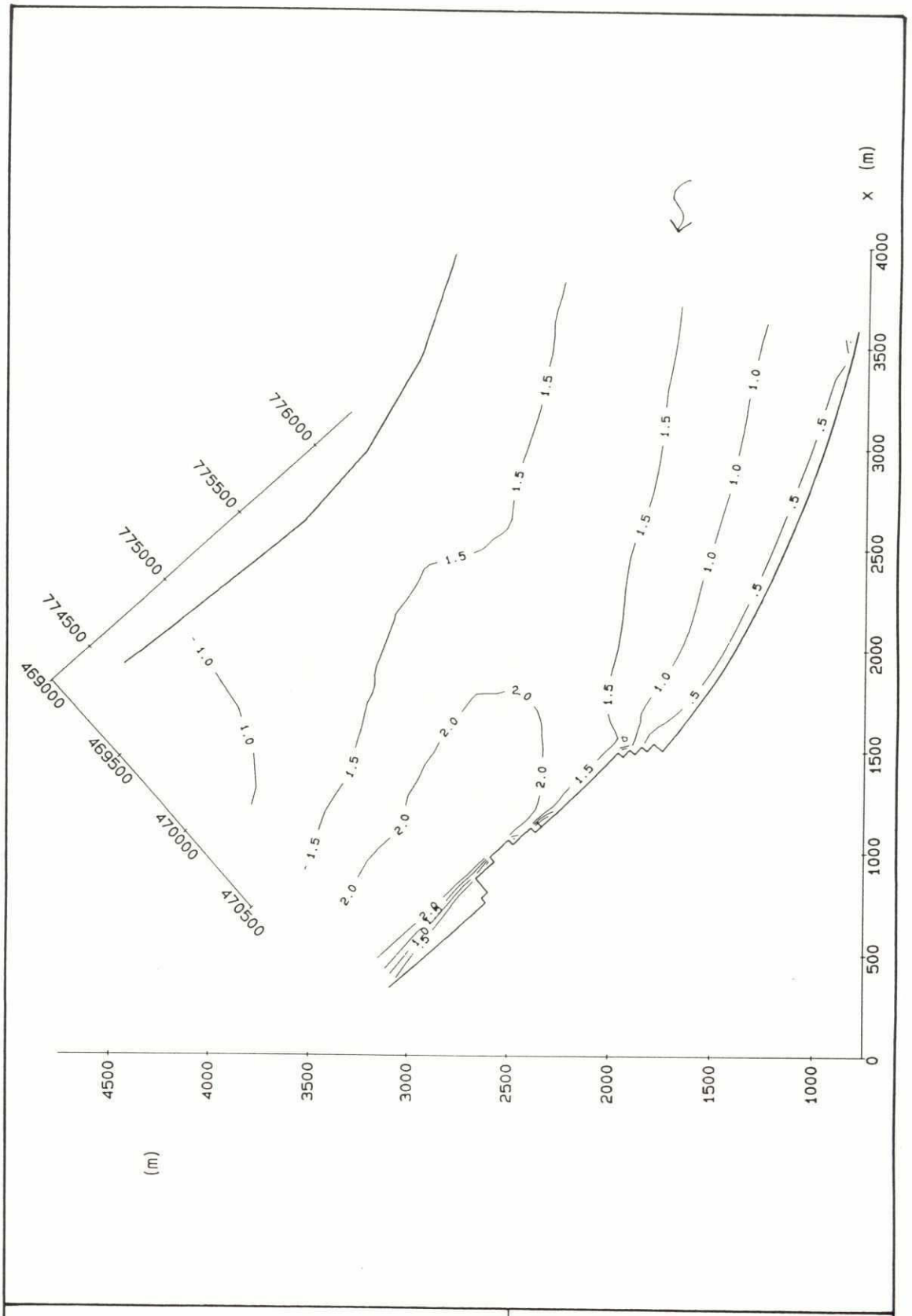


Bahadurabad area
Bank line III'95 with protections-Alignment C
Bed level isolines (-1) * (m+PWD)

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 36

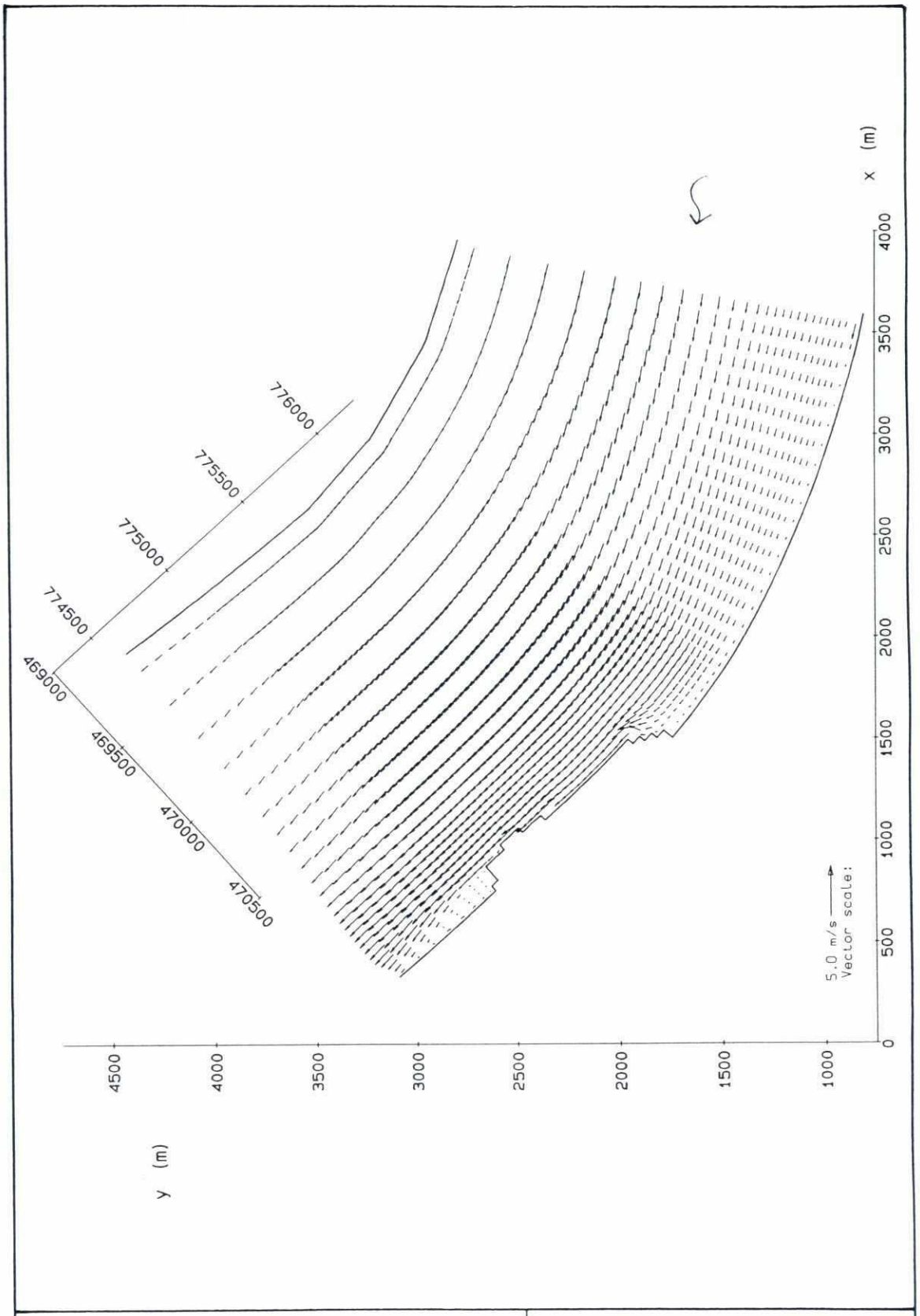
126



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 2 years - Velocity isolines (m/s)

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT	FIG. A.6 – 37

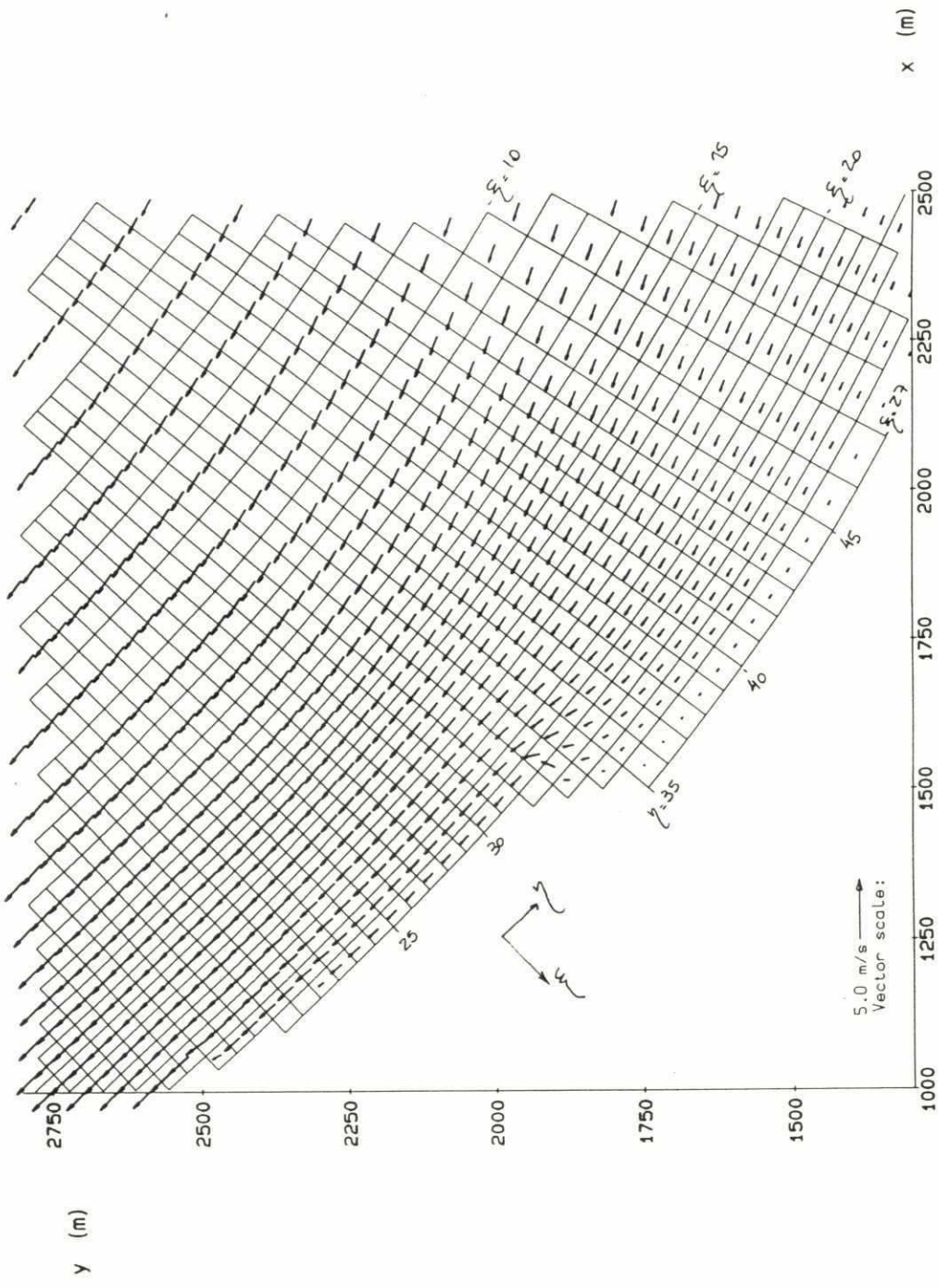


Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 2 years - Flow field

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BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

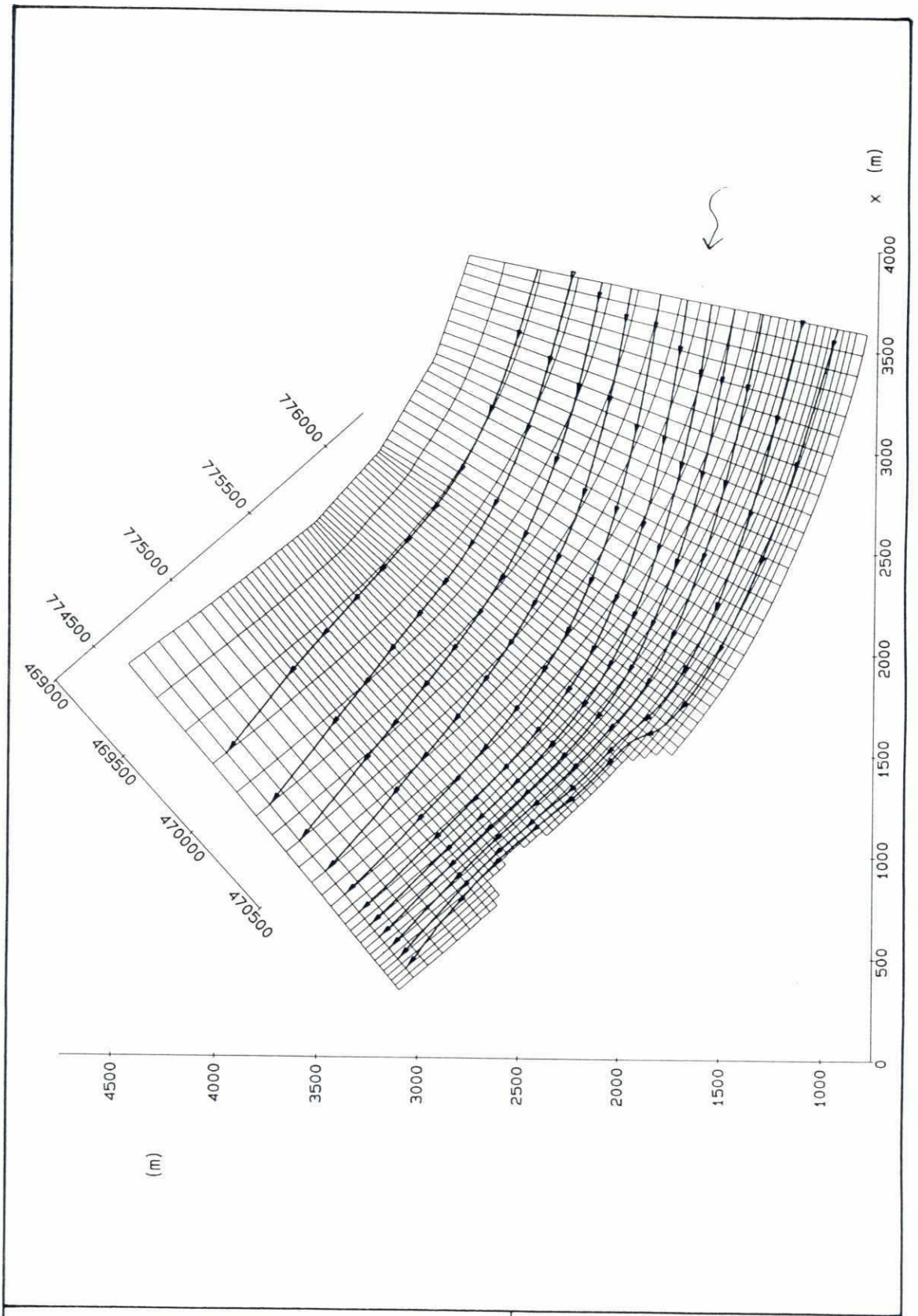
FINAL REPORT | FIG. A.6 – 38



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 2 years - Flow field (detail)

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(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 39



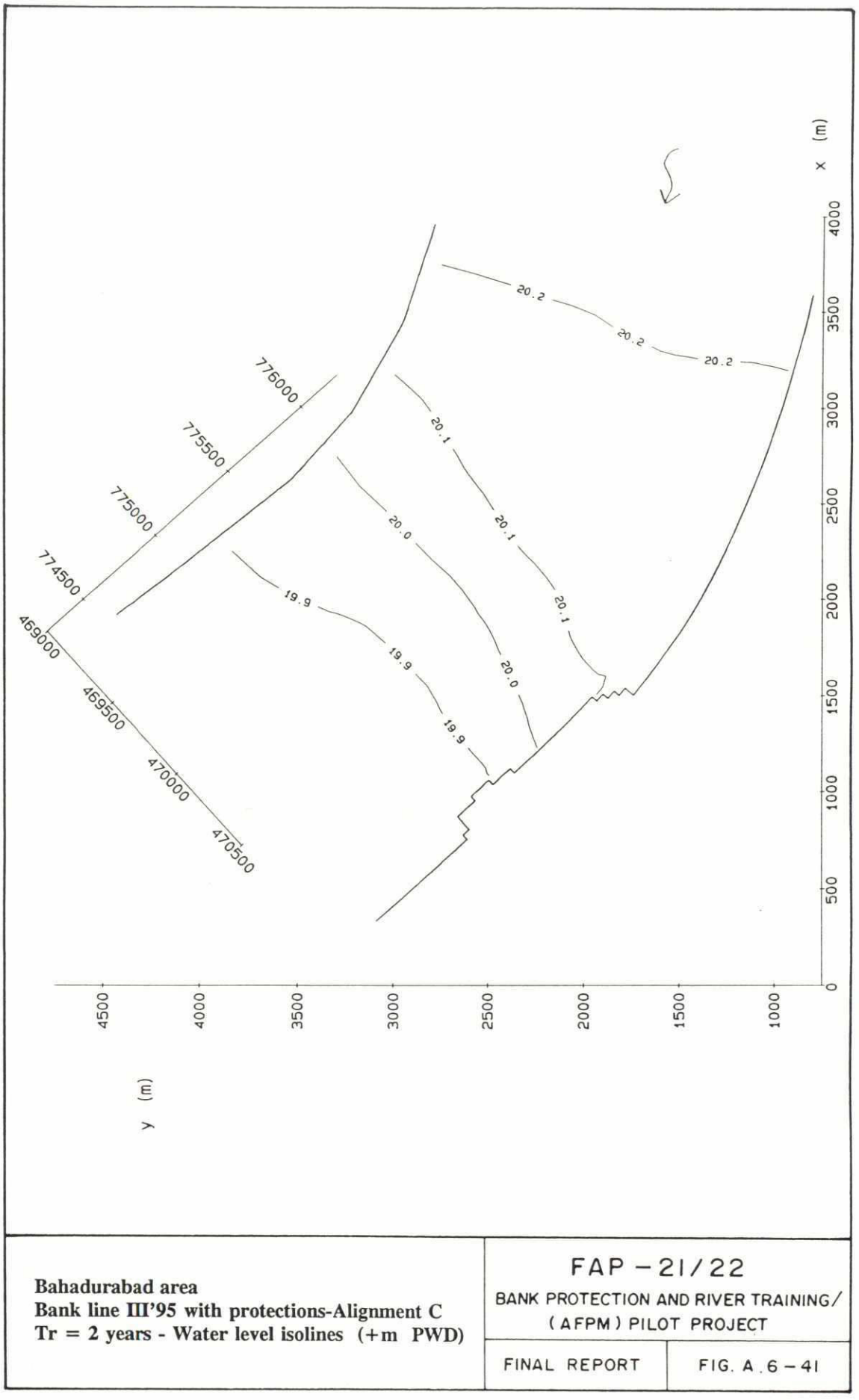
Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 2 years - Stream lines

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 40

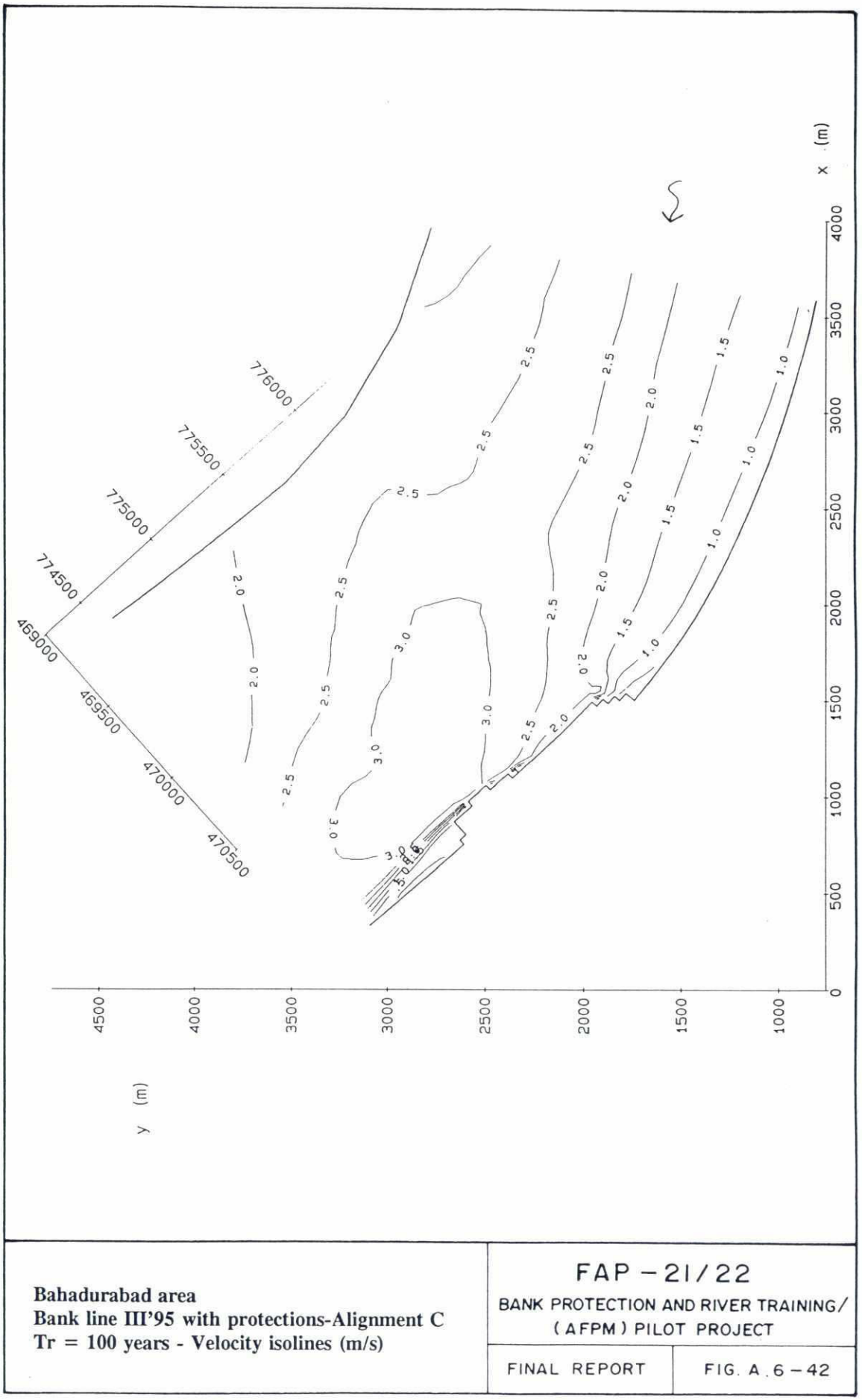
130



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 2 years - Water level isolines (+m PWD)

FAP – 21/22
BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 41



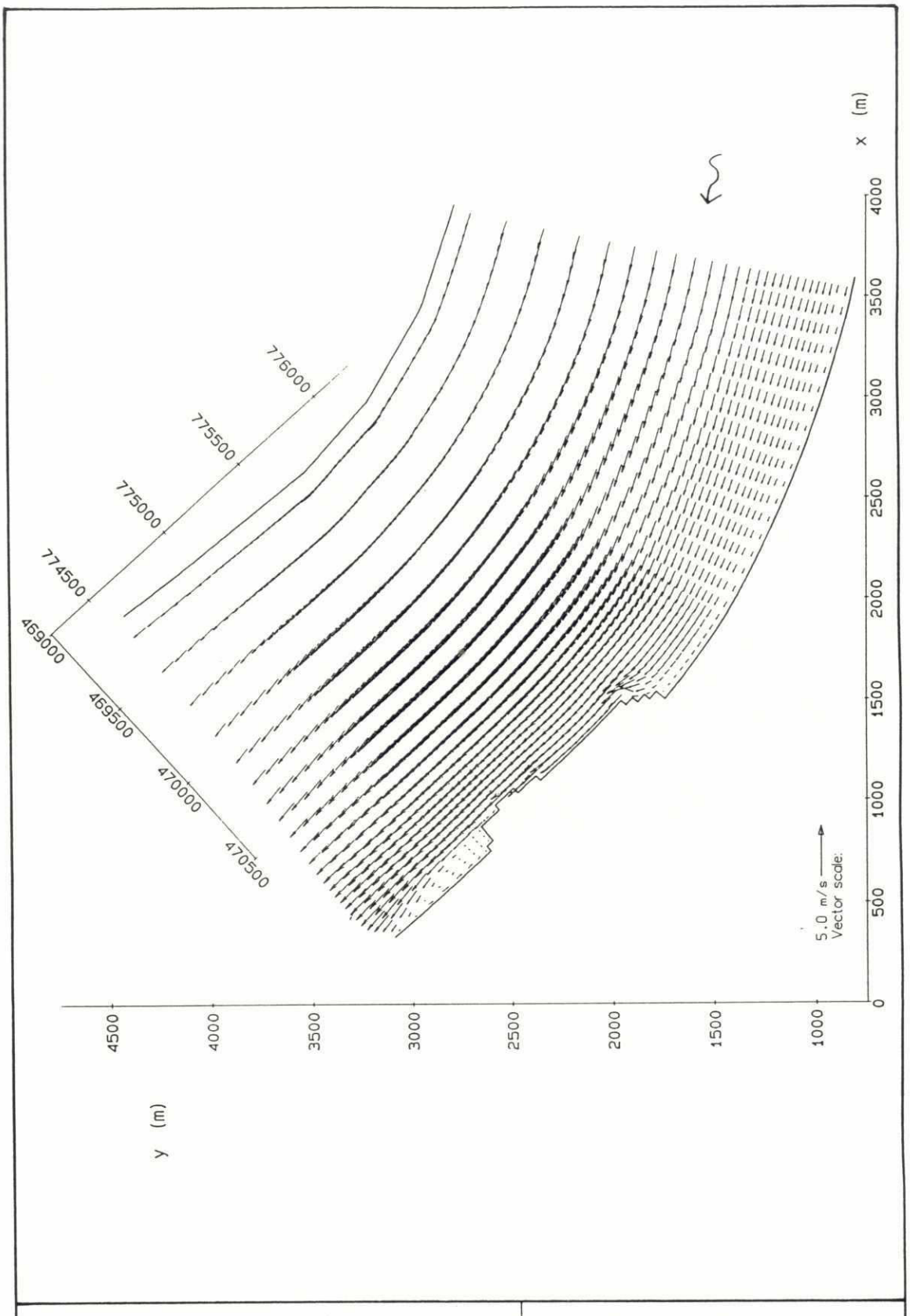
Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 100 years - Velocity isolines (m/s)

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 42

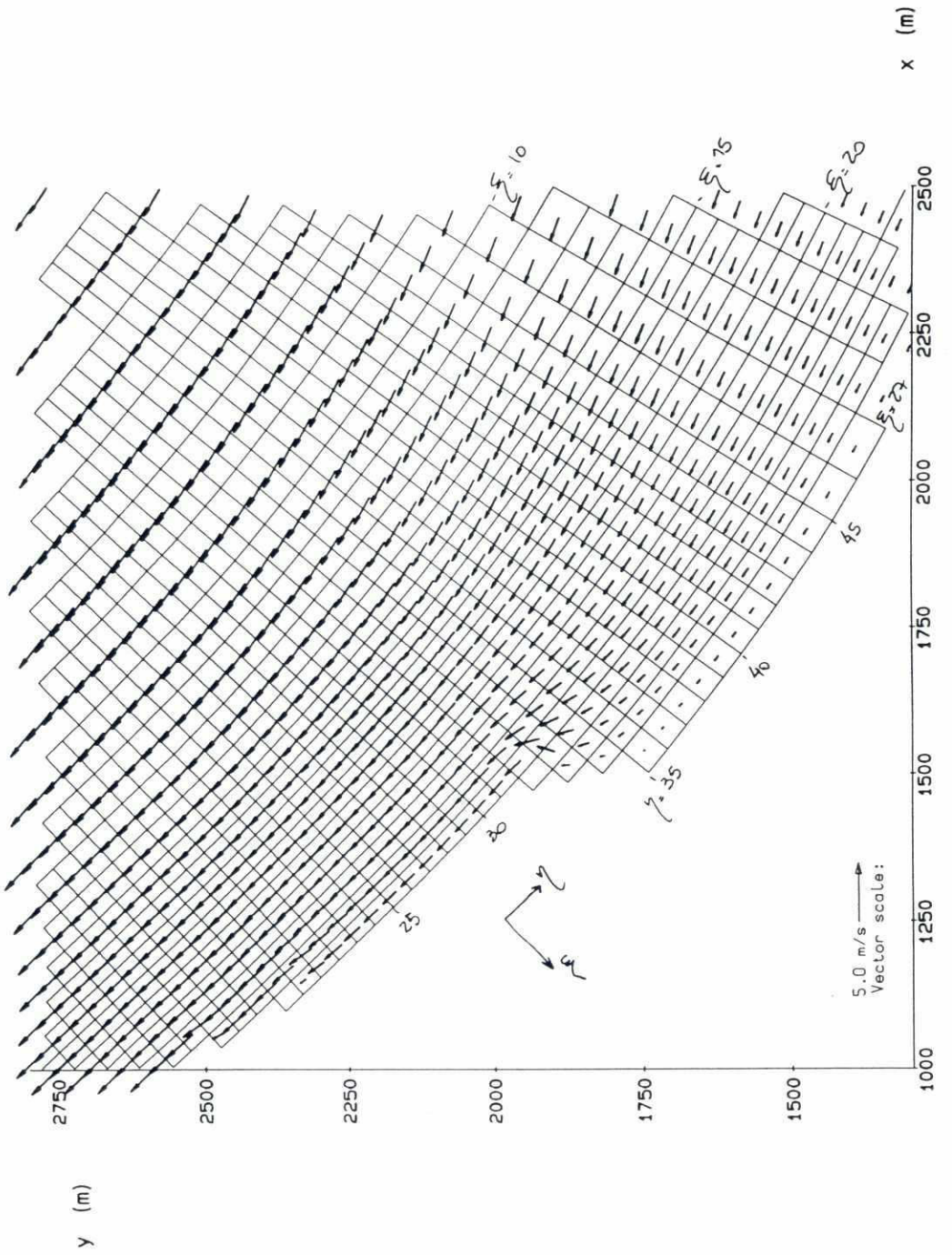
132



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 100 years - Flow field

FAP – 21/22
BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

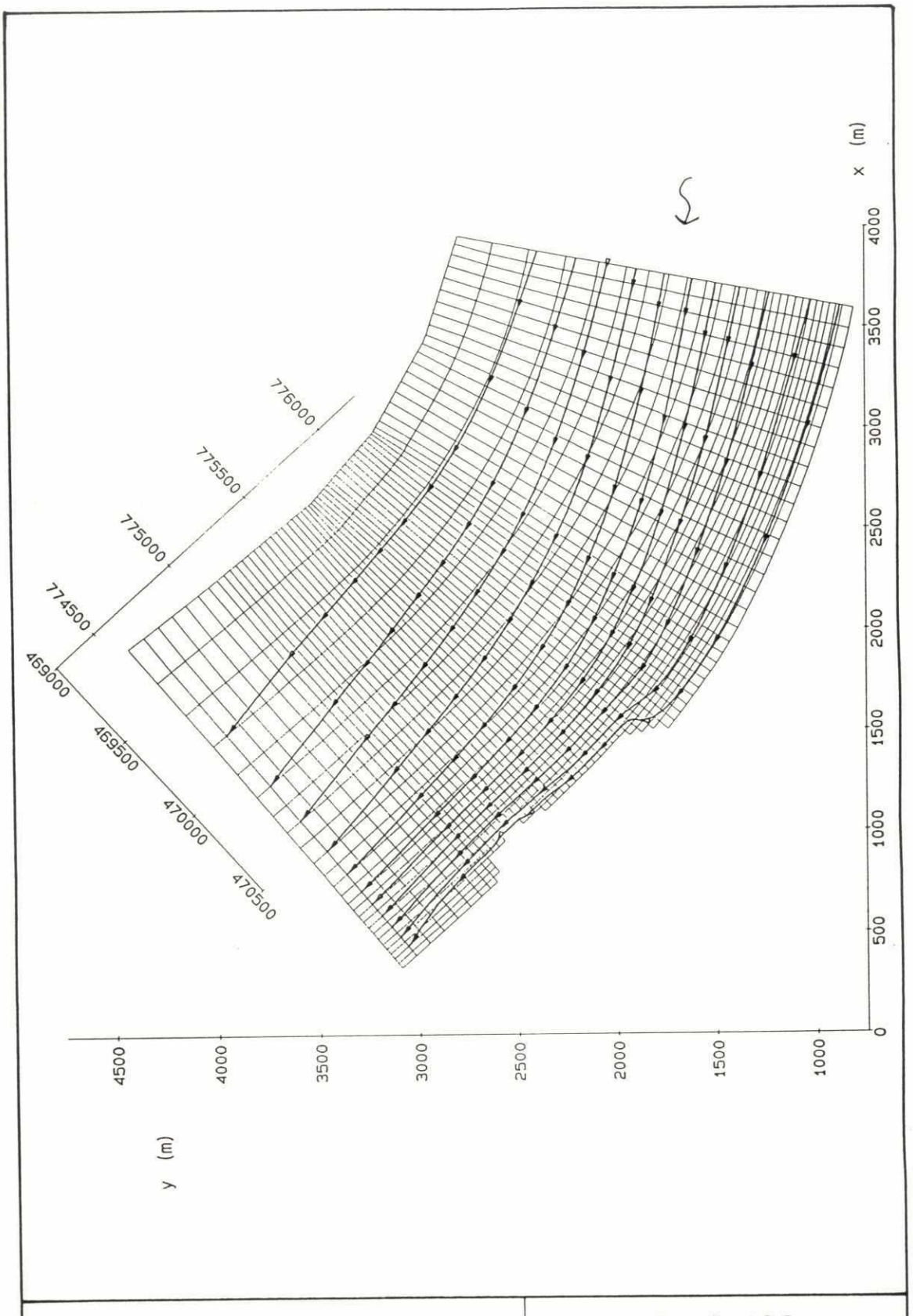
FINAL REPORT | FIG. A.6 – 43



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 100 years - Flow field (detail)

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BANK PROTECTION AND RIVER TRAINING/
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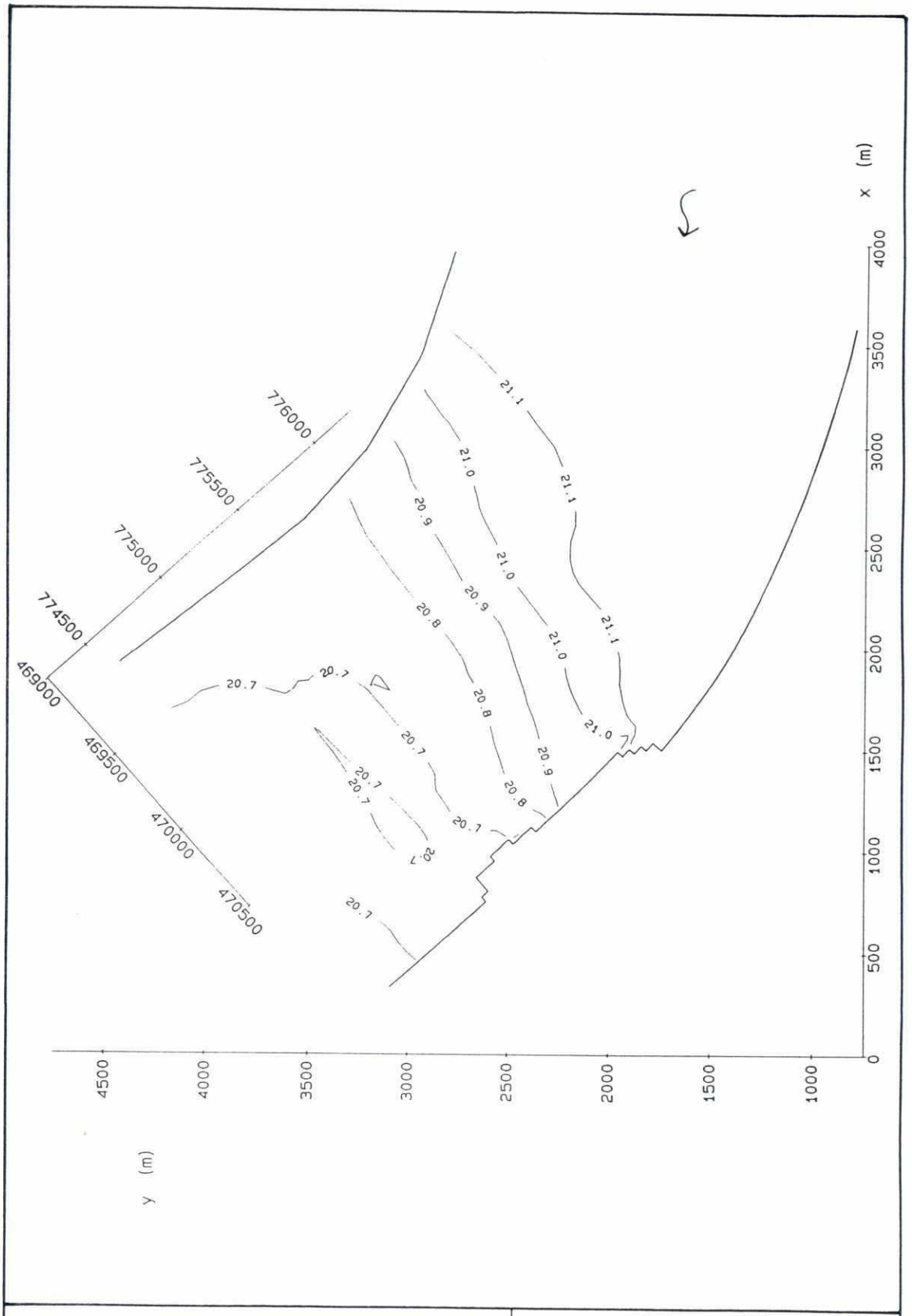
FINAL REPORT | FIG. A.6 – 44



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 100 years - Stream lines

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BANK PROTECTION AND RIVER TRAINING/
(AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 45



Bahadurabad area
Bank line III'95 with protections-Alignment C
Tr = 100 years - Water level isolines (+m PWD)

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. A.6 – 46

APPENDIX

APPENDIX 1

GENERAL DESCRIPTION OF TRISULA PROGRAMME

1 Introduction

1.1 General

The engineering activities which are planned and executed today in coastal seas, estuaries, rivers and reservoirs are becoming more and more complex. Dams are built, channels are dredged, harbors are enlarged, the entrances of estuaries are changed or partly closed.
Industrial areas or complete new towns are projected. Land reclamation is under development for new human settlements. And, as a consequence, pollution of water and sediments is growing to an alarming state in many rivers, estuaries and along many coasts, creating severe problems in the management of these water systems.

Essential for the design and management of this kind of engineering works, therefore, is a thorough insight in existing and future hydraulic and morphological conditions, and of the environmental impact of all these human activities. In this respect, numerical models are nowadays considered as an indispensable tool, as they enable to assess the influence of proposed engineering activities quantitatively, on short and on long terms as well. As such, they can adequately demonstrate, in an ever increasing range of problems, the effects of changes in conditions or in management policies.

Reliable information on water quantity or water quality, sediment transport and morphology can thus be obtained, today, from appropriate mathematical models. In general, the first step in these modelling activities concerns the simulation of the flow itself. Whether the problem is related, for example, to the stability of a hydraulic structure, to the salt intrusion or the dispersion of pollutants, or to the transport of silt and sediment, flow simulations usually form the basis of the actual consulting work. So flow calculations are used either to provide boundary conditions, as in the design of structures, or as starting point for modelling transport processes, water quality and ecological processes.

1.2 Short description of TRISULA

1.2.1 The hydrodynamic model

To assist in an efficient and up-to-date approach of flow modelling which is relevant to a wide area of applications, DELFT HYDRAULICS in collaboration with the Netherlands Ministry of Public Works and the Rand Corporation has developed the TRISULA program package. The main purpose of TRISULA is the three-dimensional (3D) simulation of non-steady and wind driven flow fields, including the effect of density differences due to a non-uniform heat and salt concentration distribution (density driven flows). Apart from the transport of salt and heat, TRISULA also takes account for other water quality parameters (dissolved material, e.g. pollutants).

However, for more dedicated water quality simulations, TRISULA is coupled with the DELFT HYDRAULICS´ DELWAQ program package. This coupling also applies to simulations of sediment transport processes, e.g. in the case of erosion and sedimentation studies.

Obviously, the TRISULA 3D system is of particular interest in applications where the flow field shows significant variations in the vertical direction. This may be essential in wind driven circulation problems and in partially mixed or layered flow problems. Examples are the salt intrusion in estuaries, the fresh-water river discharges in bays and the thermal stratification in lakes and seas.

Other typical TRISULA applications deal with the location of cooling water intakes and waste water outlets. Furthermore, as sedimentation and erosion processes are very sensitive to variations in the local flow conditions, especially in the bottom-layer, TRISULA is a useful instrument to simulate, in combination with DELWAQ, the morphology of the sea and river bed.

As a matter of fact, TRISULA can also be used for purely two-dimensional horizontal 2Dh-like (depth-averaged) flow computations, which may suffice in the case of well-mixed flow conditions.

1.2.2 The transport model

The study of technical solutions to the problem of managing fluid waste discharges in an estuary involves complicated relationships, such as those between the waste load, the location of discharges, the degree of treatment, the geometry of the estuary, the flow in the estuary, and the temperature. Models can be built to predict the probable consequences of each of the alternative solutions chosen. Using the predictions obtained from these models and whatever other information or insight is relevant, alternatives can be compared and conclusions drawn concerning the most desirable course of action.
Action is taken on the managerial level after technical alternatives have been studied and political, legal, and administrative constraints and procedures have been taken into account.

One of the first tasks in analysing the system is to outline the main relationships which exist in the system. Because the fluid waste discharged into the estuary is transported in it, a model of the fluid has to be made to establish the relationship between the transport of the pollution and the transporting medium. Also, it can be visualized that constituents are transformed during the transport by chemical or biochemical actions, and for these processes a reaction model has to be designed. The flow in the estuary is governed by the shape of the estuary and its boundaries at the sea and the inland ends, as well as by other conditions. The latitude of the area under investigation determines the effect of the earth´s rotation on the flow, which is of particular importance in large estuaries and coastal seas at higher latitudes. In the flow model, velocities of the water in the region are computed together with the water-levels. Because the tidal stage influences the location of the water´s edge on the tidal

flats, which affects surface area and cross-sections to a considerable extent, such functional relationships also have to be included in the model. The fluid waste loads in the system influence the pollution constituent transport and the fluid flow, while air, temperature, solar radiation, and exchange of gases at the water surface influence the water quality processes. The model presented here is intended in its final form as a basic tool in water quality management, which can be handled rather easily by investigators familiar with water quality studies.

1.3 Applications

The TRISULA program for three-dimensional flow simulations is based on a hydrostatic multi-level approach. The numerical model of TRISULA essentially simulates water elevation, flow velocity in three dimensions and density. Density is a function of salinity and temperature and is coupled dynamically with the flow equations to simulate density-induced motions. This results in a complete set of non-linear equations for free surface flow, conservation of heat, salt and, in addition, dissolved pollutant constituents.

The TRISULA program has a wide area of applications, ranging from wind generated currents in lakes and tidal flow in coastal seas to salt intrusion in estuaries, far field cooling water dispersion and large scale pollutant dispersion.

The approach used to model the flow is based on the "shallow water assumption". Under this assumption the vertical momentum equation is reduced to the hydrostatic pressure relation. The vertical water motion is derived from the horizontal flow field, using the continuity equation.

The shallow water assumption imposes two restrictions on the applicability of the TRISULA program :

- vertical accelerations due to buoyancy effects cannot be taken into account properly and
- sudden variations in the bottom topography, cannot be reproduced correctly.

The fluid is taken as incompressible and density variations are neglected in the equations of motion except in the buoyancy term. This assumption is known as the Boussinesq approximation.

The vertical turbulent viscosity and diffusion are presently modelled by flow dependent coefficients, which are computed according to a turbulence closure technique using local turbulence intensity and mixing length, which is known as algebraic eddy-viscosity model, taking into account buoyancy effect. The horizontal turbulent exchange coefficients are kept constant in space and time.

Wind drag on the water surface can be included. This enables to study the effects of wind-induced currents and the deflection of surface plumes by wind. At the surface and bottom quadratic friction laws are applied.

1.4 Special facilities

The TRISULA system includes a number of special facilities, of which the most important are :

- simulation of drying and flooding of intertidal flats,
- simulation of the discharge of heat and effluents, and the intake of cooling water at any location and any depth in the computational field,
- representation of narrow dams like groynes and breakwaters,
- a series of pre-processing and post-processing options for the analysis and representation of input and results.
- modular set-up, enabling the implementation of various turbulence models, including damping functions to incorporate the effect of vertical stratification.

1.5 The governing equations

* The the three-dimensional "shallow water" equations and the transport equations are presented in curvi-linear orthogonal coordinates in the horizontal plane and in σ-(sigma)-coordinates in the vertical direction.

Definitions:

ξ = ksi
η = èta
σ = sigma
ζ = zèta
ν = nu
Ξ = capital ksi

ξ, η : horizontal spatial coordinates (surface: σ = 0; bottom: σ = -1)
t : time.
U, V : depth averaged velocities in ξ- and η-direction,

defined as $U = \sum_{k=1}^{K} \Delta\sigma_k u_k$; $V = \sum_{k=1}^{K} \Delta\sigma_k v_k$

u, v, ω : velocities in ξ-, η- and σ-direction.
w : velocity in z-direction in the ω-σ-plane.
ζ : waterlevel above some plane of reference
d : waterdepth below some plane of reference
H=d+ζ : total waterdepth.
f : Coriolis parameter.
ν : eddy-viscosity in ξ- and η-direction.
Ξ : eddy-viscosity in σ-direction.
D_h, D_v : eddy-diffusivity in the horizontal and vertical direction
g : acceleration due to gravity.
ρ : water density.
P : hydrostatic water pressure.

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P_{atm} : pressure at the free surface.
s : salinity
T : temperature
$\sqrt{G_{\xi\xi}}$: physical component of a vector in ξ-direction.
$\sqrt{G_{\eta\eta}}$: physical component of a vector in η-direction.
C : concentration (of arbitrary scalar quantity eg.: salinity, temperature)
S : source and or sink term(s)

Momentum equations:

$$\frac{\partial u}{\partial t} + \frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial u}{\partial \xi} + \frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial u}{\partial \eta} + \frac{\omega}{(d+\zeta)}\frac{\partial u}{\partial \sigma} + \frac{uv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial \sqrt{G_{\xi\xi}}}{\partial \eta} - \frac{vv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial \sqrt{G_{\eta\eta}}}{\partial \xi} -$$

$$fv + \frac{1}{\rho\sqrt{G_{\xi\xi}}}\frac{\partial P}{\partial \xi} - \frac{\nu}{\sqrt{G_{\xi\xi}}}\frac{\partial A}{\partial \xi} + \frac{\nu}{\sqrt{G_{\eta\eta}}}\frac{\partial F}{\partial \eta} - \frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\Xi \frac{\partial u}{\partial \sigma}\right) = 0$$

$$\frac{\partial v}{\partial t} + \frac{u}{\sqrt{G_{\xi\xi}}}\frac{\partial v}{\partial \xi} + \frac{v}{\sqrt{G_{\eta\eta}}}\frac{\partial v}{\partial \eta} + \frac{\omega}{(d+\zeta)}\frac{\partial v}{\partial \sigma} + \frac{uv}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial \sqrt{G_{\eta\eta}}}{\partial \xi} - \frac{uu}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\frac{\partial \sqrt{G_{\xi\xi}}}{\partial \eta} +$$

$$fu + \frac{1}{\rho\sqrt{G_{\eta\eta}}}\frac{\partial P}{\partial \eta} - \frac{\nu}{\sqrt{G_{\eta\eta}}}\frac{\partial A}{\partial \eta} - \frac{\nu}{\sqrt{G_{\xi\xi}}}\frac{\partial F}{\partial \xi} - \frac{1}{(d+\zeta)^2}\frac{\partial}{\partial \sigma}\left(\Xi \frac{\partial v}{\partial \sigma}\right) = 0$$

Under the "shallow water approximation" the vertical momentum equation is reduced to the hydrostatic pressure relation, which gives after integration :

$$P = P_{atm} + gH\int_{\sigma}^{0} \rho(\xi,\eta,\sigma',t)d\sigma'$$

$$A = \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\left(\frac{\partial[u\sqrt{G_{\eta\eta}}]}{\partial \xi} + \frac{\partial[v\sqrt{G_{\xi\xi}}]}{\partial \eta}\right)$$

$$F = \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}}\left(\frac{\partial[v\sqrt{G_{\eta\eta}}]}{\partial \xi} - \frac{\partial[u\sqrt{G_{\xi\xi}}]}{\partial \eta}\right)$$

For water of constant density, the pressure terms reduce to:

$$\frac{1}{\rho\sqrt{G_{\xi\xi}}}\frac{\partial P}{\partial \xi} = \frac{g}{\sqrt{G_{\xi\xi}}}\frac{\partial \zeta}{\partial \xi}$$

$$\frac{1}{\rho\sqrt{G_{\xi\xi}}}\frac{\partial P}{\partial \eta} = \frac{g}{\sqrt{G_{\eta\eta}}}\frac{\partial \zeta}{\partial \eta}$$

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Continuity equation:

$$\frac{\partial \zeta}{\partial t} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \frac{\partial[(d+\zeta)u\sqrt{G_{\eta\eta}}]}{\partial \xi} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \frac{\partial[(d+\zeta)v\sqrt{G_{\xi\xi}}]}{\partial \eta} + \frac{\partial \omega}{\partial \sigma} = 0$$

The ω-(omega)-velocity in σ-direction is defined as

$$\omega = w - \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \left[u\sqrt{G_{\eta\eta}} \left(\sigma \frac{\partial H}{\partial \xi} + \frac{\partial \zeta}{\partial \xi}\right) + v\sqrt{G_{\xi\xi}} \left(\sigma \frac{\partial H}{\partial \eta} + \frac{\partial \zeta}{\partial \eta}\right) \right] - \left(\sigma \frac{\partial H}{\partial t} + \frac{\partial \zeta}{\partial t}\right)$$

Transport equation:

$$\frac{\partial[(d+\zeta)C]}{\partial t} + \frac{1}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \left(\frac{\partial[(d+\zeta)u\sqrt{G_{\eta\eta}}C]}{\partial \xi} + \frac{\partial[(d+\zeta)v\sqrt{G_{\xi\xi}}C]}{\partial \eta}\right) +$$

$$+ \frac{\partial(\omega C)}{\partial \sigma} + \frac{1}{(d+\zeta)} \left[\frac{\partial}{\partial \sigma} D_v \cdot \frac{\partial C}{\partial \sigma}\right] =$$

$$\frac{(d+\zeta)}{\sqrt{G_{\xi\xi}}\sqrt{G_{\eta\eta}}} \left\{\frac{\partial}{\partial \xi} \left[D_h \cdot \frac{\sqrt{G_{\eta\eta}}}{\sqrt{G_{\xi\xi}}} \cdot \frac{\partial C}{\partial \xi}\right] + \frac{\partial}{\partial \eta} \left[D_h \cdot \frac{\sqrt{G_{\xi\xi}}}{\sqrt{G_{\eta\eta}}} \cdot \frac{\partial C}{\partial \eta}\right]\right\} + (d+\zeta).S$$

1.6 Numerical aspects

In the numerical method used in TRISULA, the area under consideration is covered by a two-dimensional horizontal, curvi-linear orthogonal grids of variable size. This enables a more accurate schematisation of complicated irregular geometries and to increases the computational efficiency.

According to multi-level concept, the vertical grid consists of layers determined by a fixed number of permeable interfaces. As a result of the use of the so-called σ-transformation for the vertical coordinate, the number of layers is constant over the entire computational field. This leads to a smooth representation of the topography, giving the same order of vertical resolution for the shallow and deeper parts of the water. The vertical grids may have a non equidistant distribution, which allows a more detailed reproduction of features in zones of particular interest, e.g. in the top (heat exchange) and or bottom (sediment transport).

The momentum equations are vertically integrated over the layer thickness, which results in 2DH-like equations. The coupling of the layers exists by means of vertical advection and diffusion (turbulent shear stresses and fluxes of scalar quantities). The equations are solved by an implicit finite difference method (ADI - Alternating Direction Implicit). This method was chosen because it allows large integration time steps without negative effects on the computational stability. Grid staggering (in the horizontal mesh) is employed which gives a a

second order accuracy with acceptable computing time. Details are fully described in Stelling [1].

The transport equation is solved for each half time step $\Delta t/2$ after the computation of the water levels and the vertical velocities. The transport scheme uses an implicit time integrator for the vertical transport. The time integration follows the integration procedure for the continuity equation and combines an A.D.I.-scheme in the horizontal direction with Crank Nicolson or θ-method in the vertical direction. The equations are solved by an iterative method to decouple the horizontal and vertical direction.

To solve the transport equation, a finite difference scheme is used that conserves large gradients and higher derivatives without generating spurious oscillations. To insure that the total mass is conserved the scheme is cast into its flux-form. An implicit scheme is used for the vertical transport which allows small vertical spacing to resolve top and bottom boundary layers without instabilities in shallow areas where drying and flooding may occur. This transport scheme is unconditionally stable. The time step is limited by the accuracy desired in the results. To avoid negative concentrations a so-called Forester-filter (Forester, 1977) (a local diffusion operator) is used.

1.7 The staggered grid model in space

The horizontal staggered grid will be described for the depth-averaged case. In modelling an estuary or coastal sea, a geographical area is chosen. Its edges do not need to correspond with the north, east, south and west direction. A grid is imposed on the area, where the grid cell sizes, $\sqrt{G_{\xi\xi}}$ and $\sqrt{G_{\eta\eta}}$, are chosen in meters, and the number of grid cells in the two dimensions, XMAX and YMAX, are chosen. The X-direction for grid cell subscripts corresponds with the direction of the U- component of the velocity. The Y-direction for grid cell subscripts corresponds with the direction of the V-component of the velocity. The grid orientation can be chosen at will.

The basic physical properties pertained to each grid cell are :

- water-level
- constituent concentration
- depth
- U-component of velocity
- U-component of roughness
- V-component of velocity
- V-component of roughness.

In the computation there are four grids, one for each of the seven properties; identical in size and shape, but staggered by half a grid space in one or both directions.

Water-level and concentration points

The corner at the lower side of X and Y of the chosen geographical area coincides with the water-level point with coordinates (X=1,Y=1).

Depth points

The depth grid point with coordinates (X=1,Y=1) is translated half a grid size in the M- and N-direction, so that depth point (X=1,Y=1) falls midway between water-level grid points (X=1,Y=1) and (X=2,Y=2).

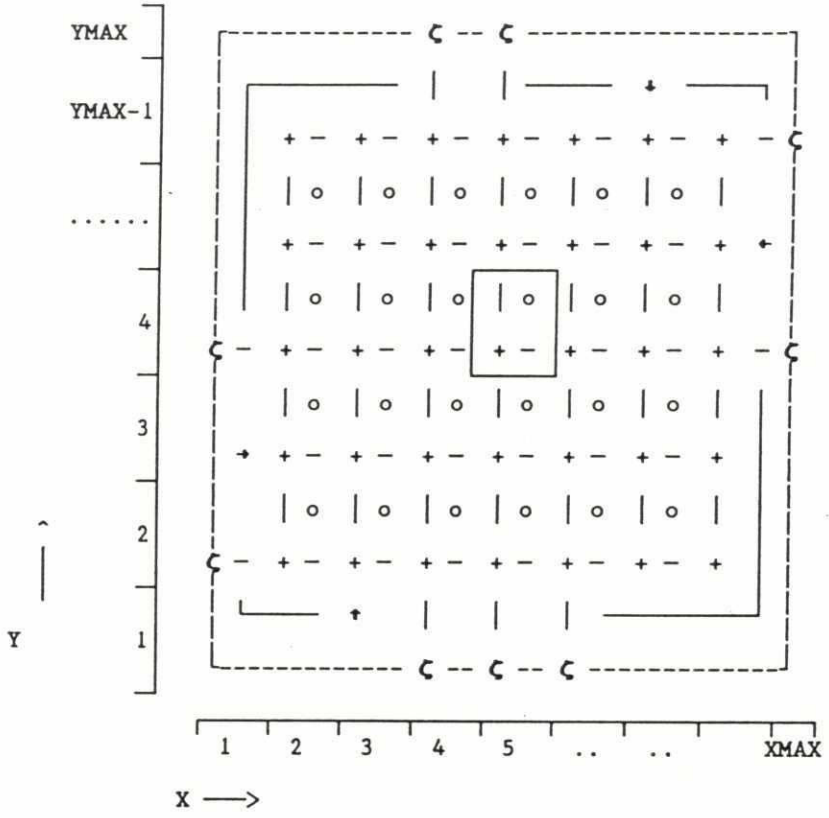
U-velocity and U-roughness grid points

The U-velocity grid point (X=1,Y=1) is translated half a grid size in the X-direction, so that it lies midway between the water-level grid points (X=1, Y=1) and (X=2, Y=1).

V-velocity and V-roughness grid points

The V-velocity grid point (X=1,Y=1) is translated half a grid size in the Y-direction, so that it lies midway between the water-level grid points (X=1, Y=1) and (X=1,Y=2).

The location of these points are depicted in the following figure :



Legend :

----	computational grid enclosure
——	computational grid boundary
+	water-level grid point, constituent concentration
–	U-velocity grid point, U-roughness grid point, $\sqrt{G_{\eta\eta}}$
|	V-velocity grid point, V-roughness grid point, $\sqrt{G_{\xi\xi}}$
o	depth grid point
ζ	water-level opening
← →	U-velocity opening
↓ ↑	V-velocity opening



staggered grid points with
the same index (X,Y) = (5,4)

Note: There are effectively one lesser row and column of velocities than water-levels on the right and top.

Figure 1.1 Default computational grid with arbitrary openings

1.8 Orthogonal and σ-transformation

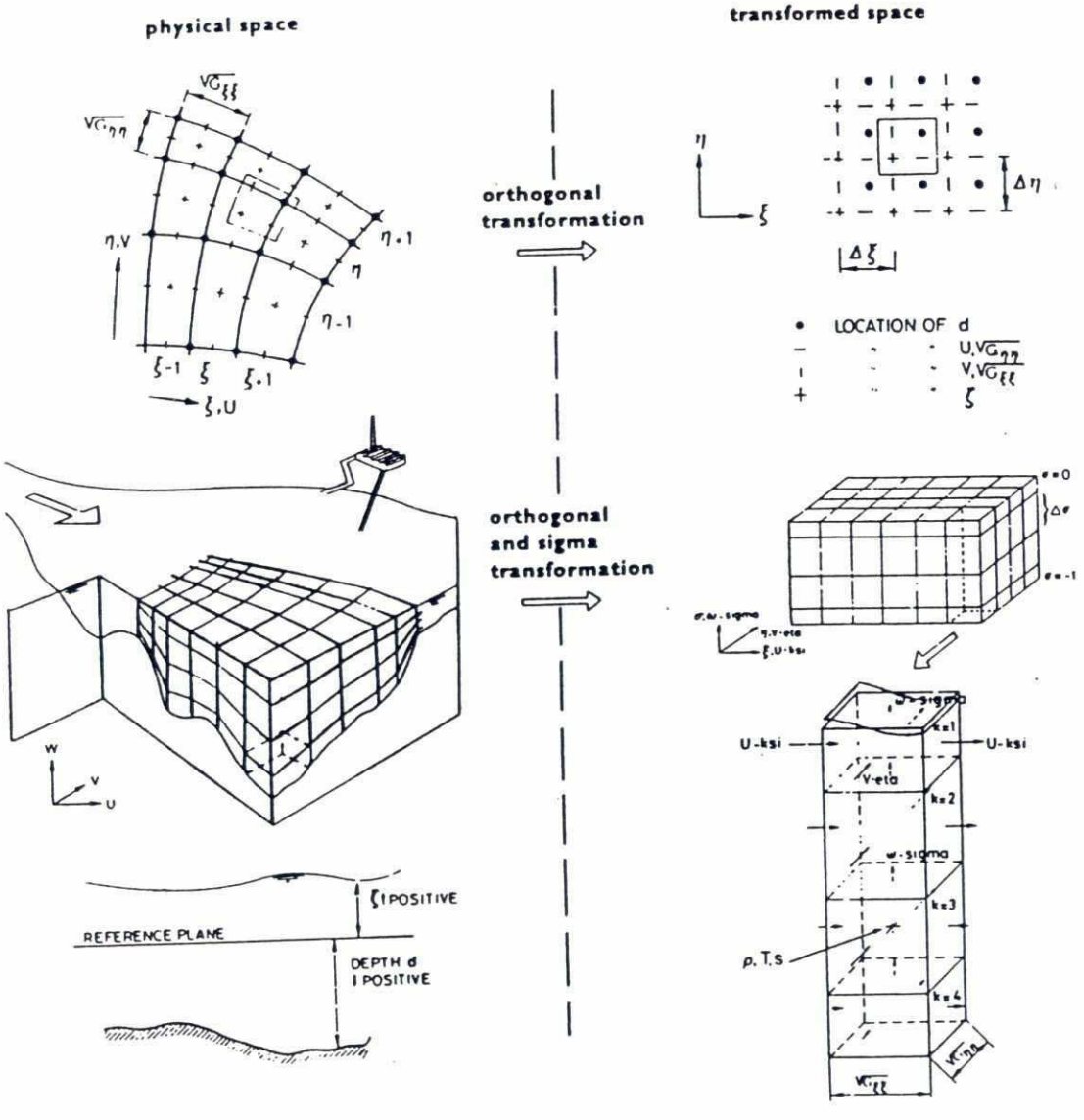


Figure 1.2 Orthogonal and σ-transformation

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ANNEX 7

SOCIO-ECONOMIC IMPACT ASSESSMENT OF THE TEST STRUCTURE PROJECT (FAP 21)

JANUARY 1993

ANNEX 7

PART C : SOCIO-ECONOMIC IMPACT ASSESSMENT OF THE TEST STRUCTURE PROJECT (FAP 21)

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GLOSSARY

AEU	-	Agro-ecological Unit
AFP	-	Active Flood Plain
AFPM	-	Active Flood Plain Management
BBS	-	Bangladesh Bureau of Statistics
BIWTA	-	Bangladesh Inland Water Transport Authority
BM	-	Bench Mark
BRAC	-	Bangladesh Rural Advancement Committee
BRE	-	Brahmaputra Right Embankment
BRTS	-	Brahmaputra River Training Studies
BWDB	-	Bangladesh Water Development Board
CARE	-	Cooperation for American Relief Everywhere
CC	-	Cement Concrete
CFD	-	Caisse Française de Development (previously CCCE)
EIA	-	Environmental Impact Assessment
EIRR	-	Economic Internal Rate of Return
FAP	-	Flood Action Plan (also used for project in FAP)
FPCO	-	Flood Plan Coordination Organization
G-5 MUV	-	Manufacturing Unit Values
GIS	-	Geographic Information System
GP	-	Gross Agricultural Product
GoB	-	Government of Bangladesh
GVA	-	Gross Value Added = GP-production costs (labour cost included)
HOG	-	Historical Occupational Appraisal
HYV	-	High Yield Variety
JAFP	-	Jamuna Active Flood Plain
KfW	-	Kreditanstalt für Wiederaufbau (German Funding Agency)
LCRC	-	Land Compensation and Resettlement Committee
LGEB	-	Local Government Engineering Bureau
LV	-	Local Variety
MIWDFC	-	Ministry of Irrigation, Water Development and Flood Control
MPO	-	Master Plan Organization
NPV	-	Net Present Value
NGO	-	Non Government Organization
NVA	-	Net Value Added or net income = GP-production costs (labour cost not included)
RRA	-	Rapid Rural Appraisal
RRI	-	River Research Institute (Faridpur)
RSA	-	Rapid Sociological Appraisal
STW	-	Shallow Tube Well
UNDP	-	United Nations Development Programme
WARPO	-	Water Resources Planning Organization

LOCAL EXPRESSIONS

Aman	-	Rice grown in mostly deep water during April/July to November as broadcast (B) or transplanted (T)
Aus	-	Rice grown in high to medium high land during mid-March to mid-September as both broadcast (B) and transplanted (T) high yielding variety
Bazar	-	Country market
Beel	-	Swampy area
Boro	-	Rice grown in lowland between November to June also as broadcast (B) and transplanted (T)
Char	-	Sand bank, also floodable areas adjacent to the banks
District	-	Administrative Unit in the care of a Deputy Commissioner
Division	-	BWDB office headed by an Executive Engineer
Khass	-	Land belonging to the Government
Khal	-	Canal
Khoa	-	Brick chips (used as concrete aggregates and filter material)
Lakh	-	100,000
Rabi	-	Crop season starting November/December and ending March/April
Tk	-	Taka
Thana	-	Administrative Unit, division of a District
Union	-	Administrative Unit, division of a Thana

CONVERSION TABLE / METRIC SYSTEM

FPS		METRIC	METRIC		FPS
1 foot	=	0.3048 m	1 meter	=	3.281 ft
1 mile	=	1.609 km	1 km	=	0.6214 mile
1 seer	=	0.9331 kg	1 kg	=	1.072 seers
1 maund	=	37.324 kg	1 kg	=	85.74 tolas
1 acre	=	0.405 ha	1 ha	=	2.471 acres
1 bigha	=	0.33 acres			
1 katha	=	1.67 decimal			
1 crore	=	10 million			
1 lakh	=	100,000			

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11 INTRODUCTION

11.1 OBJECTIVES OF THE IMPACT ASSESSMENT AND AN OVERALL APPROACH

The Kamarjani and Bahadurabad sites which may change later due to morphological reasons, are presently selected to test different kinds of riverside protection technologies.

Within the context of this uncertainty about the test site location the present study can be only from a pre-impact analysis level. In that case for instance, it is not possible to draw up a nominative census of every family affected by the expected project in order to assess accurately acquisition and resettlement measures.

The objectives of the present analysis are actually to identify the nature of the problems and benefits produced by the test structures, to assess globally various impacts and define an analysis process in the framework of a set of rural development problems which can apply to other test sites.

In examining and evaluating the impacts of a test structure it must be taken into account that the proposed test structure operating inside a riverside zone is suffering from various socio-economic problems increased by an obsessive risk of river bank erosion. Actually the future of the agricultural production sector depends closely on the local natural, socio-economic and institutional environment. Table 11.1-1 shows the causal connection system existing between the principal problems identified during the investigations.

So, the positive or negative impacts of the test structures will be analyzed through this pre-existing set of problems. It has to be stressed that the interest of the impact study approach presented in this section is thus interesting as much for its contents itself as for its methodological aspects of a rapid more or less integrated assessment at grass root level.

It does not mean on the other hand that this assessment aims at providing a methodological model to be replicated for other test sites. Additional considerations in respect to this aspect will be found later (Section 14.2).

The reader may also be surprised by the limited quantitative dimensions of the impacts of the project on some criteria, like for instance, the agricultural land to be acquired (Bahadurabad site), or the limited number of people to be displaced (Kamarjani site). Other qualitative impacts (drainage limitations in Kamarjani, sociological disrupting effects at the level of the mouzas concerned etc...) are not insignificant on the other hand.

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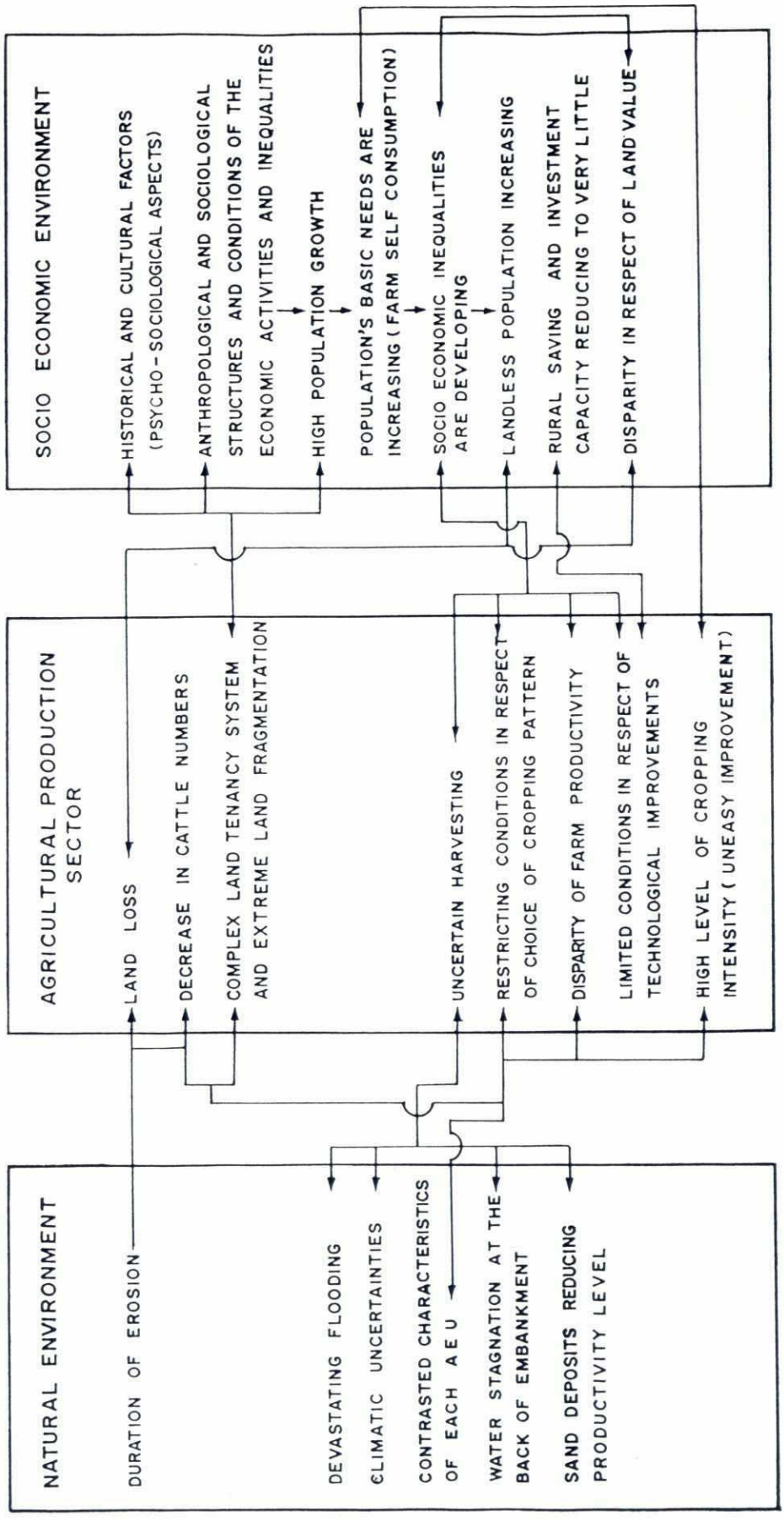


Table 11.1-1: Rural development problems

Besides, the agricultural and rural development issues identified at the micro-level of the site area, and the limited impacts of the test project lead to a better understanding of the development problems from the bottom, including both engineering and non engineering aspects, and structural and non structural potential measures.

11.2 AGRO-ECONOMIC APPRAISAL AND STUDY AREAS

The assessment of the agricultural consequences of bank protection tests is aimed at producing results more quickly than detailed surveys can produce at selected sites. The agronomic assessment activities carried out in the present study were as follows:

- collection of information; maximum use was made of documentary sources to obtain guidance on the location and content of checking interviews;
- overviews about the present agricultural situation, and
- identification of the expected consequences of the Kamarjani and Bahadurabad protection work through the local agricultural problems, during and after test structure building, taking into account direct and indirect impacts.

This analysis stage requires:

- close cooperation with the socio-economic and institutional approach and
- a quantitative and/or qualitative impact assessment resulting from these projects, according to the FPCO recommendations.

The investigation area concerns a land belt about 1.5 km wide stretching from the Jamuna bankline to the mainland. The length taken into account must be enough to identify the various AEU likely to be affected by erosion and drainage problems to the east and west of the test structure.

11.3 SOCIO-ECONOMIC AND INSTITUTIONAL APPROACH AND STUDY AREAS

A preliminary warning must be given about the limitations to detail and precision level of the socio-economic and institutional aspects of the present impact assessment (or more precisely the pre-impact assessment as explained above in Section 11.1). Limitations are of two kinds:

- the uncertainty of the final location of the test-structure sites due to the future river bank erosion and consequent bankline shifting (for the impact identification and assessment);
- the limited time and means for the site investigations, data collection and analysis (see before).

Nevertheless, a first series of data was collected and analyses were done through a Rapid Sociological Appraisal (RSA) method which, at this stage of the project, may give adequate ideas of the socio-economic and institutional conditions and aspects of the

foreseen test-structures and sites chosen.

The RSA was actually based on the following field investigations:

Kamarjani site (Analerchara and Dhutichara mauza):

- 1 day of general reconnaissance of the site with identification of the mauzas concerned and collection of first general socio-economic data through few short interviews here and there;
- 5 days of survey for the inventory of the socio-economic infrastructure and of the traditional settlement units, and
- 4 days of expert investigation, comprising some 9 group discussions and 7 individual interviews, and a sample inventory of the owners and of the land fragmentation in the gross area concerned (see Fig. 12.2-1).

Bahadurabad site (Belgacha mauza):

Due to the time limitation and the immediate schedule of implementation of the test-structure (1994 after-monsoon, vis-a-vis 1993 after-monsoon for Kamarjani site), field investigations were even less intensive, as detailed below:

- 1 day of general reconnaissance of the site with identification of the Mauza concerned and collection of first general socio-economic data through few short interviews, and
- 2 days of expert investigation including 2 group discussions and some individual interviews, and an inventory of the socio-economic infrastructure and the settlement units of the western part of Belgacha.

Besides the lack of time, the size of the Mauza and the latent conflictual relations between socio-political groups made it impossible to obtain a first inventory of the owners and of the land fragmentation of the gross area concerned.

Finally, in view of all these factors, three different dimensions of the study area were considered for the present assessment:

For Kamarjani site:

- the general socio-economic and institutional framework of the two mauzas concerned;
- the gross area directly concerned (see Fig. 12.2-1), and
- the hypothetical future structure location according to the erosion prediction method utilized (see Chapter 6, Main Report);

For Bahadurabad site:

- the socio-economic and institutional framework of the western part of Belgacha mauza;
- the gross area directly concerned (see Fig. 13.1-1), and

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- the hypothetical future structure location according to the erosion prediction method utilized (see Chapter 6, Main Report).

12 KAMARJANI SITE

12.1 BENCHMARK TECHNICAL DATA OF THE KAMARJANI TEST STRUCTURE

The main design criteria of Kamarjani test structure dealt with in the present socio-economic assessment are summarized below. It could probably be implemented in the 1993/94 dry season; but it is not yet sure. Based on the results of the model tests, 5 permeable groynes would be constructed with a length of 120 m each and with an orientation of about 15° to the flow direction.

The principal characteristics are given in Table 12.1-1 and Fig. 12.1-1.

The variations that would be investigated are:

(i) impermeable stretch
- earth dam
- sheet pile cofferdam

(ii) permeable stretch
- steel piles
- concrete piles

(iii) provision of scour protection material.

12.2 PRESENT SITUATION OF THE STUDY AREA

12.2.1 Administrative Set-up and Population

The above mentioned so called Kamarjani site[1)], as shown in Fig.12.1-1 and Fig.12.2-1, is located in fact astride the two mauzas of Analerchara and Dhutichara in Gidari Union (Thana and Zila Gaibandha).

During the last decade erosion phenomena have increased regionally, encroaching westward to the right bank of the Jamuna. In this way the previous neighbouring mauzas of Raidasbari, Nungola and Kirtaniapara have almost disappeared, and so far approximately 40% of Analerchara and 20% of Dhutichara have been eroded.

---

1) At the beginning the site was named in relation with its supposed vicinity with Kamarjani center. This name was kept afterwards throughout the project studies.

Location	Type of Structure	Length	Height	Crest Width	Core Material	Slopes	Filter	Armour Layer		Falling Apron			Land Acquis. Area
								Thickness	Material	Width	Thickness	Material	
Kamarjani	Groyne	1000 m	2.5 m	7 m	Sand/Clay	1:3	None	***1**	-	15	1	***2**	6 ha
Bahadurabad ***3**	Cross bar embankment	800-1000 m	2.5 m	7 m	Sand/Clay	1:3	None	***3**	-	-	-	-	2.4 to 3 ha

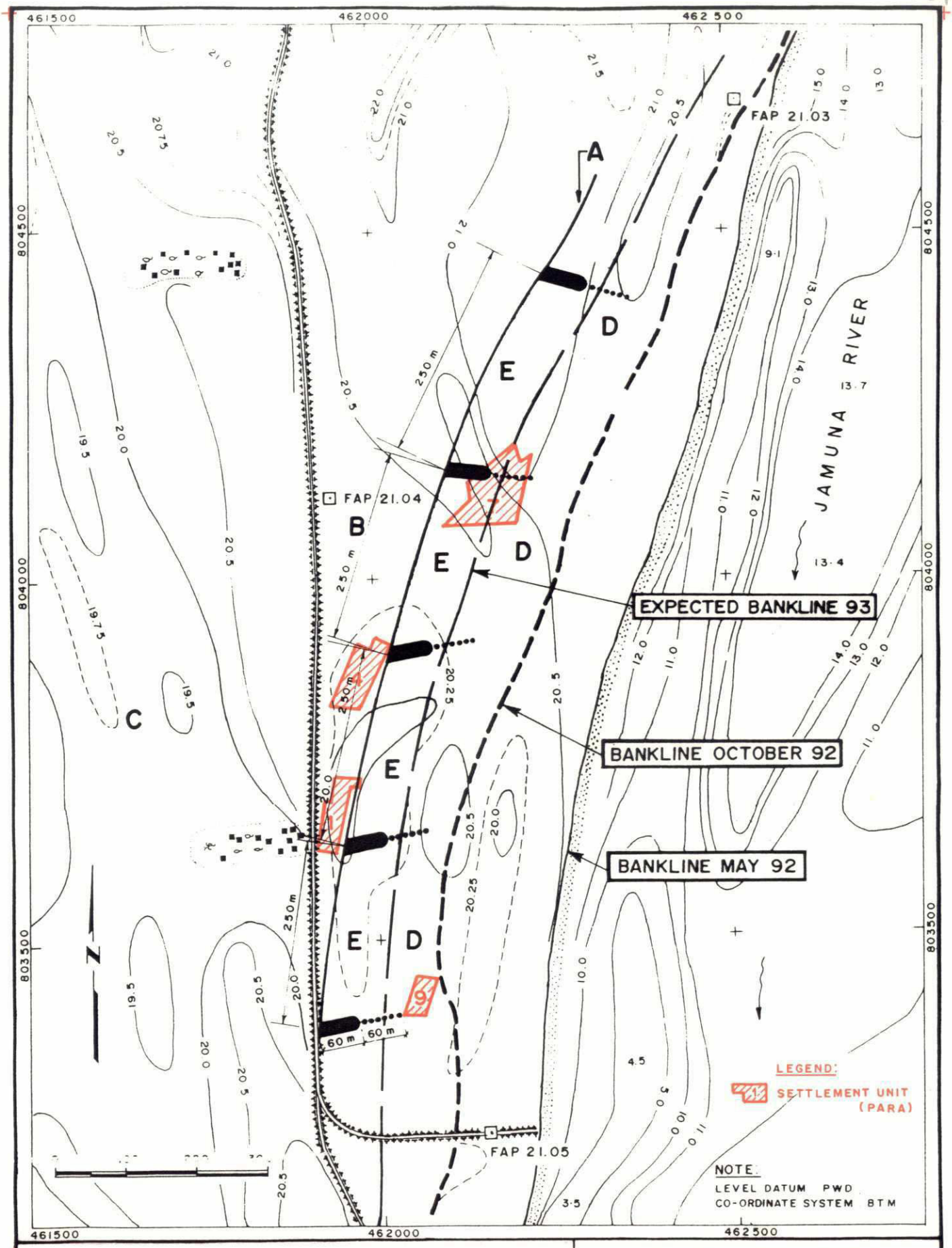
***1** The embankment includes only sand fill without filter and armour layer and falling apron and the groynes are to be constructed
1) from earth fill dam with geotextile filter and concrete blocks or grouted boulder as armour layer or from sheet pile coffer dam
2) from steel piles and concrete piles.

***2** Falling apron from CC-blocks and/or boulders and/or gabions boulder-filled and/or Geotextile sand bags.

***3** A description is given in Section 13.1 below.

Table 12.1-1: Bank protection tests

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KAMARJANI TEST SITE
GENERAL LAYOUT INCLUDING
AFFECTED AGRICULTURAL AREA (A–E)
SETTLEMENT AREAS (1–9)

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1981 census data and 1991 approximate estimates of the residing population are given below for each mauza.

Mauzas	1981 census	1991 Estimates	Average Annual Growth 1981-91
Dhutichara	3438	3680	0.68
Analerchara	1161	1474	2.42
Total	4599	5154	1.14

Table 12.2-1: Population census data and estimate

As far as the 1991 estimates are reliable, the above figures show (on the basis of a theoretical average) a natural growth rate of 2%:

(i) For Dhutichara

A negative balance exists between out-migration on the one hand and natural growth and in-migration on the other hand. As a matter of fact part of the original population has migrated, either pushed out, or threatened by river erosion. On the other side, it seems that a smaller number of displacees due to river erosion have stayed in Dhutichara[2)] (coming from Dhutichara itself or from other eroded mauzas). This not being so common phenomenon for a riverside mauza (compared to Analerchara and Bahadurabad site cases in particular), has not been so clearly explained at this stage of investigation.

Does it correspond to an efficient ban from BWDB to utilize the present embankment as a shelter site for landless people ? Or, is it due to a local socio-political control and impossibility at the level of this mauza ? Or to any other reason ? This characteristic should be highlighted in a future stage.

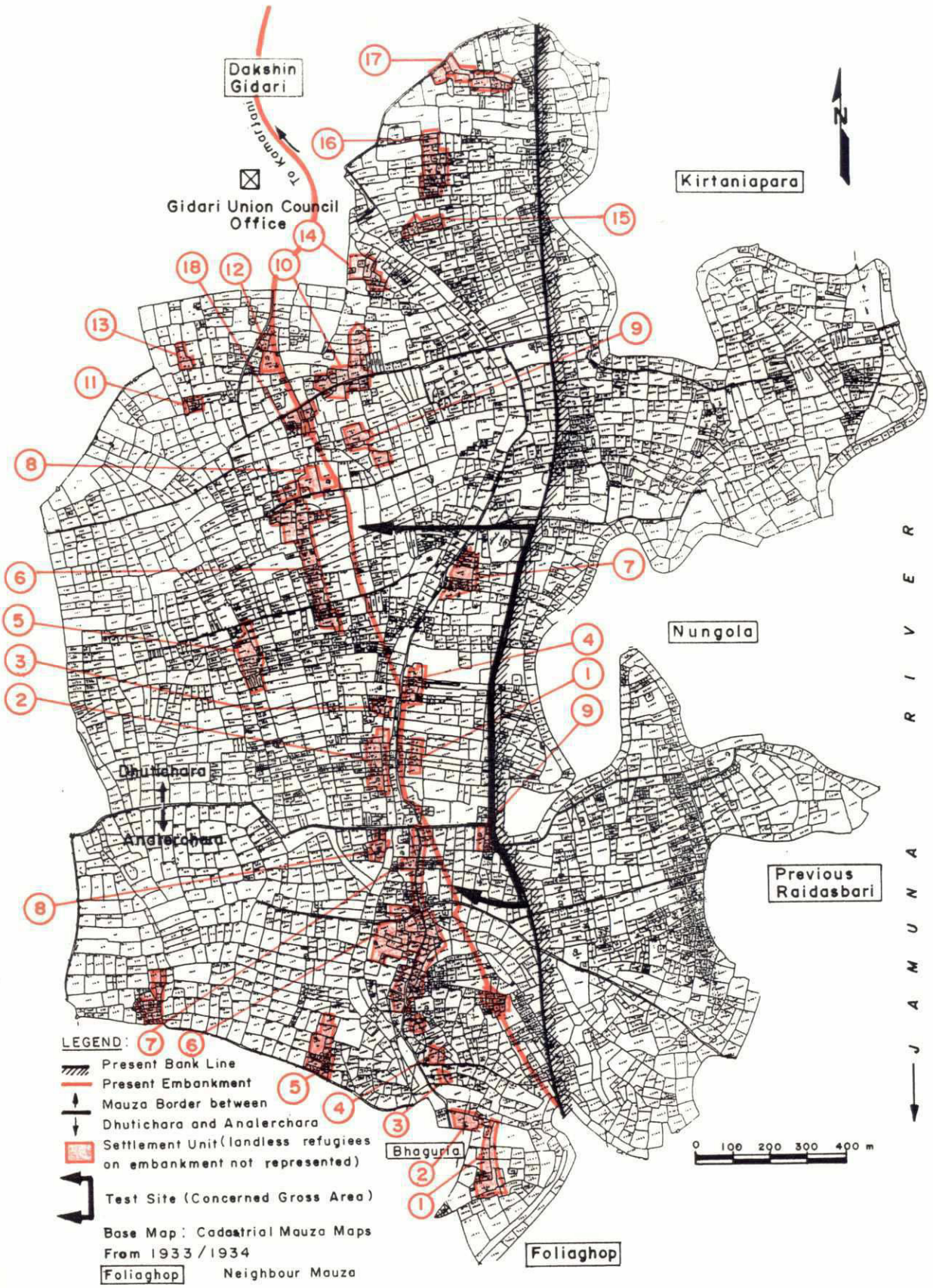
(ii) For Analerchara

In contrast there appears to be a positive balance between in-migration and natural growth on the one hand, and out-migration on the other hand. Very rough estimates from discussions with local people and elected members indicated that more than 60% of the residing households are landless (out of which 70% are from other eroded mauzas). The majority of these landless people live on the present embankments (last new one, and patches of old ones). But it was not possible to draw up an inventory of these landless people in the framework of the short field trips made.

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2) A systematic inventory on 7 selected settlement units gave "only" 33% of landless households in Dhutichara.

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ADMINISTRATIVE AND SETTLEMENT ENVIRONMENT OF THE KAMARJANI TEST SITE

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12.2.2 Social Structures and Categories

It is not the purpose of this rapid localized assessment to develop theoretical aspects related to anthropological and sociological structures, from very little and limited information about the "field reality". This will need months of research and is not necessary for the project. Some theoretical and fundamental questions have been raised in Chapter 3 of Part A. Hereafter, and in the corresponding section for Bahadurabad site, the factual data and qualitative information as they came from the field investigations will be reported along with the main commentaries and explanations.

Households, Families and Homesteads

Just for the record, and as in every rural area of Bangladesh, population can be discerned at a first glance through a number of settlement units (including landless settlements) organized in **paras** or **baris** (traditional hamlets, villages, settlement units). This settlement structure, partly shown in Fig. 12.2-1, is described below in the cases of Analerchara and Dhutichara. Each settlement unit is composed of homesteads, themselves comprising housing units and their surrounding yard, trees, gardens and ponds[1]. One household corresponds to the elementary socio-economic unit of solidarity and community residence. Most of the households are now nuclear ones, apart from local traditional notability families. Several households from the same family (extended family or small patrilinear lineage), or from different families can be gathered around the same yard in one **para** or even correspond to one single **para** (see also section "socio-political organization of the space") below.

Three paras included in the gross site area (paras No.9, 1 and 7, see Fig. 12.2-1) were surveyed during the field investigations. The results of this survey illustrate cases of the households and restricted kinship and homesteads structure. A summary is given below (see details in Table A.7-2):

Para No.1 : 1 household, 1 homestead, 1 yard, 2 houses (1 kitchen, 1 bedroom), 4 residing members (1 couple with two children).

Para No.2 : 3 households, 3 homesteads, 1 yard; 15 persons living in the para (1 couple + 4 children; 1 couple + 4 children + 5 daughters married outside; 1 couple + 2 children + 2 sons and 3 daughters married and living outside).

Para No.7 : Mistri para: (see details appendix 4), 1 lineage (**1 gusthi**), 18 households; 7 yards (2.5 households/yard); 88 persons (4.9 persons/household); 2.7 residing young and children in average per household (2.3 per mother). 25 houses (1.4/household; 3.6/yard).

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1) Apart from the linear settlements of landless along the embankments.

Occupational Groups, Castes and Lineages

When people are asked simply how they identify themselves socially above the level of the household and of the nuclear or medium-extended family (elementary lineage), they usually quote a series of generic or proper names that one could gather in three main categories, i.e.:

- names of historical castes in case of Hindus;
- names of lineages, historical families, and
- names of historical particular "occupational groups" (HOG; like Bepari or Maulovi), which can be considered as Muslim pseudo-caste groups (with possible social mobility from one group to another one through economic strategies).

This socio-cultural identification system is different from the fragmentation of actual economic activities (see below). In the field, when speaking with people, the generic name used for these social units is the Bengali word "**Bangsa**". It should be kept in mind that in fact:

(i) only for historically famous or present powerful family/lineage names, the chronological lineage identification is functional and reproduced (from generation to generation, through the well known Muslim agnatic system). In that case it does correspond to the original **bangsa** denomination;

(ii) Most men (apart from a few old ones) do not know their pedigree over four generations;

(iii) Some family or so-called "bangsa" names can correspond both to a HOG or to a lineage;

(iv) The spatial space lineage refers more to the original name **gusthi** and can correspond to one part of a para or to one single para. It can even be spread over different parts of the country. The membership feeling of a **gusthi** is experienced with or without a proper name, depending on its overall socio-cultural, economic and political position;

(v) Among Muslim endogamical marriages, strategies still exist inside families/lineages or even HOG. Preference marriage strategies exist of course as well depending on the considered overall social position. These strategies are tending either to maintain the social status or to improve it.

The Muslim dower/dowry system is the economic expression of the marriage system, which itself does operate as the back-bone of the social reproduction system[1)], and

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1) For instance among lower and middle classes, the dower for the engaged girl varies at present from around 500 takas to thousands of takas. It can be much more for glamour families despite the theoretical modern laws in this matter.

(vi) Forced endogamical marriages for low castes, and preference "promotional" marriages for the higher castes[2], are well known as still functional among the Hindus.

Results of part surveys of the social categories per para, as they are identified by local people, are given below.

Apart from the Muslim traditional lineage or family names the three historical occupational groups are defined locally as:

- **Sharkar** : "Those who are educated" (or name of traditional rulers' lineage);
- **Bepari** : Merchants, businessmen, "those who sell and buy", and
- **Maulovi** : "Those who are of clergy lineage" (religious families with Imam members).

Two other categories, not surveyed in the selected paras, were mentioned in Analerchara among landless refugees on the embankment, i.e.:

- **Upadani** : Which correspond to a Muslim religious congregation ("Those who pray like Sunni); around 100 households would appear to be now living in Analerchara, and
- **Kabiraj** : "Those who deal with medicinal plants"; around 10 households in Analerchara.

Sociological Category / Serial No. of the para (Fig. 12.2-1)	Shar-kar	Be-pari	Mau-lovi	Sheikh	Akondo	Khon-dakar	Ali	Dash (Hin-du)	Total
1 (Khuti para)	15	7		3	3				28
2		4							4
3	1								1
4								6	6
5		12		9		1			22
6 (Pochtim Para)	15	25		10					50
7	8	10		23	3				44
8	1	2		4					7
9			1						1
Total	40	60	1	49	6	1	-	6	163
%	25	37	n.s.	30	4	n.s.	-	4	100

(n.s.: not significant)

Note: HOG : Historical occupational group (may be a common family name now)
L : Lineage name
F : Common family name
C : Caste (Hindus); Sub-castes represented: Jelle (fishermen), Napit (Barbars); Bormon

Table 12.2-2: Number of households per social category and per para in Analerchara - 9 paras surveyed

[2] Not represented in the overall study area.

Sociological Category / Serial No. of the para (Fig. 12.2-1)	Shar-kar	Be-pari	Mau-lovi	Sheikh	Akond o	Khon-dakar	Ali	Dash (Hin-du)	Total
1	4	8							12
2	10	25	1						36
3	2	14							16
4	2	5							7
5	25		4				10		39
6	30	20	10	40					100
7	1	10	2						13
8		30							30
9 (Napit Para)	2							13	15
10	4	8		8					20
11			1	3					4
12			8						8
13	5								5
14 (Jelle Para)								8	8
15		13							13
16	3	4	2	30					39
17	5	3		14					22
18 (Chatai Para)	18								18
Total	111	140	28	95			10	21	405
%	27	35	7	23			3	5	100
Type of sociolo-gical category	HOG	HOG	HOG/ L	L	L	L	F/L	C	

(n.s.: not significant)

Note: HOG : Historical occupational group (may be a common family name now)
L : Lineage name
F : Common family name
C : Caste (Hindus); Sub-castes represented: Jelle (fishermen), Napit (Barbars); Bormon

Table 12.2-3: Number of households per social category and per para in Dhutichara - 18 paras surveyed

On the basis of 5.5 persons on average per household, Analerchara and Dhutichara would comprise at present respectively 270 and 670 households. The part para survey thus covered 60% of the total number of households for both Analerchara and Dhutichara. For Analerchara the percentage of landless households out of the 270 surveyed represents only 21%, whereas the overall ratio estimated is over 60% for the whole Mauza (the landless households who are now living on the embankment were not surveyed at all). On the other hand the landless ratio for Dhutichara, which is 33% for the sampled paras, could be representative of the whole Mauza.

On the whole, Table 12.2-2 above shows that the following three main categories occupy the social space of the two mauzas in a distinctly comparable proportion: The **Bepari**, the **Sharkar** and the **Sheikh**[1]. This structure is useful to know for a better understanding of the socio-political system of the mauza under the modern political party pattern, and thus the grass roots framework of a possible social consensus or conflict vis-a-vis any out-coming project or programme.

Present Economic Activities

In the framework of the survey of selected paras (see Table 12.2-2) the above sociological categories were compared with the present economic occupations. Results are given below:

Sociological Category / Main Occupation		Shar-kar	Be-pari	She-ikh	Akon -do	Mau-lovi	Bor-mon	Khon-dokar	Total No.	Total % (line)	Total % (Column)	% (Column) (*)
- Farmers	No.	25	15	20	6			1	67		44	22
	%	37	22	30	9			2		100		
- Daily labour, small traders (landless)	No.	7	10	15					32		21	60
	%	22	31	47						100		
- Businessmen and merchants	No.	6	17	10					33		21	11
	%	18	52	30						100		
- Service holders	No.	2		4		1			7		5	2
	%	n.s.		n.s.		n.s.				100		
- Fishermen	No.		8						8		5	3
	%		100							100		
- Carpenters	No.						6		6		4	2
	%						100			100		
Total	No.	40	50	49	6	1	6	1	153		100	100
	%	26	33	32	4	n.s.	4	n.s.	100			

NB: Underlined figures per occupation per sociological category are to be compared particularly with total figures per sociological category per mauza

(*) after adjustment using the overall landless ratio of the mauza (see above)

n.s.: not significant.

Table 12.2-4: Structural sociological categories and actual main occupations in Analerchara mauza (55% of the households surveyed)

[1] to be compared with the Bahadurabad site, Chapter 13.

Sociological Category / Main occupation		Shar-kar	Be-pari	She-ikh	Maw-lovi	Ali	Khon-dokar	Dash	Total		
									No.	% (line)	% (Column)
- Farmers	No.	30	25	40	12	6	6		119		30
	%	25	21	34	10	5	5			100	
- Daily labour, small traders (landless)	No.	40	50	35	10	2			137		33
	%	29	37	26	7	1				100	
- Businessmen and merchants	No.	11	62	16	3	2			94		23
	%	12	66	17	3	2				100	
- Service holders	No.	10	5	4	3				22		5
	%	45	23	18	14					100	
- Fishermen	No.							9	9		2
	%							100		100	
- Barbers	No.							12	12		3
	%							100		100	
- Net makers	No.		18						18		4
	%		100							100	
Total	No.	91	160	95	28	10	6	21	411		100
	%	22	39	23	7	2	2	5	100		

NB: Underlined figures per occupation per sociological category are to be compared particularly with total figures per sociological category per mauza

Table 12.2-5: Structural sociological categories and actual main occupations in Dhutichara mauza (61% of the households surveyed)

Without proceeding to any more detailed analysis, the following main characteristics have to be recalled:

(i) Apart from the much higher rate of landless in Analerchara mauza, commerce represents relatively more after the main occupation in Dhutichara and farming a little less;

(ii) **Sharkar** are more often occupied mainly with farming (land owners) and less with commerce, and

(iii) **Bepari**, in contrast are still more often businessmen or merchants, less often service holders but can be fishermen or craftsmen.

12.2.3 Land Holding Distribution and Farm Fragmentation

The local classification of farm sizes, as discussed at the Union Council office level, is roughly as follows for the two mauzas:

- small farmers : less than 3 bighas;
- medium farmers : from 3 to 15 bighas, and
- large farmers : over 15 bighas.

A field reconnaissance with a sample land owner inventory was conducted in the southern part of the gross site area (defined before Fig. 12.2-1) that represents around 65% of its total area. This inventory was performed on a sub-area basis and nominally[1]. Detailed figures are given respectively in Table A.7-3 and Table A.7-4 for the Analerchara part and the Dhutichara part. This survey covered in total 80 landowners (or landholding units), occupying 179 plots and 206.6 bighas (27.9 ha). The main ratios from this survey are given below.

Area Concerned	No.of Farmers	Area in the GSA (ha)	No.of Plots in GSA	Total Area of Concerned Farmers (ha)	Avg. Farm Size (ha)	Avg. Farm Portion Inside GSA (ha)	Avg. Plot Size Inside GSA (bighas)	Avg. No.of Plots/ Farm	Farms Entirely in the GSA	
									No.	Area % of plot
Analerchara part	31	6.83	60	25.80	0.83	0.22	0.84	7.3	6	26.5
Dhutichara part	49	21.06	119	27.17	0.55	0.43	1.31	3.1	23	78.8
Total surveyed area	80	27.89	179	52.97	0.66	0.35	1.15	4.1	29	

(Source: Field survey)

GSA : Gross site area
N.B. : 1 bigha = 0.135 ha
Landless not included

Table 12.2-6: Land holding distribution and farm fragmentation in the gross site area

[1] Registered names of landowners are kept in the project file for a possible second phase.

In respect of farm size distribution the main statistical dispersion characteristics are as follows (80 farms basis)

(Bighas)

	Mean	Median	Standard deviation	Variation coefficient	Minimum value	Maximum value
Analerchara part (n=31)	6.16	5.0	5.75	95	0.25	22.0
Dhutichara part (n=49)	4.08	3.25	2.81	69	0.75	10.5
Total surveyed area: (n=80)	4.86	3.86	4.29	88	0.25	22.0

Note: 1 bigha = 0.135 ha

Total surveyed area (n=80)

Farm size (ha) (landless not included)	No. of farms	%
0.4 and less	38	47.5
0.4 - 1.22	33	41.3
1.21 - 2.03	5	6.2
over 2.03	4	5.0
Total:	80	100

In conclusion, and on the basis of the 80 farmers surveyed, it appeared that the gross site area on the whole would be representative of the local land tenure and land holding distribution, with an average size of 0.66 ha and 4 plots per farm. However, a difference can be noted between the Analerchara part and the Dhutichara part of the gross site area. This difference concerns farm concentration, and size of medium-large to large farm categories, which is higher in the case of the Analerchara part (see detailed figures above). According to the cadastral mauza maps of 1933-1934 the average plot size in the gross site area was around 2.8 bighas versus 1.2 bighas at present, which illustrates the large increase in fragmentation (+133%) since that period. This phenomenon is of course mainly due to the demographic growth after the Second World War. Besides, only 3 plots were found as taken in mortgage out of the 179 plots surveyed, and 10 (12.5%) ownerships in division between 34 adult males (most of them brothers).

12.2.4 Local Institutions, Public Services and On-going Social Programmes

Socio-political Organization at Grass Root Level

In the two mauzas concerned people interviewed quoted two types of institutions with regard to local authorities: **the official Union Council and its elected members**, and the traditional **elders and samaj system**.

Among the nine elected members of the Union Council (3 members per electoral ward; 3 wards per union), one elected member is from Analerchara and another from Dhutichara (7 mauzas in total in the Union Council).

There are mainly four political parties active in the area. These are the Jatiya Party (JP), Bangladesh Nationalist Party (BNP), Awami League and the Jamat-e-Islami. The member of parliament elected from the area belongs to JP, but the Union Council chairman and members belong to BNP. The Jatiya Party seems to have a strong followers in the area. But the BNP and Awami League also have quite a good hold. Apparently, there is political rivalry amongst the groups. The village elders and the heads of the families often influence the people to vote in favour of a particular person or party. The elites could be quite a determining factor. But this does not seem to lead to serious tension in the area.

Local people often assert that political parties in fact only exist during election periods. It is also worthwhile noting that out of the nine elected members at the Union Council eight are **Beparis** and one **Sharkar**, whereas the formal three nominated women are **Sharkar**.

The samaj system comprising elders is the traditional customary socio-political one at grassroot level.

Each mauza is composed of a limited number of sub-areas which correspond to an elementary social group of solidarity gathered around one mosque and one head elder (**mattabar**). The whole is called locally **samaj** on an area basis, and for the purposes it will be called area-samaj in order to avoid any confusion with other possible kinds of samaj/solidarity groups. Inside each area-samaj, there is again one elder or "elder-assistant" for each para.

Relationships between elected representatives in the area seem rather positive. The responsibilities of the elected members vary. Not only do they have to look after the welfare of the people in this area, they also have to maintain liaison with different government agencies. Traditionally, village elders and leaders are consulted and advice is sought from them in solving local problems. The village elders also participate in local **salish**, to resolve disputes. Moulvis and Imams of mosques advise people in matters of religion. They are respected by the villagers.

In conclusion, the different levels of socio-political control of the population appear as an encased system from the family level to central government one as is simply summarized below:

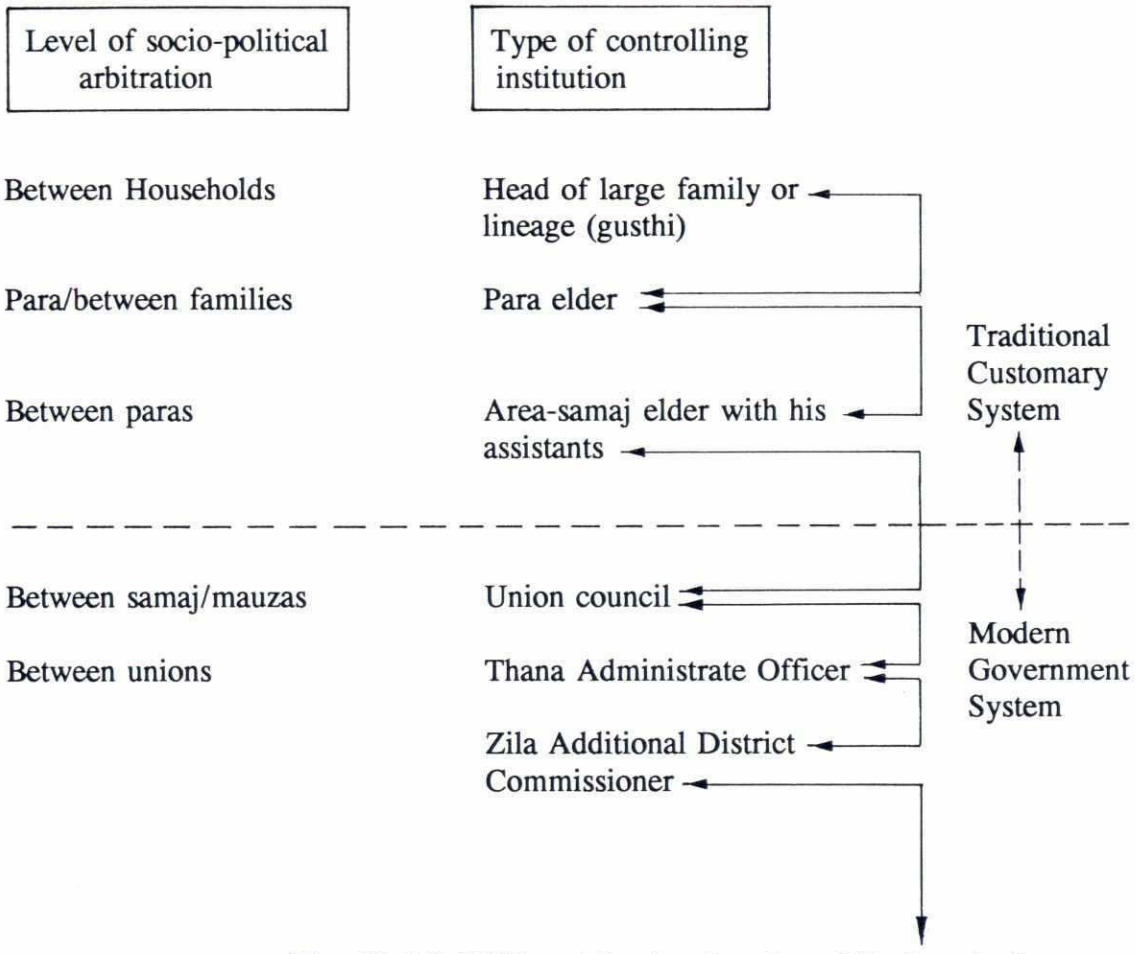


Fig. 12.2-2: Different levels of socio-political control

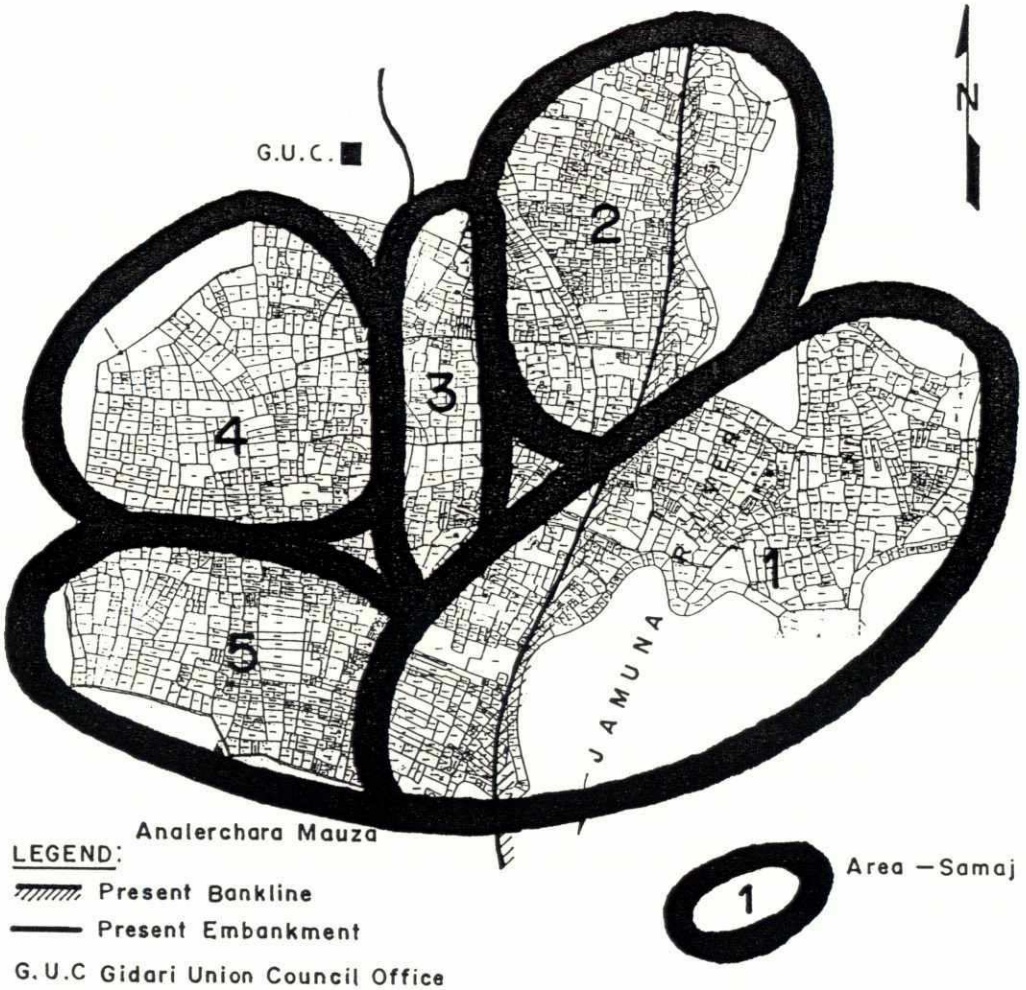
At each step of control, action can be taken either in case of its resort level or in case of failure/inefficiency of the lower resort level.

In the particular cases of Analerchara and Dhutichara there are respectively 3 and 5 area-samajes. The location of the 5 area-samajes of Dhutichara is roughly shown on in Fig. 12.2-3.

For Analerchara it would seem that the three area-samajes are defined in three portions, from east to west, but no more detailed information on their limits was obtained during the field investigations.

Public Services and Agricultural Cooperatives

Without targeting any appraisal or even assessment of the other local institutions, they will just be mentioned below with some factual comments as identified through the field investigations.



THE FIVE AREA – SAMAJES IN DHUTICHARA MAUZA

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The following socio-economic services exist in the close environment of the site area:

	Analerchara	**Dhutichara**	Elsewhere in the neighbourhood (see Fig. 12.2-1)
Madrasa	1	1	-
Primary school	1 temporary	1	-
Secondary school	-	-	1 in Foliaghop
Village health centre	1	-	-
Clinic	-	-	1 at Council Bazar (Dhaskin Ghidari)
Post office			1 at Council Bazar

Notes: (i) Government subsidies are 100% for primary schools and 70% for Madrasa and the Secondary school.

(ii) Twelve health extension workers at Ghidari Union : three for Analerchara and three others for Dhutichara. A family planning programme is also carried out at Ghidari Union Clinic apart from first aid services.

Local and regional **market facilities** are (apart from Gaibandha town):

- the council bazar (close to north border of Dhutichara, near the Union Office): Thursday and Sunday;
- Kaiyar hat: Thursday and Sunday, and
- Kamarjani: Friday and Monday.

There is no permanent **agricultural service** at Ghidari Union level. Three agricultural extension workers from Gaibandha Agricultural Service come only 4/5 days a month, proposing advice for agricultural practices, fertilizers and pesticides. At a first glance the impacts of such services seem to be very limited, all the more that cropping systems are already at high intensity level, under the ecological and technological, and economic leading conditions. One **agricultural Cooperative** was found in Dhutichara based on the collective utilization of the existing deep tube-well. In respect of **rural credit** there is no Grameen Bank Office at Ghidari Union but Karchipara Unit serves villagers in Analerchara and Dhutichara. No more detailed information on the actual extent of credit was obtained during the field visits.

On-going Social Programmes

Compared to Bahadurabad site (see Chapter 13) on-going social programmes are limited. At the level of Ghidari Union:

(i) **A Rural Maintenance Programme** is run by CARE and employs fifteen workers (out of which 5 in Dhutichara and none in Analerchara). CARE also manages a relief operation in distributing some wheat to refugees every month.

(ii) **The Distressed Mother Programme** is distributing on the other hand, 31 kg of wheat per month to the distressed mother card holders (264 card holders in total in Ghidari Union, 38 in Dhutichara and 12 only in Analerchara).

12.2.5 Psycho-sociological Atmosphere

Discussions with different groups reveal that due to continuous river bank erosion all the inhabitants of Dhutichara and Analerchara are under psychological pressure irrespective of their occupation. A significant number of people rendered homeless and landless due to river bank erosion are now living on both sides of the embankment. People stated that the squats in which they live are congested and are devoid of any public utility services. These unfortunate squatters hardly get any fruitful employment to support their families. Only now and then, they are employed by the well to do farmer as day labourers. The wage they receive is low. They do not have the means to buy the minimum food required for their family. As a result, they suffer from malnutrition and ill-health.

They have stated that the people rendered landless did not receive help from the Government or the NGOs in their rehabilitation. Only Grameen Bank extended some loans to the landless without any collateral to raise cattle and chicken. Sometimes the Grameen Bank also extended loans to some women for buying paddy and husking it into rice in their **dheki** at home, to sell it at a profit.

Group discussion revealed the dismay of the people at the existing employment opportunities available in the locality. According to them some of the young men belonging to the affected families have already gone to Rangpur and Dinajpur in search of jobs. All the individuals and groups interviewed expressed their willingness to accept any type of work to earn a living so that they may feed their family members.

Some of the people who lost land due to river erosion hope that some day the course of the river would change and they would recover their lost land.

The landholding groups whose land has not yet been eroded by the river are in a psychological trauma. They are helplessly watching the progress of river erosion, praying to Allah that it would stop. Different group discussions revealed that people are unanimous as to the necessity of controlling river erosion. In fact, in the face of this obsessive problem, people are expecting a lot from Government and from NGOs as well, as for years these have appeared to them to be structurally part of the assistance environment. Public representatives even say that "who must do it and how it must be done, is not a matter for us".

Specific Problems Faced by Some Different Groups

Landholding Groups - Group discussion revealed that public landholding groups employed in farming are the most concerned. Those who have lost their land are now

mostly living by the side of the embankment. Some of these people were well to do farmers but they are now working as day labour (**Kamla**) in others agricultural fields. As the level of unemployment is high there is intense competition to get a day labourers job. Because plenty of day labour is now available, the prevailing wage rate is also very low.

Those who have not yet lost their land but are almost sure to do so in 2/3 years time, are suffering psychologically. This is the group which advocated the immediate implementation of some river bank protection scheme in this locality so that they may not lose any agricultural land. They opined that they would be willing to sell the land required for such a scheme and would also cooperate in any way for the successful implementation of the project.

Carpenters - A group of carpenters belonging to the Hindu Bormon caste residing in Analerchara told the interviewers that 3/4 years back, before the river engulfed parts of the two mauzas, they had enough work to do in the two villages. At present the residents of these mauzas are reluctant to employ them as they are not sure as to the permanency of their homesteads. Now they have to go to villages 3 to 4 miles away in search of work. The carpenters unanimously agree that a system of river bank protection must be made to safeguard the rest of the mauzas from erosion.

Fishermen - A group of fishermen belonging to a Hindu caste (Jaludas) live in Dhutichara. These people are facing problems from two sources: i) due to over fishing, the fish population has decreased; ii) a significant number of people rendered homeless by river erosion are now employing themselves in fishing to execute a living. Now, however, they do not catch enough fish and they are facing economic hardship.

By way of conclusion the following 10 aspects are serious ones for the population :

- increase of landless;
- increase of unemployment and increase of "forced" out-migration;
- lack of social services;
- bad condition of roads;
- river bank erosion in crop land;
- increase of population density provoking an "unhygienic atmosphere";
- increase of diseases (due among other reasons to population increase);
- lack of food and under-nourishment;
- increase of highjacking and insecurity, and
- increase of quarrels between people (parents and neigbours).

On the whole "the board is black", and general under-development questions are raised, in the framework of which river bank erosion is simply aggravating factor.

Attitude Toward the Project and Erosion Control Techniques

The purpose and the nature of FAP 21/22 projects were discussed in a group meeting

held at the Union Council Office of Ghidari. Among others the Chairman and a number of members of the union council participated in the discussion. The experimental natures of the project was explained in a very simple (non-technical) manner, together with its purpose, which is to test the strength and effectiveness of groynes in river bank protection.

It was apparent that only a few persons who participated in the discussions could understand the real technical nature of the project. Particularly, they could not understand the mechanism of groynes in restraining river bank erosion. But every one without exception felt the urgency of any project aiming at river bank protection.

Those who attended the discussion were of the optimistic opinion that "even only for test on 1 km, the concerned area will be protected; and the project should be profitable and beneficial for the people". If some land has to be acquired the project will have (of course) to pay compensation. A possible practical procedure was also discussed for land compensation (see Section 12.4).

Without beating about the bush, public representatives said "that the present BWDB embankment is harmful for them. It does not control the river and is provoking drainage problems on the west side. For that reason people had to cut down the embankment". Thus they suggest not to build such a type of embankment in the future and in particular when there are no sluice gates. For combatting river erosion "the current should be deflected by pillars, stones, like in Sirajganj - or by application of any other means". Finally "the large amount of money that such embankments cost should not be misused in the future, and funds should be spent on other kind of efficient project". What else to add to such clear advice, except but that the harder issue is to combine structural and non-structural actions, and to target river bank erosion projects clearly in the real priorities of the development of the country at every level.

12.2.6 Agricultural Activities

Hydroagricultural Aspects

The different cropping sites, for the most part, may conveniently be related to physical factors, i.e. physiography, soil associations, drainage conditions, effect of flood water and erosion risks.

A transect across the village land from the highest to lowest ground shows various levels of land, which correspond to what can be called homestead land or "bhiti"; medium high lands - flooded frequently but well drained both by gravity and percolation; medium low land deeply flooded and poorly drained; lowland and very deeply flooded lands. The amount of silt and clay is higher in the medium low lands and low lands in relation to the frequency of flooding and effectiveness of drainage.

Hence surface siltation and clay deposits are observed in the low lying areas between present and/or old bank lines (AEU 3.0 and 4.0). This is particularly the case to the west of the road embankment. Along the bank line, lands are affected by sandy deposits mixed with silt in the surface layers of soil. This process appears during flooding periods of the Jamuna river followed by rapid drawing off conditions. (affected AEU are 2.1 and 3.1; see the lands map). But land levels are not strictly physical units; rather they represent Agro Ecological Units (AEU) where cultivation thus depends either upon the hydrologic state and texture of the soil or upon the availability of water for irrigation. According to the FAO/UNESCO classification these soils are EUTRIC FLUVISOLS.

The following map shows the AEU system of the Kamarjani area.

In this area the braiding nature of the channel pattern is characterized by a radical shifting of the channel course.

At the east side of the road between Analerchara and Dhutichara, shifting is gradual by bank erosion, and during the last three years bank line migration of approximately 150 to 220 m per year is observed.

On the west side overbank flow and devastating floods occur during the monsoon season. Due to the drainage congestion of rain water as well as of water flowing from the Jamuna river the western area has become increasingly aggravated, often damaging T.aman crops. This worsening of drainage conditions seems due to the blockage of water by the road embankment. However this year, drainage conditions are better since a very large break appeared during the last flooding, upstream the Manas Regulator.

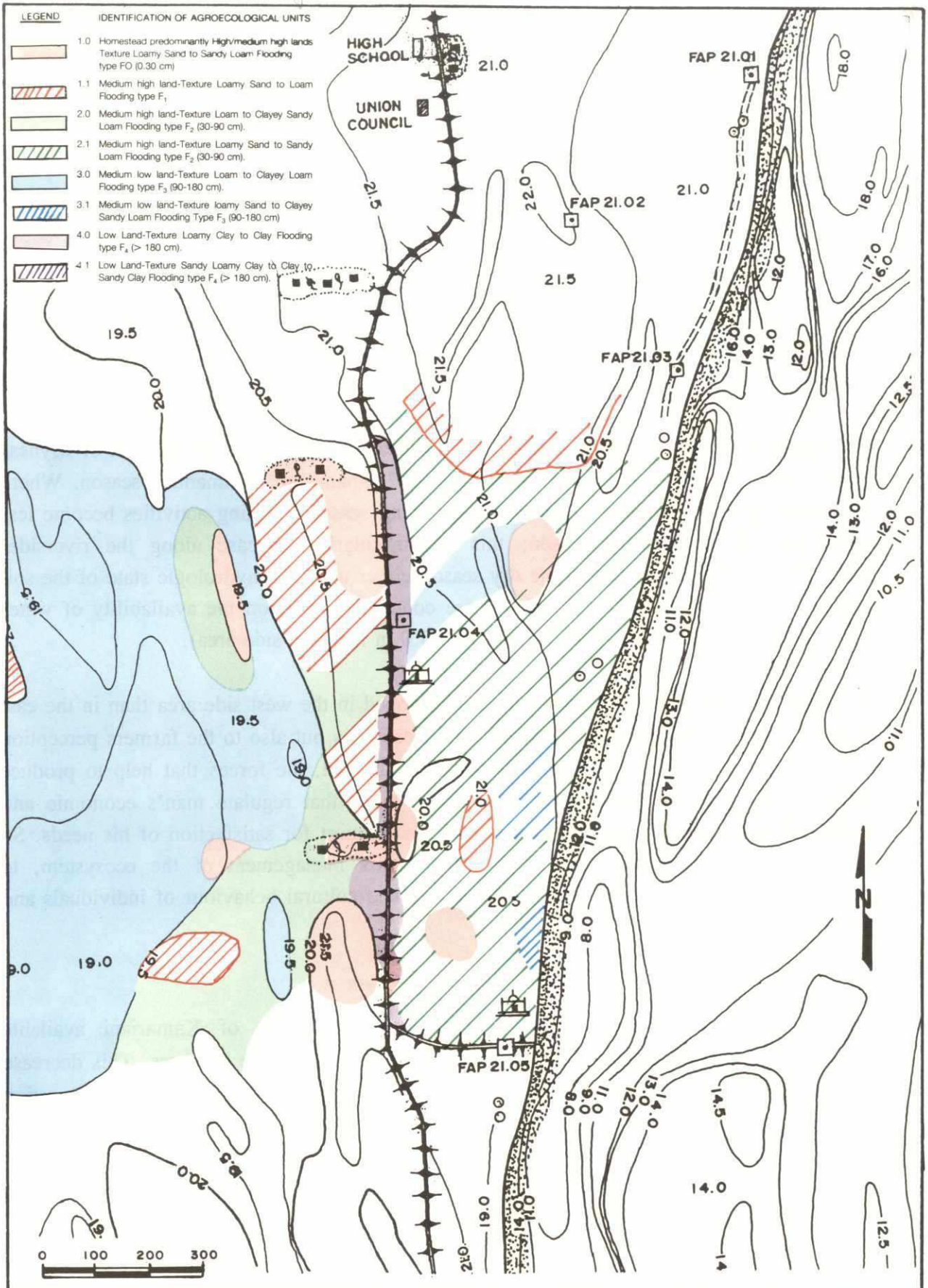
Landuse and Cropping Systems

In the investigated area of Kamarjani the major crops grown are B.aus, B.aman, T.aman (local), jute, wheat and mustard. The expansion of HYV. boro production has been facilitated by the introduction of tubewell irrigation, at the west side of the road for the most part.

This trend is probably due to the farmers' response to the bank erosion risk appearing in the east side area.

Exceptionally this year the good drainage and less flood facilitated in the west side area:

- a shift of cropping patterns from local varieties to high yielding varieties;
- a move from B.aman to T.aman, and
- an increase in the areas of HYV. boro and rabi crops.



KAMARJANI
IDENTIFICATION OF AGROECOLOGICAL UNITS

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. 12.2-4

The cropping systems shown in Table 12.2-7 are often observed at present in each agro-ecological unit identified in the Kamarjani area.

Nevertheless the plant and animal resources of an individual farm are generally exploited not only through a judicious adjustment to the physical environment but also in relation to the specific socio-economic conditions.

The farmers do not follow the same pattern of crops year after year; they change cropping patterns frequently, varying the other crops around the pivot crop of aman rice. This change is related to rainfed conditions because of variations in time, duration and amount of rainfall from year to year.

The seasonal pattern of farming activities in different AEU varies on account of dryness in the "rabi" season or excessive rainfall in the "Aghani" or "Haimantic" season. Where late floods are not available to extend the growing season, farming activities become less significant during the dry season; this is particularly the case along the riverside. Cultivation thus depends during the dry season either upon the hydrologic state of the soil (favourable as far as AEU 3.0 and 4.0 are concerned) or upon the availability of water for irrigation (possible for AEU 1.1, 2.0 and 3.0 in the west side area).

But this irrigation practice, which is more developed in the west side area than in the east side area, is not only due to the ground water resources but also to the farmers perception of the extreme erosion of the present bank line. In fact, the forces that help to produce differing land uses in the Kamarjani zone are those that regulate man's economic and social behaviour, which are end-products of man's quest for satisfaction of his needs. So land use is therefore an expression of the man's management of the ecosystem, to produce his needs according to the technologies and cultural behaviour of individuals and groups.

Livestock

During the last interviews made in the investigated area of Kamarjani available information indicates that there is a significant decrease in cattle numbers. This decrease is more noticeable in the west side of the road embankment, where drainage congestion was severe in the last few years.

From the cross checking made in the FAP 12 study it appears that the cattle population in the investigated area may have decreased by 25-40 percent in the last 8-10 years.

This decrease seems to be due to:

- selling by the farmers when there is any crop failure or financial difficulty;
- shortage of animal feeds caused by reduced area of fallow land and change in cropping intensity, and
- incidence of parasitic and viral diseases.

Agro Ecological Units (AEU)	1.0 Crops	Area %	1.1 Crops	Area %	2.0 Crops	Area %	2.1 Crops	Area %	3.0 Crops	Area %	3.1 Crops	Area %	4.0 Crops	Area %	4.1 Crops	Area %
Rainfed																
					Sugar cane	10										
					Aus	50			Aus	50	Aus	60				
							Taman	50	Jute	30						
			T.aman	55	T.aman	90	B.aman (local)	50	B.aman (local)	50	T.aman	40	T.aman	70		
					Kaon (rabi)	10	Kaon (rabi)	40								
			Mustard	15	Pulses/mustard	20										
			Rabi crops	55			Rabi crops	40					Rabi crops	10		
							Ground nuts	10								
			Vegetables and	30			Summer vegetables	10					Vegetables	10	Vegetables	7
	Homestead crops	50	Homestead crops													
Irrigated																
Boro (HYV)					Boro (HYV)	40			Boro (local)	20			Boro (HYV)	50	Boro (local)	13
									Boro (HYV)	30					Boro (HYV)	25
Wheat					Wheat	20			Wheat	20						
Onion											Vegetables	20				
									Mustard	20	Mustard	25	Mustard	10	Mustard	5
					Onion	10			Onion	10						
Cropping intensity		50		155		250		200		230		145		150		50

Table 12.2-7: Present cropping systems in the affected area

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Cattle are the main source of draft power in the project area.

According to the 1983/84 census of agriculture and livestock it may be considered that 50-75 percent of total cattle are draft animals. Taking into account the decrease in cattle population, there were between 0.8 and 1 head of draft cattle available for cultivation of 1.6-2.3 acres of land. The average farm size being around 1.6 acres in the Kamarjani zone there was apparently no overall shortage of draft power, since one pair of good bullock can cultivate 4 acres of land. But there is a real shortage of draft power among the small farmers because most of them do not have any cattle and they are dependent on hired ploughs for cultivation of their land. It is a serious problem because the small farmers represent approximately 47.5 percent of total farmers in the investigated area.

The gross product of animal husbandry includes the provision of draft power for cropping in addition to milk, meat, eggs and by-products for consumption or other uses. Its estimated value is very tentative but using the same percentage resulting from investigations already made in the framework of the main land studies (FAP 2 and 3) it may represent some 20% of the gross product of crops at market prices.

Production Assessment per AEU

The production of main crops including rice, wheat, kaon, jute, sugarcane, pulses, onion, mustard, vegetable was investigated by interviews on plots representing each principal AEU to the east and west side of the road embankment.

Table 12.2-7 shows a very high diversification of production and cropping intensity which may be observed in the framework of each AEU.

Actually, this table does not aim at giving detailed information; it is rather an indicative land use framework which must help to define the problems involved in rural socio economic prospects.

The Net Value Added (NVA) (or margin) per ha and labour per man days in normal year at market prices may be estimated as shown in Tables 12.2-8, 12.2-9 and 12.2-10 for each AEU.

As far as T.aman production is concerned, the average yields must be decreased by a percentage roughly estimated at around 20% after provision for exceptional floods.

So the total NVA per AEU must be decreased by:

10% for AEU 1.1.
5% for AEU 2.0
6% for AEU 2.1
3% for AEU 3.0
7% for AEU 3.1

The production costs of main crops at market prices as shown in Table 12.2-8 include the cost of labour accounted at the same price for family or hired labour, the cost of draft animals used for land preparation, threshing out and transport, and the cost of inputs including farm manure.

The net income derived from the main crops in a normal year, i.e. without damage due to exceptional floods, is estimated by the difference between the gross product and the production costs at market prices.

The average productivity of farm labour is revealed by the gross added value per man-day presented in Table 12.2-8. The average gross value added (gross product-cost of production; labour cost not included) is about 18,260 per ha with significant variations between the different AEU (7,279-35,592 Tk). The investigated area of Kamarjani provides about 244 workdays per ha (80-372 workdays) with an average productivity of 72 Tk per ha (62-96 Tk), whereas usual daily labour wage is 20-25 Takas.

What must be considered is a major inequality not only in terms of size but also in terms of land productivity between individual farms and between the west and east sides of the road embankment. On the east side the NVA is about 9,800 Tk per ha in a normal year (or on average 8,350 Tk per farm of 1.6 acres). On the west side the NVA is about 20,000 Tk per ha (13,000 Tk per farm of 1.6 acres).

The boro crops estimated represent approximately 12% of the cultivated areas, on the west side essentially. This crop is irrigated from a deep tubewell (about 40 acres) managed through a cooperative organization and also from several individual shallow tubewells.

Thus, with the introduction of irrigation the winter boro crop will increase the cropping intensity, which is now about 230%.

Cropping System	AGRO-ECOLOGICAL UNITS													
	1.1		2.0		2.1		3.0		3.1		4.0		4.1	
	Crops	NVA	Crops	NVA	Crops	NVA	Crops	NVA	Crops	NVA	Crops	NVA	Crops	NVA
Rainfed	T.aman	3,843	S.cane	4,518	B.aman	2,909	Aus	2,377	Aus	2,852				
	Mustard	952	Aus	2,377	Kaon	815	Jute	1,488						
	Rabi crops	1,270	Kaon	204	Rabi crops	1,145					Rabi crops	286		
	Vegetable	1,628	Pulses & Mustard	2,145	Ground-nuts	1,819					Vegetable	533		
	Homestead		T.aman	6,244	Vegetable	533								
					T.aman	3,469	T.aman	3,467	T.aman	2,775	T.aman	4,857		
Irrigated			Boro	6,952			Boro (HYV)	5,214	Vegetable	1,065			Vegetable	373
			Wheat	1,295			Boro (local)	2,060	Mustard	1,588	Boro (HYV)	5,214	Boro (local)	1,339
			Onion	2,820			Wheat	1,295			Mustard	635	Boro (HYV)	4,346
							Mustard	1,270					Mustard	318
							Onion	2,820						
Net Value Added/ha Labour (man/days/ha) GVA/man/day	7,693 208 62		26,555 372 96		10,690 232 70		19,998 348 65		8,280 169 74		11,525 200 82		6,376 80 91	
Net Value Added/man/day Cropping intensity %	37 155		71 250		46 200		37 230		49 145		110		50	

Note: Gross Value Added (GVA) = Gross Product - Direct Production Costs (labour cost not included)
Net Value Added (NVA) = Gross Value Added - labour costs (family and hired labour); family labour valued at daily labourer level.

Table 12.2-8: Net value added per ha of AEU (taking into account cropping intensity)

Crops	Production Characteristics / H_2				
	Yields T/ha	Market Price Tk/T*	Gross Product	Production Costs**	Net Value Added
Homestead crops	-	-			
Sugar cane	77	1,012	77,924	32,744	45,180
Vegetables	6.30	1,389	8,750	3,423	5,321
Onion	5.50	9,047	49,758	21,560	28,198
Mustard	1.10	13,396	14,736	8,385	6,351
Ground-nuts	2.00	16,075	32,150	13,962	18,188
Other rabi crops	1.90	4,000	7,600	4,737	2,863
Wheat	1.50	6,312	9,468	2,994	6,674
Kaon	1.10	3,750	4,125	2,087	23038
Aus	1.40	6,074	8,504	3,750	4,754
B.aman (local)	1.84	6,438	11,846	6,028	5,818
T.aman (local)	2.30	6,438	14,807	7,869	6,938
Jute	1.50	8,012	12,018	7,058	4,960
Boro (HYV)	5.52	6,212	34,290	16,908	17,382
Pulses	1.40	14,919	20,886	10,123	10,723

* Prices compiled from Statistical Yearbook of Bangladesh and estimates through 1992 interviews.
** Costs estimated through 1992 interviews and FAP 3 studies.

Table 12.2-9: Net value added of principle crops

Crop	Man-Days		
	Own	Hired*	Total
Sugar cane	189	61	250
Vegetables	89	31	120
Onion	110	40	150
Mustard	35	15	50
Ground nuts	100	50	150
Other rabi crops	110	40	150
Wheat	120	70	190
Kaon	50	25	75
Aus	78	42	120
B.aman (local)	54	26	80
T.aman (local)	100	50	150
Jute	140	70	210
Boro (HYV)	140	70	210
Pulses	57	18	75

* figures given by FAP 3 interviews as reference but inapplicable in the framework of the present study
Sources: Estimates through 1992 interviews, (FAP 12 and FAP 3.1 studies)

Table 12.2-10: Labour input per crop and per ha

Land Value

River bank erosion is a recurring and widespread phenomenon in the Kamarjani area. The farmers' perception of this phenomenon on the east side of the road embankment implies a patent decrease in land value. The land values presently observed on the west side are two to four times as high as the east side. As shown in Table 12.2-11 the price bracket on main land is very broad and must be considered with prudence because it concerns various AEU; some lands are irrigated, others are not equipped. Anyhow, depending on the recent local context (broken embankments upstream of Manas Regulator, test embankment already known), the highest land prices must be considered as related to the present economic climate and the erosion risk perception and thus may change quickly. Compared with the land production value, Table 12.2-11 shows how many years of production (in terms of Net Value) are required to meet the present market land values to the east of the road embankment and to the west. In another word this express the apparent land annuity of the peasantry accounting system: it does vary a lot according to the AEU/cropping systems concerned.

The whole, land prices often seem underestimated; on the east side, this is due to the perception of the riverside erosion; on the west side it is probably due to the risks of water stagnation.

AEU	Market Land Value (Tk/ha)	Land Value Equivalent to Net Value (in terms of production* year number)	Apparent Land Annuity (%)
RIVER SIDE	37,000 to 44,400		
(East road embankment)			
. Units 1.0/1.1		6	17
. Unit 2.1		5	20
. Unit 3.0		3	33
. Unit 3.1		6	17
. Units 4.0/4.1		7	14
MAIN LAND	59,300 to 185,200		
(West road embankment)			
. Units 1.0/1.1		8 - 24	4 - 12
. Unit 2.1		3 - 7	14 - 33
. Unit 3.0		6 - 10	10 - 17
. Units 4.0/4.1		6 - 16	6 - 17

* expressed by the Net Value Added which can be considered as a land income annuity

Table 12.2-11: Land value

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12.3 IMPACT ASSESSMENT

12.3.1 Settlement Areas and Homesteads Affected

Four settlement units (paras) are located in the gross site area as shown in Fig. 12.1-1 hereafter. A first rough estimate of the number of households composing these paras is 50 in total with the following distribution:

Sl.No. of the para	No. of households	Mauza concerned
9	1	Analerchara
1	12	Dhutichara
4	7	Dhutichara
7	18	Dhutichara

	50	

At this stage and scale of approach one cannot of course identify precisely the number of households that will be on the final construction site. Based on the assumptions concerning the future bankline and the design criteria (Section 12.1), the situation would be as follows[1)], after the 93 monsoon and at the starting point of the construction phase:

(i) para No.9 would already have shifted and at least a part of para No.7 as well;

(ii) the western edge of both para No. 4 and 1 would have to be resettled, which would represent roughly no more than 25% of the total number of households of these paras, i.e. 5 households. Such resettlement could be achieved by people themselves just in the neighbourhood, and in particular may be on the planned supporting embankment itself, after completion of the works.

Why? Not shown from map 12.1-1

The main compensatory measure for this minor resettlement will be compensation for its actual costs (see Subsection 12.4.2) below. The land acquisition and compensation procedure is also discussed below (Subsection 12.4.1).

12.3.2 Impacts on Agricultural Activities

Effect Identification and Affected AEU

The affected area includes five zones (see Fig. 12.1-1):

- an expropriation zone required for building the test bank protection (zone A);
- a zone located between the present embankment road of Kamarjani-Bhaguria and the test bank protection site (zone B);

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1) Information will be refined and updated during the detail design phase and after the peak of the 1993 monsoon.

- several land belts located along the test bank protection between each groyne (zone E);
- a main land zone to the west of the test bank protection site affected by water stagnation risks (zone C), and
- a riverside zone to the east of the test bank protection site (zone D).

The agro ecological units characterizing each one of these zones are the following:

- zone A : AEU 2.1, 3.0
  zone B : AEU 2.1, 3.0, 4.0
  zone C : AEU 2.0, 3.0, 4.0
  zone D : AEU 2.1
  zone E : AEU 2.1
- zone A concerns a land acquisition area of about 6 ha;
- zone E is an area of about 9 ha;
- zones B and C are the areas west of the test bank protection site, and
- zone D is the river side area.

In absence of the protecting measure, zones A, B, D & E are likely to be washed away by the Jamuna river within few years. Zone C however will be protected until the flood protection embankment fails.

In addition to the direct effects concerning agricultural production and livestock (shown in quantitative terms in Table 12.3-1), the principal rural development problems resulting from the test project are as shown in Table 12.3-1 below:

AEU	Financial Impacts and Affected Areas						
	Due to	Direct			Indirect		
		Affected area ha zone A	Total cost acquisition Tk/ha	Number of production years	Affected area (ha) zones		
					B	C	D
RIVER SIDE							
2.1	Land acquisition	5.1	37,000	5			
3.0	Land acquisition	0.9	44,400	3			
2.1	Land affected				7.65	13.6	-
3.0	Land affected				1.35	8.4	
MAIN LAND							70

Table 12.3-1: Direct effects concerning agricultural production and livestock

	Zones				
	A (1993)	E (1993)	B	C	Total
Cost of land affected (Tk)	228,660	-	-	-	228,660
Annual benefit lost* (Tk) in 1993	87,015	37,015			124,415
Annual benefit decrease due to the embankment NVA (Tk) total	87,015		13,200	rough:146,800	160,000
Decrease of labour activity	1,200		300	3,000	4,500
Decrease of cattle numbers					-
Average cattle numbers	14		4	50	68

* Benefit: in terms of Net Value Added

Table 12.3-1(continued): Direct effects concerning agricultural production and livestock

Appraisal Criteria

From the quantitative assessment criteria shown in Table 12.3-1 it can be seen that:

- annual production losses related to the building works in zones A and B correspond approximately to the land acquisition cost if this is estimated at the present market price of the local agricultural lands;
- areas affected by drainage problems represent about 100 ha (zones B + C);
- annual production losses due to water stagnation are roughly equal to the production losses related to the building works in zones A and E, and
- the expected decrease in cattle numbers due to land losses and drainage problems represents about 57 head, implying more shortages of draft animals.

Table 12.3-2 gives a qualitative assessment for other direct and indirect impacts during and after building works.

If the protection test is a real success, the erosion process will be stopped and the impact of such a structure will be very positive; but this event is not a certainty. Taking into account other effects related to the agricultural environment it can be seen that most of the local impacts are negative but concern very small areas.

Other very important factors for improving the agricultural situation are not directly dependent on bankline protection, such as:

- a strong decrease of population growth with regard to a possible increase of agricultural production;
- a farm saving and investment capacity;
- a sufficient job opportunity in the non-agricultural sectors;
- socio-economic inequalities, and

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- lack of solidarity and self promoted and self managed organizations at grass root level.

In years of heavy rains, water stays for weeks behind some of the road embankments and causes damage to various crops; T.aman is submerged and damaged, jute production is affected both quantitatively and qualitatively and due to early monsoon rains. Aus crops are damaged too.

Production of pulses and oilseeds, especially mustard also suffer as a result of localized delayed drainage. In addition, the availability of cattle feeds, particularly green feedstuffs are decreasing significantly due to the reduction of fallow lands and change in cropping patterns. This decrease implies a significant decrease in cattle numbers too. Available information indicates that parasitic diseases are also increasing.

The project will have a positive impact on creating temporary additional employment in the construction of the test structures. It is not possible to estimate what proportion of this additional employment will come from socio-economic groups in the Project area or which may generate labour availability problems for agricultural activities.

12.3.3 Other Socio-economic Impacts

Apart from the impacts on settlement areas and on agricultural activities, the other socio-economic impacts (direct and indirect) have been assessed on the basis of the benchmark technical data of the planned test-structure on the one hand, and according to the predicted evolution of the bankline on the other hand. In the same way as for the FAP 22 assessment a qualitative approach has been applied considering the following seven main aspects: demography, socio-cultural changes, social equality, social cohesion, lifestyle conditions, resettlement issues, land acquisition and compensation issues. For each main aspect a number of criteria or matters have been considered (Table 12.3-3 below). These may be a quantitative variable, a qualitative characteristic or a trend. The rating system utilized for this qualitative assessment has been simplified, compared to one in the FAP 22 assessment, as indicated below:

- -	:	very negative impact;
-	:	minor negative impact;
N	:	neutral impact;
+	:	minor positive impact, and
++	:	very positive impact.

Criterion rates are not subject to be added up.

Effects	Assessment Criteria	Qualitative Assessment	
		During Const.	After Const.
A. Direct			
Agricultural temporary worker	Work employment	-	+
Agricultural wages	Seasonal fluctuations disturbing agricultural economy	- -	N
Landless population	Resettlement problem	-	+
Transport of agricultural input and output	Disturbing degree	- -	N
Erosion	Trend	N	+ +
Divastating flooding	Protection degree	N	N
Water stagnation/under water (zone D)	Drainage problem/submersion	N	N
Sand deposition (zone D)	Sand deposition problems	+ +	+ +
Agricultural activities (zone A)	Production, employment, livestock	N	N
Agricultural activities (zone B)	Production, employment, livestock	N	N
Agricultural activities (zone C)	Production, employment, livestock	N	N
Agricultural activities (zone D)	Production, employment, livestock	N	+ or N
B. Indirect			
Farm saving and investment capacity			
- Site lands	Improvement in future	N	N
- Other lands	Improvement in future	N	+ +
Socio-economic inequalities	Trend	-	N
Land production value			
- Site lands	Disparity	-	N
- Other lands	Disparity	N	+
Flood protection and drainage	Improvement in future	N	+ +

Table 12.3-2: Impact assessment of agricultural activities

	Construction Phase	After Project
Demography		
- Population density (locally inside mauza)	- -	N
- Out-migration	N	N
Socio-cultural Changes[1]		
- Destructuration of values at household and social categories level	- -	N
- Women's condition	-	N
Social Equality[2]		
- Landless mitigation	N	+
- Employment (250 workers per day during construction phase)	+ +	N
- Impacts on different socio-economic categories		
. Landholders	N	+
. Craftsmen	+ +	-
. Traders/merchants	+ +	-
. Local leaders/politicians/elders/elites	+ +	-
- Income distribution	-	N
Social Cohesion[2]		
- Socio-political disrupting effects (conflicts, loss of social consensus, political advantage etc.)	-	-
- Ideological risks	-	-
Life Style Conditions[3]		
- Flood proofing facilities and shelter possibilities (landless displacees)	-	+
- Water supply (work camp and organization)	+	+
- Diseases, unhygienic conditions and pollution	- -	-
- Increase of consumer prices	- -	N
Resettlement Issues		
- Dimensional aspects (5 households)[4]	-	N[6]
- Organizational aspects (local conditions)[5]	-	
- Other lands (out of acquisitions)	N	+ +
Land Acquisition and Compensation		
- Dimensional aspects (6 ha; 24 households concerned)[4]	-	N[6]
- Organizational aspects (local condition)[5]	-	

Table 12.3-3: Assessment matrix of the socio-economic impacts (agricultural activities and agro-economic aspects not included)

Notes:

(1) **Socio-cultural changes**

. Destructuration of values at households and social category level correspond to the psycho-sociological disrupting effects of, all together, new technological references and equipment, value inputs of outside workers and technicians, sudden monetarization of the space, and increase of food and various services demand at local level, meddling of new leaderships and force intercourse, etc.

- Woman's condition: in the best case poor women will have to work physically as men; otherwise involvement of local men, and behaviour of newcomers as well, will both overload women's responsibility and works at homestead and agriculture level, and in the whole will maintain and even increase men domination. On the other hand destruction of local values will not lead to a better consideration of women among other, the gap between actual sexual intercourse "demand" from concentrated male workers and the socially authorized "supply" from women will grow hallow, increasing the woman image of a forbidden and unresponsible consumer object.

(2) **Social inequality and social cohesion**

- Actual landless should be offered employment at better quality conditions during the 8 months of the construction phase and can develop small trade. After project their condition would come back to the prevailing situation in the best case (they could have had lost their previous local patron-servants relationship). Some poor farmers will be attracted by the short term cash earning opportunity of the construction phase: this will be to the detriment of their agricultural activities and could have negative side effects after the construction phase (land transaction, disinterest of agricultural activities for the youth etc...).
- Actual traders and craftsmen will get sudden but short business and work opportunities.
- Local leaders, elders and elites could strengthen their reputation during the construction phase, but on the other hand many kinds of promises and dreams will be extinguished after project due to its limited effects (size and subject matter) vis-a-vis riverbank erosion problems, and mostly underdevelopment overall problems.
  In the whole income distribution will not be improved neither in the short term nor in a longer term, what is well known as a matter of fact is that socio-economic benefits of structural projects are usually and "naturally" intercepted by local leaders, notabilities, elites and well-to-do people if in parallel any voluntary, and adapted social and policy measures are not programmed.
  Disrupting effects in term of social cohesion and ideological risks (extremist and totalitarian attitudes) will be in fact consequences of both the socio-cultural changes and the increase of social inequality, and the additional tension between social categories.

(3) **Lifestyle conditions**

- Diseases and unhygienic conditions will be provoked by the human concentration on the building site and camp, contacts with newcomers (contaminations from outside) promiscuity, the works themselves. Increase of consumer prices will be also an effect of the economic impacts of the construction phase (monetarization and sudden growth of the demand for basic goods and services), it will have also remaining unfortunate side effects after project.

(4) **According to the predicted future bankline**

- Dimensional aspects of land acquisition: 17 landholdings concerned and 24 households, taking into account the in-division local rate. Out of these 17 landholdings affected around 30% would loss all their estate.

(5) See detail explanation para 12.4.1 below.

(6) The acquisition lands are considered as going to be destroyed by the Jamuna in a near future.

The same warnings as for the FAP 22 assessment should be given. However, although noticeable inaccuracies and uncertainties[1)] remain for the project design and its - in fact - pre-impact assessment, the scale of the study is quite different and leads to more tangible data and phenomena as they are localized at grass roots level. The fundamental objective of this rapid pre-impact approach was truly to tackle these dimensions both through actual contents and methodological aspects. Lastly it should be noticed that the qualitative approach presented in this section is also designed to avoid as much as possible any preconceptions, through the "weak" and false concepts of negative and positive impacts, as is too often the case: indeed an effect can be considered either positive or negative, it is a question of point of view and of sociological category and actor concerned.

The results of this qualitative assessment are summarized in Table 12.3-3, distinguishing the construction phase and the after-project situation. Comments and explanations are given after, in the form of concise notes.

12.4 COMPENSATORY AND MITIGATION MEASURES

12.4.1 Land Acquisition and Compensation Procedure

Land likely to be located in the construction area is all private. As occupation of the land by the test structure is supposed to last several tens of years, it will have to be acquired and will vest in public domain as foreseen by the land laws currently in force (see Section 4.1 Part A). Private land ownership in Bangladesh is normally well defined, as systematic cadastral surveys were carried on up to the 1940, and for each mauza a cadastral map was established. In the site area landowners were given land titles in 1940 and then again in 1956. Later land transactions have been systematically registered at the level of the Sub Registrar's Office of the Thana and also Tohsil Office. Social issues and alterations like fragmentation between heirs, in-division and conflictual old mortgages, were not of course always recorded at the level of the Sub-Registrar's Office, whose duty is to record

1) In particular in the case of Bahadurabad site.

"who sold to whom, with plot number, valuation and location". These are not also always recorded in Tohsil Office.

The sample survey of landholders and plots held in the gross site area (Subsection 12.2.3 above) gives an example of the order of magnitude of land fragmentation, and of the difference between the concept of landownership and landholding (in-division, mortgage, to what sharecropping system has to be added).

Nevertheless while the laws, their application and resort institutions are restricted in the face of current social practices, an un-institutionalized social system has been controlling and regulating land tenancy strongly for generations. Could it be different in a country in which access to land is so difficult now and structures vital strategies. The quick survey well proved, if it was necessary, that in the countryside everybody in the neighbourhood knows who owns what plot, who holds it, who is working it. This is typical of traditional peasantries and is based on inter-acquaintance between social groups at grass root level with their collective memory and customary arbitration system. From these considerations and the short analysis of the social structures above (subsections 12.2.2; 12.2.3 and 12.2.4), it seems obvious that the land acquisition and compensation procedure should lean on both the modern laws and institutions, as general criteria to be followed, and on the actual informal but efficient regulations and social arbitration system (see for the record Fig. 12.2-1, Subsection 12.2.4). These aspects were discussed positively in an open way during field trips, with the board of the Union Council and some elders. The procedure should be based on:

(i) detailed landholding and landownership inventory during the detailed design phase, with rapid updating and adjustment after monsoon at the start of the works;

(ii) negotiation of the type of compensation requested depending on the different situations and individual projects of the affected people, and compensation procedure, and

(iii) overall control, arbitration and follow-up by a local land compensation committee.

Detailed surveys are defined a little more precisely in Section 14.3 below, land values and valuations issues have already been discussed above (Subsection 12.2.6). Affected farmers could be gathered into the following three main categories:

a) Those who will lose only a part of their estate and who, willing to remain farmers where they are, will have to be compensated, so that their agricultural income could be maintained. Compensation should allow the purchase of new land, or cattle, or any intensification measure that will lead to the previous agricultural income level.

b) For those who will lose all their land and who will ask to remain farmers, a true individual development project should be provided for them, including funds for purchase of land (where available and considering productivity ratios for compensation; see Subsection 12.2.6) and technical support (some technical support, training if needed, and of course credit facilities for the implementation of

a new farm and sometimes farming system).

c) Those who will plan to migrate to towns and toward non-agricultural activities: In that case individual reinstallation projects should be followed up and supported by the project with compensation estimated, so that the capital of the new activity will allow the previous level of income. Additional credit facilities could also be foreseen in that case.

At this stage detailed costing of these procedures is neither possible nor necessary. For the purpose of project pre-budgeting the market cost of the best land in the mainland should be taken as envelope estimate for the land compensation programme.

As discussed and agreed at local level the basic framework of the compensation committee would be as follows in terms of membership:

- the Union Council Chairman, its Secretary and a **Tohsilder** (land record keeper);
- the elected members and nominated women;
- the head-elders of the area-samajes concerned;
- a representative of the Additional Deputy Commissioner of Gaibandha, and
- two representatives of the project authority (one Technical Officer and one expert Socio-economist).

The roles of the compensation committee will be to facilitate, to control, to make arbitration (if necessary), and to follow-up every step of the land acquisition and compensation procedure, as summarized above. If needed, or even useful, the compensation committee could invite as expert or adviser any competent person of the resort in a position to highlight or help the procedure (paras elders, wise notabilities or elites etc.).

12.4.2 Resettlement Issues

The limited order of magnitude and the nature of the resettlement issues for the Kamarjani site have been defined above (Subsection 12.3.1). Due to its minor aspect, resettlement should not demand a specific formal and organized procedure and plan, as would be the case of Bahadurabad site. The land compensation committee should just take care of its own organization at the level of the few people concerned, and control and follow up compensation for household reinstallation and homestead re-structuring. Anyhow, displaced people will also lose some agricultural land, at least some of them.

The committee should thus be designated as a Land Compensation and Resettlement Committee (LCRC). Resettlement costs if self-managed by people should cover:

- the actual cost of the area occupied by the homestead (substitution value at market cost upon the real location of resettlement);

- the cost of shifting re-usable building materials and household assets;[1)]
- the cost of new materials to be purchased (if any) for maintaining the same standard of housing, and
- a lump sum for the additional labour the family will have to provide for resettlement (on the basis of number of men x days needed and actual local daily labour wage, on average).

Table 12.4-1 below gives average rates of house costs (in the case of new construction) from FAP 3 source.

Type	Size	Cost (in Taka)
1. Straw roof, jute stick walls, mud floor	9' x 12'	2,500
2. Straw roof, bamboo-strip walls, mud floor	9' x 12'	3,500
3. Corrugated tin roof, jute stick walls, mud floor + (some wood)	9' x 12'	6,000
4. Corrugated tin-roof, bamboo strip walls, mud floor + (some wood)	9' x 12'	7,500-8,000
5. C.I. sheet tin and walls + (some wood)	9' x 12'	12,000
6. C.I. sheet roof bamboo strip walls, mud floor + (some wood)	21' x 12'	15,000
7. C.I. sheet roof, C.I. wall, mud floor + (some wood)	21' x 12'	25,000

(Source: FAP 3)

Table 12.4-1: Average rates of house costs (new construction)

1) Trees, bamboos and any valuable goods or item in the homestead will be collected by the household before shifting.

At this stage, considering rough averages of every type of homestead included, the following ratios and estimates can be considered:

. average gross area per homestead	:	200 sq.m
. average number of houses per household	:	1.5
. average house type distribution (Table 12.4-1 above)	:	types 1 and 2 : 80%; types 3, 4 and 5: 20%
. average cost of materials per house	:	3400 Tk
. Lump sum for manpower needed for reinstallation (20 days x 25 Tk/day)	:	500 Tk
. cost of homestead land (200 sq.m x 12 Tk/sq.m)	:	2400 Tk

From these assumptions the very rough average cost of resettlement of one household can be estimated as follows: 2400 x 50% x 1.5 + 500 + 200 ≃ **5500 Tk**.

12.4.3 Technological Aspects and Agricultural Development Measures

The soils of the investigation area, to the west of the road embankment, are fertile and suitable for growing most crops. With provision of drainage and irrigation it is possible to diversify and intensify the local agricultural production in order to reduce land value disparities and increase farm incomes.

To drain flood water and internal surface runoff during the monsoon, canals/channels and regulation equipment through embankments should be developed into an efficient drainage system.

In the framework of a diversification and intensification programme:

- a high biomass yielding forage crop should be cultivated on the slopes of embankments and roadsides in order to produce green feedstuff and also reduce soil erosion;
- pulses and oilseeds and fruit trees may be encouraged for improving the nutritional status of the people, providing nutritious cattle feed and increasing farm incomes, and
- an irrigation programme should be encouraged in order to reduce possible water deficits during the dry season.

This programme including a balanced used of fertilizers would help to increase crop yields and compensate for land losses.

Compensatory Measures for Agricultural Development

In order to bring these technological measures to a successful conclusion it seems necessary to strengthen the veterinary and agricultural supporting services programme of public development operations.

Such a development programme should be made to provide the agricultural inputs necessary to increase crop yields and also provide routine vaccination and mass anthelmintic doses in the project area to protect animals against prevalent infections and parasitic diseases.

In addition to these measures it is suggested that a financial assistance programme integrate both credit facilities and saving incentives at the farm level, maybe through small voluntary groups and a popular and mutual credit system.

Cooperation, saving and money to invest seem to be factors through which farmers working co-operatively will improve water management and other cultural practices on the basis of their own knowledge and determination. These factors are at the basis of every real socio-economic development including good bank protection maintenance and efficient management of the compensatory measures.

12.4.4 Other Socio-economic and Organizational Measures

Apart from the agricultural development compensatory measures at grass root level, and the specific reinstallation project for the affected farmers, as defined above, the following should be considered as general compensatory and mitigation measures against the negative qualitative and structural impacts identified before (Assessment matrix, Table 12.3-1).

(i) Planning and organization of the work camp for external workers and staff, with establishment of a permanent infirmary with a permanent qualified nurse, a well-furnished drugstore and an ambulance for evacuation toward regional hospitals, in case of serious disease or accident. These health facilities will have to be reserved for the project workers (day labourers included), but the drugstore could deliver drugs and medicines to the local population at cost rates. In addition, one physician should pay a visit to the camp and inspect the working and living conditions every month at least. Attention should also be paid to possible forthcoming pollution problems.

(ii) During the construction phase the Project Authority and Management should also try to optimize the utilization of local handicraft and other services potential. After completion of the works, possibilities of re-utilization of some works infrastructure (like buildings, roads, water supply etc.) by the local population and authorities should also be considered.

(iii) In terms of socio-cultural changes, social inequality and social cohesion, most of the direct and indirect impacts of the project cannot be really mitigated at the level of this pilot Project and its subject matter. An open and efficient information and communication system with the local population and its representatives will anyhow be useful.

(iv) As an obvious matter, jobless people must be awarded priority with regard to

access to employment by the Project. Helpless or poor women could be offered adapted tasks, and possible direct or indirect bad effects of the project on women and children will have to be monitored.

(v) With regard to after-project issues, and considering future unemployment and poverty and social inequality problems, the following ways could be investigated:

- investigation of public and private investment for further rural employment opportunities, after the works (problem of identifying micro-projects and actors outside agricultural activities);
- promotion of Mutual Solidarity Organizations for a savings - credit system, self-initiated and managed by members themselves, and
- technical training opportunities for young men during of the construction period (mechanics, electrician etc.).

(vi) Lastly, in terms of organizational and institutional measures, a precise and strong organization and monitoring pattern should be studied during the detailed design phase. In the meantime it will be of paramount importance to launch an open information campaign on the Project, its direct and indirect goals, constraint and risks. Such a campaign should involve the participation and taking of responsibility by local authorities.

Actual involvement of institutions like BWDB and BIWTA at regional and local level, during the construction phase and after, will have to be defined. Possible strengthening and participation of LGEB should also be considered.

13 BAHADURABAD SITE

13.1 BENCHMARK TECHNICAL DATA OF THE BAHADURABAD TEST STRUCTURE

The implementation of the test structures at Bahadurabad is planned for the dry season 1994/95 i.e. in two years from now. Hence, the planning of the alternatives for that site is still less detailed than the planning for the Kamarjani site.

The three main construction components of a revetment are as follows:

- the cover layer,
- the filter layer and
- the toe protection.

After carefully sorting out all construction methods and materials that are not appropriate for becoming potential standard solutions on the Jamuna because they are either technically unsuited to the requirements, or they involve too demanding construction techniques or too expensive materials that could be replaced by cheaper/local ones, the following alternative designs are under closer consideration to be applied to the test

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structures:

1. Cover Layer

a) above low water level/ground water level

. various kinds of wire mesh rip-rap
. concrete blocks, regularly placed
. open stone asphalt
. wire mesh gabions

b) below low water level/ground water level

. various types of rip-rap
. concrete blocks, randomly placed
. cable connected blocks
. blocks connected to geotextile
. geotextile bags
. tubular fabrics filled with sand/lean sand asphalt
. wire mesh mattresses filled with stones/boulders

2. Filter Layer

a) above low water level/ground water level

. various types of filter

b) below low water level/ground water level

. various kinds of geotextile filter

3. Toe Protection

. boulders
. CC blocks (cement concrete)
. chemically bonded sand blocks (Chinese system)
. geotextile bags, partially filled with sand
. cable connected blocks as extension of revetment
. tubular fabrics filled with sand or lean sand asphalt as extension of revetment
. wire mesh mattresses filled with stones/bricks
. scour prevention mat.

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A very important detail to be investigated, is the level and the dimensions of the falling apron, which is one of the decisive components for the overall safety of bank protection. Some additional model tests are therefore envisaged in that field.

A preliminary choice of the alternatives as well as the design of the test structure is proposed in the Final Report.

The layout of the test structure is shown in Fig. 13.1-1.

13.2 PRESENT SITUATION OF THE STUDY AREA

13.2.1 Administrative Set-up and Population

The proposed Bahadurabad site, as shown in Fig. 13.1-1 and in Fig. 13.2-1, is located in the western part of Belgacha mauza in Belgacha Union (Islampur Thana and Jamalpur Zila).

River erosion has increased its intensity over the last three years (see Subsection 13.2.6 below), bringing thousands of landless refugees according to elders of north-western Belgacha. Most of these refugees came from Char Belgacha and Shindurtali mauzas that have almost disappeared. Recently river bank erosion has begun to encroach the western part of Belgacha mauza, threatening the north-south firth strip of settlements.

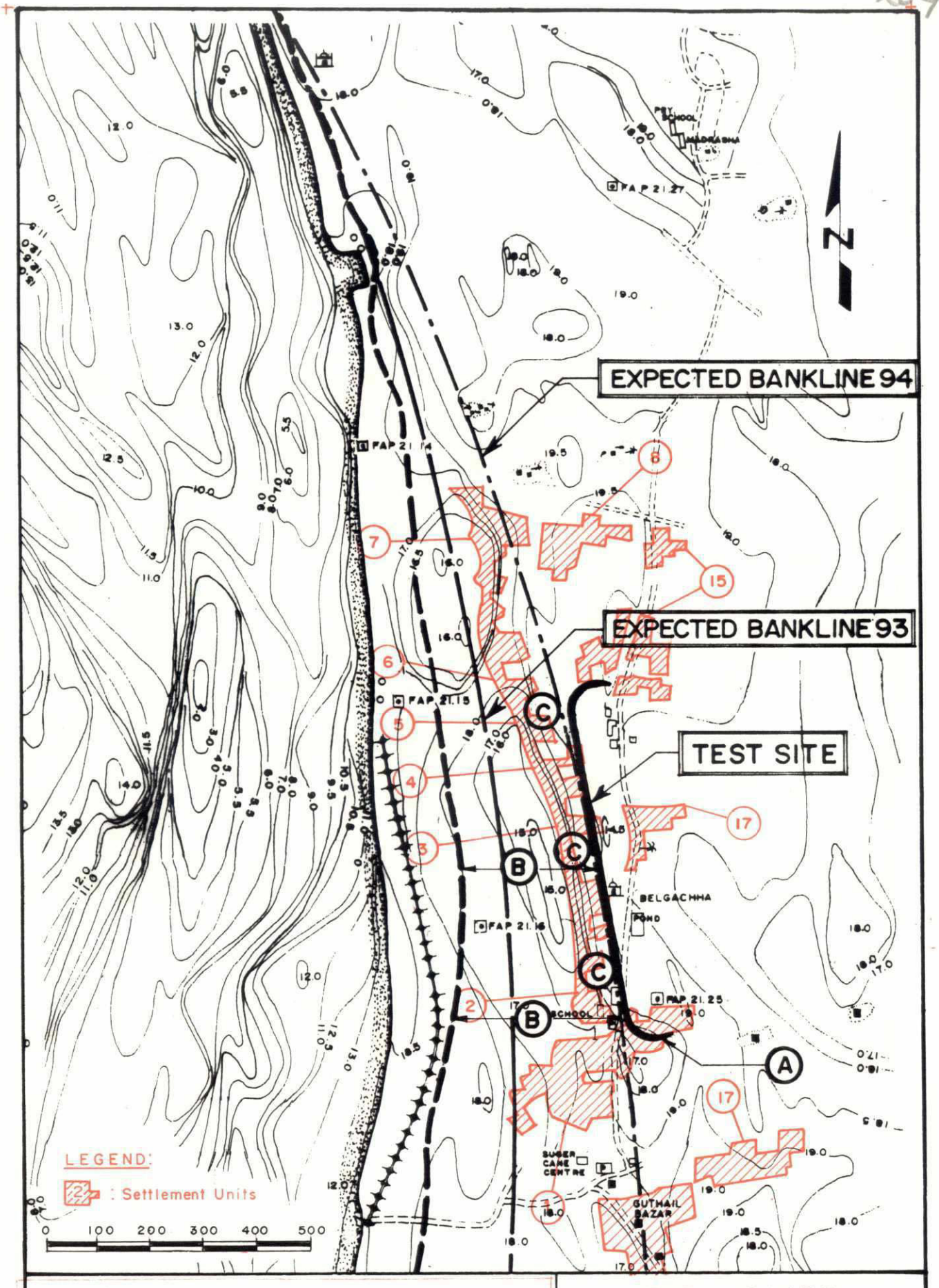
According to 1981 census data the population of Belgacha mauza is 5,670 inhabitants for 1,101 households (5.15 persons in average per household). Reliable estimates for 1991 were not found at Belgacha Union Office. Only very rough estimates were around 12,000 inhabitants in total, out of which 8,000 would appear be originally from Belgacha and 4,000 refugees.

The estimate of 8,000 original inhabitants seems high and would mean an average annual growth of 3.5%. On the basis of an average natural growth rate of even 2.2% there would be around 7,000 original inhabitants plus the refugee population. Anyhow it is an obviousness to state that in a few years the Belgacha population has increased by over 70%, due to in-migration that has provoked a major upheaval, socially, economically and politically.

13.2.2 Social Structures and Categories

In the following section the same concepts and definitions as for the Kamarjani site are utilized, with explanations of differences whenever needed. Only the concerned envelope area of western Belgacha has been studied due to time limitations and the large size of this mauza.

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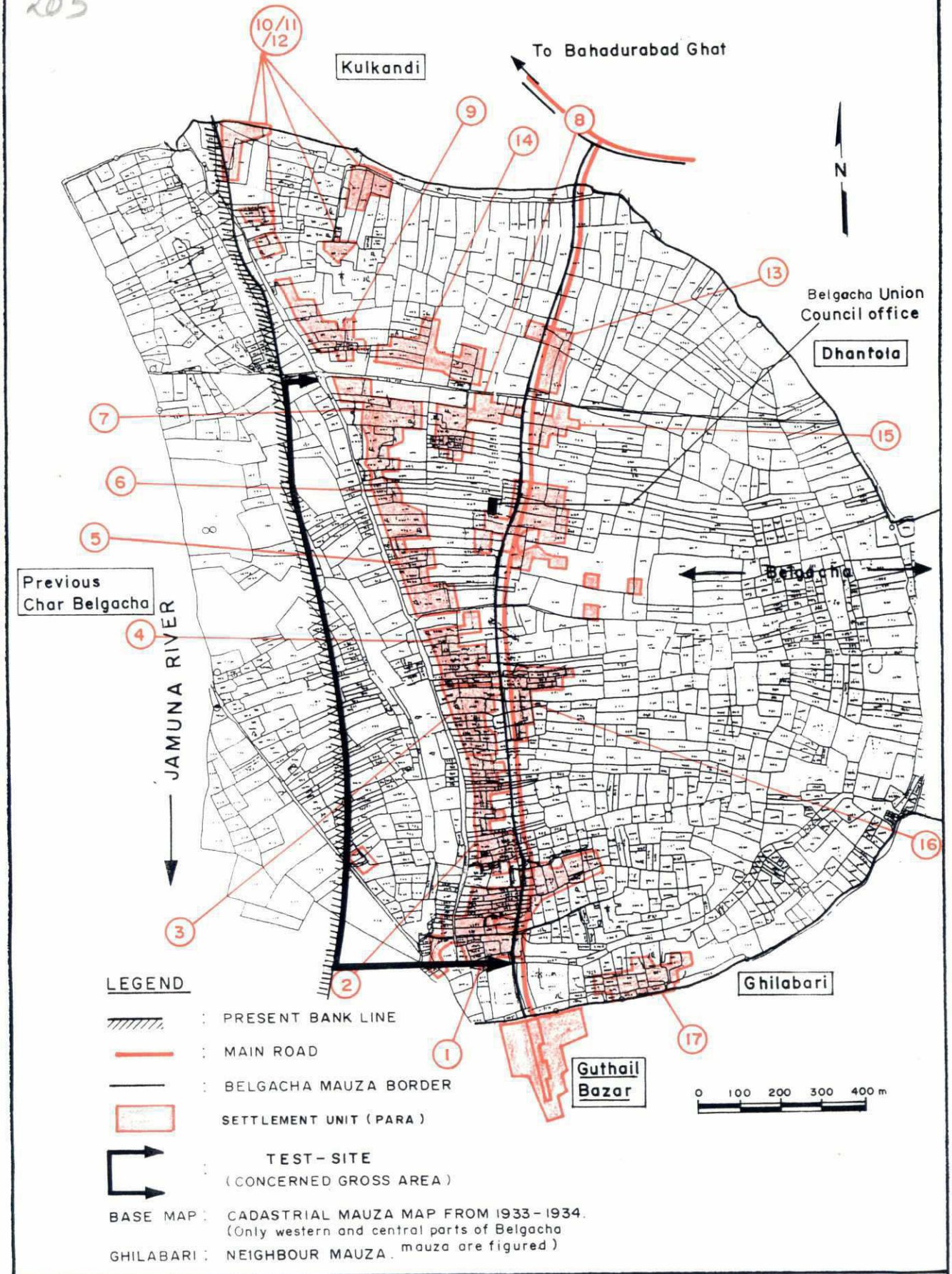


BAHADURABAD TEST SITE
GENERAL LAYOUT INCLUDING
AFFECTED AGRICULTURAL AREA (A – C)
SETTLEMENT UNITS (1 – 17)

FAP – 21/22
BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT | FIG. 13.1 – 1

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ADMINISTRATIVE AND SETTLEMENT ENVIRONMENT OF THE BELGACHA TEST SITE

FAP - 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

FINAL REPORT | FIG. 13.2-1

Households; Families and Homesteads

One **para** is just at the ridge of the present bank line. It corresponded to a single household para which shifted into the inner mainland on the day of the last mission field trip. The hypothetical eastern limit of the gross site area corresponds to the western limit of a quasi-continuous settlement strip. It was not possible to proceed with a survey of the households/ homesteads composing the paras of this settlement strip as done for the Kamarjani site. A rapid **para** inventory of western Belgacha revealed the fragmentation of this settlement strip into 7 **paras** or settlement units totalling some **481 households** (2,400 persons on the basis of 5 persons per household). In total the rapid para inventory of western Belgacha covered 17 paras or settlement units (Table 13.2-1 below) accounting altogether for 1,045 households (very roughly 47.5% of the total number of households in Belgacha on the hypothetical basis of 11,000 inhabitants and 5 persons on average per household in 1991).

Sociological Category / Serial No.of paras surveyed	Sharkar	Bepari	Akondo	Pro-dhan	Mon-dole	Dewan	Khan	Miah	Sheikh	Dash	Total	No.of Landless
1 (Sharkar bari)	47	14	15						14		90	25
2									100		100	90
3		5	11						24		40	11
4	40			15					75		130	55
5	5		22						9		36	7
6 (Mondole bari)	26				12				4		42	11
7 (Miah bari)								23	12	8	43	20
8								9	-		9	-
9		45							5		50	35
10		4	4						72		80	42
11		5				19	13		15		52	20
12									13		13	9
13					1				26		27	20
14				10				10	30		50	37
15	15		15						78		108	73
16 (Ghona para)	25		12						83	5	125	73
17 (Majipara)					10				25	15	50	25
Total No.	158	73	79	25	23	19	13	42	585	28	1045	549
%	15	7	8	2	2	2	1	4	56	3	100	52
Type of socio-logical category	HOG /L	HOG	L	L	L	L	L	L	L	C		

Notes: HOG = Historical occupational group (may be a common family name now)
L = Lineage name
C = Caste (Hindus), sub-castes represented.

Table 13.2-1: Number of households per sociological category and per para - Western Belgacha - 17 paras surveyed

Table 13.2-1 above shows that almost all the paras or the settlement units surveyed comprise a certain percentage of landless refugees. In contrast to Analerchara, landless have been given shelters here inside or between the traditional para areas. Shelters were given on plots owned by local notabilities or in the framework of particular solidarity relationships between landholders and landless, inside a same lineage or traditional occupational group.

Occupational Groups, Castes and Lineages

On the basis of the same concept approach as for the Kamarjani site, seventeen settlement units in western Belgacha were rapidly surveyed. The sociological categories identified per para are given in Table 13.2-1 below. The structure appears quite different from Analerchara and Dhutichara mauzas (Table 12.2-1 above) with the extended lineage **Sheikh** as the most important category (56% of the households surveyed). In second position the **Sharkar** represent 15% of the 1,045 households of the 17 settlement units surveyed, whereas the **Bepari** account for only 7%. The other categories are other lineages or Hindu castes, and are in the minority, ranging from 1% to 8% of the total number of households.

Present Economic Activities

In the 17 paras surveyed the above-mentioned sociological categories were compared with the present economic situation and occupations. Results are given in Table 13.2-2 below.

	Main Present Occupation						Total	
Sociological Category	Daily lab. (landless)	Service holder	Business -man	Fisherman	Cobbler	Farmer	No.	%
Sharkar	7	2	-	-	-	149	158	15
Bepari	46	-	4	-	-	23	73	7
Akondo	24	-	-	10	-	45	79	8
Prodhan	7	-	-	-	-	18	25	2
Mondole	4	-	-	-	-	19	23	2
Dewani	4	1	-	-	-	14	19	2
Khan	9	-	-	-	-	4	13	1
Miah	-	-	-	-	-	42	42	4
Sheikh	448	-	-	-	-	137	585	56
Dash	-	3	5	15	5	-	28	3
Total No.	549	6	9	25	5	451	1045	100
%	52	1	1	2	1	43	100	

Table 13.2-2: Structural Sociological categories and present main occupations western-Belgacha - 17 paras

The most salient characteristics that can be noticed are:

(i) 82% of the landless are **Sheikh**, whereas this lineage represents 56% of the surveyed households. Factual sociological or geographical explanations could not be found at this stage.

(ii) 33% of the landholders are **Sharkar**, whereas they represent 15% of the total number of households.

(iii) 5% only of **Beparis** are businessmen or merchants in the surveyed area, 63% being landless and 32% landholders.

(iv) 100% of **Miah** households are landholders.

13.2.3 Land Holding Distribution and Land Tenure

The local classification of farm sizes as discussed with elders of the south-western part of Belgacha mauza is based upon 4 main categories (against 3 categories for the Kamarjani site); these are:

- small farmers : less than 5 bighas
- lower medium farmers : from 5 to 10 bighas
- medium large farmers : from 10 to 50 bighas
- high large farmers : over 50 bighas

Thus it appears that there are some larger landholders in the case of Belgacha mauza. Unfortunately, due to time limitations and the number of settlements just next to the gross site area, it was not possible at this stage to conduct any landowner inventory, even in a part of the gross site area. Only from field discussions with landholders from the south-western part of Belgacha, and on the basis of a "sample" of 280 farmers, could the following very rough estimates in term of landholding distribution be obtained:

	No.	%	Farm size (hectares)
small farmers	150	53	less than 0.66 ha
lower medium farmers	100	36	0.66 - 1.35 ha
medium large farmers	25	9	1.35 - 6.75 ha
high large farmers	5	2	over 6.75 ha
Total	280	100	

Although the above indicators do not from a rigorous statistical approach, they nevertheless demonstrate what the local "public opinion" thinks of this matter, which is interesting anyhow.

Provided these figures reflect social reality, they are completely comparable to the ones for the gross site area of Kamarjani in terms of percentage of landholding distribution. The difference consists in the existence of a larger category of small landlords.

Without any sample plot survey in the gross site area it was not possible to get an idea of the specific situation of farm fragmentation. In the 1933-1934 cadastral mauza map the corresponding present gross site area contained roughly a hundred plots, **khass** land of the Virbiri beel not included. During field discussions people stated that 60 years ago the beel was deeper. For several years this beel has been getting more shallow through sedimentation and "land hunger"; means that people are now encroaching the beel, appropriating this **khass** land, and expecting a possible **boro** within three months for the first time. This eagerness to gain some new croppable land is in spite of the fact that this area is highly threatened by river erosion and the bankline is drawing nearer year by year.

On the basis of the same ratios and trends, as for the gross site area of Kamarjani, a very rough estimate for the Belgacha gross site area as defined above would be at present about 34 ha, 220 plots (beel not included) and a hundred farmers concerned.

13.2.4 Local Institutions, Public Services and On-going Social Programmes

Socio-political Organization at Grass Root Level

Belgacha Union is administratively composed of 9 mauzas out of which the four western ones have mostly disappeared due to river erosion, or have been highly fragmented into more or less sandy island chars.

Some group discussions were conducted that focussed on the traditional elders and samaj system (see Subsection 12.2.5 above) on the one hand, and on the roles of the elected Union members on the other hand.

Three elected members of the Belgacha Union Council including the Chairman are from Belgacha mauza, which underlines the particular political weight of this mauza inside the Belgacha Union. It was not possible to identify the weight and role of different political parties. Elected members and the Chairman (newly elected and only 30 years old) just mentioned that they are independent.

In fact the relationship between elected members on the one hand and the traditional elders or mattbars on the other is not very positive. There are two main rival political groups, one headed by the present Chairman of the Union Council and his elder brother, the other by two elders and their gusthi. The two groups often take diametrically opposite stands on almost every issue, which is worth keeping in mind for possible implementation of the foreseen test-structure in this site.

The structural sociological conflict between these two groups was revealed during the last field visit when looking into the area-samaj system of Belgacha mauza. As a matter of fact two patterns were presented by the persons we were talking with. These two sociological "versions" are summarized and illustrated in figures hereafter.

According to the two sources of information and socio-political clans the area-samajes were identified as follows:

According to the elected members group

Name/serial No. of the samajs	Position of the head-elder of the samaj	Position of the assistant head-elder (when quoted)
1. Uttar Para	Elder, ex-chairman	-
2. Maddha Para	Elected member	1 elder
3. Dakkin Para	Elder (Doctor notability)	-
4. (No name)	Elected member	1 elder
5. -	Present UC Chairman	1 elder (elder brother of the Chairman)
6. -	Elder (ex-elected member)	1 elder
7. -	Elder	-

According to the elders opposition group

1. Uttar Para	Elder, ex-Chairman
2. Maddha Para	Elected member
3. Dakkin Para	Elder (Doctor notability)
4. Mondole Bari	Elder
5. Ghona Para	"
6. Bari Gram	"
7. Molla Para	"
8. Prodhan Para	"
9. Fakir Para	"

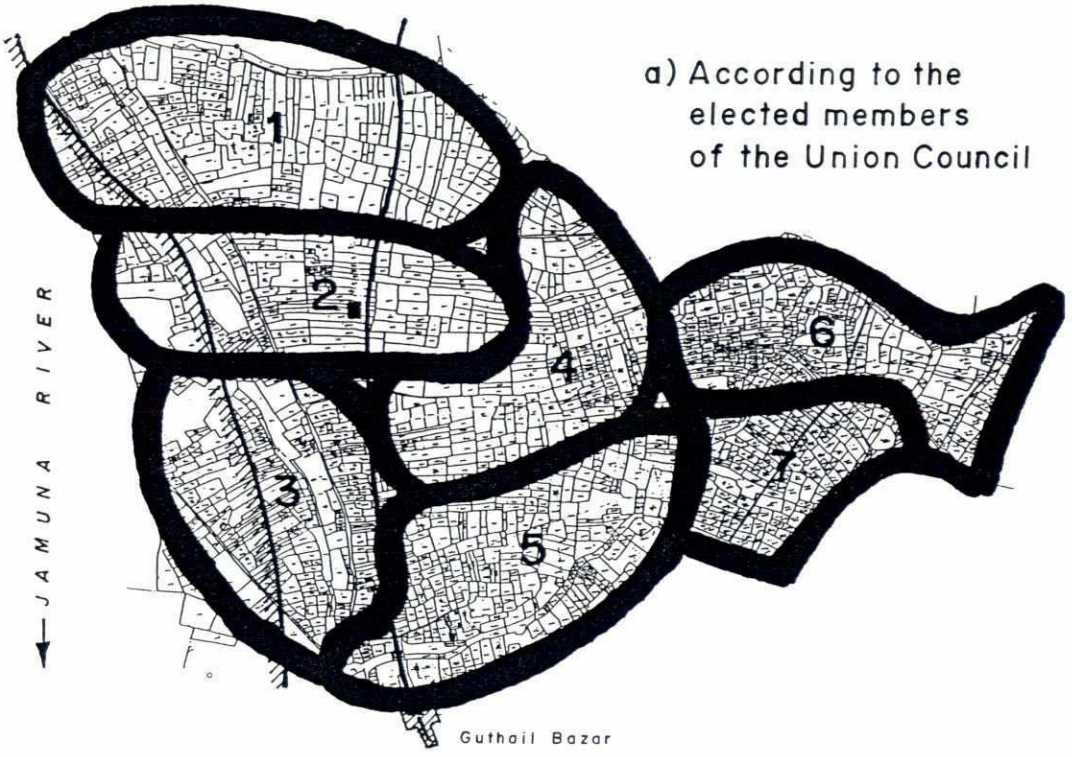
Without any additional analysis it may be noted that:

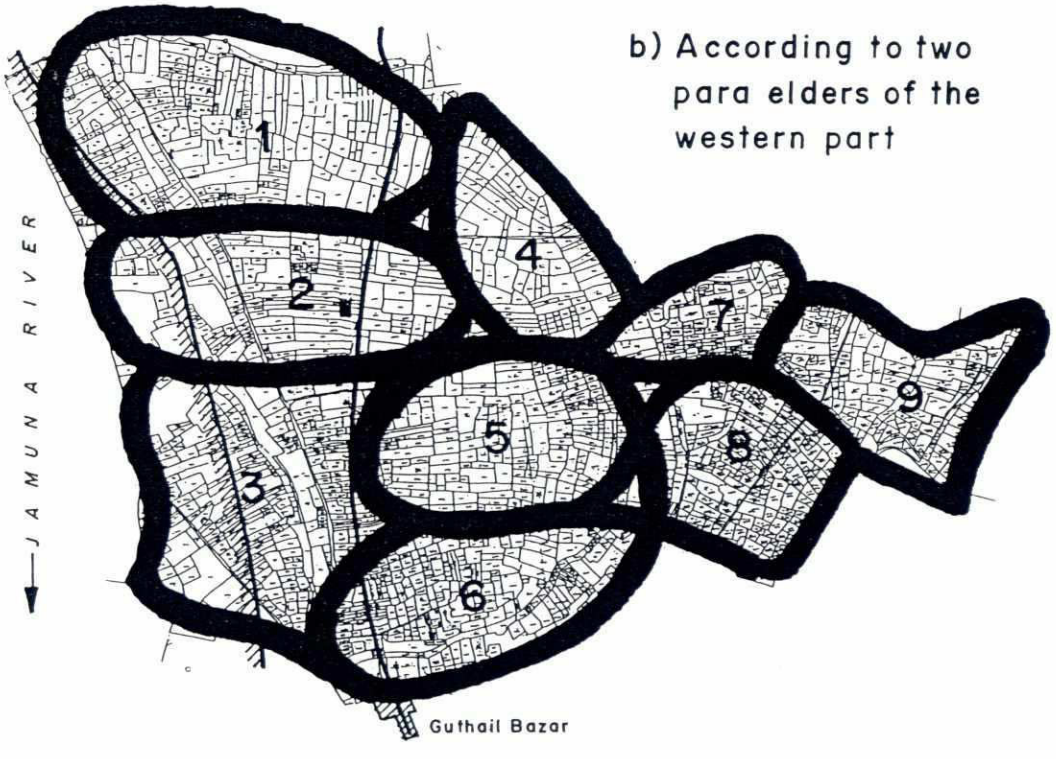
(i) In each case the three area-samajes correspond to what people used to call western Belgacha, of which the gross site area is part (Fig. 13.2-2). These 3 samajes are based on a division into three parts: western, middle and southern part. They are not subject to conflict between the two opposition groups due partly to the reputation of the three corresponding head-elders (or **matbars**) who are unanimously respected.

(ii) For the eastern part of Belgacha:

- definition of 4 samajes by Union Council members is made without any locality name but from names of "elders"
- definition of 6 samajes is based in each case on the name of one traditional **para** (hamlet by the opposition group) or **bari** (household) which thus constitutes the focal point of the area-samaj either historically or at present socio-politically.

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THE AREA – SAMAJ SYSTEM IN BELGACHA MAUZA

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Public Services and Cooperatives

The following socio-economic services were identified for Belgacha mauza.

	In Belgacha mauza	Elsewhere in the neighborhood
Kindergarten (1)	1	
Madrasa	>1	
Primary School	1	
Girls Secondary School	1	
Clinic (2)		1 at Guthail Bazar
Post Office	1	

Notes:

(1) the Kindergarten is financed by the Chairman of the Union Council

(2) see more details under "on-going social programmes"

Guthail Bazar is located at the southern border of Belgacha mauza. It is a relatively important market place (**hat**) with two particular market days, Friday and Monday.

As for the Kamarjani site there is no permanent **agricultural agent** at the level of Belgacha union. Some man-days are provided time by time from the **agriculture services** of Islampur thana. Technicians from the Dewanganj Sugar mill also come sometimes to evaluate the present or potential sugar cane production, quantitatively and qualitatively.

In respect of rural credit **Grameen Bank** maintains one Branch Office at Guthail Bazar. Its present action vis-a-vis landless refugees is explained hereafter.

There was previously an agricultural cooperative society in Belgacha. This cooperative was launched 5 years ago through a loan granted by the Dewanganj Sugar mill. It was composed of 69 members. Now this cooperative is stocked and actionless due to difficulties in recovering the loan from its members. During field discussion the main reason put forward was riverbank erosion. But sugar cane lands are located inside the main-land on better soils not threatened by river erosion for the moment. Here again it seems that riverbank erosion is quoted systematically as the multipurpose explanation for the hardness of the lifestyle and the lack of collective solidarity at grass root level.

Apart from that some farmers have formed informal "societies" (interest groups for irrigation purposes). In that respect four deep tubewells were in operation but now only one is still functioning (two were lost due to river erosion, one is out of order due to maintenance problems).

On-going Social-programmes

Initially, at the time of massive river bank erosion the Government extended help to erosion-effected destitute people by supplying them with 1 to 2 kg. of rice or wheat per person per month free of cost. This relief was distributed by the Union Council. Even this meager Government relief effort has been stopped.

At present several social assistance programmes are working with either NGO intervention or national institutions. Compared to the situation of Analerchara and Dhutichara (Kamarjani site) the aid supply is much more intensive here. The reason may be the particular attention paid to riverbank erosion in Bahadurabad ghat (railway-ghat) and around, that has developed a kind of geographical patronage from NGO's. In this way six on-going social programmes were identified in Belgacha mauza or in Belgacha union and are rapidly defined below.

The BRAC programme: BRAC (Bangladesh Rural Advancement Committee)[1] is developing a socio-economic programme in cooperation with the Relief and Rehabilitation Ministry, the World Food Programme (WFP) and the Directorate of Livestock Services of Ministry of Fisheries and Livestock Services. This programme concerns the two mauzas of Belgacha and Koulokandi (1 agent for each), and is extending credit for poultry farming for distressed mothers (269 land holders in total).

A combined health and family planning programme is being conducted by the Ministry of Health with support from the NGO Path Finder (6 trained female agents in total for Belgacha union). Main actions are care to children and mothers and contraceptive pill supply (subsidized price: 2 takas each packet).

The Action Aid Programme is structured from a permanent office with two assigned agents at Belgacha union level. It is targeted toward a combined savings credit system[2] comprising two phases: first a 15 week registration phase of **shomitis** (20 people per shomiti) with scheduled weekly savings, then an in-succession loan phase of 43 weeks. The target group is the poor. There are actually 9 unregistered women's shomities recently found in Belgacha mauza.

Another distressed mothers programme is also being developed by CARE (90% of financing) and the Union Council it self.

The Ministry of Social Welfare (Samaj Kollyan) has one building near the Union Council Office and is also supposed to implement social actions but no more factual information could be obtained about it.

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1) Including USA and UK aid and UNICEF.

2) Savings phase: 1500 takas per member; 5 in-succession loans totaling 3000 takas per member; interest rate on loans: 7.5% over 40 weeks (9.75% per year).

Lastly, **Grameen Bank** (one office at Guthail Bazar) is also implementing a **landless women credit programme** based on a comparable pattern to that of Action Aid, with the difference that the savings phase would be utilized first for the construction of a symbolic office for the Grameen Bank agent.

13.2.5 Psycho-sociological Atmosphere

Due to the sudden increase in population, especially of the landless, the employment situation in the mauza has deteriorated. Although the destitute from other mauzas are outwardly welcome to settle in Belgacha (since giving shelter to people made homeless due to river erosion is a tradition among people living in adjoining river villages), it has diversely affected the socio-economic conditions of the original residents of the mauza and thereby has created psychological tension among the residents of Belgacha. This tension is combining with the latent structural conflict between the two socio-political clans (a kind of two "halfs" in theoretical anthropology) in Belgacha mauza, as has been explained before.

Specific Problems Faced by Different Groups

Farmers

Discussions with well-to-do farmers reveal that about 20% of Belgacha mauza appears to have been eroded away by the river. One of the farmers stated that about 10 bighas of his land was lost by erosion. This homestead is now only 100 feet from the river and may be engulfed by it any time. The embankment that was there previously is now non-existent. The main problem in the area is river erosion. The cropland is fertile and is suitable for growing different crops. But if river erosion is not stopped, soon many more will become landless.

Fishermen

There are about 12-15 fishing households in the area. Only about 4-5 of these households possess any land, the rest of them have only their homesteads. Only about half of these households have their own nets and catch fish. The others buy fish from other fishermen and take them to different market places such as Guthail, Islampur and Jamalpur. The catch of fish is inadequate. Some days they may catch fish worth from Tk 50-100, other times only Tk 20-40. There are days when they do not get any fish at all.

On the whole, although fewer field discussions could be conducted in Belgacha mauza, one would undoubtly find the same main worrying questions at the level of the local population as the ten summarized above (Subsection 12.2.5) for the Kamarjani site.

Attitude Toward the Project

Although simple and precise explanations could not be really provided on the occasion of the field trips, the Chairman and elected members of Belgacha took an a prior stand

vis-a-vis the foreseen project, saying that "they will help it at any level, it is the most appropriate project for this region; and that they would sacrifice themselves in fighting riverbank erosion". No declaration on the previous BWDB embankments was recorded on the other hand. The question of the need for land acquisition and compensation was also discussed, and possible procedures as well (see details, Section 13.4 below).

13.2.6 Agricultural Activities

Hydro-agricultural Aspects

In the Bahadurabad area located on the Jamuna left bank, the same AEU as those already described in the Kamarjani area can be observed. But the sedimentation conditions are a little different (see Fig. 13.2-3). The sandy deposits affect the surface layers of a broad land area along the riverside AEU (3.1 and 4.1) and the main land (AEU 1.1 and 2.1).

The soils are recent deposits of the Brahmaputra-Jamuna river. They are mainly grey or greyish brown-neutral to moderately alkaline. In AEU 3.0, 4.0 and 4.1 thick silty and clayey deposits suffer in depth from low permeability and poor aeration. According to the FAO/UNESCO classification, these soils are "EUTRIC FLUVISOLS". The flood plain morphology of this area is very particular.

The present riverside plain, actually, is a relatively old depression located between two old banklines. The west bankline disappeared by erosion. The depression is now annually flooded with rapid flow. When water withdraws sandy deposits and small accretions appear. Gradually T.aman and boro crops spread inside the old beel especially the Ververi beel. But at the same time bankline erosion is spreading out toward the east (100 to 220 m/year).

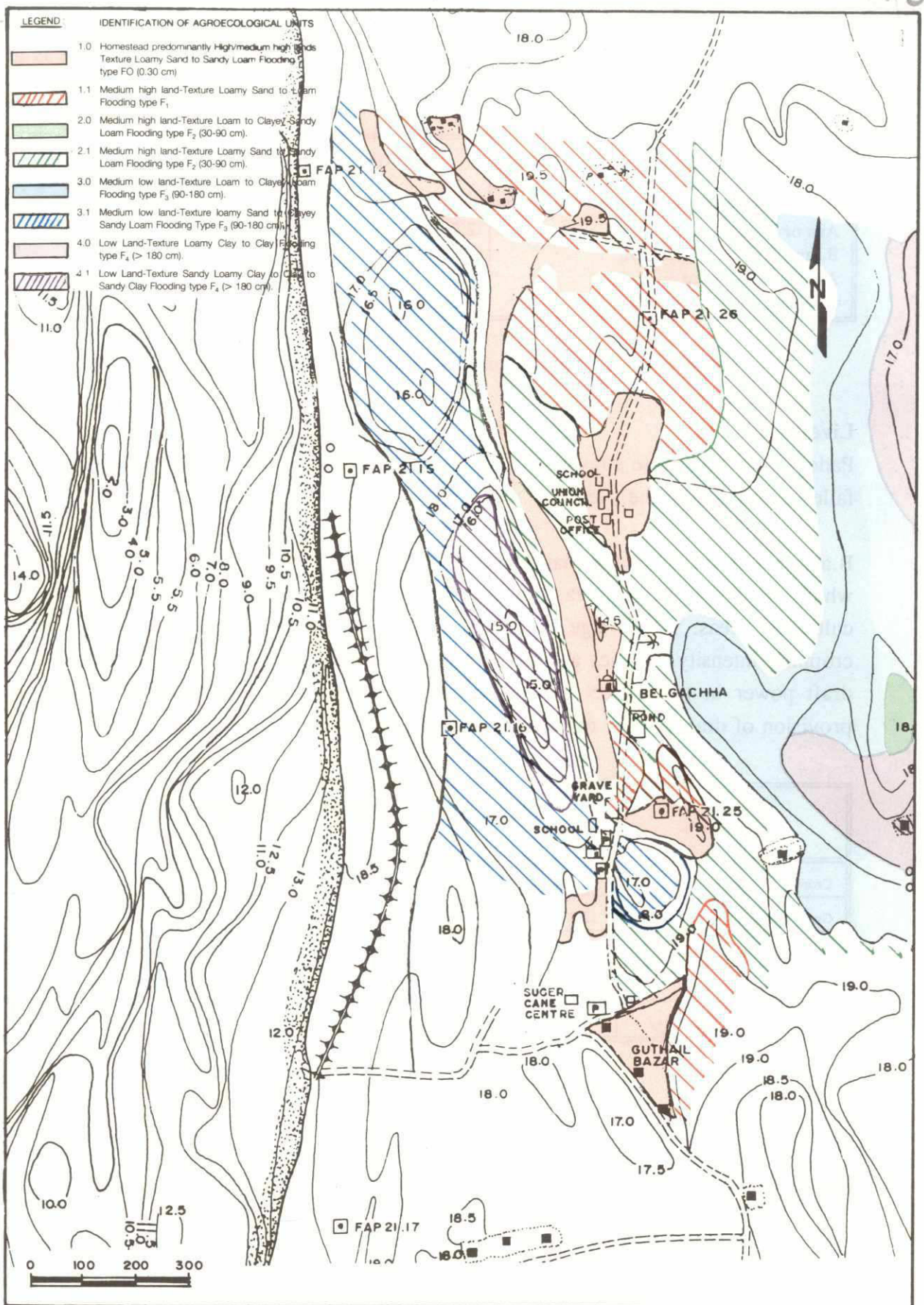
At the east of the Belgacha-Guthail road fertile lands (AEU 2.0, 2.1, 3.0 and 4.0) have large cropping possibilities. These lands are drained through the Balu khal.

Land Use and Cropping Systems

In the investigated area of Bahadurabad the main crops include rice, wheat, jute, sugarcane, pulses, mustard and onions. A very high diversification may be observed and an average of 14% of the cropped area is used for growing a broad range of cash crops such as vegetables, fruits and spices. This corresponds to an average cropping intensity of 184% and demonstrates the capacity of local farmers to make intensive use of limited land despite adverse conditions.

The crops to be cultivated in each season are selected on the basis of the soil-plant-water conditions of each AEU. The climatic factors vary in different parts, local climatic variations combining with the variations in physiography and timing and depth of flooding to determine the cropping patterns and crop productivity within this area.

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BAHADURABAD
IDENTIFICATION OF AGROECOLOGICAL UNITS

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The general relationship between land levels, flood depths and cropping patterns is given below in Table 13.2-3.

Main Crop Rotation or Land Use	AEU	Percentage of Land Areas Cultivated %
Aus or jute, rabi crop	2.0, 3.0, 3.1	42
B. and T.aman, rabi crop	1.1, 2.1, 3.1	67
Aus, T.aman, boro	2.0, 3.0	27
(T.aman), boro, rabi crop	4.0, 4.1	6

Table 13.2-3: Croping pattern and percentage of land cultivated

Livestock

Paddy straw and pulse straw were the main feedstuffs for cattle; there are no grasses and fallows available in the site.

B.aus and B.aman are the main sources of paddy straw, but sugarcane tops and pulses, which are grown in the area, are also fed to the cattle. All these feedstuffs come from cultivated areas. A shortage of animal feeds, caused by lack of fallow land, and high cropping intensity, implies a major decrease of cattle, which are also the main source of draft power in the project area. The gross product of animal husbandry including the provision of draft power, represents roughly 5 million Tk.

Production Characteristics	Agro-Ecological Units (AEU)							
	1.0/1.1	2.0	2.1	3.0	3.1	4.0	4.1	Average
Cropping intensity	155	250	200	230	145	150	50	184
Gross Value Added GVA/ha	12,823	35,592	16,150	26,571	12,492	16,466	7,279	17,444
Net Value Added NVA/ha	7,693	2,655	10,690	19,998	8,280	11,525	6,376	11,853
Labour (man-days/ha)	208	372	232	348	169	200	80	242
Productivity (GVA/man-day)	62	96	70	65	74	82	91	70

Table 13.2-4: Production assessment per AEU

Table 13.2-4 shows an average productivity of farm labour estimated at 70 Tk per man-days with major variations between the different AEU (62-96 Tk).

The mean gross value added is about 17,400 Tk/ha (7,279-35,592 Tk) for an agricultural activity which requires about 240 man-days/ha. The lowest net value added per ha are provided by local varieties of B.aman, aus and by jute and wheat.

Land Value

River bank erosion is considered in the Bahadurabad area as if it was a temporary

phenomenon which must be followed by accretions and new sedimentation processes. Under these conditions, farmers always hope to recover the land they have lost over the past few years.

This feeling explains why the land prices of the Bahadurabad riverside are a little higher than those of the Kamarjani riverside. Unlike the Kamarjani main land prices, the Bahadurabad main land prices seem to be a little cheaper. In any case the land market prices seem to be underestimated (see Table 13.2-5).

There are three ways of estimating the land prices:
- through the market price;
- through the substitute price, and
- through the land income annuity expressed in Table 12.2-8 and Table 12.3-3.

As far as this last way is concerned it can be seen that the market prices in the Bahadurabad site square with 2 to 9 income annuities.

AEU	Market Land Value	Land Value (in terms of production* year number)
River side (west test embankment)		
- Unit 2.1	49,400	3
- Unit 3.1	to	to
- Unit 4.1	61,700	8
- Chars	24,700-29,600	2
Main land		
- Units 1.0/1.1	37,000	3
- Unit 2.0	148,100	5
- Unit 2.1	49,400	3
- Unit 3.0	148,100	6
- Unit 4.0	148,100	9

* expressed by the Net Value Added which can be considered as land income annuity.

Table 13.2-5: Land value (Tk/ha)

13.3 IMPACT ASSESSMENT

13.3.1 Settlement Areas and Homesteads Affected

Considering the provisional location of the future test-structure as shown in Fig. 13.1-1 hereafter, seven settlement units are entirely or partly located in the gross site area. A first rough estimate of the total number of households composing these paras is 546, out of which 272 (50%) would be already landless refugees.

The distribution per settlement unit is given below:

Sl.No. of the settlement unit	No. of households	No. of present landless households
1	90	25
2	100	90
3	40	11
4	130	55
5	36	7
6	42	11
15	108	73
	Total: 546	272

At this stage and scale of approach and taking into account the fact that implementation is scheduled for after the 1994 monsoon, the future location of the construction site is even more subject to inaccuracy.

Just as an illustration, and on the basis of the very approximate location and mapping in Fig. 13.1-1, 60% of the construction site length would be on settlement areas not yet eroded. The order of magnitude of the resettlement to organize can be outlined as follows:

- total length of the test-embankment : 900 m
- present homesteads area taken : 900 x 28 [1] x 60% = 1.5 ha
- rough estimate of the number of households to be resettled : 1.5 ha x 50 [2] households/ha = 75 households

This very rough estimate corresponds to the assumed evolution of the future bankline after the 1994 monsoon from the prediction method utilized. According to these assumptions, and on the basis of the former data and rates, the overall situation after the 1994 monsoon and at the starting point of the construction phase would be as follows:

- 7 settlement units of the gross site area, total No. of households : 546
- No. of households that would already have shifted due to riverbank erosion : 326
- No. of households remaining beside the 1994 bankline : 220
- Out of which No. of households to be resettled due to the construction of the test-structure : 75

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1) width of the embankment.

2) 50 households in average per hectare of homestead area; 200 sq.m in average per homestead for one household (upon rough assessment from field survey and mapping).

It is clear that if, in the future, the 1994 bankline moves less eastward, the resettlement pattern could be quite different from the one above. For instance if the bankline stops just before the western edge of the settlement strip in the gross site area, the situation could be outlined as follows:

- No. of households of the 7 settlement units of the gross site area : 546
- No. of households that would already have shifted due to riverbank erosion : none significant
- No. of households to be resettled due to the construction of the test structure (900 x 28 x 90% x 50) : 115

At this stage it would be hazardous to go further into the analysis. A real impact assessment will have to be carried out in the further phases if this site is finally chosen. The main conclusion is that the magnitude of the resettlement to organize would appear to be quite different from the case of the Kamarjani site (several tens of households).

The issues of land acquisition and compensation procedure and of resettlement as well are addressed below (Section 13.4).

13.3.2 Impacts on Agricultural Activities

- Effect identification and affected AEU

  The affected area includes three zones (see Fig. 13.1-1)

  . The expropriation zone required for the building site (zone A)
  . The riverside zone which should be eroded from now to the monsoon of 1994 (zone B).
  . Inside this eroded riverside area there is a zone (zone C) which must be dug out 10 m deep below the low water level. This zone will be permanently lost for possible agricultural recovery in the future.

  The agroecological units characterizing each one of these zones are the following:

  zone A : AEU 1.0/1.1, 2.1, 3.1
  zone B : AEU 1.0/1.1, 2.1, 3.1, 4.1
  zone C : AEU 1.0/1.1, 2.1, 3.1

  Zone A concerns a land acquisition area of about 3 ha.

  Zone B is an area of about 36 ha which will be completely eroded between now and 1994. This is a physical effect, independent of the test structure.

  Zone C is an area of about 10 ha affected directly by the building site but only in the doubtful event of land recovering. In addition to the direct effects of the bank protection test at Bahadurabad concerning agricultural production and livestock

(shown in Table 13.3-1), the principal rural development problems resulting from the project are as follows in Table 13.3-2 below.

Appraisal Criteria

From the quantitative assessment criteria expressed in Table 13.3-2 it is noticed that:

- the land acquisition cost is clearly below the annual production of the lands used by the building site (in terms of NVA);
- the area directly affected by the works represents about 3 ha;
- The prospect of land recovery concerns an area of about 10 ha equivalent to a hypothetical income annuity of about Tk 76,000;
- there is no drainage problem directly due to the test structure, and
- the expected decrease in cattle due to land lost in 1994 represents about 90 head, implying more shortages of draft animals; of which only 7 would be due to the building works.

Table 13.3-4 gives a qualitative assessment for other direct and indirect impacts during and after building works.

As said with regard to the Kamarjani test structure, success in respect of erosion protection is not a certainty. Beside this potential and positive impact, it can be seen that several problems related to the agricultural environment (physical and socio-economic) are not dependent on the test structure.

The agricultural activities really affected by the test structure concern a very small gross area of about 3 ha out of which 1.5 ha would be occupied by homesteads and may be 13 ha maximum if the prospect of land recovery by future accretions is taken into account.

But more than in the Kamarjani area, every condition of socio-economic development such as

- population growth;
- farm saving and investment capacity;
- job supply;
- inequalities,

places a heavy burden on agricultural development compensatory measures.

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AEU	Due to	Direct			Indirect	
		Affected area (ha) zone A	Total cost of acquisition Tk/ha	Blockage of producing years	Affected areas (ha) zones C	Affected areas (ha) zones B
1.0/1.1	Land acquisition*	1.3	48.100*	9		
2.1	Land acquisition*	1.4	69.160*	10		
3.1	Land acquisition*	0.3	15.000*	18		
1.0/1.1	Land affected by digging				1.5	
2.1	Land affected by digging				7.3	
3.1	Land affected by digging				1.2	
1.0/1.1	Land liable to be eroded					1.9*
2.1	Land liable to be eroded					8.6*
3.1	Land liable to be eroded					18.4
4.1	Land liable to be eroded					6.4

* Out of 3 ha to be acquired, 1.5 ha would be actually occupied by homestead before project; see cost estimate paragraph 13.3.1 above.

Table 13.3-1: Financial impacts and affected area

	Zones			
	A 1994	B	C	Total
- Land acquisition cost on the building site	132,160			132,160
- Annual production benefit lost/year	27,450			243,800**
- Benefit lost by erosion 1993 and 1994		76,180		
- Loss of hope of getting agricultural production on new accretion (Tk/year)			175,680	
- Decrease in labour activity (man/days)				4,000
- Decrease in cattle (head)				90

* benefit in terms of net value added

** including livestock value

Table 13.3-2: Quantitative assessment

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Direct Effects	During the Site Building	
	Assessment criteria	Qualitative assessment
Temporary agricultural workers	Availability	-
Agricultural wages	Seasonal fluctuations disturbing agricultural economy	- -
Landless populations	Resettlement problems	-
Transportation of agricultural inputs and outputs	Disturbing degree	0
Agricultural activities	Disturbing degree	0
Direct effects	After test embankment building	
Erosion	Increasing process(1)	+
Devastating flooding	Protection degree	0
Sand deposition (zone D)	Protection degree	0
Water stagnation (zone D)	Drainage problem	0
Agricultural activities (zone A)	Production, Employment, Livestock	- -
Agricultural activities (zone B)	Production, Employment, Livestock	0
Agricultural activities (zone C)	Production, Employment, Livestock	_ _
Agricultural activities (zone D)	Production, Employment, Livestock	0
Farm saving and investment capacity	Improvement in the future	- -
Socio-economic inequalities	Trend	-
Land production value	Trend	0

(1) This impact assessment value depends on the success of the erosion protection test.

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Table 13.3-3: Impact assessment

13.3.3 Other Socio-economic Impacts

According to the same approach and method as for the Kamarjani site, and in relation with the proper degree of knowledge of the local conditions, a qualitative assessment was made, the results of which are summarized in Table 13.3-4 below.

	Construction Phase	After Project
Demography		
- Population density (locally inside mauza)[1]	++	+
- Out-migration	N	
Socio-cultural Changes[2]		
- Destruction of values at household and social category level	+	+
- Women's condition	-	N
Social Equality[3]		
- Landless increase	N	-
- Employment (1000 workers per day during construction phase)	++	-
- Impacts on different socio-economic categories	+	-
. Landholders	N	+
. Craftsmen	++	-
. Traders/merchants	++	-
. Local leaders/politicians/elders/elites	±	+
- Income distribution	-	N
Social Cohesion[3]		
- Socio-political disrupting effects (conflicts, loss of social consensus, political advantage etc.)	++	+
- Ideological risks	++	+
Life Style Conditions[4]		
- Flood proofing facilities and shelter possibilities (landless displaces)	-	+
- Water supply (work camp and organization)	+	N
- Diseases, unhygienic conditions and pollution	++	+
- Increase of consumer prices	++	+
Resettlement Issues		
- Dimensional aspects[5] (75 households, 1.5 ha of homesteads, out of which 50% landless)	=	
- Organizational aspects (local conditions)[6]	=	
Land Acquisition and Compensation		
- Dimensional aspects (1.5 ha; 6 households concerned)[5]	-	
- Organizational aspects (local conditions)[6]	=	

Table 13.3-4: Assessment matrix of the socio-economic impacts (agricultural activities and agro-economic aspects not included)

Notes:

(1) Construction works will need a thousand workers per day in total, which represents roughly. 75% of the male adult population of Western Belgacha, and 36% of the whole of Belgacha mauza.

(2) See corresponding explanatory note for Kamarjani site (para 12.3.3).

(3) Differences with the case of Kamarjani site are mainly in terms of impacts on the local notabilities as they seem to be organized into two clans. The project will undoubtedly be a pretext for the "management" of their structural rivalry. That means that one of the groups will benefit from the construction phase (most probably the Chairman and elected group), to the detriment of the other opposition group as a matter of fact. But after the project, the situation could reverse due to its actual goal outside socio-economic issues (see corresponding explanatory note for Kamarjani site). As local patrons (large landholders, large businessmen and political and religious notabilities) are at a higher level, compared to the social basis, than in Kamarjani site, the magnitude of the effect of economic growth generated by the project will be higher.

(4) See corresponding explanatory note for Kamarjani site, with a higher magnitude of issues related to health, pollution and consumer prices.

(5) According to the predicted future bankline.
Dimensional aspects of land acquisition: 4 landholdings and 6 households concerned (in division rate of 1.5), out of which 30% will loose all their estate.

(6) See detailed explanation in 13.4.1 below.

13.4 COMPENSATORY AND MITIGATION MEASURES

On the whole and at this stage of approach, foreseeable compensatory and mitigation measures cannot be identified and defined with the same relative detail as for Kamarjani site. This limitation is due to the following main reasons, as mentioned before:

(i) inaccuracy and uncertainty of the location and project design;
(ii) risk of a major shift in the construction site or even selection of an alternative new site elsewhere;
(iii) foreseen implementation schedule, and
(iv) arduous sociological context of Belgacha mauza and union.

Accordingly, only the main lines of intervention will be given below. These follow the master principles already presented in the case of Kamarjani site (see subsections 12.4.1, 12.4.2 and 12.4.4).

13.4.1 Land Acquisition, Resettlement and Compensation Procedure

According to the prediction method utilized, the project impact on agricultural land acquisition needs would be very minor (1.5 ha; around 4 land holdings and 6 households); in contrast the resettlement issues would be much greater (1.5 ha of homestead areas and 75 households).

Agricultural land acquisition and compensation itself should not demand a very sophisticated procedure and could simply be undertaken by the project itself according to the same principles as for Kamarjani site. But for resettlement aspects it appears that a sound and strongly organized programme should be envisaged. On this subject the shelter opportunity of the planned sloped embankment will have to be seriously considered with the two alternative patterns:

(i) with physical planning and a technical and socio-economic resettlement project; or
(ii) without planning or a realistic resettlement project.

These two alternatives are illustrated in Fig. 13.4-1.

The planning approach of a rational resettlement project is recommended as far as this "rationality" will take into account the displacees' own rationality and constraints, in particular vis-a-vis physical planning criteria. Such a project will have to be identified and prepared during a further stage. Its implementation by the Project Organization will need, as spokesman and support, an LCRC that should fulfil the same functions as the ones defined for Kamarjani site. If resettlement is organized with a physical planning pattern, temporary shelters should be provided to displacees during the construction period, like a tent camp for instance near the works site.

During discussions held at the level of the Belgacha Union Office with the Chairman and some elected members, agreement was not obtained from them to incorporate systematically true area-samajes and para elders in such a committee, which already revealed the bipartite structure of Belgacha mauza. The role and efficiency of the LCRC would have to be sorted out in the future, as a key point (among others) of the success of a possible resettlement project and participation of local authorities and population.

For budget planning purposes, and not yet being in a position to give even indicative costs of such a resettlement project, the rough average cost of 5,500 Tk per household, as estimated in the case of Kamarjani site, can be considered.

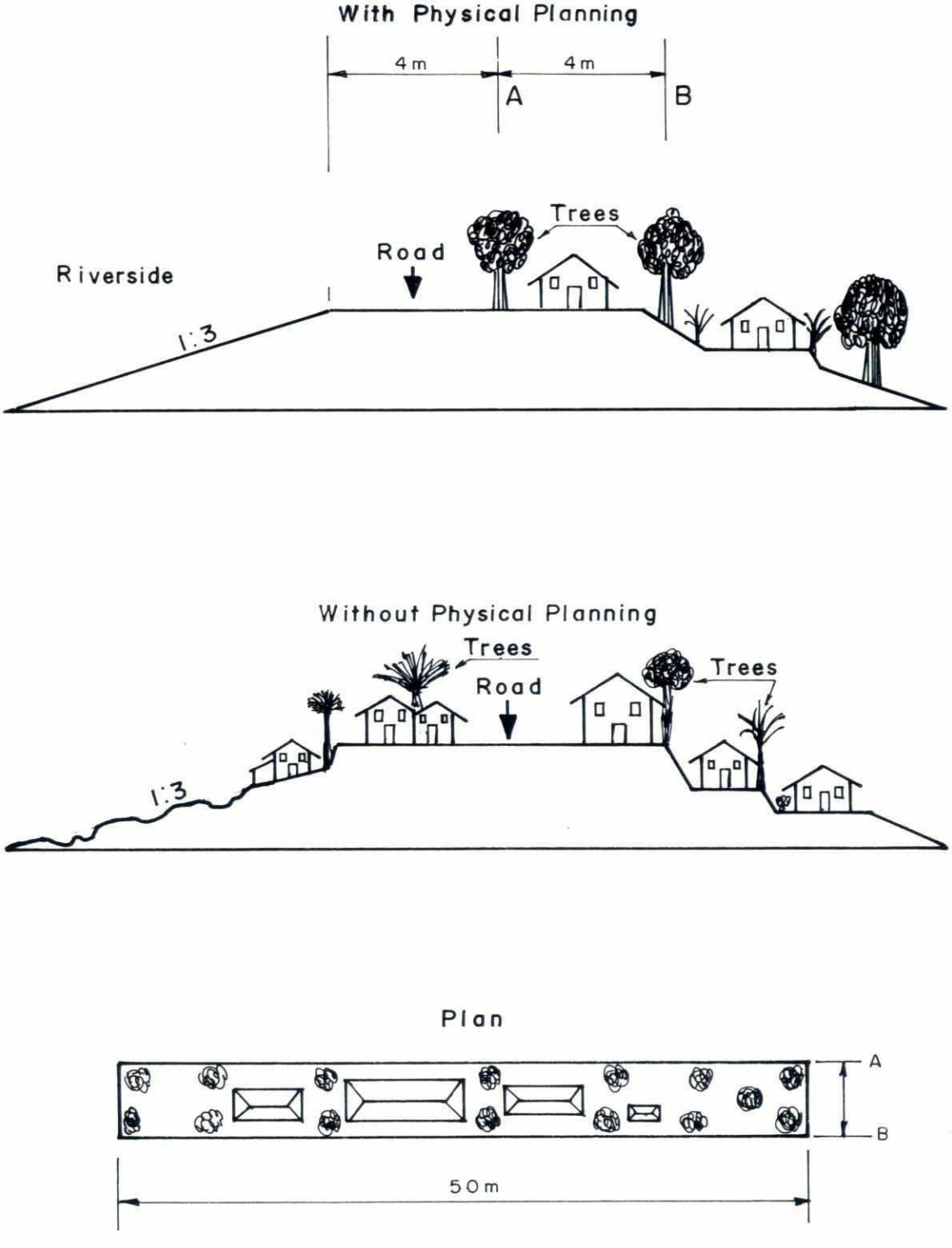
13.4.2 Technological Aspects and Agricultural Measures

The soils of the investigation area to the east of the Belgacha - Guthail Bazar road are fertile and suitable for growing most crops. The drainage system must be improved but that is not in direct relation with the test Project.

In the framework of a diversification and intensification programme, in order to compensate for small land losses:

- a high biomass-yielding forage crop should be cultivated on the available slopes and roadsides in order to produce green feedstuff and also reduce soil erosion (more than 2 ha can be recovered inside the investigated area);

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RESSETTLEMENT ISSUES ON THE EMBANKMENTS

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING/ (AFPM) PILOT PROJECT

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- pulses and oilseeds and fruit trees may be encouraged with a view to improving the nutritional status of the people, providing nutritious cattle feed and increasing farm incomes, and
- an irrigation programme should be encouraged on AEU 2.1 and 3.0 in order to reduce possible water deficits during the dry season.

The same measures suggested for the Kamarjani site may be mentioned for the Bahadurabad site, but as far as this area is concerned it will probably be more difficult to succeed in generating a broad approval and a cooperative spirit in order to improve:

- water management;
- cultural practices;
- good bank protection maintenance, and
- efficient management of the compensatory measures including technical aspects and saving and investment procedures.

13.4.3 Other Socio-economic Measures

On the whole the same socio-economic measures as for Kamarjani site should be considered, with a particular stress put on the weight of a thousand workers per day on the one hand, and the specific sociological conditions analysed before on the other hand.

14 ISSUES AND FOLLOW-UP

14.1 ISSUES

The following main issues have to be addressed for future possible stages of detail design study and implementation of works:

- absolute priority of employment for jobless (landless) people at the occasion of the Project works (women included for particular tasks; see para 12.4.4 above);
- to provide temporary shelters to displacees during the eight months of works scheduled for each site, in particular in the case of Bahadurabad site and in relation also with a planned resettlement project proposed;
- socio-political situation around Bahadurabad site;
- protection of Manos Regulator vis-a-vis drainage problems at micro-watershed level in Kamarjani region;
- information about the dredged channel on the riverside at the feet of Bahadurabad test embankment, and
- location and characteristics of borrow pits for each site, and assessment of groundwater resources in prospect of domestic and irrigation requirements in a new riverside configuration.

14.2 ADDITIONAL SOCIO-ECONOMIC STUDIES AND ACTIONS FOR SECOND PHASE

The following tasks and actions will have to be undertaken in each site case:

Before construction (in chronological order):

(i) construction of the Land Compensation and Resettlement Committee (LCRC);

(ii) first information and animation sessions of the LCRC (1 engineer + 1 socio-economist of the project);

(iii) extended information campaign and communication for their better understanding of the Project: its direct and indirect goals, its constraints and risks, and the foreseen impacts and compensatory and mitigation measures;

(iv) a detailed and nominative plot inventory at the 1/2000 or better 1/1000 scale. This inventory should be done with the effective presence of members of the LCRC. Each plot will have to be surveyed, identified compared to the situation in the old cadastral mauza map (to asses fragmentation). The following data must be contained in each plot sheet: surface, crops at the moment of the survey, type of soil, land owner, and holder, tenancy system (direct, share cropping, mortgage, in-division with socio-economic rates). For the homestead areas this survey will also identify and assess all the household assets existing such as houses per category, trees, ponds, yards etc.;

(v) aftermath, the real land acquisition and compensation procedure could start according to the principles defined above in each site case;

(vi) in case of Bahadurabad site the design and organization study would have to be completed in parallel with the structure design study, and

(vii) social, organizational and financial feasibility studies of general agronomic and socio-economic compensatory and mitigations measures will have to be undertaken during the detail design phase. In the framework of this study a value analysis of the Kamarjani drainage system should also be undertaken.

After construction a general follow-up and monitoring system should be installed vis-a-vis the socio-economic and institutional dimensions of the pilot Project (follow-up of impacts and compensatory and mitigation measures). Besides, as proposed for FAP 22 it could also be an opportune occasion to organize in partnership with other research institutions a subject matter observations of technological, cultural, social and economic changes.

A very important warning on the other hand is that, if there is any change of site elsewhere along the Jamuna; such a pre-impact or impact assessment will have to be redone, taking just some guidance from the methodological aspects of the present study.

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Serial Number of the Household	No. of Persons/ Household	Adults		Young and Children		No.of Houses	Remarks
		Male	Female	Male	Female		
1	13	2	2+1	4	4	3	
2	8	1	1	2	4	1	
3	3	1	1	1	-	1	
4	4	1	1			1	
5	5	1	1	3	-	3	
6	3	1	1	2	-	1	1 widow
7	3	1	1	1	-	1	1 bigamous
8	1	-	1	-	-	1	1 widow
9	4	1	1	1	1	1	
10	6	1	1	3	1	1	
11	2	1	1	-	-	1	
12	5	1	1	2	1	1	
13	6	1	2	1	2	3	1 bigamous
14	2	1	1	-	-	1	
15	8	1	1	2	4	1	
16	3			-	-	2	
17	7	1	1			1	
18	5	1	1			1	
Total	88	18	21	22	17 + 10	25	

(Source: Field investigations)

Table A.7-2: Case survey of Mistri para

(para No.7, Fig. 12.2-1)

Serial No. of the Farmer Surveyed	Acreage Inside the Gross Site Area	No. of Plots	Total Acreage Owned or Held
1.	1	1	5
2.	1	1	4
3.	3	3	3
4.	2	1	2
5.	2	2	2
6.	3	4	21
7.	5	5	5
8.	2	8	10
9.	2	1	7
10.	1	1	5
11.	2	2	12
12.	1	1	3
13.	2	2	17
14.	2	1	7
15.	2	1	21
16.	1	1	6
17.	1	1	2.5
18.	1	1	5
19.	3	3	3
20.	2	3	2
21.	1	1	1
22.	0.5	1	0.5
23.	1	2	2
24.	1	2	6
25.	1	1	16
26.	1	2	7
27.	1.5	2	1.5
28.	1	2	7
29.	2	2	4
30.	1	1	2
31.	0.6	1	0.6
Total	50.60	60.00	190.10

(Source: Elders of Analerchara)

Table A.7-3: Land holding distribution and farm fragmentation in the approximate gross site area
(Mauza: Analerchara)

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No. of the Farmer Surveyed	Acreage Inside the Gross Site Area	No. of Plots	Total Acreage Owned or Held
1	5.5	6	9.5
2	1.5	2	2.5
3	0.75	2	3.5
4	3.5	4	10.5
5	1.5	2	1.5
6	3	3	3
7	0.25	1	0.25
8	1.5	2	1.5
9	1.25	1	1.75
10	4	4	6
11	4.5	4	6.5
12	5	5	7
13	5	5	7
14	6	6	10.5
15	4	4	4
16	7	5	7
17	7	5	7
18	1.5	4	1.5
19	3	4	3
20	0.75	1	1.25
21	4	5	4
22	0.75	1	0.75
23	5	5	9
24	2	3	2
25	6	2	6
26	9.5	2	9.5
27	2	1	2
28	1	1	8
29	1.5	1	1.5
30	1.5	2	1.5
31	7	1	7
32	3	2	6
33	1.5	2	4.5
34	8	1	8
35	3.5	1	3.5
36	2	1	2
37	2	2	2
38	2	1	2
39	0.75	1	0.75
40	2	1	2
41	2	1	2
42	2	1	2
43	3	2	3
44	1.5	1	1.5
45	1.5	1	1.5
46	5	3	5
47	1.5	1	1.5
48	4	1	4
49	4	2	4
Total	156.00	119.00	201.25

(Source: Elders of Dhutichhara)

Table A.7-4: Land holding distribution and farm fragmentation in the approximate gross site area
(Mauza: Dhutichara)

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BANK PROTECTION AND RIVER TRAINING (AFPM) PILOT PROJECT FAP 21/22

DRAFT FINAL REPORT

ANNEX 8

ECOLOGICAL ASSESSMENT

JANUARY 1993

ANNEX 8

ECOLOGICAL ASSESSMENT

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1 INTRODUCTION

1.1 THE FAP 21/22 PROJECT

The two components of the Project need different approaches for the ecological assessment. The FAP 21 component, related to the implementation, monitoring and adaptation of test structures for bank protection viz groynes and revetment is rather restricted in area and impacts are expected to be of local nature only. On the other hand the FAP 22 component, related to the training/active flood plain management of the Jamuna between the Indian border and the confluence with the Ganges, is covering substantial water and land areas and its ecological impacts can be expected to be more extended and comparable to regional development programmes.

Since the major part of the human components were dealt within the socio-economic investigation (ANNEX 7) the present report deals with the ecological aspects only, concentrating on natural factors, biotic and abiotic.

In the present stage of the Project no full-fledged ecological assessment was envisaged because of the following reasons:

- the very early stage of the Project, particularly of the FAP 22 component;
- the locally very restricted test structures of the FAP 21 component, and
- the non-availability of the results of a number of EIA studies of various regional development projects until the submission of the present report.

On the other hand, especially the latter point viz non-availability of data by other FAP projects has caused some problems which could only partly be overcome by own field surveys which, due to the restricted time, can make no claim to be exhaustive.

1.2 USE OF THE GUIDELINES FOR EIA (FAP 16)

The study has made good use of the Guidelines and the Manual for Environmental Impact Assessment (EIA) - 1992 prepared for FPCO by FAP 16; however they could not be followed to the full extent for two reasons. On the one hand the present study is conceived as an Ecological Assessment only, without dealing with the socio-economic issues. On the other hand, it is not conceived as a full "Impact Assessment" although critical analyses and views on different aspect of the existing environmental conditions and their applications have been a major issue of the investigations.

1.3 EXCHANGE OF INFORMATION WITH OTHER FAP

However, some results and enriching discussions have been exchanged with different participants of these FAPs:

• FAP 2 : North West Regional Study	: Tom Franks, Team Leader
	: N Chilshom, Agricultural Economist
	: Faruk Khan, Environmentalist
• FAP 3 : North Central Regional Study	: Alan Potkin, Environmentalist
• FAP 3.1 : Jamalpur Priority Project	: S M Latif, Environmental Planner
	: A Bird, Environmental Planner
	: Philippe AME, Fisheries Expert
• FAP 12 : FCDI/Agricultural Review	: Parvin Sultana, Environmentalist
• FAP 13.2 : O&M Study	: Paul Thompson, Socio-economist/ Acting Team Leader
• FAP 16 : Environmental Study	: Stan Hirst, Team Leader
	: Steve Minkin, Fisheries Expert
	: M A Islam, Environmental Scientist
• FAP 17 : Fisheries Study and Pilot Project	: Mike Smith, Team Leader
	: Bernie McCarton, Fisheries Scientist
	: P Reverdy, Fisheries Expert
	: M Shafi, Project Co-Manager/ Fisheries Production

1.4 DATA COLLECTED AND AVAILABILITY

A preliminary review on the environmental data is as follows:

Data are sets of observations of environmental elements, indicators or properties. Environmental data for Bangladesh are often widely scattered, incomplete and not reliable. As a result, selection of data sets though is not impossible, but is quite difficult. The most important criteria is the relevance of the data. The second consideration is their reliability in case these data be provided by other or unknown sources. Many individuals and agencies are generating and using data. Individuals tend to be 'discipline oriented', while agencies are 'mission oriented'. In either case, the data may not be fully suitable for use in a particular environmental studies.

Referring to river training and AFPM measures envisaged in the FAP 22 component, in a number of subject areas the available database is inadequate for ecological assessment. Often they are inconsistent and on closer look, unreliable. Reviews of the available database in the natural environment (climate, landforms, hydrology, vegetation, etc.) show adequacy, although the length of time series data on dynamic seasonal and spatial context is limited. Data on the diversity of species of the natural flora and fauna is less available. In the field of ecology, water quality and groundwater levels of the Project area (AFP of the Jamuna) data are virtually non-existent, although they are primary data required for any sound environmental impact assessment for the proposed AFPM measures of the Jamuna river. The status of environmental data so far reviewed is indicated in the following table:

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Parameters	Source	Remark
Climate		
Type Temperature Rainfall Pressure Fog/Dew Storms	- MPO Report : 1986, UNDP/FAP - UNDP/FAO (Land Resources Report) : 1988 - Haroun Er. Rashid : 1991 - Interim Report FAP 2 : 1992	Adequate
Land		
Land forms Soils Landuse	- MPO Report : 1986 - Haroun Er. Rashid : 1991 - JU Masters Thesis : 1991 - Interim Report FAP 2 : 1992	Tolerably adequate
Vegetation (general)	- Interim Report; FAP 2 : 1992 - Haroun Er. Rashid : 1991 - IUCNR : 1991 - WRI/CIDE, 1990	Not adequate
Fauna (general)	- IUCNR: 1991 - Haroun Er. Rashid : 1991 - Proc. of the 7th Zoological conf. : 1990 - W.G. Harvey	Tolerable
Water Quality		
BOD,DO,DIC,DOC, POC	- Safiullah etal: 1982, 1985, 1990	Insufficient
PH	- Safiullah & Huqs : 1990	Insufficient
Suspended matter (Turbidity)	- BWDB/IWTA	Adequate
Temperature	- Nil	No study made
Pollution (Urban Industrial & Agro chemical)	- FAP 2 - Report : 1992	Sketchy
Groundwater Levels		
Water table	- MPO Report : 1986	Inadequate
Extraction & Recharge	- MPO Report : 1986	Non-specific
Fishes		
Ecology : Migration/ Reproduction	- FAP 2 - Report : 1992 - R.L. Welcome : 1979 - Chu-Fa Tsai : 1985 - M. Youssouf Ali : 1990 - IUCNR : 1991 - JMBA Report: 1987	Insufficient
Number/Types/Edibility	- Interim Report - FAP 2 : 1992 - IUCNR : 1991 - Haroun Er. Rashid : 1991 - MPO Report : 1986 - JMBA Report : 1987	Non-specific Insufficient

Table 1.4-1: Status of environmental database for AFPM (FAP 22) project

Parameters	Source	Remark
Distribution-catches (Temporal/spatial) Recent Modification	- MPO Report : 1986 - JMBA Report : 1987 - Nil	Not available
Birds		
Ecology Food Habitats Migration	- W.G. Harvey : 1990 - Haroun Er Rashid : 1991 - IUCNR : 1991 - FAP 2 - Report : 1992	Not-specific
Wildlife		
Species Distribution Ecology Rare or Protected species Ecological or food interest Recent modification predator relationship	- JMBA - Report : 1987 - Haroun Er Rashid :1991 - W.G. Harvey : 1990 - IUCNR:1991	Non-specific
Insects		
Ecology Species Interest	- Nil	Not available
Flora		
Species Distribution Ecology Rare or Protected species Interest : ecological, medical, food, fodder, religion recent modifications	- Flora of Bangladesh - BARC: 43 series - Check-list-plant names of Bangladesh - Bangladesh - National Herbarium - IUCNR: 1991 - Haroun Er.Rashid : 1991	Non-specific
Fungi		
Ecology Species Interest	- Nil	Not available
Desease		
Microflora & Microfauna	- Nil	Non-specific No study made

Table 1.4-1 (continued): Status of environmental database for AFPM (FAP 22) project

PART A: EXISTING ENVIRONMENT

2 HYDRO-PHYSICAL SETTING

The area concerned by the "Bank Protection and River Training/AFPM Pilot Project" is confined within the embankments on either banks of the Jamuna river, which includes river bed, flood plain, charlands, and strips of lands between bankline and embankments - potentially erodible by the Jamuna channels (Fig. 2-1).

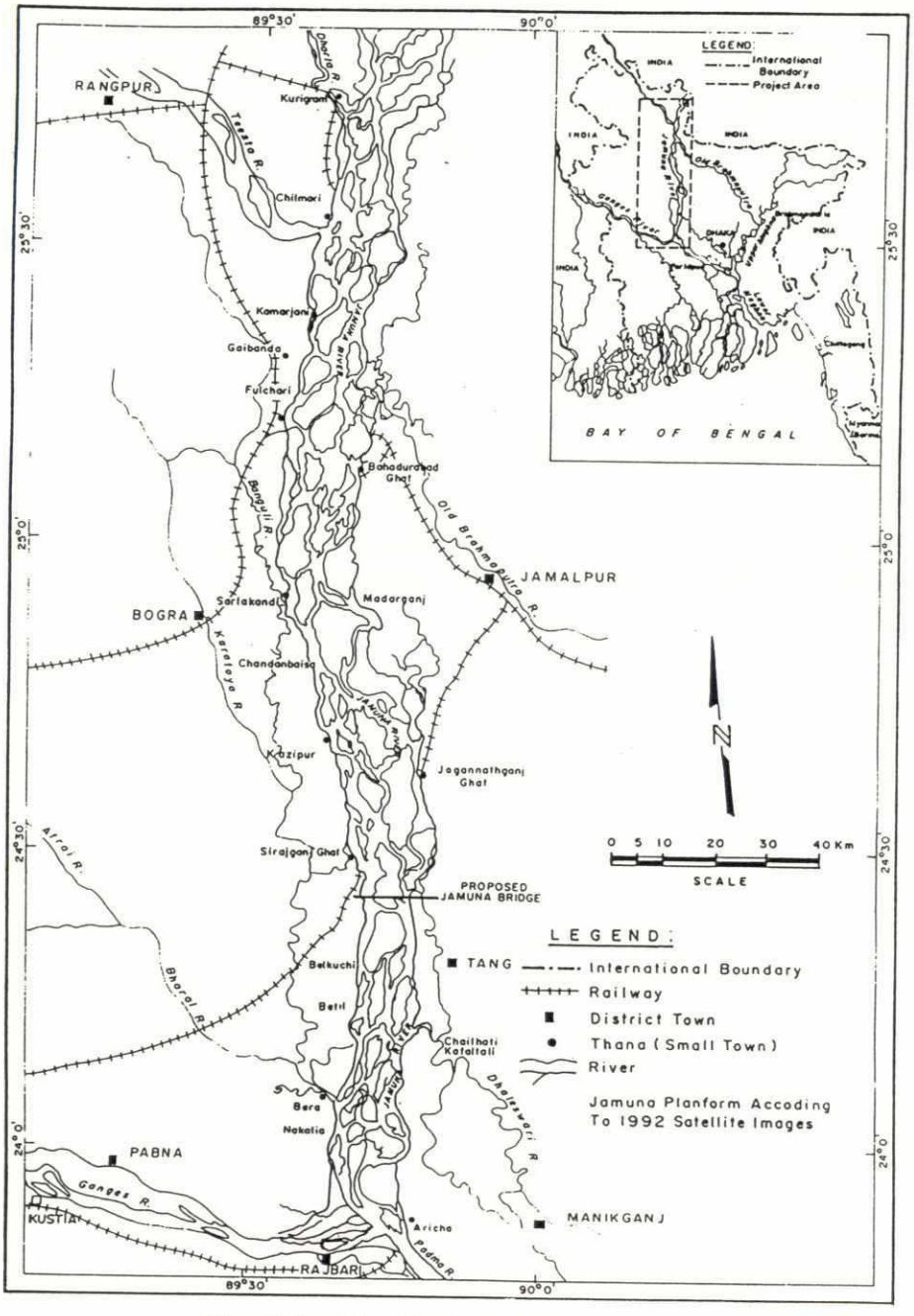


Fig. 2-1: The Project area

The present study will be related to that area.

2.1 CLIMATE

The climate and hydrological regime of AFPM project area are greatly influenced by the presence of the Himalayan mountain ranges in the north and the monsoon system operating in the Bay of Bengal. The climate is sub-tropical with hot summer and cool winter.

The summer begins in late February and ends by the onset of monsoon in early June. Temperature peaks in March and April with daily mean reaching 30°C. Summer is marked by occasional visit of Nor'westers. Weather remains hot and humid. The monsoon is spread over the months from June to October. The mean July temperature ranges between 28°C and 29°C. November to February marks the winter season with mean temperature of about 18°C. The January isotherms show an increasing trend from north to south ranging from 17°C to 18°C. Weather is dry and the sky is clear; early morning fogs and mists are common.

The mean annual rainfall ranges from 175 to 250 cm, of which 80 % occurs during the monsoon. Winter rainfall seldom exceeds 10 cm.

2.2 LAND RESOURCES

As on March 1992, the gross surface of JAFP, excluding Jamuna river channels, is about 2639 km^2 (205,842 ha), of which charlands comprises 88,987 ha and set-back land including attached chars is 116,855 ha. Agro-ecologically, the most part of the area falls within Active Brahmaputra-Jamuna Floodplain having distinct topographic and inundation types, soil and land use systems (FAO, 1988) which are defined in the socio-economic assessment.

2.2.1 Topography

The distinctive pattern of landscape of the JAFP is characterized by slightly irregular landforms with unstable chars and multiple channels of the Jamuna river. Chars frequently change their shape, size and location each year during seasonal floods; new chars are formed and previous ones eroded.There are also meta-stable islands and attached chars with their surfaces at or above dominant discharge level having typically well established vegetation cover. The difference in elevation between low and high points of these accretions may be as much as 5 meters and with the higher levels on either banks can be upto 6 meters. The deposits are mainly fine sands with silts or clayey silts. Most part of the Jamuna channel is braided, but there are stretches with no chars. Morphologically, the river exhibits different character from north to south; the section south of Sirajgonj shows a lower braiding intensity and a greater tendency towards meandering pattern.

The JAFP may be classified as a single wetland during monsoon floods. The areal extent of the wetland reduces extensively and is confined to the multiple braiding channels within the Jamuna river and adjacent low lying areas with stagnant water during low water period.

2.2.2 Erosion and Sedimentation

Jamuna erosion is known to be the most significant cause in creating landlessness among local people. It also brings a total change in the environment and ecology. Studies show that the average width of the Jamuna river has expanded at the rate of 70 m/year during 1972-88 implying active riverbank erosion. Recent study of bank erosion along the curved channels shows that the Jamuna river in most cases eroding at the rate between 0 to 500 m/year with larger values upto 1,000 m/year; and the average direction of the largest erosion is approximately perpendicular to the direction of valley slope, while for smaller erosion rates it frequently deviates substantially from the direction of the valley slope.

Much of the JAFP alluvial is unconsolidated, or poorly consolidated and comprises particles having little cohesiveness. Thus, the landscape as a whole is easily erodible and can be readily displaced, transported or otherwise re-arranged by fluvial processes. However, mechanism of the Jamuna bank-erosion is often described as rotational and extensional rather than translational. The Jamuna river is known to have migrated several km across the floodplain in the course of a single year; and within such channels themselves, channels have been eroded overnight to a depth of 20-30 m. In addition, most of the island chars of the Jamuna river are subjected to extensive aeolian action by northerly winds during dry summer period. Wind action often denudes the surface by removing non-cohesive sandy deposits. The process helps in eroding at one place and depositing in other places to form sand ripples, waves and dunes.

Changes in river flow and sediment distribution cause local bed aggradation in the channel. Consequently the flow efficiency of the channel is reduced through decrease in channel slope and aiding the formation of sand bars. There are serious navigation problems on the Jamuna due to low level of dry season flows and the development of shoals.

The Jamuna river is thought to be in a state of dynamic equilibrium; the magnitude of bankline retreat and accretion on the river may be cited as an example. Observing the magnitude of shift between 1965-66 and 1985-86 profiles, the river was divided into several sub-reaches (Fig. 2.2-1). The figure clearly shows moderate to high erosion in between Aricha and Nagarbari, between Sirajgonj Ghat and Paik Para, and also above the section of Chilmari. Sections between Nagarbari to Sirajgonj Ghat and Paik Para to Chilmari have experienced aggradation.

As erosion and deposition proceed from year to year, a rapidly changing layout of habitats and landscapes is in a state of dynamic process; and organisms colonizing such landscapes have adapted this habitat dynamism. This is thought to have favoured species with

physiological and behavioral mechanisms which can cope with the resultant stresses and exploit the powerful dynamic systems that transport and deliver massive quantities of materials, nutrients and energy. Thus, the JAFP eco-systems are characterized by mechanisms (such as migratory feeding and reproduction patterns) which are adjusted to the temporal and spatial boundaries involving the full span of annual and seasonal morphological changes. The situation is quite different from other types of environments where the range of variation is less.

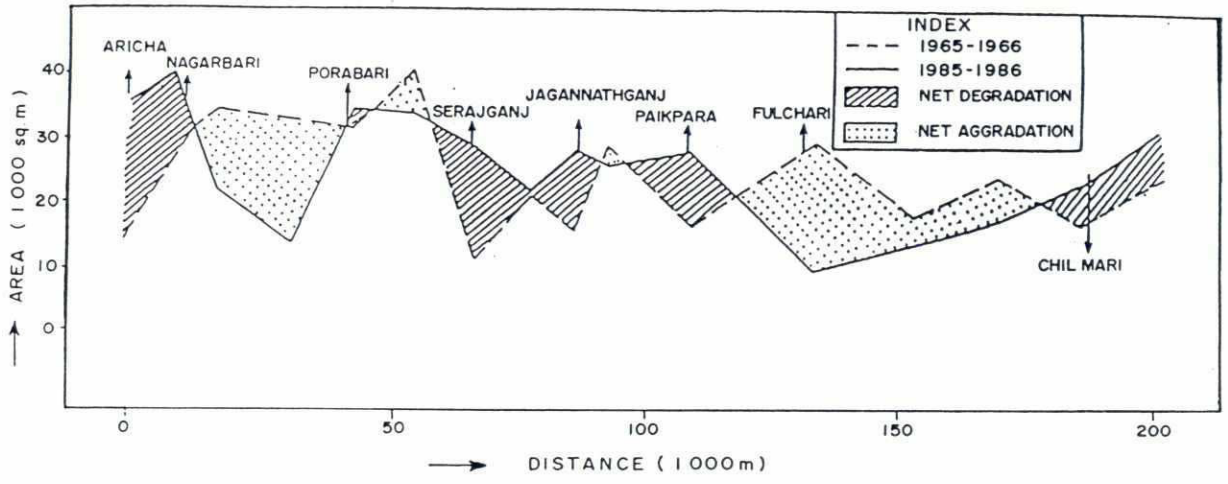


Fig. 2.2-1: Zones of aggradation and degradation (1965-1986) in the Jamuna valley

(Source: Habibullah, 1987 and Islam, 1989)

2.2.3 Soils

The alluvial soils of the JAFP consist of fine to medium sand with silts and silty-clay. Soil is formed through horizontal alluvial stratifications resulting in greater horizontal permeability than that of vertical. Soils do not show any clear profile because they are not in place for a longer period to develop soil-profile. The soil is non-calcareous alluvium (enturic fluvisols) comprising recent deposits of the Jamuna river, of which the color range is grey to grayish-brown. It is neutral to moderately alkaline in chemical reaction. The silty-clay deposits of the alluvium in places suffers from low permeability and poor aeration. The status of macro-nutrients (e.g. nitrogen), micro-nutrients (e.g. zinc and sulphur) and organic matter of the soils are not known. However, during the monsoon, land remains under flood-water for sometimes facilitating suspended sediment to settle down on the surface as silts. The algal activities and their decomposition during prolonged flooding act as natural self sustainable fertilization mechanism.

Based on the biotic mixing that destroys alluvial stratifications, the JAFP soils are grouped into two orders under USDA classification and related local soil-series. They are: Entisols, typic haplaqents, of which local series are sandy alluvial and silty alluvial; and Enceptisols, typic haplaquents (Dhamrai series) and aerie haplaquents (Sonatola series).

2.2.4 Land Use

The present landscape of JAFP is topographically slightly irregular with recently formed ridges, inter-ridges and depression together with new spill deposits alongside the active channels. The general relief is low, but the hydrographic varieties are quite remarkable. Landuse of the region is determined mainly by flood depth, soil characteristics and meta-stable condition of the landforms.

There appears no real-world information on land use in the JAFP area. Major landuse types, visibly seen in the area, are:

a. Settlements or homesteads on relatively high lands, sometimes inundated by abnormal flood. They are mostly linear in pattern along the set-back lands, attached charlands and old natural levee lands. Few temporary settlements are sometimes seen to cluster in large island chars.

b. Cultivated lands occupy most part of the medium high lands in the attached chars and set-back lands, which are subjected to seasonal inundation. A substantial portion of medium to low-lying areas of island chars, moderately to deeply inundated lands with much clayey-silts contents, are also brought under this category.

c. Fallow lands, mostly found on island chars, are subjected to yearly inundation. They are often colonized by grasses like catkin and are used as open grazing lands. The constituent materials that compose the island chars are mostly medium to fine sands having very low moisture retention capacity.

d. Water bodies consist of braiding channels, scoured pools and stagnant shallow-water bodies during low flow seasons. The main activity on these wetlands is fishing, which is practised under a system of lease or auction from Government of Bangladesh or its agencies.

2.2.5 Renewable Energy Resources

Biomass provides the bulk of traditional/renewable energy in JAFP areas. Fuel wood and animal residue are two major sources of energy. Among these two, fuel wood is more prominent. Agriculture residue is also quite important. The energy balance in this region is thought to be precarious and complex; but never comprehensively documented.

Homestead groves, supplying most wood and bamboos, appear to be depleting at a rate considerably in excess of their sustainable capabilities. This is partly because of population pressure and partly because of the riverbank erosion and occasional severe floods. To meet the requirement of fire wood the people are using their important decomposed manure, agricultural wastes mostly rice stems, cow-dung and leaves, and kash stem on the chars of which there exists alternative uses. All these matters could be used as fodder or fertilizer. So using these as fuel is a wastage of valuable organic matter. In fact, the JAFP area has shown to suffer from continuous shortage of fuel, manure and wood. Felling of homestead trees, uses of agricultural wastes and cow-dung as fuels have already affected different

habitats and biodiversity of the region. The situation is feared to worsen as human number and activities increases with the implementation of the FAP 21/22 Project and subsequent development of the area in next few years. It could be compensated successfully through propagation of long term extensive social forestry programme.

2.3 WATER RESOURCES

There are intricate relationships between flowing water, static water, groundwater and rainfall pattern. The water cycle system follows a natural pattern and any human interference that disturbs this natural pattern creates ecological imbalance. Thus, it is essential to ensure minimum disturbance to the cyclic system while undertaking development plan in the water sector.

2.3.1 Surface Water

The surface water system in the JAFP area comprises flowing water in rivers, rivulets, channels, creeks, and static water in water-bodies. The system is extended to include the movement of sediments, chemicals, heat, and biota contained in water.

The River Brahmaputra-Jamuna, rising in the northern most ranges at the Himalayas in the southwestern part of Tibetan plateau, covers a length of about 2,580 km upto its confluence with the Ganges, and has a drainage area of about 580,000 km^2. The Jamuna river is the lower portion of the Brahmaputra, passing through Bangladesh having a drainage area of about 47,000 km^2. Tributaries in Bangladesh are the Dudhkumar, Dharla, Teesta, Atrai, Gumani, Karatoya, Hurasagar on the right bank. Distributaries and spill channels are the old Brahmaputra, Jhenai, Lohajang, Dhaleswari, and Ghior on the left bank. The principal spill channel on the right bank is the Bangali. There are also innumerable rivulets and creeks joining the river from either banks.

The usual annual peak discharge of the Jamuna river varies from 45,000 to 91,100 m^3/sec; the highest recorded peak occurred in 1988 and has been estimated to be 98,600 m^3/sec. The average discharge of the river is about 19,000 m^3/sec with average annual flood flow (May through October) is about 60,000 m^3/sec. In contrast to these figures, the dry season (December through March) discharges are very low, between 3,600 to 12,100 m^3/sec. The water level slope from upstream to downstream decreases from 0.10 to 0.06 m/km; but lower reaches downstream of Sirajgonj shows relatively very flat gradient indicating backwater influence of the confluence of the Ganges and the Jamuna rivers. The silt content of the Jamuna river is very high particularly during flood season. Concentration of over 4,000 ppm have been observed, although the average sediment content is much lower. The annual volume of silt is estimated to be about 735 million metric tons at Bahadurabad, of which 94 percent occurs in the monsoon period. The bed material is quite uniform with median diameter ranging from 0.25 mm to 0.16 mm, of which the former is found near the border and the later is found at the confluence with the Ganges.

Extreme seasonal variations in hydrological conditions of the Jamuna has not only created a very evolutionary landscapes, but also given organisms a rapidly changing layout of habitats and resulted a unique and specific floodplain environment. Any imposed condition on such a dynamically balanced system is sure to bring repercussion throughout the entire ecosystem until a new balance is attained under the set conditions.

2.3.2 Ground Water

The JAFP area is underlain by a great thickness of unconsolidated sediments from sands to clay. Under these conditions it is most probable that hydraulic continuity and function of groundwater exists as a semi-unconfined storage system. The water table remains at par with surface water of the Jamuna river. Studies under FAP 3.1 indicate that direct interchange of water between the ground and the Jamuna river would be limited to a 2-3 km strip of land on either sides of the banks. Beyond this limited extent there will be relatively little interchange of water between the ground and the river, due to prevailing low hydraulic gradients. Moreover, most groundwater movement in those localities is vertical, either downwards as infiltration of rainfall and floodwater, or upwards, as capillary rise. That is, the groundwater beyond 2-3 km strip of land on either sides is recharged by rainfall and flood water.

2.3.3 Water Quality

Water quality in the Jamuna river varies seasonally with the changing flow. Water quality is generally favourable. Industrial development along the banks of the Jamuna and its tributaries is still limited:

- Dewangonj Sugar Mill, near Bahadurabad ghat, discharges its waste water into large open areas. These basins are high enough to be protected from flood but are reported to leak very badly. In 1988, these were even flooded, but the Sugar Mill was not working at this moment. Wastes are finally stocked in heaps. Most probably, no or light pollution from the Sugar Mill goes to the Jamuna.
- One major fertilizer plant, based on natural gas, has gone under production recently at Sharishabari, in Jamalpur district. The factory requires the extraction of quite large quantities of water from a tributary of the Jamuna. Some 50 % of the water pumped is recycled. The rest, treated and diluted waste water, is discharged back into a small lateral channel of the Jamuna, which is progressively getting dry. There is not enough water in it to ensure dispersion of pollutants during the dry season.

Major sources of pollution in the Jamuna river are domestic effluent which is not treated, and chemicals used in agriculture, application rates of which are higher in the factory area. There appears to have been very few data, concerning water quality, collected in the Jamuna area. No water samples were collected for this preliminary study for FAP 21/22. However data obtained from other projects have been used for this study. As each of these projects made differing analyses, a comparison of the results will be made.

All the sampling sites are indicated on a map (Fig. 2.3-1).

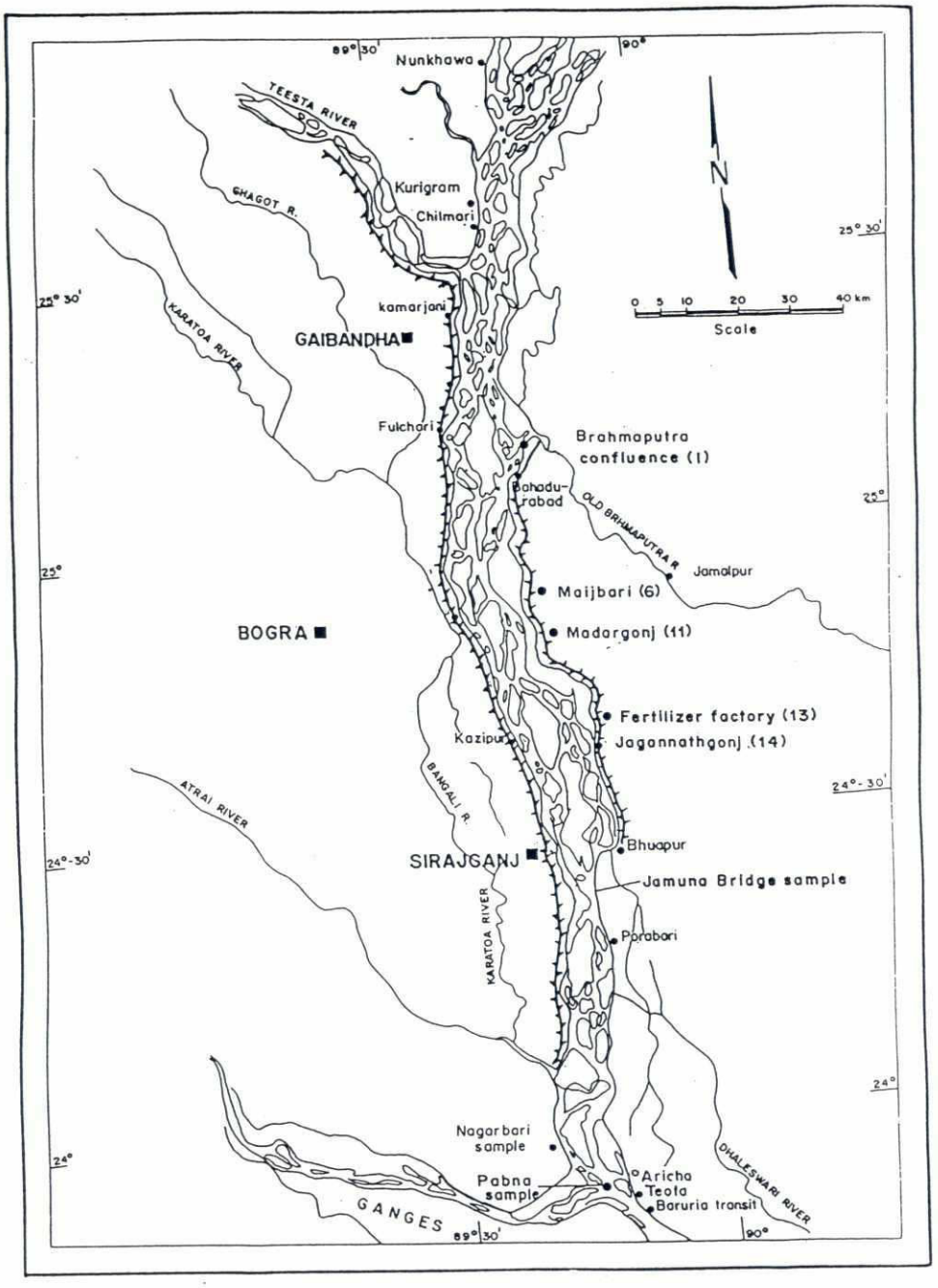


Fig. 2.3-1: Location of water samples

The results of their analyses are recorded in the following tables:

- Tables 2.3-1 and 2.3-2 : FAP 3.1, wet and dry season samples (north left bank);
- Table 2.3-3 : FAP 2, dry season samples (right bank);
- Tables 2.3-4 and 2.3-5 : Jamuna bridge project sample, and one reference table of water quality at Nagarbari, and
- Table 2.3-6 : Standards of water quality.

FAP 3.1	Chemical Analysis															Micro Biological Analysis		
Sample locations (n°)	Time	Dissol-ved Oxygen (ppm)	Free Co_2 (ppm)	pH	Tp° (°C)	$Caro_3$ Calcium bi-carbo-nate (ppm)	No_3 mitrates (ppm)	PO_4 Phos-phates (ppm)	I Iodine (ppm.10^4)	Si (ppm)	K (ppm)	Zn Zinc (ppm)	So_4 (ppm)	Fe (ppm)	Nacl Sodium chlo-ride (ppm)	Total n° of Bacteria/ 100 ml	Faecal colli-forma bacilli	Total n° of gram negative bacteria/ 100 ml
Old Brahmaputra Jamuna confluence (1)	11.11	12	6	8.5	21	80	0	0	0.88	11.0	4	nt	17	0.10	14.04	$5\text{-}8.10^{15}$	-	-
Maijbari (6)	17.10	5.8	2	9.5	21	80	0	0	0.87	8.0	4	nt	nt	3.05	5.85	-	-	-
Maderganj (11)	10.00	6	0	9.0	28	60	0.3	2	0.76	8.0	4	nt	4	0.30	12.0	$4.2.10^5$	$1.7.10^4$	$5.7.10^4$
Fertilizer factory (13)	15.05	5	0	9.5	30	56	22.0	16	0.86	6.0	11	nt	58	0.08	12.0	$1.4.10^5$	$1.0.10^4$	$7.4.10^4$
Jogannathganj (14)	15.40	4	0.01	8.5	29	55	0.4	1	0.61	7.5	3	nt	11	0.20	9.0	10.10^3	$2.2.10^4$	$38.6.10^4$

Table 2.3-1: Dry season samples of the north left bank of the Jamuna river

(Source: FAP 3.1, 1992)

	Chemical Analysis															Micro Biological Analysis		
Name of the Spot	Time	Dissol-ved Oxygen (ppm)	Free Co_2 (ppm)	pH	Tp° (°C)	$CaCo_3$ Calcium bi-carbo-nate (ppm)	NO_3 mitrates (ppm)	PO_4 Phos-phates (ppm)	I Iodine (ppm.10^4)	Si Sili-ka (ppm)	K Pota-ssium (ppm)	Zn Zinc (ppm)	SO_4 Sul-phate (ppm)	Fe Iron (ppm)	Nacl Sodium chlo-ride (ppm)	Total n° of Bacteria/ 100 ml	Colli-form bacteria	Faecal Colliform bacteria/ 100 ml
Old Brahmaputra-Jamuna confluence (1)	16.05	8.8	4	7.37	30.7	12	0.60	9.10	0.18	6	10.92	2.07	3.84	1.02	6.61	$18.0x10^5$	$15.7x10^3$	$0.2x10^2$
Majbari (6)	18.03	8.7	8	7.27	29.3	12	0.62	5.15	2.79	6	6.18	2.65	4.51	1.23	6.61	-	-	-
Maderganj (11)	14.55	5.9	7	7.60	30.0	12	1.63	13.42	0.15	3	16.10	2.81	4.13	1.10	10.75	$37.7x10^5$	$1.1x10^3$	$7.0x10^2$
Fertilizer Factory (13)	18.00	7.2	0	9.30	30.8	16	15.5	9.35	1.25	15	11.22	2.97	4.37	1.79	18.61	$25.0x10^5$	$3.3x10^3$	$4.0x10^2$
Jagannathganj (14)	18.30	12.2	2	7.08	29.1	8	0.42	6.10	1.35	5	7.32	3.26	4.79	1.10	7.45	$6.9x10^5$	$1.8x10^3$	$51.0x10^2$

Table 2.3-2: Wet season samples of the north left bank of the Jamuna river

(Source: FAP 3.1, 1992)

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Location	Do mg/l	BOD mg/l	COD mg/l	pH	NH4 mg/l	Cl mg/l	SO4 mg/l	Fe mg/l	Coliforms n°/100 ml
Kurigram (Jorgas Ghat)	8.7	2.6	25	8.2	0.1	6	11.3	0.7	130
Gaibandha (Manos Reg.)	8.6	3	21	8.1	0.3	7	0	1.6	>1000
Pabna (Nakalia bazar)	8.5	5.8	30	8	0.4	4	18.2	1.2	120

Table 2.3-3: Summary of water quality data for Jamuna river (right bank)
(Source: FAP 2, 1992)

Parameter	Level
Ph	7.9
Turbidity	18.0 mg/l
Suspended Solids (105 C)	44.0 mg/l
Suspended Solids (500 C)	< 1.0 mg
Ammonia Nitrogen (N)	< 0.05 mg/l
Total Organic Nitrogen (N)	< 0.2 mg/l
Nitrite (N)	< 0.005 mg/l
Chloride (Cl)	< 5.0 mg/l
Sulphate (SO_4)	12.0 mg/l
Reactive Phosphorous (P)	< 0.10 mg/l
Alkalinity ($CaCO_3$)	40.0 mg/l
Calcium (Ca)	23.0 mg/l
Sodium (Na)	2.7 mg/l
Potassium (K)	2.7 mg/l
Mercury	< 0.1 mg/l
Reactive Silica	8.6 mg/l
Total Iron	1.7 mg/l
Copper	< 10.0 μg/l
Zinc	20.0 μg/l
Arsenic (As)	< 5.0 μg/l
Chromium	< 10.0 μg/l
Nickel	< 10.0 μg/l

Table 2.3-4 : Water quality characteristics of Jamuna river sample taken in the vicinity of the proposed bridge project
(Source: Jamuna Bridge Project - Fisheries Study, 1982)

Parameter	Season	
	Wet	Dry
Dissolved Oxygen	6.55 ppm	7.63 ppm
Transparency	10.00 cm	23.00 cm
pH	7.82	8.22
Total Hardness	2.24 mg/l	12.60 mg/l
Chloride	8.60 mg/l	-

Table 2.3-5: Average wet and dry season water quality parameters in the Jamuna river at Nagarbari
(Source: Jamuna Bridge Project - Fisheries Study, 1982)

Tentative Water Quality Standards for Bangladesh

Parameters	Maximum allowable limits
Physical	
Turbidity	25 units
Colour	30 units
Threshold odour	unobjectionable
Chemical	
Total Dissolved Solids	1500 ppm
Chloride	600 ppm (max. 1000)
Iron	1 ppm (max. 5)
Manganese	0.5 ppm
Zinc	15 ppm
Copper	1.5 ppm
Sulphate	400 ppm
Total hardness	250 - 450 ppm
Fluoride	1 - 2 ppm
Nitrate	45 - 50 ppm
Phenolic substances	0.002 ppm
pH	6.5 - 9.2
Bacteriological	No detection of coliform bacteria in 90 % of samples
Toxic substances	
Cyanide	0.2 ppm
Hexavalent Choromium	0.05 ppm
Lead	0.05 ppm

Table 2.3-6: Standards of water quality

(Source: Department of Environment)

Standard Values for Water Quality in Banlgadesh for Various Uses

Parameter/Determinants	Unit	Drinking Water	Fishery Water	Irrigation Water
Alkalinity	mg/l	NYS	70-100	NYS
Ammonia (NH_3)	mg/l	0.5	0.25	3
Carbon Dioxide (CO_2)	mg/l	NYS	6	NYS
Chloride (Cl)	mg/l	150-600	600	600
Dissolved Oxygen	mg/l	6	4-6	5
Hardness ($CaCO_3$)	mg/l	200-500	80-120	NYS
Iron (Fe)	mg/l	0.3-1	NYS	NYS
Nitrite (NO_2)	mg/l	< 1	0.03	NYS
pH		6.5-8.5	6.5-8.5	6.0-8.5
TDS	mg/l	1000	NYS	2000

NYS: Not yet standardized

Table 2.3-6 (continued): Standards of water quality

(Source: Department of Environment)

From these data, comments on the principal results are furnished below:

Table 2.3-4 sample has been analysed three months after it was collected. Regarding this, number of parameters like NH_4+, organic nitrogen, nitrites, pH, turbidity, can not be interpreted. Jamuna Bridge Project suggests that iron and zinc concentrations can be harmful for fish. WHO standards are in agreement with this for Fe (max.:0.3 mg/l) but not for Zn (max.: 5 mg/l). Other parameters are acceptable according to usual norms used on the world.

- pH: from these data it is found that the pH value for the Jamuna water in this area is generally high, particularly on the left bank. In many cases it is in excess of the maximum tolerable pH value of 9. The high pH value indicates high photosynthetic algal activity.

  The wet season samples indicate a return to normal values, around 7 to 8, except at the fertilizer outlet. This is probably caused by the dilution effect of water. Values between 6.5 and 8, are ideal. In Majibari sample (Table 2.3-1), pH is higher than in other stations. This value can be a limiting factor for flora and fauna, and could create toxicity, in case of high NH_4+ concentration. More than 70 % of the ammonia is under gas form, in waters of pH 9.5 and 30°C, like in the fertilizer outlet. Skin and gills of fish can be destroyed if pH values is less than 5 or more than 9. In case of long term action, fish may die.
- Dissolved oxygen: oxygen saturation in warm water is less than in cold water. The percentage of oxygen saturation is satisfactory upstream, in old Brahmaputra confluence (Table 2.3-1), but then it decreases tremendously from Maijbari. However these values are still acceptable for the less exigent *Cyprinidae*. The cause of the oxygen deficit could be researched in organic matter oxydation. The situation during the wet season is quite better (Table 2.3-2).
- BOD and COD: these parameters are generally satisfactory for fish life. However Table 2.3-3 shows results of evolution of BOD and NH_4+ from upstream to downstream. Water quality is good in Kurigram, but in Pabna a moderate pollution is present.
- Transparency: transparency of the water is very low due to high sediment transport.
- Calcium carbonate: the calcium carbonate content in the river is fairly low. This factor is linked to geological substratum. Decrease of $CaCo_3$ from upstream to downstream (Table 2.3-1) probably expresses that the tributaries bring in more acid waters.
- Nitrates and phosphates: the Jamuna river does not present any sign of pollution, except at the fertilizer outlet. Here nitrates are high but still below the acceptable limit of 44 mg/l given by the WHO standard. This effluent, rich in nutrients, generates mineralo-organic pollution downstream. The water, containing high concentrations of Po_4, could be used as fertilizer for agriculture.
- Sulphates and potassium: concentrations of dry season samples are not dangerous for aquatic populations. However, the influence of the fertilizer plant can be noticed. Wet

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season concentrations are found to be higher, but this may be caused by improved analyses (see FAP 3.1 report).

- NaCl: values are in accordance with flora and fauna requirements. Wet season levels are generally even lower.
- Fe: on the left bank, iron levels are low and within acceptable standards, during the dry season. During the wet season, they rise up considerably, except in Maijbari (Table 2.3-1). On the right bank, concentration in Kurigram is already relatively high. But it is not known if there is some geological reason for that. Downstream concentrations are still higher.

  Concentrations below 1 mg/l express a moderate pollution, and above 1.5 mg/l is a real pollution.
- Silica: content is high in the river water which will promote increased growth of green algae during the dry season. Concentrations are quite lower in the wet season.
- Iodine: levels are generally low in the river.
- Bacteriology: coliforms concentration is quite acceptable on the right bank. On the left bank organic contents are generally high, especially faecal coliforms. They show significantly lower levels in the wet season due to flushing effect. Doubts have been expressed that the analyses were done too late after collection of the samples.
- Temperature: during the dry season, temperature is sensibly higher downstream on the left side (Table 2.3-1).

In summary, the study of physico-chemistry of Jamuna waters expresses a moderate pollution, with a seasonal variability. Dry season reveals a high photosynthetic activity, and high pH values (which need to be checked). This is a warning of toxicity risks near important organic effluent.

The global organic charge looks fairly light, NH_4+ concentration reveals some pollution symptoms. For metals, Fe is the one to care about.

3 BIOLOGICAL HABITAT

3.1 DIFFERENT TYPES OF HABITATS ALONG THE JAMUNA

The Jamuna river not only carries large seasonal water flows, but also silt load which means a rapidly changing layout of landscape as erosion and deposition proceed from year to year and from month to month during the flood period. Along with this landscape dynamism there exists a variety of habitats for a very diverse terrestrial and aquatic flora and fauna. Today, while species and habitats depletion prevail, diversity still remains within the avifauna and the freshwater icthyifauna.

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3.1.1 Charlands

Charlands, comprising **island chars** (char bounded by the braiding channels) including other large bedforms and **attached char** (area between the edge of the active flood plain and the actual location of bank of minor bed), are the major habitats in the JAFP area. They have distinct successions of natural and managed vegetation, settlement patterns and land use that have evolved with regard to land levels, **inundation** types (duration and depth of flood) and other landscape characteristics (e.g. soils structure and fertility). Besides, they are also important habitat for birds and livestock.

3.1.2 Homesteads

Homesteads provide the home and the main environment for people, livestock, poultry, green leaves and other vegetables, trees and bushes. They are built mostly in linear pattern along the floodplain and attached charlands, and nucleated very sparsely on the higher land levels of the island chars. The habitat provides nesting, breeding and feeding sites for a host of important insects, amphibians, birds and other small mammals. Homesteads also shelter various weeds and bush plants which have direct linkages to the ecology as well as health and productivity chain surrounding the homestead and the society together.

3.1.3 Wetlands and Waterbodies

Wetlands and waterbodies of the JAFP areas comprise rivers, beels, baors, borrow pits and ponds; of which the last two components are man-made. Wetlands and waterbodies habitats are extremely variable in their areal extent in relation to seasonal variations of local hydrological and morphological dynamics. They form vital link in the chain and maintenance of dynamics of species diversity, cycling of nutrients, sustenance of food chain, and in the control of pollution. The aquatic and seasonal terrestrial flora and fauna which they support, are the basis of survival strategies for many people. The wetlands sustain a wide variety of differing aquatic and semi-aquatic environments. They present important habitats for migratory birds. The linkages between the lowlands, wetlands and waterbodies are vital for the understanding of their working together to provide services in order to appreciate environmental management planning.

3.1.4 Fields and Open Countrysides

Fields and Open countrysides, the most wider habitats, play an important role in the increase of biodiversity. Most areas of floodplains and attached charlands are under field-cropping system. Relatively very small areas in patches do exist as fallow and/or cultivable waste representing open fields and countrysides in the floodplain and attached charlands. The situation is reverse in the island charlands, where a very high proportion of seasonal land surface remains as open **fields and countrysides**. This is because of the fact that the surface constituents of the island chars (AFP) are mostly noncohesive fine sands, of which the

moisture holding capacity is very minimum. These charlands are also subjected to both intensive and extensive wind action, not safe for population concentration.

3.1.5 Natural Banks

Natural banks on either sides of the Jamuna river provide a variety of habitats for both flora and fauna. Seasonal vertical banks are good habitats for fishing birds, particularly the King Fishers living in dig-in-holes on the vertical bank. A good number of reptiles and amphibians including snakes find vertical bank as living place. Vertical banks underwater provides good habitat for few species of eel families. There also exists sloping banks on either sides of the river. They are formed mainly through landslides. These sloping banks provide habitat for wild weeds and shrubs which are in turn good habitats for a host of insects and amphibians. If sloping bank is very gentle, vegetables and tobaccos are also cultivated. Natural banks are essential as an access to the river for seasonal fishermen as well as for cattle and people.

3.1.6 Grasslands

There appears no specific grasslands in the floodplain and attached charlands except for patches of fallow lands and **aile** (demarcating land-holdings) where wild grass (e.g. durba-ghash) are seen to grow. But, extensive areas over island chars provide seasonal growth of grasses, particularly the catkin species. These grasslands are the main cattle grazing resource, although livestock in island chars has not developed as it could be. Extensive colonisation of these grasses also helps stabilization of the charlands by halting aeolian erosion and facilitating deposition of silts during inundation.

3.1.7 Levee Lands

Natural levees are composed of non-cohesive coarser sediment, particularly medium to fine sands, and man-made levees are built using fine silt and clay materials. Natural and man-made levee lands on either sides along the Jamuna river provides habitat for a host of flora and fauna. Natural levee land are mostly under homesteads where varieties of trees, bushes and creeping weeds provide habitats to feeding, nesting and breeding of birds, insects, reptiles and amphibians. A well built levee (embankment) exists on the right floodplain of the Jamuna. Planted trees, wild grasses, weeds and bushes are frequently seen to colonise the sloping sides of the levees. They provide excellent habitat for birds, snakes, mices, insects and a host of other faunas. The man made levee on the left of the Jamuna built by local initiatives is discontinuous. They also provide good habitats for a host of flora and fauna.

3.1.8 Forestry Zones

There exists no forestry or forest land in the JAFP area. But there appears a variety of trees and plants in the homestead groves to provide fruits, building materials, domestic fuels and

timber wood. These trees and plants are also the nesting and breeding sites for many birds and insects.

3.2 BIOLOGICAL RESOURCES

3.2.1 Biodiversity

Biodiversity literally means the diversity of living forms. It includes different levels of diversity:

- genetic diversity: which refers to races and varieties within a species;
- species diversity: concerns as much the micro elements as the "macro-species" (flora and fauna) of the aquatic and terrestrial surroundings;
- ecosystem diversity: different kind of habitats shared by quantities of species with different needs.

All the living species are continuously evoluating due to the dynamics of their environment. This evolution is possible only from the gene pool of the populations. Disturbances caused by human activities may reduce this pool and the consequently possibilities to evoluate. Biodiversity is essential for improvement of agriculture (genetic resources for new species or varieties), to struggle against epidemics, for medicinal uses and also adaptation of the species to natural or human made changes of the environmental conditions.

The ecosystem diversity of the Jamuna Active Flood Plain is important due to the aquatic-terrestrial interface. A number of different habitats defined as river channel, wetlands and beels, floodplain, islands, river banks, grasslands, cultivated lands and embankments offer different physical conditions to the living forms.

The species biodiversity of Bangladesh is important due to the favourable position and climatic conditions for the growth and the development of many plants and animals. There are about 5,000 vegetables species divided in forests, cultivers, homesteads, and natural plants. About 660 birds have been inventoried, of which some 110 residents and migratory birds are found in the north-western region. About 200 species of mammals were known to live in this part of the world during the beginning of 20th century; but currently the number is less than 100 species.

There are 19 species of amphibians, 150 reptile species (including 31 turtles and tortoises), 18 species of lizards and 78 species of snakes currently known to exist in Bangladesh (some are predatory or act as biological pest controller).

There are 260 freshwater species of fishes, of which some 200 species are found in the Jamuna floodplain and other areas of the North-Western region. Of these a total of 110 species are marketed and another 40 species are valuable for local economic or social importance. The position of fish in ecological terms is at the top of aquatic food chain.

Through their feeding habits fish controls aquatic weeds, secondary disease vectors and crop pests. They are the vital link in the food chain between rivers and floodplain, and the main source of protein for the rural millions.

3.2.2 Aquatic and semi-aquatic resources

(1) Macrophytes

Aquatic plants do not seem to be so frequent in the JAFP, but the incidence of these has not been sufficiently investigated. Because of strong current and the deficiency of light caused by the high concentration of suspended matter, most of the area is likely to be low in aquatic macrophytic flora.

However, at the bank edges where the river current is not so strong, in shallow waters and on the chars some aquatic plants can grow. This is also true in the case of mainland beels and depressions.

Acquatic plants can provide shelter, food or spawning grounds for fishes. But when they grow too rapidly in stagnant waters they can hinder fish development.

During the field works some species have been identified:

Botanical Name	Bangla Name	Frequency*	Location
1. *Azola pinata*		(1)	submerged
2. *Chara*		(1)	floating
3. *Hydrilla verticillata*	Kata shaola	(1)	submerged
4. *Eicchornia crassipes* (water hyacinth)	Kachuri pana	(3)	floating (fodder)
5. *Lemna minor*	Khudi pana	(2)	floating
6. *Spirodella*		(3)	floating
7. *Spirogyria*		(2)	submerged
8. *Pista stratiotes*		(2)	floating
9. *Wolffia arrhiza*	Guri pana	(2)	floating
10. *Ipomoea aquatica*	Kalmi,Kalmishak	(2)	Semiaquatic (edible)
11. *Nymphaea nymphoides*	Shapla	(3)	floating (stem used as food)

* Frequency: 1: Not frequently found 2: Fairly common 3: Very frequently available

Water hyacinth is abundant all over Bangladesh, occurring in most of the stagnant waters. However, unlike some other countries where it is considered a pest, some use of this has been found; as a raw material for handicrafts, as mulch for seeds and as fodder, although this is of low nutritional quality.

(2) Microflora and Fungi

Microflora constitutes the primary basis of the food chain, energy and nutrient cycle for organisms. Little information about its status and distribution in the JAFP areas are known. Safiullah and Huq (1990) indicated the Plankton count of the Jamuna river showing peaks of primary productivity in June as well as during the period from December to March; July-October are the month of low production due to, among other things, poor photic condition created by high turbidity. The species (phytoplankton) identified include *diatom-myxophycae, chlorophycae, actinast, chlorella, anabaena, cyllindrosper, dyagbya, merismopoedia, mycrocystis*. Further, the role of these micro-organisms in flood carried deposit from catchments is very poorly researched.

Micro-organisms play a crucial role in the decomposition of organic matter, formulation of plant nutrients and a healthy soil environment. Little information is available on the diversity and role of fungi and bacteria. Some data on field pests in tree and field cropping are available from BRRI and BARC.

(3) Microfauna

Very little information on aquatic microfauna of the JAFP areas is available. Plankton counts on a very limited scale showed presence of the dominant zooplankton which are *rotifers, asplanchna, brachionus, filina, keratella, monostyla, notop*, etc.

(4) Molluscs

Molluscs shells of fresh water are commonly known as snail-physa, of which number and distribution are not known in the JAFP areas. Many species of fish and migratory birds feed on them. When abundant, physa indicates organic enrichment or organic pollution. Mussels, such as *carbicula*, are also seen to burrow sand from the stream bed, some have been identified during field works, in the Jamuna river.

(5) Amphibians and Reptiles

There appears a list of 19 species of amphibians and 150 reptiles in Bangladesh, of which most are regularly exploited. Among the amphibians, frogs and toads are important for the natural control of agricultural pests. They depend on aquatic ecosystems to complete their life cycle. Information on types, population and distribution of frog and toad is not known. Very short field observaton in March'92 has confirmed the presence of Kuno Bang (Ranalimnocharis), Kola Bang (*Bufo melanostictus*) and Gecho Bang (*Rhacophorus bimaculatus*). No inventory of aquatic reptiles of JAFP areas has been prepared. Field observation has confirmed the presence of four kinds of snakes in the area; they are Gokhra (*Kobra*), Laodoga, Dhora and Darash. A few fish-eating ghorials (*Gavialis gangeticus*) are reported to occur in the Jamuna. Among the fresh water tortoises, Gangetic river turtle - a threatened species, is sometimes seen in the Jamuna.

(6) Mammals

Not many aquatic mammals have been identified along the Jamuna.

The common mammals are :

- Common otter (*Lutra Lutra*)
- Gangetic dolphin (*Planista gangetica*/Shishu)

The otter is not very common in the floodplain. Shishu oil is used for its medicinal properties. Gangetic dolphin population is estimated at 1500 in Bangladesh; 1 to 2 % of this is estimated to be caught for making oil.

(7) Fish

The fish survey is one of the most important part of the Ecological Assessment as this resource concerns directly the human population and is not seen from only an ecological point of view. In fact, using FAP 3.1 figures (which must be over estimated for the Jamuna), the agronomic survey of FAP 21/22 has estimated that fish intake represents 20g per person per day, that means 50 % of the total animal protein intake.

However, the fish survey is not only one of the most important, but also probably the most difficult one. A very few reliable information about fish component is available in Bangladesh and within the time limit it was not possible to make a comprehensive fish and fisheries assessment.

Therefore, rather than using an usual methodology, this study is founded on the following basis:

- Site visits along the Jamuna river: on the riverside and by boat to collect information at two different periods March-April (dry season) and October-November (high water level);
- Interviews with fishermen on the Jamuna charlands and mainland;
- Interviews with organisations of Bangladesh (NGO, Thana Fishery Officers, Department of fisheries, etc.), and
- Results from other FAP, mostly FAP 3.1.

Using these data and combining with probable hydrological changes due to the Project, an evaluation of the likely modifications in fish population has been made.

(a) Species and Distribution

The Jamuna fishery system is a natural uncultivated fish production system composed of self-reproducing and self-sustaining populations of some 7 main groups of species: Major Carps, Catfishes, Hilsa, Prawn and Shrimps, and other Carps - the rest of the species are grouped in the "Miscellaneous Group". Breeding, multiplication and sustenance of these fish populations and prawns are tightly bounded to the pattern of flooding during the monsoon. All open water components (rivers, khals, beels) and the active flood plains become connected with each other forming an integrated single biological production system. This integrated system of the Jamuna river, lasting for 4-5 months, provides suitable aquatic habitat for reproduction, migration, feeding and growth of fishes and prawns.

One of the most important group of the fish of the Jamuna, regarding abundance, weight, commercial interest and fry collection, is the Major Carps (*Cyprinidae*): Ruhi (*Labeo rohita*), Catla (*Catla catla*), Mrigal (*Cirrhinus mrigala*), and Kalibaush (*Labeo calbaus*). In 1988-89 (see Table 3.2-1), these four species represented 5 % of the total annual catches; the whole carps catches together were 18 % including Ghania, Tatkeni, Punti, etc...

Species Name	Year		
	1986-87	1987-88	1988-89
Major Carp	46 (1.3 %)	96 (3.45 %)	129 (5.0 %)
Other Carp	179 (5.2 %)	225 (8.09 %)	345 (13.0 %)
Cat fish	224 (12.4 %)	482 (17.33 %)	474 (18.0 %)
Hilsa	920 (26.8 %)	560 (20.13 %)	493 (19.0 %)
Big Shrimp	1 (0.0 %)	00 (0 %)	00 (0 %)
Small Shrimp	168 (4.9 %)	121 (4.35 %)	118 (4.4 %)
Misc.	1694(49.4 %)	1298 (46.65 %)	1078 (41.0 %)
Total	3432 (100 %)	2782 (100 %)	2637 (100 %)

Unit : Metric ton (%)

Table 3.2-1: Annual total catch by species in the Jamuna

(Source : BBS, Statistical Yearbook of Bangladesh, 1991)

One other important group is the catfishes including a lot of species like Ayre, Bagha-ayre, Tengra, Rita, Boal, Pangas, Shilong etc; they represent 18 % of the annual catches.

In the south of the Jamuna, from Bhuapur to the confluence with the Ganges, Ilish (*Hilsa ilisha*) forms the largest, single species fishery in inland water. It amounts to 19 % of the total annual catches of the country, and 23 % of the catches in Tangail district (22 tons per year).

Refering to the Project's field observations (see Table 3.2-2), some other species, usually included into the "Miscellaneous group", are also very common in the Jamuna river, like the following ones:

- Korshula : *Mugil corsula* (*Mugilidae*)
- Bacha : *Eutropiichtys vacha* (*Schilbeidae*)
- Chela : *Salmostoma arzentea* (*Cyprinidae*)
- Gutum : *Lepidocephalus guntea* (*Cobitidae*).

	Z1	Z2	Z3			?	Z4	?	DB	Frequ-	When			When they are caught										
	G	BE	S	J	BH	SH	A	*	B	ence	C	F	B	J	F	M	A	M	J	J	A	S	O	N	D
Rui	x	x	x		x	x		x		1															
Catla/Katla	x	x	x	x	x	x	x	x		1															
Gharua	x	x	x					x		2						*									
Chela			x	x		x		x	x	3+															
Bhacha			x							3						*									
Tangra/Tengra		x	x	x	x	x	x			3															
Bacha ayre	x	x	x			x	x	x		1-4															
Kalibaush	x	x	x					x		1															
Rita		x	x			x				1-2															
Boal		x	x	x		x		x		2															
Baim			x			x				2															
Bili/Bele	x	x	x			x				1-3															
Khorshala			x							3+															
Ilish/Hilsha	x		x			x	x	x		1						*									
Gulsha		x	x							3															
Chand		x	x													*									
Bash patar	x	x	x			x				2-3															
Bao mach			x							1						*									
Shilong			x			x				1						*									
Magur		x	x					x		2															
Chital		x	x			x				2															
Koi		x	x				x			2															
Shing		x	x			x				1-2															
Punti			x		x	x	x	x		1															
Chingri				x		x	x	x		3						*									
Guzi ayre						x				3						*									
Baush						x		x		1															
Mola/Moya		x				x				2/3															
Choruli						x		x		2															
Ghora						x				2															
Gushi						x				2															
Balashi						x				2															
Potka		x				x				1															
Korali						x				2															
Verush/Ayre								x																	
Mrigal		x		x	x			x		1															
Chaoa	x							x		1						*									
Chyatengra	x							x		1						*									
Foli		x			x					2															

Table 3.2-2: Field observation of fish by FAP 21/22

	Z1	Z2	Z3			?	Z4	?	DB	Frequer	When			When they are caught										
	G	BB	S	J	BH	SH	A	*	B		C	F	B	J	F	M	A	M	J	J	A	S	O	N	D
Golda chingri	x							x		2						*								
Caya cata	x									1						*								
Pangas	x			x	x		x			1-2														
Ruai							x																	
Shoal/shole		x				x	x			1-2														
Gre							x																	
Gojar		x					x			2														
Catfish							x																	
Kazoli							x																	
Tit punti									x															
Keski				x																				
Tin cata				x																				
Ayre				x																				
Chapila		x								1														
Fasha		x								1														
Raikh		x								1														
Sar punti		x								1														
Deto punti		x								2														
Ful chela		x								2														
Darkina		x								2														
Gutum	x	x								2-3														
Pabda		x								1														
Chaga		x								1														
Kakila		x								2														
Kumirer khil		x								2														
Cheng		x								2														
Taki		x								1														
Kuchia		x								1														
Lal chandha		x								1														
Bheda		x								-														
Napita koi		x								1														
Kolisha		x								2														
Chund kolisha		x								2														
Khorshula		x								1														
Boro baim		x								2														
Tara baim		x								1														
Pankal		x								2														
Poa							x			1														

Areas:
- G = Gaibandha
- BB = Bahadurabad
- S = Shariakandi
- J = Jagannathganj ghat
- BH = Buhapur
- A = Aricha
- * = islands

Frequency:
- 1: Not frequently mentioned
- 2: fairly common
- 3: very frequently mentioned

Location:
- C = Channel (main river and side channels)
- F = floodplain
- B = beels

Table 3.2-2 (continued) : Field observation of fish by FAP 21/22

Most of these species have a small size when they are adults (from 5 to 10 cm), except the bacha which may attain a size of 30 cm. The catfishes are longer in size (10 to 45 cm).

The carps are fast growing species and may attain weight of 10 to 20 kg. These are extensively cultured in ponds. One of them ruhi, is often infected by a Copepod (*Argulus*) which can cause a heavy mortality in ponds.

Concerning the species for which we have information, most of them are caught all along the year but in variable quantities. This is less true for a little number of species like; mola (*Amblyo-pharyngodon mola/cyprinidae*), sar-punti (*Puntius sarana/Cyprinidae*), deto-punti (*Puntius stigma/ Cyprinidae*) and lal chanda (*Chanda ranga/Centroponidae*) which are found only or mostly from the rainy season to the winter time (July-December). This information needs to be checked. People from islands reported that at the end of the rainy season they eat fish every day; but in March they could consume fish only once a week, due to its scarcity.

The general tendency in Bangladesh is the decrease of total fish stock - in the Jamuna, this is less sensitive, but however, fishermen reported that catches and size of caught have declined. This can be related to over-fishing as people use smaller mesh nets, though it is legally forbidden. Young fish catches reduce the number reproduced and therefore influence the turnover of the fishstock. But most probably, there are some other reasons which are not yet identified, like effects of development. Quantity of fish caught per fisherman has also decreased as the number of occasional fishermen is increasing very quickly. In fact, all the landless people try to find some extra income from fisheries.

(2) Habitats and migrations

The knowledge is at the present time really limited regarding the ecology of fishes. However, three main kinds of fish could be defined: (see Fig. 3.2-1)

- riverine dependant species;
- flood plain dependant species, and
- major carps.

+ Riverine dependant species

The Consultant inventoried 9 species which are only (or mostly) caught in the main channels of the river. Catfishes (garua, bacha, rita, bagha ayre, ayre, pangas), hilsha, one kind of pearch (poa), shrimp and prawns (chingri) (see Table 3.2-2). In fact, it can be seen from Table 3.2-3, 99 % of the hilsa and 40 % of the shrimps and prawns are caught in the rivers; but only 13 % of the catfishes. The others are caught in beels.

These population undertake migrations,for long as well as short distances, over their habitats to breed, feed and grow. The migration can be anadromous i.e. from the sea and the coastal waters into the freshwater in the rivers as in case of Hilsa. Hilsa lives in saline water environment in the coastal areas. During the monsoon season, breeding population of hilsa

migrate upstream into the main rivers, mainly the Meghna and the Padma, and the south of the Jamuna, to spawn and multiply. The Juveniles, known as "Jatka" stay there for nursing and grazing. Then adults return to the sea.

The migration of riverine species may be catadromous also, i.e., from the fresh-water habitat into the marine waters for breeding, as in case of Giant freshwater prawn (*Macrobrachium Rosenbergii*).

Poa is also resident of saline waters and moves in the river during the rainy months.

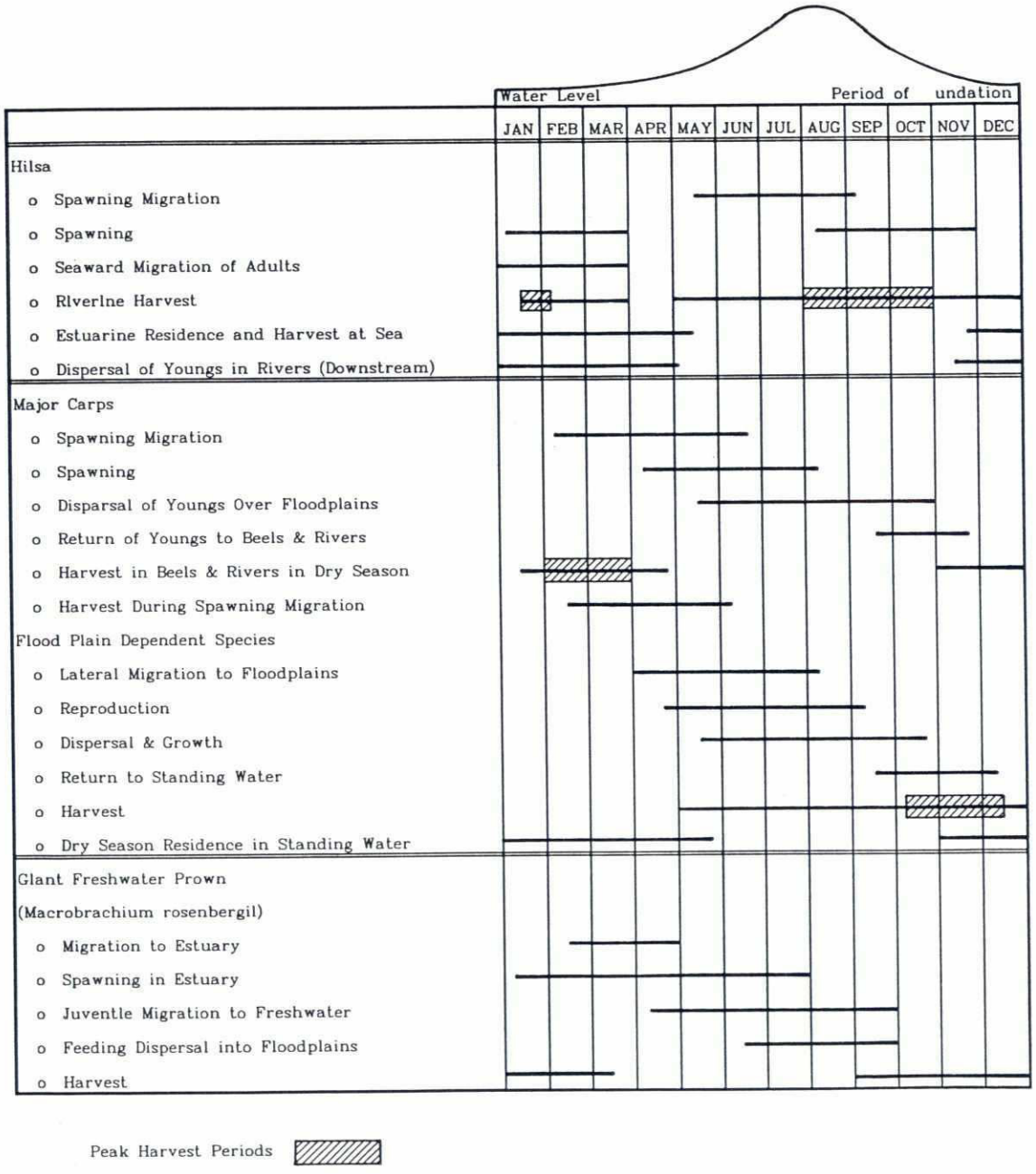


Fig. 3.2-1: Major fresh water fish and prawn activities in the open waters of Bangladesh

(Source: MPO Technical Report No. 16, 1985)

Species	River	Sundar -ban	Beel	Subsis-tence	Baor	Pond	Kaptai Lake	Shrimp Farm	Total	% of Weight
Major Carp	1,795		5,337	3,797	453	91,008	195		102,585	16.88
Other Carp	3,594		4,749			3,658	217		12,218	2.01
Exotic Fish			480		365	11,735	1		12,581	2.07
Catfish	2,989		8,562	9,046	3	2,604	623		23,827	3.92
Snake Head			1,006	9,678	88	5,301	37		16,110	2.65
Live Fish	60		583	17,068	41	7,549			25,301	4.16
Other Inland Fish	72,073	5,230	23,904	127,143	366	32,304	2,366	8,937	272,323	44.82
Hilsa/Illish	81,107	534							81,641	13.44
Big Shrimp & Prawn	2,028	507						14,986	17,521	2.88
Small Shrimp & Prawn	17,494	145	2,398	19,394	5	853		3,249	43,538	7.17
Total	181,140	6,416	47,019	186,126	1,321	155,012	3,439	27,172	607,645	100

Unit: Metric ton (%)

Table 3.2-3: Species group-wise catch in inland fisheries by sector 1988-89

(Source : Catch Assessment Survey, DOF)

+ Flood plain dependant species:

On the low lands seasonally inundated, there are occasional accumulation of animal dung and rotten vegetation. These nutrients rapidly enter into solution during the earlier stages of flooding. Combined with river borne silt, carrying minerals they support rapid growth of plants, insects and other forms of aquatic life. This outburst of productivity provides the essential conditions for reproduction, feeding and growth of many species of fishes which with rising water migrate into the flood plain for feeding and breeding.

The typical flood plain fish like Koi, Shingi, Taki, usually live in the depressions during the dry season, often in the muddy grounds. As soon as the flood comes they go up and start to spawn in the flood plain. They use the flood plain to grow and then return to the depressions. They are usually fish of small sizes. Shingi and Koi like turbid water and water hyacinth areas. These species are also found in the rivers.

+ Major Carps: (TSAI, C. 1981 and 1986)

The spawing biology of the three main major carps, *Catla catla, Labeo rohita and Cirrhinus mrigala*, is the most studied. However, factors that determine timing, location, migration and brood stock origins and extent, remain unknown. In the Jamuna river, only few days old fries are found. Major carps apparently do not spawn in the Jamuna river, they spawn on the old Brahmaputra river. From there spawn of major carps travel through the river systems to the

Bay of Bengal with the current.

Major carps spawn from April to June (with a peak on May-June), on new moon or full moon. They start to migrate just before the monsoon, when water level increases due to snow-melt. They apparently breed on shallow sections of selected rivers. The new born youngs of river breeding fish like major carps are swept downstream from the spawning grounds. These hatchlings (called fry or spawn) then move into monsoon inundated flood plains using counter-flow current, in search of food and relatively stable environment to graze, feed and grow. At the end of the rainy season, the growing fish and adults move back with the receding water into the Jamuna river.

+ Beels, Haors and Baors

Beels and haors are natural depressions that are submerged during the flood season. The term "Haor" is commonly used for depressions which are larger in size and which do not dry up during the dry season. Not many are found in the JAFP, except in the areas where there is no embankment or where it has been breached. The productivity of Beels and Haors is very high and may attain 1890 kg/ha per year.

Baors are also natural depressions, usually formed by the change of course of the river, or oxbow-bends. The average production from Baors under fish culture ranges from 150-170 kg/ha with the highest 582 kg/ha in the Government owned baors.

(C) Reproduction

To complete the general information about fish breeding, the Consultant tried to improve the knowledge through field interviews. These data must be taken with reservation, however they agree more or less with the usual knowledge. For the 46 species listed in the Jamuna river, spawning period, duration and location have been indexed (see Table 3.2-4). Looking to the distribution of spawning over the year (see Fig 3.2-2) it can be seen that between June and August, 96 % of the species are spawning, except two: Fasha and Rita. The peak of spawning is in July. However, some species spawn early in January-February (Fasha and Bele) and some spawn late in October-November (Moya and Pankal). The spawning increases progressively from March to June, that means more and more species start to spawn. On the contrary, almost all the species (95 %) stop to spawn suddenly at the end of August with the end of the rainy season; probably to leave enough time for the fry to grow.

It can be observed from Fig. 3.2-3 that the duration of spawning is **varying a lot**, between two to eight months. From that observation, it can be supposed that probably the most weak and delicate species, concerning conditions needed for reproduction, will be the ones with a short spawning time. Three different groups can be identified as follows:

- very low-tolerance species (2 to 3 months spawning): 39 %
- medium-tolerance species (4 to 5 months spawning): 46 %
- high tolerance species (6 to 8 months spawning): 15 %

	Spawning period												Length of Spawn.prd.	Places of Spawning		
	J	F	M	A	M	J	J	A	S	O	N	D	(Month)	C	F	B
Fasha													2	■		
Chital													2	■	■	■
Chapila													2	■	■	■
Foli													5	■	■	■
Rui													4	■		
Katla													4	■		
Kalibaush													3	■		
Mrigal													5	■		
Raikh													4	■		
Sar punti													2		■	■
Deto punti													2		■	■
Moya													6	■	■	■
Fulchela													4	■	■	■
Darkina													5	■	■	■
Gutum													3		■	■
Gulsha tengra													2	■	■	■
Tengra													2		■	■
Rita													3	■		
Boal													2	■	■	■
Pabda													6		■	■
Garua													5	■		
Batashi													4	■	■	■
Pangas													6	■		
Bagha ayre													2	■		
Magur													2	■	■	■
Singhi													2	■	■	■
Chaga													4	■	■	■
Kakila													5	■	■	■
Kumirer khil													4	■		
Shol													5		■	■
Gojar													5	■	■	■
Cheng													6	■	■	■
Taki													5	■	■	■
Kuchia													2	■	■	■
Lal chandha													2	■	■	■
Bheda													3	■	■	■
Napita koi													4	■	■	■
Bele													8	■	■	■
Koi													4	■	■	■
Kolisha													3		■	■
Chand kolisha													5		■	■
Khorsula													5	■		
Boro baim													5	■	■	■
Tara baim													6	■	■	■
Pankal													7	■	■	■
Potka													4	■	■	■

C= channel; F= floodplain; B= beels

NB: This list has been made form short field visits and fishermen interviews. Therefore informations are uncertain. No difference is made by people between the river bed and lateral channels: everything is called "Channel".

Table 3.2-4: Spawning periods of local fish species

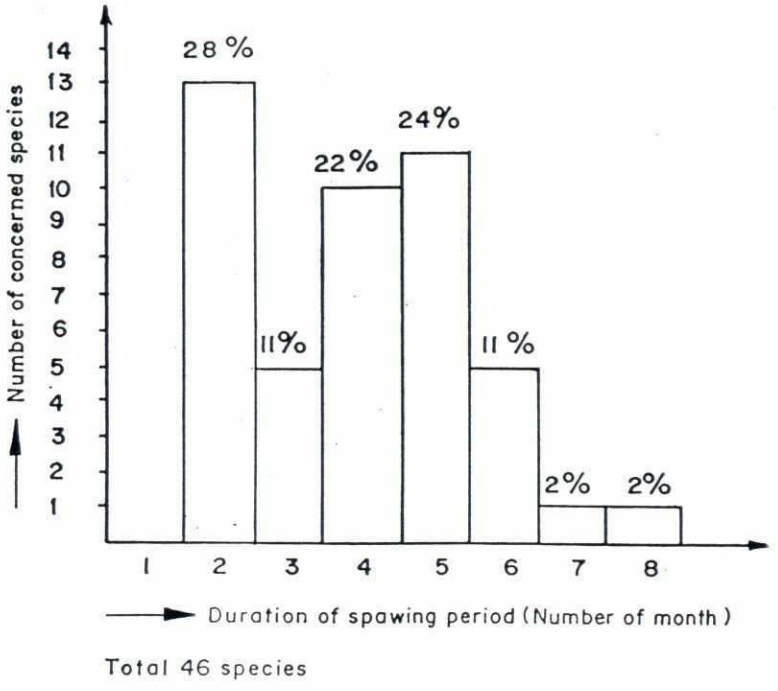


Fig. 3.2-2: Distribution of spawning over the year

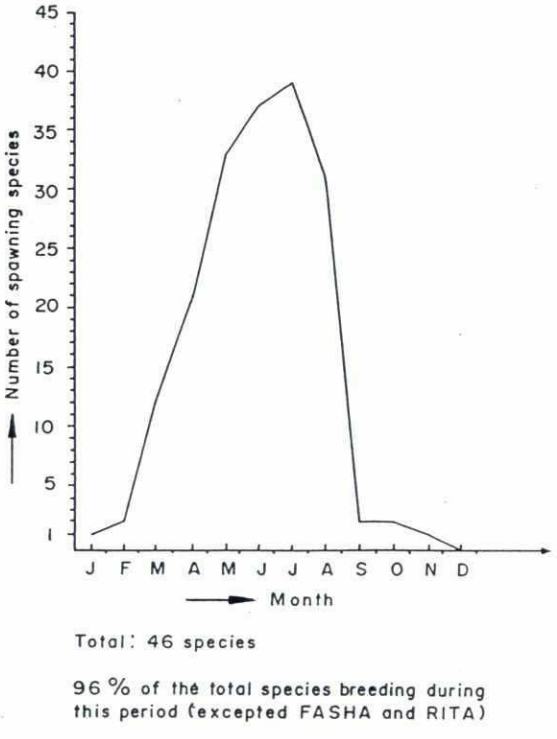


Fig. 3.2-3: Duration of spawning period (number of months)

Nevertheless, it is supposed that a short delay in starting of flood time does not affect the reproduction but only make spawning late. Fish are probably stimulated by the rising of water.

From Fig. 3.2-4 it can be observed that for 25 % of the species, "spawning" sites are localised only in the river channels; for 17 %, eggs or fry are found all over "stagnant" water, that means flood plains and beels; and for 57 % of the species eggs and hatchlings can be found in the three types of environments. It is difficult to conclude from these results for following reasons:

1. the difference between spawn, hatchling and fry is rarely made in rural Bangladesh;
2. the information may be modified during collection from fishermen, and
3. the spawns are dispersed from the point of spawning either in the flood plain or along the river.

However, there is some coherence with the existing knowledge about fish reproduction. For example, for fish known as river dependant like major carps and catfishes the "spawning" sites are localised in the main channels. Shingi, Koi and Gutum, which live in turbid water have their spawning sites in beels and flood plain. But it would be difficult to go further in conclusions without more specific data.

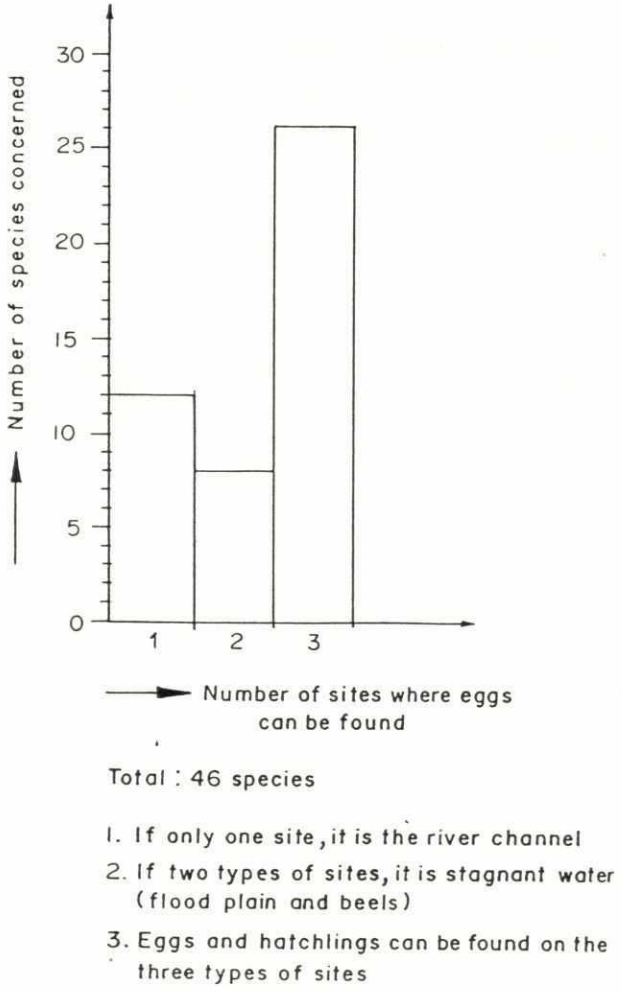


Fig. 3.2-4: Number of spawning sites

(d) Fry Collection

To provide ponds aquaculture with hatchlings, spawn (fry) is collected all along the Jamuna river. These collections concern mainly the major carps group, including a small percentage

of minor carps and other species which are not useful for pond cultivation.

The carp "spawn" fishery in the open inland waters plays a vital role in fresh water fish culture. 97 % of the total spawn production came from the spawn fishery and only 3 % was produced by hatcheries in 1984. 12,235.59 kg of spawn were collected in open water in 1989, where as 6,849.19 kg were produced artificially in private and Government hatcheries in 1987-88. Based on DoF estimation, one kg of "spawn" is about 30,000 numbers of 10 cm fingerlings, so the natural fry collection represented 367 million fingerlings in 1988-89 (Jamuna Bridge Project-Fisheries Study, 1982).

Out of the total of 52 Thanas concerned with the fry collection, 17 are located on the Jamuna river. That in 1984 represented 69 spawn collection centres out of a total of 161 and 35 centres out of a total of 112 in 1989. Most of the centres and the biggest ones are located on the right bank (Fig. 3.2-5). One of the most important centre in Bangladesh is Sirajganj (73 % of the total fry catch of the Jamuna in 1989).

In 1984, 17,509 kg out of a total of 23,657 kg (74 %) were caught in the Jamuna river system. Though in 1989 only 9,882 kg were caught, but this represented 81 % of the total fry catches of Bangladesh (See Table 3.2-5)

Sl. No.	Upazila	No. of Collectn. Centres	Catch (kg) 1984	No. of Collectn. Centres	Catch (kg) 1989
1	Kurigram	2	271.70	2	75.00
2	Chilmari	5	680.96	2	23.00
3	Gaibandha	2	360.06	1	215.00
4	Fulchari	6	2,947.02	3	897.00
5	Saghata	10	4,579.72	0	-
6	Sonatola	3	2,384.75	2	152.00
7	Sariakandi	7	962.53	3	182.00
8	Kazipur	2	3.50	2	143.00
9	Sirajganj	7	3,793.72	3	7,225.00
10	Belkuchi	2	91.50	2	175.75
11	Chauhali	4	43.00	1	4.80
12	Shahajadpur	4	271.50	3	81.00
	Total Right Bank	54	16,389.96	24	9,173.55
13	Dewangonj	3	218.05	2	500.00
14	Sarishabari	4	121.89	1	36.30
15	Gobalpur	2	16.18	2	5.00
16	Bhuapur	1	703.67	1	13.45
17	Sibalaya	5	58.80	3	50.00
18	Islampur	0	-	1	77.00
19	Madarganj	0	-	1	27.00
	Total Left Bank	15	1,118.59	11	708.75
	Total	69	17,508.55	35	9,882.30

Table 3.2-5: The spawn fishery data of the Jamuna river evaluation between 1984 and 1989

(Source: Department of fisheries)

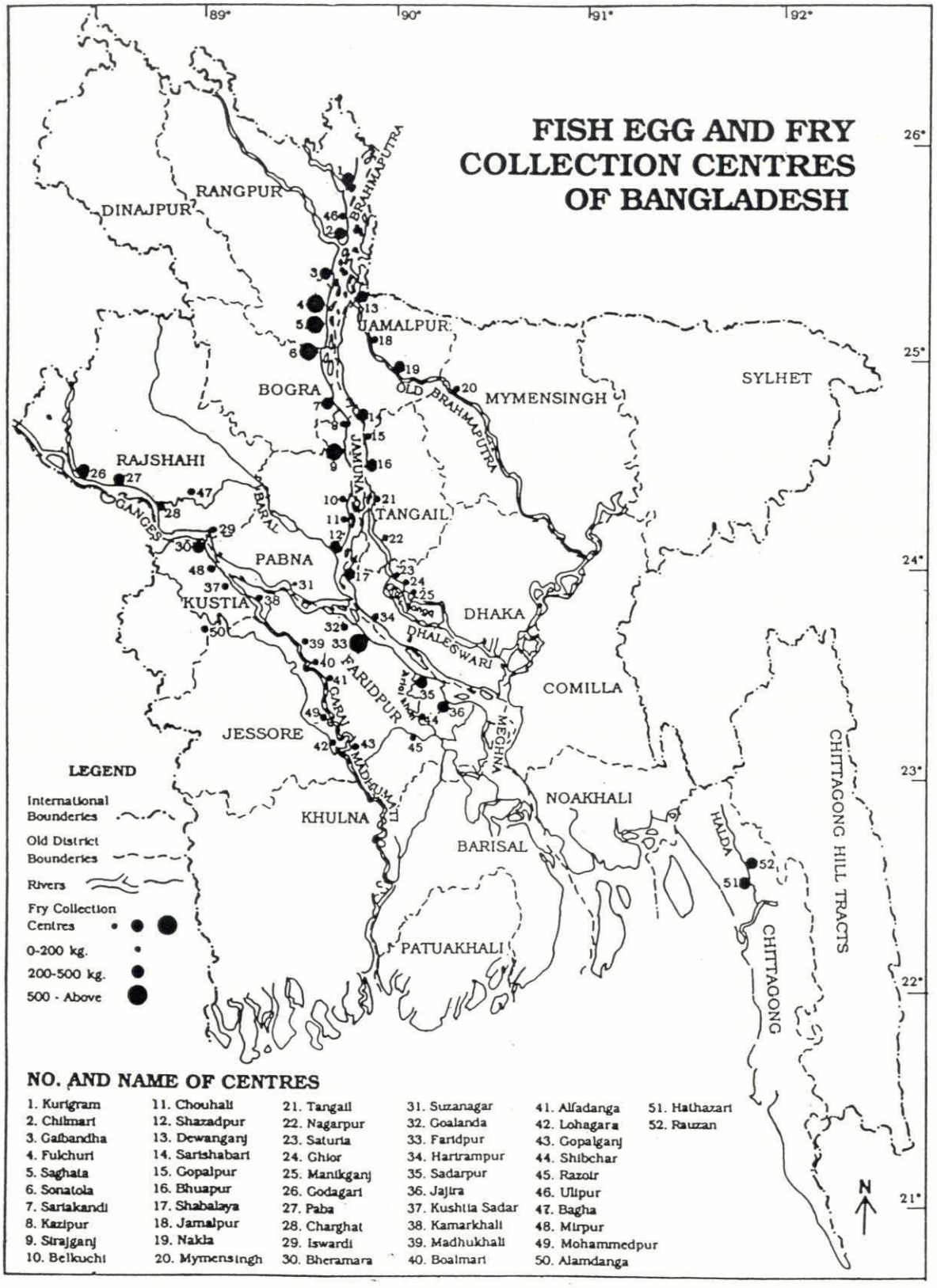


Fig. 3.2-5: Carp egg and fry collection centres of Bangladesh

From 1984 to 1989, the total quantity of fry catches (-44 %) as well as the number of centres has decreased (see Table 3.2-6); but it has increased locally in some places like: Kazipur,

Sirajganj, Belkuchi and Dewangonj. The average quantity of fry catch per centre has increased from 254 kg to 282 kg. Year by year study reveals that the total fry catch fluctuated and had decreased tremendously during 1988. Nevertheless the Jamuna system always represents a high proportion of fry catches.

		1984	1985	1987	1988	1989
Total Jamuna	Quantity (kg) number of centres	17,509 69	12,040 44	14,511 61	8,130 52	9,882 35
Total Bangladesh	Quantity (kg) number of centres	23,657 161	19,362 130	22,008 188	? ?	12,236 112

Table 3.2-6: Total quantity of fry catches

The Jamuna stock has declined but remained somewhat healthy as compared to the other stocks. The primary cause of this decline seems to be more over fishing in the carp fishery than the spawn fishery.

The collecting period starts from mid-May to the end of July, with 1 or 2 , and even 3 spawning times in Sirajganj.

The fishing intensity was 51 nets/km on the right bank of the Jamuna and 21 nets/km on the left bank. The catch per unit effort (CPUE) was 1.51 kg/net on the right bank (the highest) and 0.33 kg /net on the left bank. The CPUE decreases from upstream toward downstream (see Table 3.2-7).

On the Jamuna river 2,830 people were engaged in fry collection in 1989. Fry was sold at the price of Tk 1,000 to Tk 5,000 per kg. Collected spawn are kept in nets along the river bank. Pond owners and fish hatchling traders buy the spawn directly from Savar holders (Savar is a group of spawn collection nets operating as a unit in spawn collection) The number of nets in each Savar ranges between 4 to 60.

The topography of terrain, bank feature, water depth, current velocity, and direction of current are important factors in selecting a suitable site for spawn collection. A shallow water area along a gently sloping bank, where water depth is around 1 m, water flow is slow and gentle and the direction of current is parallel to the bank, makes a favourable site for the spawn collection. The gently sloping bank provides easy access to the river for fishermen and a wide area for setting nets. The water depth of around 1 m enables the fishermen to stand in the river to operate the nets. The constant direction of water current helps to set the nets always facing the current. In such areas, large number of Savars are congregated to form spawn-collection centres. Most of the collection centres are located in the upper section of the Jamuna river where water diverts from the main stream.

Sl. No.	Upazila	Distance* (km)	No. of Collect. centres	No. of Savars	No. of Nets	Catch (kg)	CPUE (Kg/net)	Price (Tk/kg)
Jamuna-Brahmaputra River West Bank								
1	Kurigram	25.40	2	11	121	271.70	2.25	725
2	Chilmari	57.15	5	9	282	680.96	2.41	-
3	Gaibandha	82.55	2	15	461	360.06	0.78	2,350
4	Fulchari	97.06	6	91	2,292	2,947.02	1.29	625
5	Saghata	106.95	10	114	2,725	4,579.72	1.68	650
6	Sonatola	120.69	3	20	728	2,384.75	3.27	1,240
7	Sariakandi	139.70	7	53	1,380	962.53	0.70	-
8	Kazipur	167.64	2	8	170	3.50	0.02	-
9	Sirajganj	187.96	7	79	1,715	3,793.72	2.21	2,750
10	Belkuchi	205.53	2	10	230	91.50	0.40	-
11	Chauhali	220.98	4	8	245	43.00	0.18	-
12	Shahajadpur	236.22	4	11	497	271.50	0.55	-
	Total		54	429	10,846	16,389.96	1.51	1,390
Jamuna-Brahmaputra River East Bank								
13	Dewangonj	80.10	3	33	611	218.05	0.36	-
14	Sarishabari	135.89	4	10	275	121.89	0.44	-
15	Gobalpur	149.86	2	6	126	16.18	0.13	2,550
16	Bhuapur	168.91	1	97	2,133	703.67	0.33	4,000
17	Sibalaya	241.30	5	13	196	58.80	0.30	2,833
	Total	776.06	15	159	3,341	1,118.59	0.33	3,128
Old Brahmaputra River								
18	Jamalpur	-	6	8	205	44.50	0.22	-
19	Nakla	-	2	13	296	645.26	2.18	-
20	Mymensingh	-	9	44	481	90.73	0.19	-
	Total	-	17	65	982	780.49	0.79	-
Dhaleswari-Kaliganga River								
21	Tangail	196.85	4	12	247	72.34	0.29	-
22	Nagarpur	222.25	5	20	611	153.11	0.25	-
23	Saturia	234.95	6	9	415	38.56	0.09	2,400
24	Ghior	247.65	1	4	80	9.50	0.12	2,417
25	Manikgonj	257.81	2	3	60	31.33	0.52	2,417
	Total		18	48	1,413	304.84	0.22	2,439
			104	701	16,583	18,593.88	1.12	2,087

* Distance from the Indian border

Table 3.2-7: The spawn fishery data of the Jamuna-Brahmaputra river and its tributaries, 1984

(Source: Bangladesyh Fisheries Resources Survey System TSAI, 1984)

(8) Endangered Species

It is very difficult to pin-point or specify the name and number of aquatic species which are endangered in the JAFP region, because there exists no earlier record (no inventory was made) of aquatic flora and fauna for this area. There is no other option but to guess the species which are currently endangered. Of the amphibians, Bull Frog (*Rana tigrina*) and Green Frog (*Rana hexadactyla*) seem to be endangered. Of the reptiles, most endangered species is the Ghorial (*Gavialis gangenticus*) followed by King Cobra and Bostami Tortoise. Fishing Cat (*Felix viverrina*) and common Otter (*Lutra lutra*) are two aquatic mammals that are in the endangered species list. Gangetic Dolphin appears also as a rare species. About endangered aquatic flora species, there appears no indication anywhere concerning the JAFP areas.

3.2.3 Terrestrial resources

(1) Microflora and Microfauna

The primary basis of food chain, energy and nutrient cycling is controlled by micro-organisms of the terrestrial environments. No information is available on the diversity and distribution of the terrestrial micro-organisms in the floodplain of the Jamuna. Fungi and bacteria play a crucial link in the decay and decomposition of organic matter and formulation of plant nutrients and improvement of soil quality. But no study has so far been initiated to record population, types and the role of microflora and microfauna of the area.

(2) Flora (see Table 3.2-8)

Real natural vegetation is not very abundant along the Jamuna active flood plain. All the area is totally cultivated to the water level, or to the bank, where it is very steep. The extremely high level of cultivation of land for growing rice is going on with receding of flood.

The herbaceous flora is found mostly on the steep uncultivated slopes or on the banks along the Jamuna where the cattle goes. Some species like the *Ipomoea* are used as fencing between the fields. But most of the herbaceous are developed on the new island chars which are yet to be cultivated and also around the aquatic areas and wetlands like ponds, beels, haors, borrow-pits, etc..

On the slopes of the embankment, a number of bananas are grown and sometimes also *Ipomoea*. On some part of the embankment, *Acacia albizzia* has been planted as part of the aforestation program.

In this area the most of the trees are found either on the embankments or in the homesteads. They are generally used for timber wood or fuel according to their quality, and also for shade, for growing fruits, as medicine and as fodder. Some fruits have a commercial value like those of *tamarindus indica* (Tetul), the seeds of which are used in jelly industries or specific uses like those of *diosporus peregrina* (Gab) used for tanning nets.

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Local Name	Botanical Name	Indication
Aam *	*Mangifera indica* (P)	Fruit edible.Inferior timber wood. Fuel.Common.(2)
Akand	*Calotropis procera* (F)	Rare. Medicinal plant
Akh/Kushar	*Saccharum officinarum* (A)	Cultiver. For sugar
Akashi alu	*Dillenia pentagyna* (A)	Medicinal (1)
Amra	*Spondias mangifera* (P)	Fruit edible - Rare (1)
Arahar dal	*Cajanas cajam* (A)	Fairly Common. Fruit edible. Seasonal plant
Asamlata	*Eupatorium odratum* (C)	Medicinal (3)
Aswatha	*Ficus religia* (T)	Fuel wood/religious value(1)
Ata	*Annona squamosa* (T)	Homestead. Fruit edible. (2) Fairly common
Babla	*Acacia nilotica* (T)	Fodder. Medicinal.Common (3)
Bans	*Bambosa sp.* (A,F)	For house making and fencing
Bash	*Bambosa sp.*	Fuel wood/house making (3)
Batavi lebu	*Citrus grandis* (T)	Fruit edible (2)
Bajna	*Zanthoxylum rhetsa* (T)	Fuel wood (2)
Behaya Kalmi *	?	Fencing (3)
Bel	*Eagle marmelos* (P)	Fruit edible.Timber wood (1)
Bet	*Calamus tenuis* (F)	For making furnitures, rare (1)
Bhadali +	*Linnea coromendelica* (F)	Fodder for livestock (3)
Bish katali+	*Polygonum sp.* (F)	Medicinal
Bish kachu+	*Steudnera virosa* (F)	Medicinal
Bola +	*Hibiscus taliaceus* (F)	Medicinal
Bora karni	*Euphorbia hirta*	Medicinal (2)
Bot	*Ficus bengalensis* (T)	Juice used for medicine/ fuel (1)
Buzkanta	?	Fish trapping (2)
Chaguia	?	Ornamentation plant (1)
Chalta	*Dillenia indica* (P)	Fairly common. fruit edible
Dandakalos	*Leucas aspera* (F)	Medicinal (3)
Debdaru	*Polyanthia longifolia* (F)	Fuel and wood (2)
Dhaniya	*Coriandrum sativum* (A)	Spice

Table 3.2-8: Flora found in the embankment area and flood plain

Local Name	Botanical Name	Indication
Dholkalmi	*Ipomoea fistulosa*	Erosion protection. Fuel. Medicinal Fencing (3)
Dhutura (kala)	*Datura matel* (F)	Medicinal
Dhutura (sada)	*Datura fastuosa* (F)	Medicinal. Common
Eucaliptus	*Eucalyptus dives* (P)	Introduced plant. Medicinal. Common.
Fulkuri +	*Agetarum sp.* (F)	Medicinal (3), common in fallow land
Gab	*Diosporus peregrina* (T)	Fruit used for tanning of net and also precious wood used for boat making
Gamari +	*Gamelina arbora* (T)	Medicinal/fuel (3)
Ganda (Ful)	*Tagetes sp.*	Flowering plant (2)
Ghora neem	*Melia azedarach* (P)	Medicinal plant (1)
Gol alu	*Solanum tuberosum* (A)	Underground stem edible. Common.
Golap	*Rose centifolia* (A)	Flowering plant (1)
Gulancha	*Tinospora cordifolia* (F)	Common. Medicinal (2)
Hakra +	?	Medicinal (2)
Hathisur	*Meliotropium indicum* (F)	Medicinal (3)
Helencha	*Alternanthera philoxeroides* (F)	Medicinal
Jaba	*Hibiscus-rosa-sinensis* (A)	Flowering plant. Fairly common
Jalpai	*Elaeocarpus robustus* (P)	Timber. Fruit edible. Rare
Jambura	*Citrus grandis* (P)	Fruit edible (1)
Jiban	*Trema orientalis* (T)	Fuel wood (1)
Jica +	*Lannea grandis* (T)	Medicinal. Fuel. Timber wood Common. (1)
Jog dumur	*Ficus glomerata* (T)	Fairly common fruit and latex medicinal
Kadu	*Lageneria siceramia* (A)	Fruit and leave edible
Kala jam	*Eugenia jambolana* (T)	Fruit edible. A good quality timber (2)
Kalcasunda +	*Casia tora* (F)	Medicinal
Kanta Mandar +	*Erythrina sp.* (T,F)	Mainly used for fencing
Kanthal +	*Artocarpus heterophylus* (P,T)	Costly wood. Common. Fruit
Karabi	*Nerium indicum* (F)	Medicinal plant

Table 3.2-8 (continued): Flora found in the embankment area and flood plain

Local Name	Botanical Name	Indication
Kash +	*Saccharum spontaneum* (F)	Perrenial grass. Fodder.Used against erosion. Fuel. Roof making. Common.
Kata notey *	*Amaranthus viridis* (F)	Fodder
Khejur	*Phoenix sylvestris* (P)	Fruit edible. Fuel (1)
Kochu	*Calocasia esculanta* (F)	Under ground stem used as food. Medicinal
Kola +	*Musa paradisica* (A)	Fruit edible. Common
Kalke sunde	*Cassia sophera* (F)	Medicinal (3)
Kukur sunga*	*Blumea lacera* (F)	Medicinal (3)
Kul +	*Zizyphas mauritiana* (F,A)	Fruit edible. Common
Lichu	*Litchi sinensis* (A)	Fruit edible. Common
Madan	*Xeromphis spinosa* (F)	Medicinal (1)
Maidal	*Erythrina stricta* (F)	Medicinal fuel
Mash kalai	*Vigna mungo* (A)	Fruit edible
Mehgoni	*Swetenia mehgoni* (T)	Medicinal/timber used for furniture (1)
Misti Alu +	*Ipomoea batatus* (A,F)	Underground stem edible. Commmon
Misti Kumra +	*Cucurbita maxima* (A)	Fruit and leaves edible
Nim	*Azadirachta indica* (T)	Medicinal plant also timber wood. Common (2)
Nisinda	*Vitex negundo* (F)	Medicinal. Common (2)
Narkel	*Cocos nucifera* (A)	Fruit edible. Common
Okra	*Abelmoschus esculantus* (A)	Fodder
Palta Mandar	*Erythrina indica* (F)	Fairly common. Wood use for box making. A fencing tree
Pathor kuchi	*Kalanchoe pinnata* (F)	Medicinal (1)
Pepe	*Carica papaya* (A)	Fruit edible. Medicinal. Common
Piaj	*Allium cepa* (A)	Spice. Medicinal (cultiver)
Pitraj	*Apnana mxis polystachya* (T)	Medicinal (2)
Pargacha	*Hoya parasitica* (F)	Plant parasit on most of the trees
Rasun	*Allium sativum* (A,P)	Spice. Medicinal (cultiver). Common.
Sajna	*Moringa oleifera* (T)	Fruit edible
Shama +	*Echinochloa colonum* (F)	Fodder for livestock

Table 3.2-8 (continued): Flora found in the embankment area and flood plain

Local Name	Botanical Name	Indication
Sisu	*Dalbergia sissoo* (P)	Fuel/timber (1)
Sialmuti	*Blumea lacera* (F)	Medicinal (3)
Sun gras	*Imperata cylin-drica* (F)	Fodder for livestock
Supari	*Areca catechu* (P)	Common. Tanning plant, Nut, edible. Medicinal (2)
Swarna lata +	*Cuscuta reflexa* (F)	?
Tal	*Borassus flabellifer* (P)	Fruit edible/timber (2)
Tamal +	*Diespyros cordifolia* (F)	?
Tatul	*Tamarindus indica* (T)	Seeds used in Jelly Industry. Precious wood. Fruit edible. Medicinal. Fairly common. (1)
Tela kucha	*Coccinea cordifolia* (C)	Medicinal. (2)
Thankuni *	*Lentella asiatica* (F)	Medicinal. (1)
Tit bagun	*Solanum torvum* (F)	Medicinal. Vegetable. Common.
Titpolla	*Luffu cylindrica* (F)	Medicinal.
Tula	*Gossypium herbaceum* (P)	Fruit. Medicinal and also yields cotton
Tut	*Morus alba* (P)	Introduced species. Leave used for feeding the larvae of silkworm
Vatkana	*Bixa orellana* (F)	Medicinal (2)
Veranda	*Ricinus communis* (A)	Oil. Medicine

(A) = Cultivers
(C) = Climbers
(F) = Natural grass and shrub
(T) = Natural tree
(P) = Planted tree
* = Char species

(1,2,3) = Frequency observed during field trip

Table 3.2-8 (continued): Flora found in the embankment area and flood plain

CHAR SPECIES

Nolkhagra(Nal)	*	*Phragmites karka* (F)
Durba	*	*Cynodon dactylon* (F)
Jai	*	*Avena sativa* (F)
Kata khora	*	?
Chal kumra	*	*Cucurbita pepo* (A)
Puishak	*	*Basella alba* (A)
Mandar	*	*Erythrina variegata* (F)
Tisi	*	*Linum usitatissimum* (A)

A few isolated big trees like *Ficus sp.* are also found in this area. Herbaceous are used for medicinal purpose, as vegetable, for fencing or roof making and as fodder.

Some of them have been more or less cultivated like Kash for fodder and for protection of soil. *Ipomoea* (Misti alu) is also used to stabilize sandy gentle slopes.

Some plants are linked to wet areas like Bish Kanthali.

Flora of charlands:

Twenty four island chars along the Jamuna have been visited in March 1992 (see Fig. 3.2-6) Plants have been inventoried through observations and interviews but not quantified. More investigations would be needed to understand the distribution and evolution of flora on the dynamic environment of the islands.

It has been noticed that most of the plants found on islands are also common on the main land. Some of them like Misti alu and Kash are intensively used for erosion control and cattle grass. A few trees have been planted on the highest part or on the embankments of the old chars, where settlement are existing.

Chars are interesting for natural flora in the sense that they are less settled and less cultivated. The young sandy chars are usually colonised by Kash (*Saccharum spontaneum*). The herbaceous covering is very light initially. After few years, depending on the stability and the distance from the main land, when grass starts to grow densely, people bring in their cattle for grazing. They also start to cultivate rice on the lower parts of the island. On the sandy slopes, *Ipomoea* and Kash are planted for erosion protection. Starting from this point, pasture land are maintained and enriched with organic matter.

A few years after, people start cultivation more intensively for growing rice, wheat, banana and bamboos initially, and then crop diversification starts. If the char is stable, settlement appears.

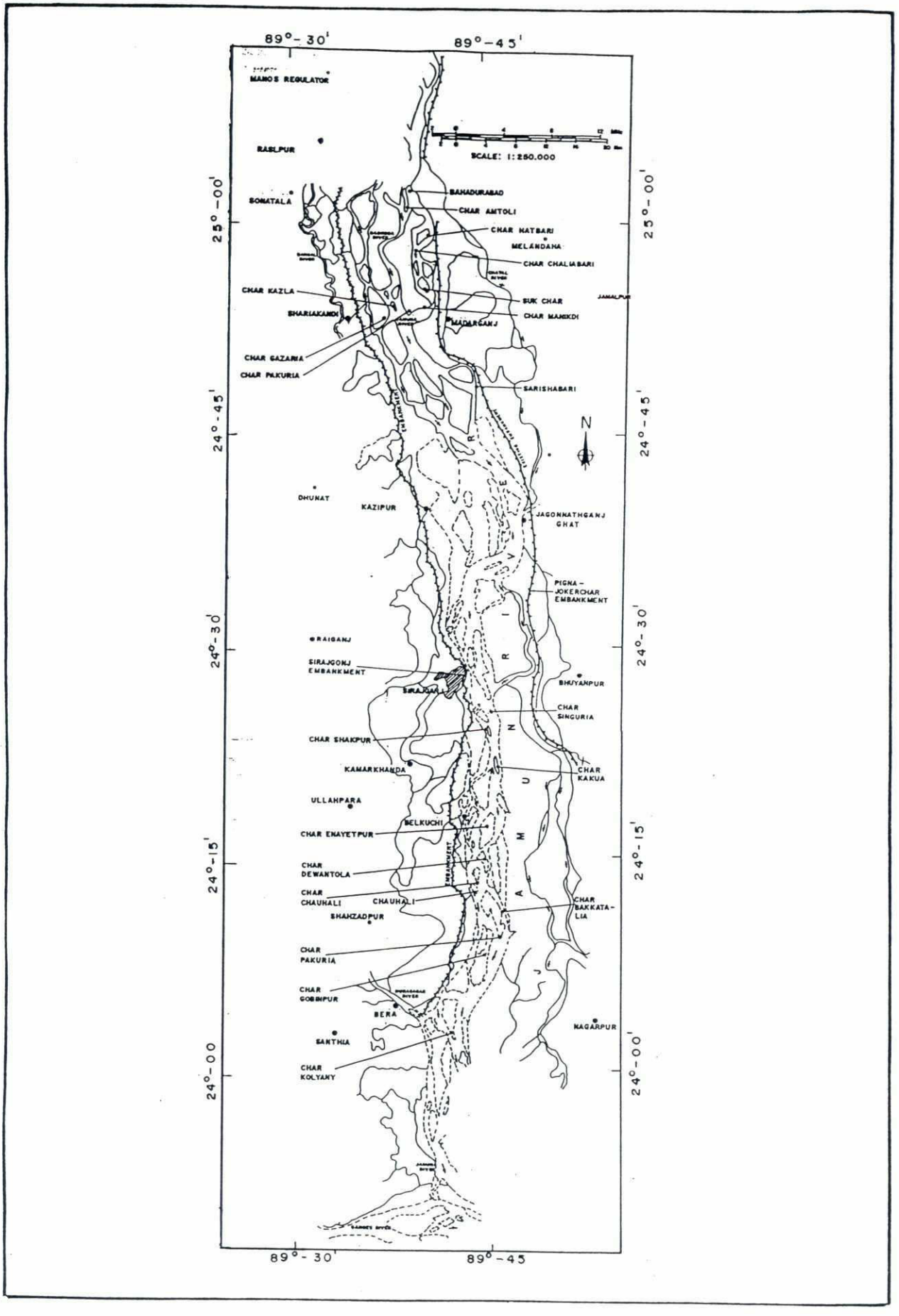


Fig. 3.2-6: Location of the visited chars

The whole evolution of natural flora can not be observed on these islands, since as soon as the soil quality improves the land is cultivated.

When the young chars are more silty, it is not overgrown with Kash but colonised with a more diversified herbaceous cover. Vegetation is short but more dense than on sandy chars (covering around 20 % of the surface). Some of the species observed to be grown on the chars are: Nalkhagra, Durba, Jai, Kata Khora, etc. On the new formed unstable chars, subject to inundation, only a few semi-aquatic flora like *Abelmochus esculantus*, and *Linnea coromendelica* grow.

During the initial stage of stabilization of the unstable chars (consisting of mostly the sand and silty sand), no thick vegetation is found. But at that time, the surface of the chars is relatively saturated, and grass like *Saccharum spontaneum* (Kash) grows. This grass serves as surface cover and prevents soil erosion from the surface. Settlement is absent due to flood inundation. Cultivators uses the land for growing boro paddy.

Most of the chars visited during the course of this study belonged to this kind (e.g. Char Shakpur, Kakua, Chanhali, Pukuria, Shibir (see Fig. 3.2-6). Relatively stable chars (around 4 to 10 years old) have a sandy loam substrata within their settlement pastures. Plants like Kash, Banana, *Imperata sp.* are the few species found on this category of chars (like char BakKatia & Gobindapur).

Stable old chars, densely populated, have semi-permanent homestead with trees, mangoes, Bananas, *Artocarpas heterophycus*. Sandy soils are covered by thick grass (char Enayetpur and char Dewantola).

(3) Insects

Very little information is available on the diversity of insects, although they are visibly seen almost everywhere. Among several species the most common insects are borers, leaf miners, leaf hoppers, plant hoppers, flies, sandflies, mosquitos, bees, termites, ticks and mites. Many of them are important pests for various crops and vectors of diseases. Many of them are useful, e.g. the lac insect or bee (*Kerya lacca*) for honey. Insects play important roles in the agriculture, health and animal husbandry sectors. Some of them has a vital role in pollination. Many birds, fishes and animals feed on them. But proper inventories of the insects of Bangladesh has never been prepared.

(4) Birds

There are about 660 avifauna (birds) in Bangladesh. Of them some 110 resident and migratory species are known to have been observed in North-Western region; but there appears no systematic record as to their types, number and distribution in the JAFP area. Table 3.2-9, presents a list of some 50 species of birds identified during a short visit in some places along the Jamuna from Bahadurabad Ghat to Aricha, during migratory period (March 1992).

English Name	Bangla Name	Location	Abundance	Scientific Name
Cattle egret (*)	Gohbak	C	2	*Bubulcus ibis*
Intermediate egret (*)	-	C	1	*Egretta intermedia*
Great egret (*)	Dar bok	C	2	*Egretta alba*
Grey heron	??	C & E	3	*Ardea cinerea*
Indian pond -heron(*)	Kani bok	E & C	2	*Ardeola grayii*
Whistling teal (*)	-	C	1	*Dendrocygna sp.*
Pintail (*)	-	C	1	*Anas acuta*
Shoveler (*)	-	C	+	*Anas clypeata*
Brahminy kite	Shongko chil	C & E	2	*Haliastus indus*
Pallas's fish Eagle	Gang chil	C	2	*Haliaeetus leucophus*
Marsh harrier	Baz	C & E	2	*Circus aeruginosus*
Sikra	Sikra	E & C	1	*Accipiter badius*
River lapwing	Hottity	C	2	*Vanellus duvacelii*
Red-wattled Lapwing	Hottity	E	1	*Vanellus indicus*
Sandpiper sp.	Khonjonaga	C	3	
Gull sp.	-	E (south Jamuna)	1	*Larus sp.*
River tern	??	C	2	*Sterna aurantia*
Black-bellied Tern	??	C	3	*Sterna acuticauda*
Blue rock Pigeon (*)	Jalali Kabutor	E	1	*Columba livia*
Collared dove (*)	-			*Streptopelia decaocto*
Spotted dove (*)	Bish ghughu	E & C	2	*Streptopelia chinensis*
Roseringed Parakeet	Tia	E	2	*Psittacula krameri*
White-breasted kingfisher	Mach ranga	C & E	2	*Halcyon smyrnensis*
Common kingfisher	Mach ranga	C & E	2	*Alcedo atthis*
Pied kingfisher	Mach ranga	C	1	*Ceryle rudis*
Green bee-eater	Shuichora	C	2	*Merops orientalis*
Hoopoe	??	E	3	*Upupa epops*
Bush lark	-	E (south Jamuna)		*Mirafra assamica*
Barn swallow	??	C	3	*Hirundo rustica*
White wagtail	-	C		*Motacilla alba*
Magpie robin	Doyel	E & C	2	*Copsychus saularis*
Black drongo	Finga raja	C	3	*Dicrurus macrocercus*
Ashy wood-swallow	??	E & C	1	*Artamus fuscus*
House crow (*)	Kak	E	3	*Corvus splendens*
Jungle crow	Kak	C & E	3	*Corvus macrorhynchos*
Asian pied starling	Shalik	C & E	3	*Sturnus contra*
Common myna	Shalik	C & E	3	*Acridotheres tristis*
Bank myna	Shalik	C & E	2	*Acridotheres ginginianus*
House sparrow (*)	Chorui	C & E	3	*Passer domesticus*

(*) = hunted species in Bhuapur area

C = char islands

E = floodplain & embankment

Table 3.2-9: List of birds found in the JAFP area

N.B: Due to the restricted time of the field work not all species could be found. Appendix 2 gives a list of birds likely to be found in Jamuna area, according to Harvey's book (1990).

The dry-season sandbars and chars with minimal vegetal cover, seasonally inundated grass and reedbeds in the floodplain, trees, shurbs and bushes in the homestead and levee-lands are the main habitats of the avifauna along the Jamuna river. Sandy low char islands are ideal wayside alter for migratory birds and for fisher birds. Birds do not get disturbed on islands where settlement does not exist or are very light. On these islands a lot of migratory ducks and geeses, cattle egrets, marshy-harrier, many sand pipers, some grey herons and ashy swallow shrike can be observed.

Some other species are used to nest in self-excavated holes in earth banks or in burrows in river banks like kingfishers, bee eaters and bank munia. Tern also rest on mudbanks to catch fishes and crabs, diving into water.

The bird population was originally a response to the natural environment, even the migrant species having favoured habitats and localities. But centuries of human occupation has taken over the natural habitats for cultivation. Settlement and technological interventions have destroyed their original nature. Even then some bird species adapted to the changes (e.g. chestnut bittern and wood sandpipers), but many did not, and survive in small, endangered pockets in the remaining patches of their favoured habitats. Rice and jute fields offer an approximation to natural swamp and wet grassland. Some of the smaller herons such as the Indian pond heron as well as seedeaters, munias, migrant waders and snipe have adapted well to the alternative habitat. Most successful have been those species such as munias, kites, crows, magpie-robins and black drongos. They have adapted well to the environs of man near villages. Kites, crows, munias and house sparrows feed on man-produced seed and waste as well as natural food.

Magpie-robins and drongos feed on the insects pests of agricultural crops. Species of birds that occur in wetland have different feeding habits. Duck and Grebe feed on small fishes, molluscs and insects; kingfisher, gull, tern, kite, eagle, petrel feed mainly on small fishes. Muddy surface feeders like snipes, sandpiper, heron, etc. feed on fishes, small amphibians, reptiles, mice, insects etc.

Most of the birds listed in Table 3.2-9 are resident of the JAFP areas or elsewhere in Bangladesh, and few of them such as ducks, geeses, snipes and other waders come every year regularly in the wetland areas. The north of Bangladesh particularly the upper reach of the Jamuna river is known as a habitat and stop-over point for migratory birds to and from Siberia and China. They feed there in the winter months - November to March. Some of the migratory birds arrive as early as September.

(5) Wildlife

Many species of mammals, amphibians, reptiles and birds constitute the wildlife diversity of Bangladesh. GOB report of the Wildlife Task Force (1991) shows a total of 840 wildlife species, of which the status of Mamalia (aves and birds), Reptiles and Amphibians are 119,578 (including 119 migratory species), 124 and 19, respectively. Due to past misuse 18

species which had a wide distribution in forest, fresh water and mangrove swamps have become extinct. These include buffalo, rhinoceros, Indian bison (gaur), swamp deer, hog deer, wolf, blue bull, hispid hare, black duck, pink headed duck, pea fowl and Bengal florican. Besides, the Royal Bengal Tiger was widely distributed in the past and now it is contained to Sundarbans only. It is also on record that wild elephants existed even in the Bhawal-Madhupur Tract in the beginning of the century, is now confined in the forests of Chittagong Hill Tracts, Cox's Bazar and Sylhet. Further, export of turtles, tortoises, frog legs, skins of lizards, crocodiles, snakes, and hunting of birds and animals have dwindled the wildlife population of many species beyond sustainability. Of the total 840 wildlife species, a substantial number must be distributed in different habitats of the JAFP areas, of which the exact population and species are not known.

(6) Endangered Species

No information on terrestrial endangered species of both plants and animals in the JAFP areas is available. However, a tentative list of 27 vascular plants threatened in Bangladesh has been prepared by World Conservation Monitoring Centre, 1989. The list incorporated as Appendix 3, does not show location-specific distribution, nor does it give function of most of the species in ecochain. Similarly, IUCN (1991) has enlisted 23 species of Bangladesh in its Red Data Book as endangered species but none is recorded in JAFP. This list, however, is not an exhaustive one and many other species will soon aquire eligibility to be placed in the Red Data Book. According to Hussain (1989), there are 27 threatened and 39 endangered species in Bangladesh. It is to be noted here that two lists do not present any division of terrestrial and aquatic species. Proportion of terrestrial and aquatic species may be 4:3, but location specific distribution of these lists is unknown.

3.3 ECOLOGICAL RELATIONSHIPS

The Project takes place in an area where species and people are adapted to the wide variations of hydrologic conditions. The interactions between the ecosystem components are so close that if one of them is modified, the repercussions will be felt at different levels. Looking to Fig. 2.3-1, it can be seen, for example, that an increase or a decrease of the algae population (microflora) could influence water quality, microfauna, fishes, birds, fishermen, etc. in some particular cases. Simultaneous modifications of different environmental factors being combined, can have a synergistic influence, which is difficult to foresee.

It is particularly important that in countries like Bangladesh where the rural population is so dependent on the natural environment, much care has to be taken for these interrelations and the indirect perturbations of a project on the human population in connection with economic, social, or health effects.

Different components of ecosystem (including people) have mutual interdependence. Input of an exogenous element (construction work) is likely to have consequences on one or several

components. Due to this complexity and the weak state of knowledge on natural environment in Bangladesh, it is difficult to foresee the possible chain of reactions of an exogenous input. However bank protection works are planned in threatened areas of the river banks, where bank erosion threatens the very means of existence of the local people and their livelihood. Bank protection works are planned in short stretches of the river having localised effects only. These works are not likely to have too much interference on natural environment. Their positive effects always outweigh the negative effects on the ecosystem including people.

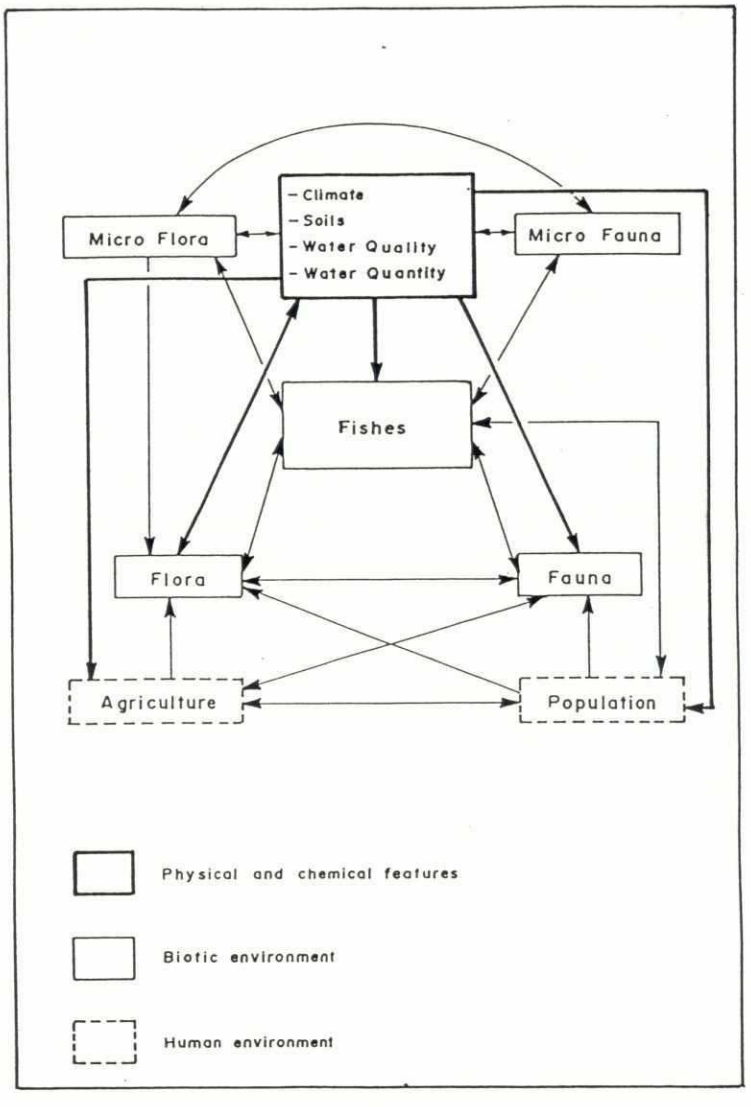


Fig. 3.3-1: Environmental interactions

4 HUMAN ENVIRONMENT

4.1 DRINKING WATER QUALITY

No inventory of the available tubewells has been made at the moment. Tubewells are often found on the main land. However, in some villages closed to the bank, people are using river water, probably because of the easy access and the proximity of the river.

During the rainy season, people of the flooded lands have no other alternative but to use the river flood water, as the pumped water is not accessible or becomes polluted. This sometimes result in the outbreak of diarrhoea and dysentery, which occasionally can induce mortality.

4.2 HEALTH

Data on diseases were collected from the Civil Surgeons of Bogra and Sirajganj. Data from Sirajganj are not complete and therefore are not useful. Data from Bogra have been recorded monthly for the year 1991. They are not reflecting the existing situation as it concerns only patients who came to health centres and hospitals. People from the charlands and from the distant countryside are probably less taken into account as they have less facilities to go to these centres. Table 4.2-1 shows the recorded data. Figures must be considered with caution as some mistakes have already been found and corrected.

The main diseases are related to the presence of long term standing water and the poor sanitary conditions. Water borne deseases have increased with the development of irrigation systems. The main diseases inventoried is diarrohea which amounts to 181,000 per year detected in Bogra district. This may include dysenteries and undiagnosed choleras. As seen in Table 4.2-2, the diarrhoea is still the cause for some deaths. Around 50 % of the population attacked by diarrhoea is under 15 years, among which 15-25 % are babies less than 1 year; 25-35 % children between 1 and 4 years of age, and 40 to 60 % between 5 and 15 years old. Diarrhoea seemed to be more frequent at the beginning of the rainy season, and also in November, during the year 1991.

In FAP 3.1 studies it was found that cholera/dysentery are more common among people living in the attached and set-back land (32 %) than charlands (23 %). This may be explained following field interviews, by the fact that people from the main land are more severely attacked during the flood period, as they are less used to drink river water than people of the chars during that part of the year.

Malaria has not been detected in Bogra district during 1991. From the statistics of Bangladesh, it is seen that this disease is less common in the JAPP (see Table 4.2-3). The percentage of malaria cases detected through blood slides is around 0.6 % for Tangail, Bogra, Pabna and Jamalpur districts combined together compared to 2.2 % for the whole Bangladesh. (Source: Directorate of Health Services, from Statistical year book of Bangladesh, 1991). Malaria is a mosquito-borne disease the frequency of which depends on availability of suitable habitats like year round standing water, water-hyacinth area, etc.

Eye problems and skin cases, intestinal worm infections, can be linked in a certain proportion to water. Bathing in standing water, lack of individual sanitation, high level of humidity are the favourable factors. This increases during monsoon season, and also with high concentration of population. Vitamin A deficiency leading to blindness is recorded to be particularly high amongst communities along the Jamuna river.

Sl. No.	Name of Major Diseases	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1.	Diarrheal Diseases	15,436	12,351	13,953	13,767	17,065	17,237	13,856	12,719	14,942	11,764	22,077	15,616	180,783
2.	Clinical Malaria	-	-	-	-	-	-	-	-	-	-	-	-	-
3.	Int Worm Infectic	7,574	11,074	7,912	6,453	6,799	6,713	8,006	8,174	6,814	6,243	7,031	4,525	87,318
4.	Peptic Ulcer	4,446	6,550	5,291	4,518	5,023	5,410	5,493	4,588	3,594	3,023	3,270	2,006	53,212
5.	Tubaculosis	45	87	66	82	110	125	68	140	98	77	238	313	1,449
6.	Acute Res.Infectic	7,735	10,494	7,399	6,243	8,525	8,368	7,894	8,670	8,166	7,412	7,735	7,510	96,151
7.	Skin Diseases	8,250	7,551	7,569	7,042	7,726	7,902	6,893	8,181	8,161	8,562	8,138	8,218	94,193
8.	Hepatitis	17	63	63	49	56	48	70	75	43	57	45	40	626
9.	Tetanus	8	135	135	68	68	-	76	-	29	18	27	12	576
10.	Deptheric	1	-	-	-	-	1	-	-	-	-	-	-	2
11.	Night Blindness	1,242	1,627	1,394	1,511	1,725	1,818	1,633	1,576	1,058	834	888	700	16,006
12.	Difficiency Diseases	4,799	5,475	6,062	6,582	7,202	6,856	6,155	6,605	6,646	7,388	5,704	6,454	75,928
13.	Anonia	1,561	1,473	5,838	5,735	6,140	5,320	6,785	6,212	5,771	5,559	6,055	6,440	62,889
14.	Agehma	6	27	26	10	-	-	-	-	-	-	-	-	69
15.	Whooping Caugh	280	429	1,272	1,368	728	832	978	1,212	1,443	1,161	1,011	880	11,594
16.	Measles	14	5	48	54	-	-	-	-	-	-	-	-	121
17.	Chicken Pox	-	-	34	-	-	-	-	-	-	-	-	-	34
18.	Diabates	412	193	70	132	198	218	218	419	984	812	548	446	4,650
19.	Eye Diseases	3,601	4,662	5,141	5,337	5,993	5,485	5,133	4,830	4,090	4,325	3,602	3,167	55,366
20.	Ear Doseases	3,704	4,319	4,636	4,678	4,361	3,564	4,870	5,850	5,487	4,886	4,922	5,060	56,337
21.	Dental Deseases	2,230	2,418	2,782	3,019	3,583	3,473	1,984	2,166	2,441	2,073	2,346	2,896	31,411
22.	Hypertention	129	167	445	277	158	176	431	314	436	398	291	165	3,387
23.	Poisoning	13	15	126	79	93	60	108	22	31	10	21	31	609
24.	Injuries	1,902	1,972	3,382	2,983	2,993	2,213	3,359	3,390	3,427	2,778	2,566	2,625	33,590
25.	Obsol Aynce Compl.	487	891	794	862	948	838	941	836	699	618	889	902	9,705
26.	Filariens	-	-	-	-	-	-	-	-	-	-	-	-	0
27.	Kala Zar	-	-	-	-	-	-	-	-	-	-	-	-	0
28.	Mental Diseases	37	7	167	218	89	15	27	20	11	15	29	13	648
29.	P.U.O.	6,092	5,451	5,408	6,810	7,493	7,967	5,868	6,277	7,007	8,509	5,503	6,609	78,994
30.	Others	18,617	30,519	19,334	18,224	20,660	21,054	21,296	23,461	25,234	28,421	25,901	32,268	284,989
	TOTAL	88,638	107,955	99,347	96,101	107,736	105,693	102,142	105,737	106,612	104,943	108,837	106,896	1,240,637

Number of institutions concerned = 63

Table 4.2-1: Recorded diseases in Bogra district (1991)

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Months (1991)	Water Diarrhoea		Blood Dysentery		Others	
	Affected	Death	Affected	Death	Affected	Death
January	19	-	42	-	537	-
February	27	-	222	-	3,291	-
March	14	-	784	-	4,745	-
April	27	4	561	-	1,318	-
May	18	1	40	-	1,508	-
June	24	-	52	-	2,882	-
July	36	-	105	-	303	-
August	107	3	58	-	3,738	-
September	342	15	100	-	5,024	-
October	1,769	24	107	-	4,080	-
November	1,832	8	80	-	4,080	-
December	364	-	51	-	3,091	-

Table 4.2-2 : Monthly report of epidemic disease Jan.'91 - Dec.'91

(Source: Sirajgonj Civil Sergeon Office)

REGION (Former District)		DYSENTARY		DIARRHOEA		MALARIA		MEASLES	
		ATTACKED	DEATH	ATTACKED	DEATH	ATTACKED	DEATH	ATTACKED	DEATH
Jamalpur	1988	125,259	27	11,317	51	52,691	100	249	2
	1989	46,950	2	4,551	4	10,326	12	90	1
Tangail	1988	85,699	11	29,644	50	94,955	101	49	-
	1989	19,470	0	4,415	0	2,772	2	403	0
Bogra	1988	52,113	29	14,880	25	29,053	172	511	-
	1989	32,030	0	11,093	11	-	0	155	0
Pabna	1988	149,484	11	40,224	106	46,222	9	390	1
	1989	93,791	3	16,277	20	402	0	804	0
TOTAL	1988	2,331,647	436	504,807	2,733	1,888,524	10,420	13,197	14
For Bangladesl	1989	1,483,166	825	360,826	1,302	289,246	587	11,043	21

Table 4.2-3: Epidemiological report on communicable diseases by district for the year 1988 and 1989

(Source: Statistical Year Book of Bangladesh, 1991)

REGION (Former District)		DIPHTHERIA		WHOOPING COUGH		TETANUS		POLIOMYLITIES	
		ATTACKED	DEATH	ATTACKED	DEATH	ATTACKED	DEATH	ATTACKED	DEATH
Jamalpur	1988	-	-	137	-	25	7	-	-
	1989	-	-	129	-	26	7	-	-
Tangail	1988	-	-	31	-	-	-	3	-
	1989	7	-	453	-	14	2	25	-
Bogra	1988	-	-	-	-	-	-	-	-
	1989	-	-	82	-	1	1	-	-
Pabna	1988	-	-	7,758	-	-	-	-	-
	1989	13	-	3,145	-	79	-	1	-
TOTAL	1988	354	3	29,018	5	401	24	358	-
For Bangladesl	1989	193	13	24,863	27	783	162	207	1

Table 4.2-3 (continued): Epidemiological report on communicable diseases by district for the year 1988 and 1989

(Source: Statistical Year Book of Bangladesh, 1991)

Leishmaniasis is not recorded in Bogra district. It seems to be rare and very localized. FAP 3.1 recorded a concentration of *leishmaniasis* (called kala-zar) at Maderganj. This disease is spread by sandflies, sometimes in association with rodents, or possibly cattle.

Fever is very often mentioned in islanders interviews, particularly during the flood, due to damp conditions: it can be viral or may be hidden malaria and typhoide cases.

Goiter seems to be really frequent along the Jamuna flood plain, particularly in the island chars. Goiter is caused by thyroid problems. It is linked to iodine deficiency in the water supply. Mostly women are easy prey to this disease as they are deprived of iodine due to breast feeding of the children. To make up this deficiency there had been instanstances in the past when tablets were distributed in the area; but it is not continuous as yet. Therefore, goiter is recorded as very frequent among people living in Gaibandha area.

4.3 NUTRITION

Like many other parts of Bangladesh, the existing situation with regard to nutrition levels in the project area is characterized by unbalanced diets amongst lower socio-economic groups, particularly lack of protein and minerals. FAP 3.1 report indicates lack of calorie intake for 44 % of the population despite the area being a major producer and exporter of rice. The situation in JAFP area cannot be better, rather is worse.

A major source of proteins for the people is fish. But per capita consumption of this item is rapidly dwindling because of non-availability/higher price. Likely decrease in the supply of proteins may result from the increase of working people and of landless people in the area. There is presently vitamin A deficiency among the communities living along the Jamuna river. Vitamin deficiency is severe due to poor diversity of consumed food, especially after flood. Various proposals for creating more balanced diets may include additional supply of different proteins (e.g. poultry and small stock) and vegetables. However, the low socio-economic level of the affected population make these proposition difficult to implement on a sustainable basis.

4.4 ARCHEOLOGY AND CULTURAL HERITAGE

The JAFP area is characterized by very little or no permanent building. In fact, there appears to be no important archeological sites or even recent ruins despite a long history of human settlement in the area. The climate is rigorous and probably has worked against the preservation of buildings. Another contributory factor may be that population pressure had destroyed what little permanent structures were available. At the present circumstances considerations that demand attention are the existence of graveyards, mosques and temples. A sensitive planning must avoid the damages or disturbances to those permanent features.

The legislation concerning "Preservation and Protection" of cultural heritage and living resources in Bangladesh is obscure by failure to implement and lack of co-ordination among agencies responsible for preserving them. The Antiquities Act 1968 as amended by the Antiquities (Amendment) Ordinance, 1976 was enacted to consolidate and amend the laws relating to preservation and protection of antiquities which replaced "The Ancient Monuments Conservation Act 1904". Under this Act antiquity means: any ancient product of human activity, movable or immovable; illustrative works of art, architecture, craft, custom, literature, morals, politics, religion, warfare; science objects or sites of historical, ethnographical, anthropological, military or scientific interest.

4.5 HAZARDS

There are a number of hazards where analysis of their implications should take place; but none are easy to evaluate. There is a known history of seismic activity in the JAFP area which is characterized by relatively rare but sudden and intense events. The Jamuna river is within the medium risk seismic zone. The recorded seismic activity has been studied by many concerned agencies. Of particular concern is the risk of liquefaction and catastrophic failure and the degree to which this can be reduced by appropriate design. Accounts of the 1897 event indicate that liquefaction was a major problem with catastrophic results in riverine sites.

Changes in the seasonal pattern of precipitation and snow melt in the Himalayas would also affect hydrology and morphology of the Jamuna river, and in turn could create sudden major increase in flow discharge that could conceivably destroy any structure on its way. Catastrophic floods of the Jamuna river engulfing the whole JAFP areas is charaterised by relatively slow rise and long duration. While floods cause loss to crops by submersion, erosion and by spread of sand on fertile lands, they at times do good to the farmland by replenishing the soil moisture and depositing silt.

Historic data indicate a phase of global warming and suggest rise in sea-level. The effects of sea level rise by one meter would create backwater effect at the Ganges-Jamuna confluence should be kept in mind. The JAFP does not fall within the devastation of cyclonic storm, but sometimes experiences heavy cyclonic rainfall. However, the area is an active zone of Nor'westers which brings torrential down pour to cause surface erosion and bank slumping.

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PART B: ANALYSIS OF POSSIBLE IMPACTS

5 ABIOTIC FACTORS FOR ECOLOGICAL IMPACT ASSESSMENT

5.1 INTRODUCTION

In this Chapter an attempt is made to clarify and describe the consequences of the considered scenarios for a Jamuna river training as far as the abiotic factors are concerned. Hereafter first the various scenarios are outlined, the activities in and along the Jamuna river are listed and next their effect on the abiotic factors is indicated. For more details on the scenarios reference is made to Chapter 5 in the Main Report (Vol.IB) and to ANNEX 1 (Vol.II).

5.2 SCENARIOS FOR RIVER TRAINING

For the present project three scenarios for river training have been defined. These scenarios are different as to (1) the ultimate conditions in the river, (2) the timing of the measures taken, (3) the relative importance of permanent and recurrent measures. How the river training works along the Jamuna river will materialize in reality depends upon a number of factors which cannot be foreseen at present, like the socio-economic development in Bangladesh in general and the development in the embanked and set back areas of the floodplain in particular, the availability of funding, and the effectivity of the recurrent measures. All three assumed scenarios studied in the project are listed in Table 5.2-1. As can be observed all three scenarios are the same in the first phase, which is supposed to span the period 1993-1998. In the next phase (for the time being supposed to span a period of some 12 years (1998-2010)) they differ in the extent to which recurrent measures are used. In scenario 1 no recurrent measures are foreseen at all, while in the scenarios 2 and 3 recurrent measures (both surface screens and artificial cut-offs) are assumed to be taken. In the last period considered (assumed to be 2010-2050) for scenario 1 more hard points are created, together with protections of the upstream parts of the islands. In scenario 2 essentially the same objectives are obtained, but these objectives are partly obtained with recurrent measures. Scenario 3 is very much different from the other two options in that the aim is to reduce the total width of the river causing the existing megachars to vanish as a consequence.

For the ecological impact assessment not only the final conditions are important but also the pace at which these activities are reached and the activities which are connected to the implementation of the measures are of concern. In Table 5.2-2 an overview of these activities is given. This is used as basis for the ecological impact assessment of the construction activities.

Phase	River Training Scenarios		
	Scenario 1 Anabranched flood channel through "hard" measures	Scenario 2 Anabranched flood channel through both "hard" and recurrent measures	Scenario 3 Braided river with reduced width
Phase I 1993-1998	1-I: (1) Implementation of FAP 1 and FAP 21 hard points and Jamuna Bridge river training works (2) FAP 22 pilot project	2-I: like 1-I	3-I: like 1-I
Phase II 1998-2010(?)	1-II: (1) Implementation of major hard points at vulnerable places along the right bank (mutual distance some 30 km) (2) No recurrent measures	2-II: (1) Implementation of some hard points along the right bank (2) Recurrent measures along the right and in a few places along the left bank	3-II: like 2-II
Phase III 2010(?)-2050(?)	1-III: (1a) Implementation of major hard points along left bank too (mutual distance some 30 km) (1b) Additional hard points in between major hard points along both right and left bank (1c) Upstream protection of the megachars	2-III: (1a) and (1c) like 1-III (1b) No additional hard points in between major hard points (2) Recurrent measures to prevent bank erosion between major hard points at mutual distance of 30 km	3-III: (1) Recurrent measures to prevent bank erosion between major hard points at mutual distance of 30 km along right bank (2) Recurrent measures along left bank to reduce width of river

Table 5.2-1: Preliminary overview of assumed river training scenarios

Phase	River Training Activities		
	Scenario 1 Anabranched flood channel through "hard" measures	Scenario 2 Anabranched flood channel through both "hard" and recurrent measures	Scenario 3 Braided river with reduced width
Phase I 1993-1998	1-I: (1a) Improvement of Sirajganj revetment over 2 km (1b) Construction of some 4 short revetments of some 250 m length between Sariakandi and Chandanbaisa (1c) Construction of three (permeable) groynes at Kamarjani (1d) Revetment at Bahadurabad over a length of 0.7 km (1e) 2 guide bunds with each a length of some 3 km for the Jamuna Bridge, 10 km south of Sirajganj --- (2) 1 row of surface screens (0.6 km) in a few years for closing one channel as a pilot project	2-I: like 1-I	3-I: like 1-I
Phase II 1998-2010(?)	1-II: (1a) Construction of some 5 revetments with a length of 250 m along the right and left bank (1b) Construction of some 15 additional (lighter?) "hard" training measures (groynes, revetments) along the right and left bank (1c) 1 to 2 upstream protections of upstream sides of megachars consisting of revetments of about 4 km --- (2) No recurrent measures	2-II: (1a) like 1-II (1b) No "additional" hard points (1c) 1 to 2 upstream protections of upstream sides of megachars consisting of revetments of about 4 km --- (2a) 2 rows of surface screens (of 1.5 km each) per year for closing two channels (2b) 1 artificial cut-off every two years by means of dredging some 2 to 5 million m^3	3-II: (1a) like 1-II (1b) No additional "hard"points (1c) No protection of upstream reaches of megachars --- (2a) 3 rows of surface screens (of 1.5 km each) per year for closing three channels (2b) 1 artificial cut-off every two years by means of dredging some 2 to 5 million m^3 like 2-II
Phase III 2010(?)- 2050(?)	1-III: (1a) Construction of some 10 revetments with a length of 250 m along the right and left bank (1b) Construction of some 25 additional (lighter?) "hard" training measures (groynes, revetments) along the right and left bank (1c) 5 protections of upstream sides of megachars consisting of revetments of about 4 km --- (2) No recurrent measures	2-III: (1a) Construction of some 9 revetments with a length of 250 m along the right and left bank (1b) No construction of additional (lighter?) "hard" training measures (groynes, revetments) (1c) 5 upstream protections of upstream sides of megachars consisting of revetments of about 4 km --- (2a) 2 rows of surface screens (of 1.5 km each) per year for closing two channels (2b) 1 artificial cut-off every two years by means of dredging some 2 to 5 million m^3	3-III: (1a) through (1c) No hard points --- (2a) 5 rows of surface screens (of 1.5 km each) per year for closing five channels (2b) 1 artificial cut-off every 2 years by means of dredging some 2 to 5 million m^3

Table 5.2-2: Activities as per assumed scenarios

5.3 EFFECT ON ABIOTIC FACTORS

Next an attempt is made to estimate the effect of the different development scenarios on the conditions in the river. This estimate is based partly on the activities itself and partly on a prediction of the response of the river upon the imposed boundary conditions. A justification for the predictions made is partly based on the morphological response to river training discussed in ANNEX 1 and partly on experience of the Consultant with similar river training works. One should realize that the prediction of the response of the river system is not a simple exercise. The number of freedoms of a braided river system is quite large and the assumed scenarios are not that extreme that no freedom is left. Hence the river can respond by changing its (average) number of channels, the (average) sinuosity of the channels, the (average) slope of the river, and the (average) dimensions of the channels. Predictions of the response of the river were done, using empirical relations. At this moment there are no better and more scientifically based methods available.

In Table 5.3-1 to 5.3-3 the effect of the different scenarios on the abiotic factors is indicated. A distinction is made between the impact of the measures during the construction phase, and the impacts of the recurrent measures (to some extent comparable to the construction activities because they are carried out at one place and in a single period) and the overall effect of the river training activities of the different scenarios.

Scenario Phase	Effect		
	Construction of hard points	Recurrent measures	Ultimate effect
1-I	(1) See impact assessment reports of BRTS (FAP1), and Jamuna Bridge	In a few years one channel (in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in this channel gradual sedimentation is taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur	(1) Effect of creation of some four hard points: locally (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks as groynes and revetments with a slope of 1:3 and consisting of large boulders or concrete blocs with a diameter of several dm along the right and to a minor extent along the left bank over a total distance of some 4 km, and actual length of surface with stony surface some 4 km, partly perpendicular to the river. (2) In between and near groynes gently sloping banks with sand as bed material increase in length by some 4 km (3) Steep eroding banks in length reduced by some 6 km (4) No change in channel dimensions etc. (5) Near groynes and revetments deep scour holes (20-30 m) (6) No changes in average velocities
1-II	See impact assessment study BRTS (FAP 1)	No recurrent measures	(1) Effect of creation of another 5 major hard and some 15 additional hard points: locally at about 25 places (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks (see above) along the right and left banks, actual length of surface with stony surface some 25 km, mostly perpendicular to the river. (2) In between and near groynes gently sloping banks with sand as bed material over about half of the river length (3) Steep eroding banks in length reduced by about 50 % along both the left and right outer banks (4) Some reduction of smaller channels which are now present near the banks (5) Near groynes and revetments deep scour holes (20-30 m) (6) No changes in average velocities
1-III	See impact assessment study BRTS (FAP 1): also the frequency of constructing activity in the river will be similar to Phase I	No recurrent measures	(1) Effect of creation of another 5 major hard and some 15 additional hard points: locally at about 25 places (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks (see above) along the right and left banks, actual length of surface with stony surface some 75 km, mostly perpendicular to the river. (2) In between and near groynes gently sloping banks with sand as bed material over about half of the river length (3) Steep eroding banks along the river outer banks almost completely eliminated; still some eroding banks at the downstream ends of the midchannel islands (4) Some reduction of smaller channels which are now present near the banks (5) Near groynes and revetments deep scour holes (20-30 m) (6) No changes in average velocities

Table 5.3-1: Assumed effects of Scenario 1 on abiotic factors

Sce-nario Phase	Effect		
	Construction of hard points	Recurrent measures	Ultimate effect
2-I	Like 1-I: (1) See impact assessment reports of BRTS (FAP1) and Jamuna Bridge	Like 1-I: In a few years one channel (in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in this channel gradual sedimentation will be taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur	Like 1-I (1) Effect of creation of some four hard points: locally (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks as groynes and revetments with a slope of 1:3 and consisting of large boulders or concrete blocs with a diameter of several dm along the right and to a minor extent along the left bank over a total distance of some 4 km, and actual length of surface with stony surface some 4 km, partly perpendicular to the river. (2) In between and near groynes gently sloping banks with sand as bed material increase in length by some 4 km (3) Steep eroding banks in length reduced by some 6 km (4) No change in channel dimensions etc. (5) Near groynes and revetments deep scour holes (20-30 m) (6) No changes in average velocities
2-II	Like 1-II, but no additional hard points.	(1)In all years two channels (each in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in these channel gradual sedimentation will taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur (2) Once every two years a channel will be dredged of some 5-7 km long, 100-200 m wide and 3 m deep, the spoil probably to be dumped on the adjacent chars	(1) Effect of creation of another 5 major hard and no additional hard points: locally at about 10 places (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks (see above) along the right and left banks, actual length of surface with stony surface some 25 km, partly perpendicular and partly parallel to the river. (2) Near groynes gently sloping banks with sand as bed material over about 15 % of the river length (3) Steep eroding banks in length reduced by about 25 % along the river outer banks (4) Some reduction of smaller channels which are now present near the banks (5) Two channels a year will be closed by surface screens (increased sedimentation, larger velocities) (6) Near groynes and revetments deep scour holes (20-30 m) (7) No changes in average velocities
2-III	No hard points and additional hard points will be constructed in this period	(1)In all years three channels (each in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in these channel gradual sedimentation will taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur (2) Once every two years a channel will be dredged of some 5-7 km long, 100-200 m wide and 3 m deep, the spoil probably to be dumped on the adjacent chars	(1) Effect of creation of 10 major hard points in previous phases: locally at about 10 places (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks (see above) along the right and left banks, actual length of surface with stony surface some 25 km, partly perpendicular and partly parallel to the river. (2) Near groynes gently sloping banks with sand as bed material over about 15 % of the river length (3) Steep eroding banks along the river outer banks reduced over 25 % of their present length (4) Some reduction of smaller channels which are now present near the banks (5) Three channels a year will be closed by surface screens (increased sedimentation, larger velocities) (6) Near groynes and revetments deep scour holes (20-30 m) (7) No changes in average velocities

Table 5.3-2: Assumed effects of Scenario 2 on abiotic factors

Scenario Phase	Effect		
	Construction of hard points	Recurrent measures	Ultimate effect
3-I	(1) See impact assessment reports of BRTS (FAP1) and Jamuna Bridge	In a few years one channel (in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in this channel gradual sedimentation will taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur	(1) Effect of creation of some four hard points: locally (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks as groynes and revetments with a slope of 1:3 and consisting of large boulders or concrete blocs with a diameter of several dm along the right and to a minor extent along the left bank over a total distance of some 4 km, and actual length of surface with stony surface some 4 km, partly perpendicular to the river. (2) In between and near groynes gently sloping banks with sand as bed material increase in length by some 4 km (3) Steep eroding banks in length reduced by some 6 km (4) No change in channel dimensions etc. (5) Near groynes and revetments deep scour holes (20-30 m) (6) No changes in average velocities
3-II	Like 1-II, but no additional hard points.	(1)In all years three channels (each in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in these channel gradual sedimentation will taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur (2) Once every two years a channel will be dredged of some 5-7 km long, 100-200 m wide and 3 m deep, the spoil probably to be dumped on the adjacent chars	(1) Effect of creation of another 5 major hard and no additional hard points: locally at about 10 places (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks (see above) along the right and left banks, actual length of surface with stony surface some 25 km, partly perpendicular and partly parallel to the river. (2) Near groynes gently sloping banks with sand as bed material over about 15 % of the river length (3) Steep eroding banks in length reduced by about 25 % along the river outer banks (4) Some reduction of smaller channels which are now present near the banks (5) Two channels a year will be closed by surface screens (increased sedimentation, larger velocities) (6) Near groynes and revetments deep scour holes (20-30 m) (7) No changes in average velocities
3-III	No hard points and additional hard points will be constructed in this period	(1) In all years five channels (each in a cross-section with 3 to 4 parallel channels) closed with surface screen at the upstream side; in these channel gradual sedimentation will taking place and locally (underneath the surface screens) high velocities (2-3 m/s) may occur (2) Once every two years a channel will be dredged of some 5-7 km long, 100-200 m wide and 3 m deep, the spoil probably to be dumped on the adjacent chars	(1) Effect of creation of 10 major hard points in previous phases: locally at about 10 places (near the groynes/ revetments) velocities up to 4 m/s; "hard" banks (see above) mostly along the right and some along the left banks, actual length of surface with stony surface some 25 km, partly perpendicular and partly parallel to the river. (2) Near groynes gently sloping banks with sand as bed material over about 15 % of the river length (3) Steep eroding banks along the river outer banks reduced over 25 % of their present length (4) Some reduction of smaller channels which are now present near the banks (5) Five channels a year will be closed by surface screens (increased sedimentation, larger velocities) (6) Near groynes and revetments deep scour holes (20-30 m) (7) Decrease in the number of parallel channels from 3 to 2; increase in sinuosity of some 10 % (8) Increase of average channel depths and width with some 10 and 20 %, respectively (9) Probably reduction of 5 to 10 % in average velocities

Table 5.3-3: Assumed effects of Scenario 3 on abiotic factors

6 EFFECT OF PAST INTERVENTIONS

As known at present, no environmental survey has been done following works in Bangladesh of the type planned under FAP 22 (groynes, screens, revetments, cut-offs). Hence the basis for the present study is field observations and interviews on sites where similar works were undertaken, like the groyne of Sariakandi.

Impacts of embankments are better known as they have been monitored for a long time. However conclusions about embankments may be of limited use only in this case. Monitoring the pilot works of FAP 21/22 will therefore be necessary and will be very useful to predict the response of the environment in the next phases.

7 EFFECTS OF THE WORKS

In the three scenarios presented Section 5.2 of this chapter, the type of works anticipated is similar. The main differences between the three scenarios consist of the frequency and extent of the different types of works, and also the phasing according to which they will be implemented. Therefore, in the following section, the main consequences of each type of works have been reviewed. It is stressed here in advance that no modification of the flooding pattern (starting period, depth, duration, time for receeding) is assumed to be induced by the Project.

7.1 HARD MEASURES

7.1.1 Revetments

(1) Construction effects

Dredging (or filling) of sand will be needed to correct the bank slope to 1:3, before the installation of revetments. These operations would temporarily increase the concentration of suspended materials in the water locally. But as the natural process of bank erosion induces heavy sediment concentration at the place of erosion and surroundings by the eroding bank material, no further impair to the present situation is expected by dredging operation.

Hence the risks which may exist in other (e.g. European) surroundings, such as

- risk of pollution by substances (toxics, nutrients), released from the sediments;
- covering of vegetation with sediments;
- decrease of light penetration which affects the productivity;
- siltation of spawning sites and fish habitats;
- perturbation of fry migrations, and
- physiological stress on fish.

are not expected to exist in the Jamuna, may be with exception of the last one.

Siltation of shallow-waters sheltering vegetation, fish habitats and spawning sites will occur only locally downstream from the dredging points. The impacts depend on the period of the dredging works, the amplitude of the sediment trail, the degree of compaction of sediments, the duration of works and the type of machine used. If water level and velocity are high (at the end of the monsoon period), then sediments will probably be dispersed more easily. Compacted sediments or sand will deposit more quickly in a more restricted area than fine sediments (silt).

Anyhow, impact will depend on the ecology of each species (e.g. some percidae are known to clean their spawning sites, if necessary). Deposited sediments will be flushed away during the next flood, in any case. Influence on fingerlings migration and physiological stress on fish should be minor and localised since dredging does not occur during fry movement or spawning period and not for a too long time. Since the released quantity of sediments will be in the time of sediment concentration at high discharge no major effects are expected.

Anyhow a pre-construction survey is strongly recommended at the alternative locations of revetments to identify local situation and to give advice on possible ecological impact.

(2) Effects of (Single) Revetments

This assessment assumes that only some single revetments may be constructed and not a continuous one along the total length. These single revetments would increase the variability of the banks which is now uniformly vertical:

- in the areas of erosion where revetments may only be built;
- improving the access by the population to the river, and
- creating gentle slopes for vegetation growth and fish spawning.

Turbulence, collapse of bank material, occasional sharp increase in sediment concentration due to bank collapse will no more prevail and the surroundings will present a calm environment and the situation is likely to improve protecting the existing natural and human environment.

The objective of revetments being the protection of (formerly) eroded banks also all natural habitats (beels, homesteads etc.) would be protected inside that area. But this would also mean a likely increase of the population density on the safe bank which would have a negative consequence on the natural habitats (natural vegetation, wild life, birds) where existing. It could further cause pollution due to domestic waste and pesticides or it could cause over fishing. These negative consequences are however, not typical for the revetments but for an over populated country as a whole.

7.1.2 Groynes

(1) Construction Phase

The impacts of the construction phase will be similar to those induced by the construction of revetments. A difference would in the fact that in case of conventionally built groynes large quantities of soil would have to be moved partly by hydraulic dredging and partly by excavation on land.

(2) Effects

The aim of groynes is (i) to reduce the current velocity at the bank and divert it from the eroding bank; (ii) to trigger sedimentation and allow accretion of land.

(i) The water flow will be completely changed at the proximity of the groynes. Between two consecutive groynes water velocity will be considerably reduced. Upstream and downstream of the groynes, eddies will be formed causing scour holes in the river bed.

Reduction of the velocity of water will cause less erosion of the banks and offer a more quiet environment for vegetation and animal species. Weeds should develop mostly, if some alluviums are mixed with deposited materials, but will have to compete with rice cultivation. Fish should find refuge in calm waters. Species that would suffer (birds, amphibians,..) would be those which were using the eroding banks previously.

(ii) As said before, the low velocity of water, added to sedimentation may favour installation of plants and fish. Gentle slope created by groynes will likely be cultivated up to the water level with rice, and with wheat on dry parts, as seen around the Sariakandi groyne. Non cultivated zones are used as fodder or will favour growth of aquatic weeds. These gentle slopes should be attractive places for fish and vegetation may offer support for fish spawning.

Gentle slopes will ultimately help establish the connection with the river. Dikes will also offer possibilities for trees, grazing and eventually shelter for landless people.

Since also the main objective of groynes would be to stop the bank erosion (with a positive side effect of local accretion of land) an increase of the local population has to be expected due to the general people's pressure in Bangladesh. The consequences would be similar to those described in Subsection 7.1.1.

7.2 RECURRENT MEASURES

7.2.1 Artificial Cut-off

(1) Construction phase

The works will consist in excavating a new straight channel for diverting the discharge in order to ultimately eliminate the initial eroding bend.

The initial excavation preferably will be conducted in dry land, whereas the upstream and downstream portion will be opened during high water.

(2) Short term effects

The new channel may in exceptional cases be dug through megachars, that means cultivated and settled islands. Therefore, lands used for grazing or cultivation would be lost (50 to 140 ha for one channel).

The spoil may be used in a planned way to construct roads on both sides of the channel which will also provide flood protection to the adjacent lands. The channel part although lost to grazing and farming, will be used by fishermen and as source of water for low lift irrigation when needed.

(3) Long term effects

Long term effects would basically be similar to those of natural cut-offs which are happening continuously every year in the Jamuna active flood plain.

The former channel will be partly silted-up. That means 15 to 35% of the old channel length will be modified for each cut-off and provide a stagnant pool of water, with the following consequences:

- 15 to 35% of riverine habitats may slightly be modified;
- diversity of habitats will not be effected in overall context;
- riverine area of the old channel will be modified giving rise to stagnant pool for culturefish; natural condition is likely to remain unchanged; consequently soil conditions (structure and moisture) will change; this should modify flora and cultivation pattern;
- migration routes of fish shall be changed via new channel; the slight increase of the average water velocity in the cut-off channel (from 1.7-1.8 m/s to 2.0-2.2 m/s) should not disturb fish movements and spawn drift; also fingerlings migration may not be hampered, and
- an increase of fishing grounds will occur.

To sum up, the implementation of artificial cut-offs on a large scale could have a significant impact on the piscicultural potential through physical perturbations and

consequent loss of habitats and shallow-waters with aquatic weeds. Perturbations of spawn and fry migration will also occur.

The aim of the cut-off is the stoppage of bank erosion and the improved access to stabilized land. This will make more land available for making homestead and for cultivation of course there increased facilities will have their marginal drawn backs which are normally associated with increase in population.

7.2.2 Surface Screens

(1) Construction phase

No major effect was identified during the construction phase except the usual ones due to the construction site.

(2) Short term effects

Surface screens will modify water velocity and flow direction to induce high sedimentation in related channel.

Underneath the surface screens, the velocity will rise up to 2 to 3 m/s which may disturb fish movement. However in a first phase, migrations routes will not completely be blocked as not more than 60% of the width of the channel will be closed.

Screens will block-up the floating debris such as water hyacinth. This could create an unfavourable environment (see Subsection 7.1.2). Downstream, algae productivity and weed growth are supposed to increase if water quality and soil conditions are favourable. Reduction of flow velocity could reduce the dilution of pollutants (if existing) and probably rise the water temperature during dry season. That may result in potable water quality problems

(3) Long term effects

They will be quite similar to those induced by artificial cut-offs, as the final aim is also to close a lateral channel. The main difference might be that the closure here will be more progressive (3 to 5 years). That will leave more time for animal species to adapt themselves to new conditions, time for soil improvement and for flora growth.

However aquatic and riverine habitats and riverine surroundings will progressively disappear.

Possibly the impacts on migratory fish could be important if they turn into the channel and then find no way upstream to go out. But most probably they will not enter channels with low discharge.

Depending on the topography of the channel bed, some stagnant water could be kept in some places. Low current and development of vegetation should favour insect development and, therefore, vector-diseases.

7.3 EFFECTS OF THE CONSTRUCTION SITES

Consequences of the construction period will not be major but however need to be mentioned:

- interruption of agricultural practice and compaction of soils;
- difficulties for fishing activities;
- increase of domestic waste water discharge and construction material waste (fuel, solvents, lubricants);
- disturbance of wildlife and birds;
- inconvenience due to local increase of population and the resultant water-supply, risk of diseases, problems of sanitation, etc., and
- socio-economic changes due to the arrival of number of workers.

8 PROJECT ALTERNATIVES AND CONSEQUENCES

8.1 PRELIMINARY IMPACT ASSESSMENT

Identifying the issues for the proposed scenarios has been carried out, but comparing the different potential impacts of each of these has proved to be difficult. This is due to lack of baseline data on the natural environment and also the present imprecise nature of the scenarios. In addition, prediction of likely river behaviour for the next 60 years is both difficult and problematic. Despite these limitations, a subjective comparative assessment has been made for each scenario issue by issue. No comparison has been made to a without project situation as there are a range of other interventions being planned, the nature of which are imprecise. These include FAP 1, (Brahmaputra Right Embankment) and the proposed Jamuna Multi-purpose Bridge. In addition, it has been indicated that, irrespective of FAP 22, a policy initiative is desired to tackle bank erosion and river movement. The work has been carried out using a matrix technique with comparison to a present steady state situation valued at 0.

The items considered to be affected by the project are listed in the Table 8.1-1.

The matrix gives a ranking of impacts using the -5/+5 scale system as required by FPCO (Guidelines for Project Assessment, Annex 8-EIA, 1992), assuming that no mitigation of negative impacts is carried out:

+5 : highly positive impact
+4 : significant positive impact
+3 : mainly positive impact
+2 : partly or moderate positive impact
+1 : slight positive impact
0 : no influence
-1 : slightly negative impact
-2 : partly negative impact
-3 : mainly negative impact
-4 : significant negative impact
-5 : severe negative impact (likely irreversible).

A positive (or negative) impact may occur either with an increase or a decrease of the factor, depending upon the nature of the issue.

As all the items should not be considered with the same importance, the first column gives a rank to each component. The rank of issues has three levels as described below:

III : factors of the first importance considering ecology or/and resources. Absolutely needs to be conserved.
II : factor ecologically important but not directly influent on human environment; or does not concern so much this area
I : factor having a few repercussions.

At the latest stage in the study, it will be necessary to know the views of local people as to which issues they consider to be of the greatest priority.

However, comments on the project consequences will need reassessment and readjustment later on when other major intervention proposed on the Jamuna will be implemented (Jamuna bridge, FAP-1). Then the situation should have changed.

The without project alternative is not mentioned in the preliminary impact assessment as this situation will not exist in the future. In fact, FAP 1 and the Jamuna Bridge projects will affect the Jamuna environment during the first phase. Those impacts are already described in the related project environmental annexes. Secondly, even without FAP 21/22 project, the right bank will need to be protected to avoid the heavy erosion and the shifting of the river. Therefore, for the present assessment, the actual situation is taken as a reference situation. This will be modified and improved in the future. The result of the ecological impact assessment are given in Table 8.1-1.

Issues	Rank	Scenario 1	Scenario 2	Scenario 3
Physical Environment				
Land Resources				
Erosion	III	+4	+3	+2
Sedimentation	II	+3	+2	+2
Soil fertility	III	0	-1	-2
Natural/cultivated area including islands	I	-1	-1	-2
Water Resources				
Ground water	III	0	0	0
Surface water regime	II	-2	-2	-3
Water quality	II	0	-1	-1
Natural Environment				
Habitats Diversity				
Aquatic	III	-4	-2	-3
Terrestrial	I	-1	-1	-2
Flora				
Aquatic weeds	I	-2	-2	-2
Terrestrial vegetation	II	-1	-1	-2
Fauna				
Amphibians & reptiles	II	-3	-2	-2
Birds	II	-1	-1	-3
Wildlife	I	-1	-1	-1
Fish				
Migrations	III	-1	-2	-3
Quantity	III	0	-2	-3
Species composition	II	0	-1	-1
Human Environment				
Fishing				
Occasional	III	-2	-2	-2
Professional	III	0	-1	-2
Fry collection	III	-3	-2	-3
Risks	III	+5	+4	+4
Health				
Water-borne diseases	III	0	-1	-1
Insect-borne diseases	II	0	-1	-1
Nutrition	III	+3	+3	+3
Archeology & cultural heritage	I	-1	-1	-1

Table 8.1-1: Subjective ecological impact assessment

Some comments need to be given regarding the impacts in Table 8.1-1. It must be pointed out that figures are quite relative and subjective:

+ Erosion and sedimentation: erosion of settled and cultivated lands should be tremendously reduced in scenario 1. In scenarios 2 and 3, erosion should be compensated by accretion. However in scenario 3, the loss of high megachars would not be replaced by new accreted low-lands before some time.

+ Soil fertility: this will not change in scenario 1; In scenarios 2 and 3, the artificial cut-offs and spoil dumping may cause some loss of fertile land, and more in case of scenario 3 where the megachars should vanish. New accreted land will be of poor fertility initially.

+ Natural area/cultivated surfaces: in each scenario, natural surfaces will decrease resulting in loss of natural banks and non permanent chars, loss of external small channels; but increase of safe cultivable lands. Hence the artificial cut-off effects should be added in case of scenarios 2 and 3, with vanishing of megachars in scenario 3.

+ Ground-water: should not be affected as the water-table is replenished mostly through rainfall and flood flow.

+ Surface water regime: small lateral channels will disappear in any case, and local or average velocity will be changed. In scenarios 2 and 3, artificial cut-offs and surface screens will generate the closing of big channels.

+ Water quality: could be affected in closed channels due to the stagnation of water.

As a result of River Training and AFPM, more land area is expected to be reclaimed for human use. This will give rise to uses of more agro-chemicals as well as the amount of sewage and waste effluent within the AJFP areas. In turn, this will increase river water pollution resulting in the low availability of oxygen, and thus affect fish growth.

+ Habitats: decrease or absence of natural eroding banks, decrease of shallow-water and slow velocity areas will affect diversity and quantity of aquatic habitats considerably. (for scenario 1)
Terrestrial habitats will be less affected, but disappearing of megachars (scenario 3) and increase of safe cultivable land will destroy the natural habitats.

+ Aquatic weeds: will decrease a lot with artificial banks, absence of shallow-waters with low velocity. Anyhow, they are apparently, not very numerous at present.

+ Flora: natural vegetation is already poor in this area but will still decrease with vanishing of chars (scenario 3), artificial banks, and increase of cultivation.

+ Amphibians, reptiles, birds and wildlife:- will be affected by the artificial banks, particularly amphibians and bank dependant birds. However, amphibians should find new habitats in slow running waters of closing channels. Birds will be really affected by the disappearing of chars, and mostly fishing and migratory birds. Increase of population should disturb wildlife (which is poor) and birds. Granivorous birds should find benefit in increasing cultivation and homesteads.

+ Fish: migrations should be disrupted through water velocity changes and decrease of number of channels, but mostly with closed channels where the risk of blocking up migration of fish is important. Therefore reproduction of migratory species could be affected and consequently a modification in species composition may be induced.

  Increase of population is likely to induce overfishing, when the fish stock is already decreasing. This could be compensated by decrease of landless people.

+ Fishing: occasional fishing will be hindered around the artificial banks, because of the difficult access and the non-attractive environment for fish. It would be also affected if overfishing increases.

  Possible decrease of fish pool and overfishing may affect professional fisheries.

  Fry collection should decrease because of closing channels (scenario 2 and 3) and artificial banks (scenario 1) and then have repercussions on pond fisheries.

+ Diseases: risks of water and insect-borne diseases may increase in the closing channel, through slow running water, development of water-hyacinth, degradation of water quality and increase of temperature (scenarios 2 and 3)

+ Nutrition:- for all scenarios, stabilization of land will have favourable influence, particularly on landless people's food income. However a nutrition program could improve the nutritional balance of this area (diversification of animal proteins, improvement of vitamin availability, iodine input etc.).

8.2 SYNTHESIS AND ADVICE

Table 8.1-1 must be taken as a simple advice and a wide estimation. It should be improved in the future with the technical progress and the observation of the river on the pilot sites, with the experience of other projects, and with the improvement of ecological knowledge.

To obtain an overall view of the likely impacts, a total has been calculated for each scenario, utilising the rank of the concerned factor and the impact value, as shown in the following example:

- magnitude of the impact of erosion in scenario 1 is:
  +4 (impact value) x III (rank of erosion) = +12

Adding all the relative values for each scenario, the following results are obtained:

- Total scenario 1 = - 8 }
- Total scenario 2 = -29 } With an amplitude of -285/+285 and a margin
- Total scenario 3 = -60 } of ± 57, if we considered that every impact value may be different for ± 1.

Therefore the interval confidence will be as follows:

scenario 1	:	[- 65; + 49]
scenario 2	:	[- 86; + 28]
scenario 3	:	[- 117; + 3]

Regarding this, figures mean nothing in themselves but may give an idea of the total comparative effects of the three scenarios on the environment, bearing in mind the relative importance of each ecological or human factor. From this, it can be observed that scenario 3 is the most problematic alternative, from an ecological and resources use point of view.

In comparing the two first scenarios, there would appear to be a significant difference between the two, with scenario 1 having a negligible influence on the environment. However this can not be the case in reality, and it is likely that scenario 1 will have a greater impact than indicated. The most objective way to compare scenario 1 and scenario 2 is by studying their consequences on the main factors:

- in the two cases, erosion will be limited and megachars will be protected.
- soil fertility will probably decrease in scenario 2, but this could be minimized through adequate mitigation measures.
- Aquatic weeds will probably be diminished more with scenario 1.
- the largest difference concerns fish stocks, which could be more negatively affected in scenario 2 than in scenario 1. However, if scenario 2 would be chosen, adequate mitigation measures could significantly decrease the impacts on fish, fry collection and fisheries. This would require a programme of detailed field studies covering the whole of the Jamuna, better general knowledge of fish ecology followed by monitoring of the pilot sites.

  The present limited knowledge of fish systems does not allow definitive conclusions to be made about the impacts of each scenario. Bank protection is likely to have less detrimental effects than closing channels, but the impact of the bank protection and resulting loss of habitats can not be predicted in detail at the moment.

In conclusion, the uncertainty of other possible interventions and the difficulty in predicting their impacts, along with the lack of understanding of natural environmental processes, make assessment difficult at this stage. Further specific natural environment data needs to be collected concerning the Jamuna river, and more precise ideas as to the specific nature of the proposed interventions are required before a firm recommendation can be given as to which scenario is likely to have less negative effect on the natural environment and resource use.

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9 PRELIMINARY SUGGESTIONS TO MINIMIZE THE IMPACTS

Mitigations and compensations should be determined in detail during further studies. However, some recommendations may be given, to reduce the effects of construction and implementation of the pilot works:

(1) Negative impacts of construction phase: the construction phase is needed to be conducted in such a way as to limit negative impacts on water pollution, domestic and material wastes, sanitary conditions, overfishing, etc. Effort will be needed to avoid the non indispensable disturbance on environment.

(2) Dredging: a preliminary analysis of sediments has to be undertaken to make sure that no toxic elements will be released. If toxics are detected, control of water-quality and fish reaction must be monitored during the operation of the dredging works.

Dredging impacts can be limited through monitoring of suspended matters throughout the period of intervention. Sufficient flow is needed to disperse the sediments. Dredging works should be discontinued or carefully conducted during the migration and spawning period (April to August).

(3) Dumping of spoil materials: analysis of these materials have to be undertaken. Attention must be given to avoid covering fertile soils with sterile materials like sand. In case this cannot be avoided, the top layer of the initial soil may be preserved in appropriate conditions, and then spread over the dumped spoil to keep the soil quality intact. In fact, a solution could be to use the sand dredged from the artificial cut-off to fill up the old channel.

To compensate the loss of fertility, soil quality could be improved with soil conditioners, which is a costly method, or through indirect manners like providing fuel in the aim to keep cow-dung for fertilization, instead of burning it like people are often doing, or planting enriching vegetal species (like leguminous).

(4) Water-quality: in the channels with decreasing discharge, water quality has to be surveyed. Discharge of waste and waste water must be controlled in these areas. Provision of all-year round safe drinking water and sanitation facilities should be provided to avoid water-borne diseases.

(5) Water-hyacinth: evacuation of these weeds has to be helped by directing the surface flow through an artificial evacuation. In case people would need water-hyacinth, this is not effective.

(6) Revetments: loss of habitats could be compensated by the provision of refuge areas and shallow-waters for fish.

(7) Groynes: plantations on the sedimented area between two successive groynes could limit later superficial erosion. With an adequate vegetation cover, safety against critical flow velocity for erosion of bare sand should be up to twice. Vegetation should also improve soil quality keeping the alluvium and enriching soil with organic matters. Biomass would increase with this supplemental contribution of vegetation matter.Gentle slopes with vegetation cover will probably provide shelter and help spawning.

Attention must be given in selecting appropriate species. Properties needed are: extensive roots system and large a rial covering, rapid growth, and facility to support some submersion. These plants must not damage the construction works. Perennial plants will be chosen. But in over-populated areas, plantation may face competition with rice cultivation. Therefore, a succession of cultivation and natural species could be planned to assure an all-year round covering.

Plants have to be found on priority basis from among local species. However, the case of very efficient foreign plants may also be studied.

Preference will go to species with maximum utilities like fodder, medicinal properties, timber wood, fuel, fruits and vegetable shade. Plantations of trees can be organized as well on the groynes themselves, in the same manner. Trees will provide new habitats for birds.

(8) Fish: temporary or permanent loss of access to fishing and spawn collection grounds have to be compensated through providing access for fishermen.

Permanent losses of fry supply for pond fisheries might be balanced with nurseries support. However, fishermen will still be affected. Compensation must be found for collectors.

Impacts on fish cannot yet be quantified with the limited present knowledge. Losses of fish in shortcut channels have to be surveyed in detail and mitigated or compensated.

Silted channels, due to artificial cut-offs and screens may be planned with artificial depressions to permit fisheries to be developed.

Further studies will allow to improve mitigations and compensating measures.

10 RECOMMENDATIONS FOR FURTHER INVESTIGATIONS

Comprehensive studies are required to collect baseline data on the natural environment and specifically ecology. This includes further collection of existing secondary data sources and also specific raw data collection programmes for the study area.

(1) Baseline Data Requirement

The present status of environmental knowledge is not sufficient to predict exactly what could be the impacts of the project. Baseline data could be collected during the feasibility phase, in the aim to update the existing situation and to adjust the impact assessment. A data collection programme covering one biological cycle, including all seasons, is desirable. This is particularly true for water quality, suspended matter concentration, fish migration and reproduction and birds both resident and migratory. These investigations could be made with local research organisms.

Water sampling needs to be carried out in a wide range of locations and at different seasons to give a global profile of Jamuna river water quality.

More data are also required concerning aquatic flora, the succession of natural vegetation (particularly on char islands), wildlife, nutrition, diseases and cultural sites.

Research on vegetation species suitable for covering the newly formed land areas needs to be undertaken. Priority should be given to using local species.

Data collection on changes induced by existing groynes and revetments will be helpful.

(2) Investigations before choice of pilot sites

Field investigations need to be carried out to determine the richness, diversity, and linkages along with the human use of resources, in the possible sites. Using this information, environmental criteria must be taken into account in the final site selection decision.

(3) Before commencement of construction works

The existing situation of the chosen sites will need to be thoroughly investigated before the start of construction. This will require an intensive period of study before commencement of construction. Ideally this needs data collection during different seasons, particularly for issues such as water quality. A comprehensive understanding of the site will permit an evaluation of the impact of the works and steps draw up to try and minimize these. This will provide the baseline data for environmental monitoring of the works.

(4) During the works

Control of water quality and the quantity of suspended matter is desirable during the dredging works. This requires frequent sampling and analysis on the site itself and also downstream which can be used to influence the nature of the dredging operation. Interviews with fishermen, and fisheries investigations would also be helpful in this work.

(5) Post construction monitoring

+ For the Test sites and pilot works, the ongoing data collection programme for the natural environment has to be continued, particularly with regard to fish and fisheries, water quality, water and insect-borne diseases and water-hyacinth growth.
+ For the areas where recurrent measures are proposed, it would be valuable to conduct the same survey on other similar but unaffected channels, as control sites. The reference channels and sites must present the same initial conditions as the pilot sites. This operation should permit exclusion of variations due to natural or external changes, and consequently allow better identification of the actual impacts of the works.
+ The outcome of the monitoring of impacts induced by other proposed projects needs to be considered, with the aim of updating the existing situation and adjusting the impact evaluation. Therefore, this could permit identification of the cumulative consequences of the different project impacts.

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PART C: ENVIRONMENTAL ASSESSMENT ON THE FAP 21 TEST SITES

11 EXISTING SITUATION AT THE TEST SITES

11.1 Kamarjani (see Fig.11.1-1 and 11.1-2)

11.1.1 Introduction

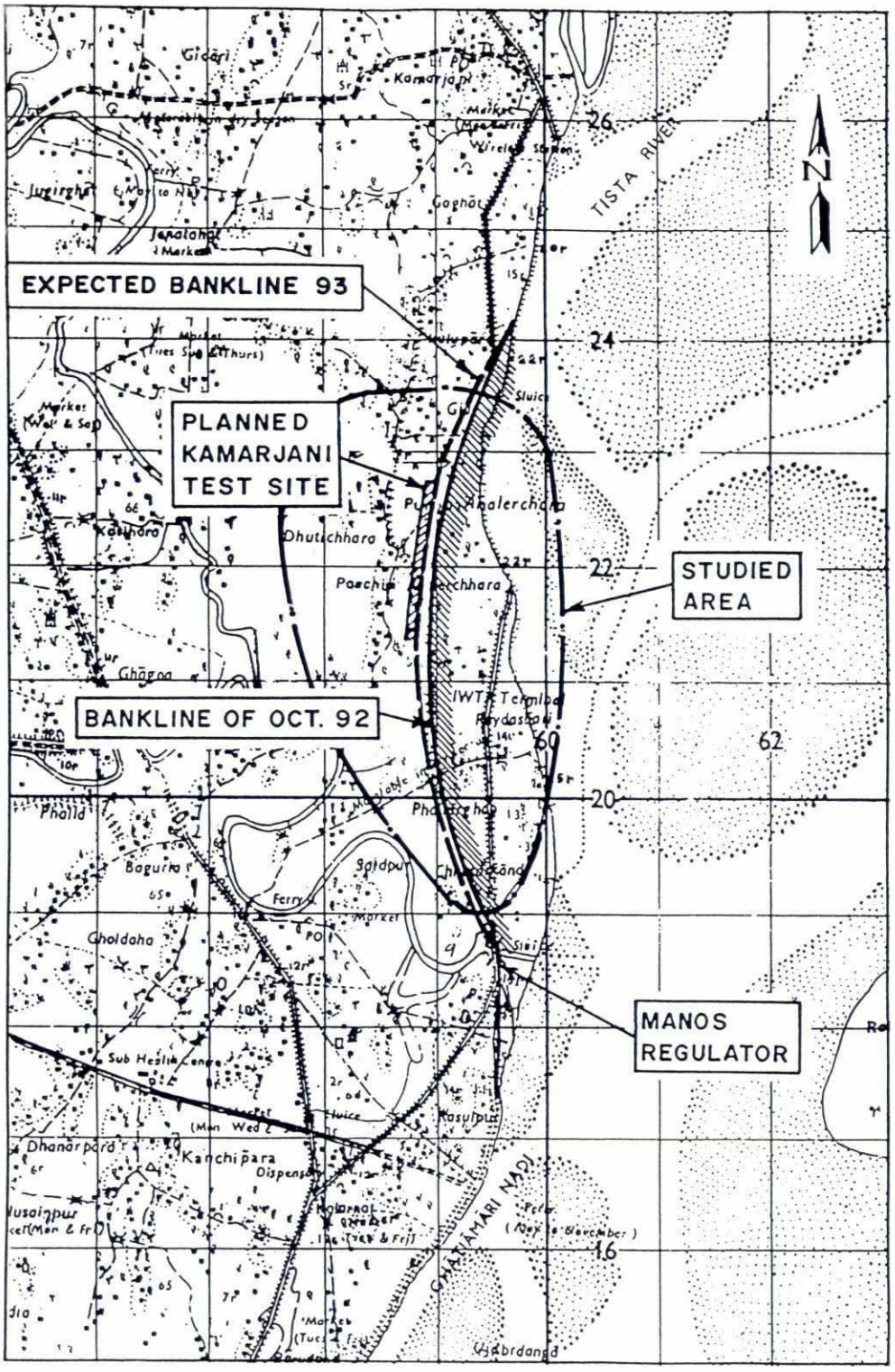
The site was heavily eroded during 1992. Local people reported that a strip of land about 500 ft (160 m) wide was lost during 1992 (see Fig.11.1-2). As a result, the selected test site may have to be moved. The proposed 3 groynes each of 120 m length will be constructed at about 250 m intervals. As the proposed test site had not been determined yet, the present environmental evaluation was done in the area on both sides of the present embankment. The riverside portion of the site forms a triangle of about 100 m length along the river from the point where the embankment has been eroded north of a side bund which is some 50 m long. The channel which connects the Jamuna with the Ghaghot and the Manos rivers flows on the north side of Kamarjani and is about 15 m deep. The channel carries large amounts of suspended sandy soil which is deposited on the agricultural fields making the farming difficult. The erosion victims displaced from their village in 1992 live on the southern side of the bund and along the embankment slope where 20 and 50 families live respectively. The triangle-shaped land area comprises about $^1/_5$ low areas (borrow pit), about $^2/_3$ medium high land and remaining area of freshly deposited sandy silt. The other side of the existing embankment has more low-lying areas, homestead and highland. The cropping pattern is different in both the areas. As there are many beels in the area more fish culture was seen. People catch fish in beels and sell them locally. Diversified water birds fauna were seen in the area.

11.1.2 Land Use

About 60% of the land in the triangle is cultivated with transplanted aman rice. Rest of the area consists of permanent waterbody and silted highland. In the other part, west side of the embankment, high silted area and lowlands exist. Silted areas are not cultivated and lowland is inundated. This area is used for fish culture.

11.1.3 Flora

As the area is low-lying and the homesteads are few and scattered, different species of trees other than specially flood resistant species are not available. Though there was flood embankment, the khal from the Jamuna that entered into the project area, inundated the low-lying areas to some extent and only those species that can withstand high moisture and flood water survived. The list of the species are given in Table 11.1-1.

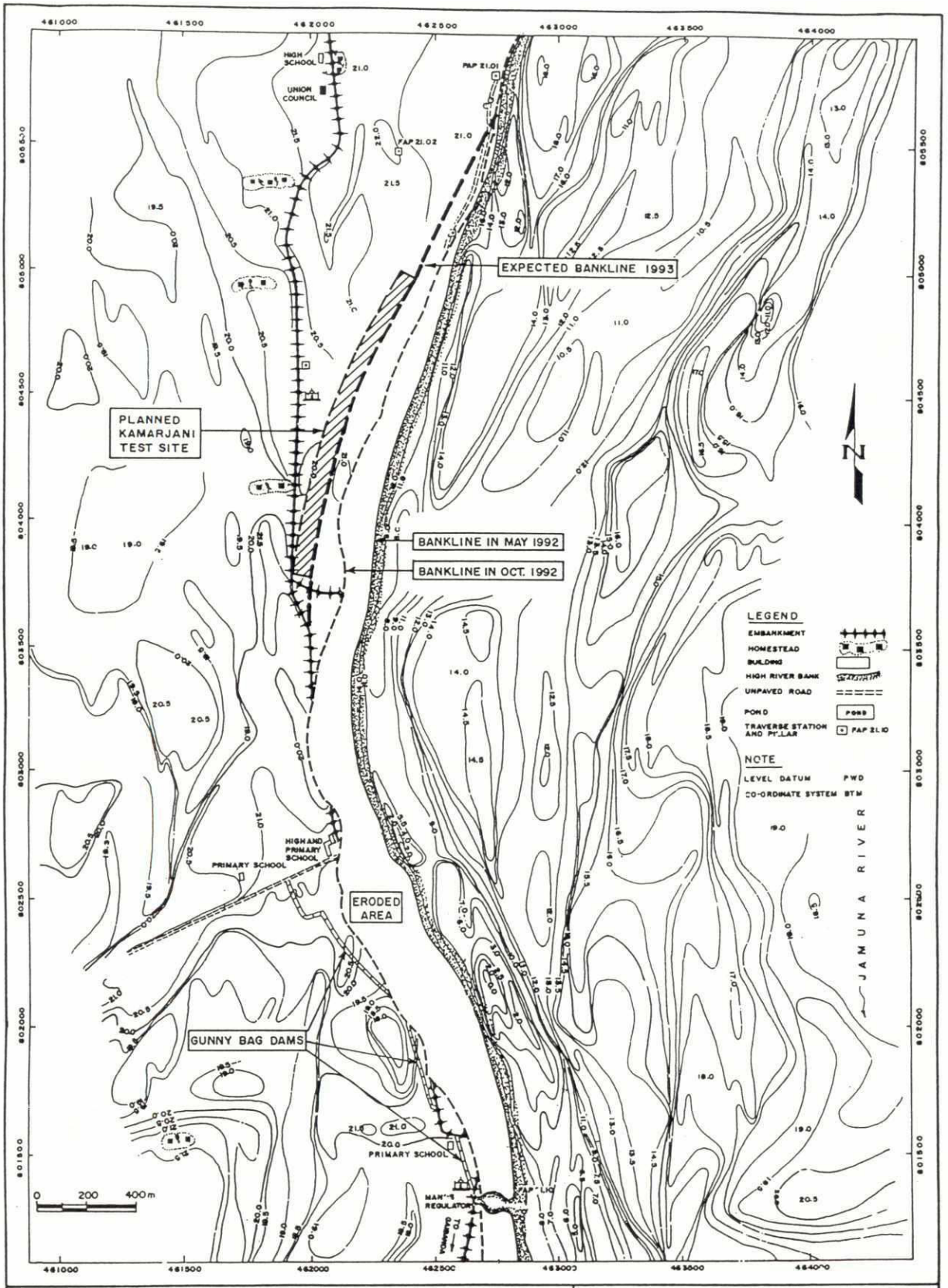


(Based on topographical map No. 78 G/11 , Compiled from aerial photographs of 1975)

0 500 1000 2000 m

LOCATION OF KAMARJANI TEST SITE	FAP – 21/22 BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT
	FINAL REPORT ANNEX- 8 | FIG. II.1-1

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KAMARJANI SITE

EXPERIENCED AND EXPECTED BANKLINES

FAP – 21/22

BANK PROTECTION AND RIVER TRAINING / (AFPM) PILOT PROJECT

FINAL REPORT ANNEX 8

FIG. II.1 – 2

Common Name	Scientific Name	Likely Status	Uses
A. Terrestrial			
Mango	*Mangifera indica*	C	Fr
Kapas	*Trema orientatis*	FC	Tm (m)
Hijal	*Barringtonia acutangula*	C	FW
Banana	*Musa spp.*	C	Fr
Dholkalmi	*Ipomoea fistulosa*	FC	Fen
Jiga	*Lannea ceromandelica*	C	Tm (m), FW
Sheora		FC	FF, FW
Verenda		R	O
Bot	*Ficus bengdensis*	R	M
Aswat	*Ficus religiosa*	R	M
Dumur	*Ficus recemosa*	C	Fr, FW
Kadam	*Anthocephalus cadamtsa*	C	T (L)
Kash	*Imperata cylindrice*	FC	TM
Mander	*Erythrina variegata*	C	T (L), FW
Coconut	*Cocos nulifera*	R	Fr, P
Jujube	*Zizybus jujuba*	R	Fr
Neem	*Azaderacha indica*	R	M
Papaya	*Corica papaya*	R	Fr
Chatin	*Alstonia scholaris*	C	Tm (L)
Tamarina	*Tamarindus indica*	R	FW, Tm (H)
Palm tree	*Borassus flabellifer*	R	FW, P
Bamboo	*Bambusa tulda*	R	
B. Aquatic			
Topapana	*Trapa natens*	C	Weed
Kalmi	*Ipomoea aquatica*	C	FF
Khudipara		C	FF
Water Hyacinth		FC	FF
Chora	*Chara chara*	C	FF
Helencha		C	FF
Shapla	*Nymphaea nonchali*	C	FF

Note:

Uses: Fr= Fruit; Tm (H)= Heavy timber; Tm (M)= Medium timber; Tm (L)= Light timber; Fen= Fence; P= Pole; Hu= Household utilities; FW= Firewood; M= Medicine; Ct= Cotton; Ch= Chemical, Cb= Chewing betel; Tnm= Tanning materials; V= Vegetables; O= Oil; W= Weed; Mo= Medicinal Oil; Th= Thatching material; Or= Ornamentals; Ff= Fish food; Sp= Spices; Cf= Cattle feed, Mul= Mulching material.

Status: FC= Fairly common; C= Common; R= Rare

Table 11.1-1: Plant species recorded in the project area during field survey in October, 1992

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11.1.4 Fish Fauna

The area is rich in diversified fish. In the low-lying areas of borrow-pit, khal, beel and main river, different types of fish are available. People stock fish in low-lying areas, borrow pits and ponds. Beel areas are mostly khas land. With the monsoon flood fish migrate to the low-lying areas and remain there. The list of fish variety found in different ecosystem are listed in Table 11.1-2 below:

Groups/ Common Name	Scientific Name	Incidences in Different Ecosystems			
		River bank	Main channel	Natural waterbodies (beel etc.)	Man-made waterbodies (pond borrow-pits)
Major carps					
Roi	*Labeo rohita*		X		X
Catla	*Catla catla*		X		X
Mrigal	*Cirrhinus mrigala*		X		X
Calibaosh	*Labeo calbasu*		X		X
Minor carps					
Bagra	*Cirrhinus reba*		X		
Chela	*Oxygaster spp.*		X	X	
Punti	*Puntias spp.*	X	X	X	X
	Rasbora spp.		X		
Minor corps					
Rani	*Botio dario*		X		
Dhela	*Rohtee cotio*	X		X	
Darkina	*Esomus danrieus*			X	X
Mola	*Amblypharyngodon mola*			X	
Garua			X		
Faisua			X		
Borail			X		
Balukakra		X			
Chanda		X	X	X	
Clupeids					
Chapila		X	X		
Ilish	*Hilsha ilisha*		X		
Snakeheads					
Taki	*Channa punctatus*	X		X	
Shol	*Channa striatus*		X	X	X
Catfish					
Magur	*Clarius batralhus*	X		X	X
Shingi	*Heteropneutes fossilis*	X		X	X
Ayr	*Mystus aor*	X			
Pangus	*Pangasius pangasius*		X		
Pabda	*Ompak pabda*	X		X	X
Boal	*Wallago atu*		X	X	
Tengra	*Mystus tengara*	X	X	X	X

Table 11.1-2: Fish species recorded in Kamarjani study site during field survey in October, 1992

Perciforms					
Chanda	*Chanda nama*	X		X	X
Anabantids					
Kolisa	*Colisa spp.*	X		X	X
Koi	*Anabas testudineus*			X	X
Other fishes					
	Mystacembelus	X		X	
Baim	*puncalus*	X		X	
Gutum	*Lepidocephalus guntes*				
Bele					
Kaski	*Psendentropius*	X		X	
Batasi	*atherinoides*	X	X	X	
Kajali	*Ailia coila*	X		X	X
Tin kata					
Prawn					
Chingri	*Macrobracchium rosenbergii*	X	X	X	X

Table 11.1-2 (continued): Fish species recorded in Kamarjani study site during field survey in October, 1992

Smaller fish are available at the river bank side, in beels and ponds. Bigger fish are available in the river. Most of the erosion victims change their occupation from farming to fishing, as they lost their cultivable land. Therefore, per capita fish catch decreased. The bigger fish were overexploited and the numbers decreased. Moreover, fish eggs and fries are collected extensively.

11.1.5 Birds

Species recorded during a short field visit are given in Table 11.1-3. Two species, pied kingfisher and plain martin were observed nesting in riverbank which might be affected by measures to halt erosion if they result in the stabilisation, grading and vegetation of the bank line.

The area on the countryside of the present embankment comprises largely cultivated fields with some homesteads. It is unlikely that any notable bird population are present although

diversity might be higher because of the larger area. Abandoned part of the area associated with embankment retirement might result in a greater area of wetland along the channel which now flows behind the present embankment just south of the eroded end of the embankment. However, without a project, an even greater area of seasonal wetland and larger channel may develop.

The adjacent newly accreted char opposite this site was also visited. The fresh silt and sparse grass attract a few waders (*Charadriforms*); but sand lark is abundant (Table 11.1-3). However, it is unlikely that birds using this island would be affected by local river training works on the mainland.

Species Name (English)	Species Name (Latin)	No. Birds Recorded on Mainland	No. Birds Recorded on Char	Remarks
Grey heron	*Ardea cinerea*			2
Indian pond heron	*Ardeola grayii*	1	(low)	
Black kite	*Milvus migrans*	(low)	1	Juvenile *M.m.*
			(low)	*lineatus*, a winter Visitors
Red-wattled lapwing	*Vanellus indicus*	1		
Little ringed plover	*Charadrius dubius*	(low)	6+	
			(moderate)	
Eurasian curlew	*Numenius arquata*		1	
Common redshank	*Tringa totanus*		1	Heard only
Great black-headed gull	*Larus ichthyaetus*	5	3	Two small flocks, both moving south over the area.
River tern	*Sterna aurantia*	3		
Pied kingfisher	*Ceryle rudis*	(2)		Recorded just to south but probably use study area
Plain martin	*Riparia paludicola*	1+		
Barn swallow	*Hirundo rustica*		50 (high)	
Sand lark	*Calandrella raytal*	10+ (high)		
White wagtail	*Motacilla alba*	5+ (mod.)	1	
Yellow wagtail	*Motacilla flava*	10 (high)		
Citrine wagtail	*Motacilla citreola*	5+		
Black drongo	*Dicrurus macrocercus*	3+		
House crow	*Corvus splendens*	2		
Large-billed Crow	*Corvus macrorhynchos*		2	
Oriental magpie robin	*Copsychus saularis*	1		
Asian pied starling	*Sturnus contra*	10+		
Common myna	*Acridotheres tristis*	20+		
House sparrow	*Passer domesticus*	30+		

Note: Names and order follow Harvey (1990). Numbers are actual numbers and estimates of minimum numbers present during one field visit on 12.10.92, it is likely that a number of other common species use the area.

Table 11.1-3: Bird species recorded at Kamarjani study site during field survey in October, 1992

11.1.6 Cropping Pattern

The common cropping pattern is B.aus/jute followed by T.aman (L) and rabi crops in the high and medium highlands. In low-lands T.aman (L)-B.aus-rabi crop is common. A large portion of the area is fallow this year because of flood and sand deposition on the field. Fertilizer and pesticide use is limited.

11.1.7 Water-borne Disease

Among the water-borne diseases, kalazar (leishmaniasis) is very common. Next comes goitre - which is a iodine deficiency disease. Diarrhoea in the area is common as the river water is rich in silicon-dioxide.

11.1.8 Present Risks and Hazards

(1) River Bank Erosion

The river bank is significantly unstable causing constant loss of cultivable land and human habitation.

(2) Siltation

Sandy soil is deposited on the crop land during the flood, turning the soil to an unfertile one.

(3) Water Logging

Water logging in the low-lying area is evident in the project area due to insufficient drainage and unplanned construction of roads.

(4) Threat to the Regulator

Manos regulator is highly threatened. If the erosion continues at the same rate, the regulator will be lost in the next monsoon season.

(5) Human Habitation on the Embankment

The erosion victims are living on the embankment causing damage to the slopes by digging to build houses.

11.2 BAHADURABAD

11.2.1 Introduction

Bahadurabad, located on the left bank of the Jamuna river, is undergoing heavy erosion (see Fig.11.2-1 and 11.2-2) evicting hundreds of people from their homestead. These people have taken shelter mainly near the main villages. Some of them went to the right bank, some to the chars. In view of the high population of this area, some of the

displaced people built houses on their own crop land or on crop land bought from others. Therefore, besides erosion a large portion of the cultivable land has been utilized for new settlement.

The area lies in the physiographic unit of the Jamuna floodplain. The soil type is mostly non-calcareous alluvium. Agricultural potential of the area ranges from moderate to very poor as the limitations include; a) risk of flood damage, b) risk of bank erosion and burial by new sediments; and c) a low soil permeability. Some bank areas have gradual slope towards the east causing water logging in monsoon. There are sudden depressions which are mostly silted up and where farmers grow rice in the dry season.

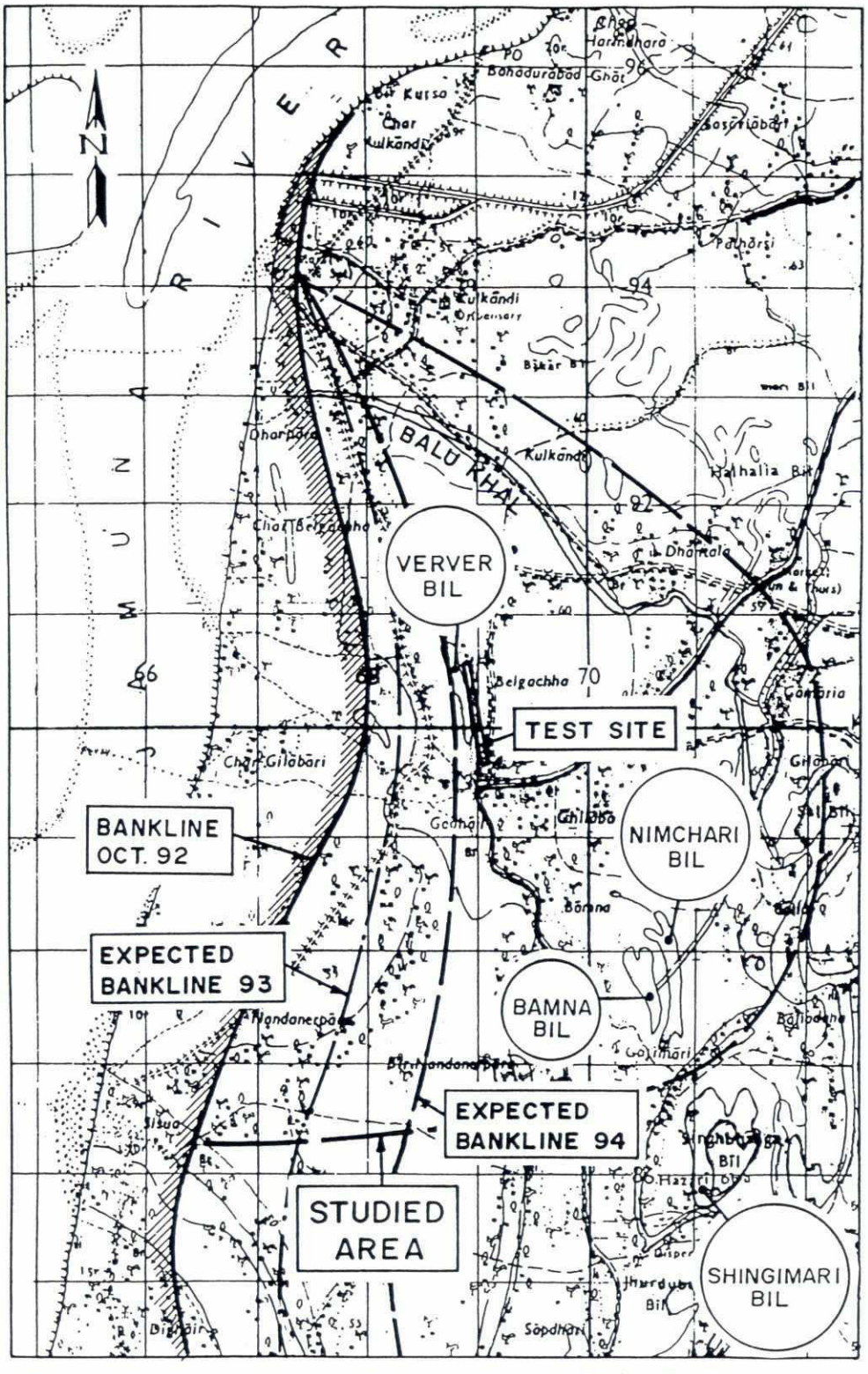
Since the old embankment has been eroded mostly near the test site exposing the whole area to seasonal normal and high flooding, a new embankment is needed to protect the area, part of which may constitute the test structure.

11.2.2 Land Use

Land use pattern is very distinct and land is used extensively. The common cropping pattern is T.aman-boro-jute. T.aman local varieties are cultivated in the comparatively lowland area and planted earlier than the other crops areas. T.aman is cultivated after the jute hence harvest will be late. Almost no fallow land has been observed.

11.2.3 Flora

A wide range of plants have been observed in the project area, however not many medicinal plants were found. People complained about commercial exploitation of the medicinal plants. The common species found in the project area during a field survey in October, 1992 are listed in Table 11.2-1.



(Based on topographical map No. 78 G / 12 , Compiled from aerial photographs of 1975)

LOCATION OF BAHADURABAD TEST SITE

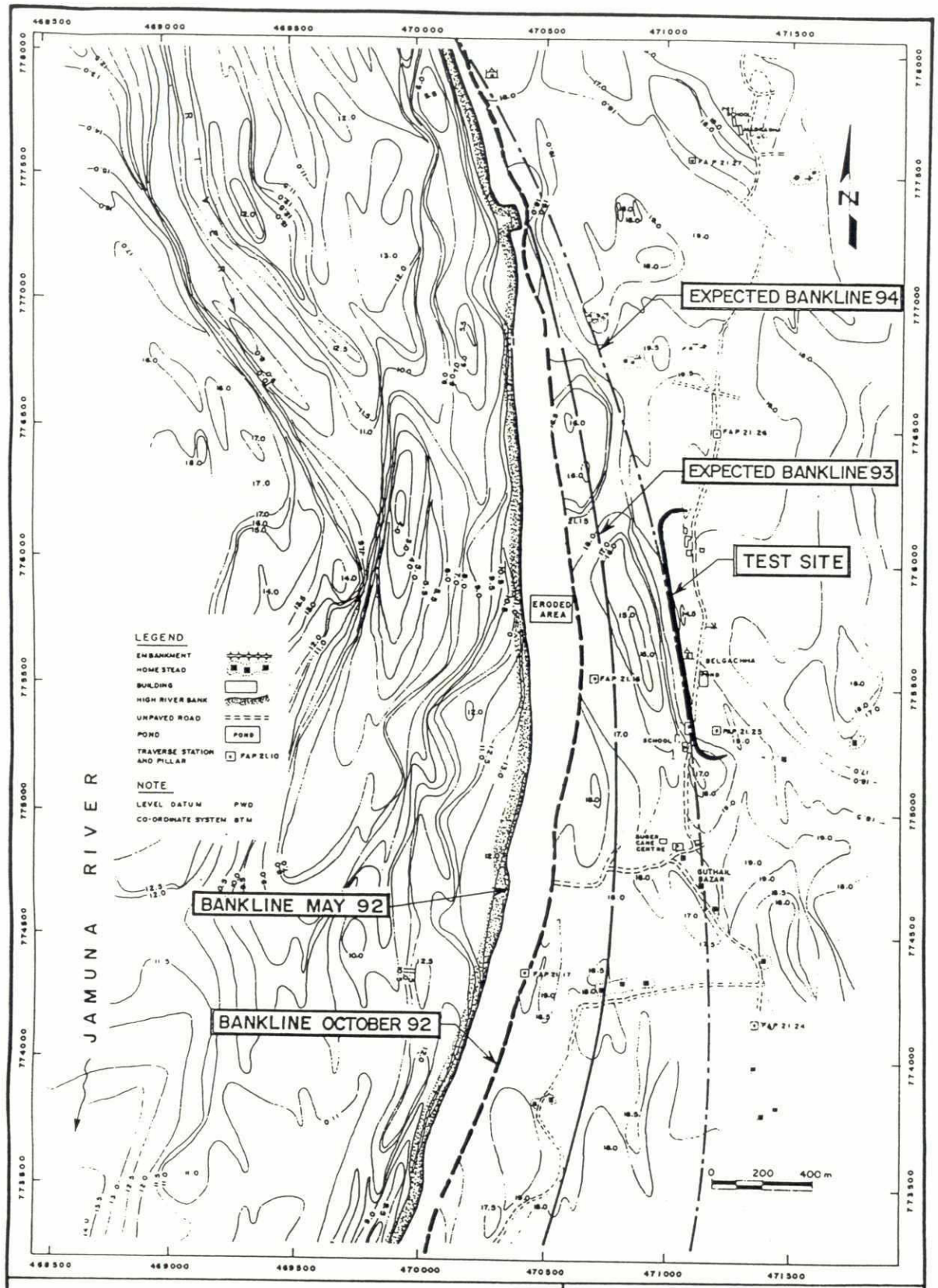
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FIG. 11.2-1

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BAHADURABAD SITE

EXPERIENCED AND EXPECTED BANKLINES

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FIG. 11.2-2

Common Name	Scientific Name	Likely Status	Uses
A. TERRESTRIAL			
Jack fruit	*Artocarpus heterophyllus*	C	Fr, Tm (H)
Mango	*Mangifera indica*	C	Fr, Tm (H)
Heartappil	*Anona squamosa*	R	Fr
Bajna	*Zanthoxylum rhetsa*	C	Tm (M)
Bamboo	*Bambusa arundinacea*	FC	Fen, P, HU
Banana	*Musa paradisiaca*	C	Fr
Jambura	*Citrus grandis*	C	Fr
Star apple	*Averrhoea carambola*	C	Fr
Zizyphus	*Zizyphus mauritiana*	R	Fr, Host of lac insect
Lichi	*Lichi chinnsis*	R	Fr
Palm	*CBorassus flabellifer*	R	Fr, P
Blackberry	*Syzygium cumini*	C	Fr, Tm (H)
Sheora	*Streblus asper*	FC	Fish attractant
Jiga	*Lannea coromandelica*	FC	Tm (H)
Kadan	*Anthocephalus kadamba*	C	M
Wood apple	*Aegle marmelus*	C	M, FW
Satim	*Alstonia scholaris*	FC	Tm (L)
Tree cotton	*Bombax ceiba*	C	Ct, Tm (L)
Tamerind	*Tamarindus indica*	C	Tm, Fr, Ch
Betelnut	*Areca catechu*	C	Cb, Tnm
Mandar	*Erythrina variegata*	FC	FW
Sajna	*Moringa oleifera*	C	V, M
Fig	*Ficus recemosa*	C	Fr, M, FW
Bot	*Ficus bengalensis*	C	Fr, M, FW
Neem	*Azaderachta indica*	C	M
Coconut	*Cocos nucifera*	R	Fr, P
Pitraz	*Aphanamixis polystachya*	C	MO, FW
Sonda	*Casia fistula*	R	Tnm
Verenda	*Rachirus cumini*	R	O, M
Kapash	*Trema orientalis*	FC	Tm (M)
Cinnamon	*Chinnamonus Zaylanicum*	R	Sp, M
Baina	*Avicennia officinalis*	R	Tm (H)
Bay leaf	*Pimenta acris*	R	Sp, M
Tulshi	*Ocimum americanum*	R	M
Basak	*Adhatoda vasica*	R	M
Kalokesi	*Eclipta alba*	C	M
Gamar	*Gmelina arborea*	FC	Tm (H)
Pathorkuchi	*Kalanchoe pinnata*	R	M
Katabisalla	*Barleria lupulina*	C	M, W
Upatlangra	*Achyranthes aspera*	R	M
Hijal	*Barringtonia acutengula*	R	Tm (M), FW
Aswath	*Ficus religiosa*	R	Tm (M), M
Dholkalmi	*Ipomoea fistucosa*	FC	FW, Fen
Papeya	*Corica papeya*	R	Fr
Kash	*Sccharum spontareum*	C	TH
Ulukhor	*Imperata cylindrica*	C	TH
Makal	*Hodsnonia macrocarpa*	R	Or
Jaba	*Hibiscus rosa-chinensis*	C	Or
Guava	*Psidium guajava*	R	Fr
B. AQUATIC			
Water hyacinth	*Echhornia crassipes*	R	CF, Mul
Khudi-phena	*Lemna perpusilla*	C	FF
Helencha	*Enhydra flactuans*	FC	V, FF
Kalmisak	*Ipomoea aquatica*	C	FF, V
Saple	*Nymphaea nouchali*	C	V
Paniphal	*Trapa dispinosa*	C	Fr
Chara	*Chara chara*	C	FF

Note:

Uses: Fr= Fruit; Tm (H)= Heavy timber; Tm (M)= Medium timber; Tm (L)= Light timber; Fen= Fence; P= Pole; Hu= Household utilities; FW= Firewood; M= Medicine; Ct= Cotton; Ch= Chemical, Cb= Chewing betel; Tnm= Tanning materials; V= Vegetables; O= Oil; W= Weed; Mo= Medicinal Oil; Th= Thatching material; Or= Ornamentals; Ff= Fish food; Sp= Spices; Cf= Cattle feed, Mul= Mulching material.

Status: FC= Fairly common; C= Common; R= Rare

Table 11.2-1: Plant species recorded in Bahadurabad study site during a field survey in October, 1992

11.2.4 Fish Fauna

Different types of fish are found in different ecosystems and the area is mostly self sufficient. The common fish resources found during a field survey in October, 1992 are shown in Table 11.2-2 below:

Fish group	Fish Species	Ecosystem			
		River Bank	Deep Channel	Natural Depression (beel etc.)	Man-made Depressions (pond, borrow-pit)
Major carps	*Labco rohite*		X	X	X
	Catla catla		X	X	X
	Cirrhina mrigale		X	X	X
	Labeo calbasu		X	X	X
Minor carps	*Oxygaster spp.*	X		X	
	Puntius spp.	X		X	
	Rasbora spp.	X		X	
	Danio spp.	X		X	
	Rohtee cotio	X		X	
	Esomus denricus	X		X	
	Amblypharyngodon mola	X		X	
	Cirrhina reba				
Clupeids	*Hilsha ilisha*		X		
Catfish	*Wallego atu*		X	X	X
	Ompok pabda		X	X	X
	Clarius batrachus	X	X	X	X
	Heteropnestes fossilis	X	X	X	X
	Mystus tengara	X		X	X
	Mystus sp. (Golsha)				
	Pangasins pangasins				
	Mystus aor	X	X	X	X
	Mystus seenghala	X	X	X	X
Snakeheads	*Channa punetatus*	X		X	X
	Channa striatus	X		X	X
	Channa marulius	X		X	X
Perciform	*Chanda nama*	X		X	
Anabantids	*Anabas testudines*			X	X
	Colisa spp.			X	
Prawn	*Macrobrachium resenbergii*	X	X	X	X
	(Chhoto chingri)	X		X	X
Others	*(Fali) Notoplerus notopterus*		X	X	
	(Chital) Notoplerus chitala		X	X	
	(Kajdi) Ailia colia				
	(Batashi) Pseudeutropius atherinoides	X		X	
	(Gutum) Lepidocephalus guntes	X		X	
	(Baim) Mastacembelus purcalus	X		X	
	(Bele)	X	X	X	X
	(Ritha)	X			

Table 11.2-2: Fish species recorded at Bahadurabad site in FAP 21/22 field survey, 1992

Due to erosion, people mostly lost their cultivable land and live on fish catching. Therefore, the number of full-time fishermen has increased and the fish catch per person declined. The fishermen have reported about more small fish in the river these days than before. Fish fry and fish egg collection is common in the river which, however decreases the number of big fish in the main channel.

11.2.5 Birds

The main areas of importance to birds at Bahadurabad are:

- the beel to the river side of the proposed embankment. This is important because of the extensive muddy margin around the beel as it dries up; this habitat appears to attract more waders than the active island chars in the Jamuna, probably because the area is much longer established and cultivation of the surrounding area results in a more diverse invertebrate fauna;
- the three beels, Bamna, Nimkuri and Singhimari are to the south-east of the proposed embankment, although these have steep banks which make them unsuitable for waders, they attract some fish eating birds despite extensive disturbance from fishermen;
- the Balu khal running from the Jamuna north of the proposed test structures and south-east around the perimeter of the area investigated, including the fresh char at its mouth;
- the homestead ridges with groves of bamboo and trees mainly along the alignment of the proposed test structures, and
- the open fields which cover the majority of the area.

A total of 42 species were recorded from the whole of the study area during three days of fieldwork. 14 species are dependent on the wetlands in the area (and a number of others make use of the wetlands and their fringes), eight species were recorded from the riverside beel, four use the group of beels to the south-east, four were found along the Jamuna only, and two were recorded in homestead ponds (Table 11.2-3). It is likely that a number of resident and migrant passerines were missed in their homestead during the study period.

Relatively large flock of Temminck's stints were found using the riverside beel - a site which is probably of local importance for migrant waders. Also little pratincole and Indian skimmer (a threatened species for which Bangladesh is the centre of the world population) were recorded. A number of other species probably pass the area while migrating and may make use of the study area; but the island chars are probably of greater importance. These chars probably hold important population of riverine birds and deserve a full survey in their own right - particularly to identify concentrations of migrating and wintering birds.

The Table 11.2-3 lists the bird species recorded during the study:

Species English	Latin Names	Likely Status	Comments
Little cormorant	*Phalacrocorax niger*	R several	13 fishing in Nimkuri beel; 1 by pond in homestead area
Indian pond-heron	*Ardeola grayii*	R few	1 by riverside beel; 2 by Bamna beel
Brahminy kite	*Haliastur indus*	R single	1+ adult over riverside beel
Hen/Palid harrier	*Circus cyaneus/ macrourus*	WV one	a female flew over Balu khal north of the proposed embankment
Small pratincole	*Glareola lactea*	? visitor	a flock of about 500 flew north along the Brahmaputra just offshore of the study area on 12.10.92
Little ringed plover	*Charadrius dubius*	?R several	10+ around shores of riverside beel
Asiatic golden plover	*Pluvialis fulva*	WV 1 flock	30 on ploughed field near riverside beel (14.10.92)
Little/ Rufous-necked stint	*Calidris minuta/ ruficollis*	PM/WV few	2 feeding with Temminck's Stints by riverside beel (separation of adult winter plumage birds of these two species virtually impossible)
Temminck's stint	*Calidris temminckii*	WV common	flock of 66 feeding on fresh mud and fields awaiting planting of L boro along edges of riverside beel; 3 by Bamna beel
Wood sandpiper	*Tringa glareola*	WV few	1 at riverside beel, 3+ by Shingi beel
Common sandpiper	*Actitis hypoleucos*	WV few	2+ along river bank
Indian skimmer	*Rynchops albicollis*	? few	a flock of 6 (5 adults and 1 immature) of this globally threatened species were resting and feeding by a small new char just at the mouth of Balu khal on 15.10.92
Rock dove	*Columba livida*	R several	small flocks in cultivated fields
Rose-ringed parakeet	*Psittacula krameri*	R common	village groves
Asian palm swift	*Cypsiurus balasinensis*	R several	around palms on countryside of riverside beel
White-throated Kingfisher	*Halcyon smyrnensis*	R few	1-2 by ponds in homestead areas
Common kingfisher	*Alcedo atthis*	R few	1 by riverside beel
Pied kingfisher	*Ceryle rudis*	R few	one along riverbank west of proposed embankment
Green bee-eater	*Merops orientalis*	R few	3 perched by Nimkuri beel
Blue-tailed bee-eater	*Merops philippinus*	? few	4 flying over riverside beel
Hoopoe	*Upupa epops*	WV few	2 flushed from tracks in paddyfields inland of proposed embankment

Table 11.2-3: Bird species recorded at Bahadurabad study site (13-15 October 1992)

Species English	Latin Names	Likely Status	Comments
Black-rumped Flameback	*Dinopium bengalense*	R few	one in homestead area
Fulvous-breasted Woodpecker	*Picoides macei*	R few	one in homestead area
Barn swallow	*Hirundo rustica*	WV common	flock of 50-100 feeding over riverside beel
Paddyfield pipit	*Anthus rufulus*	R few	fields near riverside beel
Yellow wagtail	*Motacilla flava*	WV abundant	fields near riverside beel
Citrine wagtail	*Motacilla citreola*	WV common	fields near riverside beel
White wagtail	*Motacilla alba*	WV several	along river bank and by beel
Red-vented bulbul	*Pycnonotus cafer*	R several	homestead areas
Oriental magpie robin	*Copsychus saularis*	R several	homestead areas
Zitting cisticola	*Cisticola juncidis*	R common	singing over most of aman fields during visit
Common tailorbird	*Orthotomus sutorius*	R few	1+ in homestead areas
Jungle babbler	*Turdoides striatus*	R few	a flock in homestead areas
Long-tailed shrike	*Lanius schach*	R few	2+ on edges of homestead areas
Black drongo	*Dicrurus macrocercus*	R abundant	fields
Rufous treepie	*Dendrocitta vagabunda*	R few	1+ in homestead areas
House crow	*Corvus splendens*	R common	homestead areas
Large-billed crow	*Corvus macrorhynchos*	R few	flying over
Asian pied starling	*Sturnus contra*	R abundant	flocks in fields
Common myna	*Acridotheres tristis*	R abundant	fields
Jungle myna	*Acridotheres fuscus*	R common	fields
House sparrow	*Passer domesticus*	R abundant	homesteads and fields

Notes: R = resident, WV = winter visitor, ? = status uncertain
Order and names follow Harvey (1990)

Table 11.2-3 (continued): Bird species recorded at Bahadurabad study site (13-15 October 1992)

11.2.6 Water quality

There is limited surface water in the area. But no major problems with surface water were reported, although there was a popular belief that water quality of the river was deteriorating.

11.2.7 Water-borne Diseases

The water quality analysis of FAP 3.1 shows that the water of the area contains almost no iodine, but is rich in silicon dioxide. The pH value indicates a moderate alkalinity. Dissolved oxygen is higher than at other places which indicates a better environment for fish culture. However, low iodine content in the water cause iodine deficient disease "goitre". The incidence is high (80%), mostly in case of women. Other diseases like

cholera, diarrhoea, dysentery are common. During the month of October-November outbreak of cholera and diarrhoea occur. Malaria and kalazar (Leishmaniasis) are two other vector-borne diseases that are common in the area. Due to jute rotting in the closed water, the water become rich in organic matter and harbour sandflies larvae. The sandflies that spread Leishmaniasis thrive better in stagnant water with organic matter. Therefore, the incidence of the disease is higher among the people of the project area. Night blindness is also a problem in the project area. The possible cause of night blindness is vitamin-A deficiency. The project area is mostly a monocrop area and is not producing enough vegetables which contains vitamin-A. The incidence is high among adults. Children under 6 years old are getting vitamin-A free of cost from UNICEF twice a year. Therefore, night blindness is evident among adults. No change in the existing situation is expected through the test structures.

11.2.8 Hazards and Risks

The following hazards were identified during the fieldwork based on discussions with local people. It has not been possible to estimate probabilities associated with different events, but it is clear that erosion will continue to be a major problem.

(1) Erosion

The primary hazard identified by local people is riverbank erosion. It was claimed that many displaced people have moved their homes into the study area either using their own land or buying land for this purpose. Most displaced people live along the Balu khal and along a village road to the west of the envisaged test structure sites or near its alignment. These households will be forced to move again in the next few years if the forecasted erosion will actually occur. Many more households were reported to have been moved to Pulakandi village in Dewanganj Thana where they have taken shelter on public land (road-cum-embankment), and where they have access to support from NGOs.

(2) Siltation

Sand deposition was reported on the crop fields and some recent silt deposition has occurred in the area closest to the present bank of the Jamuna. Some new chars have been built up in the area, but this does not compensate for the land lost to erosion since it is necessary to wait several years before cultivating a new char.

(3) Floods

This area has not been subjected to high flood risks in the past. In 1988 most of the area was badly flooded and all aman crops were destroyed (due to breaching and overtopping of embankment). In that year the village road which forms the proposed alignment of the test structures was under water. Previously the only year with flood damage was reported to be 1974. In subsequent years flooding did not affect badly the areas east of the village road (proposed alignment). The riverside fields were flooded several times with rises and falls of the Jamuna level, and farmers reported transplanting aman 3-4 times except in

1991 when the embankment which protected the area from flooding was eroded. It is clear that the risk of flood damages is now higher in the study area, and that there are likely to be considerable losses to T.aman without flood protection. However, a frequency analysis has not been undertaken to quantify the risk of losses.

(4) Crop pests

Although pests, such as stem-borers and caterpillars, cause some damages and loss to crops, this was not reported to be severe. There are unlikely to be any changes with the proposed project since this would merely safeguard the existing cropping pattern.

11.2.9 Variations Among the Transect Sections (see Fig.11.2-3)

Transect sections A_1, B_1, and C_1, are adjacent to the river and A_2, B_2, and C_2 are on the other side of the road. The proposed embankment will be constructed on the section B, the length of which will be two kilometers. Present environmental situation in two kilometers on either side of the proposed work has been studied.

Section A_1: This section has a khal which was closed when the eroded embankment was there. The khal named "Balu khal" was draining water from the area to the Bamna beel in section C_2. The mouth of the khal is badly silted up. In 1991 the monsoon flood water passed through this khal and deposited sand on the crop fields damaging $^1/_3$ of the crop. Most of the erosion victims settled on both banks of the khal. Fish stocking was done last year. This year due to less water, farmers are growing rice in the outfall khal. The cropping pattern is different in this area. Local varieties of aman rice are grown in the low land while highlands are either cultivated with high yielding variety or sugarcane. Due to eroded embankment water enters inside the area through the khal depositing sand on the crop fields and decreasing soil fertility, 100% of the crops damaged have been reported even after 4-5 times transplanting. No special trees have been observed.

Section A_2: Balu khal still runs through the area and crosses Dhantala village. This area is mostly crop fields. The area slopes towards the eastern side. Almost no fallow land was observed. There are some homestead along the roadside. No uncommon tree was found. Lack of water in the waterbodies restricts fish composition and population. The cropping pattern is different than A_1. High yielding varieties of boro rice (75%) and wheat (25%) follows jute and HYV aman in the medium highlands and sugarcane in the highland. After harvesting sugarcane winter vegetables are cultivated. In the monsoon season low-lying areas suffer water-logging problems and crop losses. Farmers use overdose of urea fertilizer as soil fertility had decreased due to continuous cropping.

Section B_1: This section is unique in the site having shallow natural depressions. One large depression had been lost to the river because of erosion. Out of two others, small one is already silted up and farmers have started cultivating that land with local transplanted aman. This depression is called "Ververi" beel by the local people. The other

one still has water in it. The depression was used for fish culture before, but this year due to erosion no fish fry was released. The principal species found in this depression were the same as those found in the main river. Only smaller fish like punti, chela, chanda, small chingri and mola are now available. These fish came with the flood water in 1992. People reported that large fish such as catla, boal and chital occurred in that depression before. This beel is locally significant for water birds (see Table 11.1-3). From the beel to the road transect, the entire area comprises homesteads. In the homestead area mostly common trees are found. However some people have taken the initiative to grow scarce spice species including cinnamon and bay leaf. The area was flood-free before, and people grew a wide range of species of plants. Shorea is abundant in this section. Most medicinal plants were also found in this section.

The proposed test structures will be built on the site of the Ververi beel. The beel ecosystem will probably be protected after the construction which otherwise would have lost due to erosion.

A few borrow-pits and ponds are found in this section. The pond owners culture large fish including Rui, Catla, Mrigal, Chital, silver carp and grass carp.

The cropping pattern is T.aman followed by - onion/sweet potato/millet/wheat/ jute.

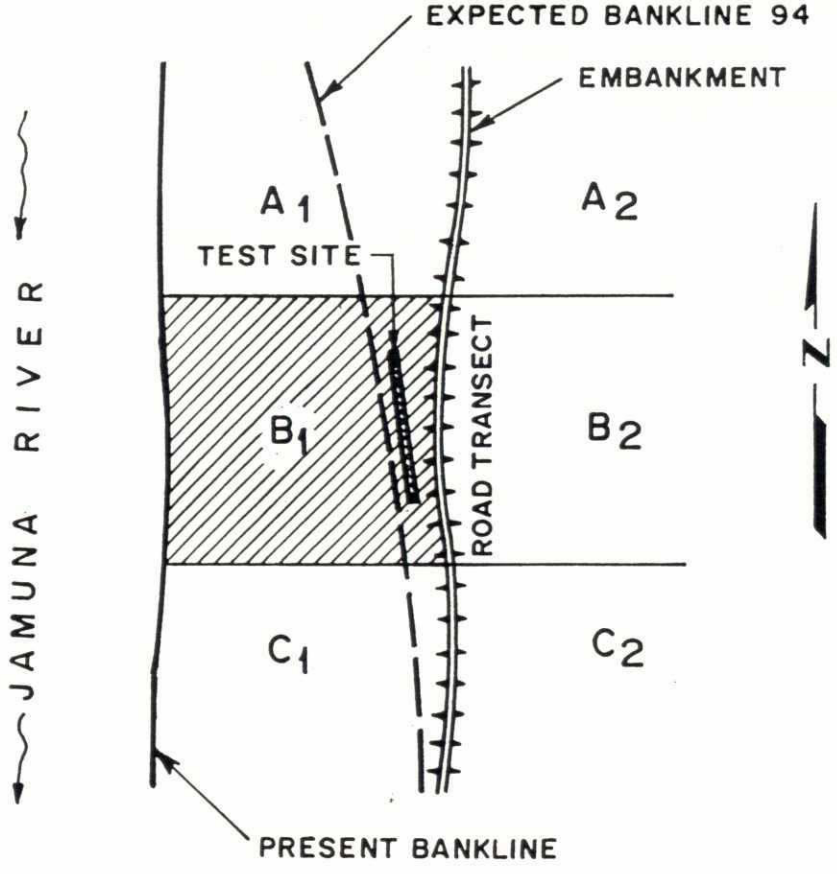


Fig.11.2-3: Transect section in Bahadurabad

Section B_2: This area is mostly crop fields. Some homesteads are there along the roadside. No special features were found. Cropping pattern is like A_2. Except some ponds there is no permanent waterbodies. Cultured fishes like mrigal, chital, silver carps are common. Bird species seen in the paddy fields are listed in Table 11.2-3. No uncommon trees are found.

Section C_1: This section has some low-lying areas. Scattered houses are seen. Number of trees are small. The low lying areas have different types of fishes. Besides common small fishes, silver carp and grass carp were caught from the area. Cropping pattern is similar to B_1. Tree species, and birds are common.

Section C_2: This section is important in having a market, large homestead area, some crop fields and 3 permanent beels namely (a) Singhimari, a smaller one around which paddy fields exist, (b) Bamna - a big permanent beel which is under khas land, (c) Nimkuri-a privately owned small one. Owners culture fish every year. Different type of water birds and fish-eating birds were seen (Table 11.2-3). In the Bamna beel all types of big and small fishes are found. But as this beel is a government owned beel, over exploitation of fish is found. The natural aquatic plants are very few. Bamna beel is connected to the Balu khal. Therefore, fishes from the river now come through this khal during monsoon. The cropping pattern is like B_2. In 1991, flood water through Balu khal did tremendous damage to crops. Yield is high in the area. Pest attack is not so severe. Farmers reported crop damage by large and black bandicoot rats. The damage is very distinct in the crop fields. Extensive use of fertilizers and pesticides are found. Soil fertility problem is reported.

12 RISKS DUE TO THE PROJECT AND POSSIBLE MITIGATIONS

12.1 KAMARJANI

During the construction period, due to human interaction, vehicular movement, machinery transfer, etc., the ecosystem will slightly be disturbed. For movement, not many roads will be constructed because mobilization for that test site will be mainly from the river by floating equipment.

After construction the groynes will induce sedimentation and accretion of land. On their new gentle slopes weeds can grow or rice cultivation may be developed. This vegetation may offer spawning and feeding grounds for some fish species.

The groynes will create enough space for tree plantation which will improve the environmental condition.

The usual users of the natural bank such as fishing birds and amphibians, which presently are not many, will be affected.

Permeable groynes may trap the water-hyacinth drifting. In case people consider it as a pest, these will be evacuated. But, despite the vegetation supply they may have a certain value as fodder or source of organic matter.

Implementation of the groynes and accretion of land may have repercussion on the next island chars. But no settled or important char is closed to this bank. There is only one low island covered with kash where a number of birds find their refuge.

12.2 BAHADURABAD

Until starting the construction works the river is expected to have eroded nearly all of the transect sections A_1, B_1, and C_1. The proposed test structures will hence protect the continuously eroding village Belgacha and also gradually expand the effect upstream to stabilize the Bahadurabad Railway Ghat. In economic terms, the benefit would be considerable, so also in agro-socio-economy of the area.

The Jamuna river erosion is likely to devour the surrounding ecosystem unless it is protected by the test structures.

Therefore, the risks that the Project would impair the existing condition to the locality is by far the less than it would do good. The erosion will stop, the continuous degrading situation will improve and surroundings will be protected.

The disturbance in the ecosystem during construction can be mitigated and actually, will be done by taking careful construction method, scheduling construction works and using labour and equipment in such a manner that the disturbance will reduce to a negligible limit.

13 COMPARISON OF FEATURES AND IMPACTS IN BOTH TEST SITES

The observed features in the areas show some similarities and some dissimilarities as seen in Table 13-1:

	Kamarjani	Bahadurabad
Bank erosion	High	High
Siltation	High	High
Beel habitat	Few	Many
Adjacent new char	Existing, one-year old	None
Water logging	High	Low
Dominant cropping pattern	T.aman Hyv-B.aus/ jute-boro Hyv	T.aman Hyv-jute boro Hyv (some sugarcane)
Use of chemical fertilizers	Low	High
Use of pesticides	Low	Low
Groundwater level	High	High
Water Quality	Rich in Sio_2	Rich in Sio_2
Fish availability	High, diverse	High, diverse
Fish culture	Low	High
Waterbodies and wetlands	High	Low
Plant species	Many	Many
Bird species	More waterbirds	Less waterbirds
Soil fertility	Moderate	Moderate (locally low)
Land use	Extensive	Extensive
Afforestation	Nil	Low
Population density	High	High
Fishermen number	High	High
Fish availability	High	Moderate
Fish diversity	High	High

Table 13-1: Comparison of the two sites

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Transferability

Every project site is unique in its features. Therefore, possibility of transfering the results of one sites to another may not be feasible in further assessment process. However, the issues like homestead and beel ecosystem may be the same but not the flora and fauna. Homesteads may look similar but their frequency, their diversity and their age must be taken into account. Beels may be quite different in their functioning. Some are protected and other are submersible. Some are cultivated. Some are not. The time of inundation is important. That means that results are not directly transposable to another site.

What is probably less variable along the Jamuna river are the bank forms and their uses. Some local differences due to the erosion and sedimentation processes and the river fish population are encountered except for species like hilsa which is rare in the north. However, regarding the limited knowledge about it, this must be checked. The water quality like its compositions, specially quantity of dissolved oxygen for fish, or the quantity of silicon dioxide in the river water for silt deposition is important for any assessment. This is almost always variable. Similarly, the overall view of the projects could be the same but the complex interaction of the component of the ecosystem may not be so.

Therefore, it may be mentioned here that study of the individual site is necessary for future development programmes.

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14 FOLLOW-UP SURVEYS OF THE TEST SITES

14.1 PREPARATORY SURVEYS

Two areas have already been investigated through a field survey. Considering the fact that the proposed structures are only test structures which will have only local repercussions, and that the two concerned areas are quite densely populated and therefore no more natural area is left, no supplemental survey appears to be needed on these two sites.

On the other hand, if the proposed works were modified or shifted, then the ecological point of view could be reconsidered. In case the works would be planned at other sites, a new field survey and environmental assessment have to be done.

14.2 FOLLOW-UP SURVEYS

The two test sites will be interesting to follow-up as a reference of the environment response to the proposed works.

Among general factors of observation, the main points to be surveyed are the following ones:

For Kamarjani:

- evolution of the accretion;
- colonisation of the new accreted soils by the vegetation, aquatic weeds or cultivation;
- modification of fisheries (quantity and species composition);
- behaviour of water-hyacinth and reaction of the people;
- modification of the fauna habits (birds);
- fry collection;
- modification of the water quality although not expected it should be checked, and
- other consequences on factors such as diseases or insects population.

For Bahadurabad:

- evolution of the beels and khal of the area;
- impacts on the fisheries;
- evolution of fry collection and consequences on pond fish culture, and
- colonisation by vegetation, fish and fauna of the protected bank.

These observations and the conclusions should provide basic data for the impact analysis of the river training and bank protection itself.

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APPENDICES

APPENDIX 1

FISHES

APPENDIX 1 PART 1

FISHES FOUND IN RIVER JAMUNA AND ITS FLOOD PLAINS

Ref: A.K. Ataur Rahman (1989) - Fresh water fishes of Bangladesh, 2001. Soc. Bangladesh

Family/Scientific name	Local/English commonname	(Abundance) Localisation
F-Angraulidae		
Satifinna phasa	**Phasha**/Anchovy	(3) In the main channels
F-Anabantidae		
Colisha sota	**Chuna khoilsha**/Goramy	(1) River, beels and flood plains
Colisha fasciatus	**Khoilsha**/Goramy	(3) In river, beels and flood plains
Colisha lalius	**Lal kholisha**/Goramy	(2) In beels, rivers and flood plains
Stenops unobilis	**Napitany**/Goramy	(2) In rivers, beels and ponds
Anabas testudineus	**Koi**/Climbing perch	(1) In beels, flood plains and pond
F-Belonidae		
Xenontodon cancila	**Kakila**/Gar	(1) River, beels and flood plains
F-Bagridae		
Rita rita	**Rita**/Bagrid catfish	(3) Mainly in the river
Batasio tengana	**Batashi tengra**/Bagrid catfish	(3) In river and flood plains
Mystus aor	**Ayre**/Bagrid catfish	(2) Distributed in river Jamuna, beels and flood plains
Mystus cavasius	**Kabashi tengra**/Bagrid catfish	(3) In Jamuna flood plains and beels
Mystus gulio	**Tengra**/Bagrid catfish	(2) In flood plains and Jamuna

Abundance : 1 = Rare 2 = Fairly common
3 = Common 4 = Highly frequent

Family/Scientific name	Local/English common name	(Abundance) Localisation
F-Channidae		
Channastarius	**Shol**/Snake headed fish	(2) Mostly in flood beels and flood plains
Channa marulius	**Gojar**/Snake headed fish	(1) In river and flood plains
Channa punctatus	**Taki**/Snake headed fish	(1) In flood plains
Channa orientalis	**Cheng**/Snake headed fish	(2) Beels and floods plains
F-Cyprinidae		
Salmostoma argentea	**Chela**/Leuciscine minnow	(2) In the channels
Esomus danricus	**Darkina**/Rasborine minnow	(3) In flood plain and river
Barilius vagra	**Tilakoksa**/Rasborine minnow	(1) Upper Jamuna
Amblyopharyngodon mola	**Mola**/Minnow	(1) Upper Jamuna
Chagunius chagunio	**Jarua**/Minnow	(1) Upper Jamuna
Labeo gonius	**Gonia**/Carp	(1) Jamuna and its flood plains
Labeo calbasu	**Kali baush**/Carp	(2) Jamuna and its flood plains
Labeo rohita	**Rui**/Carp	(1) Jamuna and its flood plains
Labeo batta	**Bata**/Carp	(1) Throughout the rivers and flood plains
Cirrhinus mrigala	**Mrigal**/Carp	(1) Throughout rivers and flood plains
Cirrhinus reba	**Raik**/Carp	(1) River and flood plains
Puntius chola	**Chola**/Barb	(2) River and flood plains

Abundance : 1 = Rare
2 = Fairly common
3 = Common
4 = Highly frequent

Family/Scientific name	Local/English common name	(Abundance) Localisation
Puntius conchonius	**Kanchonpunti**/Barb	(2) River and flood plains
Puntius ticto	**Tit punti**/Barb	(2) River and flood plains
Puntius sophore	**Jat punti**/Barb	(2) River and flood plains
Puntius terio	**Teri punti**/Barb	(1) River and flood plains
Catla catla	**Catla**/Major Carp	(1) Mostly in the river channels
Garra gotyla	**Ghara**/Carp	(1) In the upper Jamuna
F-Cobitidae		
Nemachelus botio	**Bali chata**/Loach	(3) In river and flood plains and beels
Somileptes gondota	**Poia**/Loach	(2) Mostly in the river
Botia dario	**Rani**/Loach	(3) Rivers and flood plains
Lepidocephalus guntea	**Gutum**/Loach	(3) In beels and flood plains
F-Claridae		
Clarius batrachus	**Magur**/Air breathing catfish	(2) Mostly in beels and flood plains
F-Chacidae		
Chaca chaca	**Cheka**/Square head catfish	(1) In river and beels
F-Clupeidae		
Gudusia chara	**Chapila**/Shad	(2) In the river Jamuna and flood plains
Hilsa ilisa	**Ilish**/Shad	(1) In the main channels of river Jamuna

Abundance : 1 = Rare 2 = Fairly common
3 = Common 4 = Highly frequent

Family/Scientific name	Local/English common name	(Abundance) Localisation
F-Centropomidae		
Chandaranga	**Chanda**/Glass perch	(3) In rivers, beels and flood plains
Chand beculis	**Chand**/Glass perch	(2) In rivers and flood plains
F-Gobiidae		
Glossogobius	**Bele**/Gobi fish	(1) In the lower channels
F-Hamiramphidae		
Hyporamphus gimardi	**Ekthota**/Gar	(2) In rivers
F-Heteropneustidae		
Heteropneustes fossilis	?/Stining cat fish	(2) Mostly in the beels and flood plains
F-Mastacembelidae		
Macrognathas aculeatus	**Tara baim**/Spiny eel	(2) In flood plains and beels
Mastacembelus armatus	**Baim**/Spiny eel	(1) In river, beels and flood plains
Mastacembelus pancalus	**Pankal**/Spiny eel	(2) In river, beels and flood plains
F-Mugilidae		
Rhinomugil corsula	**Khorsula**/Mullet	(3) In river
F-Nandidae		
Nandas nanas	**Meni**/Mudperch	(3+) In the river, flood plains and also in beels
F-Notop-teridae		
Notopterus chitala	**Chita**/Feather back	(3) Jamuna river also in beels and flood plains
Notopterus notopterus	**Foli**/Feather back	(2) Jamuna also in the beels and flood plains

Abundance : 1 = Rare 2 = Fairly common
3 = Common 4 = Highly frequent

Family/Scientific name	Local/English common name	(Abundance) Localisation
F-Pristolapidae		
Badis badis	**Napitakoi**/Pecoid fish	(1) In rivers, beels and flood plains
F-Psilorhynchidae		
Psilorhynchus sucatio	**Tatari**/?	(1) In the main channel
Psilorhynchus balitora	**Balitora**/?	(1) In the River near Bahadurabad
Psilorhynchus gracilis	**Balitora**/?	(1) Upper channel of Jamuna
F-Sisoridae		
Bagarius bagarius	**Baga ayre**/Bagrid catfish	(3) In the upper channel
F-Siluridae		
Wallago attu	**Boal**/Freshwater shark	(3) River and flood plains and beels
Ompok pabda	**Madhua pabda**/Butter catfish	(1) In river, beels and flood plains
Ombok bimaculatus	**Boal pabda**/Butter fish	(1) In river, beels and flood plains
F-Schilbeidae		
Silonia silondia	**Shillong**/Schilbeid catfish	(2) Mainly in the river
Pangasius pangaoius	**Pangas**/Schilbeid catfish	(2) Common in river Jamuna
Aila coila	**Kajuli**	(3) Common in river Jamuna
Pseudeutropius atherinoides	**Batashi**/Schilbeid catfish	(2) Mainly in the river

Abundance : 1 = Rare 2 = Fairly common
3 = Common 4 = Highly frequent

Family/Scientific name	Local/English common name	(Abundance) Localisation
Eutropicthys vacha	**Bacha**/schilbeid catfish	(3) In rivers and flood plains
Clupisoma murius	**Muri bacha**/?	(1) Mainly in the river
Clupisoma garua	**Gharua**/?	(2) Mainly in the river channels
F-Synagnithidae		
Doryichtys cancalus	**Kumirerkhil**/Pipe fish	(2) Main channels
Doryichthys chokderi	**Kumirerkhil**/Pipe fish	(2) Main channels
F-Symbranchidae		
Monopterus cuchia	**Kuchia**/Mudeel	(1) Near the bank, in the holes
F-Tetraodonidae		
Tetraodon cutcutia		(2) In rivers and flood plains, also in beels

Abundance : 1 = Rare 2 = Fairly common
3 = Common 4 = Highly frequent

APPENDIX 1 PART 2

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Cypriniformes (Cypriniane)	Rui, Rahit, Noala, Rao, Garma, Naosahi	Major Carps	*Labeo rahita*	Jamuna river; also other rivers, beels, haors, baors, paddy field during rainy season	Algae (35%) Higher plants (20%) Protozoa (23%) Crustacea (15%) Mud & Sand (7%)	July-August along rivers	Spawning migration-Upstream. Lateral migration to floodplain for food.
	Catla, Katal, Galtawa		*Catla catla*	Jamuna river; other rivers, beels, haors, baors, paddy field during rainy season, also in stagnant water	Algae (25%) Higher plants (20%) Protozo (10%) Crustacea (45%) (Phytoplankton: Synadra, Diatom, Volvox, Scenedesmus, Ulothrix, Uronema, Spirogyra, Nostoe, Oscillatoria, Cyclotela, Glocotila, Chlorella, Cymbela, Endorina, Triplocera, Cosmarium and Navicula. Zooplankton: mainly Crustacea also Brachionus, Moustyla, Cypris, Daphnia.	March to September	Spawning migration-Upstream. Lateral migration to floodplain for food.
	Kalibaush, Kalbaush, Kalabaush, Kalagani, Kalbashu, Kalia, Baush	Other Carps	*Labeo calbasu*	Jamuna river; other rivers, khals, beels, haors and baors, waterbodies with low current is preferred	Prefers food at bottom. Algae (10%) Higher plants (48%) Protozoa (12%) Crustacea (10%) Mollusc (5%) Mud & Sand (15%) also decayed organic matter at bottom	Spawnning starts with monsoon rain and continues through monsoon period	Spawning migration near shallow water along rivers. Lateral migration to floodplain.
	Mrigal, Mirgay, Mirgah, Mirgala, Mirka		*Cirrhina mrigala*	Jamuna river; other rivers, khals, beels, haors, baors, paddy fields in rainy season, prefers muddy bottom	Algae (20%) Higher plants (30%) Protozoa (15%) Crustacea (25%) Mud & Sand (10%)	June through September	Spawning migration to shallow water along rivers. Lateral migration to floodplain.

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Cypriniformes Cyprinidae (Puntius)	Sar-punti, Saral-punti		*Puntius sarana*	Jamuna river; other rivers, haors-baors-beels. paddy and jute fields in rainy season. Riverine environ with high velocity and sandy-bed khal are preferred as habitat	Algae, unicell animals, aquatic insects, larvae mud & sand	Mid-June to Mid-August in slow moving water in river & beels	Rivers to floodplain and vice-versa.
	Deto-punti, Punti, Karia-punti, Bhathe-punti		*Puntius stigma*	Jamuna river; other rivers, beels-haors-(in abundance) Paddy & Jute fields in rainy season.	Cyclops, Daphnia, Crustacean larvae, Organic debris, Algae, Protozoa, Diptera, mud-sand	June through August	Shallow water along river banks. Rivers to floodplain and vice-versa.
	Teet-punti, Teeta-punti		*Puntius tito*	Jamuna and other rivers. Beel-Haor-Baor. Prefers environment: Mud and Sand bed bottom with much algae and aquatic plants around	Diatom, Algae, Crustacean, Rotifer, Insects, mud & sand	During Monsoon	Moves to shallow water near river bank and floodplain for food
Cypriniformes Cyprinidae (Barilius)	Koksha, Kosha, Vegra		*Barilius vagra*	Jamuna river and rivers in Dinajpur. Prefers clear water	Not known	Not known	Not known
	Mola, Moa, Morar, Mowka, Mowrala		*Amblypharyn -godon mola*	Jamuna river, other rivers, khals, beels, haors-baors	Feeds on near-water surface food. Algae, Protozoa, Aquatic insects, Ratifers, Crustacea	May throught October	Moves in thousand near water surface
	Moa, Melanda, Mow-Mach, Gonta, Bolanga		*Rohtee cotio*	Jamuna river; other rivers, beel-haor-baor	Feeds on near water-surface food. Algae, Protozoa, Crustacea, Ratifers	Not knows	Moves in thousands near water surface

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Cypriniformes Cyprinidae (Abraminae)	Chela, Narkel-chela, Full-Chela		*Oxygaster bacaila or Oxygaster phulo*	Jamuna river; other rivers, khal-beel. Flooded paddy and Jute fields. prefers clean water	They are Larvivorous. Unicelluler, Organisms, Crustacean, insects/spiders	Not known	River to floodplain and rivers
Cypriniformes Cyprinidae (Rasborinae)	Bash-Pata, Daybodi, Bash-Patari	Barbs	*Danio devario*	Jamuna river (Clean water); othe rivers, khal-beels-haors.	Feeds on organisms near water surface	Not known	Moves in shallow water near river banks
	Dankina, Pati-chela, Darkina		*Rasbora daniconius*	Jamuna river; other rivers, khal-beel-haor. Prefers clear water environ.	Algae, Aquatic organisms, Protozoa, mud and sand	Not known	Not known
Cypriniformes Cyprinidae (Loaches)	Ghora, Rani, Beti, Bow-mach		*Botia dario*	River khal-beel-haor-baor. prefers muddy bottom.	Not known	Not known	Not known
	Gutum, Guta, Puiya, Poa		*Lepidocephalus guntea*	Rivers, khals, beels, haors-baors. prefers muddy bottom and root-system of water hyacinth	Not known	Not known	Not known

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Cypriniformes Clupeidae (Alosinae)	Il-sha, Ilish, Hilsha	Hilsha	*Hilsha ilisha*	Lives in Indo-Pacific faunistic region. Brahmapurta-Jamuna, Ganges, Padma and Meghna rivers	Mainly Plankton : (1) Zooplankton: Diatoms, Protozoa, Crustaceans, Mullnsca, Tunicates, (a) Young Hilsha takes 54% and (b) Adult takes 63%, (2) Phytoplankton: Diatom, Synedra, Melosira, Surirella and blue & blue-green algae. also Organic debris	Spawning starts with the on-set of south-west monsoon. Early spawning in Jamuna R: January-March Late spawning: June-Sept. in Jamuna R. Hilsha does not have definite spawning ground. River bends are better location.	Moves in towards rivers during summer, and migrates towards estuaries and sea (saline water) during post - monsoon period
	Chapila, chaipla, chapla, Aphila		*Gudusia chapra also Gudusia variegata*	Flowing rivers and baors, including Jamuna. Prefers both turbid and clean river water	Feeds on food available with near water surface	Spawning starts with the on-set of the monsoon	Moves in thousand - upstream & downstream. No migratory trend in known
	Fasha or Phasa, phaowa, Phaisa		*Setipinna phasa*	Estaurine mouth; is seen in thousand near water surface during rainy season.	Algae, Protozoa, Crustacea	Spawning in rivers during February and March	Migration from estaurine mouth to rivers for spawning (Feb-March); oberved in rivers in abundance during March through September
Siluriformes	Guzi Ayre; Guzi, Aire, Ar.	Cat fish	*Mystur-aor*	Haor-baor and rivers	Feeds on bottom food	March through September, spawning is performed in dig-in-holes on river bed	Lateral migration - river to floodplain
	Bagha Ayre, Boro-Ayre, Tallah-Ayre, Bash-Ayre		*Mystus seenghala*	Haor-baor and rivers	Feeds on bottom food. Preys on fries of Rui/Catla	In Summer and rainy seasons. Spawning - dig-in holes in river-bed	Lateral migration

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Siluriformes	Tengra	Cat fish	*Mystus vittatus*	Khal-beel-haor-baor and rivers. Also in flooded paddy and jute fields.	Algae (22%), Aquatic plants (27%), Protozoa (13%), Larva (2%), Broken sheels (16%) and small fish (20%)	In summer and rainy seasons	Lateral migration
	Gulsha, Gulsha-Tengra		*Mystus bleekeri*	Khal-beel-haor-baor and rivers.	Not known	Not known	Not known
	Rita		*Rita rita*	River bed with mud	Young feeds on insects and roots of aquatic plants. Adult feeds on insects, shrimps, small fishes	Not known	Not known
	Boal, Boalee, Ball, Boil, Bayari, Po-el, Kee-ali		*Wallagonia attu*	Khal-beel-haor-baor and rivers	Fingerlings of Rui-Catla; Terrestrial Insects, Rats, Mices. They are known as Fresh water Shark, and are voracious and carnivorous	Spawning time: July-August; in shallow water of khal-beel-haor-baor and rivers	Lateral migration
	Pabda, Madhu-Pabda, Pafta, Pabia, Pabla, Papaish		*Ompok pabda*	Clear water in khal-beel-haor-baor and rivers	protozoa, Aquatic insects, Crustacea, Algae - amnivorous	Not known	Lateral migration
	Gharua, Ghowra		*Clupisoma garua*	Rivers, haor and baor	Crustacea, Larvae of insects, small fishes, Decayed organic matter	Spawning begin in March in cool water upstream	Always on move; spawning migration - upstream
	Bacha, Vacha		*Eutropiichthyes vacha*	Flowing water of rivers-haors-baors	Insect larva, small fishes	Not known	Always on journey

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Siluriformes	Shilong, Shillong, Sillonda, Dhain	Cat fish	*Silonia silondia*	In rivers	Voracious and carnivorous. Fishes, decayed organic matter, garbages	Not known	Along river
	Batashi, Bashpati, Full-Tengra, Tin-kata		*Clupisoma psendeutropius atherinoides*	Haor-baor and rivers. In rainy season -khal-beel and paddy-jute fields	Not known	Not known	Lateral migration
	Pangas		*Pangasius pangasius*	In river and its mouth	Crustacea, Fishes, Insects, Mulacca, Aquatic plants, Fruits, Plant Roots - amnivorous	Not known	Up and downstream
	Baghair, Bagair, Bagur		*Bagarius bagarius*	Haor-baor and rivers	Feeds on preys, voracious	Not known	Not known
	Magur, Mozgur, Moskur		*Clarias batrachus*	Khal-beel-haor-baor and rivers. Perfers to live in stagnant water and in mud.	Aquatic plant (21%), Protozoa (15%), Insects-snails and shells (14%), Aquatic insects (11%), crustacea (27%), mud & sand (21%)	Spawning dig-in holes under shallow water, during summer and Rainy season	Not known
	Singh, Singhi, Zeewal, Zee-all		*Heteropneustes fossilis*	Khal-beel, haor-baor, rivers. Loves turbid water, shallow water-hyacinths	Algae, Aquatic plants, protozoa, small water insects, spiders, Crustacea, snails-shells, crabs, sand & mud - amnivorous	Spawning with the arival of monsoon	Not very mobile
	Chaga, Gangania, Cot-Cota, Chach-vega		*Chaca chaca*	Khal-beel-haor-baor-rivers. Prefers mud-bed	Not known	Not known	Not known

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Channiformes	Gajar, Gojal, Gajaree, Sal	Murrel	*Channa marulius*	Khal-beel-haor-baor and river. They hide in mud when threatend.	Carnivorous. Small fishes, Frogs, insects.	Spawning in paddy field or among aquatic weeds during June/July.	Lateral migration
	Shol, Chena, Chol		*Channa striatus*	Baor-beel-khal-rivers with weeds and mud	Carnivorous. Small fishes, frogs, mosquito, larva, etc.	May-June in paddy field or water bodies with much weeds.	Lateral migration
	Taki, Lata, Gorai, Latha, Lati, Rakhta, Bhetoo Taki		*Channa punctatus*	Beel-baor-rivers. Lives in aquatic weeds, and mud	Carnivorous. Small fishes, mullusca, insects, spiders.	Spawning during June-July in shallow water receptacle	Lateral migration
Osteoglossi-formes	Chitol, Chitla, Chital, Moot	Feather backs	*Notopterus chitala*	Resident of clean water in rivers-haors-baors and beels. Rarely seen in muddy water.	Carnivorous and feeds on preys. Aquatic insects, snails, shrimps, small fishes	June-July. Spawning in dig-in holes	Highly mobile, migrates to paddy and jute fields during monsoon
	Foli, Foloo, Foolai, Kana-Foli, Kanla		*Notopterus notopterus*	Clean water resident in river-khal-beel-haor-baor. In paddy and jute fields during monsoon.	Algae (10%) Higher plants (25%) Protozoa (22%) spiders-insects (17%), crustacea (10%), sand-mud (10%)	May-July spawn in dig-in holes in shallow water with much weeds	Laterla migration
Beloniformes	Kakila, Kaklay, Kakla, Thoria-mach, Bachari-mach, Kakon, Kakia, Kakhooa	Gar fish	*Xenentodon cancila*	Khal-beel-haor-baor-river-flowing water	Varacious and feeds on preys	Not known	Moves or swims over water surface

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FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Perciformes	Lal Chanda, Chanda, Chandi, Ranga Chanda	Pearch	*Chanda ranga*	Lives in beel-haor-baor and rivers; prefers clear water	Unicell organisms and larva of mosquitoes	Spawn in stagnant water	Not known
	Poa, Poma, Koi-Bhola		*Pama pama*	Resident of saline water; moves in river during rainy season	Not known	Not known	Migration of rivers during rainy season
	Bheda, Sini, Royna, Bhera, Boka, Mini		*Nandus nandus*	Lives in mud-bed in beel-haor-baor-rivers; during monsoon-seen in the paddy and jute fields. In winter they take shelter in bottom weeds.	Not known	Not known	Not known
Perciformes - Gobioidei	Belay, Sadhu Belay, Bele	Gobioid fish	*Glossogobius giuris*	Rivers-khal-beel.	Juveniles are carnivorous and insectivorous. Adults are piscivorous and mollusc eater. Both are cannibalism, also eat crustacea, insects and snails.	Many think they spawn in saline water or in estuarine environment during summer	Migrates to saline or estaurine environment during summer and returns to fresh water during monsoon.
	Chao, Nandichao		*Gobius sadanandio*	River and estaurine	Not known	Not known	Not known
	Koi or Kai		*Anabas testudineus*	Khal-beel-haor-baor-rivers. Heat tolerant; also found under water hyacinth and paddy field.	Insects, Larva, Srimps, algae	During monsoon in shallow water of beel-baor-haor	Lateral migration

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Perciformes - Gobioidei	Khalisha, Khalsha, Khaira, Khaila	Gobioid fish	*Colisa fasciata*	Khal-beel-haor-baor and rivers. Prefers clear water	Omnivorons: Algae (51%), Aquatic plants (25%), Protozoa (15%) and sand mud (9%)	Spawn in paddy and jute fields during rainy season	Lateral migration
	Chono Khalisa, Chono Baicha, Baichi, Chona		*Colisa chauna*	Khal-beel-haor-baor and rivers; in paddy & jute fields during monsoon	Not known	Not known	Not known
Mugiliformes	Khollah, Hollah	Fresh water Mullets	*Mugil corsula*	River, haor and baor-calm & quite environment swimmer	Not known	Not known	Swimmer - Prefer quite and clear water
Mastacembe - formes	Baim, Bum, Bun, Bamush, Bamuni, Goni, Goo, Boro-Baim	Eels	*Mastacembelus armatus*	River-khal-beel-haor-baor. Lives in river bank holes or in mud-bed. Prefers flowing water	Predaceous: fish eggs & fries, larvae, crustaceans	Not known	Not known
	Pankal, Ghuchi-Baim, Bash, Kera-Ban, Turi, Chirka		*Mastacembelus pancalus*	Mud-river bed, khal-beel-haor baor	Decayed organic matter, debris, Nymphula, chironomus, Limnophila, Culex, Eristalis	May-November. Spawn in dense pile of algae	Not known
	Tara-Baim, Bum, Bun		*Macrognaihus aculeatus*	Khal-beel-haor-baor and rivers; seen in running water	Algae (48%) sand & mud (41%) and fibres (11%)	Not known	Not known
Tetraodonti - formes	Potka, Boga, Fotka	Fresh water Globe fish	*Tetraodon patoca*	Resident of river mouth or estaurine. Moves into big rivers in rainy season	Not known	Not known	Migrates from estaurine to big rivers during rainy season

FISH ECOLOGY OF THE JAMUNA RIVER IDENTIFIED DURING MARCH 1991

FAMILY	LOCAL NAME	ENGLISH NAME	SCIENTIFIC NAME	HABITAT	FOOD	SPANWING	MIGRATION
Anguilli -formes	Bao-mach, Bao-Baim, Telcoma	Mud eels	*Anguilla bengallensis*	Lives in under-water holes along the big river banks	Fish (23.55%), Prawns & Shrimps (22.83%), Megalopa Larvae (14.86%), Carbs (14.50%), Macro and microphytes (6.88%), Insects (6.88%), Annelids (5.07%), and Mise (5.83%)	Spawns in sea/once in life-time and then dies	Inveriles moves in to big rivers
Clupeiformes	Keski, Kaskee, Gura-mach, Taki	Clupeoid fish	*Corica soborna*	Lives in upper strata of water surface in rivers and beel	Not known	Not known	Not known
Siluriformes	Kazoli	Cat fish	*Ailiichthys punctata*	Khal-beel-haor-baor and rivers. paddy & jute field in rainy season.	Not known	Not known	Lateral migration
Syngnathe-formes	Kumirer khil, Kera kumirer khil, Kata kumirer khil	Pipe fish	*Ichthyocampus carce*	Lives in river-bed (big rivers)	Not known	Not known	Not known
Channiformes	Cheng, Chang, Okal, Taloo, Gashoa	Murrel	*Channa gachua*	River-haor-baor	Fish eggs and Fries; insects spiders, snails, mosquitoes	Bottom of stagnant but clean water. July and August	Not known
Decapoda	Chingri	Shrimp	*Penaeib shrimps*	River month & estaurine and in coastal area	Omnivorous Lower plants (aquiatic), organic matter, aquatic organisms	Into the sea	Adult migration to sea for spawning Juvenile migration to coast then to estanrine and rivers.
	Galda Icha Mota, Baro Icha		*Macrobrachium rosenbergil*	Fresh water and river month	Omnivorous: Organic matter diatoms, Lower aquiatic plants, copepod, crastacea and sand particles	June-July	Spawning migration to coastal region of sundarbans

Ref: "Fisheries of Bangladesh"
o Muhammad Shafi
o Mia Mahammad Abdul Quaddus
Bangla Academy, Dhaka (1982), 440 pp.

APPENDIX 1 PART 3

LOCAL FISH NAMES

Aphila	see Chapila
Ar	see Guzi Ayre
Ayre	see Guzi Ayre
Ayre	see Guzi Ayre
Bacha	Eutropiichtyes vacha (Siluridae)/Vacha
Bachari-Mach	see Kakila
Bagair	see Baghair
Bagha Ayre	Mystus seenghala (Siluridae)/Boro-Ayre, Tallah-Ayre, Bash-Ayre
Baghair	Bagarius bagarius (Siluridae)/Bagair, Bagur
Bagur	see Baghair
Baichi	see Chono-Kolisha
Baim	Mastacembelus armatus (Mastacembelidae)/Bum, Bun, Bamush, Bamuni, Goni, Geo, Boro baim
Balashi	?
Ball	see Boal
Bamuni	see Baim
Bamush	see Baim
Bao mach	Anguilla bengallensis (Anguillidae)/Bao Baim Telcoma
Bao-Baim	see Bao Mach
Baro-Icha	see Golda Chingri
Bash Ayre	see Bagha Ayre
Bash	see Pankal
Bash-Patari	see Bashpata
Bash-Pati	see Batashi
Bashpata	Danio devario (Cyprinidae)/Bash Patari, Daybodi
Batashi	Clupisomia psendeutropices atherinoides (Siluridae)/ Bash pati, Full tengra, Tin kata
Baush	see Kalibaush
Baush	see Kali Baush
Bayari	see Boal
Belay	see Bele
Bele	Glossogobius giuris (Gobidae)/Belay, Sadhu Belay
Beti	see Ghora
Betoo Taki	see Taki (1)
Bhathe-Punti	see Deto-Punti
Bheda	Nandus nandus (Nandidae)/Sini, Royna, Bhera, Boka, Mini
Bhera	see Bheda
Boal	Wallagonia attu (Siluridae)/Boalee, Ball, Boil, Bayari, Po-el, Kee-Ali

Boalee	see Boal
Boga	see Potka
Boil	see Boal
Boka	see Bheda
Boro Baim	see Baim
Boro Baim	see Baim
Boro-Ayre	see Bagha Ayre
Bow Mach	see Ghora
Bum	see Baim
Bum	see Tara Baim
Bun	see Baim
Bun	see Tara Baim
Catla	Catla catla (Cyprinidae)/Katal, Galtawa
Caya Cata	?
Chach-Vega	see Chaga
Chaga	Chaca chaca (Siluridae)/Gangania, Cot Cota, Chach-vega
Chaipla	see Chapila
Chand	see Chanda
Chanda	see Lal-Chanda
Chandi	see Lal-Chanda
Chao	Gobius sadanandio (Gobidae)/Nandi Chao
Chapila	Gudusia chapra/variegata (Clupeidae)/Chaipla, Chapla, Aphila
Chapla	see Chapila
Chawg	see Cheng
Chela	Oxygaster bacaila/phulo (Cyprinidae)/Narkel-chela, Full-chela
Chena	see Shol
Cheng	Channa gachua (Channidae)/Chang, Okal, Taloo, Gashoa
Chingri	Penaeib shrimps (Palaemonidae)
Chirka	see Pankal
Chital	Notopterus chitala (Notopteridae)/Chitol, Chitla, Moot
Chitla	see Chital
Chitol	see Chital
Chol	see Shol
Chona	see Chono-Kolisha
Chono-Baisha	see Chono-Kolisha
Chono-Kolisha	Colisa chuna (Osphronemidae)/Chono Baisha, Baichi, Chona
Choruli	
Chyatengra	?
Cot-Cota	see Chaga
Dankina	see Darkina
Darkina	Rasbora daniconius (Cyprinidae)/Dankina, Pati-Chela
Day Bodi	see Bashpata
Deto Punti	Puntius stigma (Cyprinidae)/Punti, Karia-Punti, Bhathe-Punti
Dhain	see Shilong
Fasha	Setipinna phasa (Clupeidae)/Phaisa, Phasa, Phaowa
Foli	Notopterus notopterus (Notopteridae)/Foloo, Foolai, Kana Foli,

Foloo	see Foli
Foolai	see Foli
Fotka	see Potka
Full Tengra	see Batashi
Full Chela	see Chela
Gajar	Channa marulius (Channidae)/Gojal, Gajaree, Sal
Gajaree	see Gajar
Galda-Icha	see Golda Chingri
Galtawa	see Catla
Gangania	see Chaga
Garna	see Rui
Garua	Cuplisoma garua (Siluridae)/Ghowra
Gashoa	see Cheng
Ghora	Botia dario (Cobitidae)/Rani, Beti, Bow Mach
Ghowra	see Garua
Ghuchi-Baim	see Pankal
Gojal	see Gajar
Golda Chingri	Macrobrachium rosenbergii (Palaemonidae)/Galda Icha, Mota, Baro Icha
Goni	see Baim
Goo	see Baim
Gorai	see Taki (1)
Gre	?
Gulsha	Mystus bleekeri (Siluridae)/Gulsha-Tengra
Gulsha-Tengra	see Gulsha
Gura Mach	see Taki (2)
Gushi	?
Guta	see Gutum
Gutum	Lepidocephalus guntea (Cobitidae)/Guta, Puiya Poa
Guzi	see Guzi Ayre
Guzi Ayre	Mystus aor (Siluridae)/Ayre, Ar, Guzi
Hilsha	see Ilish
Il-sha	see Ilish
Ilish	Hilsa ilisha (Clupeidae)/Hilsha, Il-sha
Jerush	see Guzi Ayre, Ayre
Kai	see Koi
Kakhooa	see Kakila
Kakia	see Kakila
Kakila	Xeneutodon cancila (Belonidae)/Kaklay, Kakla, Thoria-mach, Bachari mach, Kakion, Kakia, Kakhooa
Kakion	see Kakila
Kakla	see Kakila
Kaklay	see Kakila
Kaksee	see Taki (2)
Kalabaush	see Kali Baush
Kalagani	see Kali Baush

Kalbaush	see Kali Baush
Kali Baush	Labeo calbasu (Cyprinidae)/Kalbaush, Kalabaush, Kalagani, Kalbashu, Kalia, Baush
Kalia	see Kali Baush
Kalisha	Colisa fasciata (Osphronemidae)/Khalsha, Khaira, Khaila Keraban
Kalsha	see Kalisha
Kana Foli	see Foli
Kanla	see Foli
Karia-Punti	see Deto-Punti
Kata Kumirer	see Kumirer-khil
Katal	see Catla
Kazoli	Ailiichthys punctata (Siluridae)
Kee-Ali	see Boal
Keksi	see Taki (2)
Kera-Ban	see Pankal
Kera-Kumirer-khil	see Kumirer-khil
Keski	see Taki
Khaila	see Kalisha
Khaira	see Kalisha
Khil	see Kumirer-khil
Khollah	see Khorshala
Khorshala	Mugil corsula (Mugilidae)/Khollah, Hollah, Khorshula
Koi	Anabas testudineus (Anabantidae)/Kai
Koi-Bhola	see Poa
Kollah	see Khorshala
Korali	?
Korshula	see Korshala
Kuchia	?
Kunirer-khil	Ichthyocampus carce/kera-kumirer-Khil, Kata Kumirer, Khil
Lal-Chanda	Chanda ranga (Centopomidae)/Chanda, Chandi, Ranga chanda, Chand
Lata	see Taki (1)
Latha	see Taki (1)
Lati	see Taki (1)
Madhu-Pabda	see Pabda
Magur	Clarias batrachus (Siluridae)/Mozgur, Moskur
Mini	see Bheda
Mirgah	see Mrigal
Mirgala	see Mrigal
Mirgay	see Mrigal
Mirka	see Mrigal
Moa	see Mola
Mola	Amblypharyngodon mola (Cyprinidae)/Moya, Mowrala, Moa, Morar, Mowka
Moot	see Chital

Morar	see Mola
Moskur	see Magur
Mota	see Golda Chingri
Mowka	see Mola
Mowrala	see Mola
Moya	see Mola
Mozgur	see Magur
Mrigal	Cirrhina mrigala (Cyprinidae)/Mirgay, Mirgah, Mirka, Mirgala
Nandi Chao	see Chao
Naoshi	see Rui
Napitakoi	?
Narkel Chela	see Chela
Noala	see Rui
Okal	see Cheng
Pabda	Ompok pabda (Siluridae)/Madhu pabda, Pafta, Pabia, pabla, Papaish
Pabia	see Pabda
Pabla	see Pabda
Pafta	see Pabda
Pangas	Pangasius Pangasius (Pangasidae)
Pankal	Mastacembelus pancalus (Mastacembelidae)/Ghuchi-Baim, Bash, Turi, Chirka
Papaish	see Pabda
Pati-Chela	see Darkina
Phaisa	see Fasha
Phaowa	see Fasha
Phasa	see Fasha
Po-el	see Boal
Poa	Pama pama (Seiaenidae)/Poma, Koi-Bhola
Poa	see Gutum
Poma	see Poa
Potka	Tetraodon patoca (Tetraodonnidae)/Boga, Fotka
Puiya	see Gutum
Punti	see Deto Punti
Raikh	?
Rakhta	see Taki (1)
Ranga-Chanda	see Lal-Chanda
Rani	see Ghora
Rao	see Rui
Rita	Rita rita (Siluridae)
Royna	see Bheda
Ruai	?
Ruhit	see Rui
Rui	Labeo rohita (Cyprinidae)/Ruhit, Noala, Rao, Garma, Naoshi
Sadhu Belay	see Bele
Sal	see Gajar

Saral-Punti	see Sar-Punti
Sarpunti	Puntius savana (Cyprinidae)/Saral-Punti
Shilong	Silonia Silondia (Siluridae)/Silonda, Dhain
Shing	see Shingi
Shingi	Heteropneustes fossilis (Siluridae)/Shing, Zee Wal, Zee All
Shol	Channa striatus (Channidae)/Chena, Chol
Sillonda	see Shilong
Sini	see Bheda
Taki (1)	Channa punctatus (Channidae)/Lata, Gorai, Latha, Lati, Rakhta, Bhetoo-Taki
Taki (2)	Corica soborna (Cupleidae)/Keksi, Kaksee, Gura mach
Tallah-Ayre	see Bagha Ayre
Taloo	see Cheng
Tara Baim	Macrognathus aculeatus (Mastacembelidae)/Bum, Bun
Teeta-Punti	see Punti
Teetpunti	Puntius tito (Cyprinidae)/Teeta-Punti
Telcoma	see Bao Mach
Tengra	Mystus vittatus (Siluridae)
Thoria-Mach	see Kakila
Tin Kata	see Batashi
Tincata	see Batashi
Turi	see Pankal
Vacha	see Bacha
Zee-all	see Shingi
Zeewal	see Shingi

APPENDIX 2

BIRDS

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APPENDIX 2

PROBABLE LIST OF BIRDS ALONG THE JAMUNA AND ITS ADJACENT AREAS

English Name	Scientific Name	Status	Observed Occurrence (months)	Remark
Little Grebe	*Tachybaptus ruficollis*	Locally common breeding resident	Throughout the year	Breeding period March through November (In beel, ponds & river)
Indian Shag	*Phalacrocorax fuscicollis*	Scarce resident	Throughout the year	Observed in the Month of July & December (on rivers)
Little Heron	*Ardeola Striatus*	Local breeding resident	Throughout the year	Breeding : March through August (wetlands)
Indian Pond-Heron	*Ardeola grayii*	Abundant breeding resident	Throughout the year	Breeding : March through September (wetlands)
Cattle Egret	*Bubuleusibis*	Local breeding resident	Throughout the year	Breeding : April through September (with cattle & wetlands)
Little Egret	*Egretta garzett*	Locally common breeding resident	Throughout the year	Breeding: June to Sep. (Wetlands)
Great Egret (Great White Egret)	*Egretta alba*	Locally common resident	Throughout the year	Breeding : Not known (wet land)
Grey Heron	*Ardea cinerea*	Locally common resident	Throughout the year	Breeding : November through March (wetlands)
White Spoonbill	*Platalea lcucorodia*	Rare winter visitor	Late November to February	Observed rarely (on rivers)
Fulvous Whistling Duck	*Dendrocygna bicolor*	Local Winter visitor	November through Feb.	Also observed in April & June (wetlands)
Lesser Whistling Duck (Tree Duck)	*Dendrocygna Javanica*	Common Winter visitor	Throughout the year	local breeding resident : March-October (wetlands)
Bar-headed Goose	*Anser indicus*	Local Winter visitor	November-March	Observed in November through March (wetlands)
Common Teal	*Anas crecca*	Locally common Winter visitor	September-March	Observed by many bird watthers (wetlands)
Spot-billed Duck	*Anas poecilorhyncha*	Winter visitor	November-March	Rarely seen (wetlands)
Northern Pintail	*Anas acuta*	Winter visitor	September-June	Commonly observed (wetlands)
Gargeney	*Anas querquedula*	Winter Visitor	October-March	Commonly observed (wetlands)
Tufted Duck	*Aythya fuligula*	Common Winter Visitor	October-June	Oversummering (wetlands)
Black-shouldered Kite	*Elanus caerulcus*	Local breeding resident	Throughout the year	Breeding :October through April (Its an open country bird)
Black Kite	*Milvus migrans lineatus*	Common winter visitor	October-April	Breeding Not known (Every where)
Pallas's Fish-Eagle	*Halieetus lecceoryphus*	Formerly more common	Throughout the year	Breeding : September-April (wetlands)
Egyptian Vulture	*Neophron perenopterus*	Rare visitor	April	Observed in 1984 only (In open country)

English Name	Scientific Name	Status	Observed Occurrence (months)	Remark
Grey-headed Fish-Eagle	*Ichthyophaga ichthyactus*	Local breeding resident	Throughout the year	Breeding : September-March (wetlands)
White-rumped Vulture	*Gyps bengalenis*	Locally common resident	Throughout the year	Breeding : September-march. Observed in 50 or more over carcasses Every where)
Red-headed Vulture (king vulture)	*Aegynius calvus*	Rare breeding resident	Throughout the year	Breeding : November-April (In open country)
Crested Serpent Eagle	*Spilomis cheela*	Common breeding resident	September-July	Common type Breeding: December-may in open country & wetlands)
Western Marsh-harrier	*Circus aeruginosus*	Common Winter visitor	October-March	Observed in open (country near water)
Pied Harrier	*Circus melanoleucos*	Scarce winter visitor	October-April	Breeding : Unknown
White-eyed Buzzard	*Butastur teesa*	Local breeding resident	Throughout the year	Breeding : April-June
Long-legged Buzzard	*Buteo rufinus*	Rare winter visitor	December-January	Rarely observed
Lesser Spotted Eagle	*Aquila pomarina*	Local resident	January-December	Observed throughout open country near water
Red-necked Falcon	*Falco Chiequera*	Local breeding resident	October-March	Associated with palons Breeding: January-March
Swamp Francolin	*Francolinus gularis*	Former resident	Throughout the year	Could still occur in very small number
Common Quail	*Cotumix*	Local breeding resident	Throughout the year	Observed in grassland & cultivation. Breeding: March-July
Small Buttonquil (Bastard Quil)	*Tumix sylvatica*	Former resident	Throughout the year	No recent record
Baillon's Crake	*Porzana pusilla*	Rare winter visitor	Throughout the year	Recently observed (February 1989
White breasted Waterhen	*Amallrornis phoenicurus*	Local breeding resident	Throughout the year	Breeding: July-August
Common Moorhen	*Gallinula chloropus*	Local breeding resident	Throughout the year	Breeding: June-September
Purple Swamphen	*Porphyrio porphyrio*	Scarce breeding resident	October-December & February	Frequently sold in Dhaka for food
Water cock	*Gallicrex cinerea*	Local breeding resident	Throughout the year	Breeding : May-July
Common Crane	*Grus grus*	Former winter resident	Throughout the year	No recent records available
Bronze-winged Jacana	*Metopidius indicus*	Local breeding resident	Throughout the year	Breeding: May-August
Small pratincole	*Glareola lactea*	Local breeding resident	Throughout the year	Breeding: May Distribution : (on rivers)
Little Ringed Plover	*Charadrius dubius*	Common winter visitor & local breeder	Throughout the year	Breeding : May
River Lapwing	*Vanellus duvancelli*	Resident	June-January	Rarely observed on rivers

English Name	Scientific Name	Status	Observed Occurrence (months)	Remark
Red-wattled Lapuing	*Vanellus indicus*	Local breeding resident	Throughout the year	Breeding: March-August
Jack Snipe	*Gallinago minima*	Former winter visitor	Throughout the year	Wetlands
Pintail Snipe	*Gallinago Stenura*	Common winter visitor	October-April	Wetlands
Common Snipe (Fantail Snipe)	*Gallinago gallinago*	Abundant winter visitor	September-April	Most numerous. Throughout freshwater wetlands
Asian Dowitcher	*Limnodromus semipalmatus*	Rare winter visitor	January-April	Observed on rivers
Eurasian Curlew	*Numenius arqueata*	Locally common winter visitor	August-May	Observed on rivers
Common Redshank	*Tringa totanus*	Common winter visitor	Throughout the year	Non breeders oversummering
Marsh Sandpiper	*Tringa stagnatilis*	Scarce winter visitor	September-March	Dist : Wetlands
Common Greenshank	*Tringa nebularia*	Common winter visitor	July-May	Throughout wetlands
Green Sandpiper	*Tringa ochropus*	Common 'winter visitor	July-May	Non breeders over-summering
Common Black-headed Gull	*Larus ridibundus*	Locally common winter visitor	November-May	Throughout on rivers
Gullbilled Tern	*Gelochelidon nilotica*	Common winter visitor	Throughout the year	Non breeders oversummering
River Term	*Strcus melanoleucos*	Local breeding resident	October-July	Breeding : June Throughout on rivers
Black-bellied Term	*Sterna acuticanda*	Very local breeding resident	Throughout the year	Breeding : March-April Northwest on rivers
Little Tern	*Sterna alleifrons*	Scarce breeding resident	Throughout the year	Breeding: April-May: on large rivers
Indian Skimmer	*Rynchops albicollis*	Local winter visitor	November-February	On rivers
Rock Dove	*Columba livia*	Abundant breeding resident	Throughout the year	Breeding : Throughout the year
Red Turtle Dove	*Streptopelia tranquebaria*	Locally common breeding resident	Throughout the year	Breeding: April-June
Spotted Dove	*Streptopelia chinensis*	Common breeding resident	Throughout the year	Breeding : July-March
Common Hawk Cuckoo	*Cuculus varius*	Common breeding resident	Throughout the year	They are observed where there are trees
Plaintive Cuckoo	*Cuculus variusa*	Common breeding resident	Throughout the year	Breeding: march-August
Common Koel	*Endynamys scolopacea*	Common breeding resident	Throughout the year	Breeding: March-July Throughout where there are trees
Greater concal	*Centropus sinensis*	Local common breeding resident	Throughout the year	Breeding: March-August. Throughout where there are trees
Lesser concal	*Centropus sinensis*	Locally common breeding resident	Throughout the year	Breeding: March-August in Scrub areas

English Name	Scientific Name	Status	Observed Occurrence (months)	Remark
Brown Fish-Owl	*Ketupa zeylonensis*	Locally common breeding resident	Throughout the year	Breeding : November-March. In wooded areas near water
Spotted Owlet	*Athene brama*	Locally common breeding resident	Throughout the year	Breeding : November-May wooded areas near settlement
Large-tailed Nightjar	*Caprimulgus macrurus*	Locally common breeding resident	Throughout the year	Breeding : February-May In open wooded areas
Asian Palm-Swift	*Cypsiurus balasiensis*	Abundant breeding resident	Throughout the year	Breeding: March-July Associated with palm trees
White-throated Kingfisher	*Haleyon Smyrnesis*	Common breeding resident	Throughout the year	Breeding : March-July in wetland trees
Common Kingfisher	*Ahcedo atthis*	Abundant breeding resident	Throughout the year	Breeding : March-July. Where there are water
Pied Kingfisher	*Ceryle rudis*	Locally common breeding resident	Throughout the year	Breeding : February-April on wetlands
Green Bee-cater	*Merops orientalis*	Common breeding resident	Throughout the year	Breeding ; March-May in open country
Indian Roller	*Coracias benghalensis*	Common breeding resident	Throughout the year	Breeding : March-July In open country with trees
Hoopoe	*Upupa epops*	Locally breeding resident	Throughout the year	Breeding: March-July In open country with trees
Common Grey Hornbill	*Tockus birostris*	Former resident	No recent record	Possibly absent
Rufous-winged Bushlark	*Mirafra assamica*	Local common breeding resident	Throughout the year	Breeding : March-June in open grassland & scrub
Indian Sandlark	*Calandrella raytal*	Local breeding resident	Throughout the year	Breeding : November-May On sandy rivers'
Plain Martin	*Riparia paludicola*	Local breeding resident	Throughout the year	Breeding : December-May on large rivers
Paddyfield pipit	*Anthus rufulus*	Common breeding resident	Throughout the year	Breeding: March-August. In open Grassy areas
Yellow Wagtail	*Motacilla flava*	Common winter visitor	October-February	In open area near water
Grey Wagtail	*Motacilla cinerea*	Scarce winter visitor	October-March	Near running water in wooded areas
White Wagtail	*Motacilla alba*	Abundant winter visitor	September-April	In open areas near water
White-browed wagtail	*Motacilla maderaspatensis*	Scarce breeding resident	Throughout the year	Breeding : March-june near water
Red-vented Bulbul	*pycnonotus cafer*	Abundant breeding resident	Throughout the year	Breeding: January-April Seen where scrub and trees
Magpie Robin	*Copsychus saularis*	Abundant breeding resident	Throughout the year	Breeding : March-July. In scrub & trees
Plumbeous Redstart	*Rhyacornis fuliginosus*	Rare passage migrant	Nov-Feb	Near water
Stonechat	*Saxicola torquata*	Common winter visitor	Sept-March	In open country
White-tailed bushchat	*Saxicola lcucura*	Farmer resident	No recent record	In open country

English Name	Scientific Name	Status	Observed Occurrence (months)	Remark
Plain prinia	*Prinia inornata*	Local breeding resident	Throughout the year	Breeding: June-Oct. In scrub & grasses
Ashy prinia	*Prinia socialis*	Local breeding resident	Throughout the year	Breeding: May-Aug. In Scrub woodland
Jungle prinia	*Prinia sylvatica*	Former resident	No recent record	In scrub & grass
Swamp prinia	*Prinia cineraseens*	Former resident	No recent record	In swamp grass
Large grass-warbler	*Graminicola bengalensis*	Former resident	Throughout the year	In swamp grass
Common Tailorbind	*Orthotomus sutorius*	Abundant breeding resident	Throughout the year	Breeding: April-Aug. In scrub
Grass hopper warbler	*Locustella naevia*	Winter visitor	No recent record	In grass, swamp and paddy
Clamorous reed-warbler	*Acrocephalus stentoncus*	Common winter visitor	Throughout the year	Breeding: Not known in waterside scrub, trees & reeds
Greenish warbler	*Phylloscopus trochiloids*	Abundant winter visitor	Aug-April	In trees
Inornate warbler	*Phylloscopus inornatus*	Common winter visitor	Sept-April	Throughout trees
Grey-headed Flycatcher	*Culicicapa ceydonensis*	Locally common breeding resident	Throughout the year	Breeding: March-May, In forest & woods
Common Babbler	*Tundoides candatus*	Former resident	No recent record	In north western region
Great Grey Shrike	*Lanius excubitor*	Rare winter visitor	Throughout the year	Breeding: not known In open country
Black Drongo (King crow)	*Dicrurus macro carcus*	Abundant breeding resident	Throughout the year	Breeding: April-Aug. Everywhere
Bronzed Drongo	*Dicrurus aeneus*	Locally common breeding resident	Throughout the year	Breeding: March-July In forest & woodland
Ashy wood-shallow	*Artamus fuscus*	Common breeding resident	Throughout the year	Breeding : Feb.-July, in open wooded country
House crow	*Corvus splendens*	Abundant breeding resident	Throughout the year	Breeding : Jan.-July where there are people
Large-billed crow	*Corvus macro rynchos*	Abundant breeding resident	Throughout the year	Breeding : Nov.-April everywhere
Brahming starling (B.Mynah)	*Sturnus pagodarum*	Local breeding resident	Oct.-March	Breeding : March, In open country
Asian Pied starling	*Sturnus contra*	Abundant breeding resident	Throughout the year	Breeding : March-Oct., in open country
Common Mynah	*Acridotheres tristis*	Abundant breeding resident	Throughout the year	Breeding: Feb.July, in open country
Jungle Mynah	*Acridotheres fuscus*	Common breeding resident	Throughout the year	Breeding: March-July, in open lightly wooded country
House Sparrow	*Passer domesticus*	Abundant breeding resident	Throughout the year	Breeding : Feb.-Oct., with human settlement
Baya weaver	*Ploceus philippinus*	Locally common breeding resident	Throughout the year	Breeding : Mar.-Aug., in open country near water
Sealy-breasted Munia	*Lonchura punctulata*	Common breeding	Throughout the year	Breeding : Apr.-Oct., in open country

English Name	Scientific Name	Status	Observed Occurrence (months)	Remark
Little cormorant	*Phalacrocorax niger*	Common breeding resident	Throughout the year	Breeding : Jul.-Feb. on rivers
Oriental Darter	*Anhinga melanogaster*	Locally common breeding resident	Throughout the year	Breeding : Sept.-Feb., Wetlands
Yellow bittern	*Ixobrychus sinensis*	Locally breeding resident	Throughout the year	Breeding : June & July, Wetlands
Asian Openbill	*Anastomus oscitans*	Local wandering resident	Throughout the year	Breeding : not known wetlands

APPENDIX 3

ENDANGERED SPECIES

APPENDIX 3

ENDANGERED TERRESTRIAL SPECIES

TENTATIVE LIST OF VASCULAR PLANTS THREATENED IN BANGLADESH

(including endemics)

Sl.No.	Pteridophyta		Distribution
1.	*Psilotum triquetrum Sw.*		Khulna, Barisal
2.	*Tectaria chattagramica*	(endemic)	Chittagong
	Angiosperms		
1.	*Aglaonema clarkei Hook.f.*		Bandarban
2.	*Aldrovanda vesiculosa L.*		Dhaka, Rajshahi
3.	*Aquillaria agallocha Roxb.*		Sylhet
4.	*Cirrhopetalum roxburghil Lindl.*	(endemic)	Sunderban
5.	*Cymbopogon osmastonii R.N.P.*		Bogra, Dhaka
6.	*Debregeasia dentata Hook.f.*		Chittagong
7.	*Elaeocarpus lucidus Roxb.*		Chittagong
8.	*Hippocratea macrantha Korth.*		Chittagong
9.	*Homalium schlichtii Kurz*		Chittagong
10.	*Justicia oreophila Clarke*		Chittagong
11.	*Knema bengalensis De Wilde*	(endemic)	Cox's Bazar
12.	*Limnophila cana Griff*	(endemic)	Jamalpur, Pabna, Dhaka
13.	*Mantisia spathulata Schutt.*	(endemic)	Chittagong, Sylhet
14.	*Marsdenia thyrsiflora Hook.f.*		Central, Bangladesh
15.	*Ophiorrhiza villosa Roxb.*		Chittagong
16.	*Phrynium imbricatum Roxb.*		Chittagong
17.	*Quercus acuminata Roxb.*		Chittagong
18.	*Rotala simpliciuscula (S.Kurz) Kuhne* *Semecarpus subpanduriformis Wall.*	(endemic)	Chittagong
19.	*Sonneratia griffithii Kurz*	(endemic)	Chittagong
20.	*Spatholobus listeri Prain*		Chakaria, Sunderbans
21.	*Tournefortia roxburghii Clarke*	(endemic)	Chittagong
22.	*Typhonium listeri Prain*		Chittagong, Rangamati
23.	*Vatica scaphula Dyer*		Chittagong
24.	*Vernonia thomsoni Hook.f.*	(endemic)	Chittagong
25.			Chittagong

List of Endangered and Threatened Wildlife in Bangladesh
(including endemics)

English Name	Scientific Name	Past status (about 50 years ago)	Present status
Amphibia			
Bull frog	*Rana tigrina*	VC[1]	T[2]
Green frog	*R. hexadactyla*	U[3]	T
Reptilia			
Salt water/estuarine			
Crocodile	*Crocodylus porosus*	C[4]	E[5]
Gharial	*Gavialis gangeticus*	C	E
Olive ridley turtle	*Lepidochelys olivacea*	C	E
Green turtle	*Chelonia mydas*	C	E
Hawksaw bill turtle	*Eretmochelys imbricata*	C	E
Loggerhead turtle	*Coratta coratta*	C	E
Leatherback turtle	*Dermochelys coriacea*	C	E
Batagur turtle	*Batagur baska*	C	E
Bostami turtle	*Trionyx nigricans*	C	E
Land tortoise	*Geochelone emys*	C	E
Grey lizard	*Varanus bengalensis*	C	T
Monitor/ring lizard	*V. salvator*	VC	T
Yellow lizard	*V. flaviscens*	C	T
Clouded/black lizard	*Varanus nebulosa*	C	T
Rock python	*Python molurus*	FC[6]	E

[1]VC = Very Common; [2]T = Threatened;
[3]U = Uncertain; [4]C = Common;
[5]e = Endangered; [6]FC = Fairly Common

(Source: Rashid, 1992)