CHAPTER IX

CONSTRUCTION WORKS FOR RIVER TRAINING

1. Natural Conditions at Work Sites.

(1) Meteorology.

Using atmospheric pressure, temperature, humidity and wind speed at Rangpur, Bogra, Sirajganj and Faridpur Meteorological Stations during the period from 1960 to 1972 and those on daily rainfall for the period from 1964/65 water year to that of 1969/70, temperature, wind speed and rainfall were studied with regard to the three stations of Bogra, Sirajganj and Faridpur which are respectively closest to the proposed bridge sites.

i. Temperature.

Monthly mean temperature in the five years from April 1964 to March 1969 at the three stations were calculated and are shown in Fig.9-1 together with the highest and the lowest temperatures of the month. The following facts are found from this figure.

a. Difference of temperature among the three stations.

Notwithstanding the Bogra station is located about 57 km north-northwest and the Faridpur station about 92 km south-southeast of the Sirajganj station, very little difference is found among the temperatures at the three stations.

b. Monthly mean temperature.

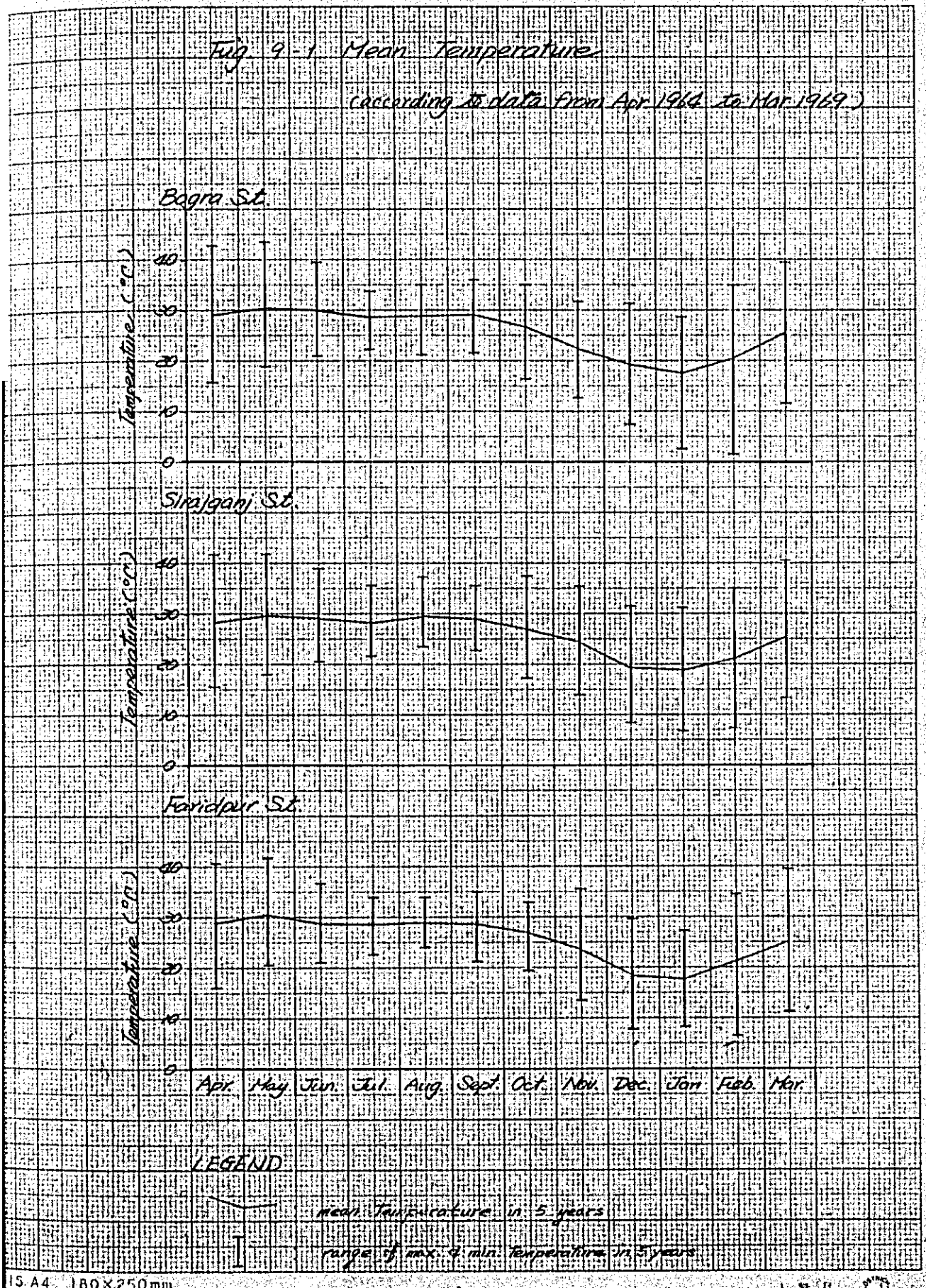
Monthly mean temperature is almost constant in the rainy season from May to September at all of the three stations ranging from 28°C to 31°C. The mean temperature gradually falls after October attaining the lowest in January and gradually rises again after it. The monthly mean temperature in January ranges from 17°C to 19°C. The annual difference of the mean temperature ranges from 11°C to 13°C.

c. The highest and the lowest temperatures.

Difference between the highest and the lowest temperatures is, at any of the stations, minimum in July, August or September

Fig. 9-1 Mean Temperature

(according to data from Apr. 1964 to Mar. 1969)



in the middle of the rainy season and gradually increases after it attaining the maximum in February or March. The highest and the lowest temperatures in the five years are as follows.

	Max. temp. (°C)		Min. temp. (°C)	
Met. sta.	Date	Temp.	Date	Temp.
Bogra	May 3,1966 May 2,1965	43.4	Feb. 4,1968	1.7
Sirajganj	Apr.17,1966 May3-5,1966	41.7	Jan.1-2,1965	6.7
Faridpur	May1-2,1965	41.7	Feb.4-5,1968	6.7

ii. Wind speed.

Fig.9-2 shows the highest wind speeds and the mean values of the highest wind speeds at the three stations by month in the five years. According to this figure, no definite trend is seen of monthly variation of maximum wind speeds at any of the three stations though the wind speed from November to February is a little lower compared with the others.

Next, Fig.9-3 shows monthly distribution of wind days of wind speed higher than 10 kt, higher than 20 kt and higher than 30 kt with respect to the average for the five years. It is seen from the figure that days of wind speed exceeding 10 kt increase toward the northern part of the land, and, between November and February, we have no records higher than 10 kt.

iii. Rainfall.

Studies were made of annual distribution of monthly rainfall, daily rainfall and distribution of rainfall days by the height of daily rainfall with regard to the three meteorological stations in the five years from April 1964 up to March 1969.

a. Monthly rainfall.

Fig.9-4 shows the annual distribution of mean monthly rainfall, the maximum and the minimum monthly rainfall in the five years.

Fig. 9-2 Maximum Wind Speed

(according to data from Apr. 1964 to Mar. 1969).

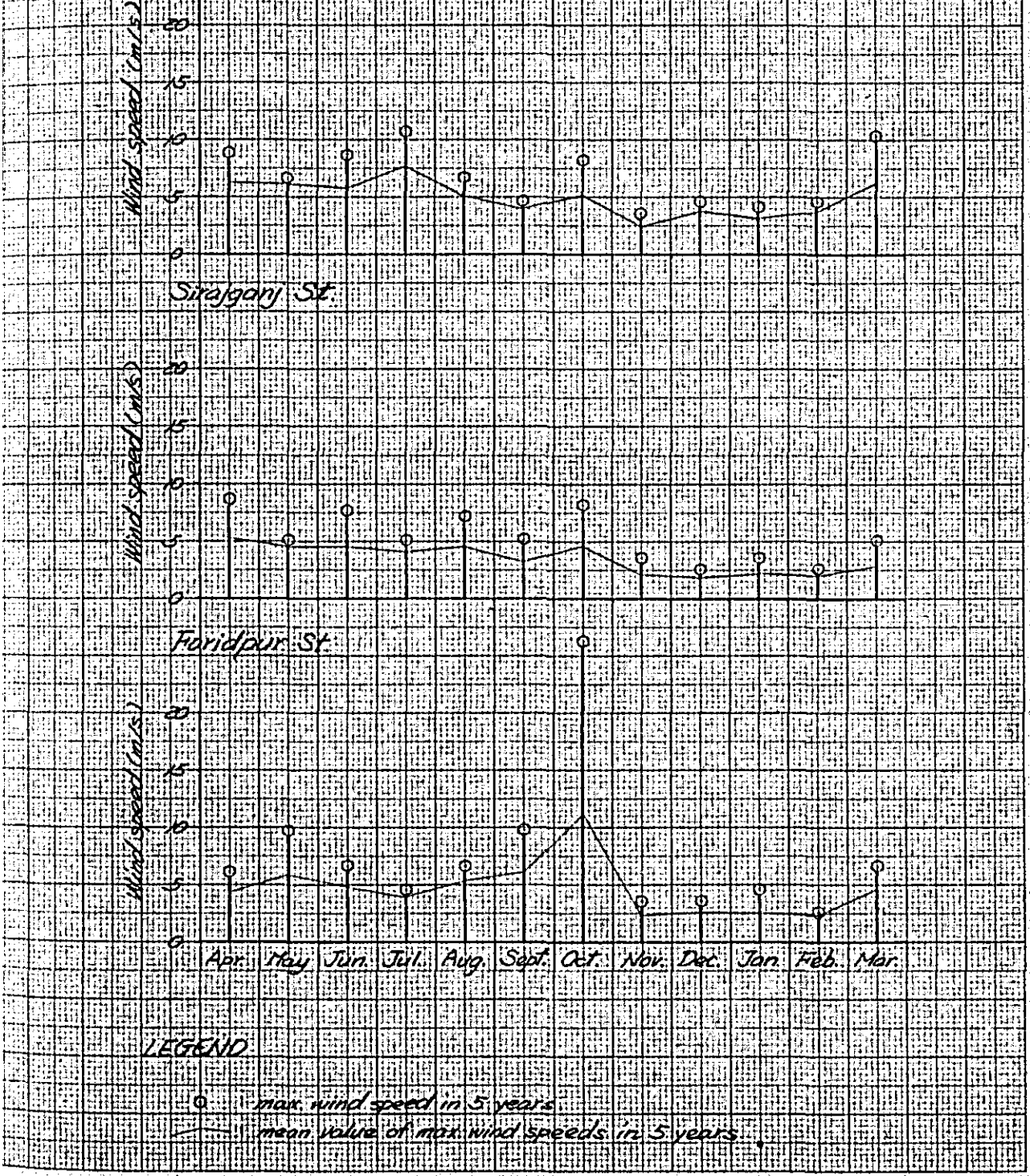


Fig. 9-3 Frequency of Wind Speed

(According to data from Apr. 1964 to Mar. 1969)

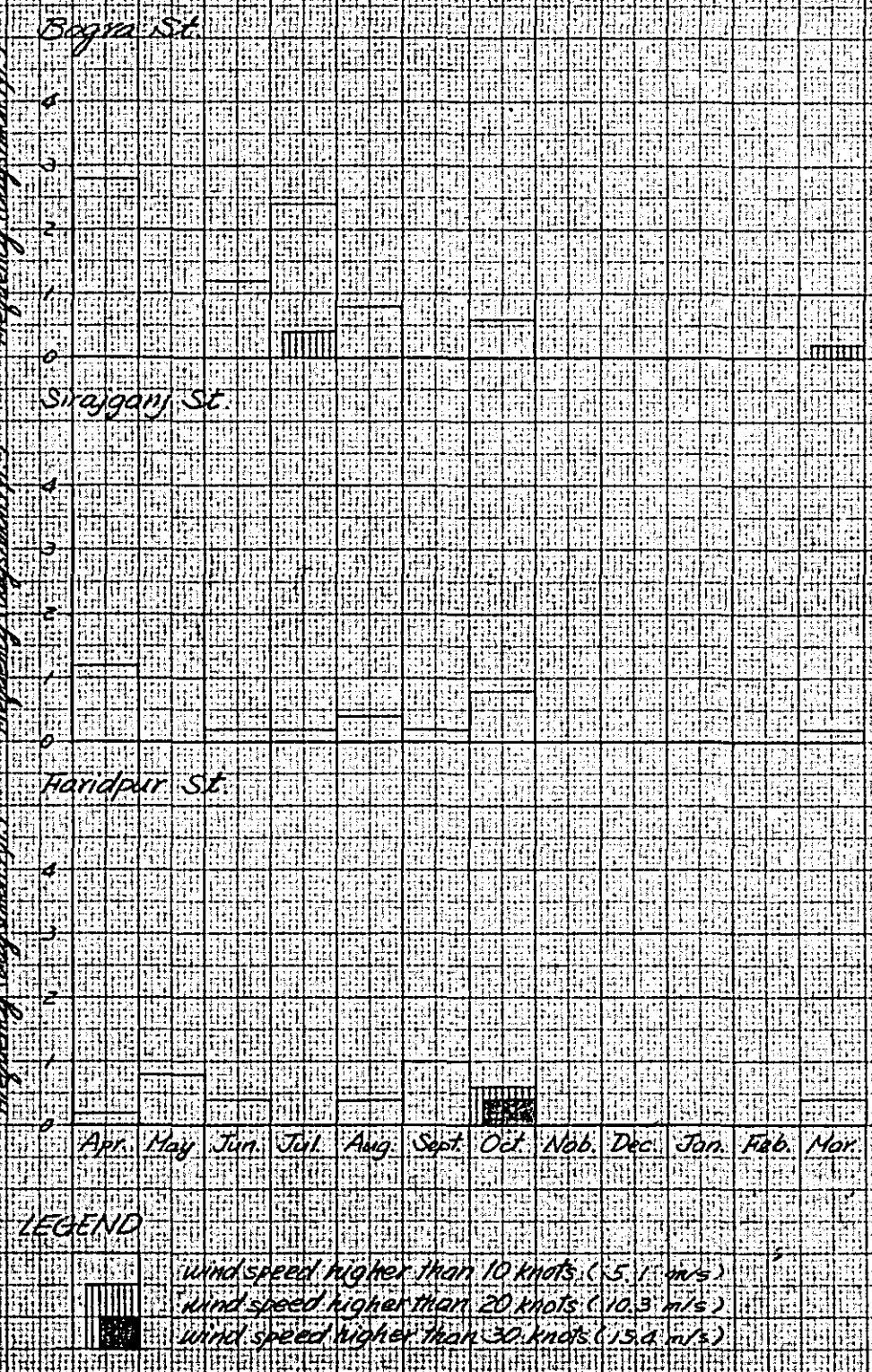
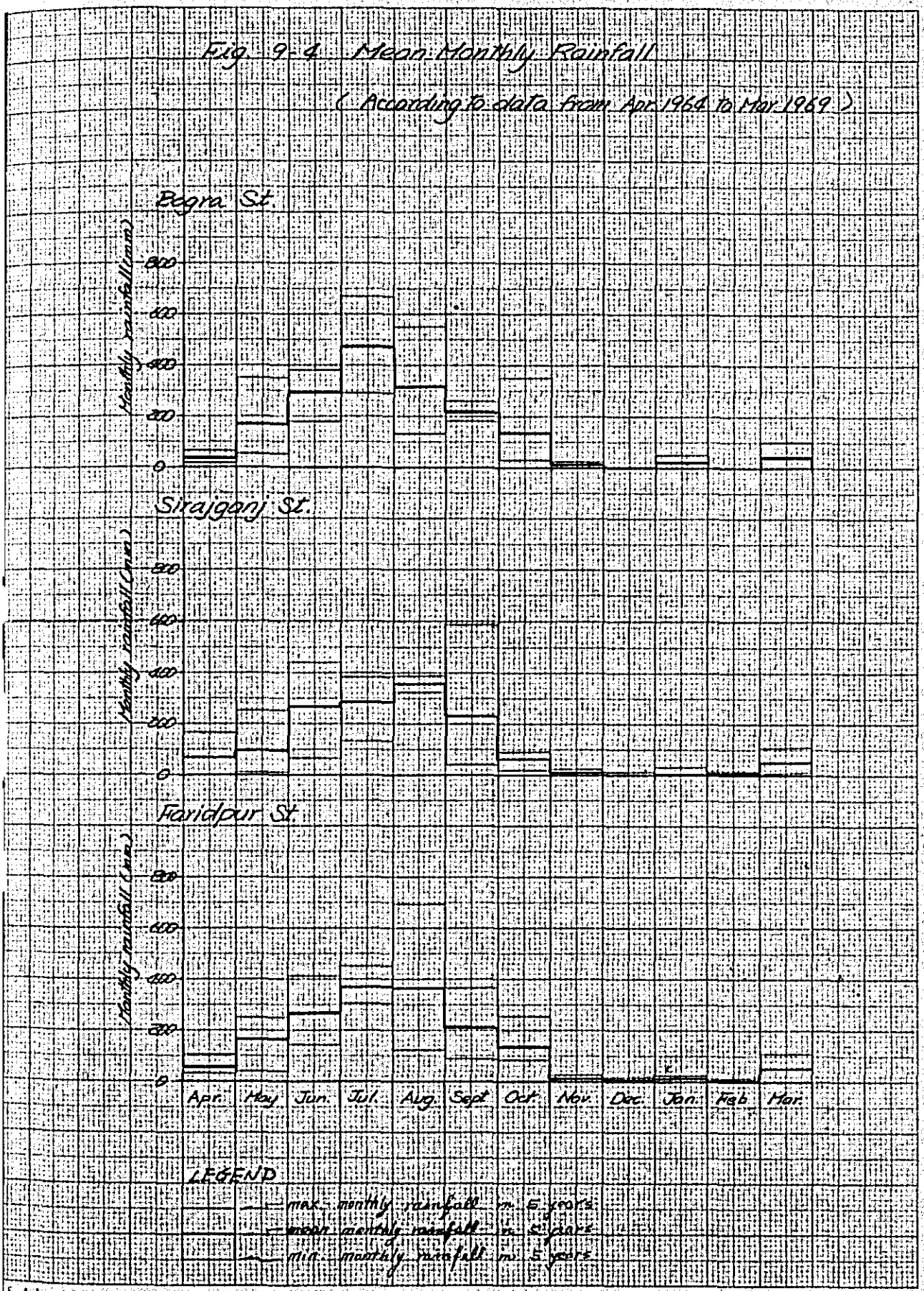


Fig. 9-4 Mean Monthly Rainfall

(According to data from Apr. 1964 to Mar. 1969)



The rainfall at every station reaches the maximum in August or September decreasing gradually before and after the months and the major part of the rainfall is concentrated in the period from May to October. Mean annual rainfall in the five years and ratios of the rainfall between May and October to the annual rainfall are given in the following table.

Met. Sta.	A. Annual rainfall (mm)	B. Rainfall bet. May & Oct. (mm)	B/A (%)
Bogra	1,651.9	1,566.1	94.8
Sirajganj	1,621.6	1,497.9	92.4
Faridpur	1,426.6	1,298.2	91.0

b. *Maximum daily rainfall.*

Fig.9-5 shows the maximum, the minimum and the average values of daily rainfall in the five years. The maximum daily rainfalls at the three stations in the five years are as follows.

Met. Sta.	Date	Max. daily rainfall (mm)
Bogra	Jul. 30, 1965	171.5
Sirajganj	Jul. 9, 1965	172.8
Faridpur	Jun. 15, 1964	152.4

c. Rainfall days by daily rainfall.

Fig.9-6 shows rainfall days of daily rainfall more than 0.1 in, more than 0.5 in, more than 1.0 in, more than 1.5 in and 2.0 in per day on the average of the five years. Figs.9-7-1 to 9-7-3 show rainfall days by intensity of daily rainfall on the average of the five years.

(2) *Water stages.*

Water stages at the BWDB gaging stations near the proposed four sites have been shown in Figs.4-3 and 4-4 in Chapter IV. Significant water stages at Bahadurabad St., Sirajganj St. and Kadamtali St. were selected from the above and the average values in the five years are shown in the following table.

Fig 9-5 Daily Rainfall

(According to data from Apr. 1964 to Mar. 1969)

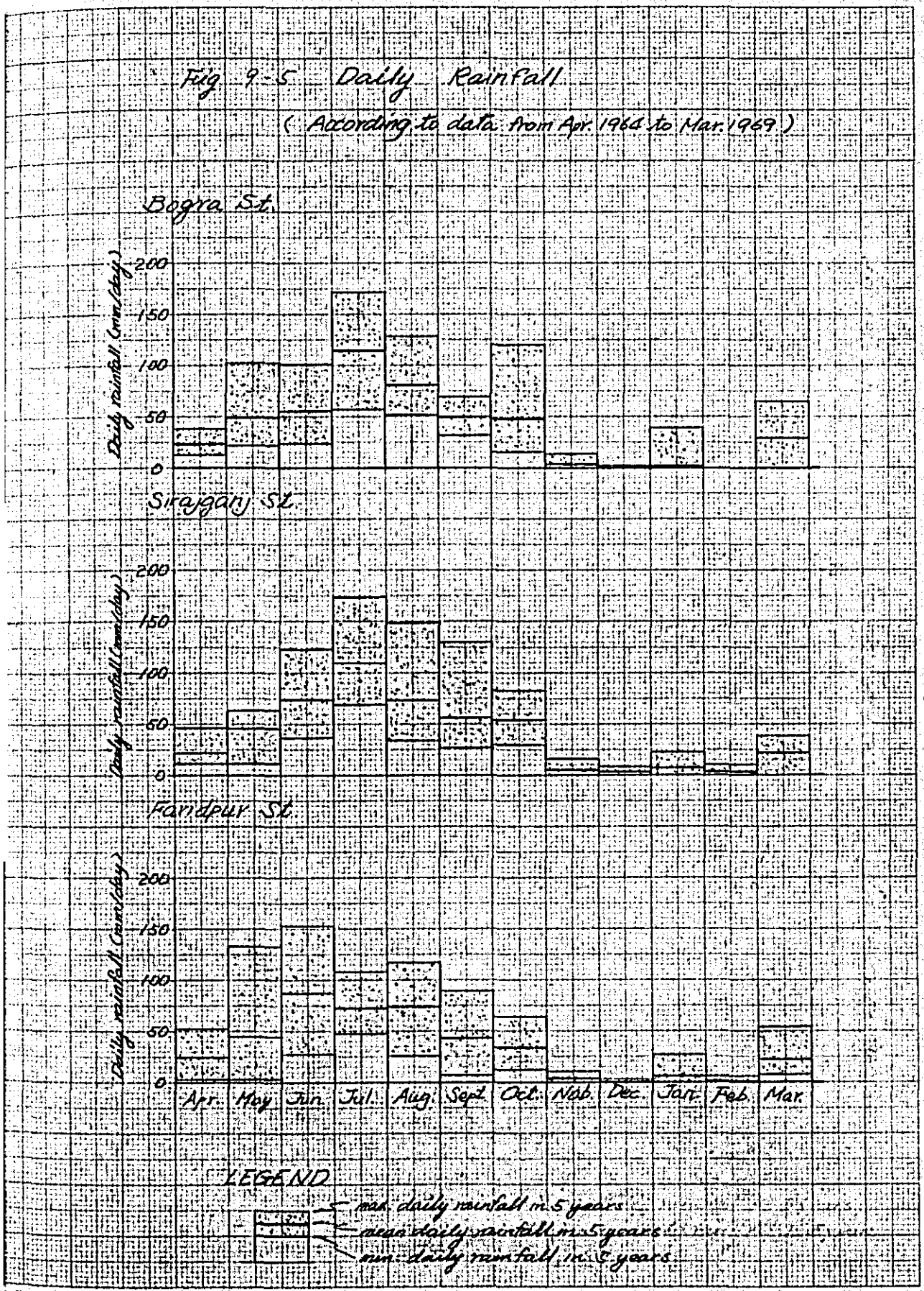
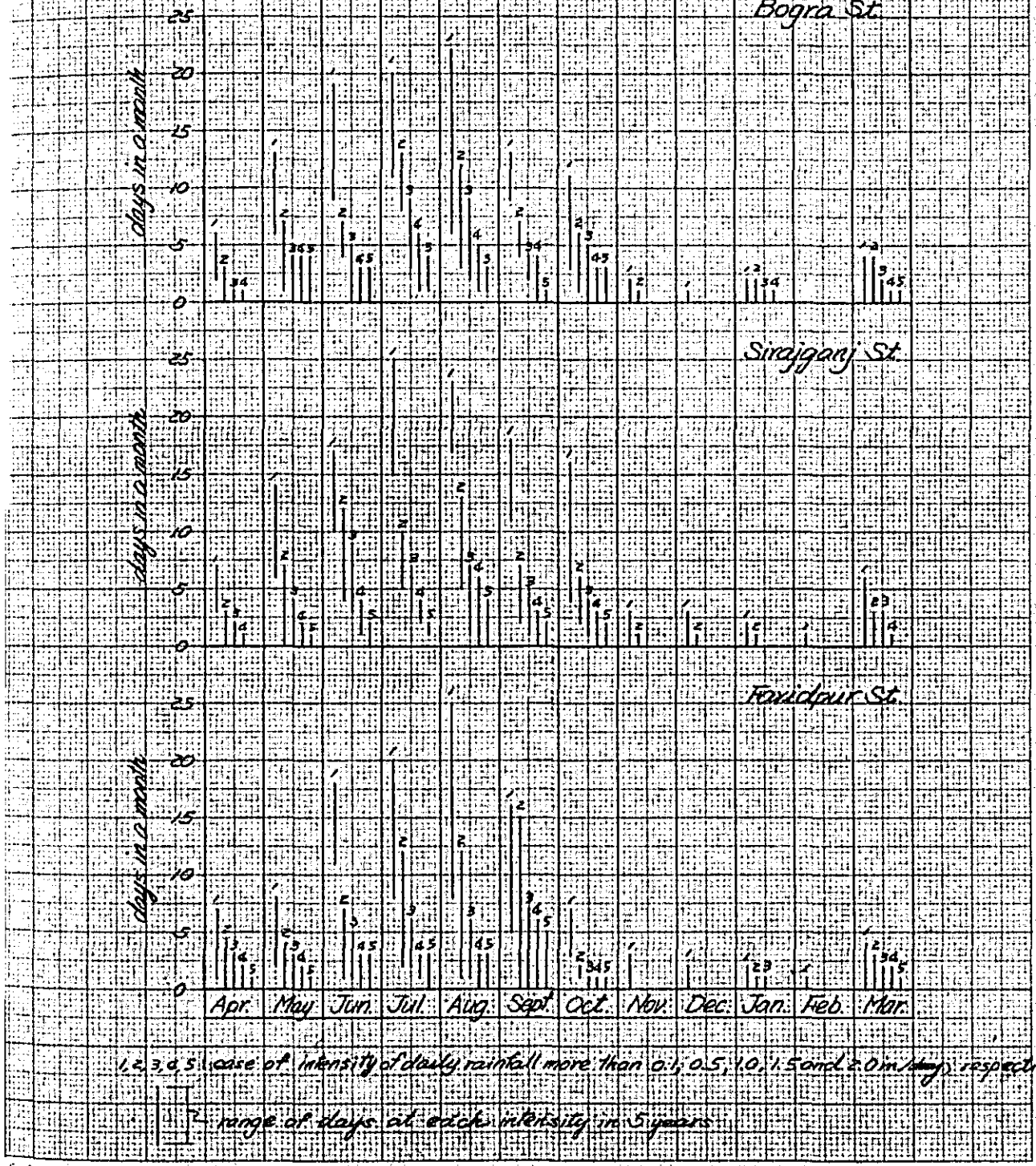


Fig. 9-6 Frequency of Rainfall in Each Month

(according to data from Apr. 1964 to Mar. 1969)

(Range of 5 years)



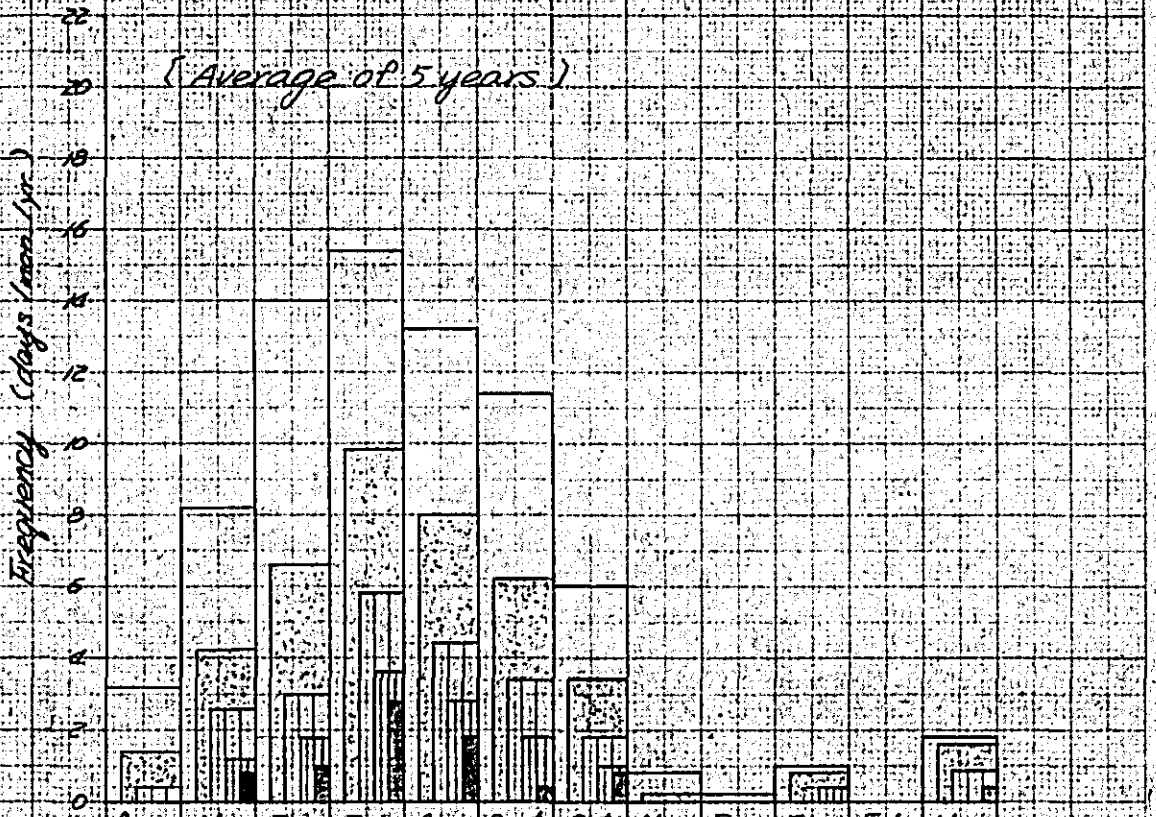
1, 2, 3, 4, 5 ; case of intensity of daily rainfall more than 0.1, 0.5, 1.0, 1.5 and 2.0 m/day respectively

: range of days at each intensity in 5 years

Fig 9-7-1 Frequency of Rainfall at Bogra St.

(according to data from Apr. 1964 to Mar. 1969)

(Average of 5 years)



LEGEND

- Days whose rainfall is more than 0.1 in/day (2.5 mm/day)
- Days whose rainfall is more than 0.5 in/day (12.7 mm/day)
- Days whose rainfall is more than 1.0 in/day (25.4 mm/day)
- Days whose rainfall is more than 1.5 in/day (38.1 mm/day)
- Days whose rainfall is more than 2.0 in/day (50.8 mm/day)

Fig. 9-7-2 Frequency of Rainfall at Singapore St.
(according to data from Apr. 1964 to Mar. 1969)
(Average of 5 years)

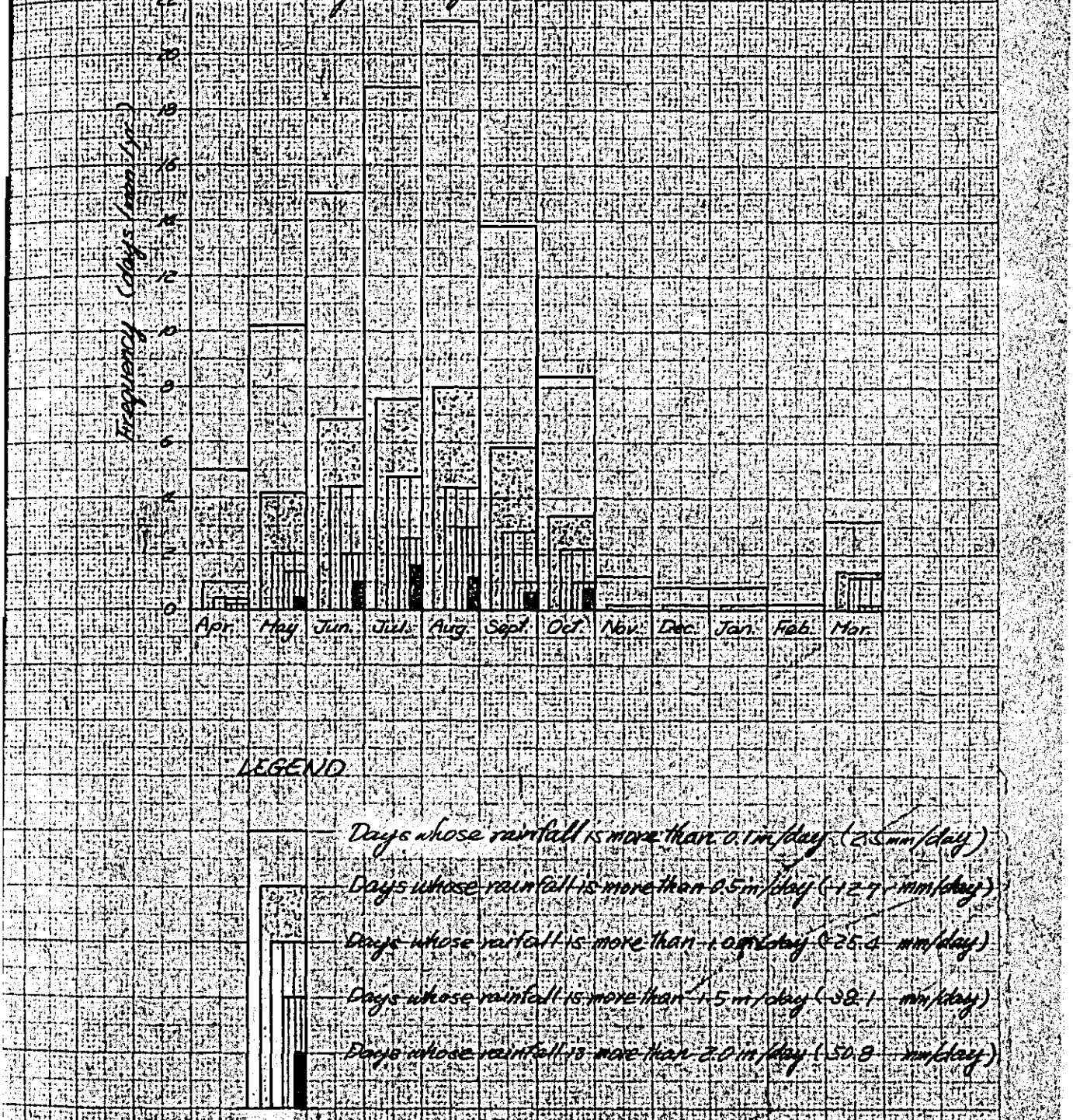
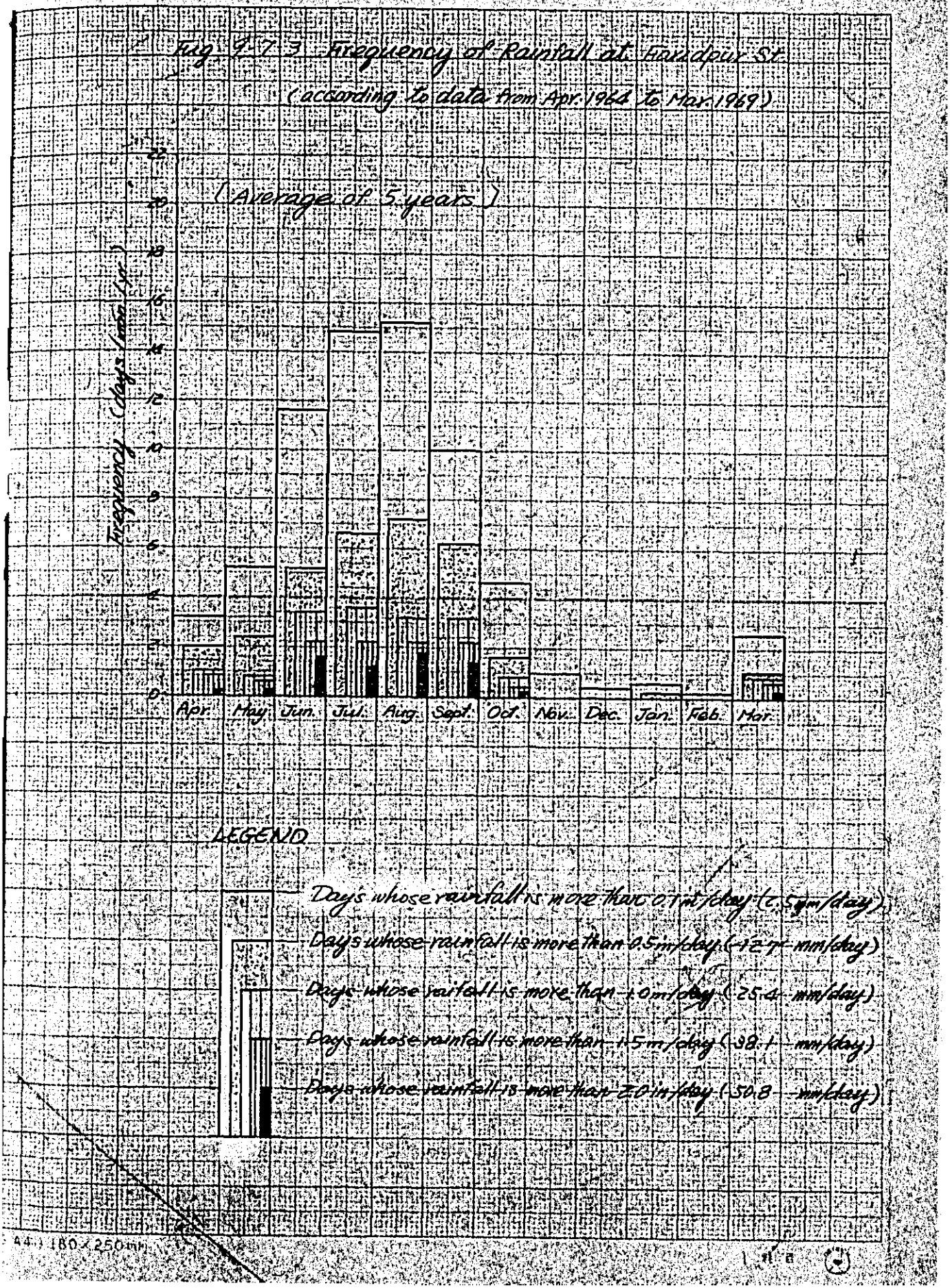


Fig. 9-7-3 Frequency of Rainfall at Haridpur St.
(according to data from Apr. 1964 to Mar. 1969)

(Average of 5 years)



Days counted from the highest water stage	Bahadurabad St. ft. PWD	m, PWD	Sirajgnaj St. ft. PWD	m,PWD	Kadamtali St. ft. PWD	m,PWD
MHHWL	64.01	19.52	45.34	13.83	25.74	7.85
95-day	58.61	17.87	40.42	12.33	20.86	6.36
185-day	49.59	15.12	30.44	9.28	11.58	3.53
275-day	44.71	13.64	24.96	7.61	7.05	2.15
MLLWL	42.91	13.09	22.80	6.95	4.93	1.50

Note: MHHWL means mean highest high water level in the five years.
MLLWL means mean lowest low water level in the five years.

Fig.9-8 shows annual distribution of the highest, the lowest and the mean water levels in the five years at the three gaging stations. It is seen from this figure that the maximum and the minimum water stages occur earlier at upstream stations and, at all of the stations, the water level reaches the highest in July or August and, going down before and after these months, reaches the lowest in February or March. Amplitude of the fluctuation of monthly mean water level is about 21.5 to 23.0 ft. The monthly highest water levels in the five years at the Bahadurabad and Sirajganj stations show scarce variation during the period from June to October. It may be presumed that this is attributed to the decrease of the water level caused by spilling of flood water.

The amplitude of the monthly mean water level is, at any of the stations, minimum in February, while it is very large in the period from June to October. The latter indicates a possibility that abnormal high water level or abnormal low water level may occur in this period.

On the basis of the data on water stages at the three stations and Jagannathganj and Mathura stations, annual variation was assumed of the monthly mean water level at the four proposed sites. Correlations were first examined between the monthly mean water levels in the Water Year 1968/69 at the Bahadurabad St. and the Jagannathganj St. and those at the Sirajganj St. and the Mathura St.. This indicates, as is shown in Fig.9-9, that there are very close correlations among them.

Since the Bahadurabad and the Sirajganj sites are located between the Bahadurabad and the Sirajganj stations and the Sirajganj and the Nagarbari

Fig. 7-8 Mean Water Level

(according to data from Apr. 1964 to Mar. 1969)

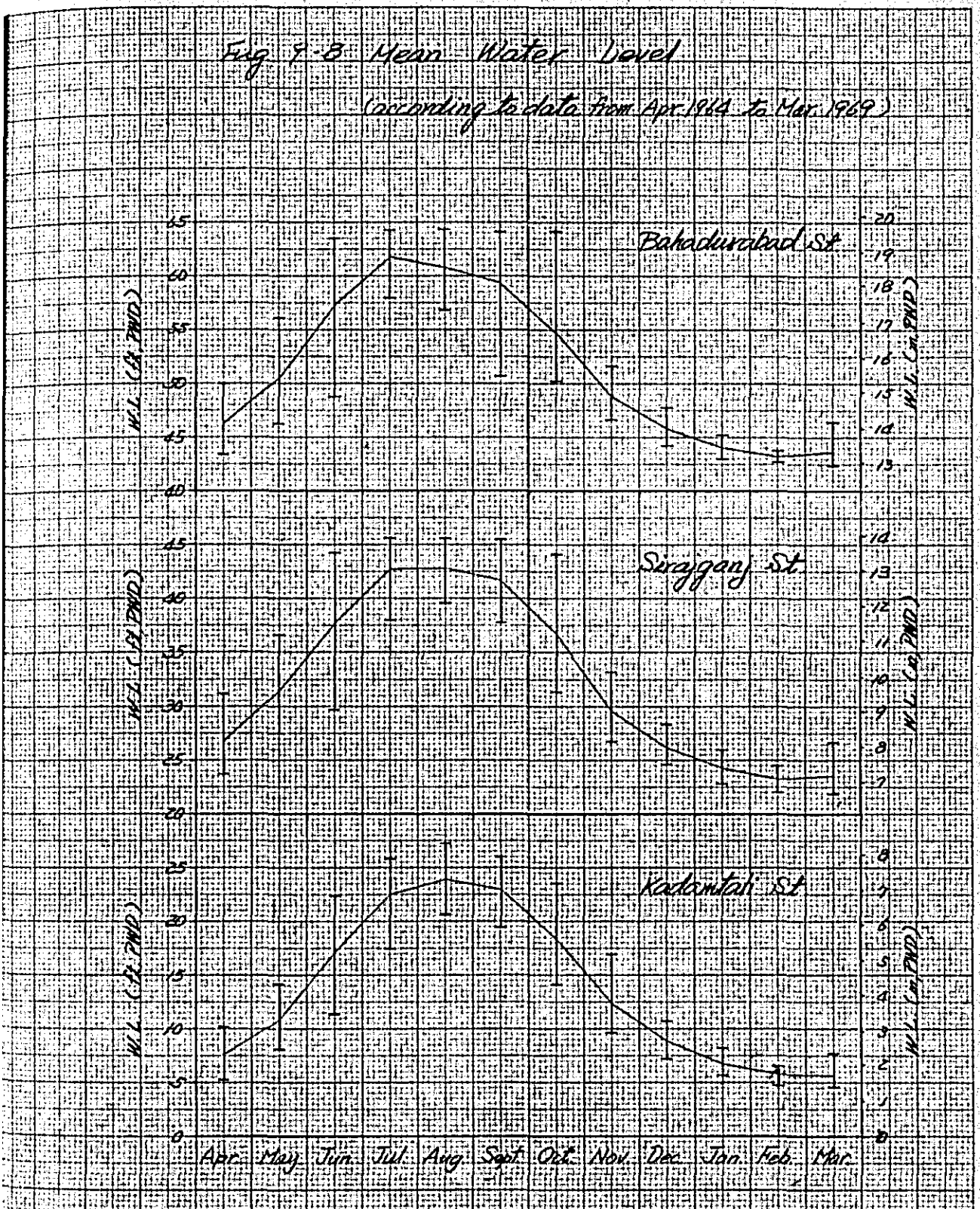
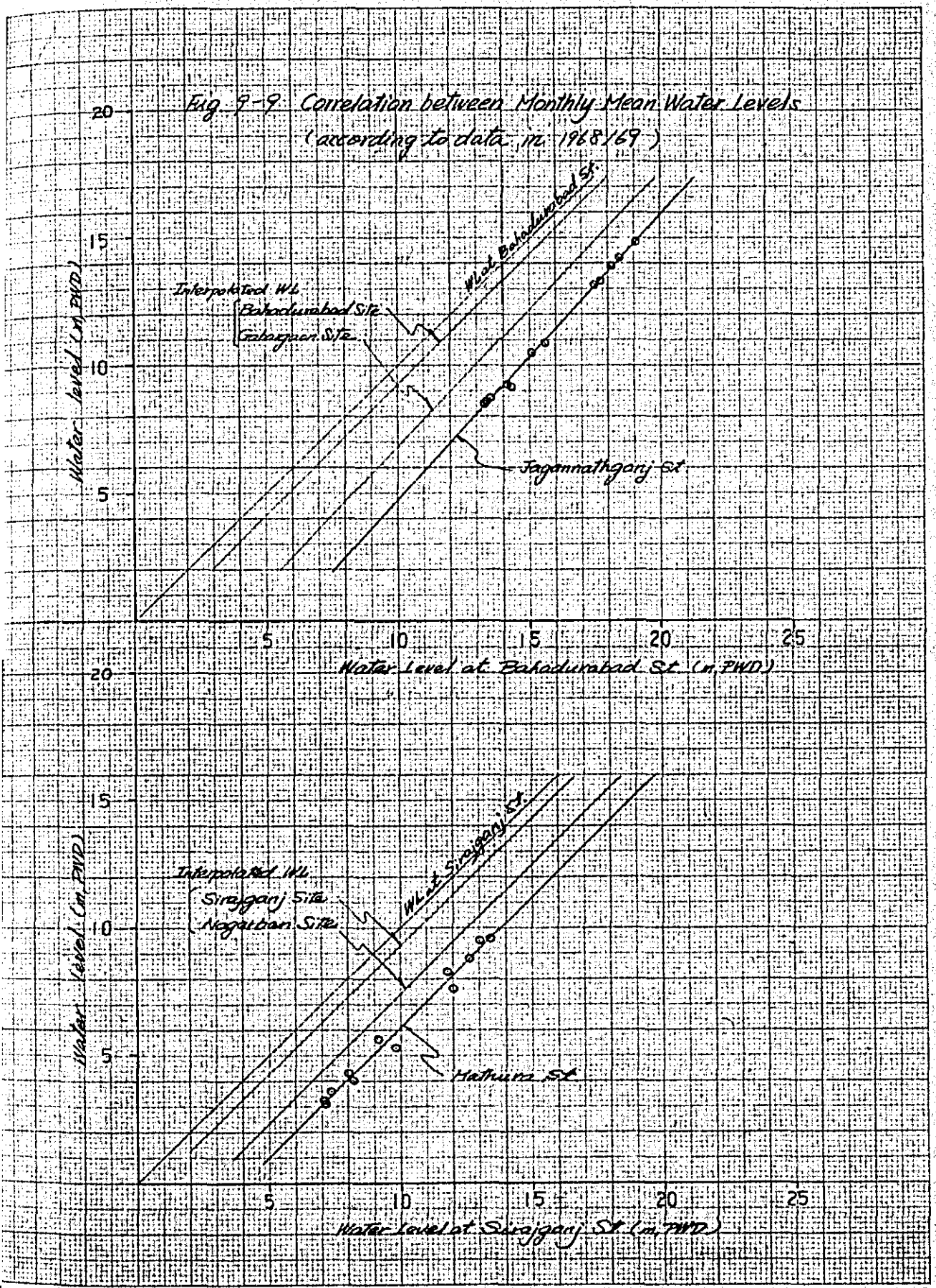


Fig. 9-9 Correlation between Monthly Mean Water Levels
(according to data in 1968/69)



sites are located between the Sirajganj and the Mathura stations, the correlations of the water stages between the former two and the latter two sites were obtained by interpolation of distances among them. These correlations are also shown in Fig.9-9.

Using these correlation curves, monthly mean water levels at the four sites were estimated as are shown in Fig.9-10. This figure also shows the several significant water levels which were estimated using the correlation curves. Table 9-1 shows the estimated monthly mean water levels and the estimated significant water levels at the four sites.

Fig.9-11 shows the water levels, the ground levels and the estimated river beds at the four sites and Fig.9-12 shows the inland water levels which were measured by BWDB in the 1970 flood.

(3) Favorable period for work.

Fig.9-13 shows, with respect to the Sirajganj site, the period in which the water level was higher than 40 ft PWD that is nearly equal to the mean ground level at the Sirajganj Station, days of wind speed higher than 10 knot on the average of nine years from 1960 to 1969 and days of rainfall more than 0.5 in/day on the average of the period from April 1964 to March 1969.

The period favorable for executing the construction works such as the guide-bank works, closing-dike works and closing works was investigated for the Sirajganj site according to the following standard.

a. Water stage.

We assume that the water stage higher than mean ground level is unfavorable for the execution of the construction works and thus the period from June 16 to October 15 is unfavorable for the works according to Fig.9-13.

b. Rainfall.

We assume that the days which have daily rainfall more than 0.5 in/day (12.7 mm/day) are unfavorable for the works. Monthly mean days of rainfall more than 0.5 in/day are counted according to Fig.9-13 and are shown below.

Fig. 9-10 Monthly Mean Water Level at Each Site

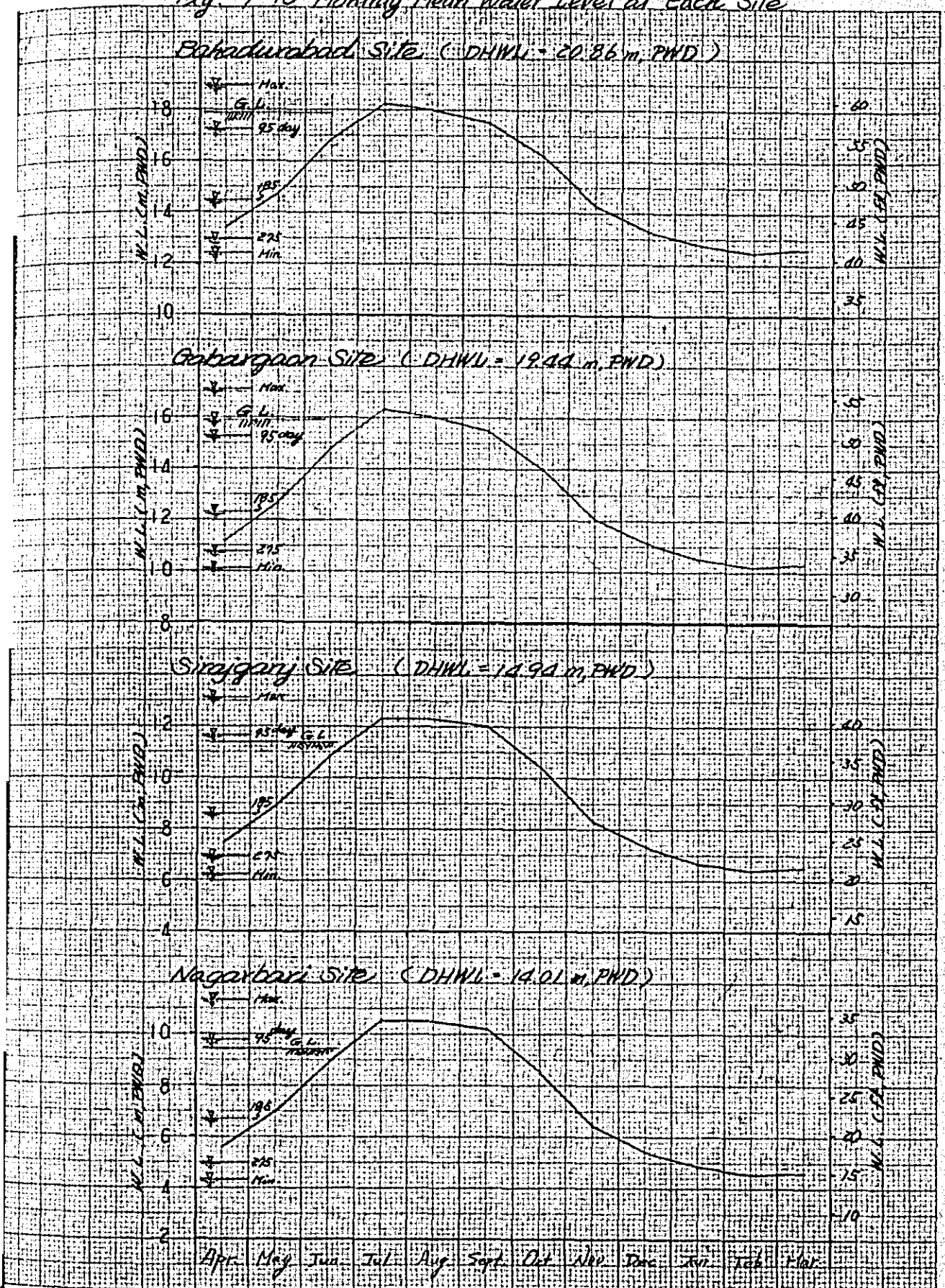


Table 9-1 Interpolated Water Level

Monthly Water Level (m,PWD)

Month	Bahadura-bad WL St.	Bahadura-bad Site	Gabar-gaon Site	Sirajganj WL St.	Sirajganj Site	Nagar-bari Site
Apr.	14.09	13.41	11.20	9.19	7.46	5.55
May	15.40	14.78	12.61	9.58	8.85	6.97
June	17.45	16.82	14.82	11.53	10.81	8.96
Jul.	18.84	18.29	16.30	13.02	12.31	10.48
Aug.	18.54	17.99	16.00	13.01	12.30	10.47
Sept.	18.11	17.50	15.50	12.66	11.95	10.11
Oct.	16.67	16.20	14.00	11.14	10.42	8.56
Nov.	14.90	14.25	12.06	9.03	8.30	6.41
Dec.	13.98	13.30	11.10	7.98	7.25	5.34
Jan.	13.44	12.77	10.52	7.41	6.67	4.76
Feb.	13.18	12.45	10.20	7.08	6.34	4.42
Mar.	13.29	12.60	10.34	7.16	6.42	4.50

Water Level Duration

Days of WL counted from HHWL	Bahadurabad Site	Gabargaon Site	Sirajganj Site	Nagarbari Site
	m,PWD	m,PWD	m,PWD	m,PWD
MHHWL	18.94	17.10	13.14	11.36
95 days	17.24	15.24	11.64	9.80
185 days	14.48	12.31	8.60	6.70
275 days	12.98	10.78	6.95	5.00
MLLWL	12.40	10.12	6.22	4.34
Mean ground level	17.95	15.93	11.38	9.45

Fig 9-11 Water level, Ground level and River Bed

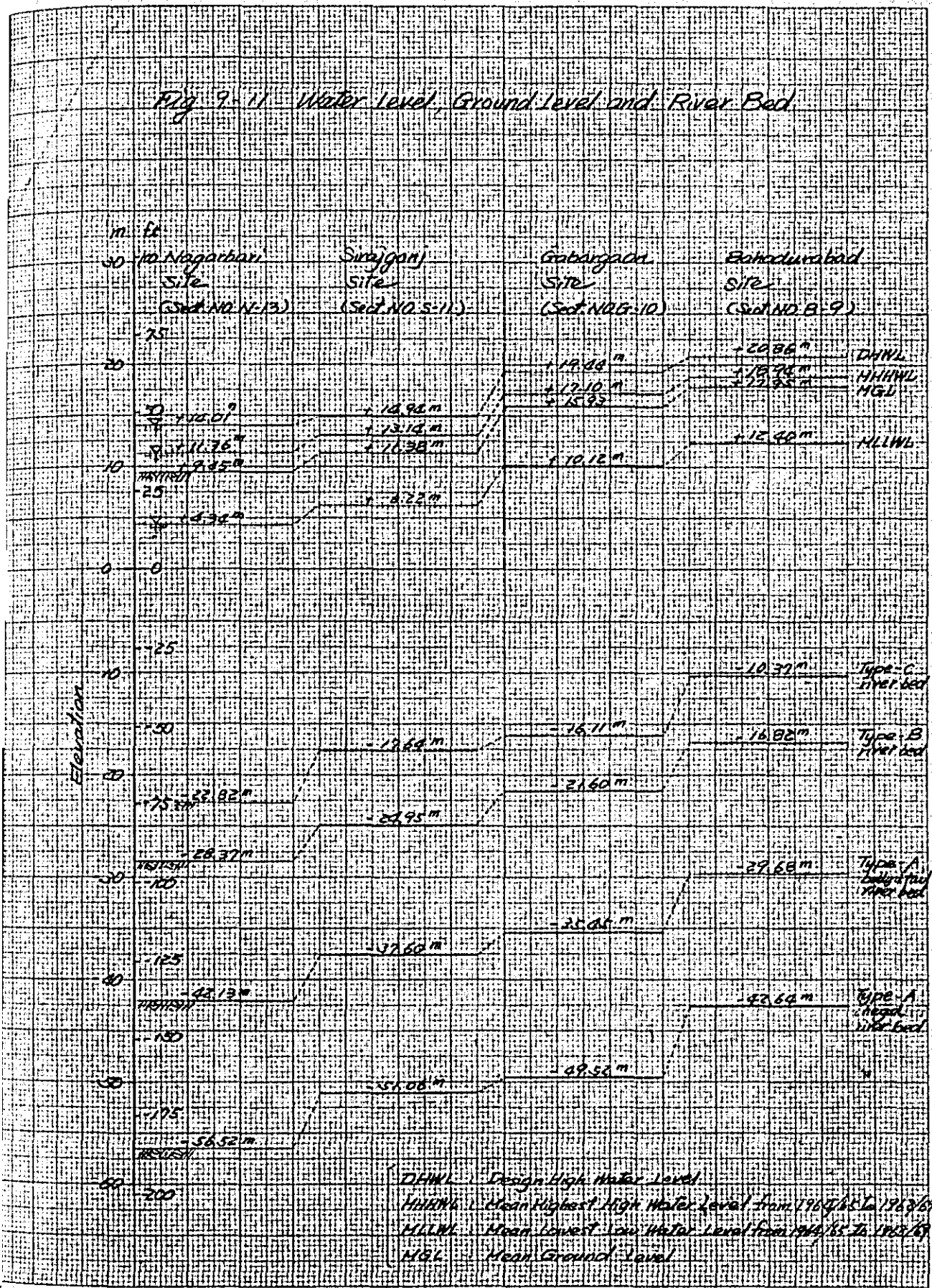


Fig. 9-12 Inland Water Level

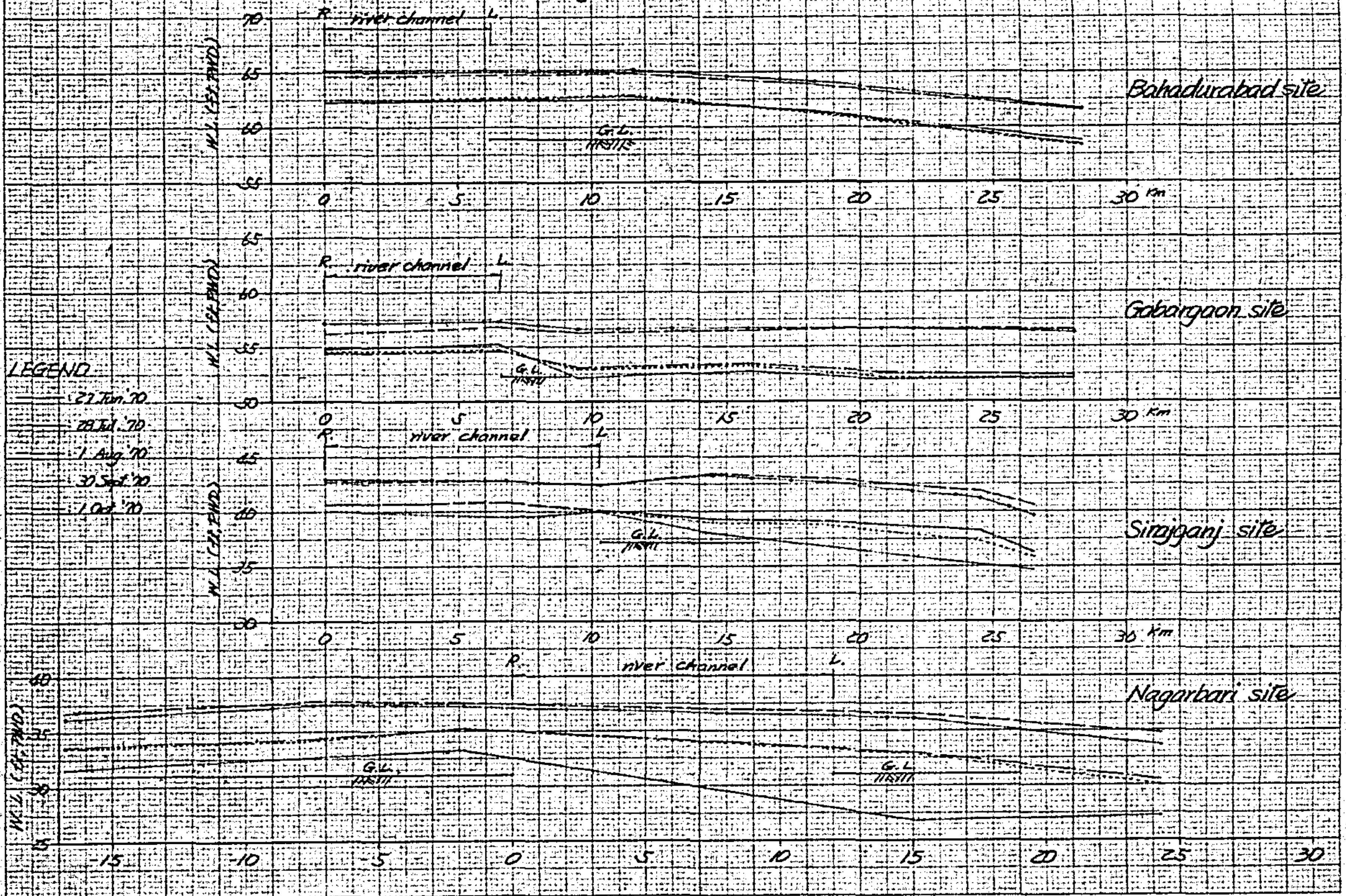
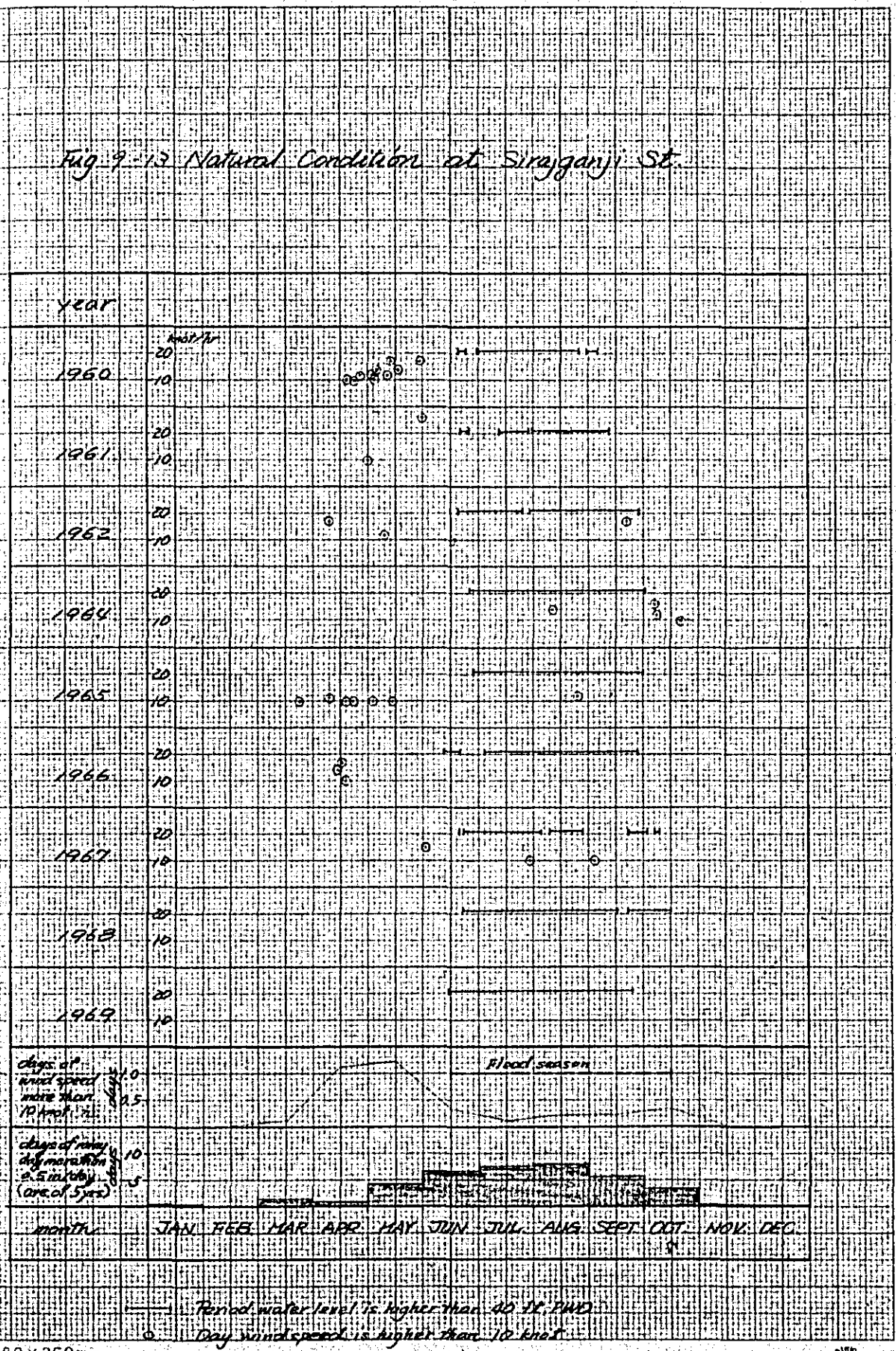


Fig 9-13 Natural Condition at Sirajganj St.



Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Days	0.2	0	1.4	1.0	4.2	6.8	7.6	8.0	5.8	3.4	0.2	0.2

c. Holidays.

We assume two holidays in a month for no work.

d. Favorable days for work.

We assume that the days except the above are all favorable for working. The favorable days were counted at 215 days in a year according to the above-mentioned standard and the detail is shown in Table 9-2. We assumed further that this period for working is also applicable to the other sites.

Table 9-2 Working Days

Month	Days in month	No working days				Total working days	
		High water days (H>MCL)	Rainy days (> 0.5 m/y)	Holidays	Total no working days		
Oct.	31	15	3.4	2	17.7	13	
Nov.	30	0	0.2	2	2.2	28	
Dec.	31	0	0.2	2	2.2	29	
Jan.	31	0	0.2	2	2.2	29	
Feb.	28	0	0	2	2.0	26	
Mar.	31	0	1.4	2	3.4	28	
Apr.	30	0	1.0	2	3.0	27	
May	31	0	4.2	2	6.2	25	
June	30	15	6.8	2	19.4	10	
Jul.	31	31	7.6	2	31.0	0	
Aug.	31	31	8.0	2	31.0	0	
Sept.	30	30	5.8	2	30.0	0	
Total	36.5	122	38.8	24	150.3	215	

2. Structure of River Training Works and quantity of works.

(1) Structure of banks.

Structure of guide banks has already been shown in Fig.7-10 and their horizontal arrangement is shown in Figs.7-11-1 to 7-11-4. The bank body will be built with dredged sand. For the purpose of preventing dredged sand from being carried away, polyethylene mats will be put between dredged sand and stones to be pitched to protect the bank from scouring. In building the portion below L.W.L., mainly in Type A, stone dikes will be built up to the height of 1.0 m above L.W.L. This method was considered by reason that the first banking must be made in the water by dredged sand as well as to secure the stability of the body of the embankment.

(2) Structure of closing dikes.

Structure of closing dikes has already been shown in Figs.7-13-1 and 7-13-2 and their horizontal arrangement has already been shown in Figs.7-11-1 to 7-11-4. The body of the embankment will be built with dredged sand. Faces of the slopes on both sides of the embankment will be protected with pitching stones up to the height not lower than M.H.H.W.L.

In building the portion below L.W.L., mainly in case of Type A of guide banks, a portion of low-water channel will first be closed by stone dikes in connection with guide banks and then dredged sand will be put between the two stone dikes.

In case there are branch low-water channels other than the main, these will be closed by closing works in order to facilitate the construction works of the closing dikes. Structure of the closing works has already been shown in Fig.7-12. The crown height of the closing structure shall be set lower than mean ground level and the body of the structure shall be covered with stones. Sheet piles will be used in consideration of prevention of scour and facilitation of the works.

(3) Quantity of works.

Quantity of works of guide banks, closing dikes and closing works is shown in Tables 9-3-1, 9-3-2, 9-4 and 9-5.

The quantity of materials shown in the tables contains the allowances for settlement and losses during the construction,but the materials of

Table 9-3-1 Quantity of Works

Site: Nagarbari

	Works	Condition	Unit	Type A Left	Type A Right	Type B Left	Type B Right	Type C Left	Type C Right
Guide bank	Embankment	O.G.	km	5.5	2.8	4.6	4.6	4.6	4.6
		U.W.	km	0	2.7	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Apron	O.G.	km	5.5	2.8	4.6	4.6	4.6	4.6
		U.W.	km	0	2.7	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Pavement		km	5.5	5.5	4.6	4.6	4.6	4.6
Closing dike		O.G.	km	0	2.10	0	0.50	0	0
		U.W.	km	0	1.05	0	0.50	0	0
		Σ	km	0	3.15	0	1.00	0	0
Closing works		O.G.	km	0	2.1	0	0.25	0	0
		U.W.	km	0	0	0	0	0	0
		Σ	km	0	2.1	0	0.25	0	0
Construction road		O.G.	km	5.5	9.7	3.2	4.6	3.2	4.6
		U.W.	km	0	2.2	1.4	2.0	1.4	0
		Σ	km	5.5	11.9	4.6	6.6	4.6	4.6
Jetty			nos.	(0)	6 (6)	(0)	1 (1)	(0)	0 (0)

Site: Sirajganj

	Works	Condition	Unit	Type A Left	Type A Right	Type B Left	Type B Right	Type C Left	Type C Right
Guide bank	Embankment	O.G.	km	5.5	1.0	4.6	4.6	4.6	4.6
		U.W.	km	0	4.5	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Apron	O.G.	km	5.5	1.0	4.6	4.6	4.6	4.6
		U.W.	km	0	4.5	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Pavement		km	5.5	5.5	4.6	4.6	4.6	4.6
Closing dike		O.G.	km	0	2.30	0	1.45	0	0
		U.W.	km	0	1.10	0	0	0	0
		Σ	km	0	3.40	0	1.45	0	0
Closing works		O.G.	km	0	1.05	0	0.20	0	0
		U.W.	km	0	0	0	0	0	0
		Σ	km	0	1.05	0	0.20	0	0
Construction road		O.G.	km	5.5	12.3	3.3	6.9	3.3	1.5
		U.W.	km	0	0.6	1.3	0.5	1.3	3.1
		Σ	km	5.5	12.9	4.6	7.4	4.6	4.6
Jetty			nos.	(0)	10 (10)	(0)	0 (0)	(0)	0 (0)

O.G. : Works on the ground

U.W. : Works under water

Σ : Sum of O.G. and U.W.

Table 9-3-2 Quantity of Works

Site: Cabargaon

	Works	Condition	Unit	Type A Left	Type A Right	Type B Left	Type B Right	Type C Left	Type C Right
Guide bank	Embankment	O.G.	km	1.4	0.3	4.6	4.6	4.6	4.6
		U.W.	km	4.1	5.2	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Apron	O.G.	km	1.4	0.3	4.6	4.6	4.6	4.6
		U.W.	km	4.1	5.2	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Pavement		km	5.5	5.5	4.6	4.6	4.6	4.6
Closing dike		O.G.	km	0.30	1.95	0.75	1.10	0	0
		U.W.	km	0.45	0.90	0	0	0	0
		Σ	km	0.75	2.85	0.75	1.10	0	0
Closing works		O.G.	km	0	1.30	0	0.45	0	0
		U.W.	km	0	0	0	0	0	0
		Σ	km	0	1.30	0	0.45	0	0
Construction road		O.G.	km	5.5	10.7	3.0	4.2	3.0	4.6
		U.W.	km	0	1.2	1.6	2.4	1.6	0
		Σ	km	5.5	11.9	4.6	6.6	4.6	4.6
Jetty			nos.	(9) 11	(11)	(0) 0	(0)	(0) 0	(0)

Site: Bahadurabad

	Works	Condition	Unit	Type A Left	Type A Right	Type B Left	Type B Right	Type C Left	Type C Right
Guide bank	Embankment	O.G.	km	3.7	5.5	4.6	4.6	4.6	4.6
		U.W.	km	1.8	0	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Apron	O.G.	km	3.7	5.5	4.6	4.6	4.6	4.6
		U.W.	km	1.8	0	0	0	0	0
		Σ	km	5.5	5.5	4.6	4.6	4.6	4.6
	Pavement		km	5.5	5.5	4.6	4.6	4.6	4.6
Closing dike		O.G.	km	3.10	0.15	1.40	0.15	0	0.15
		U.W.	km	0.45	0	0	0	0	0
		Σ	km	3.55	0.15	1.40	0.15	0	0.15
Closing works		O.G.	km	1.80	0	0	0	0	0
		U.W.	km	0	0	0	0	0	0
		Σ	km	1.80	0	0	0	0	0
Construction road		O.G.	km	11.9	5.5	7.4	4.6	4.6	4.6
		U.W.	km	0.8	0	0	0	0	0
		Σ	km	12.7	5.5	7.4	4.6	4.6	4.6
Jetty			nos.	(6) 6	(0)	(0) 0	(0)	(0) 0	(0)

O.G. : Works on the ground
U.W. : Works under water
Σ : Sum of O.G. and U.W.

Table 9 - 4 Quantity of Materials (1)

Site	Type	Side	Unit	Guide Bank			Closing Dike			Closing Works			Total		
				Stone	Chip	Dredged sand	Stone	Chip	Dredged sand	Stone	Chip	Dredged sand	Stone	Chip	Dredged sand
Bahadurabad	A	L	$10^3 m^3$	2615	225	2596	397	7	4428	139	8	–	3151	240	7024
		R	"	2309	219	1873	11	1	236	–	–	–	2320	220	2109
	B	L	"	1230	188	890	78	2	1092	–	–	–	1308	190	1982
		R	"	1290	174	1737	11	1	236	–	–	–	1301	175	1973
	C	L	"	1087	154	795	–	–	–	–	–	–	1087	154	795
		R	"	1146	174	1737	11	1	236	–	–	–	1157	175	1973
Gabargaon	A	L	"	2861	142	3300	78	3	1500	–	–	–	2939	145	4800
		R	"	2943	159	3903	341	9	4877	100	6	–	3384	174	8780
	B	L	"	1381	148	1649	21	1	473	–	–	–	1402	149	2122
		R	"	1471	187	2346	69	3	1129	56	3	–	1596	193	3475
	C	L	"	1255	148	1649	21	1	473	–	–	–	1276	149	2122
		R	"	1203	157	851	–	–	–	–	–	–	1203	157	851
Sirajganj	A	L	"	2338	203	1082	–	–	–	–	–	–	2338	203	1082
		R	"	2905	178	3760	313	9	4975	78	4	–	3296	191	8735
	B	L	"	1312	150	1428	–	–	–	–	–	–	1312	150	1428
		R	"	1311	189	1086	79	2	1126	20	1	–	1410	192	2212
	C	L	"	1144	150	1428	–	–	–	–	–	–	1144	150	1428
		R	"	1210	160	1726	–	–	–	–	–	–	1210	160	1726
Nagarbari	A	L	"	2560	239	2299	–	–	–	–	–	–	2560	229	2299
		R	"	2952	216	3360	289	10	5176	293	15	315	3534	241	8851
	B	L	"	1422	171	1921	–	–	–	–	–	–	1422	171	1921
		R	"	1518	185	2349	111	3	1622	19	1	–	1648	189	3971
	C	L	"	1290	171	1921	–	–	–	–	–	–	1290	171	1921
		R	"	1230	167	1321	–	–	–	–	–	–	1230	167	1321

Table 9 - 5 Quantity of Materials (2)

Site	Type	Side	Guide Bank			Closing Dike		Closing Works			Total				
			Polyethylene mat ($\times 10^3 m^2$)	Sodding ($\times 10^3 m^2$)	Crown pavement ($\times 10^3 m^2$)	Polyethylene mat ($\times 10^3 m^2$)	Sodding ($\times 10^3 m^2$)	Polyethylene mat ($\times 10^3 m^2$)	Earth excavation ($\times 10^3 m^3$)	Sheet pile ($\times 10^3 m$)	Polyethylene mat ($\times 10^3 m^2$)	Sodding ($\times 10^3 m^2$)	Crown pavement ($\times 10^3 m^2$)	Earth excavation ($\times 10^3 m^3$)	Sheet pile ($\times 10^3 m$)
Bahadurabad	A	L	251.0	107.5	38.5	66.2	81.8	54.7	75.8	2.09	371.9	189.3	38.5	75.8	2.09
		R	190.3	107.2	38.5	3.7	3.5	–	–	–	194.0	110.7	38.5	–	–
	B	L	116.8	90.3	32.4	14.6	32.2	–	–	–	131.4	122.5	32.4	–	–
		R	172.7	90.3	32.4	3.7	3.5	–	–	–	176.4	93.8	32.4	–	–
	C	L	103.4	90.3	32.4	–	–	–	–	–	103.4	90.3	32.4	–	–
		R	172.7	90.3	32.4	3.7	3.5	–	–	–	176.4	93.8	32.4	–	–
Gabargaon	A	L	270.3	107.3	38.5	25.3	17.3	–	–	–	295.6	124.6	38.5	–	–
		R	309.3	107.3	38.5	81.2	65.7	100.4	45.9	1.32	490.9	173.0	38.5	45.9	1.32
	B	L	162.8	90.5	32.4	7.4	6.9	–	–	–	170.2	97.4	32.4	–	–
		R	218.8	90.4	32.4	18.5	25.3	20.0	15.9	0.47	257.3	115.7	32.4	15.9	0.47
	C	L	162.8	90.5	32.4	7.4	6.9	–	–	–	170.2	97.4	32.4	–	–
		R	112.7	90.3	32.4	–	–	–	–	–	112.7	90.3	32.4	–	–
Sirajganj	A	L	161.2	107.1	38.5	–	–	–	–	–	116.2	107.1	38.5	–	–
		R	319.6	105.2	38.5	74.6	78.3	29.1	37.1	1.09	423.3	183.5	38.5	37.1	1.09
	B	L	148.0	90.4	32.4	–	–	–	–	–	148.0	90.4	32.4	–	–
		R	83.0	90.4	32.4	14.1	33.4	7.7	7.1	0.22	104.8	123.8	32.4	7.1	0.22
	C	L	146.0	90.4	32.4	–	–	–	–	–	146.0	90.4	32.4	–	–
		R	175.0	90.5	32.4	–	–	–	–	–	175.0	90.5	32.4	–	–
Nagarbari	A	L	182.6	107.3	38.5	–	–	–	–	–	182.6	107.3	38.5	–	–
		R	285.0	107.3	38.5	85.7	72.6	96.9	0	2.12	467.6	179.9	38.5	74.1	2.12
	B	L	188.5	90.5	32.4	–	–	–	–	–	188.5	90.5	32.4	–	–
		R	211.9	90.5	32.4	26.8	23.0	7.1	8.8	0.27	245.8	113.5	32.4	8.8	0.27
	C	L	188.5	90.5	32.4	–	–	–	–	–	188.5	90.5	32.4	–	–
		R	147.8	90.3	32.4	–	–	–	–	–	147.8	90.3	32.4	–	–

closing dikes given here do not contain those of the portion above the design high water level and those of the aproaches outside the both river banks. Those materials of the closing dikes and the aproaches outside the river which are not given in this report are included in the report on bridge planning.

3. Construction Schedule.

River training works which consist of construction of guide banks, closing dikes and closing works shall be completed in two years. Since the construction area will be submerged during the flood season, one guide bank and related structures on one side shall be completed in one dry season in order to avoid losses of construction materials and works due to washing away in under-construction portion.

It is a very important problem for the river training works to extract required amount of stones and transport them to the work sites as economically and efficiently as possible. It is regrettable, however, that the problem is not solved yet from unavoidable circumstances and is scheduled to be studied continually. Therefore, it was assumed in the present study that the quantity of stones required for the river training works can be obtained at required places at speed required for the execution of the works.

4. Execution of works and Equipment.

(1) Premises for selection of execution methods of works.

Sufficient supply of large quantity of stones is prerequisite for this type of bank structure, but the availability of stones are not determined yet as mentioned above. Therefore, the present study was made on the premise that the repuired quantity of stones is obtainable at specified stock yards and at any time specified.

(2) Guide banks.

i. Construction road.

Figs.9-14 and 9-15 show horizontal arrangement and cross section of construction roads. They are planned as one-way roads located along the apron part of guide banks. The first layer will be made of 0.5 m thick stone chips. In sections where the first layer is underwater, stones

Fig. 9-14 Arrangement of Construction Road

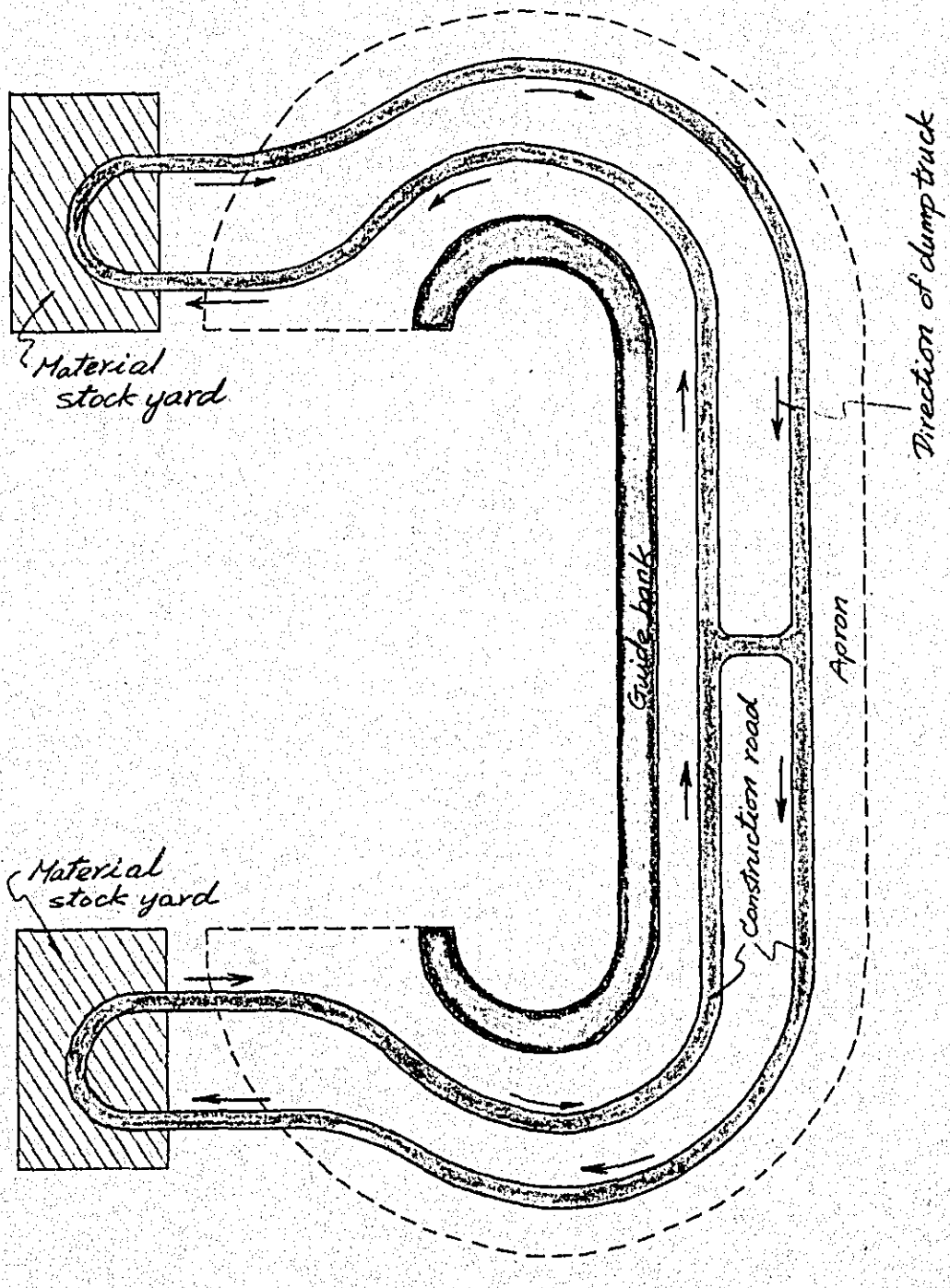
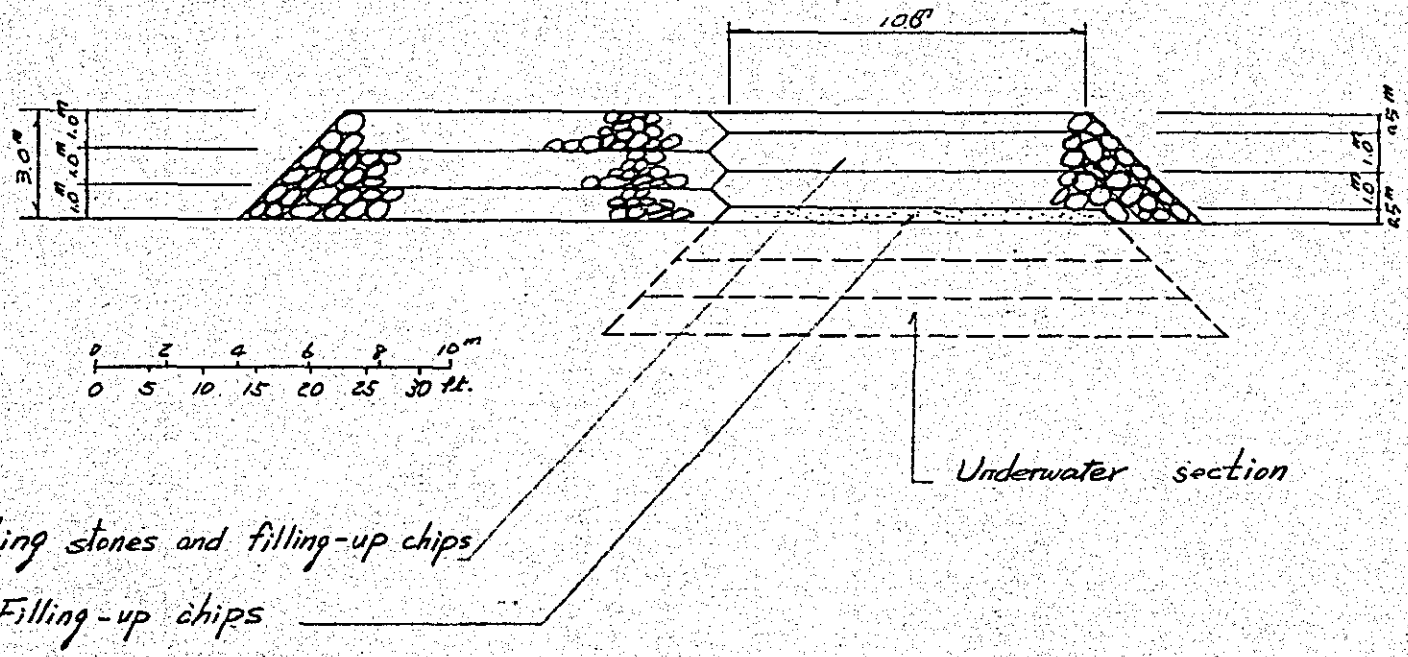


Fig. 9-15 Cross Section of Construction Road



will be placed in the water up to the surface and then 0.5 m thick stone chips will be overlaid. The construction road for the apron shall be raised with the progress of apron construction and shall be switched to new ones which will be built beside the preceding ones, The second and subsequent layers will be built with stones and filling-up chips. Thus, any new road shall be built 0.5 m higher than the preceding one.

ii. Loading, carrying and pitching of stones.

Stone pitching will basically be carried out on the ground in the following order; (1) loading by tractor shovels, (2) carrying by dump trucks and pitching by man power. On the other hand, in sections where ground work is impossible, another method of execution shall be used; (1) loading by tractor shovels and dump trucks, (2) carrying by bottom-hopper barges and (3) placing in the water from barges.

Fig.9-16 shows flow of construction works of apron and body of guide banks. In this figure, two sets of works are considered; one is ground work and the other is underwater work. The ground work will be applied to a section where the ground is dried up during the dry season and the underwater work will be applied to a section where water depth is enough for dump barges as seen in the case of Type A.

a. Principal machinery required for ground work.

Loading:	5 m^3 wheele-type tractor shoves
Carrying:	32 ton heavy duty dump trucks.
	19 ton tiredozers.
Pitching:	Manpower.

b. Principal machinery required for underwater works.

Loading:	5 m^3 wheele-type tractor shovels.
	32 ton heavy duty dump trucks.
Carrying:	1000 m^3 bottom-hopper barges.
Pitching:	Dumping by barges.

iii. Banking with earth.

Outline of banking work is shown in Figs.9-16 and 9-17. Dredged sand will be banked in blocks to be formed by sheet-pile partition walls.

Fig.9-16 Flow of Construction Works of Guide Banks

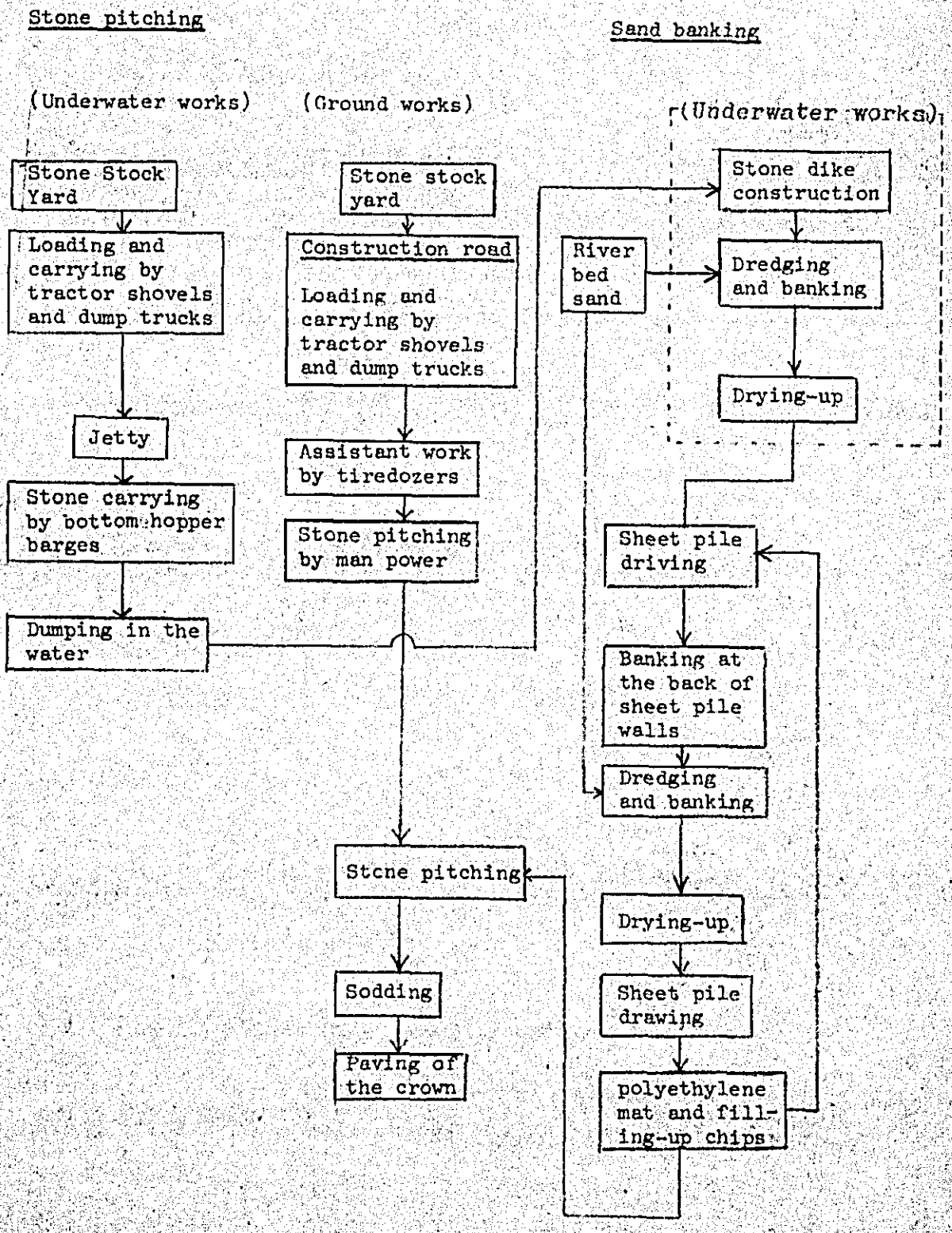
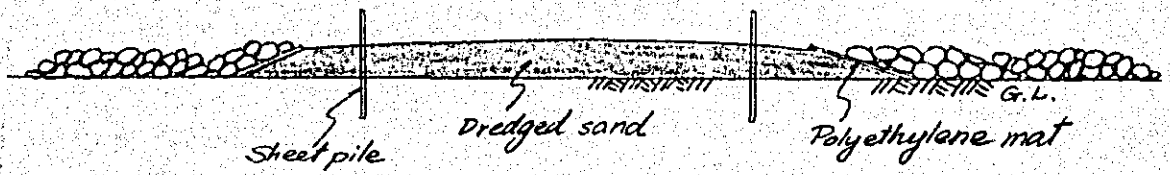
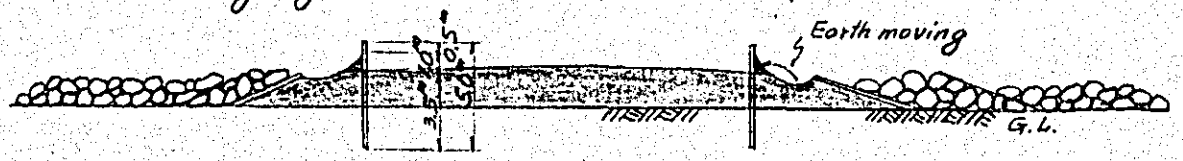


Fig. 9-17 Schematic View of Banking Work

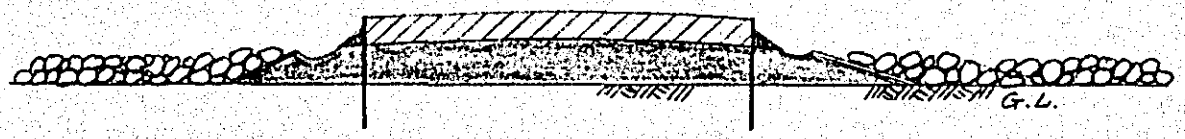
(1) Sheet pile driving



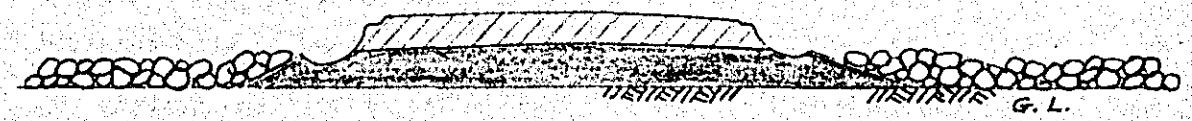
(2) Banking against the back of sheet pile walls



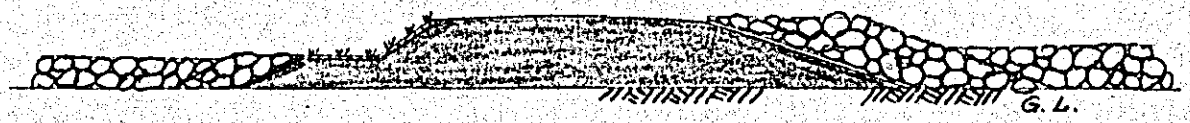
(3) Dredging, banking and drying-up



(4) Sheet pile drawing



(5) Polyethylene mat and filling-up chips



The length of the block shall be 500 m. The height of banking shall be 1.5 m at each time. For supporting sheet-pile walls, earth shall be moved and heaped up at the back of the walls by swamp-type bulldozers.

Machinery to be used in the banking works is as follows.

4000 PS Diesel pump dredgers.
15 KW vibro-pile drivers (drawer) with 20 ton crawler cranes.
125 KVA engine dynamos.
16 ton swamp-type bull dozers.

(3) Closing dikes.

i. Construction road.

The construction road for the guide-bank construction will also be used for the closing-dike construction.

ii. Loading, carrying and pitching of stones.

The method is the same as that of the guide-bank construction.

iii. Banking with earth.

The method is the same as that of the guide-bank construction.

(4) Closing works.

i. Construction road.

The construction road for the guide-bank construction will also be used for the closing-work construction.

ii. Works in dry section.

In a section where the ground surface is above water level, the following works will be done.

a. Loading and carrying of pitching stones by 5 m^3 wheele-type tractor shovels and 32ton heavy duty dump trucks.

b. Driving of sheet piles by 15 KW and 37 KW vibro-pile drivers with 20 ton crawler cranes.

c. Excavation and banking of sand by 16 ton swamp-type bulldozers.

d. Stone pitching by manpower.

iii. Works in underwater section.

In an underwater section, sheet piles will first be drived on a floating platform and then dredged sand will be banked with a moderate slope of about 1 : 10. After shaping by swamp-type bulldozers, stones will be pitched.

It is supposed that closing works will be done in a small stream other than the main channel and that it will be done in the dry season. Therefore, in general case, the flow of this stream will not be so strong. However, in some cases it may be necessary to place some stones before driving sheet piles in order to cut or weaken the flow of the stream.

The works and machinery in the underwater section are as follows.

a. Loading and carrying of pitching stones by 5 m^3 wheele-type tractor shovels and 32 ton heavy duty dump trucks.

b. Driving of sheet piles by 37 KW vibro-pile drivers with 20 ton crawler cranes on a floating platform.

c. Dredging and banking of sand by 4000 PS Diesel pump dredgers and 16 ton swamp-type bulldozers.

b. Stone pitching by manpower.

5. Schedule of Construction Works.

The schedule of river training works is shown in Fig.9-18.

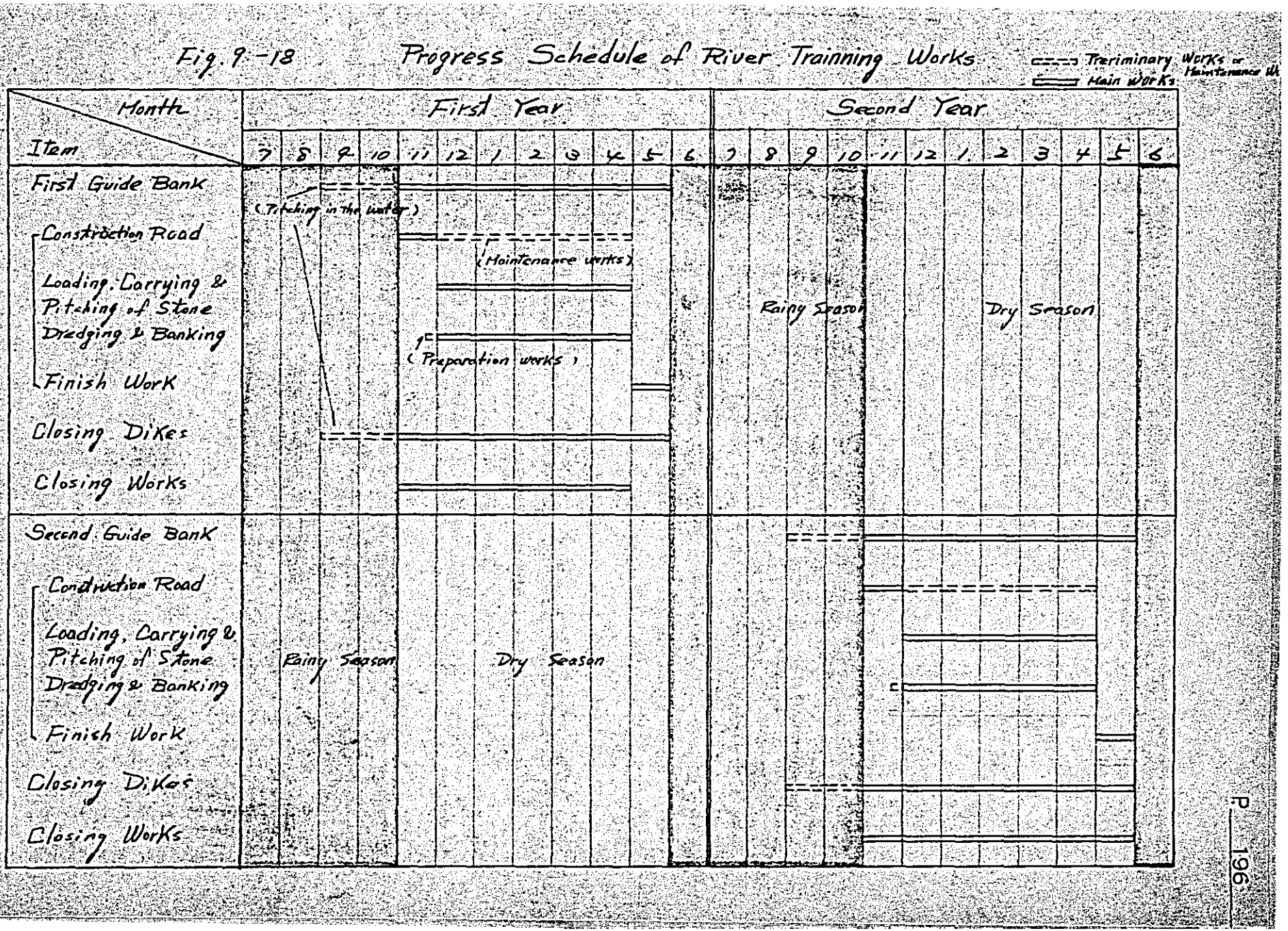
It is the basic plan of the construction works that guide bank, closing dike and closing works, if necessary, on one side of the river are completed in one year and those on the other side are completed in the following year.

In general, construction period in a year is limited to about seven months in the dry season from November to May. But two months, September and October, may be added to the above-mentioned period for dumping of pitching stones from barges in sections where underwater construction is necessary.

6. Number of main machinery and quantity of fuel.

Necessary number of main construction machinery, or the maximum number

Fig. 9-18 Progress Schedule of River Trainning Works



in one day required for executing the works in accordance with the schedule mentioned above is shown in Table 9-6.

The maximum daily fuel consumption and the total quantity required for operation of the above-mentioned machinery are shown in Table 9-7.

7. Stock Yards for Materials.

Figs.9-19 to 9-22 show location of stock yards for materials.

In general, stock yards for materials will be built at two sites up- and downstream of the planned guide bank on each side of the river in consideration of convenience of execution.

In case pitching stones must be dumped by barges as in the case of Type A, one additional stock yard with jetties will be planned at a favorable site within the range of 10 km upstream from the construction area of the guide bank.

The stock yards mentioned here are naturally used not only for pitching stones but also for steels and other materials.

8. Necessary Number of Persons.

The daily maximum number of workers for stone pitching is shown in Table 9-6. The number was counted assuming that the maximum carriage distance by manpower is 40 m, one unit of workers consists of twenty persons and the units are distributed on the pitching area as uniformly as possible.

Personnel other than the above workers, or personnel which are necessary for operation of construction machinery including pump dredgers and dump barges will comprize foremen, operators, labors and crews. The number of those persons is shown in Table 9-6.

9. Problems in Construction Works.

(1) Problems in preliminary works.

a. This type of bank structure needs a huge amount of stones and the construction was planned to be completed in two years in order to avoid losses of materials and works. Therefore, supply of stones is a main problem to be solved in the near future. If sufficient supply of stones is impossible, the bank structure itself must be reconsidered.

Table 9 - 6 Necessary Number of Equipment and Personnel

Site	Type	Side	Equipment										Personnel			
			Tractor shovel (5 m³)	Dump truck (3t)	Tire-dozer (19t)	Bull-dozer (16t)	Vibro & crane (15KW+20t)	Vibro & crane (37KW+20t)	Engine dynamo (125KW)	Pump dredger (400DPS)	Dump barge (1,000 m³)	Jetty	Foreman	Operator	Labor	Crew
Bahadurabad	A	L	15	109	12	18	121	1	33	6	9	6	482	467	8518	264
		R	15	72	5	13	91	–	23	3	–	–	475	331	8875	96
	B	L	9	48	8	9	54	–	15	2	–	–	281	216	5070	64
		R	9	38	5	13	59	–	16	3	–	–	277	219	5091	96
	C	L	7	31	5	4	41	–	11	1	–	–	227	174	4162	32
		R	8	34	5	13	59	–	16	3	–	–	250	199	4622	96
Gabargaon	A	L	16	36	5	17	115	–	30	5	15	9	225	357	3840	280
		R	23	54	12	18	174	–	45	7	20	11	294	533	4871	384
	B	L	8	36	5	13	63	–	17	3	–	–	270	225	4935	96
		R	11	49	7	14	73	1	20	3	–	–	319	273	5870	96
	C	L	8	32	5	13	63	–	14	3	–	–	246	215	4557	96
		R	8	34	5	4	41	–	11	1	–	–	249	159	4601	32
Sirajganj	A	L	15	71	5	8	60	–	15	2	–	–	470	256	8733	64
		R	20	74	13	18	140	2	38	10	18	10	358	484	6030	464
	B	L	8	34	5	8	50	–	13	2	–	–	264	205	4694	64
		R	10	52	8	10	54	1	16	2	–	–	296	226	5371	64
	C	L	7	29	5	8	50	–	13	2	–	–	222	178	4084	64
		R	8	32	5	4	41	–	11	1	–	–	232	149	4305	32
Nagarbari	A	L	16	78	5	8	82	–	21	2	–	–	521	318	10198	64
		R	16	103	12	17	173	3	47	8	11	6	550	585	9497	344
	B	L	9	39	5	8	60	–	15	2	–	–	294	212	5445	64
		R	11	52	7	14	86	–	23	4	1	1	324	304	5808	136
	C	L	9	36	5	8	60	–	15	2	–	–	294	209	5445	64
		R	8	35	5	4	41	–	11	1	–	–	255	160	4665	32

Table 9 - 7 Quantity of Main Fuel and Sheet Piles

Site	Type	Light Oil		Heavy Oil		Sheet Pile	
		Total Consumption (kl)	Max. Daily Consumption (kl)	Total Consumption (kl)	Max. Daily Consumption (kl)	Light Steel Type (t)	Heavy Steel Type (t)
Bahadurabad	A	8,255	35	13,055	92	8,959	1,485
	B	4,509	17	6,460	46	5,468	-
	C	3,554	16	4,408	46	3,952	-
Gabargaon	A	7,646	31	20,693	124	11,566	-
	B	4,906	20	7,706	46	7,353	1,057
	C	3,771	15	5,426	46	5,243	-
Sirajganj	A	7,505	31	14,300	156	8,076	330
	B	4,442	18	6,155	30	5,245	330
	C	3,452	12	4,514	30	4,076	-
Nagarbari	A	8,578	40	14,789	123	8,769	4,770
	B	4,876	22	7,781	62	6,262	-
	C	3,783	15	4,954	30	4,076	-

Fig. 9-19 Location of Material Stock Yards at Bahadurabad

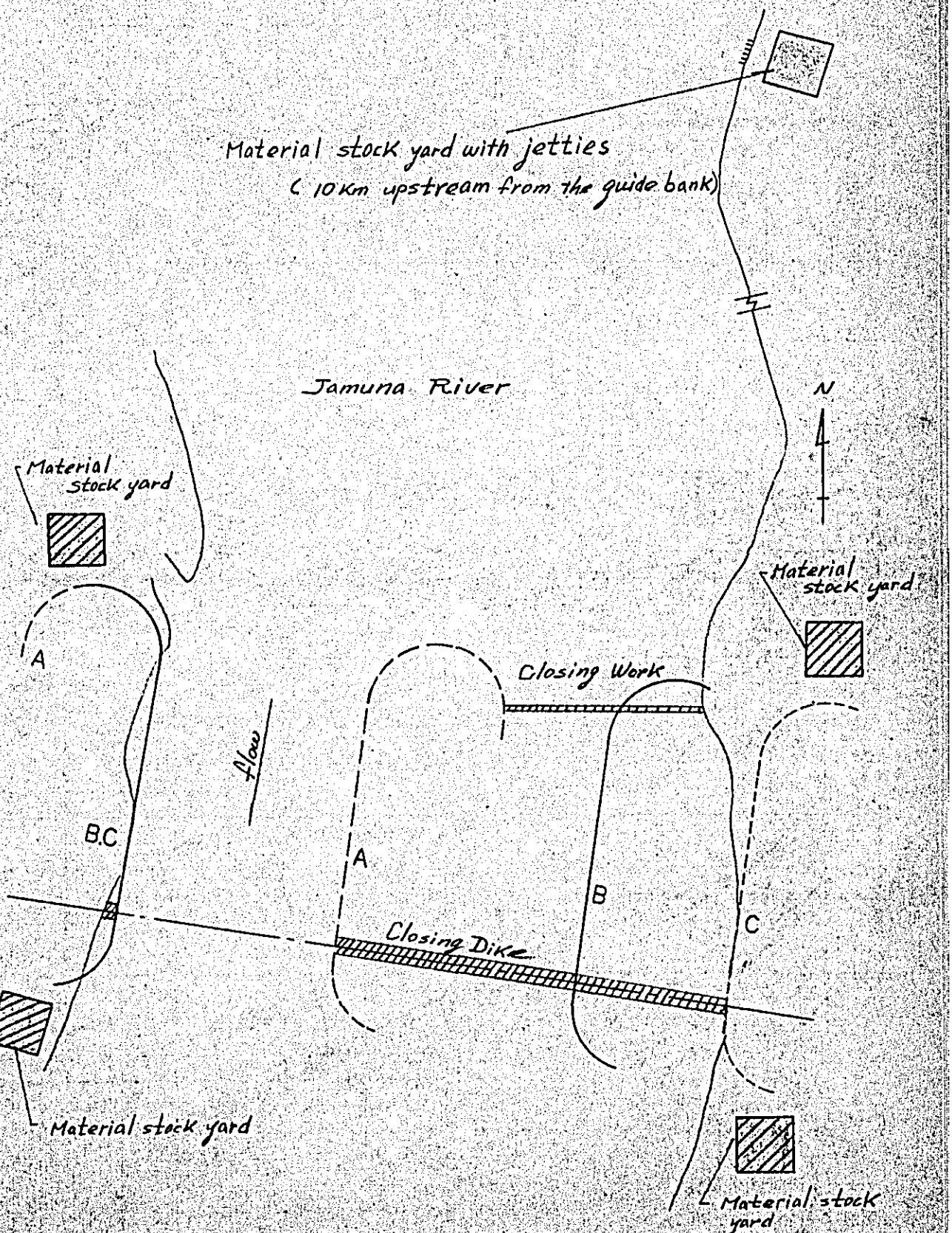


Fig. 9-20 Location of Material Stock Yards at Gabargaon

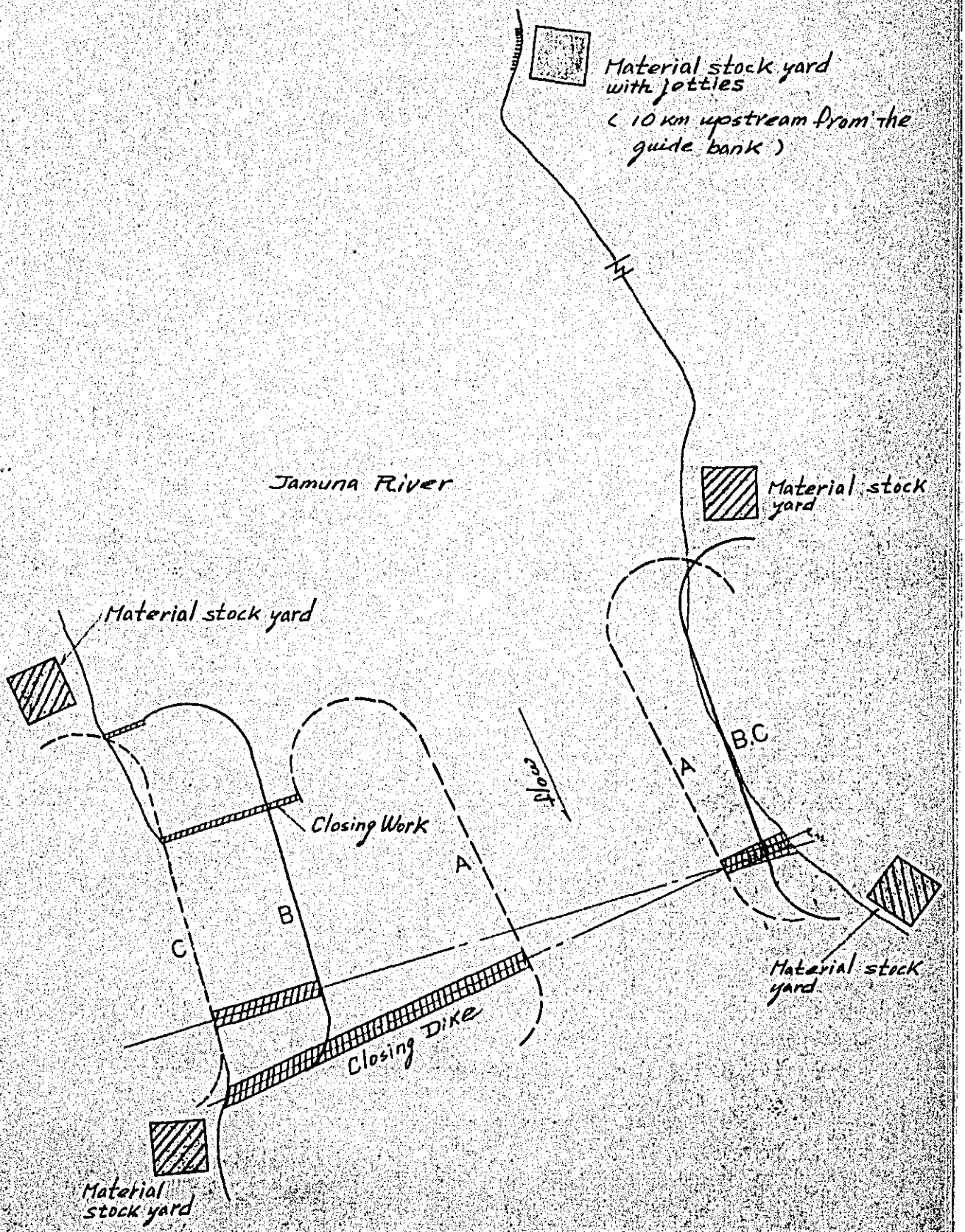


Fig. 9-21 Location of Material Stock Yards at Sirajganj

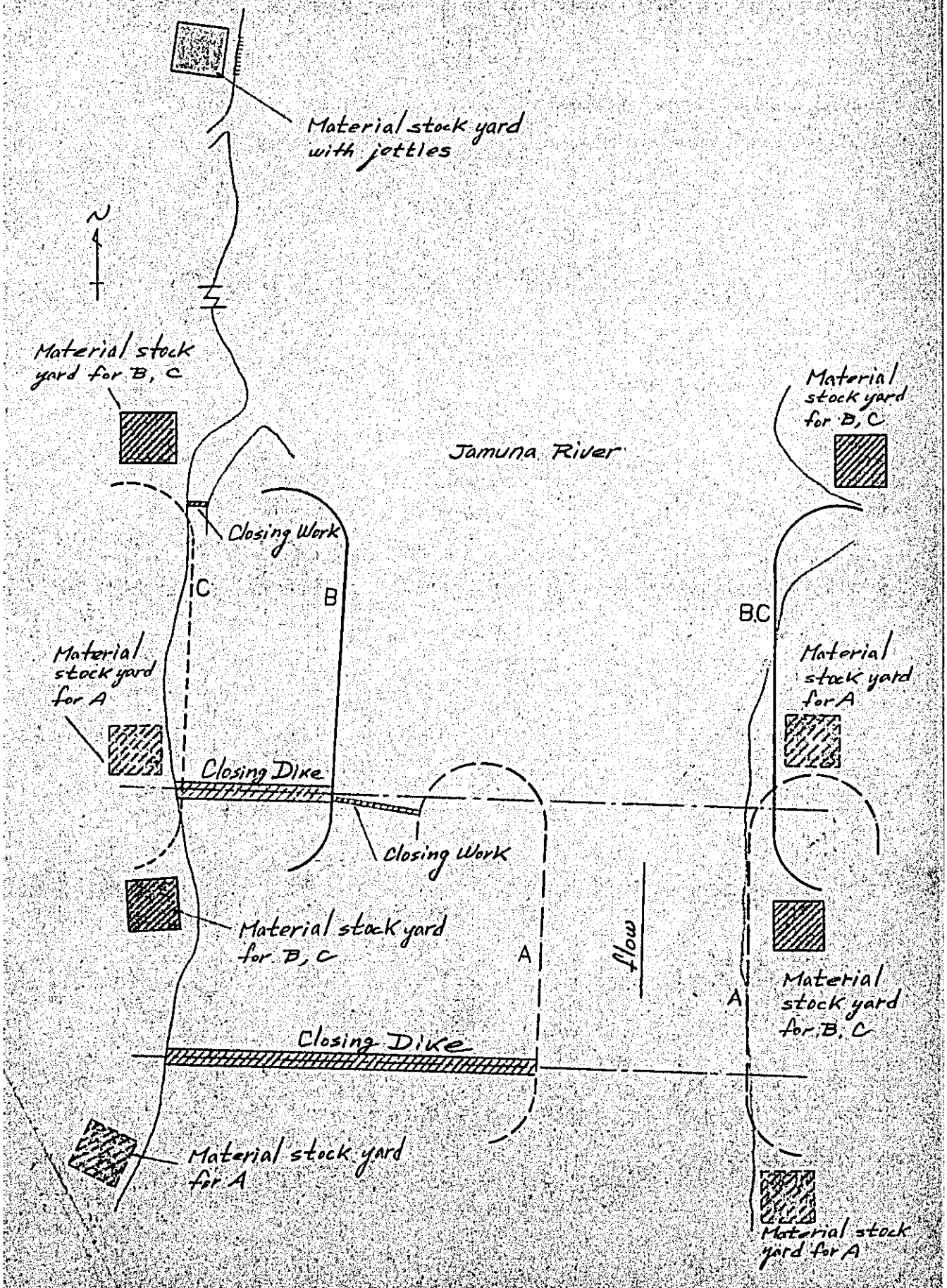


Fig. 9-22 Location of Material Stock Yards at Nagarbari

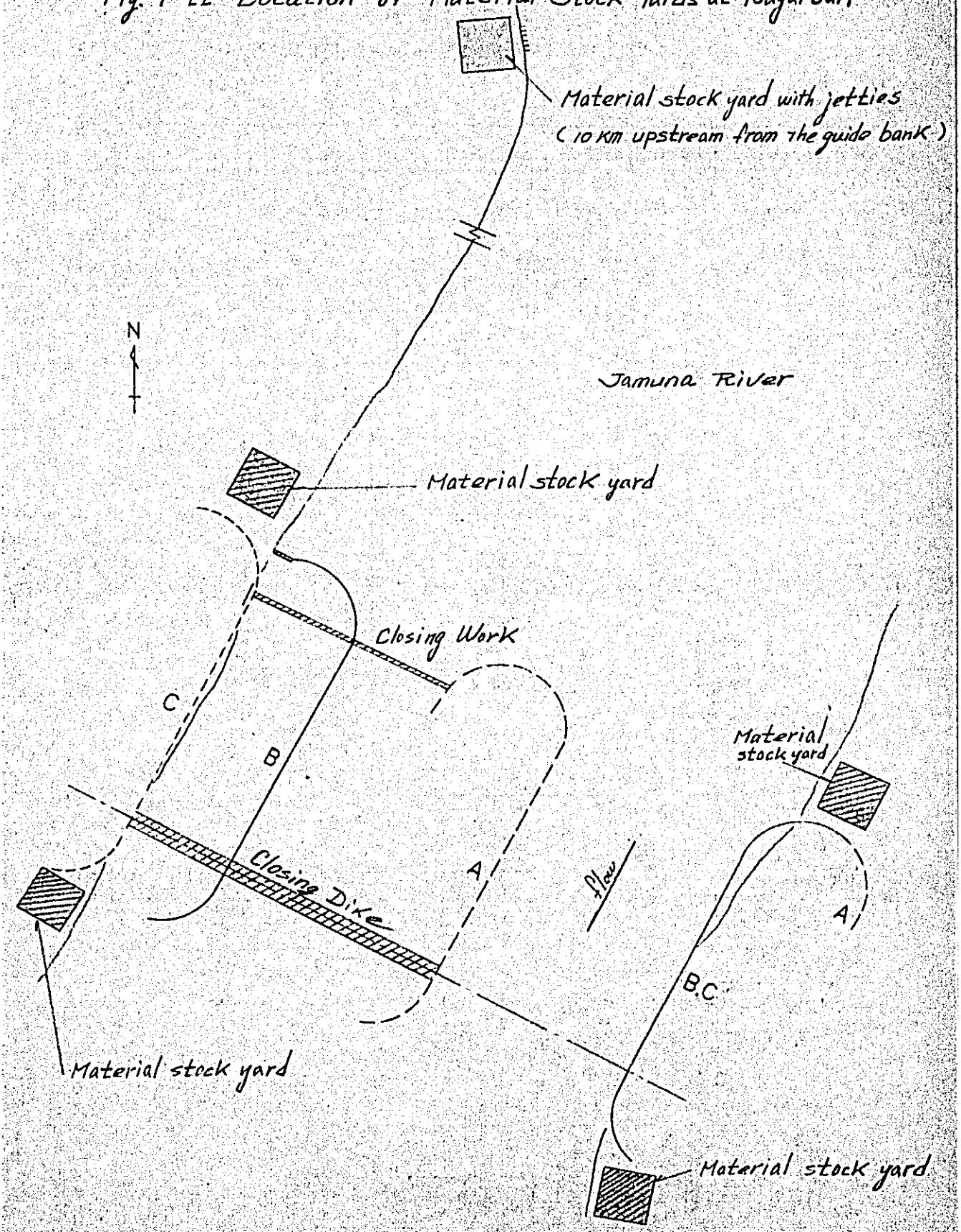


Table 9-8 Necessary Number of Workers for Stone Pitching

(unit; persons per day)

Site	Type		Guide bank	Closing work	Closing dike
Bahadurabad	A	L	6,400	620	650
		R	8,200	-	40
	B	L	4,400	-	280
		R	4,600	-	40
	C	L	3,900	-	-
		R	4,100	-	40
Cabargaon	A	L	2,900	-	170
		R	3,000	450	730
	B	L	4,400	-	80
		R	4,800	250	250
	C	L	4,000	-	80
		R	4,300	-	-
Sirajganj	A	L	8,300	-	-
		R	4,100	350	680
	B	L	4,300	-	-
		R	4,600	90	290
	C	L	3,700	-	-
		R	4,000	-	-
Nagarbari	A	L	9,100	-	-
		R	6,300	1,310	710
	B	L	5,000	-	-
		R	5,000	85	220
	C	L	4,500	-	-
		R	4,400	-	-

b. Since a great number of construction machinery and a great amount of materials must be carried in within a short time, construction of large-scale cargo-handling facilities is necessary at the early stage of the whole construction period.

c. Fuel consumption by construction machinery was estimated to be about 200 kl per day at its maximum. Therefore, large-scale facilities for fuel supply are necessary on each side of construction area.

d. Large-scale motor pools for maintenance and repairing of various construction machinery is necessary on each side of the construction area.

(2) Problems in the main works.

a. Since most of construction works are concentrated in the dry season and their amount of works is so huge, construction area is expected to be very crowded and complicated. Therefore, arrangement of construction machinery and management of personnel will be matters of importance and must be studied in detail at the stage of detail design.

b. The order of works for sand dredging and banking is as follows: 1. driving of sheet piles, 2. heaping up of sand at the back of sheet-pile walls, 3. dredging and filling, 4. drying up and 5. drawing of sheet-piles. Among these works, period of drying up was assumed at five days. This period was determined based on some data of soil investigation. As the drying-up period has a great influence on the whole construction period and cost, more precise investigation of nature of soil must be made at the stage of detail design.

CHAPTER X
CONSTRUCTION COST

The construction costs for river training works of three types at the four sites were roughly estimated on the following condition and are shown in the following table. But they do not include costs of general facilities such as living quarters, motor pools, fuel storage, material storage, cargo-handling facilities at the sites and electric power supply system for general facilities.

a. According to the first-stage survey of the quarry study team, unit price of stones when they are delivered at the stock yards at the four sites of Bahadurabad, Gabargaon, Sirajganj and Nagarbari was temporarily assumed at 6 Tk/ft^3, 6.3 Tk/ft^3,, 7 Tk/ft^3 and 7.4 Tk/ft^3 respectively.

b. Unit prices were assumed based on the results of the price survey as of the end of March of 1974.

c. Rent of main construction machinery was calculated according to the Rent List of Construction Machinery, Ministry of Construction, Japan, 1974 Edition.

d. Unit prices of heavy (regular) and light sheet piles in Japan were assumed at 58,000 ¥/ton and 62,000 ¥/ton respectively.

Table 1 - Rough Estimation of Construction Costs

Site	Type	Guide bank (10^8Yen)	Closing dike (10^8Yen)	Subtotal		Transportation (10^8Yen)	Total	
				10^8 Yen	10^8 Taka		10^8 Yen	10^8 Taka
Bahadurabad	B	266	15	281	7.8	17	300	8.3
	C	231	3	234	6.5	16	250	6.9
Gabargaon	B	305	22	327	9.1	20	350	9.6
	C	262	5	267	7.4	17	280	7.9
Sirajganj	B	307	15	322	8.9	12	330	9.3
	C	278	-	278	7.7	12	290	8.0
Nagarbari	B	365	21	386	10.7	22	410	11.3
	C	321	-	321	8.9	12	330	9.3

CHAPTER XI

BIBLIOGRAPHY AND DATA

All bibliography and data collected in Bangladesh and Japan and used in the present study are listed in this chapter. For the convenience of reference, they have been classified into the categories shown below.

WL : Data on water level.
DIS : Data on discharge.
RF : Data on rainfall.
FLD : Data on flood.
SED : Data on sediment
BR : Data on boring test.
RC : Data on river course.
SVY : Data on surveying.
TOP : Topographic map.
PHT : Photograph.
CS : Data on construction cost.
PJT : Report on project concerning the Jamuna River.
GN : Data on general description of the Jamuna River.
ADM : Data on administration.
CF : Data on consulting firms.
MET : Data on meteorology.
CON : Data on construction works.
GB : General bibliography.
JB : Report on the Jamuna Bridge.
GE : Report on geography.
GM : Report on Geomorphology.

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Seri. No.	Kind of Data	Bibliography or Data	Data Source
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