APPENDIX VIII

PUMPING STATION
AND
DESILTING BASIN

APPENDIX VIII

PUMPING STATION AND DESILTING STATION

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1. TYPE OF PUMPING STATION

1-1. Type of Pumping Station

The water required for the Project will be diverted directly from the Ganges rivers. In case the irrigation water is lifted from the rivers by pumps, the following three types of structure are generally put for comparative study :

(1) Floating type structure

All pump facilities are furnished on a floor of barge or pontoon in order to cope with the water stage fluctuation in the river and also river course shifting.

(2) Inclined Type Structure

The pump facilities are installed along the side slope of the river embankment. This type is applicable when the river course is stable.

(3) Fixed Type Structure

The pump facilities are installed inside the existing river bank with connection canals constructed to conduct water.

The above three types were carefully compared in due consideration of the adaptability with the sites, construction cost and operation and maintenance cost. The following definitions were employed in the study :

- Design Discharge	20m^3/sec	
- Design Water Level	Low Water level	9.6 m
	High Water level	20.0 m
	Delivery Water level	30.5 m
- Existing Embankment height		20.0 m
- Actual Head	20.9 m	
- Total Head	26.0 m	

Based upon the above definitions, main facilities of the pumps systems are designed as in the following table :

Items	Floating Type	Inclined Type	Fixed Type	
Type	Horizontal Axis of Volute Type	Inclined Axis with mixed flow	Vertical Axis with mixed flow	
Design Discharge (m^3)	120	120	240	360
Diameter (mm)	1,000	1,000	1,350	1,650
P × r.p.m	14×420	10×593	16×370	20×290
Total Head (m)	26	26	26	26
Output (kw/unit)	670	670	1,430	2,120
No. of Pumps	10	10	2	2
Total Output (kw)	6,700	6,700	7,100	

In this connection, a submergible motor pump are also evaluated but finally excluded from the comparative study due to the following reasons :

- Cost of the motor is extremely high.
- Supply of spare parts is very difficult
- O & M cost shall be expensive

1-2. Comparative Study for the pumping station

Three types of pumping station were comparatively studied and summarized in TABLE Ⅷ-1-1 — Ⅷ-1-6.

Regarding general lay-out, these are prepared lay-out drawing in FIGURE Ⅷ-1-1 — Ⅷ-1-3.

As a results of comparative studies, the fixed type of pump station is recommendable for the project under the following reasons.

· The construction cost is cheaper than the other two types

· The operation and maintenance costs are less than the other two types

Concerning the sedimention, countermeasures shall be required for all of the types of pumping station.

TABLE Ⅷ-1-1 (1) TYPES OF PUMP STATIONS

Type / Location / Items	Floating Type			Fixed Type
	At main stream (A)	At intake canal (B)	At intake canal (Semi-Fixed Type)(C)	At intake canal (D)
1. Pump Equipment (1) Impeller	Pumps should lift up river water directly from main stream, which is inclusive of more sediments so that, the impeller should be taken the abrasion	The intake canal shall be taken off the sediment from the river water, so that abrasion of impeller should be less than(A) and the durable period shall be longer than (A)		
(2) Cavitation	The water elevation vary within 10 meter through a year. During the higher water level, the delivery discharge should be increased at about 150 percent, and these are occurrence of the cavitation in the pump equipment and control valve. In order to protect such phenomena, rotary valve shall be required to be installed in delivery pipes, and they are very costly.			In case of vertical type pumps and inclined type pumps, the following situation is keeping in any case of variation of suction head. NBSHav ≧ NPSHre NPSH ; Net positive Suction Head av ; Available re ; Required Accordingly, there are no occurrence of cavitation, and the discharge can be control with simple valve operation.

TABLE Ⅷ-1-1 (2) TYPES OF PUMPING STATIONS

Type / Location / Items	Floating Type			Fixed Type
	At main stream (A)	At intake canal (B)	At intake canal (Semi-Fixed Type)(C)	At intake canal (D)
2. Electric Power Cable	Electric power cable should be laid with floater in the river or intake canal. In this case, the low voltage cable shall be required to avoid the damage of electric leakage. If the Barges required to remove, it is necessary to prepare additional cables, and then its required additional labour cost and less time.			No there are problem
3. Barges	A part of joint between delivery pipes of pumps and the pipe line of land should be fixed with concrete anchors. On the other hands, the barges should be required to remove at any time, and it is not only up and down but also at front and rear. Accordingly, the adjustment in above case should be done with removement of Barges anchor.			No there are problem
4. Shifting of the river course	The Barges shall be removed as a counter measure for river shifting. However, the floating pipes and cable are required to be extension or reduction.	If the river course removed far away from existing embankment, a intake canal should be extended upto the necessary distance. On the other hand, the protection facilities should be constructed for the reverse phenomena.		

TABLE Ⅷ-1-1 (3) TYPES OF PUMPING STATIONS

Items \ Location \ Type	Floating Type			Fixed Type
	At main stream (A)	At intake canal (B)	At intake canal (Semi-Fixed Type)(C)	At intake canal (D)
5. Sedimentation	Barges should be removed to other point available. However, the floating pipes and cables are required to remove at the same time. Furthermore, fixed land structures should be necessary to have reconstructed after the removement	Dredger should be provided for dredging the sediment in intake canal		
6. Operation and Maintenance	As compared with fixed type pumping station, the barge, floating pipes and cables are required to have supporting facilities for operation and maintenance. Particularly, the space yards for the repairing should be required for barges.			Pumping facilities are necessary to have regular maintenance same as the floating pumps. Housing and supporting structure shall be required to have regular maintenance. However, they are not so difficult as compared with floating type pumping station.

TABLE Ⅷ-1-1 (4) TYPES OF PUMPING STATIONS

Items / Location / Type	Floating Type			Fixed Type
	At main stream (A)	At intake canal (B)	At intake canal (Semi-Fixed Type)(C)	At intake canal (D)
7. Conclusion	As mentioned above, the floating type has several kinds of problems in view point of technics. Furthermore, construction cost is the highest as compared with other three types. So that, this is not recommendable for the project.	There are no merits for the river shifting and sedimentation as compared with fixed type. Therefore, this not so recommendable.	As compared with the other two floating types, the structure of floating pipes and cables can be simplified because of semi-fixed anchor However, it is not so expected to have much merit.	As far as concerning the river shifting, and sedimentation, there are some weak point. Particularly, concerning the sedimentation, it can be solved by dredging system. As for operation and maintenance, this type is the most acceptable for the project. Taking into consideration aboved reasons, this type is the most recommendable for this project.

TABLE Ⅷ-1-2 COMPARISON OF PUMP STATION TYPE

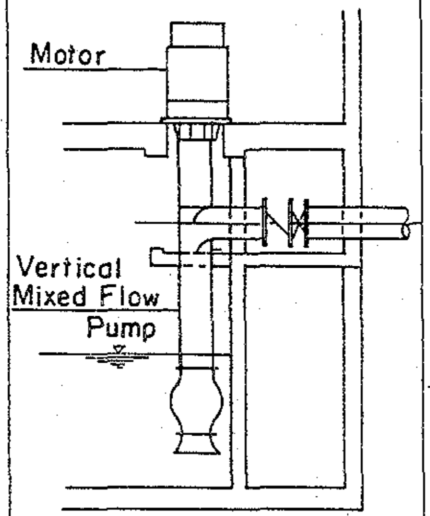
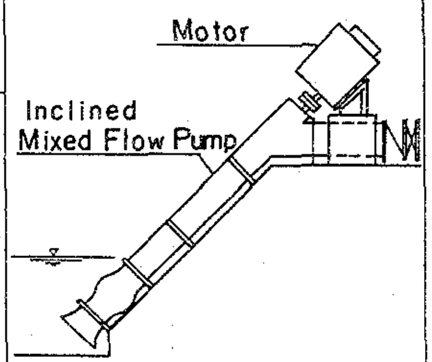
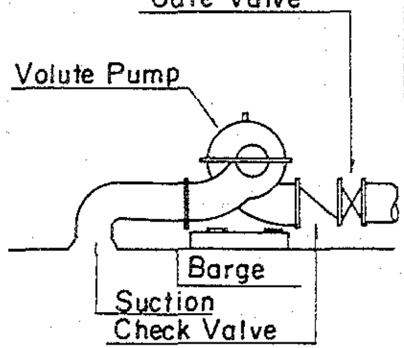
Item \ Pump Station Type	Fixed Type		Floating Type
	Vertical Type	Inclined Type	
Pump Type			
Maximum PumpBore and Capacity	2800 mm : 19.0 m³/s	1000 mm : 2.0 ~2.5 m³/s	1000 mm : 2.0 ~2.5 m³/s

TABLE Ⅷ-1-3 COMPARISON OF COST FOR EACH TYPE (1,000TK)

Item \ Type	Fixed Type		Floating Type
	Vertical Type	Inclined Type	
Pump Facilities Cost *1	337,100	432,000	345,500
Pump House *2	10,120	16,230	300,000 (Barge)
Construction Cost *2	34,150	22,850	2,530
Initial Cost	381,370	471,080	648,030
	×0.1714	×0.1714	×0.1714
Annual Repayment	65,366	80,743	111,072
Electric Charge *3	38,835	39,479	36,037
Total Annual Cost	104,201 (100%)	120,222 (115%)	147,109 (141%)

*1 Refer to TABLE Ⅶ-1-4
*2 Refer to TABLE Ⅶ-1-5
*3 Refer to TABLE Ⅶ-1-7

TABLE Ⅷ-1-4 PUMPING FACILITIES COST OF EACH TYPE (1,000TK)

Item \ Type	Fixed Type		Floating Type
	Vertical Type	Inclined Type	
[Per 20m^3/s]			
	Ø1,650,Ø1,350	Ø1,000	Ø1,000
Pump	95,500	143,600	79,600
Motor	2,150^{kw},1,430^{kw}	670^{kw}	670^{kw}
	103,800	98,500	110,800
Valve, Pipe	31,700	32,200	36,600
Crane	10,400	4,500	4,500
Electric Equipment	24,700	47,300	47,800
Equipment Work	51,100	75,000	41,700
Transportation	19,900	30,900	24,500
Total Cost	337,100	432,000	345,500

TABLE Ⅷ-1-5 CONSTRUCTION COST PER 20 ㌧

(1000TK)

Type / Item	Unit	Floating Type Quantity	Floating Type Cost	Inclined Type Quantity	Inclined Type Cost	Fixed Type Quantity	Fixed Type Cost
1. Earth Work							
Excavation	TK/m^3 31	m^3 36,160	1,120	m^3 96,891	3,003	m^3 79,638	2,467
2. Concrete Work							
Reinforced concrete	TK/m^3 2,181		——	m^3 722	1,574	m^3 1,844	4,021
From Work	TK/m^2 175		——	m^2 923	161	m^2 3,856	674
Reinforcing bar Work	TK/ t 20,360		——	t 28.9	588	t 147.5	3,003
3. Brick Work	TK/m^2 400	m^2 2,470	988	m^2 7,935	3,174	m^2 6,978	2,791
4. Steel pile 1⌋	TK/Unit 155,000		——	Unit 68	10,540	Unit 100	15,500
5. Others	20%		422		3,810		5,694
Total	TK/m^2 23,600		2,530		22,850		34,150
6. Building Works			——	m^2 688	16,230	m^2 429	10,120
7. Barge			300,000		——		——

1⌋ Refer to unit cost of Steel pile

Unit Cost

Steel Pile φ500mm × 40m (t·9mm)

V = 60min × 6.7hr／TC min = 402/273 = 1.5 set／day

Tc = (Tp + Tb + Tw) × α/B

= (36 + 40 + 88) × 1.5/0.9 = 273min

Tp = 5·n + 11 = 5 × 5+11 = 36sec

$Tb = K\alpha\ L\beta = 1.0 \times 1.2 \times 40^{0.95} = 40sec$

Tw = 22 × 4 = 88sec

B = 0.9

α = 1.5

Steel Pile φ500mm × 40m

109kg/m × 40m ·97.060TK/t × 1.3

≒ 153,000 TK

(1,290 + 110) × 2/1.5

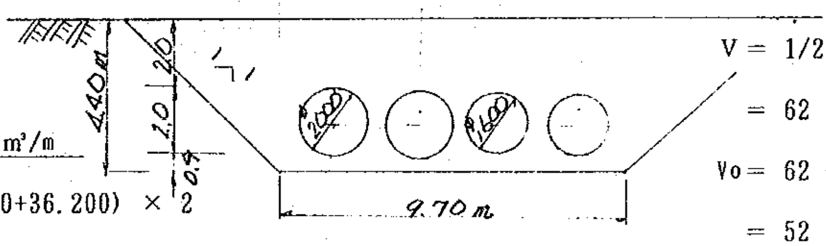
≒ 2,000

155,000 TK

TABLE Ⅷ-1-6 CONSTRUCTION COST OF PIPE LINE

(1000TK)

Diameter / Item	2000 mm	1800 mm	1600 mm	1350 mm	1200 mm
6meterlong Pipe	242.3	194.4	151.5	111.5	92.7
Others	3.7	3.0	2.5	1.9	1.6
Sub - Total	246.0	197.4	154.0	113.4	94.3
(perday) Constraction	1.8	2.0	2.2	2.6	3.0
Labour	1.5	1.4	1.4	1.4	1.3
Crane	3.2	2.5	2.0	1.8	1.8
Sub - Total	2.6	2.0	1.5	1.2	1.0
Welding	76.4	64.5	61.4	46.7	42.0
(per6meter) Total	325.0	263.9	216.9	161.3	137.3
Per·meter	54.2	44.0	36.2	26.9	22.9



Per - 20m³/m

(54.200+36.200) × 2

+ (62+52) × 25 ≒ 183,000 TK/m

V = 1/2(9.7+18.5) × 4.4

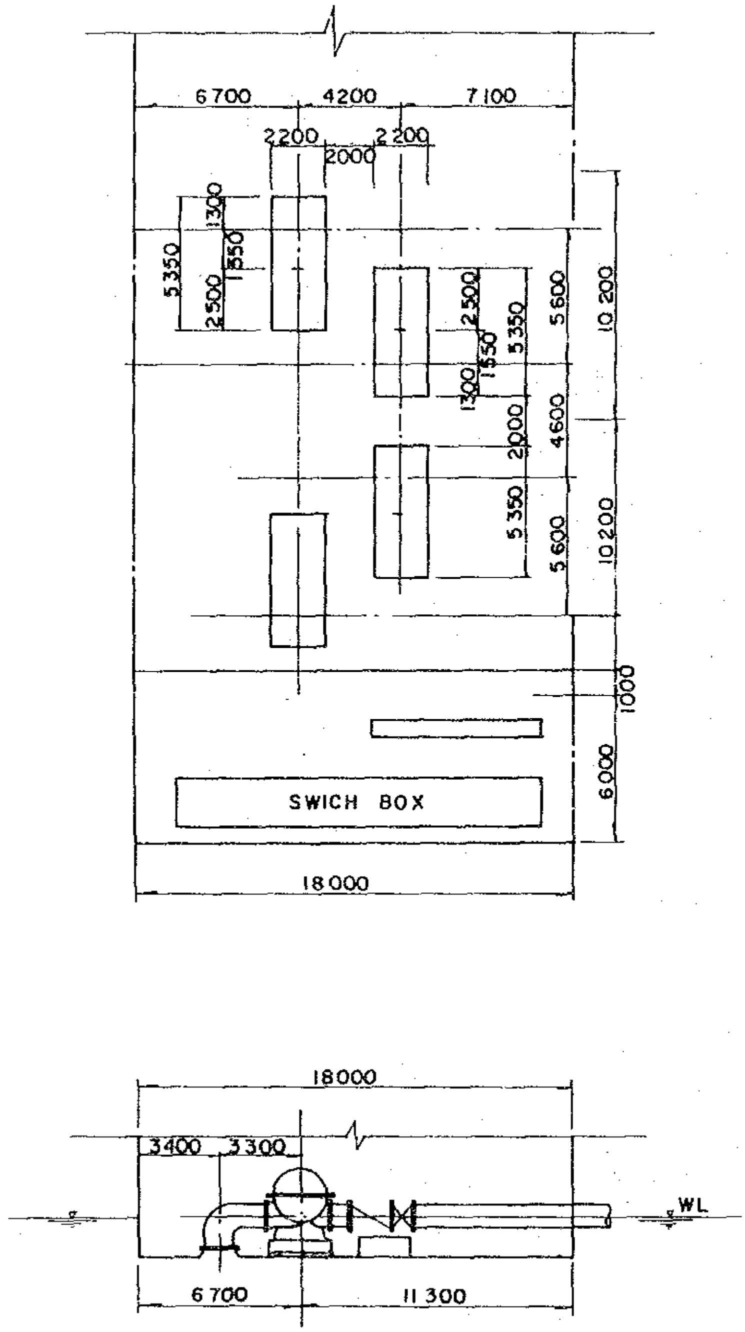
= 62 m³/m

Vo = 62 - 10

= 52 m³/m

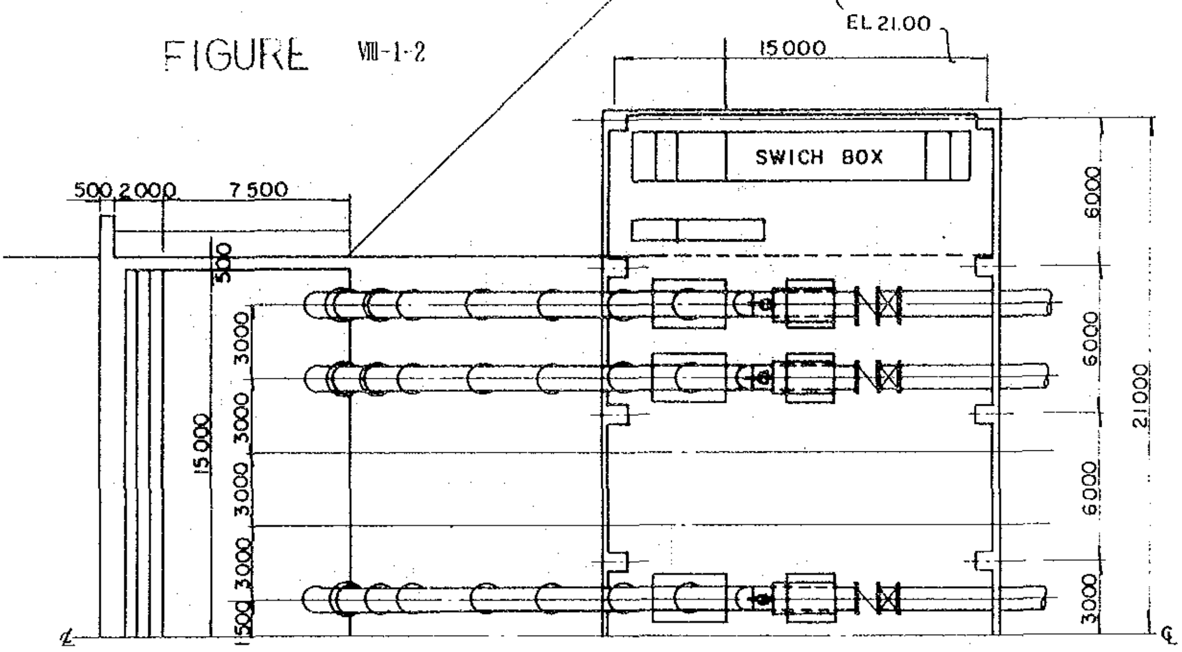
FIGURE Ⅷ-1-1 DIMENSION OF DOUBLE VOLUTE PUMP

Main Dimension of Pump		
Type	Horizontal Double Volute Pump	
Bore	1000	mm
Capacity	120	m^3/mm
Total Pumping lift	26	m
Pump Speed	420	rpm
Motor Power	670	kw
Units	10	台

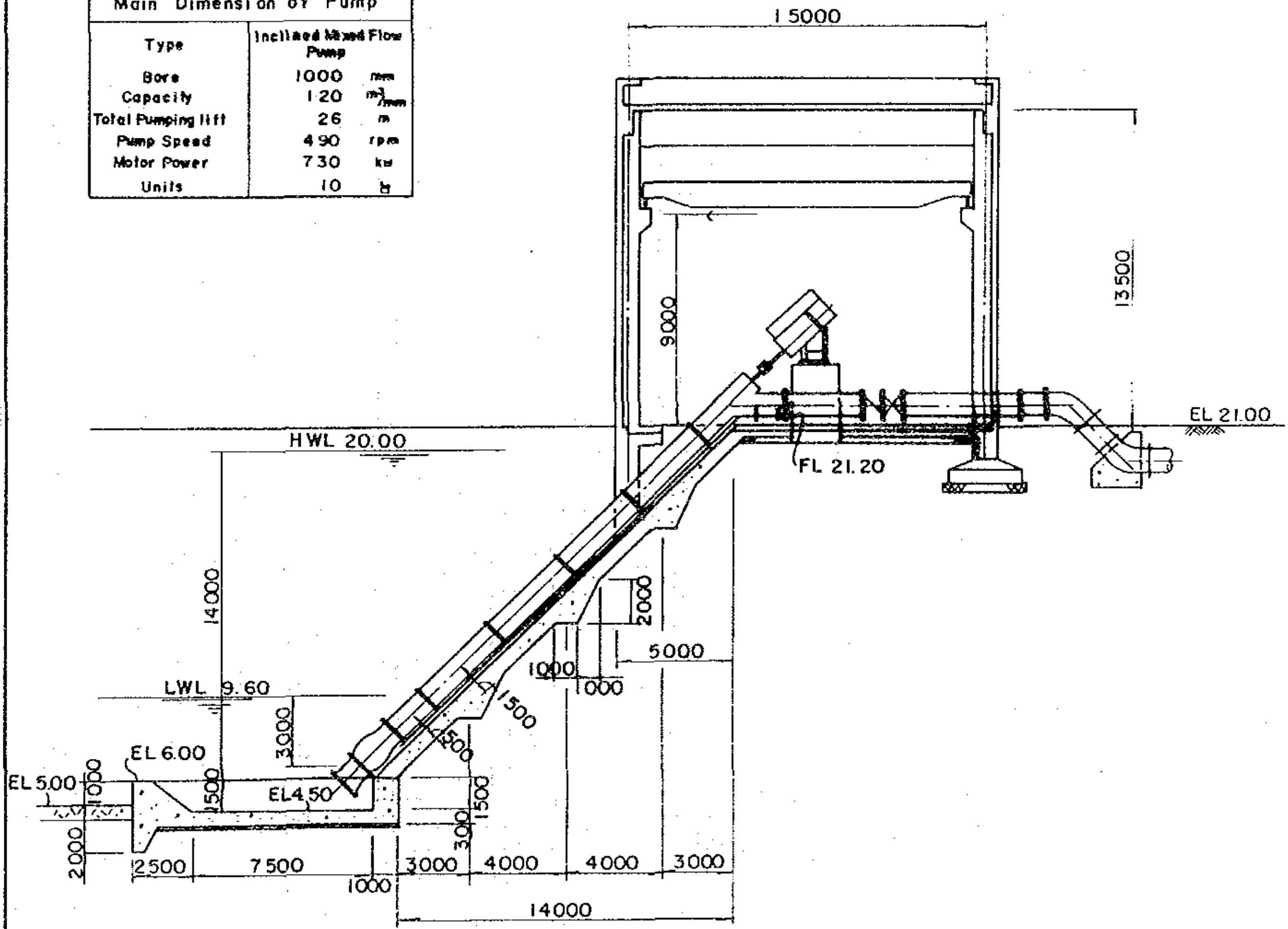


DIMENSION OF INCLINED MIXED FLOW PUMP

FIGURE VIII-1-2

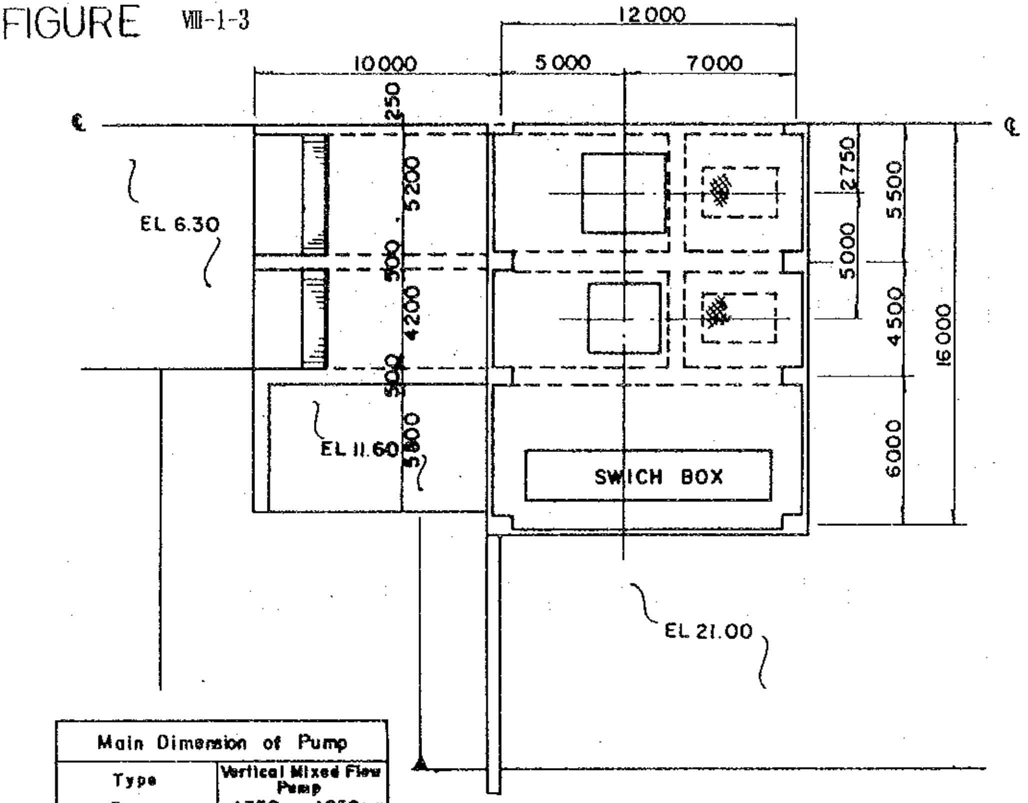


Main Dimension of Pump		
Type	Inclined Mixed Flow Pump	
Bore	1000	mm
Capacity	1.20	m^3/mm
Total Pumping lift	26	m
Pump Speed	490	rpm
Motor Power	730	kw
Units	10	台



DIMENSION OF VERTICAL MIXED FLOW PUMP

FIGURE Ⅷ-1-3



Main Dimension of Pump		
Type	Vertical Mixed Flow Pump	
Bore	1350mm	1650mm
Capacity	240 m³/m	360 m³/m
Total Pumping lift	26m	26m
Pump Speed	420rpm	330rpm
Motor Power	1430kw	2120kw
Units	2台	2台

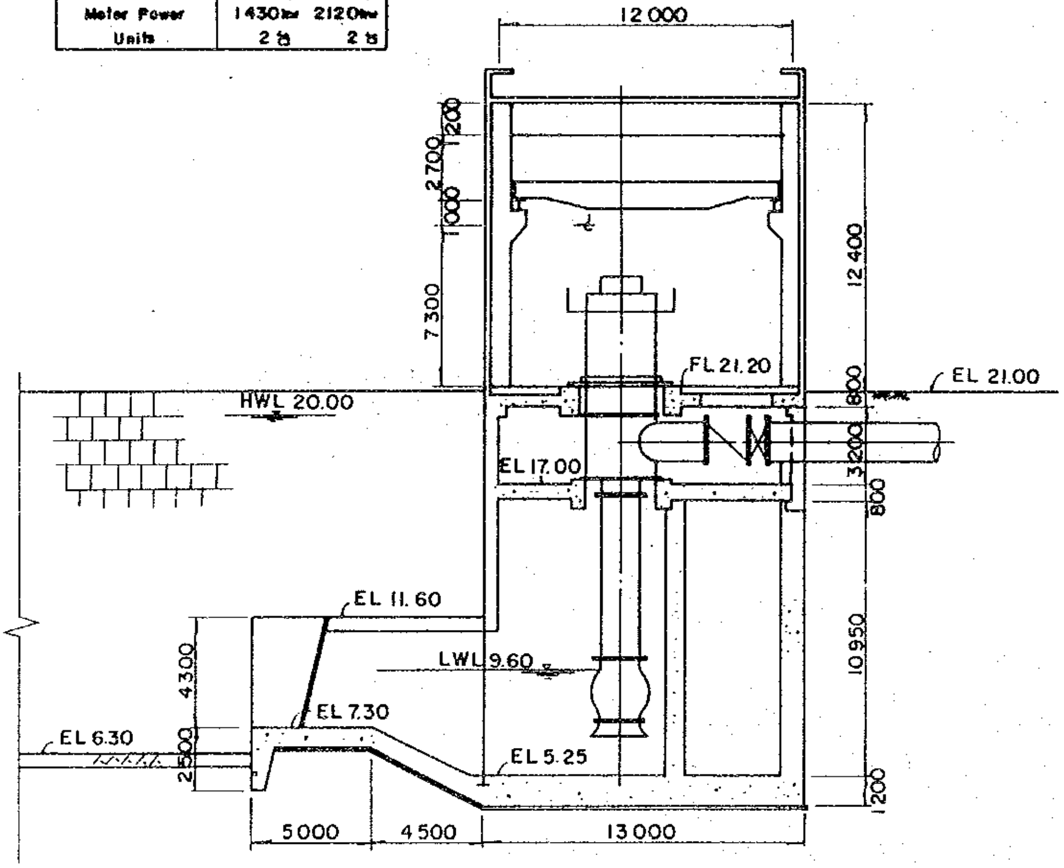


TABLE Ⅷ-1-7 OPERATION HOUR OF PUMP

Date	Unit duty of Water	Irrigable Area	Irrigation Requirement 1)	Water Level	Volute Pump		Inclined Pump		Vertical Mixed Flow Pump	
	l/S/ha	ha	m³/s	m	2) Q m³/s	Hr	3) Q m³/s	Hr	4) Q m³/s	Hr
Mar 1	1.198	40,060×0.8	38.394	9.60	2.00	4,608	2.00	4,608	20.00	461
2	1.198	〃	38.394	〃	〃		〃	4,608	〃	461
3	0.871	〃	27.914	〃	〃	3,685	〃	3,685	〃	368
Apr 1	0.783	〃	25.094	〃	〃	3,011	〃	3,011	〃	301
2	0.612	〃	19.613	〃	〃	2,354	〃	2,354	〃	235
3	0.203	〃	6.506	〃	〃	781	〃	781	〃	78
July 1	0.642	40,060	25.719	14.00	2.32	2,661	2.23	2,768	22.20	278
2	0.929	〃	37.216	17.00	2.52	3,544	2.37	3,769	23.16	386
3	0.671	〃	26.880	20.00	2.72	2,609	2.53	2,805	23.84	298
Aug 1	0.558	〃	22.353	20.00	〃	1,972	2.53	2,120	23.84	225
2	0.532	〃	14.101	20.00	〃	1,244	2.53	1,338	23.84	142
Nov 1	0.067	40,060×0.8	2.147	14.00	2.32	222	2.23	231	22.20	23
2	0.123	〃	3.912	11.00	2.10	447	2.10	441	21.12	44
3	0.884	〃	28.330	〃	〃	3,238	〃	3,192	〃	322
Dec 1	1.026	〃	32.881	〃	〃	3,758	〃	3,705	〃	374
2	1.243	〃	39.836	〃	〃	4,553	〃	4,489	〃	453
3	1.300	〃	41.662	〃	〃	5,238	〃	5,163	〃	521
Jan 1	0.422	〃	13.524	9.60	2.00	1,623	2.00	1,623	20.00	162
2	0.396	〃	12.691	〃	〃	1,523	〃	1,523	〃	152
3	0.437	〃	13.128	〃	〃	1,733	〃	1,733	〃	173
Feb 1	0.746	〃	23.908	〃	〃	2,869	〃	2,869	〃	287
2	0.746	〃	23.908	〃	〃	2,869	〃	2,869	〃	287
3	0.746	〃	23.908	〃	〃	2,295	〃	2,295	〃	230
Total	3.75TK/KWH					2,607		2,468		256
	1.65TK/KWH					58,838		59,512		6,005

1) Barind Area

2) Refer to FIGURE - Ⅷ-1-4 , Ⅷ-1-8

3) Refer to FIGURE - Ⅷ-1-5 , Ⅷ-1-8

4) Refer to FIGURE - Ⅷ-1-6, 7, 8

Estimation of Electric Charge.

Electric charge was estimated by the following procedure ;

(1) Service charge for one pumping station 400 TK/month

(2) Basic fixed charge 35 TK/year

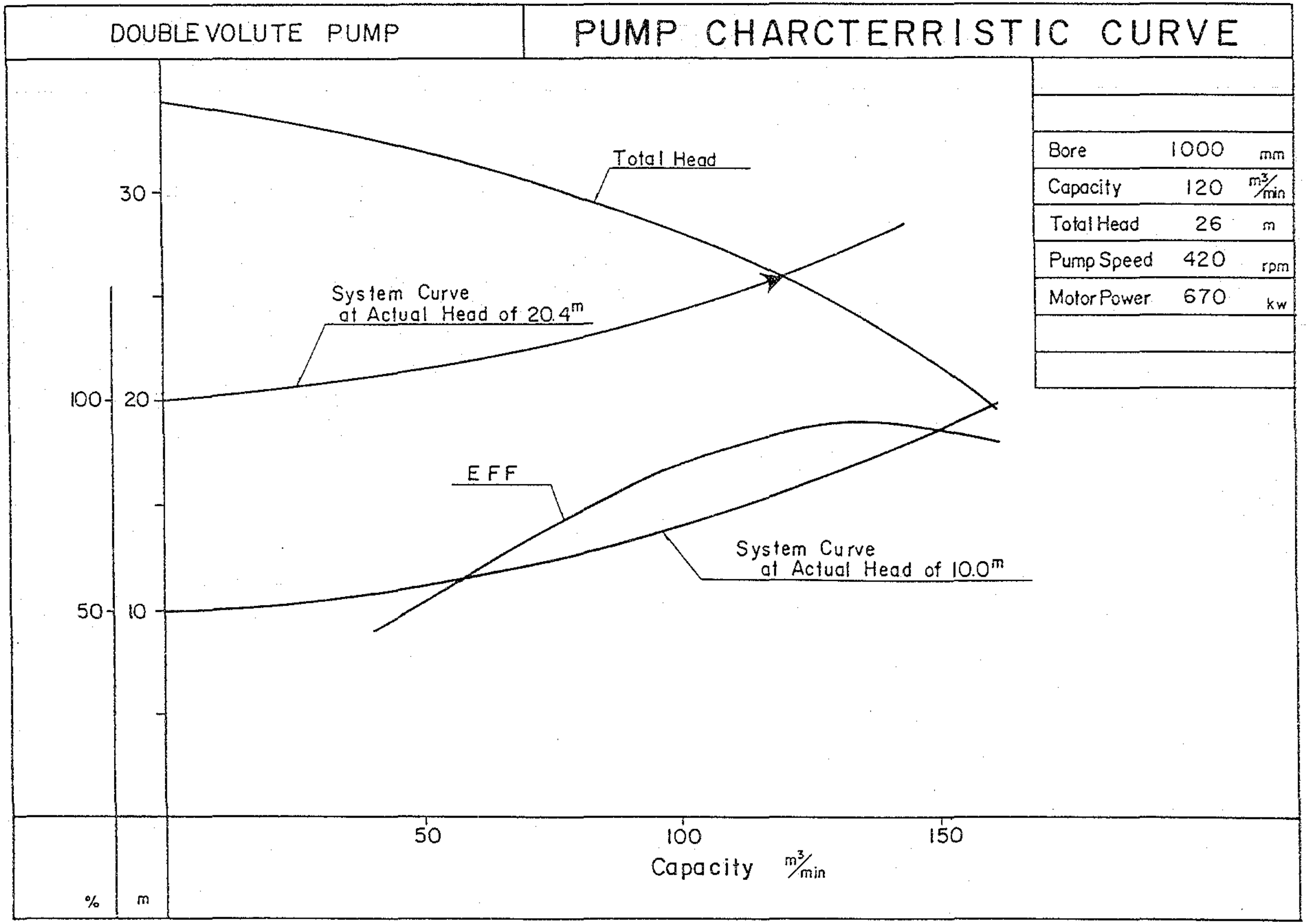
(3) Consumption cost

March - September	PM 6:00 - PM 10:00 (4hr)	3.75 TK/kwh
October - February	PM 5:00 - PM 9:00 (4hr)	
Others		9.65 TK/kwh

(4) Capacities of Pump 20 m^3/s × 2 set

Item / Type of Station	Floating Type × 1,000TK	Inclined Type × 1,000TK	Fixed Type × 1,000TK
(1) Service Charge 400TK/day/station	× 12^{month} × 2places = 9.6	× 12^{month} × 2places = 9.6	× 12^{month} × 2places = 9.6
(2) Basic Fixed Charge 35 TK/kw/year	× 670^{kw} × 10^{unit} × 2places = 469.0	× 730^{kw} × 10^{unit} × 2places = 511.0	×(1,430+2,120)×2 ×2 = 497.0
(3) Consumption Cost 3.75 TK/kwh	× $2,607^{Hr}$ × 670^{kw} = 6,550.0	× $2,648^{Hr}$ × 730^{kw} = 6,756.1	× 256^{Hr} × $7,100^{kw}$ = 6,816.0
1.65 TK/kwh	× $58,838^{Hr}$ × 670^{kw} = 65,045.4	× $59,512^{Hr}$ × 730^{kw} = 71,682.1	× $6,005^{Hr}$ × $7,100^{kw}$ = 70,348.5
Total	72,074.0	78,958.9	77,671.1
1 set (Q = 20 m^3/s)	36,037	39,479.4	38,835.5

Figure Ⅷ-1-4



DOUBLE VOLUTE PUMP
PUMP CHARCTERRISTIC CURVE
Bore 1000 mm
Capacity 120 m³/min
Total Head 26 m
Pump Speed 420 rpm
Motor Power 670 kw
Total Head
System Curve at Actual Head of 20.4m
EFF
System Curve at Actual Head of 10.0m
30
100
20
50
10
%
m
50
100
150
Capacity m³/min

Figure VIII-1-5

INCLINEO PUMP

PUMP CHARCTERRISTIC CURVE

Bore	1000	mm
Capacity	120	m^3/min
Total Head	26	m
Pump Speed	498	rpm
Motor Power	730	kw

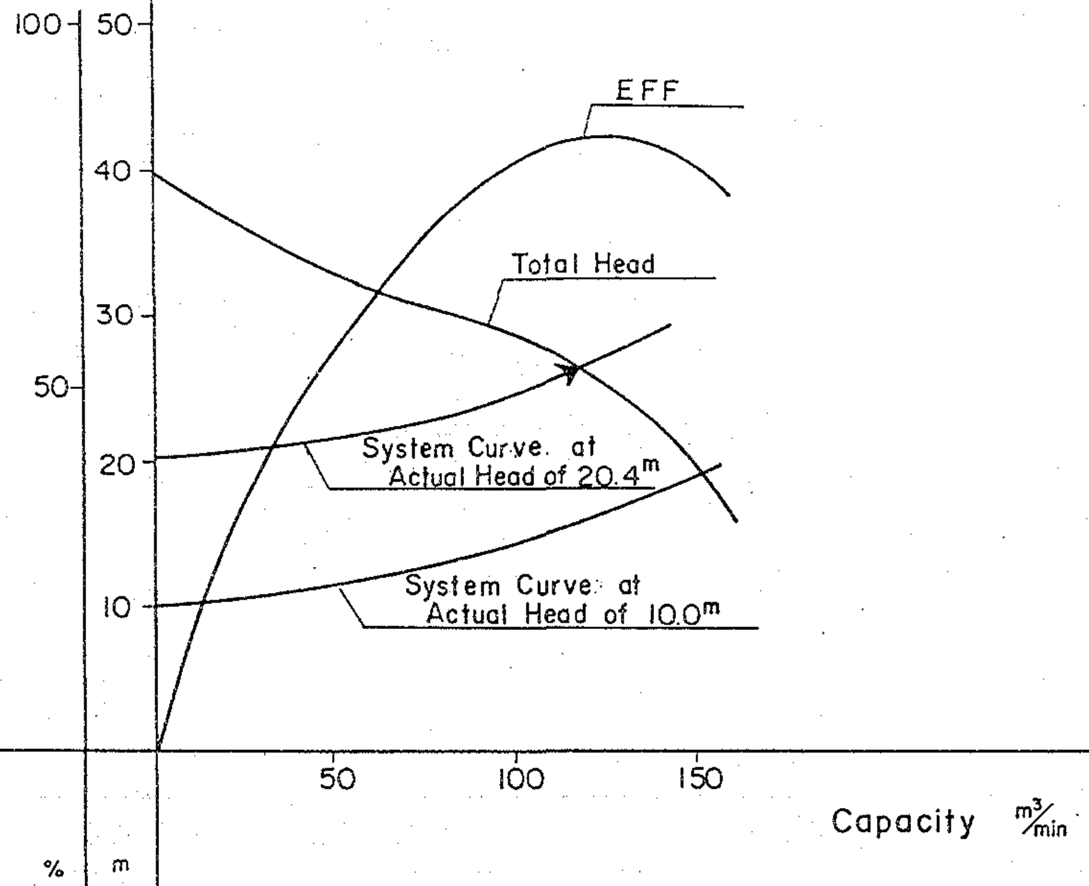


Figure Ⅷ-1-6

VERTICAL MIXED FLOW PUMP

PUMP CHARCTERRISTIC CURVE

Bore	1350	mm
Capacity	240	m³/min
Total Head	26	m
Pump Speed	423	rpm
Motor Power	1430	kw

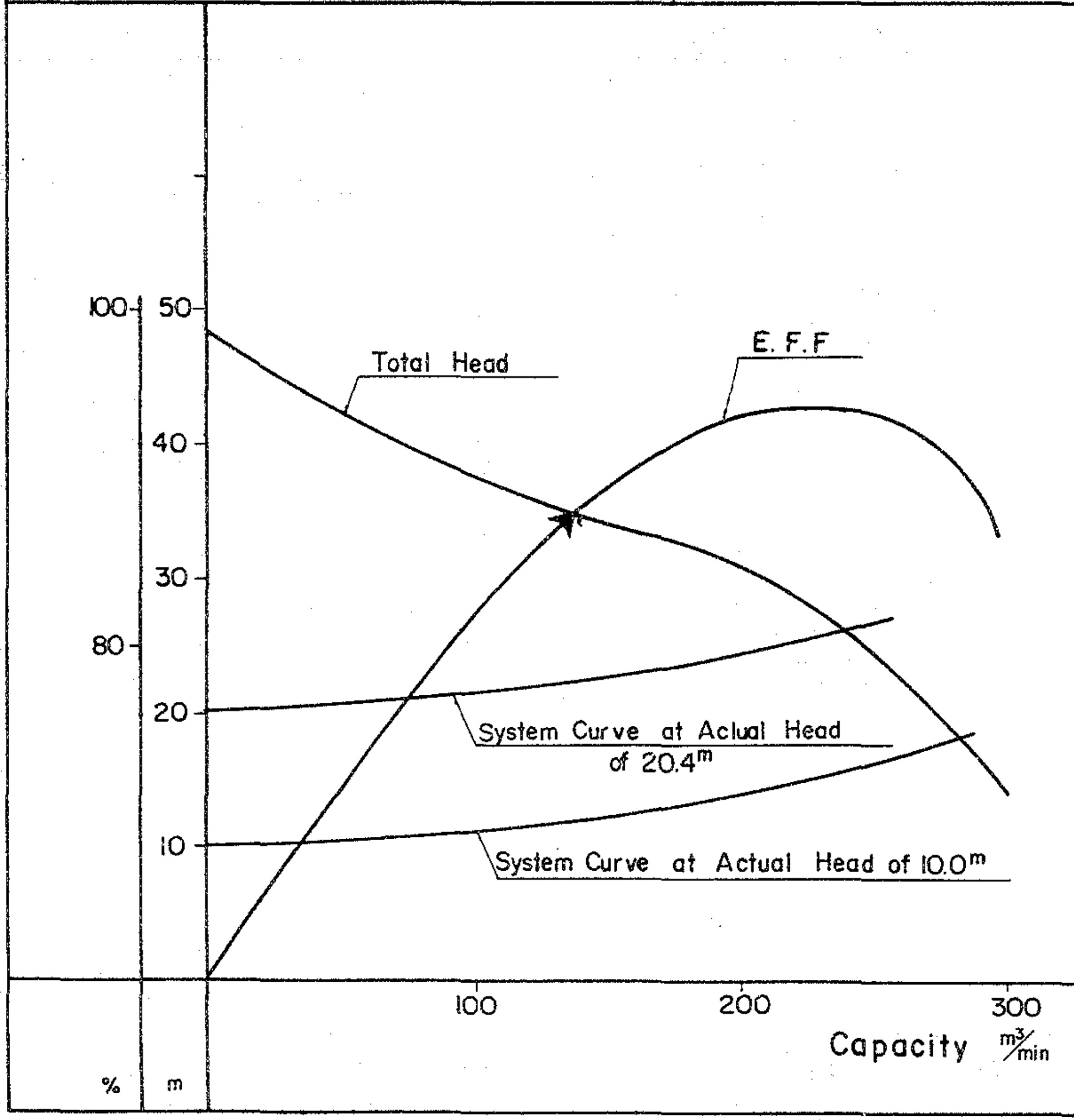


Figure VIII-1-7

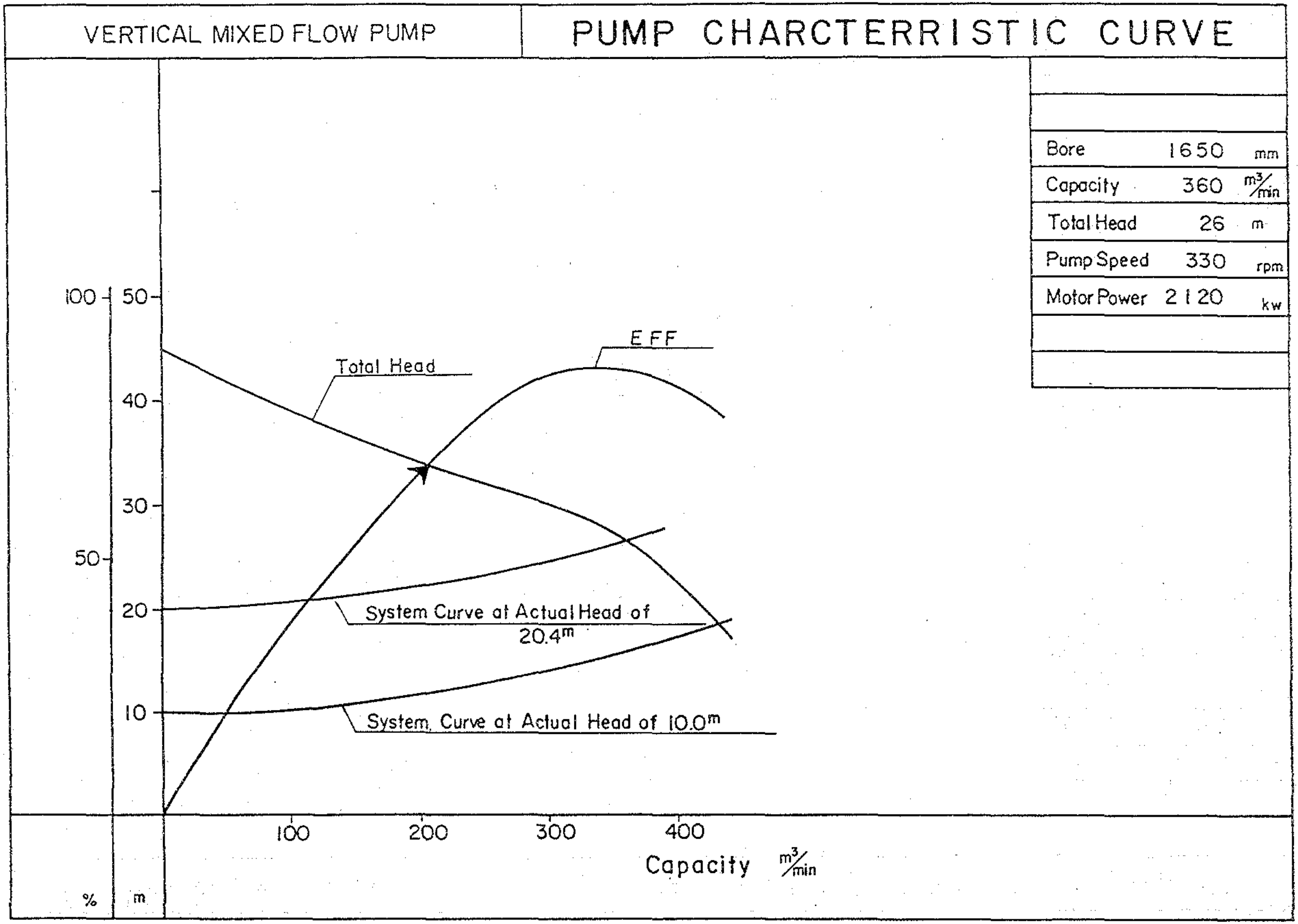


FIGURE - VIII-1-8 AVERAGE IRRIGATAON REQUIREMENT AND WATER LEVEL

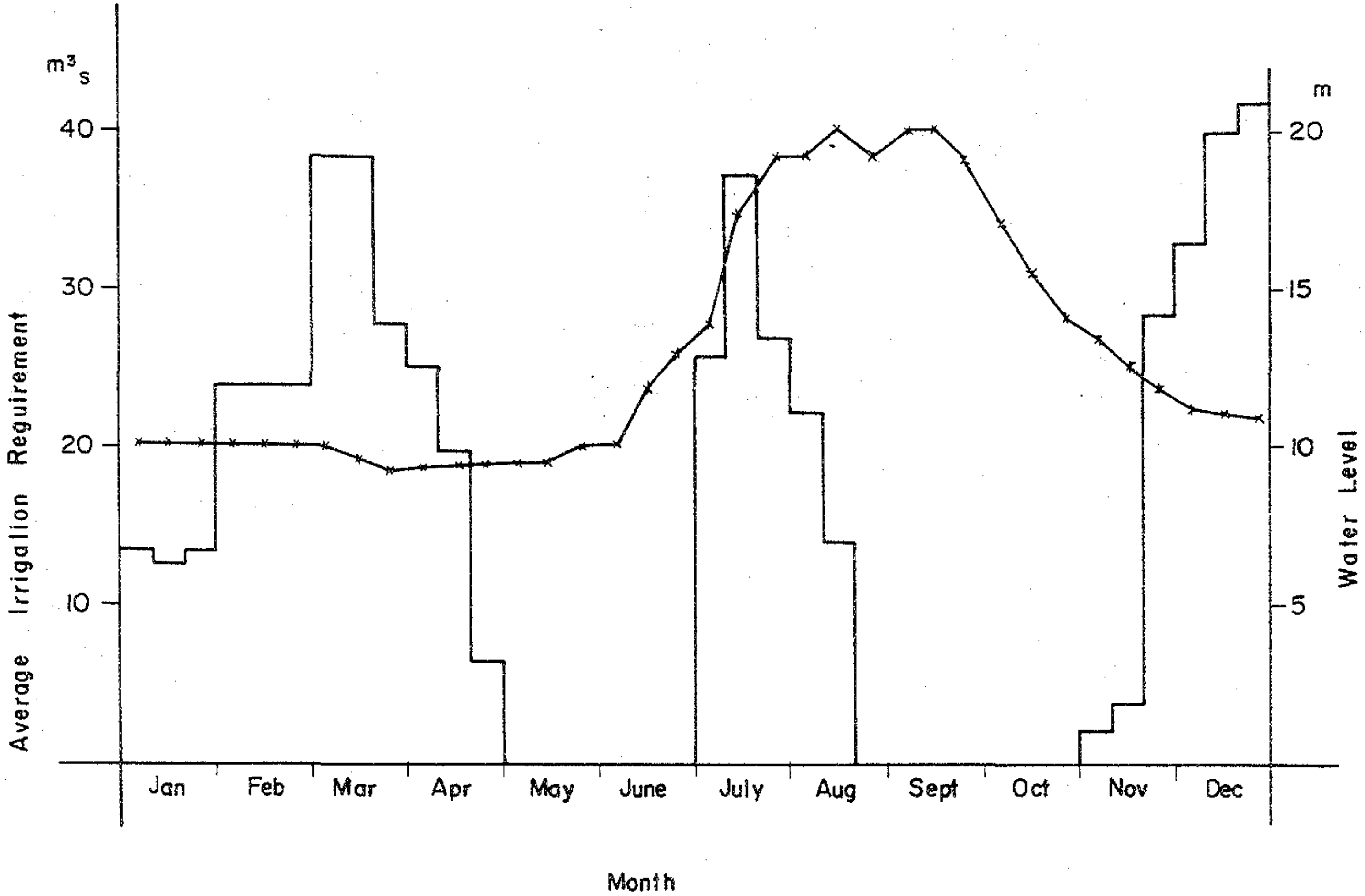


FIGURE VIII-1-9 VERTICAL MIXED FLOW PUMP

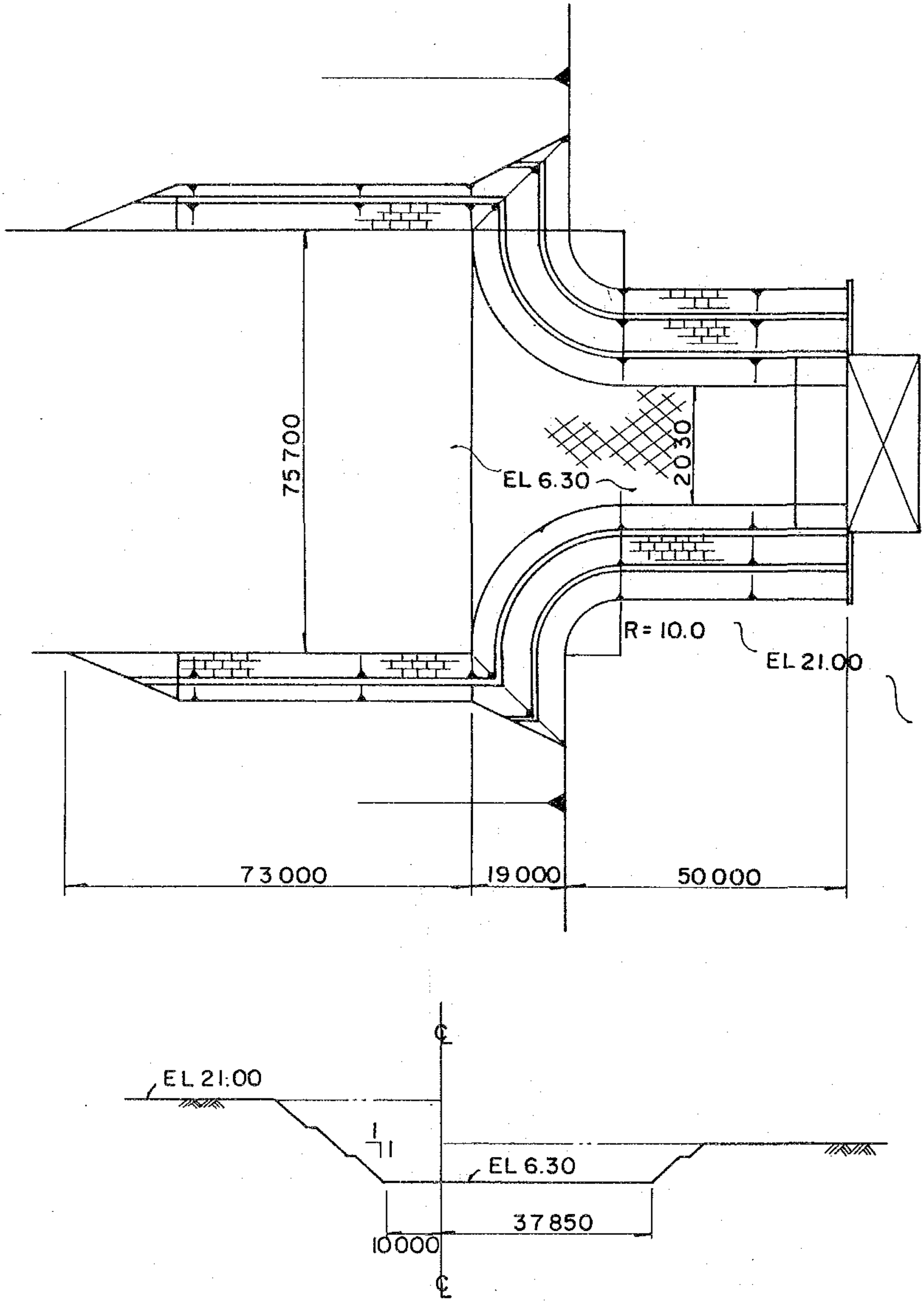
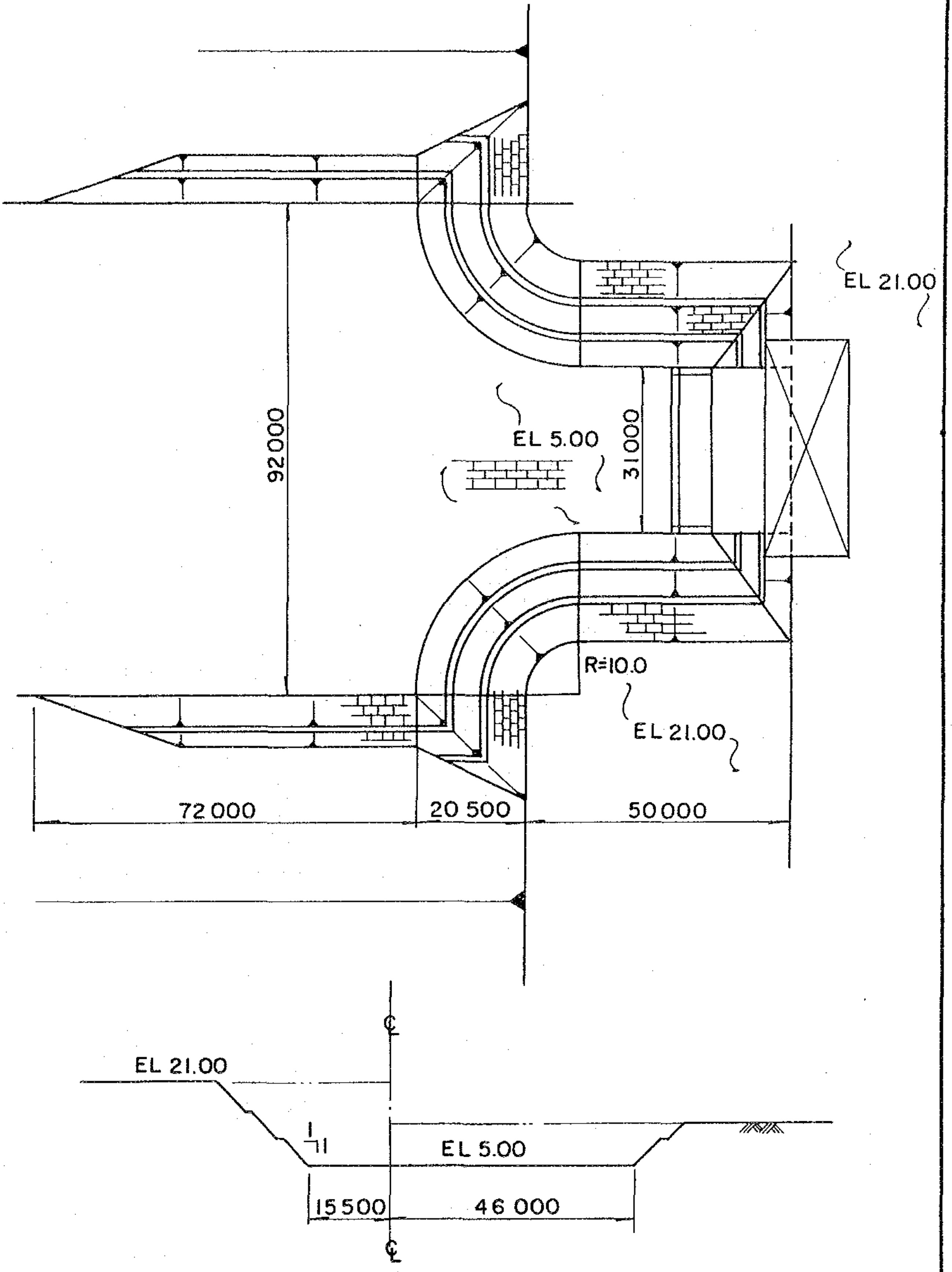


FIGURE VIII-1-10 INCLINED PUMP



1-3. Alternative Study for the Pumping Station for Barind Area

1-3-1. Alternative Plan

The proposed site for pumping stations have been selected at Baraipara on the basis of the river bank shifting records and cross section survey results of the Ganges river.

Sultanganj is also suitable to propose for a pumping station but it should be limited to utilize during the wet season only due to the sand dune in the river mouth of the Mahananda river during the dry season.

Accordingly, the following three alternatives will be compared each other to select the most suitable pump site and pumping station type.

(1) Alternative 1.1' (See FIGURE Ⅷ-1-11)

Revised plan of the selected plan No. 2 in the Interim Report ; i.e. since the Godagari site is not suitable for pumping stations as explained in Paragraph 2-2. The Baraipara site can be proposed for the pumping site for floating type for 34.0 m^3/sec instead of the Godagari site. A connecting canal to the existing natural depression for about 2.2 km will be necessary to be added to convey the water from Baraipara to Sultanganj.

At Sultanganj, pumping equipment to lift up the water from the Mahananda river for 6.0 m^3/sec together with the secondary lifting pumps of water from Baraipara for 34.0 m^3/sec will be necessary to be facilitated in the pump stations. This total capacity of 40 m^3/sec can also be utilized to lift the water from the Mahananda river during wet season.

(2) Alternative - 2 (See FIGURE Ⅷ-1-12)

The Baraipara is the only site for pumping station where the water can be lifted up throughout a year.

Instead of floating type, the standard fixed type pumping station can be proposed at Baraipara.

(3) Alternative - 3 (See FIGURE Ⅷ-1-11)

Alternative Plan 3 proposes a direct lifting up of the Ganges river water to the delivery pond at EL 30.5 m PWD by the floating pump with the capacity of 40 m^3/sec.

(4) Alternative - 4 (See FIGURE Ⅷ-1-12)

The fixed pumping station (Inclined Mixed Flow Pump) can be proposed at Baraipara instead of the floating pump.

1-3-2. Dimension of Pump Facilities on Alternative Plan

As mentioned above four kinds of alternative plans are considered. Necessary facilities for each plan are considered as in the following TABLE Ⅷ-1-8.

TABLE － Ⅷ-1-8 DIMENSION OF PUMP FACILITIES

Item ＼ Pump Station	Case Ⅰ			Case Ⅱ	Case Ⅲ	Case Ⅳ
	Sultanganj P.S (Fixed)		Baraipara P.S (Float)	Baraipara P.S (Fixed)	Baraipara P.S (Float)	Baraipara P.S (Fixed)
Irrigation Requirement (m³/s) Water Level H.W.L (m) L.W.L (m) Discharge Water Level (m) Actual Head (m) Loss Head (m) Total Head (m)	6.0 20.4 9.9 30.5 20.6 3.5 24.1	34.0 20.4 19.3 30.5 11.2 3.5 14.7	34.0 20.4 9.6 19.8 10.2 2.8 13.0	40.0 20.4 9.6 30.5 20.9 5.0 25.9	40.0 20.4 9.6 30.5 20.9 5.0 25.9	40.0 20.4 9.6 30.5 20.9 5.0 25.9
Pump Type	Vertical Mixed Flow Pump		Volute Pump OR Inclined M·F·P	Vertical Mixed Flow Pump	Double Volute Pump	Inclined Mixed Flow Pump
Bore (mm)	1650	1650 1350	1000	1650 1350	1000	1000
Capacity (m³/s)	6.0	6.0 4.0	2.0	6.0 4.0	2.0	2.0
Motor Power (kw)	2000	1220 830	340	2100 1400	670	670
Pump Efficiency (%)	84.5	84.5 83.5	85	84.5 83.5	85	85
Pump Unit	1	3 4	17	4 4	20	20
Pipe Line Diameter (mm) Length (km) Unit	 2000 0.8 1	 2000 0.8 4 , 3	 2000 1600 1.5 5 , 3	 2000 1600 1.5 2 , 4	 2000 1600 1.5 2 , 4	 2000 1600 1.5 2 , 4

Figure VIII-1-11 CASE I AND III

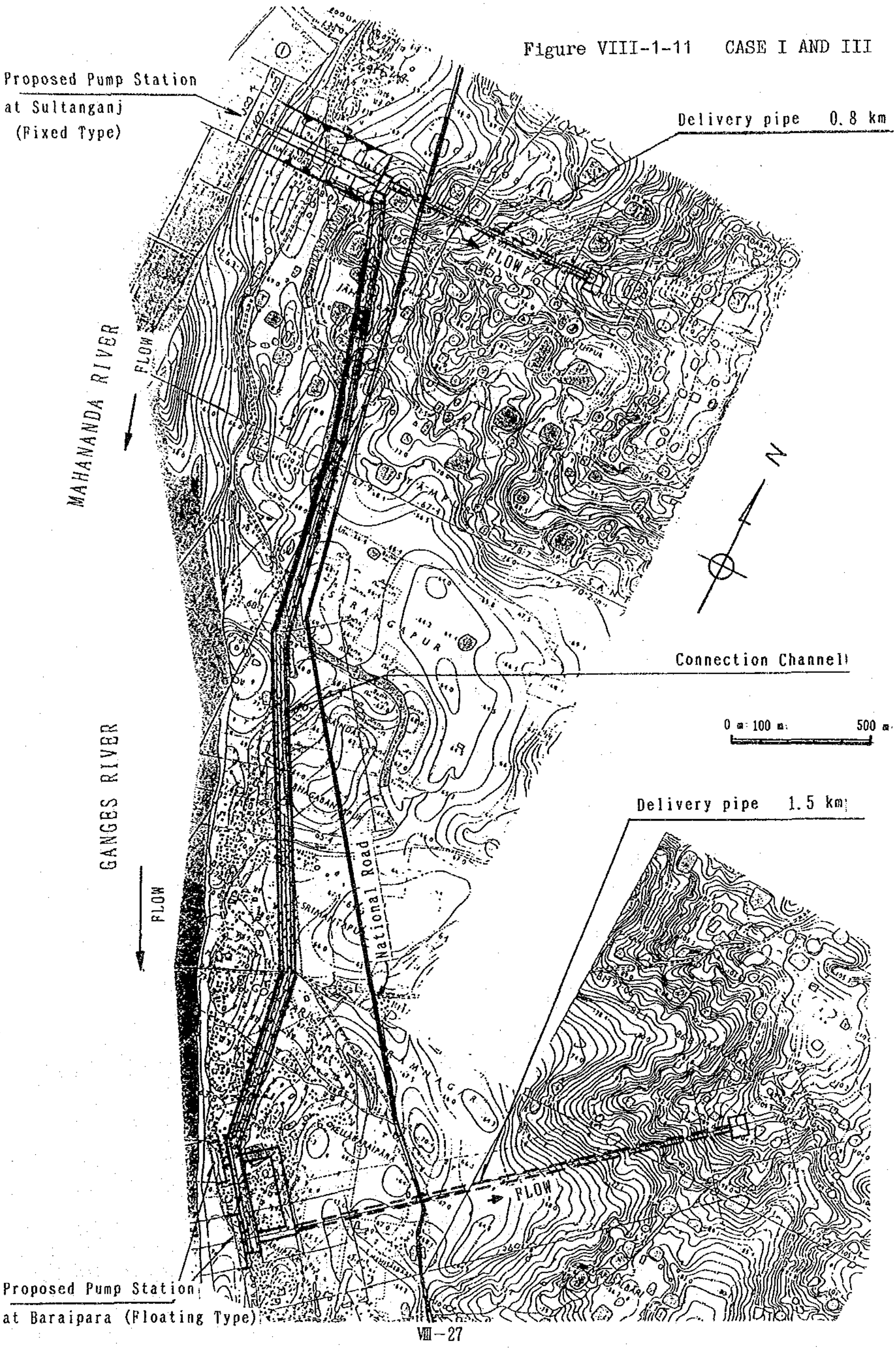
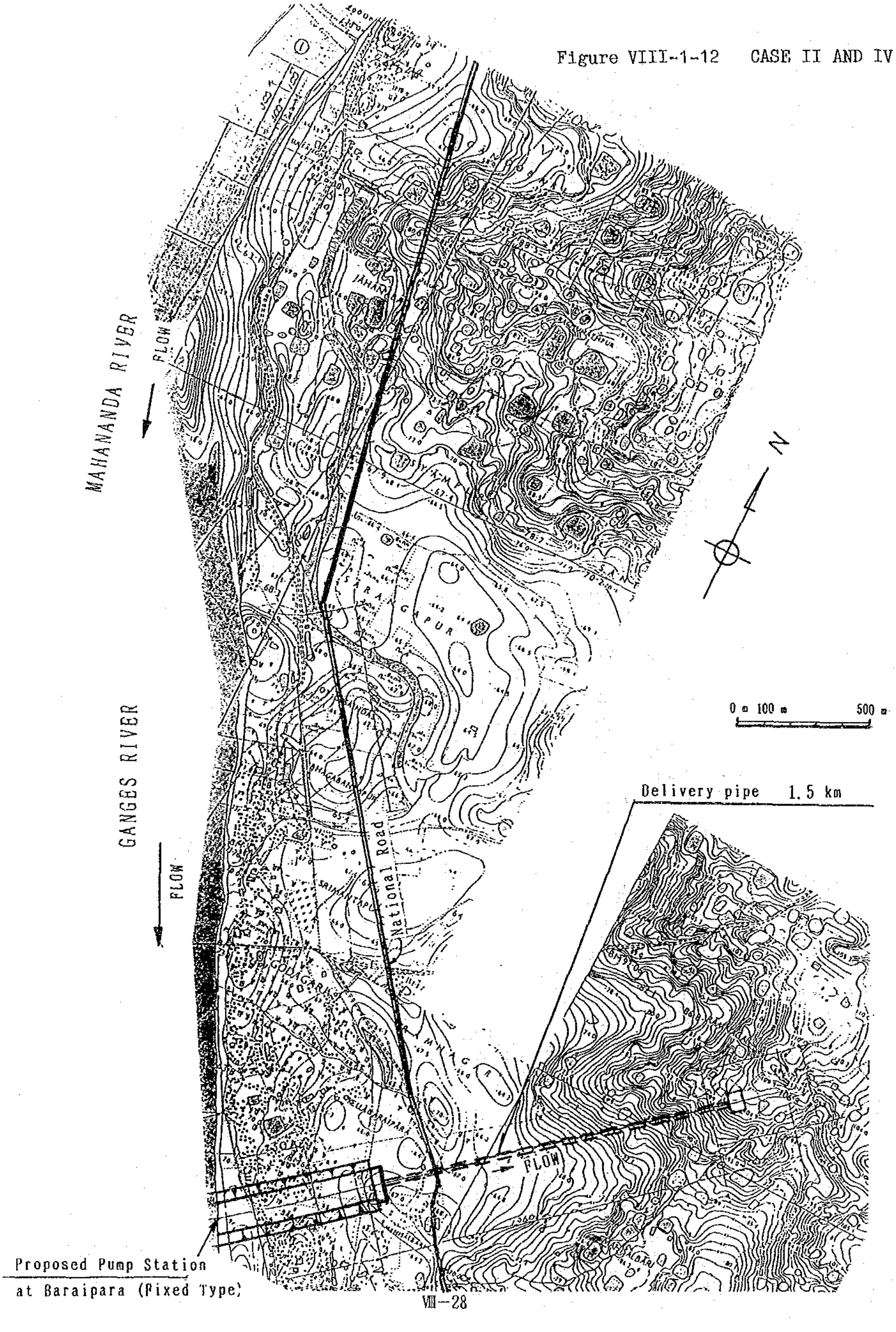


Figure VIII-1-12 CASE II AND IV



1-3-3. Cost Estimate

The cost estimate was carried out for the construction cost of structures, facilities cost of the pumps, including the accessary and operation and maintenance cost based on semi-feasibility study level.

As for fixed type pumping station, the maintenance cost for sedimentation is the most important factor, particularly, estimation of the volume of sedimentation has been estimated in the basis of the observed suspended load discharge at Hardinge Bridge, and the dredging cost calculated under the consideration of using dredgers.

Regarding the maintenance cost for floating type pumping station, it has assumed to be utilize the Towing Boat (5t), Anchor Boat (3t), and Crane Boat (10t) for the transfer of the barges in the river.

1-3-4. Results of the Cost Estimate

The results of the cost estimate is tabulated in the TABLE VIII-1-9~VIII-1-14.

It is indicated that case II proposed plan (Fixed Type at Baraipara) is the most recommendable for the construction of pumping station at Barind Tract Area.

TABLE Ⅷ-1-9 COMPARISON OF COST FOR EACH CASE

(1000TK)

Case / Item	Case Ⅰ (floating, Fixed) Mixed Flow , Volute	Case Ⅰ' (floating, Fixed)	Case Ⅱ (Fixed)	Case Ⅲ (floating)	Case Ⅳ (Fixed)
1. Construction Cost	2,223,600	1,909,800	1,327,800	1,774,000	1,463,100
2. Operation & Maintenance	231,200	206,300	112,800	137,700	112,800
Total Cost (Cost Ratio)	2,454,800 (170%)	2,116,100 (147%)	1,440,600 (100%)	1,911,700 (133%)	1,575,900 (109%)
3. Running Cost (Cost Ratio)	129,200 (108%)	122,300 (102%)	120,000 (100%)	123,800 (103%)	117,000 (98%)

1」 Refer to TABLE 1-3-3

TABLE Ⅷ-1-10 COMPARISON OF COST FOR EACH CASE

(1000TK)

Item \ Case	Case I, I' Sultanganj・P・S (Fixed)	Case I (floating) Baraipara・P・S	Case I' (Inclined) Baraipara・P・S	Case II (Fixed) Baraipara・P・S	Case III (floating) Baraipara・P・S	Case IV (Inclined) Baraipara・P・S
1. Construction Cost 1」						
Pump Facility Cost	660,600	525,600	659,700	690,200	710,000	835,900
Pump Station & Pipe	414,300	113,100	175,200	637,600	554,000	627,200
Barge		510,000			510,000	
Sub - Total	1,074,900	1,148,700	834,900	1,327,800	1,774,000	1,463,100
2. Operation & Maintenance 2」						
Dredger Equipment Cost	112,800	93,500	93,500	112,800	112,800	112,800
Maintenance Equipment (Floating Pump)	――	24,900	――	――	24,900	――
Sub - Total	112,800	118,400	93,500	112,800	137,700	112,800
Total Cost (1+2)	1,187,700	1,267,100	928,400	1,440,600	1,911,700	1,575,900
3. Running Cost 3」						
Electric Charge	66,800	32,400	32,400	104,500	100,100	100,100
Fuel Charge	1,100	1,000	1,000	1,100	1,100	1,100
Painting Charge		3,500			3,500	
Other	11,800	12,600	9,200	14,400	19,100	15,800
Total Cost	79,700	49,500	42,600	120,000	123,800	117,000

1」 Refer to TABLE-1-3-4,5

2」 Refer to TABLE-1-3-6

3」 Refer to TABLE-1-3-7

TABLE Ⅷ-1-11 PUMP FACILITIES COST

(1000TK)

Item \ Case	Case I, I' Sultanganj·P·S (Fixed)		Case I (floating) Baraipara·P·S	Case I' (Inclined) Baraipara·P·S	Case II (Fixed) Baraipara·P·S	Case III (floating) Baraipara·P·S	Case IV (Inclined) Baraipara·P·S
Capacity × Total Head × Motor Power × Unit	6×24.1×2000×1	6×14.7×1220×3 4×14.7×830×4	2×13×340×17	2×13× 340×17	6×25.9×2150×4 6×25.9×1450×4	6×25.9× 670×20	6×25.9× 670×20
Pump	28,000	84,000 78,800	135,200	244,100	291,200	159,100	287,200
Motor	36,500	46,000 72,900	122,400	108,800	207,600	221,600	197,000
Valve×Pipe	9,700	67,200	62,200	68,400	63,400	73,200	64,400
Crane	10,400		4,500	4,500	10,400	4,500	4,500
Electric Equipment	40,400		74,000	74,000	40,400	79,400	79,400
Equipment Work	126,300		79,600	99,900	126,300	107,600	126,500
Transportation	60,200		47,700	60,000	51,100	64,500	75,900
Total Cost	660,600		525,600	659,700	690,200	710,000	835,900

TABLE Ⅷ-1-12 CONSTRUCTION COST PER 20 m³/s

(1000TK)

Item \ Case	Unit Cost 10^3TK	Case Ⅰ, Ⅰ' Sultanganj·P·S (Fixed)	Case Ⅰ (floating) Baraipara·P·S	Case Ⅰ' (Inclined) Baraipara·P·S	Case Ⅱ (Fixed) Baraipara·P·S	Case Ⅲ (floating) Baraipara·P·S	Case Ⅳ (Inclined) Baraipara·P·S
Barge	300,000/20 m³/s	――― ―――	510,000	―――	―――	510,000	―――
Pump House	23.6/m²	× 730 m² 17,200	―――	×1170 m² 27,600	× 860 m² 20,300	―――	×1380 m² 32,500
Intake Canal		×34,150/20 ×40 68,300	×2,530/20×34 4,300	×22,850/20 ×34 38,800	×34,150/20 ×40 68,300	×2,530/20×40 5,000	×22,850/20 ×40 45,700
Pipe Line	183/20 m³/s /m	× 800m 292,800	×350m 108,800	×350m 108,800	×1500m 549,000	×1500m 549,000	×1500m 459,000
Regulater		36m 36,000	―――	―――	―――	―――	―――
Total Cost		414,300	510,000 113,100	175,200	637,600	510,000 554,000	627,200

TABLE Ⅷ-1-13 OPERATION & MAINTENANCE FACILITIES COST

(1000TK)

Item \ Cost	Case Ⅰ, Ⅰ' Sultanganj·P·S (Fixed)	Case Ⅰ (floating) Baraipara·P·S	Case Ⅰ' (Inclined) Baraipara·P·S	Case Ⅱ (Fixed) Baraipara·P·S	Case Ⅲ (floating) Baraipara·P·S	Case Ⅳ (Inclined) Baraipara·P·S
Dredger Pump	ϕ450 × 320 × 1 ϕ350 × 230 × 1	ϕ350 × 230 × 2	ϕ350 × 230 × 2	ϕ450 ×320 × 1 ϕ350 ×230 × 1	ϕ450 ×320 × 1 ϕ350 ×230 × 1	ϕ450 ×320 × 1 ϕ350 ×230 × 1
Dredger Pump	38,000 27,600	55,200	55,200	38,000 27,600	65,900	65,900
Floating Pipe	20,700	16,000	16,000	20,700	20,700	20,700
Towing Boat	3,700	3,700	3.700	3,700	3,700	3,700
Assemblage	13,500	11,200	11,200	13,500	13,500	13,500
Transportation	9,000	7,400	7,400	9,000	9,000	9,000
Sub - Total	112,800	93,500	93,500	112,800	112,800	112,800
Maintenance Equipment						
Floating Pump	———		———	———		———
Anchor Boat		17,100			17,100	
Crane Boat		7,800			7,800	
Sub - Total	112,800	24,900	———	———	24,900	———
Total Cost	112,800	118,400	935,500	112,800	137,700	112,800

1) Length ; 500m (Steel Pipe, Rubber Joint, Floater) $72 \times (15.3+66.9)+71 \times 29.4 = 8,000 \times 10^3$

$72 \times (18.3+103.0)+71 \times 56.6 = 12,700 \times 10^3$

TABLE Ⅷ-1-14 RUNNING COST

(1000TK)

Item \ Cost	Case Ⅰ, Ⅰ' Sultanganj・P・S (Fixed)		Case Ⅰ (floating) Baraipara・P・S	Case Ⅰ' (Inclined) Baraipara・P・S	Case Ⅱ (Fixed) Baraipara・P・S	Case Ⅲ (floating) Baraipara・P・S	Case Ⅳ (Inclined) Baraipara・P・S
Amount Motor Power (kw)	2,000	6,980	5,780	5,780	14,000	13,400	13,400
Operation Hour (hr)	4,000	4,000	3,000	3,000	4,000	4,000	4,000
Electric Charge							
Charge	3,000 11,800	10,400 41,400	6,500 25,700	6,500 25,700	21,000 83,100	20,100 79,600	20,100 79,600
Demand	―	200	200	200	400	400	400
Service	―		―	―	―	―	―
Sub - Total	66,800		32,400	32,400	104,500	100,100	100,100
Fuel Charge 1」	1,100		1,000	1,000	1,100	1,100	1,100
Painting Charge	―		3,500	―	―	3,500	―
Other	11,800		12,600	9,200	14,400	19,100	15,800
Sub - Total	12,900		17,100	10,200	15,500	23,700	16,900
Total Cost	79,700		49,500	42,600	120,000	123,800	117,000

1」 Dredger ; φ450mm × 320kw, φ350mm × 230kw

2. TYPE OF PUMP

2-1. Selection of the Pump types

Generally, the type of the pumps shall be decided based on the total head required at proposed site.

In general, the relation between the type of pumps and total head required is given as follows :

Type	Horizontal Axis	Vertical Axis
Volute Type	15.0 m more	15.0 m more
Mixed flow Type	2.0 m - 9.0 m	9.0 m - 20.0 m
Axial flow Type	1.5 m - 5.0 m	1.5 m - 5.0 m

Design water level of suction side is estimated based on computation of probability of exceedance at 100 years return period. Results of estimation is shown as follows ;

Pumping station	KASBA	BARAIPARA
Low water level	7.860 m	8.686 m
High water level	20.325 m	21.826 m
Deference	12.465 m	13.140 m

On the other hand, the actual pump head are estimated at each proposed pump site are as follows ;

KASBA	13.0 m approx
BARAIPARA	27.0 m approx

As for the selection of pump type from actual head, there are considered to be applied two type, namely, one is volute type, and other one is mixed flow type.

In case of volute type pump, there are some weak points in cavitation for variation of the water level at suction side. Accordingly, mixed flow type has been selected for both proposed sites. Comparatively, submergible motor pump is considered to be utilized at both proposed sites. However, the construction cost is excessively high for design capacity at both sites, thus, the idea has been canceled. As for supporting structure of vertical mixed flow type pump, semi-two floor type is proposed for both stations as mentioned attached TABLE Ⅷ-1-2.

3. DESIGN OF PROPOSED PUMPING STATION

According to the results studied for type of pump station, pump facilities and hydrological analysis, details lay-out has been carried out. They are as follows.

3-1. Selection of Basic Factors for the Pumping Facilities

3-1-1. Basic Factors for Design of Pumps

Design capacity of the pump has been decided under the consideration of water requirement and water level of the Ganges river at the proposed pumping site are as follows ;

Pumping station	Baraipara P.S.	Paba P.S.
Water Requirement *1	44.242 m^3/s	9.436 m^3/s
Pump Capacity *2	42.588 m^3/s	8.247 m^3/s

*1 Maximum water requirement 1978 - 1986

*2 Maximum W.R. in dry season 1978 - 1986

Regarding the difference between the water requirement and the pump capacity, there are some consideration on the water level of the Ganges river. Namely, the maximum water requirement appeared at third week of September, at the same time, the water level was higher than low water level and its about 6.0 m, so that, the pumping capacity could be reduced depending on said allowance of the head. Basic factor for the design and hydrological analysis are summarized in FIGURE Ⅷ-3-1 —— Ⅷ-3-4 and TABLE Ⅷ-3-1.

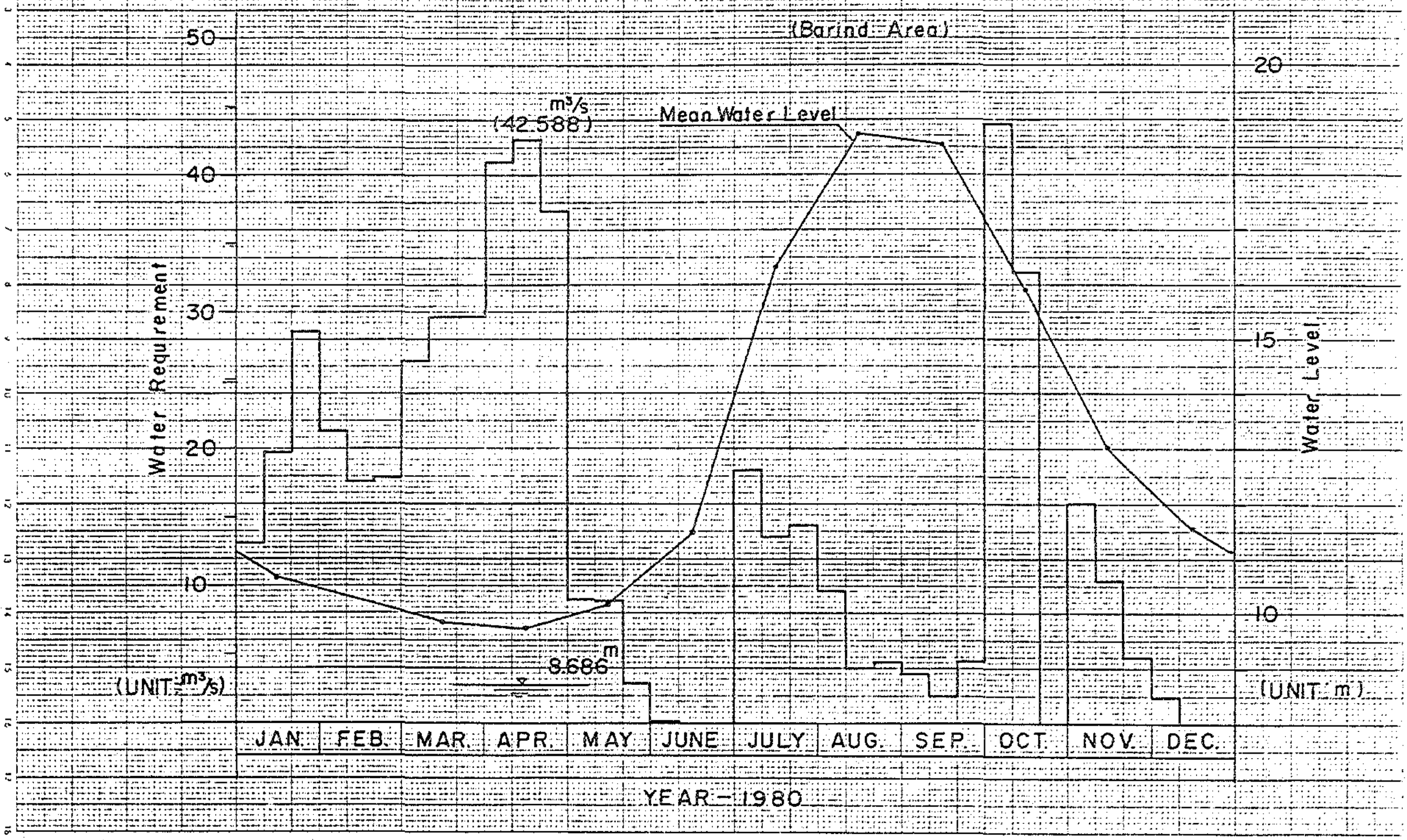
TABLE VIII-3-1 DIMENSION OF PUMP

Item \ Pump Station	Baraipara Pump Station	Paba Pump Station	
(1) Irrigation Requirement 1J			
Dry season (m^3/s)	42.588	8.247	1980-Apr
Wet season (m^3/s)	44.242	9.436	1982-Sep
(2) Water Level 2J			
H.W.L (m)	21.826	20.325	1/100 Probability
L.W.L (m)	8.686	7.860	〃
(3) Suction Water Level (m)	8.50	7.70	
(4) Discharge Water Level W.L (m)	30.50	19.80	

1J Refer to FIGURE VIII-3-1～VIII-3-4

2J Refer to 4-2

FIGURE- Ⅷ-3-1 DIVERSION WATER REQUIRMENT



FIGURE－Ⅷ-3-2 IRRIGATION REQUIREMENT AND WATER LEVEL (BARIND AREA)

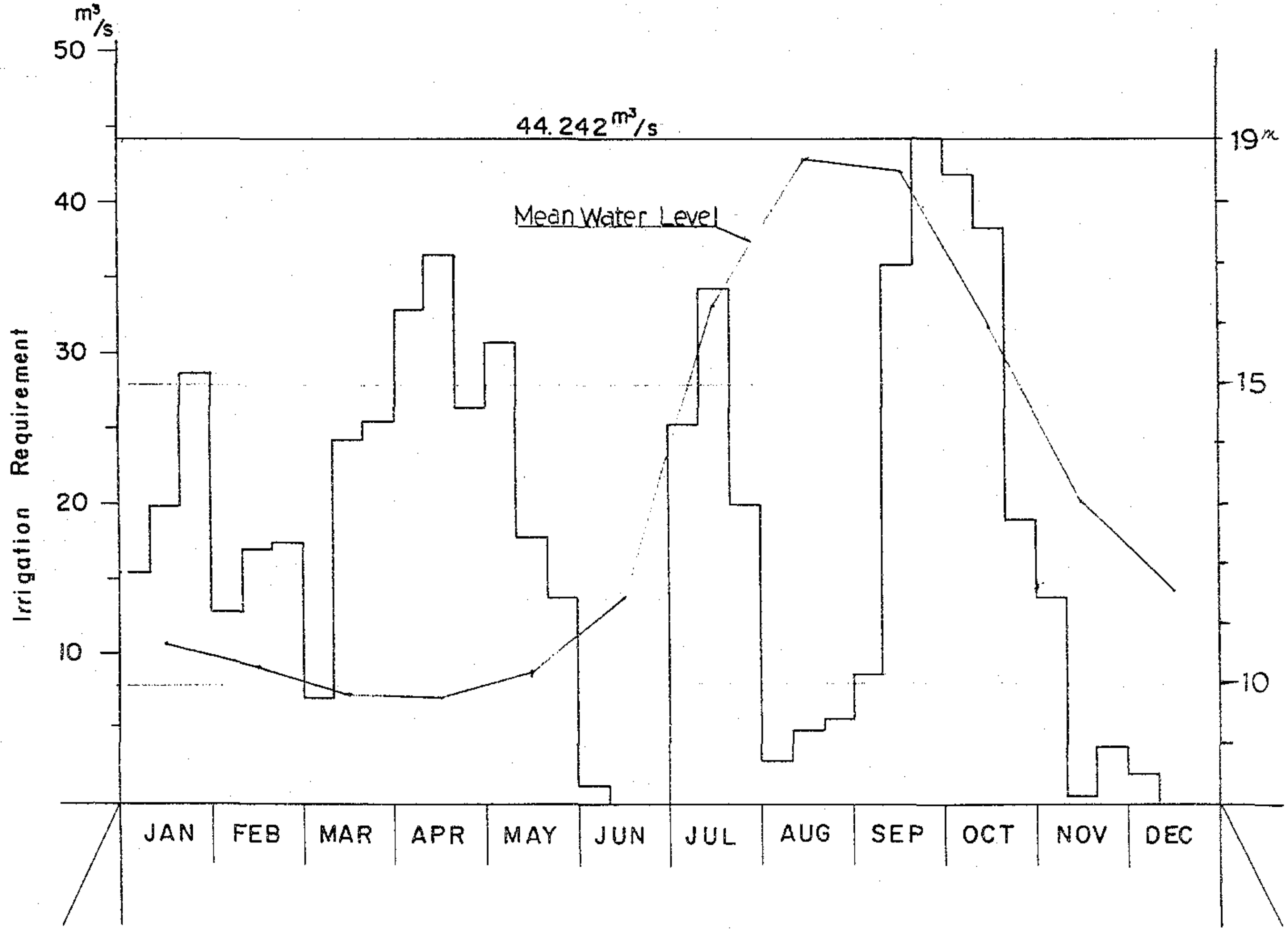


FIGURE- Ⅷ-3-3 DIVERSION WATER REQUIRMENT

(Flood Plane Area)

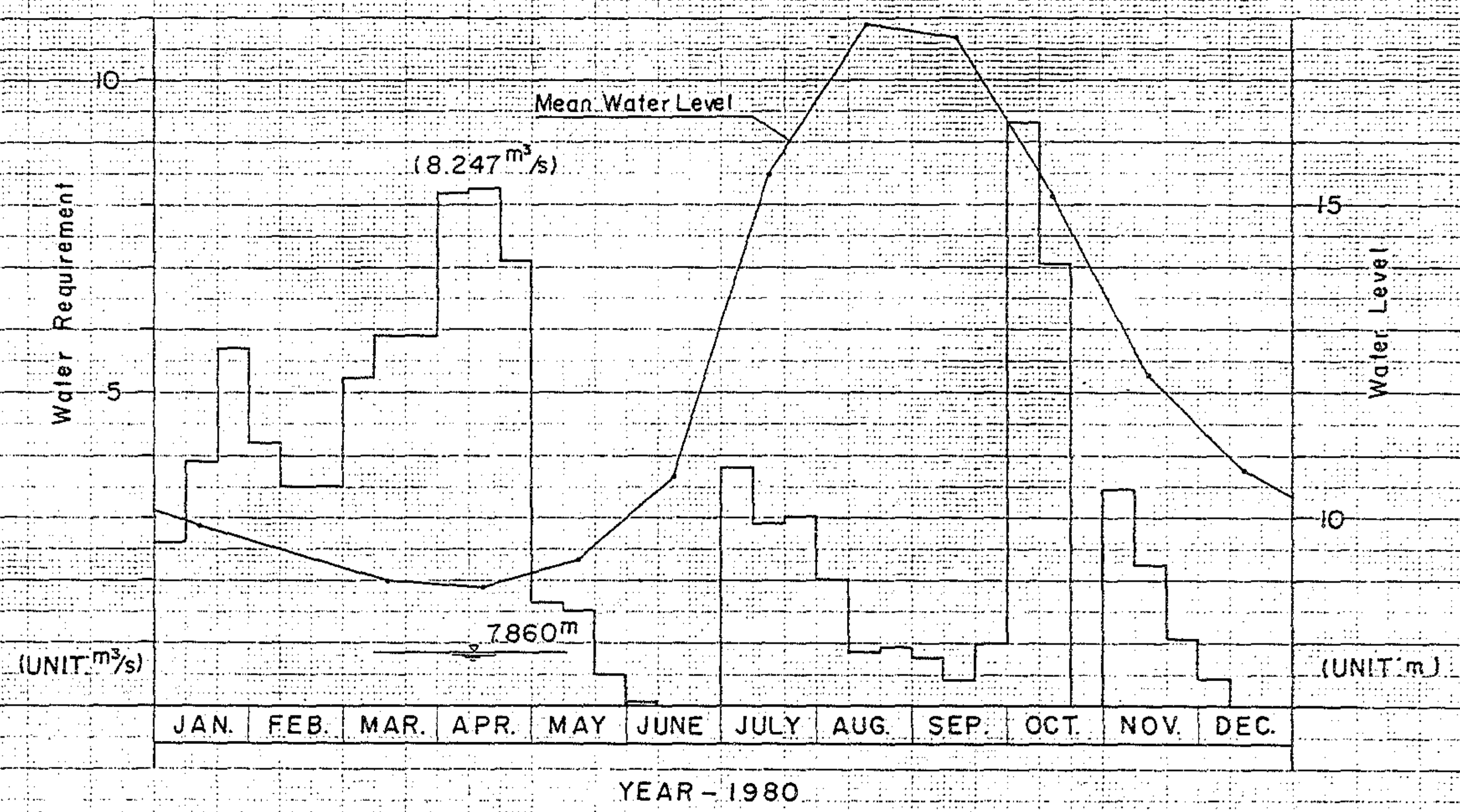


FIGURE - Ⅷ-3-4 IRRIGATION REQUIREMENT AND WATER LEVEL

(Fload Plane Area)

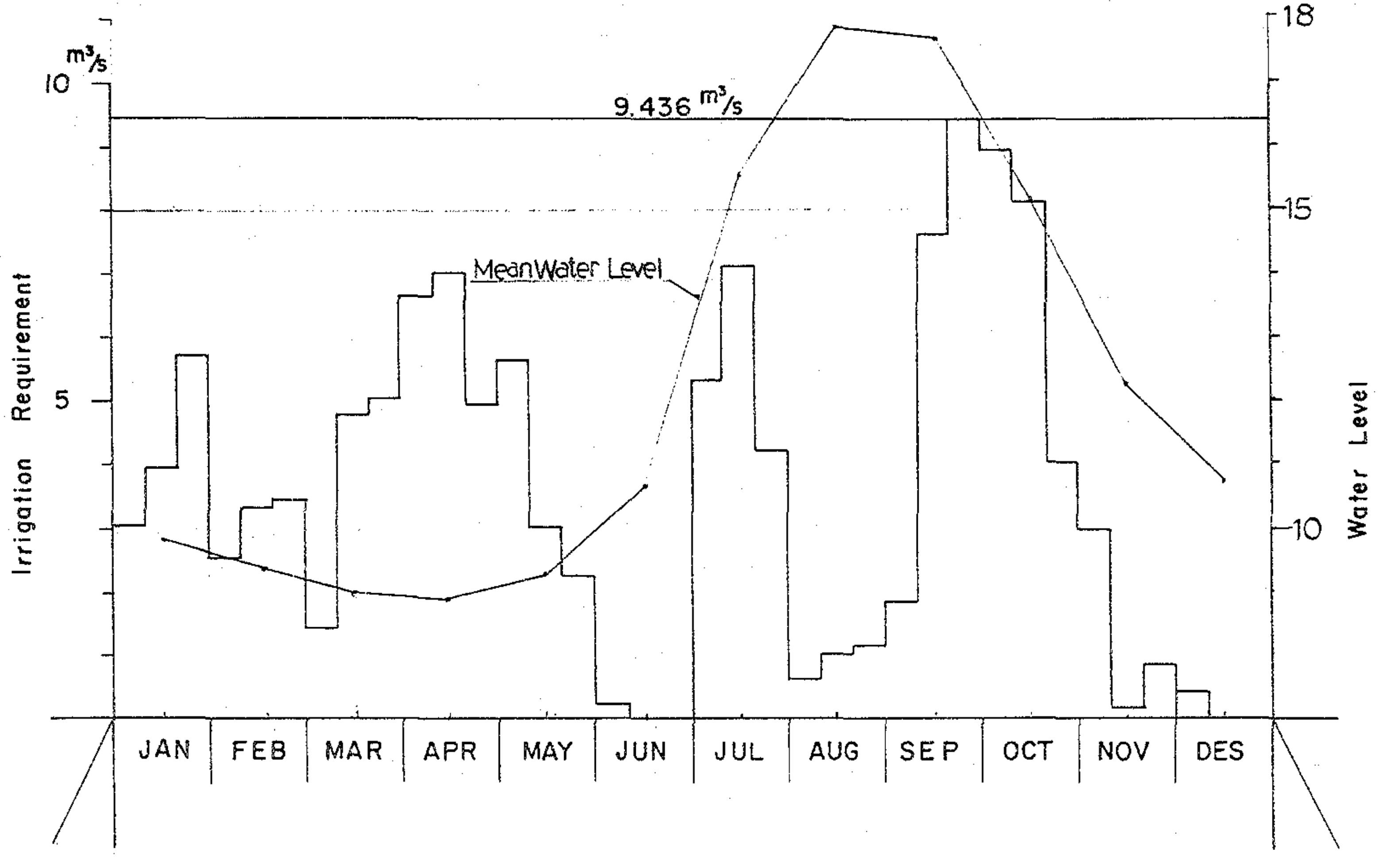


TABLE Ⅷ-3-2 Monthly Mean Water Level Rajshuhi (1977.Apr ～ 1987.Mar)

Water Year	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY.	AUG.	SEP.	OCT.	NOV.	DEC.
1977				8.483	8.658	10.042	15.094	17.515	16.877	14.903	11.960	10.569
1978	9.677	9.223	8.989	9.165	9.922	11.975	16.350	18.327	18.029	15.541	12.424	10.752
1979	9.619	9.474	9.108	8.933	9.194	9.188	14.218	16.789	14.788	12.846	10.288	9.595
1980	8.813	8.568	8.449	8.399	8.722	10.576	15.711	18.256	18.086	14.144	11.486	10.022
1981	8.994	8.631	8.244	8.373	8.798	9.530	15.670	17.726	16.712	14.133	10.884	9.667
1982	8.676	8.533	8.346	8.561	8.765	10.691	13.391	17.232	17.983	13.071	11.171	9.786
1983	8.644	8.478	8.000	7.935	8.961	9.485	13.925	16.622	18.248	16.345	12.466	10.436
1984	9.604	8.933	8.453	8.183	8.668	12.227	16.371	17.658	18.471	13.939	11.513	10.253
1985	9.613	7.084	8.646	8.461	8.722	9.587	14.727	17.761	17.571	17.477	14.001	11.637
1986	10.576	9.877	9.638	9.182	9.492	9.945	16.005	17.558	16.708	15.622	12.539	11.413
1987	10.826	9.902	9.111									
LEVEL.W.L	9.504	9.070	8.698	8.568	8.990	10.325	15.148	17.544	17.347	14.802	11.882	10.413
Kasba	9.835	9.401	9.029	8.899	9.321	10.656	15.479	17.875	17.678	15.133	12.213	10.744
Baraipara	10.661	10.227	9.855	9.725	10.147	11.482	16.305	18.701	18.504	15.957	13.039	11.570
Sultanganj	10.813	10.379	10.007	9.877	10.299	11.634	16.457	18.853	18.656	16.111	13.191	11.722

TABLE Ⅷ-3-3 DIVERSION WATER REQUIREMENT

(m³/s)

Year	BARIND AREA			FlOOD PLAIN AREA		
	Dry Season	Wet Season	Total	Dry Season	Wet Season	Total
1977	—	—	—	—	—	—
78	3.326	1.753	5.080	646	372	1.018
79	Ⓜ4.164	1.164	5.328	Ⓜ 794	248	1.042
80	Ⓐ3.383	Ⓐ1.469	Ⓐ4.853	Ⓐ 661	Ⓐ 311	Ⓐ 972
81	2.682	1.685	4.367	522	358	880
82	3.018	Ⓜ2.967	Ⓜ5.986	577	Ⓜ 628	Ⓜ1.205
83	3.782	802	4.585	727	169	896
84	3.452	837	4.290	668	178	846
85	3.338	1.039	4.377	649	222	871
86	3.435	1.370	4.805	664	291	955
	3.398	1.454	4.852	656	309	965

Dry Season ; JAN ～ JUNE

Wet Season ; JULY～ DEC

Ⓜ; Diversion Water Requirement ; Max

Ⓐ; 〃 ; Ave

3-1-2. Type of pumping station and pumping facility

On the basis of detail discussion in the previous chapter, it was decided that the pumps will be of fixed type, the pumping facilities will be of vertical mixed flow type at Baraipara & Kasba.

3-1-3. Diameter and Number of Pumps

(1) Selection of Diameter and Number of Pumps

As for mentioned subject, the following items were taken into consideration ;

- to get the most suitable combination of diameter and number for seasonal water requirement including the higher efficiency of operation.
- to consider the diversification of risks and exchangeable parts

The following combination has been studied to select the most suitable conbination of pump capacity & number.

	Baraipara P.S.	Kasba P.S.
Case-1 1/3 division	14.20 m^3/s = 852 m^3/m	2.749 m^3/s = 165 m^3/m
Case-2 1/4 division	10.65 m^3/s = 639 m^3/m	2.062 m^3/s = 124 m^3/m
Case-3 1/5 division	8.52 m^3/s = 511 m^3/m	1.65 m^3/s = 99 m^3/m

The studies for these conbination have been shown in TABLE Ⅷ-3-4 and Ⅷ-3-5, for Baraipara and Kasba stations, respectively.

The cost of the pumping facilities and the operation costs for each case have been estimated as shown in TABLE Ⅷ-3-6.

As a result,

Baraipara P.S.	Case-2	Ø1,650 $^{m/m}$ × 4 unit
Kasba P.S.	Case 2-2	Ø1,350 $^{m/m}$ × 1 unit
		Ø1,000 $^{m/m}$ × 2 unit

The scale of mentioned facilities are considerable for this project from the view point of operation and maintenance.

TABLE Ⅷ-3-4 NUMBER OF PUMP UNIT

(Brind Area)

Item \ Case	Unit	1		2		3 − 1		3 − 2	
Pump Type		Vertical Mixed Flow Pump							
Irrigation Requirement	m^3/s	42.588 (2,556 m^3/m)							
Pump Capacities	m^3/m	552	300	399	240	331	180	318	240
Pump Bore	mm	2,000	1,500	1,650	1,350	1,650	1,200	1,500	1,350
Actual Head	m	21.90							
Total Head	m	27.00							
Pump Efficiency	%	85	84	84.5	83.5	84.5	83	84	83.5
Motor Power	kw	3,290	1,810	2,390	1,460	1,990	1,100	1,920	1,460
Pump Units		3	3	4	4	5	5	2	8
Total Motor Power	kw	15,300		15,400		15,450		15,520	

TABLE Ⅷ-3-5 NUMBER OF PUMP UNIT

(Flood Plane Area)

Item \ Case	Unit	1	2 - 1	2 - 2		3
Pump Type		Vertical Mixed Flow Pump				
Irrigation Requirement	m³/s	8.247 (495 m³/m)				
Pump Capacities	m³/m	165	124	247	124	99
Pump Bore	mm	1,200	1,000	1,350	1,000	900
Actual Head	m	12.00				
Total Head	m	13.00				
Pump Efficiency	%	83	82	83.5	82	81
Motor Power	kw	490	370	720	370	300
Pump Units		3	4	1	2	5
Total Motor Power	km	1,470	1,480	1,460		1,500

1) Motor Power ; $RHP = 0.163 \dfrac{Q \times H \times (1+\alpha)}{np \times nt}$

TABLE Ⅷ-3-6 ANNUAL COST OF EACH CASE

(1000TK)

Case \ Item	PUMP FACILITIES COST 1」		Electric Charge	Total Cost
	Initial Cost 1」	Annual Cost 3」		
1. Baraipara P.S				
1	646,100	110,700	92,500	203,200
2	633,400	① 108,500	① 87,800	①196,300
3-1	701,500	120,200	88,800	208,200
3-2	651,500	111,600	88,700	200,300
2. Paba P.S				
1	230,300	39,400	12,900	52,300
2-1	250,200	42,800	11,000	53,800
2-2	216,100	① 37,000	① 10,400	① 47,400
3	274,300	47,000	10,400	57,400

1」 Refer to TABLE Ⅷ-3-7,8

2」 Refer to TABLE Ⅷ-3-9

3」 The formula of estimation on the capital recovery ratio is shown as following.

$$P = \frac{1\ (1+i)n}{(1+i)n - 1} \quad (1 + \text{Interest Ratio for Construction periods.})$$

Interest Ratio = $\alpha \times 1' \times t$

Where : f = Interest 12%

α = Farmer's share 40%

f'= Interest of Farmer's share 14%

t = Periods 5 years

n = Durable Life

(2) Economical Study

As for the mentioned proposed plan in the previous section, the costs for the facilities are summarized in TABLE Ⅷ-3-7 and Ⅷ-3-8 and O & M costs are shown in TABLE Ⅷ-3-9, furthermore, seasonal operation pumps number are shown in TABLE Ⅷ-3-10 and Ⅷ-3-11.

TABLE Ⅷ-3-7 PUMP FACILITIES COST (Baraipara·P·S)

(1000TK)

Item \ Case	1		2		3-1		3-2	
	φ2000	φ1500	φ1650	φ1350	φ1650	φ1200	φ1500	φ1350
Pump 1」	@ 38,000	@ 23,500	@ 28,000	@ 20,000	@ 28,000	@ 17,500	@ 23,500	@ 20,000
Motor 2」	@ 47,000	@ 19,000	@ 27,500	@ 15,500	@ 21,000	@ 13,000	@ 20,000	@ 15,500
Valve & Pipe	@ 14,100	@ 8,200	@ 10,500	@ 7,000	@ 10,500	@ 5,800	@ 8,200	@ 7,000
Crane	14,100		11,700		11,700		8,200	
Electric Equipment	40,000		48,200		56,400		56,400	
Equipment Work	85,600		83,700		92,700		86,100	
Transportation	57,000		55,800		61,700		57,400	
Total Cost	646,100		633,400		701,500		651,500	

1」 Refer to FIGURE Ⅷ-3-5

TABLE Ⅷ-3-8 PUMP FACILITIES COST (Kasba P.S)

(1000TK)

Case / Item	1 φ1,200	2-1 φ1,000	2-2 φ1350	2-2 φ1000	3 φ 900
Pump 1」	@ 20,000	@ 14,000	@ 25,000	@ 14,000	@ 11,000
Motor 2」	@ 17,500	@ 17,000	@ 18,000	@ 17,000	@ 17,000
Valve & Pipe	@ 11,200	@ 8,500	@ 12,500	@ 8,500	@ 6,700
Crane	7,700	7,000	8,200		6,200
Electric Equipment	26,500	30,800	26,500		35,000
Equipment Work	30,000	32,700	28,100		35,800
Transportation	20,000	21,700	18,800		23,800
Total Cost	230,300	250,200	216,100		274,300

1」 Refer to FIGURE Ⅷ-3-5

FIGURE - VIII-3-5 COST OF PUMP and MOTOR

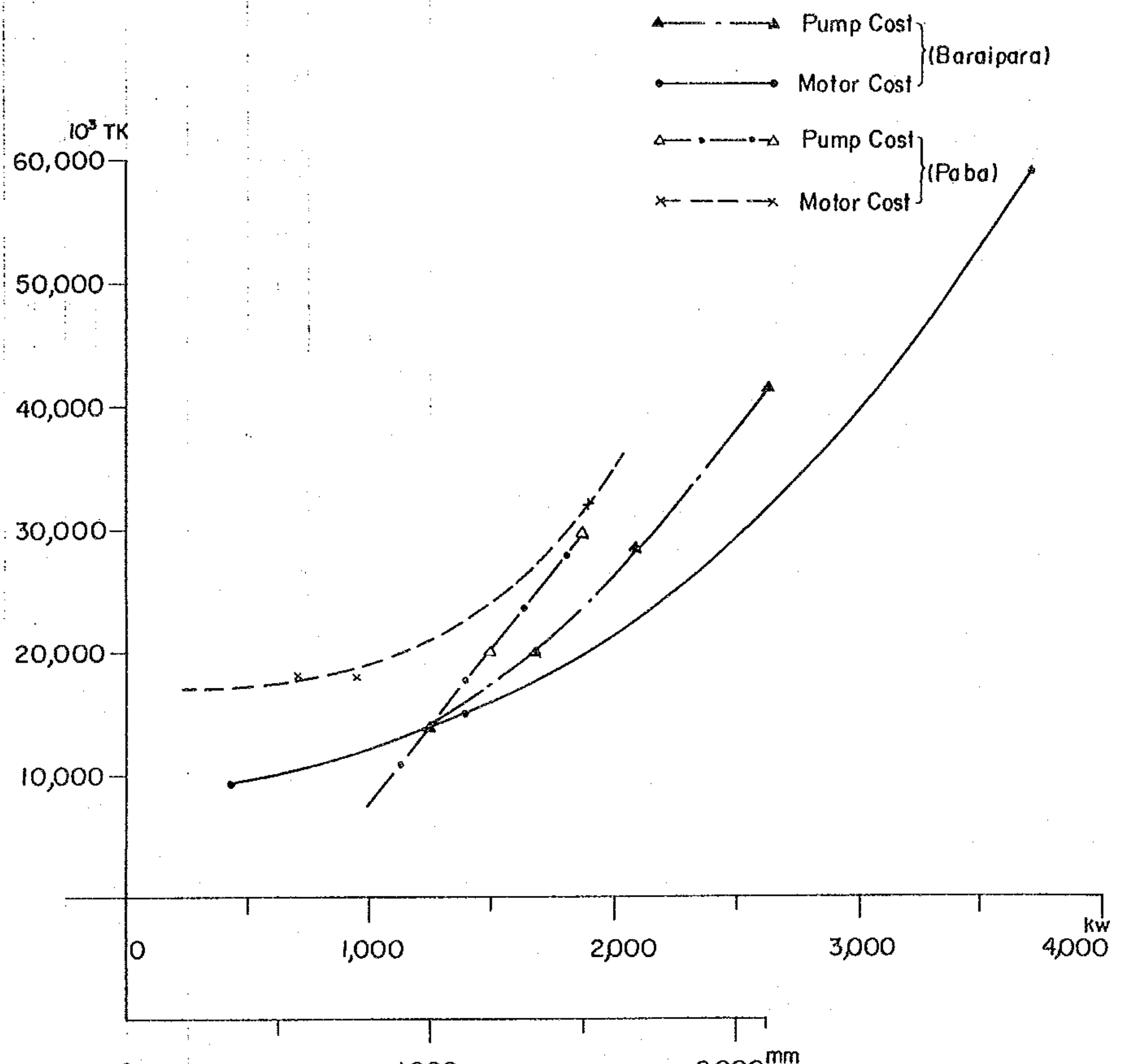


TABLE Ⅷ-3-9 ELECTRIC CHARGE

(1000TK)

Item / Case	① kw Motor power ×Pump Unit	② kw Total Motor Power	Demand Charge TK/kw/Y ②×35	Pump Operation Hour [4hr/D 20hr/D	Electric Charge ①× [3.75TK/KWH 1.65
1. BaraiparaP.S				hr	
1	3,290 ×3 1,810 ×3	15,300	500	1,568 7,840 1,416 7,080	19,300 42,500 9,600 21,100
2	2,390 ×4 1,490 ×4	15,400	500	1,532 7,660 2,460 12,300	13,700 30,200 13,700 30,200
3-1	1,920 ×5 1,100 ×5	15,450	500	2,308 11,540 2,644 13,220	16,600 36,500 10,900 24,000
3-2	1,920 ×2 1,460 ×8	15,520	500	1,008 5,040 3,748 18,740	7,200 15,900 20,500 45,100
2. Paba P.S 1	490 ×3	1,470	———	2,224 11,120	4,000 8,900
2-1	370 ×4	1,480	———	2,508 12,540	3,400 7,600
2-2	720 ×1 370 ×2	1,460	———	644 3,220 1,136 5,680	1,700 3,800 1,500 3,400
3	300 ×5	1,500	———	2,900 14,500	3,200 7,200

1」 Refer to TABLE - Ⅷ-3-10,11

TABLE Ⅷ-3-10 PUMP OPERATION UNITS OF EACH MONTH

Actual Head 21.9m

Date	Water Requirement m^3/s	%	Suction Water Level m	Actual Head m	Capacity 1/ %	1 2000×3	1 1500×3	2 1650×4	2 1350×4	3-1 1650×5	3-1 1000×5	3-2 1500×2	3-2 1350×2
JAN 1	8.685					1	—	1	1	1	1	1	1
JAN 2	17.395		10.6	19.9	104	2	—	2	1	2	3	1	3
JAN 3	17.167					2	—	2	1	2	3	1	3
FEB 1	21.269					2	1	2	2	1	5	1	4
FEB 2	〃		10.2	20.3	104	2	1	2	2	1	5	1	4
FEB 3	〃					2	1	2	2	1	5	1	4
MAR 1	29.523					3	1	2	4	5	1	1	6
MAR 2	〃		9.8	20.7	102	3	1	2	4	5	1	1	6
MAR 3	34.385					2	3	3	4	5	3	2	6
APR 1	42.685					3	3	4	4	5	5	2	8
APR 2	17.395		9.7	20.8	102	3	2	3	4	5	3	1	8
APR 3	17.167					2	2	3	2	4	3	—	7
MAY 1	2.317					—	1	—	1	—	1	—	1
MAY 2	4.507		10.1	20.4	104	—	1	—	1	1	—	1	—
MAY 3	2.583					—	1	—	1	—	1	—	1
JUN 1	0.646					—	1	—	1	—	1	—	1
JUN 2	2.194		11.4	19.1	108	—	1	—	1	—	1	—	1
JUN 3	16.070					1	1	1	2	2	2	2	1
JUL 1	16.167					1	1	1	2	1	3	2	1
JUL 2	3.410		16.3	14.2	116	—	1	—	1	—	1	—	1
JUL 3	2.405					—	1	—	1	—	1	—	1
AUG 1	1.553					—	1	—	1	—	1	—	1
AUG 2	3.199		18.7	11.8	118	—	1	—	1	—	1	—	1
AUG 3	0.945					—	1	—	1	—	1	—	1
SEP 1	0.515					—	1	—	1	—	1	—	1
SEP 2	0.008		18.5	12.0	118	—	1	—	1	—	1	—	1
SEP 3	0.760					—	1	—	1	—	1	—	1
OCT 1	22.401					2	2	2	3	5	2	1	6
OCT 2	30.240		15.9	14.6	116	3	—	2	3	5	2	2	4
OCT 3	———					—	—	—	—	—	—	—	—
NOV 1	9.326					1	—	—	2	1	1	—	2
NOV 2	8.398		13.0	17.5	110	1	—	—	2	1	1	—	2
NOV 3	5.705					1	—	1	—	1	—	1	—
DEC 1	2.540					—	1	—	1	—	1	—	1
DEC 2	10.044		11.5	19.8	108	—	2	1	1	1—	2	1	1
DEC 3	17.251					2	—	2	1	2	2	1	3
Total						392	354	383	615	577	661	252	937

1/ Refer to Figure Ⅷ-3-6

FIGURE - Ⅷ-3-6 PUMP CHARACTERISTIC CURVE
(Baraipara P. S)

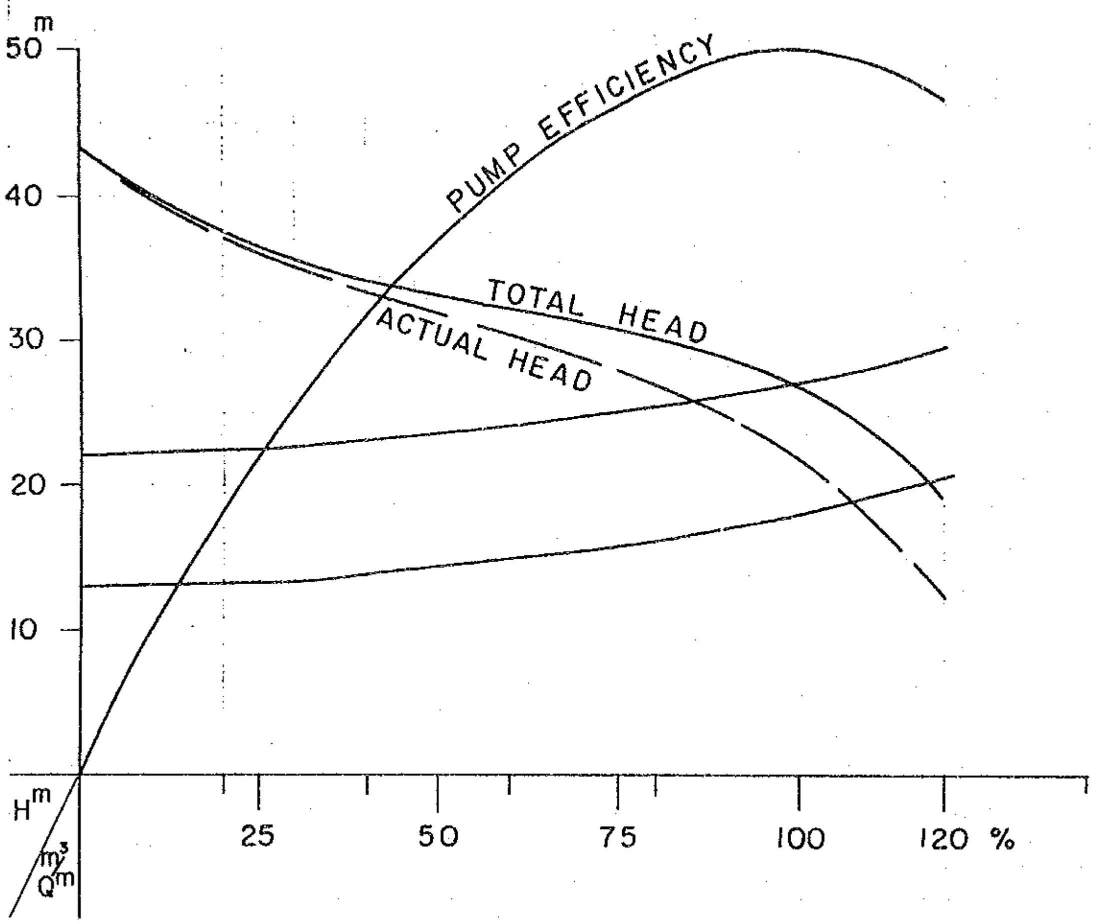


TABLE Ⅷ-3-11 PUMP OPERATION UNITS OF EACH MONTH

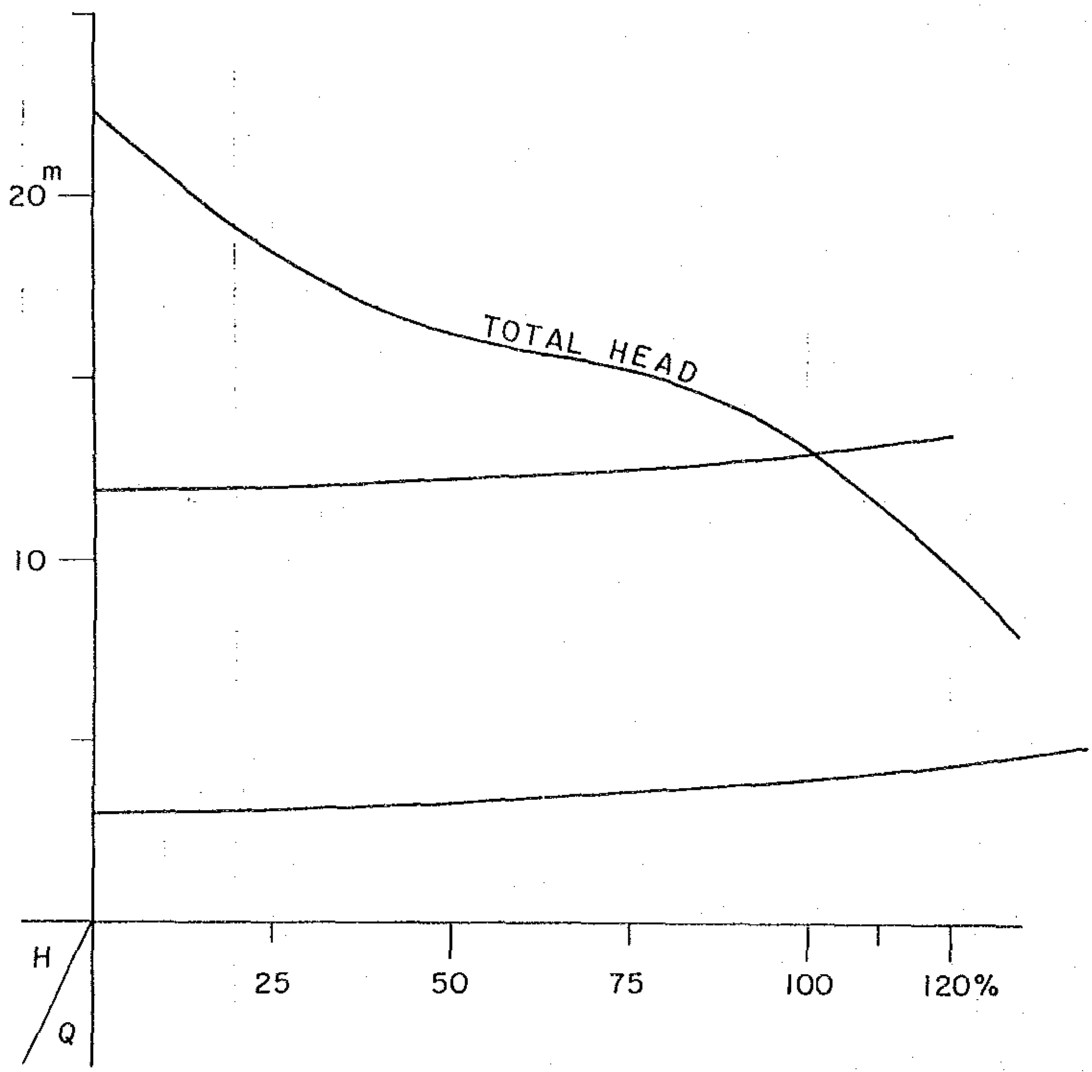
Actual Head 12.0m

Date	Water Requirement m^3/s	%	Suction Water Level m	Actual Head m	Capacity 1/ %	1 1200×3	2 1000×4	3-1 1350×1	3-1 1000×2	3-2 900×5
JAN 1	1.729					1	1	—	1	1
JAN 2	3.462		9.8	10.0	112	2	2	1	—	2
JAN 3	3.417					2	2	1	—	2
FEB 1	4.234					2	2	1	—	3
FEB 2	〃		9.4	10.4	110	2	2	1	—	3
FEB 3	〃					2	2	1	—	3
MAR 1	5.877					2	3	1	1	4
MAR 2	〃		9.0	10.8	109	2	3	1	1	4
MAR 3	6.298					3	4	1	1	4
APR 1	8.247					3	4	1	2	5
APR 2	6.779		8.8	11.0	107	3	4	1	1	4
APR 3	4.941					2	3	1	1	3
MAY 1	0.395					1	1	—	1	1
MAY 2	0.769		9.3	10.5	110	1	1	—	1	1
MAY 3	0.441					1	1	—	1	1
JUN 1	0.110					1	1	—	1	1
JUN 2	0.468		10.6	9.2	116	1	1	—	1	1
JUN 3	3.427					2	2	1	—	2
JUL 1	3.311					2	2	1	—	2
JUL 2	0.727		15.4	4.4	120	1	1	—	1	1
JUL 3	0.410					1	1	—	1	1
AUG 1	0.331					1	1	—	1	1
AUG 2	0.682		17.8	2.0	120	1	1	—	1	1
AUG 3	0.202					1	1	—	1	1
SEP 1	0.110					1	1	—	1	1
SEP 2	0.002		17.6	2.2	120	1	1	—	1	1
SEP 3	0.162					1	1	—	1	1
OCT 1	6.910					3	3	1	1	4
OCT 2	6.449		15.1	4.7	120	2	3	1	1	4
OCT 3	——					—	—	—	—	—
NOV 1	1.989					1	1	—	1	2
NOV 2	1.791		12.2	7.6	120	1	1	—	1	1
NOV 3	1.217					1	1	—	1	1
DEC 1	0.542					1	1	—	1	1
DEC 2	2.142		10.7	9.1	116	1	1	—	1	2
DEC 3	3.679					2	2	1	—	2
Total						556	627	161	284	725

1/ Refer to Figure Ⅷ-3-7

FIGURE - Ⅷ-3-7 PUMP CHARACTERISTIC CURVE

(Kasba P. S)



3-1-4. Selection of Total Head

The pipe line should be prepared from the pumping station to delivery ponds at Baraipara and Kasba. The steel pipe is the most suitable under the consideration of strength, and availabilities for construction.

In this case, the diameter of the pipes are decided based on the average velocity of 2.0 m per second. The head loss in the pipe line is computed as follows.

Station	Q m^3/s	Diameter mm	Velocity m/s	Loss Head m/m	Hf *1	hf *2
					ℓ=1,400m	
Baraipara	6.92	1,800	2.719	0.00268	4.5	0.4
	4.17	1,500	2.360	0.00256	4.3	0.3
	8.34	2,000	2.655	0.00226	3.8	0.4
					ℓ=50m	
Kasba	4.72	1,500	2.671	0.00322	0.2	0.4
	2.37	1,200	2.096	0.00267	0.2	0.3

*1 Hf = Loss Head/m × 1.2 × ℓ
*2 hf ≒ Loss Head inside of pump facilities

From the above computation, total head estimated at Baraipara and Kasba are as follows ;

Baraipara ; 30.50-8.50+4.50+0.40 = 26.9 ≒ 27.0 m

Kasba ; 19.80-7.70+0.20+0.40 = 12.7 ≒ 13.0 m

3-1-5. Special Dimension of Pumps

Items \ Station	Baraipara P.S.		Kasba P.S.	
Pump Facilities	Vertical Mixed Flow		Vertical Mixed Flow	
Capacity (m^3/s)	399	240	247	124
Diameter (m·m)	1,650	1,350	1,350	1,000
Max. Actual Head (m)	22.0	22.0	12.0	12.0
Max. Total Head (m)	27.0	27.0	13.0	13.0
Power Source	Electric motor		Electric motor	
Output (kw)	2,390	1,460	720	370
Number of Pump	4	4	1	2
Max. Discharge	415	250	283	142
W.L. of Suction pipe (m)	8.5		7.70	
W.L. of Suction pipe (m)	30.50		19.80	

Note ; The variation of actual head is 9.0 m is average year

3-2. Design of Pumping Station

3-2-1. Design of Intake Canal

The water of the Ganges river consists of sediment, and its contents vary throughout the year, and the most high value appeared at end of flood season. In order to protect the damage to the pump facilities and canals function, it is proposed to construct a silting basin in front of suction tank of the pumping station.

As a basic criterion for design, average water velocity decided to have 0.15 m/s to 0.30 m/s in the canal, and the retarding period assumed to be 30-60 seconds in the basin.

Based on the intake discharge and depth of water, the width of canal estimated as follows ;

	Baraipara		Kasba	
Width of Canal	$\frac{42.588 m^3/s}{2.0 \times 0.20}$	≑ 100 m	$\frac{8.247\ m^3/s}{1.50 \times 0.20}$	≑ 30 m

On the other hand, the length of silting basin is calculated by the following formula,

$$L = K \frac{Q}{B \cdot Vg}$$

L ; Length of silting basin

K ; Safety factor (1.5 - 2.0)

Q ; Discharge (m^3/s)

B ; Width of Basin (m)

Vg ; Silting velocity on sediment of minimum size (m/s)

where ; Vg = 0.003 m/s (Grain size 0.1 mm S.G.S.S. = 1.10)

S.G.S.S; Specific Gravity of soil suspension.(See FIGURE Ⅷ-3-8)

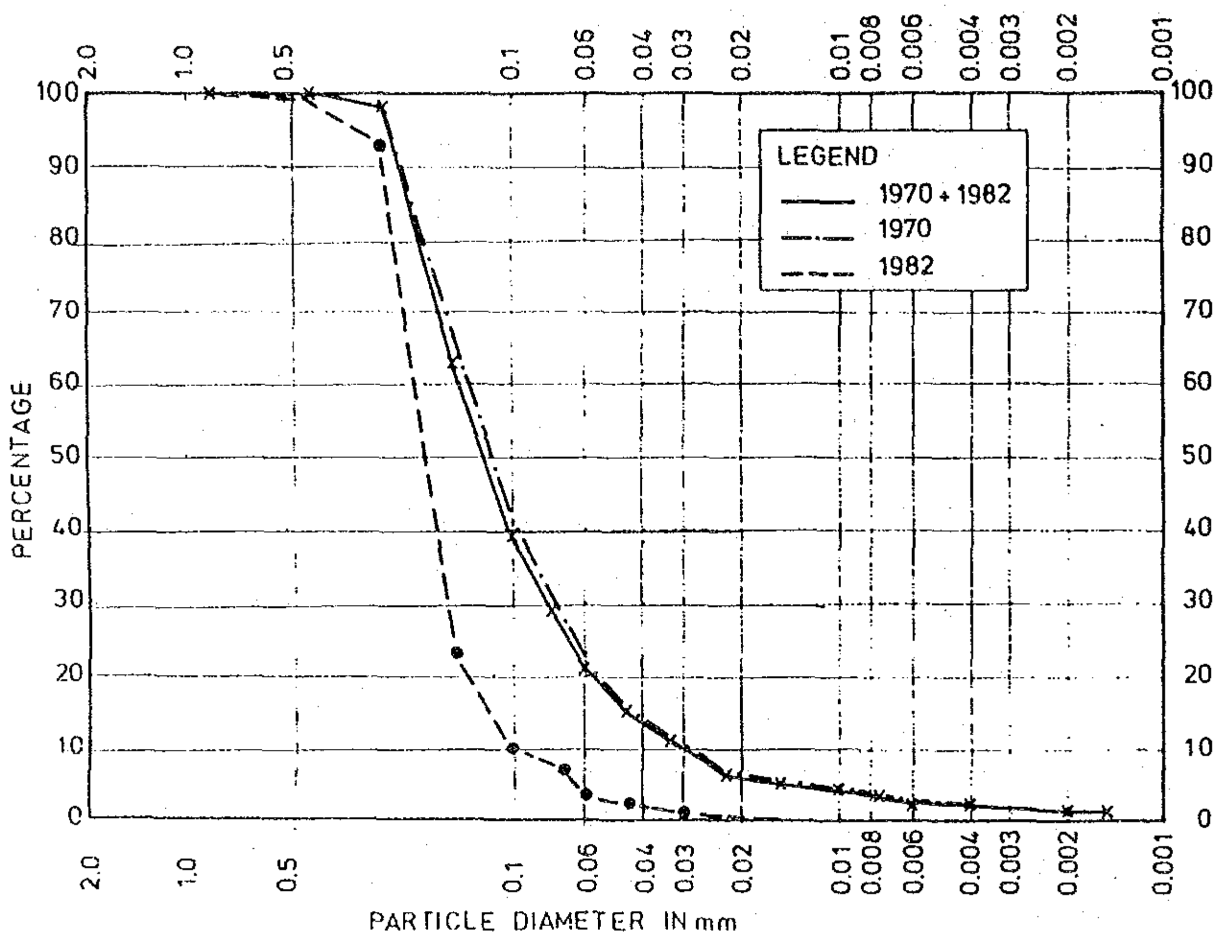
Baraipara	Kasba	Remarks
$L = 2.0 \times \frac{42.588}{100 \times 0.003}$ ≑ 300 m	$L = 2.0 \times \frac{8.247}{30 \times 0.003}$ ≑ 200 m	

Main items of silting basin are summarized as follows ;

Items	Baraipara	Kasba	Remarks
- Pump Capacity	42.588 m^3/s	8.247 m^3/s	The water depth is decided based on water level in dry season.
- Depth of water in the canal	2.10 m	1.50 m	
- Velocity of discharge	0.20 m/s	0.20 m/s	
- Width of Basin	100 m	30 m	
- Length of Basin	300 m	200 m	

FIGURE- Ⅷ-3-8

PARTICLE DISTRIBUTION OF BED MATERIAL OF GANGES RIVER



3-2-2. Design of Inlet of Pumping Station

(1) Height of sill at Inlet structure

Basically, the velocity of inlet is assumed to have 0.5 m/s below.

The results of the computation for the height of the sill are shown as follows;

	Baraipara P.S.	Kasba P.S.
Design discharge at Lowest Water Level	42.588 m^3/s	8,247 m^3/s
Width of inlet (B) *1	8.686 m	7.860 m
Water Depth (H) *2	40.20 m	11.20 m
Elevation of sill	6.5 m	6.30 m

*1 See (3) *2 Q/0.5×H ≦ H

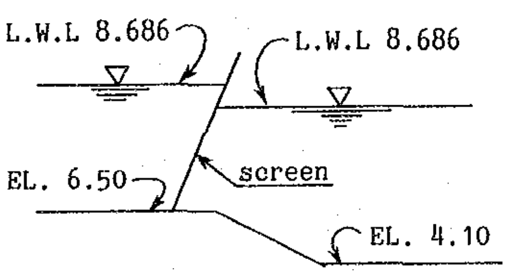
(2) Height of bottom at Suction Pump

At first, the head loss should be decided at the screen, after that, necessary water depth, and the height of bottom shall be determined. The procedure and the results are shown as follows ;

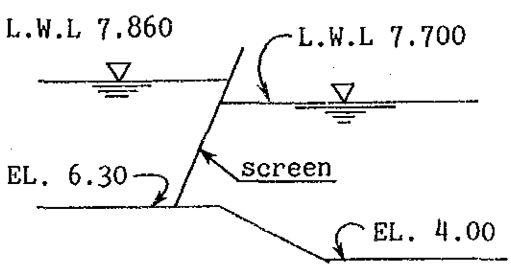
- Screen loss : $\Delta hr1$ ≒ 0.10 m

	Baraipara P.S.	Kasba P.S.
Suction Water level	8.686-0.10≒8.50 m	7.86-0.10≒7.70 m
Height of bottom at Suction pit	8.50-4.35[*3]≒4.10 m	7.70-3.65[*4]≒4.0 m

*3 Ø1,650 mm E+F = 4.25 m
*4 Ø1,350 mm E+F = 3.65 m



At Baraipara



At Kasba

3-2-3. Scale of Pumping Station

(1) Lay-out of supporting structure for pumps

Taking into consideration of the following factors, the scale of structures is decided are shown below.

- Diameter of the pumps
- Size of power equipment
- Distribution of the valves and pipe
- Scale of overhead travelling crane

	Width	Length	Height
Baraipara P.S.	15.80 m	40.80 m	13.0 m
Kasba P.S.	14.30 m	11.80 m	12.0 m

The allowance space for installation of the equipment and the space of operation are as follows;

	Width	Length	Height
Baraipara P.S.	15.80 m	5.60×2 m	13.0 m
Kasba P.S.	14.30 m	4.60×7.20 m	12.0 m

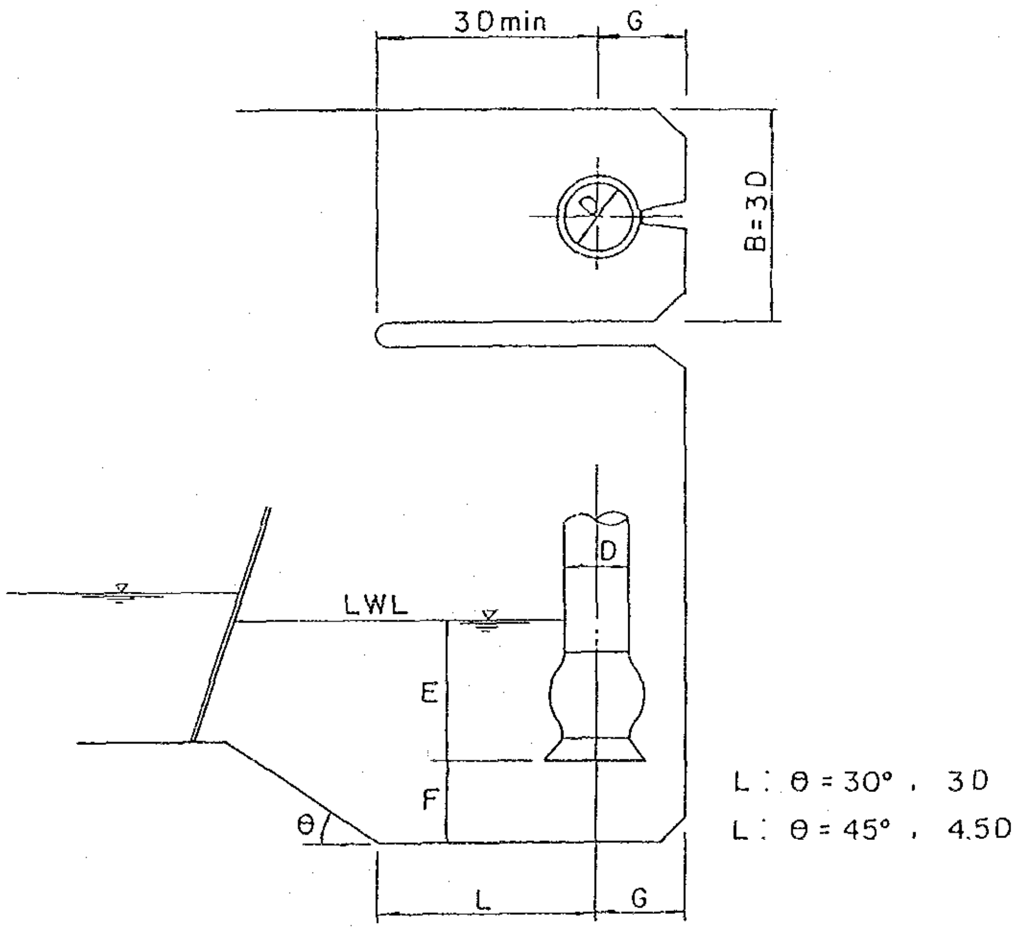
Finally, the shapes of the planes for supporting structures are shown as follows ;

	Width	Length	Spaces
Baraipara P.S.	15.80 m	52.00 m	≒ 830 m^2
Kasba P.S.	14.30 m	23.60 m	≒ 350 m^2

(2) Dimension of suction pump and space of pumps

There are some design criteria for the suction pit and space for the pump equipments. Based on the criteria, the lay-out of the structures are shown in the following figures.

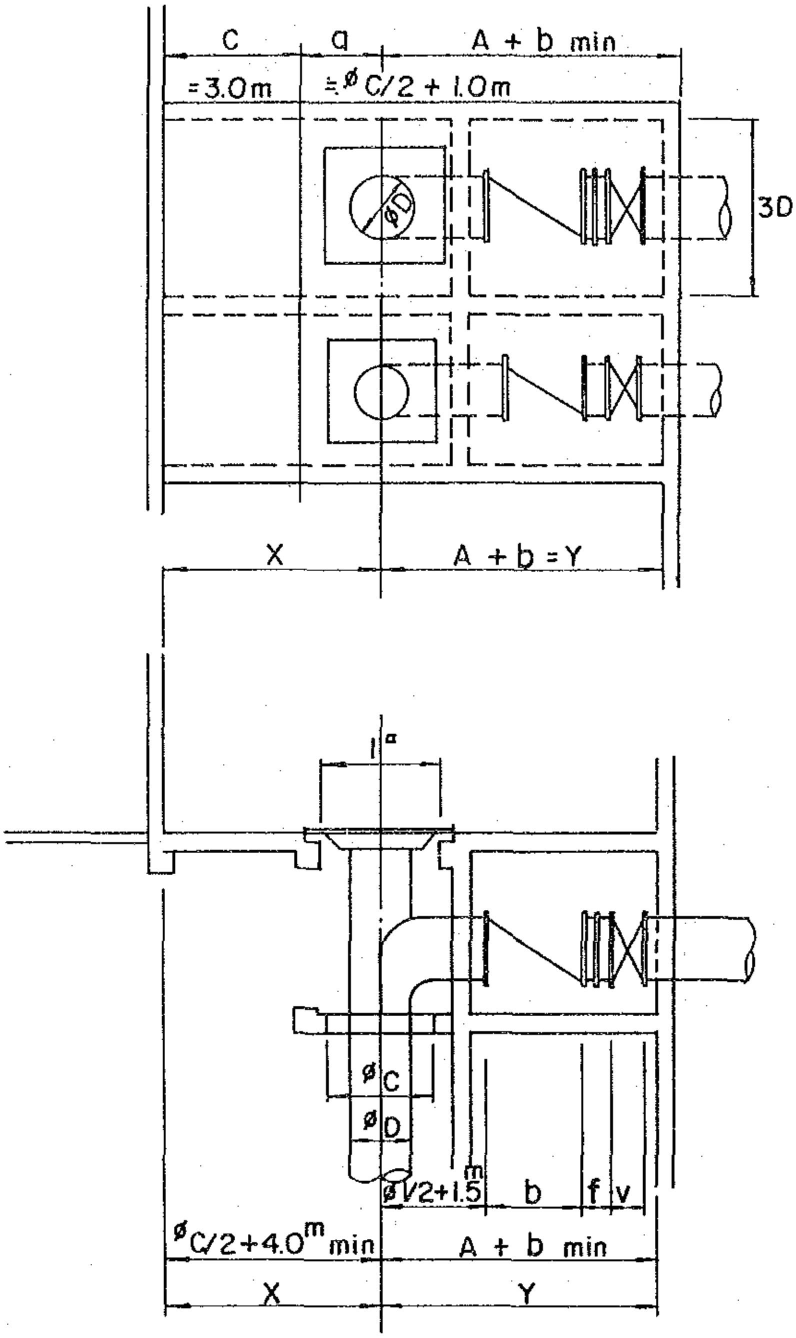
FIGURE Ⅷ-3-9 PUMP SUCTION



mm

D	B=L	E	F	G
1650	5000	2700	1650	1800
1350	4000	2300	1350	1500
1000	3000	1700	1000	1100

FIGURE- Ⅷ-3-10 PUMP PIT



øD	B≒3D	A	øC	1ª	b	X	Y
1650	5000	5500	2900	3300	2600	6000	9000
1350	4000	5000	2300	2900	2200	5500	8000
1000	3000	4500	1750	2400	1800	5000	7000

FIGURE-Ⅷ-3-11 BARAIPARA PUMPING STATION

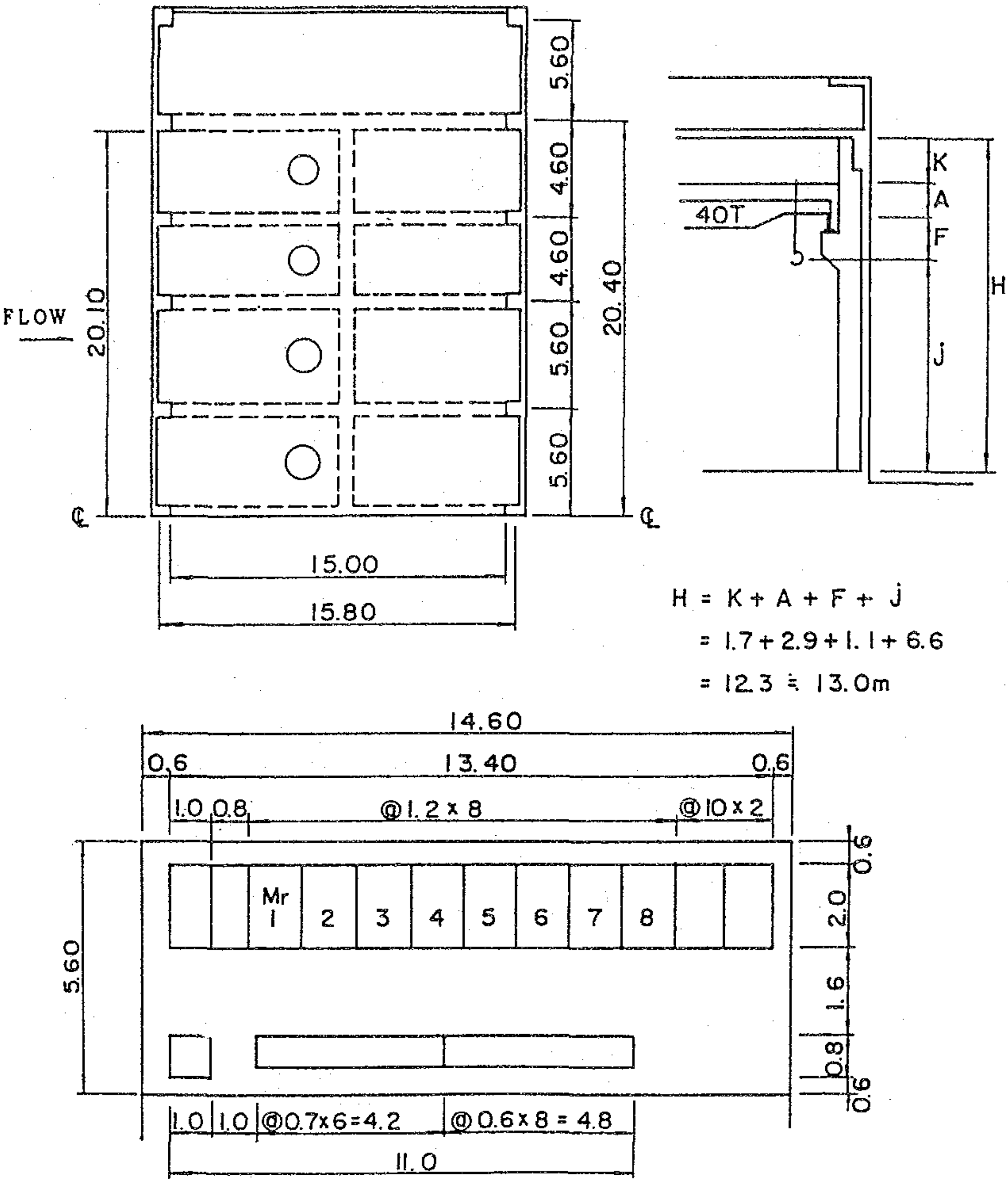
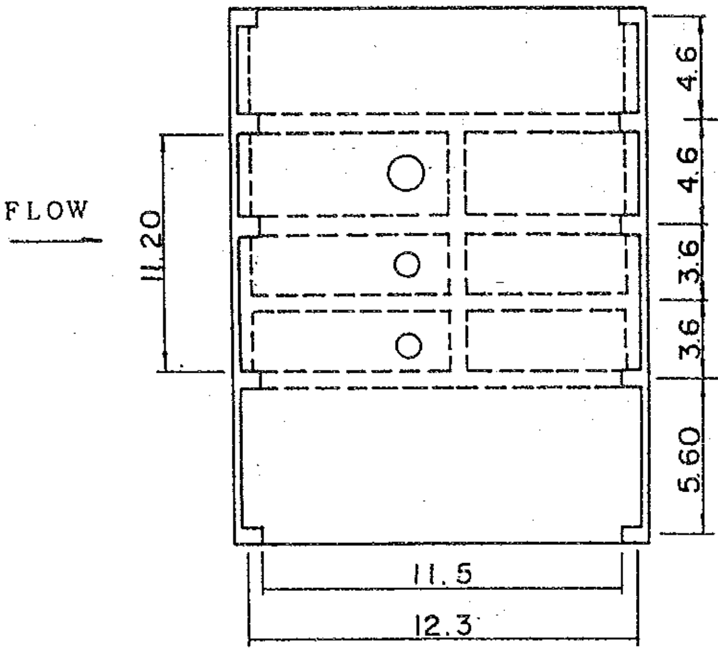
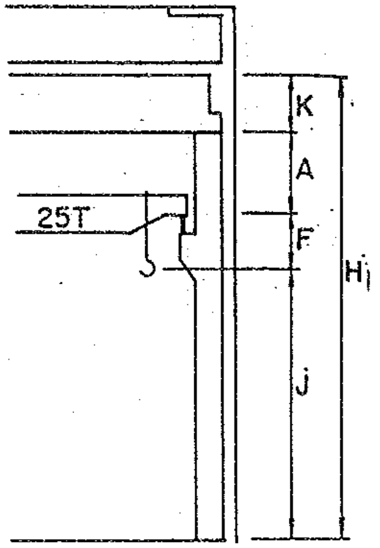


FIGURE – Ⅷ-3-12 KASBA PUMPING STATION

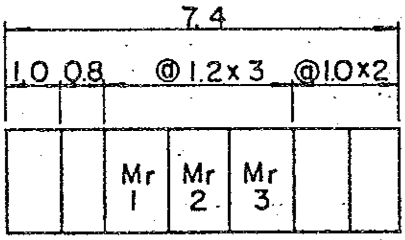


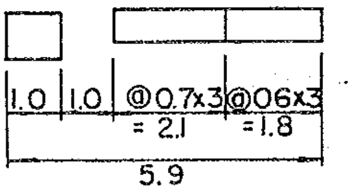


$H = K + A + F + J$

$= 1.5 + 2.6 + 0.9 + 6.2$

$= 11.2 \risingdotseq 12.0m$





3-2-4. Foundation Treatment and Protection Dike

(1) Foundation Structures

According to the test boring data at proposed pump site, shallow layer is covered with very hard clay, and deep layer consist of the sand with high degree of consolidation.

The value of N of standard penetration tests at an elevation of -3.0 m to -4.0 m is expected to be more than 30. So that, this layer can be considered as the bearing zone for the structures.

The concrete pile foundation should be previded for foundation treatment at the proposed site.

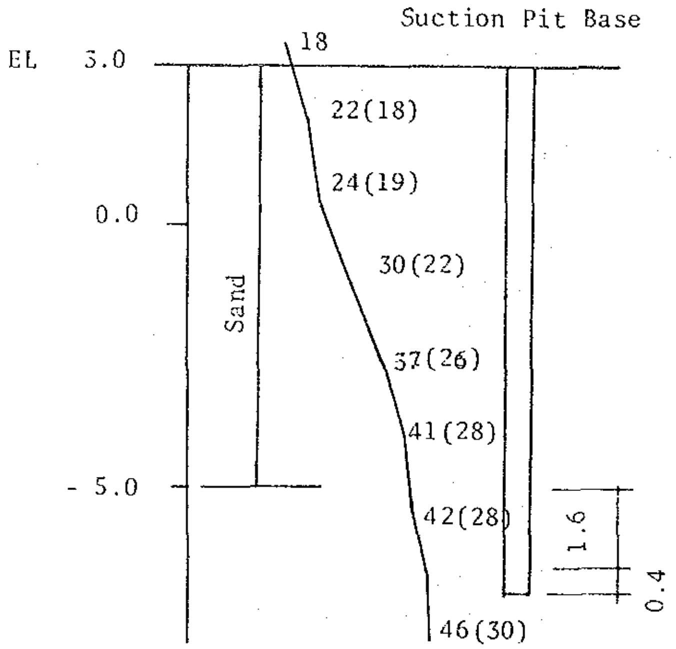
The bearing capacity of pile shall be estimated from the following formula.

$$Ra = 1/3 \{30N \cdot Ap + (\frac{NsLs}{5} + \frac{NcLc}{2}) \Psi$$

where ;

- Ra ; Long term allowable bearing capacity
- N ; N value at the top of pile under the ground
- Ap ; Cross section of top of the pile (m^2 or cm^2)
- Ns ; Average N value in sandy layer
- Ls ; Length of the pile in sandy layer
- Nc ; Average N value in clayey layer
- Lc ; Length of the pile in clayey layer
- ψ ; Length of circumference of the pile

(a) Bearing capacity of the pile at Baraipara P.S.



$Nc = \frac{113}{5} = 22$

$Lc = 8$ m

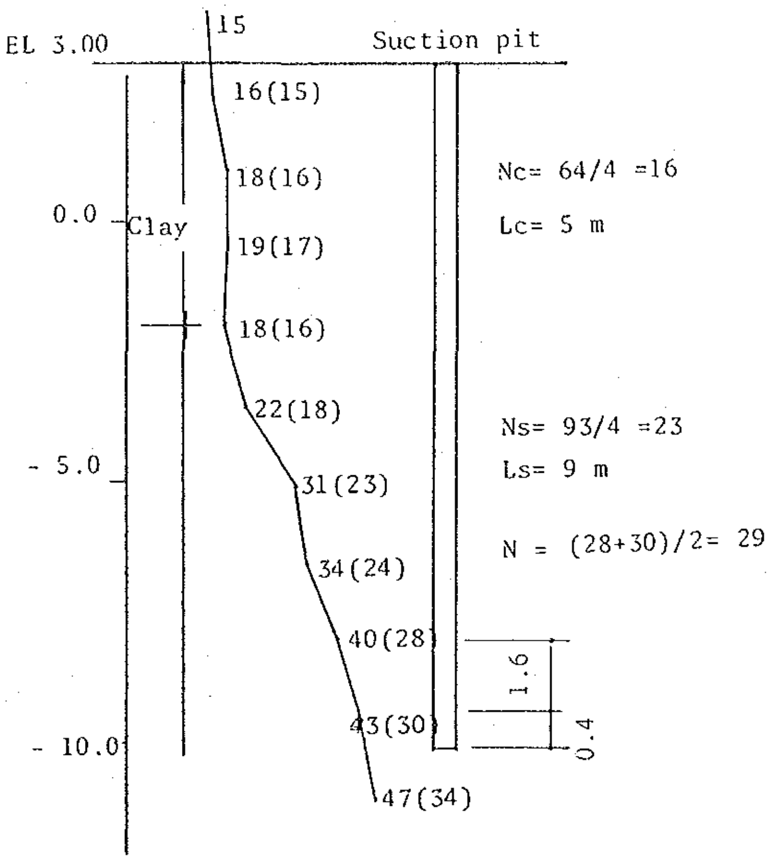
$N = \frac{28+30}{2} = 29$

□400

$$Ra = 1/3 \left\{ 30 \times 29 + 0.4 \times 0.4 + \frac{22 \times 8}{5} \times 1.6 \right\}$$

$$= 65t < 0.075 \times 40^2 = 120t$$

(b) Bearing capacity of the pile at Kasba



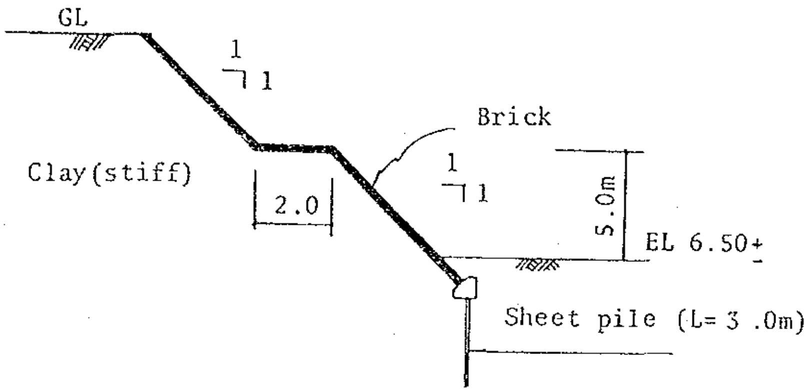
□400 $$Ra = 1/3 \{ 30\times29 + 0.4\times0.4 + (\frac{23\times7}{5} + \frac{16\times5}{2})\times1.6 \}$$

$$= 84t < 120t$$

(2) Flood Protection Structure

The flood protection structure is required to install for the protection of the erosion in the river bed at the conjunction of the Ganges river and intake canal.

A typical section of the structure is shown as follows ;



3-2-5. Design of Discharge Pond

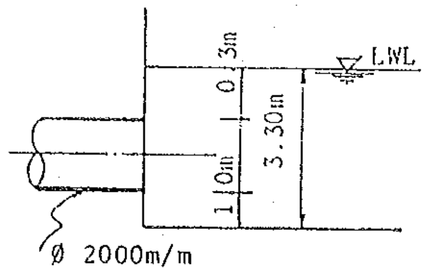
(1) Shape of the discharge pond

1) Barind Tract Area

Discharge pond should be connected with the main canal directly. Therefore, the lay-out was carried out considering the following items.

- flow velocity inside of the pond should be within 0.5 m/sec.
- the location of outlet of the pipe line should serve as a wave protector
- sedimentation in the pond

As a result of the analysis and under the consideration of the said items, the typical section of the structure is shown as follows ;



The width of discharge pond was computed by the following formula

$$B = \frac{Q}{hr \times v} = \frac{44.242}{3.30m \times 0.3} = 45 \text{ m}$$

This width could cover outlet of the pipe line (B≒23.0m) sufficiently. Necessary length of the pond was calculated by the following formula.

$$L = K \frac{Q}{B \cdot Vg} \doteqdot 80 \text{ m}$$

Q ; 44.242 m^3/x

B ; 45

Vg ; 0.025 m/s

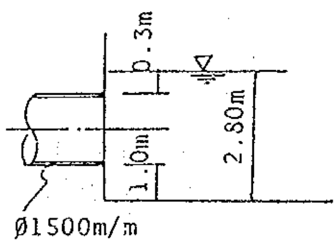
K ; 2

Therefore, dimensions of the discharge pond are as follows ;

Width	×	Length	×	Depth
45 m	×	80 m		3.30 m

2) Paba Flood Plain Area

The same approaches and considerations were applied for this area also. Typical shape is shown as below ;



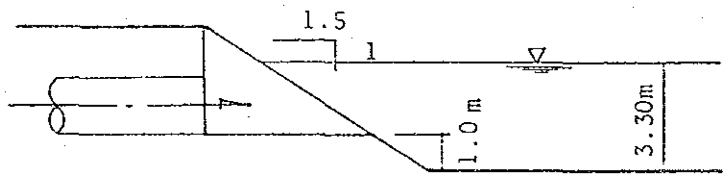
$$B = \frac{Q}{hi \times v} \doteqdot 15.0 \text{ m}$$

$$L = 2 \times Q / B \cdot Vg \doteqdot 50 \text{ m}$$

Width	×	Length	×	Depth
45 m	×	80 m		3.30 m

(2) Construction materials

It should be considered to protect the leakage of costly water.
Main dike shall be made by clayey materials with sufficient compaction and also inside surface of pond should be covered by concrete pavement.



3-2-6. Dual Purpose Pumps for Irrigation and Drainage at Kasba Pump Station

It has been proposed to review the possibility of dual purpose pumps for irrigation and drainage at Kasba Pump station. Terms to be considered for drainage plan at Kasba pump station are shown below, particularly, on the water level at the site.

- Inside water level	13.70 m
- Outside water level	20.325 m
- Actual Head	6.700 m
- Total Head	7.700 m

Pump capability has been evaluated from the pump characteristic curve considering the above mentioned points (FIGURE Ⅷ-3-13 and FIGURE Ⅷ-3-13).

From the evaluated result it is clear that the discharge should be controled by the valves to avoid cavitation.

The recommended capacities are as follows.

Ø 1,000 mm A = 160 m^3/m = 2.7 m^3/s

Ø 1,350 mm Q = 300 m^3/s = 5.0 m^3/s

Therefore, total capacity shall be at about 10.0 m^3/s.

For dual purpose application, some additional facilities shall be required. The development plan including additional facilities are shown in the following illustration.

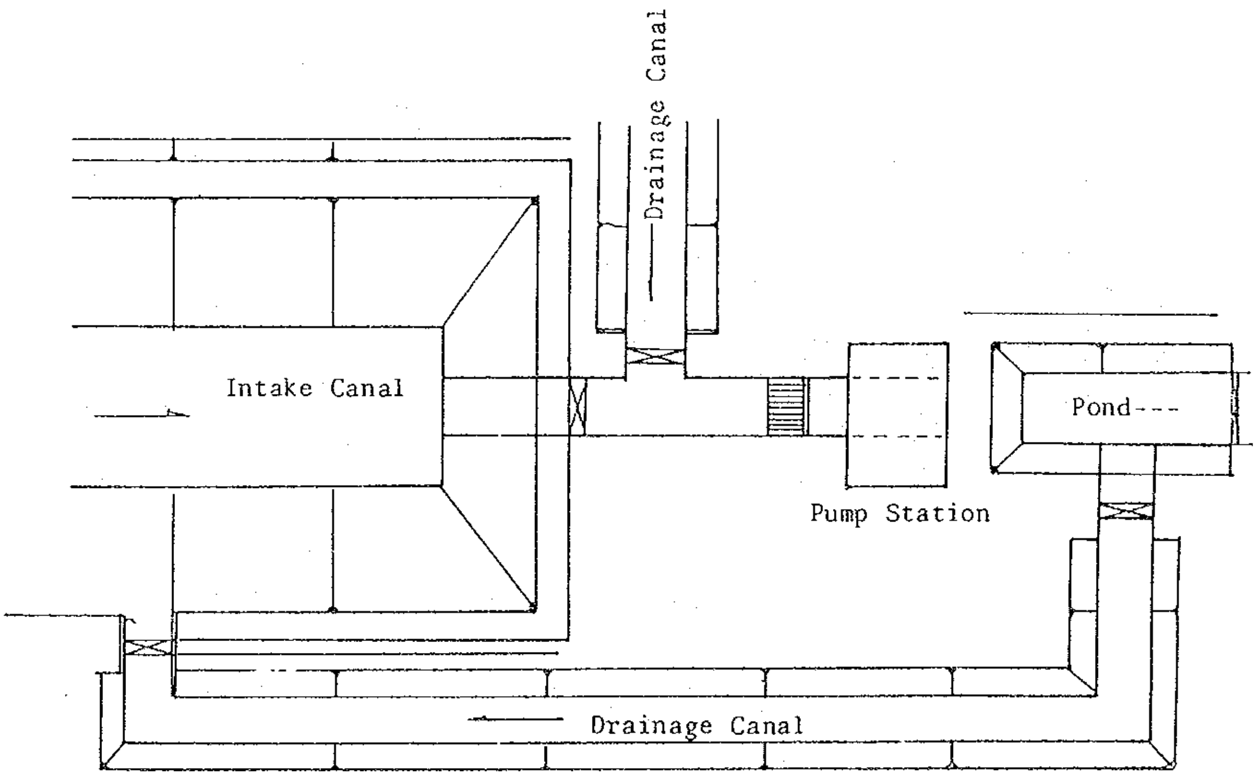


FIGURE – Ⅷ-3-13 CHARACTERISTIC CURVE

$124^{m^3/m} \times 13^{m} \times 1000^{mm} \times 370^{kw}$

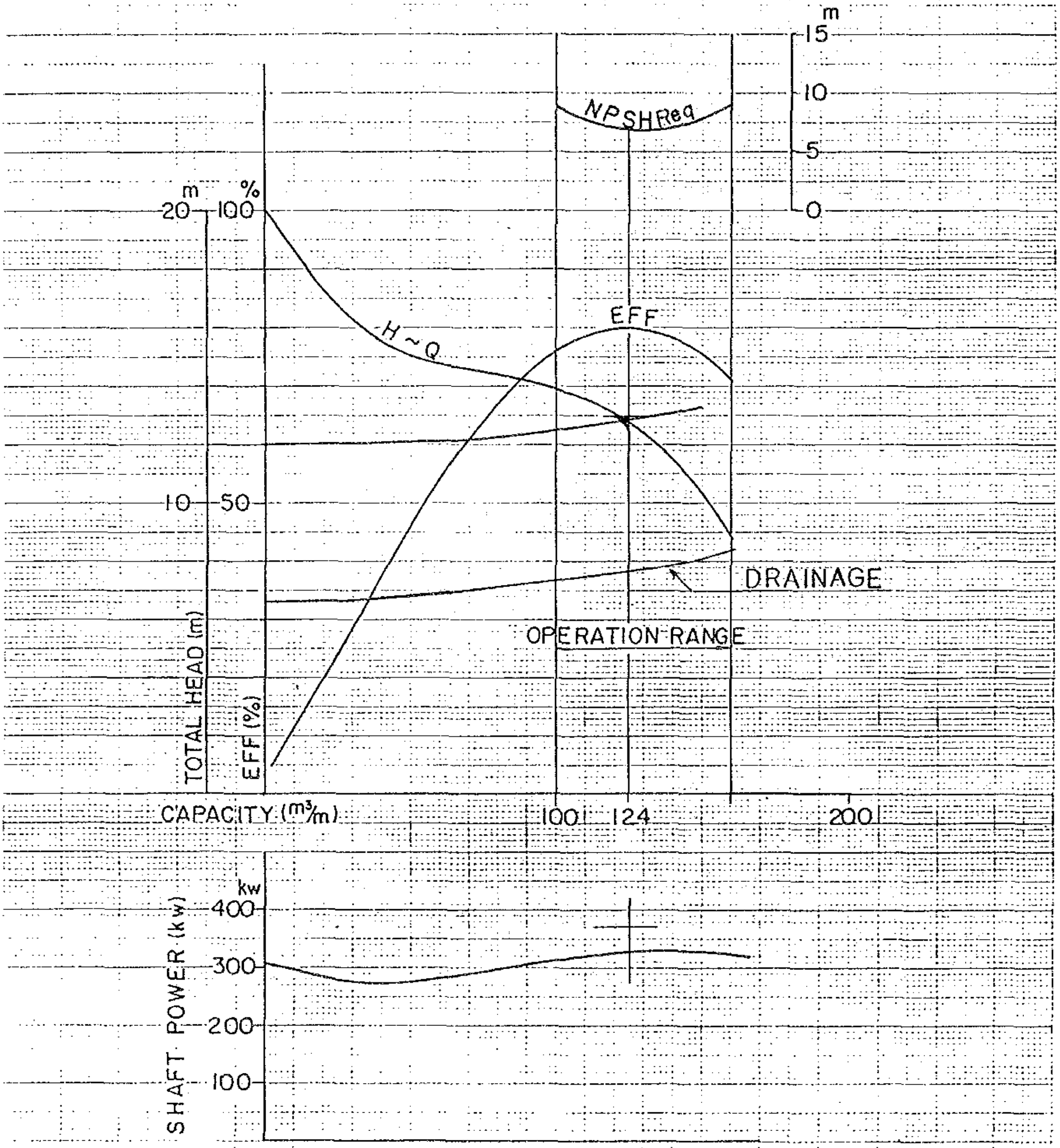
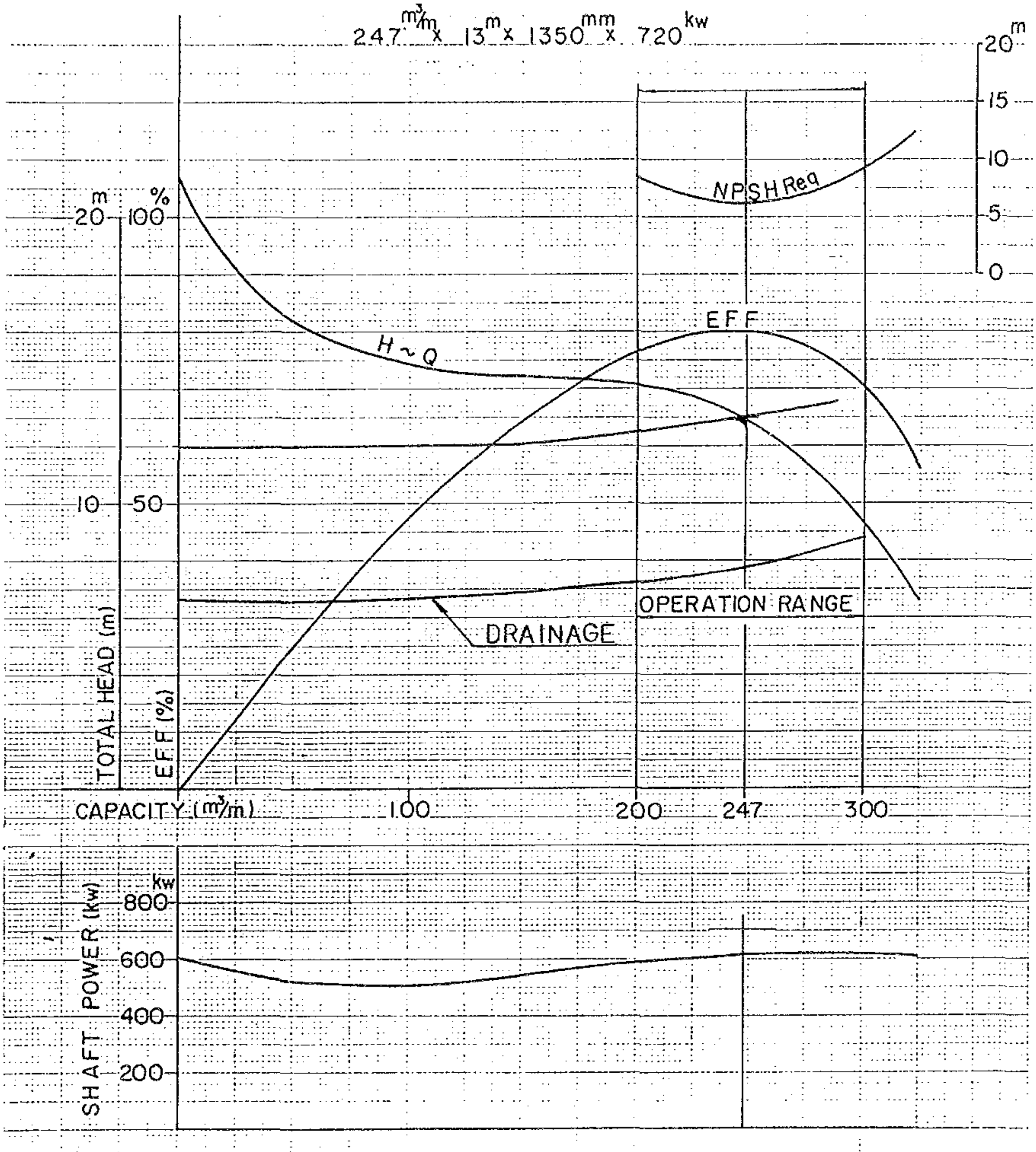


FIGURE - Ⅷ-3-14 CHARACTERISTIC CURVE



3-2-7. Power Supply

Total demand of electricity at Baraipara and Kasba pumping stations is about 17,000 kw.

Electric supply systems in the project area are described as follows, according to the information obtained from the Bangladesh Power Development Board.

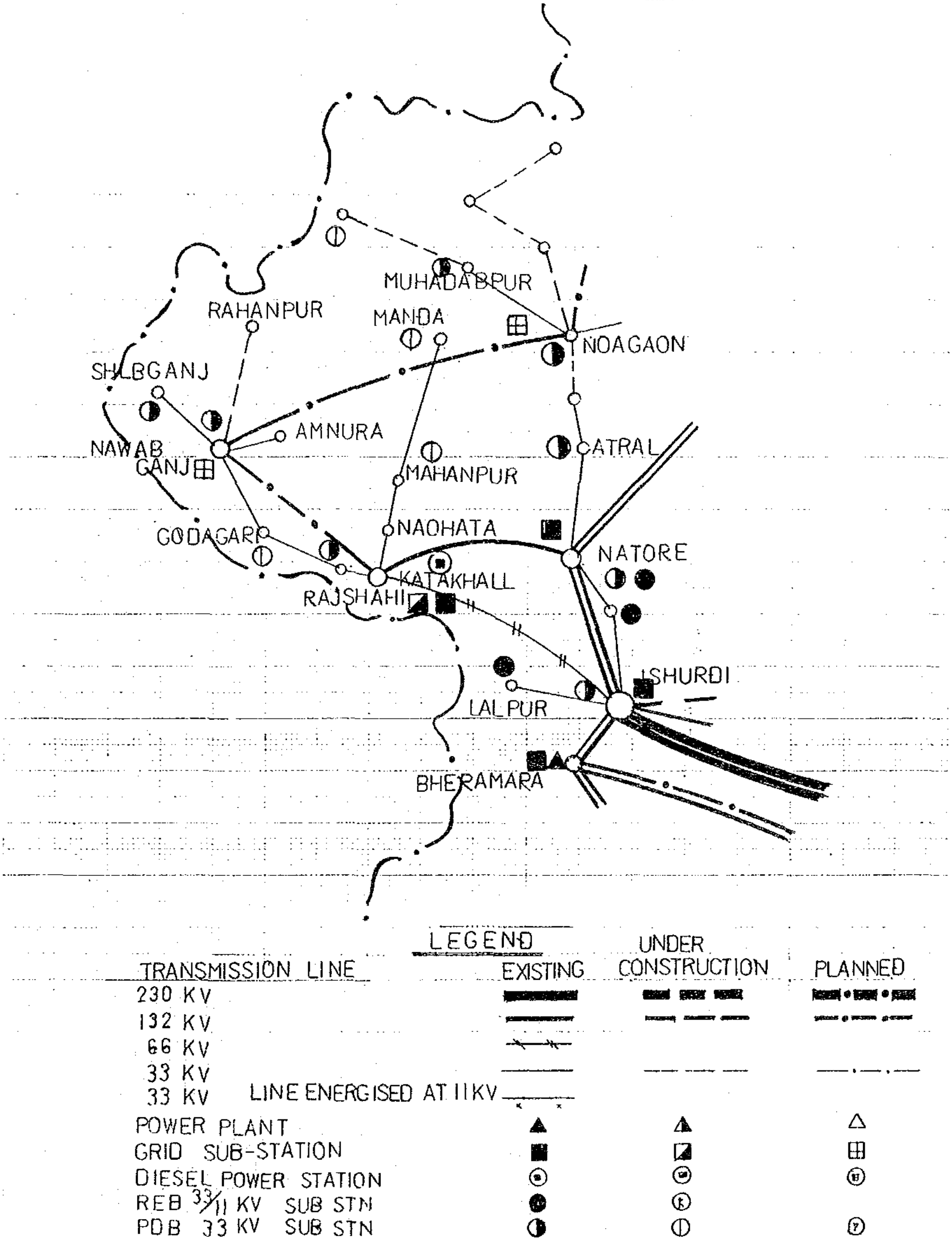
Area	Existing transmission line	Planning transmission line
	kv line(s)	kv line(s)
Natore	132 × 2	- -
Rajshahi	132 × 1 66 × 1	- -
Godagari	33 × 1	132 × 1
Sultanganj	33 × 1	132 × 1

Therefore, pumping stations at Godagari and Sultanganj, total demand of electricity can not be supplied by existing 33 kv transmission line.

However, in 1990 132 kv transmission line will be constructed and will be able to operate the pumping stations.

Transmission line in this project area is shown in FIGURE Ⅷ-3-15.

FIGURE VIII-3-15 TRANSMISSION · LINE



APPENDIX IX

ORGANIZATION AND MANAGEMENT

APPENDIX IX

ORGANIZATION AND MANAGEMENT

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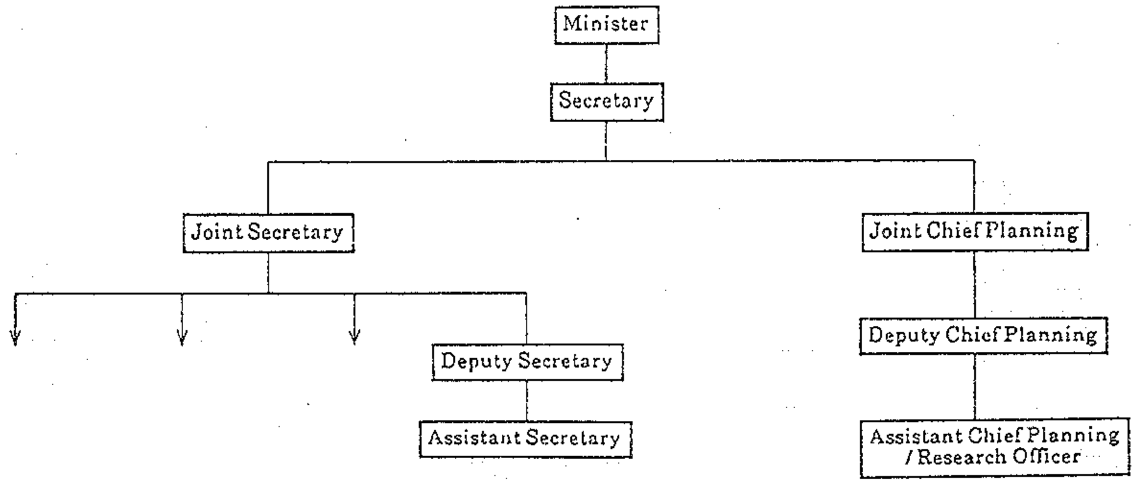
FIGURE IX-1-1 ORGANIZATION CHART OF MINISTRY SECRETARY OFFICE



ORGANIZATION CHART OF MINISTRY OF IRRIGATION, WATER DEVELOPMENT AND FLOOD CONTROL

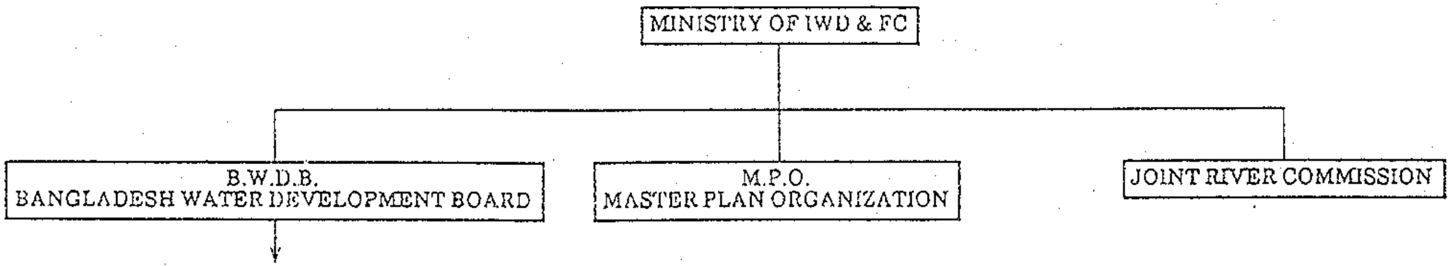


FIGURE IX-1-2 ORGANIZATION CHART OF BANGLADESH WATER DEVELOPMENT BOARD

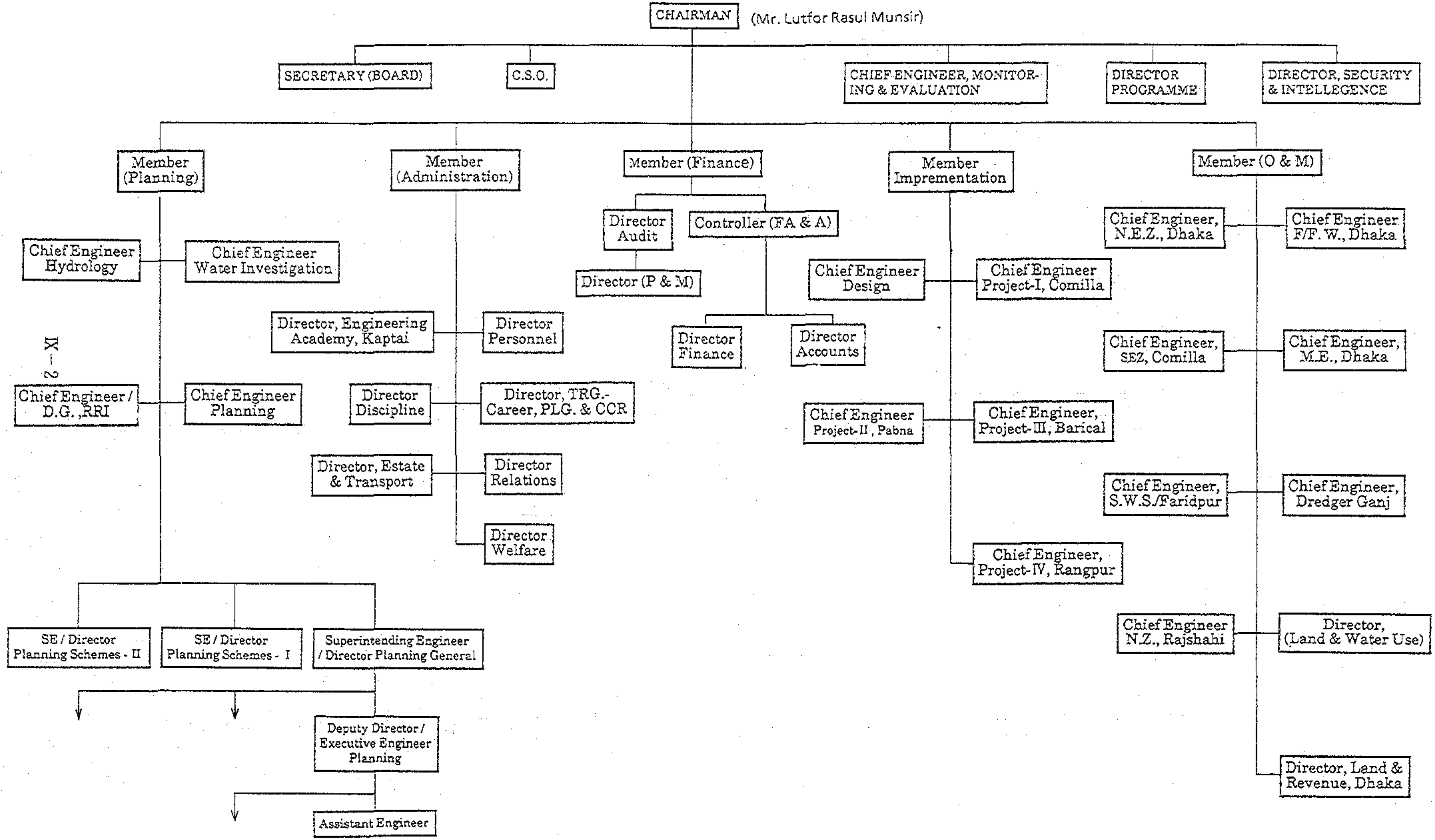
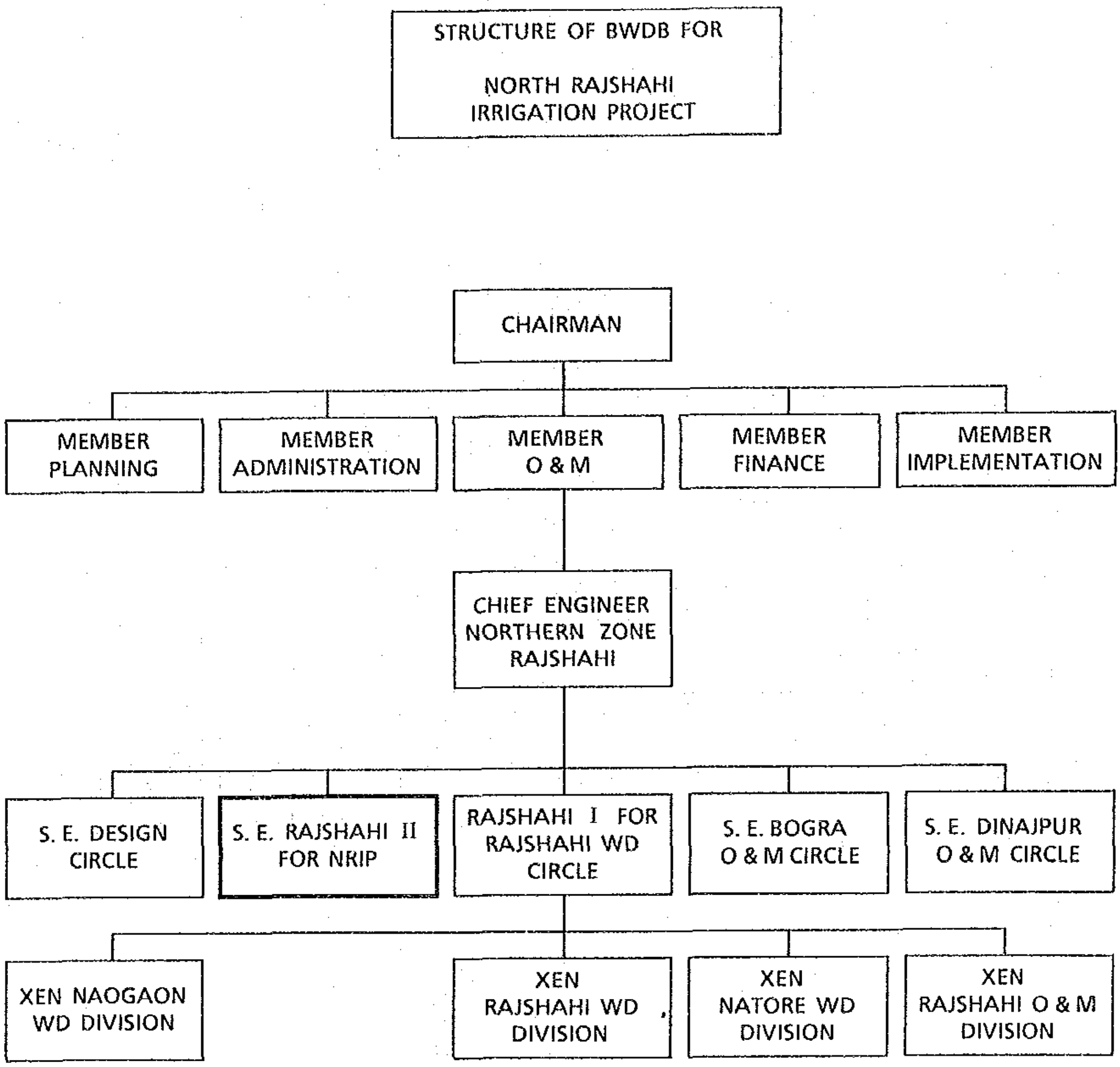
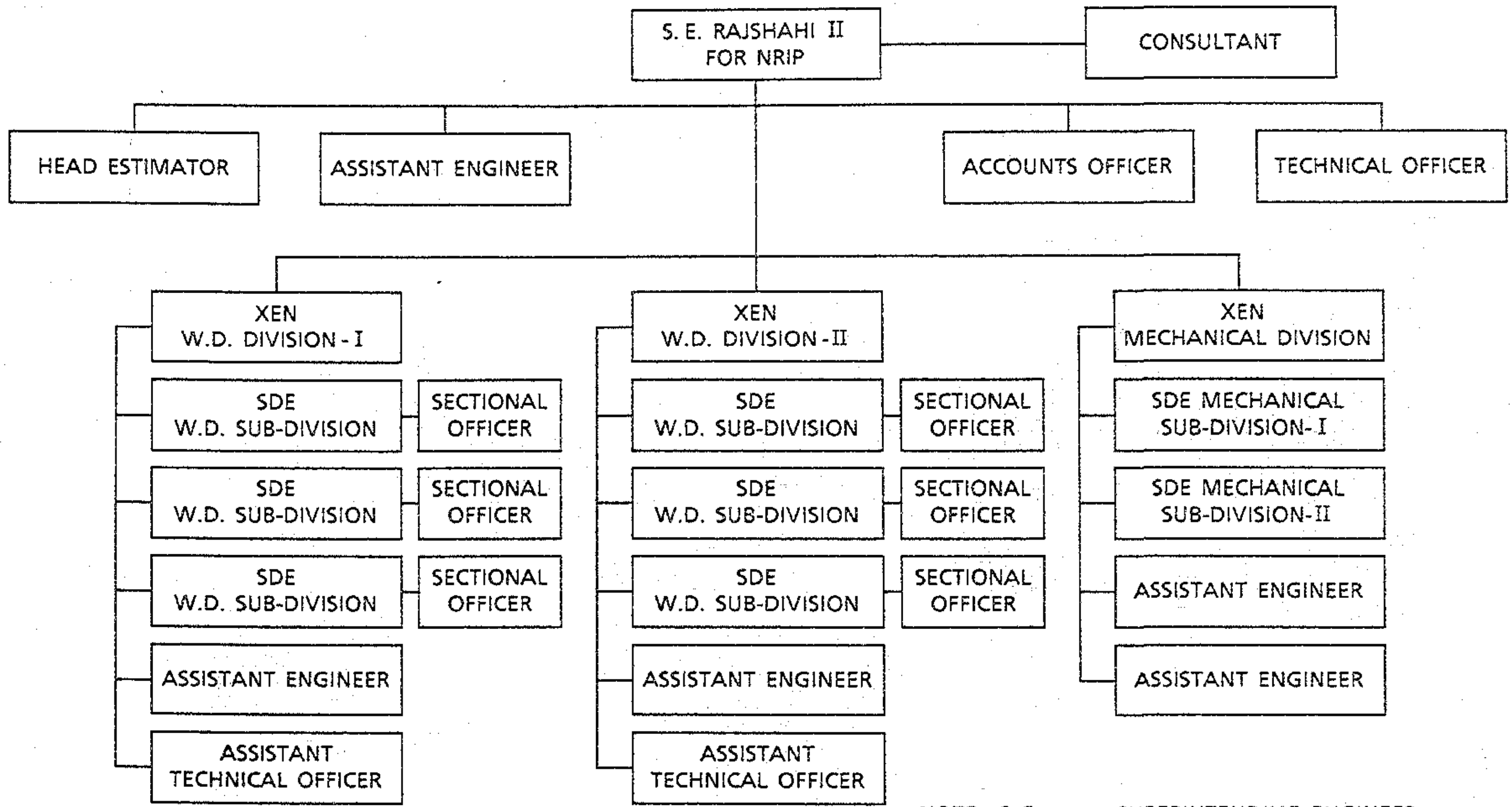


FIGURE IX-2-1



NOTE; S. E. --------- SUPERINTENDING ENGINEER
XEN -------- EXECUTIVE ENGINEER
SDE --------- SUB-DIVISIONAL ENGINEER

FIGURE IX-2-2 PROPOSED ORGANIZATION CHART FOR IMPLEMENTATION OF THE NORTH RAJSHAHI IRRIGATION PROJECT



NOTE ; S. E. -------- SUPERINTENDING ENGINEER
XEN -------- EXECUTIVE ENGINEER
SDE -------- SUB-DIVISIONAL ENGINEER

FIGURE IX-2-3 CENTRAL COORDINATION COMMITTEE

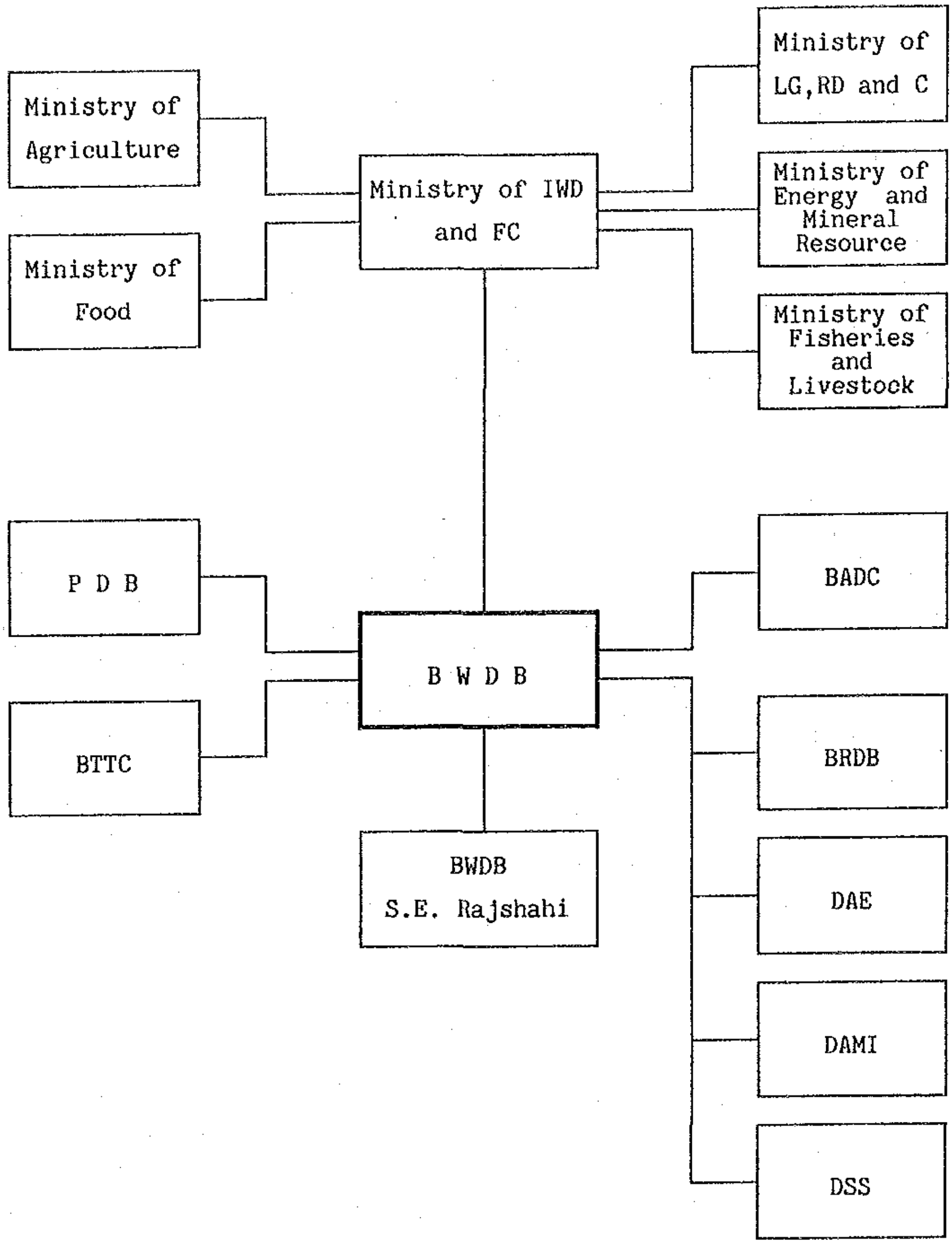


FIGURE IX-2-4 LOCAL COORDINATION COMMITTEE

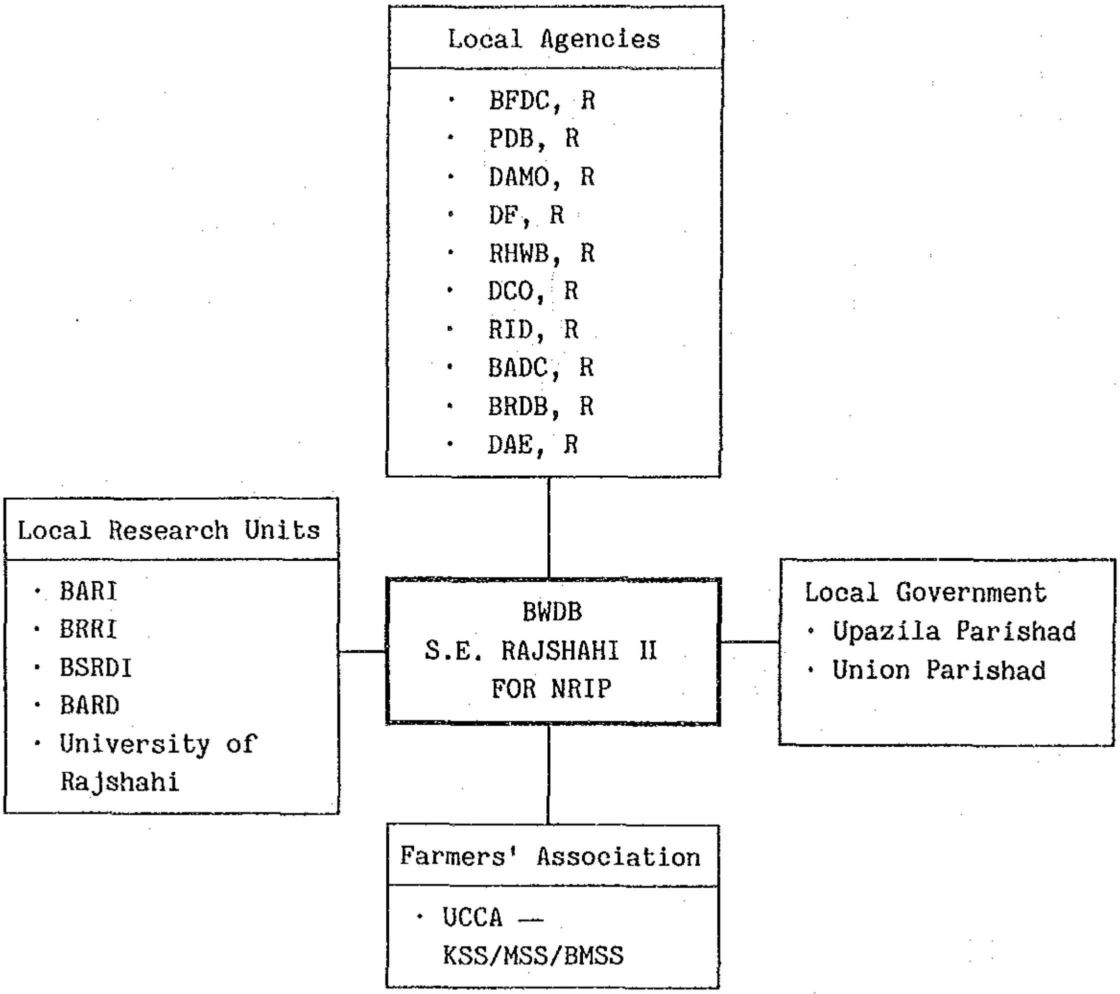


FIGURE IX-3-1 The Project Implementation Schedule

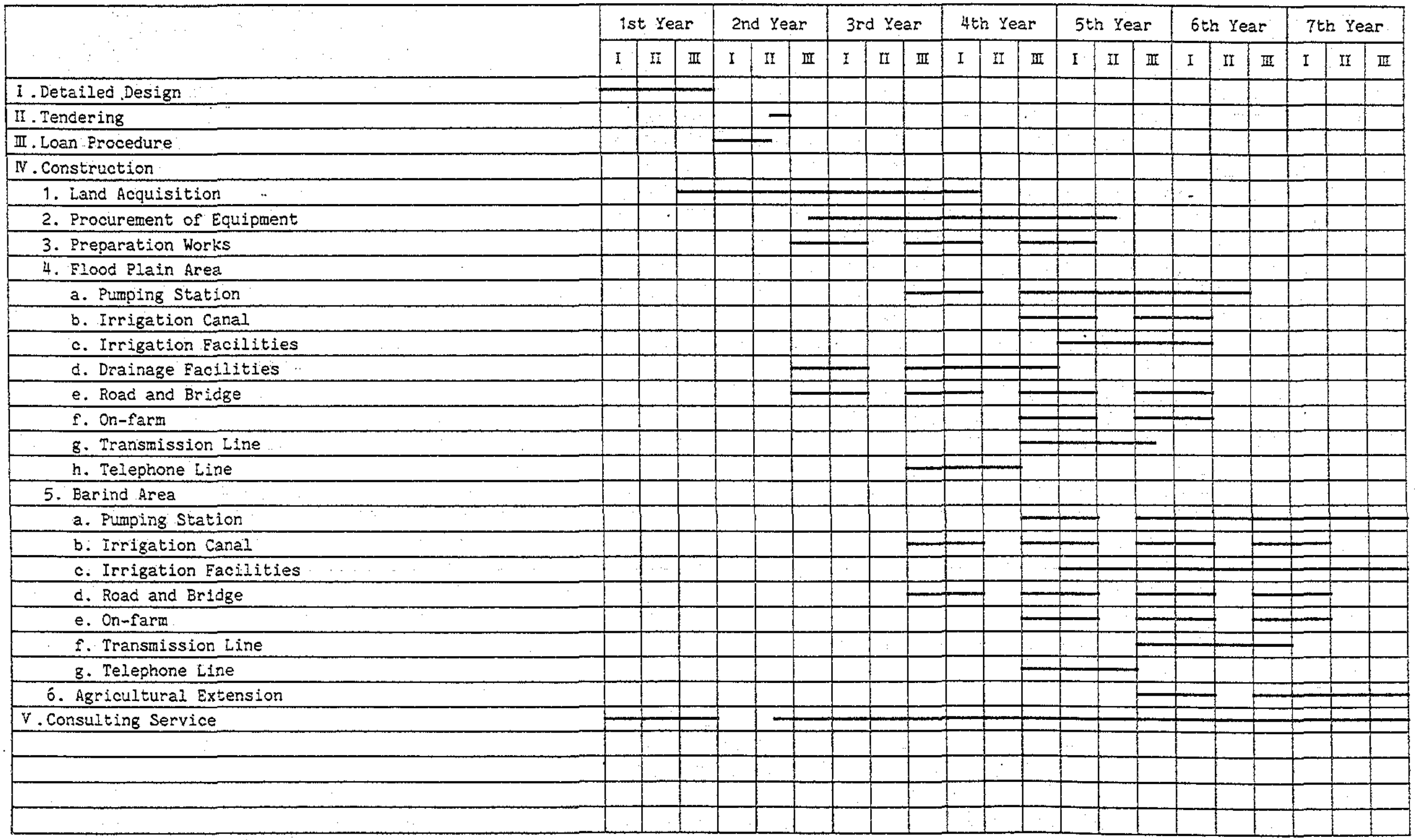
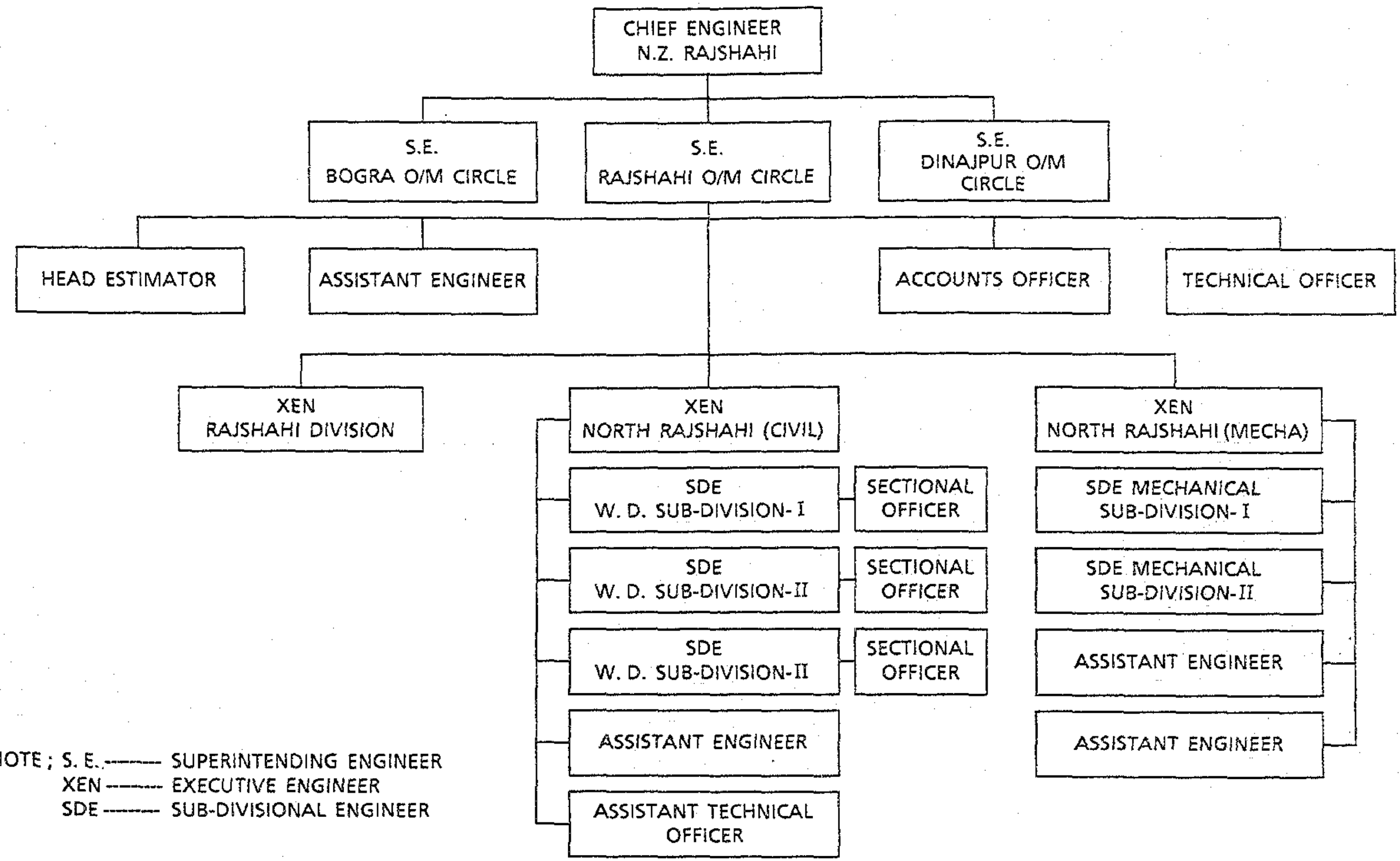


FIGURE IX 4-1 PROPOSED ORGANIZATION CHART FOR OPERATION AND MAINTENANCE OF THE PROJECT



NOTE ; S. E. ——— SUPERINTENDING ENGINEER
XEN ——— EXECUTIVE ENGINEER
SDE ——— SUB-DIVISIONAL ENGINEER