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BANGLADESH WATER DEVELOPMENT BOARD

NABAGANGA
INTEGRATED LAND & WATER USE STUDY

PHASE III
PROJECT PREPARATION
VOLUME III
APPENDICES

FINAL REPORT

FEBRUARY 1981

Tippetts-Abbett-McCarthy-Stratton / Consociates International Ltd.

(Project not approved on 5/11/82)

BANGLADESH WATER DEVELOPMENT BOARD

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Integrated Land and Water Use Study

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APPENDIX A

ANALYSIS OF PERMANENT TYPE IRRIGATION DISTRIBUTION SYSTEMS

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APPENDIX A

ANALYSIS OF PERMANENT TYPE IRRIGATION DISTRIBUTION SYSTEMS

1. INTRODUCTION

The designs and operational procedures for the existing low lift pump irrigation developments in Bangladesh are considered to be inadequate. The primary complaints are that:

(1) The 2 cfs low lift pumps are not being fully utilized. These pumps have the capacity to irrigate approximately 120 acres of rice but the command areas of these existing pumps are generally much less.

(2) The management of the systems does not assure the efficient and equitable distribution and use of the water supply.

It has been suggested that the use of permanent facilities such as lined channels and rigid structures for the irrigation distribution systems would:

- Permit an enlargement of the command areas;
- Improve water management;
- Reduce seepage losses; and
- Reduce the right-of-way requirements.

In response to the above suggestions, detailed distribution plans were prepared for four typical areas. Each of these systems would serve the maximum irrigable area consistent with the topographic constraints. Open channels of masonry lining, and underground pipelines of concrete, plastic (PVC) and asbestos cement (AC) were all considered in this analysis. However, layouts were the same for all since the systems would have to serve the higher elevation for each irrigation block and there could be little variation in the layout. The layouts and profiles for each of the typical areas are shown on Figures A-1 through A-8.

2. DESCRIPTION OF TYPICAL AREAS

The Alaipur area is located north of the Nabaganga River approximately four miles west of Magura. The irrigable lands are separated from the river by the intervening settlements, and a 1400-foot long channel would be required to convey the water from the low lift pump site on the river, through the settlements, to the irrigable area. In the middle of the area there is a low depression and the distribution system would follow a relatively long and circuitous alignment to serve the peripheral high lands. There are only 78

acres which could be reasonably irrigated by this distribution system.

The Mirzapur area is located north of the Nabaganga River immediately east of the Alaipur site. Here is an abandoned canal that could be re-excavated to channel the water supply from the river to the pump site at the fringe of the irrigable area. The area has a generally uniform topography and there are 123 acres that could be irrigated by this system.

The Sachani Rautara area is located south of the Nabaganga River, and west of the junction with Alamkhali Khal. The area is intersected by the remnants of two filled-in water courses and by an intervening settlement area which limits the area that could be irrigated from a single source. There is an area of 75 irrigable acres between the settlements and the main road that could be so served and has been selected for evaluation.

The Pabahati area is located within a curve of the Nabaganga River and east of the junction with Dopaghata Khal. Here, there is a wide settlement area along the river and a 2250-foot long channel would be needed to convey the water from the low lift pump site on the river to the irrigable area. The area has a very uniform topography and there are 123 acres here which could be served by this system.

3. DESIGN CRITERIA

All channels for the above systems were designed for a discharge of 2 cfs. The masonry open channel section would have a bottom width of 25 inches and a depth of 15 to 21 inches depending on the slope. The precast, unreinforced concrete pipe would have a diameter of 12 inches. The PVC and AC pipe would have diameters of 10 inches. The largest PVC and AC pipe now being manufactured in Bangladesh is 8 inches in diameter but the larger size would be available if demanded.

Open channels are well suited to the relatively level topography of the areas but they must cross some low areas if the systems were to be extended to the maximum feasible limits. These crossings would require extensive fill sections with the consequent excess right-of-way requirements. The earth channel layouts recommended for project implementation would generally follow the contours and would be limited by the topographic constraints rather than the maximum area. The command area would be slightly less but there would be no significant fill sections and the earthwork and right-of-way

requirements would be minimal.

These channels would parallel the field boundaries and the existing bunds between parcels would be improved as necessary, and would form one bank of the channel. Excluding the area of those bunds, the additional land requirements would be approximately one percent of the irrigable area.

The soils of the low lift pump development area are predominantly silty-clay loams with a relatively low infiltration rate of 2 inches per day. The distribution channels are relatively short and for a well maintained channel there would be only a 2 percent seepage loss.

The unlined channels would require continual maintenance to control weeds, to plug holes by burrowing animals, and to maintain the channel section. This work would be labor intensive and could provide some employment for the rural poor. This maintenance program would provide an opportunity for the organization to see the demands for maintenance and establish the procedures for maintaining the other facilities such as structures and drainage channels. In some areas, the drainage channels could also serve as irrigation channels.

The pipelines have a limited capacity, and for a discharge of 2 cfs, a relatively steep hydraulic gradient of 0.004 for the concrete pipe and 0.005 for the PVC and AC pipe would be needed. To obtain such gradients, a high structure would be needed at the pump site with a correspondingly high pumping head. These increased heads are shown graphically on the profiles. Also, there would be a prolonged implementation period if pipelines were used extensively in the project development. Farmers could contribute very little to the development, and they would have to rely on outside assistance for the financing, procurement, design, administration and supervision of construction. This assistance, both in financing and in technical services, is very limited.

4. COST ESTIMATES

The comparative capital costs for each type of lining are shown in Table A-1. For comparative purposes, the costs of the recommended earth canal distribution systems are also shown. The comparative operation and maintenance costs are shown in Table A-2. The water requirements and the corresponding pumping costs would vary depending on the types of crops irrigated. The average requirements, however, are estimated to be 36 inches per year. This would be 12 inches for the irrigation of wheat and the remainder for land preparation and for supplemental irrigation of the rice crop during the wet season. Seepage losses were conservatively considered to be 5 percent to estimate the cost of these losses.

TABLE A-1

LOW LIFT PUMP IRRIGATION DISTRIBUTION SYSTEMS
COMPARATIVE ESTIMATE OF CAPITAL COSTS
FOR DIFFERENT TYPES OF CHANNEL LININGS

	TYPES OF CHANNEL LININGS				
	OPEN CHANNEL		UNDERGROUND PIPELINE		
TYPICAL AREAS	Earthen	Masonry	12" Concrete	10" PVC	10" AC
ALAIPUR					
Length of Channel		9,225 LF	9,225 LF	9,225 LF	9,225 LF
Irrigable Area		78 Ac.	78 Ac.	78 Ac.	78 Ac.
Costs:					
Earthwork		TKS 18,000	TKS 22,000	TKS 22,000	TKS 22,000
Lining					
Additional R/W		14,300	- 0 -	- 0 -	- 0 -
Structures		42,000	24,000	24,000	24,000
Low Lift Pumps		30,000	30,000	30,000	30,000
Total Costs		TKS 833,300	TKS 565,000	TKS 2,151,000	TKS 445,000
*Parts of Alaipur and Mirzapur were combined into the following single LLP Irrigation Distribution System					
MIRZAPUR					
Length of Channel	12,240 LF	8,200 LF	8,200 LF	8,200 LF	8,200 LF
Irrigable Area	142 Ac.	123 Ac.	123 Ac.	123 Ac.	123 Ac.
Costs:					
Earthwork	TKS 31,300	TKS 16,000	TKS 19,500	TKS 19,500	TKS 19,500
Lining	- 0 -	558,000	435,000	1,845,000	328,000
Additional R/W	40,200	12,700	- 0 -	- 0 -	- 0 -
Structures	7,700	44,000	24,000	24,000	24,000
Low Lift Pumps	30,000	30,000	30,000	30,000	30,000
Total Costs	TKS 109,200	TKS 660,700	TKS 508,500	TKS 1,918,500	TKS 401,500
SACHANI RAUTARA					
Length of Channel	5,680 LF	6,400 LF	6,400 LF	6,400 LF	6,400 LF
Irrigable Area	68 Ac.	75 Ac.	75 Ac.	75 Ac.	75 Ac.
Costs:					
Earthwork	TKS 14,000	TKS 12,400	TKS 15,400	TKS 15,400	TKS 15,400
Lining	- 0 -	469,000	339,000	1,440,000	256,000
Additional R/W	22,800	9,900	- 0 -	- 0 -	- 0 -
Structures	6,800	25,000	24,000	24,000	24,000
Low Lift Pumps	30,000	30,000	30,000	30,000	30,000
Total Costs	TKS 73,600	TKS 546,300	TKS 408,400	TKS 1,509,400	TKS 325,500
PABAHATI					
Length of Channel	6,560 LF	9,685 LF	9,685 LF	9,685 LF	9,685 LF
Irrigable Area	96 Ac.	123 Ac.	123 Ac.	123 Ac.	123 Ac.
Costs:					
Earthworks	TKS 19,000	TKS 18,600	TKS 23,000	TKS 23,000	TKS 23,000
Lining	- 0 -	1,190,000	513,000	2,179,000	387,000
Additional R/W	26,700	15,000	- 0 -	- 0 -	- 0 -
Structures	5,400	39,000	24,000	24,000	24,000
Low Lift Pumps	30,000	30,000	30,000	30,000	30,000
	TKS 81,000	TKS 1,292,600	TKS 590,000	TKS 2,256,000	TKS 464,000
TOTAL OF ALL AREAS					
Length of Channel	24,480 LF	33,510 LF	33,510 LF	35,510 LF	35,510 LF
Irrigable Area	306 Ac.	399 Ac.	399 Ac.	399 Ac.	399 Ac.
Total Costs	TKS 263,900	TKS 3,332,900	TKS 2,071,900	TKS 7,834,900	TKS 1,635,900
Cost Per Irrigable Acre	TKS 862	TKS 8,353	TKS 5,193	TKS 19,636	TKS 4,100

TABLE A-2

LOW LIFT PUMP IRRIGATION DISTRIBUTION SYSTEMS
COMPARATIVE ESTIMATE OF ANNUAL OPERATION AND MAINTENANCE COSTS
FOR DIFFERENT TYPES OF CHANNEL LININGS

ITEM	TYPES OF CHANNEL LININGS				
	OPEN CHANNEL		UNDERGROUND PIPELINE		
	Earthen	Masonry	12" Concrete	10" PVC	10" AC
	Annual Cost Per Irrigable Acre				
Pumping:					
Fuel	TKS 240	TKS 240	TKS 280	TKS 280	TKS 280
Lubricants/ Filters/ Spare Parts	20	20	25	25	25
Channel Maintenance	12	3	6	2	4
Seepage Losses	13	- 0 -	- 0 -	- 0 -	- 0 -
Total Annual O&M Costs Per Irrigable Acre	TKS 285	TKS 263	TKS 311	TKS 307	TKS 209

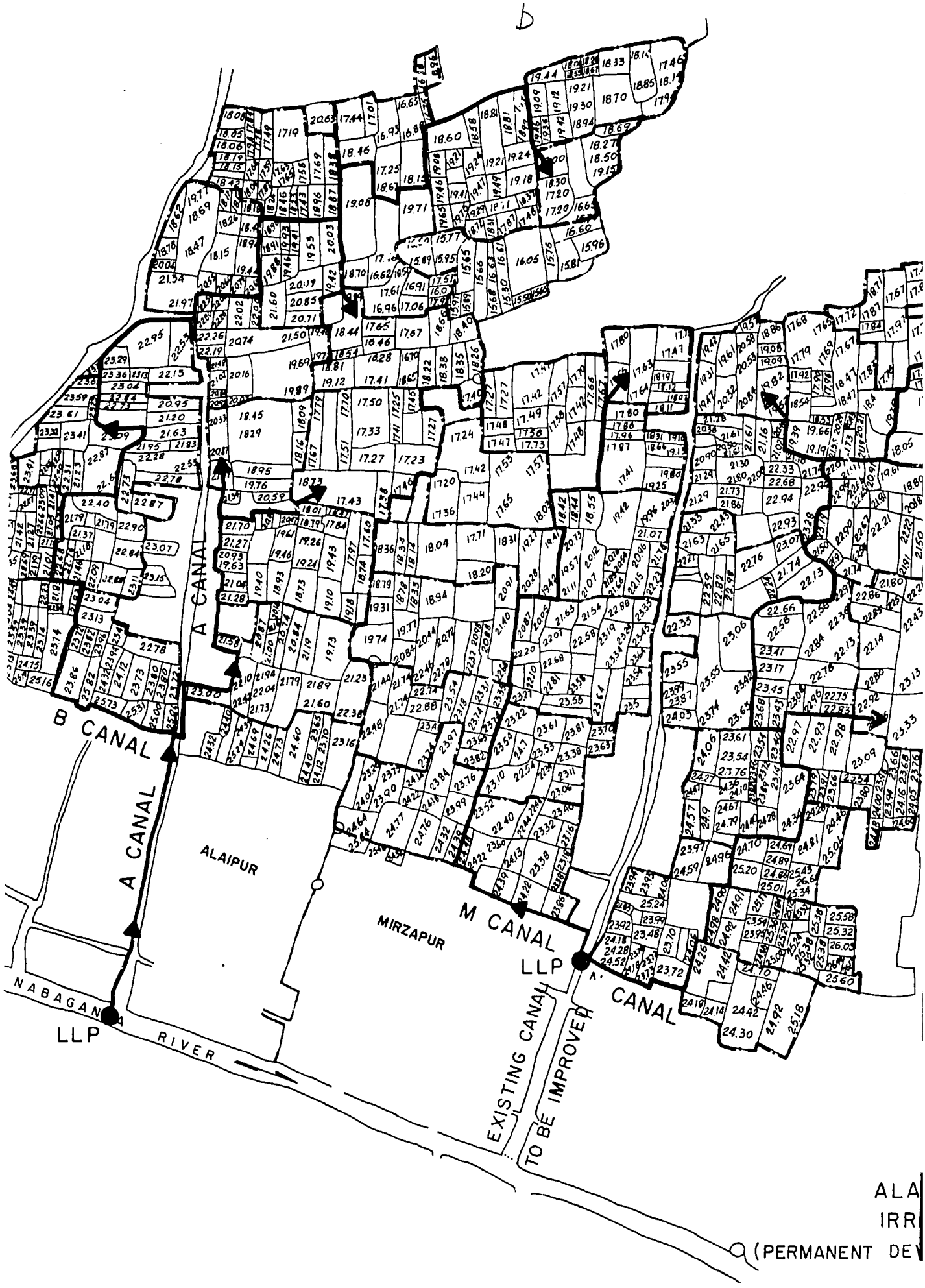
5. CONCLUSIONS AND RECOMMENDATIONS

The permanent type linings cannot be readily replicated on a project wide basis because the farmers would be unable to contribute to the development and substantial outside assistance would be needed. There is no assurance that this assistance would be available, particularly on a large scale. There would be no significant reduction in seepage losses or in right-of-way requirements with the permanent type linings and there is no indication that the water management would significantly improve with the permanent type distribution systems. The greatest water losses and the area of greatest need for water management are beyond the distribution system to the final distribution of water at the field level.

The command area of a low lift pump type of development as considered herein is limited by topographic contraints and the type of distribution system would not significantly change the limits of this area. A greater constraint could be the organizational and social considerations but these factors have not been included in this analysis.

The permanent type systems are extravagantly more costly than the earth channels and there is no indication that this additional cost is justified. Simple earth channels that can be financed and implemented by the farmers are recommended for the irrigation distribution systems.

A-1 a


A CANAL
B CANAL
A CANAL
ALAIPUR
MIRZAPUR
M CANAL
LLP
A' CANAL
NABAGANGA
LLP
RIVER
EXISTING CANAL
TO BE IMPROVED
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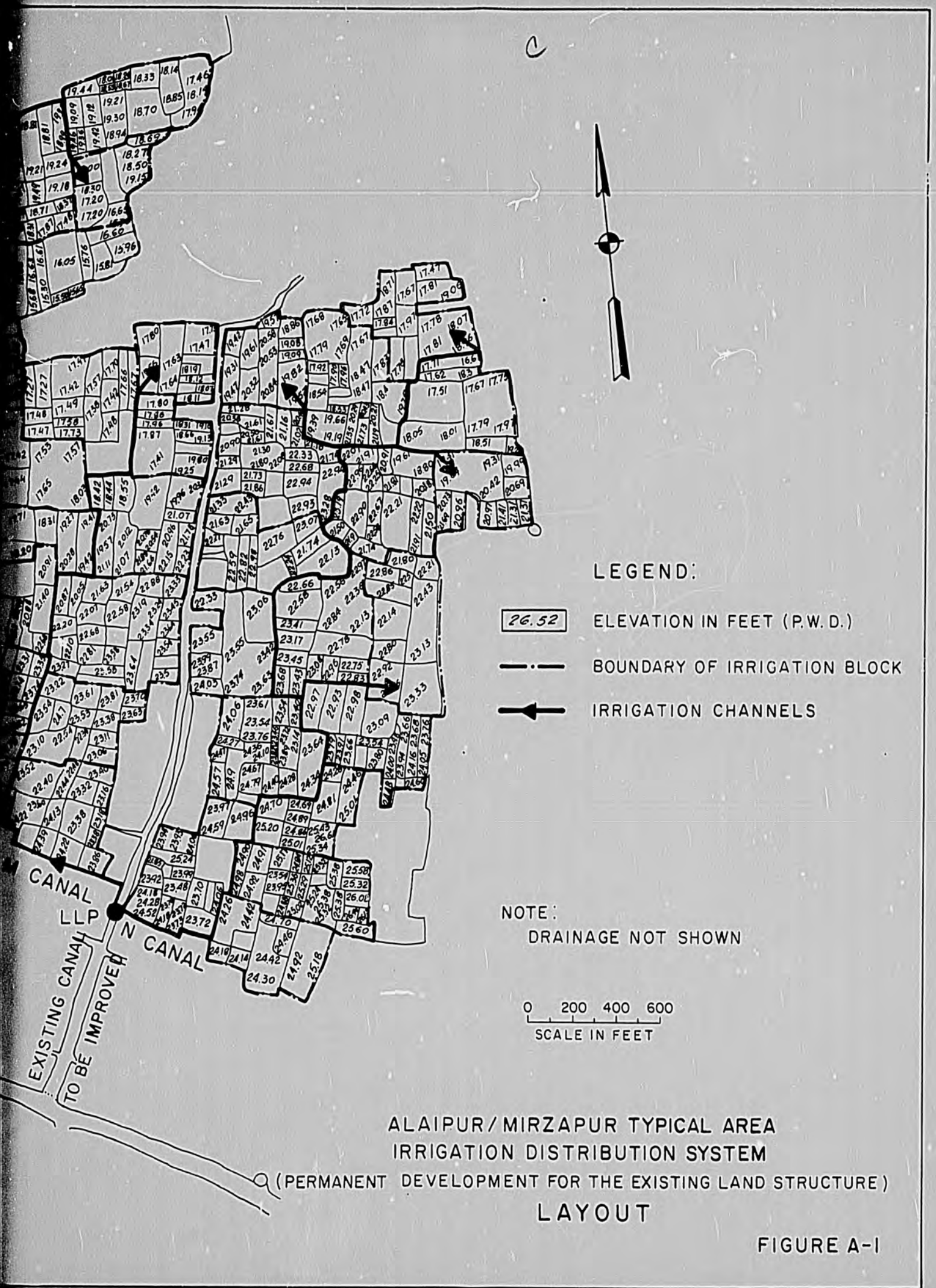
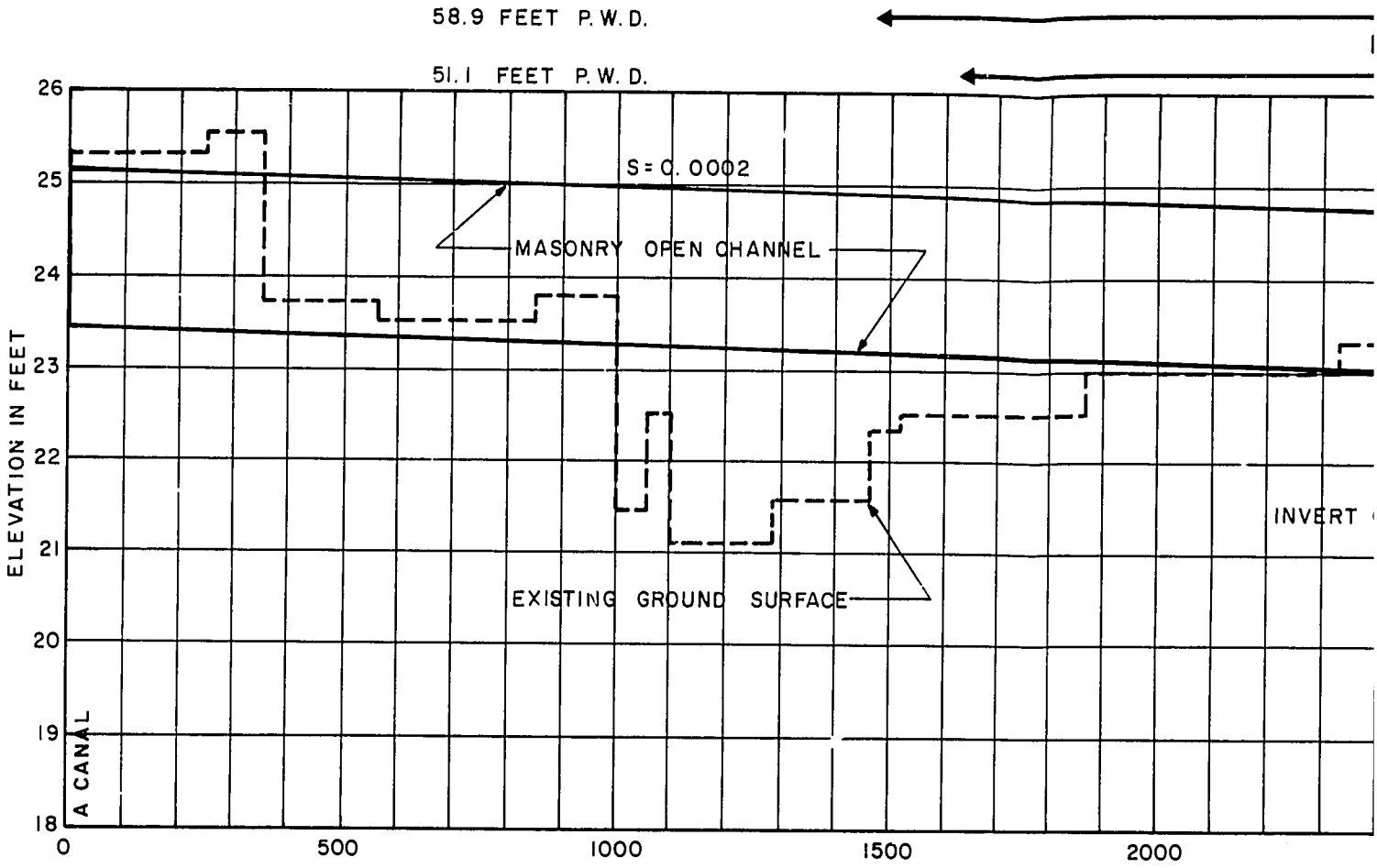
(PERMANENT DE



ALAIPUR/MIRZAPUR TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM
(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURE)
LAYOUT

FIGURE A-1

A-2 a


58.9 FEET P.W.D.
51.1 FEET P.W.D.
S = 0.0002
MASONRY OPEN CHANNEL
EXISTING GROUND SURFACE
INVERT
ELEVATION IN FEET
A CANAL
26
25
24
23
22
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18
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500
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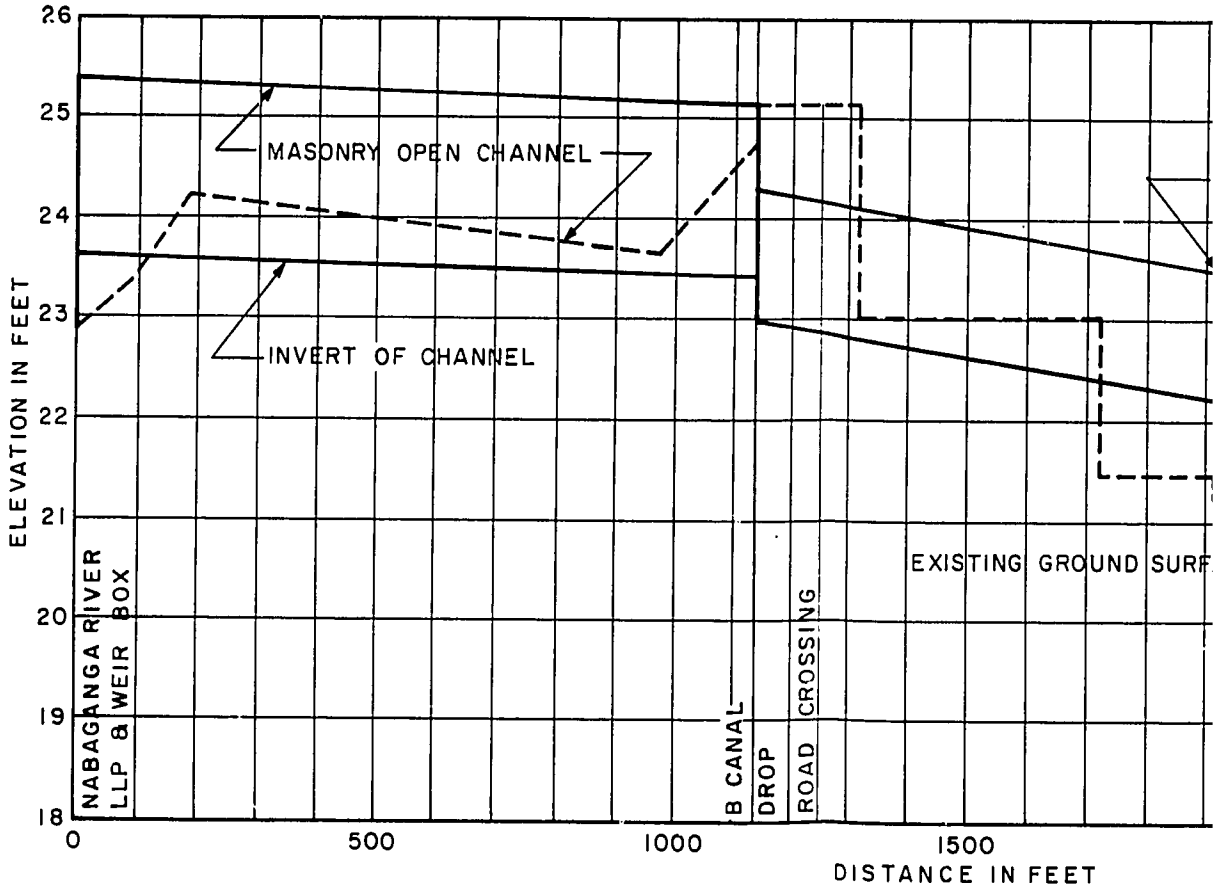
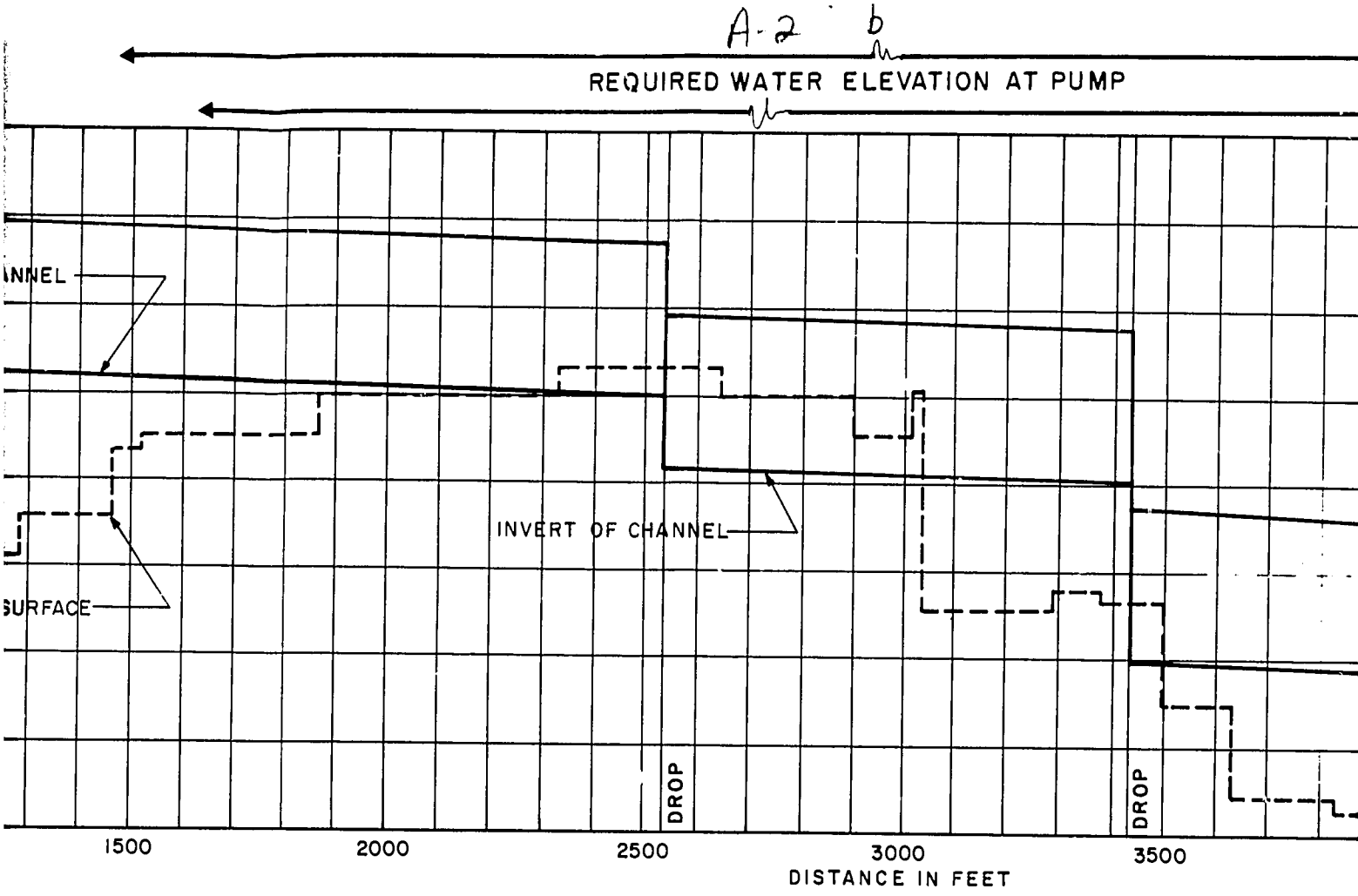
1500
2000


MASONRY OPEN CHANNEL
INVERT OF CHANNEL
EXISTING GROUND SURF
ELEVATION IN FEET
NABAGANGA RIVER
LLP & WEIR BOX
B CANAL
DROP
ROAD CROSSING
26
25
24
23
22
21
20
19
18
0
500
1000
1500
DISTANCE IN FEET

A CANAL

A-2 b



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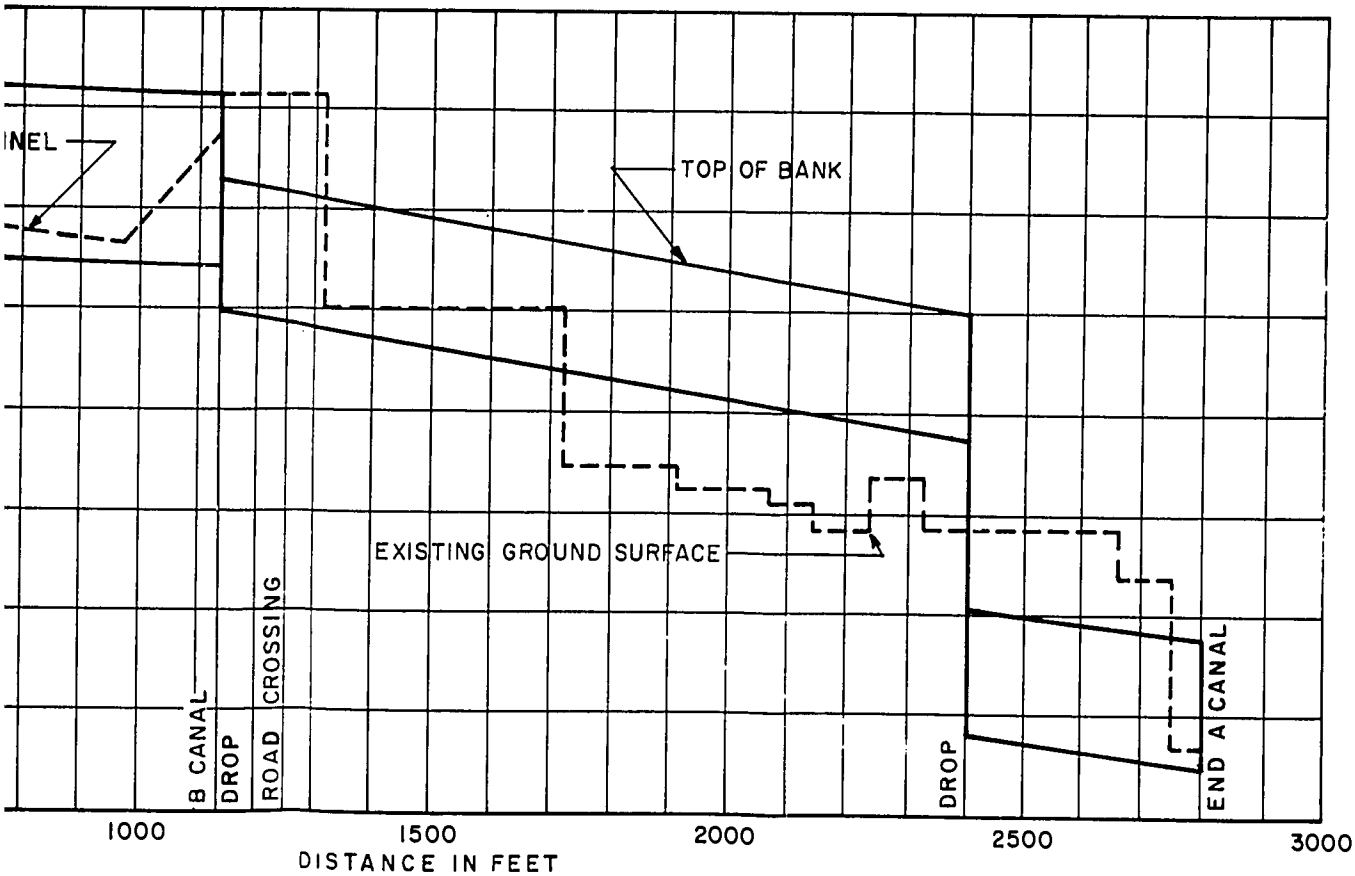

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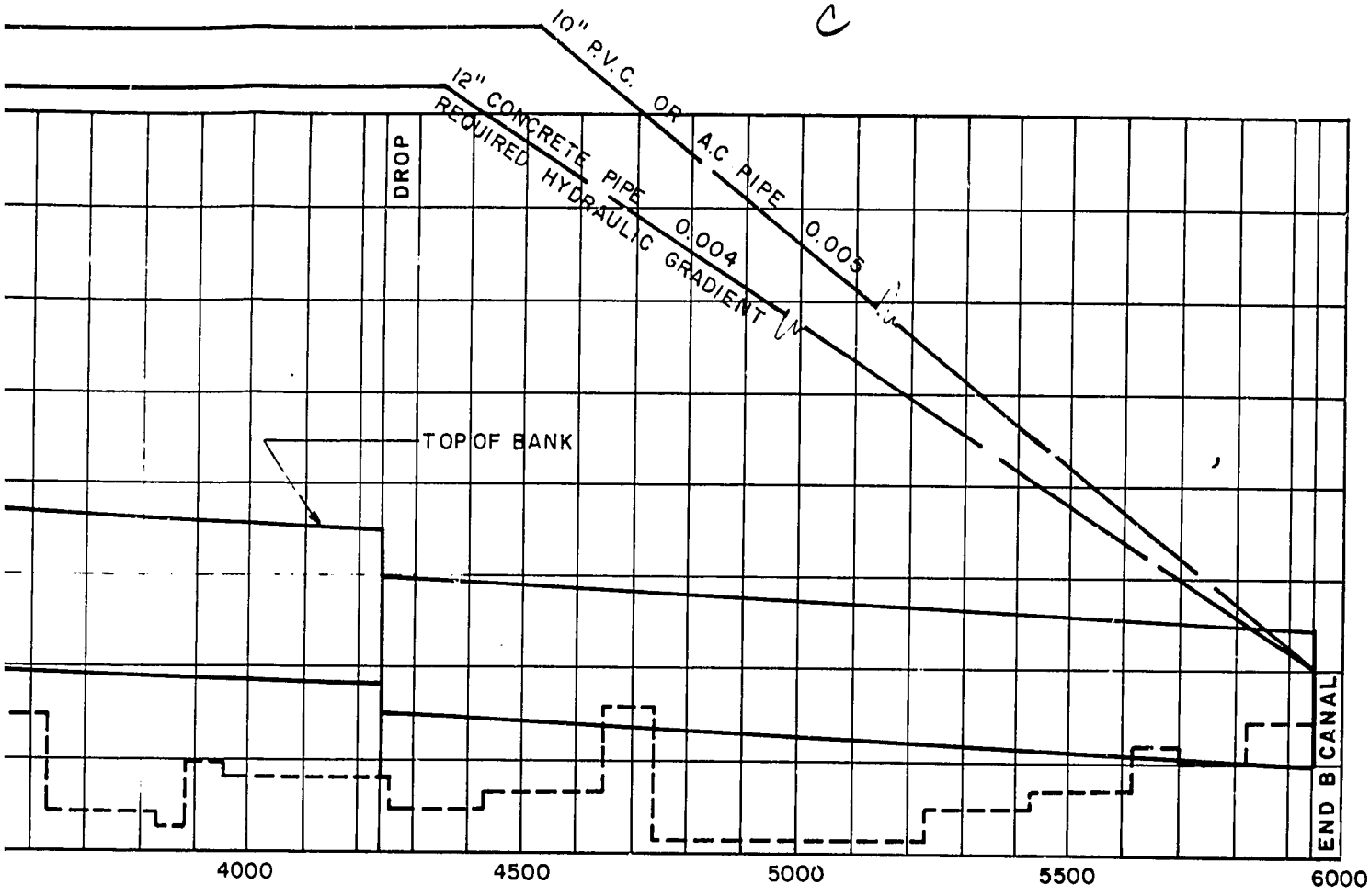


ALAIPUR TYPICAL AREA

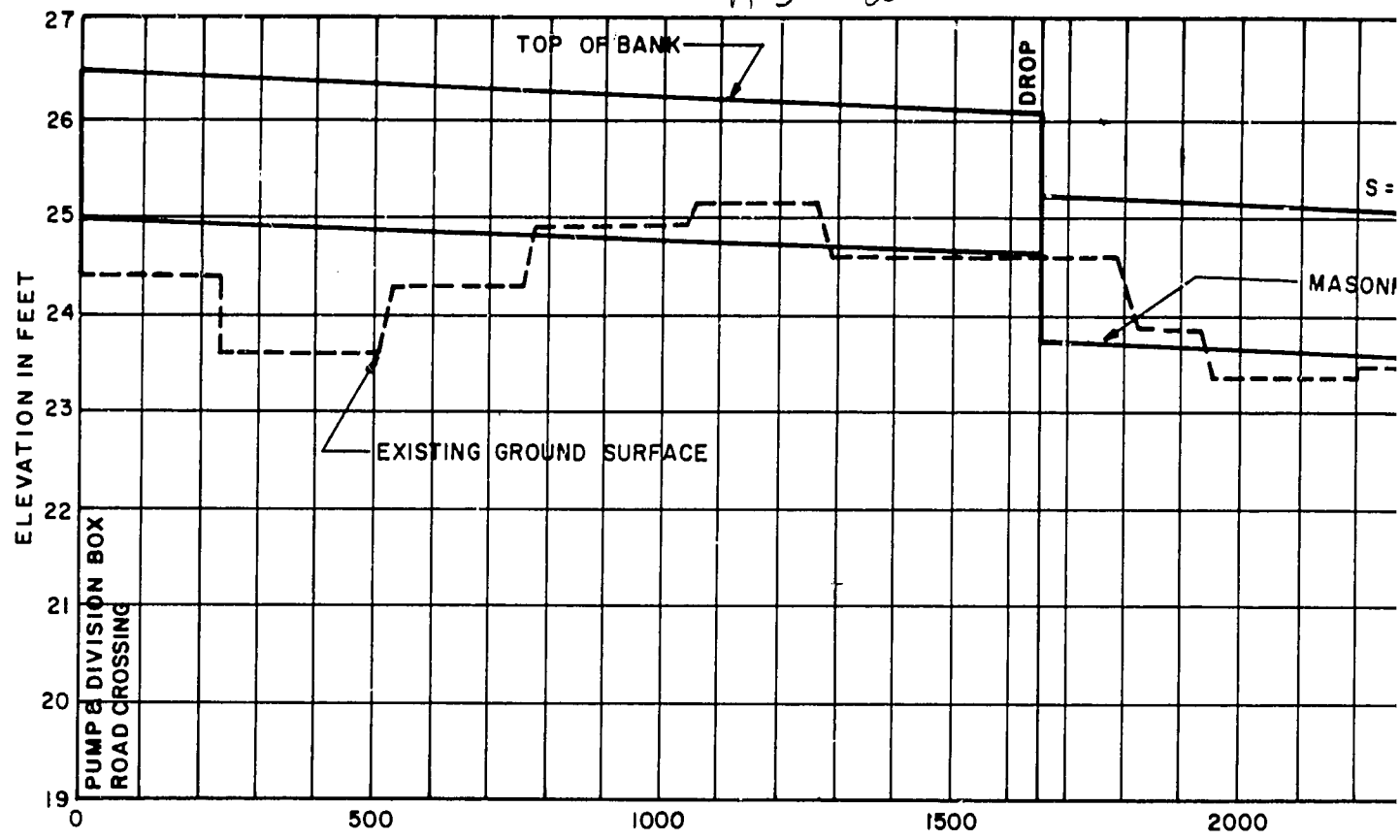
IRRIGATION DISTRIBUTION SYSTEM

(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURE)

PROFILES

FIGURE A-2

A-3 a


TOP OF BANK
DROP
S =
MASONI
EXISTING GROUND SURFACE
PUMP & DIVISION BOX
ROAD CROSSING
ELEVATION IN FEET
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26
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1500
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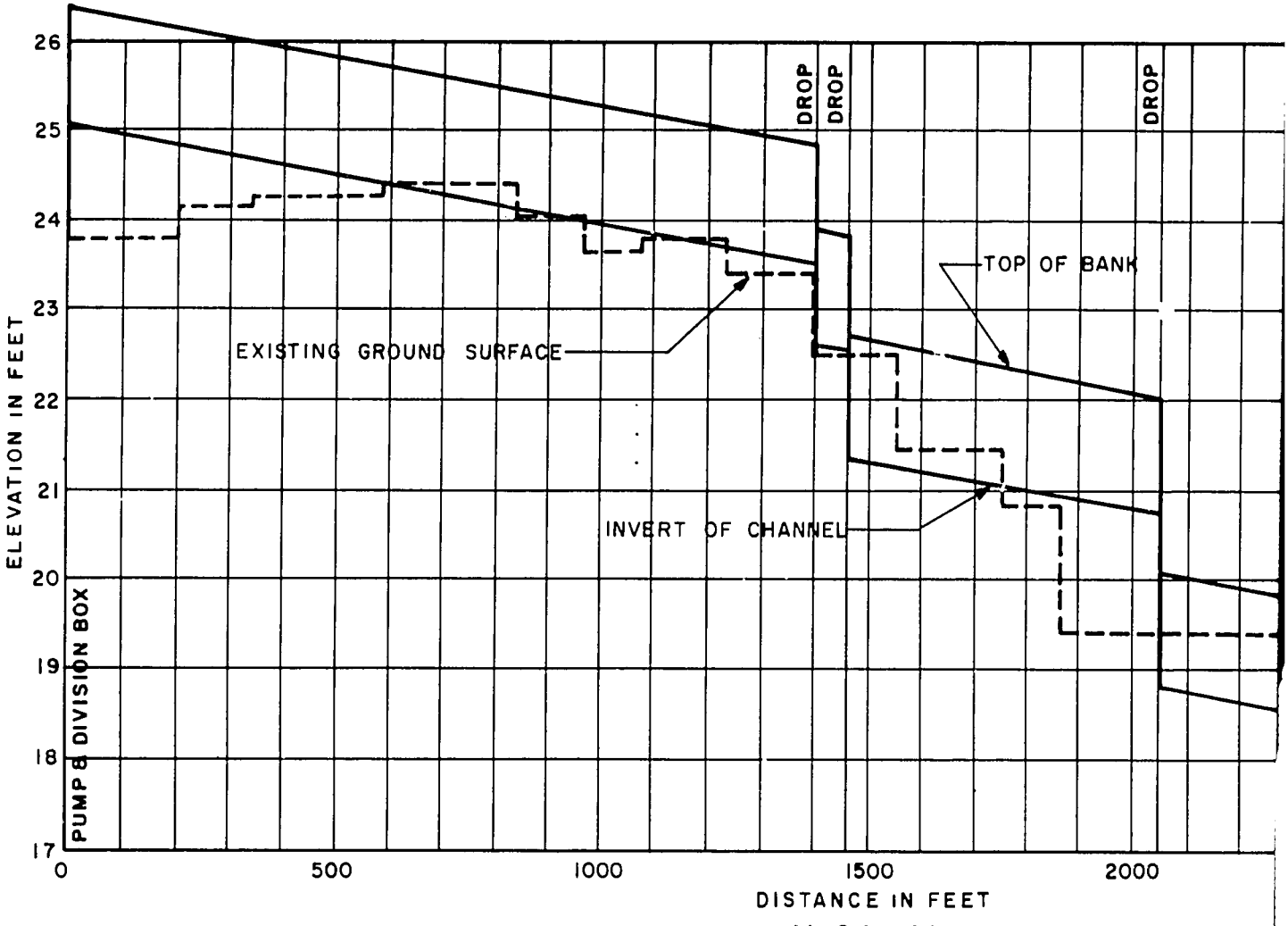
DROP
DROP
DROP
TOP OF BANK
EXISTING GROUND SURFACE
INVERT OF CHANNEL
PUMP & DIVISION BOX
ELEVATION IN FEET
26
25
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23
22
21
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19
18
17
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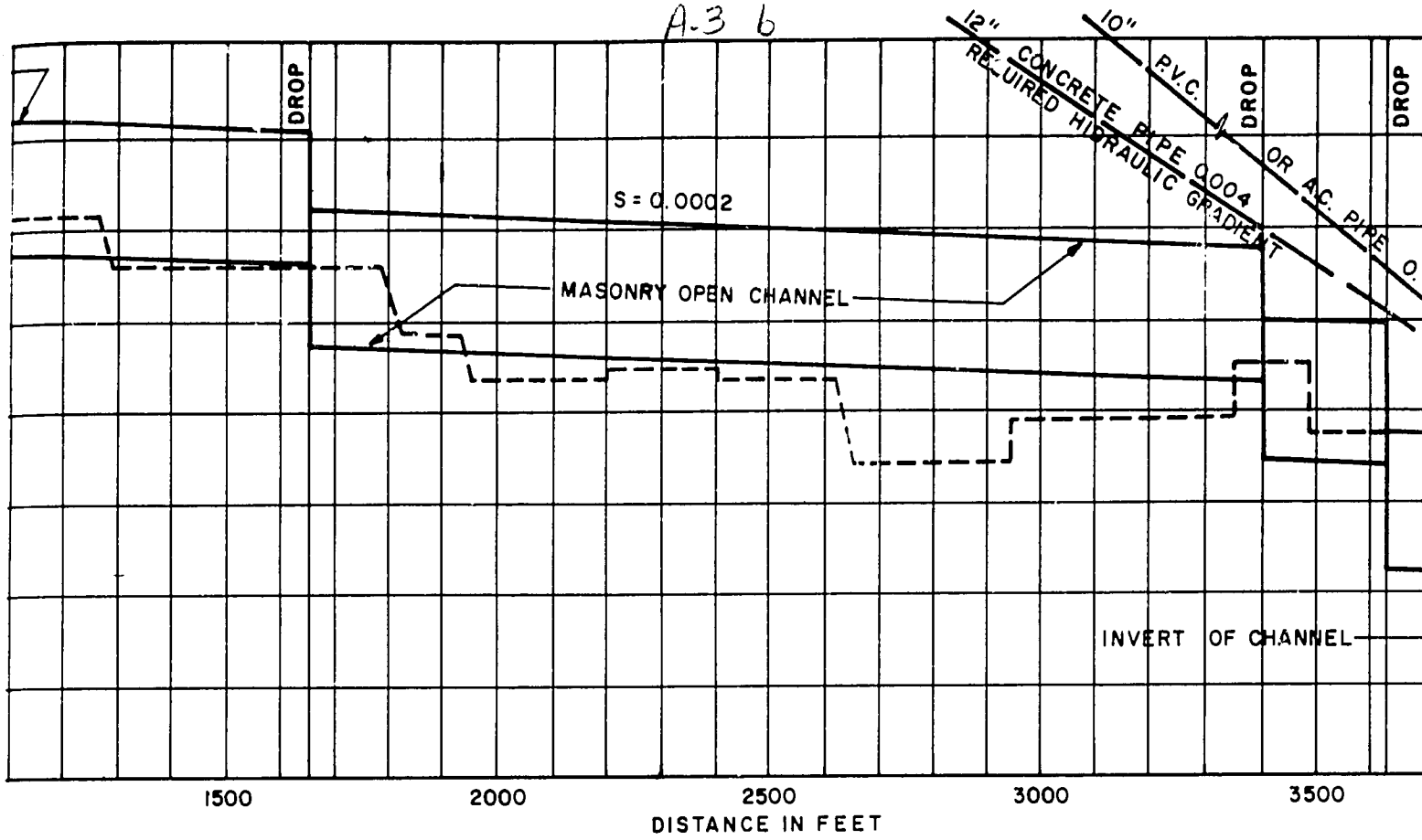
500
1000
1500
2000
DISTANCE IN FEET

M CANAL

A-3 b



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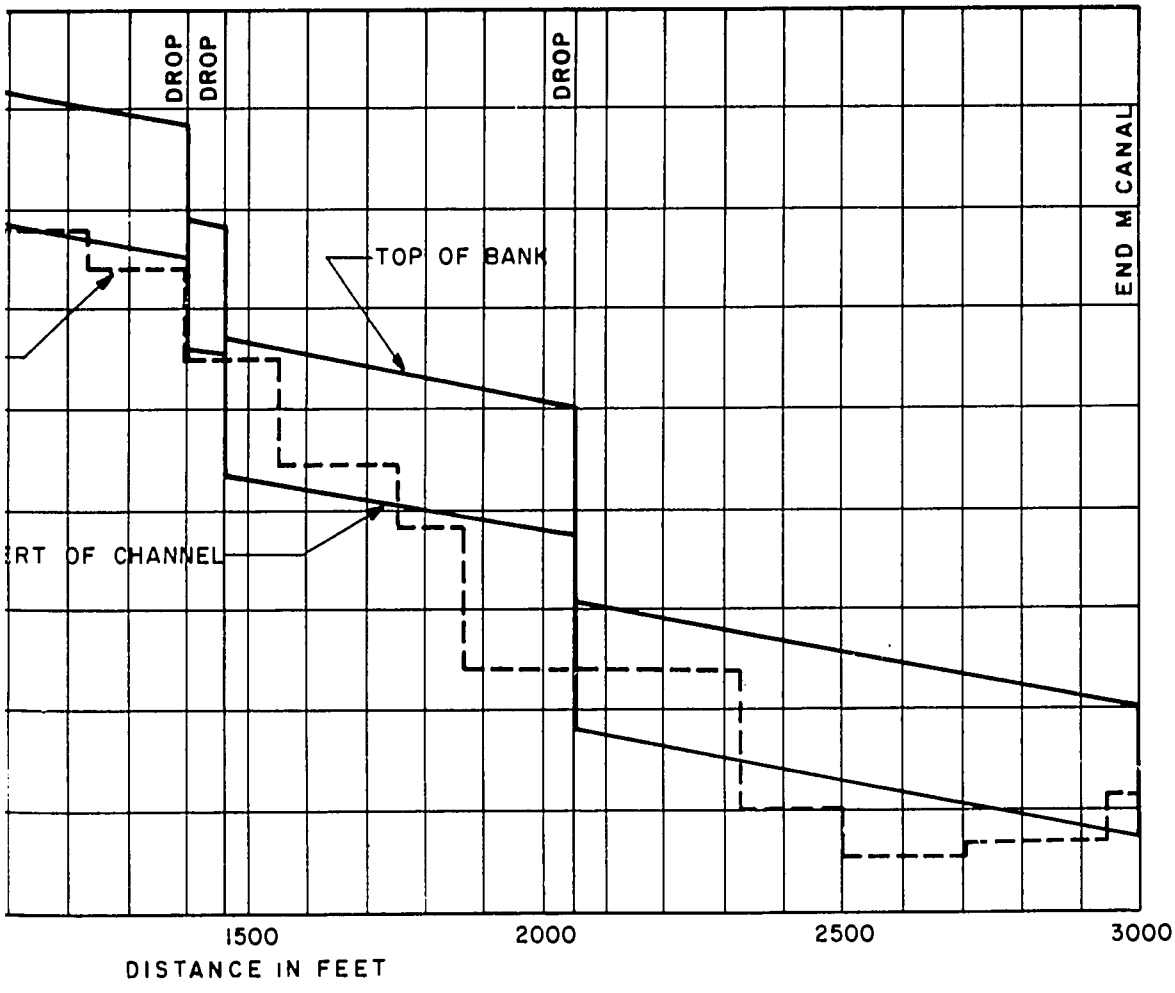
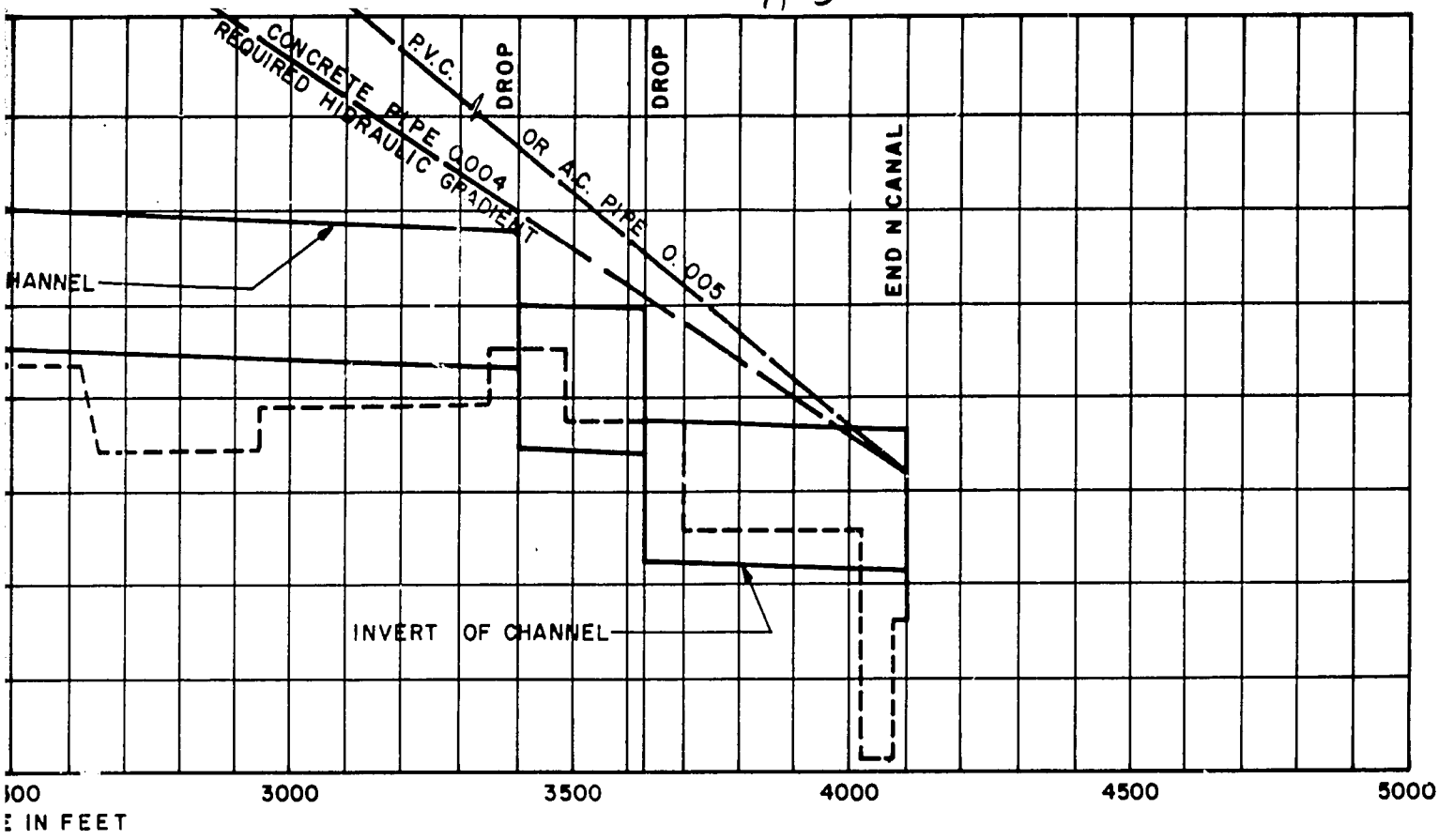


M CANAL

IRRIGAT
(PERMANENT DEVELO

A-3 c



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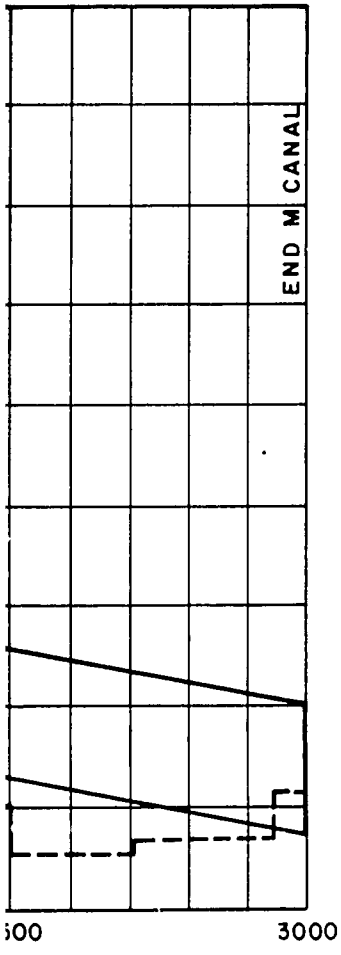

MIRZAPUR TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM
(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURE)

PROFILES

FIGURE A-3

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NO. A-4

A.5a

A-5 b

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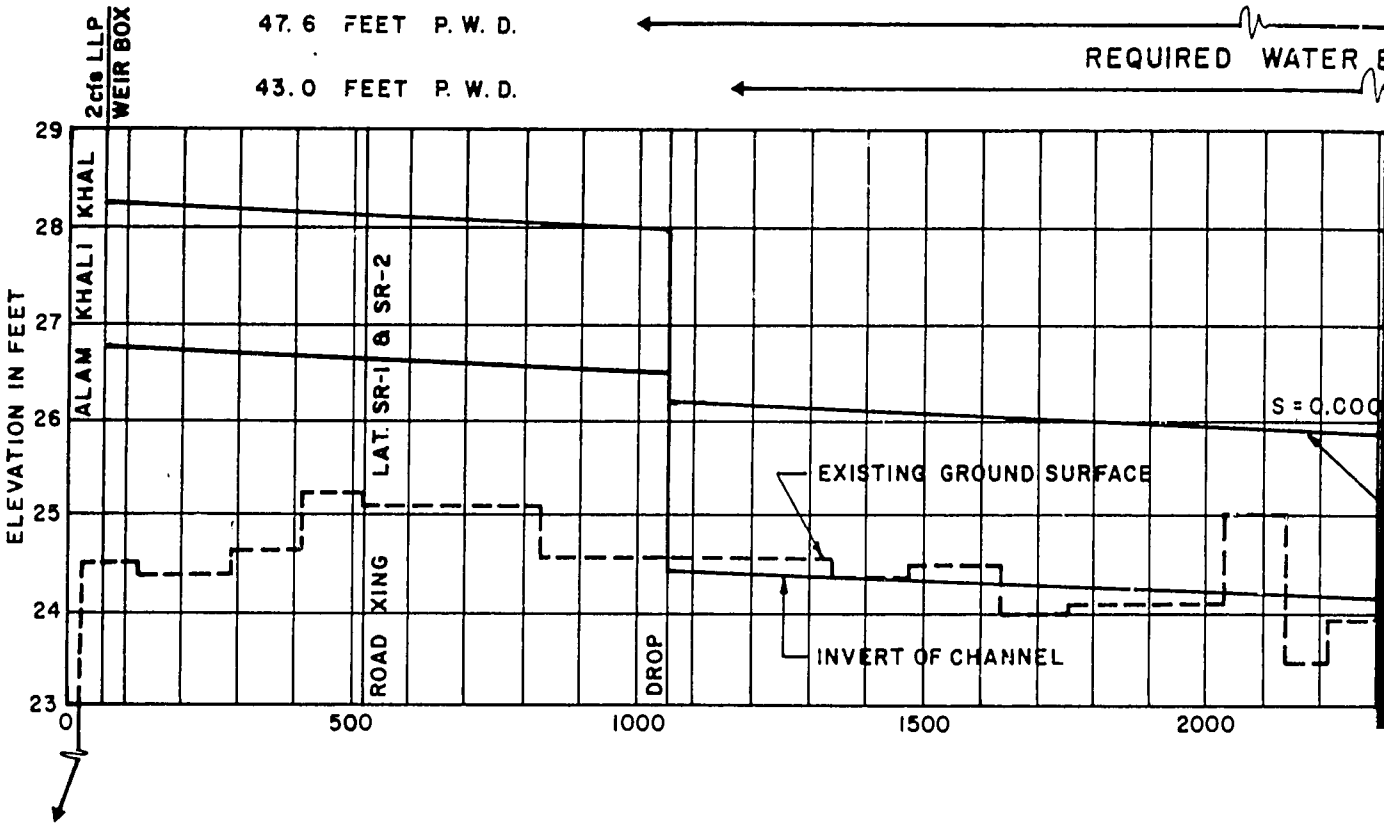
IR
(PERMANENT DE

A-5 C

SACHANI RAUTARA TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM
(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURES)
LAYOUT

FIGURE A-5

A-6 a


47.6 FEET P.W.D.
43.0 FEET P.W.D.
REQUIRED WATER
2cfs LLP
WEIR BOX
KHAL
KHAL
ALAM
LAT. SR-1 & SR-2
ROAD XING
DROP
S = 0.000
EXISTING GROUND SURFACE
INVERT OF CHANNEL
ELEVATION IN FEET
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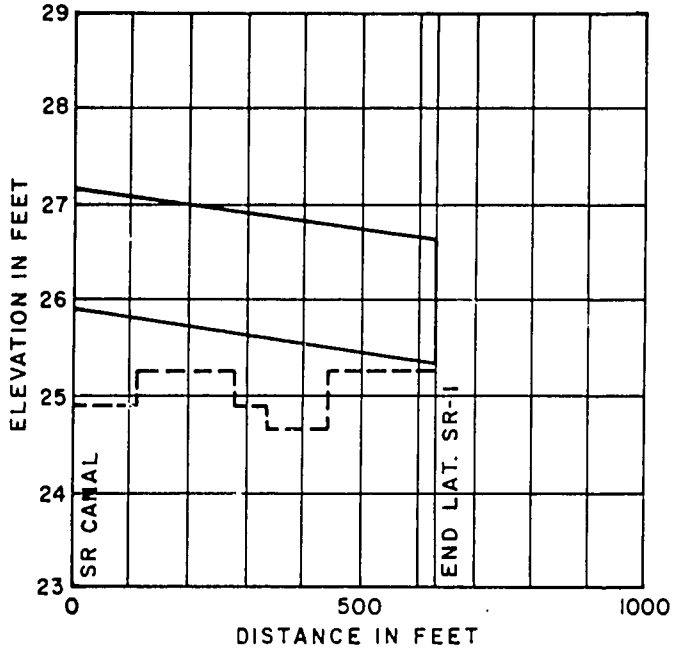
ELEVATION IN FEET
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28
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26
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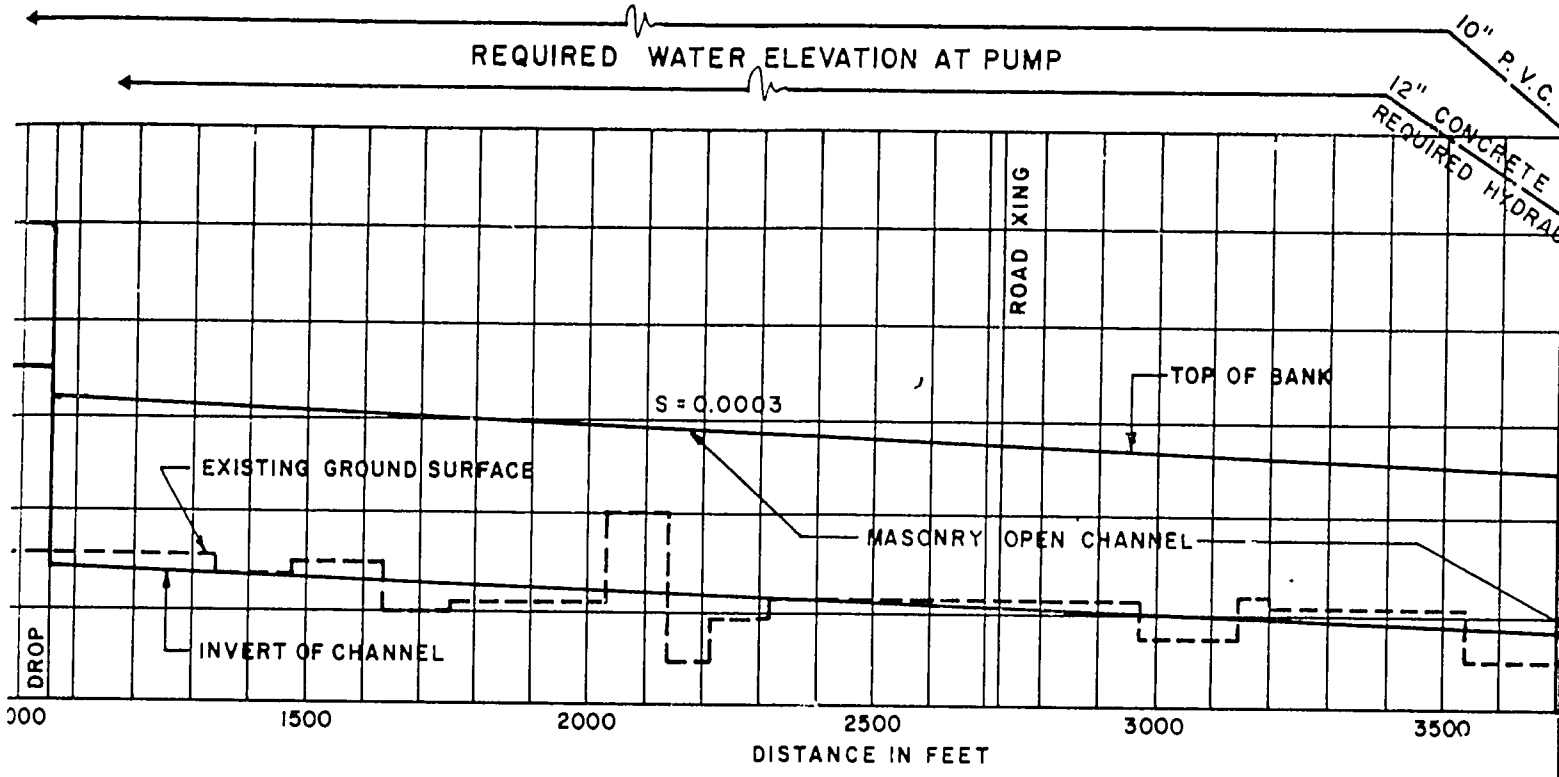
24
23
SR CANAL
END LAT. SR-1
0
500
1000
DISTANCE IN FEET

LAT. SR-1

A-6 b



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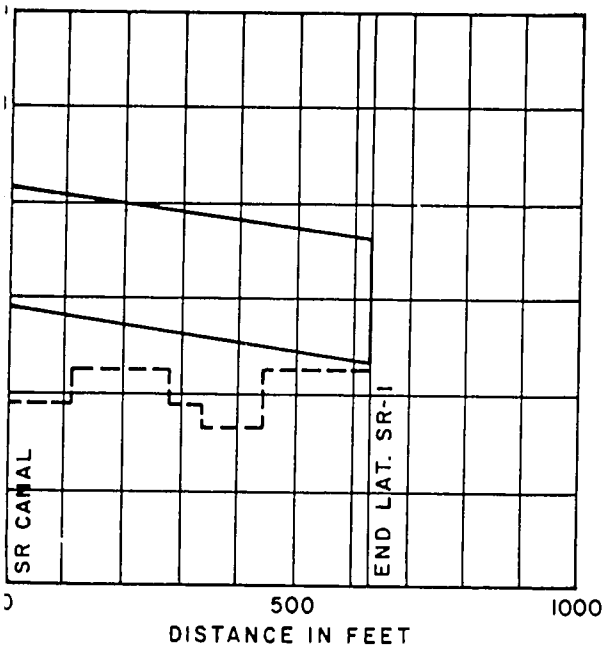

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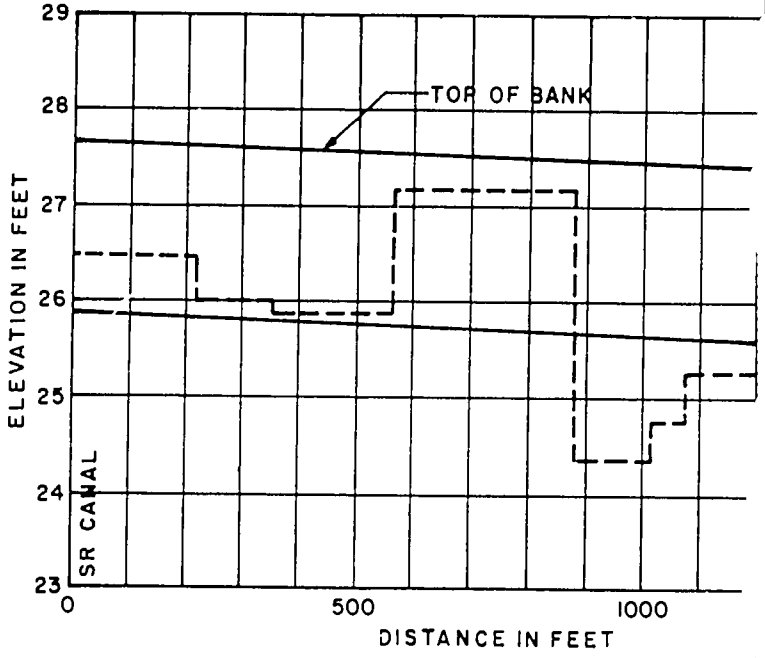
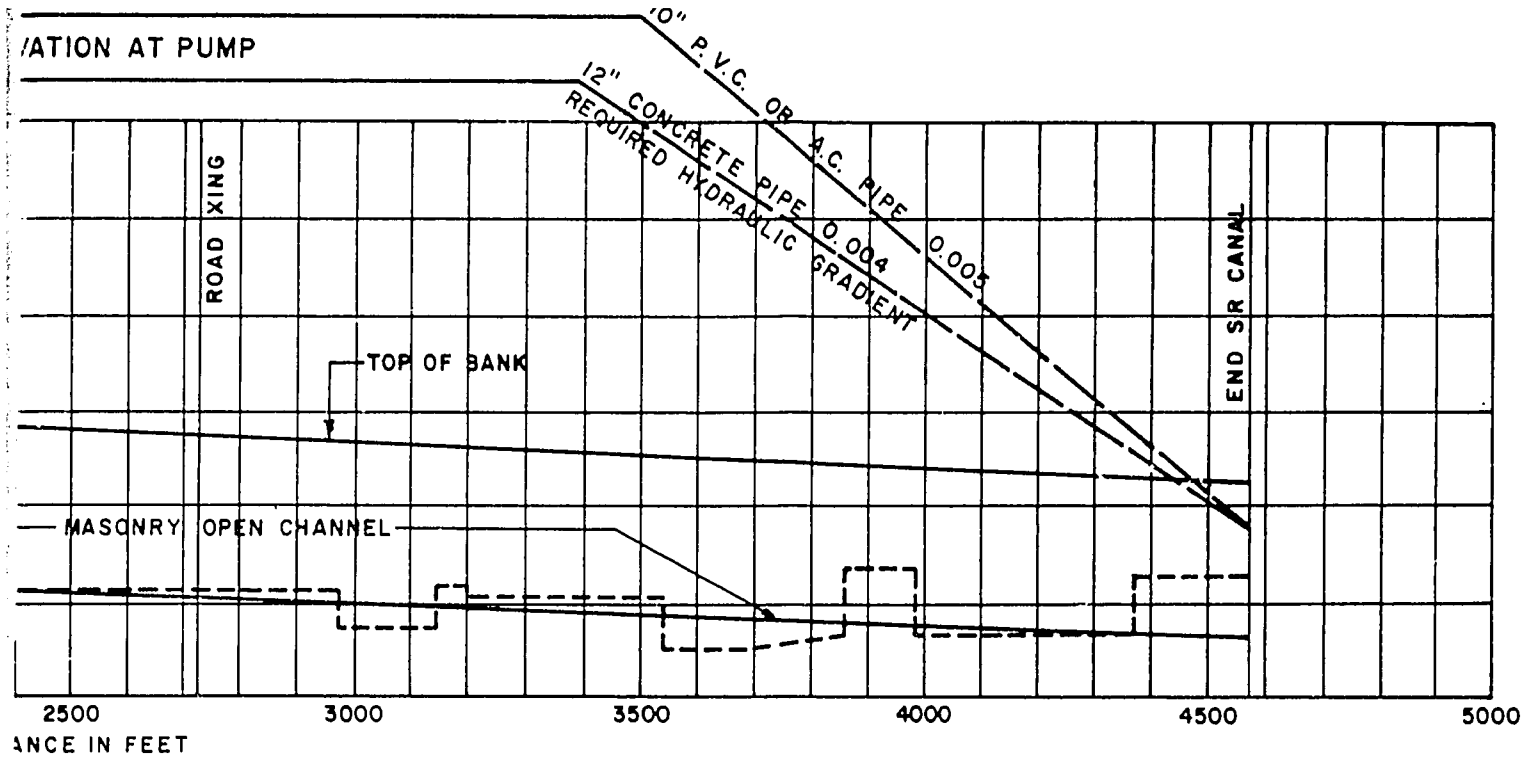


LAT. SR-2

SACHA
IRRIGAT
(PERMANENT DEVELOP

A-6-C



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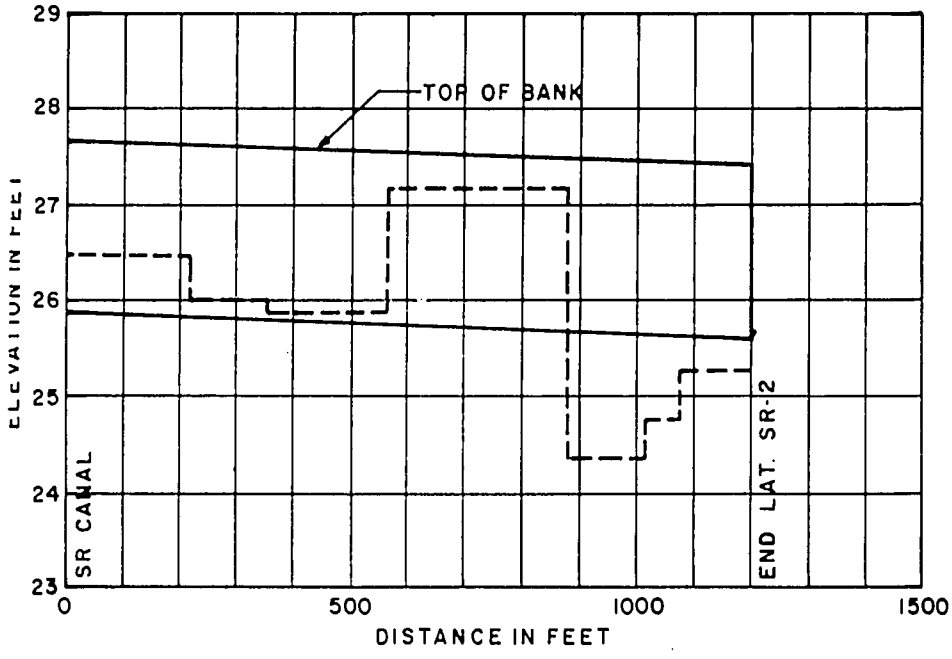


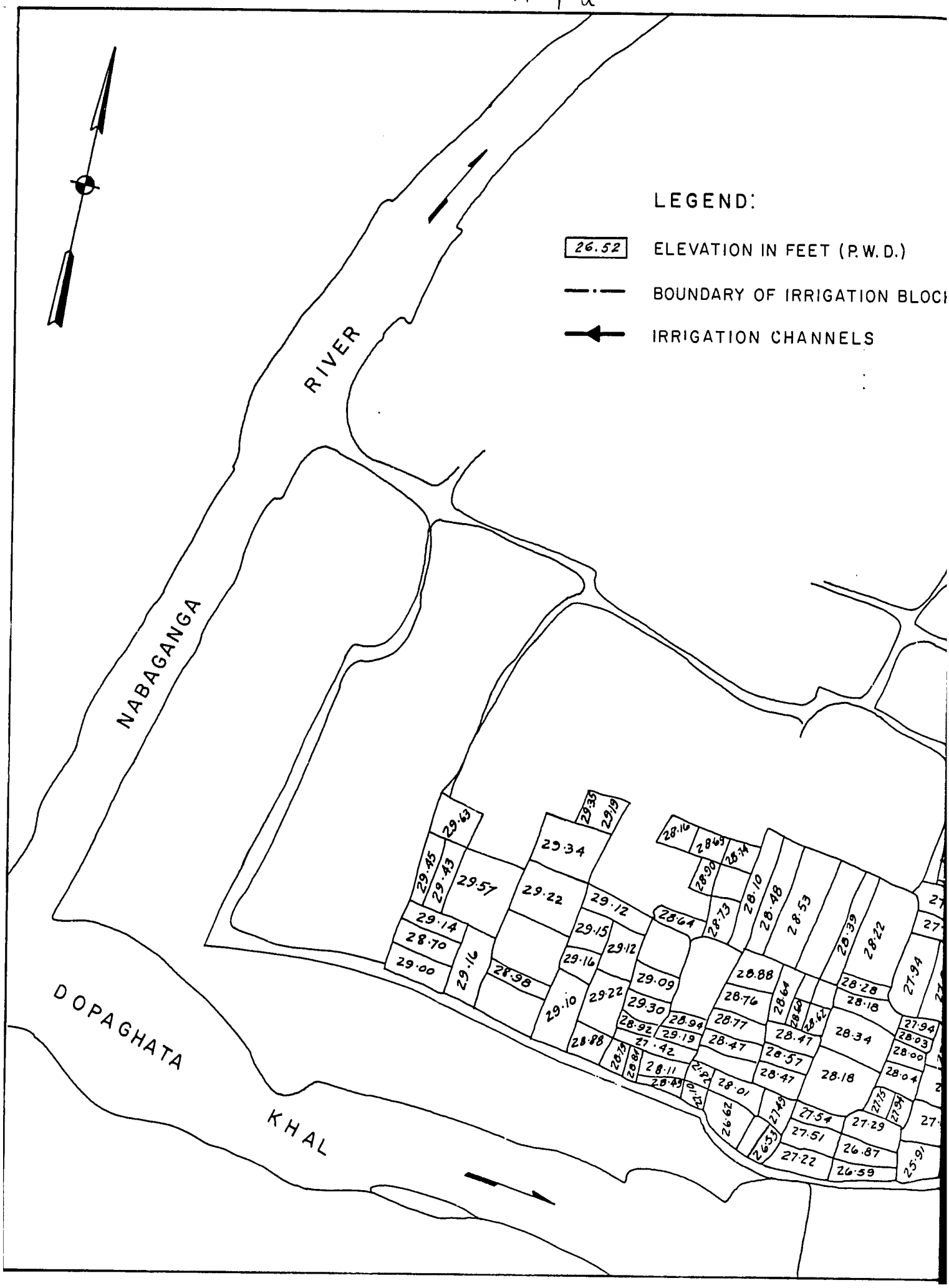
LAT. SR-2

SACHANI RAUTARA TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM
(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURES)

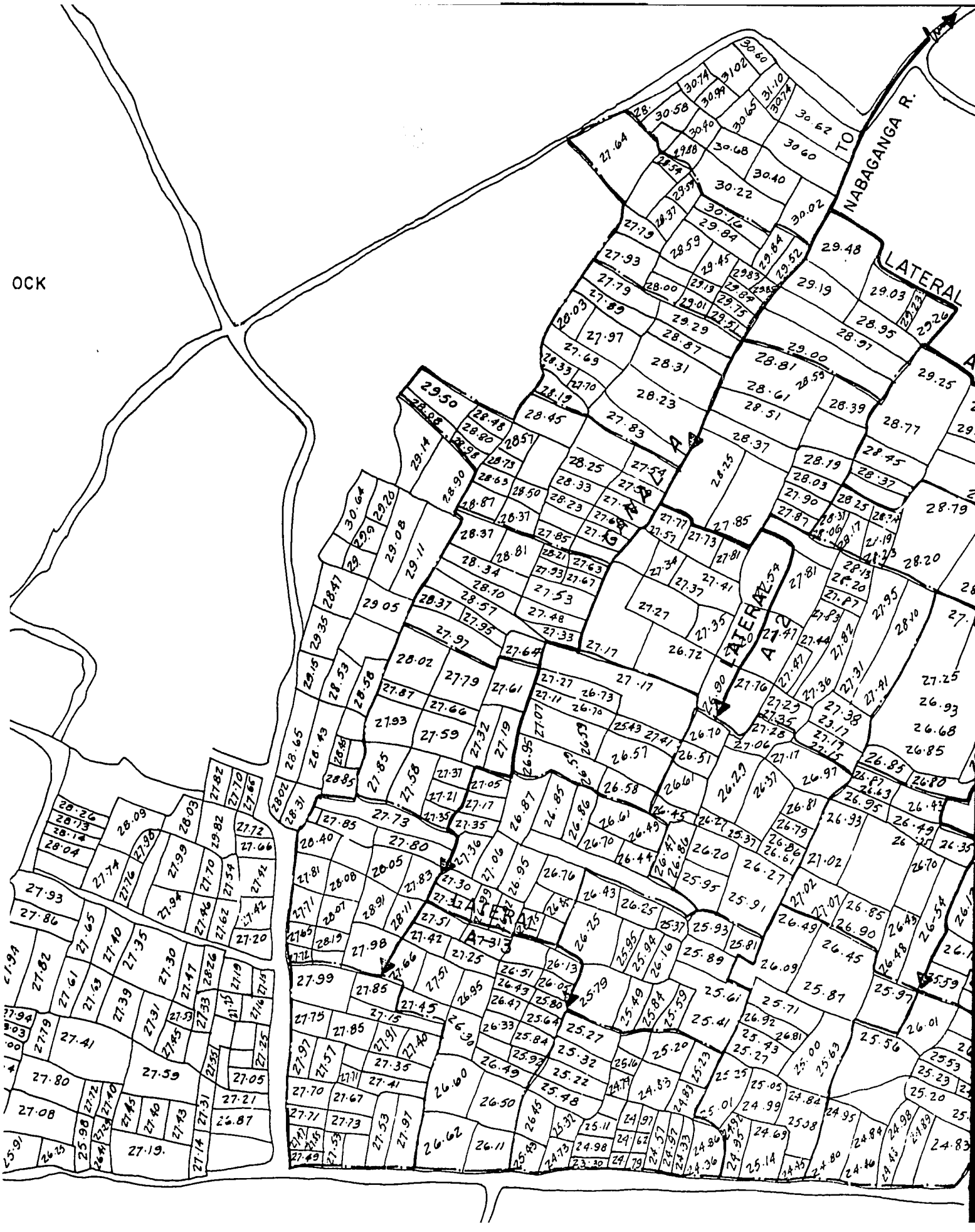
PROFILES

FIGURE A-6

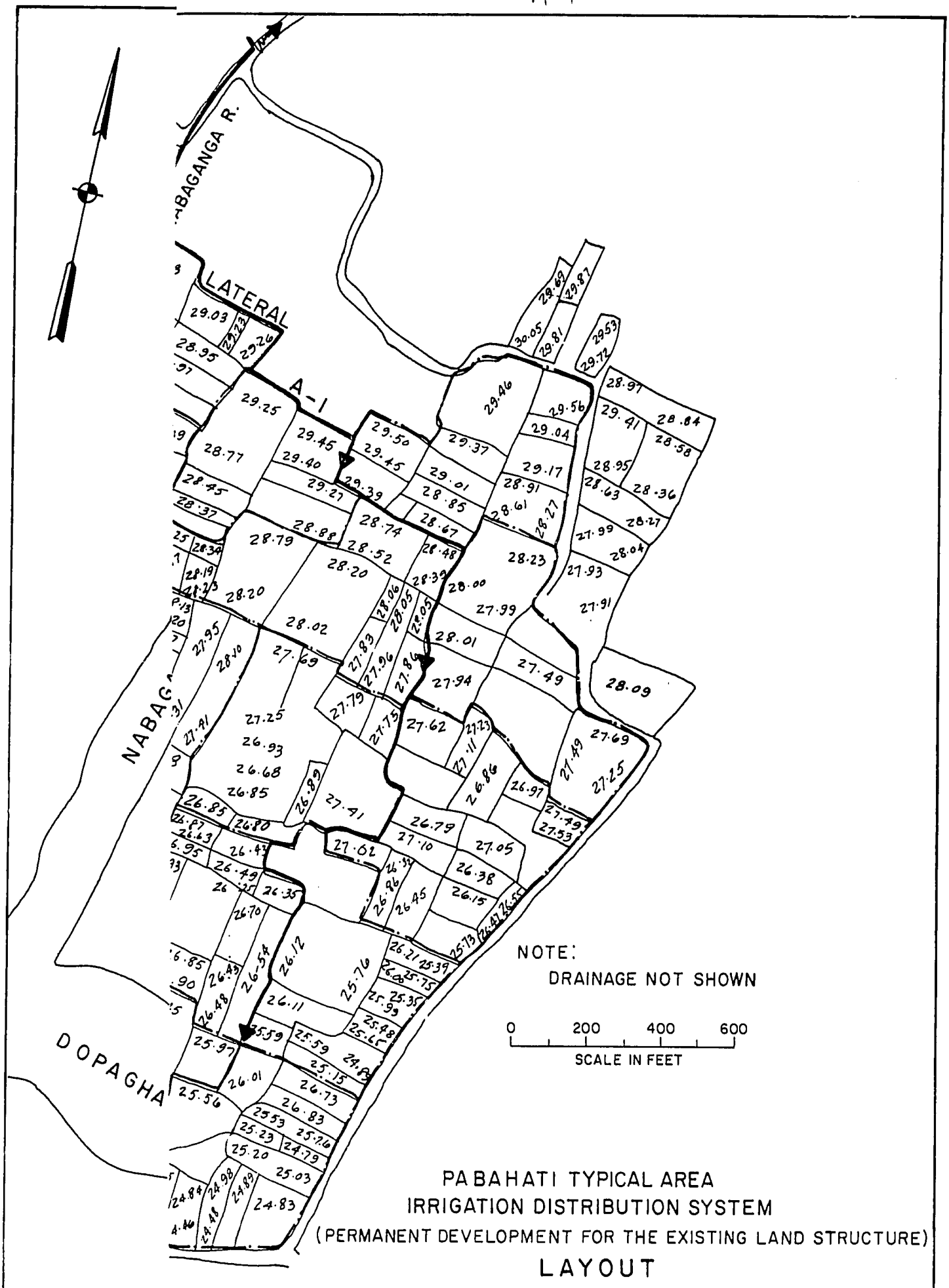
A-7 a


LEGEND:
26.52 ELEVATION IN FEET (P.W.D.)
BOUNDARY OF IRRIGATION BLOCK
IRRIGATION CHANNELS
NABAGANGA RIVER
DOPAGHATA KHAL

A-7 b



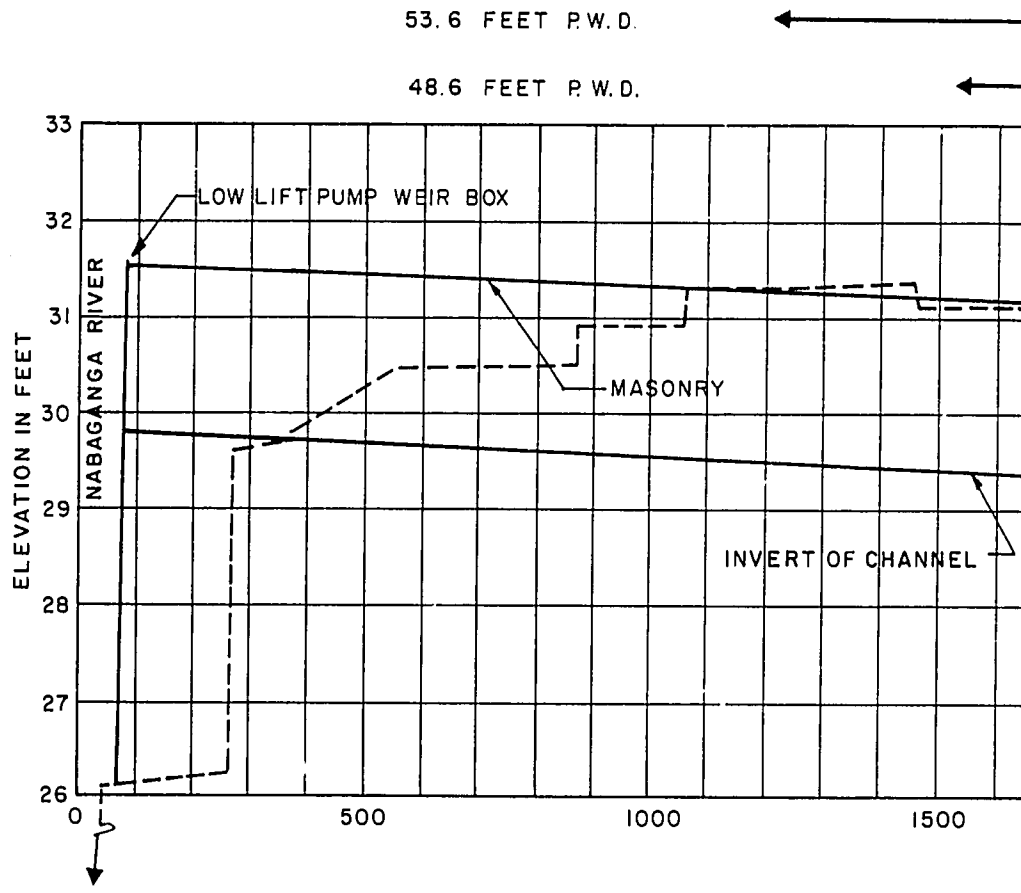
A-7-C

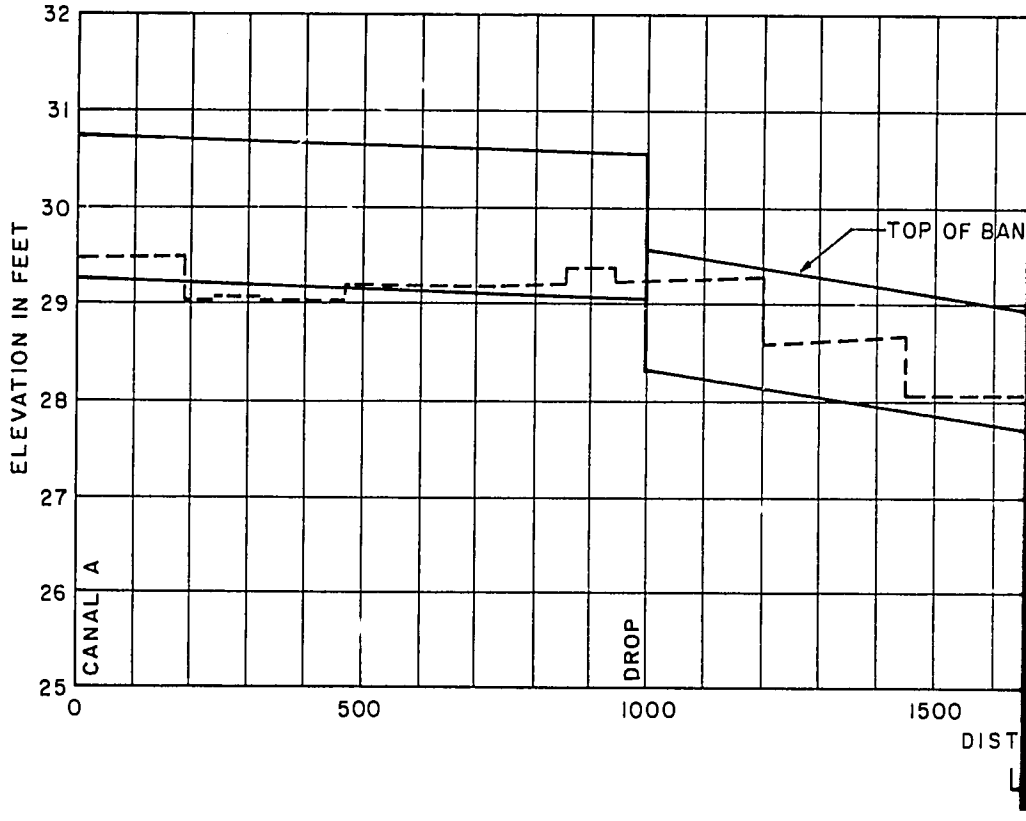


PABAHATI TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM
(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURE)
LAYOUT

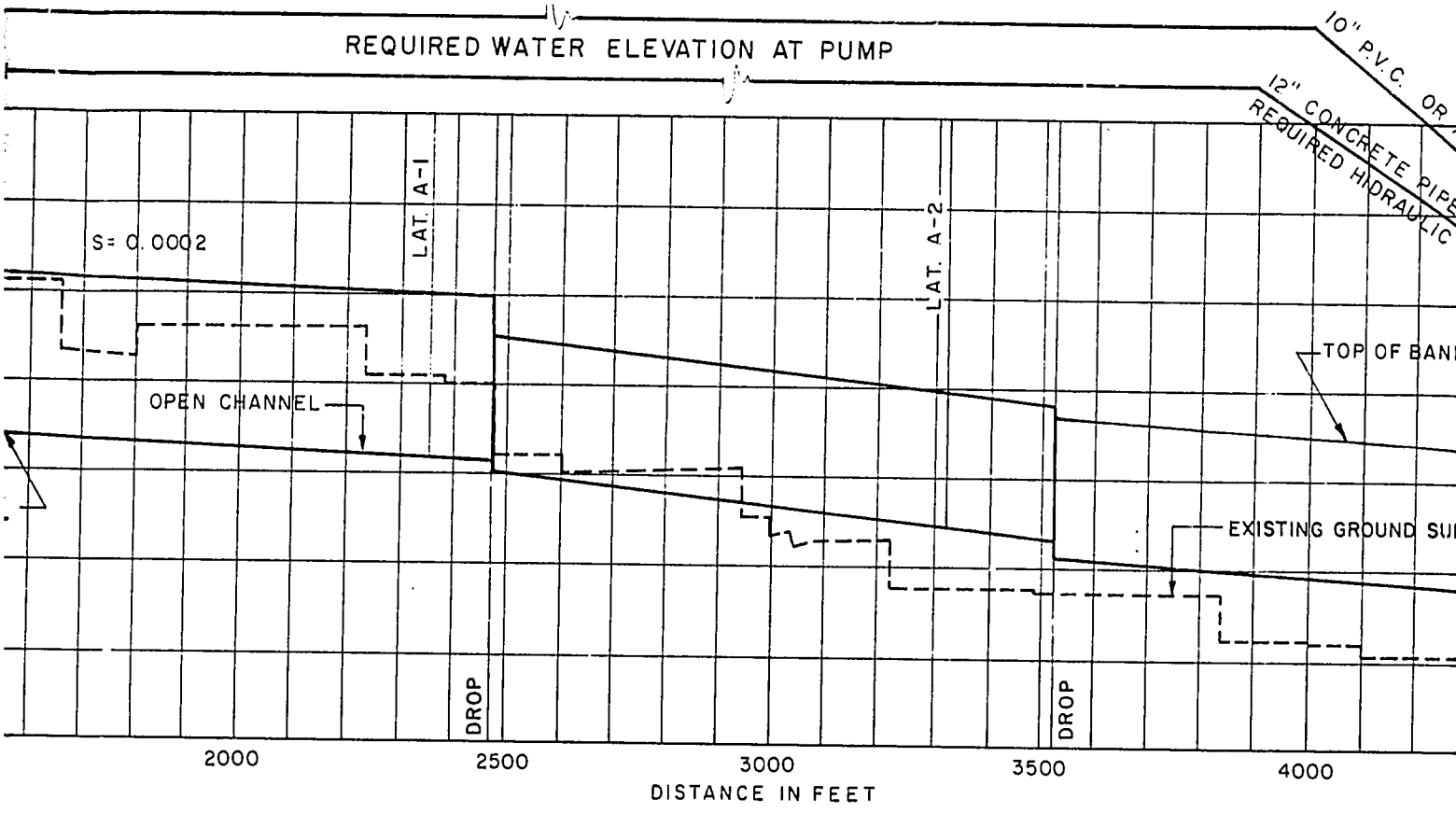
FIGURE A-7

A-8 a

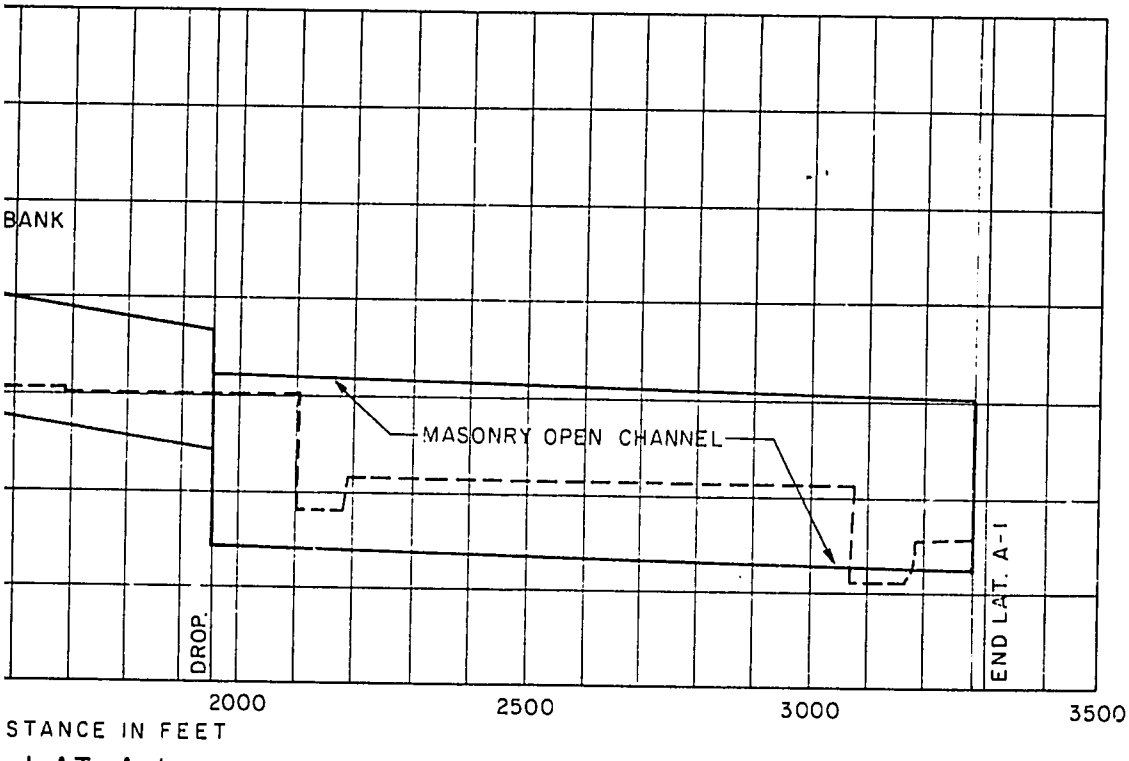

53.6 FEET P.W.D.
48.6 FEET P.W.D.
LOW LIFT PUMP WEIR BOX
NABAGANGA RIVER
MASONRY
INVERT OF CHANNEL
ELEVATION IN FEET
33
32
31
30
29
28
27
26
0
500
1000
1500


TOP OF BAN
CANAL A
DROP
ELEVATION IN FEET
32
31
30
29
28
27
26
25
0
500
1000
1500
DIST

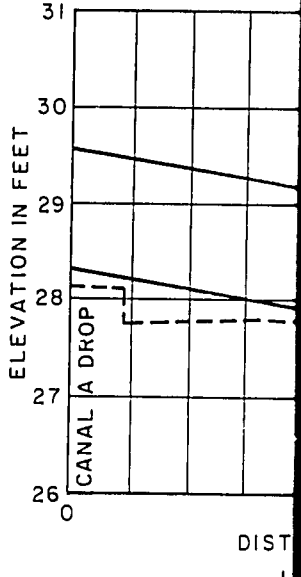
A-8-b



CANAL A

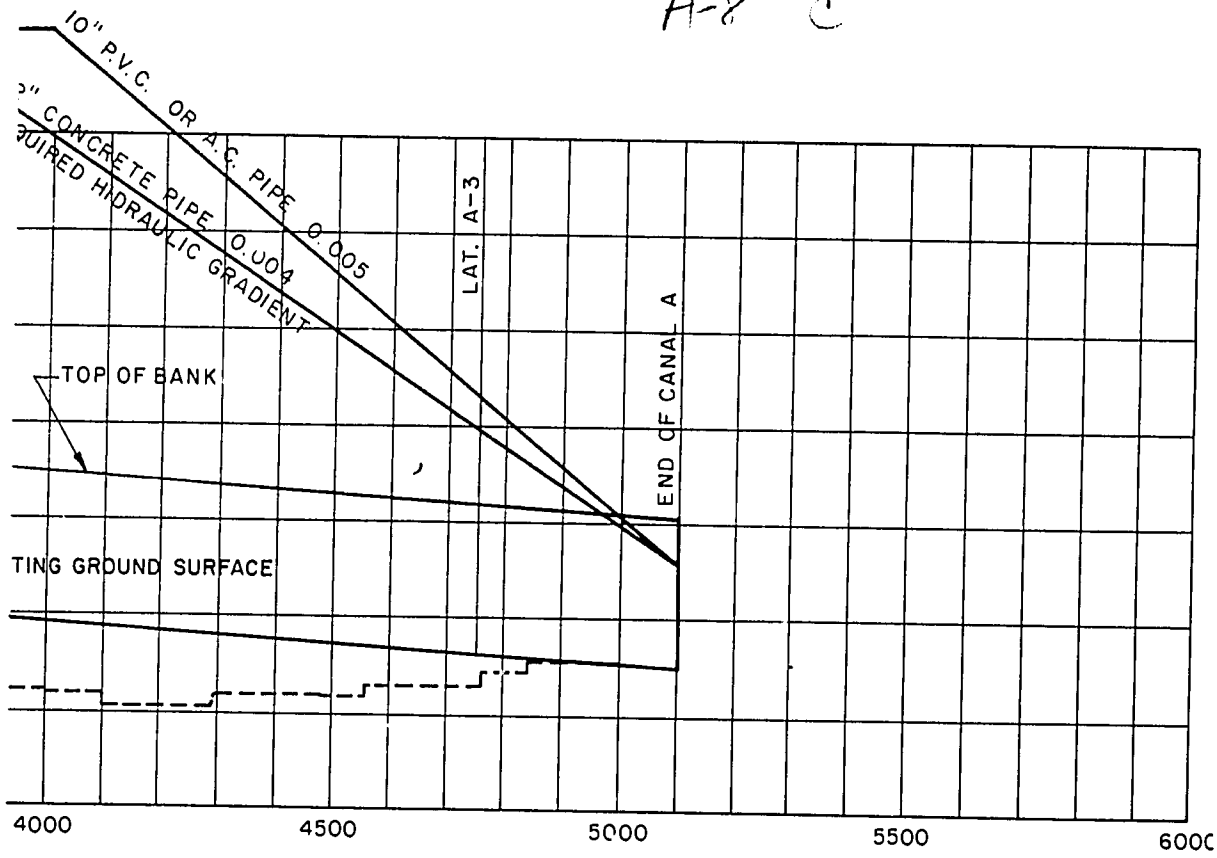


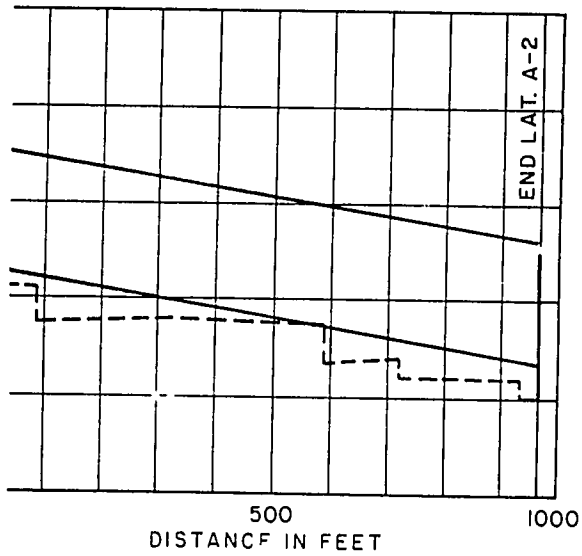
LAT. A-1



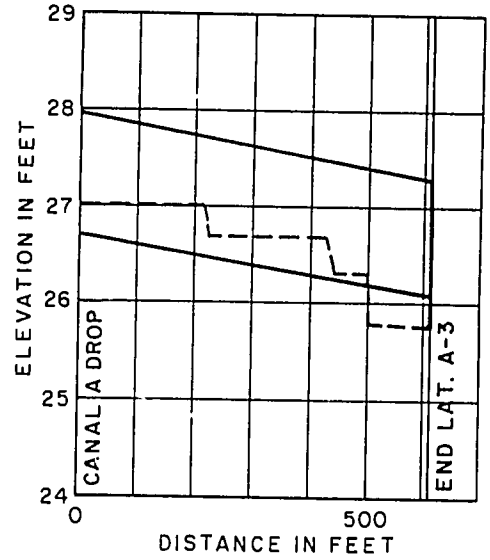
(PERM

A-8 c





LAT. A-2



LAT. A-3

PABAHATI TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM
(PERMANENT DEVELOPMENT FOR THE EXISTING LAND STRUCTURE)
PROFILES

FIGURE A-8

APPENDIX B
HYDROLOGY AND HYDRAULICS

APPENDIX B
HYDROLOGY AND HYDRAULICS

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APPENDIX B

HYDROLOGY AND HYDRAULICS

1. INTRODUCTION

This appendix summarizes the hydrologic analyses carried out for the Nabaganga Integrated Land and Water Use Study in order to determine: a) available surface water supplies: b) peak discharges for sizing of spillway; c) special flooding conditions throughout the basin; d) final crop averages for which a dependable surface water supply is available; e) criteria for operation of the existing and proposed water level control.

A rainfall runoff flood hydrologic model (HEC-1) developed by the U.S. Corps of Engineers was used to analyze flooding in the basin and to estimate peak discharges. A monthly reservoir operation computer program was used to analyze the water balance for the project and to develop operation criteria.

A preliminary evaluation of groundwater in the project area is presented in the hydrology section, as groundwater use for irrigation in some small areas inside the project area is being considered.

Section 3, Hydraulics summarizes the computations made for estimating the capacity of the existing Magura weir for the adopted design flood conditions and the capacity of the proposed weir to be located across the diversion channel. These hydraulic computations were used for the preliminary design of the weir.

2. HYDROLOGY

2.1 Drainage Area

The project area is located inside the drainage basin of the Nabaganga and Kumar rivers. The combined area above Magura is about 570 square miles (see Figure B-1).

The Nabaganga and Kumar rivers were in the past connected to the distributary channel system of the Ganges River. Through a series of natural processes and construction of canal and road embankments in the area, the Nabaganga and Kumar rivers were cut off from the major distributary channels. In their present state, the Nabaganga and Kumar rivers collect only local runoff from precipitation in the basin and irrigation return flows from the Ganges-Kobadak (G-K) Project. The Gorai river is the only right bank distributary of the Ganges river in the area.

The Nabaganga-Kumar drainage basin above Magura is bounded on the north and northeast by the Kushtia canal and Gorai River embankments; by the Nabaganga River on its south side and by the Ganges canal and railroad embankments on the west. Surface runoff in the basin occurs in a general north-south direction following the very gentle slope of the terrain. An area of about 355 square miles drains into the Kumar river channel and an area of about 215 square miles lying between the Kumar and Nabaganga rivers drains into the latter.

Three natural channels that start on the Nabaganga River (Dopaghata, Alam Khali and Haor Khali Khals) act as spill channels during flooding in the Nabaganga-Kumar basin.

Local runoff and return flows collected by the Nabaganga and Kumar rivers above Magura will constitute the surface water source for irrigation by low-lift pumping in the project area. Channel storage in both Nabaganga and Kumar rivers by means of control structures located near Magura will be used to provide water for irrigation in the dry season.

2.2 Rainfall and Evaporation Data

Daily precipitation records are available at the following stations inside or near the Nabaganga-Kumar basin:

- Shailkupa, since Oct. 1, 1962
- Magura, since July 25, 1962
- Jhenida, since March 3, 1961
- Alamdanga, since December 1, 1962

Monthly precipitation recorded at these stations is shown in Tables B-1 through B-4. Weighted monthly average basin precipitation estimated by the Thiessen polygon method using these data are shown in Table B-5.

TABLE B-1

MONTHLY RAINFALL AT MAGURA

(Inches)

YEAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	ANNUAL
62-63	0.53	7.71	9.44	6.72	14.76	6.11	0.0	0.0	0.0	0.0	0.0	0.0	45.27
63-64	3.99	4.88	15.04	7.81	7.73	17.66	5.45	0.61	0.0	0.03	0.73	0.40	64.33
64-65	10.58	4.17	16.67	12.44	11.05	3.76	11.60	0.70	0.0	Data not available			
65-66	1.10	6.47	12.50	7.97	10.10	9.18	1.03	1.20	0.0	0.90	0.0	1.78	52.53
66-67	2.02	2.65	14.49	11.21	10.36	4.32	13.10	0.0	0.31	1.38	0.45	3.33	63.62
67-68	3.09	5.83	10.53	8.71	11.05	13.14	3.49	0.0	0.0	0.02	0.15	2.04	58.05
68-69	4.36	7.16	16.98	22.05	13.75	6.93	4.58	3.58	0.0	0.0	0.25	2.57	82.21
69-70	4.45	5.25	9.94	8.28	20.0	11.29	2.58	2.35	0.0	0.84	0.56	1.64	67.18
70-71	2.92	5.87	10.73	16.85	7.97	16.45	11.04	1.03	0.0	0.78	0.10	0.10	73.84
71-72		Data not available											
72-73	3.44	6.71	10.30	7.65	11.15	4.58	0.40	0.0	0.0	0.0	0.43	2.64	47.30
73-74	3.11	19.55	19.27	10.24	11.20	11.36	5.27	3.60	2.77	0.0	0.0	3.5	89.87
74-75	3.85	8.67	8.99	19.12	14.63	11.83	3.94	0.04	0.0	0.09	0.39	0.12	71.67
75-76	0.91	8.35	4.04	25.75	8.46	8.13	7.72	0.95	0.0	0.0	0.81	0.0	65.12
76-77	2.52	8.39	4.62	7.48	12.05	8.11	5.17	0.41	0.0	0.16	0.71	0.0	49.62
77-78	10.85	8.01	16.42	14.25	10.11	9.38	5.08	3.87	1.19	0.0	0.64	0.99	80.79
Mean	3.85	7.31	12.0	12.44	11.62	9.48	5.36	1.22	0.28	0.30	0.37	1.37	65.08

TABLE B-2

MONTHLY RAINFALL AT SHAILKUPA
(Inches)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
63-64	0.0	3.95	10.87	5.45	4.55	12.35	3.76	0.88	0.0	0.0	0.02	2.10	43.93
64-65	15.60	3.29	9.95	11.28	7.50	7.06	17.15	0.0	0.0	Data not available			
65-66	2.16	3.35	10.41	10.10	12.52	12.91	2.24	0.0	0.0	0.0	0.0	0.0	53.69
66-67	2.19	3.96	11.57	11.67	11.67	4.91	3.82	0.30	0.27	0.76	0.55	3.80	55.47
67-68	2.29	2.99	10.37	12.29	14.11	13.17	3.04	0.0	0.0	0.0	0.0	1.16	59.42
68-69	1.55	7.12	15.40	16.45	14.79	5.51	1.76	3.63	0.0	0.0	0.35	1.01	67.57
69-70	2.50	5.46	7.64	11.23	16.29	12.56	2.74	1.57	0.0	1.10	0.97	0.31	62.37
70-71	3.47	4.29	9.66	18.64	6.40	12.48	13.72	0.10	0.0	0.13	0.0	0.30	69.19
71-72	Data Not Available												
72-73	3.0	3.62	5.30	5.20	9.50	2.89	1.54	0.0	0.0	0.0	1.17	2.77	34.99
73-74	2.42	10.93	14.52	6.55	9.90	10.85	2.72	1.76	2.51	0.0	0.0	2.80	64.96
74-75	4.09	9.43	7.44	19.28	8.98	11.72	1.22	0.0	0.0	0.0	0.0	0.15	62.31
75-76	2.22	8.71	4.37	26.35	7.09	11.48	2.89	1.10	0.0	0.0	0.0	0.0	64.21
76-77	3.76	5.40	9.46	6.24	9.64	5.67	3.12	1.15	0.0	0.17	1.55	0.0	46.16
77-78	10.64	7.45	16.68	10.75	7.77	6.57	7.64	2.67	1.80	0.0	0.48	2.35	74.80
Mean	3.99	5.71	10.26	12.25	10.05	9.30	4.81	0.94	0.33	0.17	0.39	1.29	58.39

TABLE B-3

MONTHLY RAINFALL AT ALAMDANCA
(Inches)

Year	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
62-63	Data not available									0.10	0.0	0.0	
63-64	8.56	3.21	13.79	6.07	10.04	10.75	4.19	0.59	0.0	0.0	0.77	0.66	58.63
64-65	8.65	4.58	8.66	12.02	5.81	6.33	9.98	0.0	0.0	Data not available			
65-66	0.50	0.0	6.76	11.67	11.11	7.13	1.07	0.89	0.0	1.60	0.0	0.0	40.73
66-67	0.25	3.0	8.91	6.13	16.48	6.09	6.94	0.54	0.71	0.87	0.0	1.5	51.42
67-68	4.75	3.35	10.55	14.85	14.39	18.52	0.0	0.0	0.0	0.0	0.0	0.69	67.10
68-69	1.93	5.02	10.74	18.57	9.32	5.49	2.32	1.27	0.0	0.0	0.54	0.79	55.99
69-70	4.85	5.18	5.45	8.09	13.14	16.71	4.90	1.72	0.0	1.86	1.65	3.02	66.57
70-71	1.01	5.43	12.72	11.81	7.35	11.14	9.31	3.63	0.0	0.23	0.0	0.21	62.84
71-72	Data Not Available												
72-73	1.19	6.94	6.78	4.19	16.75	2.41	1.03	0.0	0.0	0.0	0.76	0.50	40.55
73-74	4.60	13.13	10.63	7.13	11.70	8.46	5.64	0.77	0.0	0.08	0.0	2.13	64.27
74-75	4.16	2.91	5.59	17.37	11.40	7.43	3.58	0.0	0.0	0.0	1.61	0.09	54.14
75-76	0.88	9.55	2.29	20.32	9.50	10.93	4.49	0.85	0.0	0.0	0.83	0.31	59.95
76-77	3.64	8.89	6.46	14.19	11.61	9.72	2.44	0.40	0.0	0.07	0.0	0.0	57.42
Mean	3.46	5.48	8.41	11.72	11.43	9.32	4.30	0.82	0.05	0.37	0.47	0.76	56.63

TABLE B-4

MONTHLY RAINFALL AT JHENIDA
(Inches)

Year	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
62-63	4.09	5.92	9.38	8.52	12.08	6.88	6.54	0.0	0.0	0.0	0.0	0.0	53.41
63-64	5.20	3.53	13.89	6.05	7.36	12.78	4.89	0.54	0.0	0.35	0.47	1.22	56.28
64-65	10.43	3.83	10.45	9.65	6.03	7.45	13.88	0.04	0.0	Data not avialable			
65-66	1.80	4.02	8.25	10.50	12.79	10.43	2.20	2.22	0.0	1.26	0.0	0.0	53.47
66-67	2.47	3.91	12.37	9.42	7.63	7.10	7.41	0.35	0.34	0.88	0.17	5.71	57.81
67-68	3.00	6.69	10.57	9.74	16.94	9.08	2.10	0.0	0.0	0.0	0.0	1.65	59.77
68-69	1.48	5.37	13.69	18.63	6.80	6.58	2.45	3.50	0.0	0.0	0.22	2.47	61.19
69-70	3.20	3.19	8.82	10.68	14.71	16.99	2.29	1.33	0.0	1.29	0.68	1.60	64.78
70-71	1.65	6.77	9.15	17.84	10.70	14.97	10.67	0.0	0.0	1.23	0.0	0.53	73.51
71-72	Data Not Available												
72-73	0.54	8.92	7.78	7.56	9.81	1.67	2.25	0.0	0.0	0.0	0.59	2.94	42.06
73-74	1.17	14.22	17.03	9.70	8.61	8.40	6.62	1.04	3.60	0.0	0.0	3.94	74.33
74-75	2.98	10.04	6.98	16.19	12.44	7.34	1.90	0.0	0.0	0.13	0.41	0.0	58.41
75-76	1.27	6.73	2.42	23.34	4.91	5.66	2.[illegible]	1.25	0.0	0.0	1.57	0.17	50.25
76-77	2.16	6.90	11.46	9.21	9.64	6.98	6.20	0.60	0.0	0.07	0.69	0.0	53.91
77-78	11.02	7.21	16.32	14.03	10.68	6.32	5.68	4.19	1.92	0.0	0.25	1.52	79.14
Mean	3.50	6.48	10.57	12.07	10.08	8.58	5.20	1.0	0.39	0.37	0.36	1.55	59.88

TABLE B-5

BASIN WEIGHTED AVERAGE PRECIPITATION *
(Inches)

Year	Apr.	May.	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
63-64	4.98	3.65	13.02	6.05	7.73	12.22	4.28	0.67	0.0	0.05	0.49	1.16	54.30
64-65	11.25	4.03	10.11	11.50	6.89	6.46	12.91	0.08	0.0	0.33 (1)	0.44 (1)	1.12 (1)	55.12
65-66	1.26	2.25	8.67	10.65	11.68	9.59	1.59	0.83	0.0	0.99	0.0	0.18	47.69
66-67	1.34	3.39	10.78	8.82	13.14	5.69	6.65	0.39	0.48	0.89	0.24	2.99	54.80
67-68	3.58	3.95	10.50	12.73	14.33	15.0	1.59	0.0	0.0	0.0	0.02	1.11	62.81
68-69	1.99	5.93	13.22	18.27	11.11	5.79	2.39	2.54	0.0	0.0	0.41	1.16	62.81
69-70	3.85	5.0	7.05	9.45	15.02	14.92	3.63	1.68	0.0	1.44	1.19	1.84	65.07
70-71	2.05	5.31	11.07	15.28	7.59	12.62	11.04	1.77	0.0	0.39	0.01	0.27	67.40
71-72	Data Not Available												
72-73	1.89	6.17	6.81	5.32	12.97	2.67	1.30	0.0	0.0	0.0	0.83	1.76	39.72
73-74	3.30	13.24	13.60	7.62	10.66	9.48	4.84	1.40	1.56	0.04	0.0	2.73	68.47
74-75	3.94	6.51	6.70	17.97	11.12	9.19	2.65	0.0	0.0	0.03	0.82	0.10	59.03
75-76	1.35	8.77	3.13	23.16	8.01	10.08	4.10	0.99	0.0	0.0	0.67	0.16	60.42
76-77	3.36	7.48	7.91	10.36	10.77	7.92	3.45	0.66	0.0	0.11	0.65	0.0	52.67
Mean	3.40	5.82	9.43	12.09	10.85	9.36	4.65	0.85	0.16	0.33	0.44	1.12	58.50

* Weighted Averages Based on the Following Percentages of Total Area:

Station	% of Total Area
Shailkupa	31
Magura	10
Alamdanga	45
Jhenaidah	14
	100

(1) Estimated Values as Equal to Mean

TABLE B-6

MAXIMUM AND 2ND HIGHEST 24-HOUR PRECIPITATION
(Inches)

Year	SHAILKUPA Precip.	SHAILKUPA Date	MAGURA Precip.	MAGURA Date	JHENIDA Precip.	JHENIDA Date	ALAMDANGA Precip.	ALAMDANGA Date
1962			2.24	Jun.	3.30	Jun. 17		
					3.08	Aug. 22		
1963	3.05	Jun. 7	5.00	Jun. 7	4.04	Jun. 8	4.60	Jun. 7
	2.65	May 31	4.07	Sep. 15	2.55	Jun. 7	3.80	Apr. 18
1964	9.27	Apr. 28	7.70	Oct. 6	6.85	Oct. 6	5.31	Oct. 6
	8.50	Oct. 6	5.22	Jun. 15	5.95	Apr. 28	4.31	Jul. 17
1965	5.75	Sep. 20	5.61	May 12	5.25	Aug. 25	3.17	Aug. 25
	5.45	Aug. 25	4.04	Jun. 30	2.76	May 12	2.87	Jun. 30
1966	3.83	Jun. 21	5.20	Jun. 22	4.39	Jun. 22	4.63	Jun. 22
	3.53	Aug. 22	4.18	Oct. 1	2.52	Sep. 18	2.90	Aug. 30
1967	3.85	Jun. 18	3.92	Jun. 13	9.21	Aug. 10	4.75	Sep. 5
	3.60	Aug. 10	2.95	Apr. 19	2.95	Jun. 13	4.25	Sep. 4
1968	4.80	Jul. 8	5.90	Jul. 8	5.74	Jul. 10	6.10	Jul. 8
	4.45	Jul. 10	4.60	Jul. 10	3.59	Jul. 8	2.95	Jul. 9
1969	2.95	Sep. 28	4.00	Aug. 29	3.58	Sep. 25	7.35	Sep. 26
	2.80	Jul. 11	3.15	Aug. 2	3.26	Sep. 26	3.99	Jul. 10
1970	3.65	Jul. 21	4.00	Sep. 14	4.90	Aug. 12	3.45	Nov. 2
	3.40	Jul. 12	3.65	Oct. 24	3.65	Oct. 24	3.37	Jul. 12
1971			(Not Available)					
1972	1.80	May. 24	4.98	May 24	5.07	May 24	5.60	Aug. 29
	1.75	Jul. 24	2.35	Jun. 16	2.10	Jun. 17	5.12	May 24
1973	2.90	Sep. 19	4.35	Jun. 29	2.76	Jun. 28	4.20	Apr. 30
	2.82	Jun. 24	4.09	Aug. 1	2.53	Jul. 26	3.15	Aug. 11
1974	3.73	Aug. 19	5.10	Aug. 19	4.73	Aug. 19	6.40	Aug. 19
	2.85	May 31	2.62	Jul. 2	3.20	May 31	3.03	Aug. 21
1975	5.75	Jul. 14	5.90	Jul. 17	5.14	Jul. 16	5.04	Jul. 18
	4.85	Jul. 16	4.15	Jul. 14	4.25	Jul. 18	4.61	May 19
1976	3.83	Jun. 6	3.67	Aug. 16	5.75	Jun. 6	6.07	Sep. 11
	3.10	Aug. 16	2.30	May 8	3.80	Sep. 27	3.00	Aug. 16
1977	4.54	Oct. 4	3.42	Oct. 6	4.36	Apr. 19		
	3.35	Jun. 27	3.30	Aug. 14	3.30	Jul. 29		

Mean annual precipitation over the basin is about 60 inches. Over 70 percent of the annual rainfall is usually received during the monsoon season from June to September. Occasional thunderstorms occur during both the pre-monsoon months (April-May) and post-monsoon months October-November. Maximum and second highest 24-hour precipitation amounts recorded at the stations in the basin during the period 1962-1978 are shown in Table B-6. The highest three 24-hour precipitation values recorded at each station are shown below:

Station	Precipitation, in.	Date of Occurence
Shailkupa	9.27	April 28, 1964
	8.50	Oct. 6, 1964
	5.75	July 14, 1975
Magura	7.70	Oct. 6, 1964
	5.90	July 17, 1975
	5.20	June 22, 1966
Alamdanga	7.35	Sept. 26, 1969
	6.40	Aug. 19, 1974
	6.10	July 8, 1968
Jhenida	9.21	Aug. 10, 1967
	6.85	Oct. 6, 1964
	5.95	April 28, 1964

Mean and annual pan evaporation recorded near the project area at Jessore meteorological station are shown on Table B-7.

TABLE B-7

MEAN MONTHLY PAN EVAPORATION AT JESSORE

Month	Evaporation, Inches
January	2.50
February	3.12
March	5.39
April	5.83
May	5.49
June	3.84
July	3.86
August	3.66
September	3.47
October	3.47
November	2.93
December	2.39
ANNUAL	45.95

2.3 Stage-Discharge Data

River stages are recorded since 1965 at several locations in the drainage basin above Magura. Daily stages are recorded at the following non-tidal stations.

River	Station No.	Remarks
Nabaganga	215 - Jhenida	Discharge measurements: average of 8 per year, 1968-73.
Nabaganga	216 - Magura	Discharge measurements: average of 33 per year, 1968-73.
Nabaganga	216A - Magura (Downstream of junction with Kumar river)	Discharge measurements: average of 38 per year in period 1969-74.
Kumar	171 - Garaganj	Daily discharge measurements estimated since 1965.

Stage-discharge relationships are not well defined at above stations. Flat river slopes result in very low flow velocities and wide variations of estimated discharge for very small variations in stage. Discharge measurements for high stages at station 216A - Magura, are further distorted by backwater effects produced by the connection of the Nabaganga river to the Gorai river at Halifax cut (see Figure B-2, Nabaganga River Profile). Consequently, stage-discharge data were not used for runoff estimates. As a reference, maximum stages are shown in Table B-8.

2.4 Channel Storage

Channel storage in both the Nabaganga and Kumar rivers upstream of Magura will be used to provide irrigation water in the dry season. Figures B-3 and B-4 show the plan and profile of the Nabaganga and Kumar channels upstream of Magura, respectively. Cross-section data at locations indicated on above figures were also used to establish the Area-Storage curves shown in Figure B-5.(1)

2.5 Annual and Monthly Runoff Volumes

The surface water regime in the project area follows very closely the annual precipitation pattern, with widespread rainwater flooding during the monsoon and low or nil runoff during the dry months.

(1) Data from Southwest Regional Planning Study, Special Studies Directorate - IECO, 1979.

TABLE B-8

MAXIMUM RIVER STAGES AT

INDICATED LOCATIONS (FEET P.W.D. DATA)

WATER YEAR	NABAGANGA RIVER AT JHENIDA STA, 215	KUMAR RIVER AT GERAGANJ STA, 171	NABAGANGA RIVER AT MAGURA STA, 216	NABAGANGA RIVER AT MAGURA STA, 216 A
1965-66	22.9	22.5	16.9	14.8
66	20.2	20.9	16.4	15.6
67	22.3	23.7	17.9	17.4
68	22.7	22.1	18.5	17.3
69	23.7	24.6	21.5	21.2
70	23.8	22.0	17.5	16.8
71	N.A.(x)	30.3	27.5	26.6
72	20.2	19.0	12.9	12.5
73	22.1	22.9	16.0	15.7
74	23.1	23.4	16.6	16.3
75	21.1	23.3	16.6	15.5
76	22.4	19.8	16.7	16.2
77-78	23.6	20.4	N.A.	14.0

(x) Not Available

During the monsoon season both river and groundwater levels rise significantly. After the monsoon rains, the river levels recede quickly developing a hydraulic gradient toward the rivers producing regeneration or low flow maintenance. This river regeneration is believed to be confined to bank storage and adjacent ground within one and one-and-a-half miles of the main channels. Irrigation return flows from the Ganges-Kobaduk project also contribute to dry season flows in the Nabaganga-Kumar rivers. Flows are recorded on the Nabaganga river at station 216A - Magura even during months of zero precipitation (usually December and January).

Monthly estimates of runoff volumes for the months of February through November, therefore, were based on weighted average precipitation and the following runoff coefficients:

February	0.3	July	0.5
March	0.3	August	0.6
April	0.3	September	0.7
May	0.3	October	0.7
June	0.4	November	0.6

Runoff volumes for the low flow months of December and January were estimated based on stage and discharge data at station 216A - Magura. Ten-day averages of recorded daily stage readings were calculated for a given month and corresponding discharges were estimated. Monthly runoff volumes were then computed using these ten-day average discharges. Available water inflows to channel storage during December and January were conservatively assumed to be equal to 50 percent of above volumes. Estimated monthly volumes of surface water available for irrigation in the project area for the period 1963-64 to 1976-77 are shown in Table B-9.

2.6 Basin-Wide Analysis of Flooding Conditions

As stated in Section 2.1, flooding in the basin is caused by local monsoon rains since the Nabaganga and Kumar rivers are not part of the Ganges distributory system anymore. Most of the land in the project area is above normal flooding, according to the survey conducted for this study. Flooding in some areas varies from one foot in medium-low land to about six feet in low land or beel areas.

Exceptional flooding conditions occurred in the Magura area during the first year when the Nabaganga River was blocked by the construction of the Magura weir. Discharge through the Hoarkhali and Alamkhali khals, which were supposed to act as diversion channels, did not occur due to heavy siltation at the Nabaganga River upstream of its confluence with the Kumar River. A diversion channel was excavated to relieve the flooding. It was closed after completion

TABLE B-9

ESTIMATED RUNOFF VOLUMES AVAILABLE AT MAGURA[1]
(1000 ac-ft)

Year	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Annual
63-64	46.4	34.0	161.7	93.9	144.0	265.6	93.0	12.5	10.9	10.9	4.6	10.8	888.3
64-65	104.8	37.5	125.5	178.5	128.3	140.4	280.5	1.5	10.9	9.0	4.1	10.4	1031.4
65-66	11.7	20.9	107.6	165.3	217.5	208.4	34.5	15.5	11.7	11.7	0.0	1.7	806.5
66-67	12.5	31.6	133.8	136.9	244.7	123.6	144.5	7.3	30.8	30.8	2.2	27.8	926.5
67-68	33.3	36.8	130.4	197.6	266.9	325.9	34.5	0.0	14.3	18.3	0.2	10.3	1068.5
68-69	18.5	55.2	164.1	283.6	206.9	125.8	51.9	47.3	13.7	11.6	3.8	10.8	993.2
69-70	35.8	46.6	87.5	146.7	279.7	324.2	78.9	31.3	7.7	6.7	11.1	17.1	1073.3
70-71	19.1	49.5	137.4	237.1	141.4	274.2	239.9	33.0	6.6	3.3	0.1	2.5	1144.1
71-72					Data Not Available								
72-73	17.6	57.5	84.6	82.6	241.6	58.0	28.2	0.0	3.8	2.4	7.7	16.4	600.4
73-74	30.7	123.3	168.9	118.3	198.5	206.0	105.2	26.1	21.1	11.8	0.0	25.4	1035.3
74-75	36.7	60.6	83.2	278.9	207.1	199.7	57.6	0.0	38.2	4.1	7.6	0.9	974.6
75-76	12.6	81.7	38.9	359.4	149.2	219.0	89.1	18.4	4.9	3.0	6.2	1.5	983.9
76-77	31.3	69.7	98.2	160.8	200.6	172.1	75.0	12.3	3.7	1.6	6.1	0.0	831.4
Mean	31.6	54.2	117.1	187.7	202.0	203.3	101.0	15.8	13.7	9.6	4.1	10.4	950.5
S.D.	24.6	26.6	38.2	81.5	49.3	80.2	78.1	15.0	10.5	8.1	3.6	9.2	

1 February through November volumes estimated from rainfall data. December and January volumes based on stage-discharge data.

at the Magura weir, but it was soon reopened when there was concern of upstream flooding due to the scaled down spillway capacity of the weir. This diversion channel has remained open and is now the main flood outlet of the Nabaganga and Kumar rivers.

Monsoonal flooding in the Magura area at times has been increased by spills from the Gorai River near Kumarkhali. This infrequent event is less likely to occur in the future due to the construction of embankments in the area.

Analysis of flooding along the Nabaganga and Kumar rivers was made using the generalized computer program HEC-1 (1), that permits the simulation of the rainfall-runoff process in a whole basin.

2.6.1 Selection of Design Storm

During the available 14 years of record, the maximum 24-hour weighted average basin precipitation was 6.8 inches corresponding to the storm of October 6, 1964. It was computed as follows:

Station	24-hr. Point Rainfall, in.	% Area	Weighted Rainfall in.
Shailkupa	8.50	31	2.64
Magura	7.70	10	0.77
Alamdanga	5.31	45	2.39
Jhenida	6.85	14	0.96
		Weighted Average	6.76

In the same period the second highest weighted average daily precipitation in the basin was 5.3 inches and occurred on April 28, 1964.

A frequency analysis based on brief available records would not permit a meaningful extrapolation beyond return periods of say, 25 years. The following estimates of 24-hour precipitation for longer return periods were made using the method presented in the 1964 Master Plan Report (2), which is based on regional analysis of precipitation. The plate and figures used can be found in the referenced report.

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(1) HEC-1, Flood Hydrograph Package, Hydrologic Engineering Center, U.S. Corps of Engineers, 1973.

(2) Master Plan, 1964 - Appendix A, Hydrology - Plate AII-17, and Figures AII-9 and AII-10

- Four month index rainfall for project area (From Plate AII-17) — 45 inches
- Ratio of four month index rainfall to one day index rainfall (From Fig. AII-9) — 0.085
- One day index rainfall: 45x0.085 — 3.83
- Ratio of rainfall to one day index rainfall (From Fig. AII-10):

25-year return period	1.8
50-year return period	2.04
100-year return period	2.25

Estimated 24-hour rainfall for given return periods:

Return Period (yrs.)	Rainfall (in.)
25	3.83 x 1.8 = 6.9
50	3.83 x 2.04 = 7.8
100	3.83 x 2.26 = 8.7

As the main objective of the proposed weir on the bypass channel near Magura is to raise the water level in the Nabaganga River for irrigation by low lift pumping during the dry season, the weir can be considered a diversion structure with relatively insignificant storage capacity. Therefore, in the consideration of downstream damage potential in the event of a hypothetical failure, the proposed weir is a low-hazard structure. The effect the structure will have on upstream flood levels is therefore the major consideration for the selection of the design flood.

A storm with a return period of 25 years can be considered adequate for the design of a small diversion structure located in an area where the damage potential from floods larger than the design flood is not great. However, considering that the public's perception of hydrologic risk has been unduly heightened by the construction of an undersized spillway at Magura, the proposed weir will be designed to accommodate a 40- to 50-year flood.

A 24-hour rainfall of 7.5 inches with a return period of about 50 years was selected as design storm. It was distributed according to U.S. Corps of Engineers criteria as follows:

4-Hour Period N°	% Rainfall	Depth, in.
1	10	0.75
2	12	0.90
3	15	1.13
4	38	2.85
5	14	1.05
6	11	0.82
	100	7.50

2.6.2 Basin Modeling Using HEC-1 Program

2.6.2.1 General

As described in Section 2.1, the main channels in the basin are the Nabaganga and Kumar rivers. Flood waters can leave the basin not only through the diversion or by-pass channel and existing Magura weir but also through the Copaghata, Alamkhali and Koarkhali Khals, which start on the Nabaganga River. The basin simulation model will generate a flood hydrograph for the entire Kumar sub-basin and another hydrograph for the part of the Nabaganga sub-basin upstream of the aforementioned distributary khals. These two hydrographs will be routed separately through the corresponding main channel and combined at the junction near Magura.

Channel geometry is described by cross-sections at selected locations about 4 miles apart. Discharge and stage hydrographs are calculated at each section used to describe the channel geometry.

2.6.2.2 Rainfall-Runoff Analysis

The generalized flood hydrograph program HEC-1 provides several methods for the generation of runoff hydrographs in a basin. The synthetic unit hydrograph technique available in HEC-1 was used since no recorded rainfall-runoff data are available to develop a unit hydrograph using the program's parameter optimization technique.

Times of concentration for both sub-basins were computed assuming a flow velocity of 2 ft/sec. For the Nabaganga sub-basin with a river length of about 45 miles, this assumption results in a time of concentration (Tc) of approximately 33 hours. Similarly, the Tc for the 72 mile Kumar river is about 53 hours. Time to the peak (Tp) was assumed equal to 0.6 Tc, resulting in Tp = 20 hours for the Nabaganga sub-basin and Tp = 32 hours for the Kumar River.

The value of 0.40 for the Snyder coefficient (C_p) was used based on studies of several gaged basins with similar runoff characteristics. It was also necessary to estimate rainfall losses due primarily to infiltration and surface retention. The U.S. Soil Conservation Service curve number method was adopted and a curve number CN = 70 was selected to represent the rainfall losses in the study area on the basis of soil type, hydrologic group and land use and cover.

The unit and inflow hydrographs for the Nabaganga River were generated from the upper portion of the basin only (area 155 square miles) under the assumption that the combined outflow capacity of the flood distributaries of the Nabaganga, Dopaghata, Alamkhali and Hoarkhali khals would be equal to or greater than the inflow produced on the lower portion of the Nabaganga sub-basin. For the Kumar sub-basin, the whole area of about 356 square miles was considered as contributing to the hydrograph.

The resulting unit hydrograph for Nabaganga sub-basin has a peak discharge of 1,980 cfs or about 13 cfs per square mile considering the 215 square miles of the whole Nabaganga River. For the Kumar River, the whole basin produced a unit hydrograph peak of 2,920 cfs or about 8 cfs per square mile.

2.6.2.3 HEC-1 Program Runs

The HEC-1 program for the simulated basin as described above was run for the 50-year design storm. Total hydrographs for the Nabaganga and Kumar rivers were obtained by the model by applying the corresponding unit hydrographs to the precipitation of the design storm given in four-hour increments. The estimated peak discharge of the hydrograph produced by the Nabaganga river upper basin (155 square miles) is 7,700 cfs and the estimated peak discharge of the Kumar inflow hydrograph is about 11,900 cfs.

The Nabaganga hydrograph was then routed through the Nabaganga channel from about 8 miles upstream of Jhenida to its junction with the Kumar, and the Kumar hydrograph through the Kumar channel from river mile 28 near Geraganj to its confluence with the Nabaganga River. Channel routings were carried out by the modified Puls method using normal depth assumptions to establish channel storage-outflow-stage relationships. Roughness coefficients for channel and overbanks were assumed equal to 0.035 for both rivers. Energy gradients for each reach was assumed equal to the average channel slope. Maximum 50-year flood levels along the Nabaganga river are shown in Figure B-2 at selected locations.

The resulting hydrograph at the simulated junction of the Nabaganga and Kumar rivers near Magura has a peak discharge of 14,600 cfs. The maximum stage at the junction was 22.3 ft. P.W.D.

As already stated, flooding in the Magura area has been increased by overbank spills produced by high flood stages in the Gorai River. The Nabaganga control structures proposed in this project will be designed to accommodate the 50-year peak discharge produced by rainfall inside the Nabaganga-Kumar basin only. Control of Gorai River floods on a regional basis is the subject of other studies. Passage of flood water from Gorai River overbank spills would be provided by locating the diversion channel weir downstream of the Magura-Khamarkhali road crossing.

Computer printout sheets showing input data, sub-area runoff computations for both the Nabaganga and Kumar sub-basin, and the hydrograph routing computations for the assumed cross section downstream of the junction are at the end of this appendix. The complete printouts are on file at the Bangladesh Water Development Board and USAID offices in Dacca.

2.7 Analysis of Barabila Beel Flooding

Barabila beel is the largest depression in the project area. The minimum elevation is about 12 ft. PWD and has a drainage area of about 30 square miles. It has two channel outlets to the Nabaganga river; the Daraipur khal and Drain D1N. The former is an uncontrolled natural channel that has been silted up and the latter is an excavated channel with a control gate near the Nabaganga River. This control structure was provided by the BWDB primarily to prevent flood waters in the Nabaganga from entering into the beel and producing excessive flooding. It was designed to control the drainage of the beel through the D1N drain also.

The existing control structure on Drain D1N does not currently have the capability of flow control in both directions as one of two gates called for in the original design has not yet been provided. The additional gate is being included in the present study.

Raising the water level of the Nabaganga River during the dry season for irrigation in the project area would change the existing drainage conditions in the Barabila beel. What follows is an analysis of these modified conditions in order to determine new criteria for the operation of the D1N control structure.

During the monsoon season, the Nabaganga-Kumar water level control structures will be open to allow passage of flood runoff. Therefore, the situation after project implementation during the monsoon season would be basically the same as the present situation. The D1N drain control structure would be closed as needed to stop flood waters in the Nabaganga channel from flooding the beel.

A post-monsoonal storm could occur after the Nabaganga control structures and the D1N gates are closed and the water level in the river is already raised for dry season irrigation. Under these conditions drainage of the beel through the D1N drain would depend on the water level already stored in the Nabaganga channel.

Post-monsoon flooding in the Barabila beel was analyzed for the maximum daily rainfall recorded at the Shailkupa gage, the nearest station to the area. A total 24-hour precipitation of 8.50 inches was recorded at Shailkupa gage on October 6, 1964. From the isohyetal distribution of this storm, the 24-hour rainfall in the 31 square mile beel drainage area was estimated to be about 80 percent of the rainfall recorded at Shailkupa. The 6-hour excess rainfall was estimated to be 3.65 inches or about 60 percent of the 24-hour rainfall, distributed in the following hourly increments:

Hour	%	Incremental Rainfall, in.
1	10	0.37
2	12	0.44
3	15	0.55
4	38	1.39
5	14	0.50
6	11	0.40
TOTAL	100	3.65

A synthetic unit hydrograph for the beel sub-area was develoepd. It has the following characteristics:

Time of concentration; TC = 3 hours

Rainfall excess increment; D = 1 hour

Time to peak: $\frac{D}{2} + 0.6\ TC$; Tp = 2.5 hours

Time base of hydrograph; Tb = 2.67 Tp = 7.0 hours

Peak rate in cfs; $Q_p = \frac{484A}{T_p}$

where: A = drainage area in square miles = 31 sq. miles

$$Q_p = \frac{484 \times 31}{2.5} = 6{,}000 \text{ cfs}$$

The unit hydrograph was then applied to the above hourly precipitation pattern to obtain a total hydrograph. The peak of the resulting hydrograph is about 15,400 cfs and has a total volume of about 6,300 acre-feet.

Assuming that this entire volume of the flood hydrograph has to be stored in the beel area due to the high water level already existing in the Nabaganga River, the water level in the Barabila beel would reach elevation 16.3, approximately. (See Figure B-6, Area-Storage Curves, Barabila Beel)

A mathematical hydraulic simulation model (LATIS) was used to route the flood hydrograph through the beel, drain D1N and gated control structure assuming that the water level in the Nabaganga River was at elevation 11ft. PWD.

The model LATIS, developed by TAMS, simulates the flow in two-dimensional channel networks by solving the dynamic and continuity equations written for each "link" or channel segment and each "node" or junction of two or more links. As applied to the Barabila beel, a simple four-node LATIS network was used: one node to define the inflow hydrograph, two nodes to define storage in the beel itself and in the drain D1N and one boundary node to simulate the Nabaganga River constant water level. The gated structure on the D1N drain was simulated as a "constriction" with flow occurring in either direction depending on the water level differential between the level in the drain D1N and in the river.

Using a 10-second time interval the model was run for a total period of 19 hours. The water in the beel reached elevation 16.1 feet after about 10 hours, from the beginning of the hydrograph. This elevation is only 0.2 feet below the maximum level reached with no drainage to the river. A second run for a simulated 48-hour period starting at the end of the previous 19-hour run, indicated that the water level in the beel receded to elevation 15 feet, about 60 hours (2.5 days) after reaching the peak. Results of the 19-hour run are shown graphically in Figure B-7.

The following conclusions can be drawn from above analyses:

(a) During the monsoon season, excessive flooding in the beel from Nabaganga river waters would be controlled by operation of the improved existing control structure on Drain D1N. This condition would be basically the same as the present situation except that the control structure would be improved as part of the project to provide the type of control called for in the original design.

(b) Local flooding in the beel area from intense localized storms that could occur when the raised Nabaganga River water level prevents drainage through Drain D1N would be limited to a rather small area below elevation 163 ft. Flood water stored in the beel could be beneficially used for irrigation along Drain D1N.

2.8 Reservoir Operation Studies

Storage in the Nabaganga-Kumar channel will be controlled by the existing and proposed Magura weirs. During the monsoon months the control gates of the existing Magura weir will be open and the stop logs or boards on the crest of the proposed weir will be removed to allow passage of flood waters. Therefore, storage in the channel will not be controlled during this period. Controlled storage in the channel for winter irrigation will start after the gates of the existing weir are closed and the boards are replaced on the new weir. Storage will be controlled between the following values:

Minimim Storage = 9,500 acre-feet al Elevation 11.0 ft.
Maximum Storage = 29,500 acre-feet at Elevation 19.0 ft.
Useable Storage = 20,000 acre-feet

Analysis of the monthly operation of the Nabaganga-Kumar channel impoundment for the historic period 1965-66 to 1976-77 was made using a computer program developed by TAMS.

Besides title and other descriptive information, data for the program include the following:

- Code to determine whether, in a given month, the water control devices on the weirs are closed or open (Code = 1, indicates open conditions and Code = 0, indicates gates closed or controlled storage);
- Area-capacity-elevation data for the channel storage (from Figure B-5) and minimum and maximum storage;
- Monthly inflows to the reservoir;
- Water requirements; and
- Evaporation.

2.8 Monthly Operating Procedure

The following generalized monthly operating procedure is coded into the program:

- For months when the gates/board are open, i.e., storage is not being used, the monthly water requirement is subtracted from the monthly inflow and any excess is considered spillage.

- For months when the gates are closed, that is when storage can be used, the monthly available water is estimated as the sum of water available in storage plus the monthly inflow, minus evaporation losses estimated from pan evaporation data at Jessore (Table B-7) and on reservoir surface area at the beginning of the month. If enough water is available to satisfy all water requirements for the month, elevations are computed and printed. If the maximum storage is exceeded, spillage is computed. In the case when the available water is not enough to satisfy the monthly requirement the monthly shortage is computed and printed.

At the end of each 12-month period, yearly totals are printed as well as the percentage of shortage or spillage.

2.8.2 Monthly Inflows

Estimated monthly runoff volumes shown on Table B-9 for the period 1963-64 to 1976-77, were used as inflows to the Nabaganga-Kumar channel impoundment. A discussion of assumptions used to arrive at these figures is presented in Section 2.5 of this Appendix. Only surface water was considered to obtain rather conservative estimates of dependable water supply. Groundwater potential in the area is discussed in Section 2.10.

2.8.3 Water Requirements

The only water demand considered in the operation studies is the requirement for irrigated agriculture in the project area. Currently, there are no water requirements downstream of Magura. Future agricultural development projects downstream of Magura are being considered by others as part of the Gorai River Development Project. The Gorai River would be the source of irrigation water. Consequently, these future requirements do not affect the Nabaganga project.

Consumptive use for crops presently grown or suitable to the project area were estimated using the Penman method. Detailed analyses of crop water requirements and cropping patterns are presented in Appendix C from which the following information on irrigation requirements for wheat, the major crop in the adopted cropping pattern, was extracted:

Wheat	Nov.	Dec.	Jan.	Feb.	Mar.	Total
1. Consumptive use, in.	0.6	2.6	4.4	5.4	2.0	15.0
2. Usable Residual Soil Moisture, in.	0.6	1.0	2.0	2.6	1.0	7.6
3. Effective Rain, in.	-	-	-	-	-	-
4. Irrigation Requirement, in.	-	1.6	2.4	2.8	1.0	7.8
5. Irrigation Delivery Req. in. (65% overall efficiency)	2.5	3.7	4.3	1.5		12.0
TOTAL Irrigation Requirements for 30,000 acres of wheat, acre-feet		6,250	9.250	10,750	3,750	30,000

2.8.4 Results of Operation Studies

Using above monthly inflows and water requirements for different crop mixes, a series of runs of the reservoir operation computer program were made, in order to determine the final acreages to be included in the project at an acceptable level of hydrologic reliability. Proper timing of closing the water surface control structures was also analyzed using these runs.

From the computer aided operation studies using inflows for the historic period 1965-77 it was determined that 30,000 acres of wheat could be irrigated at about an 80 percent level of reliability, if the gates are closed at the end of October and remain closed throughout the wheat growing season. This means that, on the average, in 8 out of 10 years the full water requirements could be satisfied and maximum yields obtained provided other inputs are also fully supplied. Water shortages in years with deficient supply occurred generally in February. Water still available in March that could be used to irrigate other crops, amounted to about 5,800 acre-feet in 8 out of 10 years approximately. About 11,000 acres of a high yielding variety Aus crop with a total March requirement of 6.1 inches, including land preparation, could be irrigated with this water. Surface runoff during April and May would be sufficient to satisfy the Aus requirements during these months. A different crop mix over a larger area could include Aus and some other crop with smaller water requirements.

2.9 Operation of Water Level Control Structures

The water level in the Nabaganga-Kumar Channel will be controlled by the existing Magura weir on the Nabaganga River and the proposed weir on the diversion channel.

The crest at the Magura weir is at elevation 9.0 feet P.W.D. and has four vertical lift gates. Total net opening width is 48 feet. The surface of the road on top of the weir is at elevation 27 feet P.W.D.

The crest of the proposed weir on the bypass channel would be at elevation 15 feet P.W.D. and has a net length of 125 feet. Stop logs are provided to raise the impoundment level up to a normal elevation of 19 feet P.W.D. Overbank flow would occur in the bypass channel upstream of the weir when the water level exceeds elevation 22 feet P.W.D.

The above main control structures will be operated primarily to raise the water level in the Nabaganga-Kumar river providing a relatively small amount of storage for irrigation during the dry season and to permit passage of monsoonal and post-monsoonal flood runoff.

Based on the computer aided analyses described above, the following plan of operation is proposed:

(1) At the end of October start impoundment of water up to elevation 19 feet P.W.D. by closing the gates of the existing Magura weir and placing the stop logs on the bypass channel weir. During the period November-February when the stop logs are in place, the water surface level would be controlled by opening one or more gates of the existing Magura weir as necessary to maintain a normal water level at elevation 19 feet P.W.D.

(2) At the end of February, remove stop logs from the bypass channel weir, lowering normal impoundment level to elevation 15 feet P.W.D.

From the operation studies it was determined that February is the critical month for irrigation water supply. Deficits occurred only in the period November-February which has the lowest inflow and peak water requirements. Wheat's water requirement in March is very low and usually was satisfied with March runoff and a very small volume of carry-over storage (only in dry years). The following tabulation shows the water elevation at the end of February for the period of analysis:

Year	End of February W.S. Elevation, ft. PWD	February Deficit	March Deficit
1	15.5	No	No
2	11.0	Yes	No
3	14.7	No	No
4	15.6	No	No
5	13.5	No	No
6	16.1	No	No
7	17.7	No	No
8	12.0	No	No
9	11.0	Yes	No
10	14.7	No	No
11	15.5	No	No
12	13.1	No	No
13	11.0	Yes	No

Removing the stop logs at the end of February is recommended as the head on the logs would be negligible and storage up to elevation 15 feet P.W.D. still would be controlled.

(3) From March through May the normal water surface level would be maintained at elevation 15 feet P.W.D. by operation of the gates of the existing Magura weir for supplemental irrigation of Aus or other crops.

(4) At the end of May or first week of June, all the gates of the existing Magura weir would be fully open and would remain open through October to permit passage of monsoon and post-monsoon floods. At the end of October, the annual operation cycle restarts.

2.10 Groundwater Potential in the Project Area

2.10.1 General

Small-scale irrigated agriculture using groundwater is currently practiced in the project area mostly by means of deep tubewells. There were about 22 deep tubewells (DTW) and 8 shallow tubewells (STW) at the end of 1979, when field surveys were conducted for this project.

In the proposed Nabaganga project, irrigated agriculture in the area would depend primarily on surface water, which would be made readily available by construction at minor regulating structures. However, groundwater sources could be used on isolated high lands which could not be served by the low lift pump system to be provided for about 30,000 acres. A preliminary evaluation of groundwater in the project area was made at the beginning of this study and is presented

here. Data presented herein could be used to select smaller areas within the project area for more detailed groundwater studies.

2.10.2 Geology

The soils in the project area, like in most of Bangladesh, were formed by deposition of alluvial sediments, through the geological ages. The first 50 to 100 feet were formed by depositions of silts and clays during flooding periods when the rivers overflowed their banks, and the finest particles carried by the flood waters settled. Fine sands alone or mixed with other materials are also present in these floodplain deposits as a result of changes in the course of the rivers and meandering. Logs of bore holes in the project area (Figure B-8, 2 sheets) show that the first 50 to 100 feet are discontinuous layers and lenticular deposits of clays, silts and sands. Bore hole locations are shown in Figure B-1.

Below the floodplain layers,deltaic deposits of coarser materials are found. Fine to medium sands are present to depths of about 300 feet. A thick layer of coarse sand with gravel was found starting at about 350 feet below ground surface in bore hole 410.

Deltaic deposits are usually well sorted and constitute the best aquifers in Bangladesh. Shallow tubewells with depths to about 150 feet extract water from these deltaic aquifers(1).

The size classification system commonly used in Bangladesh is the MIT Soil Classification System (1)

Description	Grain size
Gravel	2.0 mm or coarse
Coarse sand	0.6 to 2.0 mm
Medium sand	0.2 to 0.6 mm
Fine sand	0.06 to 0.2 mm
Silt	0.002 to 0.06 mm
Clay	0.002 mm or finer

The presence of tight clays in the top 20 to 50 feet in some parts of the area accounts for semi-confinement

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(1) "Shallow Tubewell Manual," David S. Tillson, June 1978. (Prepared for Asian Development Bank and Bangladesh Krishi Bank).

of some aquifers. Both confined and unconfined aquifers can be found in the project area. The storage coefficient for the conditions encountered in the project area within 150 feet of the surface has been estimated to be 0.05.

2.10.3 Water Table Fluctuations

Four observation wells with reliable data are located inside the project area or immediate vicinity. Two wells, JE-4 and JE-6 have records since 1961 and the others since 1975-76. Figure B-9 (2 sheets) shows the water table fluctuations for the available period of record at these four representative observation wells.

The fluctuations of the water table indicate that seasonal recharge occurs during the monsoon season. In November, when pumping for dry season irrigation could start, the water table is, on the average, 8 feet below the ground at wells JE-4, JE-22 and JE-16. At well JE-6 near Magura the water table is at this time about 12 feet below the ground. During the dry season, the water table drops naturally, reaching in February 12 feet below the ground surface in well JE-4; 11 feet in well JE-22; 13 feet in well JE-16 and 17.4 feet in well JE-6. Groundwater movement seems to occur in an easterly direction, in the same direction of flow of the Nabaganga River.

2.10.4 Tubewell Development Potential

During the dry season months from November through March, groundwater could be used in some project areas for irrigation by means of STWs, which are wells that can be drilled by manual methods to a maximum depth of about 150 feet and from which the water can be pumped by centrifugal suction pumps.

Considering a maximum usable suction lift of about 22 feet and the static water levels from above observation wells, STW capacities in the project area have been estimated to vary from 0.4 cusecs to 0.7 cusecs, for maximum and minimum water table depths, respectively.

3. HYDRAULICS

3.1 General

The 50-year peak discharge at the junction of the Nabaganga and Kumar rivers was estimated to be 14,600 cfs under existing conditions. The maximum water level reached at the simulated junction just downstream of the confluence of the Nabaganga and Kumar bypass channel was 22.3 feet P.W.D. (see Section 2.6.2).

For the design of the proposed weir across the bypass channel, it was assumed that the flood water level upstream of the structure should not be increased by more than 1.5 ft above the 50-year flood level if it were to occur under existing conditions. Therefore, the maximum floodwater level upstream of the structure was assumed to be 23.8 feet P.W.D. and tailwater elevation was assumed to be at elevation 22.3 feet P.W.D.

3.2 Floor Flow through Existing Magura Weir

The above headwater and tailwater conditions would also apply to the existing Magura weir which is located not far from the proposed new structure. The discharge through the Magura spillway with all gates fully open was estimated to be about 5,000 cfs, as follows:

- Assumed approach velocity, Va = 3.0 fps
- Assumed approach velocity head, ha = 0.14 ft
- Design head, He = (23.8 + 0.14) -9.0 =14.94 ft
- Coefficient of discharge: 2.6 (Broad crested weir)
- Reduction of coefficient of discharge due to 70% submergence = 30%
- Reduced coefficient of discharge = 0.7 x 2.6 = 1.82
- Effective spillway length : 48'
- Discharge $Q = C \cdot L \cdot H^{3/2}$

  $Q = 1.82 \times 48 \times (14.94)^{3/2}$

  $Q = 5{,}000$ cfs

3.3 Proposed Weir on Bypass Channel

The capacity of the proposed weir on the bypass channel for above headwater and tailwater conditions was estimated to about 9,700 cfs, as follows:

- Assumed approach velocity, Va = 3.0 fps
- Assumed approach velocity head, ha = 0.14 ft
- Design head, He = (23.8 + 0.14) -15.0 = 8.94 ft
- Coefficient of Discharge: 3.5 (ogee shaped crest)
- Reduction of coefficient of discharge due to 83% submergence: 17%

- Reduced coefficient of discharge = 0.83 x 3.5 = 2.90
- Effective spillway length: 125'
- Discharge $Q = C \cdot L \cdot H^{3/2}$
  $Q = 2.90 \times 125 \times (8.94)^{3/2}$
  $Q = 9{,}700$ cfs

The combined discharge capacity of both the existing Magura weir (5,000 cfs) and the proposed weir (9,700 cfs) would then be about 14,700 cfs for the assumed conditions. This total discharge is slightly greater than the design discharge of 14,600 cfs corresponding to the 50-year flood.

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**********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
**********************************
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INPUT DATA

```
 1   A1        NABAGANGA R KUMAR RIVERS
 2   A2        DESIGN STORM
 3   A3        DATE: AUGUST 1980
 4   B     50      4       0       0       0       0       0       0       0       0
 5   B1     5
 6   J      1      1
 7   J1     1
 8   K      0      1
 9   K1       BASIN RUNOFF  NABAGANGA RIVER
10   M              1   155.5
11   O      6                                                                   1
12   O1   .75    .90    1.13    2.85    1.05     .82
13   T
14   W     20     .4                                                  -1     -70          .01
15   X    -.1      0       1
16   K      1    N34
17   K1       CHANNEL ROUTING REACH 38-34
18   Y                                   1       1
19   Y1     1
20   Y6  .035   .030    .035    17.5      40   21120 .000095
21   Y7     0     40      10      30    1000    29.8    1080      19    1110    17.5
22   Y7  1210     32    2220      32    2220      40
23   K      1    N30
24   K1       CHANNEL ROUTING REACH 34-30
25   Y                                   1       1
26   Y1     1
27   Y6  .035   .030    .035    11.1      40   21120 .00030
28   Y7     0     40      10      31    1010    29.1    1080    11.1    1165    11.7
29   Y7  1255   27.3    2750      30    2755      40
30   K      1    N26
31   K1       CHANNEL ROUTING REACH 30-26
32   Y                                   1       1
33   Y1     1
34   Y6  .035   .030    .035     9.7      40   21120 .000095
35   Y7     0     40      10      30    1000    27.5    1115     9.7    1135     9.8
36        1265     30    2265      28    2270      40
37   K      1    N22
38   K1       CHANNEL ROUTING REACH 26-22
39   Y                                   1       1
40   Y1     1
41   Y6  .035   .030    .035     9.2      40   21120 .000024
42   Y7     0     40      10      29    1260      26    1380     9.2    1415     9.5
43   Y7  1508   24.5    2510      25    2520      40
44   K      1    N18
45   K1       CHANNEL ROUTING REACH 22-18
46   Y                                   1       1
47   Y1     1
48   Y6  .035   .030    .035      10      40   21120 .000022
49   Y7     0     40      10      27    1000      29    1090    10.2    1200      10
50   Y7  1250     31    2250      25    2255      40
```

```
51   K      1     N14
52   K1        CHANNEL ROUTING REACH 18-14
53   Y                                  1       1
54   Y1     1
55   Y6   .035    .030    .035     12      40    21120  .000011
56   Y7     0      40      10      29    1000      25     1090      12     1200      12
57   Y7  1335      25    2340      25    2345      40
58   K      1     N10
59   K1        CHANNEL ROUTING REACH 14-10
60   Y                                  1       1
61   Y1     1
62   Y6   .035    .030    .035    8.5      40    21120  .00016
63   Y7     0      40      10      25    1000    23.8     1205     8.5     1250       9
64   Y7  1320      25    2300      25    2310      40
65   K      1     N06
66   K1        CHANNEL ROUTING REACH 10-6
67   Y                                  1       1
68   Y1     1
69   Y6   .035    .030    .035     7.5      40    21120  .000047
70   Y7     0      40      10      26    1000      25     1060       8     1070       7
71   Y7  1190    26.7    2170      25    2180      40
72   K      1     N02
73   K1        CHANNEL ROUTING REACH 6-2
74   Y                                  1       1
75   Y1     1
76   Y6   .035    .030    .035       4      40    21120  .00017
77   Y7     0      40      10      26    1000      30     1070       4     1090       6
78   Y7  1135      27    2995      26    3000      40
79   K      1     N00
80   K1        CHANNEL ROUTING REACH 2-0
81   Y                                  1       1
82   Y1     1
83   Y6   .035    .030    .035     3.2      40    10560  .000047
84   Y7     0      40      10      26    1000      25     1110     3.5     1120     3.2
85   Y7  1230      23    2215      24    2220      40
86   K      0       1
87   K1        BASIN RUNOFF - KUMAR R
88   M                1     356                                                    1
89   O      6
90   O1   .75     .90    1.13    2.85    1.05     .82
91   T
92   W     32      .4                                                  -1     -70          .01
93   X     -1                1
94   K      1     K26
95   K1        CHANNEL ROUTING REACH 28-26
96   Y                                  1       1
97   Y1     1
98   Y6   .035    .035    .035       6    32.8    10560  .00007
99   Y7    50    32.8      85      16     140       9      230       9      375       6
100  Y7   420    11.6     470    11.7     700      32
```

```
K      1     K22
K1        CHANNEL ROUTING REACH 26-22
Y
Y1     1                          1      1
Y6  .035    .035    .035     5.1     32   21120  .00004
Y7    10    31.2     100    26.2    135    11.3     200     5.1     258     6.5
Y7   360    11.0     640    13.0    810    32.0
K      1     K18
K1        CHANNEL ROUTING REACH 22-18
Y
Y1     1                          1      1
Y6  .035    .035    .035     4.2     30   21120  .00004
Y7     5    30.0      40    26.5     70    12.0     100    10.0     270     8.0
Y7   360     4.2     520     9.5    590      26
K      1     K14
K1        CHANNEL ROUTING REACH 18-14
Y
Y1     1                          1      1
Y6  .035    .035    .035       3     30   21120  .00006
Y7    70      30     110      11    160       3     230     9.5     295     5.5
Y7   380     4.5     620      11    660    28.5
K      1     K10
K1        CHANNEL ROUTING REACH 14-10
Y
Y1     1                          1      1
Y6   .03     .03     .03   -20.5     30   21120  .00004
Y7     0      30     100    23.5    170     9.5     390   -20.5     500     2.8
Y7   600    20.7     650    30.3    700      29
K      1     K06
K1        CHANNEL ROUTING REACH 10-6
Y
Y1     1                          1      1
Y6  .035    .035    .035   -12.5   29.6   21120  .00004
Y7    50      24      95    14.2    115    14.4     180     9     365   -12.5
Y7   560    13.5     595    29.5    645    29.6
K      1     K02
K1        CHANNEL ROUTING REACH  6-2
Y
Y1     1                          1      1
Y6  .035    .035    .035    -4.3     28   21120  .00004
Y7    50      28      90    12.5    220     5.5     340    -4.3     460     6.4
Y7   520    11.5     560    20.2    565    27.3
K      2     215
K1        COMBINE  2 RIVERS
K      1     KDS
K1        CROSS SECTION DOWN STREAM OF JUNCTION
Y
Y1     1                          1      1
Y6  .035    .035    .035    -4.3     28   10560  .00004
Y7    50      28      90    12.5    220     5.5     340    -4.3     460     6.4
```

```
151   Y7    520    11.5    560    20.2    565    27.3
152   K       1     222
153   K1                                                        1
154   Y          ROUTING OVER EXISTING & PROPOSED CONTROLS
155   Y1      1                      1       1
156   Y4      9      11      15      19      23                      9700      -1
157   Y5      0     350    1800    6500   13500
158   $S   7000    9700   18000   29500   49000
159   $E      9      11      15      19      23
160   $S      9
161   $D
162   K      99
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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  26 FEB 79
*********************************
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OUTPUT

RUN DATE# 81/01/15.
TIME# 07.17.55.

NABAGANGA & KUMAR RIVERS
DESIGN STORM
DATE: AUGUST 1980

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
50	4	0	0	0	0	0	0	0	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 0

RTIOS= 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

BASIN RUNOFF NABAGANGA RIVER

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	0	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	1	155.50	0.00	155.50	0.00	0.000	0	1	0

PRECIP DATA

NP	TORM	DAJ	DAK
6	0.00	0.00	0.00

PRECIP PATTERN

.75	.90	1.13	2.85	1.05	.82

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-70.00	0.00	.01

CURVE NO = -70.00 WETNESS = -1.00 EFFECT CN = 70.00

UNIT HYDROGRAPH DATA
TP= 20.00 CP= .40 NTA= 0

RECESSION DATA

STRTQ= -.10 QRCSN= 0.00 RTIOR= 1.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 5.28 AND R= 9.32 INTERVALS

UNIT HYDROGRAPH 53 END-OF-PERIOD ORDINATES, LAG= 20.10 HOURS, CP= .40 VOL= 1.00

149.	554.	1113.	1639.	1963.	1979.	1800.	1617.	1452.	1304..
1171.	1052.	945.	849.	762.	685.	615.	552.	496.	446.
400.	360.	323.	290.	261.	234.	210.	189.	170.	152.
137.	123.	110.	99.	89.	80.	72.	65.	58.	52.
47.	42.	38.	34.	30.	27.	25.	22.	20.	18.
16.	14.	13.							

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	4.00	1	.75	.01	.74	17.	1.05	8.00	26	0.00	0.00	0.00	1390.
1.01	8.00	2	.90	.13	.77	39.	1.05	12.00	27	0.00	0.00	0.00	1250.
1.01	12.00	3	1.13	.48	.65	168.	1.05	16.00	28	0.00	0.00	0.00	1124.
1.01	16.00	4	2.85	1.93	.92	726.	1.05	20.00	29	0.00	0.00	0.00	1011.
1.01	20.00	5	1.05	.84	.21	1972.	1.06	0.00	30	0.00	0.00	0.00	910.
1.02	0.00	6	.82	.69	.13	3787.	1.06	4.00	31	0.00	0.00	0.00	819.
1.02	4.00	7	0.00	0.00	0.00	5706.	1.06	8.00	32	0.00	0.00	0.00	737.
1.02	8.00	8	0.00	0.00	0.00	7138.	1.06	12.00	33	0.00	0.00	0.00	664.
1.02	12.00	9	0.00	0.00	0.00	7691.	1.06	16.00	34	0.00	0.00	0.00	598.
1.02	16.00	10	0.00	0.00	0.00	7470.	1.06	20.00	35	0.00	0.00	0.00	538.
1.02	20.00	11	0.00	0.00	0.00	6878.	1.07	0.00	36	0.00	0.00	0.00	485.
1.03	0.00	12	0.00	0.00	0.00	6195.	1.07	4.00	37	0.00	0.00	0.00	437.
1.03	4.00	13	0.00	0.00	0.00	5566.	1.07	8.00	38	0.00	0.00	0.00	394.
1.03	8.00	14	0.00	0.00	0.00	5001.	1.07	12.00	39	0.00	0.00	0.00	356.
1.03	12.00	15	0.00	0.00	0.00	4493.	1.07	16.00	40	0.00	0.00	0.00	321.
1.03	16.00	16	0.00	0.00	0.00	4037.	1.07	20.00	41	0.00	0.00	0.00	290.
1.03	20.00	17	0.00	0.00	0.00	3628.	1.08	0.00	42	0.00	0.00	0.00	262.
1.04	0.00	18	0.00	0.00	0.00	3260.	1.08	4.00	43	0.00	0.00	0.00	237.
1.04	4.00	19	0.00	0.00	0.00	2930.	1.08	8.00	44	0.00	0.00	0.00	214.
1.04	8.00	20	0.00	0.00	0.00	2633.	1.08	12.00	45	0.00	0.00	0.00	194.
1.04	12.00	21	0.00	0.00	0.00	2366.	1.08	16.00	46	0.00	0.00	0.00	176.
1.04	16.00	22	0.00	0.00	0.00	2127.	1.08	20.00	47	0.00	0.00	0.00	160.
1.04	20.00	23	0.00	0.00	0.00	1912.	1.09	0.00	48	0.00	0.00	0.00	145.
1.05	0.00	24	0.00	0.00	0.00	1719.	1.09	4.00	49	0.00	0.00	0.00	132.
1.05	4.00	25	0.00	0.00	0.00	1546.	1.09	8.00	50	0.00	0.00	0.00	120.
									SUM	7.50	4.07	3.43	101969.
										(191.)	(103.)	(87.)	(2887.44)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7691.	7581.	6835.	4603.	101902.
CMS	218.	215.	194.	130.	2886.
INCHES		.30	1.64	3.30	4.06
MM		7.68	41.54	83.92	103.22
AC-FT		2506.	13557.	27388.	33686.
THOUS CU M		3091.	16722.	33782.	41552.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

17.	39.	168.	726.	1972.	3787.	5706.	7138.	7691.	7470.
6878.	6195.	5566.	5001.	4493.	4037.	3628.	3260.	2930.	2633.
2366.	2127.	1912.	1719.	1546.	1390.	1250.	1124.	1011.	910.
819.	737.	664.	598.	538.	485.	437.	394.	356.	321.
290.	262.	237.	214.	194.	176.	160.	145.	132.	120.

TOTAL RAIN 7.50, TOTAL RAINFALL EXCESS 4.07, TOTAL FLOW 101969.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	7691.	7581.	6835.	4603.	101902.
CMS	218.	215.	194.	130.	2886.
INCHES		.30	1.64	3.30	4.06
MM		7.68	41.54	83.92	103.22
AC-FT		2506.	13557.	27388.	33686.
THOUS CU M		3091.	16722.	33782.	41552.

HYDROGRAPH ROUTING

CHANNEL ROUTING REACH 2-0

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
NOO	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0350	.0300	.0350	3.2	40.0	10560.	.00005

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

0.00	40.00	10.00	26.00	1000.00	25.00	1110.00	3.50	1120.00	3.20
1230.00	23.00	2215.00	24.00	2220.00	40.00				

STORAGE	0.00	8.52	27.05	55.29	93.23	140.88	198.23	265.29	342.06	428.52
	524.70	869.11	1665.78	2702.08	3739.32	4777.49	5816.60	6856.64	7897.61	8939.52
OUTFLOW	0.00	13.46	64.46	168.23	338.44	587.50	926.92	1367.49	1919.50	2592.74
	3396.63	4717.96	7717.85	12895.09	19768.19	28107.58	37776.87	48680.20	60744.41	73910.85
STAGE	3.20	5.14	7.07	9.01	10.95	12.88	14.82	16.76	18.69	20.63
	22.57	24.51	26.44	28.38	30.32	32.25	34.19	36.13	38.06	40.00
FLOW	0.00	13.46	64.46	168.23	338.44	587.50	926.92	1367.49	1919.50	2592.74
	3396.63	4717.96	7717.85	12895.09	19768.19	28107.58	37776.87	48680.20	60744.41	73910.85

0

MO.DA	HR.MN	PERIOD	EOP STOR	AVG IN	EOP OUT	STAGE	AVG PUMP
1.01	4.00	1	0.	0.	0.	3.2	0.
1.01	8.00	2	0.	0.	0.	3.2	0.
1.01	12.00	3	0.	0.	0.	3.2	0.
1.01	16.00	4	0.	0.	0.	3.2	0.
1.01	20.00	5	0.	0.	0.	3.2	0.
1.02	0.00	6	0.	0.	0.	3.2	0.
1.02	4.00	7	0.	0.	0.	3.2	0.
1.02	8.00	8	0.	0.	0.	3.2	0.
1.02	12.00	9	1.	4.	2.	3.4	0.
1.02	16.00	10	11.	39.	19.	5.3	0.
1.02	20.00	11	57.	236.	174.	9.1	0.
1.03	0.00	12	161.	759.	709.	13.6	0.
1.03	4.00	13	293.	1538.	1569.	17.5	0.
1.03	8.00	14	389.	2219.	2288.	19.8	0.
1.03	12.00	15	439.	2633.	2679.	20.8	0.

1.03	16.00	16	482.	2990.	3039.	21.7	0.
1.03	20.00	17	544.	3444.	3472.	22.7	0.
1.04	0.00	18	642.	3956.	3848.	23.2	0.
1.04	4.00	19	746.	4361.	4246.	23.8	0.
1.04	8.00	20	823.	4628.	4542.	24.2	0.
1.04	12.00	21	886.	4854.	4783.	24.5	0.
1.04	16.00	22	933.	5011.	4958.	24.7	0.
1.04	20.00	23	956.	5070.	5044.	24.7	0.
1.05	0.00	24	954.	5036.	5038.	24.7	0.
1.05	4.00	25	931.	4926.	4952.	24.7	0.
1.05	8.00	26	891.	4757.	4802.	24.6	0.
1.05	12.00	27	838.	4541.	4600.	24.3	0.
1.05	16.00	28	760.	4211.	4298.	23.9	0.
1.05	20.00	29	664.	3824.	3930.	23.4	0.
1.06	0.00	30	577.	3503.	3599.	22.9	0.
1.06	4.00	31	509.	3228.	3269.	22.3	0.
1.06	8.00	32	469.	2976.	2929.	21.4	0.
1.06	12.00	33	440.	2725.	2692.	20.9	0.
1.06	16.00	34	402.	2421.	2354.	20.0	0.
1.06	20.00	35	349.	2019.	1973.	18.8	0.
1.07	0.00	36	295.	1613.	1581.	17.5	0.
1.07	4.00	37	257.	1332.	1313.	16.5	0.
1.07	8.00	38	231.	1151.	1144.	15.8	0.
1.07	12.00	39	211.	1017.	1012.	15.2	0.
1.07	16.00	40	195.	913.	910.	14.7	0.
1.07	20.00	41	181.	825.	826.	14.2	0.
1.08	0.00	42	168.	748.	749.	13.8	0.
1.08	4.00	43	157.	683.	684.	13.4	0.
1.08	8.00	44	148.	628.	628.	13.1	0.
1.08	12.00	45	139.	578.	579.	12.8	0.
1.08	16.00	46	131.	533.	536.	12.5	0.
1.08	20.00	47	123.	490.	493.	12.2	0.
1.09	0.00	48	115.	451.	454.	11.8	0.
1.09	4.00	49	109.	417.	420.	11.6	0.
1.09	8.00	50	103.	387.	390.	11.3	0.
				SUM	97556.		
				(	2762.49)		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	5044.	5041.	4914.	4113.	97361.
CMS	143.	143.	139.	116.	2757.
INCHES		.20	1.18	2.95	3.88
MM		5.11	29.87	75.00	98.63
AC-FT		1666.	9747.	24474.	32186.
THOUS CU M		2055.	12023.	30188.	39700.

MAXIMUM STORAGE = 956.

MAXIMUM STAGE IS 24.7

SUB-AREA RUNOFF COMPUTATION

BASIN RUNOFF - KUMAR R

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	0	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	1	356.00	0.00	356.00	0.00	0.000	0	1	0

PRECIP DATA

NP	STORM	DAJ	DAK
6	0.00	0.00	0.00

PRECIP PATTERN

.75 .90 1.13 2.85 1.05 .82

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	-1.00	-70.00	0.00	.01

CURVE NO = -70.00 WETNESS = -1.00 EFFECT CN = 70.00

UNIT HYDROGRAPH DATA

TP= 32.00 CP= .40 NTA= 0

RECESSION DATA

STRTQ= -1.00 QRCSN= 0.00 RTIOR= 1.00

APPROXIMATE CLARK COEFFICIENTS FROM GIVEN SNYDER CP AND TP ARE TC= 8.31 AND R=14.86 INTERVALS

UNIT HYDROGRAPH 84 END-OF-PERIOD ORDINATES, LAG= 32.22 HOURS, CP= .40 VOL= 1.00

110.	415.	851.	1367.	1909.	2383.	2727.	2918.	2893.	2723.
2546.	2380.	2225.	2080.	1945.	1818.	1700.	1589.	1486.	1389.
1299.	1214.	1135.	1061.	992.	928.	867.	811.	758.	709.
662.	619.	579.	541.	506.	473.	442.	414.	387.	361.
338.	316.	295.	276.	258.	241.	226.	211.	197.	184.
172.	161.	151.	141.	132.	123.	115.	108.	101.	94.
88.	82.	77.	72.	67.	63.	59.	55.	51.	48.
45.	42.	39.	37.	34.	32.	30.	28.	26.	24.
23.	21.	20.	19.						

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	4.00	1	.75	.01	.74	357.	1.05	8.00	26	0.00	0.00	0.00	5102.
1.01	8.00	2	.90	.13	.77	374.	1.05	12.00	27	0.00	0.00	0.00	4793.
1.01	12.00	3	1.13	.48	.65	470.	1.05	16.00	28	0.00	0.00	0.00	4504.
1.01	16.00	4	2.85	1.93	.92	890.	1.05	20.00	29	0.00	0.00	0.00	4234.
1.01	20.00	5	1.05	.84	.21	1851.	1.06	0.00	30	0.00	0.00	0.00	3981.
1.02	0.00	6	.82	.69	.13	3345.	1.06	4.00	31	0.00	0.00	0.00	3745.
1.02	4.00	7	0.00	0.00	0.00	5239.	1.06	8.00	32	0.00	0.00	0.00	3525.
1.02	8.00	8	0.00	0.00	0.00	7291.	1.06	12.00	33	0.00	0.00	0.00	3318.
1.02	12.00	9	0.00	0.00	0.00	9205.	1.06	16.00	34	0.00	0.00	0.00	3125.
1.02	16.00	10	0.00	0.00	0.00	10725.	1.06	20.00	35	0.00	0.00	0.00	2945.
1.02	20.00	11	0.00	0.00	0.00	11671.	1.07	0.00	36	0.00	0.00	0.00	2777.
1.03	0.00	12	0.00	0.00	0.00	11914.	1.07	4.00	37	0.00	0.00	0.00	2619.
1.03	4.00	13	0.00	0.00	0.00	11589.	1.07	8.00	38	0.00	0.00	0.00	2472.
1.03	8.00	14	0.00	0.00	0.00	10987.	1.07	12.00	39	0.00	0.00	0.00	2334.
1.03	12.00	15	0.00	0.00	0.00	10307.	1.07	16.00	40	0.00	0.00	0.00	2205.

1.03	16.00	16	0.00	0.00	0.00	9660.	1.07	20.00	41	0.00	0.00	0.00	2085.
1.03	20.00	17	0.00	0.00	0.00	9054.	1.08	0.00	42	0.00	0.00	0.00	1972.
1.04	0.00	18	0.00	0.00	0.00	8488.	1.08	4.00	43	0.00	0.00	0.00	1867.
1.04	4.00	19	0.00	0.00	0.00	7958.	1.08	8.00	44	0.00	0.00	0.00	1769.
1.04	8.00	20	0.00	0.00	0.00	7463.	1.08	12.00	45	0.00	0.00	0.00	1677.
1.04	12.00	21	0.00	0.00	0.00	7001.	1.08	16.00	46	0.00	0.00	0.00	1591.
1.04	16.00	22	0.00	0.00	0.00	6568.	1.08	20.00	47	0.00	0.00	0.00	1510.
1.04	20.00	23	0.00	0.00	0.00	6164.	1.09	0.00	48	0.00	0.00	0.00	1435.
1.05	0.00	24	0.00	0.00	0.00	5785.	1.09	4.00	49	0.00	0.00	0.00	1365.
1.05	4.00	25	0.00	0.00	0.00	5432.	1.09	8.00	50	0.00	0.00	0.00	1299.
									SUM	7.50	4.07	3.43	238037.
										(191.)	(103.)	(87.)	(6740.46)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11914.	11793.	11110.	8731.	237206.
CMS	337.	334.	315.	247.	6717.
INCHES		.21	1.16	2.74	4.13
MM		5.22	29.50	69.54	104.96
AC-FT		3898.	22037.	51955.	78415.
THOUS CU M		4809.	27182.	64086.	96724.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

357.	374.	470.	890.	1851.	3345.	5239.	7291.	9205.	10725.
11671.	11914.	11589.	10987.	10307.	9660.	9054.	8488.	7958.	7463.
7001.	6568.	6164.	5785.	5432.	5102.	4793.	4504.	4234.	3981.
3745.	3525.	3318.	3125.	2945.	2777.	2619.	2472.	2334.	2205.
2085.	1972.	1867.	1769.	1677.	1591.	1510.	1435.	1365.	1299.

TOTAL RAIN 7.50, TOTAL RAINFALL EXCESS 4.07, TOTAL FLOW 238037.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11914.	11793.	11110.	8731.	237206.
CMS	337.	334.	315.	247.	6717.
INCHES		.21	1.16	2.74	4.13
MM		5.22	29.50	69.54	104.96
AC-FT		3898.	22037.	51955.	78415.
THOUS CU M		4809.	27182.	64086.	96724.

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HYDROGRAPH ROUTING

CHANNEL ROUTING REACH 6-2

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
K02	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0350	.0350	.0350	-4.3	28.0	21120.	.00004

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

50.00	28.00	90.00	12.50	220.00	5.50	340.00	-4.30	460.00	6.40
520.00	11.50	560.00	20.20	565.00	27.30				

STORAGE	0.00	0.00	0.00	147.93	262.98	410.90	591.95	812.33	1075.18	1380.54
	1725.75	2090.18	2464.66	2849.21	3247.81	3647.52	4056.30	4469.69	4887.68	5310.18
OUTFLOW	0.00	0.00	0.00	152.95	329.41	597.25	983.49	1529.71	2218.63	3070.05
	4206.56	5611.95	7204.25	8978.18	10930.21	13064.27	15372.02	17843.25	20473.91	23267.63
STAGE	4.30	-2.60	-.90	.80	2.50	4.20	5.90	7.60	9.30	11.00
	12.70	14.40	16.10	17.80	19.50	21.20	22.90	24.60	26.30	28.00
FLOW	0.00	0.00	0.00	152.95	329.41	597.25	983.49	1529.71	2218.63	3070.05
	4206.56	5611.95	7204.25	8978.18	10930.21	13064.27	15372.02	17843.25	20473.91	23267.63

0

MO.DA	HR.MN	PERIOD	EOP STOR	AVG IN	EOP OUT	STAGE	AVG PUMP
1.01	4.00	1	0.	0.	0.	-.9	0.
1.01	8.00	2	0.	0.	0.	-.9	0.
1.01	12.00	3	0.	1.	0.	-.9	0.
1.01	16.00	4	1.	3.	1.	-.9	0.
1.01	20.00	5	3.	7.	3.	-.9	0.
1.02	0.00	6	7.	19.	8.	-.8	0.
1.02	4.00	7	20.	51.	20.	-.7	0.
1.02	8.00	8	54.	141.	55.	-.3	0.
1.02	12.00	9	149.	393.	154.	.8	0.
1.02	16.00	10	368.	1001.	520.	3.7	0.
1.02	20.00	11	828.	2438.	1572.	7.7	0.
1.03	0.00	12	1558.	4818.	3653.	11.9	0.
1.03	4.00	13	2334.	7498.	6647.	15.5	0.
1.03	8.00	14	2919.	9754.	9322.	18.1	0.
1.03	12.00	15	3230.	11036.	10864.	19.4	0.
1.03	16.00	16	3319.	11364.	11328.	19.8	0.

1.03	20.00	17	3290.	11161.	11172.	19.7	0.
1.04	0.00	18	3206.	10703.	10741.	19.3	0.
1.04	4.00	19	3097.	10146.	10206.	18.9	0.
1.04	8.00	20	2983.	9575.	9638.	18.4	0.
1.04	12.00	21	2872.	9031.	9092.	17.9	0.
1.04	16.00	22	2766.	8522.	8594.	17.4	0.
1.04	20.00	23	2665.	8054.	8127.	17.0	0.
1.05	0.00	24	2567.	7606.	7676.	16.6	0.
1.05	4.00	25	2472.	7169.	7237.	16.1	0.
1.05	8.00	26	2379.	6757.	6839.	15.7	0.
1.05	12.00	27	2289.	6376.	6457.	15.3	0.
1.05	16.00	28	2203.	6017.	6094.	14.9	0.
1.05	20.00	29	2122.	5674.	5747.	14.5	0.
1.06	0.00	30	2043.	5352.	5432.	14.2	0.
1.06	4.00	31	1966.	5048.	5133.	13.8	0.
1.06	8.00	32	1891.	4764.	4846.	13.5	0.
1.06	12.00	33	1821.	4498.	4575.	13.1	0.
1.06	16.00	34	1756.	4254.	4325.	12.8	0.
1.06	20.00	35	1696.	4034.	4108.	12.6	0.
1.07	0.00	36	1636.	3829.	3911.	12.3	0.
1.07	4.00	37	1576.	3629.	3712.	12.0	0.
1.07	8.00	38	1516.	3435.	3517.	11.7	0.
1.07	12.00	39	1460.	3254.	3332.	11.4	0.
1.07	16.00	40	1407.	3083.	3156.	11.1	0.
1.07	20.00	41	1355.	2921.	2999.	10.9	0.
1.08	0.00	42	1303.	2769.	2854.	10.6	0.
1.08	4.00	43	1251.	2623.	2708.	10.3	0.
1.08	8.00	44	1200.	2484.	2566.	10.0	0.
1.08	12.00	45	1152.	2354.	2432.	9.7	0.
1.08	16.00	46	1107.	2235.	2308.	9.5	0.
1.08	20.00	47	1066.	2127.	2195.	9.2	0.
1.09	0.00	48	1027.	2027.	2094.	9.0	0.
1.09	4.00	49	991.	1934.	1997.	8.8	0.
1.09	8.00	50	955.	1842.	1903.	8.5	0.
				SUM	221872.		
					(6282.71)		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	11328.	11250.	10632.	8359.	220920.
CMS	321.	319.	301.	237.	6256.
INCHES		.20	1.11	2.62	3.85
MM		4.98	28.23	66.57	97.75
AC-FT		3719.	21088.	49738.	73031.
THOUS CU M		4587.	26012.	61351.	90083.

MAXIMUM STORAGE = 3319.

MAXIMUM STAGE IS

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COMBINE HYDROGRAPHS

COMBINE 2 RIVERS

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
215	2	0	0	0	0	0	0	0

SUM OF 2 HYDROGRAPHS AT 215 PLAN 1 RTIO 1

0.	0.	0.	1.	3.	8.	20.	56.	156.	539.
1746.	4362.	8217.	11610.	13543.	14368.	14644.	14589.	14452.	14181.
13875.	13552.	13171.	12714.	12189.	11641.	11057.	10391.	9678.	9031.
8402.	7775.	7267.	6709.	6081.	5492.	5025.	4661.	4343.	4067.
3825.	3603.	3392.	3195.	3011.	2844.	2688.	2548.	2417.	2293.

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	14644.	14616.	14324.	12389.	318282.
CMS	415.	414.	406.	351.	9013.
INCHES		.18	1.04	2.70	3.86
MM		4.50.	26.47	68.67	98.02
AC-FT		4832.	28410.	73717.	105217.
THOUS CU M		5960.	35044.	90928.	129783.

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HYDROGRAPH ROUTING

CROSS SECTION DOWN STREAM OF JUNCTION

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
KDS	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	0.000	0.000	0.000	0.	0

NORMAL DEPTH CHANNEL ROUTING

QN(1)	QN(2)	QN(3)	ELNVT	ELMAX	RLNTH	SEL
.0350	.0350	.0350	-4.3	28.0	10560.	.00004

CROSS SECTION COORDINATES--STA,ELEV,STA,ELEV--ETC

50.00	28.00	90.00	12.50	220.00	5.50	340.00	-4.30	460.00	6.40
520.00	11.50	560.00	20.20	565.00	27.30				

STORAGE	0.00	0.00	0.00	73.96	131.49	205.45	295.97	406.16	537.59	690.27
	862.88	1045.09	1232.33	1424.60	1621.90	1823.76	2028.15	2234.84	2443.84	2655.09
OUTFLOW	0.00	0.00	0.00	152.95	329.41	597.25	983.49	1529.71	2218.63	3070.05
	4206.56	5611.95	7204.25	8978.18	10930.21	13064.27	15372.02	17843.25	20473.91	23267.63
STAGE	-4.30	-2.60	-.90	.80	2.50	4.20	5.90	7.60	9.30	11.00
	12.70	14.40	16.10	17.80	19.50	21.20	22.90	24.60	26.30	28.00
FLOW	0.00	0.00	0.00	152.95	329.41	597.25	983.49	1529.71	2218.63	3070.05
	4206.56	5611.95	7204.25	8978.18	10930.21	13064.27	15372.02	17843.25	20473.91	23267.63

0

MO.DA	HR.MN	PERIOD	EOP STOR	AVG IN	EOP OUT	STAGE	AVG PUMP
1.01	4.00	1	0.	0.	0.	-.9	0.
1.01	8.00	2	0.	0.	0.	-.9	0.
1.01	12.00	3	0.	0.	0.	-.9	0.
1.01	16.00	4	0.	1.	0.	-.9	0.
1.01	20.00	5	1.	2.	1.	-.9	0.
1.02	0.00	6	2.	5.	3.	-.9	0.
1.02	4.00	7	4.	14.	9.	-.8	0.
1.02	8.00	8	11.	38.	24.	-.6	0.
1.02	12.00	9	32.	106.	65.	-.2	0.
1.02	16.00	10	98.	347.	227.	1.5	0.
1.02	20.00	11	284.	1142.	933.	5.7	0.
1.03	0.00	12	660.	3054.	2901.	10.7	0.
1.03	4.00	13	1164.	6290.	6626.	15.5	0.
1.03	8.00	14	1591.	9913.	10621.	19.2	0.
1.03	12.00	15	1827.	12576.	13102.	21.2	0.
1.03	16.00	16	1926.	13955.	14214.	22.0	0.
1.03	20.00	17	1959.	14506.	14594.	22.3	0.
1.04	0.00	18	1962.	14616.	14623.	22.3	0.
1.04	4.00	19	1950.	14520.	14489.	22.2	0.
1.04	8.00	20	1930.	14316.	14264.	22.1	0.
1.04	12.00	21	1903.	14028.	13957.	21.9	0.
1.04	16.00	22	1875.	13713.	13640.	21.6	0.
1.04	20.00	23	1843.	13361.	13277.	21.4	0.

1.04	16.00	22	1875.	13713.	13640.	21.6	0.
1.04	20.00	23	1843.	13361.	13277.	21.4	0.
1.05	0.00	24	1803.	12942.	12846.	21.0	0.
1.05	4.00	25	1756.	12451.	12344.	20.6	0.
1.05	8.00	26	1704.	11915.	11798.	20.2	0.
1.05	12.00	27	1650.	11349.	11227.	19.7	0.
1.05	16.00	28	1588.	10724.	10596.	19.2	0.
1.05	20.00	29	1518.	10034.	9899.	18.6	0.
1.06	0.00	30	1449.	9354.	9223.	18.0	0.
1.06	4.00	31	1384.	8716.	8605.	17.4	0.
1.06	8.00	32	1317.	8089.	7981.	16.8	0.
1.06	12.00	33	1256.	7521.	7425.	16.3	0.
1.06	16.00	34	1197.	6988.	6907.	15.8	0.
1.06	20.00	35	1127.	6395.	6309.	15.1	0.
1.07	0.00	36	1055.	5787.	5699.	14.5	0.
1.07	4.00	37	992.	5258.	5201.	13.9	0.
1.07	8.00	38	940.	4843.	4799.	13.4	0.
1.07	12.00	39	897.	4502.	4466.	13.0	0.
1.07	16.00	40	858.	4205.	4176.	12.7	0.
1.07	20.00	41	822.	3946.	3936.	12.3	0.
1.08	0.00	42	787.	3714.	3705.	11.9	0.
1.08	4.00	43	754.	3497.	3488.	11.6	0.
1.08	8.00	44	723.	3293.	3285.	11.3	0.
1.08	12.00	45	694.	3103.	3095.	11.0	0.
1.08	16.00	46	666.	2926.	2933.	10.7	0.
1.08	20.00	47	637.	2766.	2773.	10.4	0.
1.09	0.00	48	610.	2618.	2624.	10.1	0.
1.09	4.00	49	586.	2482.	2488.	9.8	0.
1.09	8.00	50	563.	2355.	2360.	9.6	0.
				SUM	317759.		
					(8997.93)		

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	14623.	14608.	14309.	12352.	316579.
CMS	414.	414.	405.	350.	8963.
INCHES		.18	1.04	2.70	3.84
MM		4.50	26.44	68.47	97.49
AC-FT		4829.	28381.	73497.	104654.
THOUS CU M		5957.	35008.	90657.	129089.

MAXIMUM STORAGE = 1962.

MAXIMUM STAGE IS 22.3

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RESERVOIR OPERATION

INTEGRATED LAND AND WATER USE STUDY - BANGLADESH

ELV	STORAGE	AREA
11.00	9500.00	1600.00
13.00	13500.00	2100.00
15.00	18800.00	2500.00
17.00	24200.00	2900.00
19.00	29500.00	3100.00
20.00	34000.00	3300.00

MONTH	IRR.REQ. AC-FT	MIN.FLOW CFS	M + I CFS	EVAPORT IN
1	0.	0.000	0.000	2.200
2	0.	0.000	0.000	0.000
3	0.	0.000	0.000	0.000
4	0.	0.000	0.000	0.000
5	0.	0.000	0.000	0.000
6	0.	0.000	0.000	0.000
7	0.	0.000	0.000	0.000
8	0.	0.000	0.000	2.200
9	6249.	0.000	0.000	2.300
10	9246.	0.000	0.000	2.100
11	10749.	0.000	0.000	2.000
12	3750.	0.000	0.000	4.300

30000.003

UPSTREAM IRR.ANNUAL REQ 0.000

INTEGRATED LAND AND WATER USE STUDY - BANGLADESH
NABAGANGA-KUMAR CHANNEL STORAGE
MONTHLY OPERATION STUDY FOR PERIOD 63/64 - 76/77
HYDROLOGIC YEAR STARTING IN APRIL

INITIAL STORAGE= 9500.00
MIN.STORAGE = 9500.00
MAX.STORAGE = 29500.003
TOTAL IRR.AREA = 30000.00

YEAR	MONTH	STORAGE	ELEV	INFLOW	REQUIR	EVAPR	SHORTAGE	SPILL
		(IN ACRE FEET						
1	1	9500.	11.0	46400.	0.	293.		
1	2	9500.	11.0	34000.	0.	0.	46400.	771.
1	3	9500.	11.0	161700.	0.	0.	34000.	565.
1	4	9500.	11.0	93900.	0.	0.	161700.	2688.
1	5	9500.	11.0	144000.	0.	0.	93900.	1561.
1	6	9500.	11.0	256600.	0.	0.	144000.	2394.
1	7	9500.	11.0	93000.	0.	0.	256600.	4266.
1	8	21706.	16.0	12500.	0.	293.	93000.	1546.
1	9	25837.	17.6	10900.	6249.	520.		0.
1	10	26972.	18.0	10900.	9246.	518.		0.
1	11	20323.	15.5	4600.	10749.	500.		0.
1	12	26436.	17.8	10800.	3[illegible]0.	936.		0.
								0.
ANNUAL VALUES				879299.	29993.	3062.	0.	0.
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	0.00
2	1	9500.	11.0	104800.	0.	547.		
2	2	9500.	11.0	37500.	0.	0.	104800.	1742.
2	3	9500.	11.0	125500.	0.	0.	37500.	623.
2	4	9500.	11.0	178500.	0.	0.	125500.	2086.
2	5	9500.	11.0	128300.	0.	0.	178500.	2967.
2	6	9500.	11.0	140400.	0.	0.	128300.	2133.
2	7	9500.	11.0	280500.	0.	0.	140400.	2334.
2	8	10452.	11.4	1500.	0.	547.	280500.	4663.
2	9	14774.	13.4	10900.	6249.	329.		0.
2	10	14144.	13.2	9000.	9246.	384.		0.
2	11	9500.	11.0	4100.	10749.	358.	2363.	0.
2	12	15576.	13.7	10400.	3750.	573.		0.
								0.
ANNUAL VALUES				1031399.	29993.	2739.	2363.	0.
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							7.87	0.00
3	1	9500.	11.0	11700.	0.	413.		
3	2	9500.	11.0	20900.	0.	0.	11700.	194.
3	3	9500.	11.0	107599.	0.	0.	20900.	347.
3	4	9500.	11.0	165300.	0.	0.	107599.	1788.
3	5	9500.	11.0	217500.	0.	0.	165300.	2748.
3	6	9500.	11.0	208400.	0.	0.	217500.	3616.
3	7	9500.	11.0	34500.	0.	0.	208400.	3464.
3	8	24586.	17.1	15500.	0.	413.	34500.	573.
3	9	29478.	18.9	11700.	6249.	558.		0.
3	10	29500.	19.0	11700.	9246.	542.		0.
3	11	18234.	14.7	0.	10749.	516.	1890.	31.
								0.

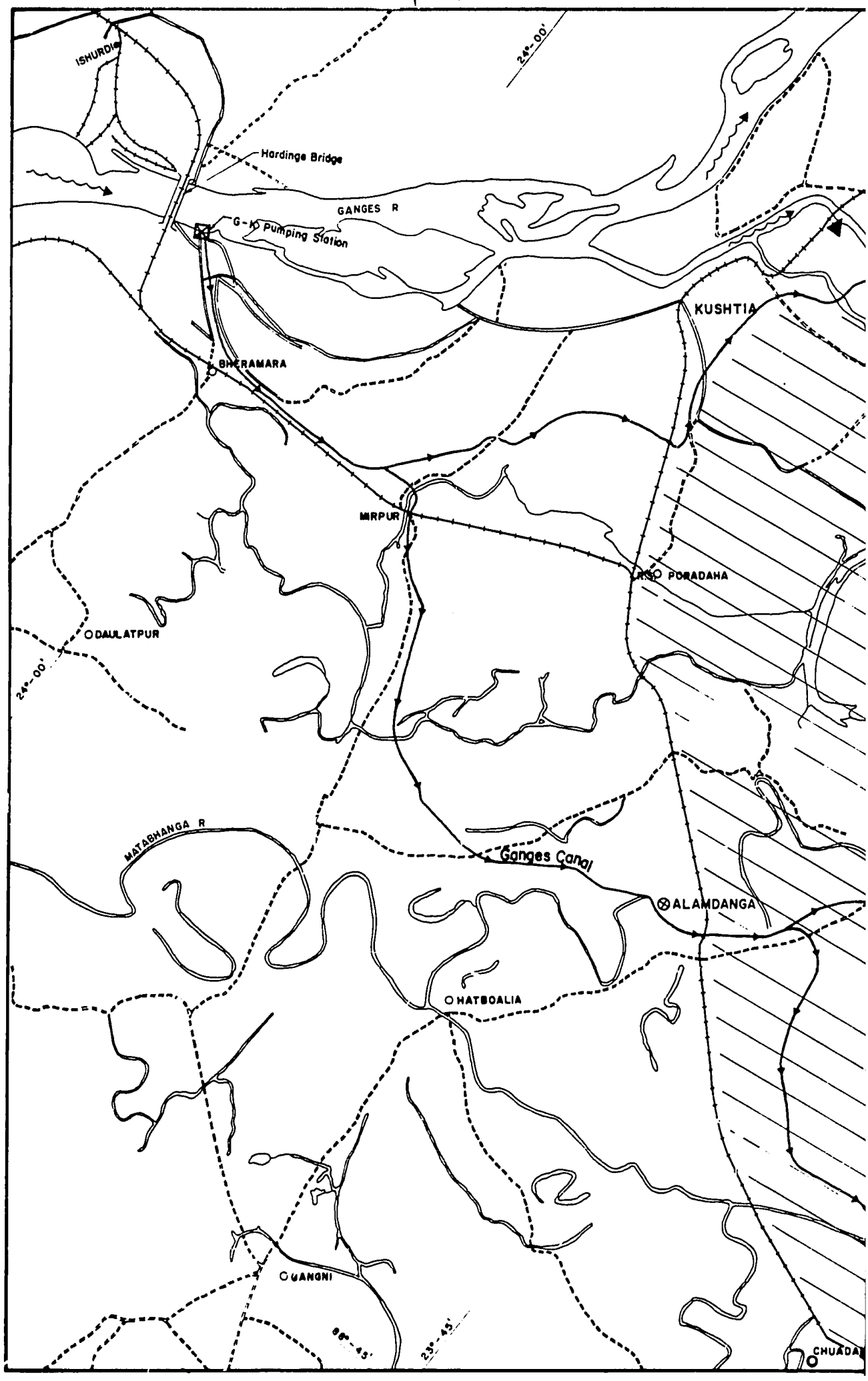
3	12	15303.	13.6	1699.	3750.	880.			0.
ANNUAL VALUES				806499.	29993.	3325.	0.	1890.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	0.23	
4	1	9500.	11.0	12500.	0.	409.		12500.	207.
4	2	9500.	11.0	31600.	0.	0.		31600.	525.
4	3	9500.	11.0	133799.	0.	0.		133799.	2224.
4	4	9500.	11.0	136900.	0.	0.		136900.	2276.
4	5	9500.	11.0	244699.	0.	0.		244699.	4068.
4	6	9500.	11.0	123599.	0.	0.		123599.	2054.
4	7	9500.	11.0	144500.	0.	0.		144500.	2402.
4	8	16390.	14.0	7300.	0.	409.			0.
4	9	29500.	19.0	30799.	6249.	444.		10996.	182.
4	10	29500.	19.0	30799.	9246.	542.		21011.	349.
4	11	20434.	15.6	2200.	10749.	516.			0.
4	12	29500.	19.0	27799.	3750.	939.		14045.	233.
ANNUAL VALUES				926499.	29993.	3262.	0.	46053.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	4.97	
5	1	9500.	11.0	33299.	0.	568.		33299.	553.
5	2	9500.	11.0	36800.	0.	0.		36800.	611.
5	3	9500.	11.0	130400.	0.	0.		130400.	2168.
5	4	9500.	11.0	197599.	0.	0.		197599.	3285.
5	5	9500.	11.0	266900.	0.	0.		266900.	4437.
5	6	9500.	11.0	325900.	0.	0.		325900.	5418.
5	7	9500.	11.0	34500.	0.	0.		34500.	573.
STORAGE BELOW MIN AW= -568.3333									
5	8	9500.	11.0	0.	0.	568.	0.		0.
5	9	17244.	14.4	14300.	6249.	306.			0.
5	10	25881.	17.6	18300.	9246.	416.			0.
5	11	14838.	13.5	200.	10749.	493.			0.
5	12	20599.	15.6	10300.	3750.	788.			0.
ANNUAL VALUES				1068499.	29993.	3142.	0.	0.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	0.00	
6	1	9500.	11.0	18500.	0.	482.		18500.	307.
6	2	9500.	11.0	55199.	0.	0.		55199.	917.
6	3	9500.	11.0	164099.	0.	0.		164099.	2728.
6	4	9500.	11.0	283600.	0.	0.		283600.	4715.
6	5	9500.	11.0	206900.	0.	0.		206900.	3439.
6	6	9500.	11.0	125800.	0.	0.		125800.	2091.
6	7	9500.	11.0	51900.	0.	0.		51900.	862.
6	8	29500.	19.0	47300.	0.	482.		26817.	445.
6	9	29500.	19.0	13699.	6249.	594.		6856.	114.
6	10	29500.	19.0	11600.	9246.	542.		1811.	30.
6	11	22034.	16.1	3799.	10749.	516.			0.
6	12	28102.	18.4	10800.	3750.	981.			0.
ANNUAL VALUES				993199.	29993.	3600.	0.	35485.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	3.57	
7	1	9500.	11.0	35800.	0.	558.		35800.	595.
7	2	9500.	11.0	46600.	0.	0.		46600.	774.
7	3	9500.	11.0	87500.	0.	0.		87500.	1454.
7	4	9500.	11.0	146700.	0.	0.		146700.	2439.

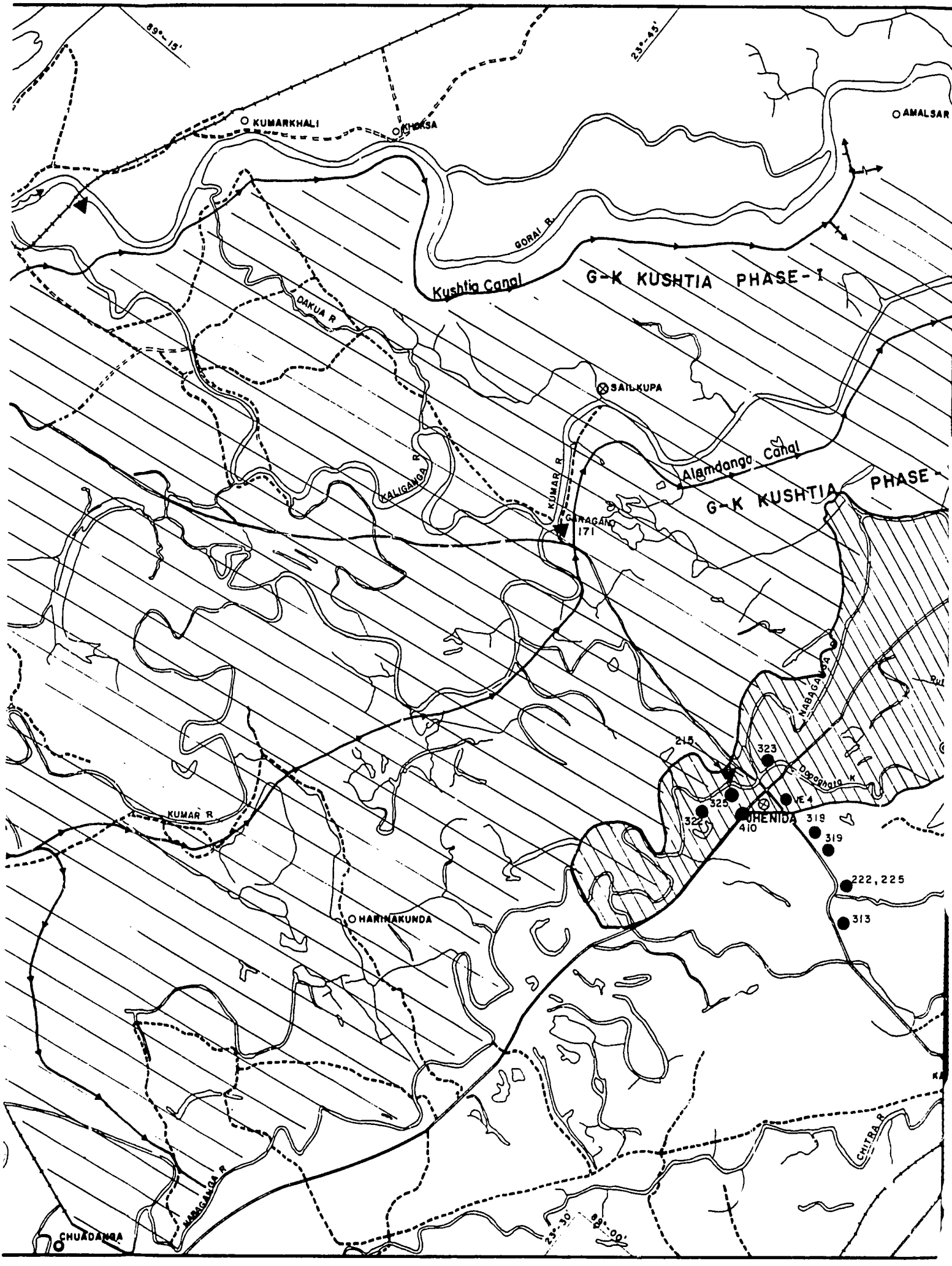
7	5	9500.	11.0	279699.	0.	0.		279699.	4650.
7	6	9500.	11.0	324200.	0.	0.		324200.	5390.
7	7	9500.	11.0	78900.	0.	0.		78900.	1311.
7	8	29500.	19.0	31300.	0.	558.		10741.	178.
7	9	29500.	19.0	7699.	6249.	594.		856.	14.
7	10	26411.	17.8	6699.	9246.	542.			0.
7	11	26265.	17.7	11099.	10749.	497.			0.
7	12	29500.	19.0	17100.	3750.	1067.		9048.	150.
ANNUAL VALUES				1073299.	29993.	3818.	0.	20646.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	1.92	
8	1	9500.	11.0	19100.	0.	568.		19100.	317.
8	2	9500.	11.0	49500.	0.	0.		49500.	822.
8	3	9500.	11.0	137400.	0.	0.		137400.	2284.
8	4	9500.	11.0	237100.	0.	0.		237100.	3942.
8	5	9500.	11.0	141400.	0.	0.		141400.	2350.
8	6	9500.	11.0	274200.	0.	0.		274200.	4558.
8	7	9500.	11.0	239899.	0.	0.		239899.	3988.
8	8	29500.	19.0	33000.	0.	568.		12431.	206.
8	9	29256.	18.9	6600.	6249.	594.			0.
8	10	22769.	16.4	3300.	9246.	540.			0.
8	11	11655.	12.0	100.	10749.	465.			0.
8	12	9735.	11.1	2500.	3750.	669.			0.
ANNUAL VALUES				1144098.	29993.	3407.	0.	12431.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	1.08	
9	1	9500.	11.0	17600.	0.	298.		17600.	292.
9	2	9500.	11.0	57500.	0.	0.		57500.	955.
9	3	9500.	11.0	84600.	0.	0.		84600.	1406.
9	4	9500.	11.0	82600.	0.	0.		82600.	1373.
9	5	9500.	11.0	241599.	0.	0.		241599.	4016.
9	6	9500.	11.0	58000.	0.	0.		58000.	964.
9	7	9500.	11.0	28200.	0.	0.		28200.	468.
STORAGE BELOW MIN AW= -298.7276									
9	8	9500.	11.0	0.	0.	298.	0.		0.
9	9	9500.	11.0	3799.	6249.	306.	2755.		0.
9	10	9500.	11.0	2399.	9246.	280.	7126.		0.
9	11	9500.	11.0	7699.	10749.	266.	3315.		0.
9	12	21576.	16.0	16400.	3750.	573.			0.
ANNUAL VALUES				600399.	29993.	2024.	13197.	0.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							43.99	0.00	
10	1	9500.	11.0	30699.	0.	496.		30699.	510.
10	2	9500.	11.0	123299.	0.	0.		123299.	2049.
10	3	9500.	11.0	168900.	0.	0.		168900.	2808.
10	4	9500.	11.0	118300.	0.	0.		118300.	1966.
10	5	9500.	11.0	198500.	0.	0.		198500.	3300.
10	6	9500.	11.0	206000.	0.	0.		206000.	3424.
10	7	9500.	11.0	105200.	0.	0.		105200.	1749.
10	8	29500.	19.0	26100.	0.	496.		5603.	93.
10	9	29500.	19.0	21100.	6249.	594.		14256.	237.
10	10	29500.	19.0	11800.	9246.	542.		2011.	33.
10	11	18234.	14.7	0.	10749.	516.			0.
10	12	29500.	19.0	25400.	3750.	880.		9503.	158.
ANNUAL VALUES				1035299.	29993.	3525.	0.	31376.	

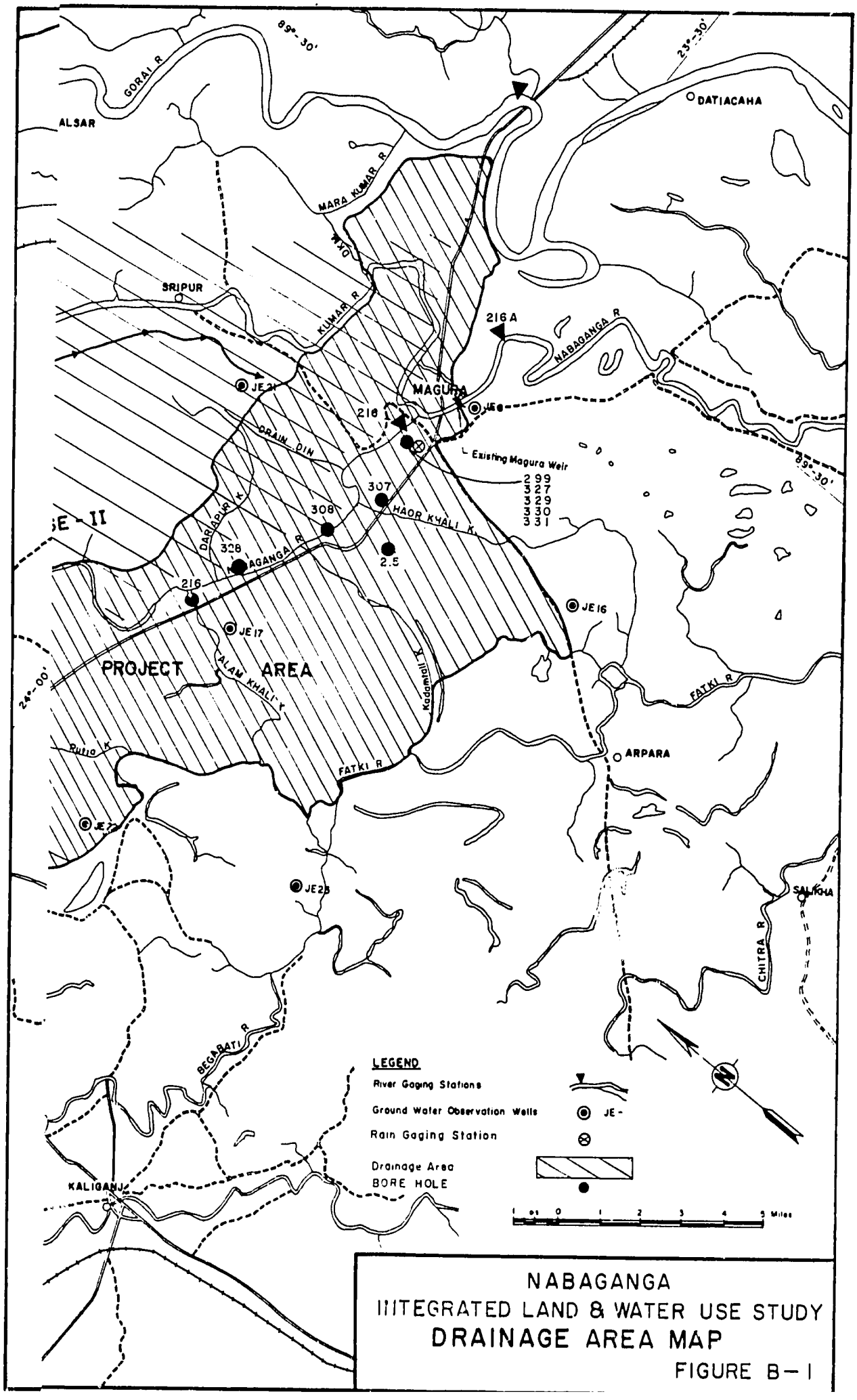
PERCENTAGE OF ANNUAL REQ AND INF RESPECT 0.00 3.03

11	1	9500.	11.0	36700.	0.	568.		36700.	610.
11	2	9500.	11.0	60599.	0.	0.		60599.	1007.
11	3	9500.	11.0	83200.	0.	0.		83200.	1383.
11	4	9500.	11.0	278900.	0.	0.		278900.	4636.
11	5	9500.	11.0	207100.	0.	0.		207100.	3443.
11	6	9500.	11.0	199699.	0.	0.		199699.	3320.
11	7	9500.	11.0	57600.	0.	0.		57600.	957.
STORAGE BELOW MIN AW= -568.3333									
11	8	9500.	11.0	0.	0.	568.	0.		0.
11	9	29500.	19.0	38200.	6249.	306.		11644.	193.
11	10	23811.	16.8	4100.	9246.	542.			0.
11	11	20183.	15.5	7599.	10749.	478.			0.
11	12	16401.	14.0	900.	3750.	932.			0.
ANNUAL VALUES				974599.	29993.	3396.	0.	11644.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	1.19	
12	1	9500.	11.0	12599.	0.	425.		12599.	209.
12	2	9500.	11.0	81700.	0.	0.		81700.	1358.
12	3	9500.	11.0	38899.	0.	0.		38899.	646.
12	4	9500.	11.0	359400.	0.	0.		359400.	5975.
12	5	9500.	11.0	149200.	0.	0.		149200.	2480.
12	6	9500.	11.0	219000.	0.	0.		219000.	3641.
12	7	9500.	11.0	89100.	0.	0.		89100.	1481.
12	8	27474.	18.2	18400.	0.	425.			0.
12	9	25546.	17.5	4900.	6249.	579.			0.
12	10	18783.	14.9	3000.	9246.	516.			0.
12	11	13818.	13.1	6199.	10749.	416.			0.
12	12	10807.	11.6	1500.	3750.	761.			0.
ANNUAL VALUES				983899.	29993.	3123.	0.	0.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							0.00	0.00	
13	1	9500.	11.0	31300.	0.	323.		31300.	520.
13	2	9500.	11.0	69700.	0.	0.		69700.	1158.
13	3	9500.	11.0	98199.	0.	0.		98199.	1632.
13	4	9500.	11.0	160800.	0.	0.		160800.	2673.
13	5	9500.	11.0	200599.	0.	0.		200599.	3335.
13	6	9500.	11.0	172099.	0.	0.		172099.	2861.
13	7	9500.	11.0	75000.	0.	0.		75000.	1246.
13	8	21476.	15.9	12299.	0.	323.			0.
13	9	18410.	14.8	3700.	6249.	517.			0.
13	10	10332.	11.4	1600.	9246.	432.			0.
13	11	9500.	11.0	6099.	10749.	284.	4100.		0.
STORAGE BELOW MIN AW= -573.3332									
13	12	9500.	11.0	0.	3750.	573.	3750.		0.
ANNUAL VALUES				831399.	29993.	2453.	7850.	0.	
PERCENTAGE OF ANNUAL REQ AND INF RESPECT							26.17	0.00	

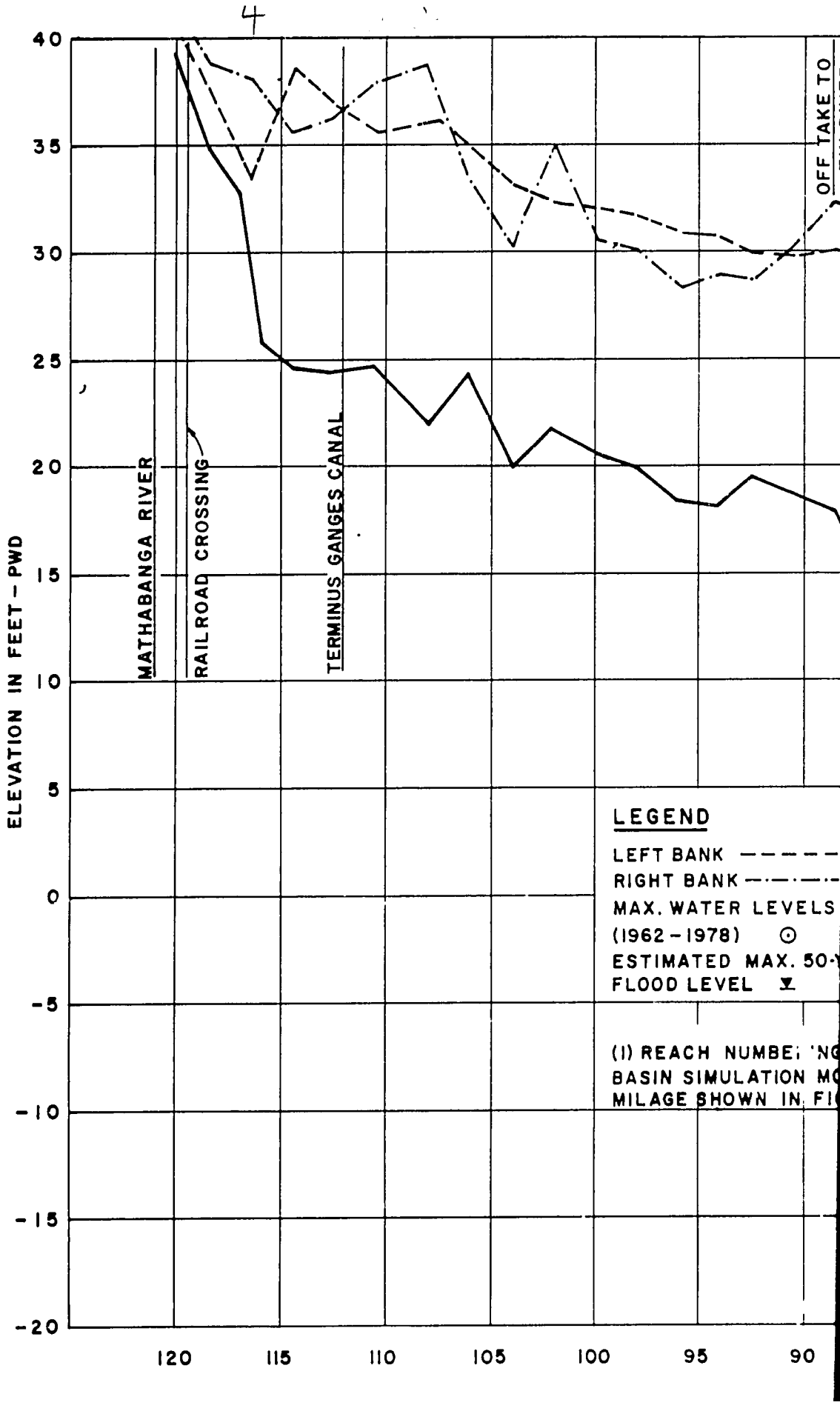
END OF RUN

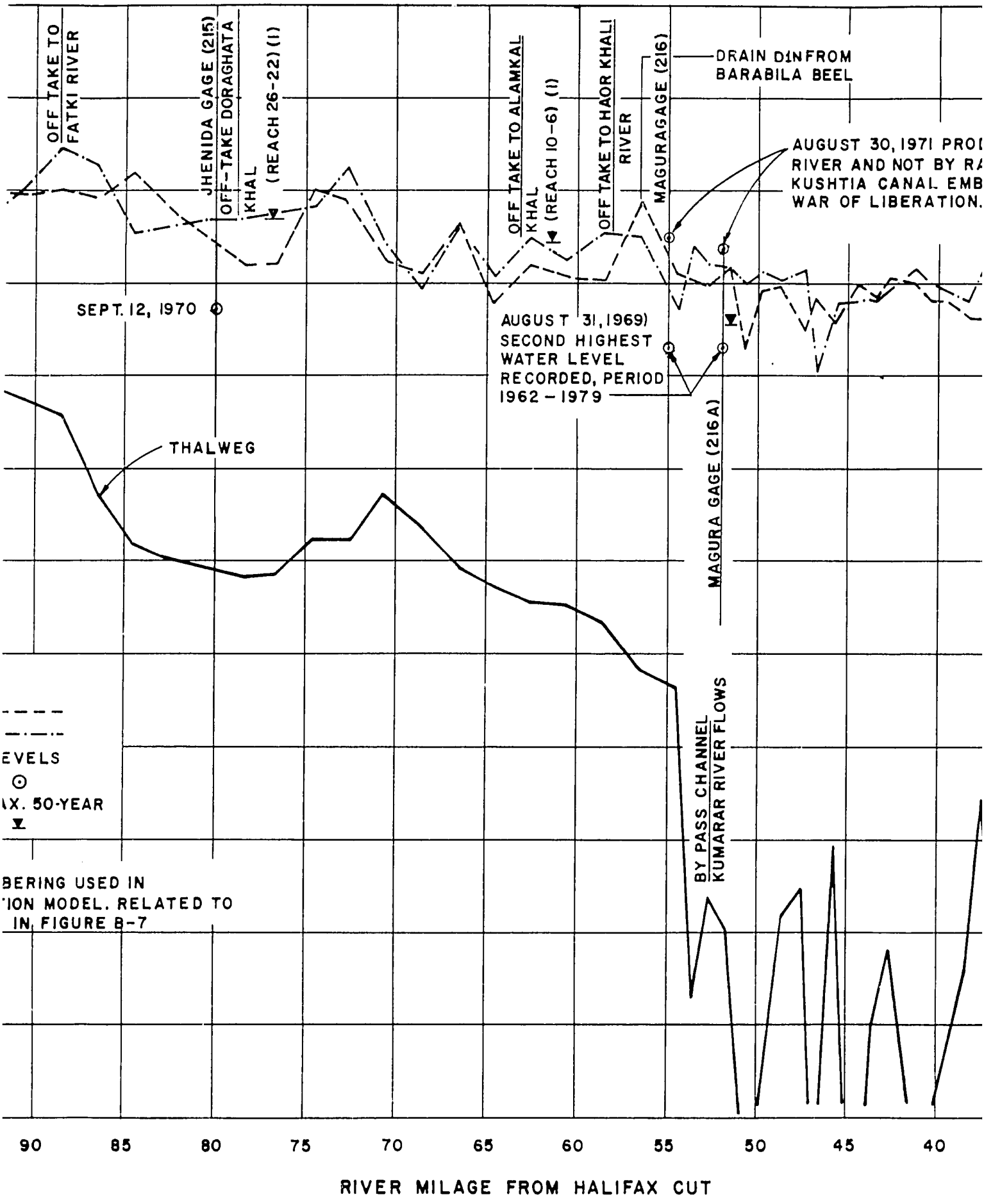

ISHURDI
Hardinge Bridge
GANGES R
G-K Pumping Station
KUSHTIA
BHERAMARA
MIRPUR
PORADAHA
DAULATPUR
24°-00'
MATABHANGA R
Ganges Canal
ALAMDANGA
HATBOALIA
GANGNI
23°-45'
CHUADA

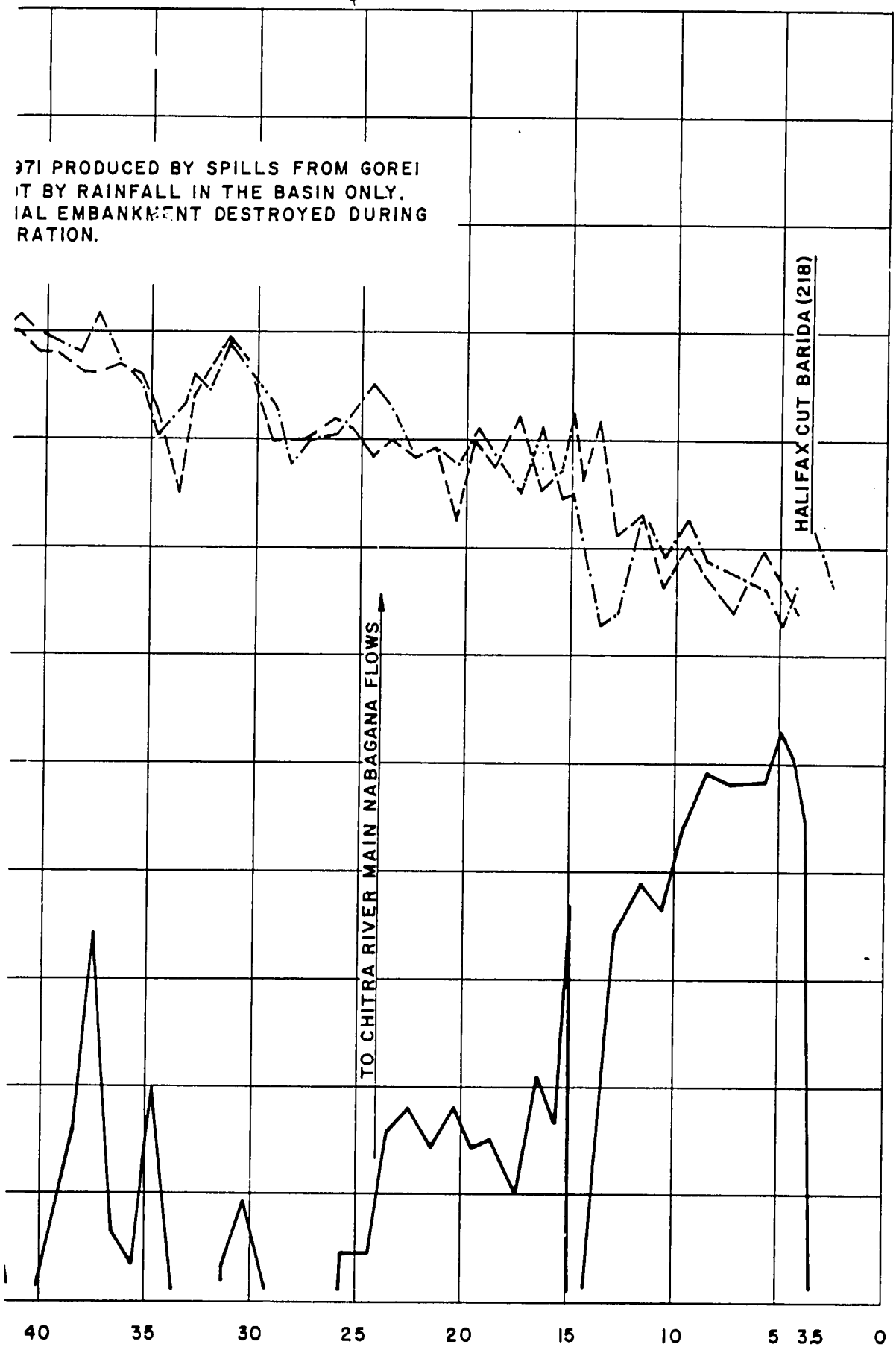

89°-15'
23°-45'
KUMARKHALI
CHOKSA
AMALSAR
GORAI R.
Kushtia Canal
G-K KUSHTIA PHASE-I
DAKUA R
SAILKUPA
Alamdanga Canal
G-K KUSHTIA PHASE
KALIGANGA R
KUMAR R
GARAGANJ
171
NABAGANGA R
215
323
Dogachia K
325
VE 4
322
JHENIDA
410
319
319
222, 225
313
KUMAR R
HARINAKUNDA
CHITRA R
NABAGANGA R
CHUADANGA
23°-30'
89°-00'



NABAGANGA
INTEGRATED LAND & WATER USE STUDY
DRAINAGE AREA MAP
FIGURE B-1

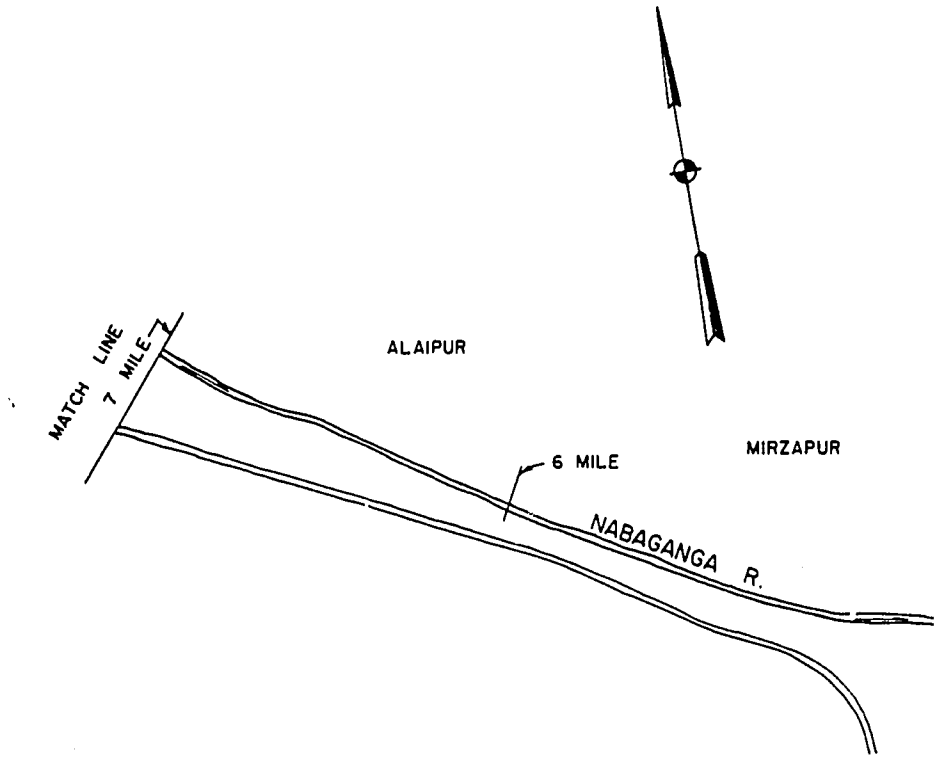

4
ELEVATION IN FEET - PWD
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
120
115
110
105
100
95
90
MATHABANGA RIVER
RAILROAD CROSSING
TERMINUS GANGES CANAL
OFF TAKE TO
LEGEND
LEFT BANK
RIGHT BANK
MAX. WATER LEVELS
(1962 - 1978)
ESTIMATED MAX. 50-
FLOOD LEVEL
(1) REACH NUMBE; 'NG
BASIN SIMULATION MO
MILAGE SHOWN IN FI

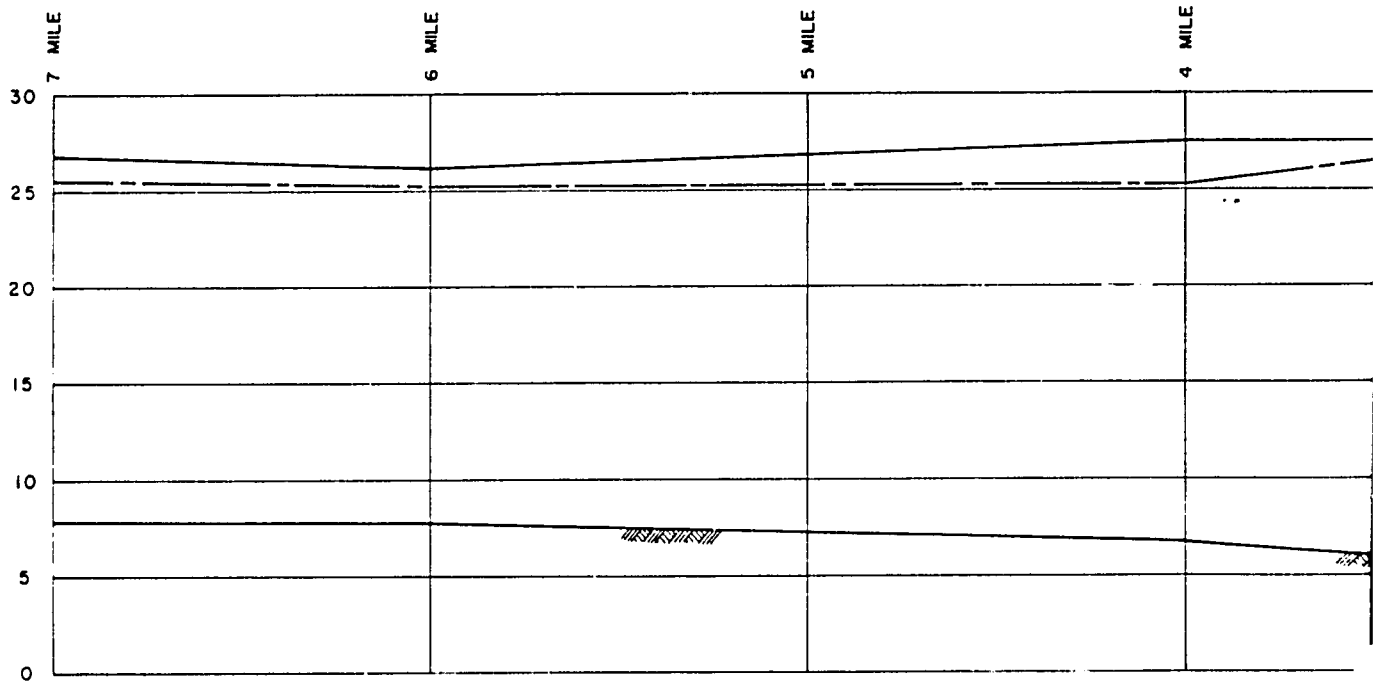

OFF TAKE TO FATKI RIVER
JHENIDA GAGE (215)
OFF-TAKE DORAGHATA KHAL
(REACH 26-22) (1)
OFF TAKE TO ALAMKAL KHAL
(REACH 10-6) (1)
OFF TAKE TO HAOR KHALI RIVER
MAGURAGAGE (216)
DRAIN DIN FROM BARABILA BEEL
AUGUST 30, 1971 PROI
RIVER AND NOT BY RA
KUSHTIA CANAL EMB
WAR OF LIBERATION.
SEPT. 12, 1970
AUGUS T 31, 1969)
SECOND HIGHEST
WATER LEVEL
RECORDED, PERIOD
1962 – 1979
THALWEG
MAGURA GAGE (216A)
BY PASS CHANNEL
KUMARAR RIVER FLOWS
EVELS
IX. 50-YEAR
BERING USED IN
ION MODEL. RELATED TO
IN, FIGURE B-7
90
85
80
75
70
65
60
55
50
45
40
RIVER MILAGE FROM HALIFAX CUT



NABAGANGA RIVER PROFILE

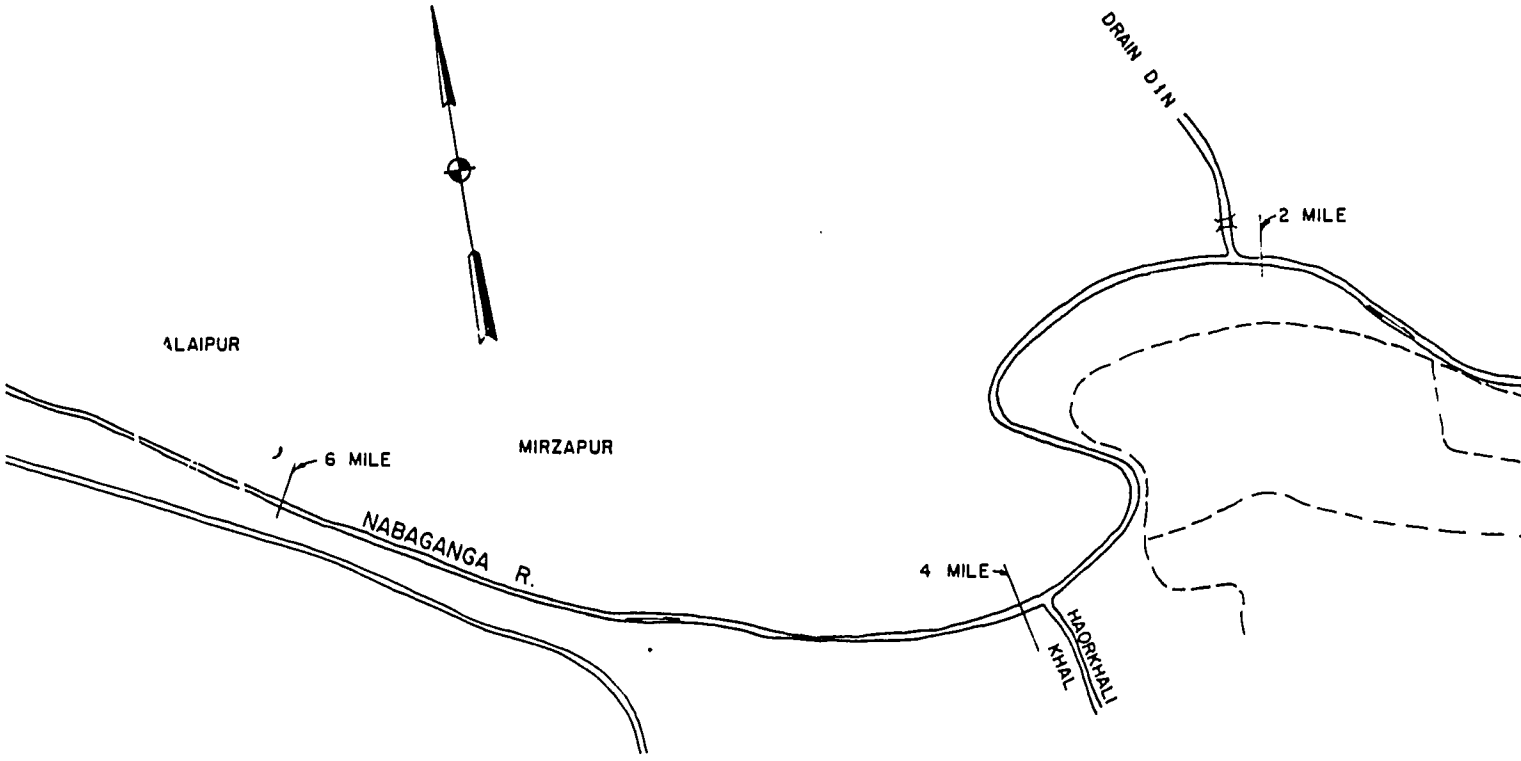
FIGURE B-2



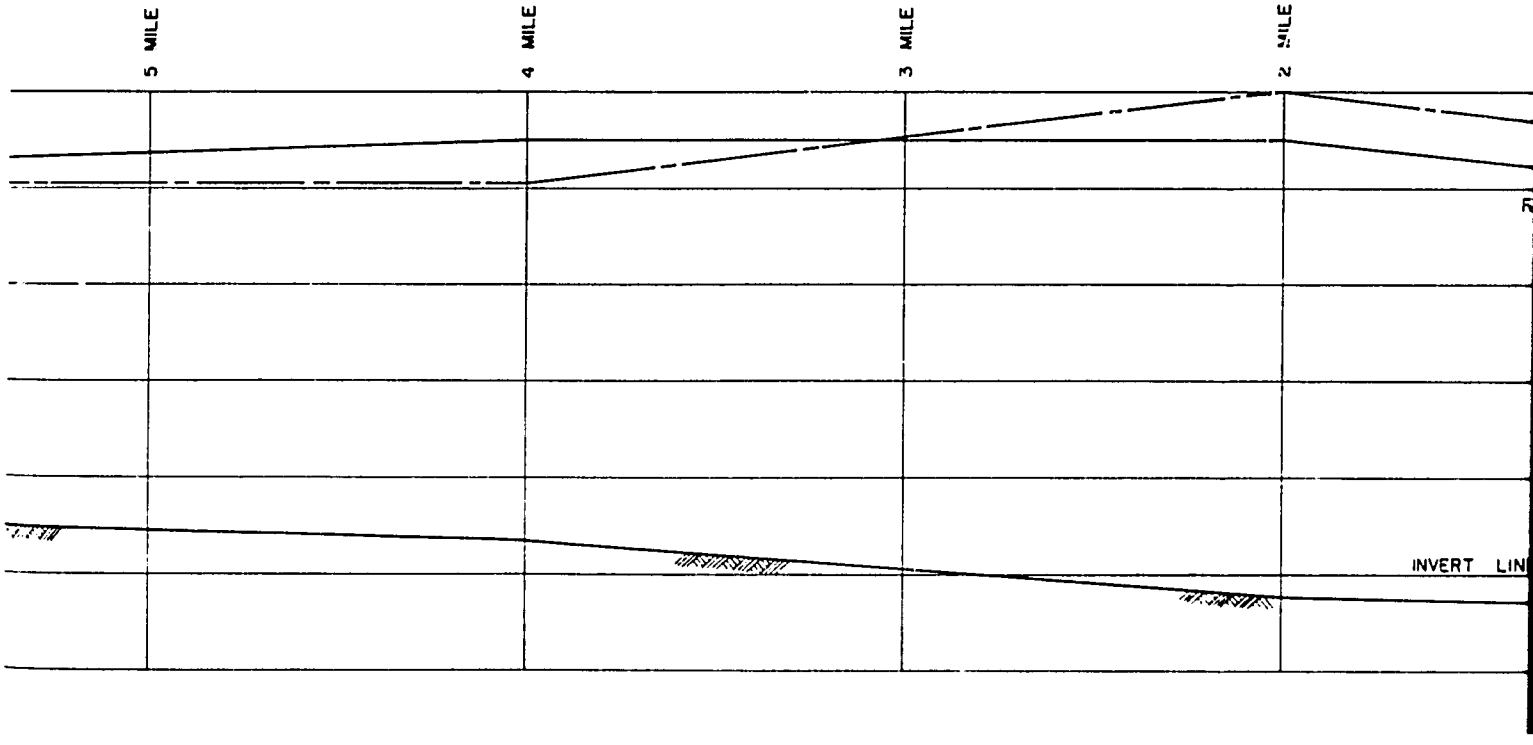


PRO

DISTANCE

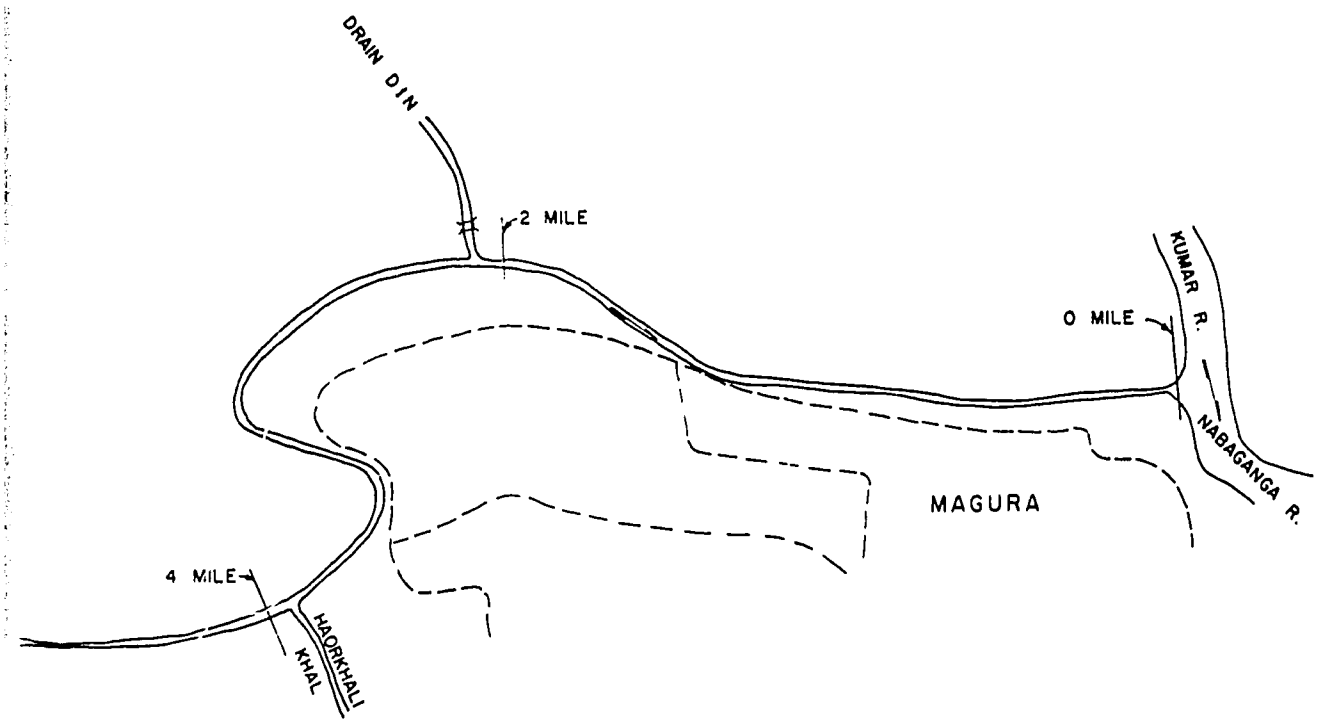


PLAN

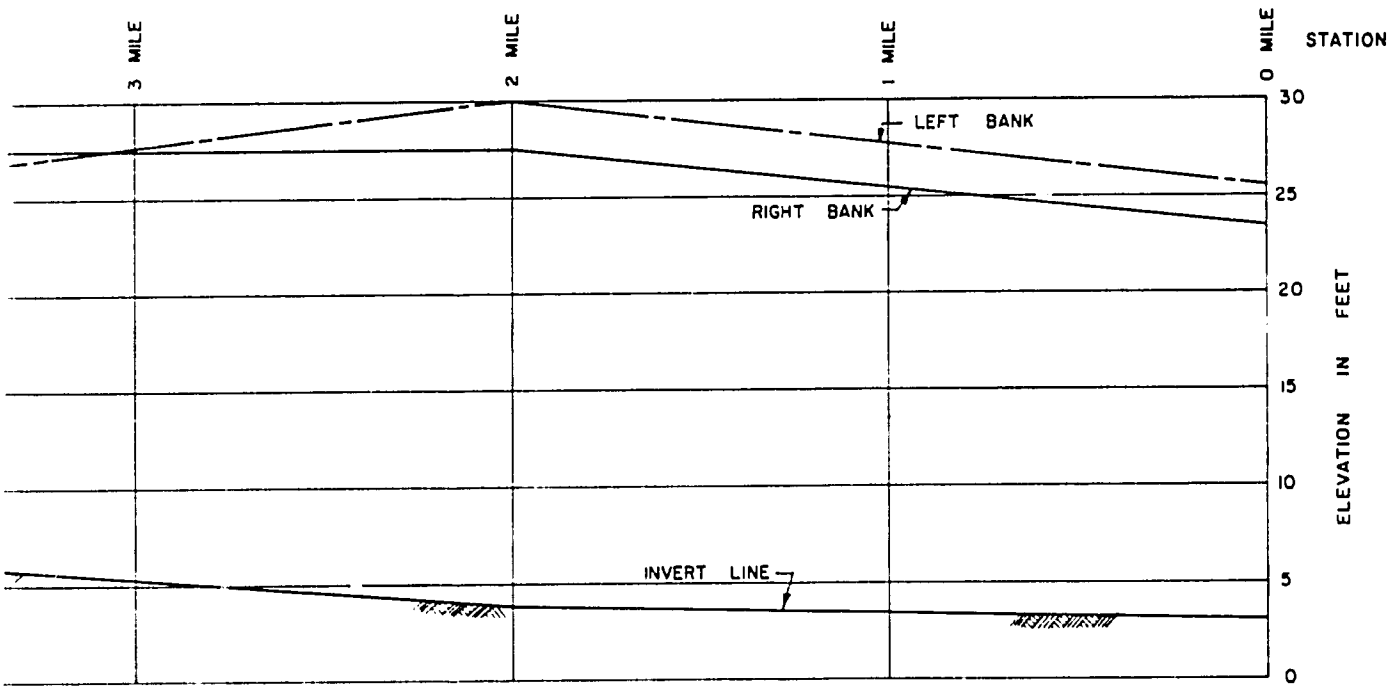


PROFILE

DISTANCE IN MILES



PLAN



E

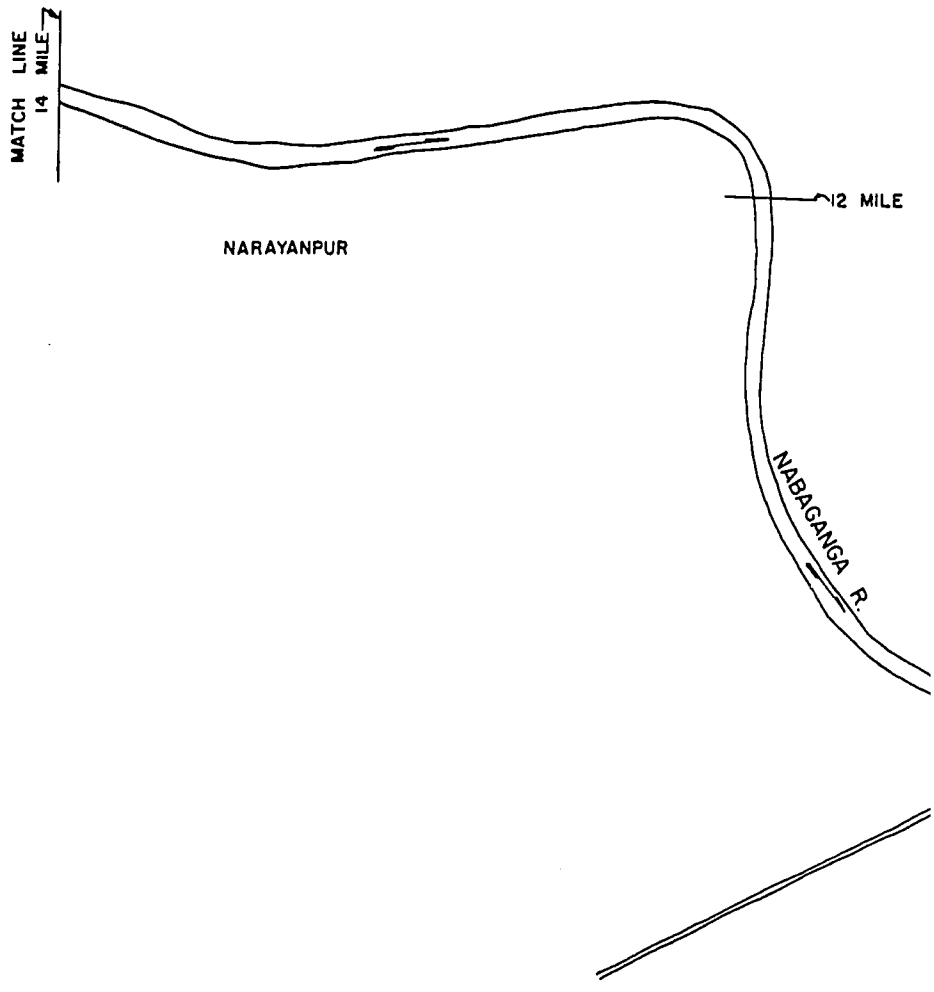
MILES

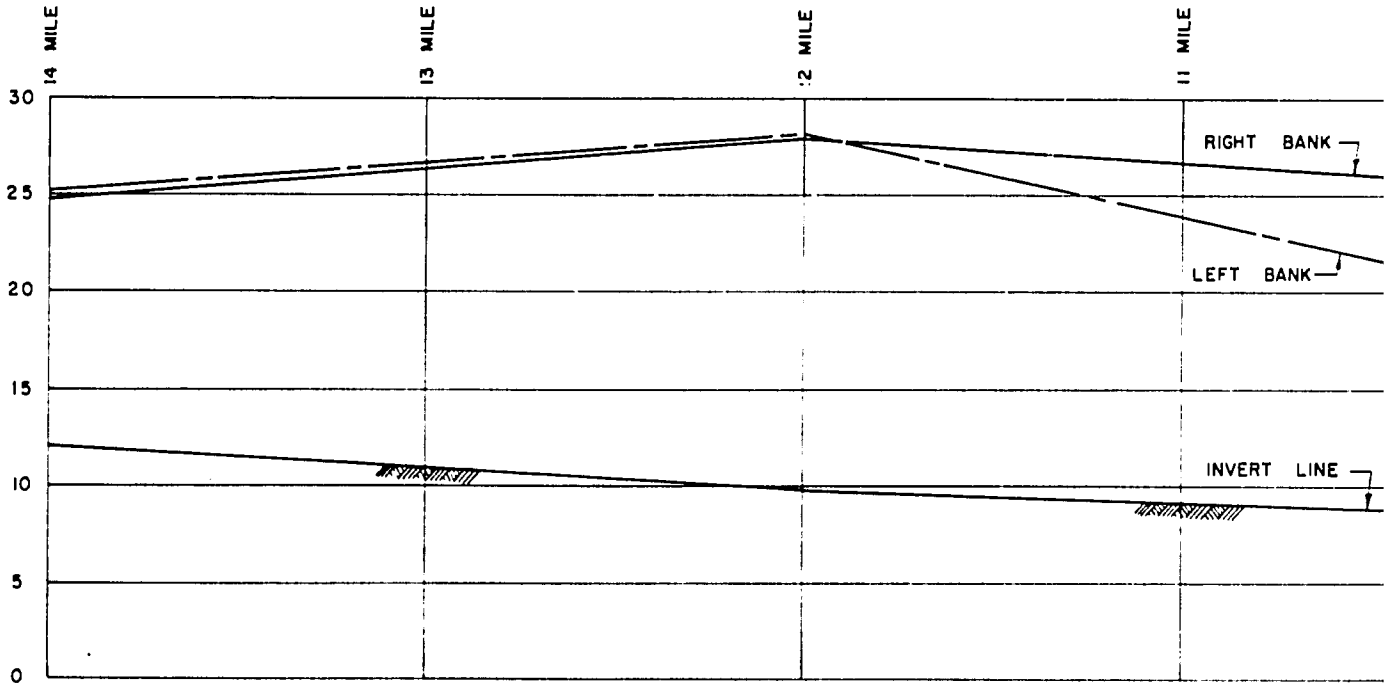
NABAGANGA RIVER

PLAN & PROFILE

FIGURE B-3

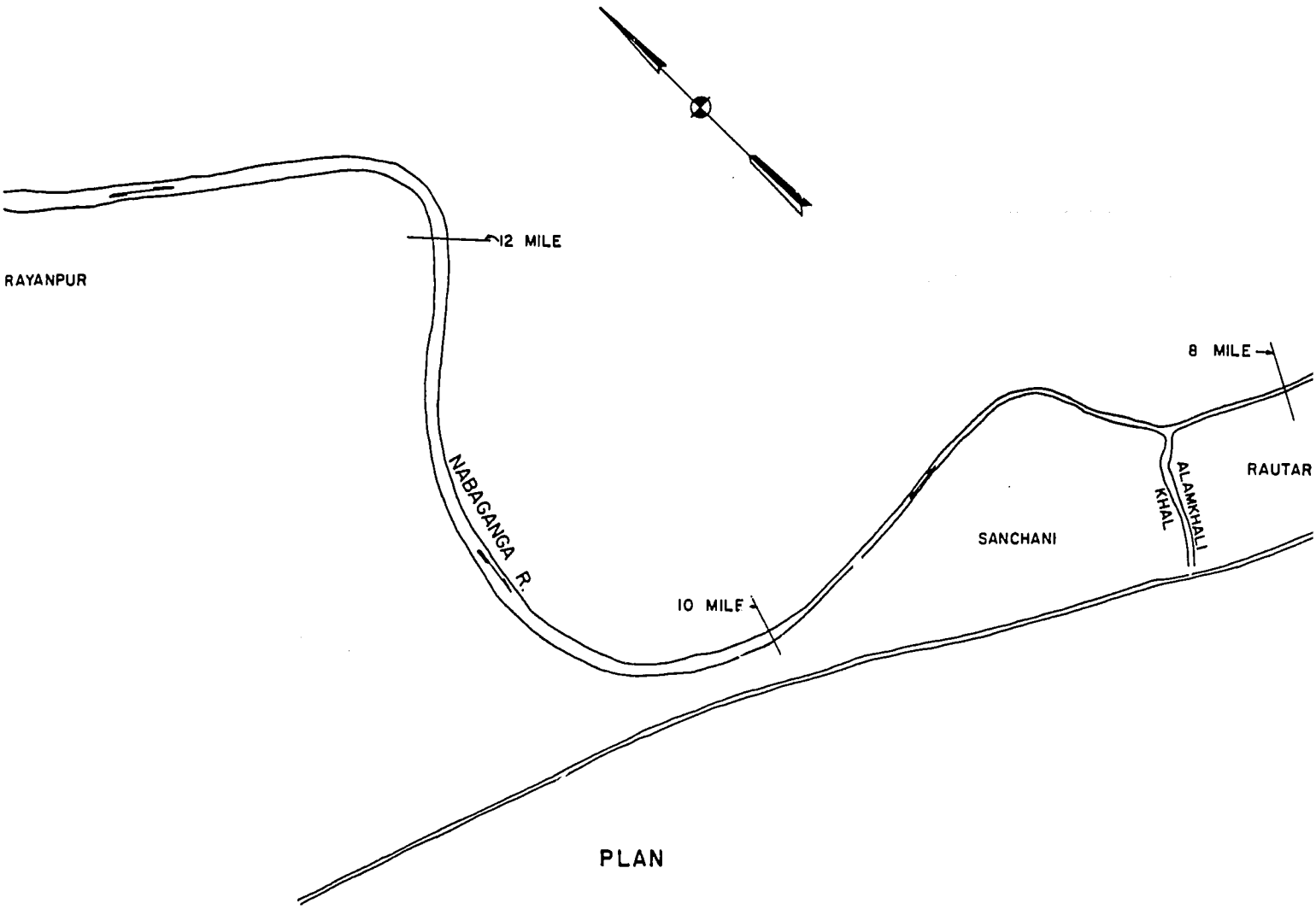
SHEET 1 OF 6



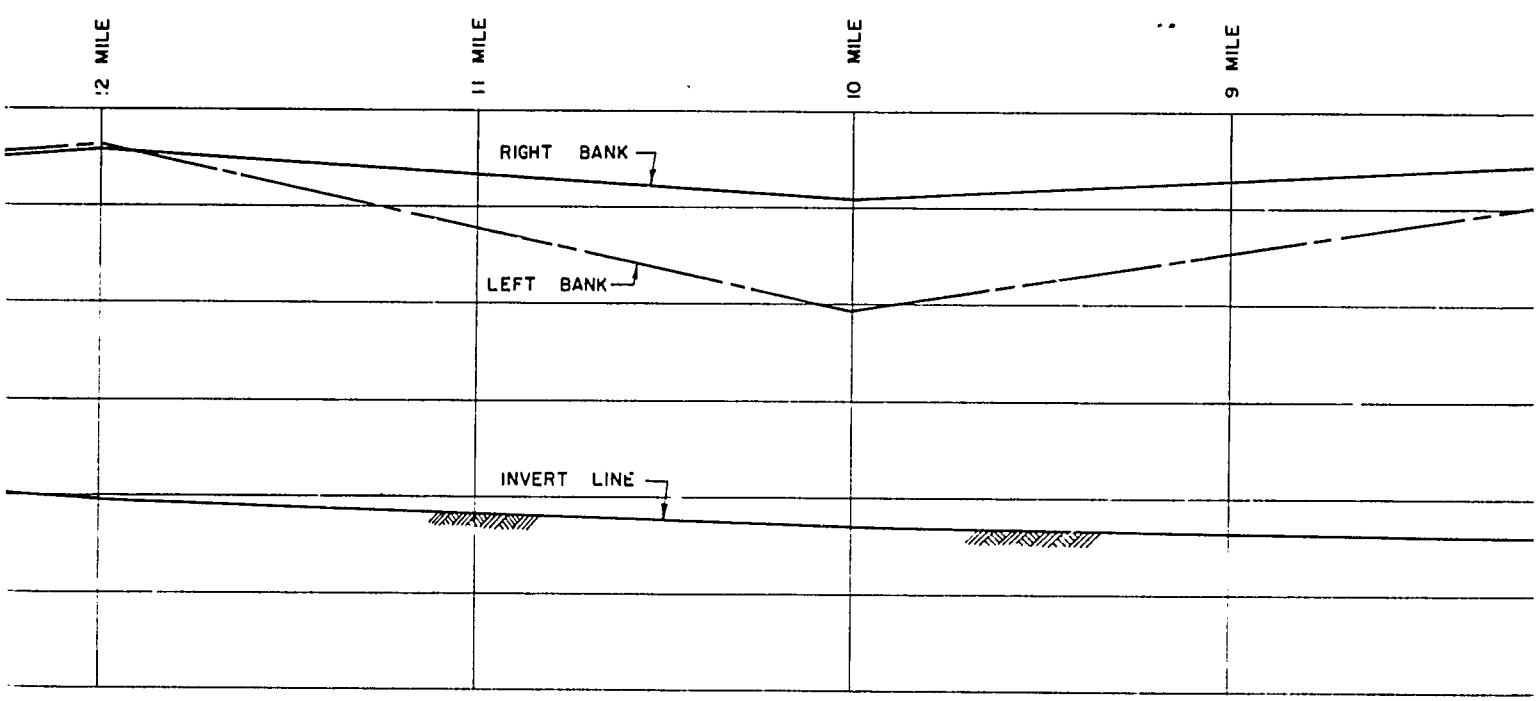


PROFI

DISTANCE I

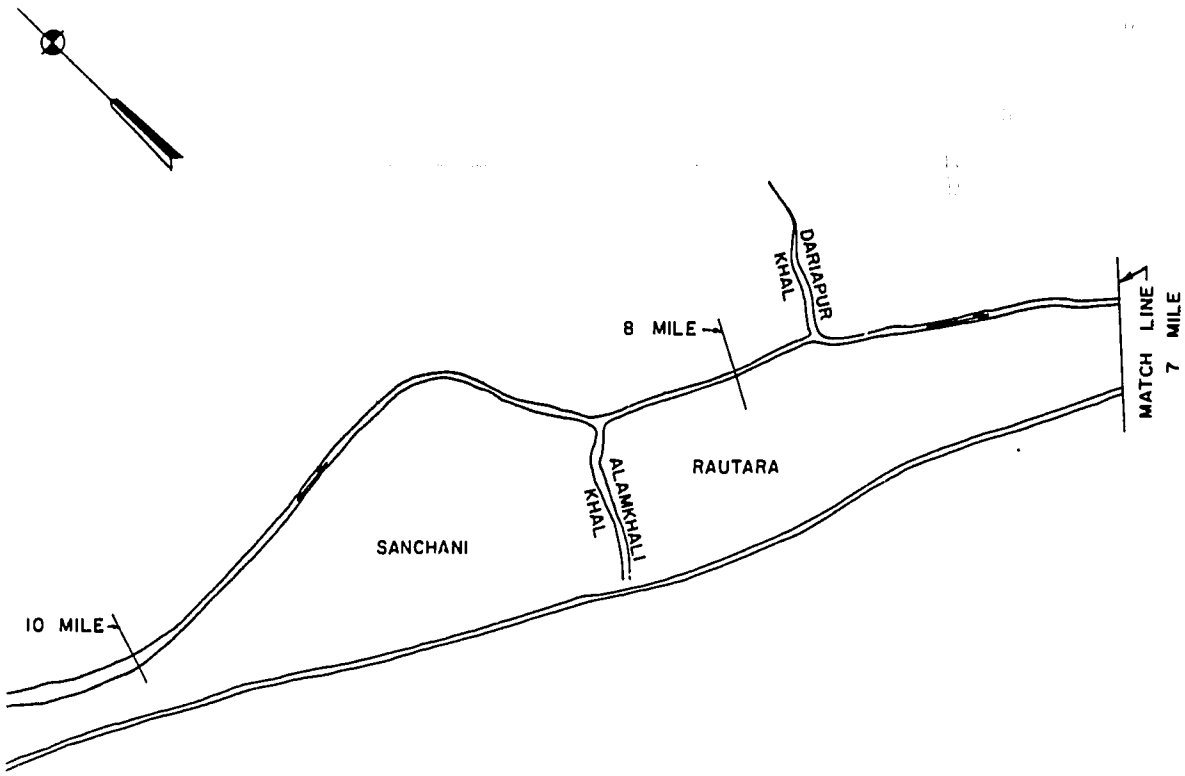


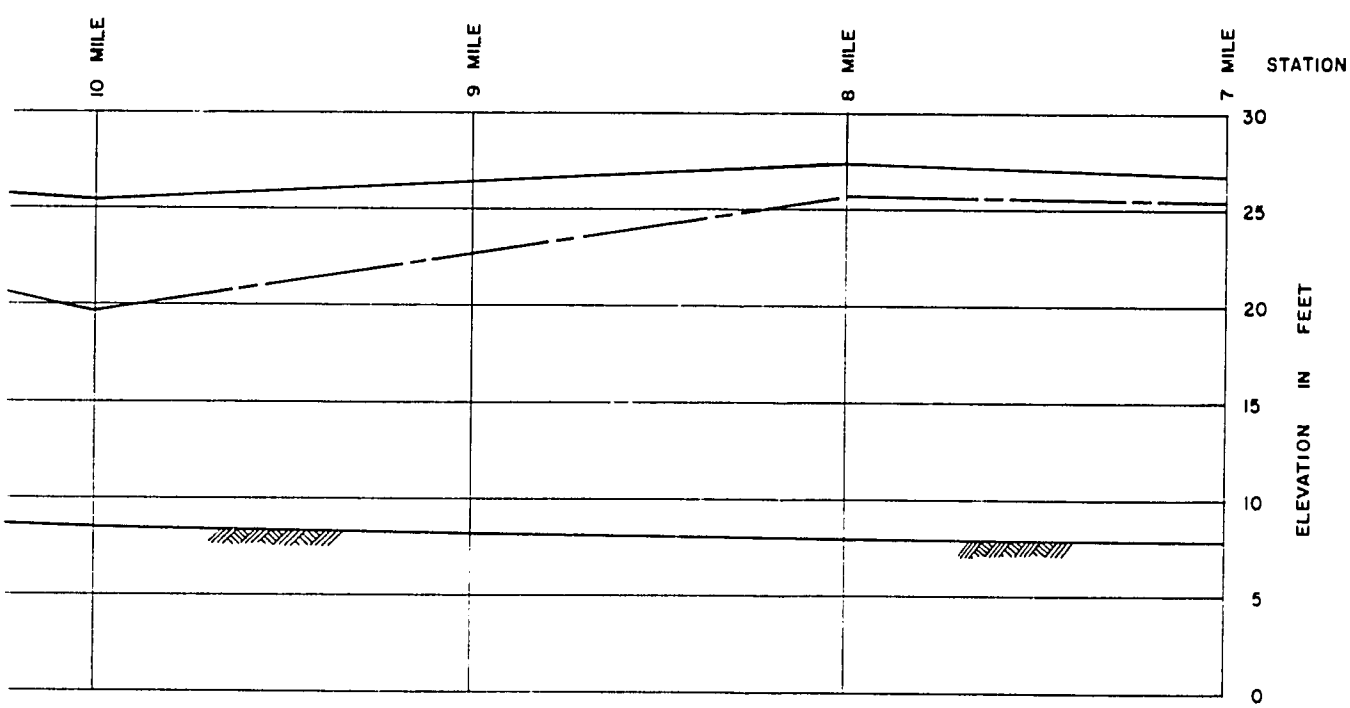
PLAN



PROFILE

DISTANCE IN MILES

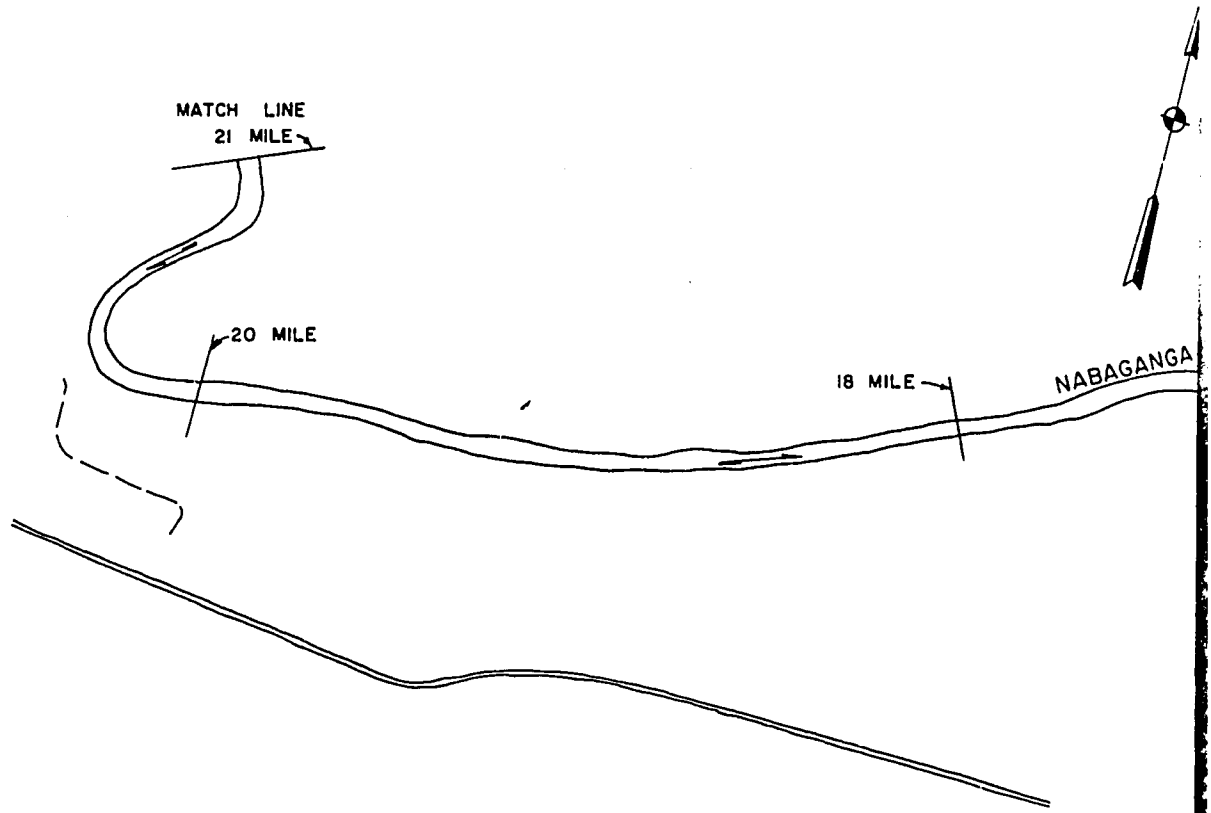


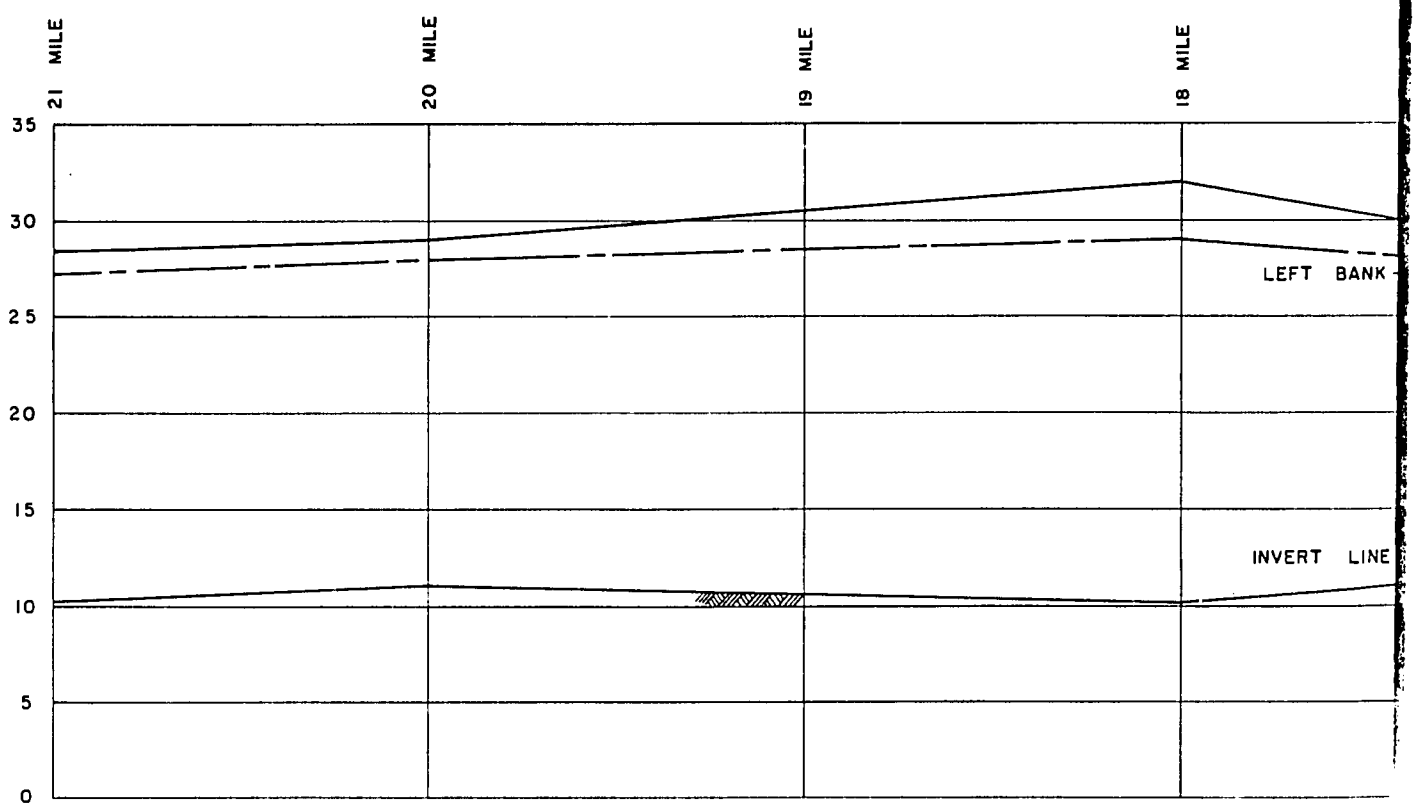


-ES

NABAGANGA RIVER
PLAN & PROFILE
FIGURE B-3
SHEET 2 OF 6

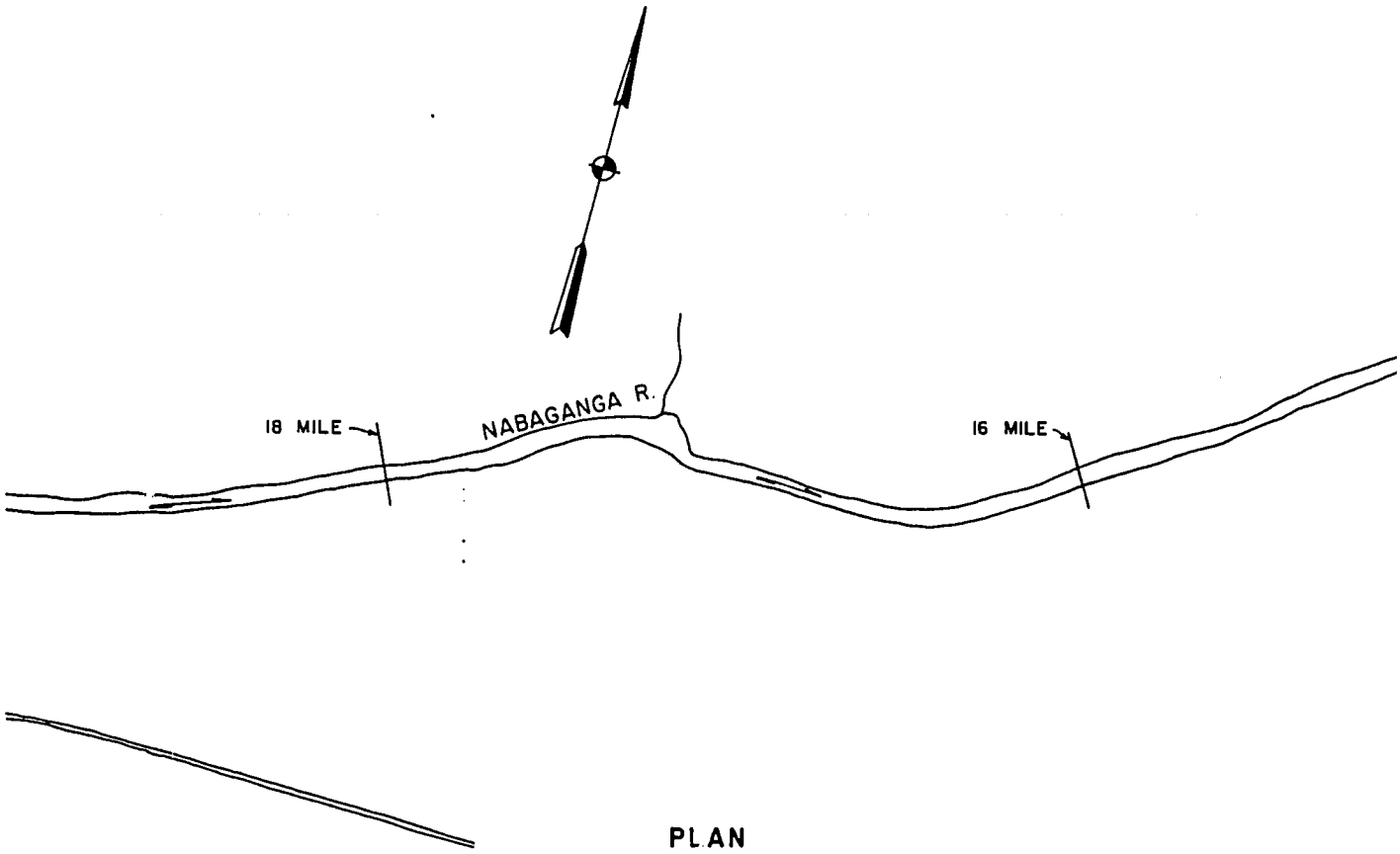
13 B3-a





PROFI

DISTANCE I



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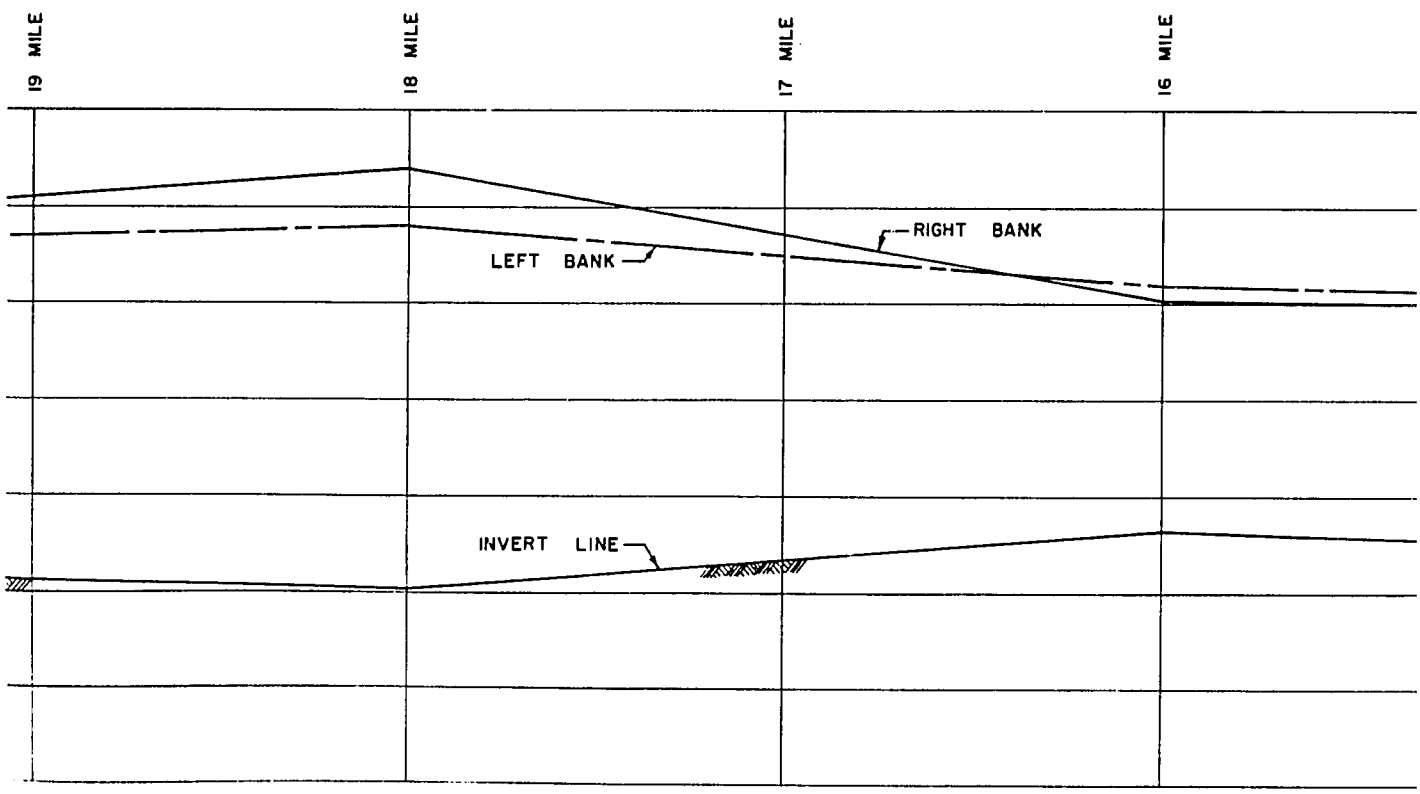
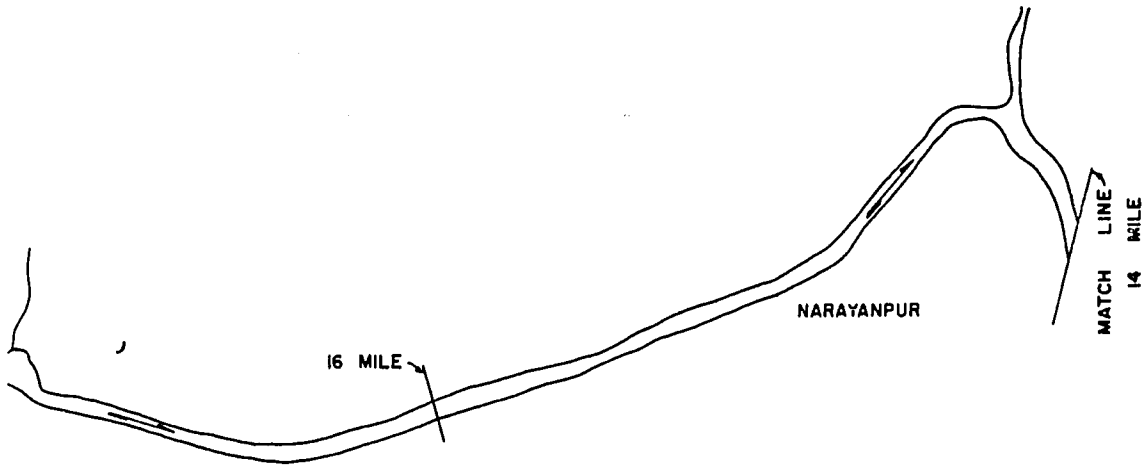


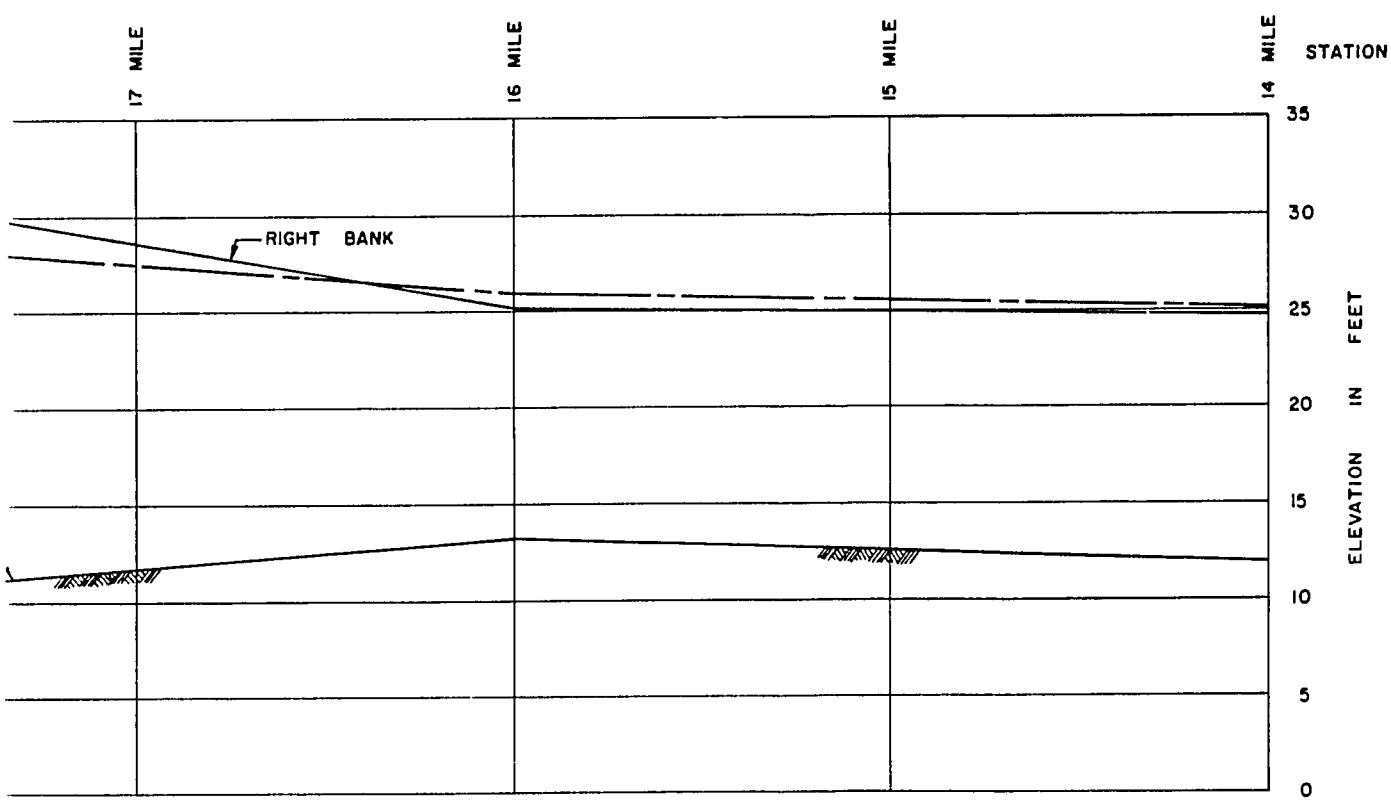
PROFILE

DISTANCE IN MILES

15 (3) B3-C



PLAN



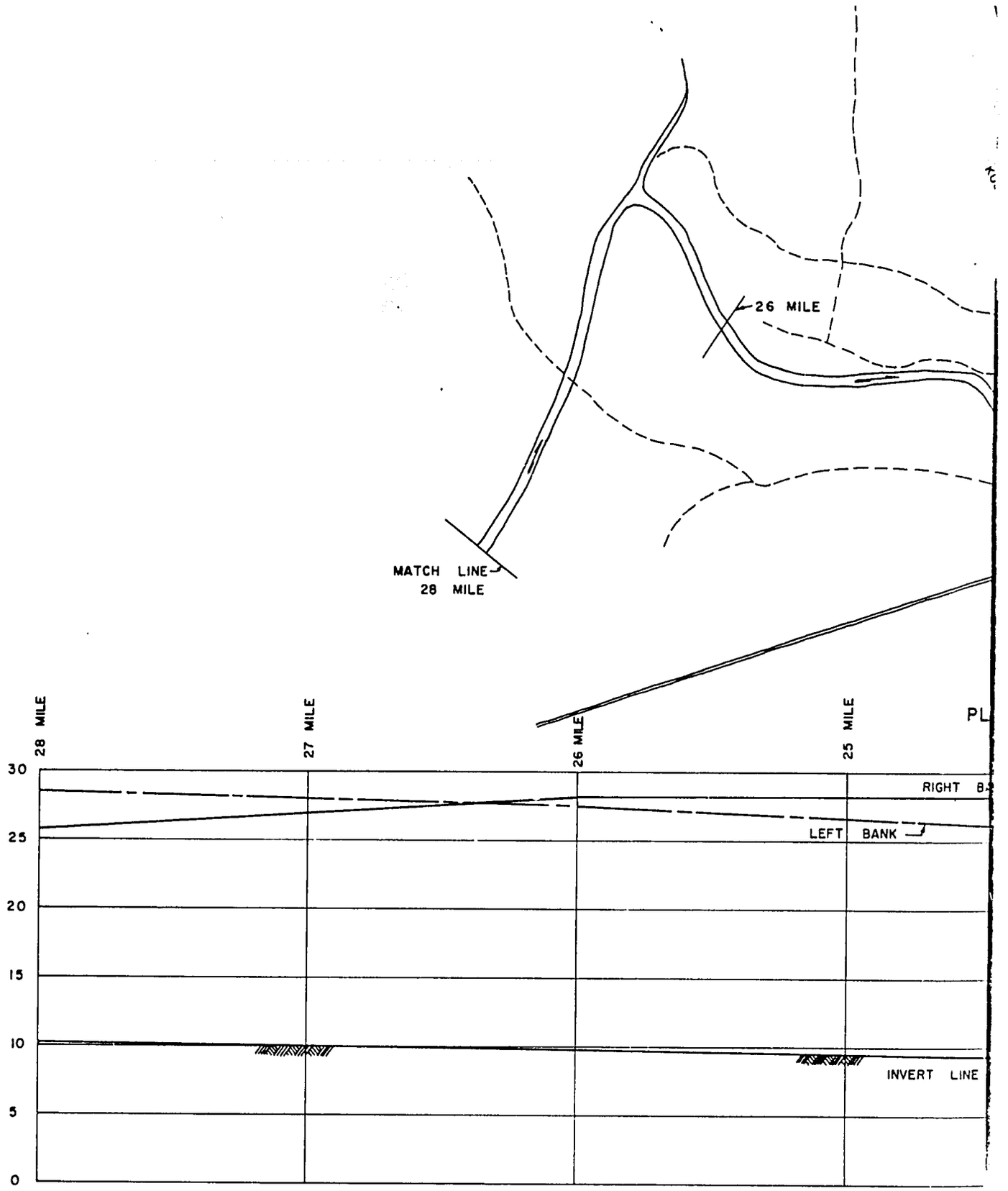
E

MILES

NABAGANGA RIVER
PLAN & PROFILE
FIGURE B-3

SHEET 3 OF 6

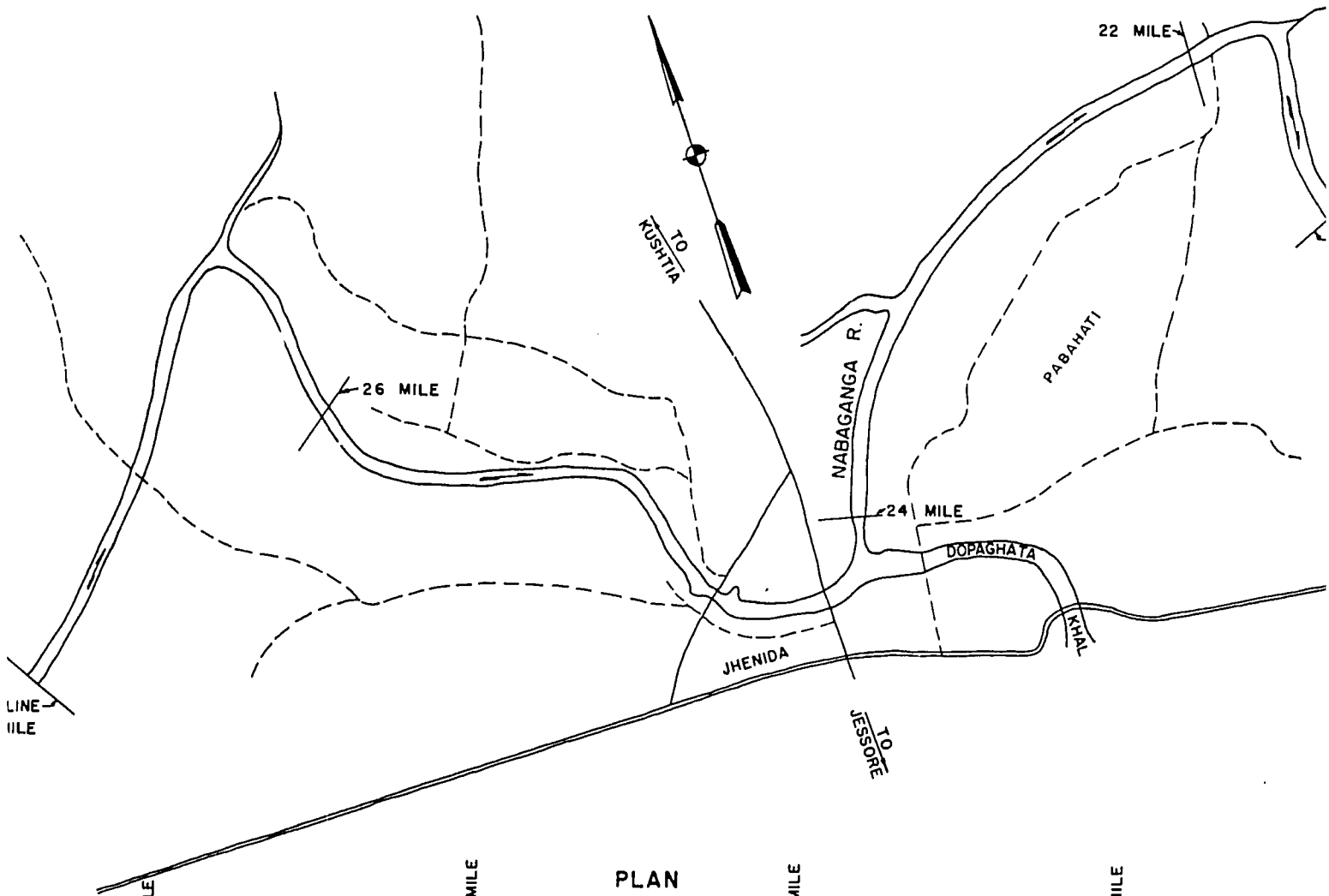
16 (4) B3 a



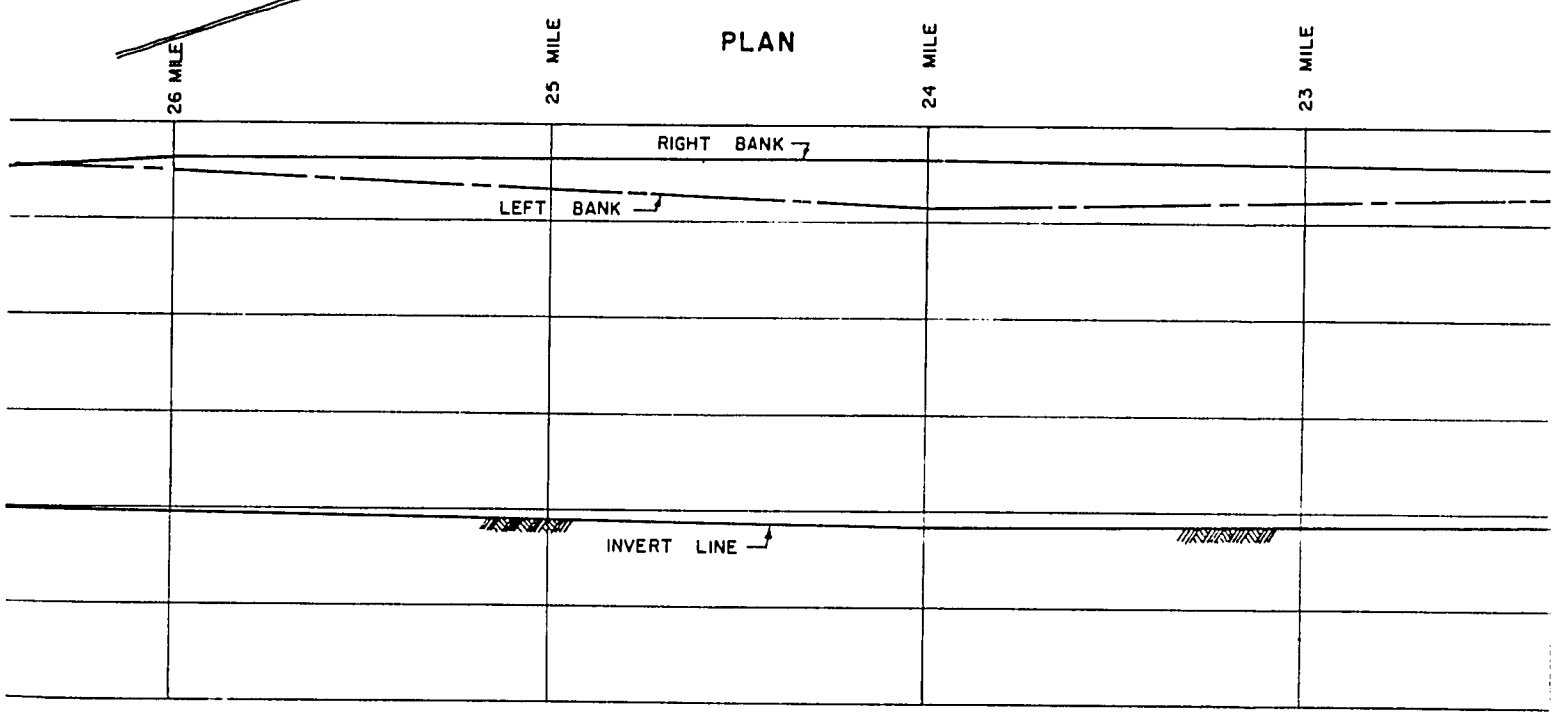
PROFIL

DISTANCE IN

17 (4) B3 b



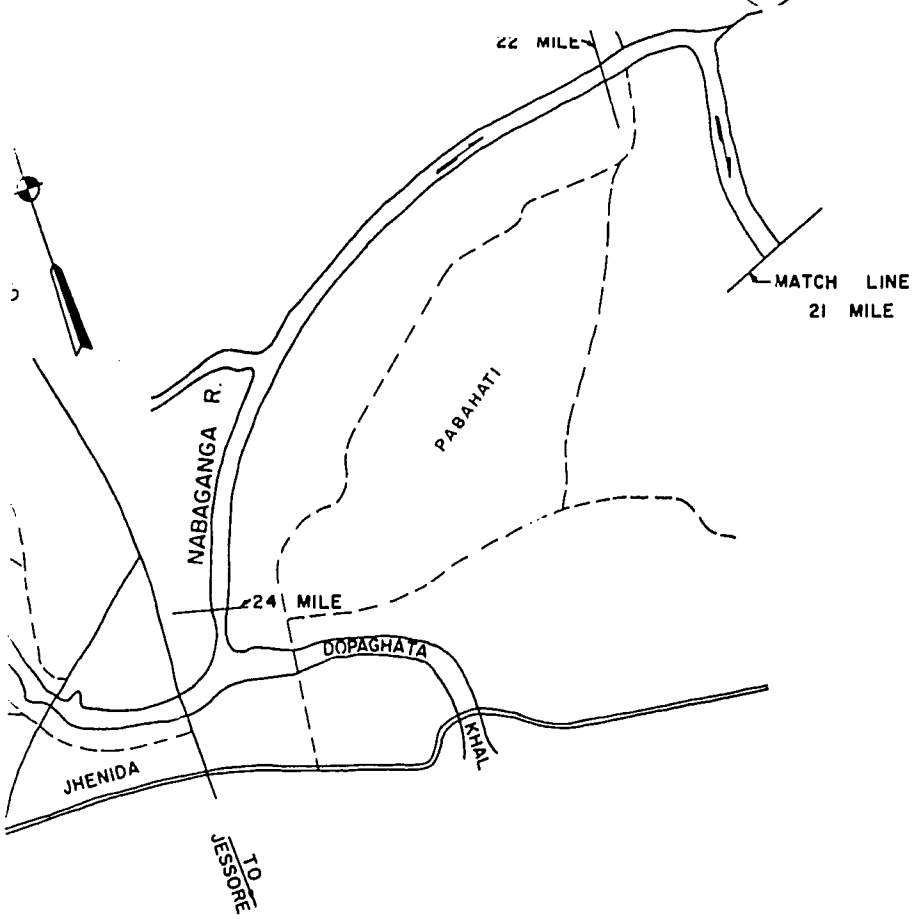
PLAN

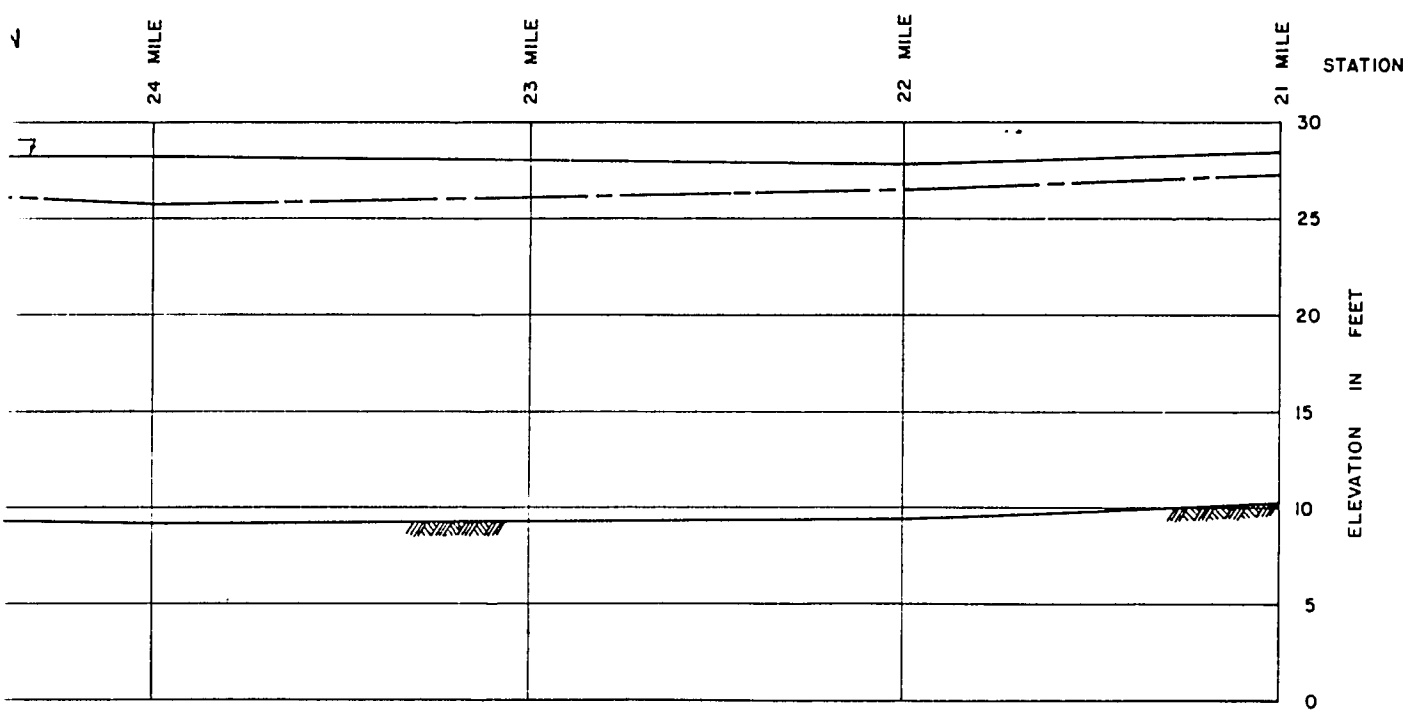


PROFILE

DISTANCE IN MILES

18 (4) B3 c

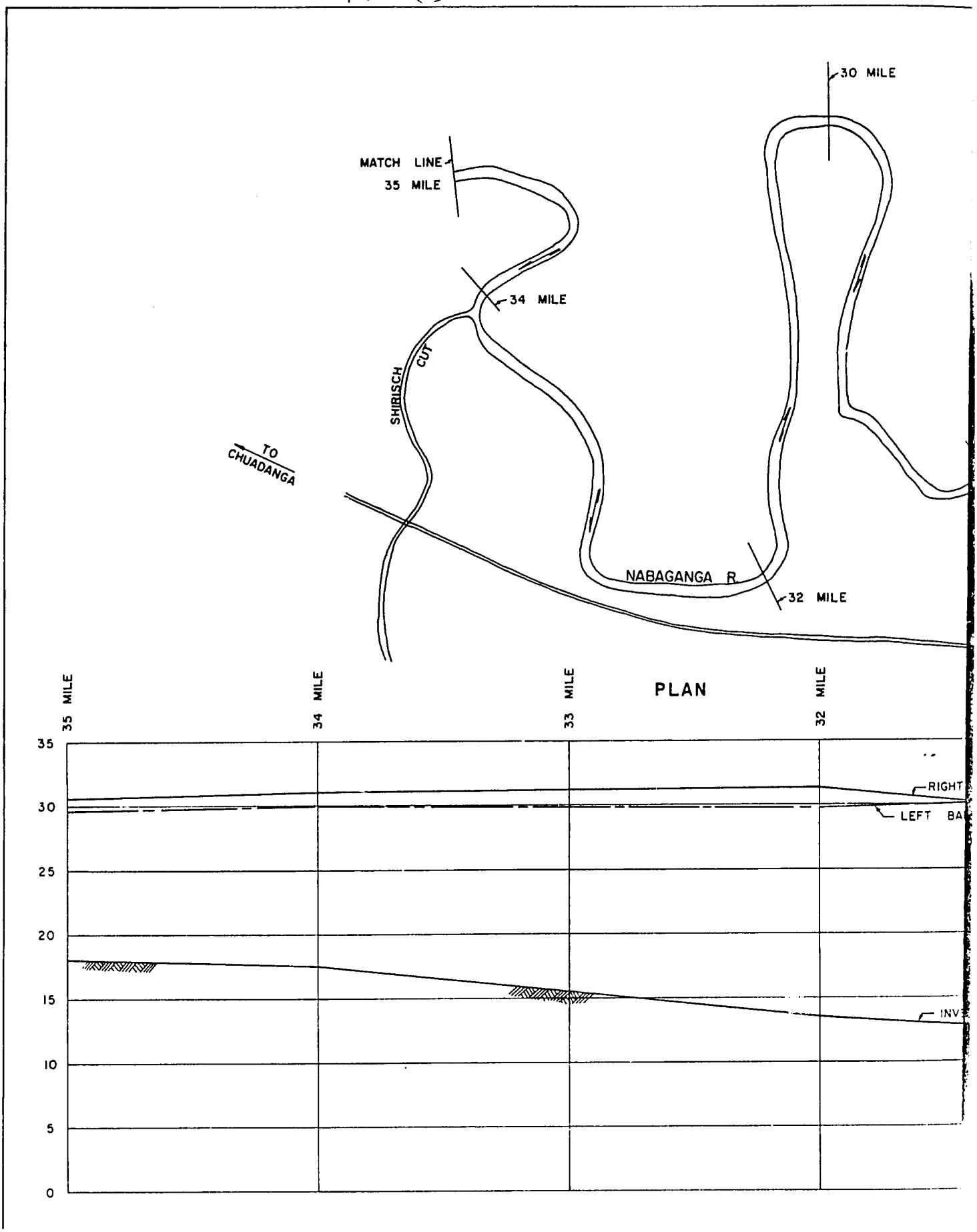




ILES

NABAGANGA RIVER
PLAN & PROFILE
FIGURE B-3
SHEET 4 OF 6

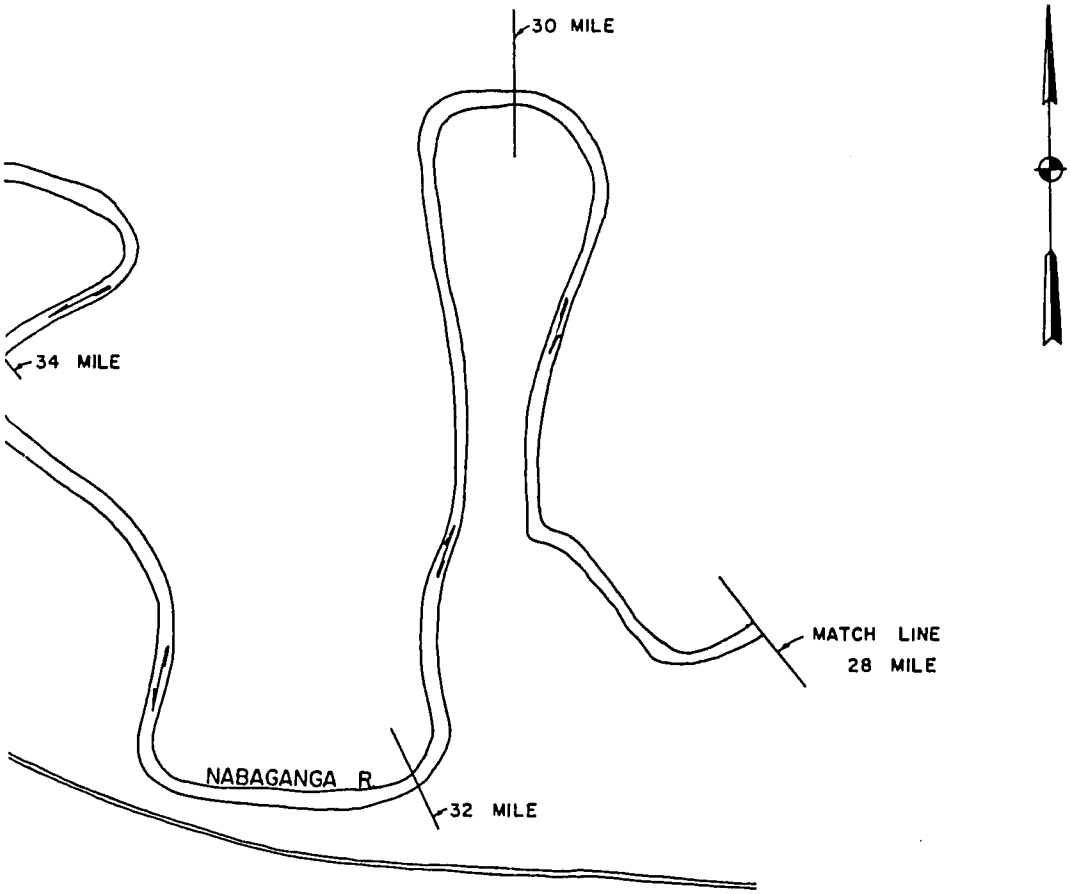
19 (5) B3 a



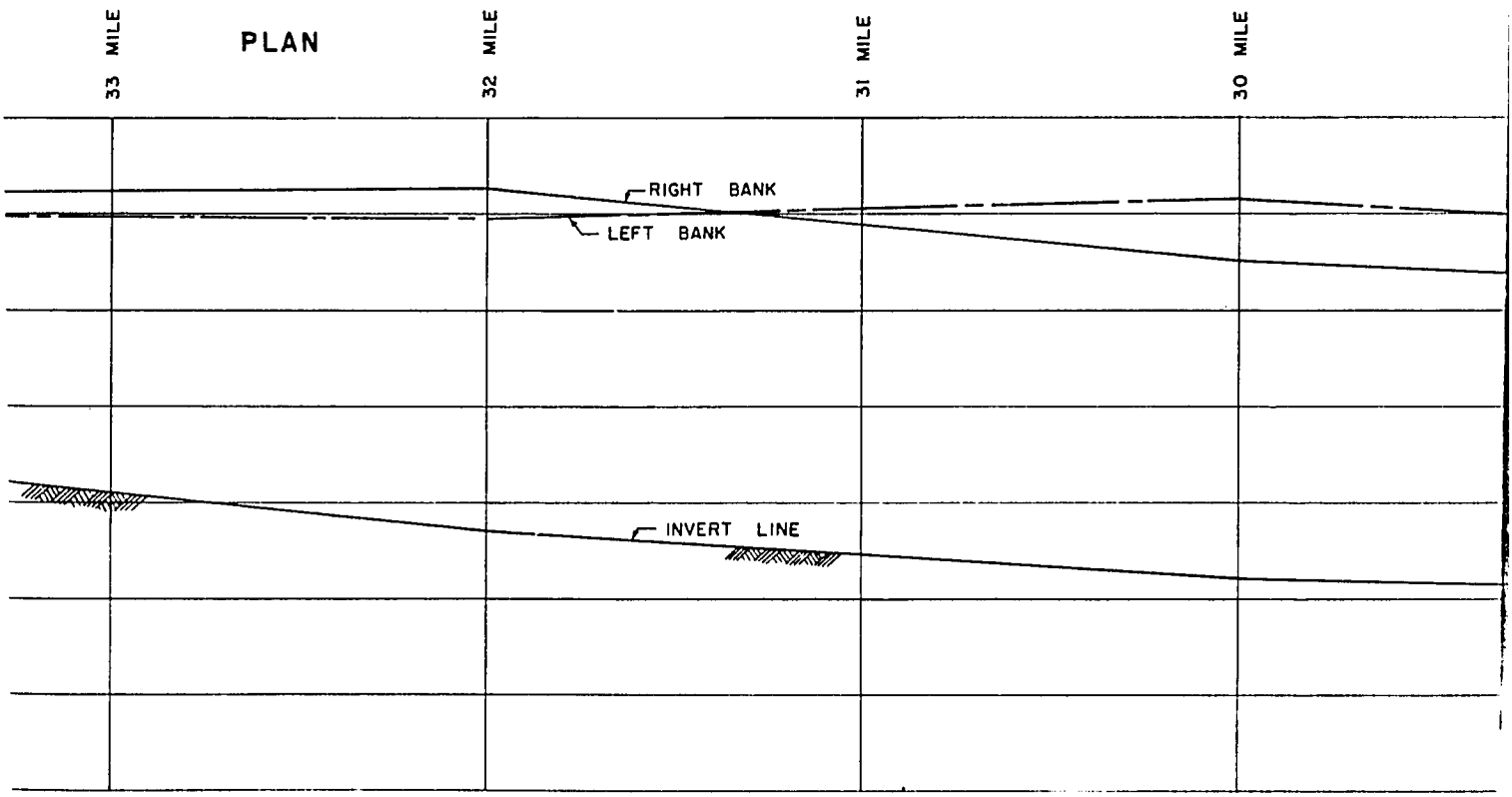
PROFIL

DISTANCE IN

20 (5) B3 b



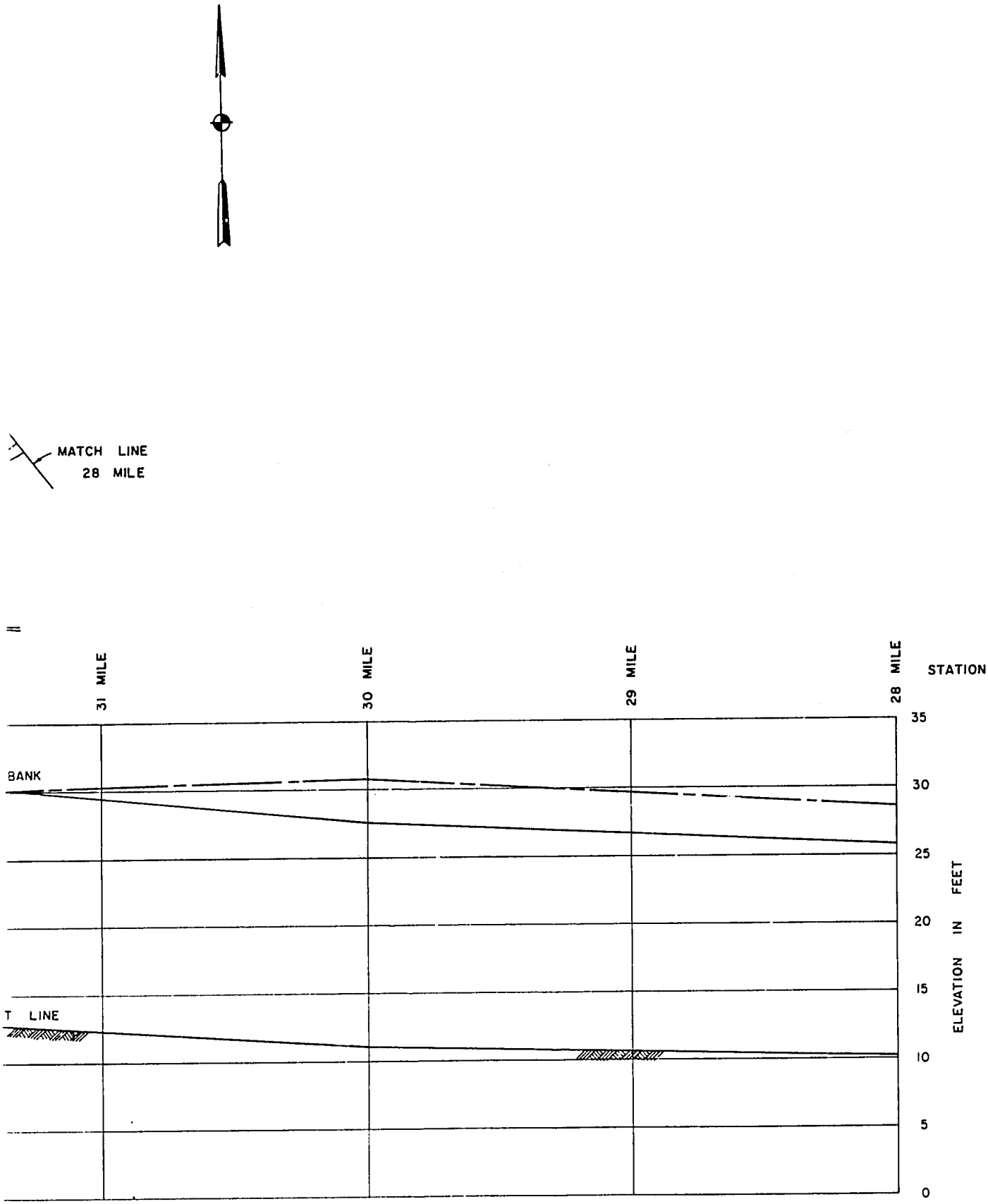
PLAN



PROFILE

DISTANCE IN MILES

21 (5) B3 c

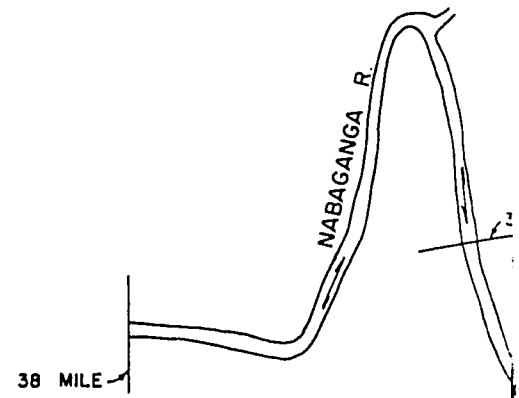


ILES

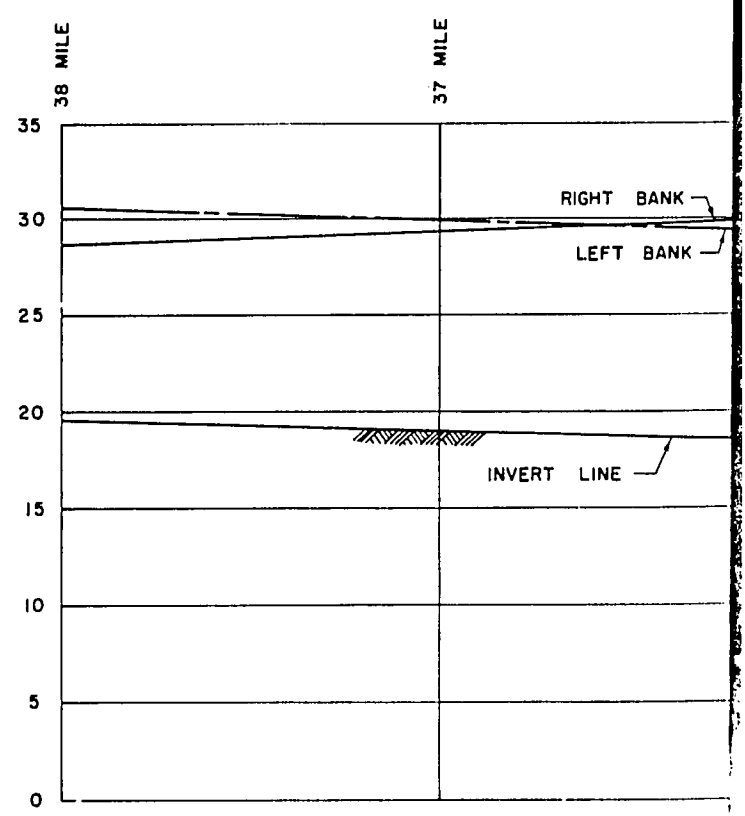
NABAGANGA RIVER
PLAN & PROFILE
FIGURE B-3

SHEET 5 OF 6

22 (6) B3 a



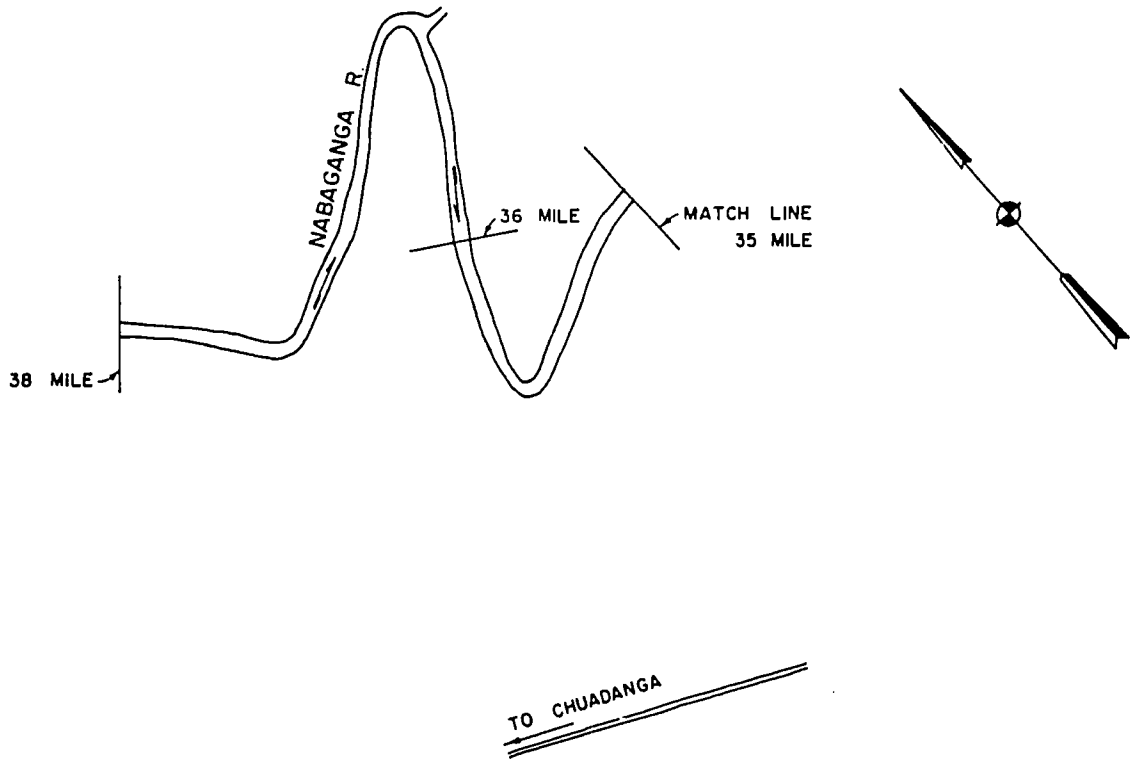
PLAN



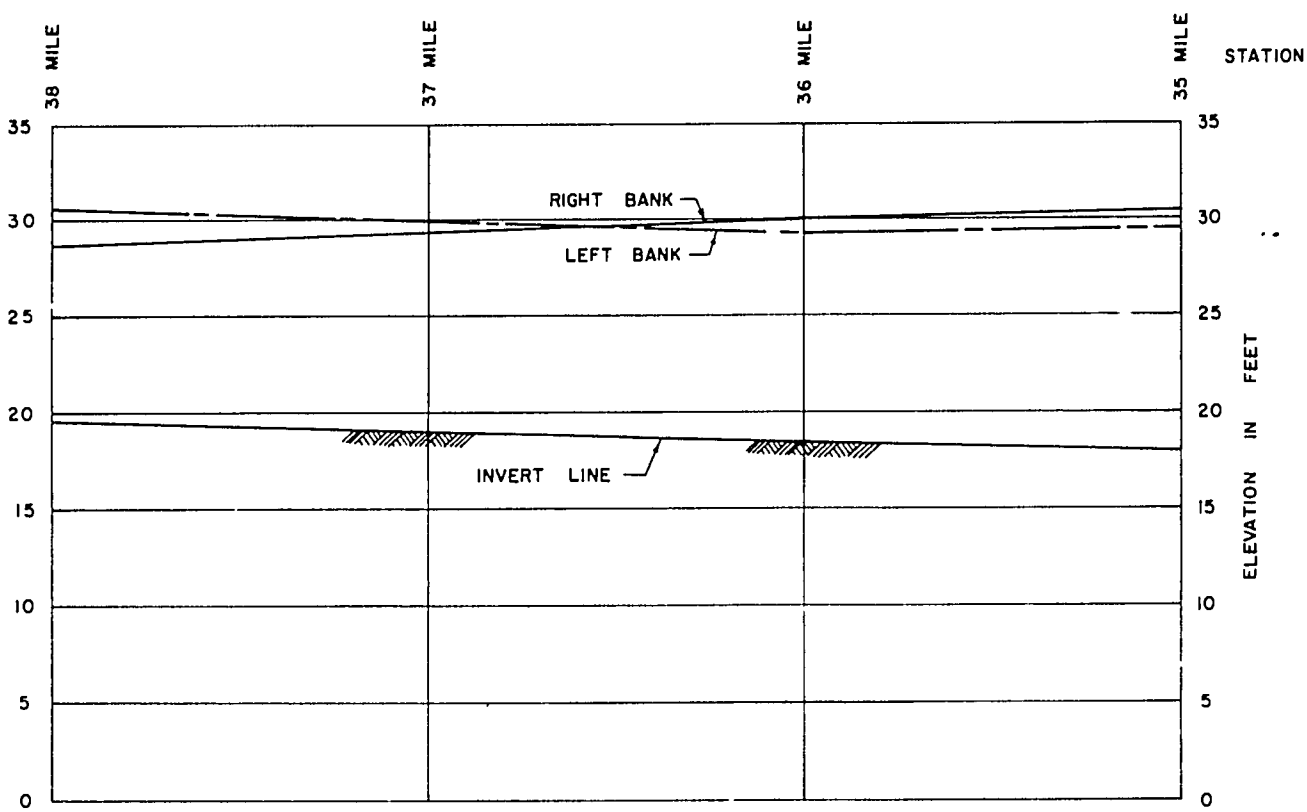
PROFILE

DISTANCE IN M

23 (6) B3 6



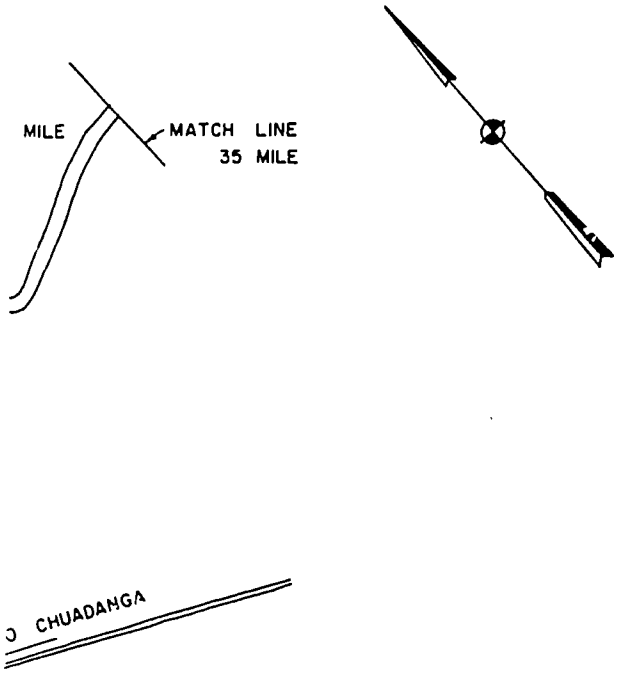
PLAN

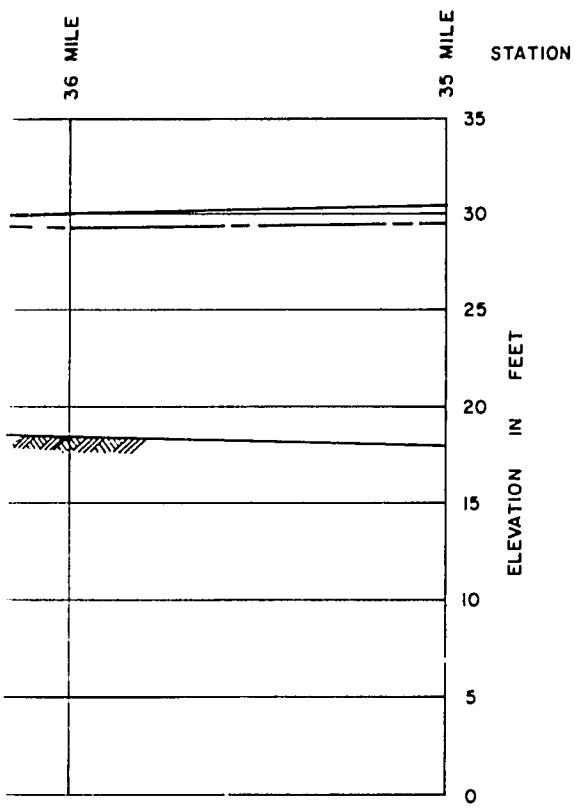


PROFILE

DISTANCE IN MILES

24 (6) B3 c



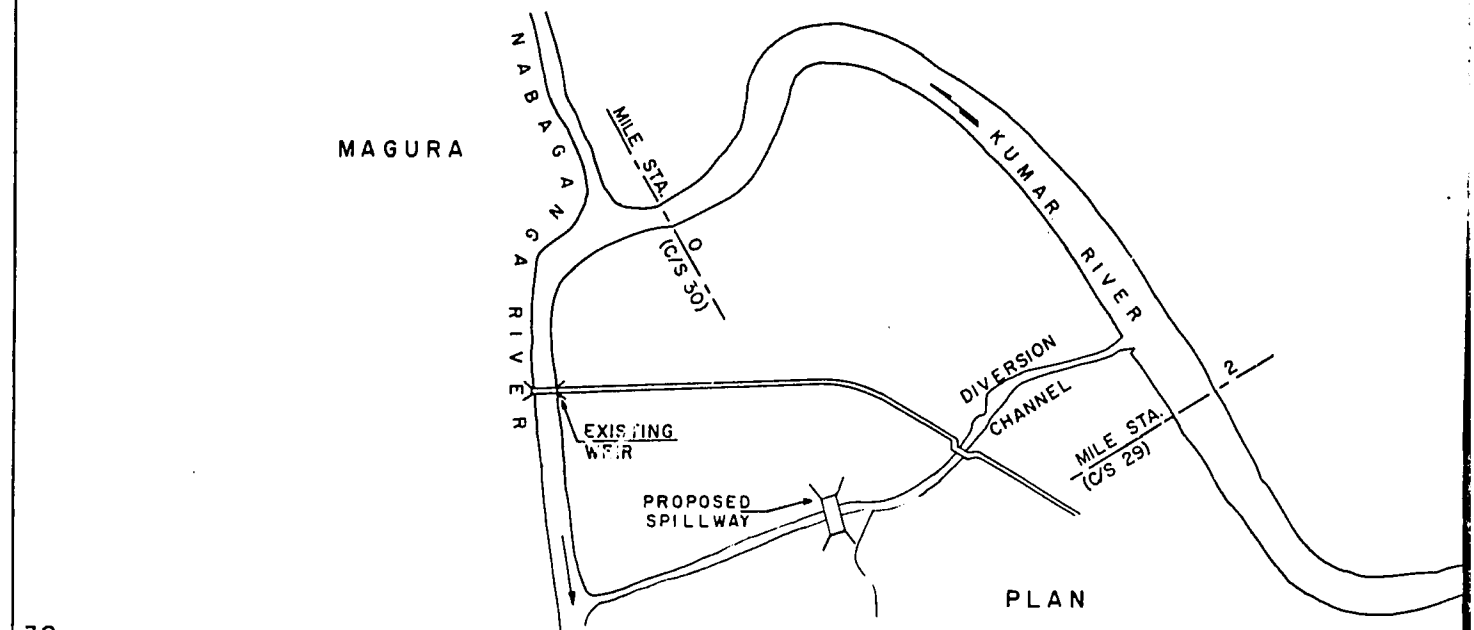


ES

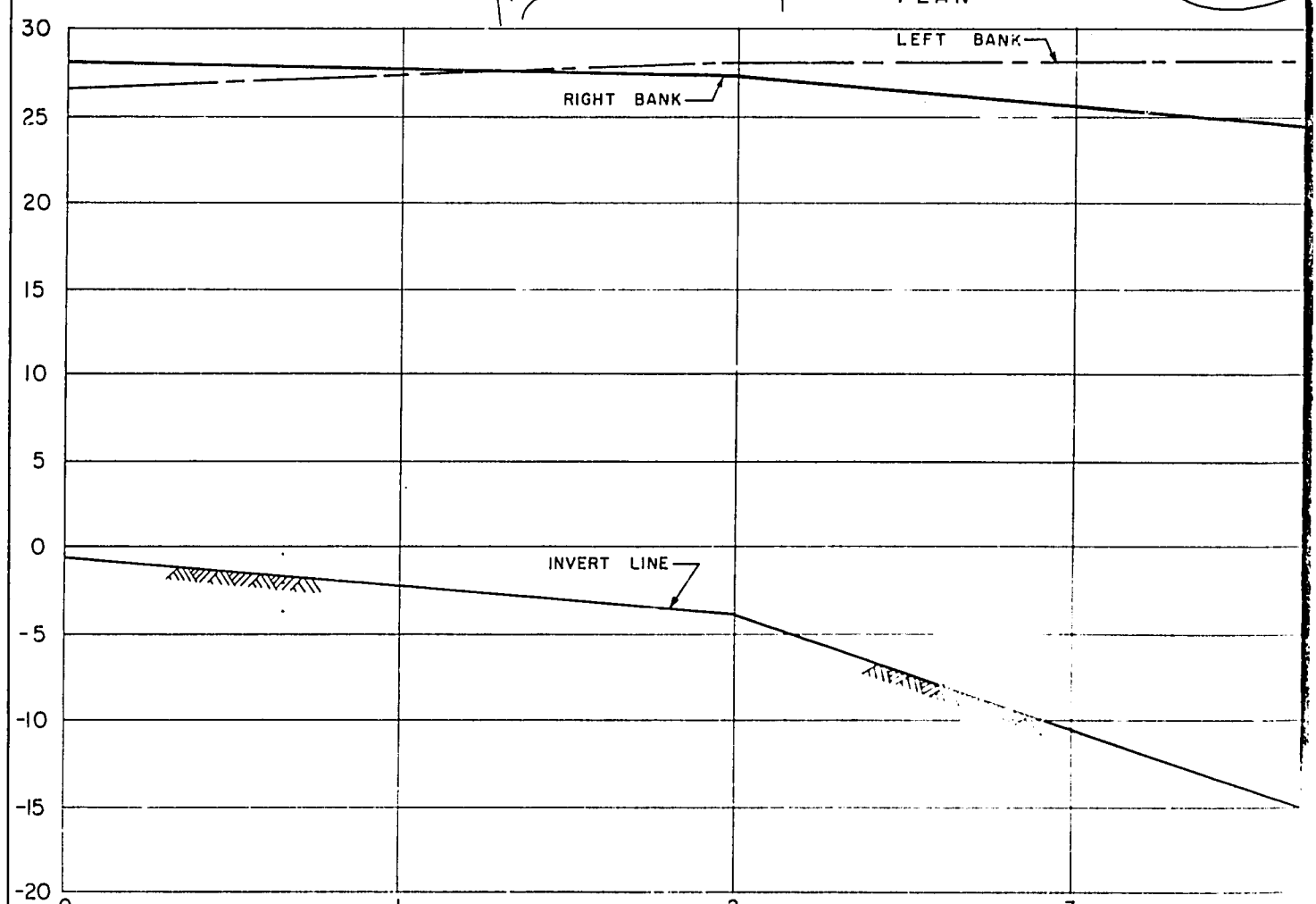
NABAGANGA RIVER
PLAN & PROFILE
FIGURE B-3

SHEET 6 OF 6

25 (1) B-4 a



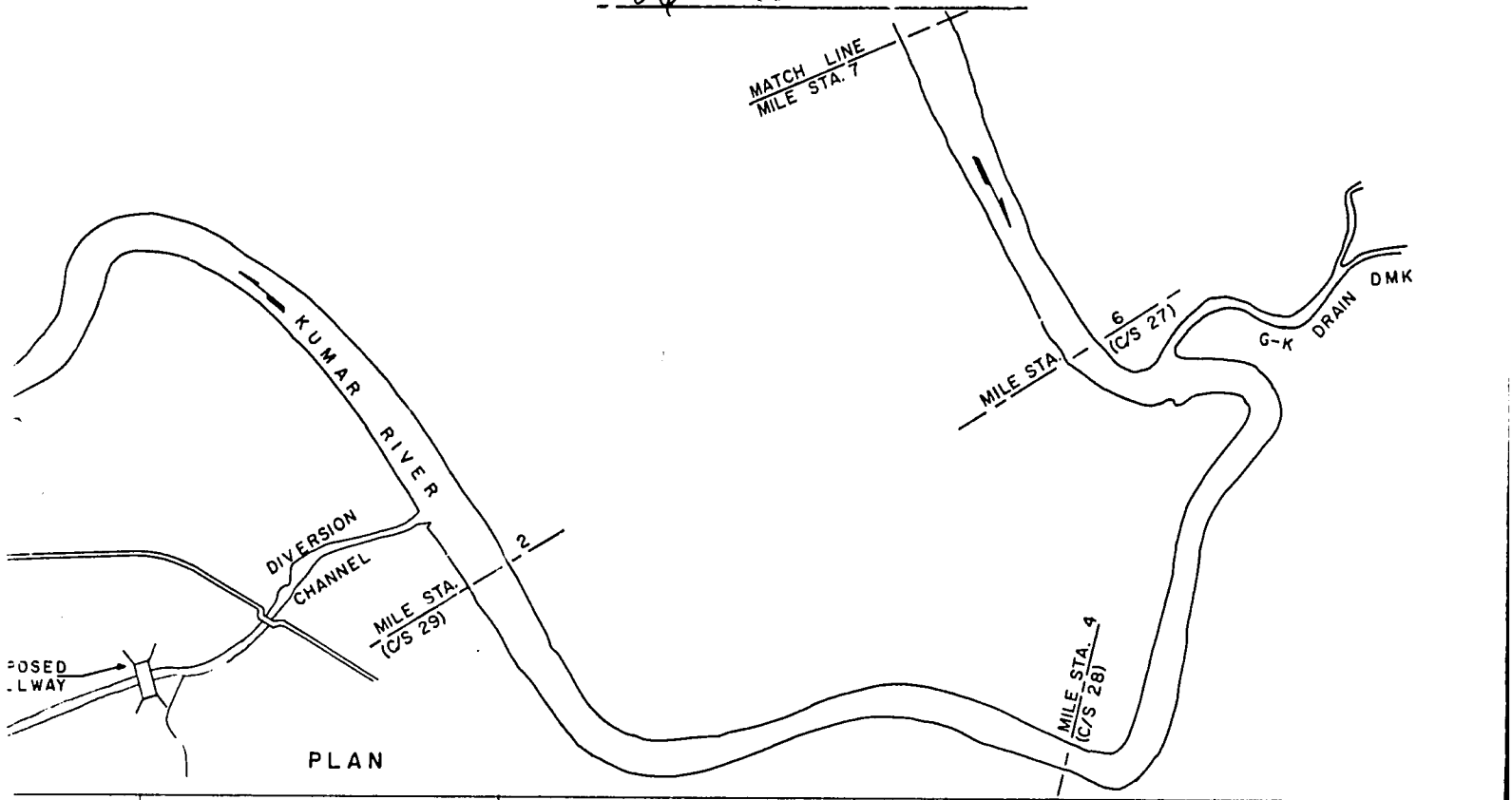
PLAN

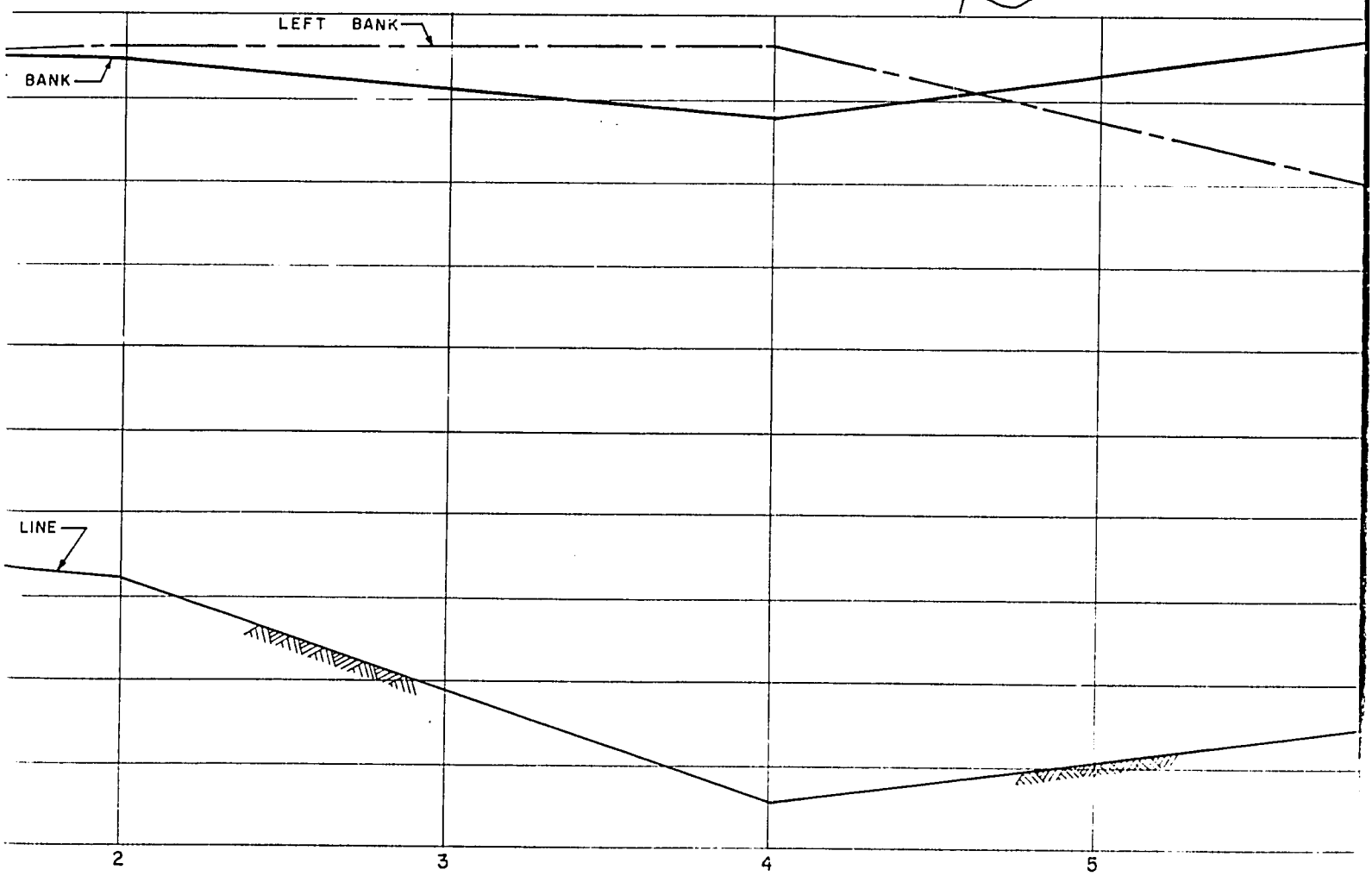


PROFILE

DISTANCE IN

26 (1) B-4 b

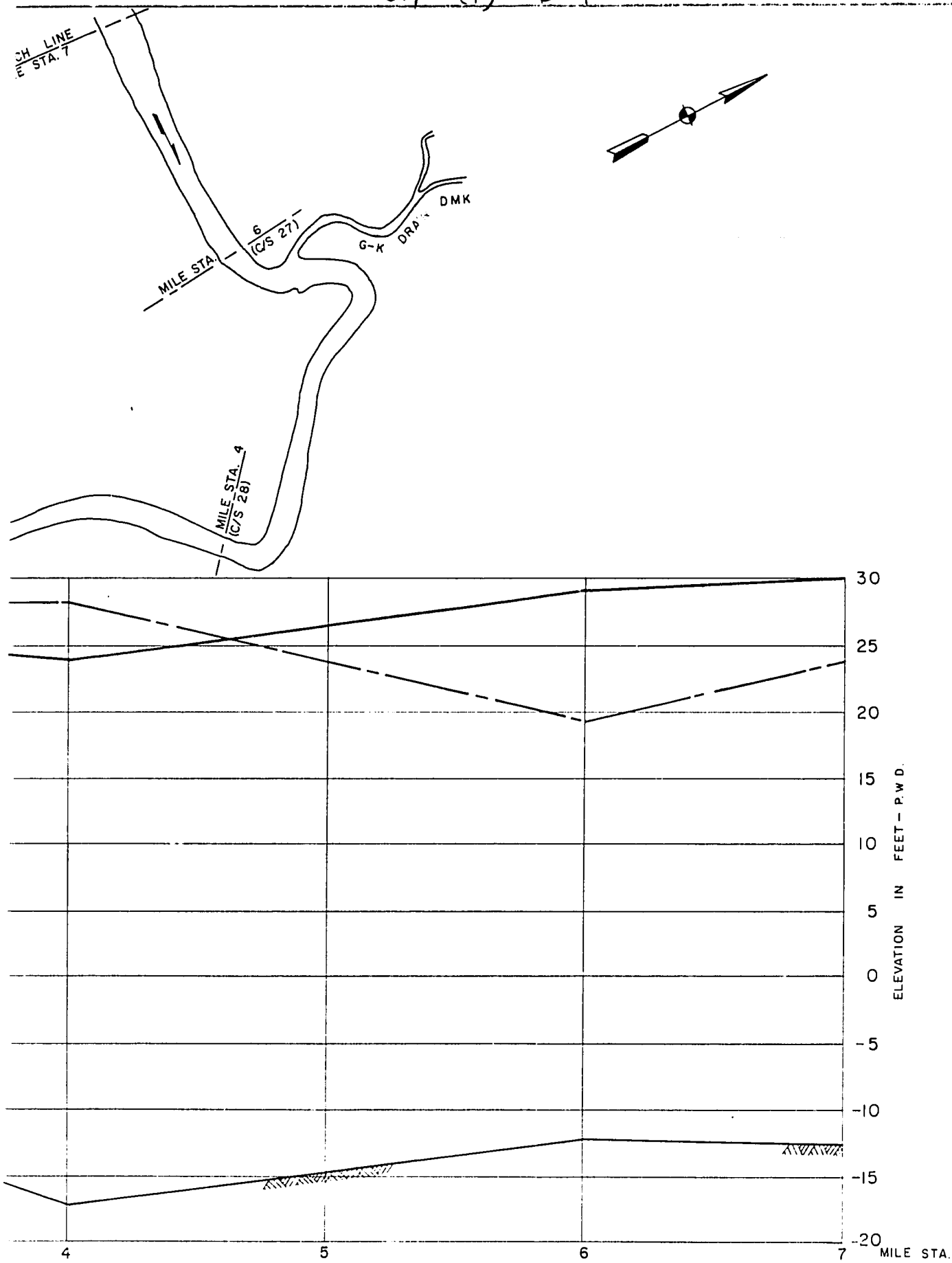




PROFILE

DISTANCE IN MILES

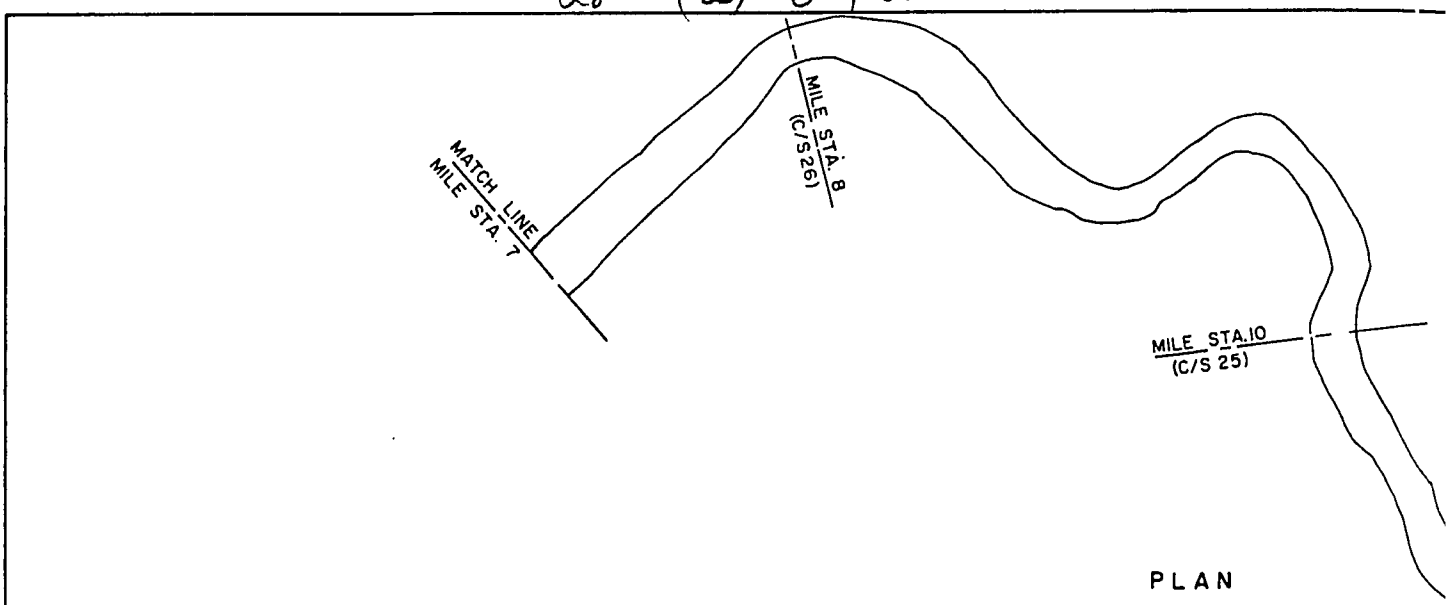
27 (1) B-4 c



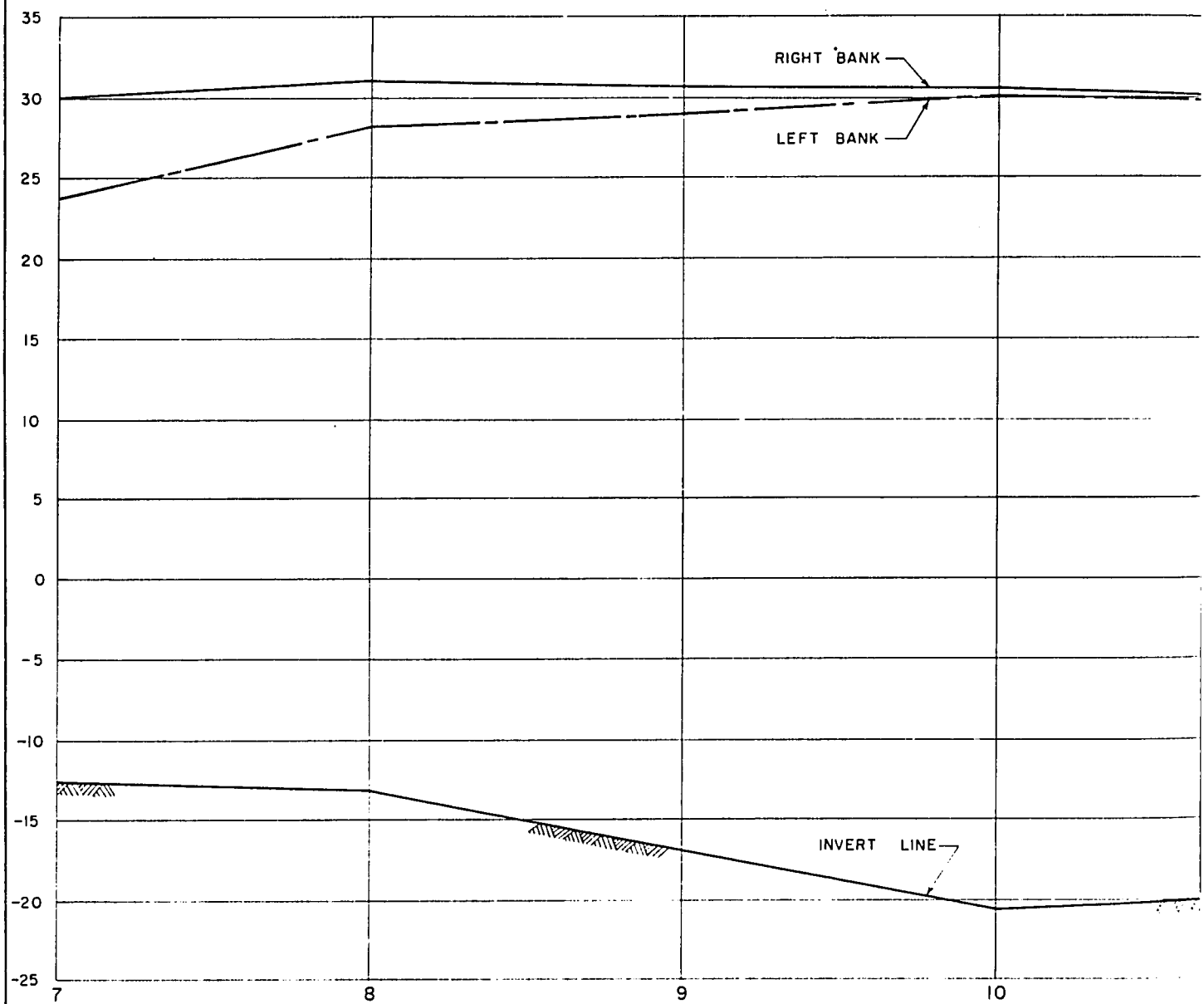
ES

KUMAR RIVER
PLAN & PROFILE
FIGURE B-4
SHEET 1 OF 5

28 (2) B-4a



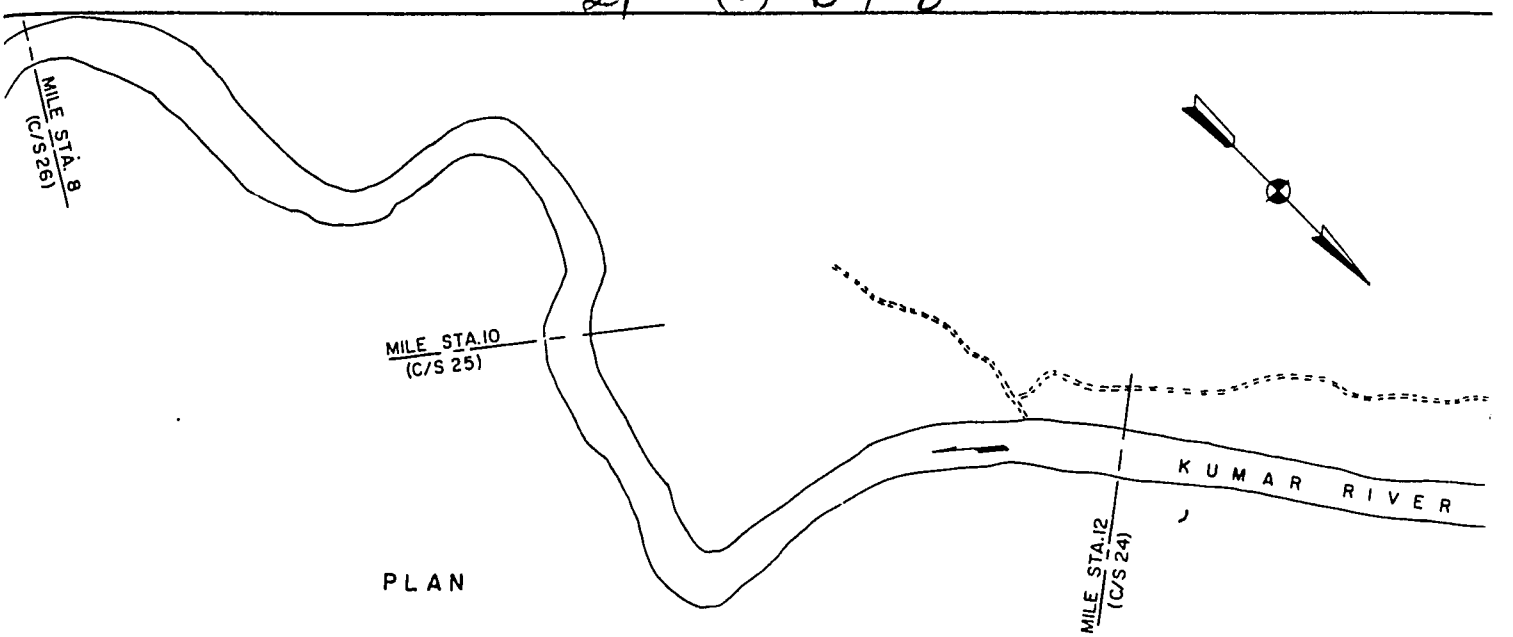
PLAN



PROFIL

DISTANCE IN

29 (2) B4 b



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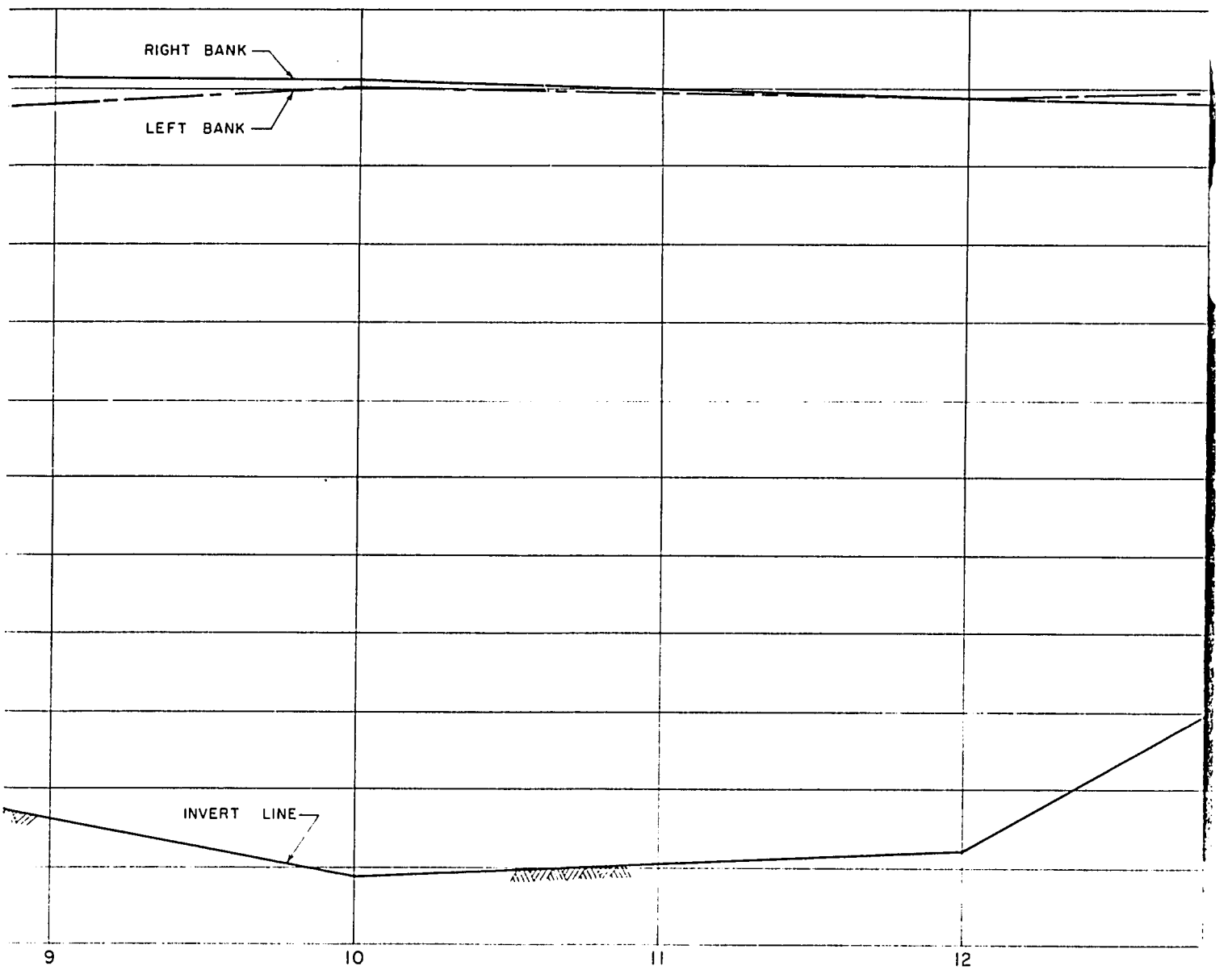
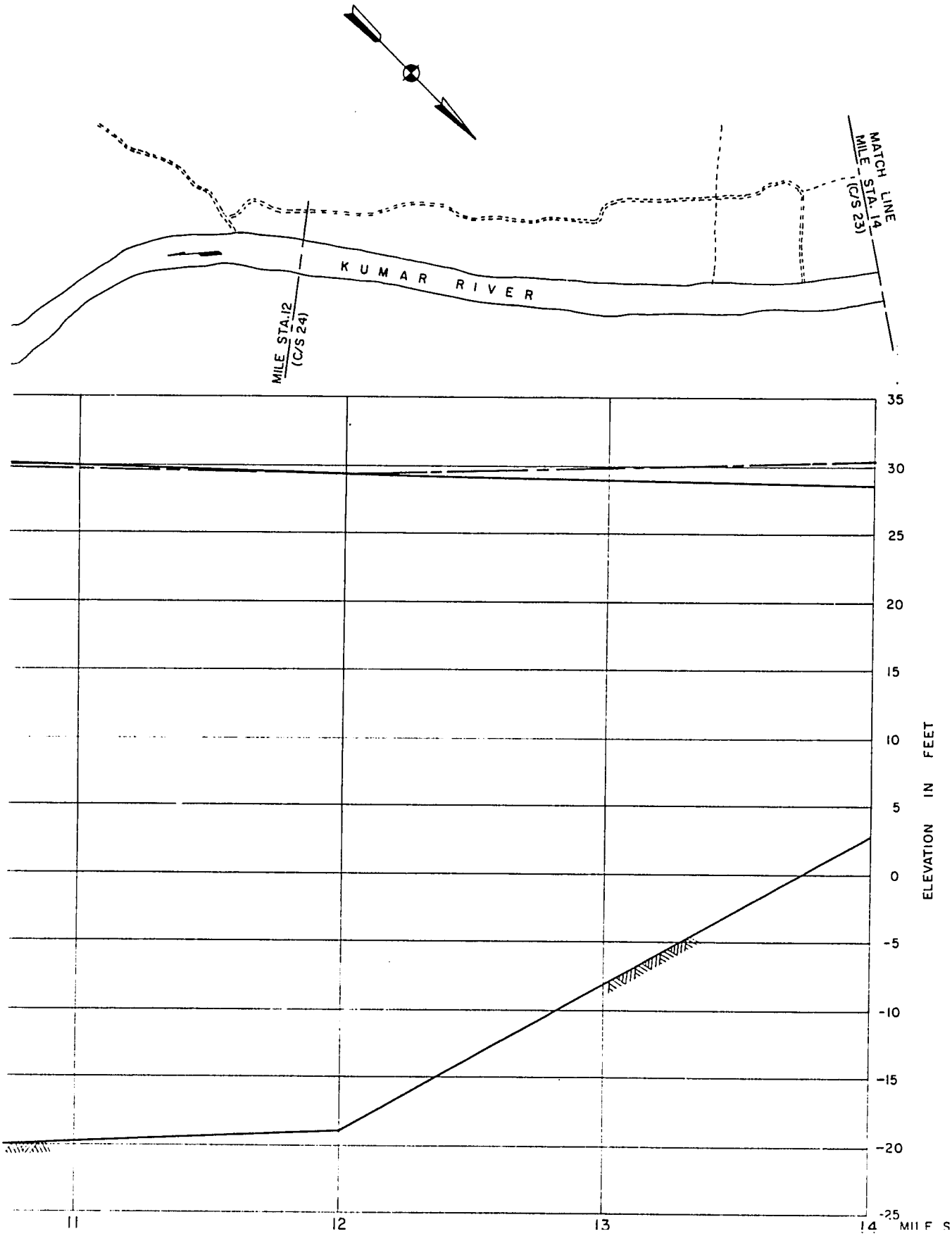


PROFILE

DISTANCE IN MILES

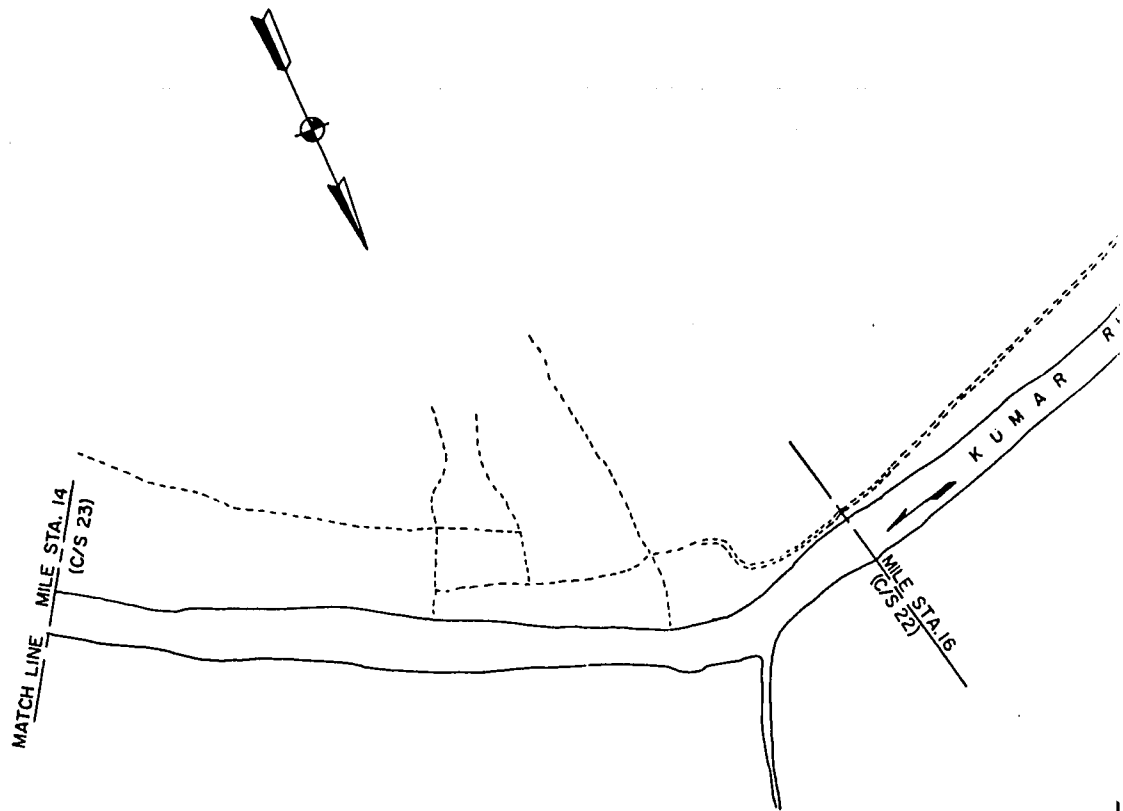
30 (2) B-4 c



LES

KUMAR RIVER
PLAN & PROFILE
FIGURE B-4
SHEET 2 OF 5

31 (3) B4-a



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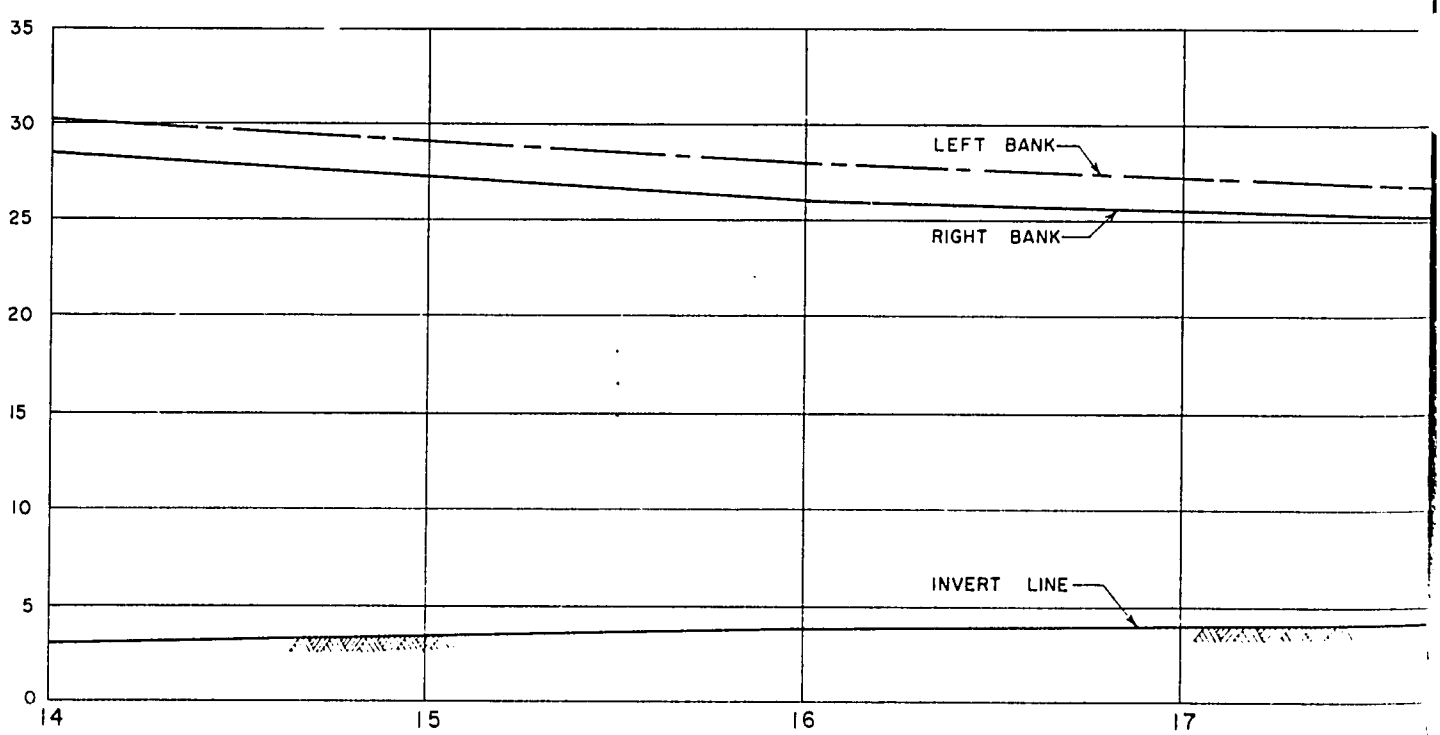
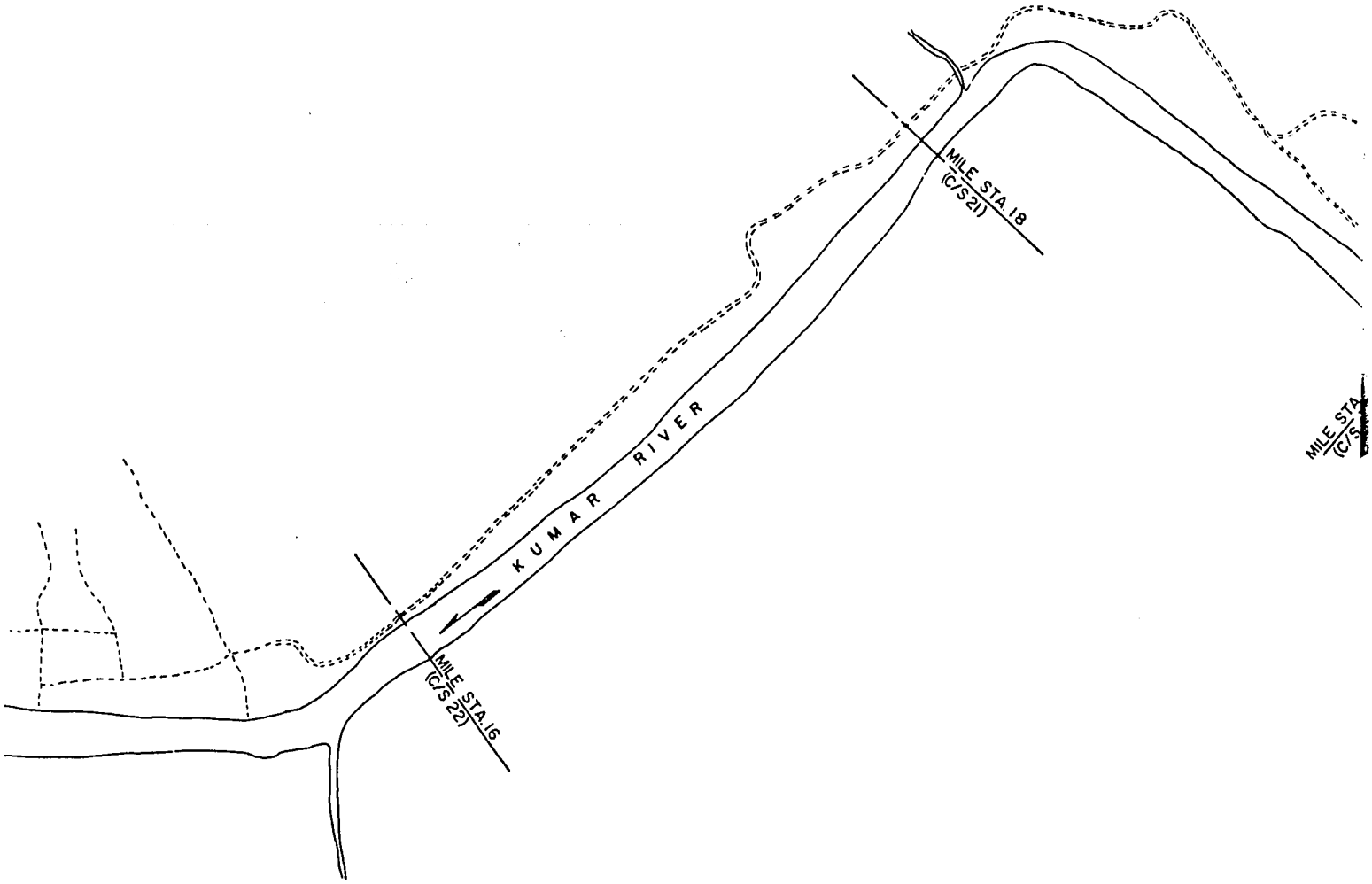


PROFIL

DISTANCE IN

32 (3) D-4 b



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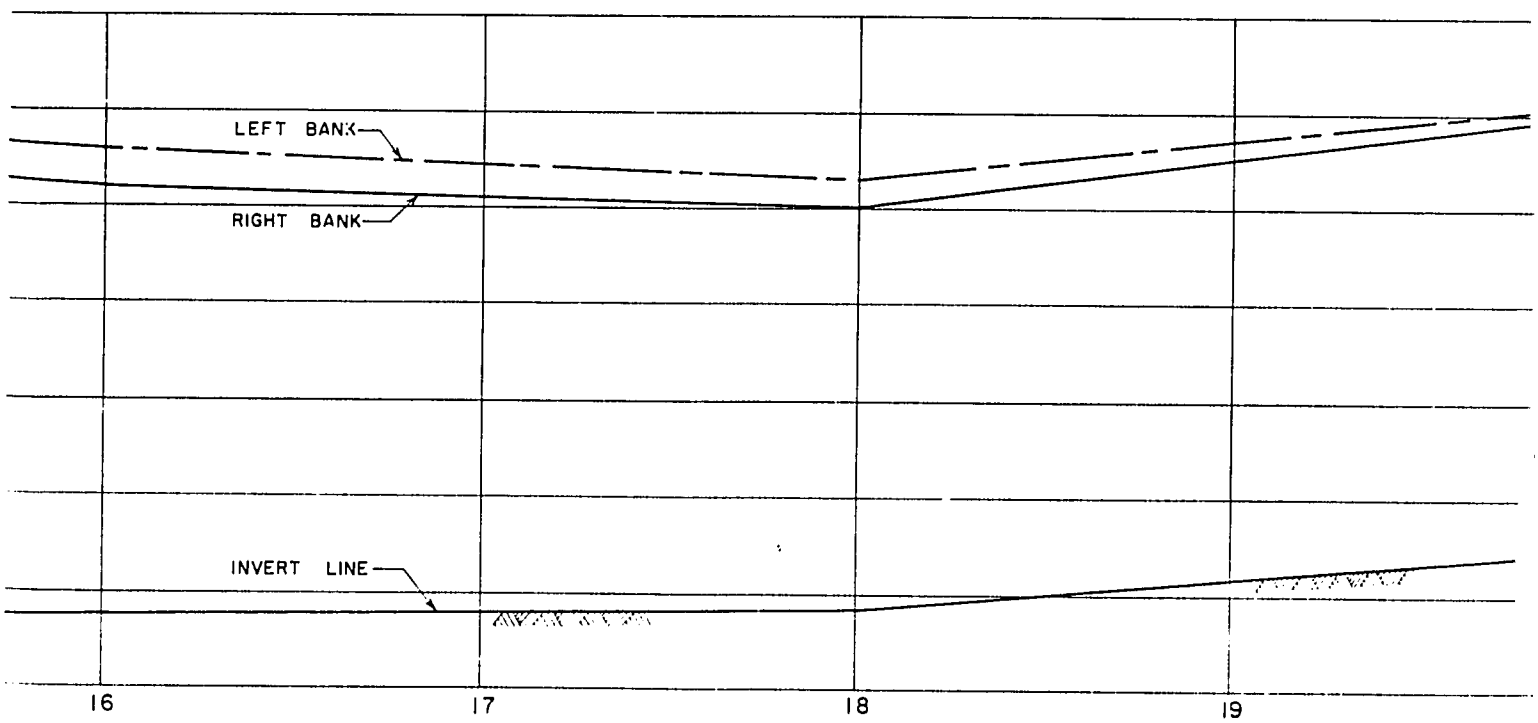
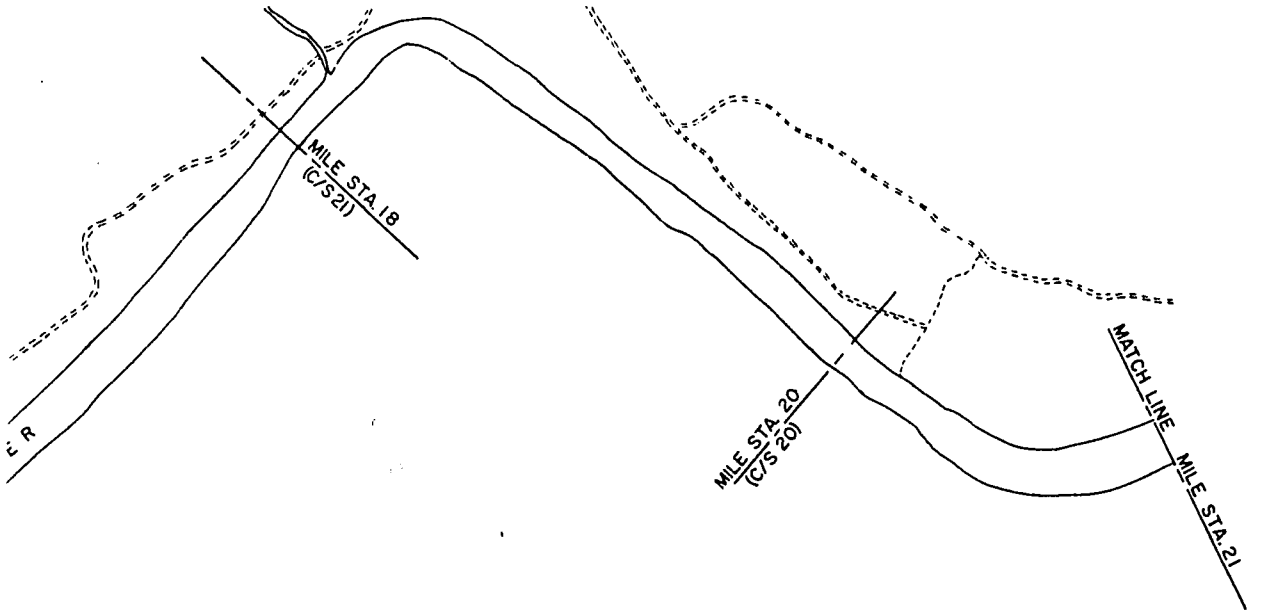
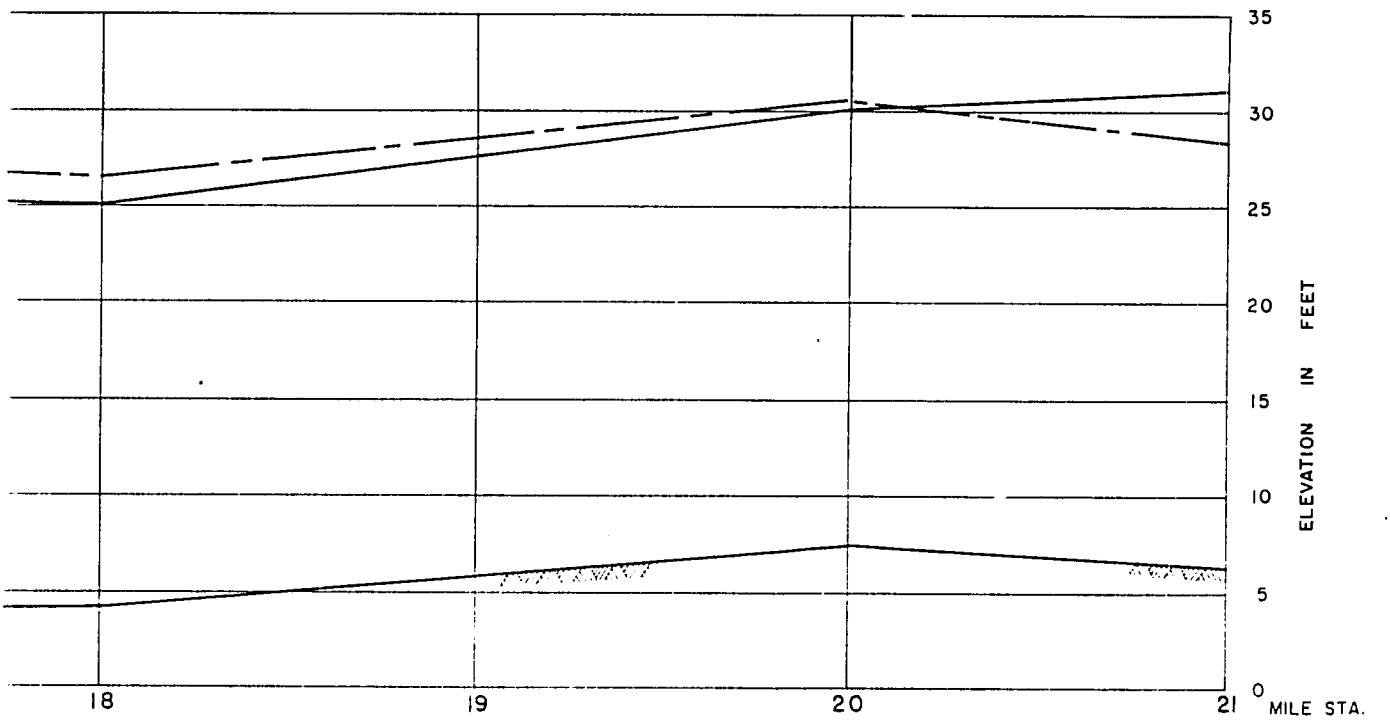


PROFILE

DISTANCE IN MILES

33 (3) B-4 c

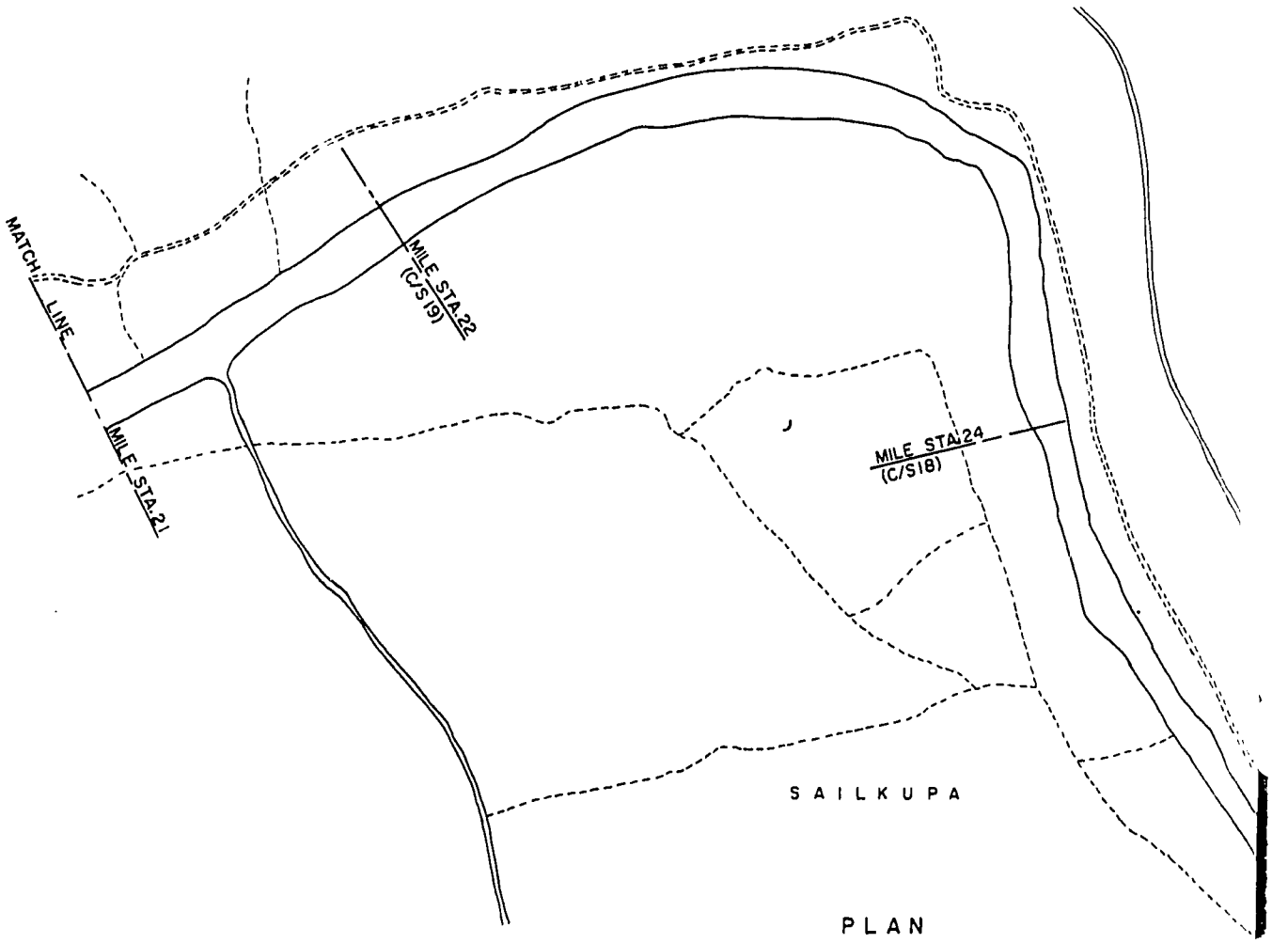




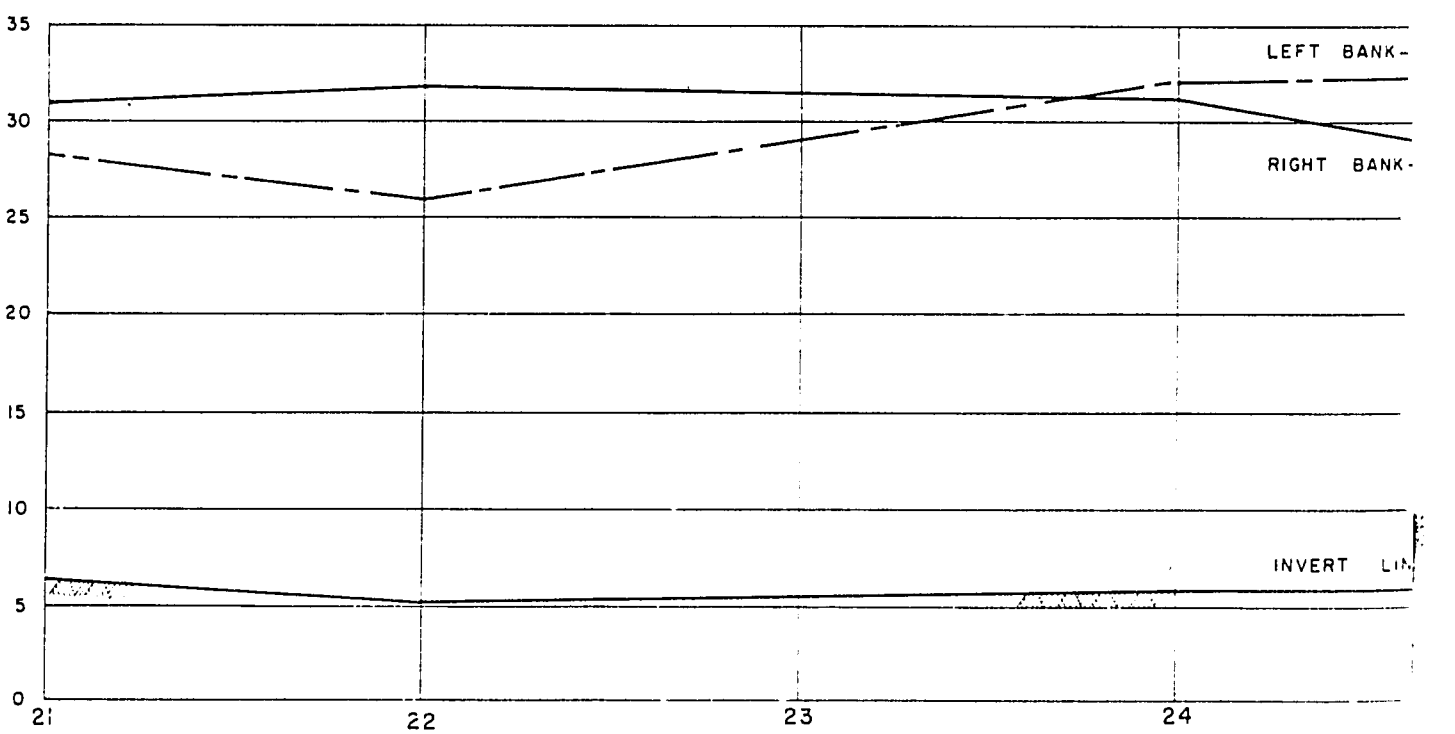
LES

KUMAR RIVER
PLAN & PROFILE
FIGURE B-4
SHEET 3 OF 5

34 (4) B4 a

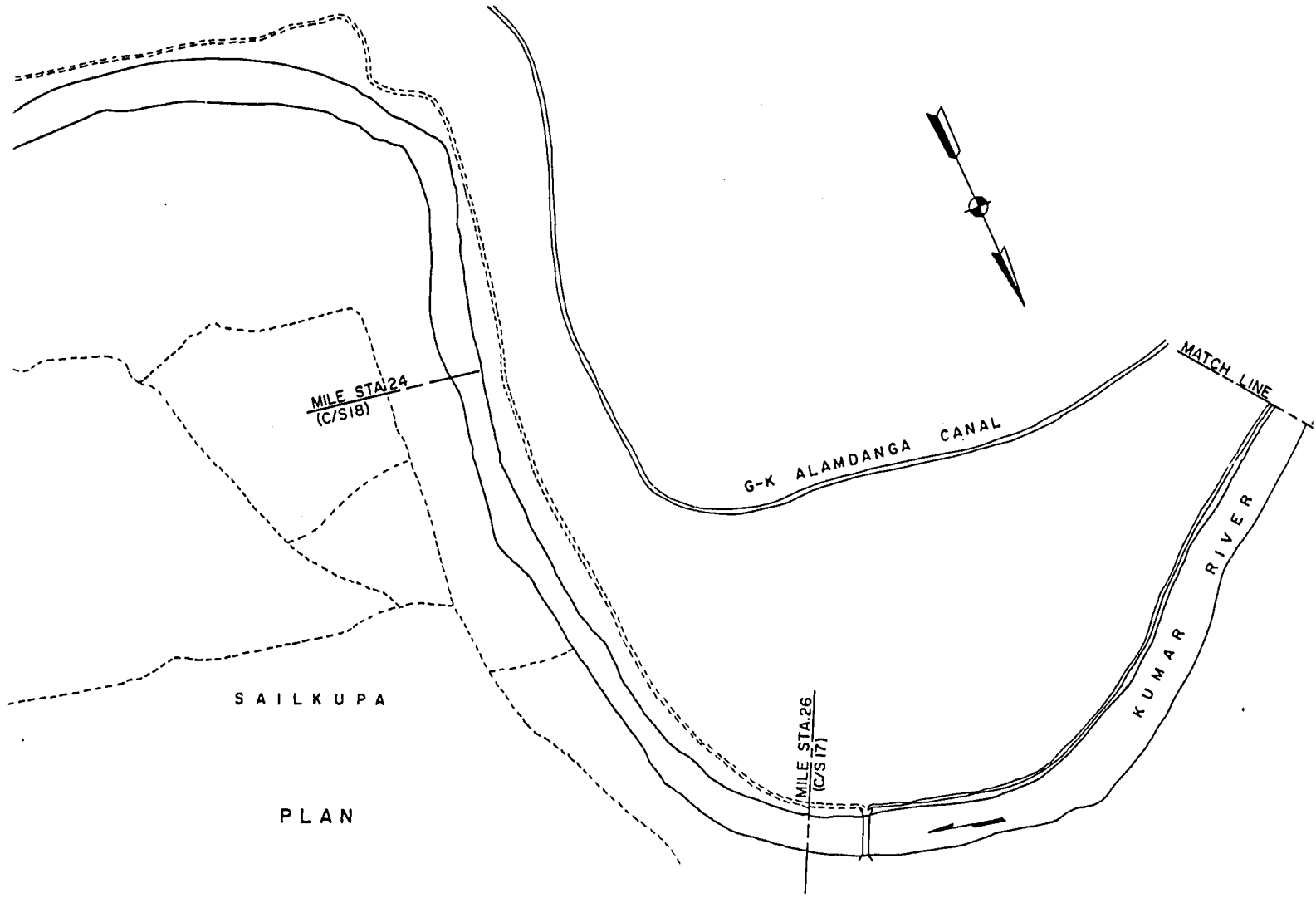


PLAN



PROFIL

DISTANCE IN



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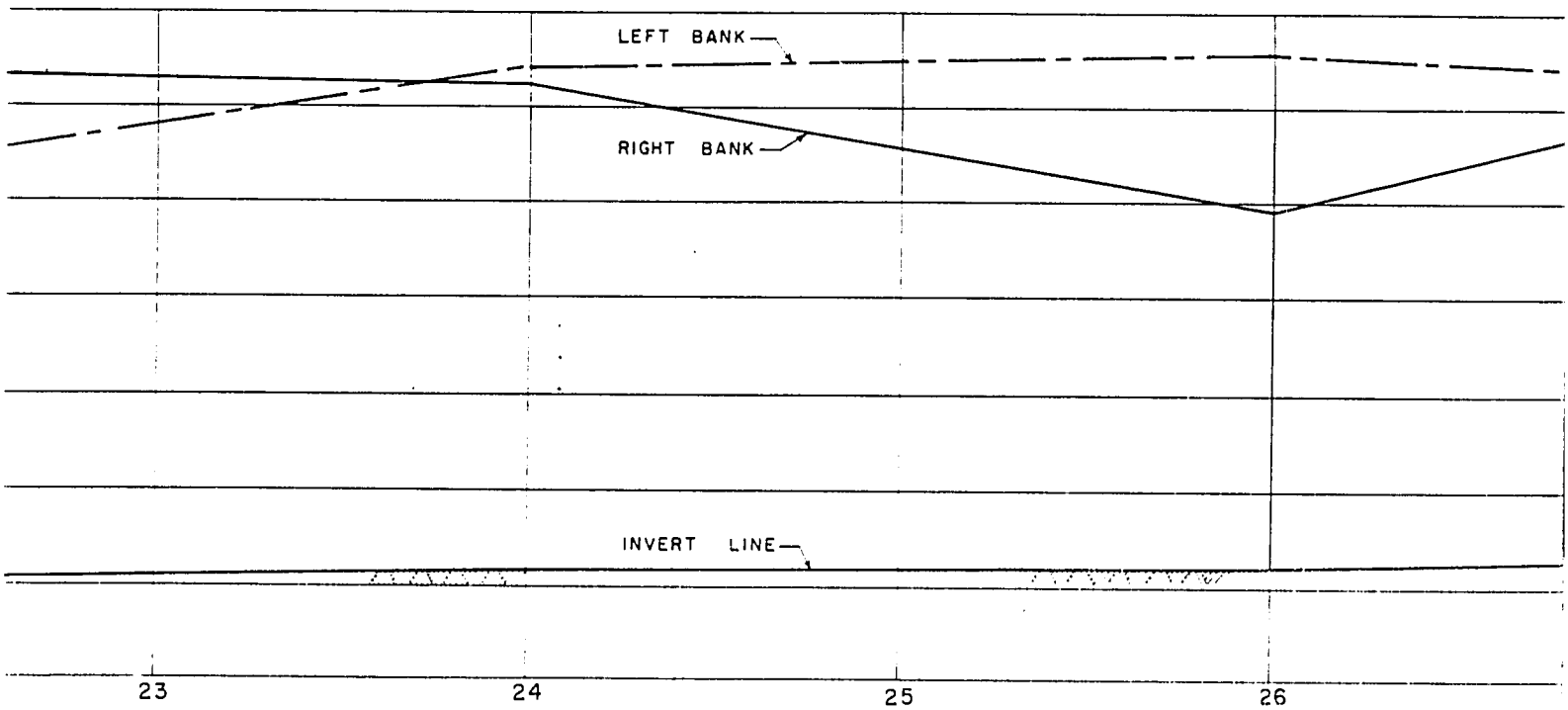
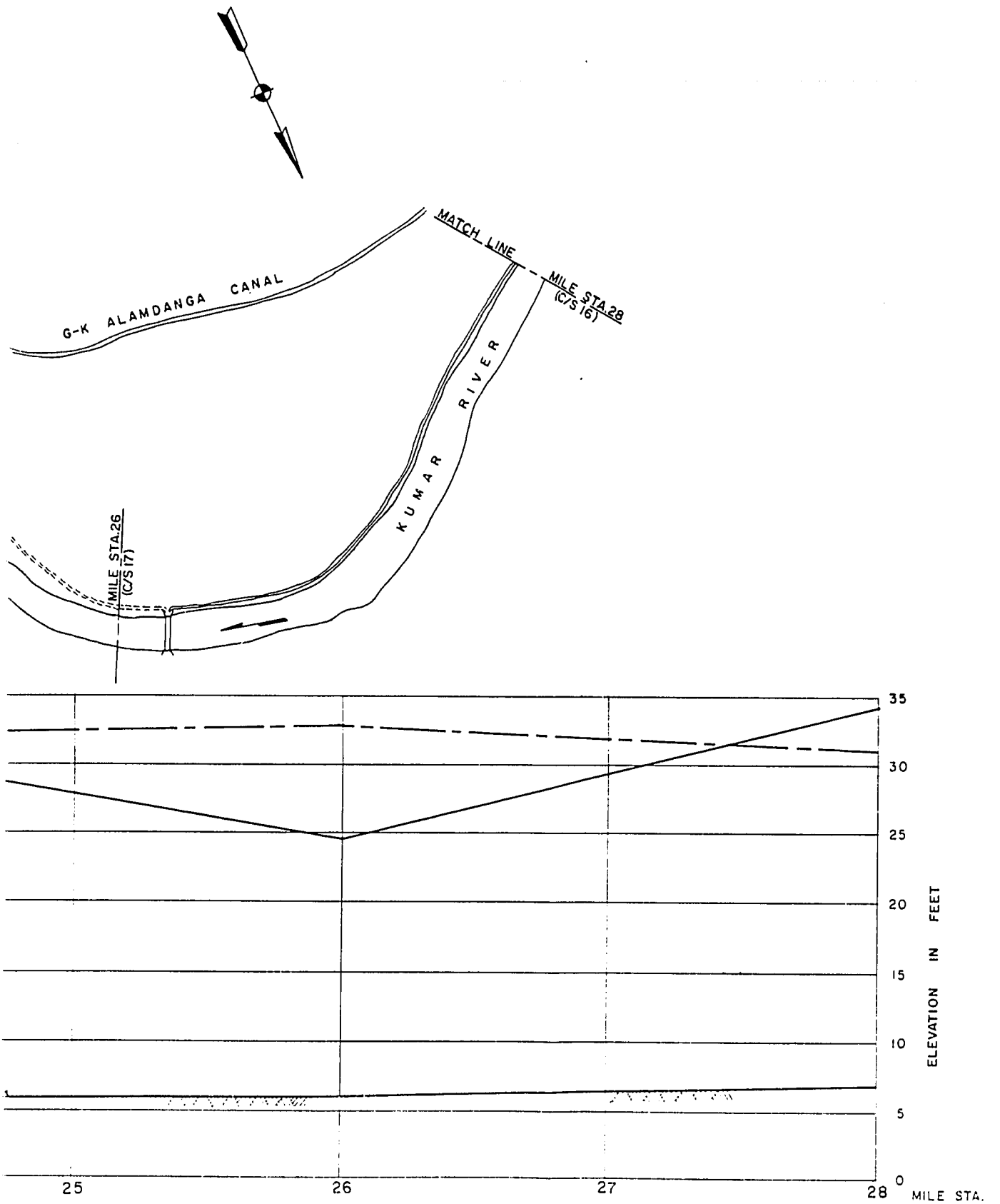


PROFILE

DISTANCE IN MILES



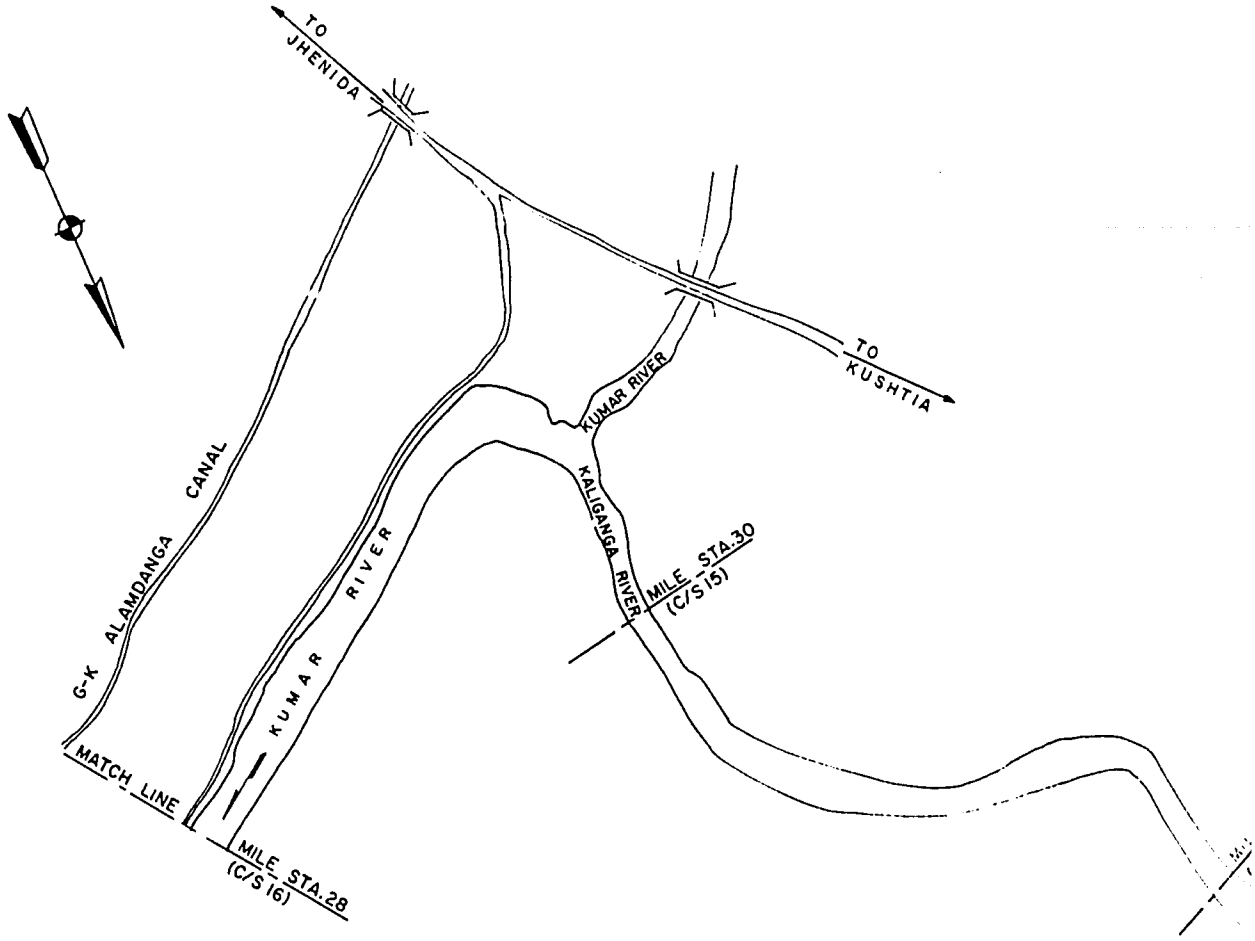
LES

KUMAR RIVER
PLAN & PROFILE

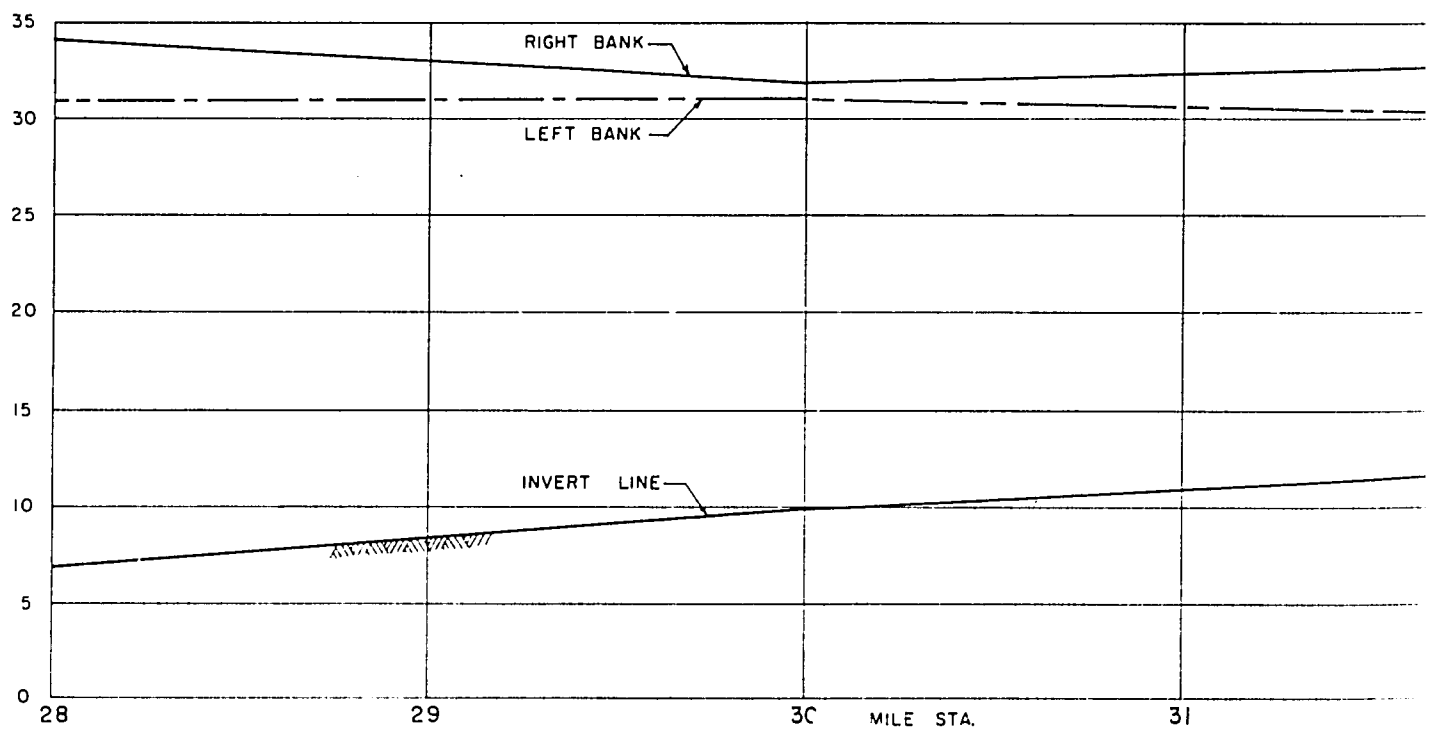
FIGURE B-4

SHEET 4 OF 5

37 (5) B-4 a



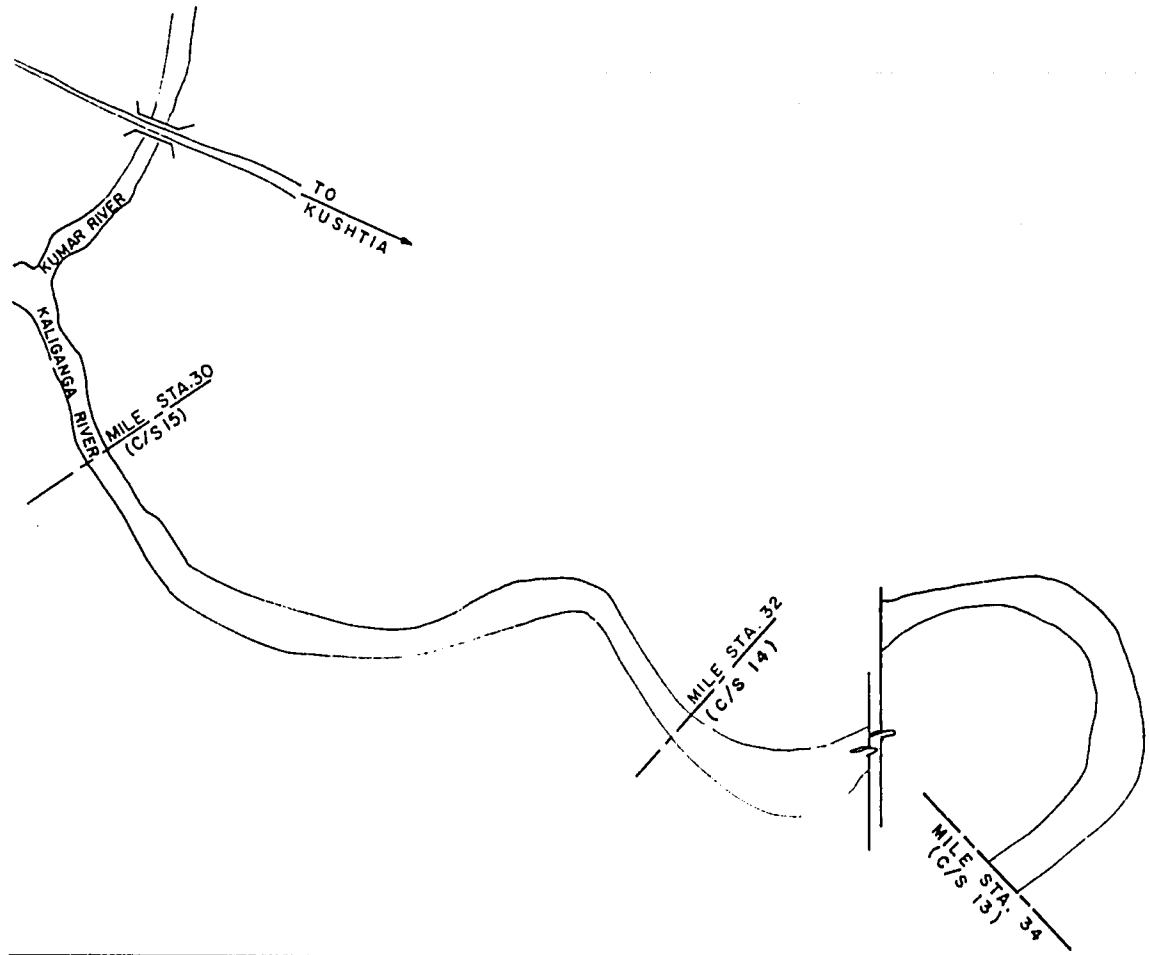
PLAN

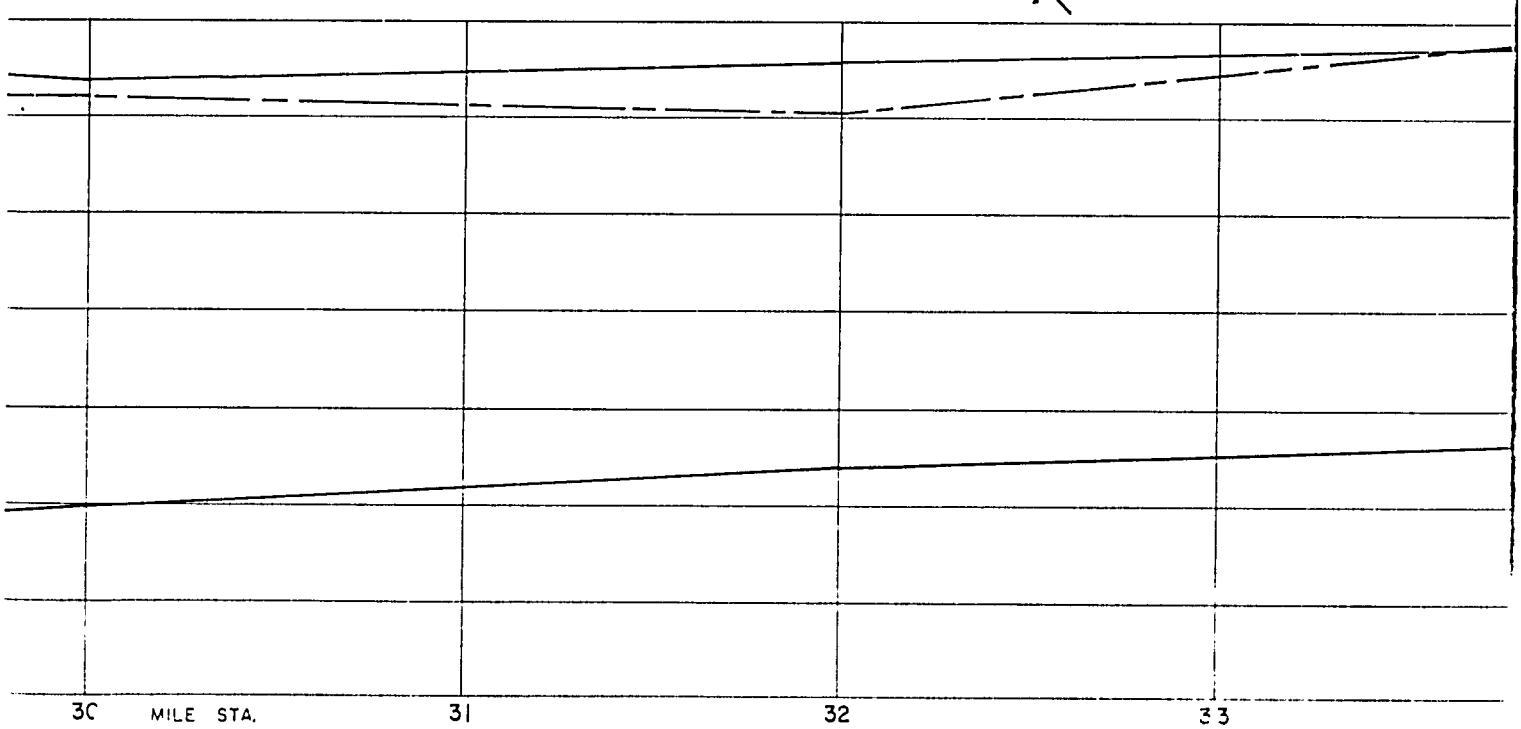


PROFIL

DISTANCE IN

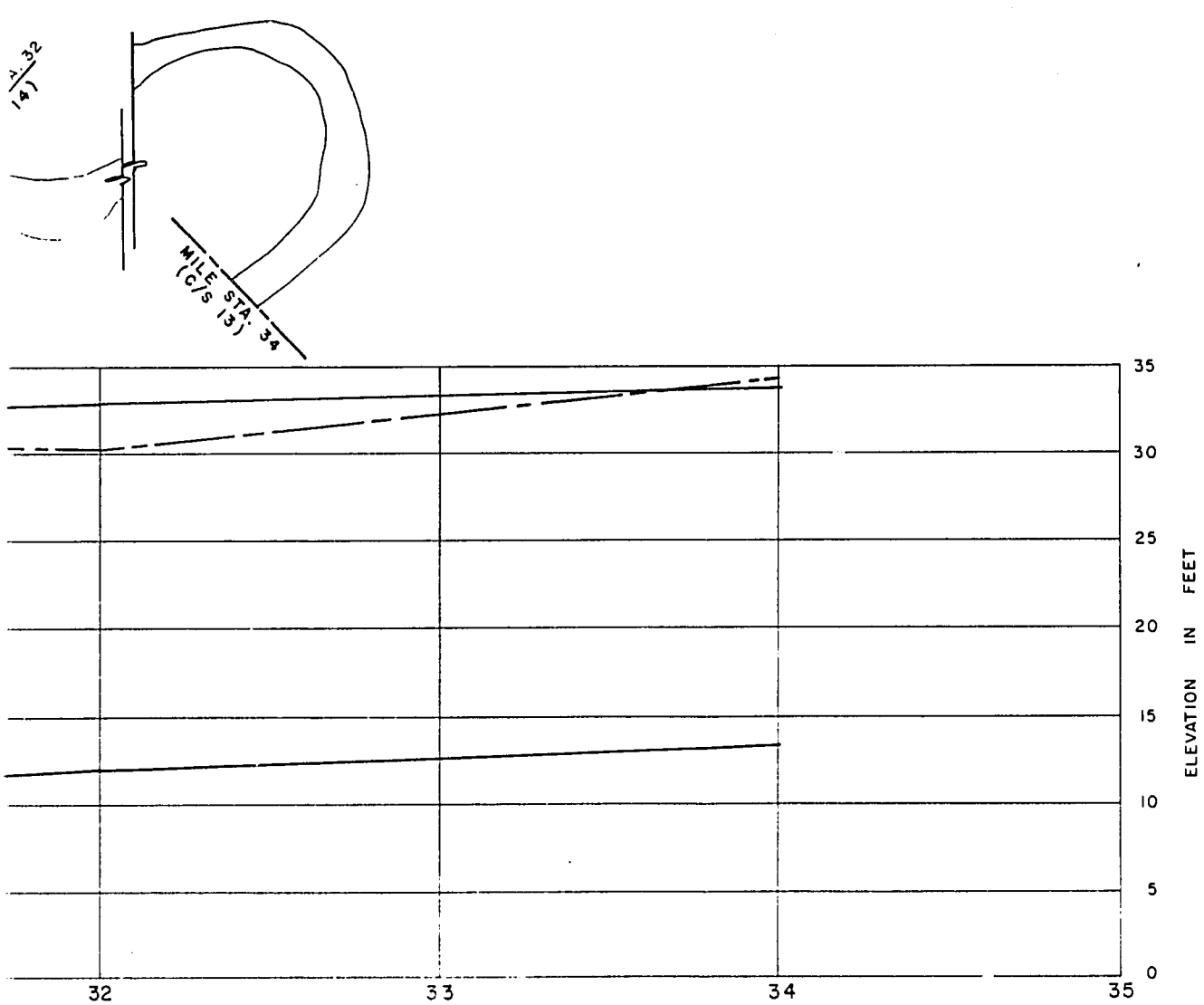
38 (5) B-4 b





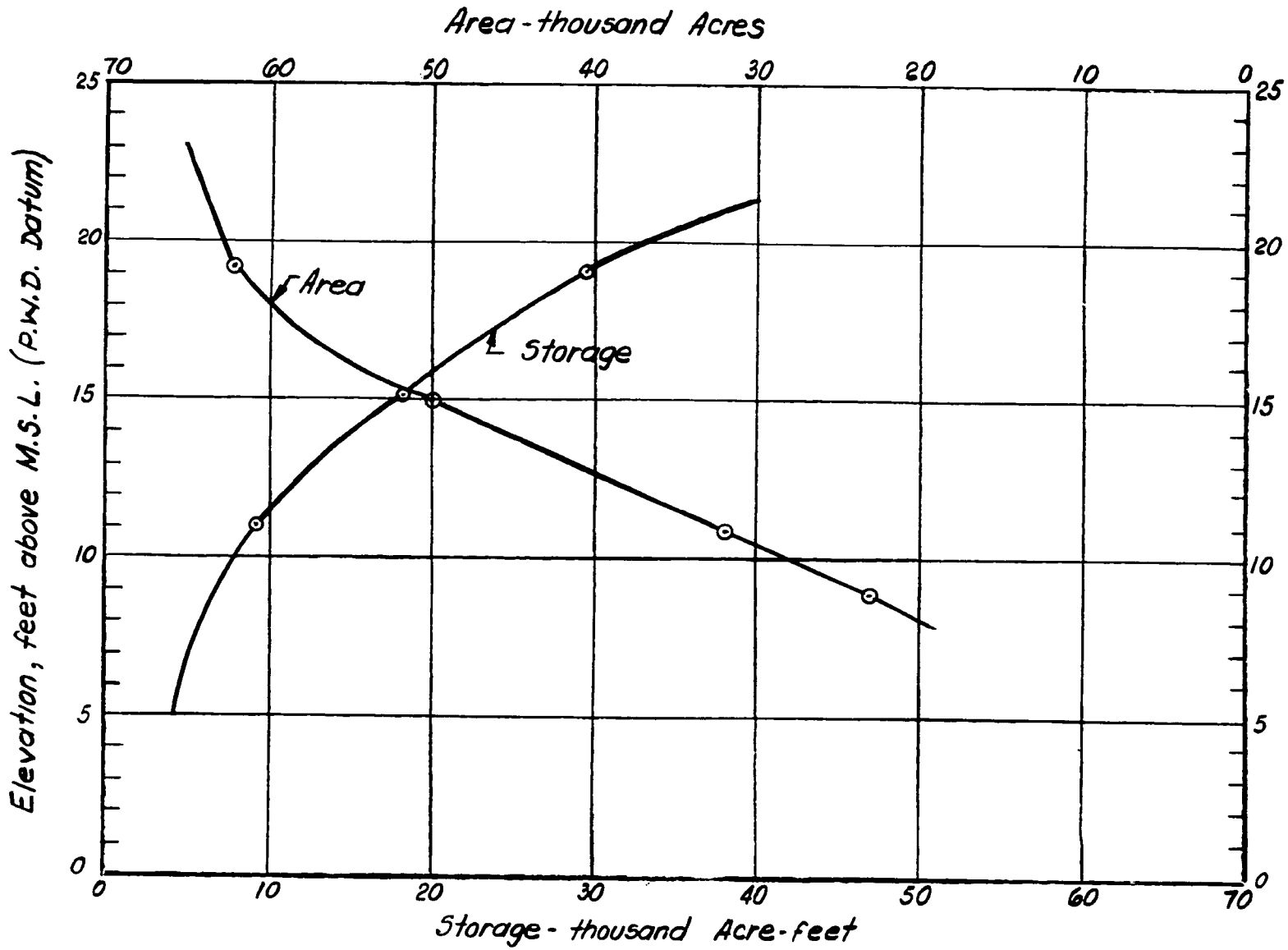
PROFILE

DISTANCE IN MILES



ILES

KUMAR RIVER
PLAN & PROFILE
FIGURE B-4
SHEET 5 OF 5



Nabaganga-Kumar
Area-Storage curves
Figure B-5

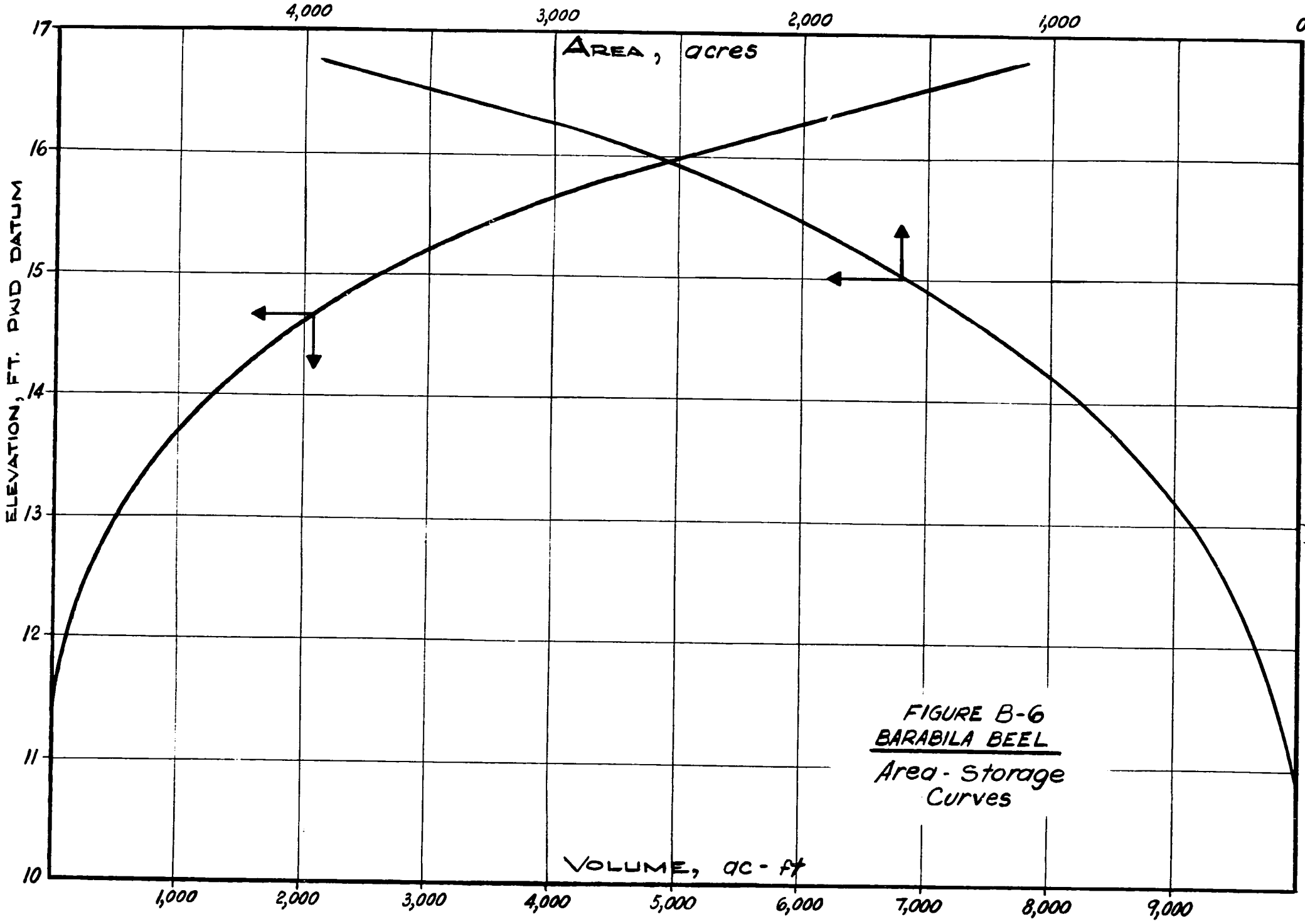
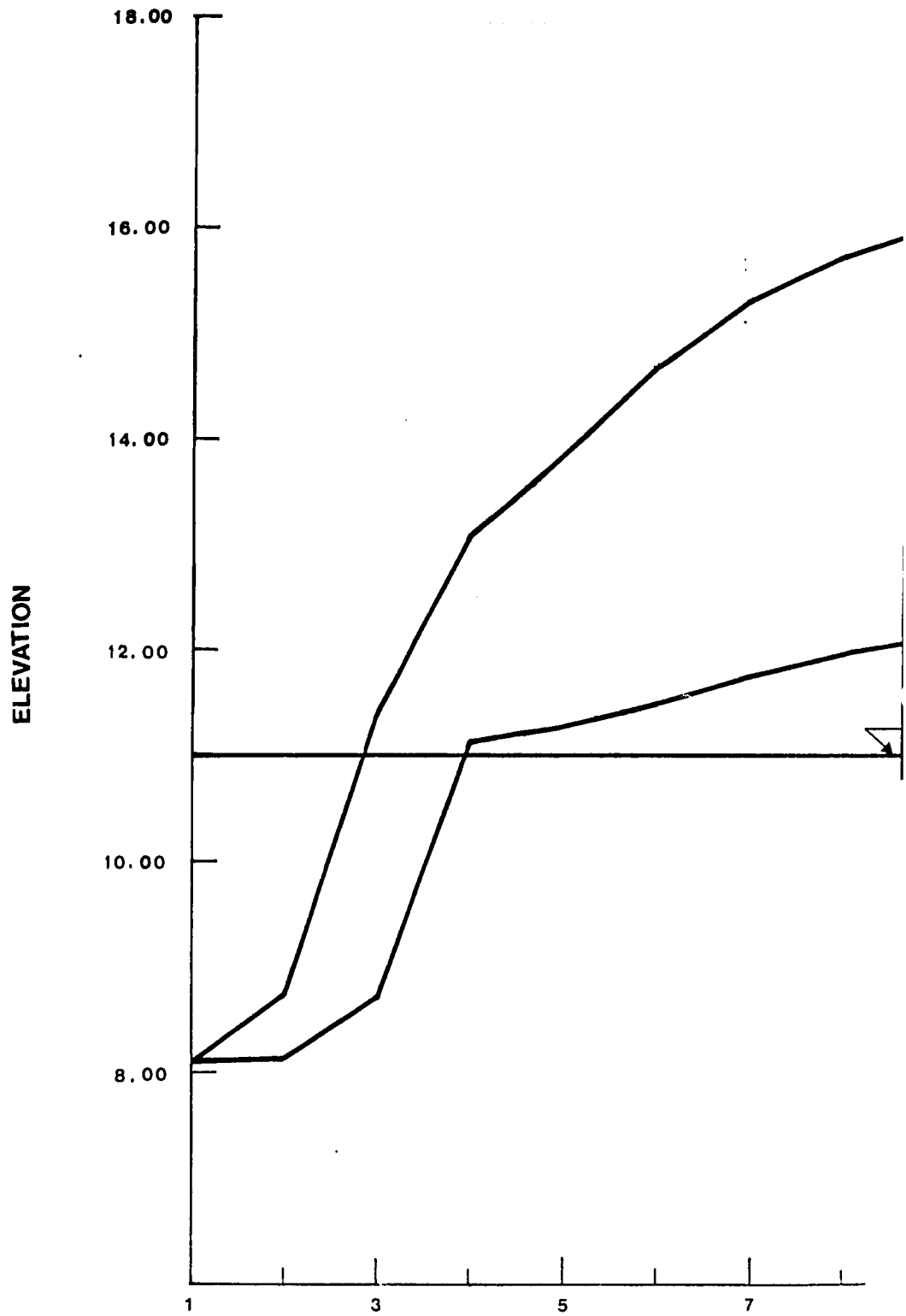


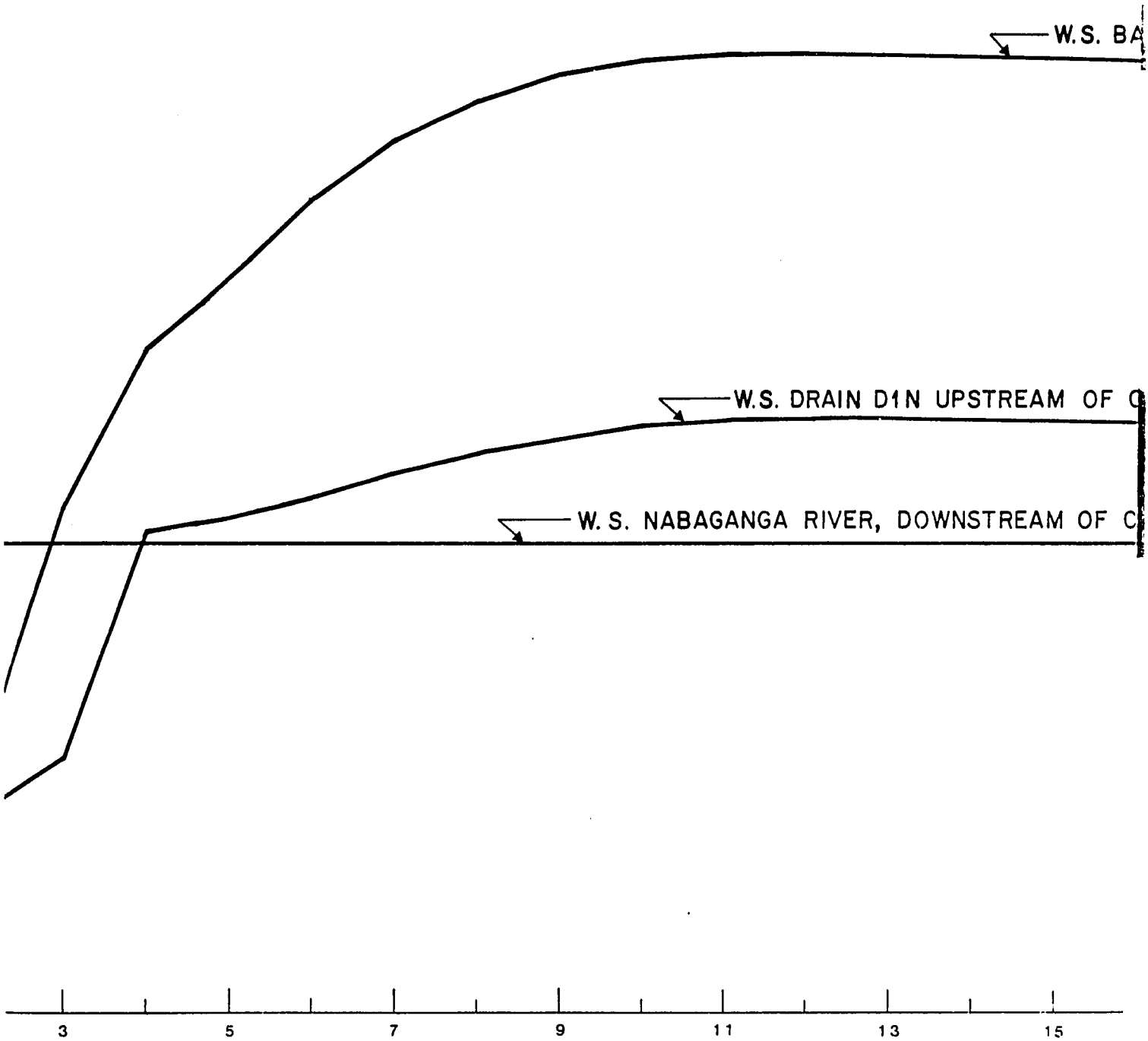
FIGURE B-6
BARABILA BEEL
Area - Storage Curves

42 B-7 a



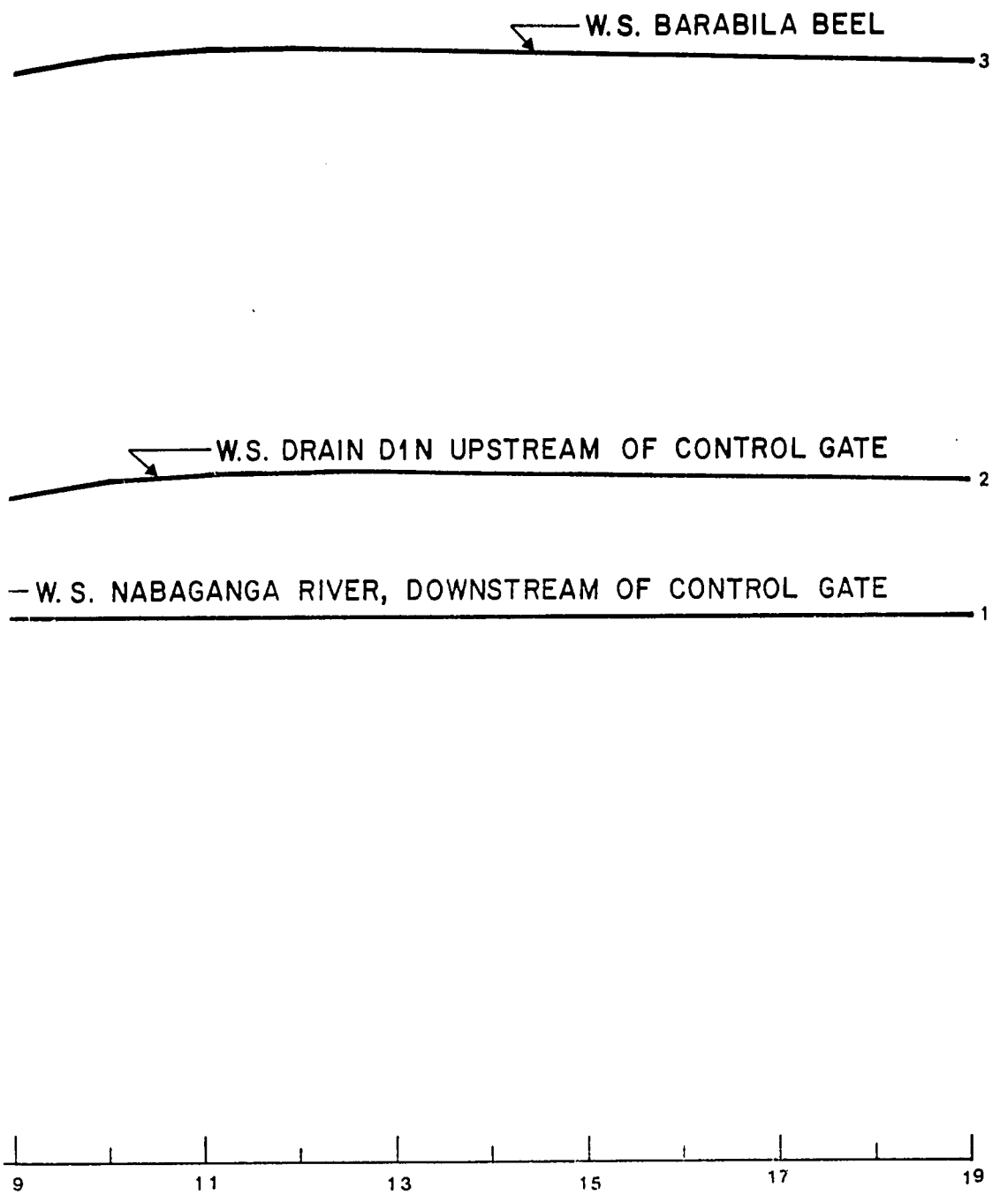
INTEGRATED LAND AND WA

43 B-7 b



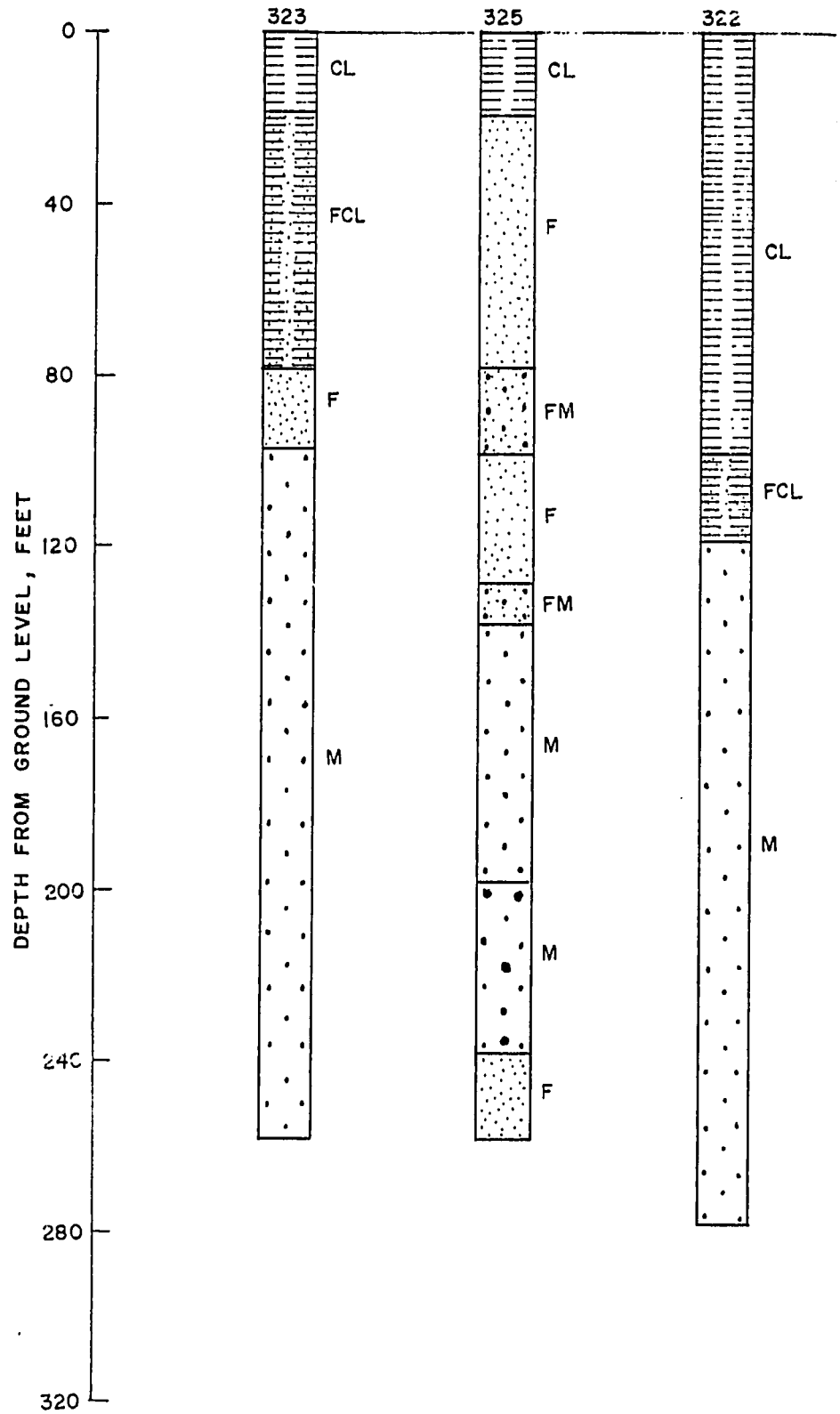
TIME INTERVALS, HOURS

INTEGRATED LAND AND WATER USE STUDY - BARABILA ROUTING ANALYSIS



R USE STUDY - BARABILA ROUTING ANALYSIS RUN 1

FIGURE B-7


DEPTH FROM GROUND LEVEL, FEET
0
40
80
120
160
200
240
280
320
323
CL
FCL
F
M
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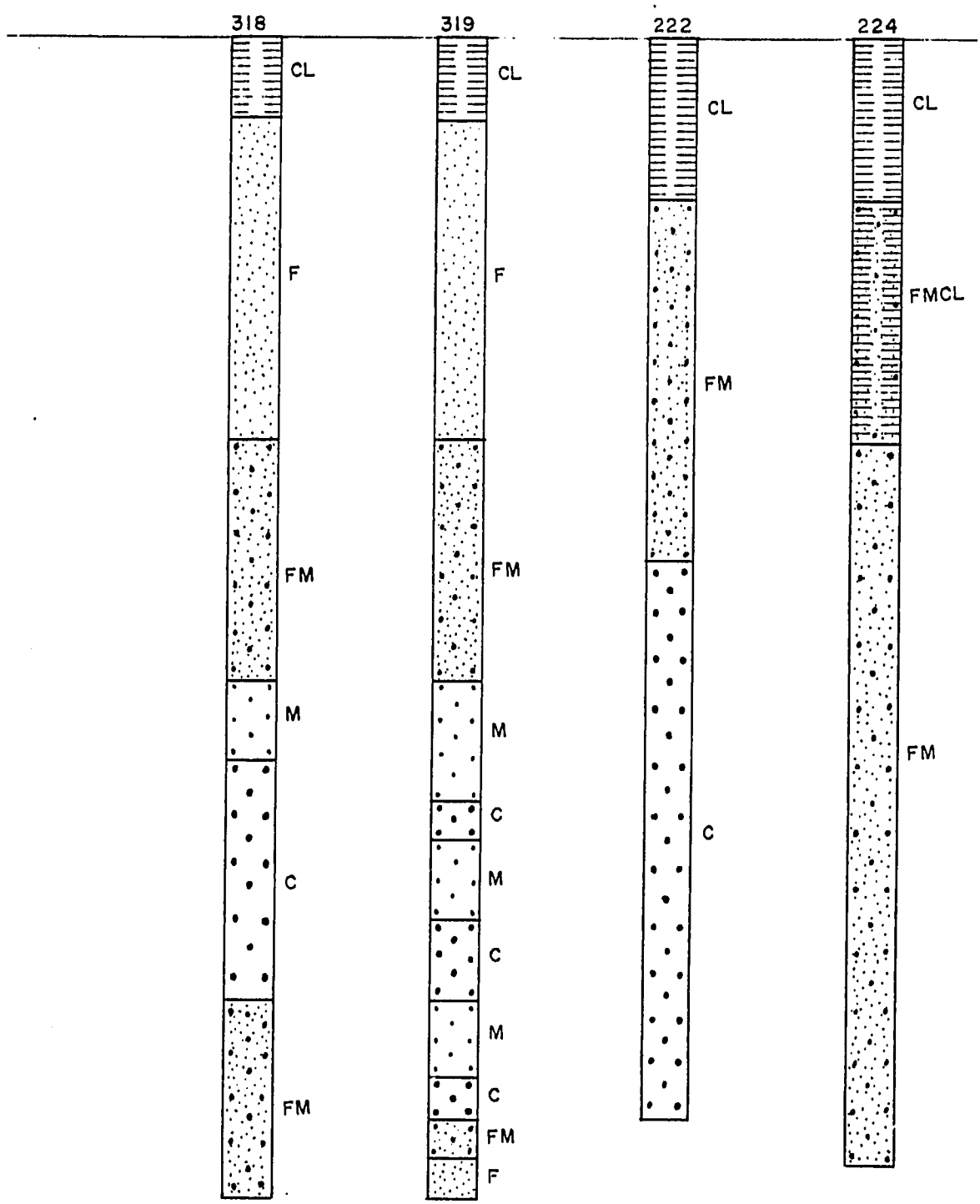
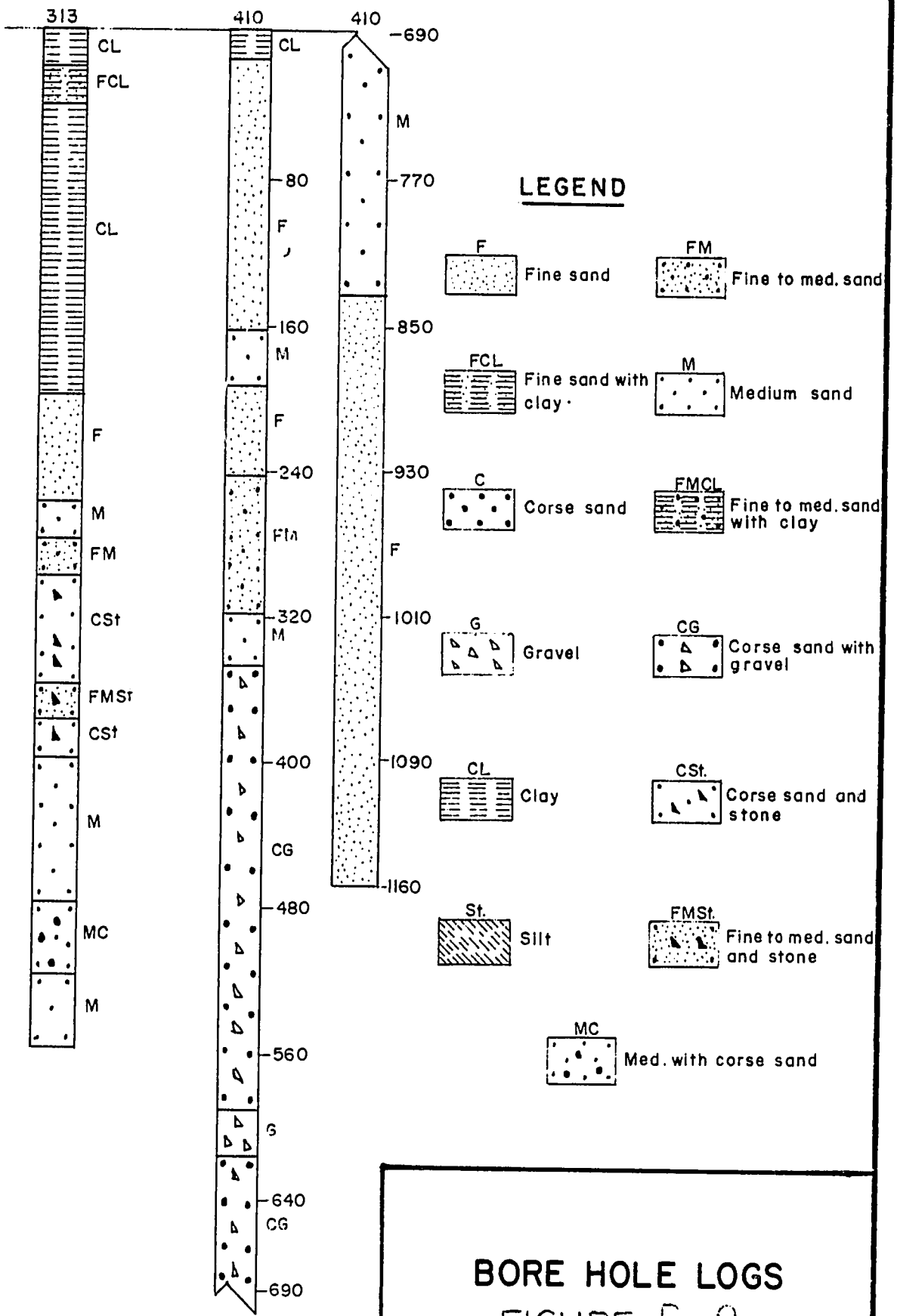
F
FM
F
FM
M
M
F
322
CL
FCL
M



From the

47 B-8 c

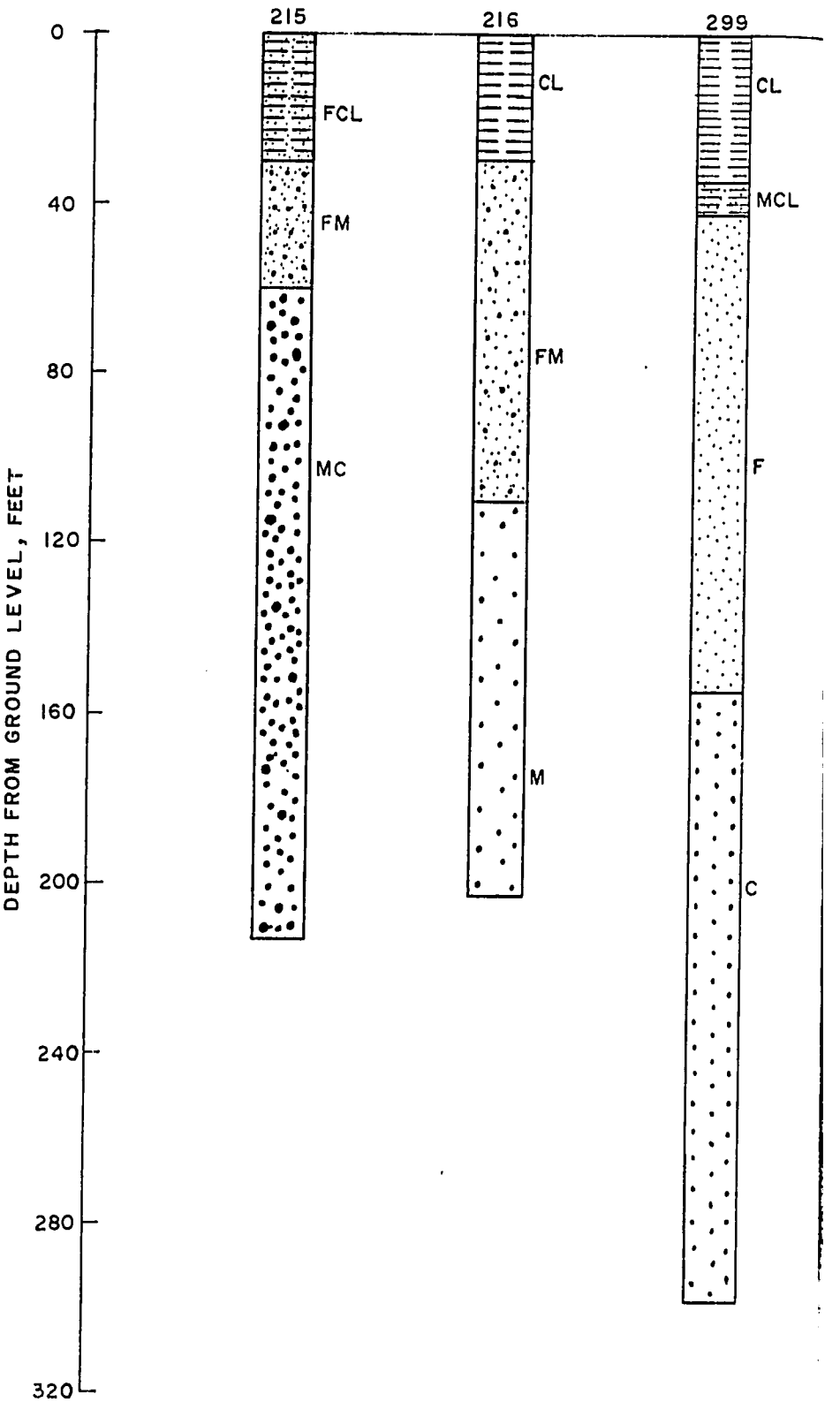


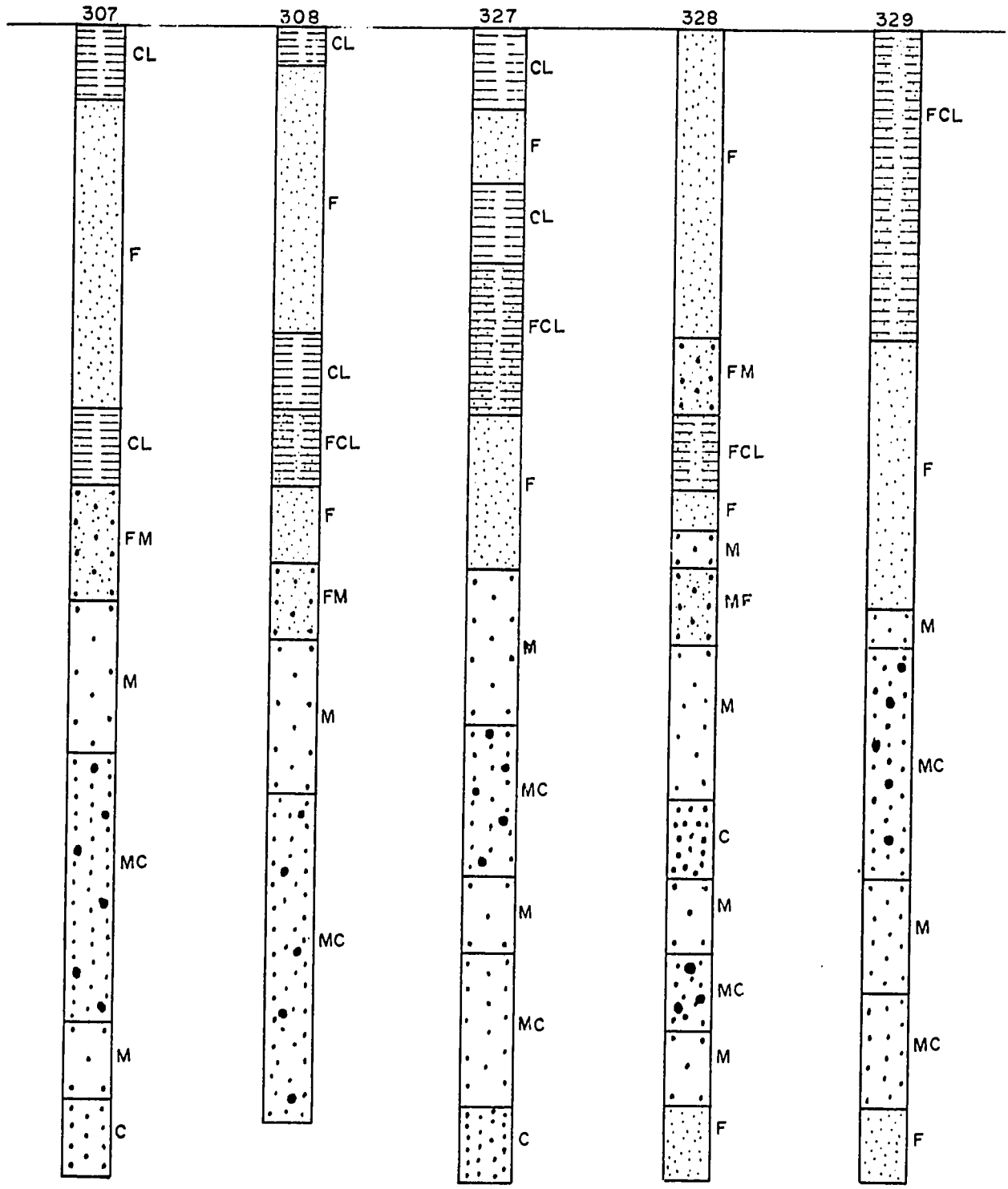
BORE HOLE LOGS

FIGURE B-8

(SHEET 1 OF 2)

48 B-8 a


DEPTH FROM GROUND LEVEL, FEET
0
40
80
120
160
200
240
280
320
215
FCL
FM
MC
216
CL
FM
M
299
CL
MCL
F
C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FM
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MC
M
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F
CL
FCL
F
FM
M
MC
327
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CL
FCL
F
M
MC
M
MC
C
328
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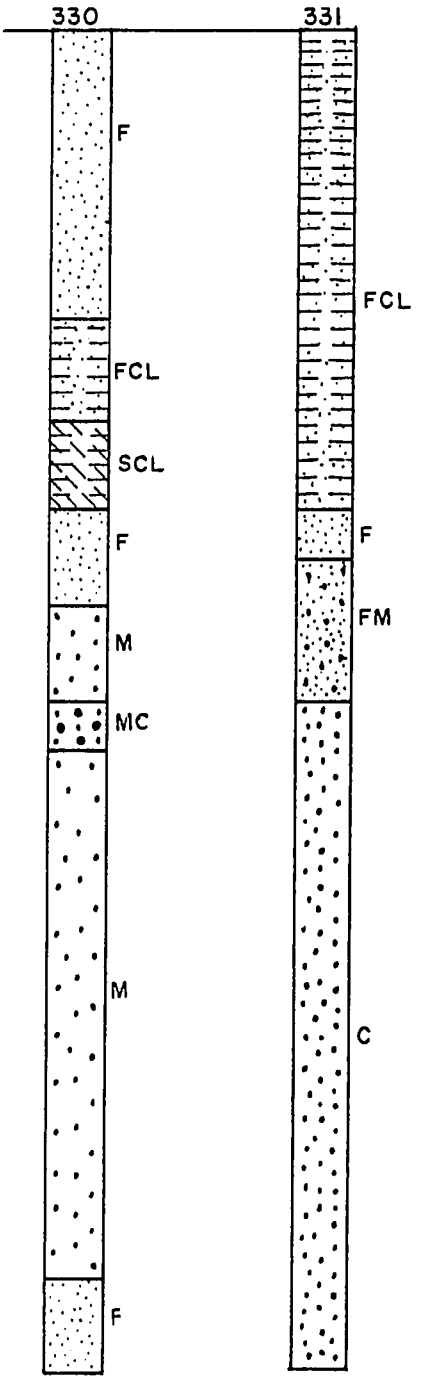
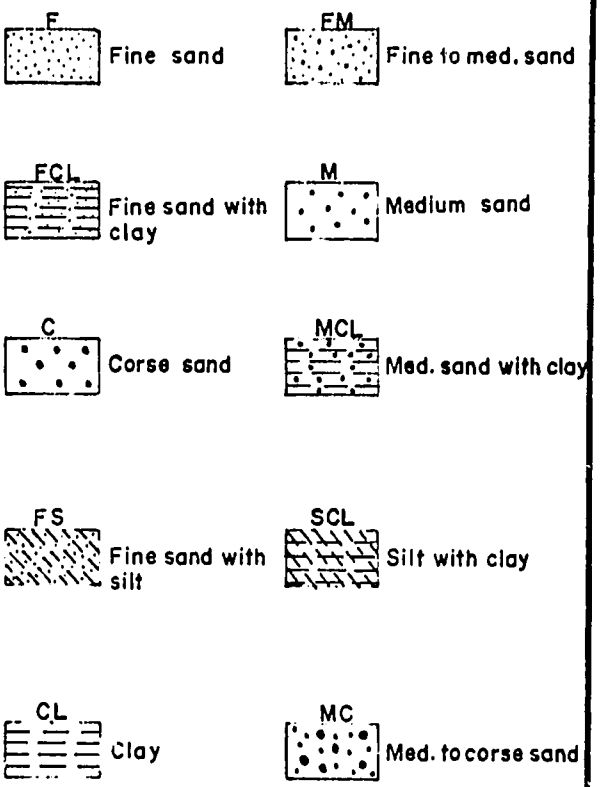
M
MC
M
MC
F



LEGEND

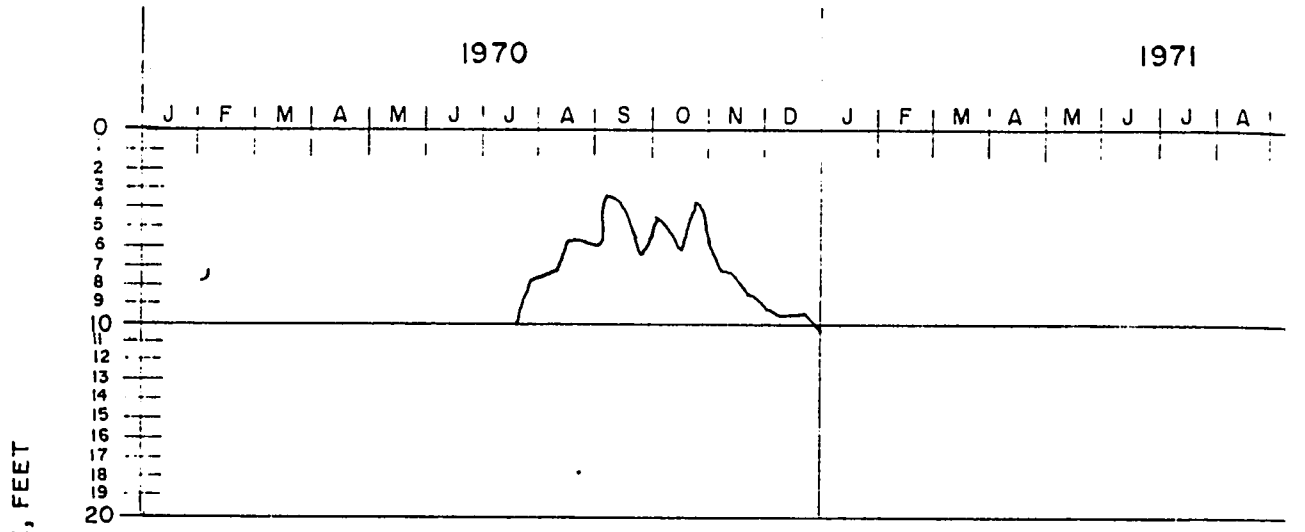


BORE HOLE LOGS

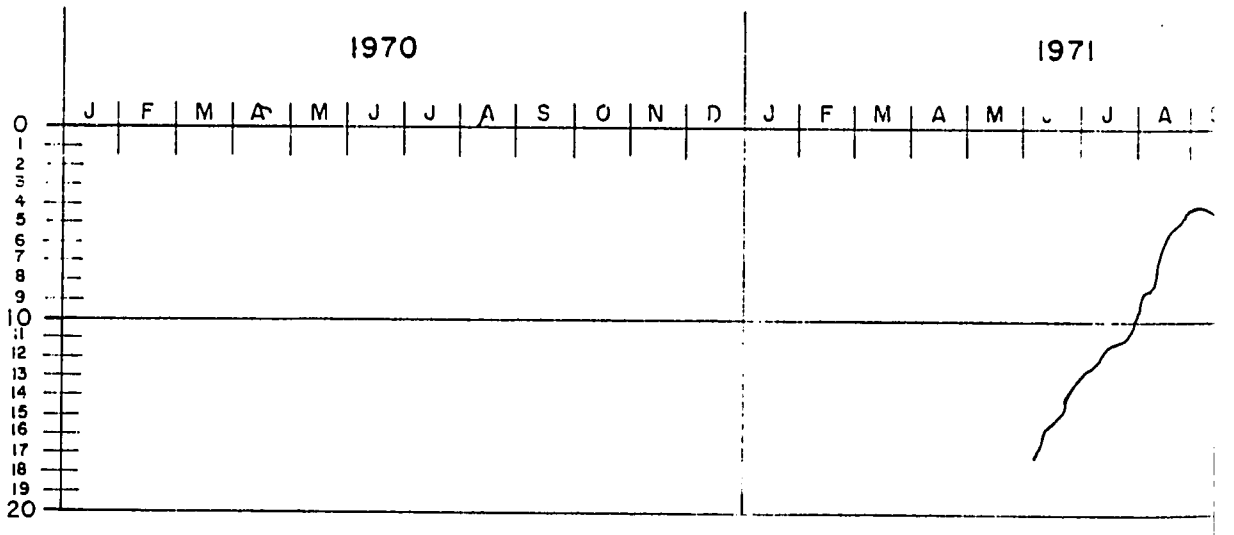
FIGURE B-8

(SHEET 2 OF 2)

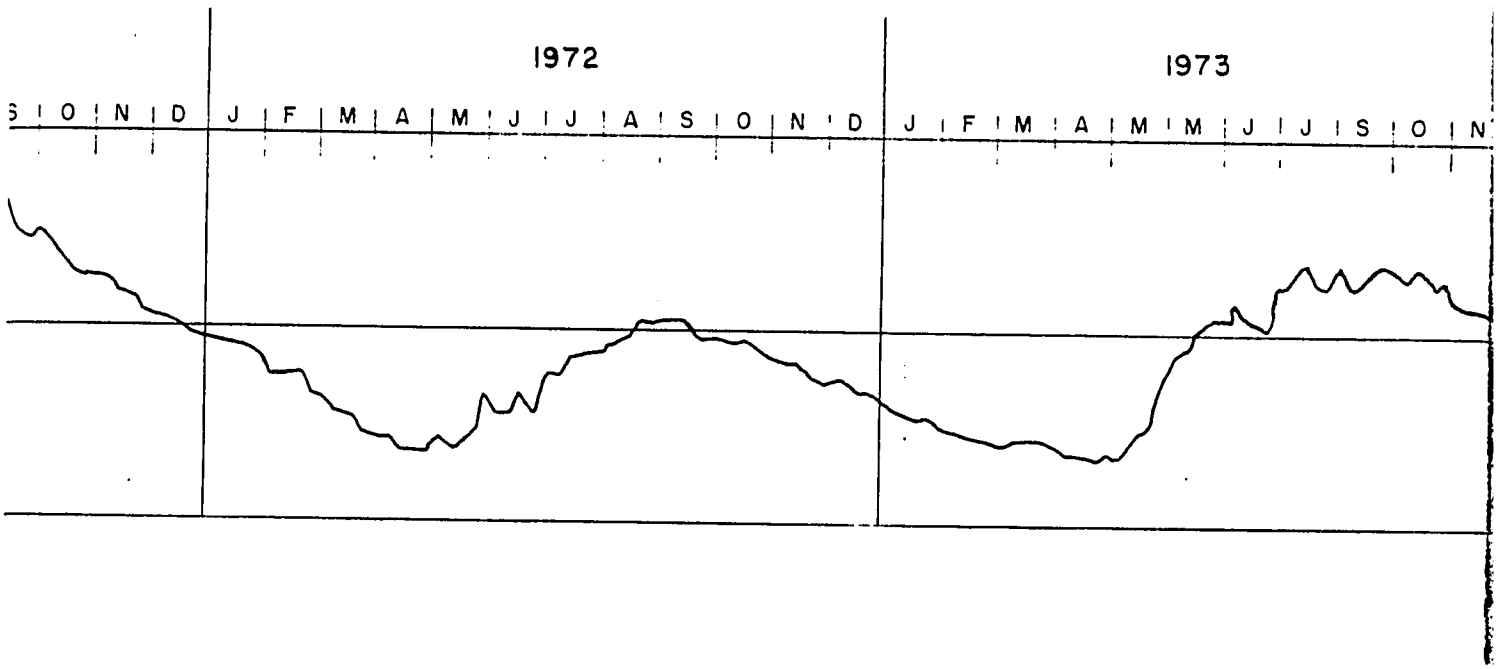
51 (1) B9 1

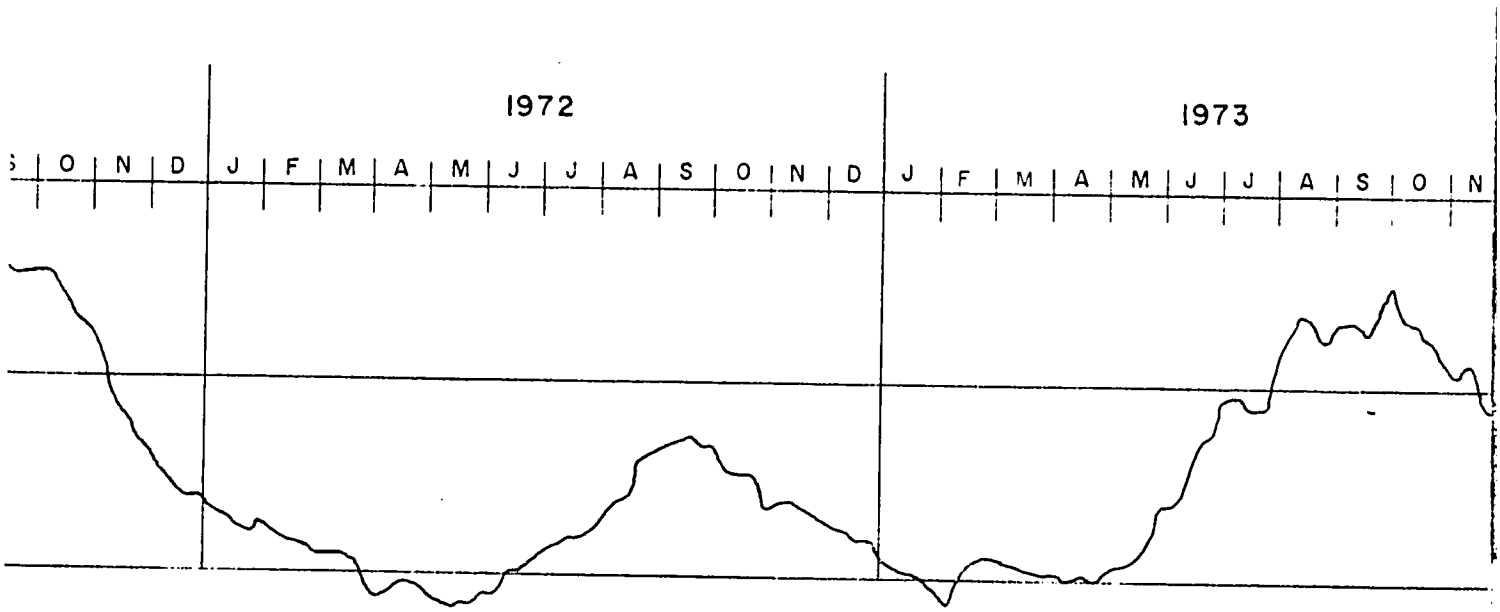


DEPTH TO WATER TABLE FROM GROUND SURFACE, FEET

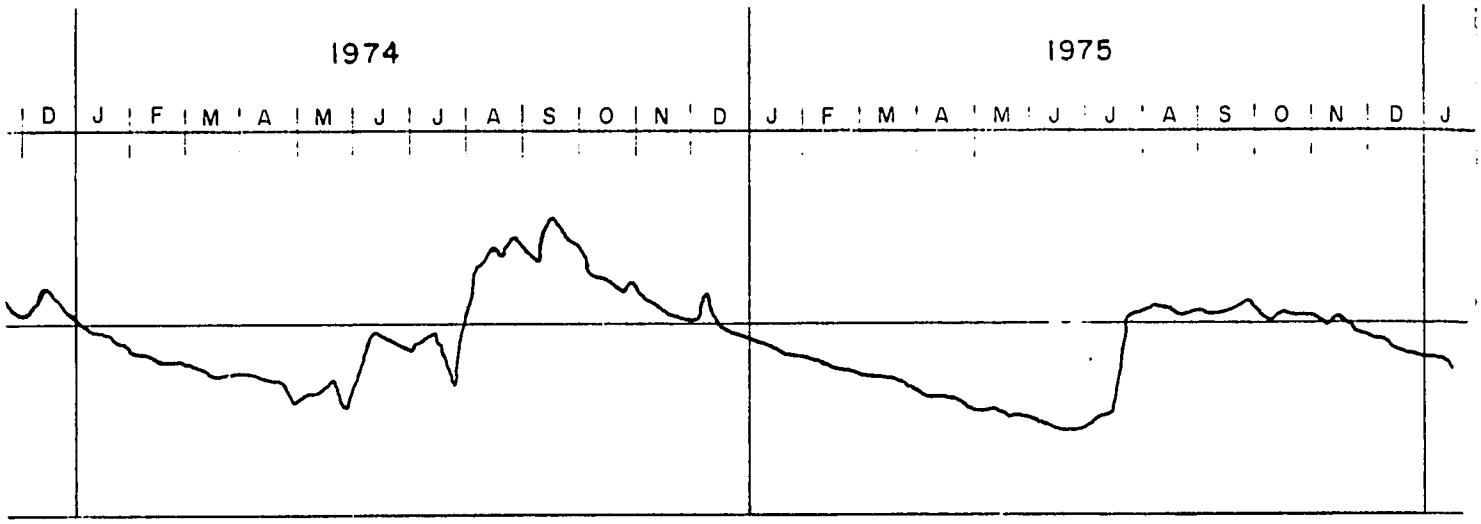


52 B-4 2


1972
1973
S O N D J F M A M J J A S O N D J F M A M M J J S O N


1972
1973
S O N D J F M A M J J A S O N D J F M A M J J A S O N

JESSORE JE-4 (GROUND ELEVATION=29.18 FT. P.W.D. DATU



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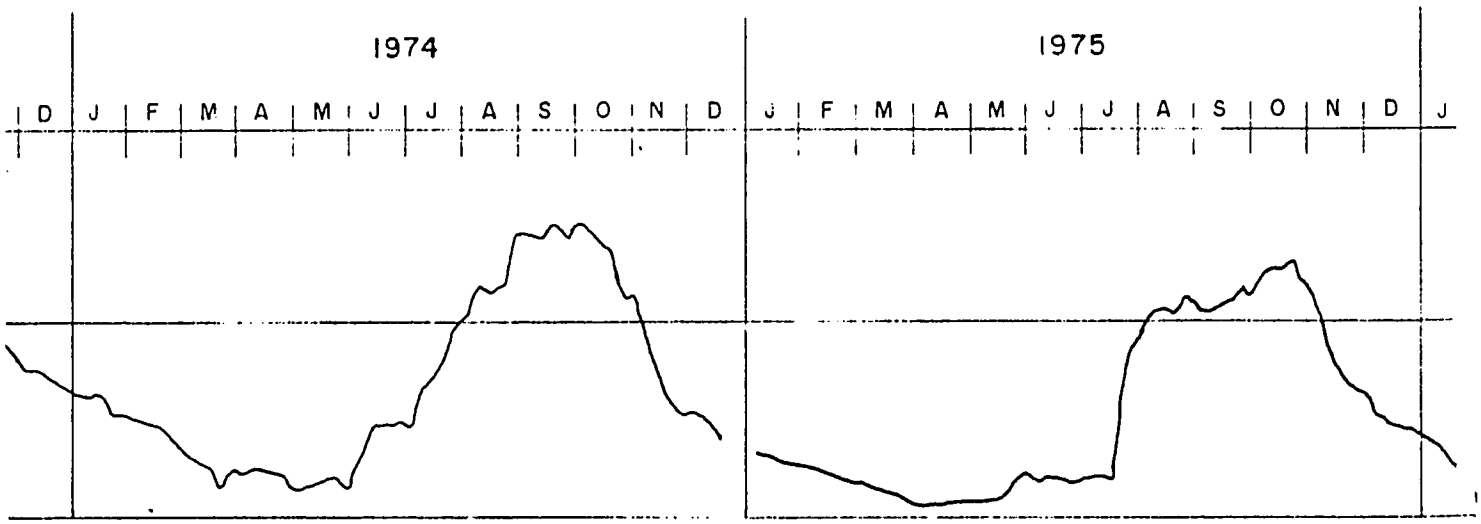
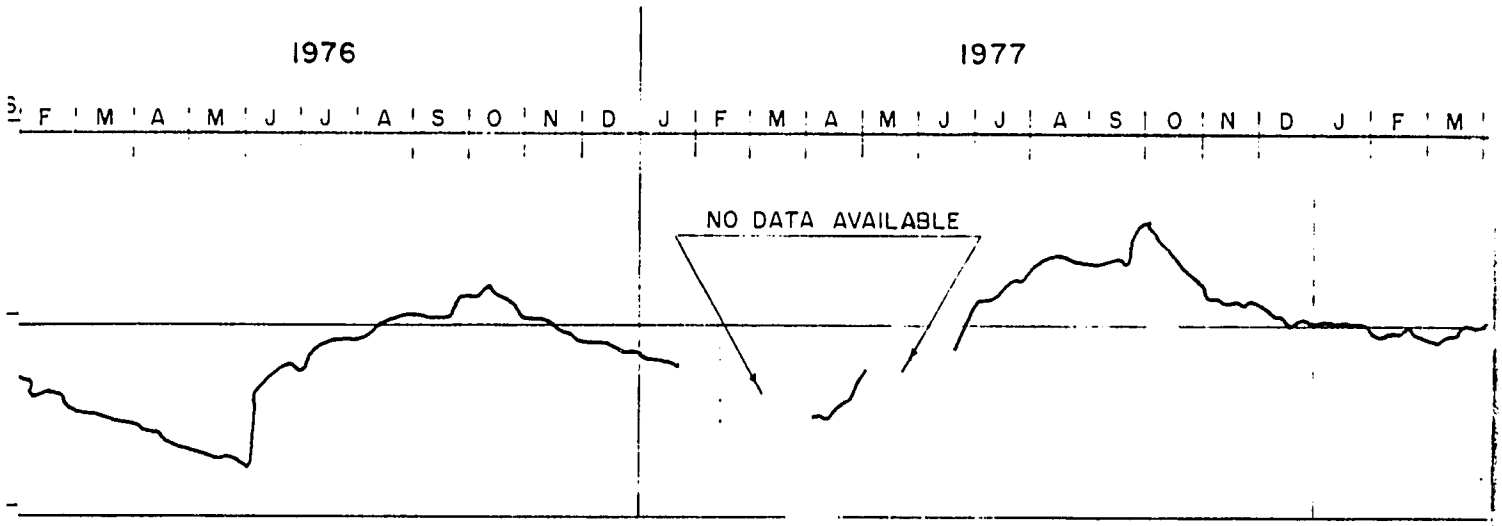
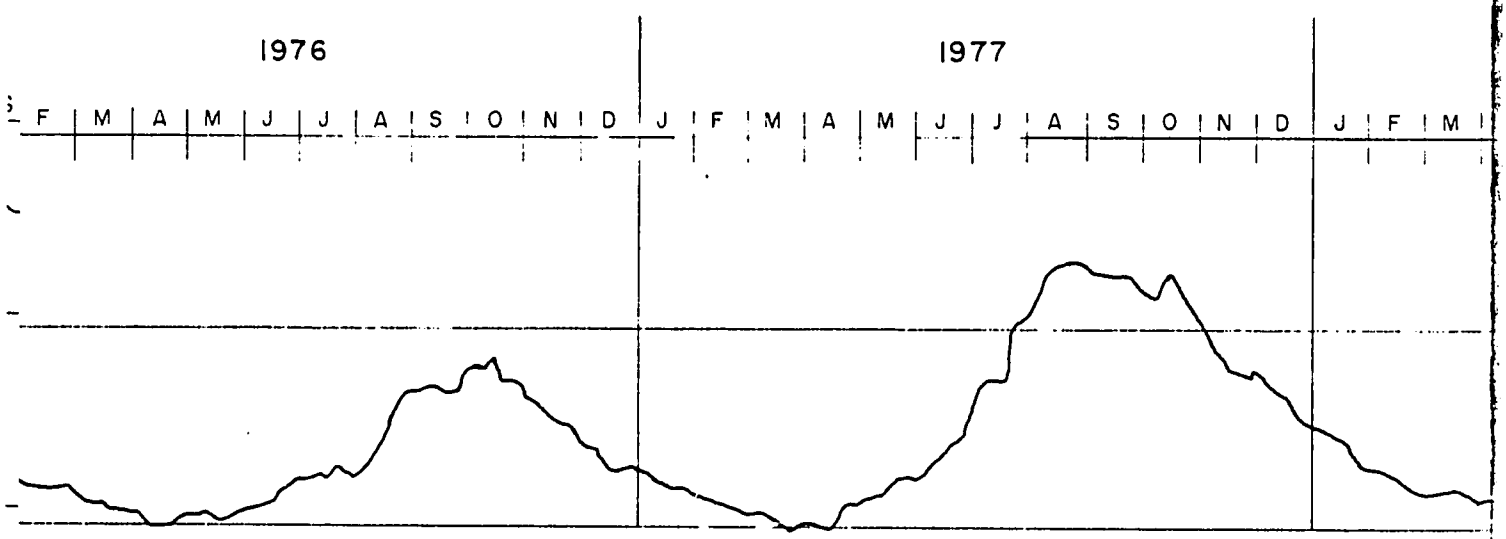


M)


1976
1977
F M A M J J A S O N D J F M A M J J A S O N D J F M
NO DATA AVAILABLE


1976
1977
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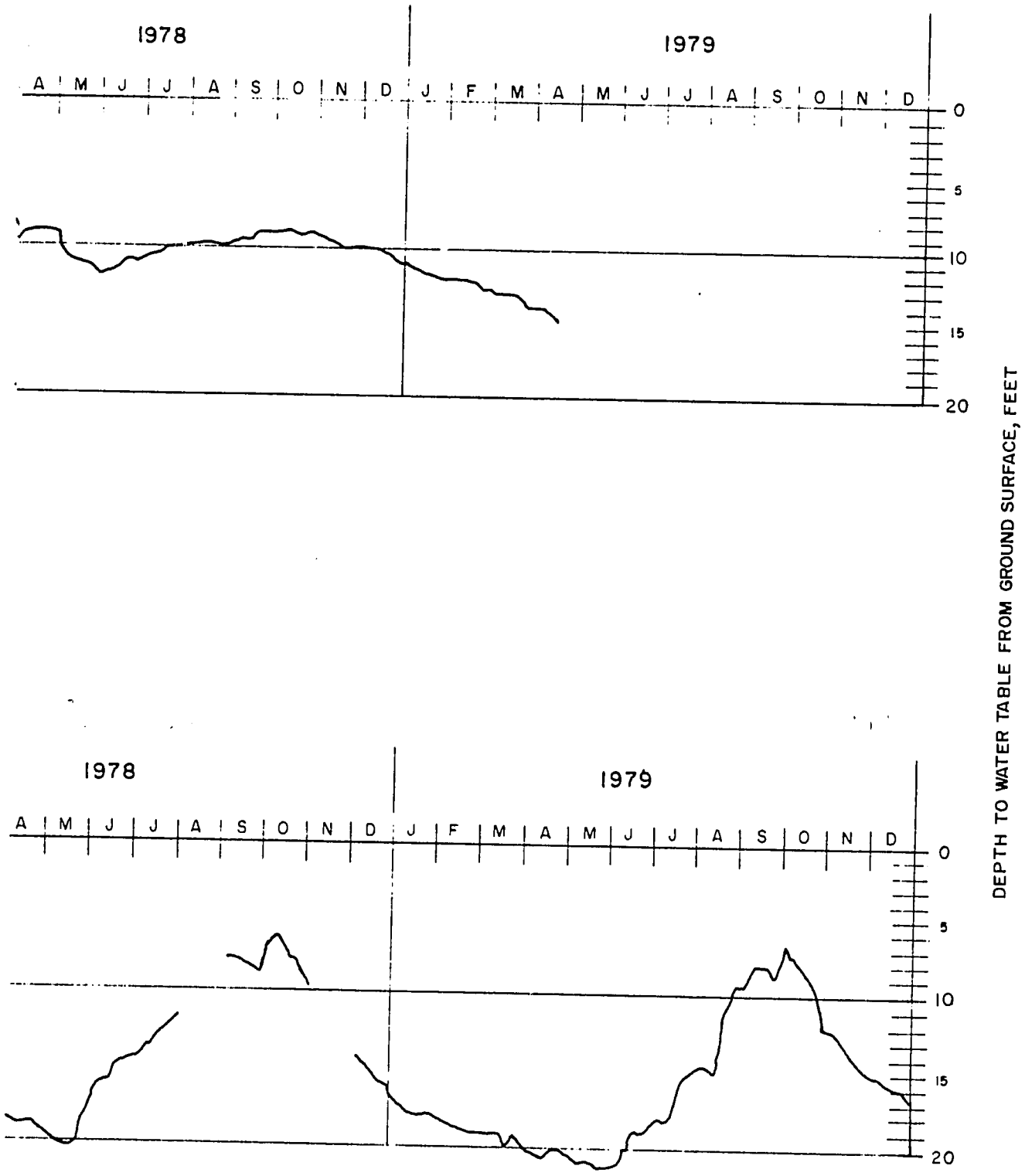


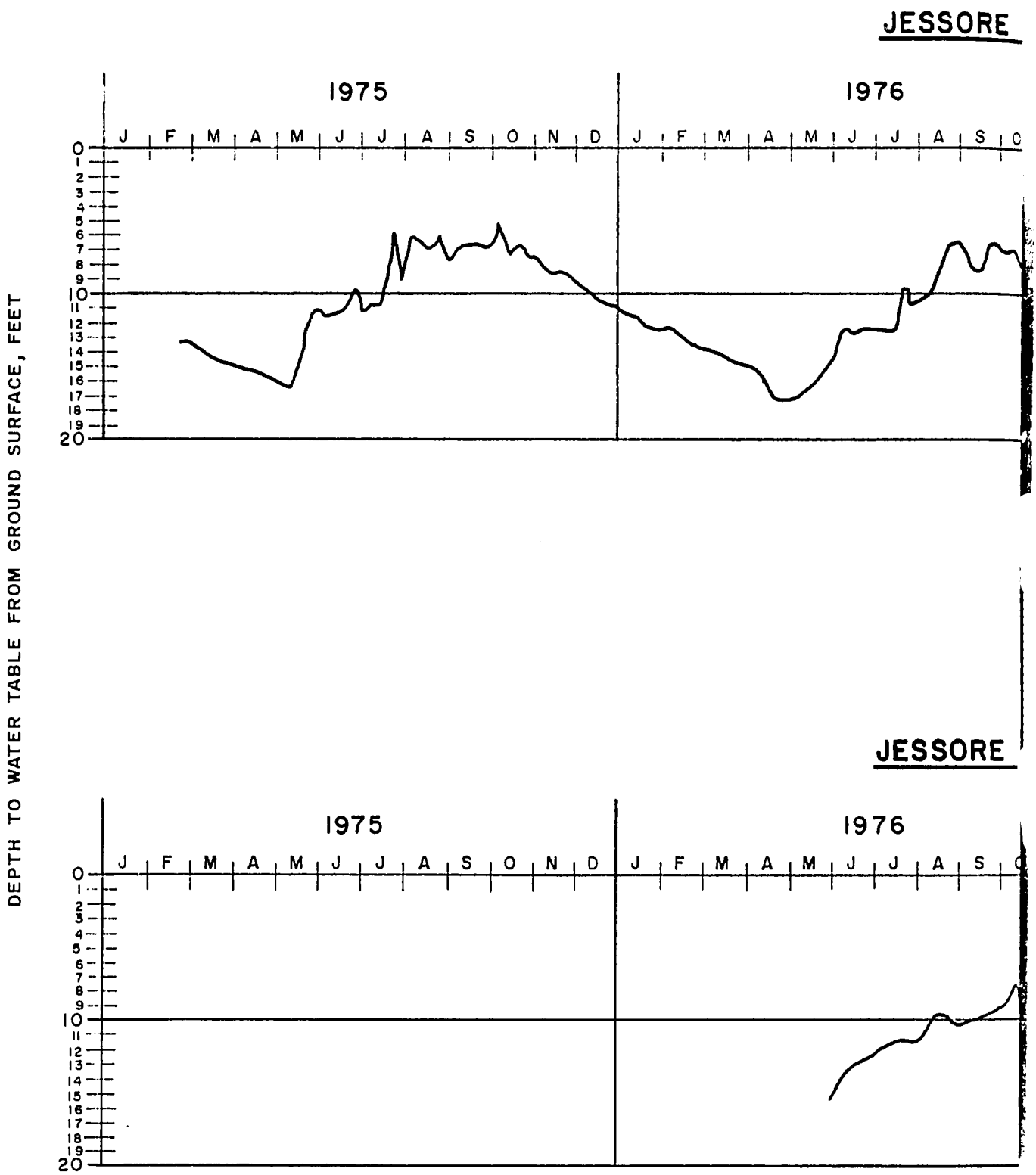
DEPTH TO WATER TABLE

OBSERVATION WELLS JE-4 & JE-6

FIGURE B-9

(SHEET 1 OF 2)

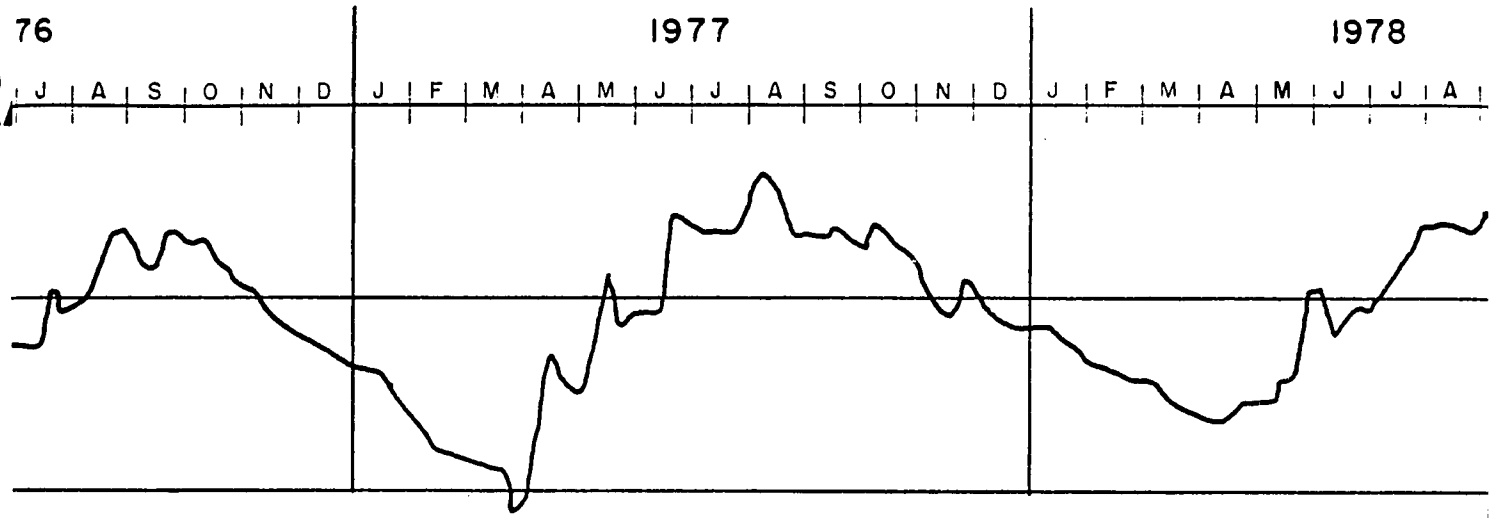
56 B9 (1)


JESSORE
1975
1976
J F M A M J J A S O N D J F M A M J J A S O
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20
DEPTH TO WATER TABLE FROM GROUND SURFACE, FEET
JESSORE
1975
1976
J F M A M J J A S O N D J F M A M J J A S O
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20

57 B9 (2)

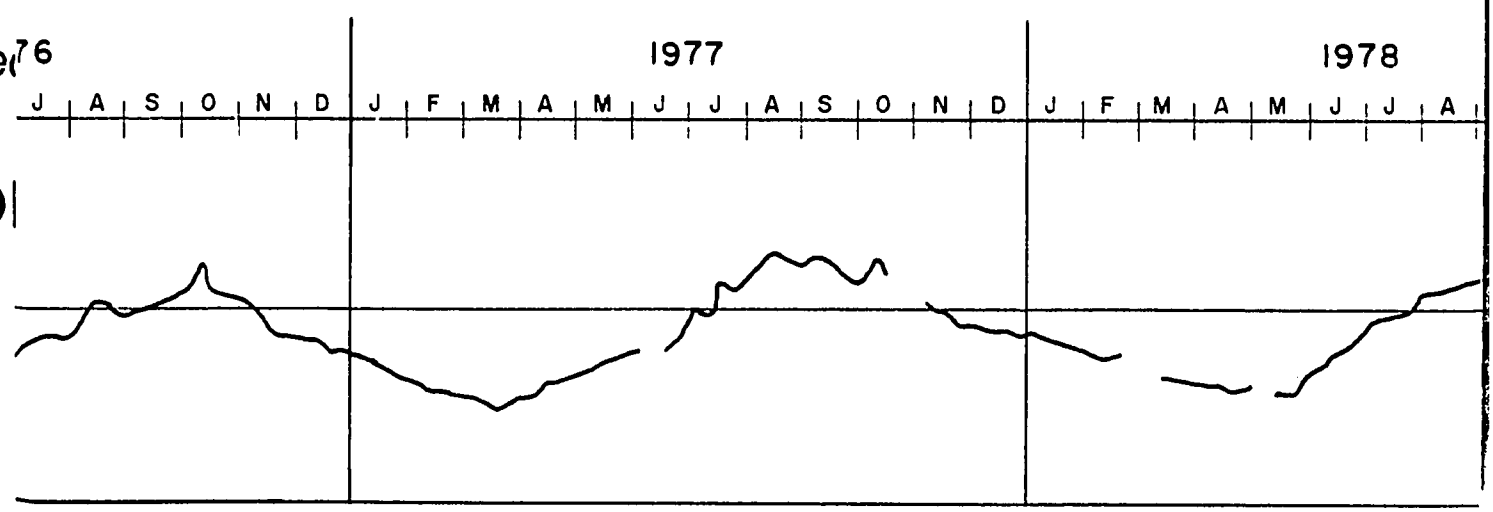
)RNI

JESSORE JE-16 (GROUND ELEVATION = 19.18 FT. P.W.D. DATUM)



JR

JESSORE JE-22 (GROUND ELEVATION = 29.48 FT. P.W.D. DATUM)

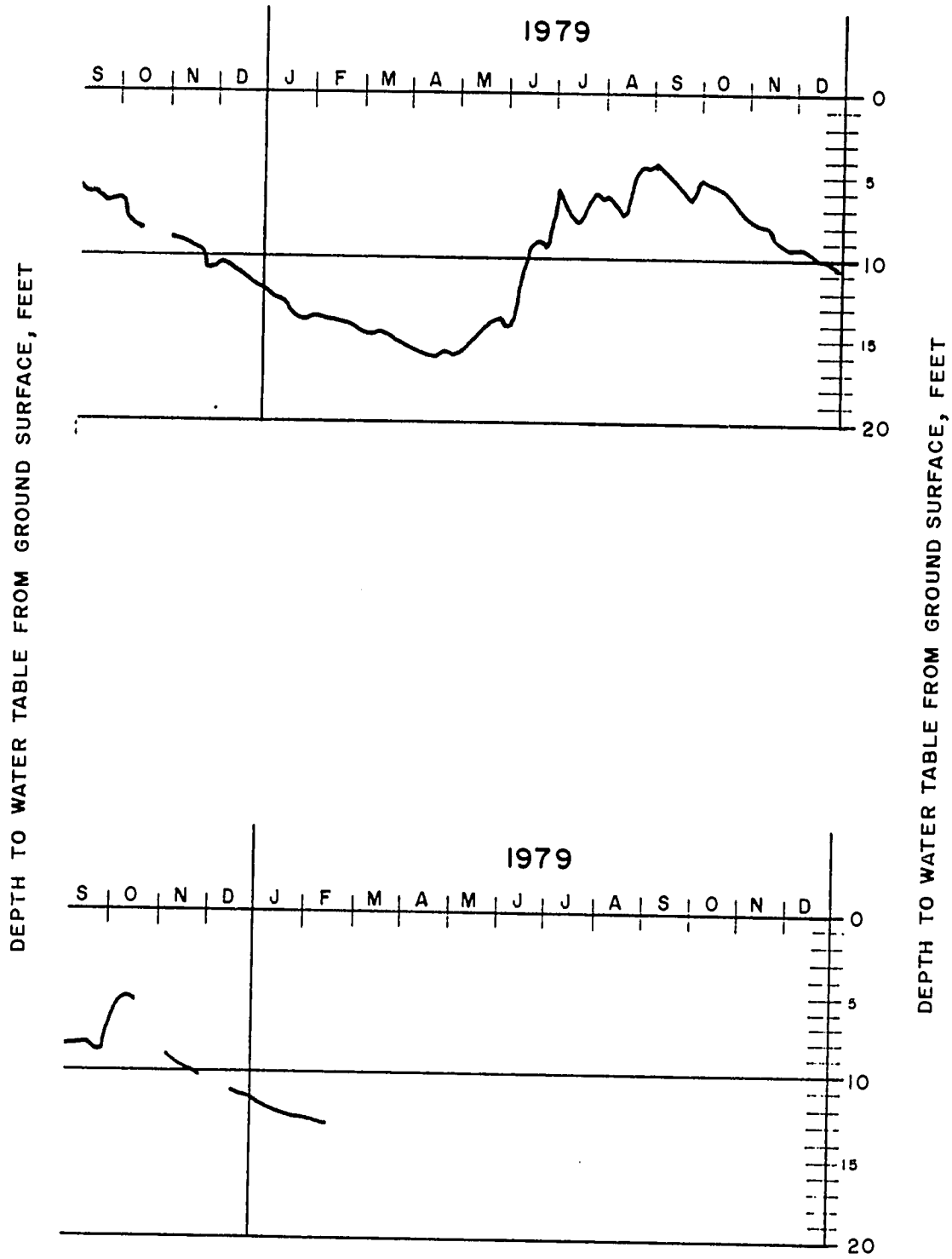


Spe

ND

). 2

58 B9 (3)



DEPTH TO WATER TABLE

OBSERVATION WELLS JE-16 & JE-22

FIGURE B-9

(SHEET 2 OF 2)

APPENDIX C
WATER REQUIREMENTS AND AGRICULTURE

APPENDIX C

WATER REQUIREMENTS AND AGRICULTURE

CONTENTS

1. Water Requirements
2. Residual Soil Moisture
3. Supporting Data

TABLES

No.	Title
C-1	Temperature at Jessore Station
C-2	Relative Humidity at Jessore Station
C-3	Wind Speed at Jessore Station
C-4	Day Length at Latitude 23°N
C-5	Hours of Bright Sunshine at Jessore Station
C-6	Calculated ETo for Jessore Station
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C-11	Sunflower Water Requirements
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C-20	Computation of Adjusted Yields
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APPENDIX C

WATER REQUIREMENTS AND AGRICULTURE

1. WATER REQUIREMENTS

Crop water requirements are defined as "the depth of water needed to meet the water loss through evapotranspiration (ETcrop) of a disease-free crop, growing in large fields under nonrestricting soil conditions including soil, water, and fertility and achieving full production potential under the given growing environment." The term evapotranspiration refers to evaporation from the soil and transpiration by the crop.

In the absence of accurate field measurements, prediction methods have been used to determine ETcrop. Crop water requirements are affected by climate, crop characteristics and local conditions including agricultural practices. The effects are expressed in the equation

$$ETcrop = ETo \cdot kc$$

where ETo is reference crop evapotranspiration and kc is a crop coefficient.

Reference crop evapotranspiration (ETo) reflects the effect of climate on crop water requirements. It is defined as "the rate of evapotranspiration from an extensive surface of 8 to 15 cm tall, green grass cover of uniform height, actively growing, completely shading the ground and not short of water."

The modified Penman method, as described in the FAO Irrigation and Drainage Paper No. 24 (1977), was employed to determine ETo. Mean daily data were used according to the following equation:

$$ETo = c\ [W \cdot Rn + (1-W) \cdot f(u) \cdot (ea-ed)]$$

where ETo = reference crop evapotranspiration in mm/day
W = temperature-related weighting factor
Rn = net radiation in equivalent evaporation in mm/day
f(u) = wind related function
(ea-ed) = difference between the saturation vapor pressure at mean air temperature and the mean actual vapor pressure of the air, both in mbar
c = adjustment factor to compensate for the effect of day and night weather conditions

The climatic data used in the analysis are shown in Tables C-1 to C-5. The data in Tables C-1, C-2, and C-3 were obtained from the Department of Meteorology in Dacca and represent mean values computed from daily measurements recorded between 1954 and 1974 at Jessore Station. The data in Tables C-4 and C-5 were taken from the Agro-Climatic Survey of Bangladesh. The ETo data calculated for each month are shown in Table C-6. The variables used in the calculations are listed in Table C-7.

TABLE C-1

TEMPERATURE (°C) AT JESSORE STATION

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Max.	25.9	28.7	33.6	36.6	35.8	33.2	31.4	31.4	31.8	31.1	29.1	26.3
Min.	11.3	13.3	19.2	23.7	25.2	25.9	25.8	25.8	25.6	23.3	17.4	12.1
Mean	18.6	21.0	26.4	30.2	30.5	29.6	28.6	26.8	28.7	27.2	23.3	19.2

TABLE C-2

RELATIVE HUMIDITY (%) AT JESSORE STATION

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
9AM	76	70	69	71	76	84	87	88	86	83	76	77
6PM	59	50	45	50	64	79	85	85	84	79	69	66
Mean	68	60	57	61	70	82	86	87	85	81	73	72
RHmax.*	90	90	90	90	90	95	95	95	95	95	90	90

*Estimated values

TABLE C-3

WIND SPEED AT JESSORE STATION

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
9AM KTS	2.6	2.4	3.9	6.0	6.8	5.4	5.4	5.0	4.6	3.1	2.3	2.6
6PM KTS	1.2	1.5	2.9	5.7	6.0	5.0	4.8	4.1	3.3	1.8	1.0	1.0
Mean 9AM KTS 6PM	1.9	2.0	3.4	5.9	6.4	5.2	5.1	4.6	4.0	2.5	1.7	1.8
Km/hr Mean	3.5	3.7	6.3	10.9	11.9	9.6	9.5	8.5	7.4	4.6	3.2	3.3
Km/day Mean	84	89	151	262	286	230	228	204	178	110	77	79
Uday(9AM) m/Sec	1.3	1.2	2.0	3.1	3.5	2.8	2.8	2.6	2.4	1.6	1.2	1.3
Uday/Unight (9AM) (6PM)	2.2	1.6	1.3	1.1	1.1	1.1	1.1	1.2	1.4	1.7	2.3	2.6

TABLE C-4

DAY LENGTH AT LATITUDE 23°N

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
10.9	11.4	12.0	12.7	13.3	13.6	13.4	13.0	12.3	11.7	11.1	10.7

TABLE C-5

HOURS OF BRIGHT SUNSHINE AT JESSORE STATION

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
9.1	9.5	8.7	8.9	9.7	4.8	5.1	5.7	5.9	8.2	9.3	9.4

TABLE C-6

CALCULATED ETo (mm/Day) FOR JESSORE STATION

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
3.4	4.7	6.5	7.9	7.8	5.0	4.8	4.7	4.6	4.6	4.0	3.2

TABLE C-7

VARIABLES USED IN CALCULATIONS OF ETo (JESSORE STATION)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
ea	21.4	24.9	34.4	42.9	43.7	41.5	39.2	39.2	39.4	36.1	28.6	22.3
ed	14.6	14.9	19.6	26.2	30.6	34.0	33.7	34.1	33.5	29.2	20.9	16.1
(ea-ed)	6.8	10.0	14.8	16.7	13.1	7.5	5.5	5.1	5.9	6.9	7.7	6.2
f(u)	0.50	0.51	0.67	0.98	1.04	0.89	0.89	0.82	0.75	0.57	0.48	0.49
(1-W)	0.33	0.31	0.25	0.22	0.22	0.22	0.23	0.23	0.23	0.24	0.28	0.33
Ra	10.4	12.1	14.0	15.4	16.4	16.5	16.5	15.8	14.5	12.8	10.9	9.9
n	9.1	9.5	8.7	8.9	9.7	4.8	5.1	5.7	5.9	8.2	9.3	9.4
N	10.9	11.4	12.0	12.7	13.3	13.6	13.4	13.0	12.3	11.7	11.1	10.7
n/N	0.83	0.83	0.73	0.70	0.73	0.35	0.38	0.44	0.48	0.70	0.84	0.88
Rs	7.0	8.1	8.7	9.2	10.0	7.1	7.3	7.4	7.1	7.7	7.3	6.8
Rns	5.3	6.1	6.5	6.9	7.5	5.3	5.5	5.6	5.3	5.8	5.5	5.1
Rnl	2.1	2.1	1.7	1.5	1.3	0.6	0.6	0.7	0.7	1.2	1.8	2.1
Rn	3.2	4.0	4.8	5.4	6.2	4.7	4.9	4.9	4.6	4.6	3.7	3.0
W	0.67	0.69	0.75	0.78	0.78	0.78	0.77	0.77	0.77	0.76	0.72	0.67
c	1.07	1.07	1.06	1.01	1.01	0.96	0.97	0.98	1.02	1.05	1.07	1.07

NOTES:

ea = mean actual water vapor pressure (mbar)

ed = mean saturation water vapor pressure (mbar)

f(u) = wind-related function

(1-W) = weighting factor for the effect of wind and humidity at different temperatures and altitudes

Ra = the amount of radiation received at the top of the atmosphere, in equivalent evaporation (mm/day)

Rs = solar radiation in equiv. evaporation (mm/day)

Rns = net shortwave solar radiation (mm/day)

Rnl = net longwave radiation (mm/day)

Rn = net radiation (Rn=Rns-Rnl mm/day)

n = mean actual sunshine hours (hrs/day)

N = mean daily duration of maximum possible sunshine hours (hrs/day)

W = weighting factor for the effect of radiation on ETo at different temperatures and altitudes

c = adjustment factor to compensate for the effect of day and night weather conditions

TABLE C-8

WHEAT WATER REQUIREMENTS (ET WHEAT)

Month	ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Nov 20-30	4.0	0.37	1.5	10	15	0.6
Dec 1-10	3.2	0.41	1.3	10	13	0.5
11-20	3.2	0.65	2.1	10	21	0.8
21-31	3.2	0.94	3.0	11	33	1.3
Jan 1-31	3.4	1.07	3.6	31	112	4.4
Feb 1-20	4.7	1.09	5.1	20	102	4.0
21-28	4.7	0.94	4.4	8	35	1.4
Mar 1-15	6.5	0.52	3.4	15	51	2.0
		TOTAL		115	382	15.0

TABLE C-9

BORO WATER REQUIREMENTS (ET BORO)

Month	ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Jan 1-31	3.4	1.1	3.7	31*	115	4.6
Feb 1-10	4.7	1.1	5.2	10*	52	2.0
11-28	4.7	1.1	5.2	18	94	3.7
Mar 1-31	6.5	1.25	8.1	31	251	9.9
Apr 1-30	7.9	1.25	9.9	30	297	11.7
May 1-10	7.8	1.25	9.8	10	98	3.9
11-31	7.8	1.0	7.8	21	164	6.5
		TOTAL		151	1,071	42.3

* Seedbed.

TABLE C-10

AUS (BROADCAST) WATER REQUIREMENTS (ET AUS)

Month	ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Mar 21-31	6.5	0.8	5.2	10	52	2.0
Apr 1-10	7.9	0.8	6.3	10	63	2.5
11-20	7.9	0.9	7.1	10	71	2.8
21-30	7.9	1.0	7.9	10	79	3.1
May 1-31	7.8	1.1	8.6	31	266	10.5
Jun 1-20	5.0	1.0	5.0	20	100	3.9
21-30	5.0	0.95	4.8	10	48	1.9
Jul 1-19	4.8	0.95	4.6	19	87	3.4
			TOTAL	120	766	30.1

TABLE C-11

SUNFLOWER WATER REQUIREMENTS (ET SUNFLOWER)

Month	ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Mar 21-31	6.5	0.3	2.0	10	20	0.8
Apr 1-10	7.9	0.5	4.0	10	40	1.6
11-20	7.9	0.8	6.3	10	63	2.5
21-30	7.9	1.0	7.9	10	79	3.1
May 1-31	7.8	1.05	8.2	31	254	10.0
Jun 1-10	5.0	1.05	5.3	10	53	2.1
11-20	5.0	0.7	3.5	10	35	1.4
21-30	5.0	0.4	2.0	9	18	0.7
			TOTAL	100	562	22.2

TABLE C-12

SOYBEAN WATER REQUIREMENTS (ET SOYBEAN)

Month		ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Jul	27-31	4.8	0.9	4.3	4	17	0.7
Aug	1-31	4.7	0.9	4.2	31	130	5.1
Sep	1-30	4.6	1.0	4.6	30	138	5.4
Oct	1-15	4.6	1.0	4.6	15	69	2.7
	16-31	4.6	0.8	3.7	16	59	2.3
Nov	1-14	4.0	0.5	2.0	14	28	1.1
				TOTAL	110	441	17.3

TABLE C-13

MAIZE WATER REQUIREMENTS (ET MAIZE)

Month		ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Jul	27-31	4.8	0.9	4.3	4	17	0.7
Aug	1-31	4.7	0.9	4.2	31	130	5.1
Sep	1-30	4.6	1.05	4.8	30	145	5.7
Oct	1-31	4.6	1.05	4.8	31	150	5.9
Nov	1-14	4.0	0.95	3.8	14	53	2.1
				TOTAL	110	495	19.5

TABLE C-14

WATER REQUIREMENTS FOR TRANSPLANTED AMAN (ET T. AMAN)

Month	ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Jun 20-30	5.0	1.1	5.5	20*	110	4.3
Jul 1-10	4.8	1.1	5.3	10*	53	2.1
11-31	4.8	1.1	5.3	21	111	4.4
Aug 1-31	4.7	1.05	4.9	31	152	6.0
Sep 1-30	4.6	1.05	4.8	30	144	5.7
Oct 1-15	4.6	1.05	4.8	15	72	2.8
16-31	4.6	0.95	4.4	16	70	2.8
Nov 1-2	4.0	0.95	3.8	2	8	0.3
		TOTAL		145	720	28.4

* Seedbed.

TABLE C-15

WATER REQUIREMENTS FOR TRANSPLANTED
DEEP WATER AMAN (ET T.D.W. AMAN)

Month	ETo mm/day	kc	ETcrop mm/day	Days	ETcrop per Period mm	inches
Apr 24-30	7.9	1.1	8.7	6*	52	2.0
May 1-31	7.8	1.1	8.6	31*	267	10.5
Jun 1-8	5.0	1.1	5.5	8*	44	1.7
9-30	5.0	1.1	5.5	22	121	4.8
Jul 1-31	4.8	1.05	5.0	31	155	6.1
Aug 1-31	4.7	1.05	4.9	31	152	6.0
Sep 1-30	4.6	1.05	4.8	30	144	5.7
Oct 1-31	4.6	1.05	4.8	31	149	5.9
Nov 1-30	4.0	1.0	4.0	30	120	4.7
Dec 1-10	3.2	0.95	3.0	10	30	1.2
		TOTAL		230	1,234	48.6

* Seedbed.

Crop coefficient (kc) reflects the effect of crop characteristics on crop water requirements. It represents the relationship between reference crop evapotranspiration (ETo) and evapotranspiration of a particular crop (ETcrop). Factors affecting the value of kc are mainly the crop properties, planting dates, rate of development, length of growing season and climatic conditions.

The values of kc for wheat, boro, aus, sunflower, soybean, maize, transplanted aman and deep water aman were determined according to the method described in the FAO Irrigation and Drainage Paper No. 24 (1977).

Crop water requirements (ETcrop) by the crops proposed for irrigated management are presented in Tables C-8 to C-15. The ETcrop values were derived from formula (1).

RESIDUAL SOIL MOISTURE

The Soil Survey of the Nabaganga Study area does not present any data on the status of available soil moisture at any particular time. Nevertheless, it reports that the medium and moderately fine textured soils such as Sara and Gopalpur, which predominate in the study area, have an available moisture holding capacity of about 10 inches in a 40-inch deep profile. This capacity undoubtedly is filled up during the rainy season and a great deal of available moisture should, therefore, remain in the soil for some time during the post-monsoon season.

In a related soil-moisture study, Rahman[1/] reported the same soils, Sara and Gopalpur, the present in conditions (BARI farm at Ishurdi) comparable to the present study area, retained considerable moisture throughout the dry season as shown in Table C-16.

TABLE C-16

AVAILABLE SOIL MOISTURE (INCHES) AT DIFFERENT DATES

Soil	Depth(cm)	Nov. 10	Dec. 16	Jan. 8	Feb. 10	Mar. 7
Sara	0-15	1.3	1.3	1.3	1.1	0.6
	15-45	4.3	4.1	4.6	3.5	2.7
	0-100	10.3	10.3	10.6	9.4	7.6
Gopalpur	0-15	1.1	0.6	1.2	0.9	0.5
	15-45	3.8	3.8	4.0	3.9	3.1
	0-100	9.4	7.7	9.0	8.1	7.4

Wheat grown by some farmers on these soils without irrigation yields about 15 maunds per acre. It is assumed, therefore, that the residual moisture will be used by dryland crops also under irrigated management. The expected availability of residual soil moisture to various crops is indicated in Table 17. Shown in the same table are data on expected water availability from rain, estimated water deficit, and projected water delivery requirements.

3. SUPPORTING DATA

Tables C-18 through C-21 provide information used to complete analyses appearing in other volumes of this report.

1/ M. Rahman, 1979. Relationship between Soil-Moisture Characteristics of Some Gangetic Soils and the Growth of Wheat under Non-Irrigated Conditions. Department of Soil Survey, Dacca.

TABLE C-17

IRRIGATION WATER DELIVERY REQUIREMENTS

Month	Crop	Cropping Pattern	ETcrop Period (inches)	Effic. Rain[1]	Soil Water (inches)	Water Deficit (inches)	W. Delivery Requirement[2] (inches/acre)
Jan.	wheat	A & B	4.4	-	2.0	2.4	3.7
	boro[3]	C	4.6	-	-	4.6	0.4[a]
Feb.	wheat	A & B	5.4	-	2.6	2.8	4.3
	boro[3]	C	2.0	-	-	2.0	0.2[a]
	boro	C	3.7	-	-	3.7	4.9 + 7.0 (LP)
Mar.	wheat	A & B	2.0	-	1.0	1.0	1.5[b]
	boro	C	9.9	1.0	-	8.9	11.9
	aus	A	2.0	-	-	2.0	3.1 + 3.0 (LP)
	sunflower	B	0.8	-	-	0.8	1.2 + 3.0 (LP)
Apr.	boro	C	11.7	2.7	-	9.0	12.0
	aus	A	8.4	2.4	3.0	3.0	4.6
	sunflower	B	7.2	2.4	3.0	1.8	2.8
	d.w.aman[3]	C	2.0	2.0	-	-	-
May	boro	C	10.4	4.6	-	5.8	7.7
	aus	A	10.5	4.1	4.0	2.4	3.7
	sunflower	B	10.0	4.1	4.0	1.9	2.9
	d.w.aman[3]	C	10.5	5.2	-	5.3	0.5[a]
Jun.	aus	A	5.8	1.8	4.0	-	-
	sunflower	B	4.2	0.2	4.0	-	-
	t.aman	B	4.3	4.3	-	-	-
	d.w.aman[3]	C	1.7	1.7	-	-	-
	d.w.aman	C	4.8	4.8	-	-	-
Jul.	aus	A	3.4	-	3.4	-	-
	maize	A	0.7	0.7	-	-	-
	t.aman[3]	B	2.1	2.1	-	-	-
	t.aman	B	4.4	4.4	-	-	-
	d.w.aman	C	6.1	6.1	-	-	-

TABLE C-17 (continued)

Month	Crop	Cropping Pattern	ETcrop Period (inches)	Effic. Rain[1]	Soil Water (inches)	Water Deficit (inches)	W. Delivery Requirement[2] (inches/acre)
Aug.	maize	A	5.1	4.1	1.0	-	-
	t.aman	B	6.0	6.0	-	-	-
	d.w.aman	C	6.0	6.0	-	-	-
Sep.	maize	A	5.7	3.7	2.0	-	-
	t.aman	B	5.7	5.7	-	-	-
	d.w.aman	C	5.7	5.7	-	-	-
Oct.	maize	A	5.9	2.9	3.0	-	-
	t.aman	B	5.6	3.8	1.8	-	-
	d.w.aman	C	5.9	3.8	2.1	-	-
Nov.	maize	A	2.1	-	2.1	-	-
	t.aman	B	0.3	-	0.3	-	-
	d.w.aman	C	4.7	0.5	4.2	-	-
	wheat	A & B	0.6	-	0.6	-	-
Dec.	d.w.aman	C	1.2	-	1.2	-	-
	wheat	A & B	2.6	-	1.0	1.6	2.5

1 Efficient rain is assumed to be 80% of the dependable rain for flooded rice, and 70% for dryland crops, but not exceeding ETcrop.

2 The water delivery requirements are based on an assumed 75% irrigation efficiency for flooded rice and 65% efficiency for dryland crops.

3 Seedbeds.

a Seedbeds will occupy only about 7% of the cropped (transplanted) area.

b Actual water delivery will take place in February, not later than two weeks before the harvest.

(LP) Water needed for land preparation before planting.

TABLE C-18

ACREAGE OF CROPPING PATTERNS[1] IN LOW LIFT PUMP DEVELOPMENT AREA

Land Capability Mapping Unit	Land Capability Units (as described in Soil Survey Report)	Cropping Pattern	Area (acres)
1a	II Dw 3 & 4	A	14,400
1b	II Dw 4 & 5, II W 4 & 5	B	4,500
1c	II Dw 4 & 5, II W 5	B	3,400
2a	II W 3 & 4	B	1,400
2b	II Dw 4 & 5, II W 4 & 5	B	2,300
2b	II W 5 (flooded over 1 ft)	C	100
2c	II Dw 5, II W 5	B	4,000
2c	II W 5 (flooded over 1 ft)	C	800
4	III Dx 2 & 3	D	200
5a	III Dr 2 & 3	D	200
5b	II Dw3 & 4, III Dr 3, III Wr 4	D	1,600
5c	III Dr 4 & 5	D	200
6	II Dw 3, III Dr 3 & 4, III Wr 4	D	500
8	III Wx 2 & 3	C	100
9c	II W5, III Wd 5, III Ww 5	C	2,200
10a	III Ww 5	C	100
10b	II W 5, III Wd 5, III Ww 5	C	1,300
11	IV Ww 5, IV Wz 5	C	900
Area under Proposed Cropping Pattern		A	14,400
Area under Proposed Cropping Pattern		B	15,600
Area with Potential for Cropping Pattern		C	5,500
Area with Potential for Cropping Pattern		D	2,700

1 Cropping patterns are described in Volume II of this report.

TABLE C-19

ACREAGE OF CROPPING PATTERNS OUTSIDE
LOW LIFT PUMP DEVELOPMENT AREA

Land Capability Mapping Unit	Land Capability Units (as described in Soil Survey Report)	Cropping Pattern	Area (acres)
1a	II Dw 3 & 4, III Dr 3	A'	800
1a	II Dw 4 & 5	B'	1,100
1b	II Dw 4	A'	300
1b	II Dw 4 & 5, II W 4 & 5	B'	1,200
1b	II W 4 & 5 (flooded over 1ft)	C'	100
1c	II Dw 4	A'	100
1c	II Dw 4 & 5, II W 5	B'	5,300
1c	II W 5 (flooded over 1 ft)	C'	100
2a	II W 3 & 4 (flooded over 1ft)	C'	100
2b	II Dw 4	A'	100
2b	II Dw 5, II D W 4 & 5	B'	900
2b	II D W 4 & 5, III Wd 5	C'	1,000
2c	II W 5	B'	5,100
2c	II W 5, III Wd 5 (flooded over 1 ft)	C'	2,000
3	II Dw 3, III Dw 2	A'	200
5c	III Dr 4 & 5	D'	600
6	II Dw 3, III Dr 3 & 4, III Wr 4	D'	300
7	III Wr 4 & 5	D'	200
9b	III Wd 4 & 5	C'	300
9c	II W 5, III Wd 5, III Ww 5	C'	2,200
10b	II W 5, III Wd 5, III Ww5	C'	1,400
11	IV Ww5, IV Wz 5	C'	1,200
12	IV Wz 5	C'	100
13	IV Wwo	C'	600
Area with Potential for Cropping Pattern		A'	1,500
Area with Potential for Cropping Pattern		B'	13,600
Area with Potential for Cropping Pattern		C'	9,100
Area with Potential for Cropping Pattern		D'	1,100

TABLE C-20

COMPUTATION OF ADJUSTED YIELDS[1]

Crop	Year of Planting	Acreage Factor[2]	Yield Factor[3]	Adjusted Yield mds/acre
wheat	1	0.6	0.5 x 35	10.5
	2	0.8	0.6 x 35	16.8
	3	1.0	0.8 x 35	28.0
	4	1.0	0.9 x 35	31.5
	5	1.0	1.0 x 35	35.0
aus	1	1.0	0.6 x 35	21.0
	2	1.0	0.7 x 35	24.5
	3	1.0	0.8 x 35	28.0
	4	1.0	0.9 x 35	31.5
	5	1.0	1.0 x 35	35.0
jute	1	1.0	0.6 x 25	15.0
	2	1.0	0.7 x 25	17.5
	3	1.0	0.8 x 25	20.0
	4	1.0	0.9 x 25	22.5
	5	1.0	1.0 x 25	25.0
t.aman	1	0.6	0.5 x 60	18.0
	2	0.7	0.6 x 60	25.2
	3	0.8	0.8 x 60	38.4
	4	0.9	0.9 x 60	48.6
	5	1.0	1.0 x 60	60.0

1 Adjusted Yield as affected by the acreage and yield factors.

2 Acreage Factor reflects assumed incomplete cropping on the land available for irrigation.

3 Yield Factor indicates the proportion of the maximum projected yield achievable in five years.

TABLE C-21

PRESENT YIELDS OF MAJOR CROPS IN STUDY AREA*

Crop	Average Yield maunds/acre
Aus	15.4
B.Aman	15.2
Mixed B. Aus &	7.8
B. Aman	7.1
T.Aman	17.1
Boro (HYV)	15.5
Jute	13.4
Wheat	7.9
Sugarcane	375
Lentil	4.0
Kheshari	5.0
Gram	5.4
Mashkalai	4.5
Mixed oilseeds &	1.8
pulses	4.1
Mustard	1.7
Linseed	2.6

* Data from the Present Agriculture and Socio-Economic Conditions, a survey report from Phase I of this study.

APPENDIX D
ENVIRONMENTAL ASSESSMENT

APPENDIX D

ENVIRONMENTAL ASSESSMENT

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APPENDIX D

ENVIRONMENTAL ASSESSMENT

1. SUMMARY

Overall, the proposed project will provide significant benefits in terms of increased agricultural production and improved standards of living for some area farmers. Significant socio-economic impacts may arise concerning equity in the distribution of benefits and services and control over land holdings. Socio-economic analysis of the proposed de-development is covered in detail in a separate section of the report.

Most of the land which will be affected by the project is already being cultivated; no new lands will be cleared or converted for agricultural use. Consequently, impacts on the limited forested part of the project area and any wildlife habitats will be insignificant. No rare or endangered species will be adversely affected.

Water quality of drainage receiving streams will be adversely affected by an increase in pesticide and nutrient levels. Aquatic weeds are likely to spread through the new distribution canal system necessitating control measures. However, it should be possible to utilize this vegetation for fertilizer, livestock or fish feed, or as an energy producer in a bio-gas unit.

Project implementation will result in an increased production from natural fish stocks amounting to about 18 additional tons of yield or an annual project benefit of around Tk 1 million. The potential interference with fish migratory routes has been mitigated by re-scheduling gate openings and closings in the control structure.

Vector disease transmission by mosquitoes may rise in the project area due to the increased availability of suitable breeding habitat. Increased surveillance and control measures may become necessary. A study presently underway in the G-K project should provide guidelines for vector control needs.

It is recommended that the use of malathion and fenithrothion for crop pest control be restricted in order to reduce the chance of early resistance formation in mosquito vectors. These pesticides are the substitute for DDT once resistance to that pesticide develops.

2. PURPOSE

The proposed project is aimed at effecting optimal use of the land and water resources available. The major engineering works under consideration include construction of control structures to regulate surface water availability, installation of a series of shallow tubewells and low-lift pumps, and implementation of concomittant irrigation systems to permit more intensive cropping practices. An on-farm management plan and an institutional program to administer the project is also proposed. Fisheries developement is envisioned as an integral part of the planned project. Details of the proposed project are presented in other volumes of the report.

3. ALTERNATIVES INCLUDING THE PROPOSED ACTION

The rationale behind selecting the specific proposed action instead of alternative schemes is presented elsewhere in this report and especially in the Phase II Optimum Combination of Factors Report.

From an environmental standpoint, the no-action alternative would result in little change from existing environmental conditions in the project area. However, if the project is not implemented, some significant benefits in terms of fisheries and improved agricultural productivity would not be realized. Also, potential problems related to the consolidation of land holdings by more wealthy farmers may in fact occur whether or not the project is completed.

The three alternatives for project development evaluated in the Phase II report were not significantly different in terms of possible environmental impacts. These alternatives basically involved irrigating different amounts of land. The proposed action will result in the least amount of land brought under intensified cultivation. Thus, this alternative will utilize lower amounts of energy and agro-chemical inputs than the other alternatives. Consequently, the proposed action would have the least detrimental impact on the water quality of drainage receiving rivers or khals. In addition, this smaller system would be easier to administer and manage simply because of its size, thus enhancing the potential for success of the proposed on-farm management and institutional programs.

All of the proposed alternatives would be subject to environmental problems related to aquatic weed growth and the possible increase of mosquito vector breeding habitats. However, the lined canal system could limit the development of rooted aquatic plants. The closed pipe system could also

reduce aquatic weeds and perhaps other maintenance problems. The closed pipe system may also improve the chances for more equitable water distribution at the block level. However, costs for this system are prohibitive and the topography in the project area severely limits use of this type of distribution (see Appendix A).

4. AFFECTED ENVIRONMENT

4.1 General

The project area is located within the Jessore District of southwestern Bangladesh. It encompasses a total area of roughly 83,000 acres, most of which is located along the Nabaganga River between the towns of Magura and Jhenida. Detailed information pertaining to the overall existing conditions in the project area is presented in other parts of the report. The following sections summarize these conditions or provide pertinent data not discussed elsewhere.

4.2 Climate

Annually, the region typically experiences a heavy rainy season from June to September. Characteristic pre-monsoonal (April-May) and post-monsoonal (November-December) periods usually have high termperatures and occasional thunderstorms.

The mean annual temperature in the area is about 78.5°F. The mean annual rainfall is around 65 inches, ranging from 43 to 115 inches. More than three-fourths of the annual precipitation falls during the monsoon season.

4.3 Land use and Soils

The project area is situated in the Ganges meander floodplain and is characterized by a nearly level or very gently undulating landscape. Soils have developed in the relatively recent geologic past (Pleistocene and Halocene) from alluvial sediments. More than 90 percent of the project area has medium to moderately fine texture (loam to clay loam) soils on ridges and fine texture (clay) soils in depressions.

About 87 percent of the project area lands are under crop cultivation for part or all of the year. Less than 4 percent of this, however, is irrigated. Of the remaining land, 12 percent are villages, roads, ditches and ponds and about one percent is made up of pasture, forests or bush.

4.4 Water Quality and Quantity

4.4.1 Surface Water

The Nabaganga River bisects the area in a channel from 12 to 20 feet deep and varying in width from 130 to 350 feet. Both it and the Kumar River are presently cut off as direct spillways from the major rivers (Ganges and Mathabganga) and now serve only as local drainage channels.

Water flows in the project area rivers vary with the annual precipitation pattern, with widespread flooding during the monsoon season and very low or negligible flows in the dry season. Minimal flows normally occur from February through March.

Tidal effects upstream of Magura, which is about 150 miles from the Bay of Bengal, are very small and are generally considered to be insignificant in the project area.

Water quality data for the project area surface waters are not available. However, these waters are obviously very productive as evidenced by the presence of extensive growths of algae and aquatic weeds, especially water hyacinths. The dense vegetation is probably a result of high nutrient inflow from agricultural run-off.

4.4.2 Groundwater

Recharge of project area aquifers is produced by rainfall during the monsoon season. The water table in the western portion of the project area fluctuates from about four feet below the ground surface at the end of the rainy season to around 13 feet at the close of the dry season. In the eastern region, comparable water table depths are 12 and 18 feet, respectively.

The Bangladesh Water Development Board has collected some limited water quality data from two wells in the project area. The data are presented in Table D-1. The data in general indicate that the project area groundwaters should be excellent sources for irrigation usage.

TABLE D-1

WATER QUALITY DATA FROM TWO PROJECT AREA WELLS

Location and Depth	Date Collected	pH	Electrical Conductivity	TDS (mg/l)	SO_4	Fe	CO_3	SAR
Jhenida (600 ft.)	9/11/73	6.9	230	0.0	1.6	Nil	1.5	0.1
	7/10/74	6.9	236	0.1	0.6	Nil	1.8	
	5/30/75	7.4	282	0.4	3.0	Nil	0.7	
	10/20/75	7.9	315	0.0	1.6	Nil	9.0	
Magura (86 ft.)	4/13/73	7.45	296	0.0	<0.1	Nil	4.0	0.1
	9/04/73	7.4	288	2.1	0.9	Nil	4.0	
	6/02/75	7.5	540	11.0	5.0	Nil	10.0	

SOURCE: Bangladesh Water Development Board Water Supply Paper 394. November, 1976.

4.5 Forestry and Wildlife

Forested portions of the project area are very limited and are comprised mainly of bamboo, palms and several hardwood species, most of which are fruit bearing. These trees are utilized for food, firewood, thatching and light construction.

There are no endangered, threatened or other relatively unique flora or fauna in the project area which would be affected by the proposed development. The most commonly observed wildlife in the area are birds including doves, parakeets, crows, brahminy kites, pond herons, cattle egrets and kingfishers.

There are no designated wildlife sanctuaries, game reserves, recreation parks or national parks within the project area.

4.6 Fisheries

The fisheries sector constitutes an important economic activity and protein supply in the project area. The most common fish species in the local surface waters are catfishes, snakeheads, featherbacks and the highly valued Indian carp which include the following:

Common Name	Scientific Name
Rohu	*Labeo rohita*
Calbasu	*Labeo calbasu*
Mrigal	*Cirrhina mrigala*
Catla	*Catla catla*

Most of the species found here spawn during the flood season when young, recently hatched juvenile fish can take advantage of the substantial food supply available due to the inundation of nutrient-rich lands. The carp species migrate to specific spawning grounds as the waters rise at the commencement of the rainy period. The carp spawn in the main river channels where current is maintained. Their eggs hatch and the fry are washed into the floodplain, utilizing it as a nursery ground.

The popular hilsa, also a common migratory species in Bangladesh's large rivers, uses neither the Kumar nor the Nabanganga Rivers as spawning grounds.

4.7 Public Health

4.7.1 Waterborne Diseases

Prevalent waterborne diseases which occur in the project area, as well as throughout the country, include gastroenteritis, typhoid, cholera and the various forms of diarrheal and dysentery diseases. Gastroenteritis and the diarrheal diseases are the most common causes of reported illness and morbidity. Cholera is a major problem in Bangladesh, periodically causing high mortality rates.

The widespread incidence of waterborne and water related diseases is due primarily to the inadequacy of both water supply and sanitation systems in urban as well as rural areas.

4.7.2 Vector Diseases

Malaria is the vector disease of most concern with respect to the proposed project development. There are four confirmed *Anopheles* mosquito vectors which transmit malaria in Bangladesh, but the most common one occurring in and around the project area is *Anopheles philippinensis*.

The most favorable breeding habitat for *A. philippinenis* is in quiet or stagnant waters including small tanks, ponds, swamps, water hyacinth pools and rice paddies. These mosquitoes are very prolific during the dry season when many small isolated pools of water are formed. The female must land upon vegetation or other debris in order to release her eggs into the water. It takes a period of about six to eight days for the development of an adult mosquito from the fertilized egg.

In 1979, about 50,000 confirmed cases of malarial infection were recorded in Bangladesh. However, the high incidence was in the northern and eastern portions of the country. Only 57 cases were reported from the Jessore District in 1979; malaria is no longer considered a serious disease hazard in this region, although-reintroduction on a large scale has occurred in other comparable areas. An indoor spraying program is conducted nation-wide using mainly DDT and recently some malathion. Resistance has not yet been observed to either of these insecticides.

Other mosquito vector diseases occurring in the country include dengue and hemorrhagic fevers and occasionally encephalitis. The confirmed vector species are Aedes aegypti, Aedes albopictus, Culex fatigans and Culex tritaeniorhynchus. These mosquitoes usually breed in ditches, drains, borrow pits and other puddles.

A parasitic disease, fasciolopsiasis, is currently spreading rapidly through Bangladesh. It is caused by atrematode fluke (Fasciolopsis buski) which obstructs the intestines, although it is not usually fatal. The fluke uses planorbid snails as an intermediate host; the common host in the project area is Indoplanorbis exuatus. Schistosomiasis, a well known disease which also involves an intermediate snail host, has not been reported in Bangladesh.

4.8 Socio-economics

Briefly, the present rural population of the project area is estimated at about 200,000, with a total population of 265,000 including the major towns of Magura and Jhenida. About 20 percent of the populace is literate, which is considerably higher than the national average. About 80 percent of the labor force is engaged in some form of farming activity. The average size of a cultivated plot is 0.27 acres; a farmer's holdings are usually distributed in several separate plots. About 20 percent of the farmers here own their own land, 50 percent are share-croppers and the remainder are tenant farmers. Manual labor is used for all cultivation operations; the average monthly wage is about Tk 73.

5. ENVIRONMENTAL CONSEQUENCES

5.1 Impacts on Land Use and Soils

Implementation of the proposed project will occur in an area where the predominant existing land use is agriculturally oriented. The most significant impact on this land use will be a beneficial improvement of land capabilities

through increased water supply which will enable more intensive crop cultivation and output. This change in land capability will occur on present agricultural lands; no new lands will be cleared or converted to agricultural use.

Increased irrigation is likely to result in some isolated increases in soil salinity. However, soils investigations have indicated that this may occur in only very localized areas. Modification in water application procedures would be recommended to minimize any soil salinity problems. In addition, salt accumulations will be flushed out during the monsoon season.

The potential increase from single to double or triple cropping patterns may improve potential soil erosion problem areas, since the vegetal cover will generally be more comprehensive and conserve soils against wind and water erosion forces.

With the maintenance of significantly higher amounts of water in the project area rivers and canals through the dry season months, some small areas presently cultivated within the river bed proper will be inundated and their agricultural productivity forgone. This total area is probably less than 20 percent of the minimum water surface area which will occur in rivers/khals following project implementation. The total area affected would thus be about 125 acres. Only single, seasonal crops are currently raised in these lands.

Similarly, some existing agricultural land will be replaced by irrigation canals, although the amount of land thus affected should be relatively small. In quantitative terms, this forgone agricultural land will be about one percent of the land area affected by the proposed open channel distribution systems. This area would of course be available for cultivation if the closed pipe distribution system were used.

5.2 Impacts Related to Water Quality and Quantity

5.2.1 Effects on Surface Water and Aquatic Weeds

Concern has been raised over a possible reduction of dry season flows in the Nabaganga River as a result of the proposed storage behind the Magura weir. While the weir will limit or will prevent dry season flows downstream in the Nabaganga, this would not constitute a significant difference from present natural dry season flow regimes. Currently, flows here from December through March usually decrease progressively, reaching negligible levels toward the end of the dry period.

In any event, this situation (whether from natural flow fluctuations or due to upstream storage and diversion) adversely affects downstream aquatic habitats. With the increasing need for protein supplies to meet local food and nutritional demands, it is recommended that consideration be given to providing downstream conservation flows to the river, at least during those years when sufficient water storage is available. Maintenance of the aquatic habitats here could significantly improve fisheries production in the river. In addition, a continuous conservation flow or perhaps a periodic release would be beneficial to flush out isolated pools of water which are the principal breeding habitats for several mosquito disease vectors.

Dredging or related construction activities along the rivers and canals is likely to be very limited due to project implementation, but will cause a temporary increase in silt, suspended solids and turbidity levels in project area surface waters. The dredge spoil will, in most instances, be a high quality topsoil and can be disposed on nearby agricultural lands, thus enhancing their fertility.

Increased pesticide usage will be required in the project area, especially for the large amount of wheat which will be grown. Consequently, adverse impacts due to pesticide toxicity and bio-magnification in the food chain may become significant, especially for the valued fisheries resources. Proper application rates and the use of the more rapidly degradable organophosphate pesticides are the principal means of limiting negative effects of pesticide runoffs.

An additional potential toxicant could enter irrigation and drainage water if asbestos cement pipe were to be used in the closed pipe irrigation distribution system. Deterioration of those pipes from scour or damage by cattle trampling or rats could result in the release of asbestos fibers into waters which may be subsequently ingested by livestock or humans. The asbestos fibers cause serious perforations to internal membranes, e.g., lung alveoli, stomach or intestinal mucosa. It is recommended that the potentially serious consequences of this danger be carefully researched before this type of pipe is considered for use in the proposed irrigation systems.

Fertilizer use which will be considerably increased in the area will result in an enrichment of drainage and receiving waters. The result may be the increased growth and spread of algae and aquatic weeds, especially water hyacinth. In addition, since the area waters already exhibit extensive algae blooms and heavy water hyacinth infestation, it is likely that these problems would spread through the proposed irrigation systems. This would be somewhat minimized with use of the closed-pipe distribution system; however, primary and secondary

canals would still be susceptible to aquatic weed proliferation.

Consequently, control of aquatic vegetation will undoubtedly be necessary following project implementation. Control may be exercised through three alternative means:

- chemical - application of biodegradable herbicides, such as 2, 4-D, which are harmless to aquatic life;

- biological - introduction of fish, ducks or other animals which feed on vegetation; and

- physical - hand removal

The third method could be combined with a utilization program for the vegetation. Aquatic weeds can be used in compost, as a fertilizing mulch or a supplement to cattle or fish feed. Chopped water hyacinth are presently being used in some areas of Bangladesh for the latter purpose.

5.2.2 Effects on Groundwater

Groundwater quality is not expected to change appreciably following project implementation. The aquifer supply is expected to remain as a high quality irrigation source. However, localized contamination could occur to some wells, especially in terms of persistent pesticides or high nitrogen levels, both the result of run-off following the application of agrochemicals. Either of these contaminants can result in illness to individuals using the water as a drinking supply. High nitrogen concentrations in water can be particularly harmful to small children. Following implementation, wells utilized for human consumption should be periodically sampled to test for nitrogen, pesticides and coliform bacteria.

In the Initial Environmental Examination, concern was raised over the potential reduction of groundwater supplies due to tubewell irrigation. However, this potential adverse impact will not occur, since planning will involve only a removal of a groundwater volume which would be, at the maximum, equivalent to the amount which would be recharged during the monsoon season.

5.3 Impacts on Forestry and Wildlife

The limited forested portions of the project area will be largely unaffected by the proposed development, since project implementation affects only existing agricultural land. It may be advisable in some areas to plant trees along channel banks or as windbreaks for erosion control.

Increased agricultural activities will favor increased populations of potential pest species such as rats, field mice and seed-eating birds, especially green parrots. The increase in aquatic habitat will be beneficial for fish, amphibians and waterfowl. There are no rare or endangered species which would be adversely affected by the proposed project.

5.4 Fisheries

Both capture and culture fisheries production would have a high potential for increased output due to project implementation. The additional water availability through the dry season months could result in an increased annual yield from the affected rivers and khals of almost 18 tons from natural fish stock production. This would amount to a windfall benefit for the project with a value of around Tk 1 million. Details pertaining to additional proposed fisheries development within the context of the project are presented in another section of this report.

Considerable concern was raised in the initial planning phases of the project involving the possible interference with fish migrations because of anticipated control structure operations. Closure of the control structure gates during the upstream in-river spawning migration of Indian carps would prevent their access to breeding grounds, which could subsequently have a relatively important adverse impact on the local capture fisheries industry. Originally, the schedule of operations indicated that the spawning migration would coincide at least partially with a period when the structure gates would be closed.

However, subsequent investigation has revealed that the gates of both proposed structures could be opened for the spawning period, which begins in May and continues through August with the peak in June. Consequently, the potential detrimental impact on carp migration patterns has been completely mitigated in the final plan of operations.

5.5 Impacts on Public Health

Irrigation supply in the dry season will make more water available which will undoubtedly be utilized for consumptive use by local residents. This may be an improvement over present dry season supplies; however, improper disposal of wastes could further contaminate these waters, thus increasing the incidence of waterborne diseases.

Of the prevalent vector diseases, malaria in particular could increase in the project area since the principal carrier--the mosquito *Anopheles philippinesis*--breeds in any quiet water area including rice paddies and other puddled irrigation or storage waters with aquatic surface vegetation

(e.g., water hyacinth). Malaria is not presently considered to be a major problem in the Kushtia/Jessore area, but reintroduction has occurred occasionally. An increase in surveillance in the project area would be warranted to monitor potential increased incidence of malaria and related vector diseases, such as dengue fever or encephalitis.

The potential for the spread of malaria due to the implementation of the G-K Project is about to be investigated by the Health Department. Information obtained from this study should be indicative of possible malaria problems for the project area.

Although the irrigated plots will be very suitable breeding habitats for vector mosquitoes, the application of pesticides will in some cases be beneficial due to toxic effects on the mosquito larvae in the water. On the other hand, this can have some secondary unfavorable impacts. The "Current List of Standardized Pesticides" as approved by the Plant Protection Committee and the Ministry of Agriculture indicates that both malathion and fenitrothion are used to control various insect pests on rice, sugarcane, some vegetables and other crops. These two pesticides are the principal substitutes for DDT in areas where mosquito resistance to pesticide application occurs. However, their unlimited use in cultivated fields enhances the potential for the development of early resistance to either malathion or fenitrothion. Since other pesticides are available, it is recommended that the use of malathion and fenitrothion on crops be restricted to ensure their effectiveness if significant resistance to DDT occurs in the future. Resistance to DDT has already been observed in many Asian countries and in fact subsequent resistance to malathion has also been reported.

5.6 Socio-economic Impacts

Social, economic and financial analyses pertaining to the implementation of the proposed project are all presented in detail in other sections of the report. Consequently, this part of the Environmental Assessment will not duplicate those discussions.

However, a few of the more significant social impacts of the proposed project will be summarized here.

Project implementation is expected to have minimal or no impacts upon current population patterns, distributions or densities.

Changes in some socioeconomic relationships among inhabitants within the communities may be significant. Some problems may arise concerning equity in the distribution of project benefits and services. The establishment of cooperatives will increase inter-dependence of farmers upon one another for labor and marketing requirements. Local leaders or large landowners may attempt to consolidate control over community irrigation schemes.

Another potential problem is land tenure conflicts which may arise in reference to right-of-way provisions for proposed irrigation systems. Similar resource allocation conflicts may become evident with the establishment of fisheries development schemes along the area's rivers and khals and within village tanks or ponds.

Moderate changes in traditional family labor distribution may occur with the increased role of women in the extension of agricultural productivity through management of home vegetable gardens, tending of duck flocks, etc.

With the maintenance of river levels through the dry season, some traditional pedestrian access routes across the Nabaganga River to and from marketing sites may be blocked. On the other hand, river transportation should be improved substantially especially between Magura and Jhenida.

Increased agricultural produce will necessitate improved marketing avenues and methods. Storage facilities may need to be upgraded, especially since a large amount of the surplus produce is expected to be transported to Dacca.

5.7 Energy Demands

The project will require an increase in the amount of petroleum products consumed, chiefly due to pump operation and to increased transportation services required for marketing. However, it is envisioned that pumps eventually will run on electricity. Details in this regard are presented in Volume II as part of the Implementation Plan.

Although the proposed project should not require additional firewood for fuel, overall future demands may exceed supply capacities. Unfortunately, there is apparently no suitable land available for the cultivation of fuelwood tree species; any land so developed would have to be at the expense of agricultural crops. However, some areas, particularly along roads and within homestead plots, could be replanted for future needs; at present, many trees are removed without provision for replanting.

Other fuel sources are available in the area and in fact will be increased due to project implementation. These include rice husks, jute sticks, wheat straw and aquatic weeds. Any or a combination of these materials and others would provide additional fuel supplies, especially with a bio-gas operation. Investigations in this sector are recommended to capitalize upon those potential fuel sources. Wheat straw, however, probably would be more valuable as a livestock feed; it is in fact a more nutritious feed than rice stalks. The large amount of wheat straw which will become available thus constitutes a project benefit for livestock production.

APPENDIX E
BACKGROUND PERTAINING TO FISHERIES DEVELOPMENT

APPENDIX E

BACKGROUND PERTAINING
TO FISHERIES DEVELOPMENT

CONTENTS

1 Introduction

1.1 Capture Fisheries Development Alternatives

1.2 Culture Fisheries Development Alternatives

APPENDIX E

BACKGROUND PERTAINING
TO FISHERIES DEVELOPMENT

1. INTRODUCTION

This appendix contains an evaluation of some potential fisheries development alternatives which were considered for incorporation in the project. The recommended alternatives for more immediate implementation, i.e., supplemental river stocking and irrigation fish culture tanks, were selected largely on the basis of their relatively low-level technology requirements. A number of the fish culture techniques discussed below are technically and economically feasible, but the training, experience and the relatively high degree of technological inputs and management needed are not presently available on a sufficiently broad scale in Bangladesh. However, these schemes are included here as a basis for future implementation.

This appendix also includes a list of some of the relevant planned and on-going fisheries projects in the country.

1.1 Capture Fisheries Development Alternatives

1.1.1 Supplemental Stocking of Beels and Other Natural Depressions

Supplemental stocking of beels and related natural depressions in the project area is unlikely to be an effective means of significantly increasing fish yields. The main reason for this is that there are simply very few beel areas available and those existing are inundated for only three or four months during the wet season. Consequently, water is not available long enough to include a growing season for most fish species. Retaining water in the beels for extended periods by means of control structures, check dams or embankments would be technically feasible, but this would cause conflicts with agricultural cropping which annually occurs in the natural depressions. If perennial water were available, the depressions could be stocked and harvested with capture yields similar to those anticipated for stocked rivers and khals (i.e., yields could be 300 to 500 pounds/acre/year). However, this would probably not exceed economic returns from cropping the beels.

As presently envisioned, beels and other similar swamp-like areas will still be inundated during the monsoon season following project implementation. These areas could be suitable carp fry sources provided that control structure gates could be opened permitting access to mature carps at the onset of the rainy period. This can be determined after final scheduling is outlined for control structure operations.

1.1.2 Stocking of Borrow Areas

Similarly, supplemental stocking of borrow areas could increase fish yields if water was available for long enough periods. However, water reliability in the borrow areas is uncertain. Also, with proposed additional cropping in the project area, the use of pesticides may increase and could be detrimental to fish in the borrow areas since irrigation drainage water will accumulate there. However, continued use of organophosphate pesticides would limit this problem since these pesticides degrade to harmless compounds in a relatively short time after application.

1.1.3 Improved Gear Introductions

It is believed that the present available range of fishing gear is adequate to effectively harvest open water fisheries; consequently, new or more sophisticated gear including motorized craft are not advisable.

1.1.4 Fishing Regulations

Fishing regulations such as limited net mesh sizes, closed seasons or the establishment of fish sanctuaries all can be effective in improving capture fisheries development. However, regulations of this nature are not likely to be realistically effective because of the amount of effort required for surveillance and enforcement. A public information campaign stimulating voluntary conservation practices would perhaps generate more favorable acceptance by the public. An approach of this nature may be recommended if surface waters are stocked with fingerlings; it will be necessary to prevent their capture before they have an opportunity to reach large, more highly marketable sizes.

1.2 Culture Fisheries Development Alternatives

1.2.1 Construction of New Fish Ponds

Generally, the construction of new ponds for fish culturing purposes is not considered a very viable alternative. The reason for this is that suitable available land for new ponds is very limited. In addition, initial capital costs for construction are relatively high (up to Tks 25,000 per pond acre). Finally, there are a sufficient number of existing tanks

and ponds in the project area which could be used for fish culture if water supplies can be made available. Following project implementation and improved water supply systems, a few new ponds might be justified in isolated circumstances.

1.2.2 Use of Village Mini-Ponds

The small village ponds located adjacent to dwellings may in some instances be utilized to culture fish. However, most of these mini-ponds are located at high elevations or are too distant from reliable water sources (even following project implementation). Pumping water up to these ponds may prove too costly.

Management of these tanks could be through existing village farming cooperatives with operations conducted by landless subsistence fishermen. Extension services can be provided from the Unit Extension Officers which are posted in Magura and Jhenida. Labor costs, if not absorbed by families or cooperatives, would include a caretaker and perhaps seasonal assistance for harvesting. The total labor cost would be about Tk 3,500.

1.2.3 Rice Paddy cum Fish Culture

Fish culture as a complementary practice to rice paddy farming may become possible in some areas of the project area following the implementation of irrigation systems. This technique is conducted successfully in other areas of Asia. Investments and management inputs are relatively small; however, resultant fish yields are not usually very high since the fish growing season is short and the amount of water available is limited due to the shallowness of e paddy.

Some modifications to the rice paddy are required to permit simultaneous fish culturing. The bunds must be raised to 1.5 to 2 feet high; screened drains are needed to prevent predator invasions, and refuge holes or trenches need to be dug to enable fish to survive temporary draining. Fish, such as carps or tilapias are stocked about a week or two after the rice plants are firmly rooted. Stocking rates are low, about 500 to 1,000 fingerlings per acre (invesement of Tk 50 to 150). Fish are harvested at the end of the rice growing cycle, but yields are only 10 to 20 pounds per acre, unless the fish are retained for a second cropping period permitting further growth and producing yields of up to 40 pounds/acre. Yields at these levels would be close to the break even point and thus perhaps not attractive to the farmers.

This alternative may not be suitable in the project area since the fish must be raised through two rice growing cycles and water may not be continually available in large enough amounts. More water is usually needed for a rice cum fish system than for rice cropping alone. In addition, pesticides cannot be applied while fish are in the water since their survival would be endangered.

1.2.4 Cage Culture

The culture of fish in floating cages constructed of bamboo and nets may be a viable alternative for producing a supplemental income for a family in the project area.

The cages would be used for a full fish growing season following the proposed water regulation and the subsequent provision of year-round surface water. Cages would occupy up to 20 percent of the river/khal surface area, or about 55 acres (not including the Kumar River), without exceeding natural productivity limits or seriously polluting the water due to excess animal wastes.

However, cages are relatively expensive to construct and maintain, especially since the fish must be fed to insure sufficient yields. A bamboo cage of about 10 by 10 by 5 feet would have the following approximate annual costs:

	INITIAL YEAR		SUBSEQUENT YEARS
Cage construction	Tk 1,500	Cage Maintenance	500
Fingerlings (1000)	150		150
Feed	700		700
Contingency	150		50
TOTAL	Tk 2,500		Tk 1,400

If properly managed, the cage should produce about 500 pounds of fish each year or around Tk 2,250. However, correct feeding procedures are necessary or yields could easily be reduced by half. Similarly, supplemental animal feeds are not readily available and are likely to increase in price significantly in the future which could make cage culture economically untenable. Cage culture also requires constant surveillance to prevent poaching.

With the inherent management problems associated with cage fish culture and the relatively high economic risk involved, this alternative may not be a viable one until farmer/fisherman can be suitably trained in fisheries management techniques. It may be advisable to construct an experimental fish cage project to demonstrate the potential of this technique for future large-scale introduction.

It should be pointed out that a related alternative which involves the use of 5 or 6 floating cages united into a large raft, which also includes a small dwelling, could be considered for use by landless fishermen. However, a large initial capital outlay would be necessary along with an expanded extension training program and a large supply of supplemental feed. The last problem could limit this alternative in the long run. Some rafts of this nature could, however, be installed along the project area rivers and canals.

1.2.5 Pen Culture

Somewhat similar to cage culture, the use of a pen or corral (made of bamboo and nets) located within natural water bodies can also be considered as a means of raising fish in the project area. Pens could also occupy about 20 percent of the available water surface area, but the total of pens, cages and similar structures should not exceed 20-25 percent.

Fish pens usually must be of a relatively large size to generate sufficient economic return, but yields can be very high even without supplemental feeds or fertilizers being used. Rough costs estimated for a one-acre fish pen are:

	INITIAL YEAR		SUBSEQUENT YEAR
Pen construction	Tk 8,000	Pen Maintenance	Tk 2,000
Fingerlings (5000)	750		750
Labor	3,500		3,500
Equipment/year	2,500		500
Contingencies	2,500		250
TOTAL	Tk 15,000		Tk 7,000

Yields from this type of fish pen should be at least 2,000 pounds/acre annually which at current farm-level prices would be about Tk 4,000. The pens in fact could easily produce much higher yields, and levels of more than 5,000

pounds/acre are not uncommon in other Asian pen culture operations. Also, labor may not be a real cost if family originated.

However, pen culture has a number of serious constraints. One is that the pens occupy traditional fishing grounds, reducing open water catches, and can result in conflicts between the pen owner and local fishermen. Another is that, like cage culture, this is a relatively sophisticated culturing technique which would require considerable training and extension inputs. Finally, the initial capital outlay as well as maintenance costs for a pen are relatively high, well beyond the resources of most fishermen. Consequently, pen culture is normally operated to the benfit of a wealthy investor rather than subsistence, landless fishermen. This may limit the viability of pen culture activities in the project area.

1.2.6 Poultry cum Fish Culture

The use of this type of integrated farming system in the project area may be very viable, since management inputs are low and potential economic returns can be very high. The system would involve constructing a chicken or duck pen overhanging a fish pond, perhaps utilizing one of the small tanks adjacent to a project irrigation system. Manure falling from the poultry pen would fertilize the fish pond naturally, thus reducing the need (and cost) for artificial fertilizer application. In addition, ducks in particular, can obtain highly suitable forage in and around a fish pond without causing any detrimental effects on the fish populations; this of course also reduces the cost of supplemental feed for the ducks.

A typical one-acre fish pond, stocked annually with 4,500 fish fingerlings, could be integrated with a duck/chicken raising operation of about 500 birds. Approximate costs would be as follows:

POULTRY COSTS

	INITIAL YEAR		SUBSEQUENT YEAR
Pen construction	Tk 5,000	Pen Maintenance	Tk 500
Ducks/chickens	2,000		1,000
Feed	1,500		1,500
Contingency	1,500		500
TOTAL	Tk 10,000		Tk 3,500

FISH POND COSTS

	INITIAL YEAR		SUBSEQUENT YEARS
Pond rehabilitation & weed clearing	2,500	Pond O & M	500
Fingerlings	700		700
Gear	1,000		250
Contingency	300		150
TOTAL	Tk 4,500		Tk 1,600

Thus, total costs for the integrated system would be Tk 14,500 in the first year and Tk 5,100 in following years. Labor costs are not included; they may be attributed to a family income or a village cooperative system. Labor could include a caretaker and perhaps some seasonal harvesting assistance to bring the total costs to about Tk 3,500 per year.

Returns from an integrated system of this nature could be substantial. A conservative estimate would be:

OUTPUT ITEM	CURRENT PRICE	GROSS INCOME
50 eggs per duck/chicken	0.50 each	12,500
250 ducks/chickens	25 each	6,250
1000 pounds of fish	4.5/pound	4,500
	TOTAL =	Tk 23,250 per yr.

Fish yields and egg output used here are very conservative and could easily be doubled or tripled.

1.3 Fisheries Projects Planned for the Second Five-Year Plan

1. Reorganization of the Directorate of Fisheries
2. Strengthening of the Planning Cell of the Directorate of Fisheries
3. Intensification of Fisheries Extension Service
4. Fisheries Training Academy
5. Establishment of Regional Fisheries Training Centers
6. Fisheries Resource Survey System
7. Bangladesh Aquaculture Development Project
8. Development of Fisheries in the Chandpur, Mahuri and Karnafuli Irrigation and Flood Control Project Area
9. Expansion of the Scheme for Construction of Fish Seed Multiplication Farms

10. Ox-bow Lake (baor) Fishery Development Project
11. Neemgachi Fish Culture Project
12. Supply of Fingerlings for Fish Culture in Canals
13. Feasibility Study of Gulshan-Rampura Fish Culture Development Project
14. Scheme for Establishment of Ancillary Facilities of Aquaculture Experiment Station, Mymensingh
15. Development of Village Fish Pond
16. Utilization of Roadside and Homestead Ditches
17. Establishment of Union Fish Seed Farm
18. Thana Demonstration Fish Farm
19. Establishment of Fish Seed Bank
20. Development of Fishery in Nandigram P.S. Begra
21. Development of Fishery in Kurigram Sub-Division, Rangpur
22. Catfish (Magur) Culture Project
23. Greater Dacca City Fishculture Feasibility Study Project
24. Extension of Shrimp and Fishculture in Coastal Districts
25. Establishment of Brackish Water Research Institute
26. Marine Fisheries Exploration and Biological Research Station at Cox's Bazar
27. Dry Fish Production
28. River Fishery Investigation Project (Utilizing the Research Vessel "Machranga")
29. Expansion of Scheme for Fish Inspection and Quality Control
30. Scheme for Enforcement of the Provisions and Rules of the Fish Act
31. Fish Habitat Development in the Rivers and Baors
32. Project for Scientific Management of Karnapuli Reservoir for Increased Production
33. Establishment of Fishery Bank
34. Development of Fishery in Halda and Ichamati Irrigation Project
35. Development of Fishery in Mahuri Irrigation Project
36. Establishment of a Giant Prawn (Golda Chingri) Hatchery
37. Establishment of a Fisheries Technological Laboratory at Chittagong

APPENDIX F
ON-FARM DEVELOPMENT

APPENDIX F

ON-FARM DEVELOPMENT

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3 Summaries of Selected Pump Groups' Records of Accomplishments

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5 Suggestions for a Homestead Plot Production Program

TABLES

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F-1	Foodgrain Program in SFYP
F-2	Selected Major Physical Targets in Agriculture in the SFYP
F-3	Irrigation Program in SFYP
F-4	Employment Projections

1. SUMMARY OF SECOND FIVE YEAR PLAN

1.1 Strategies for Agricultural Production

The Government's Second Five Year Plan (SFYP), for the period 1979-80 to 1983-84, seeks rapid growth in agricultural production and productivity. The Plan recognizes that without rapid change in agriculture there can be hardly any rural or national development in Bangladesh or significant reduction in poverty or unemployment. The Plan emphasizes the urgency of efforts to give major importance to increasing agricultural production.

The principal constraints to increasing agricultural production in irrigated land as well as in rainfed areas, which will constitute some 70 percent of the cultivated acreage by the end of the SFYP period, may best be identified by the factors to receive priority attention in the Strategy for Agricultural Production, as presented in the SFYP. Among these are:

- Self-sufficiency in food grains at a higher level per capita consumption combined with more balanced diets, through substantial increases in the production of oil-seeds, pulses, vegetables, fish, and poultry.

- Proper institutional changes and appropriate policy measures relating to the supply of inputs and supporting services, viz.,irrigation water, fertilizer, pesticides, improved seeds, credit, extension services, price -support measures, and marketing facilities. Food policy will be integrated with agricultural production.

- Increased irrigation coverage combined with expanded cultivation of HYVs of rice and wheat supported by intensive management. Irrigation coverage will be more than doubled during the SFYP, the priority areas being minor irrigation projects (such as LLP's DTWs, and SYWs), with full utilization of the capacity of existing and proposed irrigation facilities and provision of supplementary irrigation during Aus and Aman seasons.

- The area under HYVs of rice and wheat will be expanded substantially and fertilizer use will be doubled during the SFYP. Availability of fertilizer will be assured not only by better utilizing the capacity of existing fertilizer plants but also by setting up new plants at an early date and by planned imports. Better and massive use of organic manures will also be introduced. Seed multiplication and storage, both in public and private sectors, will be

part of the production plan. Credit facilities will be increased, not only by making greater allocation of funds but also by administering them better so as to ensure better recovery. A major effort will be made to ensure adequate marketing facilities, including transport and storage, without which increased production will generate serious problems. Subsidies for inputs will be reduced on a planned basis, with a definite timetable for drastically reducing them within the next five-year period. Efforts will be made to initiate production of most of the inputs required for ariculture and rural development including fertilizer, implements, and tools.

Proper incentive prices for rice, wheat, sugarcane, and jute will be maintained. Procurement and storage efforts have to be greatly improved. Adequate bufferstocks will be assembled to tide over the difficulties of possible lean periods. If possible, a marketable surplus should be aspired to. Consistent demand management will be undertaken, and the rationing system will be eliminated progressively. Prices of major food items such as rice, wheat, edible oil, sugar, baby food, pulses, fish, poultry, milk, etc., may have to be stabilized through appropriate pricing, distribution, and production policies.

In addition to the above, the Plan explicitly describes the strategy in which the policy will be implemented in rainfed as well as irrigated areas.

1.2 Second Five Year Plan Production Goals

The SFYP aims at increasing food production from a benchmark figure of 13.5 million tons in 1979-80 to just over 20 million tons in 1984-85 (see Table F-1). Most of the increase in production is expected to come from increasing the cropping index and from increases in crop yields. While the area under rice crops is expected to remain about the same, a major expansion of wheat and other crops is planned for the winter season. In 1984-85 the dominance of rice in total food grain production is expected to be reduced to 89 percent, compared with 94 percent in 1979-80. The changes in food grain production are expected to increase per capita consumption from 15.4 oz. per day to 17.2 oz. per day over the plan period.

TABLE F-1

FOODGRAIN PROGRAM IN SFYP

	1979-80			1984-85		
	Area thous. Acres	Production thou. tons	(%)	Area thous. acres	Production thou. tons	(%)
Rice						
Aus	7,795	3,103	(23)	8,000	4,830	(24)
Aman	14,260	7,422	(55)	14,000	9,550	(48)
Boro	2,703	2,239	(16)	3,000	3,400	(17)
Total	24,758	12,764	(94)	25,000	17,780	(89)
Wheat 1/	900	716	(5)	2,500	2,250	(11)
Coarse Grain	219	59	(-)	150	75	(-)
Total	25,877	13,539	(100%)	27,650	20,105	(100%)

1/Source: SFYP, page XII-24,
Wheat area and production variously estimated up to 1.4 million acres and 1 million tons, respectively.

Projected increases for sugarcane, patato, pulses and other crops, as sell as for livestock and fisheries production, are given in Table F-2. In addition, it can be seen that oil seed production is to be increased by 135 percent, from 255 thousand to 600 thousand tons. This increase will help reduce the import portion of total edible oil consumption, which currently stands at about 60 percent.

TABLE F-2

SELECTED MAJOR PHYSICAL TARGETS IN AGRICULTURE IN THE SFYP

Item	Unit	1979-80	1984-85	Increase (%)
Rice (HYV)	Million tons	12.8	17.8	39
Wheat 1/	Million tons	0.7	2.2	206
Jute	Million bales	5.4	6.5	21
Tea	Million lbs.	81.6	95.0	61
Tobacco	Million lbs.	109.6	135.1	23
Sugarcane	Million tons	6.7	7.8	17
Potato	Million tons	1.6	2.0	25
Oil-seeds	Million tons	0.3	0.6	135
Pulses	Million tons	0.2	0.4	101
Cotton	Thousand bales	4.0	263.0	large
Milk & Milk Products	Million tons	1.5	1.6	7
Meat	Million tons	0.3	0.4	22
Eggs	Million eggs	4.7	5.1	8
Timber & Fuelwood	Million cu. ft.	99.8	126.8	27
Rubber	Thousand lbs.	157.0	560.0	256
Fisheries 2/	Million tons	0.64	3.0	464

Source: SFYP, page III-7

1/ Latest wheat estimate is 1.1 million acres.

2/ Recent adjusted target.

Finally, the agricultural sector is expected to play a major role in increasing foreign exchange earnings and import substitution. Currently about 80 percent of foreign exchange earnings in trade comes from jute exports. Tea also generates foreign exchange. Production increases of 21 percent in jute and 16 percent in tea are planned over the next five year period.

The Plan provides for expanded irrigation to play a critical role in increasing crop yields and employment. Net irrigated area (NIA) is to be increased from 3.7 million acres in 1980 to 7.2 million in 1985 (see Table F-3).

TABLE F-3

IRRIGATION PROGRAM IN SFYP

	1980 Expected			1985 Target		
	No. (Thousands)	Acres (Thousands)	%	No. (Thousands)	Acres (Thousands)	%
Public						
BWDB		240	7		1,000	14
BADC						
LLP 1 cusec	-			10	250	3
2 cusec	37	1,480	40	40	1,800	25
STW	15	150	4	90	1,125	16
DTW	11	605	17	25	1,500	21
HTW	50	20	1	300	90	1
Private						
BKB-STW	12	120	3	30	375	5
IRDP-HTE	120	48	1	200	60	1
Traditional	-	1,000	27		1,000	14
Total		3,663	100		7,200	100

Source: SFYP, page XII-80

Irrigation facilties are expected to provide water during the winter period and supplemental irrigation during the monsoon. In Bangladesh careful irrigation management is especially important as the monsoon and occasional winter rains are unreliable and controlled irrigation can greatly reduce risk and uncertainties.

In the past the major sources of irrigation have been two-cusec cooperative low lift pumps (40 percent of NIA), cooperative deep tubewells (17 percent of NIA), and traditional methods such as donor and swing buckets (27 percent of NIA). By the end of the Plan period it is expected that the types of irrigation methods will have been diversified considerably. The Bangladesh Water Development Board (BWDB) will provide 14 percent of NIA, mainly from canal schemes. Through planned increases one-cusec cooperative low lift pumps will provide 3 percent of NIA, and shallow tubewells in the cooperative and private sectors will provide a total of 86 percent of NIA by 1985, most of the planned developments indicate a shift in technology toward more divisible units that are more suitable than larger units to the extremely complex hydromorphic, agroclimatic, and socio-economic conditions of Bangladesh.

1.2 Irrigation Research

Reserach and development work on irrigation in Bangladesh is scattered among a number of institutions including BARC, BARI,

BAU, BMD, BRRI, BUET, BWDB, IRDP, INA and BADC. Some of these institutions operate their own irrigation research stations. The number of institutions involved in water research may perplex the person interested in research organization and management. BARC has attempted to overcome the duplication of research and lack of communication between reserach units by forming a task force on soil and water management.

From the information on irrigation in the study, it would appear that potential gaps include:

- Knowledge of traditional systems of irrigation. Perhaps more than one-third of irrigated lands are served by dhones and swing baskets, yet little appears to have been done (except at BUET) to understand these systems, or the farmer's reasons for using them. These systems should also not be seen as alternatives to "modern" techniques; rather, parts of these well-tried systems might be integrated into modern schemes.

- Knowledge of hand pumps and hand tubewells. Research, including joint technical-cum-economic and sociological studies, should assess potentials for increasing their use and effectiveness through an alternative "package" of technologies and institutional arrangements. The improvement and expansion of the "rower pump" (a special action hand pump) would appear to have promise.

- The reasons for the less-than-satisfactory operation of deep tubewells. These appear to have been designed to irrigate much more land than is being served. This research should be done by multidisciplinary teams which can examine engineering, agronomic, and socio-economic factors, including rural institutions, that are determinants of water use at farm level.

- Knowledge of irrigation schemes where water is being used optimally and very high command area development potential is being achieved. The practical solutions to many water management problems may already exist in some locations in Bangladesh.

The Nabaganga Integrated Land and Water Resources Development Project will work closely with BARC, BARI, FAO, the World Bank, and programs which USAID is collaborating with as well as programs funded by the Ford Foundation for On-Farm Water Management Research and will try to utilize findings and recommendations from these various reserach programs in establishing and setting up on-farm water management programs using proven methodologies and approaches from these research programs being conducted in Bangladesh.

1.4 Rural Development

The reduction of rural poverty is a dominant theme of the Plan and most of the burden for providing nutritional needs, generating employment, and for supplying exports falls on the agricultural sector.

Currently it is estimated that 79 percent of all employment in Bangladesh is provided by crop production and non-crop activities, such as livestock and fisheries, in the agricultural sector. The capacity of non-agricultural activities to employ people gainfully over the next five years is slight compared with the national need for over 5 million additional jobs (Table F-4). Even if these jobs are generated there will still be widespread unemployment or seasonal unemployment.

Achieving the employment goal is essential for development objectives in two ways. First, it is only through employment that the rural households who possess no land, or have less than 0.5 acres, can obtain an income and share in the benefits of increased output. Second, employment for poor people is essential in order to generate enough purchasing power to create an effective demand for food grains. Without this effective demand, food prices will fall and food production will decline. In summary, the Plan places great emphasis on labor intensive methods of improving farming systems and soil and water management practices in order to use scarce resources effectively, increase food production, and to generate employment in Bangladesh.

TABLE F-4

EMPLOYMENT PROJECTIONS

	1978-79		1984-85		Increase over SFYP
	Millions	%	Millions	%	%
Agriculture					
Crop production	12.40	49	14.41	47	16
Non-crop activities	7.59	30	8.80	29	16
Total	19.99	79	23.21	76	16
Industry	1.19	5	1.90	6	60
Other	4.12	16	5.37	18	30
Total Employed	25.30	100	30.48	100	20
Population	90.25		100.79		12

Source: SFYP, page VI-7

1/ For example livestock, fisheries, procuring, marketing and capital formation.

On October 1, 1980, Agriculture and Forestry Minister, Mr. Naral Islam, addressed a seminar organized by the Institute of Diploma Engineers on "Application of Technology and Second Five-Year Plan in the Efforts of Doubling Food Production" as printed in the Bangladesh Times of Oct. 9, 1980.

"Referring to the objectives of the SFYP in agriculture sector, the Minister said that target had been set to increase food production to 20 million tons by 1984-85 by expanding irrigation facilities and utilizing improved farm practices. 'Farmers on their own come to us to ask for improved farm inputs and take up canal digging programmes in their localities. Earlier, we had to go to them to pursue a development project of this kind', he said. Mr. Islam stressed the need for establishing increased number of agro-based industries in the country which he said would also generate employment opportunities.

"He said under the seed-based technology, there is every possibility of increased cost of production of food crops. A farmer will have to sell every thing -- right from the straw to bran -- to ensure the return of production.

"'For instance,' he said, 'we produce some lakhs of tons of paddy. But we don't have any industry which can use rice bran.' He said that establishment of increased number of agro-based industry could facilitate the utilization of the whole of a good crop."

This project will develop opportunities for promoting and establishing agro-base industry in the Maguru Area, utilizing private industry or groups of villagers and other persons who may be interested in setting up small units utilizing local labor, either from farm families or from landless in the area. One example is for numbers of individuals or groups to form a construction company which could dig water channels or construct distribution systems for pump groups. Other opportunities will emerge for developing skills and expertise in the operation and maintenance of pumps and pump motors. As agricultural production increases and diversifies, there will be opportunities for developing pre-processing type of agri-business units for food and fiber crops utilizing local labor.

2. SELECTED PUMP GROUPS IN DONOR ASSISTED PROGRAMS

2.1 Introduction

As part of our analysis of current on-farm water management practices associated with various programs, we began an investigation of some specific pump groups. The following two cases are presented as illustrative of current conditions, problem areas and program strategies.

2.2 Case #1

Place: Madhyamar Seo, Bogra Deep Tube Well Project
Program Title: RD 1. Funding Angency: World Bank
Implementing Agency: IRDP

2.2.1 Organization

The Deep Tube Well Project was organized by an individual Mr. F. Rahman who is an overseer in the Circle Officer's office. This connection was instrumental in the organization because the approval for the deep tube well is given by a committee headed by the C.O.

The IRDP became active in the area in 1979. At that time no credit system was operating. The program offered this group a credit program and a system of water management. The deep tube well had been obtained from the BADC which assured the members that if a machine breaks down it will be repaired or replaced.

2.2.2 Criteria for Membership in the Pump Association

The criteria for membership in the pump association is landholding in the command area. Anyone in the command area is eligible for credit through the IRDP program.

2.2.3 Structure of the Pump Association

There are currently 135 members in the association. The manager is the effective decision maker. He is a major landowner in the system (the original organizer has been transferred).

2.2.4 Institutional Credit

Institutional credit is provided through the RDI project of the IRDP. Credit is organized at the local level through the KSS system. However, in this program some of the original rules of the cooperative are not binding. According to strict cooperative rules, members buy shares and contribute to an enforced savings plan. This aspect has been relaxed; there are no shares and no enforced savings. Money for fuel is deposited in advance by the manager to the RDI. Credit is contingent upon a production plan. Supervision is provided each day by RDI. RDI provides

inspectors and village accountants. Repayment is expected after the season. But if similar to other RDI projects, it may not be repaid.

2.2.5 Staff

In this particular village, the KSS members are also land holders in the pump association. The KSS therefore represents a single pump association. The pump association or KSS hires:

1. Drainman
2. Scheme manager
3. Pump Driver
4. Night Guard

The IRDP provides village accountants, inspectors and three assistant project officers.

2.2.6 Pump Ownership

Pumps are government owned, and rented to the KSS by the BADC.

Rental cost is 1200 taka per year (about $80 U.S.). The pumps are well financed by the World Bank Loan to the Government of Bangladesh. Repayment is provided by rentals from the BADC.

2.2.7 Field Channels

The field channels were laid out by the BADC staff of the Ihana level. The staff are diploma level engineers. This was done after the RDI program was initiated. The channels were constructed by the RDI and are maintained by the KSS; that is, the manager hires labor to maintain them.

2.2.8 Right of Way

Channels were designed for the boundary line. Those who lost land as a result of the irrigation channels were not repaid.

2.2.9 Payment for Construction

Although the KSS should pay for construction of field distribution channels, the RDI project actually paid for the construction which was free to the members.

2.2.10 Payment for Water

Members pay the manager in advance of each season (the advance is provided by IRDP credit). Cost per acre are 400 taka for paddy and 200 taka for wheat. (These costs include oil, fuel, pump rental, manager salary.)

2.2.11 Water Distribution Schedule

The command area has been made into six blocks, one block for each day of the week. The drainman supervises that the schedule is maintained and opens channel mouths. He has received training at the Ihana level for BADC personnel.

2.2.12 Farm Inputs

Fertilizers are distributed from RDI go downs. Seed is available from the BADC. (RDI and BADC work together for this project.) Both fertilizers and seeds are at subsidized prices.

2.2.13 Crops

The crops grown under irrigation are boro rice and some wheat in higher areas.

2.2.14 Siting of Pumps

The pump is on Mr. F. Rahman's land since he was the sponsor of the program.

2.2.15 History of Organization

The pump was operating at reduced command area prior to the arrival of RDI. The RDI project began in early November and accomplished results for the November to June season. This has been made possible by continued supervision and the incentive of agricultural loans.

2.2.16 Land Ownership Registration

The RDI project attempted to obtain land registration for all the members of the KSS for all of their lands. This was resisted. However, all the land within the command area of the pump is now recorded by the KSS.

2.3 Case #2

Place: Char Bana Baria, Sirajganj
Program: SIRDP (Seranjganj Integrated Rural Development Program)
Funding Agency: Asian Development Bank

2.3.1 Organization

The SIRDP organized a demonstration farm on the land of a very well-to-do land owner in the area. The site was chosen because of proximity to the town. The pump is a 3/4-cusec shallow tubewell.

2.3.2 Structure of the Pump Association

The major land owner is the manager of the association. There are a total of eight members representing an extended family and 2 outsiders. Decision making in such a small group can include everyone.

The criteria for membership in the association is land ownership in the area.

2.3.3 Institutional Credit

Credit is provided by the IRDP through the village KSS. The only active members of the KSS are part of this shallow tubewell scheme. Loans are provided previous to the season based on a production plan. Repayment is made at harvest time. The record of repayment is unknown but may be quite high given the reputation of the group with program staff.

2.3.4 Construction of Channels

A simicircular pucca channel has been provided by the SIRDP as a demonstration. The materials are manufactured nearby, purchased and constructed by the SIRDP.

2.3.5 Ownership of Pump

The pump is owned by the group. It was obtained from the BADC at a cost of 20,000 taka which is the same as the BADC price. It is being repaid in installments of 1,000 taka per season and will be paid off in 8-10 more years.

2.3.6 Water Payment

The costs of fuel and installments on the pump are paid in advance from members to manager. Credit is advanced by the SIRDP.

2.3.7 Field Channels

These were laid out by the SIRDP, based on soils survey team topographic maps. They were constructed by the SIRDP and are maintained by the KSS. Rights-of-way were donated by members.

2.3.8 Water Distribution

The pattern of water distribution is set by the manager, but the group is small and all participate. The pump operator is the manager's son. He has received training from the BADC.

2.3.9 Farm Inputs

Fertilizer and seed are obtained from the BADC, but the SIRDP helps the group obtain these inputs.

2.3.10 Siting of Pump

The pump is on the household plot of the major landowner. There is therefore no need of a night guard. This was decided between the landowner and the SIRDP.

3. SUMMARIES OF SELECTED PUMP GROUP' RECORDS OF ACCOMPLISHMENTS

The charts in this section compile data on working pump systems, the extent of their operation, in some cases their effectiveness, and as far as possible an evaluation of operational problems.

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Bijoynagar	26.1.70			DTW						101						
Gopalpur	15.2.70			DTW						13						
Krishnabati	13.3.70			DTW						49						
Lawkhali	2.2.70			DTW						-						
Panchbaria	5.1.71			DTW						48						
Ramnagar	29.12.70			DTW						30						
Ghurulia	2.2.72			DTW						50						
Sultanpur	2.2.72			DTW						47						
Hashimpur	6.5.73			DTW						11						
Bagdanga	6.5.73			DTW						62						
Durgapur	5.12.72			DTW						60						
Teghoria	6.2.73			DTW						15						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Crop-ping Pattern	Yields /AC	Major Reasons for Difference
Khojarhat	20.1.73			DTW						75						
Bijoynagar	26.6.72			DTW						100						
Mondalghathi	28.3.73			DTW						78						
Kazipur	8.1.73			DTW						80						
Bhaturia	12.12.72			DTW						34						
Rajapur	28.4.73			DTW						40						
Bhaina	5.5.73			DTW						8						
Munsheppur	14.2.73			DTW						50						
Rohelapur	1.8.72			DTW						88						
Sarapole	6.2.73			DTW						-						
Dakatia	25.11.72			DTW						108						
Mahidia	24.1.73			DTW						37						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Sheikhhati	17.3.73			DTW						-						
Shirajshinga	14.3.73			DTW						88						
Kharki (Chanchra)	10.8.72			DTW												
Joghati	21.3.73			DTW						37						
Dogachia	27.4.73			DTW						84						
Khitibdia	19.7.77			DTW						28						
Manikdihi	14.2.77			DTW						75						
Talbaria	1.3.73			DTW						50						
Balarampur	30.4.73			DTW						33						
Bowlia	30.10.75			DTW						-						
Bahadurpur	9.2.77			DTW						22						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Chanchra	30.1.75			DTW						90						
Kashimpur	11.2.75			DTW						95						
Kamalpur	6.2.75			DTW						97						
NorthLalitadah	28.1.75			DTW						151						
Khorichadanga	11.1.75			DTW						58						
Baniali	27.1.75			DTW						22						
Narendrapur	11.2.75			DTW						28						
Sujalpur	17.9.76			DTW						65						
Basundia	26.2.76			DTW						57						
Jhawdia	6.1.75			DTW						36						
Baromeghla	20.12.74			DTW						73						
Kachua	22.2.75			DTW						47						

SUMMARY

SELECTED PUMP GROUPS RECOPD OF ACCOMPLISHMENT

Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Peasons for Difference
Vekutia	17.2.75			DTW						38						
Arjiamdabad	31.3.75			DTW						60						
Chandpara	6.1.75			DTW						2						
Isali	17.2.76			DTW						83						
Cantonment	7.1.75			DTW						9						
Arpara	1.2.75			DTW						41						
Cantonment	7.1.75			DTW						25						
Churamonkati	21.3.75			DTW						48						
Sekarigathi	15.2.75			DTW						72						
Hogladanga	18.6.74			DTW						68						
Cantonment	16.1.75			DTW						-						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Ghuni	11.6.77			DTW						80						
Kayetkhali	3.1.75			DTW						45						
Padmabilla	30.11.78			DTW						40						
Kismatrajapur	3.2.75			DTW						108						
Sirajshinga	1.2.75			DTW						97						
Dhopakhola	15.2.76			DTW						43						
Dumdia	11.1.75			DTW						123						
Hashimpur	6.1.75			DTW						61						
Cantonment	15.6.75			DTW						35						
Cantonment	16.6.75			DTW						22						
Bagdanga Rajapur)	24.2.76			DTW						72						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Crop-ping Pattern	Yields /AC	Major Reasons for Difference
Muruli	15.2.77			DTW						-						
Daulatdihi	12.2.77			DTW						133						
Birnarayanpur	28.1.77			DTW						81						
Narangali	30.6.76			DTW						40						
Bijoynagar	17.2.77			DTW						102						
Bahirmallik	25.2.77			DTW						92						
Isali	11.2.77			DTW						68						
Chowlia	14.2.77			DTW						74						
Ramnagar	29.1.77			DTW						119						
Chanchra (Shankarpur)	29.1.77			DTW						82						
Daharpara (Nowdagram)	14.2.77			DTW						72						
Panchbaria	28.1.77			DTW						71						
Berbari	27.1.77			DTW						103						
Paranpur	13.2.77			DTW						84						
Chanchra (Bormanpara)	29.1.77			DTW						72						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

LLP Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Rudrapur	13.6.77			DTW						90						
Mahidia	17.3.77			DTW						90						
Goaldah	1.6.77			DTW						93						
Dangaboyra	15.3.77			DTW						95						
Gawghara	16.3.77			DTW						200						
North Lalitadah	28.3.77			DTW						123						
Sorsunadaha	30.5.78			DTW						95						
Agrail	30.5.78			DTW						66						
Dalennagar	30.5.78			DTW						83						
Salta	25.11.78			DTW						38						
Kismatrajapur	18.12.78			DTW						59						
Panchbaria	18.12.78			DTW						19						
Sharaidanga	5.12.78			DTW						48						
Dogachia	29.11.79			DTW						-						
Raimanik	30.10.79			DTW						-						
Lawkhali	30.11.79			DTW						-						
Mohiron	2.2.70			DTW						21						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Panchbaria	30.3.77			DTW						68						
Daulatpur	20.2.75			DTW						80						
Bakri	30.3.77			DTW						85						
Dohakhola	28.1.77			DTW						78						
Basuary	12.12.74			DTW						75						
Saitkhali	12.12.74			DTW						102						
Joyrampur	2.1.75			DTW						61						
Bhitaballa	18.12.74			DTW						56						
Saibaria	5.2.76			DTW						136						
Kanapukur	20.4.75			DTW						48						
Talbaria	10.4.75			DTW						56						
Bagharpara	28.1.77			DTW						96						
Teghori	29.1.77			DTW						63						
Majhaile	30.1.77			DTW						71						
Bhitaballa	28.3.77			DTW						91						
Nittanandapur	28.3.77			DTW						65						
Basuary	26.3.77			DTW						110						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Kholadanga	9.12.78			DTW						43						
Datpur	-			DTW						-						
Jamdia	-			DTW						-						
Daksinmath Saratali	28.4.79			DTW						-						
Depkhali	10.11.79			DTW						-						
Purbapara	-			DTW						-						
Sekendarpur	29.11.79			DTW						-						
Dakshin Mohiron	25.11.79			DTW						-						
Roypur	-			DTW						-						
Barokhudra	-			DTW						-						
Khalia	-			DTW						-						
Chanchra	26.1.77			DTW						108						
Kirtipur	1.1.70			DTW						100						
Salua	23.1.70			DTW						10						
Joykrishnapur	16.3.73			DTW						43						
Sharifpur	18.1.75			DTW						124						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Panishara	16.3.73			DTW						14						
Shiordah	16.3.73			DTW						50						
Matikumra	1.4.73			DTW						69						
Jafarnagar	8.5.73			DTW						100						
Krishnagar	1.4.73			DTW						22						
Mirzapur	15.12.72			DTW						60						
Rispopur	28.1.75			DTW						130						
Bakra	29.1.75			DTW						119						
Hazerali	29.2.76			DTW						72						
Parlla	24.2.76			DTW						66						
Mirzapur	28.5.74			DTW						55						
Jamalta	18.1.75			DTW						34						
Fulsara	23.2.75			DTW						18						
Laskarpur	24.2.75			DTW						60						
Rainagar	4.1.75			DTW						65						
Syedpur	14.2.77			DTW						53						

SUMMARY

SELECTED PUMP GROUPS RECOPD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Roypaton	25.5.78			DTW						60						
Sankarpur	11.7.78			DTW						63						
Ista.	25.5.78			DTW						60						
Kumri	12.7.78			DTW						100						
Borni	31.1.79			DTW						8						
Olakol	30.1.79			DTW						10						
Bodkhana	16.10.78			DTW						100						
Chottopodawlia	17.2.79			DTW						1						
Gulbugpur	12.12.78			DTW						7						
Asingri	13.12.78			DTW						17						
Kaliani	13.12.78			DTW						10						
Uttardaulia	27.10.78			DTW						44						
Kalagachi	20.9.78			DTW						79						
Bishnapur	28.10.78			DTW						100						
Baisha	10.10.78			DTW						32						
Hariadiara	16.10.78			DTW						60						
Majhali	11.10.78			DTW						22						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Mirzapur	16.10.78			DTW						42						
Lawjani	26.11.78			DTW						81						
Samlagachi	26.1.70			DTW						51						
Degha	9.2.70			DTW						35						
Benapole	15.12.70			DTW						62						
Chatkapota	14.12.72			DTW						90						
Samlagachi	2.12.72			DTW						80						
Barobaria	8.5.73			DTW						65						
Basatpur	8.5.73			DTW						65						
Amlai	8.5.73			DTW						125						
Ulashi	15.3.73			DTW						85						
Dhalda	8.5.73			DTW						107						
Bagachra	15.3.73			DTW						115						
Pipragachi	8.5.73			DTW						60						
Kagojpukur	22.2.73			DTW						68						
Chotoachra	26.3.74			DTW						68						
Raghunathpur	28.12.74			DTW						132						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Peasons for Difference
Boaliamanik	12.1.75			DTW						24						
Balunda	24.1.75			DTW						151						
Lawtara	14.2.75			DTW						90						
Baripota (Kulpala	23.4.75			DTW						100						
Dihi	24.4.75			DTW						86						
Sikarpur	26.4.75			DTW						78						
Ramchandrapur	27.4.75			DTW						102						
Kandarpur	30.1.75			DTW						116						
Ramchandrapur	10.4.75			DTW						-						
Tengra	27.2.75			DTW						93						
Bhaberber	24.2.75			DTW						-						
Rampur	17.2.75			DTW						91						
Kaliani	30.4.75			DTW						185						
Kaliani	23.11.76			DTW						140						
Narayanpur	15.2.77			DTW						46						
Dhannakhola	15.2.77			DTW						77						
Kulpala (Baripota)	24.1.78			DTW						50						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Samlagachi	30.1.78			DTW						82						
Kulpala	26.2.78			DTW						148						
Kulpala	28.2.78			DTW						66						
Ulashi	15.9.78			DTW						59						
Bagachra	30.10.78			DTW						77						
Baikola (Panchkaiba)	17.10.78			DTW						92						
Tengra	14.10.78			DTW						133						
Mohishakura	29.11.78			DTW						80						
Dhalda (Ramerdanga)	31.10.78			DTW						101						
Rampur	16.10.78			DTW						130						
Lawtara	26.11.78			DTW						103						
Panthapara	10.8.78			DTW						66						
Durgapur	16.5.78			DTW						103						
Kulpala	26.10.78			DTW						94						
Samlagachi	13.9.78			DTW						80						
Dighirpar	13.10.78			DTW						52						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Sadipur	12.10.78			DTW						80						
Sammandhakati	30.11.78			DTW						70						
Ulashi (Katuria)	30.11.78			DTW						122						
Kagojpukur	14.12.78			DTW						30						
Boaliamanik (Boalia)	-			DTW						-						
Boaliamanik (Mankia)	-			DTW						-						
Dhannakhola	30.10.79			DTW						-						
Shibchandrapur	7.10.79			DTW						-						
Narikelbaria	-			DTW						-						
Lakhanpur	30.11.79			DTW						-						
Paksia	28.11.79			DTW						-						
Balunda	-			DTW						-						
Bagachra	26.11.79			DTW						-						
Fatehabad	25.12.70			DTW						14						
Joypur	14.3.70			DTW						15						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Kodlapara	24.3.70			DTW						-						
Hashadanga	14.3.70			DTW						50						
Jamjami	2.4.77			DTW						40						
Rohita	3.4.77			DTW						65						
Majidpur	7.11.69			DTW						-						
Sarfabad	5.3.70			DTW						30						
Pathra	14.4.70			DTW						47						
Panjia	5.3.70			DTW						40						
Prembag	6.2.70			DTW						32						
Guakhola	6.2.70			DTW						40						
Buikara	26.1.70			DTW						40						
Kola	28.1.70			DTW						-						
Goyespur	7.1.70			DTW						-						
Shoil	13.1.70			DTW						-						
Kalicharanpur	13.1.70			DTW						38						
Baidamga	28.1.70			DTW						85						
Modhupur	23.1.70			DTW						24						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Bishoykhali	6.2.73			DTW						25						
Moharajpur	7.5.73			DTW						65						
Andalbaria	12.2.73			DTW						10						
Kanuharpur	13.2.73			DTW						21						
Bisoykhali	12.2.73			DTW						44						
Naldanga	17.5.73			DTW						25						
Lowdai	29.2.76			DTW						-						
Chotokamarkunda	28.8.75			DTW						46						
Halidhani	21.2.76			DTW						37						
S.M. Farm Bloc	7.6.74			DTW						40						
Geramara	30.8.75			DTW						21						
Defalbaria	30.8.75			DTW						105						
Mayadharapur	20.2.76			DTW						85						
Khajura	15.1.76			DTW						37						
Dhopabila	3.4.76			DTW						67						
Baraiasannagar	12.4.76			DTW						31						
Andalbaria	21.4.76			DTW						25						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Haripur	16.2.77			DTW						32						
Khajura	22.11.76			DTW						69						
Mothurapur	15.2.77			DTW						22						
Saganna	16.2.77			DTW						26						
Paschim-Bisoykhali	28.6.77			DTW						100						
Porabakri	17.12.78			DTW						18						
Dhananjoypur	23.12.78			DTW						12						
Bankira	25.12.78			DTW						14						
Mamudpur	20.12.78			DTW						19						
Dhopabila	14.2.79			DTW						49						
Chandpur	6.3.79			DTW						29						
Kulbaria	28.11.78			DTW						-						
Mrigibathan	25.3.79			DTW						31						
Rishkhali	27.4.70			DTW						45						
Balarampur	23.3.70			DTW						-						
Chatkabaria	3.5.73			DTW						-						
Bhaina	3.5.73			DTW						-						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

The Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Kapashhati	20.4.75			DTW						118						
Sreepur	16.2.77			DTW						5						
Valkisitli	25.5.76			DTW						24						
Kismatghora-gacha	15.2.77			DTW						112						
Rupdah-Shakharidah	14.2.77			DTW						99						
Ghoragacha	15.2.77			DTW						93						
Faila	31.1.70			DTW						20						
Mohisadara	31.1.70			DTW						-						
Dulalmandia	9.1.70			DTW						-						
Badidihi	6.1.70			DTW						35						
Khedapara	19.8.79			DTW						-						
Chapali	15.11.70			DTW						40						
Faila	10.3.72			DTW						-						
Pirozpur	20.3.72			DTW						55						
Belatdaulatpur	11.12.72			DTW						-						
Babra	31.12.72			DTW						25						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Chottosimla	24.9.74			DTW						45						
Kastovanga	31.10.77			DTW						80						
Mongalpoita	18.1.75			DTW						70						
Debrajpur	17.1.75			DTW						30						
Barosimla	10.2.75			DTW						45						
Singdah	2.3.75			DTW						-						
Rakra	9.1.78			DTW						10						
Khedapara	-			DTW						-						
Mohisahati	28.3.76			DTW						95						
Subarnasara	28.1.75			DTW						85						
Manaharpur	29.6.77			DTW						48						
Kastovanga	15.3.77			DTW						62						
Jagannathpur	20.2.75			DTW						80						
Badidihi	21.11.74			DTW						25						
Fulbari	20.11.74			DTW						38						
Mazdia	22.11.74			DTW						45						
Alaipur	9.11.74			DTW						40						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Thikdanga	24.11.74			DTW						60						
Pirozpur	23.11.74			DTW						-						
Badurgacha	20.11.76			DTW						30						
Belatdaulatpur	20.11.76			DTW						40						
Badurgacha	31.1.77			DTW						25						
Kastovanga	11.12.76			DTW						60						
Mazdia	25.5.78			DTW						70						
Satgachi	21.11.76			DTW						110						
Pukuria	24.5.78			DTW						30						
Maruah	9.12.76			DTW						70						
Khordoraigram	20.11.76			DTW						25						
Chapali	19.2.76			DTW						35						
Subarnasara	20.12.76			DTW						90						
Jagannathpur	19.12.76			DTW						95						
Sasarpara	31.1.77			DTW						120						
Dayapur	15.2.77			DTW						25						
Fariadkati	31.1.77			DTW						35						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Sreerampur	31.1.77			DTW						40						
Pathbilla	18.12.76			DTW						20						
Bhatpara	15.2.77			DTW						50						
Mohadebpur	18.12.76			DTW						60						
Farashpur	15.2.77			DTW						30						
Mahadebpur	31.10.78			DTW						20						
Mohadebpur	11.12.78			DTW						-						
Jatrapur	9.12.78			DTW						60						
Shibnagar	30.11.79			DTW						-						
Kaligonj	-			DTW						-						
Kamlapur	30.11.79			DTW						-						
Babra	-			DTW						-						
Allangi	6.2.70			DTW						115						
Lakxmikundu	7.1.70			DTW						30						
Soadi	22.1.70			DTW						48						
Solemanpur	7.1.70			DTW						11						
Solemanpur	4.5.73			DTW						-						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Chandpara	4.5.73			DTW						122						
Barobamunda	4.5.73			DTW						70						
Murutia	20.3.73			DTW						30						
Ramchandrapur	4.5.73			DTW						131						
Lakxmikundu	4.5.73			DTW						65						
Kotchandpur	25.4.73			DTW						20						
Noadagram	12.2.73			DTW						85						
Phulbari	31.1.75			DTW						116						
Allokdia	30.1.75			DTW						34						
Kushna	27.1.75			DTW						103						
Boluhar	27.1.75			DTW						126						
Narayanbari	27.3.75			DTW						127						
Goursuti	20.10.74			DTW						76						
Bhomradanga	22.10.74			DTW						76						
Parlot	28.4.75			DTW						53						
Bazebamunda	10.4.75			DTW						52						
Aranda	16.4.75			DTW						15						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Chaykhada	15.6.77			DTW						57						
Noadachaykhada	15.6.77			DTW						120						
Chuadanga	29.6.77			DTW						76						
Dayarampur	29.6.77			DTW						90						
Toghori	28.6.77			DTW						73						
Dhopabilla	20.6.77			DTW						91						
Teghori	28.6.77			DTW						129						
Sabdalpur	25.6.77			DTW						33						
Baliadanga	25.6.77			DTW						38						
Bagdanga	26.6.77			DTW						71						
Sherkhali	27.6.77			DTW						78						
Sabdalpur	26.6.79			DTW						50						
Kunnanagar	26.6.79			DTW						-						
Gurpara	27.10.79			DTW						-						
Talsar	28.10.79			DTW						-						
Mandarbaria	30.11.79			DTW						-						
Hatkhalishpur	6.7.70			DTW						22						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Hamidpur	2.3.70			DTW						35						
Samanta-Gopalpur	21.5.70			DTW						160						
Baichitala	21.5.70			DTW						50						
Jalilpur	23.2.73			DTW						66						
Sundarpur	24.12.72			DTW						25						
Sundarpur	22.12.72			DTW						30						
Bazrapur	14.12.72			DTW						50						
Purandapur	3.5.73			DTW						44						
Krishna-Chandrapur	3.5.73			DTW						-						
Chandpara	3.5.73			DTW						23						
Guatali	3.5.73			DTW						40						
Mandarbaria	3.5.73			DTW						-						
Karincha	9.6.75			DTW						69						
Khorda-Khalishpur	22.4.74			DTW						54						
Mandarbaria	4.11.74			DTW						28						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

LLP Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Andarkota	31.7.74			DTW						14						
Sukpukuria	6.11.74			DTW						20						
Sanchadanga	30.8.74			DTW						-						
Kharincha	7.8.74			DTW						48						
Guatali	6.8.74			DTW						30						
Patila	14.12.76			DTW						56						
Mothuranagar	30.12.76			DTW						67						
Gokulnagar	24.12.76			DTW						60						
Jadobpur	17.12.76			DTW						58						
Pirgacha	29.3.77			DTW						45						
Kasabpur	30.12.76			DTW						66						
Samanta-Gopalpur	5.3.77			DTW						85						
Samanta-Gopalpur	26.2.77			DTW						95						
Samanta-Gopalpur	4.3.77			DTW						95						
Sizia-(Amin-Nagar)	24.3.77			DTW						81						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Samanta-Gopalpur	19.3.77			DTW						120						
Bakshpota	26.3.77			DTW						97						
Bhairaba	25.2.77			DTW						68						
Kola	23.3.77			DTW						60						
Bawli (Saradipota)	25.3.77			DTW						100						
Bashbaria (Pashchimpara)	20.3.77			DTW						75						
Bashbaria (Chunnirhati)	22.3.77			DTW						52						
Gokulnagar	30.3.77			DTW						40						
Sizia (Padmapukur)	28.3.77			DTW						74						
Sizia	27.3.77			DTW						80						
Gurdah	18.5.77			DTW						45						
Shamkur	22.5.77			DTW						50						
Palianpur	5.7.77			DTW						51						
Shamkur	4.6.77			DTW						65						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Shamkur	20.5.77			DTW						55						
Samanta-Gopalpur	22.6.77			DTW						93						
Shamkur	29.6.77			DTW						75						
Samanta-Gopalpur	23.6.77			DTW						65						
Samanta-Gopalpur	24.6.77			DTW						65						
Bawli (Ninnanagar)	28.6.77			DTW						90						
Samanta-Gopalpur	25.6.77			DTW						75						
Gobindapur	26.6.77			DTW						75						
Bawli	27.6.77			DTW						76						
Sreepur-Burgalini	30.6.77			DTW						63						
Nasti	-			DTW						-						
Slibanardapur	-			DTW						-						
Lariapur	-			DTW						-						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Talshar	28.3.79			DTW						-						
Sizia	28.3.79			DTW						-						
Nalbilpara	28.3.79			DTW						5						
Talshar	28.3.79			DTW						4						
Ballavpur	-			DTW						-						
Satrujitpur	26.1.70			DTW						53						
Bishnopur	26.1.70			DTW						87						
Sawladenga	26.1.70			DTW						85						
Magura	20.1.70			DTW						-						
Moghi	24.1.70			DTW						92						
Beruil	3.12.70			DTW						-						
Satrujitpur	6.2.73			DTW						49						
Patherhat	1.2.73			DTW						25						
Sankachkhali	1.2.73			DTW						-						
Sankachkhali	1.2.73			DTW						-						
Alaipur	26.4.73			DTW						-						
Sibrampur	8.1.75			DTW						-						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Batikadanga	9.1.75			DTW						70						
Parla	18.12.74			DTW						52						
Krishnapur	20.1.75			DTW						97						
Baskota	27.11.74			DTW						82						
Sitarampur	29.4.74			DTW						90						
Bagdanga	24.1.75			DTW						82						
Barokhori	20.1.75			DTW						63						
Charbijoykhali	20.1.75			DTW						87						
Atharokhada	21.10.74			DTW						87						
Baharbag	25.1.75			DTW						-						
Tarara.	20.2.75			DTW						75						
Baskota	20.2.77			DTW						77						
Baskota	10.2.77			DTW						76						
Baskota	18.2.77			DTW						92						
Brammandanga	21.2.77			DTW						85						
Baskota (Bijoynagar)	15.2.77			DTW						77						
Arkandi	9.4.77			DTW						48						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Peasons for Difference
Tengakhali	18.3.77			DTW						87						
Hatmalanchi	10.4.77			DTW						90						
Sreerampur	10.4.77			DTW						78						
Ichakhada.	29.6.77			DTW						81						
Alokdia	29.7.78			DTW						76						
Paturia	15.10.79			DTW						-						
Durgapur	20.11.78			DTW						44						
Barai	8.11.78			DTW						35						
Baskota	31.12.78			DTW						40						
Araisato	25.12.78			DTW						77						
Purba-Bariwalla	26.12.78			DTW						53						
Chandamprotap	29.12.78			DTW						78						
Ramchandrapur	8.11.78			DTW						66						
Hazrapur	25.12.78			DTW						89						
Harishpur	2.6.75			DTW						20						
Panchkawnia	1.6.75			DTW						63						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Pukuria	2.6.75			DTW						108						
Katoly	30.5.75			DTW						73						
Bowlia	17.2.77			DTW						85						
Kumarkota	23.3.77			DTW						78						
Katigram	20.3.77			DTW						112						
Panchkownia	25.2.77			DTW						77						
Satakhali	1.3.77			DTW						75						
Darishaldah	11.2.77			DTW						91						
Saldah	14.2.77			DTW						108						
Chakulia	13.2.77			DTW						77						
Churargati	28.7.78			DTW						71						
Dumursia	26.7.78			DTW						73						
Sultanshi	24.7.78			DTW						72						
Kumrul	22.7.78			DTW						71						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Group Area	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Saitkhali	11.2.70			DTW						154						
Bonogram	6.3.70			DTW						3						
Teghori	12.2.70			DTW						40						
Khalshi	15.12.70			DTW						60						
Dakhin Sreerampur	26.10.72			DTW						58						
Dakhin Sreerampur	28.1.73			DTW						86						
Dohakhola	14.1.73			DTW						66						
Karimpur	7.5.73			DTW						-						
Chechuakhola	7.5.73			DTW						69						
Bhangura	5.12.74			DTW						80						
Khalilpur	10.12.74			DTW						46						
Habulla	12.2.75			DTW						95						
Baharampur	17.2.75			DTW						56						
Baharbag	1.1.74			DTW						101						
Indra	31.3.77			DTW						68						
Agra	31.3.77			DTW						109						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Faila-1	1970			DTW	15											
Faila-2	1972			DTW	-											
Chapali-1	1970			DTW	45											
Chapali-2	1976			DTW	50											
Alai Para	1974			DTW	5											
Sreeram Par	1977			LTW	37											
Vath Para	1977			DTW	33											
Mohadeb Par-1	1976			DTW	63											
Mohadeb Par -2	1978			DTW	39											
Valegarez	1980			DTW	21											
Vomla Par	1979			DTW	35											
Khada Para	1970			DTW	-											
Parkra	1978			DTW	23											
Soto Similla	1974			DTW	42											
Boro Similla	1975			DTW	38											
Babra-1	1975			DTW	9											
Mohadeb Par-3	1978			DTW	27											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Babra-2	1980			DTW	11											
Pathbila	1976			DTW	17											
Pukuria	1978			DTW	47											
Shibnagor	1979			DTW	21											
Dolalmandia	1970			DTW	-											
Debraj Para	1975			DTW	26											
Khordomaygrame	1976			DTW	18											
Daya Para	1977			DTW	21											
Farid Kati	1977			DTW	28											
Mahisha Para	1970			DTW	-											
Farash Para	1977			DTW	30											
Sarsan Para	1977			DTW	56											
Monohor Par	1977			DTW	24											
Badahihi-1	1970			DTW	17											
Badadihi-2	1974			DTW	32											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Bolat Dulet Par-1	1974			DTW	-											
Bolat Dulet Par-11	1976			DTW	13											
Peroz Par -1	1972			DTW	19											
Peroz Par -11	1974			DTW	20											
Thikdanga	1974			DTW	19											
Mangal Payla	1976			DTW	22											
Badurgaena-1	1976			DTW	14											
Badurgaena-11	1977			DTW	30											
Mahishati	1976			DTW	42											
Pal Bari	1974			DTW	13											
Saberno Sara-1	1975			DTW	44											
Saberno Sara -11	1976			DTW	17											
Majdhia-1	1974			DTW	46											
Majdhia-2	1978			DTW	49											
Joganath Par-1	1975			DTW	17											
Joganath Par-2	1976			DTW	28											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Crop-ping Pattern	Yields /AC	Major Reasons for Difference
Kastoranga-1	1977			DTW	53											
Kastoranga-2	1977			DTW	32											
Kastoranga-3	1976			DTW	5											
Sothgache	1976			DTW	39											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

LLP Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Kushkhali	31.12.74			DTW						68						
Baikari	12.12.74			DTW						-						
Chupria	9.2.75			DTW						87						
Katia	27.3.73			DTW						83						
Palashpole	19.5.75			DTW						87						
Rasulpur	21.5.76			DTW						45						
Satanikushkhali	19.2.77			DTW						98						
Gazipur	19.3.77			DTW						90						
Maguragopinathpur	28.2.77			DTW						78						
Tujulpur	2.3.77			DTW						75						
Akrakhola	6.4.78			DTW						61						
Ramerdanga	5.1.78			DTW						88						
Ghona	9.6.78			DTW						72						
Kathanda	9.6.76			DTW						78						
Mahmudpur	11.6.78			DTW						102						
Sikri	29.12.78			DTW						97						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Mohadebnagar	10.6.78			DTW						73						
Bhadra	14.6.78			DTW						89						
Mohmudpur	30.10.78			DTW						89						
Kowndanga	20.12.78			DTW						77						
Satani	3.11.78			DTW						87						
Labsha	15.6.78			DTW						53						
Mukundapur	8.6.78			DTW						74						
Patuli	25.11.75			DTW						65						
Jalalabad	26.11.75			DTW						67						
Borali	5.12.75			DTW						71						
Kota	23.12.75			DTW						68						
Tulshidanga	13.1.76			DTW						62						
Langaljhara	8.6.76			DTW						52						
Lohakora	11.7.76			DTW						53						
Ramkrishnapur	3.8.76			DTW						53						
Bakshabagadanga	26.8.76			DTW						54						
Salimpur	21.3.77			DTW						142						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Aichpara	26.1.78			DTW						95						
Koila	29.8.78			DTW						70						
Gopinathpur	30.1.79			DTW						63						
Goalchator	8.10.78			DTW						87						
Jhikra	28.12.78			DTW						97						
Putuni	10.9.78			DTW						96						
Alaipur	30.12.78			DTW						66						
Basantapur	30.1.79			DTW						32						
Khorda	30.1.79			DTW						45						
Mahmudpur	30.1.79			DTW						61						
Datpur	29.1.79			DTW						5						
Lakshmanpur	31.7.79			DTW						5						

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Peasons for Difference
Boro Paisal				DTW	43											
Bhararia				DTW	91											
Bartabeel-2				DTW	188											
Bartabeel-1				DTW	129											
Boro Omarpur-1				DTW	140											
Baigda				DTW	116											
Belishwar-1				DTW	95											
Belishwar-2				DTW	84											
Batulia				DTW	72											
Boro Omarpur-2				DTW	85											
Bagbari Jalsha				DTW	89											
Chandrapara East				DTW	103											
Chandrapara West				DTW	111											
Dk. Digalgram-1				DTW	108											
Dk. Diagalgram-2				DTW	92											
Dk. Kullah				DTW	115											
Dk. Laruakunda				DTW	94											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Dakhin Para				DTW	63											
Dautia-5				DTW	87											
Delda-1				DTW	102											
Delda-2				DTW	145											
Delda-3				DTW	145											
Deligangail				DTW	64											
Demran				DTW	114											
Dhalkunda				DTW	81											
Gawail-4				DTW	117											
Joypura-1				DTW	73											
Jalsha Pm.Para				DTW	81											
Jalshin-2				DTW	94											
Kalia-1				DTW	61											
Karim Kaimtara				DTW	84											
Kataboir				DTW	138											
Kullah				DTW	114											
Malancha-1				DTW	68											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Malancha-2				DTW	77											
Monishar Tek				DTW	96											
Nannar Chowna				DTW	104											
Nowgaon				DTW	115											
Nowgahati-2				DTW	148											
Paik Para				DTW	108											
Purba Bashna				DTW	120											
Pb. Laruakunda				DTW	132											
Purba Nowgaon				DTW	129											
Raghunathpur				DTW	88											
Sachna				DTW	87											
Sainpara				DTW	73											
Sanora				DTW	113											
Shithi				DTW	100											
Sree Rampur				DTW	75											
Suapur-1				DTW	135											
Sutipara				DTW	118											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Ulail-1				DTW	95											
Ulail-2				DTW	122											
Ur.Digalgram-1				DTW	86											
Ur.Laruakunda				DTW	141											

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Peasons for Difference
Rajapur, Rajbari	1974	24	2	DTW	57	'18		Wheat Aus/Aman	13	70	47		80-06	Wheat Aus/Aman	15	
Gouripur, Rajbari	1974	31-27	2	DTW	46			Wheat Aus/Aman	9	35	25		150-03	" "	10	
Rasulpur Rajbari	1974	30-30	2	DTW	48			" " IR-8	11	43-50	94		310-06	Wheat	12 35	
Jjarapara, Rajbari	1974	22	2	DTW	29			Wheat Aus/Aman	12½2	21.50	24		120-22	Wheat IR-8	10 15	
Bilmamud Pur, Farid Pur No 3 Khamar	1977	12	3/4	STW	14	.56	78-04	Boro Paddy Aus TR Aman	55 30	2.10	4	70	1.62-10	Bora IRRI - Aus TR	55 30	Change of Management
No 4 Khamar Bilmamud	1977	12	3/4	STW	21	.46	100-10	Borolari TR Aman	50	6.42	12	25	52-05	Boro Irri-TR Aman	30	" "
No 7 Khamar Bilmamud	1977	11	3/4	STW	15			" "	40	6.50	5	1.30	1.95-07	" "	40	" "
No 8 Khamar Bilmamud	1977	8.80	3/4	STW	18	.26	1.45-03	" "	40	6.85	17		88-06	" "	30	" "

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC Maunds	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Namapara				DTW					35						35	
Peravita				DTW					44						44	
Holdibari				DTW					50						50	
Jahanabad-1				DTW					40						40	
Jahanabad-2				DTW					42						42	
Boro-Chandipur				DTW					35						35	
Kalika Bar				DTW					45						45	
Rajabashor				DTW					5						5	
Huglipara				DTW					50						50	
Shingimari				DTW					Nil						Nil	

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Kanuharpur Jhenida	1971	50	2 Cusec		100	.5	5-Lrg. .2-Sml.	Rice Wheat Vegetables		50	100	.5	5-Lrg .2-sml	Local HyV	Rice 1½ T/A Wheat 1.3 T/A	No Problems
Khajura Jhenida	1976	60	2 Cusec		30	2	4-Lrg. .3-Sml.	Amna Rice								Diesel motor not working - ask for repairs. BADC says too costly apply for elec. motor; has unpaid balance will not release until paid. Farmer Coop managers have appropriated funds. Now farmers have no money.
Char Bana Bari, SIRDP	1978	[illegible]	3/4	STW	9	.33	.45-08	Boro Wheat	75	7	14		.45-08	Traman Boro Wheat	75	Irrigation Pucca Channel
Madhyo Marseo Rd 1, Boyra	1978	55	2	DTW	72			Boro Wheat	42	74	135			Boro Wheat	67 25	Irrigation Water Management

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference ~~ference~~
Akhar Kanda, Bogra	1978	55	2	DTW	65			Boro Wheat	25	81	98			Boro Wheat	25	Irrigaton Water Management
Madhyamarseo, Bogra	1978	55	2	DTW	72			Wheat Boro	42	74 (55 1R 19 Wheat)	135			Wheat Boro	25 67	Irrigation Cash/Credit for members Accounting Channel Layout Water Management Land Registrar from deed
Akhar Kanda, Gabtalij, Bogra	1978	55	2	DTW	65			Wheat Boro	25	81	98			Wheat Boro	25	
Char Bana Bari, Serajganj	1978	3	½	STW	9		.45-Lrg .08-sml	Boro/Wheat Aus/Traman	.75 mds crop cutting	7	14		.45-lrg .08-sml	Traman Boro Wheat	75 mds	Irrigation HyV Seeds Fertilizer Pucca Channel
Rajapur, Rajbari	1974	24	2	DTW	57	1-8		Wheat Aus/Aman	13	70	47		80-06	Wheat Aus Aman	15	Improved Cultivation Practices

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Gouripur, Rajbari	1974	31-27	2	DTW	46			Wheat Aus/Aman	9	35	25		1.50-03	Wheat Aus/ Aman	10	
Rasulpur, Rajbari	1974	30-30	2	DTW	48			Wheat Aus/ Aman IR-8	11	43-50	94		3.10-06	Wheat	12 35	
Ijarapara, Rajbari	1974	2	2	DTW	29			Wheat Aus/Aman	12½	21-50	24		1.20-22			

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC Maunds	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Kanaiya-3	1978			DTW	45			Aman/ Fallow	40		45			Aman/ Fallow	40	
Neeler Para-2	1973			DTW	52			Aman/ Fallow	45		52			Aman/ Fallow	45	
Neeler Para-3	1976			DTW	35			Aman/ Fallow	40		35			Aman/ Fallow	40	
Neeler Para-4	1978			DTW	36			Aman/ Fallow	41		36			Aman/ Fallow	41	
Noagaon-1	1975			DTW	38			Fallow	50		38			Fallow	50	
Harinal-2	1975			DTW	62			Fallow	40		62			Aman/ Fallow	40	
Samantapur	1979			DTW	45			Aman	40		45			Aman	40	
Jugitala-1	1975			DTW	33			Aman	35		33			Aman	40	
Kamar Bashulia	1979			DTW	50			T. Aman	40		50			T. Aman	40	
Itahata-3	1980			DTW	-			T. Aman	-		-			T. Aman	-	
Khailkair	1979			DTW	60			Aman/ Fallow	45		60			Aman/ Fallow	45	
Jazhor-1	1978			DTW	53			Aman	38		53			Aman	38	
Kunia-2	1977			DTW	75			Aman	45		75			Aman	45	
Kunia-1	1976			DTW	55			Aman	42		55			Aman	42	

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Mollapara-2	1975			DTW	9			Aman	38		9			Aman	38	
Salna South-3	1977			DTW	33			Aman	36		33			Aman	36	
Baw Para-1	1976			DTW	40			Wheat/ Cotton/ Aman	40		40			Wheat/ Cotton/ Aman	40	
Baw Para-2	1976			DTW	15			Aman	42		15			Aman	42	
Baw Para-3	1979			DTW	65			Aman/ Fallow	55		65			Aman/ Fallow	55	
Deshi Para	1974			DTW	22			Aman	41		22			Aman	41	
Araishataprashad-2	1976			DTW	55			Aman	42		55			Aman	42	
Araishataprashad-5	1979			DTW	27			Fallow	22		27			Fallow	22	
Araishataprashad-1	1976			DTW	29			Aman	43		29			Aman	43	
Araishataprashad-4	1979			DTW	18			Aman	42		18			Aman	42	
Takkathora	1978			DTW	33			Aman/ Fallow	50		33			Aman/ Fallow	50	
South Salna-1	1973			DTW	53			Aman/ Wheat	46		53			Aman/ Wheat	46	
Salna South-4	1978			DTW	37			Aman	40		37			Aman	40	
Takkathora	1979			DTW	42			Aman/ Fallow	50		42			Aman/ Fallow	50	

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Araishataprashad-3	1976			DTW	17			Boro	46		17			Boro	46	
Salna North-1	1975			DTW	40			Wheat/ Aman	44		40			Wheat/ Aman	44	
Salna North-2	1974			DTW	30			Aman	46		30			Aman	44	
Bahadurpur	1976			DTW	17			Shail	42		17			Shail	42	
Dugri-1	1975			DTW	58			Fallow	45		58			Fallow	45	
Painshail-2	1975			DTW	50			Boro	50		50			Boro	50	
Dugri-2	1976			DTW	40			Shail	50		40			Shail	40	
Dugri-3	1979			DTW	75			Aman	50		75			Aman	50	
B.K. Bari-3	1975			DTW	15			Fallow	53		15			Fallow	53	
B.K. Bari-1	1976			DTW	43			Wheat/ Aman/ Fallow	57		43			Wheat/ Aman/ Fallow	57	
Painshail-2	1975			DTW	47			Aman/ Fallow	56		47			Aman/ Fallow	56	
Painshail-3	1979			DTW	30			Boro	52		30			Boro	52	
B.K. Bari-2	1975			DTW	45			Wheat/ Aus	41		45			Wheat/ Aus	41	
Pirojali-5	1979			DTW	37			Wheat	42		37			Wheat	42	

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Pirojali-1	1979			DTW	26			Wheat	52		26			Wheat	52	
Dugri-4	1975			DTW	60			Fallow/ Aman	48		60			Wheat	48	
Pirojali-2	1979			DTW	40			Boro	54		40			Boro	54	
Pirojali-3	1978			DTW	48			W/ Vegetable	52		48			W/ Vegetable	52	
Pirojali-4	1979			DTW	50			Fallow	57		50			Fallow	57	
Kainzanob	1976			DTW	63			Aman/ Wheat/ Winter Vegetable	40		63			Aman/ Wheat/ Winter Vegetable	40	
Nandi Bari	1978			DTW	106			Aman/ Fallow	40		106			Aman/ Fallow	40	
Maze Khan-1	1978			DTW	116			Aman/ Wheat/ Jute	45		116			Aman/ Wheat/ Jute	45	
Talutia	1977			DTW	61			Aman	41		61			Aman	41	
Padhahar Baith	1978			DTW	33			Aman/ Fallow	42		33			Aman/ Fallow	42	
Maze Khan-2	1978			DTW	66			Aman/ Fallow	50		66			Aman/ Fallow	50	

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	1980 Performance: Command Area	Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Billashara	1978			DTW	35			Fallow	42		35			Fallow	35	
Kudabo	1977			DTW	52			Aman/ Fallow	50		52			Aman/ Fallow	50	
Noi Bari	1978			DTW	50			Aman/ Fallow	40		50			Aman/ Fallow	40	
Basho Gaon	1978			DTW	50			Aman/ Fallow	45		50			Aman/ Fallow	45	
Isali	-			DTW	-			Aman/ Fallow	-		-			Aman/ Fallow	-	
Maiz Gaon	1980			DTW	25			Aman/ Fallow	55		25			Aman/ Fallow	55	
Damar Para	1979			DTW	40			Aman/ Fallow	45		40			Aman/ Fallow	45	
Karam Tala	1978			DTW	45			Aman/ Fallow	45		45			Aman/ Fallow	45	
Gazi Para-2	1979			DTW	45			Aman/ Wheat/ Fallow	45		45			Aman/ Wheat/ Fallow	45	
Dattapara-1	1977			DTW	48			Aman/ 80%Fallow	48		48			Aman/ 80%Fallow	48	
Gazi Para-1	1978			DTW	53			40%Aman/ 60%Fallow	48		53			40%Aman 60%Fallow	48	

SUMMARY

SELECTED PUMP GROUPS RECORD OF ACCOMPLISHMENT

Pump Group and Location	Year Organized	Acres Command Area	Pump Size	Type of Pump STW LLP DTW	Number of Farmers	Average Size Plot	Range of Plot Sizes	Cropping Pattern	Yields /AC	Command Area	1980 Performance Number of Farmers	Average Size of Plot Sizes	Range of Plot Sizes	Cropping Pattern	Yields /AC	Major Reasons for Difference
Dattapara-1	1977			DTW	48			Aman/ 80%Fallow	48		48			Aman/ 80%Fallow	48	
Salna South-5	1977			DTW	30			Aman	37		30			Aman	37	
Salna South-2	1976			DTW	20			Aman	39		20			Aman	39	
Vanua	1979			DTW	35			Fallow	45		35			Fallow	45	

4. SURVEY OF TUBEWELL AND LOW LIFT PUMP IRRIGATION IN PROJECT AREA

A survey of existing deep tube wells, shallow tube wells and low lift pumps, within Magura Target Area, was conducted during the month of October, 1979. The location of all these irrigation outfits were visited for spot verification. Through this spot checking and interviews with farmers, managers of irrigation cooperatives and mechanics who operate them, the following factual information was collected.

4.1 Number of DTWs and STWs and LLPs

The totals of DTWs, STWs and LLPs in the target area are as follows:

	Total	Working	Not Working
Deep Tube Wells	14	11	3
Shallow Tube Wells	5	4	1
Low Lift Pumps	48	48	-

No irrigation from hand tube well was reported.

4.2 Location of Their Sites

The location of their sites in the villages has been shown in target area map No. 1.

4.3 Area Irrigated

The total area irrigated, maximum and minimum area covered. , average area by each type of well and pump are shown below.

Type	Total No. in working condition	Total Irrigated area (acres)	Min/Max. Range of area (acres)	Average area per unit (acres)
Deep Tube Well	11	533	22-75	48.45
Shallow Tube Well	4	30	5-10	7.50
Low Lift Pump	48	1811	20-66	37.73

It shows that a DTW on average covers the maximum area of 48.45 acres, under the present condition. The area covered by LLP is based on the information collected from 15 LLP sites.

4.4 Farmers' Problems

The information about the operational problems of LLPs and tube wells as collected from the farmers has been summarized below.

4.4.1 Mechanical Troubles

In the case of deep tube wells, there is little problem. Only two tube wells were found to have such problem. One was out of order for 22 days, another for 15 days. One unit which was being electrically operated faced such problems due to theft of electrical parts.

Shallow tube wells and low lift pumps also have mechanical troubles. In such cases it is not possible to put them back to work immediately for lack of quick repairing facilities in the vicinity. Reporting the matter to BADC authorities and getting a mechanic from there take time.

4.4.2 Supply of Spare Parts

Procedures for getting spare parts from BADC are time consuming. First, the user will have to inform the BADC Then the BADC mechanic will visit the locality, check the machine and make a list of required spare parts, submit the indent to the BADC. A cost estimate will be made, the money will have to be deposited in bank and the BADC office will have to be informed of the deposit of money. After that the spare parts will be released to the mechanic who will then do the necessary repairs. The story is more or less the same in case of LLP. STW are mostly privately owned and operated, still the owners had to face serious problems in procurement of spare parts.

4.4.3 Supply of Oil and Fuel

It was reported that the supply of oil and fuel is no problem except that sometimes the users had to pay a little higher price.

4.5 Crops, Inputs and Yield Per Acre

4.5.1 Crops

The crops irrigated were found to be local Aus, HYV - Aus, local T-Aman, HYVT-Aman, Boro, wheat, tobacco, egg plant and sugarcane.

4.5.2 Average Yield

The average yields of crops with irrigation have been reported to be as follows:

Aus	Range of Average yield mds/acre
a) Local	15-25
b) HYV	28-50
T. Aman	
a) Local	25-30
b) HYV	35-45
Boro HYV	30-50
Wheat	25-35
Tobacco	15
Vegetables (egg plant)	250
Sugarcane	500-600

4.5.3 Manures, Fertilizers and Pesticides

There was a general complaint that fertilizers and pesticides are not available in time and their prices are too high.

Small quantities of manure are used. The doses of fertilizers varied too much from farmer to farmer. It seems they do not use standard doses. The dose of urea for rice, varied from 0.5 mds to 1.5 mds/acre, for TSP, it varied from 0.5 to 1.5 mds/acre and for M.P. it varied from 0.12 to .50 mds per acre.

4.5.4 Area Covered by HYV

	Area in acres
Aus	23
T.Aman	255
Boro	164
Wheat	469
	911
Local Varieties	218
	1129

It shows that HYV covers 81 percent of the irrigated cropped area in which wheat alone covers 42 percent of the area. It means irrigation facilities give incentive to growers to adopt HYV crops. The varieties of rice reported were Aus BR-3 and chandina, for T.Aman, Paizam, Chandina, Naizershail, BR-4, and Irri-20, for Boro-Paizam, Purbashi or Chinese, BR-3, Irri-76 or 8 and Irratom. The variety of wheat reported was Sonalika.

4.6 Irrigation Cost

4.6.1 Deep Tube Well

For one tube well, a yearly rent of Tk. 1200 and a security of Tk. 300 which is refundable, is to be deposited to A.D.C. The cost of fuel is borne by the farmers. The cost per acre varies depending on the total area covered. If the coverage is large the cost per acre is less and vice versa.

As reported the cost varied from Tk. 120 to TK. 270 per acre.

4.6.2 Shallow Tube Well

These are supplied to the individual farmers on installment basis. The irrigation cost varies from Tk. 150 to Tk. 200 per acre.

4.6.3 Low Lift Pump

These are supplied by BADC. The irrigation cost varies from Tk. 120 to Tk. 270 per acre.

Details of individual DTW, STW and LLP are shown in Table F-5.

COLUMN HEADINGS FOR TABLE F-5.

Column No.	Description
1.	Location
2.	Number of Wells
3.	Year Commissioned
4.	Average Area Irrigated per Unit
5.	Farmers' reaction, problems, breakdowns, short supply of fuel and spare parts, and lack of quick repairing facilities.
6.	Average yield/acre in Mds.
7.	Information about inputs, seeds, fertilizers, manures and insecticides
8.	Area covered by HYV in Acres
9.	Irrigation costs per acre in Tks.
10.	Remarks

TABLE F-5

TUBE WELL AND LOW LIFT PUMP IRRIGATION

MAGURA TARGET AREA
MAGURA P.S.
INFORMATION ON D.T.W.

NO. OF D.T.W. WITHIN
THE TARGET AREA= NOS. 5
SPOT VERIFIED = NOS. 5

1	2	3	4	5	6	7	8	9	10
Hazrapur U.P. Hazrapur.	1	1978-79	60 acres (in winter)	Break down for 22 days	Aus -24.00 T.Aman-25.00 (local) BR-4 -35.00 Paijon-30.00	No problems	Aus -10.00 (HYV) T.AmanBR-4 -8.00 Paijon-5.00	Tk. 250.00 per acre 4 times (irrigation)	BR-4 =20 acres damage due to break down of Machine. Does of fertilizer used : - mds/a Urea. T.S.P. M. Aus(HYV) -0.75 0.05 0 T.Aman -1.50 1.00 0
Moghi U.P. Moghi.	1	1969-70	50 acres (kharif)	No problems.	Aus -30.00 Boro -45.00 (HYV)	Imputs available, but price was high.	(Boro HYV) BR-3=15.00 Paijon= 30.00	Tk. 180.00 per acre (3 times).	Urea. T.S.P. M. Aus -0.50 0.50 0 Boro -1.00 1.00
Bara Khari U.P. Moghi.	1	1973-74	25 acres (kharif)	Break down for 15 days.	Aus BR-3 - 50.00 HYV-IRRI-76- 45.00	- do -	BR-3= 3.00 IRRI-76 = 22.00	Tk. 250.00 per acre (5 times)	Urea. T.S.P. M. 0.85 0.50 0
Isakhada U.P. Hazrapur.	1	1975-76	30 acres	-	Paijon - 40.00 Wheat - 30.00	- do -	Paijon = 10.00 Wheat = (sonalika) 20.00	Tk. 250.00 per acre (4 times)	Urea. T.S.P. M. Paijon 1.50 1.00 0 Wheat 1.00 0.75 0
Alaipur U.P. Hazipur.	1	1976	25 acres	-	Paijon - 35.00 T.Aman (local) -25.00 Wheat - 30.00	- do -	Paijon = 10.00 T.Aman(local) = 5.00 Wheat=25.00	Tk. 180.00 per acre (2 times).	Urea. T.S.P. M. 1.00 0.50 0 1.00 0.50 0

TABEL F-5 (continued)

MAGURA TARGET AREA
JHENIDA P.S.
INFORMATION ON D.T.W

NO. OF D.T.W. WITHIN
THE TARGET AREA = NOS. 9
SPOT VERIFIED = NOS. 9

1	2	3	4	5	6	7	8	9	10
Bishaikhali U.P. Naharajpur	2	1975	75.00 acres.	One D.T.W. out of order	China =45.00 Wheat(sonalika) =30.00	Seeds and insecticides not available, timely.	China=7.00 Wheat(sonalika)=10.00	Tk.220.00 per acre in case of Boro. Wheat-Tk.200.00 per acre.	Fertilizer used. Urea. T.S.P China - 1.50 2.00 Wheat - 0.62 0.62 Insecticides used=Dia
Chhoto Kamar Kunda U.P. Municipality	1	1976	50.00 acres	Nil	Aus(local) =25.00 T.Aman (paijon) =45.00 Wheat(sonalika)=40-45 mds	No problems.	Aus(local) =20.00 T.Aman =25.00 Wheat =50.00	Tk. 140.00 per acre Roughly for all season	Wheat - 0.75 1.50 T.Aman - 1.00 1.00
Mayadharpur U.P.Maharajpur.	1	1972-73	75.00 acres	Nil	China 45-50.00 Chandina - 45-50.00	shortage of insecticides	China=7.00 Chandina =68.00	Tk. 125.00 per acre	Urea. T.S.P. Boro- 0.62 0.10
Khajura U.P. Municipality	2	1975-76	55.00 2=110	Nil	T.Aman Naijarshail =30.00 Paijan=35.00 Tobacco-1250 lb Brinjal=250 mds. S.Cane=500-600 mds. Wheat=25-35 mds.	No Problems	Naijarshail =6.00 Paijon=8.00 Tobacco=10.00 S.Cane =5.00 Brinjal=1.00 Wheat= 25.00	Tk. 150.00 per acre Tk. 237.00 Tk.230.00 Tk. 230.00 Tk. 270.00 Tk. 270.00	Urea. T.S.P. Naijarshail-1.00 Paijon - 1.00 1.00 Tobacco - 1.00 1.00 S. Cane - 3.00 2.00 Brinjal - 1.00 1.00 Wheat - 2.00 2.00
Lohajang U.P. Padmadhar	1	1979	Not yet operated		-	-	-	-	-
Fursandhi U.P. Fursandhi	1	1979	Not yet operated		-	-	-	-	-
Madhupur U.P. Porahati	1	1962-63	33.00 acres	Nil	Aus BR-3=35.00 Chandina=28.00 Local =15.00 Wheat(sonalika) =35.00	Nil	Aus BR-3=5.00 Chandina=8.00 Local =15.00 Wheat = 5.00	Tk.120 per acre in each group	Urea. T.S.P. 1.00 1.00 in each group md
	9								

TABLE F-5 (continued)

MAGURA TARGET AREA

INFORMATION ON S.T.W.

NO. OF S.T.W. WITHIN THE TARGET AREA= JHENIDA = NO. 6
MAGURA = NO. 5
11

VERIFIED =MAGURA = NO. 2
JHENIDA = NO. 3
5

MAGURA P.S.

1	2	3	4	5	6	7	8	9	10
Phulbari U.P. Hazrapur	1	1978	10.00 acres	No reaction	BR-3(Boro) =45.00 Wheat =28.00	Inputs available, but price high.	BR-3 = 5.00 Paijon=5.00 Wheat(sonalika) = 7.00	Tk. 200.00 per acre.	Fertilizer used. Urea. 1.00 T.S.P. 1.00
Patharghata U.P. Hazipur	1	1977	8.00 acres	Individual ownership	Boro HYV =50.00 Wheat =30.00	- do -	Boro HYV = 5.00 Wheat = 3.00	Tk. 200.00 per acre.	Urea. 1.25 T.S.P. 1.25 mds/ac
	2								

JHENIDA P.S.

Nagar bathan U.P. Kumrobaria.	1	1976	-	Out of order.	-	-	-	-	-
Kasalepur U.P. Maharajpur.	1	1975	7.00 acres	Individual ownership.	Wheat =28.00	- do -	Wheat(sonalika) = 7.00	Tk. 150.00 per acre.	Urea. 1.00 T.S.P. 0.50 mds./ac
Khajura U.P. Municipality	1	1976	5.00 acres	(Cadet College) ownership	Vegetable =150.00 Wheat = 30.00	- do -	Vegetable = 3.00 Wheat = 2.00	Tk. 180.00 per acre	Urea. 1.50 T.S.P. 1.00 mds/ac

TABEL F-5 (continued)

MAGURA TARGET AREA

INFORMATION ON L.L.P.
(SPOT VISITED-15)

MAGURA P.S. = NOS. 16
JHENIDA P.S.= NOS. 32

48

MAGURA P.S.

1	2	3	4	5	6	7	8	9
Hazipur U.P. HAZIPUR	3 (2 cfs-1) (1 cfs-2)	1976-77 1976-77 1978-79	40 acres 20 x 2	Lack of quick repairing	BR-3 Iratom = 25.00 Wheat(sonalika) = 30.00	Insecticides and fertilizers not available in time and price is high.	BR-3 =15.00 Iratom=5.00 Wheat(sona= lika)= 20.00	BR-3 Tk. 150.00 per acre. Wheat Tk. 120.00 per acre.
Phulbari U.P. Hazipur.	1 (2 cfs)	1976	50 acres	lack of quick repairing and spare parts.	China=30.00 Wheat=35.00	- do -	China=30.00 Wheat=20.00	Tk. 150.00 per a Tk. 120.00 per a
Naldaha U.P. Athara-khada	1 (2 cfs)	1978	25 acres	- do -	Wheat=30.00	- do -	Wheat=25.00	Tk. 130.00 per a

TABLE F-5 (continued)

MAGURA TARGET AREA
INFORMATION ON L.L.P.
(SPOT VISITED - 15)

MAGURA P.S. = NOS. 16
JHENIDA P.S. = NOS. 32
48

JHENIDA P.S.

1	2	3	4	5	6	7	8	9	10
Nagar bathan U.P. Kumrobaria.	2 (2 cfs)	1978-79	30+30 = 60 acres.	No problems	Wheat = 35.00	Insecticides and ferilizers not available in time and price is high.	Wheat(sonalika)=30+30= 60 acres.	Tk.150.00 per acre.	
Mothurapur U.P.Municipality	2 (2 cfs)	1978	40+40= 80 acres.	- do -	Wheat = 30.00	- do -	Wheat=40+40= 80 acres.	Tk.150.00 per acre.	
Jhargram U.P.Kumrobaria.	1 (2 cfs)	1977	30 acres.	- do -	Wheat = 30.00	- do -	Wheat=30.00 acres.	Tk.150.00 per acre.	
Sotalia U.P. Harisankarou	2 (2 cfs)	1975	50+66= 116 acres.	Lack of quick repairing.	Br-4=40.00 Paijon= 35.00 IRRI-20 = 35.00 Nairjarshail = 30.00 Wheat=35.00	Untimely supply of seeds and insecticides	BR-4 = 16.00 Paijon = 50.00 IRRI-20= 10.00 Naijarshail = 40.00 Wheat=35.00	Tk.200.00 per acre. Tk. 250.00 per acre.	Fertilizer Urea. T.S.P 0.75 1.00 mds/ per ac each crop. Insecticide Diazinon, 14-G.
Khajura U.P.Municipality.	3 (2 cfs-2) (1 cfs-1)	1975-76	50+50=100 25.00 acres.	No problems	Naijarshail = 30.00 Paijon=35.00 Tobacco=1250 lb. Brinjal=250.00 Wheat= 30.00 S.Cane= 500-600 Wheat= 28.00	-	Naijarshail = 6.00 Paijon-8.00 Tobacco=10.00 Brinjal=1.00 Wheat =20.00 S.Cane = 5.00 Wheat = 25.00 (for 1 cfs pump)	Tk. 150.00 Tk. 237.00 Tk. 230.00 Tk. 270.00 Tk. 270.00 Tk. 230.00	For each 2 cf Fertilizer Urea.T.S.P. 3.00 2.00 mds/per acre Tobacco and cane Urea. T.S.P. 1.00 1.00 for all other.

5. SUGGESTIONS FOR A HOMESTEAD PLOT PRODUCTION PROGRAM

The phase II report recommended that a homestead plot production program be included as a component in the Nabaganga project. The review committee suggested that such a program needed a separate feasibility study. The justification for such a program follows.

5.1 Background and Justification

Most irrigation projects concentrate on inceasing the productivity of field crops such as rice and wheat. In this focus of activity, the potential productivity of homestead plots is ignored. With the current trend in population growth rates in rural Bangladesh, and the sale of lands by poor farmers, large proportions of rural families own no more than a household plot. Of particular importance in Bangladesh is the fact that under existing social conditions the agricultural productivity of women is more or less limited to work which can be done in and around the homestead.

Under current conditions the household plots serve as a focus for many village activities(almost all of them contain household gardens). These gardens produce vegetables both for household consumption and for marketing. Primarily they consist of local varieties of bitter gourd, sweet gourd, radishes, egg plants, tomatoes, onions, watermelon, muskmelon, chilies. While it is understood that homestead plots are used for other purposes, it appears that land could still be utilized more completely.

The productivity of these plots can be increased substantially by increasing the land now devoted to gardening, by improved varieties of seeds, improved supply of fruit seedlings for fruit trees, use of fertilizer, and irrigation.

Under current conditions in the project area the women who are primarily responsible for these gardens have no access to improved varieties or to knowledge about improved methods. Neither the IRDP nor the Ministry of Agriculture currently has training classes for women in gardening and vegetable production in the project area.

An experimental farm at Jessore is run by the BADC to experiment with improved seeds and methods of horticulture. The agricultural extension program associated with their farm is linked to BADC cooperatives and a model farmer system. The improved methods and varieties initiated at such a farm could easily be introduced to homestead production if links could be established between the experimental farm and women, who will learn improved gardening methods.

While improvements in gardens are one way to increase the productivity of homestead plots, there are other activities which can be carried out as part of a program for increasing homestead productivity.

Chickens can be raised on garden plots. Ducks can be tended by women and kept on homestead areas if water is available nearby. The introduction of irrigation water frequently makes duck habitat available to almost all famillies. The major constraining factor on increased poultry production is the prevalence of disease. The homestead production program can address this constraint by a program of vaccination of poultry. In addition, calves and goats can be fed on small plots and cows can be milked.

The advantages of a homestead production program are that it addresses the productivity of all the land, it improves production of foods necessary for nutritional balance, and it is a meaningful way of increasing the participation of women. Within the scope of an irrigation project it permits women to increase their agricultural skills, increase their income, increase their knowledge of agricultural technology. It supplies then with income which supplements family income or can be used by the woman herself.

5.2 Program Objectives

The objectives of the program would be:

- to introduce and diseminate hand pumps in sufficient quantity to irrigate household plots (as well as small farm plots);
- to introduce new and improved varieties of eggplant, gourd, beans into the homestead cultivation;
- to determine which innovations (improved seeds, fertilizers, seedlings) can be most readily introduced, and can bring the most rapid gains in household production;
- increase poultry production to increase family income;
- introduce vaccination of poultry in the village areas; and
- increase livestock production on small plots.

5.3 Implementation

Within the pilot areas, this program can be introduced simultaneously with the irrigation project.

The mechanism should be a training program in horticulture, and poultry and livestock raising directed at and for village women.

In order to design this training program a specialist (or specialists) in these fields should be employed to establish the principles to be taught, design a training program, and to work with a village instructor in how to implement the program. Such a specialist must have a background in horticulture and/or animal husbandry.

It would be helpful if he or she had previous experience in Bangladesh. His/Her duties would be:

(1) Establish the principles of the course curricula. As part of this the specialist should investigate programs already in progress in Bangladesh and give a professional judgment on whether the methods being introduced are the best to maximize incomes from the homestead plots and to increase productivity.

(2) Work with the village instructor and local representatives of interested government agencies including the Water Development Board, IRDP, and the Agricultural Extension offices to ensure that they understand the objectives of the program and the expected returns in family income.

In addition to this specialist, the program should employ an instructor to give classes at the village level. This instructor should be Bangladeshi and should have practical experience in the fields to be targeted.

The instructor will work with female community organizers who will be chosen from the area and whose responsibility will be to recruit women to the program and to explain the objective of the program in the community.

APPENDIX G
BACKGROUND ECONOMIC AND FINANCIAL DATA

APPENDIX G

BACKGROUND ECONOMIC AND FINANCIAL DATA

CONTENTS

TABLES

No.	Title
G-1	On-Farm Development Cost Per Acre
G-2	Breakdown of On-Farm Development Cost Per Acre
G-3	Regulation Civil Works Cost Per Acre
G-4	Breakdown of Regulation Works Cost Per Acre
G-5	Technical Services Cost Per Acre
G-6	Fishery Cost Per Acre
G-7	On-Farm Development Cost
G-8	Regulation Works Cost
G-9	Technical Services Cost
G-10	Fishery Cost
G-11	Costs During Implementation
G-12	Costing for Technical Services
G-13	Explanation of Pump and Distribution Costs

APPENDIX G

BACKGROUND ECONOMIC AND FINANCIAL DATA

Tables G-1 through G-6 provide economic and financial costs per acre for on-farm development, regulation civil works, fishery development, and technical services. Tables G-7 to G-12 show total cost of the project for each of the above components. Table 13 provides explanatory notes on capital investment.

TABLE G-1

ON FARM DEVELOPMENT COST PER ACRE

	CAPITAL COST (Tks)		DISTRIBUTION COST (Tks)		O and M (Tks)
YEAR	ECON	FIN	ECON	FIN	
1	624	648	804	1161	364
2	624	648	804	1161	364
3	624	648	804	1161	364
4	624	648	804	1161	364
5	624	648	804	1161	364
6	624	648	804	1161	364
7	624	648	804	1161	364
8					364
9	624				364
10	624				364
11	624				364
12	624				364

TABLE G-2

BREAKDOWN OF ON-FARM DEVELOPMENT COST PER ACRE (Tks)

	FIN COST	LOCAL COST	FX COST [1]	FX SHADOW PRICE [2]	TAXES and DUTIES [3]	FX ADJ. FOR TAX. + DUT.	ECON. COST	ECON. COST ADJ. FOR INFLATION AND CONT. [4]
PUMPS	540	54	486	583	175	408	462	624
MATERIAL	100	50	50	60	18	42	92	124
LABOUR [5]	320							240
RIGHT OF WAY	440							440
TOTAL	1440	94	536	643	193	450	554	1428

1 FOR PUMPS 90% AND FOR MATERIAL 50% COST IS FOREIGN EXCHANGE.

2 FOREIGN EXCHANGE IS SHADOW PRICED AT 1.2 TIMES MARKET VALUE.

3 36 % × FOREIGN COST.

4 ALL COSTS ARE ADJUSTED FOR INFLATION @ 20% AND CONTINGENCY @ 15%.

5 FOR LABOUR 50% IS ASSUMED TO BE UNSKILLED, SHADOW PRICED AT 5%.

TABLE G-3

REGULATION CIVIL WORKS COST PER ACRE (Tks)

	MATERIAL		CONCRETE AND OTHER		LABOUR		EQUIPMENT OPERATION	O + M
YEAR	(FIN)	(ECON)	(FIN)	(ECON)	(FIN)	(ECON)	(FIN)	(FIN)
1	185	159	151	139	32	23	24	2
2	61	54	108	89	34	22	13	4
3	11	8	3	12	19	11	1	6
4					11	5		7
5					16	8		7
6 - 12								7

TABLE G-4

BREAKDOWN OF REGULATION WORKS COST PER ACRE (Tks)

YEAR	MATERIALS						CONCRETE AND OTHERS					LABOUR		EQUIPMENT OPERATION
	FC	LC	FX	TX SHADOW	EXCISE TAX	ECON COST	FC	LC	FX	FX(S)	ECON COST	FC	EC	FC
1	137	14	123	148	44	118	112	56	56	67	103	24	17	18
2	45	5	40	49	14	40	80	40	40	5	66	25	16	10
3	8	.80	72	86	3	6	10	5	5	6	9	14	8	.67
4												8	4	
5												12	6	

TABLE G-5

TECHNICAL SERVICES COST PER ACRE (Tks)

YEAR	CAPITAL	RECURRING	TOTAL
1	14	48	62
2	14	48	62
3	14	48	62
4	14	48	62
5	14	48	62

TABLE G-6

FISHERY COST PER ACRE (Tks)

YEAR	CAPITAL COST	O & M
1	1656	-
2	1541	12
3	24	22
4-12		22

TABLE G-7

ON FARM DEVELOPMENT COST (ECONOMIC)

YEAR	DISTRIBUTION (thousand Tks)	O AND M (thousand Tks)
1	685	175
2	2,056	699
3	4,113	1,747
4	8,225	3,844
5	14,394	7,513
6	8,225	9,610
7	5,141	10,920
8		10,920
9	299	10,920
10	899	10,920
11	1,797	10,920
12	3,594	10,920

TABLE G-8

REGULATION WORKS COST (ECONOMIC)

YEAR	REGULATION WORK (thousand Tks)	O AND M (thousand Tks)
1	10,368	55
2	5,346	132
3	958	172
4	162	202
5	243	205
6		205
7		205
8		205
9		205
10		205
11		205
12		205

TABLE G-9

TECHNICAL SERVICES COST (thousand Tks)

YEAR	CAPITAL	RECURRING	TOTAL
1	415	1442	1857
2	415	1442	1857
3	415	1442	1857
4	415	1442	1857
5	415	1442	1857

TABLE G-10

FISHERY COST (thousand Tks)

YEAR	CAPITAL COST	O AND M
1	2,940	
2	2,736	375
3	718	669
4-12		669

TABLE G-11

COSTS DURING IMPLEMENTATION

	DEVELOPMENT YEAR								
	1	2	3	4	5	6	7	8	TOTALS
ON - FARM DEVELOPMENT									
1. Annual Development									
a. No. of pump Units	8	24	48	96	168	96	60	-	500
b. Acreage	480	1440	2880	5,760	10,080	5,760	3,600	-	30,000
2. Accummulated Acreage	480	1920	4800	10,560	20,640	26,400	30,000		30,000
3. Annual Expeditures (in takas)									
a. Pumps	259,200	777,600	1,555,200	3,110,400	5,443,200	3,110,400	1,944,000		16,200,000
b. Materials (Structure)*	48,000	144,000	288,000	576 000	1,008,000	576,000	360,000		3,000,000
c. Labor*	153,600	460,800	921,600	1,843,200	3,225,600	1,843,200	1,152,000		9,600,000
d. Additional R/W	211,200	633,600	1,267,200	2,534,400	4,435,200	2,534,400	1,584,000		13,200,000
Totals	672,000	2,016,000	4,032,000	8,064,000	14,112,000	8,064,000	5,040,000		42,000,000 or 42,060,500
REGULATION WORKS (in takas)									
4. Materials									
a. Concrete	2,700,000	1,700,00	240,000						
b. Masonry	350,000	490,000	60,000						
c. Steal	4,100,000	1,350,000	240,000						
d. Other	300,000	210,000	10,000						
5. Labor									
a. Skilled	290,000	220,000	50,000						
b. Common	420,000	540,000	369,000	234,000	367,000				
6. Equipment Operation	530,000	300,000	20,000						
Totals	8,690,000	4,810,000	989,000	234,000	367,000		15,090,000		

*Approximately (15% of Labor and Material Costs would be borne by the Project)

TABLE G-12

COSTING FOR TECHNICAL SERVICES (FAMILY SIZE: 3 PERSONS)

(based on 20-month tour of duty with R&R at 10 mos.)

CAPITAL			
Durables (household appliances)		7500x5x3 tours	112,500
Housing/Refurbishing		6500x5x3 tours	97,500
Vehicles	3-2WD 2-4WD Toyota PV		54,000
Spares			13,500
Motorcycles	$1200		30,000
		TOTAL	307,500
RECURRENT (O AND M			
Salaries Permanent	40,000x5		1,000,000
Short time	8.4 man months	$4500	189,000
Home Office	3.6 man months	$4500	72,000
Overhead	.9		1,134,900
Fringe Benefits	0.08		100,880

Travel	RT	Cost		
Domestic	5.3	9,000		
Int'l 3. 3.5	(3000)	135,000		
R&R 3,3.5	(600)	27,000		
Short Term 35	(3000)	109,000	/5	280,000

TRANSPORTATION AND MOBILIZATION (every 20 months)		
Vehicle	3,000	
Shipping	6,500	
Air Freight	2,500	
Storage	1,500	
Mobilization	1,500	180,000
ALLOWANCES		
Hardship 25% of salary	50,000	250,000
Temp. Housing 40 days	150 per family x 5	150,000
Utilities and Guard	400/mo x [illegible]	120,000
Schooling and Transport	6500	162,500
Local P.D. 20 days at 85	810 Dacca 85	42,500
P.D. Short Term	270 Field 50/5	63,500
DIRECT COSTS		
Communications	$300/mo 4,000	
O&M Vehicles	500/mo 30,000	

TABLE G-12 (continued)

Local Support	Supplies, Printing		
	Secretary	9,000	
Insurance		3,000	230,000
TOTAL			3,975,280

Approximately $15,000 per man month

RECURRENT COSTS O AND M

Staff Senior Technical		214,000
Motorcycles	$400 ea.	50,000
Extension Agents		92,400
Overhead	.40	143,360
Fringe	.15	89,600
Profit	.10	59,136
Total		4,623,776
G and A	@ 5% on	231,188.8
Profit	@ 10%	4,854,964.80
		485,496.48
		5,340,461.28

YEARLY	1,068,092.26
PER ACRE	35.60

TABLE G-13

EXPLANATION OF PUMP AND DISTRIBUTION COSTS
(sections 3-a, b, c, and d of Table G-11)

		Per acre	
a.	Average cost of pumps per acre 540 Tk. Principal amortized at 10 yrs. 20%	108 yearly	
b.	Materials - 15% = 2,550,000 or amortized at 10 yrs. 20%	17	
c.	Labor - 15% = 8,160,000 3/4 family labor at no cost		
	1/4 hired	7	
d.	Additional R/W 440 per acre over 10 yrs. w/o int.	44	
	TOTAL		176
	O AND M		
	Pumps	260	
	Materials	10	
	Depreciation	54	
	Interest	173	
	TOTAL		497
	GRAND TOTAL		673