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NABAGANGA
INTEGRATED LAND & WATER USE STUDY

PHASE III
PROJECT PREPARATION
VOLUME II
MAIN REPORT

FINAL REPORT

FEBRUARY 1981

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

(Project not approved
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TERMS, ACRONYMS, ABBREVIATIONS AND DEFINITIONS

ADB	-	Asian Development Bank
Aman	-	Rice more or less sensitive to photo period (except modern varieties), transplanted from July to September and broadcast Aman or deep water Aman is sown in March-April and harvested in November and December.
Aus	-	Rice insensitive to photo period grown mainly as an upland rainfed crop, sown/planted during March and April and harvested in July and August.
BAC	-	Bangladesh Agricultural Development Corporation
B. Aman	-	Broadcast aman or deep water aman.
BARI	-	Bangladesh Agricultural Research Institute
BBS	-	Bangladesh Bureau of Statistics
Beel	-	Marsh or Lake; also spelled bill or bil.
BKB	-	Bangladesh Krishi Bank, and agricultural development bank.
Boro	-	Winter rice insensitive to photo period, transplanted and cultivated mostly under irrigation.
BRRI	-	Bangladesh Rice Research Institute
BWDB	-	Bangladesh Water Development Board
CARE	-	Cooperative of American Relief Everywhere
DAC	-	District Approval Committee
DEM	-	Directorate of Extension and Management
DTW	-	Deep Tubewell
FAO	-	Food and Agricultural Organization
GOB	-	Government of Bangladesh
HYV	-	High-Yielding Variety
IDA	-	International Development Agency
ILO	-	International Labor Organization
IMPP	-	Irrigation Management Pilot Project
IRDP	-	Integrated Rural Development Program
IRRI	-	International Rice Research Institute

Khal	-	Narrow natural channel of water.
Kharif	-	Summer season or rainy season.
KSS	-	Krishi Sambaya Samities (Agricultural Cooperative Society)
LLP	-	Low-Lift Pump
MLG&RD	-	Ministry of Land Administration, Local Government, Rural Development, and Cooperatives.
MOSTI	-	Manually Operated Shallow Tubewell for Irrigation.
Paddy	-	Unhusked or rough rice.
Rabi	-	Winter season or dry season.
RWP	-	Rural Works Program
STW	-	Shallow Tubewell.
Sub-Division	-	Political division of a district.
T. Aman	-	Transplanted Aman paddy.
TCCA	-	Thana Central Cooperative Association
Thana	-	Administrative unit comprising 10-15 Unions.
TIP	-	Thana Irrigation Program
TTDC	-	Thana Training and Development Center
UNDP	-	United Nations Development Program.
Union	-	Lowest administrative unit, generally comprising 10-15 villages.
Union-Parished	-	Union Council, elected 9-member local government body.
USAID	-	United States Agency for International Development
UAA	-	Union Agricultural Agent
VEA	-	Village Extension Agent
WAPDA	-	Water and Power Development Authority
WB	-	World Bank

WEIGHTS AND MEASURES

1 acre (ac)	- 0.405 hectares
1 cubic foot per second (cusec)	- 0.0283 cubic meters per second
1 tola	- 0.4114 ounces = 180 grains troy
1 chattak	- 58.322 grams
1 seer (sr)	- 16 chattak = 80 tolas = 2.057 pounds = 0.933 kilograms
1 maund (md)	- 40 seers = 82.286 pounds = 37.326 kilograms
1 (long) ton	- 2240 pounds = 1016.04 kilograms = 27.22 maunds
1 lakh	- 100,000
1 crore	- 10 million

CHAPTER I
PLAN OF DEVELOPMENT

I. PLAN OF DEVELOPMENT

1.1 Background

The considered project is located along the Kumar and Nabaganga Rivers, upstream of their confluence at Magura. Previously, these two rivers were spill channels from the Ganges and Gorai Rivers and provided the area a source of water for irrigation, for the cultivation of deep water rice, for retting jute, and for other water related activities. These spill channels are now closed and the water supply has been severely reduced. The upstream reach of the Nabaganga River has been closed by natural siltations, but the severest reduction in water supply occurred when the Kaliganga and Dakua Rivers, which are major branches of the Kumar, were closed in 1959 and 1960, respectively, by construction of the Kushtia Unit of the Ganges - Kobadak (G-K) Irrigation Project.

These upstream developments are shown on the Vicinity Map of Figure I-1.

The farmers in the project area objected to this loss of their water supply and demanded a return to pre-project (pre-closure) conditions. In response to these demands, the water development authority at that time EPWAPDA planned and constructed a weir at Magura to impound the reduced flows of the Nabaganga and Kumar Rivers. Such an impoundment would not only satisfy the demands of the farmers but also provide storage for dry season irrigation.

The preliminary design of the weir provided for a flood discharge of 16,000 cubic feet per second (cfs). This was subsequently revised, and the final designed and constructed facility had a flood discharge capacity of only 5000 cfs. It was assumed, for this final design, that the historical flood flows would be significantly reduced by the closure of the Kaliganga and Dakua spill channels, and that flows in excess of 5000 cfs would spill upstream into the

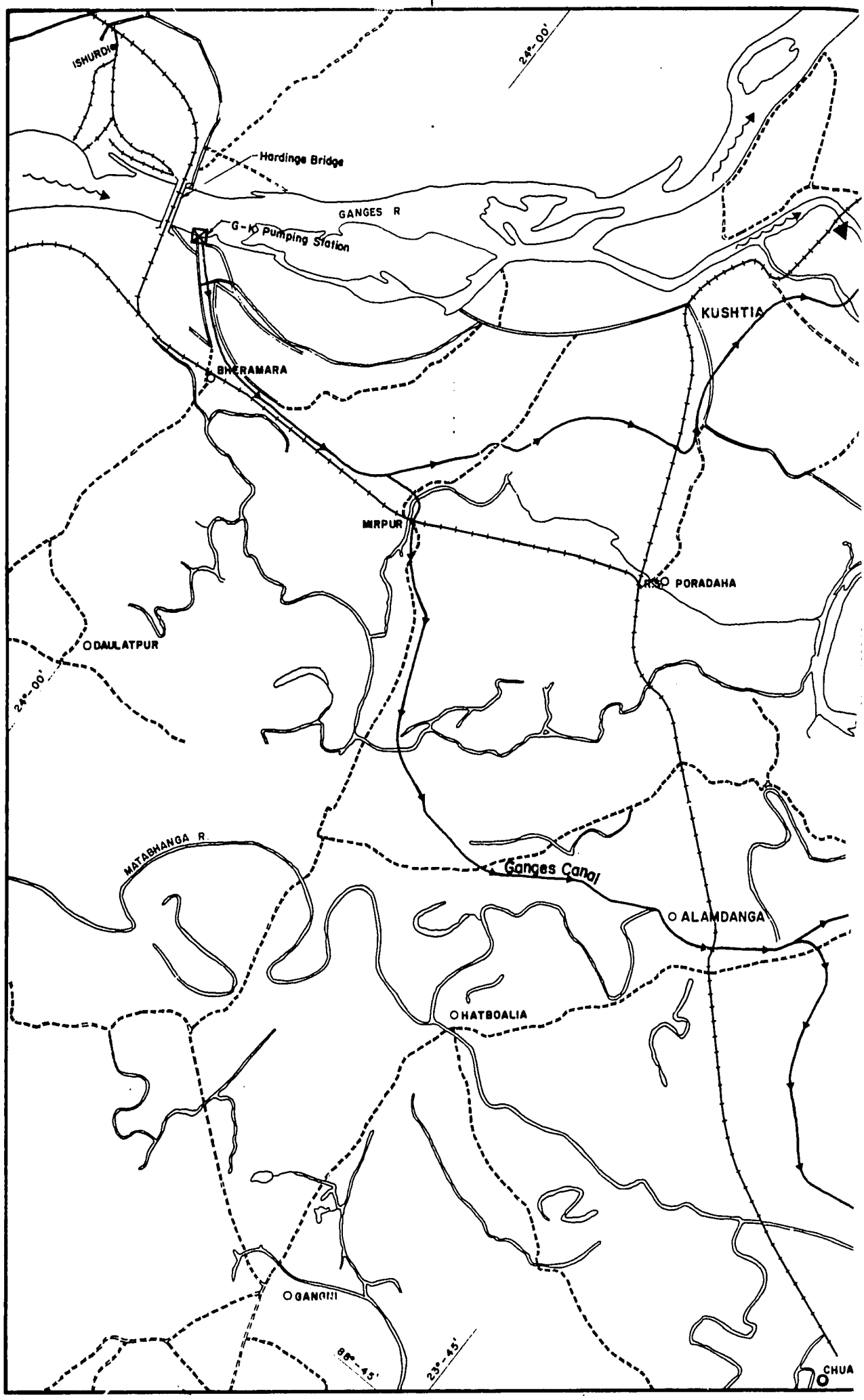
Nabaganga River and discharge through the Haorkhali and Alamkhali Khals.

It was also assumed that these two khals would serve as diversion channels during the construction of the weir when the river would be blocked. However, the Nabaganga, upstream of its confluence with the Kumar River was heavily silted; this river and the khals were blocked with local dams and footpaths; and there was no opportunity for the excess flows to discharge through the Haorkhali and Alamkhali Khals.

Consequently, severe upstream flooding occurred during the first year when the river was blocked by the construction of the weir. There was a violent local demonstration and a diversion channel had to be excavated to relieve the flooding. This channel was closed after the commissioning of the weir, but it was soon re-opened when there was some concern of upstream flooding. The diversion channel has remained opened and is now the main outlet for the Nabaganga and Kumar Rivers. The weir is being maintained and is operational but it cannot be utilized until the diversion channel is controlled. In the meantime, the farmers' expectations are unfulfilled and they continue to demand a restoration of their water supply.

A dependable surface water supply is a prerequisite to any significant irrigation development in the project area. The principal and primary component for developing this surface water supply is the closure or control of the existing Magura Diversion Channel. Other components of the proposed developments include improvements and a control structure in the Haorkhali Khal, control structures in the Alamkhali and Dariapur Khals, and some minor drainage improvements. The locations of the proposed improvements are shown on the Project Map of Figure I-2.

These improvements would permit the impoundment of water for 32 miles upstream in the Kumar River, for 36 miles in the Nabaganga River, for 2 miles in the Alamkhali Khal,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G-K Pumping Station
KUSHTIA
BHERAMARA
MIRPUR
PORADAHA
DAULATPUR
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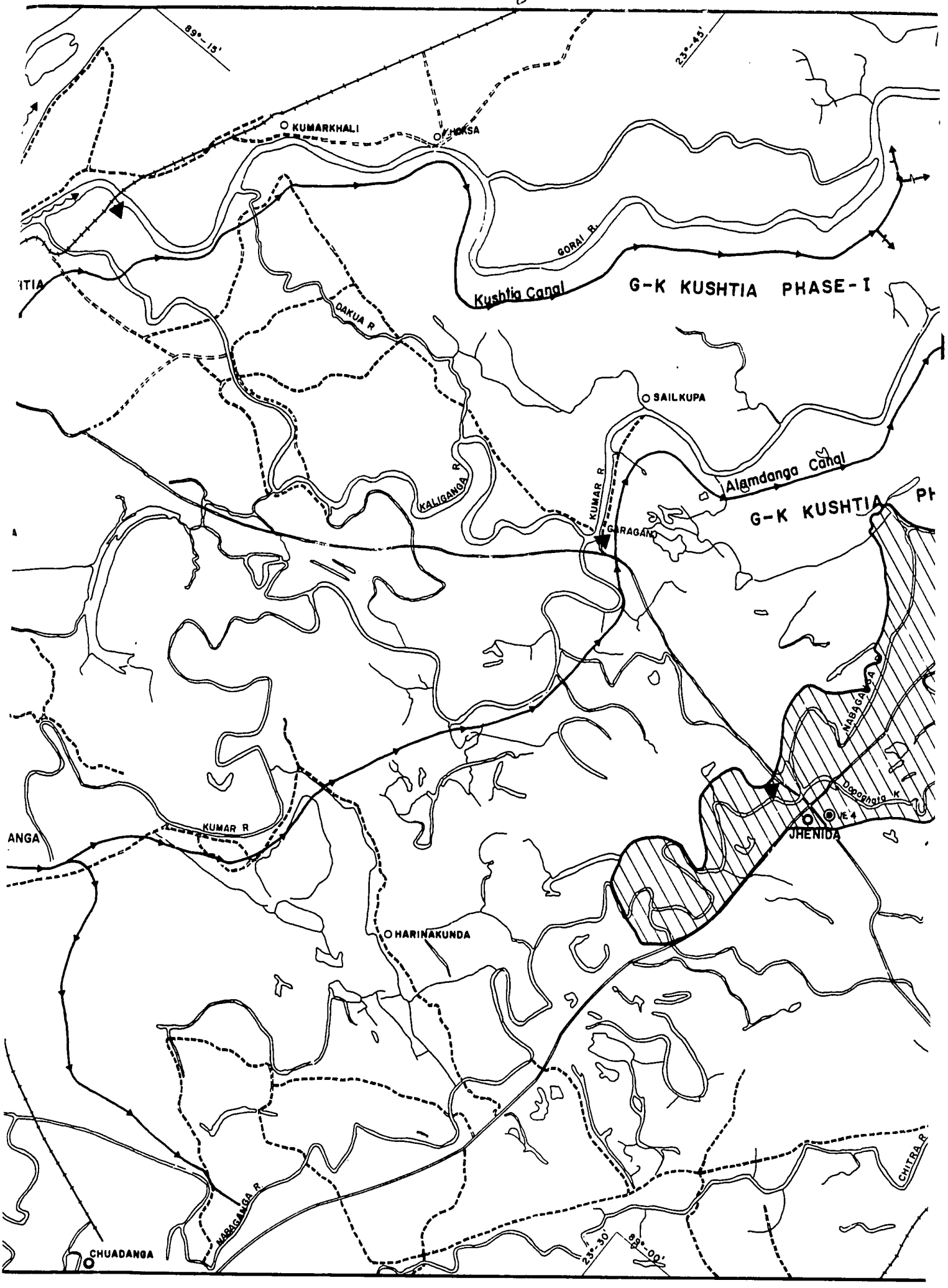
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SAILKUPA
KALIGANGA R
KUMAR R
Alamdanga Canal
G-K KUSHTIA
GARAGANJ
NABAGANGA
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JHENIDA
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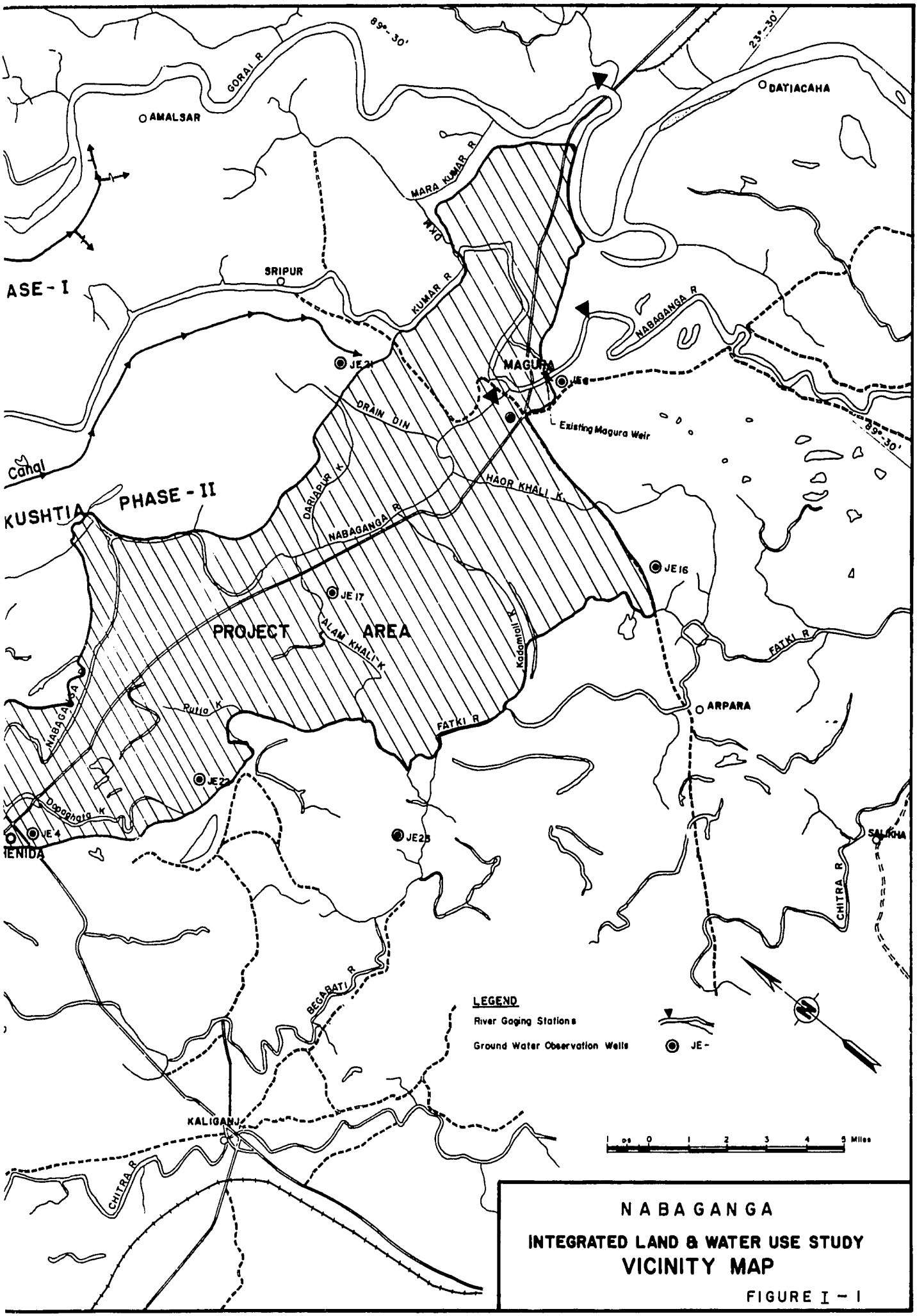
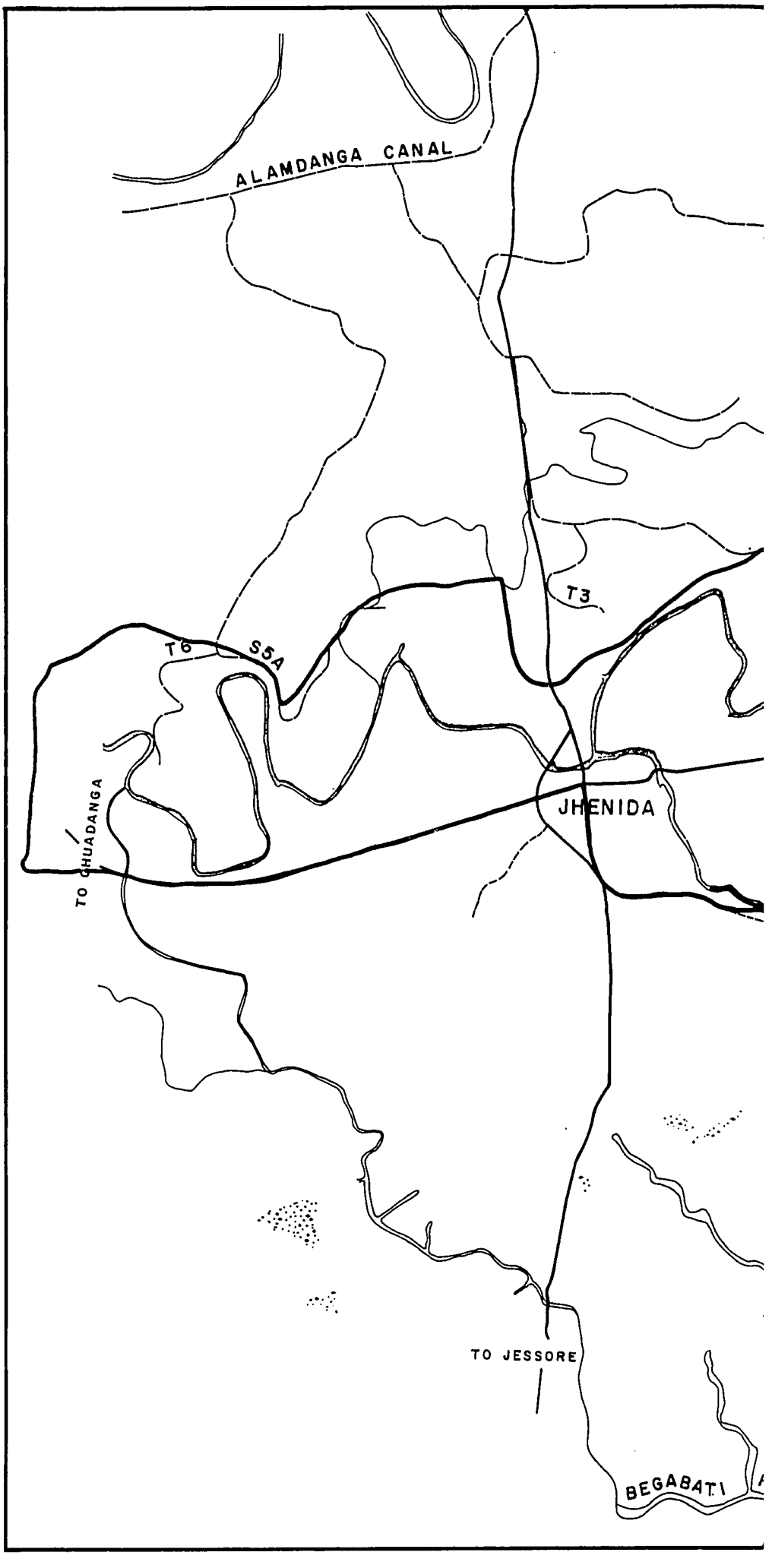


NABAGANGA

INTEGRATED LAND & WATER USE STUDY

VICINITY MAP

FIGURE I - 1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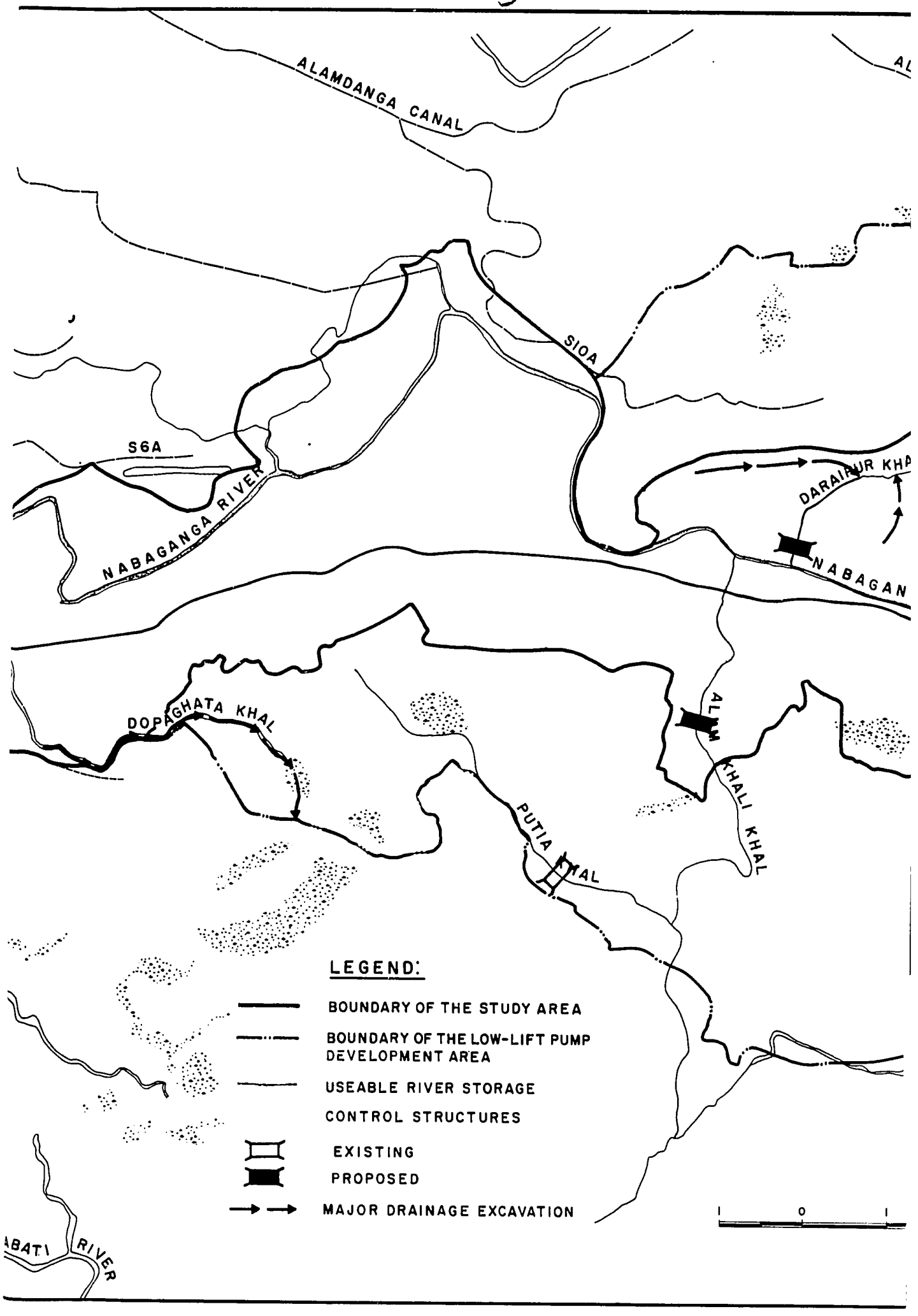
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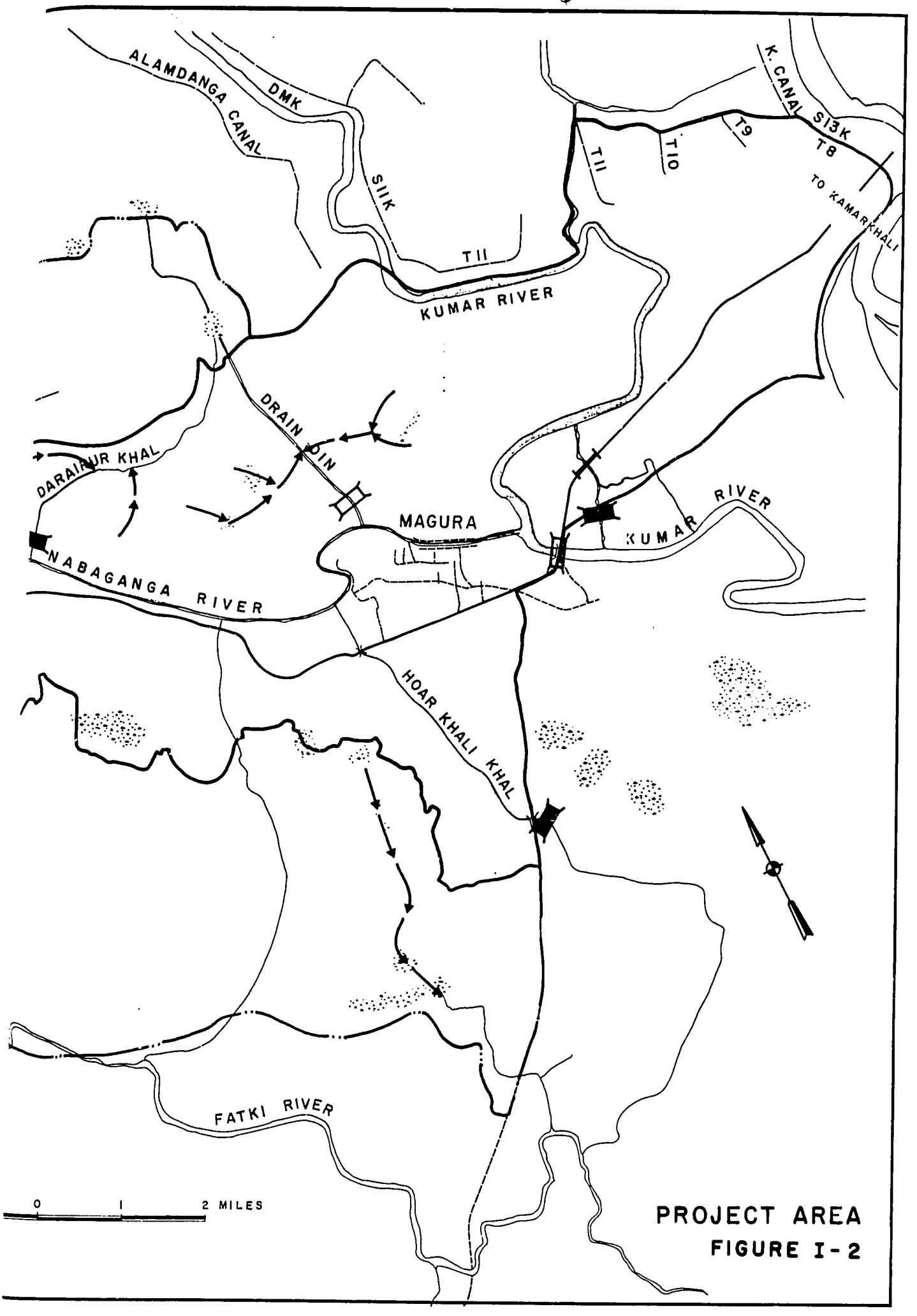
SIOA
S6A
NABAGANGA RIVER
DARAIPUR KHA
NABAGAN
DOPAGHATA KHAL
ALAM
KHALI KHAL
PUTIA
LEGEND:
BOUNDARY OF THE STUDY AREA
BOUNDARY OF THE LOW-LIFT PUMP DEVELOPMENT AREA
USEABLE RIVER STORAGE
CONTROL STRUCTURES
EXISTING
PROPOSED
MAJOR DRAINAGE EXCAVATION
RIVER



PROJECT AREA
FIGURE I-2

and for 4 miles in the Haorkhali Khal. The initial 7 miles in the Kumar River and all of other reaches of the above channels are within the project area, and would provide a source of water for low lift pump irrigation. This low lift pump irrigation development would be limited to those areas which are adjacent to and could be readily irrigated from the above sources of water. This would constitute a gross area of 52,000 acres in the project area of which 30,000 acres would be the net irrigable area that could be irrigated by the available water supply.

The irrigation of the remaining lands in the project area would require larger, more permanent pumping stations, and a more extensive conveyance system than for low lift pumps. An additional supply of water would also be required to extend the irrigable area beyond the initial designated 30,000 acres. This additional supply and irrigation expansion would be a consideration for future development.

The designated 30,000 acre Low-Lift Pump Development Area includes portions of the existing Kushtia Unit of the G-K Irrigation Project. These portions cannot always be provided an adequate irrigation supply from the G-K Project and it may be more appropriate to provide the water supply from the Nabaganga Project.

A regional planning study which included feasibility studies for specific projects was recently completed for the Southwest Region of Bangladesh including the proposed Nabaganga Project area. One of the feasibility studies, the Gorai River Development Project, presently under review, recommended extensive control and development along the Gorai River. It includes a offtake control structure and a major irrigation pumping station immediately east of Magura. The control structure would moderate downstream flooding from the Gorai River and would presumably eliminate the overbank spill into the project area. The pumping station would provide a source of supplemental water for expanding the irrigable area

within the Nabaganga Project. This proposed control structure and the pumping station would have a significant impact on the development of the Nabaganga Project and particularly, as discussed later, on the design and layout of the project's Magura Spillway.

The proposed plans of the Southwest Regional Study were discussed with all interested offices in Dacca. There was considerable uncertainty as to when, or even if these plans would ever be implemented, and it was considered prudent to develop the Nabaganga Project independently of the Southwest Regional Plan. The Nabaganga Project can be readily implemented, and it would be compatible with and would enhance any future development of the Southwest Regional Plan.

1.2 Water Requirements and Supply

1.2.1 Water Requirements

Water demand for irrigated agriculture is the only water requirement considered 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 (see Section 1.1). The Gorai river would be the source of irrigation water for these proposed developments. Consequently, these future requirements do not affect the Nabaganga Project.

Consumptive uses for crops presently grown or suitable to the project area were estimated using the Penman method. Detailed analysis of crop water requirements and cropping patterns are presented in Chapter 2, Soils and Agriculture, 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. Useable 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 Reg. 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

The irrigation efficiency of 65 percent is believed to be conservative, because the ditches are small and water does not have to travel any great distance from the pump to the field. It is expected, with a proper training program, to improve the efficiency after the first few years of operation.

1.2.2 Water Supply

Local runoff and return flows collected by the Nabaganga and Kumar rivers upstream of Magura would constitute the water source for irrigation by low-lift pumping in the project area. Possibilities exist in the area for conjunctive use of surface and groundwater and some limited development is proposed. However, as surface water would be readily available by construction of minor structures, the project has been planned primarily as a surface water irrigation project. In Appendix B, Section 2.10, a preliminary evaluation of groundwater potential is included. The chemical quality of the surface water supply is satisfactory. Nearly all of the runoff contributing to the available water supply comes from rainfall. That part which comes from drainage of irrigated

lands does not appear to accumulate sufficient concentrations of chemicals to be detrimental when applied as irrigation water.

Monthly estimates of runoff volumes for the month of February through November were made based on weighted average precipitation and monthly runoff coefficients. Runoff volumes for the low flow months December and January were estimated based on stage and discharge data at Station 216A, Magura.

Table I-1 shows the estimated monthly runoff volumes available at Magura for the period of available records. Computational details are given in Appendix B, Hydrology and Hydraulics.

1.2.3 Monthly Operation Studies

Using the natural runoff volumes shown in Table I-1 and irrigation water requirements for different crop mixes and cropping patterns, monthly operation studies were carried out to determine the final crop acreages to be included in the project. Water supply reliability of 80 percent was adopted for this analysis.

From the computer aided operation studies it was determined that 30,000 acres of wheat could be irrigated at about 80 percent level of reliability, if all water level control structures are closed at the end of October and remain closed throughout the wheat growing season. This means that in 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 mostly in February. In March, at the end of the wheat growing season, water still available could then be used to irrigate other crops. After satisfying wheat requirements, there would be about 5,800 acre-feet or more in 8 out of 10 years. An area of about 11,000 acres

TABLE I-1

ESTIMATED RUNOFF VOLUMES AVAILABLE AT MAGURA

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	

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 crops with smaller water requirements.

Details of above operation studies are presented in Appendix B.

1.3 Regulation Works

1.3.1 Existing Magura Weir

The existing Magura weir would become a major water level control structure once the spillway structure at the diversion channel is implemented as part of this project. (See Section 1.3.2 below.)

The crest at the Magura weir is at elevation 9.0 ft PWD and has four vertical lift gates. Total net opening width is 48 ft. The surface of the road on top of the weir is at about elevation 27 ft PWD.

1.3.2 Magura Diversion Channel - Spillway Structure

This structure would be located across the existing diversion channel at a site approximately one-half mile downstream of the Magura/Kamarkhali road crossing. The existing gated Magura weir would provide the means of controlling the releases and the impoundment of water in the upstream channels and this proposed spillway structure would be required only for the discharge of flood flows.

This structure would be a 125 foot wide, ogee crest, reinforced concrete structure with a crest elevation at 15 feet PWD which would operate as an ungated, overflow spillway.

During the dry season, from late October to early March some control of the crest will be needed to maintain a proper storage and to permit the water level to be raised to a maximum elevation of 19 feet PWD. This control would be realized by the insertion of timber stop logs between H - beams that would be embedded in the spillway crest.

This spillway would have a design capacity of 9700 cfs at 83 percent submergence conditions and with the upstream water level at elevation 23.8 feet PWD. The 9700 cfs peak design discharge is the calculated 50-year occurrence runoff from the drainage area. (See Appendix B, Hydrology and Hydraulics).

The banks of the diversion channel upstream of the structure are at some place below 23 feet PWD and the adjacent ground slopes off to an elevation of 20.5 feet PWD. Higher discharges that could occur from Gorai river overbank spills could flood adjacent areas without jeopardizing the safety of the weir structure.

The river banks at the structure site consist of soft to loose layers of clays and silts underlain to an undetermined depth by a stratum of medium dense fine sand. The structure would be founded on a sand fill which would be densified by driving timber piles. Generally, a "Vibro-Flotation" method is used for this densification; but the equipment is not readily available in Bangladesh, and satisfactory results have been obtained with the timber pile method.

The construction site would be enclosed by steel sheet piling to contain the foundation and to prevent a washout of the sand foundation by scour and/or piping. The sheet piling would be extended laterally at both the upstream and downstream cutoff walls to prevent scouring or piping around the structure. The sheet piling is now available in Bangladesh from a curtailed project in Khùlna.

The upstream cofferdam would be an earthfill type with a crest elevation of 12.5 feet PWD. At this elevation the site would be protected from natural river flows which would then be discharged through the existing weir which has a sill elevation of 9 feet PWD. After dewatering, the downstream face of the cofferdam would be strengthened with compacted fill which would then act as an upstream berm for the main structure.

The Site Plan of this structure and the Section is shown on Figures I-3 and I-4, respectively.

The structure is located downstream of where an existing khal branches off from the diversion channel. This existing khal and a series of beels could then be used to channel water into the project area if ever the water supply were to be supplemented by pumping from the Gorai River.

In some years, there is significant spillage into the project area from overbank flows from high flood stages in the Gorai River. There is no rational means of estimating the quantity of this spillage or to design for it. The upstream runoff superimposed on this abnormally high flood level causes extreme flooding particularly upstream of the Magura/Kamarkhali road embankment which acts as a virtual dam across the floodway. The only significant opening in this embankment for the release of flood waters is the crossing at the diversion channel. This is a critical section and nothing should be done that would constrict this section. Accordingly, the spillway structure would be located downstream out of its influence.

However, there is a temporary Bailey bridge at this crossing which could cause major problems. The bridge is old and in poor condition. It is supported on temporary timber cribs which not only partially block the channel but could be subject to undermining and failure during high discharges. A failure of either the bridge or the supports would cause a

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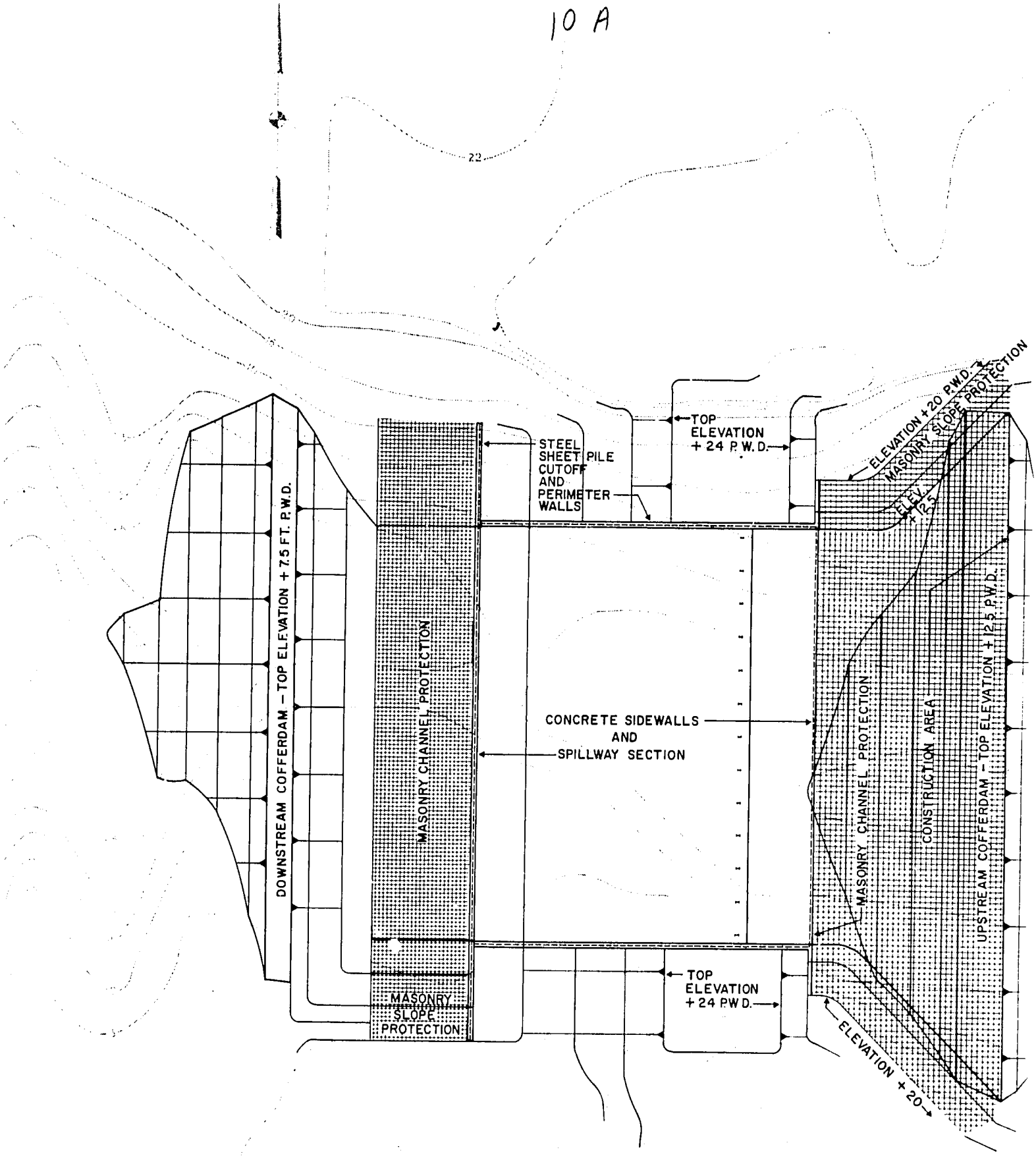
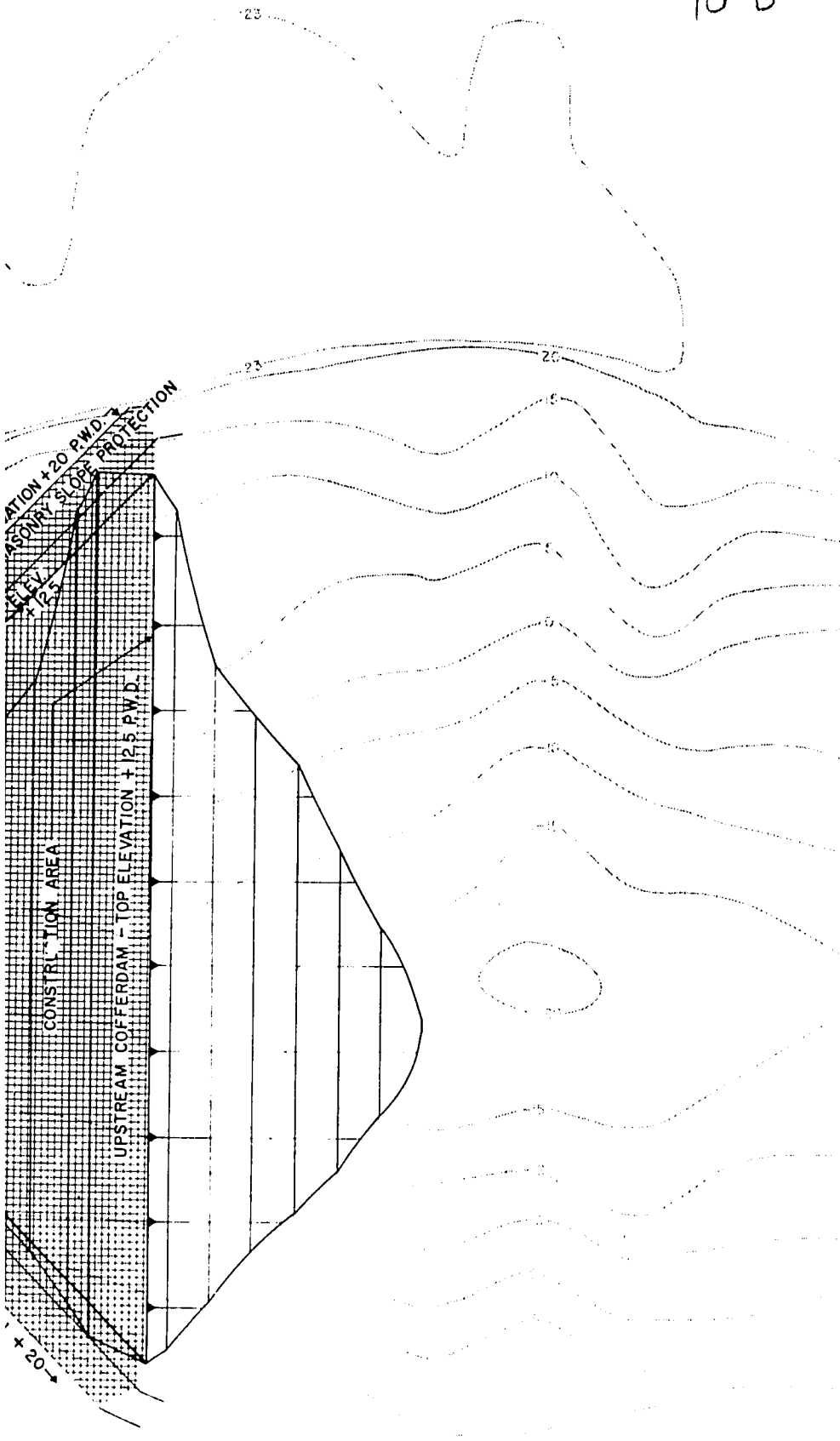
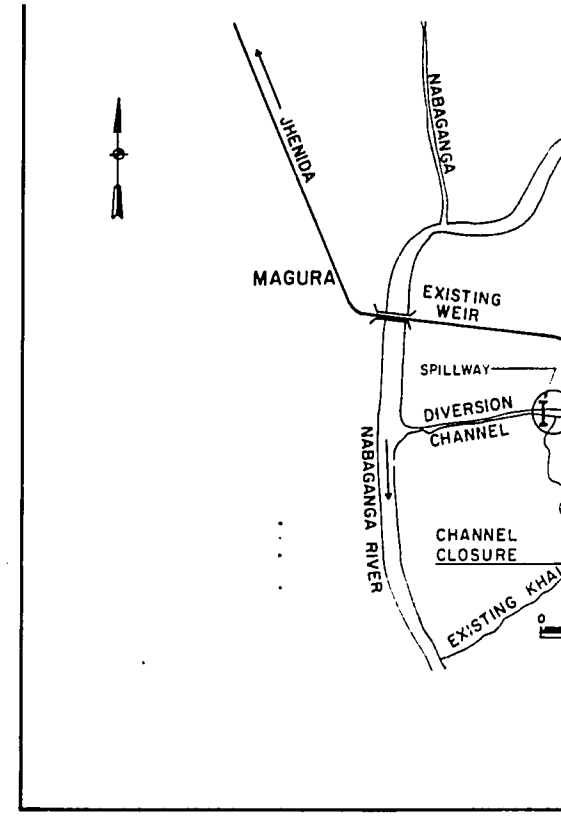

22
DOWNSTREAM COFFERDAM – TOP ELEVATION + 7.5 FT. P.W.D.
MASONRY CHANNEL PROTECTION
STEEL SHEET PILE CUTOFF AND PERIMETER WALLS
TOP ELEVATION + 24 P.W.D.
CONCRETE SIDEWALLS AND SPILLWAY SECTION
MASONRY SLOPE PROTECTION
TOP ELEVATION + 24 P.W.D.
ELEVATION + 20 P.W.D.
MASONRY SLOPE PROTECTION
ELEV. + 25
MASONRY CHANNEL PROTECTION
CONSTRUCTION AREA
UPSTREAM COFFERDAM – TOP ELEVATION + 12.5 P.W.D.
ELEVATION + 20

10 B





LOCATION MAP

NOTE:

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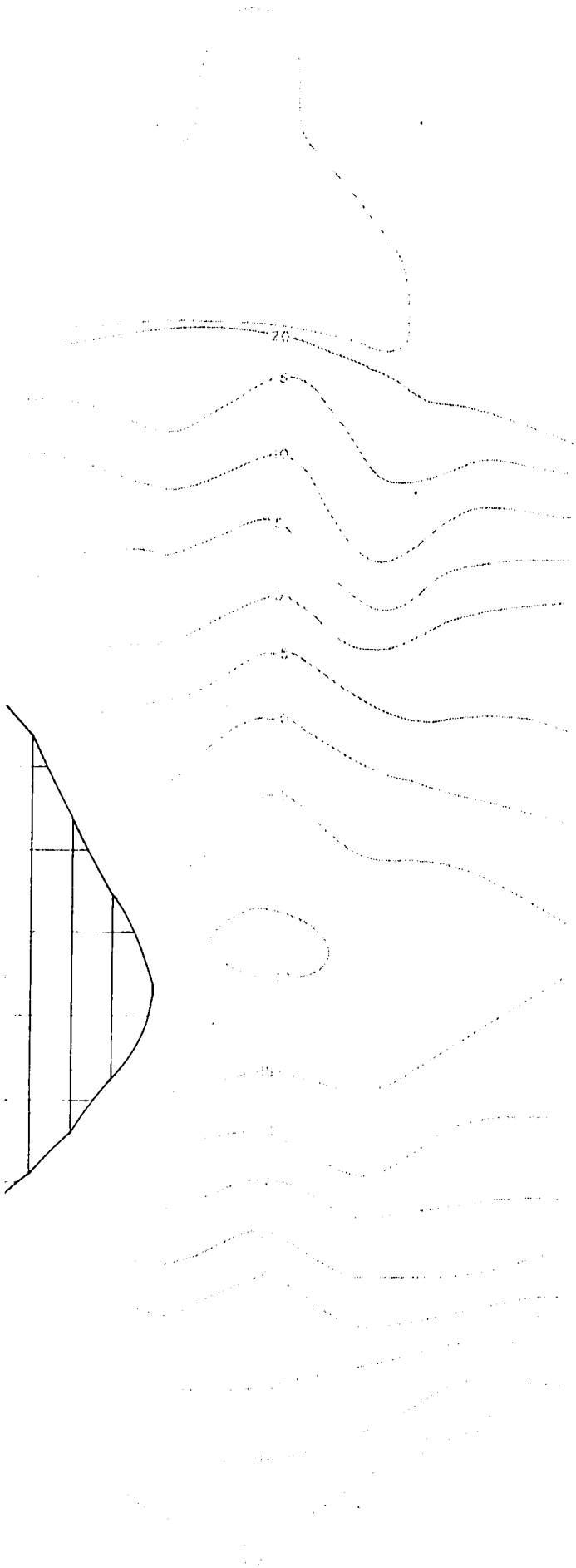
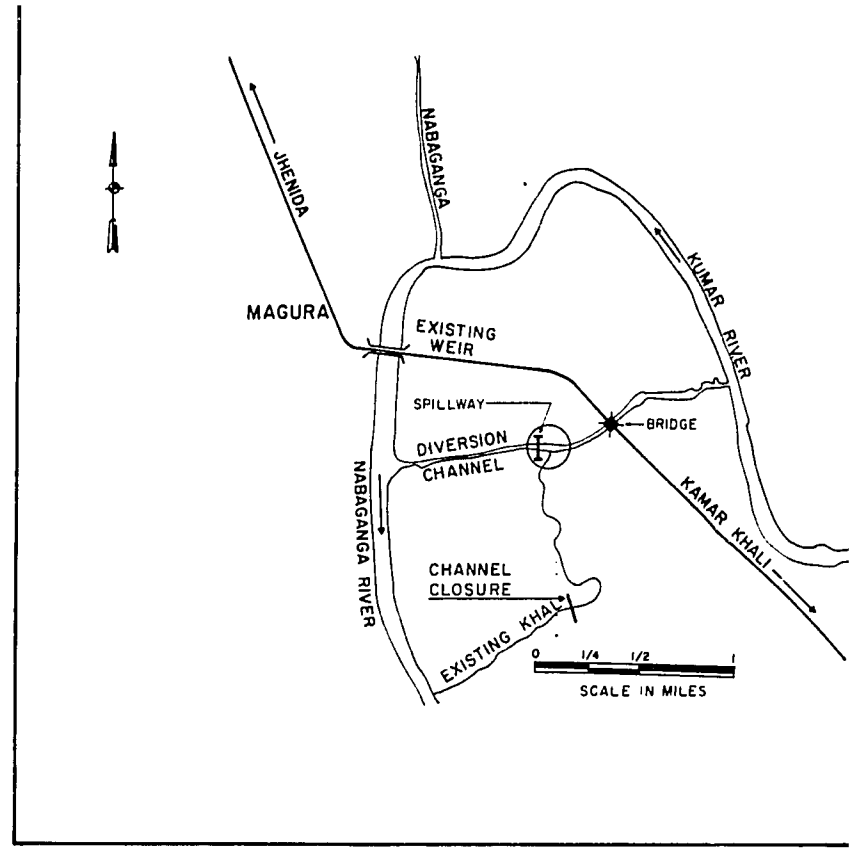
MAGURA DIVERSION
SPILLWAY STRUC
SITE PLAN

10 C





LOCATION MAP

NOTE:

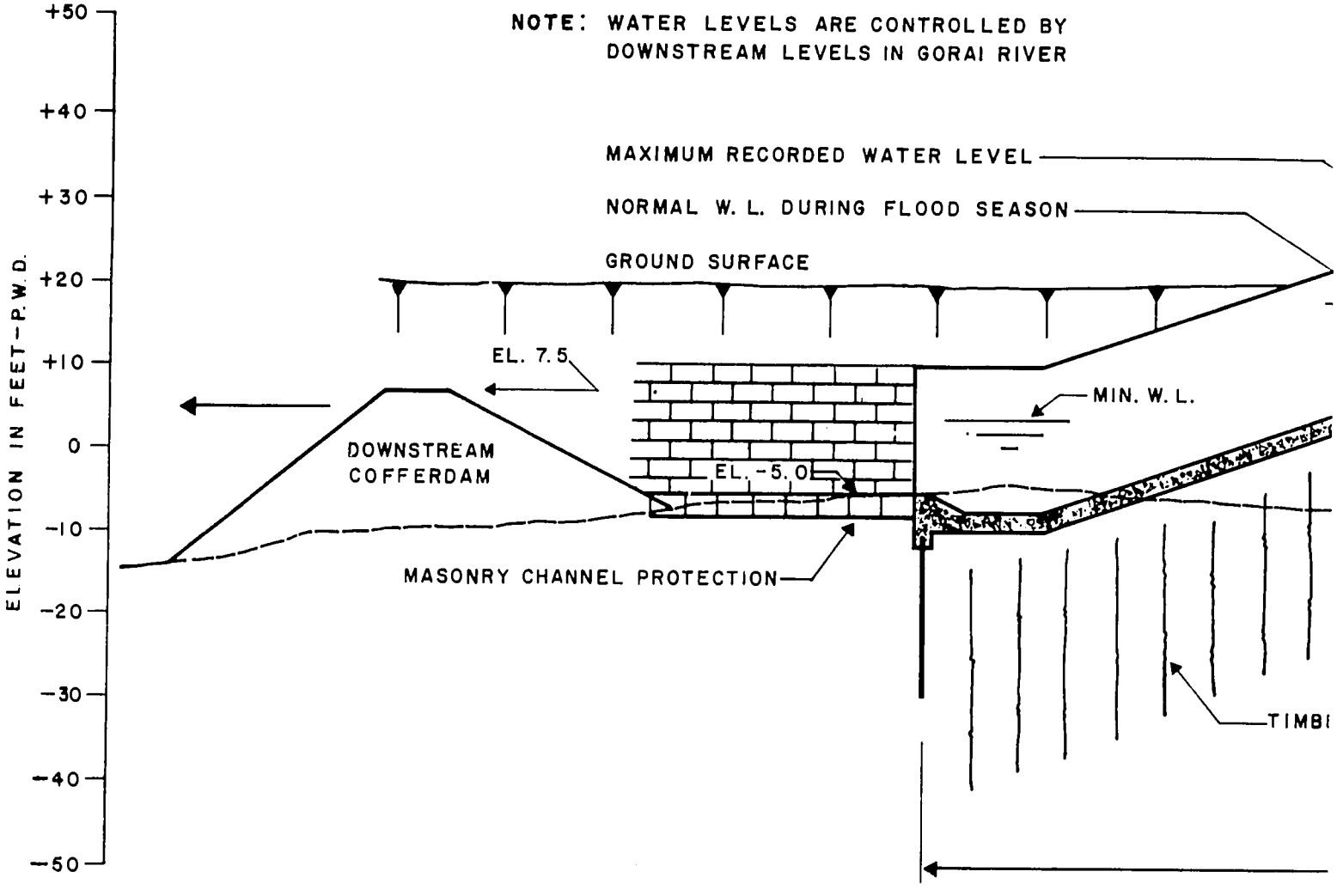
THE TOPOGRAPHIC CONTOURS SHOWN HERE ARE FOR A SITE IMMEDIATELY UPSTREAM OF THE EXISTING KHAL. THE TOPOGRAPHY AT THE PROPOSED STRUCTURE IMMEDIATELY DOWNSTREAM OF THE EXISTING KHAL IS SIMILAR EXCEPT THE SPOIL FROM THE EXCAVATION OF THE DIVERSION CHANNEL IS STILL DEPOSITED ALONG THE DOWNSTREAM CHANNEL AND THE BANK ARE 4 TO 5 FEET HIGHER

20 10 0 20 40 60
SCALE IN FEET

MAGURA DIVERSION CHANNEL SPILLWAY STRUCTURE SITE PLAN

FIGURE 1-3

10 D


NOTE: WATER LEVELS ARE CONTROLLED BY DOWNSTREAM LEVELS IN GORAI RIVER
MAXIMUM RECORDED WATER LEVEL
NORMAL W. L. DURING FLOOD SEASON
GROUND SURFACE
EL. 7.5
MIN. W. L.
DOWNSTREAM COFFERDAM
EL. -5.0
MASONRY CHANNEL PROTECTION
TIMBI
ELEVATION IN FEET-P.W.D.
+50
+40
+30
+20
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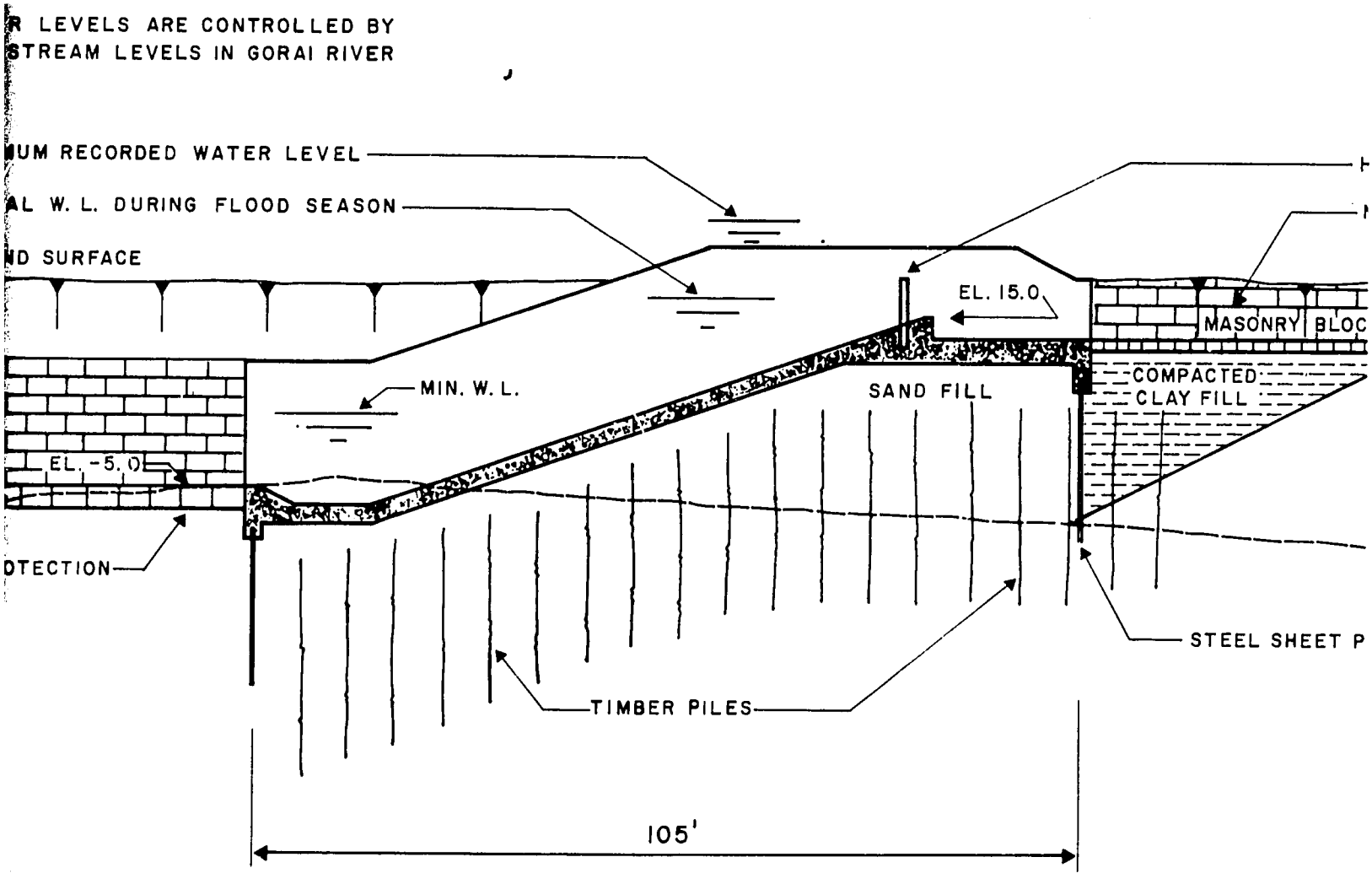

FIGURE I - 4

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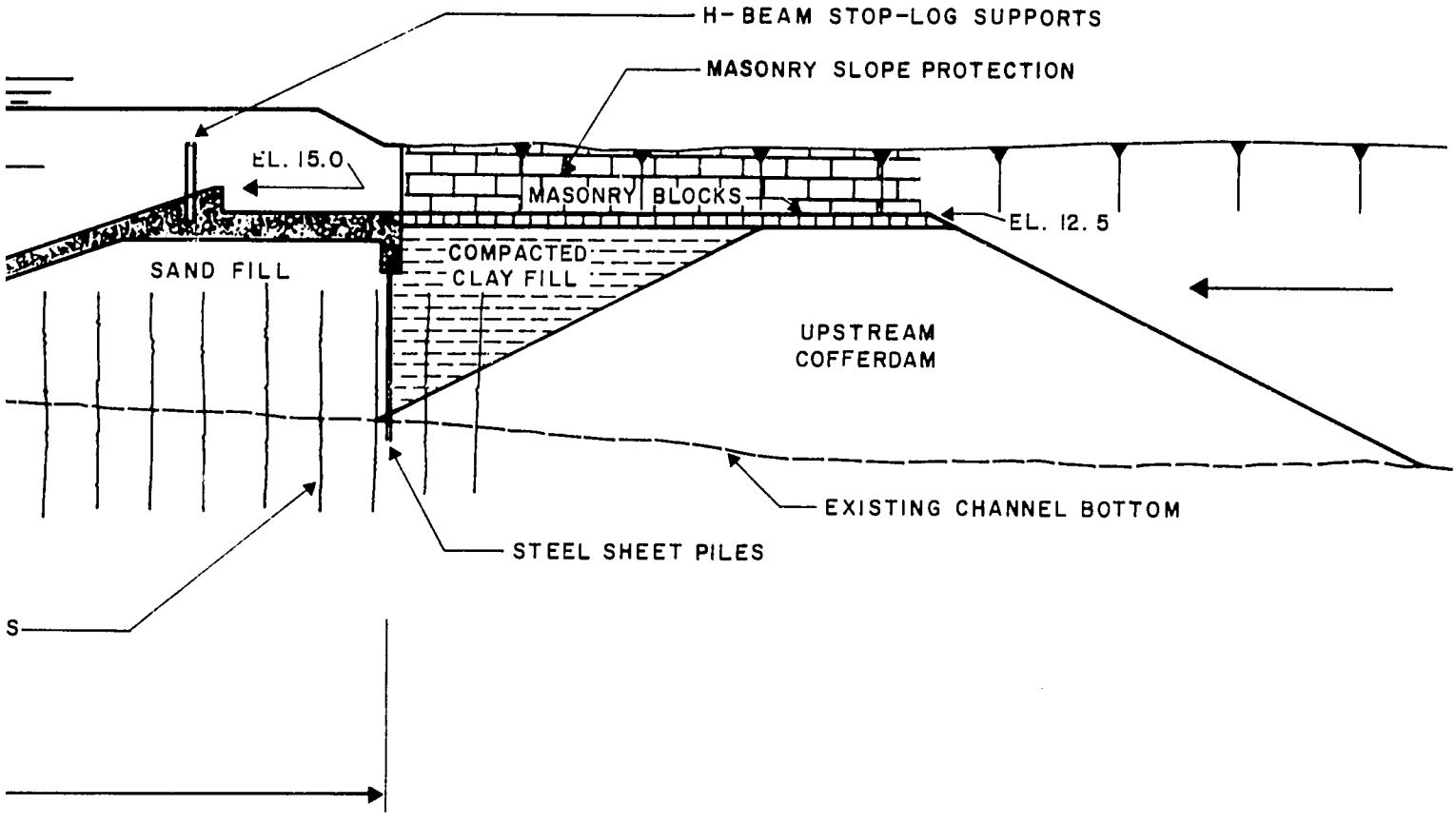


MAGURA DIVERSION CHANNEL
SPILLWAY STRUCTURE
SECTION

severe blockage of the channel with the consequent increase in upstream flooding.

To ensure that this diversion channel is fully operative and that the upstream flooding will not recur as in the earlier years, this existing Bailey bridge needs to be replaced with a permanent structure. The replacement bridge would be a single span, two lane, reinforced concrete structure.

1.3.2.1 Operation of Main 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. These structures will be operated primarily to rise 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. The following plan of operation is proposed:

- At the end of October start impoundment of water up to elevation 19 ft PWD 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 ft. PWD.

- At the end of February, remove stop logs from the bypass channel weir, lowering normal impoundment level down to elevation 15 ft PWD.

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 water requirement in March is very low and were usually

satisfied with March runoff and a very small volume of carryover 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 ft. PWD would be still controlled.

- From March through May the normal water surface level would be maintained at elevation 15 ft PWD by operation of the gates of the existing Magura weir for supplemental irrigation of Aus or other crops.

d) 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.

1.3.3 Haorkhali Khal

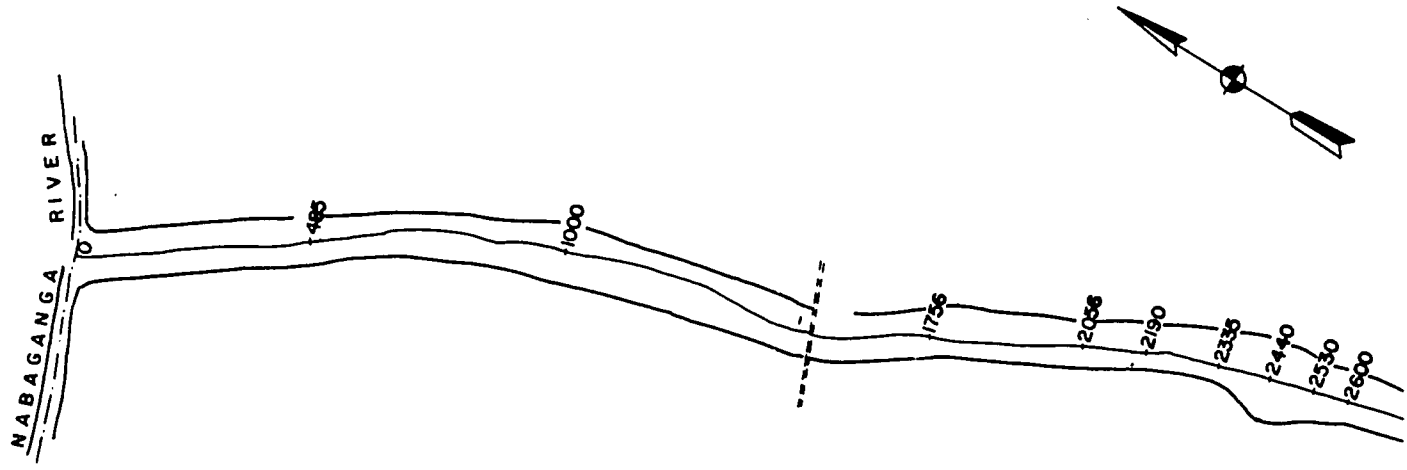
This khal is a spill channel of the Nabaganga River and takes off from the main river approximately four river miles upstream of the conflucnec with the Kumar River. There are indications that the Haorkhali Khal had been previously excavated and improved, but the upper reach is now silted and blocked with water weeds, earth dams and footpaths. The lower reach, upstream of the Magura/Apara Road bridge, has been recently cleared and improved. There is now no flow through the khal except when the water level in the Nabaganga River exceeds 16 feet PWD. There is currently no irrigation along its banks.

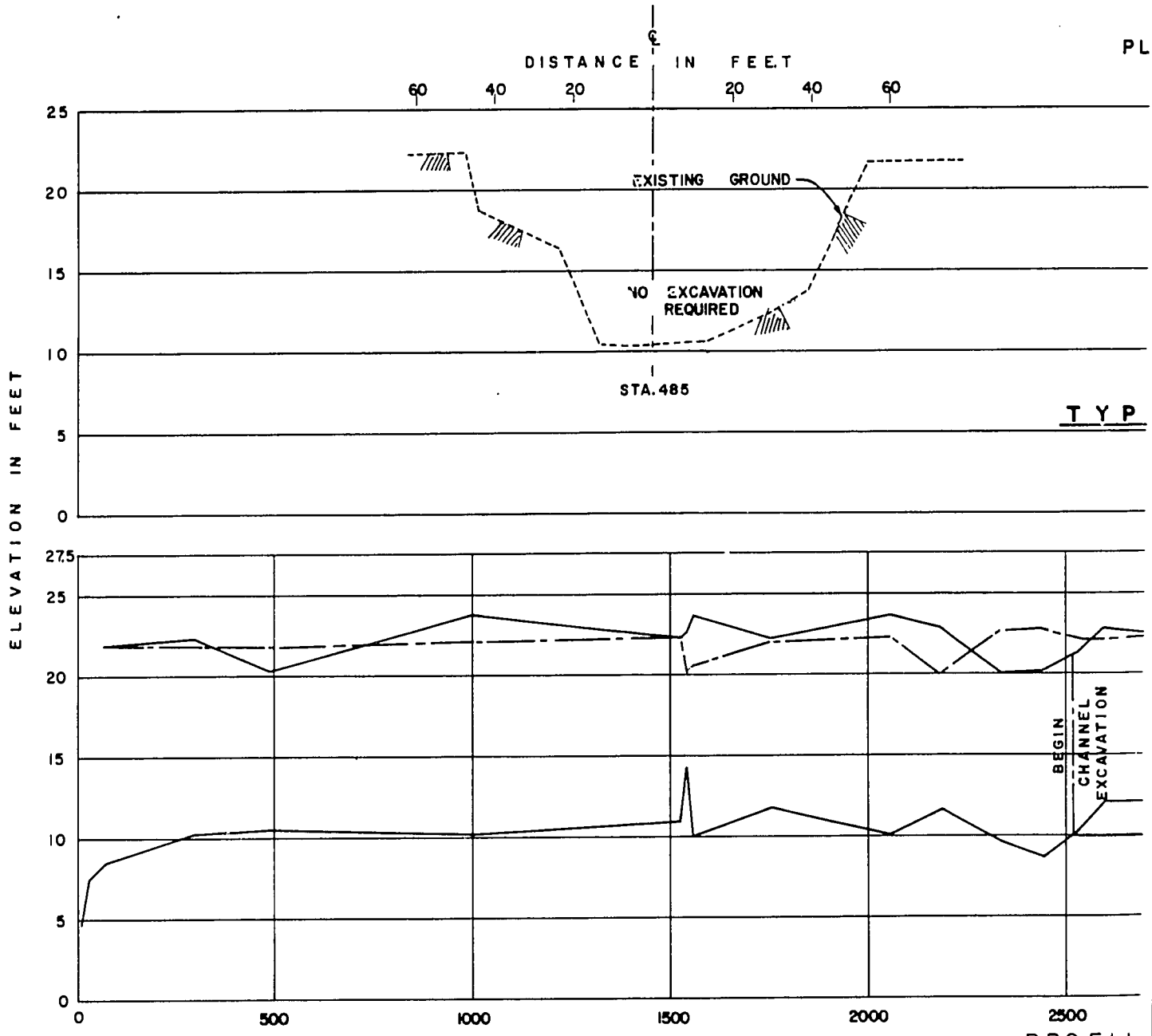
The khal would be improved to provide both flood control and irrigation benefits. The upper 14,000 feet of channel would be excavated to a uniform gradient with a bottom width of 20 feet to provide a flood discharge capacity of 1600 cfs, and to supply a source of water for irrigation, by low-lift pumps, of approximately 2500 acres along both banks. The excavated material would be placed in compacted embankments along both banks to serve as footpaths and to facilitate the possible future conversion to a gravity canal.

The areas to be excavated are mostly swamps or marginally cropped lands. The farmers have indicated a willingness to relinquish these areas if a water supply is assured.

The Plan and Profile of the Haorkhali Khal with the limits of the proposed improvements is shown in Figure I-5, Sheets I-4.

One structure would be required to impound and control the water levels in the upstream reach of the khal. This structure would be located approximately one-fourth of a mile downstream of the Magura/Apara Road bridge to extend the irrigation service to the largest possible area, and to provide potential service to the area east of the road if an additional water supply is developed. This would be a reinforced concrete structure with two, 12 feet wide by 8 feet



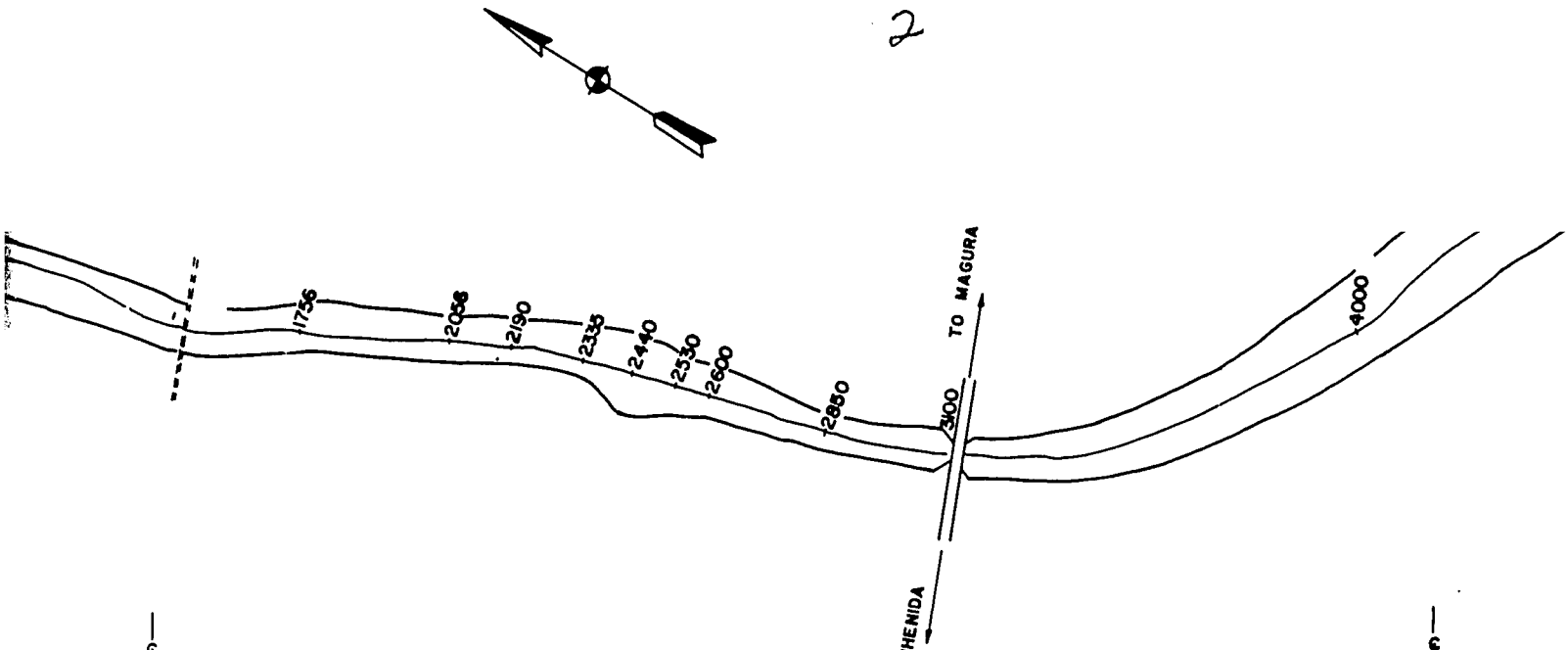


PROFIL

DISTANCE IN

FIGURE I

2



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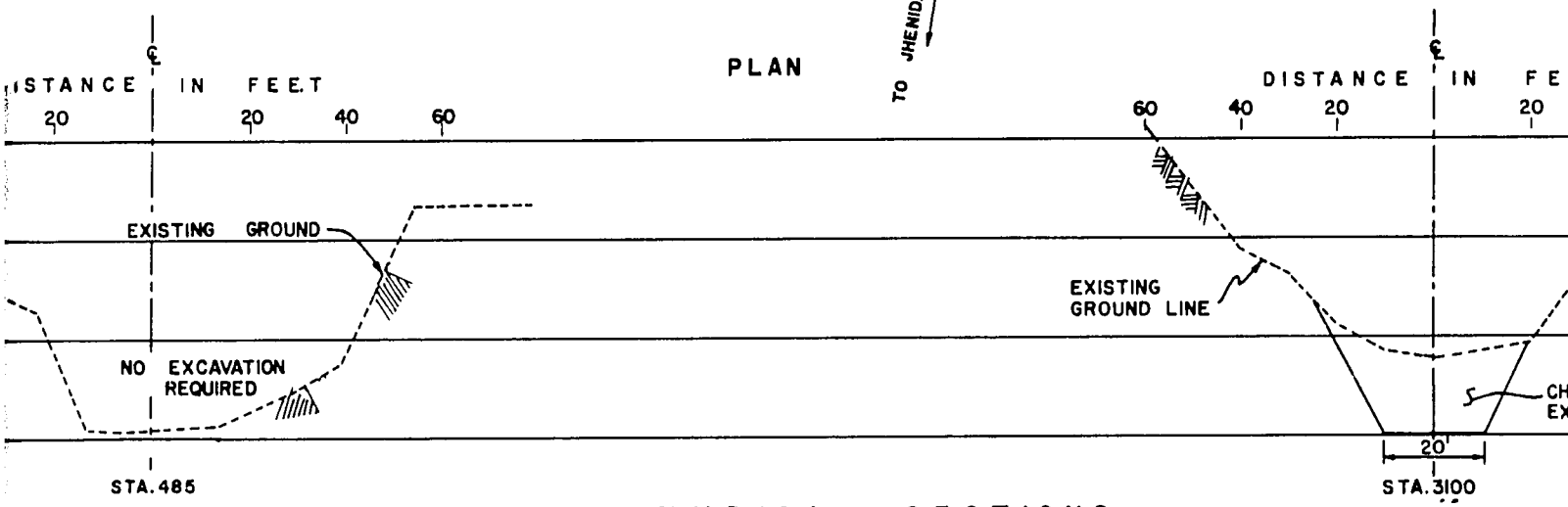
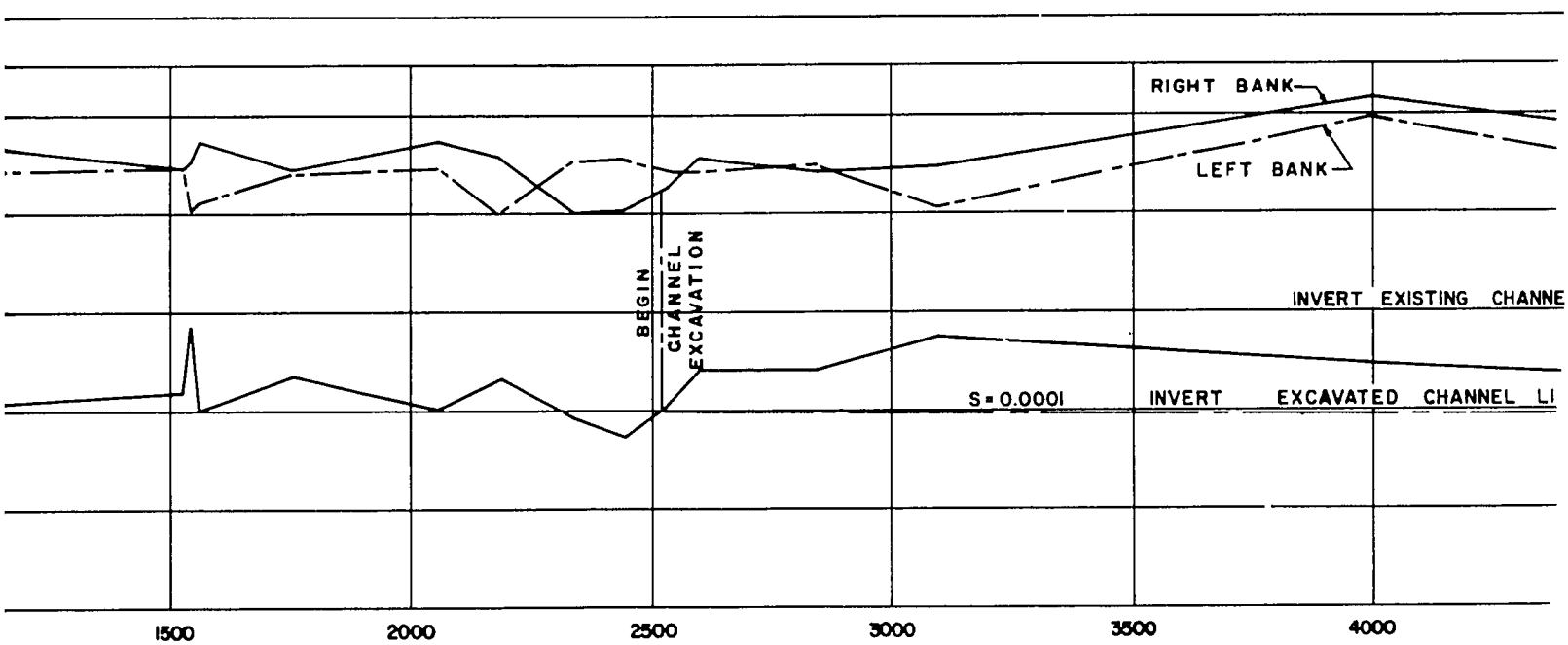


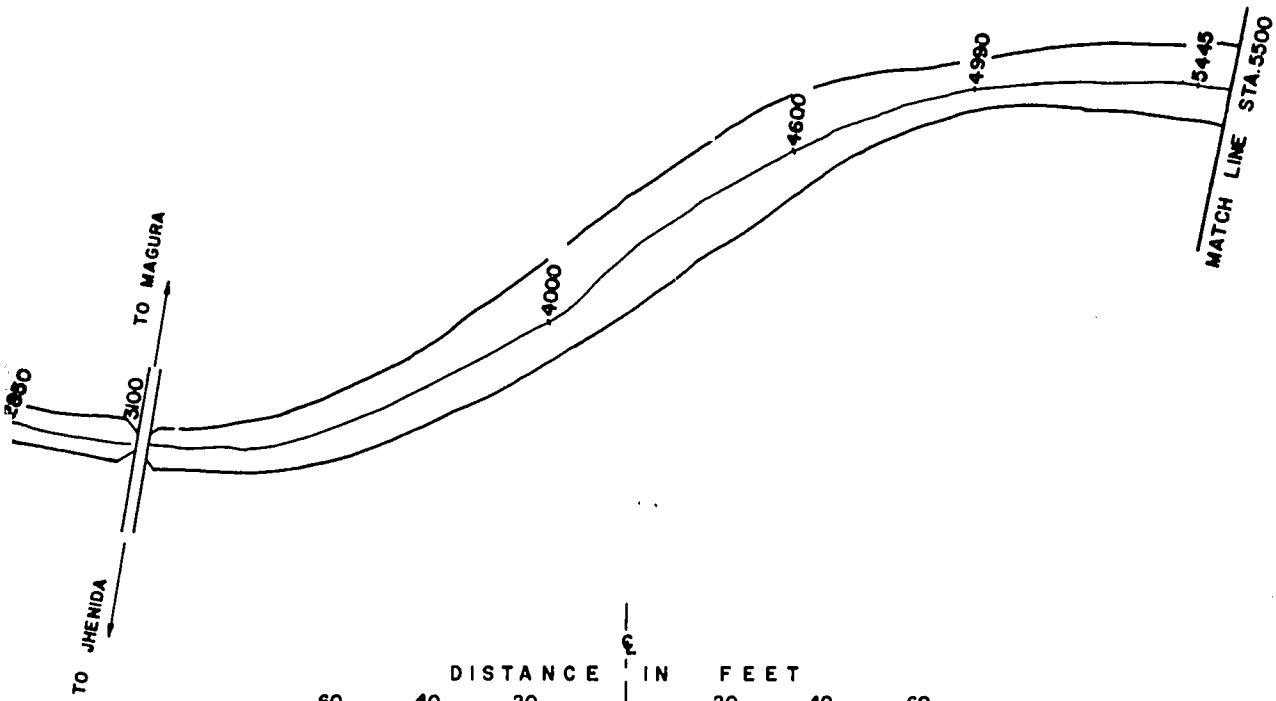
TYPICAL SECTIONS

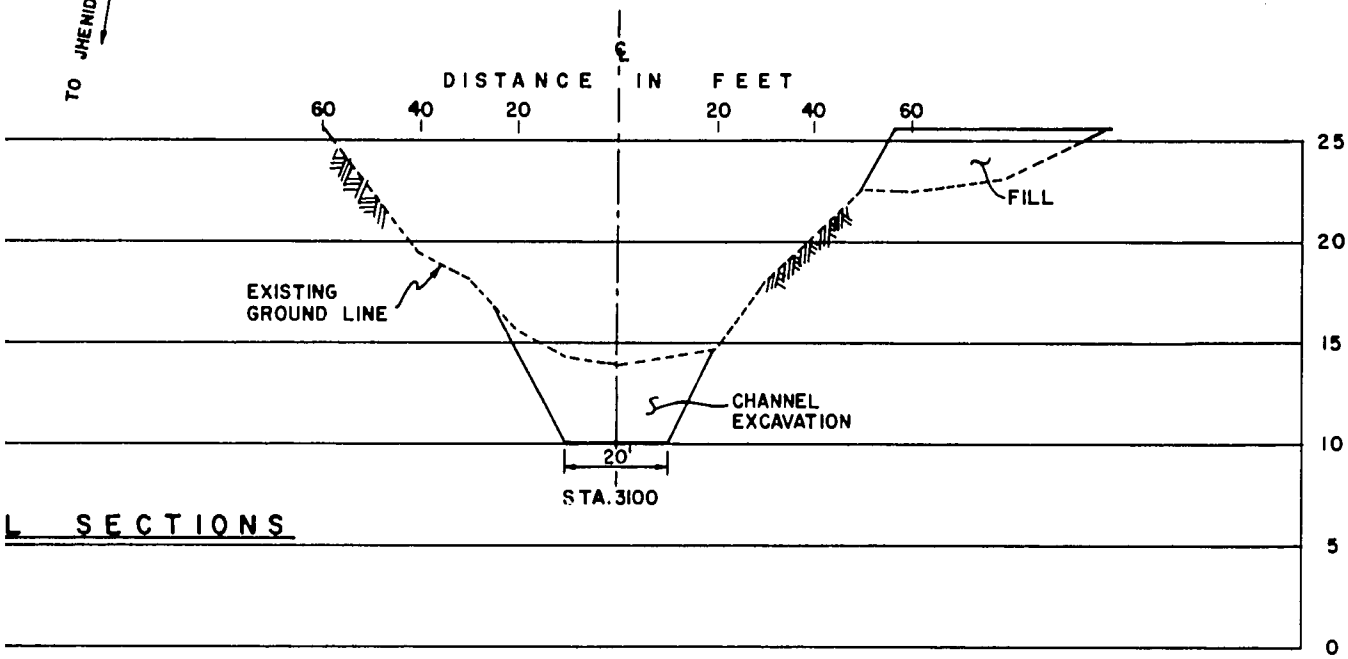


PROFILE

DISTANCE IN MILES

FIGURE I - 5





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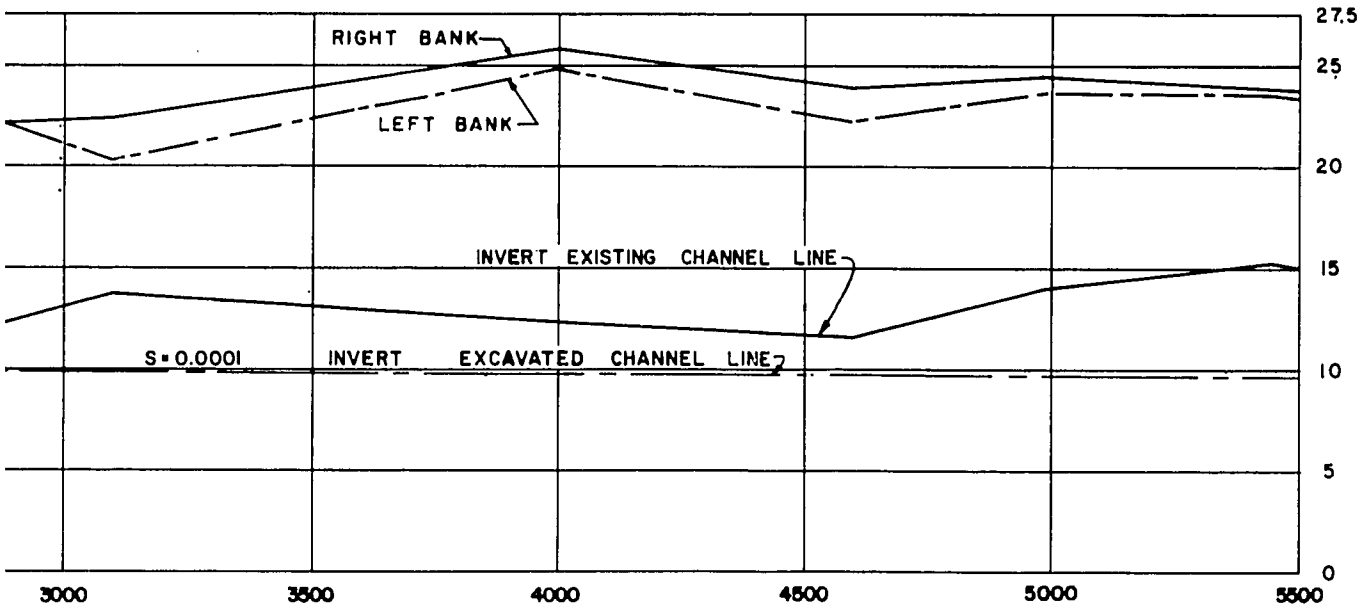

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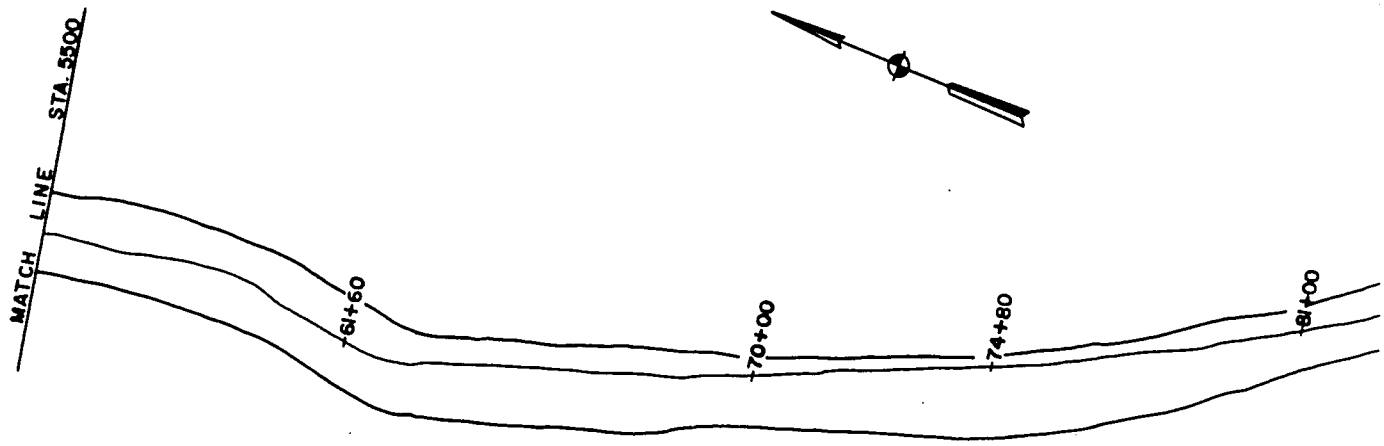
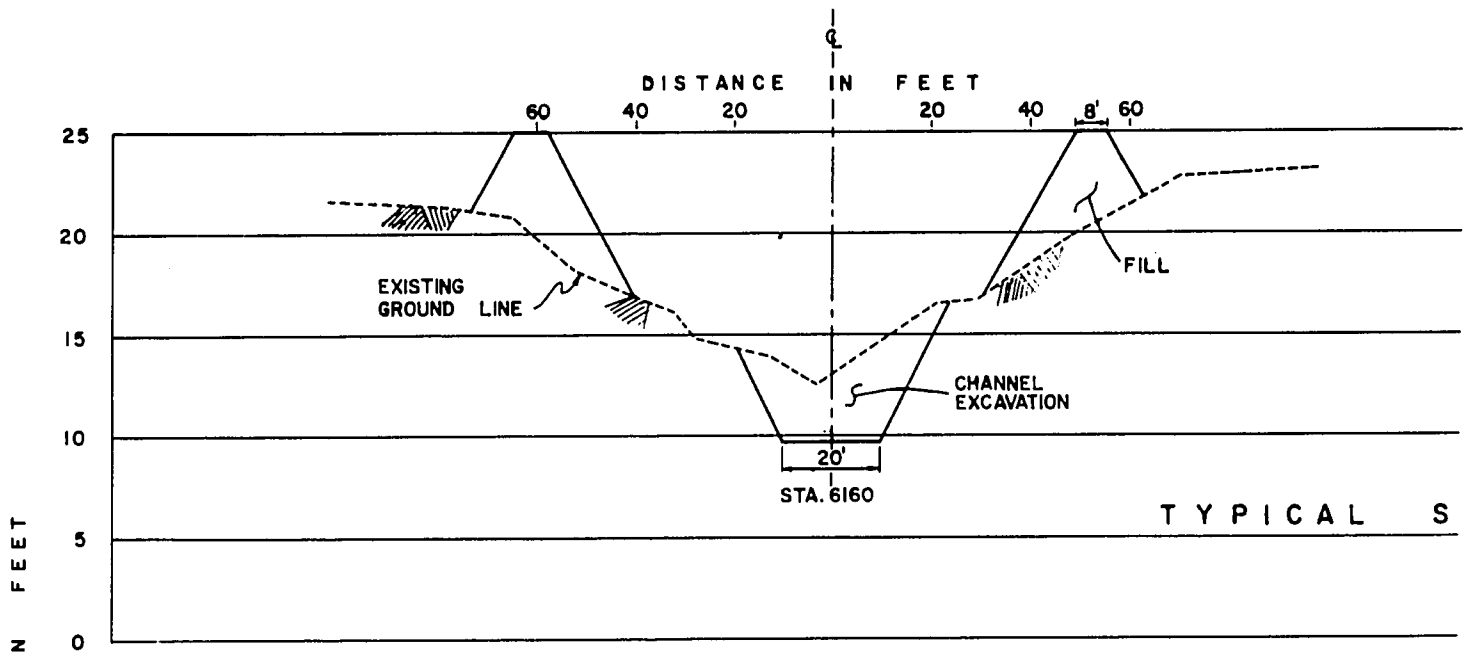
HAORKHALI KHAL

PLAN & PROFILE

SHEET 1 OF 4





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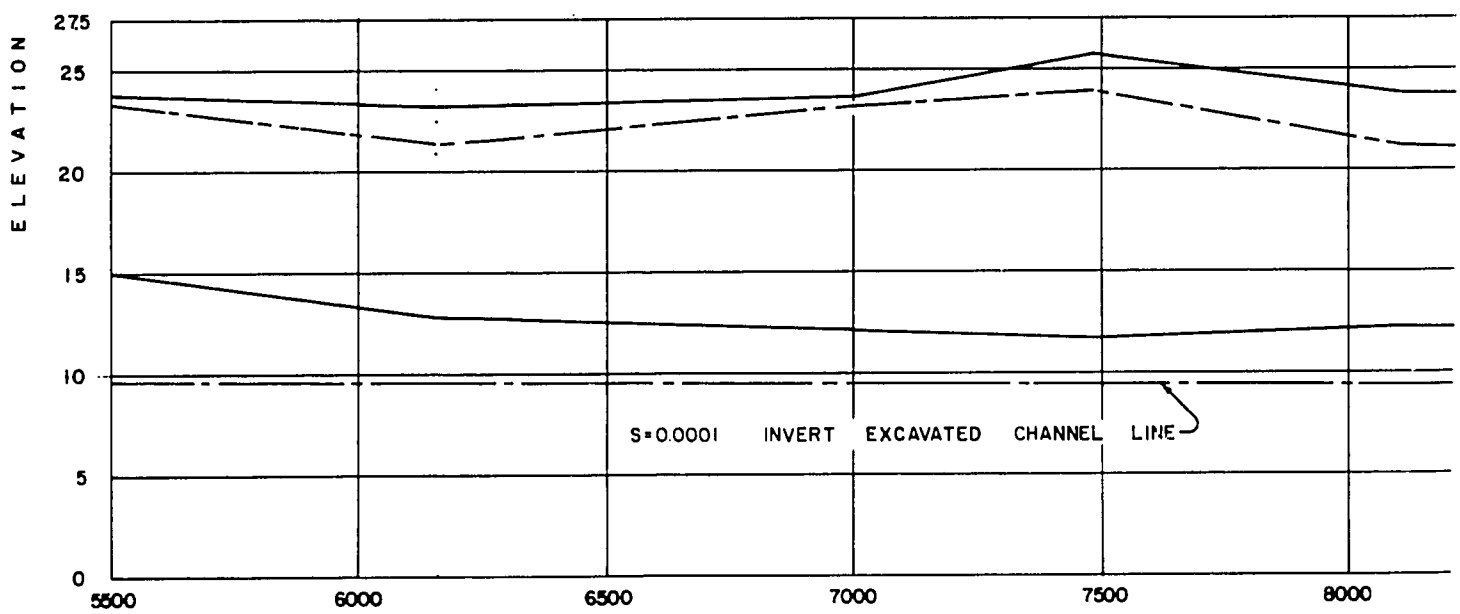
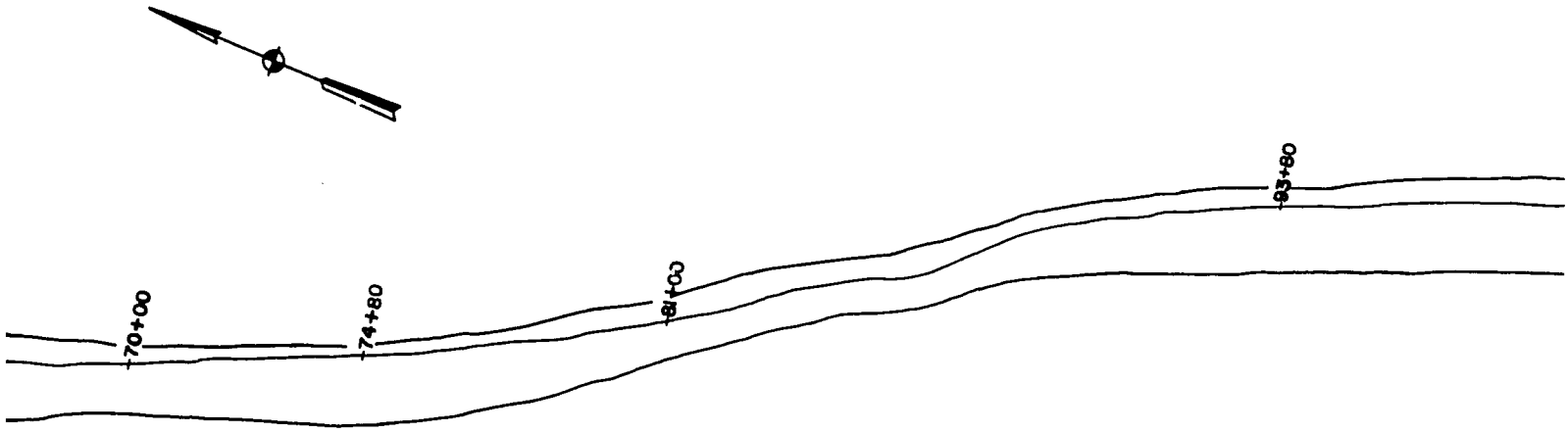


PROFIL

DISTANCE IN

FIGURE I



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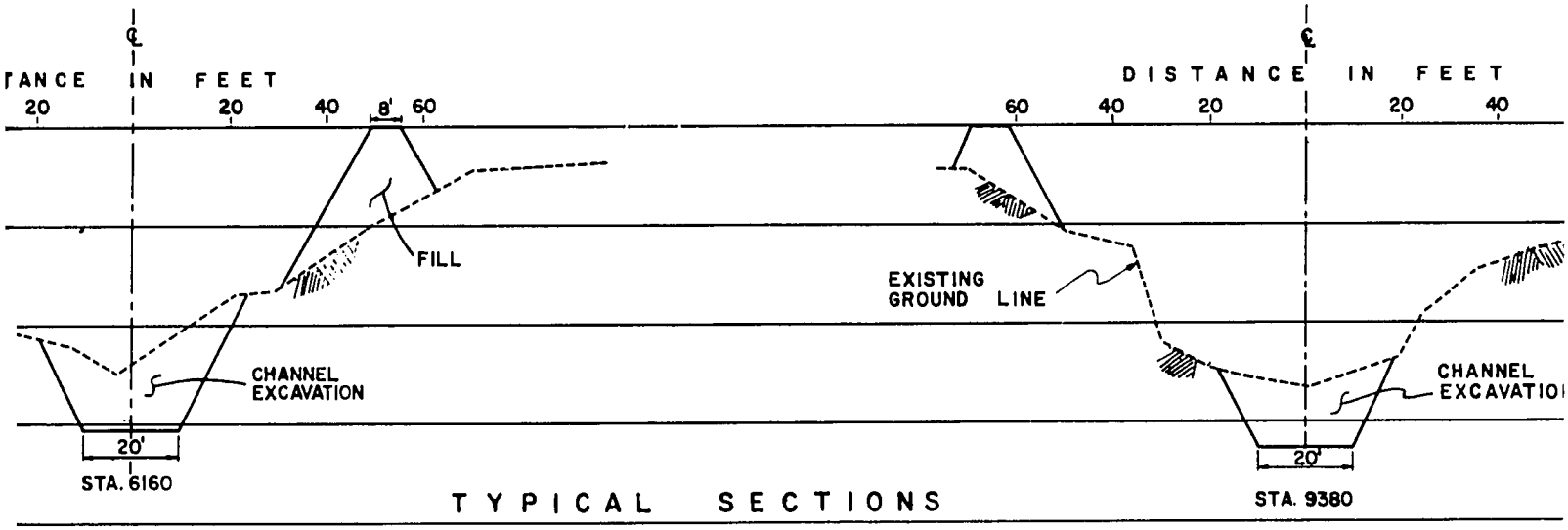

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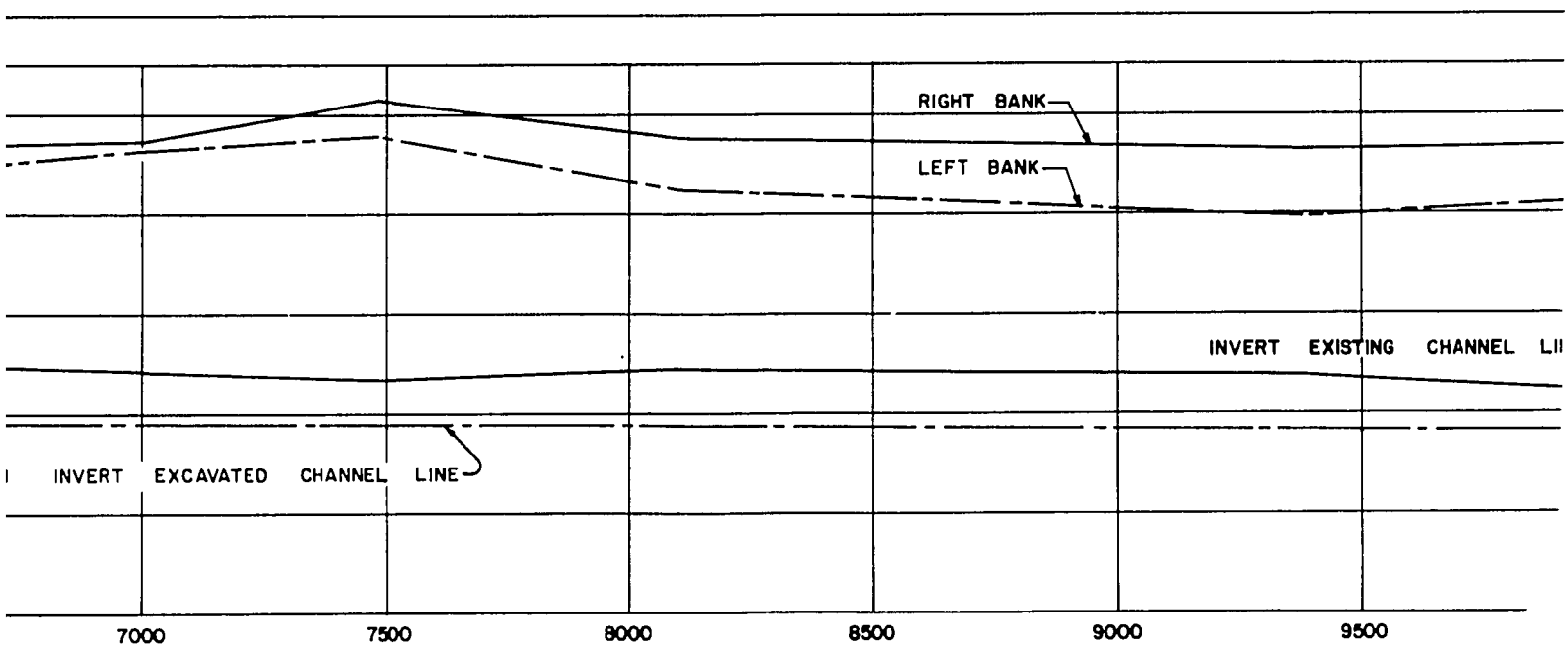
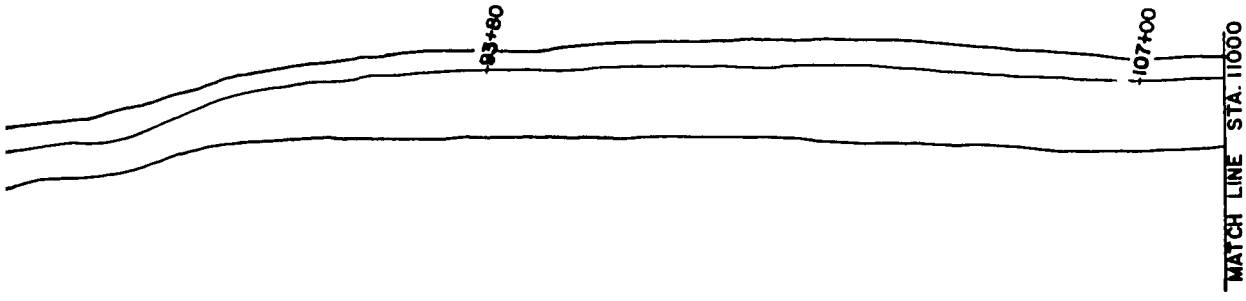
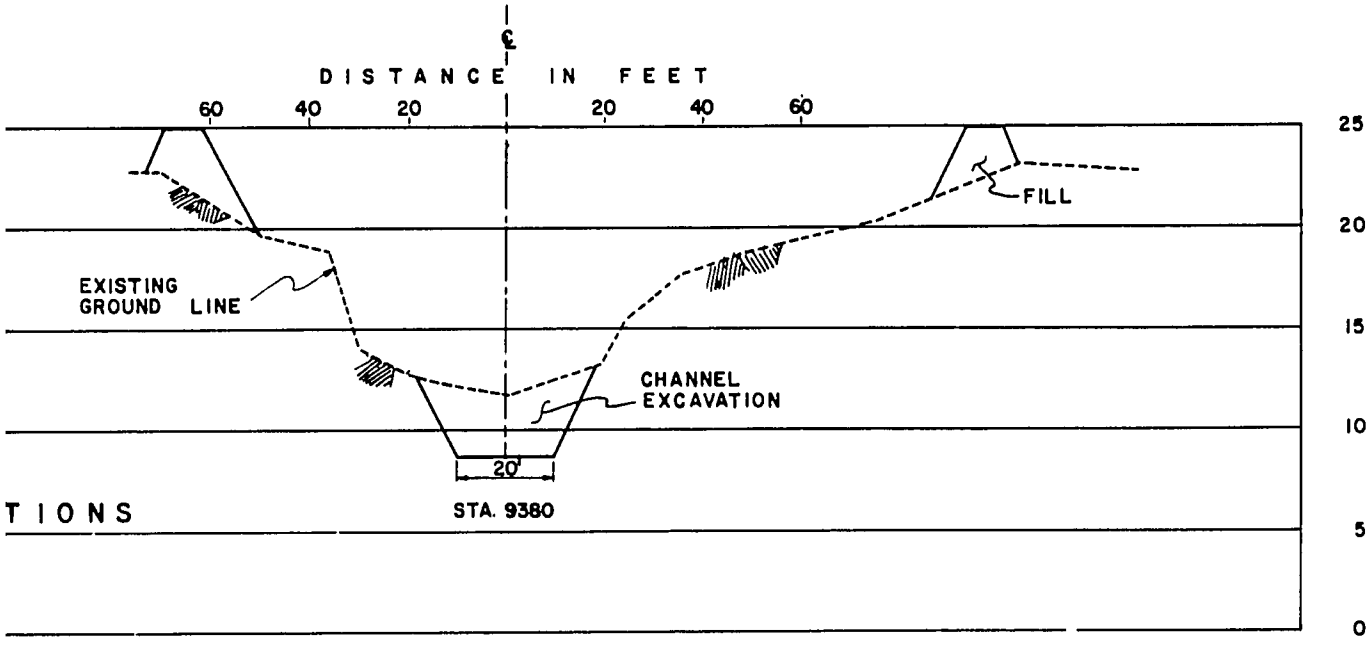


PROFILE

DISTANCE IN MILES

FIGURE I - 5





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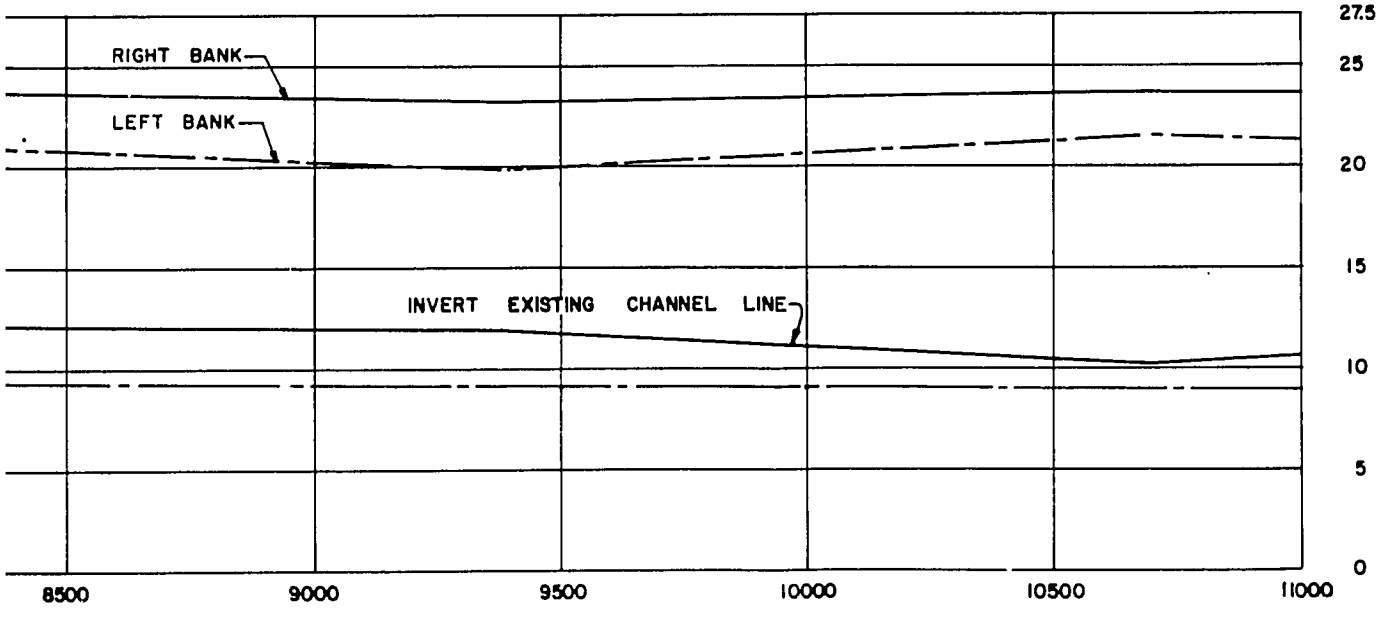


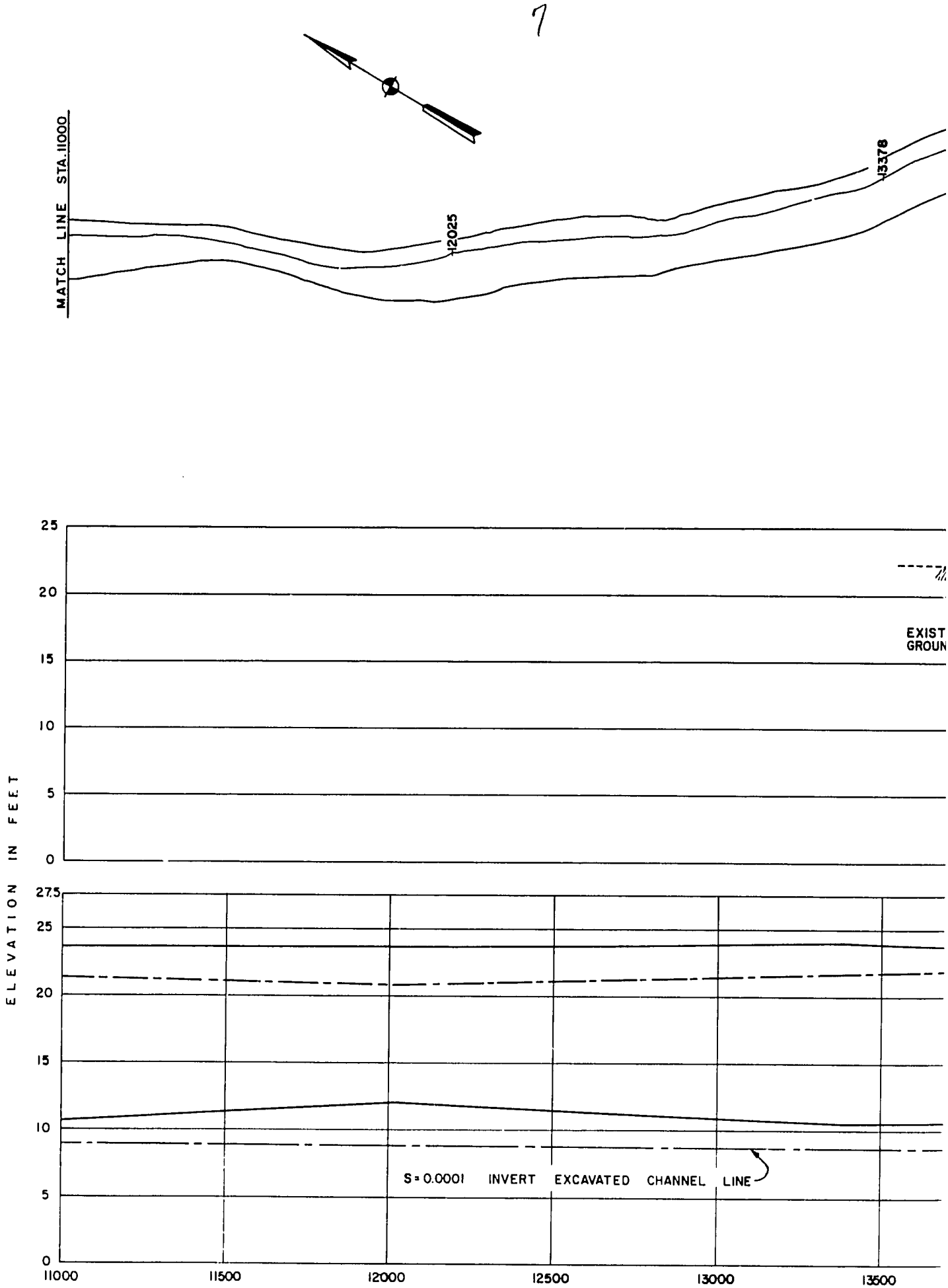
LES

HAORKHALI KHAL

PLAN & PROFILE

SHEET 2 OF 4

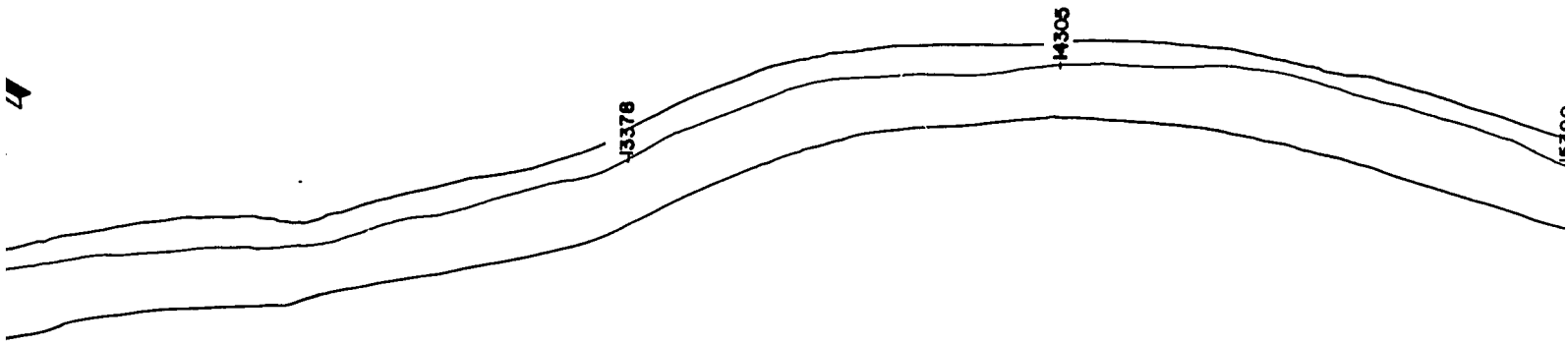
7



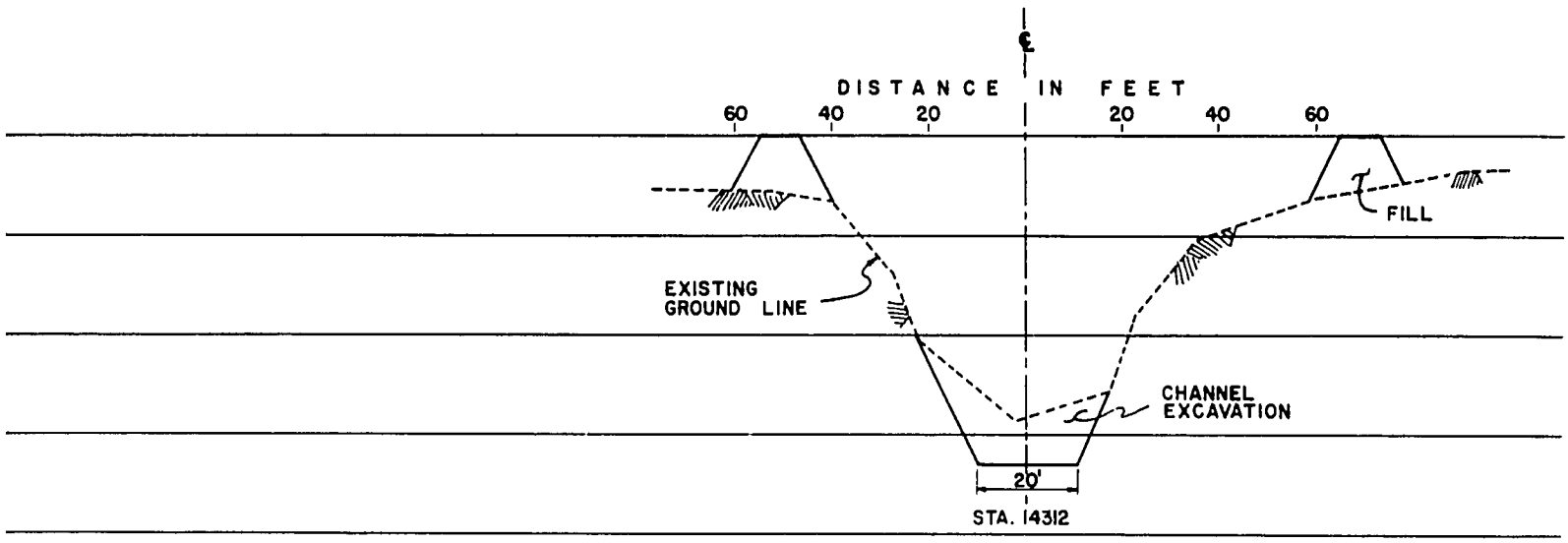
PROFIL

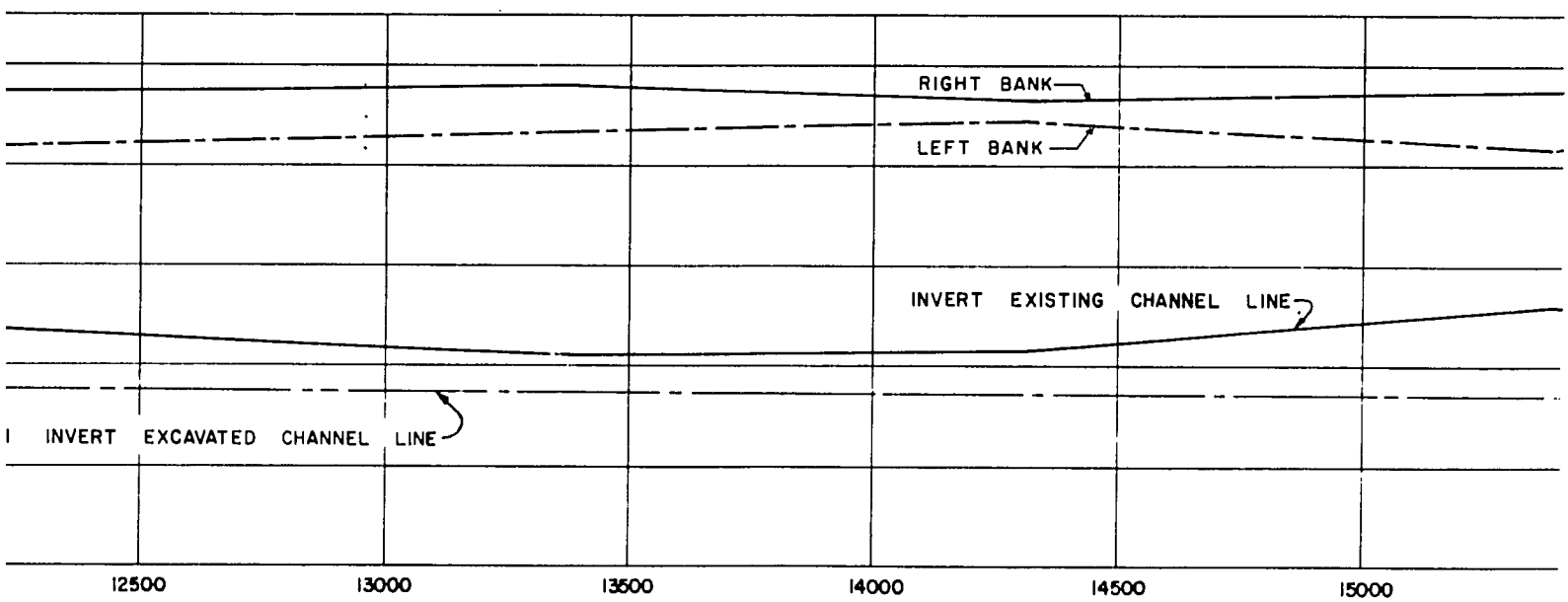
DISTANCE IN

FIGURE I



PLAN

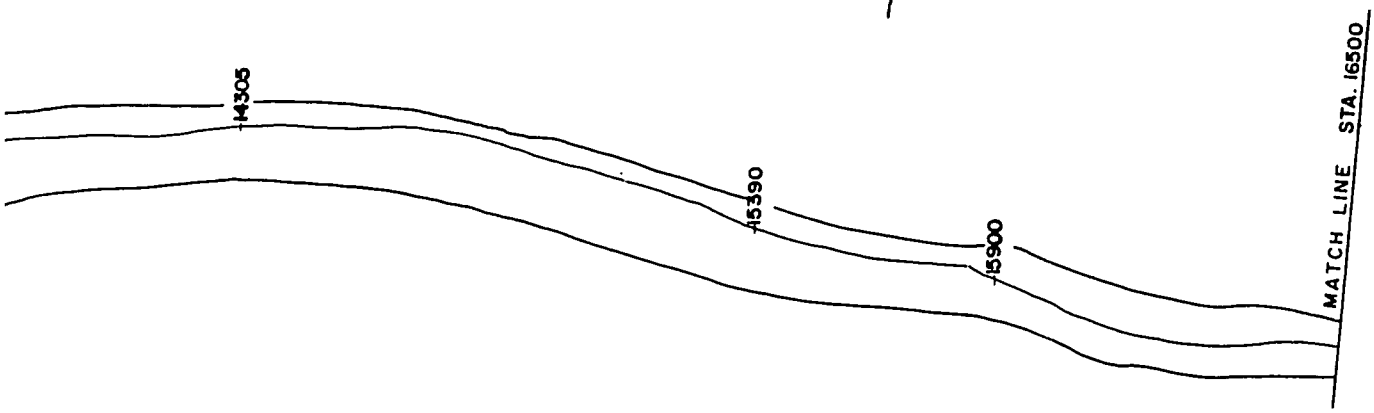


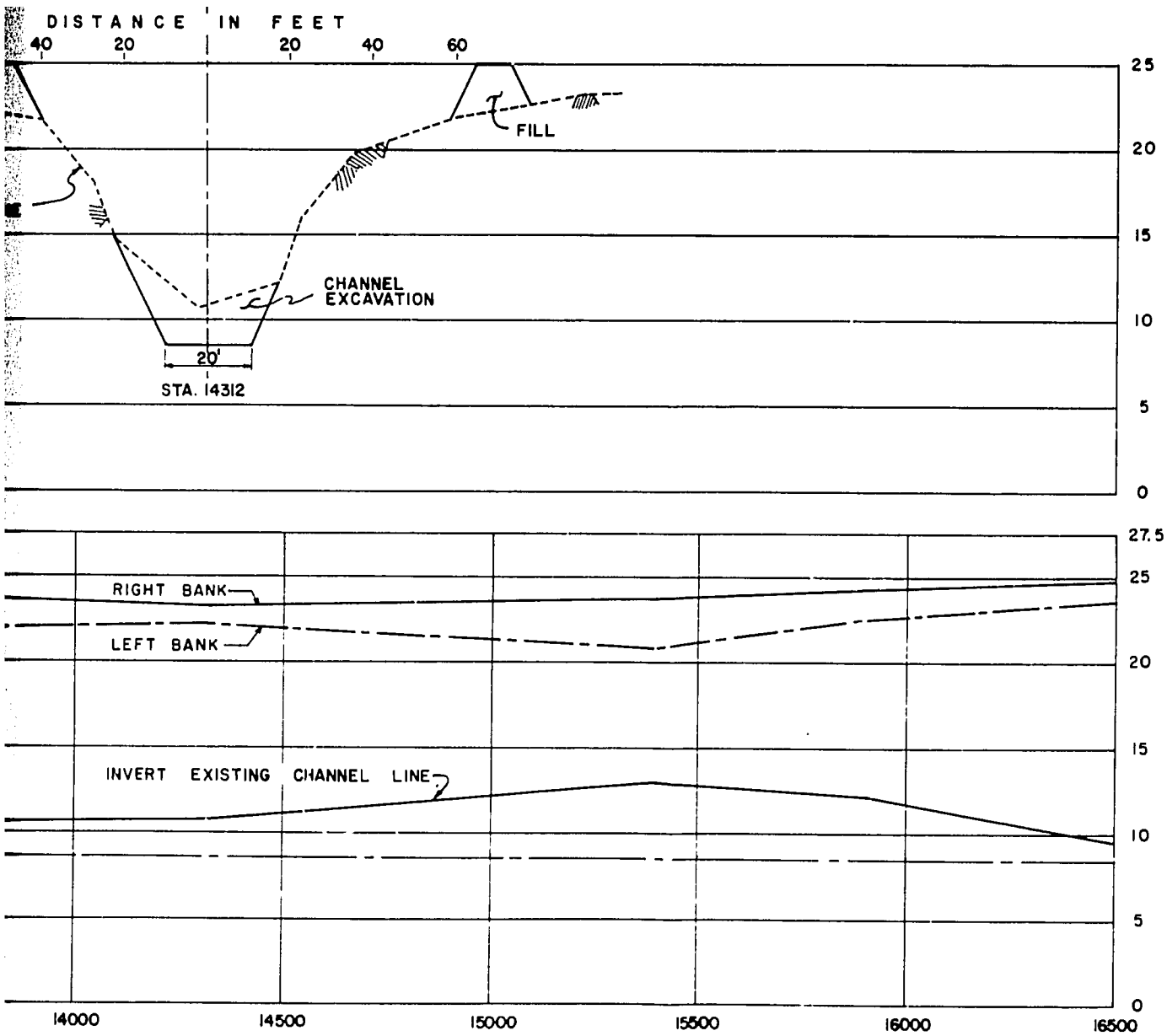


PROFILE

DISTANCE IN MILES

FIGURE I - 5



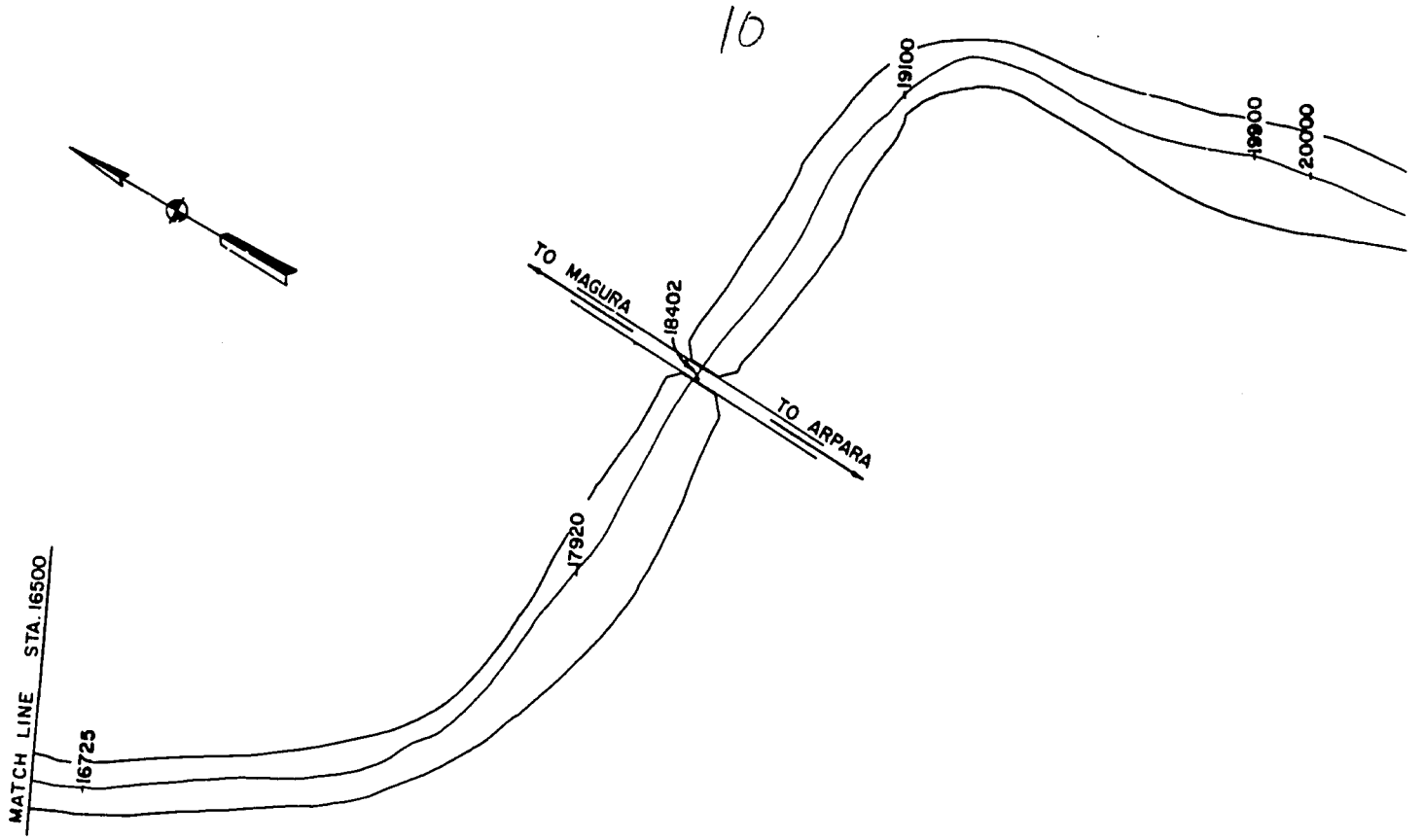


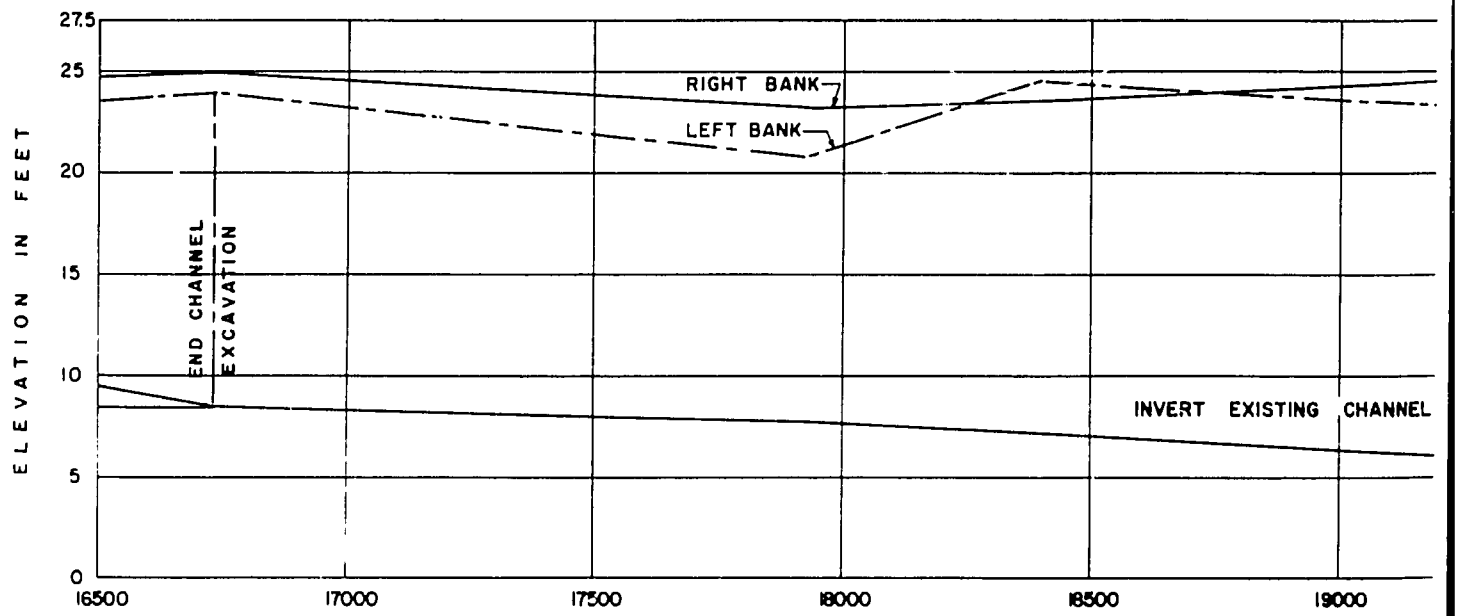
ES

HAORKHALI KHAL

PLAN & PROFILE

SHEET 3 OF 4

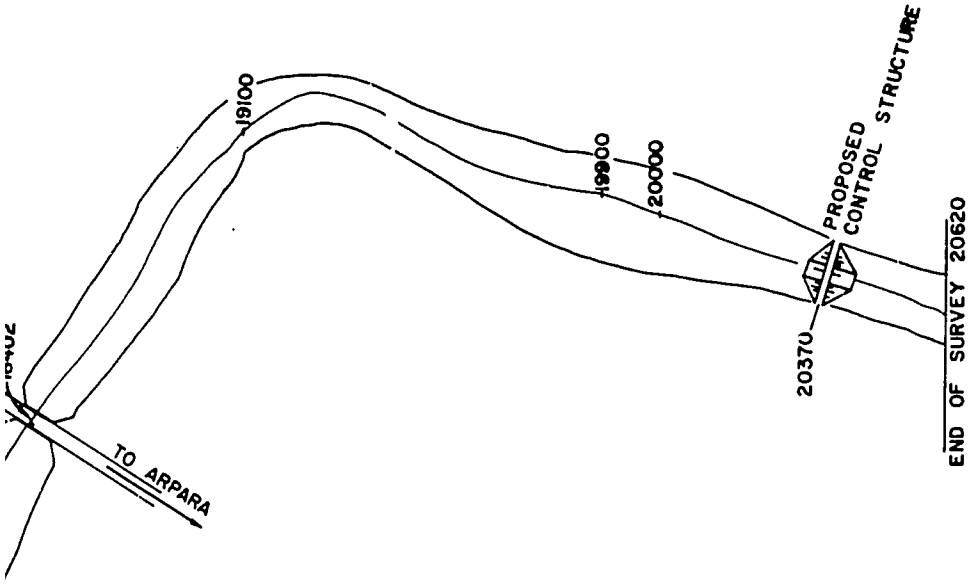




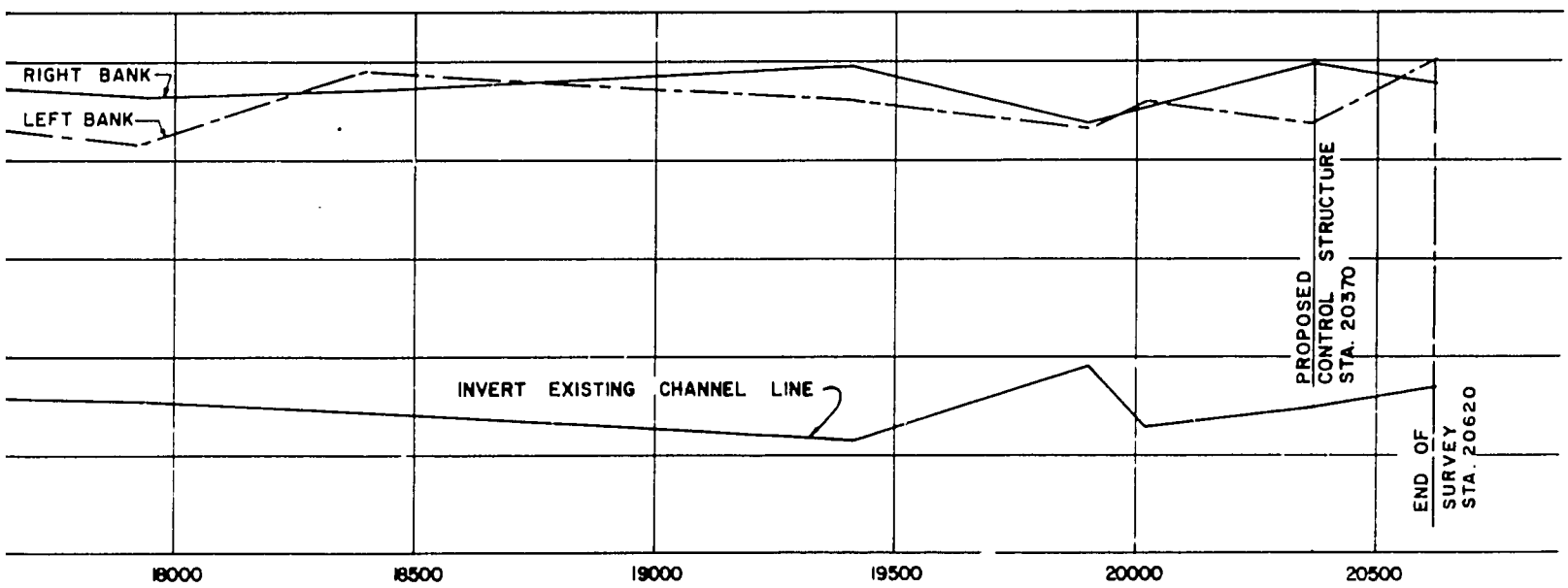
PROFIL

DISTANCE IN

FIGURE I



PLAN

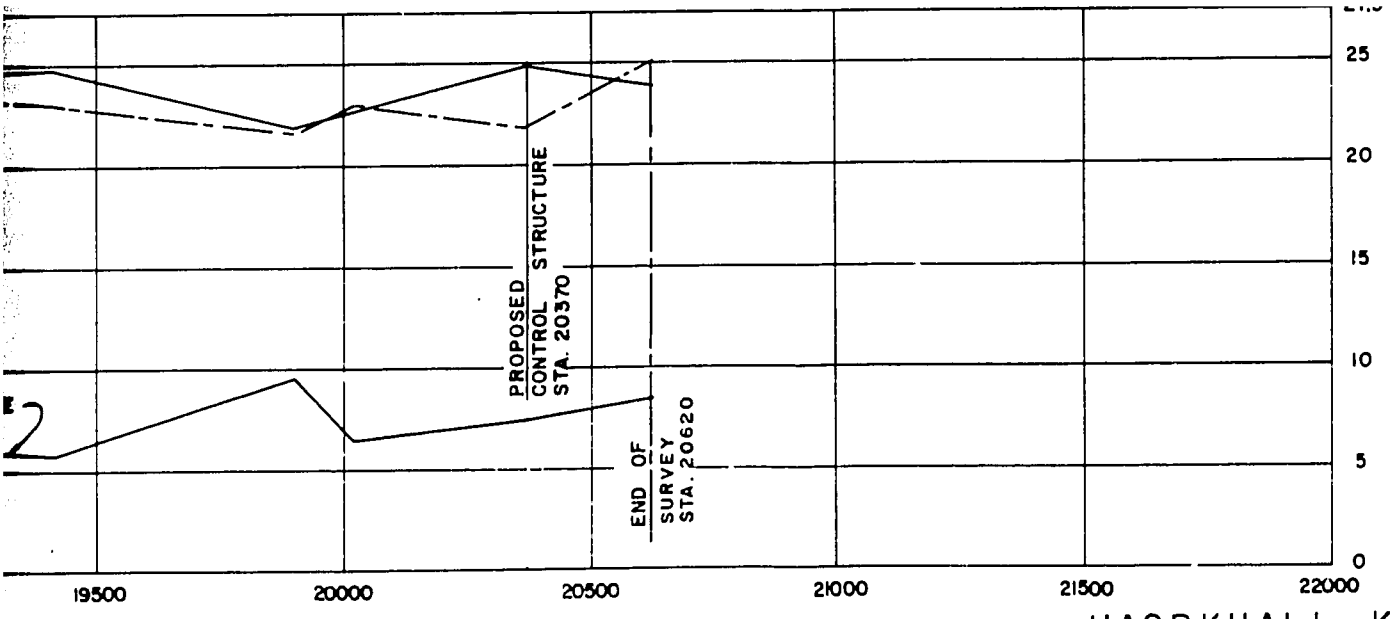


PROFILE

DISTANCE IN MILES

FIGURE I - 5

12



HAORKHALI KHAL

PLAN & PROFILE

SHEET 4 OF 4

high, fixed-wheel vertical lift gates.

The river bank at the structure site consists of soft to stiff clay underlain, to an undetermined depth, by a layer of medium dense fine sand. The structure would be founded on concrete caissons similar to the structure now being constructed by BWDB on the Putia Khal. The caissons would confine the foundation to prevent the washout of sand by scour and/or piping. Lateral cutoff walls and compacted clay backfill would prevent scouring or piping around the structure.

The Site Plan of this structure and the Section are shown on Figures I-6 and I-8, respectively.

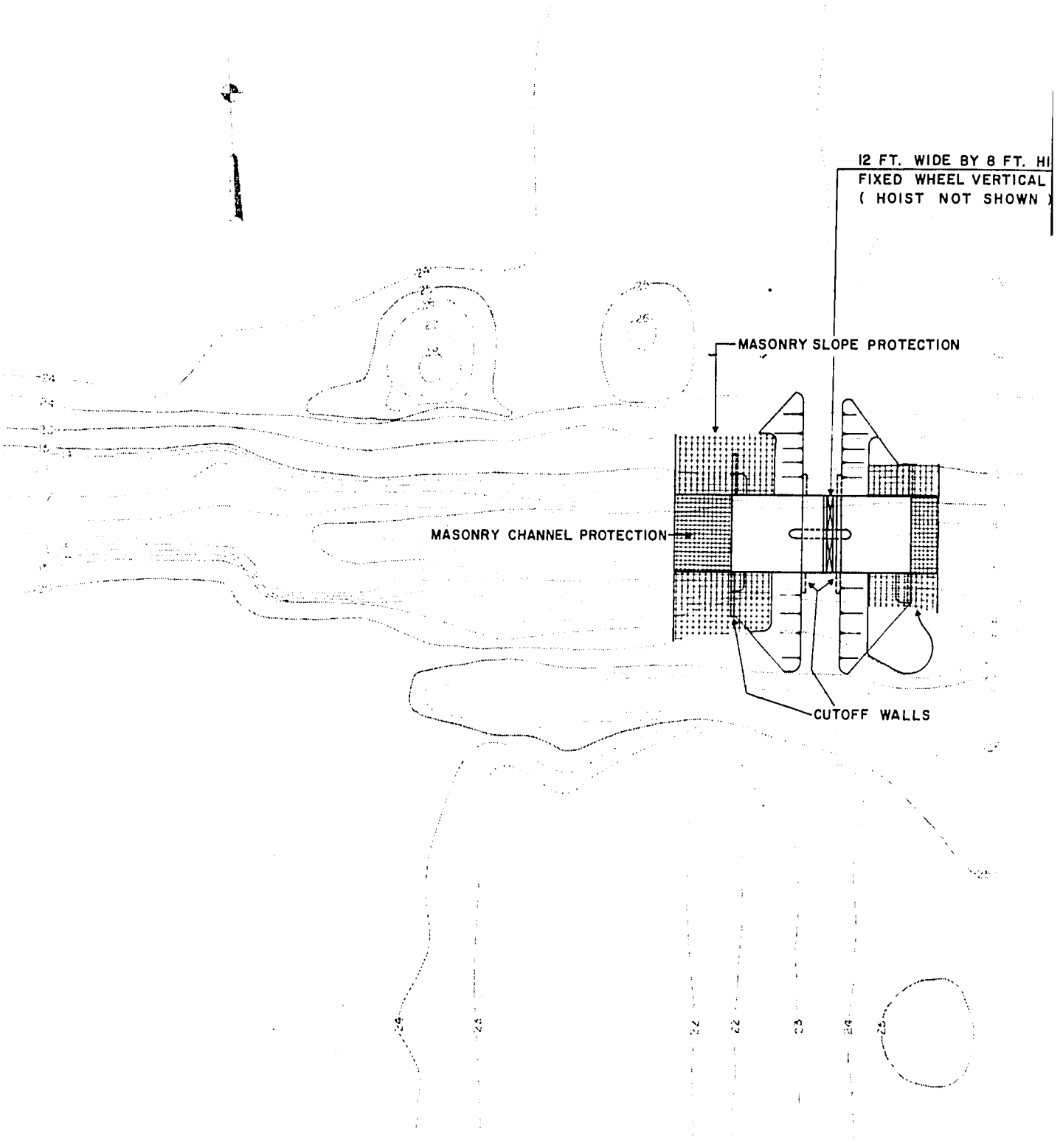
As a future development, the low-lift pumps along the Haorkhali Khal could be replaced by a single permanent pumping station at the headworks. The levees would then be completed along both banks to permit the raising of the water level for gravity irrigation of the area.

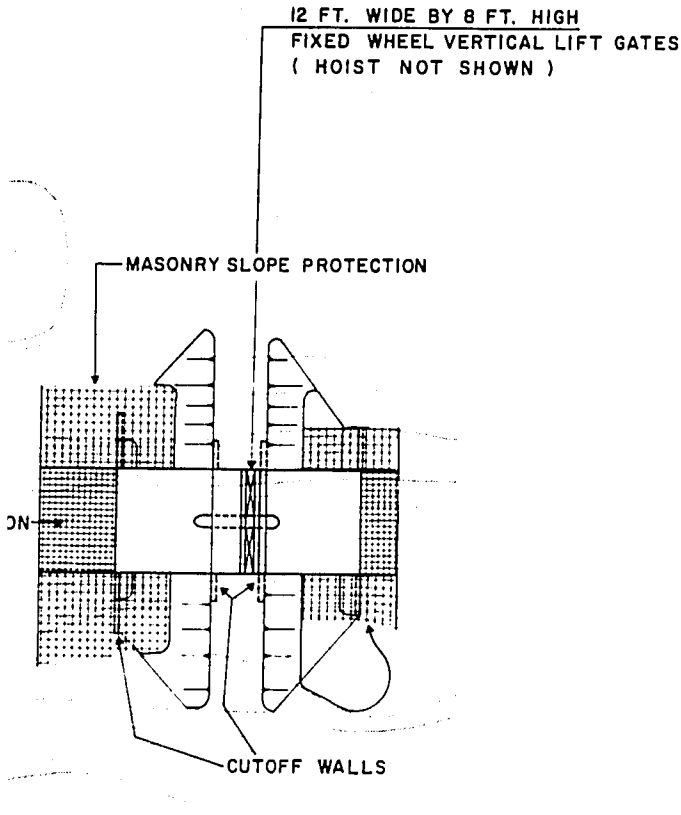
1.3.4 Alamkhali Khal

This khal has a relatively clear open channel, with a cross-section which is significantly larger than for the connecting reach of the Nabaganga River. There would be no improvements required for the channel but it has been reported that the Magura/Jhenida Road bridge is in deplorable condition and should be replaced.

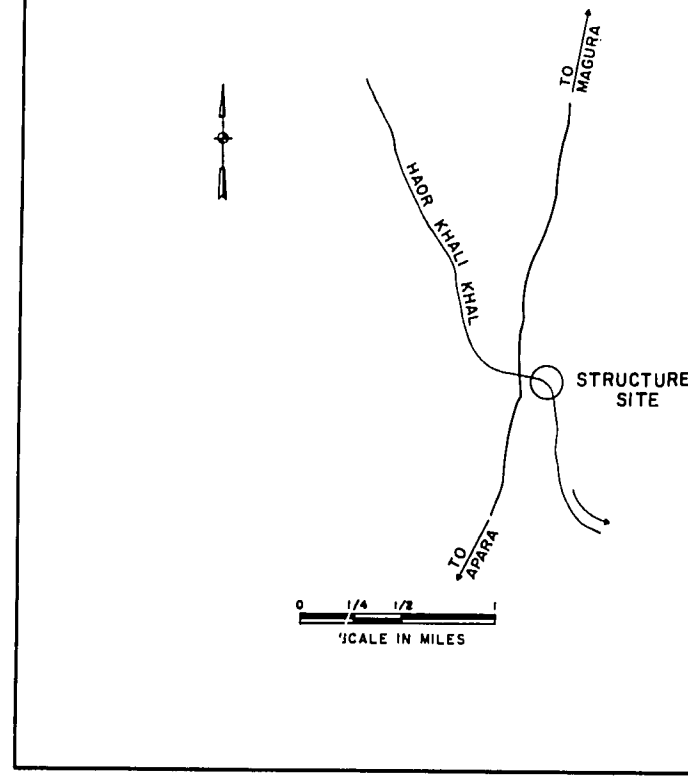
One control structure would be required to impound water in the khal and in the Nabaganga River. The structure would be located immediately upstream of Rajarampur and approximately 1½ miles downstream of the Magura/Jhenida Road bridge. There are approximately 2000 acres along both banks of this khal which could be readily irrigated by low-lift pumps from this controlled water source. There are several low-lift pumps already operating in this reach of the khal.

This structure would be of reinforced concrete construction with four, 12 feet wide by 8 feet high, fixed-

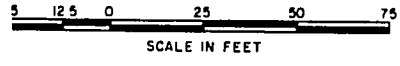

12 FT. WIDE BY 8 FT. HI
FIXED WHEEL VERTICAL
(HOIST NOT SHOWN)
MASONRY SLOPE PROTECTION
MASONRY CHANNEL PROTECTION
CUTOFF WALLS


12 FT. WIDE BY 8 FT. HIGH
FIXED WHEEL VERTICAL LIFT GATES
(HOIST NOT SHOWN)
MASONRY SLOPE PROTECTION
CUTOFF WALLS

3

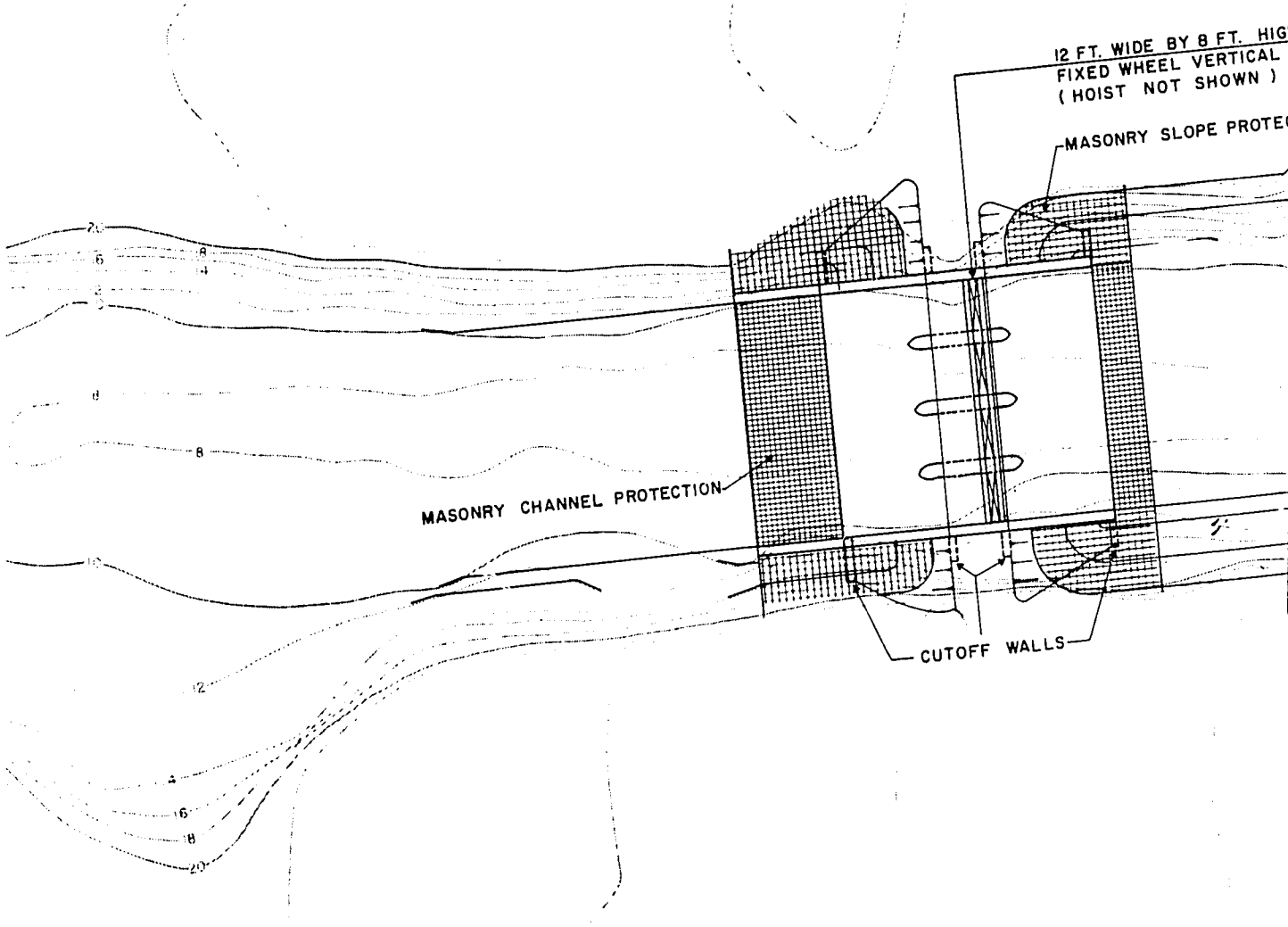


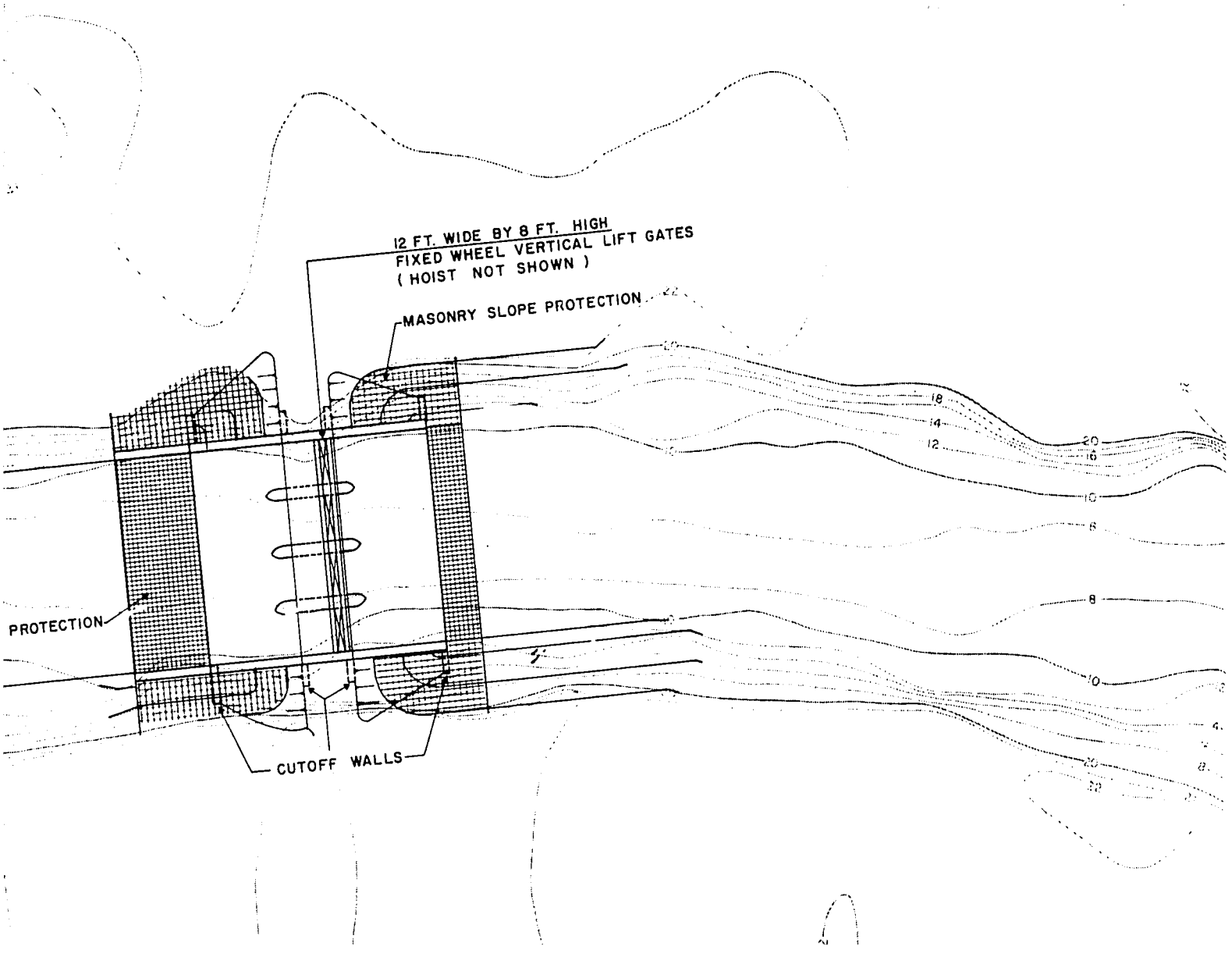
LOCATION MAP

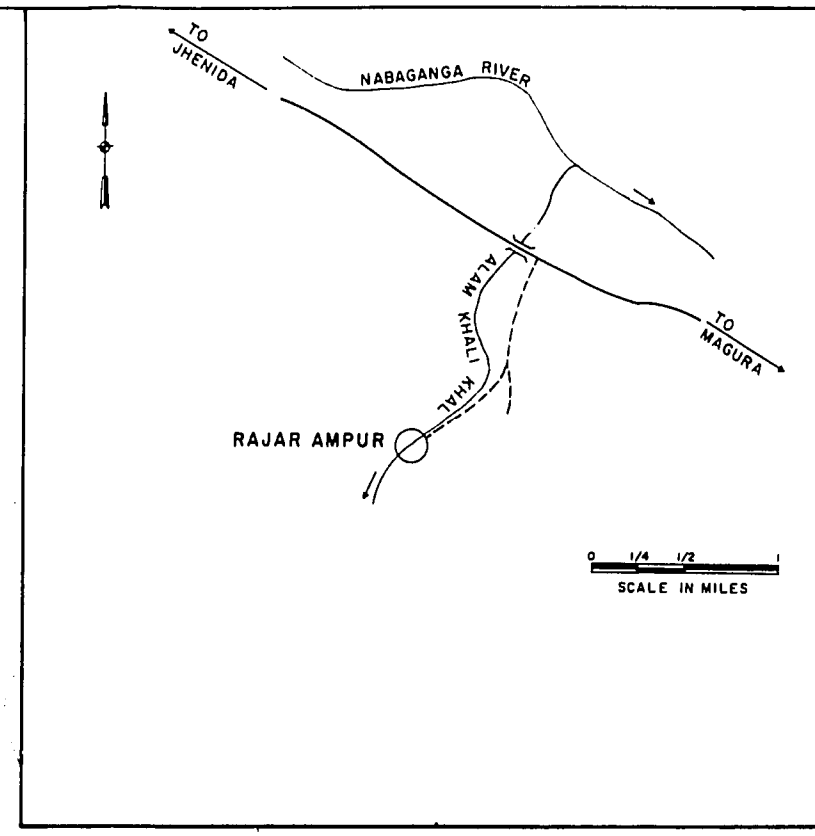


HAOR KHALI KHAL
CONTROL STRUCTURE
SITE PLAN

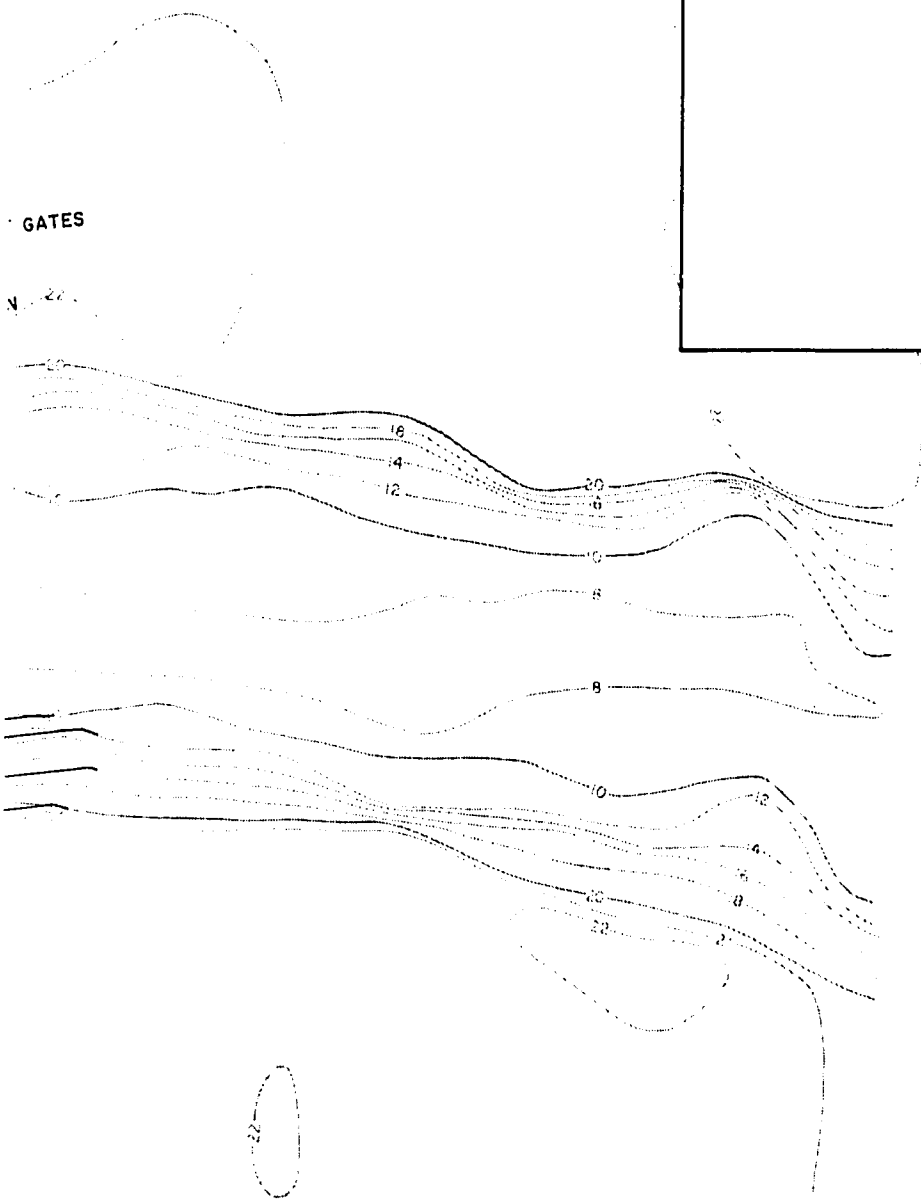
FIGURE I-6


12 FT. WIDE BY 8 FT. HIGH
FIXED WHEEL VERTICAL
(HOIST NOT SHOWN)
MASONRY SLOPE PROTEC
MASONRY CHANNEL PROTECTION
CUTOFF WALLS


12 FT. WIDE BY 8 FT. HIGH
FIXED WHEEL VERTICAL LIFT GATES
(HOIST NOT SHOWN)
MASONRY SLOPE PROTECTION
PROTECTION
CUTOFF WALLS
22
20
18
14
12
20
16
10
8
8
10
20
22



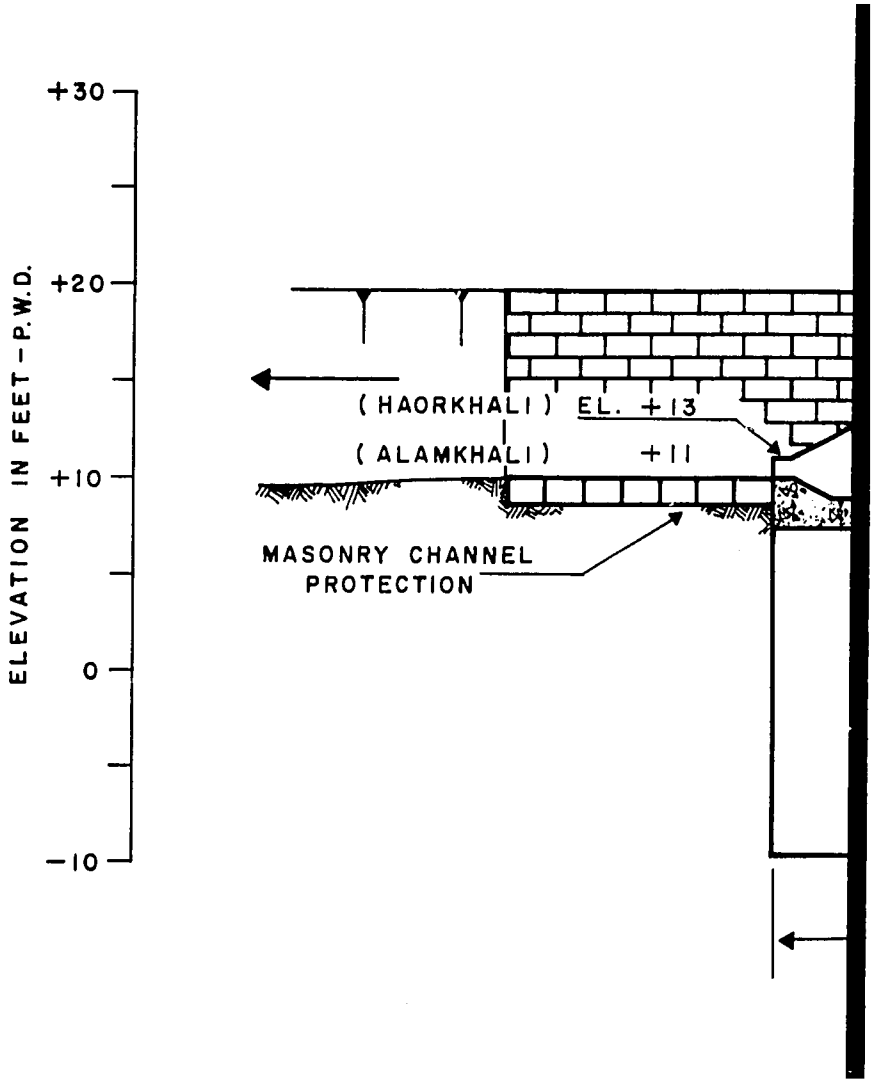
LOCATION MAP

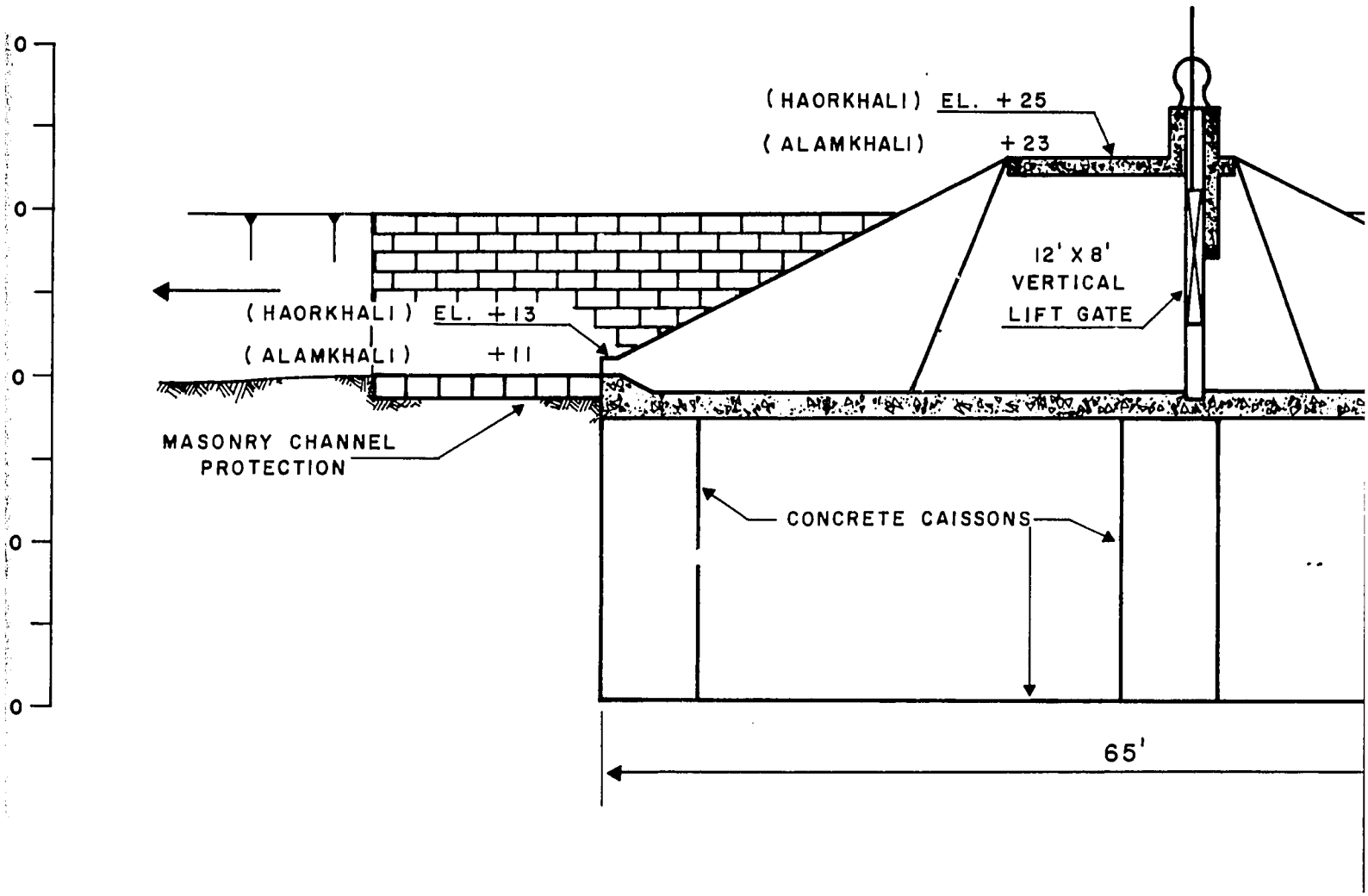


20 10 0 20 40 60
SCALE IN FEET

ALAM KHALI KHAL
CONTROL STRUCTURE
SITE PLAN

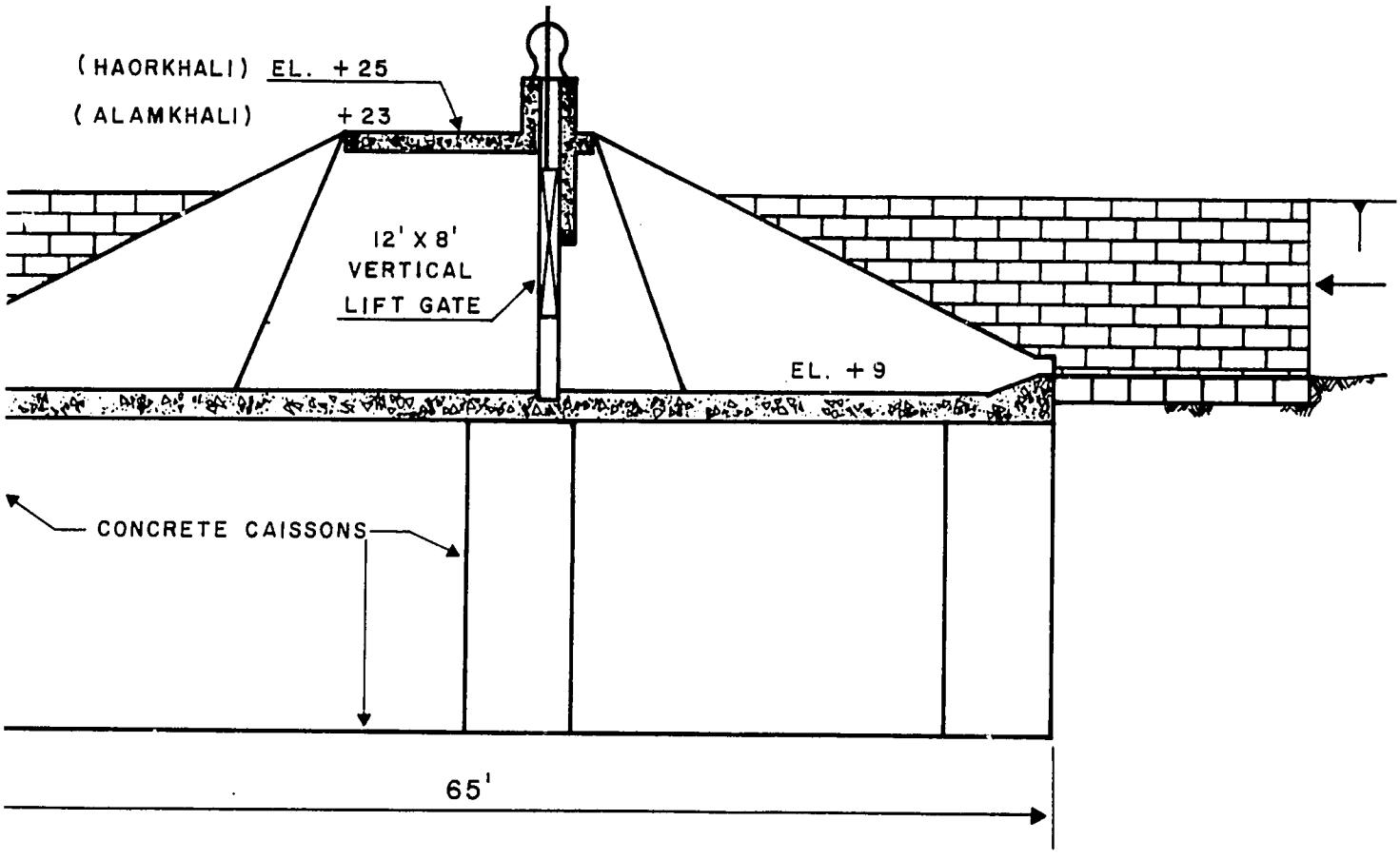
FIGURE I-7


ELEVATION IN FEET - P.W.D.
+30
+20
+10
0
-10
(HAORKHALI) EL. +13
(ALAMKHALI) +11
MASONRY CHANNEL PROTECTION



ALAM

FIGURE I - 8



ALAMKHALI AND HAORKHALI KHALS
CONTROL STRUCTURE
SECTION

FIGURE I - 8

wheel vertical lift gates. This structure would have a discharge capacity of 3400 cfs which corresponds to the capacity of the existing upstream channel.

The river bank at the structure site consists of soft clay underlain by a 15 foot thick stratum of loose silt and then by a stratum to an undetermined depth of medium dense fine sand. This structure, similar to the Haorkhali Khal structure would be founded on concrete caissons.

The Site Plan of this structure and the Section are shown on Figures I-7 and I-8, respectively.

Presently, there is some river traffic past the proposed structure site going to and from the market at Alamkhali. There is also a serviceable vehicular road from the site to the market. The local citizenry indicated that if the road were improved for all weather conditions, the river traffic would then terminate at Rajarampur and there would be no objection to the proposed closure. The road is approximately 1½ miles in length and would require only minor shaping of the road bed before placement of the bitumen pavement.

1.3.5 Dopaghata Khal

This channel takes off from the Nabaganga River at Jhenida and apparently was a major spill channel of the main river in previous times. Now, there is an existing spill beneath the Magura-Jhenida Road bridge with an approximate crest elevation of 17 feet PWD which would limit the flood spills into the Dopaghata Khal. Downstream reaches of this khal are heavily silted and in some areas almost totally obliterated. Some of these reaches have been recently re-excavated but there are still extensive areas of siltation which restrict flows and inhibit drainage.

The continued re-excavation of approximately five miles of this channel for drainage purposes is the only improvement currently being proposed.

A structure is now being constructed by DWDB downstream in conjunction with the Putia Khal improvements which will prevent over-drainage.

The existing sill beneath the Magura-Jhenida Road bridge would provide adequate control of storage levels in the Nabaganga River for the present time. For future development, a low-level structure could be incorporated into the sill for controlling flows for downstream irrigation.

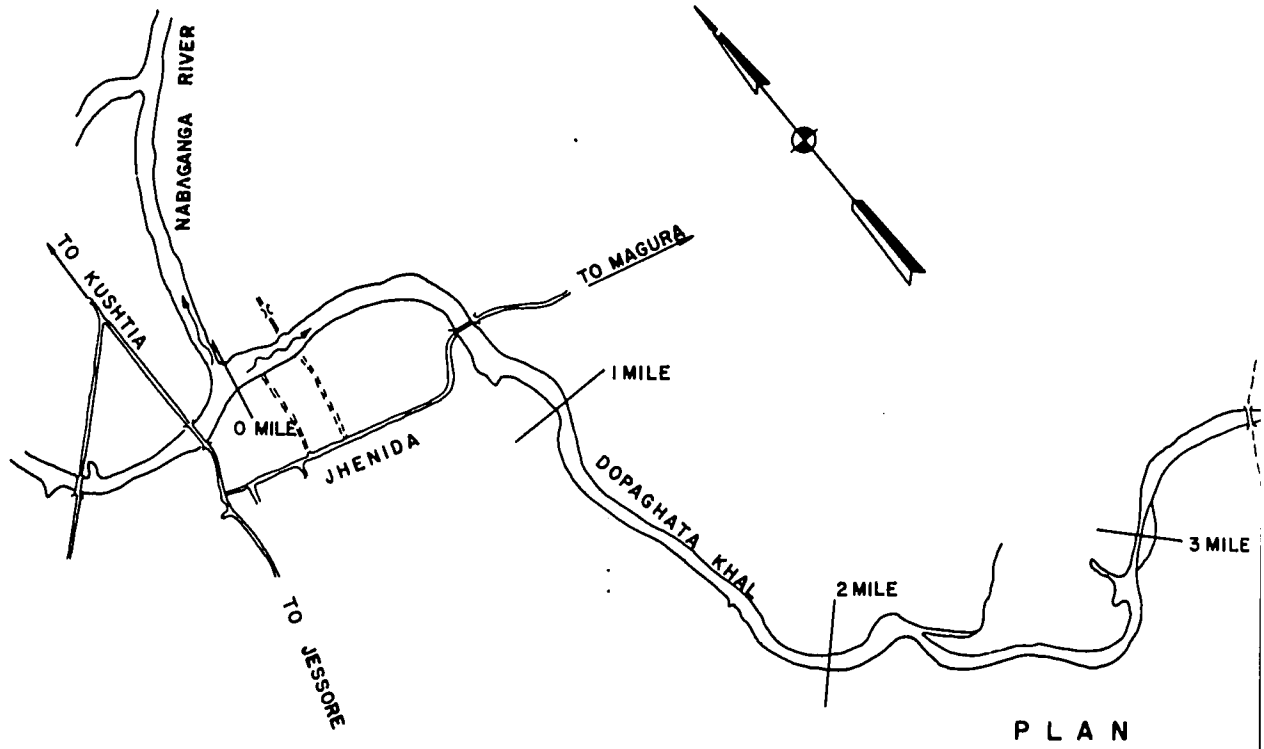
This Plan and Profile of the Dopaghata Khal is shown on Figure I-9, Sheets 1-3.

1.3.6 Dariapur Khal and Drain D1N

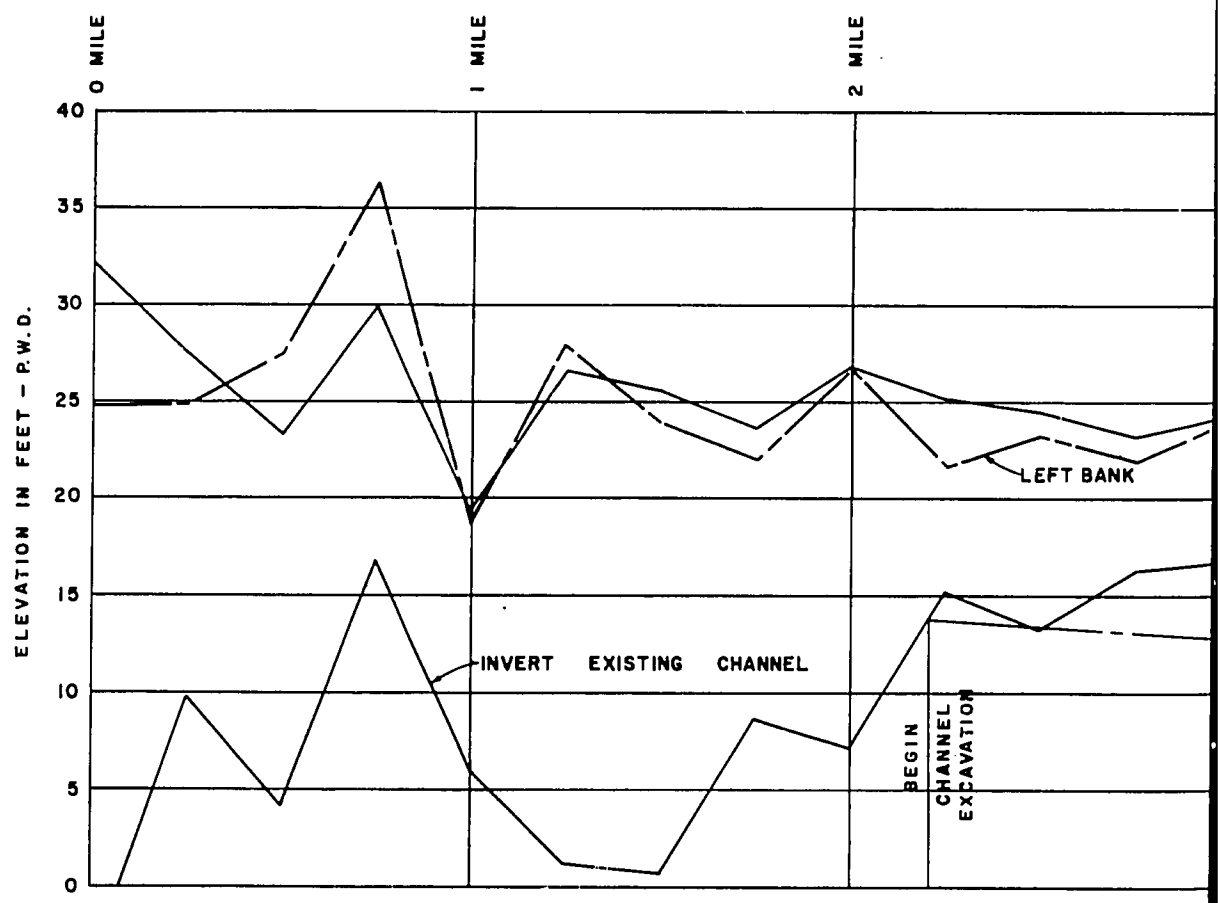
These two channels control drainage from the Barabila Beel. The four-mile long Dariapur Khal was recently re-excavated and a permanent structure is now required to prevent the ingress of flood waters from the Nabaganga River, to control over-drainage, and to release water into the khal for low-lift pump irrigation of approximately 1000 acres along its banks. This permanent control structure would consist of an earth dam and road crossing with a single 24-inch diameter reinforced concrete pipe and a simple flap gate.

There are now some temporary earth and bamboo dams in this khal to partially control the water level.

The three-mile long D1N Drain is the major drainage outlet for the lower portion of the Phase II Unit of the G-K Project. A structure was recently completed at its outlet, and this is the major control of the water levels in the Barabila Bil. The installation of a second set of control gates to complete this structure would be included in the project works.

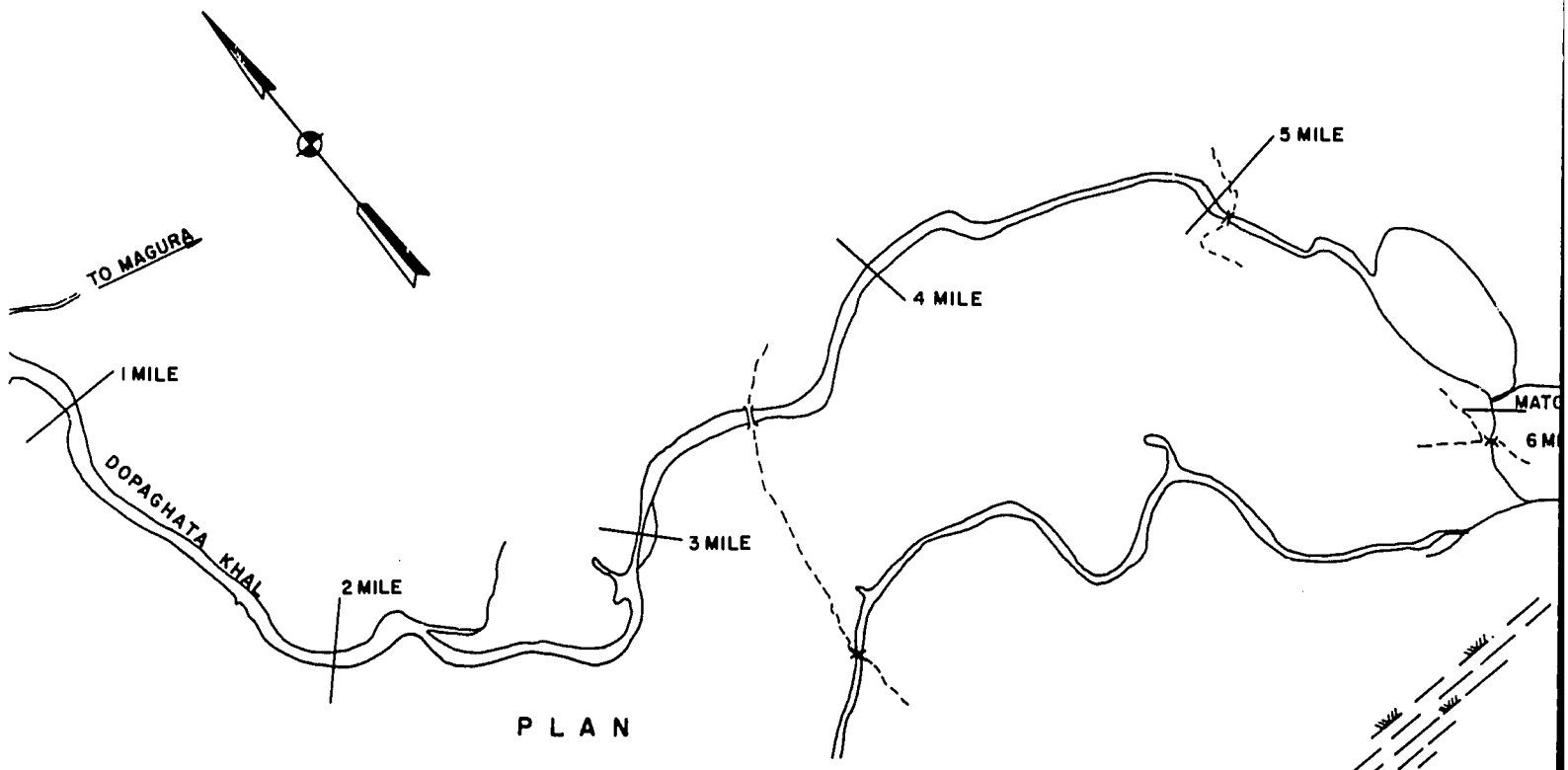

NABAGANGA RIVER
TO KUSHTIA
TO MAGURA
0 MILE
1 MILE
JHENIDA
DOPAGHATA KHAL
2 MILE
3 MILE
TO JESSORE

PLAN

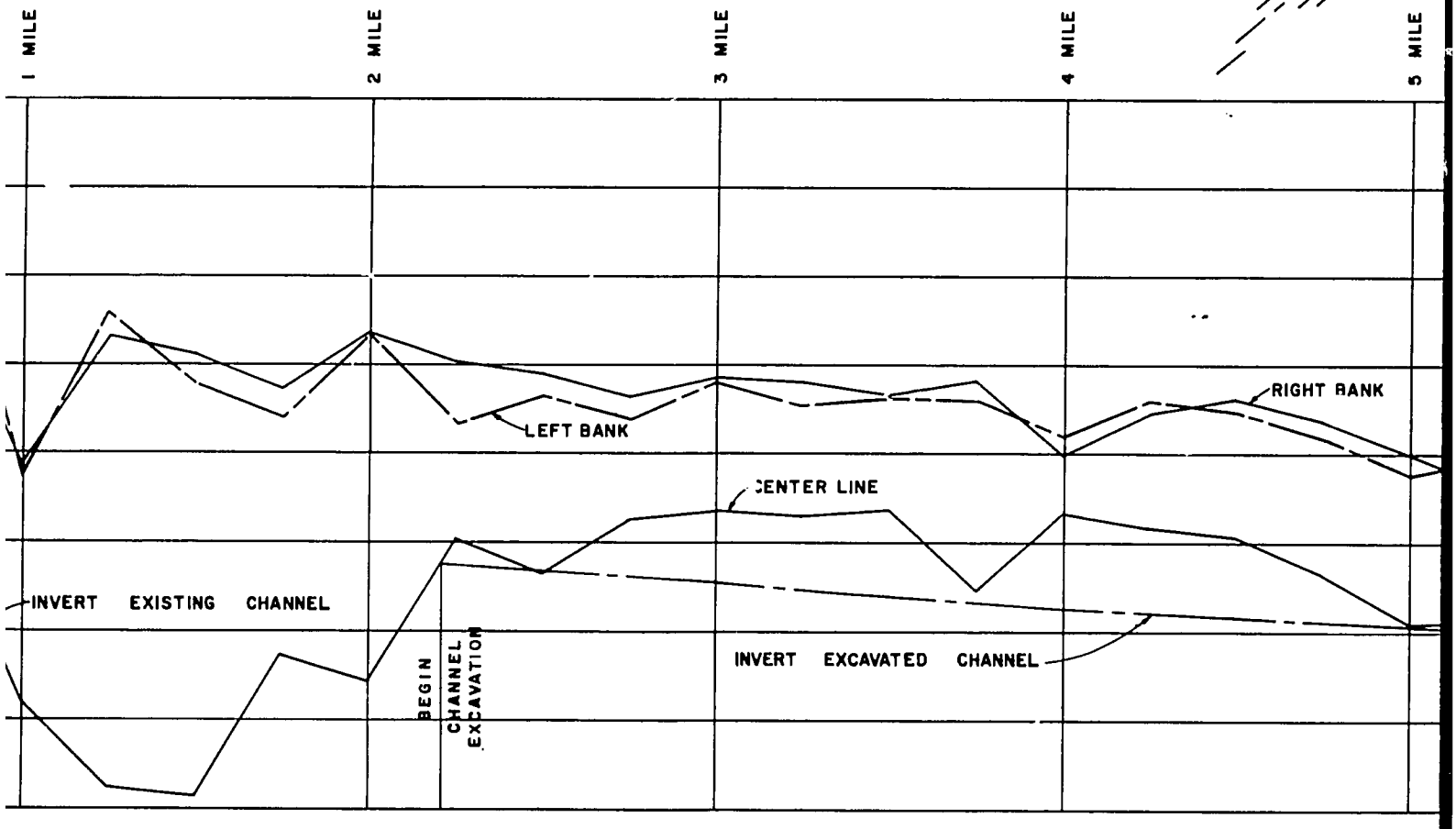

0 MILE
1 MILE
2 MILE
ELEVATION IN FEET - P.W.D.
40
35
30
25
20
15
10
5
0
LEFT BANK
INVERT EXISTING CHANNEL
BEGIN CHANNEL EXCAVATION

PR

FIGU

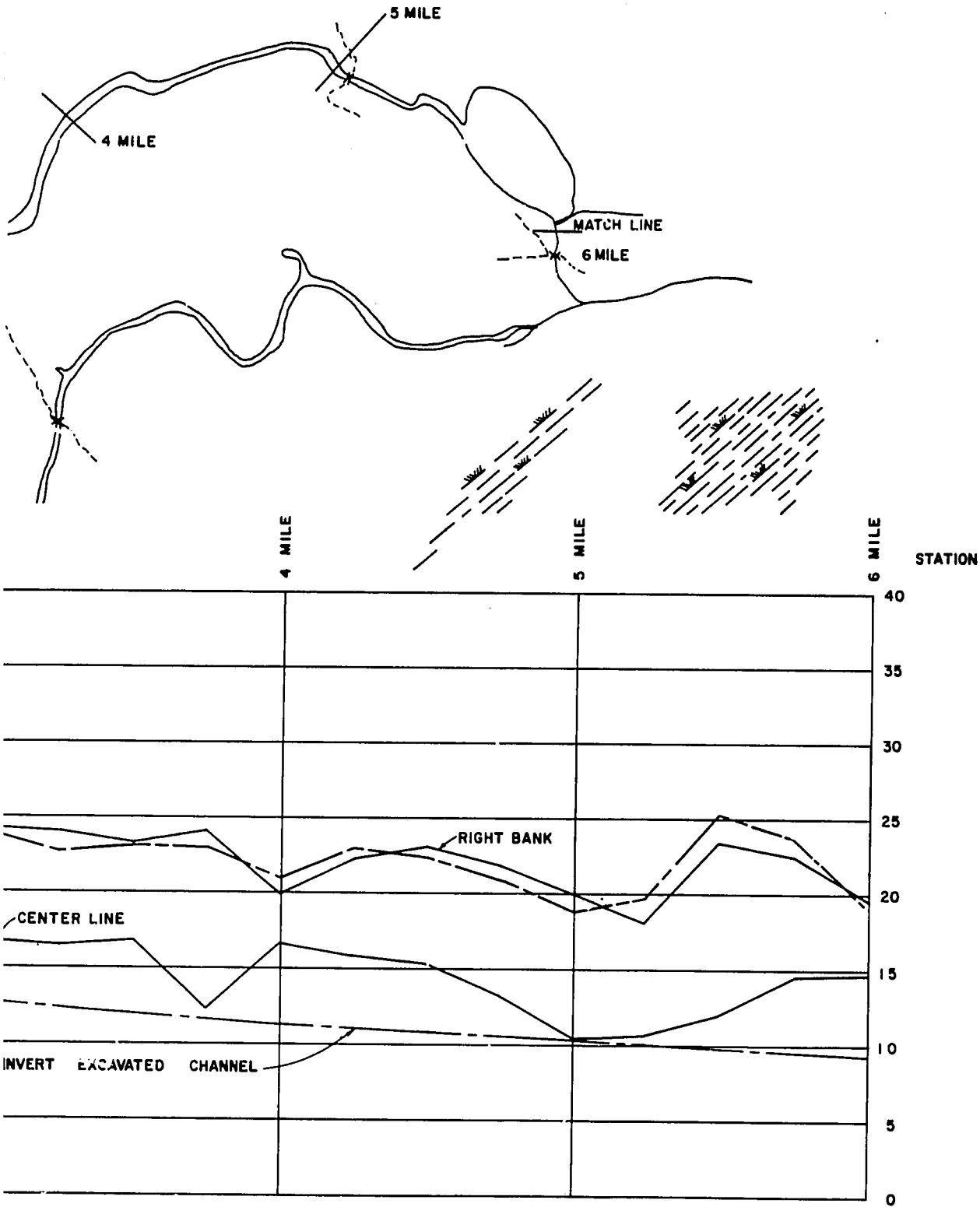


PLAN



PROFILE

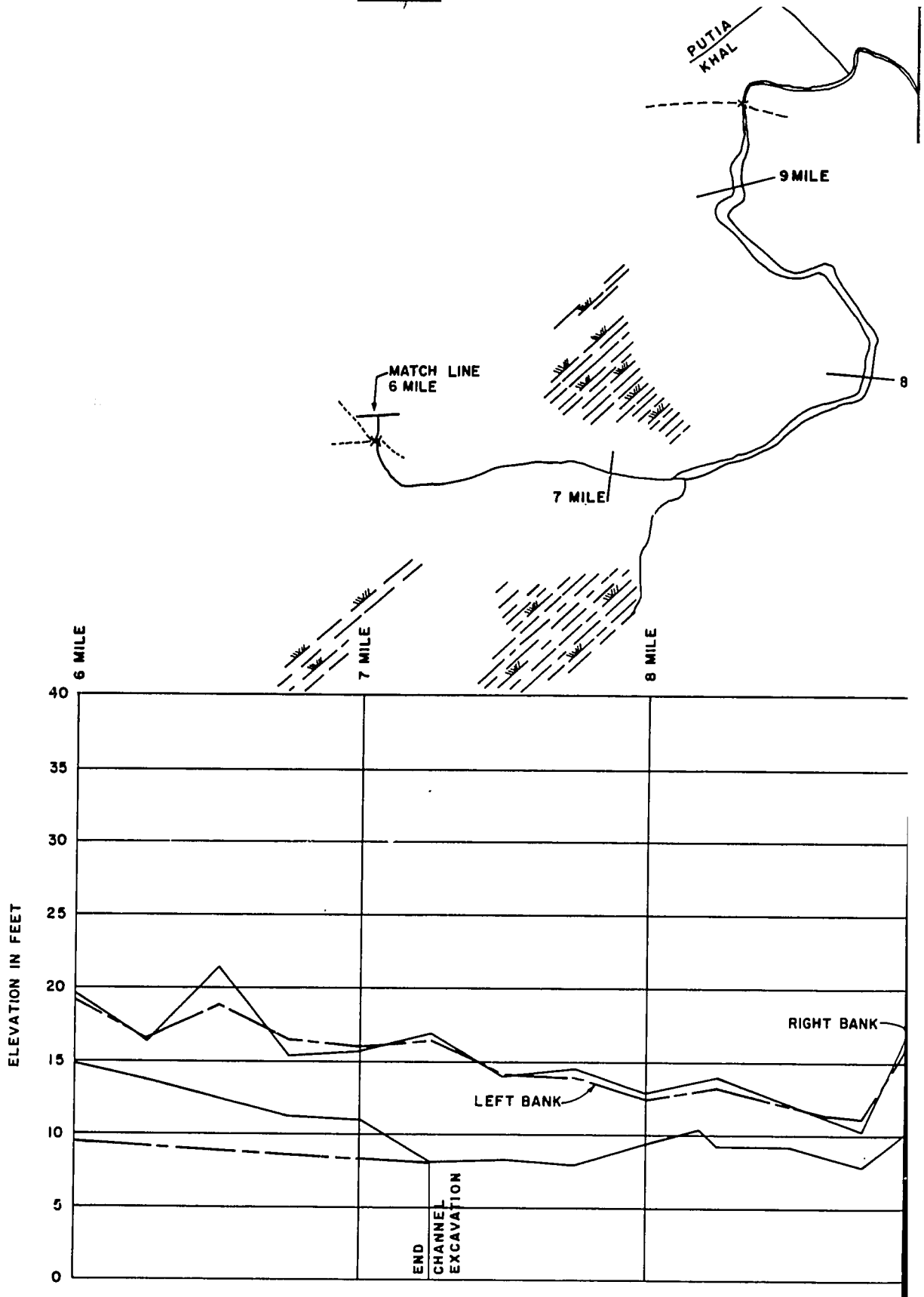
FIGURE I-9



DOPAGHATA KHAL

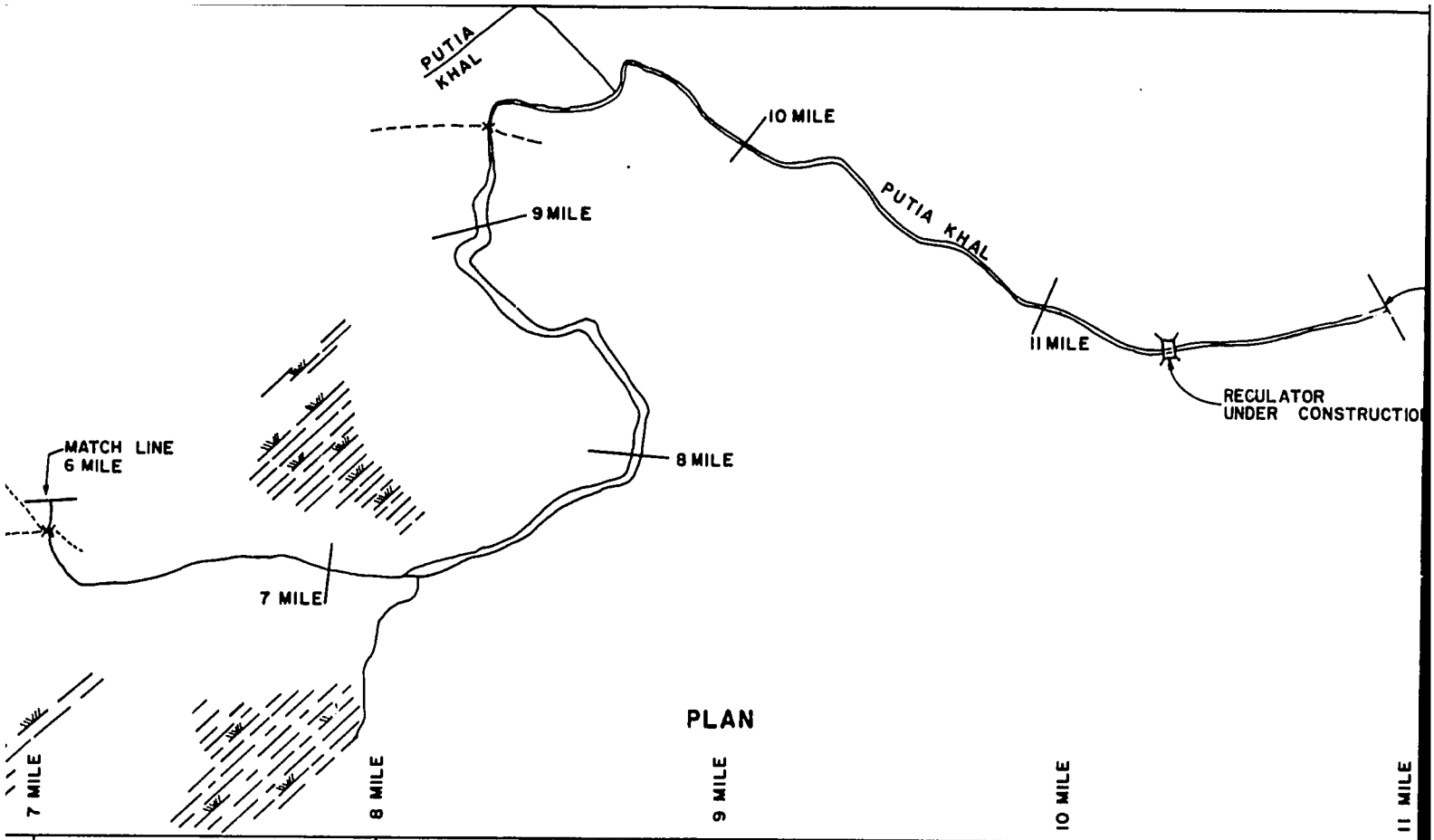
PLAN & PROFILE

SHEET 1 OF 3

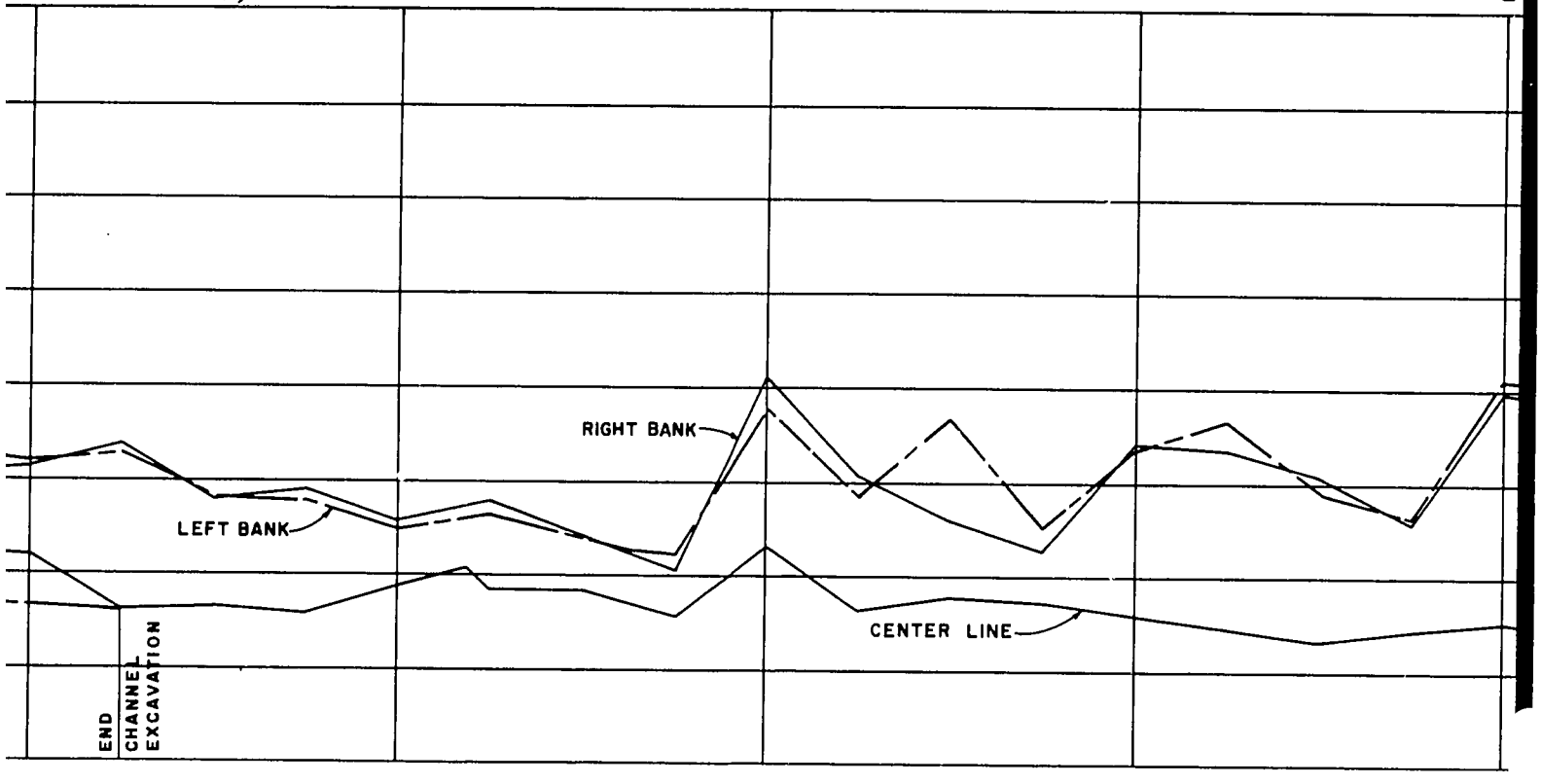

PUTIA KHAL
9 MILE
8
MATCH LINE 6 MILE
7 MILE
6 MILE
7 MILE
8 MILE
ELEVATION IN FEET
40
35
30
25
20
15
10
5
0
RIGHT BANK
LEFT BANK
END CHANNEL EXCAVATION

P

FIG

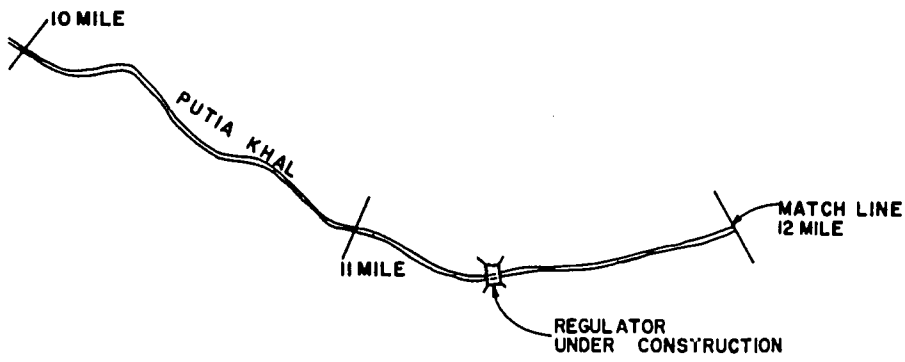


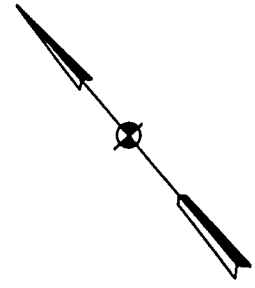
PLAN



PROFILE

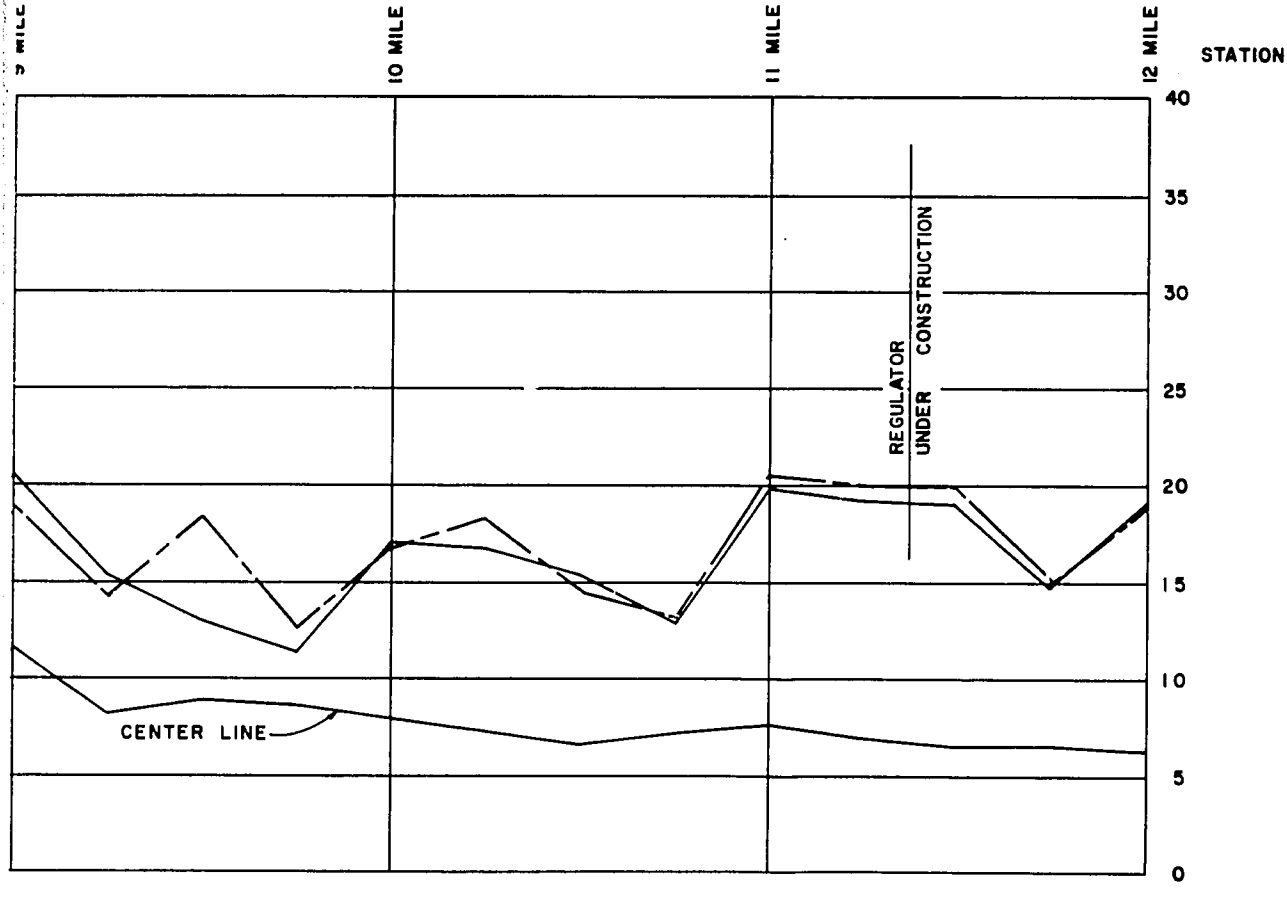
FIGURE I-9





E

AN

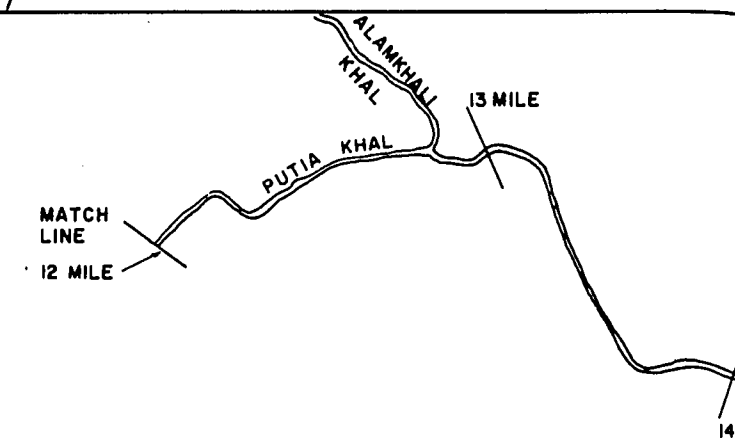


FILE

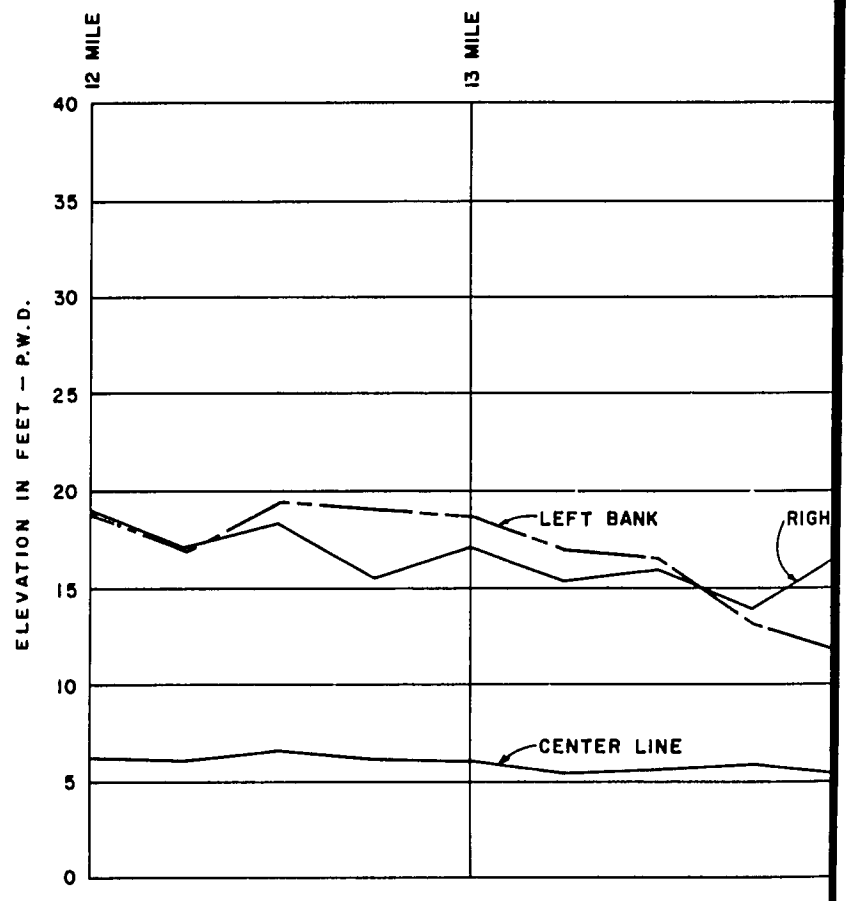
DOPAGHATA KHAL
PLAN & PROFILE

E I-9

SHEET 2 OF 3

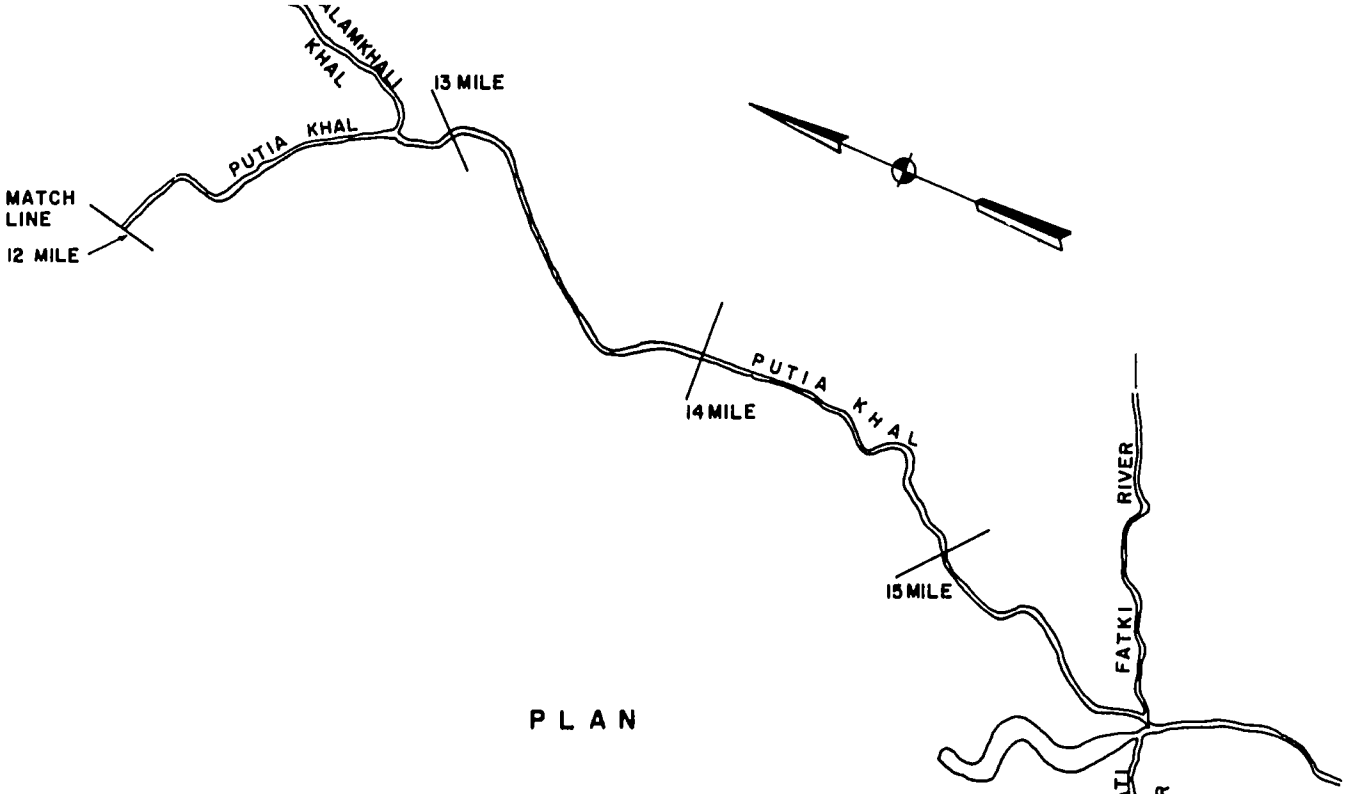


PLAN

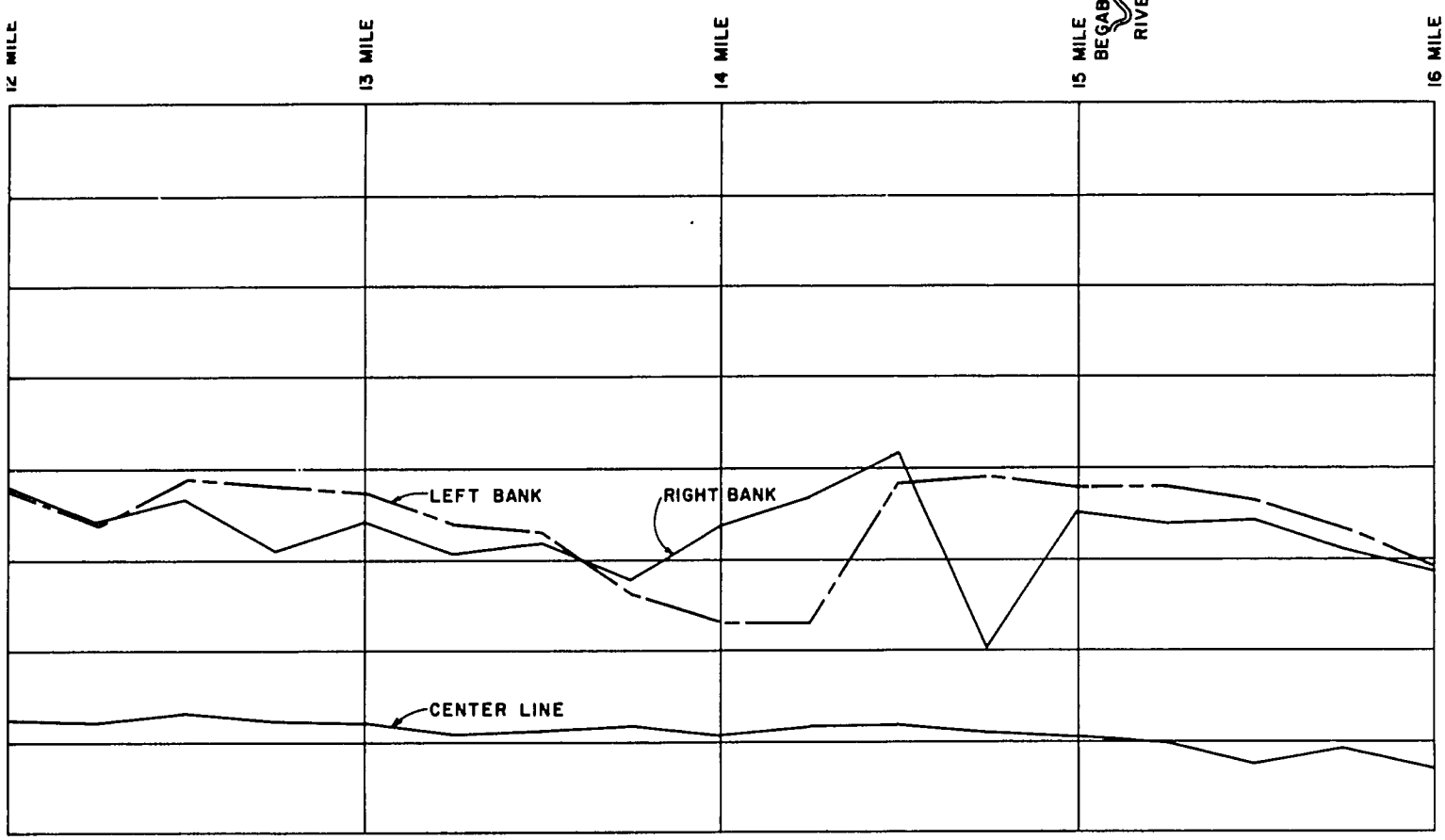


PRO

FIGU

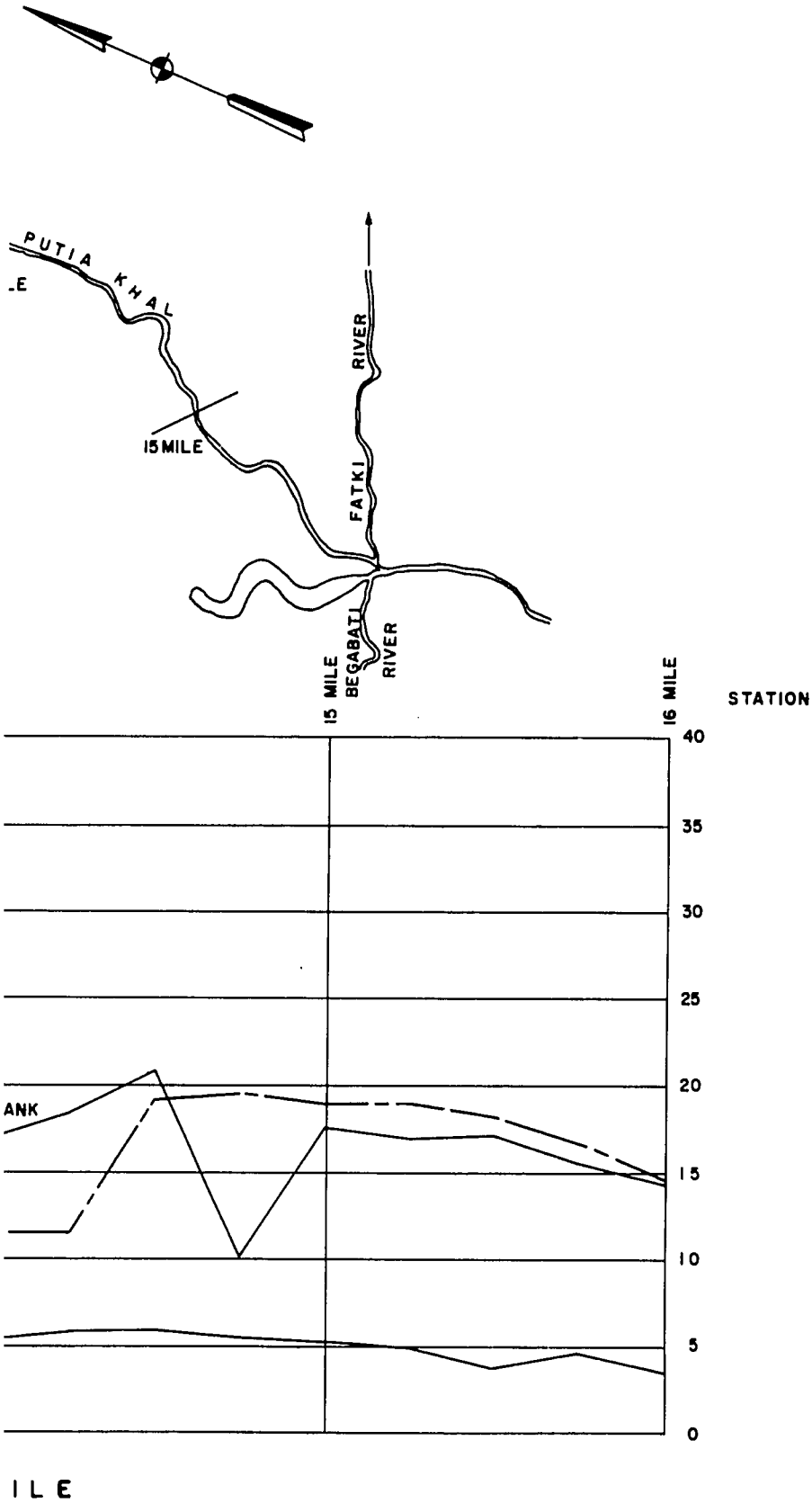


PLAN



PROFILE

FIGURE I-9



DOPAGHATA KHAL

PLAN & PROFILE

SHEET 3 OF 3

The elevation of this beel is approximately 12 feet PWD and it could not drain naturally during the period from mid-October to early spring when water is being impounded in the Nabaganga River. During this dry season, low-lift pumps would be spaced along this channel for local irrigation of approximately 2000 acres. These would lower the water level in the beel and additional water could be released into the channel from the Nabaganga river as required to satisfy the irrigation demands.

The analysis presented in Appendix B, Section 2.7 indicates that local flooding in the Barabila Beel from intense rainfall would be limited to an area below elevation 16.3 ft PWD, even in the case when no drainage to the river is possible due to water impoundment for irrigation.

1.3.7 Nabaganga River Channel

The entire 55-mile length of the Nabaganga River from its original off-take to Magura is heavily silted, particularly downstream of Alamkhali Khal. To improve drainage, the lower reach of the Nabaganga River has been re-excavated and is now open from Jhenida downstream to the confluence with the Kumar River. Additional re-excavation and cutting of loops upstream of Jhenida is now being planned and no other improvements are proposed for the Nabaganga River.

Water would be impounded in this river for a distance of 36 miles upstream of Magura, and to a maximum elevation of 19 feet PWD for low-lift pump irrigation. The river banks are generally above elevation 25 feet PWD, and this impoundment would cause no flooding nor restriction of drainage except in the Barabila Beel as previously discussed.

There is presently some marginal cultivation in the river bank during the dry season. This land will be

temporarily inundated when impound water levels are high. This level will rapidly recede early in the year and the planting will be delayed but this cultivation could continue on much of this river land.

This Plan and Profile of the Nabaganga River is shown in Appendix B.

1.3.8 Kumar River Channel

The lower Kumar and Kaliganga Rivers are generally open channels with considerable boat traffic and widths in excess of 500 feet. There are no drainage constrictions and no improvements are proposed for the Kumar River.

Water would be impounded in this river system for a distance of 32 miles upstream of Magura, and to a maximum elevation of 19 feet PWD. The river banks are above elevation 30 feet PWD and the impoundment would cause no flooding or restriction of drainage. Only the lower seven miles of this river is within the project area.

Similar to the Nabaganga River, there is some marginal cultivation in the river bank during the dry season which will have to adjust the cropping calendar to the impounded water levels.

The Plan and Profile of the Kumar River are shown in Appendix B.

1.3.9 Main Drains

Inherent with any new irrigation development is the corresponding demand for improved drainage. The local drainage requirements would be identified and assessed during the planning and design of the on-farm distribution systems. Drainage designs for three typical areas are discussed in Section 1.4.5.

Only the main drains, which would provide an outlet for the local drainage, has been considered herein. The drainage requirements and the proposed alignments have been determined from the semi-detailed soil surveys, from field observations and from aerial mapping. These alignments have not been surveyed or specifically noted in the field and their locations are only approximate. These main drains would be designed only for surface drainage during the dry season. During the wet seasons these areas are generally flooded and there would be natural overland runoff for storm discharges.

There are numerous local depressions and beel areas north of the Nabaganga River that will require drainage outlets, particularly with the advent of irrigation. Most of these improvements have been completed under G-K Project except for local areas in the vicinity of Dariapur Khal and Drain D1N. The G-K Project irrigation facilities have not been extended to these areas and the drainage works are incomplete. Approximately six miles of existing drains will require re-excavation and approximately two miles of new drains will be required. The location of these drains is shown on the map of Figure I-10.

For the area south of the Nabaganga River, drainage improvements have recently been completed near the terminal of the Kodamtali Khal. The four miles of existing Kodamtali Khal from there to the Fatki River reportedly needs re-excavation.

There are several beel areas west of the Haorkhali Khal which require an outlet. Approximately two miles of new channel have been identified for draining these areas south to a tributary of the Fatki River. The location of this drain is shown on the map of Figure I-11.

Dopaghata Khal has been identified for re-excavation to improve the drainage in the area immediately southeast of Jhenida. Further southwest and extending beyond the project

area are numerous large beel areas that require drainage outlets. A comprehensive drainage plan for the entire region is being considered by others, and is not included for consideration in this study.

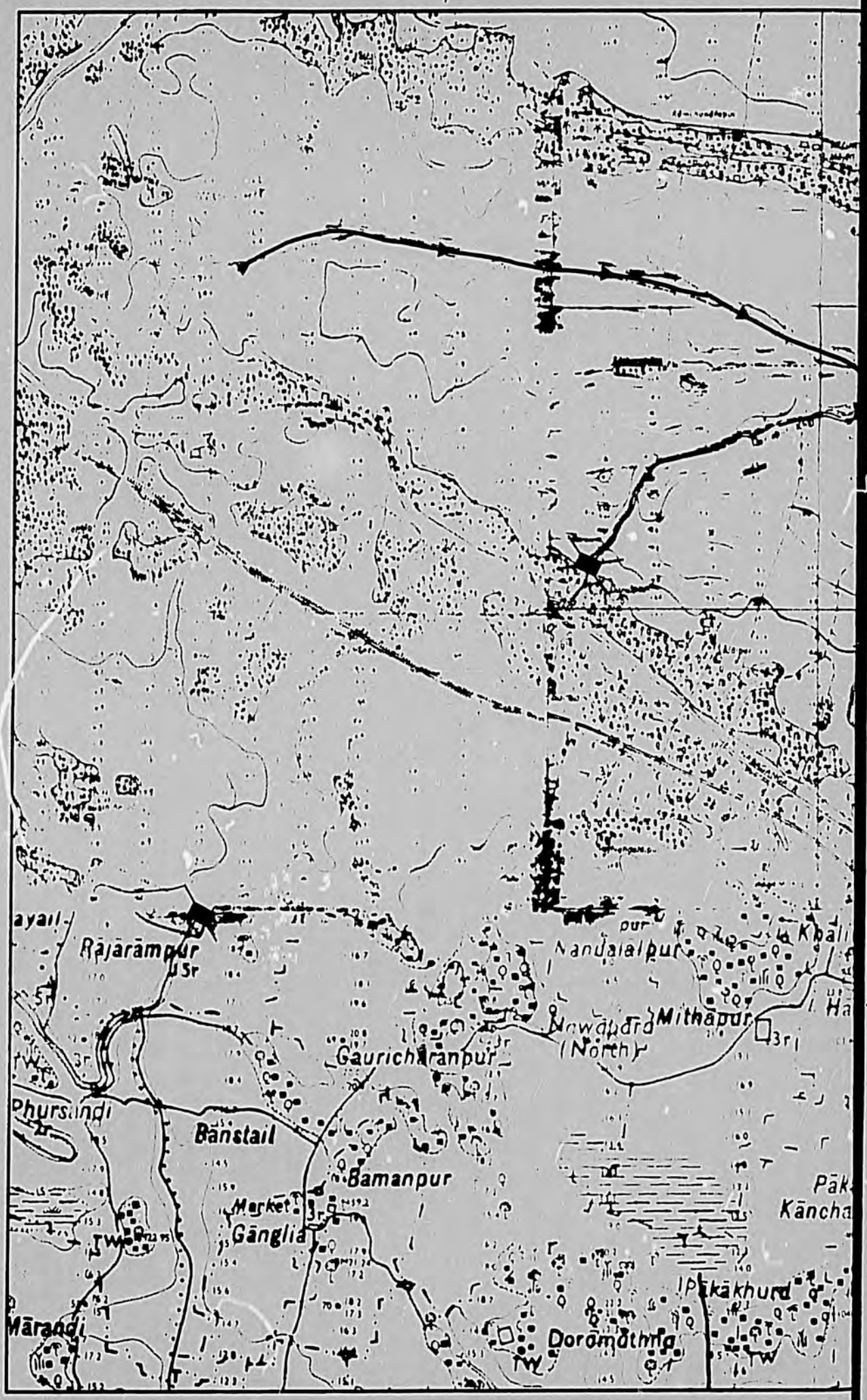
1.4 On-Farm Development

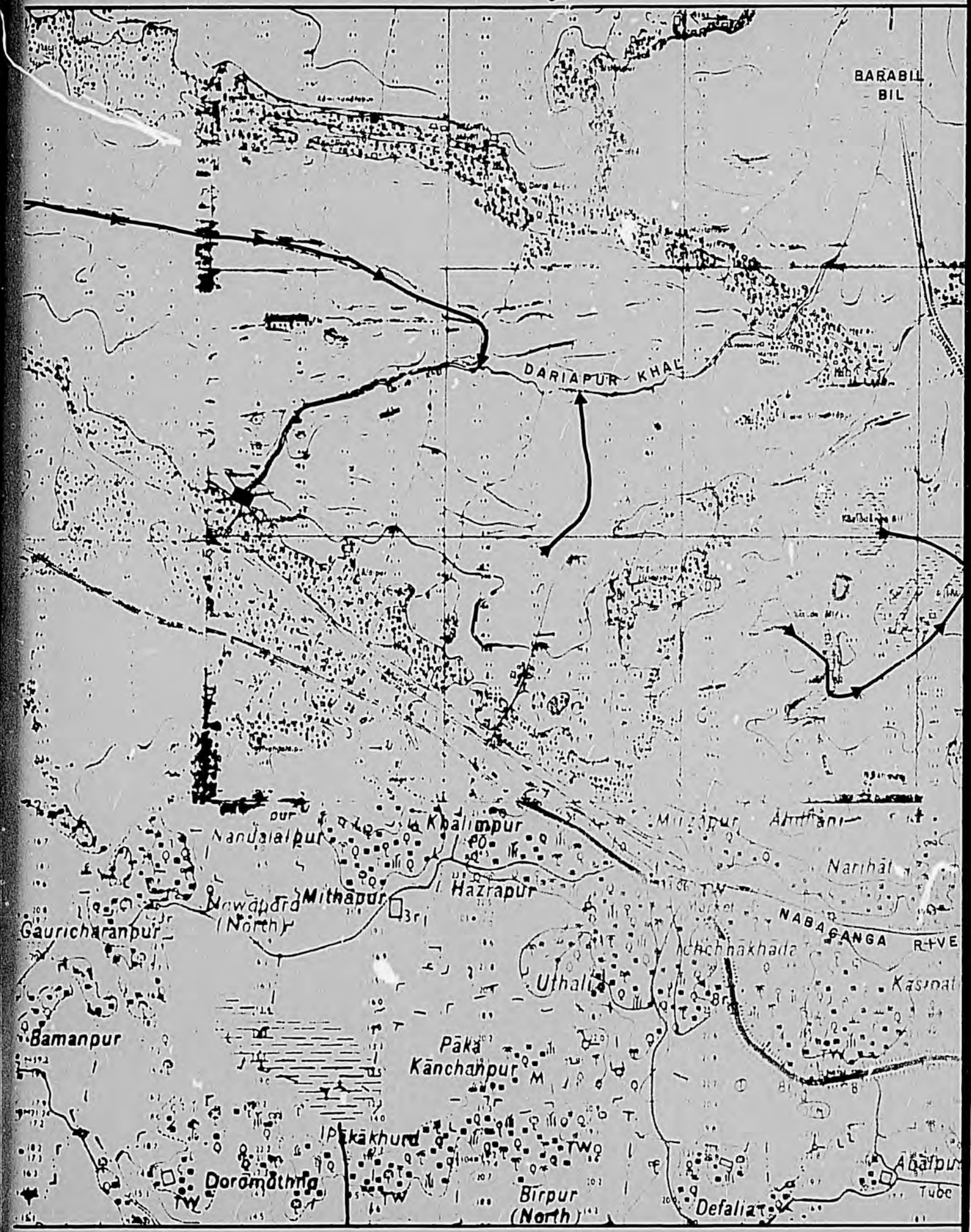
1.4.1 General Concepts and Objectives of On-Farm Development

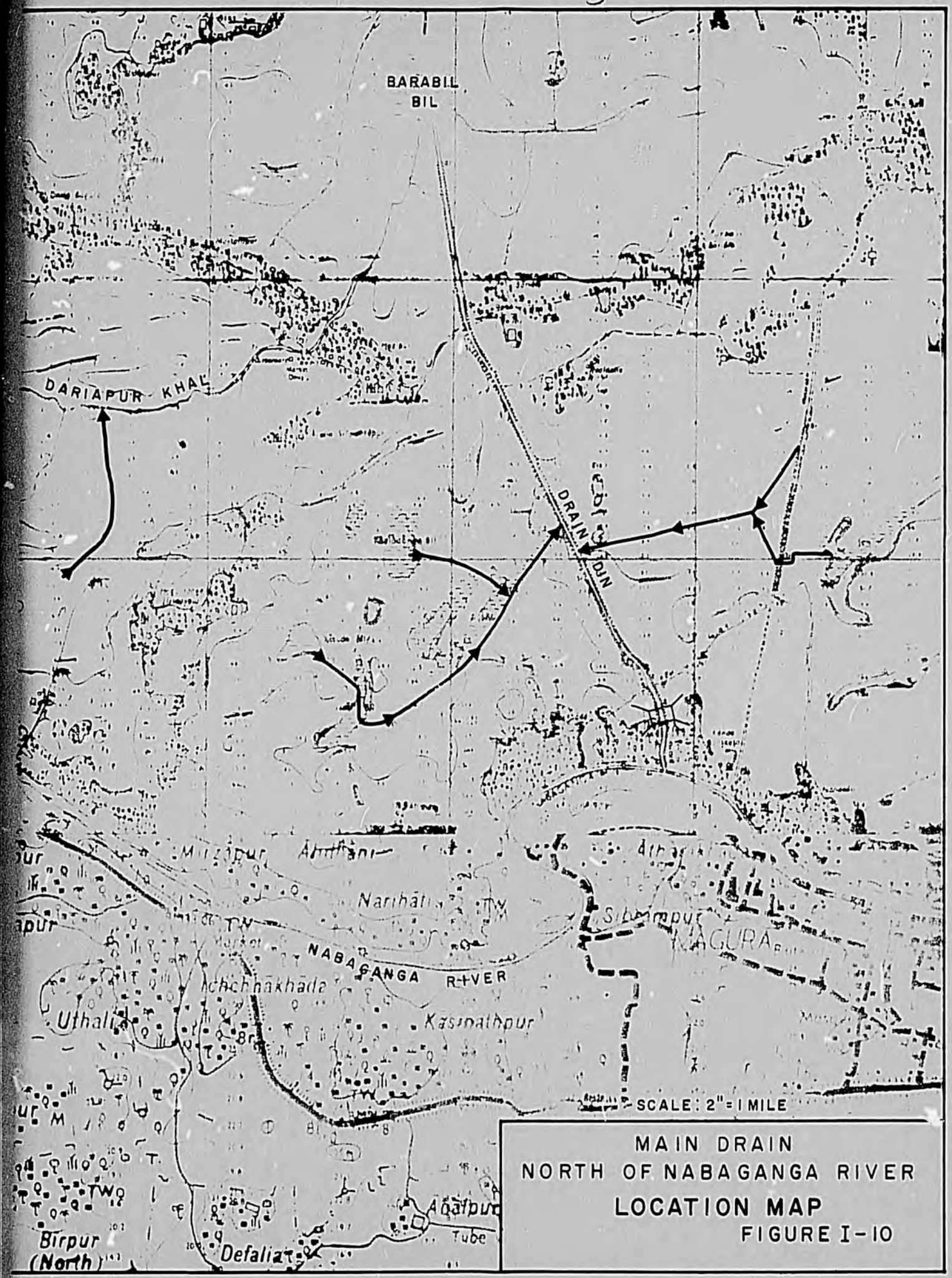
The ultimate objective of on-farm development is to obtain the optimal agricultural production from the land and water resources of the area, and thereby increase the income and improve the quality of life of the farm population. This optimum production would be achieved by irrigating the maximum area feasible, and by using the most appropriate water control and agricultural practices. However, there are some constraints which would inhibit the achievement of this objectiver. Following are the major constraints to on-farm development:

(a) The farmers have had no prior experience with the irrigation or with the corresponding water control and agricultural practices. They will need some actual operational experience combined with training and extension services before they will be able to effectively utilize the resources and to fully realize the benefits.

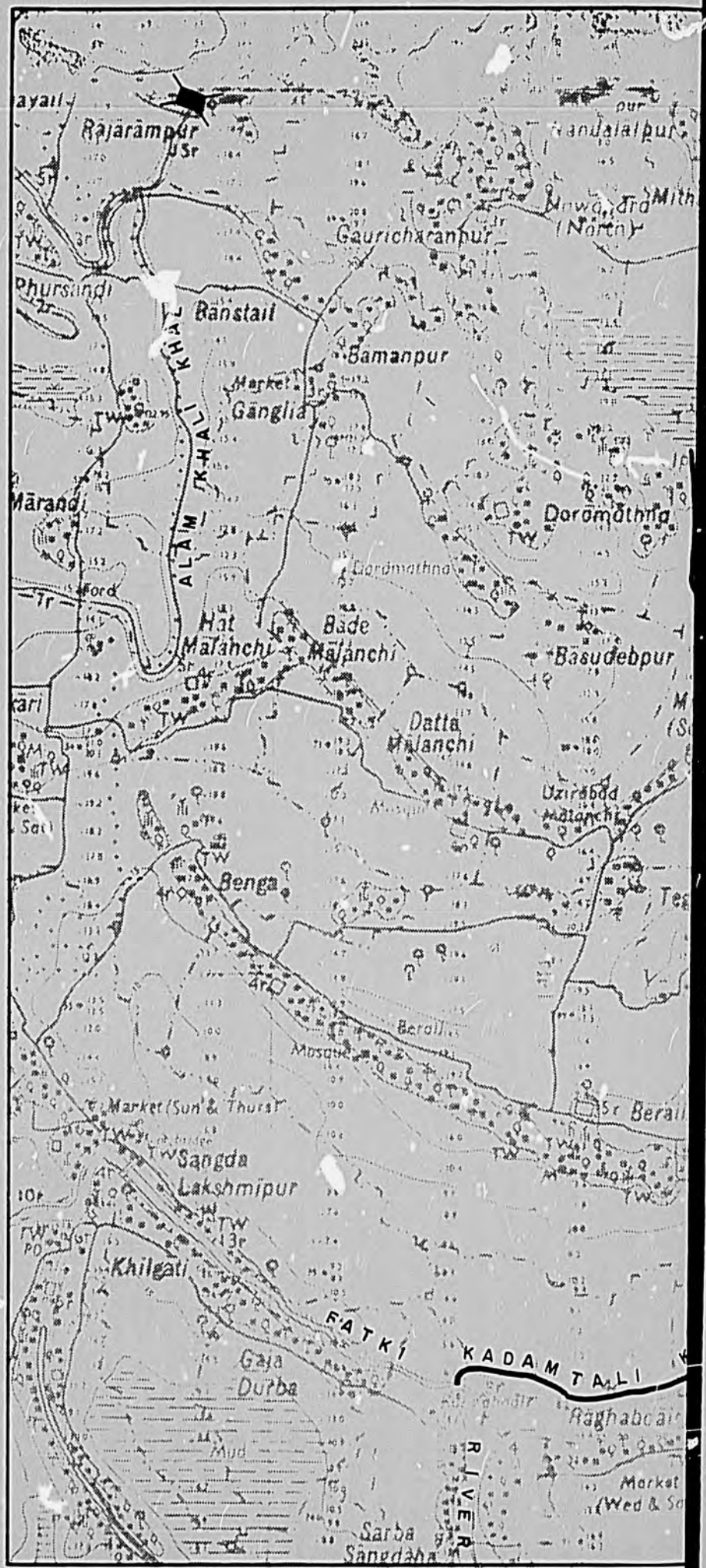
(b) The existing irregular topography does not permit the efficient use of either the land or the water resources. There are numerous shallow depressions in the area which could become water logged when the surrounding area is irrigated. It is not feasible to construct and maintain drainage outlets for each of these small depressions. It would be more appropriate to fill these areas by land leveling.

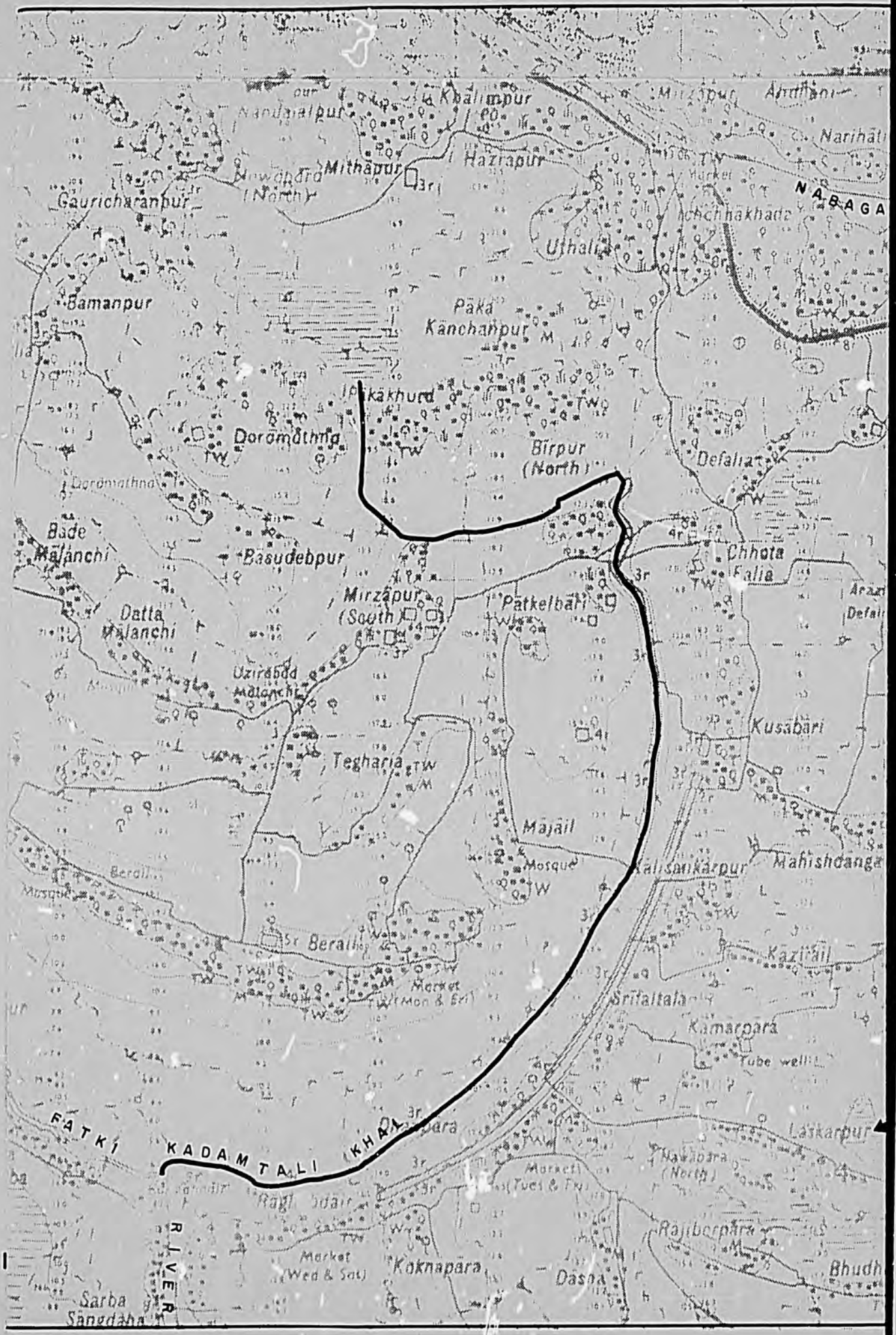

Rājarāmpur
Nandalālpur
Mithāpur
Gaurichāranpur
Bānstail
Bāmanpur
Market
Gānglia
Dorōmāthrā
Pākākhurd
Kāncha

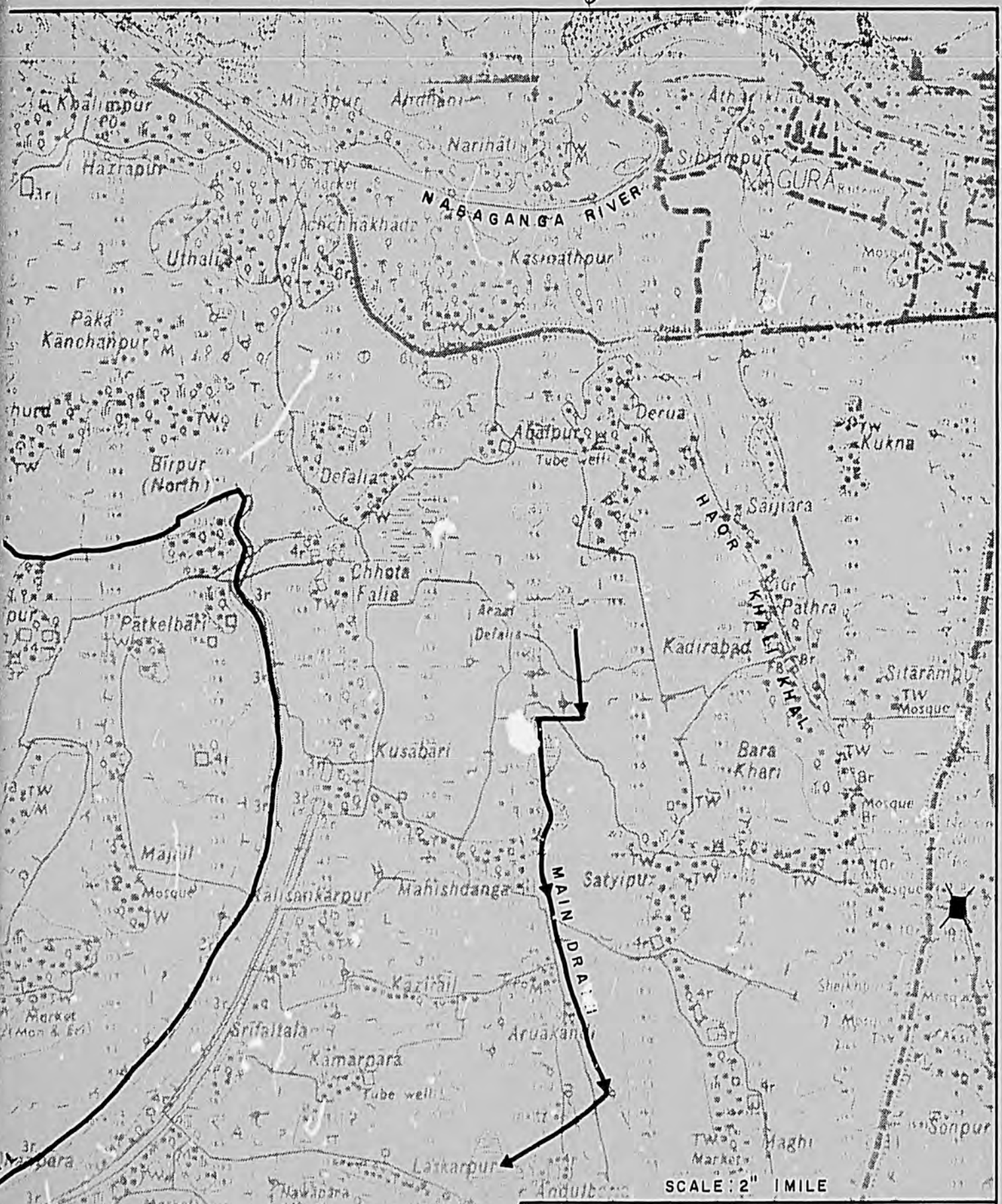

BARABIL
BIL
DARIAPUR KHAL
Nandalalpur
Khalimpur
Mithapur
Hazrapur
Gauricharanpur
Narihāt
NABAGANGA
Uthali
Kasipal
Bamanpur
Pāka
Kānchanpur
Pakakhurd
Doromathura
Birpur
(North)
Defalia
Tube



MAIN DRAIN
NORTH OF NABAGANGA RIVER
LOCATION MAP
FIGURE I-10


Rajarampur
Gauricharanpur
Banstail
Bamanpur
Market
Ganglia
ALAM KHALI KHAL
Marandi
Doromothing
Ford
Hat Malanchi
Bade Malanchi
Basudebpur
Datta Malanchi
Uzirabad Malanchi
Benga
Berail
Mosque
Market (Sun & Thurs)
Sangda
Lakshmipur
Khilgati
FATKI
KADAMTALI
Gaja Durba
Mud
RIVER
Sarba Sangdaha
Raghabcai
Market (Wed & Su


Khalimpur
Nandanalpur
Narihati
Mithapur
Hazrapur
Gaurichanpur
NABAGA
Uthali
Bamanpur
Paka Kanchanpur
Pakakhurd
Doromathna
Birpur (North)
Defalia
Bade Malanchi
Basudebpur
Chhota Falia
Mirzapur (South)
Patkelbari
Datta Malanchi
Uzirabad Malanchi
Kusabari
Tegharia
Majail
Mosque
Kalisankarpur
Mahishdanga
Berail
Kazirail
Srifaltala
Kamarpara
Tube well
FATKI
KADAMTALI KHAL
Laskarpur
Rajiberpara
Bhudh
Koknapara
Dasna
Sarba
RIVER



MAIN DRAIN
SOUTH OF NABAGANGA RIVER
LOCATION MAP
FIGURE I-II

(c) The area is heavily fragmented with an average of 3 to 4 parcels per acre. The intervening bunds between these parcels take significant areas of land out of cultivation, restrict agricultural activities, and inhibit the efficient use of the adjacent land. It is not technically viable to provide each parcel with the individual irrigation and drainage controls that are necessary to achieve the optimal yields, and ultimately some land restructuring will be needed.

(d) There would be extensive use of low lift pumps to provide the irrigation supply for the initial development. The use of these pumps is an expedient means of introducing irrigation into the ara, but they should not be considered as permanent installations. These low lift pumps are troublesome to operate and maintain; they have a relatively short operating life; and their siting and installation are not conducive to efficient use. There are high operating head losses, and they must be relocated during the wet season to prevent being submerged by the high flood waters.

Ultimately, these low lift pump systems should be consolidated into larger, more efficient units which would be served by permanently installed, larger capacity electrically driven, propeller type pumps. This consolidation is not expected to occur voluntarily until the farmers have become experienced with irrigated agriculture, have had an opportunity to assess the effectiveness of the existing organization and land structure, and have realized the potential of combining the systems into more efficient units.

It is evident that a prolonged training and development period will be required before the ultimate objective of on-farm development can be realized. Accordingly, the immediate objective should be the commencement of the training and development program by introducing irrigation into the area as expediently and as extensively as possible. The farmers should be involved to the fullest estent in the planning, financing, implementation, and operation of the irrigation

and drainage facilities. It then becomes important that these initial systems are simple and inexpensive and can be completed and maintained by the farmers using their available resources and skills.

No significant changes in the existing land structure would be expected for this initial development. However, the farmers should be strongly encouraged to consider some land leveling to fill in the small depressions. They should also be told of the possibility of future changes in the system, and that the initial development should be adaptable to, and should not inhibit future changes in, the land structure.

1.4.2 Water Supply By Pumping

All irrigation water must be pumped either from surface or from groundwater sources. The surface supply is limited geographically to the Nabaganga River and its connecting channels. This surface source could supply only the adjacent areas which could be readily irrigated by low lift pumps. In the future, if this surface supply could be increased, then larger pumps and major canals could be used to extend the irrigable area.

There will be some runoff from the irrigated areas which would collect in the beel areas. These beels could then become a source of water for local irrigation. This supply is uncertain, both in quantity and time, and has not been considered in this study.

Low lift pumps would be the primary means of supplying irrigation water from the surface source. These would be centrifugal pumps that would generally be powered by diesel engines. These pumps are being widely used throughout Bangladesh and are presently being distributed by BADC. These pumps have numerous operation and maintenance problems, but there is extensive local experience in their use, and they are recommended for the initial development.

Most of the pumps now in use have a rated capacity of 2 cfs, and a similar capacity standard size pump is recommended for all initial installations in the project. The actual capacity is probably somewhat less than the rated level because of the high operating head losses and the poor site installations.

A large discharge will be required to irrigate wheat in a level paddy to permit a rapid and uniform distribution of the water throughout the basin. A large discharge would also provide greater flexibility in the operation schedule.

The initial cost of a 2 cfs pump is Tks 18,500 F.O.B. Dacca, which is not significantly greater than the cost of a 1 cfs pump which is Tks 15,900 F.O.B. Dacca.

In addition to low lift pumps there are extensive areas in Bangladesh being irrigated by the traditional country methods. There are also several types of manually operated pumps which are being developed and evaluated for irrigation use. Both methods are suitable for irrigating small local areas and they could have particular application in the project area for irrigating narrow strips of land along the Nabaganga River and for irrigation from the beels.

These manual methods of lifting irrigation water may become increasingly significant in the future as fuel becomes correspondingly more costly. At present, the fuel for a LLP annually costs as much as the total first cost of the pump. Eventually, as fuel becomes a disproportionate cost, manual or perhaps solar pumping may become competitive or even a necessity.

Groundwater is available throughout the project area and could be used for irrigation by means of shallow tubewells (STW).

A shallow tubewell (STW) would generally command an irrigable area of 15 to 30 acres. These would be located on isolated high lands inside the project area which could

not be readily served by the low lift pump system. The STW would be centrally located within a relatively small area and the required conveyance facilities would be minimal. These STW would be equipped with centrifugal pumps similar to a low lift pump but with a maximum capacity of about ½ cfs. Section 2.10 at Appendix B presents a preliminary evaluation of groundwater in the project area.

The estimated cost of an STW and pump is Tks 27,000.

Manually operated shallow tubewells for irrigation (MOSTI) are also being widely disseminated in Bangladesh. Those have a capacity of approximately 0.02 cfs and can irrigate only a fraction of an acre. They would be primarily used for the irrigation of homestead gardens and special crops. They could be used in the development area for the irrigation of individual parcels where the farmers would not be agreeable to associating with a pump group and would prefer their independent supply.

Several types of these pumps are now being developed and evaluated for irrigation use. The costs vary from Tks 300 to 1,000 each.

Deep tubewells (DTW) could be used at any site in the project area, and would generally have a capacity of 1½ to 2 cfs. However, they would significantly lower the groundwater level in the area which could interfere with the operation of shallow tubewells both for irrigation and domestic purposes. Their initial costs vary from Tks 150,000 to 250,000 and they would have a high pumping head with the comparable high oeprating costs. Deep tubewells are not economically competitive with low lift pumps or shallow tubewells, and they are not recommended for use in the development area.

1.4.3 Methods of Irrigation

It is anticipated that rice will continue to be the principal crop during the wet season, and the irrigated

dry season crop must then be cultivated in these leveled paddy fields. This condition limits the type of irrigation to the basin method with the possible use during the dry season of corrugations or raised beds to facilitate the control of water within the field. Some fields may not be suitable for this method of irrigation, or some farmers may not be willing to do the extra work to prepare the fields, and some dissatisfactions and possible abandonment of irrigation should be expected.

Proper water management at the field or block level then becomes the singularly important element in the on-farm development. An irrigation block will consist of 10 to 20 parcels within a 3 to 5 acre area, and it is not feasible to provide each parcel with a positive inlet and outlet control. It would be necessary for the farmers comprising a block group to develop a coordinated schedule consistant with the irrigation methods. This would assure the equitable distribution of water to each parcel and, of equal importance, assure that no waterlogging occurs. This would be extremely difficult to achieve!

It is suggested that ultimately the parcels be combined and leveled into a single unit which could then be provided with positive water control, both for the application of the irrigation water and for the disposal of the excess. In the interim, it is expected that irrigation and drainage waters will generally spill from field to field with the resulting conflicts and inefficiencies. These problems can be anticipated but can not be specifically identified until irrigation begins. At that time, technical advice and assistance would be most useful.

Following is a discussion of the basin methods of irrigation:

- The basin method is the simplest and most widely used method in Bangladesh. It is suitable for most field crops and particularly for rice irrigation. The irrigation unit must have a nearly level surface which is surrounded by a small bund. The bund retains the water until it infiltrates into the soil or until the excess is drained off.

The principal disadvantages of this method is the bunds which interfere with the cultivation of the crops. These bunds also occupy a significant land area which reduces that available for cultivation. The flat surface makes it difficult to rapidly drain excess water from the basin and for some conditions individual drainage ditches may be required. Also, a large supply stream may be needed for the uniform distribution of irrigation water throughout the basin.

- Raised beds or furrows can be used in combination with a basin when the crop must be grown on a raised bed to protect the plant stems or crowns from flooding. Irrigation is accomplished by running water in the small channels (furrows) which would be formed in the basin. The water seeps into the bottom and sides of the furrow to provide the desired wetting of the soil. In some instances the water is scooped out of the furrow and spread over the surface of the raised bed.

- Corrugation is a variation of the furrow method and is used for close-spaced crops such as grain in conjunction with the basin method to help obtain uniform distribution of water. It can also be used for sloping lands. Land grading is generally limited to removing minor irregularities in the soil surface. The slope in the direction of irrigation needs to be continuous but not necessarily uniform. This may require some moving of earth to eliminate small raised areas or to fill slight depressions.

This method is sometimes used as an expedient means of introducing irrigation on gently sloping lands that could be uniformly graded. This permits irrigation until land grading can be done properly.

A priority consideration for surface irrigation is the preparation of the land surface to permit uniform distribution of the water and to permit drainage of the excess. Much of the area is now divided into basins, but only for rainfed cultivation, and the basins are not necessarily graded nor are the surrounding bunds intact. Considerable land grading will be necessary before the area can be efficiently irrigated or before any effective water management can be realized at the field level.

The farmers will need some operation experience coupled with technical assistance for them to define the extent and form of this land preparation and determine the most appropriate irrigation procedures.

1.4.4 Distribution Systems

The topography of the low lift pump development area is nearly level or very gently sloping broad natural levees with slight irregularities caused by narrow ridges and filled-in channel complexes. This irregular but overall nearly level topography limits the extent of the individual areas that could be readily irrigated by low lift pumps. Within these limits, the actual areas for each system would be defined by the organizations of farmers who would implement and operate the system. The composition and the formation of these organizations is discussed in detail in Chapter VI.

The distribution systems for these areas would consist of (1) the irrigation facilities to convey water from the pump to the turnout of the irrigation blocks and, (2) the drainage facilities to convey the excess water from the irrigation blocks to a main drainage outlet. The facilities for the control of water within the block would be the responsibility of the block members.

Generally an irrigation block would have an area of less than 100 acres for a low lift pump system and less than 25 acres for a shallow tubewell. The irrigation distribution system for each would be correspondingly small. These systems would be used only intermittently during the dry season for the irrigation of wheat or similar crops. In early spring some systems would be fully utilized for the irrigation of a boro crop or to supply water for land preparation for an aus crop.

The systems should be of simple construction that could be financed, implemented, and operated by the farmers. The systems should also be acceptable to changes as the development evolves. The irrigation distribution system would have earthen unlined channels with manually compacted banks. These channels would generally follow the contours, and the excavation and fill would be minimal. The earthwork would average 8 cubic feet per lineal foot of channel.

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. The overall channel section would be approximately 10 to 12 feet wide, but only an additional 6 feet of land would be required in excess of the existing bund. Those additional land requirements would be approximately 1 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 precedence for maintenance of other facilities such as structures and drainage channels.

Improved drainage is an inherent necessity with any irrigation development. Drainage is particularly important for the cultivation of wheat which cannot tolerate wet conditions. Drainage is also required for the positive water control needed to obtain the optimal yields of the HYV of rice. The drainage systems would be relatively shallow, open channels for surface drainage only. Initially, these channels would extend from the main outlet to those areas where significant drainage problems would develop. Ultimately, as the land is restructured the drainage channels should be extended to provide each irrigation block with an outlet.

In some areas, the drainage channels could also serve as irrigation channels. The channels would be used only intermittently for irrigation and the remainder of the time they would be empty and would serve as drains. This dual use is particularly applicable to leveled fields which would drain in any direction. This dual use would entail greater maintenance and more intensive management. However, the irrigable areas are relatively small and within sight or easy walking distance from the pump and there would be no problem with maintaining continual surveillance of the system.

Lined channels, both open masonry and underground pipelines, were considered as alternatives to unlined channels. However, the lined channels are extravagantly more costly than the earth channels. The implementation period of the lined channels would be greatly prolonged because of the time to secure financing and to procure the materials. The farmers would require technical assistance in the design of the lined channels, in the preparation of contract documents, and in the supervision and administration of the construction work. There is a limited number of technical personnel available and these systems could not be replicated on a project basis.

Lined channels are not recommended for use in the initial development. However, in the future when there is more intensive use of the facilities and the yields and incomes are significantly greater, some farmer groups may be willing to finance such installations.

An analysis of some typical installation of lined channels is shown in Appendix A, and there are some experimental installations in Bangladesh of various lining materials. These studies may be useful to those groups who may consider such installations in the future.

The recommended design criteria and some typical system layouts and profiles are discussed in the following section.

1.4.5 Typical Layout and Design of On-Farm Irrigation Distribution Systems

1.4.5.1 General Criteria

Detailed analyses of the distribution systems for three typical areas were made to assess the scope and the extent of the on-farm development; to develop a typical layout and design criteria; and to prepare typical cost estimates. The general development was discussed with the residents in each of the three typical areas, but there was no discussion of the specific layouts and designs. It would be appropriate to discuss these specifics only after there is definite assurance that the project will actually be implemented. The final planning, the financing, the implementation, and the operation and maintenance of the systems will be done by the users of the systems, and the layouts and criteria presented herein are intended only as a guide to their planning and to indicate the potential and limitations of the development.

Each typical area was divided into topographic units that were defined by settlements, isolated high lands, natural drainage ways and road embankments. Those units which could not be readily served by low lift pumps from a surface water supply would be served by shallow tubewells. The analyses of the typical areas indicated that, as an average, a low lift pump would have an irrigable area of 96 acres and a shallow tubewell would have an area of 24 acres.

Each pump unit would be sub-divided into irrigation blocks of generally symmetrical shape and with lands of similar elevation. These blocks would have an area of two to five acres and would contain from ten to twenty parcels each. The pump irrigation distribution systems would be planned to serve each block but the distribution within the block would be the responsibility of the block members. Ideally, these blocks would eventually be re-structured into a single irrigation unit to permit proper water control.

The pump irrigation distribution systems would be planned, implemented and operated by the pump association, and would consist of earth channels and simple control facilities. These channels would generally follow the contours and the earthwork and right-of-way requirements would be minimal. Open earth channels are very suitable for the relatively flat topography and for the soils of the development area. The soil are silty-clay loams which are relatively stable with a moderate to low permeability.

All channels would be designed for a discharge capacity of 2 cfs for low lift pump systems, and one-half cfs for shallow tubewell systems. This would permit the maximum flow to be directed to a single block. These channels would have a bottom width of 12 inches and a depth of 21 and 15 inches for the 2 cfs and one-half cfs channels, respectively. The depth of flow would vary depending on the slope but standard sections are recommended to simplify construction procedures

and control. The checked water surface would be a minimum of 0.5 feet above the irrigable land surface.

The structures, as with the channels, would be simple facilities that could be constructed and maintained by the users. The only permanent masonry or concrete structures would be road crossings and division boxes. The division boxes could act as a stilling basin for the pump discharges; they would regulate the distribution of flows to various laterals, and they would serve as a weir to check the pump discharge.

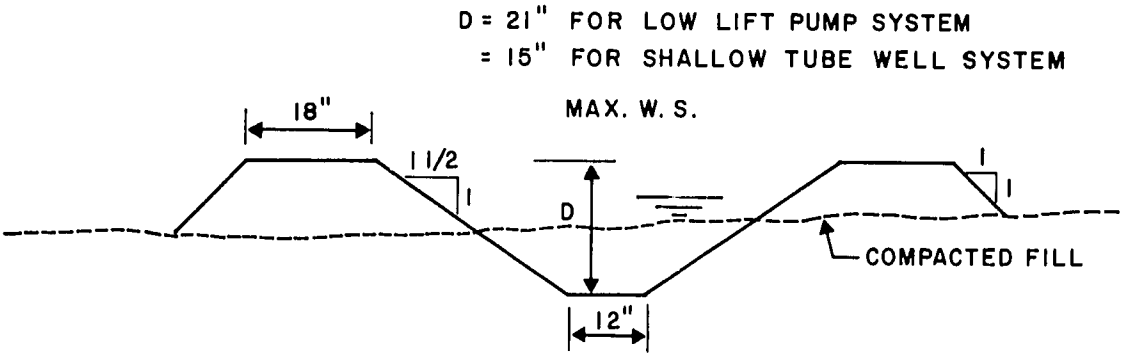
The check structures would be simple portable fabric or metal dams. Turnouts could be similar to the precast concrete pipes used in the G-K Project. Some drop structures may be appropriate to reduce the earthwork, but again these would be simple metal or timber weirs.

The typical channel sections are shown on Figure I-12 and the typical structures are shown on Figures I-13 and I-14.

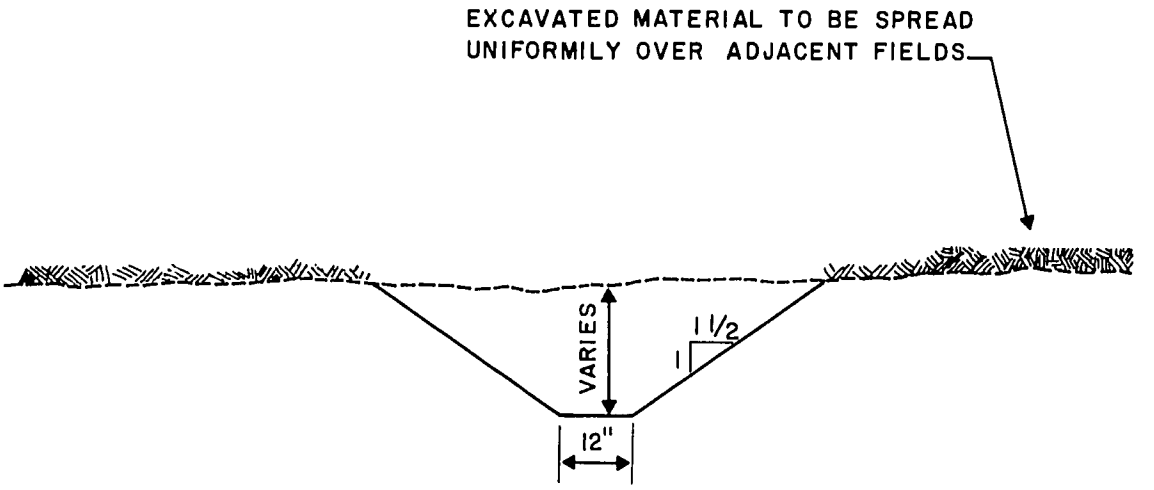
The significant characteristics and the systems for each of the typical areas are discussed in the following sections and the quantities and the cost estimates for each area are shown in Table I-5.

1.4.5.2 Alaipur/Mirzapur Typical Area

These two adjoining areas are located north of the Nabaganga River approximately four miles west of Magura. The irrigable lands are separated from the river by the intervening settlements as shown on the Vicinity Map of Figure I-15. This is a common feature along much of the river and in some locations a costly and disruptive channel would be required to convey water from the river, through the settlements to the irrigable lands. At Mirzapur, there is an abandoned canal that could be re-excavated to channel water

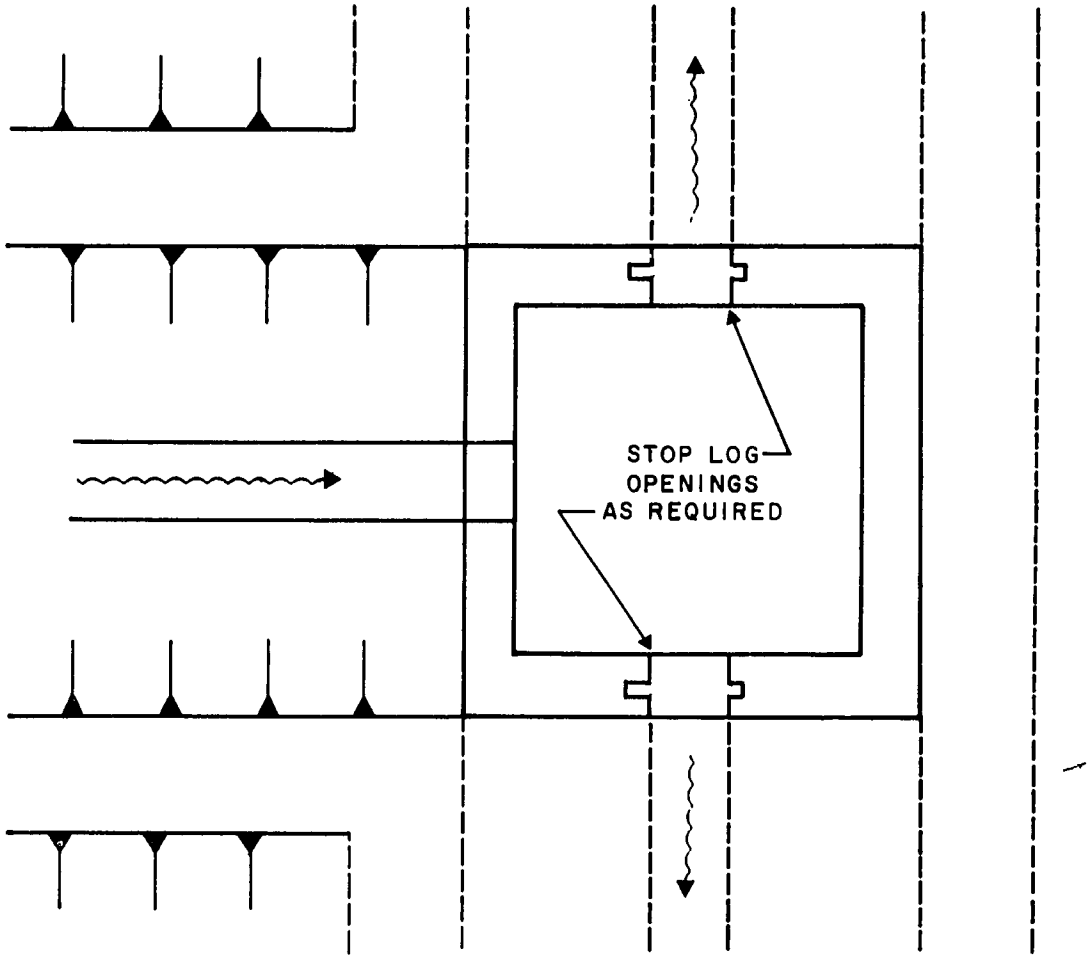


IRRIGATION CHANNEL
NOT TO SCALE

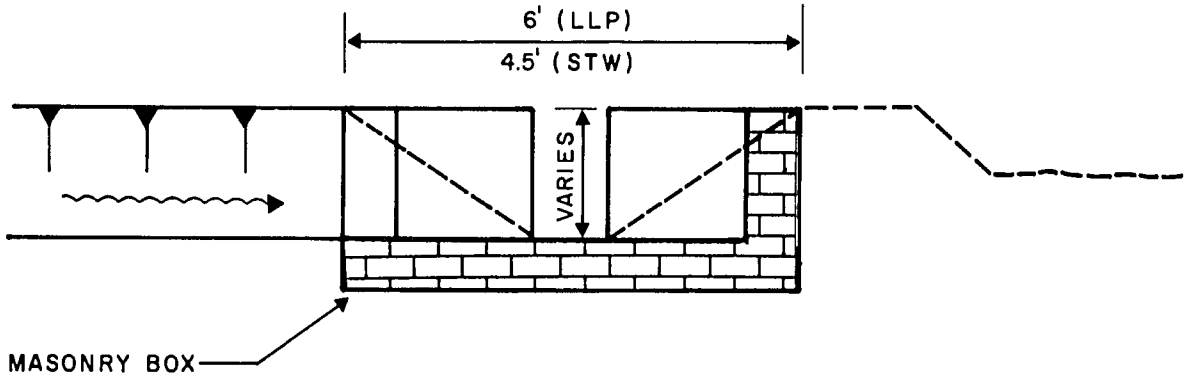


DRAINAGE CHANNEL
NOT TO SCALE

ON-FARM DEVELOPMENT
TYPICAL CHANNEL SECTIONS
FIGURE I-12

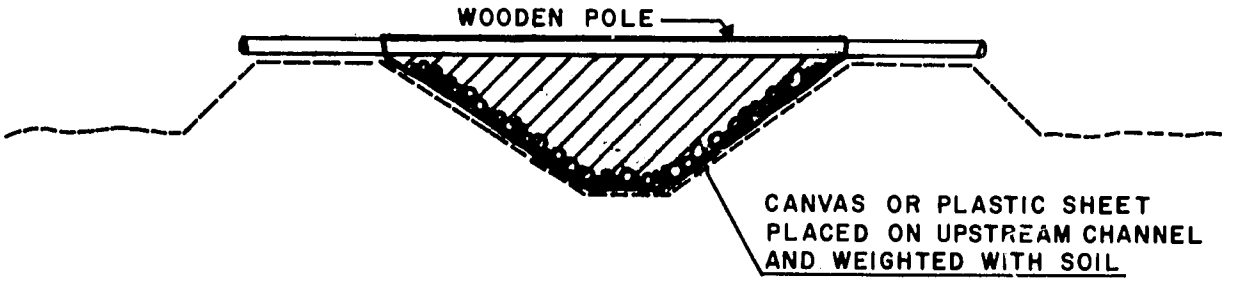


PLAN
NOT TO SCALE

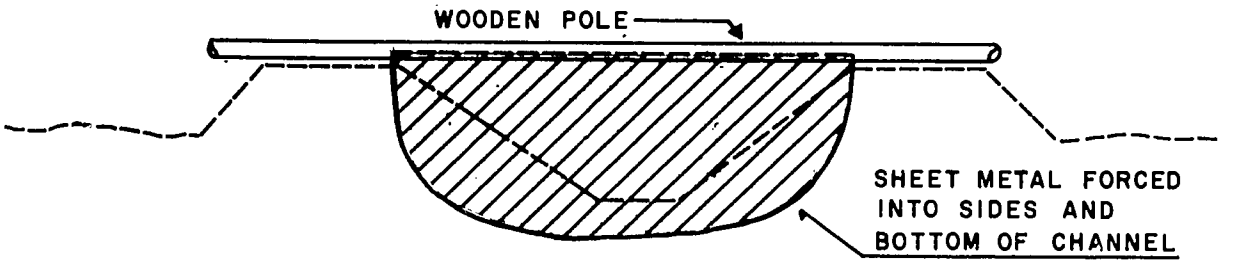


SECTION
NOT TO SCALE

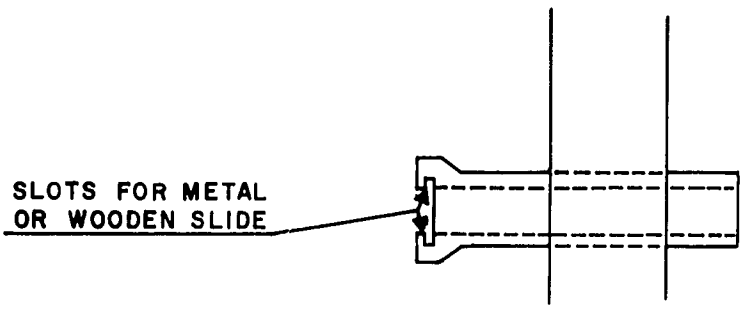
ON-FARM DEVELOPMENT
DIVISION BOX
FIGURE I-13



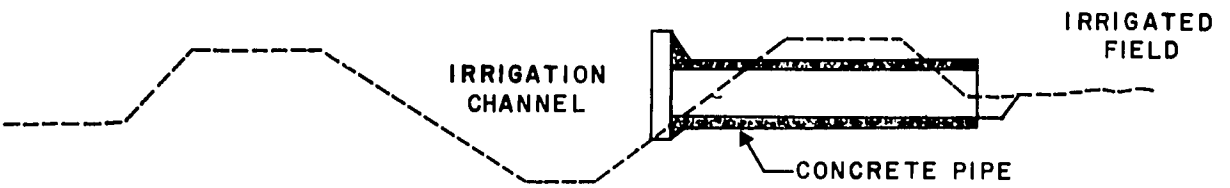
PORTABLE CANVAS OR PLASTIC CHECK
NOT TO SCALE



PORTABLE METAL CHECK
NOT TO SCALE



PLAN
NOT TO SCALE



PRECAST TURNOUT
NOT TO SCALE

ON-FARM DEVELOPMENT
TYPICAL STRUCTURES
FIGURE I-14

to the pump site at the edge of the irrigable area. The extension of this canal could also be utilized as part of the irrigation distribution systems. With some impounding embankments, this extension could be further developed as a storage reservoir and a flow-through fish tank.

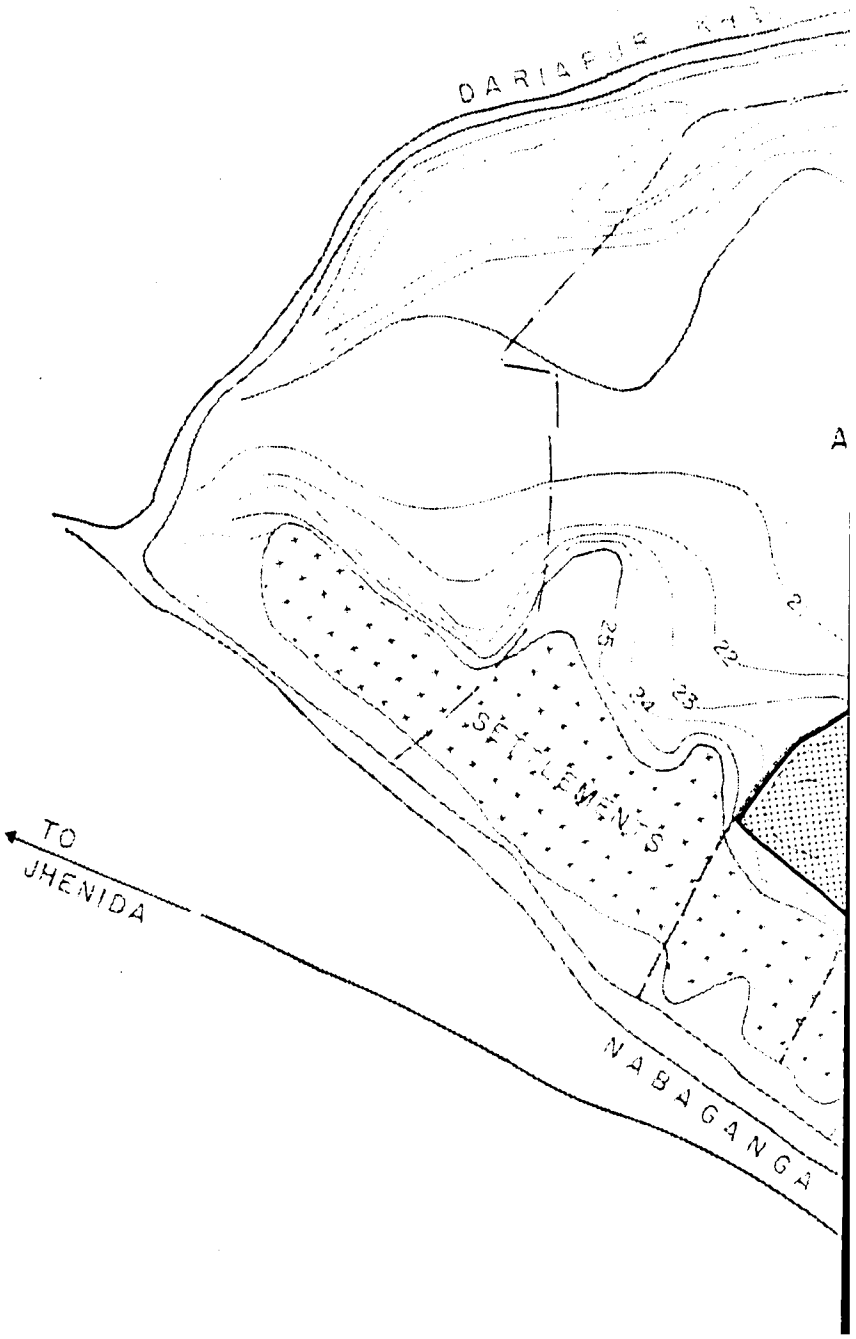
A low lift pump at the above site could readily irrigate an area of 142 acres. This is a relatively large area, and there may be difficulties in initially organizing such a large group, particularly with areas in two villages. The irrigation demand for rice for this large an area may exceed the capacity of a 2 cfs pump, and eventually a larger pump may be needed.

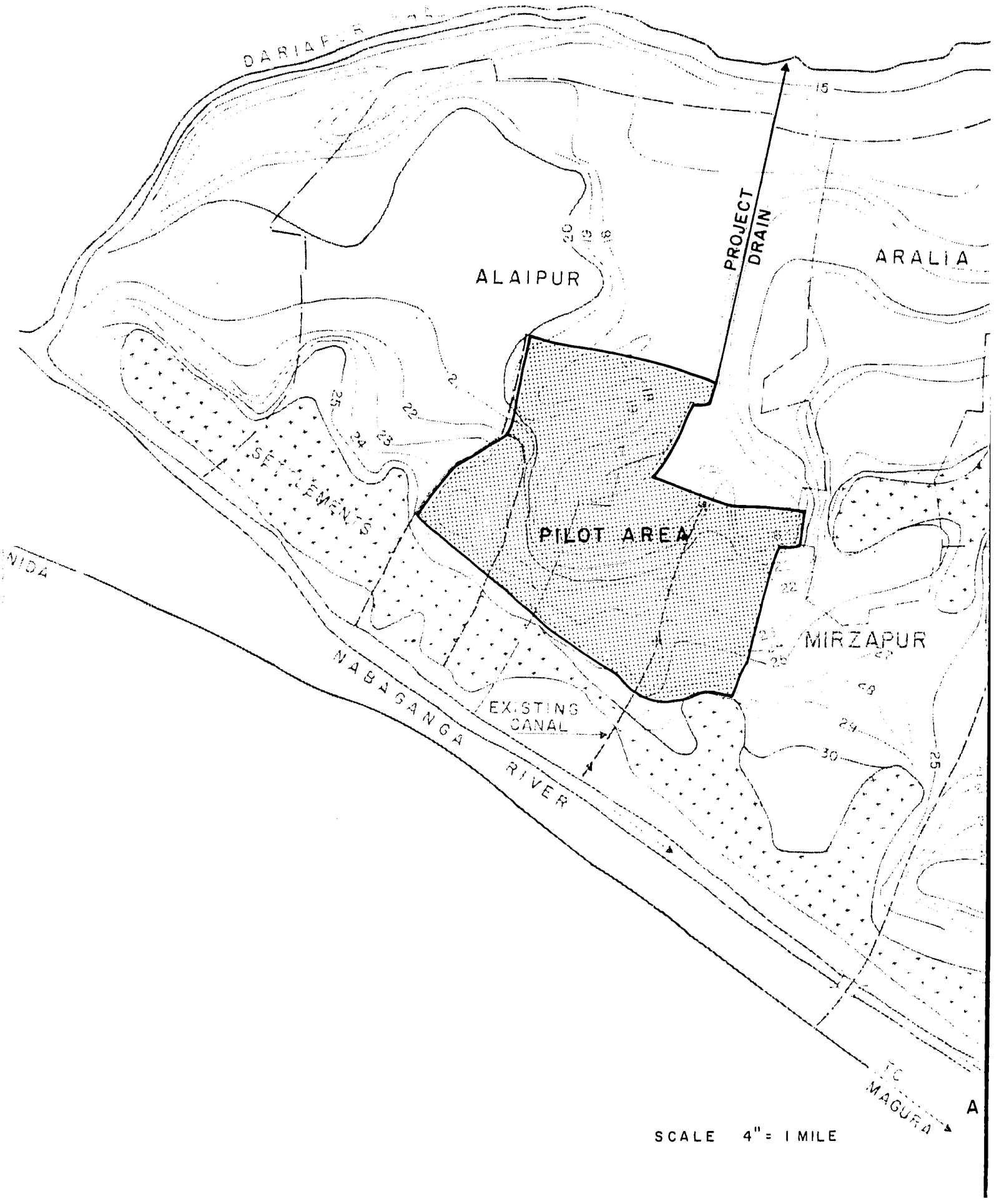
In addition to the above area, there are three isolated areas of 16, 40 and 13 acres each in Alaipur village which can best be irrigated by shallow tubewells. The irrigation demand for the 40 acre area may exceed the capacity of a one-half cfs shallow tubewell, and again a larger pump may be needed.

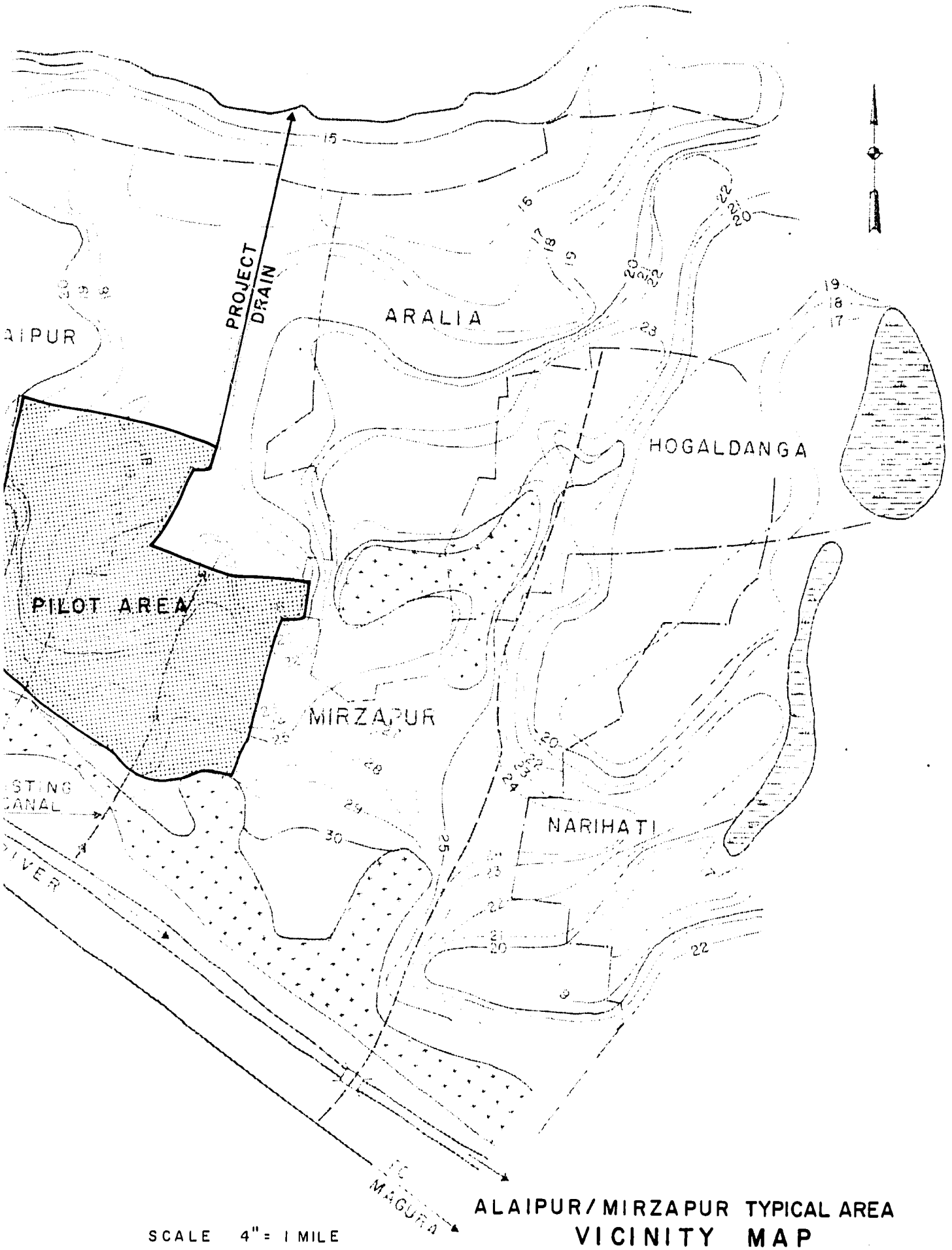
The layouts of the above systems are shown on the map of Figure I-16, and the profiles of the distribution channels are shown on Figure I-17, Sheet 1-3.

There are some significant depressions in Alaipur village which will require some positive drainage outlets. The boundary between the two villages would be the natural alignment for the collector drain which would then join the proposed project drain to the Dariapur Khal. There would be nothing unique about such drainage improvements but such improvements require significantly more right-of-way and more maintenance than the irrigation channels, and it may be difficult to convince the farmers that such improvements are really necessary.

There is an extremely low area near the outlet which would be flooded during the wet season, and even with drainage, the area could be waterlogged during the dry season. Such an


DARIAPUR
A
2
22
23
24
25
SETTLEMENTS
TO
JHENIDA
NABAGANGA

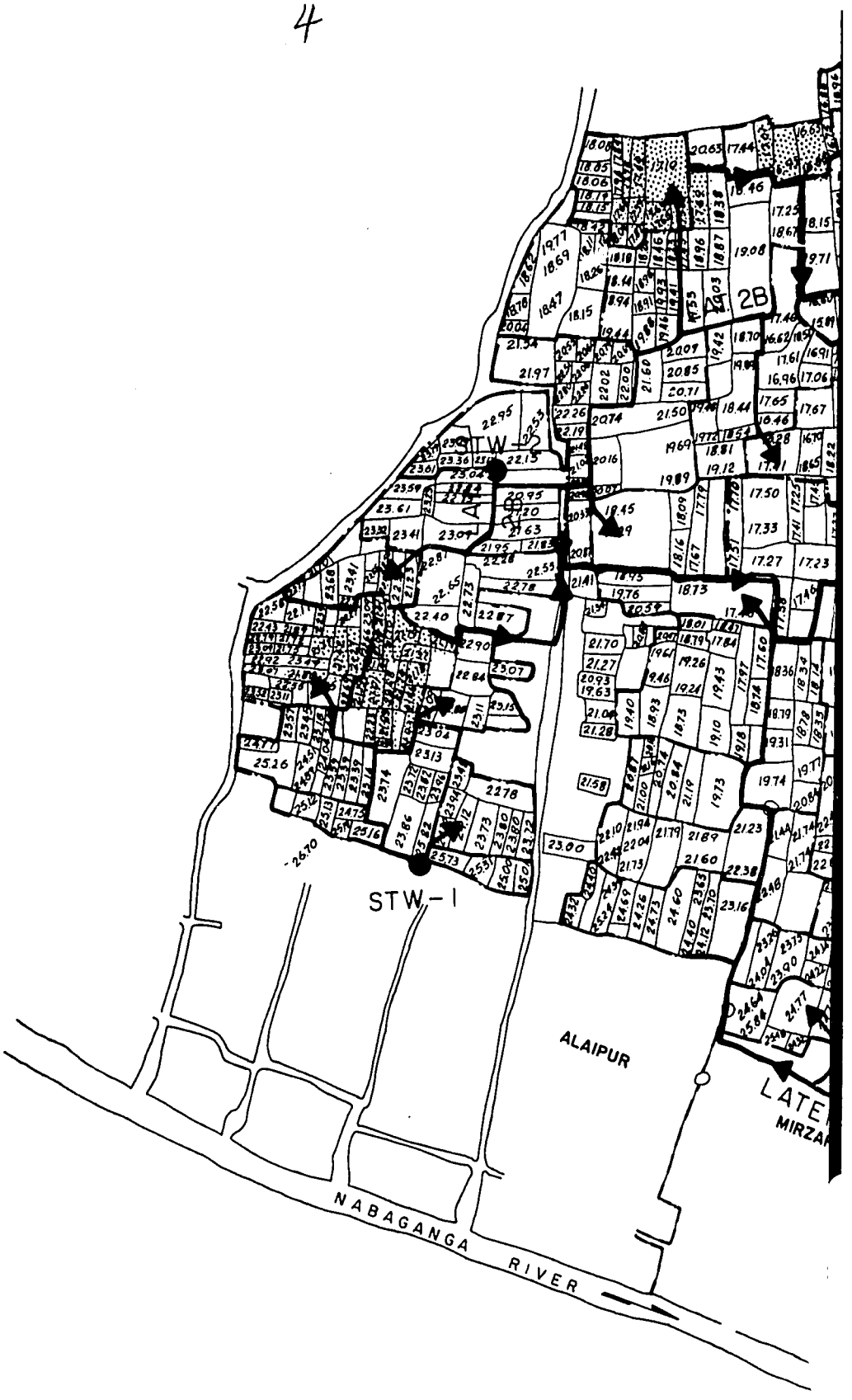

ALAIPUR
ARALIA
PROJECT DRAIN
PILOT AREA
SETTLEMENTS
MIRZAPUR
EXISTING CANAL
NABAGANGA RIVER
TO MAGURA
A
SCALE 4" = 1 MILE



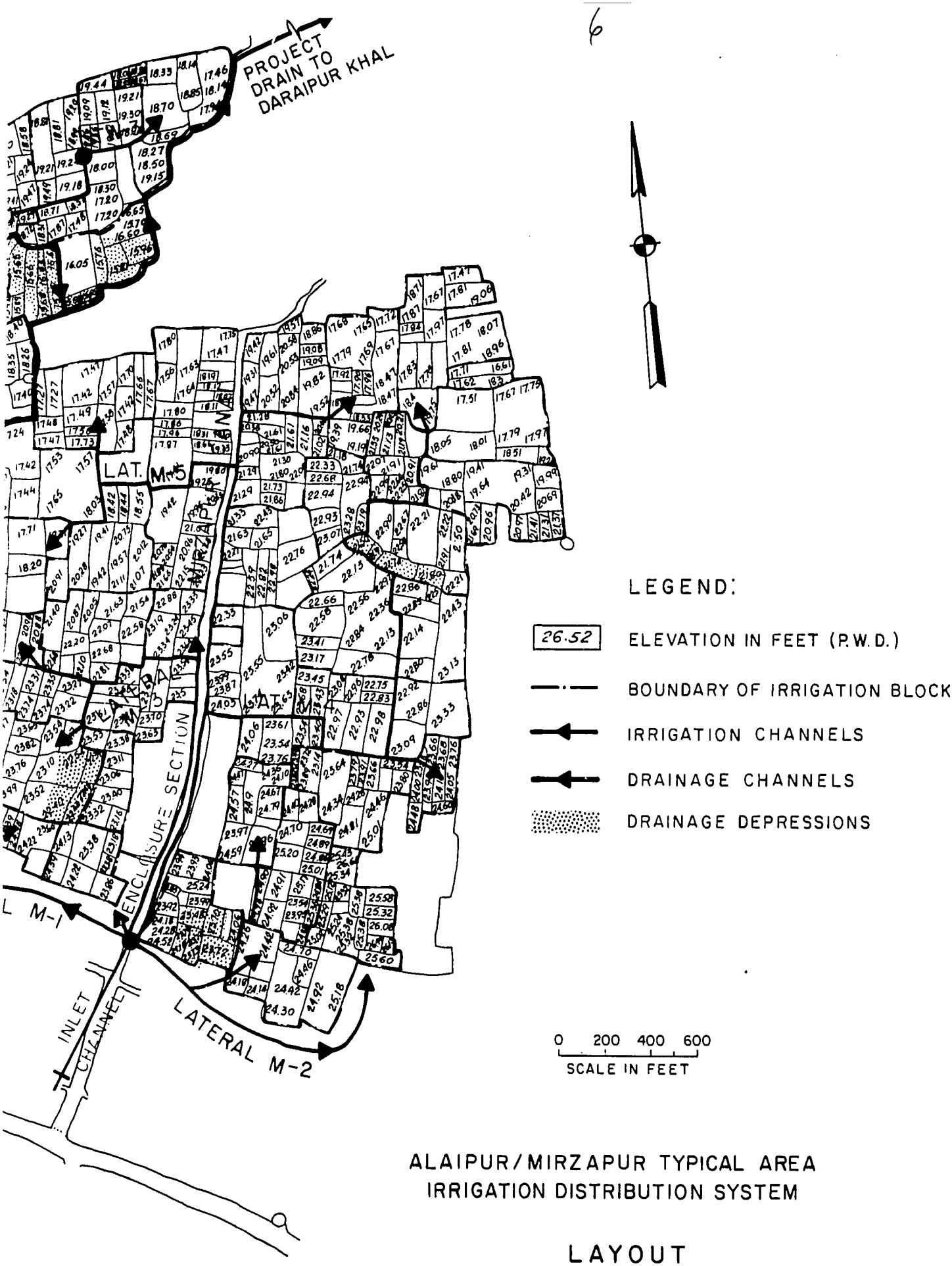
SCALE 4" = 1 MILE

ALAIPUR/MIRZAPUR TYPICAL AREA
VICINITY MAP

FIGURE I-15


STW-2
STW-1
2B
ALAIPUR
NABAGANGA RIVER

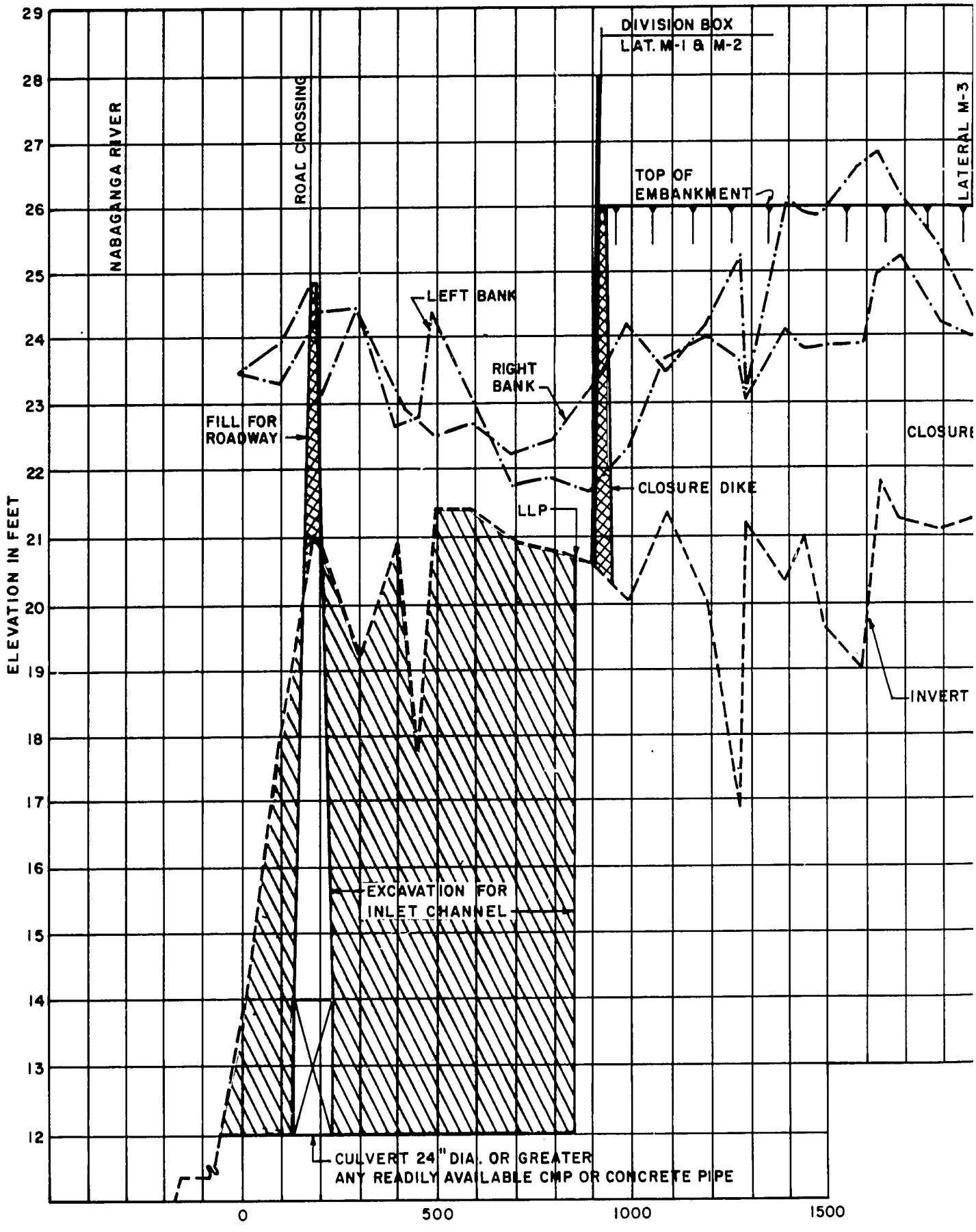
PROJECT DRAIN TO DARAIPUR KHAL
STW-2
STW-1
ALAIPUR
LATERAL M-1
MIRZAPUR
ENCLOSURE SECTION
INLET CHANNEL
LATERAL M-2
NABAGANGA RIVER
LAT. M-5
LAT. M-4
ALAIPUR IRRIGAT

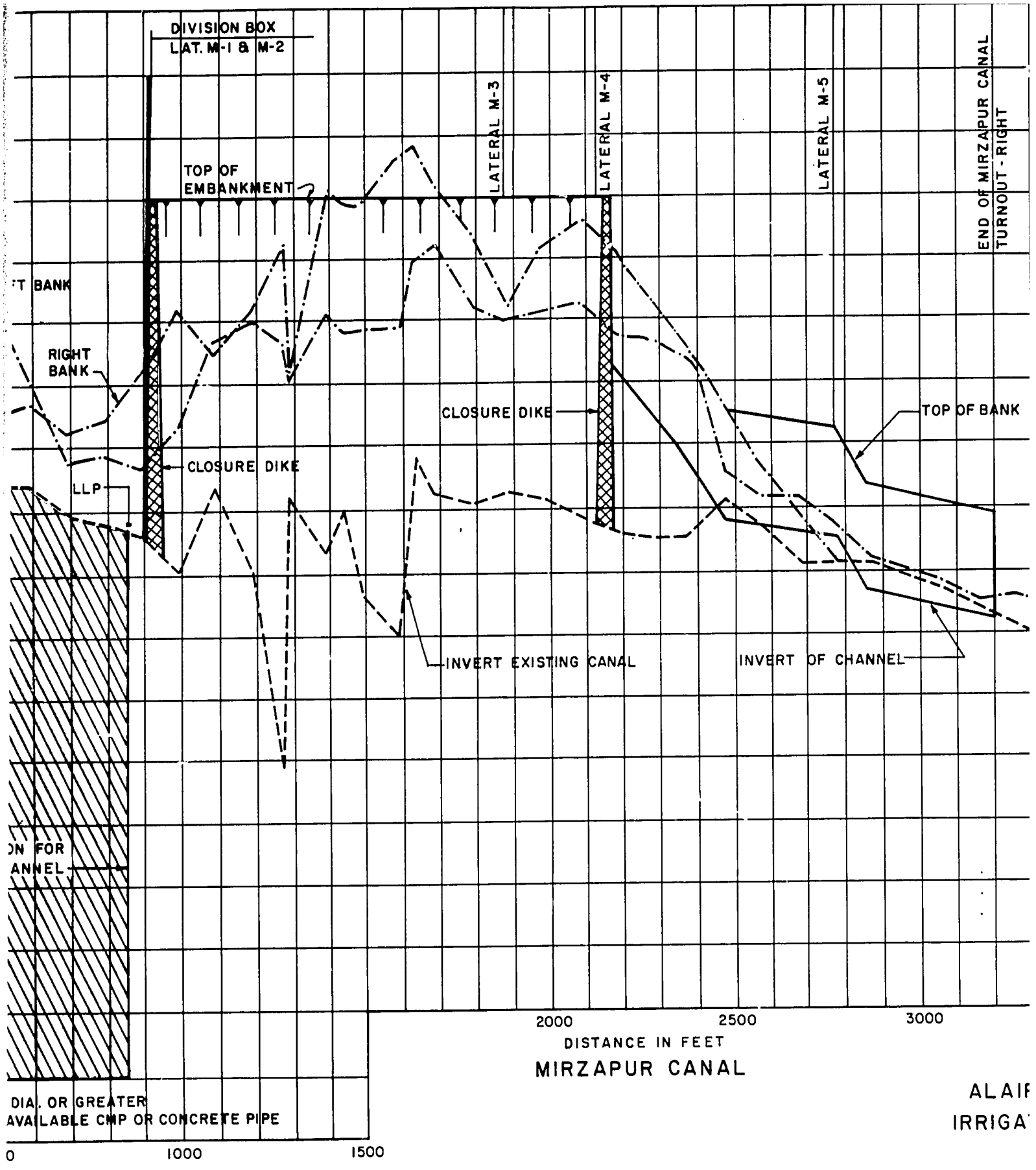


ALAIPUR/MIRZAPUR TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

LAYOUT

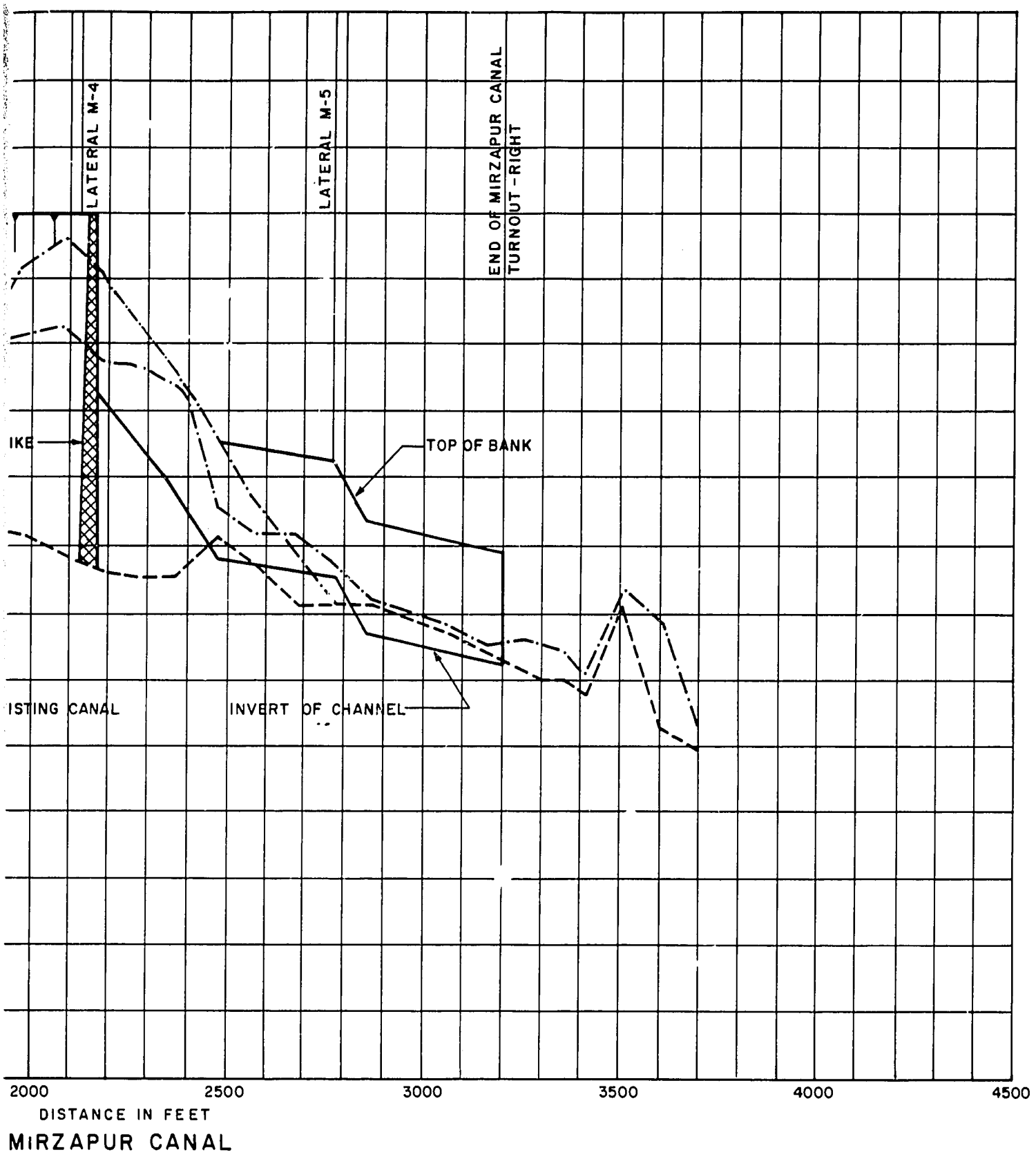
FIGURE I-16


DIVISION BOX
LAT. M-1 & M-2
NABAGANGA RIVER
ROAD CROSSING
LATERAL M-3
TOP OF EMBANKMENT
LEFT BANK
RIGHT BANK
FILL FOR ROADWAY
CLOSURE
CLOSURE DIKE
LLP
INVERT
EXCAVATION FOR INLET CHANNEL
CULVERT 24" DIA. OR GREATER
ANY READILY AVAILABLE CMP OR CONCRETE PIPE
ELEVATION IN FEET
29
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
0
500
1000
1500



ALAIF
IRRIGA

SHEET I

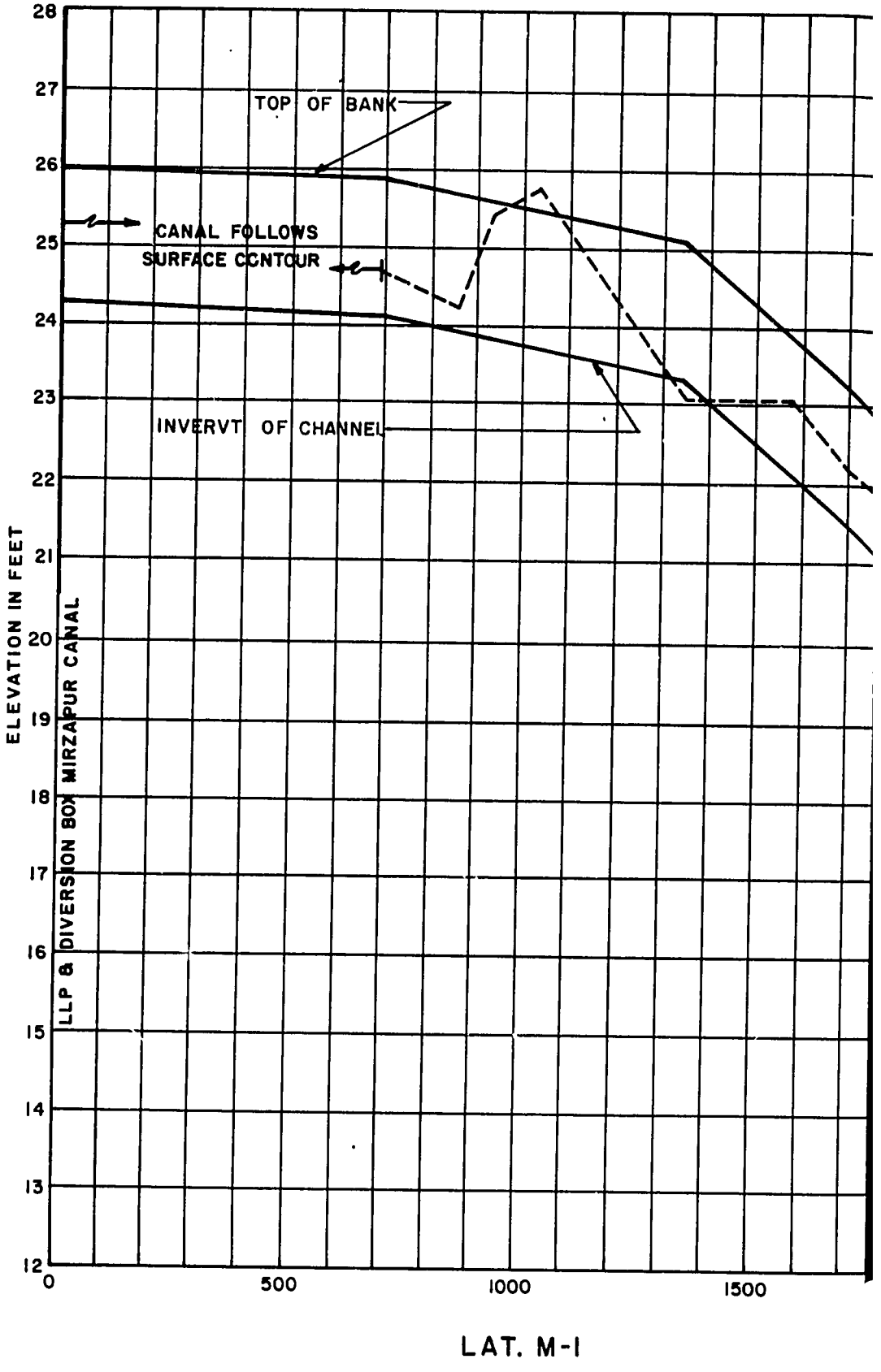


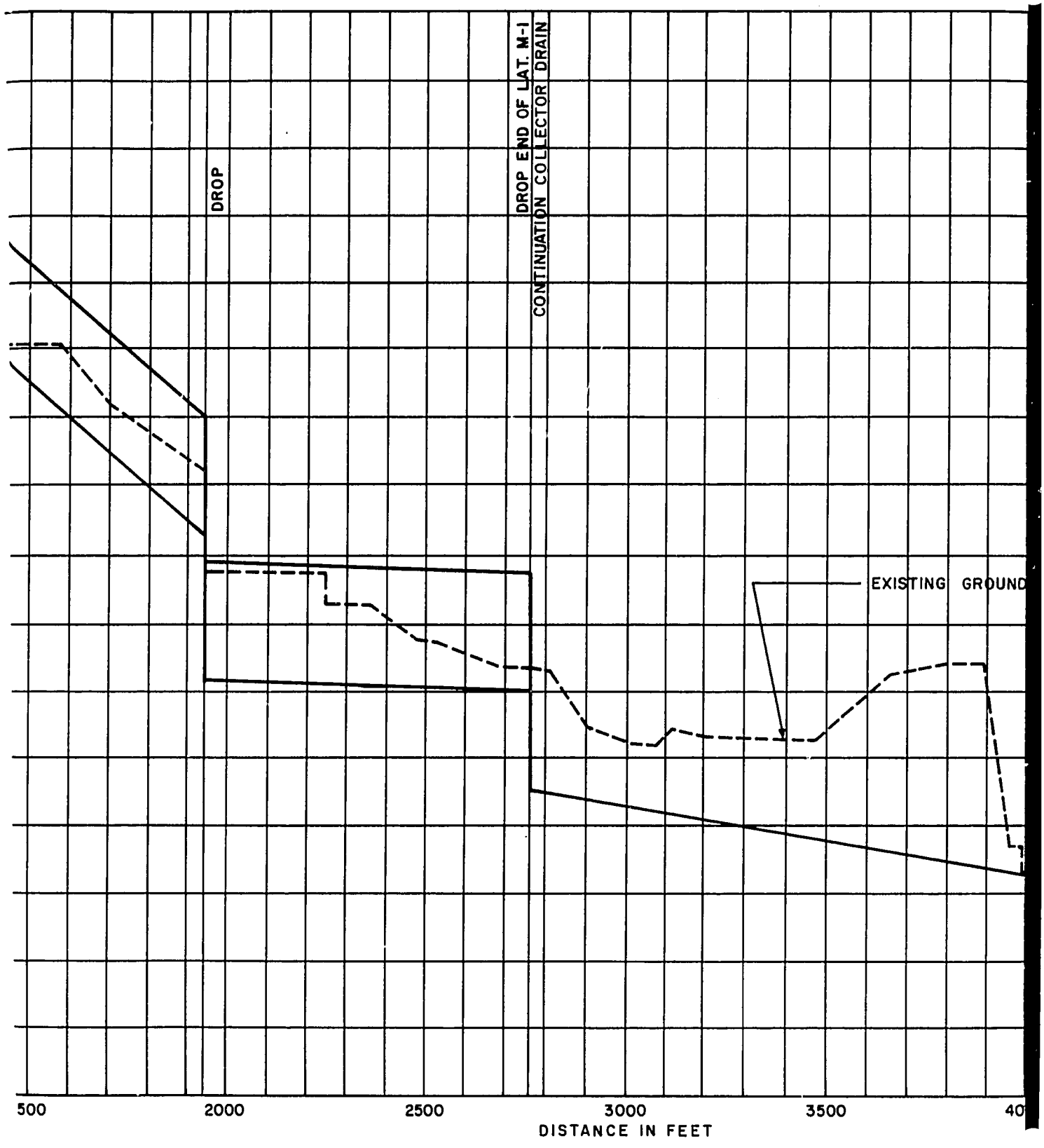
ALAIPUR/MIRZAPUR TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

PROFILES

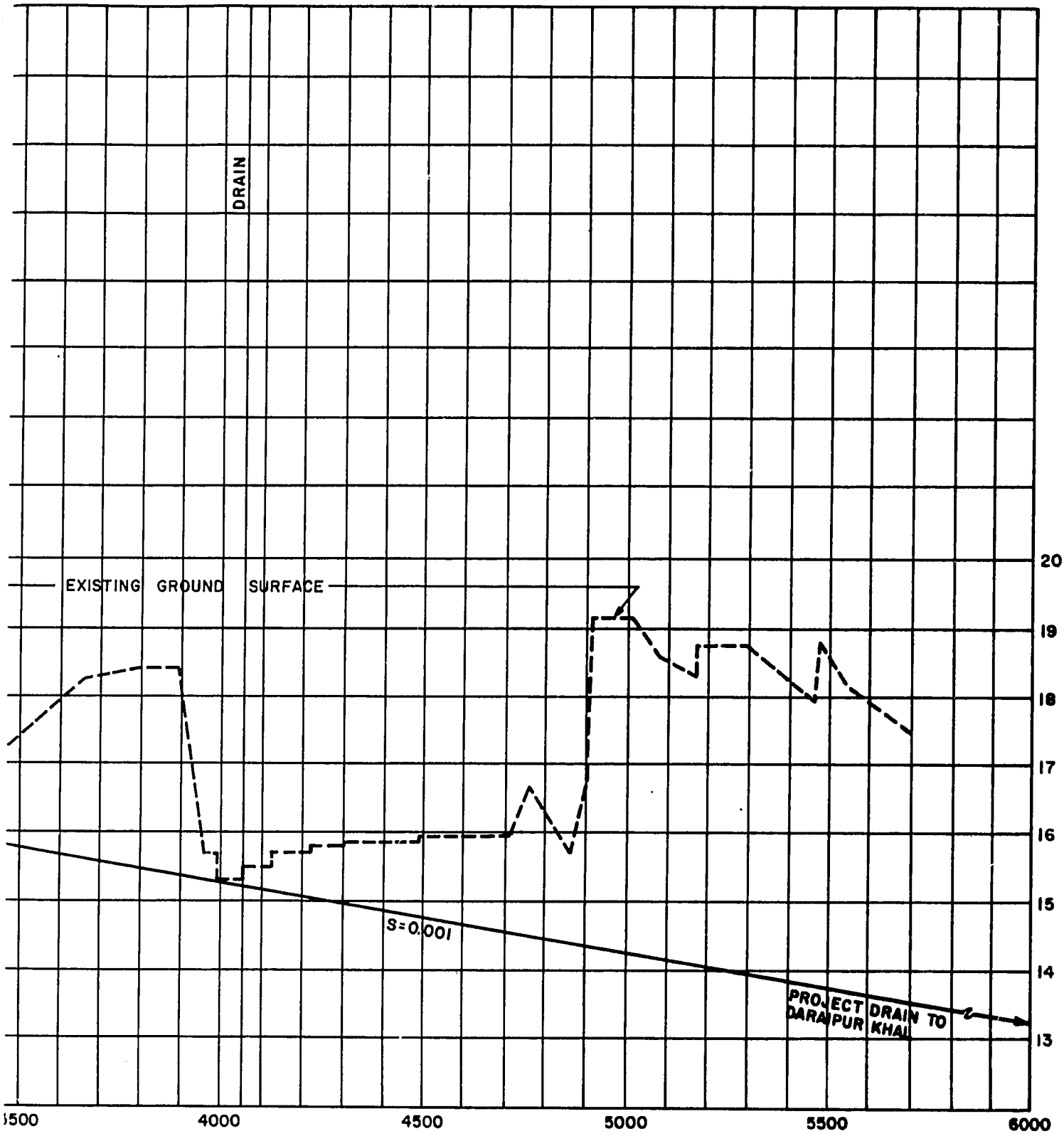
SHEET 1 OF 3

FIGURE 1-17


TOP OF BANK
CANAL FOLLOWS
SURFACE CONTOUR
INVERVT OF CHANNEL
ELEVATION IN FEET
LLP & DIVERSION BOX MIRZAPUR CANAL
28
27
26
25
24
23
22
21
20
19
18
17
16
15
14
13
12
0
500
1000
1500
LAT. M-I



COLLECTOR DRAIN

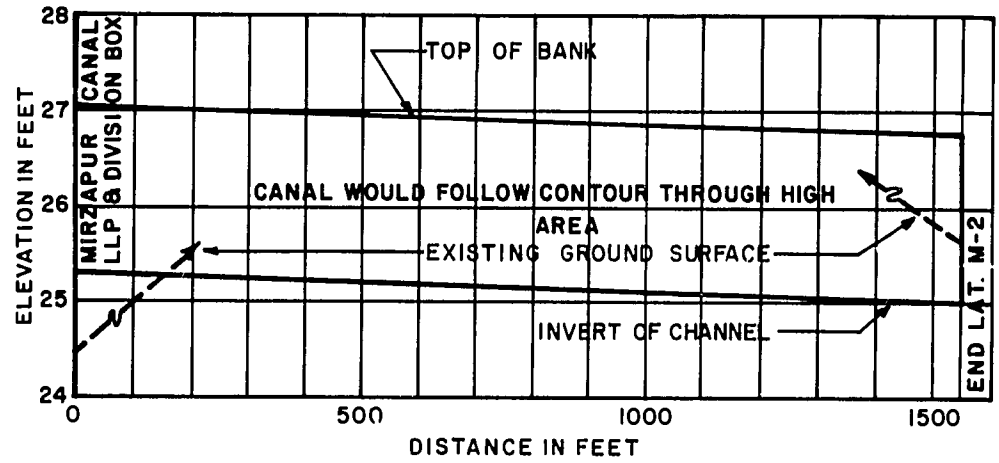


ALAIPUR/MIRZAPUR TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

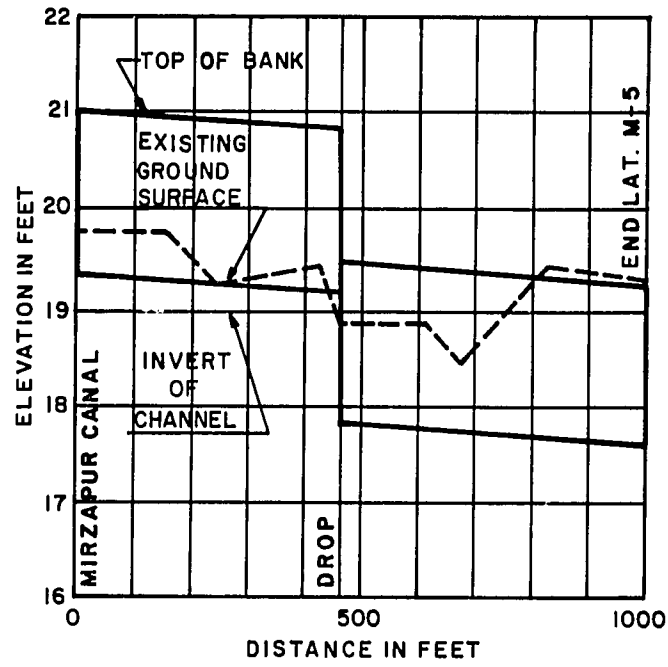
PROFILES

SHEET 2 OF 3

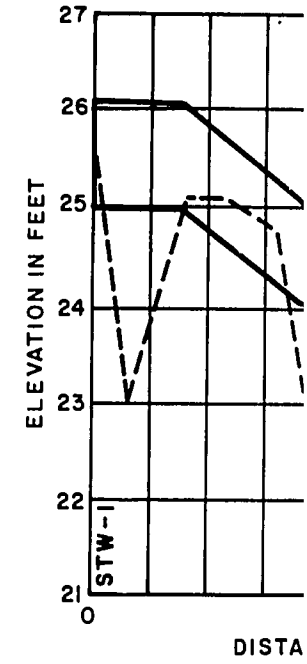
FIGURE I-17

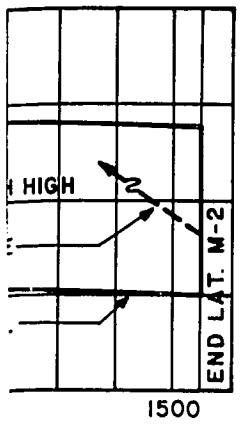

28
27
26
25
24
ELEVATION IN FEET
MIRZAPUR CANAL LLP & DIVISION BOX
TOP OF BANK
CANAL WOULD FOLLOW CONTOUR THROUGH HIGH AREA
EXISTING GROUND SURFACE
INVERT OF CHANNEL
END LAT. M-2
0
500
1000
1500
DISTANCE IN FEET

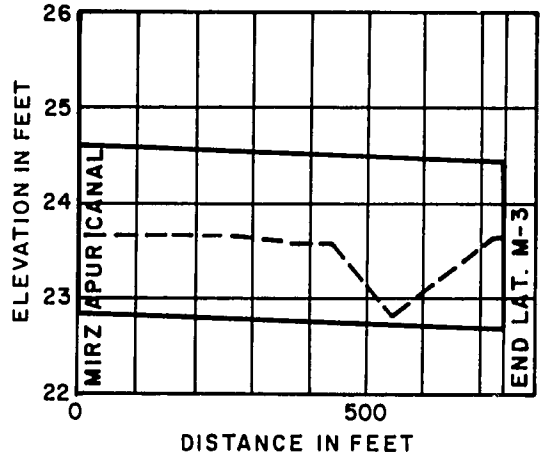
LAT. M-2


22
21
20
19
18
17
16
ELEVATION IN FEET
TOP OF BANK
EXISTING GROUND SURFACE
INVERT OF CHANNEL
MIRZAPUR CANAL
DROP
END LAT. M-5
0
500
1000
DISTANCE IN FEET

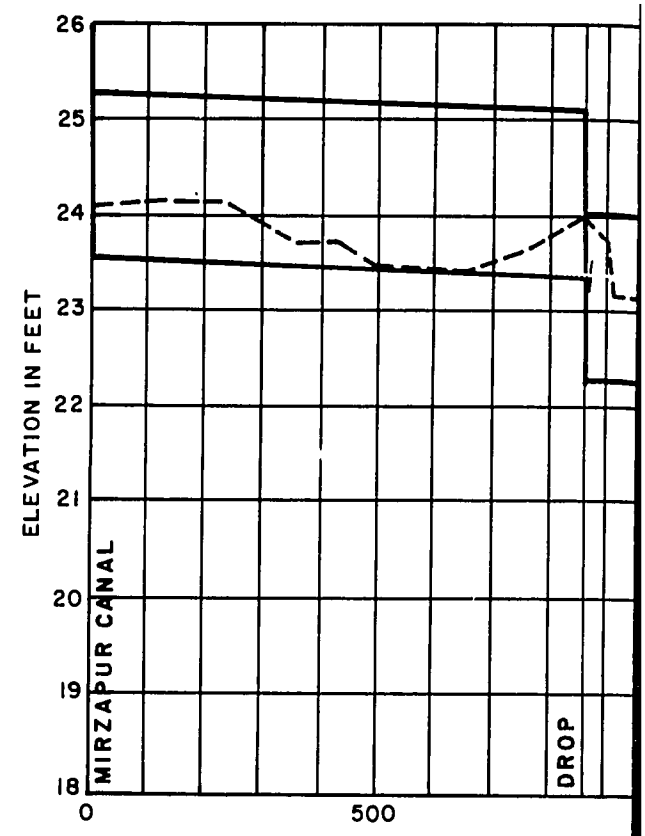
LAT. M-5

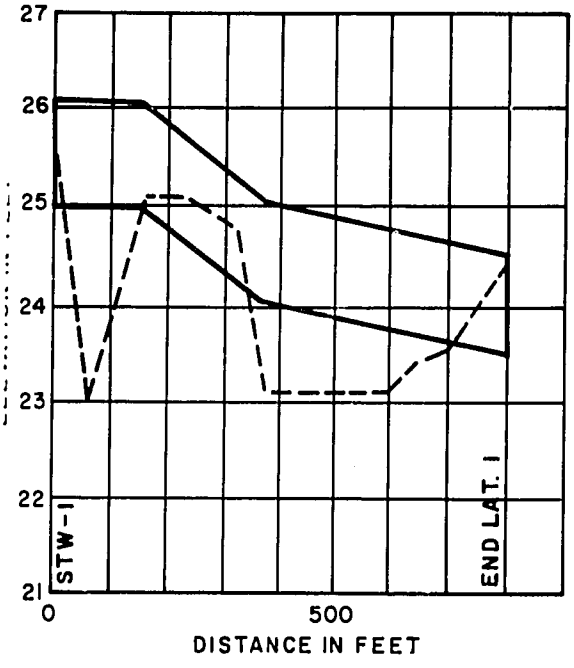

27
26
25
24
23
22
21
ELEVATION IN FEET
STW-1
0
DISTA



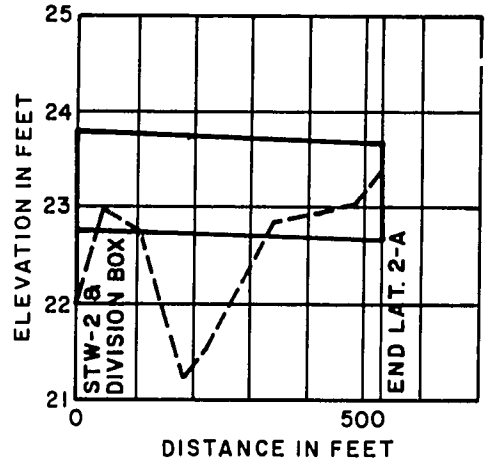


LAT. M-3

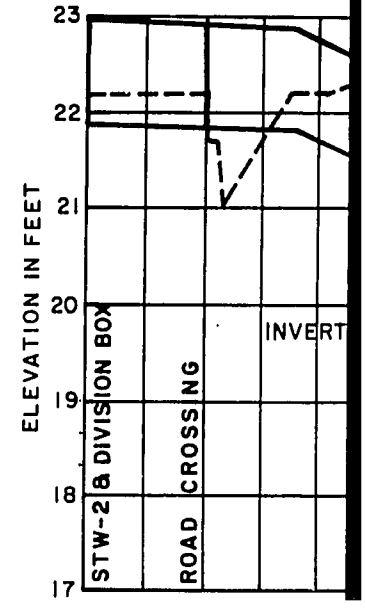


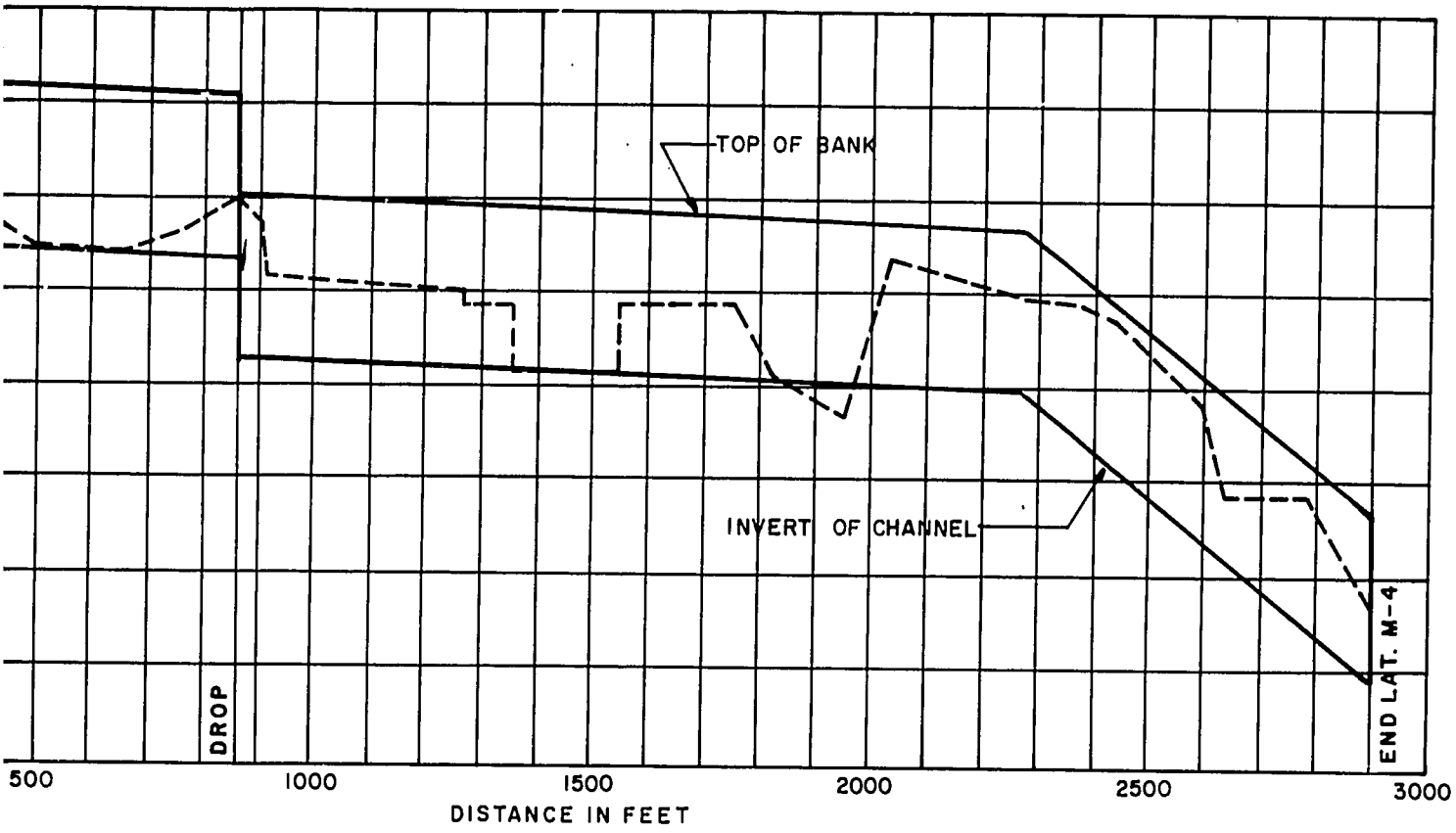


LAT. 1

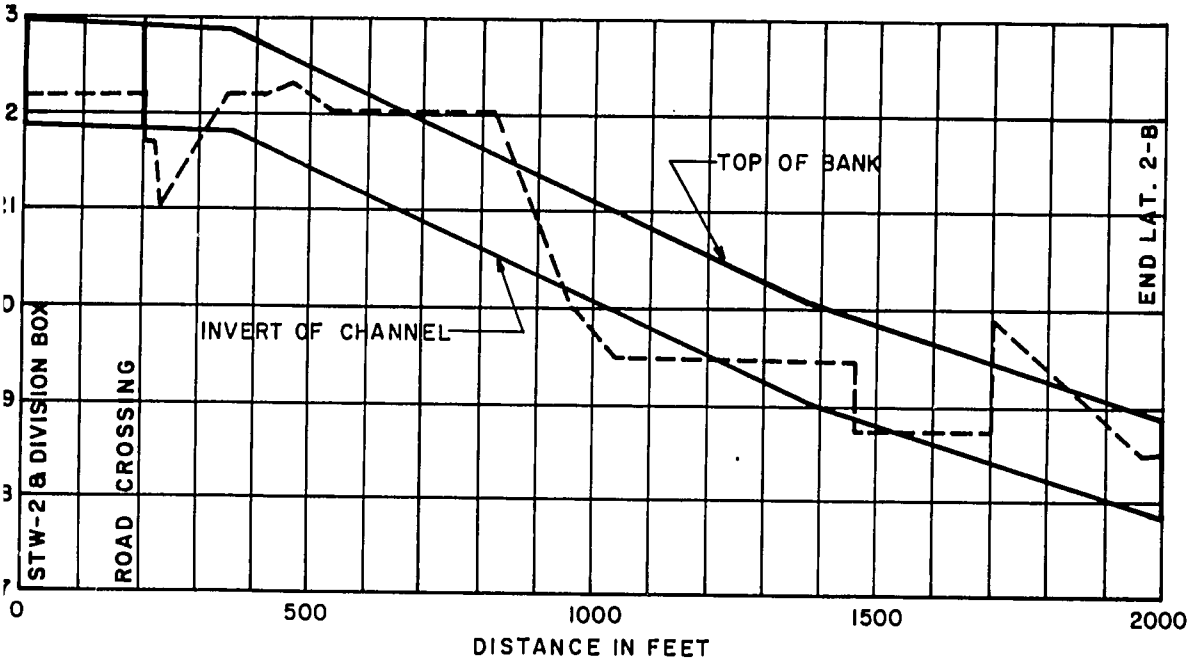


LAT. 2A





LAT. M-4



LAT. 2B

ALAIPUR/MIRZAPUR TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

PROFILES

SHEET 3 OF 3

FIGURE I-17

area would be suitable for a boro crop which could be irrigated from the collector drain, either by country methods or by gravity diversion.

1.4.5.3 Sachani Rautara Typical Area

This 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 the intervening settlement area which restricts the extent of the area that could be irrigated from a single source. These characteristics are shown on the Vicinity Map of Figure I-18.

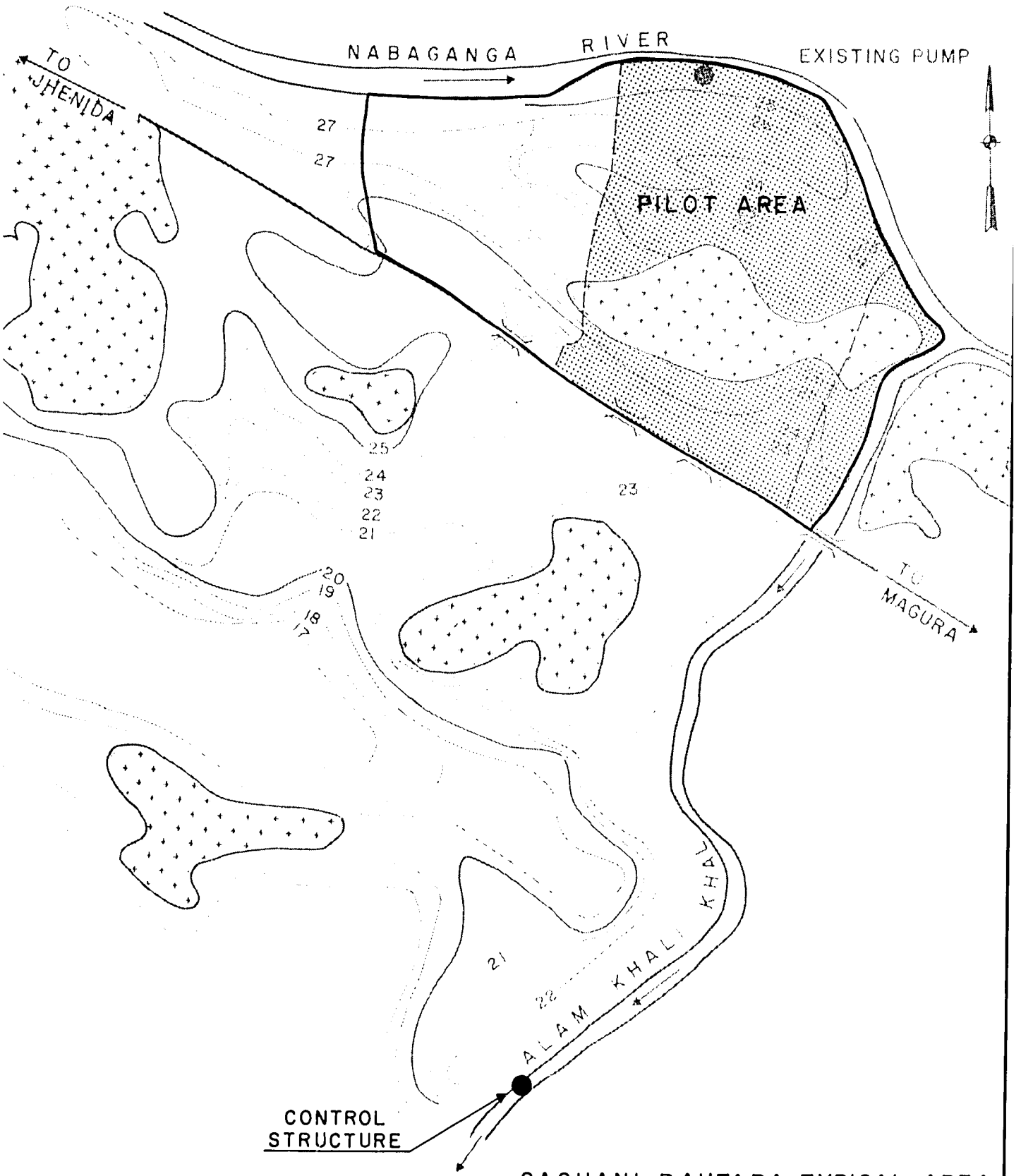
The area between the settlement and the river is presently being partially irrigated by a BADC pump. It is proposed to expand the service of this pump to the entire area of 69 acres. A drainage outlet is also proposed for the depression from the filled in water course.

There is a second area of 68 acres between the settlement and the main road which could be irrigated by a low lift pump from the Alamkhali Khal. Similar to the first area, there are also depressions here that require some drainage improvements.

The layout of the above system is shown on the Map of Figure I-19 and the profiles of the distribution channels are shown on Figure I-20, Sheets 1-2.

1.4.5.4 Pabahati Typical Area

This area is located in a curve of the Nabaganga River east of the junction with the Dopaghata Khal. Similar to the Mirzapur area, there is a wide settlement area which separates the irrigable lands from the river as shown on Figure I-21. A 2250 foot long channel through the settlement

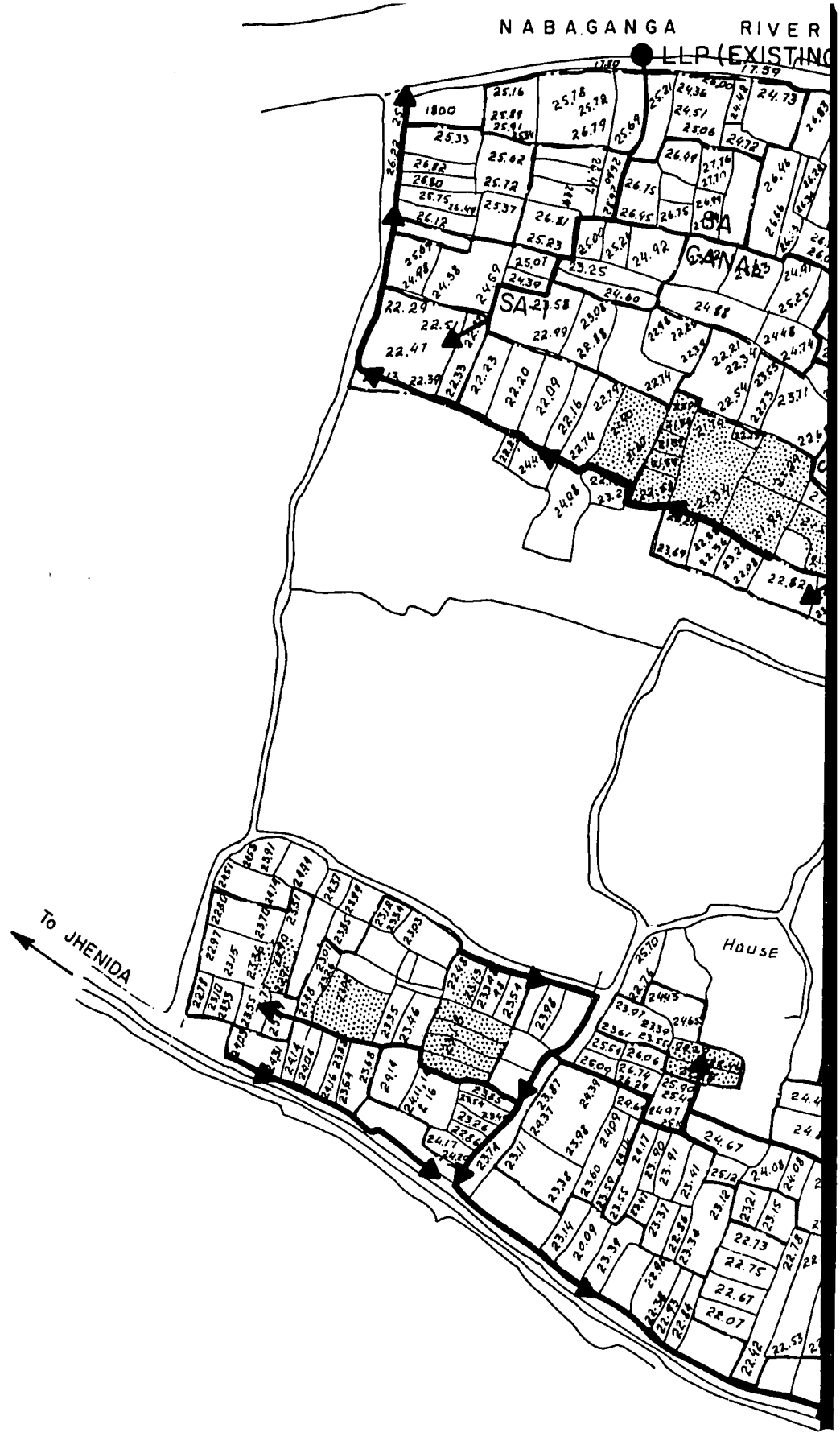


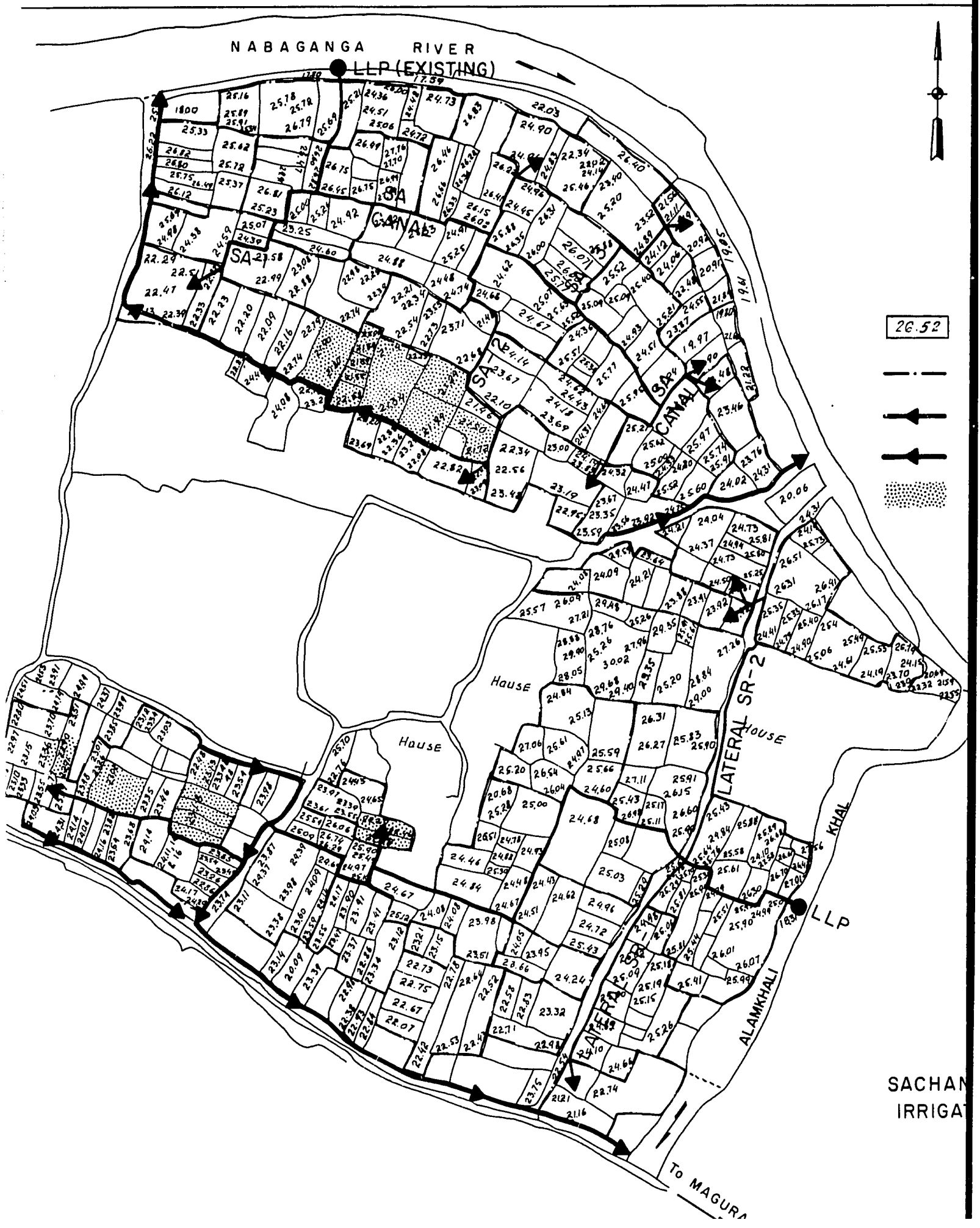
SACHANI RAUTARA TYPICAL AREA

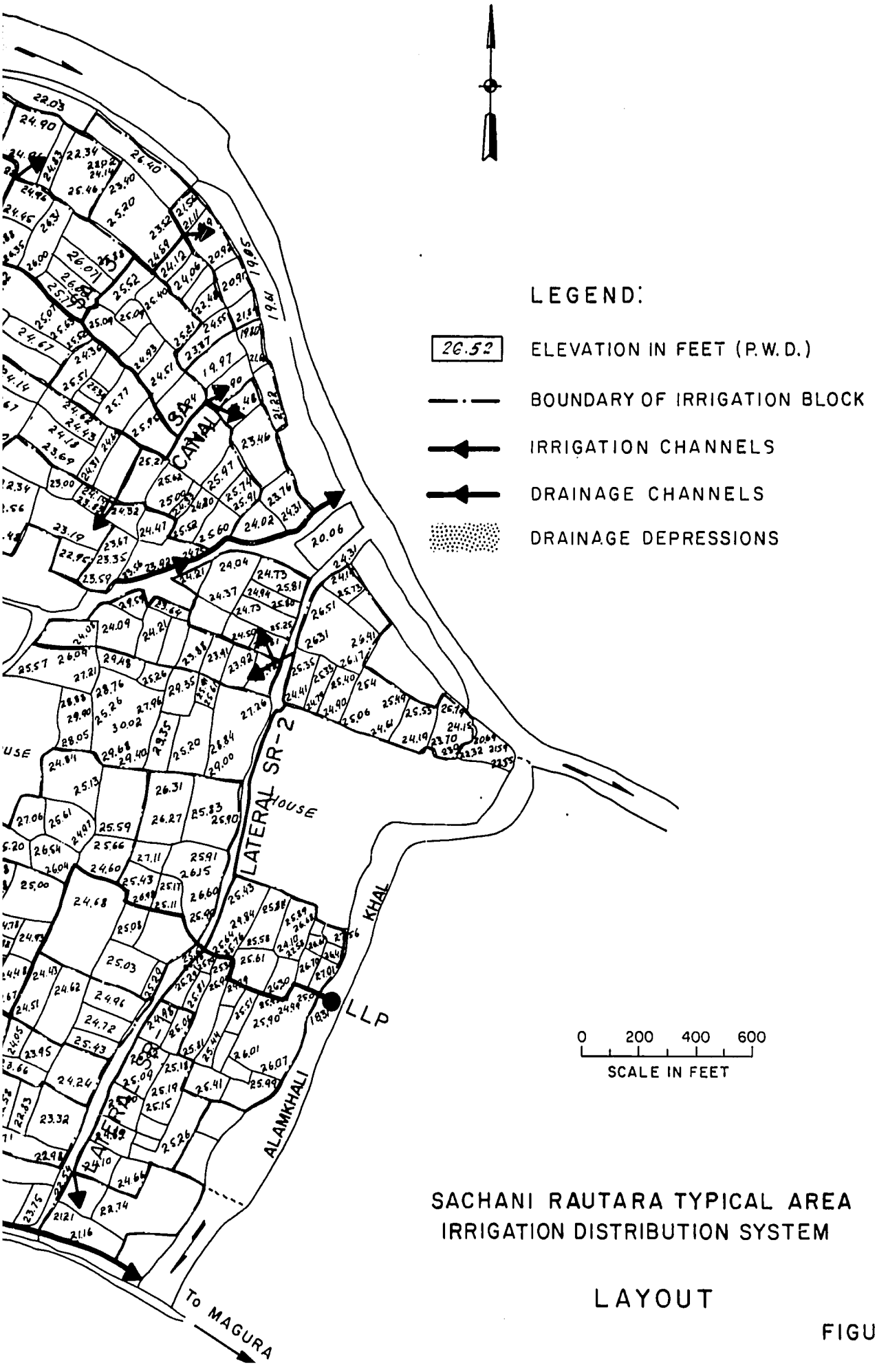
VICINITY MAP

SCALE 4" = 1 MILE

FIGURE T-18


NABAGANGA RIVER
LLP (EXISTING
SA
GANA
SA
House
To JHENIDA

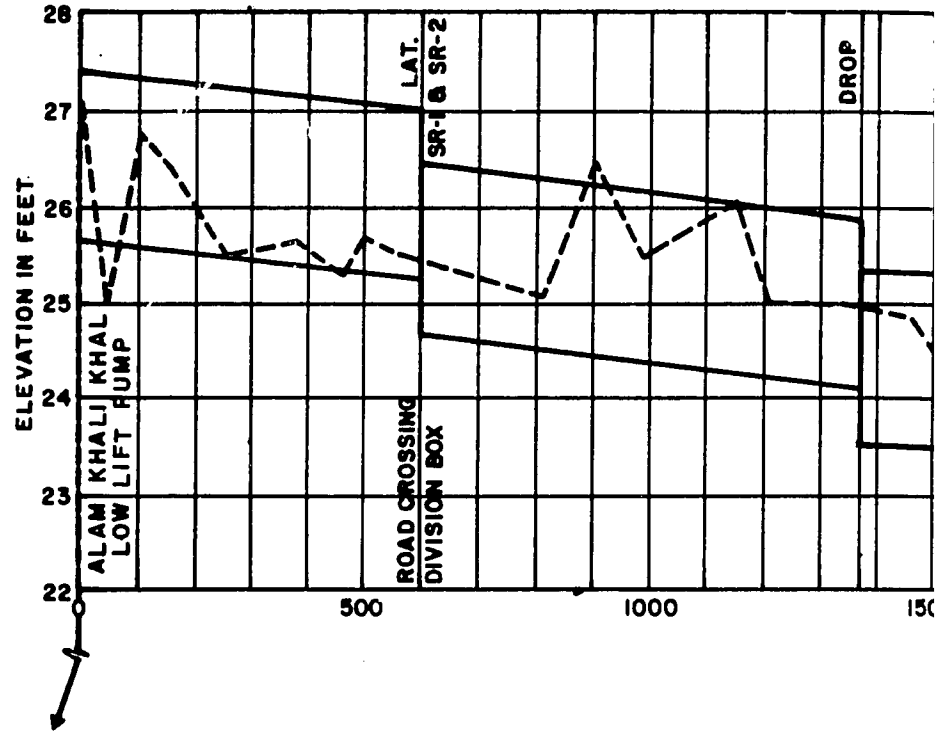

NABAGANGA RIVER
LLP (EXISTING)
SA-2
SA-3
SA-4
CANAL
LATERAL SR-2
LATERAL SR-3
HOUSE
HOUSE
HOUSE
KHAL
ALAMKHALI
LLP
26.52
To MAGURA
SACHAN
IRRIGAT

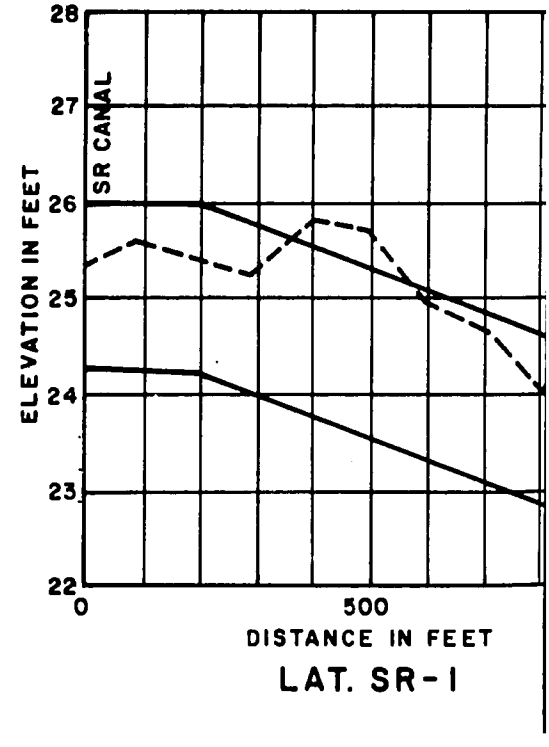


SACHANI RAUTARA TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

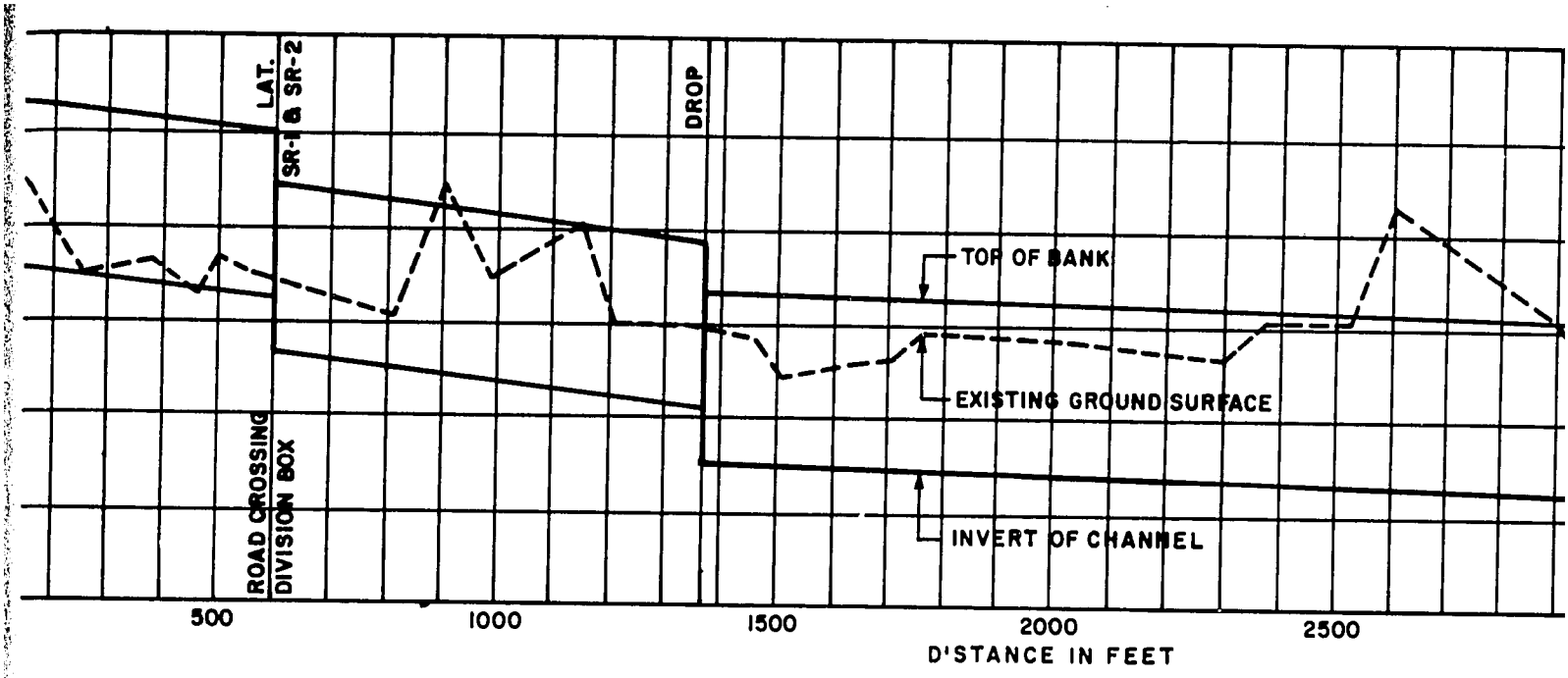
LAYOUT

FIGURE I-19

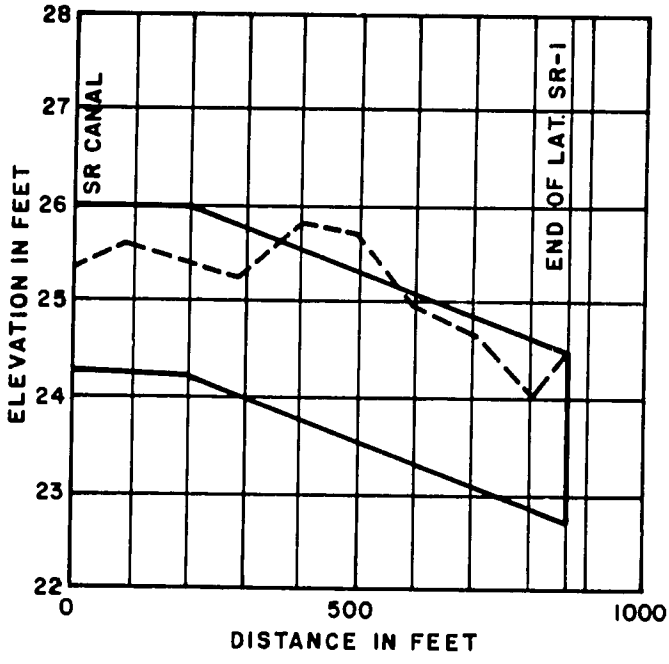

ELEVATION IN FEET
28
27
26
25
24
23
22
0
500
1000
150
ALAM LOW
KHALI LIFT
KHAL PUMP
ROAD CROSSING
DIVISION BOX
SR-1 & SR-2
LAT.
DROP


ELEVATION IN FEET
28
27
26
25
24
23
22
0
500
DISTANCE IN FEET
SR CANAL

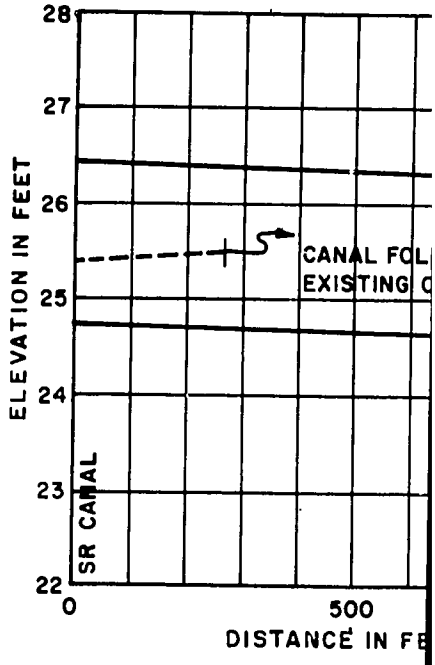
LAT. SR-1



SR CANAL



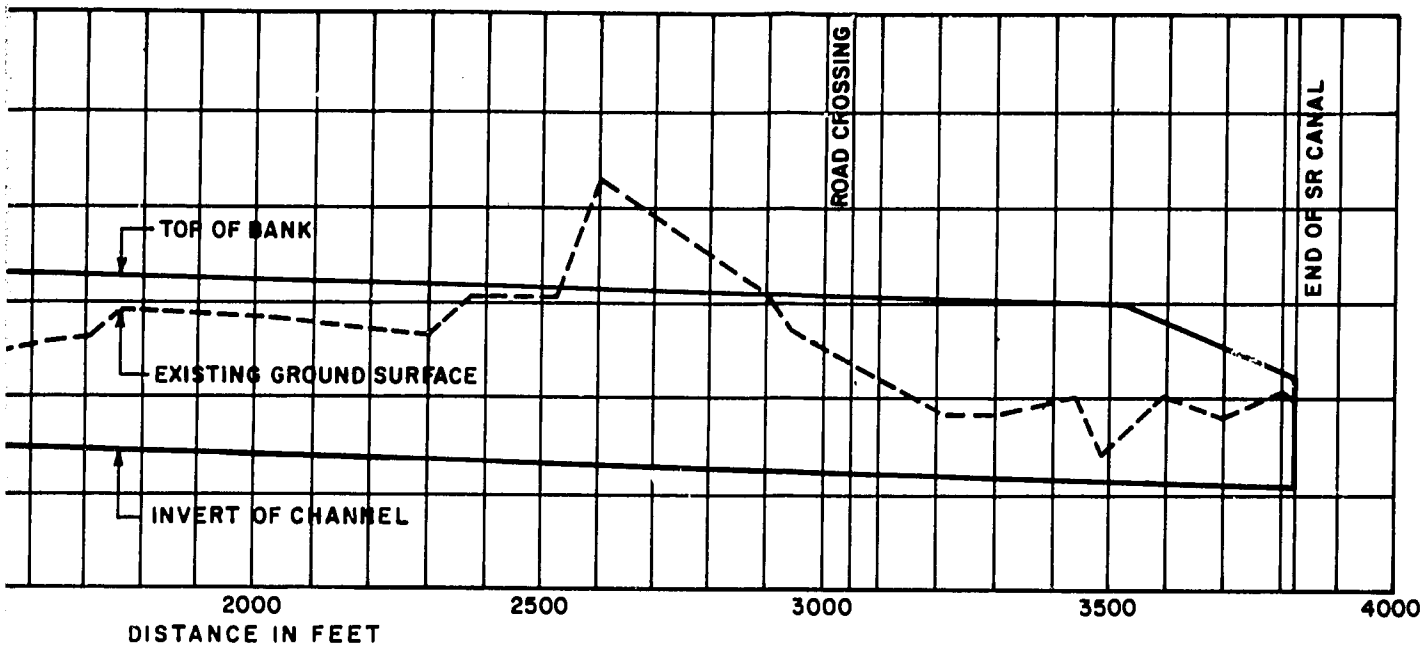
LAT. SR-1



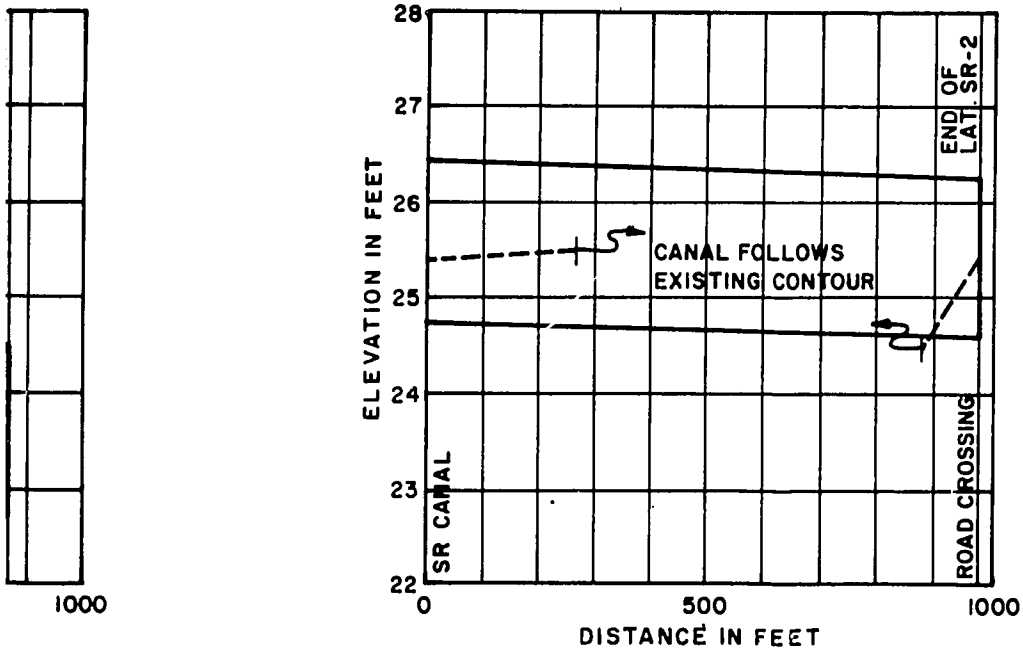
LAT. SR-2

SACHANI
IRRIGATION

SHEET 1 OF 2



SR CANAL



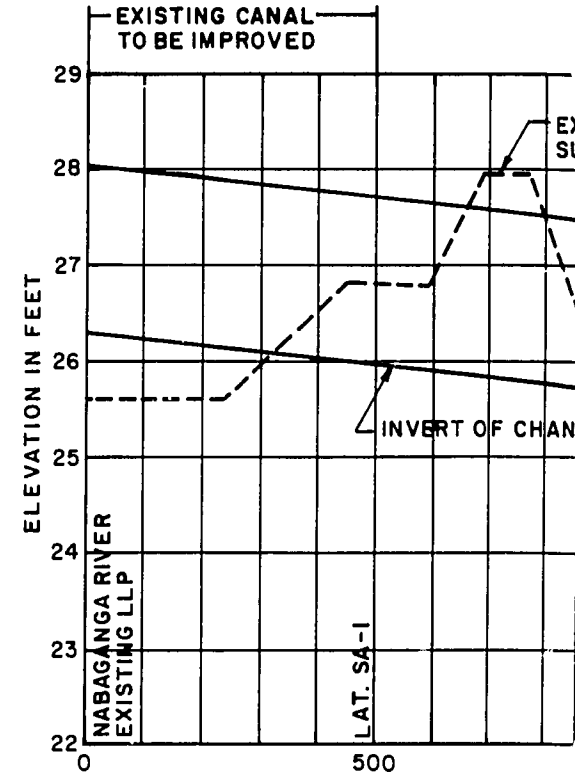
LAT. SR-2

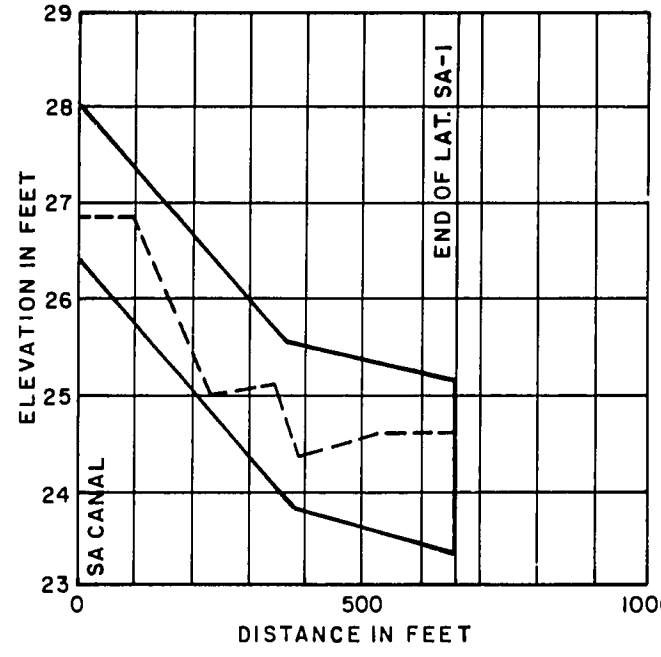
SACHANI RAUTARA TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

PROFILES

SHEET 1 OF 2

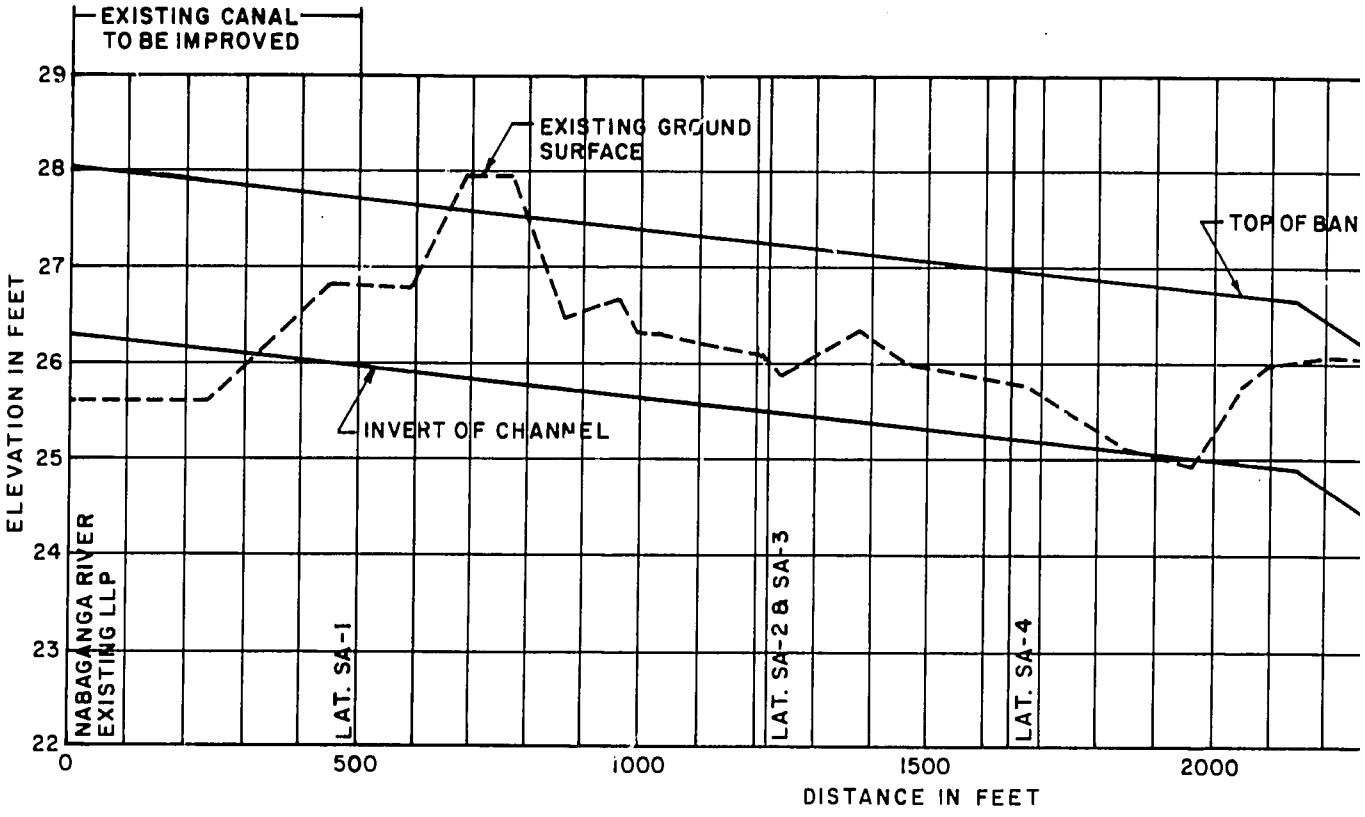
FIGURE I-20



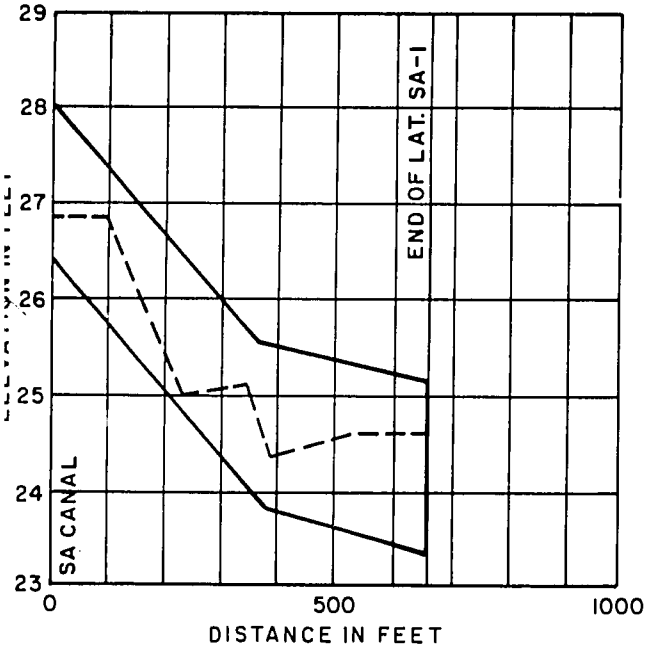


LAT. SA-I

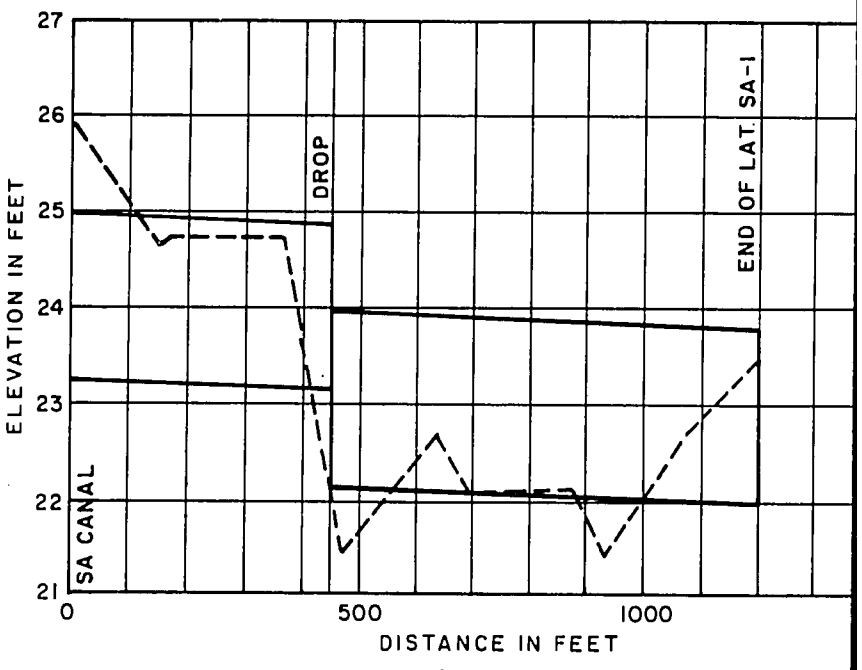
ELEVATION IN FEET



SA CANAL



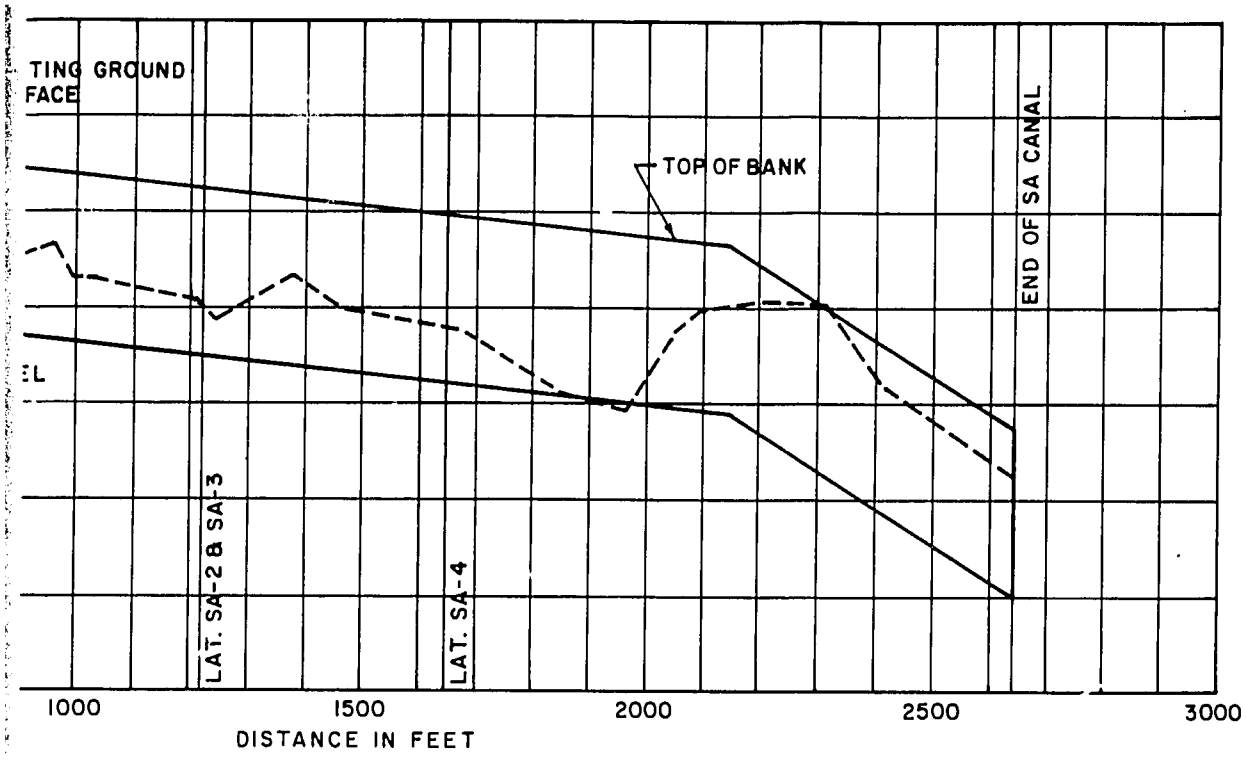
LAT. SA-1



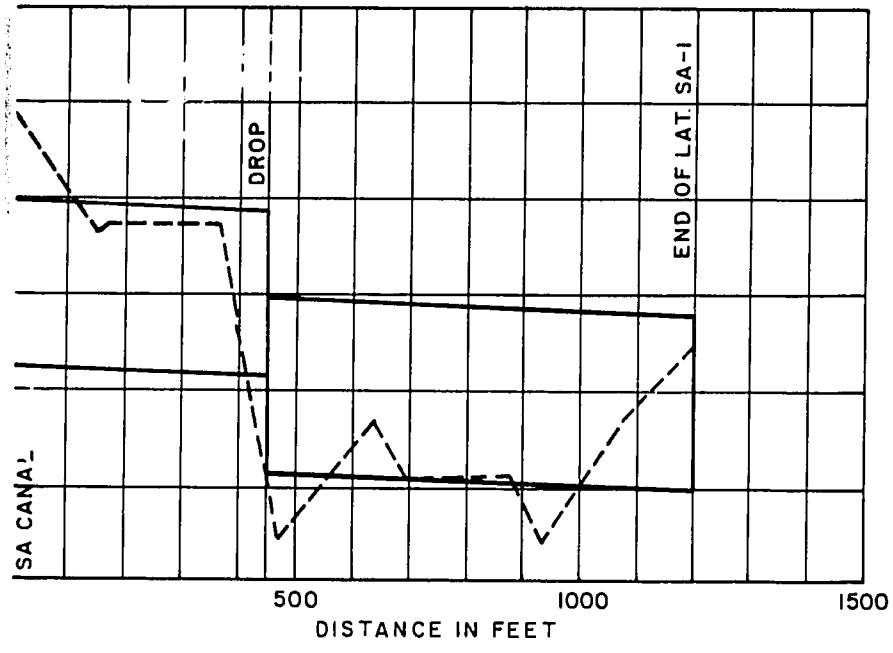
LAT. SA-2

SACHA
IRRIGATI

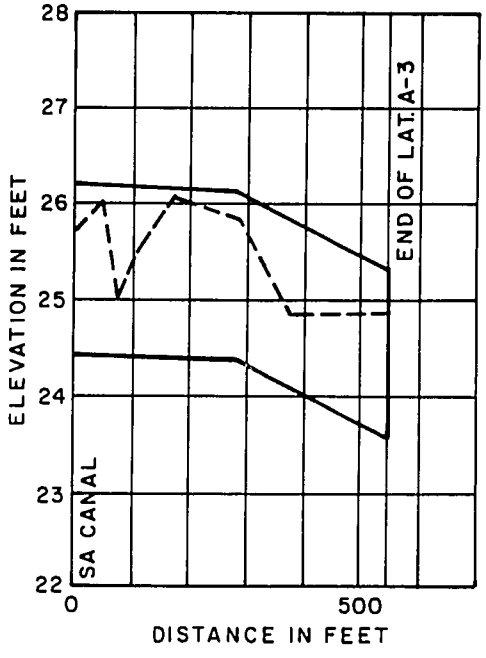
SHEET 2 O



SA CANAL



LAT. SA-2



LAT. SA-3

SACHANI RAUTARA TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

PROFILES

SHEET 2 OF 2

FIGURE I-20

area would be required to irrigate, by a low lift pump, the higher irrigable lands. This long channel is not considered feasible and the three isolated high lands of 27 acres, 27 acres, and 22 acres each would be irrigated by shallow tubewells.

The remaining area of 96 acres could be irrigated by a low lift pump on the Dopaghata Khal. There is an existing pump site on this Khal that has electrical service which could be re-activated for this system.

The layouts of the above system are shown on the map of Figure I-22, and the profiles of distribution systems are shown on Figure I-23.

This area has a uniform, gently sloping topography, and there are no significant drainage problems. However, with irrigation, some positive drainage outlets are required. The drainage from the higher lands could discharge into the main canal which then would serve a dual purpose. This and all other drainage would collect in the natural drainage along the road embankment.

1.5 Fisheries Development

1.5.1 Background

The fisheries sector constitutes the second (to agriculture) most important economic activity in the rural areas of Bangladesh. Fish and fish products are the most easily accessible animal protein supply available in the country and provide about 80 percent of this element in the Bangladeshi diet.

Between 80 and 90 percent of fishery products are derived from inland waters. However, it is believed that inland fisheries production has been declining in recent years. Although available fisheries statistics are generally unreliable, various estimates indicate that national production

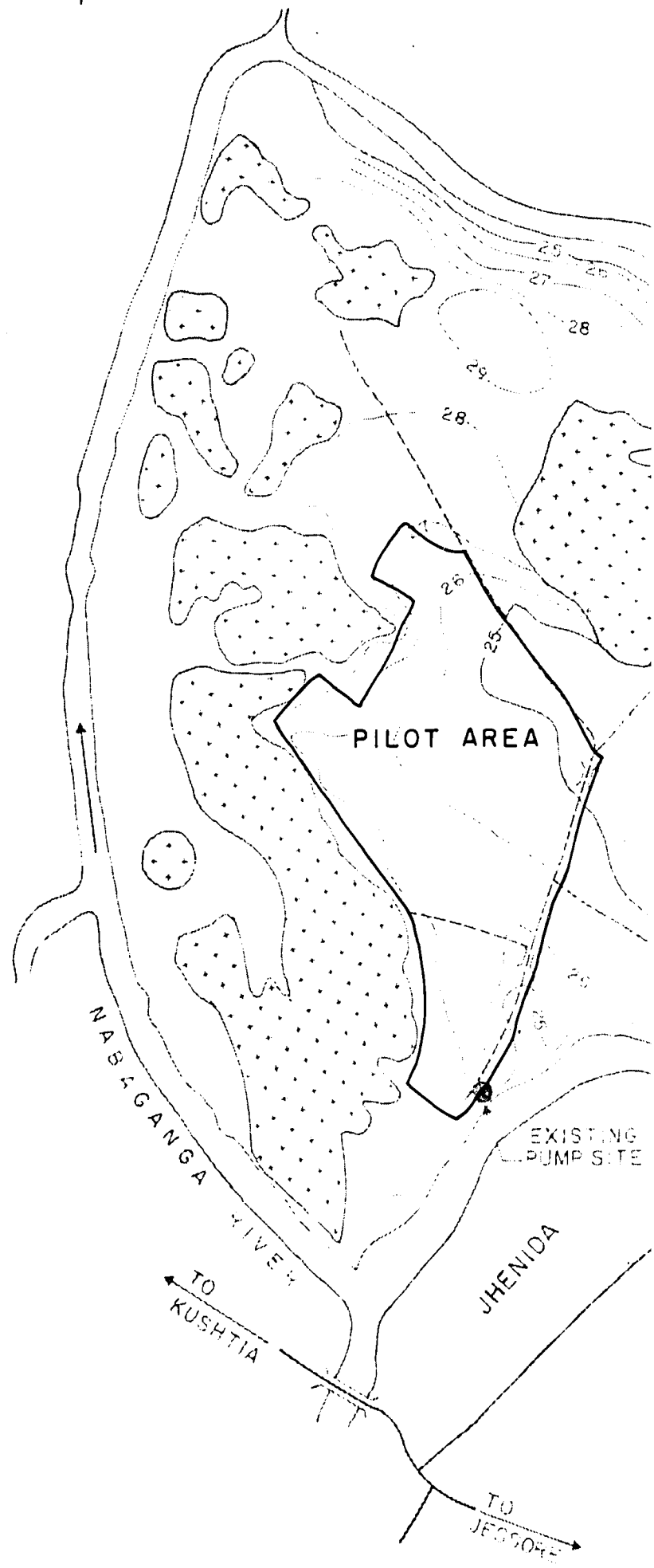
level have fallen from over 700,000 tons in the 1960's and early 1970's to a little more than 500,000 tons in the last few years. Similarly, it has been estimated that the annual per capita consumption of fish dropped from 26.4 pounds in 1962-1964 to 17.9 pounds in 1975-1976.

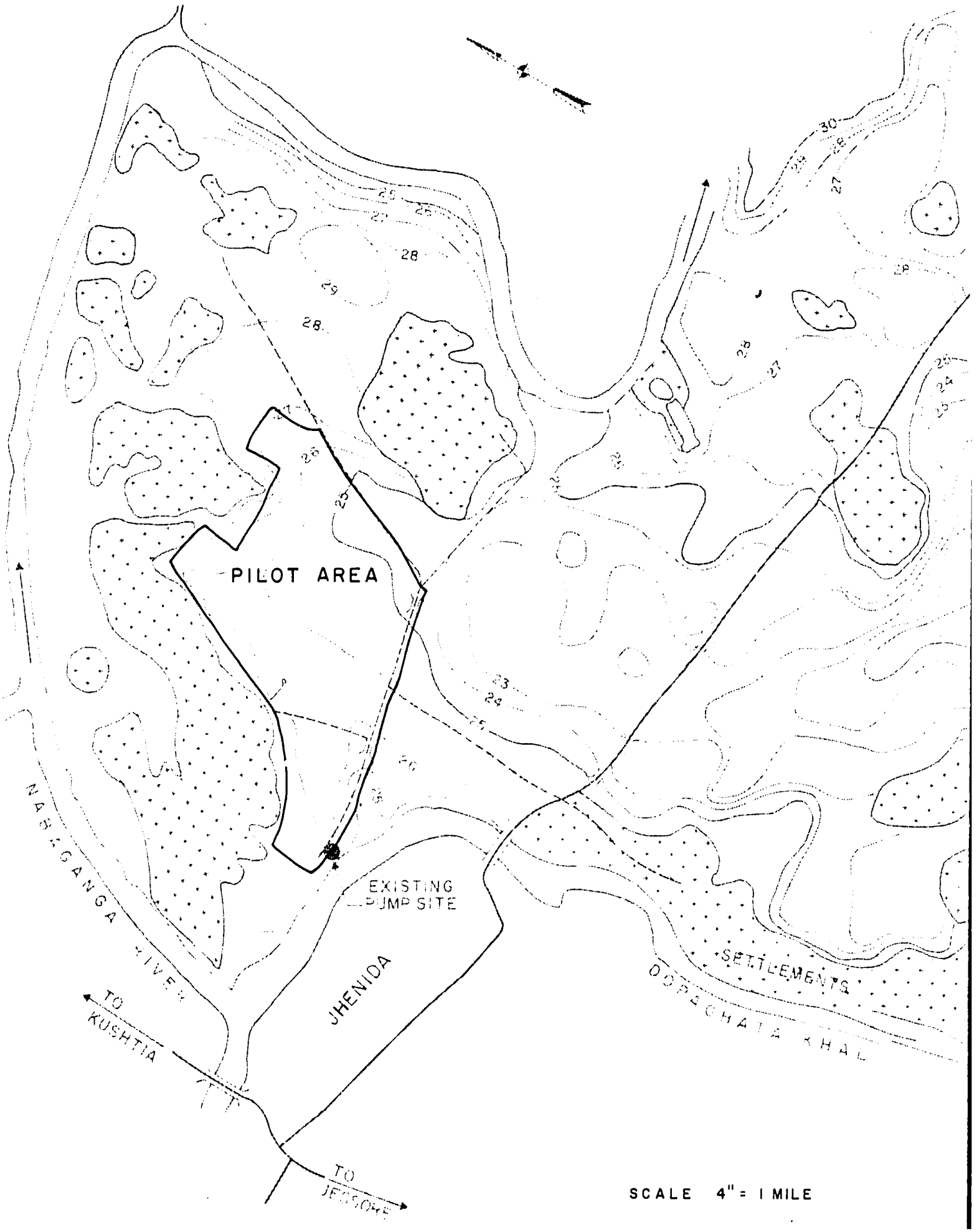
The decrease of inland fish production has been attibuted to land reclamation for agricultural use, siltation of aquatic habitats, erection of flood control embankments (which limit access to fish spawning and nursery grounds), limited interest in intensive fish culture, a lack of suitable conservation measures and other factors. Correspondingly, the demand for fish products has increased sharply as evidenced by the 150 percent rise in some freshwater fish market prices from 1972 to 1977.

1.5.2 Administration of the Fisheries Sector

Fisheries administration, management and development is conducted through multiple agency control with responsibilities divided among the Directorate of Fisheries and Bangladesh Fisheries Development Cooperation (both part of the Ministry of Fisheries and Livestock), the Department of Cooperatives, the Integrated Rural Development Programme and local governments. However, the Directorate of Fisheries is the chief administrative and coordinating agency for this sector; and its main functions include research, extension, training and the promotion of fisheries development.

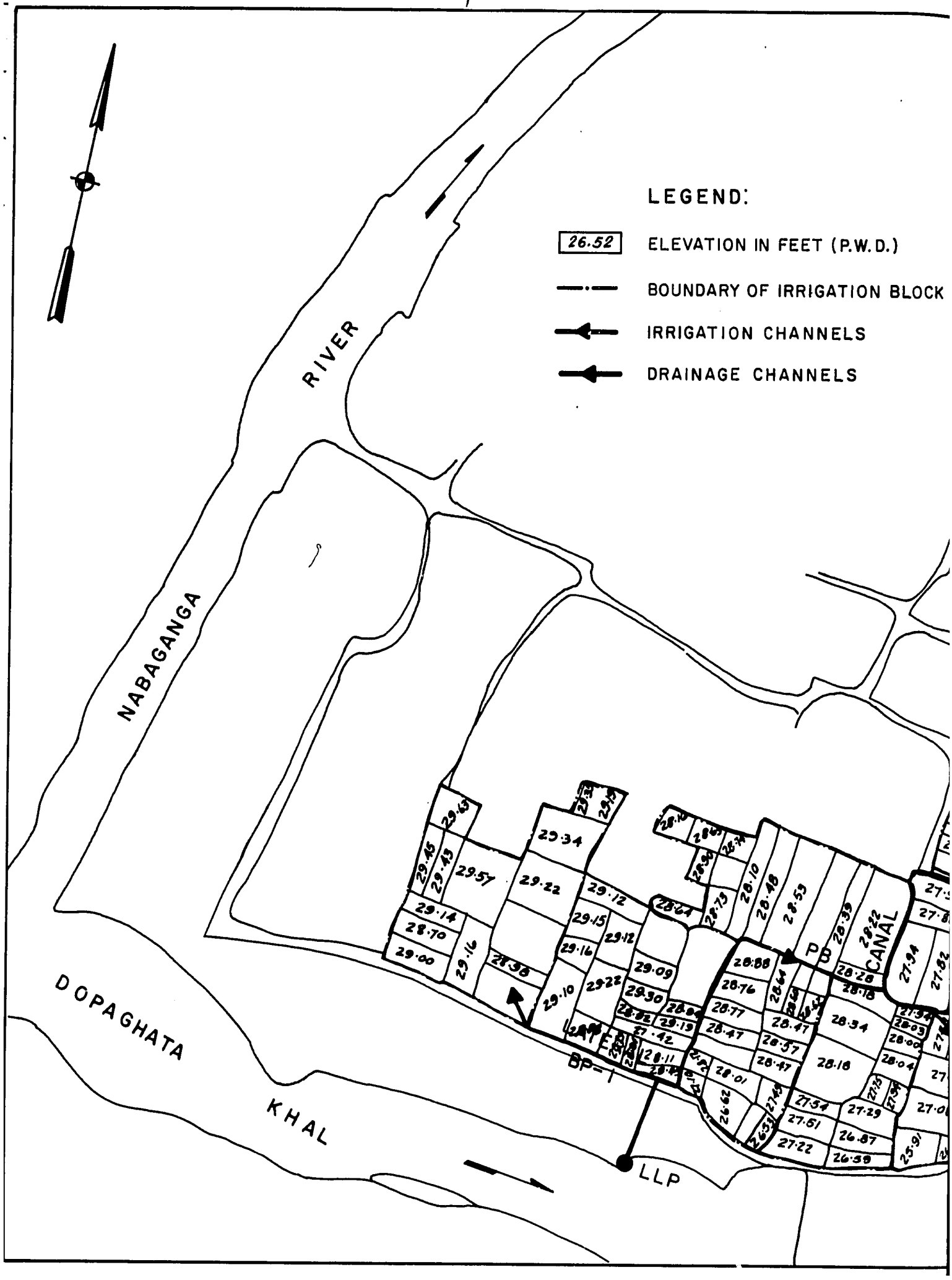
The Government of Bangladesh has included an ambitious program of fisheries development in its Second Five Year Plan. The focus is mainly upon an expansion of aquacultural activities in an effort to increase annual inland fisheries output to 2.6 million tons by 1984-85. The Government is directly funding several fishery development products, while a number of others are being sponsored by World Bank,

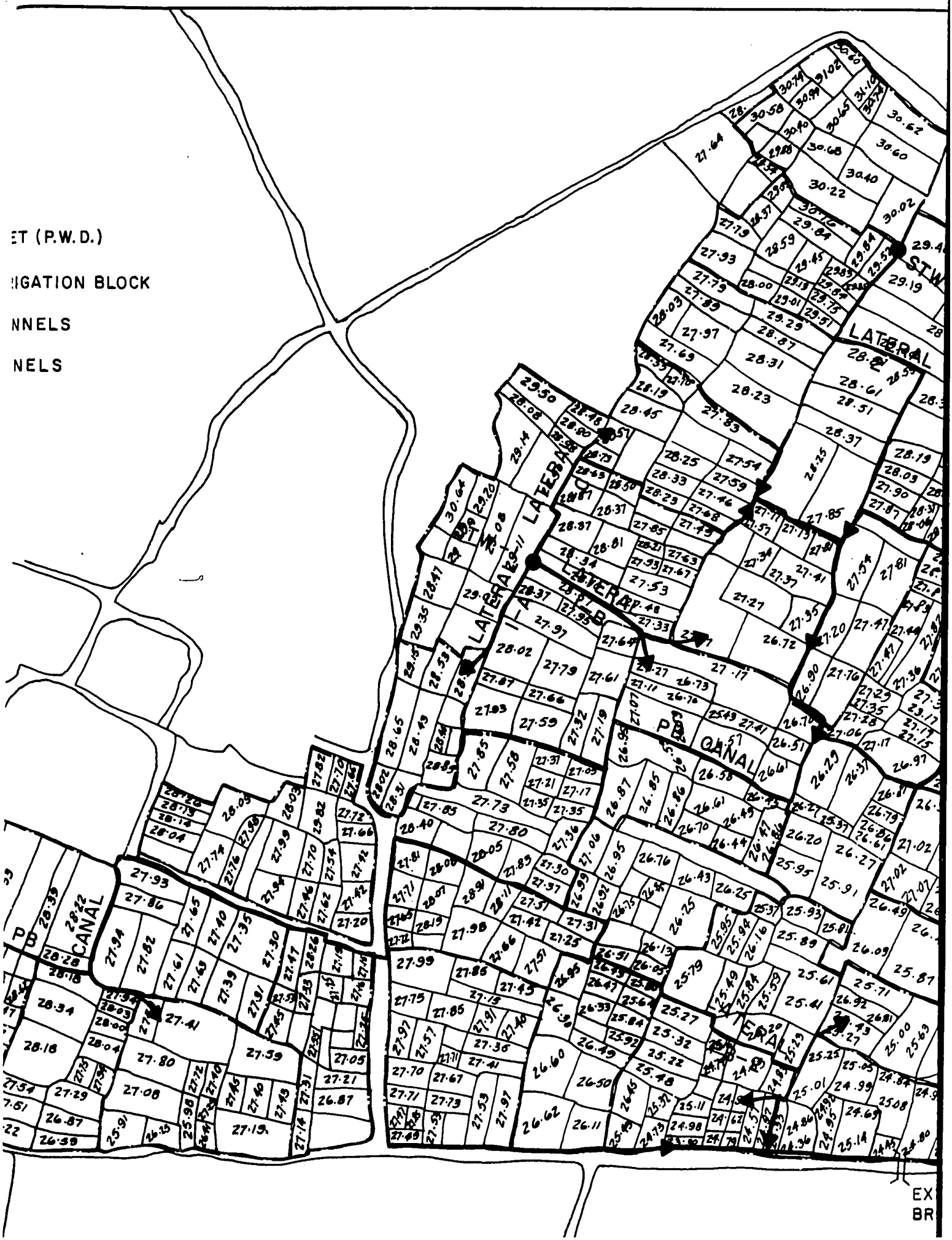

PILOT AREA
NABAGANGA RIVER
EXISTING PUMP SITE
JHENIDA
TO KUSHTIA
TO JESSORE
28
29
28
26
25


PILOT AREA
EXISTING PUMP SITE
JHENIDA
NABAGANGA RIVER
TO KUSHTIA
TO JESSORE
SETTLEMENTS
ODPACHALA KHAL
SCALE 4" = 1 MILE

SCALE 4" = 1 MILE

PABAHATI TYPICAL AREA
VICINITY MAP
FIGURE I - 21

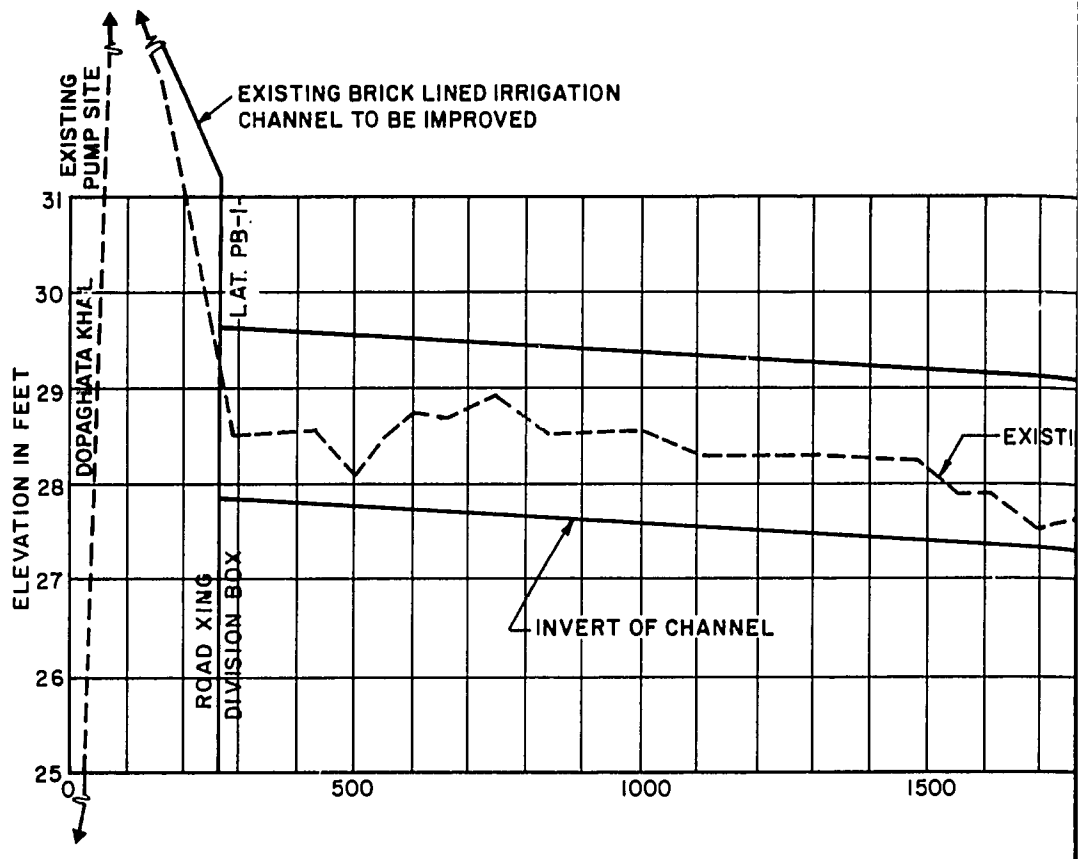

LEGEND:
26.52 ELEVATION IN FEET (P.W.D.)
BOUNDARY OF IRRIGATION BLOCK
IRRIGATION CHANNELS
DRAINAGE CHANNELS
NABAGANGA
RIVER
DOPAGHATA
KHAL
CANAL
PB
BP=1
LLP

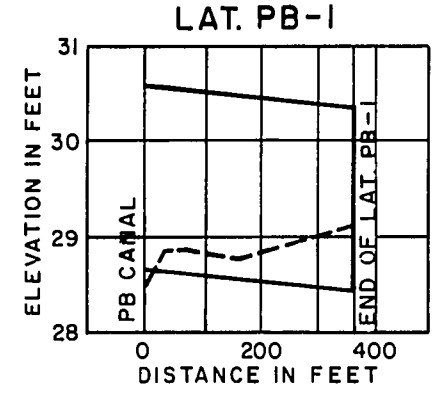

ET (P.W.D.)
IGATION BLOCK
NNELS
NELS
LATERAL
LATERAL
LATERAL
LATERAL
CANAL
CANAL
CANAL

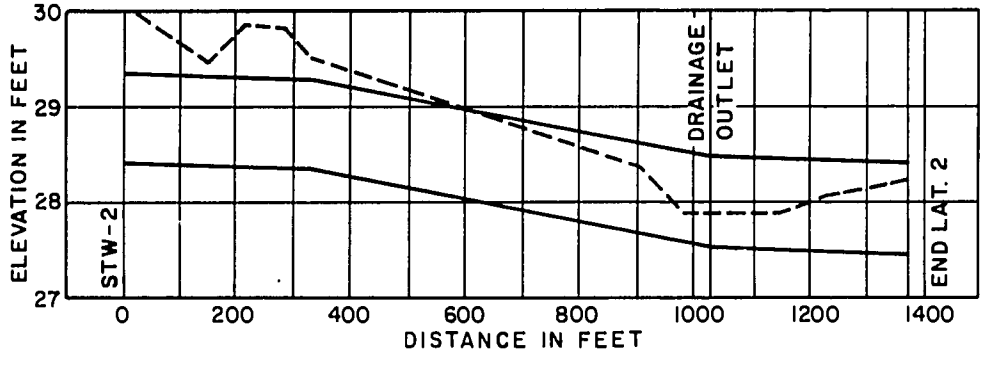
PABAHATI TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

LAYOUT

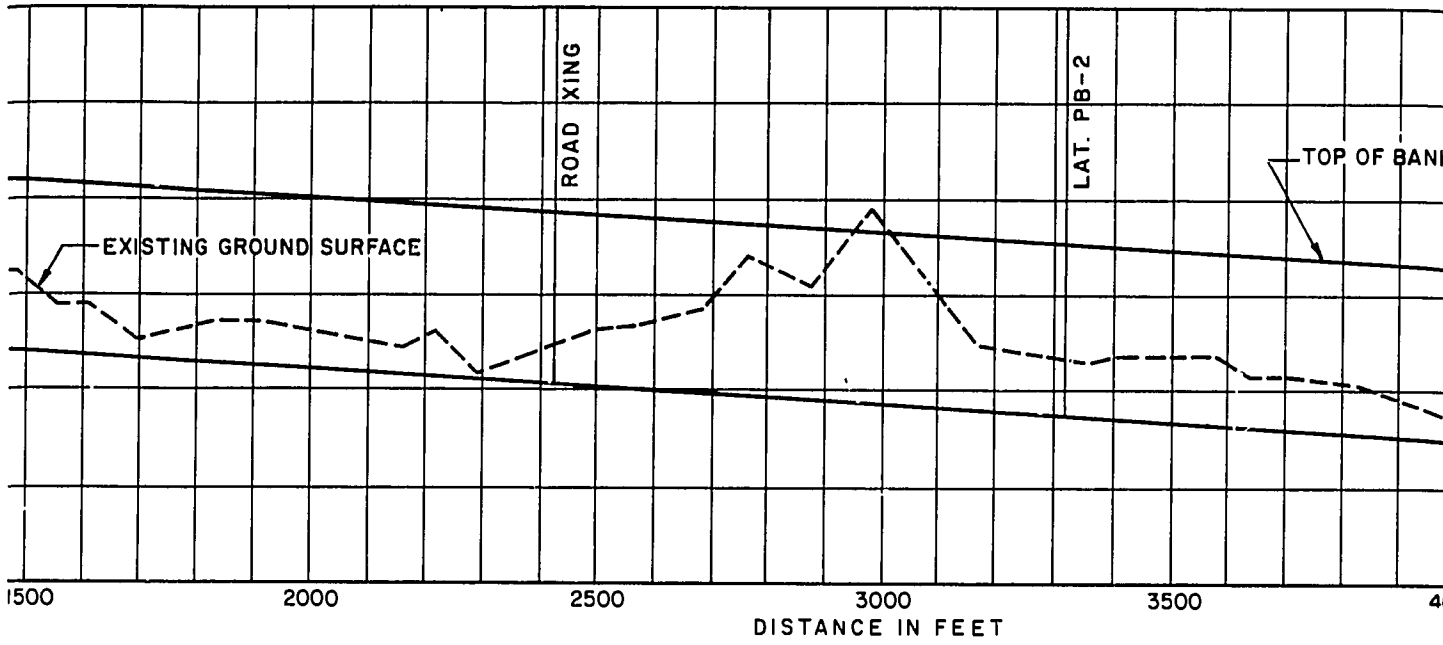
FIGURE I-22


EXISTING BRICK LINED IRRIGATION CHANNEL TO BE IMPROVED
EXISTING PUMP SITE
DOPAGHATA KHAL
LAT. PB-1
ROAD XING
DIVISION BOX
INVERT OF CHANNEL
EXISTI
ELEVATION IN FEET
31
30
29
28
27
26
25
0
500
1000
1500

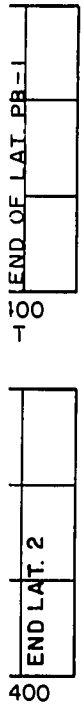

LAT. PB-1
ELEVATION IN FEET
31
30
29
28
PB CANAL
END OF LAT. PB-1
0
200
400
DISTANCE IN FEET


ELEVATION IN FEET
30
29
28
27
STW-2
DRAINAGE OUTLET
END LAT. 2
0
200
400
600
800
1000
1200
1400
DISTANCE IN FEET

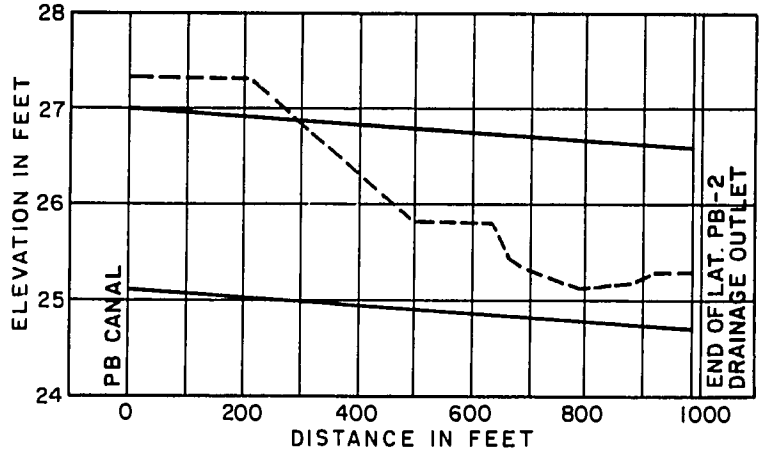
LAT. 2



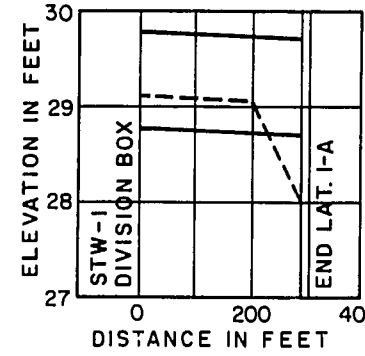
PB CANAL

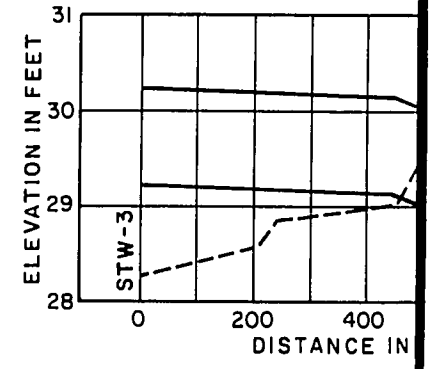


LAT. PB-2

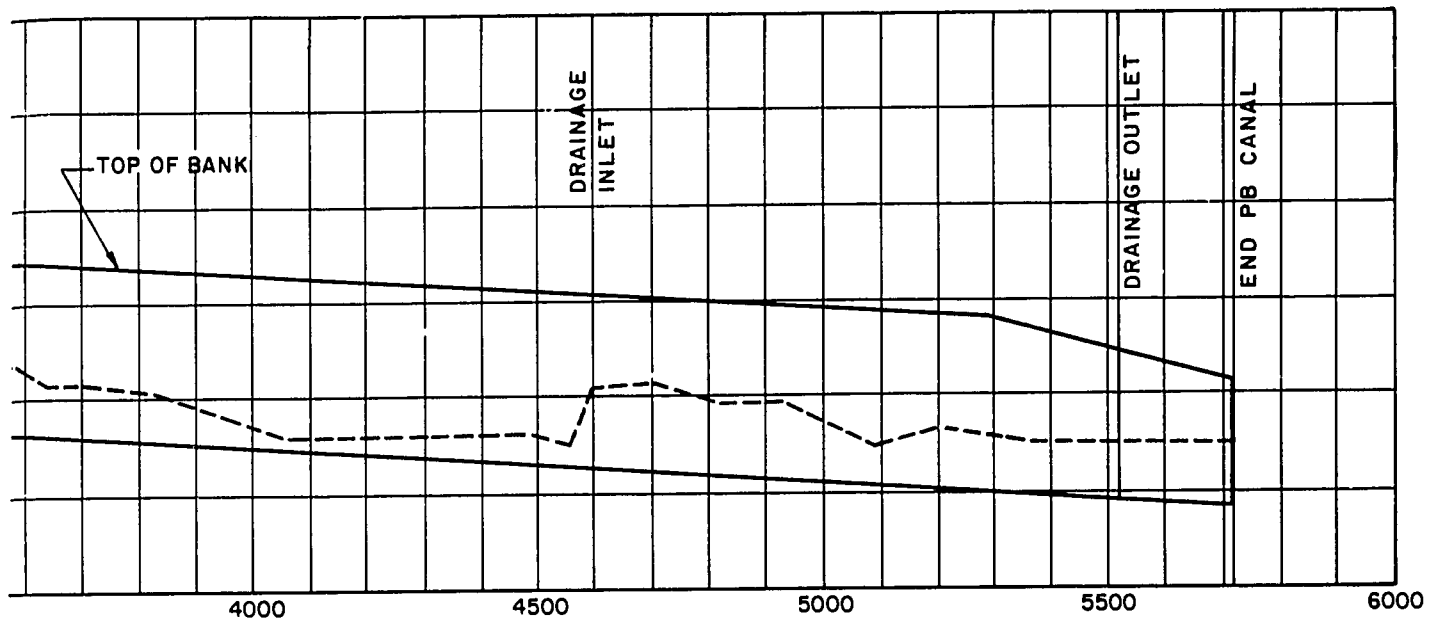


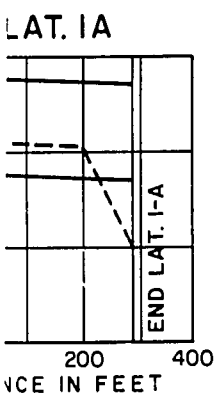
LAT. IA

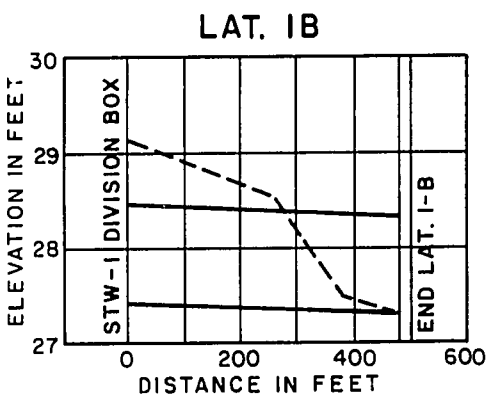


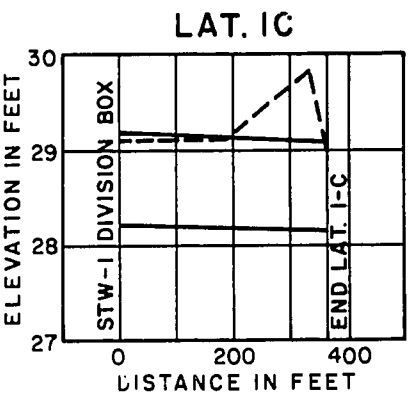


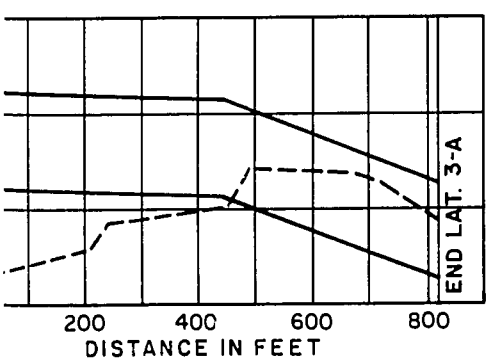
LAT. 3

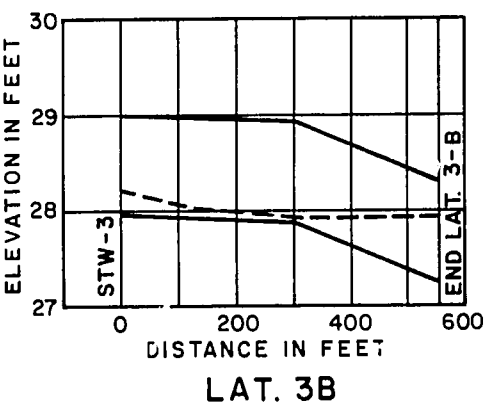












PABAHATI TYPICAL AREA
IRRIGATION DISTRIBUTION SYSTEM

PROFILES

FIGURE I-23

ADB, UNDP, FAO, UNICEF, bilateral assistance from foreign governments and by voluntary agencies. A list of some of the more relevant of these proposed and on-going projects is presented in Appendix E.

One current project of particular interest (funded by IDA) involves the construction of a large fish hatchery and the development of fisheries on six ox-bow lakes in the Jessore District. The hatchery is expected to produce 200 million hatchlings of native major carps and Chinese carps. It is envisioned that 150 million hatchlings will be sold to the nursery operators, and 50 million will be reared to fingerling size for stocking the oxbow lakes and to sell to local fish farmers. In the project area, the Directorate of Fisheries maintains Fish Seed Multiplication Farms at Magura and Jhenida. At present, the farms are each managed by a Unit Extension Officer. Fingerling size fish are raised at these farms and sold to fish farmers in the region who in turn raise these fish to marketable size in their own ponds. Both of the farms can raise about 200,000 each year, but the limited physical facilities and manpower restrict their production capabilities. In addition, the number of fingerlings raised at the farms is much less than the annual demand.

With donor assistance, the Directorate of Fisheries is planning to upgrade about 100 of the Fish Seed Multication Farms around the country, including those in Magura and Jhenida. This will involve rehabilitation of some of the rearing ponds, improvement of water supplies and an increase in staff. It is envisioned that a manager with supporting staff will be assigned to the farms thus permitting the Unit Extension Officers to concentrate on providing extension services.

1.5.3 Regulation of Open and Impounded Waters

Until recently, open waters including beels, boars, lakes and segments of rivers were leased to individuals or fishermen cooperatives on a periodical basis by the Ministry of Land Administration and Land Reform. The lessee then employed fishermen on a license or share basis to exploit the respective fishery resource from these water bodies. Under this system, the illiterate fishermen were usually at a disadvantage and remained at a subsistence income level. In addition, the lessee with a relatively short lease period, made no effort to manage or maintain the fishery resource. As a result, fish populations decreased due to over-fishing.

The present lease system has been modified whereby prospective lessees are selected on the basis of submitted production and management plans for specific open water areas. Parties offering the most attractive production plans will be awarded leases. Further, to ensure more direct benefits to the fishermen and to provide more appropriate technical inputs to this production oriented management, administrative responsibility for the open water fisheries has been transferred to the Directorate of Fisheries. It is expected that with the rise of fish production in these waters, the government revenue will correspondingly increase.

In a similar fashion, the Directorate of Fisheries will now lease government owned impounded waters, e.g. ponds, tanks and reservoirs on the basis of proposed production plans. Previously, lessees of these waters made little effort to develop intensive fish culture or to maintain the water bodies. Consequently, many ponds and tanks became derelict due to the overgrowth of vegetation, erosion, siltation and a deterioration of support banks.

Many privately owned ponds have also undergone similar management problems. In addition, due to multiple ownership and inheritance complications, co-sharers of a pond often fail to reach agreement for pond rehabilitation and fishery management. The Government, under provision of the Tank Improvement Act, is now taking steps to improve this situation. Private ponds which are not effectively utilized for fish production will be appropriated by the Government, and fish culturing activities will be subsequently developed with a principle aim to provide benefits for youths, unemployed women and landless farmers.

1.5.4 Fisherman Cooperatives

There is an apex fishermen's association at the national level called the National Fishermen's Cooperative Society, Ltd.,along with eight central societies and 370 Primary Societies scattered throughout the country. However, many of these societies are based upon a vested interest controlled by a few individuals. The result is that many fishermen who are members of the societies are exploited and realize few benefits from the cooperative organizations.

In the Jhenida and Magura subdivisions there are 61 Primary Societies and a Central Society in Magura. Total membership is around 1,000. However, many of these societies are inactive and essentially non-functional.

1.5.5 Credit

With the increasing interest by the Government to develop fish culture activities in rural areas, a program has been launched to extend credit to fish farmers for the rehabilitation of ponds and to defray operational expenses. The Bangladesh Krishi Bank and all nationalized commercial banks

have been participating in this program since 1977. However, because of procedural formalities and stringent terms for collaterial, many fish farmers have been unable to take advantage of the available credit. A significant impediment is that farmers, especially the poorer ones, have limited property to apply as collateral to obtain loans.

1.5.6 Existing Fisheries in the Project Area

The fish species which dominate the capture, or open-water fisheries, throughout Bangladesh freshwaters are Indian carps, cat fishes, feather backs and snakeheads. In the project area, these species are found in the Nabaganga and Kumar rivers as well as in the canals, tanks, backwaters, beels and other natural depressions.

Most of the quietwater habitats are re-populated annually during monsoon periods when fish move onto the floodplains from the perennial rivers and canals. In addition, the Indian carps annually migrate within the rivers to local spawning grounds. The carp spawn from May to August releasing eggs in areas where slow currents are maintained. The eggs hatch in 12 to 16 hours, and the young fry are washed into the floodplain which is utilized as a feeding ground. The fry reach a fingerling size (about two inches) in about one month. Carp eggs and newly hatched fry are collected in many floodplain areas of Bangladesh and sold as "fish seed" to fish pond owners.

It should be noted that neither the Kumar nor the Nabaganga River is considered to be an important source of carp fry in the region. Carp populations in the project area are not extensive, and they have undoubtedly declined since implementation of the Ganges - Kobadak Project which significantly reduced flooding in the region.

The highly valued migratory Indian shad (Hilsa ilisha), although previously found in the project area, no longer occurs in the Nabaganga or Kumar Rivers since its access to these rivers has been blocked due to siltation and changes in rivers courses.

Fishing activities are conducted year-round, but maximum catches are usually made at the end of the rainy season when flood levels drop, concentrating fish in relatively confined areas. In the dry season, isolated pools on intermittent rivers and canals are probably fished to exhaustion. Fishermen employ a variety of seines, gill nets and traps and a few non-motorized canoes in the project area.

No statistics are available concerning the number of fishermen or the fish yields from the capture fisheries in the project area. However, a reasonable estimate of annual yields from beels, boars, floodplain pools, etc. is about 100 pounds/acre. Many of the fishermen are landless, illiterate and operate at the subsistence level only. Fishermen are often indebted to the fish merchants to whom they sell their catch at well below market prices. For example, in the project area during 1976, fishermen sold their catch to traders for Tk 1.60/pound (Tks 130/maund) while the wholesale price in Jessore was Tk 3.65/pound (Tk 300/maund). Current market prices in the project area are about Tk 6/pound.

Fish culture operations throughout Bangladesh are conducted at a low level of intensity with limited technological or managerial inputs. In the project area, for example, fish culture is practiced only by farmers who stock their ponds with carp fingerlings. Fertilizers and supplemental fees are not used except on occasion. The carp reach marketable size (about 1-2 lbs.) in approximately one year. Ponds operated in this fashion (and stocked with 3,000 fingerlings per acre) will annually yield 400 to 600 pounds/acre although average yields nationwide may not be more than 100 pounds/acre.

In many instances, the farmer maintains the pond for home consumption only. Farm level fish prices are around three-fourths of the wholesale market prices, or presently about Tk 4.50/pound.

1.5.7 Proposed Fisheries Development

1.5.7.1 General

It should be noted that proposed water regulation schemes would result in an increase of potential fish yields from the project area rivers and canals even without any manipulation of natural fish stocks or other fisheries management inputs. The amount of water available throughout the year in the regulated rivers and canals will be approximately doubled. Dry season water levels will be substantially increased.

The additional surface water area available in river and canal sections throughout the year (and thus for a full growing season for most food source fish species) would be about 1,500 acres along 32 miles of the Kumar River (only 7 miles are actually in the project area), 225 acres in the Nabaganga River and around 50 acres in khals connected to the Nabaganga. Since standing water bodies now have an average yield of about 100 pounds/acre, approximately 177,500 additional pounds/year of fish should be harvestable from the natural fish populations as a direct benefit of project implementation. At present market prices, this would amount to an annual benefit of over Tk. 1 million.

In addition, project implementation will enable the initiation of fishery management programs which could significantly increase fish yields from the area's surface waters. The most feasible opportunities recommended for fisheries development include the supplemental stocking of expanded open water areas (rivers, khals) and the culture of fish in

small ponds which are located along irrigation routes. Both of these practices would take advantage of, and could be incorporated into, the proposed regulation schemes and irrigation systems. In addition, these are low-level technology alternatives which minimize constraints due to limited fish farming expertise and restricted supplies of inputs. However, this approach would necessitate an upgrading of the Fish Seed Multiplication Farms to meet future demands for fish fingerlings. Details of these aspects of the proposed fisheries development for the project are presented in the following sections. Other, more sophisticated fish culture practices could be introduced in the future after experience is gained with the less intensive programs. Brief descriptions of some of the potential, higher level technology culturing methods are given in Appendix E.

1.5.7.2 Supplemental Stocking of Rivers and Khals

The proposed regulation schemes will increase water availability in the project area rivers and khals, especially during the dry season. It is anticipated that water depths in these channels would be as great as three or four feet even in the driest periods. In effect, these channels would function as long, narrow standing waters and could be managed accordingly in terms of fisheries development.

Supplemental stocking of fingerlings in these channels could augment existing fish populations and significantly increase overall yields, and consequently increase incomes for project area fishermen. A suggested stocking rate of about 2,000 fingerlings/acre can subsequently produce a yield of around 300 pounds/acre annually, assuming natural mortality rates of 20-40 percent.

The rearing schedule of carps in the rivers/khals would coincide with the proposed operations of the control structures. Carp fry are collected in June and raised to the fingerling stage in about two months. Thus, the fingerlings would be available for stocking at about the time the control structure gates would be closed in October. The fish can then be reared to marketable size by the end of the next dry season and removed for marketing prior to the re-opening of the gates.

Stocking at the above rate in the project area rivers, khals and perhaps a few beels or other natural depressions would require the availability of about 3.5 million fingerlings annually. This is based upon the minimum area of surface water which should normally persist through the dry season due to the proposed regulation scheme. A substantially lower number of fingerlings would be needed to stock, for example, only the Nabaganga River and its khals.

1.5.7.3 Tanks Adjacent to Irrigation Systems

There are a number of relatively large existing tanks, about 1/3 to 3 acres in area, which could receive reliable, high quality water from proposed irrigation systems. These tanks appear to be very viable for low-level technology fish culture operations.

The tanks under consideration are those which could be easily incorporated within the direct transport routes of the proposed irrigation systems. These tanks would receive water at the initial irrigation source i.e. immediately adjacent to a river pumping site. Water could flow continually through these ponds, exiting into the irrigation system. The continual water exchanged would benefit fish culture operations by ensuring a constant supply of high quality water (high dissolved oxygen, etc.) and flushing out wastes accumulated within the densely populated ponds.

There are about 60 tanks which have been tentatively identified as potentially suitable for incorporation into this proposed system (See Figure I-24).

In most instances, a low lift pump would be utilized to fill the prospective fish tank from a river or khal. Subsequently, water will be drawn from the tank by gravity flow into channels of the distribution system. Occasionally topographic conditions may permit direct gravity flow to a tank, thus obviating the need for a pump for recharging it; however, this will probably be a relatively unlikely phenomena.

Some of the proposed tanks will require rehabilitation such as partial excavation, embankment repair or vegetation clearing. Screening may also be necessary in some cases to prevent the loss of stocked fish and to limit predator access.

A recommended stocking density for the proposed tank program would be about 3,000 carp fingerlings per surface acre. Expected annual yield, without any further inputs would be at least 500 pounds per acre. However, with tanks of this size, fertilizers and perhaps some supplemental feed could be used which would enable higher stocking rates and result in significantly increased yields. Yields of more than 2,000 pounds per acre have been obtained in the country from ponds using basic fertilizers and feed with stocking rates of 4,500 fingerlings per acre.

1.5.7.4 Fingerling Study

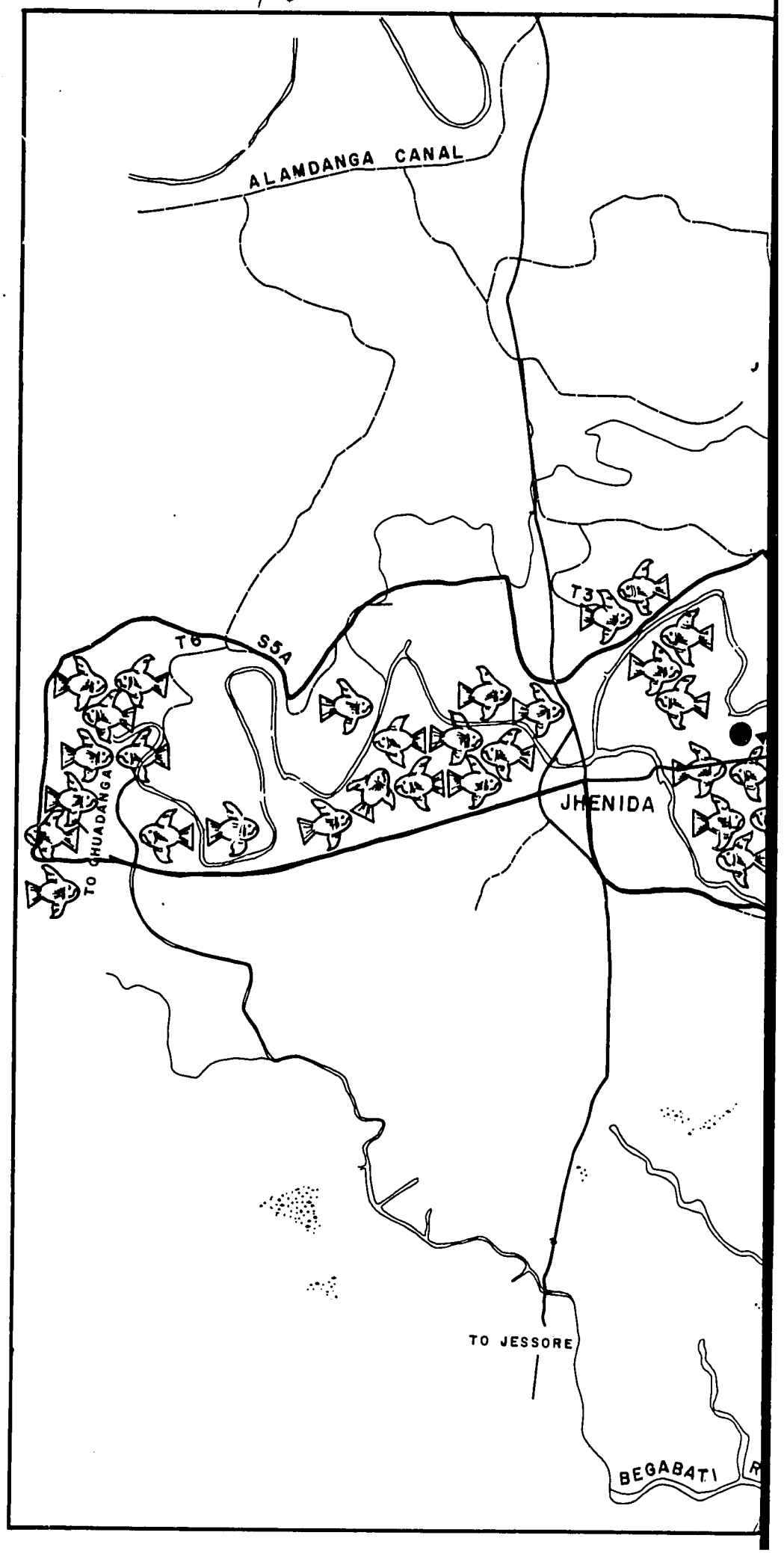
Neither the existing Fish Seed Multiplication Farms in Magura and Jhenida nor the natural fry sources available locally are sufficient to meet either current or future demands for carp fingerlings. Successful implementation of the recommended supplemental stocking of project area rivers and

khals and the development of the irrigation fish culture tanks will necessitate the provision of a large, reliable supply of fish fingerlings. This could be the major constraint to any intensified fisheries management program for the region.

There are several alternatives for increasing fingerlings of Indian carps and other food source species. One would be to increase the fry supply from natural fish populations. However, it is believed that existing suitable spawning grounds are already being heavily exploited. Fingerling production could be doubled at each of the Fish Seed Multiplication Farms in the project area with the provision of a suitable water supply the construction of some new reading ponds and an increase in equipment and manpower. These type of improvements are planned for the two farms under the nationwide Directorate of Fisheries program mentioned previously. However, this would probably increase total fingerling output to about 800,000 per year, which would be much less than 3.5 million fingerlings needed for the two proposed fisheries projects. In addition, this system would still rely upon natural fry collection which can fluctuate significantly from year to year and is in general declining throughout the country.

Another possibility may be to upgrade and utilize the two farms as just discussed, but to purchase fry from the new central hatchery being constructed near Jessore. This may be very feasible, provided that the new hatchery is capable of producing a surplus of fry beyong what will be required for the ox-bow lake program. Six ox-bow lakes are initially scheduled for development, but an additional nine or more may be incorporated into the program in the future. This would place a very heavy demand on the new central hatchery to produce enough fish seed to supply all of the ox-bow lakes as well as other areas.

46 a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S5A
T3
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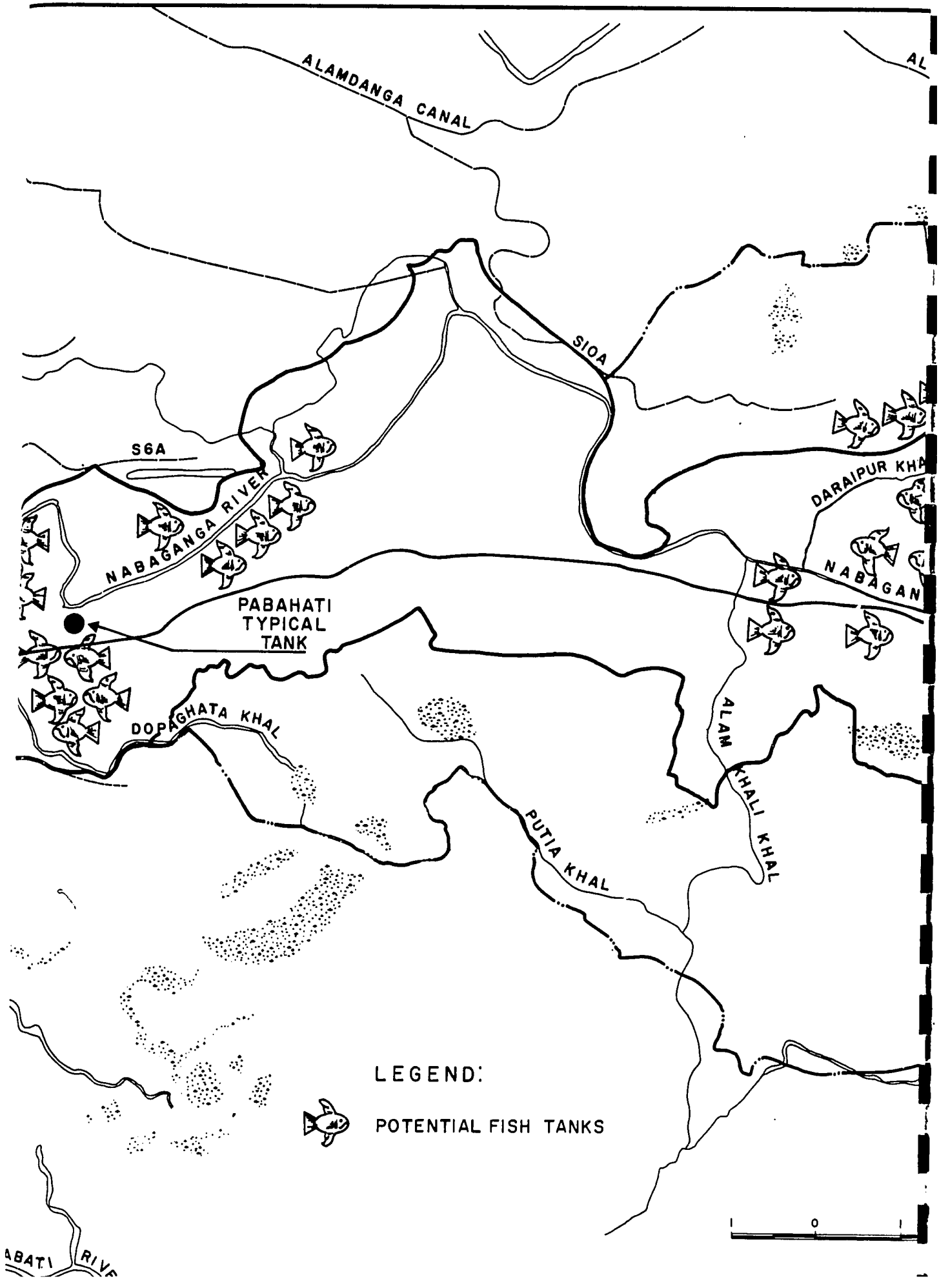
TO CHUADANGA
TO JESSORE
BEGABATI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NABAGANGA RIVER
DARAIPUR KHA
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ALAM KHALI KHAL
PUTIA KHAL
LEGEND:
POTENTIAL FISH TANKS
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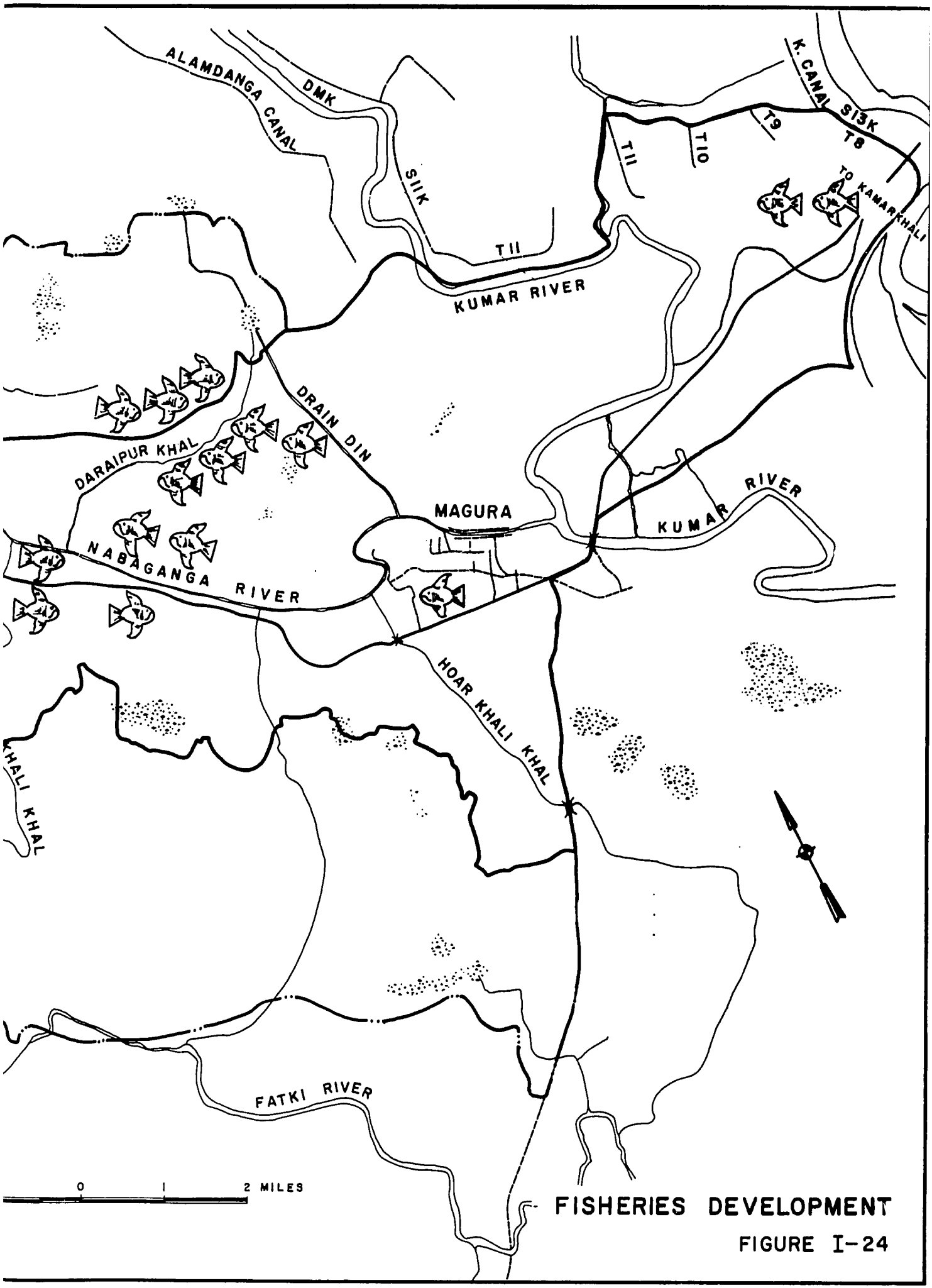
ABATI RIVE



FISHERIES DEVELOPMENT

FIGURE I-24

Taking all of this into consideration, it is recommended that the two existing seed farms in Magura and Jhenida be upgraded to install induced breeding facilities and expand both nursery and rearing capabilities. This would entail development of an efficient water delivery system with shallow tubewells and associated piping along with the construction of some new ponds, the renovation of hatchery and maintenance buildings and the purchase of laboratory equipment and vehicles. Staffing for each improved farm would include a hatchery manager, an aquacultural field assistant and support personnel.

With the improved facilities and increased manpower, a reliable supply of young fry could be obtained from artificial spawning of adult fish in the controlled hatchery environment. Each farm could be capable of rearing about two million fingerlings annually for stocking of open waters or for sale to pond owners.

1.5.7.5 Administration, Credit and Marketing

As presently planned, the Hatchery Managers would be trained and assigned to the Magura and Jhenida seed farms by the Directorate of Fisheries. The Hatchery Manager would be responsible for all seed farm operations, the production of fry and fingerlings and the sale and dissemination of the fingerlings. The latter would be coordinated with a Unit Extension Officer, also assigned by the Directorate of Fisheries. This Officer would also work in conjunction with the local government in order to establish fishing regulations and issue leases for harvesting the stocked open waters in the project area. In addition, the unit Extension Officers will provide technical assistance for operation of the proposed irrigation fish culture tanks. These Officers will also be responsible for aiding fishermen to obtain credit for boats and collecting gear.

Use of some of the area tanks for fisheries development may be restricted by conflicting ownership claims. For the tanks whichwould in effect become part of the irrigation systems, it is recommended that the Pump Association Groups assume administrative responsibility for supervising fish cultivation. This may be in the form of hiring landless fishermen to operate the tanks, permitting legitimate owners of the tank area to privately develop the ponds or leasing the tank to experienced fishermen. In the latter cases, landless fishermen may also benefit as part of the labor force needed to operate the tanks. If conflicting ownership claims preclude effective fisheries development of a tank , it is suggested that the Government exercise rights under the Tank Improvement Act to requisition the tank and consign its ownership to the Pump Association Group. This Group will also be responsible for securing credit for the inputs needed for fish culture operations.

Present local market demands are very high for all fish and fish products. However, at full operation, the proposed ox-bow fisheries project near Jessore will generate about 1,000 tons of fish annually in the region. Additional markets may have to be surveyed for the absorption of large quantities of fish, especially if harvest times coincide with the ox-bow project and any intensive fish culture in the project area. In general, the development of marketing avenues and small scale fisheries industries i.e., ice storage, drying facilities, etc. would be primarily through privage channels.

The relatively substantial fisheries development would limit the ability of the two regional Unit Extension Officers to initially meet all the demands of an expanded industry. Thus, it is recommended that a Fisheries Biologist be provided as part of the project's Management Consultant Team to supervise the upgrading of the Fish Seed Multiplication Farms in Magura and Jhenida, to assist in the initiation of

induced breeding operations at the farms and provide extension assistance for siting and upgrading tanks and for planning stocking and harvesting procedures.

It is recommended that this advisor be available from the beginning of project implementation, remaining initially for a period of 18 months. It is suggested that he subsequently return to monitor progress in each of the three succeeding years for short periods of about two months each.

1.5.7.6 Costs and Benefits

The total costs for upgrading equipment and facilities at one of the existing seed farms will be about Tk 1.5 million. Annual operation and maintenance costs including labor costs for each farm will be around Tk 220,000.

The major cost involved for the supplemental stocking of the project area rivers and khal will be the purchase of the fingerlings (about Tk. 0.15 each). This would amount to Tk 530,000. This cost could be subsidized by the Government and/or regained through fees for leases.

Tank renovation will cost around Tk 2,000 to 3,000 per tank. Initial year costs would be about Tk 1,000. Annual operations costs including fingerling purchases and gear and tank maintenance would be about Tk 1,000. If used, the cost for fertilizers (super-phosphate, manure, etc.) and for occasional feeding (rice bran, oil cake) would be less than 1,000 per acre annually.

Gross benefits, based upon farm level prices, would be about Tk 2.4 million from supplemental stocking of open water and around Tk. 2.5 million if all 60 prospective fish tanks are utilized. In addition, work connected with operating the tanks, as well as actual fishing in both tanks and in the rivers and khals is available if village residents choose to take it up, under the project. Improved nutrition

of village residents is also a likely side effect of an improved local fishing industry. The total annual benefits of the industry over present low levels are Tk. 2 million and the benefit/cost ratio would be 2.7 : 1, while the IRR would be over 50 percent.

1.6 Cost Estimates

1.6.1 General

Cost estimates have been prepared for both the construction, and for the operation and maintenance of the regulation works, the on-farm development, and the fisheries. The construction estimates were based on a review of BWDB Schedule of Rates for 1979-80 and on an evaluation of the market conditions in mid-1980. The operation and maintenance costs were based on the fuel and labor prices in mid 1980. There has been no escalation or revision of these prices to reflect inflation or future conditions.

The engineering and administration costs for the construction have been included in Technical Services. The farmers of the area have had no prior experience with irrigated agriculture and they will need substantial and prolonged technical assistance during the development phase. These technical services, including logistic support, would be the major external cost of the project.

Estimates have also been prepared for the manpower and for the material requirements during project implementation.

The agricultural production costs are considered in the farm budget and have been discussed in Chapter III.

1.6.2 Construction Costs

1.6.2.1 Regulation Works

The major regulation works would be the Magura Spillway Structure on the diversion channel and the control structures on the Alamkhali and Haorkhali Khals. These are standard reinforced concrete structures that would be constructed in accordanc3 with the standard specifications of BWDB and

other relevant agencies. There are experienced personnel and contractors in the area; the necessary equipment and materials are readily available; and these structures should be completed with no unusual difficulties or delays.

The steel sheet piling for the spillway structure is available from a curtailed project in Khulna at a cost of $491 per metric ton plus 75 percent for freight and importation costs. Much of the remaining materials for the spillway structure are presently stockpiled in Magura. The vertical lift gates for the control structures and the gates for the Drain D1N structure would be fabricated locally from available stock. These gates would be similar to the gates on the existing Magura weir which were fabricated by the Mechanical Equipment Organization (MEO).

The underlying foundations at all three sites are deep deposits of moderate to dense fine sands. The control of groundwater through the sands into the construction site could be a problem at the stilling basin for the spillway structure. This portion of the structure would be below sea level and positive dewatering would be necessary. Deep wells were successfully used for dewatering the site for the existing Magura weir and would be similarly used for the spillway. The construction sites for the two control structure are at a relatively high elevation and groundwater control would not be a problem. However, a 15 percent contingency factor has been added to the estimated costs of all three structures because of the uncertainty of foundation problems.

The diversion of the existing stream flows during construction would not be a problem at any of the above three sites. At the sites of the two control structures, the flows are negligible during the dry season when the floor slabs and superstructures would be constructed. At the spillway structure, the existing khal would serve to divert flows around the structure site.

The costs estimates for these three structures are shown in Table I-2.

There are also some minor miscellaneous construction to be included in the regulation works. This would be primarily channel excavation which would be done by manual labor and possibly under the Food for Work Programs. This excavation would primarily be along existing channels or through beel areas and right-of-way acquisition should not be a problem.

A factor has been included in the excavation costs to provide for the uniform disposal of the excavated material.

The cost estimates for the miscellaneous works are shown in Table I-3, and a summary of all regulation works is shown in Table I-4.

1.6.2.2 On-Farm Development

The on-farm development would consist of the pumps, and the irrigation and drainage systems. The pumps would be purchased directly by each group through a pump distributorship and a credit institution. Both of these entities would be expanded and strengthened to support these direct purchases. Following is the estimated costs of these individual pump units:

Item	2 cfs, 9HP Low-lift Pump	½ cfs, 5HP Shallow Tubewell
Pump	7,500	5,500
Engine	15,000	12,500
Trolley & Piping	6,000	-
Casing, 4"	-	6,500
Installation and Development	1,500	2,500
	Tks 30,000	Tks 27,000

TABLE I-2

MAJOR CONTROL STRUCTURES

CONSTRUCTION COSTS IN TAKAS

ITEM	UNIT PRICE	MAGURA SPILLWAY QUANTITY	MAGURA SPILLWAY COST	ALAMKHALI KHAL CONTROL STRUCTURE QUANTITY	ALAMKHALI KHAL CONTROL STRUCTURE COST	HAORKHALI KHAL CONTROL STRUCTURE QUANTITY	HAORKHALI KHAL CONTROL STRUCTURE COST
EARTHWORK:							
Cofferdams	Tks 0.125/CFT	174,000 CFT	Tks 21,750	6,000 CFT	Tks 750	-	
Structure Exc.	0.120/CFT	170,000 CFT	20,400	6,000 CFT	720	5,000 CFT	Tks 600
Back Fill	0.110/CFT	127,000 CFT	13,970	7,000 CFT	770	13,000 CFT	1,430
Sand Fill	0.150/CFT	147,000 CFT	22,050	-	-	-	-
Royalty	0.020/CFT	174,000 CFT	3,480	7,000 CFT	140	13,000 CFT	260
CONCRETE							
Mass Concrete	TKS 24/CFT	-	-	17,200 CFT	TKS 412,800	12,400 CFT	TKS 297,600
Structure Concrete	30/CFT	38,800 CFT	TKS 1,164,000	11,400 CFT	342,000	6,800 CFT	204,000
Forming	4/SFT	9,100 SFT	36,400	5,900 SFT	23,600	4,600 SFT	18,400
Reinf. Steel	6/lbs	190,000 lbs	1,140,000	57,000 lbs	342,000	34,000 lbs	204,000
STEEL SHEET PILE:							
Material	TKS 12,500/Ton	154 Ton	TKS 1,925,000	-	-	-	-
Placement	TKS 20/SFT	11,000 SFT	220,000	-	-	-	-
TIMBER PILES	TKS 22/LF	10,500 LF	TKS 231,000	-	-	-	-
CAISSONS, SINKING to a Depth of 20 Feet	TKS 3/SFT	-	-	19,000 SFT	TKS 57,000	9,800 SFT	TKS 29,400
MASONRY CHANNEL PROTECTION	TKS 15/CFT	20,000 CFT	TKS 300,000	5,000 CFT	TKS 75,000	3,560 CFT	TKS 53,400
TIMBER STOP LOGS	TKS 120/CFT	85 CFT	TKS 10,200	-	-	-	-
METAL SLIDE GATES 12' Wide, 8' High	TKS 80,000/each	-	-	4 each	TKS 320,000	2 each	TKS 160,000
MISC. METAL	TKS 8/lbs.	1,700 lbs	TKS 13,600	-	-	-	-
ROAD PAVING	TKS 12/SFT			79,200 SFT	TKS 950,400		
HIGHWAY BRIDGE	TKS 800/SFT	4,000 SFT	TKS 3,200,000				
PUMPING FOR DEWATERING	TKS 16/Pump-Hr	5,000 Hrs.	TKS 80,000	600 Hr.	TKS 9,600	600 Hr.	TKS 9,600
SUB-TOTAL			TKS 8,401,850		TKS 2,534,780		TKS 978,690
CONTINGENCIES - 15%			TKS 1,260,278		TKS 380,217		TKS 146,804
TOTAL CONSTURCTION COSTS			TKS 9,662,128		TKS 2,914,997		TKS 1,125,494
SAY			Tks 9,700,000		Tks 3,000,000		Tks 1,100,000

TABLE I-3

MISCELLANEOUS REGULATION WORKS

CONSTRUCTION COSTS

ITEM	QUANTITIES		COSTS
1. Drain DlN Structure			
Additional Gates	L.S.		Tks 300,000
2. Dariapur Khal Control Structure			
Channel Closure	33,000 CFT	Tks 6,600	
Concrete Pipe, 24"	64 LF	6,400	
Timber Gate	1 each	600	
Sub-Total		Tks 13,600	
Say			Tks 14,000
3. Channel Excavation*			
Haorkhali Khal	970,000 CFT	Tks194,000	
Dopaghata Khal	2,100,000 CFT	210,000	
Sub-Total			404,000
4. Main Drains			
South of Nabaganga R.			
Length	16,600 LF	-	
Earthwork	224,000 CFT	44,800	
Right-of-Way	3 Acres	90,000	
North of Nabaganga R.			
Length	54,200 LF	-	
Earthwork	730,000 CFT	146,000	
Right-of-Way	9.7 Acres	291,000	
Sub-Total			572,000
Total, Miscellaneous			Tks 1,290,000

* These are existing channels and no Right-of Way woule be required.

TABLE I-4

REGULATION WORKS

SUMMARY OF CONSTRUCTION COSTS

ITEM			COST
1. Magura Spillway		Tks	9,700,000
2. Alamkhali Khal Control Structure			3,000,000
3. Haorkhali Khal Control Structure			1,100,000
4. Drain D1N Structure Additional Gates			300,000
5. Dariapur Khal Control Structure			14,000
6. Channel Excavation:			
Haorkhali Khal	Tks 194,000		
Dopaghata Khal	210,000		
Main Drain, South	135,000		
Main Drains, North	437,000		
Sub-Total			976,000
Total Regulation Works		Tks	15,090,000

Manually operated pumps for both tubewells and surface supplies would be important components of the overall development. However, such pumps would generally irrigate less than one acre and would be installed and controlled by a single farmer. Neither the costs nor the numbers of such installations have been estimated herein.

The irrigation and drainage systems would consist of small earth channels with simple structures that could be planned and implemented by the individual farm groups. The farmers would provide the labor and the right-of-way and little actual financial costs would be incurred. These costs, however, have been estimated for the economic analysis and for comparative purposes.

The earthwork for the irrigation channels was estimated at Tks 400 per thousand CFT. This high rate reflects the extra time and effort to shape and compact the small channels and the channel banks. For drainage channels, the cost was estimated at Tks 200 per thousand CFT which reflects the extra effort to uniformly place the excavated material over the adjacent fields.

The additional right-of-way was estimated at Tks 30,000 per acre. The existing bunds between parcels would serve as one bank of the irrigation channel and the area of this bund, estimated to be five feet in width, was not included in the right-of-way requirements.

The structures would be small, standard units. Following is the estimated cost of these standard units:

- 6" concrete pipe turnout	Tks	120 each
- 12" concrete pipe road crossing	Tks	750 each
- Masonry division box	Tks	1,600 each

The construction quantities and costs for the on-farm development were estimated from detailed analyses of three typical areas. These analyses indicated the total cost of on-farm development would be approximately Tks 1400 per irrigable acre. These quantities and costs are shown in the Table I-5.

TABLE I-5
ON FARM DEVELOPMENT
CONSTRUCTION COSTS

DISTRIBUTION SYSTEMS	IRRIGABLE AREA ACRES	CHANNEL LENGTH FEET	EARTHWORK QUANTITY CFT	EARTHWORK COST TKS.	ADDITIONAL R/W QUANTITY ACRES	ADDITIONAL R/W COST TKS	STRUCTURES TURNOUT EACH	STRUCTURES DIVISION BOX EACH	STRUCTURES ROAD CROSSING EACH	STRUCTURE COSTS TKS.	PUMP COSTS TKS	TOTAL COST TKS
ALAIPUR/MIRZAPUR												
LAT. M-1	25	2,760	22,600	9,040	0.37	11,100	10			1,200		
LAT. M-2	17	1,550	7,500	3,000	0.20	6,000	5			600		
LAT. M-3	18	740	4,800	1,920	0.11	3,300	6			720		
LAT. M-4	44	2,900	21,000	8,400	0.38	11,400	14			1,680		
LAT. M-5	23	1,000	6,900	2,760	0.14	4,200	6		1	1,470		
MIRZAPUR CANAL												
INLET	--	960	125,000	25,000	Public R/W	--		1	1	1,600	30,000	
CLOSURE	--	2,250	6,100	2,440	Public R/W	--	3			7,000		
DISTRIBUTION	15	1,040	9,300	3,720	0.14	4,200	4			360		
STW - 1	16	800	10,200	4,080	0.11	3,300	8	1		480		
STW - 2	40	2,530	5,900	2,360	0.29	8,700	15	1	1	2,560	27,000	
STW - 3	13	750	2,300	920	0.09	2,700	5	1		4,150	27,000	
DRAINS	10	5,900	79,000	15,800	1.06	31,800	--	-	1	2,200	27,000	
SUBTOTALS	221	23,180	300,600	79,440	2.89	86,700	76	4	4	750		
										24,770	111,000	301,910
SACHANI RAUTARA												
SR CANAL	52	3,830	26,500	10,600	0.53	15,900	19	1	2	5,380	30,000	
LAT. SR - 1	6	870	5,200	2,080	0.11	3,300	2			240		
LAT. SR - 2	10	980	3,300	1,320	0.12	3,600	3		1	1,110		
DRAIN		3,700	50,000	10,000	0.67	20,100	--		2	1,500		
SA CANAL	36	2,640	24,600	9,840	0.39	11,700	16	1		3,520	30,000	
LAT. SA - 1	13	660	4,400	1,760	0.08	2,400	5			600		
LAT. SA - 2	14	1,200	11,400	4,560	0.17	5,100	5			600		
LAT. SA - 3	6	550	2,800	1,120	0.07	2,100	3			360		
DRAIN		3,000	40,500	8,100	0.54	16,200	--			---		
SUBTOTALS	137	17,430	168,700	49,380	2.68	80,400	53	2	5	13,310	60,000	203,090
PABAHATI												
PB CANAL	74	5,220	36,800	14,720	0.69	20,700	20	1	1			
LAT. BP -1	5	360	3,400	1,360	0.06	1,800	1			4,750	30,000	
LAT. BP -2	17	980	7,200	2,880	0.14	4,200	5			120		
STW - 1	27	1,140	5,500	2,200	0.11	3,300	9	1		600		
STW - 2	27	1,370	4,900	1,960	0.12	3,600	9	1		2,680	27,000	
STW - 3	22	1,370	10,400	4,160	0.18	5,400	6	1		2,680	27,000	
DRAINS		5,000	67,500	13,500	0.90	27,000	--			2,320	27,000	
SUBTOTALS	172	15,440	135,700	40,780	2.20	66,000	50	4	1	13,150	111,000	230,930
ALL AREAS												
TOTALS	530 Ac.	56,050 LF	605,000 CFT	Tks.169,600	7.77 Ac	Tks.233,100	179	10	10	Tks.51,230	Tks.282,000	Tks. 735,930
PER IRRIGABLE ACRE	--	106 LF/Ac.	1,142 CFT/Ac	Tks.320/Ac	1.5%	Tks.440/Ac.				Tks 97/Ac	Tks.532/Ac	Tks. 1,389 Ac
									SAY	Tks 100/Ac	Tks.540/Ac	Tks. 1,400 Ac

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In some areas along the major rivers, extensive inlet channels may have to be excavated to provide a surface water supply to the irrigable lands. The cost of these channels have been included in the on-farm development costs. However, these excavations would be supervised and paid for by the project, possibly under the Food for Work Program.

1.6.2.3 Fisheries Development

It is proposed that the Fish Seed Multiplication Farms in Magura and Jhenida be upgraded. Following is the estimated capital cost for completing one farm.

Item		Cost
Shallow-tube well/Distribution System	Tk	100,000
Laboratory Apparatus/Installation		190,000
Additional Nursery/Rearing Ponds		325,000
Hatchery & Other Buildings		300,000
Cement Breeding Tanks		65,000
Fencing		25,000
Vehicle		240,000
	Tk	1,245,000
	Contingency	250,000
	Total Cost Tk	1,495,000

Consequently, the total capital cost for upgrading both farms will be approximately Tk. 3.0 million.

Additional capital cost for the proposed fisheries development will include about Tk 2,500 for renovating each of the tanks which will support fish cultivation as part of an irrigation system plus about Tk 1000 per tank for collecting gear and maintenance equipment. If all 600 tentatively identified tanks are developed, the total capital costs for this aspect of the program would be about Tk 210,000.

1.6.3 Technical Services

The farmers in the development area have had no prior experience with irrigated agriculture, and they will need substantial technical assistance in the organization, the on-farm management, and in planning and construction of the irrigation and drainage works. Technical assistance would also be required for the fisheries development, for establishing the sources of supply for the needed inputs, for assuring that credit would be available, and for developing a market for the increased production.

It is proposed that this technical assistance be provided by the management consultants. This consultant group would consist of five resident expatriates and seven Bangladeshi specialists supplemented by 42 extension agents. These services would extend over a five year period.

The estimated cost of these services are shown in Table I-6

1.6.4 Operation and Maintenance Costs

1.6.4.1 Regulation Works

The operation of the regulation structures would generally be infrequent but a regular intervals and a full-time operator would not be required for this purpose. However, for security and general purposes, it has been estimated that one person would be assigned full-time to each structure.

No standard maintenance would be required for these structures except for repair or replacement of deteriorated portions. These replacements are estimated to be 20 percent for timber gates and stop logs, 5 percent for channel protection and 5 percent for metal gates.

The main drains would be cleaned twice a year at an annual cost of Tks 300 per mile.

TABLE I-6

TECHNICAL SERVICES

COST ESTIMATE

ITEM	UNIT RATE	QUANTITY	TAKA COSTS	U.S. $
Salaries:				
(Includes Overhead & Benefits)				
Bangladeshi	Tks 4,500/mo.	2202 mos.	10,269,000	
Expatriate	$8,000/mo.	360 mos.		2,880,000
Travel & Allowances				
(Expatriate field staff)	$4,000/mo.	300 mos.		1,200,000
Field & Offices Expenses				
(Includes Vehicle Operations)	Tks 65,000/mo.	60 mos.	3,900,000	
Imported Equipment:				
Vehicles w/spare parts L.S.				67,500
Motor cycles				30,000
Appliances & household effects				210,000
		Totals	Tks 14,169,000	$ 4,387,500

The operations and maintenance costs for the regulation works are summarized in Table I-7.

1.6.4.2 On-Farm Development

The on-farm systems are relatively small and the actual operational requirements would be minimal and infrequent, and would be the responsibility of designated personnel in the group. No costs are assigned to these operations. Some maintenance would be required to replace, repair and clean the structures and channels. The annual channel maintenance is estimated to be Tks 600 per mile or Tks 12 per irrigable acre. Structure costs were estimated to be 10 percent of initial costs or Tks 10 per irrigable acre.

The really significant on-farm cost is the operation of the pumps. It is estimated that the annual pumping will be 3-acre feet per acre. This would consist of 12 inches for the dry season (wheat) crop and 24 inches for land preparation and supplemental irrigations during the wet season for the rice crop. A 2 cfs pump uses approximately 0.6 gallons of diesel per hour at a cost of Tks 22 per gallon. The annual cost for fuel would be Tks 240 per irrigable acre plus an additional Tks 20 for lubrication, spare parts and maintenance. The total pumping cost per irrigable acre would be Tks 260.

1.6.4.3 Fisheries Development

Annual labor costs to operate one of the upgraded seed farms would include the following:

TABLE I-7

ANNUAL OPERATION AND MAINTENANCE COSTS

REGULATION WORKS

Cost Items

Facility	Operating Personnel	Channel Clearing or Protection	Gates or Stop Logs	Total
1. Spillway Structure	Tks 10,000	Tks 15,000	Tks 2,000	Tks 27,000
2. Magura Weir	10,000	15,000	16,000	41,000
3. Control Structures				
Haorkhali Khal	10,000	3,000	8,000	21,000
Alamkhali Khal	10,000	4,000	16,000	30,000
Drain D1N	10,000	4,000	15,000	29,000
Dariapur Khal	10,000	-	-	1,000
4. Main Drains		3,000		3,000
	Totals			Tks 152,000

Personnel		Salary/Year
1 Hatchery Manager	Tk	12,000
1 Aquaculturalist		10,800
4 Field Assistants		31,200
1 Driver		6,600
2 Watchmen		7,200
	Total	67,800

Operating costs for each farm including fertilizer and feed, equipment, transportation and building and pond maintenance are estimated at about Tk 150,000. Consequently, recurrent costs for both farms will be about Tk 435,000.

The major cost associated with the supplemental stocking of project area waters would be the purchase of carp fingerlings:

1,775 acres (at minimum pool elevation) x 2,000 fingerlings/acre x surface area x 0.15 Taka/fingerling = 532,500

For the irrigation fish culture tanks, annual operations and maintenance cost, including gear and tank repair and purchase of fingerlings will be around Tk. 1000 per tank or about Tk 60,000 for all proposed tanks.

1.6.5 Manpower Schedule

With the exception of the technical services program, the development activities would be relatively simple and there would be a minimum need for special skills and talents. The three major structure would be constructed in successive years to extend the construction period, and thereby reduce the peak demands for construction workers, particularly skilled and supervisory personnel. These structures would have no complex design or construction problems and the regular technical staff of BWDB, with the assistance of an expatriate consultant, could prepare the design and contract documents and supervise construction.

There would be a peak demand of 100 skilled construction workers during the first year and diminishing to 20 workers the third year. These workers would be available from the area.

There would be a general demand for 300 to 400 unskilled workers for each of the initial five years of development. These would be used primarily for earthwork, some of which could possibly be done under the Food for Work Program. There would be no shortage of workers for this type work.

The on-farm development would be simple structures and small channels that could be directly implemented by the farmers. These systems would be constructed during a 2 to 3 months period early in the dry season and would require approximately 20 man-days per irrigable acre.

These farmers will require considerable technical advice and assistance in developing irrigated agriculture. This technical service would be provided by five expatriate and seven Bangladeshi consultant supplemented by 42 extension agents. It is intended that these agents would be deputed to the development by appropriate government agencies.

1.6.6 Material and Equipment Schedule

With the exception of irrigation pumps, no special materials or equipment would be required for the development. Following is a tabulation of the principal materials needed for the construction program:

	DEVELOPMENT YEAR			
Item	1	2	3	Total
Cement, bags	20,000	12,000	2,000	34,000 bags
Reinforcement Steel, lbs.	190,000	1,200,000	60,000	1,450,000 lbs.
Brick Masonry, CFT	20,000	5,000	3,600	28,600 CFT
Aggregate, CFT	90,000	50,000	8,000	148,000 CFT

There would be a requirement of 154 tons of steel sheet piling. This would be available from a curtailed project in khulna. There is also a requirement for 20,500 LF of timber piles. Such piles are normally provided by the commercial operations in the Sundarban Forest, and with sufficient notice they could supply the above demand.

The construction work would be labor intensity and the only equipment that would be needed are a few concrete mixers and de-watering pumps, and a crane to handle the steel sheet piling. Such equipment is available for rental from BWDB and other government agencies.

The control gates would be fabricated by MEO or local shops using available stock.

The only materials or equipment which would be imported directly for this development would be some equipment for improving the fish hatcheries and five vehicles and 25 motorcycles for the technical services group.

The irrigating pumps would be purchased directly by the farmers from the local distributors from their regular inventory. Following is a tabulation of these requirements:

DEVELOPMENT YEAR	NOS. OF PUMPS REQUIRED
1	8
2	24
3	48
4	96
5	168
6	96
7	60
Total	500

The requirements for agricultural inputs would progressively increase during the development years until the maximum requirements are reached in year eight. Following is a tabulation of these requirements for the critical inputs:

Input	DEVELOPMENT YEAR 1	2	3	4	5	6	7	8
HIGH YIELD VARIETY SEEDS - In Tons								
Wheat	13	52	130	290	560	720	820	820
Aus	-	1	4	11	24	48	60	70
Jute	-	-	1	2	3	7	8	10
T. Aman	-	1	5	12	27	53	68	78
FERTILIZERS - In Tons								
Urea	24	120	336	768	1560	2350	2820	3000
TSP	21	108	304	696	1415	2130	2560	2730
MP	12	62	177	406	830	1270	1530	1640
FUEL - In 1000 Gallons								
Diesel	5	21	52	114	223	285	324	324

LIST OF REFERENCES - ENGINEERING

Numerous reports and references were reviewed during this study. A selected list of these references is compiled at the end of this volume. Following are the primary references and sources of data used in the engineering studies:

TOPOGRAPHIC DATA

- 4" = 1 mile topographic maps
- 1:30,000 aerial photos, 1975
- Surveys by BWOD for Southwest Regional Study
- Surveys by TAMS/CIL
- Survey data available in BWOD Field Office

HYDROLOGIC DATA

- BWDB Surface Water Hydrology Directorate
- BWDB Groundwater Circle
- EPWAPDA Master Plan, 1964

GEOPHYSICAL DATA

- BWDB River Research Institute Report Number: Soils 20(80), 1980
- EPWAPDA Hydraulic Research Laboratory Report Number: Soils 15(62), 1962

COST DATA

- BWDB Schedule of Rates, 1979-80 for Coastal Embankment Project
- Islam, Md. S. & Mazed, M.A. Comparison of Performance of Different Types of Manual Pumps, BARI, 1980
- KSB Low Pressure Centrifugal Pumps Leaflet BD7
- Rahman, Mohibur, Use of Diesel and Electrical Operated Pumps for Irrigation, 1975

LIST OF REFERENCES - FISHERIES

Bureau of Consulting Engineers, 1976, Preliminary Feasibility Report on Inland Fisheries Project in the District of Jessore. Directorate of Fisheries, Dacca. 155 pp.

FAO/UNDP. 1977. Agriculture Mission. March-April 1977: Fisheries Sector. Working Paper No. IV. 34 pp.

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CHAPTER II
SOILS AND AGRICULTURE

II SOILS AND AGRICULTURE

2.1 Soils

The soils of the study area have developed from alluvial sediments of the Ganges meander flood plain. The nearly level to very gently undulating landscape comprises an extensive system of broad ridges, inter-ridge depressions, infilled channels and broad basins. The old sediments (77% of the area), decalcified to a variable depth, are mainly medium to fine textured on the ridges and fine textured in the depressions, channels and basins. The young sediments (22% of the area) are predominantly silty and calcareous. Peat basins (1%) with organic deposits of a variable thickness overlie the Ganges sediments in some abandoned meander loops.

The upper parts of the ridges are above normal flood level and usually become intermittently wet or very shallowly (up to 1/2 foot) flooded only during heavy rainfalls. The lower parts of the ridges, the inter-ridge depressions, edges of the infilled channels and basin margins are shallowly (1-3 feet) flooded during the monsoon season. The bottoms of the infilled channels and basins are seasonally moderately deeply (3-6 feet) to deeply (more than 6 feet) flooded. The flooding is caused mainly by the rain water. Most of the ridges become droughty in the dry season and the basins often remain wet in the early part of the dry season. Some basin bottoms and local depressions are almost perennially wet.

2.2 Land Capability

A soil survey of the study area has been undertaken by the Department of Soil Survey, Dacca. In the Soil Survey Report completed in 1980 (Appendix of this Study), the soils were grouped according to their properties, topography and hydrological conditions into land capability classes, subclasses and units indicating their suitability for sustained cultivation of crops adapted to local conditions.

The land capability class II (good agricultural land) encompasses 62.8% of the study area, class III (moderate agricultural land) 14.9% and class IV (poor agricultural land) 3.8%. Classes I and V were not recognized. Settlements occupy 16.8% and water bodies cover the remaining 1.7% of the area.

The land capability subclasses represent soils having the same limitations for agricultural use. The primary limiting factor in the study area is flooding. About 46% of the land is subject to flooding for more than 15 days at a time (subclass W). Soils which are not normally flooded or which are intermittently flooded for a period of less than 15 days (subclass D) amount to 54%.

The land capability units group soils suitable for similar cropping sequences and management practices. The Soil Survey Report recognized 7 units within the class II, 16 units within the class III and 3 units within the class IV agricultural land. Soil texture characteristics and related internal drainage were used as main criteria in determining the best suitable cropping systems (see details in the Appendix). Because of the intricate distribution throughout the study area these units could not be individually shown on the semi-detailed map attached to the Soil Survey Report. Instead, generalized land capability mapping units were used.

Each land capability mapping unit (subunit) comprises several land capability units and reflects the predominant textural properties of the included soils, land topography and hydrological conditions. The mapping units and their distribution in the study area are presented in Table II-1.

From the 63,500 acres of net cultivatable land only about 3,600 acres (units 5a, 5b, 5c, 6 and 7) is presently considered unsuitable for the proposed irrigation system, because of irregular relief. The remaining land could be planted with irrigated dryland or wetland crops in accordance with local conditions. However, it is not expected that the lowlift pump system could

Table II-1 Land Capability Mapping Units and Their Distribution

Mapping Unit	Description of Unit	Study Area acres	LLPD Area acres
1a	Seasonally intermittently wet highland with medium to moderately fine textured soils	16,300	14,400
1b	Seasonally intermittently wet highland with moderately fine to fine textured soils	6,100	4,500
1c	Seasonally intermittently wet highland with fine textured soils	8,900	3,400
2a	Seasonally shallowly flooded land with medium to moderately fine textured soils	1,500	1,400
2b	Seasonally shallowly flooded land with moderately fine to fine textured soils	4,400	2,400
2c	Seasonally shallowly flooded land with fine textured soils	11,900	4,800
3	Non-flooded droughty highland with moderately coarse to medium textured soils	200	-
4	Seasonally intermittently wet highland with moderate river erosion hazard and moderately coarse to medium textured soils	200	200
5a	Seasonally intermittently wet highland with irregular relief and moderately coarse to medium textured soils	200	200
5b	Seasonally intermittently wet highland with irregular relief and medium to moderately fine textured soils	1,600	1,600
5c	Seasonally intermittently wet highland with irregular relief and moderately fine to fine textured soils	800	200
6	Seasonally intermittently wet highland and shallowly flooded land with irregular relief and medium to moderately fine textures soils	800	500

Mapping Unit	Description of Unit	Study Area acres	LLPD Area acres
7	Seasonally shallowly flooded land with irregular relief and moderately fine to fine textured soils	200	-
8	Seasonally moderately deeply flooded land with moderate river erosion hazard and moderately coarse to medium textured soils	100	100
9a	Seasonally moderately deeply flooded land, early draining in dry season, with moderately fine textured soils	Minor	Minor
9b	Seasonally moderately deeply flooded land, early draining in dry season, with moderately fine to fine textured soils	300	Minor
9c	Seasonally moderately deeply flooded land, early draining in dry season, with fine textured soils	4,400	2,200
10a	Seasonally moderately deeply flooded land, slowly draining in dry season, with moderately fine to fine textured soils	100	100
10b	Seasonally moderately deeply flooded land, slowly draining in dry season, with fine textured soils	2,700	1,300
11	Seasonally moderately deeply and deeply flooded wetland with fine textured soils and flood hazard	2,100	900
12	Seasonally deeply flooded land with fine textured soils and severe flood hazard	100	-
13	Seasonally moderately deeply to deeply flooded land with flood hazard, perennial wetness and low bearing capacity (peat)	600	-
	Total Cultivatable Land	63,500	38,200

reach lands much beyond a 1 mile range from the Nabaganga reservoir. It is, therefore, estimated that the low-lift pump development area (LLPDA) would amount to about 38,200 acres. The extent of individual land capability mapping units within the LLPDA as determined from the Land Capability Map by planimetry is shown in Table II-1.

Most of the LLPDA consists of non-flooded highlands and seasonally shallowly flooded medium highlands suitable for cultivation of dryland rabi crops such as wheat, under irrigation. About 30% of these lands (those with fine textured soils) would be also suitable for boro rice if water supply for irrigation was not limited. However, the soil survey team reported percolation rates over 5 inches per day in most of the fine textured soils tested during the dry season. These soils contain an appreciable amount of swelling clays (mainly montmorillonite and illite) which shrink under dry conditions and develop a network of interconnected cracks spreading from the surface throughout the subsoil. Under continuous flooding the clays swell, the cracks gradually close up and the infiltration rates go down. But the first month of irrigation, approximately one half of the water supplied to keep the land flooded percolates through the soil profile so that irrigation has to be repeated very frequently. It has been estimated that the total irrigation water demand for boro cultivated on soils with a basic infiltration rate of 4.8 inches per day would exceed 85 inches for short-term varieties and 100 inches for late maturing varieties. Inadequate water supply would result in considerably lower yields and waste of inputs. Lack of water during critical periods could bring about a total loss of the crop.

A ploughpan (compacted layer of soil particles) would considerably decrease percolation losses. However, formation of the ploughpan is a long process requiring frequent puddling and the technical know-how is yet inadequate, as transplanting is a relatively new practice in the project area. In addition, high content of calcium carbonate in many of the soils make puddling extremely difficult.

For these reasons cultivation of boro rice on the highlands and medium highlands is not recommended. Boro could be successfully grown on the remaining lowlands and medium lowlands (units 9b, 9c, 10a, 10b and 11) if irrigation water is available.

2.3 Crop Water Requirements

In order to determine the extent of the area that can be irrigated by the LLP system drawing water from the Nabaganga reservoir, water requirements by major crops have been determined according to the FAO Irrigation and Drainage Paper No. 24 (1977), using the modified Penman method for predicting the Reference Crop Evapotranspiration (ETo).

Based on the water requirements shown in Table II-2 and the data on water availability in Section 1.2, it has been estimated that under good water management and average weather conditions the water from the Nabaganga reservoir would be sufficient for irrigation of about 30,000 acres of wheat. No water from the LLP system would be available for possible cultivation of boro on lowlands and medium lowlands.

It is anticipated that the LLP system would be available not only for the full-scale irrigation of the wheat crop, but also for supplemental irrigation of subsequent crops during drought spells. If more water is available than presently projected, a corresponding acreage of boro could be planted on medium lowlands and lowlands close to the water source.

2.4 Proposed Cropping Patterns

The proposed cropping patterns are based on the land capability mapping units described in Table II-1, on the existing crop management practices reported in the Present Agriculture and Socio-Economic Conditions (a survey report from Phase I of this study) and on projected socio-economic development possibilities in the study area. Four main cropping patterns, A,B, C and D, are designed for use under irrigated management and another four, A',B'C' and D' for rainfed management.

Table II-2 Water Requirements[1] by Wheat and Boro

Month	Crop	Period (Days)	ET crop / Period (inches)	Effic. Rain (inches)	Soil Water (inches)	Water Deficit (inches)	W. Delivery Requirement[2] (inches/acre)
Nov.	wheat	10	0.6	-	0.6	-	-
Dec.	wheat	31	2.6	-	1.0	1.6	2.5
Jan.	wheat	31	4.4	-	2.0	2.4	3.7
	boro[3]	31	4.6	-	-	4.6	0.4*)
Feb.	wheat	28	5.4	-	2.6	2.8	4.3
	boro[3]	10	2.0	-	-	2.0	0.2*)
	boro	18	3.7	-	-	3.7	4.9 & 7.0 (LP)
Mar.	wheat	15	2.0	-	1.0	1.0	1.5+)
	boro	31	9.9	1.0	-	8.9	11.9
Apr.	boro	30	11.7	2.7	-	9.0	12.0
May	boro	31	10.4	4.6	-	5.8	7.7

Notes:

1) Detailed calculations of water requirements by major crops throughout the year can be found in Appendix C.

2) The water delivery requirements are based on an assumed 65% irrigation efficiency (wheat) and 75% efficiency (boro).

3) Seedbeds.

*) Seedbeds will occupy only about 7% of the boro area.

+) Actual delivery will take place at the end of February.

(LP) Water needed for land preparation.

Their schematic form is convenient for feasibility analyses as well as for the Proposed Land Use Map showing their potential distribution. At the same time, the patterns are flexible enough to permit modifications for management application in accordance with specific local conditions.

2.41 Cropping Patterns for Irrigated Management

The limited source of irrigation water can be utilized in two ways: it can be exhausted by irrigating an extended area (up to 30,000 acres) of the first crop in the dry season, or some water can be saved for subsequent crops by limiting the extent of the first crop. Although the latter alternative could greatly improve crop management in selected areas it seems very unlikely that many farmers would give up the opportunity to have at least one fully irrigated crop so that others could irrigate two crops. The following cropping patterns are, therefore, based on the assumption that all water will be used for irrigation of the first rabi crop, such as wheat. Other crops will receive supplemental irrigation as soon as the water reserve is replenished.

Cropping Pattern A:

wheat - aus/jute - (arif dryland crops)

is proposed for unit 1a, seasonally intermittently wet highland with medium to moderately fine textured soils.

Wheat, HYV, will be sown in mid-November and fully irrigated by the LLP system throughout the growing season. In accordance with specific local conditions (soils, socio-economic situation) the wheat crop can be to a certain extent replaced with other cash crops of comparable growth requirements such as tobacco, spices, oilseeds and soybeans, and with locally more water available, vegetables and fast growing fruits. As a long-term crop, sugarcane can under favorable marketing conditions substitute for a limited acreage of wheat and the subsequent crops in the pattern.

Aus rice, HYV, will be broadcast or sown in lines at the beginning of the rainy season (March-April). Basically, rainfed,

it will receive supplemental irrigation later in the growing season (April-July) from the replenished Nabaganga LLP system. Jute can replace aus to an extent given by favorable marketing conditions.

Only a few kharif dryland crops can be successfully grown in the monsoon season even on the better drained land. Maize appears to be the most suitable crop for conditions where planting dates are uncertain. It can be grown for green fodder in 45 to 60 days, green cobs in 60 to 80 days or grain in 90 to 120 days. The short-term options would be especially convenient after a delayed harvest of the preceeding aus crop. Cost and availability of seed might be a drawback for the green-fodder option. Soybeans and kharif vegetables would be grown only if early rains or exceptional water supply permitted to sow the preceding aus crop in mid-March and harvest it by the end of July.

Cropping Pattern B:

wheat - (short-term crops) - transplanted aman

is proposed for units 1b and 1c, seasonally intermittently wet highland with moderately fine soils, and units 2a, 2b and 2c, seasonally shallowly flooded land with medium to fine textured soils.

Wheat, HYV, will be sown in mid-November and fully irrigated by the LLP system throughout the growing season. Other rabi crops such as oilseeds, pulses and spices can replace the wheat crop to some extent. Sugarcane can be cultivated only on the better drained highlands.

Cultivation of short-term dryland crops such as sunflowers, til (sesame) and some green-fodder crops is subject to early rains (March), residual soil moisture or residual irrigation water supply in the Nabaganga LLP system. The growing period of these crops cannot be much extended or delayed if the optimum yield of the following crop is to be secured.

Transplanted aman rice, HYV, will be sown (seedbed) in mid-June and transplanted in mid-July. Although basically rainfed,

it will receive supplemental irrigation from the LLP system whenever needed, namely during prolonged dry spells.

Cropping Pattern C:

boro - transplanted deep water aman

is proposed for units 9c, 10a and 10b, seasonally moderately deeply flooded land with moderately fine to fine textured soils and units 8 and 11, seasonally moderately deeply and deeply flooded land with flash-flood or erosion hazard.

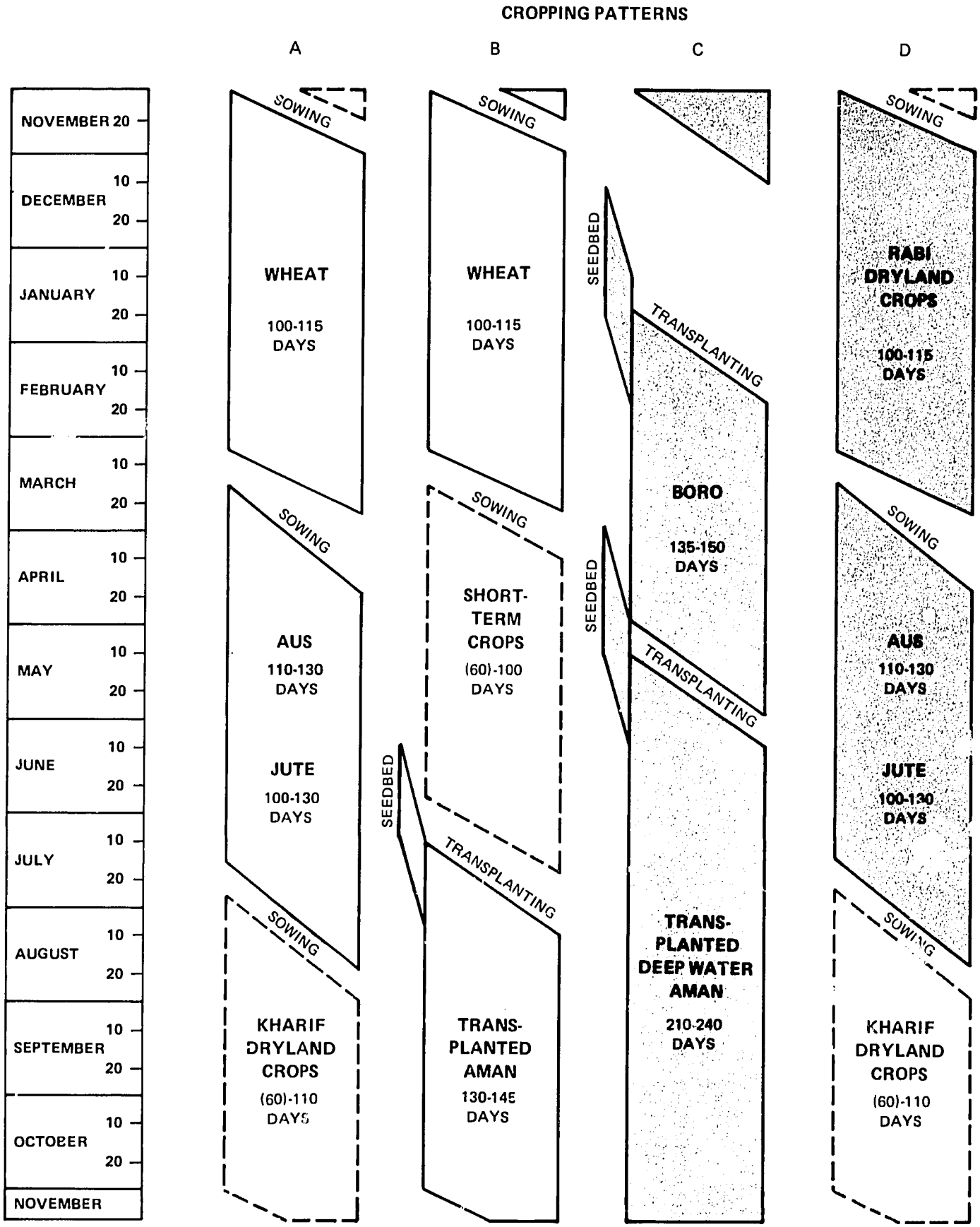
Boro rice, HYV, can be sown (seedbed) in early January and transplanted in mid-February. However, cultivation of boro is subject to water availability from the LLP system or from shallow tubewells.

Transplanted deep water aman rice, LIV, can be sown in April (seedbed) and transplanted in May to early June. Transplanting is necessary in order to accommodate both crops in the cropping pattern. Boro and aman have relatively long life cycles and will compete for the same land in April and May. For this reason the aman seedbeds would have to be placed elsewhere. With improved drainage and consequent prevention of deep flooding, some of the deep water aman (about 1,400 acres) could be replaced by transplanted aman (HYV).

Cropping Pattern D:

rabi dryland crops - aus/jute - (kharif dryland crops)

is proposed for units 5a, 5b, 5c and 6, seasonally intermittently wet highland with irregular relief and mainly medium to moderately fine textured soils, and for unit 4, with moderately coarse to medium textured soils and moderate river erosion hazard. Because of the irregular relief, it is not anticipated that the crops in this cropping pattern would directly benefit from the LLP system. Mainly small-scale irrigation by hand pumps and other simple means will be possible in the nearest future. The proximity of the Nabaganga primary system may to some degree offset the disadvantage of the irregular landscape. The dryland rabi crops can include wheat, tobacco, spices, oilseeds, pulses, soybeans, vegetables and fast growing fruits. Maize, soybeans and



CROPPING SCHEDULE FOR IRRIGATED MANAGEMENT

vegetables can be among the kharif dryland crops. Sugarcane can in some areas replace the whole crop sequence. Crop management would substantially improve after ground levelling.

The extent of individual cropping patterns is given in Tabel II-3 and their distribution throughout the LLPDA can be found in the Proposed Land Use Map (in cover pocket).

Table II-3 Acreage of Cropping Patterns under Irrigation

Area under Proposed Cropping Pattern A	14,400 acres
Area under Proposed Cropping Pattern B	15,600 acres
Area with Potential for Cropping Pattern C	5,500 acres
Area with Potential for Cropping Pattern D	2,700 acres
Total Area of Low-Lift Pump Development	38,200 acres

The Cropping Schedule shown in Figure II-1 is designed for the maximum use of land in the LLPDA. It is based on the assumption that the crop water requirements can be fulfilled either by rain or irrigation. However, the present estimates of dependable precipitation and the projected water reserve in the Nabaganga system indicate a possible water deficit in March for the dryland crops and a total lack of water for boro. Under such circumstances the boro crop in the cropping pattern C and the short-term dryland crops in B could not be grown and also the kharif crops in A would have to be omitted due to delayed cultivation of the rain-dependent aus. The wheat and aman crops would remain unaffected, the aus crop would be delayed in accordance with the onset of the rainy season and the cropping pattern C would be replaced by C' (rainfed management).

If more water is available in March than presently projected, at least some of the aus crop could be planted immediately

after wheat and some of the kharif crops following aus could be grown. The water delivery requirement for land preparation is about 3 inches per acre and the requirement for irrigation of the aus crop in March (second half) another 3.1 inches at 65% irrigation efficiency. With more water available than needed for aus, some of the short-term dryland crops in the cropping pattern B could be sown. The total water delivery requirement for land preparation and irrigation of sunflowers in the second half of March is 4.2 inches per acre.

While the LLP irrigation system would be available for all the crops in cropping patterns A and B, additional development would be needed for irrigation of boro on the lowlands. It is believed that a considerable amount of water could be drawn by means of shallow tubewells from the ground water reserve which might be partially replenished by water percolating from the surrounding highlands with irrigated wheat. However, the available data on the ground water reserve in the study area are inconclusive to justify a project extension at the present time.

2.42 Cropping Patterns for Rainfed Management

Flooding in the monsoon season and severe water deficiency in winter are the dominant factors shaping crop management in the study area. In the first typical existing pattern (about 30% of the cultivated land) deep water aman rice is broadcast on the lands affected by flooding throughout most of the growing season. After the harvest part of the land is planted with short-term rabi crops and the rest remains fallow. In the second pattern (30%) broadcast aus rice is followed by transplanted aman, rabi crops or a fallow. In the third pattern (20%) jute is followed by rabi crops or a fallow. Sugarcane, transplanted aman, rabi crops and some spices cultivated as a sole crop in a year cover most of the remaining land. Triple cropping is practiced on less than 2%

of the cultivated land. The proposed cropping patterns indicate possible improvements in rainfed crop management.

Cropping Pattern A':

(rabi dryland crops) - aus/jute -(kharif dryland crops)

is proposed for seasonally intermittently wet highland with medium to moderately fine textured soils (unit 1a) and droughty highland with moderately coarse to medium textured soils (unit 3).

Rabi dryland crops may include wheat, barley, pulses, oilseeds, spices, tobacco and the drought-tolerant millets and sorghum. They should be planted as early as possible in order to utilize the residual soil moisture. The length of the growing season and yields will mainly depend on the moisture-holding capacity of individual soils and on the proximity of the ground water table. Some special crops such as castor beans, turmeric, ginger, cashew-nuts and jack-fruit trees could be suitable for the droughty unit 3.

Aus/jute will be planted at the beginning of the rainy season (March-April). Limited acreage, can be also planted with til (sesaem), sunflowers and early kharif vegetables.

Kharif dryland crops such as maize, soybeans, groundnuts and vegetables can be planted immediately after the harvest of the previous crops. If the planting is delayed, they can be grown to full maturity only at the expense of the following rabi crops. Maize for green fodder or green cobs can be accommodated between aus and rabi crops even if the land is available for only 60 days.

Cropping Pattern B':

(rabi short-term crops) - aus/jute - transplanted aman

for seasonally intermittently wet highland with moderate fine to fine textured soils (units 1b and 1c) and for seasonally shallowly flooded land with medium to fine textured soils (units 2a, 2b and 2c). Rabi short-term crops are subject to

timely harvest of t. aman and residual soil moisture. Aus and jute will be planted at the beginning of the rainy season and the aman crop can be transplanted immediately after their harvest.

Cropping Pattern C':

(rabi short-term crops)- aus mixed with deep water aman

for seasonally moderately deeply and deeply flooded land (units 9b, 9c, 10b, 11, 12 and 13). Rabi short-term crops are subject to timely harvest of the aman crop and availability of residual soil moisture. Aus and deep water aman seeds can be mixed and broadcast at the beginning of the rainy season (March-April). The aus crop is harvested before the floods come. The deep water aman crop is left in the field to continue its growth with the rising flood water level and complete its life cycle in October-December.

Cropping Pattern D':

(rabi crops)- aus/jute - broadcast aman

for seasonally intermittently wet highland and shallowly flooded land with irregular relief and moderately fine to fine textured soils (units 5c, 6 and 7). Aus is the main crop of the pattern. It can be broadcast in a mixture with aman (deep water aman) and cultivated in a similar manner as in C' on flooded lands. Rabi crops are subject to soil moisture availability, which can become locally critical quite early in the dry season due to irregular topography. Drought-tolerant crops such as sorghum and millets could help to solve the problem.

The extent of individual cropping patterns is given in Table II-4 and their distribution can be found on the Proposed Land Use Map.

Table II-4 Acreage of Rainfed Cropping Patterns

Area with Potential for Cropping Pattern A'	1,500 acres
Area with Potential for Cropping Pattern B'	13,600 acres
Area with Potential for Cropping Pattern C'	9,100 acres
Area with Potential for Cropping Pattern D'	1,100 acres
Total Area outside LLPDA	25,300 acres

2.5 Crop Production

Yield of individual crops (mds/acre) and cropping intensity (number of crops/acre/year) are the most important indicators of crop production. Cropping intensity is derived from the optimum combination of crops in a cropping pattern, but its evaluation as a single indicator can be misleading. Two long-term crops may produce more than three short-term crops under some circumstances. Crop yield is a result of several factors including the inherent qualities of a crop (seed), temperature, water availability, soil fertility and availability of inputs such as fertilizers, pesticides, etc.

2.51 Existing Conditions

The existing crop production in the study area is characterized by mediocre cropping intensity (148%) and low yields (see Appendix C) reflecting limited inputs and a strong dependence on monsoon rains. Only about 4% of the cultivatable land is irrigated, mainly by water from deep tubewells. Rice is by far the most important crop in terms of acreage (60% of the cropped land) and total value of production (65% of the total value received from all crops). Jute is the second most important crop with an acreage covering about 14% of the cropped area and total value that is 18% of the total crop production. Local pulses, oilseeds, spices, vegetables,

sugarcane and some special crops make up the rest of the cropped acreage (26%) and total value (17%). Wheat is successfully grown in some areas but its extent is still rather limited (2% of the cropped land). The rice crop is predominantly cultivated as broadcast aus (40%) and broadcast aman (38%). The mixture of the two is broadcast on only 2% of the rice land. About 20% of rice is transplanted, almost exclusively during the aman season. The acreage of boro is insignificant.

2.52 Production with the Proposed Project

Because water availability to crops is during part of the year a limiting factor in agricultural production, irrigation is the key element for future development of the study area. Under irrigation the cropping intensity can be considerably increased and high yielding varieties of major crops introduced. With sufficient water supply such varieties can make full use of fertilizers and their yield potential. On the remaining land without irrigation only modest improvements can be expected.

From the 38,200 acres of net cultivatable land within the LLPD area only the land proposed for cropping patterns A and B (30,000 acres) will receive direct benefits from irrigation by the LLP system. Because of the limited water supply and uncertain weather conditions in March only the crops that can be grown with a higher degree of reliability, i.e., wheat, aus, transplanted aman and jute, have been selected for computation of benefits derived from irrigation under this project. The cropping patterns in which these crops are incorporated are listed in Table II-5. The existing and projected yields as well as total production are shown in Table II-6 and cropping intensity in Table II-7. Main agronomical benefits derived from the project are summarized in Table II-8.

Table II-5 Cropping Patterns for LLP-Irrigated Land

Cropping Pattern	Crops in the Cropping Pattern	Projected Area acres
A	wheat[1)]-aus[2)]-(kharif dryland crops)[4)]	9,400
A	wheat[1)]-jute[2)]-(kharif dryland crops)[4)]	5,000
B	wheat[1)]-(short-term crops)[5)]-t.aman[3)]	15,600
	Total Area under LLP Irrigation	30,000

Notes:
1) Full-scale irrigation throughout the wheat crop growing season.
2) Supplemental irrigation during the later growth stages, starting as soon as water is available from the replenished Nabaganga reservoir.
3) Supplemental irrigation during dry spells in the monsoon and post-monsoon seasons.
4) Subject to timely harvest of the preceding aus crop, which is dependent on early rains.
5) Subject to water availability from the Nabaganga reservoir or from early rains (mid-March).

Table II-6 Crop Production from LLP-Irrigated Land

Crop	Projected Area	Present Yield	Projected Yield	Projected Production
	acres	mds/acre	mds/acre	maunds
wheat	30,000	(8)	35	1,050,000
t. aman	15,600	(17)	60	936,000
aus	9,400	(15)	35	329,000
jute	5,000	(13)	25	125,000

Table II-7 Cropping Intensity[1)]

Present Cropping Intensity in the Study Area	148%
Projected Cropping Intensity in the Area of 30,000 acres with LLP-Irrigated wheat, t. aman, aus and jute	200%

Notes:

1) $\text{Cropping Intensity} = \frac{\text{Cropped Area}^{2)}\ \text{(acres/year)}}{\text{Cultivatable land (acres)}} \times 100$

2) Cropped Area = 1st crop (acres) + 2nd crop (acres) + 3rd crop (acres)/year

Table II-8 Main Agronomical Benefits from the Project

1) Introduction of an extra crop, high yielding wheat, on the land which is at present fallow or scarcely cropped during the dry season.

2) Introduction of high yielding aus rice in areas where mostly low yielding local varieties are cultivated under uncertain rainfall conditions.

3) Introduction of high yielding varieties of transplanted aman rice where either low yielding local varieties of t. aman are cultivated or low yielding traditional varieties of b. aman are boradcast under conditions of flooding and irregular rain with drought spells.

4) Introduction of improved varieties of jute with higher yields secured by supplemental irrigation.

5) Better crop management with less flood damage and higher net yields resulting from improved drainage in the LLPD area and some parts of the study area outside the LLP irrigation scheme.

Overall Benefit: Increased Crop Production

Under favorable circumstances (more rain or irrigation water available than presently estimated), additional benefits could be obtained from full materialization of the proposed cropping patterns A, B, C and D as described in Section 2.41 and Table II-5. On the rainfed land outside the LLPD area improvements are possible to the extent indicated in section 2.42 if the farmer is given an incentive to risk higher inputs under conditions of uncertain precipitation.

2.53 Implementation of Production Goals

The projected acreage, yields and total production of the four major irrigated crops (Table II-6) and the projected cropping intensity of 200% will be achieved through gradual development over several years. The Implementation Schedule shown in Table II-9 is based on the development of pump units discussed in Chapter IV and on predicted conditions expected to arise from the complicated process of introducing new technology and management practices.

If the implementation program starts in the spring of 1981, the first crop planted under the newly developed LLP irrigation system will be wheat in the rabi season 1981-82. The following spring and summer of 1982 the first aus, jute and transplanted aman crops with supplemental irrigation will be grown. It is expected that in the first year of cultivation only 60% of the areas already available for irrigated wheat and transplanted aman will be actually planted (Acreage Factor). Full cropping of the developed land is anticipated by the third (wheat) to fifth (t. aman) years. Aus and jute are well established in the area and no delays in complete cropping are foreseen. The development of the yield potential (Yield Factor) is planned to take five years. The total area of 30,000 acres proposed for irrigation by the LLP system is thus expected to reach its full productivity by the twelfth year of the implementation program.

TABLE II-9 IMPLEMENTATION SCHEDULE FOR IRRIGATED CROP PRODUCTION

YEAR OF IMPLEMENT.	WHEAT AREA ACRES	WHEAT (YIELD)*) (MDS/ACRE)	AUS AREA ACRES	AUS (YIELD)*) (MDS/ACRE)	JUTE AREA ACRES	JUTE (YIELD)*) (MDS/ACRE)	T.AMAN AREA ACRES	T.AMAN (YIELD)*) (MDS/ACRE)
1								
	480	(10.5)	-		-		-	
2								
	480	(16.8)	150	(21.0)	80	(15.0)	250	(18.0)
	1,440	(10.5)	-		-		-	
Sub-total	1,920		150		80		250	
3								
	480	(28.0)	150	(24.5)	80	(17.5)	250	(25.2)
	1,440	(16.8)	450	(21.0)	240	(15.0)	750	(18.0)
	2,880	(10.5)	-		-		-	
Sub-total	4,800		600		320		1,000	
4								
	480	(31.5)	150	(28.0)	80	(20.0)	250	(38.4)
	1,440	(28.0)	450	(24.5)	240	(17.5)	750	(25.2)
	2,880	(16.8)	890	(21.0)	490	(15.0)	1,500	(18.0)
	5,760	(10.5)	-		-		-	
Sub-total	10,560		1,490		810		2,500	
5								
	480	(35.0)	150	(31.5)	80	(22.5)	250	(48.6)
	1,440	(31.5)	450	(28.0)	240	(20.0)	750	(38.4)
	2,880	(28.0)	890	(24.5)	490	(17.5)	1,500	(25.2)
	5,760	(16.8)	1,780	(21.0)	980	(15.0)	3,000	(18.0)
	10,080	(10.5)	-		-		-	
Sub-total	20,640		3,270		1,790		5,500	
6								
	1,920	(35.0)	150	(35.0)	80	(25.0)	250	(60.0)
	2,880	(31.5)	450	(31.5)	240	(22.5)	750	(48.6)
	5,760	(28.0)	890	(28.0)	490	(20.0)	1,500	(38.4)
	10,080	(16.8)	1,780	(24.5)	980	(17.5)	3,000	(25.2)
	5,760	(10.5)	3,130	(21.0)	1,710	(15.0)	5,240	(18.0)
Sub-total	26,400		6,400		3,500		10,740	
7								
	4,800	(35.0)	600	(35.0)	320	(25.0)	1,000	(60.0)
	5,760	(31.5)	890	(31.5)	490	(22.5)	1,500	(48.6)
	10,080	(28.0)	1,780	(28.0)	980	(20.0)	3,000	(38.4)
	5,760	(16.8)	3,130	(24.5)	1,710	(17.5)	5,240	(25.2)
	3,600	(10.5)	1,780	(21.0)	980	(15.0)	3,000	(18.0
Sub-total	30,000		8,180		4,480		13,740	
8								
	10,560	(35.0)	1,490	(35.0)	810	(25.0)	2,500	(60.0)
	10,080	(31.5)	1,780	(31.5)	980	(22.5)	3,000	(48.6)
	5,760	(28.0)	3,130	(28.0)	1,710	(20.0)	5,240	(38.4)
	3,600	(16.8)	1,780	(24.5)	980	(17.5)	3,000	(25.2)
	-		1,220	(21.0)	520	(15.0)	1,860	(18.0)
Sub-total	30,000		9,400		5,000		15,600	
9								
	20,640	(35.0)	3,270	(35.0)	1,790	(25.0)	5,500	(60.0)
	5,760	(31.5)	3,130	(31.5)	1,710	(22.5)	5,240	(48.6)
	3,600	(28.0)	1,780	(28.0)	980	(20.0)	3,000	(38.4)
	-		1,220	(24.5)	520	(17.5)	1,860	(25.2)
Sub-total	30,000		9,400		5,000		15,600	
10								
	26,400	(35.0)	6,400	(35.0)	3,500	(25.0)	10,740	(60.0)
	3,600	(31.5)	1,780	(31.5)	980	(22.5)	3,000	(48.6)
	-		1,220	(28.0)	520	(20.0)	1,860	(38.4)
Sub-total	30,000		9,400		5,000		15,600	
11								
	30,000	(35.0)	8,180	(35.0)	4,480	(25.0)	13,740	(60.0)
	-		1,220	(31.5)	520	(22.5)	1,860	(48.6)
Sub-total	30,000		9,400		5,000		15,600	
12								
	30,000	(35.0)	9,400	(35.0)	5,000	(25.0)	15,600	(60.0)

Note: *) Yield (=Adjusted Yield) reflects assumed initial incomplete cropping (Acreage Factor) and possible difficulties arising from the introduction of new management practices (Yield Factor). Detailed computation of Adjusted Yield is shown in Appendix C.

2.6 Recommended Agronomical Practices

The production goals projected in Section 2.5 can be achieved only with good water management and adequate inputs. Without sufficient water supply during the critical growth stages, neither the existing land potential nor the potential of inputs can be efficiently used by the crops.

2.61 Recommended Irrigation Practices

The four crops proposed for irrigation have different water demands and require different water management. Three of them, wheat, aus and jute need only periodical water delivery to keep the soil moist, whereas, transplanted aman grows best when the soil is continuously submerged. Fields should be levelled for all the irrigated crops in order to provide uniform distribution of water and prevent formation of pools after irrigation.

Wheat (HYV) is sensitive to excessive wetness and should be irrigated only when the topsoil is dry 3-4 inches below the surface. For best results the soil should be kept continuously moist until about two weeks before the crop is ripe. Water saturation for more than several hours may damage or completely destroy the crop. For that reason, drains should be provided between plots so as to remove excess water rapidly. On less permeable soils, wheat should be grown on special ridges or raised beds. The most appropriate times to irrigate are: (1) about three weeks after sowing, (2) just before the heading stage and (3) before the grain-filling stage.

Broadcast aus (HYV) will receive supplemented irrigation during the later stages of growth, when the Nabaganga reservoir is replenished. The topsoil should be kept continuously moist until two weeks before harvest. The most critical times for irrigation are same as those for wheat.

Transplanted aman (HYV). The soil should be kept continuously under water (or at least wet) until two weeks after flowering. During tillering (for 3-4 weeks after transplanting) the water level should not be much over 2 inches for most varieties. Only Brrisail (BR-4) can stand 6-8 inches deep water. After tillering, the water level can rise up to 6 inches without detrimental effects.

Jute should be irrigated as needed to keep the soil moist, especially during prolonged drought spells.

2.62 Recommended Inputs

Considerable improvements in existing management practices are necessary to fully utilize the agricultural potential of the land and of the irrigation water made available by the project. High yielding crop varieties (Table II-10), fertilizers (Table II-13) and pesticides (Table II-14) will be among the most effective inputs employed in the proposed crop production, but equal attention must be paid to management practices such as timely planting (Table II-12), sowing in lines, weeding, plant protection, timely harvest, post-harvest processing and storage. Many of the practices, namely irrigation, the use of high yielding varieties and pesticides, sowing in lines and transplanting of aman rice will be new to a number of farmers in the study area. Appropriate training and close cooperation with extension services will be, therefore, prerequisite for successful completion of the project.

Table II-10 Recommended High Yielding Varieties of Selected Crops

Crop	Earlier Varieties	Life Cycle (days)	Later Varieties	Life Cycle (days)
Wheat	Sonalika	100-104	Jupateco-73	109-115
	Sonora-64	100-105	Kalyansona	109-115
	Tanori-71	102-106		
	Norteno	105-107		
	Inia-66	105-108		
Aus	BR-6	106	Asha BR-8	124
	Purbachi	110-115	Mala BR-2	115-125
	Sufala BR-9	115	Brribalam BR-7	115-130
	Chandina BR-1	115-120	Biplab BR-3	130-135
T. Aman	Irrisail IR-20	130-140	Biplab BR-3	140-145
	IR-5	135-145	Brrisail BR-4	140-150
	Mukta BR-11	140-142	Progoti BR-10	145-148
Jute-Desi	C-4, C-5, C-6	100	C-2, C-3	110
	CVE-3/70	100	D-154	105-120
			CVL-1/70	105-120
Jute-Tossa	C.G.	104-112	0-2	114-127
	0-3	109-120	0-4	118-132
	0-5	110-122		

Table II-11 Recommended Seed Rates

Crop	Wheat	Aus	T.Aman	Jute
Seed Rate *) (seers/acre)	55	15	10	4

*) The seed rates will vary to some extent with different crop varieties, local conditions and the quality of seed. Sowing in lines will save seed and make weeding, as well as other field operations, easier.

Table II-12 Recommended Planting Dates

Crop	Range of Dates	Target Date
Wheat (sowing)	November (early December)	November 20
Aus (sowing)	March - April	March 20
T. Aman - Seedbed	June to mid-July	June 10
- Transplanting	July to mid-August	July 10
Jute - Desi (white)	March - April	March 20
- Tossa	April to mid-May	April 15

Table II-13 Recommended[1] Use of Fertilizers Under Irrigation

Crop		Urea[2] seers/acre	TSP[3] seers/acre	MP[4] seers/acre
Wheat (Sonalika)		100	90	50
Aus	BR-1	85	60	50
	BR-2	100	85	50
	BR-3	100	60	35
T. Aman	IR-5	120	85	65
	IR-20	120	120	35
Jute		40	20	60

Notes:

1) The recommendations are based on The Fertilizer Guide by BARC (1979) and the Cropping Calendar by BADC (1978). The doses should be modified in accordance with local conditions, namely soil fertility, previous manuring, rain intensity, flooding, crop varieties, etc.

2) Half the urea should be incorporated into the soil during the last stages of land preparation for planting. The remaining half should be applied as a top-dressing in the following manner:

   Wheat - 1/2 with the first irrigation (3 weeks after sowing), another 1/2 with the second irrigation, just before heading.

   Aus - 1/2 three weeks after sowing, another 1/2 just before heading.

   T. Aman - 1/2 before the first weeding (3-4 weeks after transplanting, another 1/2 before the second weeding (2-3 weeks after the first top-dressing, a few days before heading).

   Jute - one top-dressing when the plants are about six weeks old.

3) TSP = Triple Super Phosphate applied as a base dose during land preparation for planting.

4) MP = Muriate of Potash applied as a base dose during land preparation for planting.

5) The amount of commercial fertilizer can be reduced by 2 seers of urea, 1 1/2 seers of TSP and 2 seers of MP for every 10 maunds (dry weight) of manure or compost applied.

Table II-14 Approved*) Pesticides for Selected Crops

WHEAT

Vitavex-200 for treatment of seed before sowing.

Malathion 57EC spray against aphids.

RICE

Stemborer (conventional liquid): Dicrotophos (Bidrin 85% WM/Carbicron-100), phosphamidon (Dimecron-100), diazinon 50% & 60% EC, fenthion (Lebaycid 50% EC), Sumithion 50% EC, cartap (Padan 50% SP) and monocrotophos (Azodrin 60% WSC).

Stemborer (granular): Diazinon granules (Basudin), Sevin (Sevidol), disulfoton (Solvigum 10 G), thimet (Paddigard 10 G), quinalphos (Ekalux 5 G) and cartap (Padan 10 G).

Pest Complex: Malathion 57% EC, oxydemeton-methyl (Metasystox-R), phosmet (Imidan 50 WP/Safidon 40 WP), carbaryl (sevin 85% SP), fenitrothion 50% EC, methyl-parathion, methyl bromophos (Nexion 25% EC) and formothion (Anthio 25% EC).

Earcutting Caterpillar and Swarming Caterpillar: DDVP/dichlorovos (Nogos/Vapona) and carbaryl (Sevin 85% SP).

Bacterial Leaf Blight: Copper Oxychloride containing 50% metallic copper, and fentiazon (Celdion 50% WP).

Seed Born Disease: Granosan-M/Agrosan 5W.

Blast Disease: Kasugamycin (Kasumin) and Blasticidin.

JUTE

Caterpillar and Apion: Methyl-parathion 50% EC, diazinon 50%/60% EC, carbaryl (Sevin 85% SP), oxydemeton-methyl (Metasystex-R 25% EC) and methyl-bromophos (Nexion 25% EC).

Field Cricket: Heptachlor 40% WP, Dieldrin 50% WP/20% EC and Chlordane 40% WP.

Mites: dicofol (Kelthane 40 MF).

Stem Rot and Anthracnose: Tuzet and mancozeb (Dithane M-45).

Seed Born Disease: Granosan-M/Agrosan 5W.

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*) Approved by the Plant Protection Committee and the Ministry of Agriculture, Bangladesh (1978). Due to the health-hazardous nature of pesticides, their application should be guided by extension specialists.

CHAPTER III
FINANCIAL AND ECONOMIC ANALYSIS

CHAPTER III. FINANCIAL AND ECONOMIC ANALYSIS

3.1 General

In project analysis there are two distinct but complementary aspects which must be considered. One is the total return to society of all resources committed to a project regardless of who receives the benefits or who contributes the inputs. This is the social or economic return of the project and constitutes the basis of the economic analysis. The second is the return to the individual participants of their contributed equity capital. This is the financial analysis.

Following are some important distinctions between economic and financial analysis which were incorporated in this report and used in the data development.

- Economic analysis uses adjusted shadow prices which reflect social values. Financial analysis always uses market prices which include such items as taxes and subsidies.

- Economic analysis treats taxes and subsidies as transfer payments and;

- Interest on capital is not deducted from gross returns in economic analysis while in financial analysis it is treated as a cost.

Each project analyzed, while incorporating standardized analytical methodology, is subject to certain assumptions and conventions representing properties unique to a particular country, region, area or type of project. The following is a brief description of standardized methodology and conventions used in both the financial and economic analysis of this project.

Costs

Cost of the project are initial investment, recurring and replacement costs.

In financial analysis of the project, all the costs have been considered in financial terms while for economic evaluation all costs are presented in terms of their scarcity value, i.e., the opportunity costs to the economy. Market values are shadowed on the basis of demand and supply, and also the elasticity factor to obtain true values of commodities or services. All costs are entered into the analytical stream on the year these would occur, throughout the life of the project.

The costs mentioned above are all direct costs, besides there are also secondary and intangible costs which were not quantified in this analysis.

Land Costs

The market price of land is highly distorted, so caution is necessary for land cost treatment in economic analysis.

In the economic analysis, land cost has been treated as net value of production without project foregone i.e., the net product lost to the economy as a result of withdrawal of land from agricultural use. These costs then become a recurring item in the cost stream.

Labor

Labor component of an agricultural project is easy to identify. But unskilled labor does raise special valuation problems.

Presence of unemployment and under-employment in rural sector and abundance of the supply unskilled labor relative to demand poses certain difficulty in ascertaining the economic cost of unskilled labor. Construction activity in Bangladesh is a seasonal affair, this season also coincides with the peak requirement for agricultural labor. Some off-farm employment opportunity also exists. Accordingly, the unskilled labor costs were shadowed by 0.5 to represent their opportunity costs.

Taxes and Interest

In the economic analysis, all taxes and interest were ignored since these are only transfer payments. A nominal interest rate of 20 percent was used in the financial analysis. This rate is higher than most present commercial rates, but it represents a rate that is sufficient to ensure recovery of loan costs.

Subsidies

In economic analysis, the amount of subsidy was added to the cost of commodity or service to reflect true value.

Input Costs

International prices were used for seeds, fertilizers, insecticides and other tradable products. Normal prices were used for non-tradable items.

Foreign Exchange

The element of foreign exchange was given a premium of 1.2 to consider the scarcity value.

Local Currency

Local currency was taken at par value.

Benefits

An agricultural project can generate three kinds of benefits: (1) direct or primary benefits, (2) secondary benefits and (3) intangible benefits.

For evaluation purpose, only the direct tangible benefits, which can be reliable estimated in monetary terms, were considered. Other secondary or intangible benefits were only described, and if quantified, listed separately.

Evaluation Criteria

Economic evaluation of the Nabaganga Land and Water Use study was determined through internal rate of return, present net worth and benefit/cost ratio.

Sensitivity Analysis

In the economic analysis, a sensitivity analysis was done to evaluate the sensitivity of increase in costs or decrease in benefits on the internal rate of return, net present worth and cost/benefits anslysis of the Projct.

Valuation of Output

Valuation of output is a complex problem, particu - larly for agricultural products in Bangladesh.

The general practice for pricing agricultural products is to distinguish between tradable and non-tradable

output. For non-tradable items, acceptable domestic prices were used. For tradable items, since the Bangladesh market is a protected market,world market prices were used because world markets are more nearly perfect markets than protected markets.

The unit values were taken as follows:

- Market Price at farm-gate during harvesting period for non-tradable items. Government procurement prices for applicable items were also taken.
- International trend price for 1985, adjusted to farm-gate prices, for tradable items such as rice, wheat and jute, and fertilizers. The estimated prices of these four commodities are shown below and the methodology of evaluating these prices are shown on the following page.

IBRD PRICE FORECAST FOR 1985 AT 1980 CONSTANT U.S. $

ITEMS	PRICE 1985 U.S. $/MT
Rice	
Thai; Milled 5% broken FOB Bangkok	423.9
Wheat	
Canadian No. 1, Western Red Spring (CWRS) Ex-Thunderbay	187.8
Jute	
Bangladesh, White D FOB Chalna/Chittagong	394.6
Chemical Fertilizers	
Urea, FOB Europe's Post-Bagged	180.0
TSP, FOB Gulf, USA	165.0
MP, FOB Vancouver	230.0

NOTE:

(a) Price escalation to count to 1979 Price-Add 8%

(b) To adjust quality, deduct 20% for rice and wheat only.

Methodology of Evaluating of Farm-Output/Input Prices

Tradable Items	1985 Prices
Rice/Wheat	
Rice, FOB, Bangkok M/TON	
Medium quality, 25% broken	U.S. $
Wheat, Thunderbay F.O.B.	U.S. $
Add:	
Post charges, shipping and insurance.	
Sub-Total: CIF/Chittagong/Chalna	
Add:	
Post charges, handling transportation to site, marketing, etc.	
Sub-Total:	
Deduct:	
Marketing, processing, transportation	
Sub-Total: Farm-gate Price	
Paddy Equiv. 0.67	
Jute	
Medium to fine-FOB Chalna/Chittagong	U.S. $
Deduct:	
Baling, Shipping, Transportation, etc. (Approx. 35%)	
Sub-Total: Farm-grate price	
Chemical Fertilizers/Pesticides	
Fertilizers/Pesticides FOB Prices N.W. Europe M/TON	U.S. $
Add:	
Insurance and shipping, etc.	
Sub-Total: CIF/Chalna/Chittagong	
Add:	
Part handling, local transportation, storage, marketing, etc.	
Farm-gate cost/Ton	
Farm-gate cost/Md. or lb.	

3.2 Financial Analysis

3.2.1 Farm Budgets

A farm budget was developed representing per acre costs and returns for both a without project (present situation), and for an irrigated project. The without project farm budget represents field conditions, cropping patterns and cropping intensities as indicated through the socio-economic survey of the project area. Tables III-1 to 3 show present production, income and costs per net acre. Cropping intensity is 1.48 and the cropping pattern is more highly diversified than in the irrigated project.

The estimated farm budget resulting from the irrigation project is shown in Tables III-4 through 6. Cropping intensity has been increased to 2.0 and the level of crop diversification has been reduced to four major crops. This cropping pattern was established based on soils and irrigation potential as presented in Chapter II of the report.

Analysis for both the financial and economic analysis was based on costs and returns per net acre farmed. This was determined through analysis of cropping patterns in the project area both at present and under irrigation. Table III-6 represents the adjusted net returns per net acre while Table III-7 represents the project cropping pattern. In addition, since irrigation is an introduced production input into the project area representing not only infrastructure development (distribution channels), but technological innovation and cultural changes, there would be a period of time needed to bring an acre up to full production. On a per acre basis, a six year period is needed to obtain full production (Table III-8). On a project basis, full implementation of irrigation works for 30,000 acres is expected to take seven years with full project production obtained in the 12th year.

TABLE III-1

WITHOUT PROJECT PRODUCTION AND INCOME

(per 100 acres)

Crop	Area (Acres)	Yield (Maunds)	Price Tks	Production (Maunds)	Gross Income (Tks)
B. Aus	35	15.4	170	539	91,630
B. Aman	35	15.2	170	532	90,440
T. Aman	7	17.1	170	120	20,400
Jute	20	13.4	115	268	30,820
Boro	1	15.0	170	15	2,550
Wheat	3	7.9	110	24	2,640
Pulses	18	5.0	150	90	13,500
Oil Seeds	24	4.5	200	108	21,600
Veg/Fruits	1	105	65	105	6,825
Spices	2	40	340	80	27,200
Sugar Cane	2	375	12	750	9,000
	148				316,605

1. Per acre gross income = TK. 3166
2. Cropping intensity is 1.48

TABLE III-2

WITHOUT-PROJECT PRODUCTION COSTS
(In Tks per 100 Acres)

Crop	Area (Acres)	Seed	Fertilizer	Pesticides +Other*	Total Cost
B. Aus	35	141	68	280	17,115
B. Aman	35	111	35	280	14,910
T. Aman (L)	7	82	79	344	3.535
Jute	20	32	87	321	8,880
Boro HYV	1	96	313	344	753
Wheat	3	150	49	146	1,035
Pulses	18	77	6	80	2,934
Oil Seed	24	43	7	67	2,808
Veg/Fruits	1	50	100	150	300
Spices	2	200	100	165	930
Sugarcane	2	560	85	443	2,176
	148				Tks 55,296

* Interest on loans and miscellaneous.

1. Per acre input cost = Tk. 553
2. Cropping intensity 1.48
3. Labor Human Tk. 320
   Animal Tk. 40
   Total Cost Per Acre Tk. 913

TABLE III-3

WITHOUT PROJECT FARM PRODUCTION COSTS - LABOR

Mandays /100 ACRES

CROP	FAMILY	HIRED	TOTAL
B. Aus	1120	630	1750
B. Aman	1120	595	1715
T. Aman	273	126	399
Jute	840	460	1300
Pulses	324	36	360
Boro	41	29	70
Wheat	78	12	90
Oilseeds	456	24	480
Veg. Fruits	54	3	57
Spices	76	4	80
Sugarcane	144	40	184
	4526	1959	6485
Per Acre Mandays	45	20	65

Animal Hire 2 Days x Tks 20

Cost Per Acre. Financial: 20 x Tks 16 = 320 Hired Farm Labor
20 x Tks 20 = 40 Animal Labor
Tks 360

Economic: 65 x Tks 12 = Tks 780 Family and Hired Labor
25 x Tks 15 = Tks 375 Animal Labor

TABLE III-4

Gross Returns Per Irrigated Cropped Acres

Crop	Yield (Md/Ac)	Price (Tks/Md)	Gross Income (Tks)
Wheat	35	110	3850
T. Aman HYV	60	170	10200
Aus HYV	35	170	5950
Jute	25	175	4375

TABLE III-5

Gross Irrigation Cost Per Cropped Acre

(in Tks)

Crop	Seed	Fertilizer	Pesticides	Human	Animal	Irrigation Works	Total Tks/Ac
Wheat	75	230	594	112	40	337	1388
T. Aman HYV	58	225	553	192	40	175	1243
Aus HYV	50	200	550	112	20	105	1037
Jute	20	324	650	64	0	56	1114

TABLE III-5A

IRRIGATED FARM PRODUCTION COSTS-LABOR

Crop	Mandays/Acre		
	Family	Hired	Total
Wheat	16	7	23
Transplanted Aman HYV	26	12	38
Aus HYV	13	7	20
Jute	6	4	10
	61	30	91

Animal Labor Estimated at 5 days Tks 20 per day = Tks 100

FINANCIAL:	30 x 16 = Tks 480	Hired Labor
	2 x 20 = Tks 40	Animal Labor
	61 x 8 = Tks 488	
ECONOMIC:	30 x 16 = Tks 480	Family + Hired Labor
	25 x 20 = Tks 500	Animal Labor

TABLE III-5B

PUMP SETS AND DISTRIBUTION COSTS

(Tks/Ac)

Pumps and Distribution	108	(Amortized 10 yrs 20%)
Materials	17	(Amortized 10 yrs 20%)
Labor (Hired) ¼ Total	7	
Right of Way	44	(440/ac 10 yr no interest)
Pumps	260	
Structures	10	
Depreciation	54	
Interest	173	
Total	Tks 673/Ac	

TABLE III-6

NET RETURNS PER NET ACRE

(in TKS)

Crop	Gross Returns	Gross Costs	Net Return Per Cropped Acre	Adjustment For Cropping Intensity	Net Return Per Net Acre
Wheat	3850	1388	2462	1	2462
T.Amans HYV	10200	1243	8957	.52	4659
AUS HYV	5950	1037	4913	.313	1540
Jute	4375	1114	3261	.166	542
			NET INCOME PER NET ACRE: TK		9203

TABLE III-7

IRRIGATED CROP PRODUCTION AND RETURNS - PROJECT AREA

(30,000 Acres)

Crop	Area (AC)	Yield (Mds/Ac)	Productions (mds,000)	Gross Income (TK,000)	Gross Costs (TK,000)	Net Income (TK,000)
Wheat	30,000	35	1,050	115,500	41,640	73,860
T.Amans HYV	15,600	60	936	159,120	19,391	139,729
AUS HYV	9,400	35	329	55,930	9,748	46,182
Jute	5,000	25	125	21,875	5,570	16,305
			TOTALS	352,425	76,349	276,076
			TOTALS PER ACRE (TK)	11,748	2,545	9,203

The production costs include not only input costs for fertilizer, insecticides, interest, but also repayment for pump sets and distribution. This was included in the financial analysis as a payback item at the farm level rather than a project expense for two reasons:

(1) Incremental returns from both irrigation and management inputs allow for repayment of pumping and distribution costs;

(2) Rural credit would stimulate a demand, at the farm level for a free market in irrigation equipment.

Per acre production costs are expected to increase with irrigation to Tk. 2545 from the without situation of Tk. 913. Labor costs for purposes of financial analysis are relegated to hired labor only (Table III-5A) and increase from 20 man days (Tk. 320) in the present situation to 30 man days (Tk. 480) in the irrigated farm budget. Animal labor in the financial analysis is also relegated only to that hired with both without and irrigated requirements at Tk. 40. Irrigation costs include both pump sets and distribution channels. Table III-5B details the annual per acre costs for capital equipment, operation and maintenance. Only the cost for hired labor is used. The per acre costs were derived from full development costs of the 30,000 acre project and allocated equally back to each acre. Allocation of irrigation costs were then related to each crop on a percentage basis of cropped area per acre.

3.2.2 Farm Income

Estimated annual net farm income per irrigated acre at full implementation would be Tk. 9203.

TABLE III-8

PRODUCTION BUILD UP PER ACRE COSTS AND RETURNS (FINANCIAL)

CROP	Year of Planting	Adjusted Yield	Returns	Cost Variable Pump	Net Returns	Net Returns Adjusted for Cropping Intensity
Wheat	1	10.5	1155	631 + 337	187	187
	2	16.8	1848	841 + 337	670	670
	3	28.0	3080	1388	1692	1692
	4	31.5	3465	1388	2077	2077
	5	35.	3850	1388	2462	2462
AUS	1	21	3570	1037	2533	793
	2	24.5	4165	1037	3128	979
	3	28	4760	1037	3723	1165
	4	31	5270	1037	4233	1325
	5	35	5950	1037	4913	1540
JUTE	1	15	2625	1114	1511	251
	2	17.5	3062.5	1114	1954	324
	3	20	3500	1114	2386	396
	4	22.5	3937.5	1114	2824	469
	5	25	4375	1114	3261	542
'.AMAN	1	18	3060	641 + 337	2082	1083
	2	25.2	4284	748 + 337	3199	1663
	3	38.4	6528	854 + 337	5337	2775
	4	48.6	8262	961 + 337	6964	3621
	5	60	10,200	1243	8957	4659

Without the project the net income for the project area, expressed on an acre basis, is Tks 2253.

Incremental net financial benefits per acre at full development would be Tks 6950.

Table III-9 shows the net incremental cash flow over a six year build up period. The purpose behind this incremental analysis is to show the increased returns from a without project situation which would justify the added expense of the irrigation. It is anticipated that net returns under present conditions would not increase in real terms (using a 1980 basis) due to input and technology constraints and are therefore kept at a constant. The farm budget income assumes a loan payback for irrigation equipment which is amortized at 20 percent over 10 years. (Appendix Table G-12) In actuality, this payback could be stepped up to a 5 year loan period, given expected returns, to encourage participation by private distributors. Incremental returns in the 1st year of production are negative and as such it would be recommended that a grace period for any payback, either equipment or production, be extended until the end of the 2nd year crop returns.

The summation of the financial analysis is shown in Table III-10. Farm income has been enhanced through both the inputs of irrigation and management by Tk. 6950 per year. Equally important, the productivity of family labor has increased by 194 percent from Tks 50 per may day to Tks 147 per man day. The returns also cover the cost of technical services which are treated as project costs (it is assumed that the Regulation Works are a sunk cost with no payback consideration) Net incremental farm returns at full repayment (farm budget and project) are Tk. 6710. Incremental returns to family labor at full repayment are Tk 419/acre.

TABLE III-9

FARM UNIT FINANCIAL RETURNS (Tks/Acre)

Year	Development Year 1	2	3	4	5	6
RETURNS						
Wheat	1155	1848	3080	3465	3850	3850
Aus HYV		1118	1305	1491	1651	1864
Jute		437	510	583	656	729
T. Aman HYV		1591	2228	3395	4296	5304
TOTAL; Returns	1155	4994	7123	8934	10453	11748
Costs	968	2197	2463	2518	2545	2545
NET	187	2797	4660	6416	7908	9203
NET WITHOUT PROJECT	2253	2253	2253	2253	2253	2253
NET INCREMENTAL BENEFIT	(2065)	544	2407	4163	5655	6950

Table III-10

FINANCIAL SUMMARY AT FULL DEVELOPMENT

(ONE ACRE)

	WITHOUT PROJECT	PROJECT
GROSS RETURNS PER YEAR (TK)	3166	11748
Cash Costs of Farm Production (Tables 2, 4 and 8)	913	2545
NET FARM RETURNS (TK)	2253	9203
INCREMENTAL RETURNS OVER PRE-PROJECT		6950
Project Costs		
Technical Services		240
INCREMENTAL RETURNS WITH FULL PROJECT PAYMENT		6710
Family Labor (Man-Days)	45	61
Net Return Per Man-Day (TK)	50	147
Family Labor (Incremental Man-Day)		16
Incremental Returns to Labor (Full Repayment)		419
(Annual Cost)		434

A comparison of family farm net cash positions (Table III-11) with and without project conditions show that, after subtracting family food needs and farm associated household expenses, the farm returns are Tks 3744 and Tks 2966 respectively.

Without project conditions, the farm production on one acre is not sufficient to support a typical farm family. There must be off farm income to offset the deficit. This off-farm income is estimated to be Tk. 6470. The irrigated farm would generate enough income to cover all farm and household farm related expenses and allow a surplus cash position even with full project payback. Off-farm income levels could still be attained as without project case.

3.3 Economic Analysis

3.3.1 Introduction

The economic analysis was developed to determine the returns to society resulting from the irrigation/management project. In the financial analysis, the concern was whether the costs associated with irrigated farm production could be justified by giving net returns over and above the existing farm situation. In the economic analysis the concern is whether economic farm returns justify the economic costs of all components of the project i.e. Regulation, On-Farm Distribution, Technical Services, and Fisheries Development.

3.3.2 Economic Farm Income

3.3.2.1 Without Project

Table III-11

NET FARM FAMILY CASH POSITION

Annual Food Needs Farm Family Per Acre (TK)[1]

Cereal:	2760
Other Foods:	834
TK.	3594

		WITHOUT	IRRIGATION	
Net Farm Production (Acre)	:	2253	9203	
Food Needs (TK)	:	(3594)	(3594)	
Balance	:	(1341)	5609	
Household Expenses[1]		(1625)	(1625)	
Cash Position[2]	:	(2966)	3744	
Project Payback	:	0	240	
Net Cash Position	:		3504	
Incremental Cash Benefit	:			6470

1. SOURCE: Phase II Soci-Economic Survey of Project Area/

2. Other Income (off farm) of Tk. 6470 is not included as this analysis ismeant to show returns to family farm labor only. Since 16 more mandays are needed to produce the added income it might be assumed that the other income (off farm) in the irrigation case might drop somewhat from the level of the Tk. 6470. However since farm labor is greatly underutilized,16 additional man days can be absorbed at the farm level leaving the same off farm labor availability as in the without case. With the inclusion of off farm income, the net cash position without project is Tk. 3504 and with irrigation is Tk. 9974.

Tables III-12 and 13 detail the economic returns and costs per acre for the without project. The methodology is the same as that used for the financial analysis differing only in economic pricing. Gross returns per acre were Tk. 3619; gross costs were Tk. 2236, net returns were Tk. 1383.

Labor costs have increased to include family farm labor (45 days shadow priced at Tk. 8/day) and family owned animal labor (an additional 23 days).

As in the financial analysis, the without project assumes no real growth and is therefore kept at a constant through the life of project.

3.3.2.2 Irrigated Project

Tables III-14 and 15 detail economic costs and returns per acre for irrigated farm production. Table III-16 adjusts net returns from cropped to net acre (previously described in the financial analysis) as prescribed by the established irrigated cropping pattern. Net economic returns per net acre at full development are Tk. 9717. Full crop potential would take six years to attain. Table III-17 shows an annual crop production build up on a per acre basis with net returns adjusted to show cropping intensity.

The cropping pattern within the 30,000 acre project area would be:

Wheat 30,000 acres
T. Aman 15,600 acres
Aus 9,400 acres
Jute 5,000 acres

cropping intensity would be 2.0 which means that there are 2 cropped acres for every net acre farmed. Wheat represents one full cropped acre while T. Aman, aus and jute represent the

Table III-12

WITHOUT PROJECT ECONOMIC FARM INCOME
(100 Acres)

CROP	ACRES	YIELD (Md/Ac)	PRODUCTION	ECONOMIC PRICE Tks/Md	ANNUAL INCOME
B.AUS	35	15.4	539	185	Tks.99,715
B.AMAN	35	15.2	532	185	98,420
T.AMAN	7	17.1	120	185	22,200
JUTE	20	13.4	268	175	46,900
BORO	1	15.0	15	185	2,775
WHEAT	3	7.9	24	125	3,000
PULSES	18	5.0	90	150	13,500
OILSEEDS	24	4.5	108	300	32,400
VEG/FRUITS	1	105.1	105	65	6,825
SPICES	2	40	80	340	27,200
SUGARCANE	2	375	750	12	9,000
	148				361,935

TOTAL INCOME PER ACRE 3619 TK

Table III-13

WITHOUT PROJECT ECONOMIC FARM PRODUCTION COSTS

(100 Acres)

CROP	ACRES	SEED Tks	FERTILIZER Tks	PESTICIDES Tks	OTHERS[1] Tks	TOTAL COST Tks
B. AUS	35	294	204	-	230	25,480
B.AUS	35	233	105	-	230	19,800
T. AMAN	7	172	237	-	230	4,473
JUTE	20	67	261	174	270	15,440
BORO	18	202	939	138	400	30,222
WHEAT	1	315	147	20	200	682
PULSES	3	162	18	-	90	810
OILSEED	24	90	21	-	70	4,344
VEG/FRUITS	1	105	300	-	180	585
SPICES	2	420	300	-	180	1,800
SUGARCANE	2	1176	255	-	480	1,822
TOTAL	148					Tks 105,583

INPUT COST/ACRE =Tks 1056

LABOR COST/ACRE =Tks 1180

Tks 2236

1. INTEREST and MISCELLANEOUS

2. LABOR: ANIMAL DAYS: 25 x 20 = TK 500

MAN DAYS: 20 HIRED x 16 = TK 320

45 FAMILY x 8 = TK 360

TK 1180

Table III-14

ECONOMIC ANALYSIS

GROSS RETURNS PER IRRIGATED ACRE

CROP	YIELD Md/Ac	PRICE TK Md	GROS TK
Wheat	35	125	4,375
T.Aman HY	60	185	11,100
AUS HY	35	185	6,475
Jute	25	175	4,375

Table III-15

GROSS COST PER IRRIGATION ACRE (TK)

CROP	SEED	FERTILIZER	PESTICIDES	LABOR HUMAN	ANIMAL	COST TK/Ac
Wheat	158	690	300	484	250	1882
T. Aman HYV	122	675	300	252	130	1479
AUS HYV	210	450	100	151	78	989
Jute	42	972	200	81	42	1337

Table III-16

NET RETURNS PER NET ACRE
(in Tks)

CROP	GROSS RETURN (Tks)	GROSS COST (Tks)	NET RETURN FOR CROPPED ACRE (Tks)	ADJUSTMENT FOR CROPPING INTENSITY	NET RETURN PER ACRE
Wheat	4375	1882	2493	1	2493
Aman	11100	1479	9621	.52	5003
AUS	6475	989	5486	.313	1717
Jute	4375	1337	3038	.166	564
					Tks 9717

Table III-17

	Year	Returns (Tk)	Adjusted for Cropping Intensity	Costs (Tk)	Adjusted for Cropping Intensity	Net Return (Tk)
Wheat	1	1313	1313	1129	1129	184
	2	2100	2100	1506	1506	594
	3	3500	3500	1882	1882	1618
	4	3938	3938	1882	1882	2056
	5	4375	4375	1882	1882	2493
us HYV	1	3885	1216	989	310	906
	2	4533	1419	989	310	1109
	3	5180	1621	989	310	1311
	4	5735	1621	989	310	1485
	5	6475	2027	989	310	1717
Jute	1	2625	436	1337	222	214
	2	3036	508	1337	222	284
	3	3500	581	1337	222	359
	4	3938	654	1337	222	432
	5	4375	726	1337	222	504
Aman	1	3330	1732	887	461	1271
	2	4662	2424	1035	538	1886
	3	7104	3694	1183	615	3079
	4	8991	4675	1331	692	3983
	5	11100	5772	1479	769	5003

second cropped acre at .52, .3133 and .166 of that acre respectively.

The economic analysis requires a per acre return for each of the development years to develop an economic benefit stream. Full project development would take seven years with full production attained in the 12th year of project.

Table III-18 shows project implementation as registered by crops, acreage planted and net income per development year. Under full development net returns from farm production would be Tk. 171,497,000.

Table III-19 shows cash flow from fishery development. A net incremental benefits are estimated to be Tk. 1,946,000 for the first two years and Tks. 2,081,000 for years onward. Detail information on fishery development is given in Section 1.5 on fisheries development.

3.3.3 Economic Evaluation

Table III-19 represents the economic summation of project activities (implementation, costs, returns) from which annual net project benefits are derived and on which the economic evaluation techniques are applied.

Following the development of cost-benefit streams for 12 years as shown in Table III-19, the following measures of feasibility were calculated for the project.

- Internal Rate of Return (IRR)
- Net Present Value (NPV) of the investment at 12, 15 and 20 percent Discount Rate.
- Benefit/Cost (B/C) ratio at discount rate of 12, 15 and 20 percent.

The result of this analysis are summarized below with details shown in Tables III 20A, 20B, and 20C.

	Discount Rates		
	12%	15%	20%
Net Present Value	Tks. 253,354	Tks. 193,735	Tks. 124,837
Benefit/Cost Ratio	3.68	3.34	2.84

Irr = 56%

3.3.4 Sensitivity Analysis

The results of the economic analysis are subject to a number of possible deviations. Actual project costs may vary from the estimates. Future benefits may vary from those projected. The actual crop prices or yields could vary from estimates thus affecting anticipated benefits.

To test the sensitivity of the economic analysis to variation in cost or benefits, analyses were made to determine the effects of:

- A change in cost of + 20 percent at interest rate 15 percent.
- A change in Benefits of - 20 percent at interest rate 15 percent.
- A change in Cost of + 20 percent and Benefits - 20 percent at interest rate 15 percent.

The sensitivity analysis results are summarized below and detailed in Table III 21,

	Cost + 20%	Benefits - 20%	Cost + 20% Benefits - 20%
RR	48	47	41
Net Present Value, Tks. 1000	173,962	138,418	121,848

show that economic soundness of project does not significantly change with increase in cost or decrease in benefits. The project benefits seems to exert more influence on the Net Present Value than on the costs.

TABLE III-18

ANNUAL CROP IMPLEMENTATION AND RETURNS

Acres (Returns-Cost)

Year	Wheat	Aus	Jute	T.Aman	Total(000
1.	480 (1313-1129)				88
2.	480 (2100-1506)	150 (1216-310)	80 (436-222)	250 (1732-461)	
	1440 (1313-1129)				1,021
3.	480 (3500-1882)	150 (1419-310)	80 (508-222)	250 (2424-538)	
	1440 (2100-1506)	450 (1216-310)	240 (436-222)	750 (1732-461)	
	2880 (1313-1129)				4,235
4.	480 (3938-1882)	150 (1621-310)	80 (581-222)	250 (3694-615)	
	1440 (3500-1882)	450 (1419-310)	240 (508-222)	750 (2424-538)	
	2880 (2100-1506)	890 (1216-310)	490 (436-222)	1500 (1732-461)	
	5760 (1313-1129)				7,294
5.	480 (4375-1882)	150 (1795-310)	80 (654-222)	250 (4675-692)	
	1440 (3938-1882)	450 (1621-310)	240 (581-222)	750 (3694-615)	
	2880 (3500-1882)	890 (1419-310)	490 (508-222)	1500 (2424-538)	
	5760 (2100-1506)	1780 (1216-310)	980 (436-222)	3000 (1732-461)	
	10,080 (1313-1129)				27,925
6.	1920 (4375-1882)	150 (2027-310)	80 (726-222)	250 (5772-769)	
	2880 (3938-1882)	450 (1795-310)	240 (654-222)	750 (4675-692)	
	5760 (3500-1882)	890 (1621-310)	490 (581-222)	1500 (3694-615)	
	10,080 (2100-1506)	1780 (1419-310)	980 (508-222)	3000 (2424-538)	
	5760 (1313-1129)	3130 (1216-310)	1710 (436-222)	5240 (1732-461)	56,120
7.	4800 (4375-1882)	600 (2027-310)	320 (726-222)	1000 (5772-769)	
	5760 (3938-1882)	890 (1795-310)	490 (654-222)	1500 (4675-692)	
	10,080 (3500-1882)	1780 (1621-310)	980 (581-222)	3000 (3694-615)	
	5760 (2100-1506)	3130 (1419-310)	1710 (508-222)	5240 (2424-538)	
	3600 (1313-1129)	1780 (1216-310)	980 (436-222)	3000 (1732-461)	89,305
8.	10,560 (4375-1182)	1490 (2027-310)	810 (726-222)	2500 (5772-769)	
	10,080 (3938-1882)	1780 (1795-310)	980 (654-222)	3000 (4675-692)	
	5760 (3500-1882)	3130 (1621-310)	1710 (581-222)	5240 (3694-615)	
	3600 (2100-1506)	1780 (1419-310)	980 (508-222)	3000 (2424-538)	
		1220 (1216-310)	520 (436-222)	1860 (1732-461)	121,595
9.	20,640 (4375-1882)	3270 (2027-310)	1790 (726-222)	5500 (5772-769)	
	5760 (3938-1882)	3130 (1795-310)	1710 (654-222)	5240 (4675-692)	
	3600 (3500-1882)	1780 (1621-310)	980 (581-222)	3000 (3694-615)	
		1220 (1419-310)	520 (508-222)	1860 (2424-538)	145,845
10.	26,400 (4375-1882)	6400 (2027-310)	3500 (726-222)	10,740(5772-769)	
	3600 (3938-1882)	1780 (1795-310)	980 (654-222)	3000 (4675-692)	
		1220 (1621-310)	520 (581-222)	1860 (3694-615)	158,234
11.	30,000 (4375-1882)	8180 (2027-310)	4480 (726-222)	13,740(5772-769)	
		1220 (1795-310)	520 (654-222)	1860 (4675-769)	168,796
12.	30,000 (4375-1882)	9400 (2027-310)	5000 (726-222)	15,600(5772-769)	171,497

Table III-19

PROJECT ECONOMIC CASH FLOW

(Tks 1000)

	WITHOUT PROJECT	YEAR 1	2	3	4	5	6	7	8	9	10	11	12
FARM PRODUCTION													
Wheat		630	2899	8485	2054	43182	68632	95786	113610	125580	129680	131250	131250
Aus		-	182	760	1964	4426	8886	12305	15546	16863	18146	18771	19054
Jute		-	35	145	382	868	1743	2418	2947	3251	3484	3252	3630
T. Aman		-	433	1905	5340	12771	26838	41764	58305	71336	82887	88003	90043
Total	671'	630	3549	11295	28227	61247	106099	152273	190418	217030	234197	241276	243977
FARM COST													
Operating Cost		542	2528	7060	20933	33322	49979	52968	68823	71185	75963	72480	72480
Total		88	1021	4235	7294	27925	56120	99305	121595	145845	158234	168796	171497
NET FARM BENEFIT	671'												
Incremental		(583)	350	3564	6564	27254	55449	88634	120924	145174	157563	168125	170826
Fishery Production													
Net Fishery Benefit	450	2396	2396	2531	2531	2531	531	2531	2531	2531	2531	2531	2531
Incremental		1946	1946	2081	2081	2081	2081	2081	2081	2081	2081	2081	2081
Total Incremental		2529	2296	5645	8645	29335	57530	90715	123005	147255	159644	170206	172907
PROJECT COSTS													
On Farm		635	2056	4113	5225	14394	8225	5141					
O&M		175	699	1747	3844	7513	9110	10920	10920	299	899	1797	3594
Regulation		10318	5346	958	162	243				10920	10920	10920	10920
O&M		55	132	172	202	205	205	205	205	205	205	205	205
Fishery		2940	2736	718									
O&M		375	669	669	669	669	669	699	699	699	699	699	699
Technical		415	415	415	415	415							
O&M		1442	1442	1442	1442	1442							
TOTAL PROJECT COST		16455	13495	10234	14959	24881	18709	15935	11794	12093	12693	13591	15388
NET PROJECT BENEFIT		(13926)	(11199)	(4589)	(6314)	4454	38821	73780	111211	135162	146951	156615	157519

TABLE III - 20A

BENEFIT/COST ANALYSIS AT 12 PERCENT DISCOUNT RATE
(TKS 1,000)

YEAR	BENEFIT	COST	DISCOUNTED BENEFIT	COST
1	2,529	16,455	2,258	14,694
2	2,296	13,495	1,830	10,755
3	5,645	10,234	4,019	7,287
4	8,645	14,959	5,498	9,514
5	29,335	24,881	16,633	14,107
6	57,530	18,709	29,168	9,485
7	90,715	16,935	41,003	7,655
8	123,005	11,794	49,694	4,765
9	147,255	12,093	53,159	4,365
10	159,644	12,693	51,405	4,087
11	170,206	13,591	48,849	3,901
12	172,907	15,388	44,437	3,955
			TKS 347,953	TKS 94,570

$B/_C$ RATIO = 3.68

TABLE 20 - B

BENEFIT/COST ANALYSIS AT 15 PERCENT DISCOUNT RATE
(TKS 1,000)

YEAR	BENEFIT	COST	DISCOUNTED BENEFIT	COST
1	2,529	16,455	2,200	14,316
2	2,296	13,495	1,736	10,202
3	5,645	10,234	3,714	6,734
4	8,645	14,959	4,945	8,557
5	29,335	24,881	14,579	12,366
6	57,530	18,709	24,853	8,082
7	90,715	16,935	34,109	6,368
8	123,005	11,794	40,223	3,857
9	147,255	12,093	41,820	3,434
10	159,644	12,693	39,432	3,135
11	170,206	13,591	36,594	2,922
12	172,907	15,388	32,334	2,877
		TKS	276,539	TKS 82,850

B/C RATIO = 3.34

TABLE 20-C

BENEFIT/COST ANALYSIS AT 20 PERCENT DISCOUNT RATE
(TKS 1,000)

YEAR	BENEFIT	COST	DISCOUNTED BENEFIT	COST
1	2,529	16,455	2,107	13,707
2	2,296	13,495	1,593	9,365
3	5,645	10,234	3,268	5,925
4	8,645	14,959	4,167	7,210
5	29,335	24,881	11,793	10,002
6	57,530	18,709	19,272	6,267
7	90,715	16,935	25,309	4,725
8	123,005	11,794	28,660	2,748
9	147,255	12,093	28,567	2,346
10	159,644	12,693	25,862	2,056
11	170,206	13,591	22,978	1,835
12	172,907	15,388	19,365	1,723
		TKS	192,941	TKS 67,909

B/C RATIO = 2.84

TABLE III-21

SENSITIVITY ANALYSIS

(TKS 1000)

YEAR	COST	BENEFITS	COST + 20%	BENEFIT - 20%	NET BENEFITS WITH COST + 20%	NET BENEFITS WITH BENEFITS - 20%	NET BENEFITS WITH COST + 20% BENEFIT - 20%
1	16,455	2,529	19,746	2,023	-17,217	-14,432	-17,723
2	13,495	2,296	16,194	1,837	-13,898	-11,658	-14,357
3	10,234	5,645	12,281	4,516	- 6,636	- 5,718	- 7,765
4	14,959	8,645	17,951	6,916	- 9,306	- 8,043	-11,035
5	24,881	29,335	29,857	23,468	- 522	- 1,413	- 6,389
6	18,709	57,510	22,451	46,024	27,673	27,315	23,573
7	16,935	90,715	20,322	72,572	70,393	55,637	52,250
8	11,794	123,005	14,153	98,404	108,852	86,610	84,251
9	12,093	147,255	14,512	117,804	132,743	105,711	103,292
10	12,693	159,644	15,232	127,715	144,412	115,022	112,483
11	13,591	170,206	16,309	136,165	153,897	122,574	119,856
12	15,388	172,907	18,466	138,326	154,441	122,938	119,860

CHAPTER IV
IMPLEMENTATION

CHAPTER IV. IMPLEMENTATION

4.1 General

The proposed development has two principal and distinct components - the regulation work which would be financed and constructed by the Project, and the on-farm development which would be financed and constructed by the farmers but with technical assistance from the Project. These farmers are very enthused about the development; they have expected and have waited many years for the regulation works to provide them a surface water supply; and they are willing to contribute land, labor and funds for the on-farm development. However, there must be definite evidence that the long awaited project is to be a reality before the farmers would be expected to become seriously involved in the development.

A priority activity then must be this definite signal to the farmers that the project is to be implemented. This would best be demonstrated by initiating construction of the Spillway structure. The farmers would then be receptive to, and would benefit from the technical assistance program. A limited number of pump associations could be organized; their on-farm systems planned and constructed; and a dry season (wheat) crop could be irrigated during the initial year of development. However, as discussed later, this schedule is predicated upon a pre-project selection and training program for the initial group of extension agents. They could then start the technical assistance program early in the development year.

The Development Schedule, with the critical first year activities noted in red, is shown in Figure IV-1, and the details are discussed in the following sections.

4.2 Regulation Works

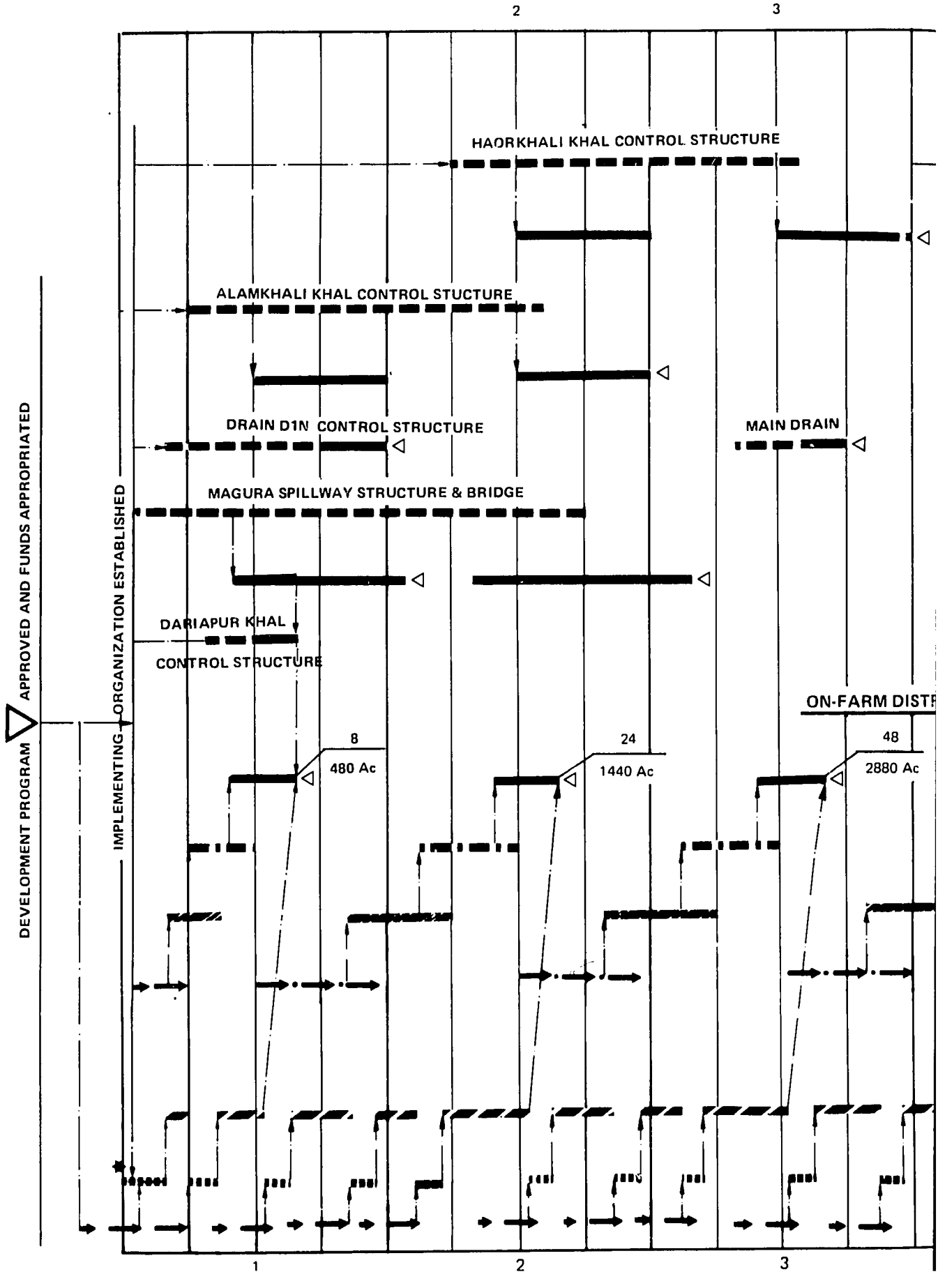
The Spillway Structure, which would permit the closure of the existing Magura Diversion Channel, is the principal and primary component needed to develop the surface water supply. This would be a relatively simple structure and the designs and construction supervision could be done by the regular technical staff of BWDB with some technical assistance by consultants. All construction materials are now stockpiled in Magura or are readily available; the minimal equipment needed for construction can be provided by BWDB; and this structure could be completed during the dry season of the initial year of development. Water impoundment and irrigation could then begin early in this initial dry season after the upstream cofferdam has been completed, and the existing khal has been closed.

The Dariapur Khal would be closed concurrently with the above closure to prevent flooding of the Barabila Beel. The water level is the Nabaganga and Kumar Rivers could then be maintained at an elevation slightly lower than 12.5 feet PWD. This is the control elevation of the sill beneath the bridge crossing for Alamkhali khal and is the designated crest elevation of the upstream cofferdam at the Spillway. At this elevation, there would be more than an adequate water supply in the rivers for the initial irrigation development.

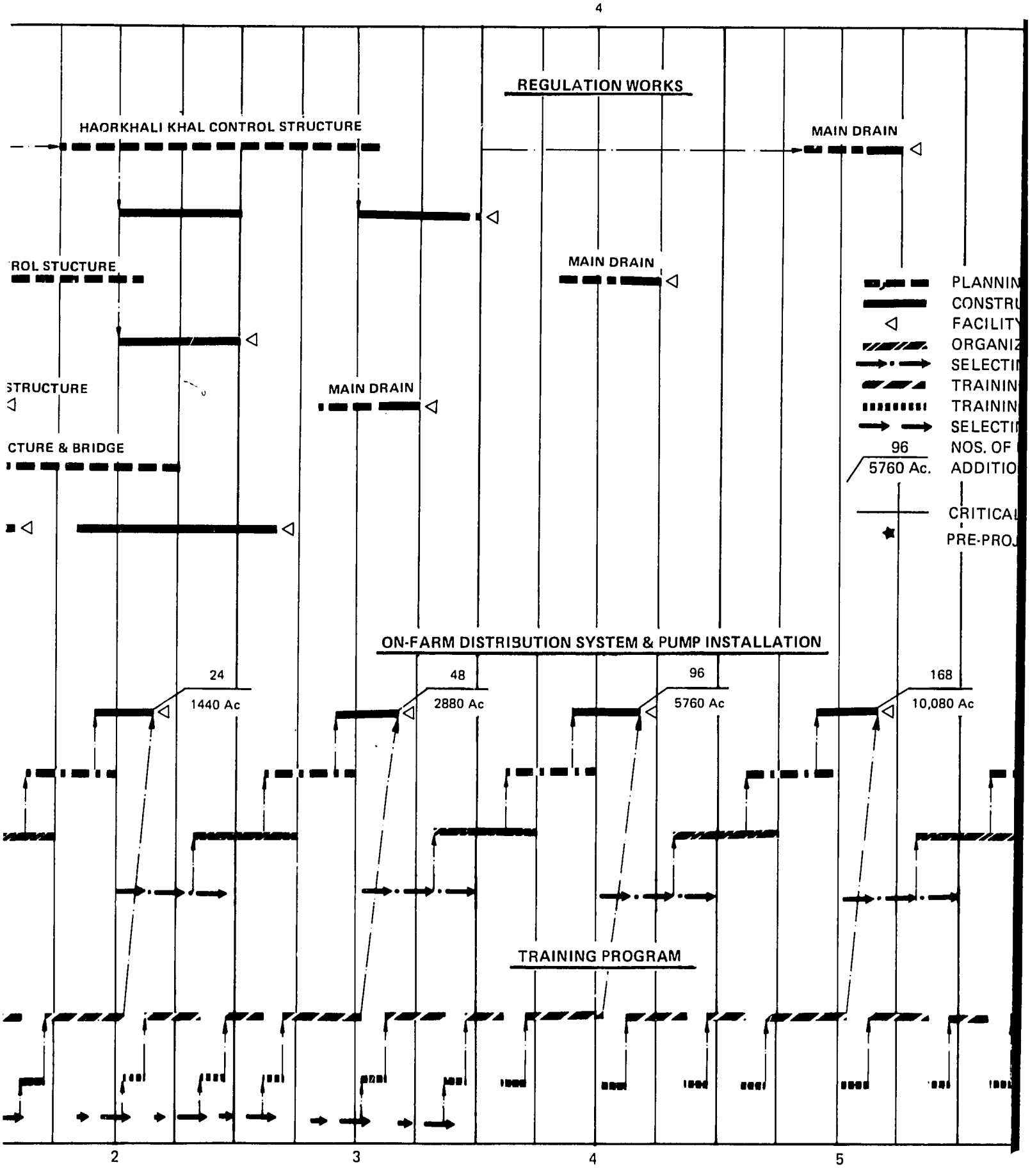
The control of Alamkhali Khal would have the next priority. The caissons for the foundation would be sunk during the first year of development and the superstructure and control gates would be completed during the second year. The water level in the main rivers could then be maintained at elevation 16.8 feet PWD which is the existing invert of the Haorkhali Khal.

The Haorkhali Khal would be controlled in the third year with the structure similar to Alamkhali Khal, being completed in a two year construction period.

IV 2a

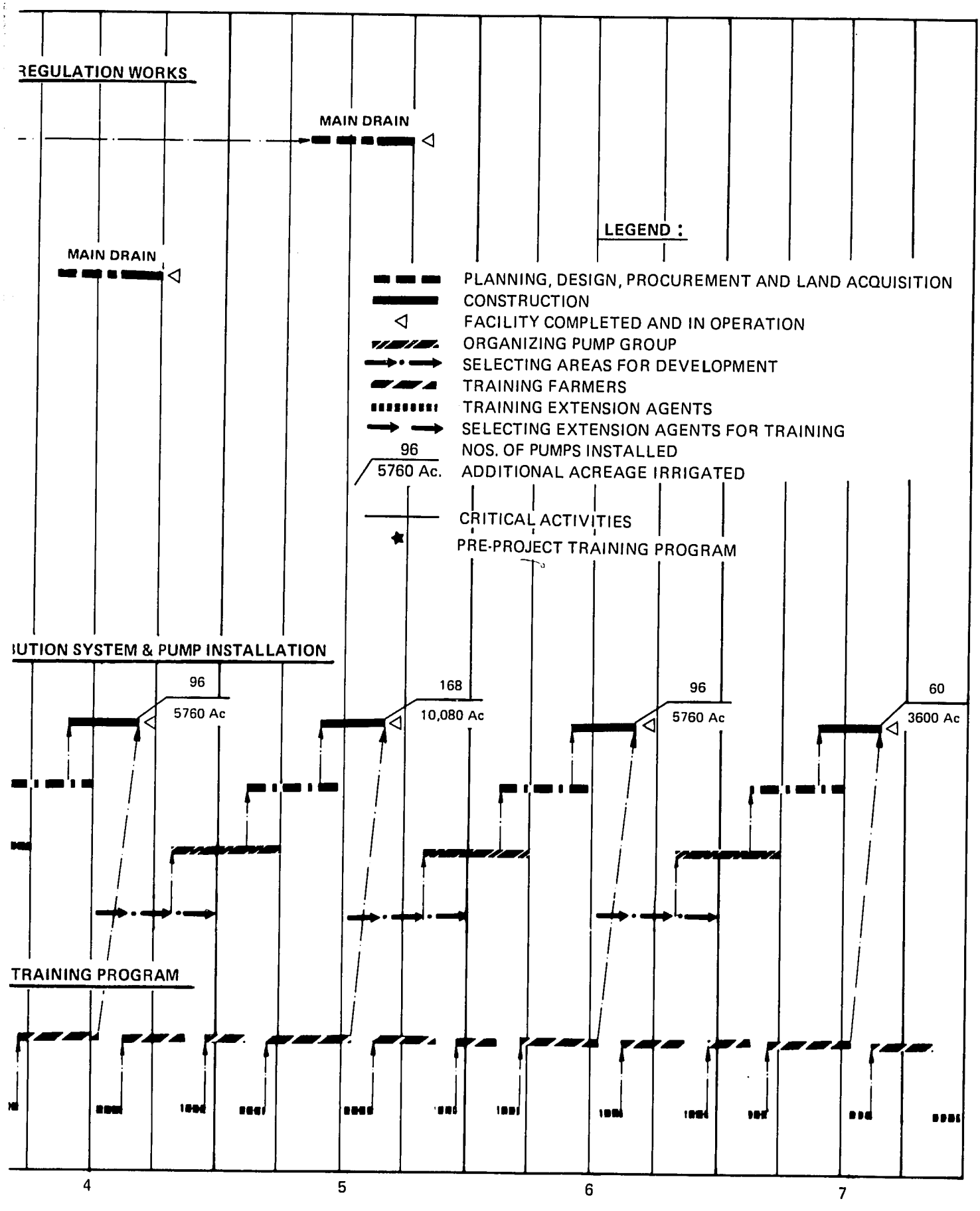

2
3
HAORKHALI KHAL CONTROL STRUCTURE
ALAMKHALI KHAL CONTROL STUCTURE
DRAIN D1N CONTROL STRUCTURE
MAIN DRAIN
MAGURA SPILLWAY STRUCTURE & BRIDGE
DARIAPUR KHAL
CONTROL STRUCTURE
ON-FARM DISTR
8
480 Ac
24
1440 Ac
48
2880 Ac
DEVELOPMENT PROGRAM
APPROVED AND FUNDS APPROPRIATED
IMPLEMENTING ORGANIZATION ESTABLISHED
1
2
3

2b



DEVELOPMENT YEARS
(MAY 1 through April 30)

IV 2c



EVELOPMENT YEARS
IAY 1 through April 30)

DEVELOPMENT SCHEDULE

FIGURE IV – 1

Excavation of the main drains and the Dopaghata Khal are scheduled for years 3, 4 and 5, but these could be completed earlier if convenient.

4.3 On-Farm Development

These developments would be directly financed and implemented by the farmers. These farmers have been waiting many years for a surface water supply, and it is expected that many would hurriedly install the pumps in the initial years before the technical assistance becomes fully available. These installations may lack proper planning and organization, and the farmers may not realize their full potential or benefits. However, the farmers would realize some benefits; they will be gaining valuable experience; and the basic system would have been established which could then be expanded or improved when the full complement of extension agents become available for technical assistance.

This technical assistance would entail a prolonged and substantial effort by the Project and some time would be needed to train the personnel and to develop a proper organization for this sustained effort. This organization would consist of a consultant group of five expatriates and seven Bangladeshies who would train and supervise 42 extension agents who would then directly train and assist the farmers. These agents would be deputed from relevant government agencies or recruited directly by the consultants as appropriate. Six such agents would be selected, trained and fielded in the first year, 16 the second year, and the final 20 agents in the third year.

Following is the technical assistance schedule for these extension agents:

Development Year	Nos. of Pump Groups Organized	Planning and Implementation of On-Farm Development Acres Irrigated	
		By Year	Accumulated
1	8	480	480
2	24	1440	1920
3	48	2880	4800
4	96	5760	10560
5	168	10080	20640
6	96	5760	26400
7	60	3600	30000
TOTAL	500	30000	

This schedule is dependent upon a pre-project program to select and train the initial group of extension agents. This pre-project selection and training program would develop the basic organization, and would recruit, train and supervise the extension agents for the initial year of development. This pre-project program would be conducted by an expatriate group consisting of an On-Farm Irrigation Engineer, an Agricultural Extension Specialist, and a Village Group Formation Advisor with Bangladeshi counterparts. It would be a two-month course of mostly field work supplemented by classroom instruction.

Approximately 20 recent graduates, consisting of 7 agricultural engineers, 8 agricultural extension and training specialists, and 5 village group formation advisors would be selected for the course. Those who are qualified, willing and adaptable to the assignment would then become the nucleus of the group of extension agents who would be directly assisting the farmers.

4.4 Fisheries Development

No schedule has been prepared for this phase of the development. The improvement to the hatcheries would extend over several years to allow time for the purchase and importation of the special equipment. The stocking and development

of the fisheries in the rivers and tanks would follow accordingly. The development of the tanks would be further delayed until an appropriate irrigation development could provide the needed pumps for the individual tanks.

CHAPTER V
SOCIAL ANALYSIS

SOCIAL ANALYSIS

5.1 Attitudes in the Project Area Toward Irrigation

The project encompasses an area of 83,000 acres along both banks of the Kumor and Nabaganga Rivers upstream of Magura. Portions of this area north of the Nabaganga River were initially scheduled to be irrigated under the Kushtia Unit Phase II of the Ganges-Kobadak (G-K) project. Since its inception, a number of developments have taken place which have prevented the G-K project from providing irrigation water to those areas. These include certain technical design problems, difficulties in coordinating farmer groups with water delivery and availability, and introduction of new high yielding varieties of rice which demanded more water than had previously been anticipated. As a result, it is now recognized that the G-K Project will not in the foreseeable future be able to provide irrigation water for the farmers in the project area north of Magura.

The farmers in the area were interviewed, as part of the Phase I Study concerning their interest in the project. Because of their proximity to the G-K Project, their attitudes conveyed a combination of enthusiasm and reservation. They were fully aware of the benefits to be derived from irrigation water which they saw being provided free of charge to the more fortunate farmers to the north and east. Yet, having been denied water which had been promised at various times, there exists among farmers in the project area a sense of grievance.

In addition, the history of previous unsuccessful projects has left a legacy of mistrust. During the construction of the Magura Weir, upstream flooding occurred. The people in the area rebelled violently causing the present diversion canal to be excavated. A drainage canal was cut into one of the beels in the area several years before the sluice gate could be constructed. This caused flooding at the wrong time of year, and drainage at times when water should have been stored. The

timing and reasons behind these difficulties cannot be easily conveyed to farmers, and the situation is one in which rumors are quickly generated.

In interviews with the villagers in selected villages, questions of interest and commitment were explored.

Different villages showed different degrees of interest and, particularly, of organization which would be capable of utilizing irrigation techniques. However, in all interviews interest was expressed in the availability of water together with pumps and improved methods of farming.

What emerged from our analysis of interviews in the Project Area was that farmers were very interested in irrigation, and reasonably knowledgeable about it and what it could do for them. They were prepared to participate in a system if they felt they could trust it, but they were hesitant to believe that the system would actually be built and bring water to them.

5.2 Social Structure and Irrigation Groups

The population of the area to be developed is primarily rural and involved in agriculture and agriculturally related activities.

There are approximately 340 villages in the Project Area. Until recently, villages had little administrative signifi-ance, and the lowest level of elected government was the Union Parishad which is composed of approximately 20 villages. Recently, the Gram Sarkar was instituted, which will be formed at the village level and will be the lowest level of representative government. It is yet to be determined how this will actually function.

The social units which function for the members of the community are: the bari which represents a homestead unit; and para which represents several homestead units clustered together in proximity to each other.

Because of the scarcity of land, there is great rivalry at the local level over land ownership. Ownership still represents status for most villagers who are farmers by occupation. Much social mobility within a village depends upon accumulation of land through purchase, by one family from another. Therefore, many of the disputes which take place are over land.

This situation presents numerous potential problems for the organization of irrigation groups. Pumps, water and the end result - irrigated land - represent major assets to be obtained. On the other hand, it is very difficult for a number of groups to cooperate.

Family groups competing with each other may find it difficult to form an alliance to cooperate in a pump group. Furthermore, differing religious groups are represented within villages. In addition, political factions which represent conscious political alliances, usually organized around an influential man or family, may not cooperate with rival faction members in a irrigation group. While a para represents a group of people who may work together and live in adjacent homestead plots, none of the functioning social units can be located territorially on the fragmented plots to be irrigated.

If a command area for a low lift pump or shallow tube well is determined simply by topographic considerations, it may overlap religious groups, family groups and factions.

5.3 Land Tenure: Size and Distribution of Holdings

Land holdings in the Project Area, as in the rest of rural Bangladesh, are extremely fragmented. The average size of a cultivable plot is .27 acres. While a farmer may own several acres of land, his holdings will normally be dispersed in several small cultivable plots in addition to his harvested plot. This fragmentation is very evident in the irrigation layout maps in Chapter I.

The legal limit on land holding size is 33 acres. The degree of inequality in land holding distribution varies from one village to another. In some villages a single landowner will control 200 acres. In other villages the largest owner may own only 10 acres. Because of the fear of government intervention and further land reform, accurate information on land holding and ownership is very difficult to obtain, and most statistics must be interpreted with this in mind.

A survey (conducted by F.T. Jannuzi and J.T. Peach in 1977) for rural Bangladesh produced the following statistical profile of land ownership:

Number of Acres	% of Households
Zero	11.07
0.01-1.00	47.44
1.01-2.00	16.43
2.01-3.00	8.91
3.01-4.00	5.27
4.01-5.00	3.29
5.01-6.00	2.09
6.01-7.00	1.43
7.01+	4.67

In this survey, 58 percent of the households were found to own less than one acre of land. Translated into spatial distribution, this means that on a typical 100 acre irrigable block of land, there will be some 200 owners, and 400 plots.

A study of a 95 acre command area for Rainagar Pilot Area yielded the following results:

	Size of Holdings	
Acres	Owner #	%
.01- .25	104	50.7
.24- .50	63	30.6
.51- .75	20	9.7
.76-1.00	7	3.2
1.01-1.25	4	1.8
1.24-1.50	3	1.4
1.52-1.75	3	1.4
2.01-2.25	1	.4
2.76-3.00	1	.4
4.01-4.25	1	.4
	207	100.0%

Source: Bangladesh Rural Advancement Committee (BRAC). Who Gets What and Why: Resource Allocation in a Bangladesh Village.

5.4 Operatorship and Tenancy

There are three principle mechanisms by which land is transferred by an owner to the operator. Land can be leased, mortgaged, or sharecropped. Sharecroppers generally pay for all the inputs and receive one-half of the crop.

Both large and small landowners may make use of any of the mechanisms, and much of the exchange from ownership to operatorship takes place among relatively small owners. The resulting overall distribution of operational holdings is not very different from the original land ownership distribution. National figures on tenancy show that 35.5 percent of farm households are either tenant or owner-cum-tenant households.

According to the above study by BRAC, the small holders as a group sharecropped out more land than they sharecropped in. This group also accounted for the largest part of the sharecropped land. That is, most sharecroppers are small owners who sharecrop the land of other small owners.

From BRAC statistics, the following approximate figures can be derived:

Of 100 irrigable acres, approximately:
10% will be leased:
4% will be mortgaged;
10% will be sharecropped.

Januzi and Peach believed that the proportion of sharecropped land is much higher, but their own figures show 23% of land cultivated is sharecropped.

Only farmers with holdings of less than one acre can farm their lands relying on their own, plus family, labor. They supplement family labor with reciprocal labor. Small holders (1-2½ acres) supplement family labor with daily labor. Large holders hire daily labor and permanent labor.

5.5 Trends in Land-holding and Fragmentation

Muslim inheritance laws combined with high birth rates and early marriage provide strong social forces for increased fragmentation of land hol ing in the rural areas.

However, once a plot becomes too small to provide a family with subsistence, the plot may be mortgaged or sold. Below a certain size, plots are not subdivided.

According to M. Alamgir, the overall distribution of farm size has remained stable for the last twenty years:

TABLE V-1
DISTRIBUTION OF FARM AREA BY NUMBER AND SIZE OF FARMS (OPERATIONAL HOLDINGS) BANGLADESH--1960, 1968, 1974

Percent of Farms Ranked by Size	Percent of Farms Area Operated		
	1960	1968	1974
First (bottom 20% of farms)	2.3	3.0	1.6
Second	8.4	8.3	3.4
Third	14.3	13.3	14.4
Fourth	21.8	22.4	25.6
Fifth	53.2	53.0	55.0

Source: Alamgir, Mohiuddin. 1975. "Some aspects of Bangladesh agriculture: Review of performance and evaluation of policies" Bangladesh Development Studies 3:261-300

5.6 Social Structure and Agricultural Labor

The basic forms of agricultural labor are three: owner farmers, tenant farmers, and laborers. As mentioned before, most tenant farmers are small holders who also own ploughs and bullocks. Laborers can be permanent (if the owner has enough land to support this) or they can be hired by the day, or seasonally.

The amount of agricultural labor which is required under irrigated farming is significantly higher than that required where there is no irrigation. However, the form of labor, and, therefore, the conditions of laborers brought about by the introduction of irrigation, is less certain.

Most sociologists believe that the result is a transformation in labor relations. Independent tenant farmers became more rare, and paid laborers increase. It is frequently assumed that paid labor, because it is seasonal, is less secure than tenant labor. However, little evidence is available

concerning this. In any case, decreases in job security must be weighed against overall increases in employment opportunities, and increases in income within the community.

5.7 Employment

The introduction of irrigation and improved agricultural practices increases the demand for agricultural labor and thus provides more agricultural jobs. Little information is available on the types of jobs (family--tenant, season) which are most affected. However, a careful study by M.A. Hamid (in 1977) concluded that irrigation has a quite significant impact on the increase of rural employment. In a boro season, the man days required per acre without irrigation were 30.54; with irrigation it more than doubled to 64.04.

5.8 Organizing Pump Associations

5.8.1 Comilla Thana Irrigation Program

The history of the introduction of low lift pumps into Bangladesh and the various social experiments in organization of pump groups associations can be traced to the Comilla Thana Irrigation Program in the 1960s. Some of the major features of this program were:

- The organization of farmers into cooperatives. These cooperatives permitted farmers to work together toward the solution of common problems such as the organization of on-farm ditches and problems of right-of-way.

- A disciplined program of savings and investment. Cooperative members made weekly deposits of savings into the village level cooperatives, the Krishi Sambaya Samities. Weekly meetings were held to reinforce the discipline required to ensure a regular savings program. This group pressure made the cooperative programs effective and permitted credit institutions to reach large numbers of farmers who individually had small savings.

- The cooperatives were associated with a training program and a training center at the Thana level. Every pump association appointed a pump manager and a model farmer received training at the Academy for Rural Development.

- In the beginning the low lift pumps were completely subsidized. In addition, the credit cooperatives were partially subsidized.

5.8.2 Extension of Comilla Model to Other Programs

The Comilla experiments provided the model for group formation for more recent programs in Bangladesh. This includes the G-K Project which was based upon a gravity feed system, and other projects administered by the BWDB, as well as programs under the Integrated Rural Development Program (IRDP).

The IRDP began as an effort to extend the Comilla community approach to the entire country under government sponsorship. Under it, each administrative village will be organized into a single credit cooperative, which will permit members to utilize credit to carry out local development projects including, but not limited to, irrigation projects. The Bangladesh Agricultural Development Corporation (BADC), also in its pump distribution system, in theory relies upon a variant of the Comilla model. Farmers are asked to form into cooperatives before applying for a pump from the BADC.

5.8.3 Problems of Existing Pump Associations

During the Phase II Study, an examination was made of:

- Pump groups functioning under BADC sponsorship within the Project Area;

- Pump groups organized and still functioning in Comilla under the original cooperative setting;

- Pump groups established under various pump distribution schemes, and now monitored, aided and encouraged by a number of donor and volunteer agencies.

- Pump groups organized at Faridpur Academy, a private group.

The results of this study revealed the following information (see Appendix F, Section II for details) for pump associations outside of the original Comilla program:

- In almost all cases, the pump was sited before any groups were organized. In existing groups now being monitored and encouraged, under special projects group organization and credit was the result of a large secondary effort and was based on an existing pump site. Only at the time of monitoring was land holding determined by the project staff for the command area of the pump.

- In many cases, the most important element of the Comilla approach--credit with enforced savings--was not operating. Frequently, insistence on enforced savings was neglected. Loans were given before patterns of savings and repayment could be established by the group.

- In cases where there was not an intensive IRDP effort, the functioning group was rarely a cooperative. Rather it was a relatively small group of farmers who paid for fuel and pump rental individually. The group was organized and managed by an influential farmer who was usually designated as the pump manager.

5.8.4 Pump Management in the Project Area

A number of pumps are currently in operation in the Project Area. These include low lift pumps operating from the Nabaganga River where sufficient water exists, and a number of shallow and deep tube wells.

Under the current system, a pump users group is organized usually under the direction of a larger landowner. This group can then obtain a pump from the BADC. The price of obtaining the pump includes a bakshish fee which ensures that those who can pay more will get access to better service, and to newer and better pumps. When villagers are asked specifically who obtained the pump for the village, they usually identify an influential man with contacts outside the village. Given the current scarce distribution of pumps in the Project Area and the mode of distribution this is not surprising. In fact, it

has been suggested by M. Hamid that the existence of such an influential farmer in the scheme, with considerable self interest in its operation, is a necessary condition for group success.

While the BADC provides machines and maintenance, the staff does not take an interest in group formation, or water management. In one village, a single land owner owned and operated virtually the entire command area of the pump. An interview with a "small farmer" in the system yielded a sharecropper on the land of the larger owner, who paid all farm inputs including fuel for a 50:50 split of the crop. In two other cases, three or four farmers with about seven acres each had organized a pump group. The actual command area was about 30 acres.

Under current subsidized rental rates the organization of four medium to large farmers for a 30-acre command area is financially feasible. In another village, an extended family with sufficient contiguous fields were organized into a single pump users group. Interviews showed that existing pumps are now serving an average of about 30 acres each, which is about the same as in the rest of the country under similar conditions.

5.8.5 Credit and Credit Cooperatives

Two types of cooperatives now exist in the Project Area. Cooperatives formed under the Ministry of Local Government, Rural Development and Cooperatives (LGRD&C) obtain loans through the Central Cooperative Bank. In 1977, the IRDP became active in the Magura and Jenida Thanas. They intend to establish village cooperatives in all villages, although they were not active in villages where the LGRD & C already exist. The IRDP cooperatives are linked to an extension program for cooperative managers and model farmers.

The two adjoining study villages, Mirzapur and Alaipur, represent the two types of cooperatives. The cooperative in Mirzapur has been in existance since 1964. It is still active and has a good record for loan repayment.

It appears that some of the IRDP cooperatives are suffering from problems of overextension without proper guidance or managerial experience. Records of repayment are not high.

Cooperative membership appears to be limited, although government objectives include extension to the entire village.

5.8.6 Pump Group Organization Under Private Sponsorship

A private effort to organize pump groups, after wells have already been drilled and established, was carried out at Faridpur Academy. In these cases, farmers were urged to organize and utilize existing pumps under a contractual arrangement, giving them a straight percentage of the harvest. The division of harvest for a tenant farmer was 1/3 for the tenant, 1/3 for the owner and 1/3 for the management. Under these circumstances sharecroppers found it financially advantageous to join and participate in pump groups without recourse to overall village credit schemes. At the time of organization, village organizers established land ownership and land operatorship, with reference to village mouza (parcel) maps.

5.9 Irrigation Technology and Social Change

Interviews with farmers and studies of existing pump groups indicate that farmers in Bangladesh are ready to use irrigation facilities if they are made available. Viewed in an historical perspective, there has been a great deal of social change in the last twenty years since the introduction of low lift pumps in Comilla. While much of the literature stresses goals of production, efficiency, and equity which have not been achieved, this should not obscure the fact that, in many cases, low lift pumps and tube wells are operating under some kind of management system all over the country. The conclusion to be derived from this is that Bangladeshi farmers are appropriating irrigation technology in their own way.

Based on this conclusion, it is believed that the current systems for pump and agricultural input distribution may in fact be hindering the rapid expansion of irrigation technology rather than promoting it. It is a reasonable assumption that Bangladeshi farmers are prepared to purchase their own pumps and systems if they can be made available to them under private companies.

5.10 Equity Issues and Irrigation

5.10.1 Distribution Problems

A major study was carried out in 1978 by M.A. Hamid *et al* of Rajshahi University to assess the different effects of irrigation technology upon large and small land holders. The major conclusions to that study were:

- Both small holders and large holders benefit substantially from irrigation;
- On a per acre basis, small holders actually benefit proportionately more than large holders; but
- On a per household basis, the larger land owners (having more acres per household) benefit more, and the per household net income gap between large holders and small holders is widened.

The latter conclusion, which demonstrates that benefits under irrigation schemes may be inequitable, is supported by findings of M.A. Hamid's 1977 study:

> The management committees of the irrigation groups are controlled by big farmers.
>
> The per acre net income is higher for small and medium farms than for large farms, the difference between the small and large farms is to the extent of 22%. This gap has been reduced in the deep tubewell (DTW) irrigated schemes. This may be due to the fact that the small and medium farmers are relatively more efficient in using HYV (high yielding varieties) technology than larger farmers.
>
> The net agricultural income per household is higher for large farms than for small ones. Whereas in the new-irrigated areas the difference between small and large farms was about 170%, this was widened to 327% in the irrigated areas. Therefore, the concept that

DTW irrigation produces an unfavorable impact on equity distribution is not without empirical backing.

The overall result is not necessarily due to problems related to the distribution of inputs (credit, pumps, seed, fertilizer, etc.). Irrigation increases the value of the land. In so doing the income position of large land holders is enhanced relatively to small holders.

The related point of concern to government officials is that this is achieved due to very large subsidies. It has been estimated that the amount of subsidy of deep tubewell projects is at least 84 percent.

After considerable discussion, it was decided that there was little that can be done to change this situation from the point of view of the proposed project. Policy measures which could be used include the adjustment of the land tax which is collected at the village level. If the Government continues to provide such large subsidies, then appropriate taxation of irrigated land would appear justified. This policy could not be recommended without careful study.

The long run effects of irrigation on equity are open to speculation. The fears of those concerned with distributive justice is that the introduction of irrigation would permit larger land holders to consolidate their position. Smaller land holders are forced to sell or mortgage their land. The overall result according to this argument is that landlessness will increase. In a rural society with 58 percent landless, this result is to be avoided if possible. In addition, combined with population growth, this view involves large numbers of small owner-cum tenant families being bought out by larger holders. The position of sharecroppers deteriorates, and they become wage laborers without assurance of regular work.

The alternate view is that this represents the first phase of a structural change in society which must be commenced in any case. The increases in income are sufficient to make the overall position of the community improved, and the increased need for agricultural labor means that even the landless will be

better off. The major gains will be seen in some 10 to 15 years of general economic development in the country.

5.10.2 Other Equity Issues

In addition to the major equity problem discussed above, the following equity issues have been identified in the literature on irrigation and development in Bangladesh:

1. In almost all cases, the large land owners acquire and control government distributed pumps which are then situated on their land.
2. Water user groups organized for the distribution of water around deep tubewells or low lift pumps have a tendency to break down, with water delivered to more powerful land owners while less influential farmers or farmers further away from the pumps have limited access. Bangladeshi villages were organized internally by factions with clear lines of patron-client relationships. In many carefully documented cases, government resources, if they reach the village level, are appropriated by a faction leader and used to maintain his position within the village.
3. Pump fuel and maintenance charges are usually passed on to tenant farmers. That is, tenant farmers pay the cost of inputs (seeds, fertilizers, insecticides, fuel), in return for one-half of the crop. Since small holders and tenants may not have cash to pay for these inputs, this sometimes results in not irrigating rather than taking the risk of going into debt for a crop.
4. Agricultural credit, if not under careful management, has a tendency to go to larger holders. There is a recent history of defaulting among the larger land owners with the result that the credit cooperative loses its credit standing. Our village survey data showed that credit was most frequently taken by

larger land owners, and that for the most part it was not repaid. It also showed that the larger land owners received seeds and fertilizers at subsidized rates. Smaller farmers are forced to buy these inputs at escalated black market rates.

5. The benefits of irrigation do not go directly to the landless, who according to the recent statistics make up over one-half of the population. Indirect benefits include increased employment opportunities.
6. Major problems are sometimes encountered in irrigation projects because of a failure to enlist the participation of the users of the facilities. It is almost impossible after irrigation facilities are installed at government expense to then enlist the support of users in paying for the facilities, maintaining them, or agreeing to a water use plan which either deprives tail-end users of water or uses water excessively. These problems are exacerbated when over 200 farmers must agree to cooperate to irrigate large command areas of over 100 acres.
7. Traditional irrigation projects have done little to directly increase the participation of women in society. The objectives of the projects are to increase yields of cereal grains which, particularly in Bangladesh, are grown by men. The indirect effect will be to increase the work which women would do at harvest, particularly husking or paddy and seed preservation. The villagers who participate in the project through cooperatives, agricultural credit programs, agricultural extension, use of improved varieties, and learning of irrigation management are predominantly male. The increased productivity of female labor is correspondingly neglected.

5.10.3 Mechanisms to Address Equity Issues

5.10.3.1 Creation of Independent Pump Associations With Assistance From a Management Consultant

An overall problem with most agency managed irrigation programs, is a tendency to want to control rather than to create autonomous farm management societies. One way this happens is that programs develop mechanistic schedules for the delivery of services. They then try to oblige farmers to meet this schedule.

It is suggested that farmers groups be given a chance to respond to offers of joining the irrigation groups. If within a stipulated period the group does not respond by consent to participation, then the project coordinators move on to offer technical assistance to the next group.

The terms of the technical assistance should be made clear to all villagers participating in the program. While the exact terms are left to be worked out in the implementation phase, they should include:

- participation in construction of on-farm ditches;
- agreement on cropping patterns;
- repayment schedule;
- election of a pump management group; and
- agreement on payment for inputs and management services.

Institutionally, it is important that there be a mechanism for project management to move out of the operation of these pump groups once the organization has been accomplished.

For this reason, it is suggested that this technical assistance should be sought on a contract basis from within the private sector. This management consultant would provide technical advisory services in setting up, operating, and managing self-sustaining pump groups.

5.10.3.2 Target Group Approach to Reach Operators on the Land

One of the major problems has been how to involve the actual operators of the land in the organization and maintenance of the pump group system. Without a special effort to locate and involve the operators in the establishment of a pump group cooperative, inevitably their position within the group will be weak or nonexistent.

An essential step to be carried out by the Management Consultant is a mechanism for the identification and enlistment of operators. This should be done by a complete listing of owners and operators with reference to the village parcel maps; this should also be verified by a community meeting and roll call.

There has been difficulty obtaining accurate information on land ownership. It is suggested that the time at which this information can be best obtained is at the initiation of the project implementation. Villagers are willing to cooperate with a program which will be to their benefit, but are not willing to divulge information which they feel would be harmful to them.

5.10.3.3 Direct Assistance in the Organization of Pump Associations

Especially where larger areas are concerned, the organization of up to 200 cultivators is a major task. Such a difficult task requires some outside assistance both in the organization, in laying out the principle of the cooperative group, and in training of the pump management. The terms of the irrigation group must be fully explained including the layout of field distribution systems, the labor required in building such systems, the method of payment or repayment, payment rates for water use and full participation of the group elicited. The objective will be to establish pump users groups which are owned and operated independently of government, which secure agricultural inputs for their members, and which act as "business" cooperatives.

While the goal of the program is to obtain complete village coverage, there must be a mechanism to permit assistance to go where it will be best utilized. Therefore, while the roll call procedure will be used for potential groups,technical assistance will not be offered unless agreement can be reached on the terms of the irrigation groups.

Group organization would be carried out by a Management Consultant Team. A basic principle is that considerable time must be spent at the village level working with pump association groups before pumps can be installed.

5.10.3.4 Technical Assistance in the Layout of Water Distribution Systems at the Command Area Level

Many of the organization and distribution problems surrounding pump groups are technical. Direct assistance in design and layout of field distribution systems could appreciably improve the functioning of water distribution systems and the areas they serve.

This assistance should be properly phased with the process of group formation. Thus, the first water distribution plan should originate from the irrigation group itself. A number of alternative plans will be proposed. By using the target group approach, the group organizer can determine which plans are most appropriate. Once these plans have been outlined, the technical assistance of a trained field engineer will be sought in improving the layout designing control structures, etc.

The alternative distribution systems should be actually outlined with stakes on the field to permit farmers to react to the proposed systems and understand their functioning.

5.10.3.5 Program for Homestead Plots

A program directed at improving the productivity of homestead plots by a hand pump distribution system and a program to identify and introduce better strains of vegetables

and fruits can be a meaningful way of directing program activities and benefits at women. This program can be combined with a poultry and livestock program designed to increase incomes on the homestead plots (see Appendix F).

5.10.3.6 Provision of Credit to Small Farmers, Tenants and the Landless

Current credit procedures are particularly inequitable at the village level. A mechanism needs to be established within the pump users group which will permit small holders and landless tenants to obtain credit against a production schedule. In addition a mechanism should be found to finance landless workers in small enterprises. For example, the introduction of irrigation into an area will considerably increase the demand for labor, especially for farmers possessing ploughs and bullocks. It is, therefore, recommended that a credit program be made available for landless permitting them to buy improved hand tools and animal drawn implements including bullocks, small hand tillers and wheeled seed drills. This would be included as part of the agricultural extension program.

CHAPTER VI
ON-FARM MANAGEMENT

VI. ON-FARM MANAGEMENT

6.1 Review of Existing Irrigation Developments

An extensive literature review and field observation program of selected pump groups was conducted to evaluate their performance and collect data on utilization of pumping equipment and water use efficiency. Following is a representative list of the projects analyzed.

(1) The Bangladesh Agricultural Development Corporation publishes a Districtwise Status of Irrigation as shown in Table VI-1. However, the command areas shown are not actual, but are the potential areas based on 40 acres per cfs for deep tubewells (DTW) and 30 acres per cfs for shallow tubewells (STW) and for low lift pumps (LLP).

(2) The Mennonite Central Committee (MCC) has installed 40 STW's in Noakhali and Comilla Districts during the past six years. Twenty-eight of these are still functioning. The pertinent details of these installations are tabulated below:

	Comilla Development	Noakhali (Feni) Development
Nos. of Tubewells	17	11
Nos. of Members:		
Total	289	245
Average Per Pump	17	22
Irrigable Acres:		
Total	315	141
Average Per Pump	19	13

TABLE VI-1

DISTRICTWISE STATUS OF IRRIGATION

AS ON 30.6.79

Sl No.	Name of District	Cultivable area in acres.	Existing irrigation facilities										% of cultivable land brought under irrigation facilities
			B A D C Projects						BKB STW		BWDB PROJECT	Total command area in acres.	
			LLP		DTW		STW						
			Cusec capacity.	Command area in acres.	Cusec capacity.	Command area in acres.	Number	Command area in acres.	Number	Command area in acres.	Command area in acres.		
1.	Dinajpur	9,50,495	683	20,490	1,444	57,760	401	6,015	835	12,525	1,04,717	2,01,507	21.20
2.	Rangpur	16,20,100	1,724	51,720	2,512	1,00,480	475	7,125	901	13,515	—	1,72,840	10.67
3.	Bogra	7,22,300	1,286	38,580	1,732	69,280	1,665	24,975	1,286	19,290	—	1,52,125	21.06
4.	Rajshahi	16,87,300	3,028	90,840	1,384	55,360	1,110	16,650	925	13,875	—	1,76,725	10.47
5.	Pabna	8,71,070	1,151	34,530	634	25,360	820	12,300	90	1,350	—	73,540	8.44
	Rajshahi Division	58,51,265	7,872	2,36,160	7,706	3,08,240	4,471	67,065	4,037	60,555	1,04,717	7,76,737	13.27
6.	Jessore	11,71,618	1,364	40,920	1,066	42,640	502	7,530	96	1,440	56,028	1,48,558	12.68
7.	Kushtia	6,00,860	1,162	34,860	888	35,520	448	6,720	219	3,285	63,685	1,44,070	23.98
8.	Khulna	9,45,140	1,704	51,120	90	3,600	292	4,380	30	450	—	59,550	6.30
9.	Patuakhali	5,85,740	3,512	1,05,360	—	—	—	—	—	—	—	1,05,360	15.36
10.	Barisal	11,77,545	6,987	2,09,610	—	—	5	75	—	—	—	2,09,685	17.81
	Khulna Division	45,80,903	14,729	4,41,870	2,044	81,760	1,247	18,705	345	5,175	1,19,713	6,67,223	14.57
11.	Faridpur	12,05,118	2,551	76,530	530	21,200	570	8,550	—	—	—	1,06,280	8.82
11.	Dacca	12,55,604	6,186	1,85,580	3,314	1,32,560	360	5,400	304	4,560	—	3,28,100	26.13
13.	Tangail	6,03,770	1,733	51,990	2,166	86,460	1,152	17,280	89	1,335	—	1,57,245	26.04
14.	Mymensingh	14,65,040	2,850	85,500	2,832	1,13,280	1,029	15,435	4	60	—	2,14,275	14.63
15.	Kishoregonj	9,80,550	7,898	2,36,940	1,324	52,960	289	4,335	3	45	—	2,94,280	30.01
	Dacca Division	55,10,082	21,218	6,36,540	10,166	4,06,640	3,400	51,000	400	6,000	—	11,00,180	19.97
16.	Sylhet	17,26,615	6,812	2,04,360	78	3,120	4	60	—	—	—	2,07,540	12.02
17.	Comilla	12,98,730	6,320	1,89,600	2,104	34,160	706	10,590	113	1,695	—	2,86,045	22.02
18.	Noakhali	9,19,200	1,779	53,370	216	8,640	59	885	73	1,095	—	63,990	6.96
19.	Chittagong	7,87,838	6,107	1,83,210	162	6,480	192	2,880	—	—	—	1,92,570	24.44
20.	Chittagong H. Tracts	1,63,437	425	12,750	—	—	—	—	—	—	—	12,750	7.08
	Chittagong Division	48,95,820	21,443	6,43,290	2,560	1,02,400	961	14,415	186	2,790	—	7,62,895	15.58
	Total	2,08,38,070	65,262	19,57,860	22,476	8,99,040	10,079	1,51,185	4,968	74,520	2,24,430	33,07,035	15.87

(1) Thanawise Statistics on Irrigation Facilities; BADC, March 1980

(3) A survey of tubewells and LLP irrigation in the Project Area was conducted in October, 1979 as part of the Phase II Study. This survey showed a total of 63 pumps in oepration; 60 are two cfs pump and three are one cfs pumps. The command area averages are:

DTW	-	48.4 acres
STW	-	7.5 acres
LLP	-	37.7 acres

(4) At the Kashimpur Agricultural Development Estate from 1968 to 1976, 201 DTW's were sunk. By December 1976, 146 DTW's were still in operation, irrigating 4,300 acres, for an average of less than 30 acres per DTW.

(5) At the Pabna Agricultural Development Estate, from 1969 to 1977, 57 DTW's and 31 STW's were sunk. By March 1977, 30 DTW's and 16 STW's were irrigating 910 acres, for an average of less than 20 acres per well.

(6) During 1979-80, CARE's Deep Tubewell Irrigation and Credit Program in Bangladesh (DTICP) had a total of 75 two cfs DTW's covering a total of 5,000 acres, for an average of 67 acres per DTW, or 33.5 acre per cfs. This performance is considerably better than most pump groups due mainly to the assured credit program, the supervision and management provided by CARE.

(7) The Christian Reformed World Relief Committee (CRWRC) in 1978-79 had five STW's in the Bogra District, irrigating from 10 to 25 acres per well, with an average of 14.8 acres per well.

CRWRC also has a Hand Tubewell Project wherein a total of 1,056 hand tubewells were supplied to farmers from November 1979 to April 1980. The average acreage irrigated by each hand tubewell was about one-half acre. (Note: Hand tubewells, hand pumps or Rower pumps with the attendant Mini-Pump Associations are also included in the On-Farm Management Model.)

(8) During 1979-80, the Intensive Management Pilot Program (IMPP) was inaugurated in IRDP-RD-I in the Bogra and Mymensingh Districts. The primary objectives were to increase the command area and crop yields. A total of 20 DTW's were carefully selected from hundreds of DTW's in operation in Bogra and

Mymensingh. After several consultations and tentative commitments, 11 DTW groups in Bogra and 9 DTW groups in Mymensingh were selected for the IMPP. During 1979-80, the command areas were increased from an average 51.5 acres to an average 94 acres. The yields were increased 57 percent, the Krishi Sambaya Sanities (KSS) membership increased 52 percent and the non-membership increased 73 percent. Moreover, production costs were reduced by an average of 30 percent per acre.

It is significant that the IMPP had unlimited financial backing in combining proven elements of success: planning, organization; management; credit; infrastructure; guaranteed inputs; extension; training; operation and maintenance; technical, operational and supervisory personnel; monitoring and evaluation. The program is limited in its replication; however, its formula for successful on-farm water management is worthy of consideration.

6.2 Constraints to Effective On-Farm Management

The constraints to effective on-farm water management are numerous and apply to most existing pump groups. Many are not in operation as a result of initial, repetitive and combinations of constraints. Following are excerpts from three particularly relevant reports:

(1) An Evaluation of Kushti Unit of the Ganges-Kobadak Irrigation Project, Netherlands Mission Report, September 1978.

Water management in field channels

Field channels branching off from tertiary canals generally serve areas in the order of 50 to 150 acres. Distribution of water is supposed to be arranged by the cooperative societies in which farmers who are not members also participate.

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The following problems are met:

- Influential farmers near the outlet use all or most of the water irrespective of the supply.
- The organization into cooperative societies is not based on mutual understanding and communal effort to achieve a common goal, but mainly on possible individual gains. This has been explained in sociological studies by the historical patterns of settlement, where neighbours came to live next to each other by chance (e.g. on levees) and are looking toward each other rather as competitors and where the organizational structure of society has always been loose or practically nonexistent.
- When the influential farmer can use his power (often also by taking up an influential position in the cooperative society) to gain control over the water, not much hope should be expected from persuasion only, under the given circumstances.
- The block channels leading towards the fields away from the field channels are often nonexisting or poorly laid out.
- Many of the field channels have been wrongly aligned.

(2) Manual for Agricultural Production and Deep Tubewell Command Area Development in Siranjang Integrated Rural Development Program.

Physical

- Soil structure in the SIRDP area is loose and sandy. Water retaining capacity is very poor;
- Soil character varies between deep tubewells and between plots of the same tubewell;
- Topography of the land is uneven;
- Brick lined channels are becoming costlier day by day;
- Maintenance of the tubewells cannot be timely ensured for want of spare parts, mechanics, etc;
- Handling of tubewells by untrained drivers causes serious damage to the machines;

- Lack of steady supply of inputs such as fuel oil at times disrupts efficient operation of the tubewells and ultimately damage crops, discouraging farmers participating in the scheme next season; and
- Unsteady supply of fertilizer and insecticides also disrupts efficient farming.

Social

- Selfish motives of the managers of co-op irrigation groups responsible for water management;
- All owners of lands within the scheme are not co-operative nor participate in the scheme;
- Absentee land owners hardly join the co-op irrigation groups and thereby create problems in constructing channels, etc;
- Lack of basic statistics on land ownership and lack of accurate production plans;
- Lack of an agreed and systematized water supply to plots of the same participants;
- Individualistic and parochial attitude of the members and lack of fellow-feeling;
- Lack of systematic visits/supervision and extension work;
- Lack of a coordinated and integrated approach from the Thana level concerned officers; and
- Farmers are not always aware of the crop suitable to their lands and also economics of farming. They produce varieties of crop in a traditional way.

Economic

- Farmers lack required capital for meeting farm expenses;
- Credits made available to them are not fully utilized for farming. Therefore, inputs like good variety seed, fertilizer, pesticides are not adequately and timely used resulting in poor yield and difficulty in repayment of credit;

- Credit is not always made available to the farmers timely;
- Lack of steady fund flow for meeting expenses on water supply;
- Lack of proper accounting, mistrust amongst the members on accounting; and
- Farmers do not get good prices for their products due to lack of organized marketing facility. They are at the mercy of the buyers. Buyers decide the price and the producers sell their products at the offered rate because they need cash immediately.

(3) Prior to implementing the IMPP, the IRDP-RD-I officials supported by local consultants and the field offices of BADC and DEM (Directorate of Extension and Management) conducted a field survey of the DTW's in the Bogra and Mymensingh Districts to determine the constraints to effective on-farm management. Based on the analysis of the survey, the following major constraints were identified:

<u>Absence of necessary institutional arrangement in the field for</u>

- Motivating the individual farmers for active participation in, and effective management of , water groups/cooperatives. This happened mainly because while siting the equipment, due attention was not given to the motivation and willingness of the prospective beneficiaries for group action, nor much effort followed subsequently to organize them into viable user's groups;
- Irrigation and water and water-use management. There is hardly any field agency entrusted exclusively with the task of irrigation and water-use management, i.e. for field surveys, preparation of land maps, layout of field channels, water distribution and rotation system, etc; and

- Coordination of Component Agencies such as IRDP in organizing the user's groups and channeling credit and other complementary inputs to such groups, BADC in operating and mainteining the tubewells and supplying seeds, fertilizer, etc., and the DEM in giving extension services, provide integral inputs for the optimum use of the tubewells. These inputs must be insured in a concerted way as a package, but there is no arrangement in the field to ensure coordination among these agencies.

Inadequacy of technical management due to:

- Frequent break down of the equipment;
- Nonavailability of spares in time;
- Irregular repair and maintenance;
- Lack of user's knowledge on efficient operation and maintenance of the equipment; and
- Uncertain supply of fuel,lubricant, etc.

Lack of definite arrangements for training and extension on irrigated cultural practices including irrigated cropping pattern, water use, etc., for the group.

Uncertain and irregular supply of complementary inputs like credit, seed, fertilizer, plant protection material, etc. Lack of adequate funds for purchased inputs and nonavailability of other inputs on time depressed farmers' participation and lowered the irrigated area per DTW.

Inefficient management of KSS-Irrigation due to:

- Dearth of motivated cooperative leadership;
- Absence of required production plan, irrigation budget, etc;
- Poor collection of irrigation costs and maintenance of proper accounts thereof;
- Lack of training of KSS members;
- Inadequate supervision/support from the concerned officials;

- Risks of crop failures due to various constraints;
- High water rates resulting from sub-optimum use of DTW's; and
- Domination of some KSS's by rich farmers. In some cases the rich farmers managed the DTW's by investing their own funds and exploited the poorer farmers by extracting high water rates. They were even unwilling to expand the command area often due to a paucity of funds.

A summary of the accomplishments of some selected pump groups is presented in Appendix F, Section III.

Briefly stated, the combined effects of all the above constraints result in the following conclusions:

- The actual command areas receiving adequate irrigation water supply are below the potential;
- Overall water conveyenace and distribution efficiencies are very low;
- Beneficiaries of existing schemes are considerably fewer than originally intended at the planning and design stages;
- Pumping equipment is poorly maintained and under utilized; and
- There is no coordinated efforts by responsible agencies for the timely supply of credit, technical assistance, training, extension, operation and maintenance, planning and management.

6.3 On-Farm Management Structure

6.3.1 Conceptual Model For On-Farm Management

A conceptual model for on-farm management has been developed based on extensive analyses of the constraints previously described. Parallel to the development of this model, the institutional development was evaluated to determine the requirements and support available to agricultural production in Bangladesh, and in the Project Area in particular.

The basic premise around which the model has been developed is that the impetus for initiating institutional support should emanate from the on-farm demand. Traditionally, the initiative for rural development has flowed from the national level down through the various regional, district and thana levels, to eventually reach the farmer. Inasmuch as the farmer in his traditional role is not prepared to accept either the philosophy or production inputs, the results have not always been successful.

To overcome this problem, the farmer must first be prepared to take full advantage of all available support and inputs which can increase his production and income. It is vital that the demand for goods and services be initiated at the farm level. In response to this demand, the supply of goods and services would then come through the optional channel of either the established institutions or the recommended private enterprises servicing the rural sector. The catalyst which will ensure this demand-pull is the development of a strong rural credit system.

6.3.2 Components of the Model

6.3.2.1 Block Groups

The corner stone of a Pump Association, is the Block Group. Each Block Group may be composed of from 3 to 20 or more individual farmers, who will receive water from a single source, either a turnout from an open system or a tubewell. Separate Block Groups will be established on the basis of the following factors:

- Size of the individual parcels of land;
- Number of farmers involved;
- Topography of the area;
- Discipline of the farmers individually, collectively, acquired and practiced;
- Willingness of the farmers to work together;
- Homogeneity of the group;
- Demonstrated desire to overcome obstacles;

- Ability to absorb the required technology, i.e.: educational and training assistance, adapt to irrigated from rain-fed production and adopt new cropping patterns; and
- Factors of family, group, village dynamics and association.

The Block Group will hold meetings with the guidance and assistance of team members of the technical and training staff and will:

- Determine and agree on the general cropping plans for the various growing seasons;
- Calculate the necessary inputs, i.e.: seeds, fertilizers, plant protection materials, credit, labor, fuel, etc;
- Determine the amount of water per acre required for each cropping season;and
- Elect, select, appoint or otherwise provide a Block Representative who will be a member of the Board of Directors of the Pump Association. He will represent and be responsible to the Block Group in all matters pertaining to the performance and execution of the irrigation project and the Pump Association.

The Block Representative will have the following qualifications and responsibilities:

Qualifications

- The individual must be a respected member of the village or subvillage and have the confidence and respect of his peers;
- He must be teachable and be able to impart acquired knowledge to his group; and
- He must be an active farmer with a better than average record of crop production and adoption of improved technology (if and when available).

Duties and Responsibilities

- He will be a member of the Board of Directors of the Pump Association and provide communication, data and information to the Pump Association and to the Block Group; and
- He will work with the members of the Block Group in preparing cropping patterns, i put requirements, block water requirements, production loans or credit requests, and collect water use and water delivery charges.

6.3.2.2 Pump Associations

The number of Block Groups comprising the Pump Association depends upon (1) the topography of the area; (2) the type of delivery system selected; and (3) the total command area to be irrigated by the pump.

A mini Pump Association is an alternative where one or more farmers, either isolated by topography, family ties, or religion may obtain a manually operated pump.

Each Pump Association will be governed by a Board of Directors composed of one Block Representative from each of the Block Groups comprising the command area. The Board of Directors will:

- Elect, select or otherwise appoint a Chairman who will be the presiding officer;
- Adopt a set of rules, regulations, policies and procedures for the membership;
- Select a Pump Manager;
- Select a Water Master;
- Select a Secretary/Treasurer;
- Prepare an irrigation budget based on the area to be irrigated and the crops to be grown in each Block;
- Determine the per acre water charge and collect the money from each Block Group;
- Arrange loan requests based upon Block Groups requirements;

- Define operation and maintenance procedures for motor, pump and distribution system; and
- Allocate water on an equitable basis to each Block Group.

Qualifications and responsibilities of the Pump Manager would be:

Qualifications

- The individual must have sufficient education to be able to keep an accurate record of the number of hours of pump operation, the amounts of oil, fuel, lubricants, repairs and parts used; and be able to forecast future requirements based upon past performance records;
- He must possess qualities of self-control, teachability, self-reliance, dependability and orderliness; and
- He must be a respected member of the village with a reputation of moral integrity.

Duties and Responsibilities

- The selected individual will work under the direction of and be responsible to the Board of Directors of the Pump Association;
- Be responsible for the operation, care, repair, and protection of the pump;
- Maintain an accurate record of hours of operation, the amounts of oil, fuel, lubricants, repairs and parts used on pump and motor;
- Be familiar with the operating manuals of all equipment and follow recommended maintenance program;
- Be a responsible unit of the team for providing water to each Block as per irrigation schedule agreed by the Board of Directors and administered by the Water Master, and
- Provide reports and other information as directed by the Board of Directors.

Qualifications and responsibilities of the Water Master would be:

Qualifications

- The individual must have sufficient education to be able to keep accurate records and, having received training, be able to draw up a schedule for equitable water distribution to each block;
- He must possess qualities of self-control, teachability, self-reliance, dependability, orderliness, organization, persuasion and self-confidence; and
- He must be a respected member of the village with a reputation of moral and ethical integrity.

Duties and Responsibilities

- Work under the direction of and be responsible to the Board of Directors of the Pump Association;
- Work closely with each Block Group in determining water requirements for each cropping period;
- Coordinate all of the Block Groups' water requirements and determine, with the Pump Manager the number of hours per week of pump operation;
- Make a schedule for delivery of water to each Block Group based upon the cropping pattern, season of the year, total water demand and the number of hours the pump must operate to deliver the required amount of water;
- Meet with each Block Group and explain delivery schedule;
- Monitor, supervise and deliver water to each Block Group as per delivery schedule; and
- Provide reports, investigate reported infractions and provide such data and information as the Board of Directors shall require.

Qualifications and responsibilities of the Secretary/ Treasurer would be:

Qualifications

- The individual must have sufficient education and capability to be able to keep accurate records; learn principles of accounting and bookeeping; maintain accurate records of all financial transactions;
- He must have the respect and confidence of his village and peers and a reputation of moral and ethical integrity; and
- He must be teachable, dependable, orderly and demonstrate organizational and management capabilities.

Duties and Responsibilities

- Work under the direction of and be responsible to the Board of Directors of the Pump Association;
- Set up an accounting system and keep orderly and accurate records of all financial transactions from the Block Groups and Pump Association;
- Be prepared to submit an accounting of all finances to an authorized auditor;
- Provide reports, data, finance statements and other required information to the Block Groups, Pump Association and the Water Authority; and
- Keep accurate minutes of all meetings including important items as decisions, recommendations, Board action, rules, regulations, etc., to be implemented by the Block Groups, Pump Association and the Water Authority.

6.3.2.3 Procedures for Group Formation

The mechanism and sequential planning for organizing both the pump associations and the block groups are discussed in the following sections. These procedures are flexible and must be adaptable to specific conditions. However, the form and composition of the organization will significantly affect

the future development and operation of the system, and considerable time and thought should be put into organizing the groups.

The procedures for group formation would include the following steps:

1. The purposes and objectives of the program would be presented to the village elected representatives and in community meetings. It would be explained to Primary School teachers, Iman of the mosque, Union Parishad members and former Union Parishad members. Thus no group would be neglected in the initial explanation of the project objectives. The program must be seen as directed to all villagers and not to only special interests, faction or group.

   It would be explained that the community organizers are there to help groups who would participate in forming their own associations and purchasing their own pumps.

2. Proposals would be called for from groups of contiguous land owners. This would be the beginning of the formation of Block Groups. Group applications will be related to a corresponding mouza map.

   Land holding would be established as part of this procedure. Land holding for any group seeking irrigation will be verified in an open community meeting with roll call procedures.

3. Appropriate systems would then be adapted to the farmers group association. The program would be flexible in offering different kinds of irrigation systems.

The following aspects would be taken into consideration:

- Size of the group which can work together;
- Homogeneity of the group;
- Topography; and
- Size and type of pump appropriate to the group.

4. Technical assistance would be provided in the design and layout of on-farm distribution systems.

5. The land holders and tenants would be instructed in their rights and duties as part of the Pump Association.

   This would include obtaining credit for the purchase of the system, the method of repayment for the water, the maintenance of the field system, construction of the system, and participation in the formulation of a production plan to be adhered to by the members.

7. Agreements would be finalized with the members of the Pump Association, with rights and obligations specified.

6.3.4 Landless Group Pump Associations

One experimental approach now being tested by some small donor assisted projects (BRAC) involves the organization of groups of landless farmers, permitting them to purchase pumps as an investment. They then sell water on a commercial basis.

This would not be a major activity in the project development, but such opportunities for the rural poor should be encouraged and supported.

CHAPTER VII
DEVELOPMENT INSTITUTIONS

VII. DEVELOPMENT INSTITUTIONS

7.1 Background

One of the goals of the Government of Bangladesh's (GOB) Second Five Year Plan is to increase the income and thereby improve the quality of life of the rural population. This would be accomplished by a comprehensive program of rural development and expanded agricultural production. This coordinated planning and implementation program would encompass the following three general categories of development:

- Production, e.g. agriculture, fisheries, poultry, livestock, cottage and small industries;
- Infrastructure, e.g. roads, canals, electrification: and
- Social services e.g. education, health, family planning, water supply, housing.

All these activities are to be planned and executed through local government and private institutions at the regional and village level drawing upon government institutional support through its lowest administrative leve, the thana.

Agriculture and rural developments in the past have not been as successful as planned. The major constraints have been:

- A unique environment prone to natural disaster such as severe monsoon season flooding, periodic cyclones, and droughts;
- Population pressure of mounting intensity. While 80 percent of the population depend on land, about 50 percent of the rural population have either no land or land below one acre. The consequences are a high population-land ratio, growing landless of the predominantly rural population, high rural/ unemployment and underemployment, and poverty and malnutrition;

- Poor land use, and low productivity. Efficient management of resources is critical for increased production;
- Inadequate access to modern inputs and support services, particularly irrigation, improved seeds, fertilizers, credit marketing and transport services;
- A tenural system marked by widespread share cropping and absentee land ownership. This together with insecurity borne out of natural disasters does not encourage extensive use of costly modern inputs or land development;
- An agricultural sector which is mostly on the subsistence level. An assured cereal supply for the family is of paramount importance to the subsistent farmer, and he is neither able to experiment with new cropping patterns nor can he use large quantities of purchased inputs;
- The lack of local level institutions and the minimal participation of the people in local planning and implementation; and
- Widespread illiteracy of the farmers, lack of proper extension service, and inadequate provision for research facilities.

The GOB has undertaken a number of institutionally administered projects to mitigate these constraints and to increase production. These projects developed in the previous five years have generally been treated as experimental in an attempt to identify organizational constraints, bottlenecks and successes from which to build an appropriate development model. These projects indicated that the critical elements for development are:

1) Spatial development planning emanating from demand for inputs and services at the village level. It is essential for the villagers to express themselves as the primary unit for regional planning as they would have the necessary ability to interact horizontally with peer groups and vertically with governmental units.

2) A comprehensive program including a simultaneous development of complementary components rather than full integration of these components. By complementary components is meant the full range of agro-support services i.e. marketing, supply, credit, roads, extension, training, cottage industry, health services, family planning and research. Lag time in development of these components would delay progress, since each component relies for its effectiveness on the other components.

Experience has indicated that it is not physically or administratively possible to integrate all components of comprehensive rural development under one program. Horizontal integration of two or more components of rural development may be possible within a geographic area. Such planning is generally referred to as the integrated approach. However, if there is no effective linkages between the agencies involved in the various stages of sector project, the implementing agencies tend to extend their internal organization to include a full range of development activities. This expanded vertical integration creates severe problems in (1) the flow of resources, (2) redundancy of labor, (3) competition instead of coordination among agencies, (4) inadequate training of staff, and (5) support logistics. These aspects in themselves while causing inefficiencies and time lags can be remedied.

However, regardless of the efficiency of the administrative (institutional) input, it would not be able to manage the magnitude of development needed in Bangladesh without creating serious economic repercussions. In order to initiate and supply inputs, provide maintenance and repairs throughout the rural sector along with training, credit, research and extension, the appropriate institutions would become so top heavy with personnel as to jeopardize their own well being and effectiveness. An example of this may serve to illustrate the point.

The Irrigation Management Pilot Project (IMPP) was started in 1979 to help mitigate problems in the RD-Iproject in the Bogra District. The specific problems were concerned with management, technology, input supply, and organization. In general, IMPP has resolved these problems and has been deemed a success. The command area has increased from 54 acres to 94 acres,production has increased and both the management and organizational structures are sound. Beginning next year, 65 new DTW's are to be added and expectations are high for additonal successes.

The concept and approach to this type of project seems realistic and,if implemented throughout the country with simultaneous development of complementary services,could very well lead to food self sufficiency within the next decade. However, under this project all inputs would come from institutional channels. The farmers would demand a higher level of input supply and credit, and additional personnel would be needed to manage and monitor the project. Considering the number of institutional personnel involved in the present 20 DTW's; and extrapolating to determine the personnel requirements for all potential DTWs and other irrigation projects for which this approach would prove effective in Bangladesh, it is evident that the man-power requirement would be massive. What would occur could be likened to an inverted pyramid in which the farmer forms the apex and the institutional involvement the base.

This dilemma of institutional overburden could be eliminated by encouraging private enterprise to participate as an alternative source of supply, maintenance and repair including their training and extension services. The development of the private sector in the distribution of agricultural inputs is in full accordance with the Second Five Year Plan. This would then free institutional personnel from the burdensome aspect of input suppliers and they could concentrate on their base activities of policy planning, training, extension, research, support and infrastructure development. In terms of economic development, the example of the inverted pyramid would still hold true, but in this case the base would be shared with agro-industry which would add a definite and positive component to the Gross Domestic Product (GDP).

The catalytic agent neeced for the demand pull of inputs from either government institutions or from free enterprise would be a well structured and active rural credit program. This coupled with improved farm management would generate the initiative at the farm or village level to demand their support and inputs.

In summation, the traditional governmental pattern of agricultural and water resource development in Bangladesh has been through institutionally administered projects. The projects have tended to be tailored to the respective implementing institution, placed in a geographic locality. The constraints to development through this institutional approach are threefold:

- Inter-Institutional;
- Intra-Institutional; and
- The inherent problem of development being initiated at the national level and flowing down to the village level, rather than the desire for development emanating at the farm level.

In addition, project experience indicates that the project or sector approach does not in itself have sufficient scope or capacity for the simultaneous component development necessary for comprehensive rural development. Nor is it possible to replicate the institutionally administered projects on a national scale due to budgetary and manpower constraints coupled with ministerial overlap.

7.2 Implementing Agencies

7.2.1 Introduction

There are more than 35 ministries and agencies in Bangladesh that are involved in some manner with water resources and agricultur. Only the following five, however are directly responsible for implementing or providing major support activities for integrated land and water projects:

- Bangladesh Water Development Board (BWDB);
- Bangladesh Agriculture Development Corporation (BADC);
- Integrated Rural Development Program (IRDP);
- Directorate of Extension and Management (DEM); and
- Credit Institutions.

The functions and capabilities of these five agencies are discussed in the following sections. These would all support and participate in the project development on an equal status. As discussed above, the traditional procedure of implementing agricultural and water resources development through a specific institution has not been successful. For this project, it is recommended that a separate entity be established which would be responsible for coordinating the activities of these agencies and monitoring the development progress.

7.2.2 Bangladesh Water Development Board (BWDB)

BWDB, a semi-autonomous authority under the Ministry of Power, Water Resources and Flood Control (PWR and FC) is responsible for the planning, design, implementation and operation of facilities for the development and control of the water resources of Bangladesh. Such developments include irrigation, flood control, land reclamation, drainage, salinity intrusion, and dredging and stabilization of inland channels.

BWDB is managed by a Chairman and five members responsible respectively for Planning, Implementation, Supply and Services, Finance, and Administration. Under their overall direction, day-to-day management is provided by 12 Chief Engineers (CE) and approximately 50 Superintending Engineers (SE) and Directors. BWDB has a total staff of 18,500 of which 2,000 are engineers or similar professionals, 6,500 technical and accounting personnel, and 10,000 non-technical classifications.

The planning program is responsible for supervision, guidance, control and coordination of project preparation including feasibility studies. Reporting directly to the Member

Planning are the Chief Engineers for Planning I and II, Design and Research, Hydrology and the Director for Economic Evaluation.

The implementation program is responsible for the design, construction, operation, and maintenance of all BWDB schemes as well as the planning of the small schemes under the zonal C.E.'s. Responsibility for implementation runs on a linear basis from the Member Implementation through five Chief Engineers to Superintending Engineers to Executive Engineers.

The Directorate of Land and Water Use operates under the Member Implementation and directs BWDB's irrigation extension service. In addition, the Directorate is responsible for an irrigation training center; a soil and agricultural survey division; and an irrigation agronomy division which conducts research on cropping patterns, input requirements, and changes in farmer practices necessary for successful introduction of irrigation .

The remaining functions of Supply and Services, Finance, and Administration would have no active involvement in the project development.

Until recently, the BWDB has been operating with its primary goal toward implementing the 1964 Master Plan with the subsequent development of staff, infrastructure, and investment. However, this implementation has not progressed successfully and has been severely curtailed dur to inadequate and untimely funding. BWDB is now redirecting and reorganizing its efforts with more emphasis on quick-yielding irrigation projects rather than flood control and drainage. While it is recognized that flood protection is important, the requirements of food production have assumed increasing importance in recent years.

This redirection of effort is in accordance with the findings and recommendations of a 1979 joint review of BWDB by GOB and the World Bank. Following are some of these findings and recommendations that are pertinent to the proposed development.

Findings

- There has been extensive deterioration of existing facilities due to inadequate funds for a proper operation and maintenance program;
- An insufficient level and slow process of funding for construction work is a major constraint to implementation of BWDB projects;
- There is serious underemployment of personnel and lack of adequately trained key staff; and
- On-farm management is very poor which can be directly attributed to inadequate extension services.

Recommendations

- Planning needs to be strengthened to ensure that schemes better reflect national objectives and agricultural production goals;
- A more systematic interdisciplinary approach is needed in the planning and evaluation process;
- A program needs to be initiated to increase cost recovery from water sector investment, i.e. to develop a water price policy;
- Development should be redirected towards low capital investment per acre schemes. These would include small, minor, and divisible flood control, drainage and irrigation schemes;
- Existing facilities should be re-habilitated, repaired and improved;
- Developments now in progress should be completed;
- Pump subsidies and water use charges should be reviewed; and
- The technical assistance and training program should be strengthened. It was further recommended that BWDB maintain its own extension services until such time as DEM has developed sufficient capability to take over sole source of extension activities.

The extension service within BWDB has been considered generally superior to that of the Directorate of Extension and Management (DEM) in the Ministry of Agriculture due primarily to adequacy of funding, but it is still inadequate to reach sufficient numbers of farmers to gain any real significant management achievements. BWDB assumed this activity when the G-K Project was first initiated and there were no other extension programs in the country. There is now a Directorate of Extension and Management under the Ministry of Agriculture. The record of DEM achievements to date is not spectacular due to lack of both trained staff and funding; therefore, the recommendation is to maintain extension capabilities within BWDB for the present.

7.2.3. Directorate of Extension and Management (DEM)

DEM is in the Ministry of Agriculture and is charged with basic extension services throughout the country. It is organized on six levels, corresponding to the administrative units of the country. The headquarters are in Dacca where administration and overall supervision is under the Director. There are four regional offices which coordinate the activities throughout the country.

In general, the performance of DEM has not been satisfactory. The inability of the DEM to achieve its objectives on a reliable basis has resulted in the creation of various extension arms under several other agencies. This has caused a duplication of cost and pyramiding institutional activities which diffuse their main goals.

Some of DEM's problems are:

- Weakness in structure and organization;
- Lack of sufficient funding levels;
- Lack of educationally trained extension officers;
- DEM is not associated with any agricultural or research institute. There is a limited flow of research information down to the Extension Agent and restricted reverse flow of the farmers problems back to the researchers.

Greater emphasis is being placed on extension, and DEM is to be assisted by both GOB and donor funds. To date, about 500 agricultural graduates and qualified extension personnel have been posted in different regions, districts and thana. In addition, village extension agents (VEA) have been posted in each of 4330 unions. Extension service will be further strengthened where justified by production potential. It is expected the number of VEA's will be increased by 40-45 percent. Also, the system of T and V (Training and Visits) which relies on regular visits to farmers, continuous in-house training and close supervision and control at all levels by a strong and unified chain of command, will be further strengthened by a cadre of crop production specialists equipped with training materials. The present extension services of the Plant Protection Directorate, BWDB, Horticulture Development Board and Tobacco Development Board are to be eventually amalgamated within DEM.

Eleven agricultural extension training institutes are expected to graduate 1,200 VEAs annually. Standards of training are to be improved by curricula development, quality instruction, and introduction of the T and V method. Higher level training institutes such as Central Extension Resources Development Institute and the Graduate Training Institute (CERDI and GTI) will be expanded to provide in-service training to mid and high level extension personnel.

7.2.4 Bangladesh Agricultural Development Corporation (BADC)

BADC was established in 1961 to bring about a major and quick breakthrough in agricultural development. It was entrusted with the task of promoting "modern technology" in what has been described as the 'traditional' sector.

The major responsibilities assigned to BADC are: a) the procurement and sale of fertilizers and pesticides; b) the procurement and sale or rental of agricultural inputs such as diesel engines, electric motors, pumps, tractors and other farm machinery; c) provision of service and training; d) management of seed multiplication farms and the purchase and sale of im-

proved seed variety, and e) irrigation development by means of low-lift pumps and tubewells.

BADC is a public sector corporation and one of the largest organizations in Bangladesh, and as a public corporation its activities are regulated by a charter. It receives its funds from the Government on the Basis of physical program targets which are approved annually by the ministries of Planning and Agriculture.

BADC's policy-making and administrative responsibilities are vested in the Board of Directors consisting of a Chairman and five Directors. The activities of the corporation are carried out by various wings, each under the control of one Member-Director.

Since irrigation management is a principal function within BADC, the greatest manpower accumulation is under this Directorate. Maintenance, operating, and general management functions are currently segregated along technical lines with separate Chief Engineers for deep tubewell (DTW), shallow tubewells (STW), and low lift pumps (LLP). The Chief Engineers report to the Director-Member (Irrigation).

Each Chief Engineer has significant autonomy and full authority over the day to day operations of his division. His duties include a)drafting of plans for allocation of new and existing equipment, b) supervise the operation of pumping installations, c) provide for seasonal maintenance and annual overhaul of equipment, d) prepare procurement budget for operating and maintenance supplies and e) oversee the management of field operations including administrative offices, inventory storage facilities and workshops.

Procurement is managed by a central Division with separate groups responsible for low-lift supplies and materials for STWs and DTWs.

The LLP operations have administrative offices and maintenance facilities spread throughout most of the country. Central offices and storage facilities are in Dacca; field operations are currently supported through three Regional, 46 zonal, 286 Thana (Unit) and 253 Sub-Unit offices. The LLP operations has a staff of 1100 supervisory and engineering

personnel, 2500 mechanics and 40,000 pump operators.

Tubewell operations do not have the same organizational structures or administrative and maintenance procedures as LLP programs. While separate offices for management are maintained at headquarters, there is a good deal of sharing of staff and facilities in the field.

Starting from a zero base in 1961, BADC has supplied pumps to irrigate approximately 2,255,000 acres of land. This has been an impressive achievement, particularly considering the service and maintenance problems and low utilization of equipment. The BADC irrigation program is directed toward relatively simple schemes that are low cost and quick yielding. The major resource constraint to program expansion relates to the availability of surface waters during the dry season.

Currently, BADC rents out over 35,000 LLP's per year, has sold nearly 10,000 STW's, and rents to farmers over 11,000 DTW's.

BADC is responsible for all repairs and maintenance service for LLP's and DTW's and to some extent for STW's. However, delays in procurements, shortages, and high prices for spare parts are chronic problems. The present number of workshops, facilities, and mechanics is inadequate. Transportation for mechanics is not available, necessitating reliance on local transport. In mid-1979 there were 42,720 serviceable pump sets suitable for fielding with 5,500 unrepaired and 7,550 condemned sets stockpiled in warehouses. To maintain stand-by stocks to cover breakdowns and circumvent logistical bottlenecks, only 90 percent of the serviceable stock is fielded each season. Pump sets rented by BADC are fielded and collected on a seasonal basis. Untimely fielding due to transport problems has obvious repercussions on the farmers, while pump-sets left in the field after the season suffer from immersion and weathering.

It has become apparent that the scope of operations within the BADC service program has outgrown BADC's ability to manage it. This has resulted in severe problems in the distribution of pump sets and spare parts, and in poorly

equipped and staffed repair facilities, causing strong criticism from farmers and other institutions reliant on BADC.

Of particular importance is BADC's performance in irrigation. In addition to supplying pumps BADC gives technical assistance in pump siting and provides maintenance services. BADC possesses limited water planning capability and has given only modest technical assistance to farmer groups. Most of its work has been in pump siting.

BADC is aware of its problems and is addressing improvement of inventory control and management practices with technical assistance from UNDP/ILO. This should strengthen the internal structure of BADC in terms of staff and financial resources along with implementing a proper maintenance program. Manpower problems are to be alleviated by a UNDP/ILO program for training 6,000 local pump operators to be qualified field level mechanics for repair and maintenace of pump sets.

Supplies of inputs, particularly fertilizer, are to be strengthened through development of warehouses at the district and local level through a USAID financed program. BADC has proposed that the private sector be allowed to import spare parts for pump sets and develop repair facilities. The intent is to involve the private sector in these activities, to encourage village level enterprise, and to include importation and sales of pumps and production inputs by the private sector. Toward this end, BADC has turned sales of plant protection materials over to the private sector and is now selling pumps sets to individuals.

7.2.5 Integrated Rural Development Program (IRDP)

IRDP is under the Ministry of Land Administration, Local Government, Rural Development and Cooperatives (MLG & RD) and evolved from the positive aspects of the Comilla experiment, which demonstrated that farmers, no matter how marginal, had the potential to improve their economic stations by cooperative

efforts. The program is headed by a Director-General, with Directors of Administration, Finance-Accounts-Audit, Training and Extension, Cooperative-Credit and Marketing, Planning, Research-Evaluation and Training who carry out the various administrative functions.

The IRDP prime consideration is to organize farmers into cooperatives utilizing a two-tier structure. By this is meant organization at the village level to form Krisha Samabay Samity (KSS), and at the thana level to form Thana Central Cooperative Associations (TCCA) to federate and support the KSS. The thana level is the lowest governmental administrative level, and it is from this level upwards that TCCA's would be active in ensuring farm level representation. It is also at this level that other institutions and agencies would supply inputs to enable an integrated development.

The thana office of IRDP is to encourage village members to form cooperatives, assist them in completing the proper papers for organization, and ensure that the cooperative is registered. Probably the most important function of the IRDP staff is to train and instruct the members, management committee, and cooperative manager as to their duties and responsibilities. Record keeping and accounting for the funds appear to be where most failures occur.

The thana office of the IRDP is where a village cooperative or a group of farmers not in a cooperative go for assistance to get a pump. The IRDP worker verifies that the group is properly organized either as a village cooperative, a pump committee of a village cooperative, or as a special pump cooperative, and if not assists them in meeting one of these three requirements. The request for a pump under the Thana Irrigation Program (TIP) must be reviewed and approved by various thana committees, and IRDP aids in obtaining this approval and procuring the pump from BADC. After the pump is installed, the IRDP is responsible for obtaining extension assistance for training a Model Farmer who in turn trains the other farmers in the use of

the irrigation system, high yielding varieties, fertilizers and pesticides. The IRDP also assist the farmers in obtaining credit to purchase these inputs.

Internally, IRDP had been plagued in the past by administrative and organizational problems. Due to rapid expansion, no action was taken to formulate proper rules, regulations and procedures. This caused internal problems among employees in terms of promotion and recuitment. Formulation and acceptance of these rules by the Establishment Division and Administrative Ministry has led to an alleviation of these problems.

Until recently, there was no effective chain of command linking the head of office with the field offices. The system has been improved by division of the country into four regions under the charge of a Director at the head office. Project Directors are now responsible to the Director-in-Charge of a particular division. Periodic reporting by the Project Directors has been introduced through the monthly submission of a proforma which highlights some of the vital aspects of Project Directors' activities, i.e. loan collection and disbursement, and problems identified with KSS and TCCA with actions taken.

The Training and Extension Division within the IRDP is one of the weak areas within the organization. The quality of training at the thana levels needs a good deal of upgrading in terms of quality and content. Key IRDP personnel in TCCA along with management officials of both TCCA and KSS are given higher training at different training institutions such as Bangladesh Agricultural Research Institute (Comilla), Rural Development Academy (Bogra) and Rural Development Training Institute (Sylhet). These are excellent training facilities with libraries and multidisciplinary staff.

TCCA's extension service to KSS consists of training the model farmer and managers in cooperative activities, innovative production programs, and the use of improved cultural techniques. TCCA's procure inputs such as fertilizers, seeds, irrigation tubewells and pumps, and credit. Extension service in the KSS is

thus provided by the trained model farmers and managers. The inherent problem with this system is that the model farmer may use his training and inputs to develop his own "model farm" with no transference to the rest of the KSS.

In addition to normal training, extension and support facilities, IRDP has undertaken special extension projects in collaboration with donor agencies and voluntary associations such as:

- Collaboration with UNICEF to put in operation over 56,000 hand tubewells for irrigation;
- Coordination, Education and Agricultural Development Project (CEADP) in cooperation with CARE; and
- IRDP - Mennonite Christian Council, International Voluntary Service and Health Education and Economic Development.

The Cooperative, Credit and Marketing Division is the most active division within IRDP. The Cooperative Division has expanded to well over 500 villages and helps to promote rural cottage industries and multiple income activities as well as health and family planning. The cooperative movement has not met with as much success as imagined due to resistance on the part of villagers and the need for strong incentives and performance through previous cooperative development, which has not been all that evident.

The Credit Division operates at the thana and KSS level where IRDP officials not only provide financial assistance but supervise loan operations. The TCCA's and their affiliated KSS's are cooperative bodies registered under the Cooperative Societies Act and managed by elected committees. As such, they are eligible for funding from the National Commercial Banks (NCB's). The major lender among the NCB to IRDP cooperatives is the Sonali Bank, which primarily acts as a refinancer. IDRP loan activities consist of capital formation at the thana level through the purchase of shares and savings. The KSS manager approaches the TCCA to arrange credit for the group which as a whole is derived from aggregation of production budget requests. The loan, usually short-term for a particular crop, is supervised to ensure its proper utilization and repayment. The IDRP

credit program has been able to play a greater role in development at the farm level than other credit institutions due to greater farm level contacts and knowledge of local conditions.

The Research, Evaluation and Monitoring Division, created in 1972, studies field conditions, identifies problems, evaluates performance of projects, and suggests the future course of policy formation. This division performs a particularly useful function as it registers wants, desires, and needs at the field level from which to develop or tailor projects aimed at bettering the rural poor. IRDP in the past has studied such areas as landlessness, rural credit and its uses, and commercial operation of rice mills.

The most intensified undertakings within IRDP, and certainly the ones embodying the truest sense of integrated rural development, have been the intensive area development projects e.g. Rural Development-1 (IDA supported), Serajganj Integrated Rural Development Project 9ADB (UNDP,UNICEF supported), Noakhali Integrated Rural Development Project (DANIDA supported), and the Irrigation Management Pilot Project (IMPP-IDA supported). These projects are location-specific development projects under which multi-sectoral development activities are undertaken, such as agriculture, livestock, fisheries, industries, credit, health and sanitation, family planning, infrastructure development, and education. These activities are implemented by the appropriate Line Ministries and coordinated from field to national level. IRDP is the sponsoring agency and is in charge of coordinating agency involvement, cooperative development, and management.

The intensified area development projects have met with limited success. RD-1 was the precursor and the areas in which it met problems included:

- Lack of inter-agency cooperation;
- General ineffective supervision of project;
- Inflexible functions within TCCA/KSS;
- Unaccepted and complex regulations and procedures governing KSS membership;
- Poor performance in loan payback; and
- Poor training of project and TCCA/KSS personnel.

As such, the Irrigation Management Pilot Project (IMPP) in the Bogra District reflects a transition phase attempting to overcome problems identified in RD-1 before to implementing RD-2. IMPP has met with a great deal of success particularly in terms of a credit program and increasing command area efficiency.

Success of IMPP has come about due to a great deal of intensified management, sufficient funding levels, timely and sufficient supply of inputs, and a strong selection basis of co-operating and high potential pump groups. Two inherent problems with this approach are the possibility and probability of replication on a national basis, and the fact that IRDP programs make no provision for incorporation of the private sector for supply of inputs, extension, etc. In fact, IRDP makes a strong suggestion that input supply and development be kept within the institutional aspects operating through thana levels. This philosophy seems to form a dichotomy with the National Planning Commission (NPC) emphasis on private sector development and in particular with BADC's desire to bring the private sector into the business of input and equipment supply.

7.2.6 Credit Institution

The government credit system is under the Bangladesh Bank (BB) whichcontrols money supply, has credit regulatory powers, and establishes reserve requirements. Institutional agricultural credit is provided by the Bangladesh Krishi Bank (BKB); six National Commercial Banks (NCBs) - Sonali, Janata, Agrani, Pubali, Repali and Uttara; and the cooperative credit made up of traditional (Bangladesh Samabaya Bank Limited and its affiliates) and IRDP administered credit.

The NCBs have over 3,300 branches throughout the country, of which the Sonali Bank is the leader in agricultural financing. The Janata and Agrani Banks have also begun some agricultural lending particularly in STW's. However, further expansion would require a significant change in loan policy together with a

training program of staff in agricultural loans, appraisal and supervision. The Sonali Bank's primary contribution to agricultural finance has been through IRDP cooperatives.

Of the cooperative banks, the Bangladesh Samabaya Bank Limited has a dismal record and as of mid-1979 was operating with a negative net worth, relying exclusively on borrowings for loan operations, and extending short-term credit solely on resources made available by the Bangladesh Bank. The primary reason for this position is due to the inherent weakness at the primary level of the traditional credit structure. IRDP credit cooperatives were developed to offset this problem by establishing a two tier cooperative credit system, KSS/TCCA. IRDP cooperatives have so far been able to play a greater role at the farm level compared to other credit institutions. This is due largely to concentrated efforts on a project basis, coupled with greater farmer interaction and knowledge of the local area. However, a major fault with the IRDP credit program lies in formation and motivation within KSS's, and the exclusivity of this credit only to federated cooperatives under IRDP.

BKB is the foremost agricultural credit organization of the country, and with adequate funding for infrastructure development, a sufficient credit base and experienced rural loan officers could make a significant contribution toward an expansion of the agricultural sector. In addition, BKB has a non-collateralized rural cottage industry loan portfolio which if expanded would be an ideal catalyst to help develop employment not only for landless poor, but also for agri-business support enterprises.

BKB is a government owned autonomous body that was formed in 1973 to assume the operations of the Agricultural Development Bank of Pakistan. The management and administration is through a GOB appointed, seven member Board of Directors headed by a Managing Director. He is supported by a senior staff of three General Managers, an Officer on Special Duty for recovery, ten Deputy General Managers and 400 officers. There are 3000 other staff members, including 600 field assistants.

BKB's annual loan disbursement in 1978/79 totalled Tks. 746.6 million. There was a total number of 258,000 borrowers of which 52 percent had 2.5 acres of land or less and accounted for 73 percent of the total loan disbursements. BKB is emphasizing short-term agricultural production loans under a Tks. 1000 million program. Those loans are made against potential crop production unless the potential borrower is a sharecropper, in which case a co-signer is required. Loans for the purchase of manually operated shallow tubewells for irrigation (MOSTI) are collateralized against one-fourth acre of land or more.

The BKB loan policy is very detailed and prescribed, with most loans over TK. 2,000 requiring a mortgage of land as collateral. This requires verification of records for a search of encumbrances on the land offered as security. Considerable delay is encountered before loans can be disbursed. There is also an unavoidable expenditure accrued to the borrower since BKB charges a TK. 20 search fee plus 50 percent of travelling and daily allowance.

Loan disbursion procedures prescribed by the Bangladesh Bank (BB) are also applicable to both BKB and National Cooperative Banks (NCBs). They involve complete reliance on Union Parishad Chairman/ward members for identification of borrowers and estimates of their credit needs. The BB recognizes the extreme importance of each bank having direct contact with the farmer/borrowers, and has advised the banks to strengthen their field operations accordingly. Both BKB and Sonali Bank have been advised to structure a system on a pilot basis to sanction annual credit limits so borrowers are assured of time loans for following crops, rather than the present credit estimation made prior to each cultivation.

Similar to other agencies, BKB has a critical need for adequately trained personnel, particularly at the field level. A critical and necessary activity of any agricultural lending institution is the ability for in-house technical advisory services which act as extension agents through whose proper advice

loan repayments are assured.

7.3 Findings and Recommendations

7.3.1 Institutional Structure

There are serious problems throughout all phases of agricultural production. The major problems are:

- Inadequate irrigation and drainage system;
- Inadequate on-farm management of resources;
- Shortage of repair facilities, and an uncertain supply of spare parts and fuel;
- Non-abailability of inputs (seeds, fertilizers, pesticides);
- Difficulties in obtaining short-term crop production loans and non-availability of medium-term capital loans; and
- Social and political rivalries within production groups.

Efforts to resolve these problems have generally relied upon the institutions to plan, implement, and support developments in the private sector. For this proposed Nabaganga Project, it is recommended that both the public and the private sectors participate in and contribute to the development. The regulation works would be planned, financed, implemented and operated by the Government through BWDB. For the on-farm development, these functions would be the responsibility of the farmers through their local associations, with technical assistance provided by both government agencies and private enterprises.

This technical assistance is particularly important and is the prime necessity if the optimum agricultural production is to be realized. This problem has been recognized and substantial efforts are being made to improve the capabilities of DEM. This effort should be supported and sustained. Support should also be provided for some private assistance as discussed in the following section.

7.3.2 Equipment and Production Inputs

The shortage or improper supply of these items has also been a serious deterrent to full production. BADC is the prime supplier of these items. They have recognized the problems and are improving their inventory control and management practices. They are also encouraging the private sector to become involved in these activities. They have turned over the sale of plant protection material to the private sector and are now selling pumps to individuals.

The private sector should be further encouraged and supported in their participation in the supply and servicing of the agricultural inputs. Established pump and engine manufacturers such as Yanmar, Duetz, KSB, Mitsubishi, and Ruston have indicated a willingness to open local distributors and workshops not only to sell and service directly to the private sector but also to train local pump operators. Distributors of plant protection materials such as Bangladesh Agricultural Industries should be encouraged to establish distributorships at the local level to sell directly to the public. It is expected that these plant protection companies would also provide an extension service to educate farmers on application and range of that particular company's products.

The above companies are interested in opening village distributorships as soon as the demand justifies the venture. There is a need to provide an effective vehicle to facilitate and expedite this type of enterprise. The provision of an adequate rural credit program would provide production credit to the Pump Associations and equipment financing to the local dealers. The dealer in turn could act as an intermediary, granting credit in turn to the Pump Association with payback on an installment basis. The payback basis would create a built-in monitoring and performance program for both the Pump Association and dealer. The dealer would insure that maintenance and repairs were affected on a scheduled routine and would operate a workshop and training program for pump attendents. The Pump Association in turn

would need to operate purchased equipment at optimum efficiency to insure scheduled pay back. Since this concept is based on a business relationship, responsibilities would lie with both the dealer and purchasers.

7.3.3 Credit

A well structured and active rural credit program is essential to the success of the proposed development and particularly for the above proposed procurement policy.

Historically, institutional credit reaches only a small percentage of the rural population. A 1966 estimate indicated that friends, relatives, and money lenders provided approximately 96 percent of agricultural credit. Since then, a moderate expansion in institutional credit has lowered the non-institution credit to about 70 percent of the total. In most cases, this non-institutional credit is for consumption or short-term production purposes. However, there are severe shortages in the amounts of this credit, and often borrowers are subject to serious interest rates or land mortgage schemes. These credit shortages and high rates restrain the adoption of new production technologies.

Not all of the problems of rural credit result from bank administration or credit supply. Part of the problem lies at the farm level, particularly in terms of equitable distribution. This is partly a function of bank procedures and partly a function of the local political structure. An additional problem is the limited loan recovery rate from the rural poor, who in many cases default with anticipation of debt waivers due to political changes.

USAID started a Rural Finance Experiment Project (RFEP) in November 1978 to test the suitability of eight different credit models for extension and recovery of agricultural credit, given the constraints referred to in the preceeding discussion. The RFEP is designed to reach a particular defined target group (ownership of less than 2 acres, annual gross cash income Tks. 6000 or less) and uses the basic hypothesis that interest rates

representing the actual cost of credit are crucial for overcoming the major constraints encountered in rural credit supply. This full cost credit is expected to: 1) reduce the distribution bias toward village elite who would normally capture cheap credit; 2) augment the financial viability and incentives along with capability of institutions to serve the rural poor; and 3) mobilize local capital and expand total rural credit supply to small producers. Credit risk due to poor repayments are expected to be offset through strong loan administration including: sufficient loan amounts given, timely fund release, and strong monitoring.

It is suggested that the above program be expanded into the project area. It would be particularly relevant here where there will be a new and organized demand for credit.

The complementary management of a loan by both the private and public institutions is also a recommended means providing credit for the proposed development. This procedure, as discussed in Section 7.3.2, would have the distributor obtain a business loan from a regular bank, and then act as an intermediary for installment sales of equipment to the production groups. This procedure would (1) allow the bank to grant an aggregate loan which would be monitored through a single source (distributor) which has an established credit, (2) help a distributor to become established in the rural area, and (3) establish a business relationship between farmers and the private source of supplies and equipment.

CHAPTER VIII
MANAGEMENT OF PROJECT DEVELOPMENT

VIII MANAGEMENT OF PROJECT DEVELOPMENT

8.1 Introduction

Generally the farmers in Bangladesh are receptive to any developments that would increase their production. Their efforts, however, have been handicapped by an inadequate and unreliable distribution network for farm inputs such as high yielding varieties of seeds, fertilizers, pump fuel and spares, by a lack of a surface water supply during the dry season, and by an ineffective technical assistance program. Such assistance is particularly needed for improving the on-farm management, and for the planning for the irrigation and drainage systems. The marketing, processing and storage facilities, and the rural credit program are also inadequate.

The traditional procedure for implementing agricultural and water resources developments and responding to the above problems has been through a specific institution acting as the implementation agency. This procedure has not been fully successful, as discussed in Chapter VII, and for the Nabaganga Project it is recommended that a separate entity, the development manager, be established who would coordinate the activities of all interest groups and institutions, and monitor the progress of development. Such an entity would rely on the support of all interested, but if necessary would employ its own resources to resolve any inadequacies or short-comings.

A separate entity is recommended because:

- The on-farm development is not designed for institution building. It is designed to benefit the rural poor through the initial expediency of farm management. This would insure that farm demands are met through whichever channels, including private enterprise, offer the most efficiency.
- The institutionally administered approach to program development and management has proved of limited success in the past, and significantly, what successes there have been are not replicable on a large scale due to manpower and budgetary constraints; and

- Implementation under any particular governmental institution is liable to limit the technical advisors to solving internal problems. The World Bank is actively engaged in projects to strengthen those institutions evaluated for this project. However, the technical advisors provided in this project would work actively with field level institutional staff particularly in extension and credit.

The Organization Chart for the proposed development management is shown in Figure VIII-1.

8.2 Planning Commission

The Planning Commission would be the responsible agency acting in behalf of the Government of Bangladesh. The Commission would select which agency would be responsible for implementing the development and would monitor and review the progress.

8.3 Implementing Agency

The implementing agency would be the contractual agent and would provide logistic support to the development manager. For this project, it is recommended that BWDB be selected as the implementing agency. BWDB is very active in the area, and they have staff and office facilities in both Magura and Jhenida with additional support available from the adjacent G-K Project.

As a separate role, BWDB would be responsible for the construction and future operation and maintenance of the regulating works.

8.4 Development Manager

The development Manager would supervise and monitor all development activities. They would work closely with and secure support from all interests including BWDB, BADC, IRDP, rural credit

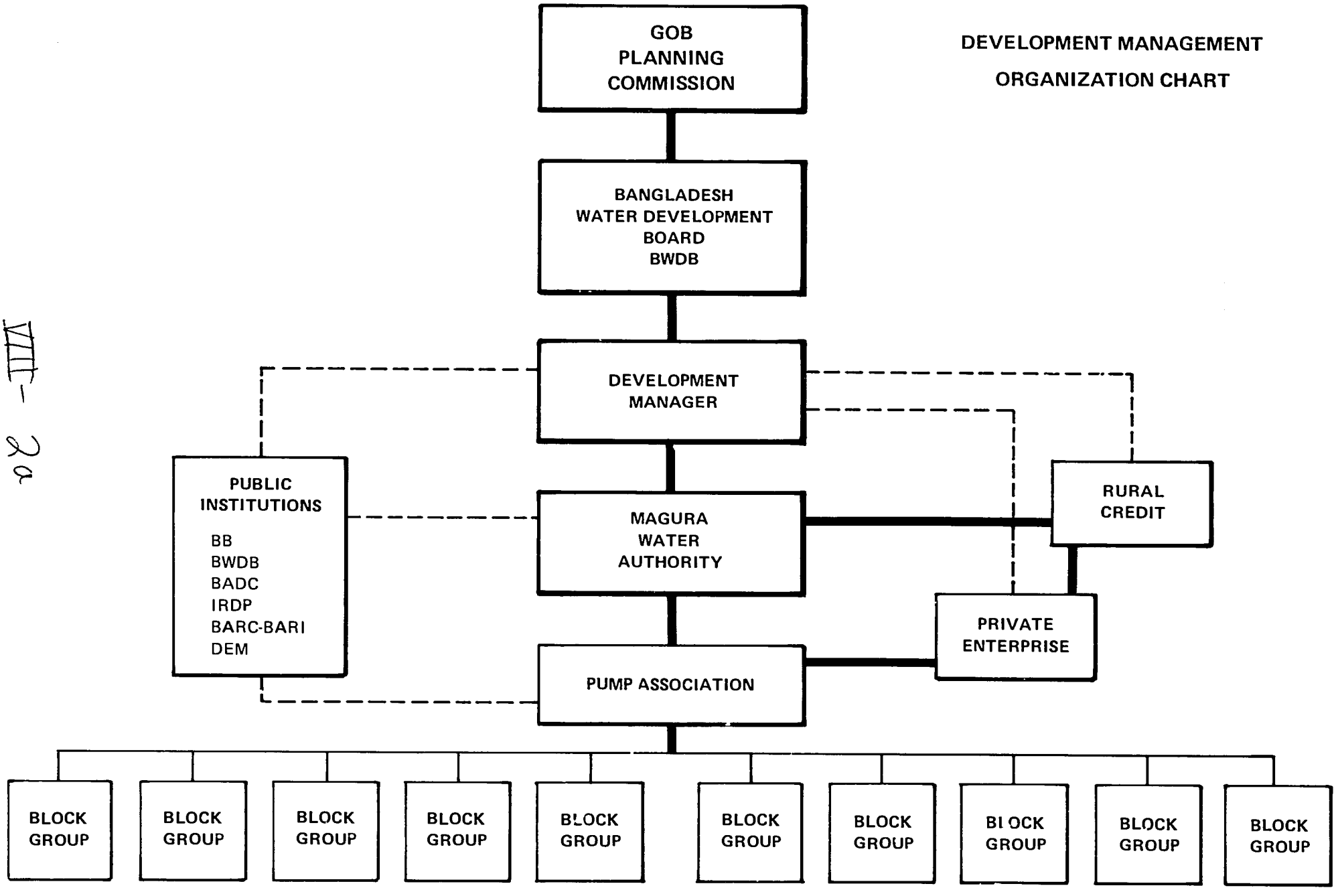

FIGURE VIII – 1

agencies, and private enterprises. The major responsibilities of the development manager would be:

- Develop and monitor a training and extension program for on-farm management and fisheries development;
- Encourage and assist in the formation of pump associations, fishery groups and other production units;
- Assist in the planning and design of on-farm irrigation and drainage systems, of fisheries development, and regulating works;
- Maintain liaison and coordination with interested agencies at both the national and local level;
- Initiate a linkage between government and private enterprise for the supply of inputs, for marketing, and for rural credit; and
- Establish an evaluation program.

For the Nabaganga Project, it is recommended that private consultants be selected for the development manager. These consultants would be a group of expatriate and Bangladeshi specialists in engineering, particularly on-farm development, agricultural training and extension, village group formation, marketing, finance, credit, and fisheries.

It is anticipated that the consultant groups would be active during the initial five years of development. During this period the Magura Water Authority would be assuming a continually greater role in coordination and monitoring of the operations of the development, and would replace the consultants at the appropriate time.

8.5 Magura Water Authority

The Magura Water Authority would be comprised of representatives of the pump associations, the fishery groups, and other interests. The Authority's principal function would be a coordinator between the above interest groups and the private and public agencies that would provide agricultural inputs, credit, marketing facilities, and extension and training services. Those

functions are more specifically defined below:

- Representation of the accumulated interest groups in utilizing the Magura weir;
- Liaison between the interest groups and government both at local and national levels. Has free access to K.S.S. and thana level;
- Responsible for accessing credit, production and capital inputs for the interest groups and insuring these inputs are provided by either institutional or private sources. Monitor production and application of inputs and credit pay back;
- Collect any water use charges payable to the BWDB. Act as the official voice of the interest groups to insure BWDB supplies an adequate water supply; and
- Form the macro-level of involvement between Government, private enterprise and the interest groups to facilitate linkages and interactions.

CHAPTER IX
EVALUATION PLAN

IX-EVALUATION PLAN

9.1 Introduction

Evaluation criteria have been designed to determine if the objectives of the development are being fulfilled, and to measure the impact on the target groups. The major objectives of the development are to:

- Increase the number and the effectiveness of the pump associations and other production groups;
- Improve access to water, fertilizer, seed and credit to small holders and operators;
- Improve cropping patterns, intensity and yields; and
- Increase income to small land holders, tenants and the landless.

A summary of the development objectives and the evaluation criteria is shown in Table IX-1.

9.2 Procedures for Monitoring and Evaluating

9.2.1 Introduction

There would be four types of project monitoring and evaluating studies which would be used to assess the effectiveness of the development.

The data required for these studies would be collected by the extension agents in conjunction with, or in addition to, their regular activities in the villages. It is expected that some villagers would hurriedly install pumps as soon as water is available and before technical assistance can be provided. It is uncertain if or when these villagers would be receptive to technical assistance or to providing the following data.

9.2.2 Village Census

A census would be taken in each village during the initial phase of organizing the production groups. This will establish baseline conditions and identify socio-economic conditions in the village. It would also provide a sampling frame against which any future surveys

TABLE IX - 1

SUMMARY OF SOCIO-ECONOMIC EVALUATION PLAN

Development Objective	Indicator	Method
1. Improved incomes to the target groups.	Measurement of gross income: value of livestock, livestock products, crops consumed and sold.	Household Survey
2. Improvement in cropping pattern, intensity and yields.	Number of crops per year. Yields per acre.	Project monitoring Household Survey
3. More effective water user groups	Number of groups: Owning and operating independently. Providing inputs to their groups. Acting as business corporation.	Project monitoring
4. Access to water, fertilizer, seed and credit for small holder provided by pump management group.	Higher proportion of target group in the project system; Higher proportion of target groups receiving water, fertilizer, seed credit.	Project monitoring records
5. Increased ownership of production assets by landless.	Ownership of draft animals or hand tillers to landless and small holders.	Village household sample survey, baseline and at yearly intervals.

may be carried out.

One of the objectives of this evaluation would be to examine procedures which could extend irrigation benefits to small holders, landless and operators of the land. The degree to which the project is successful at meeting this objective can only be determined if the composition of the community is known with statistical accuracy. Only a complete household listing can establish the population composition accurately. Combined with the records on irrigation groups, it will be possible to determine the proportion of the small land holders and landless operators included in the system.

Information to be collected during a village census is described on a sample format sheet provided at the end of this chapter (Form A - Village Census Data). Once this data is compiled, the specific target groups can be identified using a classification as presented in Form B - Group Identification.

9.2.3 Land Operator/Ownership Maps

Land operator/ownership maps would be prepared for each pump group during the planning for the on-farm distribution systems. The basis would be village mouza maps. They would be updated with the aid of village registration and community meetings. Roll call procedures, if carried out, would determine the actual operators and owners of the land.

These will provide baseline information both for the organization of block groups and pump associations. These would be used in conjunction with records on cropping patterns, credit advances, and agricultural inputs for monitoring the extension of irrigation and improved farming practices in the villages. These maps would be able to demonstrate the acreage currently under cultivation, the size and extent of pump associations, and the number of tenant farmers cooperating.

9.2.4 Block Groups

Various records would be maintained in order to monitor individual farmer development within respective block groups. The types of information which should be collected annually are presented on sample Forms C, D and E at the end of this chapter. Based on the village

census data and the group records, it would be possible to determine the effectiveness of the project in delivering benefits to the target groups.

9.2.5 Pump Association Observation Study

With the project, there would be substantial increase in the number of groups owning and operating their own pumps, providing input to their members, and operating as a regular business.

In order to assess how effectively these groups are organizing and providing inputs, a process of monitoring their operation would be necessary. This monitoring would also provide on-going feedback to the project management.

The form of this observational analysis would be the recording of the process of group formation, which could be performed at periodic intervals. The observation will include figures on size, acreage, and number of members. But the emphasis would be on the accurate description of the process by which groups organize themselves to perform functions necessary for their operation. These include: preparing production plans, purchase of pumps, lay out of distribution system, construction of system, obtaining seeds, fertilizers and other inputs, operation and maintenance of pumps and field distribution system, use of credit, and payment for inputs. These would be prepared at six month intervals. A list of the information required is presented in sample Form F included at the end of the chapter.

The project records on the development of pump associations would be compared with other relevant existing programs in Bangladesh to provide evidence concerning the increased effectiveness of the approach taken in the proposed project. Recommended comparisons would involve IMPP, RD1 and CARE. Where statistics and records are not equivalent, smaller intensive investigations may be undertaken. This comparison will not be the direct responsibility of the project but would be done by the donor agencies.

9.2.6 Household Sample Survey

Household surveys would be carried out at periodic intervals to monitor overall improvements in incomes, agricultural practices, yields

and employment. The recommended time is at year one and five of the project. These would establish baseline conditions and would permit an accurate measurement of changes in socio-economic conditions over the life of the project.

The sampling frame will be provided by the village census. The survey will be carried out by a survey organization.

The following socio-economic changes would be expected.

- Increased incomes to farmers using irrigation including small holders and tenants;
- Improved yields;
- Improved farming practices;
- Increase in income due to increased employment opportunities;
- Improved access to water, fertilizer, seed and credit especially to small holders; and
- Increased ownership production assets for landless (draft animals, ploughs, etc.).

This survey would be done by a reliable survey organization and would not be the direct responsibility of the project. Topics which should be included in a household survey would include:

- Identification of household;
- Household composition;
- Land holding;
- Income;
- Agricultural practices;
- Ownership of assets;
- Employment; and
- Access to HYV seeds and credit.

FORM A - VILLAGE CENSUS DATA

1. Name and address:

   (a) Name -
   (b) Father's name -
   (c) Village -
   (d) Dangi/Para -

2. Quantity of Homestead Land -

3. Number of ploughs -

4. Qunatity of cultivable land

   (a) Own land -
   (b) Own cultivation -
   (c) Barga given -
   (d) Barga taken -

5. Fallow land

   (a) Water -
   (b) Vacant -

6. Position of homestead land and quantity

   (a) Ditch -
   (b) High -

7. Number of family members

   (a) Able -
   (b) Disabled -
   (c) Male -
   (d) Female -
   (e) Child -

8. Number of houses

   (a) Tin shed -
   (b) Straw, etc. -

9. Number of fruit trees

   (a) Mango -
   (b) Jack fruit -
   (c) Cocoanut -
   (d) Betel nuts -
   (e) Banana bush -
   (f) Lemon -
   (g) Etc. -

10. Domestic animals and birds

    (a) Bullocks/Buffalos -
    (b) Cows -
    (c) Calfs -
    (d) Goats -
    (e) Sheep -
    (f) Horses -
    (g) Chicken -
    (h) Ducks -

11. Number of literate persons

    (a) Male -
    (b) Female -
    (c) Child -

FORM B - GROUP IDENTIFICATION

Group No.	Categories	No. of families
1.	Homeless	
2.1	Homestead family only	
2.2	Homestead family with plough	
2.3	Homestead family with .50 acre land	
3.1	Plough family with land up to 2.50 acre	
3.2	Plough family with land up to 5.00 acre	
3.3	Plough family with land up to 7.50 acre	
4.1	Plough less land holders up to 2.50 acre	
4/2	Plough less land holders up to 5.00 acre	
4.3	Plough less land holders up to 7.50 acre	
5.	Large land holders and plough family above 7.50	

FORM C - BLOCK GROUP REGISTRATION

Serial No.	Land holder Name	Father Name	Khatian No. (Mouza Map)	Quantity of Land (Acre)	When Does Flood Water Come	When Does Flood Water Recede	How Much Flood Water in Rainy Season	Type of Soil	Crops 1980-1981	Crops Entered In	Name of Tiller	Signature(s) Owner Tiller

FORM D - BLOCK STATISTICAL SUMMARY

1. Name of Pump Association
2. Name of Block Group
3. Location
4. Number of Plots
5. Number of Land Owners/Land Operators

	Owners	Operators
1. Without homestead		
2.1 Homestead family only		
2.2 Homestead family with plough		
2.3 Homestead family with .5 acre		
3.1 Plough family w./land up to 2.50		
3.2 Plough family w./land up to 5.00		
3.3 Plough family w./land up to 7.50		
4.1 Ploughless land holders up to 2.50		
4.2 Ploughless land holders up to 5.00		
4.3 Ploughless land holders up to 7.50		
5.0 Large land holders and plough above 7.50		

Total

6. Number of acres
7. Type of Soil
8. Use of fertilizer and HYV Seed
9. Source of Credit
10. Cropping Pattern
11. Approximate yields (mounds per acre)

FORM E - EFFECTIVENESS AT REACHING TARGET GROUPS

Landholding Categories	Village Total No. of Population	Block Association Membership	No. of Village Population Reached
1.			
2.1			
2.2			
2.3			
3.1			
3.2			
3.3			
4.1			
4.2			
4.3			
5.			

FORM F - PUMP OBSERVATION STUDY
BI-ANNUAL REPORTS

1. Name of Pump Association.
2. Name of Representative.
3. Number of members.
4. How were the associations formed?
5. How was representative selected?
6. How were members selected?
7. How was pump obtained?
8. How was pump sited?
9. How was payment obtained?
10. How was water distribution system designed?
11. How was it installed?
12. What system of credit is used?
13. What crops are planted?
14. How many acres are under cultivation?
15. Where are seeds and fertilizer obtained and Who provides them?
16. Was a production plan prepared?
17. Describe problems of organization.

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LEGEND:

—··— BOUNDARY OF THE STUDY AREA

——— BOUNDARY OF THE LOW-LIFT PUMP DEVELOPMENT AREA

8

LEGEND:

BOUNDARY OF THE STUDY AREA

BOUNDARY OF THE LOW-LIFT PUMP DEVELOPMENT AREA

ROADS

BRIDGES

WATER BODIES

NARROW STREAMS

SETTLEMENTS

CROPPING PATTERNS PROPOSED FOR IRRIGATED MANAGEMENT

A = WHEAT[1] – AUS/JUTE[2] – (KHARIF DRYLAND CROPS)[4]

For seasonally, intermittently wet highland with medium to moderately fine textured soils (Land - Capability - Map unit 1a).

B = WHEAT[1] – (SHORT-TERM CROPS)[5] – TRANSPLANTED AMAN[3]

For seasonally, intermittently wet highland with moderately fine soils (Land - Capability - Map units 1b and 1c) and seasonally, shallowly flooded land with medium to fine textured soils (units 2a, 2b and 2c).

C = BORO[6] – TRANSPLANTED DEEP WATER AMAN[7]

For seasonally, moderately deeply flooded land with moderately fine to fine textured soils (Land - Capability - Map units 9c, 10a, and 10b) and seasonally, moderately deeply and deeply flooded land with flash flood or erosion hazard (units 8 and 11).

D = RABI DRYLAND CROPS[8] – AUS/JUTE – (KHARIF DRYLAND CROPS)[9]

For seasonally, intermittently wet highland with irregular relief and mainly medium to moderately fine textured soils (Land - Capability - Map units 5a, 5b, 5c and 6) and for seasonally, intermittently wet highland with moderately coarse to medium textured soils and moderate river erosion hazard (unit 4).

CROPPING PATTERNS PROPOSED FOR RAINFED MANAGEMENT

A' = (RABI DRYLAND CROPS)[10] – AUS/JUTE – (KHARIF DRYLAND CORPS)[11]

For seasonally, intermittently wet highland with medium to moderately fine textured soils (Land - Capability - Map unit 1a) and droughty highland with moderately coarse to medium textured soils (unit 3).

B' = (RABI SHORT - TERM CROPS)[12] – AUS / JUTE – TRANSPLANTED AMAN

For seasonally, intermittently wet highland with moderately fine to fine textured soils (Land - Capability - Map units 1b and 1c) and for seasonally, shallowly flooded land with medium to fine textured soils (units 2a, 2b and 2c).

C' = (RABI SHORT - TERM CROPS)[12] – AUS MIXED WITH DEEP WATER AMAN

For seasonally, moderately deeply and deeply flooded lands (Land - Capability - Map units 9b, 9c, 10b, 11, 12 and 13).

D' = (RABI CROPS)[12] – AUS/JUTE – (BROADCAST AMAN)

For seasonally, intermittently wet highland and shallowly flooded land with irregular relief and moderately fine to fine textured soils (Land - Capability - Map units 5c, 6 and 7).

fine textured soils (units 2a, 2b and 2c).

C' = (RABI SHORT - TERM CROPS)[12] – AUS MIXED WITH DEEP WATE

For seasonally, moderately deeply and deeply flooded lands (Land Ca
9c, 10b, 11, 12 and 13).

D' = (RABI CROPS)[12] – AUS/JUTE – (BROADCAST AMAN)

For seasonally, intermittently wet highland and shallowly flooded land
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NOTES:

1) THE WHEAT CROP WILL RECEIVE FULL-SCALE IRRIGATION THROUGHOUT THE GROWING SEASON. IT CAN BE REPLACED BY TOBACCO, SPICES, OILSEEDS, SOYBEANS, VEGETABLES, FRUITS OR SUGARCANE TO SOME EXTENT.

2) AUS RICE AND JUTE WILL RECEIVE SUPPLEMENTAL IRRIGATION FROM THE REPLENISHED NABAGANGA RESERVOIR IN THE LATER PART OF THE GROWING SEASON.

3) TRANSPLANTED AMAN RICE WILL RECEIVE SUPPLEMENTAL IRRIGATION AS NEEDED DURING DRY SPELLS IN THE MONSOON AND POST-MONSOON SEASONS.

4) KHARIF DRYLAND CROPS SUCH AS MAIZE, SOYBEANS AND VEGETABLES ARE SUBJECT TO TIMELY HARVEST OF THE PRECEDING AUS AND JUTE CROPS WHICH ARE DEPENDENT ON EARLY RAINS.

5) SHORT-TERM CROPS SUCH AS SUNFLOWERS, TIL (SESAME) AND GREEN-FODDER CROPS ARE SUBJECT TO WATER AVAILABILITY FROM THE NABAGANGA RESERVOIR (RESIDUAL RESERVE) OR FROM EARLY RAINS.

6) BORO IS SUBJECT TO WATER AVAILABILITY FROM THE PROPOSED LOW-LIFT PUMP SYSTEM OR FROM LOCAL SHALLOW TUBE WELLS, WHICH ARE NOT PART OF THIS PROJECT AT THE PRESENT TIME.

7) TRANSPLANTING OF THE DEEP WATER AMAN RICE IS NECESSARY IN ORDER TO ACCOMODATE BOTH LONG-TERM CROPS IN THE PATTERN.

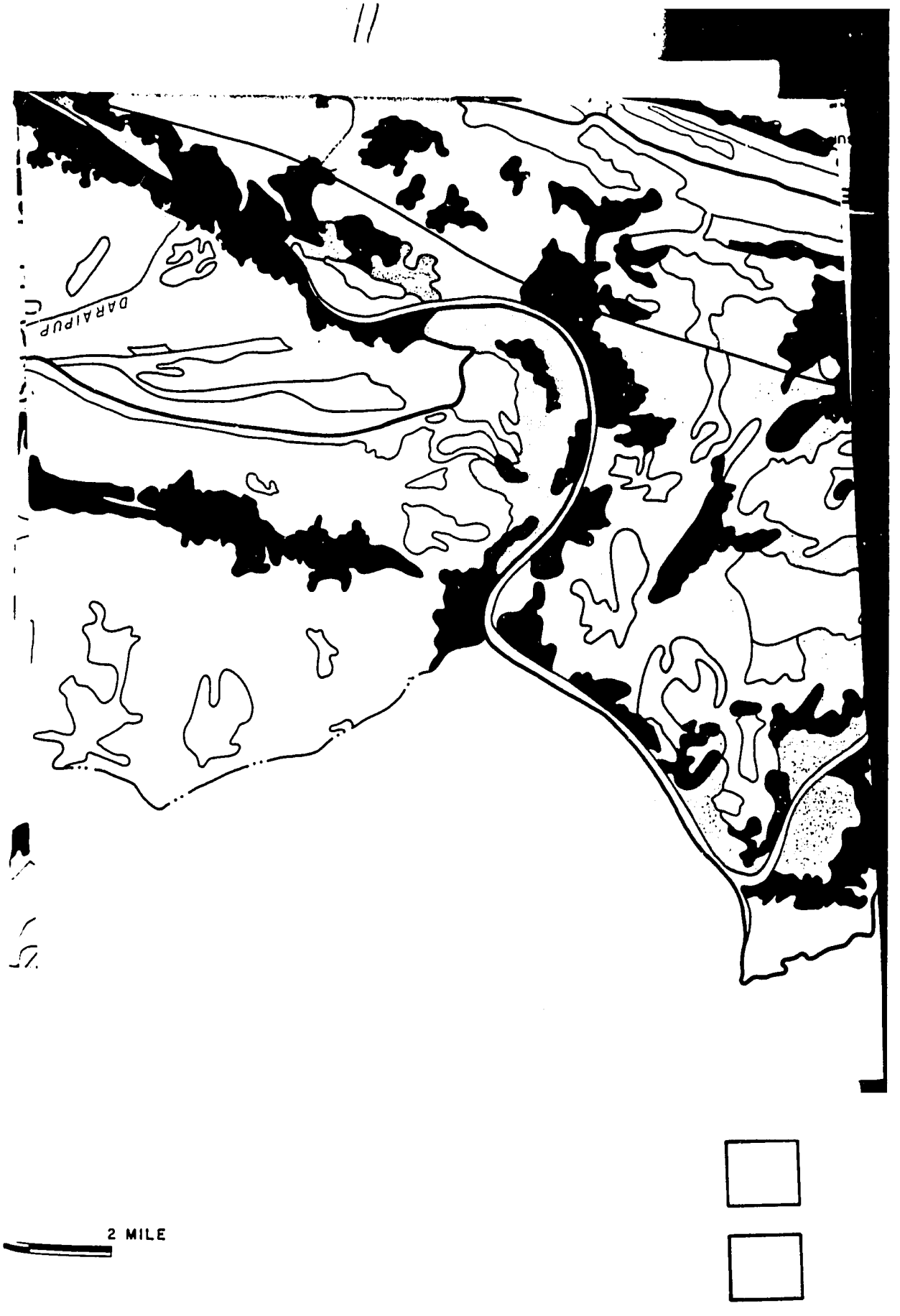
8) RABI DRYLAND CROPS MAY INCLUDE WHEAT, TOBACCO, SPICES, OILSEEDS, PULSES, SOYBEANS, VEGETABLES, FRUITS AND SUGARCANE, BUT BECAUSE OF IRREGULAR RELIEF MAINLY SMALL-SCALE IRRIGATION BY HAND PUMPS AND BY OTHER SIMPLE M[illegible] POSSIBLE. CROP MANAGEMENT WOULD SUBSTANTIALLY IMPROVE AFTER GROUND LEVELLING.

9) KHARIF DRYLAND CROPS SUCH AS MAIZE, SOYBEANS AND VEGETABLES ARE SUBJECT TO TIMELY HARVEST OF THE PRECEDING CROP.

10) RABI DRYLAND CROPS SUCH AS WHEAT, BARLEY, PULSES, OILSEEDS, SPICES, TOBACCO AND THE DROUGHT-TOLERANT MILLETS AND SORGHUM ARE SUBJECT TO SOIL RESIDUAL MOISTURE AVAILABILITY.

11) KHARIF DRYLAND CROPS SUCH AS MAIZE, SOYBEANS, GROUNDNUTS AND VEGETABLES CAN BE PLANTED IMMEDIATELY AFTER THE PREVIOUS AUS/JUTE CROPS. IF PLANTING IS DELAYED THE KHARIF CROPS CAN BE GROWN TO FULL MATURITY ONLY AT THE EXPENSE OF THE FOLLOWING RABI CROPS.

12) RABI CROPS ARE SUBJECT TO TIMELY HARVEST OF THE AMAN CROP AND TO RESIDUAL SOIL MOISTURE AVAILABILITY.



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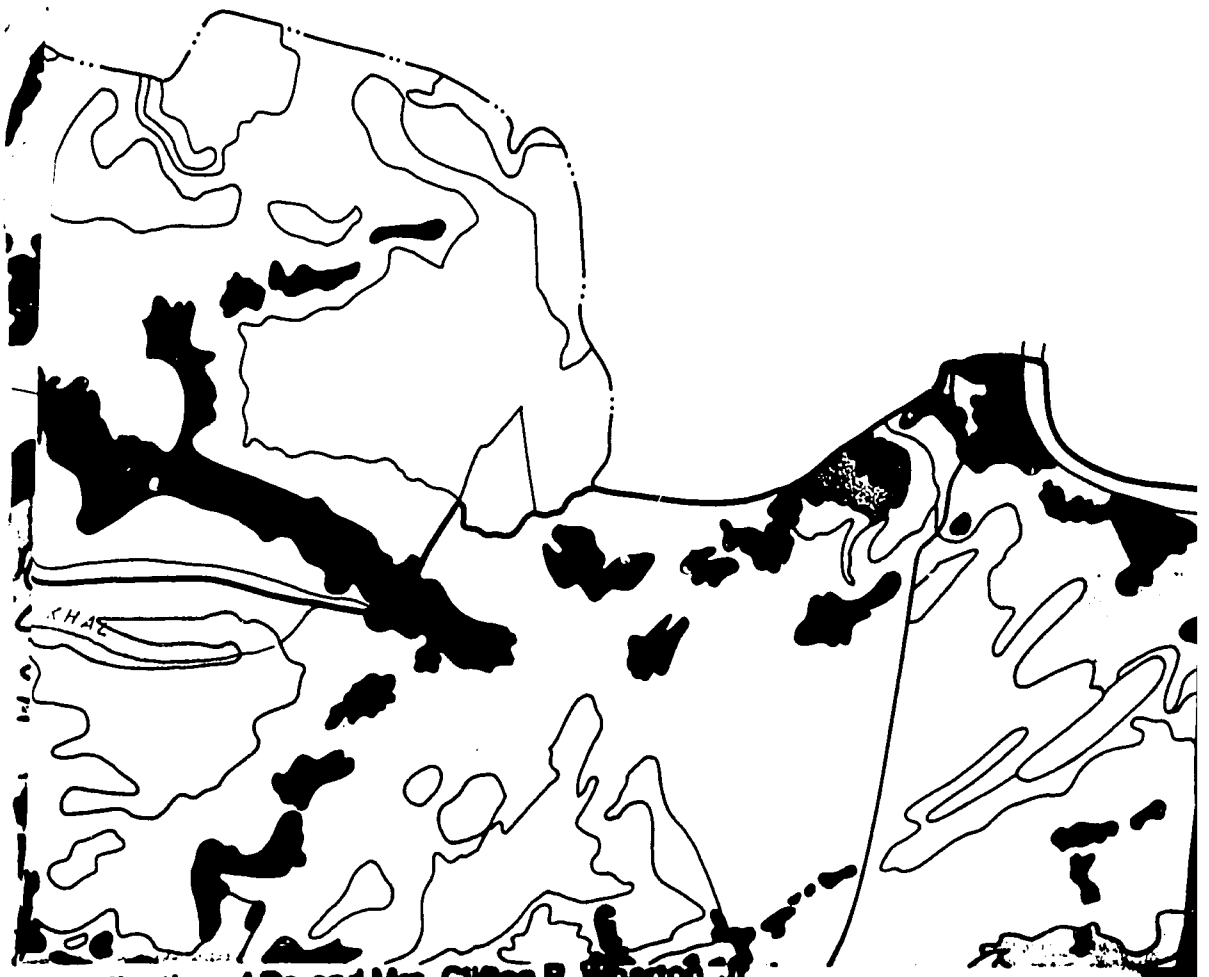

From the collection of Dr. and Mrs. Clifton R. Wharton, Jr.

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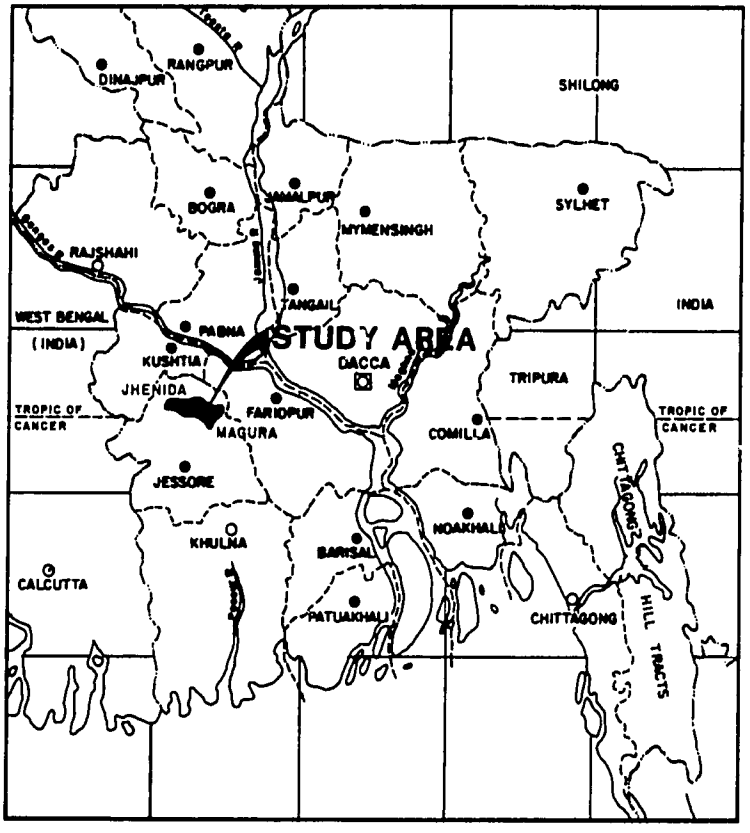

LOCATION MAP

NABAGANGA INTEGRATED LAND AND WATER USE STUDY

PROPOSED LAND USE MAP

MAINLY JHENIDA AND MAGURA THANAS, JESSORE DISTRICT

FEBRUARY 1981