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ABBREVIATIONS

BADC	=	Bangladesh Agricultural Development Corporation
B/C	=	Benefit-Cost Ratio
BRRI	=	Bangladesh Rice Research Institute
BSC	=	Bangladesh Shipping Corporation
BWDB	=	Bangladesh Water Development Board
CAD	=	Command Area Development
CARE	=	Cooperative of American Relief Everywhere
DEM	=	Directorate of Extension and Management
DTW	=	Deep Tube-Well
ECI	=	Engineering Consultants, Incorporated
FAO	=	Food and Agricultural Organization
GOB	=	Government of Bangladesh
HYV	=	High Yielding Variety
IRDP	=	Integrated Rural Development Program
KSS	=	Krishi Sambaya Samities (Agricultural Cooperative Society)
LLP	=	Low Lift Pump
MRD	=	Ministry of Local Government, Rural Development and Cooperatives
PEC	=	Planners, Engineers, and Consultants
RWP	=	Rural Works Program
SAE	=	Sub-Assistant Engineer, RWP
SDE	=	Sub-Divisional Engineer, RWP
STW	=	Shallow Tube-Well
TCCA	=	Thana Central Cooperative Association
TIP	=	Thana Irrigation Program
USAID	=	United States Agency for International Development
WAPDA	=	Water and Power Development Authority
WB	=	World Bank
XEN	=	Executive Engineer RWP

CURRENCY EQUIVALENTS

US $ 1 = Taka 15.00
Taka 1 = US $ .067

WEIGHTS AND MEASURES

1 acre (ac)	=	.405 hectare (ha)
1 bigha (bi)	=	.33 acre (ac)
1 sq mile	=	640 acres (ac)
1 maund (md)	=	82.28 pounds (lbs)
1 maund (md)	=	37.3 Kilograms (kg)
1 metric ton (ton)	=	26.8 maunds (md)
1 seer (sr)	=	2.06 pounds (lbs)
1 cubic foot per second (cusec)	=	0.283 cubic meters per second

GLOSSARY OF TERMS

Aman = Rice sown/planted during March to July/August and harvested in November or December.

Aus = Rice sown/planted during March and April and harvested in July and August.
T. aus = transplanted aus; B. aus = broadcasted aus.

Beel = Marsh or lake; also spelled bill or bil.

Boro = Winter rice, planted during November and December and harvested during April to June.

Char = Newly formed sandy alluvial tract.

Drain = Canal to provide drainage or irrigation water.

Khal = Narrow natural channel of water.

Kharif = Summer season or rainy season.

Kutcha = Temporary, lower grade or dirt structures.

Paddy = Unhusked or rough rice (oryza sativa).

Pucca = Permanent, good quality structures.

Rabi = Winter season or dry season.

Thana = Political sub-division of a sub-division: police station or revenue unit.

Sub-Division = Political division of a district.

CHAPTER IV

ENGINEERING

PART 1

GENERAL DESIGN INFORMATION

Section 1: Design Criteria

The design criteria for the Rural Irrigation Works Study were developed by the Consultant for the design of works as stated in each case of the sub-projects proposed and for general use of the on-farm distribution as described in the following. An on-farm system is defined as one that is operated by an irrigation group whose property totals from about 50 to 150 acres, the water supply for which is normally a 2-cusec deep tube-well (DTW) or low-lift pump (LLP). This type of on-farm system will be given specific consideration because it is the basic unit of most small irrigation projects as well as many larger projects in the country.

No criteria were developed for the design of pumps for on-farm distribution systems in the country because they are normally specified and supplied by BADC, an agency of the Ministry of Agriculture. They supply low-lift pumps, which are centrifugal pumps for pumping from streams; turbine pumps for deep tube-wells; and centrifugal pumps for shallow tube-wells. The drilling of the wells and the construction of the pump houses is also done by that agency.

Section 2: On-Farm Distribution System Criteria

A. Summary

Development of the design criteria herein includes detailed descriptions, justification, tables, figures and illustrative examples. For convenience to the reader, the most important criteria are summarized below:

1. The maximum area to be irrigated at one time by water from a 2-cusec tube-well or low-lift pump is 1-1/2 acres.

2. Land in the sub-projects will be divided into blocks of about three to five acres each. A brick-lined canal distribution system will be designed to serve each block through one turnout each. Ditches within blocks, if required, will be constructed by the land owners.

3. The entire pump flow is to be directed to one turnout at a time. Therefore, all main ditches will be designed for a discharge capacity of two cusecs.

4. Main ditches will be lined with locally-made bricks or tiles.

5. The design will include a rectangular weir at each pump outlet for the measurement of the discharge.

6. The water surface elevation at block turnouts will be at least 0.5 feet above the highest plot to be served.

7. The distribution system will be designed to operate 20 hours per day and seven days per week.

8. Average irrigation requirements from which pumping costs will be determined and on which command areas will be based, and peak irrigation requirements are given in Tables IV-21 through IV-24. They are based on the Penman method of calculating evapotranspiration and on an overall efficiency of 60 percent for non-flooded crops and 85 percent for flooded rice.

B. General

Sub-projects that include design of distribution systems for LLPs or DTWs now have command areas generally of fifty acres or less. The basic problem of existing distribution systems in Bangladesh is their failure to use the full capacity of pumping facilities. Command areas are usually about half the area that could be irrigated with the available pumping capacity.

Robert R. Nathan Associates (1979), Brammer (197,1978), and Biswas et al. (1978) have listed reasons for the under utilization of the pumping facilities, asd given below, with which the Consultant's observations agree:

1. Inadequate maintenance and repair of pump equipment and inadequate provisions for supplying fuel and lubricants. This makes users reluctant to increase command areas because of the increased possibility of the pump becoming inoperable due to break-down or lack of fuel.

2. Inadequate availability of fertilizer, pesticides, and of the inputs required to produce high enough yields to make irrigation economical.

3. Lack of availability of credit for financing operation and maintenance, construction of distribution systems, and inputs for crop production.

4. Subsidized rental and maintenance charges that discourage increasing command areas because there is little or no cost advantage to the small group using the water. Costs paid by irrigation groups increase in nearly direct proporiton with the number of acres irrigated.

5. Poor management of the irrigaton groups; lack of cooperation among, and inadequate organization of, the many owners of small land parcels that make up a large enough area to fully utilize a pump.

6. Inadequate training and motivation of farmers and operators in irrigation and agronomic practices.

7. Lack of realization that the pumps can run continuously.

8. Low farm-gate prices for crops produced by irrigation.

10. Improper design, construction, and maintenance of distribution facilities.

By considering these agronomic, engineering, economic, and social factors, the design criteria developed in this section are intended to enable command areas to be increased to the optimum acreage.

C. Water Application Method

All agricultural land in the sub-projects of the study is now divided into small, level basins. This is true of nearly all agricultural land in the country. Under non-irrigated conditions, the basins store and evenly distribute rainfall and provide a means of applying irrigation water. The bunds separating the basins usually serve as property boundaries as well as water control structures. Basin sizes are typically between 1/4 and 3/4 acres.

This basin method of irrigation is considered to be the cost suitable one for the country and is used for the sub-projects in the study.

Section 3: Soil Intake Characteristics

A. General

For basin irrigation the intake characteristics of soils are needed to determine the correct irrigation stream size (flow rate) and to estimate deep percolation loss. The irrigation stream size is not critical when adding water to maintain rice in a flooded condition but is very important in obtaining efficient water distribution for other crops and when applying water to rice not flooded.

No data could be found on measured intake rates in Bangladesh, so soil intake tests were performed on sub-projects having existing deep tube-wells and low-lift pumps that could be used to supply water for the tests. These tests provide a basis for design of these sub-projects, and, by correlating the test results with soil association maps and observed soil textures in other areas, will be useful for future design work by MRD.

Information on soil intake rates and measurement methods has been published by the U.S. Department of Agriculture (1956) and Israelson Hansen (1967).

B. Methodology

Normally soil intake rates are measured by using cylinder infiltrometers, which are smooth steel cylinders with an inside diameter of at least nine inches. Because most farm land in Bangladesh is divided into small bunded parcels, these parcels were used for testing rather than a steel cylinder with water. This methods is probably more accurate than using the steel cylinders because a much larger area is covered by water. This eliminates test inconsistencies caused by local variation in soil characteristics. It is also judged to be a

better procedure for MRD personnel to use in the future because it eliminates the need for constructing, storing, and transporting the steel cylinders and appurtenant heavy driving hammer and plate.

Using the bunded fields for these tests requires some modifications of normal procedures. The intake rate is highest at the beginning of the test, then decreases to a fairly constant rate, called the basic intake rate. It is not possible to measure the intake during the time the basin is filling with water, so a procedure was developed for determining the intake characteristics of the soil during this filling period, which was usually about thirty minutes. This procedure is described below under "Plotting Soil Intake Curves."

For each sub-project where tests were performed, two or three basins were selected. If soil texture varied in the sub-project area, tests were performed on basins that appeared to be representative of each soil type. The tests were run for all of the basins simultaneously. Small basins were selected, where possible, to minimize the filling time.

After the basin was filled to a depth of three or four inches, the flow of water into the basin was stopped by damming the inlet; the first measurement was made immediately. Measurements were made with a hook guage.

The duration of the tests was usually about four and one-half hours. This provided adequate time for the basic intake rate to be reached.

C. Recording of Test Data

Table IV-1 shows a set of sample data. In addition to the actual test data, information on soils, crops, and other factors that are pertinent in interpreting the test results were recorded. The data from columns 4 and 5 of the form are used for plotting the soil intake curves, as described below.

D. Plotting Soil Intake Curves

To represent the soil intake characteristics, it is necessary to plot the accumulated intake vs. time and the intake rate vs. time curves. The general equation for accumulated intake is $D = CT^n$, where D is accumulated intake, T is time, and C and n are constants. Because the equation is of this form, the data is normally plotted on a straight line on log paper; however, data from columns 4 and 5 of the "Soil Intake Test Data" form do not fall on a straight line because the accumulated intake from column 4 does not include the depth of water that infiltrated during the "Filling Time", which is defined on the data form. This may be accounted for by following the procedure given below:

1. Plot Accumulates Intake vs. Adjusted Elapsed Time from Columns 4 and 5 on log paper as shown on Figure IV-1.

2. By trial and error, add the depth infiltrated during the filing time to the plotted points and plot the resulting points such that a straight line is formed. For the example shown in Figure IV-1, the depth infiltrated during the filling time was found by trial to be 0.30 inches. That is, by adding 0.30 to each point on the Accumulated Intake vs. Adjusted Elapsed Time Curve, a straight line is formed. This straight line represents the actual accumulated intake for the soil.

3. In log firm, the equation $D = CT^n$ is $\log D = n \log T + \log C$. Therefore, the parameters of the equation can easily be determined from the curve plotted in step 2, C being the accumulated intake at T = 1 and n being the slope of the line. The slope can be determined by scaling linearly, without regard to the scale of the log paper.

4. The equation for rate of intake is $I = 60CnT^{n-1}$, which in log form is $\log I = (n-1) \log T + \log (60\ Cn)$. Because the values of C and n were determined in step 3, the intake rate can be plotted as shown in Figure IV-1 by solving for n-1, which is the slope, and for 60 Cn, which is the intake rate at T=1.

5. The curves may be transferred from the log plot to a linear plot is desired. Linear plots of the curves from Figure IV-1 are shown on Figure IV-2.

To help determine the depth infiltrated during the filling time, the approximate average intake rate between each hook gauge reading was calculated and plotted as shown in Figure 4-2. For tests where data were badly scattered or where data points did not fall exactly on a straight line, it was helpful to first construct the intake rate curve on the log paper. A straight line was drawn to fit the calculated intake rate points, and the parameters of the intake rate curve determined. The accumulated intake curve could then be constructed and the depth infiltrated during the filling time estimated by subtracting the values of the data points from corresponding values on te curve. Steps 2 through 4 were then followed, making sure the curves agreed with both the accumulated intake and calculated intake rate data.

E. Summary of Test Results

Because the tests were conducted after te monsoon season had begun, the soil moisture content prior to the tests was usually very high. Consequently, intake rates early in the tests were probably lower than they would be at the beginning of an irrigation. However, the basic intake rates determined and the general characteristics shown by the curves are a valuable tool for designing irrigation systems on the soils tested. A summary of the basic intake rates for the soils in each sub-project tested is shown in Table IV-2. Also shown in the table are the soil association in which the sub-project is located and soil texture information.

F. Intake Rate Under Flooding

The term "basic ntake rate" refers to a rate that is reached during relatively short periods of flooding. For long periods of flooding, such as under continuously flooded rice conditions, infiltration gradually decreases over a period of days or weeks to a rate

significantly lower than the initial rate. This is mainly due to formation of slime on the soil surface. The scope of the project did not permit conducting long duration tests that would be required to determine these rates for the soils in the sub-projects. However, one such test was run at the Rajghat Deep Tube-well Pucca Drain Sub-project in Savar Thana, Dacca District. A field was kept ponded for a period of four days, with the intake rate (plus evapotranspiration) gradually decreasing to 0.66 inches per day, or 0.03 inches per hour. No attempt was made to measure evapotranspiration during the test.

Section 4: Irrigation Stream Size

For irrigation of flooded rice, the stream size is of little importance except from an operational standpoint. But for irrigation of other crops and rice not flooded, the relationship between the stream size and area on which it is flowing must be considered in order to efficiently apply water. For the distribution systems under this study the total irrigation stream size is fixed at the capacity of the tube-wells or low lift pumps. Using the determined soil intake characteristics and standard procedures, this section will define the best relationship between stream size and area under irrigation at a particular time.

Several references are in agreement on a criterion for using soil intake characteristics to determine the design stream size. Stabbers (1971) states: "The highest distribution efficiency is obtained when all water is applied in about one-third of the average total intake time." According to Doorenbos and Pruitt (1977), "the water should be applied between 0.2 and 0.4 of the time necessary for the required depth of water to enter the soil." The U.S. Soil Conservation Service (1969) states that "The minimum-size irrigation stream...must equal or exceed...a stream large enought to permit coverage of the average size leveed basin in a maximum of one-fourth the time required for the soil to absorb the net amount of water to be applied."

The U.S. Soil Conservation Service (1974) has published curves that simplify the procedure for determining stream size. Curves are given for different basic intake rates ("intake families"), manning roughness coefficients, and net depths of irrigation. As shown in Table IV-2, the basic intake rates of most of the soils tested are between 0.3 and 0.5 inches per hour. The applicable roughness coefficient for a rice or wheat crop of 0.15. The net depth of irrigation for the sub-projects will be from two to four inches. Normal bund heights prevent applying more than four inches, and in precision in land levelling required that at least two inches be applied to cover all land within the basins. Designs will be based on a two-inch net depth for three reasons: (1) To conform with the common practice of growing rice under unsaturated conditions, the moisture content is still kept at a high level and very light irrigations are required to prevent deep percolation. (2) A light irrigation may be required to wet the soil near the surface, thereby providing for germination and early growth of wheat and other crops. (3) With all other conditions remaining the same, application efficiency decreases as net depth decreases. Consequently, the two-inch net depth will be used for designs so that, under all situations, the canal size will be satisfactorily efficient.

Figure IV-3 shows the curves for basic intake rates of 0.3 and 0.5 inches per hour. The measured flowrate from most of the tube-wells and low-lift pumps in the project ws about 1.8 cusecs, which is also the flowrate used by the Brammer (1977 and 1978) in determining command areas; therefore, it is judged to be a good estimate of typical conditions and will be the assumed flow rate. Table IV-3 shows the application efficiency that can be expected for a stream size of 1.8 cusecs and various sizes of basins, as determined form Figure IV-3.

Table IV-3 also shows that is the flow from a 2-cusec pump is not applied to more than 1-1/2 acres, net depths greater that two inches and a flow of more than 1.8 cusecs, efficiencies would be higher. On sub-projects where the soils are of the 0.3 intake family, up to three acres at a time could be irrigated with an efficiency of at least 70 percent. However, in order to provide for high efficiencies and to

simplify the criteria, it is recommended that water not be appplied to more than 1-1/2 acres at a time. This does not seem to be conservative when considering general guidelines given by Doorenbos and Pruitt (1977), who indicate that for a flow of 1.8 cusecs on clay loam soil, the basin size should be about 1/2 acre. Their recommendation for clay soil is about one acre. (Doorenbos and Puritt recommend that further field tests be performed to develop criteria; these figures are for reference only).

Section 5: Distribution System

A. Alternative Distribution Systems

Two types of on-farm distribution systems were considered and are described as follows:

1. The first alternative consists of dividing the sub-project into blocks and designing main ditches with one turnout to each block. One level of operation and maintenance would be concerned with this mainditch or pipeline. Another level would be within the blocks where water would be distributed to each land parcel. This would require that farmers within blocks coordinate their agronomic practices and agree on irrigation scheduling to within their block. This type of system provides an orderly means of distributing water to the numerous small landowners.

   There are several advantages to this type of system. A manager can be elected from each block to coordinate activities with the main ditch operation staff, rather than all farmers being required to do so. Such a system also clearly defines the system operators' responsibility for providing water to a relatively small number of block turnouts on a orderly basis. This is much more manageable than trying to keep track of scheduling to each farm in the project. A block system, such as this, assumes that scheduling to individual farms can be done more efficiently by the farmers themselves and by their elected block manager.

2. The second alternative consists of grading land into larger level basins that presently exist and marking property lines by some means other than bunds. These basins would be blocks similar to those described in the first alternative and would have those same advantages but would simplify distribution, management, and coordination within the blocks. The foremost disadvantage is that land leveling is expensive.

The Consultant concludes that the block system described in the first alternative is most suitable. This system has also been recommended for these conditions by the World Bank and Food and Agriculture Organization of the United Nations (FAO) who have had experience with this kind of distribution system in Bangladesh (FAO, 1979).

B. Detailed Design Criteria

The following deign criteria have been determined for the selected block distribution system. Most of these criteria have been adopted by the World Bank and FAO for Bangladesh as a result of their research and experience.

1. Main ditches providing water to block turnouts will be constructed as part of this project. Ditches within blocks, if necessary, will be designed, constructed, operated, and maintained by farmers within the blocks. Each of these small in-block systems is very simple and can be easily constructed by the farmers.

2. Main ditches will be brick-lined to ensure that the systems will operate as designed. Lining discourages unauthorized cutting of the banks, which causes loss of control of the water and failure of the project. It also solves leakage and seepage problems that plague all of the existing distribution systems. Even in projects having heavy soils, where seepage rates are low, lateral leakage is a severe problem. The high ditch banks are the most desirable habitat for ants, rodents, and other animal life because they remain dry; therefore, the banks become perforated and leak badly. The problem is aggravated by farmers who

have land adjacent to the ditch and who reduce the width of the banks to enlarge their farms. This problem is eliminated by brick-lined ditches.

3. Flow will be measured at the pump outlet by a rectangular wier, which is the most simple and effective measurement device for these sub-projects. Adequate head is available for calibration of the weir. The measurement of flow will provide a basis for water charges and scheduling and will aid in evaluating the performance of the pumps and distribution systems.

4. All flow from the pump will be discharged at only one block turnout at a time. This practice of irrigating no more than 1-1/2 acres at a time conforms to the criterion described in Section 4 of this chapter, it also simlifies management. This requires that all main ditches be designed to carry the entire flow from the pump.

5. The water surface elevation at block turnouts will be at least 0.5 feet above the highest land parcel to be served.

6. Scheduling of deliveries is done by roster.

7. Pumps will operate twenty hours per day, seven days per week during periods of peak water use. This criterion was suggested for tube-wells by FAO (1979). This schedule is roughly equivalent to operation six days per week, 234 hours per day, which is often used to allow one day each week for maintenance and repair.

C. Layout of Distribution Systems

Specific criteria for laying out distribution systems cannot be developed to apply to all conditions; however, the guidelines listed below were developed to be used with judgment by a designer (also uses Appendix C, Design Manual).

1. Main ditches should be located to serve areas on each of their sides. This arrangement will be more economical and more efficient than placing ditches on the periphery of the command area.

2. Main ditches should be as straight as possible so that their cost is minimized. Secondary ditches should be located on plot boundaries.

3. Where practical, main ditches should be located on the same alignment as existing ditches.

4. Blocks should be between three and five acres and should be laid out so that a relatively short ditch can be constructed through the middle of the block, serving all parcels in the block without using branching ditches.

These guidelines should minimize percolation and seepage losses by limiting use of unlined ditch systems and by providing a block of land within which land owners can distribute the water properly.

Section 6: Crop Water Requirements

Crop water requirements include all water required for actual plant growth, water applied to compensate for inefficiency of application to fields, conveyance and distribution losses, losses due to inefficiency in management, and water needed for such applications as the leaching of salts; for rice irrigation; percolation loss usually also constitutes a significant percentage of the crop water requirement.

A. Evapotranspiration

Evapotranspiration (ET), sometimes called consumptive use, is defined as the water used by plants. It includes two components: (1) transpiration, which is the process by which water enters plant roots and is used to build plant tissue or is passed through plant leaves into the atmosphere; and (2) evaporation of water from adjacent soil, water surfaces, or plant leaves. The sources of water used for ET include irrigation, precipitation, dew, upward movement from groundwater, or any other source.

Available data on ET measurements in Bangladesh are scarce and highly variable. Where information was available on methods used to make these measurements, they were judged by the Consultant to be unreliable. Therefore, ET estimates are based on calculations.

The Penman method, presented by Doerenbos and Pruitt (1977), was used to calculate reference crop evapotranspiration from the available climatological data. The basic Penman equation consists of an energy (radiation) term and an aerodynamic (wind and humidity) term. Although radiaton is seldom measured at weather stations, it can be estimated from records of sunshine duration or cloudiness.

1. Reference Crop Evapotranspiration: Reference crop evapotranspiration (ETc), often called potential evapotranspiration, is defined as the rate of evapotranspiration of water from an extensive surface of actively growing green grass that is from three to six inches tall, that is of uniform height, that completely shades the ground and that is not short of water. It represents the effect of climate on a reference crop, and is a convenient parameter for use in determining ET for various crops when the ratio between crop ET and that of the reference crop is known. This ratio is called the crop coefficient.

ETo was determined for each district in which sub-projects were located. Climtological data used for calculating ETc, from Manalo (1975), are shown in Tables IV-4 through IV-9. They were not available for any station in Tangail or Rajshahi Districts; therefore, data for the Dacca station were used for Tangail, and Pabna station data were used for Rajshahi. Table 9 shows the calculated values for ETo.

2. Crop Evapotranspiration: Whereas ETo accounts for the effect of climate on a reference crop, the effect of crop characteristics on crop water requirements is accounted for by use of crop coefficients (kc). Crop evapotranspiration (ETc) is found by:

$$ETc = kc \times ETo$$

Procedures for selection of appropriate kc values take into account such things as time of planting or sowing and stages of crop development. Therefore, cropping patterns must be considered. Figure IV-4 shows the five basic cropping patterns that will be recommended for the sub-projects. Other crops such as vegetables and pulses may also be grown during the same time period as wheat. However, because recommended acreages for these crops will be very small they will not be considered separately. It will be assumed that their water requirement will be the same as wheat.

Using the information from Figure IV-4 and the procedures given by Doorenbos and Puritt (1977), the crop coefficient curves shown in Figure IV-5 and IV-6 were developed. Figure IV-5 applies to patterns in which wheat is the main irrigated crop and Figure IV-6 applies to patterns in which wheat is the main irrigated crop and Figure IV-6 applies to cropping patterns in which boro is the main irrigated crop. As determined from these curves, monthly coefficients for each crop are shown in Tables IV-12 and IV-13 for wheat-based and boro-based cropping patterns, respectively.

B. Irrigation Efficiency

The distribution system will be designed for a high level of control and minimum practical opportunity for inefficient use of water. Therefore, relatively high efficiencies are expected. Estimated efficiencies for each part of the distribution system are shown in Table IV-11.

Inefficiencies in main ditches are caused by such things as leakage and operation and management problems. With the turnout located at the highest part of the block, field ditches should not be required for more than about half of the blocks. Field ditch efficiency is higher for flooded rice than other crops because water leaking through banks is used, but bank leakage onto non-flooded fields over-irrigates the land adjacent to ditches.

C. Land Preparation and Percolation loss

Up to nine inches of water is required to prepare land for transplanted HYV rice during the dry season. BWDB (1979) has recommended that transplanted rice should not be grown on soils that have an infiltration rate of more than 0.2 inches per day.

Land preparation requirements and percolation losses vary according to location and availability of water from natural sources. Land preparation rquirements also depend on the initial soil moisture content; therefore, they are higher for aus when it follows wheat rather than boro in a cropping pattern. Table IV-13 shows the estimated requirements under various conditions that will be used for design and cost estimating. The land preparation requirements given for average conditions are used to calculate average water requirements; the ones for peak conditions are used to determine command areas. For design of the sub-projects, it is assumed that all rice will be maintained in a flooded condition.

D. Rainfall

Mean monthly rainfall (Rm) data are given in Table IV-15 (EPWAPDA, 1964). The stations shown are operated by the Meteorological Department. Other agencies maintain stations within the distrticts where sub-projects are located, but data from some of these have been shown to be unreliable.

Some rainfall may not be available for plant growth, such as in upland areas where rainfall might occur when the soil moisture reservoir is full, resulting in deep percolation loss; for flooded rice, the duration and intensity of rainfall may cause its loss through surface drainage. The amount of rainfall that is available for plant use is called effective rainfall (Re).

During the irrigation (dry) season, rainfall in Bangladesh is normally not intense enough to cause overtopping of bunds of flooded rice fields. Therefore, for rice, Re is assumed to equal mean precipitation. For wheat and jute, as well as other upland crops, effective rainfall may be calculated by the following equation (Soil Conservation Service, 1970):

$$Re=(.70917Rm^{.82416}-.11556)(10)^{.02426ETc}(.531747+.295164D-.0576D^2+.003804D^3)$$

where Rm is mean rainfall and D is net irrigation depth. By definition, Re cannot exceed either Rm or ETc.

To determine peak irrigation requirements, dependable rainfall data is necessary to ensure sufficient irrigation water at specific levels of dependability. Rainfall data having a 90-percent probability of being equalled or exceeded have often been used for irrigation projects in Bangladesh; however, for tube-well systems where water rather than land is the limiting resource, probability is too conservative because it results in under utilization of the pump during nine years out of ten. There is a need for research to determine the optimum probability. For this project, the commonly used 75-percent rainfall probability is used and is referred to as "dependable

rainfall" (Rd). For upland crops, Rd is rainfall at the 75-percent level of probability, adjusted by the above equation for effective rainfall.

E. Irrigation Requirements for Crops and by Districts

Crop evapotranspiration, effective rainfall, and dependable rainfall are shown in Tables IV-15 through IV-20. Tabular values of ETc were calculated by multiplying ETo from Table IV-10 by kc from Tables IV-12 and IV-13. Where a crop is grown for only part of a month, ETo values wre estimated by interpolation and adjustment for the shorter period. An example of an interpolation calculation is shown below for t. aus and a wheat-based cropping pattern in the Chittagong District during April. The croping period for t. aus includes the last 25 days of the month, as indicated in Figure IV-4:

April ETo = 7.4 (From Table IV-10)
May ETo = 8.1 (From Table IV-10
April kc = 1.10 (From Talbe IV-12)

$$ETc = [7.4 + (\frac{2-1/2}{30})(8.1 - 7.4)] [\frac{25}{30}] [1.10] = 6.8 \text{ inches}$$

In calculating effective rainfall, this interpolation method was not used to determine rainfall for the portion of a month included in a croping period because it often resulted in the rainfall for part of the month being greater than the monthly depth. The rainfall during a part of a month ws assumed to be equal to the monthly rainfall multiplied by the fraction of the month being considered.

For wheat and jute, effective rainfall was calculated by the equation given previously, assuming a net irrigation depth of three inches. Actually the net depth may be as low as two inches. The values of Rc determined by the equation are lower for a two-inch irrigation depth than for a three-inch depth; however, if calculations of effective rainfall were based on a two-inch depth, they would be too conservative because little, if any, rainfall will be lost by

surface runoff from the bunded fields in the sub-projects, and the equation given above for Re is based partly on losses due to surface runoff.

The dependable rainfall values given in Tables IV-16 through IV-20 are from Manalo (75) who provides no information for th Chittagong and Dacca stations. Consequently, the values for the Kutubdia station in Chittagong District and Joydevpur station in Dacca District were used because they appeared to be typical of the two districts. Because it was available, Rd information from the Rajshahi station was used rather than that from Pabna station as was necessary to calculate evapotranspiration.

Little irrigation is presently practiced on jute except, occasionally, at the time of seeding. Study of Tables IV-16 through IV-20 shows that in most districts there is little or no deficit between crop evapotranspiration and effective rainfall for just. The largest deficit is for Rajshahi, where it is a total of 3.5 inches for April and May (Table IV-19). This amount could easily be supplied to the crop from soil moisture storage. Consequently, irrigation of Jute is probably not necessary during years of average rainfall. Furthermore, farmers generally do not want to irrigate jute. Therefore, no further attention will be given to this crop in developing sub-project design criteria. It is assumed that no irrigation water will be applied to jute.

F. Average and Peak Irrigation Requirements

Corresponding values of ETc, Re, and Rd from Tables IV-16 through IV-20 as well as efficiencies and percolation rates discussed previouisly were used to calculate the average and peak irrigation requirements shown in Tables IV-21 through IV-24.

The term "P" in these tables refers to water applied to compensate for percolation loss. Values of P were calculated by multiplying the percolation rate in inches per day by the number of days the rice crop was growing in a month.

There were two exceptions to this method of calculation: One is the time near harvest when fields are allowed to dry and no water is required to replace percolating water. The length of this period is the time it takes for the normal three-inch depth of standing water to infiltrate, as calculated below:

0.2 inch/day percolation rate: $\frac{3 \text{ in.}}{0.2 \text{ in./day}} = 15$ days

0.15 inch/day percolation rate: $\frac{3 \text{ in.}}{0.15 \text{ in./day}} = 20$ days

0.1 inch/day percolation rate: $\frac{3 \text{ in.}}{0.1 \text{ in./day}} = 30$ days

Any percolation that occurs during these periods is not included in P. (Refer to Figure IV-4 for times of harvest.)

The other excepton is during the month of transition between the wet and dry seasons: that is, the month when irrigation is required for only part of the month. In this case, P was estimated through the following equation:

$$\frac{\text{ETc} - \text{rainfall}}{\text{ETc}} \times \frac{\text{P for time during month when crop is growing}}{.86}$$

If rainfall exceeded ETc during a month, it was assumed that there was no requirement to add water to compensate for percolation.

The water required for a peak irrigation period of less than one month is often used for design in order to ensure that adequate water is always available. However, in this case, that practice was not adopted because (1) water rather than land is the limiting factor, and (2) the crop calendars in Figure IV-4 show only average dates; and (3), as discussed previously, design is based on 20-hour per day pump operation, which allows a potential increase of 17 percent (four hours per day) in operating time if necessary during periods of peak water use.

Section 7: Sub-Project Command Areas

By using the horizontal pipe method, the Consultant has made estimates of discharge from both LLPs and DTWs in the sub-projects, and most of them have been found to discharge approximately 1.8 cusecs. Consequently, to determine command areas a pump discharge of 1.8 cusecs will be used for both LLPs and DTWs, unless flow measurements by the consultant during the design and construction phase indicate that the flow from a tube-well is greater than this. If the flow from a tube-well has been measured at less than 1.8 cusecs, design should still be based on 1.8 cusecs: It is assumed that under such conditions steps will be taken by the water-use group to increase the efficiency of the pumping unit. Because an irrigation group often uses a different low-lift pump each year, 1.8-cusec average yield is used as a criterion for all low-lift pump systems.

Once the cropping pattern for a sub-project is determined, the peak irrigation requirements can be used to determine the command areas through the following procedure.

1. Show recommended crops and type of land (highland, lowland, etc.) on the sub-project map.

2. Planimeter the area available for each crop.

3. Tabulate peak monthly water requirements for the crops, using appropriate values of peak irrigation requirement (Ip) from Tables IV-21b, IV-22b, IV-23b, and IV-24.

4. On the basis of croping priorities, determine the acreage that can be grown of each crop and the total command area. This is illustrated by the example below. While laying out the irrigation distributon ditches and irrigation blocks for the sub-projects, adjustment of crop areas may be necessary due to physical constraints.

EXAMPLE

Location: Rangpur District

Area available for crops:

- Wheat - 180 acres on medium highland
- Boro - 20 acres on high lowland
- T. Aus - 180 acres on medium highland following wheat
  - 20 acres on high lowland, following boro
- T. Aman - 180 acres on medium highland (same land as wheat)

Boro acreage could be increased by growing it instead of wheat on medium highland, but priority was given to wheat for this example on the medium highland.

Peak irrigation requirements:

As per step 3, tabulate the peak irrigation requirements as follows:

TABLE IV-Ex-1

PEAK IRRIGATION REQUIREMENTS: RANGPUR DISTRICT

Month	T. Aman (from Table IV-21b) Ip	Wheat (from Table IV-24) Ip	Boro (from Table IV-22b Ip	T. Aus (from)Table IV-23b Following Wheat Ip	T. Aus (from)Table IV-23b Following Boro Ip
Oct	6.9				
Nov	4.2				
Dec		2.7	5.0		
Jan		5.3	9.3		
Feb		7.7	11.6		
Mar		5.3	14.2	4.5	
Apr			4.9	16.3	7.0

Cropping priorities:

For this example it is assumed that the first priority is to grow boro followed by t. aus on the 20 acres of high lowland.

Crop acreages and command area calculations:

The acreage of t. aus on medium highland can be calculated by using the data for April from the above table:

(Note: Approximate opeating hours per month
= (30 days) (20 hours/day) = 600 hours

$$\frac{(1.8 \text{ ac-in/hr})(600 \text{ hrs})-(20 \text{ ac})(4.9 \text{ in})-(60 \text{ ac})\ (7 \text{ in})}{16.3} = 51.7 \text{ acres}$$

(1.8 ac-in/hr is the pump capacity. One ac-in/hr is approximately equal to one cfs.)

From the table it is obvious that the maximum wheat acreage must be determined from the data for either February or March:

$$\text{February: } \frac{(1.8 \text{ ac-in/hr})(600 \text{ hr})-(20 \text{ ac})(11.6 \text{ in})}{7.7 \text{ in}} = 110.1 \text{ ac}$$

$$\text{March: } \frac{(1.8 \text{ ac-in/hr})(600 \text{ hr})-(20 \text{ ac})(14.2 \text{ in})-(51.7 \text{ ac})(4.5 \text{ in})}{5.3 \text{ in}}$$

$$= 106.3 \text{ ac}$$

These calculations show that the peak irrigation requirements in March govern wheat acreage, and the maximum wheat acreage that should be grown is 106.3 ac. Therefore, the total command area is:

Wheat - 106.3 ac

Boro - 20.0 ac

126.3 ac

To see whether t. aman can be planted on the 106.3 acres of medium highland that will be included in the command area, the following calculation is made for possible t. aman acreage.

$$\text{For October:} \quad \frac{(1.8 \text{ ac-in/hr})(600 \text{ hr})}{6.9 \text{ in}} = 156.5 \text{ ac}$$

Because t. aman must be grown on land where wheat is planted, the above figure shows that there is enough water available for 106.3 acres of t. aman.

Summary of acreages:

Wheat	-	106.3 ac
Boro	-	20.0 ac
T. aus following wheat	-	51.7 ac
T. aus following boro	-	20.0 ac
T. aman	-	107.4 ac
Total command area	-	126.3 ac

Operation costs:

The above acreages can be used to calculate operation costs by using the total average irrigation requirements (Ia) from Tables IV-21a, IV-22a, IV-23a, and IV-24.

TABLE IV-Ex-2

TOTAL WATER REQUIREMENTS

Crops	Area (acres)	Ia (inches)	Total Water Requires (acre-inches)
Wheat	106.3	18.6	1977
Boro	20.0	39.2	784
T. Aus following wheat	51.7	15.6	807
T. Aus following boro	20.0	5.0	100
T. Aman	106.3	3.9	415
Total			4083

The total water required can then be multiplied by the appropriate unit operating costs to determine the total annual operating costs.

CHAPTER IV

PART 2

SUB-PROJECT DESCRIPTIONS, REQUIREMENTS, AND DESIGNS

Preface

In the section that follows, all the sub-projects are described in detail. This includes general information, cropping patterns, engineering drawings, qualities of materials, and cost estimates for each sub-prject.

Drawings and plans were prepared for each sub-project. However, due to the nature of work, the following figures, contained in Appendix C, are standard for either DTWs, LLPs, or sluiceway sub-projects, as specified.

DTWs and LLPs

Figure C-1: Distribution System Structures
Figure C-2: Distribution System Weir Box
Figure C-3: Discharge Table
Figure C-4: Weir Gauge - Stop Check
Figure C-5: Alternative Canal Sections

Sluice Ways

Figure C-11: Sluice Gate, Flap Gate, Gate Leaf
Figure C-13: Gear Lift Assembly
Figure C-14: Parts of Gear Lift Assembly
Figure C-15: Parts of Gear Lift and Stem Guide
Figure C-16: Parts of Gear Lift Assembly and Threaded Stem
Figure C-12: Gear Lift Pedestal and Details

Section 1: Sub-Project No. 1

NAME: Re-excavatin of Khan Mohan Khal
THANA: Patiya
DISTRICT: Chittagong

A. Location

The sub-project is located on the Chittagong-Cos's Bazar highway and lies about seventeen miles southeast of Chittagong town. The sub-project area covers the lands of the villages of Dengapara, Khan Mohan, and Suchakradandi in Patiya Police Staton (P.S.).

B. Communications and Marketing Facility

The area can be reached both by road and by rail. Khan Mohan Railway Station is on the project site. The Chittagong-Cox's Bazar highway and railway line pass near the sub-project area. The Patiya Sub-Division Headquarters is very near the sub-project area. There are several markets at Patiya.

C. Description of Sub-Project

The sub-project requires re-excavatuon of an existing khal, called Khal Mohan, to permit irrigation by LLPs of about 300 acres of land in the vollages of Dengapara, Khan Mohan, and Suchakradandi in P.S. Patiya. This khal originates from the Patiya hill ranges on the eastern side of the sub-project area and falls in the west to the Chandkhali river, which ultimately falls into the Karnafuli as well as in the Sangu river. The Chandkhali River is tidal, and the normal tidal range at the site is about five feet. The length of the Khan Mohan Khal is not good; it is silted up.

Farmers now irrigate 150 acres with water from this khal, using three LLPs. They wish to re-excavate the khal to permit irrigation of an additional 150 acres. Implementation of the project should include consolidation of water users' groups to better coordinate use of LLPs. The people plan to obtain three additional pumps, but this may not be necessary. The 300-acre project probably should be designed to use a total of 3 LLPs.

The length of the re-excavated portion of the khal is about 5,000 feet. The people plan to construct a sluice gate at the outfall of the Khan Mohan Khal, thereby permitting storage of water during periods of low tide.

D. Soils

This sub-project is located in the Pahartali-Mirsarai Soil Association, which is developed in the piedmont alluvial plain. The following are descriptions of the major soil series in the association:

1. Pahartali Series, highland and medium highland phases: The highland phase is located on the middle part of the flood plain ridges, whereas the medium highland phase will be on the lower portions. The subsoil's texture for both phases is loam to silt loam in texture, and its color is gray mixed with brown. Both phases are droughty during the dry season, and the medium highland phase is subject to seasonal, shallow flooding. The major cropping pattern is aus-t. aman - rabi crops. On the medium highland phase, boro may follow t. aman.

2. Mirsarai Series, medium highland phase: This phase of the series is located on lower portions of the ridges in medium highlands. The subsoil textures range from clay loams to silty clay loams, and the color is grey mixed with brown. This phase has seasonal, shallow flooding but is droughty during the dry season. The two major cropping patterns are aus - t. aman - fallow and t. aman - boro.

E. Land Tenure

Due to the large area benefitted by development of this sub-proejct, a sample of 300 acres was selected for land tenure analysis. The average farm size was found to be equal to 2.7 bighas. Out of a total of 330 farms in the area, 240 have less than three bighas; eighty have between three and six bighas; and ten have more than six bighas.

F. Existing Cropping Patterns and Intensities

Development of the sub-project will drain an area of approximately 760 acres. Water will be available in the re-excavated canal to irrigate approximately 345 acres. Currently, 190 acres receive irrigation water. The major cropping patterns under the existing categories of irrigated and non-irrigated acres are shown in Table IV-25. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-26. The cropping intensities for the irrigated and non-irrigated areas are equal to 2.00 and 1.4, respectively.

G. Recommended Cropping Patterns with Sub-Project Development

With the re-excavation of this khal, approximately 760 acres of land will be drained. The Khal will contain enough water for winter irrigation of approximately 345 acres.

For the lands that are drained but have no irrigation water available, the cropping intensity will increase slightly. In higher lands, the broadcast aman and mixed paddy cop may be replaced in part by t. aman during the monsoon period. In lower lands, some of the boro acreage may be eliminated due to the drainage of water but normally will be replaced with b. aus and t. aman. However, the yields of crops will increase due to the elimination of waterlogged conditions. General recommended cropping patterns for lands, drained but not irrigated, are outlined in Table IV-27.

The 345 acres that are drained and can be irrigated during the dry season have the highest potential for both increased crop intensities and crop yields. Cropping intensities could reach 2.00. Table IV-28 outlines the recommended cropping patterns with both drainage and irrigation available. With the implementation of the irrigation component of this sub-project, specific cropping patterns should be determined for each proposed LLP command area according to the cropping pattern procedure outlined in Chapter III. Using this information and the crop water requirements criteria in Chapter IV, the actual command area size can be determined for each proposed pump.

H. Sluiceway Design

This sub-project will store tidal water for irrigation of approximately 345 acres during the winter season and will provide drainage during the monsoon. The tide fluctuation during the irrigation season is five feet. The drainage area of the sub-project is 760 acrs. The estimated rate of runoff is 72 cubic feet per second. A khal approximately 1-1/2 mile long will store irrigation water and convey drainage water. A sluiceway with one-unit flap gates on the country side will provide regulation of the water flow.

For the design of the proposed facilities in the sub-project area, the reader is referred to the following figures contained in Appendix C and to the following figures contained in Appendix E (Maps):

Figure E-1-1 - Countour Plan
Figure E-1-2 - Plan and Section of Sluice Gate
Figure E-1-3 - Layout Plan
Figure E-1-4a- Profile and Cross-Sections of Khal
E-1-4b
Figures C-11 through C-16 - show the Standard Design for Sluiceways

An abstract of the quantities and the cost summary are given in Table IV-29. Table IV-30 shows the amounts of different materials required for construction.

Section 2: Sub-Project No. 2

NAME: Nabajugh Tebhage Khamer Deep Tube-Well Pucca Drain
THANA: Hathazari
DISTRICT: Chittagong

A. Location

The sub-project is located in the vicinity of Chittagong University about fifteen miles north of Chittagong City on the road to Hathazari. The sub-proejct area covers the land of Jobra Mouza in Hathazari P.S.

B. Communications and Marketing

The Chittagong-Hathazari Highway and Railway bound and serve the sub-project area. A large market at Hathazari is about two miles to the north.

C. Description of the Sub-Project

The sub-project will provide tube-well irrigation for 115 acres in Jobra Mouza. It is located within the command area of Karnafuli Irrigation Project, whose embankments along the Halda River provide flood protection into the area. Internal drainage is accomplished by gravity sluices through the embankments. Irrigation facilities will be provided by building a dam on the upper stem of the Halda River, which will release irrigation water to the area below the dam.

There is a DTW in the sub-project area. The farmers have built well-graded kutcha field canals and now want pucca lined canals. They now irrigate 70 acres, and the farmers believe that lining the canal will permit irrigation of 150 acres.

C. Soils

This sub-project is located in the Pahartali-Mirsarai soil association, which is developed in the piedmont alluvial plain. The following are descriptions of the major soil series in this association:

1. Pahartali Series, highland and medium highland phases: The highland phase is located on the middle part of the floodplain ridges, whereas the medium highland phase will be on the lower portions. The subsoil's texture for both phases is loam to silt loam, and its color is gray mixed with brown. Both phases are droughty during the dry season and the medium highland phase is subject to seasonal, shallow flooding. The major cropping pattern is aus. - t. aman - rabi crops. On the medium highland hase, boro may follow t. aman.

2. Mirsarai Series, medium highland phase: This phase of the series is located on lower portions of the ridges in medium highlands. The subsoi's texture ranges from clay loams to silty clay loams, and its color is gray mixed with brown. The area has seasonal, shallow flooding but is droughty during the dry season. The two major cropping patterns are aus - t. aman - fallow and t. aman - boro.

E. Land Tenure

The sub-project area contains 105 farms with an average farm size of six bighas. Information obtained at the sub-project site indicates that out of the 105 farms, eighty consist of three bighas or less; twenty consist of between three and six bighas; and five consist of more than six bighas. The three largest farms have areas of ten, eleven, and twelve bighas.

F. Existing Cropping Patterns and Intensities

This sub-proejct comprises a total area of 115 acres, fifty of which are now irrigated by a deep tube-well. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-31. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 2.60 and 1.38, respectively, or an average intensity of 1.91 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

Table IV-33 shows the recommended cropping patterns with sub-project development for each land type found in the command area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide an equitable distribution of water from the DTW to each plot in the area. To accomplish this, a system of brick-lined canals serving blocks of from three to five-acres each will be constructed. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Delivery of water to the blocks will be scheduled by roster. The water to the plots within a block will be distributed cooperatively by the farmers working the plots. Distribution of the water is described in the Operation and Maintenance Manual, Appendix B.

The procedures for designing the distibution system are set forth in the Design Manual, Appendix C.

The sub-project is divided into 29 blocks. Two canals and five branch canals, having a total length of 1.7 miles, serve these blocks. A weir box will be constructed at the DTRW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown on Figure E-2-1 structures, canal sections and slopes, and delivery water surface and elevations are shown on Figure E-2-2.

The structure list (D-1, D-2, D-3 of Appendix D) specifies stations, elevations, and dimensions necessary for laying out the structures in the field for construction.

The quantity and cost summary (D-4) lists the items of contract work and the estimated cost for the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated and summed and multiplied by the estimated unit costs to determine the total cost per item. To the sub-total of item costs is added a contingency of 15 percent. This contingency is an item of standard engineering estimating practice, the amount of which is based on extensive records of many completed works.

The Construction Materials Chart (D-5) specifies the amounts of different materials required for completion of the distribution system for the sub-project. A summary of this figure is contained in Table IV-35.

The canals of the distribution system are located on the boundaries between the plots of blocks. This placement of canals least disrupts farming operations and consumes least land for canal right-of-way. The system has been laid out and estimates have been made, based on a rectangular brick section for the conveyance canals. To minimize O & M costs and to maintain continuity of service, this system is preferred. This system's only disadvantage is its relatively high construction cost. Two alternative sections have been considered, a comparative study of which is included in the Design Manual (Appendix C). The design to be used for the section will be made at the time of sub-project implementation.

Procedures for developing the plan and locating sub-projct canals are set forth in the Design Manual.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system and its operation as well as their expected contributions must be ensured.

The farmers concurrence with the adopted plan will be signified in writing before starting field staking for construction. During the review and field staking, adjustments in alignment and structure location will be made to accommodate actual field conditions.

Section 3: Sub-Project No. 3

NAME: Re-excavation of Farange Sublong Khal
THANA: Satkania
DISTRICT: Chittagong

A. Location

The sub-project is located about 55 miles southeast of Chittagong town. Its area covers the lands of Faranga Mouza in Chunati Union in Satkania P.S.

B. Communications and Marketing

Communications in the area are poor. The Chittagong-Cox's Bazar Highway passes about eight miles northwest of the sub-project site, but there is little road communication to the interior. The area is served by the River Dalua.

The sub-project area has no marketing facility, but there are small markets in adjoining areas.

C. Description of the Sub-Project

The sub-project would provide construction of a one-mile-long canal to divert water from a perennial stream, construction of three cross dams, and re-excavation of two canals. Farmers are willing to excavate the new canal and construct two of the cross-dams using their own funds and labor.

The sub-project area is bounded on the North, South, and East by high hills covered with forests. The River Dalua originates in these hills on the southeast side of the sub-project area and flows northwest, crossing the Chittagong-Cox's Bazar highway and falling into the Sankha River. It is the entire valley's main river to supply water and also acts as the main drainage. During the monsoon season, when there is concentrated rainfall in the watershed area, the River Dalua and other small streams cannot carry the flood discharge; consequently, they overtop the banks in many places, depositing silt in the paddy fields and thus damaging the crops.

There are three hilly charas: Sublong, Faranga, and Sonachhari. These originate in the hills and pass through the sub-project area to the Dalua River. Farmers want to build a dam over Sublong Chara and re-excavate a khal to connect the existing Faranga Khal in order to divert water for irrigation of the adjoining lands between Sublong and Faranga. They would also like to build a dam over the Farange Chara and re-excavate a khal to connect the existing Sonachhari Khal to divert water for irrigation of the lands between Faranga Khal and Sonachhara Khal. Excavation of a new khal, about one mile long, would connect a third proposed dam over Sonachhara Khal to the Dam River. The transfer of water from the Sublong Khal to the Faranga Khal would require construction of two sluice gates and a dam to divert the Sublong Khal.

Data for this sub-project is very limited, especially relative to hydrology, and no firm conclusions can be drawn regarding engineering design. Therefore, further studies and investigations are required for this sub-project in order to determine its merits.

Due to the remoteness of the area, mapping and hydrologic data were not available for the design of structures and canals. Likewise, no information concerning downstream uses of the khal has been obtained. Because it is probably the source of domestic water, complete diversion would not be environmentally acceptable.

Due to a considerable lack of factual data, sub-project implementation will be postponed.

Section 4: Sub-Project No. 4

NAME: Pucca Sluice Gate in the Bepula Chara
THANA: Hathazari
DISTRICT: Chittagong

A. Location

The sub-project is located about fifteen miles north of Chittagong town. Its area covers the lands of the village Uttar Pahartali in Mirzapur Union in Hathazari P.S.

B. Communications and Marketing Facility

The area is served by road and by railway. The Chittagong-Nazirhat Highway and the railway line bound one side of the sub-project area. The nearest railway station is at Sarkarhat, about one mile to the South.

Both Sarkarhat and Hathazari have markets.

C. Description of the Sub-Project

The sub-project will provide a water control structure over the hilly stream "Billa," locally called Bepula Chara. This chara, which originates in the Sitakunda Hill Range on the west and flows towards the valley to the east and into the River Halda, carries considerable silt. Each year during the rainy season, there is flooding on both

banks of the chara. It was re-excavated in 1978 from the railway line to the road under the Food for Work Program. During the dry season, a nominal quantity of water passes through the khal, which is about five miles long. there is no LLP on this khal.

Farmers now irrigate about 500 acres. They believe that if a water control structure is constructed over the chara near the railway crossing, water from the hill ranges can be stored for irrigation of more land. Farmers of Gumanmordan U.P. think that if the sluice is located near the railway station, the lands below the railway line and on the east side of the road crossing would not benefit. The sub-project envisages the construction of a small retention reservoir at a suitable location on the stream flowing from the Sitakunda Hill Range; the reservoir would store water during the rainy season for later release into a distribution system to irrigate the valley between the hills and the railway-highway line. However, storage of water in the reservoir in the hill range is a separate project, which is outside the scope of this study and that component is not recommended for development.

This sub-project falls within the command area of the Karnafuli Irrigation Project, a large project now under construction by BWDB, which provides irrigation, drainage, and flood protection. The development of the sub-project will be part of that project and, therefore, has not been proposed separately in this report.

Section 5: Sub-Project No. 5

NAME: Pucca Drain for Kawanara Irrigation Project

THANA: Saturia

DISTRICT: Dacca

A. Location

This sub-project is located about eight miles northeast of Manikganj Sub-Divisional headquarters town and seven miles north of Golora village on the Dacca-Aricha highway. It overs the lands of the village Kawanara in Saturia Union.

B. Communications and Marketing

A kacha road about seven miles long, from Saturia to Golora, joins the Dacca-Aricha highway.

A large weekly market place and a daily bazaar are held about 200 yards from the sub-project site.

C. Description of Sub-Project

The sub-project would provide LLP irrigation from the river Gazikhali for 158 acres on the left bank in Saturia Union. This sub-project is located within the command area of the project "Brahmputra Left Flood Embankment", which will protect the site from flooding. Internal drainage would be effected by gravity drainage regulators.

The river Gazikhali provides enough water for irrigation throughout the year. Farmers now irrigate about sixty acres, and they are interested in having a lined canal that will increase the irrigated acreage.

D. Soils

This sub-project is located in the Dhamrai Sabhar Bazaar Soil Association. There are three major soil series in this soil association: (1) the Sonatala series, which occupies the highest portion of the floodplain ridges and generally accounts for 10 percent of the association; (2) the Dhamrai series, which occupies the major portion of the ridges lands--but in a lower position than the Sonatala series--and generally accounts for 35 percent of the association; and (3) the Sabhar Bazaar which is extensive in most basin lands and generally accounts for 25 percent of the association. The Dhamrai and Sabhar Bazar constitute the primary series found at this particular sub-project.

The major land use for this association is mixed aus and broadcast aman, as well as some jute and rabi crops, such as mustard and pulses.

The agricultural capacity of this association is good to moderate.

1. Dhamrai Series: The Dhamrai series is composed of seasonally flooded (often 3-8 feet), poorly drained soils developed mostly in moderately fine textured Brahmaputra alluvium and located on the upper slopes of the young and active Brahmaputra floodplain ridges. The soils color is gray to olive-gray, finely mottled and of friable composition. Their textures range from loams to silty clay loams and have prismatic and angular blocky structures. These soils are neutral to modertely alkaline below the cultivation layer. Dhamrai soils differ from the associated Sonatala soils in that they are finer in texture and have a stronger structure. In general, the topsoil's texture ranges from silt loam to clay and the sub-soil ranges from loam to silty clay loam.

2. Sabhar-Bazaar Series: The Sabhar-Bazaar series is composed of seasonally flooded, (often 8-10 feet for 6-7 months), poorly drained soils developed from fine-textured, young Brahmaputra alluviaum and is located in basin sites on the Jamuna and Lakha floodplains. The soils are gray silty clays to clays with rather compact, prismatic, and angular blocky sub-soils having prominent gray coatings on the peds. They are normally neutral to moderately alkaline below the cultivated layer. Sabhar Bazaar soils differ from associated Sonatala and Dhamrai soils in that they are finer in texture, have a heavier consistency, and have a more strongly developed structure. The topsoil textures range from silty clay loam to clay, and those of the sub-soil range from silty clay to clay.

E. Land Tenure

The sub-project area has 188 farms with an average farm size of 2.5 bighas. Information obtained at the sub-project site indicates that 105 farms consist of less than three bighas, 65 of between three and six bighas, and eighteen of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 158 acres sixty of which are now irrigated by two low-lift pumps. The major cropping patterns under the existing irrigated non-irrigated areas are shown in Table IV-36. The cropped aceages give an intensity for the existing irrigated and non-irrigated areas of 1.75 and 1.38, respectively, or an average intensity of 1.52 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

Table IV-38 shows the recommended cropping patterns with sub-project development for each land type found in the command area. The acreage for each crop in the recommended cropping patterns is shown for each land type in Table IV-39. These cropped acreages give an intensity, with sub-project development, of 2.36 for the 158-acre command area.

H. Pucca Drain Distribution System-Design

The objective of the design of the distribution system for this sub-project was to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of from three to five-acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at

a time. Delivery of water to the blocks will be scheduled by roster. Water to the plots within a block will be distributed cooperatively by the farmers working the plots. Distribution of the water in the system is described in the Operation and Maintenance Manual. The Design Manual specified the procedures for designing the distribution system.

The sub-project is divided into 34 blocks. Two canals and three branch canals having a total length of 2.3 miles serve these blocks. A weir box will be constructed at the DTW dischrge pipe to measure all water used by the sub-project. The locations of canals and blocks are shown on Figure E-5-1. Structures, canal sections and slopes, and delivery water surface and elevations are shown on Figure E-5-2.

The structure list (D-6 through D-9) specifies the stations, elevations, and dimensions necessary for laying out the structures in the field for construction. The Quantity and Cost Summary (D-10) lists the items of contract work and the estimated cost for the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated and summed and multiplied by the estimated unit costs to determine total costs per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-11) shows the amount of different materials required for completion of the distribution system for this sub-project. A summary of this chart appears in Table IV-40.

The canals of the distribution system are located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right-of-way. The system has been laid out and estimates made, based on a rectangular brick section for conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered. A comparative study of them is included in the Design Manual. The

design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accommodate actual field conditions.

Section 6: Sub-Project No. 6

NAME: Rajghat Deep Tube-well Pucca Drain
THANA: Savar
DISTRICT: Dacca

A. Location

This sub-project is located in the Rajghat Union, Savar P.S., in the District of Dacca. It is situated on the Dacca-Aricha Highway, approximately 12 miles northwest of Dacca city.

B. Communications and Marketing

The sub-project area is easily accessible by land and water. The Dacca-Aricha Highway bonds the sub-project area on the west. The Dhaleswari River, which runs close to the area, is navigable throughout the year.

Farmers sell their products at the bi-weekly markets at Fulbaria, one mile from the sub-project area, and at Savar, three miles north of the sub-project area.

C. Description of Sub-Project

The source of water is a DTW with yield of 1.75 cusecs. It presently serves 40 acres of irrigation area. The sub-project is on relatively low land, a fact that precludes extension of the command area without the construction of a high-level canal.

It is proposed, therefore, that a high-level, brick-lined canal be built with proper laterals and turn-outs to enable farmers to irrigate 70 additional acres. This will also permit cultivation of an additional crop each year.

D. Soils

The Savar Rajghat DTW is located in the Dhamrai-Sabhar Bazaar Soil Association. This soil association has three major soil series: the Sonatala series, which occupies the highest portion of the floodplain ridges and accounts for 10 percent of the association; the Dhamrai series, which occupies the major portion of the ridge lands below the Sonatala series and accounts for 35 percent of the association; and the Sabhar Bazaar series, which is extensive in most of the Basin lands and accounts for 25 percent of the association. The Dhamrai and Sabhar Bazaar constitute the principal series in this particular sub-project area.

The predominant land uses for this association are mixed aus, broadcast aman, some jute, and rabi crops, such as mustard and pulses.

The agricultural capacity of this association is good to moderate.

1. Dhamrai Series: The Dhamrai series is composed of seasonally flooded (often 3-8 feet), poorly drained soils, developed mostly in moderately fine-textured Brahmaputra alluvium and located on the upper slopes of the young and active Brahmaputra floodplain ridges. The soil's color is gray to olive-gray and finely mottled, and of friable composition.

Their textures range from loams to silty clay loams and have prismatic and angular blocky structures. These soils are neutral to moderately alkaline below the cultivation layer. Dhamrai soils differ from the associated Sonatala soils in that they are finer in texture and have a stronger structure. In general, the topsoil's texture ranges from silt loam to clay, and the sub-soil's from laom to silty clay loam.

2. Sabhar Bazaar Series: The Sabhar Bazaar series is composed of seasonally flooded, (often 8-10 feet for 6-7 months), poorly drained soils developed from fine-textured young Brahamaputra alluvium and is located in basin sites on the Jamuna and Lakha floodplains. The soils are gray silty clays to clays with rather compact, prismatic and angular blocky sub-soils having prominent gray coatings on the peds. They are normally neutral to moderately alkaline below the cultivated layer. Sabhar Bazaar soils differ from associated Sonatala and Dhamrai soils in that they are finer in texture, have a heavier consistency, and have a more strongly developed structure. The top soil texture ranges from silty clay loam to clay and that of the sub-soil ranges from silty clay to clay.

E. Land Tenure

The sub-project area has 83 farms with an average farm size of four bighas. Information obtained at the sub-project area indicates that out of the 83 farms, 42 consist of three bighas or less, 28 of between three and six bighas, and 13 of more than six bighas. Of the three largest farms, two have areas of 15 bighas each and one has 16 bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 110 acres, 40 of which are presently irrigated by a DTW. The major cropping patterns under the existing irrigated and non-irrigated areas are as shown in Table IV-41. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-42. These cropped acreages give an intensity from the existing irrigated and non-irrigated areas of 2.0 and 1.5, respectively, which is equivalent to an average intensity of 1.68 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

Table IV-43 shows the recommended cropping patterns, with sub-project development, for each land type found in the command area. The acreage for each crop in the recommended cropping patterns is shown for each land type in Table IV-44. This cropped acreage gives an intensity, with sub-project development, of 2.40 for the 110-acre command area. Figure E-6-3 shows the areas recommended for each cropping pattern at the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the blocks will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 32 blocks. Two canals and five branch canals, having a total length of 1.4 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-6-1. Structures, canal sections and slopes, and surface and elevations of delivery water are shown in Figure E-6-2.

The structure list (D-12, D-13, D-14) specifies stations, elevations, and dimensions necessary for laying out the structures in the field for construction.

The Quantity and Cost Summary (D-15) lists the items of contract work and the estimated costs of the sub-project.

The length of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-16) specifies the amounts of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-45.

The canals of the distribution system are located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 7: Sub-Project No. 7

NAME: Embankment of Saldah River
THANA: Sreepur
DISTRICT: Dacca

A. Description of sub-project

This sub-project would dam the Saldah River with an earth embankment and construct an LLP station and distribution system to irrigate land adjacent to the river.

The Saldah River drains a large area. During monsoons, it carries a large flow, whereas during the dry season, it is almost dry. The dam would store the little available water for daily pumping to serve the project lands. A temporary dam, to be replaced after each flood season, has been suggested; however, such temporary dams traditionally are not replaced after the first washout. Such a scheme is not acceptable as a sub-project feature. The alternative is construction of a permanent dam across the channel, a large sluiceway, and wing dikes.

The land to be irrigated lies between the River and paralleling hills. Its area is approximately sixty acres, which are divided into two sections of twenty and forty acres by a deep khal. There are twenty plots which can be irrigated. One of these contains about twenty acres.

Two pump stations will be required to serve the land. Crossing the dividing khal would require an excessive length of canal and a crossing structure.

This sub-project is technically and economically infeasible, and therefore will not be given further consideration.

Section 8: Sub-Project No. 8

NAME: Aricha-Ichhamati Irrigation Project. Parts I, II, III, and IV
THANA: Shivalaya
DISTRICT: Dacca

A. Introduction

This sub-project, as submitted by the local people, is an ambitious plan to irrigate approximately 20,000 acres. Figure 4-8-1 (following this chapter) shows the main features of the project, which are (1) transfer of water from the Padma River to the Ichhamati and Khirai Rivers by way of re-excavated canals between the rivers; (2) large pump stations on the Padma River to supply the canals; (3) construction of dams across the Ichhamati and Khirai Rivers to permit storage of water that is conveyed there from the Padma; and (4) construction of gates to permit drainage of surface runoff into the Padma River. Because of the large size and complexity of this sub-project, the Consultant was instructed to make recommendations on its implementation rather than doing design work.

B. Dacca Southwest Project

The sub-project area lies within the boundaries of the Dacca Southwest Project, a large irrigation, drainage, and flood control project that has been previously studied. The original feasibility study for the Dacca Southwest Project was conducted by Engineering Consultants Inc. (ECI) for EPWAPDA during 1967 and 1968, and the report was issued in 1969. Following review of the original study by the International Development Association (IDA), additional studies and investigations were performed and the report submitted in 1970 in the following form:

Volume I - "Summary, Conclusions, and Recommendations"
Volume II - "Engineering and Costs"
Volume III - "Agriculture, Economic, and Project Organization"
Volume IV - "Hydrology and River Hydraulics"
Report by D. B. Simons - "River Mechanics and Morphology"

The report was reviewed by EPWAPDA and their general consultant, ACRES, and by an IDA appraisal mission. Discussion between them and ECI led to preparation of a "Definite Project Report" in 1971, which presented a phased development plan for the project. At the time of its submittal, sufficient design work and contract documents had been prepared to permit contract awards for the first portion of construction as soon as project financing was secured.

The following is a brief summary of the recommendations made in the feasibility report:

1. Construction of embankments to form three adjacent polders.

2. Primary pumping plants were to be located on the Dhaleswari and Kaliganga Rivers. High capacity, electric motor-driven propeller pumps were proposed to serve both for irrigation and drainage of the polder areas. Total capacity of the

pumping plants ranged from 600 cfs to 2,700 cfs. The governing criterion for their capacity was drainage during the monsoons. These plants included sluiceways for gravity flow and locks for navigation.

3. The primary irrigation distribution system was to be the existing canals within the project area, with improvement where necessary. The water level in these canals was to be such that secondary pumping would be required. This secondary pumping would consist initially of portable low-lift pumps serving only the adjacent land. Later, when water users' groups were sufficiently organized, larger permanent secondary pump stations were to be installed to supply gravity canal systems.

4. Operation and maintenance was to include dredging of the inlet to the Dhaleswari River if necessary for an adequate water supply.

5. Operation and maintenance of major engineering works was to be done by EPWAPDA employees.

BWDB has recently received proposals from consultants for design of the Dacca Southwest Project. It is intended that the project be constructed when financing can be secured.

C. Existing Facilities

Efforts by the local farmers and government officials to develop irrigation facilities by their own efforts have been impressive. In at least one part of the sub-project they have demonstrated their ability to organize themselves and implement irrigation works to a higher degree than is normally observed in Bangladesh. A relatively large pumping facility at Aricha supplies water to a large canal, from which water flows by gravity into smaller canals. This requires a great deal more organization and management than a small irrigation group receiving water from a 2-cfs LLP.

The efforts of the local people have been hampered by a lack of engineering help and a lack of funds for major facilities. The existing pump station at Aricha consists of thirty 2-cfs LLPs with electric motors. The inadequate power supply causes extended non-operation periods and rapid deterioration of the motors. Even though the pump station is inefficient, it is the best that can be done by the water users on their own and appears to be a wise investment for them.

D. Recommendations

Because there are still plans to construct the Dacca Southwest Project, any work done on the sub-project should conform to the recommendations in the Dacca Southwest Project report. That report states that the Padma River should not be used as a water source because of its instability, which could result in erosion of the land on which the pump stations are constructed or in shifting of the river away from the pump station, thereby requiring construction and maintenance of an inlet channel. The pump stations for the proposed sub-project would be much smaller than the main pump stations of the Dacca Southwest Project and could be used as secondary pump stations when that project is constructed. It is not practical for the water users in the sub-project to obtain water from the Dhaleswari River because of the distance over which water would have to be conveyed. The complexity and size of such a project would approach that of the Dacca Southwest Project since it would require (1) coordination with other potential water users along the conveyance routes; (2) larger pumping, conveyance, and control structures than the proposed sub-project; (3) possible dredging of the inlet to the Dhaleswari River, which would be too large a task for the local people; and (4) a higher level of operation and management than the proposed sub-project due to the larger service area. Therefore, it is recommended that the Padma River be used as a temporary water source for the sub-project. In the future when the Dacca Southwest Project is completed, the main source of water for the project will probably be the Ichhamati and Khirai Rivers, which would receive water pumped from the Dhaleswari River and conveyed westward in other main channels. The pump stations on the

Padma could be relocated at that time if necessary.

Construction of the proposed permanent dams on the Ichhamati and Khirai Rivers is not recommended because they would serve no useful purpose: a continuous supply of water pumped from the Padma is already available from that source. The storage of monsoon water would not be sufficient to justify their cost.

Unless justified by a detailed economic analysis, the Ichhamati and Khirai Rivers should probably not be used for distribution of water within the sub-project if the water surface elevation of the canals supplying the rivers is significantly higher than that of the rivers. Such a system would require lifting of water to be needlessly repeated. It would probably be more economical to construct other distribution channels that would retain the water surface near its originally pumped level. For example, the existing pump station at Aricha lifts the water into a canal, adjacent to the Asian Highway, that supplies irrigation water by gravity flow without additional pumping. Water from this canal should not be allowed to flow into the Ichhamati River, from which it would have to be pumped again to ground level.

As mentioned previously, the pump station at Aricha is probably a good investment on the part of the local people. Although it is inefficient and costly, it is the best alternative for the people because BADC rental charges are minimal. However, other alternatives would be more desirable for the economy of the country.

To serve the 20,000 acre sub-project, a total pumping capacity of roughly 400 cfs would be required. Considering the number of pump stations proposed, pumps with capacities of between 10 and 25 cfs should probably be used. For ease of maintenance and repair, only about three different pump sizes should be specified for the stations. This would allow enough flexibility in operation but would provide duplication of units used.

Pump stations of this size could not be operated by the local people and MRD has no provisions for furnishing trained operators. The following alternatives are suggested for operation of the pump stations: (1) the pump manufacturer could operate and maintain the

pump stations under contract with MRD or (2) the local people could form a limited company and contract with the pump manufacturer to operate and maintain the stations. Either of these two alternatives could be undertaken in the form of purchase or lease of the pumping equipment. Although this has not been done in Bangladesh, a local pump supplier has shown interest in such an arrangement. It would provide an interim solution to the problem until the Dacca Southwest Project is constructed, at which time operation could be turned over to BWDB.

E. Summary and Conclusions

The farmers in the sub-project area are severly handicapped by the delayed development of the proposed Dacca Southwest Project, which would provide them with needed irrigation water. Because there is no definite schedule for construction of that project, early development of the proposed sub-project should be considered because it would greatly benefit the people in the area. However, engineering and financial assistance is needed because of the size and complexity of the project. Plans to put dams in the Ichhamati and Khirai Rivers should be abandoned, and engineered pump stations should be considered to replace the planned "make-shift" stations composed of small BADC-supplied low-lift pumps. Operation of the sub-project irrigation system will also require engineering help. Because this is clearly beyond the scope of MRD services, responsibility for operation and maintenance of the pump stations, which would be the most costly and complex part of the system, possibly could be shifted to the pump manufacturer.

Section 9: Sub-Project No. 9

SUB-PROJECT NAME: High Irrigation Pucca Drain

THANA: Palash

DISTRICT: Dacca

A. Location

This sub-project is located at Palash Thana under Narsingdi Sub-Division of Dacca District. The sub-project area lies north of Ghorashal Railway Station, six miles northeast of the Sitalakhya River, in Palash Union. The distance between the sub-divisional headquarters and the sub-project area is six miles.

B. Communication and Marketing

The sub-project area is served by land and water routes. A kutcha road leads to the sub-project area from the sub-divisional headquarters. Access to the project area is very difficult during the rainy season. A large weekly market and daily bazaars are held at Charsindur, about 400 yards from the sub-project area.

C. Description of the Sub-Project

The sub-project area consists of 116 acres. A tube-well in the sub-project area has a 3-cfs pump capacity but, due to excess seepage, is irrigating only twenty acres of land. The proposed development would extend the irrigated area to 165 acres.

The farmers of the area now irrigate only one crop: HYV boro. They feel that they will be able to grow additional crops, such as oilseeds, if they are provided with expanded irrigation distribution facilities. Perhaps 95 percent of the land can be brought under triple cropping and the balance under double cropping. The local leaders and people are anxious to develop this area.

D. Soils

This sub-project is located in the Sonatala-Silmandi Soil Association, which has developed in the old Brahmaputra floodplain. The following are descriptions of the major soil series in this association:

1. Sonatala Series, Medium Highland Phase: This phase of the series is normally located on the middle part of ridges in medium highland areas. The subsoil ranges from silt loam to silty clay loam in texture and is pale olive to brown in color. It is seasonally flooded and usually droughty in the dry season. The major cropping patterns are: aus/jute - t. aman - rabi crops.

2. Silmandi Series: This series is normally located on the upper slopes of ridges in the old Brahamputra and Jamuna floodplains. The subsoil is usually silty clay loam in texture and gray with yellowish brown-mottles in color. It is seasonally flooded and often suitable for only broadcast aman. Other crops may be aus, t. aman, jute, sugarcane, mustard, and rabi vegetables.

E. Land Tenure

The sub-project area has 110 farms with an average farm size of 3.20 bighas. Information obtained at sub-project site indicates that out of the 110 farms, seventy consist of less than three bighas, and forty of from three to six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 116 acres, twenty of which are now irrigated by a DTW. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-46. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-47. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 2.00 and 1.51, respectively, or an average intensity of 1.59 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

Table IV-48 contains the recommended cropping patterns with sub-project development for each land type found in the command area. Table IV-49 shows the acreage for each crop in the recommended cropping patterns for each land type. These cropped acreages give an intensity, with sub-project development, of 2.17 for the 116 acre command area. Figure E-9-3 shows the areas recommended for each crop pattern at the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance manual. Delivery of water to the block will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 31 blocks. Three canals and five branch canals, having a total length of 2.1 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-9-1. Structures, canal sections, and slopes, and surface and elevations of delivery water are shown in Figure E-9-2.

The structure list (D-17 through D-20) specifies stations, elevations, and dimensions necessary for laying out the structures in the field for construction.

The Quantity and Cost Summary (D-21) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100 foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-22) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-50.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 10: Sub-Project No. 10

NAME: Construction of Sluice Gate Over Saras Kati Khal
THANA: Kalaroa
DISTRICT: Khulna

A. Location

The sub-project sluice site is about 15 miles north-east of Satkhira Town by road. The area covers the lands of the villages of Ofapur, Bamankhali, Gazalmari, Panchnal, Baidyapur, Gazna, Paikpara, Gochmara, Naryanpur, Khetrapara, Jaynagar, and Basantapur in Kalaroa P.S.

B. Communications and Marketing

The area is served by road. The Satkhira-Jessore Highway passes through Kalaroa Thana Headquarters from south to north, and is about five miles west of the sluice site. There are markets at Saraskati, Bamankhali and Kalaroa. The Saraskati and Kalaroa markets are also connected to the sub-project area by the rivers Kapotakshi and Betna.

C. Description of the Sub-Project

The sub-project will provide irrigation facilities to a large area of land and provide flood control to about 5,000 acres. The sub-project is bounded by the Kapotakshi River on the East and the Betna on the West; both rivers are tidal. The Kalaroa-Saraskati Road divides the sub-project area into two parts. One khal, locally known as Saraskati, connects the Betna River on the West to the Kapotakshi River on the East. It is about 4 1/2 miles long. High tide water enters this khal from Kapotakshi. The water of the Kapotakshi River is fresh at the sub-project site, whereas the water of the Betna is saline. Farmers have closed the Saraskati Khal offtake at Betna by one earthen cross dam. The other end of the khal at Kapotakshi is

open. The Kapotakshi River is perennial with stable banks and adequate discharge to irrigate a large tract of land. Four LLPs are installed on the banks of Saraskati Khal. These pumps irrigate about 300 acres of land during the winter season. During ebbtide, water flows out of Saraskati Khal, thereby limiting the water supply and precluding the extension of irrigation.

If a controlling structure is built across this khal on the bank of the Kapotakshi River, the inflow of this river during high tide could be stored in the Saraskati Khal section. A much larger area of about 1,700 acres could be irrigated by installing more LLPs along both banks of this khal.

Some low pockets on both sides of the khal will also benefit from controlled drainage through the sluice.

This sub-project falls within the command area of "Ganges-Kobadak Project - Khulna Unit" of the Master Plan of BWDB which would take care of the sub-project by providing flood protection, improved drainage, and irrigation.

D. Soils

Three soil associations are in this sub-project area: Sara-Amjhupi-Ishurdi; Ishurdi-Amjhupi; and Garuri-Pakuria-Gangni. These three associations are developed from the Ganges meander floodplain.

The following are descriptions of the major soil series in the Sara-Amjhupi-Ishurdi Association:

1. Sara Series, Medium Highland Phase: This phase of the series is normally located on the upper part of the ridges in medium highlands. The subsoil is a brown silt loam. It is subject to shallow flooding and is droughty during the dry season. Major cropping patterns include: (1) aus/til/jute - rabi crops and (2) aus/til/jute - t. aman/rabi crops. The lower ridges will be cropped to mixed aus/til and broadcast aman/rabi crops.

2. Amjhupi Series: This series is normally located on middle slopes of gently undulating ridges. The subsoil is an olive-brown, silty clay. It is intermittently flooded during the monsoon and is droughty during the dry season. The major cropping patterns are generally the same as the Sara series.

3. Ishurdi Series, medium lowland phase: This phase of the series is normally located on the lower part of ridges in medium lowland areas. The subsoil is a pale brown, silty clay. It is moderately flooded during the monsoon but, without irrigation, droughty during the dry season. The major cropping pattern is mixed aus/til and broadcast aman-fallow.

The Ishurdi-Amjhupi Association has two major soil series: Ishurdi and Amjhupi. Both of these series have been described under the Sara-Amjhupi-Ishurdi Association.

The following are descriptions of the major soil series in the Garuri-Pakuria-Gangni Association:

1. Garuri Series: This series is normally located on nearly level floodplain ridges. The subsoil is silty clay-loam to clay in texture and olive brown to dark grayish brown in color. It is seasonally flooded. These soils are mainly used for mixed aus and broadcast aman, followed by rabi crops, or sometimes for aus or jute, followed by t. aman.

2. Pakurai Series: This series is located on the lower slopes of gently undulating floodplain ridges. The subsoil is an olive brown to dark grayish brown clay. It is seasonally flooded and is used for mixed aus or jute and broadcast aman followed by rabi crops. The medium highland sites are suitable for an aus-t. aman - fallow pattern.

3. Gangni Series: This series is often located on lower ridge slopes and in basin margins. The subsoil is usually silty clay in texture and olive brown to dark gray in color. It is shallowly flooded during the monsoon and droughty during the dry season. The soils are used for aus followed by t. aman.

E. Land Tenure

Due to the large area that development of this sub-project will benefit, a sample of 200 acres was selected for land tenure analysis. The area was found to have 118 farms with an average farm size of 5.10 bighas. Out of the 118 farms, fifty consist of less than three bighas, 35 of from three to six bighas, and 33 of more than six bighas. The three largest farms in the sub-project consist of 55, 60, and 80 bighas, respectively.

F. Existing Cropping Patterns and Intensities

The major cropping patterns under the existing irrigated and non-irrigated areas in this sub-project are shown in Table IV-51. The average cropping intensities for these existing irrigated and non-irrigated areas are 1.8 and 1.40, respectively.

G. Recommended Cropping Patterns with Sub-Project Development

With the construction of the proposed sluice gate, there may be enough water in the Khal for winter irrigation of approximately 5,000 acres. Additional investigation is required to determine the actual amount of land that could be irrigated. Factors such as distance the channels can carry water from the khal may significantly affect how large an area can be irrigated.

Table IV-52 gives the recommended cropping patterns for lands with flood control but without irrigation. Table IV-53 gives the recommended cropping patterns for lands with both flood control and irrigation.

H. Design of Sub-Project

This sub-project will store tidal water for irrigation of approximately 5,000 acres during the winter season and flood protection and drainage during the monsoon. The tide fluctuation during the irrigation season is four feet. The drainage area of the sub-project is 5,350 acres. The estimated rate of runoff is 333 cubic feet per second. A khal four miles long will store irrigation water and convey drainage water. A sluiceway with three units, flap gates on the river

side, and slide gates on the country side will provide regulation of the water flow.

Table IV-54 shows the quantity and cost summary. Table IV-55 shows the quantities and costs of construction materials needed for development of sub-project.

Design of engineering structures for this sub-project appear on the following figures in Appendix E:

Figure E-10-1 Contour Map

Figure E-10-2 Sluiceway Map

Figure E-10-3 Layout Plan

Section 11: Sub-Project No. 11

NAME: Extension of Kismat Pucca Drain to Railway Line

THANA: Sadar

DISTRICT: Khulna

A. Location

This sub-project is located about two miles from Khulna Town on the road and rail lines to Bagerhat Town. The sub-project area covers the lands of Kismat Mouza in Khulna Sadar P.S.

B. Communications and Marketing

The area is served by road, railway, and river. Rupsa Railway Station is 1 1/2 miles from the sub-project site. The Khulna-Bagerhat Railway Line and the highway pass by the sub-project area. There are good marketing facilities at Rupsa and Khulna Town.

C. Description of Sub-Project

Sub-project development will provide LLP irrigation from the river Bhairab, locally called Attorabanki, for land on the south side of Rupsa-Bagerhat Railway. This sub-project is located within the command area of the Coastal Embankment Project, whose embankments would protect the site from floods. Internal drainage would be effected through sluices. The source of water is perennial, and the pumping unit is installed on the left bank of the river. The river can provide sufficient water suitable for irrigation of the sub-project area. The river is tidal with a range of from six to eight feet. Another river, locally called Bhairab or Rupsa, is very near the sub-project site, but its water is saline.

The irrigated area lies about 3,000 feet away from the pumping unit. The sub-project is intended to extend an existing pucca canal about 2,000 feet to the irrigated site. The section of the existing pucca canal is rectangular, two feet wide and 2 1/2 feet deep. The main distribution canal is to be constructed in the sub-project area. The existing pucca drain is not in use this year and needs repair and maintenance work. There is no evidence that it has been used in the past, but farmers say that the pump was once in operation. The users have requested a pump of greater capacity, either one 5-cusec pump or two 3-cusec pumps. At present, there is not irrigation, but farmers expect to irrigate the entire area depending on the availability of water in the pucca drain. An existing short-span bridge on the railroad and an adjacent culvert under the road will provide the means of crossing the area without having to excavate the railroad embankment.

D. Soils

This sub-project is located in two soil associations: the Mirpur-Darsana Complex and the Dumuria Bajoa Association. Both associations developed on the ridges of the old Ganges meander floodplains.

The following are descriptions of the major soil series in the Mirpur-Darsana Complex:

1. Mirpur Series, Made-Land Variant: This variant is normally located on man-made platforms in highland positions. The subsoil is a pale brown silt loam. Its limitations are the small size of the individual platforms and droughtiness in the dry season. It is normally used for coconut and betel-nut gardens and for rabi and kharif vegetables.

2. Darsana Series, Highland and Medium Highland Phases: The highland phase is normally located on the upper portion of ridges, whereas the medium highland phase will be on middle portions of the ridges in a medium highland position. The subsoil in both phases is a pale brown silty clay loam. Both phases are slightly droughty during the dry season. The medium highland phase has shallow flooding during the rainy season. Major cropping patterns are aus - t. aman - rabi crops. Til and jute may replace some aus on the highland phase.

The following are descriptions of the major soil series in the Dumuria-Bajoa association:

1. Dumuria Series, Medium Highland, Saline Phase: This soil type is located in basins. The subsoil is a gray-to-dark-gray silty clay. Its limitations are shallow tidal flooding and droughtiness and salinity during the dry season. These soils are generally cropped with t. aman.

2. Bajoa Series, Medium Highland Phase: This phase is located on ridges in medium highland areas. Its subsoil is a gray, silty clay loam. Its limitations include shallow tidal flooding and salinity and droughtiness during the dry season. These soils are generally single cropped with t. aman.

E. Land Tenure

The sub-project area has 200 farms with an average farm size of 1.80 bighas. Information obtained at the sub-project site indicates that out of the 200 farms, 145 consist of less than three bighas, forty from three to six bighas, and fifteen of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 120 acres. The major cropping patterns in the area are shown in Table IV-56. The acreage for each crop in the area is shown in Table IV-57. These cropped acreages give an intensity for the existing non-irrigated areas of1.67.

G. Recommended Cropping Patterns with Sub-Project Development

Table IV-58 lists the recommended cropping patterns with sub-project development for each land type found in the command area. Table IV-59 shows the acreage for each crop in the recommended cropping patterns for each land type. This cropped acreage gives an intensity, with sub-project development, of 2.6 for the 120-acre command area.

H. Irrigation Rehabilitation and Extension Design

This sub-project requires the rehabilitation of a partially completed, bricklined, rectangular pucca drain; construction of weir box at the low-lift pump site on the bank of the River Bhairab; and construction of a new lined canal for the sub-project lands. The existing canal is 2,390 feet long with a culvert under a kutcha road. The rehabilitation includes repointing, replacing missing bricks, and increasing the height of walls in the reach where the base has settled. New construction includes 2,500 feet of lined canal, a concrete pipe siphon under the railroad and road, a culvert under a kutcha road, and a turnout. The plan, profile, and siphon are shown in Figure E-11-1.

The canal extension and structures will be in accordance with Figure C-1 of the Design Manual. The dimensions of the section will be the same as those of the existing lined canal.

Five road crossings will be provided for access from the road to homes. Distribution of water from the end of the lined canal will be effected by the farmers.

Appendix D shows a Quantity and Cost Summary (D-24). The Construction Materials Chart (D-25) shows the amount of different materials required for construction of sub-projects; that information is summarized in Table IV-60.

The survey for the profile established that the original slope for the completed section was 0.0008. This slope is satisfactory for the extension and has therefore been used for the entire lined canal.

Section 12: Sub-Project No. 12

NAME: Re-excavation of Chowdhury's Canal from Basuri to Nalua river
THANA: Mollahat
DISTRICT: Khulna

A. Location

The sub-project area is located about fifty miles northeast of Khulna Town by river and four miles south of Mollahat Thana headquarters. The project covers nearly six square miles of cultivable land, mainly in the villages of Ambari, Dattadanga, Khalpur, Kamargra, Katadura, and Atjuri in Mollahat P.S.

B. Communications and Marketing

The sub-project area is served primarily by the river Attarbanki. A kutcha road and a pucca road extend from Khulna Town, but road conditions are not good; the kutcha road cannot be used during bad weather. An unpaved road within the sub-project area connects it to the Thana Headquarters. There is a market at the Thana headquarters, and there are also small village markets in the vicinity.

C. Description of the Sub-Project

The sub-project area is bounded by the Modhumati River on the East and the Attarbanki on the North and West. A small river, the Nalua, originates from the Attarbanki on the North; the Attarbanki flows to the West and then to the South, ultimately joining the Modhumati River. The five-mile long Chowdhury's Khal, which connects the Nalua River and the Modhumati River, needs re-excavation. The Nalua River is nearly silted up and remains dry during the early part of the year. Its water is saline during the monsoon. There is a flood embankment along the right bank of the Modhumati. A small sluice gate at the outfall of Chowdhury Khal in the embankment near Basuri is used to drain rainwater and to control the entry of floodwater from the Modhumati. It is sometimes used to retain rainwater in the khal for irrigation. There are possibilities of pumping water into the khal, thereby maintaining a water level to permit gravity flow. However, farmers are too poor to use power pumps and prefer to lift the water by domes or other manual means. The system cannot be developed to its full capacity because farmers generally wish to grow only what they need; therefore, it is doubtful that the large area served by the canal would be used for maximum production. Some tube-wells in the area have failed because of the unavailability of fuel, spare parts, and mechanics. Farmers now irrigate fifty acres. This area would have to be increased in order to use a low-lift pump to its full capacity.

The Chowdhury Khal may be re-excavated to proper section and slope for drainage in the area, but there should be no connection with the Nalua River because its water is saline. Moreover, the one sluice gate at the outfall of the Chowdhury Khal will help retain rainwater, thus permitting irrigation.

This sub-project also falls within the command area "Coastal Embankment Project" as specified by the Master Plan of BWDB. The Project's embankments will protect this sub-project from flooding during high tide and river stages.

Section 13: Sub-Project No. 13

NAME: Reconstruction of Fatepur-Baitpur Embankment, Excavation of Khal and Construction of Two Sluice Gates.

THANA: Bagerhat

DISTRICT: Khulna

A. Location

The sub-project is located about two miles south of Bagerhat sub-divisional headquarters town. Its area covers the lands of the villages Baitpur, Fatepur, Chitali, Rajapur, and Dhalnagar in Bemorta Union in Bagerhat P.S.

B. Communications and Marketing

The sub-project area is served by road from Bagerhat town, where there is a good marketing facility.

C. Description of the Sub-Project

The sub-project will provide flood protection, drainage, and irrigation through reconstruction of an existing embankment, re-excavation of an existing khal, and construction of two sluice gates. The project area is bounded by the Bagerhat-Pirojpur highway on the west and south and by the existing embankment Fatepur-Baitapur on the east and north. The area is triangular and covers 500 acres. The Daratana River, which flows in a north-south direction about one mile west of the sub-project area, is tidal and contains saline water. One khal originates from the Daratana River on the west, flows eastward into the sub-project area, and then flows north to the Bhairab River outside the embankment; it ultimately falls in the Baleswar River in the east. High-tide saline water enters the sub-project area through the above khal. The existing embankment is not in good condition and

requires resectioning in order to prevent floods. The Baleswar River contains fresh water, which, during high tide and the monsoon season, enters the sub-project area through the existing khals. Farmers want to put one sluice on the east end of the khal at the highway crossing to drain the area and to prevent entry of saline water.

The farmers are very enthusiastic about developing the sub-project.

This sub-project also falls in the command area of "Coastal Embankment Project", whose embankments and drainage sluices would prevent high tides and river stages from flooding the land. Irrigation is not included in this project.

D. Soils

This sub-project is located in the Mirpur-Darsana complex, which developed in the old Ganges meander floodplain, and in the Barisal-Pirojpur soil association, which developed in the Ganges tidal floodplain.

The following are descriptions of the major soil series in the Mirpur-Darsana complex:

1. Mirpur Series, made-land variant: This variant is normally located on man-made platforms in highland positions. The subsoil is pale brown, silt loam. Its limitations are the small size of the individual platforms and droughtiness in the dry season. It is normally used for coconut and betelnut gardens and for rabi and kharif vegetables.

2. Darsana Series, highland and medium phase: The highland phase is normally located on the upper portion of ridges, whereas the medium highland phase is found on middle portions of the ridges in a medium highland position. The subsoil in both phases is a pale brown, silty clay loam. Both phases are slightly droughty during the dry season. The medium highland phase has shallow flooding during the rainy season. Major cropping patterns are aus - t. aman - rabi crops. Til and jute may replace

some aus on the highland phase.

The following are descriptions of the Barisal-Pirojpur association:

1. Barisal Series, medium highland, saline phase: This phase is located in basin areas of medium highlands. The subsoil is a gray to dark-gray, silty clay or clay. Its limitations include shallow tidal flooding and both droughtiness and salinity during the dry season. The area is cropped only to t. aman.

2. Pirojpur, medium highland, saline phase: This phase has the same position as the Barisal series. The subsoil is gray to dark-gray in color, ranges in texture from silty clay to clay, and overlies peat or muck within a four-foot depth. The limitations and land use are the same as those in the Barisal series.

E. Land Tenure

Due to the large area that development of this sub-project will benefit, a sample of 200 acres was selected for land tenure analysis. The average farm size was found to be 6.10 bighas. Out of a total of 98 farms, forty consist of less than three bighas, 35 of from three to six bighas, and 23 of more than six bighas.

F. Existing Cropping Patterns and Intensities

The major cropping patterns under the existing non-irrigated area in this sub-project are shown in Table IV-61. There is currently no irrigated land in the area.

The average cropping intensity for the existing non-irrigated area is 1.00. Cropping patterns and cropping intensities are restricted in this sub-project because there is no drainage facility to relieve the lands of flood water and there is no irrigation. The sub-project also has severe salinity problems.

G. Recommended Cropping Patterns with Sub-Project Development

With the development of this sub-project, approximately 640 acres of land will be drained. Enough water will also be available in the khal for winter irrigation of approximately 500 acres.

For the lands that are drained but that have no irrigation water available, the cropping intensities normally do not increase; however, the intensity for the non-irrigated lands in this sub-project is very low, and the potential exists to increase it to approximately 1.5 or 1.6 when drainage becomes available. Moreover, the yields of crops will increase due to the elimination of waterlogged conditions. General recommended cropping patterns for lands, flood protected but not irrigated, are outlined in Table IV-62.

The 500 acres that are drained and can be irrigated during the dry season have the highest potential for both increased crop intensities and crop yields. It is estimated that cropping intensities could be 2.50 to 2.60. Table IV-63 outlines the recommended cropping patterns with both flood control and irrigation available. Specific cropping patterns should be determined for each low-lift pump command area according to the procedure outlined in Chapter III (Cropping Patterns). Using this information and the design criteria in this chapter, an accurate command area can be determined for each pump.

H. Sub-Project Design

Development of this sub-project will provide storage of tidal water for irrigation of about 500 acres during the winter season and flood protection and drainage for 640 acres during the rainy season. The tide fluctuation during the winter season is three feet. The estimated rate of runoff is 40 cubic feet per second. A 0.6-mile-long khal will store irrigation water and convey drainage water. A sluice way with one flap gate on the river side and slide gates on the country side will regulate the water flow. The other is a flushing sluiceway with one unit, a slide gate on the river side and a flap gate on the country side. An existing 3.25-mile-long embankment along the south of the sub-project area will be reconstructed.

Designs of engineering structures for this sub-project appear in the following figures contained in Appendix E.

Figure	4-13-1	Contour map
Figure	4-13-2a	Sluice way map No. 1
Figure	4-13-2b	Sluice way map No. 2
Figure	4-13-3a	Layout plan No. 1
Figure	4-13-3a	Layout plan No. 2
Figure	4-13-4a	Embankment profile
Figure	4-13-4b	Embankment profile
Figure	4-13-5a through 4-13-5e	Embankment cross sections
Figure	4-13-6a	Profile cross section of khal
Figure	4-13-6b	Profile cross section of khal

Table IV-64 shows the Quantity and Cost Summary. Table IV-65 shows the construction materials required for development of this sub-project.

Section 14: Sub-Project No. 14

NAME: Sluice Gate at Parshikhali Khal
THANA: Fakirhat
DISTRICT: Khulna

A. Location

The sub-project area is located about 23 miles south of Khulna town, about eleven miles southwest of Fakirhat Thana headquarters, and covers the cultivable land of the villages Tekatia, Bighat, Ghanashyampur, Surotia, Saittala, and Kismat Bighat. It consists of about 2,000 acres.

B. Communications and Marketing

A pucca road of about twelve miles connects Fakirhat and Khulna town. An eleven-mile-long kutcha road leads to the project area; however, it can only be used in the dry season. There is a large market, Noapara bazaar, about five miles from the sub-project area and several small markets in the vicinity.

C. Description of the Sub-Project

The sub-project area is bounded by the River Pasur on the west, the Kumarkhali Khal on the south, a road on the north, and highland on the east. River Pasur is tidal and carries saline water. The tidal range at the sub-project site is about ten feet. The Kumarkhali Khal originates from the Pasur River and finally meets the Bhola River in the south. The Parshikhali Khal originates from the Kumarkhali Khal and enters the sub-project area. During high tide, saline water enters the sub-project area through the Parshikhali Khal and causes flooding. Residents have requested a sluice gate over Parshikhali Khal to exclude saline water during high tide and to permit storage of water in a two-mile-long natural channel. This sluice gate may also serve as a drainage outlet. The khal has many sub-canals for storage of fresh water accumulated during the rainy season.

The residents themselves have constructed an embankment around the sub-project area, which prevents entry of saline water, but it leaks badly and requires maintenance and care.

The proposed sluice gate will serve mainly to prevent the entry of saline water. An artificial reservoir would have to be constructed to hold rainwater for irrigation.

This sub-project also falls in the command area of "Coastal Embankment Project", which would provide the sub-project area with adequate flood protection and drainage facilities. The coastal embankments will prevent high tides and river stages from flooding the land. Drainage sluices would be constructed at drainage channel outlets. Irrigation is not included in the coastal embankment project.

D. Soil

The sub-project is located in two soil associations: the Barisal-Dumaria, saline phase, and the Darsana-Garuri association. The former is developed from the Ganges tidal floodplain; the latter from the old Ganges meander floodplain.

The following are descriptions of the major soil series in the Barisal-Dumaria, saline phase, association:

1. Barisal Series, medium highland, saline phase: This soil is located in basin areas in medium highlands. The subsoil is a gray to dark-gray, silty clay or clay. Its limitations are shallow tidal flooding and both droughtiness and salinity during the dry season. The area is normally single-cropped to t. aman.

2. Dumaria Series, medium highland, saline phase: The description of the series is the same as that for the Barisal series, the only difference being that the Barisal subsoil is non-calcareous.

The following are descriptions of the major soil series in the Darsana-Garuri association:

1. Darsana Series, highland and medium highland phases: The highland phase is located on the middle portion of ridges in highland areas, whereas the medium highland phase is found on the lower portions of ridges in medium highland areas. The subsoils of both phases are pale brown, silty clay loams. Both phases are droughty in the dry season, and the medium highland phase is shallowly flooded. The major cropping pattern is aus - t. aman - rabi crops. Til and jute are also grown on the highland phase.

2. Garuri Series, medium highland phase: This series is also located in basins in medium highland areas. The subsoil is a dark gray clay. It is subject to shallow flooding and droughtiness during the dry season. The soil is also limited by its heavy consistency. The major cropping patterns are aus - t. aman - fallow or t. aman - fallow.

E. Land Tenure

Due to the large area that development of the sub-project will benefit a sample area of 200 acres was selected for analysis. The average farm size was found to be 8.20 bighas. Out of 73 farms, thirty consists of less than three bighas, 25 of from three to six bighas, and eighteen of more than six bighas.

F. Existing Cropping Patterns and Intensities

There is no irrigation in this sub-project at present. The major cropping patterns under the existing non-irrigated area are shown in Table IV-66. The average cropping intensity for the non-irrigated land is 1.65. Both cropping patterns and cropping intensities are restricted in this sub-project because the lands are flooded by saline water from the Pasur River during high tide and because no water is available for irrigation.

G. Recommended Cropping Patterns with Sub-Project Development

With the development of this sub-project, approximately 1,700 acres of land will be drained and protected from flooding. However, it appears that water stored in the khal will not be sufficient for irrigation.

Crop intensities do not generally increase when a sub-project has only flood control measures. It may, however, be possible to increase the crop intensity of this sub-project by introducing aus (HYV) on some lands and by expanding the rabi-crop acreage. The yields of aman and rabi crops should increase due to the elimination of water logged conditions and saline water. General recommended cropping patterns for the lands protected from flooding are outlined in Table IV-67.

Table IV-68 shows the recommended cropping patterns, should irrigation water become available.

This sub-project will drain and provide flood protection for an area of approximately 1,700 acres during the monsoon season. The tide fluctuation during the irrigation season is ten feet. The drainage area of the sub-project is approximately 1,700 acres. The estimated

rate of runoff is 113 cubic feet per second. A khal 1.8 miles long will convey drainage water. A sluiceway with one-unit flap gates on the river side and slide gates on the country side will provide regulation of the water flow.

Table IV-69 shows the Quantity and Cost Summary. Table IV-70 shows the construction materials needed for development of this sub-project.

Designs of engineering structures for this sub-project appear in these figures in Appendix E:

Figure E-14-1 Contour Plan
Figure E-14-2 Sluice Gate Plan and Section
Figure E-14-3 Layout Plan

Section 15: Sub-Project No. 15

NAME: Re-excavation of Nalburia Dhanasagar Khal
THANA: Sarankhola
DISTRICT: Khulna

A. Location

The sub-project is located about 110 miles south of Khulna town by river and is about six miles north of Sarankhola Thana headquarters. Its area covers the lands of Dhanasagar, Rajapur, and Nalburia Mouza, an area of about thirteen square miles of cultivable land.

B. Communications and Marketing

Communications in the sub-project area are not good. It is most easily accessible by river; the trip by motor launch from Khulna takes about eighteen hours. The area can also be reached by land travel to Morellganj Thana headquarters, about seventy miles south of Khulna

town, and by then proceeding about ten miles south by river. There is no marketing facility in the sub-project area, but there is a small market about 1-1/2 miles away.

C. Description of the Sub-Project

The River Bhola, which carries saline water, runs by the west side of the sub-project area. The Baleswar River, carrying fresh water nearly one mile away, flows by the east side of the sub-project. These two rivers are tidal with a range near the site of about nine to ten feet. A canal, Dhanasagar Khal, connects these two rivers. The sub-project consists of re-excavating the Nalburia Dhanasagar. Embankments on the north and west sides of the sub-project area prevent entry of saline water. A cross dam on the main Dhanasagar Khal near its meeting with the Bhola River excludes saline water. As a result, only fresh water can enter this khal from Baleswar River. Two pipe culverts are located at the off-take and out-fall of Nalburia Dhanasagar Khal. The bed level of this khal is five to six feet higher than the main Dhanasagar Khal. During high tide, a very small quantity of water enters this khal for a limited time. Due to tidal inflow from both ends, the khal Nalburia is easily silted up. Six low-lift pumps are operating there for irrigation purposes. The section of the khal is also inadequate. Now residents feel that if the 3.5-mile-long Nalburia Dhanasagar Khal were re-excavated with a proper section and slope, they could get enough irrigation water for their present needs and more area could be brought under command.

This sub-project also falls in the command area of the "Coastal Embankment Project", which will protect the sub-project area from saline intrusion during high tide.

D. Soils

This sub-project is located in the Barisal-Jhalakati soil association, which is developed in the Ganges tidal floodplain. The following are descriptions of the major soil series in this association:

1. Barisal Series, medium highland, saline phase: This phase is located in basins in medium highlands. The subsoil is gray to dark-gray, silty clay or clay. Its limitations include shallow tidal flooding and both droughtiness and salinity during the dry season. The area is cropped to t. aman.

2. Jhalakati Series, medium highland, saline phase: This series is located in middle to lower portions of ridges in medium highland areas. The subsoil is a gray to dark-gray, silty clay loam. This series has the same limitations and land use as the Barisal series.

E. Land Tenure

Due to the large area that development of this sub-project will benefit, a sample of 200 acres was selected for analysis. The average farm size was found to be 11.80 bighas. Of 51 farms, 20 consist of less than three bighas, fifteen of from three to six bighas, and sixteen of more than six bighas.

F. Existing Cropping Patterns with Intensities

The major cropping patterns under the existing irrigated and non-irrigated areas in this sub-project are shown in Table IV-71. The average cropping intensities for these existing irrigated and non-irrigated areas are 2.10 and 1.56, respectively. Due to the silting of the khal, the availability of irrigation water is decreasing, thus lowering both crop intensities and yields.

G. Recommended Cropping Patterns with Sub-Project Development

With the development of this sub-project, there will be a drainage area of approximately 8,000 acres. Conceivably there could be enough water available in the khal for winter irrigation of approximately 6,000 acres. However, additional investigation of this is necessary before any conclusions can be made. Consideration must be given to the distance canals can extend from the khal and which areas can realistically be developed to irrigation.

For lands to be drained and protected from flooding but not irrigated, the cropping intensity will not change drastically. In higher lands, the broadcast aman and mixed paddy crop may be replaced in part by t. aman during the monsoon period. In lower lands, some of the boro acreage may be eliminated due to the drainage of water but will normally be replaced with b. aus and t. aman. However, the yields of many crops will increase due to the elimination of water-logged conditions. General recommended cropping patterns for lands with flood control but not irrigation are outlined in Table IV-72.

Acreage that is irrigated during the dry season and protected from flooding has the highest potential for both increased crop intensities and crop yields. Cropping intensities could increase to 2.50 or 2.60. Table IV-73 outlines the cropping patterns recommended when both drainage and irrigation are available. With the implementation of the irrigation component of this sub-project, specific cropping patterns should be determined for each low-lift pump command area according to the procedure outlined in Chapter III. Using this information and the design criteria in this chapter, an accurate command area can be determined for each pump.

H. Design of Sub-Project

This sub-project will store tidal water for irrigation of approximately 6,000 acres during the winter season and will provide flood protection and drainage during the monsoon. The tide fluctuation during the irrigation season is ten feet. The drainage area of the sub-project is approximately 8,000 acres. The estimated rate of runoff is 338 cubic feet per second. A four-mile-long khal will store

irrigation water and convey drainage water.

This sub-project requires the excavation of 109,860 cubic feet at a total cost of Tk 1,633,000, which includes 15 percent for contingencies. No construction materials are required for sub-project development.

Engineering designs for this sub-project are shown on the following figures, contained in Appendix E.

Figure E-15-1	Contour map
Figure E-15-2a through E-15-2e	Profiles and cross sections of khal

Section 16: Sub-Project No. 16

NAME: Re-excavation of Canal from Beel Katchua to Beel Pankha Under Hatkalupara U.P.

THANA: Atrai

DISTRICT: Rajshahi

A. Location

The sub-project is located about nine miles northeast of Atrai Railway station on the Ishurdi-Santahar line. Its area covers the lands of the villages Kochpara, Simla, Haturia, Pharpur Buzrag, Kismat Jatabari, Khord Bahdaikhara, Sanyasbari, and Hatkalupara in Atrai P.S.

B. Communications and Marketing

Communications in the sub-project area are very poor. The area is served by the river Atrai and deplorable kutcha roads. One weekly market is held about three miles away from the sub-project site.

C. Description of the Sub-Project

The sub-project will provide drainage to an area of 1,300 acres under Hatkalupara Union Parishad in P.S. Atrai. It is about two miles south of the River Atrai and east of a kutcha road, which runs northward. South of the sub-project area is Gutia Khal, which falls into the Atrai River, forming the main drainage outlet of the area. The sub-project area is flooded during the rainy season every year. A khal (about 1.5 miles long) leads from the bil south to Gutia Khal. This khal is inadequate to cope with the flood water, which damages the crops grown in the sub-project area each year. Residents feel that if this khal is re-excavated with a proper section, it would eliminate the problem of early monsoon flooding. The farmers also operate low-lift pumps on this khal when water is available during the dry season. Irrigation will be improved and more areas can be brought under irrigation if by deepening it water can be stored in the khal.

This sub-project is inside the boundary of the Gorai River Irrigation Feasibility Project, a study currently being carried out by International Engineering Company, Inc., and funded by IBRD. Their report is due in early 1981.

The residents of Beel Pankha, Beel Katchua, Beel Santhi, and the surrounding area submitted a letter to the Project Manager, E.C.I., Dacca on October 9, 1979. In the letter, a much larger sub-project was proposed. They commented on the sub-project as proposed in the Rural Irrigation Works Study: "But we like to say that this scheme will have no benefit at all." As an alternative, they propose to drain Beel Pankha and Beel Katchua into the River Atrai.

A scheme of this magnitude is beyond the scope of this study. Additional field work would be required to survey the beels to be drained and the route of the khal to the river. Hydraulic studies would be required of the river hydrograph and drainage potential of the watersheds of the beels. The proposal merits further study and investigation.

Even though the Consultant does not recommend development of this sub-project as originally proposed, engineering designs and maps are provided upon request by MRD.

D. Soils

This sub-project is located in the Elanga-Safapur Complex, which developed in the older Atrai meander floodplain, and the Santhia-Teghar association, which developed in the oldest Ganges meander floodplain.

The following are descriptions of the major soil series in the Elanga-Safapur Complex:

1. Elanga-Series, normal flooding and flood-hazard phases: Both of these phases are located in lowland basins and have a dark-gray, silt loam subsoil. The normal flooding phase has deep flooding and remains wet during most of the dry season. The flood hazard phase also has deep flooding, but there is a rapid rise of the flood water. The main land use is single cropping with broadcast aman. Jute replaces b. aman in some areas, and boro is grown is some depressions.

2. Safapur Series, medium lowland phase: This series is located in medium lowland basins. The subsoil is a gray clay loam. There is moderately deep flooding in this series, and the soil remains wet early in the dry season. The land use is the same as in the Elanga series. There may be areas of aus/jute - rabi crops or aus/jute - t. aman - rabi crops.

The following are descriptions of the major soil series in the Santhia-Tehar association:

1. Santhia Series, medium lowland and lowland phases: These phases are found in both lowland and medium lowland basins. The subsoil is a dark gray, heavy clay, which is calcareous below 20 to 25 inches. It becomes very hard and cracks when dry. Limitations include moderately deep to deep flooding and heavy consistency. Most of this area is single-cropped to broadcast aman.

2. Teghar Series, medium highland phase: This phase is found on ridge slopes in medium highland areas. The subsoil is a yellowish-brown, clay loam. Limitations include shallow flooding and droughtiness in the dry season. The major cropping pattern now used is aus - t. aman, usually followed by rabi crops.

E. Land Tenure

Due to the large area that development of this sub-project will benefit, a sample of 200 acres was selected for analysis. The average farm size was found to be 2.06 bighas. Of 291 farms, 240 consist of less than three bighas, fifty of from three to six bighas, and eleven of more than six bighas.

F. Design of Sub-Project

This sub-project will provide drainage and flood protection for an area of approximately 1,300 acres with an estimated flow of 27 cubic feet per second. A 1.3-mile-long khal will convey rainwater to the sluiceway and will provide daily storage of irrigation water.

This sub-project requires the excavation of 183, 860 cubic feet at a total cost of Tk 435,000, which includes 15 percent for contingencies. No construction materials are required for development of sub-project.

A Contour map appears in Figure E-16-1. Cross sections and profiles of the khal appear in Figures E-16-2a through E-16-2c, contained in Appendix E.

Section 17: Sub-Project No. 17

NAME: Low-Lift Pump Pucca Drain at Salinafar

THANA: Bagatipara

DISTRICT: Rajshahi

A. Location

The sub-project is located on the right bank of the Baral River about two miles northeast of Arani Railway station and four miles west of Bagatipara Thana headquarters. The sub-project area covers the lands of Salinafar Mouza in Bagatipara P.S.

B. Communications and Marketing

The sub-project area is served by railway, rivers, and kutcha roads. The railway station on the Rajshahi-Iswardi route is about two miles to the southwest. A kutcha road about one mile south of the site connects Arani and Bagatipara Thana headquarters. There is a large weekly market at Arani.

C. Description of Sub-Project

The sub-project would provide low-lift pump (LLP) irrigation from the River Baral for 111 acres of land on its right bank in Salinafar Mouza. This sub-project is located within the command area of the southern Rajshahi sub-project, which will provide flood protection, internal drainage, and LLP irrigation on both banks of the River Baral from the River Ganges.

There are two LLPs in the sub-project area on the right bank of the Baral River at Salinafar. Residents are interested in constructing lined canals for the LLPs or in constructing a larger canal that would supply water to lands farther from the water source, as well as serve the existing LLP command area. Because the winter flow in the river is very limited, it has been proposed that only the west LLP be considered. This pump is located at a wide, deep reach of the river, which serves as a natural reservoir.

D. Soils

This sub-project is located in two soil associations: namely, the Sara-Gopalpur association, irregular-relief phase; and the Gopalpur-Ishurdi-Sara association. Both associations developed in the young Ganges meander floodplain.

The following are descriptions of the major soil series in the Sara-Gopalpur association:

1. Sara Series, shallow phase: This phase is found on the upper part of the ridges in highland areas. The subsoil is a pale-brown, silt loam overlying sand at less than twenty inches. Limitations include irregular relief, droughtiness during the dry season, and wetness during the rainy season. The major land use is aus followed by rabi crops.

2. Gopalpur Series, highland phase: This phase is found in the same position as the Sara series. The subsoil is a pale-brown, silty clay loam. The limitations are the same as those outlined for the Sara series. The major cropping use is aus followed by rabi crops, with jute replacing aus in certain areas. The highest locations are sometimes used for sugarcane.

The following are descriptions for the major soils series in the Gopalpur-Ishurdi-Sara association:

1. Gopalpur Series, highland phase: This phase is found on the upper portions of ridges in highland positions. The subsoil is a pale-brown, silty clay loam. These soils are droughty during the dry season and wet during the monsoon. The major land use is aus followed by rabi crops. Some jute may replace aus. Sugarcane is grown on the highest ridges.

2. Ishurdi Series, highland phase: This phase is found on the slopes of ridges in highland areas. The subsoil is a pale-brown, silty clay. Soil limitations and land use are the same as those of the Gopalpur series.

3. Sara Series, shallow phase: This series is much the same as the Gopalpur series with the exception of the subsoil texture, which is a pale-brown, silt loam over sand at less than twenty inches.

E. Land Tenure

The sub-project area has 55 farms with an average farm size of six bighas. Information obtained at sub-project site indicated that out of the 55 farms, twenty consist of less than three bighas, thirty of three to six bighas, and five of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 111 acres, thirty of which are now irrigated by a low-lift pump. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-74. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-75. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 2.0 and 1.72, respectively, for an average intensity of 1.80 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area are shown in Table IV-76. The acreage for each crop in the recommended cropping patterns is shown for each land type in Table IV-77. These cropped acreages give an intensity, with sub-project development, of 2.30 for the 111-acre command area. Figure E-17-3 shows the areas recommended for each cropping pattern at the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block

will be scheduled by roster. The farmers working the plots with a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 33 blocks. Two canals and five branch canals, having a total length of 1.8 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-17-1. Structures, canal sections, and slopes, and surface and elevations of delivery water are shown in Figure E-17-2.

The structure list (D-26 through D-28) specifies stations, elevations, and dimensions necessary for laying out the structures in the field of construction.

The Quantity and Cost Summary (D-29) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-30) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-78.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and

locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 18: Sub-Project No. 18

NAME: Pucca Canal and Spans Acqueduct in Milky Bidirpur
THANA: Nawqbganj
DISTRICT: Rajshahi

A. Location

This sub-project is located in the outskirts of Nawabganj Sub-Divisional town, on the left bank of River Mohananda. Its area covers the lands of the village Kallayanpur in the Nayagola Union under Nawabganj P.S.

B. Communications and Marketing

The area is served by railway, road, and river. Nawabganj railway station is very near the sub-project area. There is good road communication between Nawabganj and Rajshahi Divisional town. The River Mohananda joins the Ganges. A bi-weekly market, Nawabganj market, near the project site, is famous for mangoes and natural silk.

C. Description of Sub-Project

The sub-project would provide LLP irrigation from the River Mohananda for about 400 acres of land. An existing pucca irrigation canal connects the left bank of Mohananda River to the Milki-Huzrapur T.I.P. It was constructed by the thana council and is being used by local farmers. The proposed canal will be about 2,500 feet long if the aqueduct in the Bidirpur Khari is connected with a raised canal. This will also eliminate the use of the double pumping originally proposed. If the proposed canal is excavated beyond the aqueduct area and connected with two existing tanks of about 1/3 acre each, they may serve as reservoirs. The stored water then can be used to irrigate about 250 acres at the other end by gravity flow from the tanks, in addition to 150 acres on both sides of the canal. If the aqueduct area is abandoned, there is no necessity for LLPs.

This sub-project would construct a 3,000-foot, lined canal that would extend an existing canal to serve land across Bidepur Khal from the existing irrigated land. The new canal would be constructed on the alignment of an existing kutcha ditch to Bidepur Khal, cross the Khal on a bridge, and continue through a built-up area to a small existing tank. The tank is privately owned and covers only about 1/3 acre. It is too small to provide enough storage for the sub-project. A two cusec flow is equivalent to 2.7 acre-feet in sixteen hours. In a 0.3-acre tank, this would require a reservoir having a depth of nine feet. There is no land this low to be irrigated. An existing kutcha ditch that extends south along the east side of Bidepur Khal cannot be served because where it intersects the proposed canal alignment its elevation is higher than the take-off point of the proposed canal. The canal will be on a six-foot fill and will require a right-of-way up to 30 feet wide, taking up more than the width of the existing kutcha road along which the existing canal runs. It will also disrupt drainage and communication patterns.

If water is available for this proposed scheme, it would seem more practical to enlarge the irrigated area adjacent to the existing pucca canal. No maps of this area are available.

It is obvious from the above discussion that the proposed scheme is totally infeasible. Therefore, the sub-project should not be considered for implementation.

Section 19: Sub-Project No. 19

NAME: Sluice Gate at Pabdamari Dara Under Alinagar Union Parishad
THANA: Gomastapur
DISTRICT: Rajshahi

A. Location

The sub-project is located about one mile north of Rahampur Railway Station on the Rajshahi-Maldha (India) line. The sluice site is about three miles northeast of Rahampur. The project area covers the lands of Alinagar Union in Gomastapur P.S.

B. Communications and Marketing

A large weekly market is held at Rahampur, which is also a business center for rice and mangoes. The sub-project area is served by two rivers: The Mohananda River and the Purnabhaba River, which originates in India, meet near the sub-project site and flow into the river Ganges at Godagari in Bangladesh. A railway line from Rajshahi runs via Annura to the border between Bangladesh and India. A kutcha road leads from the thana headquarters at Gomostapur to the sub-project area.

C. Description of the Sub-Project

The sub-project would provide a water control structure over the Pabdamari Dara Khal to provide flood protection and drainage of an area of about 5,000 acres in Alinagar Union. The sub-project is bounded by the Purnabhaba River on the south and east, by the Mohan-

anda River on the west, and by the Indian border on the north. The railway line divides the area into two parts. The periphery of the sub-project area is at higher elevations through its center. There are several low pockets, locally called "bils". These are Charui Bil, Bil Haldi, Pathar Jaganathpur, Kismat Nityanandpur Jot Hamda, and Panar Bil. A small nala, called "Pabdamari Dara", comes from the low pockets and falls into the River Purnabhaba near Muraa Khali to the south. A vast area is flooded during monsoons every year. If the flood comes early, it affects both aus and aman crops very badly; but if the entry of flood waters can be prevented, the crops of the area can be saved. Residents propose to construct a sluice gate at the above location in order to prevent the entry of flood water as well as to drain excess water during the rainy season.

D. Soils

This sub-project is located in two soil associations; namely, the Santhia association, developed in the oldest Ganges meander floodplain, and the Sara-Gopalpur-Gomastapur association, developed in mixed Ganges and Mahananda meander floodplains.

The following description applies to the major soil series in the Santhia association:

1. Santhia Series, medium highland, medium lowland and lowland phases: The medium highland phase is found in basin margins, whereas the medium lowland phase is found within medium lowland basins. The lowland phase is found in basin depressions. The subsoil of all three phases is a dark-gray, heavy clay. The medium highland phase is subject to shallow flooding and is droughty late in the dry season. The medium lowland and lowland phases are more deeply flooded and remain wet early in the dry season. These are also affected by flood water. The major land use is broadcast aman which, in cases, may be followed by rabi crops. Some ridges are used for aus or jute, followed by rabi crops. Boro is grown in some depressions.

The following descriptions apply to the major soil series in the Sara-Gopalpur-Gomastapur associations:

1. Sara Series, moderately well drained variant: This variant is locted on the upper portion of ridges in highland areas. The subsoil is a pale-brown, calcareous silt loam over sand below twenty inches (shallow phase has sand at less than twenty inches). This series has severe droughtiness in the dry season. The major land use is for mango orchards.

2. Gopalpur Series, highland phase: This phase is found on ridge slopes in highland areas. The subsoil is pale-brown, calcareous, and silty clay loam in texture. Limitations include droughtiness in the dry season and wetness in the rainy season. Land use includes aus followed by rabi crops, as well as mango orchards.

3. Gomastapur Series: This series has the same location, limitations, and land use as the Gopalpur series, but it has a grayish-brown, non-calcareous subsoil that is clay in texture.

E. Land Tenure

Due to the large area that sub-project development will benefit, a sample of 200 acres was selected for analysis. The average farm size was found to be 2.20 bighas. Out of a total of 273 farms, 175 consist of less than three bighas, ninety of from three to six bighas, and eight of more than six bighas.

F. Existing Cropping Patterns and Intensities

There is no irrigation in this sub-project area at present. The major cropping patterns in the sub-project area are shown in Table IV-79. The actual acreage planted with each crop is shown in Table IV-80. This gives an average cropping intensity of 1.40.

G. Recommended Cropping Patterns with Sub-Project Development

With the construction of the sluice gate, approximately 5,000 acres of land will be drained. However, it appears that water will not be available in the canal for irrigation during the dry season.

For the lands that are drained and protected from flooding, the cropping intensity is expected to increase slightly. In higher lands, the b. aman and mixed paddy crop may be replaced in part by t. aman during the monsoon period. In lower lands, some of the boro acreage may be eliminated due to the drainage of water and be replaced with b. aus and t. aman. The crop yields will increase due to the elimination of waterlogged conditions. General recommended cropping patterns for lands drained and protected from flooding are shown in Table IV-81. The acreages recommended for each crop are shown in Table IV-82. This gives an average crop intensity of 1.68.

H. Sub-Project Design

This sub-project will provide drainage and flood protection for an area of 5,000 acres with an estimated flow of 220 cubic feet per second. A sluiceway with three vents, a flap/slide gate on the river side and a flap/slide gate on the country side will be built. A one-mile-long khal will be re-excavated to provide drainage to the sub-project area.

Table IV-83 shows a quantity and cost summary. Table IV-84 shows the construction materials needed for development of this sub-project.

Engineering designs for this sub-project appear in the following figures, contained in Appendix E.

Figure E-19-1	Contour Map
Figure E-19-2a through E-19-2c	Cross Sections and Profiles

Section 20: Sub-Project No. 20

NAME: Nawapara Multipurpose Society Deep Tube-well Pucca Drain
THANA: Gurudaspur
DISTRICT: Rajshahi

A. Location

This sub-project is located about fifteen miles southeast of Natore Sub-Divisional town and eight miles west of Gurudaspur Thana headquarters. The sub-project area covers the lands of Nawapara Mouza in Gurudaspur P.S.

B. Communications and Marketing

The sub-project area is served by kutcha roads only, which connect with a pucca road about two miles away. This pucca road connects the Gurudaspur Thana headquarters and the Pabna-Natore highway. A small weekly market is held near the sub-project, and a large weekly market is held at Nawapara about 2.5 miles away.

C. Description of Sub-Project

The sub-project would provide DTW-irrigation for 116 acres of land in Chapila Union. This sub-project is located within the command area of Chalna Bill Project, which will protect the DTW site from floods and provide pumping plants for internal drainage.

There is a DTW in the project area with a yield of about 1.75 cusecs. The quality of ground water is good and contains no iron.

At present an area of only thirty acres has been brought under cultivation. The farmers believe that the brick-lined canal distribution system would enable them to extend irrigation to a larger area.

D. Soils

This sub-project is located in two soil associations: namely, the Gopalpur-Ishurdi-Sara association, developed in the young Ganges meander floodplain; and the Mehendiganj-Gopalpur-Ghoir association, developed in mixed young and old Ganges meander floodplains.

The following are descriptions of the major soil series in the Gopalpur-Ishurdi-Sara association:

1. Gopalpur Series, highland phase: This phase is found on the upper portions of ridges in highland positions. The subsoil is a pale-brown, silty clay loam. These soils are droughty during the dry season and wet during the monsoon season. The major land use is aus followed by rabi crops. Some jute may replace aus. Sugarcane is grown on the highest ridges.

2. Ishurdi Series, highland phase: This phase is found on the slopes of ridges in the highland areas. The subsoil is a pale-brown, silty clay. Soil limitations and land use are the same as those of the Gopalpur series.

3. Sara Series, shallow phase: This series is the same as the Gopalpur series with the exception of the subsoil texture, which is a pale-brown, silt loam over sand at less than twenty inches.

The following are descriptions of the major soil series in the Mehendiganj-Gopalpur-Ghoir association:

1. Mehendiganj Series: This series is found in basin margins and centers in medium lowland areas. The subsoil is a pale-brown and dark-gray clay. Its limitations include moderately deep flooding, wetness early in the dry season, and a heavy consistency. Major land use in the basin centers is a single crop of broadcast aman. The basin margins are cropped to mixed aus and b. aman followed by rabi crops.

2. Gopalpur Series, medium highland phase: This phase is found on the lower portions of the ridges in medium highland areas. It has a pale-brown, silty clay loam subsoil. The limitations include shallow flooding and droughtiness in the dry season. The major land use is aus followed by rabi crops.

3. Ghoir Series, medium lowland phase: This phase is the same as the Mehendiganj series except that the subsoil is calcareous below fifteen to twenty inches.

E. Land Tenure

The sub-project area has eighty farms with an average farm size of 4.4 bighas. Information obtained at the sub-project site indicates that of the 80 farms, 25 consist of less than three bighas, forty of from three to six bighas, and fifteen of more than six bighas. The three largest farms have areas of fifteen, eighteen, and twenty bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 116 acres, thirty of which are now irrigated by a DTW. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-85. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-86. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 2.06 and 1.08, respectively, or an average intensity of 1.61 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area are shown in Table IV-87. The acreage for each crop in the recommended cropping patterns for each land type is shown in Table IV-88. Figure E-20-3 shows the areas recommended for each crop pattern at the sub-project area. These cropped acreages give an intensity, with sub-project development, of 1.92 for the 116-acre command area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at at time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 27 blocks. Three canals and three branch canals, having a total length of 1.6 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-20-1. Structures, canal sections and slopes, and surface and elevations of delivery water are shown in Figure E-20-2.

The structure list (D-31 through D-33) specifies stations, elevations, and dimensions necessary for laying out the structures in the field for construction.

The Quantity and Cost Summary (D-34) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-35) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-89.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 21: Sub-Project No. 21

NAME: Mouza Gobrol Deep Tube-Well Pucca Drain

THANA: Jaldhaka

DISTRICT: Rangpur

A. Location

This sub-project is located about forty miles northeast of Rangpur town and about three miles southeast of Jaldhaka Thana headquarters. The sub-project area covers the lands of Gobrol Mouza in Jaldhaka P.S.

B. Communications and Marketing

The sub-project area is served by road only. A reasonably good pucca road runs from Rangpur Town to Jaldhaka with only kutcha roads to the area. The nearest market place is at Jaldhaka, where farmers carry their goods for marketing.

C. Description of Sub-Project

The sub-project would provide tube-well irrigation for about 130 acres of land in Kaimari Union. This sub-project is located within the command area of the Teesta Project. Flood protection is provided to the area by the Teesta South Embankment, but due to local rainfall, some 20 percent of the project area is flooded for short periods. At present a DTW is installed in the area. Its yield is about 1.75 cusecs. The quality of water is good and contains no iron. Farmers have built kutcha main canals and field canals to irrigate their lands. The existing tube-well has not been operated yet. Farmers have proposed to construct a brick-lined canal distribution system.

D. Soils

The sub-project is located in the Gangachara-Srirampur association, which developed in the old Teesta meander floodplain. The following are descriptions of the major soil series in this association:

1. Gangachara Series: This series is normally found on the upper slopes of nearly level to very gently undulating abandoned levees. The subsoil is an olive-gray loam to silt loam. It is intermittently to seasonally flooded. The major land use is double cropping to aus/jute - t. aman - grazed fallow on seasonally flooded areas and aus/jute - rabi crops on higher lands.

2. Srirampur Series: This series is normally found on the middle slopes of nearly level to very gently undulating abandoned levees. The subsoil is an olive-gray, fine sandy loam. The limitations and land use of this series are the same as those of the Gangachara series.

E. Land Tenure

The sub-project area has 102 farms with an average farm size of 3.6 bighas. Information obtained at the sub-project site indicates that out of the 102 farms, fifty consist of less than three bighas, forty of from three to six bighas and twelve of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 122 acres. The DTW was installed only last season, and the farmers have not yet produced an irrigated crop. The major cropping patterns under the existing non-irrigated area are shown in Table IV-90. The acreage for each crop in the non-irrigated cropping patterns is shown in Table IV-91. These cropped acreages give an intensity for the existing non-irrigated area of 1.64, or an average intensity of 1.64 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area are shown in Table IV-92. The acreage for each crop in the recommended cropping patterns for each land is shown in Table IV-93. These cropped acreages give an intensity, with sub-project development, of 2.38 for the 122-acre command area. Figure E-21-3 shows the areas recommended for each crop pattern at the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to served blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 26 blocks. Two canals and one branch canal, having a total length of 1.3 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-21-1. Structures, canal sections and slopes, and surface and elevations of delivery water are shown in Figure E-21-2.

The structure list (D-36 and D-37) specifies stations, elevations, and dimensions necessary for laying out the structures in the field of construction.

The Quantity and Cost Summary (D-38) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-39) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-94.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 22: Sub-Project No. 22

NAME: Uttam Deep Tube-Well Pucca Drain

THANA: Kotwali

DISTRICT: Rangpur

A. Location

This sub-project is located about three miles to the northwest of Rangpur Town. The sub-project area covers the lands of Uttam Mouza in Kotwali P.S.

B. Communication and Marketing

The sub-project area is served by roads. The Rangpur-Dinajpur highway passes on one side of the sub-project area. There are kutcha roads also passing through the command area, which in turn, are connected with the national highway.

Burirhat market is about two miles away from the sub-project area and is connected to it by road. Rangpur Sadar market is about three miles away from the sub-project area.

C. Description of Sub-Project

This sub-project would provide tube-well irrigation for 124 acres of land in Uttam village. It is located within the command area of the Teesta Project. Flood protection is provided to the area by the Teesta South Embankment Project. Drainage of internal runoff is provided by Ghagot River. There is a DTW in the project area with a yield of about 1.65 cusecs. The quality of water is good and has no significant iron content. The farmers have built the kutcha main canal and field ditches. At present an area of forty acres is being irrigated. Farmers believe that with the improvement of canal lining, they can cover a larger area.

D. Soils

This sub-project is located in two soil associations: namely, the Prigachha-Ganga-Chhara, irregular relief phase; and the Gangachara-Pirgachha-Kaunia association. Both developed in old Teesta meander floodplains.

The following descriptions apply to the major soil series in the Pirgachha-Gangachara association:

1. Pirgachha Series, irregular relief phase: This phase occupies areas of slightly irregular overall topography. The subsoil is an olive-brown loam to silt loam. This series is normally above flood level but may have brief waterlogging after heavy rains. It is droughty during the dry season. Major land use is double cropping to aus followed by rabi crops, such as tobacco, mustard, potatoes, etc.

2. Gangachara Series, irregular relief phase: This phase occupies the upper areas of slightly irregular topography. The subsoil is the same as that of the Pirgachha series. It is intermittently to seasonally flooded. The major land use is double cropping to aus/jute - t. aman - grazed fallow on seasonally flooded areas and aus/jute - rabi crops on higher lands.

The following are descriptions of the major soil series in the Gangachara-Pirgachha-Kaunia association:

1. Gangachara Series: This description is almost identical to that of the Gangachara series, irregular relief phase, except that this series is located on the upper slopes of nearly level to very gently undulating abandoned levees.

2. Pirgachha Series: This description is almost identical to that of the Pirgachha series, irregular relief phase, except that this series is located on the middle slopes of nearly level to very gently undulating abandoned levees.

3. Kaunia Series: This series occupies the lower slopes of nearly level to very gently undulating abandoned levees. The subsoil is an olive-gray, silty clay loam. It is seasonally flooded. The major land use is double cropping to aus/jute - t. aman or sometimes aus/jute - rabi crops.

E. Land Tenure

The sub-project area has fifty farms with an average farm size of 7.50 bighas. Information obtained at sub-project site indicates that out of the fifty farms, 22 consist of less than three bighas, fifteen of from three to six bighas, and thirteen of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 124 acres, forty of which are presently irrigated by a DTW. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-95. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-96. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 2.0 and 1.67, respectively, or an average intensity of 1.77 for the total sub-project area.

G. Recommended Cropping Patterns with Sub Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area are shown in Table IV-97. The acreage for each crop in the recommended cropping patterns for each land type is shown in Table IV-98. These cropped acreages give an intensity, with sub-project development, of 2.31 for the 124-acre command area. Figure E-22-3 shows the areas recommended for each crop pattern at the sub-project area.

H. Irrigation Distribution System Design The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block will be scheduled by

roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 29 blocks. Three canals and five branch canals, having a total length of 1.7 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-22-1. Structures, canal sections and slopes, and surface and elevations of delivery water are shown in Figure E-22-2.

The structure list (D-40 through D-42) specifies stations, elevations, and dimensions necessary for laying out the structures in the field of construction.

The Quantity and Cost Summary (D-43) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-44) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-99.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and

locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 23: Sub-Project No. 23

NAME: Hatia Deep Tube-Well Pucca Drain
THANA: Ulipur
DISTRICT: Rangpur

A: Location

This sub-project is located about twelve miles south of Kurigram Sub-Divisional town and eight miles east of Ulipur Thana headquarters. It is situated on the right bank of the Brahmaputra River. The sub-project area covers the lands of Hatia Baksi Mouza in Ulipur P.S.

B. Communications and Marketing

The sub-project area is served by roads, railway, and rivers. There is a railway line from Kurigram Sub-Divisional headquarters to Chilmari inland river port via Ulipur in a southern direction. A reasonably good kutcha road also passes through these places. One kutcha road, about eight miles long, runs eastward from Ulipur to the sub-project site. The River Brahmaputra lies east of the sub-project site, which is also approachable from Kurigram by the rivers Dharla and Brahmaputra, the distance being about twelve miles.

There is one village market at Anantapur, about one mile north of the sub-project; the thana market at Ulipur is about eight miles west of the area. About ten miles south of the project area at Chilmari, there is a large market known for jute trading.

C. Description of Sub-Project

This sub-project would provide tube-well irrigation for 130 acres of land in Hatia Baksi Mouza. It is located within the command area of Kurigram Project, which will protect the site from floods. The internal runoff of the site would be handled by drainage outlet structures. The BWDB has already begun the Kurigram Project, and a number of drainage structures and flood embankments along the main rivers have already been constructed.

There is a two-cusec DTW in the sub-project area. This tube-well project is a training demonstration for farmers in the Union. Seventy acres of land are now under irrigation. The farmers have built a kutcha main canal and field ditches. They believe that the installation of canal lining will permit extension of irrigation to 200 acres.

D. Soils

This sub-project is located in the Gangachara-Kaunia soil association, which developed in the older Teesta meander floodplain. The following are descriptions of the major soil series in this association:

1. Gangachara Series, highland irregular phase and medium highland phase: The highland irregular phase is found on the upper portions of irregular ridges, and the medium highland phase occupies slopes of slightly smooth ridges. Both phases have a gray, silt loam subsoil. The medium highland phase has shallow flooding, and both are droughty during the dry season. The major land use is double cropping with aus/jute - t. aman and aus/jute - rabi crops on the upper ridges.

2. Kaunia Series, normal flooding phase and flood hazard phase: The normal flooding phase occupies medium highland, and the flood hazard phase occupies the low ridges and the edges of basins in medium highland areas. Both phases have a silty clay loam subsoil. The limitations and land use are the same as those for the Gangachara series.

E. Land Tenure

The sub-project area has eighty farms with an average farm size of 4.90 bighas. Information obtained at the sub-project site indicates that out of the eighty farms, 45 consist of less than three bighas, 28 of from three to six bighas, and seven of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 130 acres, seventy of which are now irrigated by a deep tube-well. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-100. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-101. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 1.63 and 1.45, respectively, or an average intensity of 1.55 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area area shown in Table IV-102. The acreage for each crop in the recommended cropping patterns for each land type is shown in Table IV-103. These cropped acreages give an intensity, with sub-project development, of 2.29 for the 130-acre command area. Figure E-23-3 shows the areas recommended for each crop pattern at the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 34 blocks. Three canals and two branch canals, having a total length of 1.6 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-23-1. Structures, canal sections, and slopes, and surface and elevations of delivery water are shown in Figure E-23-2.

The structure list (D-45 through D-47) specifies stations, elevations, and dimensions necessary for laying out the structures in the field of construction.

The Quantity and Cost Summary (D-48) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-49) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-104.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 24: Sub-Project No. 24

NAME: Sluice Gate at Malibari U.P.

THANA: Gaibanda

DISTRICT: Rangpur

A. Location

The sub-project is located about six miles north of Gaibanda town. Its area covers the lands of Malibari Union in Gaibanda P.S.

B. Communications and Marketing

The area is served by kutcha roads only. During the rainy season, communications become difficult. Several kutcha roads run from Gaibanda town to the north, leading to the sub-project site in Malibari Mouza. The nearest railway station is at Kamarpara on Gaibanda-Rangpur line, which is about four miles northwest of the sub-project area, connected to it only by kutcha road. There is a small market near the sub-project site.

C. Description of the Sub-Project

The sub-project would provide a water control structure over a khal for flood protection of an area of about 700 acres in Malibari Union. The area is bounded by roads on the east and north, highlands on the west, and the River Manas on the south. An existing khal drains the beel area into the River Manas, whose waters, during flood peak, enter the khal and damage crops. The khal is about one mile long and has a capacity of about 100 cfs. A low kutcha road passes over an existing concrete box culvert in the khal. Residents have requested a sluice gate over the khal to prevent floods.

The sub-project falls within the command area of the Teesta Project and the Brahmaputra Right Flood Embankment. These projects provide flood protection, gravity drainage, and irrigation.

D. Soils

The sub-project is located in two soil associations: namely, the Gangachara-Jamun, protected phase; and the Farabari-Gangachara association. Both of these developed in the older Teesta meander floodplain.

The following are descriptions of the major soil series in the Gangachara-Jamun association:

1. Gangachara Series, medium highland phase: This phase occupies the lower portions of ridges in medium highland areas. The topsoil is a gray, silt loam. Limitations include shallow flooding and slight droughtiness during the dry season. The major land use is double cropping to aus/jute - t. aman or aus/jute - rabi crops on the higher ridges. Lower areas are used for deep water t. aman - fallow.

2. Jamun Series, medium highland phase: This series is almost identical to the Gangachara series except that its subsoil is mixed gray and yellowish-brown in color.

The following are descriptions of the major soil series in the Farabari-Gangachara association:

1. Farabari Series, normal flooding phase: This phase occupies the nearly level medium highland areas. It has a dark-brown, silty clay loam subsoil. Limitations include shallow flooding and slight droughtiness in the dry season. The major land use is aus/jute - rabi crops and aus/jute - t. aman.

2. Gangachara Series, medium highland phase: This phase occupies lower portions of ridges in medium highland areas. The subsoil is gray, silt loam. The limitations and land use are as described in the Farabari series except that lower areas may be cropped to broadcast aman and then fallowed.

E. Existing Cropping Patterns and Intensities

The major cropping patterns under the existing irrigated and non-irrigated areas in this sub-project are shown in Table IV-105. The average cropping intensities for these existing irrigated and non-irrigated areas are 2.55 and 1.80, respectively.

F. Recommended Cropping Patterns with Sub-Project Development

With the construction of this sluice gate, approximately 700 acres of land will be drained and protected from flooding.

Cropping intensities generally do not increase for lands that become protected from flooding but are without irrigation. However, the aus and aman crops should not suffer from flood damage, and the yields of many crops should increase due to the elimination of water-logged conditions. Generally recommended cropping patterns for lands with flood control are outlined in Table IV-106.

G. Sluiceway Design

This sub-project will provide drainage and flood protection for an area of 700 acres with an estimated flow of 45 cfs. A sluiceway with one vent, a flap gate on the river side and a slide gate on the country side will be built. A 0.9-mile-long khal will convey rain-water to the sluiceway and will provide daily storage of irrigation water.

Table IV-107 shows the quantity and cost summary. Table IV-108 shows the construction materials required for development of this sub-project.

Designs of structures for this sub-project appear on the following figures contained in Appendix E.

Figure	E-24-1	Contour Map
Figure	E-24-2	Sluice Gate Plan and Section
Figure	E-24-3	Layout

Section 25: Sub-Project No. 25

NAME: Patilvasar Nala Sluice Gate

THANA: Badarganj

DISTRICT: Rangpur

A. Location

The sub-project is located about seventeen miles southwest of Rangpur town and covers the lands of Kutubpur Mouza in Badarganj P.S.

B. Communications and Marketing

The area is served by roads, and the nearest railway station is at Syampur on the Rangpur-Dinajpur Line. There is one seven-mile-long kutcha road between Syampur Railway Station and the sub-project site at Kutubpur. A pucca road runs from Syampur to Rangpur town. A small market at Nagarhat, about one mile away, serves the sub-project area. One large market, at Badarganj Thana headquarters, is about nine miles northwest of the site and is accessible by a kutcha road in bad condition. Another large market is at Syampur, where a sugar mill is situated.

C. Description of the Sub-Project

The sub-project would provide a flood control and a drainage structure over the Patilvasar Nala for protection of an area of about 500 acres in Kutubpur Mouza, Badarganj P.S. The sub-project area is about 1-1/4 miles long in a north-south direction and about one-half-mile wide. It is bounded by the River Jamuneswari on the west and the Syampur-Kutubpur road on the east. Another small river, called Katgora, flows nearly parallel to the Syampur road. This river remains dry throughout the year except during the monsoons. The drainage of the sub-project area is effected through the Patilvasar Nala, which falls into the Katgora River at Kutubpur. This Nala is small and connects with the beel area. Flood waters from the Katgora River enter the beel through the Patilvasar Nala and damage young seedlings. The bank of the Jamuneswari River is high; thus no flood water from this river enters the sub-project area. Farmers believe that if a sluice is constructed over the Patilvasar Nala to regulate the floods and provide drainage, they will be able to cultivate their crops properly with no damage. The Patilvasar Nala requires re-

excavation to proper section for drainage.

This sub-project falls within the command area of the Teesta Project, which provides irrigation, flood control, and drainage for a gross area of 1,850,000 acres in the districts of Rangpur, Bogra, and Dinajpur.

D. Soils

This sub-project is located in the Gangachara-Pirgacha-Kaunia soil association, irregular relief phase, which developed in the older Teesta meander floodplain. The following are descriptions of the major soil series in this association:

1. Gangachara Series, irregular relief phase: This phase occupies the upper slopes in areas of slightly irregular topography. The subsoil is an olive-brown loam to silt loam. It is intermittently to seasonally flooded. The major land use is double cropping to aus/jute - t. aman - grazed fallow on seasonally flooded areas and aus/jute - rabi crops on higher lands.

2. Pirgachha Series, irregular relief phase: This phase occupies areas of slightly irregular overall topography. The subsoil is an olive-brown loam. This series is normally above flood level but may have brief waterlogging after heavy rains. It is droughty during the dry season. Major land use is double cropping of aus followed by rabi crops, such as tobacco, mustard, and potatoes.

3. Kaunia Series, irregular relief phase: This phase occupies the lower slopes in areas having slightly irregular topography. The subsoil is an olive-gray, silty clay loam. It is seasonally flooded. The major land use is double cropping with aus/jute - t. aman or sometimes aus/jute - rabi crops.

E. Land Tenure

Due to the large area that sub-project development will benefit, a sample of 200 acres was selected for analysis. The average farm size was found to be 5.88 bighas. Of the 104 farms, 48 consist of less than three bighas, thirty of from three to six bighas, and 26 of more than six bighas.

F. Existing Cropping Patterns and Intensities

The major cropping patterns under the existing irrigated and non-irrigated areas in this sub-project are shown in Table IV-109. The average cropping intensities for these existing irrigated and non-irrigated areas are 1.75 and 11.30, respectively. Both cropping patterns and cropping intensities are restricted in this sub-project due to the flooding and lack of drainage facilities.

G. Recommended Cropping Patterns with Sub-Project Development

With the construction of the sluicegate, approximately 500 acres of land will be drained and protected from flooding.

Cropping intensities generally do not increase for lands that become protected from flooding but remain without irrigation. However, the non-irrigated lands in this sub-project can have both improved cropping patterns and improved cropping intensities. Generally recommended cropping patterns for lands with flood control are outlined in Table IV-110.

H. Sub-Project Design

This sub-project will provide drainage and flood protection for an area of 500 acres with an estimated flow of 38 cfs. A sluiceway with one vent, a flap gate on the river side and a slide gate on the country side will be built. A 0.4-mile-long khal will convey rainwater to the sluiceway and will provide daily storage of irrigation water.

Table IV-111 shows a quantity and cost summary. Table IV-112 shows a list of construction materials needed for development of sub-project.

Designs of engineering structures for this sub-project apppear on the following figures contained in Appendix E.

Figure	E-25-1	Contour Map
Figure	E-25-2	Sluice Gate Plan and Section
Figure	E-25-3	Layout

Section 26: Sub-Project No. 26

NAME: Sluice Gate on Berubari Embankment at Nakulardara
THANA: Nageswari
DISTRICT: Rangpur

A. Location

The sub-project is located about three miles southeast of Nageswari Thana headquarters. Its area covers the lands of Berubari Union in Nageswari P.S.

B. Communications and Marketing

The area is served only by kutcha roads. During the rainy season, the roads become muddy and movement is hampered. There are small markets in the area and a large one at the thana headquarters.

C. Description of the Sub-Project

The sub-project will provide a sluice gate on Berubari Embankment at Nakular Dara in the village Lalarampur in Berubari Union for flood protection of an area of about 7,500 acres. The sub-project area is bounded by kutcha roads on the west and south and by an embankment-

cum-road on the east and north.

The following bils are in the sub-project area: Chatta Bil, Balstali Payradanga Bil, Kumuria Bil, Gushaika Bil, Bhangamor Bil, Madaikhat Bil, and Chakchaka Bil. A number of culverts under the roads act as drainage outlets for some bils. The embankments on the northeast provide flood protection from the Dudhkumar River, which lies east of the project area. The presence of this embankment facilitates the growing of crops in the area, but during the rainy season excess rainwater damages the standing crops on the south side of the embankment.

This sub-project also falls within the command area of Kurigram Project. It provides flood protection and gravity drainage for an area of 345,000 acres, of which 277,000 acres would be irrigated. Flood protection and drainage facilities include embankments along the Dudhkumar, Dharla, Brahmaputra-Jamuna, and Teesta Rivers. Several gravity drainage structures remove internal runoff. Irrigation pumping plants on the Kharla and Dudhkumar Rivers at suitable locations would provide irrigation for the sub-project area.

D. Soils

This sub-project is located in the Uttargaon soil association, which developed in the older Teesta meander floodplain. The following are descriptions of the major soil series in this association:

1. Uttargaon Series, medium highland phase: This phase occupies nearly level, medium highland areas. The subsoil is a dark-brown, silty clay. Its limitations include shallow flooding, droughtiness at the end of the dry season, and a heavy consistency. Major land use is double cropping with aus/jute - t. aman and with some aus/jute - rabi crops.

2. Uttargaon Series, medium lowland, normal flooding phase: This phase occupies basin centers in medium lowland areas. The subsoil is a dark-brown, silty clay. The limitations are similar to those of the medium highland phase except that the flooding is

moderately deep. Major land use is aus/jute - t. aman and mixed aus and b. aman - fallow.

E. Land Tenure

Due to the large area that development of the sub-project will benefit, a sample of 200 acres was selected for analysis. The average farm size was found to be 12.50 bighas. Of the 48 farms, 22 consist of less than three bighas, twelve of from three to six bighas, and fourteen of more than six bighas.

F. Existing Cropping Patterns and Intensities

There is no irrigation in this sub-project area at present. The major cropping patterns under the existing non-irrigated areas are shown in Table IV-113.

The average cropping intensity for the existing non-irrigated lands is 1.77. Crop yields are severely affected in this sub-project because there is no drainage facility to remove the excess water following heavy rainfalls.

G. Recommended Cropping Patterns with Sub-Project Development

With the construction of this sluice gate, approximately 500 acres of land will be flood protected and drained. The removal of excess water should significantly improve the production of both the b. aus and t. aman crops. Because no irrigation water is available, the cropping intensity is not expected to increase very much. General recommended cropping patterns for lands drained are outlined in Table IV-114.

H. Sub-Project Design

This sub-project will provide drainage and flood protection for an area of approximately 500 acres with an estimated flow of 327 cfs. A sluiceway with four vents, a flap gate on the river side and a slide gate on the country side will be provided. A two-mile-long khal will convey rainwater to the sluiceway and will provide daily storage of irrigation water.

Table IV-115 shows the quantity and cost summary. Table IV-116 shows the construction materials needed for development of this sub-project.

Engineering designs for this sub-project appear on the following figures, contained in Appendix E:

Figure	E-26-1	Contour Map
Figure	E-26-2	Sluice Gate Plan and Section
Figure	E-26-3	Layout Plan

Section 27: Sub-Project No. 27

NAME: Construction of Dubail-Basail Deep Tube-Well Drain
THANA: Basail
DISTRICT: Tangail

A. Location

The sub-project is located about seven miles northwest of Mirzapur town in Tangail District. Its area covers the lands of Dubail village in Basail P.S.

B. Communication and Marketing

The area is served by the Dacca-Tangail highway. There is no direct road communication with Basail Thana headquarters. There is a large weekly market at Jamurki, one mile south of the sub-project, and another weekly market at Natipara, about two miles north.

C. Description of the Sub-Project

The sub-project will provide tube-well irrigation for 123 acres in Dubail village in Basail P.S. It is located within the command area of the Brahmaputra Left Flood Embankment Project, which protects the area from flooding by embankments and provides internal drainage by gravity sluices through the embankment. The Old Brahmaputra Project provides irrigation facilities in that zone.

There is one DTW in the sub-project area with a yield of about 1.75 cusecs. The tube-well is located in a good position for effective irrigation. The quality of ground water is good and contains no iron. At present an area of sixty acres is under irrigation, the average in the thana being forty acres per DTW. Seepage from the kutcha canal is causing crop damage during early growth stages. Farmers believe that production is reduced due to this seepage. They are anxious to improve the system by land-grading. About thirty acres are very low and become inundated during the monsoon season. About 25 acres are medium low, the remaining 25 acres being medium high.

D. Soils

This sub-project is located in the Silmandi-Sabhar Bazar soil association, which developed in the older Jamuna meander floodplain. The following are descriptions of the major soil series in this association:

1. Silmandi Series: This series generally occupies floodplain ridges. The subsoil is a gray, mottled, silty clay loam. It is seasonally flooded. Major land use is mixed aus and t. aman followed by rabi crops, such as khesari, mustard, wheat, and lentils.

2. Sabhar Bazar Series: This series generally occupies nearly level basin areas. The subsoil is a dark-brown to yellowish-brown, mottled, silty clay to clay. It is seasonally flooded, sometimes to a depth of from six to ten feet. The major land use is mixed aus and b. aman - rabi crops. The deeper areas are cropped to mixed aus and b. aman or solely b. aman.

E. Land Tenure

The sub-project area has 105 farms with an average farm size of 3.5 bighas. Information obtained at the sub-project site indicates that of the 105 farms, 22 consist of less than three bighas, 56 of from three to six bighas, and 27 of more than six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 123 acres, sixty of which are now irrigated by a DTW. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-117. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-118. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 1.80 and 1.46, respectively, or an average intensity of 1.67 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area are shown in Table IV-119. The acreage for each crop in the recommended cropping patterns for each land type is shown in Table IV-120. These cropped acreages give an intensity, with sub-project development of 2.0 for the 123-acre command area. Figure E-27-3 shows the areas recommended for each crop pattern at the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block

will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided in 28 blocks. Three canals and four branch canals, having a total length of 1.7 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-27-1. Structures, canal sections and slopes, and surface and elevations of delivery water are shown in Figure E-27-2.

The structure list (D-50 through D-52) specifies stations, elevations, and dimensions necessary for laying out the structures in the field for construction.

The Quantity and Cost Summary (D-53) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-54) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-121.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. This system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and

locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers' concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 28: Sub-Project No. 28

NAME: Re-excavation of Godtala Mir-Kumilli Khal
THANA: Tangail
DISTRICT: Tangail

A. Location

The sub-project is located about five miles southeast of Tangail town. Its area covers the lands of the villages of Boaljan, Nalua, Jalalia, Bhabki, Betjha, Scharatail, Gathtala, and Mirkumilli on the right bank of Lohajang River in Tangail P.S.

B. Communications and Marketing

The area is served by road and river. One road, partly pucca and mostly kutcha, passes on the western side of the sub-project area and connects it with Tangail town and Mirzapur Thana headquarters. The River Lohajanj flows on the north and east boundaries of the sub-project area. A market is situated about two miles from the sub-project.

C. Description of the Sub-Project

The sub-project will provide drainage for an area of 4,000 acres under the Union of Pathrail and Deldvar in Tangail P.S. It is located within the command area of the Brahmaputra Left Flood Embankment Project, which provides flood protection and gravity drainage. Irrigation of the area is provided by the Old Brahmaputra Project.

An existing khal, Mirkumilli, passes through the villages of Pathrail, Boaljan, Nalua, Bhabki, Betjha, Seharatail, and Mirkumilli eastward and joins the Lohajang River. A kutcha road along the western boundary of the sub-project area serves as a flood embankment. This road connects Tangail town on the northern side and Mirzapur Thana headquarters on the southeast side. There are several low pockets in the sub-project area on both sides of Mirkumilli Khal. The drainage of these low pockets is not properly effected due to siltation of the khal. Early monsoons damage the young seedlings and cause drainage congestion. The condition of the River Lohajang is good. Farmers feel that if the Mirkumilli Khal is re-excavated to proper section and slope, the drainage congestion would be eliminated. The length of the khal excavation would be 3.3 miles. Some small drainage khals would be required to connect the low pockets with the main Mirkumilli Khal in order to facilitate early drainage of the area.

D. Soils

This sub-project is located in the Silmandi-Sabhar Bazar soil association, which developed in the older Jamuna meander floodplain. The following are descriptions of the major soil series in the association:

1. Silmandi Series: This series generally occupies floodplain ridges. The subsoil is a gray, mottled, silty clay loam. It is seasonally flooded. Major land use is mixed aus and b. aman followed by rabi crops, such as khesari, mustard, wheat, and lentils.

2. Sabhar Bazar Series: This series generally occupies nearly level basin areas. The subsoil is a dark-brown to yellowish-brown, mottled silty clay to clay. It is seasonally flooded, sometimes to a depth of from six to ten feet. The major land use is mixed aus and b. aman - rabi crop. The deeper areas are cropped to mixed aus and b. aman or solely b. aman.

E. Land Tenure

Due to the large area that development of this sub-project will benefit, a sample 200 acres was selected for land tenure analysis. The average farm size was found to be 3.4 bighas. Of the 176 farms, ninety consist of less than three bighas, fifty of from three to six bighas, and 36 of more than six bighas.

F. Existing Cropping Patterns and Intensities

The major cropping patterns under the existing irrigated and non-irrigated areas in this sub-project area are shown in Table IV-122. The average cropping intensities for these existing irrigated and non-irrigated areas are 1.40 and 1.44, respectively. Both cropping patterns and cropping intensities are restricted in this sub-project because there is no drainage facility to relieve the lands of flood water and there is only partial irrigation.

G. Recommended Cropping Patterns with Sub-Project Development

With the re-excavation of this khal, approximately 4,000 acres will be drained. Conceivably, enough water could be available from the khal to irrigate 2,000 acres; however, before the irrigation component is implemented, further investigation is needed to determine which area can be irrigated and the capacity of the distribution systems from the khal.

For the lands that are drained but have no available irrigation water, the cropping intensity will normally increase slightly. In higher lands, the b. aman and mixed paddy crop may be replaced in part by t. aman during the monsoon period. In lower lands, some of the boro acreage may be eliminated due to the drainage of water, but it

would normally be replaced with b. aus and t. aman. The yields of crops will increase due to the elimination of waterlogged conditions. General recommended cropping patterns for lands drained but not irrigated are outlined in Table IV-123.

The area that is drained and could be irrigated during the dry season has the highest potential for both increased crop intensities and crop yields. Cropping intensities may reach 2.50. Table IV-124 outlines the recommended cropping patterns with both drainage and irrigation available. With the implementation of the irrigation component of this sub-project, specific cropping patterns should be determined for each low-lift pump command area according to the procedure outlined in Chapter III on Cropping Patterns. Using this information and the design criteria given at the beginning of this chapter, an accurate command area can be determined for each pump.

H. Sub-Project Design

This sub-project will provide drainage and flood protection for an area of approximately 4,000 acres with an estimated flow of 53 cfs. A 3.3-mile-long khal will convey rainwater to the sluiceway and will provide daily storage of irrigation water.

Development of this sub-project requires the excavation of 510,300 cubic feet of silt at a total cost of Tk 117,000, which includes 15 percent for contingencies.

A contour map of this sub-project appears in Figure E-28-1. Cross sections and profiles of the khal appear in Figures E-28-2a through E-28-2c.

Section 29: Sub-Project No. 29

NAME: Construction of Lowhati North Deep Tube-Well Pucca Drain

THANA: Nagarpur

DISTRICT: Tangail

A. Location

The sub-project is located about twelve miles south of Tangail District headquarters and five miles northeast of Nagarpur Thana headquarters. Its area covers the lands of Lowhati Mouza in Nagarpur P.S.

B. Communications and Marketing

The area is served by rivers and a five-mile-long kutcha road, which connects the sub-project to Elasin. There is one pucca road to the district headquarters, Tangail. There is a weekly market about two miles south of the area.

C. Description of Sub-Project

The sub-project will provide tube-well irrigation to 78 acres of land in Lowhati Mouza. Its area is surrounded on the east and west by the Bansi and the Dhaleswari Rivers. This sub-project is located within the command area of Brahmaputra Left Flood Embankment Project, which protects the area from flooding and provides internal drainage by gravity sluices through the embankments. The old Brahmaputra Project provides irrigation.

In the sub-project area, one DTW was installed in 1977 and irrigates only eight acres. With a brick-lined canal and proper management by the water users' group, the DTW should serve 78 acres. Principal beneficiaries of the sub-project are small farmers, who are very interested in sub-project development and are willing to contribute land for the needed right of way.

There is no waterlogging in the area. About fifteen acres are moderately low and are flooded during the rainy season.

D. Soils

This sub-project is located in the Dhamrai complex, which has developed in the active Jamuna meander floodplain. The following are descriptions of the major soil series in this complex:

1. Dhamrai Series: This series generally occurs on floodplain ridges and levees. The subsoil is an olive-gray to gray, silty clay loam. Limitations include seasonal flooding. The major cropping pattern is mixed aus and b. aman followed by khesari. Some areas are used for aus/jute - t. aman - fallow/rabi crops, such as khesari and mustard.

2. Sonatala Series: This series generally occurs on the crests of ridges and levees in gently undulating topography. The subsoil is a gray to olive-brown, mottled silt loam. Limitations and land use are the same as those for the Dhamrai series.

E. Land Tenure

The sub-project area has 87 farms with an average farm size of 2.8 bighas. Information obtained at sub-project site indicates that out of the 87 farms, sixty consist of less than three bighas and 27 of from three to six bighas.

F. Existing Cropping Patterns and Intensities

This sub-project comprises a total area of 78 acres, eight of which are presently irrigated by a DTW. The major cropping patterns under the existing irrigated and non-irrigated areas are shown in Table IV-125. The acreage for each crop in the irrigated and non-irrigated cropping patterns is shown in Table IV-126. These cropped acreages give an intensity for the existing irrigated and non-irrigated areas of 1.50 and 1.24, respectively, or an average intensity of 1.29 for the total sub-project area.

G. Recommended Cropping Patterns with Sub-Project Development

The recommended cropping patterns with sub-project development for each land type found in the command area are shown in Table IV-127. The acreage for each crop in the recommended cropping patterns for each land type is shown in Table IV-128. These cropped acreages give an intensity, with sub-project development, of 2.60 for the 78-acre command area. Figure E-29-3 shows the recommended areas for each crop pattern of the sub-project area.

H. Irrigation Distribution System Design

The objective of the design of the distribution system for this sub-project is to provide equitable distribution of the water from the DTW to each plot in the sub-project area. To accomplish this, a system of brick-lined canals would be constructed to serve blocks of three to five acres each. The irrigation water will be available at each block's turnout at an elevation six inches above the highest plot within the block. The total flow of the pump will be delivered to only one block at a time. Distribution of the water is described in the Operation and Maintenance Manual. Delivery of water to the block will be scheduled by roster. The farmers working the plots within a block will cooperatively distribute the water to their plots.

The Design Manual specifies the procedures for designing the distribution system.

The sub-project is divided into 15 blocks. Two canals and one branch canal, having a total length of 0.3 miles, serve these blocks. A weir box will be constructed at the DTW discharge pipe to measure all water used by the sub-project.

The locations of canals and blocks are shown in Figure E-29-1. Structures, canal sections, and slopes, and surface and elevations of delivery water are shown in Figure E-29-2.

The structure list (D-55) specifies stations, elevations, and dimensions necessary for laying out the structures in the field of construction.

The Quantity and Cost Summary (D-56) lists the items of contract work and the estimated cost of the sub-project.

The lengths of each canal section in 100-foot stations are accumulated. The quantities of the various contract items are calculated, summed, and multiplied by the estimated unit cost to determine total cost per item. To the sub-total of item costs is added a contingency of fifteen percent.

The Construction Materials Chart (D-57) shows the amount of different materials required for completion of the sub-project distribution system. A summary of this chart appears in Table IV-129.

The canals of the distribution system are all located on the boundaries between plots. This placement of canals least disrupts farming operations and uses the least land for canal right of way. The system has been laid out and estimates made, based on a rectangular brick section for the conveyance canals. The system minimizes O & M costs but has relatively high construction costs. Two alternative canal sections have been considered, and a comparative study of them is included in the Design Manual. The design for the section to be used will be made at the time of project implementation. The Design Manual also specifies procedures for developing the plan and locating project canals.

Before construction of the distribution system is begun, the system must be carefully explained to the farmers and the locations reviewed with them in the field. Their understanding of the system, its operation, and their expected contributions must be ensured.

The farmers's concurrence with the adopted plan must be signified in writing before field staking for construction is started. During the review and field staking, adjustments in alignment and structure location will be made to accomodate actual field conditions.

Section 30: Sub-Project No. 30

NAME: Construction of Sluice Gate at Deojan Khal
THANA: Tangail
DISTRICT: Tangail

A. Location

The sub-project is located about 2-1/2 miles south of Tangail town. Its area covers the lands of the villages of Aloa Tarini, Araola, Kumania, Bandhabari, Gumjain, Mangalhor, Chinakhala, Baratia, and Deojan on the right bank of the Lohajang River in Tangail P.S.

B. Communications and Marketing

The area is served by kutcha roads and, on the north side, the Lohajang River. One kutcha road, about 3/4 mile east of the proposed sluice site, runs north towards Tangail. The nearest market places are at Tangail town and Karatia.

C. Description of the Sub-Project

The sub-project will provide a drainage control structure over the Khal Deojan for an area of 2,500 acres. The sub-project area is triangular and is bounded by kutcha roads, which serve as flood embankments. Farmers feel a sluice constructed over Deojan Khal at its tail end would provide flood protection and internal drainage. Deojan Khal is connected with the beel and the Lohajang River at its out-fall. The condition of the Lohajang River is good. The sluice, when constructed, will hold water in the Deojan Khal and in the beel at control levels facilitating irrigation by LLPs.

This sub-project also falls within the command area of Brahmaputra Left Flood Embankment Project, which provides flood protection and gravity drainage. Irrigation of the area is provided by the Old Brahmaputra Project.

D. Soils

This sub-project is located in the Silmandi-Sabhar Bazar soil association, which is developed in the older Jamuna meander floodplain. The following are descriptions of the major soil series in this association:

1. Silmandi Series: This series generally occupies floodplain ridges. The subsoil is a gray, mottled, silty clay loam. It is seasonally flooded. Major land use is mixed aus and b. aman followed by rabi crops, such as khesari, mustard, wheat, and lentils.

2. Sabhar Bazar Series: This series generally occupies nearly level basin areas. The subsoil is a dark-brown to yellowish-brown, mottled, silty clay to clay. It is seasonally flooded, sometimes to a depth of from six to ten feet. The major land use is mixed aus and b. aman - rabi crop. The deeper areas are cropped to mixed aus and b. aman or solely b. aman.

E. Land Tenure

Due to the large area that development of this sub-project will benefit, a sample of 200 acres was selected for analysis. The average farm size was found to be 3.4 bighas. Of the 175 farms, 135 consist of less than three bighas, 35 of from three to six bighas, and five of more than six bighas.

F. Existing Cropping Patterns and Intensities

The major cropping patterns under the existing irrigated and non-irrigated areas in this sub-project are shown in Table IV-130. The average cropping intensities for these existing irrigated and non-irrigated areas are 2.10 and 1.6, respectively.

G. Recommended Cropping Patterns with Sub-Project Development

With the construction of a sluice gate, approximately 2,500 acres of land will be drained, and waterlogging damage to the crops should be reduced. The cropping intensity should slightly increase for the non-irrigated lands, and the yields should improve. Generally recommended cropping patterns for the lands drained but not irrigated are outlined in Table IV-131.

Table IV-132 outlines the recommended cropping patterns for lands drained as well as irrigated with LLPs.

H. Sub-Project Design

This sub-project will provide drainage and flood protection for an area of approximately 2,500 acres with an estimated flow of 100 cfs. A sluiceway with one vent, a flap gate on the river side and a slide gate on the country side is proposed. A three-mile-long khal will convey rainwater to the sluiceway and will provide daily storage of irrigation water.

Table IV-133 shows the quantity and cost summary. Table IV-134 shows the construction materials needed for development of sub-project.

Engineering designs of structures for this sub-project appear in the following figures, contained in Appendix E.

Figure	E-30-1	Contour Map
Figure	E-30-2	Sluice Gate and Section
Figure	E-30-3	Layout Plan
Figure	E-30-4a through 4-30-4c	Profiles and Cross Sections

PART 3

INFORMATION PERTINENT TO IMPLEMENTATION

Section 1: Specifications

Appendix A consists of general specifications for construction of the sub-projects and includes the following sections: Instructions to Tenderers, Tender, Bill of Quantities, Forms, General and Special Conditions, and Technical Specifications. The general specifications are tender documents that do not contain specific information regarding any particular sub-project but can be readily adapted to tender documents for construction of several sub-projects under one contract. The technical specifications cover every item of work that will be required for construction of all sub-projects; they have been prepared for use of local materials and for the construction to be done by either local or international contractors. Standards of construction have been specified to maintain quality control and to ensure good workmanship.

The original concept of the project was to construct up to 30 sub-projects during the first construction year and an approximately equal number during year each were prepared for tendering by international contractors. Local contractors responding to a questionnaire clearly indicated that the proposed construction was beyond their capabilities; however, as designs, bills of quantities, and cost estimates were being finalized, and as further consideration was given to the type of construction, manpower plans, construction scheduling, and implementation requirements, the magnitude of construction to be undertaken was decreased to a level that is within the capabilities of local contractors. The Consultant's recommended implementation schedule may be found in Chapter VII.

To adopt the general specifications for tendering by local contractors, the tender and general conditions should be replaced by the standard printed documents required by the Government of Bangladesh (GOB) for construction of civil works by contract; those documents are entitled "Item Rate Tender and Contract for Works", and consist of the following parts: General Rules and Directions for the Guidance of Contractors; Tender for Works; Conditions of Contract; Model Rules Relating to Layout, Water Supply, Canteen and Sanitation in Labor Camps; Additional Conditions; and Additional Specifications. The technical sections of the general specifications are generally applicable for local as well as international tendering.

Section 7: Materials

A. General

All materials required for construction of the sub-projects are available in Dacca or Chittagong, and, in some cases, the materials are also available in the vicinity of the work. The sub-projects have been have been designed to maximize use of local materials and to restrict the use of imported materials to only those generally and readily available from local supplies. It will not be necessary for construction contractors to import materials for the Project.

The materials requirement of each sub-project have been combined by districts and are given in Tables IV-136 through IV-141. Each table lists the materials required for the construction of all sub-projects within the district, the primary source, and the estimated unit prices of the materials. The unit prices are valid at the sources indicated and are based on quotations from local suppliers, tender prices, and Government-fixed prices. It should be noted that materials prices, particularly the imported materials, such as cement, vary and often are not available except at higher prices. For example, the Government-fixed price for cement is 80 taka per bag, whereas the going market price varies from 100 to 115 taka per bag.

Carriage costs of materials from the sources of supply to the points of use at the sub-projects have been included in the detailed cost estimates.

B. Timely Delivery of Materials

To ensure completion of construction in accordance with adopted schedules, timely availability and delivery of materials will be required. Shortages of materials in Bangladesh, particularly imported items, have occurred during the preceding year and it is prudent to include in contracts for construction of irrigation works such provisions as are necessary to minimize the likelihood of delays due to a shortage of materials.

Each constructon contract will require different quantities of materials at different locations and times, and the materials will be required during the dry season when shortages are most likely to occur. The various means of ensuring the timely availability and delivery of materials are described below.

1. Additional Lead Time: Construction work is generally scheduled to provide a reasonable period for mobilization and procurement of materials, providing additional lead time for the procurement of materials will decrease the likelihood of a delay due to a shortage of materials; however, in most cases additional lead time is not available, acceptable, or adequate to ensure the timely availability of materials.

2. Bonus and Liquidated Damages: A bonus for early completion of a contract and a penalty for failure to complete a contract on time are common in construction contracts and generally ensure completion of the work on, or before, the required time when the supply of materials can be expedited by payment of a surcharge. Where prices of materials are fixed by the Government and such materials are not available at those prices, the provisions for assessment of liquidated damages are not enforceable; therefore, this alternative is not considered a practicable means of ensuring the timely delivery of materials.

3. Contractor Obtains Materials Before Commencing Work: Each construction contract will require various quantities of different materials, and a few materials critical to completion of the work within the specified time may be in short supply. To ensure that construction work will not be delayed due to a shortage of materials, the contract could prohibit the commencement of construction work until all materials critical to the timely completion of thework have been delivered to the site. This procedure will require an increase in the contract period and generally will not be acceptable except for small construction projects.

4. MRD to Furnish Critical Materials: It is expected that different materials may be in short supply in different districts, that the availability of materials will vary from year to year, and that critical materials for completion of a contract can be identified during the preparation of tender documents. MRD's furnishing these critical materials wil generally ensure the timely availability of such materials and the completion of the work as scheduled. Under most contracts, the critical materials may be limited to cement, steel reinforcing bars, vertical lift gates, and timber flap gates, and the contractor would be responsible for carriage of materials to the site of work.

5. MRD to Furnish All Materials: To obtain the maximum assurance that materials will be available as required, MRD could furnish all materials at specified locations and in accordance with a prescribed schedule.

C. Timely Delivery of Materials: Recommendations

To ensure the timely delivery of materials during construction, it is recommended that MRD furnish critical materials to the contractors as described in Subparagraph 4, above. The advantages of this alternative are as follows:

1. More construction can be accomplished during the dry-season construction period because the contractor can be assured of the availability of critical materials.

2. This alternative provides a reasonably high degree of confidence that the construction work will not be delayed due to a shortage of materials.

3. Materials may be purchased in larger quantities and well in advance of construction when prices and demands for such materials may be lower.

4. The time for fabrication of gates can be increased with no adverse effect on the construction schedule.

5. Better quality control and standardization of gates can be maintained.

The principal disadvantages of furnishing critical materials to contractors are the costs involved in storing the materials until required by the contractor, and in accounting of the quantities and costs for the materials delivered to the contractor.

D. Quality of Materials

Quality control of materials can be ensured by adequate inspection at the point of manufacture or fabrication and also at the work site. The Specifications set forth the standards and methods of tests for materials and permit the rejection of defective materials at any time prior to the final acceptance of work. An adequate number of competent inspectors are required to ensure that all materials and workmanship are in accordance with the drawings and specifications (See MRD Staff requirements in Manpower Plan for each district, Chapter VIII).

Section 3: Contracting

The recommended construction schedule, by sub-projects and contracts, is shown in Table IV-141.

The construction schedule and number of contracts may be varied by the future consultant during the design and construction stage.

Sub-projects recommended for construction during the first construction year were selected on the basis of the following criteria:

1. The sub-projects should have a better than average probability of providing substantial benefits.

2. The sub-projects should be accessible by road and within a reasonable distance of cities, towns, and villages where materials, services, manpower, and living accommodations are available in sufficient quantities, to the maximum practical extent.

3. The first sub-projects to be constructed should be those that are likely to have the fewest problems during construction.

4. Construction work should be undertaken in as many districts as practical during the first year.

5. The volume of construction during the first year should be nominal to ensure satisfactory completion of the work undertaken. Experience gained during the first year of construction will permit an increase in volume of construction work during the second and third years of construction.

6. Each contract during the first construction year should be awarded at approximately the same time to different contractors.

The construction of the sub-projects does not involve any unusual or difficult operations that cannot be performed by local contractors who have completed similar works; however, it is recommended that contractors pre-qualify prior to being invited to tender. Only contractors with the necessary supervisory staff and organization, financial capabilities, and construction experience should be invited to tender for the proposed work.

Pre-qualificaion of contractors should be accomplished in accordance with the standard procedures used by MRD, BWDB, and PWD. Only contractors with valid certificates of eligibility from appropriate authorities to tender for works of a similar type and magnitude should be accepted as qualified to tender for the proposed sub-projects.

To determine the interest and capabilities of local contractors to construct the sub-projects, a questionnaire was prepared and distributed to contractors. The questionnaire described each sub-project, contained a map showing the locations of the work, requested the firm to express its interest in tendering for the work, and requested data to determine the capabilities and qualifications of the firm to undertake the work. The questionnaire was sent to all firms that responded to a newpaper advertisement of the questionnaire, to contractors who were known to have completed similar work and to other interested contractors. Of the 26 responding contractors, four were not interested, nine were interested in the work in only one district, six were interested in the work in two districts, four were interested in the work in three districts, and three were interested in the work in six districts. The results of the questionnaire also indicated most local contractors would not undertake more than one or two sub-projects in one construction year. About seventeen of the 21 contractors interested in the work are qualified to undertake the construction of one sub-project, and about seven contractors have the capabilities to construct two sub-projects in one construction year.

Section 4: Estimate of Cost

A. General

Unit prices, FAR costs, and project costs reflect prices as of December 1979. Costs have been developed on the basis of labor-intensive methods of construction with a foreign consultant providing general supervision of construction.

The estimates of costs are based on the plans and specifications as recommended in this report. The cost of supervision of construction by employees of governmental agencies, under the general supervision of the future consultant, has been assumed (See MRD Staff requirements in Manpower Plan for each district, Chapter VII.) The cost of the future consultant required during the design and construction stage has been excluded from the estimates.

B. Direct Costs

Material costs are based on the costs of the materials from local suppliers, unless prices are fixed by the Government, in which case they are based on the fixed prices.

Carriage costs of materials are based on transporting the materials from the primary source of supply to the site of the work.

Labor costs are based on present market prices and the cost of labor in the rural areas. The average prices used for labor costs were 16, 20, and 25 taka per day for cooli, unskilled labor, and skilled labor, respectively. The unit labor costs are based on an estimate of the unit of work or the number of units of work that could be performed in an eight-hour day.

No equipment costs were included in the costs estimated because all work may be completed by labor-intensive methods.

C. Indirect Costs

Indirect costs of the contractor's expenses include the following: mobilization; travel and transportation; supply of hand tools for construction; home office administration; field office supervision and administration; providing living accommodations at the site of the work for permanent employees; providing labor camps, where required; complying with Government regulations relating to the facilities for labor; contingencies; and other overhead. An amount equal to 20 percent of the direct costs was used to cover the contractor's indirect costs and profit.

D. Fixed Amount Reimbursement Costs

Fixed amount reimbursement (FAR) costs for each sub-project are given in the quantity and cost summary. Also shown are the quantities of work for each structure, the items of work, the units of work, the total quantities of work, the unit costs, the total cost for each item of work, and the total of all items of work. A contingency of 15 percent has been added to the sub-total to cover the costs of miscellaneous items and costs of unforeseen field conditions. The FAR cost, therefore, consists of the following: direct costs of labor and material, including carriage; indirect costs of overhead and profit; and a contingency factor. FAR costs do not include engineering costs during construction, construction supervision and administration, or an allowance for inflation.

The units of construction recommended for construction in the first year of the project, which may be considered for financing by FAR, are shown in Table IV-142. (The contract does not call for FAR costs for the second and third years of the project, but they have been calculated and may be found on the quantity and cost summary sheet for each sub-project in this chapter.)

E. Sub-Project Costs

Sub-project costs are given in Tables IV-143 through IV-147 for contracts No. 1 through 5. These contracts cover the work involved in constructing the sub-projects that the consultant has recommended for construction during the first year. A summary of sub-project costs is shown in Table IV-135.

Sub-project costs consist of the FAR costs, the costs of the MRD staff to handle engineering and construction supervision (see (Manpower Plan, Chapter VIII), and an allowance for inflation.

An inflation rate of 18 percent per year (1.5 percent per month) has been adopted. This inflation rate is based on recent annual rates of inflation and present economic forecasts.

TABLE IV-1

SOIL INTAKE TEST DATA

Project PUCCA DRAIN FOR KAWANARA IRRIGATION PROJECT

Thana SATURIA District DACCA Date 13 JUNE 1979

Test No. 3 Soil Association _____ Soil Texture CLAY TO CLAY LOAM

Crop and Stage of Growth IRRI BORO, HARVESTED

Soil Surface Conditions 2" to3" STUBBLE, 30% SMALL GRASS COVER, SMALL CRACKS

Soil Moisture Condition Before Test FIELD CAPACITY (HEAVY RAIN PREVIOUS DAY)

Extent of Bund Leakage NONE

Other Comments CLOUDY DAY; 600 FT. EAST FROM PUMP

Time When Water Entered Field 11:30 (A)

Test Starting Time (The time midway between times A and B) 11:36

Time when Water Covered Field 11:42 (B)

Filling Time (Elapsed time from "Test Starting Time" to time of first hook gauge reading) 29 Minutes

(1) Elapsed Time (from first hook gauge reading in minutes)	(2) Time of Hook Gauge Reading	(3) Hook Gauge Reading (inches)	(4) Accumulated Intake (inches)	(5) Adjusted Elapsed Time[1] (minutes)
0	12:05	6.23	0.00	29
5	:10	6.18	.05	34
10	:15	6.14	.09	39
20	:25	6.06	.17	49
30	:35	5.98	.25	59
45	:50	5.86	.37	74
60	1:05	5.75	.48	89
90	1:35	5.53	.70	119

(Continued)

TABLE IV-1

(Continued)

(1) Elapsed Time (from first hook gauge reading in minutes)	(2) Time of Hook Gauge Reading	(3) Hook Gauge Reading (inches)	(4) Accumulated Intake (inches)	(5) Adjusted Elapsed Time[1] (minutes)
120	2:05	5.33	.90	149
180	3:05	4.95	1.28	209
240	4:05	4.58	1.65	269

[1] Elapsed Time from column (1) plus "Filling Time"

TABLE IV-2

SOILS INFORMATION AND BASIC INTAKE RATES

District	Sub-Project Number	Topsoil Texture[1]	Range in Soil Texture[2]	Soil Association	Basic Intake Rate (in/hr)
Chittagong	2	sandy loam	sandy loam to silt loam	Pahartali-Mirsarai	.20
Dacca	5	clay loam / clay	silty clay loam to clay	Dhamrai Sabhar Bazar	.40
Dacca	6	silty clay loam / sandy	silty clay loam to clay	Dhamrai Sabhar Bazar	.40
Dacca	9	clay loam	silt loam to silty clay loam	Sonatala-Silmandi	.30
Rajshahi	17	clay loam / sandy loam	loam to silty clay loam; often clay loam	i) Gopalpur-Ishurdi-Sara ii) Sara-Gopalpur	.55 .30
Rajshahi	18	clay	clay	Santhia	.30
Rajshahi	20	silty clay loam	i) clay to silty clay loam ii) loam to silty clay loam	i) Mehindiganj-Gopalpur ii) Gopalpur-Ishurdi-Sara	.50

(Continued)

TABLE IV-2

(Continued)

District	Sub-Project Number	Topsoil Texture[1]	Range in Soil Texture[2]	Soil Association	Basic Intake Rate (in/hr)
Rangpur	21	sandy clay / clay loam	loam to silt loam	Gangachara-Srirampur	.30
Rangpur	22	clay / sandy clay	loam to silt loam; rarely silty clay loam	i) Gangachara-Pirgacha-Kaunia ii) Pirgacha-Gangachara	.40
Rangpur	23	silt loam	loam to silt loam	Gangachara-Kaunia	.30
Tangail	27	sandy clay / sandy clay loam	silty clay loam to rarely silt loam or silty clay	Silmandi-Sabhar-Bazar	.30
Tangail	29	sandy clay loam	silt loam or silty clay loam	Dhamrai Complex	.50

[1] Observed by irrigation engineers performing intake tests.

[2] From Soil Survey Reports for soil association.

TABLE IV-3

BASIN DIMENSIONS AND SIZES

Basin Area (Acres)	Basin Dimensions[1] Length (feet)	Basin Dimensions[1] Width (feet)	Qu[2] (cubic feet per second)	Efficiency 0.5 Intake Family (percent)	Efficiency 0.3 Intake Family (percent)
3/4	200	163	.0100	81	90
1	200	218	.0083	77	87
1 1/2	250	261	.0069	68	80
2	300	290	.0062	60	75
3	350	373	.0048	48	70

[1]Dimensions were selected that would give nearly square basins with a length that would allow convenient use of the curves.

[2]Qu is the stream size per foot of basin width.

TABLE IV-4

AVERAGE VAPOR PRESSURE (9 A.M. AND 6 P.M. OBSERVATIONS), IN MILLIBARS

Name of Station	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Chittagong	16.2	18.3	23.7	29.2	30.9	31.9	31.8	31.9	31.6	29.7	22.7	18.1
Dacca	14.3	15.1	19.4	26.0	30.7	33.9	32.9	32.8	32.6	28.4	20.4	21.1
Khulna	15.5	17.6	22.9	30.0	32.6	34.2	34.0	33.7	33.4	29.3	21.3	16.8
Pabna	15.7	16.8	19.1	24.4	30.4	24.5	34.2	34.1	33.0	29.7	21.8	17.2
Rangpur	14.2	15.1	17.4	23.5	28.3	31.7	33.2	33.5	32.9	28.3	29.8	15.9

TABLE IV-5

MEAN MONTHLY MAXIMUM AND MINIMUM TEMPERATURES, IN DEGREES CELSIUS

Station		Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Chittagong	Max	25.8	27.6	30.5	32.0	32.2	31.0	30.5	30.3	31.1	30.7	29.1	26.3
	Min	13.8	15.9	20.3	23.6	24.9	25.2	24.9	24.8	25.0	23.7	18.9	15.4
Dacca	Max	25.3	28.3	32.8	34.4	33.5	31.5	30.1	30.9	31.3	30.7	28.7	25.9
	Min	11.9	14.1	19.3	23.3	25.1	25.8	26.1	26.2	25.8	23.6	17.7	12.8
Khulna	Max	26.3	29.2	33.4	34.6	34.3	32.6	31.2	31.3	31.7	31.3	29.1	26.7
	Min	13.6	16.1	21.0	24.2	25.6	26.1	26.2	26.2	26.0	24.3	19.1	14.7
Pabna	Max	25.7	28.3	33.4	36.3	35.1	33.2	31.8	31.8	32.3	31.9	29.3	26.6
	Min	11.5	13.7	18.2	22.6	24.6	25.6	25.9	26.2	25.9	23.3	17.4	12.8
Rangpur	Max	24.5	27.2	31.6	34.5	32.9	32.0	31.9	32.0	32.1	30.9	28.4	25.7
	Min	10.2	11.9	15.4	20.9	22.8	24.7	25.6	26.4	25.7	22.2	16.4	12.1

TABLE IV-6

RELATIVE HUMIDITY, IN PERCENTAGES

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chittagong	9 AM	72	87	70	73	75	82	85	85	83	89	76	77
	6 PM	65	63	67	73	77	84	86	86	81	81	73	69
Dacca	9 AM	74	65	64	70	78	84	87	86	84	78	73	78
	6 PM	61	48	44	54	75	81	82	83	83	79	71	70
Khulna	9 AM	73	71	73	76	78	83	86	85	83	78	72	72
	6 PM	62	55	55	65	74	82	84	84	83	78	69	67
Pabna	9 AM	77	71	67	71	79	85	86	85	84	79	75	76
	6 PM	68	55	44	41	61	81	85	84	85	81	76	75
Rangpur	9 AM	83	75	60	67	78	86	85	86	84	83	80	86
	6 PM	67	54	42	47	65	81	81	82	82	77	74	77

TABLE IV-7

AVERAGE WIND SPEED, IN KILOMETERS PER HOUR

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chittagong	5.6	6.5	8.9	13.2	12.4	16.7	15.0	13.2	10.0	6.0	4.1	4.1
Dacca	5.2	6.0	9.3	13.2	15.9	13.5	13.9	11.9	12.0	8.9	5.2	5.6
Khulna	3.0	3.9	5.8	7.8	8.9	7.4	7.8	6.9	5.6	3.9	3.2	3.0
Sirajganj (Pabna Dist.)	3.0	3.3	5.0	7.6	8.4	7.4	7.0	6.0	4.8	3.2	2.3	5.8
Rangpur	1.9	2.3	3.3	4.8	5.4	4.8	4.5	4.1	3.3	5.8	1.7	1.5

TABLE IV-8

HOURS OF BRIGHT SUNSHINE

Station	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Chittagong	9.1	9.5	8.7	8.8	8.2	4.3	4.8	5.0	5.9	7.4	9.3	9.0
Dacca	8.8	8.8	8.6	8.4	8.7	5.0	5.4	5.6	5.9	7.3	9.2	9.1

TABLE IV-9

CLOUDINESS, IN OKTAS

Station		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Khulna	6 AM	0.8	1.3	2.5	3.0	3.8	5.7	6.4	6.2	5.3	3.2	1.5	0.6
	9 AM	1.2	2.2	2.7	3.7	5.3	6.3	6.9	6.8	5.9	3.8	1.7	1.8
	Noon	1.3	1.7	2.3	3.1	4.3	6.1	6.5	6.2	5.8	3.7	1.8	1.2
	Avg.	1.1	1.7	2.5	3.3	4.5	6.0	6.6	6.4	5.7	3.6	1.7	1.2
Pabna	6 AM	1.6	9.5	1.7	2.0	3.7	5.6	6.5	6.4	5.4	3.4	1.3	0.7
	9 AM	1.9	1.0	1.7	2.1	3.6	5.3	6.7	6.6	5.3	3.5	1.5	1.1
	Noon	1.5	1.1	2.1	2.5	4.3	5.5	6.3	6.2	5.8	3.0	1.3	1.0
	Avg.	1.6	0.9	1.8	2.2	3.9	5.5	6.5	6.4	5.5	3.3	1.4	0.9
Rangpur	6 AM	1.0	0.9	1.9	3.5	5.1	6.1	6.1	6.0	5.5	3.3	1.1	0.6
	9 AM	1.8	1.2	1.8	3.1	5.1	6.1	6.3	6.0	5.1	3.3	0.9	1.9
	Noon	1.5	1.1	1.6	1.5	3.0	5.1	5.4	5.2	4.4	3.1	1.0	0.9
	Avg.	1.4	1.1	1.8	2.7	4.4	5.8	5.9	5.7	5.0	3.2	1.0	0.8

TABLE IV-10

MONTHLY REFERENCE CROP EVAPOTRANSPIRATION (ETo), IN INCHES

Month	Station				
	Chittagong	Dacca	Khulna	Pabna	Rangpur
Jan	4.3	3.9	4.5	3.7	3.1
Feb	5.0	4.9	5.4	5.0	4.4
Mar	6.8	7.8	7.2	7.3	6.5
Apr	7.8	8.7	7.6	8.0	7.9
May	7.9	8.2	7.9	8.5	7.6
Jun	5.2	5.5	6.6	6.9	7.8
Jul	5.2	5.6	6.5	6.3	6.9
Aug	5.1	5.5	6.2	6.2	6.4
Sep	5.1	5.2	5.8	5.7	5.8
Oct	4.8	5.1	5.8	5.6	5.5
Nov	4.5	4.3	4.6	4.2	3.9
Dec	3.9	3.8	4.1	3.8	3.1

TABLE IV-11

DISTRIBUTION SYSTEM EFFICIENCIES

System Components	Efficiency	
	Non-flooded Crops (percent)	Flooded Rice (percent)
Brick-lined Ditches (Pucca)	95	95
Field Ditches (Katcha, within Blocks)	90	95
Application	70	95
Overall (Product of Above)	60	85

TABLE IV-12

CROP COEFFICIENTS (kc) FOR WHEAT-BASED CROPPING PATTERN

Month	T. aman	Wheat	T. aus	Jute
Aug	1.10			
Sep	1.06			
Oct	.98			
Nov	.95			
Dec		.50		
Jan		1.04		
Feb		1.04		
Mar		.60		
Apr			1.10	.30
May			1.12	1.00
Jun			1.07	1.10
Jul			.97	.80

TABLE IV-13

CROP COEFFICIENTS (kc) FOR BORO-BASED CROPPING PATTERNS

Month	T. aman	Boro		T. aus
		Medium Highland and High Lowland	Lowland	
Aug	1.10			
Sep	1.07			
Oct	1.01			
Nov	.96			
Dec				
Jan		1.13	1.10	
Feb		1.25	1.20	
Mar		1.19	1.26	
Apr		1.01	1.08	
May			.99	1.10
Jun				1.10
Jul				.99

TABLE IV-14

LAND PREPARATION REQUIREMENTS AND PERCOLATION LOSSES

	Land Preparation Requirements (Inches)		Percolation Loss (Inches/Day)
	Average (La)	Peak (Lp)	
Boro			
Medium Highland	5	7	.2
High Lowland	3	5	.15
Lowland	0	2	.1
T. Aus			
Following Wheat	7	9	.2
Following Boro on Medium Highland	6	8	.2
Following Boro on High Lowland	5	7	.15
T. Aman			
Medium Highland and Highland	0	2	.2

TABLE IV-15

MEAN MONTHLY RAINFALL (Rm), IN INCHES

Month	Station				
	Chittagong	Dacca	Khulna	Rajshahi	Rangpur
Jan	0.35	0.40	0.53	0.38	0.40
Feb	1.09	1.01	0.86	0.77	0.64
Mar	2.37	2.17	1.56	1.71	1.00
Apr	5.74	5.84	3.55	2.88	3.35
May	10.07	9.41	7.26	7.07	11.61
Jun	20.67	13.46	12.20	11.45	19.64
Jul	25.31	12.72	14.28	10.53	16.28
Aug	22.50	13.43	12.05	10.85	13.54
Sep	13.95	9.15	8.13	8.82	12.77
Oct	8.60	5.57	4.33	5.73	6.76
Nov	2.07	0.72	1.05	0.61	0.29
Dec	0.53	0.17	0.16	0.12	0.06

TABLE IV-16

CROP EVAPOTRANSPIRATION (ETc), EFFECTIVE RAINFALL (Re), AND DEPENDABLE RAINFALL (Rd) FOR CHITTAGONG DISTRICT, IN INCHES

Wheat-Based Cropping Pattern

Month	T. Aman			Wheat			T. Aus			Jute		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	5.6	5.6	5.6									
Sep	5.4	5.4	5.4									
Oct	4.7	4.7	4.7									
Nov	2.9	1.4	.5									
Dec				2.0	.3	.2						
Jan				4.5	.2	.0						
Feb				5.2	.9	.0						
Mar				3.3	1.4	.2						
Apr							7.2	4.8	1.4	2.0	2.0	1.1
May							8.8	8.8	6.8	7.9	7.9	4.3
Jun							5.6	5.6	5.6	5.7	5.7	5.7
Jul							3.4	3.4	3.4	3.5	3.5	3.5

(Continued)

TABLE IV-16
(Continued)

Boro-based Cropping Pattern

Month	T. Aman			Boro: Medium Highland and High Lowland			Boro: Lowland			T. Aus		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	3.1	3.1	3.1									
Sep	5.5	5.5	5.5									
Oct	4.8	4.8	4.8									
Nov	4.3	2.1	.8									
Dec												
Jan				4.9	.4	.0	2.5	.2	.0			
Feb				6.3	1.1	.2	6.0	1.1	.2			
Mar				8.1	2.4	.4	8.6	2.4	.4			
Apr				5.1	3.8	1.3	8.4	5.7	2.0			
May							1.3	1.3	1.1	8.7	8.7	6.8
Jun										5.7	5.7	5.7
Jul										5.1	5.1	5.1

TABLE IV-17

CROP EVAPOTRANSPIRATION (ETc), EFFECTIVE RAINFALL (Re), AND DEPENDABLE RAINFALL (Rd) FOR DACCA DISTRICT, IN INCHES

Wheat-Based Cropping Pattern

Month	T. Aman			Wheat			T. Aus			Jute		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	6.1	6.1	6.1									
Sep	5.5	5.5	5.5									
Oct	5.0	5.0	2.7									
Nov	2.8	.5	.4									
Dec				1.9	.1	.0						
Jan				4.1	.3	.0						
Feb				5.1	.8	.2						
Mar				3.8	1.3	.5						
Apr							7.9	4.9	3.0	2.2	2.2	1.9
May							9.2	9.2	6.4	8.2	6.9	5.0
Jun							5.9	5.9	5.9	6.1	6.1	6.1
Jul							3.6	3.6	3.6	3.7	3.7	3.7

(continued)

TABLE IV-17
(Continued)

Boro-Based Cropping Patterns

Month	T. Aman			Boro: Medium Highland and High Lowland			Boro: Lowland			T. Aus		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	4.0	4.0	4.0									
Sep	5.6	5.6	5.6									
Oct	5.2	5.2	2.7									
Nov	4.1	.7	.5									
Dec												
Jan				4.4	.4	.0	2.3	.2	.0			
Feb				6.1	1.0	.3	5.9	1.0	.3			
Mar				9.3	2.2	.8	9.8	2.2	.8			
Apr				5.8	3.9	2.4	9.4	5.8	3.6			
May							1.4	1.4	1.1	9.0	9.0	6.4
Jun										6.1	6.1	6.1
Jul										5.5	5.5	5.5

TABLE IV-18

CROP EVAPOTRANSPIRATION (ETc), EFFECTIVE RAINFALL (Re), AND DEPENDABLE RAINFALL (Rd) FOR KHULNA DISTRICT, IN INCHES

Wheat-Based Cropping Pattern

Month	T. Aman			Wheat			T. Aus			Jute		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	6.8	6.8	6.8									
Sep	6.1	6.1	5.9									
Oct	5.7	4.3	3.4									
Nov	3.0	.7	.0									
Dec				2.1	.0	.0						
Jan				4.7	.4	.0						
Feb				5.6	.7	.0						
Mar				3.5	1.1	.1						
Apr							7.0	3.0	1.3	1.9	1.8	.8
May							8.8	7.3	4.5	7.9	5.5	3.6
Jun							7.1	7.1	7.1	7.3	7.3	6.4
Jul							4.2	4.2	4.2	4.3	4.3	4.3

(continued)

TABLE IV-18
(Continued)

Boro-Based Cropping Patterns

Month	T. Aman			Boro: Medium Highland and High Lowland			Boro: Lowland			T. Aus		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	4.5	4.5	4.5									
Sep	6.2	6.2	5.9									
Oct	5.9	4.3	3.4									
Nov	4.4	1.1	.0									
Dec												
Jan				5.1	.5	.0	2.6	.3	.0			
Feb				6.8	.9	.0	6.5	.9	.0			
Mar				8.6	1.6	.3	9.1	1.6	.3			
Apr				5.1	2.4	1.0	8.2	3.6	1.5			
May							1.3	1.2	.8	8.7	7.3	4.5
Jun										7.3	7.3	7.3
Jul										6.4	6.4	6.4

TABLE IV-19

CROP EVAPOTRANSPIRATION (ETc), EFFECTIVE RAINFALL (Re), AND DEPENDABLE RAINFALL (Rd) FOR RAJSHAHI DISTRICT, IN INCHES

Wheat-Based Cropping Pattern

Month	T. Aman			Wheat			T. Aus			Jute		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	6.8	6.8	6.6									
Sep	6.0	6.0	6.0									
Oct	5.5	5.5	1.6									
Nov	2.8	.4	.0									
Dec				1.9	.0	.0						
Jan				3.8	.3	.0						
Feb				5.2	.6	.0						
Mar				3.6	1.0	.0						
Apr							7.4	2.4	.3	2.0	1.5	.2
May							9.5	7.1	3.1	8.5	5.5	2.7
Jun							7.4	7.4	7.4	7.6	7.6	5.8
Jul							4.1	4.1	4.1	4.2	4.2	4.2

(continued)

TABLE IV-19
(Continued)

Boro-Based Cropping Patterns

Month	T. Aman			Boro: Medium Highland and High Lowland			Boro: Lowland			T. Aus		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	4.5	4.5	4.4									
Sep	6.1	6.1	6.1									
Oct	5.7	5.7	1.6									
Nov	4.0	.6	.0									
Dec												
Jan				4.2	.4	.0	2.2	.2	.0			
Feb				6.3	.8	.0	6.0	.8	.0			
Mar				8.7	1.7	.0	9.2	1.7	.0			
Apr				5.3	1.9	.3	8.6	2.9	.4			
May				1.4			1.4	1.2	.5	9.4	7.1	3.1
Jun										7.6	7.6	7.6
Jul										6.2	6.2	6.2

TABLE IV-20

CROP EVAPOTRANSPIRATION (ETc), EFFECTIVE RAINFALL (Re), AND DEPENDABLE RAINFALL (Rd), FOR RANGPUR DISTRICT, IN INCHES

Wheat Based Cropping Pattern

Month	T. Aman			Wheat			T. Aus			Jute		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	7.0	7.0	7.0									
Sep	6.1	6.1	6.1									
Oct	5.4	5.4	2.6									
Nov	2.6	.2	.0									
Dec				1.6	.0	.0						
Jan				3.2	.3	.0						
Feb				4.6	.5	.0						
Mar				3.2	.6	.0						
Apr							7.2	2.8	1.2	2.0	1.7	.8
May							8.5	8.5	8.5	7.6	7.6	6.4
Jun							8.3	8.3	8.3	8.6	8.6	8.6
Jul							4.6	4.6	4.6	4.7	4.7	4.7

(continued)

TABLE IV-20
(continued)

Boro-Based Cropping Patterns

Month	T. Aman			Boro: Medium Highland and High Lowland			Boro: Lowland			T. Aus		
	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd	ETc	Re	Rd
Aug	4.7	4.7	4.7									
Sep	6.2	6.2	6.2									
Oct	5.6	5.6	2.6									
Nov	3.6	.3	.0									
Dec												
Jan				3.5	.4	.0	1.9	.2	.0			
Feb				5.5	.6	.0	5.3	.6	.0			
Mar				7.7	1.0	.0	8.2	1.0	.0			
Apr				5.2	2.2	1.0	8.5	3.4	1.4			
May							1.3	1.3	1.3	8.4	8.4	8.4
Jun										8.6	8.6	8.6
Jul										6.8	6.8	6.8

TABLE IV-21a

AVERAGE IRRIGATION REQUIREMENTS (Ia) FOR T. AMAN, IN INCHES (HIGHLAND AND MEDIUM HIGHLAND)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Re .86	P .86	Ia	ETc-Re .86	P .86	Ia
Chittagong						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	1.7	.6[1]	2.3	2.6	1.8[1]	4.4
Total			2.3			4.4
Dacca & Tangail						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.7	1.0[1]	3.7	4.0	2.9[1]	6.9
Total			3.7			6.9
Khulna						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	1.6	1.7[1]	3.3	1.9	1.9[1]	3.8
Nov	2.7	1.2	3.9	3.8	3.5	7.3
Total			7.2			11.1
Rajshahi						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.8	1.0[1]	3.8	4.0	3.0[1]	7.0
Total			3.8			7.0

(continued)

TABLE IV-21a

(continued)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Re / .86	P / .86	Ia	ETc-Re / .86	P / .86	Ia
Rangpur						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.8	1.1 [1]	3.9	4.0	3.2 [1]	7.2
Total			3.9			7.2

[1] $\frac{ETc-Re}{ETc} \times \frac{P \text{ for entire month}}{.86}$

TABLE IV-21b

PEAK IRRIGATION REQUIREMENTS (Ip) FOR T. AMAN,
IN INCHES (HIGHLAND AND MEDIUM HIGHLAND)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Rd .86	P .86	Ip	ETc-Rd .86	P .86	Ip
Chittagong						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	.0	.0	.0	.0	.0	.0
Nov	2.8	1.0[2]	3.8	4.1	2.8[2]	6.9
Dacca & Tangail						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	2.7	3.2[2]	5.9	2.9	3.4[2]	6.3
Nov	2.8	1.2	4.0	4.2	3.5	7.7
Khulna						
Aug	.0	.0	.0	.0	.0	.0
Sep	.2	.2[2]	.4	.3	.3[2]	.6
Oct	.7	7.0	9.7	2.9	7.0	9.9
Nov	3.5	1.2	4.7	5.1	3.5	8.6
Rajshahi						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	4.5	5.0[2]	9.5	4.8	5.0[2]	9.8
Nov	3.3	1.2	4.5	4.7	3.5	8.2

(continued)

TABLE IV-21b
(continued)

DISTRICT	Wheat-Based Cropping Pattern			Boro-Based Cropping Pattern		
	ETc-Rd / .86	P / .86	Ip	ETc-Rd / .86	P / .86	Ip
Rangpur						
Aug	.0	.0	.0	.0	.0	.0
Sep	.0	.0	.0	.0	.0	.0
Oct	3.3	3.6 [2]	6.9	3.5	3.8 [2]	7.3
Nov	3.0	1.2	4.2	4.3	3.5	7.8

[2] $\frac{\text{ETc Rd}}{\text{ETc}} \times \frac{\text{P for entire month}}{.86}$

TABLE IV-22a

AVERAGE IRRIGATION REQUIREMENTS (Ia) FOR BORO, IN INCHES

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia
Chittagong												
Dec		5.0		5.0		3.0		3.0				
Jan	5.2		7.0	12.2	5.2		5.2	10.4	2.7	.0	1.7	4.4
Feb	6.0		7.0	13.0	6.0		5.2	11.2	5.7		3.5	9.2
Mar	6.6		7.0	13.6	6.6		5.2	11.8	7.2		3.5	10.7
Apr	1.5		1.2	2.7	1.5		.0	1.5	3.1		.6	3.7
May									.0		.0	
Total				46.5				37.9				28.0
Dacca & Tangail												
Dec		5.0		5.0		3.0		3.0				
Jan	4.7		7.0	11.7	4.7		5.2	9.9	2.4	.0	1.7	3.9
Feb	5.9		7.0	12.9	5.9		5.2	11.1	5.7		3.5	9.2
Mar	8.3		7.0	15.3	8.3		5.2	13.5	8.8		3.5	12.3
Apr	2.2		7.0	3.4	2.2		.0	2.2	4.2		.6	4.8
May									.0		.0	
Total				48.3				39.7				30.2
Khulna												
Dec		5.0		5.0		3.0		3.0				
Jan	5.3		7.0	12.3	5.3		5.2	10.5	2.7	.0	1.7	4.4
Feb	6.9		7.0	13.9	6.9		5.2	12.1	6.5		3.5	10.0
Mar	8.1		7.0	15.3	8.1		5.2	13.1	8.7		3.5	12.2
Apr	3.1		1.2	4.3	3.1		.0	3.1	5.3		.6	5.9
May									.1		.0	.1
Total				50.8				42.0				32.6

(continued)

TABLE IV-22a

(continued)

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia
Rajshahi												
Dec		5.0		5.0		3.0		3.0				
Jan	4.4		7.0	11.4	4.4		5.2	9.6	2.3	.0	1.7	4.0
Feb	6.4		7.0	13.4	6.4		5.2	11.6	6.0		3.5	9.5
Mar	8.1		7.0	15.1	8.1		5.2	13.3	8.7		3.5	12.2
Apr	4.0		1.2	5.2	4.0		.0	4.0	6.6		.6	7.2
May									.2			.2
Total				50.1				41.5				33.1
Rangpur												
Dec		5.0		5.0		3.0		3.0				
Jan	3.6		7.0	10.6	3.6		5.2	8.8	2.0	.0	1.7	3.7
Feb	5.7		7.0	12.7	5.7		5.2	10.9	5.5		3.5	9.0
Mar	7.8		7.0	14.8	7.8		5.2	13.0	8.4		3.5	11.9
Apr	3		1.2	4.7	3.5		.0	3.5	5.9		.6	6.5
May									.0		.0	.0
Total				47.8				39.2				31.1

TABLE IV-22b

PEAK IRRIGATION REQUIREMENTS (Ip) FOR BORO, IN INCHES

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Rd/.86	Lp	P/.86	Ip	ETc-Rd/.86	Lp	P/.86	Ip	ETc-Rd/.86	Lp	P/.86	Ip
Chittagong												
Dec		7.0		7.0		5.0		5.0				
Jan	5.7		7.0	12.7	5.7		5.2	10.9	2.9	2.0	1.7	6.6
Feb	7.1		7.0	14.1	7.1		5.2	12.3	6.7		3.5	10.2
Mar	9.0		7.0	16.0	9.0		5.2	14.2	9.5		3.5	13.0
Apr	4.4		1.2	5.6	4.4		.0	4.4	7.4		.6	8.0
May									.2		.0	.2
Dacca & Tangail												
Dec		7.0		7.0		5.0		5.0				
Jan	5.1		7.0	12.1	5.1		5.2	10.3	2.7	2.0	1.7	6.4
Feb	6.7		7.0	13.7	6.7		5.2	11.9	6.5		3.5	10.0
Mar	9.9		6.0	16.9	9.9		5.2	15.1	10.5		3.5	14.0
Apr	4.0		1.2	5.2	4.0		.0	4.0	6.7		.6	.3
May									.3		.0	.3
Khulna												
Dec		7.0		7.0		5.0		5.0				
Jan	5.9		7.0	12.9	5.9		5.2	11.1	3.0	2.0	1.7	6.7
Feb	7.9		7.0	14.9	7.9		5.2	13.1	7.6		3.5	11.1
Mar	9.7		7.0	16.7	9.7		5.2	14.9	10.2		3.5	13.7
Apr	4.8		1.2	6.0	4.8		.0	4.8	7.8		.6	8.4
May									.6		.0	.6

(continued)

TABLE IV-22b

(Continued)

DISTRICT	Medium Highland				High Lowland				Lowland			
	ETc-Rd/.86	Lp	P/.86	Ip	ETc-Rd/.86	Lp	P/.86	Ip	ETc-Rd/.86	Lp	P/.86	Ip
Rajshahi												
Dec		7.0		7.0		5.0		5.0				
Jan	4.9		7.0	11.9	4.9		5.2	10.1	2.6	2.0	1.7	6.3
Feb	7.3		7.0	14.3	7.3		5.2	12.5	7.0		3.5	10.5
Mar	10.1		7.0	17.1	10.1		5.2	15.3	10.7		3.5	14.2
Apr	5.8		1.2	7.0	5.8		.0	5.8	9.5		.6	10.1
May									1.0		.0	1.0
Rangpur												
Dec		7.0		7.0		5.0		5.0				
Jan	4.1		7.0	11.1	4.1		5.2	9.3	2.2	2.0	1.7	5.9
Feb	6.4		7.0	13.4	6.4		5.2	11.6	6.2		3.5	9.7
Mar	9.0		7.0	16.0	9.0		5.2	14.2	9.5		3.5	13.9
Apr	4.9		1.2	6.1	4.9		.0	4.9	8.3		.6	8.9
May									.0		.0	.0

TABLE IV-23a

AVERAGE IRRIGATION REQUIREMENTS (Ia) FOR T. AUS, IN INCHES

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern Medium Highland				Boro-Based Cropping Pattern High Lowland			
	ETc-Re .86	La	P .86	Ia	ETc-Re .86	La	P .86	Ia	ETc-Re .86	La	P .86	Ia
Chittagong												
Mar		3.5		3.5								
Apr	2.8	3.5	1.9[1]	8.2		6.0		6.0		5.0		5.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0		.0		.0	.0
Total				11.7					6.0			5.0
Dacca & Tangail												
Mar		3.5		3.5								
Apr	3.5	3.5	2.2[1]	9.2	.0	6.0		6.0		5.0	.0	5.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				12.7				6.0				5.0
Khulna												
Mar		3.5		3.5								
Apr	4.7	3.5	5.8	14.0		7.0		6.0		5.0		5.0
May	1.7		1.2[1]	2.9	1.6		1.1	2.7	1.6		.8[1]	2.4
Jun	.0		.0	.0	.0		.0	.0	.0	.0		.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				20.4				8.7				7.4

(continued)

TABLE IV-23a

(continued)

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern							
					Medium Highland				High Lowland			
	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia	ETc-Re / .86	La	P / .86	Ia
Rajshahi												
Mar		3.5		3.5								
Apr	5.8	3.5	5.8	15.1		6.0		6.0		5.0		5.0
May	2.8		1.8 [1]	4.6	2.7		1.7	4.4	2.7		1.3 [1]	4.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				23.2				10.4				9.0
Rangpur												
Mar		3.5		3.5								
Apr	5.1	3.5	3.5 [1]	12.1		6.0		6.0		5.0		5.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				15.6				6.0				5.0

[1] $\frac{ETc-Re}{ETc} \times \frac{P \text{ for entire month}}{.86}$

TABLE IV-23b

PEAK IRRIGATION REQUIREMENTS (Ip) FOR T. AUS, IN INCHES

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern Medium Highland				Boro-Based Cropping Pattern High Lowland			
	ETc-Rd .86	Lp	P .86	Ip	ETc-Rd .86	Lp	P .86	Lp	ETc-Re .86	Lp	P .86	Ip
Chittagong												
Mar		4.5		4.5								
Apr	6.7	4.5	5.8	17.0		8.0		8.0		7.0		7.0
May	2.3		1.6 [2]	3.9	2.2		1.5 [2]	3.7	2.2		1.1 [2]	3.3
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0	.0	.0	.0	.0		.0	.0	.0		.0	.0
Dacca & Tangail												
Mar		4.5		4.5								
Apr	5.7	4.5	5.8	16.0		8.0		8.0		7.0	.0	7.0
May	3.3		2.1 [2]	5.4	3.0		2.0 [2]	5.0	3.0		1.5 [2]	4.5
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Khulna												
Mar		4.5		4.5								
Apr	6.6	4.5	5.8	16.9		8.0		8.0		7.0		7.0
May	5.0	4.5	3.4 [2]	8.4	4.9		3.4 [2]	8.3	4.9		2.5 [2]	7.4
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0

(continued)

TABLE IV-23b

(continued)

DISTRICT	Wheat-Based Cropping Pattern (Medium Highland and Highland)				Boro-Based Cropping Pattern Medium Highland				Boro-Based Cropping Pattern High Lowland			
	ETc-Re / .86	Lp	P / .86	Ip	ETc-Re / .86	Lp	P / .86	Ip	ETc-Re / .86	Lp	P / .86	Ip
Rajshahi												
Mar		4.5		4.5								
Apr	7.0	4.5	4.8	[2] 16.3		8.0		8.0		7.0		7.0
May	7.4	4.5	4.7	[2] 12.1	7.3		4.7	12.0	7.3		3.5	[2] 10.8
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Rangpur												
Mar		4.5		4.5								
Apr	7.0	4.5	4.8	[2] 16.3		8.0		8.0		7.0		7.0
May	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jun	.0		.0	.0	.0		.0	.0	.0		.0	.0
Jul	.0		.0	.0	.0		.0	.0	.0		.0	.0
Total				15.6				6.0				5.0

[2] $\frac{ETc-Rd}{ETc} \times \frac{P \text{ for entire month}}{.86}$

TABLE IV-24

AVERAGE AND PEAK IRRIGATION REQUIREMENTS (Ia AND Ip)
FOR WHEAT, IN INCHES

DISTRICT	Ia $(\frac{ETc-Re}{.60})$	Ip $(\frac{ETc-Rd}{.60})$
Chittagong		
Dec	2.8	3.0
Jan	7.2	7.5
Feb	7.2	8.7
Mar	3.2	5.2
Total	20.4	
Dacca & Tangail		
Dec	3.0	3.2
Jan	6.3	6.8
Feb	7.2	8.2
Mar	4.2	5.5
Total	20.7	
Khulna		
Dec	3.5	3.5
Jan	7.2	7.8
Feb	8.2	9.3
Mar	4.0	5.7
Total	22.9	
Rajshahi		
Dec	3.2	3.2
Jan	5.8	6.3
Feb	7.7	8.7
Mar	4.3	6.0
Total	21.0	

(continued)

TABLE IV-24
(continued)

DISTRICT	Ia $(\frac{ETc-Re}{.60})$	Ip $(\frac{ETc-Re}{.60})$
Rangpur		
Dec	2.7	2.7
Jan	4.8	5.3
Feb	6.8	7.7
Mar	4.3	5.3
Total	18.6	

TABLE IV-25

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS
SUB-PROJECT NO. 1

Irrigated	Non-Irrigated
Boro (HYV) - B. aman	Aus (L) - Pulses
T. aus (HYV) - T. aman-Rabi Crops	Aus (HYV) - Pulses
Vegetables - Pulses	Aus (L) - T. aman (L)
T. aman - Vegetables	Vegetable - aus (L)

TABLE IV-26

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS
SUB-PROJECT NO. 1

Irrigated		Non-Irrigated	
Crop	Area (acres)	Crop	Area (acres)
Boro (HYV)	60	Boro (L)	370
T. aman (HYV)	75	B. aus (L)	200
B. aman (L)	85	T. aman	100
T. aus (HYV)	75	Oilseeds	100
Oilseeds	80		

TABLE IV-27

RECOMMENDED CROPPING PATTERNS WITH DRAINAGE AND WITHOUT IRRIGATION: SUB-PROJECT NO. 1

Land Type	Recommended Cropping Pattern
High Land	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV) - Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-28

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL AND WITH IRRIGATION: SUB-PROJECT NO.1

Land Type	Recommended Cropping Pattern
High Land	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-29

QUANTITY AND COST SUMMARY: SUB-PROJECT NO.1

Item	Unit	Unit Cost(Tk)	Quantity	Total Cost(Tk)
Excavation	% cu.ft.	20	3390	67,800
Compacting Embankment	% cu.ft.	18	200	3,600
Brick Masonry	% cu.ft.	2400	140	336,000
Brick Lining	% sq.ft.	750	23	17,250
Plastering Brick Work	% sq.ft.	250	26	6,500
Concrete Class A	% cu.ft.	3500	14	49,000
Concrete Class B	% cu.ft.	3200	34	108,000
Flap Gate	each	15000	2	30,000
Stop Logs	sq.ft.	80	210	16,800
			Sub-total	635,750
			Contingencies (15%)	95,250
			FAR Cost	731,000

TABLE IV-30

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 1

Item	Unit	Unit Cost(Tk)	Quantity	Total Cost(Tk)
Bricks	thousand	800	234	187,200
Sand	% cu.ft.	300	39	11,700
Cement	bag	80	1,360	108,800
Chips	% cu.ft.	780	45	35,100
Flap Gate	each	15,000	2	30,000
Fall Board	sq.ft.	80	210	16,800
Total				389,600

TABLE IV-31

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:
SUB-PROJECT NO. 2

Irrigated	Non-Irrigated
Boro (HYV) - Aus (L) - T. aman (HYV)	Boro (HYV) - B. aus (L) T. aman (HYV)
Boro (HYV) - T. aman (HYV)	Vegetables - B. aus (L) T. aman (HYV)
Aus (L) - T. aman (L)	Pulses - B. aus (L) T. aman (HYV) B. aus (L) - T. aman (HYV)

TABLE IV-32

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:
SUB-PROJECT NO. 2

Irrigated		Non-Irrigated	
Crops	Area (acres)	Crops	Area (acres)
Boro (HYV)	50	B. aus (L)	20
Aus (L)	20	T. aman (HYV)	50
Aus (HYV)	10	Boro (HYV)	5
T. aman (HYV)	40	Vegetables	5
T. aman (L)	10	Pulses	10

TABLE IV-33

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT
FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 2

Land Type	Recommended Cropping Patterns
Highland	
Lower Phase	Boro (HYV - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
Higher Phase	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Wheat - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)

TABLE IV-34

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:
SUB-PROJECT NO. 2

Crop	Highland	
	Lower Phase (acres)	Higher Phase (acres)
Boro (HYV)	15	
Wheat (HYV)	17	5
Oilseeds	5	5
Pulses	5	5
Vegetables	5	5
T. aus (HYV/LIV)	21	41
T. aman (HYV/LIV)	43	39

TABLE IV-35

MATERIALS SUMMARY: SUB-PROJECT NO. 2

Material	Quantity
Brick	442 thousand
Cement	2241 bags
Sand	16,000 cu.ft.
Chips	1,600 cu.ft.
Concrete Pipe	60 lin.ft.
Wood Stop-checks	42 each
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ca.
1899 Mild Steel Weir Gage, Enamelled	1 ca.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ca.

TABLE IV-36

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:
SUB-PROJECT NO. 5

Irrigated	Non-irrigated
Boro (HYV)	Mixed aus & aman
	Mixed aus & aman - Wheat
	Mixed aus & aman - Pulses
Boro (HYV) - T. aman (L)	Jute - Oilseeds
	Jute - Wheat
	Sugarcane

TABLE IV-37

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:
SUB-PROJECT NO. 5

Irrigated		Non-Irrigated	
Crop	Area (acres)	Crop	Area (acres)
Boro (HYV)	60	Mixed aus & aman	70
		Jute	15
T. aman (L)	45	Wheat	20
		Oilseeds	15
		Pulses	10
		Sugarcane	5

TABLE IV-38

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 5

Land Type	Recommended Cropping Patterns
Highland	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Pulses - T. aus (HYV)
	Pulses - Jute
	Oilseeds - T. aus (HYV)
	Oilseeds - Jute
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Sugarcane
Medium Highland	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)
Medium Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-39

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:
SUB-PROJECT NO. 5

Crop	Highland (acres)	Medium Highland (acres)	Medium Lowland (acres)
Wheat (HYV)	46		
Pulses	15		
Oilseeds	15		
Boro (HYV)		61	16
T. aus (HYV/LIV)	56	20	
Jute	20		
T. aman (HYV/LIV)	50	61	
T. deep water aman			8
Sugarcane	5		

TABLE IV-40

MATERIALS SUMMARY: SUB-PROJECT NO. 5

Material	Quantity
Brick	582 thousand
Cement	2800 bags
Sand	19,000 cu.ft.
Chips	1,600 cu.ft.
Concrete Pipe	24 lin.ft.
Wood Stop-checks	38
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ca.
1899 Mild Steel Weir Gage, Enamelled	1 ca.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ca.

TABLE IV-41

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 6

Irrigated	Non-irrigated
Boro (HYV) - T. aman (HYV/L)	Wheat - Jute - T. aman (L)
	Jute - T. aman (L)
	Mixed aus and aman - Khesari
	Mixed aus and aman

TABLE IV-42

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 6

Irrigated Crops	Area (acres)	Non-irrigated Crops	Area (acres)
Boro (HYV)	40	Wheat	10
T. aman (HYV)	35	Jute	20
T. aman (L)	5	T. aman (L)	70
		Khesari	5

TABLE IV-43

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 6

Land Type	Recommended Cropping Patterns
Medium Highland	Wheat - T. aus (HYV) - T. aman (HYV)
	Wheat - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Oil seeds - T. aus (HYV) - T. aman (HYV)
	Oil seeds - Jute - T. aman (HYV)
Low Highland	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (HYV)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-44

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 6

Crop	Medium Highland Area (acres)	Low Highland Area (acres)	Medium Lowland and Lowland Area (acres)
Boro (HYV)		22	18
T. aman (HYV/LIV)	45	22	
T. deep water aman			9
T. aus (HYV)	50	8	
Jute	20		
Wheat (HYV)	65		
Oilseeds/Pulses	5		

TABLE IV-45

MATERIALS SUMMARY: SUB-PROJECT NO. 6

Material	Quantity
Brick	354 thousand
Cement	1,773 bags
Sand	11,000 cu.ft.
Chips	1,200 cu.ft.
Wood Stop-checks	38 ca.
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ca.
1899 Mild Steel Weir Gage, Enamelled	1 ca.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ca.

TABLE IV-46

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:
SUB-PROJECT NO. 9

Irrigated	Non-Irrigated
Boro (HYV) - Jute - T. aman (L)	Boro (Local)
Boro (HYV) - Aus (L) - T. aman (L)	B. aus (L) T. aman (HYV/L)
	Jute - T. aman (L)
Boro (HYV) - T. aman (HYV)	B. aus (L) - T. aman (L)
	Vegetable

TABLE IV-47

ACREAGE OF CROP IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 9

Irrigated		Non-Irrigated	
Crops	Area (acres)	Crops	Area (acres)
Boro (HYV)	20	Boro (L)	20
Aus (L)	10	B. aus (L)	35
T. aman (HYV/L)	5	T. aman (HYV)	35
Jute	5	T. aman (L)	40
		Jute	15

TABLE IV-48

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 9

Land Type	Recommended Cropping Patterns
Highland	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Oilseeds - T. aus (HYV)
	Oilseeds - Jute
	Vegetables - T. aus (HYV)
	Vegetables - Jute
Medium Highland	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Vegetables - Jute - T. aman (HYV)
Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-49

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 9

Crop	Highland Area (acres)	Medium Highland Area (acres)	Lowland Area (acres)
Wheat (HYV)	18	58	
Oilseeds	5	5	
Vegetables	5		
Boro (HYV)		20	5
T. aus (HYV/LIV)	10	34	
Jute	5	20	
T. aman (HYV/LIV)		62	
T. deep water aman			5

TABLE IV-50

MATERIALS SUMMARY: SUB-PROJECT NO. 9

Material	Quantity
Brick	532 thousand
Cement	2600 bags
Sand	15,000 cu.ft.
Chips	1,800 cu.ft.
Concrete Pipe	24 lin.ft.
Wood Stop-checks	38 each
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ea.
1899 Mild Steel Weir Gage, Enamelled	1 ea.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ea.

TABLE IV-51

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 10

Irrigated	Non-Irrigated
Wheat - Aus (L)	Wheat - Aus (H)
Boro (H) - Jute	Oilseeds & Pulses - Aus (L)
Boro (H) - T. aman (L)	Boro (H) - B. aman
Vegetables - Jute	Boro (H) - Jute
Vegetables - T. aman	Aus - T. aman
Oilseeds - Aus	Jute - T. aman
Pulses - Aus	Vegetables - Aus
	Vegetables - Jute
	Jute - T. aman
	Jute - Pulses & Oilseeds
	Sugarcane

TABLE IV-52

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 10

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabbi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-53

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

AND IRRIGATION: SUB-PROJECT NO. 10

Land Type	Recommended Cropping Pattern
Highland	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-54

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 10

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	671	13,420
Compacting Embankment	% cu.ft.	18	517	9,306
Brick Masonry	% cu.ft.	2,400	156	374,400
Brick Lining	% sq.ft.	750	93	69,750
Plastering Brick Work	% sq.ft.	250	44	11,000
Concrete Class A	% cu.ft.	3,500	18	63,000
Concrete Class B	% cu.ft.	3,200	42	134,400
Flap Gate	each	15,000	6	90,000
Fall Board	sq.ft.	80	560	44,800
Sub-Total				810,076
Contingencies (15%)				121,924
FAR Cost				932,000

TABLE IV-55

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 10

Item	Unit	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Brick	thousand	800	208	166,400
Sand	% cu.ft.	300	83	24,900
Cement	bag	80	1,671	133,680
Chips	% sq.ft.	780	54	42,120
Flap Gate	each	15,000	6	90,000
Fall Board	sq.ft.	80	560	44,800
Total				501,900

TABLE IV-56

EXISTING NON-IRRIGATED CROPPING PATTERNS: SUB-PROJECT NO. 11

Non-Irrigated
B. aus (L) - T. aman (L)
A. aus (L) - T. aman (L) - Boro/Wheat/Pulse
Boro (L) - T. aman (L)
B. aus (L) - Pulses

TABLE IV-57

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 11

Non-Irrigated	
Crop	Area (acres)
T. aman (L)	80
B. aus (L)	20
Boro (L)	20
Pulses	20
Wheat	60

TABLE IV-58

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT:

SUB-PROJECT NO. 11

Land Type	Recommended Cropping Patterns
Highland	T. aus (HYV) - Vegetables - Pulses
	T. aus (HYV) - Vegetables - Oilseeds
Medium land	Wheat - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)

TABLE IV-59

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS

Crop	Area (acres)
T. aus (HYV)	80
T. aman (HYV)	100
Boro (HYV)	40
Wheat (HYV)	60
Vegetables	20
Oilseeds and Pulses	20

TABLE IV-60

MATERIALS SUMMARY: SUB-PROJECT NO. 11

Material	Quantity
Brick	276 thousand
Cement	1,272 bags
Sand	8,000 cu.ft.
Chips	4 cu.ft.
Concrete Pipe	120 lin.ft.
Wood Stop-checks	4 each

TABLE IV-61

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 13

Irrigated	Non-Irrigated
None	T. aman (L) Boro (L) Wheat

TABLE IV-62

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 13

Land Type	Recommended Cropping Pattern
Highland	Line-sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line-sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T.aman (HYV/LIV)
	Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-63

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

AND WITH IRRIGATION: SUB-PROJECT NO. 13

Land Type	Recommended Cropping Pattern
Highland	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (LIV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-64

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 13

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	24,098	481,960
Compacting Embankment	% cu.ft.	18	19,644	353,592
Brick Masonry	% cu.ft.	2,400	219	525,600
Brick Lining	% sq.ft.	750	57	42,750
Plastering Brick Work	% sq.ft.	250	49	12,250
Concrete Class A	% cu.ft.	3,500	18	63,000
Concrete Class B	% cu.ft.	3,200	66	211,200
Flap Gate	each	15,000	3	45,000
Slide Gate and Hoist	each	35,000	1	35,000
Stop Logs	sq.ft.	80	357	28,560
			Sub total	1,798,912
			Contingencies (15%)	270,088
			FAR Cost	2,069,000

TABLE IV-65

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 13

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Bricks	Thousand	800	355	284,000
Sand	% cu.ft.	300	110	33,000
Cement	Bag	80	2,475	198,000
Chips	% cu.ft.	780	76	59,280
Flap Gate	each	15,000	3	45,000
Slide Gate and Hoist	each	35,000	1	35,000
Stop Logs	sq.ft.	80	357	28,560
			Total	682,840

TABLE IV-66

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 14

Irrigated	Non-irrigated
None	Oilseeds - T. aman (HYV) Potato - T. aman (L)

TABLE IV-67

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 14

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-68

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

AND WITH IRRIGATION: SUB-PROJECT NO. 14

Land Type	Recommended Cropping Pattern
Highland	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-69

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 14

Item	Unit	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	740	14,800
Compacting Embankment	% cu.ft.	18	299	5,382
Brick Masonry	% cu.ft.	2,400	96	230,400
Brick Lining	% sq.ft.	750	29	14,250
Plastering Brick Work	% sq.ft.	250	23	5,750
Concrete Class A	% cu.ft.	3,500	6	21,000
Concrete Class B	% cu.ft.	3,200	19	60,800
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	1	35,000
Fall Board	sq.ft.	80	176	14,080
			Sub-Total	416,462
		Contingencies (15%)		62,538
			Far Cost	479,000

TABLE IV-70

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 14

Item	Unit	Unit Cost (Tk)	Quantity	Unit Cost (Tk)
Bricks	thousand	800	120	96,000
Sand	% cu.ft.	300	45	13,500
Cement	bags	80	760	60,800
Chips	% cu.ft.	780	24	18,720
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	1	35,000
Fall Board	sq.ft.	80	176	14,080
			Total	253,100

TABLE IV-71

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 15

Irrigated	Non-irrigated
Boro (H) - T. aman (L)	T. aman
Boro (H) - T. aus - T. aman	T. aman - Chilly
Boro (H) - Jute	T. aman - Til
Til - T. aman	Jute - T. aman
	T. aman - Oilseeds

TABLE IV-72

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 15

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV) Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-73

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

AND WITH IRRIGATION: SUB-PROJECT NO. 15

Land Type	Recommended Cropping Pattern
Highland	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-74

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 17

Irrigated	Non-Irrigated
B. aus (L) - T. aman (HYV)	B. aus (L) - Wheat
T. aman (HYV) - Wheat	B. aus (L) - Pulses
T. aman (HYV) - Pulses	B. aus (L) - Oilseeds
T. aman (HYV) - Oilseeds	B. aman (L) - Pulses
T. aman (HYV) - Jute	B. aman (L)
	Jute - T. aman (HYV)
	Jute - Oilseeds
	Jute - Pulses
	Sugarcane

TABLE IV-75

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 17

Irrigated Area		Non-Irrigated Area	
Crops	Area (acres)	Crops	Area (acres)
B. aus (L)	20	B. aus (L)	40
T. aman (HYV)	10	B. aman (L)	25
Wheat	20	Pulses	10
Jute	3	Jute	10
Pulses	3	Wheat	10
Oilseeds	4	T. aman (HYV)	25
		Oilseeds	10
		Sugarcane	10

TABLE IV-76

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 17

Land Type	Recommended Cropping Patterns
Medium Highland	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (HYV)
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)

TABLE IV-77

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS

Crop	Highland Area (acres)	Medium Highland Area (acres)
Wheat (HYV)	50	16
Pulses	10	
Oilseeds	10	
Boro (HYV)		20
T. aus (HYV/LIV)	24	13
Jute	15	10
T. aman (HYV/LIV)	50	30
Sugarcane	5	

TABLE IV-78

MATERIALS SUMMARY: SUB-PROJECT NO. 17

Material	Quantity
Brick	458 thousand
Cement	2,200 bags
Sand	1,450 cu.ft.
Chips	15 cu.ft.
Concrete Pipe	24 lin.ft.
Wood stop-checks	39 ca
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ca
1899 Mild Steel Weir Gage, Enamelled	1 ca
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ca.

TABLE IV-79

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 19

Irrigated	Non-Irrigated
None	B. aus (L) - T. aman (L) B. aus (L) - Oilseeds B. aman (L) - Oilseeds T. aman (L) - Wheat Boro (L)

TABLE IV-80

ACREAGE OF CROPS IN EXISTING CROPPING PATTERN:

SUB-PROJECT NO. 19

Crop	Area (acres)
B. aus (L)	1,500
B. aman (L)	1,500
T. aman (L)	500
Boro (L)	1,000
Wheat (L)	500
Oilseeds	2,000

TABLE IV-81

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT FOR DIFFERENT LAND TYPES WITH FLOOD PROTECTION BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 19

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line - sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV) - T. aman (HYV/LIV) Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

TABLE IV-82

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 19

Crop	Area
Boro (L)	1,300 acres
T. aus (L)	1,300 acres
T. aman (L)	900 acres
Wheat	800 acres
Oilseeds & Pulses	2,000 acres
M. aus & aman	1,000 acres

TABLE IV-83

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 19

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	265	5,300
Compacting Embankment	% cu.ft.	18	461	8,292
Brick Masonry	% cu.ft.	2,400	574	1,377,600
Brick Lining	% sq.ft.	750	54	40,500
Plastering Brick Work	% sq.ft.	250	314	78,500
Concrete Class A	% cu.ft.	3,500	30	105,000
Concrete Class B.	% cu.ft.	3,200	112	358,400
Flap Gate	each	15,000	3	45,000
Slide Gate and Hoist	each	35,000	3	105,000
Fall Board	sq.ft.	80	400	32,000
			Sub-total	2,155,598
		Contingencies (15%)		323,402
			FAR Cost	2,479,000

TABLE IV-84

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 19

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Brick	thousand	800	665	532,000
Sand	% cu.ft.	300	261	78,300
Cement	bag	80	4,030	322,400
Chips	% cu.ft.	780	128	99,840
Flap Gate	each	15,000	3	45,000
Vertical Slide Gate and Hoist	each	35,000	3	105,000
Fall Board	sq.ft.	80	400	32,000
			Total	1,214,540

TABLE IV-85

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 20

Irrigated	Non-Irrigated
Boro (HYV) - B. aman (L)	B. aus (L) - T. aman (L)
Boro (HYV) - T. aman (HYV)	B. aus (L) - Vegetables
Wheat - Jute - T. aman (HYV)	B. aus (L) - Pulses
Vegetable - T. aus (HYV)	
T. aman (HYV)	Jute - T. aman (L)
	Wheat - Jute
	Wheat - B. aus (L)
	Mustard - Jute
	Mustard - B. aus (L)
	Potato - Jute
	Potato - B. aus (L)
	B. aman (L) - Kheshari
	B. aman (L)

TABLE IV-86

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 20

Irrigated Area		Non-Irrigated Area	
Crops	Area (acres)	Crops	Area (acres)
Boro (HYV)	20	B. aus (L)	25
Wheat	5	T. aman (L)	20
Vegetable	2	Jute	15
T. aman (HYV)	15	B. aman (L)	25
B. aman (L)	10	Wheat	10
Jute	5	Pulses	10
T. aus (HYV)	5	Kheshari	15
		Mustard	5

TABLE IV-87

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 20

Land Type	Recommended Cropping Patterns
Highland	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Vegetables - T. aus (HYV)
	Vegetable - Jute
	Oilseeds - T. aus (HYV)
	Oilseeds - Jute
	Pulses - T. aus (HYV)
	Pulses - Jute
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
Medium Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-88

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 20

Crop	Highland Area (acres)	Medium Highland Area (acres)	Medium Lowland Area (acres)
Wheat (HYV)	40	32	
Vegetables	5		
Pulses	10		
Oilseeds	10		
Boro (HYV)			19
T. aus (HYV)	30	16	
Jute	10	10	
T. aman (HYV)		22	
T. deep water aman			19

TABLE IV-89

MATERIALS SUMMARY: SUB-PROJECT NO. 20

Material	Quantity
Brick	414 thousand
Cement	2,000 bags
Sand	130 ¾ cu.ft.
Chips	13 ¾ cu.ft.
Concrete Pipe	12 lin.ft.
Wood Stop-checks	32 ea.
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ea.
1899 Mild Steel Weir Gage, Enamelled	1 ea.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ea.

TABLE IV-90

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 21

Irrigated	Non-Irrigated
None	B. aus (L) - T. aman (HYV) B. aus (L) - T. aman (HYV) Pulses Wheat - Jute - T. aman (HYV) Boro (L)

TABLE IV-91

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 21

Irrigated	Non-Irrigated	
	Crops	Area (Acres)
None	Boro (L)	10
	B. aus (L)	70
	Jute	20
	T. aman (HYV)	65
	Wheat	10
	Pulses	25

TABLE IV-92

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 21

Land Type	Recommended Cropping Patterns
Highland	
Higher Phase	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Oilseeds - T. aus (HYV)
	Oilseeds - Jute
	Pulses - T. aus (HYV)
	Pulses - Jute
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
Lower Phase	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)
Medium Highland	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)

TABLE IV-93

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 21

Crops	Highland		Medium Highland
	Higher Phase Area (acres)	Lower Phase Area (acres)	Area (acres)
Wheat (HYV)	46	34	
Oilseeds	10	5	
Pulses	10	5	
Boro (HYV)			12
T. aus (HYV/LIV)	35	25	4
Jute	15	5	
T. aman (HYV/LIV)	44	29	12

TABLE IV-94

MATERIALS SUMMARY: SUB-PROJECT NO. 21

Material	Quantity
Brick	340 thousand
Cement	1,600 bags
Sand	100 % cu.ft.
Chips	10 % cu.ft.
Concrete Pipe	lin.ft.
Wood Stop-checks	29 ea.
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ea.
1899 Mild Steel Weir Gage, Enamelled	1 ea.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ea.

TABLE IV-95

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 22

Irrigated	Non-Irrigated
Boro (HYV) - T. aman (HYV)	Wheat - B. aus (L) - T. aman (L)
Wheat - T. aman (HYV)	Tobacco - B. aus (L) - T. aman (L)
Tobacco - T. aman (HYV)	Jute - T. aman (L)
	B. aus (L) - T. aman (L)

TABLE IV-96

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 22

Irrigated Area		Non-Irrigated Area	
Crops	Area (acres)	Crops	Area (acres)
Boro (HYV)	20	Wheat	20
Wheat	8	Tobacco	25
Tobacco	12	B. aus (L)	35
T. aman (HYV/L)	40	Jute	10
		T. aman (L)	50

TABLE IV-97

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 22

Land Type	Recommended Cropping Patterns
Highland	
Higher Phase	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Tobacco - T. aus (HYV) - T. aman (HYV)
Lower Phase	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)

TABLE IV-98

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 22

Crop	Highland (Higher Phase) Area (acres)	Highland (Lower Phase) Area (acres)
Wheat (HYV)	25	39
Tobacco	20	
Pulses	5	5
Oilseeds	5	5
Boro		20
T. aus (HYV/LIV)	30	23
Jute	10	10
T. aman (HYV/LIV)	37	53

TABLE IV-99

MATERIALS SUMMARY: SUB-PROJECT NO. 22

Materials	Quantity
Brick	432 thousand
Cement	2,100 bags
Sand	130 ¾ cu.ft.
Chips	13 ¾ cu.ft.
Concrete Pipe	24 lin.ft.
Wood Stop-checks	36 each
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ea.
1899 Mild Steel Weir Gage, Enamelled	1 ea.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ea.

TABLE IV-100

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 23

Irrigated	Non-irrigated
Boro (HYV)	B. aus - T. aman (L)
Boro (HYV) - T. aman (HYV)	Wheat - Jute
Wheat - Jute	Tobacco - Jute
Tobacco - Jute	Aus (L) - Mustard
Sugarcane	T. aus (L) - Pulses
	T. aus (L) - Follow

TABLE IV-101

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 23

Irrigated Area		Non-irrigated Area	
Crops	Area (acres)	Crops	Area (acres)
Boro (HYV)	35	T. aus (L)	18
Wheat	20	B. aus (L)	18
Tobacco	10	Wheat	12
Jute	30	Pulses	6
T. aman (L)	15	Mustard	6
Sugarcane	4	Jute	15
		T. aman (L)	12

TABLE IV-102

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 23

Land Type	Recommended Cropping Patterns
Highland	
Higher Phase	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Pulses - T. aus (HYV)
	Pulses - Jute
	Oilseeds - T. aus (HYV)
	Oilseeds - Jute
	Tobacco - T. aus (HYV)
	Tobacco - Jute
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Tobacco - T. aus (HYV) - T. aman (YYV)
	Tobacco - Jute - T. aman (HYV)
	Sugarcane
Lower Phase	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Pulses - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Boro (HYV) - T. aus (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)

TABLE IV-103

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 2

Crop	Highland	
	Higher Phase Area (acres)	Lower Phase Area (acres)
Wheat (HYV)	49	16
Oilseeds	10	5
Pulses	10	5
Tobacco	15	
Boro		15
T. aus (HYV/LIV)	30	26
Jute	15	5
T. aman (HYV/LIV)	60	32
Sugarcane	5	

TABLE IV-104

MATERIALS SUMMARY: SUB-PROJECT NO. 23

Material	Quantity
Brick	413 thousand
Cement	3,600 bags
Sand	200 ⅞ cu.ft.
Chips	15 ⅞ cu.ft.
Concrete Pipe	72 lin.ft.
Wood Stop-checks	38 ea.
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade 6" x 36"	1 ea.
1899 Mild Steel Weir Gage, Enamelled	1 ea.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ca.

TABLE IV-105

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 24

Irrigated	Non-irrigated
Boro (H) - 1 aus (H) - T. aman (H)	Boro (L)
Boro (H) - Jute - T. aman (H)	B. aus - T. aman (L&H) Jute - T. aman (L&H)
Wheat - B. aus - T. aman (H)	Mixed aus & aman

TABLE IV-106

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 24

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops Sugarcane
	T. aus (HYV) - T. aman (HYV/LIV) Jute - T. aman (HYV/LIV)
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV) Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV) Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops B. aman - Rabi crops Boro

TABLE IV-107

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 24

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	318	6,360
Compacting Equipment	% cu.ft.	18	188	3,384
Brick Masonry	% cu.ft.	2,400	108	259,200
Brick Lining	% sq.ft.	750	7	5,250
Plastering Brick Work	% sq.ft.	250	22	5,500
Concrete Class A	% cu.ft.	3,500	16	56,000
Concrete Class B	% cu.ft.	3,200	16	51,200
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	5	35,000
Fall Board	sq.ft.	80	196	15,680
			Sub-Total	452,574
			Contingencies (15%)	67,426
			FAR Cost	520,000

TABLE IV-108

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 24

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Bricks	thousand	800	124	99,200
Sand	¾ cu.ft.	300	52	15,600
Cement	bag	80	1,015	81,200
Chips	¾ cu.ft.	780	33	25,740
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	5	35,000
Fall Board	sq.ft.	80	196	15,680
			Total	287,420

TABLE IV-109

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 25

Irrigated	Non-irrigated
Boro (H) - T. aman (L&H)	Wheat - Aus (L)
Wheat - Mixed aus & aman	Pulses - Aus (L)
T. aman - Pulses	Wheat - Jute
T. aman - Tobacco	Oilseeds - Jute
Sugarcane	Boro (L)
Wheat	Sugarcane
	Mixed aus & aman

TABLE IV-110

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 25

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV) - Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-111

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 25

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	145	2,900
Compacting Embankment	% cu.ft.	18	1,040	18,720
Brick Masonry	% cu.ft.	2,400	172	412,800
Brick Lining	% sq.ft.	750	20	15,000
Plastering Brick Work	% sq.ft.	250	30	7,500
Concrete Class A	% cu.ft.	3,500	7	24,500
Concrete Class B	% cu.ft.	3,200	28	89,000
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	1	35,000
Fall Board	sq.ft.	80	231	18,480
			Sub-total	639,500
			Contingencies (15%)	95,500
			FAR Cost	735,000

TABLE IV-112

CONSTRUCTION MATERIALS: SUB-PROJECT NO. 25

Item	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Bricks	thousand	800	203	162,400
Sand	% cu.ft.	300	74	22,200
Cement	Bags	80	1,218	97,200
Chips	% cu.ft.	780	33	25,740
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	1	35,000
Fall Board	sq.ft.	80	231	18,480
			Total	376,260

TABLE IV-113

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 20

Irrigated	Non-Irrigated
None	B. aus - T. aman
	Jute - T. aman
	Boro (L)
	Wheat - B. aus
	Oilseed - Jute - T. aman

TABLE IV-114

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 26

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV) Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

TABLE IV-115

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 26

Item	Unit	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	966	19,320
Compacting Embankment	% cu.ft.	18	346	6,228
Brick Masonry	% cu.ft.	2,400	333	799,200
Brick Lining	% sq.ft.	750	20	15,000
Plastering Brick Work	% sq.ft.	250	41	10,250
Concrete Class A	% cu.ft.	3,500	17	59,000
Concrete Class B	% cu.ft.	3,200	80	256,000
Flap Gate	each	15,000	4	60,000
Slide Gate and Hoist	each	35,000	4	140,000
Fall Board	sq.ft.	80	360	28,800
			Sub-total	1,394,298
		Contingencies (15%)		209,702
			FAR Cost	1,604,000

TABLE IV-116

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 26

Item	Unit	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Bricks	thousand	800	383	306,400
Sand	% cu.ft.	300	160	48,000
Cement	bag	80	3,000	240,000
Chips	% sq.ft.	780	90	70,200
Flap Gate	each	15,000	4	60,000
Slide Gate and Hoist	each	35,000	4	140,000
Fall Board	sq.ft.	80	360	28,800
			Total	893,400

TABLE IV-117

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 27

Irrigated	Non-Irrigated
Boro (HYV)	Mixed aus & aman
	Mixed aus & aman
	Wheat - Jute
	Mustard - Jute

TABLE IV-118

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 27

Irrigated Area		Non-Irrigated Area	
Crop	Area (acres)	Crop	Area (acres)
Boro (HYV)	60	Mixed aus & aman	35
		Jute	10
B. aman (L)		Wheat	20
		Mustard	5

TABLE IV-119

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 27

Land Type	Recommended Cropping Patterns
Lowland	Boro (HYV)
	Boro (HYV) - deep water aman
Medium Lowland	(Lower) Boro (HYV) - deep water aman
	(Higher) Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Mustard - T. aus (HYV)
	Khesari - T. aus (HYV)
	Khesari - Jute
Medium Highland	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Mustard - T. aus (HYV)
	Mustard - Jute
	Khesari - T. aus (HYV)
	Khesari - Jute

TABLE IV-120

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 27

Crop	Medium Highland Area (acres)	Medium Lowland Area (acres)	Lowland Area (acres)
Wheat (HYV)	24	40	
Mustard	10	20	
Boro (HYV)			29
T. aus (HYV)	34		
Jute		10	
Mixed aus and aman[1]		50	
T. deep water aman			29

[1] For this example, crop intensity was increased by suggesting the addition of mixed aus and aman on 50 acres, since irrigation water was only available for 34 acres of T. aus and the timing and depth of flooding prevents the use of ordinary varieties of T. aman

TABLE IV-121

MATERIALS SUMMARY: SUB-PROJECT NO. 27

Materials	Quantity
Brick	430 thousand
Cement	2,100 bags
Sand	9,000 cu.ft.
Chips	1,000 cu.ft.
Concrete Pipe	12 lin.ft.
Wood Stop-checks	35 each
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade - 6" x 36"	1 ca.
1899 Mild Steel Weir Gage, Enamelled	1 ca.
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 ca.

TABLE IV-122

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 28

Irrigated	Non-Irrigated
Boro (H) - Jute	Wheat - Mixed aus & aman
Boro (H) - T. aman	Pulses - Mixed aus & aman
Boro (H) - Vegetables	Jute - Oilseeds
Wheat - T. aman	Boro (L)
Boro	B. aus (L)
B. aus - Oilseeds	Mixed aus & aman

TABLE IV-123

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 28

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder-Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV) Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-124

RECOMMENDED CROPPING PATTERNS WITH FLOOD CONTROL

AND WITH IRRIGATION: SUB-PROJECT NO. 28

Land Type	Recommended Cropping Pattern
Highland	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

TABLE IV-125

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 29

Irrigated	Non-Irrigated
Boro - T. aman (HYV)	Mixed aus & aman
Wheat - T. aman (HYV)	Mixed aus & aman - Khesari
Mustard - T. aman (HYV)	Jute - T. aman (L)
	Wheat - Jute
	Mustard - Jute

TABLE IV-126

ACREAGE OF CROPS IN EXISTING CROPPING PATTERNS:

SUB-PROJECT NO. 29

Irrigated		Non-Irrigated	
Crops	Area (acres)	Crops	Area (acres)
Boro (HYV)	8	Mixed aus and aman	37
Wheat	3	T. aman (L)	10
Mustard	1	Jute	10
T. aman (HYV)	12	Mustard	5
		Wheat	10
		Khesari	5

TABLE IV-127

RECOMMENDED CROPPING PATTERNS WITH SUB-PROJECT DEVELOPMENT

FOR DIFFERENT LAND TYPES: SUB-PROJECT NO. 29

Land Type	Recommended Cropping Patterns
Highland	Wheat (HYV) - T. aus (HYV)
	Wheat (HYV) - Jute
	Oilseeds - T. aus (HYV)
	Oilseeds - Jute
	Potatoes - T. aus (HYV)
	Potatoes - Jute
	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Wheat (HYV) - Jute - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Oilseeds - Jute - T. aman (HYV)
	Potatoes - T. aus (HYV) - T. aman (HYV)
	Potatoes - Jute - T. aman (HYV)
Medium Highland	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV)

TABLE IV-128

ACREAGE OF CROPS IN RECOMMENDED CROPPING PATTERNS:

SUB-PROJECT NO. 29

Crops	Highland Area (acres)	Medium Highland Area (acres)
Wheat (HYV)	49	
Oilseeds	10	
Potatoes	2	
Boro (HYV)		17
T. aus (HYV/LIV)	51	6
Jute	10	
T. aman (HYV/LIV)	41	

TABLE IV-129

MATERIALS SUMMARY: SUB-PROJECT NO. 29

Materials	Quantity
Brick	230 thousand
Cement	1,100 bags
Sand	71 ¾ cu.ft.
Chips	8 ¾ cu.ft.
Concrete Pipe	lin.ft.
Wood Stop-checks	16 each
3/8" Ø Mild Steel Rod	40 ft.
12 ga. Mild Steel Weir Blade 6" x 36"	1 each
1899 Mild Steel Weir Gage, Enamelled	1 each
1" Ø P.V.C. Pipe	4 ft.
1" P.V.C. Elbows	4 each

TABLE IV-130

EXISTING IRRIGATED AND NON-IRRIGATED CROPPING PATTERNS:

SUB-PROJECT NO. 30

Irrigated	Non-Irrigated
Boro (H) - T. aman (L)	Wheat - Jute
Boro (H) - T. aman (L) - Oilseeds	Oilseeds - Jute
Jute - T. aman	Oilseeds - B. aus and aman
Jute - T. aman - Oilseeds	B. aman & aus - Pulses
	Jute - T. aman

TABLE IV-131

RECOMMENDED CROPPING PATTERNS WITH DRAINAGE

BUT WITHOUT IRRIGATION: SUB-PROJECT NO. 30

Land Type	Recommended Cropping Pattern
Highland	Line sown aus (HYV) - Rabi crops
	Jute - Rabi crops
	Line sown aus (HYV) - Fodder - Rabi crops
	Sugarcane
	T. aus (HYV) [1] - T. aman (HYV/LIV) [2]
	Jute - T. aman (HYV/LIV) [2]
Medium Highland	T. aus (HYV/LIV) - T. aman (HYV/LIV)
	Jute - T. aman (HYV/LIV)
	T. aus (HYV/LIV) - T. aman (HYV/LIV) Rabi crops
	Jute - T. aman (HYV/LIV) - Rabi crops
Medium Lowland and Lowland	Mixed aus and aman - Rabi crops
	B. aman - Rabi crops
	Boro

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-132

RECOMMENDED CROPPING PATTERNS WITH DRAINAGE AND IRRIGATION

Land Type	Recommended Cropping Pattern
Highland	Wheat (HYV) - T. aus (HYV)
	Pulses - T. aus (HYV)
	Oilseeds - T. aus (HYV)
	Tobacco - T. aus (HYV)
	Vegetables - T. aus (HYV)
	Sugarcane
Medium Highland	Wheat (HYV) - T. aus (HYV) - T. aman (HYV)
	Pulses - T. aus (HYV) - T. aman (HYV)
	Oilseeds - T. aus (HYV) - T. aman (HYV)
	Vegetables - T. aus (HYV) - T. aman (HYV)
	Boro (HYV) - T. aman (HYV)
	Boro (HYV) - T. aus (HYV/LIV) - T. aman (LIV) (Limited Area)
Medium Lowland and Lowland	Boro (HYV)
	Boro (HYV) - T. deep water aman

[1] May need supplemental irrigation in case of drought

[2] Where water depth is suitable

TABLE IV-133

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 30

Items	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Excavation	% cu.ft.	20	1,372	27,440
Compacting Embankment	% cu.ft.	18	274	4,932
Brick Masonry	% cu.ft.	2,400	138	331,200
Brick Lining	% sq.ft.	750	29	21,750
Plastering Brick Work	% sq. ft.	250	33	8,250
Concrete Class A	% cu.ft.	3,500	32	112,000
Concrete Class B.	% cu.ft.	3,200	12	38,400
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	1	35,000
Stop Logs	sq.ft.	80	217	17,360
			Sub-total	611,332
			Contingencies (15%)	91,668
			FAR Cost	703,000

TABLE IV-134

QUANTITY AND COST SUMMARY: SUB-PROJECT NO. 30

Items	Units	Unit Cost (Tk)	Quantity	Total Cost (Tk)
Bricks	thousand	800	167	133,600
Sand	¾ cu.ft.	300	66	19,800
Cement	bag	80	1,410	112,800
Chips	¾ cu.ft.	780	40	31,200
Flap Gate	each	15,000	1	15,000
Slide Gate and Hoist	each	35,000	1	35,000
Stop Logs	sq.ft.	80	217	17,360
			Total	364,760

TABLE IV-135

SUMMARY OF SUB-PROJECT COSTS

District	Thana	Sub-Project Number	Estimated FAR Cost (Tk)
Chittagong	Patia	1	731,000
	Hathazari	2	1,202,000
Dacca	Saturia	5	1,524,000
	Savar	6	967,000
	Palash	9	1,438,000
Khulna	Kalaroa	10	932,000
	Sadar	11	748,000
	Bagerhat	13	2,069,000
	Fakirhat	14	479,000
	Sarankhola	15	1,633,000
Rajshahi	Bagatipari	17	1,219,000
	Gomostapur	19	2,479,000
	Gurudaspur	20	996,000
Rangpur	Jaldhaka	21	934,000
	Kotwali	22	1,129,000
	Ulipur	23	1,144,000
	Gaibanda	24	520,000
	Badarganj	25	735,000
	Nageswari	26	1,604,000

(continued)

TABLE IV-135
(continued)

District	Thana	Sub-Project Number		Estimated FAR Cost (Tk)
Tangail	Basail	27		1,117,000
	Tangail	28		117,000
	Nagarpur	29		600,000
	Pathrail	30		703,000
			Total	25,020,000

TABLE IV-136

LIST, SOURCE, AND COST OF REQUIRED MATERIALS:

CHITTAGONG DISTRICT

Materials	Source	Unit	Price (Tk)
Bricks - 1st Class	Chittagong	1,000	800
Bricks - Picked Jhama	"	1,000	800
Cement	"	cwt	80
Steel Reinforcing Bars	"	cwt	525
Sand - Sylhet (F.M. of 2.500)	Sylhet	100 cu.ft.	400
Sand - Local (F.M. of 1.80)	Chittagong	100 cu.ft.	325
Khoa for Concrete	Chittagong	100 cu.ft.	780
Form Lumber	"	sq.ft.	7
Reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	120
15-inch diameter	"	lin.ft.	170
18-inch diameter	"	lin.ft.	250
24-inch diameter	"	lin.ft.	400
Non-reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	100
15-inch diameter	"	lin.ft.	150
18-inch diameter	"	lin.ft.	220
24-inch diameter	"	lin.ft.	360
Vertical Lift Gates	"	each	30,000
Timber Flap Gates	"	each	30,000
Wooden Stoplogs	"	sq.ft.	70

TABLE IV-137

LIST, SOURCE, AND COST OF REQUIRED MATERIALS:

DACCA DISTRICT

Materials	Source	Unit	Price (Tk)
Bricks - 1st Class	Manikganj	1,000	800
Bricks - Picked Jhama	"	1,000	800
Cement	Dacca	cwt	80
Steel Reinforcing Bars	"	cwt	525
Sand - Sylhet (F.M. of 2.50)	Sylhet	100 cu.ft.	400
Sand - Local (F.M. of 1.80)	Dacca	100 cu.ft.	325
Khoa for Concrete	"	100 cu.ft.	780
Form Lumber	"	sq.ft.	7
Reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	120
15-inch diameter	"	lin.ft.	170
18-inch diameter	"	lin.ft.	250
24-inch diameter	"	lin.ft.	400
Non-reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	100
15-inch diameter	"	lin.ft.	150
18-inch diameter	"	lin.ft.	220
24-inch diameter	"	lin.ft.	360
Vertical Lift Gates	"	each	30,000
Timber Flap Gates	"	each	20,000
Wooden Stoplogs	"	sq.ft.	70

TABLE IV-138

LIST, SOURCE, AND COST OF REQUIRED MATERIALS:

KHULNA DISTRICT

Materials	Source	Unit	Price (Tk)
Bricks - 1st Class	Khulna	1,000	850
Bricks - Picked Jhama	Khulna	1,000	850
Cement	Dacca	cwt.	80
Steel Reinforcing Bars	Dacca	cwt.	525
Sand - Sylhet (F.M. of 2.50)	Sylhet	100 cu.ft.	400
Sand - Local (F.M. of 1.80)	Khulna	100 cu.ft.	350
Khoa for Concrete	Khulna	100 cu.ft.	800
Form Lumber	Khulna	sq.ft.	10
Reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	120
15-inch diameter	"	lin.ft.	170
18-inch diameter	"	lin.ft.	250
24-inch diameter	"	lin.ft.	400
Non-reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	100
15-inch diameter	"	lin.ft.	150
18-inch diameter	"	lin.ft.	220
24-inch diameter	"	360	360
Vertical Lift Gates	"	each	30,000
Timber Flap Gates	"	each	20,000
Wooden Stoplogs	"	sq.ft.	70

TABLE IV-139

LIST, SOURCE, AND COST OF REQUIRED MATERIALS:

RAJSHAHI DISTRICT

Materials	Source	Unit	Price (Tk)
Bricks - 1st Class	Rajshahi	1,000	850
Bricks - Picked Jhama	"	1,000	850
Cement	Dacca	cwt.	80
Steel Reinforcing Bars	Dacca	cwt.	525
Sand - Sylhet (F.M. of 2.50)	Sylhet	100 cu.ft.	400
Sand - Local (F.M. of 1.80)	Rajshahi	100 cu.ft.	350
Khoa for Concrete	"	100 cu.ft.	800
Form Lumber	"	sq.ft.	10
Reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	120
15-inch diameter	"	lin.ft.	170
18-inch diameter	"	lin.ft.	250
24-inch diameter	"	lin.ft.	400
Non-reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	100
15-inch diameter	"	lin.ft.	150
18-inch diameter	"	lin.ft.	220
24-inch diameter	"	lin.ft.	360
Vertical Lift Gates	"	each	30,000
Timber Flap Gates	"	each	20,000
Wooden Stoplogs	"	sq.ft.	70

TABLE IV-140

LIST, SOURCE, AND COST OF REQUIRED MATERIALS:

RANGPUR DISTRICT

Materials	Source	Unit	Price (Tk)
Bricks - 1st Class	Rangpur	1,000	860
Bricks - Picked Jhama	"	1,000	860
Cement	Dacca	cwt.	80
Steel Reinforcing Bars	"	cwt.	525
Sand - Sylhet (F.M. of 2.50)	Sylhet	100 cu.ft.	400
Sand - Local (F.M. of 1.80)	Rangpur	100 cu.ft.	360
Khoa for Concrete	"	100 cu.ft.	800
Form Lumber	"	sq.ft.	9
Reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	120
15-inch diameter	"	lin.ft.	170
18-inch diameter	"	lin.ft.	250
24-inch diameter	"	lin.ft.	400
Non-reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	100
15-inch diameter	"	lin.ft.	150
18-inch diameter	"	lin.ft.	220
24-inch diameter	"	lin.ft.	360
Vertical Lift Gates	"	each	30,000
Timber Flap Gates	"	each	20,000
Wooden Stoplogs	"	sq.ft.	70

TABLE IV-141

LIST, SOURCE, AND COST OF REQUIRED MATERIALS:

TANGAIL DISTRICT

Materials	Source	Unit	Price (Tk)
Bricks - 1st Class	Tangail	1,000	800
Bricks - Picked Jhama	"	1,000	800
Cement	Dacca	cwt.	80
Steel Reinforcing Bars	"	cwt.	525
Sand - Sylhet (F.M. of 2.50)	Sylhet	100 cu.ft.	400
Sand - Local (F.M. of 1.80)	Tangail	100 cu.ft.	325
Khoa for Concrete	"	100 cu.ft.	780
Form Lumber	"	sq.ft.	7
Reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	120
15-inch diameter	"	lin.ft.	170
18-inch diameter	"	lin.ft.	250
24-inch diameter	"	lin.ft.	400
Non-reinforced Concrete Pipe:			
12-inch diameter	Dacca	lin.ft.	100
15-inch diameter	"	lin.ft.	150
18-inch diameter	"	lin.ft.	220
24-inch diameter	"	lin.ft.	360
Vertical Lift Gates	"	each	30,000
Timber Flap Gates	"	each	20,000
Wooden Stoplogs	"	sq.ft.	70

TABLE IV-142

RECOMMENDED CONSTRUCTION SCHEDULE

District	Construction Year No. 1 (1981-82)	Construction Year No. 2 (1982-83)	Construction Year No. 3 (1983-84)
Chittagong	S/P 1 & 2		
Dacca	S/P 9	S/P 5	S/P 6
Khulna	S/P 10	S/P 13 & 14	S/P 11 & 15
Rajshahi	S/P 17 & 20	S/P 19	
Rangpur	S/P 22 & 25	S/P 21	S/P 23
		S/P 24	S/P 26
Tangail		S/P 27	S/P 29
		S/P 28	S/P 30
Number of Contracts	5	7	7

TABLE IV-143

UNITS RECOMMENDED FOR CONSTRUCTION DURING FIRST YEAR

District	Thana	Sub-Project Number	FAR Cost (Tk)
Chittagong	Patiya	1	732,000
	Hathazari	2	1,202,000
Dacca	Palash	9	1,438,000
Khulna	Kalaroa	10	932,000
Rajshahi	Bagatipara	17	1,219,000
	Gurudaspur	20	996,000
Rangpur	Kotwali	22	1,129,000
	Badarganj	25	735,000

TABLE IV-144

SUB-PROJECT COST - CONTRACT NO. 1

District: Chittagong

Scope of Contract: Construct Patiya and Hathazari Sub-projects, Nos. 1 and 2, respectively

Construction Schedule

Award Contract: July 1981

Commence work: October 1981

Complete work: April 1982

Item	Taka
FAR Cost - December 1979	
Sub-project No. 1 - Patiya	732,000
Sub-project No. 2 - Hathazari	1,202,000
Sub-total	1,934,000
MRD Staff Cost	
Engineering during Construction (1.5%)	29,000
Construction Supervision and Administration (4.5%)	87,000
Sub-project Cost - December 1979	2,050,000
Allowance for Inflation (1.5% per month x 19)	584,000
Sub-project Cost - July 1981	2,634,000

TABLE IV-145

SUB-PROJECT COST - CONTRACT NO. 2

District: Dacca

Scope of Contract: Construct Sub-project No. 9 - Palash

Construction Schedule

Award Contract: July 1981

Commence work: October 1981

Complete work: April 1982

Item	Taka
FAR Cost - December 1979	1,438,000
MRD Staff Cost	
Engineering during Construction (1.5%)	21,600
Construction Supervision and Administration (4.5%)	64,800
Sub-project Cost - December 1979	1,524,400
Allowance for Inflation (1.5% per month x 19)	434,000
Sub-project Cost - July 1981	1,958,400

TABLE IV-146

SUB-PROJECT COST - CONTRACT NO. 3

District: Khulna

Scope of Contract: Construct Sub-project No. 10 - Kalaroa

Construction Schedule

Award Contract: July 1981

Commence work: October 1981

Complete work: April 1982

Item	Taka
FAR Cost - December 1979	932,000
MRD Staff Cost	
Engineering during Construction (1.5%)	13,980
Construction Supervision and Administration (4.5%)	41,940
Sub-project Cost - December 1979	987,920
Allowance for Inflation (1.5% per month x 19)	281,577
Sub-project Cost - July 1981	1,269,477

TABLE IV-147

SUB-PROJECT COST - CONTRACT NO. 4

District: Rajshahi

Scope of Contract: Construct Bagatipara and Gurudaspur Sub-projects, Nos. 17 and 20, respectively

Construction Schedule

Award Contract: July 1981

Commence work: October 1981

Complete work: April 1982

Item	Taka
FAR Cost - December 1979	
Sub-project No. 17 - Bagatipara	1,219,000
Sub-project No. 20 - Gurudaspur	996,000
Sub-total	2,215,000
MRD Staff Cost	
Engineering during Construction (1.5%)	33,200
Construction Supervision and Administration (4.5%)	99,600
Sub-project Cost - December 1979	2,347,800
Allowance for Inflation (1.5% per month x 19)	669,000
Sub-project Cost - July 1981	3,016,800

TABLE IV-148

SUB-PROJECT COST - CONTRACT NO. 5

District: Rangpur

Scope of Contract: Construct Kotwali and Badarganj Sub-projects Nos. 22 and 25, respectively

Construction Schedule

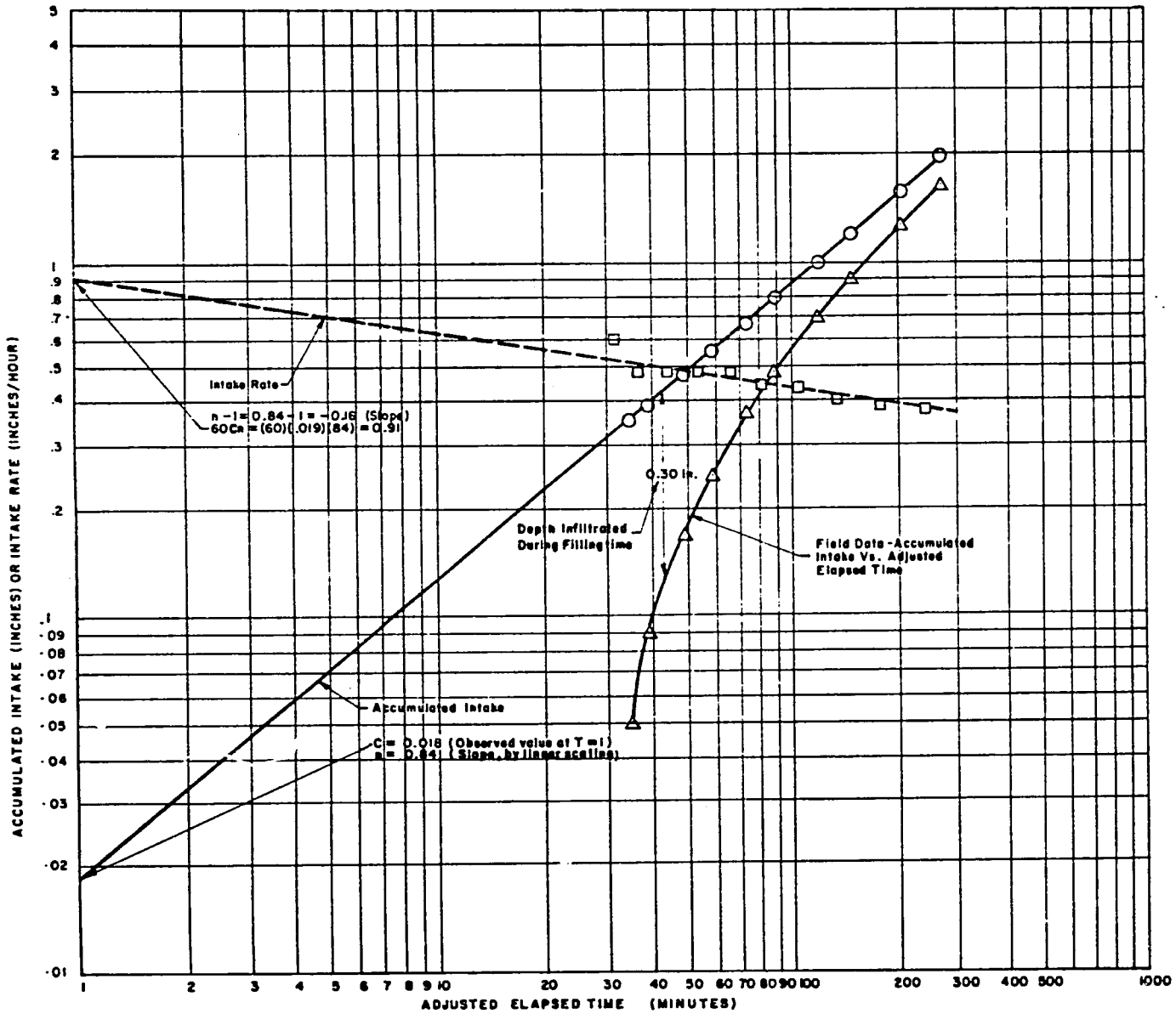
Award Contract: July 1981

Commence work: October 1981

Complete work: April 1982

Item	Taka
FAR Cost - December 1979	
Sub-project No. 22 - Kotwali	1,129,000
Sub-project No. 25 - Badargonj	735,000
Sub-total	1,864,000
MRD Staff Cost	
Engineering during Construction (1.5%)	28,000
Construction Supervision and Administration (4.5%)	84,000
Sub-project Cost - December 1979	1,976,000
Allowance for Inflation (1.5% per month x 19)	563,000
Sub-project Cost - July 1981	2,539,000

FIGURE IV-1



C = 0.018
n = .84
n-1 = - .16
60Cn = .91

DEPTH INFLTRATED DURING FILLING TIME = .30 INCHES

NOTES :

PROJECT PUCCA DRAIN FOR KAWANARA IRRIGATION PROJECT
THANA SATURIA
DISTRICT DACCA
TEST NO 3
LEGEND
FIELD DATA
ACCUMULATED INTAKE
INTAKE RATE
CALCULATED INTAKE RATE

INTAKE CURVES

FIGURE IV-2

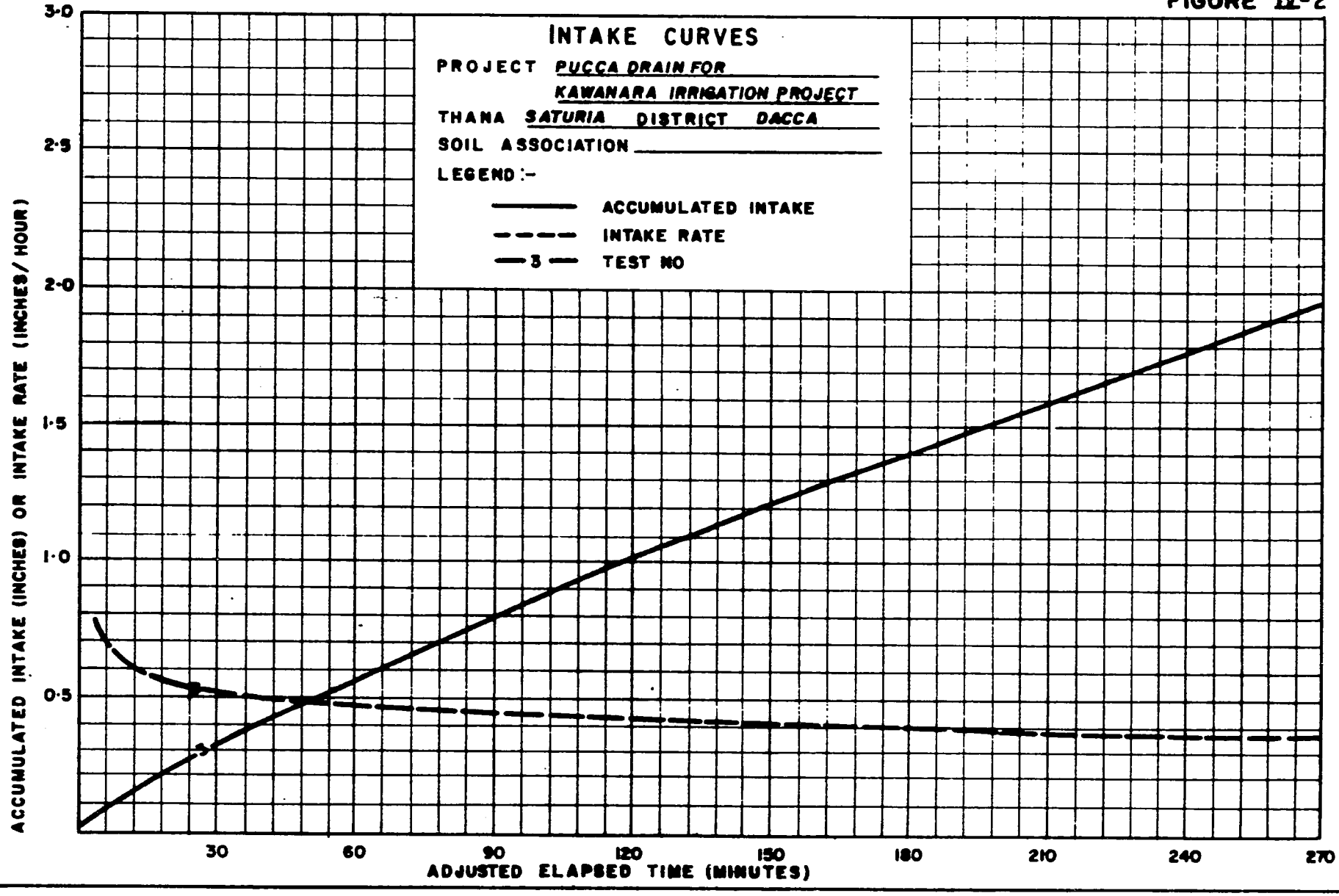
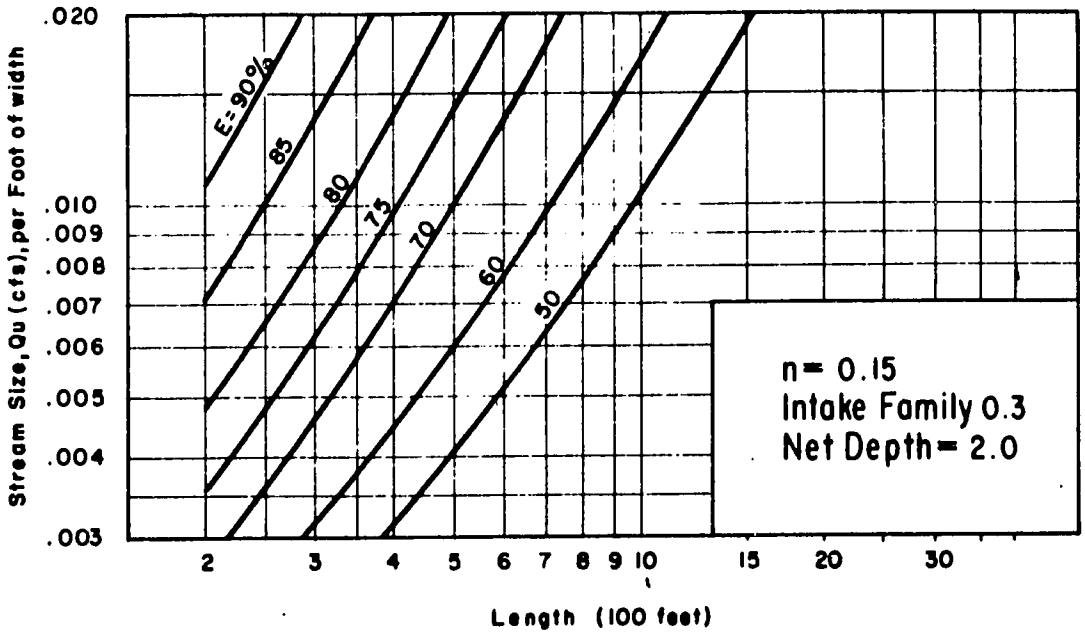

INTAKE CURVES
PROJECT PUCCA DRAIN FOR
KAWANARA IRRIGATION PROJECT
THANA SATURIA DISTRICT DACCA
SOIL ASSOCIATION
LEGEND :-
ACCUMULATED INTAKE
INTAKE RATE
3 TEST NO
ACCUMULATED INTAKE (INCHES) OR INTAKE RATE (INCHES/HOUR)
3·0
2·5
2·0
1·5
1·0
0·5
30
60
90
120
150
180
210
240
270
ADJUSTED ELAPSED TIME (MINUTES)

FIGURE IV-3

BASIN DESIGN CHARTS



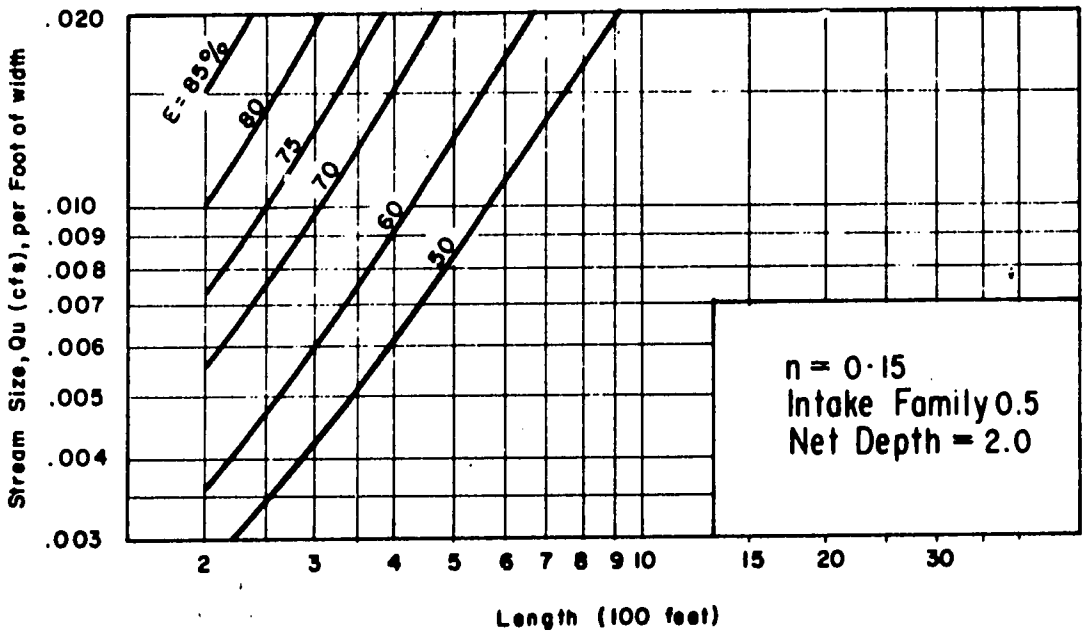


FIGURE IV-4

CROPPING PATTERNS

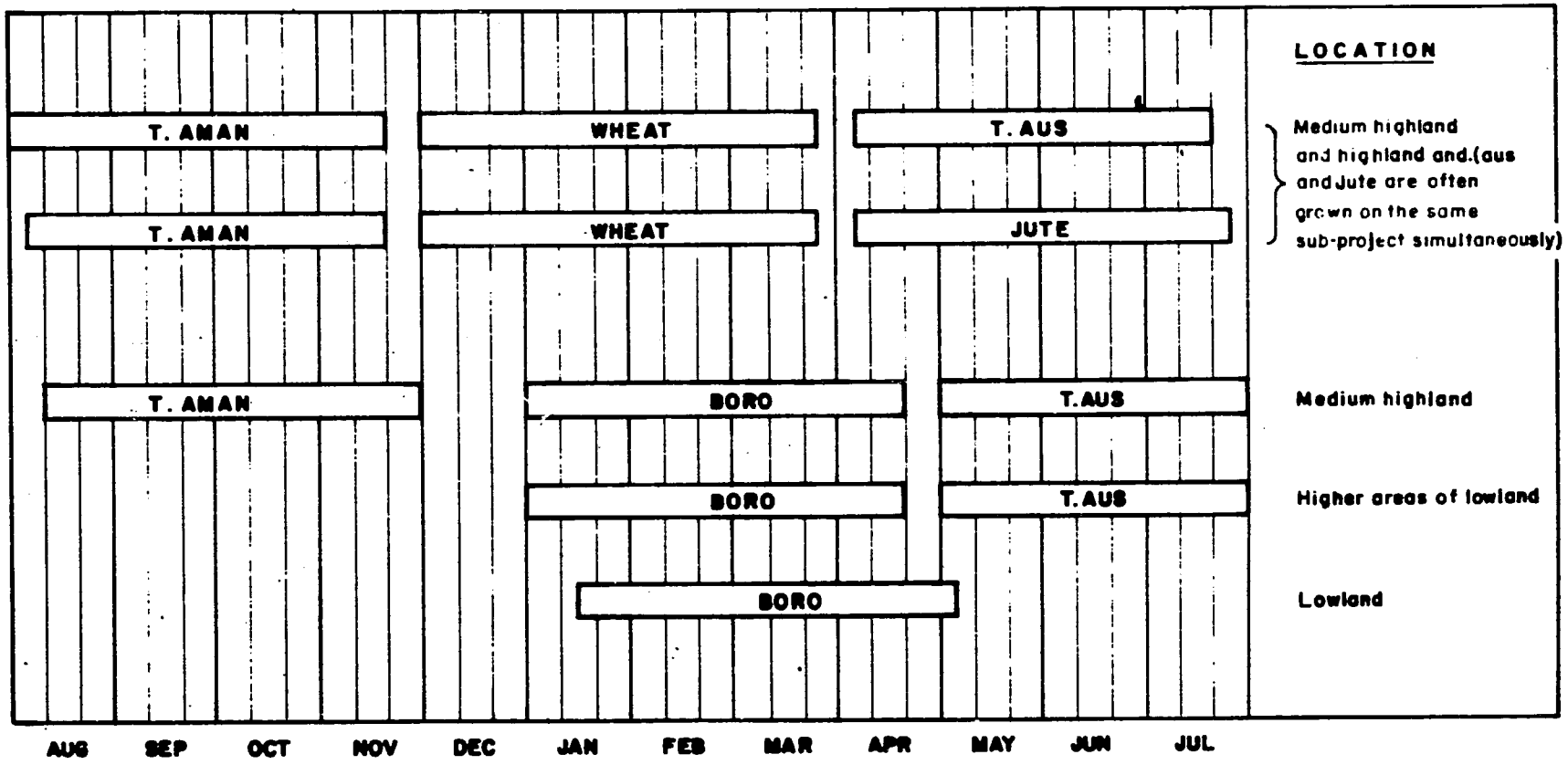


FIGURE IV-5

CROP COEFFICIENTS (kc) FOR WHEAT-BASED CROPPING PATTERN

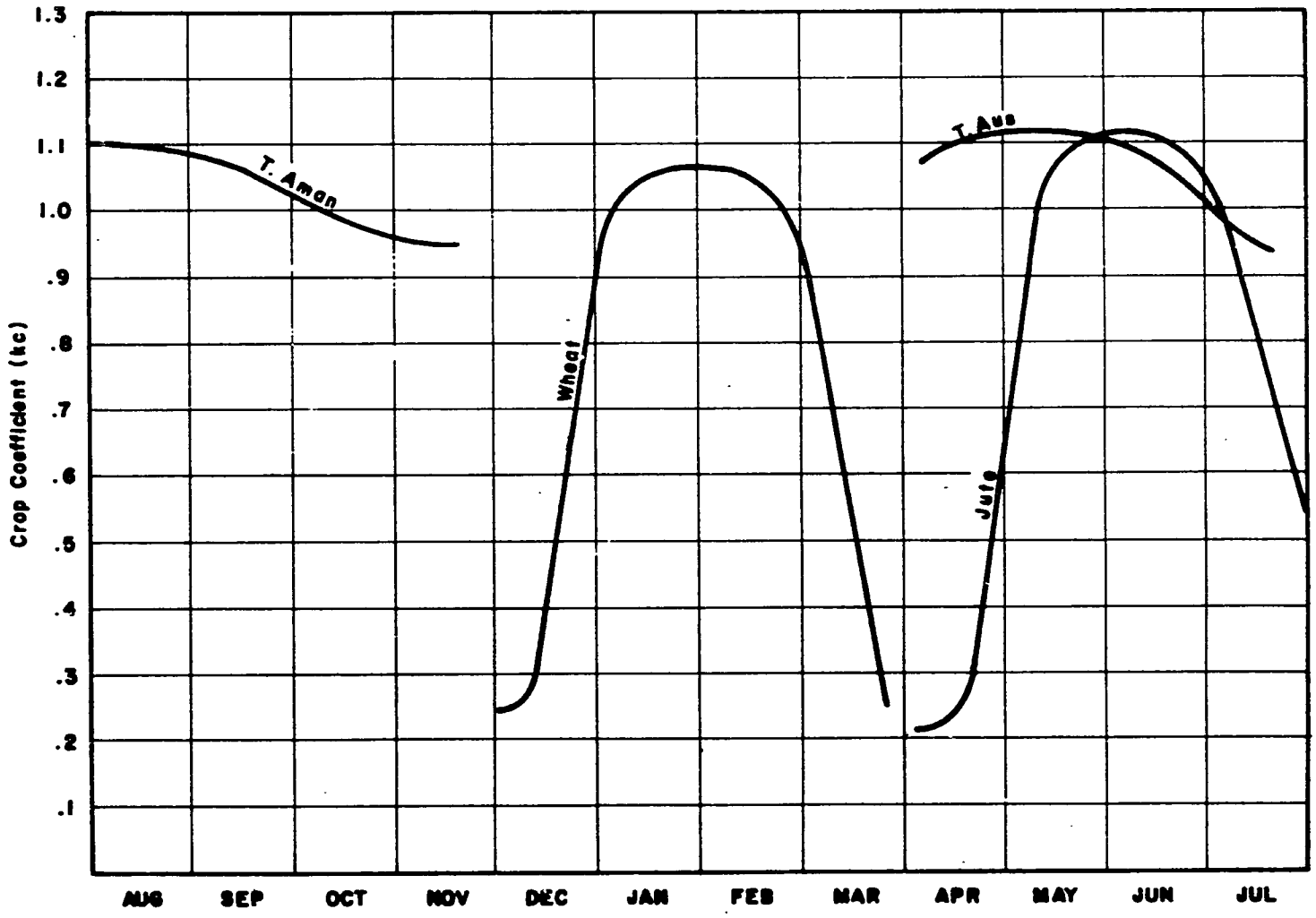


FIGURE IV-6

CROP COEFFICIENTS(kc) FOR BORO-BASED CROPPING PATTERNS

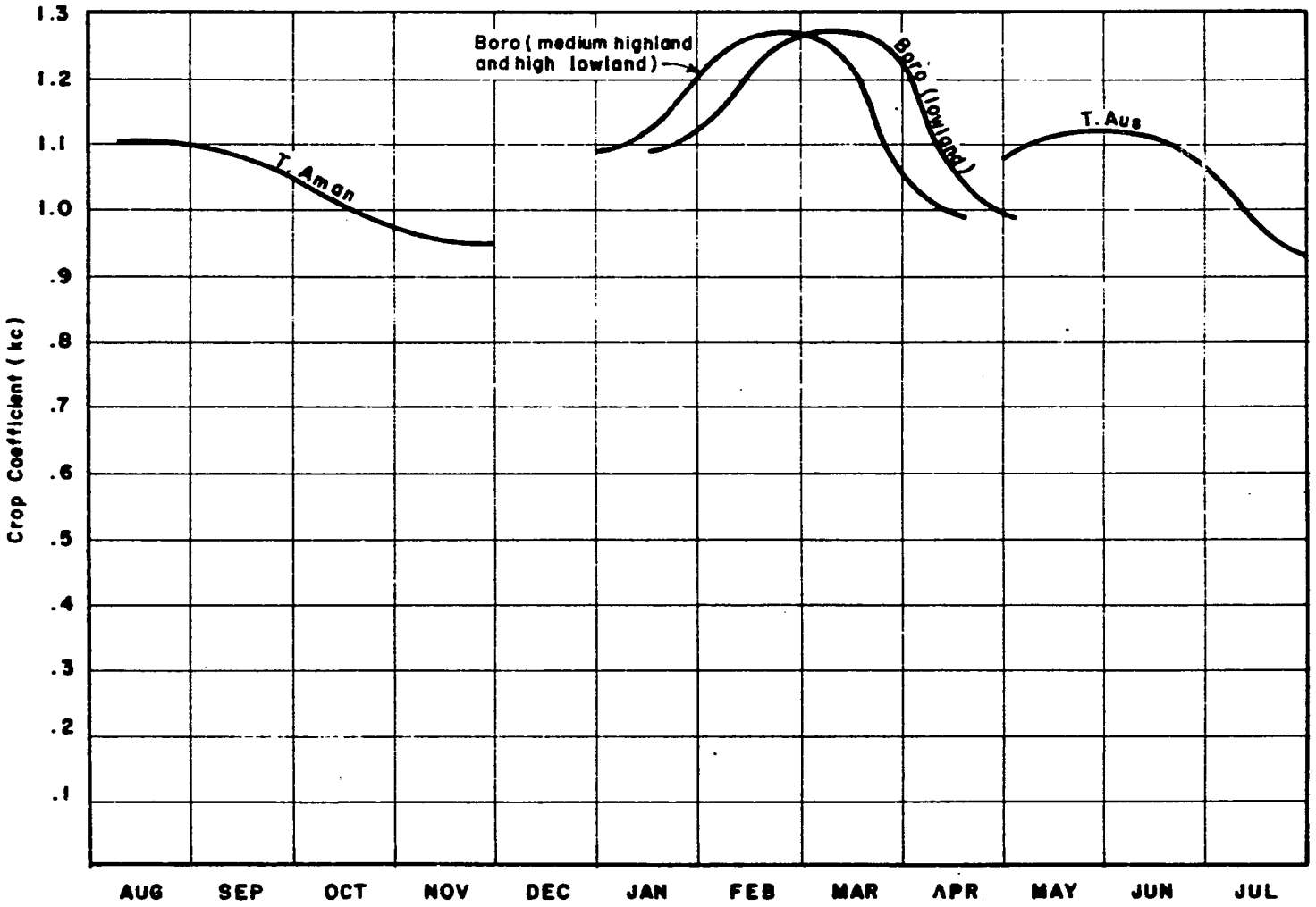
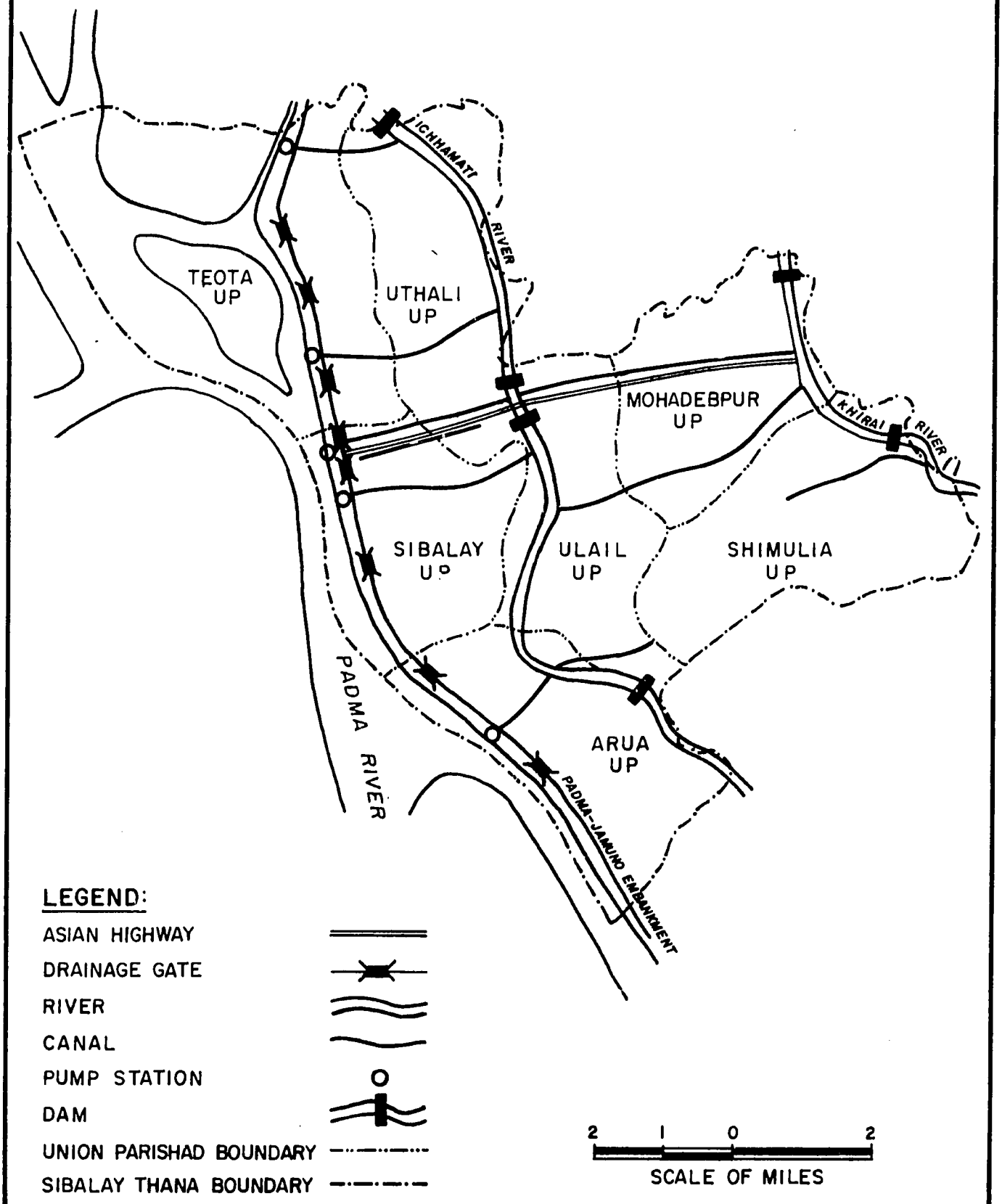


FIGURE IV-8-1

ARICHA-ICHHAMATI IRRIGATION PROJECT