UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

Review of

KURIGRAM FLOOD CONTROL AND IRRIGATION PROJECT FEASIBILITY STUDY AND REPORT (REVISED AND UPDATED) JANUARY 1975

by

ENGINEERING CONSULTANTS, INC.
DENVER, COLORADO, U.S.A.

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HOME OFFICE
1901 SOUTH NAVAJO STREET
DENVER COLORADO, 80223
TELEPHONE WEST 6-3417
CABLE ADDRESS ECIDEN

ECI ENGINEERING CONSULTANTS INC.

P.O. BOX 1010
BANGKOK, THAILAND
CABLE ADDRESS ECISIAM

October 27th, 1975

Mr.J.S.Toner
Director
United States Agency For International Development
United States Embassy
Dacca
Bangladesh

Our File: 1168/281
B379/75

Sugject: Review of Kurigram Flood Control and Irrigation Project Feasibility Report (North Unit only)

Dear Mr.Toner

We enclose herewith ten (10) copies of the report covering our review of the Kurigram Flood Control and Irrigation Project Feasibility Report (Revised and Updated) January 1975. This review was carried out by our Messrs. T.C.Patterson and C.D.Slaugnter acting as Consultants to USAID under Work Order No.4 to USAID/ECI Contract No.AID/otr-c-1303.

The main conclusion reached is that although the feasibility report is extensive, additional studies need to be carried out before the North Unit can be prudently internationally financed. A revision of the feasibility report, followed by international lending agency appraisal, negotiations with the Bangladesh Government on the scope and organization of the project, and final design and construction, is an approach which could be adopted. However, since time is clearly the essence of agricultural development in Bangladesh, we have not recommended this frequently adopted but time consuming course of action. Rather, we have recommended a management team approach in which USAID, the Bangladesh Government and a fully qualified firm of consultants work together, throughout the time required

to properly consider the several outstanding technical problems, to fully define the scope of the project, establish management systems, and reach agreement on all major aspects of the project. Final design could well start on selected aspects of the project during this same period once full project implementation is assured. We consider that as USAID has a well staffed mission in Dacca, and as USAID is provisionally interested in financing the project implementation phase, this approach is totally practicable, and should result in the earliest possible start on construction. The suggested phasing for the preparation of this Definite Plan is given in Chapter 5.

Implementation of the project and realization of project goals will require a considerable number of trained personnel in design, contract administration, supervision of construction, surveying, agricultural extension, water management, operation and maintenance, and other fields not only related to the North Unit but to all accelerated agricultural development in Bangladesh. It is strongly recommended that the scope of the project include an effective goal orientated training program for all levels of project personnel.

We should like to extend our sincere thanks to you and the staff of the USAID mission in Dacca for the very considerable help and cooperation given to us during our review of the Kurigram Project.

If we can be of any further assistance please let us know.

Yours very truly,

ENGINEERING CONSULTANTS, INC.

Colin D. Slaughter

Colin D.Slaughter
General Manager

cc: USAID Washington
Encls. 10 copies of review report

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LIST OF ABBREVIATIONS AND LOCAL TERMS

Government	-	Government of the People's Republic of Bangladesh
Project	-	the Kurigram Flood Control and Irrigation Project, North and South Units
Report	-	the Kurigram Flood Control and Irrigation Project, Feasibility Study and Report (Revised and Updated) January 1975 by Techno Consult Eastern Ltd.
Consultants	-	messrs. Colin D. Slaughter and Theodore C. Patterson of Engineering Consultants, Inc., Denver, Colorado, U.S.A.
BWDB	-	Bangladesh Water Development Board
EPWAPDA	-	East Pakistan Water and Power Development Authority
BADC	-	Bangladesh Agricultural Development Corporation
IECO	-	International Engineering Co. Ltd. San Francisco, U.S.A.
TECL	-	Techno Consult Eastern Ltd., Dacca, Bangladesh
beel	-	inland swamp or lake
paddy	-	unhulled rice
aus	-	rice crop sown in March/April and harvested in July/August

aman	-	rice planted before or during the monsoon season and harvested in November/December
boro	-	rice crop sown in December and harvested in April/June
kharif season	-	summer season
rabi season	-	winter season
B	-	broadcast
T	-	transplanted
District	-	Major political sub-division administered by a Deputy Commissioner. There are 19 districts in Bangladesh.
Thana	-	Administrative unit below District. There are 413 thanas in Bangladesh.
Union	-	A unit of local government below the thana which embraces several small villages. There are over 4,000 unions in Bangladesh.
seer	-	unit of weight equivalent to 2.06 pounds. 40 seers = 1 maund
maund	-	unit of weight equivalent to 82.286 pounds

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CHAPTER

INTRODUCTION

CHAPTER 1

INTRODUCTION

1.1 NEED FOR PROJECT

The Brahmaputra, Meghna, and Ganges rivers rise in the Himalayas, converge and run together within Bangladesh, and discharge as the Padma River into the Bay of Bengal. Peak flows in the Padma River of up to 5 million cusecs occur during the period June to September, when all three rivers simultaneously carry surface runoff from the melting snows in the Himalayas and the southeast monsoon rains. Flows in the Padma River drop as low as 200,000 cusecs during December to May when rainfall is minimal.

The catchment area of these three major rivers is 600,000 square miles, of which less than 10 percent is in Bangladesh. The continuous deposition of silt and sand from these rivers has created the largest and potentially most fertile delta in the world; a delta which comprises almost all of Bangladesh. The combination of large flows in these rivers, widespread heavy monsoon rainfall, cyclones and high tides in the Bay of Bengal between June and September, annually inundate up to one third of the country's 55,000 square miles, or up to roughly one half of the country's 35,000 square miles of cultivatable area. Usually, one third of the cultivatable area can be expected to be flooded. This annual flooding supplies water for the rice and other crops, but at the same time, by both its severity and variability, causes considerable

damage to crops and property, and frequently results in considerable loss of life. It severely inhibits national, rural and agricultural development.

The Bangladesh Government's current policy is to increase foodgrain production so as to become self-sufficient in foodgrains as rapidly as possible. The population is at present in excess of 75 million and is increasing at over 3% per year. The problem of reaching this self-sufficiency is, therefore, considerable. It is generally recognized that to achieve the required rapid increase in foodgrain production, the annual flooding must be reduced, water required for year round crop production must be made available when needed, and supporting agricultural services must be improved.

Coupled with the need for rapid increases in agricultural production is a need to create employment opportunities for the present and future population and, of course, an urgent need to reduce the rate of population growth. With increased employment should come increased income, increased purchase of food and consumer goods (in that order), increased labour productivity, and ultimately an improved economic climate and standard of life. It is clear that the problems in Bangladesh are extremely time sensitive and interdependent, and that a dynamic investment policy must be followed which takes urgent development of the agricultural sector as its central aim if these problems are to be humanitarianly solved.

The Kurigram Flood Control and Irrigation Project, subsequently referred to as the Project, is in a potentially highly fertile agricultural area which suffers from annual flooding, a lack of irrigation water, a lack of good drainage, and a lack of adequate supporting agricultural services. Road, rail and air access is poor and there is no supply of electricity to the area. The area's standard of living is reported to be below the national average. If the Project is undertaken, there will be an immediate and considerable demand for labour for construction. Long term employment opportunities will be created by the introduction of a boro crop and elimination of the crop losses during the aus and aman crops. Agricultural production will increase considerably. The general standard of living in the Project area will be increased and, through this, the problem of reducing the population growth should be made easier. Depending somewhat on the success of the latter, the production of foodgrains in the Project area should exceed that needed by the area's population, and the benefits of the Project should spill over and help development in adjacent areas. The phased inclusion of an adequate road network to and within the Project area, and the provision of an electric power distribution system will greatly enhance the likelihood of total success of the Project.

The Consultants consider that proper implementation of a carefully prepared Project plan would represent a significant step towards satisfying the current and future needs of Bangladesh and the Kurigram area in particular.

1.2 PROJECT DESCRIPTION AND HISTORY

The Project is bounded by the Brahmaputra River, the Dudhkumar River, the Teesta River and the international boundary with India. The Dharla River crosses the Project area to discharge into the Brahmaputra and divides the Project into a North Unit and a South Unit.

Each of the bounding rivers causes flooding at one time or another during the monsoon season. Rainfall during the monsoon season is highly variable, and drainage of surplus runoff from certain parts of the Project area is poor. These factors combine to cause significant loss to the aus and aman crops, inhibit the introduction of non-indigenous and high yielding varieties of rice and other crops, and generally discourage the farmers in their efforts to improve yields. Inadequacy in the quality, quantity and management of agricultural inputs, and loosely established farmers' institutions further hamper agricultural development in the area.

During the boro season, rainfall is minimal and essentially no boro crop is grown in the area.

The Project was identified in the Master Plan prepared in December 1964 for the East Pakistan Water and Power Development Authority by International Engineering Consultants Inc. This Master Plan recommended early completion of a feasibility report for a start of construction in 1968 and envisaged the following principle engineering features. In the North Unit, there was to be a peripheral flood embankment, an irrigation canal system supplied from a pump station on the Dudkhumar River,

and an improvement of the natural internal drainage system. These drain were to discharge by gravity through sluices in the flood embankment; drainage pumps were stated to be not required. In the South Unit, there was to be a similar arrangement except that the pump station was to be located on the Dharla River.

In 1969, Techno Consult Ltd. prepared the "Kurigram Flood Control and Irrigation Feasibility Report" for EPWAPDA. Details of the proposals given in this report were not made available for this review, but it is believed that for the North Unit the concept was similar to that proposed by IECO in 1964.

Following preparation of the 1969 feasibility report, TECL were retained by EPWAPDA to revise the report to include the following:- a general updating; a plan for a pilot irrigation project using groundwater resources; a formulation plan ensuring that land use is consistent with project development objectives; integration of all associated disciplines in the Project plan; utilization of all available relevant studies, data and reports; consideration of the effects of the Project on other developments; proposals for operating the Project and individual tubewell installations; personnel training requirements; details of the governmental and legislated action required for successful completion of the project; and a study of the method of cost recovery.

This latter report, the "Kurigram Flood Control and Irrigation Project, Feasibility Study and Report (Revised and Updated), January 1975" subsequently referred to as the Report, is the subject of this review. The Report concludes that for the North Unit, the development should comprise a pump station on the Dudhkumar River, a gravity irrigation canal system covering the entire area, a peripheral flood embankment, and an improved internal drainage system with four pumping stations located at points along the peripheral embankment to evacuate surplus runoff. In the South Unit, the Report proposes a barrage over the Dharla River, a head regulator and gravity irrigation canal system serving the southeast part of the Unit, a deep tubewell irrigation system serving the northwest part of the Unit, a peripheral flood embankment, and five pump stations to evacuate surplus runoff.

It is understood that subsequent to preparation of the Report in January 1975, the Bangladesh Water Development Board requested certain minor modifications. Details of these modifications were not made available to the Consultants for this review. They were, however, described by TECL as being only minor changes in unit prices which did not change the reported Project benefits.

1.3 TERMS OF REFERENCE

The purpose of the review presented herein is to generally evaluate the completeness of the Report as it relates to the North Unit only; to advise on the adequacy of the Report to meet the needs of international lending agencies; to recommend how to carry out any further review which may be necessary; and to prepare a scope of work for correcting any critical deficiencies which may be present in the Report.

The full terms of reference are reproduced in Appendix C.

CHAPTER 2

CONCEPT OF PROJECT

CHAPTER 2

CONCEPT OF PROJECT

2.1 RECOMMENDED PROJECT

The Report concludes that the North Unit project should comprise the following elements (see Table IX-2A of Volume I of Report).

- a flood embankment around the perimeter of the North Unit.
- a surface water irrigation system supplied from a pump station at the Pateswari railway bridge, with necessary training of the Dudhkumar River.
- improvement of the natural drainage channels and evacuation of surplus runoff by gravity/ pump stations.
- provision of buildings and transport.
- construction of a transmission line and sub-stations for electrical power distribution.
- a road system for servicing the project infrastructure. (estimated at Tk2,000,000 only)

2.2 ALTERNATE PROJECT DEVELOPMENTS CONSIDERED

- tubewell irrigation of entire North Unit;

- gravity irrigation of part of the North Unit by constructing a barrage across the Dudhkumar 5 miles downstream from the Pateswari bridge; tubewell irrigation of the remaining part of the North Unit;

- gravity drainage of surplus runoff.

2.3 METHOD OF RATING ALTERNATE DEVELOPMENTS

The method of rating all alternate developments was on the basis of economics.

The following table is a summary of economic results for the North Unit with surface irrigation, flood control and pump drainage.

Benefit Cost Ratio	13.6	@	10% interest
	9.4	@	15% interest
Internal Rate of Return	128%		

CHAPTER 3

COMMENTS ON THE FEASIBILITY STUDY

CHAPTER 3

COMMENTS ON THE FEASIBILITY STUDY

3.1 PHYSICAL CONDITIONS

3.1.1 Land Forms

The entire area occupied by the North Unit was created by the deposition of alluvium from the four rivers traversing the area, the Brahmaputra, Teesta, Dharla and Dudhkumar.

The topography is very gently undulating and generally slopes from the northwest to the southeast. Ground elevations in the northwest are in the order of 100 to 104 feet, and ground elevations in the southeast are about 82 to 86 feet. The project is about 18 miles long in the northwest-southeast direction, giving an average ground slope of approximately one foot per mile.

Typical of delta topography, the North Unit area abounds with minor meandering streams, shallow depressions and land locked beels. Under the existing agricultural system, the poor drainage from these depressions and beels has distinct advantages in that the monsoon rains are retained for irrigation of the aman crop during its October flowering period.

Soils in the area generally range from light coloured fine sands to medium to dark grey silts. The soils are generally uniform in texture and are generally very fertile. No saline conditions were noted and advice from TECL was that none exist.

The Consultants consider that the Report adequately describes the general surface conditions.

3.1.2 Geology and Lithology

The primary geological features in the region are the Himalayas to the north, the Indian mass of ancient rocks to the west and the Malaysia - Burma fold arch to the east. Bangladesh is located where these three major complexes meet. The vast region south of the Himalayas has been described as an east west trending trough filled with alluvium. Deposited on and interfingering with these deposits are the Teesta fan deposits comprising fine to coarse sands with lenticular deposits of silt and clay. The Indian mass of rocks, which is reported believed to be pushing beneath the Himalayas and the Malaysia - Burma arch, lies beneath the Kurigram Project at too great a depth to be of any practical influence on the Project. The overlying alluvial deposits form a source of abundant groundwater, as discussed in Chapter 3.2.3.

Since the entire Project will be constructed in alluvial materials of considerable depth, and since the structures themselves are relatively minor, the location and extent of any faulting in the basement rocks is of no major concern to the Project. The region is, however, tectonically active and the larger structures will have to be designed for earthquakes.

The surface geology is described in various publications as being predominantly "stream-bed, meander-belt, flood plain and low level terrace deposits including some swamp deposits." In the western portion of the North Unit, the surface deposits are somewhat coarser and have been described as "silt, sand and gravel deposits at a slightly higher level than the adjacent flood plain and low level terrace deposits".

During the Consultants' field trip it was observed that the deposits laid down in the lower reaches of the Dharla and the adjacent reaches of the Brahmaputra were anisotropic and consisted of layers of silt and fine, micaceous sand. This is to be expected. During times of high stage in alluvial streams with considerable variation in flow, the stream carries a considerable amount of relatively coarse grained material as both bed load and suspended sediment. When the river overtops its banks, the water spreads out over the river terraces and carries with it the suspended silts and sands. The velocity of flow over the terraces is considerable less than in the mainstream and the coarser particles settle out forming a system of natural levees along either side of the river channel. Later, as the river stage drops, the water's velocity over the terraces further

decreases and the finer silts settle out from suspension. In interior beels where the overbank spill is entrapped, the finest suspended particles settle out as the water evaporates or percolates into the ground.

The Report does not present the geology and lithology of the region in much detail. However, for a purely surface irrigation system, as recommended in the Report for the North Unit, it is considered that extensive study of the geology and lithology is not justified as subsurface conditions play a relatively minor role in determining the scheme's technical and economic feasibility. While it is believed that foundation conditions at the pump station site, as proposed or as relocated, will not have a great impact on the North Unit's feasibility, it is considered that drill holes should be put down to determine exact subsurface conditions at each pump station as soon as their locations are fixed. This is discussed further in Chapters 3.5.1 and 3.5.3. Similarly, that subsurface conditions along the main and branch canals be ascertained as soon as their alignments are essentially firm to confirm that lining is or is not required. See Chapter 3.5.1. The adequacy of the subsurface investigations for determining the feasibility of groundwater development in the North Unit is discussed in Chapter 3.2.3.

3.1.3 Communications

Access to the North Unit is poor, as can be seen from the following tabulation. This has not always been the case, however. Before partition in 1947, the East Bengal Railway ran through Lalmanirhat, crossed the Dharla River, ran across what is now the North Unit, crossed the Dudhkumar on the Pateswari bridge, and connected with the narrow gauge Assam Railway. Unfortunately, this railway line cannot be easily reactivated as the bridge across the Dharla River and some 13 miles of railway embankment between Lalmanirhat and Pateswari are in Indian territory.

Road access to the North Unit has always been poor and river crossings have always been made either across the railway bridges on foot, or by country boat.

The Consultants were advised that there is only one telephone line into the North Unit from Kurigram and that when this goes out of action, the only means of communication is by police or military radio.

Communication with the North Unit must be improved prior to starting major implementation work. Otherwise, transport of men, materials and equipment to the site, and supervision of construction will be extremely difficult and time consuming, and project benefits will be delayed beyond reasonably acceptable limits.

The Consultants, consider that improvement of communications must be included as part of the North Unit project, and undertaken as early in the implementation program as possible. The following steps are recommended:

- complete the partially completed road between Rangpur and Kaunia, and between Teesta and Kurigram. Most of the embankment and a small part of the surfacing are reported completed.

- modify the decking on the Kaunia-Teesta railway bridge to make it suitable for vehicular traffic.

- ensure that radio or telephone communications between Dacca and Kurigram are good, not just barely adequate.

- improve telephone communications between Kurigram and the North Unit, and provide telephone communications within the North Unit.

- reactivate the airstrip at Lalmanirhat and improve the surfacing of the road between Lalmonirhat and Kurigram.

- make arrangements whereby senior project personnel can travel by helicopter or light aircraft between Dacca and Lalmanirhat. Early assignment of a helicopter to the Project is recommended as it would be invaluable during both the design and implementation stages.

- provide short range radios for senior site staff for the design and implementation phase.

Improvement of communications within the North Unit should also be made part of the North Unit project. As far as the roads are concerned, this will entail integration of the existing road system with the canal road system, improving the existing system where necessary by raising the road embankment, constructing culverts and ditches, widening, providing cross drainage, laying a crushed brick surfacing or brick soling, and, where the road is to act as a main feeder road, providing an all weather macadam surfacing. To facilitate water management, telephone communications should be provided between the Dudhkumar pumping plant, the drainage plants, the central administration centre for the North Unit and strategic points throughout the system.

PROJECT ACCESS SITUATION

	Road	Rail	Air	Water
National	Asian Highway, Calcutta to Dacca.	Broad gauge rail service Calcutta to Jessore	Many international carriers fly into Dacca airport	Deep sea port facilities are available at Chittagong and Chalna. Shallow water facilities available at Dacca
Regional	By single lane paved road Dacca - Rangpur with a steamer ferry crossing of the Brahmaputra (Sirajganj, Pabna District-Sibalay, Dacca District) and a powered ferry crossing of the Karatoya (Raiganj, Pabna District). Time is 12 hours downstream, 14 hours upstream.	Ballasted metre gauge rail service Rangpur-Kaunia-Teesta-Lalmanirhat. Lalmanirhat is a large rail depot.	Regular service from Dacca to Thakurgaon, Dinajpur District. Thakurgaon to Rangpur takes 4 hours by road.	Possibly powered barge access from Dacca to Project area (Chilmari?) during early and late monsoon periods.
South Unit	Rangpur-Kaunia, kucha dirt road only at present. Reported unusable during height of monsoon. New road under construction.	Ballasted metre gauge Teesta-Lalmanirhat. Diesel driven trains used on this line.	nil	
	Teesta-Kurigram -ditto-	Unballasted metre gauge Teesta-Kurigram-Chilmari. Only light steam engines use this line due to lack of ballasting.	A disused concrete paved military airstrip, reported to be 7,000 feet long, is located about 3 miles from Lalmanirhat	A ferry operates across the Teesta during low flow season only
	Farm to village roads are kucha dirt and reported unusable during monsoon season.			
	Village to market towns of Kurigram and Lalmanirhat -ditto-			
	There is no road crossing of the Teesta into the South Unit.			
North Unit	Single lane concrete road from Bhogpanga (opp. Kurigram across the Dharla.	Nil	Nil	A country boat ferry operates across Dharla River when water depths are adequate.
	Farm to village roads kucha dirt.			
	Village to market centres - ditto-			

3.1.4 River System, Regimes and Development

The Teesta, Dharla and Dudhkumar rivers all rise in the Himalayas and flow southeast to south-southeast across relatively flat alluvial land in the Cooch Behar area in India before entering Rangpur District in Bangladesh. The catchment areas of these river are given in the Report as:

Teesta	-	4,900	square miles
Dharla	-	1,980	square miles
Dudhkumar	-	2,240	square miles

The Teesta is by far the largest of these rivers and has been responsible for the formation of the majority of the alluvial fan covering the Project area. This fan appears to have been at least partly responsible for the abrupt change in the Brahmaputra's direction of flow from a westerly direction through the trough between the Shillong Hills and the Himalayan foothills, to a southerly direction through Bangladesh. This abrupt change in direction occurs right at the Project area with the Project area on the outside of the curve. The upper reaches of the Brakmaputra are migrating westwards. This and the fact that the Project is on the outside of this major curve in the river means that considerable care must be taken when laying out a flood embankment on this reach of the Brahmaputra River.

East of the Project area, the bed material of the Brahmaputra River becomes increasingly coarse, and is reported to consist of boulders some 50 miles from the Project area. Further upstream, the river is reported to become progressively narrower and deeper and to flow between basement rocks.

Information in the Report on sediment transport by the various rivers in the Project area is sparse, and the Report recommends bed-load sampling on the Dharla and Dudhkumar Rivers. All rivers, however, clearly carry heavy sediment load as evidenced by their braided pattern. From the nature of the terrain through which the various rivers flow, and from the pattern of the rivers, it is anticipated that the Brahmaputra and Teesta rivers carry a heavier, coarser sediment than the Dharla and Dudhkumar rivers. The Brahmaputra is highly braided at the Project and the river valley is approximately 9 miles wide. The Teesta is also highly braided. From aerial photographs (1952-53, 1:63,000), the Dharla River is less braided than the Teesta or the Brahmaputra rivers and the valley is approximately 4 miles wide. The sides of the valley are between 1 and 3 miles from the 1952-53 dry weather channel. The Dudhkumar River appears to be the least braided of all four rivers. The valley is about 3 miles wide and the sides of the valley are from 1 to 2

miles from the 1952-53 dry weather channel. See Figure 3-1. The 1975 series of aerial photographs do not, unfortunately, cover the Dudhkumar River, probably due to its proximity to the international border. Based on the 1952-53 photographs, however, the Pateswari railway bridge forms a stable point in the river, and the river is reasonably straight immediately downstream from the bridge for about 2½ miles. In this reach, there are several sand bars and some braiding. After that, however, the river develops a highly sinuous meander pattern with normal bank cutting on the outside of the curves. A comparison between the 1952-53 photographs and up-to-date photographs would give a good indication of the relative stability of the river reaches both upstream and downstream of the bridge.

The need to train the stretch of river upstream and to the east of the bridge must be considered. If the river erodes the railway embankment at this location, the bridge could well be outflanked and a pumping station at the bridge totally bypassed.

The hydrographs given in the Report indicate that the Dharla and Dudhkumar Rivers have somewhat flashy characteristics during the monsoon season. These two rivers are relatively short and do not rise as deeply in the Himalayas as

the Teesta and Brahmaputra rivers. Runoff from snowmelt would, therefore, be less and would contribute a lesser portion of the total flow during the monsoon season. Monsoon storms would thus be expected to have a greater influence on the shape of the hydrographs and produce the flashy characteristics.

Bank movements of the Brahmaputra between 1830 and 1963 were studied by IECO and are summarized as follows:

Reach	Right Bank	Left Bank
Mouth to Dhaleswari River	20,600 ft W	1,000 ft W
Dhaleswari River to Sirajganj	11,500 ft W	6,900 ft E
Sirajganj to Gabragaon	8,800 ft W	13,200 ft E
Gabragaon to Old Brahmaputra	24,300 ft W	11,300 ft W
Old Brahmaputra to Teesta River	31,900 ft W	22,600 ft W
Above Teesta River	13,600 ft W	10,100 ft W

In Professor J.M. Coleman's Paper (Brahmaputra River: Channel Processes and Sedimentation), movements of the Brahmaputra banks in the Project area are given as follows:

Reach	Right Bank	Left Bank
Chilmari at Teesta-Brahmaputra Confluence		
1944-1952	1,200 ft/yr W	1,150 ft/yr W
1952-1963	0 ft/yr W	200 ft/yr E

The above figures clearly indicate the general movement of the Brahmaputra towards the west and the variability of that movement. At the Teesta -Brahmaputra confluence the flow patterns are complex and the backwater effect of each river on the other highly variable. The bank lines in this area, and at the mouths of the Dharla and Dudhkumar rivers, are expected to be quite unstable.

There are several developments contemplated for the future which have a bearing on the future behaviour of the river system in the Project area. The Teesta Barrage, if constructed, will be located about 35 miles upstream of the Kaunia railway bridge. This structure will divert irrigation water from the Teesta for irrigation of approximately 1,500,000 acres in Rangpur and Bogra Districts. The peak winter diversion requirement will be approximately 3,580 cusecs and will reduce flows in the Teesta at the Project site to a very low level. Sediment transport during low river stages is a small percentage of that carried at high stages so that this reduction in river flows will have relatively no effect on sediment deposition in the reach downstream of the barrage. At high stage, the diversion requirement will be only about 14% of the total river discharge, so again diversion will have a small effect on sediment deposition downstream of the barrage. This almost non-interference with sediment deposition is important since a significant reduction in deposition at the Teesta River's confluence with the Brahmaputra River could allow an acceleration of the Brahmaputra's westerly migration.

It is understood that preliminary plans have been made for a road bridge across the Teesta River within the Project area. This will have no significant effect on the river regime other than in the reaches immediately upstream and downstream of the bridge.

The Report proposes a barrage on the Dharla River just upstream of Kurigram and a canal head regulator in the right abutment of the barrage to divert about a maximum of 1,500 cusecs for irrigation of the South Unit. For reasons similar to those for the Teesta barrage, this development is unlikely to have a major effect on sediment transport or on the stability of the west bank of the Brahmaputra River. However, a barrage structure, with its upstream and downstream guide banks (not proposed in the Report), represents a very significant restraint on the river regime and upsets the sensitive balance between the stream bed material size, the water surface slope and the meander pattern, particularly downstream of the barrage. Any embankments constructed to prevent flooding of the North Unit by the Dharla River must therefore be located taking possible future construction of a barrage into account.

Certain river training works have been carried out on the Dharla River at Kurigram township in an attempt to protect the town from bank erosion. From the aerial photographs and from various reports, it would appear that the measures taken

have not been entirely successful. Future attempts to arrest this erosion could significantly affect stability of the river channel and endanger the North Unit flood embankment along the left bank of the Dharla. Future town protection works must be considered in final design of the North Unit embankment.

The Report proposes that the supply pump station for the North Unit be located on the Dudhkumar River just downstream of the railway bridge at Pateswari. Other than the North Unit embankment, no other possible developments are know of on the Dudhkumar River.

The lengths and drainage areas of the Brahmaputra, Teesta, Dharla and Dudhkumar Rivers on the Indian side of the border are considerable, and the Report states that many miles of embankment have been built along these rivers in India. Significant further development of these rivers by India is a distinct possibility which will require careful checking.

If the full agricultural potential of Bangladesh is to be eventually realized, the rivers in Bangladesh must be contained within embankments. This was proposed in the Master Plan, and appears to be generally accepted by various authorities as the most practical solution to the flooding problem. Once the rivers are contained within embankments, however, the behaviour of the rivers will significantly change. Scour depth, river bed profiles, meander amplitude and frequency, and the

ferocity of the rivers' attack on embankments as the river tries to readjust to the imposed constraints will increase. Other phenomena such as the build up of coastal sediments may also have significant effects on the river regimes. The entire river containment program should be carefully engineered on both a national, basinwide and project basis. Some steps have been taken towards understanding the Bangladesh rivers, but as yet the mechanics of the entire system are not clearly understood, either as the system exists today or as the system would be as each of the various project embankments are completed. No one segment of flood control embankment, such as the North Unit embankment or the Dacca Southwest embankment, will have a pronounced effect on the river system However, the Consultants consider that progressive construction of embankments without knowing what the short, medium and long term effects will be is imprudent. Failure of embankments could be sudden and catastrophic. It is, therefore, recommended that this overall problem be extensively studied and a suitable model developed to provide overall criteria for the containment program. It is further recommended that this study be undertaken before too many containing embankments are constructed. It is not expected that this study would be performed as part of the Project studies.

The Report does not address the problem of future behaviour of the rivers in the Project area in any detail, either from the point of

view of the Project's effect on river regimes, or from the point of view of the effect other projects may have on river regimes and thereby on the Project. Being at the northernmost end of the Bangladesh portion of the Brahmaputra, developments within Bangladesh cannot affect the Project. This is one advantage the Project has over alternate projects further downstream. However developments in India and within the Project area could have significant effects. It is considered that these possible effects need to be studied in more detail in the pre-final design stage.

3.1.5 Socio Economic Conditions

The general socio-economic conditions throughout Bangladesh are well known and the Report presents particular details of conditions in the Project area. These can be summarized as follows:

- population 600,000 (1975)

- Project area 261,000 acres total
  215,000 acres cultivated

- population density 2.8 person/cultivated acre

- rate of population growth +3%

- literacy rate +20%

- population age distribution (1969)

0 -9 years	40%
10-19 years	16%
20-39 years	27%
40-59 years	13%
60+ years	4%

Males and females are about equal in number. Note that about 56% of the population was under 20 years of age in 1969.

- average farm size North Unit 3.3 cultivated acres
  South Unit 3.6 cultivated acres

- industries in North Unit
  - 2 brick factories
  - minor cottage industries

  in South Unit
  - 1 brick factory
  - minor cottage industries
  - rail terminal at Lalmanirhat
  - township enterprises at Lalmanirhat and Kurigram

The North Unit economy is almost totally based on agriculture. The conditions in the Unit can be gauged from the following calculation based on Table IV-3A of the Report.

- population about	280,000 persons
- cultivated area	77,100 acres
- annual rice yield (no catastropnic losses)	1,300,000 maunds paddy
- annual jute yield (no catastrophic losses)	200,000 maunds
- annual rice income	Tk65,000,000
- annual jute income	Tk10,000,000

rice yield/person = 4.6 maunds paddy
= 267 lbs rice

consumption per person should be about
1 lb/day = 365 lbs

Per person annual jute income = Tk 36
This buys about 60 lbs of rice.

Vegetables are grown for local consumption only.

From this simplified calculation, it can be seen that the North Unit as a whole is barely at subsistence level.

The Report does not analyse the average amount of land owned and rented by the average farmers or present clear details of rental costs and tax burdens. This information may be too hard to assemble in any definitive form, but should be determined as accurately as possible in order to present a clear picture of benefits to the farmer for international lending agencies.

The socio-economic conditions are clearly bad, and it is considered unnecessary to analyse present conditions to a very fine degree before implementing the North Unit project. A benchmark socio-economic survey should, however, be carried out in the North Unit as part of he project in order to determine and analyse the effects of the project. This survey should be initiated later in the pre-final design stage so that should the international lending agencies require more data before committing funds, it could be presented without excessive delay.

3.2 HYDROLOGY AND CLIMATOLOGY

3.2.1 Meteorology

The major items of climatological input used in the Report for the various analyses performed were rainfall, temperature, humidity, evaporation, wind speed and daylight hours.

3.2.1.1 Rainfall

Rainfall data from Kurigram 1902-date; Ulipur, 1961-date; Lalmanirhat, 1962-date; Bhurungamari, 1963-date; Chilmari, 1963-date; and Kaunia, 1962-date was considered for preparation of the Report. All six stations are located within or on the periphery of the Project area. As the Kurigram station is centrally located and had the longest period of record, all rainfall studies were based on data from this station.

During the Consultants' field trip to the Project area, moisture conditions in the North Unit appeared noticeably different from those in the South Unit, indicating possible local variation in precipitation patterns. This was confirmed in discussion with local officials. A network analysis of the North Unit using precipitation data from Lalmanirhat, Bhurungamari and Kurigram should yield more reliable data for the North Unit than if Kurigram station alone is used. Provided that there is good correlation between the

stations at Lalmanirhat and Bhurungamari and the station at Kurigram, the records at the first two stations could be extended using those of the latter. It is believed that this approach would yield more applicable monthly rainfall data for the North Unit.

The Kurigram rainfall records were used in conjunction with the Master Plan frequency analysis data for determination of effective rainfall. A 90 percent exceedence frequency rainfall was used as the design rainfall. Thus, any change in the North Unit rainfall assumptions will affect the effective rainfall determinations and hence diversion requirements. The studies of drainage requirements will be similarly affected.

The Report states that daily rainfall records at the six stations mentioned above cover only 3 to 6 years and are inadequate for an independent storm frequency analysis. However, not all records available were considered as can be seen by reference to Figure 3-2. Daily rainfall records have generally been kept since 1961, so that some 14 years of daily records are currently available for the Project area. Monthly records have been kept at Kurigram and Ulipur since 1902.

Although the Report states that daily rainfall records are not sufficient for storm frequency analyses, such an analysis was in fact undertaken in Appendix A of Volume II from records reported available for Kurigram station for the years

1946-49 and 1961-67. This analysis was undertaken as a preliminary step in the drainage study for the N3 drainage basin. A comparison of results obtained from this analysis with those developed from data in the Master Plan is as follows. Both sets of results are for a 10 year frequency storm.

Rainfall in Inches

Duration	1 day	3 day	10 day
Master Plan	8.5	14.9	23.3
Kurigram Record	5.8	9.8	18.0

These results are significantly different and point up the differences in methodology.

It is considered that not only should the rainfall assumptions for the North Unit be re-studied for their effect on effective rainfall and diversion requirements, but that the storm duration-frequency analyses for the drainage studies should also be re-studied. Clearly, all available data should be used when re-studying the hydrology, and every use made of correlation and extension techniques.

The tabulation of available hydrological and meteorological data given in Figure 3-2 was prepared by BWDB Hydrology Section for the Consultants.

3.2.1.2 Temperature, Humidity, Evaporation and Windspeed

The temperature, humidity, evaporation and wind speed data used for preparation of the Master Plan was used for consumptive use determinations in the Report. This data was that recorded at Rangpur up to 1962. BWDB has indicated that this data is available from 1961, suggesting that two years only were used in the Master Plan. Use of the full record would result in more reliable empirical consumptive use determinations.

3.2.2 River Hydrology

Three rivers affect the North Unit; the Brahmaputra, the Dharla and the Dudhkumar. Peak water levels in all three rivers will affect flood embankment heights while the minimum flow in the Dudhkumar could affect the area to be irrigated by the pump station located on its banks.

The available stage and discharge records are listed in Figure 3-2 and the locations of the gaging stations in Figure 3-3. On the Brahmaputra River, daily water level records are available at Old Bahadurabad (Station 47L) from 1949 to date, and discharge records from 1949-1966. At Bahadarabad Transit (Station 46.9L) daily water level records are available from 1964 to date, and mean daily discharge records from 1966 to date. Bahadurabad is about 40-50 miles downstream from the North Unit. At the south Unit, Chilmari (Station 45.5), daily water levels are available from 1957 to date. At the North Unit, Noonkhawa (Station 45), daily water levels are available from 1957 to date. There are other stations close to Bahadurabad.

On the Dharla River at Kurigram, daily water levels are available from 1946 to date, and discharge records from 1964 to date. The BWDB Hydrology Section questioned the reliability of the discharge data because of the Brahmaputra backwater effect, and also the gage readings especially at high flows. Further upstream, near the international boarder, daily water levels have been recorded at Taluksimulbari since 1960.

On the Dudhkumar River there is only one discharge and gaging station. This is located at the Pateswari railway bridge. Daily water level records and discharge records are available from 1960.

The above discharge records are reported by BWDB Hydrology Section as being "about weekly" up to 1963 and mean daily thereafter.

In the Report, water levels and their frequency of recurrence at nine different stations were analysed for preliminary design of the North Unit embankments. The 100 year frequency water level was selected for design of the Brahmaputra embankment, and then combined with the 100 year Teesta water levels for design of the Teesta embankment, the 50 year Dudhkumar water levels for design of the Dudhkumar embankment, and the 100 year Dharla water levels for design of the Dharla embankment. The period of record at each of the nine stations was extended by correlation as follows:

River	Station	Extended Using
Brahmaputra	Noonkhawa	Bahadurabad
Brahmaputra	Chilmari	Bahadurabad
Brahmaputra	Kamarjani	Bahadurabad
Brahmaputra	Bahadurabad	-
Dharla	Taluksumulbari	Kurigram
Dharla	Kurigram	-
Dudhkumar	Pateswari	Kurigram

Extension of records using Kurigram data is considered questionable because of the backwater influence of the Brahmaputra. The Consultants were unable to obtain detailed information on the correlation coefficients from the analyses in the Report so were unable to fully judge the adequacy of these analyses.

No attempt was made in the Report to run discharge frequency analyses on the Brahmaputra or Dudhkumar rivers.

In connection with the Dharla barrage, the 100 year frequency flood was, however, predicted as follows:

Eleven years of daily flows on the Teesta River were analysed using a standard frequency analysis to arrive at a 100 year frequency flow in the Teesta of 400,000 cusecs. This discharge and the Teesta drainage area were then substituted into the following equation to determine the factor K for the Teesta basin.

$Q = KA^n$ where: Q = flow in cfs

K = factor based on watershed characteristics

A = drainage area in square miles

n = 1/2

The Dharla basin was then assumed to have the same watershed characteristics, and hence the same K. Then, by substituting the Dharla drainage area and the factor K into the above equation, a 100 year Dharla flood of 254,000 cusecs was determined. As the maximum recorded discharge on the Dharla during the period of about nine years apparently studied for preparation of the report is given as 228,000 cusecs, a design flood flow of only 254,000 is seriously questioned. An alternate approach could have been studied. Simulteneous periods of record on the Teesta and Dharla rivers could have been correlated and the records for the Dharla River at Kurigram and Taluksimulbari extended. Frequency analyses could then have been carried out on these extended records to give a flood flow value at the frequency selected.

In the absence of there being long term records, empirical formulae, envelope curves for similar watersheds, frequency abalyses even though questionable, and other "order of magnitude" methods have to be employed and the results compared. For a major structure such as the Dharla barrage,

a hydrometeorological study to determine the probable maximum precipitation over the basin and hence the absolute maximum possible river discharge should be considered depending on the adequacy of other data. These various results should then be tempered with sound judgement bearing in mind the possible damage which could result from overtopped embankments, deliberate breaching of the embankments at pre-selected locations just prior to overtopping, and so on, and the design flow selected.

In the determination of the Dharla barrage discharge, the Dharla and Teesta rivers were considered as having the same watershed characteristics. Due to the fact that the Teesta rises deeper in the Himalayas than the Dharla, this is questioned.

The Dudhkumar flow records used in the Report were for the period 1961-64 and 1967-70. During this period the peak flow was 216,000 cusecs and the minimum was 2,190 cusecs. The maximum dry season diversion requirement was given as 27,816 acre feet over 15 days in Table III-17 of Volume I. that is, approximately 934 cusecs. The safety margin appears adequate, except that the diversion requirements are questioned by the Consultants in Chapter 3.2.4 and 3.2.5, and the full set of records appears not to have been studied for preparation of the Report. If diversion requirements are firmed up and a river discharge frequency analyses carried out, the chance of the dry weather flow being inadequate to supply requirements

can be determined. The tolerable interference with flows by India can also be determined. If these studies are combined with a rainfall drought study, the chance of major crop failure due to inadequate river flows and inadequate rainfall occurring at the same time can also be determined.

Since the feasibility of an irrigation project depends so much on the adequacy of the water supply, it is common and sound practice to fully complete all hydrologic studies before embarking on project implementation. It is considered that the studies undertaken so far indicate the "order of magnitude" only, and that full studies should be carried out during the pre-final design stage.

3.2.3 Groundwater Hydrology

It has been recognized for some time that the groundwater resources of Bangladesh are a valuable asset to the country, and considerable development and utilization of this valuable resource has been undertaken in many parts of the country in recent years. Under the ongoing IDA Deep Tubewell Project some 3,000 tubewells will be installed throughout the country. Twenty of these wells are programmed for the North Unit and 50 for the South Unit.

The Report considers utilization of groundwater for irrigation in both the North and South Units in two ways, as the sole source of irrigation water and as the source of irrigation water for only a portion of the area. For the North Unit, the Report concludes that any utilization of ground water is not economically feasible.

At the time of starting the up-dated version of the Report, information on groundwater conditions in the Project area was minimal, although conditions were believed to be good. The up-date of the Report was to include a BWDB groundwater investigation program, but the program was apparently severely re-

duced and only three of the eight programmed bore holes and two of the four programmed test wells were apparently completed in the North Unit. Bore holes Nos. 1 and 3 are located in the northern portion of the North Unit and No. 7 is located in the south-central portion. Well tests were performed in bore holes Nos. 3 and 7. In addition to the data obtained from these bore holes and tests, the Report utilizes records and test data from 16 wells recently constructed by the Bangladesh Agricultural Development Corporation (BADC) in Kaunia, some 20 miles or more from the centre of the North Unit. The value of this data with respect to the North Unit is questionable because of its distance from the North Unit. Groundwater contours were developed from observations made in eight domestic wells within the Project area during the period 1967-68 and in 1973. The number of these wells in the North Unit is not clear. Plate III-4 in Volume I of the Report shows only one well in the North Unit, whereas the large scale Plate III-4 in Volume III of the Report shows four in the North Unit for the 1968 observations and two for the 1973 observations.

Analysis of the step drawdown pumping tests on the 16 BADC test wells in Kaunia, and wells Nos. 3 and 7 in the North Unit, were undertaken for the Report. Transmissivities of 84,000 to 310,000 gallons/day/foot and capacities of 42 to 155 gallons/minute/foot of drawdown were estimated. A modified Jacob method was used. The results are considered questionable as the usability of pumped well drawdown data obtained during a step drawdown test is limited for determining aquifer constants. It is to be noted that observation well data was available for well No. 7, but was not used. Also, in reviewing TECL's files, the origin of the data used to derive the constant discharge drawdown versus log time relationship plotted as Figures III-15 and III-17 could not be determined.

Using raw data provided for well No. 7 and the four observation wells, the Consultants performed a number of analyses using accepted techniques to better define the North Unit aquifer conditions. Non equilibrium analyses were performed on drawdown data obtained during Step 1 of the step-drawdown test, and non-equilibrium analyses were carried out on recovery data from the same five wells. Resulting transmissivities ranged from 120,000 to 900,000 gallons/day/foot. The storage

coefficients were as low as 10^{-3} indicating the possibility of semi-confinement. This is inconsistent with literature describing these alluvial aquifers of Bangladesh.

Although evidence in the report and the Consultants additional analyses are inconclusive, there appears to be some indication that the aquifers, when groundwater levels are at their highest in June and July, behave as semi-unconfined aquifers. It is probable that during April or May, the period of the lowest groundwater levels, the aquifers are totally unconfined.

The three exploratory borings in the North Unit show general lithologic correlation. However, the alluvial constituents are generally coarser in the south, suggesting that groundwater potential may increase from north to south.

If, during the early part of the pre-final design stage, the use of groundwater appears to compete favourably with using the Dudhkumar as a source of irrigation water, several investigation procedures should be initiated as follows.

A network of twenty to thirty observation wells within the North Unit and a sufficient number around the outside of the North Unit to define regional conditions should be established. Existing domestic wells, and certainly those which were monitored for preparation of the Report, should be used wherever possible. These wells should then be read every two weeks, contour maps prepared and the fluctuations correlated with rainfall in the observation area.

To firmly establish aquifer conditions, constant discharge long term pump tests should be conducted at well No. 7 with close technical supervision using the existing observations wells. This would allow study of delayed gravity drainage effects and an evaluation of recharge characteristics if the steady state is reached. Two observation wells should be drilled near well No. 3 and similar tests conducted there. Two additional test wells, each with two observation wells should be constructed, one in the northwest part of the North Unit and one in the southwest part of the North Unit, and similar tests carried out. It is possible that these tests could be carried out as part of the IDA Deep Tubewell Project. First pump tests should be scheduled in April/May and a retest in mid-July.

An important factor in the long term operation of a tubewell field is the groundwater recharge during a period of pumping use. Extraction of groundwater results in lowering of the water table and thereby an increase in pump lift and pumping cost. Unless the extracted water is periodically replenished, the cost of extraction can become prohibitive and eventually the well field can become useless. The recharge potential in the Project Area was determined in the Report from a water balance study and from direct measurement of groundwater fluctuations. In the latter, a storage coefficient was estimated as 0.2. The Consultants believe that storage coefficients are lower than estimated in the Report, and that they may vary with groundwater levels due to semi-confinement. Only four (maximum) observations wells were located in the North Unit for the

1968 observations, and only two (maximum) for the 1973 observations. Several judgement factors relating to run-off versus rainfall, questioned consumptive use determinations as discussed in Chapter 3.2.4, and inadequate basic data for establishing subsurface inflow gradients were used in determining the aquifer recharge potential. It is considered that the data on which these recharge calculations were based is inadequate and therefore the results unreliable. If, during the pre-final design stage, the use of groundwater sources becomes economically and practicably attractive, then it is recommended that a more vigorous and systematic approach using more reliable data should be adopted to define recharge potential and the ability of the aquifer to provide long term yields.

Notwithstanding the above comments on the general adequacy of the Report with respect to groundwater potential, the Consultants are optimistic that the aquifer characteristics and recharge potential would be suitable for full agricultural development of the North Unit using groundwater. The North Unit lies in the Teesta fan, comprising thick lenticular deposits of fine to coarse sand, with some silt, clay and gravel deposits. Literature indicates that groundwater in the area is unconfined and that domestic supplies of good quality water can be obtained from "shallow tubewells" only 25 feet deep. In the Thakurgaon Tubewell Project, Dinajpur District, the aquifer is unconsolidated quarternary deposits with appreciable thicknesses of sand several

hundred feet deep, similar to that beneath the North Unit. Tubewells, 250 to 300 feet deep with around 120 feet of screen, yield discharges of between 1 and 4 cusecs in this project. Similar long term capacities are expected for the North Unit.

3.2.4 Crop Water Requirements

Determination of the consumptive use of water for the crops to be grown in a project area throughout the various stages of their growth, that is, the evaporation of water from soil, plants and free water, and transpiration of water from crops, provides a data base for design of the entire project.

Several well known empirical methods exist for determining crop evapo-transpiration, but it is considered important, where possible, to support and verify these empirical calculations by direct measurement studies conducted in the locale of the project in question. The Consultants were unable to obtain a clear picture of what direct measurement studies have been undertaken, but it is believed that certain lysimeter tests have been, or are being, carried out, and that certain field experimental plots may have been monitored.

The evapo-transpiration figures used in the Report are based on the Penman formula. This formula is based on the concept that the potential consumptive use of a crop (ET) is directly proportional to a calculated reference evaporation (ET^1)

$$ET = K.ET^1$$

In the above formula , K is generally referred to as the crop factor, or consumptive use coefficient. ET^1 varies throughout the year according to meteorological conditions, and K varies with the crop and its stage of growth. K is the ratio of the evapo-transpiration requirement of the crop to the potential evapo-transpiration of a closely cut grass lawn.

For lowland paddy rice cultivation in Southeast Asia, the Penman formula is generally considered sufficiently accurate for design purposes, and it is also commonly used for upland crops. According to the Report, evaporation index figures (ET^1) were calulated on a country-wide basis using meteorological data collected from 15 stations throughout the country for the period 1959 to 1968. It is not known if TECL did these calculations or if they were done by Acres International (Overseas) as former general consultants to EPWAPDA. In the Report, the evaporation index figures for Rangpur were used as being applicable to the Project area.

The crop factors used were those suggested by Acres, presumably based on data available up to about 1968 or 1969. The crop factors given in Table VII-17 of Volume I of the Report for HYV rice appear somewhat conservative.

From Figure 3-4 herein[(1)], the crop consumptive use figures appear to be in the correct order.

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(1) Cornell University Thesis by Jacob Kampen 1970

Table VII-18 of the Report gives the winter peak use as 4.21 inches per 15 days (7.1 mm/day) and the peak monsoon season use as 3.29 inches per 15 days (5.6 mm/day).

The water requirement for land preparation is considered to be too low. Seven inches is used in the Report, applied over 15 days. A total requirement of 8 inches is commonly adopted in heavy silty soils of which about 4 1/2 inches are for liquid mud preparation and 3 1/2 inches for establishing a water layer. As the soils in the North Unit are not particularly heavy, considerably more than 7 inches of land preparation water would seem to be required. A comparison with Figure 3-5 herein also suggests that the 7 inches is too low (7" = 178 mm). Further, with only animal power available for land preparation, the 15 days allowed for this work is considered to be very optimistic.

The degree of refinement which should be undertaken to determine consumptive water use for design of a project is open to question. However, it is considered that in any given situation, all available data should be utilized to arrive at a design value of consumptive use. Significantly more meteorological data is available than was used in the Report. This should be utilized and the evaporation index figures up-dated. Comparison between predicted evapo-transpiration values with observed values from various research stations in Bangladesh would be of value in determining the validity of the predictions.

3.2.5 Diversion Requirements

The amount of rainfall which can be considered effective, and the losses which occur between diverting irrigation water from its source and its actually contributing to crop growth, have to be assessed in order to determine diversion requirements.

In cultivation of upland crops, the available soil moisture, its rate of depletion, and the moisture content at which optimum growth occurs are of importance when advanced rotational irrigation practices are to be adopted. Recent developments in rice cultivation also make use of available soil moisture. However, at the present stage of Project development, the assumption of zero available soil moisture, as made in the Report, is considered correct.

The Report utilizes the data in the Master Plan to determine effective rainfall. The rainfall for the 90 percent dry month, that is, the rainfall which is equaled or exceeded 90 percent of the time, was used to determine the dependable effective rainfall. All of this 90 percent dry month rainfall was then considered effective for supplying deep percolation and evapotranspiration requirements. In any irrigation system, there is a delay in shutting off supplies early enough to be able to utilize all rainfall for crop production. If a field

already has a full cover of water and a heavy rainstorm occurs, the farmer will drain off any water he cannot use, or the surplus may overtop the paddy bunds. Also, farm turnouts, lateral turnouts, and even the headworks cannot be operated sufficiently in advance of a heavy rain to ensure that all rainfall is kept in the project area and does not run off the fields. The distance of the Project from its water source, degree of water management being excercised, time of the year, condition and type of the soil, amount and intensity of the rainfall, crop growth stages and various other factors also influence the amount of rainfall which is effective. The full value of rainfall is usually not taken as effective, but only a fraction thereof. In the case of rice, the maximum effective precipitation can be taken as the crop evapo-transpiration plus deep percolation for the period considered.

IBRD has established provisional criteria for determining effective rainfall in Bangladesh based on six years of rainfall data analysed at Harvard in 1968. These criteria are as follows:

- In the months of May through October, the minimum surface run off is 20 percent of the rainfall, that is, 80 percent of

the rainfall is effective for evapo-transpiration and deep percolation losses from bunded plots with transplanted paddy.

- In the months of November through April, no surface runoff occurs.

Average monthly rainfall at Kurigram is less than one inch during November-March, 4.5 inches in April, and 6-20 inches during May -October.

These criteria would therefore be acceptable to the Consultants for ponded paddy lands pending review of operational experiences at other projects in Bangladesh.

Effective rainfall for upland crops will vary from about 100 percent in the winter to about 50 percent during the peak of the monsoon season.

The losses to be considered are as follows:

farm losses	- deep percolation - surface runoff due to farmers' inefficient use of water

	- lateral seepage - other farm inefficiences
conveyance losses	- seepage through canal banks - evaporation from surface of canal water - evapo-transpiration from canal bank vegetation - operational inefficiences

For ponded rice fields, deep percolation loss is continuous and must be taken into consideration. It is maximum during land preparation and then decreases as the paddy is formed. Field determination of this loss for the major soil associations is the North Unit should be made, thus eliminating the need to include this loss in a general Project efficiency as done in the Report. A review of water application requirements at research stations, together with details of the sub-strata, meteorological conditions, crop stage etc. could provide useful data for assessing this loss. These field determinations would also serve as one guide towards establishing water management techniques, that is, continuous irrigation versus rotational irrigation. For the soils in the North Unit, deep percolation could readily account for 2-3 mm/day in the dry season

and 1-2 mm/day in the wet season, say 2-3 inch/month and 1-2 inch/month respectively. Surface runoff has to assessed from experimental data, other project records etc.

Seepage through canal banks can be fairly readily assessed from published data depending on the embankment type, height of full supply level above groundwater, etc. Evaporation from canal water surfaces, and evapo-transpiration from canal bank vegetation are minor losses and can be fairly accurately assessed. Operational inefficiences can be estimated.

All losses are grouped together in the Report. Project efficiency for the surface irrigation water supply scheme is taken at 50 percent, and for the groundwater scheme at 60 percent. The latter higher efficiency is stated as being due to having used lined canals for the groundwater scheme. The 50 percent figure is reported based on a 64.5% farm efficiency and a 77.5% conveyance efficiency. Note that the farm efficiency includes deep percolation. These efficiencies are considered too high for the degree of water management likely to be attainable during the early life of the Project, the unlined high level main canals, and the inclusion of deep precolation.

Following determination of peak diversion requirements based on the evapo-transpiration calculations, the 90 percent dry month for

effective rainfall, and a 50 percent estimate of Project efficiency, an arbitrary 20 percent was added to allow for short drought periods not accounted for in the 90 percent dry month calculation. In Chapter 3.2.2 of this report it is recommended that drought studies should be made.

It is considered that determination of the diversion requirements in the Report is rather empirical, does not utilize all reasonably available data, and probably results in an underestimation of requirements. It is considered that diversion requirements should be further studied before final design is undertaken.

3.2.6 Drainage Requirements

The Report proposes improvement of the drainage ways in the four natural drainage basins within the North Unit and installation of one pumping station to evacuate surplus drainage water from each of these basins. Evacuation of water from each area is to be by pump when the river is at high stage and by gravity when it is at low stage. All pumps are of 200 cusec rated capacity, although pumping heads vary from 15 to 30 feet. The Report states that the pumps will be required to operate for three to four months in the year.

The design approach taken was to perform a frequency analysis on eleven years of daily rainfall records (1946-49, 1961-67) from the Kurigram Station, for maximum short period rainfalls of 1, 3, 5, 10 and 15 day duration. The 15 day, 10 year recurrence storm was then taken as the design storm, that is, the 15 day storm which can be expected to be exceeded once in 10 years. Distribution of the rainfall over the basin area was then determined using the procedure given in the Master Plan and the dispersion factor was calculated as 0.8, that is, average rainfall intensity over the area was 0.8 times the rainfall intensity at the centre of the storm.

It was assumed that 70 percent of the basin area would be in paddy and 30 percent in upland crops, and various assumptions were made as to retention, infiltration and evapo-transpiration in determining overland storm flow to the main drains. A synthetic unit outflow hydrograph was then determined using techniques commonly adopted for watersheds in which none of the streams have been gaged.

Apart from a careful check on the qualitative and quantitative aspects of the drainage systems which would normally be undertaken during final design, the following should be undertaken at the pre-final design stage:

- utilize all available rainfall records.

- use Master Plan graphs and procedures with caution as these are now 13 years old.

- verify the design storm selection. Short duration storms have higher intensities than long duration storms, and peak outflow from the system could be greater for short storms.

- Consider time, depth and area of inundation related to ability of crops, houses, roads, etc. to withstand this temporary inundation when determining design and installed pumping capacity.

- match assumptions regarding percentages under rice and upland crop cultivation to the proposed cropping pattern.

- consider storm patterns and occurrence of heavy storms superimposed on heavy rains, such as would nullify any benefits from initial retention.

- consider any retention effects of the rail embankment culverts, etc.

- standardize on pumps as much as possible when deciding on installed capacity, etc., considering the sacrifice in efficiency on the one hand and interchangeability of parts on the other.

- Carefully review economics of sluice vs. pump drainage. The Report states that 20 percent of the land will be flooded once in 10 years. Lesser flooding will obviously occur more frequently. Consider possibility of interconnecting drainage courses.

Drainage routings and selection of pumping capacities were based on the synthetic inflow hydrograph. These were not thoroughly reviewed as they depend on the validity of the inflow hydrograph, but the procedures appeared to be standard.

3.3 AGRICULTURE AND IRRIGATION

3.3.1 Present Land Use

Proper assessment of present agricultural and socio-economic conditions in an area being considered for development is clearly an important part of any feasibility study.

From preparation of the 1969 Feasibility Report, 19 villages in the North Unit were selected at random and approximately 3,000 farmers were interviewed to ascertain the present land use, cultural practices, socio-economic conditions etc. According to the Report, the surveyed area represented about 8 percent of the gross Project area, and all major soil associations, areas and land use units. Unfortunately, this extensive survey was conducted in the last six months of 1967, some eight years ago. It is doubted, however, if conditions have improved.

In early 1973 and mid 1974, during the updating of the 1969 Feasibility Report, the original data was revised by field interview teams. The report concludes that the 1967 data is essentially valid. It appears that the senior staff of TECL are very familiar with the area and critical errors are considered unlikely.

Present land use is given in Chapter IV of Volume I of the Report and is summarized as follows:

PRESENT LAND USE - NORTH UNIT

Use	Area in Acres	Percent of Gross Area
Cultivated Areas	77,170	74.56
Fruits	4,813	4.65
Pasture and Fallow	1,004	0.97
Homesteads and Ponds	8,652	8.36
Other Use	4,771	4.61
Farm, Markets, Schools, etc.	7,090	6.86
	103,500	100.00

The present cropping intensity for the North Unit is given as 1.52. Broadcast aus was found to be the principal cereal crop in the North Unit and occupied some 65 percent of the total cultivated area. It was estimated that 45 percent of the land in the North Unit is single cropped and 52 percent is double cropped. It appears that the major double crop rotations are B. aus followed by T. aman and jute followed by T. aman.

It is considered that with minor checking, the data in the Report will provide a satisfactory base from which to determine Project benefits.

3.3.2 Present Use of Irrigation

It is stated in the Report that irrigation facilities are nearly non-existent in the North Unit and that the area should be considered as a rainfed area. Some abandoned irrigation systems do, however, exist in the North Unit and were noted in the area north of the abandoned railway line at Pateswari. In discussions with local officials it was learned that low-lift pumps had at one time been used in this area. In the USAID Memo to File dated April 22, 1975 it mentions that at Burungamari (in the area mentioned above) 32 out of 39 low-lift pumps were working. Whether or not these utilized the small irrigation canals noted is not known. Study, with respect to the failure or success of these small systems could provide information regarding problems to avoid in implementation of the North Unit.

At the time of the Consultants' field visit, the North Unit appeared to be essentially fully cropped with either jute or T. aman. Some fields were short of water and the majority of fields were inadequately fertilized. Manual irrigation methods were not seen to be in extensive use, but undoubtedly these methods are used adjacent to beels during the early aus and late T. aman season.

The information in the Report on present irrigation practices is considered adequate.

3.3.3 Soil Survey and Land Classification

It appears to the Consultants that much of the information presented in the Report is from the Reconnaissance Soil Survey of East Pakistan. This survey is of reconnaissance level only.

The office and field work undertaken specially for the Report was aerial photograph interpretation, field traverses, field examination of profile pits and auger holes, and field and laboratory analyses of master samples. Eleven soil series were identified in the Project area (Bonarpara, Gangachara etc.), and were then grouped into fourteen soil associations based on geomorphological features (Palashban-Banapara association etc.). The fourteen soil association boundaries were plotted on Plate V-1 of the Report as the Soil Map. The master samples, eleven in all, were taken to represent each of the soil series. The sample pit dug for each master sample varied from 23 inches to 57 inches and mechanical and chemical analyses were performed on each major horizon in the pit. A total of 55 samples from these pits were chemically analysed for some of the following:

- pH
- Organic carbon content
- Total nitrogen percent
- Available potassium
- Available phosphorus
- Total soluble salts
- Bicarbonate
- Cation exchange capacity
- Electrical conductivity

Twenty seven of the samples were analysed for all of the above properties.

Fifteen samples were taken from six of the series and tested for mechanical properties including hydraulic conductivity, moisture content and aeration.

A land capability map was also prepared, Plate V-2 in the Report. For this map, the soil associations were grouped into a total of six classifications ranging from "predominantly good agricultural land" to "mainly moderate agricultural land with some good and poor agricultural land". Although the separation of the land capability classifications into various sub-classes depending on limitations due to drought (d), limitations due to relief (r) and limitations due to flooding (w) is discussed in the Report, these sub-classes were not plotted up in the Report.

Each soil series was classified for crop suitability, before and after project, on a 1 to 4 rating. The rating for each of the crops is given in Table V-5 of the Report.

In summary, the Report presents a soil map (Plate V-1) giving general outlines of eleven soil series associations; a land capability map giving general outlines of good, medium and poor agricultural land; a tabular classification of each soil series as to its present and future suitability for particular crops, and a small number of chemical and physical test results. From the data given, there

is no way to classify particular areas of land according to their capability to support rice or other crops.

The number of auger holes taken range from about 1 to 8 per square mile (say 2 per sq.km.). One test pit was taken for each typical soil series. One soil sample was tested for about every 4 square miles. The auger work could be considered adequate for feasibility studies, but the extent of the laboratory testing places the studies in the reconnaissance category. Possibly additional raw data is available which could be utilized to obtain a clearer delineation of the various classes of land.

The laboratory data presented in the Report indicates the following general soil properties:-

> somewhat acid soils with expected lesser acidity at the deeper horizons (if the samples were taken during the dry season, this acidity could be expected to reduce with long submergence); low organic carbon content indicating a low nitrogen supplying ability for plant use over periods of time ; moderately available plant nutrients (potassium and phosphorous); salinity problems unlikely (pH < 7, EC < 2); reasonably inherent fertility (CEC generally > 5); and highly variable hydraulic conductivities ranging from rapid to extra slow. It should be noted that only 27 samples from 5 of the 11 series were tested

for all chemical properties listed earlier and only 15 samples from 6 series were tested for mechanical properties. These general properties may therefore not be applicable to the whole 74,000 acres in the North Unit.

The Report concludes that good to moderate agricultural land covers most of the project area, and poor land very little of the area. This general assessment would appear to be correct.

For optimum design of an irrigation system, it is necessary to delineate and classify areas as to their suitability for certain crop production, delineate areas which require levelling to improve their classification, delineate areas which need drainage improvements and their effect on the classification, and so on. This information is also required for later optimum management of the project, that is, establishing the amounts and timing of water applications, planning the addition of nutrients, planning improvements such as land consolidation, establishing optimum cropping patterns and rotations, and teaching sound agricultural practices. Further, the problem of aeration and re-texturing of soils for upland crop cultivation immediately following paddy rice cultivation, and the problem of waterlogging lands growing dry foot crops when paddy crops are grown on immediately adjacent lands, are matters for which accurate soil surveys, land classification maps and land drainage maps are required. It is, therefore, recommended that a detailed land classi-

fication and drainage study be initiated as early in the pre-final design stage as may be prudent. It is recommended that classification be on a dual system, one classification for rice, one for upland crops. The results should be presented in report form and summarized as a practical soils management guide for operation and improvement of the project.

Since time is the essence of developing the North Unit, the study could be phased to initially provide sufficient detail for basic design and construction, and then to later provide the detail required for optimum management. Field and laboratory work capabilities would have to be studied to determine how rapidly these phases could be accomplished. The following table gives an idea of reasonable production rates and sample densities.

LAND CLASSIFICATION STANDARDS

(As Adopted by RID, Thailand)

October 1975

Grade of Study	Field Work Production Rate * Sq km/mo/crew	Auger Borings No/sq km	Test Pits	Laboratory Samples** Tested No/sq km	Remarks
Reconnaissance	220	0.25	1 or 2 per major class	0.5	
Semi-detailed	33	2 to 4	1 or 2 per major class	5	Feasibility grade
Detailed	11	8 to 10	1 per sq km	10	Final management grade. Try to complete before final design

* 1 crew = 1 Land classifier, 2 helpers, 1 driver, maybe 2 labourers

** 1 auger hole or pit would contain say 4 to 8 samples

3.3.4 Need for Irrigation

The climate in the area can be broken into three seasons:

- March through May, warm season
- June through mid-October, monsoon season
- October through February, cool season

Mean daily temperatures vary from about 64°F in January to about 85°F in August. Maximum and minimum temperatures recorded in the Project area are about 107°F and 39°F. Temperatures are high enough to allow year round crop cultivation, but unfortunately 75 percent of the annual rainfall of about 86 inches falls in the monsoon season. Even during the monsoon season, temporary droughts of two to three weeks cause moisture stress to the aus, T. aman, and jute crops.

With a dependable supply of irrigation water, the aus and aman crops will be assured adequate supplemental water, and cultivation of a boro crop will be possible.

Even though changes in the project plan and the project economics are expected, every indication is that irrigation alone (without a flood embankment if that is technically feasibility) will yield considerable increases in foodgrain production and benefits to the farmer.

3.3.5 Cropping Patterns and Crop Yields

Selection of a proposed cropping pattern for the Project and estimation of the crop yields under improved conditions is of major importance in determining the economic viability of the Project, and the benefit of the Project to the farmer. In addition, the selected cropping patterns have a strong influence on water requirements for the Project.

In planning the future cropping patterns and crop calendars for the North Unit, the main objective appears to have been to intensify and diversify the present cropping pattern and optimize benefits. This has resulted in the adoption of a highly complex cropping pattern and crop calendar. If this can be achieved in practice, the cropping intensity will be 2.7 as opposed to the present 1.5.

Experience has shown that planning a complex cropping pattern and crop calendar with detailed consideration of minor upland crops, has limited value in determining feasibility. Wide crop diversification and the patterns of minor crop distributions are dependent upon the individual preference of the farmers involved and will in all probability vary from year to year based on availability of labour, animal power, seasonal peculiarities, etc.

Twenty five different rotations on single, double and triple cropped land are proposed in the Report. The Consultants feels that this pattern should be

simplified and made more in line with what can be reasonably expected as the result of normal well planned and enthusiastic extension effort. Upland crops vary little in evapo-transpiration requirements and could therefore be grouped together. This approach would simplify all analyses based on the future crops, such as water requirements, input requirements, costs of production, benefits to the farmer and feasibility of the Project.

The farmers in the area are apparently able to utilize their land more effectively than the average farmer in Bangladesh even though irrigation water is not available except from small water-courses within the area. Current cropping intensity is given as 1.52 against the national average of 1.36. As far as can be determined from the Report, the present 1.52 cropping intensity figure does not include any correction for major annual flooding and loss of cropped area.

Crop yields are low. The area is remote from the sources of input supplies, and access to the area is poor. The use of HYVs of rice appears to be minimal, and was reported to be due to poor experiences with low grade seeds, lack of fertilizers, and the vagaries of the water supply. It is understood that farmer resistance to change and improvement is low, and given good seeds, fertilizers and a dependable water supply, HYVs of rice will be cultivated in a con-

siderable portion of the area, if the extension work is enthusiastically undertaken.

The present cropping pattern is characterized by the fact that 45 percent of the cultivated area is single cropped, only 52 percent double cropped, and nil triple cropped. These areas break down as follows:

PRESENT CROPPING PATTERN

Single Crop

			Area (in acres)
Rice:	B aus		20,908
	T aman		11,230
	Boro		nil
Other Crops:	Jute		4,459
	Kharif	pulses	281
		vegetables	230
		chilli	140
		kaon	114
		sugarcane	102
	Rabi	s. potato	45

Double Crop

Rice:	B aus		29,560
	T aman		32,813
	Boro		nil
Other Crops:	Jute		10,319
	Kharif	wheat	58
		barley	29
		mustard	5,156
		onion and garlic	163
		tobacco	163
		potato	579
		pulses	456
		kaon	55
	Rabi	S. potato	42
		chilli	248
		vegetables	172

Summary

	Area (acres)	Yield (maunds)
Rice:		
B aus	50,468	12
T aman	44,096	15
Boro	Nil	Nil
Other Crops:		
Jute	14,778	15
Kharif mustard	5,156	5
other	2,412	various
Rabi	465	various
	117,375	

$$\frac{117,375}{77,000} = 1.52 \text{ cropping intensity}$$

The above figures are those given in the Report. The B aus yields are usual, but the T aman yields are low. Farmers in one village quoted 24 maunds/acre. These figures should be double checked.

The projected cropping pattern utilizes all HYVs of rice in the aus, aman and boro crops. The principal projected crops and their areas are as follows. Note that only 74,000 acres are taken as the cultivated area and not the 77,100 at present cultivated. Some cultivation outside the embankments will obviously continue.

PROJECTED CROPPING PATTERN

		Area (acres)	Yield (maunds)
Rice:			
T aus (Chandina)		47,000	50
T aman (Irri.)		47,250	40
T aman (DA-31)		6,500	27
Boro (Irri.)		13,750	50
Other Crops:			
Jute		15,000	23
Kharif	mustard	5,000	12
	fodder	16,750	120
	other	22,000	various
Rabi	fodder	25,000	100
	other	2,750	various
		201,000	

$$\frac{201,000}{74,000} = 2.7 \text{ cropping intensity}$$

The projected cropping intensity is clearly high, but it should be noted that the present cropping pattern given in the Report includes no fodder crop, whereas the projected cropping pattern includes 41,750 acres of fodder. As shown in Table VII-21A of Volume I of the Report, this extensive fodder crop contributes little to the economic feasibility of the Project. Without the fodder crop, the cropping intensity is 159,250 ÷ 74,000 = 2.15, which is considered ultimately achievable.

Analysis of the present and future patterns indicates the following salient points.

INCREASES IN YIELDS

Crop	Present			Future			Net Total Yield Increase (maunds)
	Area (acres)	Yield (maunds/ acre)	Total Yield (maunds)	Area (acres)	Yield (maunds/ acre	Total Yield (maunds)	
Rice:							
Aus	50,500	12	606,000	47,000	50	2,350,000	1,744,000
Aman	44,000	15	660,000	54,000	40	2,160,000	1,554,000
Boro	Nil	-	-	14,000	50	700,000	700,000
Other Crops:							
Jute	15,000	15	225,000	15,000	23	345,000	120,000
Kharif	10,000			27,000			
Rabi	500			3,000			

The following general comments on the future cropping pattern are based on discussions with various officials in Kurigram.

- The present North Unit population could consume the total yield from about 7,500 acres of wheat (2 seers of wheat flour/ month/person).

- Farmers in the Project area are currently selling jute to middlemen at about Tk70/maund. At a maximum yield of say 25 maunds/acre jute is unlikely to displace HYV rice unless the Government introduces heavy subsidies or world market prices change considerably. Jute would replace the aus crop.

- Sugarcane is not grown in quantity in the area largely due to the problem of access to a sugar mill. The closest mill is at Lalmanirhat. Current prices are about Tk10/maund at the collection point. Yields are about 400 maunds/ acre. If access were to be improved, sugarcane production could well compete with rice, particularly once the area is self sufficient in rice, and since with improved agricultural practices the yield could probably be increased from 2 to 2.5 times over say 10 years.

Alternative cropping patterns should be developed based on providing supplemental irrigation during the aus and aman crop, and using minimum irrigation water during the dry season. The North Unit feasibility must be tested for such a pattern as it may be forced on the Project if India diverts significant quantities of water from the Dudhkumar River during the winter months.

In preparing any of the cropping patterns and crop calendars, peaks in labour and water requirements should be avoided.

With an assured water supply, flood control, improved water and farm amanagement, all required inputs, use of guaranteed HYV seeds, and a significantly better extension service, the above projected yields are attainable. It will take, however, probably 5 to 10 years after provision of irrigation water to achieve them.

3.3.6 Agricultural Inputs

3.3.6.1 Fertilizer:

During the Consultants' field visit to the North Unit, the use of inorganic fertilizer was seen to be almost nil. In discussion with officials in Thakurgaon, Kurigram and Rangpur, the inadequacy of timely fertilizer supplies, and the poor distribution of any supplies made available to the District were repeatedly put forward as a severe restraint to improving crop yields.

At the time of the Consultants' field visit, the system used for distributing fertilizers was understood to be as follows:

- Preparation of a fertilizer indent by the BADC Sub-Division office.
- Submittal of indent to BADC Dacca for approval and allocation of approved amount.
- Transfer of approved amount to BADC Sub-Division godown (storage space not a problem).
- Transfer to BADC Thana godowns using local transport contractor arranged by BAFC (storage space not a problem).
- Thana Committee allots their supply to the various Unions based on a list of deserving farmers prepared by the Union Committee.
- Local dealers from each Union purchase from the Thana godown to sell to the farmers on the list (storage not a problem).

This rationing system was apparently established due to the critical shortage of fertilizer in the country. It was a complex system and one which was expected to be changed when fertilizer supplies became more readily available. The preparation of a list of deserving farmers by the Union Committee was criticized by the various officials.

During preparation of this report, the fertilizer distribution system was partially de-controlled to make it easier for the small farmer to buy fertilizer at the Government subsidized prices. The new system will also help to reduce black marketeering with its adverse effects on the small farmers' debt situation and foodgrain production in general. The present "open sale" distribution system is understood to be essentially as before until the fertilizer reaches the Thana Agriculture Development Committee godown. From that point, the fertilizer is distributed to approved retailers according to an allocation list prepared by the Thana Agriculture Development Committee. The farmers then buy from whichever retailer they choose.

The supply and distribution of fertilizers must clearly be improved if the yields forecast in the Report are to be achieved. The fertilizer industry as a whole is receiving attention and the availability of adequate quantities of fertilizers to the farmers at controlled prices should improve. There are 200 ton godowns at Kurigram, Phulbari

and Nageswari, and plans are laid to construct a 2,000 ton godown at Kurigram and a 400 ton godown at Burungamari. While improvements in the present inadequate fetilizer situation can be expected, the feasibility of the North Unit project should be tested for less than fully adequate fertilizer supplies.

3.3.6.2 Seeds

The farmers in the North Unit have been discouraged from using HYVs of rice by occasional total crop failures and poor yields. This was reported to be due to the supply of poor seed, in turn due to inadequate procedures for developing breeder, registered and certified seeds by BADC.

Recent changes in these latter procedures, whereby the Ministry of Agriculture is to be responsible for the certification of seeds, and the BADC (now Bangladesh Agricultural Input Supplies and Services Corporation) responsible only for multiplication, should improve the quality of seed available to the farmer. The current IBRD Cereal Seeds Program is designed to ensure an adequate supply of quality seeds to the farmers. The present unsatisfactory situation should have improved by the time the North Unit is being developed and should not be a restraint on development.

3.3.6.3 Pesticides

The availability of pesticides and their application does not appear to be critical, at the present time, to increasing crop yields.

It is understood that the Union Agricultural Department (Ministry of Agriculture) arranges for required protection through the Plant Protection branch of the Agriculture Department. In the past, the pesticides have been provided free, but now have to be purchased by the farmer. Extension effort in plant protection is reported to be operating satisfactorily in the area.

3.3.6.4 Credit

The Report advises that credit in the area is severely restricted, but this view appears to be based on census data dated 1961 and disbursements of credit through the Agricultural Bank of Bangladesh during 1970-71.

Officials in Kurigram advised that credit was no problem, that most of the farmers had title deeds to their lands and could

obtain credit at 9 percent through the Agricultural Bank or other banks. One group of about 10 farmers living in an area adjacent to the Brahmaputra, with no dependable water supply, suffering from loss of land to the river, and obviously with a low standard of living, advised that they could buy fertilizer, if it was made available, from their own resources.

An accurate assessment of the credit situation could not be made within the time available, and conflicting opinions as to the adequacy of the present arrangements were voiced by various groups.

Regardless of whether or not the current availability of credit is adequate for the present agricultural conditions, under an accelerated agriculture program the need for credit will almost certainly exceed the present supply. Steps should therefore be taken, during the pre-final design stage, to review the current and future credit supply arrangements in detail, and to establish a credit supply system under which credit can be obtained by the farmers at reasonable rates, with minimum documentation and delay, and in the amounts which will be required. Failure to provide this credit will severly restrict development.

3.3.6.5 Marketing

Under the present low level of agricultural development, marketing facilities are not critical. The rice grown in the area is consumed in the area. Jute is a minor crop in the North Unit, and is shipped in country boats across to Kurigram where it is collected and transported by rail to Dacca.

If the North Unit development is implemented, the present marketing facilities will be totally inadequate. The major markets immediately outside the North Unit will probably remain at Kurigram and Lalmanirhat. Access from the North Unit to Kurigram is by country boat. From Kurigram, Lalmanirhat can be reached by kucha road, or by train via Teesta. The train journey is rather tedious and time consuming so that if the Kurigram -Lalmanirhat road is not improved. Kurigram will probably be the main market town for the sale of surplus rice, wheat and vegetables grown in the North Unit.

Local marketing of crops will be severely restricted by the internal road system. These roads are almost impassable in the monsoon season. Transportation to local markets is by boat or by bullock cart. In an accelerated agricultural development plan, these roads must be improved and the canal road system must be laid out with improvement of the internal access facilities in mind.

The absence of good access within and without the North Unit would be a severe restraint to achieving the forecast agricultural development.

3.3.6.6 Manpower

The Project area has an abundance of under-employed manpower. Some 56 percent of the population in under 20 years of age and the population is growing at over 3 percent per annum. The availability of labour will not be a constraint to completion of the engineering works or to intensive agriculture. The lack of skilled labour for construction may be a problem.

3.3.6.7 Agricultural Extension and Institutions

Extension

Agricultural extension work is at present carried out by BADC, BWDB, the Ministry of Agriculture and others. Recent changes in the organization of the Ministry of Agriculture have seperated the agricultural input side (BADC) from the research and development side. The BADC participation in extension should decline in the future and their direct involvement in extension on the Project should be nil. Even if BWDB initially act as lead agency on the Project, the extension work should clearly be carried out by the Extension Department of the Ministry.

An efficient agricultural extension program is clearly required for the North Unit project. It is recommended that during the pre-final design stage, the existing and proposed extension organization and programs be carefully reviewed and that an agricultural extension development program for the North Unit be included in the scope of the Project. The program should be integrated with other training programs already initiated and should cover planning and organization of the extension service, training of personnel in extension work, selection of extension topics, development of curricula, extension strategies and methods, preparation of extension and training aids, and evaluation of the extension service performance and the efficiency of the methods employed.

Cooperatives

At the present time, the formation of agricultural Cooperatives comes under the Intergrated Rural Development Program of the Ministry of Cooperatives and Rural Development. These cooperatives are not contributing greatly to agricultural development in Bangladesh. This could be because until the basic problems of dependable irrigation, freedom from flooding, provision of adequate supplies of inorganic fertilizers, and supply of certified seeds are solved, the farming population sees no real advantage in cooperative action.

The development of cooperatives in the North Unit is not considered a priority undertaking, but plans should be laid during the pre-final design stage for handling this problem at some allotted time in the future. The North Unit is a single irrigation unit, and eventually one multi-purpose cooperative could be formed to cover the area with as many branch offices as may be needed. If the area is to be intensively cultivated, a multi-purpose cooperative or a similar organization, supplying all the basic needs of the farmers such as extension advice, seeds, fertilizer, credit and implements will be of considerable help.

Irrigation Associations

Similarly, the question of system operation and maintenance and the possibility of working towards an irrigation association which can handle a part of this should be considered. Again, this is not an immediate problem as BWDB will have to operate and maintain the system for some years after project completion, but the users of the water should be organized towards accepting an increasing share of maintaining a portion of the irrigation system and all of the embankment during the implementation period. The manner in which to achieve this should be considered during the pre-final design stage and plans laid at that time. It would seem

logical to use the Union and Thana boundaries as sub- units for cooperative and irrigation association development. However, these boundaries will not coincide with the logical irrigation association boundaries and some compromise will be necessary.

Integration of Agricultural Services

It is recommended that current national policies covering multipurpose cooperatives, irrigation associations, operation and maintenance procedures, cost recovery, and project ownership be studied and reviewed with the Government during the pre-final design stage to determine what reforms or additional studies should be undertaken during project implementation. Appropriated policies will become increasingly important as the national accelerated agriculture program progresses, and it may be advisable to use the North Unit as a pilot project for any new or modified approaches.

Agricultural Research

When setting up the North Unit project organization, provisions must be made for transmitting the results of appropriate research programs to the extension workers in the North Unit.

3.7.6.8 Storage Facilities

Storage facilities at present are reported to be adequate. The quality of the storage facilities

could undoubtedly be improved, but such improvements as may be necessary should present no problem under guidance from the extension workers.

3.3.7 Livestock and Poultry

These items are of minor importance to the feasibility of the North Unit.

The present livestock situation appears to be that many of the draft animals have been lost due to floods. While purchase and breeding of draft animals (and the breeding of poulrty) will probably take care of itself shortly after the crop yields begin to improve, the quality of the available animals must receive planned attention. With intensive year round agricultural development, the input required from animal labour is going to increase. The draft animals must be bred and nourished to be able to work long hours for days on end during the land preparation stage, if land preparation time (fallow land time) is to be minimized. At the present time, the available draft animals are in very poor condition.

3.3.8 Pilot Areas

The terms of reference for preparation of the Report called for proposals for the development of pilot areas using the proposed test tubewells. The Report proposes five 150 to 170 acre pilot areas, two in the North and three in the South. The size was presumably selected so that it could be supplied by one tubewell. The areas in the North Unit are located at Chandipur slightly south-east of the centre of the North Unit, and at Nilurkhamar, just north of the centre. The reason for selecting these two particular areas is not readily apparent. Both areas are above normal flood levels. The two areas contain similar soil classifications, although there is a greater area of more sandy soils at Chandipur. Both areas are level to gently sloping.

In the selection of pilot areas, it is essential to first determine the type of demonstrations which are to be carried out. For example, these areas can be utilized to determine the benefits from different degrees of water management, rotational versus continuous irrigation, different densities of secondary canals (laterals and sublaterals), lined versus unlined canals, as well as the more usual items such as new crop varieties and new cropping patterns. They can be used as pilot areas for setting up cooperatives, irrigation associations or water users groups, which can be expanded to cover additional areas around the pilot areas as the

additional areas are brought under irrigated agriculture. Later, they can be used as pilot areas for land consolidation programs, that is, re-alignment of farm boundaries, provision of all weather farm plot access roads, and provision of a controllable water inlet and a controllable drainage outlet for each and every farm plot.

Management of pilot areas, which it is assumed will remain owned by the various farmers, must be carefully established at the predesign stage. The Governmental agencies responsible for the various inputs into the area must be organized as a term and their various responsibilities and inter-relationships established. The question of subsidies on seeds, fertilizers and pesticides, and compensation for failures must be clarified. An organization for transporting groups of farmers from other areas in the North Unit to the pilot area for lectures and explanations should be established. Training programs, farmer clubs, and the staff to supervise and organize these, should be considered at the pre-design stage. Training facilities and materials must be planned for.

In selecting the pilot areas, one special point should be kept in mind. Dry season irrigation will depend largely on the low flow in the Dudhkumar River. If this flow is decreased by India, alternate cropping patterns will have to be implemented. The pilot areas should be used to encourage these new cropping patterns. Those

farmers near the headworks will probably be able to continue with their established improved cropping patterns, but those at remote ends of the system will suffer from the shortage and have to change their cropping patterns. One pilot area should, therfore, be located in the potential water shortage area.

The pilot area management proposals in the Report stress what is to be done rather than how the various tasks are to be done and by whom. The organization of the pilot area should be a miniature of the desired Governmental organization for accelerated agricultural development throughout Bangladesh, and be an integrated part thereof. The pilot area organization should be established with this in mind.

3.3.9 Fisheries

Most of the rivers surrounding the North Unit, and most of the interior beels, provide fish for the local population.

May to June is reported to be the best season for river fishing when plenty of fish are available. During the remainder of the year, the supply of fish is reported to be well below the demand.

It is understood that a Northern Bangladesh Fisheries Project is underway at the present time, and that a fish hatchery has been constructed at Nageswari as part of this project.

The development of inland fisheries should be a part of the North Unit development, but it would appear that co-ordination with existing programs is all that has to be included in the scope of the North Unit Project.

3.4 FLOODING

3.4.1 Flood Damage

Due to the absence of good records, it is difficult to determine the extent, depth and duration of flooding, and to thereby assess the value of the flood damage and the probability of a certain level of damage occuring during any given period of time. Notwithstanding this absence of data, all evidence indicates that the area's development is severely restricted by the annual flooding and the demoralizing effect of this flooding on the population.

An accurate record of the flooded area was obtained during 1967 for preparation of the Report. Copies of the final flood reports for 1972, 1973 and 1974 for the whole Kurigram Subdivision are given in Appendix A.

Figure 3-6 presents information on the 1967, 1972, 1973 and 1974 floods extracted from the available data in the Report and Appendix A. This information does not appear to be consistent with regard to the duration of flooding as the detailed reports for 1974 studied at Kurigram gave the duration of flooding as up to 59 days. Nevertheless, the damage from flooding is obviously severe.

Although 1967 was not a severe flood year, 20 percent of the cultivated land was inundated. In 1973, 26 people lost their lives, 700 cattle were lost, and almost 900 square miles of cropped area were damaged. In 1974, a bad flood year for most of the country, the damage in Kurigram was less than in 1973. The area flooded in 1974 is shown in Appendix A. This map indicates areas in which the canal system could be constructed before the flood embankments are finished in order to bring some of the area under irrigation as soon as possible.

The three rivers, Brahmaputra, Dharla and Dudhkumar, do not necessarily peak at the same time and there is no way to predict which area will be flooded at any one time or to what extent. The Brahmaputra stays in high stage for some considerable period of time each year and causes backwater effects in the Dharla and Dudhkumar Rivers. Based on the stage and discharge hydrographs and the topographic maps, it is possible to predict the extent of flooding say once in 10 years, but obviously no way to predict when flooding may occur. The Dharla and Dudhkumar rivers are flashy rivers, as discussed earlier, and their flood peaks are usually of short duration. If it were not for the Brahmaputra backing up the outflow from these rivers, the rice crops could well survive this short period of inundation without critical damage. As it is, the period and depth of inundation, the speed at which the water deepens, and the variations in the time when the floods hit, prohibit the possibility of a change in cultivation practices to lessen the damaging effect of flooding on the rice crop.

The overbank flooding of these rivers has an additional bad effect on the areas flooded. If the flood is particularly severe, sand can be carried far inland and the depth of blanketing can be considerable. Kurigram residents advised that the 1974 floods had rendered some agricultural land useless by depositing 6 to 12 inches of clean sand on them. At the river banks, 18 inch thick layers of clean micaceous sand were seen to be common.

A good effect of the flooding, apart from filling inland beels which can then be used for irrigation of the later stages of growth in the aman crop, is that if the floods are not too severe, fine silt rather than sand is deposited on the river terraces. This silt carries nutrients and tends to fertilize the top soil, but the exact value of these silts is not known. Studies carried out at Hawaii University in 1974 indicated that "sediment deposition does not measurably increase the soil fertility of soil in the Mekong Delta." The report cautions the transfer of these findings to even the northern sector of the Delta, let alone to other deltas. The relationship between sediment and fish production was not considered in these studies.

3.4.2 Flood Control Possibilities

It is generally accepted that, in Bangladesh, flood control must be achieved by constructing embankments along both banks of the rivers to sufficient height to contain a 100 year flood. Diversions of the major rivers have been considered as flood control measures, but as the Project is at the extreme upstream end of the Bangladesh portion of the Brahmaputra River, the Project would be unaffected by such schemes even if they were implemented.

River training by construction of spurs, half panels, deflection dikes or similar measures has not been undertaken as a matter of routine on the Bangladesh Rivers. The Belkuchi Project embankment (right bank of the Brahmaputra) has almost come under direct attack from the Brahmaputra River, and it is understood that river training methods have been proposed. The effectiveness of any measures which may be adopted could provide valuable information for planning protection of the Project embankments. If training measures cannot be economically or successfully developed, then provisions will have to be made for protecting the embankment itself using brick mattresses, facines, or other applicable methods, or building a new embankment further inland before any existing embankment fails. These protective measures may be able to be carried out under a routine maintenance program, but also since the short-term lateral migration of the Brahmaputra channel can be as high as 2,600 feet per year, they may have

to be undertaken on an emergency basis. Developing a well organized and properly equipped maintenance staff should be an essential part of the Project. This organization should include provisions for emergency mobilization of local labour and should include provisions for the maximum practicable local involvement in the entire operation and maintenance program for the Project. This involvement is seen best accomplished as a planned step by step program.

An alternate means of flood control which could by considered is the submersible embankment. This embankment would be located on the same alignment as the full height embankment, but would be of less height and give full protection for say only a 25 year flood. Peak flows in the river in the Project area could occur anytime from about mid-June through September, that is, during the latter part of the aus crop and the early part of the aman crop. During the latter part of the aus crop, significant flooding could be tolerated by the maturing plants without excessive damage. Therefore, the sluices could be opened to balance water levels on both sides of the embankment and the crop allowed to be subjected to the normal flood hazard. Balancing water on both sides of the embankment would ensure that on a slow rising river stage the embankment would not be overtopped. If a flash flood were to occur, however, which exceeded the capacity of the sluices to balance water levels on either side of the embankment the embankment could be overtopped and severely damaged. Rapid flooding of the irrigation system could also cause considerable erosion of canal banks and silting of the canals.

During the early part of the aman crop the hazard of overtopping would necessitate the sluices being left open to balance water levels on either side of the embankment. The aman crop would, therefore, be subjected to the normal flood hazard at a critical stage in its growth. Losses would therefore be unreduced. Thus, the only benefits achieved from a submercible embankment design would appear to be the prevention of flood damage during the early part of the aus crop when the plants are small and susceptible to flooding, and during the latter part of the aman crop when the plants are nearly fully grown and could anyway stand some inundation.

In the opinion of the Consultants, the submersible embankment concept is not practicable for the North Unit. The difficulties of operating the sluices to prevent overtopping (flood warnings from India would probably be minimal), and the hazard of severely damaging the embankment and irrigation system, are considered too great for the small degree of real protection and benefit afforded.

Flood waters penetrate the inland areas by backing up the drainage courses, and then, when the river banks are overtopped, by overland spill. Small regulating structures on the drainage courses could prevent initial inundation, but the benefits would be small. The structures would quickly be circumvented and the rivers and depressions on the landward side of the structures soon filled by

overland spill. Erosion of river banks on the landward side of any such structures would be severe.

The Consultants consider that the only practicable flood control measure which should be undertaken, if flood control is to be undertaken at all, is the full height flood embankment with suitable means of evacuating surplus rainfall from the poldered area.

3.5 PRELIMINARY DESIGN AND ENGINEERING FEATURE

3.5.1 Irrigation System

3.5.1.1 Irrigation from Surface Water Source

General

The scheme proposed in the Report comprises a 6 x 430 cusec pumping plant located on the Dudhkumar River just downstream from the Pateswari railway bridge; a main canal with laterals which runs close to the main north-south road and serves the east and central portion of the North Unit; and a branch canal with laterals which serves the west portion of the North Unit.

Pumping Plant

The pumping plant is set back from the river bank a distance of about 1,200 feet and is supplied via a brick lined intake channel. The location of the pumping plant and the maintenance of a clear intake channel which will always be connected to the main river channel is a major concern of the Consultants.

The location of the main river channel varies from year to year. USAID officials report that in 1974 the main channel was close to the left bank at the Pateswari bridge. At the time of the Consultants' site visit a 10 to 12 foot deep channel (bed El ±84) ran close to the right bank.

The river takes a sharp left hand turn just as it approaches the bridge so there is a natural tendency for the stream channel to swing over to the right bank. However, the stream bed is a fine alluvium and a considerable variation in the dry weather channel location must be anticipated when designing the pump station and associated works.

The bridge is probably some 45 years old and both the abutments and piers are probably founded on caissons taken well below maximum bed scour depth. The bridge abutments are protected by a pitched guide bank extending upstream and downstream and appear to be stable. Subject to checking the original bridge design, it would appear that the bridge abutments, guide banks, and possibly the piers, could be utilized in the final design.

At any permanent control in an alluvial stream, the area immediately upstream of the control is more stable than that downstream. Locating the pumpstation downstream of the bridge is therefore questioned. The use of such a long approach channel is also questioned. Minimum flows in the intake channel will be zero when the river flows and sediment transport are a maximum. Eddies downstream of the bridge will carry sediment into the channel, which has a bed level considerably lower than the river bed, and considerable depths of silt will be deposited in the channel. Maximum velocities in the approach channel will be about $\frac{4 \times 430 \text{ cusecs}}{(El.85-El.78)125} = 2$ ft/sec. This velocity will

not effectively flush out the channel, and dredging as a routine maintenance undertaking will be necessary.

The other problem which must be considered is how to ensure that the dry weather river channel remains adjacent to any intake channel.

In locating the pump station, the following problems must be overcome:

- the land on which the pump station is located must be stable against river bed and bank scour.
- the river must be trained so that the dry weather channel passes adjacent to the pump station intake channel.
- the intake channel must be relatively self cleaning, or of such a design that it remains free from excessive silt and sand depositions.

To satisfactorily design such an installation, the Consultants consider that a mobile bed model of the Dudhkumar River in the vicinity of the Pateswari bridge should be used.

Any pumping station founded on a "soft" foundation must be designed with due attention to the effects of differential settlement between differently loaded and founded portions of the structure, and with attention to the effects of any settlements on the installed equipment.

No foundation density tests were carried out at the pumping plant. The Standard Penetration Tests carried out at the Dharla barrage site, a considerable distance from the Pateswari pumping plant site, indicate blow counts in the order of 20 at 30 feet below ground level. Above that point the blow counts are considerably lower. From 1952-53 aerial photographs, the probable location of the pumping plant will be within the rivers meander belt (prior to construction of the bridge), and therefore loose, poorly graded sands can be expected in the foundation. Early drilling at the proposed pump station site will be required to determine the best form of foundation treatment and pumping plant design. Foundation densification by the vibroflotation process may be advisable.

Canals, Laterals and Structures

For preparation of the Report, a continuous mode of irrigation water application was assumed for a 100 percent irrigable area. This system, as opposed to rotational irrigation, results in smaller canal sizes but is wasteful of water. A water saving in the order of 20 percent can be achieved with a properly managed rotational system of irrigation. Also, if the paddy fields are not kept continuously inundated, the soil-moisture bond, which increases with loss of soil moisture, can be made use of to reduce deep percolation losses. Further, retention and utilization of rainfall is greater if the paddy fields are not deeply inundated. If India

diverts part of the Dudhkumar flows, water conservation will be essential. Proper account of these matters should be made at the early design stage and the system designed accordingly.

It is considered essential that all concerned parties should agree on the mode of future operation and on the project's basic design criteria, before final design is started.

Variations in the shape of canal cross-sections, canal roughness coefficients, borrow pit locations etc. would not materially affect the North Unit's feasibility. These items have not therefore been considered in detail.

The decision on whether or not to line the canals is, however, likely to have a significant effect on the project, although again it is unlikely that this decision would make the project not feasible. The report compares only the two following cases:

- main canal lined, distribution system unlined
- main canal unlined, distribution system unlined.

The capital costs only are compared and the Report concludes that the unlined scheme is cheapest by a very narrow margin (Tk66,001,924 vs Tk65,332,410). The benefit of reduced maintenance costs on the lined canal and on the smaller pumping plant, and the benefit of the reduced total water demand should India reduce low flows in the Dudhkumar,

are not considered. Also, no study is indicated as having been made on the benefits and disadvantages of lining the distribution system down to the field ditches. The silt carried by the water from the Dudhkumar River (not present in water from tubewells) will tend to seal any unlined canal banks. However, the effectiveness of this seal will depend on the material from which the canal banks are constructed and the suspended sediment particle size. Similar conditions to those which can be expected in the North Unit can undoubtedly be found in other irrigation projects in Bangladesh and simple canal loss tests can be performed in matured canals to determine actual likely losses for use in deciding on the feasibility of lining for both the surface water and groundwater schemes. These tests would be preferable to using empirical formulae to determine canal losses. Lining would reduce the maintenance costs, or, if maintenance is not what it should be, ensure that the canal remains a reasonably efficient water carrier. It would also reduce the necessary full supply level, as less head is required to reach the furthest points in the irrigated area. Canal costs would thereby be reduced. Lining the laterals and sub-laterals would discourage the farmers from breaching the canal banks for their own benefit.

If the final decision is to not line the canals, the velocities in the canals and the cross-sections of the canals must be carefully matched with the materials from which the canal banks will be constructed to ensure that the canal will neither scour nor silt up. Also,

the banks of unlined canals are highly susceptible to erosion from surface water runoff. Very careful attention to canal bank drainage details will be necessary in the design stage if major maintenance problems are to be avoided.

The preliminary layout of the laterals and sub-laterals appears adequate for feasibility studies. In the pre-final design stage, however, consideration should be given to re-routing the main and branch canals for the following reasons:

Firstly, all canal cross-sections will have an access road running along one side of the canal on top of the canal bank. This will be required for canal maintenance and will create a network of elevated roads for transport of produce to markets. The main canal access road acts as a feeder road for each of the lateral and sub-lateral roads. Frequently, this feeder road is fully paved. If, therefore, the main canal runs adjacent to the existing paved road, the construction of the main canal will not improve access throughout the North Unit as much as it would if it was routed away from the main road.

Secondly, the 1974 flood penetrated well inland and flooded across the proposed main canal align- at about mid point, see Appendix A. If irrigated agriculture is to be brought to the North Unit in the shortest possible time, earliest possible construction of the main canal, laterals and sub-laterals must be the target. Full flood protection, however, will not be achieved until towards the

end of the project construction period when the drainage plants have been essentially completed. Therefore, more of the irrigation system will be able to be safely constructed if the main canal, or branch canal, or both canals, are located in ground not subject to flooding.

When laying out the canals and drains, due recognition should be given to the probable eventual need to undertake a land consolidation program. This is more important if farm ditches (serving considerably more than one farm) are included in the project. Also, the density of supply canals should be established with due regard to the planned operation of the system. General experience is that water use efficiency increases with a decrease in the area served by a controlled turnout.

It is noted that the Report locates the canal borrow pits adjacent to the canal cross-section. If excavation is to be carried out by manual labour, there is little that can be done about this. If, however, excavation is to be by machine, then fill materials should be taken from high land as much as possible to preserve the agricultural land adjacent to the canal. Deep borrow pits immediately adjacent to the toe of the canal bank can intersect the seepage line from the canal and should be avoided (assuming unlined canals). The 6:1 seepage line shown in the canal cross-sections is acceptable only for homogeneous sandy silt (note that the borrow pits intersect this line). In silty sand or sand the design seepage line would be flatter, about 8:1. If layers of fine sand are immediately below the canal banks, these layers could be exposed in the sides of the borrow pits and seepage exit velocities could well be sufficient to cause piping and canal bank failure.

Permanent right-of-way requirements should be minimized and borrow taken so as to minimize taking land out of agricultural use. Fish ponds and buffalo walloes abound in the area, so water-logged borrow pits will be of no real value.

The canal structures are not covered in detail in the Report, as is usual in feasibility work. Some typical details are, however, given in Volume III.

Although these are possibly Bangladesh standards, improvements are desirable and possible. For example, the typical lateral turnout is designed to take water from the upper portion of the main canal. If the main canal is running at less than FSL for any reason, the supply to the lateral cannot be maintained. Also, sections of the main canal cannot be drained for repair except through wasteways placed at unnecessarily frequent intervals.

In general, for efficient management of any irrigation system, means of accurately measuring where the water is going must be incoporated into the system. The control methods should be simple and the devices used to operate the structures should be part of that structure to avoid loss and theft. Small wooden stoplogs for instance are frequently lost or stolen. This results in say a check structure not being operated properly, a deficiency in head in the canal, and a water shortage in outlying areas, possibly at a critical growth stage. The structures must perform satisfactorily under all conditions of operation and their performance should be reasonably man-safe.

Concrete materials and formwork are not indigenous to the area and will be difficult to obtain. Brick masonry should therefore be utilized to the maximum extent possible. Careful quality control of brick manufacture will be required.

In any irrigation system there is a considerable amount of repetition in the structures. Structures should, therefore, be standardized as much as possible. Precasting of standard concrete units, or sub-units, could reduce the need for transporting large quantities of concrete materials to each of the many structure sites.

The variation in cost of the minor structures which may result from modifications in their design will not materially affect the feasibility of the North Unit.

Some of the above considerations are correctly outside the scope of a feasibility study. However, these points, and others, should be settled in the pre-final design stage.

3.5.1.2 Irrigation from Ground Water Source

Tube Wells

In the Report, the design of tubewells to serve the irrigation requirements of the North Unit is based on limited data on actual aquifer conditions, as discussed in Chapter 3.2.3 of this report. The further testing recommended in Chapter 3.2.3

would be required to finalize design. The well design selected in the Report for a yield of 3 cusecs appears to be based on economics alone.

Design discharge and well spacing are the two most important considerations in well field design. With proper information on the aquifer, several different alternatives could be fully evaluated by the development of a finite difference aquifer model. Major inputs to such a model would include: (1) saturated thickness, (2) direct surface recharge, (3) variable boundary conditions governed by river stage fluctuations, (4) aquifer transmissivity, (5) storage coefficients, (6) simulated well locations and extraction rates.

The model would be capable of physically optimizing spacing, pumping schedules and general groundwater basin management techniques to assure the adequacy of the designed field. Sustained yields could be evaluated from the model. The practical sustained yield may be less than the rate of recharge, but cannot exceed the long term mean annual recharge without depleting storage within the aquifer. The practical sustained yield can be limited either by the physical size of the groundwater reservoir or by the rate at which water moves through the reservoir from the recharge area to the withdrawal area.

It is seldom that any single value of sustained yield can be correct for an extended period of time due to changing conditions. The groundwater model of the area would allow testing of various project conditions and evaluation of increasing recharge due to lowering of the water table. The model would even allow different pumping patterns and cropping patterns to be used and the subsequent effect on direct and boundary recharge determined.

Once the well field design is finalized, the consideration of individual tubewell design can be initiated and the data developed from the model can be used as design criteria.

Although not specifically connected with tubewell design, it should be recognized that efficient operation and maintenance of the pumping equipment is essential for optimum use of the design well field. Design of the wells and selection of pumping equipment must include proper consideration of future maintainability.

The above discussed model is clearly not required for feasibility grade studies, and should only be considered if the pre-final design studies indicate that groundwater should be developed.

In the Report, one tubewell per 140 acres has been assumed. This is considered adequate for feasibility studies.

Distribution System

The sample area developed in the Report covers one tubewell distribution system, an area of about 140 acres. This represent a very minor percentage of the total service area. If tubewell development looks economically feasible or attractive for other reasons in the pre-final design stage, the sample area should be fully representative and should cover about 10 percent of the total area.

It must be noted that there are two significant differences between the sample distribution system for the surface water irrigation scheme and that for the groundwater irrigation scheme. These are:

- The density of canals provided for the groundwater scheme is much greater than that provided for the gravity scheme.

- All canals in the groundwater scheme are lined whereas no canals, laterals, sub-laterals or field ditches are lined in the gravity scheme.

A criteria for the density of supply canals to be provided as a part of the project should be developed and applied equally to the two systems. Also, the question of lining the minor distribution system should be reviewed. See Chapter 3.5.1.1.

3.5.1.3 Irrigation from Combined Surface and Grounwater Sources

General

The scheme studied in the Report envisages a barrage across the Dudhkumar River; a gravity irrigation system for the southern portion of the North Unit, and a tubewell irrigation system for the northern portion of the North Unit.

The barrage is used to head up the flows in the Dudhkumar for diversion into the gravity irrigation system. A pump station was not used because of the problem of lateral shift of the flood season and dry weather channels in a totally uncontrolled stretch of the river.

The single most costly item of construction in a gravity system is the headworks. Once this cost is incurred, greatest overall economy is usually obtained by serving the largest possible area of land. The economic result given in the Report is therefore to be expected.

This general reasoning also applies to locating a pump station or other form of headworks at the Pateswari bridge. Once this cost has been incurred, the gravity system should generally be run out as far as possible, and should only be stopped when the frequency of water shortage makes it uneconomical to irrigate more land from this single source. From the hydrology in the Report, severe water shortages are unlikely. Therefore

if a total development using tubewells is less economical than a total development using surface water, it is difficult to visualize a circumstance under which a partial system would be economical. Diversion of a significant portion of the Dudhkumar flows by India would of course change this picture.

Barrage

This structure was not laid out in the Report and the costs were only roughly estimated. The design discharge was taken as 275,000 cusecs as opposed to a peak discharge of 216,000 cusecs in only six years of records. Had the scheme looked competitive, this structure would have no doubt been considered in greater detail.

At the quoted Tk460 per cusec, the total cost of the Dudhkumar barrage would be Tk460 x 275,000 = Tk126,500,000. The ratio of foreign exchange in this total cost and the applicable exchange rates are unknown. At Tk16 = $1, the total cost is considered to be considerably under-estimated. In West Pakistan, the Qadirabad Barrage structure without headworks cost $38/cusec (1964-67). If 33% of this cost is considered unchanged labour cost and 67% is considered escalable over 10 years, this rate today would be about $55-65/cusec. Using this rate, the total cost of the Dudhkumar barrage would be about $16 million. This additional cost would make the scheme using a barrage over the Dudhkumar River even less attractive.

Canals, Laterals and Structures

These are not discussed in detail in the Report. Details of the system and costs per acre would be similar to those developed for the scheme utilizing a pumping plant at the Pateswari bridge.

Tubewells and Distribution System

These are not discussed in detail. Details and layouts would be similar to those developed for the scheme using only groundwater sources for the North Unit.

3.5.2 Flood Protection

3.5.2.1 General

As mentioned earlier, there appears to be only one practicable way to protect the area against flooding, and that is by constructing embankments around the perimeter of the North Unit.

3.5.2.2 Layout of Embankments

The Report shows the perimeter embankment tying into the disused railway embankment to the north, and into high ground at the Indian border to the northwest. The tie to the railway embankment should be satisfactory, although the condition of the embankment, the condition of any culverts running through it, and the degree of flooding to the north of the embankment must be studied and necessary improvements to the embankment etc. incorporated into the project plan. The other tie, into high ground near the Indian border, should be studied using topographic maps of the adjacent Indian territory and on the ground, to ensure that the Dharla River cannot flood in behind the embankment. When considering this latter tie, the effect of possible future construction of an embankment along the right bank of the Dharla River must be considered.

The embankment is shown set back from the present river bank about 1/4 to 1 mile. It crosses old embayments and in places will clearly obstruct flow and therefore come under severe attack. The

embankment at the Dharla barrage is one such location. The embankment layout is adequate for costing in the feasibility report. However, during the pre-final design stage, the alignment should be refined and reasonably firmly established.

The embankment should not attempt to severely control the river flows, but only guide them. Abrupt changes in alignment should be avoided. Aerial photographs should be studied to locate the historical river valley or meander belt and the embankment should be retired beyond that limit unless there are strong reasons for doing otherwise. Particular care should be taken with the layout at the river mouths where river regimes tend to be highly unstable. The selected layout should be analysed for its effect on river meander, stages and discharges, and in particular for its likely effect on Kurigram township.

Construction of the North Unit embankment will have a relatively minor effect on the Brahmaputra River as the amount of overbank spill and overland flow prevented by the embankment will be small compared to the flow in the river. On the smaller Dharla and Dudhkumar rivers, however, particularly on the Dharla River where an embankment will be constructed as part of the South Unit development, the river regimes could be significantly changed.

Once embankments are constructed, river bed and bank scour will increase, water surface gradients will flatten, and silt deposition downstream of the embanked reach will increase. Sinuosity of the main stream is likely to increase as the stream attemps to re-establish a regime. Studies on Dacca Southwest project indicate that the rise in water levels due to embankment construction is less than the year to year variation in stage for any given discharge. Those results will probably hold true for the North Unit. However, these and other effects of embankment construction should be studied before final design is started.

3.5.2.3 Design

The cross-section of a typical embankment is given in Volume III of the Report. Crest widths are proposed as 14 feet except along the Brahmaputra where the crest width is 24 feet. Side slopes are given as 1 vertical to 3 horizontal on the riverside and between 1 to 3 and 1 to 4 on the land side. Borrow pits up to 10 feet deep are shown 30 feet from the riverside toe of the embankment. The seepage line gradient is shown as 1 vertical to 6 horizontal. It is assumed that the dimensions given are for the net compacted section.

The crest width to be used for an embankment is usually a function of the method of construction, the ultimate use of the crest and the types of rodent prevalent in the area. With a 14 foot crest width, it must be assumed that manual labour and small compaction equipment was envisaged for

construction, and that if heavy equipment is required for routine or emergency maintenance, an access way will be requisitioned under energency powers along the landward toe of the embankment. Once the embankment has been constructed, maintenance of the edges of the crest and their load carrying capacity are likely to be inadequate to allow passage of anything but the lightest mechanical equipment. With the narrow crest width it is also assumed that the hole making rodent population is small. It is considered that the crest width of 25 feet along the Brahmaputra is adequate. The 14 foot crest width along the Dudhkumar and Dharla rivers is, however, considered inadequate.

In the sandy silty soils available in the North Unit, 1:3 side slopes with the 24 foot crest width should be adequate. The soils in the borrow pits should be routinely checked for dispersive properties before construction starts.

The seepage line of 1:6 is adequate for a silty soil. It the soil is a sandy soil, as the bore logs given in Figure B-1 of Volume II indicate it will be, the assumed hydraulic gradient should be 1:8. At least 2 feet of cover over this line should be provided at the landward toe. This can be achieved by introducing a break in the landward slope.

Seepage through the embankment, or under the embankment through coarser sand layers, may become a problem. Toe drains may be required.

The location of the borrow pits on the river side is correct as these will eventually silt up and can be cultivated. However, it is considered that they should be at least 50 feet from the toe of the embankment, and should not be taken deeper than 6 feet. River flows will be parallel to the embankment and these borrow pits could develop into secondary river channels, creating parallel scour velocities at the embankment toe. The borrow pits should, therefore, not to be continuous over lengths exceeding 500 feet. Between these length, strips of original ground not less than 50 wide should be left in place. A 6 foot deep borrow pit should fill reasonably quickly with river deposits, should not become excessively water-logged, and should be cultivable one or two years after embankment construction.

The question of full, partial or minimal compaction of the cross-section should also be established at the pre-final design stage as this also affects the dimensions of the cross-section.

The use of grass slope protection is quite adequate as proposed. Attention must be paid to the adequacy of the soil to support grass growth, and topsoiling should be undertaken where necessary. Careful sprigging, nurturing and maintenance of the grass cover will be necessary if adequate protection against gullying and wave wash is to be achieved.

Road ramps of 1:33 are considered too flat. These will extend far out into the country or too far along the embankment. Ramps of 1:15 are probably adequate for buffalo carts. Ramps will be required on both sides of the embankments where there is considerable farming activity on the river side of the embankment.

3.5.3 Drainage Works

3.5.3.1 General

Reference is made to Chapter 3.2.6, Drainage Requirements, where the hydrological data used to design the drainage works and the processing of this data is discussed.

3.5.3.2 Drainage Improvements Without Irrigation

Improvement of the poor drainage in the North Unit without supplying irrigation water is touched on in the Report and is generally discarded as not being worthwhile. This is considered correct as the gain in agricultural land would probably be offset by the loss in crop production due to not having as much water available in the beels for irrigation during the latter stages of aman growth.

3.5.3.3 Drainage Improvements with Irrigation and Flood Control:

With the application of adequate quantities of irrigation water, there are no benefits to be gained from poor drainage. On the other hand, by improving drainage, additional land can be made available for year round cultivation. The improvements proposed in the Report comprise re-shaping existing drainage channels, and interconnecting low lying lands to enable them to drain to one of the four major drainage channels.

It appears that no drainage water is designed to be taken into the irrigation system. This is considered correct during the monsoon season when irrigation water is plentiful, as to do otherwise makes operation and maintenance of the irrigation system extremely difficult. During the dry season, however, and particularly if India reduces flows in the Dudhkumar River, it may be desirable to actually check flows in the drainage ways and pump the water into the irrigation system. Also, following a more detailed study of the river hydrology, if it is found that critical shortages could occur, permanent provisions could be made for emergency pumping from the larger drainage courses, particularly those which have a large catchment area and carry considerable return and bank regeneration flow.

For evacuation of surplus rainfall from within the poldered area, there would appear to be only three possibilities, by gravity drainage through gated sluices, by pumping, or by a combination of the two. The Report proposes the latter so that surplus rainfall can be drained by gravity during low river stages and by pumping during high stage. The concept is common and practicable.

The Report proposes 4 drainage pumping stations for the North Unit. The approach would undoubtedly effectively control flooding in the poldered area. However, each station would require resident, well trained maintenance staff. Also, a system for indenting for spare parts, procuring them from

overseas or manfacturing them within Bangladesh, and maintaining an adequate and readily available stock of spares would have to be developed and operated. Local stores and workshops would be required, with adequate facilities and trained mechanics, for all but the most major overhauls and repairs. Foreign exchange would have to be made available for parts procured from overseas. All these, and other aspects of pump maintenance, require great attention in Bangladesh at the present time. Of 42,000 low lift pumps operated by BADC, 15,000 are operable. Of 370 deep tubewells operated by BWDB at Thakurgoan, only 270 are operable. There is thus a clear need to reduce the reliance on complex machinery in the North Unit as much as possible, and, where this cannot be practicably achieved, for grouping the machinery together as much as is practicable to simplify maintenance problems.

The possibility of connecting two or more drainage courses so that they both utilize one pumping station should be considered in the pre-final design stage. The land is relatively flat and considerable borrow pit excavation will be necessary. Some of these borrow pits could possibly be designed as drainage courses.

For preparation of the Report, a comparison between gravity drainage and pumped drainage was made for one of the four drainage basins. See Volume II, Appendix A. The method used was as follows. For the gravity drainage scheme it was

assumed that at the start of the inflow storm, the river level would be at elevation 84, the level within the poldered area would also be at elevation 84, and all sluices would be open. The storm outflow flood was then routed through sluices of various sizes. The interior flood level was determined and crop losses calculated for the average area one foot below the flood level. The best size of sluice was then assumed to be that at which the incremental benefit of increased size of sluice equalled the incremental cost of increased size.

A similar approach was taken for the pumped drainage scheme. The outflow flood was routed through various capacity pump stations, crop losses were determined as before, and the pump station size was selected on an incremental benefit-cost basis.

The two "best" sizes were then compared and the pump station selected on the following basis:

	20 Vent Sluice	800 cfs Pump Station
Capital cost	Tk 1,280,000	Tk 10,320,000
Annual cost	83,000	1,670,000
Annual crop damage	9,480,000	2,030,000
Annual average loss	7,929 acres	1,680 acres

Now, the flood routing for the sluice scheme was started from an assumed existing flood elevation of 84 inside and outside the embankment, and it was assumed that damage would start as soon as

flood waters rose above elevation 80. The routing indicates that the total size of the sluice structure has little effect on the level of interior flooding; a 4 vent sluice, that is, 4 openings 5' x 6' in size, results in an interior flood elevation of 86.65, whereas a 24 vent sluice results in a flood elevation of 86.54. Thus, regardless of the size of sluice, over 70 percent of the crop damage was assumed caused by inadequate internal drainage before the design storm occured. When considering the pumped drainage scheme, the flood waters inside the embanknent were assumed to be at elevation 80 when the storm occured. The Report indicates that the installed pumping capacity has a significant effect on the level to which the flood waters rise. With a 200 cusec capacity pump, the flood level rose to elevation 84.65; with 1,600 cusec pumping capacity, the flood level rose to elevation 82.00; and with the 800 cusec capacity installation selected, the flood waters rose to elevation 83.28. Therefore, the selected pump station kept the rise in flood water down to 3.28 feet, whereas the selected sluice kept the rise down to about 2.6 feet.

It is clear that a considerable portion of any justification for pumped drainage lies outside the comparative study given in the Report. The justification for pumped drainage lies in the fact that the water level can be kept below the assumed elevation 80 throughout most of the monsoon season, whereas with gravity sluices the interior runoff cannot be evacuated unless the interior water level rises above the river level. Although the use of pumped drainage is probably justified, an amplified approach to establishing this justification is considered necessary.

The comparison studies should be started from a common base, such as the elevation 80 below which it is stated that no damage occurs. This could necessitate starting the study at the begining of the monsoon season and determining how interior flood levels increase with crop growth. Such an analysis has many variables and can be effectively carried out by computer.

A more detailed review of the need for pumped drainage, and whether or not the number of pump stations can be reduced, is considered necessary because of the problems Bangladesh is having, and will have for some time to come, in every aspect of operating and maintaining complex machinery. The spin-off benefits from installing pump stations could, however, be considerable, and must be taken into account when deciding the definite project plan. For example, the electrical power distribution system required for the pump stations could also be used for rural electrification and for running tubewells in the area outside the flood embankments. Rural electrification would not only raise the general standard of living, but would also contribute to population control.

To summarize on the question of drainage:

- the basic hydrology needs to be updated
- the need for pumped drainage needs to be studied in greater detail
- the use of return and bank regeneration flows to correct for possible irrigation water shortages needs to be reviewed

- if pumped drainage is justified, possible interconnections of drainage courses should be studied
- operation and maintenance organizations and procedures for pump stations must be established as part of the project
- spin-off benefits from installing pump stations must be taken into consideration

Conditions in each drainage basin differ. Due recognition has to be made of the possible influence of the Dharla barrage head pond in deciding on the drainage works for basin N4. Where future construction could alter the drainage works design, the possibility of staged construction should be considered.

3.6 MISCELLANEOUS PROJECT ELEMENTS

3.6.1 Topography

Throughout the world, inadequate topographic mapping is frequency the cause of considerable wasted time and money on an implementation project. The necessity for early preparation of accurate topographic maps to the scales required, or the checking of existing maps, cannot be too strongly emphasized.

It is believed that the quality of existing maps in Bangladesh is fairly high. Nevertheless, project control points and the accuracy of the service area maps must be checked at critical points as soon as possible in the pre-final design stage. Sufficient numbers of qualified survey tems must be assigned to the project at an early date to ensure that basic control is installed and carefully checked, that canal strip topography, drainage course centrelines and cross-sections, and structure site topography are obtained in a systematic and timely manner for use in preliminary and final design, and that river surveys at the proposed Dudhkumar pump station are obtained for preparation of the mobile bed model.

3.6.2 Low Lift Pumps

The Report discusses the possibility of using large capacity (2-4 cusec) low lift pumps to lift irrigation water from the various drainage channels in the area. See Page C-3 Volume II. This study was apparently carried out at the request of IBRD with the idea that land acquisition costs would be almost nil. The back up and layout details for the studies are not included in the Report (Figure C-1 is not bound into the Report).

Precise criteria for the studies are not clearly defined, although it is deduced that, for the North Unit, the assumed project plan was gravity drainage through sluices, a flood embankment, and irrigation by low lift pumps. The Report concludes that this approach to supplying irrigation water is only practicable if water can be pumped from the river back into the drainage channels.

Without the study backup data, detailed comment is not possible. In general, however, the conclusion reached in the Report would seem reasonable. The drainage channels are much steeper than those further south in Bangladesh, and the mouths of the drainage channels will not be connected to deep water channels in the rivers during the low flow season. The amount of irrigation water would clearly be more than that flowing naturally in

the drainage channels, so some means of lifting water from the deep water river channels into the drainage channels would have to be devised. This water would then have to be pump lifted upstream in the drainage channels through a series of regulating structures, and then pumped from the drainage channels into canal distribution systems.

In the flatlands of Bangladesh, the use of drainage channels as irrigation channels during the dry season is economical and quite practicable. The Dacca Southwest and Belkuchi Projects are examples of this approach. For the North Unit, however, where there is a good fall to the land, it would appear impracticable. Also, because of the current problems of effectively maintaining low lift pumps, it would appear imprudent to adopt such a scheme when more reliable and practicable methods of supplying irrigation water are available.

It is considered that further study of this alternative is not required.

3.6.3 Hand Pumps

UNICEF has developed a soundly designed and relatively trouble free low lift hand pump capable of discharging about 0.2 cusec if operated continuously.

It has been suggested by various agencies that irrigation of the North Unit could be carried out by this method. The aquifer is perfectly adequate and these pumps could undoubtedly firm up the monsoon season rainfall for particularly energetic farmers and their families, and provide dry season irrigation.

One hand pump could be expected to yield, at a 33% operator efficiency, approximately 2,400 cubic feet in a 10 hour day. Land preparation will be the critical period for water application, when up to 10 inches of water may have to be applied in 15 to 30 days. Therefore, if a 20 day period is allowed for land preparation, one pump could handle 1.3 acres, three pumps could handle an average farm.

Pumping labour costs would be in the order of Tk5-6 per day, or per rice crop about an average of Tk500-600/acre.

Recent studies carried out by the Department of Agricultural Economics at Mymemsingh University on rainfed rice cultivated on 60 farms are reported to have yielded the following data:

Rice Variety	Yield maund/acre	Gross Input Tk/acre	Return Tk/acre	Net Return Tk/acre
Local Nizershail	25	856	1,518	662
IR-20	38	1,008	1,961	953

Manual labour costs were a large percentage of the above gross input cost. It was reported that the area " has normally plenty of rainfall".

Rainfall in the North Unit is reported to be too variable to grow HYV rice. With adequate irrigation (and all inputs), the yields could therefore be increased as follows:

Aus 12 to 50 maunds/acre (416 percent increase)

T aman 15 to 40 maunds/acre (266 percent increase)

Taking the fully developed farm condition per acre, the net return per crop would be:

Gross input Tk1,008+Tk550 (pumping = Tk1,558
Gross return $\frac{(40+50)}{2}$maunds x Tk50/maund = Tk2,250
Net return = Tk 692

This is a better margin on investment usually enjoyed by the farmer.

From the above very rough study, the use of hand pumps would seem to be a distinct possibility for individual farmers. However, the work is undoubtedly arduous and requires an excessive amount of labour input. If such a scheme were

to be pushed for the whole project, a 75,000 strong, new type of labour force would have to be created. This force would represent 12 percent of the total population or about half of the males between 10 and 40 years of age. The need for this extra resident help on the farms could well encourage the farmers to have larger families and the scheme could thereby work against the present population control programs.

It is doubted if a hand pump scheme could be successfully or quickly implemented for the entire North Unit, in which case the potential of the area would not be realized and the standard of the entire population in the North Unit, and the fringe areas, would not increase as desired. There would probably not be a rice surplus in the North Unit for export to adjacent areas. When intensive agricultural development is initiated at a later date, there would be no irrigation system to act as a unifying influence on the farmers. The development of co-operatives would therefore be more difficult. There would be no improvement in the road network. On the other hand, large scale surface irrigation development would enable the full agricultural potential of the area to be systematically developed, would open up the area by providing a network of roads, would provide effective irrigation to the entire popu-

lation quickly, and by opening up communications would encourage community activities, a group approach to problems, and a better way of life. Extension work would be made easier as the farmers could be formed into water users groups by lateral or sub-lateral service areas.

In conclusion, it is the Consultant's opinion that the large scale use of hand pumps would represent a short-term, partial solution to the problem of accelerated agricultural development. In the long run, a reliable, controlled supply of irrigation water will be necessary if the agricultural potential of the area is to be achieved, as it must. It is considered that the thoughts of the farmers should not be diverted by interim irrigation measures, but should be firmly directed towards community wide agricultural and social development of the North Unit.

3.6.4 India's Reduction of Flows in the Dudhkumar River

Since the Dudhkumar River's catchment area is almost all in India, any diversion from the river in India could have a significant effect on the proposed surface water irrigation system for the North Unit. The land on the Indian side of the border appears to be fairly flat and diversion of some of the Dudhkumar flows for irrigation appears to be a distinct possibility.

During the monsoon period, the river carries snowmelt and rainfall. Diversion requirements for the North Unit and any developments on the Indian side would be minimum during this season. Any diversion of flows in India would, therefore, be unlikely to affect thesupply of supplemental irrigation water to the North Unit during the aus and aman seasons. During the dry season, the river flows must come from bank regeneration, as rainfall in India is almost nil and all snowmelt ceases. The river must act as a groundwater drain. Diversion requirements for the North Unit and for any Indian developments would be maximum in the dry season, and any Indian developments could therefore have a significant effect on the boro and rabi crops. If the developments were sufficiently far upstream, however, bank regeneration and return flows could be adequate for the North Unit. Diversion close to the border could, however, be critical.

Guarantees from the Indian Government on minimum flows should be sought as early as possible after the minimum flows have been firmly established. If these guarantees cannot be obtained, details and timing of potential developments should be sought and their effects on flows in the Dudhkumar established. If these details are not obtainable, estimates of possible diversion requirements should be made from whatever maps are available for the Indian portion of the Dudhkumar catchment area. Once this information has been obtained, the possible effects on the North Unit irrigation system can be determined. If guarantees from India cannot be obtained,contingency plans should be laid for modifying the irrigation system as and when India reduces flows in the Dudhkumar sufficiently to cause irrigation water shortages in outlying areas. These could include the use of low lift pumps to pump return flows and ary bank regeneration from the various drainage channels into the distribution system, or the installation of tubewells to pump into the remote parts of the existing distribution system.

The Joint River Commission should be approached as soon as possible on this problem.

3.6.5 Areas Outside Embankment

The flood control embankments must be located a considerable distance from the river bank if they are to be safe against river attack. A large number of farms will be divided by the embankment and a large number will be left on the river side of the embankment. The land on the river side of the embankment will not always be flooded and could be utilized to grow a good aus and boro crop if irrigation water can be supplied.

If electrically driven drainage pumps are required at each of the drainage area outlets, a source of power for tubewells would be at hand. Diesel driven shallow lift tubewells could also be considered for these areas. Maintenance of a distribution system of any sort would be a problem. Portable pipe distribution systems could be considered. Hand pumps may also be practicable for these areas.

It is considered that in developing the definite project plan, the socio-economic inequalities between the areas just inside and those outside the embankment must be considered. The area outside the embankments is too large to do otherwise.

3.6.6 Government Organizational Structure

The Report proposes that the Project implementation, operation and maintenance be carried out using the existing Governmental organizations rather than by establishing a semi-autonomous Project Authority. The Consultants consider that, in principle, this is the best approach to follow.

The creation of a Project Authority is certainly a short term way to get one project completed. However, as the Authority would have to be largely self contained, duplication of departments and disciplines already established in other agencies would be enevitable. Also, such authorities have a tendency to remain unnecessarily large once the implementation period is finished, and trained staff which should be released to assist on other projects is frequently held longer than necessary. Further, the experience gained on the Project would tend to remain with the Project rather than be disseminated back through the concerned Government agencies.

The Report recommends that BWDB be the implementing agency and that there should be two committees, an advisory committee chaired by a Minister and including the Secretary of each of the concerned Ministries, and a project development committee

chaired by the local Member of Parliament and including senior officers of each of the concerned Government agencies. The stated reason for having the project committee chaired by a politician is to ensure that funds are made available as required. The Consultants consider that once the North Unit has been approved by the Government, the allocation of funds would be according to the budget application of the lead Ministry, that is, through normal civil service channels rather than through political channels. It is further considered that although co-ordination of the various social, economic and technical groups is clearly necessary at project level, the senior civil administrator should chair the committee rather than the leader of the political party who happens to be in office at the time. This would avoid implementation of the project being manipulated for political advantage.

The Report outlines the Project implementation, operation and maintenance inputs, but does not develop a management structure to show how these inputs are to be co-ordinated to ensure success of the Project. A construction organization chart is given in Table VIII-11 for BWDB's part of the site work.

The magnitude of the implementation problems and the degree of success in achieving the project aims, will depend to a very large extent on the smoothness of co-ordination between the various agencies at central Government level. When developing a management organization chart for the

Project, it will, therefore, be necessary to review the present Government systems as they relate to irrigated agricultural developments, and, if necessary, to consider changing them. An in-depth analysis of what is required to make the North Unit project succeed will undoubtedly reveal the strengths and weaknesses of these systems.

Once the best project management organization is established, with or without changes in the Government system, the actual implementation of the North Unit project will be an excellent testing and training ground for later development of the South Unit and other development areas.

The need to prepare a detailed management organization, with clearly defined lines of communication, liaison reporting, service support, and so on, cannot be over stressed. The fact that there will be many Ministries involved in implementation of the project must be carefully considered and the responsibilities of each Ministry clearly defined.

Consideration should be given to establishing an Accelerated Agricultural Development Committee, possibly as part of the Planning Commission, to be responsible for national level policy decisions and co-ordination of all Ministries in the field of agricultural development. Each major project could then have a Project Co-ordinating Committee comprising selected representatives from each concerned Ministry and agency. This would be the decision making committee for the project and

would handle all matters which could not be handled routinely at agency level or by the Project Implementation Committee. It is envisaged that the Project Co-ordinating Committee would have its chairman and secretary drawn from the Planning Commission. This committee should be fully endowed with authority to act for the Government on all matters concerning the project within the policies extablishes by the Accelerated Agricultural Development Committee. The Project Implementation Committee would function at the project site to coordinate the work of the civic authorities with that of the project staff.

The scope of the North Unit project, from the Government's point of view, should be defined at an early stage so that the management organization can be developed accordingly. Questions such as, are rural fisheries, livestock, rural electrification etc. to be included in the North Unit project, must be resolved early so that these activities can be properly represented on the committees from the very beginning of the project.

3.6.7 Electricity Distribution and Rural Electrification:

It is understood from the Report that a 33 KV transmission line extension is planned as follows:

- to Kurigram via Lalmanirhat
- to Chilmari via Ulipur

Information obtained during the site visit was that the towers for the above extension are essentially completed but that stringing of the conductors is held up due to lack of funds.

It is recommended that the completion of the Lalmanirhat-Kurigram leg be included in the North Unit project, if funds cannot otherwise be made available. Extension of the line into the North Unit is covered in the Report.

It is further recommended that consideration be given to including rural electrification in the total scope of work for the North Unit project.

3.6.8 Indian Enclave

The Project maps show an enclave of Indian territory in the North Unit with the canal system skirting the area.

Undoubtedly the people in this area will want to benefit from the proposed development, but prior agreement with the Indian Government will presumably be required.

It is understood that moves have been made to exchange various enclaves located on either side of the international boundaries. If such an exchange cannot be arranged, however, it would seem prudent to not run any canal through the enclave which is designed to serve an area on the other side of the enclave.

The status of this enclave should be clarified as early as possible during the pre-final design stage.

3.6.9 Cost Recovery

The Report indicated that cost recovery provisions have already been made by law as follows:

Flood Control and Drainage:

> The farmer pays a proportion of the project cost according to the benefits he derives, or a proportion of the project cost according to the area benefitted. The amount paid is such that the works pass to the beneficiaries in 20 years.

Irrigation:

> The farmer pays not more than 10 percent of the increase in crop value.

The laws relating to cost recovery have not been studied. This must be done during the pre-final design stage and the method and extent of cost recovery established with the Bangladesh Government. The amount to be recovered for flood control and drainage would appear to rest on the value the Bangladesh Government places on the North Unit Project.

For the irrigation charge, although HYVs of rice cannot reportedly be grown in the area due to the variation in rainfall, some of the increase in yield will come not from irrigation but from improved agricultural inputs. An equitable assessment of the increase in crop value due to irrigation would appear to be necessary under the present cost recovery system.

Cost recovery and eventual ownership of any works raises the question of maintenance of those works, both during the paying off period and after the farmers own the works.

The need to carry out a cost recovery study is discussed in Chapter 3.3.6.7. It would entail a review of the effectiveness of the present laws and their enforcement, an assessment of the adequacy of present systems once national policies regarding farmer's institutions, operation and maintenance, and ownership of works have been put into effect, and the drafting of any necessary acts or laws. As mentioned in Chapter 3.3.6.7, any necessary reforms could be included in the scope of the North Unit project.

3.7 PROJECT IMPLEMENTATION, QUANTITIES AND COSTS

3.7.1 Implementation Schedule

The implementation schedule proposed for the North Unit is given in Figure VIII-8/1 of Volume II of the Report.

The principal construction features are scheduled to take the following periods of time:

Flood embankment	3 years 9 months
Irrigation headworks	4 years 1 month
Irrigation system	5 years
Drainage System	4 years
Transmission Line etc.	4 years
River training works	2 years
Total period	6 years

It is noted that there is no phasing within the North Unit to bring selected areas under irrigated agriculture before the whole project is completed. In fact, the Report states that there will be no benefits to the farmers before 7 years has elapsed. This is an unnecessary delay as water could be made available as soon as the pump station, the river training works and a significant portion of the canal system have been completed.

A clear picture could not be obtained from the Report as to how the various parts of the works are to be carried out, whether by force account, local contractor, or by international contractor. Reference is made, however, to a "project execution authority " on page VIII-15 of Volume I. On page

VIII-33, it states that the embankments, canals and drainage channels would be constructed by head basket, and compaction of fill would be by sheepsfoot roller. On page VIII-15, it states that field ditches would be constructed and maintained by the farmers.

Time is the essence of developing the North Unit. However, at the same time as accelerating development, full use of labour capabilities should be made. The two requirements are somewhat contra-active. From discussions with BWDB staff at Kurigram, it is suspected that BWDB may not be able to provide sufficient numbers of qualified staff to construct, supervise and manage the entire project on their own without running a risk of greatly overrunning the time estimates and thereby losing valuable benefits. It is therefore suggest-that the following general construction implementation approach be considered:

BWDB
- lead agency, responsible for total project development,
- land acquisition
- liaison with Project Implementation and Co-ordinating Committees
- co-ordination of agricultural inputs from Ministry of Agriculture
- co-ordination of input from other agencies,
- supply of majority of support staff to consultant
- supervising Food for Work construction
- supervising local contractors

Ministry of Agriculture	- responsible for supervising agricultural extension programs, - supplying all agricultural inputs - liaison with Project Implementation and Co-ordinating Committees - development of farmers institutions
Consultant	- responsible for project scheduling, design and management of construction with staff seconded from BWDB and other agencies as necessary - preparation of contract documents, contract measurements and payment certification.
Construction	- embankments by Food for Work Program (BWDB supervise). - pump stations and river training by international competitive bids - main canals and laterals by international competitive bids - sub-laterals and field ditches by local contractors.

With international bidding on the major works, timely completion, good equipment maintenance, and maximum practical use of labour consistent with the time schedule laid down would be more likely. Bangladesh companies may be successful in this bidding of course, or may joint-venture with overseas companies. Equipment supply contractors would be "nominated" as sub-contractors to the main contractor, who would then be ultimately responsible for their performance. Equipment supply contracts would be let early to ensure timely delivery.

Poor supply of cement, resteel and stone could delay the works. The nominated sub-contractor approach could again be used to keep ultimate responsibility in the hands of the main contractor, and to ensure that local industry is properly favoured.

The question of field ditch design and construction must be carefully studied. One ditch will pass through many farms and will not reach all plots on one farm or all farms. It is recommended that the design and construction be made a part of the project to ensure timely completion. The farmers could then be left to arrange water transfer from plot to plot.

If the above approach is taken, it is believed that there will be a better chance of meeting target dates, the quality of the work will be adequate and maintenance will therefore be cheaper, and the existing resources of BWDB will not be overstrained. And, most important, irrigated agriculture will be possible over large areas within say 3 years of starting construction.

3.7.2 Quantities

These appear to have been considered in some detail in the Report. The introduction of canal lining would significantly affect these.

3.7.3 Costs

The Report states that unit costs are based on 1972-73 costs mostly obtained through the Planning Commission. The Report recommends updating these costs to correspond to the date when construction starts. Figure 3-7 refers.

No contingencies have been allowed. It is recommended that 15 percent of the construction cost be included to cover contingencies.

Engineering and investigation costs have been taken at 15 percent of the construction cost. For the present level of study, this allowance is adequate, although it is considered conservative.

BWDB management costs have been taken at 2.5 percent which seems low. A value of 5 percent would be acceptable.

Interest during construction has been taken as 6.25 percent for local currency and 4 percent for foreign currency, applied to the total construction cost. As capital is not consumed at the start of the job, these rates are equivalent to about 12.5 percent and 8 percent respectively on the progressive borrowings. However, it is noted that 6.25 percent and 4 percent figures were also used when calculating annual costs. When finalizing construction and annual costs for the definite project plan, the rates used should be in line with the rates and repayment conditions likely to apply to local and foreign loans. The current

Bangladesh central Bank interest rate is 8 percent. Ninety day treasury bills were issued in August 1975 at 7 percent. The interest rates on foreign Capital will range from about 0.75 percent to 8.5 percent. Sensitivity analysis must be carried out to determine the effect of varying repayment requirements.

Note that the cost of providing access to the North Unit, and completing the transmission line to Kurigram is not included in the capital costs presented in the Report, and that lump sums only have been included for river training and improvement of internal roads.

Taxes, duties and similar inter-governmental costs have not been included in the estimates of project costs.

When calculating annual costs in the Report, interest on borrowed capital at 6.25 percent local and 4 percent foreign, replacement reserve at 3 percent increase in present worth per year, and O&M costs varying with each item were included. These allowances are considered to be low, except in the case of foreign capital which, if a soft loan is obtained, will cost anywhere from 0.75 percent to 3 percent.

When considering O&M costs in the re-working of the project costs and benefits, existing O&M costs on other projects should be used with caution. For example, O&M on the Thakurgaon Project is clearly inadequate. Also, if these

costs are not calculated from first principals and a percentage of the construction cost is taken as the O&M cost, care must be taken to ensure that the construction cost and O&M cost are considered on the same basis, that is, that shadow pricing is not used for one and not the other.

3.8 PROJECT BENEFITS

The benefits from irrigation alone are considerable, for without a dependable water supply the high yielding varieties of rice apparently cannot be grown in the aus and aman season, and a large scale boro crop is out of the question. The Report deduces that the benefits from flood protection do not exceed the cost. This is considered conceptually incorrect, as it would be most imprudent to complete the irrigation system for the entire area without protecting it against flood damage. Certainly, a portion of the irrigation system could be constructed which would be free from flood hazard, but then the cost of the headworks would increase in proportion to the area served, and the benefit - cost ratio would decrease.

It appears logical to the Consultants to develop the North Unit as one complete unit, considering irrigation, flood control and drainage as inseparable parts of the completed project, and to determine the feasibility of the project on that basis.

The Report is difficult to follow as to when the costs and benefits have been shadow priced and when not. *The following table of present worth benefits is, therefore, only believed to be what the Report concludes. See page X-2, Table X-1 and Table VII-21A of the Report.

*PROJECT BENEFITS

	Tk
Pre-project gross production value	83,258,000
Pre project cost of cultivation	37,727,000
Pre project benefit	45,531,000
After project gross production value	369,640,000
After project gross production value	140,711,000
After project benefit	228,929,000
Net benefit	183,398,000
Cultivated area	74,000 acres

$\therefore$ Average income increase/farm = $\frac{183,398,00 \times 3.3}{74,000}$

= Tk 8,180

An alternate approach to check the above conclusion was taken by the Consultants and is presented below:

Present cropping factor	1.52
Future cropping factor	2.2
Assume average present yield	15 maunds/acre
Assume future yield	50 maunds/acre
Assume present and future crop present worth values	Tk70 and Tk50/maund
Assume one farm area	3.3 acres (cultivated)
Assume current cost of production	Tk600/acre
Assume future cost of production	Tk1,000/acre.

Pre-project production cost/farm = 600x3.3x1.52

= Tk 3,010

Pre-project production value/farm

a) 1/3 share cropped

3.3 x 2/3 x 15 x 70 x 1.52

+ 3.3 x 1/3 x 1/2 x 15 x 70 x 1.52

= Tk 4,388

b) no share cropping

3.3 x 15 x 70 x 1.52 = Tk 5,267

∴ Pre-project net income/farm (excl. taxes etc.) = Tk 1,378 to Tk 2,257

After-project production cost/farm

= 1,000 x 3.3. x 2.2 = Tk 7,260

After-project production value/farm

a) 1/3 share cropped

3.3 x 2/3 x 50 x 50 x 2.2

+ 3.3 x 1/3 x 1/2 x 50 x 50 x 2.2 = Tk15,125

b) no share cropping

3.3 x 50 x 50 x 2.2 = Tk18,150

After-project income/farm (excl. taxes etc.) = Tk 7,865 to Tk10,890

∴ Net income increase/farm = Tk6,478-Tk8,633

Note that this is not significantly different from the Tk 8,180 believed given by the Report.

If taxes, cost recovery payments etc. are deducted from these figures, each average farmer could expect to increase his income by 4 to 5 times.

Note that the present worth of future paddy production was taken as Tk 50/maund in the Report. In the above rough farm budget analysis a price drop is assumed; the present value of paddy is taken as Tk 70/maund, which is the actual present value, and the present value of future paddy is taken as Tk 50/maund. International rice prices are forecast by IBRD to drop in the next 10 years from about $233/metric ton to $165/metric ton (25-35% broken, f.o.b. Bangkok). Tk 50/maund for paddy corresponds to about $124/metric ton for rice at an exchange rate of $1 = Tk 16. If anything, therefore, the benefits forecast in the above farm budget analysis would appear to be slightly underestimated. IBRD have recently used the following rates for future paddy prices in appraisals, which again suggests that the above analysis is conservative.

aus	Tk 79/maund
aman	Tk 92/maund
boro	Tk 82/maund

3.9 PROJECT ECONOMICS

The following economic indices were determined in the Report, as defined, to test the economic viability of the Project:

Benefit-Cost Ratio

Present worth value of the total benefits over the life of the project (50 years assumed) divided by the present worth value of the total costs over the life of the project. The annual benefits to annual cost ratio was not used.

Net Contribution

The present worth of the total benefits over the life of the job minus the total present worth of the total cost.

Internal Rate of Return

The discount rate at which the present worth of the total benefits over the life of the job equals the present worth of the costs.

The Report states that the recommendations of the Planning Commission Manual "Manual for Project Evaluation, Government of the People's Republic of Bangladesh, 1973", were followed for shadow pricing farm output.

The results of the economic analyses, as given in the Report, are as follows:

(1)	Construction cost (Table IX-2A)	Tk223,517,464
(2)	Annual project cost at 6.25 % local (Table IX-7A) and 4% foreign interest rates	Tk 18,498,395
(3)	Gross annual production value with project (Table VII-21A)	Tk369,640,000
(4)	Gross annual cost of production with project (Tables X-1 and G-3)	Tk120,679,000
(5)	Net annual production value with project. (3) - (4)	Tk248,961,000
(6)	Gross annual production value without project (Vol. I, pg X-2)	Tk 83,258,000
(7)	Gross annual cost of production without project (Table G-1)	Tk 26,864,000
(8)	Net annual production value without project (6) - (7)	Tk 56,394,000
(9)	Annual net benefit (5) - (8)	Tk192,567,000
(10)	Annual benefit-cost ratio (9) ÷ (2)	10.4
(11)	Total costs at 10% discount rate (Table G-27)	Tk 92,108,000,000

(12)	Total benefit at 10% discount rate (Table G-27)	Tk1,253,429,000,000
(13)	Total benefit - total cost ratio at 10% discount rate	13.6
(14)	Net contribution at 10% discount rate [(13) - (12)]	Tk1,161,320,000,000
(15)	Internal rate of return	128%

A full check on this data is beyond the scope of this review. The following order of magnitude check was, therefore, carried out by the Consultants.

Recent development costs in Bangladesh have been estimated as follows by various authorities on a present worth basis.

Belkuchi $440/acre for 80,000 acres
$1,100/ha
includes assumed value of existing Brahmaputra right embankment, embankment around remainder of project, a lot of double pumping, internal road and 33 kv distribution systems.

Barisal $200/acre for 140,000 acres
$510/ha
includes no embankments, local contractor for civil works, double pumping, lots of gates.

Muhuri $520/acre for 50,000 acres
$1,300/ha
includes major barrage and regulator, flood control and irrigation.

Karnafuli $550/acre for 38,000 acres
$1,370/ha
includes tidal charging of streams, pumped irrigation, small embankments.

These costs will be escalable over the construction period. IBRD has recently assumed the following escalation rates

RATES OF ESCALATION

Year	Foreign Exchange Civil	Foreign Exchange Equipment	Local
1975	16	12	25
1976	14	10	20
1977	12	8	17
1978	12	8	15
1979	12	9	13

For the North Unit Project assume

U.S.$1 = Tk16

Project life 50 years

Opportunity cost of capital throughout project life = 8.5%

Capital cost of project $1,200/ha including access road to Kurigram, 33 kv transmission line to Kurigram and Teesta railway bridge modification	=$ 35,520,000
Loan repayment period	= 30 years
Annual O&M @ 3%	=$ 1,065,600
Replacement fund @ 8.5% over 50 years	=$ 51,976
Net project benefit p.a., see Chapter 3.8 (Tk7,560)	=$ 472
Net project benefits p.a. ($\frac{\text{Tk7,560}}{\text{3.3 acres}}$ x 74,000 acres =Tk169,527,272.cf. item (9) above: Note that no benefit from a fodder crop is included in this)	=$ 10,595,454

Increased O&M and replacement costs will be offset by increased production value.

Full annual project benefits will be achieved after 7 years, half full project benefits will be achieved during the first 7 years.

All costs and benefits are based on present value.

No benefits gained from completion of the Kurigram access road, 33 kv transmission line to Kurigram or modification of the Teesta railway bridge. This is conservative.

Then:

Annual Benefit Cost Ratio

Annual cost - loan redemption	=	$ 3,305,156
O&M	=	$ 1,065,600
replacement	=	$ 51,976
		$ 4,422,732
Annual project benefits	=	$ 10,595,454
∴ Annual benefit-cost ratio during loan repayment for 30 years	=	2.4
Annual benefit-cost ratio after loan repayment for 20 years	=	9.5

Total Benefit Cost Ratio

Total cost - loan redemption, 30 years	=	$ 99,154,680
O&M, 50 years	=	$ 53,280,000
replacement	=	$ 2,598,800
		$155,033,480
Total benefits 10,595,454 x 43 + 10,595,454 x 0.5 x 7	=	$492,688,611
∴ Total benefit - total cost ratio at end of Project life	=	3.2

Internal Rate of Return

Ignoring annual variations in benefits and costs, and refinements in calculation, the average internal rate of return over the project life will be somewhere between

$$\frac{10,595,454-4,422,732}{35,520,000} \quad \text{and} \quad \frac{10,595,454-1,117,576}{35,520,000}$$

or 17% 27%

Sensitivity analyses were performed for the Report on the following basis:

- 10% increase in benefits, 10% decrease in costs
- 10% decrease in benefits, 10% increase in costs

The results were:

	Optimistic	Pessimistic
Benefit-cost ratio @ 10%	16.5	11.2
Internal rate of return	140%	100%

Sensitivity analyses are usually carried out to determine the effect of variations in certain inputs which for various reasons cannot be accurately estimated. The analyses serve to highlight those inputs which are most critical to success of the project, and thereby enable project management to foresee and guard against shortfalls in these critical inputs.

In the pre-final design stage, it is recommended that the following sensitivity analyses be carried out, and that the results be plotted as curves covering the full range of possible shortfalls.

- reductions in fertilizer supplies
- variations in paddy price
- variations in paddy yield
- variations in the shadow exchange rate
- increases in farm labour rate as the surplus labour is progressively employed.
- increases in the price of inputs
- increases in construction cost
- increases in construction time
- increases in time taken to reach full forecast benefits
- increases in power costs (fuel costs if diesel tubewells used).

CHAPTER 4

SUMMARY OF ADEQUACY OF FEASIBILITY STUDY AND REPORT

CHAPTER

SUMMARY OF ADEQUACY OF FEASIBILITY STUDY AND REPORT

4.1 GENERAL

A considerable amount of work has been carried out for preparation of the Report, and all indications are that the North Unit Project will be economically and technically feasible. The Consultants, however, consider that the best use of available data has not been made, that several major problems must be addressed before project implementation starts, and that, in its present form, the Report is inadequate for application to the international lending agencies for financing.

Notwithstanding the above, the Consultants consider that, provided the problem of Indian diversion of Dudhkumar flows can be resolved, the project recommended in the Report is technically feasible. Also, that the benefit-cost ratio and the internal rate of return will be high, although not as high as given in the Report. The benefits obtained from the project will depend to some degree on what is finally included in the project, for example the access road and transmission line to Kurigram, and on how rapidly full development can be achieved. The latter will depend on how well the Government prosecutes the entire undertaking, and on the management structure established for the project.

4.2 CRITICAL DEFICIENCIES

In Chapter 5, it is recommended that a pre-final design, or Definite Plan report be prepared. During preparation of this report, the various minor and major inadequacies in preparation of the project for implementation, as discussed previously, should be rectified. Some of these inadequacies are commonly taken up by the international lending agencies and by the Government, for example, the management and organization of the project, and cannot properly be considered critical deficiencies in the Report. The following list then covers only the major aspects of the North Unit project which the Consultants consider are critical to the feasibility of the project and should be studied and settled before a full go-ahead to project implementation is given -

- provisions for improving communications should be firm;
- project hydrology should be re-studied;
- the need for pumped drainage should be confirmed
- the use of surface water rather than grounwater for irrigation should be comfirmed;
- means of getting water to the Pateswari pump station should be reasonably firmly established;
- water diversion requirements should be firmly established;
- Guarantees should be obtained from India that India will not jeopardize these requirements;

- if guarantees are not obtainable, contingency plans should be laid for using alternate water sources as may be necessary;

- semi-detailed (minimum) soil surveys and land classification should be undertaken, if not already available;

- the necessary improvements in agricultural support services for the North Unit should be determined with the Government, and provisions made for making these improvements in the project area. See Chapter 3.3.6.7.

- the basic operation and maintenance system for the completed project should be established with the Government, and any necessary studies required to ensure that the North Unit is effectively operated and maintained included in the project. See Chapters 3.6.9 and 3.3.6.7.

- the full scope of the project should be established and the basic Government/lending agency/consultant organizational system possitively laid down;

- practical guarantees should be obtained from the Government that the agreed management structure and organizational systems will be established, and that they can and will be properly staffed.

- project economics should be updated.

CHAPTER 5

RECOMMENDATIONS

CHAPTER 5

RECOMMENDATIONS

5.1 GENERAL APPROACH TO IMPLEMENTATION

The North Unit is an isolated self-contained area, physically separated from adjacent areas in Bangladesh. The lack of amenities in the area is almost total, and to realize the forecast benefits it will be necessary to provide a considerable amount of that basic infrastructure which is often already present in an area when irrigated agriculture is introduced. It is, therefore, recommended that the North Unit project be considered as a integrated regional development covering the following broad development categories:

- irrigated agriculture with all associated inputs
- drainage
- flood control
- road access to and within the North Unit
- electrical power supply
- tele-communications
- and possibly rural electrification

Bangladesh is clearly in need of urgent assistance with its agricultural development program. Extensive tubewell development has already been undertaken, but it is not yielding the forecast benefits because of a lack of adequate operation and maintenance procedures. The current IDA deep tubewell project will add considerably to this problem unless adequate steps are taken to provide a sound operation and maintenance system. ADB are contemplating an extensive use of shallow lift tubewells which will compound the problem. Low lift irrigation pumps operating from rivers and beels have been emphasized in the past, again without prior establishment of an efficient operation and maintenance system. At the present time it is reported that 15,000 out of 42,000 low lift pumps are operational and the boro season is two months away.

The Consultants believe that because of these operation and maintenance problems, which are unlikely to be resolved in the near future, a development of the North Unit using as little mechanical equipment as possible is to be favoured. If, on re-analysis of the tubewell and surface water irrigation schemes, the tubewells appear to be economically justified, careful attention must be given to the present and future national maintenance problems before making a decision.

It is considered that the long term irrigated agricultural development in Bangladesh requires a mix of short-term interim developments combined with long-term and ultimately more productive developments. The North Unit is in the latter category.

5.2 ADDITIONAL EVALUATION REQUIRED

As discussed in Chapter 4, it is considered that the Report is not complete enough for international financing applications. It is recommended that the data in the Report, amplified and modified as necessary, should be used as the basis for preparing a Definite Plan report which presents all relevant project data to a standard acceptable to the international lending agencies. This report would

- establish project aims
- eliminate major development options
- establish scope of project
- present basic layouts for the major physical components of the project
- establish basic project design criteria
- present project cost estimates, and construction schedules
- establish construction and development schedules
- establish project output targets
- establish project level and farmer level economic benefits
- identify necessary manpower, physical and financial inputs
- establish implementation and completed project operation and management systems and agency responsibilities.
- identify contraints to achieving projects aims, output targets and benefits
- identify risks

When preparing this report, proper attention must be given to the items which international lending agencies consider important, and to published guidelines, so that the time between appraisal and loan agreement is minimized. Typical examples of the points commonly addressed are given in Appendix D. It is recommended that each of the potential lending agencies be approached at the commencement of this report work to obtain their general agreement on the scope of work.

5.3 SUGGESTED IMPLEMENTATION PLAN

It is recommended that a consultant experienced in accelerated irrigated agricultural development in countries similar to Bangladesh be retained to prepare, in close cooperation with the Government and USAID, a Definite Plan Report in the shortest time possible. Primary target dates after mobilization should be approximately as follows.

3 months:	to have eliminated major development options and initiated all field surveys and investigations
6 months	to have essentially fixed the project layout
10 months	to have finalized cost estimates, established project organization, and issued draft Definite Plan report
12 months	to have reached agreement with the Government on all major issues and finalized Definite Plan Report

The success in meeting these dates will depend on the degree of teamwork developed between all concerned groups.

Discussions with the Indian Government and the Joint River Commission should start as soon as the diversion requirements are fixed.

Discussions with the consultants for the IDA deep tubewell project should be started as soon as possible to defer installation of the 20 deep tubewells assigned to the North Unit. Use of these wells for demonstration purposes is not recommended unless a tubewell development is eventually selected for the North Unit.

Foundation investigation at the pump stations, if these are required, should commence as soon as the major development options have been eliminated.

If AID intend financing implementation of the North Unit, the first steps towards loan agreement could probably be taken towards the end of the 6th month when the project layout will be essentially fixed and adequate economic analyses will be available.

Hydraulic model studies for the Pateswari pumping station should be initiated as soon as all development options have been eliminated, and their elimination agreed with BWDB. Topographic survey work for the model should start as soon as it is decided to proceed with this suggested implementation plan.

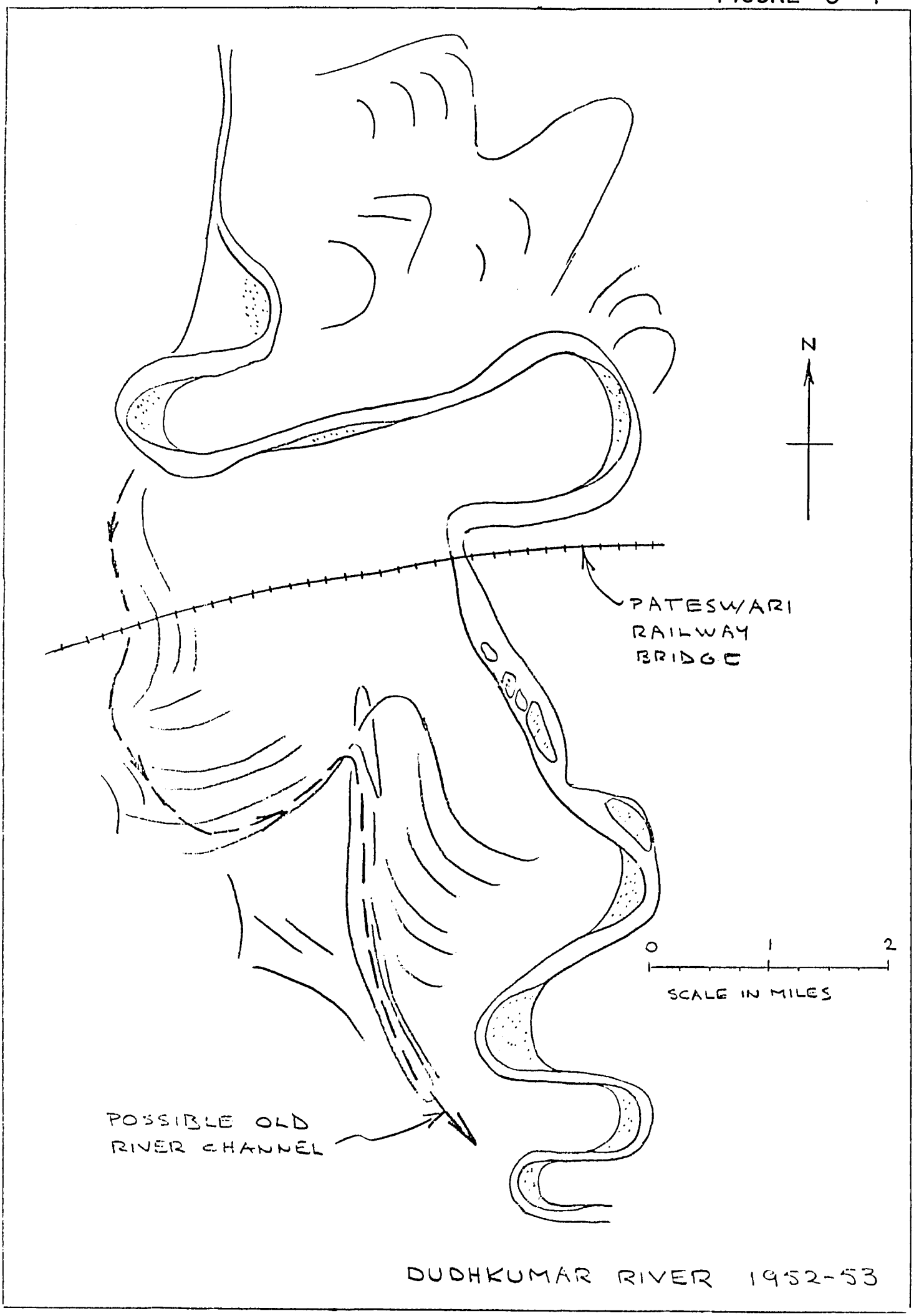
It is recommended that the consultant be retained with a view to having him continue with final design if the project is implemented. In this way, the consultant would be able to plan accordingly and considerable work towards final design could be done during preparation of the Definite Plan report. For example, design of the flood embankments could be finalized and a start made on construction of the embankments under the Food

for Work Program. As these embankments would be only partially completed for several flood seasons, precautions would have to be taken to make sure that whatever lengths were constructed could not be damaged by floods.

Earliest completion of the access road, installation of adequate tele-communications, and provision of suitable air and road transportation facilities for project staff is recommended. Design and implementation of the project will be seriously hampered for as long as these facilities are not provided.

FIGURES

FIGURE 3 – 1


N
PATESWARI
RAILWAY
BRIDGE
0
1
2
SCALE IN MILES
POSSIBLE OLD
RIVER CHANNEL
DUDHKUMAR RIVER 1952-53

KURIGRAM PROJECT

AVAILABILITY OF HYDROLOGICAL DATA

FIGURE 3-2

September 1975

RIVER	STATION NO.	STATION	PERIOD	DETAILS OF PUBLICATION		REMARKS
				Daily Water Level	Discharge	
Dudhkumar		Pateswari G.D.	Since 1960	1960-62 WSP 148 1963-64 WSP 278 1964-73 H.Y.B. 1973 to date under processing.	1960-62 WSP 148 1963-64 WSP 278 1964-73 H.Y.B. 1973 to date under processing.	Prior to 1964 discharge taken mostly weekly. After 1965 mean daily discharges taken.
Dharla		Kurigram G.D.	Since 1946	1946-58 WSP 65 1959-61 WSP 154 1962 WSP 175 1963-64 WSP 236 1964-73 H.Y.B. 1973 to date under processing.	1964-58 WSP 65 1965-61 WSP 154 1962 WSP 175 1963-64 WSP 236 1964-72 H.Y.B. 1972 to date under processing	
		Taluksimulbari	Since 1960	1960-61 WSP 154 1962 WSP 175 1963-64 WSP 236 1964-73 B.Y.B. 1973 to date under processing.		
Brahmaputra	45	Noonkhawa G.	Since 1957	1957-58 WSP 53 1959-61 WSP 102 1962 WSP 192 1963-64 1964-73 H.Y.B. 1973 to date under processing.		Not published. R.D.A.

RIVER	STATION NO.	STATION	PERIOD	DETAILS OF PUBLICATION: Daily Water Level	DETAILS OF PUBLICATION: Discharge	REMARKS
Brahmaputra (cont.)	45.5	Chilmari G.	Since 1957	1957-58 WSP 55 1959-61 WSP 102 1962 WSP 192 1963-65 1965-73 H.Y.B. 1973 to date under processing.		Not published R.D.A.
	46	Kamarjani G.	Since 1957	1957-58 WSP 58 1959-61 WSP 102 1962 WSP 192 1963-64 1964-73 H.Y.B. 1973 to date under processing.		Not published R.D.A.
	46.7L	Kholabari G.	Since 1964	1964-73 H.Y.B. 1973 to date under processing.		R.D.A.
	46.7R	Kristomoni G.	Since 1964	1964-73 H.Y.B. 1973 to date under processing.		R.D.A.
	46.9L	Bahadurabad Transit G.D.	Since 1964	1964-73 H.Y.B. 1973 to date under processing.	1966-72 H.Y.B. 1972 to date under processing.	* R.D.A.
	46.9R	Fulchori Transit G.	Since 1949	1964-73 H.Y.B. 1973 to date under processing.		

RIVER	STATION NO.	STATION	PERIOD	DETAILS OF PUBLICATION		REMARKS
				Daily Water Level	Discharge	
	47L	Old Bahadura-bad G.D.	Since 1949	1949-58 WSB 18 1959-61 WSB 102 1962 WSB 192 1963-65 WSB RDA 1965-73 H.Y.B. 1973 to date under processing	1949-58 WSB 18 1959-61 WSB 102 1962 WSB 192 1963-65 1965-66 H.Y.B.	R.D.A.
	47.3R	Patilbari G.	Since 1964	1964-66 H.Y.B.		
	47.3L	Jognaichor G.	Since 1965	1965-73 B.Y.B. 1973 to date under processing.		
Teesta		Kaunia G.D.	Since 1945	1945-58 WSP 27 1959-61 WSP 94 1962 WSP 209 1963-64 RDA 1964-73 H.Y.B. 1973 to date under processing.	1945-58 WSP 27 1959-61 WSP 94 1962 WSP 209 1963-64 1964-73 H.Y.B. 1973 to date under processing.	R.D.A.
		Kligonj G.	Since 1948	1948-58 WSP 93 1959-61 WSP 94 1962 WSP 209 1963-64 1974-73 H.Y.B. 1973 to date under processing.		R.D.A.

NAME OF STATION	PERIOD	DETAILS OF PUBLICATION
Evaporation		
1. Mahipur	Since 1962	1962-64 WDP 248 1964-73 H.Y.B. 1973 to date under processing.
2. Rangpur	Since 1961	1961-64 WSP 248 1964-73 H.Y.B. 1973 to date under rpocessing.
3. Kaliganj	Since 1961	1961-64 WSP 248 1964-73 H.Y.B. 1973 to date under processing.
Rainfall		
1. Bhurangamari	Since 1963	1963 WSP 266 1964 WSP 285 1964-73 H.Y.B. 1973 to date under processing.
2. Lalmanirhat	Since 1962	1962 WSP 227 1963 WSP 266 1964 WSP 285 1964-73 H.Y.B. 1973 to date under processing.
3. Kurigram	Since 1902	1902-50 WSP 9 Monthly 1961 WSP 170 Daily 1962 WSP 227 Daily 1963 WSP 266 Daily 1964 WSP 285 Daily 1964-73 H.Y.B. 1973 to date under processing.
4. Ulipur	Since 1902	1902-50 WSP 9 Monthly 1961 WSP 170 Daily 1962 WSP 227 Daily 1963 WSP 266 Daily 1964 WSP 285 Daily 1964-73 H.Y.B. 1973 to date under processing.

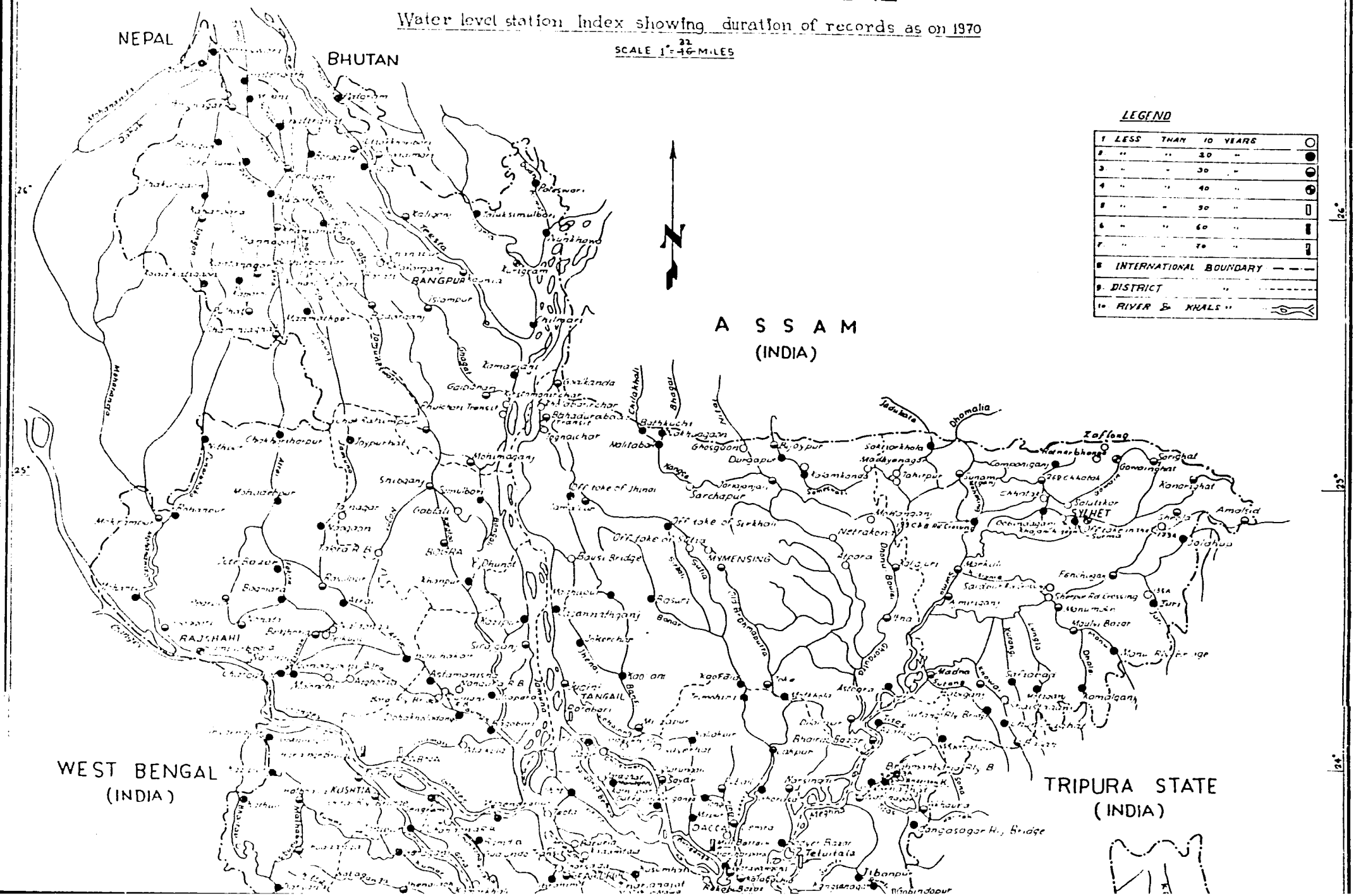
NOTES:

1. H.Y.B. means Hydrological Year Book.
2. W.S.P. means Water Supply Paper.
3. No evaporation station at Kaunia.
4. 1964 onwards all available data published by Hydrological Year Book for water year.
5. * Same section location
6. 1963 onwards are daily rainfalls.
7. G means stage readings.
   D means discharge readings.

BANGLADESH WATER ATLAS

Water level station Index showing duration of records as on 1970

SCALE 1" = 16 MILES



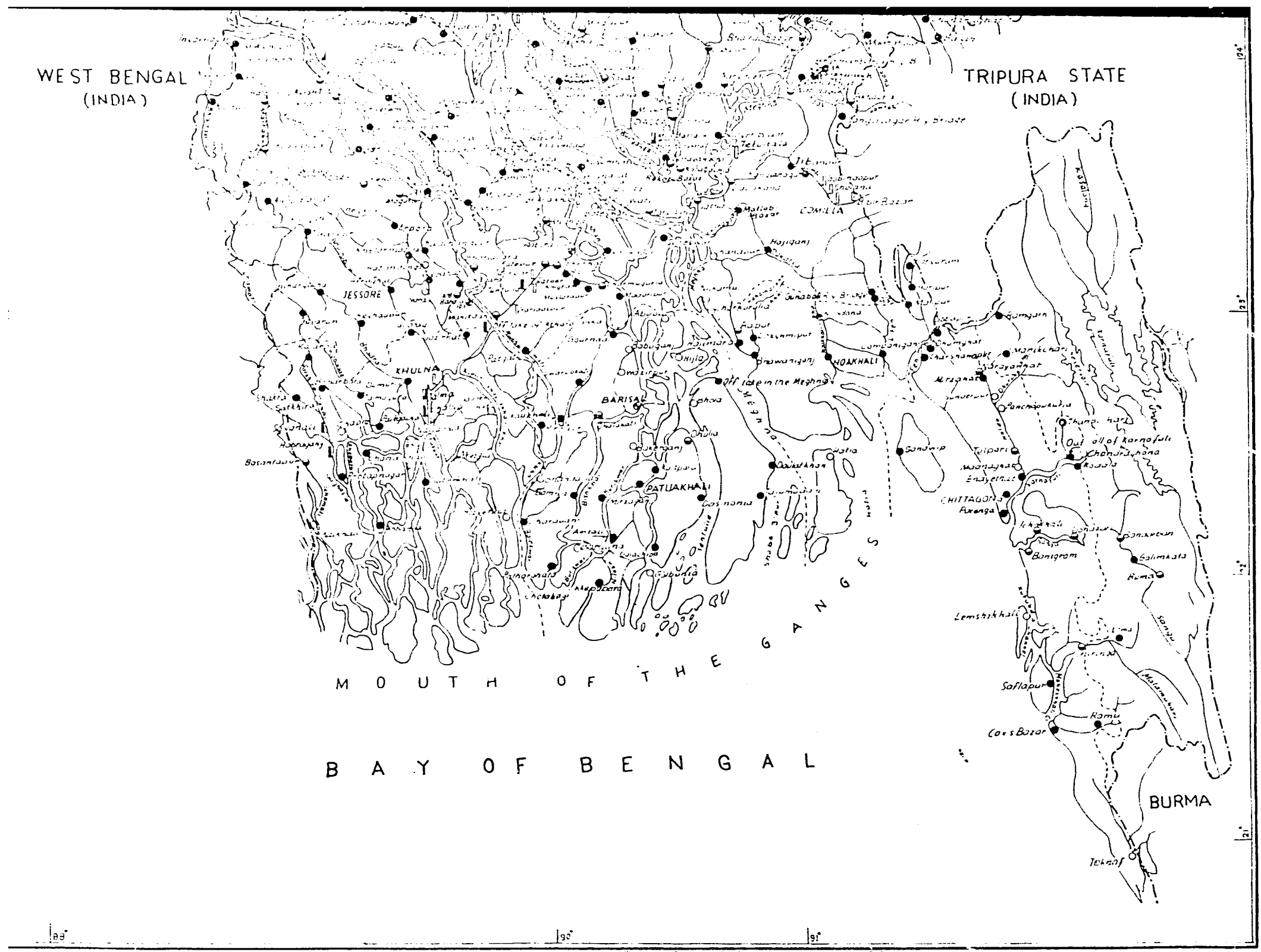


FIGURE 3 — 3

Prepared and published by the Processing Division Surface Water (Hydrology) BWDB Dacca.

Figure 3-4

EVAPO-TRANSPIRATION OF LOWLAND RICE (1)

Quantity and Units Listed in the Original Source	Country or Area	Unit mm/day	Reference No.
Wet season, 4.8 mm/day	Cambodja	4.8	172
Dry season, 6.6 mm/day	Cambodja	6.6	172
From 600 to 650 mm/crop season	China	5.0-6.5[a]	126
From .2 to 8.3 mm/day	India	.2-8.3	162
From 400 to 766 mm/season	India	4.0-5.1	47
Per season, 635 mm	India	4.0-5.1[a]	191
From 4.0 to 6.0 mm/day	Indonesia	4.0-6.0	84
Over 8.0 mm/day	Iran	8.0	85
Wet season, 218 to 3.9 mm/day	Laos	5.0	134
Wet season, 5.0 mm/day	Malaysia	5.0	87
Dry season, 5.5 mm/day	Malaysia	5.5	87
From 8.0 to 11.8 mm/day	Pakistan	8.0-11.8	104
Below 7.0 mm/day over long periods	Surinam	7.0	75
From 600 to 650 mm per 110 day season	Taiwan	5.4-5.9	127
From 380 to 830 mm per season	Thailand	5.0-6.0[a]	134
Wet season, 5.1 mm/day	Thailand	5.1	208
Subtropics, 7.0 mm/day	Japan	7.0	214,219
From 5.0 to 7.0 mm/day	East Asia	5.0-7.0	214,219
per season, 25.57 inches	S.E. Asia	6.2	57

a. Estimate of the daily evapo-transpiration made from source other than the one indicated.

(1) Extract from Cornell University thesis by Jacob Kampen 1970.

Figure 3-5

WATER REQUIREMENTS FOR LAND PREPARATION IN LOWLAND RICE CULTIVATION (1)

Location	Total mm	Time days	Seedbeds mm	Land soaking mm	Initial flooding mm	Reference
Ceylon	330	-	-	-	-	12
India	230	-	250[a]	200	-	46,66
India	230-390	-	199-400[a]	210-350	-	188
Japan	130	-	-	-	-	14
Malaysia	225	-	-	125	100	88
Malaysia	176	-	-	-	-	133
Surinam	420	-	-	300	120	75
Taiwan	120-150	20	-	-	-	55
Taiwan	200-210	20	200[a]	150	30	223
Thailand	300-400	-	-	-	-	134
S.E. Asia	220-240	-	250-400[a]	150-200	-	134

a. The total quantity in mm required for seedbeds is divided by a factor of 15 to 25, according to the seedbed ratio, to obtain an average water requirement per ha.

(1) Extract from Cornell University thesis by Jacob Kampen 1970.

FLOOD DAMAGE ESTIMATE

Figure 3-6

Area	Year	Cropped Area Inundated Sq. Miles	Cropped Area Damaged Sq. Miles	Lives Lost	Cattle Lost	People Affected	Depth & Duration of Flooding
North Unit	1967	31 (26%)	15				Up to about 6'. Up to 50 days, see hydrographs in Report.
Kurigram Sub-Division	1972	264	72	Nil	3,937	200,000	Normal 2'-3' Abnormal 2'-7' 3-10 days
Kurigram Sub-Division	1973	1,150	874	26	700	3,048,670	5'-3' 7-10 days
Kurigram Sub-Division	1974	173	110	2	134	107,710	Normal 2'-3' Abnormal 3'-6'-3" 3-10 days

KURIGRAM PROJECT

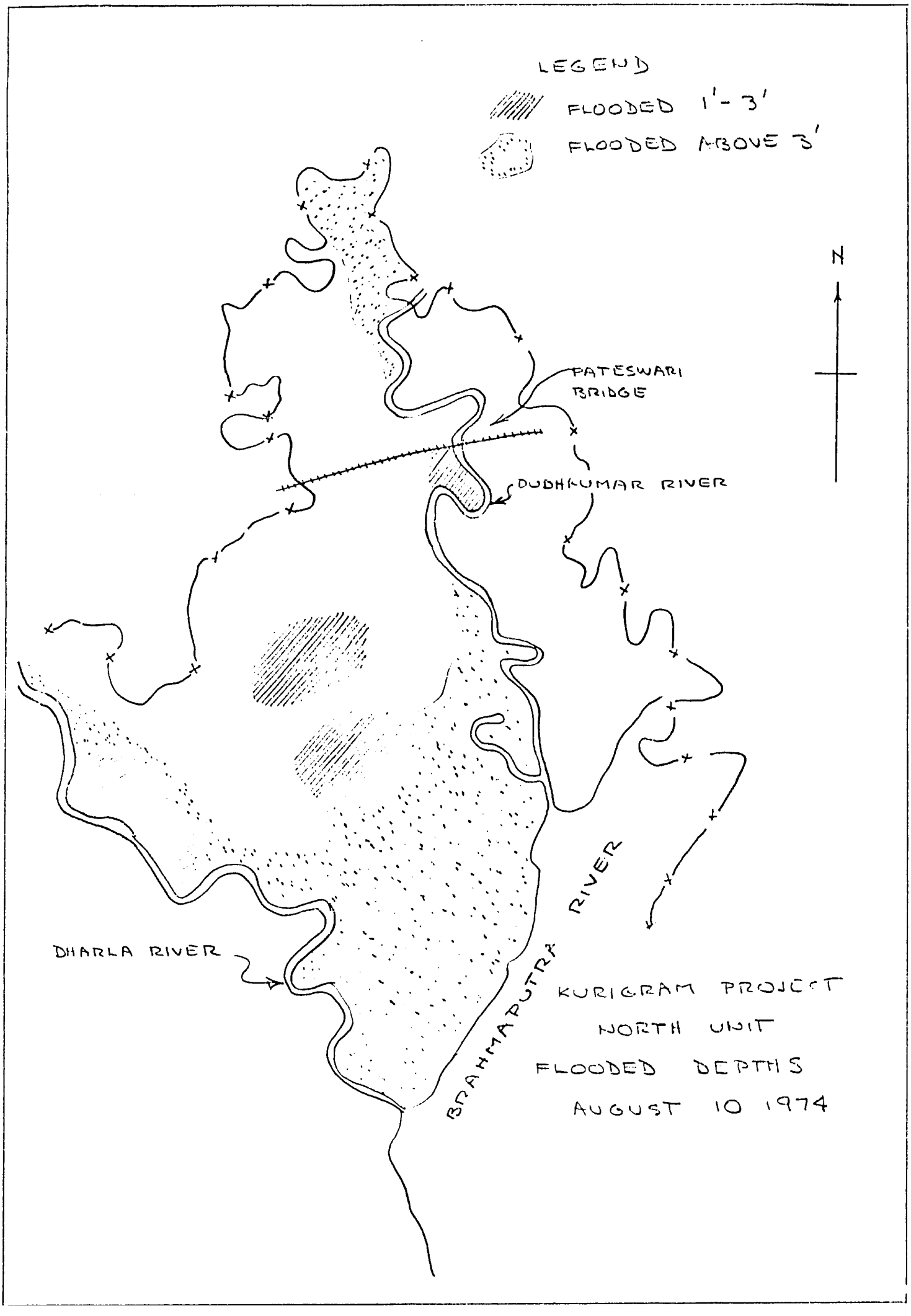
Figure 3-7

Comparison of Unit Costs

Item	Unit	Kurigram Feasibility Report Tk	ADB (Khulna Road) Tk	USAID/Dacca for Kurigram Tk
Earthwork				
canals	1,000 cu. ft.	60		
embankments	1,000 cu. ft.	80	390	150
structures	1,000 cu. ft.	60		150
Concrete				
1:4:8	100 cu. ft.	900		1,700
1:2:4	100 cu. ft.	1,200		4,000
Land	Acre	5,000	10,000 (farmland)	
Resteel	ton	5,500	8,000	8,000
Fabricated Structural Steel	ton	9,000	10,000-12,000	15,000
Cement	ton		1,000	1,000
Bricks	1,000		700-800	650
Brickwork	100cu. ft.			1,600
Sand	100 cu. ft.	100	200 (Sylhet)	100
Stone	100 cu. ft.	250 (rip rap) 500 (pitching)	800 (crushed)	500(boulders)
Tubewell	1 No.	160,000 (2 cusec, 250 ft. deep, Pg. VIII-29) 177,000 (3 cusec, 250 ft. deep, Pg. VIII-29)	IBRD, 1970, 2 cusec, Tk130,000 @ Tk16 = $1	30,700 (2 cusec, 200 ft. deep, incl. pump house)

APPENDIX A

FLOOD RECORDS


LEGEND
FLOODED 1'-3'
FLOODED ABOVE 3'
N
PATESWARI BRIDGE
DUDHKUMAR RIVER
DHARLA RIVER
BRAHMAPUTRA RIVER
KURIGRAM PROJECT
NORTH UNIT
FLOODED DEPTHS
AUGUST 10 1974

FINAL FLOOD REPORT OF 1974 IN KURIGRAM SUB-DIVISION:

Sl. No.	Time of flood occurence duration of flood.	Total area of flood including normal flooding flooded area	Total cropped area inundated.	Total acres of each type of crops damage & percentage damaged of each crop.	Severaly affected Thanas of area	No. of homestead road, bridges, culverts, railway line & structures partly or wholly damaged	No. of people affected by flood & loss of livestocks & human lives	Breach or erosion of flood Control embkt. & bank of rivers etc.	Depth of flooding.
1	2	3	4	5	6	7	8	9	10
	From middle of June to last week of September/74. 3 to 10 days.	507 sq. miles.	173 sq. miles.	Approximate(16 sq. miles) acres Borrow paddy 30% damaged. Approx. (44 sq. miles) 281.60 acres Aus paddy 30% damaged. Approx. 15,000 acres jute. 50% jute damaged. Approx. 152 sq. miles = 97920 acres Aman paddy= 50% damaged. Approx. 20 sq. miles = 12800 acres Amon seedling = 20% damaged.	1)Ulipur. 2)Chilmari. 3)Rowmari. 4)Kurigram. 5)Nageswari. 6)Bhurangamari. 7)Phulbari. 8)Lalmonirhat. Chilmari, Rowmari & parts of Kurigram, Ulipur, Nageswari & Lalmonirhat Thanas were worst effected.	Home-stead 2000 Thana Council & Union Council road Approx. =400 miles Bridge = 30 Nos.	1,07,710 Nos. affected. 2 Nos. human live lost. about 134 Nos. cattles los.	Thana Council & Union council embkt. about 121 miles. About 150' brick mattressing damaged.	Normal flood . 2'-0" to 3'-0" Abnormal flood 3' to 6'-3'

Note :- Begining the flood Aus paddy & jute has been affected and damaged. But in the middle of the flood season the Amon paddy has been affected including area of Aus paddy and jute. As such the Amon paddy has been damaged maximum. So, the crops area or crops damaged shown in repetedly.

Sd/-
Executive Engineer,
Kurigram W.D. Division, Kurigram.

FINAL REPORT OF FLOOD OF THIS SEASION 1973.
IN THE RANGPUR DISTRICT.

(Consolidated report of 4 flood occured in 1973)

Sl. No.	Time of flood occurance & duration of flood.	Total area of flooded including normal flooded area in sq. miles	Total cropped area inundated	Total acreage of each type of crops damaged & percentage damaged of each crop.	Severely affected Thanas.	No. of homestead, roads, bridges & culverts, Railway lines & structures partially or wholly damaged.	No. of people affected by the flood & loss of live stocks & human lives.	Breach or erosion of flood control embkt. bank of rivers etc.	Depth of flooding.
	1. 1st. flood :- June/73 = 7 to 10 days. 2. 2nd. flood :-August/73 = 7 to 10 days. 3. 3rd. flood :-Sept/73 = 2 days. 4th flood Oct/73 =4 days	1220 Sq.miles.	1150 Sq. miles.	1)Approx.(240 Sq.miles) = 1,53,600 Acrs. Jute 30% damage. 2)Approx.(440 Sq. miles)2,81,600 Acrs Aus paddy 50% damaged. 3)Approx.630 sq.miles =4,03,200 acres Amon seedling 60% damaged. 4)Appr. (273 Sq.miles) =1,74,720 acrs.Amon paddy 75% damaged.	KURIGRAM SUB-DIVN. 1)Kurigram. 2)Chilmari. 3)Ulipur. 4)Rowmari. 5)Phulbari. 6)Balmonirhat. 7)Nageswari. 8)Bhurangamari. NILPHAMARI SUB-DIVN. 1)Dimla. 2)Jaldhaka. 3)Kishorganj. RANGPUR SADAR SUB-DIVN: 1)Batibandha. 2)Gangachara. 3)Kaunia. 4)Kaliganj. 5)Patgram. GAIBANDHA SUB-DIVN: 1)Gaibandha. 2)Sundarganj. 3)Pirgacha 4)Shaghata. 5)Phulchari.	1100 Nos. house were fully damaged. Culvert= 5 Nos. Road = 6 " Railway= 50 " Land=5.05 Sq. miles.	30,48,670 Nos. 26 Nos. human live were lost About 700 Nos. different type of cattle were lost.	½ mile a.v.	5'to 3'

Sd/-
Executive Engineer,
Kurigram W.D. Division,Kurigram.

FINAL REPORT ON FLOOD OF THIS SEASON 1972, IN THE DISTRICT OF RANGPUR.

Sl. No.	Time of flood occurrence & duration of flood.	Total area of flooded area including normal flooded area	Total cropped area inundated	Total acreage of each type of crops affected & percentage damaged of each crop.	Severely affected Dhara of areas	No. of Home-stead roads, bridges, culverts, Rail-way lines & structures partially or wholly damaged.	No. of people affected by the flood & loss of live-stocks & human lives	Breach or erosion of flood control Embkt. bank of rivers etc.	Depth of flooding.
1	2	3	4	5	6	7	8	9	10
1.	[illegible] of Middle of June to 1st.week of [illegible]er'72 [illegible] 3 to 10 days.	618 sq. miles.	264 sq. Miles.	1) Approx. 260 [illegible] seedling 75% damaged. 2) Paddy (Aus) 1,1000 Acres 95% damaged. 3) Jute 59,000 acres 60% damaged.	Kurigram Sub-Division. 1) Chilmari P.S. 2) Rowmari P.S. 3) Bhurungamari P.S.(Partly) 4) Phulbari " " Nilphamari Sub-Divn. 1) Dimla P.S. 2) Jaldhaka " 3) Kishorganj "(Partly) RANGPUR. 1) Kaliganj P.S. " 2) Gangachara " " 3) Kaliganj " " 4) Mandiganj " " GAIBANDHA. 1) Phulchari P.S. 2) Sherghata " 3) Gaibandha " (Partly) 4) Sundarganj " "	Home-stead =41,930 Nos. Bridge & culverts = 71 Nos. Live-stocks =3,937 Nos.	2 Lakhs (Approx.) peoples affected.	There was severe erosion in the area of Purbabhalkari & adjacent locality of Dimla P.S., Gaddimari & adjacent areas of Kalibandha P.S., Mohipur Mornia & adjacent area of Gangachara P.S. Haragacha and adjacent area of Kawnia P.S. & near Phulchari P.S. There was a bridge in Kawnia, Phulchari flood embkt. near Gaibandha & damage in right bank Guide bundh & Dimla P.S.	Normal =2' to 3'ft. Abnormal. 2' to 7' ft.

(A.M.JAHANGIR)
EXECUTIVE ENGINEER,
KURIGRAM WATER DEV. DIVISION,
KURIGRAM, RANGPUR.

APPENDIX B

MASTER PLAN DETAILS OF KURIGRAM PROJECT

NW 6 KURIGRAM PROJECT

LOCATION

The Kurigram Project is located on the right bank of the Brahmaputra-Jamuna River, north of the Teesta River, as shown on Plate NW 6-1.

DESCRIPTION OF THE PROJECT

The project would provide flood protection and gravity drainage for a gross area of 345,000 acres of which 277,000 acres would be irrigated. The area is naturally divided into two units by the Dharla River. Flood protection and drainage facilities include embankments along the banks of the Dudhkumar, Dharla, Brahmaputra-Jamuna and Teesta Rivers and nine gravity drainage outlet structures to remove internal runoff from the project area. No drainage pumps are required. Two irrigation pumping plants, one for each unit, would be constructed. One would be located on the Dudhkumar River and the other on the Dharla River.

PHYSICAL DATA

Embankment	
Total length	135 miles
Crest width	14 feet
Irrigation Pumping Plants	
Number of plants	2
Total capacity	3,750 cusecs
Average static head	25 feet
Total horsepower	16,800 hp
Gravity Drainage Outlets	
Unit I	5
Unit II	4
Construction Period	5 years
Development Period	10 years

AGRICULTURE

The present cropping pattern is governed by flooding during the monsoon season and by the lack of soil moisture during the winter months. Aus and transplanted aman are the dominant crops, although some jute and winter crops are also grown. Present cropping intensity is 121 percent.

Irrigation and flood protection are not expected to introduce new crops, but the cultivation and yields of crops presently grown will be significantly increased. With the project, the cropping intensity would rise to about 240 percent. (See page 206)

PRESENT CROP PRODUCTION AND REVENUE

Crops	Acreage (Total)	Yield/Ac in Mds	Total Production in Mds	Price/Md in Rs	Total Value in Rs
T. Aman	99,720	16.0	1,595,520	12	19,146,200
Aus	127,420	14.0	1,783,880	12	21,406,600
Boro	1,108	12.0	13,296	12	159,600
Sugarcane	1,662	600.0	997,200	2	1,994,400
Jute	42,660	15.0	639,900	25	15,997,500
Rabi Vegetables	3,320	56.0	185,920	10	1,859,200
Fruits	1,390	100.0	139,000	9	1,251,000
Oilseeds	24,930	5.0	124,650	30	3,739,500
Pulses	19,390	5.0	96,950	10	969,500
Tobacco	1,940	6.0	11,640	100	1,164,000
Chillies	550	3.6	1,980	76	150,500
Wheat	11,080	9.0	99,720	17	1,695,200
Total	335,170	(Cropping intensity = 121%)			69,533,200

STATUS OF THE PROJECT

This project is the subject of a preliminary study based on limited information. Further study, when additional field data becomes available, will be required to confirm the economic results of this preliminary investigation.

FUTURE CROP PRODUCTION AND REVENUE

Crops	Acreage (Total)	Yield/Ac in Mds	Total Production in Mds	Price/Md in Rs	Total Value in Rs
T. Aman	175,650	30	5,269,500	12	63,234,000
Br. Aman	10,000	18	180,000	12	2,160,000
Aus	181,410	20	3,628,200	12	43,538,400
Boro	31,000	32	992,000	12	11,904,000
Sugarcane	5,540	600	3,324,000	2	6,648,000
Jute	24,960	18	449,280	24	10,782,700
Rabi Vegetables	5,940	73.5	436,590	10	4,365,900
Fruits	11,550	145	1,674,750	9	15,072,700
Oilseeds	37,920	8	303,360	30	9,100,800
Ground Nuts	10,100	13.5	136,350	32	4,363,200
Pulses	3,600	10	36,000	10	360,000
Tobacco	4,140	15	62,100	100	6,210,000
Chilies & Spices	5,940	10	59,400	60	3,564,000
Wheat	15,420	15	231,300	17	3,932,100
Fodder	125,640	100	12,564,000	0.5	6,282,000
Maize	1,800	20	36,000	14	504,000
Cowpeas	8,280	100	828,000	0.5	414,000
Potatoes	4,140	125	517,500	10	5,175,000
Total	663,030	(Cropping Intensity = 240%)			197,610,800

ESTIMATES OF COSTS AND BENEFITS

A. Capital Costs (Millions of Rupees)

Construction		
Pumping facilities	Rs	26.080
Irrigation facilities		28.250
Flood protection works		24.934
Drainage improvement		9.592
Contingencies (15%)		13.329
Total Construction Cost	Rs	102.185
Engineering		15.328
Land and Rights of Way		14.236
General Administration		6.587
Interest during Construction		19.090
Total Capital Cost	Rs	157.426

Unit Cost per Acre Rs 568

B. Annual Cost

Interest and amortization	Rs	8.627
Operation and maintenance		3.933
Replacement reserve		0.185
Total Annual Cost	Rs	12.745

Unit Cost per Acre Rs 460

C. Benefits (Full Development)

Annual Gross	Rs	128.078
Annual Net	Rs	64.039

Benefit-Cost Ratio 5.0

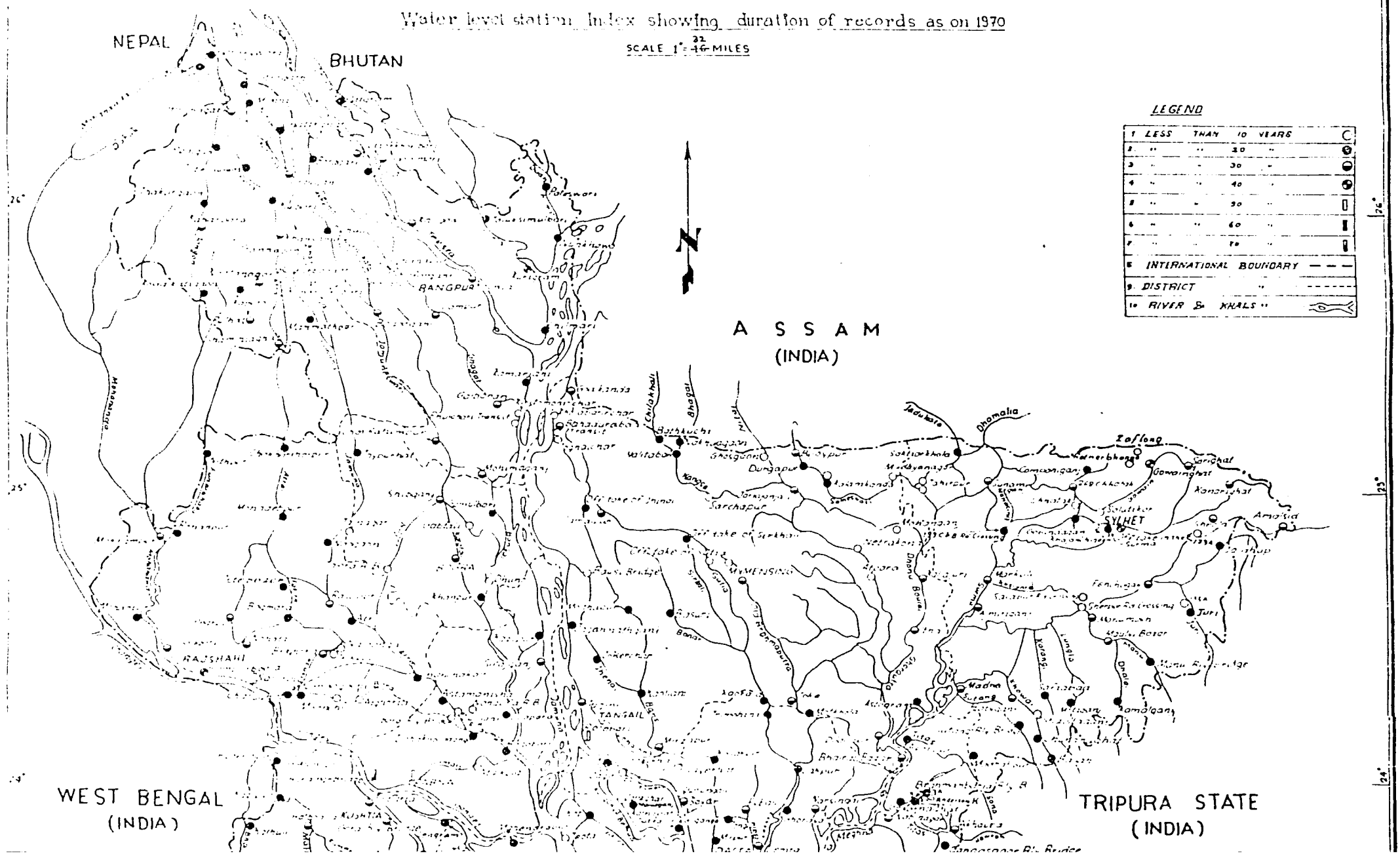
ACTION RECOMMENDED

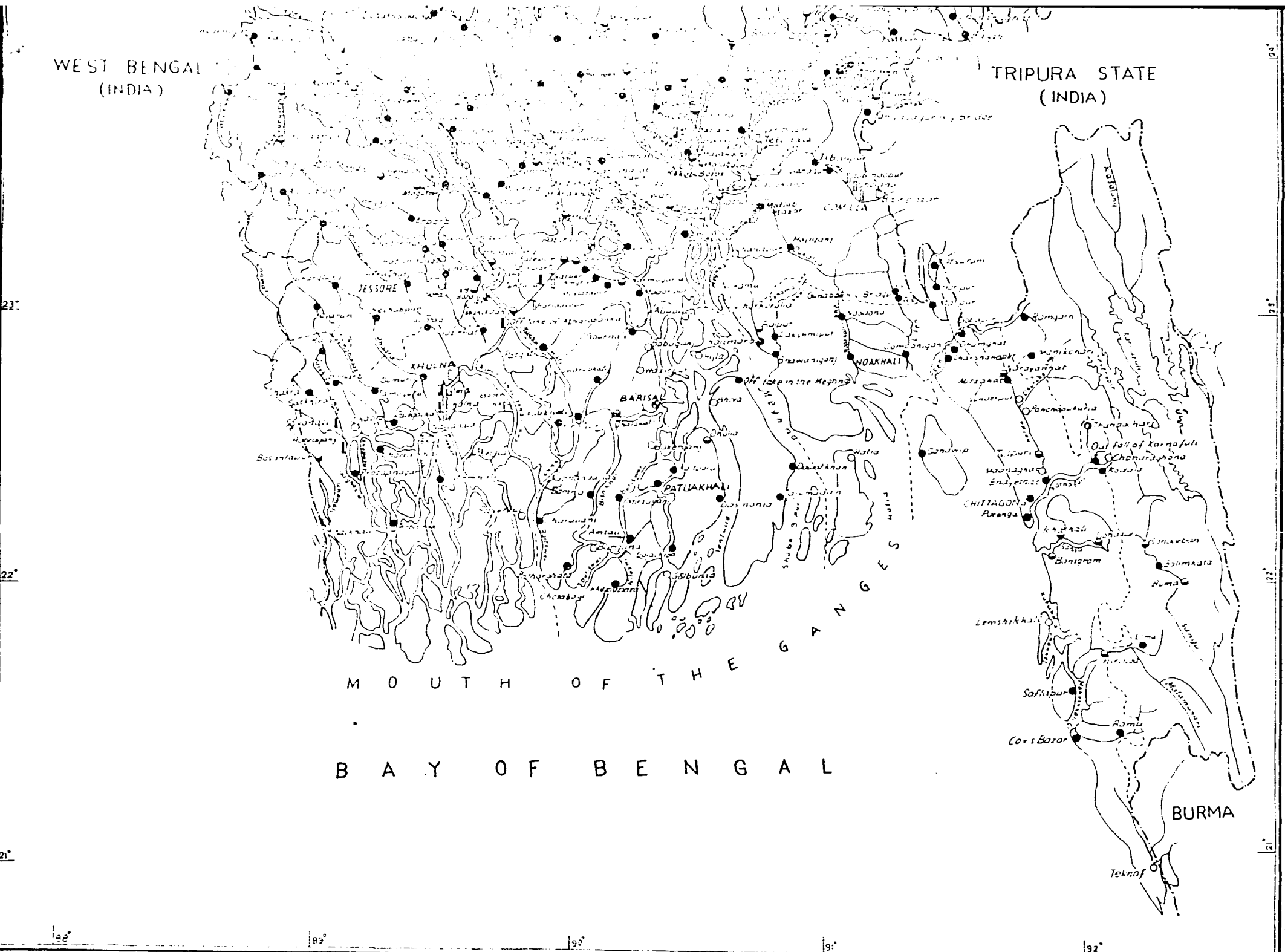
A feasibility report should be prepared soon. Subject to the determination of the feasibility report, engineering plans should be completed in time for construction to start in 1968.

BANGLADESH WATER ATLAS

Water level station Index showing duration of records as on 1970

SCALE 1" = 22 MILES





Prepared and published by the Processing Division, Surface Water (Hydrology) BWDB Dacca.

FIGURE 3 — 3

APPENDIX C

CONSULTANTS TERMS OF REFERENCE

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

July 28, 1975

Engineering Consultants, Inc.
1901 South Nevaho Street
Denver, Colorado 80223

Subject: Work Order No. 4 to
Contract No. AID/otr-C-1303

Gentlemen:

Enclosed is one (1) executed copy of subject document.

Two (2) certified true copies will be forwarded to you as soon as they have been reproduced.

Sincerely yours,

L. E. Stanfield
Contracting Officer
Chief, OTR Branch
Central Operations Division
Office of Contract Management

Enclosure: a/s

AUG 1 1975

JOB NO. .....

TO		DATE
GR	✓	8/1
CML		
MKK		
WCW	✓	
PE		
HNC		
JCI		
AD		
YAY		
PNO		
JGN		
ASA		
O & P		
ACCT	✓	

FILE C1152-04

Copy to Slaughter

WORK ORDER UNDER REQUIREMENTS FOR ARCHITECT AND ENGINEERING SERVICES	CONTRACT NO. WORK ORDER NO. 4 MULTIPURPOSE WATER RESOURCES

NEGOTIATED PURSUANT TO THE FOREIGN ASSISTANCE ACT OF 1961, AS AMENDED, AND EXECUTIVE ORDER NO. 11223

AUTHORIZED ORDERING ACTIVITY Agency for International Development Office of Contract Management Central Operations Division Washington, D.C. 20523	CONTRACTOR Engineering Consultants, Inc. 1901 South Navaho Street Denver, Colorado 80223
COGNIZANT SCIENTIFIC/TECHNICAL OFFICE Office of Engineering Administrative Officer Room 509 Agency for International Development Washington, D.C. 20523	MAIL VOUCHERS TO Agency for International Development Office of Engineering Washington, D. C. 20523
EFFECTIVE DATE See Article VII	ESTIMATED COMPLETION DATE See Article VII

ACCOUNTING AND APPROPRIATION DATE

WORK ORDER TOTAL: $13,000.00 OBLIGATED AMOUNT: $13,000.00	PIO/T No.: 388-008-3-6001 Appropriation No.: 72-11X1023 Allotment No.: 402-50-338-00-69-61

The Contractor shall perform all the services set forth in this Work Order. This Work Order is issued pursuant to the terms of Requirements Contract No. AID/otr-C-1303 . The entire contract between the parties hereto consists of: (a) This Work Order including the Cover Page, the Schedule, and Additional Provisions (if any); and (b) Requirements Contract No. AID/otr-C-1303.

UNITED STATES OF AMERICA
AGENCY FOR INTERNATIONAL DEVELOPMENT

BY L E Stanfield

TYPED OR PRINTED NAME

L. E. Stanfield

TITLE Contracting Officer

DATE 25 JUL 1975

SCHEDULE

I. AID PROJECT TITLE

Architect and Engineering Services, Multipurpose Water Resources, Kurigram Flood Control and Irrigation Project, Evaluation of Feasibility Study - Northern Unit

II. OBJECTIVE

The objective of this order is to evaluate the completeness of the project feasibility study of the Kurigram Flood Control and Irrigation Project prepared by the Bangladesh firm, TCEL, as it relates to the Northern Unit.

III. SCOPE OF SERVICES

In accomplishment of the above, the contractors water resource engineer shall review the preliminary draft of the feasibility study prepared by TCEL, dated February 8, 1975, No. EGP/11, and shall prepare a report which evaluates the feasibility study.

The evaluation will be made from information obtained by:

(1) Visiting Dacca and conferring with officials of USAID, the Government of Bangladesh Water Development Board and TCEL, and others as appropriate.

(2) Examining the project area to assess physical conditions on site.

(3) Reviewing in detail the portions of the report which relate to the Northern unit.

The review shall consider but not be limited to assessing:

(1) Adequacy of the surface and ground water supplies for the alternate projects. In making this determination, the contractor with concurrence of USAID may call to service his ground water hydrologist.

(2) Identification of the practical and physical problems associated with each alternative.

(3) Adequacy of engineering and geological information.

(4) Adequacy of agronomic and climatological data and appropriateness of its application to cropping forecasts in the report.

(5) Adequacy of construction costs and project benefits.

(6) Adequacy of the economic analysis.

(7) Adequacy of report to meet requirements of international lending agencies.

If this review fails to produce a complete evaluation of the study, the Contractor shall furnish recommendations as to how the evaluation should be undertaken, with personnel and time requirements.

If the feasibility study is found to be critically deficient in any way, the contractor shall prepare a scope of work for services necessary to correct the deficiency.

IV. REPORTS

The final report shall be submitted in ten copies to USAID/Bangladesh and ten copies to the cognizant technical office.

V. RELATIONSHIPS AND RESPONSIBILITIES

For the accomplishment of the consulting services to be performed in Bangladesh under this work order, the Contractors team shall be responsive to the technical directions of the Government of Bangladesh, Water Development Board. The AID liaison official will be the USAID/Bangladesh Assistant Director for Capital Development.

VI. LOGISTICS SUPPORT

USAID/Bangladesh shall supply in kind, or provide local currency for the procurement of, office space, office equipment, and transportation in country.

VII. TERM OF PERFORMANCE

Effective Date: August 1, 1975

Estimated Completion Date: October 10, 1975

VIII. ESTIMATED LEVEL OF EFFORT

TITLE	NO. MAN-DAYS	FIXED DAILY RATE	TOTAL
Water Resource Engineer	30	$239.41	$7,182.30
Groundwater Hydrologist	10	210.69	2,106.90
	TOTAL		$9,289.20

IX. ESTIMATED COST

Total Fixed Rates	$ 9,289.20
Total Other Direct Costs*	3,710.80
TOTAL	$13,000.00
Ceiling Amount	$13,000.00

* Includes provision for per diem international travel enroute, telephone and telegraph, visas, report preparation, medical examinations and inoculations, and out-of-pocket expenses.

APPENDIX D

TYPICAL INTERNATIONAL LENDING AGENCY APPRAISAL FORMAT

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MAP NO.

11537 Project Location
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