CHAPTER 4

DEVELOPMENT PLAN

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4-1. General

(a) Constraints on Agricultural Development

Under the natural and social conditions mentioned in the previous chapter, the agriculture in the Study area has stagnated to a relatively low productivity level, lagging behind on the introduction of improved cultivation technologies such as high yielding rice varieties and fertilizer applications.

The most significant and fundamental factor which restricts the development of agriculture in the Study area seems to be the present water conditions. Flood water levels in the three outer rivers along the Study area are so high above the lands in the lower reaches of the Study area as to cause annual inland flooding either by inflow from the outer rivers or by inland runoff from the upper reaches in the rainy season. This not only brings about damages to crop production but also hinders the practice of improved technologies, which includes new varieties and fertilizer applications, requiring stable water conditions.

In the Study area, most of the available land has been exploited for cultivation. In the rainy season, crops are grown in principle by rain-fed water, while, in the dry season, the cropping area is limited to only about 28 % of the total cultivable land, which is equipped with small scale irrigation pumps. In this situation, the basic way to develop agriculture seems to be to increase productivity in the rainy season and/or to expand the cropping area in the dry season. And, the most fundamental measure to be taken for that purpose is considered to be irrigation.

Among the other restricting factors are the lack of technical know-how and resources of farmers as well as insufficient infrastructures for transportation and marketing. The countermeasures would be strengthening the extension activities for improved technologies, promoting cooperative activities, improving and constructing roads and warehouses, etc..

(b) Development Objectives

The objectives of the proposed development plan are to increase agricultural production and to raise farmers' incomes and thus to contribute to increase of employment opportunities, regional economical development and improvement of people's living standards, through comprehensive implementation of countermeasures to sweepingly eliminate the above-mentioned constraints on agricultural development. For these objectives, the proposed development plan contains construction of irrigation and drainage systems and flood protecting embankment together with related measures including road network improvement and agricultural supporting services strengthening.

(c) Development Strategy

1) At present, a large number of depressions and meandering channels existing in the Study area function as natural flood control reservoirs. Therefore, in principle, the current natural drainage system from farm to main channel level is to be left as it is. Approximately 80 % of the embankment for the Study area has been already constructed. The unfinished sections of the embankment are to be built and the existing sections to be rehabilitated.

2) Irrigation water is planned to be taken in mainly by pumping up from the Duhdkumar river. Supplementary water intake by installing a reversible pump station for the southern part of the Study area is to be studied for an efficient drainage plan. The irrigation system is to be studied taking into consideration minimizing banking hight, crossing points with settlements and drainage channels and the total pumping energy cost.

3) The most important crop currently grown in the study area is rice, which are followed by jute and wheat. The proposed development plan is aimed at making it possible to significantly expand cropping area in the dry period and to raise productivity in the monsoon period. Introduction of high yield varieties and profitable crops as well as application of improved technologies are to be studied so that they will be of optimum level for farmers in the Study area.

4) It is important for successful and effective implementation of irrigation and drainage development to be incorporated with indispensable measures for supporting farmers' cultivation. In this respect, the construction of roads and

warehouses for input supply and marketing as well as strengthening extension services and cooperatives are to be studied comprehensively.

5) In the planning, emphasis is to be placed on lowering the construction cost as well as the future operation and maintenance cost by employing appropriate technology.

6) The implementation schedule is to be discussed as to asure the development investments to bear fruit as soon as possible. Considering this aspect, a step-by-step development method will be studied.

4-2. Proposed Land Use

(a) Land Suitability Classification

Land suitability classification can be defined as the grouping of specific areas of land for specific uses. It reflects the degree of suitability such as S1:highly suitable, S2:moderately suitable, S3:marginally suitable and N:not suitable.

The land suitability classification of the project area was conducted on the basis of land characteristics, land quality and crop requirements (Table 4-1). The land suitability map for the project area is shown in Figure 4-1.

(b) Proposed Land Use

The proposed land use is shown in Table 4-2, which is made based on the land suitability of crops under irrigation. Land suitability was determined in comparison with land characteristics and crop requirements.

Soil units No. 2, 4, 5 and 6 are situated mainly in highland and medium highland areas, which are highly or moderately suitable for dry land crops and moderately suitable for rice crops. The proposed land use for this area is T.Aus/jute-T.Aman-wheat/Rabi crops, T.Aus/jute-T.Aman-fallow or T.Aman-Boro.

Soil units No.3, 7, 8 and 9 are found mainly in medium highlands, which are highly or moderately suitable for Boro and moderately or marginally suitable for T.Aus, T.Aman and some dry land crops. The proposed land use for this area is T.Aman-Boro, T.Aus-wheat or T.Aus-T.Aman-fallow.

Soil unit No. 10 is situated mainly in medium lowlands areas, which is moderately suitable for Boro and marginally suitable for T.Aus, T.Aman and wheat. The proposed land use for this area is mainly T.Aman-Boro.

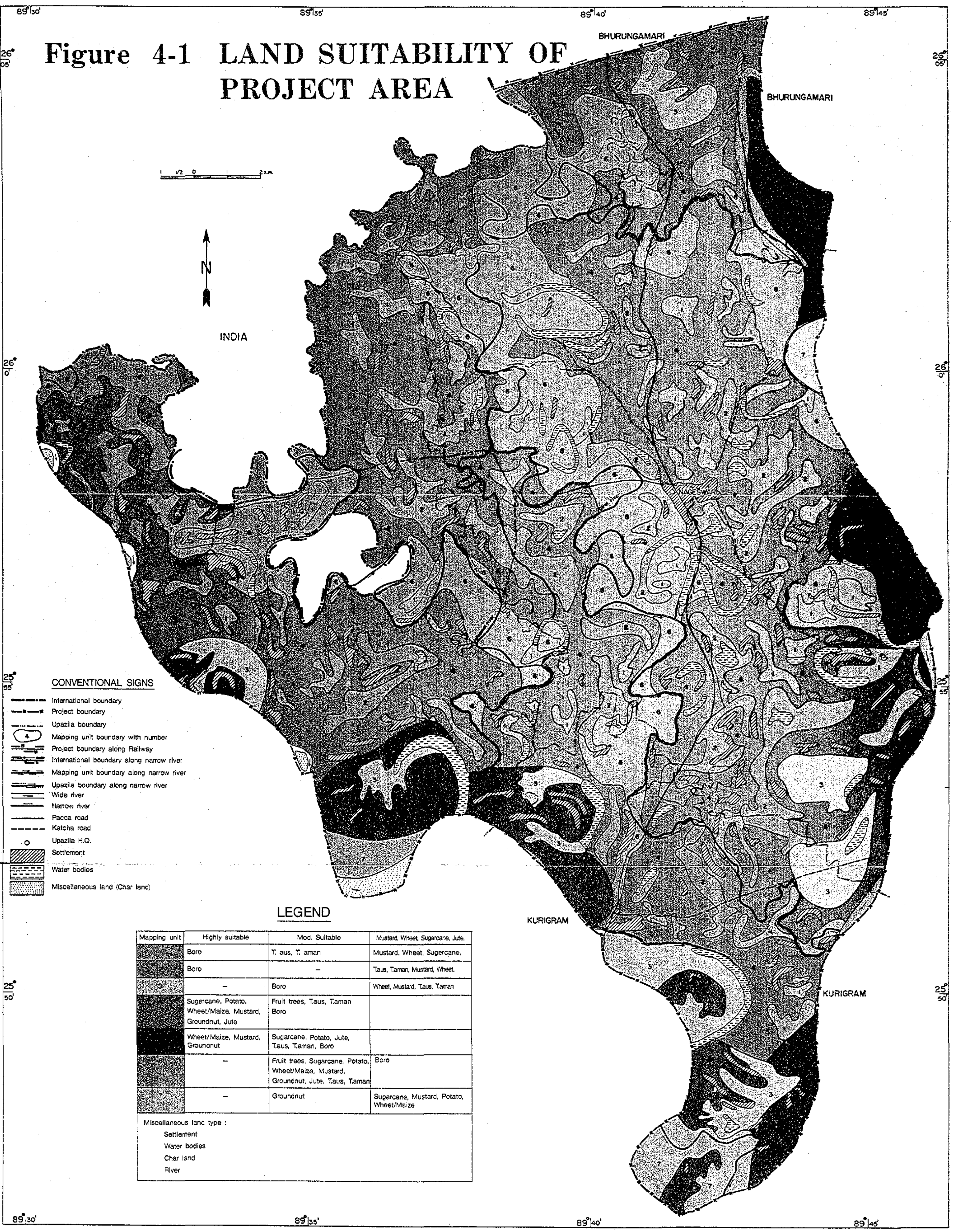
Table 4-1 Land Suitability Mapping Unit

Mapping unit	Land suitability			Component soil unit
	Highly suitable	Moderately suitable	Marginally suitable	
1	Boro	T.Aus, T. Aman	Mustard,Wheat Sugarcane, Jute	7, 8
2	Boro	-	T.Aus, T. Aman Mustard, Wheat	9
3	-	Boro	Wheat, Mustard T.Aus, T. Aman	3, 10
4	Sugarcane Potato, Wheat Maize, Mustard Groundnut, Jute	Fruit trees T.Aus, T. Aman Boro	-	4, 5
5	Wheat, Maize Mustard Groundnut	Sugarcane, Jute Potato, T. Aus T.Aman, Boro	-	2
6	-	Fruit trees Sugarcane, Jute Potato, Wheat Maize, Mustard Groundnut T. Aus, T. Aman	Boro	6
7	-	Groundnut	Sugarcane Mustard, Potato Wheat, Maize	1

Table 4-2 Present and Proposed Land Use in the Project Area

Land suit.unit	Soil unit	Present land use	(ha)	Land suitability S1	Land suitability S2	Land suitability S3	Proposed land use	(ha)
1	7, 8	T. Aman-Boro	1,500	Boro	T. Aus	Mustard, Wheat	T. Aman-Boro	(3,180)
		T. Aman-Fallow	1,900		T. Aman	Sugarcane, Jute		
2	9	T. Aman-Boro	1,300	Boro		T. Aus, T. Aman	T. Aman-Boro	(2,430)
		T. Aman-Fallow	1,300			Mustard, Wheat		
3	3	Aus / Jute-Rabi crops	390		Boro	Mustard, Wheat	T. Aus-Wheat	(360)
		Aus / Jute-T.Aman-Fallow	260			T. Aus. T. Aman	T. Aus-T.Aman-Fallow	(240)
		Boro-Fallow	650				T. Aman-Boro	(610)
	10	T. Aman-Boro	650		Boro	Mustard, Wheat	T. Aman-Boro	(880)
		T. Aman-Fallow	280			T. Aus. T. Aman		
4	4, 5	Aus / Jute-T. Aman-Fallow	5,670	Sugarcane,Potato	Fruit Trees		T. Aus / Jute-T. Aman-Fallow	(2,800)
		Aus /Jute-T. Aman-Rabi Crops	1,930	Wheat, Maize	T. Aus		T. Aus / Jute-T. Aman-Wheat	(9,880)
		Aus / Jute-Rabi crops	3,130	Mustard, Jute	T. Aman		T. Aus / Jute-T. Aman-Rabi c.	
		Aus / Jute-Fallow	3,870	Gronudnut	Boro		T. Aman-Boro	(1,800)
		T. Aman-Boro	900					
5	2	Aus / Jute-T. Aman-Fallow	1,430	Wheat, maize	Sugarcane		T. Aus / Jute-T / Aman-Fallow	(860)
		Aus / Jute-T. Aman-Rabi crops	820	Mustard	Potato, Jute		T. Aus / Jute-T. Aman-Wheat	(2,390)
		Aus / Jute-Rabi crops	1,230	Groundnut	T. Aus. T. Aman		T. Aus / Jute-T. Aman-Rabi c.	
		T. Aman-Boro	410		Boro		T. Aman-Boro	(380)
6	6	Aus / Jute-T.Aman-Fallow	3,850		Fruit trees	Boro	T. Aus / Jute-T. Aman-Fallow	(1,400)
		Aus / Jute-T.Aman-Rabi crops	780		Sugarcane, Potato		T. Aus / Jute-T. Aman-Wheat	(4,730)
		T. Aman-Fallow	390		Wheat, Maize		T. Aus / Jute-T. Aman-Rabi c.	
		Aus / Jute-Rabi crops	1,930		Mustard, Jute		T. Aman-Boro	(360)
					Groundnut			
					T. Aus. T. Aman			
7	1	Aus / Jute-Rabi crops	180		Groundnut	Sugarcane	T / Aus / Jute-Wheat	(170)
		Rabi crops-Fallow	350			Mustard, Potato	Rabi crops-Fallow	(330)
						Wheat, Maize		

Figure 4-1 LAND SUITABILITY OF PROJECT AREA



LEGEND

Mapping unit	Highly suitable	Mod. Suitable	Mustard, Wheet, Sugarcane, Jute.
	Boro	T. aus, T. aman	Mustard, Wheet, Sugercane,
	Boro	–	T.aus, T.aman, Mustard, Wheet.
3	–	Boro	Wheet, Mustard, T.aus, T.aman
	Sugarcane, Potato, Wheet/Maize, Mustard, Groundnut, Jute	Fruit trees, T.aus, T.aman Boro	
	Wheet/Maize, Mustard, Groundnut	Sugarcane, Potato, Jute, T.aus, T.aman, Boro	
6	–	Fruit trees, Sugarcane, Potato, Wheet/Maize, Mustard, Groundnut, Jute, T.aus, T.aman	Boro
7	–	Groundnut	Sugarcane, Mustard, Potato, Wheet/Maize

Miscellaneous land type :

- Settlement
- Water bodies
- Char land
- River

4-3. Agricultural production

(a) Basic Cropping Pattern Concepts

Any cropping plan under surface irrigation is subject to various constraints. The following should be taken into account while formulating a practical and compatible cropping plan.

1) current food situation in the project area
2) agricultural policy orientation
3) marketing situation in and around the project area
4) currently prevailing cropping practices
5) agricultural supporting systems and the environment
6) crop adaptability or suitability to soils/climate
7) economic viability or profitability
8) water balance under proposed irrigation

Despite recurring natural calamities, the project area have kept a high level cropping intensity, implying a wider Rabi crop coverage and hence less room for further expansion. There is less opportunity to develop newly cultivatable land or hitherto unexploited chaar land within the project area. All the "with-project" production therefore must be based on diversified crops and an elevated cropping intensity along with yield improvements.

(b) Proposed Crops

The current food situation, especially the prevailing food deficit in the southern part of the project area and in the Kurigram adjacent urban area , suggests that staple food crops should form the major frame of crop schedules under irrigation, in order to achieve food self sufficiency as fast as possible.

With regards to the agricultural policies, crop diversification has recently been emphasized for maximizing the efficient use of agricultural resources, at the same time minimizimng the risks of crop damages and production costs. It will provide ways to divert less promising crops into more remunerative or less risky ones. Diversification should be promoted within applicable strategies that the heavy dependency on paddy and jute can be mitigated by replacing them with various other useful crops to improve nutrition and income or to substitute food import.

In this context, industrial crops might increase income as well as serve as import substitutes. Sugarcane is one of the such promising crops widely grown around Rangpur but very limitedly cropped in the southern part of Fulbari in the project area. It is far from recommendable because of its long growth period which is hardly acceptable by small and marginal farmers, and the remoteness (far from the existing sugar-mills) of the project area would lead to costly transport charges and a loss of sugar content in the cane.

Tobacco is another crop commonly found in Rangpur, Saidpur and Larmonilhat, where BTC factories are located and cropping on a contract basis which has been widely diffused. Less bulky dried leaves can easily be transported, but it is also not recommended partly because soils in the project area are too sandy and less fertile as compared with those found in the current major production area suitable for tobacco plants, partly because it is not currently encouraged for health hazard reason caused as smoking and from a food deficit situation. Diversification from tobacco to other crops is also suggested to existing tobacco growers.

As for other cash crops for example vegetables, tree fruit etc., there also exist marketing problems either posed by a seriously feeble purchasing power of the population in and around the project area, higher transport charges for the ferry to cross the Dharla river and heated competition with surrounding production areas supplying fresher perishable products to their neighboring consumption areas like Kurigram, Larmonilhat etc.. The expansion of future demand is only sluggishly expected in these areas.

Besides, Rangpur has traditionally played the leading role as one of the major suppliers of horticultural products to adjacent consumption areas. This would impose upon the project area a great handicap with its access to existing markets. With such a land-locked situation, farmers in the project area have to pay extra transport costs at the rate of 40 taka per ton per km. by track and 13 taka by bullock cart to carry both inputs and outputs. Therefore, there is narrower room for these crops to be chosen as component crops for the proposed projects.

From the above mentioned review it is quite clear that a very limited number of crops can be adopted for future development. They are staple food crops i.e. paddy and wheat which are suitable crops for irrigation, jute is to maintain its present share, oil crops, pulses and other comparatively storable vegetables and potatoes which promise a longer shelf life. The HYV for these crops should be adopted as much as possible as to elevate yield levels, for they are the only input responsive ones. Under the proposed cropping patterns HYV paddy again inevitably plays a major role in so far as it is the most suitable and safest crop assuming that the condition of flood submersion will to some extent remain even with the flood control measures by the project.

There are various crops either promoted or brought under field trials on farmers' plots through crop diversification campaigns. Yet farmers hardly accept them partly because of their conservativeness, partly because of various other constraints like a tight supply of chemical fertilizers, the high costs of inputs like pesticides, a high water table for upland crops like maize and soyabeans which hardly allow a healthy development of root systems.

(c) Recommended Cropping Patterns

The cropping intensity in the project area has already reached a fairly high rate i.e.177%, but crop coverage during the Rabi season has levelled off due to shortages in soil moisture and the unavailability of enough irrigation water. Therefore, major development under the proposed project is expected mainly with crop intensification during the Rabi season, and the replacement of local varieties with HYVs for all year round. Cropping conditions in the Rabi season are the most favourable with less weeds, pests, diseases, flood, height of water table under dry and cooler climates. Making full use of these benefits, the targets on a with-project basis were determined as shown below:

Without Project			With Project		
		cropping	seasons		
Kharif Crop	Rabi Crop	Total	Kharif Crop	Rabi Crop	Total
77%	23%	100%	54%	46%	100%
		cropping	intensity		
137%	40%	177%	131%	113%	244%
		varietal	composition		
HYV_s Local	Varieties	Total	HYV_s Local	Varieties	Total
39%	61%	100%	94%	6%	100%

There are however two major constraints in the Rabi season, i.e. shortage of irrigatable water and low temperatures. Farmers grow presently much less water-consumptive crops such as wheat, mustard etc. instead of Boro paddy, potatoes and winter vegetables which always require irrigation even in low-lying paddy fields where some residual soil moisture is available. Even on the with-project basis, such water economization should be maintained during the Rabi season since the river's flow is depleted during this period.

The other hazard being low night temperatures, often reaching as low as 7 degrees centigrade in january and sometimes in February as well as in early March, may affect the healthy growth of paddy seedlings in the nurseries. Yet, low temperature seldom give disastrous damages to crops except for hailstorms which occasionally occur during this period, leaving heavy damages to tobacco and other leaf harvesting crops.

In order to maximize land use in the project area under the conditions stated above, triple cropping (per annum) systems should be pursued as much as possible. It follows that the growth period of component crops are inevitably curtailed or early maturing varieties should be chosen somewhat at the sacrifice of yield levels. As far as transplantable crops are concerned, a nursery requiring a much smaller area than the acreage required for transplanting can help meet the necessary crop shortening period. It must be noted that a too heavy cropping intensity often results in the fast degradation of soil fertility especially in soils with higher sand contents. For this reason either the introduction of a fallow period or green manure should be incorporated after the highly intensive exploitation of crop fields.

From the viewpoint of crop/water economy, traditional crops with lower inputs i.e. all local varieties should be replaced with HYVs (even pajam paddy will be replaceable by other HYVs). Complementary starchy crops like kaun (low moisture tolerant crop) or sweet potato should also be replaced. However, HYV potatoes will constitute a part of irrigated crops because of their high marketing value and storability.

The triple cropping of paddy is also best avoided from the standpoint of fertility conservation, from water economy and for tight land management though it is possible for a year or two. Rather, the double cropping of paddy with one extra upland crop is preferable, consisting at maximum of up to eleven crops during a four years rotation period. From a crop diversification point of view it is recommended to establish a crop rotation system so that a rotation cycle covers three to four years. By adopting such a system as to avoid continuous single crop cultures, the nutrient balance will improve, a well balanced water use can be realized and the vicious cycle of recurring pests and diseases or weeds will be mitigated.

In formulating the with-project cropping pattern, a higher cropping intensity can be applied to the highlands as well as the flood-free part in the medium highlands (proposed cropping intensity or c.i. = 275%), while a lower intensity be applied to the medium lowlands and lowlands (c.i. = 175 %) so as to avert flood damages.

The share for paddy in the total cropping should be much lower than that in the existing patterns, aiming at the higher achievement of crop diversification. In the proposed predominant pattern for the highlands either Boro-Aman or Aus-Aman paddy combinations will form the frame of the rotation, for Boro and Aus paddy crops heavily overlap their growth periods. For all other patterns only one paddy per year or even no paddy is adopted. However, paddy is the only suitable crop for the Kharif season in medium lowlands and lowlands where either high water levels or shallow submersion takes place during the season.

The proposed cropping patterns are shown in Fig. 4-2, in which the following systems are selected as components, based on flood-type classification assuming the improved drainage by the project (Table 4-3 and Table 4-4).

1) A highly intensive cropping system is to be applied to the highlands (pre-project Fo, post-project also Fo), covering 19,200 ha. (58.5% of the total planned acreage in the project area), with c.i. = 275%.

2) Another intensive cropping system (c.i. = 275%) is to be applied to a part of the medium highlands (pre-project F1, post-project Fo, improved by the project) covering 3,500 ha. (10.7% of the total project area).

3) A less intensive cropping system (c.i. = 175 % exclusive of green manure) is to be applied to the rest of the medium highlands, with the area of 7,900 ha., whose class will remain unchanged (pre-project F1, post-project F1, 24.1 % of the total project area). Land under this system will be kept fallow for the most part during the flooding period.

4) Another less intensive cropping system (c.i. = 175%) is to be applied to the medium lowlands with an acreage of 900 ha. with the improved class by the project (pre-project F2, post-project F1), covering 2.7% of the total acreage in the project area, with complete fallow during the flooding period.

5) A similar system but with the same intensity (c.i. = 175 %, exclusive of green manure) is to be applied to the rest of the medium lowlands, (pre-project F2, post-project F2), whose acreage is equivalent to only 4% of the total acreage in the project area, or 1,300 ha., also with complete fallow during flood periods.

As to the compatibility with the drainage improvement plan stated in 4-5, 4) and 5) of the above mentioned systems completely cover the area of maximum submergence exclusive of depressions in the present case of the drainage design. Land type distribution is presented in Fig. 4-3.

Table 4-3 Planned Acreage under the Proposed Cropping Patterns

unit : ha.

Crop	Total Field Acreages	F_0 - F_0 19,200ha.	F_1 - F_0 3,500ha.	F_1 - F_1 7,900ha.	F_2 - F_1 900ha.	F_2 - F_2 1,300ha.
B-Aus Local	3,075	-	-	1,975	450	650
T-Aus HYV	12,450	9,600	875	1,975	-	-
T-Aman HYV	10,475	9,600	875	-	-	-
T-Aman Local	1,975	-	-	1,975	-	-
LateT-AmanII	4,800	4,800	-	-	-	-
Boro HYV	7,100	4,800	1,750	-	225	325
Wheat HYV	7,875	4,800	875	1,975	225	-
Jute HYV	7,875	4,800	875	1,975	225	-
Potato HYV	1,425	-	875	-	225	325
Mustard HYV	7,650	4,800	875	1,975	-	-
Khesari	7,100	4,800	1,750	-	-	-
Mungbean	5,675	4,800	875	-	-	-
Summer Veget	875	-	875	-	-	-
Winter Veget	225	-	-	-	225	-
Fodder Crop	1,525	-	875	-	-	650
Total Crop	80,100	52,800	9,625	13,825	1,575	2,275
C. Intensity	244%	275%	275%	175%	175%	175%
Green Manure	1,975	-	-	1,975	-	-

Note: Cropping intensity equal to total cropped acreage / Total field acreage excluding green manure which is not harvesed as a product.

Source: calculated from with - project cropping pattern. Veget: vegetables

Table 4-4 Cropping Development

unit : ha. %

Season/Crop	Current Land Use Area	%*	Without-Project Area	%*	With - Project Area	%*
Kharif						
Total Crops	49,971	142	48,123	137	43,050	131
Food-grains	45,117	128	43,166	123	32,775	100
Cash Crops	4,854	14	4,957	14	8,750	27
Other Crops	0	0	0	0	1,525	4
Rabi						
Total Crops	12,251	35	14,099	40	37,050	113
Food-grains **	10,471	30	12,088	34	27,750	85
Cash Crops	1,569	4	1,561	4	9,300	28
Other Crops	211	1	1,450	2	0	0
Crop Coverage		177		177		244
Share of Kharif ***		80		77		54
Share of Rabi ***		20		23		46

Note: * percentages to the croppig land area (without P= 35,100 ha.with - P = 32,800 ha.).

** including pulses

*** percentage to the total annual crop coverage excluding G. M .

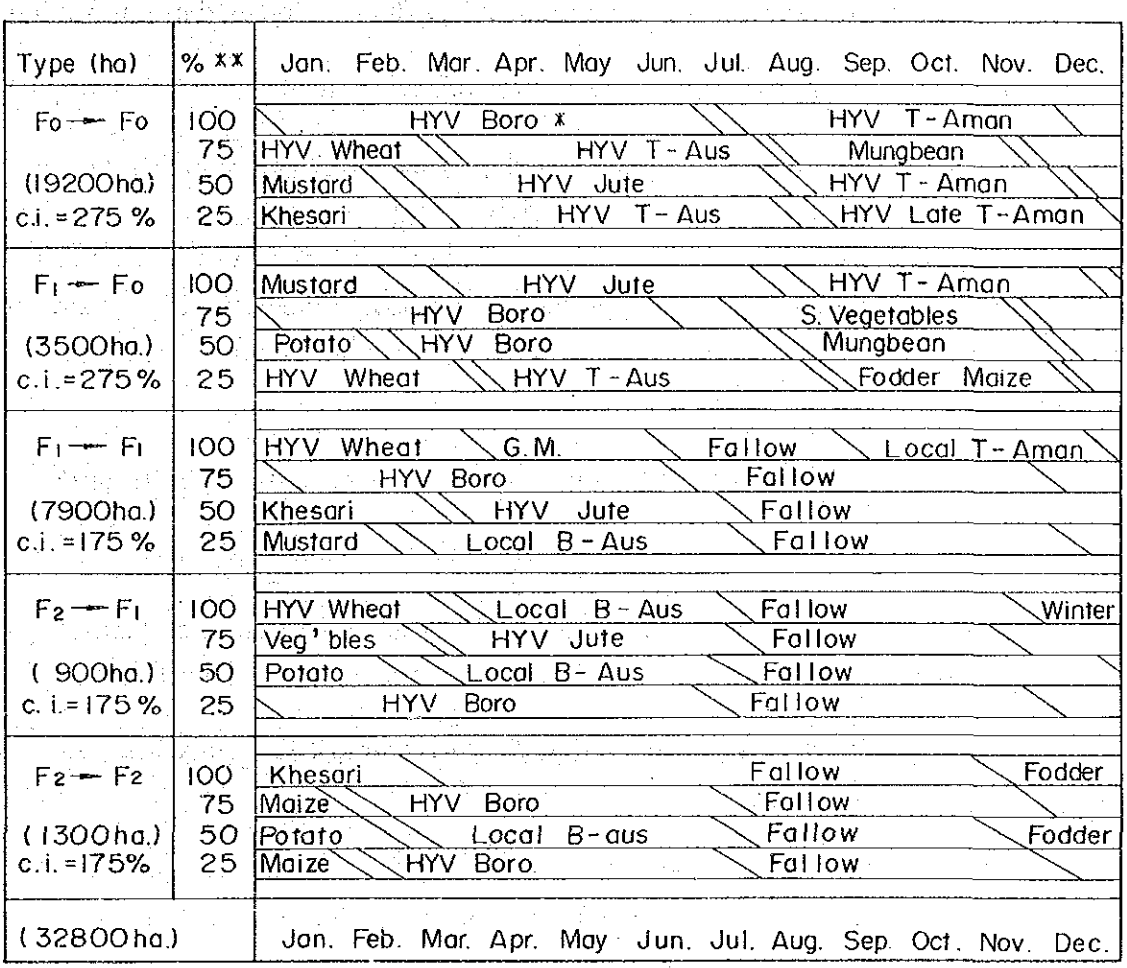


Fig. 4-2 Proposed Cropping Patterns

Note: F_0 ; type of land free from flood or with occasional minor flood whose water depth never exceeds 0.3 meter.

F_1 ; land type possibly submerged by flood with the depth 0.3-0.9 m.

F_2 ; land type with fairly deep floods with the depth 0.9-1.8 m.

Virtualy no land type under F_3 exists in either pre- and post project. Here, land types under flood levels are variable with reclamation, drainage activities because they can prevent, mitigate or improve flood attacks. For example, pre-project land conditions F_2 will be improved to the post-project conditions F_1, and this is expressed as F_2-F_1. While in the case F_0-F_0, both land conditions of pre- and post-project will remain unchanged.

c.i. ; proposed cropping intensity under the given land type shift.

G. M. ; green manure like doincha which is not counted in c. i.

Follow is inevitably proposed in any land with F_1 and F_2 as post-project conditions since there are still flood risks even on post-project basis.

* ; G. M. can be followed after Boro when it is timely harvested in May-June.

** ; 0-100% indicates crop area coverage. In this column, 25% interval is attributed to the assumed 4-year rotation.

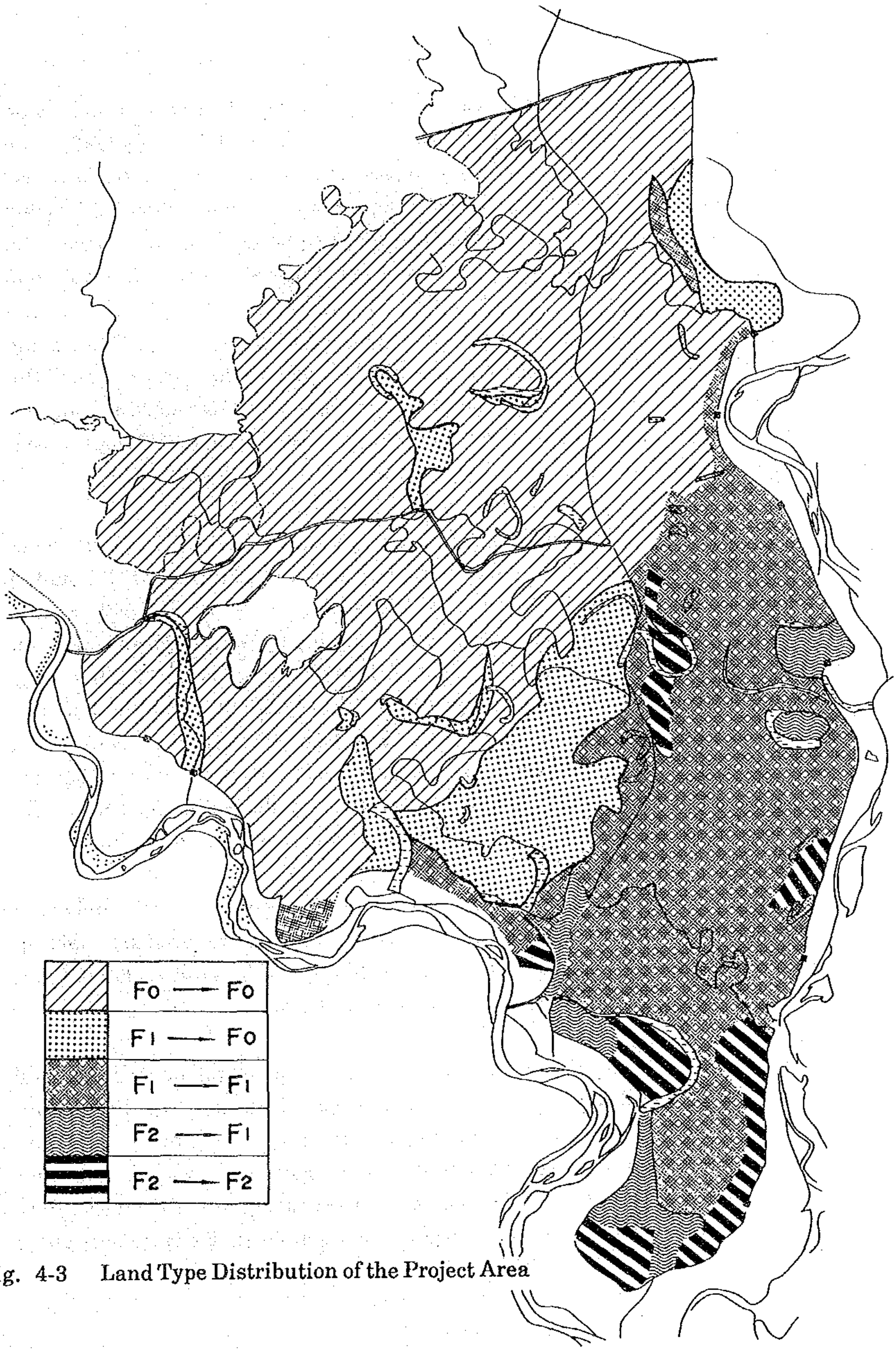


Fig. 4-3 Land Type Distribution of the Project Area

(d) Target Yields and Cropping Techniques

Data were collected from statistics networks and also survey results on crop yields were obtained from the farm interview survey by the study team. The acreage and yields for the "without-project estimation" are based on these results. Since recent trends of yield development show many abnomalities due to the two consecutive years suffered from exceptionally severe floods, the proposed yield growth rates for planned and existing crops were estimated from the projected long term trends and the expected rates under damage protection rather than from apparent recent short term trends. The same cropping intensity as the current prevailing system was assumed for the without-project. Current trends on acreage expansion or decline for the existing major crops are also reflected in the estimation of "without-project acreage".

Available yield data for irrigated crops are quite limited, but some were collected from the BARI on farm trials, from data published by the MPO, from the BWDB Mohipur and the Takurgaon experiment farms, of which BARI results are fairly applicable because they were obtained from on-farm trials on farmers' plots located near the project area. Based on these, and referring to the project proforma of "Teesta Irrigation Project". Target yields were estimated as shown in Table 4-5 , and checked with other estimated current yield performances. Some of the proposed targets seem to be too ambitious, but they are possible in exceptionally favourable physiological conditions as mentioned in 3-3 and the present comparatively high levels of yields are taken into account.

Local DAE staff were frequently visited for discussions on yield and area estimations. The high yield levels as proposed can only be realized by applying a series of modern cropping techniques, including high dose s of fertilizer, manure and deeper or more frequent tillage by bullocks.

With regards to cropping techniques, an ample amount of labour power should efficiently be utilized for any field work. There are many applicable and readily available techniques without incurring heavy investments like line planting, green manuring, cowdung applications, special nursery preparation during cold spells, etc.. Such improvements, causing minor changes solely done, but will achieve far-reaching targets when combined. Extension activities coupled with relevant input supply and facility maintenance services will be essential to make full use of valuable irrigation water.

(e) Crop Production Estimation and Input Demand

Assuming that the proposed cropping patterns are completely developed through the project's implementation, the expected production is estimated as shown in Table 4-5. According to these results, the present heavy acreage under paddy will be dropped from 79% to 50% of the total cropping acreage, whereas the paddy production from the project area will be increased by 74% provided that the currently prevailing cropping intensity will have been levelled off and not be raised any more.

Crop budgets with and without the project are shown in Appendix Tables. As a result of increased water availability local paddy cropping (mainly T-Aman and to some extent B-Aus) areas will be replaced by HYVs and upland crops like jute, oil seeds, pulses and vegetables, etc..

The cropping intensity is also further improved from 177% to 244% (green manure is not independently counted). It is acceptable if the current cropping intensity observed in Bhurungamari or Fulbari (over 200%) is referred to.

In parallel with the expanded production, the levels of input requirements will greatly be augmented in such a way that the project area will absorb almost the same or a lager amount than the currently distributed chemical fertilizers for the whole district (Table 4-6). With regard to HYV seed, various HYVs as listed in the Appendix Table V-4-3 can be grown according to a variety's suitability to ambient conditions realized by the project's implementation. 2.3 thousand tons of HYV seed will have to be provided along with 2.3 thousand tons of tuber seed for the project every year. As for insecticides etc, (fungicides are still much less important) around 110 tons/kls. should annually be delivered (Table 4-6). Considering this crop rotation could economize on the consumption of chemicals by minimizing the possibility of pest outbreaks.

The reasons why such enormous amounts of fertilizer are supposed to be applied are as follows: 1) shallow draught cultivation of the surface soil layers along with low CEC limiting the nutrient holding capacity, 2) expected low rate of nutrient utilization ratio due to the simple spreading of powdery (nongranulated) fertilizers, 3) higher yields caused by HYV and higher cropping intensity leading to a higher degree of soil nutrient deprivation. Organic manure or cowdung as well as using ball shaped fertilizers devices would ease the heavy rate of fertilizer requirements by improving the nutrient holding capacity of soils and preventing nutrient loss by mineralization.

Farm labour requirements would reach 11.4 million man-days per annum, which may be equivalent to 48 thousand active farm workers or 7.0% of the total population in the project area (Appendix Table V-4-7). Draught power requirements will come to 21.8 million hrs. equivalent to about 70,000 pairs of bullock, which will utilize 52% of the total available bullocks in the project area (Table 3-19).

The demand for manure would greatly increase especially for sandy soils and because of heavily intensified cropping.If the estimated quantity manure requirements could be covered by the present livestock population, it would be necessary to collect it at the rate of 5.1 kg. per head/day. At the same time application of depleted micronutrients (Zn and S) will become essential as the cropping is intensified. Zinc deficiencies were observed in pulse fields in the form of leucosis located in areas where neutral to alkaline pH soil in lowlands along the Dharla/Dhudukmar rivers. Sulphor levels also low in some areas. Accordingly, gypsum and zinc sulphate are to be applied to grain crops because these are harvested in great bulk, though heavy rates would not be required because a part of these elements can be supplied from cowdung and green manure.

Table 4-5 Planned Crop Production (with-Project)

unit: ha. ton / ha. ton

Crops	Area under Crop(ha.)	Yield (ton/ha.)	Production (ton)	Difference (with-P - without-P) Area(ha.)	Yield	Production (ton)
B-Aus Local	3,075	2.0	6,150	-10,167	+1.17	- 4,840
T-Aus HYV	12,450	3.0	37,350	+ 9,694	+0.87	+31,480
T-Aman HYV	10,475	4.0	41,900	- 470	+1.25	+12,629
T-Aman Local	1,975	2.8	5,530	-12,499	+1.23	-17,194
Late T-Aman H	4,800	3.0	14,400	+4,800	+0.52	+14,400
Boro HYV	7,100	4.5	31,950	+ 1,355	+1.41	+14 198
Other Paddy	-	-	-	- 3,621	-	-5 313
Paddy	39,875	3.4	137,280	-11,358	+1.6	+45,360
Wheat HYV	7,875	3.5	27,562	+4,579*	+1.25	+20,841
Jute HYV	7,875	2.3	18,112	+ 3,118*	+0.61	+10,743
Potato HYV	1,425	20.0	28,500	+ 765	+9.78	+21,755
Mustard HYV	7,650	1.3	9,945	+ 7,049*	+0.44	+ 9,428
Khesari(Pulses)	7,100	1.0	7,100	+ 6,850	+0.10	+ 6,875
Mungbean	5,675	0.9	5,107	+ 5,675	-	+ 5,675
S.Vegetables	875	25.0	21,875	+ 675	+15.00	+19,875
W.Vegetbls	225	40.0	9,000	- 75	+25.00	+ 3,600
Fodder Crop	1,525	90.0	137,250	+ 1,525	-	+ 137,250
Kaun	-	-	-	- 1,175	-	- 928
Sweet Potato	-	-	-	- 200	-	1,550
Cropped T.	80,100	-	-	+17,878	-	-
Dhoincha	1,975	30.0	59,250	-	-	-

Source : estimated. Note: * including local vars. for without - project

Table 4-6 Total Input Requirements

unit: ton, *1,000 man - days **1,000 hr / pair, ***1,000 nos

Input Item	Seed	Urea	TSP	MP	GS	ZS	Manure	Chem	Labor	Cattle	Implm
With-Project	2,905	9,885	6,683	3,636	2,311	302	307,300	110	11,397	21,754	205
W.O. Project	2,716	5,966	3,654	2,019	1,243	180	85,811	51	8,138	5,198	143
increment	289	3,919	3,029	1,617	1,068	122	221,489	59	3,259	16,556	62
W.P. kg/ha.	89	301	204	111	70	9	9,369	3	1.4my	663hr	6.3n
W.O. kg/ha.	77	189	104	58	35	5	2,445	2	0.9my	148hr	4.1n
increment	12	112	100	53	35	4	6,924	1.5	0.5my	515hr	2.2n
WP crop/ha.	36	123	84	45	29	4	3,840	1.5	0.6mn	272hr	2.6n
WO crop/ha.	43	107	59	32	20	3	1,381	0.8	0.5mn	84hr	2.3n
inprement	-7	16	25	13	9	1	2,459	0.2	0.1mn	188hr	0.3n

Note : * ; unit of labor , my ; man - year (250 days-8 hrs.basis) , mn ; man / ha.
** ; unit of draught power on pair basis , ***; unit for farm implement, n ; numbers (e.g. sickles),
GS ; Gypsum , ZS ; Zinc Sulphate, WP ; With - Project etc.
Breakdown figures by crop listed in Appendix.

(f) Livestock Production

The livestock sector as an agricultural component will play a key role, because it supplies draught power for intensive cropping, organic soil matter for sandy soils to provid more fertility which tend to be exhausted with heavy cropping. It also helps alleviates malnutrition within the poorer population by providing milles, meat, eggs etc., and if the livestock population can be expanded it gives broader labour opportunities within the agricultural sector.

Existing bovine herds have been kept under over-populated conditions because of traditional reasons as mentioned in Chapter 3. It follows that there will be little room for the further expansion of herds, nor would there be any acute need of increasing the draught power. Rather, the enrichement at feed resources through the expansion of farm by-protections like straw, brun, oilcakes as well as newly introduced fodder crops or even green manure crops can be fed to strengthen the feeding capacity for existing ruminant herds and flocks of chicken and ducks.

As the nutritional situation of the existing herds/flocks is improved by ameliorated feeding, their fertility then their draught power ability will be harnessed and at the same time their mortality lowered, therefore their frequent replacement with fatter culled animals will be realized from which heavier carcasses will be produced.

The expected feed expansion and the production of by-products on a with-project basis is estimated in the Appendix Table V-4-9, from which higher daily gain and a higher conception rate can be expected for ruminant livestock (cattle, buffaloe and West Bengal goats)(The basis for these calculations is shown in Appendix Table V-4-8).

The importance of green manures is particularly stressed and it is proposed to incorporate it into the cropping patterns. Considering the above it is suggested that existing ruminant herds be tethered on farm plots with green manure before ploughing it into the soil so that it can be utilized more efficiently as feed first and then be converted into dung left on the field. To this end, various leguminous substitutes for doincha (sesbania) like cicer, clotaralia, smithia etc., can be utilized for this dual purpose, in parallel with the sowing of sesbania. A similar on the field feeding can be applied for fodder-maize/ cowpea fields, but cutting practices will be needed in this case as to minimize the feeding loss of precious fodder crops.

Livestock production is planned to secure draught power in proportion to intensified cropping practices, with subsequent result in the increased sale of culled animals and goats as a cash income source, within the increased amount of by-products or supplementary feed production by the project.

Another possibility lies in cow or buffalo or goat milk production, but this requires a heavier protein input. Unfortunately, shortages of protein feed still continue even with the project, and it will be difficult to meet this demand unless some sophisticated devices like straw treatment with pressured ammonium gas and urea be applied to the fields. This is hardly recommendable because of high prices and an unstable supply.

The limited availability of digestable crude protein (D.C.P.) will act as a bottleneck in expanding the size of the herds within the project area. By-products from the increased production can improve the nutritional handicap of ruminants in the following way. The increment of by-products is first of all used for the fortification of draught which promises both field work and cowdung (fuel and fertilizer). It can then be used for the expansion of goats/sheep, herds for they provide an extra cash income for the keepers. The reason why fowl production is not included is that suitable feed with a higher D.C.P. is scarce, and priority should be given to ruminants.

The estimated benefits from this sector stem from increased herds and the live weight of culled draught animals and saleable goats, which are estimated at around 8 million Taka per year, when labour, veterinary and transport costs are neglected (Appendix Table V-4-3-9). In this estimation rations for ruminants are improved from the present underfed levels, except for goats, enabling to shorten replacement intervals for draught power and to realize the heavy live weight of culled or saleable herds.

It should not be overlooked that even with the project it is essential to rely on natural available vegetation mostly in the periphery or outside the project. (the extent of this dependence still outweighs 60 per cent of the nutritional demand.)

(g) Farm Management Improvement Plan

The improved agricultural net value per farm-household based on the improvement plan for the farm management of farmers by different farm scale and by different area in response to the proposed cropping patterns and the land use plan is shown in the following.

Agricultural Net Value Improvement Plan
(per Farm-household) Unit; Taka

Zone	Small Farmers (0.7ha)	Medium Farmers (1.6ha)	Large Farmers (4.3ha)
F0 → F0	21,731	49,668	133,490
F1 → F0	25,186	57,568	154,714
F1 → F1	12,247	27,993	75,232
F2 → F1	14,525	33,200	89,225

Source: Feasibility Study.

As compared with the present agricultural net income, farmers will be able to improve from 1.2 times (except large farmers) to 3.1 times after the implementation of the Project.

As for agricultural net value by different zones, the F1-F0 are the highest, that is, small farmers will be able to earn Taka 25,186, medium farmers Taka 57,568 and large farmers Taka 154,714 which will be two times that of F1-F1 zone being the lowest, respectively.

Besides, the increase of crop labour requirements after the implementation of the Project will reach 3.46 million man-days, accordingly Taka 83 million will be brought to the project area every year, which will principally be distributed among small farmers and so on.

4-4. Irrigation Plan

(a) Proposed Irrigated Area

Based on the study results of the available river discharge and layout of the irrigation system as mentioned in the following sections, it is proposed that the present cultivated land area will be irrigated in the with project except for the area used for the planned canal sites. The proposed land use for every category is shown in Table 4-7, in which the proposed irrigated area is given as 32,800 hectares.

Table 4-7 Land Use for different categories

Land Use	Area (ha)	(%)
Gross area	42,800	100
Settlements	5,290	12.3
Grass land	350	0.8
Charland	120	0.3
Water bodies	1,940	4.6
Proposed canals	2,300	5.4
Cultivated land	32,800	76.6

(b) Irrigation Water Requirements

A water requirement analysis was done based on theoretical methods including Penman's, Blaney-Criddle and the radiation methods. A field investigation, to measure the rainfall intensity as well as total losses including percolation, evaporation and transpiration in a 40 sq.m spot, was conducted at three observation stations from the Phase I Study until the end of the Phase II field work (March, 1990). In addition, another field investigation, to measure the total irrigated area and the total water consumption of a deep tube well irrigation scheme, was carried out at two sampled points in the Phase II Study. As for criteria on water losses and evapotranspiration calculation, discussions were had between the concerned BWDB officials and the Study team members. These results were examined comprehensively to determine water requirements.

1) Consumptive use

The modified Penman's method is employed to calculate the consumptive use, which is described in "crop water requirements" published by the FAO.

First, evapotranspiration values (ETo) are given based on meteorological data as follows:

Evapotranspiration (ETo) (mm/day)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2.5	3.6	4.9	5.6	5.1	4.9	4.1	4.2	3.9	3.9	3.4	2.5

Values of consumptive use (ETcrop) are calculated with the following equation:

$$ETcrop = Kc \times ETo$$

where, Kc is a crop coefficient.

Kc values for respective crops are selected as shown in Table VI-4 and summarized as follows:

Crops	Kc Values
HYV.Boro	0.85-1.29
HYV.T.Aman	0.85-1.10
HYV.Wheat	0.45-1.15
HYV.Jute	0.60-1.15

2) Percolation rate

The percolation rate is given for paddy irrigation as 6.0 mm/day, considering the results from the field investigation.

3) Effective rainfall

As for effective rainfall during crop growth, daily rainfall of 5.0 mm or less is considered ineffective, while rainfall exceeding 5.0 mm is considered 80% effective. When effective rainfall exceeds the daily water requirement, the surplus is stored in the paddy field and used the following day. Effective rainfall, however, is limited to 80.0 mm/day due to over spill. The results from calculations of effective rainfall at the Bhrungamari and Kurigram rainfall stations are shown in Appendix Table VI-5.

4) Growing stage requirements

Water requirements during crop growth are computed as the sum of the daily consumptive use and percolation rate.

For puddling water, 150 mm depth water is provided during 30 days.

5) Irrigation efficiency

The conveyance efficiency for canals is set at 85%. The field efficiency for paddy is given as 85% (the percolation rate of 6 mm/day includes field loss.), while the field irrigation efficiency including application efficiency for upland crops is given as 0.70.

6) Diversion water requirements

In accordance with the proposed cropping calendar and land use as well as with the above-mentioned factors, diversion water requirements for the project were computed for 10 years from 1979 to 1988 as shown in Appendix Table VI-6 and Fig.VI-2.

The maximum diversion water requirements for the proposed two intakes during a 10 year period appeared in the third 10 day-period in April in 1979 as shown in Appendix Table VI-7, which are given as follows:

- Pateswari Pumping Station 42.78 m3 /s
- Tangonmari Pumping Station (reversible use) 4.87 m3 /s

7) Design Water requirements for canals

Considering the estimated irrigation efficiencies of each irrigation canal, the design unit water requirements are given as follows:

Canals	Unit design water requirements
Main canals	1.453 l/s/ha
Secondary canals	1.453 l/s/ha

(c) Water Source for Irrigation

In the Study area, approximately 8,300 hectares of lands are currently irrigated by pumping up ground water from wells and surface water from beels and creeks. These small scale irrigation facilities might be kept to supplement the planned irrigation system which is to utilize the nearby river water. However, it is proposed that the irrigation system fully depend on surface water from rivers based on the following points:

- The water diversification from the Dudhkumar and Brahmaputra rivers is available to cover the whole cultivated area in the study area as mentioned in 5-1.

- The maximum amount of available ground water, of which the deciding factor is considered to be recharge caused by vertical water percolation from the ground surface, is roughly estimated to be as much as to cover less than 30 % of the project area. (refer to 3-1, Ⅵ, Volume Ⅱ) Therefore, irrigation water to cover the whole project area has to be mainly depend on rivers. And once an irrigation system introducing river water is established, it will be efficient from investment cost, operation and maintenance viewpoints that the irrigation system cover the whole project area incorporating the existing irrigated area by small scale pumps.

- Approximately a half of the diverted river water for irrigation is supposedly drained through percolation and through drainage channels to form a part of base-flow of the Brahmaputra (refer ro 3-2, VI, Volume II.). If the ground water is used for supplementary irrigation water source, a part of this drained water will be retained in the project area to supplement directly or indirectly the absorbed ground water, which will cause to reduce the base-flow supply to the Brahmaputra nearly as much as the used ground water. Accordingly, it is considered to make practically no difference in the influence to the downstream river discharge whether the ground water is used or not for supplementary irrigation water.

- Even in the case that the existing small scale pumps are left for supplementary use, year-round irrigation by introducing river water will raise the ground water to so high level that the existing deep tube wells which are costly for investment and operation are considered to be substituted with shallow tube wells or low-lift pumps. And these small pumps will anyway come to utilize the water introduced by the new irrigation system. Therefore, it is advantageous that the proposed irrigation system command the whole project area for better specifying and administration of beneficiaries.

Among available three rivers around the project area, the Dharla river is supposed to be reserved for irrigation for Kuriguram South Unit area in accordance to the basic development strategy of the whole Kurigram area of the BWDB. Following this strategy, the proposed irrigation system is to mainly take water from the Dudhkumar river.

(d) Water Intake

To take irrigation water from the Dudhkumar river, a main pump station is planned for installation at Pateswari, on the downstream side of the abolished railway bridge, as was proposed by the existing 1969 feasibility study report. The proposed site is considered to be the most suitable situation according to the following points:

- It commands the highest river water level along the periphery of the project area as well as the highest part of the project area, which minimizes the head of the pumps to be planned and makes it possible to distribute irrigation water from the upper part to the lower part.

- The river's course and banks are relatively stable due to the existing protection work for the railway bridge.

- It is situated on the convex side of the curved river's course, which keeps good conditions with less sedimentation and with a closer water flow to intake water.

The justifiability for installing a reversible pump station for the dual usage of drainage and supplementary irrigation for the southern part of the project area was studied from the following viewpoints:

- To reduce the total cost of irrigation and drainage pumps,

- To decrease the intake water from the Dudhkumar river which has a limited available discharge in the drought period, by taking a part of the total required water from the Brahmaputra river.

- Topographical suitability for an irrigation and drainage system of reversible pump.

- The river's stability for intake.

As a result, a reversible pump station which commands 3,350 ha for irrigation is proposed for installation at the Tangonmari regulator.

(e) Water Conveyance System

The layout of the irrigation canal routes was studied taking into consideration the minimizing height and avoiding to cross settlements, rivers and roads as much as possible, based on collected maps and aerial photographs as well as on field observations. Further studies for water conveyance systems were done based on results of the route survey, while focusing on the stability of earth structures as well as on the minimization of construction costs and land expropriation. As for the western part of the study area, whose altitude is relatively high, alternative plans to supply water from the Pateswari intake were discussed to lower canal banking and to decrease the total pumping energy cost for the whole system. Consequently, a framework of the water conveyance system is proposed as shown in Fig. 4-4, Fig. 4-5 and Fig. 4-6. In this plan, water is to be supplied at lower levels than farm land and to be lifted by farmers as required for the limited higher part of the Project area.

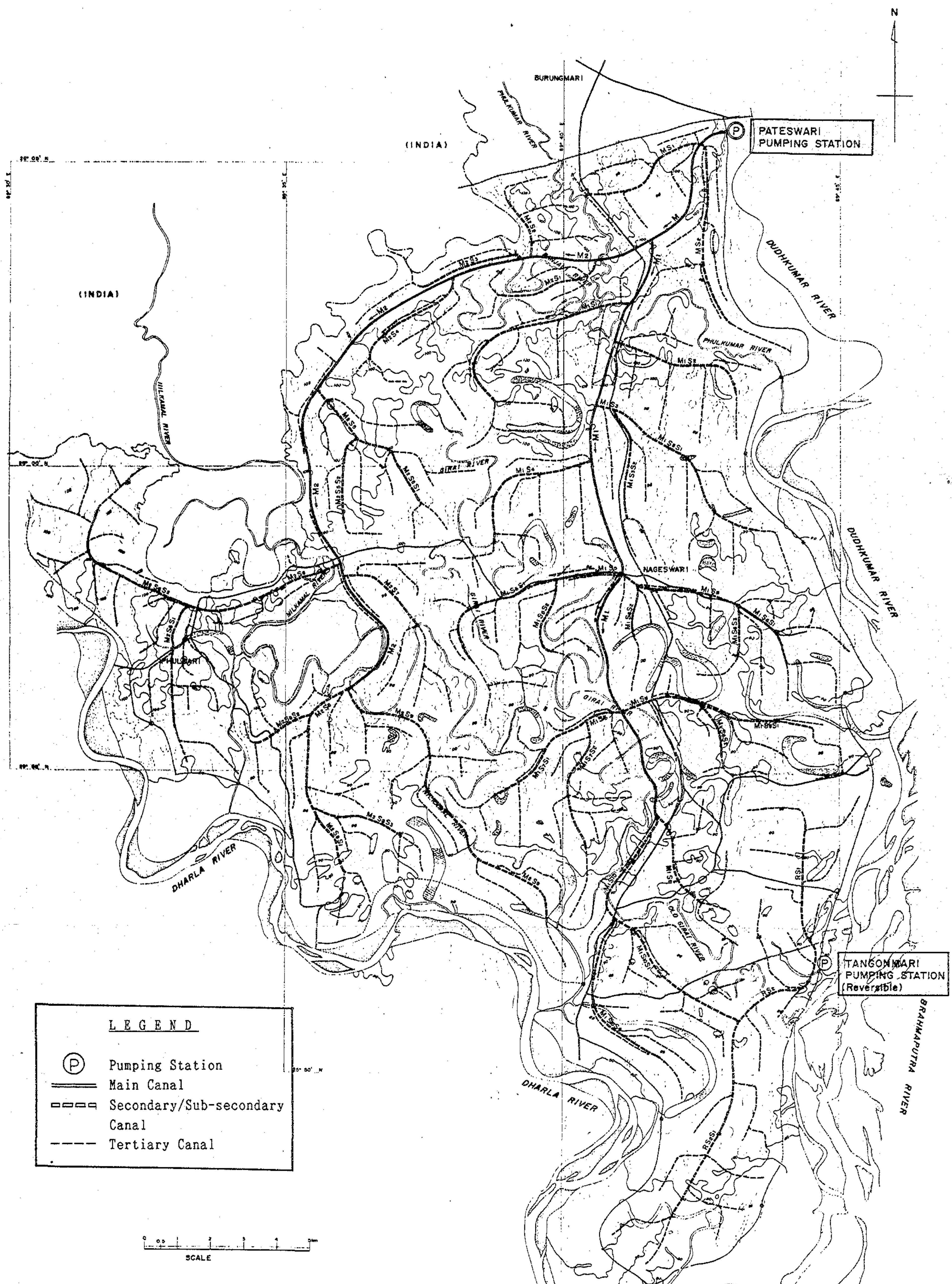
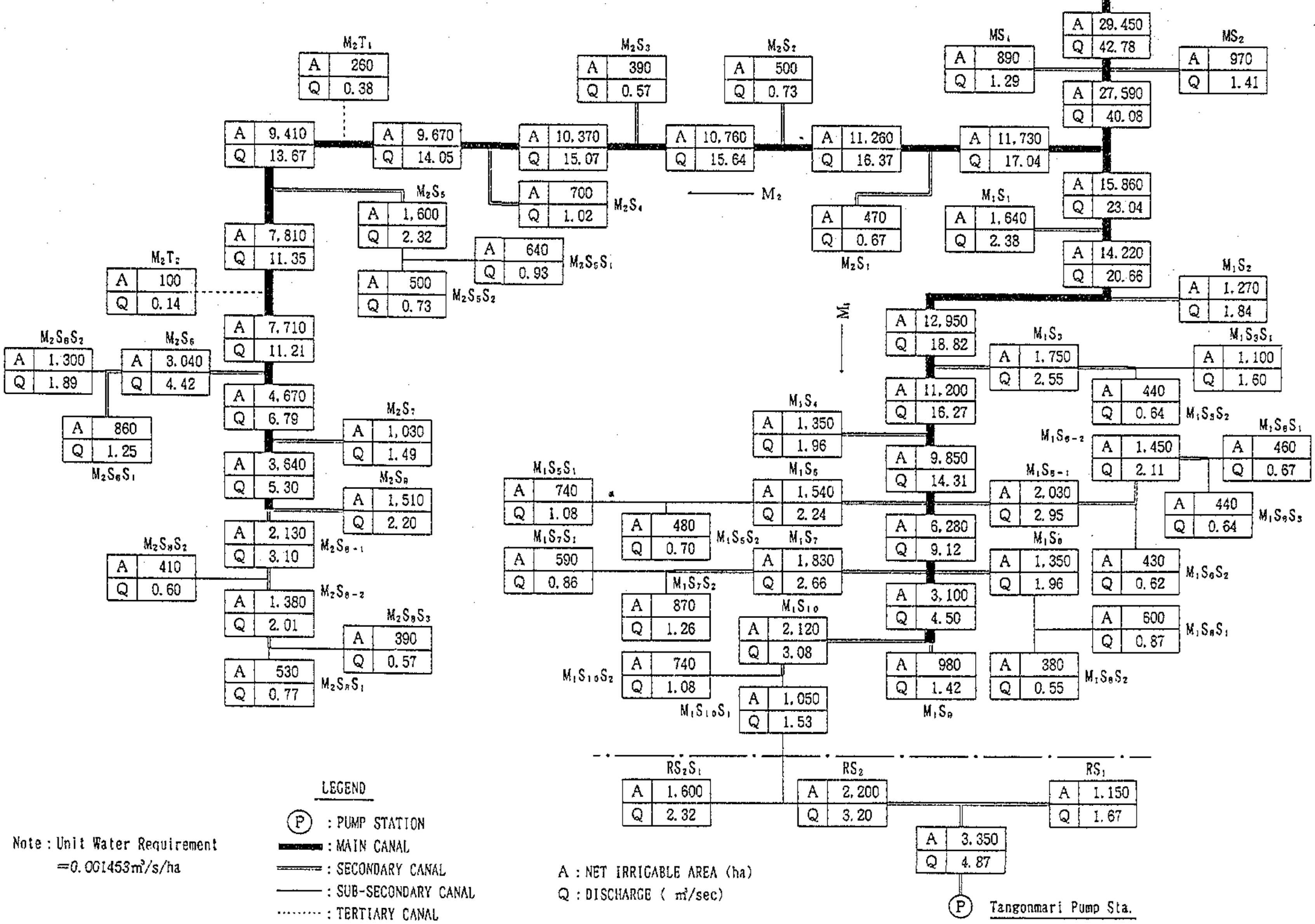


Fig. 4-4 Plan of Irrigation System

Fig. 4-5 Network of Irrigation Water Distribution



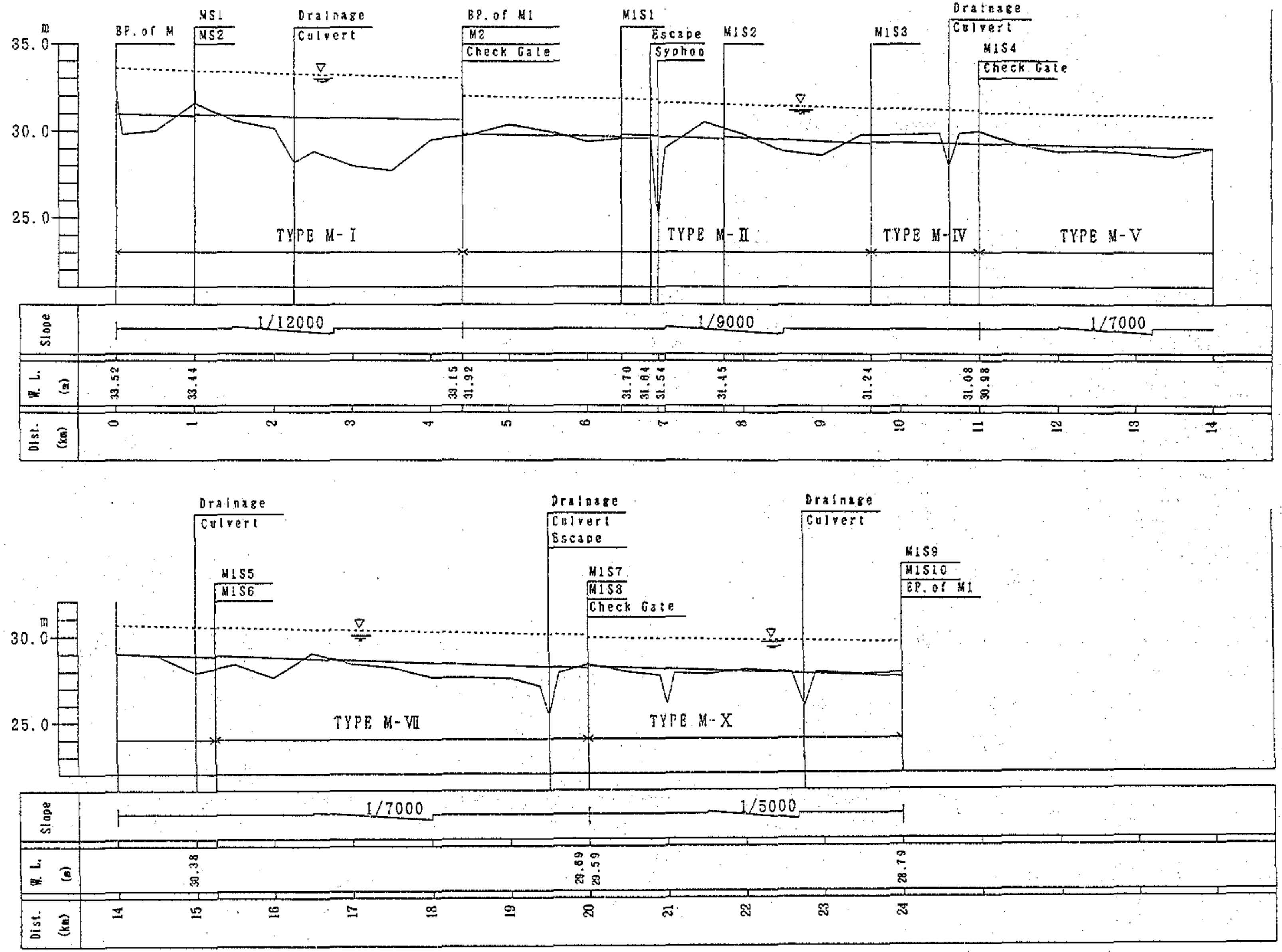


Fig. 4-6 (a) Longitudinal Profile of Main Canals (M~M1)

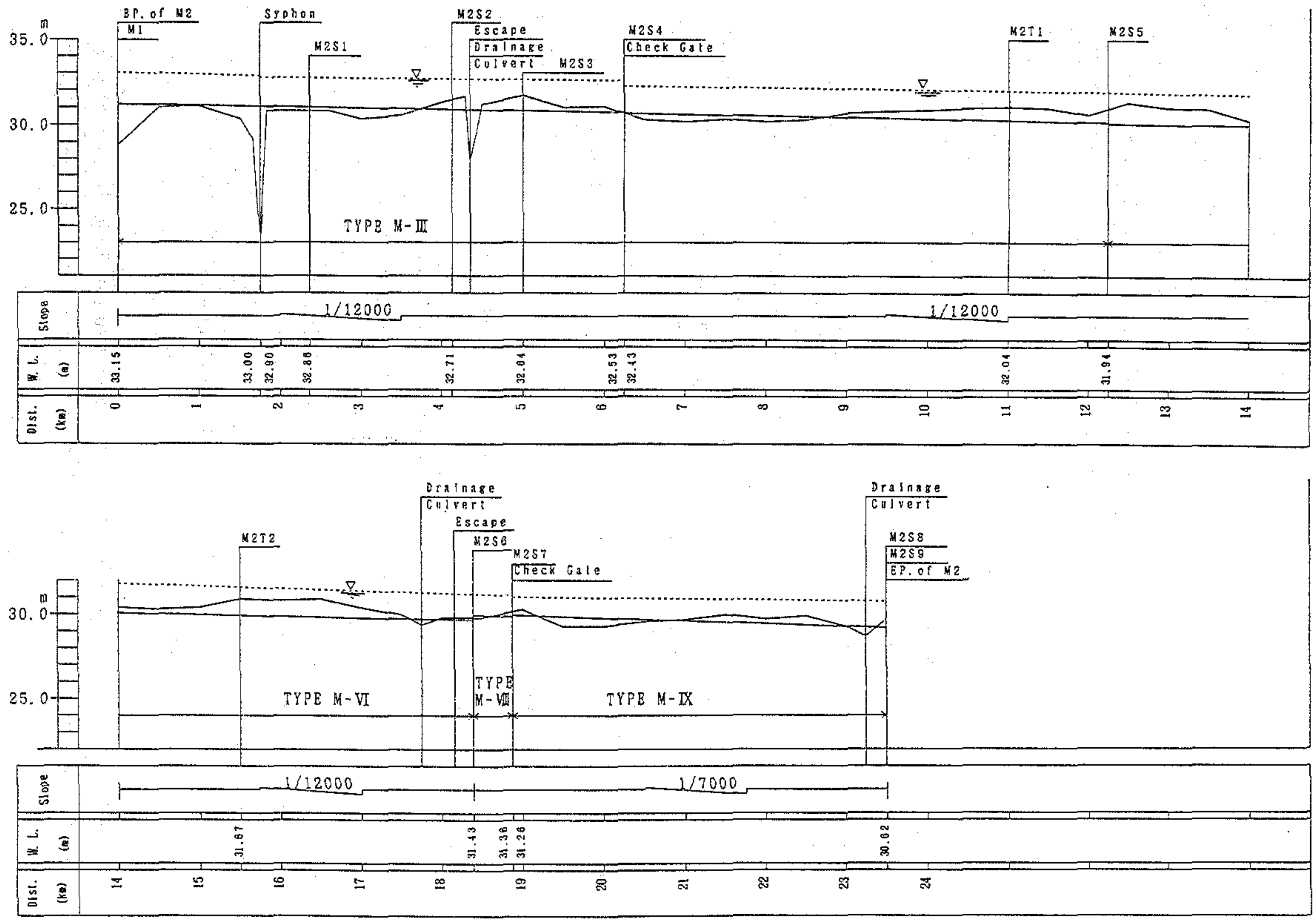


Fig. 4-6 (b) Longitudinal Profile of Main Canals (M_2)

4-5 Drainage and Flood Protection Plan

(a) Drainage Improvement Plan

1) Criteria for Planning

With opinions from BWDB personnel concerned with a number of alternative studies on drainage, the criteria for planning drainage improvements have been established as follows.

Design rainfall for inland runoff
- 5-year return period
- 5-day consecutive rainfall
- area rainfall with the Thiesen Method

Design water levels in outer rivers
- water levels from 2-year return period, which were obtained from observed annual maximum 5-day rainfall which occured in the last 20 years

Datum field level
- ground levels under which 20 % of the drainage block area exept water courses and depressions are covered

Allowable submergence for crops
- over 0.30 m standing water over the datum field level for no more than 5 days

Regulator planning
- vent size 1.52 m x 1.83 m
- flow capacity to allow a 0.15 - 0.23 m water level difference between the upstream and downstream sides

Beneficial area by flood protection and drainage improvement
- submerged area, except depressions and river courses, caused by a one-in-5-year flood in the outer rivers in the present conditions with embankment gaps and therefore receive less submergence by some improvement measures

Damaged area by flood
- area, except depressions and river courses, submerged over 0.30 m of standing water for more than 5 days

To supplement the above, alternative criteria on the datum field level data and the allowable submergence for crops as "Ground level under which 10 % of ..."

and "... for no more than 3 days" have also been examined for comparison purposes, respectively.

2) Drainage Analysis

A mathematical simulation model, in which inland runoff was calculated with the "Integrated Unit-hydrograph Method", has been employed for drainage analysis. Methods and procedures of the analysis are presented in Appendix Ⅶ-3. A large number of alternative studies for alternative criteria and measures for improvement have been worked out as presented in the Appendix. The results have finally been compiled into Table 4-8.

The criteria for allowable submergence is herein examined. Suppose a 3-day submergence is employed, and the number of required regulator vents are the same as that of a 5-day submergence, the required pumping capacity then becomes 1.2 - 2.0 times for the protection of over 80 % and 90 % of beneficial area respectively.

Meanwhile, the allowable submergence for crops differ per growing stage and cropping pattern. If the design flood occurs during and before harvesting of T-Aus, the plant is already tall enough above the standing water, while if it occurs during and after the transplaning of Aman, areas in such standing water are programed uncropped as indicated in the proposed cropping pattern. Accordingly the criteria of the 5- day submergence may be justified.

More details on 5-day submergence criteria results are presented in Table 4-9, in which case-1 aims to protect over 90 % of the submerged area in each drainage block from flood damage while case-2 over 80 %. A comparison of these two alternatives presents a clear picture of the effects of improved drainage conditions and the necessary measures to be taken.

At present 17,140 ha (40 % of the project area) is submerged in the case of a one-in-5-year flood among which 10,188 ha suffer crop damages. There are 42 regulators vents however they are not functioning because of the remaining embankment gaps.

Case-1 requires an additional 47 regulator vents and a 28 cms pumping capacity in total while crops on 1,211 ha (8 % of the total beneficial area) remain damaged.

On the other hand, Case-2 requires an additional 47 regulator vents and a 10 cms pumping capacity in total while crops on 2,255 ha (15 % of the total beneficial area) remain damaged.

When comparing with pumping irigation water capacities (42.8 cms) at Pateswari, the pumping of an additional 28 cms for drainage as in Case-1 is too costly since it is only 10 cms for Case-2. The difference in damaged areas is 1,044 ha (7% of beneficial area), and this means that an additional 19 cms of pumping is necessary to save only 1,044 ha though 93 % of the area is protected by 10 cms pumping. Consequently, employment of Case-2 may be justified.

The location and dimensions of the existing and proposed additional/new regulators and pumping stations are presented in Fig. 4-7 and Table 4-10 wherein names are temporarily given.

In Table 4-10, the Girai-Nilkamal Pass caries half the water from the Girai catchment to Pateswari Chara, which is at the downstream end of the Nilkamal River. When flood runoff arrives along the Girai, a portion goes into the Tangonmari-Old Girai Block to cause more flooding therein. A study has been made on the flow capacity of the Pass in meeting with the capacity of the Pateswari Chara Regulator, and the necessity for widening the cross-section has been confirmed. (see Appendix Ⅶ-5)

3) Policy for Plan Formulation

Some basic policies for plan formulation has to be established in order to meet technical, social, economic and local requirements. The following policy is accordingly proposed.

- Untouched natural drainage sysem:
The existing drainage systems of on-farm, tertiary, secondary and main drainage level channels will be left as they are at present. This is because the improvement of drainage channel networks would bring about worse

drainage in the lower reaches of the project area although it would certainly work for improved drainage in the upper reaches. A large number of depressions and meandering channels are functioning like flood control reservoirs to a good extent and thus protecting the downstream reaches from intensive flood concetration.

- Supplemental drainage by pumping:
Drainage by pumping is the most costly measures that a pumping plant for both irrigation and drainage can undertake but can be much advantageous in cost allocation. A stuty was made on whether a 5 cms drainage pump in the Tangonmari-Old Girai Block may function for irrigation purposes. It was found affirmative that the pump was planned for dual purpose. Meanwhile in the South Tail Block, 5cms pumping was found not for dual purposes, since this block is the most handicapped with gravity drainage and the pump has to be located in the most downstream end of the block wherefrom pumped water canot be delivered to the upstream reaches of land for irrigation.

(b) Flood Protection Planning

1) Criteria for Planning

For planning of flood embankment, discussions were carried out on the criteria between the BWDB personnel concerned and the Study Team. The following criteria were set-up in consistency with those proposed in the "Action plan for flood control."

Rivers	Design flood water level	Freeboard
Dharla	one -in-50 year flood	1.20m
Dudhkumar	one -in-50 year flood	1.20m
Brahmaputra	one -in-100 year flood	1.50m

(N.B. For the Dharla and Dudhkumar, 0.30 m freeboard for the future rise of the river bed is included)

2) Policy for Plan Formulation

The construction of flood embankments along the project area started in FY 1980-81, and as of date 60.5 km out of 84 km have been accomplished. 13 embankment places are left for construction and therefore are not functioning for flood protection. The completion of the whole length of the embankment is accordingly the first priority for the formulation.

The durability of embankments built with conventional methods are not always satisfactory and often require repars and/or rehabilitation a few years after construction. For embankment construction/repair/rehabilitation under the project, durable embankment structure and improved methods for construction/repair/ rehabilitation shall be planned and formulated.

A sufficient number of regulator vents which are planned under the afore-mentioned drainage improvement plan shall be constructed simultaneously or in advance so as not to worthen the present drainage condition after the embankment's completion.

The embankment shall be planned to be durable against ordinary intensive rainfall, wind, water table, traffic etc. as to avoid investments for ertreme cases. The embankment may be located at 300 - 500 m apart from river water ridges to escape flood flows as to avoid expensive long length river bed and slope protection work. The construction of cross-bars may be done when necessary along the embankment instead.

3) Embankment Planning

Embankment gaps are to be constructed/reconstructed/upgraded from roads and the work lengths are presentd in Table 4-11 to show a total length 22.1 km. On the other hand, work lengths for reconstruction, major repairs, minor repairs and shaping are presented in Tabld 4-12. In the Table 4-12 embankments in need of such works are given as follows.

Reconstruction:

- Embankment washed away by the river's flow need reconstruction and protection measures against encrochment.

Major repairs:

- Embankment crests very undulated and/or deeply erroded on most of the length.
- Side slopes that have slid, suffered gully errosion and/or been washed-out by turfing alone most of the length.
- 4WD car not trafficable.
- Longitudinally discontinued and irregular parts.

Minor repairs:

- Embankment crest very undulated and/or erroded on some of the length.
- Side slopes that have slid, erroded and/or washed-out turfing along some of the length.
- Ordinary car trafficable with care.
- Longitudinally undulated with some irregularities.

Shaping:

- Embankment crests slightly undulated and erroded along most of the length.
- Side slopes that have erroded and turfed or washed away in some of the length.

No repairs:

- No damages or only slight damages; easily repaired by local farmers.

Table 4-8 Regulators and Pumps needed for Drainage Improvement

Protected Area	over 80 % of area		over 90 % of area	
Allowable Submerge Criteria	< 5-day	< 3-day	< 5-day	< 3-day
No. of vents of regulator	89	89	89	89
Total pumping capacity (cms)	10	18	28	37
No. of pumping plant	2	3	3	3

Table 4-10 List of Structures for Drainage Improvment

Name	Dimensn /Capacity	Remarks
Taluk Simulbari Reg.	2 - 1.52 × 1.83	new construction
Shagon Chara Reg.	8 - 1.52 × 1.83	additional const.
Barabhko Reg.	2 - 1.52 × 1.83	new construction
Bangamore Reg.	3 - 1.52 × 1.83	new construction
Pateswari Chara Reg.	7 - 1.52 × 1.83	additional const.
Pulkumar Reg.	18 - 1.52 × 1.83	- do -
Gogagada Reg.	4 - 1.52 × 1.83	new construction
Begomganj Reg.	3 - 1.52 × 1.83	- do -
Tangonmari Pump Station	5cms	new const. 2 -way
Begomganj Pump Station	5cms	new construction
Girai-Nilkamal Pass	2.0km	widening

Table 4-9 Results of Drainage Simulation Analysis

Drainage Block / Item	① Shagon-Up.Nilk	② Girai-Lw.Nil	③ Phulk-mar	④ Bahara-mpur	⑤ Tango-O.Girai	⑥ South Tail	Total
PRESENT CASE							
Max.Flood Level (m)	29.65	27.30	29.37	28.39	27.57	27.15	
Max.Submgd Area (ha)	989	3,251	1,550	2,062	5,969	3,319	17,140 ha
Ditto excpt Depress(ha)	924	2,771	1,100	1,845	5,559	2,945	15,146 ha
Damaged Area (ha)	51	881	621	1,485	4,307	2,843	10,188 ha
No. of Regulator (vent)	5	12	8	8	4	5	42 vents
CASE-1 OVER 90 % OF SUBMERGED AREA PROTECTED							
Max.Flood Level (m)	28.46	26.45	28.35	27.23	25.59	24.62	
Max.Submgd exc Dprss(ha)	189	911	334	797	1,243	845	3,996 ha
Damaged Area (ha)	6	169	0	185	556	295	1,211 ha
No. of Reg. req'd (vent)	15	22	26	8	8	8	87 vents
Pump Capac. req'd (cms)	0	0	0	7	14	7	28 cms
CASE-2 OVER 80 % OF SUBMERGED AREA PROTECTED							
Max.Flood Level (m)	28.46	26.45	28.35	27.27	25.83	24.70	
Max.Submgd exc Dprss(ha)	189	911	334	841	1,687	913	4,826 ha
Damaged Area (ha)	6	169	0	379	1,112	589	2,255 ha
No. of Reg. req'd (vent)	15	22	26	8	8	8	87 vents
Pump Capac. req'd (cms)	0	0	0	0	5	5	10 cms

N.B. 1. "No. of Reg. req'd" includes number of existing ones
2. Two more vents of a regulator in Taluk Simulbari along the Dharla.

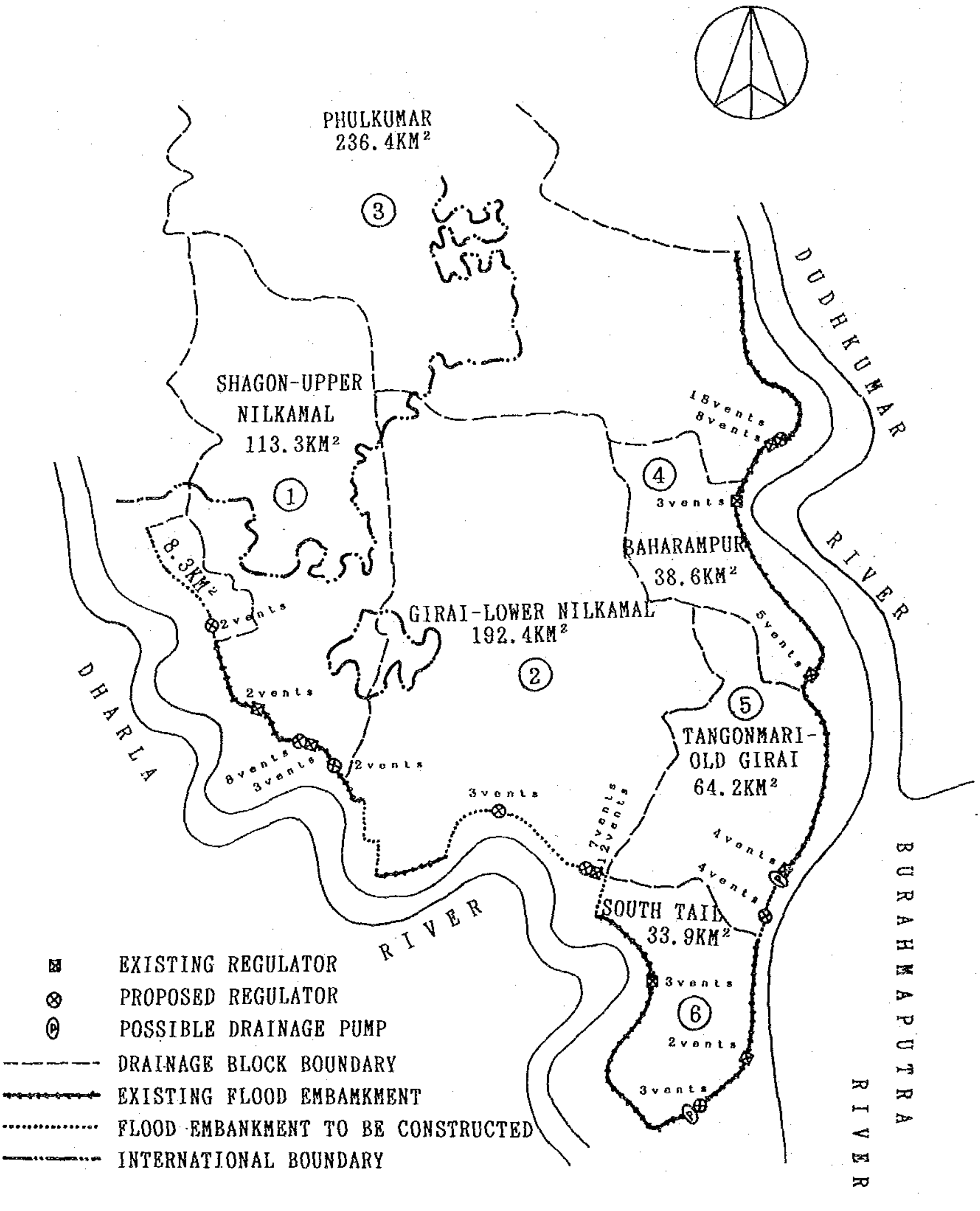


Fig. 4-7 Drainage Plan

Table 4-11 Gaps of Embankment

(as of the end of FY '89 - '90)

From (KM)	To (KM)	Length (M)	Remarks
[along Dudhkumar Rigth Embankment]			
0+01		5	Cut by farmers for local drainage
9+86	10+07	210	Phulkumar River running through
31+88	32+95	1,070	Swamp of old Girai River; a regulator planned
41+34		aprx.300	Swamp of old Dharla River; a regulator planned
[along Dharla Left Embankment]			
0+00	6+00	6,000	Not constructed yet
12+10		90	Shagon Chara River running through; additional regulator planned
13+		5	Cut by farmers for local drainage
15+13	18+93	3,800	Existing road
20+43	29+43	9,000	Not constructed yet; a regulator planned
29+43	31+03	1,600	Existing road

Not constructed	6 plc	16,670m
Cut by farmers	2	10
Use of existing road	2	5,400
Total	10 places	22,080 m

Table 4-12 Needs for Repair for Flood Embankment

Degree of Needs	Dudhkumar Right Embankment	Dharla Left Embankment	Total
Reconstruction	0.20km	- km	0.20km
Major Repair	8.33	3.95	12.28
Minor Repair	8.89	3.50	12.39
Shaping	18.61	10.22	28.83
No Repair	2.60	4.20	6.80
Total	38.63km	21.87km	60.50km

Source: Field inspection by the Study Team in Feb. '90

4-6. Marketing and Agricultural Supporting Services

(a) Agricultural Input Supply

When irrigation water is timely supplied to crops after the implementation of the project, farmers are to proceed with intensive agriculture aiming at high harvesting of crops according to the proposed cropping patterns and farming criteria, for which farmers are to use a lot of fertilizers, pesticides and improved crop seeds. In order to respond to these increasing demands smoothly, it is necessary to strengthen the distribution system for crop production materials.

Fertilizers and improved crop seeds have been monopolisticly distributed to local dealers (including the UCCA/KSS/BSS/MBSS system) by the BADC, at the PMP or the TSC through the district and upazila offices of the BADC under the Government's subsidy policy. However, in order to improve the efficiency of distribution and pricing of fertilizers, the Government has actively promoted participation of private dealers, especially the cooperatives of UCCA/KSS/BSS/MBSS system in both wholesale and retail sectors.

After implementation of the Project, it is anticipated that the quantity of fertilizers used in the Project area will amount to approximately 23,000 ton per year or 6 times of what is presently applied for crop production. Accordingly, for the efficient distribution and pricing for crop production materials such as fertilizers, it is considered to be most appropriate to expand the organization of UCCA/KSS/BSS/MBSS system in the Project area under the full cooperation of the BRDB and to encourage immediate participation of those cooperatives in both the wholesale and retail sectors. Moreover, as a part of the UCCAs' economic activities, the stationing of proper godowns and primary distribution centers with proper storage capacities should be promoted. At the same time, it is necessary to improve transportation and communication facilities.

(b) Marketing of Agricultural Products

After the implementation of the Project, it is expected that the quantity of foodgrains (rice and wheat) will amount to approximately 180,000 ton a year or twice as much as that produced at present. Accordingly, it is also expected that the marketed products quantity will increase.

The Government has been executing a price support programme for foodgrains for stabilization of the prices in the open market, although the open market price for paddy has recently been likely to be higher than the procurement price by the Government. Recently, as for paddy, it is expected that the quantity procured by the Government has ranged from 2 to 6% of the total production or from 10 to 30% of the actually marketed paddy and the rest has been marketed in the open market. As long as the Government's policy remains unchanged, the considerable portion of the increased paddy production brought about by the Project implementation is expected to be marketed in the open market. Besides, as a result of expanded irrigation, the production of cash crops such as vegetables is also expected to increase and to be marketed in the open market.

Markets for major crops are classified into three categories, namely, village markets, semi-urban point markets and terminal market in big cities. The more farmers sell their good quality products to semi-urban points or big cities, the more they obtain returns. To realize that, it is necessary to set up or improve marketing facilities for farmers, including rice and wheat mills with large capacities which can deal with increased products, godowns which can keep increased products in high quality, transporting means such as boats, trucks etc., and marketing information networks.

This is important especially for small scale farmers who are in poor marketing environment. It is frequently observed that small scale farmers under poor economic condition sell their products of foodgrains to petty collect merchants in rural areas at lower prices than the open market prices and the Government's procurement prices to get cash on the spot without any troublesome procedures. Therefore, it is necessary that the UCCA/KSS/BSS/MBSS systems will be organized among small scale farmers to obtain stronger stance for profitable marketing.

At the same time, it is necessary to provide or to improve the social infrastructure including the municipally-run markets in urban areas, the road network and the transportation facilities for crossing the Dharla River. A construction plan of roads is to be proposed on the basis of studies focusing on the usage for operation of the irrigation and drainage systems as well as considering the usage for the agricultural material supply and marketing.

(c) Agricultural Supporting Services

Although farmers in the Project area are accustomed to paddy cultivation, the projected shift from rainfed paddy cultivation to irrigated paddy cultivation and the introduction of irrigated vegetable cultivation will entail some major adjustments for the farmers' cultivation and management practices. Accordingly, in order to achieve agricultural target production after the implementation of the Project, it is important to formulate the adaptable irrigated cultivation methods of paddy and upland crops based on accumulated research results and to transfer them to farmers in the Project area. For this purpose, it is proposed to establish under the BWDB a model farm situated at a representative point in the Project area with facilities and staff for operating it.

The summary of the proposed model farm is as follows:

- Location:
- Land area: 7ha (leased land system)
- Farm: divided 3 (three) blocks;
  - (1) First block (2ha) --- for experiments
    - subdivided 2 (two) blocks
    - paddy block
    - upland crops block
  - (2) Second block (3ha) --- for demonstration
  - (3) Third block (1ha) ---- for training of farmers

- Facilities:
  - (1) Irrigation facilities
  - (2) Buildings;
    - office (including experimentation room, working room and training room)
    - warehouse

- Organization:
  - (1) Chief (an agronomist of ranking as senior scientific officer) 1
  - (2) Subject matter specialist (SMO) 2 (plant protection, water management)
  - (3) Extension overseer 1 (additional of training officer)
  - (4) Assistant 2

(5)	Junior	2
(6)	Farm laborers	20-22

Under the DAE which plays the main role in technology transfer, the extension service organizations are placed at regional, zila, upazila and union levels respectively. The extension system called "Training and Visit (T&V) System" is practiced, for which zila offices work as bases.

In order to practice satisfactory extension service activities corresponding to the expansion of the cropped area, the diversification of crops and the introduction of improved irrigated farming techniques after the implementation of the Project, it is evident that staff and equipment for extension services will have to be strengthened from their present status. It is proposed to train and newly assign the personnel concerned, and to provide equipment and facilities including vehicles. Especially, it is desirable to increase the number of block supervisors so that they can directly transfer agricultural new technology to all farmers and to give them the necessary number of motorcycles so that they can fully display their mobility.

4-7. Environmental Impacts

The project area is located at the northern - most territorial boundary, sur - rounded with three rivers , implying land lockedness or underdeveloped virgin area , as far as ecological environment is concerned. However , population pressure has been as high as other part of the country , with an increasing trend giving detrimental effects on vegetative coverage or fauna in the project area.

Another salient feature represents relative abundance of water body distribution (4-5 % of the total surface area), consisting of beels or river-bed lakes, and water ponded depressions, also implying popularity of aquatic flora and fauna.

The impact of over-populatedness should not be overlooked, before debating environmental impacts, which randomly exploits vegetation like bamboo and trees for fire wood and feeds, fishing resources and even waterweeds for food, as very few are devoted to observance of closing period for their conservation. Taking account of this population impact, incomparable to any other from different origins, environmental impacts caused by the project will be mentioned bellow.

The environmental issues in the project area arising from the project can arise from three different categories, i. e. ,effects on human health, those on fish resources and on natural vegetation (the latter two consist of eco-system of the area). While land development activities proposed in the project include; construction of pumping facilities, canals and embankment within the periphery of the project area, and intensive use of agricultural inputs on improved farming areas.

Firstly, possible negative effects are concerned about the construction of pumping stations along side rivers on spawning grounds, One major station is designed at Pateswari where Dudhukmar river has a narrowest section and hence its river bed has been deepened by high velocity river flow. Another station is planned at Tangonmari facing directly to an axis of main stream flow where high velocity of river flow is also observed. These two stations evidently gives negligeable effects on spawning grounds, for they are surely situated in shallow parts of water bodies with deadly-slow water flow.

The third pumping station for drainage is scheduled at Begomganj, just at the confluence point of one small drainage channel and Dharla-Dudhukmar confluence area. Any spawning area cannot be formed in such narrow and unstable waterbodies, because only shallow and deadly slow water movement are required for waterweed and algae to prosper. According to the authority concerned, major spawning grounds are now developed only along Brahmaputra river, rather than fast flowing tributaries like Dharla and Dudhukmar.

As regards impacts on fish resources, there is another concern, i. e. ,newly constructed canals might inhibit free migration of fish from a beel (river) to another, and such constraint inevitably evolves so far as canal structures separate hitherto continuous water area into two parts. However, generally any fish species other than demersal ones can move through irrigation systems from a river or a dighi or a beel to another. There have been many irrigation projects already implemented in Bangladesh but so far no fatal damage on fish resources were encountered due to impacts of project implementation.

With respect to the conservation of fish resources as well as protection of current fishing activities, it will be required to pay due attention to possible measures or conservation, such as culverts and other structures to secure fish migration and drainage, lest artificial structures should completely block or choke free migration of fish. As already mentioned, drainage efficiency wouldn't be so high, and water within a catchment area cannot be well-drained to the extent that threatens fish population because of surface water shortage.

Presently, fish resources in northern part of the project area often suffer from low water level due to drought in dry season or occasional dry spell during rainy season, but when the project is completed the ground water table will certainly be elevated to the level at least 1 meter above the currently recorded average. Evidently this will contribute to maintenance of water levels in dighis or beels in the problem areas, as well as water supply to rhyzosphere of trees and bamboo brushes.

As to the interruption of fish migration by embankment construction, currently available regulators can serve as a passage for fish migration. If it does pose this sort of problem, already constructed embankment by other projects which covers more than 80 % of required embankment for this project would have caused detrimental effect on fish resources. However, no such effect has so far been reported from the authorities concerned.

Water in depressions and meanders will be reserved and stabilized due to introduction of irrigation water from the river and due to lowering of flooding brought about by the improved drainage. Thus the project will lead to better conditions for fish culture.

Secondly, whether the project might affect natural vegetation is assessed. Due to enormous population pressure and flat topography no forest area has been registered within the project area, though virtually scattered bamboo groves are seen throughout the area, especially in northern part, which is counted as a part of homestead area (around 9 % of the total surface area is under homestead). Also, jack fruit trees and silk-cotton trees (Kantal and Simul) are widely found at road sides. Both roads and homestead sites are created by earth-filling with higher elevation than the level of sorrounding ground, against flooding submersion. These homestead areas are kept unexploited by the proposed project, and the project will provide higher water table as mentioned above, in order to better protect these vegetation from drought attacks.

Thirdly, concern would arise from the plan that more chemicals (fertilizers and pesticides / fungicides) are to be consumed by the project, and this could influence human or animal health. The planned levels of chemical use approaches those employed by many developed countries, although they are still much lower than those in the developed world, which are considered to be safe from health point of view. therefore, only if pertinent care for utilizing them would be taken and instructions for their usage would be observed, it is possible to minimize any detrimental effects arising from input use.

For example, certain chemicals against pests, disease and weeds are highly poisonous to aquatic fauna. The toxicity shows great variability, and such chemicals as endrin, terodrin, benzoepin and PCP are terribly toxic, while captan, triazin, dihortane etc. are fairly toxic to fish. These chemicals are not planned nor recommended in the project and use of them should be legally prohibited in the light of importance of fish resources in bangladesh.

Simultaneously, it would be recommendable to pay due attention to residual accumulation of hardly decomposable herbicides and other chemicals in the soils.

Especially, pesticides containing PCB (poly-chlorinated biphenyl), aldrin, dieldrin, DDT, BHC and other organo - chlorine pesticides should be refrained from chronical use in order to avoid their accumulation in paddy soils.

As to prevention of adverse, health threatening effects of agricultural chemicals, there would be a possibility of potable water contamination with these harmful chemicals or fertilizers. Fortunately, many hand pumps have been drilled in the areas concerned (for example, 1390 in Bhurungamari Upazila, 2374 in Nageswari Up., 1159 in Kurigram Sadar and 1992 in Fulbari Up.) by which 16 families can utilize a handpump for potable and cooking water. So inhabitants would not have to use risky surface water and only if chemicals could be carefully treated and spraying farmers could take care of not inhaling chemical mist during practices ,or avoid spraying on windy days, problems would not arise from chemicals. These cautions are now being diffused among farmers through extension activities by DAE.

Contamination of ground water with chemical fertilizers would happen because fairly big amount of them is to be applied by the project , Nitrate ion, derived from ammonium ion originated from urea etc. can be easily converted into nitrite ion which is toxic and chronical drinking of contaminated water possibly cause methanoglobinemia especially for infants and other vulnerable population. Generally, during percolation through soil layers ammonium ion can be caught by soil colloids forming stably adsorbed ion-comlex until it is absorbed by plant roots or micro-organisms. So, there exists least opportunities that ammonium ion reach as far as groundwater to form nitrite ion. However, when urea and other nitrogen fertilizers are spread as top dressing over water ponded paddy fields during rainy season, it will easily be washed away into deep beels where surface water and ground water directly contact, and thus causing higher risk of contamination .

It is therefore suggested that top dressings are better applied in the form of solid balls (possibly prepared with moist clay or cowdung). which can be pushed down into paddy soil with toes rather than spreading in powered soluble form over water surface. This practice will be easy with ample surplus labour and would contribute rconomization of fertilizers owing to higher absorption rate, or lower rate of loss from nitrification.

According to the proposed input requirement, 9855 tons of area will be applied to crops every year. Around 40 % of the applied will be absorbed by crops, and

40 % of the rest (i.e. 24 % of the applied) will get rid of decomposition through nitrification and washed out in surface water, and 5 % of which is infiltrated into ground water. Under the above mentioned estimation, and from effective rainfall and run-off rate (40 %), average concentration of ammonium ion in run-off surface water is estimated at 4.7 ppm. in the lowermost part of drainage system and only 0.16 ppm. in ground water. This level would be lowered further during rainy season by dilution with rain water supply.

Similarly, sulphate ion derived from applied zinc sulphate, gypsum and admixture of TSP are estimated at 2.2 ppm. in ground water, assuming that 80 % of the total applied amount is leached into ground water.

According to WHO (world health organization) guidelines for potable water quality, nitrate ion (derived from ammonium ion) in water samples should be less than 10 ppm. (as N), while sulphate ion concentration should not exceed 400 ppm. In this connection, even if 100 % of ammonium ion solved in ground water is converted into nitrate ion, nitrate concentration comes to well below the standard (only 1/60). Also, sulphate ion level remains in safer range (only 1/190).

In the case of zinc, WHO prescribes 5.0 ppm soluble zinc in samples as a standard, whereas applied zinc in total would be equivalent to 0.12 ppm. only even if all amount is dissolved into ground water.

The above assessment proves that there will be no hazardous outcome derived from the proposed project, which is quite similar to other ones already implemented quite recently in the same region. On the contrary, it is confident that the implementation of the proposed project will give positive, beneficial impact on environmental conservation in the project area by preventing floods and drought damages to natural flora and fauna and by improving phytonutritional conditions. Finally, it would be worthwhile to reconsider population impact. But for population problems necessity would not arise to implement an agricultural project to increase food production, then risks of contaminating environment with chemicals never become controversial. Just as there be no development without producing pollution, so industrial improvement always accompanies some extent of environmental degradation as a sacrifice. Such degradation could not be avoided by canceling project implementation. Because densely exploding population cannot refrain from exploiting scarse resources comprising biomass or ecosystem in its very environment in the absence of industrial development project.

In addition to the above -mentioned matters inside the project area, the impacts of the river water diversion to the downstream should be looked over. In the case of the water intake in 1979, the most drought year for last 10 years, combined with the river discharge of 5 year return period at Pateswari of the Dudhkumar, the two largest cases of intake ratio appear at the second and third 10 - day periods in April and at these periods the downstream river discharge after the water intake are estimated as shown below (refer to 5-1, Volume I.) :

Unit : m^3/sec.

Items	April	
	11th~20th	21th~30th
Intake	37.3	42.8
River discharge	82.6	93.1
Water intake ratio to river discharge	0.45	0.46
River discharge after intake	45.3	50.3

The river section influenced by the water diversion is approximately 20 km long from Pateswari to the confluence of the Brahmaputra and is not a important navigation course since the Indian border is situated only 5 km upstream from Pateswari. Accordingly, the proposed water diversion which leaves a considerable amount of the downstream river discharge seems to be acceptable.

CHAPTER 5

MAIN FACILITY PLANNING

CHAPTER 5 MAIN FACILITY PLANNING

5-1. Pateswari Pumping Station

(a) Intake Work

1) Intake Water Design Level and River Discharge.

- Intake water design level:
  L.W.L = 25.50m (P.W.D)---(Lowest water level in 1966)

The annual minimum water level for the proposed Pateswari Intake Point at the Dudhkumar River has been changing every year caused by river bed fluctuations with the river up / down moving and the water surface width has been also changing.

The *minimum water level movement ranges approximately* between L.W.L = 25.8~26.4m and the minimum discharge at 60~90m^3 / sec. It is also recognized that the minimum water level is rising at present.

Considering the results from the above analysis, the water design level was determined to safely assure the future workings of the pump.

- Maximum water design level:
  H.W.L = 30.86m (P.W.D)---(Highest water level in 1984)

- Maximum intake design discharge: Qp = 42.78m^3/sec

- Minimum river descharge's conditions. (Year: 1964~1989)
  - The lowest discharge: 56m^3 /sec (5th in April of 1980)
  - Probable discharge 1 / 5: 73m^3 /sec (Annual minimum discharge)
  - River 10 daily average's discharge in March and April in the drought periods is shown in Table 5-1.

Table 5-1 River 10 Daily Average Discharge (March and April)

Unit: m^3/sec

Period		Minimum Discharge	Mean Discharge	Maximum Discharge	Probable Discharge 1/5	Probable Discharge 1/10
MARCH	1 (1-10)	59	93	135	75.4	68.2
	2 (11-20)	62	89	128	75.0	68.4
	3 (21-31)	63	90	131	72.8	67.4
APRIL	1 (1-10)	63	93	133	76.5	68.8
	2 (11-20)	70	108	178	82.6	75.4
	3 (21-30)	65	143	289	93.1	80.5

Table 5-2 River Intake Ratio (Probable Discharge 1/5 of 10 Daily Averages)

Period		River Intake Discharge	Probable River Discharge 1 / 5	Water Intake Ratio
MARCH	1 (1-10)	25.81	75.4	0.34
	2 (11-20)	25.93	75.0	0.35
	3 (21-31)	25.37	72.8	0.35
APRIL	1 (1-10)	27.40	76.5	0.36
	2 (11-20)	37.29	82.6	0.45
	3 (21-30)	☆ 42.78	☆ 93.1	☆ 0.46

According to Table 5-2, the maximum water intake ratio is 46%. It is judged that the water diversion requirements can be taken from the river without greatly influencing in the lower reach side. (refer to Appendix Ⅷ. 1-1)

2) Groin Work

At present, the river's low water surface width is about 300 m and the stream's centerline is located nearer to the right bank being 180~200 m off the left bank. It was planned to secure intake water with installing groin works, which are outlined as follws.

- Groin works are planned for the purpose of maintaining the channel and the water depth near the right bank with the directional turning of the stream's flow towards the opposite (right) bank.
- An inlet Basin is planned to secure a smooth water intake.
- Considering the annual minimum water level's fluctuation every year, the proposed backwater ground sill work of 1.0 m in hight is to be set and is expected to secure intake work directly near the lower reach side of the intake point.

As a result, on the other hand, there is the possibility that sedimentation will increase during flooding.

Taking into consideration the above point, accumulated sedimentation will be treated once every 1~2 years at the beginning of the dry season. (refer to Appendix Ⅷ. 1-2~6)

3) River Revetment Work

The low channel stream at the water intake point is fixed and a strong river revetment work was planned to protect the proposed pump station from a big flood.

(b) Pumping Station

1) Selection of Proposed Pump Station Type

The proposed pump station types were carefully compared among ① Vertical Mixed Flow Pump Type Structure ② Inclined Pump Type Structure and ③ Screw Pump Type Structure; in due consideration with their adaptability to the sites, construction costs and their O & M costs. As a result, the Vertical Mixed Flow

Pump Type Structure is recommended as the most suitable for the project. Cost comparison for different pump structure types is shown in Table 5-3.

A floating pump type was excluded in the comparative study because a barge carrying large bore pumps is not available at a 1.5~2.0 m depth of the site in the dry season. (refer to Appendix Ⅷ. 2-1~2)

2) Selection of Pump's Number

The number of the vertical mixed flow pumps was planned comprehensively considering the following points.

- Pump equipment costs for a total discharge generally tend to rise, as the pump number increases.
- The larger the pumps bore is, the higher its efficiency becomes, which brings about the lower running cost.
- The risk diversification in case of a possible break down of a pump.
- To respond to the fluctuation of the required water intake discharge during a year.
- Parts exchangeability for easy maintenance.

Taking the above points into consideration, the proposed pump number was carefully compared among three cases with 3, 4 and 5 pumps regarding the investment costs and operation and maintenance costs. As a result, the case with 4 vertical mixed flow pumps of 2,200 mm bore was found to be the most suitable. (Table 5-4, refer to Appendix Ⅷ, 3-1 in detail.)

Table 5-3 Comparative Study Results for Different Types of Pumps

Items \ Pump Type	Vertical Mixed Flow Pump	Inclined Mixed Flow Pump	Screw Pump
1. Design Dimension			
• Design discharge	42.78m³/sec	42.78m³/sec	42.78 m³/sec
• Pump bore	φ2.200mm	φ1.000mm	φ3.400mm
• Pump numbers	4	22	12
• Pump capacity	10.70m³/sec	1.95 m³/sec	3.57m³/sec
• Pump total head	8.6m	9.0 m	9.2m
• Pump speed	225rpm	493rpm	26rpm
• Pump efficiency	86%	82%	75%
• Pump power	1,220KW	250KW	500KW
• Pump total power	4,880KW	5,500KW	6,000KW
2. Initial Cost	(Exchange annual cost, Durable life :30 year)×10³ TK		
• Pump facilitie's	Cost 104,172	143,079	142,602
• Pump house	4,288	5,567	4,169
• Civil work	13,272	3,201	14,406
sub Total	121,732	151,847	161,177
3. Annual O & M	49,744	57,677	61,840
cost Total	171,476 (100)	209,524 (122)	223,017 (130)
4. Driving and Operation	-ON-OFF drive at water suction level	- do left -	- do left -
	-Not available drive below L.W.L.	- do left -	-Available drive below L.W.L and drive is easy.
5. Maintenance	Pump assembly and inspection are done by crane.	- do left - -For large bores, reassembly is required with highly skilled personel.	-Painting of impellor is required one time in per 1 to 2 year.
6. Passing of dust	-Possible to lift water to pass considerable amounts of dust.	-Possible to pass dust through screens.	- do left -
7. General evaluation ranking	1	2	3

Table 5-4 Comparative Study Results for the Quantity of Pumps

Items \ Case	3 Pumps	4 Pumps	5 Pumps
1. Design discharge			
• Design discharge	42.78 m^3/sec	42.78 m^3/sec	42.78 m^3/sec
• Pump bore	φ2,600mm	φ2,200mm	φ2,000mm
• Pump capacity	14.26 m^3/sec	10.70 m^3/sec	8.56 m^3/sec
• Pump total head	8.6m	8.6 m	8.8m
• Pump speed	184rpm	225rpm	245rpm
• Pump efficiency	87%	86%	85%
• Pump power	1,600KW	1,220KW	1,010KW
• Pump total power ☆1	4,800KW	4,880KW	5,050KW
2. Initial Cost	(Exchanged to annual cost, Durable life ;30 years)		
			$\times 10^3$ TK
• Pump facilitie's Cost	112,431	104,172	106,872
• Pump house	A=22m ×40m	A=20m ×45m	A=19m ×46m
	=880m² 4,192	=900m² 4,288	=874m² 4,164
• Civil work	12,872	13,272	13,506
sub Total	129,495	121,732	124,542
3. Annual O & M cost	50,090	49,744	51,253
Total	179,585	171,476	175,795
	(105)	(100)	(103)
4. Working ratio when one pump is in trouble(risk diversification)	Low 67%	Medium 75%	High 80%
5. Required irrigation water match operation	Low	Medium	Good
6. General evaluation Ranking	1	2	3

☆1: Total Pump Power excludes additional electric power required of about 100KW for house lights, butterfly valves, cranes and the dust removal equipment.

3) Outlet Pond and Settling Basin

A settling basin was planned to protect the main canal's sedimentation after lifting water. The settling basin scale:
$A = 120m \times 360m = 43{,}200m^2$ (Minimum grain size sediment $d = 0.02mm$)

Considering the ON-OFF hours of the pump, the effective water depth of the settling basin was determined to safeguard the pump facilities. The design dimensions of the settling basin are planned as:

- H.W.L = 33.52m
- L.W.L = 30.52m

} H = 3.0m (effective water depth)

- Settling basin effective volume (V)

  $V = 43{,}200m^2 \times 3.0m = 129{,}600m^3$

- Pump working hours (T)

  $T = 129{,}600m^3 / 42.78m^3/sec \times 60\ sec = 50\ min.$

  (Maximum lifting discharge)

4) Power Supply

The existing transmission lines to be used are 11KV standard. In order to supply power to the proposed pump station, a 11KV transmission line of 5.5 Km length are required.

A worry is the possibility of a voltage drop on the existing transmission line when the pump is on. Considering this worry, the required electric power must certainly be secured from the power supply source. (refer to Appendix Ⅷ. 3-3~5)

The layout for the intake work and the pump stations are shown in Fig. 5-1 (a, b).

5-2. Tangonmari Reversible Pumping Station

(a) River Conditions at Intake Point

1) Rever Bed Movement

According to the past recorded annual minimum water levels (1962~1988), the river bed movements at each point are:

- Pateswari (Dudhkumar River):
  Tends to gradually rise. (Recently the rising value is about 0.3 m)
- Noonkawa (Brahmaputra River):
  Tends to go down on a large scale. (Dropping value is about 2.0 m)
- Chilimari (Brahmaputra River):
  Tends to rise a large scale. (Rising value is about 1.5 m)
- Bahadurabad (Brahmaputra River):
  Tends to gradually rise. (Rising value is about 0.6 m)

2) River Bank Shifting Conditions

The river bank's shifting conditions from the Dudhkumar River confluence point to the proposed reversible pump station section was recorded as being in the moving range of 200~1,300 m length with the cardinal point of the existing flood embankment.

The river bank point at the proposed reversible pump station is situated at 250 m from the existing flood embankment at present and that is about 8 Km downstream from the Dudhkumar River confluence point. As for the river bank shifing, the river bank has been comparatively stable and the movements have ranged between 250~600 m in width.

(b) Design Intake Water Level

1) Water Level and River Bed Movements

The water level and the river bed movements at the Noonkawa, Chilimari and Brahadurabad stations were analysed based on past recorded water level and discharge data during a 25 years period. These points are shown in Table 5-5. From this Table, it is found that the range of minimum water level changes is rather large during the past 10 years. It seems that the river bed gradient has been fluctuating between steep and gentle gradients in the long run.

Table 5-5 Water Level and river Bed Movement

Items \ Obsevation station	Noonkawa	Chilimari	Brahadurabad
1. Annual Minimum Water	-Year: 1962~1980 • L.W.L=ranges of 21~22m (P.W.D) -Year: 19811988 • L.W.L=ranges of 20~21m (P.W.D) The river bed has had large degradations by about 2.0m during the last 10 years.	Conversely at Noonkawa point, L.W.L=ranges of 16~17.6m • The river bed has had large gradations by about 1.6m during the last 10 years.	The river bed has been repetitively fluctuating Up/Down within a 5 year cycle. Recently, it shows gradually rise. (Rising Value is about 0.6m)
2. Annual Minimum Water Surface Gradient Movements	Section distance is about 35Km from Noonkawa to Chilimari -Year: 1962~1980 • I=1/6,600~1/7,800 (Movements of steep gradients) -Year: 1981~1988 • I=1/8,600~1/13,900 (Movements of steep gradients)		———
3. Fluctuation of Annual Maximum Water Level	-Year: 1962~1980 • H.W.L=ranges of 27.3~28.1m -Year: 1981~1988 • H.W.L=ranges of 27.2~27.7m The annual maximum water levels went down about 1.0m in the last 10 years, the highest water level was recorded with 28.0m during the big flood in 1988.	The annual maximum water level ranges of 23.3~24.6m excluding H.W.L=25.1m the big flood in 1962and 1988.	The river bed have been repetitively fluctuating Up/Down within 10 years. This point's movements range is smoller than the Noonkawa point at about 1.5m.
4. Annual Maximum Water Surface Grandient Movements	Section distance is about 35Km from Noonkawa to Chilimari -Year: 1962~1980 • I=1/8,100~1/11,700 (Movement of steep gradients) -Year: 1981~1988 • I=1/11,500~1/16,400 (Movement of steep gradients)		———

2) Design Low Water Level for Water Intake

The lowest water level during the past 10 years for the intake site is obtained as follows;

L.W.L = 19.99*1 - 0.07*2 = 19.92 → 19.9 m

*1 : The lowest water level at the Noonkawa station which was recorded in 1987.

*2 : The water surface drop obtained from the river gradient and the 2 Km of distance between the Noonkawa station and the pump station site.

Considering the previously mentioned large range of the past low water level fluctuation and the supposed discharge reduction caused by artificial activities in the future, the design low water levels for the proposed pump station are planned as follows. (refer to Appendix Ⅷ. 4-1-3)

- For the intake regulator, conduit and the pump suction sump,
  L.W.L = 19.9-1.0*3 = 18.9 m

  *3 : A planned drop of the low water level to secure the intake during the durable period of the pump station.

- For the head race canal, for which the canal bed can easily be cut down respoding to a possible future drop of the water level,
  L.W.L = 19.9 m

3) Water Level Changes of the Past 10 Years

The water level movements at the Noonkawa station, which is located about 2 Km upstream from the proposed pump station site, are found as follows;

- Variation range of the water level in the rainy season (Jun.~ Oct.)
  W.L = 24~27m (P.W.D)
- Variation range of the water level in the dry season (Nov.~Apr.)
  W.L = 20~23 m (P.W.D)

Namely, the existing ground elevation at the proposed pump station is about 24 m.

4) Intake Water Problems

Considering the river bank's shifting conditions and the annual water level movements, the maintenance of the head race will need to be carried out. Treatment for accumulated sedimentation in the head race must be carried out at the beginning of the dry season every year in order to secure the designed intake ($Q = 4.87\ m^3/s$).

The proposed location of the reversible pump station at the Tangonmari regulator site is considered suitable regarding to it topographic conditions and the water intake can be done with a small intake discharge compared with the river discharge, although there is the sedimentation problem as mentioned above.

(c) Reversible Pump Station Plan

1) Design Dimensions

The design dimensions for the reversible pump station are shown in Table 5-6.

Table 5-6 Design Dimensions of the Tangonmari Reversible Pump Station

Items	Standard
1. Irrigation Area	A = 3,350 ha
2. Design Maximum Discharge	
· Irrigation Discharge	4.87 m^3 / s
· Drainage Discharge	5.00 (7.30) m3 / sec *1
3. Pump Type	Vertical Mixed Flow Pump
4. Pump Bore	ϕ900
5. Pump Efficiency	81%
6. Pump Numbers	3 Nos.
7. Pump Maximum Discharge	
· Irrigation Discharge	1.63 m^3 / sec = 98 m^3 / min / one unit
· Drainage Discharge	2.43 m^3 / sec = 146 m^3 / min / one unit
8. Pump Total Head	
· Irrigation	8.0 m (Actual Head 7.5 m)
· Drainage	4.2 m (Actual Head 3.6 m)
9. Pump Power	
· Irrigation	200 KW / one unit
· Drainage	140 KW / one unit
10. Pump Speed	490 rpm
11. Pump Total Power	600 KW

*1: To be planned by the pump's characteristic curve if available. (7.30m^3 / s)

2) Outlet Tank and Settling Basin

Considering the pump's easy operation and maintenance, the pump's driving is carried out with the sluice gate's operation at two places, namely at the sluice gate and at the outlet tank which were installed for irrigation and drainage.

The design dimensions of the outlet tank and the settling basin are planned as:

a) Outlet Tank:

- Design water level's dimension

  - For Irrigation: H.W.L = 27.30m, L.W.L = 25.50m → H = 1.80 m (Effective water depth)

  - For Drainage: H.W.L = 28.10m (Outlet water level), L.W.L = 24.50m (Pump suction water level)

- Scale of the sluice gates

  - For Irrigation: W × H = 2.0m × 2.2m × 2 Nos

  - For Drainage : W × H = 2.5m × 2.5m × 1 No

b) Settling Basin

- Scale of the settling basin

  A = 70m × 70m = 4,900 m^2

- Design water level's dimension

  - H.W.L = 27.30m
  - L.W.L = 25.50m

  H = 1.80m (Effective water depth)

- Settling basin effective volume (V)
  V = 4,900m^2 × 1.80m = 8,820m^3

- Pump working hours ability (T)
  T = 8,820 m^3 / 4.87 m^3 / sec × 60 sec = 30 min
  (refer to Appendix Ⅷ. 4-4~6)

3) Power Supply

In the same manner as the proposed Pateswari pump station, the length required for the new construction transmission line of 11KV standard is approximately 7.0 Km.

The layout for the intake work and reversible pump station are shown in Fig. 5-2 (a, b)

5-3. Begomganj Drainage Pumping Station

(a) Basic Dimensions of Drainage Plan

- Design drainage pump discharge Qdp = 5.0 m^3 / sec
- Design drainage conduit work (New construction)
  W × H = 1.52 m (5 feet) × 1.83 m (6 feet) × 3 culverts
- Design outside water level (Highest water level)
  H.W.L = 27.00 m (Recorded in 1988)

The highest water level at Begomganj was calculated from the surface water gradient based on the Noonkawa~Chilimari station data.

- Noonkawa highest water Level
  H.W.L = 28.10 m (Recorded in 1988)
- Chilimari Highest Water Level
  H.W.L = 25.06 m (Recorded in 1988)

The Begomganj drainage pump station is at about a 12 Km point of the lower stream reach side from the Noonkawa observation station and the Begomganj highest water level was determined with

H.W.L. = 27.00 m

- Design minimum water level for drainage pump suction sump.
  L.W.L = 24.00 - 0.10 (*1) = 23.90 m
  *1: Screen loss
- Existing flood embankment's height
  EL = 28.70 m

(b) Design Dimensions of Drainage Pump Station

- Design discharge: Qdp = 5.00 m^3 / sec = 300 m^3 / sec
- Design minimum water level for drainage pump suction sump
  L.W.L = 23.90 m
- Design maximum water level at the outlet water tank
  H.W.L = 27.20 m
- Pump type: Vertical axial flow pump
- Pump bore: ϕ900 mm
- Pump numbers: 3 Nos
- Pump capacity: 1.67m^3 / sec = 100m^3 / sec / one unit
- Pump total head: H = 4.0 m (Actual head: Ha = 3.3 m)
- Pump power: P = 100 KW / one unit
- Pump total power: ΣP = 300 KW
- Power transmission line (11 KV): 10 Km

The layout for the Begomganj drainage pumping station is shown in Fig. 5-3.

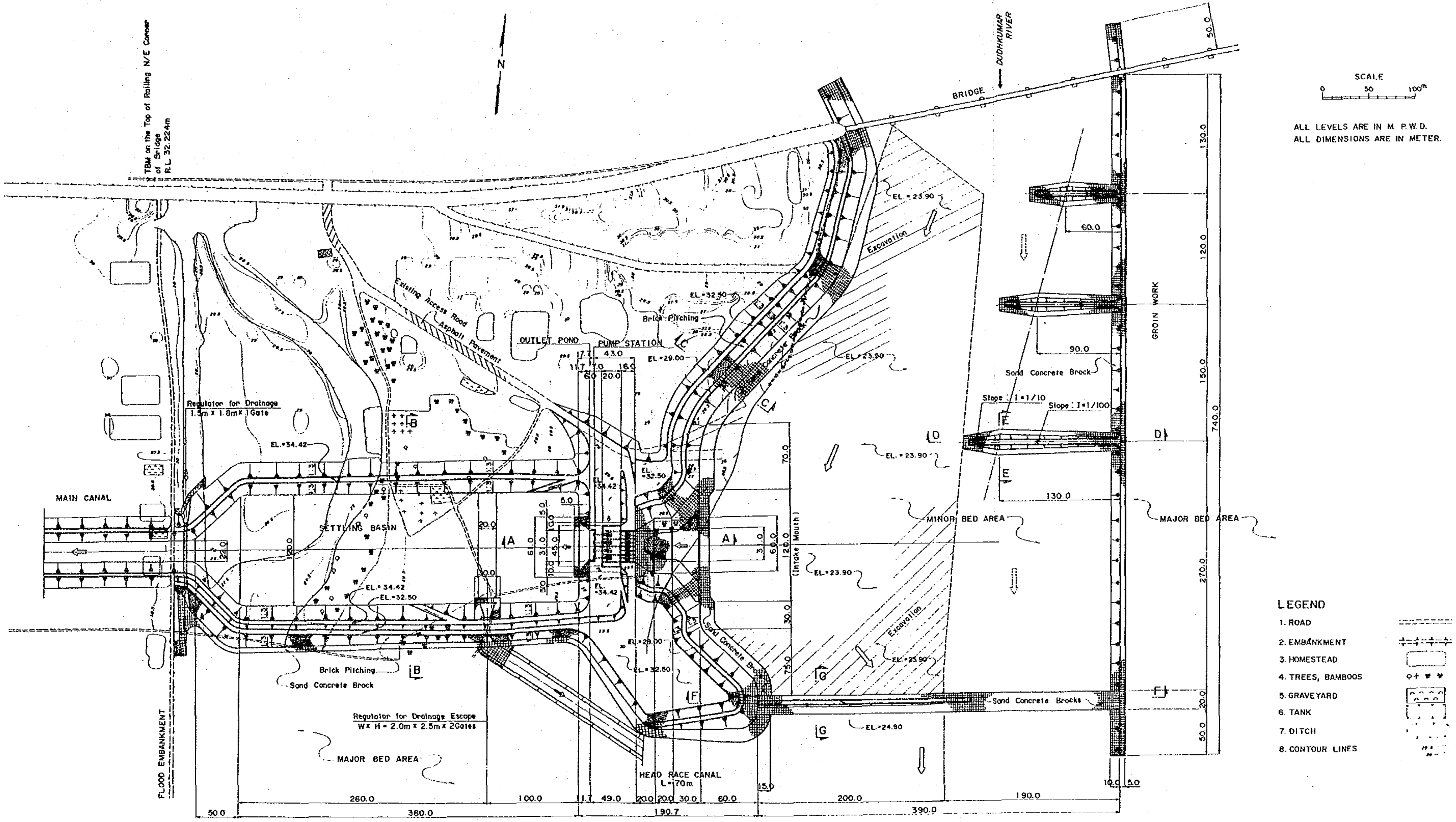


Fig. 5-1 (a) Layout of the Pateswari Pump Station (1/2)

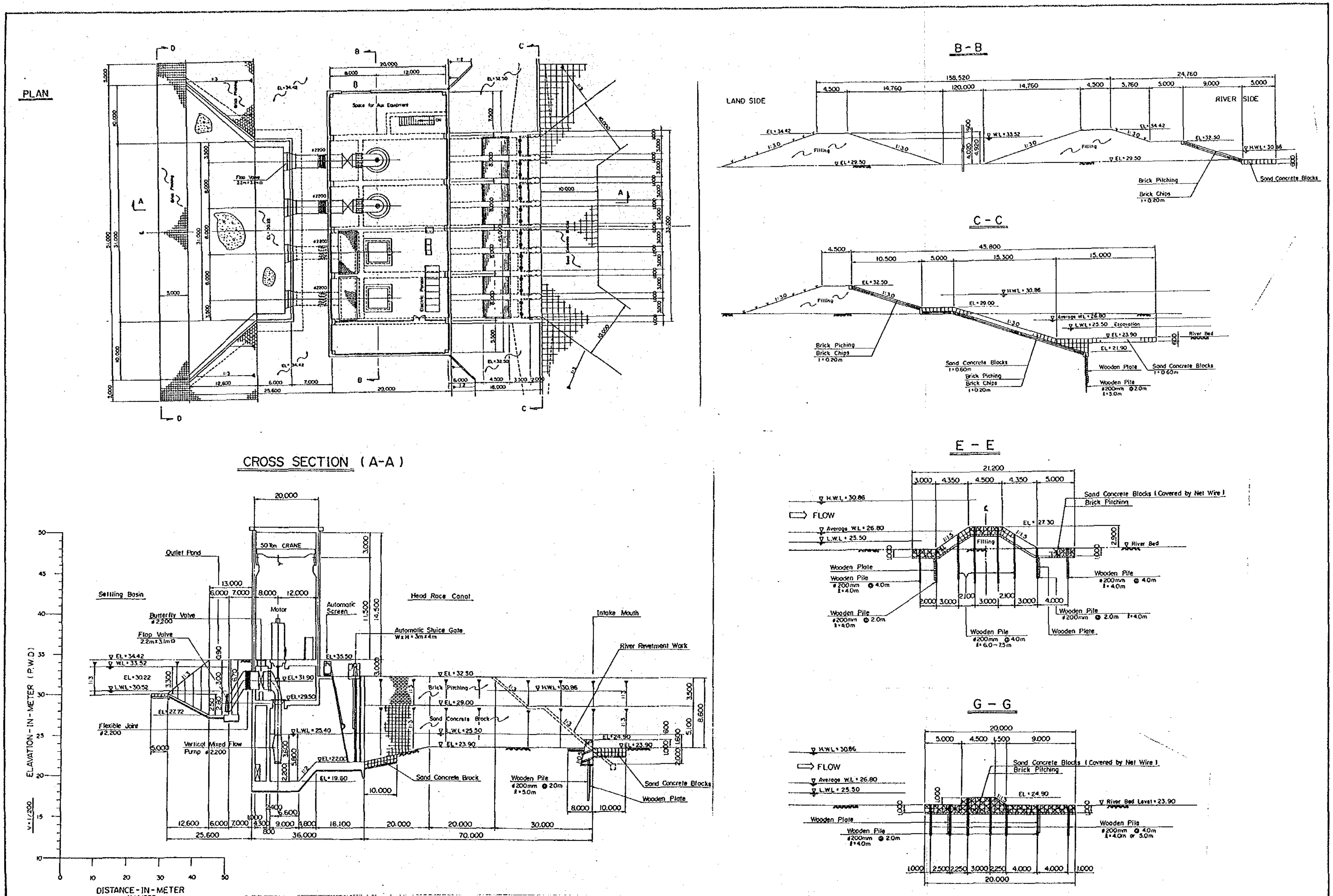
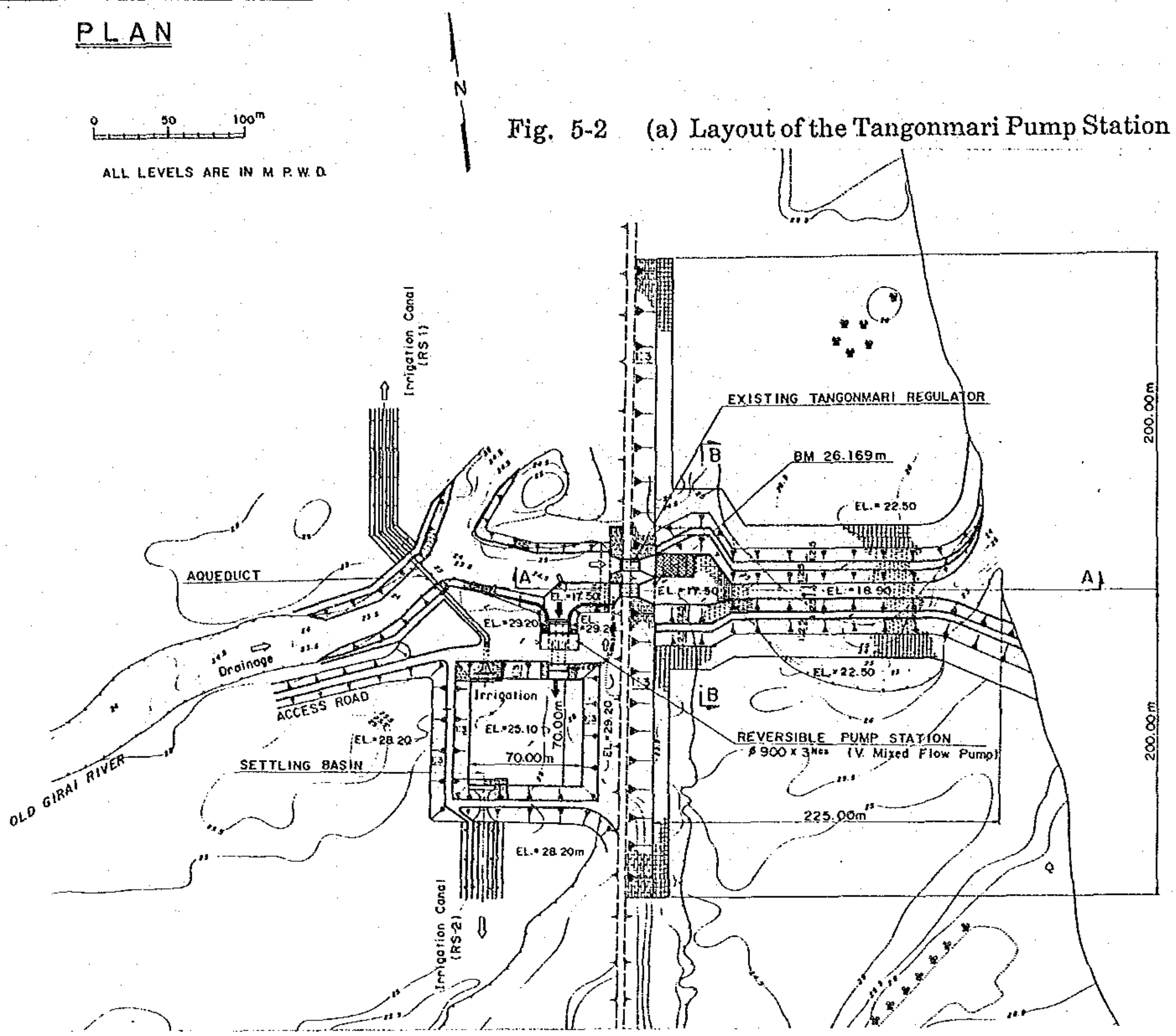
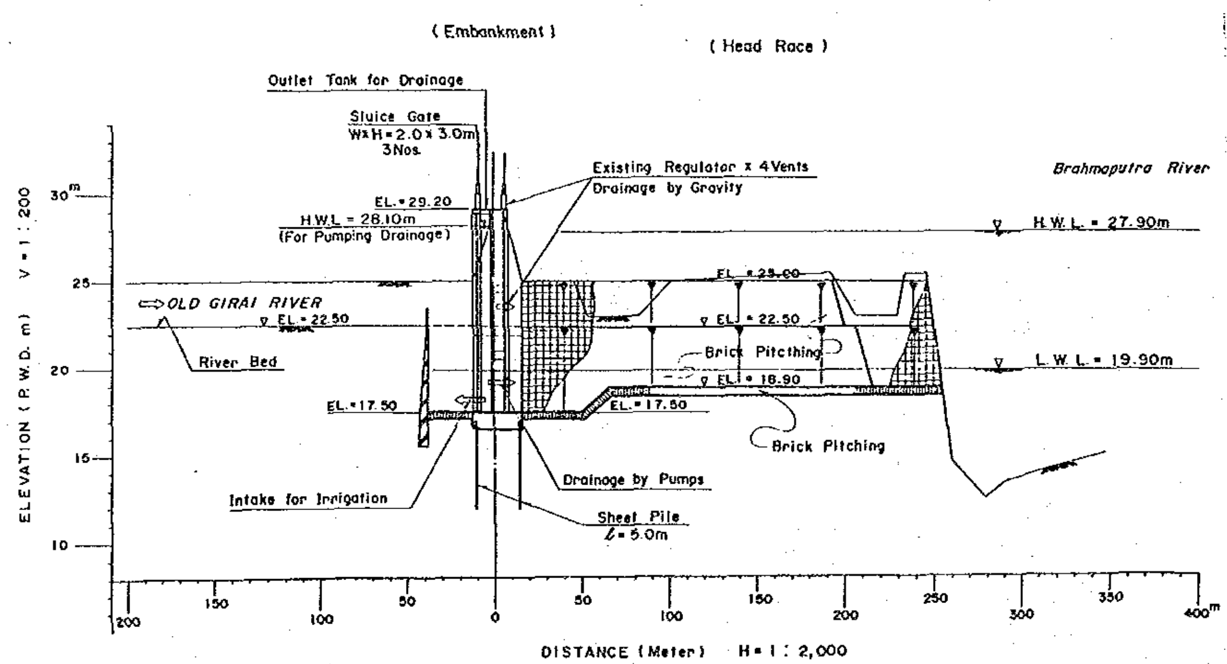


Fig. 5-1 (b) Layout of the Pateswari Pump Station (2/2)

Fig. 5-2 (a) Layout of the Tangonmari Pump Station (1/2)



A – A



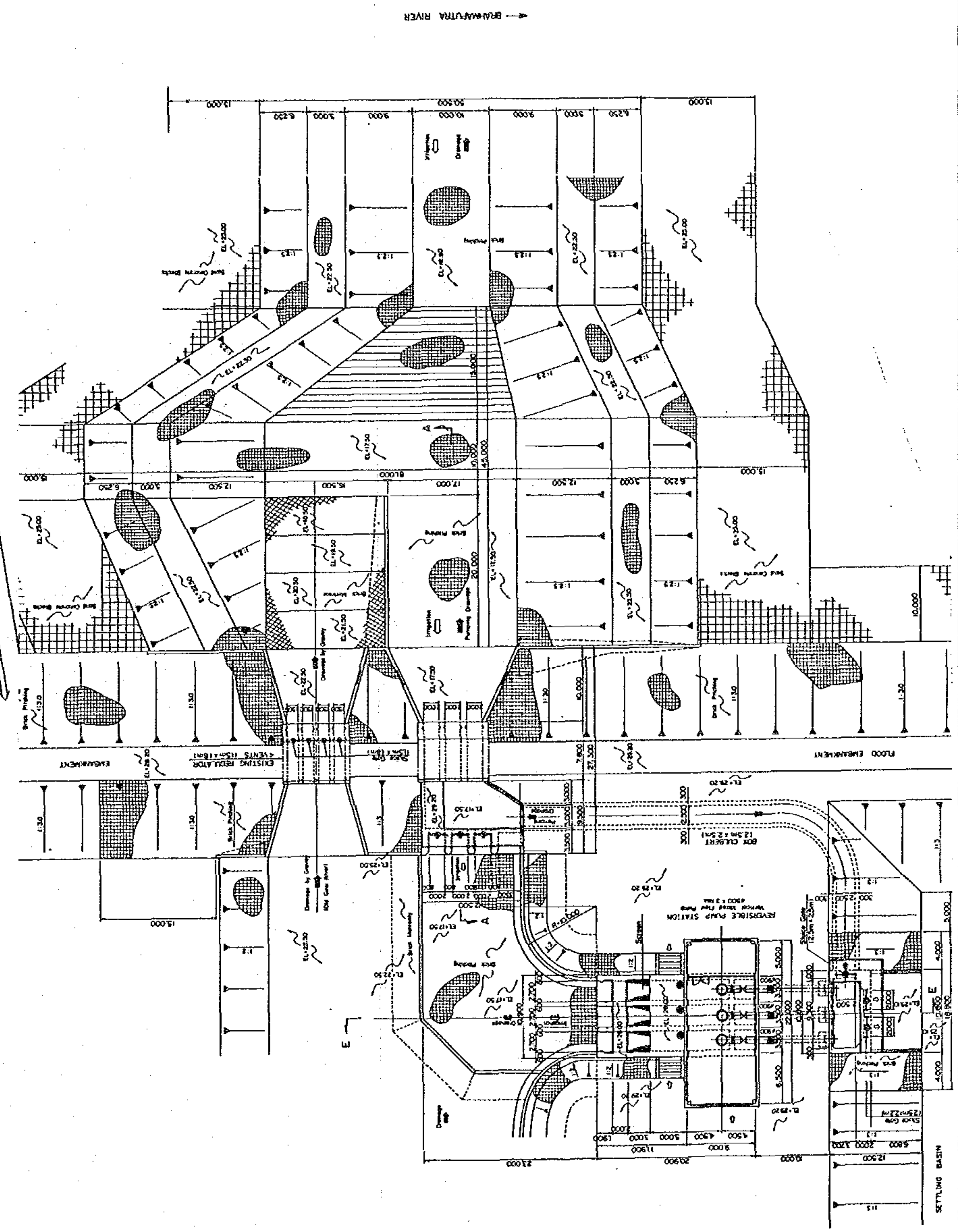
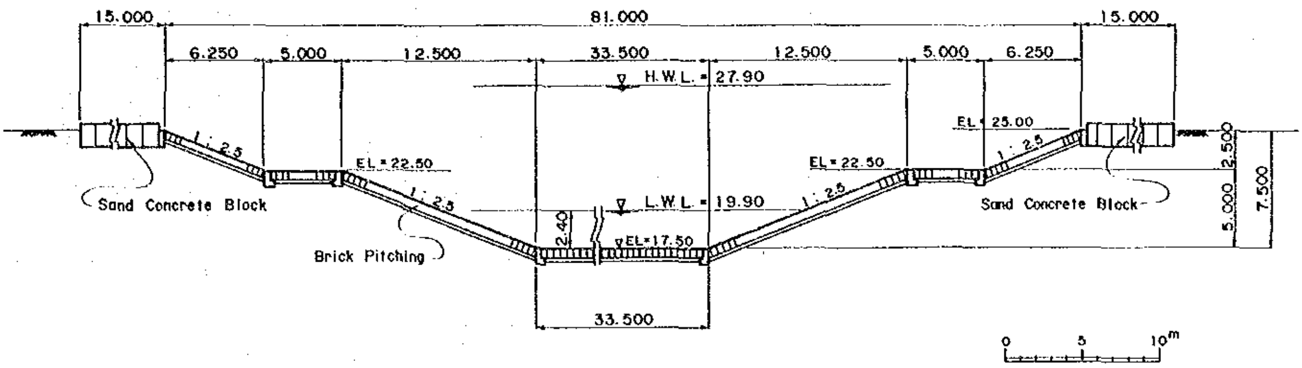
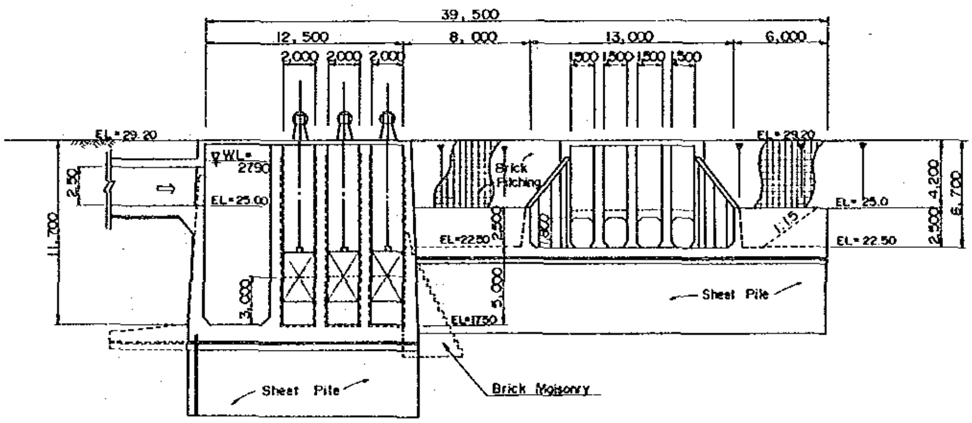


Fig. 5-2 (b) Layout of the Tangonmari Pump Station (2/2)

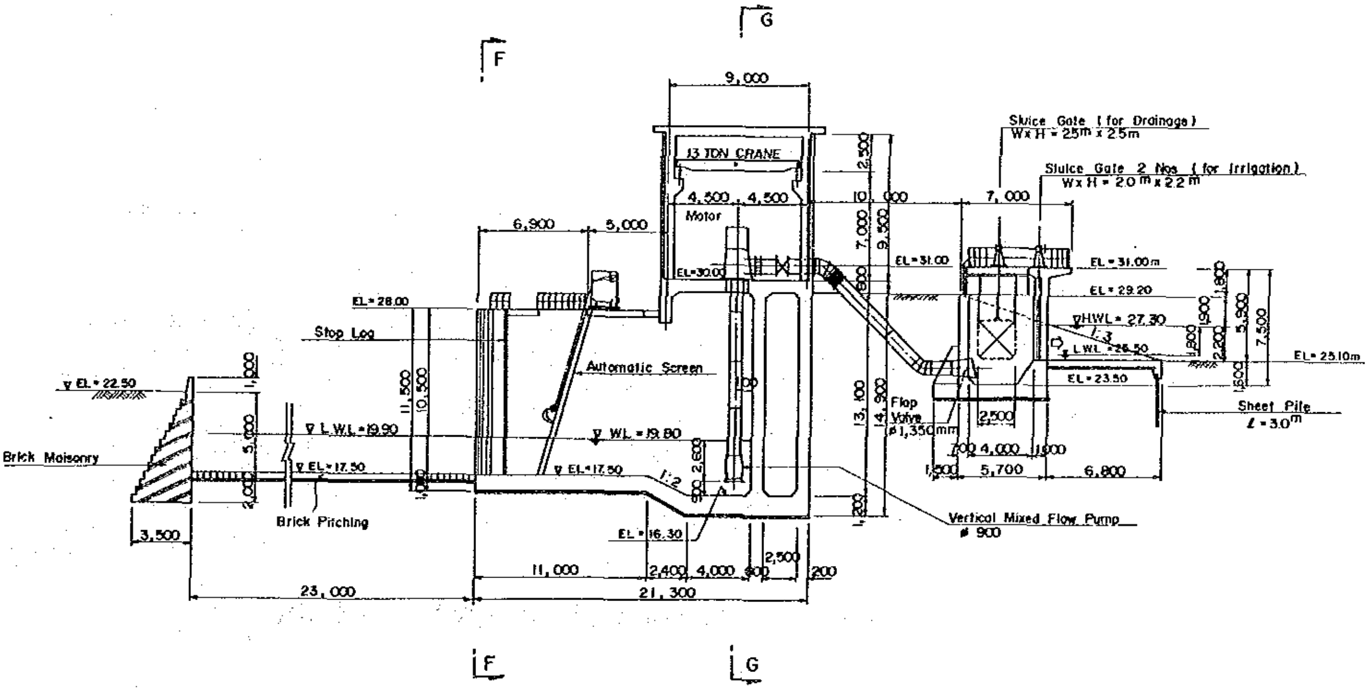
B — B



D — D



E — E



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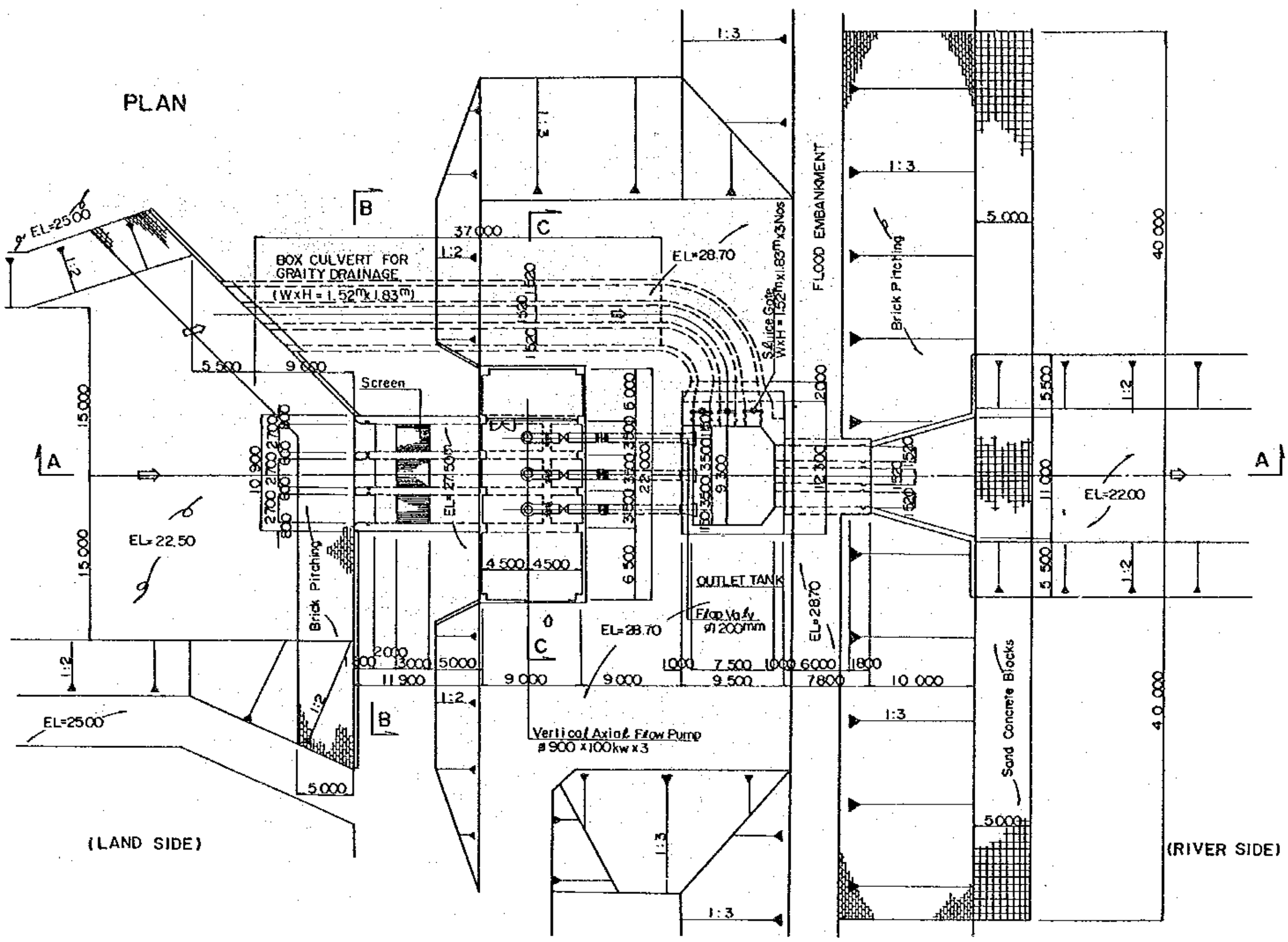


A – A

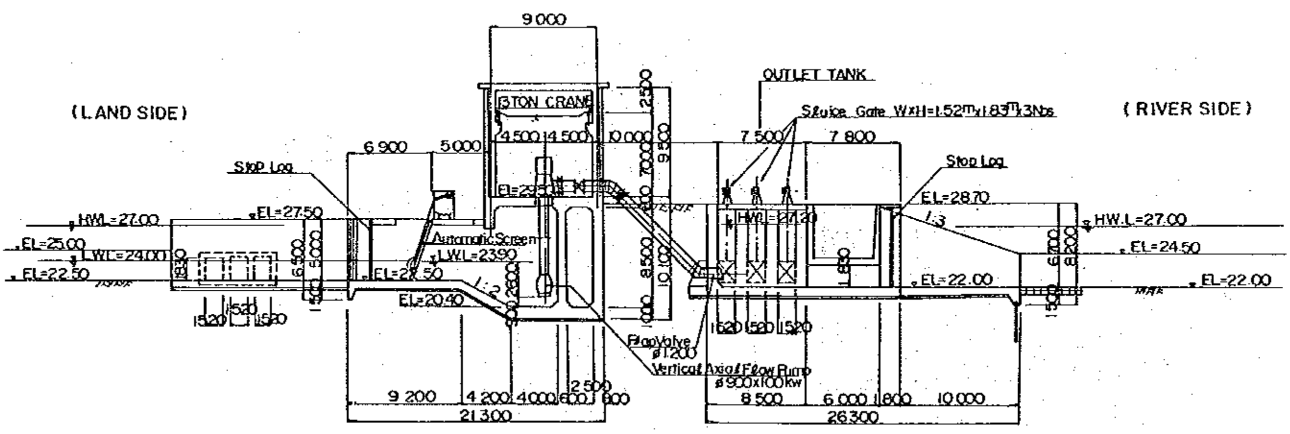


Fig. 5-3 Layout of the Begomganj Drainage Pump Station

5-4. Irrigation Canals

(a) Selection of Canal Cross Sections

1) Hydraulic shape

A cross section of irrigation canal is planned as an unlined trapezoid type from an economical viewpoint.

2) Canal bed gradient

The longitudinal bed slope of a canal is selected considering the maximum and minimum allowable velocities in the canal and the present topographic conditions.

3) Permissible velocity

The maximum allowable velocity is to be 0.6 m/sec considering the soil characteristics of this area, and the minimum, 0.3 m/sec, as a non-silting and a non-weed velocity. The Manning's formula is used as a mean velocity formula to plan canals, as presented below:

$$V = 1/n \cdot R^{2/3} \cdot I^{1/2}$$
$$Q = A \cdot V$$

where, V ; Mean velocity (m/sec)
n ; Coefficient of roughness = 0.025 *)
R ; Hydraulic mean radius (m)
I ; Canal slope
A ; Cross sectional area (m^2)
Q ; Design canal discharge (m^3/sec)

*) The n-value was decided with reference to the value adopted in the Teesta Project.

4) Discharge and depth relationship

The following empirical formula is used to obtain the optimal water depth to a bed width.

$$d = 0.5 \cdot b^{1/2}$$

where, d; Water depth (m)
b; Canal bed width (m)

Keeping the optimal relation between the bed width and water depth optained by the above formula, the optimal water depth to each discharge was studied. And then it was revised cosidering such economic aspects as the earth work cost and the land acquisition cost. (refer to APPENDIX Ⅷ,5-3)

As a result, the following standard water depths are planned for respective canal discharges:

Canal Discharge (m^3 /sec)	Standard water depth (m)
Q = 40	d = 2.5
Q = 20	d = 2.0
Q = 15	d = 1.8
Q = 10	d = 1.5
Q = 5	d = 1.4

5) Freeboard

The formura for freeboard is given bellow with a maximum limit of 0.90 m:

$$Fb = 0.25\,d + 0.30$$

where, Fb; Freeboard (m)
d; Water depth for design discharge (m)

6) Side slope

Side slopes of the fillied canal embankments were determined through a slope stability analysis, considering the hydraulic grade line through the embankment in case of outside slopes. (refer to APPENDIX Ⅷ,5-4)

As a result, the side slopes of the canals are planned as shown in the following table:

Embankment height (m)	Side slope (inside)	(outside)
less than 2.5	1 : 1.5	1 : 2.0
2.5 ~ 3.0	1 : 2.0	1 : 2.0
3.0 ~ 3.5	1 : 2.5	1 : 2.5
3.5 ~ 4.0	1 : 3.0	1 : 30
above 4.0	above 3.5	above 3.5

The side slopes of the cutting embankments of the canals are planned as 1:1.5.

7) Bank top width

The bank top width for one side of the main canals is to be 4.5m as an inspection road, and that for the other side, 2.5 m.

The bank top widths for the secondary and sub-secondary canals are to be 3.5 m for the inspection road sides and 1.5 m for the other sides.

8) Borrow pits

Borrow pits are required for obtaining embankment material. They are to be laid at both the outsides of a canal.

The maximum depth of the borrow pits is to be 2.0 m with a cutting slope of 1:1.

(b) Standard Canal Cross Sections

As for the standard canal cross sections, which are satisfied with the above-mentioned criteria and of least cost, the following canal types are proposed for the main canals and the secondary and sub-secondary canals as shown in Figure 5-4, 5-5 and Table 5-7, 5-8, respectively.

Table 5-7 Dimensions of Main Irrigation Canals : meter

Type	Q(m^3/s)	b	B	d	Fb	H	Canal Slope
M-Ⅰ	42.78 ~40.08	22.0	39.25 ~39.00	2.56 ~2.52	0.89 ~0.88	3.45 ~3.40	1/12,000
M-Ⅱ	23.04 ~18.82	15.0	26.60 ~25.40	2.06 ~1.84	0.84 ~0.76	2.90 ~2.60	1/9,000
M-Ⅲ	17.04 ~13.67	14.0	25.00 ~24.00	1.95 ~1.73	0.80 ~0.77	2.75 ~2.50	1.12,000
M-Ⅳ	16.27	14.0	24.00	1.75	0.75	2.50	1/9,000
M-Ⅴ	14.31	13.0	20.05	1.61	0.74	2.35	1/7,000
M-Ⅵ	11.35	12.0	19.35	1.72	0.73	2.45	1/12,000
M-Ⅶ	9.12	9.0	15.60	1.51	0.69	2.20	1/7,000
M-Ⅷ	6.79	7.0	13.45	1.46	0.69	2.15	1/7,000
M-Ⅸ	5.30	5.5	11.80	1.43	0.67	2.10	1/7,000
M-Ⅹ	4.50	4.5	10.35	1.31	0.64	1.95	1/5,000

Note : Side slope - Type M-Ⅰ ; m1=2.5, m2=3.5
Type M-Ⅱ ~ M-Ⅳ ; m1=2.0, m2=2.0
Type M-Ⅴ ~ M-Ⅹ ; m1=1.5, m2=2.0

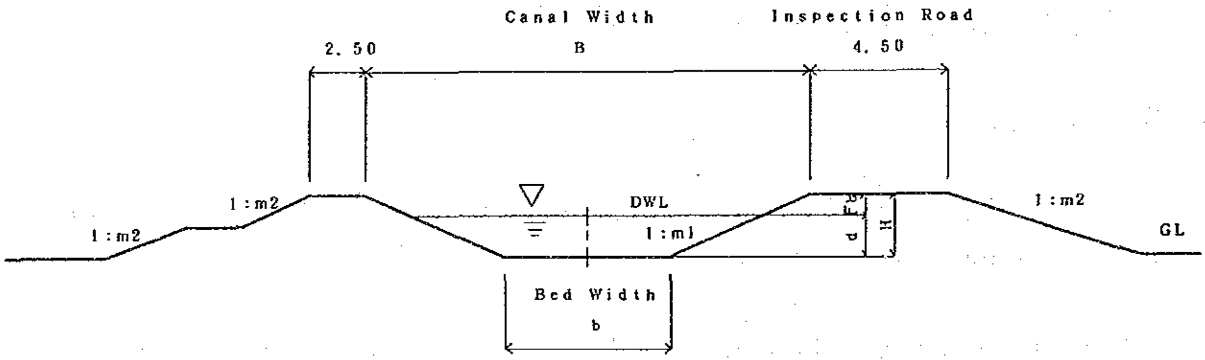


Fig. 5-4 Typical Cross Section of Main Irrigation Canal

Table 5-8 Dimensions of Secondary and Sub - secondary Canals ; meter

Type	Q(m^3/s)	b	B	d	Fd	h	Canal Slope
S - 1	4.50	4.5	10.80	1.43	0.67	2.10	1/7,000
S - 2	4.00	4.0	9.70	1.29	0.61	1.90	1/5,000
S - 3	3.50	4.0	9.40	1.20	0.60	1.80	
S - 4	3.00	3.5	8.75	1.17	0.58	1.75	
S - 5	2.50	3.0	8.10	1.14	0.56	1.70	
S - 6	2.00	3.0	7.65	1.01	0.54	1.55	
S - 7	1.50	2.5	6.85	0.94	0.51	1.45	
S - 8	1.00	2.5	6.10	0.75	0.45	1.20	
S - 9	3.00	3.0	7.95	1.09	0.56	1.65	1/3,000
S - 10	2.50	2.5	7.30	1.07	0.53	1.60	
S - 11	2.00	2.5	7.00	0.95	0.55	1.50	
S - 12	1.50	2.0	6.20	0.89	0.51	1.40	
S - 13	1.00	2.0	5.60	0.72	0.48	1.20	
S - 14	0.75	1.5	4.95	0.70	0.45	1.15	
S - 15	0.50	1.0	4.30	0.65	0.45	1.10	

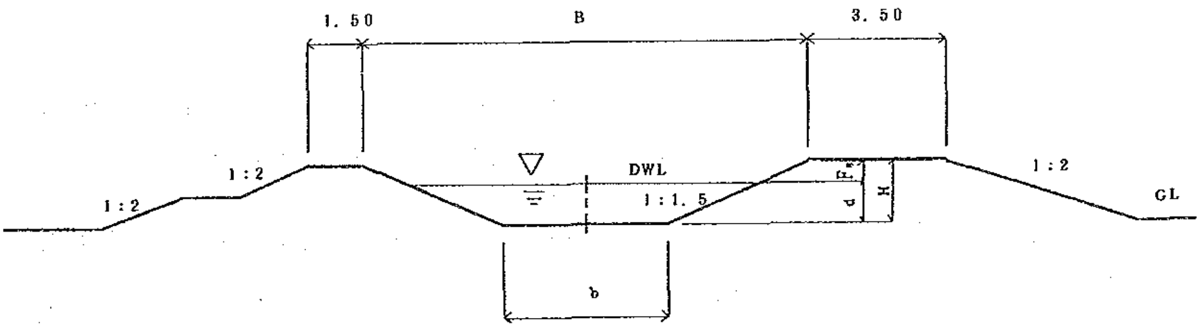


Fig. 5-5 Typical Cross Section of Secondary and Sub - Secondary Canal

5-5. Appurtenant Structures

(a) Bifurcations

Bifurcation structures will be provided at all the places where irrigation canals branch off from their parent canals. Diversion of irrigation water from a main canal or a secondary canal to a secondary canal or a sub-secondary canal will be done by a head gate attached with a water level gauge to measure the water level in the main or secondary canal.

(b) Check Gates

Check gates are proposed to control and raise the water levels in irrigation canals so that the required water can be diverted at head gates of the bifurcations. Check gates are to be situated at the downstream of major bifurcation structures of main and secondary canals at intervals of 5 to 10 km.

(c) Escapes

An escape is provided for the following purposes:

- to discharge the surplus water for regulation and protection of the canal system,
- to scour out the sediment deposited in canals,
- and to evacuate water in canals.

An escape which has the regulating gates incorporates an uncontrolled overflow type spilway to spill out an excess water automatically.

The location of a escape is to be selected near a natural drain as far as possible so that the escape water can easily be drained out through it.

(d) River Crossing Structures

In order to carry irrigation water across a river or a drainage channel, either a syphon or an aqueduct is planned in consideration of the relative bed levels, water levels and discharges of the canal and the drainage.

In case an irrigation canal crosses a small drain or a depression, a drainage culvert or a drainage pipe culvert is advantageous.

(e) Road Crossing Structures

A bridge is planned where an irrigation canal crosses a road. In case the flow amount of the canal is little, a road cross culvert will be adopted instead from an economical viewpoint.

5-6. On-farm Facilities

As on-farm facilities farm ditchs, farm turnouts, road and drainage structures and farm drains are proposed.

The standard cross section of a farm ditch is planned as a trapezoid shape with 0.3 m of bed width, 0.6 m of canal depth, 0.5 m of bank top width and 1:1 of side slope. Diversion of water from a tertiary canal to a farm ditch is done by a pipe culvert and is to be operated by a stop log. A check structure is to be provided in a farm ditch to raise the water level.

In case a farm ditch crosses a road or a drain, a pipe culvert of crossing structure will be provided. A farm drain is planned at lower part of the area at a minimum number and is connected with a natural drain.

5-7. Flood Embankment

Among embankment materials, silty/impervious soils are used to be insufficient in volume along the work site. In the conventional methods, embankment is built only by sandy soils and turfing is placed directly on the slope after shaping.

Under the project, much attention is paid on slope protection that following two types of embankment structure as shown in Fig.5-6 are proposed. Selection out of the two will be made by availability of silty soils in/near the work site. Even if no such soils are available, distant hauling of such soils shall be made in order to secure durability of the embankment.

Necessary heights of embankment crest at key places have been worked out by adding freeboard to HWL of the outer rivers. Profiles of the existing embankment are shown in Fig.5-7 and Fig.5-8 together with HWL and necesary crest height. As seen from the profile, no heightening of esisting embankment crest is necessary unless otherwise damaged/weathered to lower height.

For the existing embankment, methods for repair/rehabilitation are proposed as illustrated in Fig.5-9 . It must be noted that repaired/rehabilitated portion of the cross-section shall not be recovered into the original but be of one of the two improved types.

5-8. Drainage Canal

Regarding the Girai-Nilkamal Pass as mentioned in the previous chapter, necessity for improvement by widening of channel bed has been found (see Appendix Ⅶ,5. for study details). Design discharge as 44.7 cms requires 50 sq.m of sectional area to secure velocity not exceeding 0.9 m/s (150 % of allowable velocity 0.6 m/s for sandy loam soils) during flood. As shown in Fig.5-10, channel bed is proposed to be 17.0 m wide by 6.0m widening from 11.0 m.

Any other portions or reaches of existing drainage channels have been found not to necessarily be improved, so that flood retention function of the project area can be preserved.

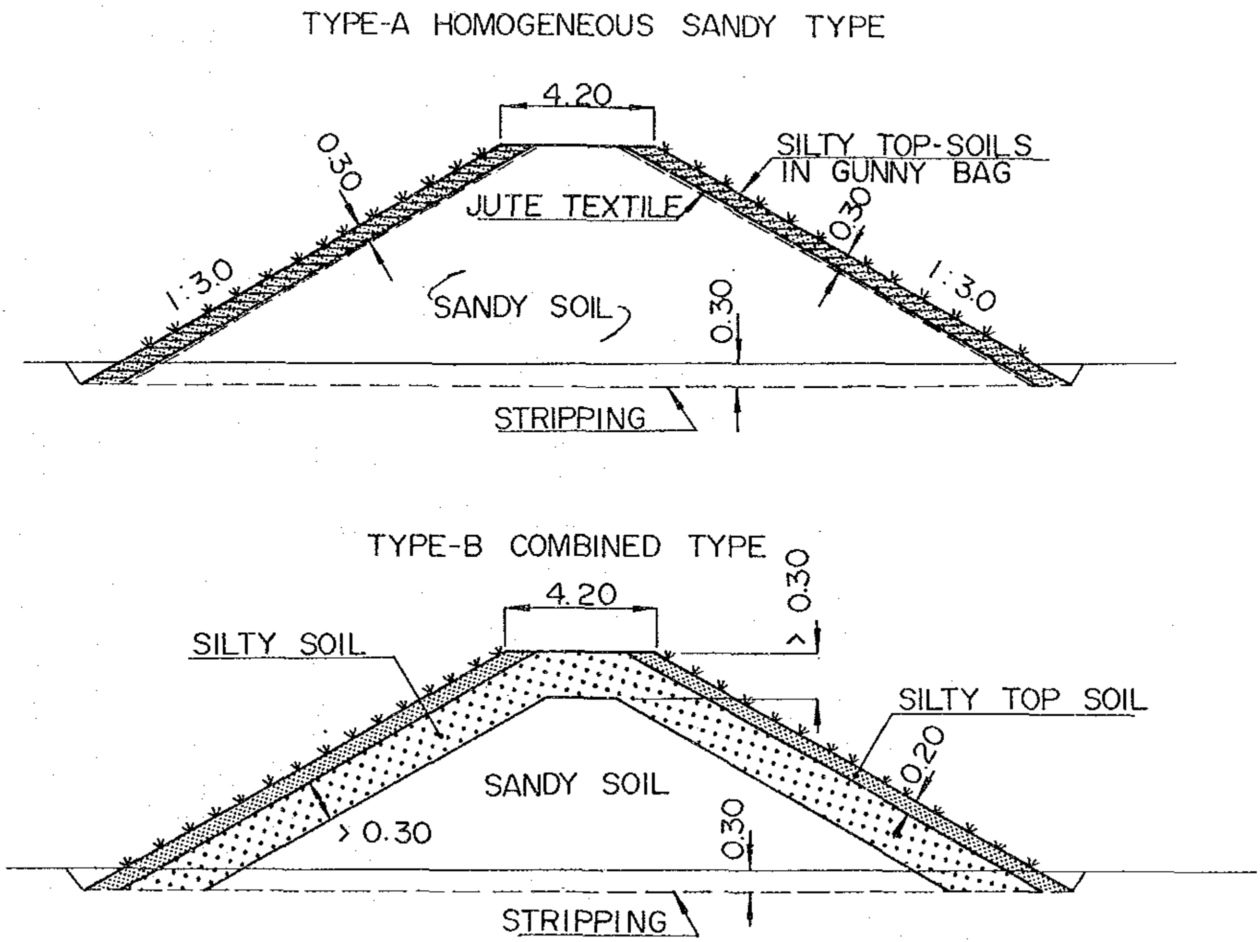


Fig. 5-6 Proposed Flood embankment Cross-section

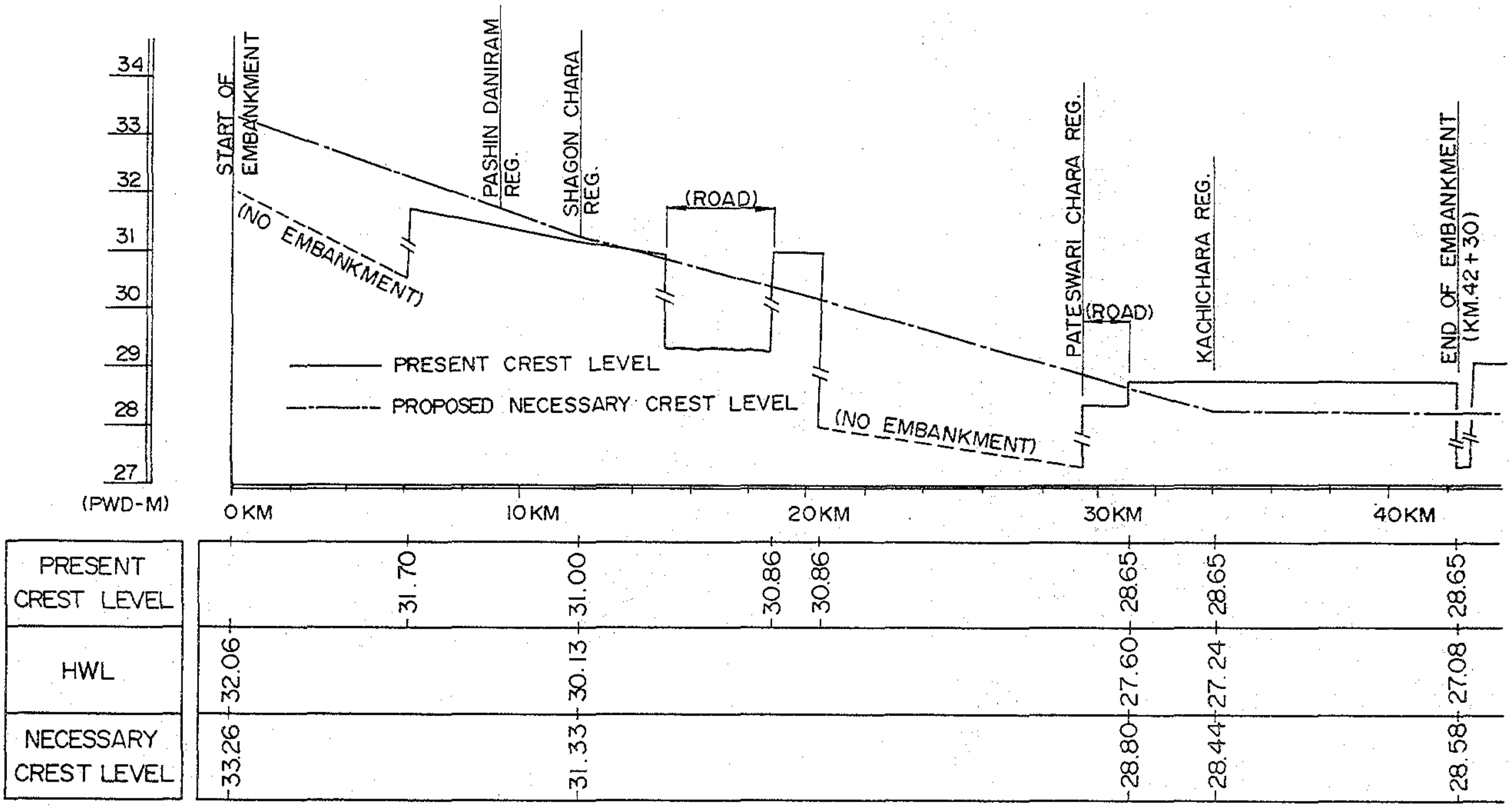
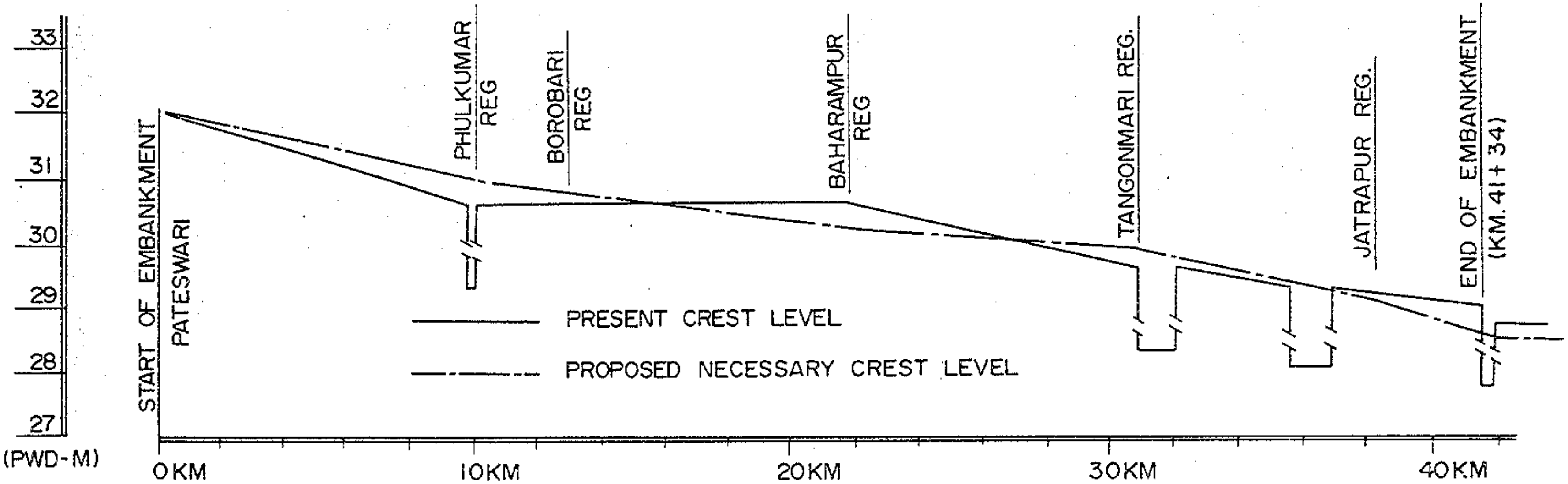


Fig. 5-7 Profile of Dharla Left Embankment



PRESENT CREST LEVEL	32.00	30.60	30.60	29.57	29.26	28.96
HWL	30.90	29.95	29.10	28.52	27.76	27.08
NECESSARY CREST LEVEL	32.10	31.15	30.30	30.02	29.26	28.58

Fig. 5-8 Profile of Dudhkumar Right Embankment

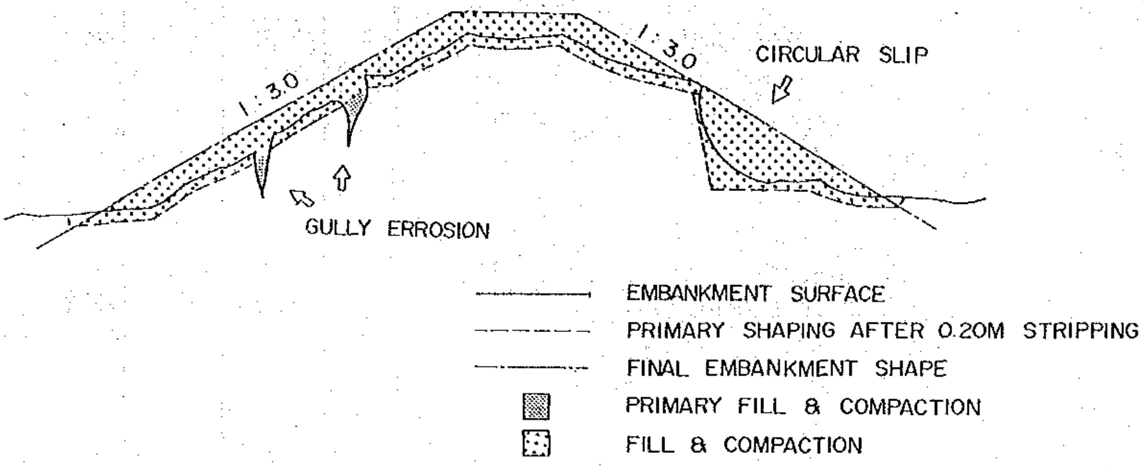


Fig. 5-9 Method of repair / Rehabilitation of Flood Embankment

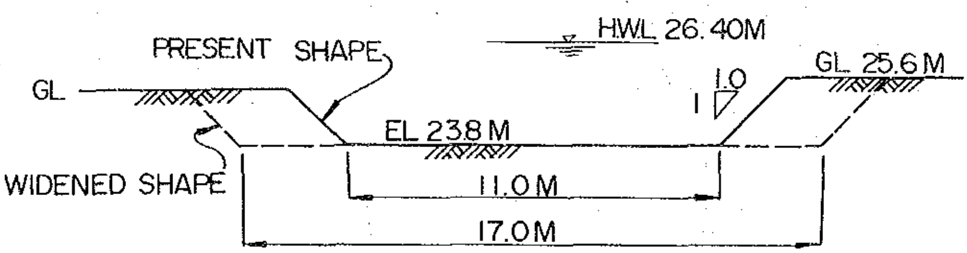


Fig. 5-10 Typical Cross-section of Girai-Nilkamal Pass

CHAPTER 6

COST ESTIMATE

CHAPTER 6 COST ESTIMATE

6-1. Condition of Cost Estimation

The project cost is estimated under the following conditions.

- The project cost is estimated on the basis of the market price as of March, 1990.

- The construction works will be done on contract basis. Civil works are to be done on the local contract basis, while mechanical and electrical works in the pumping stations are on the foreign contract basis.

- The unit prices of materials, labours and civil works are mainly based on "Schedule of Rates for Project- Ⅳ, BWDB, Rangpur(Oct.1989)".

- Data on taxes and inland transportation charges on the imported materials and equipment are quoted from "Customs and Sales Tax, 1989, Ministry of Finance" and "Schedule of Rates for Transportation, 1989-90, Ministry of Food".

- The price of the land acquisition is based on the actual rates in the works of BWDB, Kurigram 1988 to 1989.

- The physical contingency is set at 10 % to the construction and associated costs.

- The price escalation rate is predicted at 10 % for local portion and 7.0 % for foreign portion considering the recent tendency.

- The exchange rate between Bangladesh Taka and US dollar is adopted at US$1.00 = Taka 33.0.

6-2. Project Cost

(a) Project Cost Components

The project cost is to be composed of the following items:

- Construction cost,
- Associated cost,
- Physical contingency, and
- Price escalation.

The construction cost consists of the following construction works:

- Pump stations,
- Irrigation canals and irrigation facilities,
- Drainage facilities,
- Roads,
- On-farm facilities, and
- Transmission and telephone lines.

The associated cost is composed of the following items:

- Construction machinery,
- Agricultural extension facilities,
- Land acquisition,
- Consulting service, and
- Project administration.

(b) Project Cost

The project cost is estimated at about 3,261 million Taka, including local currency component of 1,507 million Taka, foreign currency of 1,372 million taka and import tax of 382 million Taka.

The summary of the project cost is shown in Table 6-1.

Table 6-1 Summary of Project Cost

(Unit; × 1,000 Tk)

Item	L/C	F/C	Tax	Total
1. Construction cost				
a. Pump stations	241,176	685,026	260,830	1,187,032
b. Irrigation canals	146,559	-	-	146,559
c. Irrigation facilities	190,890	74,673	-	265,563
d. Flood embankments	51,100	-	-	51,100
e. Drainage regulators	37,750	24,449	-	62,199
f. Roads	8,078	-	-	8,078
g. On-farm facilities	105,287	14,169	-	119,456
h. Transmission and telephone lines	4,805	17,530	7,997	30,332
Sub-total	785,645	815,847	268,827	1,870,319
2. Associated cost				
a. Construction machines	3,201	57,258	27,519	87,978
b. Agricultural extension facilities	12,765	6,605	1,865	21,235
c. Land acquisition	146,674	-	-	146,674
d. Consulting service	36,608	199,207	-	235,815
e. Project administration	87,986	11,552	1,630	101,168
Sub-total	287,234	274,622	31,014	592,870
Total(1+2)	1,072,879	1,090,469	299,841	2,463,189
3. Physical contingency	78,884	87,311	29,635	195,830
4. Price escalation	354,844	194,703	52,651	602,198
Grand total	1,506,607	1,372,483	382,127	3,261,217

The breakdown of the project cost is given in Table IX -2-1 to Table IX -3-13 of Appendix IX.

(c) Annual Disbursement Schedule

The annual disbursement schedule of the project is based on the project implementation schedule, and the summary is shown in Table 6-2.

Table 6-2 Annual Disbursement Schedule
(Unit; million Tk)

Year	L/C	F/C	Tax	Total
1st	17.5	55.7	-	73.2
2nd	78.4	105.1	34.1	217.6
3rd	238.7	323.0	111.7	673.4
4th	416.6	395.4	121.9	933.9
5th	399.0	342.5	112.4	853.9
6th	257.2	95.9	0.8	353.9
7th	99.2	54.9	1.2	155.3
Total	1,506.6	1,372.5	382.1	3,261.2

Detail of Annual Disbursement Schedule is given in Table IX-6-2 of Appendix IX.

6-3. Operation and Maintenance Cost

After the construction works are completed, the following costs will be incurred every year for operation and maintenance of the project:

- Electricity charge for pumping operation,
- Operation and maintenance cost for pump stations,
- Dredging cost for intake channels,
- Maintenance cost for canals, embankment, hydraulic structures, and
- Administration cost.

The summary of annual operation and maintenance cost is shown in Table 6-3.

Table 6-3 Summary of Annual Operation and Maintenance Cost
(Unit; × 1,000 Tk)

Description	Pateswari Pump Station Area	Tangonmari &Begomganj Pump Station Area	Total
1. Pump stations			
a. Mechanical	8,144	3,320	11,464
b. Electricity	42,041	6,867	48,908
c. Civil work	120	240	360
d. Dredging	252	362	614
Sub-total	50,557	10,789	61,346
2. Irrigation and drainage facilities			
a. Canals	4,300	385	4,685
b. On-farm	2,654	294	2,948
c. Hydraulic structures	1,392	132	1,524
d. Embankment	1,260	141	1,401
e. Regulators	72	30	102
Sub-total	9,678	982	10,660
3. Miscellaneous	3,011	588	3,599
4. Administration	4,584	-	4,584
Total	67,830	12,359	80,189

Detail of Operation and Maintenance Cost is given in Table IX -5-2 of Appendix IX.