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THE PEOPLE'S REPUBLIC OF BANGLADESH
FLOOD PLAN COORDINATION ORGANIZATION

FEASIBILITY STUDY ON GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A

FAP 8A

SUPPORTING REPORT I

JUNE 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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ON
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ABBREVIATIONS

ADB	Asian Development Bank
AIT	Asian Institute of Technology
BBS	Bangladesh Bureau of Statistics
BMD	Bangladesh Meteorological Department
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CAAB	Civil Aviation Authority of Bangladesh
DIT	Dhaka Improvement Trust (now RAJUK)
DMAIUDP	Dhaka Metropolitan Area Integrated Urban Development Plan
DMC	Dhaka Municipal Corporation
DND Triangle	Dhaka - Narayanganj - Demra Triangle
DPHE	Department of Public Health Engineering
DOE	Department of Environment
DWASA	Dhaka Water and Sewerage Authority
ERD	External Resources Division Ministry of Finance
FAP	Flood Action Plan
FPCO	Flood Plan Coordination Organization
GDPP	Greater Dhaka Protection Project
GDFCD Project	Greater Dhaka Flood Control and Drainage Project
GOB	Government of Bangladesh
JICA	Japan International Cooperation Agency
MIWDFC	Ministry of Irrigation, Water Development and Flood Control
MPO	Master Plan Organization
PDB	Power Development Board
PHD	Public Health Department
PWD	Public Works Department
RHD	Roads and Highways Department

RAJUK	Rajdhani Unnayan Katripakkha (Capital Development Authority)
RRI	River Research Institute of the Ministry of Irrigation, Water Development and Flood Control
SOB	Survey of Bangladesh
SWMC	Surface Water Modelling Center
SPARRSO	Space Research and Remote Sensing
UNCHS	United Nations Center for Human Settlements
UNDP	United Nations Development Programme
WAPDA	Water and Power Development Authority
WASA	Water and Sewerage Authority
WMO	World Meteorological Organization

SUPPORTING REPORT A
URBAN PLANNING AND LAND USE

SUPPORTING REPORT - A : URBAN PLANNING AND LAND USE

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1. General

Three areas have been selected for feasibility study. Though they constitute a continuous zone along the eastern side of the metropolitan area, they have different characteristics and are at different stages of urban development. (See Fig. A. 1).

The purpose of this section is to determine which parts of each area are likely to be developed within the flood protection plan period and when, so as to provide a more detailed picture than the master plan for use in determining the feasibility of flood protection proposals. Showing the areas most likely to be developed for urban use permits a better delineation of land needed for flood protection measures (especially retarding areas). This land needs to be protected from further development prior to acquisition. The section also outlines development control measures needed, discusses land acquisition, management, and cost-recovery issues, and makes an initial assessment of suitable uses for retarding areas.

The Greater Dhaka East is by far the largest area but is the least developed of the feasibility study areas. This is mostly because, under current conditions, large parts of the central and southern areas are flooded for most of the year, while the higher land to the north is quite distant from the city. Nevertheless, considerable peripheral development has taken place during the last decade by means of landfill, especially in the southern portion closest to the city centre. The construction of the new RAJUK spine road has also provided a platform for further peripheral development to the East. Further north, in Uttara, RAJUK has initiated sizable developments.

Further planned and unplanned peripheral development may be anticipated during the next decade, both on higher land and on land made higher by landfill. However, more comprehensive development of the area depends on flood protection, and because of the area's size would be over a long period.

The DND is the second largest area bounded by metalled roads and flood walls. As the area was developed for irrigation it is drained and largely flood-free. Because of its proximity to the city, and because it is relatively flood free, the DND has developed quite rapidly during the last decade, particularly in the north west corner. Currently RAJUK is preparing a development plan for the area. Further substantial development is anticipated over the next decade.

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Narayanganj West is the third feasibility study area, much smaller but much more intensively developed. The town is on relatively high land and developed independently from Dhaka. However, as Dhaka grew, the area between the two towns has become almost continuously built up. The development of the DND will see Narayanganj further becoming part of Dhaka.

A series of maps and overlays have been prepared for each of these feasibility study areas. These have been used to determine which are the likeliest parts to be developed. The overall development context is that forecast for Dhaka in the Master Plan : the total development distributed in each area corresponds to the population increase forecast for each of these areas in the periods 1990-2000 and 2000-2010. These development areas have been drawn on the basis of land suitability, proximity to existing services and existing developments, and provide the broad picture required. An indicative land use maps 2010 have been prepared to show an ideal distribution of major land uses and road network, but no attempt has been made to distinguish or zone future land uses. Such an exercise would be soon outdated by the metropolitan plan studies due to start in 1992. The intention here is only to forecast the likely extent of development for use in determining the feasibility of flood protection measures.

2. GREATER DHAKA EAST

2.1. Physical Features. (see Figs. A.2 and A.3)

The area covers 118.62 square kilometers. It is bounded on the north by the Turag river, to the east by the Balu river, to the south by the Demra road, and to the west by the Dhaka-Mymensingh road, the DIT (Rampura) road and Biswa road.

Apart from small portions in the north west and south west, the area is drained east to the Balu river. It forms some two-third of the Greater Dhaka drainage basin, which includes Gulshan and Banani, Tejgaon, and other areas to the south in central Dhaka.

There is an area of higher land (5m+) along the western border, the larger portion being to the north in Uttara East, but with another large portion from Khilgaon to Jatrabari in the south. This land is usually flood-free. However most other areas are low-lying and under water for over half the year. In the central part, in particular, most of the land is under 2.5 metres, with perhaps half of that under 2 metres.

2.2. Outline Flood Protection Strategy (see Fig. A.4)

The Greater Dhaka East area is divided into five drainage zones for the purpose of stormwater drainage. The catchment area of these zone extends beyond the Rampura - Biswa road. However for the protection of the area from external sources of flood water the Greater Dhaka East is also divided into four compartments defined by embankments. The compartments and the drainage zones are complementary and serves specific purposes (see Fig. A.4).

Since compartments and their embankments will have profound effect on the urban planning / landuse issues this section emphasises on the four compartments while drainage zones and their related issues are covered in the Supporting Report of E.

The northern and eastern boundaries of Greater Dhaka East will be defined by the main flood protection embankment, designed to a 100 year flood frequency. The western boundary, on the existing new road, will be raised and flood proofed to form a permanent partition within the internal compartmentalization strategy. It will be designed to withstand floods of 50 year frequency. Similarly, the southern boundary of the zone, the existing embankment and flood wall on the Demra road, will be rehabilitated to form a partition in the compartmentalization system.

Four compartments enclosed by embankment are proposed within the Greater Dhaka East (instead of three) as the result of reviewing the three drainage zones at the Master Plan study. These are from the north ;

1)	Northern compartment	(4,070 ha)
2)	Central compartment	(3,200 ha)
3)	Southern compartment - 1	(1,460 ha)
4)	Southern compartment - 2	(3,130 ha)

The southern compartment - 2 has two retarding areas, with a combined size of 525 ha, to cater for one-fourth of the Greater Dhaka East drainage zone which includes Demra and the southern peripheral zone between the Begunbari khal and the Dhaka-Demra road and also extends upto Motijeel and part of Ramna. Water drains through pump and sluice gate to the Balu river.

The southern compartment - 1 also drains east mainly by the Begunbari khal through a pump and sluice gate, to the Balu river. The drainage zone includes Badda and Shatarkul and also extends upto Gulshan, Tejgaon, Dhanmondi and a part of Ramna.

The northern compartment, apart from its northern edge, also drains east through two retarding areas (263 ha), pump and sluice gate, to the Balu river. The central compartment, similarly drains east through a retarding area (558 ha), pump and sluice gate. In addition, half the International Airport drains through this zone.

The internal embankments between the four compartments, the main drainage pattern, and the exclusion of the retarding area areas from development, form a framework within which urban development has to take place.

2.3 Existing and Proposed Development (see Figs. A.5 and A.6)

As Dhaka has grown, with land availability not keeping pace with population growth densities have increased and development has been squeezed into those peripheral areas which are relatively flood free and closest to areas of job opportunity, In the Greater Dhaka East, it is the south west portion which has experienced most such peripheral growth. Areas of planned development on existing higher land and on land made higher by fill, are interspersed with areas of katcha and squatter development on lower lying, more peripheral, and less attractive land.

Further north, the completion of the Rampura road has accelerated eastwards growth during the past few years, again mostly on higher or fill land not too far back from the road frontage. Development has not been as intense as to the south, because of greater distance from the city centre. Most of the development has been in planned fashion.

North of the Airport, despite extensive areas of high, flood-free ground, there has been little development to the east of the railway line. There are however, currently, indications of linear growth along the major access roads into the area. Because of distance from city , development pressures clearly been despite the flood-free elevation.

Fig. A.5 shows the existing land use. Apart from the fringe areas along the Rampura road, the predominant land use is agriculture and rural. Only 20% of the area is built-up. The table below shows the areas of existing land use.

EXISTING LAND USE OF GREATER DHAKA EAST (1990)

	Unit = ha.	
Total Area	11,862	(100%)
Residential	2,248	(19 %)
Commercial	40	(0 %)
Industrial	1	(0 %)
Institutional	23	(0 %)
Agricultural	8,814	(75%)
Water Bodies	735	(6 %)
Built-up Area	2,313	(19%)

During the next decade, the absence of a pubic transport system which allows northern expansion and the non-availability of large areas of serviced land, suggest that peripheral development pressures will persist. The Greater Dhaka East is one of the major areas where such growth will be apparent.

Fig. A.6 shows the areas currently under construction. In addition there are other areas where RAJUK intend to implement their own development and where development is intended to proceed in accordance with a RAJUK zonal plan. There are also commitments for large scale planned private development. Elsewhere, unapproved development is to be proceeding. A continuation of such peripheral growth may be expected even without protection afford by embankments. But, as public perceptions regarding flood protection become established, an acceleration may be anticipated. Such development, and its associated landfill, may affect the drainage pattern and prejudice flood protection. In the absence of an overall guidance plan for the area, a rational development will be difficult to achieve. It is important then to delineate all areas needed for flood protection measures (and other major infrastructure needs) at the earliest, so that such reservations may be safeguarded until construction take place.

2.4 Infrastructure (see Fig. A.7)

The present framework of services shows a predictable pattern, being restricted to areas already developed. Provision of services usually follows the development of unplanned areas, but will be provided at the same time for planned, higher cost, construction. Infrastructure provision may also proceed and influence the pattern of growth. Thus, unplanned growth may follow roads. This is already seen in both the

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northern and the southern compartments. Flood protection measures, which create new areas of developable land, will also influence the pattern.

Current infrastructure distribution suggest that over the next decade, incremental peripheral development will continue. services will be extended as demand arises. In the longer term, safeguarding areas of land from flooding will permit a much more extensive scale of development, but, again, it will be incremental, from west to east.

2.5 Population and Land Use (see Fig. A.8 and A.9)

The 1981 census and the Master Plan provide the basis for estimates of existing and future population levels in this area.

The Master Plan contains our estimates of current population and forecasts of future growth for the Dhaka conurbation. It also distributes this forecast population growth between different parts of the city. This is based on a number of stated assumptions regarding ;

- the proportion of relatively rich and poor
- the unfair allocation of land between them
- increased densities and new land development
- the attraction of proximity to work opportunities
- the possibility of improved urban land delivery post 2000

Population totals resulting from these assumptions, for 1990, 2000 and 2010, were tabulated into over 100 study area zones. These tabulations are the source of the population distributions for the Greater Dhaka East area which are quoted here. They reflect our strategic forecast regarding the growth of the metropolitan area. Total population of the area for 1990 is estimated around 638,000. An estimated 427,000 are in the southern compartment-2 and 24,000, which is the lowest figure, in the southern compartment-1. The northern compartment holds about 126,000 and the central compartments have 61,000 . By the end of the century, the population of the whole of the area is expected to double to almost 1.15 million. Almost 60% of this will be in the southern compartment-2, but greater percentage gains will be seen in the northern and central parts. By 2010, a further overall increase of almost 90% is anticipated, to over 2.2 million. The greatest proportional increase is anticipated in the north, the rate of growth in the south having decreased in this period.

Over the whole twenty year period, the relative importance of the southern compartment-2 declines. However, it will retain the heaviest concentration of population throughout. Nearly 45% of the population of the whole area will be here even by 2010. This distribution between compartments is summarized below :

	1990	2000	2010
North	126,000	282,000	772,000
Central	61,000	140,000	259,000
South -1	24,000	52,000	212,000
South -2	427,000	677,000	958,000
Total :	638,000	1,151,000	2,201,000

The distribution of population within each of the compartments is made with different degrees of confidence

1) for 1990, distribution is made on the basis of the existing lade use survey. The population for each zone is distributed between each developed area in that zone.

   If our overall assumptions on 1981-1990 growth are reasonable, then it probably provides a reasonably accurate distribution of existing population.

2) for 2000 there will be some loss of accuracy, but the development pattern may be predicted with some confidence and commitments in the area are known. Distribution is based on the assumption that peripheral growth will continue in the most favourable areas, closest to existing services and on higher land. An indication of the extend of developed areas and their populations for 1990 and 2000 is shown on Fig. A.8.

3) post 2000, the overall population forecast, influenced by a variety of factors, is less sure. The extent of development will depend on whether the flood protection framework will be in place, and whether mechanisms for delivery of urban land will have been developed.

4) Fig.A.9 shows an indicative land use pattern at the year of 2010. Although the delineation of future land use pattern is beyond the scope of the study, an ideal distribution pattern of major land use and road network are shown on the

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assumption that, further urban growth will be controlled, flood protection measures will be fully implemented as proposed, and finally, planned development of infrastructure and public facilities will be undertaken by relevant public sectors on a certain higher standard which was stated in the Master Plan study. The following table shows the land use table of the area in 2010.

FUTURE LAND USE OF GREATER DHAKA EAST (2010)

	Unit = ha	
Total Area	11,862	(100%)
Residential	5,917	(50 %)
Commercial	436	(4 %)
Industrial	39	(0 %)
Institutional	2,158	(18 %)
Agricultural	1,310	(11 %)
Water Bodies	2,002	(17 %).
Built-up Area	8,550	(72 %)

5) if these assumed acts on the part of the government are not carried out as planned, then the developed pattern could be more intensive, with smaller areas being development after landfilling, especially in the southern compartment - 2 and the northern compartment.

2.6 Major Development Issues affecting Flood Protection Proposals

The implementation of flood protection measures will provide part of the framework for future urban development. But there are also overall development, acquisition, control and land management issues which will affect the achievement of such a flood protection plan. These overall issues are discussed in Sections 5 and 6. In addition, there are specific development issues in the Greater Dhaka East which touch upon the nature of the flood protection measures. These are discussed below :

1) A by-pass linking Demra and Tongi, on the proposed Balu river embankment, has been proposed in some quarters. The provision of such a road would affect embankment design. The proposed Dhaka Transportation Study should provide a reasoned answer to whether such a road is needed. As, unfortunately, this study is unlikely to start until early 1992, we assume that this authoritative answer is unlikely until late '92, after the completion of our study. Current

traffic levels on segments of the Biswa/Rampura road, which forms the current eastern 'by-pass' are low. This suggests that provision is unwarranted.

While embankment design could incorporate the later addition of a by-pass, additional land acquisition would be needed for the increased width. In view of the magnitude of prospective land acquisition costs overall, and other road priorities elsewhere, we suspect that further present costs to provide for a long term need would be unjustified. We would therefore advise that while embankment design can reflect possible long term widening, actual land acquisition and construction should be at a later stage. At present, the external embankment should reflect flood protection requirements.

2) The current nature of development in the area makes no allowance for long term growth. Thus no reservations are made for long term needs. In particular, there is no framework of roads outlined which would enable the area to be developed in a planned fashion. In the southern portion it is already difficult to see how a major E-W distributor could be provided in the area without substantial demolition. Already the existing roads are inadequate and crowded.

We therefore consider that development of the four compartments could be on a framework where the access roads into the area would be on the internal embankments. However, those access roads would not function as major roads of the new areas, so that internal and inter-regional trunk roads will be required both for E-W and N-S directions. These roads could be phased as development requires. Again, the prospective transportation study may propose the most appropriate width. Provisionally, we suggest that the reservations for the major roads to serve such large area should be of dual carriageway standard (though the road itself could be widened in stages) allowing two vehicles, two rickshaws and a footpath in each direction. This could be incorporated within a 30 metre road reserve. Careful coordination with the stormwater drainage system must be taken up for more integrated development.

3) The need to protect retarding areas is commented on in Sections 5 and 6. The retarding areas are located in low-lying areas, mostly some distance from existing development. However, the pace of growth, particularly in the south-west (which could well accelerate if further E-W links are provided in Dhaka West) is such that particular difficulty may be experienced in protecting the pond in this south-west corner.

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4) Current development control policies take limited account of flood protection requirements. The need to do so is discussed in subsequent sections. Applications such as that by Eastern Housing for the development of 830 acres in this area have not taken the required ground height level into account and limited attention is paid on their effect on major drainage channels. The plotting of this development by RAJUK suggests that the development does impinge on a major drainage channel. We proposed therefore that any future major applications in this areas should only be approved after ensuring that it complies with flood protection requirements.

5) Again, in Section 6, we comment on the need to recognize that settlement on embankments cannot be prevented in some areas. Accordingly, we suggest that in such areas, the design of the embankment takes this into account. In Greater Dhaka East, the internal embankments are likely to be attractive places for development, while the Balu river embankment is too distant from work opportunities to be regarded as such.

6) For most of the year, navigable water exists between the Balu River on one side and Rampura road and Madartek on the other (through the Begunbari Khal). the Rampura road by the T.V. Station is a major port for the Balu river. Major items transferred to road transport here include passengers, bamboo, sugarcane, building supplies, pottery, and some foodstuffs. There are distinct benefits in keeping this waterway open, given the advantages of water transport.

It therefore appears that the embankment road dividing the southern compartment -1 and the southern compartment - 2, will replace this waterway.

7) There is currently no overall strategy for development of the Greater Dhaka East area. RAJUK plans in preparation for a narrow strip fronting the Rampura road are not being prepared in accordance with any overall framework. Decisions on private development applications are not made in accordance with any overall framework. No consideration is being given to medium and long term probabilities. Neither the future rational development of the area is possible without such a framework, nor can flood protection requirements be safeguarded in its absence. We therefore very strongly recommended that some overall plan is prepared for the Greater Dhaka East. In Section 5.4 we consider how the proposed metropolitan planning study may satisfy this requirement.

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3. DND

3.1 Physical Features (see Figs. A.10 and A.11)

The area covers a total of 56.79 km^2. The area is of a triangular shape and formed by three major roads. North of this area is bounded by the Demra road. A second road, Dhaka-Narayanganj highway bounds the area on the western side and the third road is Demra to Narayanganj highway and bounds the area on the East. The last two joins together in the south of the area to form the triangular shape.

The area was subject to annual flooding prior to the construction of the road-cum-embankment in the mid 1960s that encompass the area. However the flood of 1988 was higher than the embankment and the government constructed a flood wall in 1988 to stop the water. With the construction of the road-cum-embankments in the mid 1960s the area became generally flood free with good agricultural potential. Apart from a small area in the south and built up areas on the north-west, generally the better part of DND has an elevation less than 5 m. Large areas in the centre and east are below 2.5 m.

The entire DND area is criss-crossed by irrigation canals, the pump station in the peripheral roads pump water in and out as the area demands. There are pockets of permanent water bodies and linear canals along the DND flood wall.

One central spine of Dhaka-Katchpur highway cuts across the DND area and other than that, the rest of the roads are unplanned and sporadic.

3.2 Outline Flood Protection Strategy (see Fig. A.12)

The DND area is already protected by the three roads and the concrete wall on top forming the flood wall. There is a lot to be said about the effectiveness of this concrete wall, though it forms an integral part of the present flood wall. It is noted that the present flood wall was sufficient to provide flood protection in 1988 and the water was upto the level of this flood wall.

The flood protection strategy recommends that the present flood wall be rehabilitated. Certain parts of this flood wall will have to be raised to give the flood wall equal height in all parts.

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The strategy outlines two drainage zones for the DND area. Fig. A.12 shows an internal drainage sub-zones separating the DND area into that northern part and the southern part.

Three new canals are proposed (shown in double broken lines) within this area to facilitate drainage. These will add to the already existing network of canals to form an efficient system.

One pumphouse already exists near the Katchpur bridge and this will be supported by a new pumphouse further south. Mostly the DND drainage will be handled by these pumpstations. The existing pumpstation is of limited capacity and the area around the pumpstation does not allow the creation of a sufficiently large retarding area. This prompted the necessity of a second larger station in the south with sufficiently large retarding area. The canal network is also adjusted to facilitate smooth functioning of the system.

Six retarding areas are proposed in the DND area. The location and sizes were determined after careful consideration of land contours, existing settlements, RAJUK's scheme, population growth areas (projected to 2010) and DND area drainage requirements. Three retarding areas are in the northern drainage zone cumulatively occupies 266 hectares, while the other three on the southern zone occupies 377.5 hectares. The entire DND area drains eastwards and water is pumped out through pumphouses.

3.3 Existing and Proposed Development (see Figs. A.13 and A.14)

The DND area is in between Dhaka and Narayanganj. This fact in the past has initiated development pressures from Dhaka and Narayanganj side. The high cost of land and high densification around the CBD area of Dhaka has spilled developments over the northern part of the DND. All along the three major highways around the DND, sporadic development has taken place.

Around the north-west of DND area there is a large settlement opposite the Jatrabari area. On the southern tip of the area the land adjacent to the Narayanganj West is also developed to an extent. There are village settlements of small and large sizes throughout the DND in general.

Commercial enterprises such as brick fields, building materials trans-shipment points, have grown along the western highway. Dhaka WASA has a large area designated as sewage treatment area, also in the west. Medium density settlements have grown all along the highway housing commuters working either in Dhaka or Narayanganj. Recent developments along the Dhaka-Katchpur highway suggests that within a short time unless planned settlements are made, the growth of the unplanned settlements will continue.

Table below and Fig. A.13 shows the existing land use pattern.

EXISTING LAND USE OF DND (1990)

	Unit = ha	
Total Area	5,679	(100%)
Residential	1,864	(33 %)
Commercial	56	(1 %)
Industrial	196	(3 %)
Institutional	59	(1 %)
Agricultural	3,173	(56 %)
Water Bodies	332	(6 %)
Built-up Area	2,174	(38 %)

Fig. A.14 shows the areas presently under construction. There are substantial RAJUK project in the pipeline designated for this area. A better part of the added new development areas of the DND during the next decade will be initiated by the RAJUK. There are at least four settlements to be developed by the RAJUK out of which one in the south, namely Panchabati is in an advanced stage of land acquisition.

Unplanned developments are sure to continue in the future with the existing metropolice becoming more dense day by day. The recent floods in 1988 which inundated a better part of Dhaka, could not penetrate the DND area. This in itself has provided a moral boost to the would be developers of DND area and it is reasonable to assume development of further settlements in the area at an accelerated rate in the coming decade.

RAJUK has drawn up a schematic master plan for the DND area, showing roads and settlement areas. This plan is on the process of Government approval. Apparently this scheme does not take into account certain issues such as topography, ground height of

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landfilling, drainage, etc. With the completion of the JICA study and the Metropolitan Plan study in 1992, the RAJUK master plan may have to undergo certain changes.

3.4 Infrastructure (see Fig. A.15)

The new N-S spine road connecting middle of the Demra road and Narayanganj is now under construction and being executed by Roads and Highways Department. This road will stimulate the escalation of urban development of DND.

The present provision of services are clearly inadequate for any large scale development. Though electrical connections are quite developed and the proximity to the Siddirganj Power Station renders considerable potential, the water and gas services leaves a lot to desire. With the planned growth of the settlement areas these services however will develop rapidly as suggested by similar trends in other areas of the city.

3.5 Population and Land Use (see Figs. A.16 and A.17)

The total population of DND in 1990 was calculated at 449,000. The study area was segmented into 14 zones and population were calculated for the year 2000 and 2010 against each of the areas. These increases took into account new areas of development and further densification of the existing settlement areas. The larger part of the 1990 population is concentrated along the boundary roads, and also in the north-east and the south of the area. However new areas of development either sporadic or planned, will be in the central area. By the turn of the century the total population will amount to 880,000. This again will increase to 1,314,000 in the year 2010. Table A.4 shows the growth of population and land use for the three dates.

The new areas of development are largely known for the next decade. The proposed areas of RAJUK are included in the tabulations. It is assumed that RAJUK will be able to control development in the retarding areas. However, in the event of RAJUKs developments and if alternate urban areas in the Dhaka conurbation is slow to develop, the DND will bear the highest pressure of development.

Fig. A.17 shows an indicative land use pattern at the year 2010. This ideal map shows most of the new areas will be developed according to RAJUK scheme and necessary areas for retarding areas and agricultural areas will be well controlled. The land use composition is shown in the table below :

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FUTURE LAND USE OF DND (2010)

	Unit = ha	
Total Area	5,679	(100%)
Residential	2,463	(43 %)
Commercial	172	(3 %)
Industrial	482	(8 %)
Institutional	1,153	(20 %)
Agricultural	532	(9 %)
Water Bodies	877	(15 %).
Built-up Area	4,270	(75 %)

3.6 Major Development Issues affecting Flood Protection Proposals

The future developments in the study area must follow guidelines as spelled out by the flood protection proposals. However certain issues with regard to RAJUK's plans will affect flood control plans. These are summarized below :

1) The Dhaka Narayanganj road which is under construction by the Roads and Highways Department will provide a barrier to the drainage plans. RAJUK intends to extend this road upto the Demra road, which again will further compartmentalize the area.

2) The irrigation canals within the DND should be kept away from development.

3) RAJUK's new settlements must be in conformity with the drainage plan. Indiscriminate cutting or filling for levelling purposes may also adversely effect the drainage plan.

4) Retarding areas will be hard to control. Given the pressure on land and the developments by RAJUK, holding the retarding areas away from development may pose to be one of the main problems facing RAJUK. We must therefore suggest that some form of control and management procedure be drawn up along with development schemes that would enable RAJUK or BWDB (as the case may be) to control developments in the retarding areas.

5) The Metropolitan Development Plan to be commissioned in 1992 will make an in-depth study into this area vis-a-vis the rest of urban Dhaka. Their

recommendations will directly influence the growth of the area along with safeguarding the flood protection plans.

4. NARAYANGANJ WEST

4.1 Physical Features (see Figs. A.10 and A.11)

The area covers 18.63 km^2. The wider mass of this area has the Dhaka Manikganj road on the west and the Lakhya river on the east. The area extends upto Saiyedpur on the South and the Dhaka Narayanganj road on the north. A linear part of the Narayanganj West area extends all the way upto the Demra road and is placed between the DND and the Lakhya river.

The area is predominantly built up and only a small portion on the south-west is low land and drains to the Dhaleswari river. All along the Sitalakya river bank the area is dominated by industrial and non-agricultural landuse. The major part of the south-east comprises of the Narayanganj urban area. The central part of the wider segment on the south has multitudes of water bodies. Only a small part of the north east is below 3 m elevation and almost all the land along the Lakya river bank is well above 5 m. Most of the land is usually flood free.

4.2 Outline Flood Protection Strategy (see Fig. A.12)

It is proposed in our flood protection strategy that Narayanganj West area will be bounded by embankment on the west, south and east (along Lakhya river). The DND area is on the north and therefore protects it. The embankment, following the river line will vary in design depending on the nature of the area where it is proposed.

After careful consideration the strategy outlines that Narayanganj West area be divided into five drainage zones. The first and second being the western half of the lower wider part. These areas will drain westwards. Water will be collected in three retarding areas and pumped out by two pump stations. The total area of retarding area will be 84 hectares.

The third zones includes the Eastern half of the Narayanganj West area together with a portion of the Northern linear segment. This zone reaches upto the Adamjee Jute Mills. Since this zone is relatively high and predominantly built-up, it is proposed that it showed drain to the Lakhya river by gravity.

The forth and fifth zones are the northern one. It is proposed that these zones would drain east with the help of two retarding areas and pump stations. The total area of the retarding area being 26 hectares.

4.3 Existing and Proposed Development (see Figs. A.13 and A.14)

Narayanganj town has grown on its own, independent of Dhaka, but the last quarter of the century has witnessed growth along the Dhaka-Narayanganj highway. The major settlement areas of Narayanganj is in the south-east where population pressure is highest. The urban area concentration will show major industrial and manufacturing establishments in the northern part. Apart from the Siddirganj Power Station and Adamjee Jute Mills there are large and medium sized industrial units all along the eastern belt. There is little buildable land left in the Narayanganj West area except in the south-western part.

RAJUK has lately taken up planned residential development schemes in the DND-Narayanganj area and one such scheme (Panchabati) overlaps into the north-western part of the Narayanganj West area (see Fig. A.14). With the completion of the embankment, the rest of the low land on the western periphery is expected to be urbanized fast since it is both close to the workplaces and transportation has also improved in the recent times. However, such developments may effect the drainage pattern of the whole area in the event that a comprehensive master plan is not adhered to.

Table below and Fig. A.13 shows the existing land use pattern.

EXISTING LAND USE OF NARAYANGANJ WEST (1990)

	Unit = ha	
Total Area	1,863	(100%)
Residential	981	(53 %)
Commercial	86	(5 %)
Industrial	178	(10 %)
Institutional	67	(4 %)
Agricultural	464	(25 %)
Water Bodies	87	(5 %)
Built-up Area	1,312	(70 %)

4.4 Infrastructure (see Fig. A.15)

The present pattern of the infrastructure clearly encompass the entire built up area. Electricity, gas and water lines follow all the existing roads. This leaves only the south-western low land (which is still not urbanized) unserved.

As far as the electrical distribution is concerned, it may extend to the south west at will. In the event that this area may be urbanized in the coming decades the power lines can easily accommodate their demand and stretch westwards. WASA has already done a comprehensive plan and most of the urbanized land is served by their system. It can be assumed that further development on the west can also be accommodated. RAJUK's planned Panchabati model town is also located on the north western part of this area and will surely be served by WASA.

Gas connections are so far limited to the Narayanganj area, however distribution of gas lines will also follow from east to west.

Fig. A.15 shows the existing and proposed main services as laid out by their concerned departments.

4.5 Population and Land Use (see Figs. A.16 and A.17)

The 1981 census and the Master Plan provide the basis for estimates of present and future population. Unlike the Dhaka East area, the Narayanganj West is already densely populated.

The tabulated population figures reflect our forecast regarding the Narayanganj West area. The total population in the Narayanganj West in 1990 is estimated at 470, 000. This population is expected to increase to 696,000 by the year 2000. After the turn of the century the growth rate will decline from 4.0% to 2.9% and the 2010 population is expected to be 927,000. It is important to understand the fact that the present high density of the study area coupled with non-availability of further buildable land will arrest further concentration of population in this area. Urbanization ratio of the study area at 1990 is already 70% by year 2000 it is expected to become 92% which is almost a ceiling after reservation of land for drainage purposes.

Table A.7 shows the growth of population and land use for the three dates.

Urban density is also expected to increase between 1990 and the year 2010. The density in persons per hectare will move from 359 in 1990 to 450 in 2000 and culminate in 539 by the year 2010.

Fig. A.17 shows an indicative land use pattern at the year 2010, and land use table is shown in the table below ;

FUTURE LAND USE OF NARAYANGANJ WEST (2010)

	Unit = ha	
Total Area	1,863	(100%)
Residential	827	(44 %)
Commercial	173	(9 %)
Industrial	292	(16 %)
Institutional	427	(23 %)
Agricultural	8	(0 %)
Water Bodies	135	(7 %)
Built-up Area	1,720	(92 %)

4.6 Major Development Issues affecting Flood Protection Proposals

The Narayanganj West area to most part is already urbanized. However current trends of the growth disregards every long term plan. With the flood protection scheme in motion some issues must be dealt with before further developments are allowed to take place. Some of these issues which affects the flood protection measures are discussed below :

1) The current trend of development is from east to west. The eastern river bank is densely populated and structural density diminishes towards the west. The services are also concentrated in the eastern region. However the central part of the wider segment is low land with scattered water bodies and with the western most part of the area being the lowest, the central areas also drains through this place. Therefore a long term planning strategy incorporating development areas, retarding areas, drainage channels and road network should be formulated.

2) Retarding areas if any must be located in the low-lying areas of the western or the central part. The present growth trend is limiting this possibility and must be controlled before all the central low land water bodies are encroached upon.

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3) The development control policies as they stand today takes no account of the flood control needs. This is evident by the RAJUK's Panchabati project that encroaches the very low-land which forms a part of the natural drainage channels. Since the Narayanganj West area is predominantly built up and area for retarding areas are in short supply, we must suggest that any future development proposal must incorporate the flood protection requirements and be strictly adhered to.

4) The under construction Dhaka-Narayanganj link road will increase the commercial potential of the central low-land area and subsequent development will take place in this area. With view to reserving retarding area certain amount of development control should be enforced in the immediate future. With major part of the area in urban use, the remaining scattered water body should be held back from development to fulfill drainage needs.

5. MANAGEMENT OF FUTURE URBAN DEVELOPMENT

5.1 The Need for Management

Management and control of land use changes are needed if urban development is to proceed in accordance with a preferred strategy; to ensure that land is developed effectively, to safeguard public interest, and to allow most efficient provision of major infrastructure investments.

Flood control and protection measures will be major determinants of city form. Major investment may be anticipated in this sector. It has to be ensured that land needed for flood protection purposes will be available where required : such land will have to be delineated, safeguarded, and in many cases, acquired. Control, management and acquisition powers should be sufficiently powerful to :

- maintain certain areas in rural use, by preventing urban development and preventing infill.
- acquire land for flood protection structures and measures.
- acquire land for resettlement of those affected by proposed embankment and khal improvement works and retarding areas.
- prevent further development (including landfill) in areas to be subsequently acquired by the government, (but permit appropriate temporary use) so as to prevent an increase in purchase costs.

- prevent encroachment onto land already government owned which might cause later difficulties .
- ensuring sufficient protection in low-lying areas by enforcing standards regarding infill and road crests heights.
- control/modify particular development proposals which might hinder efficient drainage or impede flood water flow, for example, by ensuring that road alignments do not cut across such flows but are in accord with compartmentalization requirements.

These powers should be available at the earliest to safeguard the areas of land needed for flood control and protection, given the pace of peripheral urban development, and the rate of increase in land prices.

Control and acquisition are complementary measures, but the former is clearly preferable if a choice exists. It is particularly significant that funds for land acquisition will need to be found locally. Thus, as well as making maximum use of control methods to reduce acquisition costs, it is imperative that the government manages to recoup some of the benefits of its investments from the beneficiaries, to allow further purchases in a rolling programme. Necessity to recover these public service costs means that the public authority is able to have the resources to service new land for development at the required rate. The resulting shortage in serviced land sees a continuing rapid increase in land value, and further difficulties in project implementation.

5.2 Existing Legislation

RAJUK is the planning and land development authority for Dhaka Metropolitan Area. It has development and control powers. In its development role, it can acquire land and prepare improvement schemes (by providing layouts, services and sub-divisions). This can be for the improvement of existing areas, but more usually is for the development of new ones. The major area developments initiated by RAJUK (or DIT) have been listed in the Master Plan Report. However, the scale and speed of urbanization in Dhaka is such that existing legislation and its enforcement has only a minimal impact. Current mechanisms cannot bring about the implementation of major infrastructure (including flood prevention) proposals needed, in an orderly fashion.

1) Land Use Control and Construction Control

<u>The East Bengal Construction Act</u> of 1952, and subsequent updates in 1961 and 1986, provides that within any area where Government may extend its application, all construction shall have previous permission from the designated "authorized officer". The Act also empowers the discontinuation of non-conforming use. RAJUK is responsible for control of construction in Dhaka. In general, there is some control of permanent buildings, but specifically as regards planning - as opposed to construction - the act operates mainly through the application of set-back (building line) rules.

<u>The Town Improvement Act of 1953</u> established the Dhaka Improvement Trust (DIT) as a development body with powers to take over, improve, and return land to and from private and municipal owners. For guidance, it was authorized to prepare "schemes" and "zone plans". Planning control took the form of urban on all construction not conforming to such plans. In 1958, references to schemes and zonal plans were replaced by references to a "master plan". At the same time, it was mandated that an official of DIT should be designated as the "authorized officer" for the area within the jurisdiction of DIT. RAJUK (DIT) has the power to approve or reject proposals for building which are not in conformity with the Master Plan. The development control system is minimal, being based on the need to apply for the granting of an exception where a proposal is not in conformity with the plan. But the plan, prepared in 1960, is now clearly outdated and only covers part of the RAJUK area - not including many of the peripheral areas where development pressures are greatest. In this peripheral urban area, RAJUK can prevent/permit development, but decisions are made on an ad hoc basis. In actual fact, except in instances where private developers need official approval prior to obtaining a bank loan, most development proceeds without application for permission. There is also little control over development by public bodies, and a reluctance to enforce action against private uses.

Overall, there is some control over development in RAJUK's own development areas. But there is little over the rest of the city or it's fastest developing peripheral areas (where, in fact, most of the land needed for flood protection is located). Further, while permission is needed for excavation of tanks, none is needed for changing the land level by landfilling. The prospects for the control of development so as to safeguard flood protection needs must, if present practices continue, be regarded as slim.

2) Land Acquisition

The Acquisition and Requisition of Immovable Property Act of 1982, with subsequent minor amendments, has replaced previous acquisition acts. After notice of intent to acquire land in the public interest, the district officer will determine compensation on the basis of the average market value for one year of similar land in the vicinity. The compensation includes an addition of 20% of market value, to compensate for the compulsory nature of the acquisition. The entire amount is to be paid in full before the land can be legally acquired and handed over. The law prohibits the use of acquired land for a purpose other than that for which it is acquired. If the land remains unutilized after acquisition or is used for another purpose, the land is liable to be surrendered to the district officer. The Act aims to ensure the the organisation requiring land for public and development purposes will decide upon the minimum requirement. RAJUK is the principal single land acquisition and development agency, but the private sector, overall, undertakes most development.

However, the legislation does have drawbacks. The Background Report to the Metropolitan Development Plan Preparation and Management, Dhaka and Chittagong, notes that difficulties arise from :

- high prices. Most land that is developable on the urban fringe is privately held. Unless it can be serviced and released at the rate needed for urban growth, its shortage will fuel a continuing rise in land prices. However, as public authorities fail to recover services cost from beneficiaries, they lack the resources to service land at the rate needed

- the legal registration system, involving two ministries, the Ministry of Lands and the Ministry of Works, also hinders the efficient and speedy operation of the land market.

- lengthy land acquisition procedures further reduce the capacity to service land at the required rate. There are 16 steps involved, in a process which has to be completed in 1 year.

- public sector landowners also contribute to land scarcity/high prices by failing to service and develop land. Public sector agencies hold about half the buildable land in Dhaka. Much remains vacant or under - used

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In such a context, it will be difficult to acquire land for flood prevention measures, unless it is done well in advance of urbanization pressures, before any substantial increase in land values.

The 1989 Property Emergency Acquisition Act provides for emergency acquisition to control inundation and prevent river erosion. Its duration is restricted to five years, but has so far only been applied in connection with the Jamuna Bridge Construction Project and the existing Dhaka Embankment.

The Act attempts to accelerate acquisition. The order to acquire is issued by the DCC on condition of previous Government approval. Appeals are required in ten days, as are claims of interest in the land for compensation. Within the same days, the DCC will determine provisional compensation based on an assessment of appropriate market value. Thereafter payment of provisional compensation is made in full and possession is taken. Final compensation is calculated within ninety days on the same qualifications as the 1982 Ordinance. Appeal is also the same as for the '82 Act, with the difference that the claimant may accept payment 'on protest' without forfeiting his right to appeal.

Clearly, the '89 legislation speeds up the acquisition process, but cannot have any effect on the increase in land prices.

3) Cost Recovery

The Betterment Fees Act of 1952 allows the government to levy betterment if land value is enhanced as a result of any Government improvement scheme, fixed at one-half the increase in land value. DMAIUDP notes serious inconsistencies and drawbacks in the legislation :

- it takes no account of increases in value unrelated to the Government improvement.
- it can levy betterment fees for works executed before 1953
- procedure for determining market value is not laid down
- there is no guidance for determining the extent of the area within which land values enhanced

The Town Improvement Act 1953 contains the power to impose a betterment fee on DIT (RAJUK), though the legislation differs in some respect from the 1952 Act.

The betterment laws have not, in the past, been enforced in Bangladesh.

The Wealth Tax Act of 1963 could (according to DMAIUDP) be used to realize a portion of windfall gains, but is not designed for such purpose and has been ineffective.

The East Pakistan Finance Act 1966 allows a capital gains tax to be collected on profits or gains arising from sale, transfer, or exchange of property. Capital gains are now treated as income, liable to tax. The 1976 Finance Ordinance attempted to reduce evasion by requiring tax authority approval prior to the issue of any document transferring any property valued over Tk. 20,000. As tax on capital gains is collected with income tax, it is not possible to discover how much of the increase in land value is recouped by the method.

The Gift Tax Act 1963 and The Estate Duty Act 1958 also attempt to recoup the unearned increment in land values. DMAIUDP concluded that this goal is unlikely to be achieved by this legislation, without reorganized tax administration and removal of loopholes.

It is difficult to see any effective recovery of costs of infrastructure investment/land development by an agency such as RAJUK under the legislation now existing as now applied. Without this, effective action to cater for anticipated rapid growth is not possible, in any sector. Indeed, continuing failure to recoup costs, in this urbanization context, means that conditions in the capital will get worse rather than better, as the amount of land and the major infrastructure required cannot be provided in a sensible fashion.

5.3 Land Improvement Issues

1) While this study is particularly concerned with flood prevention and control, the factors which can, and will, prejudice the achievement of a successful flood control system will also prevent progress in other major sectors. Any legal, administrative and institutional changes should apply to urban development in general, and not just address the flood prevention sector. Otherwise there is a danger of a mass of sector-specific legislation which could better be catered for under a single multi-sectoral law.

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2) A corollary to point 1) is that the activities connected to urban development and management should be the responsibility of one agency. While a number of organizations - BWDB, DWASA, DCC etc - are involved in flood control and associated aspects, and do need to be consulted as required, the responsibility for land acquisition, control, and management of land should be the responsibility of one agency, RAJUK. Any cost recovery, though, could well involve more than one agency.

3) If land is needed for flood control structures, acquisition at market value appears unavoidable. If the land needed remains unzoned (as at present), such value would reflect the urbanization potential and would become increasingly expensive within the proposed embankment area as urbanization prospects drew closer. If however, land needed for retarding areas was zoned for retarding areas, its market value would continue to be its agricultural value. In fact, less, as its agricultural value would decrease, though compensation if acquisition took place would still be at agricultural value. There would be no potential urban use value. Owners of such land would feel understandably aggrieved, but any zoning system makes decisions with quite different implications for land values, even for adjacent plots. It may then be possible to reduce acquisition costs by speedy zoning.

4) The development of land readjustment mechanisms could allow a more equitable spread of costs and benefits. Under such a system, the public development agency would prepare a development plan for an area, consolidate land holdings and reserve land for infrastructure needs. The remainder is reconstituted into plots, the agency possibly selling a number to recoup some costs. The remaining plots are re-allocated to all the original owners in the area on the basis of percentage held of the whole delineated area. While the plots would be smaller, their value would be much higher as following flood protection measures, they would now have urban development potential. There is also no arbitrary differentiation between land needed for storage of water and land with urban development potential following the formation of retarding areas on adjacent plots.

   Nevertheless, there must be some doubt about whether such procedures could be applicable over large areas, given the amount of agreement and coordination required. But, given possible benefits, some further consideration would be appropriate.

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There are some specific issues with regard to the flood protection project, its land acquisition cost and management mechanisms, these are

5) As pointed out in the Master Plan, though huge areas would be reserved for retarding areas, most of the retarding areas could be used for cultivation pre and post monsoon. Such cultivable areas were estimated as constituting 70% of total pond areas. Thus, the Government could consider not acquiring outright but rather controle the owner for use of retarding areas.

6) An alternative means of controlling retarding areas would be to make developers provide their own storage capacity. This should be on the basis of $1200m^3/ha$ or a retarding area corresponding to 12% of the development area as on-site retarding areas. This could be imposed as a condition of development. This is an equitable measure as it is the beneficiaries who have to contribute. However, problems would arise from obtaining a contribution from those who develop without permission, and from those not developing not contributing : the area of retarding area needed would be the same, irrespective of whether the surrounding area was developed officially, unofficially, or undeveloped.

7) Everyone in Dhaka would benefit from flood protection measures. Everyone should in principle contribute towards the cost. A tax based on the increase in land values (as suggested in the ADB Aide-memoire) would be an equitable measure. It would reflect the disproportionate benefits that flood protection will bring some owners (in allowing conversion from rural to urban) as well as the increased land values overall resulting from flood protection. (It would also reflect increase in values resulting from other public infrastructure investment).

8) In the following section, there is a summary of the measures underway to bring about more efficient land management and cost recovery. Thus, in the medium term, say from 1994 on, there is the possibility of an approved zoning master plan for all of Dhaka metropolitan area, incorporating flood protection needs, which would (with difficulty) be enforceable by RAJUK. Until that time, control will have to be undertaken under existing legislation.

5.4 Prospects for Improvements

A number of plans and proposals are underway which will investigate and recommend improved mechanisms for land control, development, and management.

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The adoption - and vigorous enforcement - of the measures recommended, should provide the means whereby flood protection (and other infrastructure) measures can be implemented.

1) The prerequisite for the successful application of any land management legislation is a zoning map which defines future needs.

   The proposed Metropolitan Development Plan Study for Dhaka will prepare an integrated development plan and sectoral priority plans for the city. The project document for this study lists the outputs as including :

   - a structure plan, indicating broad land uses and the framework for development

   - a master plan, with a strong spatial basis, which will specify in more detail permissible land uses and development standards. This will be incorporated into the legal/administrative framework, and will be the basis for regulatory activities by RAJUK (Such a master plan should incorporate the major land requirements needed for flood protection, as contained in this JICA Master Plan, and zone them for particular flood protection purposes as required.)

   - detailed area/project plans, which will include the land use, engineering, cost, and institutional elements needed for proposed priority developments.

   The study will also assist RAJUK to produce and review plans, and improve its regulatory and management functions. The terms of reference for the study specify an examination of land acquisition and assembly procedures within RAJUK, the development of improved land management machinery, and the installation and evaluation of new approaches, including guided land development techniques and land pooling/readjustment. The tasks will include;

   - an assessment of planning and control area boundaries

   - a review of the enabling powers and regulations under the Acts, with particular reference to flexible and differentiated development control zones and performance - related construction codes, and of RAJUK's powers in relation to urban utility agencies

- an assessment of the degree and nature of unauthorized construction and of practical levels of operations, prior to recommending flexible arrangements of land use control and construction approvals in accordance with varying levels of performance related building and planning regulations

2) We have noted, in previous sections, the need for development in the Dhaka East and DND areas to be in accordance with an overall framework which allows rational, phased development. There is no such framework for Dhaka East. For the development of the DND, RAJUK's plan does not take into account the topographical characteristics of the area, the drainage pattern or the need to reserve land for flood protection measures. It does not seem to take into consideration the pattern of the existing road network or the need to retain as much of existing development as possible. We think it may require some re-casting before it reflects these considerations fully.

The 'detailed area/project plans' proposed for the Metropolitan Plan Study would permit major infrastructure (including flood protection) needs to be coordinated and safeguarded in a manner which would take all factors - investment, institutional needs, land availability, development pressures - into account.

The TORs for this study also propose that the current RAJUK zonal plans should be reviewed. It proposes the identification of priority investment projects for which the development problems are clearly evident. It further notes that particular attention should be given to the outflying urbanization areas of the RAJUK zone.

While we cannot forecast the particular priorities which will be identified in the study, the foregoing suggests very strongly that the DND and at least the southern part of Greater Dhaka East would be identified as areas where detailed plans will be given priority. In this event, we can be confident that flood protection requirements will be safeguarded.

Currently, we estimate a realistic starting date for this study to be March 1992. The initial set of plans are to be prepared within two years. The Reporting

Schedule shows that the draft metropolitan plans should be produced at the end of month 18 (July 1993 if our starting date is correct). Within two years, then, a satisfactory plan for the two larger feasibility areas should be produced.

3) FAP 15, the Land Acquisition and Resettlement Study, may also identify improvements in acquisition and resettlement procedures, in urban as well as the rural areas covered by the various flood action programmes. FAP 15 is based on the rationale that efforts are needed to minimize the negative impacts of embankment construction and provide fair compensation to those affected. It notes that many of those affected by acquisition, and not resettled, end up squatting on embankments. Delays in resettlement (as in the case of the current Dholai Khal improvement where land acquisition and cost problems have led to delays) can also lead to increased settlement on the embankment. This is discussed further under 6.2(b).

Neither the 1982 nor 1989 Land Acquisition Acts make any reference to householders losing land due to acquisition

4) Following the ADB Mission in July 1991 in connection with FAP 8B (Dhaka Integrated Flood Protection), ADB has agreed to provide the Government of Bangladesh with advisory technical assistance in conjunction with the loan. This is for a study which will :

- recommend appropriate building and land development standards to ensure that investments in better flood control and drainage are not negated by uncontrolled growth

- develop improved cost recovery methods for meeting the growing needs for infrastructure and services as the city grows

- rationalize the needs and uses of vacant and underused Government land in the city

It is anticipated that this programme will start in June 1992 and continue for a period of 8 months. The team will be responsible for coordinating its activities with other related projects, to ensure that recommendations are complementary. The proposed study clearly has some overlaps with the proposed metropolitan plan study. It should also establish mechanisms which would apply to the implementation of the JICA Flood Protection proposals as well as those under

FAP 8B, as indeed they would apply to infrastructure investments in other sectors.

5) A review of physical planning and development control legislation was undertaken in 1985, leading to the Draft Physical Planning (Land Use) and Development Control Ordinance. The first main thrust of the draft is to provide very flexible formulae permitting the assignment to any public agency, at any level of government, for any area of jurisdiction, such planning responsibilities or development control powers (out of an all-inclusive list) as may seem desirable taking into account the capacity of the agency and the characteristics of the problems it faces. The second is to encourage coordination and collaboration among various branches of Government in the uses of powers which could influence the effectiveness of planning and development.

In Dhaka, control would be exercised by means of specific development control rules appropriate to particular areas and as specified in the prospective metropolitan plan. RAJUK would be responsible for all planning and control.

The adoption of this draft legislation could provide the basis for land control and management in the city.

We have already noted the needs, the inadequacies of current plans and mechanisms, and made general observations on changes needed. As these are soon to be examined in a comprehensive fashion, it is premature to comment further. But until comprehensive measures are enacted, existing methods will have to be employed more efficiently.

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6. DEVELOPMENT CONTROL MEASURES AND MULTIPLE USES

6.1 Land Acquisition and Resettlement

As noted in Section 5, a large amount of land will be needed for construction of flood prevention structures. Despite of the land already purchased for the Eastern embankment along the Balu river, new land with be need to be acquired for the construction or expansion of embankments, flood walls, sluices, pumping station, drainage channels and those related works. This amounts to a total of 636.9 hectares in the three feasibility study areas, of which 304.9 hectares would be for embankments and associated works and 332.0 hectares for drainage channels and the related facilities sites.

This will involve the resettlement of resident populations and compensation for demolishing the existing building structures including shops and industrial factories in some cases.

The resettlement figures are as follows :

- Population 7,000
- No. of houses 1,200
- No. of commercial / industrial buildings 200
  (Partial demolition in most cases)

Although the land acquision and resettlement works are usually very difficult to implement within the limited resources and period, it will be essential to acquire the required land prior to planned implementation in order to minimize risks associated with project implementation

6.2. Development Control Measures

1) On and around flood prevention structures

<u>Set back from the retarding area and drainage channel :</u>

It is logical to assume that the development pressures will eventually lead to encroachment of the retarding areas and drainage channel. Technically, a set back is required from the retarding area boundary and the reasons are two fold:

a) The wet season water level and the dry season level will vary. It is assumed that dry season water will occupy a small portion of the retading area and open up large dry areas around it, for which various uses are discussed in Section 6.3. There is also a danger of encroachment of this dry season open area by squatters and even by the neighbouring land owners. The example of Gulshan area will show that due to the placement of the lake on the rear side of the plots, a lot of the plot owners actually disregarded RAJUK's regulations and encroachment upon the lake. Since the lake cannot be seen from the road, this encroachment goes unnoticed. Encroachment by the squatters is a common sight and needs no elaboration.

A scrutiny of the Dhanmondi lake will provide pleasant respite from such problems. In case of the Dhanmondi area, the road net work is placed so that the lakes are encircled by road network and a strip of park area (protected by barbed wire) lies between the lake and the road. The lakes are managed and looked after by concerned government agency who also has an office at the spot. There are capital generating schemes such as rent of angling platforms and annual catch of fish by farming. All these put together create an environment where encroachment have been averted so far. It is our assessment that in case of Gulshan it could not be done mainly because the lake was on the negative space and did not serve any other use.

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b) Technically for the sake of management and maintenance of the pond areas as well as the drainage channels there is a need to have service roads around the retarding areas or channels. Again this service lane may be prone to encroachment and requires careful study as to how it may be kept free.

From the above arguments we must conclude that the best way to ensure non-encroachment of the water bodies and also ensure maintenance access is to have the following :

- The pond areas should be encircled by roads which serve as access roads to plots. For khals and drainage channels there should be roads on both sides of the khal, at least one being a two way access road. Apart from increasing accessibility, it would also keep the environment clean.

- Plantation may be provided at the edge of the retarding areas and khals. This would help keep a green belt along the water line as well as add to the environmental quality.

- Some form of fencing should be provided, defining the edge of the pond area or canal. This would enable better control and discourage encroachment.

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- Some form of revenue generating scheme should be attached to the use of the retarding area. Uses such as fish pond, agriculture, recreation etc. are discussed in detail in Section 6.3.

- Maintenance and management should be carried out by concerned government bodies or by private entrepreneur who wish to take the pond area on lease for fish culture or other uses which conform to the flood control project. They should have a site office in the project area to maintain constant vigilance.

Embankment

It will likely prove difficult to prevent encroachment onto flood embankments as examples on those parts already constructed already illustrate. In addition to those who might be affected by embankment construction (as already mentioned), there will be a greater number attracted to the embankment from adjacent slum and squatter areas. The embankment offers a rent-free, flood-free opportunity, close to place of work, to those whose other choices are few.

Unfortunately, settlement, whether urban or rural in character, has detrimental effects on the embankment. Construction cuts into the embankment's profile, and the removal of the vegetation cover together with associated development of footpaths brings about erosion. Free access for maintenance purposes is hindered. Grazing and cropping will also lead to accelerated erosion. Ideally, then, development on embankments should be discouraged. But this is likely to prove difficult. It would clearly be impossible to remove people sheltering on the embankment immediately after flooding, and little easier to move them later when they become established. It would also be particularly difficult to resist the claims of those who move onto the embankment as a result of being affected by embankment construction.

From a flood protection point of view then, habitation on embankments should be resisted. To some extent, the numbers may be minimized by speedier land acquisition and resettlement procedures. But in practice, we suspect this will be impossible to achieve, particularly nearest to more densely populated areas. It may therefore be more realistic to acknowledge this and take appropriate measures to avoid the worst effects.

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Clearly, unhindered rights of way for maintenance must be preserved. Elsewhere, consideration should be given to modifying embankment design to allow shallower slopes which could more safely accommodate settlement on the land side of the embankment. One of the objectives of FAP 15 (currently underway) is to review embankment design criteria to see if development or use of the embankment can be permitted in a manner which does not threaten safety and stability. Employing some of the squatters to be responsible for upkeep of sections of the embankment may be one possibility. Nevertheless, where the embankment section has not been designed to permit settlement, such settlement has to be discouraged.

As mentioned before. The modified embankment structure will be allowed the road construction along the embankment. It is recommended that the Government introduce building controls to restrict development within 50 meter (minimum) of the edge of the right of way of the embankment so as to preserve a strip of land along the country side of the embankment to accommodate any future roadway and also other type of land uses.

2) Regulations for site development

Minimum heights for development

In addition to control activities associated with suitable land uses, control of minimum height levels is also needed to ensure flood protection. Development in areas protected by embankment should be by filling up the land higher than the proposed internal design water level of the retarding area, khal and trunk drain as illustrated in fig. below.

The Master Plan specified the minimum ground elevations of future low land development as being from 4.5 to 5.5m PWD for the Greater Dhaka drainage zone (including Dhaka East and the DND) and from 4.5 to 5.0 m PWD for Narayanganj. The different height requirements for different areas are shown on Fig. A.18.

Required On-site retarding area

For RAJUK's approval, the private developers are required to prepare the public land, which is around 30-40% of the development area. Those areas has to keep for non-housing uses such as commercial, educational, medical and openspace. We propose, as described in Section 5.3, within or encouraging the condition, certain portion say 5-10% of the development area should be allotted to provide their own water storage as on-site retarding area.

6.3. Multiple Use of Retarding Areas

In the three feasibility study areas it has been estimated that retarding areas will cover an area of 26 km^2. They will (when full) constitute the second major land use in terms of area (after residential, and if rural / agricultural use is not considered). Those huge area should be reserved by way of proper measures which are discussed in the previous sections by the government because their primary use is clearly for flood protection. But, in a country with such major population/land ratios as Bangladesh with such intensive urban densities as Dhaka, and for realization of the proposed retarding areas to be practical, maximum multiple usage should be encouraged.

1) Recreation

DMAIUDP notes that the majority of recreational pursuits are carried out in or near the home. While there is a wide demand for sports pitches, it reasons that this should be met in local residential areas. A total of 145 hectares was considered to be available for public and semi-public recreation in the city, mostly in newer areas. In the old town, a ratio of only 0.024 hectares per 1000 people was available. Given the scarcity of available and suitably priced land, it considered the attainment of higher standards in these areas as unrealistic.

The study identified the reservation of larger scale outdoor areas for day trips within easy travelling distance of the city as a major recreational requirement. This need is currently being (partly) met to the north of the city but a number of other potential

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locations were suggested. Within the metropolitan area also, some potential recreational locations were identified. None of these areas are located within the feasibility study areas.

DMAIUDP's underlying concept behind providing recreational space is to use the natural potential of the city environment together with the engineering works proposed for urban development purposes, to create a number of outdoor recreational spaces. An opportunity exists to use at least some of the works associated with flood protection for such purposes, for very limited extra costs. This can be done both by ensuring right of way and access to embankments and use of the most suitable retarding areas as recreational areas.

Not all the proposed retarding areas should be reserved for such use, and it is probably realistic that at best, given lack of funds, only one such pond could be so developed. The northernmost areas are too distant from the city's centre of population and will continue to be too distant, to justify selection. The area on the south-eastern edge of the city is however identified in DMAIUDP as "urgently requiring planned provision of public open spaces". This area is closest to the poorly served Old Dhaka and the equally poorly served and currently growing eastern extension. It offers the most central location for serving a wider catchment than other possible choices.

Two retarding areas are proposed in this area, one based on the northern part of the Dholai Khal, the other, smaller, pond further north, on the Gerani khal linked with Begunbari Khal. Given the current rate of development in this area, the likely greater degree of encroachment near to the city as well as lower land prices further out for any complementary acquisition, the latter location is preferred for recreation development.

Provision of the spaces for green, sports, fishing, boating, etc. will be possible at the part of the pond, especially in dry season.

2) Agriculture

The change from agricultural to urban use in the DND will clearly see a reduction in agricultural output. In Greater Dhaka East however, an area currently under water for large parts of the year and where in most parts therefore only one crop is possible, will be empoldered. This will permit more than one crop in most areas, at least for that period until the area becomes developed.

In the long term, overall, as urban development proceeds, the effects of flood protection will be to reduce the area under agricultural use. Given the forecast doubling of population over the next twenty years, food requirements will also need to be doubled, even to maintain existing sub-standard nutritional levels.

Due to the importance of agriculture in or near the metropolitan area, around 10% of Greater Dhaka East and Narayanganj DND feasibility areas are zoned for agricultural use. In addition to that, it has been estimated in the Master Plan Report that 70% of the pond areas would be cultivable for most of the year. The availability of irrigation water from the retarding areas should also allow higher yields in these areas. Continuing agricultural activities should then be encouraged given the loss of agricultural land to urban development and the difficulties of supplying Dhaka with foodstuffs as it doubles in size.

3) Fishing ponds

Most flooded areas in Bangladesh are used for fishing. Self-contained ponds are usually fished in a managed fashion, while larger seasonal water bodies are fished in a less organized manner. Currently, in addition to small privately owned tanks, fish culture is practised in a number of ponds in Khilgaon and in the DND Canal. Less organized fishing takes place in the khals, ditches, ponds and beels within the seasonally inundated areas. The variety of fish caught is likely to amount to around thirty types.

Generally, with empoldering, the importance of fishing is reduced as-

- inward movement of wild fish into the water bodies of the flood plain either ceases or declines drastically as a result of the embankment. Spawning usually takes place in large rivers, with fish fries and fingerlings coming into an area with annual floods. Poldering curtails this process of natural recruitment.

- there is virtual disappearance of water bodies traditionally used for wild fishing.

- the quality of water inside the embankment deteriorates as a result of lack of flow, resulting in depleted oxygen levels and an inferior habitat for fish.

The importance of maintaining fish production may be gauged from the fact that 70%-80% of animal protein supplies in Bangladesh is obtained from fish. Fish is also

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the cheapest form of such animal protein. While the construction of the embankment will clearly affect the present pattern of fishing , it does also offer an opportunity for higher yields from fish farming.

A total of 2,660 hectares of retarding areas are proposed in the three feasibility study areas. Though one such pond has been suggested for recreational use, this does not preclude some form of pisiculture. Of this total, some 30%, or 800 hectares, will be permanently under water, in fifteen separate ponds. These ponds will vary in size (at minimum) from under 10 ha to 170 ha.

The arguments for fish farming in the permanent water bodies of the retarding areas are :

- good value of catches, especially of the marketable carp family, estimated conservatively at Tk.60 per Kg, with production at 500-600 Kg per hectare. Possible fish varieties suitable for such lakes include silver, common, and grass carp, katla and ruhi, sarputi, mrigal and magur.

- immediate access to a large and growing market.

- tried and tested technology and existing institutional mechanisms. Ponds could be leased to entrepeneurs or groups of fishermen by government, or if government leased rather than purchased the land, by the original owners.

- possible opportunity to introduce lower priced fish such as tilapia nailoti (which could reproduce within the ponds) and which are more affordable by poorer people.

- management of the water body reduces a potential health hazard. If no use was made of the ponds after the original stock had been fished out, the pond would increasingly become a breeding ground for insect larvae.

- management similarly would deal with the periodic removal of water hyacinth from pond areas, which would not be flushed out in annual floods, and which would otherwise reduce fish harvest and constrict drainage channels.

Currently, ponds may be leased to entrepeneurs or groups of fishermen by government. If the government leased rather than purchased land for retarding areas, the original owners could practise fish farming, with advice from the Ministry of Fisheries. Management would need to stock the ponds annually with large fingerlings produced by local hatcheries, as carp needs to reproduce in spawning grounds away from ponds. At present, the capacity of hatcheries and nurseries in the Dhaka area is insufficient to produce fingerlings for this area of pond. One or more new hatcheries would be required. The establishment of such hatcheries would need to be done by government, as private investment, at least initially, would be unlikely.

A possible danger would derive from pollution as the city continued to grow. Large inflows of domestic sewage would consume large amounts of oxygen, resulting in BOD levels too low for good yields. Water quality management would thus be crucial. Though carp is very resilient to high organic inflows there could also be dangers from chemical pollutants and illegal discharges. This would be particularly so for those ponds to which the existing industrial areas drain. The likely nature and degree of toxicity of possible effluents would have to be determined. In addition, after completion of embankments, cultivation of higher yield crops with irrigation would increase the use of fertilizer. Thus the amount of agro-chemicals could have an effect on the ponds.

Given the considerable potential of fish farming in retarding areas, it is recommended that further study be carried out into :

- possible variety of fish and estimates of yields and markets for different types ;
- costs and returns ;
- preferred institutional arrangements for managing ponds and nature of advising assistance required ;
- number and type of beneficiaries with emphasis on potential for assisting those affected by embankment construction ;
- risk from agricultural and industrial effluents ;
- prerequisites for further pisiculture schemes in the area, in the form of nursery and hatchery requirements.

4) Oxidation ponds for sewage treatment

Although, the investigation sewerage of is not the scope of this study, as the existing oxidation pond in Pagla has been provided for purification of sewage water from part of the Old Dhaka area, development of new oxidation ponds serving the other part of urban area and the new urban development area in low land zone would be one of the options for the future sewage treatment in the metropolitan area.

The proposed retarding areas would be potential location to facilitate those oxidation ponds. It is assumed that if all the sewer water would be treated by new oxidation ponds in the whole feasibility study area, some 1,000 ha of such oxidation ponds area is required, while the proposed retarding areas is 2,660 ha.

And it is noticed that a multiple use, such as oxidation pond cum fishing pond or oxidation pond cum irrigation, of retarding areas is more realistic.

Further investigations on the above four options for the multiple use of the retarding areas are strongly required.

The Fig. 19-A~C illustrate a general idea of the development steps in the existing low land agricultural area where are going to be urbanized in the future.

YEAR	1990	2000	2010
TOTAL AREA (sq.km)	118.62		
POPULATION (person)	637,500	1,150,656	2,201,935
BUILT UP AREA (sq.km)	22.85	50.27	85.49
URBAN DENSITY (p/ha)	279	229	258
URBAN RATIO	19%	42%	72%

NORTHERN COPM	40.69 sq.km		
POPULATION (person)	126,079	281,674	772,278
BUILT UP AREA (sq.km)	8.49	19.43	35.41
URBAN DENSITY (p/ha)	149	145	218
URBAN RATIO	21%	48%	87%

CENTRAL COMP	32.04 sq.km		
POPULATION (person)	61,195	139,572	259,314
BUILT UP AREA (sq.km)	3.36	9.97	15.52
URBAN DENSITY (p/ha)	182	140	167
URBAN RATIO	10%	31%	48%

SOUTHERN COMP-1	14.57 sq.km		
POPULATION (person)	23,574	52,157	212,482
BUILT UP AREA (sq.km)	1.14	4.35	8.91
URBAN DENSITY (p/ha)	207	120	238
URBAN RATIO	8%	30%	61%

SOUTHERN COMP-2	31.32 sq.km		
POPULATION (person)	426,652	677,253	957,861
BUILT UP AREA (sq.km)	9.86	16.52	25.65
URBAN DENSITY (p/ha)	433	410	373
URBAN RATIO	31%	53%	82%

TABLE A.1 POPULATION GROWTH AND URBANIZATION, 1990-2010 : DHAKA EAST

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	POPLAND DATA OF DHAKA EAST DRAINAGE ZONE 1990											
	ZONE NAME	TOTAL AREA (ha)	DETAILED LAND USE (ha) Residential high	mid	low	Com'cial	Industry	Inst'tion	Agr'ture	Water	BUILT UP AREA(ha) 1990	POP'TION 1990
DHAKA EAST TOTAL		11,862	168	328	1,752	40	1	23	8,814	735	2,313	637,500
NORTHERN COMP'T		4,069	0	27	811	8	0	3	3,080	140	849	126,079
1A	Uttar Khan	1,811	0	0	180	8	0	0	1,585	38	188	23,111
1A	D. Khan Cant	186	0	6	113	0	0	0	9	58	119	26,179
1A	D. Khan Gulshan	766	0	9	171	0	0	2	580	5	182	25,847
1A	Cantonment 3	12	0	0	5	0	0	0	6	0	5	431
1A	Beraid U. Gulshan	281	0	1	20	0	0	0	260	0	21	4,688
		3,056	0	16	490	8	0	2	2,440	101	516	80,256
1B	D. Khan Cant	102	0	3	62	0	0	0	5	32	65	14,336
1B	D. Khan Gulshan	681	0	8	152	0	0	1	515	4	162	22,977
1B	Cantonment 3	230	0	0	106	0	0	0	120	3	107	8,510
		1,013	0	11	321	0	0	1	641	39	334	45,823
CENTRAL COMP'T		3,204	0	20	315	1	0	0	2,698	169	336	61,195
2	Cantonment 3	500	0	0	231	1	0	0	261	7	231	10,928
2	Beraid U. Gulshan	1,590	0	2	43	0	0	0	1,544	0	45	10,789
2	Gulshan 57	1,114	0	18	42	0	0	0	893	161	60	39,478
SOUTHERN COMP'T-1		1,457	0	56	85	0	0	0	1,070	246	141	23,574
3A	Beraid U. Gulshan	2	0	0	0	0	0	0	1	0	0	150
3A	Gulshan 57	976	0	55	12	0	0	0	773	136	67	11,102
3A	Beraid Demra	404	0	0	55	0	0	0	240	110	55	7,309
3A	Demra	75	0	1	18	0	0	0	56	0	20	5,013
SOUTHERN COMP'T-2		3,132	168	224	541	31	1	20	1,965	180	986	426,652
3B	Ward 34	147	73	16	0	1	1	8	23	24	99	77,957
3B	Ward 36	167	20	45	68	9	0	3	8	16	144	65,467
3B	Ward 38	98	21	36	27	7	0	0	0	7	91	54,056
3B	Ward 39	185	54	61	38	1	0	0	30	1	155	109,560
3B	Ward 40	351	0	43	174	11	0	8	59	56	236	65,378
3B	Beraid Demra	173	0	0	6	0	0	0	108	59	6	812
3B	Demra	1,160	0	18	157	1	0	0	979	5	176	45,118
3B	Matuail GD	850	0	4	72	1	0	1	758	13	79	8,304

TABLE A.2 DETAIL LAND USE TABLE, 1990 : DHAKA EAST

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	POPLAND DATA OF DHAKA EAST DRAINAGE ZONE 2010 (ha)											
	ZONE NAME	TOTAL AREA (ha)	DETAILED LAND USE (ha) Residential high	mid	low	Com'cial	Industry	Ins'tion	Agr'ture	Water	BUILT UP AREA(ha) 2010	POP'TION 2010
DHAKA EAST TOTAL		11,862	2,031	2,997	889	436	39	2,158	1,310	2,002	8,550	2,201,935
NORTHERN COMP'T		4,069	695	1,196	626	181	24	819	240	288	3,541	772,278
1A	Uttar Khan	1,811	203	405	405	96	19	295	240	149	1,422	292,073
1A	D. Khan Cant	186	54	43	11	9	0	70	0	0	186	62,693
1A	D. Khan Gulshan	766	176	322	88	31	3	143	0	4	762	160,124
1A	Cantonment 3	12	2	2	0	1	0	6	0	0	11	1,861
1A	Beraid U. Gulshan	281	11	74	29	1	0	38	0	128	153	31,004
		3,056	446	845	533	138	22	552	240	281	2,535	547,756
1B	D. Khan Cant	102	29	24	6	5	0	38	0	0	102	34,332
1B	D. Khan Gulshan	681	156	286	78	27	3	127	0	4	677	142,342
1B	Cantonment 3	230	64	41	9	11	0	102	0	3	227	47,849
		1,013	249	351	93	43	3	268	0	7	1,006	224,522
CENTRAL COMP'T		3,204	257	665	88	71	0	471	1,070	582	1,552	259,314
2	Cantonment 3	500	136	87	29	24	0	216	0	7	492	76,992
2	Beraid U. Gulshan	1,590	95	138	6	2	0	69	720	561	309	62,790
2	Gulshan 57	1,114	26	439	53	46	0	186	350	13	751	119,532
SOUTHERN COMP'T-1		1,457	287	270	59	27	0	248	0	566	891	212,482
3A	Beraid U. Gulshan	2	0	0	1	0	0	0	0	0	2	133
3A	Gulshan 57	976	287	186	9	19	0	191	0	284	692	203,906
3A	Beraid Demra	404	0	79	42	7	0	50	0	225	179	7,394
3A	Demra	75	0	5	7	1	0	6	0	57	19	1,049
SOUTHERN COMP'T-2		3,132	793	866	117	156	15	620	0	566	2,565	957,861
3B	Ward 34	147	107	10	0	2	1	11	0	17	130	142,679
3B	Ward 36	167	100	40	8	9	0	11	0	0	167	110,446
3B	Ward 38	98	56	33	0	6	0	2	0	0	98	79,509
3B	Ward 39	185	76	44	6	25	0	32	0	1	184	134,871
3B	Ward 40	351	115	56	0	40	0	138	0	3	348	171,774
3B	Beraid Demra	173	21	44	20	3	0	42	0	43	131	7,803
3B	Demra	1,160	149	516	67	43	7	185	0	194	967	113,389
3B	GE-Matuail	850	170	124	15	27	7	198	0	309	541	197,390

TABLE A.3 — DETAIL LAND USE TABLE, 2010 : DHAKA EAST a8

Table A.4: POPULATION GROWTH AND URBANIZATION, 1990-2010: DND

YEAR	1990	2000	2010
POPULATION (person)	448,590	879,523	1,313,749
BUILT UP AREA (sq.km)	21.74	36.14	42.70
URBAN DENSITY (p/ha)	206	243	308
URBAN RATIO	38%	64%	75%

Table A.5: DETAIL LAND USE TABLE, 1990: DND

	TOTAL	DETAILED LAND USE(ha)								BUILT UP	POP'TION
	AREA	Residential			Com'cial	Industry	Ins'tion	Agr'ture	Water	AREA(ha)	(persons)
ZONE NAME	(ha)	(high)	(mid)	(low)						1990	1990
Ward 31	8	4	0	0	0	3	1	0	0	8	4,992
Ward 32	162	41	61	34	9	14	3	0	0	162	90,448
Ward 33	52	12	18	10	4	1	2	4	1	47	26,947
DND-Matuail	1,479	0	0	568	5	0	7	886	12	581	102,331
Shyampur	397	40	40	9	9	35	10	129	126	142	71,224
DND-Siddirganj	564	0	0	105	1	22	1	428	7	129	20,383
DND-Simulpara	198	3	14	38	9	61	25	1	47	150	19,876
Kutubpur	1,243	0	0	286	5	19	0	869	64	310	37,098
DND-Godnail	826	0	0	211	8	19	0	584	5	238	14,351
Fatullah	478	0	0	231	6	10	6	159	66	253	37,593
DND-Enayetnagar	22	0	0	6	0	4	1	9	1	12	1,173
DND-N'ganj 1	44	0	1	11	0	2	1	27	2	15	2,817
DND-N'ganj 2	49	0	1	28	0	4	0	14	1	34	4,170
DND-N'ganj 3	156	5	0	86	0	0	3	63	0	93	15,186
DND TOTAL	5,679	104	135	1,625	56	196	59	3,173	332	2,174	448,590

Table A.6: DETAIL LAND USE TABLE, 2010: DND

	TOTAL	DETAILED LAND USE(ha)								BUILT UP	POP'TION
	AREA	Residential			Com'cial	Industry	Ins'tion	Agr'ture	Water	AREA(ha)	(persons)
ZONE NAME	(ha)	(high)	(mid)	(low)						2010	2010
Ward 31	8	4	1	0	0	2	1	0	0	8	5,936
Ward 32	162	103	18	0	10	11	12	0	7	155	145,427
Ward 33	52	28	12	0	6	2	2	0	2	50	37,330
DND-Matuail	1,479	349	349	78	63	52	390	78	119	1,282	353,378
Shyampur	397	154	27	0	7	85	88	0	36	361	227,928
DND-Siddirganj	564	97	75	43	20	74	96	31	127	406	88,232
DND-Simulpara	198	26	12	9	6	43	18	0	84	114	26,752
Kutubpur	1,243	179	281	51	21	83	229	188	212	844	167,402
DND-Godnail	826	74	92	18	9	42	82	235	275	317	74,396
Fatullah	478	95	118	24	11	53	166	0	11	467	91,832
DND-Enayetnagar	22	5	4	2	1	3	8	0	0	22	4,778
DND-N'ganj 1	44	13	7	1	2	9	9	0	2	42	15,007
DND-N'ganj 2	49	13	8	1	2	16	9	0	0	49	15,716
DND-N'ganj 3	156	51	32	9	13	6	43	0	2	154	59,635
DND TOTAL	5,679	1,189	1,038	236	172	482	1,153	532	877	4,270	1,313,749

Table A.7: POPULATION GROWTH AND URBANIZATION, 1990-2010: NARAYANGANJ WEST

YEAR	1990	2000	2010
POPULATION (person)	470,449	696,123	926,820
BUILT UP AREA (sq.km)	13.12	17.20	17.20
URBAN DENSITY (p/ha)	359	405	539
URBAN RATIO	70%	92%	92%

Table A.8: DETAIL LAND USE TABLE, 1990: NARAYANGANJ WEST

POPLAND INFORMATION OF N'GANJ WEST DRAINAGE ZONE(ha) 1990											
	TOTAL	DETAILED LAND USE(ha)								BUILT UP	POP'TION
	AREA	Residential			Com'cial	Industry	Ins'tion	Agr'ture	Water	AREA(ha)	(persons)
ZONE NAME	(ha)	(high)	(mid)	(low)						1990	1990
NW-Matuail	136	0	52	63	1	0	1	17	1	118	38,687
NW-Siddirganj	183	2	10	28	0	8	0	132	2	49	14,556
NW-Simulpara	411	25	57	17	16	108	44	75	70	266	63,869
NW-Godnail	164	0	0	61	2	5	0	95	1	68	7,686
NW-Enayetnagar	33	0	4	14	0	11	3	0	0	32	5,865
Kashipur	140	11	11	88	0	0	0	27	3	110	41,173
NW-N'ganj 1	85	5	22	27	0	11	3	10	7	68	24,140
NW-N'ganj 2	86	0	7	67	1	11	0	0	0	86	19,810
NW-N'ganj 3	78	0	14	42	0	0	2	20	0	58	17,518
N'ganj 4	184	31	43	49	3	22	10	26	1	157	71,058
N'ganj 5	100	28	28	14	12	1	4	14	0	86	52,632
N'ganj 6	55	43	2	0	1	0	0	8	0	47	62,977
N'ganj 7	124	5	19	70	0	0	0	28	2	94	32,318
N'ganj 8	85	11	7	6	50	0	0	12	0	73	18,161
N'GANJ WEST TOTAL	1,863	160	275	546	86	178	67	464	87	1,312	470,449

Table A.9: DETAIL LAND USE TABLE, 2010: NARAYANGANJ WEST

POPLAND INFORMATION OF N'GANJ WEST DRAINAGE ZONE(ha) 2010											
	TOTAL	DETAILED LAND USE(ha)								BUILT UP	POP'TION
	AREA	Residential			Com'cial	Industry	Ins'tion	Agr'ture	Water	AREA(ha)	(persons)
ZONE NAME	(ha)	(high)	(mid)	(low)						2010	2010
NW-Matuail	136	34	27	7	5	5	45	6	7	123	48,440
NW-Siddirganj	183	39	35	13	13	24	52	1	5	177	47,874
NW-Simulpara	411	103	30	15	24	143	85	0	11	400	130,942
NW-Godnail	164	44	20	16	4	22	54	1	2	161	53,431
NW-Enayetnagar	33	2	0	0	0	1	2	0	28	5	5,865
Kashipur	140	35	27	5	8	3	11	1	48	91	41,173
NW-N'ganj 1	85	33	2	0	4	19	25	0	1	83	59,959
NW-N'ganj 2	86	33	2	0	4	29	17	0	1	85	63,455
NW-N'ganj 3	78	33	6	2	7	4	24	0	1	76	56,962
N'ganj 4	184	59	3	0	24	36	57	0	6	178	135,802
N'ganj 5	100	46	11	0	24	2	14	0	4	96	76,221
N'ganj 6	55	34	9	2	2	0	4	0	4	51	62,977
N'ganj 7	124	55	10	3	9	5	28	0	15	110	93,246
N'ganj 8	85	26	3	0	45	0	8	0	3	82	50,475
N'GANJ WEST TOTAL	1,863	578	186	64	173	292	427	8	135	1,720	926,820

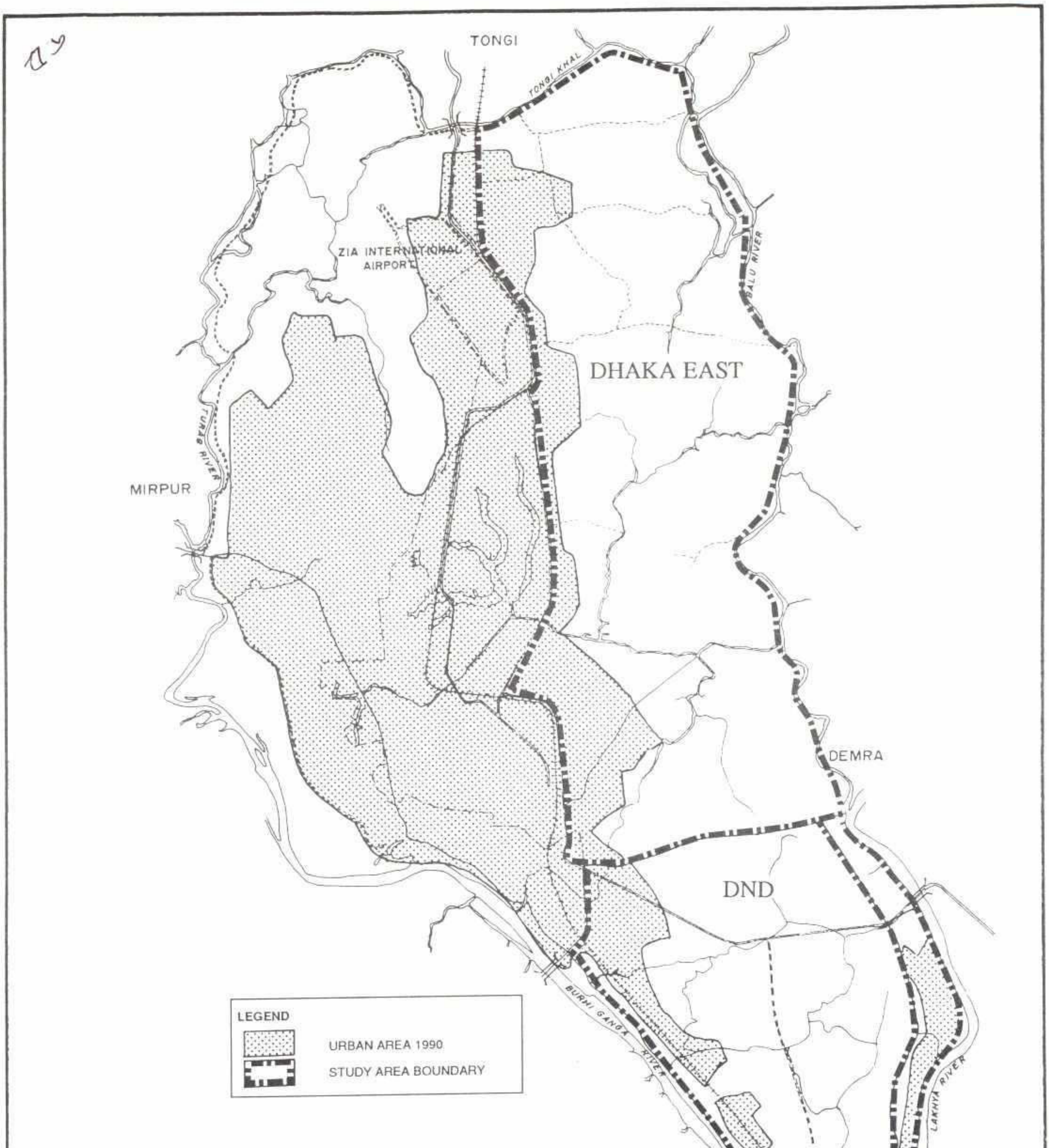

FIG. A.1 LOCATION OF FEASIBILITY STUDY AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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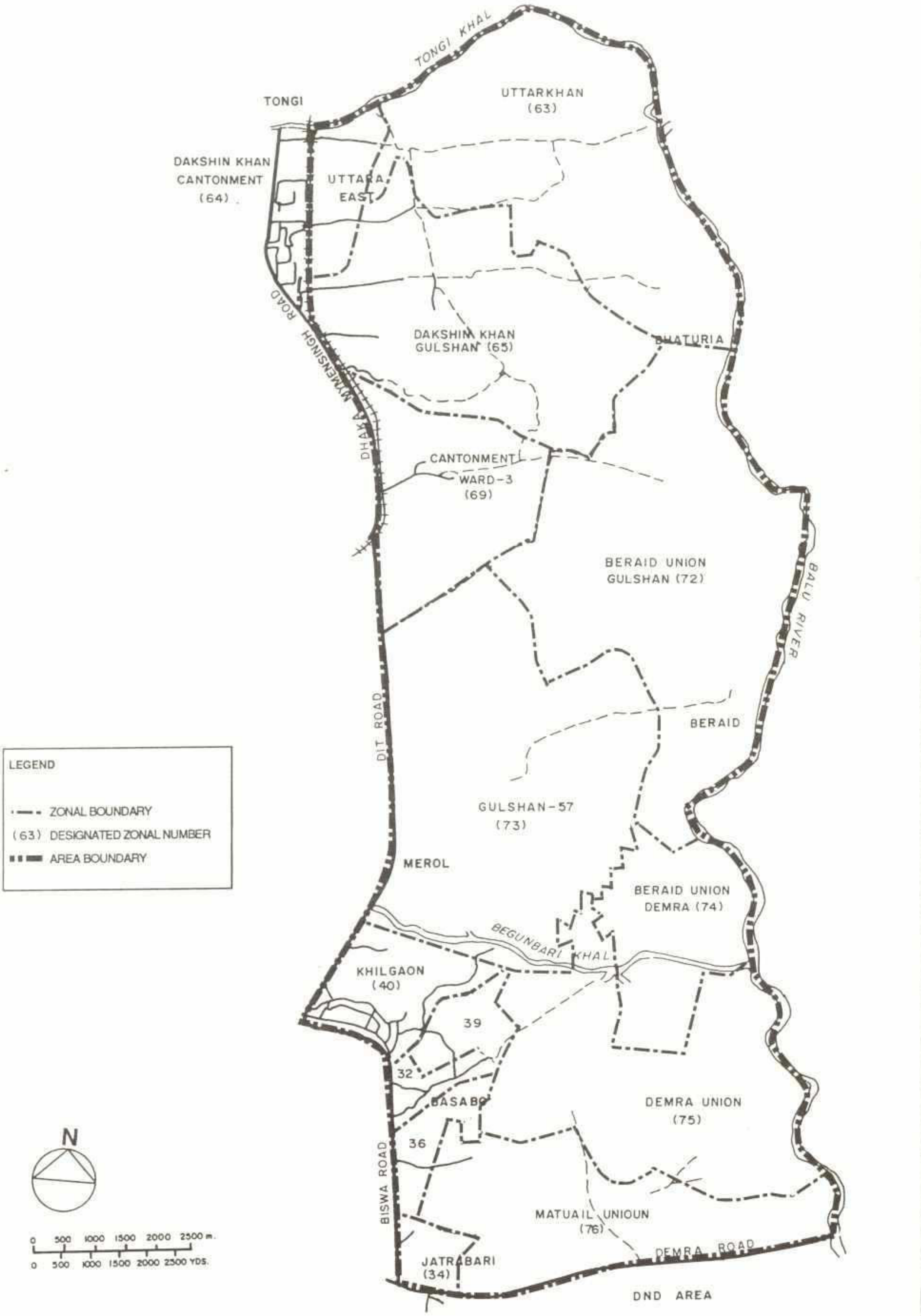

FIG. A.2 BASE MAP : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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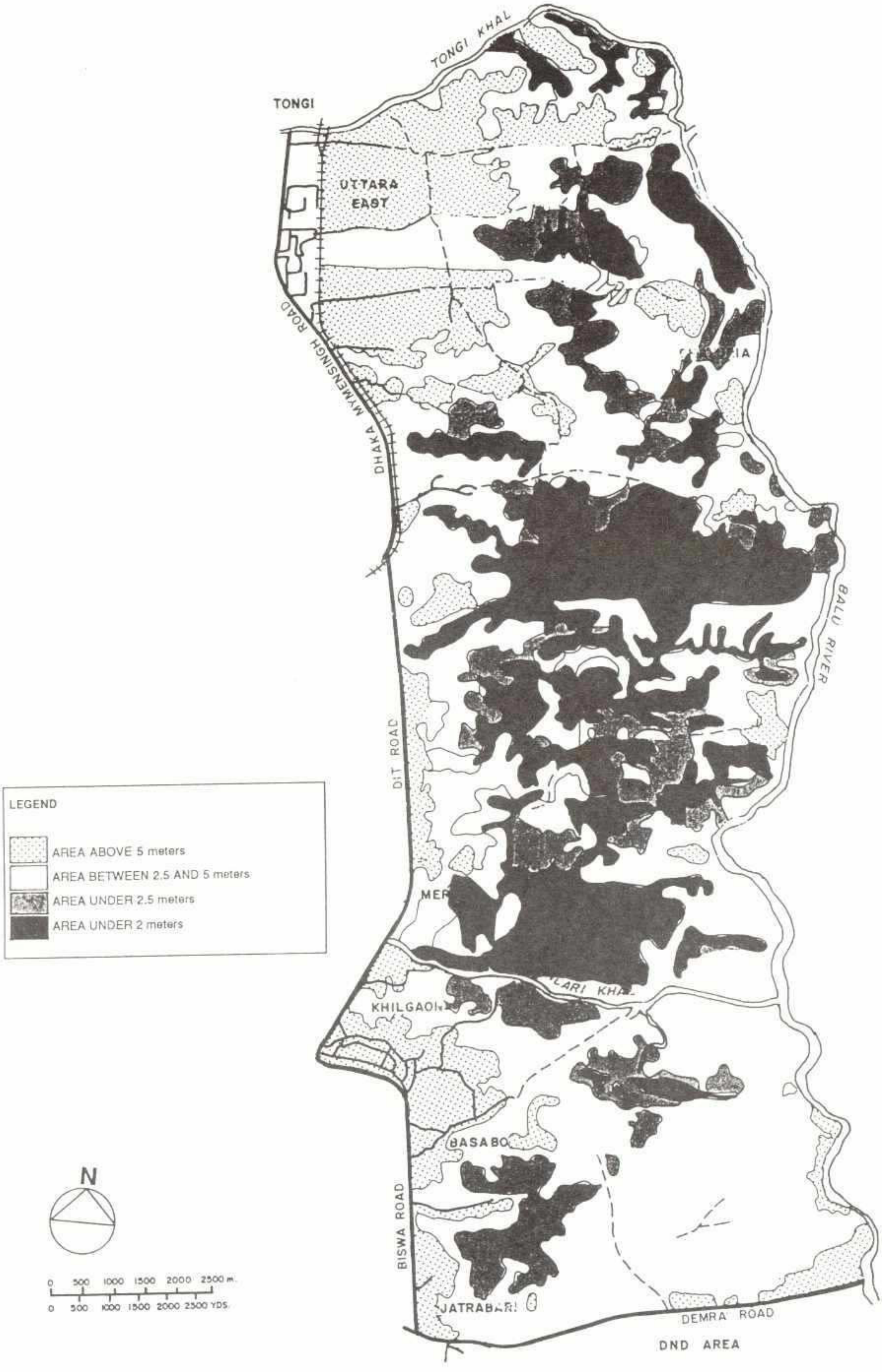

FIG. A.3	EXISTING LAND HEIGHT : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

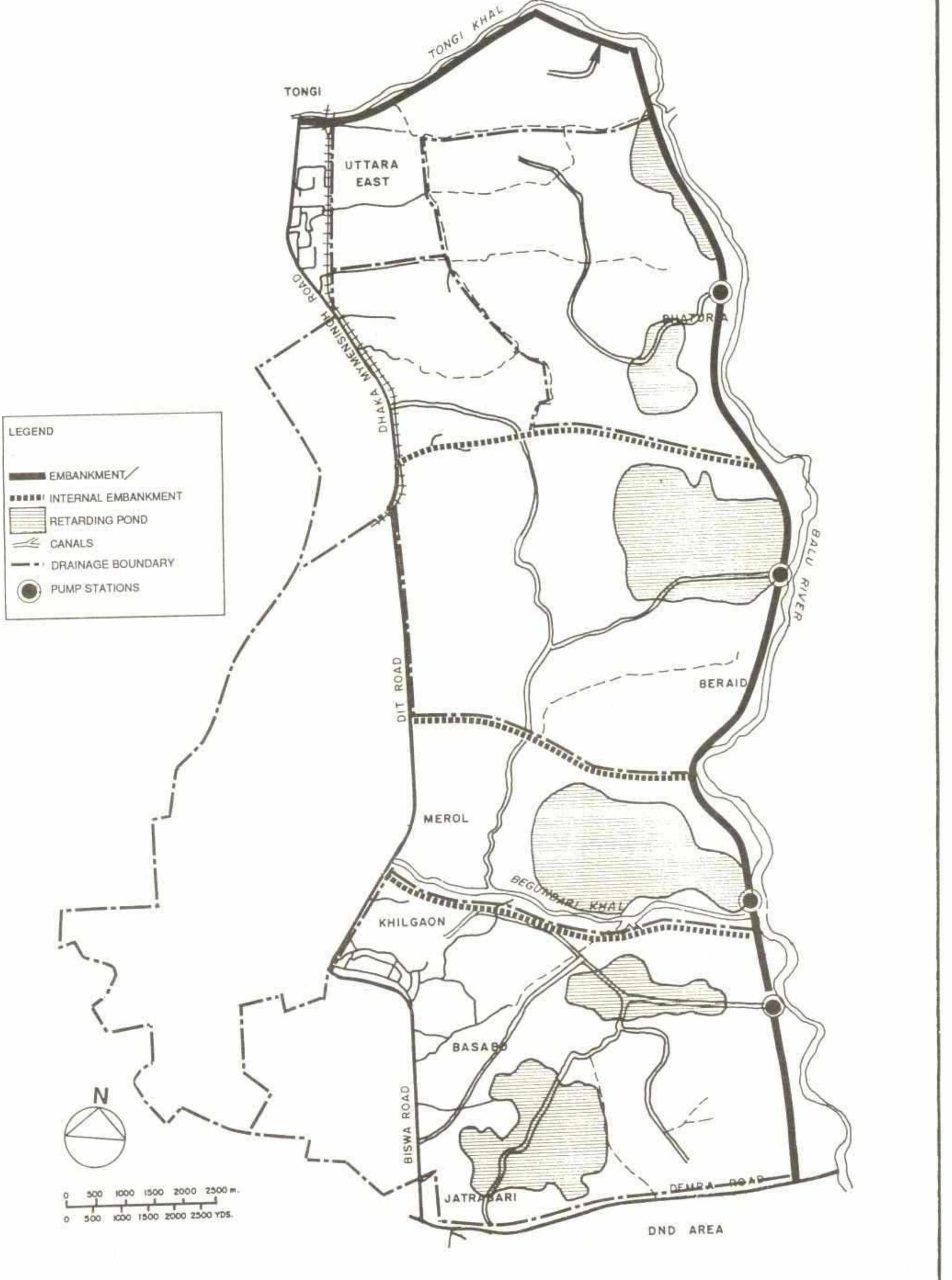

FIG. A.4 FLOOD PROTECTION PROPOSAL : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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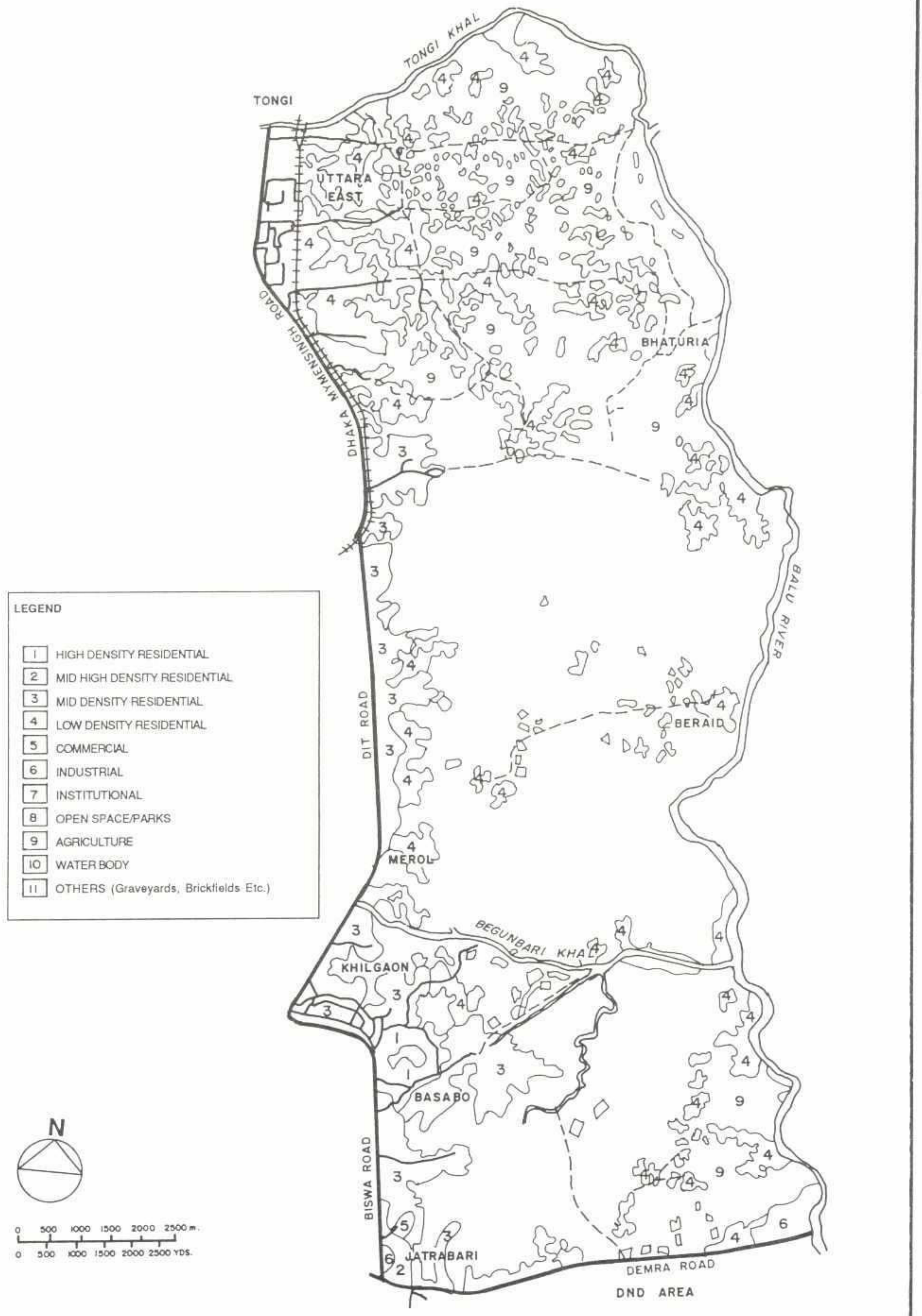

FIG. A.5 EXISTING LAND USE : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

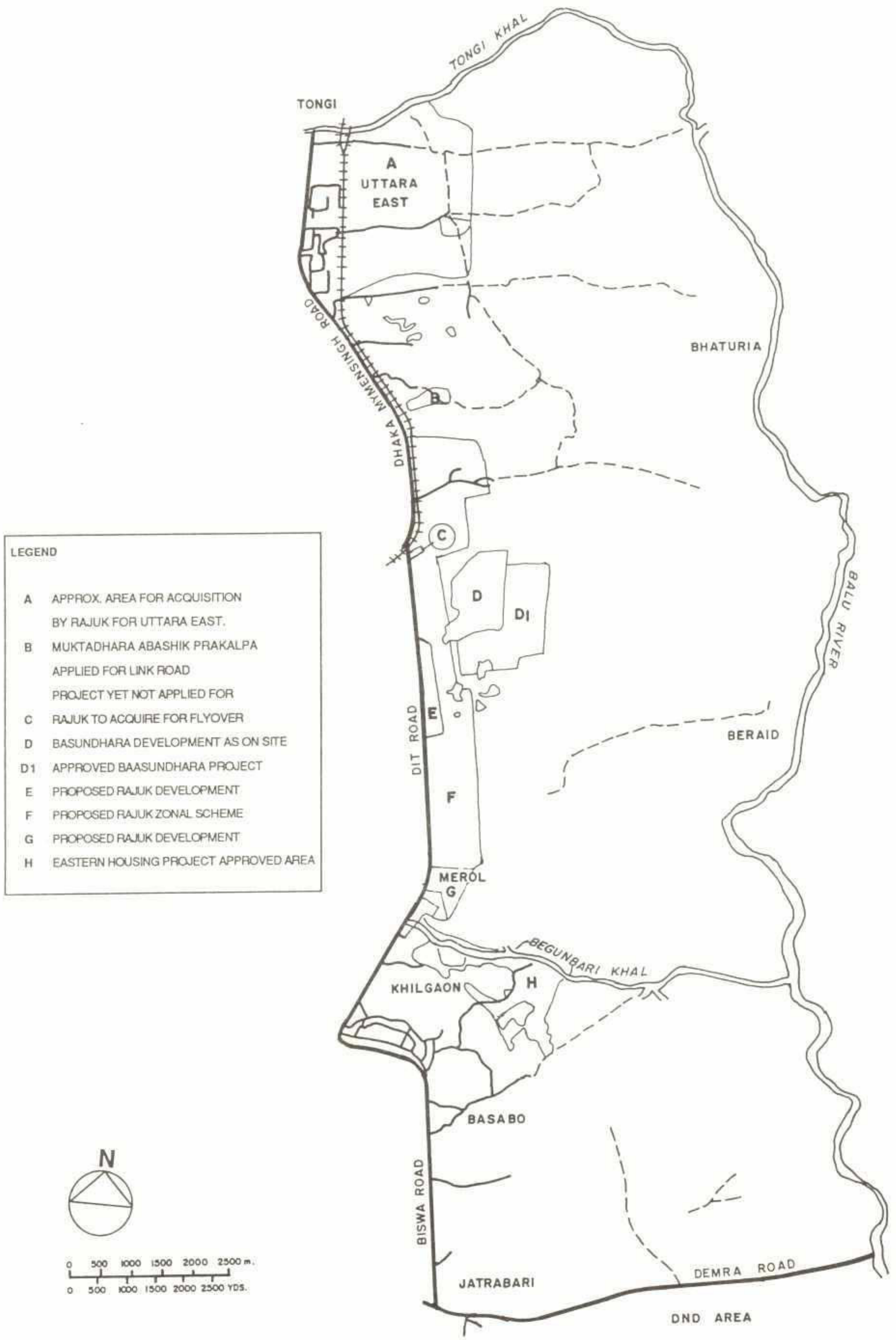

FIG. A.6 DEVELOPMENT COMMITMENTS : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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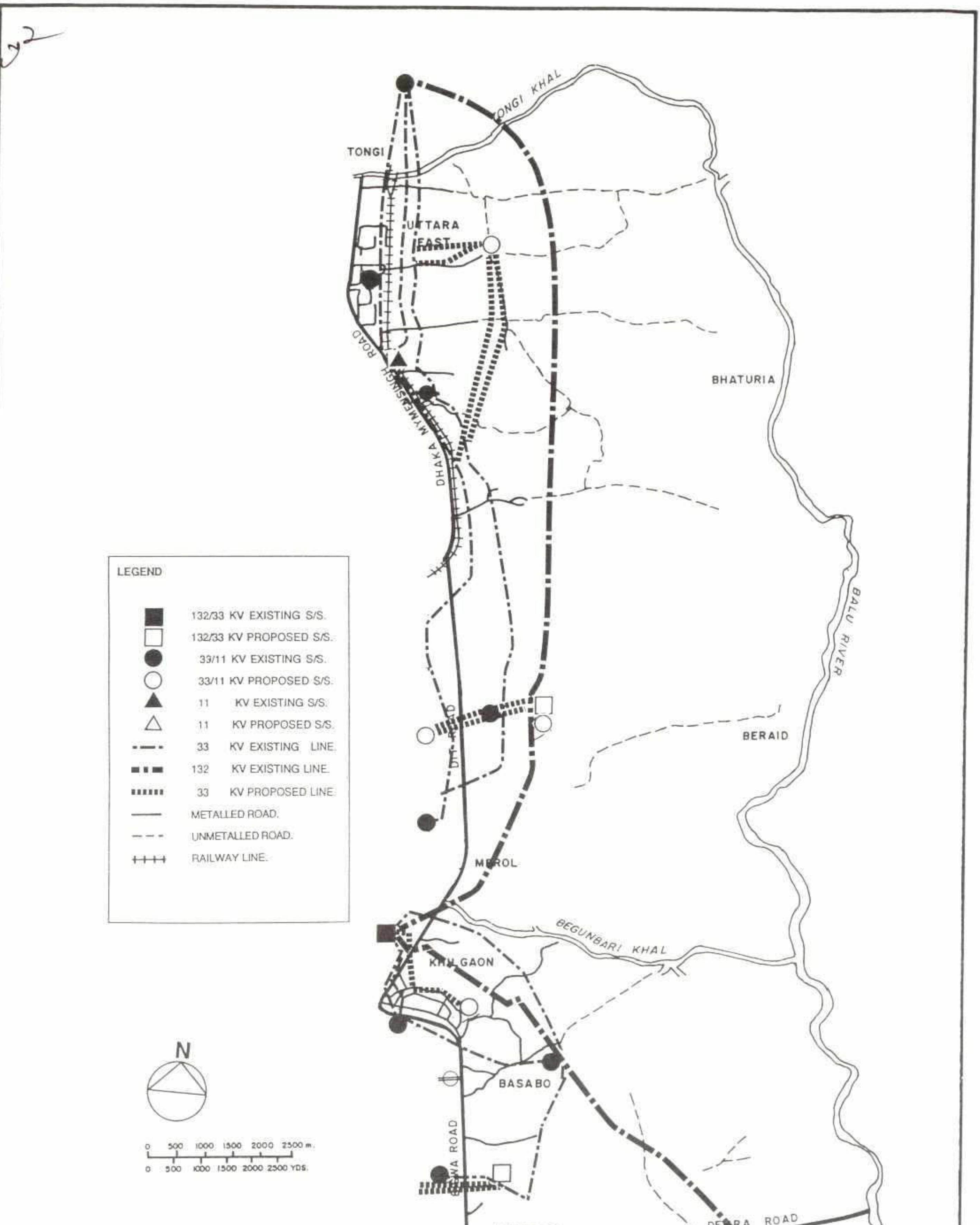

FIG. A.7 INFRASTRUCTURE : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

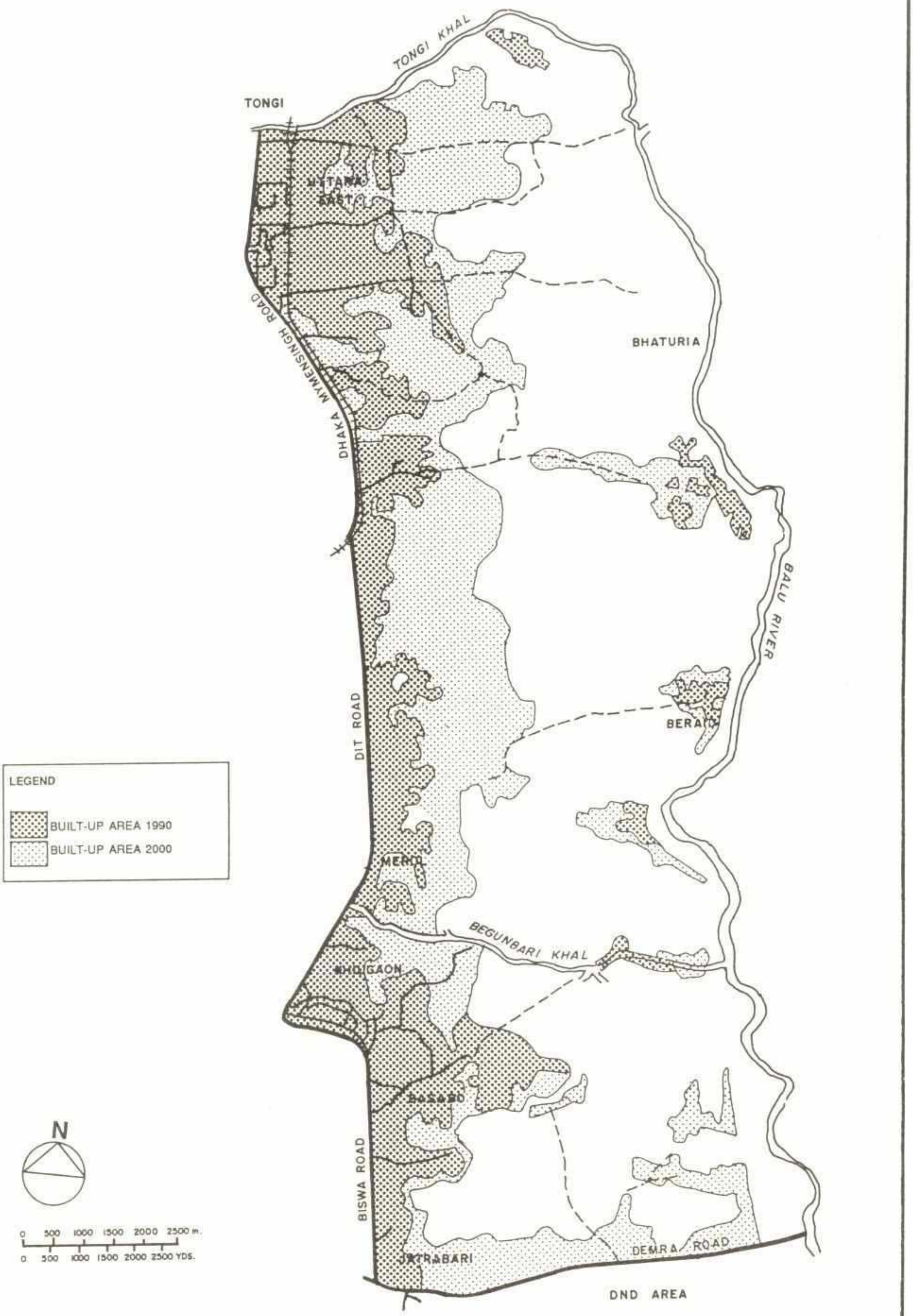

FIG. A.8	BUILT-UP AREA 1990/2000 : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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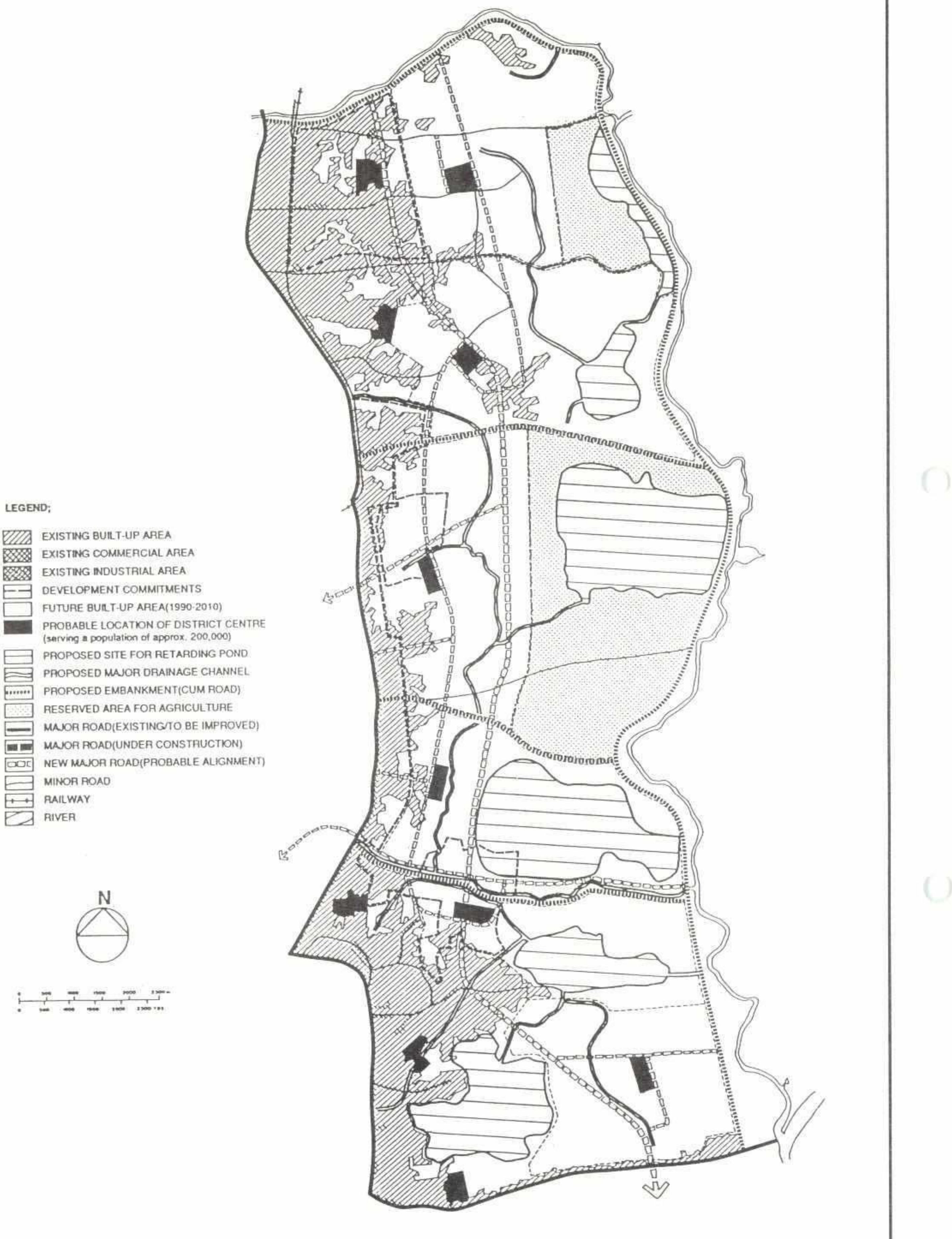

FIG. A.9 INDICATIVE LAND USE MAP OF GREATER DHAKA EAST, 2010

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

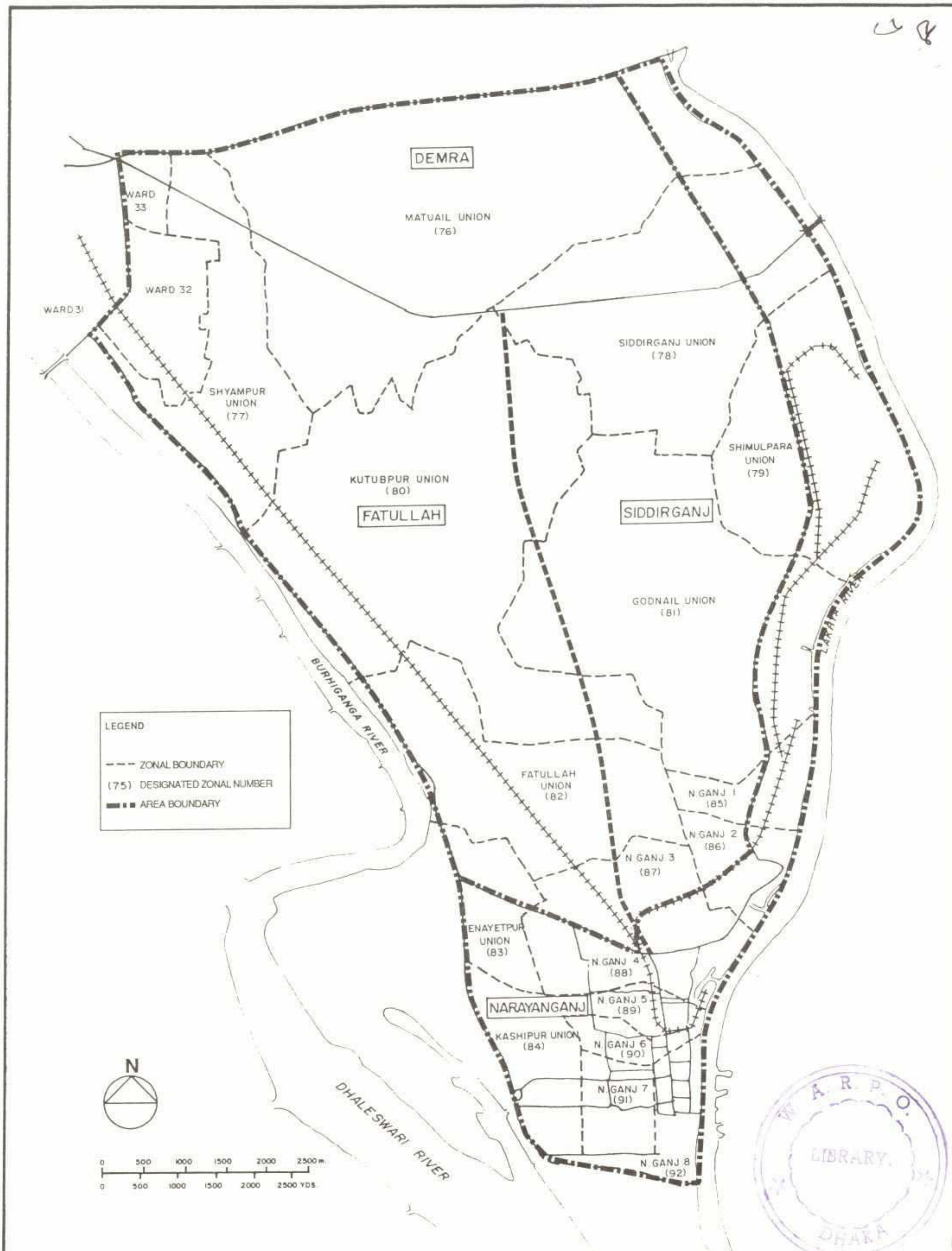

FIG. A.10 BASE MAP : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

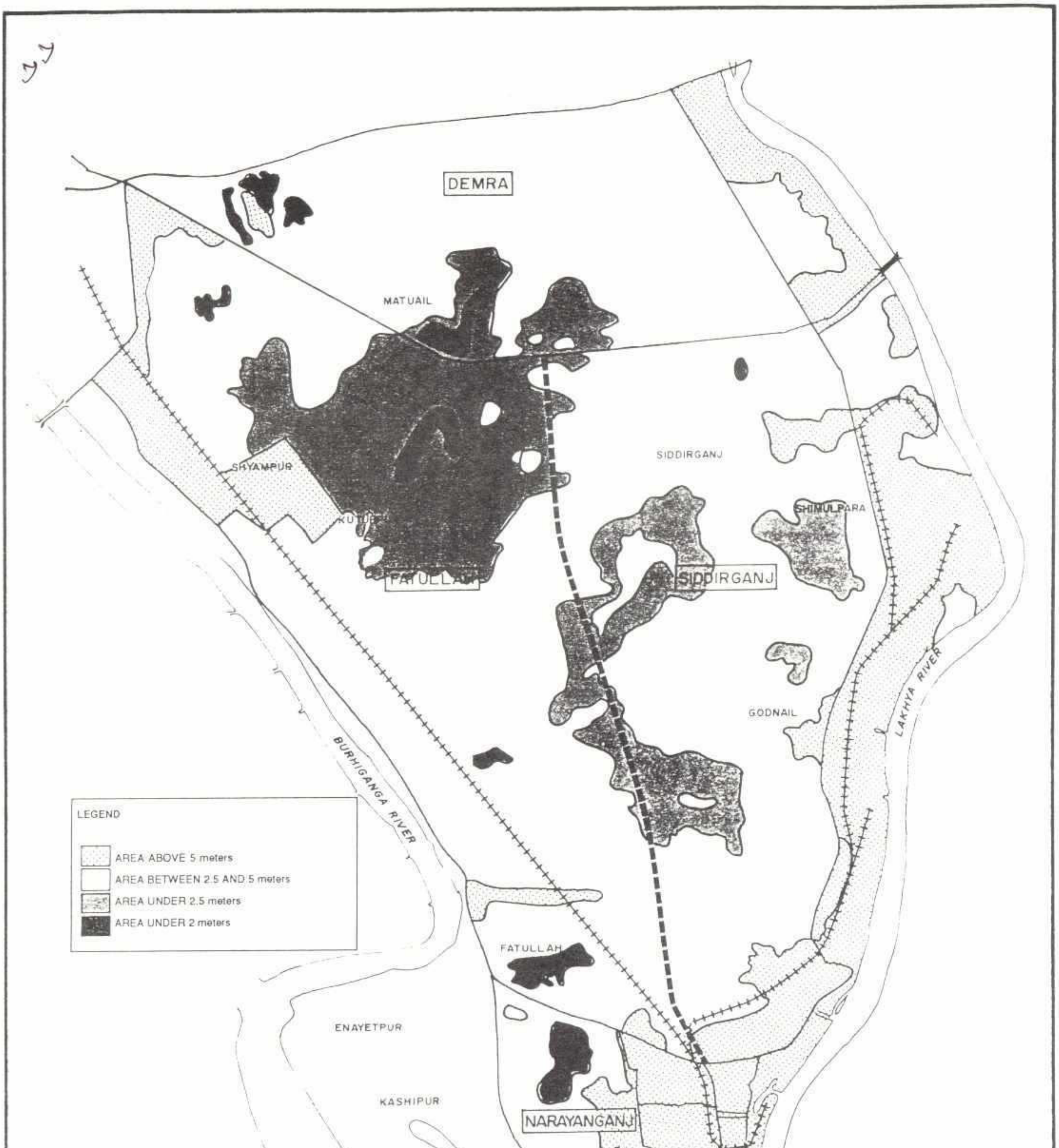

FIG. A.11 EXISTING LAND HEIGHT : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

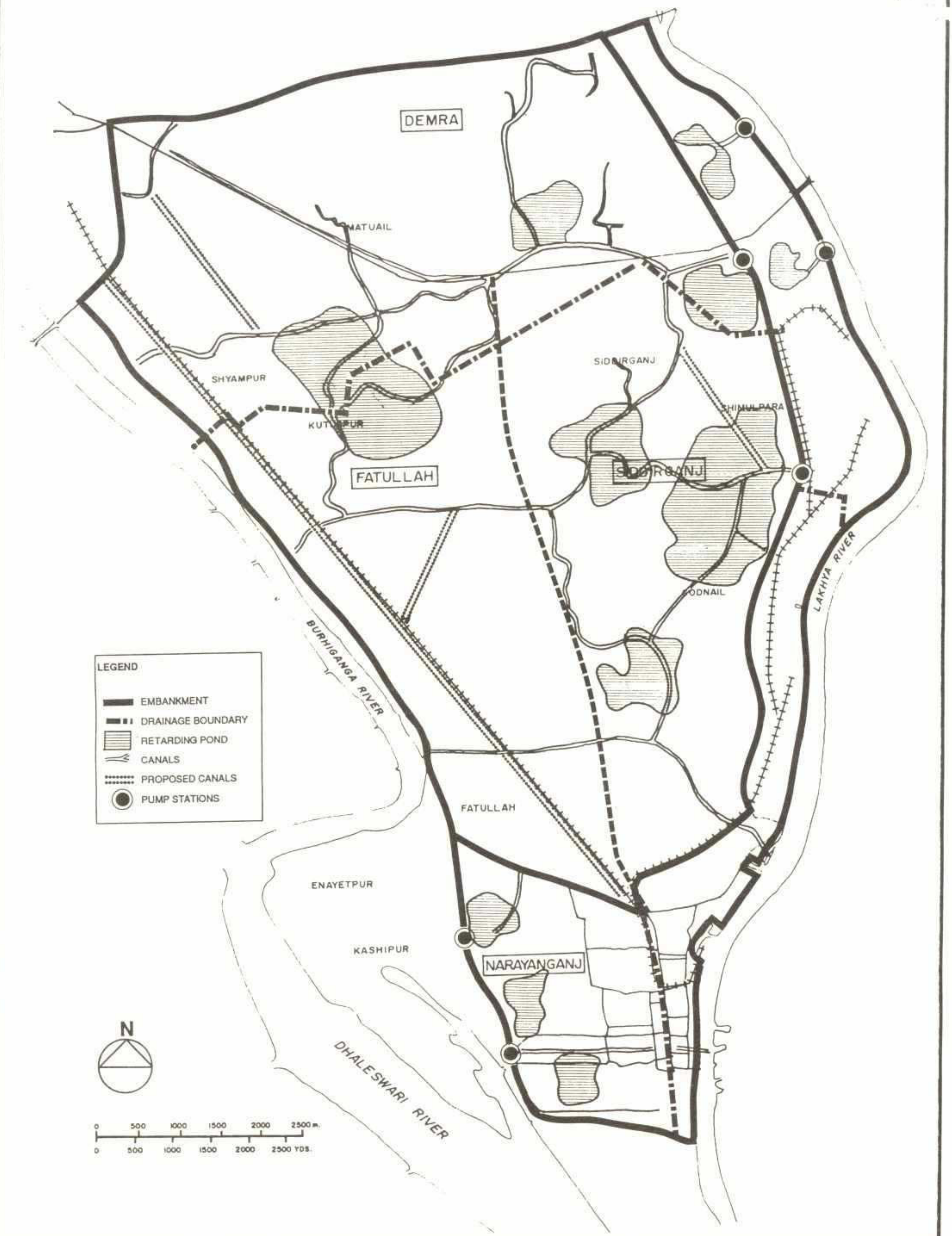

FIG. A.12 FLOOD PROTECTION PROPOSAL : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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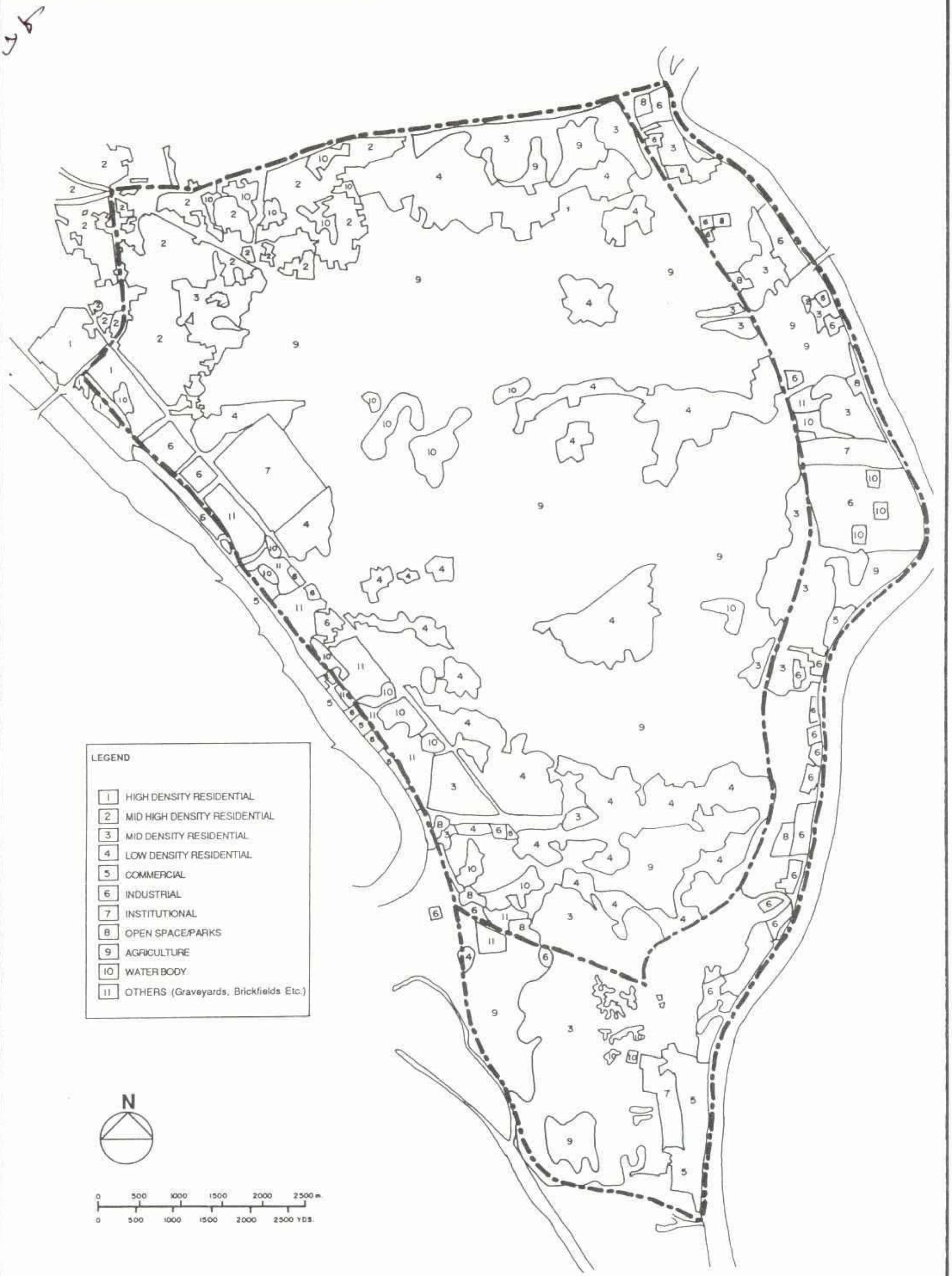

FIG. A.13 EXISTING LAND USE : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

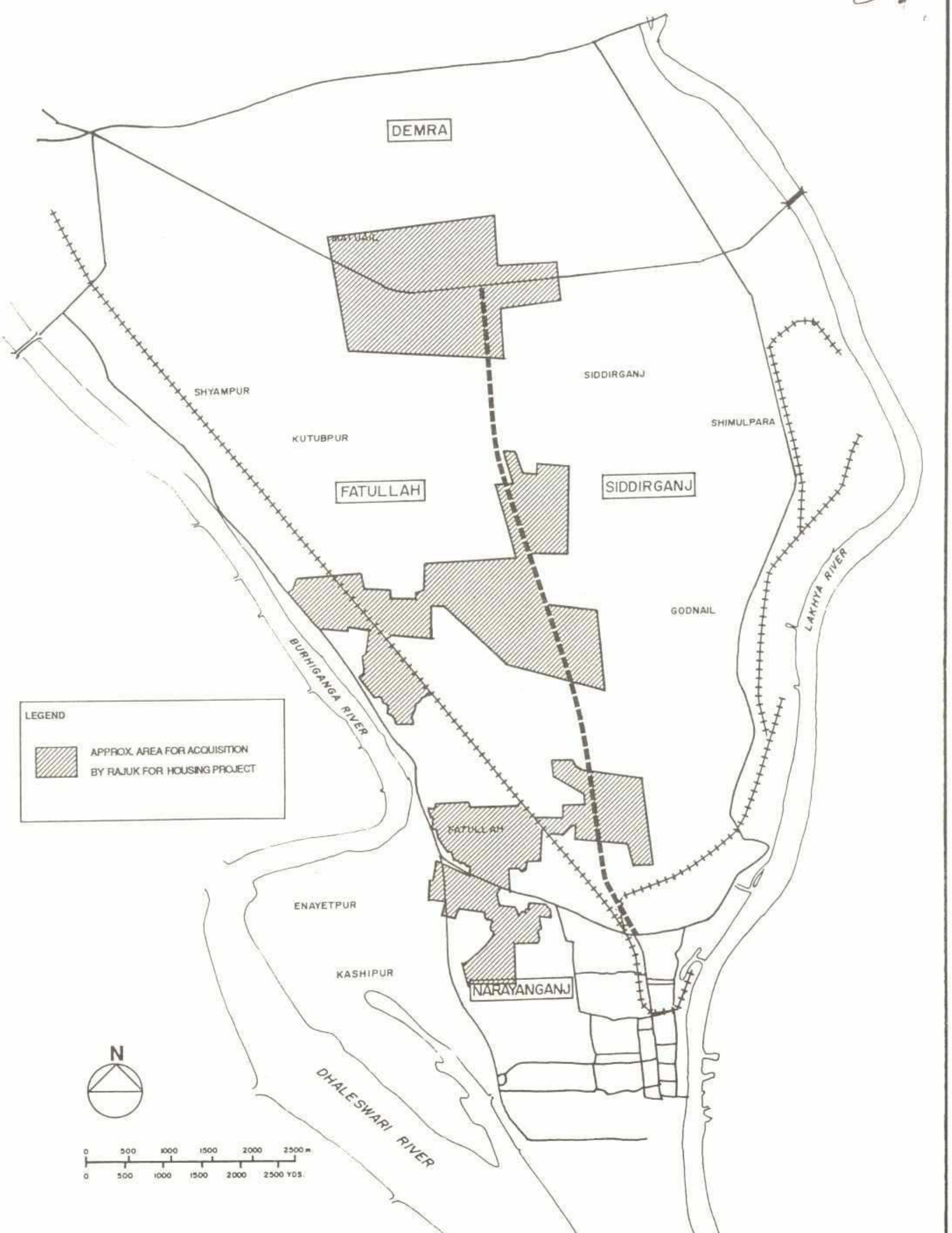

FIG. A.14 DEVELOPMENT COMMITMENTS : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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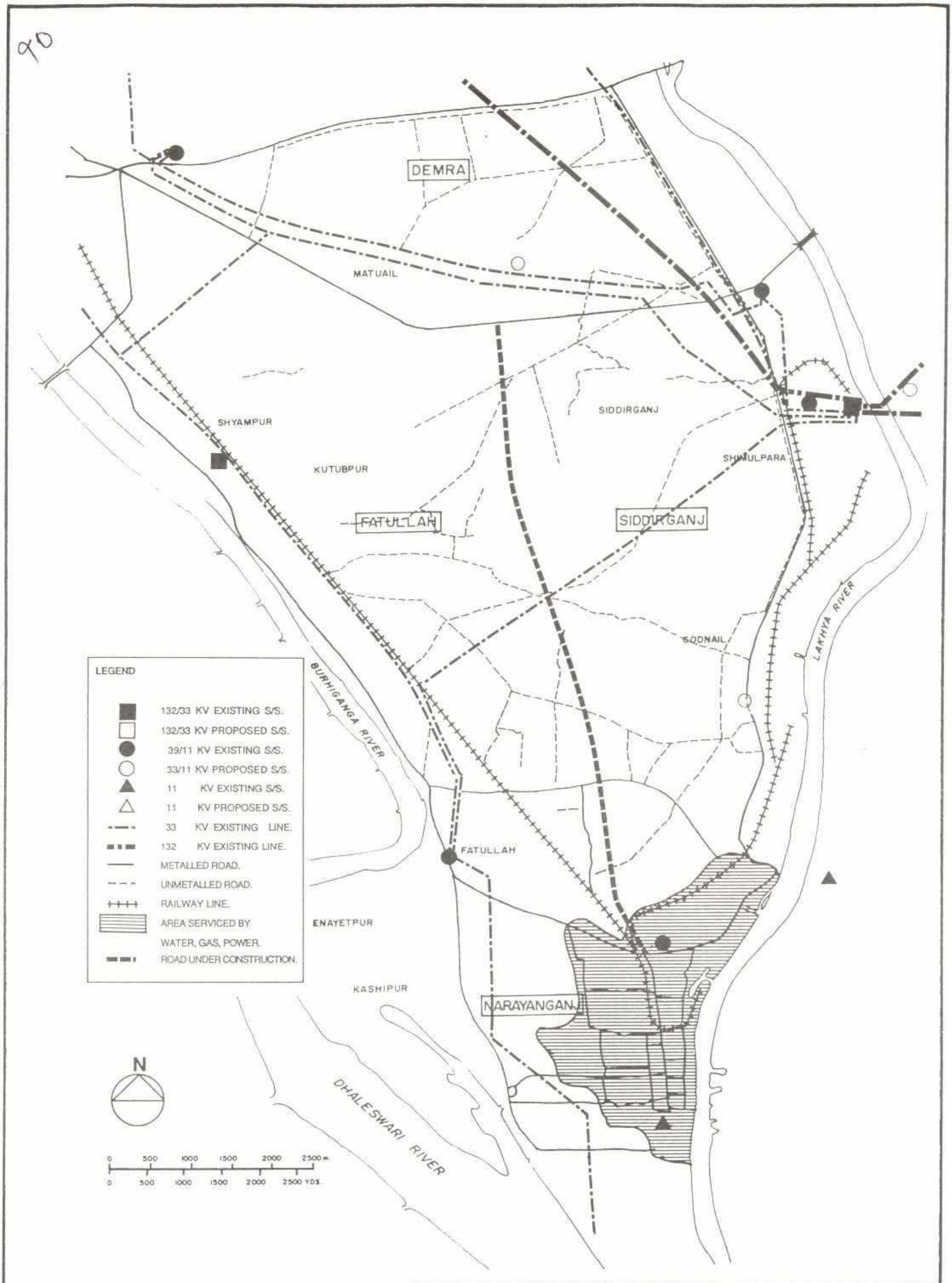

FIG. A.15 INFRASTRUCTURE : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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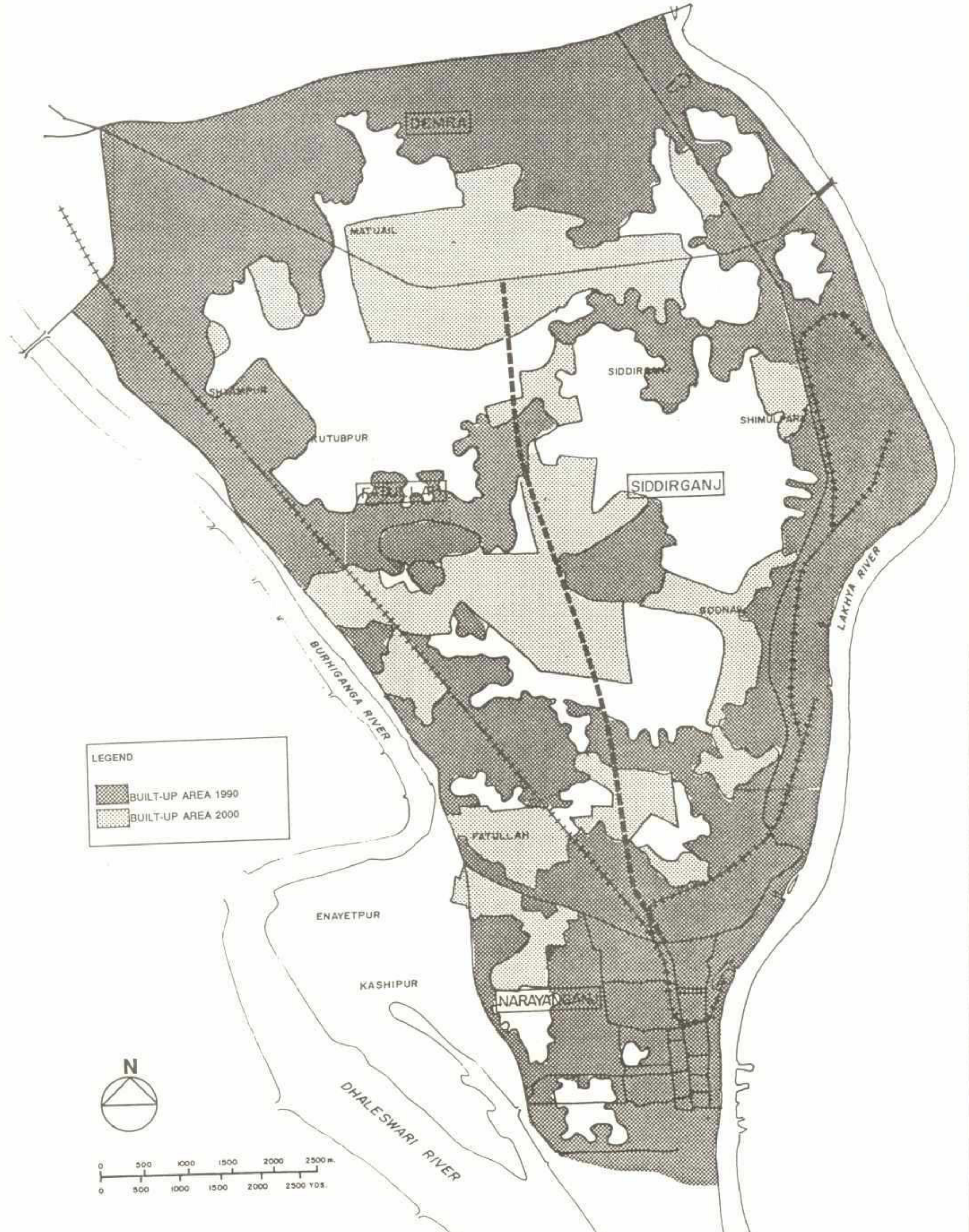

FIG. A.16 BUILT-UP AREA 1990/2000 : DND/NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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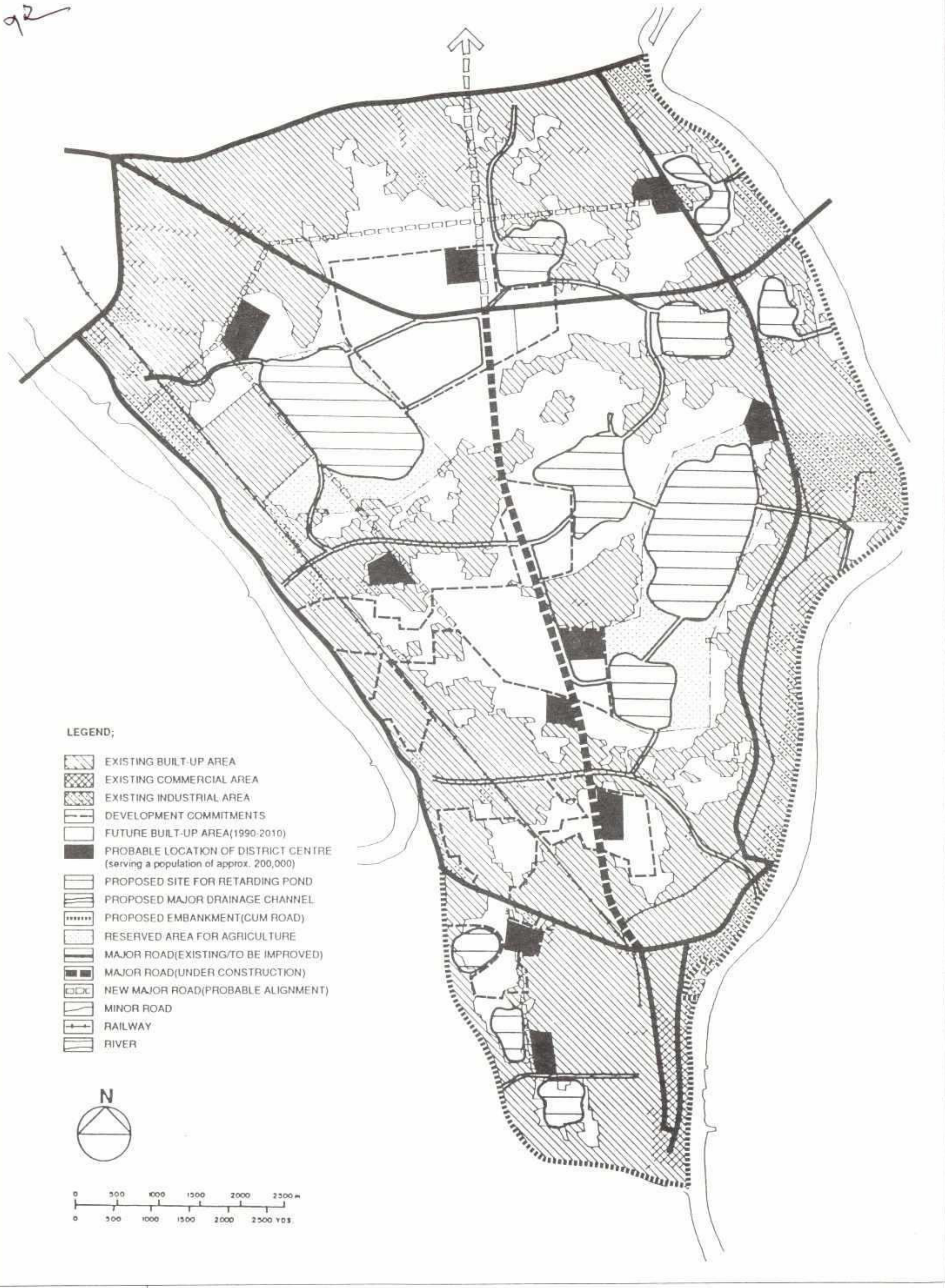

FIG. A.17 INDICATIVE LANDUSE MAP OF NARAYANGANJ DND/WEST, 2010

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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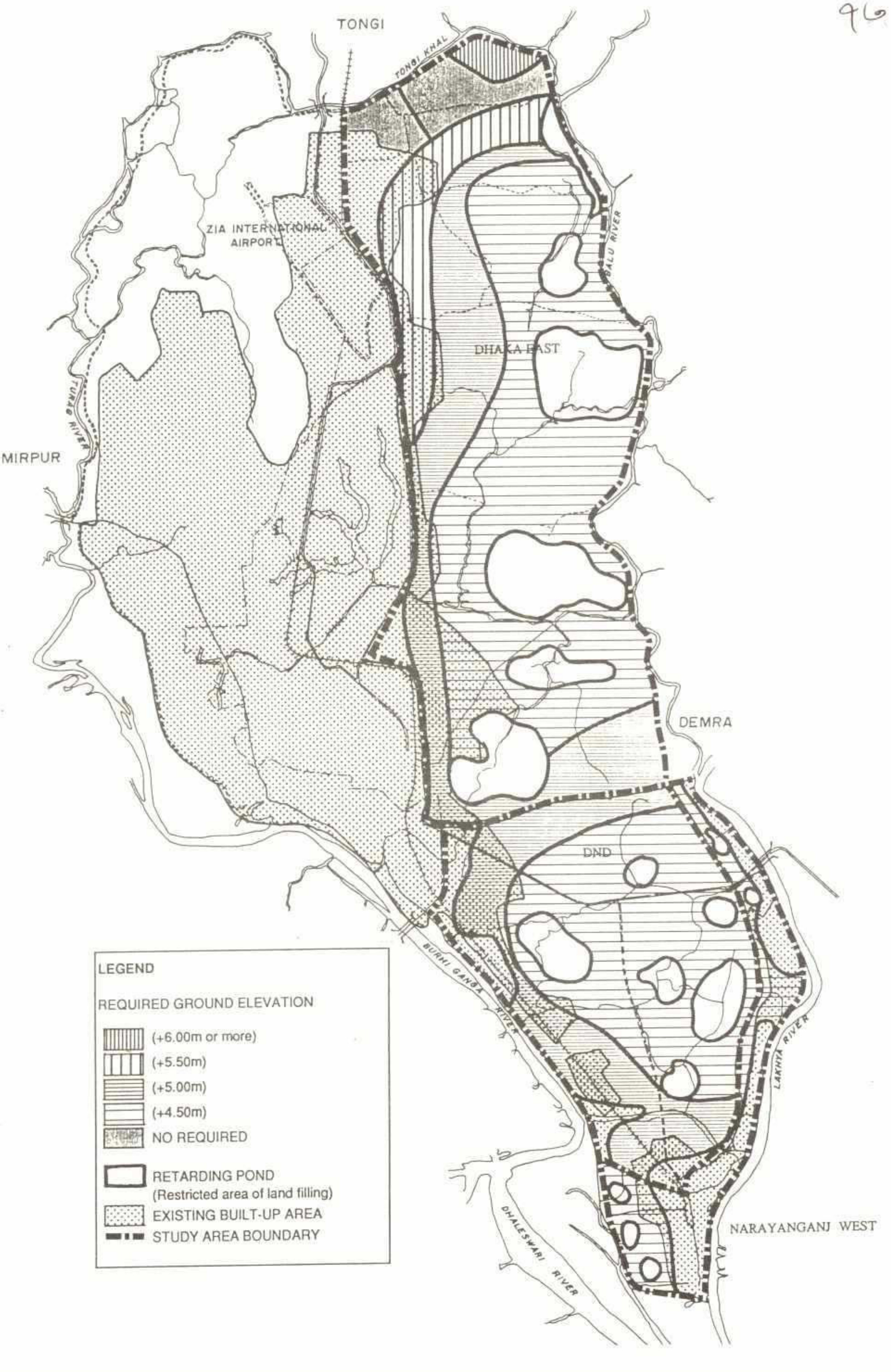

FIG. A.18 MINIMUM HEIGHTS FOR DEVELOPMENT

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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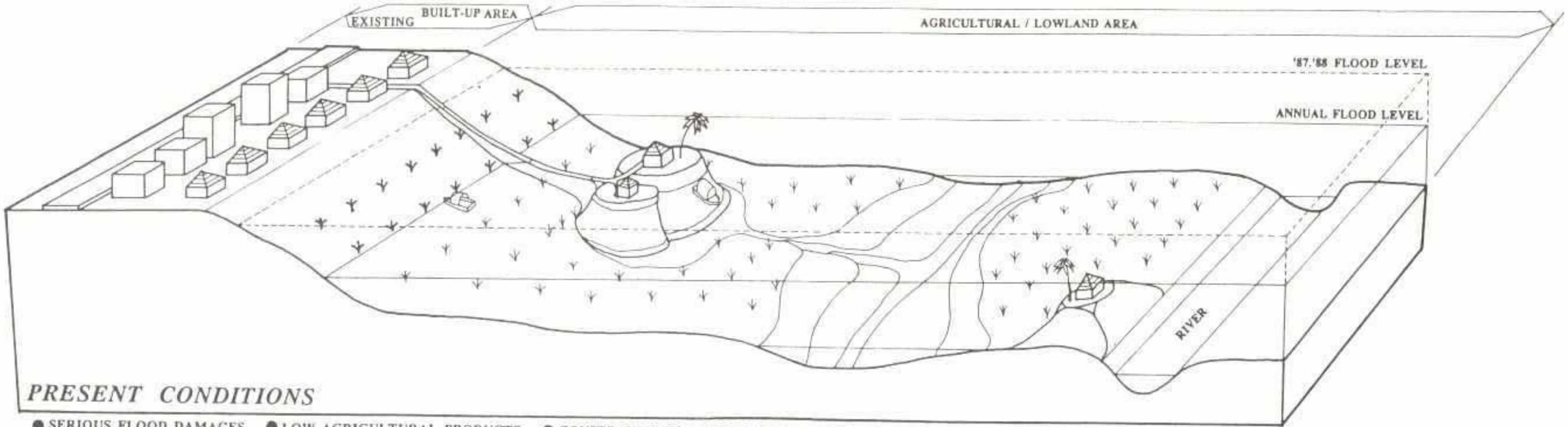
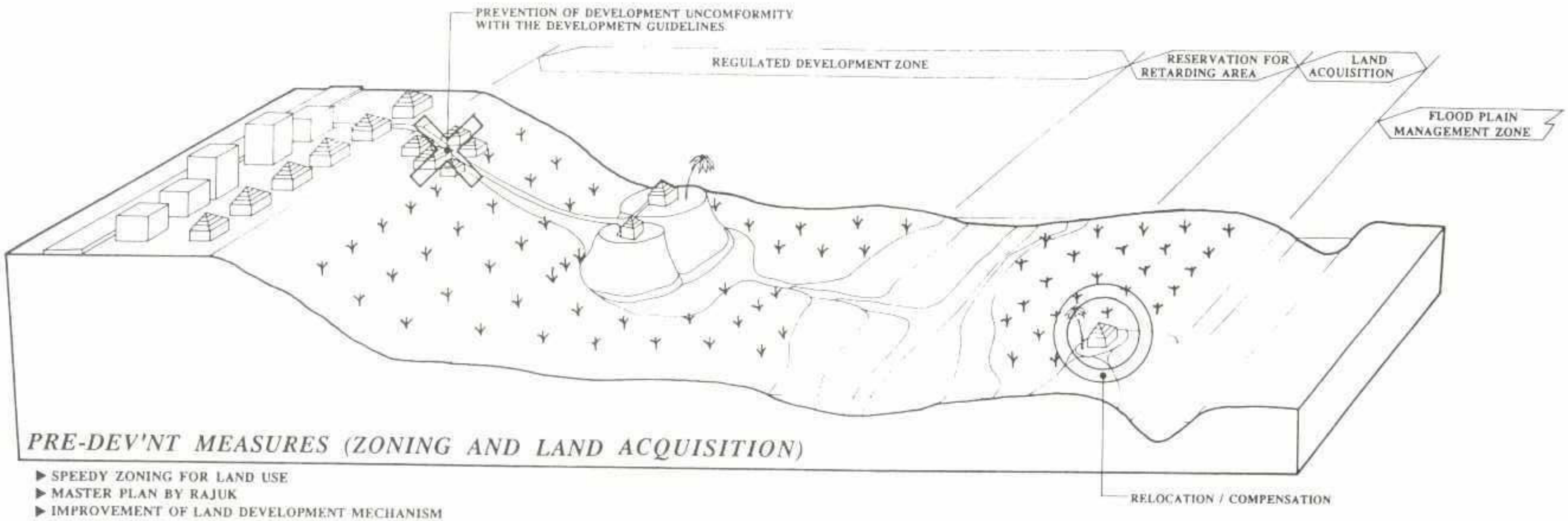


PRESENT CONDITIONS

● SERIOUS FLOOD DAMAGES ● LOW AGRICULTURAL PRODUCTS ● CONSTRAINTS FOR URBAN DEVELOPMENT
○ NATURAL DRAINAGE BASIN ○ OPENSPACE / GREEN ZONE ○ NAVIGATION AREA IN RAIN SEASON



PRE-DEV'NT MEASURES (ZONING AND LAND ACQUISITION)

- ▶ SPEEDY ZONING FOR LAND USE
- ▶ MASTER PLAN BY RAJUK
- ▶ IMPROVEMENT OF LAND DEVELOPMENT MECHANISM
- ▶ DEVELOPMENT OF COST RECOVERY SYSTEM

FIG. A.18(1) URBAN DEVELOPMENT STEP OF LOW LAND AREA-1

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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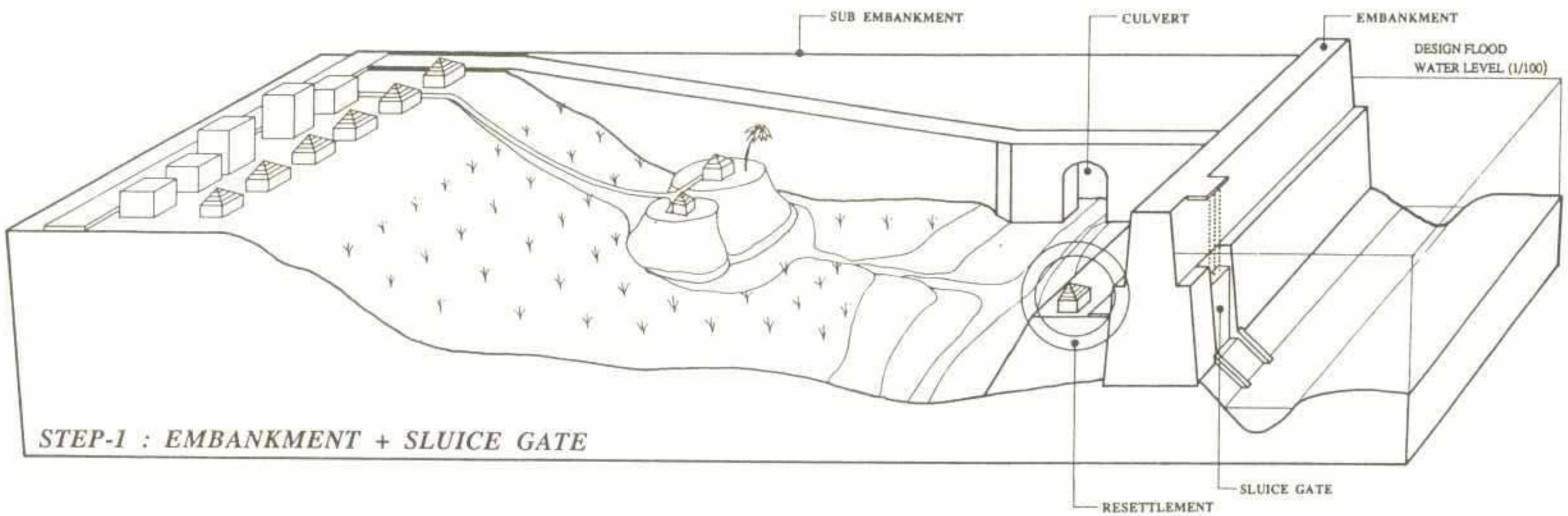
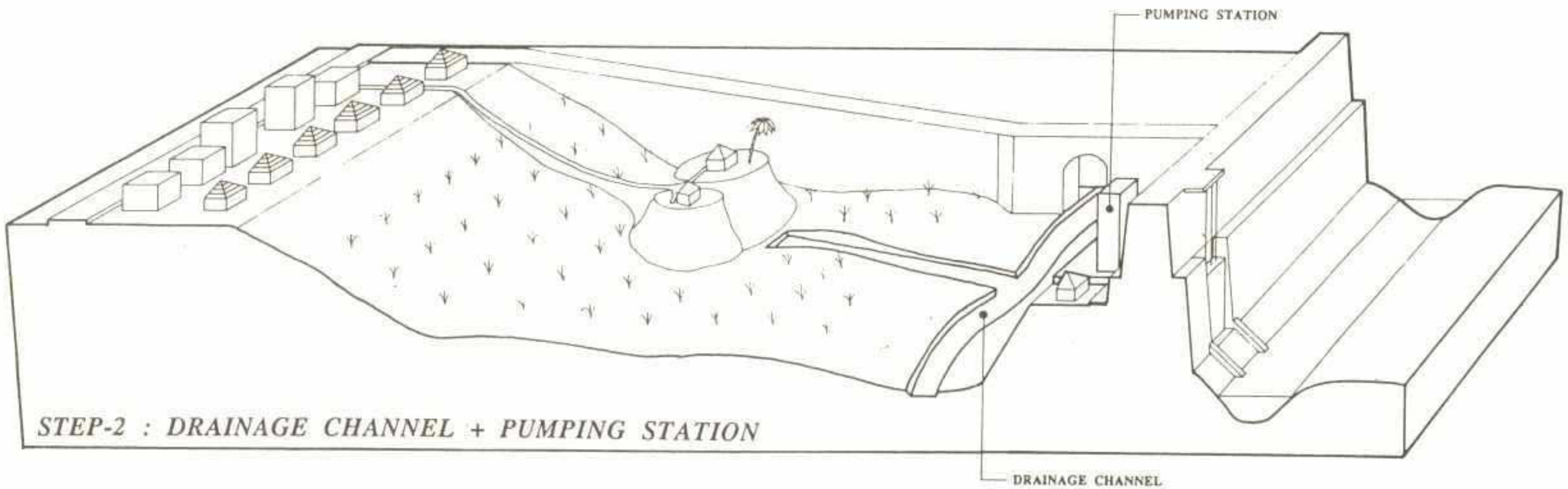


STEP-1 : EMBANKMENT + SLUICE GATE



STEP-2 : DRAINAGE CHANNEL + PUMPING STATION

FIG. A.18(2)	URBAN DEVELOPMENT STEP OF LOW LAND AREA-2

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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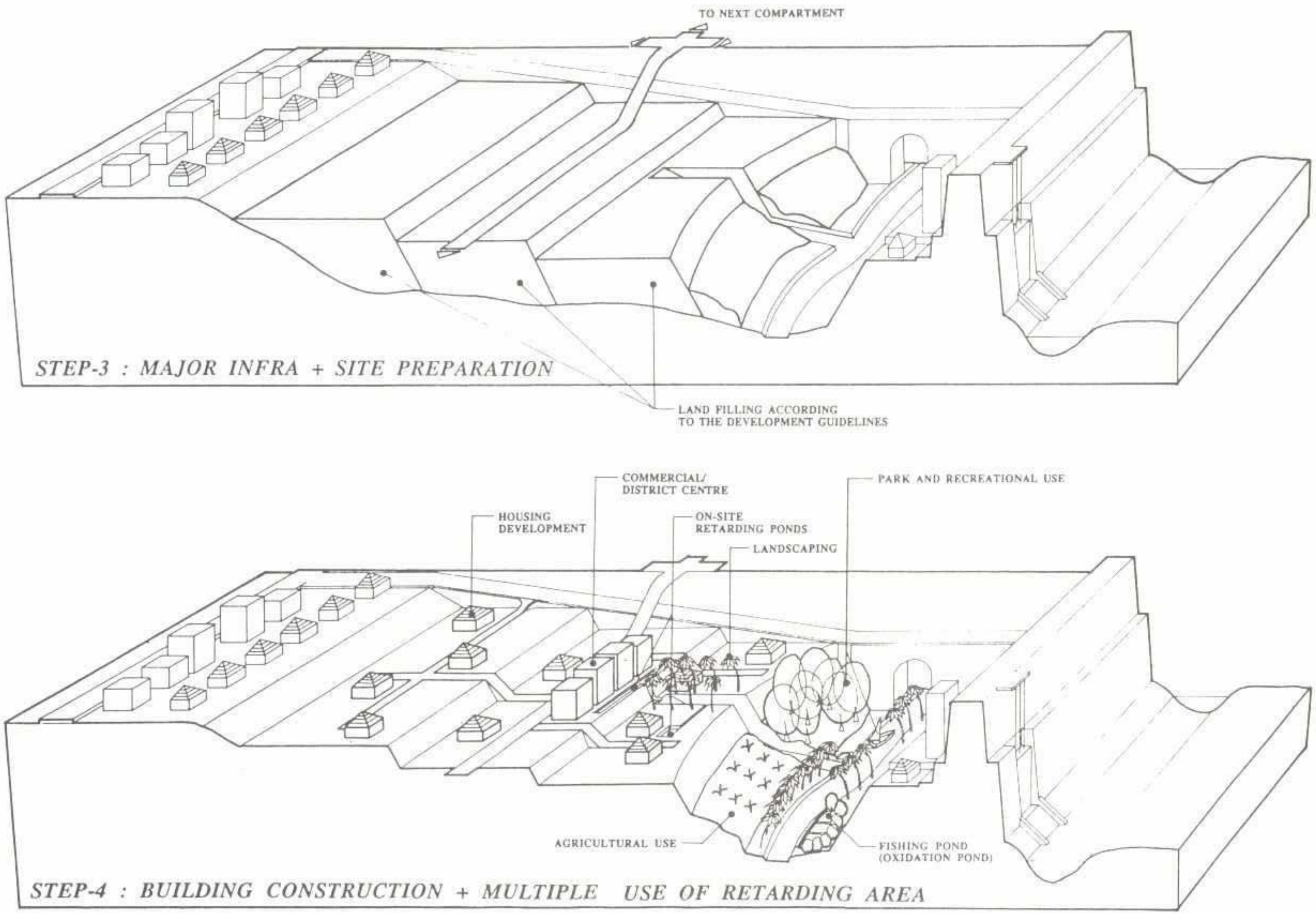

FIG. A.18(3)	URBAN DEVELOPMENT STEP OF LOW LAND AREA-3

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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SUPPORTING REPORT B

FLOOD AND FLOOD DAMAGE

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SUPPORTING REPORT B : FLOOD AND FLOOD DAMAGE

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SUPPORTING REPORT B : FLOOD AND FLOOD DAMAGE

1 Flood Condition

1.1 General

There are two types of floods, external and internal, in the study area. External floods are caused by overflow of surrounding rivers, while internal floods are caused by stormwater flooding due to insufficient drainage facilities in the built-up areas.

Most of floods within the study area have been derived from the surrounding rivers.

Major floods of the study area were recorded in 1954, 1955, 1958, 1970, 1974, 1980, 1984, 1987 and 1988 since the water level observation was initiated at Mill Barak in Dhaka in 1945.

During the 1988 flood, a large part of the built-up area, which is usually flood free, was submerged by flooding from the surrounding rivers. Most parts of Greater Dhaka East were submerged.

The study area experienced severe floods consecutively in 1987 and 1988. The 1987 flood was assessed as the medium-size flood of a 10-year return period, while the 1988 flood was the largest one recorded and estimated as the flood of a 70-year flood return period.

During the Phase I (Preliminary Review Stage) and the Phase II (A Master Plan Study Stage), a questionnaire survey on "external and internal floods" in the study area of 850 km^2 was carried out. The survey on external floods was executed on the last three floods of the 1987 flood, the 1988 flood and the 1990 flood. The 1990 flood was considered as an "annual flood". The survey on internal floods were done on the annual flood and the worst one.

For this feasibility study stage, supplementary flood surveys have been carried out for the F/S area including a related area of Dhaka City. The survey areas are Greater Dhaka East and a part of Dhaka City, which belongs to the drainage area of the Balu River, Narayanganj DND and West.

The supplementary surveys consist of the followings :

(1) Review of the flood depth and duration survey data in the Master Plan Study according to the land use of each administrative unit, and

(2) Collection of supplementary data and information on flood damages to public utilities and traffic, from RHD, DCC, Bangladesh Railways, Power Development Board, etc.

Concerning the internal flood conditions of zones No. 1 to 53 in the Dhaka Sub-Area, the survey results of the 1987 JICA Study were referred to.

1.2 Greater Dhaka East

The survey area covers Greater Dhaka East (118.62 km^2) and a part of Greater Dhaka West (47.74 km^2), mostly built-up, which drains off eastwards to the Balu River.

The survey area consists of 39 zones based on the administrative division of wards and unions. (Refer to Fig. B.1).

1.2.1 External Flood

1) Annual Flood

(1) Flood Area

The total flood area by the annual external flood is estimated at 7,850 ha, or 47% of the survey area. There is no flooding in the built-up area.

Most of the agricultural area in Greater Dhaka East is submerged during the flood season, and rural villages or settlements there are likely to be isolated, but still flood free because their house lots are built a little higher than the annual flood stage. (Refer to Fig. B.3).

(2) Flood Depth and Duration

There are only limited cases of flooding by the annual flood. However, it does not mean that the study area is free from the annual flood. The flood depth and duration were surveyed only for houses and assets, which are mostly located on high plots that are safe from annual external floods. However, most of rural villages and settlements are isolated because of inundation.

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2) 1987 Flood

(1) Flood Area

The flood area by the 1987 flood is estimated at 10,716 ha, or 64% of the survey area.

Within the flood area, the built-up area is estimated at 1,121 ha, or 17% of the total built-up area. (Refer to Fig. B.4).

(2) Flood Depth and Duration

During the 1987 flood, the maximum flood depth and duration in the survey area were 0.91m and 22 days respectively, and the average depth and duration were 0.27 m and 7.47 days respectively. (Refer to Table B.2 and Fig. B.6).

The flood map, Fig. B.4 shows the flood depth and the flood duration at houses and the flood depth around settlements. Flooded depth around settlement areas were from 0.4 m to 4.0m.

3) 1988 Flood

(1) Flood Area

The 1988 flood is the most severe flood that has ever hit the study area. The flood area is estimated at 13,173 ha, or 79% of the survey area. The built-up area of 3,285 ha, or 49% of the total built-up area was affected and shown in Table B.6.1. and Fig. B.5.

(2) Flood Depth and Duration

The 1988 flood recorded the maximum flood depth and duration of 2.13 m and 65 days respectively in the survey area. The average flood depth and duration are estimated at 0.72 m depth and 19.66 days respectively. (Refer to Table B.2 and Fig. B.6).

The flood map, Fig. B.5 shows flood depth and duration by the 1988 flood. The flooded depth around rural settlements is estimated at 0.3 m to 4.6 m.

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1.2.2 Internal Flood

1) Annual Flood

(1) Flood Area

The internal flood area is estimated at 417 ha, or 3% of the survey area.

The internal flood area lies mostly in the highly built-up areas. (Refer to Table B.1.1, Fig. B.7).

(2) Flood Depth and Duration

The maximum flood depth and duration are 0.61 m depth and 4 days respectively. Also, the average flood depth and duration are 0.37 m depth and 0.44 days respectively. (Refer to Table B.2 and Fig. B.8).

2) Worst Flood

(1) Flood Area

The internal flood area by the worst flood is estimated at 417 ha, or 3% of the survey area.

The internal inundation areas are mostly distributed in the highly built-up areas. (Refer to Table B.1.1, Fig. B.7 and Fig. B.8).

(2) Flood Depth and Duration

The maximum flood depth and duration in the worst internal flood are estimated 0.91 m depth and 6.0 days, respectively. On the other hand, the average depth and duration of inundation are estimated at 0.54 m and 1.19 days, respectively. (Refer to Table B.2. and Fig. B.8) b4

1.3 Narayanganj DND and West

1.3.1 DND

DND area consists of 14 zones based on administrative divisions of wards and unions. (Refer to Fig. B.2).

1) External Flood

(1) Annual Flood

DND area is free from flood due to the existing embankment. (Refer to Tables B.3.1, B.3.2 and Fig. B.3).

(2) 1987 Flood

DND area was not affected by the 1987 flood.

(3) 1988 flood

DND area was marginally safe from the 1988 flood by the flood fighting measures during the flood, reinforcing the embankment by sand bags, because the flood level exceeded partly the top of embankment. (Refer to Tables B.3.1, B.3.2, Figs. B.5 and B.6).

2) Internal Flood

(1) Annual Flood

The internal flood area is estimated at 410 ha, or 7% of DND area. (Refer to Table B.3.1, Figs. B.7 and B.8).

The maximum flood depth and duration of inundation are 0.15 m depth and 2.0 days, respectively. Also, the average flood depth and duration are 0.13 m and 2.0 days, respectively. (Refer to Table B.4 and Fig. B.8).

(2) Worst Flood

The internal flood area is estimated at 410 ha, or 7% of DND area. (Refer to Table B.3.1, Figs. B.7 and B.8).

The maximum depth and duration of inundation by the worst flood were estimated at 0.76 m depth and 7.0 days, respectively. On the other hand, the average flood depth and duration are estimated at 0.28 m and 2.74 days respectively. (Refer to Table B.4 and Fig. B.8).

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1.3.2 Narayanganj West

The study area consists of 14 zones based on administrative divisions of wards and unions. (Refer to Fig. B.2).

1) External Flood

(1) Annual Flood

The total flood area in the annual external flood is estimated at111 ha, or 6% of Narayanganj West area. However, there is no flooding in the built-up area. (Refer to Table B.5.1 Figs. B.3 and B.6).

There are only few cases of flooding due to the annual flood. However, it does not mean that the area is free from annual external flood. The flood depth and duration was surveyed on rural settlements, which are mostly located on high plots that are not affected by the annual floods. (Refer to Table B.5 and Fig. B.6).

(2) 1987 Flood

The flood area by the 1987 flood is estimated at 606 ha, or 33% of Narayanganj West area.

The built-up area affected by the flood is 379 ha, or 29% of the total built-up area. (Refer to Table B.5.1, Figs. B.4 and B.6).

The maximum flood depth and duration in the Narayanganj West area are estimated at 0.61 m depth and 15.0 days respectively, and the average depth and duration are 0.27 m and 8.11 days, respectively. (Refer to Table B.6 and Fig. B.6).

Fig. B.4 shows the flood depth and duration at houses of residence and the depth around settlements.

(3) 1988 Flood

The flood area is estimated at 1863 ha. The built-up area affected by the flood is 1312 ha, which is the whole of the built-up area. (Refer to Table B.5.1, Figs. B.5 and B.6).

The 1988 flood recorded the maximum flood depth and duration of 1.63 m and 40.0 days respectively. The average flood depth and duration are estimated at 0.84 m depth and 21.69 days respectively. (Refer to Table B.6 and Fig. B.6).

Fig. B.5 shows flood depth and duration. Flood depth around settlements is estimated at 0.8 m to 2.6 m.

2) Internal Flood

(1) Annual Flood

The internal flood area is estimated at 87 ha, or 5% of Narayanganj West area. The internal flood areas are distributed mostly in the highly built-up areas. (Refer to Table B.5.1, Figs. B.7 and B.8).

The maximum flood depth and duration are estimated at 0.12 m depth and 0.08 days respectively, and the average flood depth and duration are 0.12 m and 0.08 days respectively. (Refer to Table B.6 and Fig. B.8).

(2) Worst Flood

The internal flood area is estimated at 87 ha, or 5% of Narayanganj West area. The internal inundation areas are located mostly in the highly built-up area. (Refer to Table B.5.1, Figs. B.7 and B.8).

The maximum depth and duration in the worst internal flood are estimated at 0.82 m depth and 2 days, respectively. On the other hand, the average flood depth and duration are estimated at 0.28 m depth and 0.79 days, respectively. (Refer to Table B.6 and Fig. B.8).

2. Flood Damage

Flood damages are estimated for Greater Dhaka East, Narayanganj DND and Narayanganj West areas. The Greater Dhaka East area is divided into 4 compartments incorporating parts of drainage areas belonging to the Greater Dhaka West area as shown in Fig. B.12. Flood damages are also estimated for each of the above 4 compartments.

The 4 compartments are named Dhaka East - 1, -2, -3, and -4, or DC-1, -2, -3, and -4 starting the number from the northernmost compartments.

Flood damages are calculated for both the external and internal floods. The external floods are classified into the annual, the 1987-scale and the 1988-scale floods, while the internal floods are classified into the annual and the worst floods. The most recent typical annual external flood occurred in 1990. The worst internal flood was experienced in 1986.

Flood damages take the form of direct damages to houses, shops, industries and institutions, income / profit losses for households, shops and factories, traffic damages, direct damages to infrastructures and profit losses for public enterprises.

Direct damages to houses, shops, industries and institutions as well as income / profit losses for households, shops and factories are estimated based on the area, depth and duration of inundation and the unit value and number of the above-mentioned properties.

Traffic damages are worked out based on lower sales, higher operating cost and greater time cost per vehicle during floods and the volume of traffic.

Direct damages to infrastructures such as roads, bridges, railways, electric supply, water supply, gas supply and telecommunication facilities are estimated based on the concepts of damages per unit quantity multiplied by the total quantity.

In estimating flood damages for the Narayanganj DND area, it was assumed that the raised roads and flood walls now surrounding the area will not function properly and be defective in the future unless overall reinforcements are done.

In estimating internal flood damages, the results of the "Study on Storm Water Drainage System Improvement Project in Dhaka City" in 1987 were referred to and utilized.

Flood damages are estimated for both 1990 and 2010. Flood damages for 2010 will be greater than those in 1990 because the unit value and number / quantity of properties, the volume of traffic and the quantity of infrastructures will be greater in 2010 than in 1990. Various kinds of flood damages are added together at a final stage and ultimately they are converted into "average annual flood damages".

2.1 Direct Damages to Properties and Income / Profit Losses of Economic Units

2.1.1 Concept / Methodology of Direct Damage Estimation

Damageable properties are classified into 5 categories, namely houses, shops, factories, institutions and cropped farm land.

Building properties and crops in the farm land will be damaged when they are immersed in flood water. The degree of the damage will get greater in proportion to the depth and duration of the immersion. The degree of the damage will be different depending on the categories of properties. Flood damages multiply in accordance with the unit value and number / quantity of inundated properties.

The unit value and number / quantity of properties by category are estimated for 1990 and 2010. The unit value and number/quantity of properties for 2010 are forecast based on the estimated growth of population and economy.

The number / quantity of properties in inundation areas is determined based on the land use and the inundation ratio. It is worked out by type of properties by zone by type / scale of floods and by year.

Using regressional equations determining the relationships between inundation depths/ durations and flood damage ratios per unit property, ultimately direct flood damages to properties are estimated.

(For more detailed explanation and information refer to 2.3 Methodology for Flood Damage Estimation (page E-12 to E-15) in Master Plan Supporting Report I.)

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As a specific example the calculation steps leading to the estimation of the direct damages to houses by a 1987 - scale flood in Greater Dhaka East are explained in detail in Annex 1.

2.1.2 Concept / Methodology for Income / Profit Loss Estimation

Economic activities in an area will be affected when a flood hit the area. Wage earners will not be able to work and shops and factories will be forced to close due to inundation. The amount of those economic losses will be proportionate to the number of non-workable days and the latter will be closely connected with the depth and duration of inundations. The number of non-workable days may be different depending on the types of economic units. Economic losses multiply in accordance with the average income / profit and number of affected households, shops and factories.

The average yearly income / profit per household, shop and factory and the number of those economic units are estimated for 1990 and 2010. The average income / profit and number of economic units for 2010 are forecast based on the estimated growth of population and economy. The number of economic units in inundation areas is determined based on the land use and the inundation ratio. It is worked out by type of economic units by zone by type / scale of flood and by year.

Using regressional equations determining the relationships between inundation depths / durations and ratios of non-workable days per economic unit, ultimately income / profit losses for households, shops and factories are estimated. (For more detailed explanation and information refer to 2.3 Methodology for Flood Damage Estimation in Master Plan Supporting Report I.)

As a specific example the calculation steps leading to the estimation of the income losses to households by a 1987 - scale flood in Greater Dhaka East are explained in detail in Annex 1.

2.1.3 Estimated Damages and Losses

1) No. of Properties in the Study Area

The total number of houses, businesses, industries and institutions in the Greater Dhaka East area in 1990 is estimated at 341,673, 13,851, 1,499 and 19,497, respectively. The majority of those properties concentrate in the two compartments of DC-3 and DC-4 as shown in Table B.7.

The total number of the four types of properties in the above order in the Narayanganj DND area in 1990 is estimated at 87,634, 2,408, 1,226 and 3,544, respectively. Likewise, the total number of the four types of properties in the same order in the Narayanganj West area in the same year is estimated at 81,762, 3,465, 1,013 and 2,461, respectively.

In the target year of 2010, the total number of houses, businesses, industries and institutions in the Greater Dhaka East area is projected to increase to 716,785, 23,306, 2,270 and 36,079, respectively.

It is to be noted that properties will in 2010 still concentrate in the two southern compartments, but the growth rate is higher in the two northern compartments.

In 2010 the total number of the four types of properties in the above order in the Narayanganj DND area is projected to increase to 256,643, 6,410, 3,873 and 11,656, respectively. Similarly, the total number of the four types of properties in the same order in the Narayanganj West area in the same year is projected to increase to 160,891, 6,021, 2,245 and 4,509, respectively.

It is to be noted that the growth rate of properties is greater in the Narayanganj DND area than in the Narayanganj West area. (Refer to Table B.7).

2) No. of Properties in Inundation Areas

(1) Year 1990

The annual external flood in 1990 did not inundate any properties in the Study Area. Supposing the 1987-scale flood had hit the Greater Dhaka East area in 1990, 61,376 houses, 1,658 businesses, 319 industries and 3,057 institutions would have been inundated. It is to be noted that the inundation of properties would have been witnessed mostly in the two southern compartments.

The 1987-scale flood would in 1990 have inundated 25,414 houses, 698 businesses, 356 industries and 1,028 institutions in the Narayanganj DND area. Likewise, the same flood would have inundated 23,043 houses, 688 businesses, 218 industries and 346 institutions in the Narayanganj West area.

Supposing the 1988-scale flood had hit the Greater Dhaka East area in 1990, 165,978 houses, 5,102 businesses, 486 industries and 7,287 institutions would have been inundated. The same flood would have inundated 87,634 houses, 2,408 businesses, 1,226 industries and 3,544 institutions in the Narayanganj DND area. Similarly, the same flood would have inundated 64,679 houses, 3,068 businesses, 705 industries and 1,500 institutions in the Narayanganj West area (Refer to Table B.9.).

(2) Year 2010

Supposing the annual external flood hit the Greater Dhaka East area in 2010, 164,951 houses, 3,254 businesses, 20 industries and 5,006 institutions would be inundated. It is to be noted that the number of properties to be inundated are not too much different among the 4 compartments.

The annual external flood would in 2010 inundate 7,699 houses, 192 businesses, 116 industries and 350 institutions in the Narayanganj DND area. Likewise, the same flood would inundate 6,517 houses, 329 businesses, 47 industries and 127 institutions in the Narayanganj West area.

Supposing the 1987-scale flood hit the Greater Dhaka East area in 2010, 303,957 houses, 6,096 businesses, 502 industries and 10,028 institutions would be inundated. The same flood would inundate 69,294 houses, 1,731 businesses, 1,046 industries and 3,148 institutions in the Narayanganj DND area. Likewise, the same flood would inundate 47,550 houses, 1,706 businesses, 398 industries and 878 institutions in the Narayanganj West area.

Supposing the 1988-scale flood hit the Greater Dhaka East area in 2010, 465,002 houses, 11,714 businesses, 751 industries and 17,308 institutions would be inundated. The same flood would inundate 256,643 houses, 6,410 businesses, 3,873 industries and 11,659 institutions in the Narayanganj DND area. Similarly, the same flood would inundate 148,026 houses, 5,118 businesses, 5,082 industries and 4,067 institutions in the Narayanganj West area. (Refer to Table B. 10.)

3) Estimated Damages and Losses

Direct damages to properties and income/profit losses of economic units were combinedly broadly classified as residential, commercial, industrial, institutional and agricultural damages.

Residential damages consist of damages to buildings, damages to household effects and income losses. Commercial and industrial damages consist of damages to buildings, damages to equipment & inventories and profit losses. Institutional and agricultural damages mean damages to buildings and damages to agricultural crops, respectively.

(1) Year 1990

There were no annual external flood damages in 1990 in the Study Area. Supposing the 1987-scale flood had hit the Greater Dhaka East area in 1990, damages and losses amounting to Tk. 493.0 million would have been incurred, of which 54.8% and 45.0% would have been accounted for by residential and agricultural damages, respectively. Most of residential damages would have been witnessed in the two southern compartments and agricultural damages would have been observed all over the area. (Refer to Table B.11).

The 1987-scale flood would in 1990 have inflicted damages in the Narayanganj DND area amounting to Tk. 142.9 million, of which 82.0% and 17.7% would have been accounted for by residential and agricultural damages, respectively. Likewise, the same flood would have inflicted damages in the Narayanganj West area amounting to Tk. 75.5 million, of which 82.6% and 17.0% would have been accounted for by residential and agricultural damages, respectively.

Supposing the 1988-scale flood had hit the Greater Dhaka East area in 1990, damages and losses amounting to Tk. 3,086.0 million would have been incurred. Out of them, 76.9%, 14.4% and 8.7% would have been accounted for by residential, commercial / industrial / institutional and agricultural damages, respectively. The same flood would have inflicted damages in the Narayanganj DND area amounting to Tk. 1,864.1 million, of which 72.0%, 23.3% and 4.7% would have been accounted for by residential, commercial / industrial / institutional and agricultural damages, respectively. Similarly, the same flood would have inflicted damages in the Narayanganj West area amounting to Tk. 1,310.8 million, of which 77.5%, 20.9% and 1.6% would have been accounted for by residential, commercial / industrial / institutional and agricultural damages, respectively. (Refer to Table B.12).

The annual internal flood in 1990 brought on the damages to house buildings and household articles in the Greater Dhaka East area amounting to Tk. 121.0 million. Most of the damages were witnessed in the two southern compartments. The same flood brought on the damages to houses amounting to Tk. 27.3 million and Tk. 0.8 million in the Narayanganj DND and West areas, respectively. (Refer to Table B.16).

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The worst internal flood in 1990 would have brought on the damages to house buildings and household articles in the Greater Dhaka East area amounting to Tk. 257.3 million. The same flood would have brought on the damages to houses amounting to Tk. 43.4 million and Tk. 9.9 million in the Narayanganj DND and West areas, respectively.

(2) Year 2010

Supposing the annual external flood hit the Greater Dhaka East area in 2010, damages and losses amounting to Tk. 157.6 million would be suffered, most of which would be in the form of income losses of households. The same flood would cause damages amounting to Tk. 7.1 million and Tk. 6.1 million in the Narayanganj DND and West areas, respectively. (Refer to Table B. 13).

If the 1987-scale flood hit the Greater Dhaka East area in 2010, damages and losses amounting to Tk. 2,884.6 million would be suffered, of which 99.2% would be borne by the residential sector. The same flood would cause damages amounting to Tk. 518.8 million and Tk. 229.4 million in the Narayanganj DND and West areas, respectively. Most of them would be borne by the residential sector. (Refer to Table B. 14).

If the 1988-scale flood hit the Greater Dhaka East area in 2010, damages and losses amounting to Tk. 12,995.7 million would be suffered, of which 88.2%, 11.6% and 0.2% would be borne by the residential, commercial / industrial / institutional and agricultural sectors, respectively. (Refer to Table B.15).

The 1988-scale flood would in 2010 cause damages in the Narayanganj DND area amounting to Tk. 8,530.8 million, of which 74.3% and 25.6% would be borne by the residential and commercial / industrial / institutional sectors, respectively. The same flood would cause damages in the Narayanganj West area amounting to Tk. 5,678.1 million, of which 63.7% and 36.3% would be borne by the residential and commercial / industrial / institutional sectors, respectively.

If the annual internal flood hit the Greater Dhaka East area in 2010, the damages to house buildings and household articles would amount to Tk. 185.9 million. The same flood would bring on the damages to houses amounting to Tk. 109.1 million and Tk. 2.0 million in the Narayanganj DND and West areas, respectively. (Refer to Table B. 16).

If the worst internal flood experienced in 1986 hit the Greater Dhaka East area in 2010, the damages to house buildings and household articles would amount to Tk. 389.9 million. The same flood would bring on the damages to houses amounting to Tk. 171.0 million and Tk. 24.4 million in the Narayanganj DND and West areas, respectively.

2.2 Traffic Damages

2.2.1 Concept / Methodology

In the circumstances where one witnesses inundation everywhere due to floods, vehicle and human traffic is slowed, hampered or stopped.

In the peak of a flood sometimes vehicles will be unable to be operated for days. At the beginning and the latter part of a flood vehicles will be operated, but slowly and in a haphazard way.

In the non-operatable days commercial vehicles will lose sales and profit in proportion to the length of those days.

In the slow-operating days it will take more time for a vehicle to reach a destination because the driver will have to slow down its speed or he will be forced to take a roundabout route. Slower speed will mean less operating distance. Less operating distance will in turn mean less sales for commercial vehicles. Slower speed will also mean consumption of more oil per hour.

All of these things will mean additional cost and/or less profit to vehicle owners and/or passengers.

To know the extent of traffic damages, firstly one must know the number of both non-operating and slow-operating days by type/scale of floods and by type of vehicles.

The types of vehicles were classified into rickshaw, auto-rickshaw, motor cycle, car, jeep, micro bus, mini bus, bus, mini truck, pick-up van and truck.

Secondly, one must know average sales, average oil cost and average incremental operating hours per day per vehicle by type of vehicles in both the normal time and the slow-operating flood time. Thirdly, one must know average number of passengers per vehicle by type of vehicles.

Multiplying the number of non-operating days by the average profit per day per vehicle in normal time, one gets profit losses per vehicle due to non-operation. The multiplication will be done by type/ scale of floods and by type of vehicles.

Comparing the average sales minus oil cost per day per vehicle in normal time and in flood time, one gets profit losses in slow-operating flood time. Time will be converted into financial terms. Then, multiplying the average incremental operating hours per day per vehicle by the average number of passengers per vehicle, one gets incremental time cost per day per vehicle in the slow-operating flood time. The calculation will be done by type of vehicles.

Profit losses and incremental time cost per day per vehicle in the slow-operating flood time are multiplied by the number of slow-operating days. The multiplication will be done by type / scale of floods and by type of vehicles.

Going through the above procedure, one gets traffic damages per vehicle by type of vehicles by type / scale of floods. When one multiply traffic damages per vehicle by the number of vehicles, one will get the total amount of damages.

The number of vehicles is estimated by type of vehicles, by area and by year. The number of vehicles for each area was estimated based on the results of traffic survey and the estimated number of properties in each area. The number of vehicles for 2010 was forecast based on the projected population and economy.

2.2.2 Traffic and Traffic Damage Surveys

1) Traffic Survey

Traffic survey was conducted to know the volume of vehicle traffic at major flood vulnerable points in the Greater Dhaka East and Narayanganj areas.

20 traffic points which are susceptible to internal floods were selected, of which 16 belong to the Greater Dhaka East area and 4 to the Narayanganj West area. Also, 8 traffic survey points which were inundated in the 1988 external flood were picked up, of which 2 are in the Greater Dhaka East area, 5 in the Narayanganj DND area and 1 in the Narayanganj West area. (Refer to Figs. B.9, B.10 and B.11). Survey time was basically from 7 am to 8 pm. Vehicles were classified into 8 types,namely rickshaw, auto-rickshaw, motor cycle, car/jeep, micro bus, bus/mini bus, mini truck/pick-up and truck.

According to the survey results, total traffic in the above 28 survey points comes to 580,839 rickshaws, 111,622 auto-rickshaws, 41,189 motor cycles, 125,320 cars/jeeps, 24,858 micro buses, 39,373 buses/mini buses, 7,429 mini trucks/pick-ups and 17,409 trucks. Out of it, about 75% belongs to the Greater Dhaka East & related areas and about 25% to the Narayanganj areas. (Refer to Table B.17).

2) Traffic Damage Survey

Traffic damage survey was conducted along with traffic survey to know about the average sales, oil cost, incremental time cost, etc. per vehicle by type of vehicles for each type/scale of floods. The number of samples were 30 for each type of vehicles. The survey was conducted mostly in the Greater Dhaka East and related areas.

The survey took the form of the sampling questionnaire survey.

The questionnaire consisted of questions regarding the type of vehicles, the number of days affected by flood in terms of non-operating days and slow-operating days in each type/scale of floods, the average operating km per day per vehicle in normal time as well as in time of flood (in slow-operating days), the average oil consumption per day per vehicle in normal time as well as in time of flood (in slow-operating days), etc.

2.2.3 Estimated Traffic Damages

1) Impacts of Floods on Vehicle Traffic

It was revealed as a result of traffic damage survey that in the 1987 flood buses and trucks could not operate for 10.4 days on average and all types of vehicles except rickshaws were forced to operate slowly for 18.6 days on average. In the 1988 flood vehicles could not operate for 20.1 days on average and also they were forced to operate slowly for 38.9 days on average. Likewise, in the 1986 flood which was the worst internal flood vehicles could not operate for 1.3 days on average and also they operated slowly for 12.9 days on average.

Operating distance per day per vehicle is on average 131.0 km in normal time, while it is 104.7 km in the slow-operating flood time. Operating speed is on average 41.5 km per hour in normal time, while it is 30.7 km per hour in flood time.

Oil consumption per day per vehicle excepting rickshaws is on average 30.8 liter in normal time, while it is 29.2 liter in the slow-operating flood time. Sales per day per commercial vehicle is on average Tk. 1,511 in normal time, while it is Tk. 1,266 in flood time.

It is to be noted that operating hours per day per vehicle on average increases from 3.16 hours in normal time to 3.41 hours in flood time, oil consumption per km per vehicle increases from 0.235 liter in normal time to 0.279 liter in flood time and sales per km per commercial vehicle increases from Tk. 11.5 in normal time to Tk. 12.1 in flood time. It is also to be noted that the rate of increase in oil consumption is higher than the rate of increase in sales in flood time.

(Refer to Table B.18).

2) Traffic Damages per Vehicle

In the 1987 flood traffic damages per commercial vehicle are estimated to have been Tk. 9,379 on average. The damages to buses were the highest with Tk. 19,866 per vehicle, followed by the damages to mini buses with Tk. 16,916 per vehicle. Rickshaws earned more profits than in normal time.

In the 1988 flood traffic damages per commercial vehicle were Tk. 23,438 on average. The damages to buses were the highest with Tk. 58,211 per vehicle, followed by mini buses with Tk. 36,081 per vehicle. Rickshaws earned the profits of Tk. 150 per vehicle.

In the 1986 flood which was the worst internal flood traffic damages per commercial vehicle were Tk. 4,271 on average. The damages to buses were the highest with Tk. 12,509 per vehicle, followed by mini buses with Tk. 7,101 per vehicle. Rickshaws got profits instead of damages.

(Refer to Table B.20).

3) Number of Vehicles

(1) Year 1990

It is estimated that there were 58,277 rickshaws, 4,194 auto-rickshaws, 23,797 motor cycles, 6,727 cars, 1,061 jeeps, 2,400 micro buses, 1,780 mini buses, 790 buses, 455 mini trucks, 684 pick-up vans and 2,411 trucks in 1990 in the Greater Dhaka East area. Most of vehicles belonged to the two southern compartments.

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In the Narayanganj DND area it is estimated that there were 15,238 rickshaws, 1,080 auto-rickshaws, 6,236 motor cycles, 1,763 cars, 227 jeeps, 513 micro buses, 466 mini buses, 207 buses, 111 mini trucks, 166 pick-up vans and 586 trucks in 1990. Similarly, in the Narayanganj West area there were 14,217 rickshaws, 1,011 auto-rickshaws, 5,818 motor cycles, 1,645 cars, 219 jeeps, 496 micro buses, 435 mini buses, 193 buses, 137 mini trucks, 205 pick-up vans and 723 trucks.

Summing up, it is estimated that there were 102,576 vehicles in the Greater Dhaka East area in 1990, of which 56.8% were accounted for by rickshaws. In the Narayanganj DND area there were 26,593 vehicles, of which 57.3% were rickshaws. Likewise, in the Narayanganj West area there were 25,099 vehicles, of which 56.6% were rickshaws. (Refer to table B.21).

(2) Year 2010

It is projected that in 2010 there will be 190,135 rickshaws, 13,498 auto-rickshaws, 77,670 motor cycles, 21,957 cars, 2,940 jeeps, 6,652 micro buses, 5,809 mini buses, 2,577 buses, 1,167 mini trucks, 1,752 pick-up vans and 6,181 trucks in the Greater Dhaka East area. Compartment wise, the two southern compartments will dominate in the number of vehicles, but the growth rate of vehicles in the two northern compartments will be higher.

In the Narayanganj DND area it is projected that in 2010 there will be 71,910 rickshaws, 5,115 auto-rickshaws, 29,428 motor cycles, 8,319 cars, 1,117 jeeps, 2,526 micro buses, 2,201 mini buses, 976 buses, 505 mini trucks, 758 pick-up vans and 2,674 trucks. Likewise, in the Narayanganj West area there will be 45,081 rickshaws, 3,189 auto rickshaws, 18,448 motor cycles, 5,215 cars, 650 jeeps, 1,471 micro buses, 1,380 mini buses, 612 buses, 406 mini truck, 609 pick-up vans and 2,150 trucks.

Summing up, it is estimated that in 2010 there will be 330,338, 125,529 and 79,211 vehicles in the Greater Dhaka East, Narayanganj DND and Narayanganj West areas, respectively. (Refer to Table B.22).

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(3) Estimated Traffic Damages

a. 1987-scale Flood

Supposing the 1987-scale flood had hit the Greater Dhaka East area in 1990, traffic damages amounting to Tk.86.5 million would have been incurred, most of which would have occurred in the two southern compartments. The same flood would have inflicted traffic damages in the Narayanganj DND and West areas amounting to Tk. 22.0 million and Tk. 23.2 million, respectively.

Supposing the 1987-scale flood hit the Greater Dhaka East area in 2010, traffic damages amounting to Tk. 256.5 million would be incurred. The same flood would inflict traffic damages in the Narayanganj DND and West areas amounting to Tk. 102.2 million and Tk. 71.4 million, respectively. (Refer to Table B.23.)

b. 1988-scale Flood

Supposing the 1988-scale flood had hit the Greater Dhaka East area in 1990, traffic damages amounting to Tk.187.3 million would have been incurred, most of which would have occurred in the two southern compartments. The same flood would have inflicted traffic damages in the Narayanganj DND and West areas amounting to Tk. 47.4 million and Tk. 50.5 million, respectively.

Supposing the 1988-scale flood hit the Greater Dhaka East area in 2010, traffic damages amounting to Tk. 551.1 million would be incurred. The same flood would inflict traffic damages in the Narayanganj DND and West areas amounting to Tk. 220.5 million and Tk. 155.1 million, respectively. (Refer to Table B.24.)

c. Worst Internal Flood

Supposing the 1986-scale flood which is the worst internal flood had hit the Greater Dhaka East area in 1990, traffic damages amounting to Tk.36.5 million would have been incurred. The same flood would have inflicted traffic damages in the Narayanganj DND and West areas amounting to Tk. 10.1 million and Tk. 10.3 million, respectively.

Supposing the 1986-scale hit the Greater Dhaka East area in 2010, traffic damages amounting to Tk. 119.8 million would be incurred. The same flood would inflict traffic damages in the Narayanganj DND and West areas amounting to Tk. 47.0 million and Tk. 32.0 million, respectively. (Refer to Table B.25.)

2.3 Direct Damages to Infrastructure and Profit Losses for Public Enterprises

The JICA Study Team conducted interview surveys visiting the officials concerned in RHD, DCC, Dhaka District Council, NMC, Bangladesh Railways, Power Development Board, T&T, DWASA, NWASA, Titas Gas, CAA and other related agencies.

The study team wanted to gather information and data on the direct damages to infrastructures such as roads, bridges, railways, electricity supply facilities, telecommunication facilities, water supply facilities, sewerage facilities, gas supply facilities and the airport in each of the 5 types/scales of floods for each of the 3 areas. Also, the study team wanted to collect information and data on profit losses for public enterprises such as Bangladesh Railways, Power Development Board, T&T, DWASA, NWASA, Titas Gas and CAA.

2.3.1 Concept / Methodology of Damage Estimation

The basic approach to the estimation of direct damages to infrastructures was the establishment of total quantity (length or number), construction cost per unit quantity and the ratio of repair cost to construction cost for each type of infrastructures. By combining these three factors direct damages to infrastructure will be arrived at.

The direct damages to infrastructures and profit losses for public enterprises for 2010 were forecast based on the projected number of properties such as houses, shops, factories and institutions.

2.3.2 Estimated Damages and Losses

1) Direct Damages to Infrastructures

Direct damages to infrastructures in the Greater Dhaka East area was found to total Tk. 41.5 million in the annual external flood, Tk. 68.7 million in the 1987 flood, Tk. 458.1 million in the 1988 flood, Tk. 22.6 million in the annual internal flood and Tk. 58.1 million in the worst internal flood. Damages were concentrated in the two southern compartments.

Direct damages to infrastructures in the Narayanganj DND area totaled Tk. 1.4 million, Tk. 1.4 million, Tk. 22.4 million, Tk. 7.8 million, Tk. 10.3 million in the annual external, the 1987, the 1988, the annual internal and the worst internal floods, respectively.

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Likewise, direct damages to infrastructures in the Narayanganj West area summed up to Tk. 5.5 million for the annual external flood, Tk. 17.5 million for the 1987 flood, Tk. 134.2 million for the 1988 flood, Tk. 19.1 million for the annual internal flood and Tk. 31.9 million for the worst internal flood. (Refer to Table B.26).

Supposing the annual external flood hit the Greater Dhaka East area in 2010, direct damages to infrastructures amounting to Tk.133.7 million would be incurred. Likewise, the 1987-scale, the 1988-scale, the annual internal and the worst internal floods would inflict damages amounting to Tk. 221.1 million, Tk. 1,474.5 million, Tk. 72.9 million and Tk. 186.9 million, respectively. Damages will still predominate in the two southern comportments, but the growth of damages in the two northern compartments will be conspicuous.

Supposing the annual external flood hit the Narayanganj DND area in 2010, direct damages to infrastructures amounting to Tk.6.6 million would be incurred. Likewise, the 1987-scale, the 1988-scale, the annual internal and the worst internal floods would inflict damages amounting to Tk. 6.6 million, Tk. 106.0 million, Tk. 36.9 million and Tk. 48.8 million, respectively.

Supposing the annual external flood hit the Narayanganj West area in 2010, direct damages to infrastructures amounting to Tk.17.4 million would be incurred. Likewise, the 1987-scale, the 1988-scale, the annual internal and the worst internal floods would inflict damages amounting to Tk. 55.3 million, Tk. 422.8 million, Tk. 60.3 million and Tk. 100.7 million, respectively. (Refer to Table B.28).

2) Profit Losses for Public Enterprises

It was found out that profit losses for public enterprises are not marked compared to direct damages to infrastructures.

The 1987 and 1988 floods are estimated to have caused profit losses amounting to Tk. 6.2 million and Tk. 43.0 million respectively for public enterprises in the Greater Dhaka East area. Likewise, the two floods caused profit losses amounting Tk. 1.1. million and Tk. 8.0 million respectively for public enterprises in the Narayanganj West area.

Supposing the annual external flood hit the Greater Dhaka East area in 2010, profit losses amounting to Tk. 1.5 million would be suffered by public enterprises. Likewise, the 1987-scale, 1988-scale, the annual internal and the worst internal floods would bring on profit losses amounting to Tk. 20.3 million, Tk. 138.6 million, Tk. 1.0 million and Tk. 1.8 million respectively to public enterprises in the area. Also, the 1987-scale and 1988-scale floods in 2010 would bring on profit losses amounting to Tk. 3.6 million and Tk. 25.3 million respectively to public enterprises in the Narayanganj West area. (Refer to Table B.29).

2.4 Summary of Flood Damages

2.4.1 Summary of Flood Damages by Type / Scale of Floods

Direct damages to properties, income / profit losses of economic units, traffic damages, direct damages to infrastructures and profit losses for public enterprises are added together by area, by type / scale of floods and by year. In doing so, 10% addition is done to the results of the above summation to rake up unaccounted-for damages.

The 10% addition is explained and substantiated in Annex 2.

The below table summarizes flood damages worked out in the above mentioned way.

(Unit : Tk. Million)

Area	External Flood			Internal Flood	
	Annual	1987-Scale	1988-Scale	Annual	Worst
1. 1990					
DC - 1	2.8	89.8	293.5	1.8	6.7
DC - 2	1.3	53.6	233.8	0.7	2.8
DC - 3	21.3	219.6	1,263.4	66.6	167.0
DC - 4	20.8	357.1	2,361.2	89.3	214.6
Dhaka East	46.2	720.1	4,151.9	158.4	391.1
Narayanganj DND	1.5	182.9	2,127.4	38.6	70.2
Narayanganj West	6.1	129.0	1,653.6	21.9	57.3
Total	53.8	1,032.0	7,932.9	218.9	518.6

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2. 2010

DC - 1	75.8	1,415.9	3,516.7	10.0	38.5
DC - 2	33.8	322.9	1,425.3	5.1	21.0
DC - 3	100.0	863.1	4,746.4	128.9	345.5
DC - 4	112.5	1,118.9	6,988.0	141.8	363.2
Dhaka East	322.1	3,720.8	16,676.4	285.8	768.2
Narayanganj DND	15.1	690.4	9,743.6	160.6	293.5
Narayanganj West	25.9	395.7	6,909.4	68.5	172.8
Total	363.1	4,806.9	33,329.4	514.9	1,234.5

(For more details refer to Tables B.30 and B.31.)

2.4.2 Average Annual Flood Damages

Based on the figures tabulated in the preceding section, average annual flood damages are calculated. (The methodology for the calculation of average annual flood damages is explained in 2.3.5 Estimation of Average Annual Flood Damages in Master Plan Supporting Report I).

The results are shown in the below table.

(Unit : Tk. Million)

Area	1990	2010
DC - 1	43.2	648.4
DC - 2	26.4	176.7
DC - 3	195.1	628.5
DC - 4	293.0	791.3
Greater Dhaka East	557.7	2,244.9
Narayanganj DND	153.4	639.9
Narayanganj West	113.4	395.3
Total	824.5	3,280.1

As a specific example the calculation steps leading to the estimation of average annual flood damages for Greater Dhaka East are explained in detail in Annex 3.

The above-tabulated flood damages are expected in the "without" situation. In other words, the benefits of the same amount can be expected in the "with" situation. (The average annual flood damages broken down into external and internal flood damages are shown in Table B.32).

TABLE B.1(1) FLOOD AREA AND LAND USE AT DHAKA EAST/ DRAINAGE RELATED AREA (BUILT UP)

Name of Zone	Total Area	Total B/U Area in 1990	Total B/U Area in 2010	External Flood: Annual Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	1987 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	1988 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	Internal Flood: Total Flood Area	Ratio of Flood Area
	(ha.) (a)	(ha.) (b)	(ha.) (c)	(ha.) (d)	(%) =(d)/(a)	(ha.) (e)	(%) =(e)/(b)	(ha.) (f)	(%) =(f)/(c)	(ha.) (g)	(%) =(g)/(a)	(ha.) (h)	(%) =(h)/(b)	(ha.) (i)	(%) =(i)/(c)	(ha.) (j)	(%) =(j)/(a)	(ha.) (k)	(%) =(k)/(b)	(ha.) (l)	(%) =(l)/(c)	(ha.) (m)	(%) =(m)/(a)
Ward 4	96	94	96	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11
Ward 7	199	185	185	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	6
Ward 8	83	83	79	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	27	33
Ward 9	72	72	72	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	21
Ward 11	12	12	12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	12
Ward 13	31	31	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	42
Ward 27	14	14	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9	64
Ward 28	20	20	20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Ward 29	46	46	46	0	0	0	0	0	0	0	0	0	0	0	0	23	51	23	51	23	51	12	26
Ward 34	151	103	134	48	32	0	0	31	23	98	65	50	49	81	61	145	96	97	94	128	96	1	1
Ward 35	103	98	103	0	0	0	0	0	0	0	0	0	0	0	0	43	42	38	39	43	42	20	19
Ward 36	190	164	190	26	14	0	0	26	14	41	22	15	9	41	22	172	90	146	89	172	90	0	0
Ward 37	76	76	76	0	0	0	0	0	0	0	0	0	0	0	0	64	84	64	84	64	84	15	20
Ward 38	105	98	105	6	6	0	0	6	6	16	15	9	9	16	15	105	100	98	100	105	100	0	0
Ward 39	185	155	184	31	17	0	0	30	16	130	70	99	64	129	70	185	100	155	100	184	100	0	0
Ward 40	439	295	434	143	33	0	0	139	32	230	52	86	29	225	52	325	74	181	62	321	74	13	3
Ward 41	96	96	96	0	0	0	0	0	0	0	0	0	0	0	0	71	74	71	74	71	74	38	39
Ward 42	80	80	80	0	0	0	0	0	0	0	0	0	0	0	0	32	40	32	40	32	40	18	22
Ward 43	128	128	128	0	0	0	0	0	0	0	0	0	0	0	0	30	24	30	24	30	24	48	37
Ward 44	230	230	230	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	37	16
Ward 45	194	194	194	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	55	28
Ward 46	161	161	161	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	5
Ward 47	156	140	152	11	7	0	0	7	5	27	17	11	8	23	15	48	31	33	23	44	29	15	10
Ward 48	326	314	315	12	4	0	0	1	0	99	30	88	28	88	28	140	43	128	41	129	41	0	0
Ward 49	131	131	128	0	0	0	0	0	0	10	7	10	7	6	5	19	15	19	15	16	13	8	6
Ward 50	93	93	93	0	0	0	0	0	0	1	2	1	2	1	2	4	5	4	5	4	5	20	22
Ward 51	672	639	649	33	5	0	0	10	2	210	31	177	28	188	29	480	72	447	70	458	71	0	0
Ward 52	186	150	179	36	19	0	0	29	16	128	69	92	61	121	68	186	100	150	100	179	100	0	0
Ward 53	193	169	190	24	12	0	0	21	11	95	49	71	42	92	48	121	63	97	58	118	62	0	0
Uttar Khan	1811	188	1422	850	47	0	0	461	32	1460	81	0	0	1072	75	1562	86	0	0	1173	82	0	0
D. Khan Cant	288	184	288	18	6	0	0	18	6	28	10	0	0	28	10	115	40	11	6	115	40	0	0
D. Khan Gulshan	1448	344	1440	878	61	0	0	870	60	1245	86	142	41	1237	86	1353	93	249	72	1345	93	0	0
Cantonment 1	825	794	825	5	1	0	0	5	1	70	8	39	5	70	8	293	36	262	33	293	36	8	1
Cantonment 3	1118	518	1101	429	38	0	0	412	37	568	51	0	0	552	50	1016	91	416	80	999	91	0	0
Beraid U. Gulshan	1872	67	463	1644	88	0	0	235	51	1842	98	37	55	433	94	1872	100	67	100	463	100	0	0
Gulshan 57	2145	174	1490	1511	70	0	0	856	57	1959	91	0	0	1304	88	2145	100	174	100	1490	100	0	0
Beraid Demra	578	61	310	517	90	0	0	249	80	578	100	61	100	310	100	578	100	61	100	310	100	4	1
Demra	1236	196	986	1007	82	0	0	757	77	1174	95	134	68	924	94	1236	100	196	100	986	100	11	1
DE-Matuail	850	79	541	621	73	0	0	312	58	706	83	0	0	397	73	808	95	36	46	499	92	0	0
Summary	16636	6672	13241	7850	47	0	0	4475	34	10716	64	1121	17	7337	55	13173	79	3285	49	9794	74	417	3

TABLE B.1(2) FLOOD AREA AND LAD USE AT DHAKA EAST/DRAINAGE RELATED AREA (AGRICULTURAL LAND)

Name of Zone	Total Area	Total Agricul. Area in 1990	Total Agricul. Area in 2010	External Flood: Annual Flood: Total Flood Area	Annual Flood: Ratio of Flood Area	Annual Flood: Flood Area in Agri. in 1990	Annual Flood: R. of Agri. in Flood Area in 1990	Annual Flood: Flood Area in Agri. in 2010	Annual Flood: R. of Agri. in Flood Area in 2010	1987 Flood: Total Flood Area	1987 Flood: Ratio of Flood Area	1987 Flood: Flood Area in B/U in 1990	1987 Flood: R. of Agri. in Flood Area in 1990	1987 Flood: Flood Area in B/U in 2010	1987 Flood: R. of Agri. in Flood Area in 2010	1988 Flood: Total Flood Area	1988 Flood: Ratio of Flood Area	1988 Flood: Flood Area in B/U in 1990	1988 Flood: R. of Agri. in Flood Area in 1990	1988 Flood: Flood Area in B/U in 2010	1988 Flood: R. of Agri. in Flood Area in 2010
	(ha.) (a)	(ha.) (b)	(ha.) (c)	(ha.) (d)	(%) =(d)/(a)	(ha.) (e)	(%) =(e)/(b)	(ha.) (f)	(%) =(f)/(c)	(ha.) (g)	(%) =(g)/(a)	(ha.) (h)	(%) =(h)/(b)	(ha.) (i)	(%) =(i)/(c)	(ha.) (j)	(%) =(j)/(a)	(ha.) (k)	(%) =(k)/(b)	(ha.) (l)	(%) =(l)/(c)
Ward 4	96	1	0	0	0	0	0	0	-	0	0	0	0	0	-	0	0	0	0	0	-
Ward 7	199	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 8	83	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 9	72	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 11	12	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 13	31	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 27	14	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 28	20	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 29	46	0	0	0	0	0	-	0	-	0	0	0	-	0	-	23	51	0	-	0	-
Ward 34	151	23	0	48	32	23	100	0	-	98	65	23	100	0	-	145	96	23	100	0	-
Ward 35	103	3	0	0	0	0	0	0	-	0	0	0	0	0	-	43	42	3	100	0	-
Ward 36	190	9	0	26	14	9	100	0	-	41	22	9	100	0	-	172	90	9	100	0	-
Ward 37	76	0	0	0	0	0	-	0	-	0	0	0	-	0	-	64	84	0	-	0	-
Ward 38	105	0	0	6	6	0	-	0	-	16	15	0	-	0	-	105	100	0	-	0	-
Ward 39	185	30	0	31	17	30	100	0	-	130	70	30	100	0	-	185	100	30	100	0	-
Ward 40	439	74	0	143	33	74	100	0	-	230	52	74	100	0	-	325	74	74	100	0	-
Ward 41	96	0	0	0	0	0	-	0	-	0	0	0	-	0	-	71	74	0	-	0	-
Ward 42	80	0	0	0	0	0	-	0	-	0	0	0	-	0	-	32	40	0	-	0	-
Ward 43	128	0	0	0	0	0	-	0	-	0	0	0	-	0	-	30	24	0	-	0	-
Ward 44	230	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 45	194	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 46	161	0	0	0	0	0	-	0	-	0	0	0	-	0	-	0	0	0	-	0	-
Ward 47	156	0	0	11	7	0	-	0	-	27	17	0	-	0	-	48	31	0	-	0	-
Ward 48	326	0	0	12	4	0	-	0	-	99	30	0	-	0	-	140	43	0	-	0	-
Ward 49	131	0	0	0	0	0	-	0	-	10	7	0	-	0	-	19	15	0	-	0	-
Ward 50	93	0	0	0	0	0	-	0	-	1	2	0	-	0	-	4	5	0	-	0	-
Ward 51	672	0	0	33	5	0	-	0	-	210	31	0	-	0	-	480	72	0	-	0	-
Ward 52	186	0	0	36	19	0	-	0	-	128	69	0	-	0	-	186	100	0	-	0	-
Ward 53	193	0	0	24	12	0	-	0	-	95	49	0	-	0	-	121	63	0	-	0	-
Uttar Khan	1811	1585	240	850	47	812	51	240	100	1460	81	1422	90	240	100	1562	86	1524	96	240	100
D. Khan Cant	288	14	0	18	6	0	0	0	-	28	10	0	0	0	-	115	40	14	100	0	-
D. Khan Gulshan	1448	1095	0	878	61	869	79	0	-	1245	86	1095	100	0	-	1353	93	1095	100	0	-
Cantonment 1	825	4	0	5	1	0	0	0	-	70	8	4	100	0	-	293	36	4	100	0	-
Cantonment 3	1118	583	0	429	38	412	71	0	-	568	51	552	95	0	-	1016	91	583	100	0	-
Beraid U. Gulshan	1872	1806	720	1644	88	1644	91	720	100	1842	98	1806	100	720	100	1872	100	1806	100	720	100
Gulshan 57	2145	1666	350	1511	70	1206	72	350	100	1959	91	1655	99	350	100	2145	100	1666	100	350	100
Beraid Demra	578	348	0	517	90	348	100	0	-	578	100	348	100	0	-	578	100	348	100	0	-
Demra	1236	1035	0	1007	82	1002	97	0	-	1174	95	1035	100	0	-	1236	100	1035	100	0	-
DE-Matuail	850	758	0	621	73	607	80	0	-	706	83	692	91	0	-	808	95	758	100	0	-
Sumary	16636	9034	1310	7850	47	7036	78	1310	100	10716	64	8744	97	1310	100	13173	79	8972	99	1310	100

TABLE B.2 FLOOD CONDITION OF DHAKA EAST/DRAINAGE RELATED AREA

Name of Zone	External Flood																		Internal Flood											
	Annual Flood						1987 Flood						1988 Flood						Annual Flood						Worst Flood					
	Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)		
	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.
Ward 4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.64	0.00	16.00	16.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.85	0.73	0.00	18.00	17.00	0.00	0.61	0.37	0.00	4.00	0.62	0.00	0.91	0.52	0.00	4.00	0.77	0.00
Ward 9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 13	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	4.00	4.00	0.00	0.76	0.76	0.00	20.00	20.00	0.00	0.08	0.08	0.00	0.15	0.15	0.00	0.23	0.23	0.00	0.50	0.50	0.00
Ward 27	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 28	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 29	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.72	0.56	0.27	26.00	18.66	9.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 34	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.54	0.00	16.00	11.50	0.00	1.22	0.88	0.46	34.00	23.66	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	0.10	0.10	0.00
Ward 35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.84	0.84	0.84	29.00	29.00	29.00	0.61	0.37	0.00	3.00	0.37	0.00	0.91	0.47	0.00	5.00	1.03	0.00
Ward 36	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	2.00	2.00	0.00	1.19	0.76	0.00	35.00	23.33	0.00	0.61	0.33	0.00	0.50	0.15	0.00	0.91	0.48	0.00	2.00	0.55	0.00
Ward 37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.29	0.15	14.00	10.29	6.00	0.61	0.56	0.30	0.50	0.32	0.21	0.91	0.76	0.61	6.00	2.50	0.50
Ward 38	0.00	0.00	0.00	0.00	0.00	0.00	0.18	0.17	0.00	6.00	6.00	0.00	1.19	1.08	1.01	36.00	30.00	20.00	0.30	0.30	0.30	2.00	0.72	0.13	0.61	0.49	0.30	6.00	2.60	1.00
Ward 39	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.00	5.00	5.00	0.00	1.10	0.88	0.40	34.00	27.29	12.00	0.30	0.30	0.30	2.00	0.58	0.08	0.91	0.51	0.30	5.00	2.08	0.42
Ward 40	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.12	0.00	5.00	5.00	0.00	1.13	0.60	0.00	36.00	18.42	0.00	0.61	0.36	0.00	3.00	0.40	0.00	0.91	0.57	0.00	4.00	0.96	0.00
Ward 41	0.00	0.00	0.00	0.00	0.00	0.00	0.53	0.53	0.00	18.00	18.00	0.00	1.52	0.57	0.00	45.00	17.60	0.00	0.61	0.37	0.00	1.00	0.37	0.00	0.91	0.61	0.00	3.00	1.03	0.00
Ward 42	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	1.00	1.00	0.00	0.64	0.44	0.00	15.00	10.67	0.00	0.61	0.44	0.30	0.63	0.38	0.21	0.91	0.70	0.30	2.00	1.02	0.50
Ward 43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.61	0.00	27.00	21.00	0.00	0.61	0.47	0.00	3.00	0.46	0.00	0.91	0.72	0.00	5.00	0.82	0.00
Ward 44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.45	0.00	3.00	0.64	0.00	0.91	0.67	0.00	6.00	1.44	0.00
Ward 45	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.45	0.00	3.00	0.84	0.00	0.91	0.69	0.00	4.00	1.86	0.00
Ward 46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.61	0.00	15.00	15.00	0.00	0.61	0.44	0.30	0.50	0.30	0.17	0.91	0.61	0.30	2.00	0.69	0.25
Ward 47	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	2.00	2.00	0.00	0.94	0.85	0.00	18.00	16.50	0.00	0.61	0.38	0.00	2.00	0.50	0.00	0.91	0.58	0.00	3.00	1.17	0.00
Ward 48	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.54	0.00	15.00	11.17	0.00	1.80	0.83	0.00	32.00	18.91	0.00	0.61	0.46	0.30	0.63	0.52	0.42	0.91	0.76	0.61	2.00	2.00	2.00
Ward 49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.62	0.00	17.00	14.00	0.00	0.61	0.37	0.00	0.63	0.37	0.00	0.91	0.53	0.00	4.00	1.27	0.00
Ward 50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.82	0.81	0.00	20.00	20.00	0.00	0.61	0.42	0.00	0.63	0.40	0.00	0.91	0.62	0.00	2.00	1.18	0.00
Ward 51	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.46	0.00	10.00	10.00	0.00	0.99	0.58	0.00	30.00	19.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 52	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	4.00	4.00	0.00	0.76	0.60	0.00	25.00	17.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 53	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	5.00	5.00	0.00	0.90	0.37	0.00	22.00	10.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Uttar Khan	0.00	0.00	0.00	0.00	0.00	0.00	0.66	0.41	0.00	18.00	11.94	0.00	1.93	1.04	0.00	35.00	22.88	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
D. Khan Cant	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.07	0.60	0.00	28.00	16.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.26	0.00	1.00	1.00	0.00
D. Khan Gulshan	0.00	0.00	0.00	0.00	0.00	0.00	0.69	0.34	0.00	22.00	9.90	0.00	1.74	0.66	0.00	40.00	19.82	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Cantonment 1	0.00	0.00	0.00	0.00	0.00	0.00	0.64	0.39	0.00	12.00	7.70	0.00	1.83	0.89	0.00	35.00	19.30	0.00	0.11	0.11	0.00	0.20	0.20	0.00	0.46	0.46	0.00	0.40	0.40	0.00
Cantonment 3	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.28	0.00	15.00	9.00	0.00	1.40	0.81	0.00	65.00	24.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beraid U. Gulshan	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.00	7.00	7.00	0.00	1.25	0.70	0.00	39.00	19.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gulshan 57	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.24	0.00	12.00	7.77	0.00	1.19	0.78	0.00	38.00	21.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Beraid Demra	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.24	0.00	7.00	7.00	0.00	0.99	0.74	0.30	23.00	16.57	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Demra	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.29	0.00	13.00	9.75	0.00	1.52	0.92	0.29	42.00	26.84	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DE-Matuail	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.41	0.00	12.00	9.67	0.00	2.13	0.86	0.00	36.00	27.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUMMARY	0.00	0.00	0.00	0.00	0.00	0.00	0.91	0.27	0.00	22.00	7.47	0.00	2.13	0.72	0.00	65.00	19.66	0.00	0.61	0.37	0.00	4.00	0.44	0.00	0.91	0.54	0.00	6.00	1.19	0.00

TABLE B.3.1 FLOOD AREA AND LAND USE AT DND(BUILT UP AREA)

Name of Zone	Total Area	Total B/U Area in 1990	Total B/U Area in 2010	External Flood: Annual Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	1987 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	1988 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	Internal Flood: Total Flood Area	Ratio of Flood Area
	(ha.) (a)	(ha.) (b)	(ha.) (c)	(ha.) (d)	(%) =(d)/(a)	(ha.) (e)	(%) =(e)/(b)	(ha.) (f)	(%) =(f)/(c)	(ha.) (g)	(%) =(g)/(a)	(ha.) (h)	(%) =(h)/(b)	(ha.) (i)	(%) =(i)/(c)	(ha.) (j)	(%) =(j)/(a)	(ha.) (k)	(%) =(k)/(b)	(ha.) (l)	(%) =(l)/(c)	(ha.) (m)	(%) =(m)/(a)
Ward 31	8	8	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ward 32	162	162	155	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	6
Ward 33	52	47	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Matuail	1479	581	1282	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	8	1
Shyampur	397	142	361	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	3
DND-Siddirganj	564	129	406	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Simulpara	198	150	114	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	5
Kutubpur	1243	310	844	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	109	9
DND-Godnail	826	238	317	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	146	18
Fatullah	478	253	467	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	57	12
DND-Enayetnagar	22	12	22	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	14
DND-N'ganj 1	44	15	42	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	33	74
DND-N'ganj 2	49	34	49	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
DND-N'ganj 3	156	93	154	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22	14
Summary	5679	2174	4270	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	410	7

TABLE B.3.2 FLOOD AREA AND LAND USE AT DND (AGRICULTURAL AREA)

Name of Zone	Total Area	Total Agricul. Area in 1990	Total Agricul. Area in 2010	External Flood: Annual Flood						1987 Flood						1988 Flood					
				Total Flood Area	Ratio of Flood Area	Flood Area in Agri. in 1990	R. of Agri. in Flood Area in 1990	Flood Area in Agri. in 2010	R. of Agri. in Flood Area in 2010	Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of Agri. in Flood Area in 1990	Flood Area in B/U in 2010	R. of Agri. in Flood Area in 2010	Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of Agri. in Flood Area in 1990	Flood Area in B/U in 2010	R. of Agri. in Flood Area in 2010
	(ha.) (a)	(ha.) (b)	(ha.) (c)	(ha.) (d)	(%) =(d)/(a)	(ha.) (e)	(%) =(e)/(b)	(ha.) (f)	(%) =(f)/(c)	(ha.) (g)	(%) =(g)/(a)	(ha.) (h)	(%) =(h)/(b)	(ha.) (i)	(%) =(i)/(c)	(ha.) (j)	(%) =(j)/(a)	(ha.) (k)	(%) =(k)/(b)	(ha.) (l)	(%) =(l)/(c)
Ward 31	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ward 32	162	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ward 33	52	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Matuail	1479	886	78	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Shyampur	397	129	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Siddirganj	564	428	31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Simulpara	198	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Kutubpur	1243	869	188	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Godnail	826	584	235	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fatullah	478	159	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-Enayetnagar	22	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-N'ganj 1	44	27	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-N'ganj 2	49	14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
DND-N'ganj 3	156	63	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Summary	5679	3173	532	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TABLE B.4 FLOOD CONDITION OF DND

External Flood

Name of Zone	Annual Flood						1987 Flood						1988 Flood					
	Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)		
	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.
Ward 31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 32	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-Matuail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Shyampur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-Siddirganj	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-Simulpara	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kutubpur	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-Godnail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fatullah	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-Enayetnagar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-N'ganj 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-N'ganj 2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-N'ganj 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUMMARY	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Internal Flood

Name of Zone	Annual Flood						Worst Flood					
	Depth (meter)			Duration (day)			Depth (meter)			Duration (day)		
	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.
Ward 31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Ward 32	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.31	0.00	0.30	0.21	0.00
Ward 33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-Matuail	0.00	0.00	0.00	0.00	0.00	0.00	0.29	0.23	0.00	0.35	0.24	0.00
Shyampur	0.00	0.00	0.00	0.00	0.00	0.00	0.43	0.43	0.00	0.30	0.30	0.00
DND-Siddirganj	0.15	0.13	0.00	2.00	2.00	0.00	0.26	0.24	0.21	7.00	6.39	6.00
DND-Simulpara	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.23	0.00	7.00	7.00	0.00
Kutubpur	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.23	0.00	7.00	6.67	0.00
DND-Godnail	0.00	0.00	0.00	0.00	0.00	0.00	0.26	0.19	0.00	7.00	4.63	0.00
Fatullah	0.00	0.00	0.00	0.00	0.00	0.00	0.41	0.29	0.00	3.00	0.90	0.00
DND-Enayetnagar	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-N'ganj 1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
DND-N'ganj 2	0.00	0.00	0.00	0.00	0.00	0.00	0.09	0.09	0.00	0.25	0.22	0.00
DND-N'ganj 3	0.00	0.00	0.00	0.00	0.00	0.00	0.76	0.51	0.00	1.00	0.81	0.00
SUMMARY	0.15	0.13	0.00	2.00	2.00	0.00	0.76	0.28	0.00	7.00	2.74	0.00

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TABLE B.5(1) FLOOD AREA AND LAND USE AT NARAYANGANJ WEST(BUILT UP)

Name of Zone	Total Area	Total B/U Area in 1990	Total B/U Area in 2010	External Flood: Annual Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	1987 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	1988 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of B/U in Flood Area in 1990	Flood Area in B/U in 2010	R. of B/U in Flood Area in 2010	Internal Flood: Total Flood Area	Ratio of Flood Area
	(ha.) (a)	(ha.) (b)	(ha.) (c)	(ha.) (d)	(%) =(d)/(a)	(ha.) (e)	(%) =(e)/(b)	(ha.) (f)	(%) =(f)/(c)	(ha.) (g)	(%) =(g)/(a)	(ha.) (h)	(%) =(h)/(b)	(ha.) (i)	(%) =(i)/(c)	(ha.) (j)	(%) =(j)/(a)	(ha.) (k)	(%) =(k)/(b)	(ha.) (l)	(%) =(l)/(c)	(ha.) (m)	(%) =(m)/(a)
NW-Matuail	136	118	123	0	0	0	0	0	0	7	5	0	0	0	0	136	100	118	100	123	100	0	0
NW-Siddirganj	183	49	177	0	0	0	0	0	0	12	7	0	0	6	4	183	100	49	100	177	100	0	0
NW-Simulpara	411	266	400	0	0	0	0	0	0	50	12	0	0	40	10	411	100	266	100	400	100	23	6
NW-Godnail	164	68	161	0	0	0	0	0	0	9	5	0	0	6	4	164	100	68	100	161	100	16	10
NW-Enayetnagar	33	32	5	1	2	0	0	0	0	26	80	26	80	0	0	33	100	32	100	5	100	0	0
Kashipur	140	110	91	30	21	0	0	0	0	140	100	110	100	91	100	140	100	110	100	91	100	0	0
NW-N'ganj 1	85	68	83	0	0	0	0	0	0	36	42	19	28	34	41	85	100	68	100	83	100	0	0
NW-N'ganj 2	86	86	85	0	0	0	0	0	0	47	54	46	54	45	53	86	100	86	100	85	100	2	3
NW-N'ganj 3	78	58	76	0	0	0	0	0	0	10	13	0	0	9	11	78	100	58	100	76	100	1	1
N'ganj 4	184	157	178	27	15	0	0	22	12	104	56	76	49	98	55	184	100	157	100	178	100	6	4
N'ganj 5	100	86	96	10	10	0	0	6	6	23	23	9	10	19	20	100	100	86	100	96	100	23	23
N'ganj 6	55	47	51	0	0	0	0	0	0	18	32	10	20	14	28	55	100	47	100	51	100	0	0
N'ganj 7	124	94	110	30	24	0	0	16	14	76	61	45	48	61	56	124	100	94	100	110	100	3	2
N'ganj 8	85	73	82	12	14	0	0	10	12	49	58	37	51	47	57	85	100	73	100	82	100	12	14
Summary	1863	1312	1720	111	6	0	0	53	3	606	33	379	29	471	27	1863	100	1312	100	1720	100	87	5

TABLE B.5(2) FLOOD AREA AND LAND USE AT NARAYANGANJ WEST(AGRICULTURE AREA)

Name of Zone	Total Area	Total Agricul. Area in 1990	Total Agricul. Area in 2010	External Flood: Annual Flood: Total Flood Area	Ratio of Flood Area	Flood Area in Agri. in 1990	R. of Agri. in Flood Area in 1990	Flood Area in Agri. in 2010	R. of Agri. in Flood Area in 2010	1987 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of Agri. in Flood Area in 1990	Flood Area in B/U in 2010	R. of Agri. in Flood Area in 2010	1988 Flood: Total Flood Area	Ratio of Flood Area	Flood Area in B/U in 1990	R. of Agri. in Flood Area in 1990	Flood Area in B/U in 2010	R. of Agri. in Flood Area in 2010
	(ha.) (a)	(ha.) (b)	(ha.) (c)	(ha.) (d)	(%) =(d)/(a)	(ha.) (e)	(%) =(e)/(b)	(ha.) (f)	(%) =(f)/(c)	(ha.) (g)	(%) =(g)/(a)	(ha.) (h)	(%) =(h)/(b)	(ha.) (i)	(%) =(i)/(c)	(ha.) (j)	(%) =(j)/(a)	(ha.) (k)	(%) =(k)/(b)	(ha.) (l)	(%) =(l)/(c)
NW-Matuail	136	17	6	0	0	0	0	0	0	7	5	6	34	0	0	136	100	17	100	6	100
NW-Siddirganj	183	132	1	0	0	0	0	0	0	12	7	10	8	1	100	183	100	132	100	1	100
NW-Simulpara	411	75	0	0	0	0	0	0	0	50	12	0	0	0	100	411	100	75	100	0	100
NW-Godnail	164	95	1	0	0	0	0	0	0	9	5	8	9	1	100	164	100	95	100	1	100
NW-Enayetnagar	33	0	0	1	2	0	100	0	-	26	80	0	100	0	-	33	100	0	100	0	-
Kashipur	140	27	1	30	21	27	100	0	0	140	100	27	100	1	100	140	100	27	100	1	100
NW-N'ganj 1	85	10	0	0	0	0	0	0	-	36	42	10	100	0	-	85	100	10	100	0	-
NW-N'ganj 2	86	0	0	0	0	0	100	0	-	47	54	0	100	0	-	86	100	0	100	0	-
NW-N'ganj 3	78	20	0	0	0	0	0	0	-	10	13	10	50	0	-	78	100	20	100	0	-
N'ganj 4	184	26	0	27	15	26	100	0	-	104	56	26	100	0	-	184	100	26	100	0	-
N'ganj 5	100	14	0	10	10	10	73	0	-	23	23	14	100	0	-	100	100	14	100	0	-
N'ganj 6	55	8	0	0	0	0	0	0	-	18	32	8	100	0	-	55	100	8	100	0	-
N'ganj 7	124	28	0	30	24	28	100	0	-	76	61	28	100	0	-	124	100	28	100	0	-
N'ganj 8	85	12	0	12	14	12	100	0	100	49	58	12	100	0	100	85	100	12	100	0	100
									-						-						-
Summary	1863	464	8	111	6	104	22	0	0	606	33	160	34	2	26	1863	100	464	100	8	100

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TABLE B.6 FLOOD CONDITION OF NARAYANGANJ WEST

Name of Zone	External Flood																		Internal Flood											
	Annual Flood						1987 Flood						1988 Flood						Annual Flood						Worst Flood					
	Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)			Depth (meter)			Duration (day)		
	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.	Max.	Ave.	Min.
NW-Matuail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	0.77	0.00	22.00	18.30	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NW-Siddirganj	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.94	0.81	0.73	23.00	19.30	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NW-Simulpara	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.30	0.00	15.00	13.50	0.00	1.22	0.72	0.15	31.00	20.50	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NW-Godnail	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.14	0.67	0.15	20.00	13.80	6.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NW-Enayetnagar	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30	0.00	7.00	7.00	0.00	1.31	0.92	0.00	30.00	21.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Kashipur	0.00	0.00	0.00	0.00	0.00	0.00	0.58	0.40	0.00	13.00	9.10	0.00	1.63	0.91	0.15	32.00	18.40	3.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
NW-N'ganj 1	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.11	0.00	6.00	5.00	0.00	0.99	0.78	0.64	30.00	24.00	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15	0.15	0.00	1.00	1.00	0.00
NW-N'ganj 2	0.00	0.00	0.00	0.00	0.00	0.00	0.20	0.20	0.00	7.00	7.00	0.00	1.07	1.07	0.00	30.00	30.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.24	0.18	0.00	1.00	1.00	0.00
NW-N'ganj 3	0.00	0.00	0.00	0.00	0.00	0.00	0.46	0.46	0.00	15.00	15.00	0.00	1.07	0.74	0.23	35.00	22.50	7.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08	0.08	0.00	0.25	0.25	0.00
N'ganj 4	0.00	0.00	0.00	0.00	0.00	0.00	0.23	0.21	0.00	8.00	6.33	0.00	1.14	0.67	0.00	40.00	19.57	0.00	0.12	0.12	0.00	0.08	0.08	0.00	0.82	0.45	0.00	0.83	0.47	0.00
N'ganj 5	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.25	0.00	12.00	7.25	0.00	1.14	0.88	0.58	35.00	22.43	15.00	0.00	0.00	0.00	0.00	0.00	0.00	0.30	0.30	0.00	0.50	0.50	0.00
N'ganj 6	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.34	0.00	14.00	8.67	0.00	1.60	1.14	0.91	30.00	25.75	21.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
N'ganj 7	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.24	0.00	14.00	6.33	0.00	1.58	1.01	0.46	35.00	23.71	18.00	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.61	0.00	2.00	2.00	0.00
N'ganj 8	0.00	0.00	0.00	0.00	0.00	0.00	0.34	0.20	0.00	7.00	4.00	0.00	1.10	0.61	0.00	30.00	23.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.38	0.21	0.00	0.50	0.28	0.00
SUMMARY	0.00	0.00	0.00	0.00	0.00	0.00	0.61	0.27	0.00	15.00	8.11	0.00	1.63	0.84	0.00	40.00	21.69	0.00	0.12	0.12	0.00	0.08	0.08	0.00	0.82	0.28	0.00	2.00	0.79	0.00

Table B.7 No. of Properties by Area by Type of Properties by Year

1. 1990

(Unit : Number)

Name of Areas	Houses	Businesses	Industries	Institutions
Dhaka East - 1	27,976	1,026	0	1,565
Dhaka East - 2	10,210	75	0	81
Dhaka East - 3	151,019	6,366	1,217	10,381
Dhaka East - 4	152,468	6,384	282	7,470
Dhaka East (Sub-Total)	341,673	13,851	1,499	19,497
Narayanganj DND	87,634	2,408	1,226	3,544
Narayanganj West	81,762	3,465	1,013	2,461
TOTAL	511,069	19,724	3,738	25,502

2. 2010

(Unit : Number)

Name of Areas	Houses	Businesses	Industries	Institutions
Dhaka East - 1	130,785	2,736	0	2,600
Dhaka East - 2	43,650	479	0	418
Dhaka East - 3	286,965	10,571	1,830	18,303
Dhaka East - 4	255,385	9,520	440	14,758
Dhaka East (Sub-Total)	716,785	23,306	2,270	36,079
Narayanganj DND	256,643	6,410	3,873	11,656
Narayanganj West	160,891	6,021	2,245	4,509
TOTAL	1,134,319	35,737	8,388	52,244

Note : No. is on household basis.
Source : Population Census 1981 and JICA

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Table B.8 Farm Houses by Area in 1990 and 2010

(Unit : Number)

Name of Areas	1990	2010
Dhaka East - 1	9,683	593
Dhaka East - 2	8,271	2,642
Dhaka East - 3	6,262	0
Dhaka East - 4	21,179	0
Dhaka East (Sub-Total)	45,395	3,235
Narayanganj DND	14,492	1,868
Narayanganj West	3,459	26
TOTAL	63,346	5,129

Source : Upazila Statistics of Bangladesh 1988 and JICA.

Table B.9 No. of Properties in Inundation Areas by Area by Type of Properties in 1990

(Unit : Number)

Name of Areas	Houses	Businesses	Industries	Institutions
1. Annual Flood				
Dhaka East - 1	0	0	0	0
Dhaka East - 2	0	0	0	0
Dhaka East - 3	0	0	0	0
Dhaka East - 4	0	0	0	0
Dhaka East (Sub-Total)	0	0	0	0
Narayanganj DND	0	0	0	0
Narayanganj West	0	0	0	0
TOTAL	0	0	0	0
2. 1987 - Scale Flood				
Dhaka East - 1	4,031	108	0	44
Dhaka East - 2	1,012	1	0	2
Dhaka East - 3	24,731	771	313	1,463
Dhaka East - 4	31,602	778	6	1,548
Dhaka East (Sub-Total)	61,376	1,658	319	3,057
Narayanganj DND	25,414	698	356	1,028
Narayanganj West	23,043	688	218	346
TOTAL	109,833	3,044	893	4,431
3. 1988 - Scale Flood				
Dhaka East - 1	11,002	357	0	325
Dhaka East - 2	9,831	63	0	73
Dhaka East - 3	48,812	1,605	458	2,872
Dhaka East - 4	96,333	3,077	28	4,017
Dhaka East (Sub-Total)	165,978	5,102	486	7,287
Narayanganj DND	87,634	2,408	1,226	3,544
Narayanganj West	64,679	3,068	705	1,500
TOTAL	318,291	10,578	2,417	12,331

Note : No. is on household basis.
Source : Population Census 1981 and JICA.

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Table B.10 No. of Properties in Inundation Areas by Area by Type of Properties in 2010

(Unit : Number)

Name of Zones	Houses	Businesses	Industries	Institutions
1. Annual Flood				
Dhaka East - 1	52,593	1,010	0	333
Dhaka East - 2	21,573	186	0	180
Dhaka East - 3	35,187	544	1	594
Dhaka East - 4	55,598	1,514	19	3,899
Dhaka East (Sub-Total)	164,951	3,254	20	5,006
Narayanganj DND	7,699	192	116	350
Narayanganj West	6,517	329	47	127
TOTAL	179,167	3,775	183	5,483
2. 1987 - Scale Flood				
Dhaka East - 1	90,600	1,462	0	532
Dhaka East - 2	33,991	257	0	261
Dhaka East - 3	84,086	1,814	471	3,070
Dhaka East - 4	95,280	2,563	31	6,165
Dhaka East (Sub-Total)	303,957	6,096	502	10,028
Narayanganj DND	69,294	1,731	1,046	3,148
Narayanganj West	47,550	1,706	398	878
TOTAL	420,801	9,533	1,946	14,054
3. 1988 - Scale Flood				
Dhaka East - 1	106,827	1,987	0	1,268
Dhaka East - 2	42,450	440	0	392
Dhaka East - 3	130,085	3,468	690	5,780
Dhaka East - 4	185,640	5,819	61	9,868
Dhaka East (Sub-Total)	465,002	11,714	751	17,308
Narayanganj DND	256,643	6,410	3,873	11,659
Narayanganj West	148,026	5,118	5,082	4,067
TOTAL	869,671	23,242	9,706	33,034

Note : No. is on household basis.
Source : Population Census 1981 and JICA.

Table B.11 1987 - Scale Flood Damages by Area by Type of Properties in 1990

Bd = Building(s), H.E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

(Unit : Tk. Million)

Name of Areas	Residential			Commercial			Industrial			Institutional	Agricultural
	Bd	H.E	Ic	Bd	E & I	Pf	Bd	E & I	Pf	Bd	Cp
Dhaka East - 1	20.2	0.3	5.2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	46.7
Dhaka East - 2	2.1	0.0	1.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	41.7
Dhaka East - 3	65.0	3.2	26.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0	28.7
Dhaka East - 4	105.2	4.7	36.7	0.0	0.0	0.4	0.0	0.0	0.0	0.0	104.6
Dhaka East (Sub-Total)	192.5	8.2	69.7	0.0	0.0	0.9	0.0	0.0	0.0	0.0	221.7
Narayanganj DND	87.0	0.0	30.2	0.0	0.0	0.4	0.0	0.0	0.0	0.0	25.3
Narayanganj West	40.4	0.9	21.1	0.0	0.0	0.3	0.0	0.0	0.0	0.0	12.8
TOTAL	319.9	9.1	121.0	0.0	0.0	1.6	0.0	0.0	0.0	0.0	259.8

Source : JICA

Table B.12 1988 - Scale Flood Damages by Area by Type of Properties in 1990

Bd = Building(s), H.E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

(Unit : Tk. Million)

Name of Areas	Residential			Commercial			Industrial			Institutional	Agricultural
	Bd	H.E	Ic	Bd	E & I	Pf	Bd	E & I	Pf	Bd	Cp
Dhaka East - 1	91.0	45.9	14.0	2.5	5.8	0.5	0.0	0.0	0.0	9.6	57.6
Dhaka East - 2	87.7	42.7	13.3	0.5	1.0	0.1	0.0	0.0	0.0	2.3	47.3
Dhaka East - 3	348.1	187.4	53.2	9.8	24.9	2.0	18.9	62.9	9.9	77.8	34.2
Dhaka East - 4	914.2	434.9	140.0	23.6	50.6	5.0	1.2	4.1	0.6	130.3	130.6
Dhaka East (Sub-Total)	1,441.0	710.9	220.5	36.4	82.3	7.6	20.1	67.0	10.5	220.0	269.7
Narayanganj DND	838.3	386.5	117.6	17.7	40.1	3.7	54.7	180.5	26.8	110.7	87.5
Narayanganj West	639.7	288.7	87.5	24.1	53.6	5.0	29.6	98.5	15.2	48.0	20.9
TOTAL	2,919.0	1,386.1	425.6	78.2	176.0	16.3	104.4	346.0	52.5	378.7	378.1

Source : JICA

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Table B.13 Annual Flood Damages by Area by Type of Properties in 2010

Bd = Building(s), H.E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

(Unit : Tk. Million)

Name of Areas	Residential			Commercial			Industrial			Institutional	Agricultural
	Bd	H.E	Ic	Bd	E & I	Pf	Bd	E & I	Pf	Bd	Cp
Dhaka East - 1	0.0	0.0	52.2	0.0	0.0	0.6	0.0	0.0	0.0	0.0	0.0
Dhaka East - 2	0.0	0.0	21.4	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Dhaka East - 3	0.0	0.0	31.8	0.0	0.0	0.3	0.0	0.0	0.0	0.0	0.0
Dhaka East - 4	0.0	0.0	50.3	0.0	0.0	0.9	0.0	0.0	0.0	0.0	0.0
	0.0	0.0									
Dhaka East (Sub-Total)	0.0	0.0	155.7	0.0	0.0	1.9	0.0	0.0	0.0	0.0	0.0
Narayanganj DND	0.0	0.0	7.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0
Narayanganj West	0.0	0.0	5.9	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0
TOTAL	0.0	0.0	168.6	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0

Source : JICA

Table B.14 1987 - Scale Flood Damages by Area by Type of Properties in 2010

Bd = Building(s), H.E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

(Unit : Tk. Million)

Name of Areas	Residential			Commercial			Industrial			Institutional	Agricultural
	Bd	H.E	Ic	Bd	E & I	Pf	Bd	E & I	Pf	Bd	Cp
Dhaka East - 1	984.2	27.3	217.7	0.0	0.0	1.5	0.0	0.0	0.0	0.0	3.1
Dhaka East - 2	180.3	0.0	69.8	0.0	0.0	0.3	0.0	0.0	0.0	0.0	13.5
Dhaka East - 3	399.1	9.0	152.8	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0
Dhaka East - 4	616.2	20.9	185.2	0.0	0.0	2.2	0.0	0.0	0.0	0.0	0.0
Dhaka East (Sub-Total)	2,179.8	57.2	625.5	0.0	0.0	5.5	0.0	0.0	0.0	0.0	16.6
Narayanganj DND	382.3	0.0	132.5	0.0	0.0	1.5	0.0	0.0	0.0	0.0	2.5
Narayanganj West	150.9	3.7	73.5	0.0	0.0	1.3	0.0	0.0	0.0	0.0	0.0
TOTAL	2,713.0	60.9	831.5	0.0	0.0	8.3	0.0	0.0	0.0	0.0	19.1

Source : JICA

Table B.15 1988 - Scale Flood Damages by Area by Type of Properties in 2010

Bd = Building(s), H.E = Household Effects, Ic = Income, E & I = Equipment and Inventories, Pf = Profit, Cp = Crops

(Unit : Tk. Million)

Name of Areas	Residential			Commercial			Industrial			Institutional	Agricultural
	Bd	H.E	Ic	Bd	E & I	Pf	Bd	E & I	Pf	Bd	Cp
Dhaka East - 1	1,736.0	817.7	246.9	24.1	55.5	5.0	0.0	0.0	0.0	63.1	3.6
Dhaka East - 2	671.6	326.9	102.4	6.1	12.9	1.3	0.0	0.0	0.0	22.6	16.0
Dhaka East - 3	1,648.9	849.4	252.7	36.0	87.6	7.5	45.9	152.6	24.1	258.4	0.0
Dhaka East - 4	2,901.2	1,369.3	445.4	73.5	155.2	15.4	4.5	15.2	2.1	539.1	0.0
Dhaka East (Sub-Total)	6,957.7	3,363.3	1,047.4	139.7	311.2	29.2	50.4	167.8	26.2	883.2	19.6
Narayanganj DND	3,956.1	1,824.2	554.9	75.7	172.1	15.8	278.4	918.9	136.6	586.8	11.3
Narayanganj West	2,267.7	1,039.5	309.4	63.5	142.2	13.2	341.0	1,119.6	182.0	199.8	0.2
TOTAL	13,181.5	6,227.0	1,911.7	278.9	625.5	58.2	669.8	2,206.3	344.8	1,669.8	31.1

Source : JICA

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Table B.16 Internal Flood Damages to Houses and Household Articles by Area by Year by Scale of Floods

(Unit : Tk. Million)

Name of Areas	Annual Flood	Worst Flood
1. 1990		
Dhaka East - 1	0.2	0.4
Dhaka East - 2	0.0	0.0
Dhaka East - 3	49.9	106.2
Dhaka East - 4	70.9	150.7
Dhaka East (Sub-Total)	121.0	257.3
Narayanganj DND	27.3	43.4
Narayanganj West	0.8	9.9
Total	149.1	310.6
2. 2010		
Dhaka East - 1	0.0	0.1
Dhaka East - 2	0.0	0.0
Dhaka East - 3	85.0	178.2
Dhaka East - 4	100.9	211.6
Dhaka East (Sub-Total)	185.9	389.9
Narayanganj DND	109.1	171.0
Narayanganj West	2.0	24.4
Total	297.0	585.3

Source : JICA

Table B.17 Summary of Traffic Survey Results

Unit : Number

Location	Rickshaw	Auto Rickshaw	Motor Cycle	Car / Jeep	Micro Bus	Bus/ Mini Bus	Mini Truck/ Pick-up	Truck
Dha1	53300	8120	3118	9160	2270	3923	769	869
Dha2	1199	3214	995	404	125	1385	77	46
Dha3	26116	3573	1003	2412	471	1397	170	19
Dha4	29270	4939	3603	6693	957	3304	227	418
Dha5	310	186	2630	4289	1087	277	197	93
Dha6	26720	3686	1071	1565	465	317	231	245
Dha7	35840	9215	2338	3603	695	2006	213	140
Dha8	12966	1489	1037	2194	450	173	120	123
Dha9	43480	5783	2134	2665	607	161	128	78
Dha10	38775	8574	4225	8064	1783	1314	470	107
Dha11	30630	2130	1710	5119	993	76	222	142
Dha12	54060	4287	1802	5528	741	3078	273	170
Dha13	39460	8698	2813	13205	1680	192	253	90
Dha14	36490	5153	1223	3759	754	85	142	142
Dha15	11460	5428	1525	7492	1119	1507	222	601
Dha16	0	14123	2532	21472	2896	1802	762	643
Nar-1	23750	325	575	864	328	2127	146	707
Nar-2	22210	338	209	381	77	1673	64	102
Nar-3	7242	103	114	176	59	3	43	37
Nar-4	1231	2	30	41	2	0	17	215
Airport	0	5103	1668	6131	2131	3404	697	807
Mirpur Road	20340	5635	1986	14365	3043	1927	482	466
Jatra-1	3290	2245	292	244	102	541	66	273
Jatra-2	12790	1473	585	1527	723	2648	429	2666
Jatra-3	15130	4565	732	1405	393	2258	345	2743
China Bridge	6600	1871	527	1009	298	1655	212	3318
DND Pump	2790	828	326	573	193	779	224	1094
Narayanganj	25390	536	386	980	416	1361	228	1055
Total	580839	111622	41189	125320	24858	39373	7429	17409
Total Dha, Nar	494509	89366	34687	99086	17559	24800	4746	4987
Total-Dhaka	440076	88598	33759	97624	17093	20997	4476	3926
Total Dha10, Nar-1	62525	8899	4800	8928	2111	3441	616	814

Note : Survey time was from 7 am to 8 pm.

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Table B.18 Results of Traffic Damage Survey

Type of Vehicles	Average No. of Flood Affected Days/Vehicle								Average Operating Kilometers/ Day/Vehicle		Average Speed (km / hour)		Average Oil Consumption /Day/Vehicle (liter)		Average Sales per Day per Vehicle (Tk.)	
	1987		1988		1986		1990									
	Non-Operating	Slow Operating	Non-Operating	Slow Operating	Non-Operating	Slow Operating	Non-Operating	Slow Operating	Normal Time	Flood Time	Normal Time	Flood Time	Normal Time	Flood Time	Normal Time	Flood Time
Rickshaw	0.0	1.2	3.4	15.5	3.9	8.7	0.0	0.0	64.0	43.3	11.7	8.4	0.0	0.0	118.5	175.0
Auto-Rickshaw	1.5	11.9	18.0	32.2	2.6	8.7	0.0	0.0	130.7	98.5	29.0	21.0	15.7	16.4	612.5	535.0
Motor Cycle	0.0	8.4	13.1	27.6	2.4	14.4	0.0	0.0	91.0	67.5	39.0	30.8	5.9	4.8	-	-
Car	0.0	14.3	19.0	37.5	0.0	9.5	0.0	0.0	131.5	105.5	65.5	48.5	22.3	21.5	-	-
Jeep	0.0	15.5	13.5	37.5	0.0	8.2	0.0	0.0	110.0	84.5	53.1	40.5	26.5	22.9	-	-
Micro Bus	0.0	18.2	14.6	38.5	0.0	11.4	0.0	0.0	104.5	84.0	57.0	44.5	19.1	18.6	-	-
Mini Bus	9.9	25.5	25.2	48.5	0.0	16.7	0.0	0.0	207.7	166.0	46.5	33.9	42.1	37.4	2,045.0	1,565.0
Bus	6.2	21.0	26.0	47.0	3.0	14.9	0.0	0.0	257.9	251.6	58.0	44.5	79.0	86.6	3,780.0	3,325.0
Mini Truck	9.1	19.2	26.3	40.5	0.0	10.5	0.0	0.0	86.0	66.0	29.5	20.7	22.5	20.0	942.0	750.0
Pick-up Van	13.4	22.0	27.5	49.0	0.7	11.1	0.0	0.0	105.0	67.0	32.8	20.6	27.6	21.6	1,115.0	730.0
Truck	13.2	29.5	34.5	54.5	1.5	28.0	0.0	0.0	153.2	117.5	34.3	24.6	47.4	42.1	1,965.0	1,785.0

Source : JICA

Table B.19 Profit Loss and Incremental Time Cost in Flood Time per Day per Vehicle

Type of Vehicles	Average Oil Cost /Day/Vehicle * (Tk)		Average Sales minus Oil Cost/Day/Vehicle (Tk)		Profit Loss in Flood Time /Day/Vehicle (Tk)	Average Operating Hours/ Day/Vehicle		Average Incremental Operating Hours in Flood Time/Day/ Vehicle	Average Number of Passengers	Incremental Time Cost in Flood Time /Day/ Vehicle (Tk)
	Normal Time	Flood Time	Normal Time	Flood Time		Normal Time	Flood Time			
Rickshaw	-	-	-	-	-17	5.466	5.149	-0.317	2	-0.463
Auto-Rickshaw	200	229	393	306	87	4.507	4.690	0.183	4	0.534
Motor Cycle	83	67	-	-	-	2.333	2.195	-0.138	0	0.000
Car	332	322	-	-	-	2.008	2.175	0.167	2	0.244
Jeep	395	341	-	-	-	2.072	2.086	0.014	3	0.031
Micro Bus	268	260	-	-	-	1.833	1.888	0.055	6	0.241
Mini Bus	590	523	1,455	1,042	413	4.467	4.897	0.430	40	12.556
Bus	1,105	1,212	2,675	2,113	562	4.447	5.654	1.207	56	49.342
Mini Truck	315	279	627	471	156	2.915	3.188	0.273	-	-
Pick-up Van	387	302	728	428	300	3.201	3.252	0.051	-	-
Truck	663	589	1,302	1,196	106	4.466	4.776	0.310	-	-

Notes : * : Oil cost/liter .... octan = Tk. 14.95, diesel = Tk. 14.00, petrol = Tk. 14.00

*2 : Profit ratio to sales is assumed as 30%.

*3 : Time value of a passenger is assumed as Tk. 0.73 /hour based on the estimated per capita GDP, Tk. 6,401 in the Region of Dhaka in 1990.

Source : JICA

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Table B.20 Traffic Damages per Vehicle by Type of Vehicles by Scale of Flood

Type of Vehicles	1987 Flood				1988 Flood				1986 Flood			
	Profit Loss		Incremental	Total	Profit Loss		Incremental	Total	Profit Loss		Incremental	Total
	by Non-Operation	by Slow Operation	Time Cost		by Non-Operation	by Slow Operation	Time Cost		by Non-Operation	by Slow Operation	Time Cost	
Rickshaw	-	-20	-1	-21	121	-264	-7	-150	139	-148	-4	-13
Auto-Rickshaw	276	1,033	6	1,315	3,308	2,796	17	6,121	478	755	5	1,238
Motor Cycle	-	-	0	0	-	-	0	0	-	-	0	0
Car	-	-	3	3	-	-	9	9	-	-	2	2
Jeep	-	-	0	0	-	-	1	1	-	-	0	0
Micro Bus	-	-	4	4	-	-	9	9	-	-	3	3
Mini Bus	6,074	10,522	320	16,916	15,460	20,012	609	36,081	-	6,891	210	7,101
Bus	7,031	11,799	1,036	19,866	29,484	26,408	2,319	58,211	3,402	8,372	735	12,509
Mini Truck	2,573	2,997	-	5,570	7,436	6,322	-	13,758	-	1,639	-	1,639
Pick-up Van	4,482	6,609	-	11,091	9,199	14,721	-	23,920	234	3,335	-	3,569
Truck	7,781	3,132	-	10,913	20,338	5,786	-	26,124	884	2,973	-	3,857

Notes : * : Profit ratio to sales is assumed as 30%.
Source : JICA

Table B.21 Number of Vehicles by Area by Type of Vehicles in 1990

(Unit : Number)

Type of Vehicles	Greater Dhaka East					Narayanganj DND	Narayanganj West	Total
	DC-1	DC-2	DC-3	DC-4	Sub-Total			
Rickshaw	3,606	1,775	26,259	26,637	58,277	15,238	14,217	87,732
Auto-Rickshaw	251	118	1,926	1,898	4,194	1,080	1,011	6,285
Motor Cycle	1,476	727	10,746	10,849	23,798	6,236	5,818	35,852
Car	417	205	3,038	3,067	6,727	1,763	1,645	10,135
Jeep	42	5	567	447	1,061	227	219	1,507
Micro Bus	95	11	1,284	1,010	2,400	513	496	3,409
Mini Bus	110	54	804	811	1,779	466	435	2,680
Bus	49	24	357	360	790	207	193	1,190
Mini Truck	19	2	231	203	455	111	137	703
Pick-up Van	28	3	347	305	683	166	205	1,054
Truck	99	12	1,224	1,076	2,411	586	723	3,720

Source : Statistical Yearbook of Bangladesh 1990 and JICA

Table B.22 Number of Vehicles by Area by Type of Vehicles in 2010

(Unit : Number)

Type of Vehicles	Greater Dhaka East					Narayanganj DND	Narayanganj West	Total
	DC-1	DC-2	DC-3	DC-4	Sub-Total			
Rickshaw	24,399	13,432	80,406	71,898	190,135	71,910	45,081	307,126
Auto-Rickshaw	1,624	898	5,833	5,143	13,498	5,115	3,189	21,802
Motor Cycle	9,985	5,497	32,905	29,283	77,670	29,428	18,448	125,546
Car	2,823	1,554	9,302	8,278	21,957	8,319	5,215	35,491
Jeep	69	50	1,563	1,258	2,940	1,117	650	4,707
Micro Bus	157	113	3,536	2,846	6,652	2,526	1,471	10,649
Mini Bus	747	411	2,461	2,190	5,809	2,201	1,380	9,390
Bus	331	182	1,092	972	2,577	976	612	4,165
Mini Truck	43	26	609	489	1,167	505	406	2,078
Pick-up Van	65	39	914	734	1,752	758	609	3,119
Truck	229	137	3,225	2,590	6,181	2,674	2,150	11,005

Source : Statistical Yearbook of Bangladesh 1990 and JICA

Table B.23 Traffic Damages by Area by Year in 1987 - Scale Flood

(Unit : Tk. Million)

Type of Vehicles	1990								2010							
	Greater Dhaka East					Narayanganj		Total	Greater Dhaka East					Narayanganj		Total
	DC-1	DC-2	DC-3	DC-4	Sub-Total	DND	West		DC-1	DC-2	DC-3	DC-4	Sub-Total	DND	West	
Rickshaw	-0.1	0.0	-0.6	-0.6	-1.3	-0.3	-0.3	-1.9	-0.5	-0.3	-1.7	-1.5	-4.0	-1.5	-0.9	-6.4
Auto-Rickshaw	0.3	0.2	2.5	2.5	5.5	1.4	1.3	8.2	2.1	1.2	7.7	6.8	17.8	6.7	4.2	28.7
Motor Cycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jeep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Micro Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mini Bus	1.9	0.9	13.7	13.8	30.3	8.0	7.4	45.7	12.6	7.0	41.6	37.1	98.3	37.2	23.3	158.8
Bus	1.0	0.5	7.1	7.2	15.8	4.1	3.8	23.7	6.6	3.6	21.7	19.3	51.2	19.4	12.2	82.8
Mini Truck	0.1	0.0	1.3	1.1	2.5	0.6	0.8	3.9	0.2	0.1	3.4	2.7	6.4	2.8	2.3	11.5
Pick-up Van	0.3	0.0	3.8	3.4	7.5	1.8	2.3	11.6	0.7	0.4	10.1	8.1	19.3	8.4	6.8	34.5
Truck	1.1	0.1	13.4	11.7	26.3	6.4	7.9	40.6	2.5	1.5	35.2	28.3	67.5	29.2	23.5	120.2
Total	4.6	1.7	41.2	39.1	86.6	22.0	23.2	131.8	24.2	13.5	118.0	100.8	256.5	102.2	71.4	430.1

Source : JICA

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Table B.24 Traffic Damages by Area by Year in 1988 - Scale Flood

(Unit : Tk. Million)

Type of Vehicles	1990								2010							
	Greater Dhaka East					Narayanganj		Total	Greater Dhaka East					Narayanganj		Total
	DC-1	DC-2	DC-3	DC-4	Sub-Total	DND	West		DC-1	DC-2	DC-3	DC-4	Sub-Total	DND	West	
Rickshaw	-0.5	-0.3	-3.9	-4.0	-8.7	-2.3	-2.1	-13.1	-3.7	-2.0	-12.1	-10.8	-28.6	-10.8	-6.8	-46.2
Auto-Rickshaw	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.1	0.4
Motor Cycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.3
Jeep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Micro Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mini Bus	3.9	2.0	29.0	29.3	64.2	16.9	15.7	96.8	26.9	14.8	88.8	79.0	209.5	79.4	49.8	338.7
Bus	2.8	1.4	20.8	21.0	46.0	12.0	11.2	69.2	19.3	10.6	63.6	56.6	150.1	56.8	35.6	242.5
Mini Truck	0.3	0.0	3.2	2.8	6.3	1.5	1.9	9.7	0.6	0.4	8.4	6.7	16.1	6.9	5.6	28.6
Pick-up Van	0.7	0.1	8.3	7.3	16.4	4.0	4.9	25.3	1.6	0.9	21.9	17.6	42.0	18.1	14.6	74.7
Truck	2.6	0.3	32.0	28.1	63.0	15.3	18.9	97.2	6.0	3.6	84.3	67.7	161.6	69.9	56.2	287.7
Total	9.8	3.5	89.4	84.5	187.2	47.4	50.5	285.1	50.7	28.3	255.1	217.0	551.1	220.5	155.1	926.7

Source : JICA

Table B.25 Traffic Damages by Area by Year in 1986 - Scale Flood

(Unit : Tk. Million)

Type	1990								2010							
Vehicles	Greater Dhaka East					Narayanganj		Total	Greater Dhaka East					Narayanganj		Total
	DC-1	DC-2	DC-3	DC-4	Sub-Total	DND	West		DC-1	DC-2	DC-3	DC-4	Sub-Total	DND	West	
Rickshaw	0.0	0.0	-0.3	-0.3	-0.6	-0.2	-0.2	-1.0	-0.3	-0.2	-1.0	-0.9	-2.4	-0.9	-0.6	-3.9
Auto-Rickshaw	0.3	0.1	2.4	2.4	5.2	1.3	1.3	7.8	2.0	1.1	7.2	6.4	16.7	6.3	3.9	26.9
Motor Cycle	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Car	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Jeep	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Micro Bus	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mini Bus	0.8	0.5	5.7	5.7	12.7	3.3	3.1	19.1	5.3	2.9	17.5	15.6	41.3	15.6	9.8	66.7
Bus	0.6	0.3	4.5	4.5	9.9	2.6	2.4	14.9	4.1	2.3	13.7	12.2	32.3	12.2	7.7	52.2
Mini Truck	0.0	0.0	0.4	0.3	0.7	0.2	0.2	1.1	0.1	0.0	1.0	0.8	1.9	0.8	0.7	3.4
Pick-up Van	0.1	0.0	1.2	1.1	2.4	0.6	0.7	3.7	0.2	0.1	3.3	2.6	6.2	2.7	2.2	11.1
Truck	0.4	0.0	4.7	4.1	9.2	2.3	2.8	14.3	0.9	0.5	12.4	10.0	23.8	10.3	8.3	42.4
Total	2.2	0.9	18.6	17.8	39.5	10.1	10.3	59.9	12.3	6.9	54.0	46.6	119.8	47.0	32.0	198.8

Source : JICA

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TABLE B.26(1) DIRECT DAMAGES TO INFRASTRUCTURES (1/2)

1. Greater Dhaka East

(Unit : Tk Million)

Infrastructure	External Flood			Internal Flood	
	Annual	1987	1988	Annual	Worst
Road / Bridge	14.1	39.8	171.3	6.1	9.8
Railway	0.0	0.0	0.0	0.0	0.0
Electricity	0.2	0.7	2.3	0.3	0.5
Telecom.	26.2	26.2	147.0	15.2	45.8
Water Supply	0.0	0.0	4.9	0.0	0.0
Sewer. / Drain.	1.0	2.0	7.7	1.0	2.0
Gas	0.0	0.0	44.9	0.0	0.0
Airport	0.0	0.0	80.0	0.0	0.0
Total :	41.5	68.7	458.1	22.6	58.1

2. DND

(Unit : Tk Million)

Infrastructure	External Flood			Internal Flood	
	Annual	1987	1988	Annual	Worst
Road / Bridge	0.0	0.0	13.2	6.0	7.6
Railway	0.0	0.0	0.0	0.0	0.0
Electricity	0.0	0.0	0.0	0.0	0.0
Telecom.	1.4	1.4	9.2	1.8	2.7
Water Supply	0.0	0.0	0.0	0.0	0.0
Sewer. / Drain.	0.0	0.0	0.0	0.0	0.0
Gas	0.0	0.0	0.0	0.0	0.0
Airport	0.0	0.0	0.0	0.0	0.0
Total :	1.4	1.4	22.4	7.8	10.3

TABLE B.26(2) DIRECT DAMAGES TO INFRASTRUCTURES (2/2)

3. Narayanganj West

(Unit : Tk Million)

Infrastructure	External Flood			Internal Flood	
	Annual	1987	1988	Annual	Worst
Road / Bridge	3.2	15.4	101.7	15.4	25.6
Railway	0.0	0.0	0.0	0.0	0.0
Electricity	0.0	0.0	1.4	0.0	0.0
Telecom.	2.3	2.1	25.4	3.7	6.3
Water Supply	0.0	0.0	0.0	0.0	0.0
Sewer. / Drain.	0.0	0.0	0.0	0.0	0.0
Gas	0.0	0.0	5.5	0.0	0.0
Airport	0.0	0.0	0.0	0.0	0.0
Total :	5.5	17.5	134.0	19.1	31.9

TABLE B.27 SALES LOSSES FOR PUBLIC ENTERPRISES

(Unit : Tk Million)

Area	Enterprises	External Flood			Internal Flood	
		Annual	1987	1988	Annual	Worst
Greater Dhaka East	PDB	1.5	2.0	3.0	0.6	1.0
	T & T	0.2	0.2	3.8	0.5	1.0
	Titas Gas	0.0	18.5	128.8	0.0	0.0
	CAA	0.0	0.0	7.7	0.0	0.0
	Total :	1.7	20.7	143.3	1.1	2.0
DND	T & T	0.0	0.0	0.3	0.0	0.1
Narayanganj West	T & T	0.1	0.0	0.7	0.1	0.1
	Titas Gas	0.0	3.8	25.8	0.0	0.0
	Total :	0.1	3.8	26.5	0.1	0.1

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Table B.28 Direct Damages to Infrastructures by Area by Year

(Unit : Tk. Million)

Year	Area	External Flood			Internal Flood	
		Annual	1987-Scale	1988-Scale	Annual	Worst
1990	Dhaka East - 1	2.5	4.1	27.5	1.4	3.5
	Dhaka East - 2	1.2	1.9	12.9	0.6	1.6
	Dhaka East - 3	19.1	31.6	210.3	10.4	26.7
	Dhaka East - 4	18.7	31.1	207.4	10.2	26.3
	Dhaka East (Sub-Total)	41.5	68.7	458.1	22.6	58.1
	Narayanganj DND	1.4	1.4	22.4	7.8	10.3
	Narayanganj West	5.5	17.5	134.0	19.1	31.9
	Total	48.4	87.6	614.5	49.5	100.3
2010	Dhaka East - 1	16.1	26.6	177.6	9.1	22.6
	Dhaka East - 2	9.2	14.5	98.0	4.6	12.2
	Dhaka East - 3	57.8	95.7	637.0	31.6	80.9
	Dhaka East - 4	50.6	84.3	561.9	27.6	71.2
	Dhaka East (Sub-Total)	133.7	221.1	1474.5	72.9	186.9
	Narayanganj DND	6.6	6.6	106.0	36.9	48.8
	Narayanganj West	17.4	55.3	422.8	60.3	100.7
	Total	157.7	283.0	2003.3	170.1	336.4

Source : JICA

Table B.29 Profit Losses for Public Enterprises by Area by Year

(Unit : Tk. Million)

Year	Area	External Flood			Internal Flood	
		Annual	1987-Scale	1988-Scale	Annual	Worst
1990	Dhaka East - 1	0.0	0.4	2.6	0.0	0.0
	Dhaka East - 2	0.0	0.2	1.2	0.0	0.0
	Dhaka East - 3	0.3	2.8	19.7	0.2	0.3
	Dhaka East - 4	0.2	2.8	19.5	0.1	0.3
	Dhaka East (Sub-Total)	0.5	6.2	43.0	0.3	0.6
	Narayanganj DND	0.0	0.0	0.1	0.0	0.0
	Narayanganj West	0.0	1.1	8.0	0.0	0.0
	Total	0.5	7.3	51.1	0.3	0.6
2010	Dhaka East - 1	0.0	2.6	16.8	0.0	0.0
	Dhaka East - 2	0.0	1.6	9.2	0.0	0.0
	Dhaka East - 3	1.0	8.5	59.7	0.6	1.0
	Dhaka East - 4	0.5	7.6	52.9	0.4	0.8
	Dhaka East (Sub-Total)	1.5	20.3	138.6	1.0	1.8
	Narayanganj DND	0.0	0.0	0.5	0.0	0.0
	Narayanganj West	0.0	3.6	25.3	0.0	0.0
	Total	1.5	23.9	164.4	1.0	1.8

Source : JICA

Table B.30 Summary of Flood Damages by External Floods

Prop. = Property damages, Tra. = Traffic damages, Inf. = Infrastructure damages, Prof. = Profit loss for public enterprises, Oth. = Other damages

(Unit : Tk. Million)

Area	Annual Flood						1987-Scale Flood						1988-Scale Flood					
	Prop.	Tra.	Inf.	Prof.	Oth.	Total	Prop.	Tra.	Inf.	Prof.	Oth.	Total	Prop.	Tra.	Inf.	Prof.	Oth.	Total
1. 1990																		
DC - 1	0.0	0.0	2.5	0.0	0.3	2.8	72.5	4.6	4.1	0.4	8.2	89.8	226.9	9.8	27.5	2.6	26.7	293.5
DC - 2	0.0	0.0	1.2	0.0	0.1	1.3	44.9	1.7	1.9	0.2	4.9	53.6	194.9	3.5	12.9	1.2	21.3	233.8
DC - 3	0.0	0.0	19.1	0.3	1.9	21.3	124.0	41.2	31.6	2.8	20.0	219.6	829.1	89.4	210.3	19.7	114.9	1,263.4
DC - 4	0.0	0.0	18.7	0.2	1.9	20.8	251.6	39.1	31.1	2.8	32.5	357.1	1,835.1	84.5	207.4	19.5	214.7	2,361.2
Dhaka East	0.0	0.0	41.5	0.5	4.2	46.2	493.0	86.6	68.7	6.2	65.6	720.1	3,086.0	187.2	458.1	43.0	377.6	4,151.9
Nara. DND	0.0	0.0	1.4	0.0	0.1	1.5	142.9	22.0	1.4	0.0	16.6	182.9	1,864.1	47.4	22.4	0.1	193.4	2,127.4
Nara. West	0.0	0.0	5.5	0.0	0.6	6.1	75.5	23.2	17.5	1.1	11.7	129.0	1,310.8	50.5	134.0	8.0	150.3	1,653.6
Total	0.0	0.0	48.4	0.5	4.9	53.8	711.4	131.8	87.6	7.3	93.9	1,032.0	6,260.9	285.1	614.5	51.1	721.3	7,932.9
1. 2010																		
DC - 1	52.8	0.0	16.1	0.0	6.9	75.8	1,233.8	24.2	26.6	2.6	128.7	1,415.9	2,951.9	50.7	177.6	16.8	319.7	3,516.7
DC - 2	21.5	0.0	9.2	0.0	3.1	33.8	263.9	13.5	14.5	1.6	29.4	322.9	1,159.8	28.3	98.4	9.2	129.6	1,425.3
DC - 3	32.1	0.0	57.8	1.0	9.1	100.0	562.4	118.0	95.7	8.5	78.5	863.1	3,363.1	255.1	637.0	59.7	431.5	4,746.4
DC - 4	51.2	0.0	50.6	0.5	10.2	112.5	824.5	100.8	84.3	7.6	101.7	1,118.9	5,520.9	217.0	561.9	52.9	635.3	6,988.0
Dhaka East	157.6	0.0	133.7	1.5	29.3	322.1	2,884.6	256.5	221.1	20.3	338.3	3,720.8	12,995.7	551.1	1,474.9	138.6	1,516.1	16,676.4
Nara. DND	7.1	0.0	6.6	0.0	1.4	15.1	518.8	102.2	6.6	0.0	62.8	690.4	8,530.8	220.5	106.0	0.5	885.8	9,743.6
Nara. West	6.1	0.0	17.4	0.0	2.4	25.9	229.4	71.4	55.3	3.6	36.0	395.7	5,678.1	155.1	422.8	25.3	628.1	6,909.4
Total	170.8	0.0	157.7	1.5	33.1	363.1	3,632.8	430.1	283.0	23.9	437.1	4,806.9	27,204.6	926.7	2,003.7	164.4	3,030.0	33,329.4

Source : JICA

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Table B.31 Summary of Flood Damages by Internal Floods

Prop. = Property damages, Tra. = Traffic damages, Inf. = Infrastructure damages, Prof. = Profit loss for public enterprises, Oth. = Other damages

(Unit : Tk. Million)

Area	Annual Flood						Worst Flood					
	Prop.	Tra.	Inf.	Prof.	Oth.	Total	Prop.	Tra.	Inf.	Prof.	Oth.	Total
1. 1990												
DC - 1	0.2	0.0	1.4	0.0	0.2	1.8	0.4	2.2	3.5	0.0	0.6	6.7
DC - 2	0.0	0.0	0.6	0.0	0.1	0.7	0.0	0.9	1.6	0.0	0.3	2.8
DC - 3	49.9	0.0	10.4	0.2	6.1	66.6	106.2	18.6	26.7	0.3	15.2	167.0
DC - 4	70.9	0.0	10.2	0.1	8.1	89.3	150.7	17.8	26.3	0.3	19.5	214.6
												0.0
Dhaka East	121.0	0.0	22.6	0.3	14.5	158.4	257.3	39.5	58.1	0.6	35.6	391.1
Nara. DND	27.3	0.0	7.8	0.0	3.5	38.6	43.4	10.1	10.3	0.0	6.4	70.2
Nara. West	0.8	0.0	19.1	0.0	2.0	21.9	9.9	10.3	31.9	0.0	5.2	57.3
Total	149.1	0.0	49.5	0.3	20.0	218.9	310.6	59.9	100.3	0.6	47.2	518.6
1. 2010												
DC - 1	0.0	0.0	9.1	0.0	0.9	10.0	0.1	12.3	22.6	0.0	3.5	38.5
DC - 2	0.0	0.0	4.6	0.0	0.5	5.1	0.0	6.9	12.2	0.0	1.9	21.0
DC - 3	85.0	0.0	31.6	0.6	11.7	128.9	178.2	54.0	80.9	1.0	31.4	345.5
DC - 4	100.9	0.0	27.6	0.4	12.9	141.8	211.6	46.6	71.2	0.8	33.0	363.2
Dhaka East	185.9	0.0	72.9	1.0	26.0	285.8	389.9	119.8	186.9	1.8	69.8	768.2
Nara. DND	109.1	0.0	36.9	0.0	14.6	160.6	171.0	47.0	48.8	0.0	26.7	293.5
Nara. West	2.0	0.0	60.3	0.0	6.2	68.5	24.4	32.0	100.7	0.0	15.7	172.8
Total	297.0	0.0	170.1	1.0	46.8	514.9	585.3	198.8	336.4	1.8	112.2	1,234.5

Source : JICA

Table B.32 Average Annual Flood Damages by Area by Year

(Unit : Tk. Million)

Area	Average Annual Flood Damages		
	External Flood	Internal Flood	Total
1. 1990			
Dhaka East - 1	40.7	2.5	43.2
Dhaka East - 2	25.4	1.0	26.4
Dhaka East - 3	121.0	74.1	195.1
Dhaka East - 4	195.5	97.5	293.0
Dhaka East (Sub-Total)	382.6	175.1	557.7
Narayanganj DND	116.0	37.4	153.4
Narayanganj West	88.5	24.9	113.4
Total	587.1	237.4	824.5
2. 2010			
Dhaka East - 1	634.5	13.9	648.4
Dhaka East - 2	169.3	7.4	176.7
Dhaka East - 3	480.4	148.1	628.5
Dhaka East - 4	631.9	159.4	791.3
Dhaka East (Sub-Total)	1,916.1	328.8	2,244.9
Narayanganj DND	483.8	156.1	639.9
Narayanganj West	318.8	76.5	395.3
Total	2,718.7	561.4	3,280.1

Source : JICA

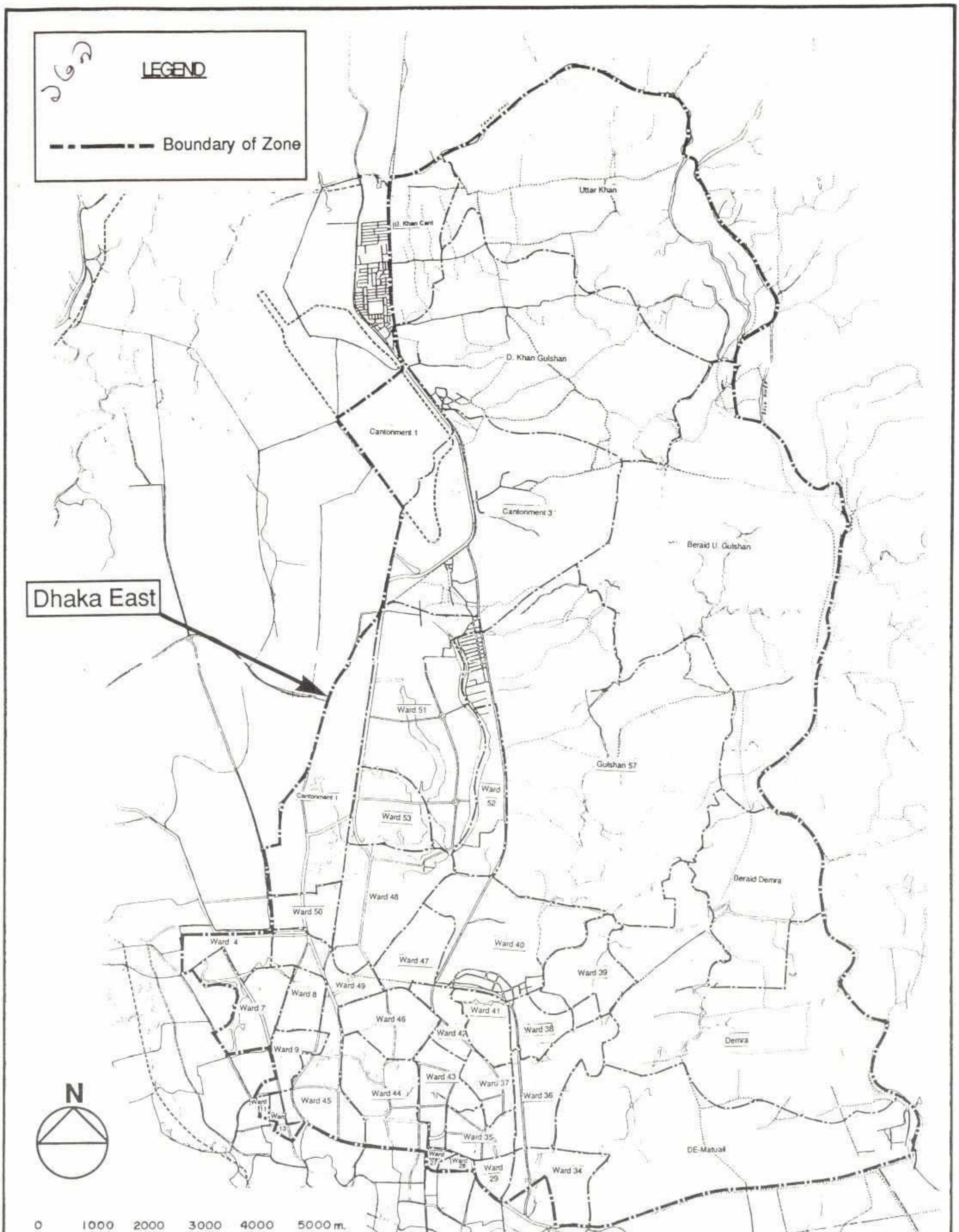

FIG. B.1 DIVISION OF STUDY AREA BY ZONE : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

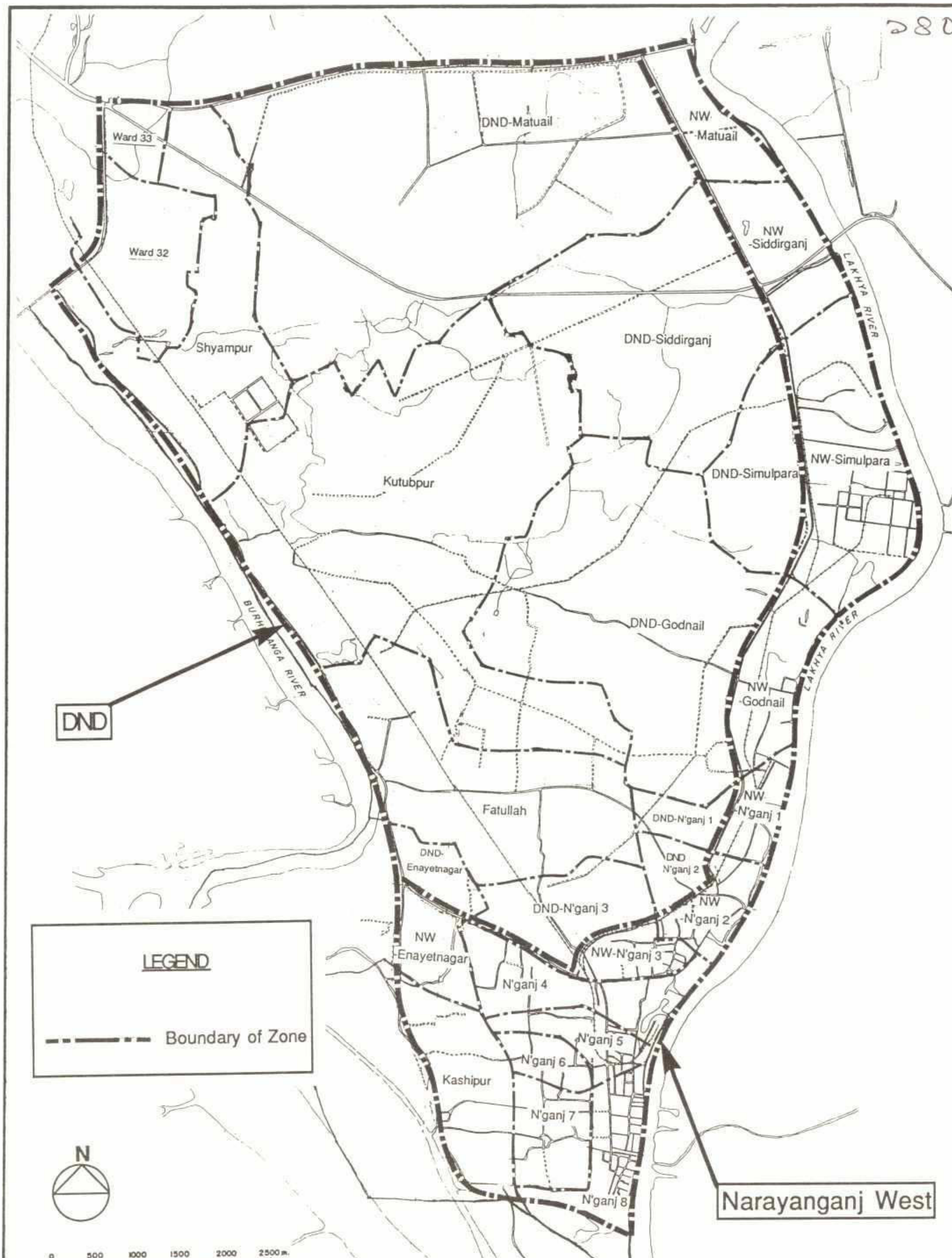

FIG. B.2	DIVISION OF STUDY AREA BY ZONE : DND, NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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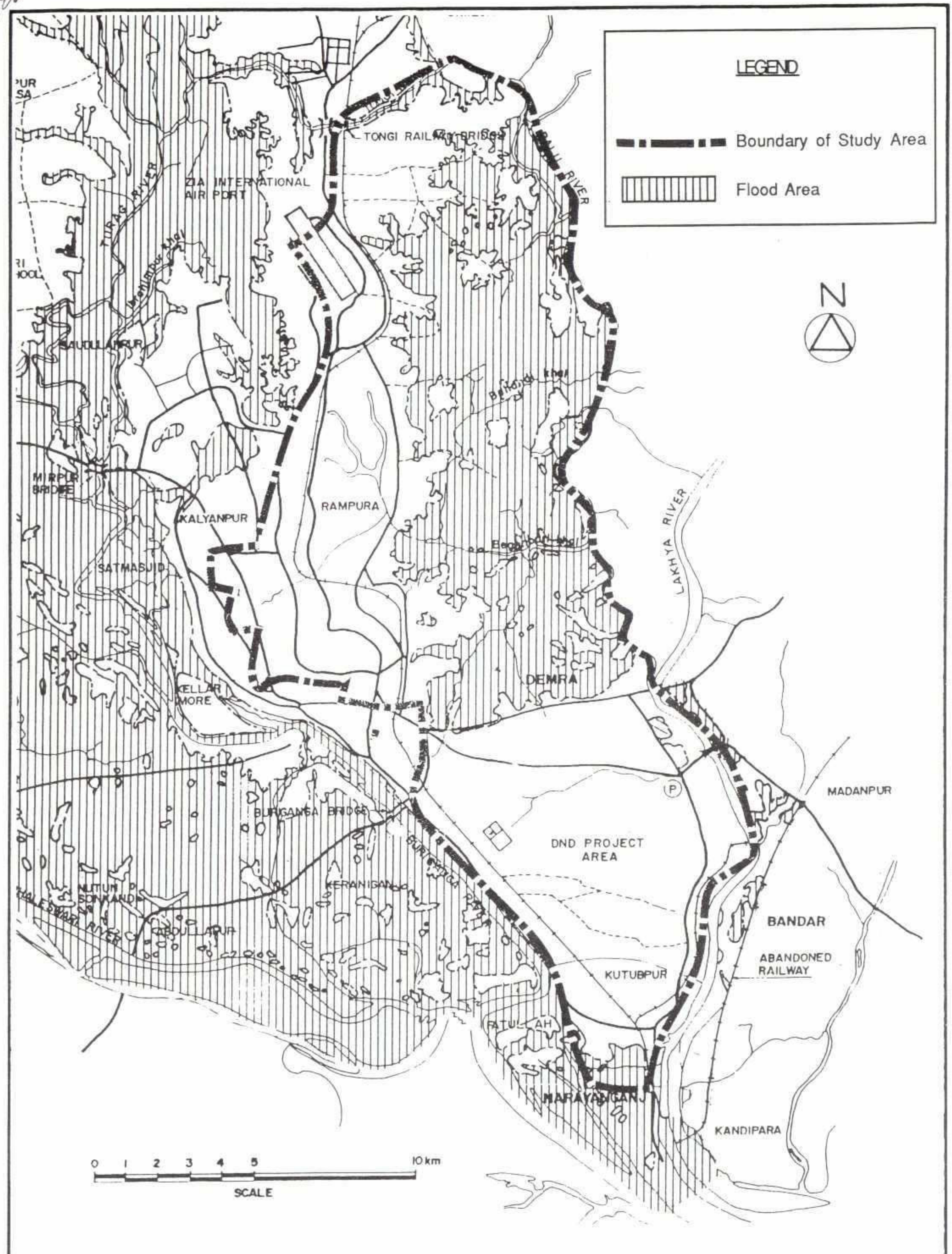

FIG. B.3 EXTERNAL FLOOD MAP : ANNUAL FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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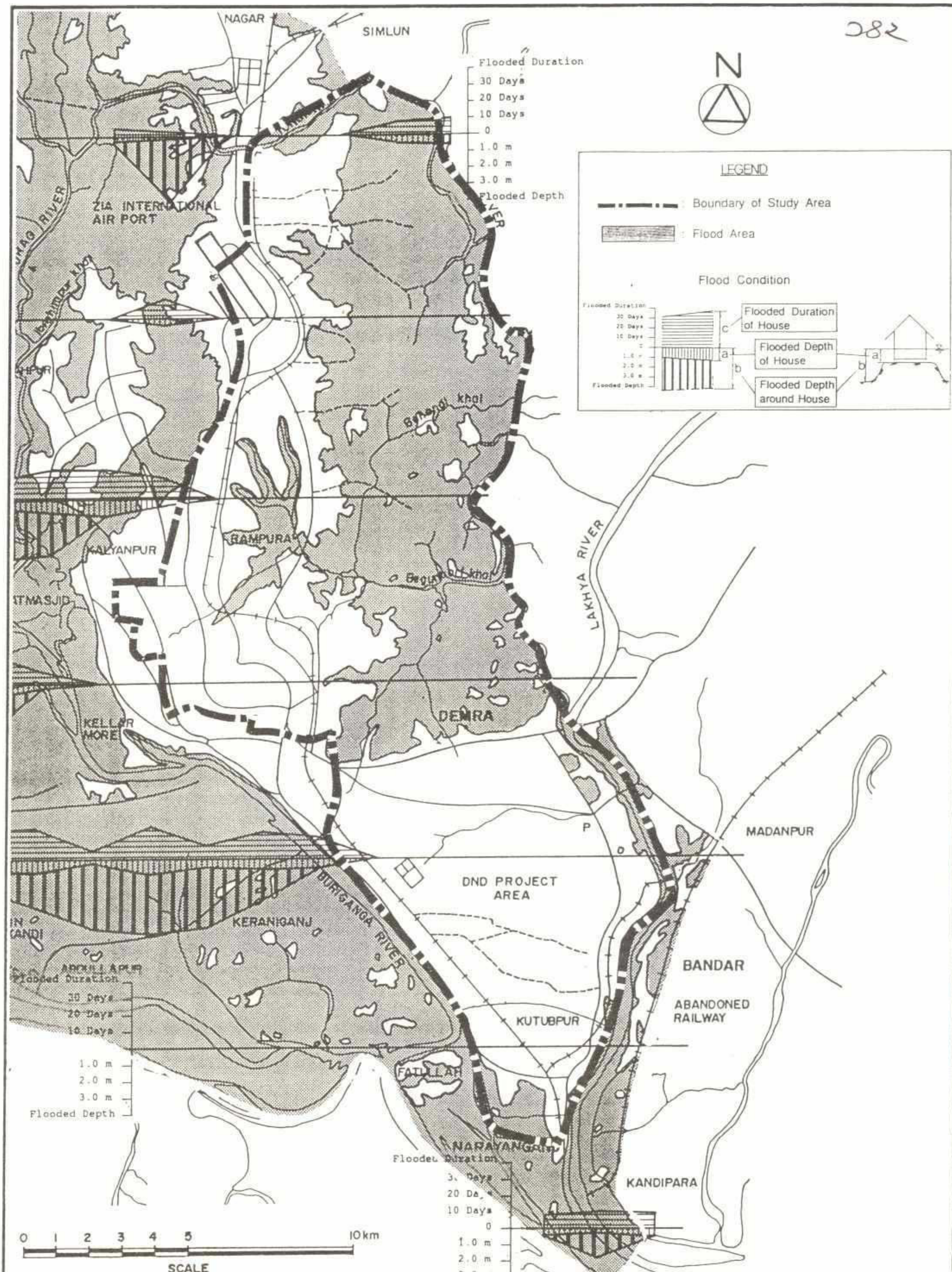

FIG. B.4 EXTERNAL FLOOD MAP : 1987 FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

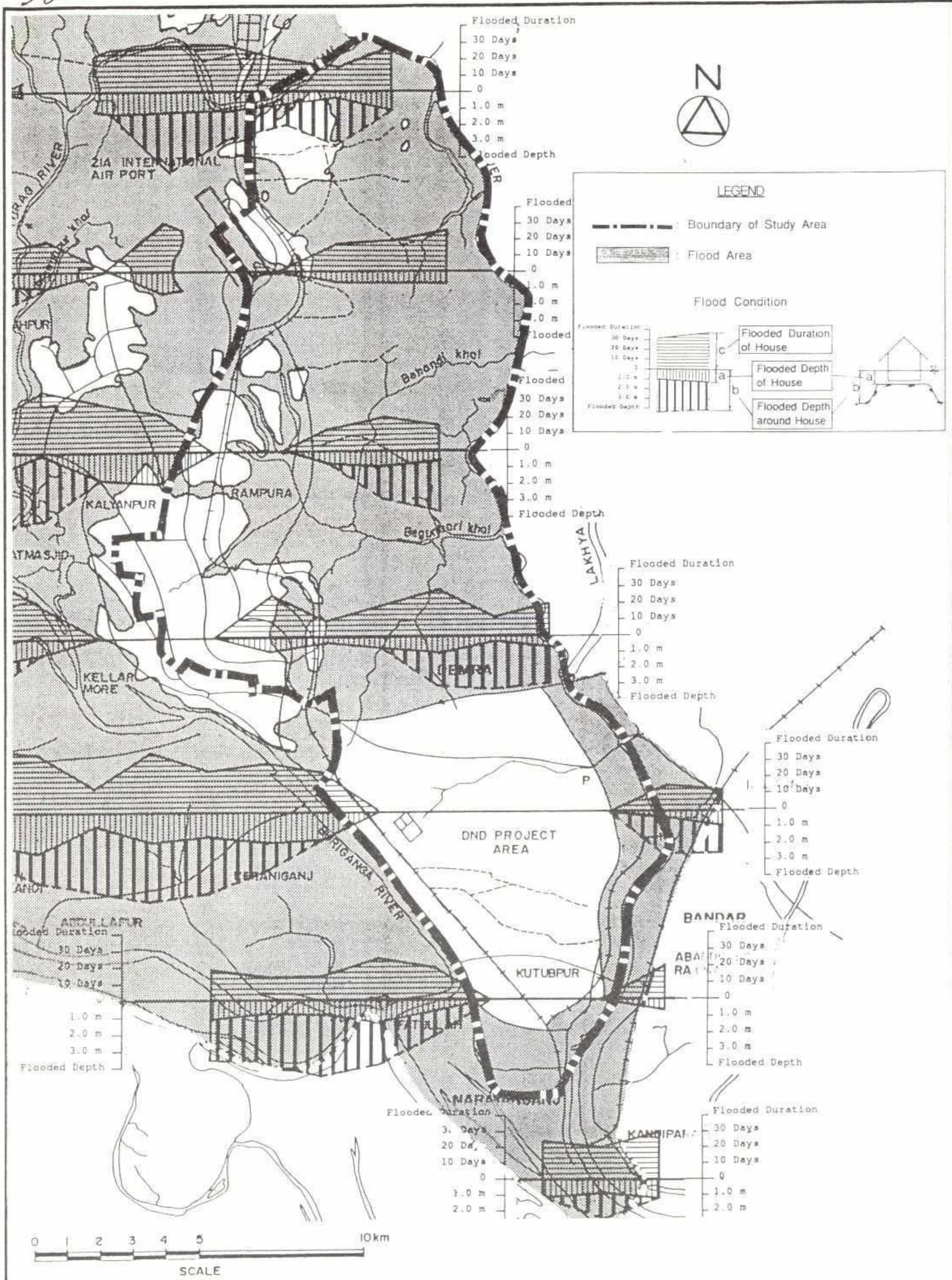

FIG. B.5 EXTERNAL FLOOD MAP : 1988 FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

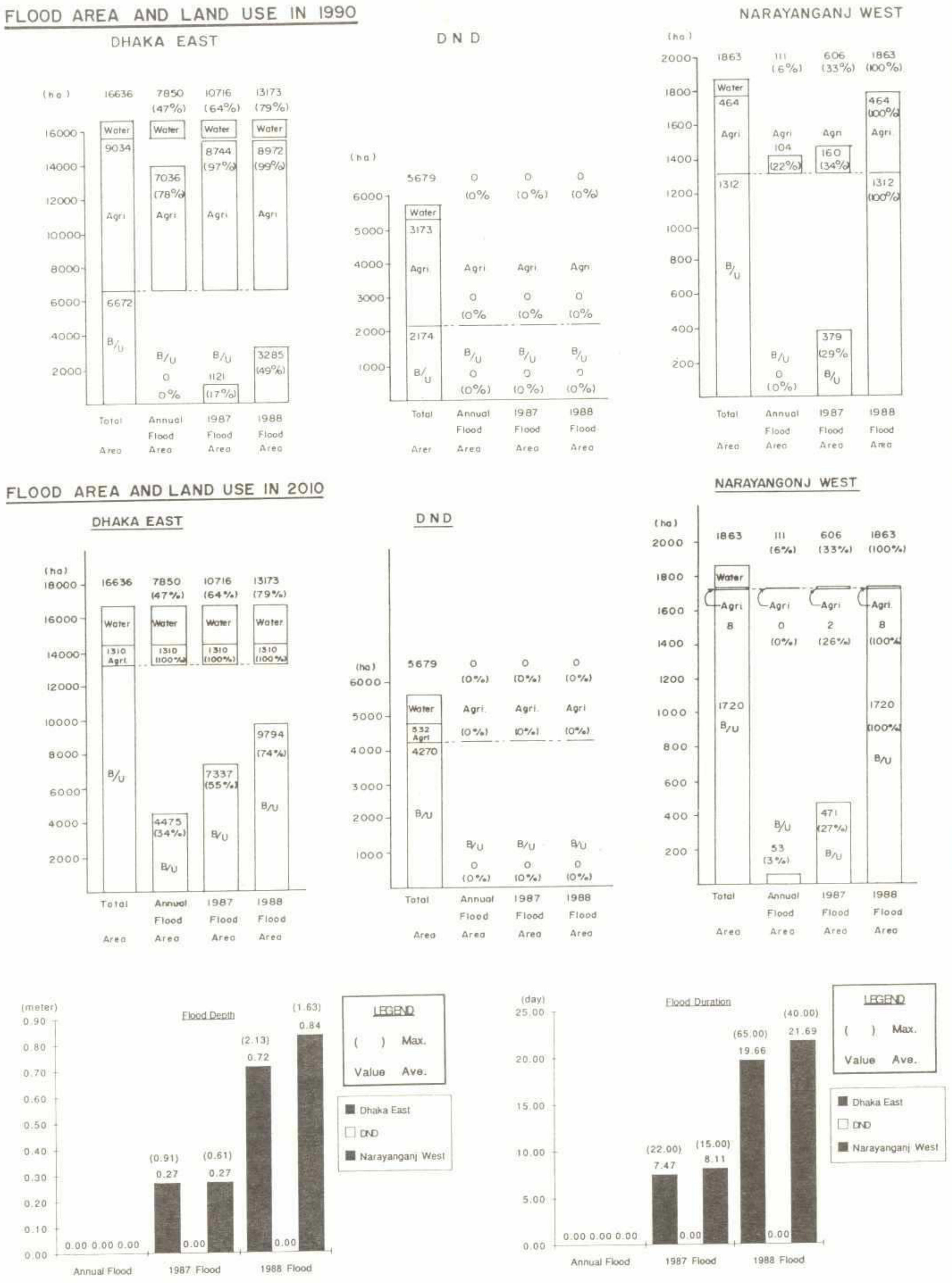

FIG. B.6 EXTERNAL FLOOD CONDITIONS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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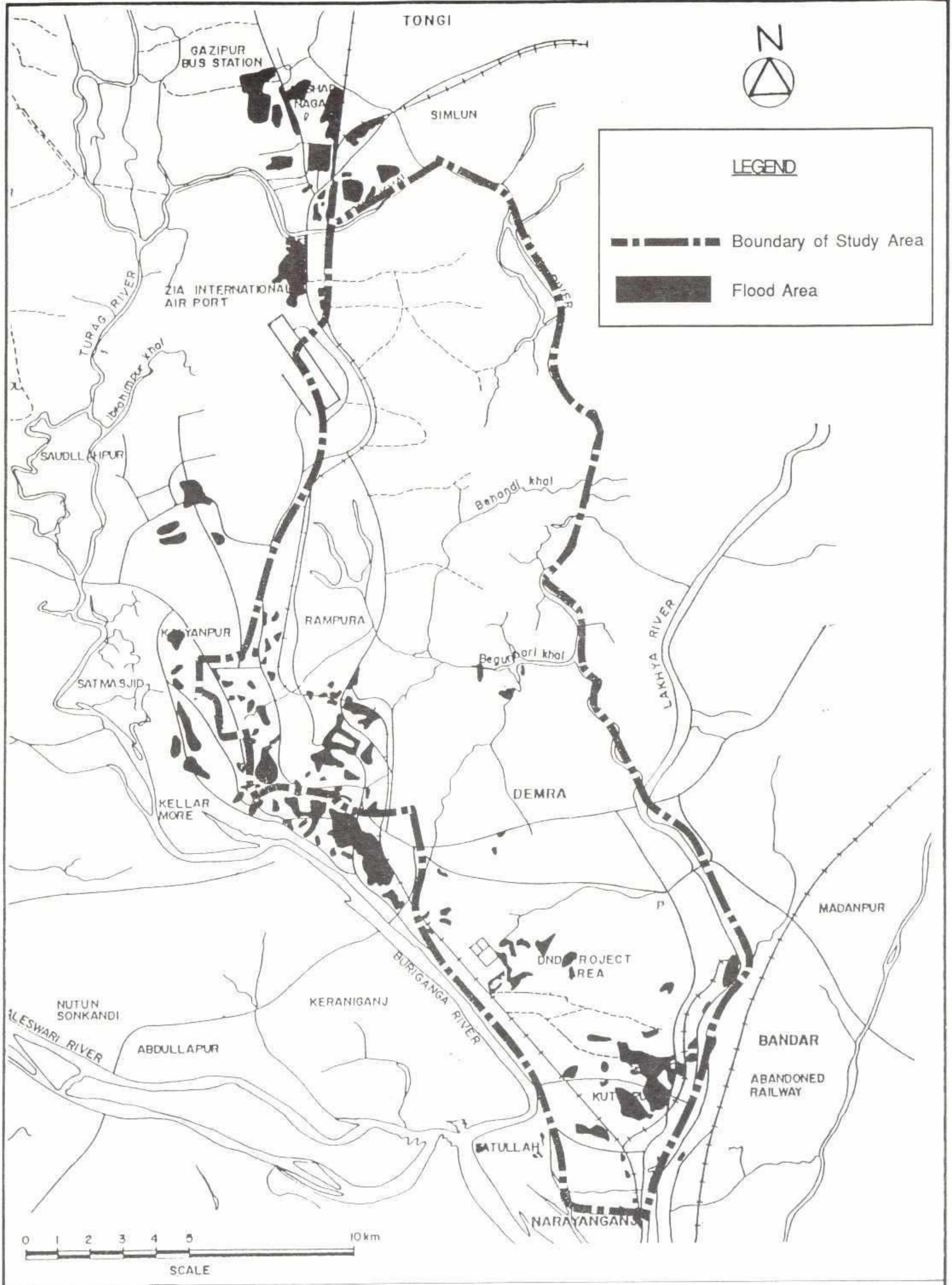

FIG. B.7 INTERNAL FLOOD MAP

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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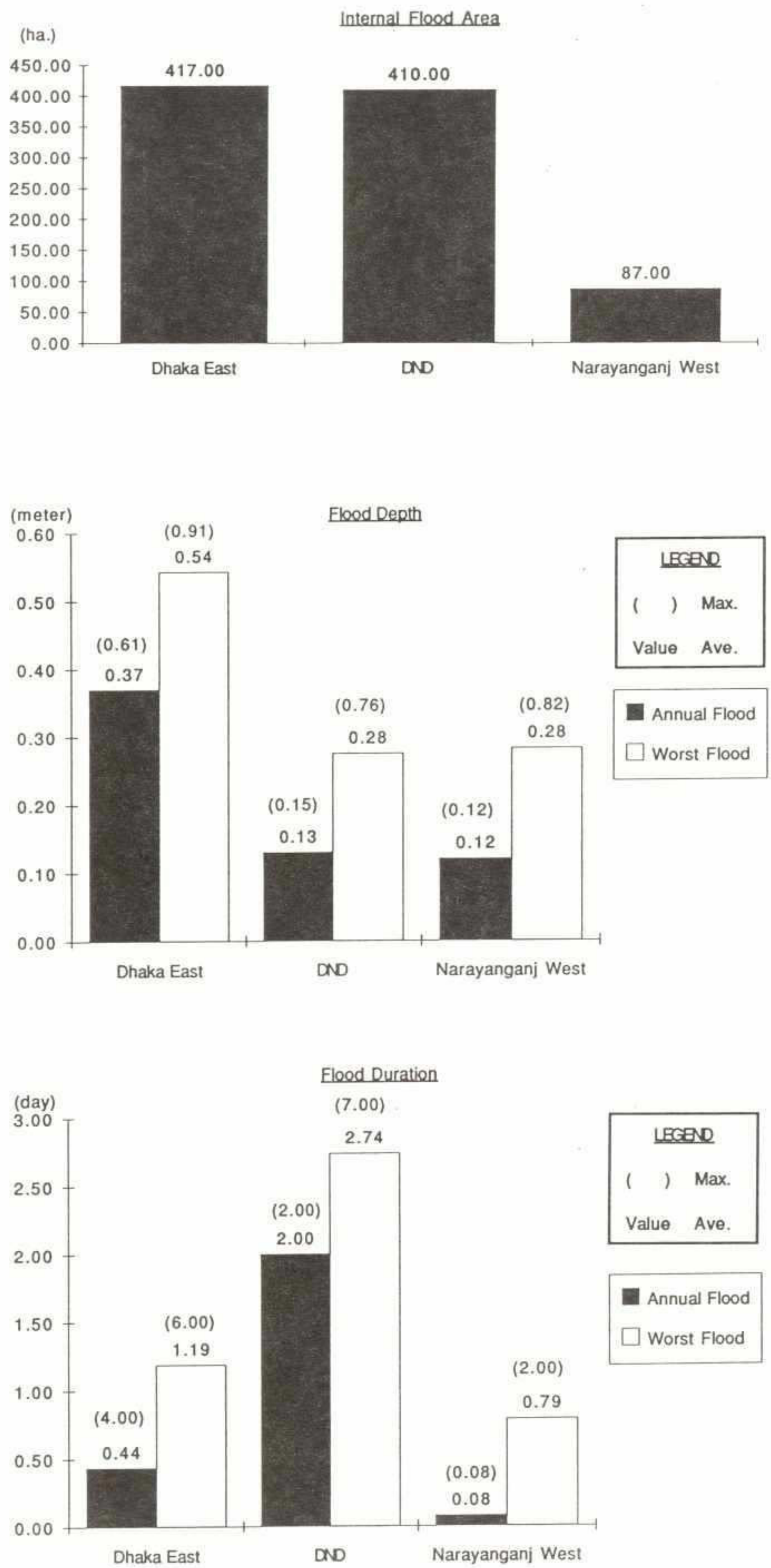

FIG. B.8 INTERNAL FLOOD CONDITIONS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

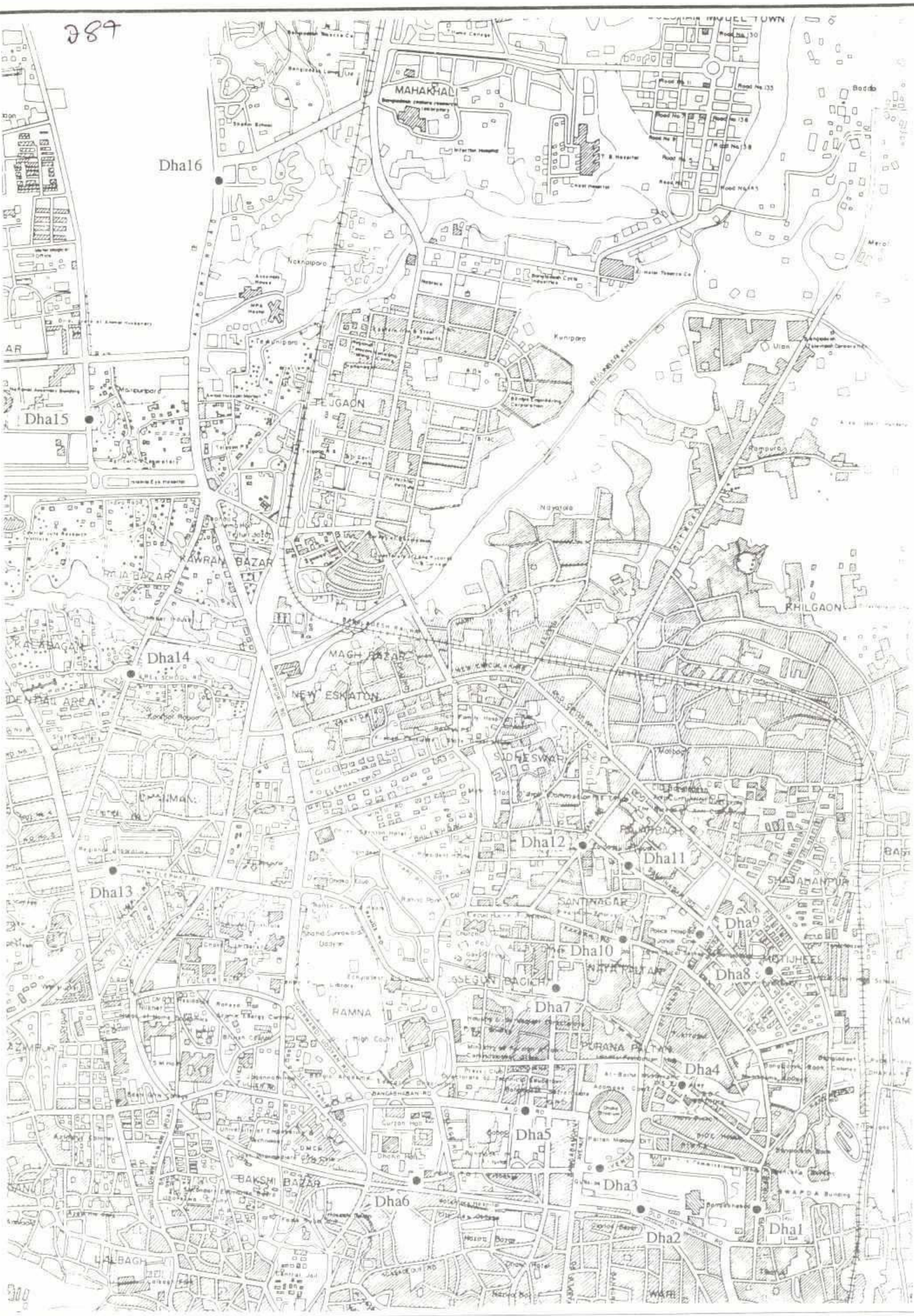

FIG. B.9 TRAFFIC SURVEY POINTS FOR INTERNAL FLOOD : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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FIG. B.10 TRAFFIC SURVEY POINTS FOR INTERNAL FLOOD : NARAYANGANJ

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

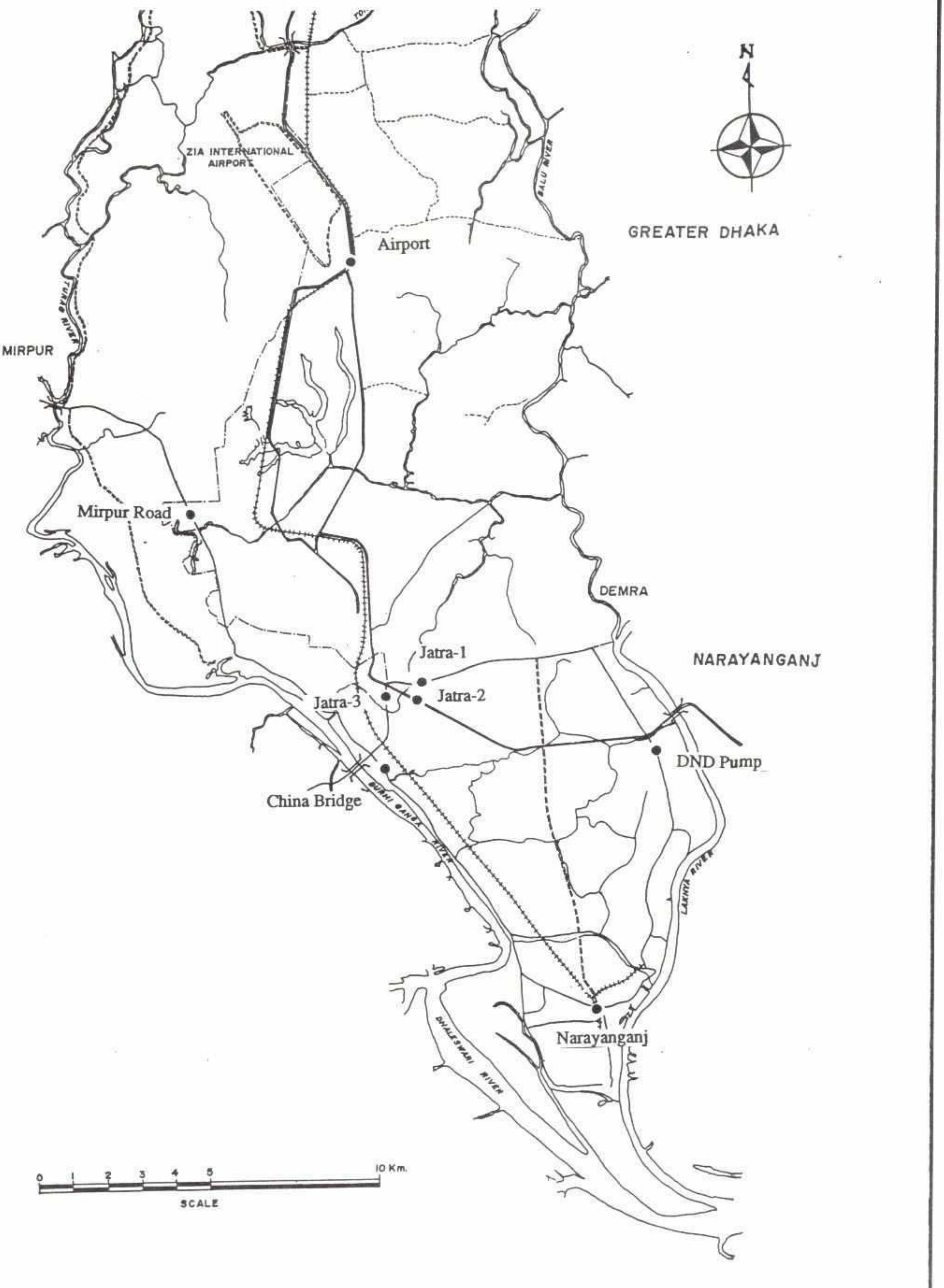

FIG. B.11 TRAFFIC SURVEY POINTS FOR EXTERNAL FLOOD

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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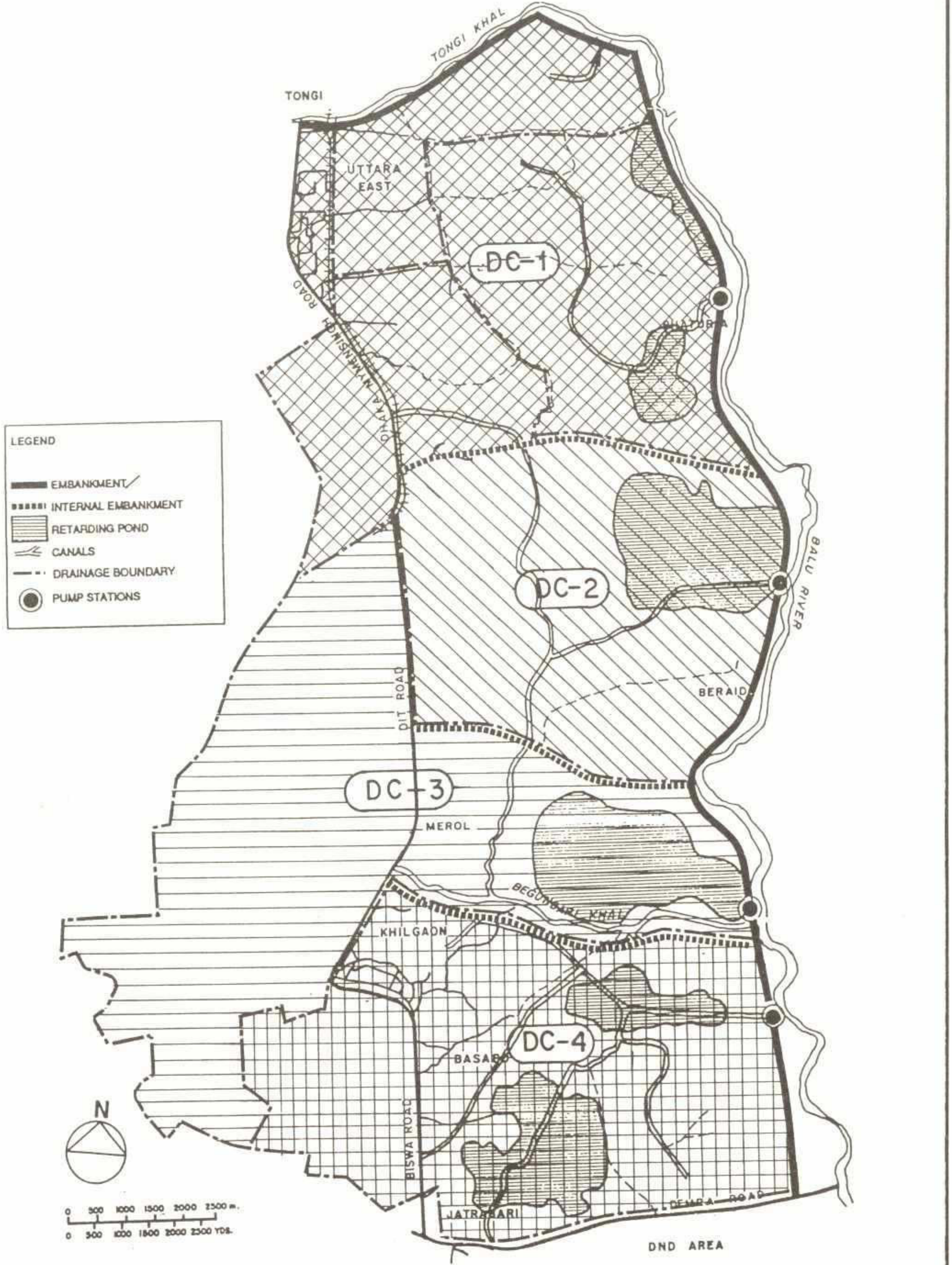

FIG. B.12 COMPARTMENTALIZATION OF GREATER DHAKA EAST FOR ECONOMIC EVALUATION

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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ANNEXES

ANNEX 1. CALCULATIVE STEPS LEADING TO ESTIMATION OF NUMBER OF INUNDATED PROPERTIES AND RESIDENTIAL DAMAGES BY A 1987-SCALE FLOOD IN GREATER DHAKA EAST

1. Estimation of Number of Inundated Properties

1) The number of houses, businesses, industries and institutions in Greater Dhaka East for 1990 was estimated by Zone based on Population Census 1981. The number for 2010 was estimated based on Zone-wise population growth forecasts from 1990 to 2010. (Refer to Tables A1.1, A1.2 and A1.3.)

2) The number of the above four types of properties to have been inundated due to a 1987-scale flood in 1990 was estimated by multiplying the number of houses in each Zone in 1990 by the inundation ratio in the built-up areas in each Zone in 1990 due to the 1987-scale flood. (Refer to Table A1.2, Table B.1(1) and Table A1.4.)

   The number of properties to be inundated in 2010 due to a 1987-scale flood was estimated in the same way. (Refer to Table A1.3, Table B.1(1) and Table A1.5.)

2. Estimation of Residential Damages

1) Flood damage ratios for residential building(s) and household effects per household and income loss ratio per household in a 1987-scale flood were estimated by using multiple regression equations determining the relationships between the depth/duration of inundation and flood damage ratios or income loss ratio in a 1987-scale flood, and the depth/duration of inundation in each Zone in a 1987-scale flood. (Refer to Table E.10(1) of the Master Plan Supporting Report I and Table B.2.)

2) The average values of residential building(s) and household effects per household and the average annual income per household for 1990 were estimated as a result of the sampling questionnaire survey. (Refer to Table B.4(1) 3. and Table E.12(1) of the Master Plan Supporting Report I.)

   The average values of residential building(s) and household effects per household and the average annual income per household for 2010 were estimated on the assumption that the above values and income will increase in parallel with the growth of per capita GDP in the Study Area.

   In the Fourth Five Year Plan 1990 to 1995 the government of Bangladesh worked out the 5% annual economic growth for the whole country. According to the Statistical

Yearbook of Bangladesh 1990 the annual population growth in Bangladesh during the same period is estimated at 2.26% (refer to Table B.1(1) of the Master Plan Supporting Report I). It follows from the above that the annual per capita economic growth of 2.68% is planned for the country during 1990 to 1995.

Against this background, the average annual economic growth of 7% and 6.5% against the average annual Study Area population growth of 3.99% was assumed from 1990 to 2010 for the two northern compartments (DC-1 and DC-2) and the two southern compartments (DC-3 and DC-4), respectively. That is to say, the annual per capita economic growth of 2.89% and 2.41% was assumed for the northern and southern compartments, respectively.

The reason the per capita economic growth is higher in the two northern compartments than in the two southern compartments is that the people who will move and settle in the newly developed areas in the northern compartments were assumed to be richer on average.

3) Multiplying 1) by 2), and then multiplying the results by the number of inundated houses we get flood damages to residential buildings and household effects and household income losses in Greater Dhaka East due to a 1987-scale flood in 1990 and 2010. (Refer to Tables A1.6, A1.7, A1.8 and A1.9.)

Table A1.1 Population by Zone in Greater Dhaka East in 1990 and 2010

No.	Name of Zones	1990	2010
1	4	49,956	71,741
2	7	55,084	141,718
3	8	44,959	77,131
4	9	45,481	50,421
5	11	27,216	23,427
6	13	33,750	51,302
7	27	54,566	21,775
8	28	47,311	34,540
9	29	42,051	52,269
10	34	103,587	156,361
11	35	60,656	94,928
12	36	74,394	125,507
13	37	45,280	65,717
14	38	58,125	85,494
15	39	109,560	134,871
16	40	81,722	214,717
17	41	59,402	87,403
18	42	62,963	62,565
19	43	48,913	73,851
20	44	64,399	111,226
21	45	52,698	94,231
22	46	64,258	94,038
23	47	93,935	109,208
24	48	114,062	171,764
25	49	34,857	71,863
26	50	65,956	48,061
27	51	66,843	160,066
28	52	70,388	105,367
29	53	56,766	84,665
30	Gulshan 57	57,177	331,265
31	Cantonment Ward-1	79,283	115,296
32	Cantonment Ward-3	29,655	234,795
33	Dakshin Khan Cantt.	40,515	97,025
34	Uttar Khan	23,111	292,073
35	Dakshin Khan Gulshan	48,824	302,466
36	Beraid Gulshan	15,627	93,927
37	Beraid Demra	8,121	15,197
38	Demra	50,131	114,438
39	Matuail Dhaka	8,304	197,390
	Greater Dhaka East	2,149,886	4,470,099

Table A1.2 No. of Properties by Zone by Type of Properties in Greater Dhaka East in 1990

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	8,370	355	5	272
2	7	7,822	198	0	751
3	8	7,204	196	8	403
4	9	6,524	511	0	545
5	11	4,271	130	0	51
6	13	4,932	220	0	185
7	27	8,208	862	4	257
8	28	7,218	364	33	241
9	29	6,812	301	30	293
10	34	20,511	521	13	1,933
11	35	9,940	635	0	539
12	36	13,071	387	0	193
13	37	5,345	157	0	85
14	38	10,523	528	0	133
15	39	19,676	447	0	447
16	40	7,055	224	0	182
17	41	9,149	155	0	147
18	42	9,580	637	0	810
19	43	7,066	534	0	499
20	44	7,998	490	142	1,098
21	45	6,698	166	0	1,757
22	46	9,827	232	147	372
23	47	14,746	667	0	565
24	48	18,878	154	1,111	1,951
25	49	4,764	875	0	62
26	50	9,594	779	0	430
27	51	11,862	449	0	1,007
28	52	12,754	328	0	300
29	53	9,847	501	4	715
30	Gulshan 57	9,382	18	0	53
31	Cantonment Ward-1	14,092	797	0	1,654
32	Cantonment Ward-3	5,133	168	0	110
33	Dakshin Khan Cantt.	7,240	411	0	851
34	Uttar Khan	3,823	1	0	6
35	Dakshin Khan Gulshan	8,117	226	0	29
36	Beraid Gulshan	2,665	2	0	5
37	Beraid Demra	1,193	13	0	5
38	Demra	8,301	165	0	396
39	Matuail Dhaka	1,485	48	1	164
	Greater Dhaka East	341,673	13,851	1,499	19,497

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Table A1.3 No. of Properties by Zone by Type of Properties in Greater Dhaka East in 2010

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	12,020	509	8	390
2	7	20,124	509	0	1,932
3	8	12,360	336	13	691
4	9	7,233	566	0	604
5	11	3,676	112	0	44
6	13	7,496	334	0	282
7	27	3,276	344	2	102
8	28	5,270	266	24	176
9	29	8,468	374	37	364
10	34	30,961	787	19	2,918
11	35	15,556	993	0	843
12	36	22,052	653	0	325
13	37	7,758	228	0	124
14	38	15,478	777	0	196
15	39	24,221	550	0	550
16	40	18,536	588	0	478
17	41	13,461	228	0	217
18	42	9,519	633	0	805
19	43	10,668	807	0	754
20	44	13,813	846	245	1,897
21	45	11,976	297	0	3,141
22	46	14,381	340	216	545
23	47	17,143	775	0	657
24	48	28,428	232	1,673	2,938
25	49	9,821	1,805	0	127
26	50	6,991	568	0	313
27	51	28,405	1,075	0	2,410
28	52	19,092	491	0	450
29	53	14,686	747	6	1,066
30	Gulshan 57	54,358	103	0	308
31	Cantonment Ward-1	20,493	1,159	0	2,406
32	Cantonment Ward-3	40,638	1,327	0	871
33	Dakshin Khan Cantt.	17,337	985	0	2,038
34	Uttar Khan	48,315	16	0	81
35	Dakshin Khan Gulshan	50,286	1,398	0	182
36	Beraid Gulshan	16,021	11	0	32
37	Beraid Demra	2,232	25	0	9
38	Demra	18,949	377	0	904
39	Matuail Dhaka	35,288	1,136	26	3,909
	Greater Dhaka East	716,785	23,306	2,269	36,079

Table A1.4 No. of Properties in Inundation Areas by Zone by Type of Properties in 1990 (1987-Scale Flood)

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	0	0	0	0
2	7	0	0	0	0
3	8	0	0	0	0
4	9	0	0	0	0
5	11	0	0	0	0
6	13	0	0	0	0
7	27	0	0	0	0
8	28	0	0	0	0
9	29	0	0	0	0
10	34	10,051	255	6	947
11	35	0	0	0	0
12	36	1,176	35	0	17
13	37	0	0	0	0
14	38	947	48	0	12
15	39	12,592	286	0	286
16	40	2,046	65	0	53
17	41	0	0	0	0
18	42	0	0	0	0
19	43	0	0	0	0
20	44	0	0	0	0
21	45	0	0	0	0
22	46	0	0	0	0
23	47	1,180	53	0	45
24	48	5,286	43	311	546
25	49	333	61	0	4
26	50	192	16	0	9
27	51	3,321	126	0	282
28	52	7,780	200	0	183
29	53	4,136	210	2	300
30	Gulshan 57	0	0	0	0
31	Cantonment Ward-1	705	40	0	83
32	Cantonment Ward-3	0	0	0	0
33	Dakshin Khan Cantt.	0	0	0	0
34	Uttar Khan	0	0	0	0
35	Dakshin Khan Gulshan	3,328	93	0	12
36	Beraid Gulshan	1,466	1	0	3
37	Beraid Demra	1,193	13	0	5
38	Demra	5,644	112	0	269
39	Matuail Dhaka	0	0	0	0
	Greater Dhaka East	61,376	1,657	319	3,057

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Table A1.5 No. of Properties in Inundation Areas by Zone by Type of Properties in 2010 (1987-Scale Flood)

(Unit: Number)

No.	Name of Zones	House	Business	Industry	Institution
1	4	0	0	0	0
2	7	0	0	0	0
3	8	0	0	0	0
4	9	0	0	0	0
5	11	0	0	0	0
6	13	0	0	0	0
7	27	0	0	0	0
8	28	0	0	0	0
9	29	0	0	0	0
10	34	18,886	480	12	1,780
11	35	0	0	0	0
12	36	4,852	144	0	71
13	37	0	0	0	0
14	38	2,322	117	0	29
15	39	16,955	385	0	385
16	40	9,639	306	0	248
17	41	0	0	0	0
18	42	0	0	0	0
19	43	0	0	0	0
20	44	0	0	0	0
21	45	0	0	0	0
22	46	0	0	0	0
23	47	2,571	116	0	98
24	48	7,960	65	468	823
25	49	491	90	0	6
26	50	140	11	0	6
27	51	8,237	312	0	699
28	52	12,983	334	0	306
29	53	7,049	359	3	512
30	Gulshan 57	47,835	90	0	271
31	Cantonment Ward-1	1,639	93	0	192
32	Cantonment Ward-3	20,319	663	0	436
33	Dakshin Khan Cantt.	1,734	99	0	204
34	Uttar Khan	36,236	12	0	61
35	Dakshin Khan Gulshan	43,246	1,202	0	156
36	Beraid Gulshan	15,059	10	0	30
37	Beraid Demra	2,232	25	0	9
38	Demra	17,812	354	0	850
39	Matuail Dhaka	25,760	829	19	2,853
	Greater Dhaka East	303,957	6,096	502	10,027

Table A1.6 Formulas for Estimation of Flood Damages to Houses by 1987-Scale Flood in 1990

1. H19BDDM(i)=H19P(2,i)*(HAV(1,1)*RT1+HAV(1,2)*RT2+HAV(1,3)*RT3)*(H87A(1)+H87B1(1)*DP(2,i)+H87B2(1)*DR(2,i))/100/1000000

where,

H19BDDM(i): Direct flood damages to house building(s) (Tk. million) by 1987-scale flood for Zone No. i in 1990

H19P(2,i): No. of houses in inundation areas by 1987-scale flood for Zone No. i in 1990

HAV(1,1)(=33216), HAV(1,2)(=167767), HAV(1,3)(=377182): Value (Tk.) of house building(s) for Low, Middle and High Classes

RT1(=.6), RT2 (=.37), RT3 (=.03): Composition of No. of households for Low, Middle and High Classes

H87A(1)(=-6.482), H87B1(1)(=2.093), H87B2(1)(=1.182): Coefficients of regression equation for house building

DP(2,i): Depth of inundation (m) for Zone No.i by 1987-scale flood
DR(2,i): Duration of inundation (days) for Zone No.i by 1987-scale flood

2. H19HEDM(i)=H19P(2,i)*(HAV(2,1)*RT1+HAV(2,2)*RT2+HAV(2,3)*RT3)*(H87A(2)+H87B1(2)*DP(2,i)+H87B2(2)*DR(2,i))/100/1000000

where,

H19HEDM(i): Direct flood damages to household effects (Tk. million) by 1987-scale flood for Zone No. i in 1990

HAV(2,1)(=9429), HAV(2,2)(=37802), HAV(2,3)(=158998): Value (Tk.) of household effects for Low, Middle and High Classes

H87A(2)(=-4.638), H87B1(2)(=5.521), H87B2(2)(=.312): Coefficients of regression equation for household effects

3. H19ICDM(i)=H19P(2,i)*(HAV(3,1)*RT1+HAV(3,2)*RT2+HAV(3,3)*RT3)*(H87A(3)+H87B1(3)*DP(2,i)+H87B2(3)*DR(2,i))/100/1000000

where,

H19ICDM(i): Income losses (Tk. million) by 1987-scale flood for Zone No. i in 1990

HAV(3,1)(=21754), HAV(3,2)(=56703), HAV(3,3)(=217810): Annual household income (Tk.) for Low, Middle and High Classes

H87A(3)(=1.383), H87B1(3)(=.157), H87B2(3)(=.185): Coefficients of regression equation for household income

Table A1.7 Formulas for Estimation of Flood Damages to Houses
by 1987-Scale Flood in 2010

1.
```
H20BDDM(i)=H20P(2,i)*(HAV(1,1)*RT1+HAV(1,2)*RT2+HAV(1,3)*RT3)*
(H87A(1)+H87B1(1)*DP(2,i)+H87B2(1)*DR(2,i))/100/1000000*GRT
```

where,

H20BDDM(i): Direct flood damages to house building(s) (Tk. million) by 1987-scale flood for Zone No. i in 2010

H20P(2,i): No. of houses in inundation areas by 1987-scale flood for Zone No. i in 2010

HAV(1,1)(=33216), HAV(1,2)(=167767), HAV(1,3)(=377182):
Value (Tk.) of house building(s) for Low, Middle and High Classes

RT1(=.6), RT2 (=.37), RT3 (=.03):
Composition of No. of households for Low, Middle and High Classes

H87A(1)(=-6.482), H87B1(1)(=2.093), H87B2(1)(=1.182):
Coefficients of regression equation for house building

DP(2,i): Depth of inundation (m) for Zone No.i by 1987-scale flood
DR(2,i): Duration of inundation (days) for Zone No.i by 1987-scale flood

GRT (=1.070^20/(6710661/3068927) for DC-1 & DC-2,
1.065^20/(6710661/3068927) for DC-3 & DC-4):
Per capita GDP growth rate from 1990 to 2010

2.
```
H20HEDM(i)=H20P(2,i)*(HAV(2,1)*RT1+HAV(2,2)*RT2+HAV(2,3)*RT3)*
(H87A(2)+H87B1(2)*DP(2,i)+H87B2(2)*DR(2,i))/100/1000000*GRT
```

where,

H20HEDM(i): Direct flood damages to household effects (Tk. million) by 1987-scale flood for Zone No. i in 2010

HAV(2,1)(=9429), HAV(2,2)(=37802), HAV(2,3)(=158998):
Value (Tk.) of household effects for Low, Middle and High Classes

H87A(2)(=-4.638), H87B1(2)(=5.521), H87B2(2)(=.312):
Coefficients of regression equation for household effects

3.
```
H20ICDM(i)=H20P(2,i)*(HAV(3,1)*RT1+HAV(3,2)*RT2+HAV(3,3)*RT3)*
(H87A(3)+H87B1(3)*DP(2,i)+H87B2(3)*DR(2,i))/100/1000000*GRT
```

where,

H20ICDM(i): Income losses (Tk. million) by 1987-scale flood for Zone No. i in 2010

HAV(3,1)(=21754), HAV(3,2)(=56703), HAV(3,3)(=217810):
Annual household income (Tk.) for Low, Middle and High Classes

H87A(3)(=1.383), H87B1(3)(=.157), H87B2(3)(=.185):
Coefficients of regression equation for household income

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Table A1.8 Flood Damages to Houses by Zone in Greater Dhaka East in 1990 - (1987-Scale Flood)

(Unit: Tk. Million)

No.	Name of Zones	Buildings	Household Effects	Household Income
1	4	0.0	0.0	0.0
2	7	0.0	0.0	0.0
3	8	0.0	0.0	0.0
4	9	0.0	0.0	0.0
5	11	0.0	0.0	0.0
6	13	0.0	0.0	0.0
7	27	0.0	0.0	0.0
8	28	0.0	0.0	0.0
9	29	0.0	0.0	0.0
10	34	77.3	4.7	14.7
11	35	0.0	0.0	0.0
12	36	0.0	0.0	0.8
13	37	0.0	0.0	0.0
14	38	0.9	0.0	1.0
15	39	0.0	0.0	11.9
16	40	0.0	0.0	1.9
17	41	0.0	0.0	0.0
18	42	0.0	0.0	0.0
19	43	0.0	0.0	0.0
20	44	0.0	0.0	0.0
21	45	0.0	0.0	0.0
22	46	0.0	0.0	0.0
23	47	0.0	0.0	0.8
24	48	38.7	2.4	7.6
25	49	0.0	0.0	0.2
26	50	0.0	0.0	0.1
27	51	19.5	0.8	4.5
28	52	0.0	0.0	6.8
29	53	0.0	0.0	3.9
30	Gulshan 57	0.0	0.0	0.0
31	Cantonment Ward-1	2.3	0.0	0.8
32	Cantonment Ward-3	0.0	0.0	0.0
33	Dakshin Khan Cantt.	0.0	0.0	0.0
34	Uttar Khan	0.0	0.0	0.0
35	Dakshin Khan Gulshan	18.4	0.3	4.4
36	Beraid Gulshan	3.0	0.0	1.6
37	Beraid Demra	2.6	0.0	1.3
38	Demra	29.8	0.0	7.4
39	Matuail Dhaka	0.0	0.0	0.0
	Greater Dhaka East	192.4	8.2	69.7

Table A1.9 Flood Damages to Houses by Zone in Greater Dhaka East in 2010 - (1987-Scale Flood)

(Unit: Tk. Million)

No.	Name of Zones	Buildings	Household Effects	Household Income
1	4	0.0	0.0	0.0
2	7	0.0	0.0	0.0
3	8	0.0	0.0	0.0
4	9	0.0	0.0	0.0
5	11	0.0	0.0	0.0
6	13	0.0	0.0	0.0
7	27	0.0	0.0	0.0
8	28	0.0	0.0	0.0
9	29	0.0	0.0	0.0
10	34	234.1	14.4	44.4
11	35	0.0	0.0	0.0
12	36	0.0	0.0	5.6
13	37	0.0	0.0	0.0
14	38	3.4	0.0	3.8
15	39	0.0	0.0	25.8
16	40	0.0	0.0	14.7
17	41	0.0	0.0	0.0
18	42	0.0	0.0	0.0
19	43	0.0	0.0	0.0
20	44	0.0	0.0	0.0
21	45	0.0	0.0	0.0
22	46	0.0	0.0	0.0
23	47	0.0	0.0	3.0
24	48	94.0	5.7	18.4
25	49	0.0	0.0	0.4
26	50	0.0	0.0	0.1
27	51	78.0	3.3	17.8
28	52	0.0	0.0	18.2
29	53	0.0	0.0	10.7
30	Gulshan 57	238.7	0.0	92.6
31	Cantonment Ward-1	8.5	0.0	3.1
32	Cantonment Ward-3	152.6	0.0	43.3
33	Dakshin Khan Cantt.	0.0	0.0	1.7
34	Uttar Khan	508.0	21.1	95.1
35	Dakshin Khan Gulshan	423.5	6.1	101.5
36	Beraid Gulshan	55.0	0.0	29.3
37	Beraid Demra	7.7	0.0	4.0
38	Demra	151.3	0.0	37.6
39	Matuail Dhaka	224.9	6.5	54.5
	Greater Dhaka East	2,179.7	57.1	625.7

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ANNEX 2. EXPLANATION/SUBSTANTIATION OF 10% ADDITION TO ANALYTICALLY WORKED OUT FLOOD DAMAGES

The 10% addition was made at the final stage to the summation of flood damages (that is, benefits) analytically worked out. The reasons/background are explained under in qualitative as well as quantitative terms.

1. On page 11-5 to 11-9 of the F/S Main Report socio-economic impact assessment of the project is done. As negative impacts displacement of people, adverse effects on boating and fishing people, and loss of farm land and occupation as farmers are taken up. Out of them, displacement of people was taken into consideration in economic analysis in the form of resettlement cost. The other two are negative impacts from the standpoint of the parties directly concerned, but will bring positive impacts on the economy in the long run.

2. As positive impacts population to be saved from inundation, area to be saved from inundation, creation of employment, reduction of water-borne diseases, removal of psychological burden and elevation of land use are listed. The first two are related to flood damages to be saved and can be considered to have been incorporated in economic analysis as benefits. Economic theories are divided over whether the creation of employment should be treated as a benefit. The latter three are obviously important benefits, but were not taken into account in economic analysis due to difficulty in expressing them in quantitative terms in a sufficient manner.

3. The quantitative information on the reduction of water-borne diseases is not sufficient enough to incorporate it in economic analysis. But, trial estimation of the benefits of water-borne disease reduction in 1990 was done below.

   1) 1987-Scale Flood

      Tk. 45.0 million * 1.0399 ^ 3 = Tk. 50.6 million

      where 1.0399 is the estimated average annual growth rate of population in the Study Area

   2) 1988-Scale Flood

      (Estimation of incremental water-borne disease cases using the information from both the Yearbook of Bangladesh and the results of the field survey)

      178,984 * 0.2969 * Tk. 3,178 = Tk. 168.9 million
      Tk. 168.9 million + Tk. 45.0 million
      = Tk. 213.9 million
      Tk. 213.9 million * 1.0399 ^ 2
      = Tk. 231.3 million

where,

178,984	:	the difference in the number of cases of water-borne diseases in the Region of Dhaka between 1988 and 1987
0.2969	:	population ratio of the Study Area to the Region of Dhaka in 1990
Tk. 3,178	:	average medical cost per case in 1990

In the above cost the cost for the mortal cases is not included.

4. The removal of psychological burden is very hard to be expressed in monetary terms. But, its far-reaching effects and importance in socio-economic context cannot be overemphasized.

5. Elevation of land use is reflected in the value, that is, price of land. The benefits related to it can be expressed as the difference in the value of urban land between the W and WO cases. The price of urban land in the W case can be surmised from the price of the existing urban land which was not inundated in 1987 and 1988 external floods as well as in internal floods on one hand. On the other the price of urban land in the WO case can be derived from the price of the existing urban land which was affected in the two external floods as well as in internal floods.

   Supposing the said net difference is Tk.300 per sq. m, which is a conservative estimate the ultimate benefits of the increase of land value in the W case are calculated at Tk. 57,705 million (= 19,235 ha * @ Tk. 3 million). It is 2.60 times greater than the project costs.

   Note) 19,235 ha: Estimated built-up area in the Study Area in 2010

   Although such benefits as the reduction of flood damages are considered to be reflected in the incremental land value, the amount is quite massive.

6. The JICA Study Team visited the government offices and NGO concerned to gather the data and information on the extent of relief the affected people received in the form of commodities (food, clothes, etc.) and money in the 1987 and 1988 floods. The survey results reveal that people in the Study Area received the relief amounting to Tk. 12.5 million and Tk. 137.6 million in 1987 and 1988, respectively. This is the foreign aid provided through the government and NGO. It can be counted in as a benefit. In 1990 the benefit will grow to Tk. 15.1 million (= Tk. 12.5 million * 1.0399 ^ 3 * 1.0249 ^ 3) in a 1987-scale flood and Tk. 156.3 million (= Tk. 137.6 million * 1.0399 ^ 2 * 1.0249 ^ 2) in a 1988-scale

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flood.

Note) 1.0249: the estimated average annual growth rate of the per capita GDP in the Study Area

7. The reduction of water-borne diseases and flood relief add up to Tk. 65.7 million in a 1987-scale flood in 1990. Similarly, they add up to Tk 387.6 million in a 1988-scale flood in the same year. On the other hand, the 10% addition is calculated at Tk. 93.9 million and Tk. 731.3 million in 1987- and 1988-scale floods respectively in 1990. That is to say, the two benefits have already explained away 70.0% and 53.0% of the 10% addition in the two floods. If the benefit of land value increase is further added to the above two benefits (which is methodologically not immediately possible), the resultant size of benefits may be by far greater than the 10% addition.

8. Flood damages (that is, project benefits) are almost always underestimated in the same way that project costs are apt to be underestimated according to the experience of JICA. It is because there are innumerable factors related to flood damages. In our case, for instance, we have not taken into account the dead people directly due to flood, mortal water-borne disease cases due to flood, the cost of temporary/permanent flood protection measures individual households/establishments are forced to take in the WO situation, direct flood damages to vehicle equipment, loss of livestock, the stoppage/slowing down of human traffic (vis-a-vis vehicular traffic), damages to water life (including fish) by flood, general health hazards in time of flood, loss of amenity due to inaccessibility to piped water, electricity, etc. and so on.

The above flood damages are expected in the WO case. That is to say, They are considered benefits in the W case.

It is to be emphasized, moreover, that those flood damages that have been taken into account are in themselves probably an underestimate because of the limitations and constraints surrounding the data and information on which analyses are based.

9. Because of the reasons as expounded above it is considered necessary to make a 10% addition at least. It resembles the practice in the cost estimate in which 10% to 30% additions are made to the base cost at the last stage as contingencies.

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ANNEX 3. CALCULATIVE STEPS LEADING TO ESTIMATION OF AVERAGE ANNUAL FLOOD DAMAGES FOR GREATER DHAKA EAST

1. Formulation of the Relationships between the Return Period and Flood Damages, and between Frequency and Flood Damages

1) External Flood

It is assumed that if the return period is equal to or less than 10 years, then the relationships between the return period and flood damages will be expressed as the convex logarithmic curve satisfying the coordinates (1, D(m,1)) and (10, D(m,2)). Likewise, if the return period is equal to or greater than 10 years, then the above relationships will be expressed as the equation of the first degree satisfying the coordinates (10, D(m,2)) and (70, D(m,3)).

Note) D(m,n): External flood damages
m : 1 = 1990, 2 = 2010
n : 1 = Annual flood, 2 = 1987-scale flood
3 = 1988-scale flood

The relationships between frequency and the return period is formulated as follows:

RP = 1/(1-FQ) ....Formula 1

where, RP: Return period
FQ: Frequency (non-exceedance)

The relationships between frequency and flood damages derive from the relationships between the return period and flood damages, and Formula 1.

Table A3.1 shows damage - return period and damage - frequency formulas for Greater Dhaka East in the external flood. Table A3.3 derives from and visualizes Table A3.1. Fig. A3.1 graphically shows the relationships between frequency and external flood damages for Greater Dhaka East.

2) Internal Flood

It is assumed that the relationships between the return period and flood damages will be expressed as the convex logarithmic curve satisfying the coordinates (1, D(m,1)) and (10, D(m,2)).

Note) D(m,n): Internal flood damages
m : 1 = 1990, 2 = 2010
n : 1 = Annual flood, 2 = Worst flood

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This way of formulation is based on the similar relationships proved to exist between the return period and rainfall intensity.

The relationships between frequency and the return period is formulated as follows:

RP = 1/(1-FQ) ....Formula 1

where, RP: Return period
FQ: Frequency (non-exceedance)

The relationships between frequency and flood damages derive from the relationships between the return period and flood damages, and Formula 1.

Table A3.2 shows damage - return period and damage - frequency formulas for Greater Dhaka East in the internal flood. Table A3.3 derives from and visualizes Table A3.2. Fig. A3.1 graphically shows the relationships between frequency and internal flood damages for Greater Dhaka East.

2. Formulation of Functions for Calculation of Average Annual Flood Damages

One can employ either damage - return period formulas or damage - frequency formulas to calculate average annual flood damages.

1) Adoption of Damage - Return Period Formulas

Let us first suppose that one adopts the former formulas.

External Flood

If the return period is equal to or less than ten years, then one divides the function concerned by RP^2 and integrates the resultant function by RP with respect to the section (1, 10). Likewise, if the return period is equal to or greater than 10 years, then one divides the function concerned by RP^2 and integrates the resultant function by RP with respect to the section (10, 100). (The facilities concerned will be designed so that damages and losses may not occur under the external floods of the 100 year or less than 100 year return period.) The two values worked out in this way are added together.

Internal Flood

One divides the function concerned by RP^2 and integrates the resultant function by RP with respect to the section (1, 5). (The facilities concerned will be designed so that damages and losses will not occur under the internal floods of the 5 year or less than 5 year return period.)

(Refer to Table A3.4(1).)

2) Adoption of Damage - Frequency Formulas

Then, let us suppose that one adopts the former formulas.

External Flood

If frequency is equal to or less than 0.90, then one integrates the function concerned by FQ with respect to the section (0.00, 0.90). Likewise, if frequency is equal to or greater than 0.90, then one integrates the function concerned by FQ with respect to the section (0.90, 0.99). (The facilities concerned will be designed so that damages and losses may not occur under the external floods of the 0.99 or less than 0.99 frequency.) The two values worked out in this way are added together.

Internal Flood

One integrates the function concerned by FQ with respect to the section (0.00, 0.80). (The facilities concerned will be designed so that damages and losses will not occur under the internal floods of the 0.80 or less than 0.80 frequency.)

(Refer to Table A3.4(2).)

Table A3.1 Damage - Return Period and Damage - Frequency Formulas for Greater Dhaka East (External Flood)

1. Flood Damages

1) 1990

D(1,1)=46.2, D(1,2)=720.1, D(1,3)=4,151.9

```
where, D(1,1): Annual flood damages in 1990
       D(1,2): 1987-scale flood damages in 1990
       D(1,3): 1988-scale flood damages in 1990
```

2) 2010

D(2,1)=322.1, D(2,2)=3,720.8, D(2,3)=16,676.4

```
where, D(2,1): Annual flood damages in 2010
       D(2,2): 1987-scale flood damages in 2010
       D(2,3): 1988-scale flood damages in 2010
```

2. Damage - Return Period Formulas

1) Return Period =< 10 Years

```
D(m,n) = D(m,1)+(D(m,2)-D(m,1))/log10*logRP

where, D(m,n): Flood damages
       m      : 1 = 1990, 2 = 2010
       n      : 1 = Annual flood, 2 = 1987-scale flood
                3 = 1988-scale flood
       RP     : Return period
```

2) 10 Years =< Return Period

```
D(m,n) = (10*D(m,3)-70*D(m,2))/(10-70)+
         (D(m,2)-D(m,3))/(10-70)*RP
```

3. Damage - Frequency Formulas

1) Frequency =< .9

```
D(m,n) = D(m,1)+(D(m,2)-D(m,1))/log10*log(1/(1-FQ))

where, FQ     : Frequency (non-exceedance)
```

2) .9 =< Frequency

```
D(m,n) = (10*D(m,3)-70*D(m,2))/(10-70)+
         (D(m,2)-D(m,3))/(10-70)*(1/(1-FQ))
```

Table A3.2 Damage - Return Period and Damage - Frequency Formulas for Greater Dhaka East (Internal Flood)

1. Flood Damages

1) 1990

D(1,1)=158.4, D(1,2)=391.1

where, D(1,1): Annual flood damages in 1990
D(1,2): Worst flood damages in 1990

2) 2010

D(2,1)=285.8, D(2,2)=768.2

where, D(2,1): Annual flood damages in 2010
D(2,2): Worst flood damages in 2010

2. Damage - Return Period Formula

D(m,n)=D(m,1)+(D(m,2)-D(m,1))/log10*logRP

where, D(m,n): Flood damages
m : 1 = 1990, 2 = 2010
n : 1 = Annual flood, 2 = Worst flood
RP : Return period

3. Damage - Frequency Formula

D(m,n)=D(m,1)+(D(m,2)-D(m,1))/log10*log(1/(1-FQ))

where, FQ : Frequency (non-exceedance)

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Table A3.3 Damage - Return Period and Damage - Frequency Tables for Greater Dhaka East

1. External Flood

Frequency (Non-exc-eedance)	Return Period (Years)	Estimated Damages (Tk. Million)			
		1990		2010	
		WO	W	WO	W
0.00	1.00	46.2	0.0	322.1	0.0
0.10	1.11	77.0	0.0	477.6	0.0
0.20	1.25	111.5	0.0	651.5	0.0
0.30	1.43	150.6	0.0	848.6	0.0
0.40	1.67	195.7	0.0	1,076.1	0.0
0.50	2.00	249.1	0.0	1,345.2	0.0
0.60	2.50	314.4	0.0	1,674.6	0.0
0.70	3.33	398.6	0.0	2,099.2	0.0
0.80	5.00	517.2	0.0	2,697.7	0.0
0.90	10.00	720.1	0.0	3,720.8	0.0
0.95	20.00	1,292.1	0.0	5,880.1	0.0
0.98571	70.00	4,151.9	0.0	16,676.4	0.0
0.99	100.00	5,867.8	0.0	23,154.2	0.0

2. Internal Flood

Frequency (Non-exc-eedance)	Return Period (Years)	Estimated Damages (Tk. Million)			
		1990		2010	
		WO	W	WO	W
0.00	1.00	158.4	0.0	285.8	0.0
0.10	1.11	169.0	0.0	307.9	0.0
0.20	1.25	181.0	0.0	332.5	0.0
0.30	1.43	194.4	0.0	360.5	0.0
0.40	1.67	210.0	0.0	392.8	0.0
0.50	2.00	228.4	0.0	431.0	0.0
0.60	2.50	251.0	0.0	477.8	0.0
0.70	3.33	280.1	0.0	538.0	0.0
0.80	5.00	321.1	0.0	623.0	0.0
0.90	10.00	391.1	70.0	768.2	145.2
0.95	20.00	461.1	140.0	913.4	290.4
0.98571	70.00	587.8	266.7	1,175.9	552.9
0.99	100.00	623.8	302.7	1,250.6	627.6

Note: WO = Without Case, W = With Case

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Table A3.4(1) Calculation of Average Annual Flood Damages

Either Method I or Method II can be employed.

1. Method I

1) External Flood

(1) 1990

$$\int_{1}^{10}(D(1,1)+(D(1,2)-D(1,1))/\log 10*\log RP)/RP^{2}dRP+\int_{10}^{100}(10*D(1,3)-70*D(1,2))/(10-70)+(D(1,2)-D(1,3))/(10-70)*RP)/RP^{2}dRP$$

= Tk. **382.6** Million

(2) 2010

$$\int_{1}^{10}(D(2,1)+(D(2,2)-D(2,1))/\log 10*\log RP)/RP^{2}dRP+\int_{10}^{100}((10*D(2,3)-70*D(2,2))/(10-70)+(D(2,2)-D(2,3))/(10-70)*RP)/RP^{2}dRP$$

= Tk. 1,916.1 Million

Note: Regarding D(1,1), D(1,2), D(1,3), D(2,1), D(2,2), D(2,3) and RP refer to Table A3.1.

2) Internal Flood

(1) 1990

$$\int_{1}^{5}(D(1,1)+(D(1,2)-D(1,1))/\log 10*\log RP)/RP^{2}dRP$$

= Tk. 175.1 Million

(2) 2010

$$\int_{1}^{5}(D(2,1)+(D(2,2)-D(2,1))/\log 10*\log RP)/RP^{2}dRP$$

= Tk. 328.8 Million

Note: Regarding D(1,1), D(1,2), D(2,1), D(2,2) and RP refer to Table A3.2.

Table A3.4(2) Calculation of Average Annual Flood Damages

2. Method II

1) External Flood

(1) 1990

$$\int_{0.00}^{0.90}(D(1,1)+(D(1,2)-D(1,1))/\mathrm{log10}*\log(1/(1-FQ)))dFQ+$$

$$\int_{0.90}^{0.99}((10*D(1,3)-70*D(1,2))/(10-70)+(D(1,2)-D(1,3))/(10-70)*$$

$$(1/(1-FQ)))dFQ = \text{Tk. } 382.6 \text{ Million}$$

(2) 2010

$$\int_{0.00}^{0.90}(D(2,1)+(D(2,2)-D(2,1))/\mathrm{log10}*\log(1/(1-FQ)))dFQ+$$

$$\int_{0.90}^{0.99}((10*D(2,3)-70*D(2,2))/(10-70)+(D(2,2)-D(2,3))/(10-70)*$$

$$(1/(1-FQ)))dFQ = \text{Tk. } 1{,}916.1 \text{ Million}$$

Note: Regarding D(1,1), D(1,2), D(1,3), D(2,1), D(2,2), D(2,3) and FQ refer to Table A3.1.

2) Internal Flood

(1) 1990

$$\int_{0.00}^{0.80}(D(1,1)+(D(1,2)-D(1,1))/\mathrm{log10}*\log(1/(1-FQ)))dFQ$$

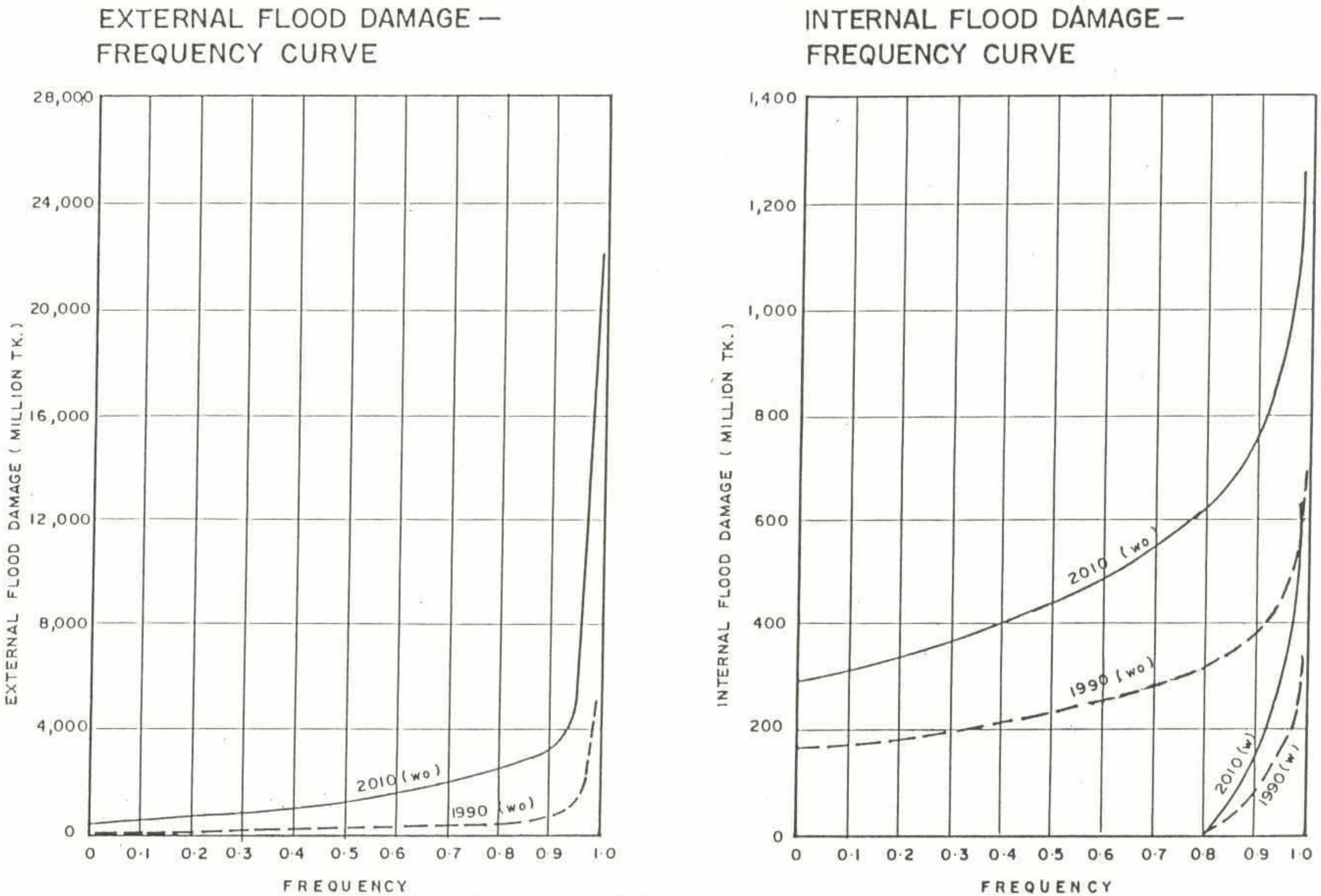
$$= \text{Tk. } 175.1 \text{ Million}$$

(2) 2010

$$\int_{0.00}^{0.80}(D(2,1)+(D(2,2)-D(2,1))/\mathrm{log10}*\log(1/(1-FQ)))dFQ$$

$$= \text{Tk. } 328.8 \text{ Million}$$

Note: Regarding D(1,1), D(1,2), D(2,1), D(2,2) and FQ refer to Table A3.2.



Note: WO = Without Case
W = With Case

FIG. A3.1 DAMAGE - FREQUENCY CURVES FOR GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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ANNEX 4. NOTE ON THE TWO ESTIMATIONS OF 1987 AND 1988 FLOOD DAMAGES IN MASTER PLAN STUDY AREA

1. Abbreviated Naming of the Two Estimations

For the sake of convenience the estimation of 1987 and 1988 flood damages in the master plan study area based on data collected from agencies concerned will from now on be called Estimation I, while the estimation of 1987-scale and 1988-scale flood damages in 1990 in the master plan study area as a result of analysis using data collected through sampling questionnaire surveys will be called Estimation II.

2. Request for Explanation

In the Record of Discussion dated 28 May, 1992 prepared by FPCO it is asked that the wide difference in flood damages as shown below be explained in detail.

(Unit: Tk. Million)

Item	1987 Flood	1988 Flood
Estimation I	347	781
Estimation II	3,884.4	13,655.8

This annex is prepared to meet the above request.

3. Reason for Reporting Estimation I in Master Plan Study Report

The JICA Study Team sent men to the Deputy Commissioner, Dhaka Region and Upazila Offices of Narayanganj, Keraniganj, Savar and Tongi to collect data concerning 1987 and 1988 flood damages in the early part of the M/P study period.

All the officials concerned were reportedly very cooperative and helpful. It was felt that the data collected should be reported in some way or another.

The Team was to start the sampling questionnaire surveys over the entire master plan study area with the number of samples reaching 5,200. The samples consisted of houses, farm houses shops and factories. The surveys aimed at obtaining the information on the inundation depths/durations, damage ratios and income/profit loss ratios of various types of inundated properties, etc. in time of 1987, 1988 and other floods for each of the 116 wards or unions over the master plan study area. This information along with the information on the number and value of various types of properties was used to arrive at the damage estimates of 1987, 1988 and other floods in 1990 and 2010. Those damage estimates were ultimately converted into benefits and utilized in the economic analysis.

Estimation I is made up of three steps, i.e. (1) the estimation of the quantities (number, area, length, etc.) of properties/farms/infrastructures damaged by 1987 and 1988 floods, (2) the estimation of flood damages per unit quantity and (3) multiplication of (1) by (2). Also, damage items are limited in this estimation.

It was thought that some information in Estimation I would be helpful and meaningful in the course of preparation/formulation of Estimation II. However, from the beginning Estimation I was not intended for use in the flood damage estimation, benefit calculation and economic analysis.

Just in order to pay respect to the officials who cooperated with the JICA Study Team Estimation I was shown in the Master Plan Study Report.

4. Basic Differences in the Two Estimations

1) There is methodological difference in the two estimations. The difference is already mentioned in the above section. Detailed methodology for Estimation II is described in Table A4.1.

   The methodology for Estimation I is very simple, while the methodology for Estimation II is structural as well as analytical.

2) The sources of data and information are different. In Estimation I they are several offices concerned, while in Estimation II they are 5,200 houses, shops and factories which directly experienced 1987 and 1988 floods distributed over the master plan study area.

3) The number of damage items is different. In Estimation I they are 6, while in Estimation II they are 11. (Refer to Tables A4.2 and A4.3.)

5. Resultant Major Derivative Differences in the Two Estimations

As a result of methodological and other basic differences the following crucial differences are derived. (Refer to Tables A4.2, A4.3 and Fig. A4.1.)

1) Quantities (number, etc.) of the affected properties and other objects are different. For instance in the 1987 flood the number of affected houses in Estimations I and II is 95,009 and 414,304, respectively and in the 1988 flood the number of affected houses in Estimations I and II is 268,042 and 642,939, respectively.

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2) Damages per unit quantity of affected properties and other objects are different. For instance in the 1987 flood damages per house are Tk. 1,426 and Tk. 5,775 in Estimations I and II, respectively and in the 1988 flood damages per house in Estimations I and II are Tk. 1,439 and Tk 10,632, respectively.

3) Because of the above two differences in the 1987 flood house damages in Estimation II (which account for 61.6% of the total flood damages) are 17.7 times greater than in Estimation I and in the 1988 flood house damages in Estimation II (which account for 50.0% of the total flood damages) are 17.2 times greater than in Estimation I.

4) Damageable items such as household effects, commercial buildings, commercial equipment & inventories, industrial buildings, industrial equipment & inventories, institutional buildings, income losses for households, profit losses for businesses and profit losses for industries (which account for 17.4% and 42.9% of the total flood damages in Estimation II in 1987 and 1988 floods, respectively) are almost lacking in Estimation I.

5) In the 1987 flood damages to crops in Estimation II are 6.5 times greater than in Estimation I and in the 1988 flood damages to crops in Estimation II are 5.4 times greater than in Estimation I.

6. Conclusions

Estimation I and Estimation II are schematically compared in Fig. A4.1. By viewing it one can grasp the background leading to the wide gap in the two estimates.

That is to say, it is:

1) Wide difference in house damage estimates. This explains away the majority of difference in the two estimates.

2) Damages to other properties and income/profit losses which occupy important positions in Estimation II are little considered in Estimation I.

3) Difference in crop damage estimates.

Table A4.1(1) Methodological Comparison of Two Estimations of 1987 and 1988 Flood Damages in the Master Plan Study Area

1. Estimation of 1987 and 1988 flood damages based on data collected from agencies concerned

   A Estimation of the quantities (number, area, length, etc.) of properties/farms/infrastructures damaged by 1987 and 1988 floods.

   B Estimation of flood damages per unit quantity.

   C (= A * B). Calculation of flood damages.

2. Estimation of 1987-scale and 1988-scale flood damages in 1990 as a result of analysis using data collected through sampling questionnaire surveys

   A Estimation of the number of properties by Zone (based on ward or union) by type of properties (i.e. houses, businesses, industries and institutions) in 1990.

   B Estimation of ratios of inundation area to total area by Zone in 1987 and 1988 floods.

   C (= A * B). Calculation of the number of properties to have been inundated by 1987-scale and 1988-scale floods by Zone by type of properties in 1990.

   D1 Estimation of unit value of properties by type and detailed breakdown of properties (i.e. residential buildings, household effects, commercial buildings, commercial equipment & inventories, industrial buildings, industrial equipment & inventories and institutional buildings).

   D2 Estimation of annual income per household, annual profit per commercial establishment and annual profit per industrial establishment.

   E1 (= C * D1). Calculation of the value of properties to have been inundated by 1987-scale and 1988-scale floods by Zone by type and detailed breakdown of properties in 1990.

   E2 (= C * D2). Calculation of income/profit of properties to have been inundated by 1987-scale and 1988-scale floods by Zone by type of properties in 1990.

   F Estimation of average depths/durations of inundation by Zone in 1987 and 1988 floods.

Table A4.1(2) Methodological Comparison of Two Estimations of 1987 and 1988 Flood Damages in the Master Plan Study Area

G1 Formulation of regressional equations determining the relationships between depths/durations of inundation and ratios of flood damages to properties by type and detailed breakdown of properties in 1987 and 1988 floods.

G2 Formulation of regressional equations determining the relationships between depths/durations of inundation and ratios of income/profit losses to properties by type of properties in 1987 and 1988 floods.

H1 (from E1, F and G1). Calculation of property damages due to 1987-scale and 1988-scale floods by Zone by type and detailed breakdown of properties in 1990.

H2 (from E2, F and G2). Calculation of income/profit losses due to 1987-scale and 1988-scale floods by Zone by type of properties in 1990.

I Estimation of the number of farmers by Zone in 1990.

J Estimation of inundation ratios in agricultural areas in 1987 and 1988 floods.

K (= I * J). Calculation of the number of farmers to have been affected by 1987-scale and 1988-scale floods by Zone in 1990.

L Estimation of average economic value of agricultural crops in the flood season per farmer.

M (= K * L). Calculation of economic value of agricultural crops to have been affected by 1987-scale and 1988-scale floods by Zone in 1990.

N Estimation of average depths/durations of inundation in agricultural areas by Zone in 1987 and 1988 floods.

O Formulation of regressional equations determining the relationships between depths/durations of inundation in agricultural areas and ratios of flood damages to agricultural crops in 1987 and 1988 floods.

P (from M, N and O). Calculation of crop damages due to 1987-scale and 1988-scale floods by Zone in 1990.

Table A4.2 Breakdowns of 1987 Flood Damages in the Master Plan Study Area for Comparison

1. 1987 Flood Damages (based on data collected from agencies concerned)

Item	Houses	Crops	Schools	Roads	Live-stock	Rehabili-tation	Total
Quantity (A)	95,009 (No.)	19,729 (ha)	690 (No.)	1,333 (km)	2,968 (No.)	-	-
Amount (B) (Tk Mln.)	135.5	124.9	16.2	58.2	12.3	-	347.1
B/A (C) (Tk)	1,426	6,331	23,478	43,661	4,144	-	-

Note: Rehabilitation = Rehabilitation costs of power, water-supply, gas, telecommunications and transportation facilities

2. 1987-Scale Flood Damages in 1990 (results of analysis using data collected through sampling questionnaire surveys)

Item	Residential			Commercial		
	Bd	H.E	Ic	Bd	E&I	Pf
Quantity (A) (No.)		414,304			12,051	
Amount (B) (Tk Mln.)	2,392.5	137.3	531.1	0.0	0.0	6.7
B/A (C) (Tk)	5,775	332	1,282	0.0	0.0	556

Item	Industrial			Institu-tional	Agricul-tural	Total
	Bd	E&I	Ic	Bd	Cp	
Quantity (A) (No.)		2,316		10,507	160,006	-
Amount (B) (Tk Mln.)	0.0	0.0	0.0	0.0	816.8	3,884.4
B/A (C) (Tk)	0.0	0.0	0.0	0.0	5,105	-

Note: Bd = Building(s), H.E = Household Effects, Ic = Income, E&I = Equipment & Inventories, Pf = Profit, Cp = Crops

Table A4.3 Breakdowns of 1988 Flood Damages in the Master Plan Study Area for Comparison

1. 1988 Flood Damages (based on data collected from agencies concerned)

Item	Houses	Crops	Schools	Roads	Livestock	Rehabilitation	Total
Quantity (A)	268,042 (No.)	29,377 (ha)	878 (No.)	2,106 (km)	2,356 (No.)	-	-
Amount (B) (Tk Mln.)	385.7	178.3	20.7	97.1	9.8	89.5	781.1
B/A (C) (Tk)	1,439	6,069	23,576	46,106	4,160	-	-

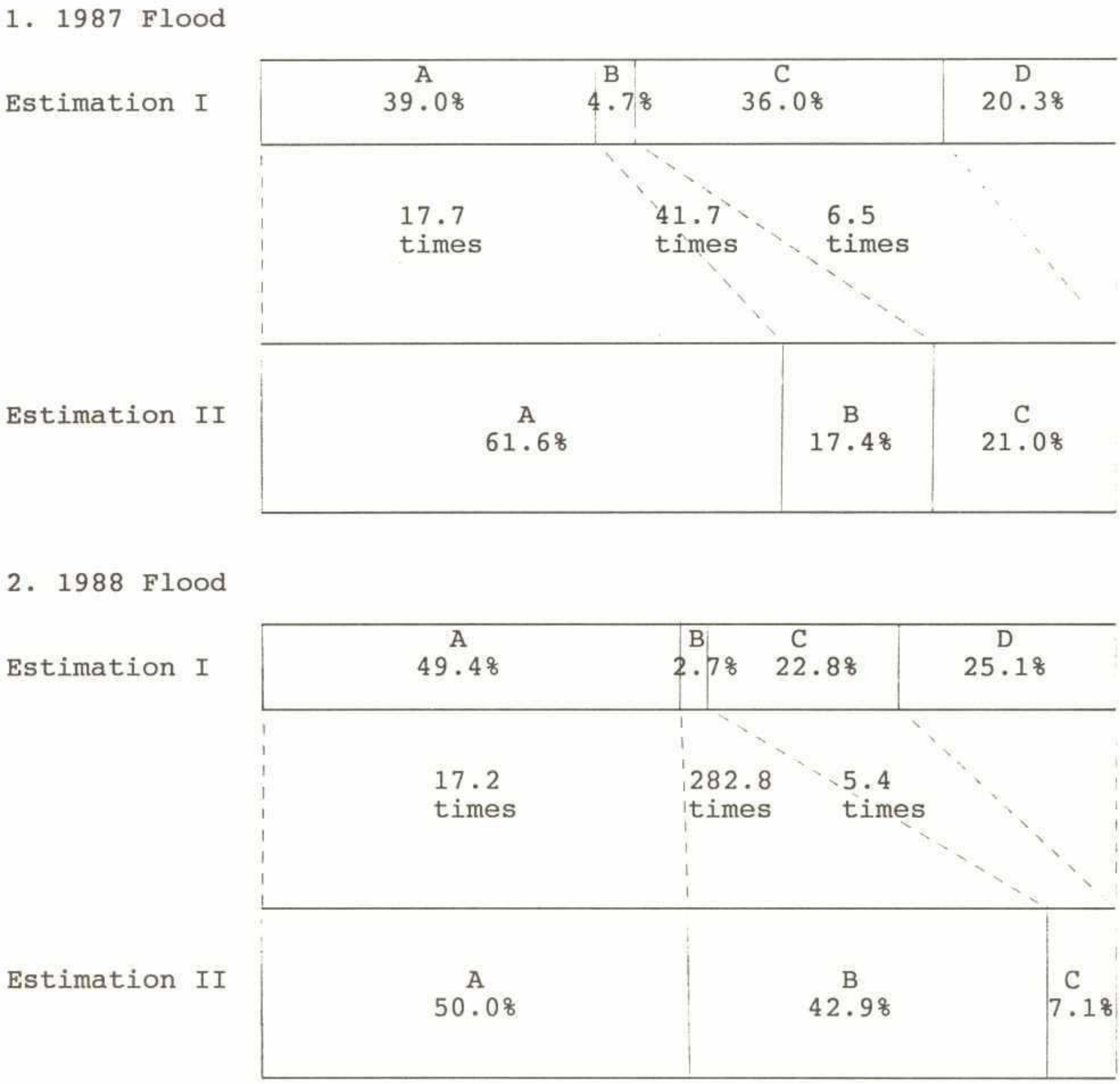
Note: Rehabilitation = Rehabilitation costs of power, water-supply, gas, telecommunications and transportation facilities

2. 1988-Scale Flood Damages in 1990 (results of analysis using data collected through sampling questionnaire surveys)

Item	Residential			Commercial		
	Bd	H.E	Ic	Bd	E&I	Pf
Quantity (A) (No.)		642,939			20,683	
Amount (B) (Tk Mln.)	6,836.0	2,928.7	868.2	150.7	352.1	31.4
B/A (C) (Tk)	10,632	4,555	1,350	7,286	17,024	1,518

Item	Industrial			Institutional	Agricultural	Total
	Bd	E&I	Ic	Bd	Cp	
Quantity (A) (No.)		4,595		19,834	160,006	-
Amount (B) (Tk Mln.)	189.5	629.6	99.8	603.4	966.4	13,655.8
B/A (C) (Tk)	41,240	137,018	21,719	30,423	6,040	-

Note: Bd = Building(s), H.E = Household Effects, Ic = Income, E&I = Equipment & Inventories, Pf = Profit, Cp = Crops



Legend: Estimation I = Estimation of 1987 and 1988 flood damages based on data collected from agencies concerned
Estimation II = Estimation of 1987-scale and 1988-scale flood damages in 1990 as a result of analysis using data collected through sampling questionnaire surveys

A = Damages to houses, B = Damages to other properties and income/profit losses, C = Damages to crops, D = Damages to infrastructures, etc.

FIG. A4.1	SCHEMATIC COMPARISON OF TWO ESTIMATIONS OF 1987 AND 1988 FlOOD DAMAGES IN M/P STUDY AREA

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SUPPORTING REPORT C
LIVING ENVIRONMENT AND ECOLOGY

DRAFT FINAL REPORT

SUPPORTING REPORT C : LIVING ENVIRONMENT AND ECOLOGY

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SUPPORTING REPORT C : LIVING ENVIRONMENT AND ECOLOGY

1. Introduction

1.1 General

The environmental study in the feasibility study (FS) stage is principally targeted at the anticipated major environmental consequences, both of direct and indirect nature, by the implementation of the proposed flood control and drainage works. The predominant indirect consequence will be due to subsequent urbanization of the project area as emphasized in the master plan report (ref. Supporting Report F, Master Plan Study, FAP 8A, November 1991). Though urbanization itself would lead to much direct environmental impacts, living environmental issue with specific concern to sanitation is only selected as the priority element for detailed consideration in this flood control and drainage project. The other major direct environmental issues of urbanization shall be addressed by future studies of direct concern. Nevertheless, major environmental effects, both of direct and indirect, are still identified along with their degree of significance. Possible mitigatory measures are also recommended.

1.2 Environmental Study Area

Based on the previous master plan study of FAP-8A, conducted covering an area of about 850 sq.km. of Greater Dhaka and its vicinity, namely Narayanganj, Keraniganj, Tongi and Savar, an area of about 340 sq.km. covering Greater Dhaka and Narayanganj was delineated as the priority area of project implementation. The environmental study area covers this whole priority area, in general (ref. Fig. C.1).

This priority area is subdivided into four (4) areas as per the master plan study. They are :

(1) Greater Dhaka
- Dhaka West
- Dhaka East

(2) Narayanganj
- DND
- Narayanganj West

The existing population, and flooding conditions along with that of future population land use and the retarding areas proposed to be reserved for planned internal flooding

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as envisaged by this FAP-8A master plan and feasibility study, in the priority area until the year 2010, is summarized in Table C.1.

From the above table it is evident that built up area would account for 80% of land use in 2010, against its present share of 45.5% in the priority area. While, the agricultural land use would decrease to 7% from the existing share of 43.5%. The population will double to about 10.8 million from 5.4 million.

The feasibility study of the highest priority area, Dhaka West, was conducted by ADB under FAP-8B project. Accordingly, the detailed environmental considerations of this area by the project are dealt with in FAP-8B study reports and the progress EIA for DFPP report by DOE of July 1990, hence are not duplicated in this study.

2. Ecology

A comprehensive ecological survey, based on available secondary data in combination with judicious field verification, was carried out for establishing the base line conditions of existing ecological resources in the priority area of Greater Dhaka and Narayanganj (ref. Fig. C.1), and hence to identify significant impacts, if any, on such resources by the project implementation, on a preliminary basis. The ecological resources targeted by the survey are flora and fauna, termed as general ecological resources, and agriculture and aquaculture, termed as productive ecological resources in consideration to their direct economic value.

The survey was conducted during the six (6) month period from October 1991 to February 1992, to encompass as far as possible both the flood season and dry season conditions. This is in due consideration to the distinct environmental conditions in the flood plains that predominates East Dhaka (Balu River flood plain).

The ecological survey results incorporating a comprehensive ecological evaluation by the project is presented in the subsequent sections.

The impacts by the project on ecology, both due to the direct dry up effect of embankments and the subsequent change in land use due to urbanization, is evaluated to be insignificant when assessed from a broad perspective on a national basis.

2.1 General Ecology

Flora and fauna are the defined general ecological elements. Faunal elements of an ecosystem could be grouped into four (4) categories. They are, in the sequential order of their evolutionary status, amphibia, reptiles, birds and mammals. Such a simple classification is impossible for flora due to their complex evolutionary status and varieties.

Nevertheless, floral elements in the priority area falls into two (2) broad categories of aquatic and terrestrial species. The aquatic species are classified into four (4) groups based on their degree of submergence in water. They are, species of floating, completely submerged, partly submerged and marsh plants with very little submergence. While, the terrestrial plant species are also grouped to for (4) categories, namely, trees, shrubs, climbers and herbaceous weeds.

2.1.1 Flora

A total of 112 floral species are identified in the objective area, of which 81 being terrestrial belonging predominantly to the high lands, and 31 being aquatic of low lands and flood plains. Terrestrial plants are generally not seasonal and present for years, while the aquatic ones dominate mostly during the flood season from July to October.

The terrestrial plant species belonging to trees, shrubs and climbers are prominent in homesteads and village thickets, most being planted. The herbaceous weeds grow mostly in waste areas and agricultural lands.

In case of the aquatic plant species, some floating types are very dominant in flooded low lands and flood plains during rainy/flood season, from July to October. In particular, water hyacinth/kachuri pana (Eichhornia crassipes) is the most invasive in most shallow water bodies/areas of Dhaka East and DND in association with topa pana (Pistia stratiotes), duckweed/khudi pana (Lemna spp.) and indurkani pana (Salvinia cucullata).

The number of these floral species, classified according to their groups, along with the respective important species, is summarized below ;

Floral Class	Species in Objective Area		Important Species
	Types	Number	
Terrestrial Species	Trees	32	10
	Shrubs	11	2
	Climbers	7	2
	Herbeceous Weeds	31	2
Aquatic Species	Floating	10	3
	Completely submerged	4	1
	Partly submerged	11	6
	Marsh plant	6	4
Total :		112	30

Floral species of significant economic value are considered as important species. It is noted that irrespective of importance of a species, all the species that are found in the priority area also found elsewhere in the country. Moreover, most of the important terrestrial species are planted trees in homestead like jackfruit, coconut, mango trees and others. While most important aquatics have relatively indirect economic value, like water hyacinth being protective to fish nursery development, a cattle feed and also an organic manure, and duck weed (Wolffia arrhiza) being a favorite food for fish.

Consequent to the embankment and dry-up of flood plains followed with progressing urban development, Dhaka East area in particular, terrestrial plant species would become dominant replacing the aquatic plants, other than in the lowland retarding areas and other water bodies. Even among the terrestrial species, planted homestead ones of direct economic importance will predominate with increasing residential development. The existing already protected DND triangle area depicts the evolution of above mentioned state, in reality.

Nevertheless, in consideration to the fact that most of Bangladesh is a delta with vast flood plains, such a dominance by terrestrial species in place of aquatics in the priority area is assessed to be insignificant. Moreover, of the master plan area of 850 km^2, still an area of 328 km^2 is proposed to remain as flood plains with no significant change in land use, where aquatics will continue to dominate (ref. Chapter 10 of Main Report, Master Plan).

2.1.2 Fauna

Most faunal elements, other than amphibia, in the objective area are either aquatic or terrestrial of origin. The total number of identified faunal species are 177. Their breakdown according to the four (4) categories are, seven (7) species of amphibia, 22 species of reptiles, 127 species of wild birds and 21 species of wild mammals. Of the bird species 90 are resident, hence considered to be present throughout the year. While 37 are migratory bird species and mostly reside during the dry winter season, from November to February. The 21 wild mammal species has one (1) semi-aquatic species, the otter.

The number of the existing species, separated according to their faunal classification, along with the respective important species, is summarized below;

Fauna	Number of Species in Objective Area				Important Species
	Aquatic	Terrestrial	Aquatic & Terrestrial	Total	
Amphibia *	-	-	7	7	1
Reptiles	6	16	-	22	7
Birds : Resident	17	73	-	90	9
: Migratory	24	13	-	37	2
Mammals (Wild)	-	20	1	21	7
Total	47	122	8	177	26

* Amphibia by its nature is both aquatic and terrestrial

The important faunal species are considered as those of economic importance as well as those of which population are somewhat affected or threatened as per the baseline conditions.

Irrespective of importance, all the species are expected also in elsewhere of the country. No species is identified to be peculiar to the priority area.

The important species identified in the priority area includes the following endangered species cited in the CITIES convention. Those species are also supposed to be present on a country wide basis. Hence the required protective measures are recommended to be undertaken on a national basis based on the causative elements of their demise. In most cases, human pressure like hunting and others is the major cause. Such species endangered due to human pressure are best protected in wild-life sanctuaries and in other areas away from urban environment.

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The endangered species, listed in CITIES convention, identified in the priority area are confined to reptiles (2 species) and birds (3 species). They are as follows:

Endangered reptiles

Peacock soft shell turtle (Trionyx hurum) : Aquatic reptile
Grey land monitor (Varanus bengalensis) : Terrestrial reptile

Endangered birds

Comb duck/Nukhta (Sarcodiornis melanotus) : Aquatic bird
Great eared nightjar (Eurostopodus macrotis) : Terrestrial bird
Slork billed kingfisher (Pellargepsis capensis) : Terrestrial bird

All the above three (3) are resident bird species. Moreover, the nation-wide status of Comb duck and Great eared nightjar are uncertain. Hence an intensive study on wild life ecology remain to be undertaken on a national basis to determine the base line condition and to formulate a rational wild life conservation strategy.

It is noted that the faunal survey does not take into consideration of the domestic species reared by man for their economic and other usefulness, among which the mammals predominate. There are six (6) such domestic mammal species widely distributed in the whole country, namely, cow, buffalos, horse, goat, dog and cat. These domestic species would thrive and their population would not be in danger in consideration for their direct importance to human welfare, hence are not covered in this comprehensive survey.

With the embankment and subsequent dry-up and urban development, similar to the floral species dealt with in the foregone section, terrestrial species will become dominant in place of aquatic species, other than in the low land retarding areas and other water bodies. Amphibian species, as it is both aquatic and terrestrial is highly versatile in adapting to this environmental change. While those highly mobile aquatic species of birds and reptiles would find alternative areas that will prevail around the priority area. In this regard, the flood plain management area of 328 km^2 of the master plan area is of significance as alternative aquatic habitat, though a vast flood plain still surrounds even the master plan area of 850 km^2. Even those aquatic reptiles with low mobility like turtle species would find adequate habitat in the remaining low lands, canals and other water areas.

The following urban development and the subsequent reduction of wood lands would still affect the terrestrial species of wild origin due to inherent loss of their habitat. Moreover, with increasing residential development terrestrial domestic species with direct economic and other importance to human welfare, like dog, cat, cow etc., would become dominant at the expense of terrestrial species of wild origin.

A wild life sanctuary like the botanical garden and zoo in Mirpur of West Dhaka, is recommended to be established in Dhaka East area as well. This could also serve as recreational area of urban population. Kaskara area in the northern most compartment of the proposed flood control and drainage plan (DC-1) along with northern most retarding area is recommended for further studies as a potential terrestrial and aquatic wild life sanctuary. Land use of this area surrounding the northern most retarding area of Dhaka East is proposed to be agriculture, as per the indicative land use plan in 2010 (ref. Fig. A.9 of Supporting Report A). A portion of this proposed agricultural area and retarding area could still be reserved for wild life conservation.

Moreover the high land rural area in Savar (about 43 km^2) and the low land flood plain management areas (about 328 km^2), the land use of which are proposed to remain unchanged according to the previous master plan study encompassing an area of 850 km^2, are potential areas of natural wild life conservation. Development of portions of these areas as natural wild life conservation areas is recommended for detailed investigation as further studies (ref. Table C.12, Fig. C.17 and Fig. C.18 of Supporting Report C, Master Plan).

As long as the land use of these proposed rural master plan areas are ensured to remain unaffected natural protection of both the general and productive ecological elements of flora, fauna, agriculture and aquaculture can be reasonably expected.

2.2 Productive Ecology

The representative productive ecological elements are the agricultural crops and the aquacultural species of both natural (generally known as fishery) and artificially cultured (generally known as aquaculture), in the priority area.

During flood season, the lowland areas, that account for about 33% (11,200 ha) of the priority area of 34,000 ha, are encompassed by open water bodies due to overflow from surrounding rivers. Such open water bodies are vast in East Dhaka Balu river

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flood plains. While closed water bodies and marsh lands cover an area of about 3,600 ha.

These open water bodies of potential aquaculture during flood season becomes single cropped agricultural lands during dry season. This is a very typical phenomenon in most lowland flood plains of the whole country.

2.2.1 Agriculture

1) Existing Condition

The environmental study area, priority area, covers about 34,000 ha (ref. Fig. C.l). Under the existing conditions of land use, agriculture accounts for 44% of the total land use covering about 14,800 ha, which is very significant (ref. Table C.1).

The land use distinguished between agriculture and others in Greater Dhaka (Dhaka West and Dhaka East) and Narayanganj (DND and Narayanganj West) is summarized below.

Agricultural Land Use in 1990

Land Use	Greater Dhaka		Narayanganj		Priority Area (Total)	
	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture	11,181	42.5	3,637	48.2	14,818	44
Others	15,126	57.5	3,905	51.8	19,031	56
Total	26,307	100	7,542	100	33,849	100

The farming practice comprises three annual seasons, namely Karif - I (March - June), Karif - II (July - October) and Rabi (November - February).

(1) <u>Karif - I (pre monsoon) season</u>

This is a very good crop production season though not a prominent crop planting season. The climatic condition is marked with high temperature and low humidity resulting in high evaporation. Rain fall is very low while solar radiation is high.

(2) Karif - II (monsoon) season

This season is marked with high rainfall and high humidity. This is also the flood season in which the low-lying agricultural lands, predominantly in East Dhaka, and the crops if not harvested get inundated by external and/or internal flood water. Hence no cropping is possible in low lands with no flood protection and drainage measures during this season.

(3) Rabi (post monsoon - winter) season

This season is characterized with low temperature, high solar radiation, low evaporation and little or no rain fall. This season also marks the receding of external flood water form the surrounding rivers in flood pains, like that of Balu River flood pains in East Dhaka, making them suitable for single crop cultivation. This is the predominant crop planting season.

(4) Farming Practice

The existing farming practice is to suit the above climatic and the related land and flood water area changes. Rice and wheat are the major crops cultivated. Their varieties are itemized below. Rice cultivation predominates in Karif I and Karif II seasons, though Rabi is its major planting season. While wheat and other products like oil seeds, potatoes, vegetables and pulses are cultivated in Rabi season.

Rice (Boro)

HYV	:	Br-3, Br-8, Br-9, Br-12, IR-8.
Local	:	Amboro, Khaiyaboro, Chiniboro.
Improved	:	Pyzam.

Rice (Aman)

HYV	:	Br-3, Br-4, Br-10, Br-11, IR-20.
Improved	:	Pyzam.

Rice (Aus)

HYV	:	Br-12, Br-15, Br-16, IR-8.

Wheat

Recommended variety	:	Sonalika, Balaka, Ananda, Barkat, Akbar, Kanchan.

(5) Annual Cropping Intensity

Single cropping, which is mainly confined to Rabi and Karif-I season, is predominant that covers about 58% of the total agricultural lands which are mostly flood plains. While double cropping encompassing two seasons accounts for about 33% and triple cropping covering all three (3) seasons accounts for the remaining 9% of agricultural lands, being confined mostly to flood protected DND area.

Accordingly, the average cropping intensity in the whole objective area (priority area) becomes 152%, which is much less than the cropping intensity of Dhaka district with 171%. Hence, it could be concluded that this priority area that encompasses both the existing and the potential future urban area is more suited for urban land use than that of agriculture, based on the existing conditions. Nevertheless, it is to be admitted that flood mitigation and drainage would increase the potential cropping intensity of the protected agricultural land as well. This aspect is hypothetically analyzed in the subsequent section on future condition. Breakdown of cropping pattern along with the respective crops is tabulated below.

Existing Cropping Pattern in Priority Area

Pattern	Cultivated Crops	Cultivated Area		Cropped Area	Cropping Intensity
		ha	%	ha	%
Single Cropping	Boro (Local) or Boro (Improved) or Boro (HYV) or Fruits	8,523	57.5	8,523	57.5
Double Cropping	Boro (HYV) followed with T. Aman (HYV) or Rabi crops followed with T. Aus (HYV) or Rabi Crops followed with T. Aman (HYV)	4,945	33.4	9,890	66.8
Triple Cropping	Rabi crops followed with Boro (HYV) and T. Aman (Improved)	1,350	9.1	4,050	27.3
Total :		14,818	100	22,463	151.6

Note : Rabi crops include all, other than rice and fruits, in general.

The total annual production of major agricultural crops of rice, wheat, potatoes, oil seeds, pulses vegetables and fruits in the above agricultural lands of the priority area along with their respective yields, cost of production and market price and other related information is given in Table C.2.

The total annual net value added of agricultural production, under existing condition, is about 389 million Tk., as evident from Table C.2. Total annual net value added is defined as the difference between total annual market price and that of production cost of the whole agricultural production in a year.

2) Future Condition

The future agricultural condition is assessed under two(2) scenario. First, it is hypothetically assumed that no change in existing agricultural land use, though such a change to urban use is inevitable, would occur even under with project conditions of flood control and drainage facilities. Then the change in land use is superimposed in accordance with the land use and urban planning study results as summarized in Table C.1, the major indirect effect of the project.

Under the hypothetical scenario of with project, the cropping intensity is estimated to increase to 160%, with a cropped area of 23,733 ha, which is still less than the existing level for Dhaka district with 171%.

The projected cropping pattern under this hypothetical scenario is summarized below.

Future hypothetical Cropping Pattern

Pattern	Cultivated Crops	Cultivated Area		Cropped Area	Cropping Intensity
		ha	%	ha	%
Single Cropping	Boro (Local) or Boro (Improved) or Boro (HYV) or Fruits	7,273	49.1	7,273	49.1
Double Cropping	Boro (HYV) followed with T. Aman (HYV) or Rabi crops followed with T. Aus or Rabi Crops followed with T. Aman (HYV)	6,175	41.7	12,350	83.4
Triple Cropping	Rabi crops followed with Boro (HYV) and T. Aman (Improved)	1,370	9.2	4,110	27.6
Total :		14,818	100	23,733	160.1

The total annual production of major crops and other related information similar to that of Table C.2, for this hypothetical case is given in Table C.3. The cost estimation is

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made assuming that both the cost and price of per ton product will remain unchanged even in future.

As per Table C.3, the total net value added of this hypothetical agricultural production becomes about 485 million Tk. This amounts to a net gain of 96 million Tk., if land use remain unchanged, the hypothetical agricultural benefit of the project.

Nevertheless, the project is aimed at protecting both the existing and potential future urban area of Dhaka from flood damage. The potential future urban areas were identified based on the "pull area" concept developed in the Master Plan (ref. Supporting Report C on Landuse and Urban Planning).

Hence even with no project conditions, change in land use from agricultural to urban would proceed, as the major factor inducing such a change is the existing urban area of Dhaka.

As per Table C.1, the future agricultural land use in 2010 will occupy 2,452 ha against the existing area of 14,818 ha. Nevertheless, atleast a portion of retarding areas (about 70%) could also be used for agriculture, during dry season. These retarding areas have multiple potential use as illustrated in Supporting Report A. Accordingly, assuming the most critical condition with future agricultural land area of 2,452 ha, the total annual net value added of future agricultural production that will remain in 2010 is estimated at 80 million Tk.

Hence, the overall maximum annual agricultural production loss including the indirect effect of urbanization becomes 309 million Tk., in terms of total net value added agricultural production.

2.2.2 Aquaculture

In this section, fish species that occurs naturally in open water bodies is referred to as capture fishery or simply "fishery" while that is cultured artificially in ponds as culture fishery or aquaculture.

Most low lands and flood plains of single cropped agriculture are the potential open water capture fishery areas of non cropping period. The Balu river flood plain of East Dhaka is the predominant spawning grounds of open water capture fishery. The low lands of DND area also possesses considerable fishing potential.

1) Fishing system

There exist four major fishery/aquaculture systems in the objective area. They are ;

(1) River/Khal fishery

This is a year round activity carried out by professional fishermen which will not be significantly affected by the project, as the project does not interfere with river, khal networks, other than their development.

(2) Flood plain fishery

This is the fishery activity confined predominantly to the flood season and the beginning of dry season prior to crop planting in flood plains. This will be affected by the embankment as flooding itself will be prevented. This fishing activity is also conducted by professional fishermen.

(3) Beel and reservoir fishery

This is both a professional and subsistence fishing activity confined to those beels in flood plains, derelict ponds and other permanent water bodies, carried out predominantly in the dry season. This will also be affected as disappearance of flood plains and their subsequent change in land use to urban and others also means the disappearance of beels, in principle, other than those retarding areas.

(4) Culture fishery or aquaculture

This is artificial culturing of fish in fish ponds. Flood control and drainage facilities will enhance the potential of culture fishery, provided land is allocated for such purpose. At present, culture fishery is widely prevalent in DND area, which is protected from external flooding. The proposed retarding areas are potential grounds for aquaculture, an important component of their multipurpose use.

2) Fish species

A total of 86 open water general capture fish species comprising 74 fish species, 10 freshwater prawn species, and 2 crab species is identified in the priority area. In

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addition, five (5) exotic fish species are also found to exist. All cultured species are also found naturally in open waters. Of the 86 general species 25 species are identified to be commercially important. They are grouped into eight (8) categories as given below.

Commercially Important Species	
Group Name	No. of Species
Clupeoid	1
Feather back	1
Major carp	3
Minor carp	4
Cat fish	6
Snake head	3
Perches	5
Prawn	2
Total	25

3) Fish harvest

The harvest of both the capture and culture fisheries in the priority area, under existing conditions, was preliminary estimated for the survey period of six (6) months from October 1991 to March 1992. This half year period, which predominantly comprised the dry season, represents higher fish harvest but lower fish production in comparison to the other half year period that was not surveyed.

(1) Capture fishery

The total capture (harvest) of open water fishery in flood plains, beels and other internal rivers for this half year is estimated to be about 17,120 ton, with a total current market price of 742 million Tk.

Of this, the share of flood plains and beels fishery, that would predominantly be affected directly be the construction of embankment and the subsequent dry-up of fish spawning grounds, is determined to be about 11, 910 ton having a current market price of 424 million Tk. Accordingly the potential loss of capture fishery with respect to total capture by the project, within the priority area, is anticipated to be a 70% based on total quantity of harvest, but only a 57% based on current market price, for the six (6) months survey period.

However additional production loss, though indirectly due to change in land use and potential increased pollution load discharge by urban and other developments, to internal khal and irrigation canal fishery also may result in future.

The water quality aspect on aquaculture/fishery is illustrated in details, based on the baseline water quality in the proposed retarding areas, in Chapter 4 on Environmental Monitoring.

(2) Culture fishery

The survey period encompassed both the flood season and dry season harvest, which is practised twice times in a year, of cultured fishery in the priority area. The annual harvest is estimated to be about 2,500 ton, with a current market price of about 148 million Tk.

The project will enhance the potential of aquaculture in the flood protected land as in case of agriculture. However, reservation of lands for such purpose is necessary. The retarding areas are potential grounds to enhance culture fishery (aquaculture) production, as a component of multiple beneficial use.

4) Fishery Development

It is to be noted that as per Table C.1, the area of potential future water body is expected to increase to 13% (4,361 ha) from the existing ratio of 11% (3,631 ha). Hence the potential for culture fishery development is very significant, provided the water quality deterioration is controlled. Moreover, there is much room to improve the fish culturing and management technology, which is at a rather primitive stage in comparison to agriculture, in order to increase the harvest biomass.

Highly profitable species of culturing (aquaculture) are identified as follows:

(1) Freshwater fish species

(i) Family-Cyprinidae (carp)
- Labeo rohita (ruhu)
- Cirrhina mrigala (mrigal)
- Catla catla (catla)

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(ii) Family-Claridae (cat fish)
- Clarias batrachus (cat fish)

(2) Freshwater prawn species

Family-Palaemonidae
- Microbrachium rosenbergii

(3) Exotic fish species

Family-Cyprinidae
- Cyprinus carpio ver specularis (mirror carp)
- Hypopthilmichthys molitrix (silver carp)
- Ctenopharyngodon (grass carp)

Development of aquaculture/fishery technology, along with culturing the above identified and other profitable species, is recommended as a rational means to compensate the inevitable loss of open water capture fishery in the existing flood plains and low lands.

The loss of open water capture fishery can be grossly visualized from Table C.1. The projected increase in future builtup area to 80% (27,036 ha) from the existing ratio of 45% (15,400 ha) is mainly achieved by subsequent reduction in the existing flood plain area with a ratio of 35% (11,914 ha). This flood plain area (noted as annual external flood area) is not only the major spawning grounds of capture fishery but also single cropped agriculture land.

Nevertheless, this loss of flood plain area, and the accompanied fishery and agriculture resources, is insignificant from a national view point in consideration to the availability of vast flood plains around the priority area.

In fact of the master plan area of 850 km^2, the flood plains to be lost by the embankments and the subsequent change in land use are concentrated principally in the Dhaka East area only. Bulk of the flood plains, with an area of 328 km^2, of the master plan are is planned to remain intact with no significant change in land use (ref. Table C.12 of Supporting Report C, Master Plan). Guidelines of flood plain management are proposed for this area in Chapter 10 of Main Report, Master Plan.

This flood plain management area has the potential for the development of open water capture fishery, as well as agriculture. Further studies and research are recommended to enhance the productivity and harvest of fishery and agricultural resources in this area. A combined development both fishery and agriculture, simultaneously, is a field of study worth for detailed investigation.

3. Living Environment

3.1 General

An inventory study covering the whole study area of master plan of 850 sq. km, which incorporated this priority area of 340 sq. km, concerning water supply, sewerage and sanitation and solid waste management, the prime living environment aspects, has already been presented in Supporting Report F of the Master Plan study (FAP-8A).

Most of the existing piped water service area, sewered area and solid waste service area (ref. Fig. F. 1 ~ Fig. F. 3 of Supporting Report F, Master Plan), other than the Bandar area in Narayanganj East of Narayanganj Municipality and Tongi Municipality, is encompassed within the priority area of this study. Hence, a supplemental living environment study targeting the on-site sanitation aspects in the priority area of Greater Dhaka and Narayanganj (DND area and Narayanganj West) was carried out, in order to elucidate the existing sanitation condition and hence to identify its short commings and the possible means of sanitation improvement.

3.2 Sanitation in Priority Area

3.2.1 Sewerage

The existing sewered area of DWASA, that covers about 33% of Dhaka City Corporation (DCC) area of 226 sq.km, is entirely encompassed by the Greater Dhaka area portion of the priority area of this study. This sewerage system is dealt with in details in Chapter 3 of Supporting Report F, Master Plan (ref. also Fig. F. 2).

The sewerage system is estimated to serve only a 15% of the population even within its service area. Hence the whole objective area is dependent on some form of on-site sanitation system for human waste disposal.

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3.2.2 Sanitation System

The population in the objective area are presently using various alternative methods or ways of human waste disposal such as septic tank, pit latrine/leaching pit, bucket latrine, katcha latrines (make-shift latrine) and public toilets and open defecation. There are no exact data available about latrines. Most of the households with permanent housing structures are either connected to the existing sewer system (if available) or have septic tank arrangements. House holds with semi-permanent housing mostly have single pit on-set latrines or twin pit off-set latrines and katcha housing have katcha latrine or no latrine. Hence both the type of housing and sanitation system is dependent on house hold income class distribution. This socio-economic aspects of sanitation is dealt with in the subsequent section.

The various alternative on-site systems that exist in the priority area are classified into five (5) main categories principally based on their technical features. They are septic tank, pit latrine or leaching pit, bucket latrine, surface latrine and other practice. Their salient features are briefed below.

1) Septic Tank

The most complete fluid on-site system and treatment plant is the septic tank, in which the night soil from water closets (generally having piped water supply) is collected from one or more (clusters of) houses through small diameter underground pipes. In the septic tank a partial removal of wastes through anaerobic digestion processes under fluid conditions is achieved for settled solids while the effluent is drained through a soak-way or drain/infiltration field. The total annual costs of septic tanks are, generally speaking for urban core of Dhaka and Narayanganj, higher than those of a sewer system-cum-treatment plant. However, considering that the costs for the building of septic tanks is a part of the initial investment costs for the construction of a house, while constructing a sewer system as mainly an undertaking to be financed from public funds, and when such public funds are not available, septic tanks would be the practical option by those people who can afford its high cost of investment.

2) Pit Latrine

Pit latrine is widely known as leaching pit, which is essentially a covered pit dug at the compound. This pit is used to retain solid contents of night soil while the fluids infiltrate into the surrounding subsoil as the pit wall is unsealed. Solids that remain in the pit are decomposed through anaerobic digestion processes under dry conditions, in general. Mostly a pit with a volume of about 1.5 m^3 will suffice for one household for one year (Source : Bangladesh Water Supply and Sanitation Sector Study, Hasconing, 1986). Various designs for the pit latrine/leaching pit have been developed in the course of time with or without water seal, with different types of lining for the pit, with on to or set a side pit, single or twin pit arrangements and various types of superstructures, with each design having its own costs and performance advantages and disadvantages.

3) Bucket Latrine

One of the oldest methods for the collection of the nightsoil is with a bucket latrine, either situated inside the house or in the compound. Although it is not costly in construction, the emptying of the bucket has to be regular and hence very demanding and is very often accomplished in an insanitary manner. It imposes great health risks to the sweepers as it is extremely difficult to avoid direct contact with nightsoil. Although bucket latrines can be applied every where and in itself do not require any specific water supply facilities and is therefore cost widely acceptable by the users, as long as they do not do the emptying job by themselves, it is essentially an insanitary latrine.

4) Surface Latrine

Surface latrines are insanitary latrines where excreta is simply flushed to drains in immediate vicinity, though the latrine superstructure itself may be a permanent structure.

5) Other Practice

There are some other practices which are insanitary. Along ponds, streams and rivers, hang-latrines may be found, constructed above the water level and consisting of a superstructure and a floor with a hole in it. It is obvious that only flowing water courses with an adequate self-purification capacity are capable of absorbing the pollution load thus discharged / disposed.

A majority of the population still uses open areas as a place to relieve themselves. It is very clear that these "open latrines" are a serious public health hazard not to mention the pollution effects. The same goes for the hang-latrines over ponds and stagnant water courses, in this regard. However, as long as no safe low-cost sanitary alternatives are provided these practices will unfortunately continue.

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One system worth mentioning is the communal sanitation facility or public latrine. There are only a few in operation in the priority area. Experience has shown that more attention to be paid to the maintenance by an appointed care taker who is to charge for the service and to keep the facility clean. Local community participation in organizing a maintenance system would be very helpful.

3.2.3 Socio-Economic Aspects of Sanitation

No specific recent studies on sanitation condition of Dhaka or Narayanganj was conducted. As a result, no detailed information is available. However, a sanitation survey was conducted in Manikganj, a district town adjacent to Dhaka during August, 1989. The survey was carried out as a component of 18 District water supply and sanitation project by Netherlands-Bangladesh Co-operation Programme, the findings of which could be considered quite representative to both the unsewered areas of Dhaka and Narayanganj as well. Nevertheless, the data of the Manikganj town were modified to suit the local conditions to the extent possible based on the information obtained from DCC and Narayanganj Municipality.

1) Distribution of Sanitary Facility

The existing sanitary facilities and their types are related to the type of housing and hence household income levels.

The income class separation as low (poor), mid and high (rich) income levels and their respective incomes and percent of population in the priority area is given below :

Income Group According to Real Income in Priority Area

Income Class	Income (in Tk.) per month	Percentage of population
Low income (Poor)	Tk. 2,000	40%
Medium income (Middle class)	Tk. 2,000 - 8,000	30%
High income (Rich)	Tk. 8,000 to above	30%

Source : Social Formation in Dhaka City, University Press Ltd. 1990

Type of sanitary facilities used by each income group, which is also related to type of housing, along with the percentage of population in Greater Dhaka is given below:

Sanitary Facilities According to Income Group - Greater Dhaka

Income Group	House Type	Facility	Percent Population
High & Medium	Pucca	Sewerage	15%
High & Medium	Pucca	Septic Tank	40%
Low & Medium	Semi-pucca	Pit Latrine	15%
Low	Katcha	Bucket Latrine and Others	30%

Source : Based on Water Supply and Sanitation Sector in Bangladesh. UNDP, 1991 (a proposal for future strategies)

Information to an extent to that of the above table could not be determined for Narayanganj Area. However, a distribution of sanitation facility according to housing type is estimated as given below.

Facility	Percent(%) user according to housing
Septic tank	Pucca Housing - 20% Semi-pucca housing - 15% Katcha housing - 0%
Pit latrine	Pucca housing - 80% Semi-pucca housing - 60% Katcha housing - 24%
Bucket latrine and others	Pucca housing - 0% Semi-pucca housing - 25% Katcha housing - 76%

From the above tables it could be concluded that in general high and medium income people have access to acceptable sanitary facilities like septic tank and pit latrine/leaching pit.

A general definition of Pucca, Semi-pucca and Katcha housing is as follows:

Pucca house : House having R.C.C. roof with brick wall and cement floor.

Semi-pucca house : House having brick wall and cement floor with tined roof.

Katcha house : A house made of bamboo or wood having earthen floor with tined roof or thached roof.

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2) Construction Cost of Sanitary Latrine

The cost of a surface latrine, a pit latrine and a septic tank on average for installation and construction as reported by the above 18 Town Water Supply and Sanitation Project is given below:

Surface water latrine	-	Tk. 112
Pit latrine	-	Tk. 2,301
Septic tank	-	Tk. 9,600

Users satisfaction of the three majors sanitation facilities is determined to be as follows:

Surface water latrine	-	15%
Pit latrine	-	70%
Septic tank	-	100%

3.2.4 Operation and Maintenance

DWASA is responsible only for operation and maintenance of sewerage while DCC is responsible for all other sanitary facilities in Dhaka. In Narayanganj as there is no sewerage, municipality is the sole responsible organ for operation and maintenance of sanitary facilities. Due to improper operation and maintenance sewer line is blocked and broken in various places. There are even sewage disposal points towards low lands other than the designated Pagla Treatment Plant and are not at all maintained. Most of the septic tanks are broken and full of sludge and also many street manholes are blocked and without lid. Some even abandoned. Cleaning is mostly done by hired sweepers. The frequency of cleaning is very irregular hence it is difficult to relate it to the sanitation facility.

It is understood that atleast 50% of the septic tanks and pit latrine are never desludged. Mostly hired cleaners do the desludging job. The average amount people pay to get their latrine or septic tank desludged/emptied is in the range of Tk. 300/ = and Tk. 400/=.

3.2.5 On-going Sanitation Improvement Projects

The feasibility study was undertaken by ADB / UNDP under a sub-contract to the Housing Development Project (HDP) in 1985. The HDP is within the Urban Development Directorate of the Ministry of Works. The study comprised two study components namely Subcontract A and Subcontract B. Location of these study areas are as follows:

- Subcontract A, the old Dhaka project, involves the upgrading and development of sections of the oldest part of of the city.

- Subcontract B, the Mirpur project, concentrates on the development/improvement of new urban areas in Mirpur, a relatively modern part of the city .

1) Sub-contract 'A' (Housing Development Project, Old Dhaka)

Project area covers Shaheednagar, Islambag and Rasulpur in Old Dhaka. One of the most obvious problems within the project area is the poor sanitary facilities. The situation is aggravated by the absence of sufficient drainage facilities for stormwater and sullage water from the house holds. Though DWASA sewer encompasses the whole project area, the sewerage coverage is not very significant. In general, a very small part of the population has proper sanitary facilities such as sewerage, septic tanks, pit latrines. Due to very poor maintenance (desludging) even these facilities do not function satisfactorily. Appropriate water seal latrines are few in number and are mainly located in pucca houses along the main paved access roads. Some times the septic tank are shared with other households.

The majority of the population who are slum dwellers rely on katcha latrines or hang latrines (make-shift latrine) without water seal and mostly built above ponds, ditches or the river. This project is aimed at improving this deteriorated living conditions among low income communities in Islambag, Shaheednagar and Rasulpur. The project is targeted for completion by 1996 to 1997 in the name of "Environmental Improvement Project" sponsored by LGRD and Co-operative local government division, with the technical assistance of UNDP. The executing and operational agency is DCC. The project has several components namely sanitation, community development, water supply, roads and footpaths, local drain improvement and khal rehabilitation.

Under the sanitation component 3,690 twin pit pour-flush latrines, 980 single pit latrines and 826 communal latrines to be constructed in the project area. According to DCC, the implementation phase will commence in 1992.

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The mechanism of cost recovery envisaged for the sanitary facilities to be provided is given below.

Single Pit Latrine

Total cost per unit (excluding superstructure) is Tk. 3,500.00. This will be recovered by installment payment of Tk. 105.00 per month in 3 years

Twin Pit Latrine

Total cost per unit (excluding superstructure) - Tk. 5,000.00. Recovery by installment payment - Tk. 150.00 each month in 3 years

2) Subcontract 'B' (Housing Development Project, Mirpur).

An extensive septic tank waste disposal system exists in the project area of Mirpur as reported by the Housing and Settlement Directorate. The effluent from these septic tanks is discharged to lowland open areas through a piped sewer system with several outlets.

Low income groups mainly use insanitary facilities, though some use pit latrines. Approximately 25% of these people use open areas for human waste disposal and remaining 75% use some form of facility which is mainly open pits, including some shared arrangement.

According to Appraisal Report by ADB in 1988, the existing sewered area at Mirpur discharges its wastewater through 9 disposal points towards low-lying areas.

In order to improve the living condition of Mirpur, this Subcontract 'B' proposes, small bore sewer, infill development (land reclamation for new housing), basic infrastructure improvement like water supply, sanitation, gas, electric supply and solid waste disposal etc. The project will be implemented until 1994 under the name of Dhaka Urban Infrastructure Development Project with ADB finance.

There are three major components namely small bore sewer, infill development, roads and footpaths improvement to be executed by WASA, HSD and DCC respectively. Small bore sewer component,which includes construction of 123 km of new sewer lines with 5 pump stations, is aimed at both the rehabilitation and expansion of the existing sewered area. Even after the project implementation wastewater will be discharged untreated towards low-lying areas, which is not appropriate on a long term basis.

3.2.6 Sanitation Improvements Measures

The existing sanitary conditions and the available facilities and their operation and maintenance are very unsatisfactory in Dhaka. This is particularly so with the low income population living in makeshift (Katcha) housings as emphasized in the foregone sections.

The priority actions necessary for the improvement of sanitation are itemized below. They are elaborated in details under the FAP-8B comprehensive environmental management plan.

1. Organizing a public sector based scheme by the local authority like DCC/DWASA, Municipality for desludging, transport and sanitary disposal of septic tank sludge.

2. Provision of twin leaching pit toilets, if necessary at a subsidized rate atleast on a communal basis as public toilets, for low income population with markeshift or no toilet facilities.

3. Conversion of bucket latrines that remain into twin leaching pit type toilets and prohibition of construction of bucket latrines for new housings by the local authority concerned.

4. Education and campaign to increase the awareness of general populance on the importance, means, and benefit of mitigating fecal-oral transmission of disease by adopting sanitary practices and customs.

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3.3 Impact on Living Environment

The project in itself has only beneficial effects on living environment as flood mitigation and drainage measures contribute to public health improvements.

However, as the project is aimed at future urban development as its prime objective, the prime effects/demands that would be generated by future population increase in the priority area is determined as done in the case of Master Plan study (ref. Table F. 13 of Supporting Report F, Master Plan).

The basic living environmental demand parameters considered are potable water requirement, pollution load generation and solid waste generation by the inhabitants.

Employing the same criteria as used in the Master Plan study of Supporting Report F, the potable water demand in the priority area in 2010 is determined to be 1300 MLD, an average annual increase of 14.8% from the existing demand of 438 MLD in 1990.

The pollution load generation is estimated to increase to 260 ton BOD_5/day from the existing one of 110 ton BOD_5/day, with an average annual increase of 12.3% while, the solid waste generation in 2010 is estimated at 5075 ton/day against the existing one of 1880 ton/day in 1990, with an average annual increase of 13.5%.

The necessary means to meet these demands shall be taken up with progressing urbanization in the form of future water supply, sewerage and sanitation and solid waste management development programs.

4. Environmental Monitoring

4.1 Significance of Retarding Area

In the feasibility study, the priority monitoring requirement that would be generated by the implementation of the project in the whole priority area of 340 sq.km is identified.

The proposed retarding areas of internal drainage and subsequent pumping are identified to be the most comprehensive future environmental monitoring stations of water quality, though they alone may not be sufficient. This is due to the fact that a retarding area would be temporary storage location of the whole surface run-off from the drainage basin concerned. Such surface run-off include the pollution load run-off due to all human and other related concerns such as domestic, institutional, industrial, agricultural and other activities.

Accordingly, the base line water quality under the existing conditions in the proposed retarding areas were monitored both during flood season (October 1991) and dry season (February 1992) at fifteen (15) locations. The sampling locations are shown in Fig. C. 1. The water quality parameters measured respectively in field and in laboratory are the same as those of master plan study and itemized below.

(1) Field measurement : Temperature, Colour, Odour, Turbidity, PH, Electric Conductivity (EC) and Total Dissolved Solids (TDS).

(2) Laboratory measurement : Suspended Solids (SS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Organic Nitrogen (Org-N), Ammonia Nitrogen (NH_4N), and Fecal Coliform Density (FC).

The results of water quality analysis both during flood season and dry season is summarized respectively in Table C.4 and Table C.5.

4.2 Water Quality Evaluation

4.2.1 Basic Consideration

The baseline water quality conditions as measured both during flood and dry seasons in the proposed retarding areas were evaluated based on the important beneficial uses of aquaculture (fishery), irrigation and other water contact activities.

The criteria of evaluation is described in Supporting Report F, Master Plan (ref. Chapter 6).

It is to be noted that though most proposed retarding areas are just low lands and yet to serve their purpose, still three (3) sampling locations in Dhaka West of FAP-8B project area, namely, location No. 12, 13, 14 of Fig. C.1, already function as defacto retardings areas to some extent due to the existence of the DFPP embankment constructed by GOB after the 1988 floods. However, the drainage pump facilities are yet to operational. Hence the present condition, also the condition during the time of both sampling, reflects neither without nor with project state.

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This precarious situation and its environmental implication is documented in previous reports, notably, the Progress EIA Report by DOE in 1990 and the FAP-8B Feasibility Report of 1991, and is not reproduced here. However the situation will be rectified with the implementation of FAP-8B project.

Moreover, all the six (6) number proposed retarding areas in DND, as the whole area is enclosed by polder under existing condition, already serve their purpose unintentionally to some extent. They are drained by the single irrigation cum drainage pump facility of the DND project in Demra.

Nevertheless, as long as the land use of this DND area remain predominantly agricultural without much urban and industrial use, the water quality aspect need not require much consideration unlike Dhaka West and the southern portion of Dhaka East at north of DND area. Still there are jute milling industry predominantly in Narayanganj, and also in DND area, the major source of pollution generation in these areas.

The southern portion of Dhaka East area, which is proposed to be enclosed with compartments DC-4 and DC-3 as per the flood mitigation plan (ref. Fig. B.12 of Supporting Report B), drains also the drainage related area of Dhaka West via Segunbagicha and Begunbari Khals.

This drainage related area of Dhaka West includes both highly urbanized and industrialized areas of Motigheel and Tejgaon and the high-class residential areas of Dhanmondi, and Banani-Gulshan.

Hence the major contributor of pollution load discharge into the southern portion of Dhaka East, under the existing condition, is the above drainage related area of Dhaka West. While the pollution load generated within this Dhaka East area is yet to be significant.

Detailed information on the drainage aspects of Dhaka East and DND could be referred to respectively in Chapter 3 and Chapter 4 of Supporting Report E.

4.2.2 Evaluation

This 15 sampled locations (ref. Fig. C.1) covered a portion of the retarding area of the proposed project, two (2) locations in Narayanganj West (No. 1 and No.4) four (4) locations in DND area (No. 2~3, No. 5~6), five (5) locations in Dhaka East (No. 7~11), all in Balu River flood plain, and four (4) locations in Dhaka West (No. 12~15).

As expected, in an overall sense critical condition in water quality occurred under dry weather flow conditions, in dry season, during which the major composition of run-off is wastewater discharge.

However, in some specific instances rainy season water quality may be deteriorated than that of dry season, in low lying areas. This is because pollutants, that would otherwise be retained in or near the point of their generating source during dry season, are get washed off due to the availability of large quantity of rain-fall run-off as their carrying agent.

Water quality wise, if not quantity wise, all the sampled water bodies in rainy/flood season, except that of Shasongaon pond of Kashipur belonging to Narayanganj West region of the project (location No. 1 in Fig. C.1), are found to be suitable for all beneficial use including as a source of potential water supply with treatment.
Leachete run-off from nearby solid waste dump site of Shasongaon pond, which the pond water body itself encompassed in rainy season but not in dry season, was suspected to be the possible cause of the much deteriorated rainy /flood season water quality in comparison to that of dry season (ref. Table C.4 and Table C.5). The flood season sampling results indicate a virtual anaerobic condition, while that of dry season a normal unpolluted water body.

Moreover, a complaint of industrial pollutant run-off during rainy season from milling industries, affecting the water quality of Nayamati bil in DND area (location No.2), was made by local residents. It was reported that both the water and the captured fish in this bil taste bitter in rainy season, but not so in dry season.

It should be emphasized that all proposed retarding areas of Dhaka East (sampling location No. 7~11) are a large sheet of navigable water body, virtually a portion of Balu River, during rainy/flood season. This vast dilution and pollution wash-off effect of the river is responsible for the excellent flood season water quality of these locations in comparison to that of dry season. Also this "benefit" of annual flushing of pollution by the river will disappear with the construction of embankments, which would be further exacerbated by subsequent urban and other developments, unless the necessary pollution control measures targeting the sources of pollution load generation are

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undertaken. However, the drainage pumping facility will beneficially contribute by reducing the retention of polluted water in the retarding area, to some extent.

Such pollution control measures to tackle the already existing urban and industrial area in Dhaka West, even with the existence of sewerage system, is far from adequate. This is amply demonstrated by the extremely poor dry season water quality, exhibiting anaerobic condition, in all major khals carrying the city run-off, rendering them unsuitable for any beneficial use.

The dry season sampling results of Keodanga bil and Trimohani khal (location No. 7 and 8 of Fig. C.1 and Table C.5), which receive their run-off respectively via Segunbagicha cum Gerani khal from Motigheel commercial area, and Begunbari cum Gerani khal from almost the whole commercial and industrial area (Tejgaon), both of Dhaka West, is sufficient to justify the above point. Similar condition were also noted during water quality sampling for Master Plan (ref. the dry season sampling results for location No. 15, 16 and 21 of Table F.10, Supporting Report F of Master Plan).

Finally, the baseline water quality of the following eight (8) sampling locations are assessed to be suited for all major beneficial use, including aquaculture/fishery, on a year round basis, based on both the analysis results of rainy/flood and dry seasons.

Location No. 2 - Nayamati bil in DND area
Location No. 3 - Kadamtoli pond in DND area
Location No. 4 - Shimrail pond in Narayanganj West area
Location No. 5 - Matuail khal in DND area
Location No. 6 - Pagla pond in DND area
Location No. 9 - Gazaria bil in Dhaka East area
Location No. 10 - Baraid Bazar pond in Dhaka East area
Location No. 11 - Dhamaahl bil in Dhaka East area

The water bodies of best water quality are identified to be location No. 9 and No. 11, both of which are rural remote locations of Dhaka East.

4.3 Recommendation on Monitoring

Institution of stream water quality monitoring station in the retarding areas, in the internal drainage channels (Khals) leading to those retarding areas and in the Balu-Lakya River, as required, would become necessary with the implementation of this

FAP-8A F/S project in Dhaka East, DND and Narayanganj West and the progressing urban, industrial and other developments. This will assist in formulating and implementing the necessary pollution control measures abreast the change in land use.

The parameters of monitoring shall be decided based on the inventory data of the existing sources of pollution load generation due to human living environment, industry and agriculture. However, it is strongly recommended to monitor atleast all those living environment related water quality parameters, as measured by the Study Team, listed in Section 4.1. Additional parameters may be decided depending on the type of other industrial and agricultural activities in the drainage basin concerned.

The frequency of monitoring will depend on the degree of time series variation in water quality, but a minimum frequency of two (2) times a year, once each during dry season (December ~ February) and rainy season (July ~ September) is recommended in order to account for the maximum annual deviation in water quality.

Priority monitoring locations are the two (2) retarding areas of FAP-8B project (location No. 13 and 14 in Fig C.1) and the related khals, namely, Ibrahimpur Khal and Kalyanpur Khal of Dhaka West, Begunbari Khal in Dhaka East at down stream of Rampura, and river water quality in Balu River, preferably upstream of Balu ~ Lakya confluence in Demra. These are the most urbanized and fast urbanizing reaches of Dhaka city, at present.

It is also recommended to monitor for industrial pollutants, in Begunbari khal at Rampura, as it carries run-off from Tejgaon industrial area as well.The parameters shall be decided based on the inventory of industrial activity in this area.

It is worth to mention that for a small and confined basin like DND and Narayanganj West, monitoring the water quality in some selected retarding areas only would suffice for an overall assessment of both the pollution load discharge as well its run-off. However, for large basins like those of Dhaka West and East, monitoring of water quality in some related internal drains (khals) in addition to those retarding areas would be required due to the potential deviation between pollution load discharge at urbanized/industrialized upstream reaches and its run-off to retarding areas at downstream.

Finally, it is to be emphasized that monitoring in itself is just a data collection process. Unless the derived data are translated into action programmes by the agency concerned,

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DOE, to identify and regulate the polluters, it has the danger of manifesting as a worthless effort of resource wastage. Moreover environmental improvement measures do not always require monitoring results to justify the required action, as already pointed out in Section 9.2 of Supporting Report F, Master Plan.

Urban and industrial pollution control measures are the only means to render the internal drainage channels (khals) and retarding areas to be suited to a varriety of beneficial use. Otherwise, they would simply serve as pollution transport, storage and discharge locations.

5. Environmental Effects

Environmental effects by the project will be predominantly beneficial though adverse to some extent. Specifically adverse effects would be social in nature that is felt by the immediate concerns in the vicinity of project implementation, such as those population displaced in making way for the project facilities and others.
These effects would be both of short term and long term and caused directly and indirectly by the project. Such effects are delineated below.

However, it is emphasized that the benefits expected by the project implementation is overwhelming, for both the existing and future urban area of Dhaka, and the anticipated adverse effects in no way could justify the vice-versa. A comprehensive evaluation of the project is shown in Table I.11 of Supporting Report I.

5.1 Beneficial Effects

Major beneficial effects of short and long term realized by the project are summarized below.

5.1.1 Short Term

1) Employment opportunity

Employment opportunities will be generated for construction works. This is considered a short term benefit as it would disappear with the completion of construction activities. In order to maximize such employment opportunities labour intensive methods are adopted as far as possible. Also technical training opportunities on design and construction technology are availed of for engineers

/ technocrats. The total man-year of construction activity, covering Dhaka East, DND and Narayanganj West project components of this feasibility study, is estimated at 66,513.

5.1.2 Long Term

1) Flood damage mitigation

Mitigation of flood damage to properties, facilities and other economic activities will be realized, the basic reason for this project formulation. Also psychological stress and flood induced displacement of people will be eliminated. The population saved from inundation in the year 2010 from a 1988 year scale floods in the F/S area is estimated to be about 5.3 million. This is almost the existing (1990) population in the whole priority area of Greater Dhaka and Narayanganj (ref. Table C.1).

2) Enhanced land use potential

Enhanced land use potential of flood free lands for urban, institutional, industrial and agricultural uses would be realized. This will be reflected by increased land value. The land availability for multipurpose use, excluding those of water bodies and retarding areas, would increase to about 26,000 ha in 2010 from the existing area of about 18,300 ha.

3) Public health improvement

Public health improvement by mitigation of cross contamination of water resources inherent to flooding, and the resultant waterborne epidemics is very significant. Flood mitigation would also facilitate the applicability of on-site sanitation/human waste disposal means such as pit latrine/leaching pit.

The additional economic loss due to waterborne disease caused by 1988 floods is estimated to be Tk. 75.7 million. Both this loss and hence the benefit of its mitigation by the project will increase with increasing population.

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4) Generation of employment

Permanent employment along with technical training opportunities for operation and maintenance of the flood control and drainage facilities will be generated. In consideration to the long term nature of operation and maintenance requirements of the projects facilities constructed, the O/M related employment is assessed to be a long term benefit.

5.2 Adverse Effects

Significant adverse effects of short and long term are given below.

5.2.1 Short term

1) Severance

Severance in general implies inconvenience or difficulties which may be physical or psychological in nature experienced by those who are well adapted to the way of living under the conditions without project and are forced to re-adapt to the change in way of living imposed by the project.

Such severance effects by the construction of embankment flood/wall are as follows:

Interference to accessibility due to embankment / flood wall between the protected and unprotected area. This in effect means separation of communities. However, in case the embankment is along riverine area this effect is lessened as river itself separates the community. Interference to accessibility to ones property due to flood walls is also a severance effect.

It is to be noted that a future effective transport network system utilizing the embankments as roads would contribute to the enhancement of accessibility, far out weighing the short term severances.

2) Navigation

Passenger and material transportation by boats is widely prevalent in East Dhaka Balu River flood plains, particularly, during flood season.

In the absence of any all weather land based road link between Balu River and Rampura-Biswa Road such a water based transportation is more a necessity than an option.

With the implementation of Balu River flood mitigation embankments and the subsequent urbanization a more efficient road based transport network would be developed as the alternative link. The sub-embankments of compartmentalization are major potential future link roads. This change over to road transportation will be beneficial to the national economy.

However, this change over from water based to road based transportation may be detrimental to the livelihood of the boatmen engaged in this trade under the existing conditions. In order to assess the significance of this social impact on boatmen, the study team conducted an interview survey with toll collectors at eleven (11) major boating terminals of Dhaka East in November, 1991. The results revealed that 2625 person are employed by this boating business in East Dhaka. The survey is dealt with in details under social impacts in Supporting Report I.

Though this social impact may be significant as far as these boatmen are concerned, still the alternative road transportation development would open a more lucrative multiple employment opportunities than boating. Some of these people may be forced to this boating business, under the existing flooding conditions, in the absence of a suitable alternative employment opportunity.

Moreover, a compartmentalized development of flood protection embankments in stages, as proposed for East Dhaka having four (4) cells, would facilitate a gradual change over from water based to land based transportation with both functioning concurrently during the initial development stages. This would help in moderating the social impacts on those boating employed persons by providing a time frame to switch over to alternative employment, and hence an orderly adaptation to the environmental change.

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3) Construction effects

The major construction activities involves earthen embankment by filling and compaction, khal improvements such as excavation and widening and pump stations.

The significant effect will be vibration and noise pollution and to some extent air pollution due to dust by the construction activities. However, embankment construction is widely practised in Bangladesh, and the major embankment sites along Balu river and the retarding areas of pump stations are rural areas which means these effects will not be very significant.

However some khal reaches of improvement are in urban areas, where such works would interfere with human actives. Furthermore, excavation and other earth works would temporarily raise the turbidity of khal water, affecting the water quality. Nevertheless, as most khals are polluted as per their base line conditions, these added short term effects may not be significant. In order to minimize interference with human activities night time work schedule may be adopted, if necessary.

5.2.2 Long Term

1) Resettlement

Resettlement of population and other facilities like factories displaced by land acquisition and the subsequent demolition of houses and other buildings for the project facilities like embankments and khal improvements is an important negative social impact of the project. This is considered to be relatively long term in consideration to the movement and the subsequent adaptation involved by those moved.

Duly recognizing the social significance of this involuntary displacement of those people whose houses would be demolished to make way for the construction/ improvement of embankment/khals, a sampling questionnaire survey was conducted by the study team in December 1991 targeting the would be displaced residents, in order to get to know their psychological/mental perception regarding displacement. The survey covered residents of 61 would be acquired houses located en route to the proposed embankment along Balu River in Dhaka East.

The analysis results of the sampling survey is elaborated in details under social impacts in Supporting Report I.

A majority of the residents surveyed, about 70%, had no objection to displacements provided they received adequate compensation to venture into a "new life". It also became clear that most residents expect house compensation be higher than current selling value of house, reflecting their anxiety of being forced to build a new house costing more than the current value of house. Such a higher expectation of compensation for building a new house is reasonable from a sociological view point so that those displaced would not end up as slum dewellers as happened in the past with most resettlers in many developing countries.

Accordingly, a per building compensation costs of Tk. 40,000 is assumed against the estimated current value of Tk. 30,000 by by the Study Team, based on this interview survey results.

The total population to be resettled due to the implementation of this FAP-8A feasibility study in Dhaka East, DND and Narayanganj West is estimated at 7000. The total amount of compensation of house and other buildings becomes Tk. 328 million. This cost is incorporated as a negative benefit by the project in the cost-benefit analysis (ref. Supporting Report I).

2) Living environment

This is a major indirect consequence by the project, due to subsequent urbanization and the resultant potable water demand, pollution load and solid waste generation by the increased population. The mitigatory measures are the provision of such basic public health amenities in future. In this regard, the water quality monitoring of retarding areas would also help in assessing the change in condition with respect to pollution load generation and the required action with progressing urbanization.

These living environmental demands are quantified in Section 3.3.

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3) Change in land use on ecology

The existing agricultural and open water capture fishery lands, other than those retarding areas, would be changed to urban use in principle, another indirect consequence. Nevertheless, agricultural productivity and culture fishery will be enhanced in the flood protected lands, provided land is reserved for such uses. The retarding areas are suited for such uses atleast during dry season.

As evident from Table C-1, the agricultural land use in the priority area will decrease from 43.5% in 1990 to just 7% in 2010, resulting in a loss of 12,366 ha of agricultural land to urban use, an inevitable indirect consequence of this project. This loss in financial terms, as total net value added loss of agricultural production, is estimated at 309 million Tk. (ref. Section 2.2.1).

Moreover terrestrial homestead floral species and terrestrial domestic faunal species will become predominant with progressing residential development at the expense of both the aquatic floral and faunal species, and terrestrial faunal species of wild origin.

However, in consideration to the availability of vast flood plains around the priority area and their high cropping intensity in comparison to the priority area that includes the flood plain management area of Master Plan, effects of change in land use to urban in the priority area is assessed to be not very significant, not only with respect to both the agriculture and open water capture fishery of productive ecological elements but also the general elements of flora and fauna.

Table C.1 Existing and Future Condition in Priority Area

Existing Condition in 1990

Item	Land Area (ha)	Builtup Area (ha)	Agriculture Area (ha)	Water Body (ha)	Annual Flood Area (ha) *		Population in 1990
					External	Internal	
Dhaka West	14,445	9,601	2,367	2,477	3,959	597	3,804,494
Dhaka East	11,862	2,313	8,814	735	7,850	417	637,500
DND	5,679	2,174	3,173	332	0	410	448,590
Narayanganj West	1,863	1,312	464	87	111	87	470,449
Total	33,849 (100%)	15,400 (45%)	14,818 (44%)	3,631 (11%)	11,914 (35%)	1,511 (4.4%)	5,361,033

Future Condition in 2010

Item	Land Area (ha)	Builtup Area (ha)	Agriculture Area (ha)	Potential Water Body (ha)	Retarding Area (ha)	Population in 2010
Dhaka West	14,445	12,496	602	1,347	980	6,385,301
Dhaka East	11,862	8,550	1,310	2,002	1,675	2,201,935
DND	5,679	4,270	532	877	682	1,313,749
Narayanganj West	1,863	1,720	8	135	128	926,820
Total	33,849 (100%)	27,036 (80%)	2,452 (7%)	4,361 (13%)	3,465 (10%)	10,827,805

* All flood condition refer to that of before 1988 floods - prior to DFPP embankments.
Internal flood area represents area flooded in built-up area.

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Table C. 2 Existing Crop Production in Priority Area (1991)

Crop	Cropped Area (Ha)	Yield (Ton/Ha)	Total Production (Ton)	Production Cost			Market Price		
				Cost/Ha (Tk.)	Cost/Ton (Tk.)	Total Cost (1000 Tk.)	Price/Ha (Tk.)	Price/Ton (Tk.)	Total Price (1000 Tk.)
1a Boro (L)	983	1.90	1868.0	6,200	3,263	6094.6	12,827	6,750	12609.0
1b Boro (HYV)	10,545	3.50	36908.0	10,700	3,057	112831.5	23,170	6,620	244331.0
1c Boro (Imp.)	2,040	2.70	5508.0	7,300	2,704	14892.0	18,225	6,750	37179.0
1d T. Aus (HYV)	340	2.90	986.0	8,800	3,035	2992.0	21,141	7,290	7187.9
1e T. Aman (HYV)	4,605	3.30	15197.0	8,300	2,515	38221.5	24,058	7,290	110786.1
1f T. Aman (Imp.)	1,350	2.87	3875.0	6,100	2,125	8235.0	21,313	7,425	28771.9
1. RICE	19,863	3.24	64342.0	9,227	2,848	183266.6	22,195	6852	440864.9
2. WHEAT	130	0.80	104.0	5,600	7,000	728.0	8,320	10,400	1081.6
3. POTATO	185	12.40	2294.0	12,800	1,032	2368.0	66,960	5,400	12387.6
4. OIL SEEDS	850	0.50	425.0	3,300	6,600	2805.0	5,400	10,800	4590.0
5. PULSES	290	0.69	200.0	3,200	4,640	928.0	21,035	30,500	6100.0
6. VEGETABLES	1,085	19.20	20832.0	8,500	443	9222.5	96,000	5,000	104160.0
7. FRUITS	60	27.00	1620.0	-	-	-	324,000	12,000	19440.0
TOTAL	22,463	4.00	89817.0	8,873	2,219	199318.1	26,204	6,554	588624.1

Note : HYV - High yielding variety, L - Local variety, Imp. - Improved variety
Source: JICA, DND Project, BARC

Table C. 3 Future Hypothetical Crop Production in Priority Area

Crop	Cropped Area (Ha)	Yield (Ton/Ha)	Total Production (Ton)	Production Cost			Market Price		
				Cost/Ha (Tk.)	Cost/Ton (Tk.)	Total Cost (1000 Tk.)	Price/Ha (Tk.)	Price/Ton (Tk.)	Total Price (1000 Tk.)
1a Boro (L)	450	1.90	855.0	6,200	3,263	2789.9	12,825	6,750	5771.3
1b Boro (HYV)	10,698	4.10	43862.0	12,534	3,057	134086.1	27,142	6,620	290366.4
1c Boro (Imp.)	1,740	2.80	4872.0	7,571	2,704	13173.9	18,900	6,750	32886.0
1d T. Aus (HYV)	520	3.00	1560.0	9,105	3,035	4734.6	21,870	7,290	11372.4
1e T. Aman (HYV)	5,655	3.80	21489.0	9,557	2,515	54044.8	27,702	7,290	156654.8
1f T. Aman (Imp.)	1,370	2.87	3932.0	6,099	2,125	8355.5	21,310	7,425	29195.1
1. RICE	20,433	3.75	76570.0	10,629	2,836	217184.8	25,755	6,873	526246.0
2. WHEAT	150	1.25	188.0	8,773	7,000	1316.0	13,035	10,400	1955.2
3. POTATO	205	13.25	2716.0	13,673	1,032	2802.9	71,543	5,400	14666.4
4. OIL SEEDS	1,010	0.85	859.0	5,613	6,600	5669.4	9,185	10,800	9277.2
5. PULSES	370	0.70	259.0	3,248	4,640	1201.8	21,350	30,500	7899.5
6. VEGETABLES	1,505	19.50	29348.0	8,639	443	13001.2	97,502	5,000	146740.0
7. FRUITS	60	27.00	1620.0	-	-	-	324,000	12,000	19440.0
TOTAL	23,733	4.70	111560.0	10,162	2,162	241176.1	30,600	6,510	726224.3

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Table C. 4 Flood Season Water Quality Sampling Results in Retarding Area (Oct. 1991)

Location		PH	EC	TDS	SS	DO	BOD	COD	Org - N	NH_4-N	FC
No.	Description		(Umho/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(No./100ml)
1	Shasongaon Kashipur	7.7	397	156	52	0.6	37	84	1.3	1.2	1.4×10^4
2	Nayamati Bil	7.0	260	134	34	4.9	0.8	16	0.7	1.0	7.1×10^3
3	Kadamtoli Pond	7.0	220	112	28	5.8	2.9	20	1.1	1.1	3.5×10^2
4	Shimrail Pond	7.2	190	97	26	2.9	4.0	8	1.4	1.3	1.0×10^4
5	Matuail Khal	7.0	120	64	32	3.1	5.7	12	0.7	1.4	9.0×10^4
6	Pagla Pond	7.0	380	193	42	2.3	8.5	20	1.1	1.1	1.3×10^3
7	Keodanga Bil Manda	7.0	167	84	26	7.4	4.2	24	1.8	0.2	9.0×10^3
8	Trimohani Khal	7.6	113	57	23	7.9	4.0	14	0.8	1.0	4.4×10^3
9	Gazaria Bil Mad	7.0	71	30	18	4.3	3.9	16	1.0	0.2	$<1.0 \times 10^2$
10	Baraid Bazar Pond	7.0	51	26	20	7.5	2.0	20	1.7	0.9	2.0×10^4
11	Dhamaahl Bil	7.3	49	25	15	7.1	2.0	12	1.2	0.1	8.0×10^3
12	Alakdi Khal Mirpur-12	7.1	166	83	32	5.1	0.7	16	1.6	0.5	2.5×10^3
13	Agunda Bil Mirpur-1	7.0	94	47	18	4.9	2.0	8	1.7	0.2	7.0×10^2
14	Gabtoli Bus Station Pond	6.9	218	109	32	5.8	4.0	12	2.0	1.5	5.7×10^3
15	Kamrangir Char	7.0	91	48	33	5.8	1.3	12	1.5	2.3	2.0×10^4

Table C. 5 Dry Season Water Quality Sampling Results in Retarding Area (Feb. 1992)

Location		PH	EC	TDS	SS	DO	BOD	COD	Org - N	NH_4-N	FC
No.	Description		(Umho/cm)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(mg/l)	(No./100ml)
1	Shasongaon Kashipur	7.0	406	203	42	4.4	1.0	12	1.1	0.4	2.2×10^{2}
2	Nayamati Bil	7.4	107	536	92	2.3	15	36	1.1	1.0	8.0×10^{2}
3	Kadamtoli Pond	7.3	480	239	52	6.0	2.9	12	1.1	1.5	7.0×10^{4}
4	Shimrail Pond	6.8	751	375	53	5.0	2.0	8	0.9	0.3	3.0×10^{4}
5	Matuail Khal	7.2	777	389	95	3.6	12	27	0.6	1.8	1.0×10^{2}
6	Pagla Pond	7.6	543	272	42	6.1	1.4	16	0.7	0.4	1.4×10^{3}
7	Keodanga Bil Manda	7.2	328	263	110	0	50	125	1.0	24.0	$1.8\ 10^{6}$
8	Trimohani Khal	7.6	261	230	105	0	55	175	1.9	18.5	2.7×10^{6}
9	Gazaria Bil Mad	7.0	394	197	88	4.6	2.4	12	0.5	0.2	8.0×10^{2}
10	Baraid Bazar Pond	7.0	382	191	45	6.1	0.7	8	0.6	1.5	1.2×10^{3}
11	Dhamaahl Bil	7.2	133	64	49	5.9	0.3	4	0.6	1.0	6.0×10^{2}
12	Alakdi Khal Mirpur-12	7.3	265	132	100	1.4	15	42	1.2	0.7	3.5×10^{4}
13	Agunda Bil Mirpur-1	6.9	785	392	24	7.1	1.6	8	0.4	4.3	1.4×10^{3}
14	Gabtoli Bus Station Pond	7.3	851	425	43	3.4	12	45	1.4	6.0	4.0×10^{2}
15	Kamrangir Char	7.4	558	279	22	2.7	7.7	10	0.4	15.5	3.0×10^{4}

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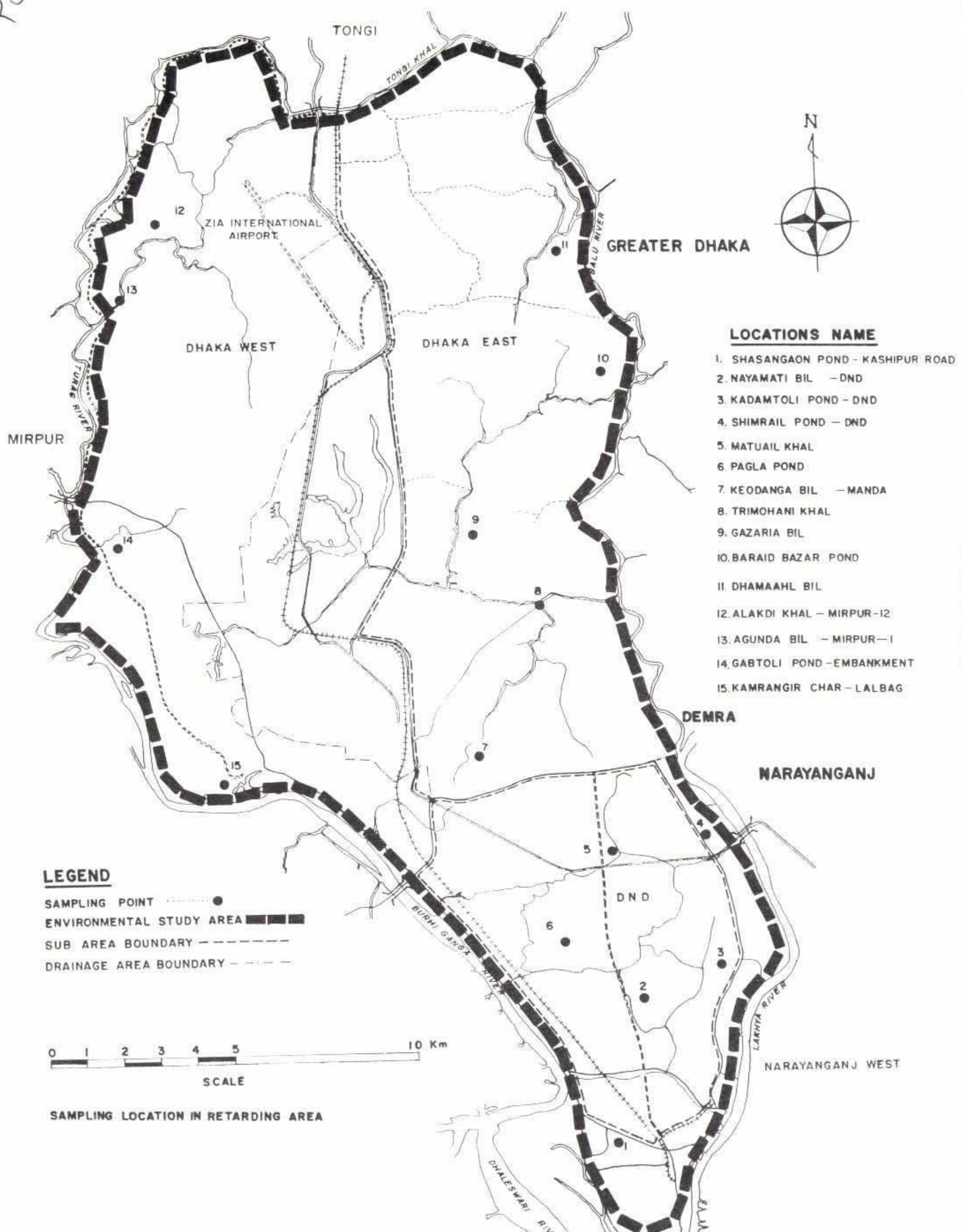

FIG. C. 1 WATER QUALITY SAMPLING LOCATION IN PRIORITY AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

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SUPPORTING REPORT D
METEOR-HYDROLOGY

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SUPPORTING REPORT D : METEOR HYDROLOGY

1. General

As the feasibility area (the study area) is included in the master plan area, meteorological and hydrological descriptions in this report overlaps that of the Master Plan Report. Furthermore, supplemental water level data are collected and analysed and hydraulic simulations for drainage areas are conducted.

2. River and Khal System

2.1 River System

The study area as well as the master plan area is surrounded by tributaries and distributaries of three famous international rivers of the Ganges, the Brahmaputra and the Meghna Rivers.

The river system of the master plan area is shown in Fig. D.1 and listed below ;

(1)	Dhaleswari River	:	Distributary of the Jamuna River
(2)	Bansi River	:	- ditto -
(3)	Turag River	:	Distributary of the Old Brahmaputra River
(4)	Buriganga River	:	- ditto -
(5)	Balu River	:	Tributary of the Lakhya River
(6)	Lakhya River	:	Distributary of the Old Brahmaputra River
(7)	Karnatali River	:	Distributary of the Dhaleswari River and joining with the Turag River
(8)	Tongi Khal	:	Connecting the Turag River with Balu River

The study area is surrounded by the Tongi Khal in the north, the Balu River and the Lakhya River in the east, the Dhaleswari River in the south and the Buriganga River in the west. Above river system sometimes causes external floods by the big flood discharge through the Ganges and the Brahmaputra-Jamuna Rivers or the high backwater stage of the Meghna River.

Water levels of the above river system are the lowest in January-February and the highest in August-September as shown in Fig. D.8.

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2.2 Khal System

Fig. D.2 shows the khal system of the study area. There are three big khal networks in the study area. They are the khal system of DND, the Begunbari Khal and the Jamair Khal in the Greater Dhaka East. The khal system of DND is composed of like braided network. But the khal systems of the Begunbari Khal and the Jamair Khal are composed of simple network.

3. Meteor-hydrology

The climate of the study area is classified as tropical monsoon type, characterized by three seasons of monsoon, post-monsoon and pre-monsoon. The monsoon is the rainy season normally from May to October during which 90% of annual rainfall occurs. Post-monsoon is the dry season from November to December. Pre-monsoon is the transition season between the rainy season and the dry season during which some rainfall occurs. Annual average rainfall in Dhaka is about 2000 mm.

In the beginning of the monsoon and the post-monsoon , cyclones with destructive winds hit Bangladesh. But, Dhaka area is almost always outside the affected area.

Average temperature varies from about 20^0C in December and January to about 30^0C in April to September. Maximum temperature sometimes exceeds 40^0C in March and April. Monthly average evaporation varies from 80 to 130 mm. It is the lowest in November and the highest in August.

Table D.1 shows the climatic conditions in the Study Area.

4. Features of Storm Rainfall and Flood Water Level

Storm rainfall and flood water level are the main factors of causing internal floods and external floods to the study area respectively. In this chapter, features of the storm rainfall and flood water level are described by using the results of the Master Plan Study.

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4.1 Hydrological Observation Networks and Available Data

Hydrological observation networks in and around the study area as well as the master plan area is shown in Fig. D.1. There are ten (10) active and two (2) closed rainfall gauging stations and thirteen (13) active water level gauging stations as listed below :

1) Rainfall Gauging Station

	Station		Remarks
(1)	Dhaka (B.M.D) **	:	Auto recorder (1958-1983)
(2)	Narayanganj (B.M.D) *	:	Closed in 1979
(3)	Dhaka (BWDB, St. 9) **	:	Incorporated into Dhaka (B.M.D) in 1985
(4)	Joydebpur (BWDB, St. 17) *	:	
(5)	Savar (BWDB, St. 31) *	:	
(6)	Narsindi (BWDB, St. 76) *	:	
(7)	Bancharampur (BWDB, St.351)*	:	
(8)	Daudkandi (BWDB, St.357)*	:	
(9)	Munshiganj (BWDB, St.365)*	:	
(10)	Narayanganj (BWDB, St.368)*	:	Closed in 1977
(11)	Nawabganj (BWDB, St.412)*	:	

Notes; 1)* : Manual
2)** : Manual and automatic rain gauge

The period of gauging and available data at each gauging station is shown in Table D.2.

There were only two automatic rain gauges in the study area, but they have not been used since 1984.

The others are all measured manually once a day at 9:00 A.M.

2) Water Level Gauging Station

(1)	Pubali	(BWDB St. 7	:	Balu River)
(2)	Demra	(BWDB St. 7.5	:	Balu River)
(3)	Nayarhat	(BWDB St. 14.5	:	Bansi River)
(4)*	Mill Barak	(BWDB St. 42	:	Buriganga River)
(5)	Hariharpara	(BWDB St. 43	:	Buriganga River)
(6)	Savar	(BWDB St. 69	:	Bansi River)
(7)	Kalatia	(BWDB St. 70	:	Dhaleswari River)
(8)	Kalagachia	(BWDB St. 71	:	Dhaleswari River)
(9)	Rekabi Bazar	(BWDB St. 71A	:	Dhaleswari River)
(10)	Demra	(BWDB St. 179	:	Lakhya River)
(11)	Narayanganj	(BWDB St. 180	:	Lakhya River)
(12)	Meghna Ferry Ghat	(BWDB St. 275.5	:	Surma-Meghna River)
(13)	Tongi	(BWDB St. 299	:	Tongi Khal)
(14)	Mirpur	(BWDB St. 302	:	Turag River)

Notes; 1) * : Autometic water level gauging station

2) : Narayanganj data was collected as the supplemental data in this study.

3) : Observation of Narayanganj (St. 180) had been conducted by BWDB until 1976. It has been conducted by BIWTA since 1977.

There is only one automatic gauging station at Mill Barak. The others are measured manually five times daily at 6:00, 9:00, 12:00, 15:00, 18:00. Period of gauging and available data at each station is shown in Table D.3.

The water level data of Narayanganj (St. 180) contains some inconsistency during the transition period from BWDB to BIWTA, though the consistency can be observed for the annual maximum water level data. Hence, reliability of its data is seemed to be less than the other data a little.

4.2 Features of Storm Rainfall

In the master plan, probable storm rainfall was calculated. The pump drainage plans including retarding ponds were formulated by using two days consecutive rainfall with five year return period with typical design hyetograph.

Furthermore, rainfall intensity and duration curves were formulated for various return periods. The drainage channels and culverts were planned by using the curve with 5-year return period.

Finally, areal reduction curves for converting point rainfall to basin mean rainfall were made.

Above results are also applied to this study.

4.2.1 Probable Storm Rainfall

Probable storm rainfall was calculated by the Gumble-Chow's method by using the maximum one day, two day, five day and one month rainfall as shown in Table D.4 to Table D.7 in the master plan stage.

Before conducting the frequency analysis, correlation of the rainfall data between Dhaka (B.M.D.), Joydebpur (BWDB st. 17), Savar (BWDB st. 31) and Narayanganj (B.M.D.) were studied for two day consecutive rainfall which is the most dominant rainfall of causing the internal floods of Dhaka area as described in the 1987 JICA Study. As a result, no correlation could be found between above stations.

Table D.8 shows the results of the frequency analysis.

As shown in this table, probable rainfalls of above four stations are almost same for one day and two day rainfall of two year and five year return period.

For this reason, probable rainfall in Dhaka (B.M.D.) of one day and two day rainfall of two year and five year return period can also be applied to Savar, Tongi and Narayanganj.

Furthermore, the difference in probable rainfall at Dhaka (B.M.D.) between this study and the 1987 JICA study of one day and two day rainfall of two year and five year return period is compared as shown below :

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PROBABLE RAINFALL AT DHAKA (B.M.D)

(Unit : mm)

Duration	Return Period	This Study	1987 JICA Study
1 day	2 Year	137	135
	5 Year	184	192
2 day	2 Year	184	183
	5 Year	239	245

As shown above, probable rainfalls are almost same between the two studies.

Hence, above values of the 1987 JICA Study are also applicable. Furthermore, the 1987 JICA Study's values of five year return period are safer values than those of this study.

The typical rainfall pattern of one day rainfall of Dhaka (B.M.D.) was found to be six hours consecutive rainfall with peak rainfall intensity in the centre part. The design hyetograph for pump drainage plan was determined as shown in Fig. D.3 by using the design rainfall of two days consecutive rainfall with a 5-year return period.

For calculating the rainfall runoff, rational formula was applied.

Above design rainfall, design hyetograph and rational formula are to be also applied in this study.

4.2.2 Rainfall Intensity and duration

Fig. D.4 shows the rainfall intensity duration curves adopted in the master plan stage. The curves up to 120 minutes were made by conducting frequency analysis for the storm rainfall with short durations in the 1987 JICA study. The curves between 120 minutes and 24 hours were made in the master plan stage.

Drainage channels and culverts were designed by using the above rainfall intensity curve with a 5-year return period. It is able to express the curve as follows ;

$i = 9005 / (t + 50)$ for $t \leq 2.0$ hr

$i = 12437 / (t + 115)$ for $2.0 \text{ hr} \leq t \leq 24.0$ hr

Where, i = rainfall intensity (mm/hr)

t = duration (min)

Rainfall runoff was calculated by rational formula.

Above rainfall intensity and rational formula are to be also applied to this study.

4.2.3 Areal Reduction of Point Rainfall

In order to convert the design point rainfall of Dhaka (B.M.D.) to the design basin mean rainfall of sub-catchments in the drainage areas, areal reduction curves were made in the master plan stage as shown in Fig. D.5.

These curves are also to be applied in this study.

4.3 Features of Flood Water Level

In the master plan stage, flood mitigation plan was formulated using the higher value of 100-year probable flood water level or 1988 Floods' flood water level as the recorded maximum floods of 1988 Floods was estimated to be 70-year return period.

In this section, features of major floods and probable flood water level are described.

4.3.1 Features of Major Flood

1) Historical Floods

Major floods recorded in the Dhaka Metropolitan area occured in 1954, 1955, 1970, 1974, 1980, 1987 and 1988.

The maximum water levels at Mill Barak (St.42) and Demra (St.7.5) and Savar (St. 69) during the major floods are listed as follows :

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ANNUAL MAXIMUM DAILY WATER LEVEL

(Unit : PWD in m)

Flood Year	Demra (St. 7.5)	Mill Barak (St. 42)	Savar (St.69)
1954	---	7.02	8.17
1955	---	7.05	8.26
1958	---	6.41	----
1970	6.24	6.47	7.99
1974	6.58	6.57	7.80
1980	6.23	6.39	----
1984	6.33	6.00	7.58
1987	6.46	6.60	8.30
1988	7.10	7.54	9.68

Note :

1) The above water levels of Mill Barak (St.42) and Demra (St.7.5) are revised by the results of check survey conducted in the 1987 JICA study (see Table D.9).

Fig. D.6 shows the estimated flow directions of 1970, 1974, 1980, 1984, 1987 and 1988 Floods by using the recorded flood water level.

According to these figures, the flow directions around the study area are always west to east for the Tongi Khal and the Dhaleswari River and north to south for the Balu River, the Lakhya River and the Buriganga River.

2) 1988 Floods

The 1988 Floods was the biggest floods among the recorded floods.

This was caused not only by the abnormally heavy and intensive rainfall in the upper catchment areas of the Ganges and the Brahmaputra Rivers in Himalayas during the end of August and the beginning of September, but also by the high backwater stage of the Meghna River which coincided the floods.

Fig. D.7 and Fig. D.8 shows the monthly rainfall and maximum water level in 1988. Fig. D.9 and Fig. D.10 shows the daily rainfall and maximum water level during

August and September. The monthly rainfall amount of August and September of 1988 in and around Dhaka area was 2/3 of annual average.

Considering these, 1988 Floods can be characterized as follows :

(1) The contribution of the rainfall of Dhaka area to the 1988 Floods was small.

(2) Sharp hydrographs in the north-western part and gentle hydrographs in the east and south parts coincide with the fact that the 1988 Floods came from the direction of the Brahmaputra-Jamuna River.

4.3.2 Probable Flood Water Levels

Probable flood water levels in and around the study area are revised by using the supplemental water level data of Narayanganj (BWDB St. 180).

The annual maximum water levels of the water level gauging stations in and around the study area is shown in Table D.9.

In order to estimate an accurate water level of large return period like 100 years, it is necessary to use the data with long duration including the 1988 Floods.

Gauging stations satisfying with the above conditions are listed as follows :

1)	Mill Barak (St.42)	:	37 years data
2)	Savar (St. 69)	:	33 years data
3)	Demra (St. 7.5)	:	35 years data by combining Demra (St. 7.5 and Demra (St. 179) using their correlation.
4)	Narayanganj (St. 180)	:	35 years

As the reliability of Narayanganj data seems to be less than the other data (refer to 4.1 (2)), data of Mill Barak (St. 42), Savar (St. 69) and Demra (St. 7.5) are used in conducting frequency analysis.

Before conducting frequency analysis, correlations between the water level data of Mill Barak (St. 42), Savar (St. 69) and Demra (St. 7.5) with other data are checked by using the results of the master plan stage. Fig. D.11 shows the correlation. They are also listed as follows :

CORRELATION OF WATER LEVEL GAUGING STATIONS

Station (X) Station (Y)	Mill Barak (St. 42)	Savar (St. 69)	Demra (St.7.5)
Mirpur (St. 302)	Y = 1.15 x +0.344	-----	----
Tongi (St. 299)	Y = 1.04 x +0.267	-----	----
Hariharpara (St. 43)	Y = 0.848 x +0.543	-----	----
Nayarhat (st. 14.5)	---	Y = 1.105 x -0.432	----
Kalatia (St. 70)	---	Y = 0.867 x +0.367	----
Demra (St. 179)	----		Y = 0.943 x +0.267
Narayanganj (St. 180)	----		Y = 0.848 x +0.561
Pubali (St. 7)	----		Y = 1.066 x -0.130
Rekabi Bazar (St. 71A)	----		Y = 0.834 x +0.549
Kalagachia (St. 71)	----		Y = 0.752 x +0.896

As for the probable water levels, frequency analysis is conducted for Mill Barak (St.42), Savar (St. 69) and Demra (St. 7.5) by the Gumbel-Chow's method and other probable water levels are calculated by using the correlation described above.

The results are same as that of the master plan stage except Narayanganj (st. 180). They are shown in Table D.10.

By using this table, return periods of the 1987 Floods and the 1988 Floods are estimated as follows ;

RETURN PERIODS OF THE 1987 FLOODS AND THE 1988 FLOODS

Station	1987 Floods	1988 Floods
Demra (St. 7.5)	8-Year	50-Year
Mill Barak (St. 42)	10-Year	70-Year
Savar (St. 69)	15-Year	200-Year

5. Hydraulic Simulation for Drainage Area

In this chapter, hydraulic simulation for drainage area is described. The simulation is conducted by one dimensional unsteady flow model using Mike 11 software.

5.1 Objective of Hydraulic Simulation

As described in Supporting Report E " Flood Mitigation and Drainage Plan", drainage facilities of drainage channel, pump station and retarding ponds are planned by using simple methods as follows ;

a) Drainage Channel : channel design is conducted by using the design discharge given by rainfall runoff calculation. Rainfall runoff calculation is conducted by the rational formula using rainfall intensity curve of 5-year return period. Channel size is determined mainly by conducting uniform flow calculation.

b) Pump Station : pump capacity is determined by mass curve analysis so as to discharge out the total rainfall runoff amount of 2 day consecutive rainfall with a 5 year return period into the drainage area within 2 days.

c) Retarding Pond : retarding pond capacity is determined by mass curve analysis so as to storage the maximum difference between the accumulated amount of rainfall runoff and that of pump discharge during the 2 days.

Due to the flat topography and not simple network of the drainage system, it is necessary to check the validity of the above design by unsteady flow calculation.

Especially, the retarding effect can be checked clearly by the hydraulic simulation.

5.2 Hydraulic Simulation for DND

As the topography of DND is very flat and the drainage network of DND is like braided system, the priority of necessity of checking the validity of the design of simple method is very high.

1) River Network

Fig. D.12 shows the river network of DND area for hydraulic simulation.

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The network is composed of drainage channels, retarding areas and pump stations which are planned by Drainage Improvement Plan using simple design method as described in sub-section 5.1.

All the cross sections of the topographic survey data of about 250-500 m interval are used to set up the network.

Rainfall runoff of sub-catchments are imputed into the network as boundary discharge or lateral inflow.

Fig. D.13 shows the drainage channels and sub-catchments of the DND area corresponding to Fig. D.12.

2) Boundary Conditions

Boundary conditions relating to the above network and simulation case are consist of following items ;

a) Rainfall Runoffs of Sub-Catchments

Rainfall runoffs of sub-catchments are calculated by the rational formula using the design hyetograph. The design hyetograph are created for each sub-catchment by each time of concentration as same as the design hyetograph shown in Fig. D.3.

b) Water Level of the Lakhya River

Water level of the Lakhya River is LWL for gravity flow condition and HWL for pump operating condition.

3) Cases of Simulation

Cases of simulation for DND area are as follows :

CASES OF SIMULATION

Simulation Case		Water Level of the Lakhya River (PWD m)	Pump Capacity (m3/s)
Case 1-1	Without retarding areas and without pump stations	LWL : KN-1 side : 3.00 Kn-4 side : 3.00	-
Case 1-2	Without retarding areas and without pump stations	HWL : KN-1 side : 5.75 KN-4 side : 5.65	KN-1 side:14.5 KN-4 side:50.2
Case 2-1	Without retarding areas and without pump stations	LWL : KN-1 side : 3.00 KN-4 side : 3.00	-
Case 2-2	Without retarding areas and without pump stations	HWL : KN-1 side : 5.75 KN-4 side : 5.65	KN-1 side:14.5 KN-4 side:50.2

4) Results of Simulation

Fig. D.14, Fig. D.15 and Fig. D.16 show the profiles of simulated peak water level, water level hydrographs and discharge hydrographs of case 1-1, 1-2, 2-1 and 2-2.

As shown in Fig, D.14, the peak water levels of the cases of without retarding ponds (case 1-1 and case 1-2) are higher than the design bank and those of the cases of with retarding ponds (case 2-1 and case 2-2) are lower than the design bank. Hence, it can be said that the simple design method using rational formula, uniform flow calculation and mass curve calculation is adequate for designing drainage facilities such as drainage channels, pump stations and retarding area of the DND area.

But, as the differences between the peak water levels and the design bank heights of case 2-1 and case 2-2 are bigger than the design allowance in several ten centimeters, it is possible to modify slightly, the sizes of drainage channels, pump stations and retarding ponds to adjust the above difference to the design allowance by using this one-dimensional unsteady flow model.

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5.3 Hydraulic Simulation of Greater Dhaka East

There are three big khals in the Greater Dhaka East. They are the Boalia Khal, the Jamair Khal and the Begunbari Khal. As the khal systems of the Jamair Khal and the Begunbari Khal are not symple, it is necessary to check the design of drainage channels, pump stations and retarding ponds by simple design method as described in sub-section 5.1 by one-dimensional flow model of MIKE 11 for these khals.

5.3.1 Sub-drainage Zones

The sub-drainage zones of the Jamair Khal and the Begunbari Khal are determined as follows by "Flood Mitigation and Drainage Plan".

Jamair Khal	:	Sub-drainage zone DC-2
Begunbari Khal	:	Sub-drainage zone DC-3 (northern half)
		Sub-drainage zone DC-4 (southern half)

These sub-drainage zones as well as their drainage channels and sub-catchments are shown in Fig. D.17.

5.3.2 Hydraulic Simulation of Sub-drainage Zone DC-2

1) River network

Fig. D.17 shows the rive network and proposed simulation model of sub-drainage zone DC-2.

Sizes of drainage channels, pump stations and retarding areas are given by the simple design method all the cross sections of the topographic survey data of about 250-500 interval are used to set up the network.

2) Boundary conditions

Rainfall run-off of sub-catchments are imputed into the network as boundary discharge or lateral inflow.

Water level of the Balu River is LWL for gravity flow condition and HWL for pump operating condition.

3) Cases of Simulation

Simulation cases are for cases as shown below ;

CASES OF SIMULATION

Simulation Case		Water Level of the Balu River (PWD m)	Pump Capacity (m3/s)
Case 1-1	Without retarding areas and without pump stations	LWL : 3.00	-
Case 1-2	Without retarding areas and without pump stations	HWL : 6.15	54.6
Case 2-1	Without retarding areas and without pump stations	LWL : 3.00	-
Case 2-2	Without retarding areas and without pump stations	HWL : 6.15	54.6

4) Results of Simulation

Fig. D.18, Fig. D.19 and Fig. D.20 show the profiles of simulated peak water level, water level hydrographs and discharge hydrographs of case 1-1, 1-2, 2-1 and 2-2.

As shown in Fig, D.18, the peak water levels of the cases of without retarding areas case 1-1 and case 1-2 are higher than the design bank and those of the cases of with retarding areas case 2-1 and case 2-2) are lower than the design bank with a little bigger allowance in the downstream portion than the design allowance.

Hence, the simple design method can be said appropriate.

Furthermore, slightly modification of the sizes of drainage channels, pump stations and retarding areas to adjust the above allowance in downstream portion to the design allowance can be done by using this one-dimensional unsteady flow model.

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5.3.3 Hydraulic Simulation of Sub-drainage Zone DC-3

1) River Network

Fig. D.21 shows the rive network and proposed simulation model of sub-drainage zone DC-3

2) Boundary Conditions

Boundary conditions are given by the same way as DC-2.

3) Cases of Simulation

Simulation cases as shown below ;

CASES OF SIMULATION

Simulation Case		Water Level of the Balu River (PWD m)	Pump Capacity (m3/s)
Case 1-1	Without retarding areas and without pump stations	LWL : 3.00	-
Case 1-2	Without retarding areas and without pump stations	HWL : 6.05	53.10
Case 2-1	Without retarding areas and without pump stations	LWL : 3.00	-
Case 2-2	Without retarding areas and without pump stations	HWL : 6.05	53.10

4) Results of Simulation

Fig. D.22, Fig. D.23 and Fig. D.24 show the profiles of simulated peak water level, water level hydrographs and discharge hydrographs of case 1-1, 1-2, 2-1 and 2-2.

As shown in Fig, D.22, the peak water levels of the cases of without retarding areas case 1-1 and case 1-2 are higher than the design bank and those of the cases of with retarding areas case 2-1 and case 2-2) are lower than the design bank with a little bigger allowance in the downstream portion than the design allowance.

Hence, the simple design method can be said appropriate.

Furthermore, slightly modification of the sizes of drainage channels, pump stations and retarding areas to adjust the above allowance in downstream portion to the design allowance can be done by using this one-dimensional unsteady flow model.

5.3.4 Hydraulic Simulation of Sub-drainage Zone DC-4

1) River network

Fig. D.25 shows the rive network and proposed simulation model of sub-drainage zone DC-4

2) Boundary Conditions

Boundary conditions are given by the same way as DC-2.

3) Cases of Simulation

Simulation cases as shown below ;

CASES OF SIMULATION

Simulation Case		Water Level of the Balu River (PWD m)	Pump Capacity (m3/s)
Case 1-1	Without retarding areas and without pump stations	LWL : 3.00	-
Case 1-2	Without retarding areas and without pump stations	HWL : 6.00	47.2
Case 2-1	Without retarding areas and without pump stations	LWL : 3.00	-
Case 2-2	Without retarding areas and without pump stations	HWL : 6.00	47.2d

2d9

4) Results of Simulation

Fig. D.26, Fig. D.27 and Fig. D.28 show the profiles of simulated peak water level, water level hydrographs and discharge hydrographs of case 1-1, 1-2, 2-1 and 2-2.

As shown in Fig, D.26, the peak water levels of the cases of without retarding areas case 1-1 and case 1-2 are higher than the design bank and those of the cases of with retarding areas case 2-1 and case 2-2) are lower than the design bank with a little bigger allowance in the downstream portion than the design allowance.

Hence, the simple design method can be said appropriate.

Furthermore, slightly modification of the sizes of drainage channels, pump stations and retarding areas to adjust the above allowance in downstream portion to the design allowance can be done by using this one-dimensional unsteady flow model.

TABLE D.1 CLIMATE CONDITIONS IN THE STUDY AREA

MONTH	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	oct	Nov	Dec
Temperature, °c High (Extreme)	34.2	36.6	40.6	42.3	40.6	38.4	35.2	35.9	35.3	38.8	33.3	31.2
Low (Extreme)	5.6	4.5	10.4	15.6	18.4	20.4	21.7	21.0	22.0	10.4	10.6	6.7
Avg.	18.8	21.5	26.1	28.7	28.9	28.7	28.7	28.7	28.7	27.4	23.6	19.8
Relative Humidity, Percent	70	66	63	71	79	86	87	86	86	81	75	74
Evaporation, millimeters	104	79	81	77	78	83	87	130	118	106	75	105
Days of Rain, per month	1	2	4	8	14	19	22	22	16	9	2	1
Average Rainfall, millimeters	6.5	20.2	52.3	124.0	283.0	398.2	391.4	328.0	264.0	160.0	25.3	7.4
Wind Velocities, Knots (Knot=1,852 km/hr)	2	2	3	5	5	4	4	4	3	2	1	1

Data : 1) Bangladesh Meteorological Department (1953-1985)

2) Evaporation , H.R. Laboratory (Dhaka) No. E-10 (1978-1979)

Source : JICA; Study on Storm Water Drainage System Improvement Project in Dhaka City, 1987

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TABLE D.2 LIST OF RAINFALL GAUGING STATIONS AND AVAILABLE DATA

STATION NAME	AGENCY	STAION NO.	LOCATION		DATE OF ESTAB-LISHMENT	MEASUREMENT	DATA	REMARKS
1) DHAKA	B.M.D.	-	Latitude : Longitude :	23 deg. 46.0 min. N 90 deg. 23.0 min. E	1949	Manual Auto	1953 - 1990	Auto recorder(1957 - 1983)
2) NARAYANGANJ	B.M.D.	-	Latitude : Longitude :	23 deg. 37.0 min. N 90 deg. 30 .0min. E	1867	Manual	1948 - 1979	Closed in 1979
3) DHAKA	BWDB	9	Latitude : Longitude :	23 deg. 47.2 min. N 90 deg. 24.2 min. E	08. 07. 1960	Manual Auto	1957 - 1990	Incorporated into Dhaka(B.M.D.) in 1985
4) JOYDEBPUR	BWDB	17	Latitude : Longitude :	24 deg. 00.0 min. N 90 deg. 25.0 min. E	11. 03. 1961	Manual	1961 - 1990	
5) SAVAR	BWDB	31	Latitude : Longitude :	24 deg. 01.0 min. N 90 deg. 11.0 min. E	23. 11. 1961	Manual	1962 - 1990	
6) NARSINDI	BWDB	76	Latitude : Longitude :	23 deg. 57.3 min. N 90 deg. 44.5 min. E	06. 03. 1961	Manual	1961 - 1990	
7) BANCHARAMPUR	BWDB	351	Latitude : Longitude :	23 deg. 44.5 min. N 90 deg. 45.7 min. E	02. 03. 1961	Manual	1961 - 1990	
8) DAUDKANDI	BWDB	357	Latitude : Longitude :	23 deg. 32.0 min. N 90 deg. 43.0 min. E	27. 06. 1961	Manual	1983 - 1990	
9) MUNSHIGANJ	BWDB	365	Latitude : Longitude :	23 deg. 33.1 min. N 90 deg. 32.2 min. E	25. 11. 1960	Manual	1963 - 1990	
10) NARAYANGANJ	BWDB	368	Latitude : Longitude :	23 deg. 36.8 min. N 90 deg. 30.2 min. E	-	Manual	1961 - 1977	Closed in 1977
11) NAWABGANJ	BWDB	412	Latitude : Longitude :	23 deg. 39.5 min. N 90 deg. 10.0 min. E	13. 03. 1961	Manual	1965 - 1990	

TABLE D.3 LIST OF WATER LEVEL GAUGING STATIONS AND AVAILABLE DATA

STATION NAME	AGENCY	STAION NO.	RIVER	LOCATION		DATE OF ESTAB-LISHMENT	MEASUREMENT	DATA OF WATER LEVEL	DATA OF DISCHARGE	DATA OF RATING CURVE
1) PUBAIL	BWDB	7	Balu	Latitude : Longitude :	23 deg. 56.5 min. N 90 deg. 29.8 min. E	26. 6. 1945	Manual	1945 - 1990	-	-
2) DEMRA	BWDB	7.5	Balu	Latitude : Longitude :	23 deg. 44.0 min. N 90 deg. 30.0 min. E	21. 10. 1964	Manual	1962 - 1990	1979 - 1989	1979 - 1987
3) NAYARHAT	BWDB	14.5	Bansi	Latitude : Longitude :	23 deg. 54.7 min. N 90 deg. 14.0 min. E	11. 06. 1963	Manual	1964 - 1988	1979 - 1989	1977 - 1989
4) MILL BARAK	BWDB	42	Buriganga	Latitude : Longitude :	23 deg. 41.9 min. N 90 deg. 25.3 min. E	10. 10. 1906	Manual Auto	1945 - 1990	-	-
5) HARIHARPARA	BWDB	43	Buriganga	Latitude : Longitude :	23 deg. 38.0 min. N 90 deg. 28.5 min. E	04. 06. 1945	Manual	1945 - 1990	-	-
6) SAVAR	BWDB	69	Dhaleswari	Latitude : Longitude :	24 deg. 01.0 min. N 90 deg. 11.o min. E	13. 07. 1945	Manual	1945 - 1990	-	-
7) KALATIA	BWDB	70	Dhaleswari	Latitude : Longitude :	23 deg. 42.9 min. N 90 deg. 15.9 min. E	01. 10. 1958	Manual	1968 - 1990	-	-
8) KALAGACHIA	BWDB	71	Dhaleswari	Latitude : Longitude :	23 deg. 34.7 min. N 90 deg. 32.7 min. E	15. 06. 1945	Manual	1977 - 1990	-	-
9) REKABI BAZAR	BWDB	71A	Dhaleswari	Latitude : Longitude :	23 deg. 34.4 min. N 90 deg. 29.7 min. E	16. 12. 1965	Manual	1968 - 1990	-	-
10) DEMRA	BWDB	179	Lakhya	Latitude : Longitude :	23 deg. 44.0 min. N 90 deg. 31.5 min. E	18. 06. 1945	Manual	1952 - 1990	-	1977 - 1989
11) NARAYANGANJ	BWDB BIWTA	180	Lakhya	Latitude :	23 deg. 38.1 min. N 90 deg. 38.8 min. E	26. 06. 1946	Manual	1947 - 1990	-	-
12) MEGHNA FERRY GHAT	BWDB	275.5	Surma-Meghna	Latitude : Longitude :	23 deg. 36.2 min. N 90 deg. 37.5 min. E	25. 09. 1965	Manual	1968 - 1990	-	-
13) TONGI	BWDB	299	Tongi Khal	Latitude : Longitude :	23 deg. 52.8 min. N 90 deg. 24.2 min. E	25. 03. 1960	Manual	1960 - 1990	-	-
14) MIRPUR	BWDB	302	Turag	Latitude : Longitude :	23 deg. 47.3 min. N 90 deg. 20.3 min. E	-	Manual	1953 - 1990	1983 - 1989	1977 - 1989

TABLE D.4 ANNUAL MAXIMUM DAILY RAINFALL

(unit : mm)

NO.	STATION	DHAKA B.M.D.	NARAYANGANJ B.M.D	DHAKA BWDB STA. NO.9	JOYDEBPUR BWDB STA. NO.17	SAVAR BWDB STA. NO.31	NARSINDI BWDB STA. NO.76	BANCHARAMPUR BWDB STA. NO.351	DAUDKANDI BWDB STA. NO.357	MUNSHIGANJ BWDB STA. NO.365	NARAYANGANJ BWDB STA. NO.368	NAWABGONJ BWDB STA. NO.412
	DATA	1953-1990	1948-1979	1957-1990	1961-1990	1962-1990	1961-1990	1961-1990	1983-1990	1963-1990	1961-1977	1965-1990
NO.	YEAR											
1	1948		-									
2	1949		119									
3	1950		183									
4	1951	-	149									
5	1952		133									
6	1953	90	-									
7	1954	147	-									
8	1955	115	86									
9	1956	326	149									
10	1957	73	62	72								
11	1958	137	158	113								
12	1959	125	134	120								
13	1960	141	160	112								
14	1961	185	202	154	140		168	137			116	
15	1962	116	87	81	107	246	110	-			-	
16	1963	189	197	207	127	87	146	171		73	163	
17	1964	114	231	144	161	165	136	-		-	-	
18	1965	177	-	222	173	179	122	118		112	109	127
19	1966	257	216	283	137	122	186	164		83	216	179
20	1967	125	137	98	140	142	126	146		109	118	96
21	1968	145	135	137	177	163	101	97		144	135	180
22	1969	86	252	76	69	93	157	244		109	91	72
23	1970	152	81	113	112	82	192	90		137	81	108
24	1971	251	106	196	126	88	202	135		127	-	128
25	1972	231	167	165	77	114	116	64		102	-	224
26	1973	168	170	216	206	133	144	182		127	115	129
27	1974	-	-	107	165	136	181	108		127	166	109
28	1975	143	132	158	165	235	122	179		127	132	105
29	1976	163	105	158	107	162	186	121		136	147	-
30	1977	100	193	149	104	126	123	90		141	-	53
31	1978	128	-	134	184	165	226	181		127		99
32	1979	108	-	127	229	187	157	184		127		61
33	1980	91		91	95	-	164	55		-		79
34	1981	83		81	125	114	285	136		82		86
35	1982	146		146	129	165	106	65		239		-
36	1983	128		133	193	146	199	188	125	174		179
37	1984	150		151	112	184	181	161	107	161		78
38	1985	92		92	83	107	164	61	94	113		81
39	1986	176		176	167	109	147	212	104	206		-
40	1987	138		138	153	99	120	174	155	69		79
41	1988	135		135	155	-	122	189	119	108		-
42	1989	118		118	129	102	89	73	125	84		69
43	1990	-		-	-	-	-	-	-	-		-
	AVERAGE	146	150	139	140	140	154	138	118	126	132	111

TABLE D.5 ANNUAL MAXIMUM TWO DAY RAINFALL

(unit : mm)

NO.	STATION	DHAKA	NARAYANGANJ	DHAKA	JOYDEBPUR	SAVAR	NARSINDI	BANCHARAMPUR	DAUDKANDI	MUNSHIGANJ	NARAYANGANJ	NAWABGONJ
		B.M.D.	BMD	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB
				STA. NO.9	STA. NO.17	STA. NO.31	STA. NO.76	STA. NO.351	STA. NO.357	STA. NO.365	STA. NO.368	STA. NO.412
	DATA	1953-1990	1948-1979	1957-1990	1961-1990	1962-1990	1961-1990	1961-1990	1983-1990	1963-1990	1961-1977	1965-1990
NO.	YEAR											
1	1948		-									
2	1949		143									
3	1950		233									
4	1951		165									
5	1952		172									
6	1953	127	-									
7	1954	255	-									
8	1955	120	124									
9	1956	346	178									
10	1957	98	97	102								
11	1958	140	166	176								
12	1959	179	171	178								
13	1960	223	238	151								
14	1961	185	202	189	152		205	207			177	
15	1962	141	130	123	156	297	133	-			-	
16	1963	257	307	278	131	110	181	184		108	167	
17	1964	206	266	195	254	196	244	-		-	-	
18	1965	181	-	225	221	184	225	118		154	133	129
19	1966	270	302	339	229	167	211	251		100	302	202
20	1967	147	207	141	231	161	189	232		150	207	96
21	1968	240	263	235	210	197	168	172		259	263	183
22	1969	104	255	122	107	117	196	258		182	165	92
23	1970	262	132	185	147	118	232	134		164	133	172
24	1971	328	188	272	162	139	319	135		229	-	166
25	1972	251	183	215	117	145	191	98		178	-	292
26	1973	177	204	224	221	133	255	213		203	136	213
27	1974	-	-	183	182	136	237	147		229	170	154
28	1975	212	246	257	264	371	227	353		198	246	112
29	1976	263	194	275	199	250	310	168		224	218	-
30	1977	133	228	155	115	150	148	109		208	-	93
31	1978	191	-	185	267	199	230	186		168		160
32	1979	166	-	168	330	268	191	212		218		79
33	1980	125		125	132	-	203	86		-		109
34	1981	148		148	201	160	288	170		123		122
35	1982	167		167	181	208	182	96		301		-
36	1983	194		199	290	249	362	321	242	248		189
37	1984	200		201	160	261	247	234	180	219		105
38	1985	132		105	142	159	217	95	151	117		142
39	1986	321		321	271	164	234	270	196	277		-
40	1987	172		172	230	168	193	209	201	107		119
41	1988	175		175	283	-	200	301	138	155		-
42	1989	151		151	160	155	112	119	127	145		107
43	1990	-		-	-	-	-	-	-	-		-
	AVERAGE	194	200	192	198	187	218	188	176	187	193	145

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TABLE D.6 ANNUL MAXIMUM FIVE DAY RAINFALL

(unit : mm)

NO	STATION	DHAKA	NARAYANGANJ	DHAKA	JOYDEBPUR	SAVAR	NARSINDI	BANCHARAMPUR	DAUDKANDI	MUNSHIGANJ	NARAYANGANJ	NAWABGONJ
		B.M.D.	B.M.D.	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB
				STA. NO.9	STA. NO.17	STA. NO.31	STA. NO.76	STA. NO.351	STA. NO.357	STA. NO.365	STA. NO.368	STA. NO.412
	DATA	1953-1990	1948-1979	1957-1990	1961-1990	1962-1990	1961-1990	1961-1990	1983-1990	1963-1990	1961-1977	1965-1990
NO.	YEAR											
1	1948		-									
2	1949		224									
3	1950		295									
4	1951		198									
5	1952		183									
6	1953	150	-									
7	1954	323	-									
8	1955	181	182									
9	1956	430	259									
10	1957	184	191	175								
11	1958	170	166	200								
12	1959	309	298	297								
13	1960	331	257	188								
14	1961	317	264	226	283		264	299			264	
15	1962	164	160	164	223	297	204	-			-	
16	1963	327	350	325	144	188	234	338		188	197	
17	1964	241	299	231	295	238	315	-		-	-	
18	1965	219	-	239	307	277	272	192		241	203	147
19	1966	288	343	360	279	190	347	389		212	327	244
20	1967	250	292	223	326	170	329	317		223	292	179
21	1968	379	343	325	263	289	314	345		377	387	301
22	1969	199	297	200	192	173	361	313		227	240	126
23	1970	303	163	248	254	157	347	229		269	142	204
24	1971	355	331	296	300	273	616	180		381	-	236
25	1972	314	215	263	163	202	283	205		394	-	377
26	1973	205	252	271	269	154	420	344		381	168	225
27	1974	-	-	236	209	174	285	211		508	220	202
28	1975	401	429	445	475	507	331	576		315	428	230
29	1976	436	318	447	368	358	410	305		288	380	-
30	1977	175	308	198	189	192	264	123		273	-	160
31	1978	216	-	244	288	283	324	311		338		231
32	1979	234	-	180	500	446	239	222		396		142
33	1980	259		259	215	-	307	140		-		188
34	1981	168		168	309	185	349	278		174		175
35	1982	193		193	209	254	361	105		338		-
36	1983	250		255	363	286	450	419	407	284		249
37	1984	296		296	315	377	491	452	330	319		146
38	1985	169		169	302	262	329	130	193	147		170
39	1986	401		401	331	255	361	355	236	402		-
40	1987	234		234	406	203	272	390	290	168		151
41	1988	301		301	413	-	369	399	243	191		-
42	1989	152		152	178	208	195	129	128	207		175
43	1990	-		-	-	-	-	-	-	-		-
AVERAGE		265	265	255	289	254	333	285	261	290	271	203

TABLE D.7 ANNUAL MAXIMUM MONTHLY RAINFALL

(unit : mm)

NO.	STATION	DHAKA	NARAYANGANJ	DHAKA	JOYDEBPUR	SAVAR	NARSINDI	BANCHARAMPUR	DAUDKANDI	MUNSHIGANJ	NARAYANGANJ	NAWABGONJ
		B.M.D.	B.M.D	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB
				STA. NO.9	STA. NO.17	STA. NO.31	STA. NO.76	STA. NO.351	STA. NO.357	STA. NO.365	STA. NO.368	STA. NO.412
	DATA	1953-1990	1948-1979	1957-1990	1961-1990	1962-1990	1961-1990	1961-1990	1983-1990	1963-1990	1961-1977	1965-1990
NO.	YEAR											
1	1948		-									
2	1949		414									
3	1950		711									
4	1951	-	484									
5	1952		438									
6	1953	392	552									
7	1954	810	-									
8	1955	502	340									
9	1956	690	387									
10	1957	487	415	349								
11	1958	267	374	280								
12	1959	568	605	544								
13	1960	655	533	489								
14	1961	856	489	495	-		-	537			-	
15	1962	395	298	430	393	-	477	486			-	
16	1963	621	418	678	355	-	573	711		-	-	
17	1964	629	451	673	512	554	912	-		-	-	
18	1965	480	-	442	592	575	705	484		-	-	416
19	1966	496	479	607	490	391	581	671		414	501	439
20	1967	504	525	476	550	395	563	504		431	509	304
21	1968	590	502	449	565	537	588	451		565	501	471
22	1969	540	428	494	498	628	754	489		459	434	448
23	1970	496	285	414	439	403	601	355		396	304	365
24	1971	550	644	485	629	595	911	384		930	-	471
25	1972	380	356	469	274	357	589	295		808	-	491
26	1973	621	521	618	536	444	875	524		953	-	462
27	1974	-	634	604	593	485	1048	604		1514	623	670
28	1975	559	627	625	634	647	490	608		876	655	399
29	1976	627	542	649	487	547	722	602		736	647	-
30	1977	381	539	593	385	392	504	290		526	-	422
31	1978	529	-	583	788	542	898	716		500		285
32	1979	525	-	437	685	707	635	299		632		196
33	1980	414		411	411	-	676	362		-		422
34	1981	411		320	485	-	672	446		334		392
35	1982	514		514	494	489	568	288		501		-
36	1983	408		434	639	401	705	552	-	611		344
37	1984	891		707	559	591	1065	773	963	567		378
38	1985	399		399	530	352	504	235	526	288		258
39	1986	687		687	498	477	590	558	422	596		-
40	1987	526		526	744	532	636	520	460	429		-
41	1988	580		579	716	-	692	1069	374	418		-
42	1989	347		347	484	-	332	211	362	329		-
43	1990	-		-	-	-	-	-	-	-		-
	AVERAGE	537	481	509	534	502	674	501	518	600	522	402

TABLE D.8 PROBABLE STORM RAINFALL

(Unit : mm)

DURATION	RAIN STATION	RETURN PERIOD (YEAR)					
		2	5	10	20	50	100
1 day	Dhaka (B.M.D.)	137	184	215	244	283	311
	Savar (BWDB Sta.31)	133	171	196	220	251	274
	Joydebpur (BWDB Sta. 17)	133	167	190	211	239	260
	Narayanganj (B.M.D.)	142	184	212	239	273	299
2 day	Dhaka (B.M.D.)	184	239	276	311	357	391
	Savar (BWDB Sta.31)	177	231	267	301	346	379
	Joydebpur (BWDB Sta. 17)	189	240	275	308	350	382
	Narayanganj (B.M.D.)	191	239	270	301	340	369
5 day	Dhaka (B.M.D.)	251	324	372	418	478	523
	Savar (BWDB Sta.31)	240	316	367	416	479	527
	Joydebpur (BWDB Sta. 17)	274	351	402	451	514	561
	Narayanganj (B.M.D.)	253	314	355	394	444	482
1 month	Dhaka (B.M.D.)	514	636	716	793	892	967
	Savar (BWDB Sta.31)	486	573	630	686	757	811
	Joydebpur (BWDB Sta. 17)	515	619	687	753	838	901
	Narayanganj (B.M.D.)	437	558	620	679	757	814

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TABLE D.9 ANNUAL MAXIMUM WATER LEVEL

COMPARISON OF ANNUAL MAXIMUM WATER LEVEL RIVISED BY CHECH SURVEY

(UNIT :PWD in m)

NO.	STATION	PUBAIL	DEMRA	NAYARHAT	MILL BARAK	HARIHARPARA	SAVAR	KALATIA	KALAGACHIA	RAKABI BAZAR	DEMRA	NARAYANGANJ	MEGHNA FERRY GHAT	TONGI	MIRPUR
		BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB	BWDB
		STA. NO.7	STA. NO.7.5	STA. NO.14.5	STA. NO.42	STA.NO.43	STA. NO. 69	STA. NO.70	STA. NO. 71	STA. NO. 71A	STA. NO. 179	STA. NO.180	STA. NO.275.5	STA. NO.299	STA. NO. 302
	RIVER	BALU	BALU	BANGSHI	BURIGANGA	BURIGANGA	DHALESWARI	DHALESWARI	DHALESWARI	DHALESWARI	LAKHYA	LAKHYA	SURMA-MEGHNA	TONGI KHAL	TURAG
	DATA	1945-1990	1962-1990	1964-1990	1945-1990	1945-1990	1945-1990	1968-1990	1977-1990	1968-1990	1952-1990	1947-1990	1968-1990	1960-1990	1953-1990
NO.	YEAR														
1	1945	-			6.00	-	7.41								
2	1946	-			5.96	5.28	6.84								
3	1947	5.53			5.60	-	6.98					5.09			
4	1948	5.82			6.26	-	7.20					5.36			
5	1949	-			5.96	5.94	7.23					5.33			
6	1950	5.43			5.72	-	7.04					5.27			
7	1951	-			-	-	7.35					5.27			
8	1952	5.41			5.45	-	7.10				5.58	5.33			
9	1953	-			5.66	5.24	7.06				5.58	5.27			6.27
10	1954	6.65			7.02	6.22	8.17				6.52	6.04			7.64
11	1955	-			7.05	6.40	8.26				6.77	6.16			7.66
12	1956	6.19			5.64	4.82	6.83				5.73	5.24			6.03
13	1957	5.92			5.32	5.06	7.20				5.52	5.58			6.20
14	1958	6.54			6.41	-	-				5.97	5.46			7.17
15	1959	6.08			5.74	5.33	7.12				-	-			6.52
16	1960	6.17			6.06	5.53	7.57				-	-		6.40	6.62
17	1961	-			5.48	-	7.30				-	-		-	5.98
18	1962	6.92	6.29		-	-	-				-	5.94		7.27	7.57
19	1963	-	5.92		-	-	-				-	-		6.55	6.75
20	1964	-	6.40	8.16	-	-	-				-	-		7.00	7.17
21	1965	-	5.81	7.62	-	-	-				5.83	-		6.54	6.56
22	1966	-	6.24	8.00	-	-	-				6.30	-		6.78	6.98
23	1967	-	5.43	7.07	-	-	-				5.46	-		5.87	-
24	1968	-	6.08	8.03	6.30	5.85	7.69	6.84		5.75	6.09	5.90	5.68	6.70	6.76
25	1969	6.19	5.85	7.55	5.89	5.63	7.08	6.46		5.47	5.87	5.58	5.63	6.34	6.37
26	1970	6.74	6.24	8.69	6.47	6.04	7.99	7.10		5.85	-	-	5.87	7.11	7.17
27	1971	6.42	6.03	-	6.19	5.85	7.36	6.81		-	6.08	5.76	-	6.72	-
28	1972	5.64	5.40	6.97	5.26	5.01	6.66	6.07		5.00	5.44	5.12	5.11	5.81	5.74
29	1973	6.25	5.88	7.70	5.84	5.55	7.21	6.55		5.46	5.88	5.52	5.44	6.36	6.36
30	1974	6.95	6.58	8.44	6.57	6.34	7.80	7.12		6.07	6.60	6.23	6.19	7.10	7.09
31	1975	5.73	5.60	-	5.39	5.23	-	-		5.18	5.60	5.36	5.29	-	-
32	1976	5.64	5.47	6.44	5.13	4.98	6.31	5.98		-	5.53	5.17	5.32	-	-
33	1977	6.03	5.92	7.15	5.60	5.39	6.88	6.34	5.34	5.39	5.81	5.52	5.59	6.03	5.99
34	1978	-	-	6.48	5.22	5.05	6.29	5.83	5.03	-	5.43	5.22	-	5.56	5.51
35	1979	-	5.59	6.46	5.25	5.08	-	-	-	-	5.49	5.00	-	5.60	5.54
36	1980	6.66	6.23	8.58	6.39	-	-	7.21	-	5.61	-	6.03	-	6.99	7.20
37	1981	-	5.74	6.74	5.42	-	-	-	-	-	5.65	-	5.40	-	5.79
38	1982	-	6.00	6.34	-	-	-	-	-	-	5.35	5.20	5.19	6.02	5.41
39	1983	6.05	5.90	7.23	5.73	5.43	6.96	6.38	5.44	5.49	5.81	5.54	5.56	6.40	6.03
40	1984	6.35	6.33	8.12	6.00	5.72	7.58	7.11	5.91	5.74	6.04	5.77	5.73	7.10	6.63
41	1985	5.83	5.70	7.04	5.37	5.12	6.70	6.18	5.06	5.28	5.57	5.33	5.44	5.75	5.79
42	1986	5.70	5.25	6.77	4.96	4.82	6.69	6.20	4.65	4.97	5.14	5.03	5.03	5.50	5.43
43	1987	6.90	6.46	8.74	6.60	6.23	8.30	7.53	5.92	6.02	6.38	6.09	5.99	7.02	7.30
44	1988	7.29	7.10	9.90	7.54	7.17	9.68	8.91	5.97	6.43	-	6.63	6.55	7.96	8.39
45	1989	5.47	5.44	6.21	5.06	4.78	6.34	5.92	5.04	5.10	5.34	5.23	-	5.38	5.42
46	1990	-	-	-	-	-	-	-	-	-	-	5.23	-	-	-
	AVERAGE	6.16	5.96	7.52	5.88	5.54	7.28	6.70	5.37	5.55	5.81	5.52	5.59	6.46	6.52

Notes : 1) The above water levels of Mill Barak, Mirpur, Tongi and Demra(Sta. 7.5) are revised by the results of check survey conducted in 1987 JICA STUDY.

2) The equations for the revision are as follows ;

Mill Barak :	$Y=X-0.037$	where,	X : raw data
Mirpur :	$Y=X+0.042$		Y : revised data
Tongi :	$Y=X+0.122$		
Demra(7.5) :	$Y=X+0.007$		

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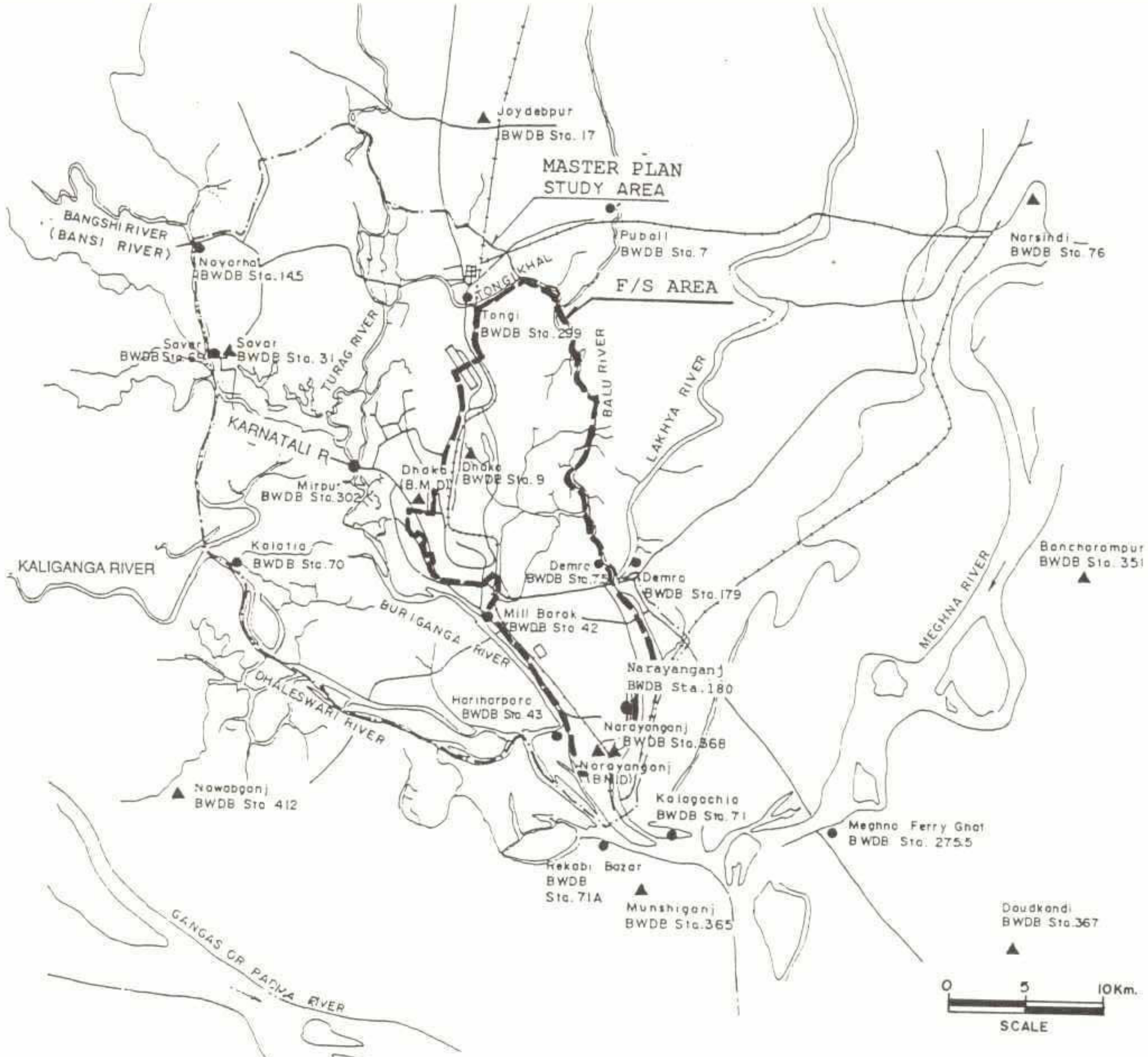
TABLE D.10 PROBABLE FLOOD WATER LEVEL

(Unit : PWD in m)

WATER LEVEL STATION	RETURN PERIOD (YEAR)											1988 Flood	1987 Flood	1974 Flood
	2	3	5	10	20	30	50	100	200	300	400	500			
1) Pubail (BWDB Sta. 7)	6.15	6.34	6.55	6.83	7.09	7.24	7.43	7.67	7.93	8.08	8.17	8.26	7.29	6.90	6.95
2) Demra (BWDB Sta. 7.5)	5.89	6.07	6.27	6.53	6.77	6.91	7.09	7.32	7.56	7.70	7.79	7.87	7.10	6.46	6.58
3) Nayarhat (BWDB Sta. 14.5)	7.49	7.80	8.14	8.56	8.98	9.21	9.51	9.91	10.31	10.54	10.71	10.84	9.90	8.74	8.44
4) Mill Barak (BWDB Sta. 42)	5.78 (5.82)	6.03 (6.04)	6.30 (6.29)	6.65 (6.59)	6.98 (6.89)	7.17 (7.09)	7.40 (7.27)	7.72 (7.56)	8.04	8.23	8.36	8.46	7.54	6.60	6.57
5) Hariharpara (BWDB Sta. 43)	5.45	5.66	5.89	6.19	6.47	6.63	6.82	7.10	7.37	7.53	7.64	7.72	7.17	6.23	6.34
6) Savar (BWDB Sta. 69)	7.17	7.45	7.76	8.14	8.52	8.73	9.00	9.36	9.72	9.93	10.08	10.20	9.68	8.30	7.80
7) Kalatia (BWDB Sta. 70)	6.58	6.83	7.09	7.42	7.75	7.94	8.17	8.48	8.79	8.98	9.11	9.21	8.91	7.53	7.12
8) Kalagachia (BWDB Sta. 71)	5.33	5.46	5.61	5.81	5.99	6.09	6.23	6.40	6.58	6.69	6.75	6.81	5.97	5.92	-
9) Rakabi Bazar (BWDB Sta. 71A)	5.46	5.61	5.78	6.00	6.20	6.31	6.46	6.65	6.85	6.97	7.05	7.11	6.43	6.02	6.07
10) Demra (BWDB Sta. 179)	5.82	5.99	6.18	6.42	6.65	6.78	6.95	7.17	7.40	7.53	7.61	7.69	-	6.38	6.60
11) Narayanganj (BWDB Sta.180)	5.56	5.71	5.88	6.10	6.30	6.42	6.57	6.77	6.97	7.09	7.17	7.23	6.63	6.09	6.23
12) Tongi (BWDB Sta. 299)	6.28 (6.46)	6.54 (6.70)	6.82 (6.97)	7.18 (7.33)	7.53 (7.67)	7.72 (7.86)	7.96 (8.11)	8.30 (8.43)	8.63	8.83	8.96	9.07	7.96	7.02	7.10
13) Mirpur (BWDB Sta. 302)	6.30 (6.42)	6.59 (6.64)	6.90 (6.91)	7.30 (7.25)	7.68 (7.58)	7.90 (7.76)	8.17 (8.00)	8.53 (8.31)	8.90	9.12	9.27	9.39	8.39	7.30	7.09

Notes : 1) The results of the check survey for the water level gauging stations of Mill Barak, Mirpur, Tongi and Demra(Sta. 7.5) conducted by 1987 JICA STUDY are reflected.

2) Water levels in the parentheses are probable water levels of 1987 JICA STUDY.



LEGEND

▲ Rainfall gauging station

● Water level gauging station

Notes :

1) Narayangang Rainfall Station (B.M.D.) was closed in 1979.

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FIG. D.1 RIVER SYSTEM AND GAUGING STATIONS IN AND AROUND THE STUDY AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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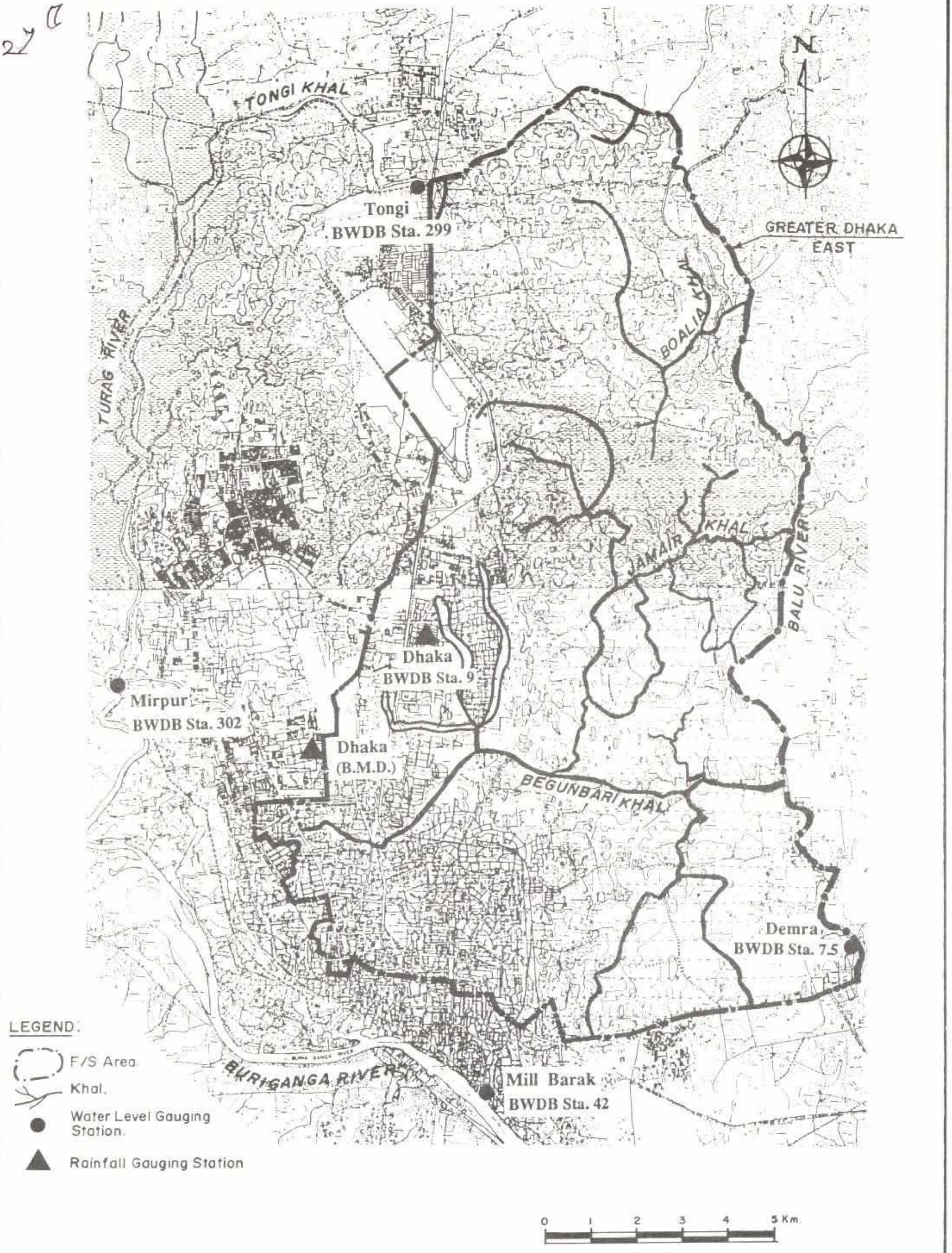

FIG. D.2(1)	KHAL SYSTEM OF GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

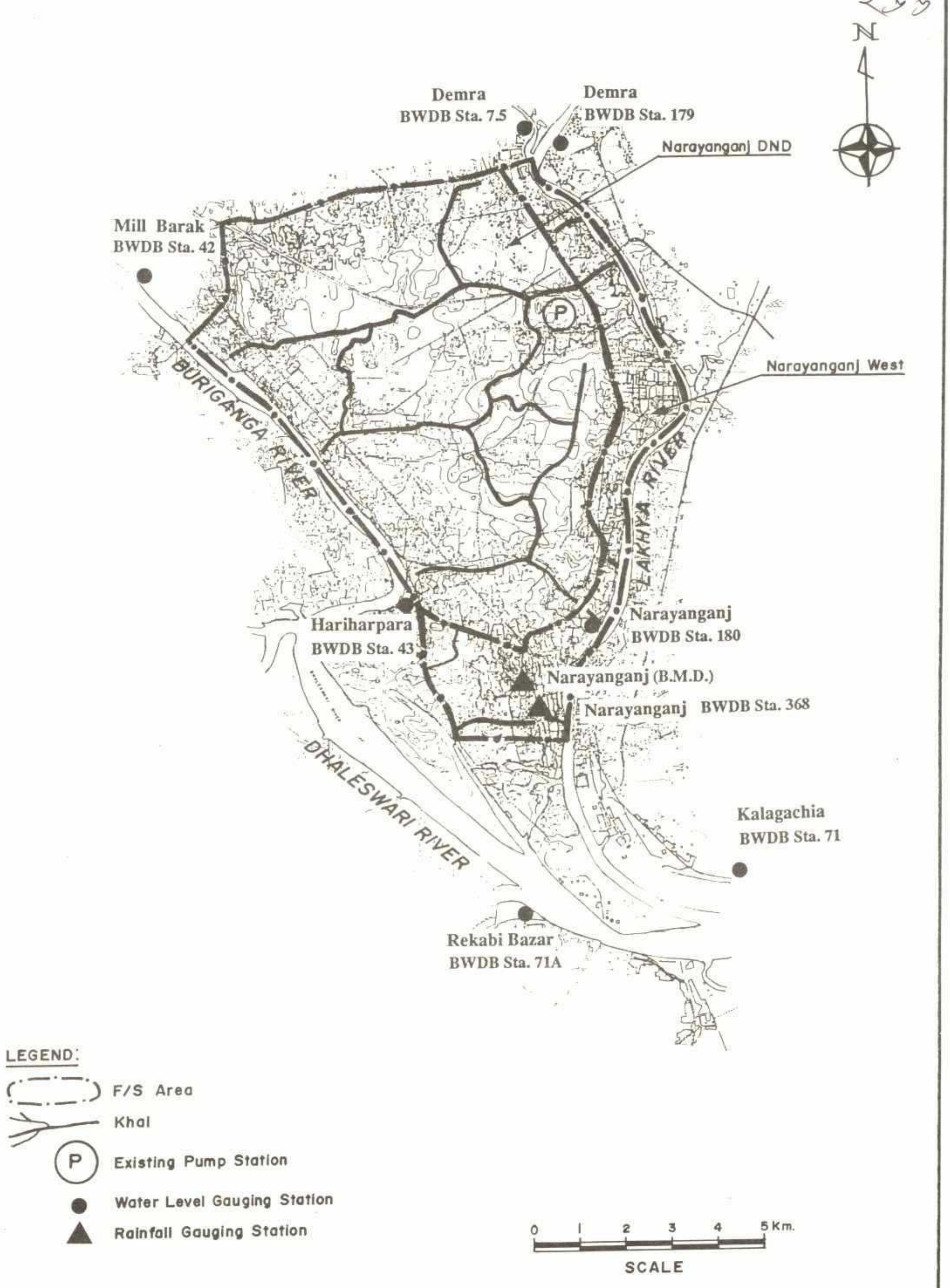

FIG. D.2(2)	KHAL SYSTEM OF DND AND NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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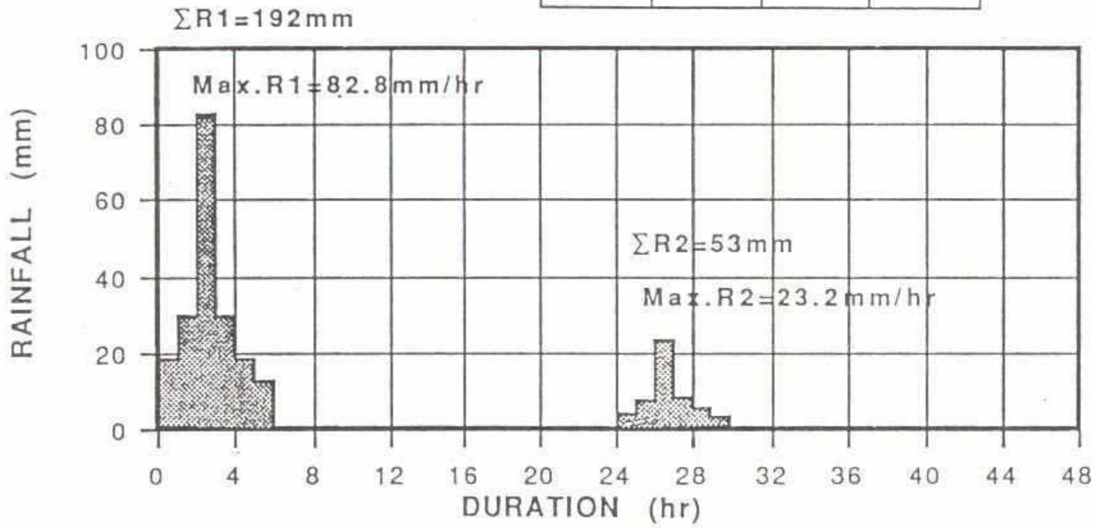
HOURLY DISTRIBUTION

hr	%	R1	R2
1	9	17.4	4.8
2	15	28.3	8.0
3	44	82.8	23.2
4	16	30.6	8.5
5	9	18.0	5.0
6	7	14.9	3.5
TOTAL	100	192.0	53.0



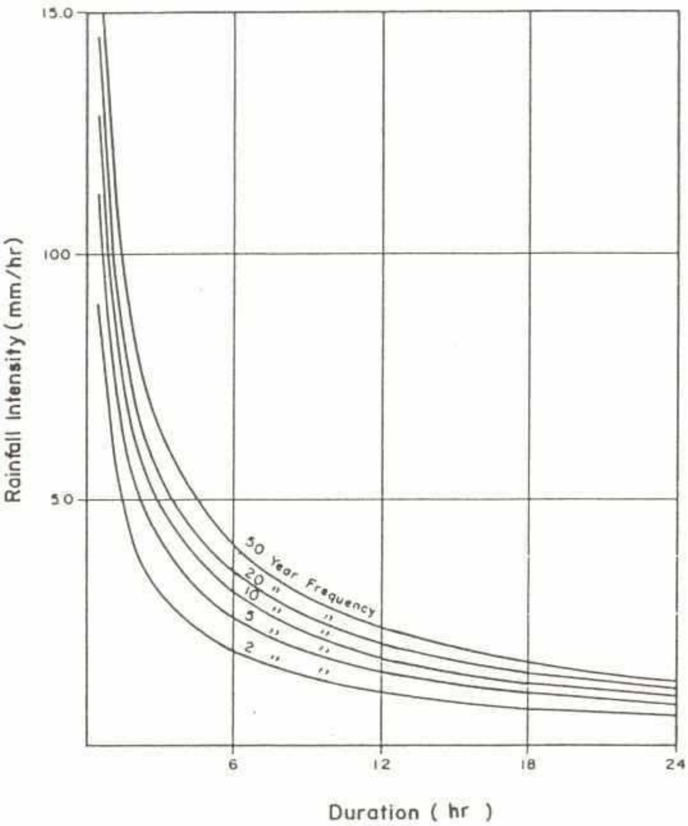
Source :

JICA; Study on Storm Water Drainage System Improvement Project in Dhaka City, 1987

FIG. D.3 PROPOSED DESIGN HYETOGRAPH FOR PUMP DRAINAGE PLAN

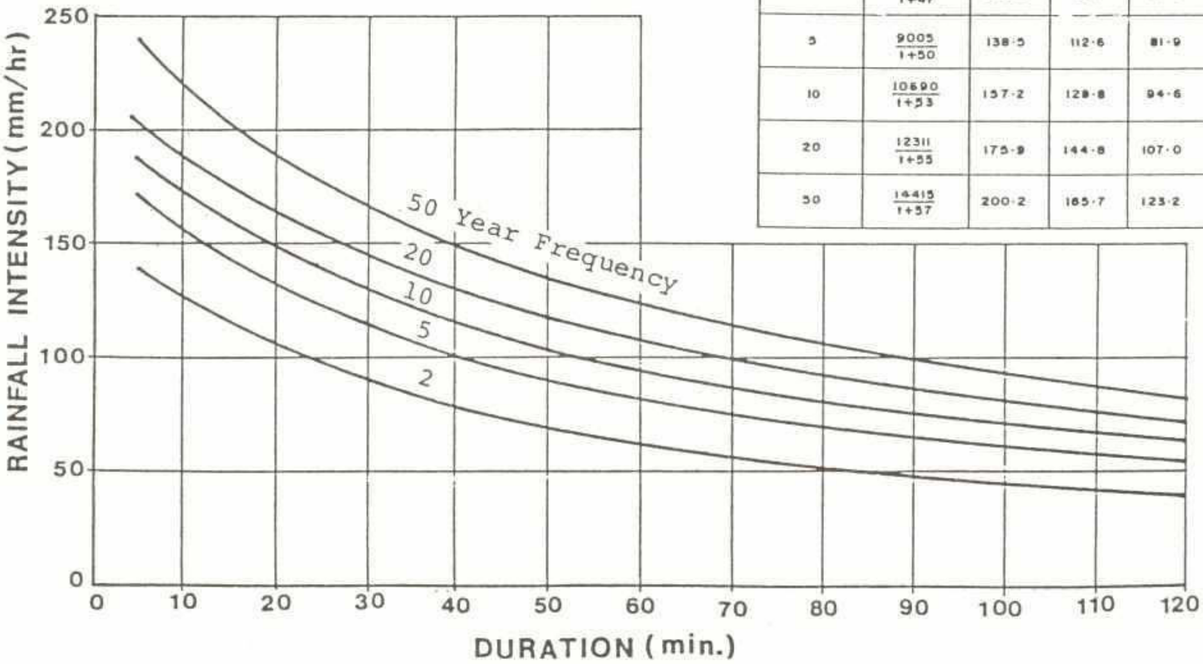
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA



RAINFALL INTENSITY-DURATION FORMULA

RETURN PERIOD	EQUATION	RAINFALL INTENSITY			
		15	30	60	120
2	$\frac{6689}{t+44}$	113·4	90·4	64·3	40·8
3	$\frac{7674}{t+47}$	123·8	99·7	71·7	46·0
5	$\frac{9005}{t+50}$	138·5	112·6	81·9	53·0
10	$\frac{10690}{t+53}$	157·2	128·8	94·6	61·8
20	$\frac{12311}{t+55}$	175·9	144·8	107·0	70·3
50	$\frac{14415}{t+57}$	200·2	165·7	123·2	81·4

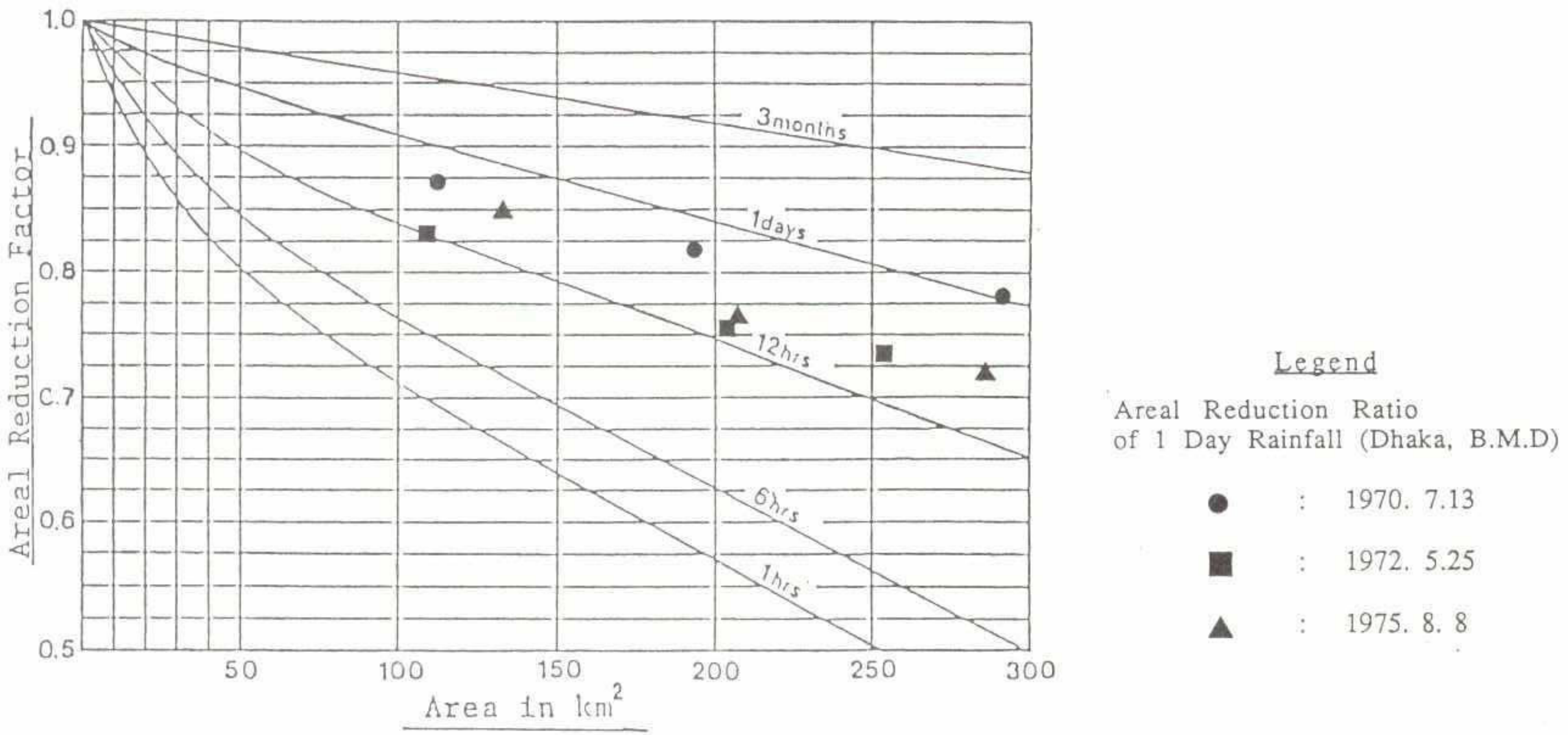


Source :

JICA; Study on Storm Water Drainage System Improvement Project in Dhaka City, 1987

FIG. D.4 RAINFALL INTENSITY AND DURATION RELATIONSHIP

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



Source :

NEDECO ; master Plan for Drainage and Flood Control of Jakarta, 1973

FIG. D.5	AREAL REDUCTION CURVES FOR POINT RAINFALL
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH	

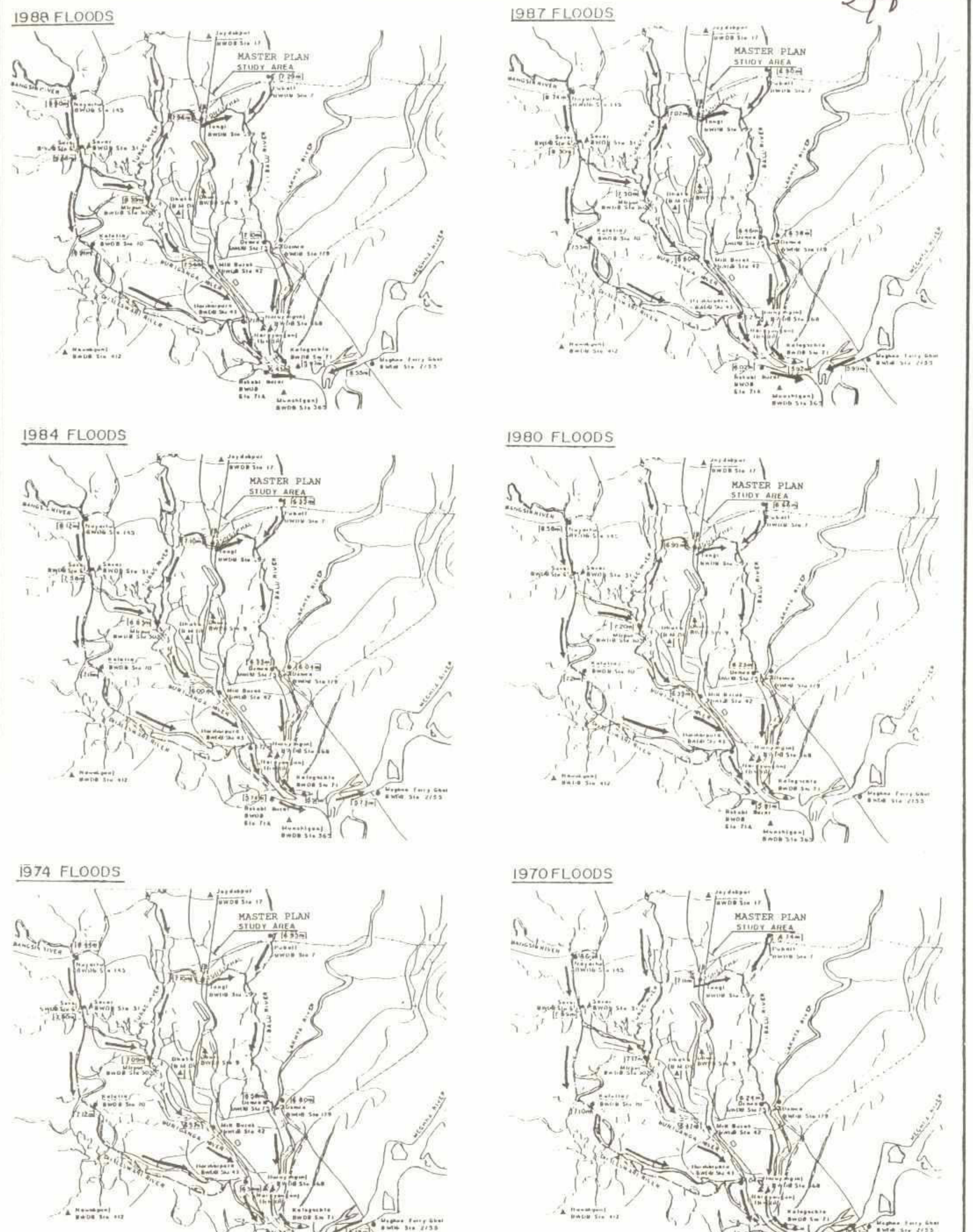


FIG. D.6 ESTIMATED FLOW DIRECTION OF MAJOR FLOODS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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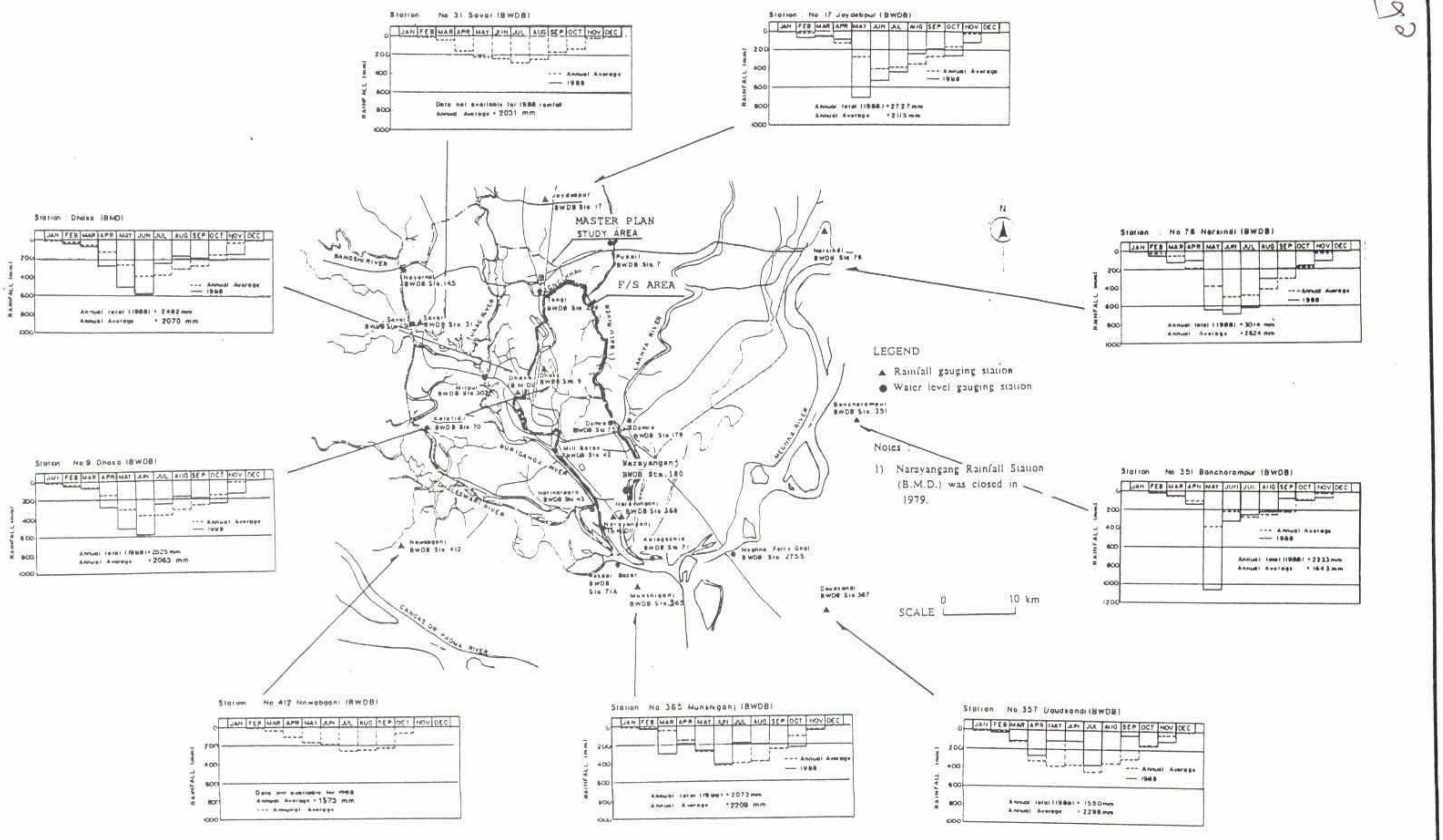

FIG. D.7 MONTHLY RAINFALL-1988 AND ANNUAL AVERAGE

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

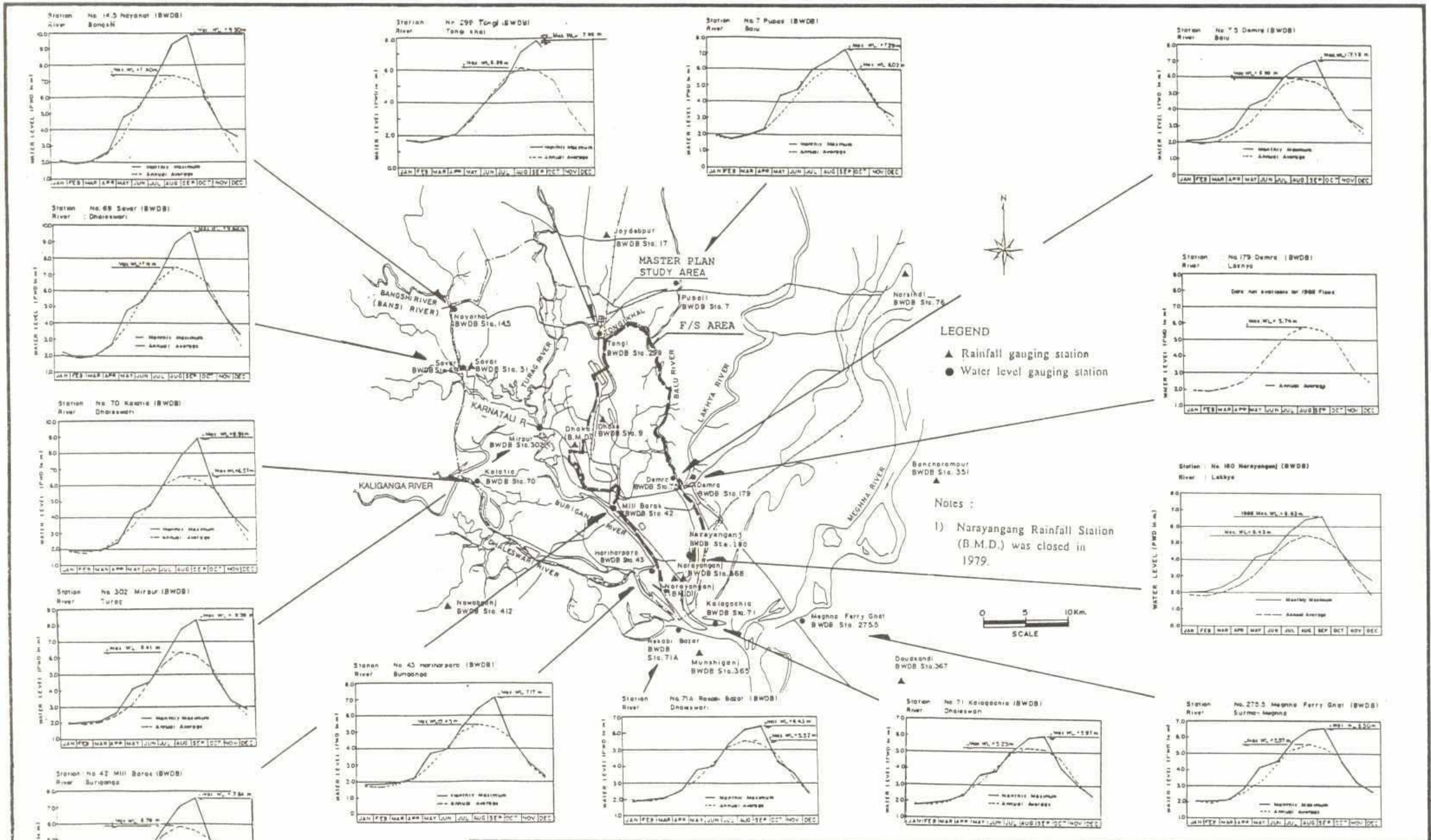

FIG. D.8 MONTHLY MAXIMUM WATER LEVEL - 1988 AND ANNUAL AVERAGE

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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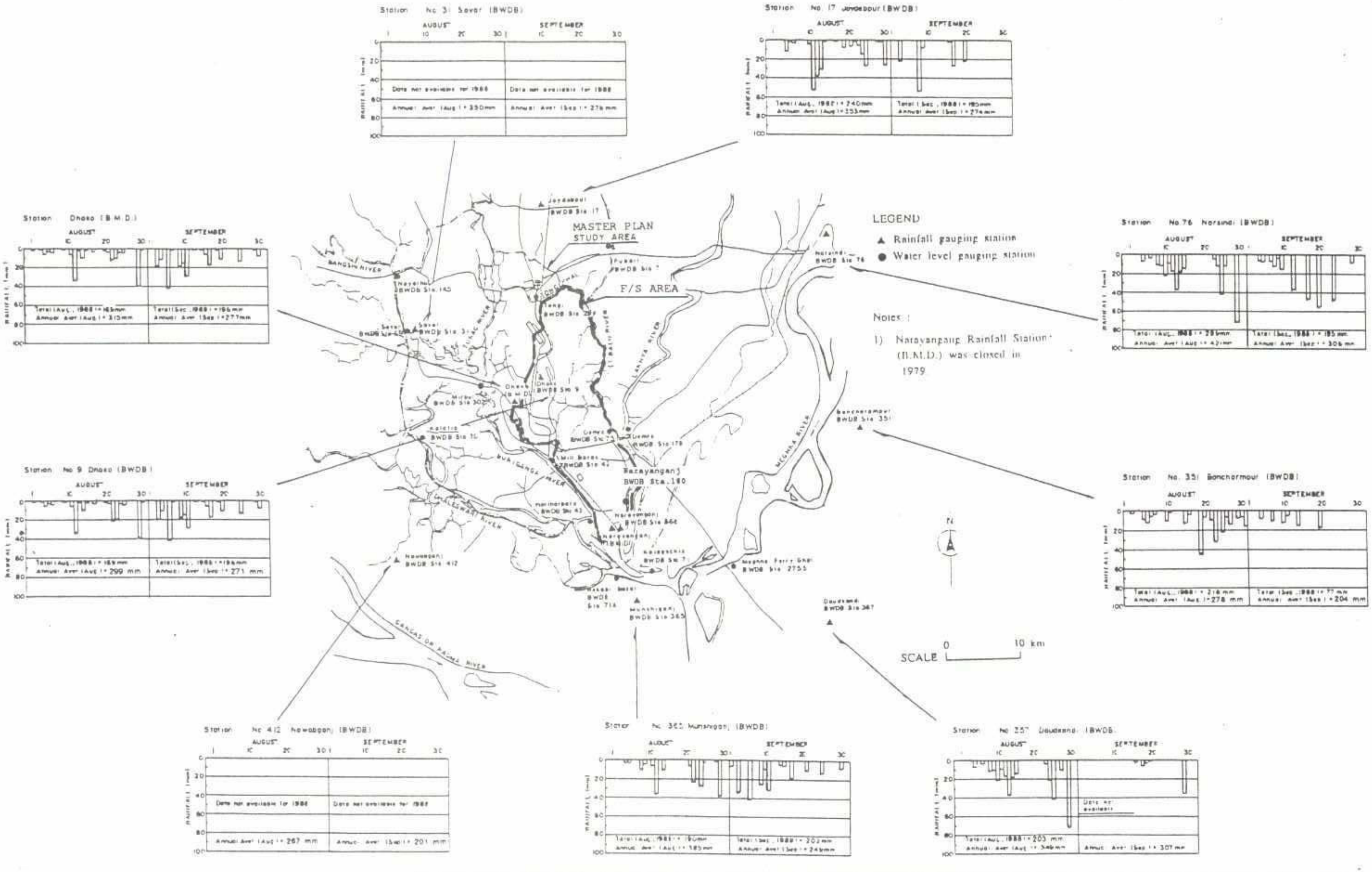

FIG. D.9 DAILY RAINFALL DURING 1988 FLOODS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

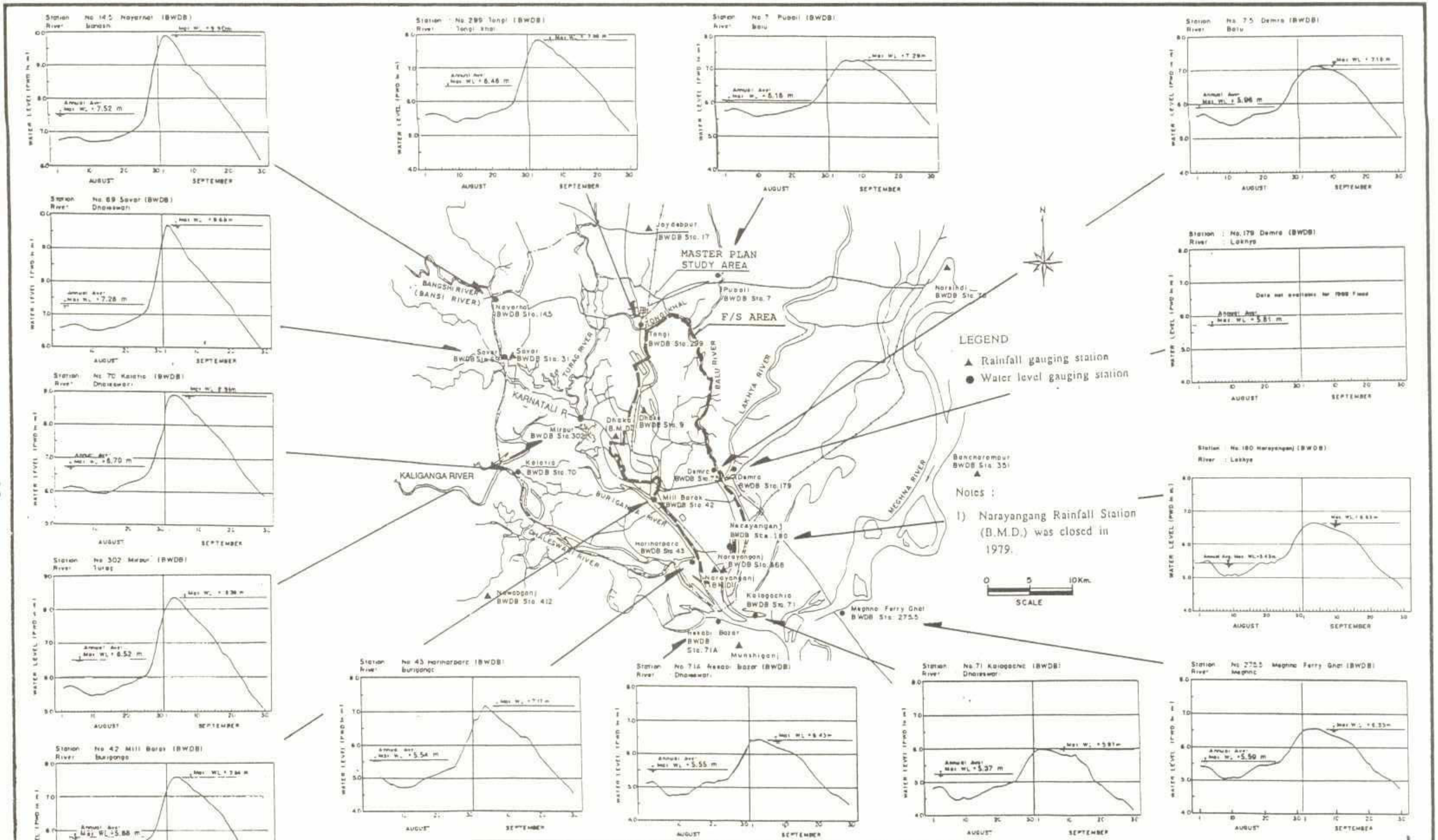

FIG. D.10 DAILY MAXIMUM WATER LEVEL DURING 1988 FLOODS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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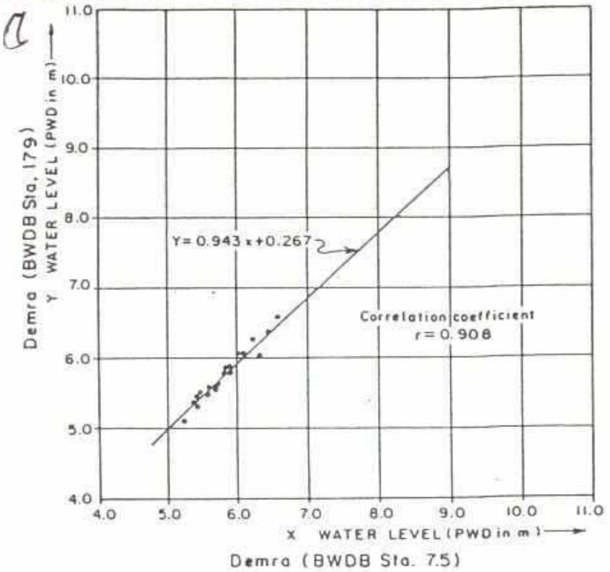
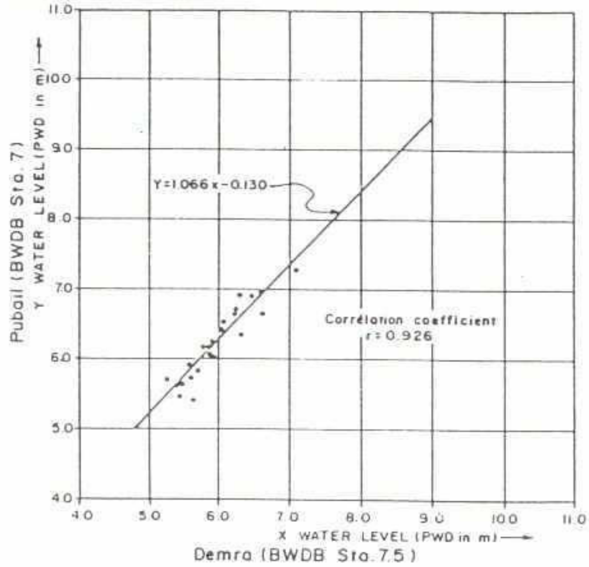
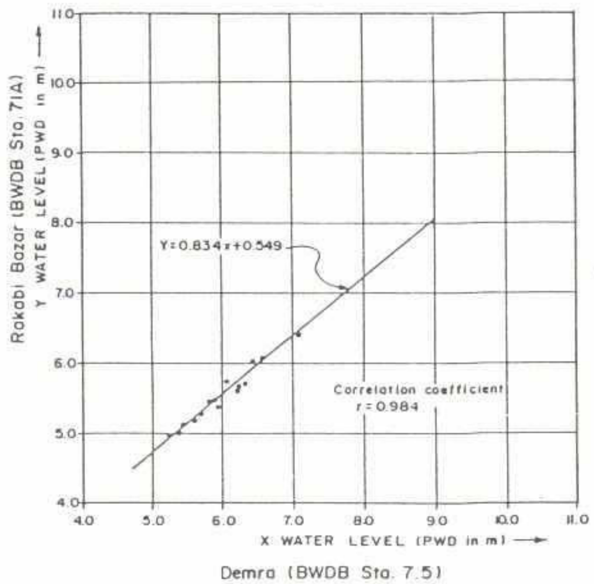
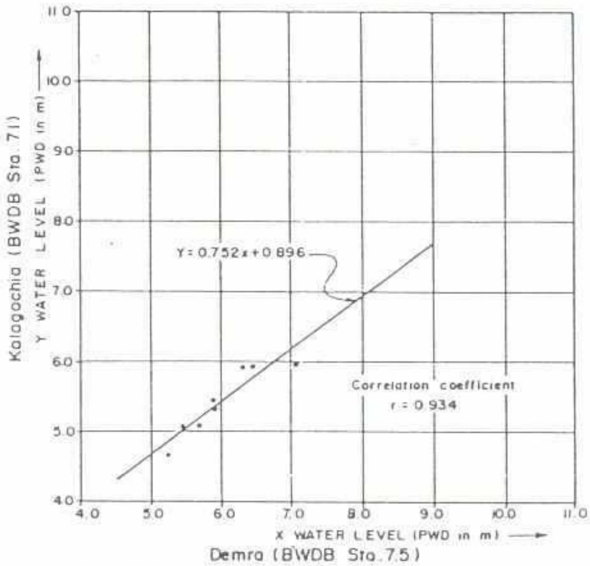


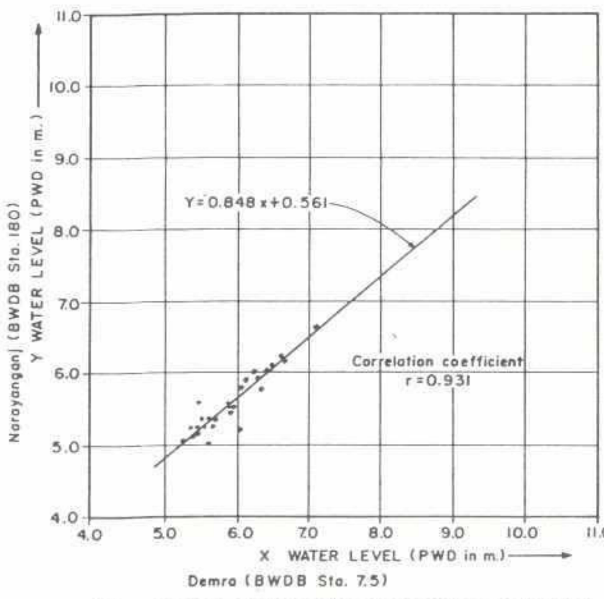


Notes: 1) Water level data of Demra (Sta 7.5) are supplemented by that of Demra (Sta. 179) using their correlation.





Notes: 1) Water level data of Demra (Sta. 7.5) are supplemented by that of Demra (Sta. 179) using their correlation.



Notes:- 1) Water level data of Demra (Sta. 7.5) are supplemented by that of Demra (Sta. 179) using their correlation.

FIG. D.11(1) CORRELATION AMONG WATER LEVEL GAUGING STATIONS (1/3)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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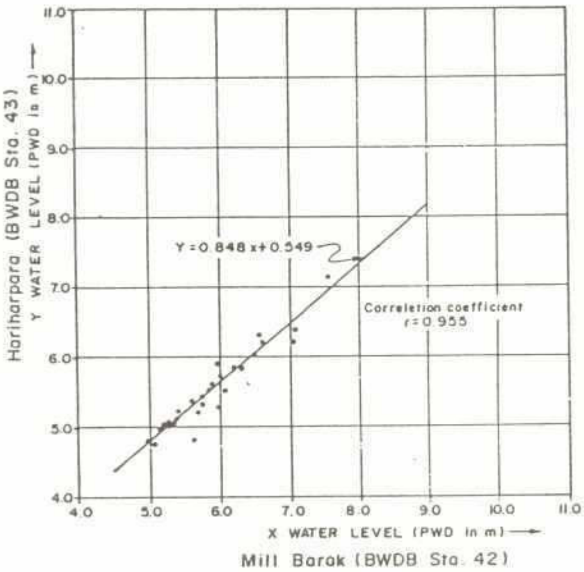

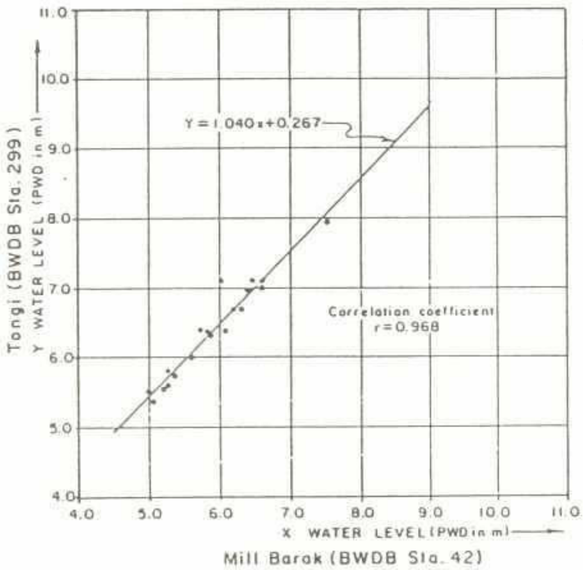

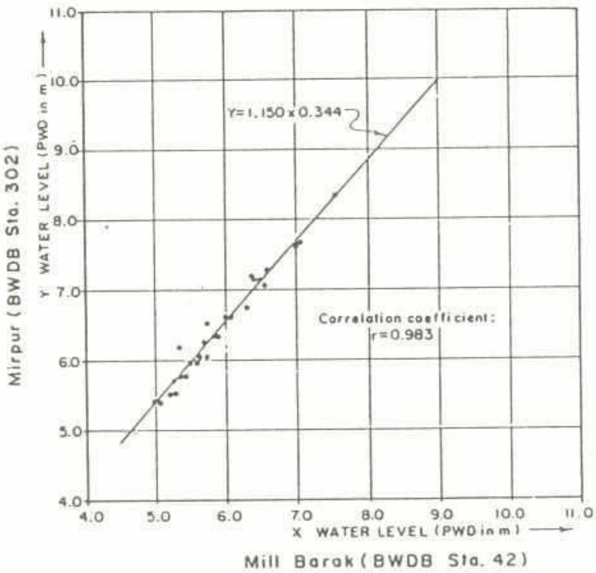

FIG. D.11(2) CORRELATION AMONG WATER LEVEL GAUGING STATIONS (2/3)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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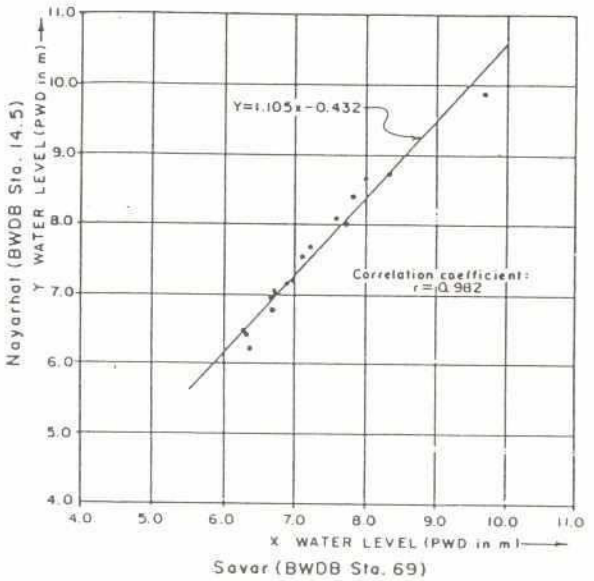

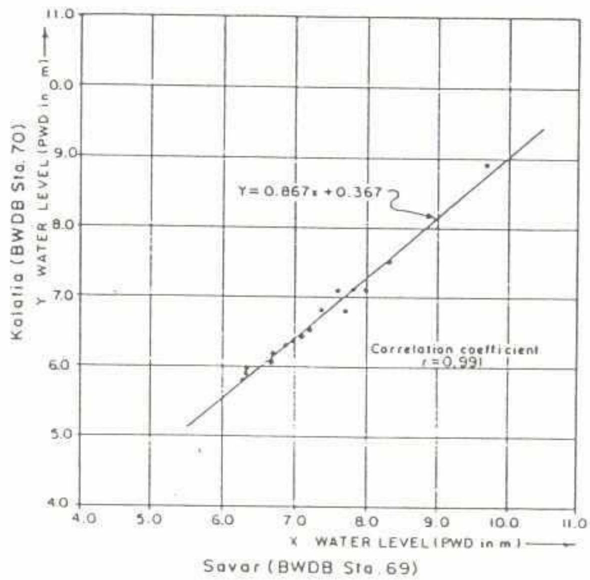

FIG. D.11(3) CORRELATION AMONG WATER LEVEL GAUGING STATIONS (3/3)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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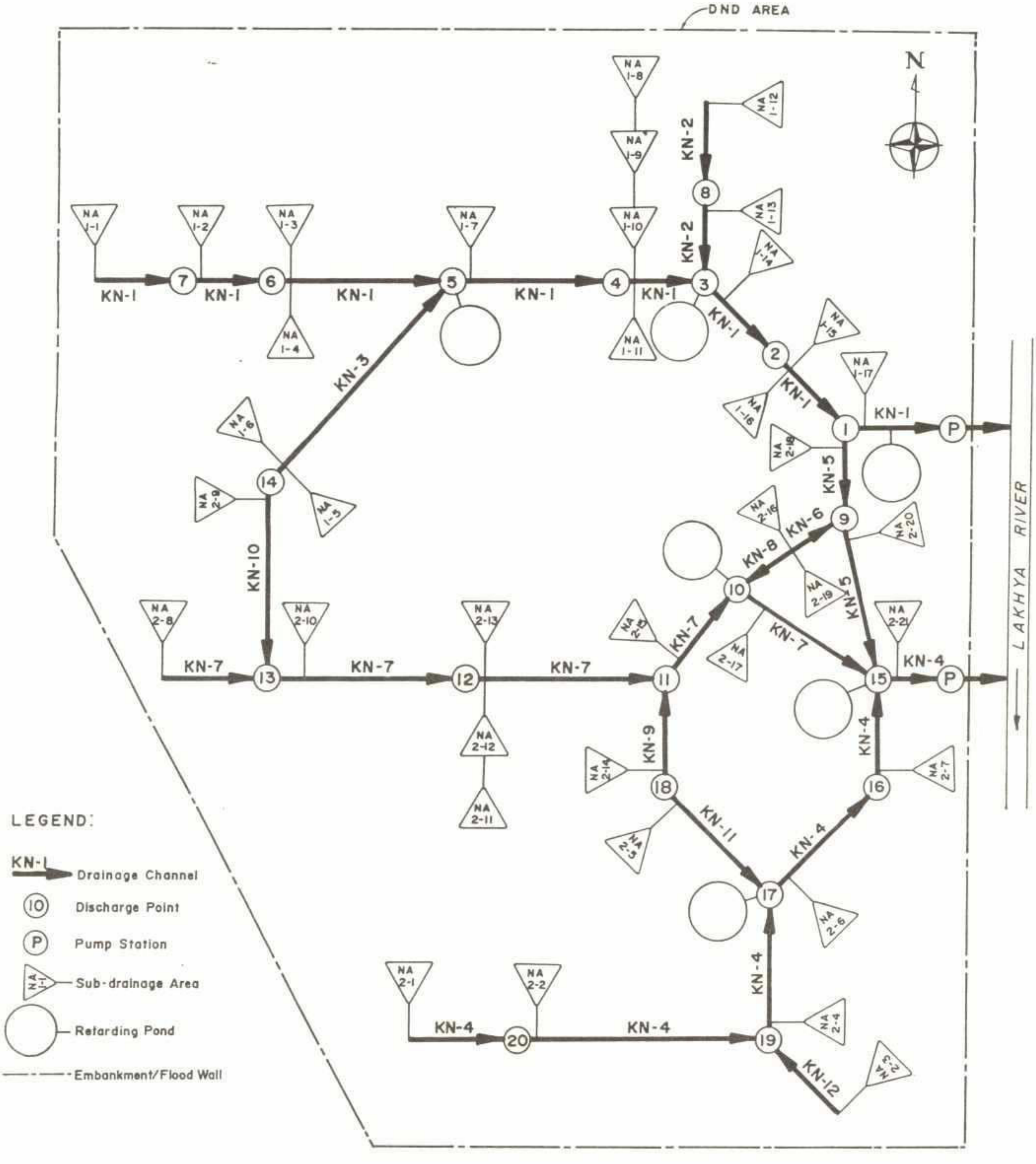

FIG. D.12 PROPOSED SIMULATION MODEL OF NARAYANGANJ DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

FIG. D.13 DRAINAGE CHANNELS AND SUB-CATCHMENTS OF NARAYANGANJ DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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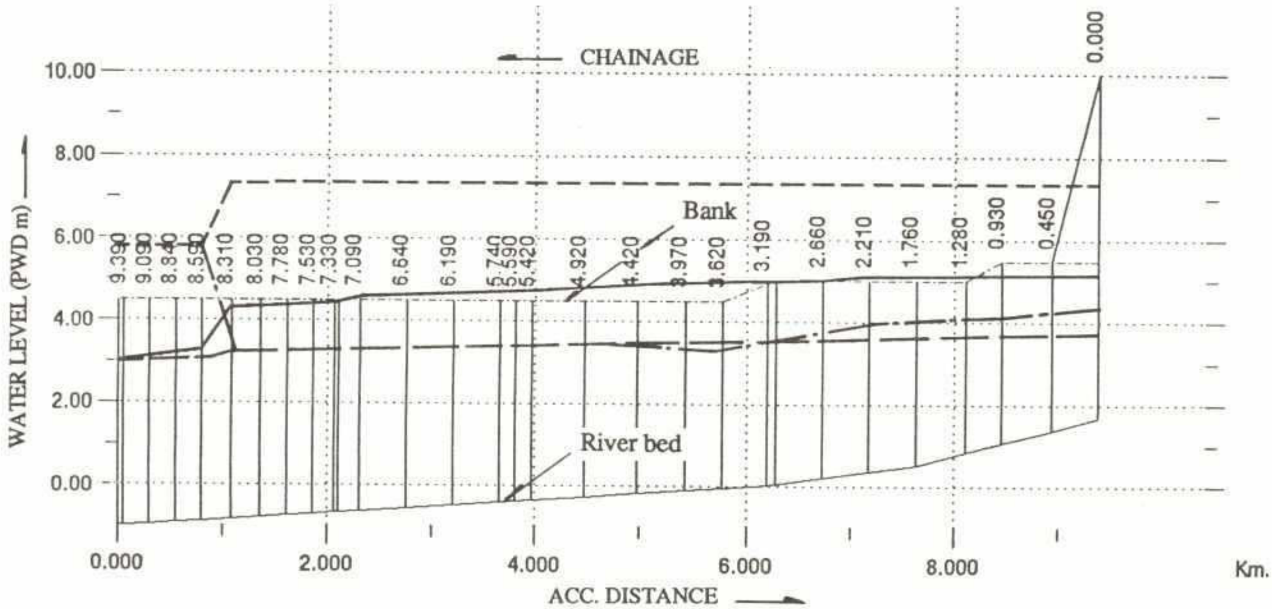
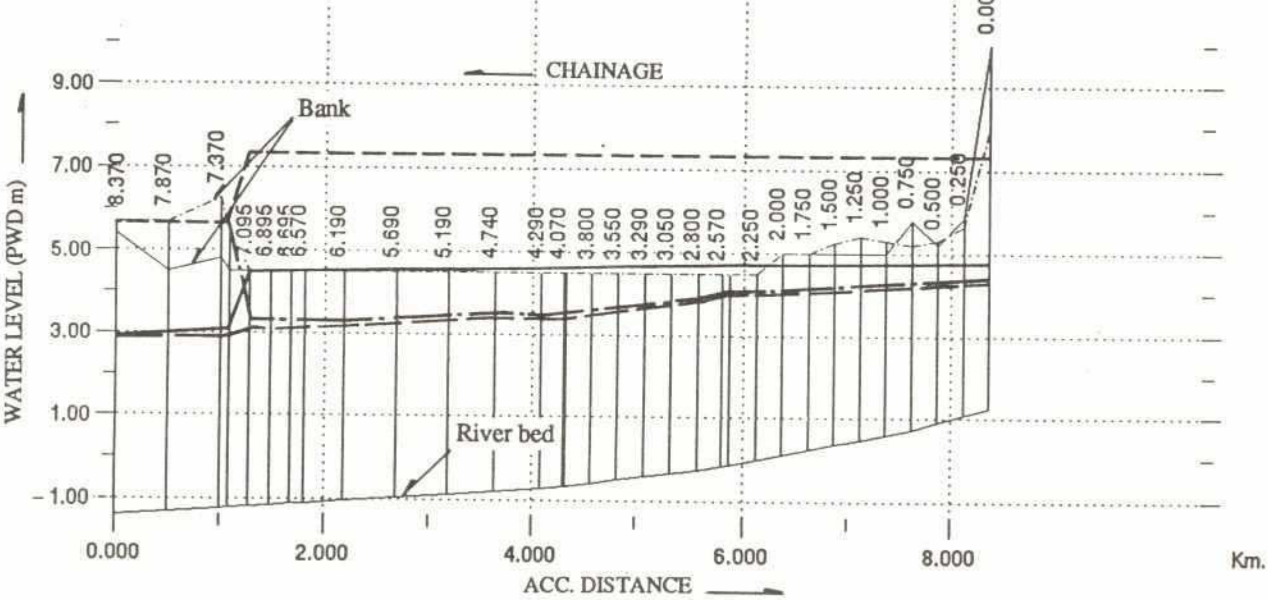
DRAINAGE CHANNEL : KN-1



DRAINAGE CHANNEL : KN-4



LEGEND :

Water Level

- Case 1-1 : Without retarding pond and without pump station
- Case 1-2 : Without retarding pond and with pump station
- Case 2-1 : With retarding pond and without pump station
- Case 2-2 : With retarding pond and with pump station

FIG. D.14 PROFILE OF SIMULATED PEAK WATER LEVEL OF NARAYANGANJ DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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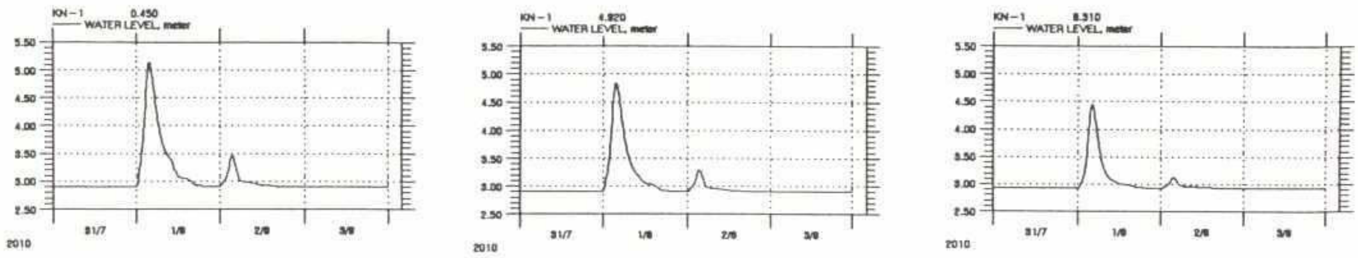
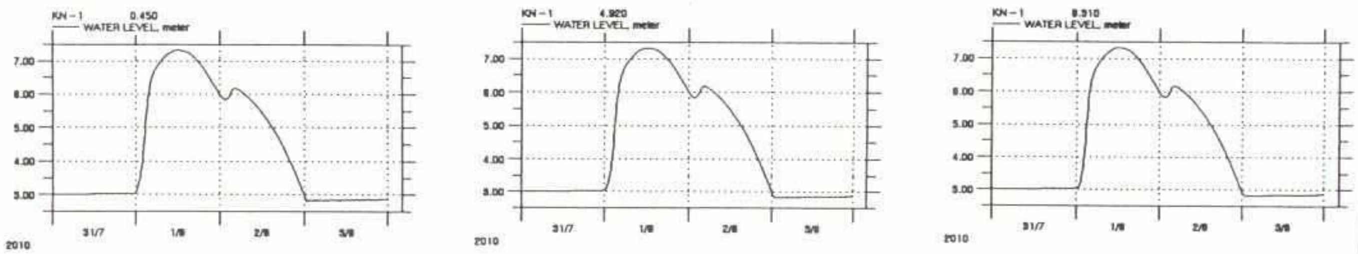
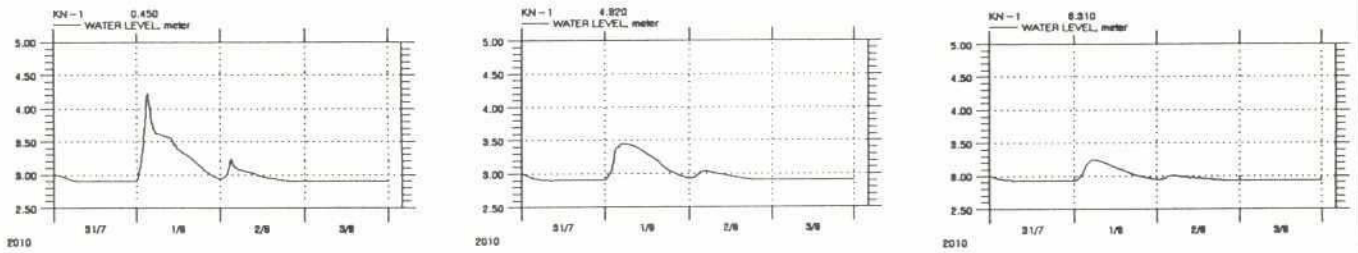
Case 1-1 : Without retarding pond and without pump station



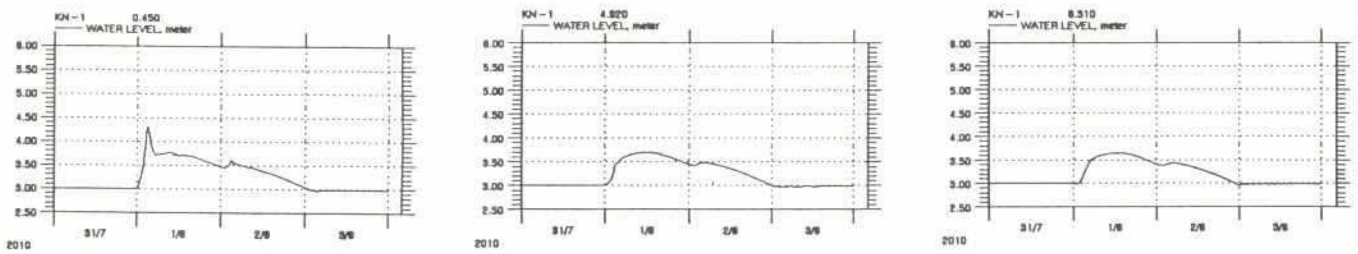
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-1	4.920

FIG. D.15(1) SIMULATED WATER LEVEL HYDROGRAPH OF NARAYANGANJ DND(1)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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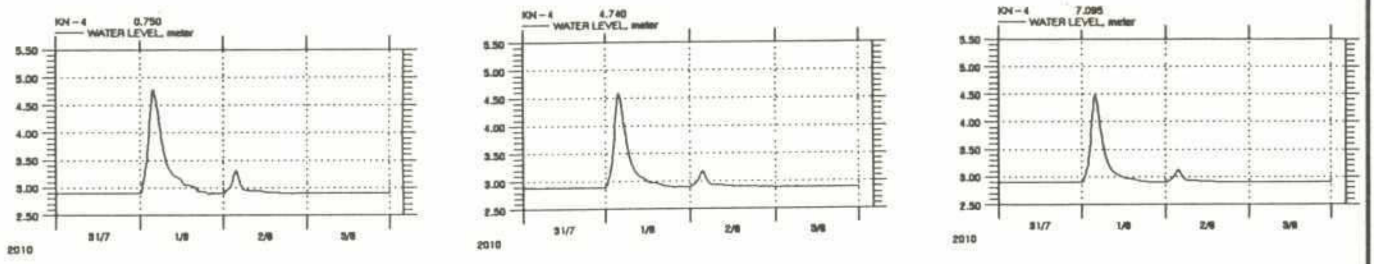
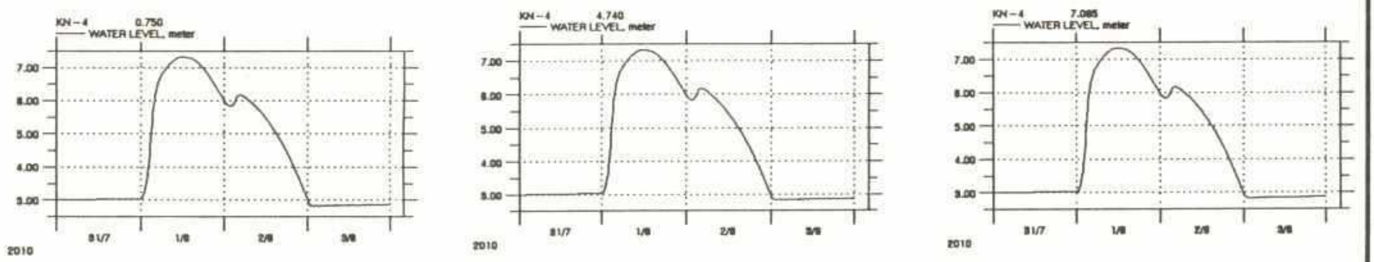
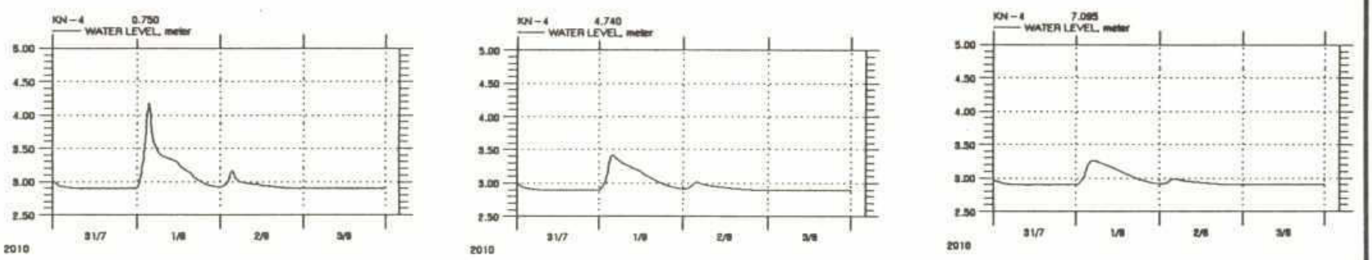
Case 1-1 : Without retarding pond and without pump station



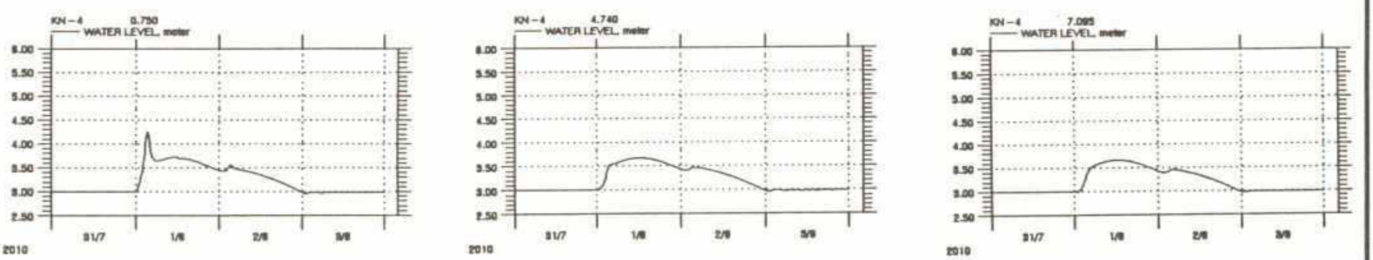
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



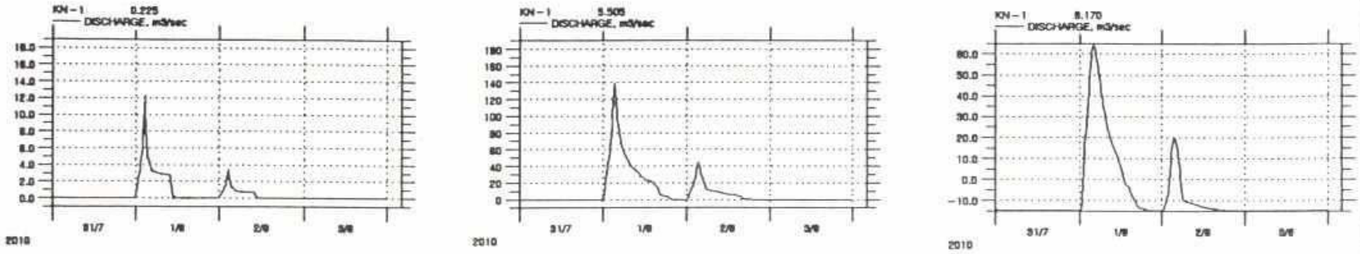
LEGEND :

Channel Name	Chainage(km)
KN-4	4.740

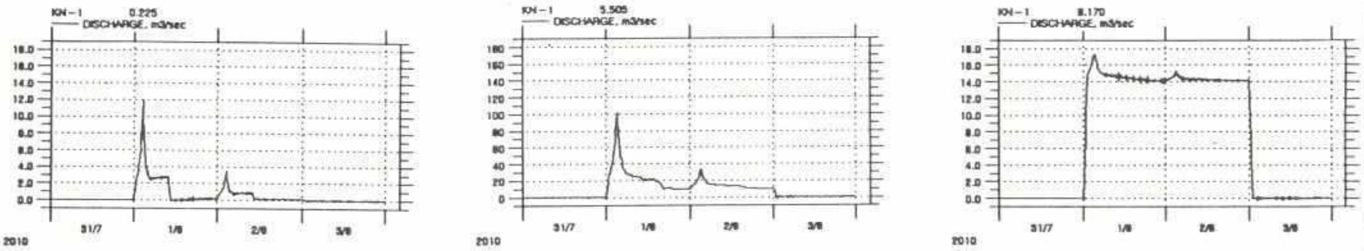
FIG. D.15(2) SIMULATED WATER LEVEL HYDROGRAPH OF NARAYANGANJ DND(2)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

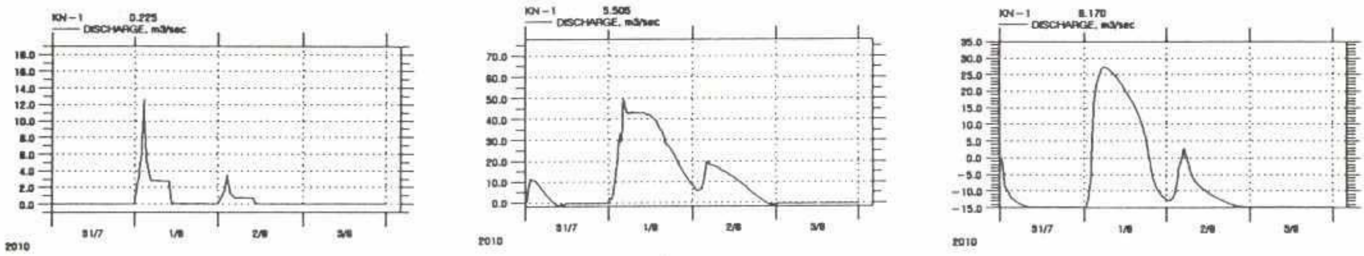
Case 1-1 : Without retarding pond and without pump station



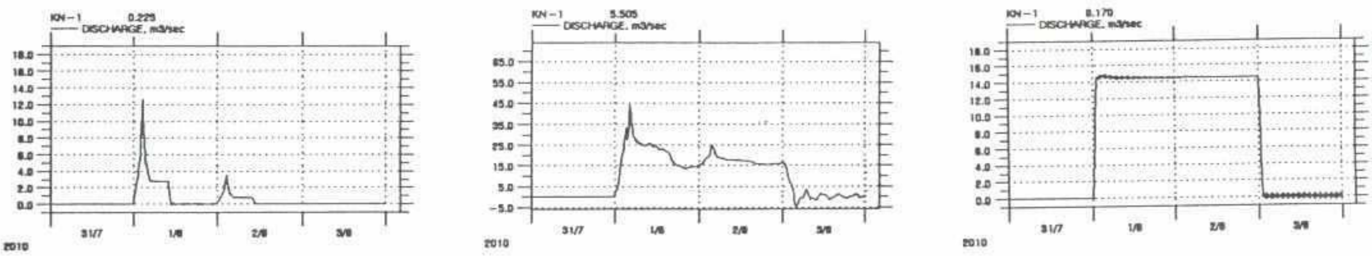
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-1	5.505

FIG. D.16(1) SIMULATED DISCHARGE HYDROGRAPH OF NARAYANGANJ DND(1)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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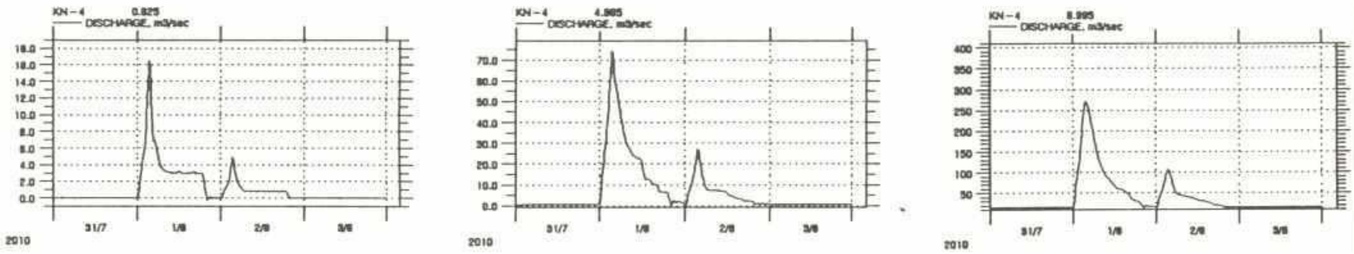
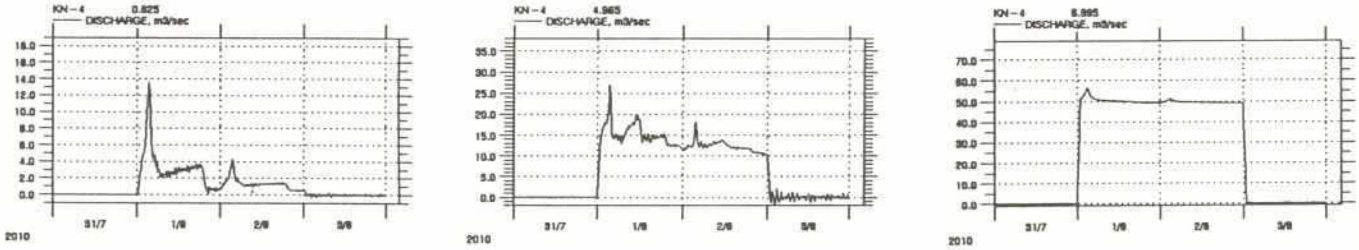
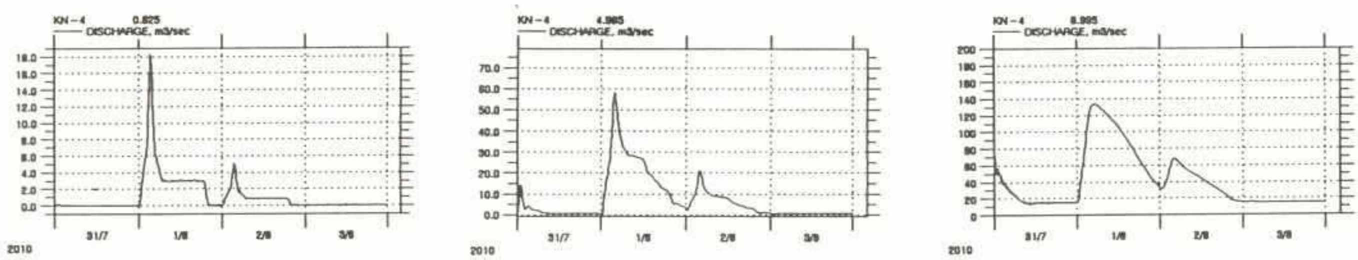
Case 1-1 : Without retarding pond and without pump station



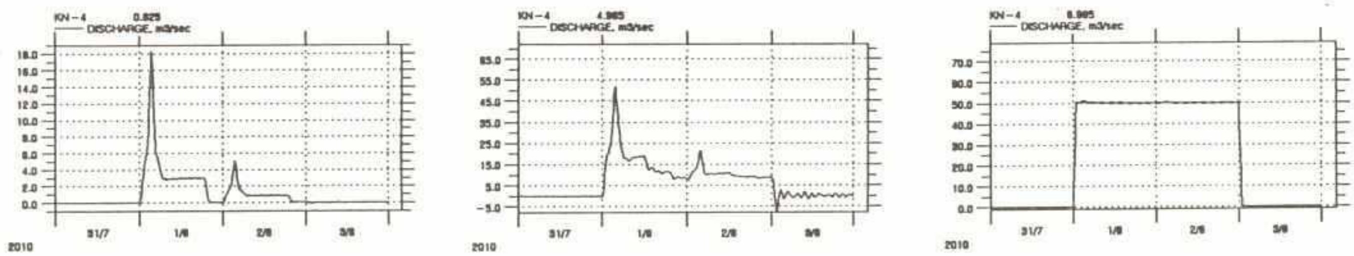
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station

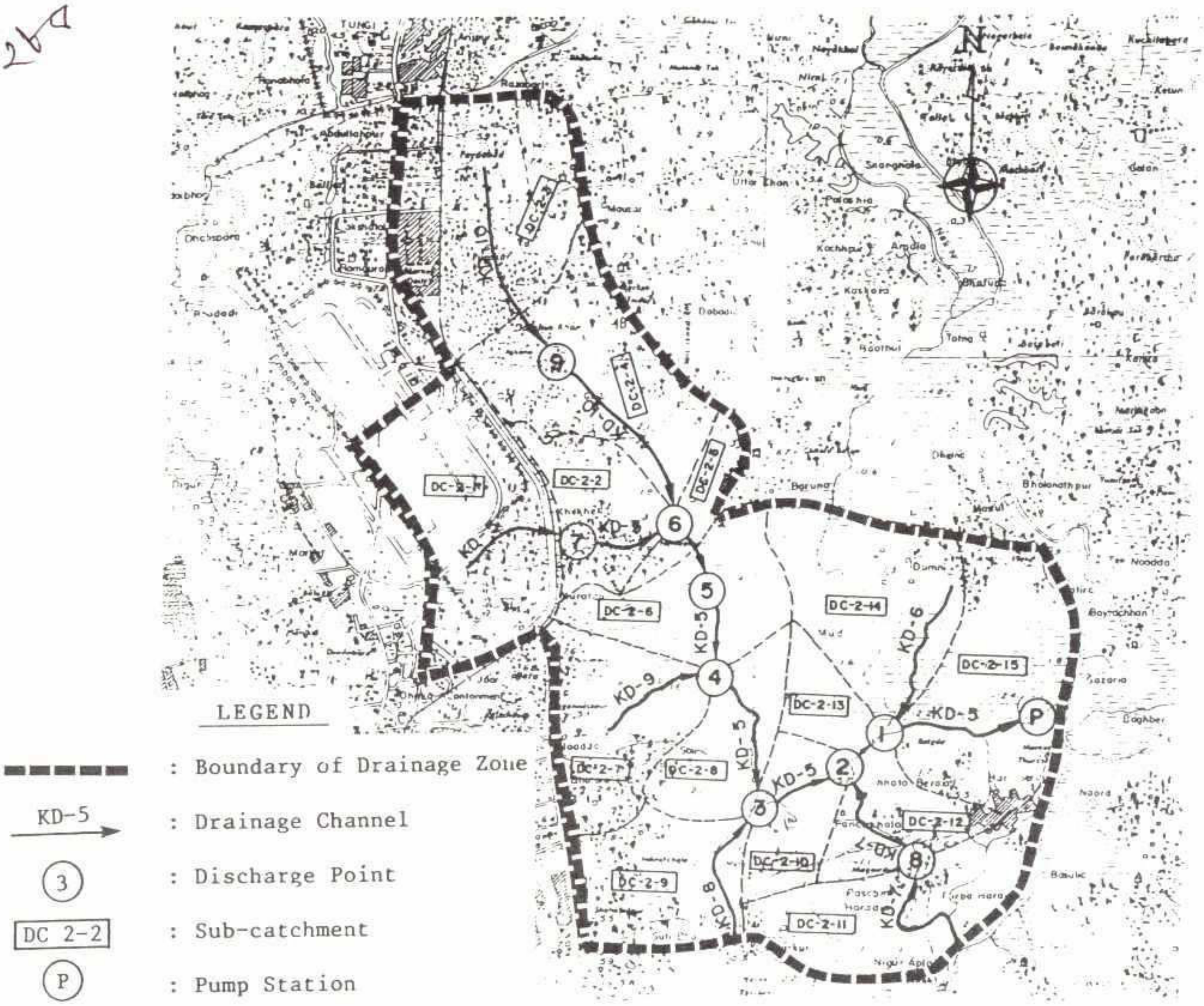


LEGEND :

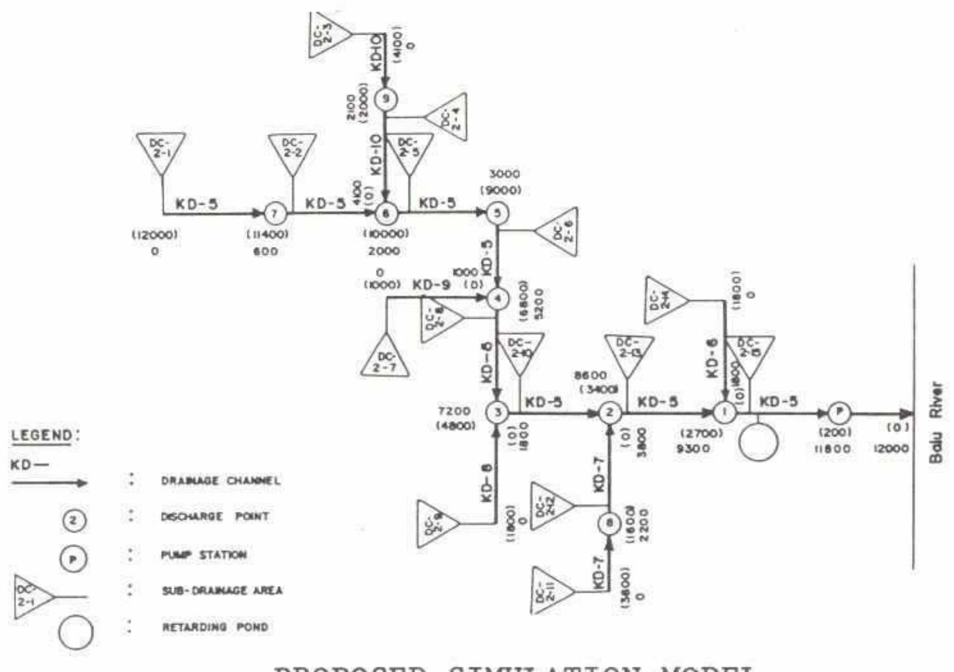
Channel Name	Chainage(km)
KN-4	4.965

FIG. D.16(2) SIMULATED DISCHARGE HYDROGRAPH OF NARAYANGANJ DND(2)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DRAINAGE CHANNELS AND SUB-CATCHMENTS



PROPOSED SIMULATION MODEL

FIG. D.17 DRAINAGE CHANNELS AND SUB-CATCHMENTS, AND PROPOSED SIMULATION MODEL OF SUB-DRAINAGE ZONE DC-2

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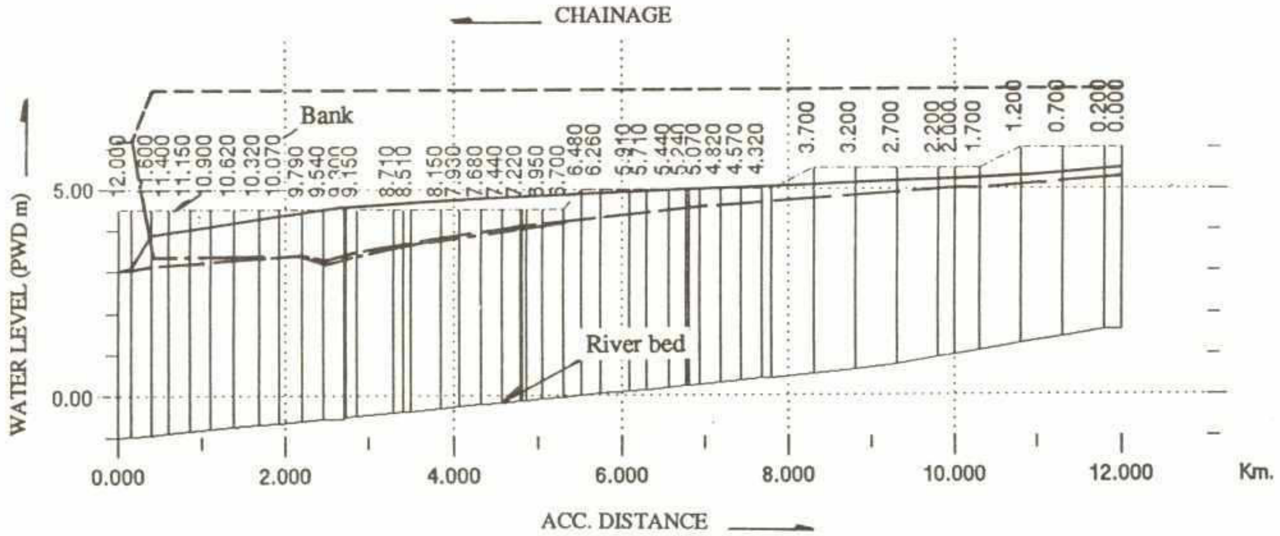
DRAINAGE CHANNEL : KD-5



LEGEND :

Water Level
Case 1-1 : Without retarding pond and without pump station
Case 1-2 : Without retarding pond and with pump station
Case 2-1 : With retarding pond and without pump station
Case 2-2 : With retarding pond and with pump station

FIG. D.18	PROFILE OF SIMULATED PEAK WATER LEVEL HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-2

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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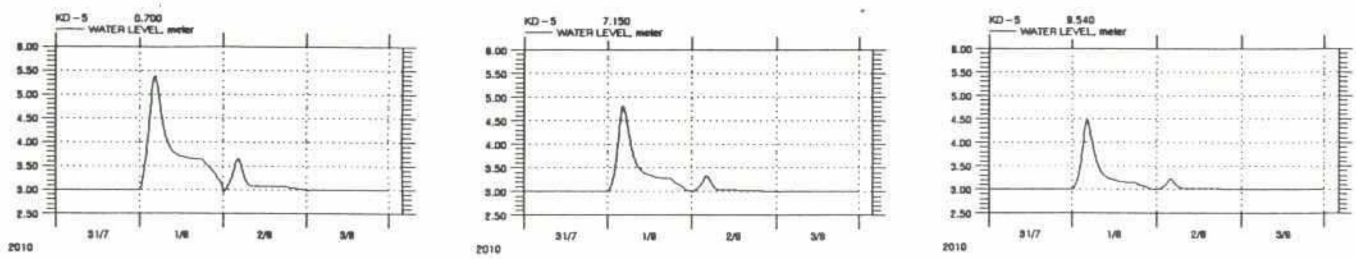
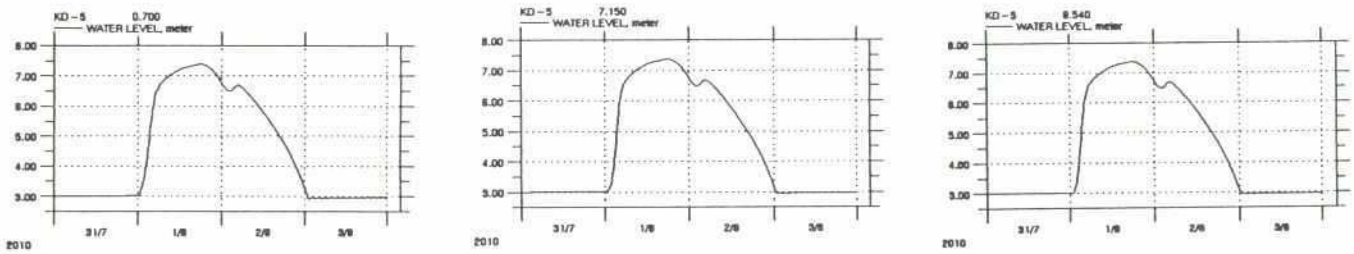
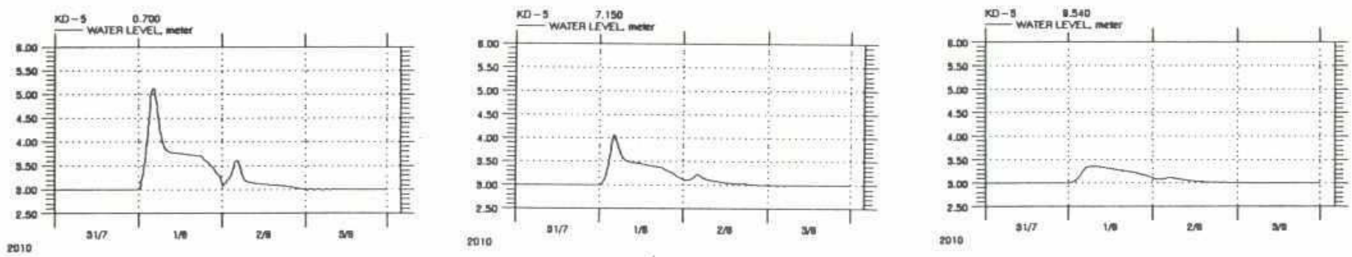
Case 1-1 : Without retarding pond and without pump station



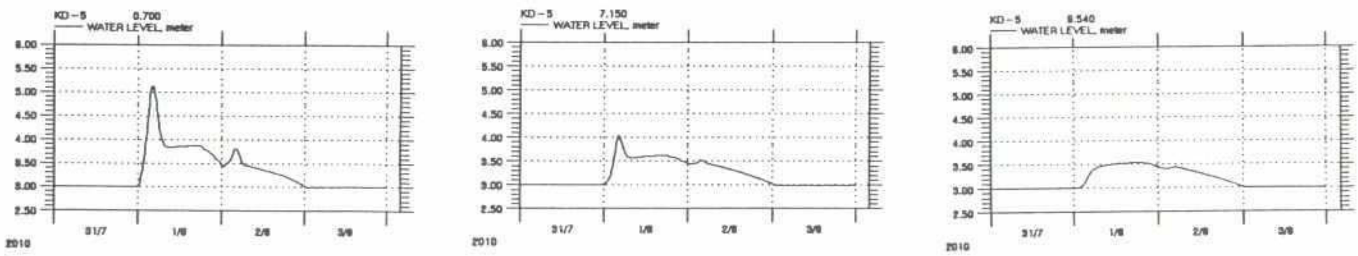
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-5	7.150

FIG. D.19 SIMULATED WATER LEVEL HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-2

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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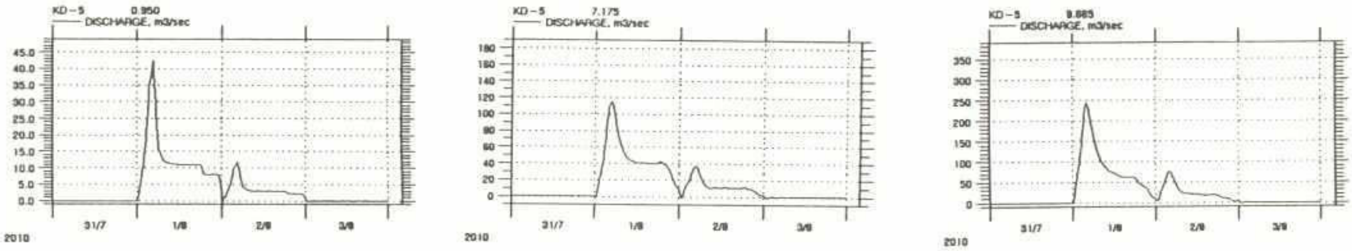
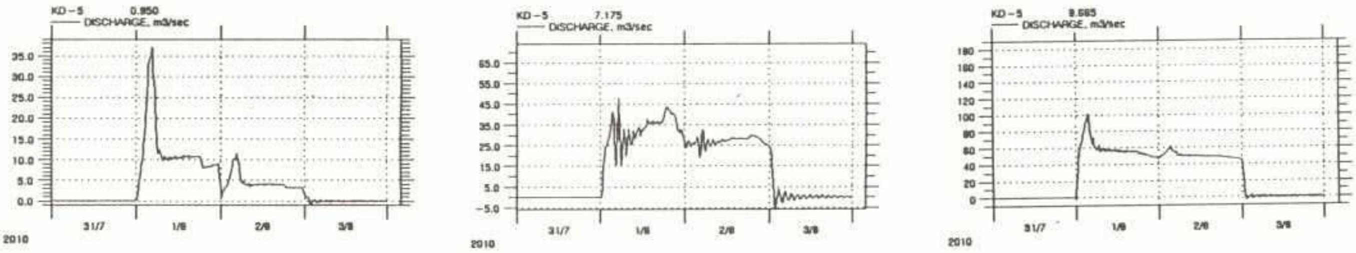
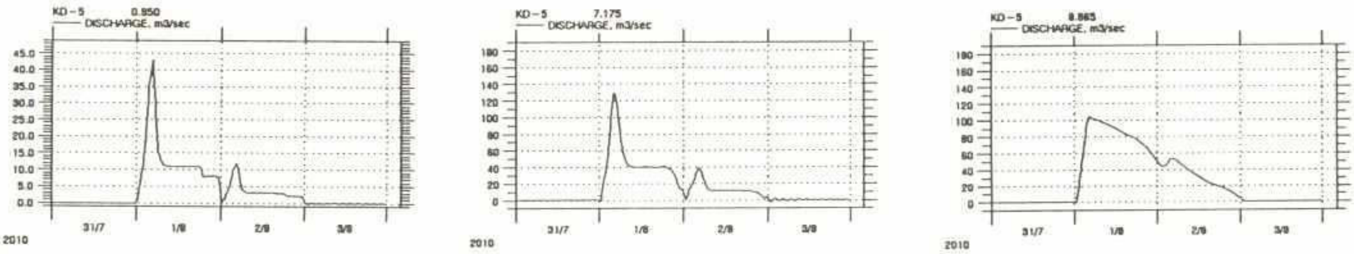
Case 1-1 : Without retarding pond and without pump station



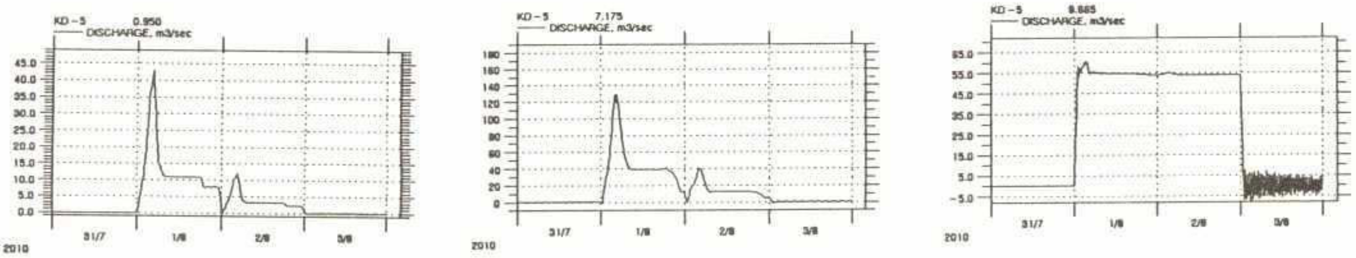
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station

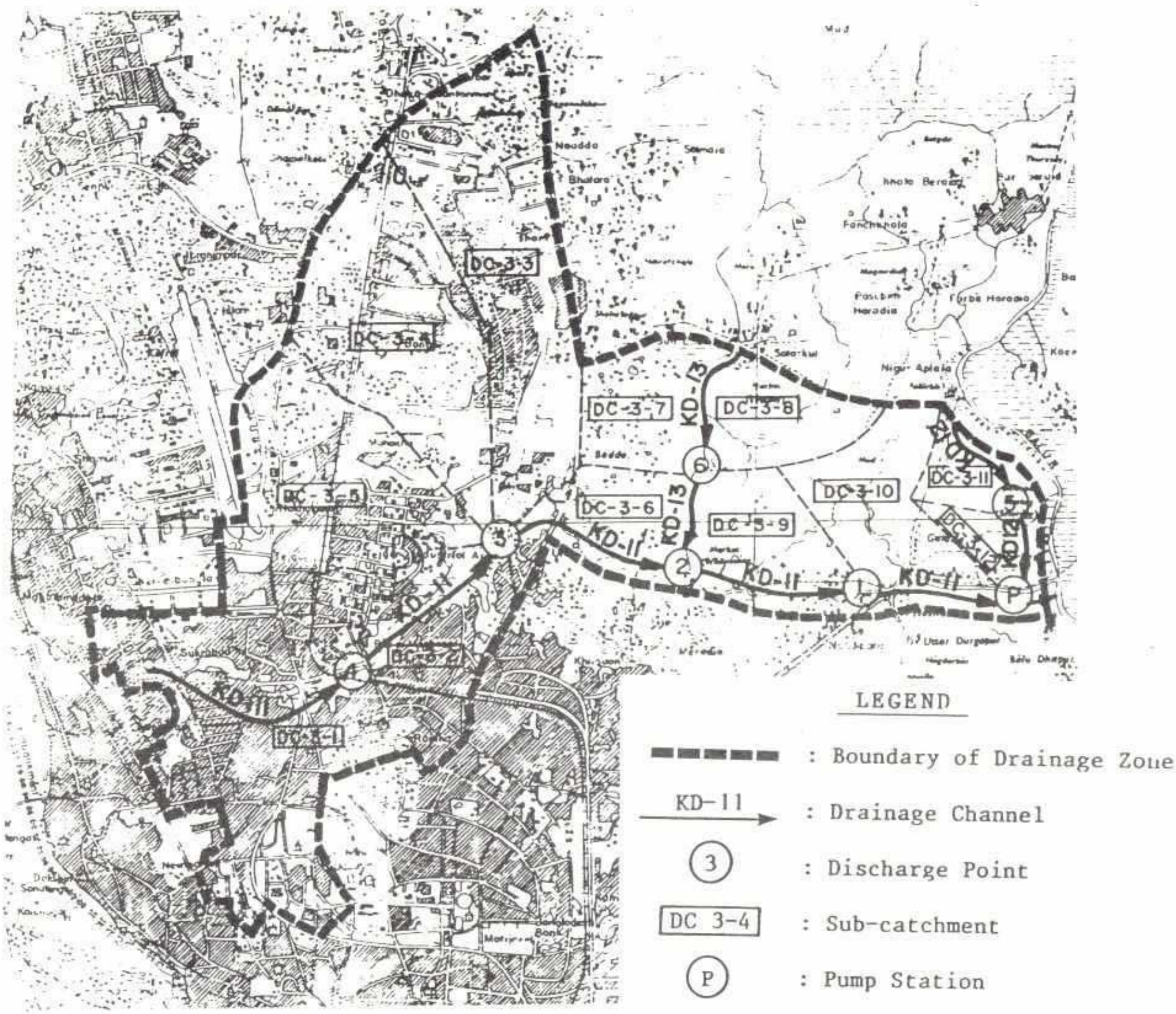


LEGEND :

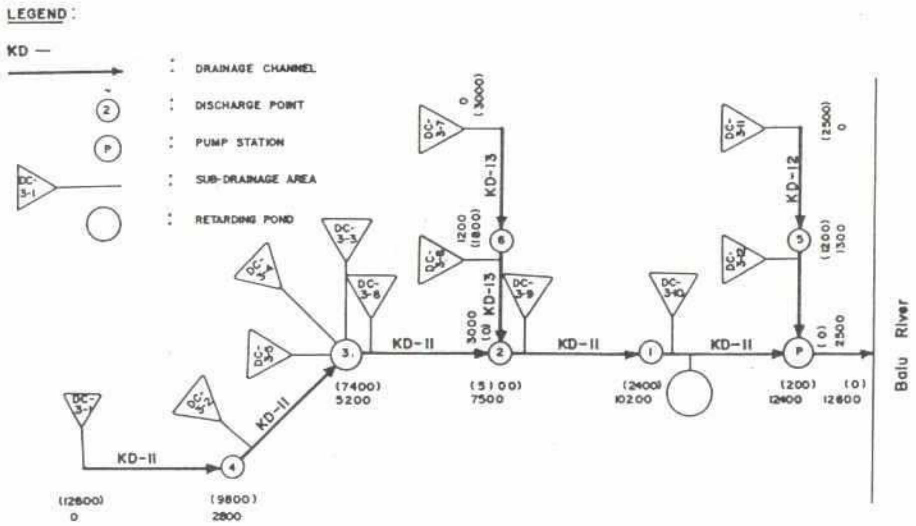
Channel Name	Chainage(km)
KN-5	7.175

FIG. D.20 SIMULATED DISCHARGE HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-2

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DRAINAGE CHANNELS AND SUB-CATCHMENTS



PROPOSED SIMULATION MODEL

FIG. D.21	DRAINAGE CHANNELS AND SUB-CATCHMENTS, AND PROPOSED SIMULATION MODEL OF SUB-DRAINAGE ZONE DC-3

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

DRAINAGE CHANNEL : KD-11

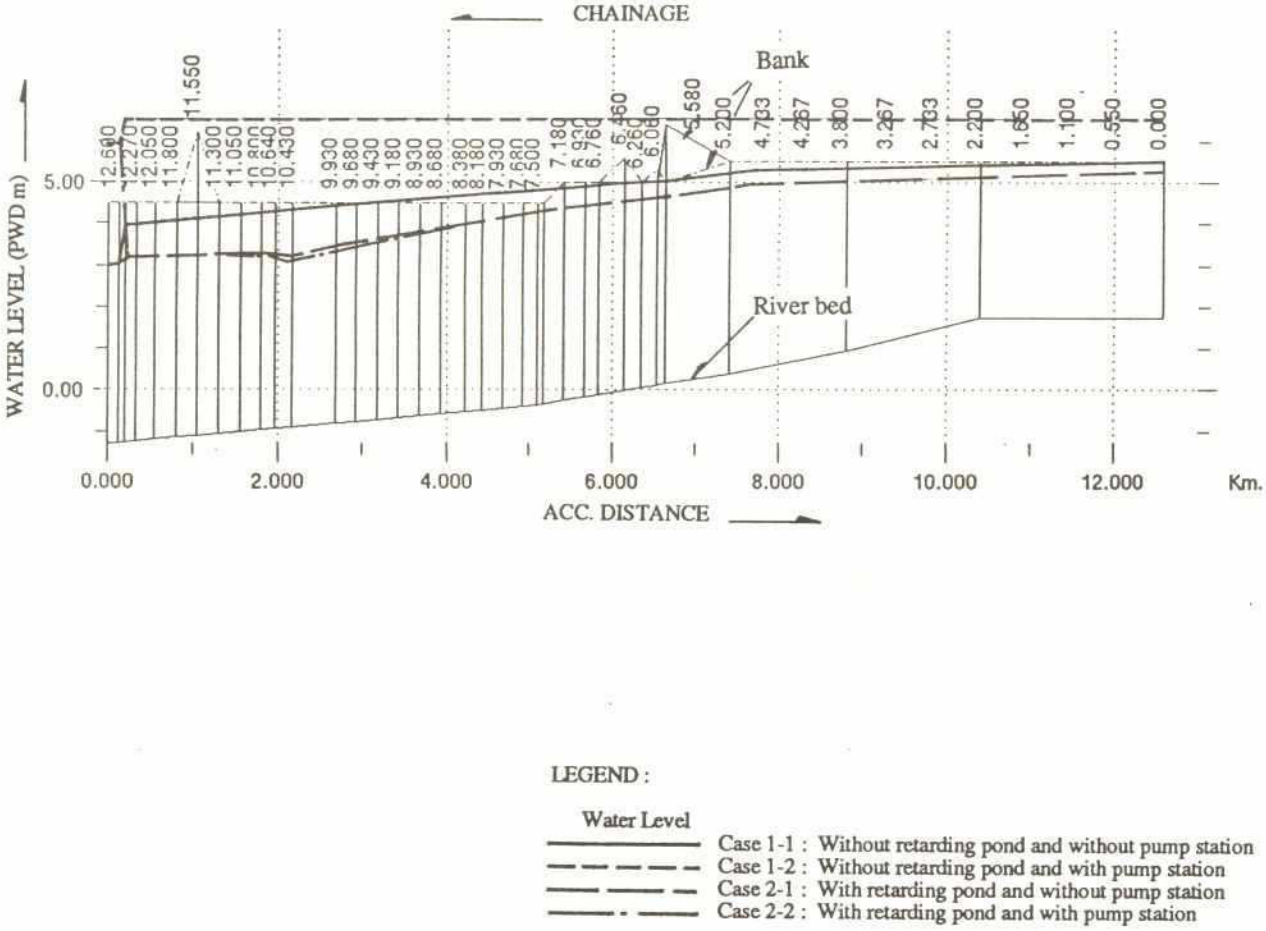


FIG. D.22	PROFILE OF SIMULATED PEAK WATER LEVEL HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-3

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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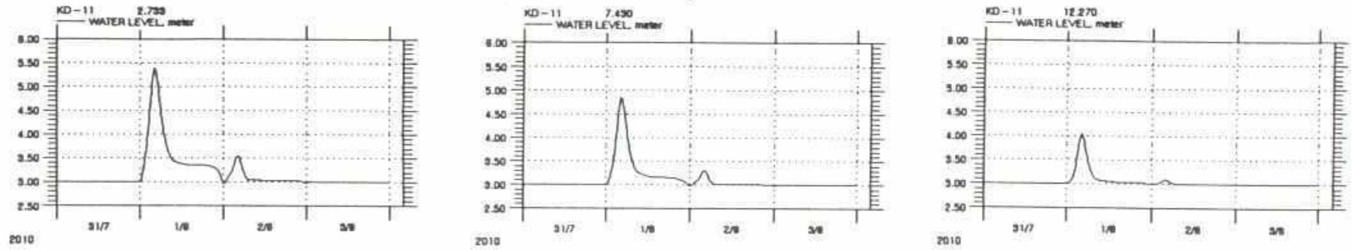
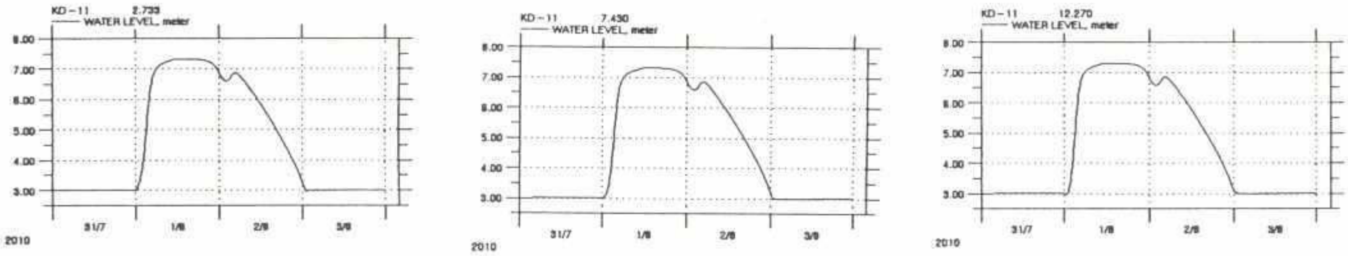
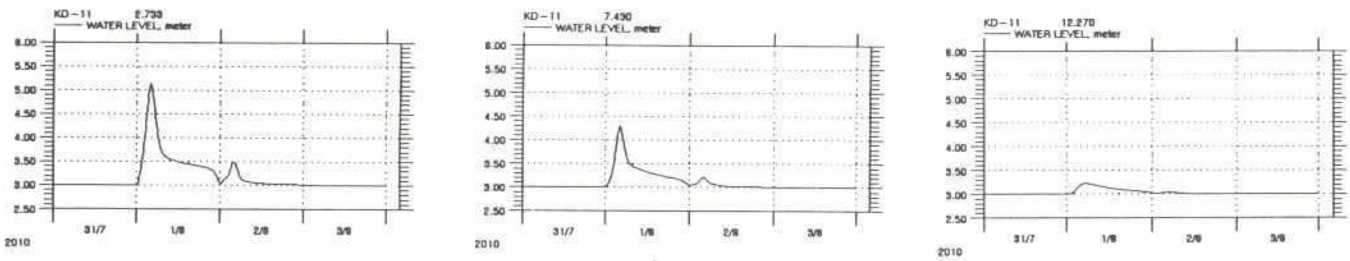
Case 1-1 : Without retarding pond and without pump station



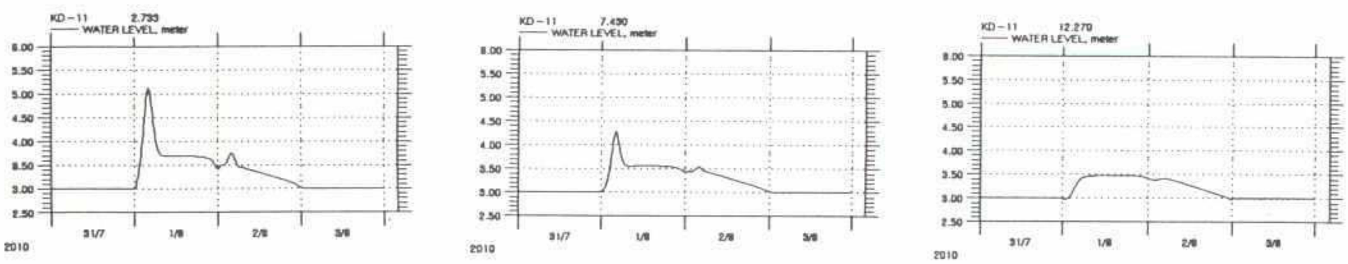
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-11	7.430

FIG. D.23 SIMULATED WATER LEVEL HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-3

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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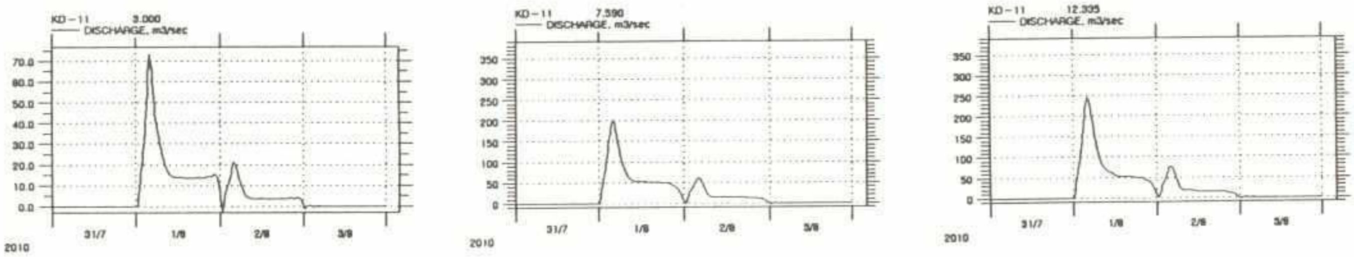
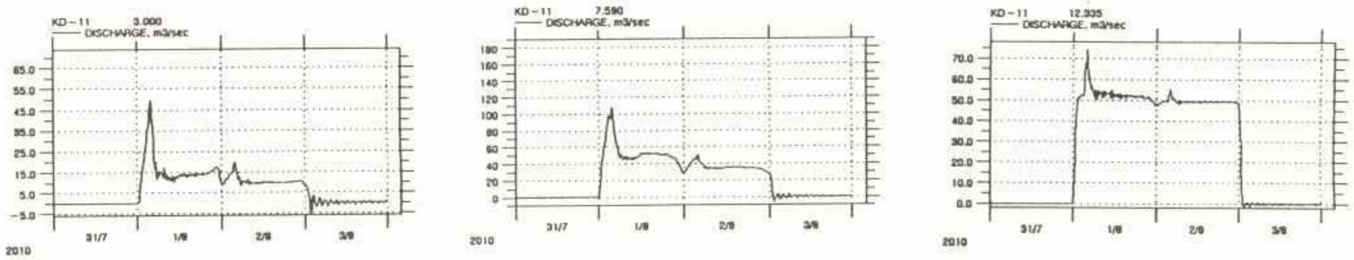
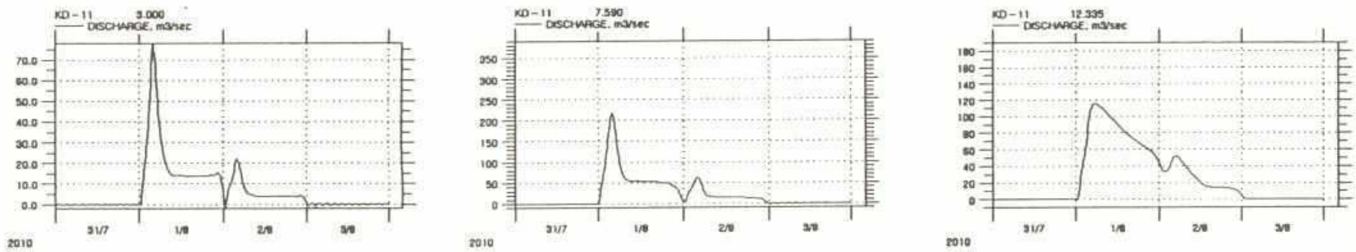
Case 1-1 : Without retarding pond and without pump station



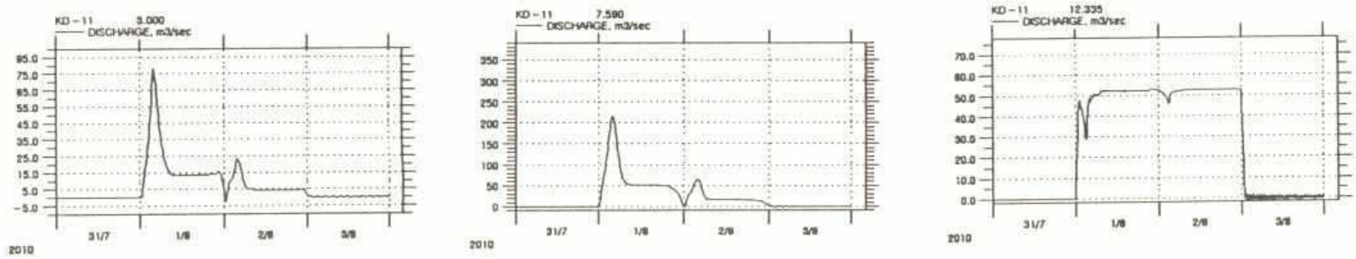
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-11	7.590

FIG. D.24 SIMULATED DISCHARGE HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-3

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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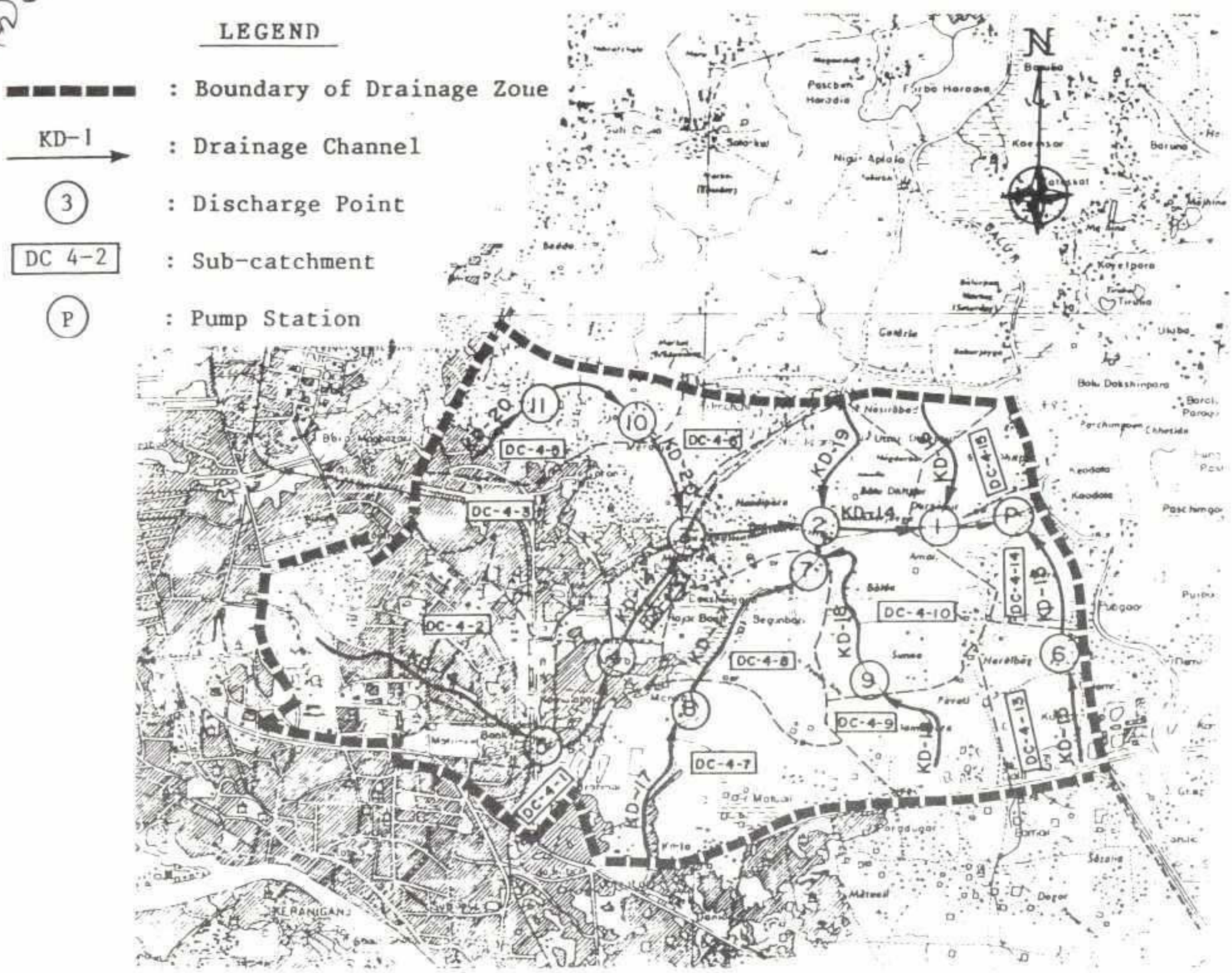
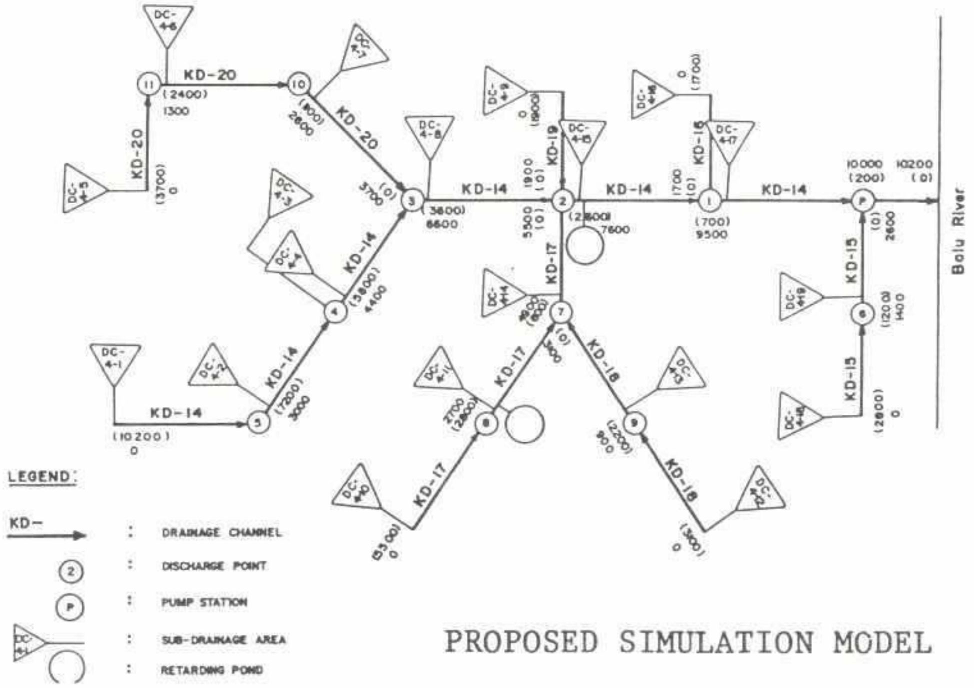


DRAINAGE CHANNELS AND SUB-CATCHMENTS



PROPOSED SIMULATION MODEL

FIG. D.25 DRAINAGE CHANNELS AND SUB-CATCHMENTS, AND PROPOSED SIMULATION MODEL OF SUB-DRAINAGE ZONE DC-3

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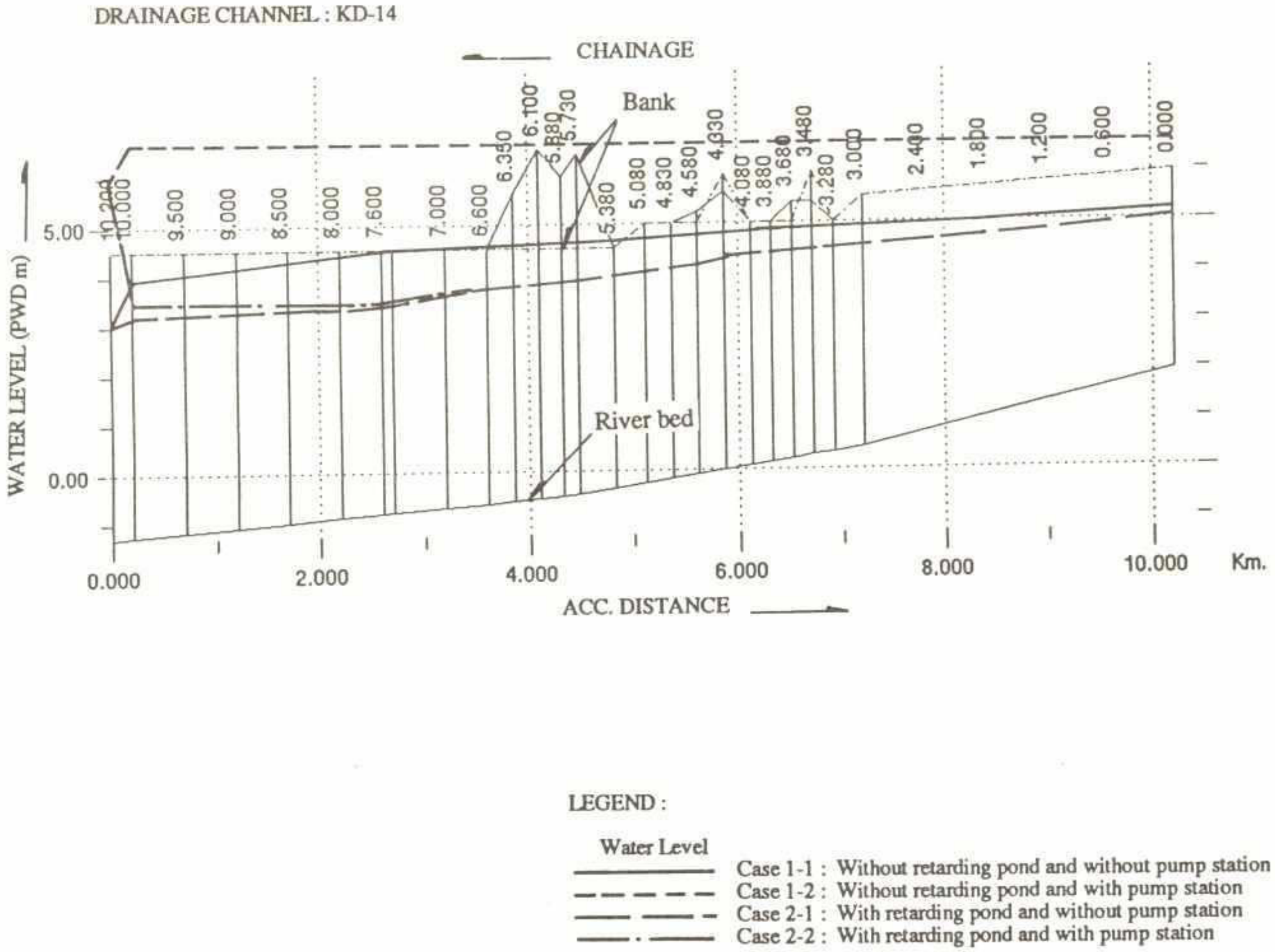

FIG. D.26	PROFILE OF SIMULATED PEAK WATER LEVEL OF SUB-DRAINAGE ZONE DC-4

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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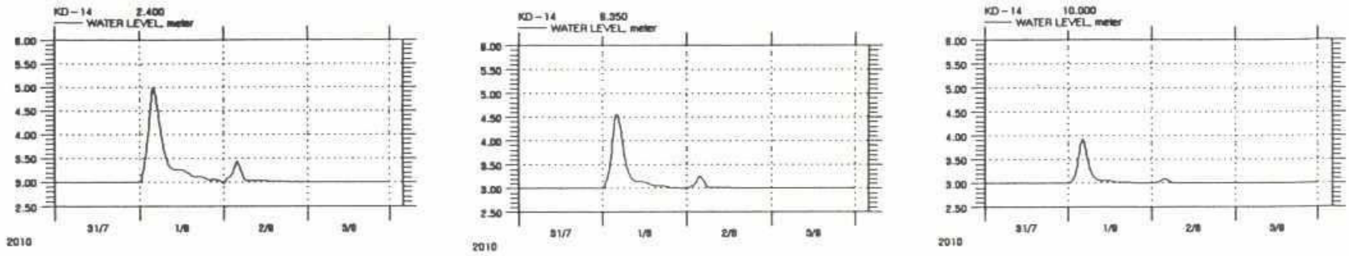
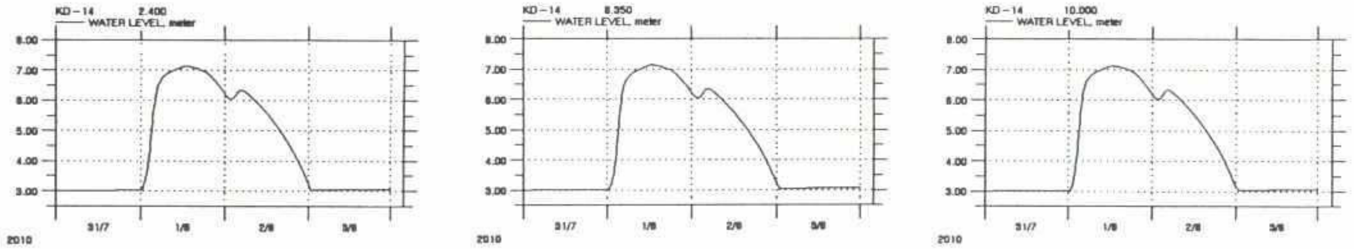
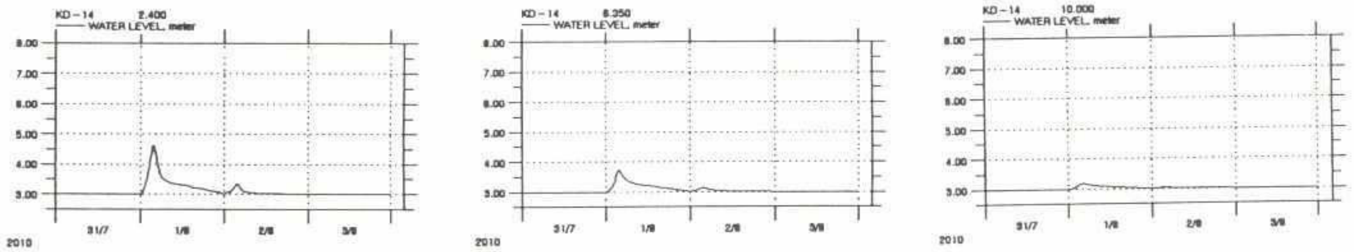
Case 1-1 : Without retarding pond and without pump station



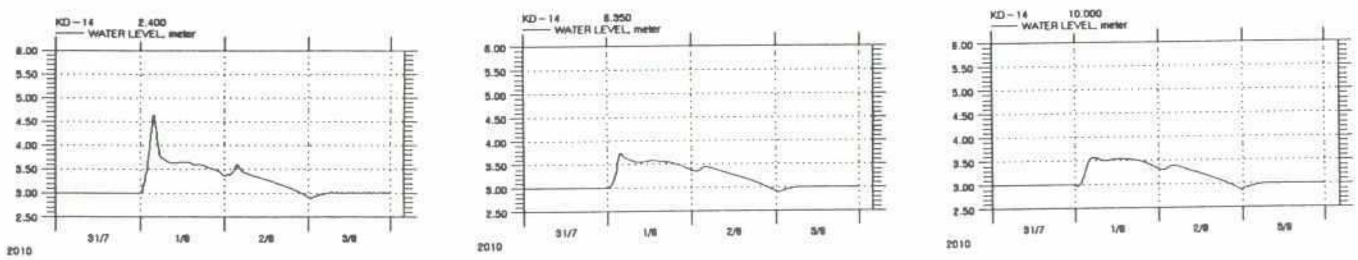
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-14	6.350

FIG. D.27	SIMULATED WATER LEVEL HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-4

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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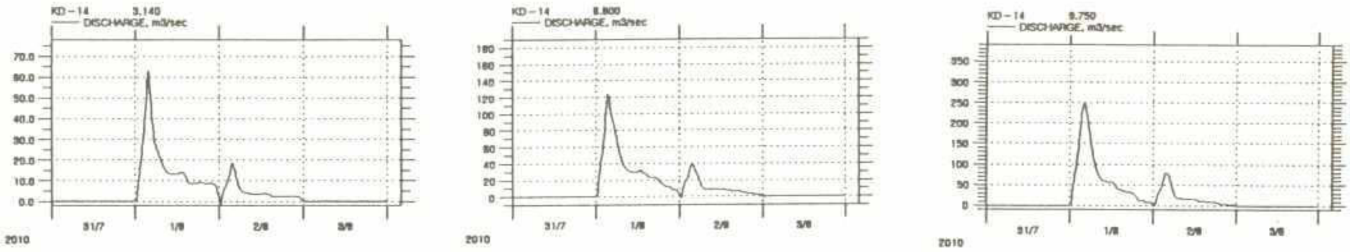
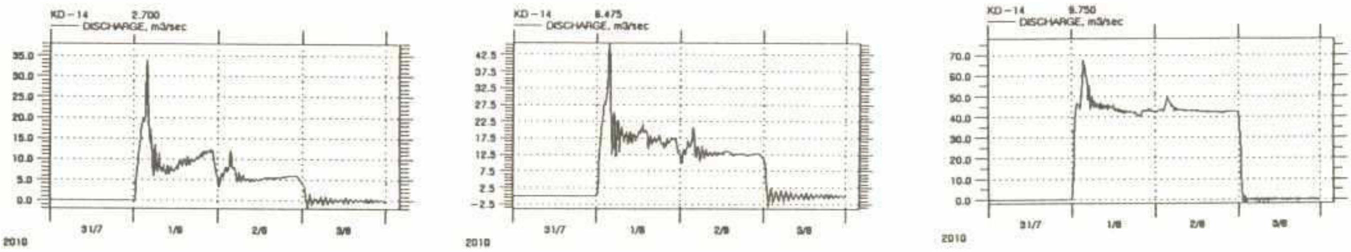
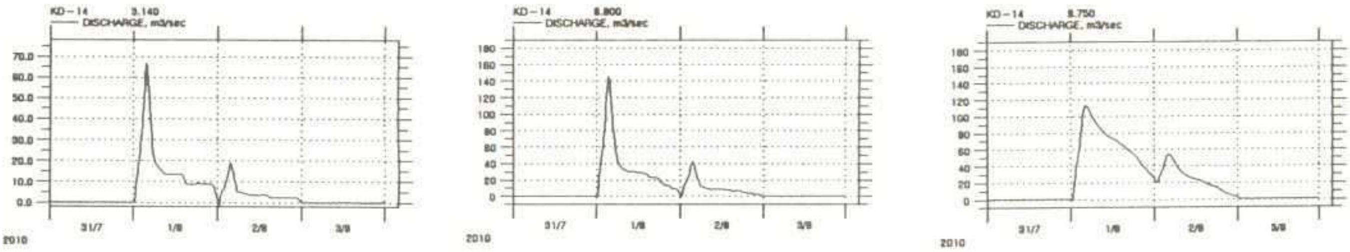
Case 1-1 : Without retarding pond and without pump station



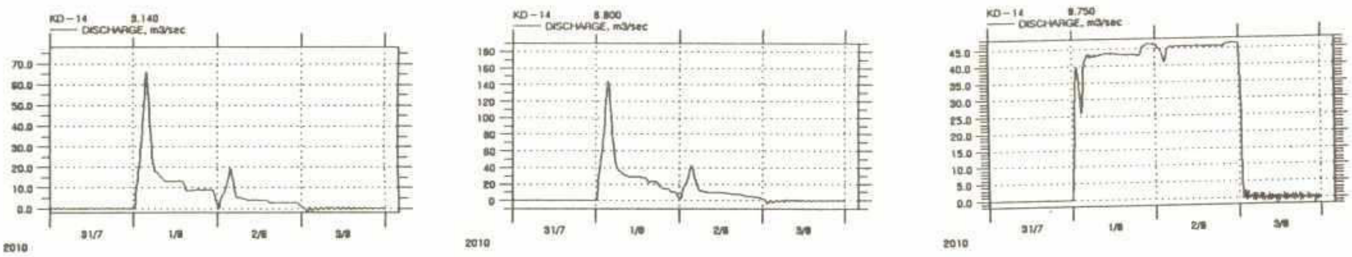
Case 1-2 : Without retarding pond and with pump station



Case 2-1 : With retarding pond and without pump station



Case 2-2 : With retarding pond and with pump station



LEGEND :

Channel Name	Chainage(km)
KN-14	6.800

FIG. D.28 SIMULATED DISCHARGE HYDRAOGRAPH OF SUB-DRAIANGE ZONE DC-4

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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SUPPORTING REPORT E
FLOOD MITIGATION AND STORMWATER DRAINAGE IMPROVEMENT PLAN

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SUPPORTING REPORT E : FLOOD MITIGATION AND DRAINAGE IMPROVEMENT PLAN

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SUPPORTING REPORT E : FLOOD MITIGATION AND DRAINAGE IMPROVEMENT PLAN

1. Introduction

1.1 General

The study is composed of three (3) phases, and the objectives of each phases are introduced as follows :

Phase I : Preliminary Review Stage (Oct. 1990-Dec. 1990)

- To prepare a general study program based on the Scope of Work,
- To review the existing conditions and to prepare a detailed study plan.

Phase II : Master Plan Study (Jan. 1991-Aug. 1991)

- To carry out a master plan study on comprehensive flood control and Stormwater drainage for Dhaka Metropolitan area (850 km^2)

- Tot identify priority projects for a feasibility study.

Phase III : Feasibility Study for Priority Area (Sep. 1991-April 1992)

- To conduct a feasibility study on flood control and stormwater drainage for the priority area identified during the Phase II.

1.2 Study Areas and Projects Identified in the Master Plan

During the phase II, the following priority areas were identified for the feasibility study areas.

- Greater Dhaka West (FAP 8B, ADB)
- Greater Dhaka East
- Narayanganj DND
- Narayanganj West

However, the feasibility study of Greater Dhaka West was taken by ADB financed consultants, FAP 8B. Accordingly the feasibility study of FAP 8B has been decided to be carried out on the other three (3) priority areas (see Fig E.1.1).

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1.3 Planning Concept Adopted in the Master Plan

1.3.1 Flood Mitigation Plan

1) Flood Mitigation Policy

By considering natural and social conditions of the study area the following flood mitigation policy were adopted :

- The future development area shall be protected as much as possible.

- The proposed flood mitigation will comprise both structural and non-structural measures.

- The structural measures shall include facilities which are to be constructed as early as possible and within the target yera 2010.

2) Flood Protection Level

Based on the flood mitigation policy economical evaluation and investment effectiveness of existing flood facility, which is designed for a 100-year flood frequency, a scale of highest design flood frequency of 100-years or the 1988 flood was selected.

3) Flood Mitigation System

The empoldering measure is determined to be most suitable for the study area based on the following consideration

- River training by dredging will not be effective for lowering the flood water level due to the peculiar hydraulic characteristics of the area

- It is very difficult to maintain the design river bed due to the sedimentation problem

4) Standard Empoldering Facilities

As standard design, the following types of polder are considered in principle.

- Embankment
- Flood wall (T and I Type)
- Road-Cum-Embankment

1.3.2 Storm Drainage improvement Plan

1) Planning Policy

A planning policy for preparation of stormwater drainage master plan are briefly summarized as follows :

- Plans are to be prepared to meet the population and land use in the target year 2010.

- For the existing urbanized areas of Dhaka city (approximately 137 km2). the plans shall meet the requirements of Storm Water Drainage System Improvement Project in Dhaka City and Dholai Khal Rehabilitation and Area Development Project committed by JICA and World Bank respectively.

- The plans are to consist of structural and non-structural measures.

- Scope of the structural measures for the existing built-up areas are construction of pumping stations with gates, and improvements of khals and trunk drain to mitigate the existing internal flood damages.

- For the future urbanized areas, only pumping stations and improvements of trunk khals are to be proposed as structural measures. Some non-structural measures are to be recommended in the form of guideline for the future urban development.

2) Design Concept

(1) Design Flood Water Level

The pump drainage system, shall be adopted for the most part of the future built-up areas. It is proposed that the frequent flood water level with 2-year return period is employed as the design outlet water level for demarcation of a gravity and pump drainage.

(2) Design Rainfall

- For Pumping Station and Retarding Pond

  2-days consecutive rainfall with a 5-year frequency is applied as the design rainfall for pumping station and retarding pond.

- For Khal Improvement and Trunk Drain

The rainfall intensity with a 5-year frequency is employed for the design of trunk drains and khal improvements. The rainfall intensity is to be applied for the Rational Formula.

(3) Design Discharge and Drainage Conditions

- Specific Peak Run-off
  Specific peak run-off is estimated by Rational formula
- Drainage Period

As discharge period 2-days discharge period by pumps is proposed in view of technical and economical reasons.

(4) Specific Requirement of Pump and Retarding Pond

- Specific pump capacity and storage requirements of the retarding pond in the pump drainage area are estimated by Storage basin Model.

- As the calculation results, specific requirements of both facilities are to be 1.14 m3/s/km2 and 0.120 x 106 m3/km2 respectively.

2. Outline of Related Project (FAP-8B)

2.1 General

The outline of related project : FAP-8B is introduced based on the "Executive Summary of FAP-8B"

- A feasibility study for the Dhaka Integrated Flood Protection Project, financed by the ADB, started in January 1991. The project is being formulated under the coordination of the FPCO in the context of an Integrated Environmental Management Plan (IEMP) as a long term integrated development strategy for Dhaka Metropolitan Area (260 km^2).

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The Project objective is to undertake an integrated urban development program consisting of : (i) flood control and drainage works ; (ii) complementary environmental improvement programs in low cost water supply and sanitation programs for the low income residents, solid waste management, and slum and squatter area development; and (iii) institutional support for improved efficiencies in urban management and revenue generation.

The Project is being formulated as a five year program between December 1991 to December 1996 for a first stage integrated flood control and drainage program covering the westerly part of Dhaka city, in the context of progressively developing future facilities to ultimately provide full protection to all Dhaka over a period of about 10 to 15 years.

The BWDB will be the lead implementing agency, and primary responsibilities for execution of the Project components will be shared between : (i) the BWDB for Part A: flood protection ; (ii) DWASA for Part B: Drainage; and (iii) DCC for Part C: Environmental Improvements.

2.2 Project Components and Scope

As a first phase of a long term flood protection program, the Project will initially focus on the highest priority area, the westerly part of Dhaka City. The Project area (see Fig.E.2.1) covers approximately 136 sq.km, encompassing about 95% of the commercial and industrial properties and some 87% of the total city population. The Project scope covers mainly the completion and augmentation of the flood protection and drainage program initiated by GOB following the 1988 floods. It is designed to initially provide flood security against the 50 year recurrence interval flood levels, with complementary environmental improvements focused on the urban poor. The Project works are designed to be self-contained, but will be suitable for expansion in the future.

The Project components concerning the Flood Protection and Stormwater Drainage are described as follows :

Flood Protection (BWDB)

- Specialized remedial works and foundation stabilization on 7.8 km of the existing embankment ;
- Erosion control and slope protection over 11.5 km;
- Minor remedial works and slope protection over 24.2 km;
- Repair and stabilization of parts of 5.3 km of existing concrete flood wall;

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- Construction of 1.6 km of new flood wall/embankment;
- Construction of 5 additional sluices along the existing embankment;
- Raising and flood proofing of the central spine road (Tongi Railway Bridge to Friendship Bridge);
- Construction of the first stage (22.5 cm3/s) of Pump Station No. 3 at Goranchatbari along the westerly embankment;
- Establishment of a maintenance program and supply of maintenance equipment to safeguard the flood protection investment.

Drainage (DWASA)

- Rehabilitation and upgrading of 21 existing priority khals (including completion of the crash program initiated by the government), for a total length 78.6 km;
- Rehabilitation and construction of 50.7 km of pipe drains;
- Establishment of a maintenance program and supply of maintenance equipment to safeguard the drainage improvement investment.

The Environmental Improvement Program Covers slum/squatter area improvement, solid waste management and sanitation improvements, Rehabilitation and extension of 131 km surface drains and installation of some Public water stand pipes in low income areas.

2.3 Project Cost and Implementation Schedule

The estimated Project costs are summarized as follows :

1.	Base Cost	$ 99.92	million
	1) Flood protection :	$ 46.66	million
	2) Drainage :	$ 37.38	million
	3) Environmental Improvement :	$ 9.94	million
	4) Project implement Assistance :	$ 5.94	million
2.	Contingency	$ 18.10	million
3.	Interest During Construction:	$ 3.20	million
	Total	$ 121.22	million

The Project implementation schedule is shown in Fig.E.2.1

According to the Fig.E.2.1, the drainage work and flood protection works are to be completed by middle of 1994 and 1996 respectively.

The environmental improvement program is to be completed by the end of 1996.

3. Greater Dhaka East

3.1 Review of Master Plan

3.1.1 General

Based on supplemental information, topographic and soil investigation results obtained in this F/S stage, the following review and supplemental study were carried out :

- A review of Alignment of Embankment for Nali River Portion
- Alignment Study on outlet of Begunbari Khal
- A review of compartmentalization by Sub-Embankment

3.1.2 Embankment Alignment of Nali River Portion

In the Master Plan, a portion of the alignment along Nali River was briefly studied based on the limited topographic and soil boring data, and it was suggested that for embankment construction an alignment along Nali River is better rather than that along Balu river alignment mainly due to poor sub-soil condition along Balu river.

However, the alignment is reviewed by using the supplemental topographic and soil survey results.

1) Alignment Alternative A

(1) Natural and Social Condition

This alignment was planned in Phased Program II of GOB by BWDB and information on land acquisition has been informally released to the local people.

This alignment runs on flood plain area along Balu river, where ground level ranges from about 1.5 m to 3.0 m P.W.D. The area of about 215 ha in between Balu and Nali Rivers is used for rice cultivation in the dry season, however it goes underwater in the rainy season.

The soil data on the alignment by BWDB shows that poor sub-soil condition (N-value is less than 4) prevails along the whole alignment (see Fig.E.3.1).

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(2) Main Feature of Alignment Alternative A

For the embankment construction, foundation treatment is necessary for whole alignment stretch due to poor sub-soil condition. Furthermore, one sluice gate is required at the crossing of Nali river for local drainage. The main feature of the alternative is summarized in Table E.3.1. The alignment and longitudinal and typical cross-sections are shown in Fig. E.3.1.

The construction costs of the embankment and sluice gates are roughly estimated by using the Unit Cost used in the Master Plan.

The total construction cost which includes land acquisition is estimated at 900 million Taka.

2) Alignment Alternative B

(1) Natural and Social Condition

This alignment was planned along Nali river where ground level ranges from about 2.0 m to 5.0 m P.W.D.

This alignment was recommended in the Master Plan since good soil foundation was expected from the topographical condition.

The peripheral area along Nali river is being used for both residential and agricultural purposes.

The soil data investigated by the Study Team and FAP 8B show that good soil foundation prevails most portion of the alignment (see Fig. E.3.1).

(2) Main Feature of Alignment Alternative B

For the embankment construction, foundation treatment is required only 30% of the total alternative alignment.

One sluice gate is required for local drainage system at the crossing of Nali river. The main feature of the alternative is summarized in table E.3.1 and the plan and longitudinal section is shown in Fig. E.3.1.

The total construction cost which includes land acquisition is estimated at about 570 million Taka.

3) Selection of Alignment Alternative

The alternative is selected based on the following aspects :

(1) Economical aspects : Comparison between the expected benefit from additional protected land and the construction cost increased by the Alternative.

(2) Social aspects : Requirement of resettlement.

The study shows that the construction cost of alternative A is higher than that of alternative B by 330 million taka. However the benefit from additional protected land of alternative A is estimated at 538 million taka in terms of land acquisition cost. Accordingly, alternative A is better selection in terms of economical aspect.

For the social aspect, alignment A is much recommendable since it requires no resettlement of residence and social recognition of the land acquisition information. While, alternative B involves the replacement of some residential houses.

Based on the above condition, alternative A is recommended.

3.1.3 Alternatives for Navigation System of Begunbari Khal

1) General

Begunbari Khal is utilized as navigation canal as well as drainage channel for central part of Dhaka area.

Most of the commodities and construction material such as vegetable, fruit, timber, brick, soil, etc. are transported by boats from outer area to Dhaka city through Begunbari Khal.

Based on interview survey at Rampura bridge the maximum size of boat observed in the rainy season is said to be about 40 m in length and 8 m in width. The most of the big boats are used for soil transportation, while small boats are used for daily use commodity and passenger transportation in the khal basin. Based on navigation survey at least 70 - 100 boats per day come to this area in the wet season. Even in dry season 15 - 20 boats per day come to this area. About 50% of these boats carry passengers and the rest carry wood, bamboo, sugarcane and other rural produce. About 700 to 1000 passengers come to this point in the wet season. After Tongi, Rampura is the most important in terms of income generated from navigational activities. Rampura handles an estimated 71.2 million Taka worth of material annually. (see Table E.3.2).

2) Alternatives for Navigation System

Two alternatives for navigation system are conceived in principle when embankment is planned along Balu river.

Alternative A

The alternative A is to construct a navigation lock at the outlet of Begunbari Khal and to maintain the existing navigation system in the future. (see Fig. E.3.3(1)).

This alternative involves large amount of Construction and Operation/Maintenance costs, however negative social impact is negligible small.

Alternative B

The alternative B is to construct the transportation road along the khal which connects the boat yard at the outlet of Begunbari khal to Rampura bridge instead of the lock construction. This alternative allow navigation with small boats during a low water level, below 3.5 m of drainage design water level by opening the sluice gate. This alternative suggest the changes of existing navigation system to road transportation in the future (see Fig. 3.3.(2)).

This alternative involves only small amount of operation and maintenance cost. This road is utilized for transportation system. However, some negative social impact such as employment problem by boat transportation is expected.

While, construction of back water levee from the outlet of the Khal to Rampura bridge is not considered as an alternative because this alternative involves far larger amount of construction cost than that of alternative A.

The main feature of the above two alternatives is described below :

(1) Alternative A : Construction of Navigation Lock

The dimension of navigation lock is determined with due consideration of the maximum size of boat and the number of shipping under the present navigation condition.

Based on this condition, the lock having Myter type gate with 9.6 m high, 20.0 m width and 100 m long is planned.

The construction cost is estimated at about 640 million taka. The operation and maintenance cost per year is estimated at 9.6 million taka, which is equivalent to 1.5 percent of construction cost.

(2) Alternative B : Construction of Road

The dimension of the sluice gate and road for the alternative B is determined as follows :

- Elevation of Road Top : 7.0 m (Approximately same elevation with Rampura Road)
- Road width : 7.0 m (Two lane traffic)
- Road Distance : 6.3 Km (Outlet of Begunbari Khal to Rampura Bridge)

The construction cost with land acquisition costs is estimated at about 640 million taka.

3) Selection of Alternative

The construction cost of alternative A of navigation lock is almost the same cost of Alternative B of transportation road construction.

The operation and maintenance cost of the lock, 9.5 million Taka per year is far bigger than the expected revenue of 7 million Taka which is assumed to be 10% of transported charge value.

The lock should be well maintained and operated for whole year and no mechanical / electric trouble is allowed in the rainy season as well as flooding period.

By consideration the above conditions, construction of transportation road is recommended for the future transportation system.

However, sudden abolishment of the navigation system gives serious impact to the social economy and social activity. In order to soften the impact, the present navigation system is to be kept upto certain stage by means of block-wise (compartmentalization) implementation program and its flood mitigation system.

3.1.4 Compartmentalization by Sub-Embankment

1) General

Sub-Embankments were planned in order to minimize the expected damage when main embankment was breached due to some unexpected reasons.

For this purpose, two alignments of sub-embankment were planned in the Master Plan.

This compartment was mainly determined by considering the existing drainage zones by three trunk khals.

In this F/S stage, the compartmentalization is to be reviewed with due consideration of implementation program which is deeply related to the tendency of urban development and urgency of flood protection.

2) Alternatives of Compartmentalization

Two alternatives, i.e, 1) Case A - Three (3) compartment and, 2) Case B- Four (4) compartment are considered from view point of implementation aspect.

The difference between Case A and Case B is that whether the previous southern component is divided into two or not.

The main feature of the implementation aspect of Case A and Case B is described below:

Case A: The whole area is to be divided into 3 compartments of 41, 32 and 46 km^2 from north to southern compartment (DC-1 to DC-3). However the drainage area, which has direct relation with the scale of project cost is about 31km2, 48km2 and 88 km2 respectively (see Fig. E.3.4).

By using the total project cost in the Master Plan and its areal proportions the each project cost is estimated to be about 4,200, 6,400 and 11,800 million taka respectively.

Based on the above cost condition, early implementation and completion of the southern part (DC-3) might be difficult.

Case B : The whole area is to be divided into 4 compartments. The sizes of project area allocated with FAP-8B, from northern compartment to southern compartment (DC-1 to DC-4) are about 41, 32, 15 and 31 km^2 respectively. While, the drainage area is 31, 48, 47 and 41 km^2.

The each project cost estimated is approximately 4,200, 6,400, 6,300 and 5,500 million taka respectively.

3) Selection of Alternatives

The alternative, Case B is recommended based on the following considerations :

- Implementation program can be formulated with much flexible manner with due consideration of the scale of the project cost and the development tendency.

- Drainage system can be designed with flexible manner depending on the topographic and areal development condition.

- Present navigation system of Begunbari khal will be kept upto certain stage by considering the implementation schedule.

4) Main Feature of Compartments

The Greater Dhaka is divided into two areas i.e. Greater Dhaka East and West. The divided boundary of these areas is recognized as the central spine road which runs from

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Tongi to Saidabad. However the drainage zone of the compartments of Dhaka East includes some part of Dhaka West area.

The central spine road is going to have a function of flood protection having capacity of 50-year flood frequency level.

For effective use of the spine road, this road is planned as flood protection boundary with sub-embankments of each compartment. The main feature of each compartment is shown below :

Name of Compartment	Area of Compartment (km^2)	Trunk Khal	Drainage Area (km^2)	Remarks
DC-1	40.69	Boalia Khal	30.56	
DC-2	32.04	Rashidkhali Khal	47.88	
DC-3	14.57	Begunbari Khal	46.58	
DC-4	31.32	Dholai Khal	41.34	

3.2 Flood Mitigation Plan

3.2.1 Planning Conditions

1) Flood Protection Level

A scale of 100-years flood frequency is adopted for the design of embankment since the existing embankment in Dhaka West has been constructed with the same protection level.

2) Flood Protection System

A compartmentalization system by sub-embankment and flood wall proposed by FAP-8B along spine road is applied with due consideration of the bigger drainage size of whole area of 166.3 km^2.

3) Design High Water Level (H.W.L) and Design Top Levels of Poldering facilities

The design high water levels corresponding to 100-year flood recurrence and the design top levels of the embankment, sub-embankment and flood wall adopted in this study are shown below :

Place	H.W.L. (m PWD)		Top EL (m PWD)
Tongi	8.60	Embankment	9.80
Patira	7.99	Embankment Sub-Emb. (SA) Flood Wall. (R)	9.19 8.59 8.59
Nigur Aplaid	7.73	Embankment Sub-Emb. (SB) Flood Wall. (R)	8.93 8.33 8.33
Outlet of Begunbari	7.60	Embankment Khal Sub-Emb. (SC) Flood Wall (R)	8.80 8.20 8.20
Demra	7.40	Embankment	8.60

While the freeboard of sub-embankment, 60 cm is determined as half of the main embankment with due consideration of the occurrence chance of breach, implementation schedule and the flood condition of the future flood plains.

3.2.2 Polder Facilities Plan

1) Route of Poldering Facilities

The embankment alignment is planned along Balu river as proposed by GOB in the Phase II program.

About ten percent (10%) of the required land has been acquisited by this present time by the BWDB and the remaining land acquisition procedure has been stopped so far because the FAP studies related to the matter is being conducted. The acquisited land portions are shown in Fig. E.3.5.

The sub-embankments are basically designed along the existing roads with due consideration of sub-soil conditions and future transportation system.

However, on the places nearby urbanized areas the routes are determined so as not to involve the displacement of residences as much as possible.

(1) Sub-Embankment

Considering the above, the alignment of sub-embankment is designed as follows :

1. Sub-Embankment : SA

The alignments are designed along the existing road from Patira at Balu river to Khilkhet at the spine road for the sub-embankment.

2. Sub-Embankment : SB

The alignments are designed along the existing road from Nigur Aplaid at Balu river site to Shahajadpur at the spine road.

3. Sub-Embankment : SC

The alignments are designed along the Begunbari Khal from Balurpar to Rampura at the spine road.

(2) Flood Wall (R)

The alignment of flood wall is designed by FAP-8B along existing spine road from Tongi railway bridge to Saidabad (see Fig. E.3.5).

2) Longitudinal and Standard Cross-Sections

The longitudinal profile of the embankment is determined based on the design high water levels (H.W.L) at Tongi and Demra. The design top level of embankment and sub-embankment are accordingly obtained by adding 1.2 and 0.6 m of the freeboards respectively. The gradient of the main embankment ranges about 1 in 23,000, while the sub-embankment is designed in horizontal lines (see Fig. E.3.6(1) to E.3.6(3)).

The standard cross-section of the embankment is to be a compound cross-sections with berms on both river and land sides.

A ditch is also designed along the embankment of the land side in order to protect the foot portion of the embankment from some local scouring by stromwater flows.

For most streches of the embankment, foundation treatment is required due to poor soil condition. The detailed study is made in Supporting Report F.

The following dimensions of the standard embankment section are determined with due consideration of stability and maintenance :

Crest width	:	4.0 m
Side slope	:	1 V : 3 H
Berms	:	River side - 3.0 m
		Land side - 5.0 m

Revetment is designed in order to protect the bank toe and the slope from scouring by tractive forces due to mainly wave action and current flow pressure, etc.

The revetment is applied to some streches of the embankment.

The protection level by the revetment is determined by referring the erosion conditions of the existing embankment. The revetment is to be provided from the toe of embankment to top of the embankment.

The sub-embankment is also designed with berms, but is symmetrical the shape (see Fig. E.3.7).

The major dimension of the sub-embankment is the same with that of the embankment, however no revetment is applied taking small occurrence chance of breach into consideration.

The empoldering structure along spine road / railway is designed in a type of flood wall by considering the small raised height from the road / railway top and available space. The proposed flood mitigation facilities are summarized in Table E.3.

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3.2.3 Sluice Gates

1) Location

Sluice gates are principally planned at crossing points of existing khal and proposed pump station. Some small drainage areas are integrated and to be drained by minimum number of sluice gates from view point of construction cost and easy maintenance.

The sluice gate without pump station is planned on.

- The ground level of the basin is to be totally higher than the design river water level of corresponding 2-year flood frequency, so that the basin is to be free from inundation by annual floods.

The sluice gate with pump station is generally applied to the basins where low-lying area is prevailing and reclamation is not feasible from economical aspects.

A total of 4 sluice gates with pump stations and 3 sluice gates without pump station are planned along the Balu River embankment and Sub-embankment, SA. The locations of proposed sluice gates is shown in Fig.E.3.5.

2) Main Features of Sluice Gates

Two types of sluice gates, i.e. (1) Box Culvert Type and (2) Open Channel Type are considered for design selection.

The selection of open channel type is only applied in the condition that the drainage channel / khal might be used for navigation.

Except the above condition, box culvert type is basically applied in view point of construction cost, and easy operation and maintenance.

The flow area of box culvert type sluice gates is determined based on the design discharges and its design velocity of 2.5 m/s.

However, the minimum size of flow area is to be more than 1 m^2 with due consideration to maintenance.

The elevation of outlet is determined referring to the existing bottom level of khals.

The main feature of proposed gates are summarized below :

No.	Sluice Gate No.	Station No.	Name of Khal	Type of Structure	Design Discharge (m3/S)	DL. of Outlet (m in PWD)	Remarks
1	14	E.68+150	KD-4	Box	22.57	+2.45	-
2	15	E. 55	KD-3	Box	37.34	+2.45	-
3	16	E. 45+320	Boalia Khal (KD-1)	Box	83.13	- 0.7	Pump Station : P. 5
4	17	E. 28+150	Jamair Khal (KD-5)	Box	114.61	- 1.0	Pump Station : P. 6
5	18.A	E. 11+340	Begunbari Khal (KD-11)	Box	129.49	- 1.3	Pump Station : P. 7A
6	18.B	E. 8+90	KD-14	Box	140.67	- 1.3	Pump Station : P. 7B
7	Sub-1	SA11+100	KD-5	Box	83.2	+ 0.64	Sub. Sa

3.3 Stormwater Drainage Improvement Plan

3.3.1 Present Conditions of Drainage Area

1) Drainage Area and Drainage System

In Master Plan study, Greater Dhaka area of approximately 260 km^2 surrounded by four rivers, Buriganga, Turag, Tongi and Balu rivers was identified as one of the priority areas. The area was finally divided into two zones, Greater Dhaka East of about 119 km^2 and Greater Dhaka West of about 141 km^2 and these feasibility studies was decided to conduct by JICA and ADB respectively.

As shown in Fig. E.3.8 most central part of Dhaka city of about 48 km^2 in Greater Dhaka West area including Motijheel commercial area, Dhanmondi residential area, Tejgaon industrial area and Gulshan-Banani high class residential area is drained into East area through the several khals. So, the actual drainage area of the study consists of the following two areas with a total area of 166.36 km^2.

- Greater Dhaka East : A = 118.62 km2 (F/S area)
- Part of Greater Dhaka West : A = 47.74 km^2 (Drainage Related area)

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The existing built-up area of 66.7 km^2 (approx. 40% of the total area) situated above 6.0 m PWD is projected to be 95.7 km^2 (approx. 58% of the total area) in 2000 and 132.4 km^2 (approx. 80% of the area) in 2010. Almost 54% of the total drainage area is low-lying area situated in the eastern part of the area and is mainly used as an agricultural land in dry season. The population is estimated to be approximately 2.15 x 10^6 in 1990, 2.96 x 10^6 in 2000 and 4.47 x 10^6 in 2010. Table E.3.4 shows the present and future land use and population of the drainage area.

Stormwater collected by drainage pipes or open ditches is drained through the khals : Segunbagicha, Geraini, Begunbari, Jamair and Boalia khals into the Balu River by gravity flow. There are no pumping station. In flood season between June and November, the low-lying areas are under the flood water with a maximum depth of about 3.5 m because no embankment is provided for the overflow from the Balu River.

2) Drainage Facilities

The existing major drainage facilities consist of drainage pipes, khals and related structures. No pumping station is provided in Greater Dhaka East.

(1) Drainage Pipe

Drainage Related area of about 48 km^2 in Greater Dhaka West has been installed with drainage pipes of about 76 km in length corresponding to almost 70% of a total length of drainage pipes in the city of Dhaka. Pipe diameter ranges from 0.3 m to 3.0 m. The drainage pipes are made of brick with diameters from 1.2 m to 3.0 m, and of reinforced concrete with diameters below 1.2 m. The location of the trunk drainage pipes is shown in Fig. H. 2 in the Supporting Report H of Master Plan study.

No drainage pipes are provided in Greater Dhaka West of 118.62 km^2 .

(2) Khal

There are 6 major khals with a total length of about 20 km in Drainage Related area. These khals are listed below :

- Gulshan - Banani khal : l = 5,000 m
- Mohakhali khal : l = 3,200 m
- Begunbari khal : l = 5,800 m
- Paribag khal : l = 1,000 m
- Segunbagicha khal : l = 3,000 m
- Khilgaon - Basabo khal : l = 1,400 m

Stormwaters of part of Greater Dhaka West area collected by drainage pipes or open ditches are drained into the Greater Dhaka East through the above khals.

On the other hand, there are a number of major khals totalling 59.5 km long in Greater Dhaka East. Major khals including Begunbari, Gerani, Jamair and Bolia khals function both to drain stormwater for the Balu River and to supply irrigation water for paddy field or cultivated areas in dry season.

Existing drainage capacities of 27 major khals shown in Fig. E.3.8 are calculated based on the longitudinal and cross sectional survey results of the khals. According to the calculation results shown in Table E.3.3, khal sections having a required specific discharge capacity of approx. 8 $m^3/s/km^2$ are very few. These are mostly less than 3 $m^3/s/km^2$ and shall be improved to have an adequate discharge capacity.

3.3.2 Planning Policy and Criteria

1) Planning Policy

A planning policy for preparation of stormwater drainage improvement plan are briefly summarized below :

- Plans are to be prepared to meet the population and land use in the target year 2010. The whole area to be planned is approximately 119 km^2. The population and built-up area in 1990 and 2010 of the drainage area are shown in Table E.3.4.

- FAP 8B project (DIFPP) is on-going by financial assistance for ADB as mentioned in Section 2. Some khals in Greater Dhaka East for which khal improvements are proposed to be implemented by DIFPP, are to be excluded in this project. Location and list of the excluded khals are shown in Fig. E.3.9.

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- Scope of countermeasures for the existing built-up areas are construction of pumping stations with retarding ponds, and improvements of khals and trunk drains to mitigate the existing internal flood damage. Secondary and tertiary drainage pipes are excluded in the proposal, taking into account that the investment for project implementation must be reasonable.

- For the future urbanized areas, only pumping stations with retarding ponds and improvements of trunk khals are to be proposed as countermeasures. Land acquisition will be recommended for the proposed countermeasures except the retarding ponds, for which it will be proposed that the required areas be preserved by land use regulation, in order to limit the project cost.

2) Planning Criteria

(1) Design Flood Water Level

The existing built-up areas in the study area are mostly formed on the high lands over 6.0 m PWD, which are free from habitual floods. Further built-up areas are, however, mostly expected to develop on the surrounding low lands below 3.5 m PWD, which will be protected from the external floods by the polder dikes.

Considering the above, the pump drainage system, which is more uneconomical than the gravity one, shall be adopted for the most part of the future built-up areas. So, in order to adopt a more efficient and economical pump drainage system, it is proposed that the frequent flood water level with 2-year return period is employed as the design outlet water level for demarcation of a gravity and pump drainage system.

The following design flood water levels are applied for each drainage area or zone based on the calculation results of probable water level at Tongi (BWDB Sta. 299) and Demra (BWDB Sta. 7.5) gauging stations. They are as follows :

- DC 1-A sub-zone : 6.40 m PWD
- DC 1-B sub-zone : 6.25 m PWD
- DC 2-C sub-zone : 6.15 m PWD
- DC 3-B sub-zone : 6.05 m PWD
- DC 4-B sub-zone : 6.00 m PWD

Note : Location of sub-zone is shown in Fig. E.3.1.2.

The pump equipment is designed to be operated during the flood of a 100-year flood frequency. Considering about 2 m difference in water levels between the floods of a 2-year and a 100-year flood frequency, the flood water level at the highest pump efficiency of 100% will actually be higher than that of a 2-year frequency flood.

The pump will be designed based on the most effective water level equivalent of the annual maximum water level on average which is equivalent about 2.3 - 2.8 return period.

(2) Design Rainfall

Considering that the investment for project implementation must be reasonable, the design rainfall for drainage facilities is usually adopted from an appropriate scale of rainfall occurrence. In this study, the following criteria are proposed from a practical point of view :

- For pumping Station and Retarding Pond

  2 day consecutive rainfall with a 5-year return period is applied as the design rainfall for required pumping capacity and retarding pond volume. The design rainfall and its hourly distribution are presented in Fig. E.3.10.

- For Khal Improvement and Trunk Drain

  The rainfall intensity with a 5-year frequency is employed for the design of trunk drains and khal improvements. The rainfall intensity to be applied for the Rational formula is calculated by the following two formulae :

  $i = 9005/t+50$ .... $(t \leq 2 \text{ hr})$
  $i = 12437/t+115$ .... $(2 \text{ hr} < t < 24 \text{ hr})$

  Where, i : Rainfall intensity (mm/hr)
  t : Duration (min)

  The applied rainfall intensity-duration curve is shown in Fig. E.3.11.

- Areal Reduction Factor

The above design rainfalls are made based on the point rainfall data at Dhaka station (B.M.D.). For the calculation of the design discharge, the areal reduction factor is to be considered. The areal reduction curves are illustrated in Fig. E.3.11.

(3) Run-off Coefficient and Run-off Ratio

The following values of run-off coefficient by land use projected for the target year 2010, are used for calculation of the design peak discharge by the Rational formula :

Land Use	Runoff Coefficient
Commercial Area	0.65
Industrial Area	0.55
High Class Residential Area	0.30
Middle and Low Class Residential Area	0.50
Green Zone and Others	0.20
Water Bodies	1.00

The runoff ratio (total runoff/total rainfall) of 0.80 is employed for estimating required pump capacity and retarding pond volume.

(4) Drainage Criteria

From both technical and economical point of view, short duration internal flooding with a low flood damage will be allowable. For pump drainage area, 2-days discharge period by pump is recommended.

3.3.3 Zoning

The drainage area of 166.36 km2 covers Greater Dhaka East (118.62 km2) and 47.74 km^2 of Greater Dhaka West (142.90 km2), which covers most part of Dhaka City. Apart from the small areas in the north, where drainages flow into the Tongi khal, the area that drains into the Balu River through the major khal systems consisting of the Segunbagicha khal, the Gerani khal, the Begunbari khal, the Jamair khal and the Boalia khal are shown in Fig. E.3.8.

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As shown in Fig, E.3.12, the area is divided into four (4) drainage zones of DC-1 to DC-4 and nine (9) sub-zones considering the existing topographic condition, khal systems, road networks and the proposed four (4) compartments by embankments or sub-embankments.

Drainage areas by zone or sub-zone including main khal of each zone are listed as follow :

Zone	Sub-Zone	Area (km^2)	Name of Major Khal
DC-1	DC 1-A	8,45	
	DC 1-B	22.11	Nali River, Boalia Khal
	Sub-total	30.56	
DC-2	DC 2-A	5.71	
	DC 2-B	10.13	Jamair Khal
	DC 2-C	32.04	
	Sub-total	47.88	
DC-3	DC 3-A	32.01	Begunbari Khal, Gulshan Banani Khal
	DC 3-B	14.57	Begunbari Khal
	Sub-total	46.58	
DC-4	DC 4-A	10.02	Segunbagicha Khal
	DC 4-B	31.32	Gerani Khal
	Sub- total	41.34	
	Total :	166.36	

Note : 1) Refer to Fig. E.3.12

2) Stormwater of sub-zone DC 2-A is drained through sub-zone DC 2-B, which is part of the Northern compartment, into the Central compartment of sub-zone DC 2-C.

3.3.4 Countermeasures

Stormwater drainage countermeasures are proposed for each four zones with a whole area of approx. 119 km^2 . As almost 80% of the area is still unurbanized, the proposed measures will consist of the followings :

- All the required pumping stations with retarding ponds
- Trunk khal improvements

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Lateral drains and tertiary drainage pipes are excluded. Because a beneficial effect of lateral drains and tertiary pipes will be expected only after completion of the connected major drainage works in newly developed area.

Land acquisition of the proposed pumping stations and khal improvements are required for protection from illegal land development by the private sector. For the retarding ponds, however, land use regulation will be necessary to preserve their storage capacity and to limit the pump capacity.

3.3.5 Pump Drainage Plan

1) Pump Drainage Area

According to the existing topographic condition and the design flood water levels of a 2-year frequency flood, each drainage zone except sub-zone of 8.45 km2 in the northern part of DC-1, needs a pump drainage system. Gravity drainage system is adequate only for the sub-zone of DC 1-A. Pump drainage areas are summarized as below ;

Zone	Pump Drainage Area (km^2)	Gravity Drainage Area (km^2)	Total (km^2)
DC-1	22.11	8.45	30.56
DC-2	47.88	-	47.88
DC-3	46.58	-	46.58
DC-4	41.34	-	41.34

Note : 1) Refer Fig. E.3.12

2) Pump Operation Period

Climate of Dhaka and Narayanganj area is classified into the following three seasons ;

- monsoon season : May. to Oct., R = 1.825 mm
- cool season : Nov. to Feb., R = 60 mm
- hot season : Mar. to Apr., R = 175 mm

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Almost 90% of the annual rainfall of 2,060 mm occurs during the season from May to October based on the rainfall data from 1953 to 1990. Maximum monthly rainfall of approx. 400 mm occurs in June. Variation of monthly rainfall is illustrated in Fig.E.3.13.

On the other hand, flood water levels of surrounding rivers start to rise in April, reach to a peak in mid. August and then fall down to February. Considering the relation between an average ground elevation of low-lying area (3.0m to 3.5 m PWD) in Greater Dhaka East and variation of annual monthly flood waters of Tongi Khal and Balu River, it can be noted that the required pump operation period will be at least five (5) months between June and October in very year as shown in Fig.E.3.13.

3) Required Pump and Retarding Pond Capacities

The application of retarding pond in urban stormwater drainage system economizes the total pump drainage cost by reducing the required pump capacity and khal cross section dimension.

Specific requirements of pump capacity and storage volume of retarding pond are estimated by utilizing the following storage basin model under the applied design criteria.

$$I - O = \frac{DS}{dt} \quad \text{..............................} \quad (1)$$

$$I = 10 \times f \times Rt \times A \quad \text{......................} \quad (2)$$

$$O = Qp \times dt \quad \text{..............................} \quad (3)$$

Where,

	I	:	Inflow volume due to rainfall during dt (m^3)
	O	:	Outflow volume due to pumping during dt (m^3)
	dt	:	Calculation time interval
	S	:	Storage volume of retarding pond (m^3)
	f	:	Run-off ratio (0.8)
	A	:	Catchment area (ha)
	Rt	:	Rainfall during dt (mm)
	Qp	:	Pump discharge volume during dt (m^3)

As the calculation results, specific requirements of both facilities are to be 1.14 $m^3/s/km^2$ and 0.120 x 160 m^3/km^2 respectively as shown in Fig. E.3.10.

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The required pump capacity and the storage volume of retarding pond of each pump drainage area are summarized below ;

Zone	Area (km^2)	Required Pump Capacity (m^3/s)		Required Storage Volume of Retarding Pond ($x10^6m^3$)	
		Specific	Total	Specific	Total
DC-1	22.11	1.14	25.6	0.12	2.65
DC-2	47.88	1.14	54.6	0.12	5.75
DC-3	46.58	1.14	53.1	0.12	5.59
DC-4	41.34	1.14	47.2	0.12	4.96
Total :	157.91	-	180.5	-	18.95

4) Proposed Pumping Station

(1) Proposed Site

In view of the existing khal conditions and the economic efficiencies, the pumping station having the required capacity is proposed for each drainage zone at the crossing of the trunk khal and the proposed embankment along the Balu River. Their locations are shown in Fig.E.3.14 and listed below :

Sub-Drainage Area	No. of Pumping Station	Station No. of Embankment	Name of Khal
DC - 1	P5	E 43+320	KD-1 (Boalia Khal)
DC - 2	P6	E 28-150	KD-5 (Jamair Khal)
DC - 3	P7A	E 11-340	KD-11(Begunbari Khal)
DC - 4	P7B	E 8-90	KD-14

(2) Design Water Level of Pump Station

The frequent flood water level with 2-year return period is basically applied as the design outlet flood water level (H.W.L.) of the pumping station, considering employment of a more efficient and economical pump drainage system. However, the pump equipment shall also be operated during 100-year frequency flood (H.H.W.L.), which is the design water level for flood embankment.

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The average monthly water level of about 3.0 m PWD at the beginning of June (beginning of flood season) and end of October (end of flood season), is employed as the design outlet L.W.L. for the proposed pumping stations.

On the other hand, inner design L.W.L. and H.W.L. of the pumping stations shall meet the requirements of the proposed retarding ponds, which are 3.0 m and 4.0 m PWD respectively. These are described in next section.

The design and maximum static head for the pump equipment is calculated as follows;

- Design Static Head : H.W.L. of Balu River - L.W.L. of Inland
- Max. Static Head : H.H.W.L. of Balu River - L.W.L. of Inland

Table E.3.6(1) shows hydraulic requirements of the proposed four (4) pumping stations

5) Proposed Retarding Pond

(1) Proposed Site

The proposed sites of the retarding ponds are selected under the following concept.

- a vast low-lying area below 3.0 m PWD
- a low potential area for urban development
- an area with required for hydraulic effect
- an area with possibility of land use regulation

Number of the proposed sites of the retarding pond for each drainage zone is as follows :

DC - 1 : 2 sites (RP 5-1 and RP 5-2)
DC - 2 : 1 site (RP 6)
DC - 3 : 1 site (RP 7-1)
DC - 4 : 2 sites (RP 7-2 and RP 7-3)

Location of the above sites are shown.in Fig.E.3.14.

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(2) Design Water Level and Area of Pond

The design L.W.L. of the retarding pond during flood season is proposed to be 3.0 m PWD due to the following consideration.

- to meet average ground elevation of the proposed site of the retarding pond
- to meet average water level of Balu River at the beginning and end of flood season as shown in Fig.E.3.13.

On the other had, the design H.W.L. of the retarding pond is related with the design L.W.L., the required storage volume and area of the pond. In this study, the design H.W.L. is proposed to be 4.0 m PWD taking into account of the case study results in Master Plan study.

The require area of retarding pond is estimated by the following formula;

$$A = \frac{S}{H.W.L - L.W.L}$$

Where, A	:	required area of retarding pond (m^2)
S	:	required storage capacity of retarding pond (m PWD)
H.W.L.	:	Design high water level of retarding pond (m PWD)
L.W.L.	:	Design low water level of retarding pond (m PWD)

Calculation results are shown in Table E.3.6(2).

3.3.6 Khal Improvement Plan

1) Design Discharge

(1) Division of Sub-drainage Zone

In order to estimate the design discharge at several distinct points of the khals for preparation of more deep khal sections, each drainage zone is divided into several sub-drainage zones taking into account of the existing topographic conditions and the proposed drainage khal networks. The number of sub-drainage zones are as follows :

DC - 1	Zone	:	9	sub-zones
DC - 2	Zone	:	15	sub-zones
DC - 3	Zone	:	12	sub-zones
DC - 4	Zone	:	19	sub-zones
Total	Zone	:	55	sub-zones

Fig. E. 3.15 shows the proposed khal networks and divided sub-drainage zones.

(2) Run-off Coefficient.

Run-of coefficients of sub-drainage zones are estimated based on the proposed standard run-off coefficient and the projected land use in 2010 shown in Table E.3.7.

Estimated run-off coefficients by sub-zone are shown in Table E.3.8 and Fig. E.3.15.

(3) Design Discharge

For the hydraulic design of khal improvement, flood run-off estimation has basically been made by Rational Method considering the following reasons ;

- Khal improvements are to be planned to meet the land use in 2010, during which almost 80% of the catchment area is projected to be urbanized.

- Rational method is one of famous, simple and reasonable methods for estimation of peak run-off of the khals in urbanized area.

- Application of unit hydrography model, Mike 11 NAM model and other mathematical models, of which formula have some hydrological parameters, will not be possible in this study. Because, at this stage, available hydrological data can not be obtained for calibration, which is necessary to fix the adequate value of hydrological parameters for these models.

Applied Rational formula is as follows :

$$Q = 360\ C \times I \times A$$

Where, Q : peak run-off (m3/s)
C : run-off coefficient
I : average rainfall intensity during time of concentration

Time of concentration (Tc) expressed in minutes is;

$$Tc = T\,in + L/V$$

Where, T in : in flow time of rain water (min.)
L : length of khal (m)
V : average velocity of khal (m/s)

In this study, the value of Tin and V for the khal are adopted 20 as minutes and 0.8 m/s respectively.

However, Rational formula is not able to calculate accurate run-off of the downstream stretches from the retarding pond in consideration of the hydraulic storage effect of the retarding pond. The run-off calculated by Rational formula will be larger than the actual run-off.

Accordingly, the design discharges of some trunk khals located at the downstream stretches from the retarding pond, are reviewed and modified by utilizing the hydraulic simulation results of Mike 11, details of which are mentioned in Supporting Report D.

The design discharges for the khal improvements are shown in Table E.3.9 and Fig. E.3.16.

2) Proposed Khal Improvement

As the design discharges of the most existing khals do not meet the design discharges, khal improvements by widening and dredging are required.

Planning concept for longitudinal and cross sections of the khals to be improved are as follows ;

(1) Bed elevation at the mouth of the khal is planned to be same or higher than that of Balu River.

(2) Khal bed slope is planned to be nearly same as the existing one.

(3) Whenever there is a change in khal bed slope, the ratio of variation between downstream slope and upstream slope is planned to be within 0.5.

(4) The following two types of khal cross section are proposed :

- Type (1) : Trapezoidal shape with 1:2 slope protected by sodding
- Type (2) : Trapezoidal shape with 1:1 slope protected by brick

Type (1) is applied for khal sections situated in existing agricultural land where comparatively easy land acquisition is expected. Type (2) are proposed for khal sections located in existing built-up areas where land acquisition is likely to be difficult.

Table E.3.10 shows the hydraulic design of khal improvements. Fig. E.3.17(1) to (4) illustrate the proposed longitudinal and cross section of the trunk khals of each drainage zone, KD-1, KD-5, KD-11 and KD-14 respectively.

As related structures, twelve (12) road bridges and one (1) railway bridge are planned to be reconstructed or newly constructed at the khal crossing with road and railway. Location of the proposed related structures are shown in Fig. E.3.18. Details of these structures are mentioned in Supporting Report F.

The proposed khal improvement works are shown in Table E.3.11 and Fig. E.3.19 and summarized below :

Zone	Open Channel (km)		Road Bridge (place)	Railway Bridge (place)
	Type (1)	Type (2)	New Construction	Reconstruction
DC - 1	12.70	-	-	-
DC - 2	24.30	-	8	1
DC - 3	12.10	-	-	-
DC - 4	21.90	2.0	4	-
Total :	71.00	2.20	12	1

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4. Narayanganj Area - 1 (DND Triangle Area)

4.1 Flood Mitigation Plan

4.1.1 Planning Conditions

1) Existing Facilities

DND area is surrounded by flood wall and railway-cum-embankment. The I-shape concrete flood wall was built along the ring road of DND area after the 1988 floods.

The design top level was basically set at the level of 1988 flood water level plus 2 feet.

Accordingly, most portion of flood wall have a capacity of more than 50 years recurrence floods in terms of flood water level.

From the structural view point, the most part of the flood wall were evaluated as tentative structures due to its strength against expected external loads by heavy vehicle.

The railway track from Chasara to the crossing point at Demra road was heightened upto about 6.8 m to 7.4 m in P.W.D for flood protection purpose.

While, the 1988 flood water level at Launch Terminal of IWTA of Lakhya river is measured about 6.6 m PWD.

This railway top elevation is corresponding about 50 year flood frequency in terms of flood protection capacity.

The total length of the flood wall and railway-cum-embankment is measured at 31.5 km in length (see Fig. E.4.1).

2) Flood Protection Level and Improvement Requirements

DND area has been developed as agricultural project area. However, after the 1988 floods, DND area has been rapidly developed mainly due to existence of flood mitigation and stormwater drainage facilities and short distance to Dhaka centre area and surrounding industrial area.

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Some land development projects by both RAJUK and Private sectors have been carried out in the DND area. A trunk road construction in the centre portion by RHD is being constructed.

By considering above social condition, the flood protection level is set basically at more than 1988 floods or 100-year flood occurrence level.

Most part of the existing flood wall is satisfied both to the design height and its strength against flood water pressure.

However, rehabilitation works is required for some portion according to the shortage of height and disturbed foot conditions of existing flood wall.

3) Flood Protection System

DND area may be protected by double polder on the eastern part when the embankment / flood wall of Narayanganj West is completed.

In this stage, flood protection is to be considered as one polder system, and the outer polder of Narayanganj area is to be considered as main polder.

4) H.W.L and Top Level of Polder

The design high water levels corresponding to 100-year flood recurrence or more are to be adopted for DND area. The design top levels of the flood wall are shown below :

Route/Location		H.W.L (m P.W.D)	Top E.L. (m P.W.D)	Remark
1.	Chasara to Buriganga Bridge (DW)			
-	Chasara(DW.0)	6.96	7.56	-----
-	Panchabati(DW.6+200)	7.20	7.80 100-year	More than
-	Buriganga Bridge(DW.27)	7.80	8.40	-----
2.	Buriganga Bridge to Demra (DN)			
-	Buriganga Bridge(DN.0)	7.80	8.40	-----
-	Jatrabari(DN.6)	7.80 / 7.40	8.40 / 8.00	-----
-	Demra (DN.22)	7.40	8.00	-----
3.	Chasara to Hajiganj (DS)			
-	Chasara (DS.0)	6.96	7.56	-----
-	Hajiganj (DS.6)	6.96	7.56	-----
4.	Hajiganj to Demra (DE)			
-	Hajiganj (DE.0)	6.96	7.56	-----
-	Existing Pump Station (DE.18)	7.29	8.49	-----
-	Demra (DE. 26)	7.40	8.00	-----

4.1.2 Polder Facility Plan

1) Rout of Flood Wall

The existing flood wall is to be used for flood mitigation facility and only short distance of re-construction and rehabilitation work of the existing flood wall is designed for DND area.

For this reason, the alignment of flood wall is basically not changed from the existing one.

The alignment of existing flood wall is shown in Fig. E.4.1.

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2) Longitudinal and Standard Cross-Sections

The longitudinal profile of the flood wall is decided based on the design high water levels. The design top level of the flood wall are accordingly obtained with the design high water level by adding 0.6 m of the freeboard (Fig. E.4.2).

The proposed rehabilitation work is classified into the following works according to the existing flood wall condition.

1. Heightening the wall
2. Strengthening of foot portion.
3. Repairing of damaged portion of flood wall.

The existing flood wall and typical rehabilitation works are shown in Fig E.10.

4.1.3 Sluice Gate

1) Location.

One sluice gate is planned at the proposed pump station of Adamjee Nagar. The location is shown in Fig. 4.1.

2) Main Features of Sluice Gates

A culvert type sluice gate is selected in view points of construction cost, operation and maintenance work.

The main feature of the proposed gate is shown below :

No.	Sluice Gate No.	Station	Name	Design Discharge (m3/S)	DL. of Outlet (m in PWD)	Remarks
1	20	DE. 10+300	KN-4	143.5	-1.4	Pump Station

4.1.4 Stop Log Structure

There are many openings on the existing flood wall. The openings are being used for private and publics for entrance to the ring roads.

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As a crossing structure of the openings during the flooding period, stop log structure is planned for DND area. This stop log is designed only the entrance of public use.

For smaller openings less than 5m in width or 1.0 m in height, some simple counter measures such as sand bags, timber stopper are to be considered.

A total of 17 stop log structures are planned and the proposed location is shown in Chapter of "Preliminary Design".

4.2 Stormwater Drainage Improvement Plan

4.2.1 Present Condition of Drainage Area

1) Drainage Area and Drainage System

DND area of 56.79 km^2 is of triangular shape and surrounded by three major roads : The Demra road to the north, the Dhaka-Narayanganj highway to the west and south, and the Demra-Narayanganj highway to the east. The area has been developed as an agricultural land since 1968 by BWDB, and protected by the peripheral road-cum-embankment as polder dikes from floods of the Buriganga, Dhaleswari, Balu and Lakhya rivers. However, the area is rapidly changing to an urban area due to its high potentiality for development. Apart from a small area in the south and built-up areas on the north-west, the ground elevation of DND area is mostly less than 5 m PWD. Large areas in the center and east area below 2.5 m PWD.

The existing built-up area of 21.74 km^2 (approx. 38% of the area) is projected to be 36.14 km^2 (approx. 64% of the area) in 2000 and 42.70 km^2 (approx. 75% of the area) in 2010 . The population is estimated to be 0.45×10^6 in 1990, 0.88×10^6 in 2000 and 1.31×10^6 in 2010. Table E.4.2 shows the present and future built-up area and population of the DND area.

The entire area is crisscrossed by irrigation and drainage channels. The stormwater collected by open ditches is conveyed to Khasder Ghoshpara near the Katchpur bridge by the major khals under one drainage basin, and discharges into the Lakhya River through the Demra pumping station as shown in Fig. E.4.6.

2) Drainage Facilities

The existing major drainage facilities are classified into khal, pumping station and related structures. No drainage pipe is provided in the DND area.

(1) Khal

There are eighteen (18) major khals with a total length of 34.7 km as shown in Fig. F.4.6. These khals collect stormwater and surplus water from paddy field through the connected secondary channels, and convey them to the Demra pumping station.

Existing drainage capacities of the khal are calculated based on the longitudinal and cross-sectional survey carried out by the study team. Calculation results are shown in Table E.4.3. The existing khal sections are mostly insufficient for the future requirements, which can carry only a specific discharge of 8 $m^3/s/km^2$. Khal improvement by widening and dredging will be necessary for future development.

(2) Demra Pumping Station

This pumping station was constructed by BWDB in 1968 in connection with DND irrigation project. It serves both as a stormwater drainage and as an irrigation facility for the DND project area. The specifications of the pumping station are as follows :

- Total design discharge : 3.63 m3/s x 4 unit = 14.52 m3/s
- Design H.W.L. (suction side) : 1.8 m PWD
- Design L.W.L. (suction side) : 1.0 m PWD
- Design H.W.L. (discharge side) : 5.94 m PWD
- Pump head : 4.9 m
- Pump type : Vertical axial flow pump
- Pump diameter : 1300 mm
- Number of pump : 4 units

Fig. E.4.7. shows the plan and section of the existing Demra pumping station.

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According to the annual operation record between 1970 and 1989 shown in Table E.4.4, annual operation hour and five (5) months operating hour between June and October for irrigation and stormwater drainage works are as follows :

- For irrigation

  Annual : Max. = 5,099 hr, Min. = 2,382 hr, Ave. = 3,114 hr
  5 months : Max. = 693 hr, Min. = 146 hr, Ave. = 415 hr

- For stormwater drainage

  Annual : Max. = 7,921 hr, Min. = 2,160 hr, Ave. = 4,827 hr
  5 months : Max. = 7,214 hr, Min. = 2,059 hr, Ave. = 4,223 hr

So, annual operating hour per one pump is approx 1,200 hr in average for stormwater drainage works.

Through the field investigation, it is found that the pump equipment is sometimes not operated because of stoppage of power supply. It is required to connect an additional power line or to install a generator with enough capacity.

4.2.2. Planning Policy and Criteria

1) Planning Policy

A planning policy for preparation of stormwater drainage improvement plan are briefly summarized below :

- Plans are to be prepared to meet the population and land use in the target year 2010. The whole area to be planned is approximately 57 km^2. The population and built-up area in 1990 and 2010 of the project area are shown in Table E.4.2.

- Scope of countermeasures for the existing built-up areas are construction of pumping station with retarding pond, and improvements of khal and trunk drain to mitigate the existing internal flood damage. Secondary and tertiary drainage pipes are excluded in the proposal, taking into account that the investment for project implementation must be reasonable.

- For the future urbanized areas, only pumping station with retarding pond and improvements for trunk khals are to be proposed as countermeasures. Land acquisition will be recommended for the proposed countermeasures except the retarding ponds, for which will be proposed that the required areas be preserved by land use regulation, in order to limit the project cost.

2) Planning Criteria

(1) Design Flood Water Level

The design flood water levels of 2-year frequency are applied based on the calculation result of probable water levels at Demra (BWDB Sta. 179) and Narayanganj (BWDB Sta. 180). They are;

- NA - 1 zone : 5.75 m PWD
- NA - 2 zone : 5.65 m PWD

Note: Location of zone is shown in Fig. E.4.8.

The pump equipment is designed to be operated during the flood of a 100-year flood frequency. Considering about 2 m difference in water levels between the floods of a 2-year and a 100-year flood frequency, the flood water level at the highest pump efficiency of 100% will actually be higher than that of a 2-year frequency flood.

The pump will be designed based on the most effective water level equivalent of the annual maximum water level on average which is equivalent about 2.3 - 2.8 return period.

(2) Design Rainfall, Run-off Coefficient, Run-off Ratio and Drainage Criteria

They are applied all the same criteria as Greater Dhaka East (refer to Section 3.3.2, 2, Fig. E.3.10. and E.3.11)

4.2.3 Zoning

DND area is planned to be protected against the external flood from the Buriganga, Balu and Lakhya rivers by road-cum-embankment with concrete flood wall as shown in Fig. E.4.1.

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In order to cope with the increasing run-off due to the future forecast urbanization, another pumping station which drains stormwater into the Lakhya River will be required. The area is proposed to be divided into two drainage zone, northern and southern zones (NA-1, NA-2) as shown in Fig. F.4.8, considering the topographic condition and the existing khal networks. Their drainage area and main khals are summarized below ;

Zone	Area (km2)	Main Khal
NA - 1	25.10	Shampur Khal
NA - 2	31.69	Pagla Khal, Fatualla Khal
Total :	56.79	

4.2.4 Countermeasures

Stormwater drainage countermeasures are proposed for the whole area of 56.79 km2. As almost 62% of the area is still an urbanized, the proposed measures will consist of the followings :

- All the required pumping stations with retarding ponds
- Khal improvements

However, lateral drains and tertiary drainage pipes are excluded in this project. Because a beneficial effect of these facilities will be expected only after the completion of the connected khals in newly developed areas.

Land acquisition of the proposed pumping station and khal improvement is required to prevent illegal land development by the private sector. For the retarding pond, however, land use regulation will be necessary to preserve their storage capacity and to limit the pump capacity.

4.2.5 Pump Drainage Plan

1) Pump Drainage Area

The existing built-up areas of approx. 22 km^2 are situated on the slight high land between 5 to 6m PWD. Remaining area of approx. 35 km^2 is low-lying, where ground elevation varies from 2.5m to 5m PWD. The entire DND area of 56.79 km^2 needs to adopt the pump drainage system.

2) Pump Operation Period

As mentioned is Section 3.3.5, the required pump operation period will be at least five (5) months between June and October in every year. This situation is almost same as that of Greater Dhaka East.

3) Required Pump and Retarding Pond Capacity

A pump drainage system combined with retarding ponds is also recommended to economize the pump drainage cost by reducing the required pump capacity.

The required pump and retarding pond capacities are estimated based on the both specific requirements, P = $1.14 m^3/s/km^2$ and V = $0.0120 \times 10^6 m^3/km^2$ respectively as shown below :

Zone	Area (km^2)	Required Pump Capacity		Required Storage Volume of Retarding Pond	
		Specific ($m^3/s/km2$)	Total (m3/s)	Specific (m^3/km^2)	Total (m^3)
NA-1	25.10	1.14	28.6	0.12	3.01
NA-2	31.69	1.14	36.1	0.12	3.80
Total :	56.79	-	64.70	-	6.81

4) Proposed Pumping Station

(1) Proposed Site

In view of the continuous demand for irrigation in DND and the economized pump drainage cost, the existing Demra pumping station will be utilized in the plan. The existing pump capacity of 14.5 m^3/s is, however, less than the required pump capacity of zone NA-1 (28.6 m^3/s).

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Since it is difficult to get the construction space for additional pump facilities at the Demra pumping station, the pump capacity of $14.1 m^3/s$ is to be added to the new pumping station planned at Siddirgonj in Zone NA-2.

Location of the proposed pumping stations are shown in Fig.E.4.9 and listed below :

Sub zone	No. of pumping Station	Station No. of Embankment	Name of Khal
NA-1	P10 (Demra P.S)	DE 17+350	KN-1
NA-2	P11	DE 10+300	KN-4

(2) Design Water Level of Pumping Station

As topographic, hydrological and hydraulic conditions of DND area are very similar with those of Greater Dhaka East, the design water levels of pump station is planned to apply the same value as Greater Dhaka East pumping station, except the H.H.W.L. of the Lakhya River.

Hydraulic requirements of the proposed pumping stations are shown in Table E.4.5 (1).

5) Proposed Retarding Pond

(1) Proposed Site

The Proposed sites of the retarding ponds are selected under the following concept.

- a vast low-laying area below 3.0m PWD
- a low potential area for urban development
- an area with necessary hydraulic effect
- an area with possibility of land use regulation

A number of the proposed site of the retarding pond for each drainage zone is follow:

NA-1 : 3 sites (RP10-1, RP10-2 and RP11-3)
NA-2 : 3 sites (RP11-1, RP11-2 and RP11-3)

Location of the proposed six (6) sites are shown in Fig. E.4.9.

(2) Design Water Level and Area of Pond

The design L.W.L. of the retarding pond during flood season is planned to be 3.0m PWD due to the followings:

- to meet average ground elevation of the proposed site of the retarding pond
- to meet average water level of the Lakhya River at the beginning and end of flood season as shown in Fig. E.3.13.

On the other hand, the design H.W.L. of the retarding pond is proposed to be 4.0m PWD considering an effective storage depth of 1.0m which is same as that of Greater Dhaka East. Because topographic conditions of low-lying areas in DND and Greater Dhaka East are very similar.

Table E.4.5 (2) shows the hydraulic requirements of the retarding pond.

4.2.6 Khal Improvement Plan

1) Design Discharge

(1) Division of Sub-drainage Zone

In order to calculate the design discharges at several distinct points for preparation of more deep khal sections, each drainage zone is divided into approximately 20 sub-drainage zones based on the existing topographic condition and the proposed khal networks as shown in Fig. E.4.10. The number of sub-drainage zones are,

- NA - 1 : 17 sub-zones
- NA - 2 : 21 sub-zones

Total : 38 sub-zones

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(2) Run-off Coefficient

Run-off coefficient of each sub-zone is estimated based on the standard run-off coefficient by land use and the projected land use plan in 2010 mentioned in Supporting Report A. Estimated run-off coefficients by sub-zones are shown in Table E.4.6 and Fig. E.4.10.

(3) Design Discharge

Design discharges for khal improvements are calculated by Rational method, the same method as Greater Dhaka East.

As mentioned before, however, Rational formula can not be used to evaluate the hydraulic storage effect of retarding pond, by which the actual discharges of downstream stretches of the retarding pond will be decreased.

Accordingly the design discharges of some downstream stretches of the retarding pond are reviewed and modified by utilizing the hydraulic simulation results of Mike 11, details of which are mentioned in Supporting Report D.

The design discharges are shown in Table E.4.7 and Fig. E.4.11.

2) Proposed Khal Improvement

The discharge capacities of the existing khals in the DND area mostly do not meet the design discharge. Khal improvement by widening and dredging are required.

Planning concept for longitudinal and cross sections of the improved khals is as follows :

(1) Bed elevation at the mouth of khal is planned to be same or higher than that of Lakhya River.

(2) Khal bed slope is planned to be nearly same as the existing one.

(3) Ratio of upstream bed slope and downstream bed slope at inflection point is planned to be within 0.5.

(4) The following two types of khal cross section are proposed :

- Type (1) : Trapezoidal shape with 1:2 slope protected by sodding
- Type (2) : Trapezoidal shape with 1:1 slope protected by brick

Type (1) is applied for khal sections situated in existing agricultural land where comparatively easy land acquisition is expected. Type (2) are proposed for khal sections located in existing built-up areas where land acquisition is likely to be difficult.

Table E.4.8 shows the hydraulic design of khal improvements. Fig. E.4.12 (1) and E.4.12 (2) show the proposed longitudinal and cross section of khal No. KN-1 and KN-4 respectively.

As related structures, road bridge, railway bridge and aqueduct are planned to be reconstructed or newly constructed at khal crossing with road, railway, and irrigation canal. The number of related structures are as follows :

- Road bridge : reconstruction; 28 places, new construction; 6 places
- Railway bridge : reconstruction; 4 places
- Aqueduct : reconstruction ; 2 places

Location of he above structures are shown in Fig. E.4.13. Detailed of the related structures are mentioned in Supporting Report F.

The proposed khal improvement works are shown in Table E.4.9 and Fig. E.4.14, and summarized below :

Zone	Open Channel (km)		Road Bridge (place)		Railway Bridge (place)	Aqueduct (place)
	Type (1)	Type (2)	Recons-truction	New Construction	Reconstruction	Reconstruction
NA-1	15.80	8.10	9	3	0	1
NA-2	17.90	9.40	19	3	4	1
Total :	33.70	17.50	28	6	4	2

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5. Narayanganj Area - 2 (Narayanganj West)

5.1 Flood Mitigation Plan

5.1.1 Planning Condition

1) Flood Protection Level

A scale of 100-year flood frequency is adopted for the design of embankment with due consideration of importance of the area and consistency with the flood protection level of DND area.

2) Flood Protection System

After the completion of polder facility along the Buriganga and Sitalakhya river, the flood protection system is to be one system for whole Narayanganj area.

Accordingly existing flood wall along the ring road / railway on the southern and eastern part become secondary flood mitigation facility.

3) Design High Water Level (H.W.L) and Design Top Level

A design high levels corresponding to 100-year flood recurrence are determined based on the result of statistic analysis of water level. The design top levels of the embankment and flood wall are calculated by adding freeboards of 1.2 m and 0.60 m respectively.

The H.W.L and design top levels at specific point are shown below :

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Route/Location		H.W.L (m P.W.D)	Top E.L. (m P.W.D)	Remarks
1.	Narayanganj to Panchabati (NW)			
	Narayanganj(NW.0) Flood wall	6.80	8.00/7.40	Embankment/
	Panchabati(NW.29)	7.20	8.40	Embankment
2.	Narayanganj to Demra (NE)			
	Narayanganj(NE.0)	6.80	7.40	Flood Wall
	Adamjee Nagar Back Levee(NE.48)	7.10	7.70/8.30	Flood Wall/ Embankment
	Existing Pump Sta. Back Levee(NE.72)	7.29	8.49	Embankment
	Demra (NE.88)	7.40	8.60/8.0	Embankment/ Flood Wall.

5.1.2 Polder Facility Plan

1) Alignment of Polder

(1) Narayanganj to Panchabati (NW)

The embankment and road-cum-embankment type are planned from Panchabati to Narayanganj along Panchabati via Saiyedpur on western part. The road-cum-embankment along the existing road is planned to start from Saiyedpur and connected to the flood wall of DND area at Panchabati.

While the embankment is planned form Narayanganj to Saiyedpur.

(2) Narayanganj to Demra (NE)

The alignment composed of flood wall and embankment is planned from Narayanganj to Demra along Lakhya river.

This alignment is planned along the river bank in order to protect the existing buildings,industrial asset as much as possible.

The alignment is shown in Fig.E.5.1.

2) Alternatives of Flood Wall Type

(1) Alternatives

For the stretch from Narayanganj to Siddirganj Power station along the Lakhya river (NE), many houses, godowns, loading and unloading facilities etc. are densely located on the peripheral area of river bank. For this area, embankment type polder required wider space of construction is not much available. While, for the remaining strech the construction space for the the embankment construction is available.

Accordingly, the flood wall types applicable to this stretch may be the following 4 types (see Fig. E.5.2).

Type 1	:	Concrete Wall I/T - type
Type 2	:	Concrete Sheet Pile
Type 3	:	Reinforced Concrete Retaining Wall
Type 4	:	Concrete Block Retaining Wall

After the cost estimate I/T type which are proposed in the Master Plan is selected for the basic type of flood wall.

The main features of I type is described below :

This I or T types flood wall is planned in the Master Plan. This is to be constructed on the high land nearby buildings or the place of buildings after resettlement. The I type is applied for lower wall, while the T type is for higher wall. Both I and T type requires land acquisition, resettlement and its compensation.

(2) Longitudinal and Standard Cross-Sections

(a) Longitudinal Profile

The longitudinal profile of the road-cum-embankment (NW) is decided based on the design high water levels of Hariharpur and Rekabi Bazar water level Gauging stations.

The longitudinal profile of flood wall and embankment along Lakhya river also decided in the same manner of that western side polder. The H.W.L at Narayanganj down stream is decided based on the water levels of Kalagachia and Rakabi Bazar gauging stations and Demra for upstream. The freeboards adopted are 1.2 m for embankment and 0.6 m for flood wall.

b) Standard Cross Sections

The shape of standard cross-section of road-cum-embankment is almost the same geometry with the embankment (see Fig. E.5.4).

However, the road-cum-embankment is to be connected to the existing road space in addition to the berm on land side.

The standard cross-section of the embankment along Lakhya river is the same as that of Greater Dhaka East.

The standard cross-section of flood wall along the Lakhya river is proposed after the detailed study of type selection. Some variation will be made to particular portion according to the soil conditions at site.

For this strech, foundation treatment is required about 14% of its streches due to the poor soil foundation.

The longitudinal section and standard cross-sections proposed are shown in Fig E.5.3 and E.5.4.

5.1.3 Sluice Gate

1) Location

A total of 14 sluice gates are planned at crossing points of existing khals and at the proposed pump stations. The location is shown in Fig.E.5.1.

2) Main Features of Sluice Gates

A culvert type of sluice gate is selected for every proposed location in view point of construction cost and easy maintenance.

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The main feature of proposed sluice gate are summarized below :

No.	Sluice Gate No.	Station No.	Name of Khal	Type of Structure	Design Discharge (m3/S)	DL. of Outlet (m in PWD)	Remarks
1	21	NE.84+120	KN-18	Box	7.33	+3.30	----
2	22	NE.77+160	KN-19	Box	16.72	±0.0	With Pump Station (NE)
3	23	NE.69+100	KN-20	Box	20.04	±3.0	With Pump Station (NE)
4	24	NE.49+100	KN-22	Box	21.90	+2.63	----
5	25	NE.46+180	KN-23	Box	10.54	+3.12	----
6	26	NE.40+170	KN-24	Box	10.31	+3.11	----
7	27	NE.32	KN-25	Box	8.83	+3.06	----
8	28	NE.26+150	KN-26	Box	9.18	+3.04	----
9	29	NE.19	S-1	Box	10.47	+3.33	----
10	30	NE. 8+50	S-2	Box	6.17	+3.00	----
11	31	NE.5+70	KN-27	Box	7.18	+2.98	----
12	32	NE. 5+70	S-3	Box	3.89	+3.25	----
13	33A	NE.1+150	KN-28	Box	26.97	+0.50	With Pump Station (NW)
14	33B	NE.14+190	KN-30	Box	43.15	+0.50	With Pump Station (NW)

5.1.4 Stop Log Structure

For the flood wall along Lakhya river, many stop log structure are required for the openings of public use.

On this plan, a total of 58 stop log structures are planned at the entrance from public roads to river bank for the public use.

The proposed locations are shown in Chapter of "Preliminary Design".

Table E.3 Proposed Flood Mitigation Facility : Dhaka East

5.2 Stormwater Drainage Improvement Plan

5.2.1 Present Condition of Drainage Area

1) Drainage Area and Drainage System

The drainage area of 18.63 km^2 identified one of the priority areas covers the narrow strip between the Demra - Narayanganj Road and the Lakhya River, and Narayanganj town on the west bank of the Lakhya River. The area has developed as a business and industrial areas. The urbanized area is situated on high land about 6.0 m PWD, which is free from habitual flood. The rural area is located in low land, which is under the water of max. 2.5 m depth in flood season and is mainly used as a paddy field in dry season. Narayanganj town is under the jurisdiction of Narayanganj Municipality and the other areas are under the Zila Parishad.

The existing built-up area of 13.12 km^2 (approx. 70% of the area) is projected to be 17.20 km^2 (approx. 92% of the area) in the target year 2010. The population is estimated to be 0.47×10^6 in 1990, 0.70×10^6 in 2000 and 0.93×10^6 in 2010. Table E.5.2 shows the present and future built-up area and population of the Narayanganj West area.

Industrial areas along the Lakhya River are filled up and drained directly into the river by their own drains under the gravity flow. Stormwater of low lands surrounding the industries is drained into the Lakhya River through several khals.

Narayanganj town has provided U-type or covered type brick masonry drains on one side or both sides of the roads. The total length of the drain is almost 9.5 km. Some main drains, which convey stormwater to the Lakhya River, have inadequate sections causing mainly internal flood when there is heavy rainfall. Secondary and tertiary drains are filled up at many places with town garbage and earth causing hindrance to stormwater flow.

The western parts of Narayanganj town are rapidly and adhock developing. Almost 25% of the area has internal flood problem due to lack of sufficient drainage facilities. This area is drained into the Kashipur - Bholai Khal, which drains to the Dhaleswari River, through the Shasongaon and Mondal Para khals.

2) Drainage Facilities

The existing major drainage facilities consist of brick masonry drain and khals. No pumping station and drainage pipe are provided in Narayanganj West area.

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(1) Brick Masonry Drain

Brick masonry drains are provided at one side or both side of the roads in the eastern part of Narayanganj town between the Bangabandhu Road and the Lakhya River. There are two types, open ditch type and covered channel type. The width of drain vary from 0.25 m to 1.0 m and its depth vary from 0.30 m to 1.5 m as per elevation of road. The total length of the drains including secondary drain is reported to be about 9.5 km by Narayanganj Municipality.

(2) Khal

There are eight (8) major khals with a total length of 6.21 km as shown in Fig. E.5.6. These khals are mainly used for stormwater drainage except two khals in western Narayanganj town, Shasongaon and Mondal Para khals, which are also used for irrigation in dry season.

Based on the longitudinal and cross sectional survey results, the existing drainage capacity of the above khals are calculated. According to the calculation results shown in Table E.5.3, almost a half of the khals have sufficient sections for the required specific discharge capacity of about $8m^3/s/km^2$. Small scale khal improvement only will be required.

5.2.2 Planning Policy and Criteria

1) Planning Policy

A planning policy for preparation of stormwater drainage improvement plan are briefly summarized below :

- Plans are to be prepared to meet the population and land use in the target year 2010. The whole area to be planned is approximately 19 km^2. The population and built-up area in 1990 and 2010 of the project area are shown in Table E.5.2.

- Scope of countermeasures for the existing built-up areas are construction of pumping station with retarding pond, and improvements of khal and trunk drain to mitigate the existing internal flood damage. Secondary and tertiary drainage pipes are excluded in the proposal, taking into account that the investment for project implementation must be reasonable.

- For the future urbanized areas, only pumping station with retarding pond and improvements of trunk khals are to be proposed as countermeasures. Land acquisition will be recommended for the proposed countermeasures except the

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retarding ponds, for which it will be proposed that the required areas be preserved by land use regulation in order to limit the project cost.

2) Planning Criteria

(1) Design Flood Water Level

The design flood water levels of 2-year frequency are applied for each drainage zone based on the calculation results of probable water levels at Demra (BWDB Sta. 179), Narayanganj (BWDB Sta. 180), Hariharpara (BWDB Sta. 43) and Kalagachia (BWDB Sta. 71) gauging stations. They are as follows :

- NB 1 Zone : 5.80 m PWD
- NB 2 Zone : 5.70 m PWD
- NB 3 Zone : 5.45 m PWD
- NB 4 Zone : 5.50 m PWD
- NB 5 Zone : 5.45 m PWD

The pump equipment is designed to be operated during the flood of a 100-year flood frequency. Considering about 2 m difference in water levels between the floods of a 2-year and a 100-year flood frequency, the flood water level at the highest pump efficiency of 100% will actually be higher than that of a 2-year frequency flood.

The pump will be designed based on the most effective water level equivalent of the annual maximum water level on average which is equivalent about 2.3 - 2.8 year return period.

(2) Design Rainfall, Run-off Coefficient, Run-off Ratio and Drainage Criteria

The criteria applied are the same as that of Greater Dhaka East. (refer to Section. 3.3.2, 2), Figs. E.3.10 and E.3.11.

5.2.3 Zoning

Narayanganj West area is planned to be protected against the external floods from the Dhaleswari River and the Lakhya River by embankment, flood wall and road-cum-embankment as shown in Fig. E.5.1.

As shown in Fig. E.5.7, the area is divided into small five (5) drainage zones, NB-1 to NB-5, based on the proposed alignment of the flood protection facilities, inner drainage system and road networks. The drainage area and the main khal of each zone are summarized below :

Zone	Area (km^2)	Main Khal
NB-1	2.30	K-19
NB-2	3.99	K-20, 21
NB-3	5.33	K-23, 24
NB-4	2.36	Shasongaon Khal (K-25)
NB-5	3.65	Mondal Para Khal (K-26)
Total :	18.63	

Note : Refer to Figs. E.5.6 and E.5.7.

5.2.4 Countermeasures

Stormwater drainage countermeasures are proposed by five (5) zones for the whole area of 18.63 km2. As almost 70% of the area is already urbanized, the proposed measures will consist of the followings :

- All the required pumping stations with retarding ponds
- Improvements of khal and trunk drain

However, lateral drains and tertiary drainage pipes are not included in this project in order to limit the project cost.

5.2.5 Pump Drainage Plan

1) Pump Drainage Area

Each drainage zone is demarcated into pump and gravity drainage areas based on the following demarcation criteria.

- The area above the design flood water level plus 0.5 m can drain stormwater by open channel under the gravity flow.

- The area below the design flood water level plus 0.5 m can not drain stormwater by gravity flow. Pump drainage system is required.

- Future urbanized areas in the existing low-land will be built-up by land filling of min. 2.0 m.

Pump and gravity drainage areas by each zone are summarized below :

Zone	Area (km^2)		
	Pump Drainage	Gravity Drainage	Total
NB-1	1.73	0.57	2.30
NB-2	1.92	2.07	399
NB-3	----	5.33	5.33
NB-4	2.36	----	2.36
NB-5	4.65	----	4.65
Total :	10.66	7.97	18.63

Note : Refer to Figs. E.5.7.

2) Pump Operation Period

As mentioned in Section 3.3.5, the required pump operation period will be at least five (5) months between June and October in every year. This situation is almost the same as that of Greater Dhaka East and DND.

3) Required Pump and Retarding Pond Capacities

In order to economize the total pump drainage cost by reducing the required pump capacity, it is proposed to adopt a pump drainage system combined with retarding pond.

Specific requirements of pump capacity and storage volume of retarding pond are estimated to be $P = 1.14\ m^3/s/km^2$ and V = 0.120 x 106 m3/km2 respectively by utilizing storage basin model as shown in Fig. E.3.10.

The required pump capacity and storage volume of retarding pond for each zone are summarized below ;

Zone	Area (km^2)	Required Pump Capacity Specific ($m^3/s/km^2$)	Total (m^3/s)	Required Storage Volume of Retarding Pond Specific ($\times 10^6 m^3/km^2$)	Total ($\times 10^6 m^3$)
NB-1	1.73	1.14	2.0	0.12	0.21
NB-2	1.92	1.14	2.2	0.12	0.23
NB-4	2.36	1.14	2.7	0.12	0.28
NB-5	4.65	1.14	5.3	0.12	0.56
Total :	10.66	---	12.2	---	1.28

4) Proposed Pumping Station

(1) Proposed Site

Considering the required pump capacity, one small pumping station by each zone is proposed at the crossing of the main khal and the proposed embankment.

Location of the proposed pumping stations is shown in Gig. E.5.8 and listed below:

Sub-Zone	Pumping	No of Embankment station	Station No. of Name of khal
NB-1	P12	NE 77 + 160	KN - 19
NB-2	P13	NE 69 + 100	KN - 20
NB-3	P14A	NW 23	KN - 28 (Shasongaon Khal)
NB-4	P14B	NW 14 + 190	KN - 30 (Mondal Para Khal)

Note: 1)Refer to Fig. E.5.8

(2) Design Water Level of Pumping Station

Design flood water levels of pumping stations are determined through the same technical approach as Greater Dhaka and DND. However, ground elevation of low-lying areas (expected retarding pond) in NB-2 and NB-5 is almost 3.5m PWD, which is 0.5m higher than others. Accordingly, the design flood water levels of P13 and P14B pumping stations is planned to be 0.5m higher than that of other stations.

Hydraulic requirements of the proposed pumping station are shown in Table E.5.4 (1)

5) Proposed Retarding Station

(1) Proposed Site

Even if this area is expected to be urbanized fast, low-lying areas having sufficient storage potential are proposed as retarding pond areas. The number of retarding ponds drainage zone is as follows;

NB-1	:	1 site (RP12)
NB-2	:	1 site (RP13)
NB-3	:	1 site (RP14-1)
NB-4	:	1 site (RP14-2 and RP 14-3))

(2) Run-off Coefficient

Run-off coefficients of sub-zones are estimated based on the proposed standard run-off coefficient mentioned in Section 3.3.2 and land use in 2010. Calculation results are shown in Table E.5.5 and Fig. E.5.8.

(3) Design Discharge

Design discharges for improvements of khal and trunk drain are calculated by Rational formula, the same method as Greater Dhaka East and DND.

Calculation results are shown in Table E.5.6. and Fig. E.5.9.

5.2.6 Khal and Trunk Drain Improvement Plan

The conveyance capacities of the existing khals and trunk drains located in the Narayanganj town do not meet to the design discharges. Improvement of khal channels by widening and dredging, or replacement of trunk drainage channels or pipes are required.

The proposed types for khal and drainage improvement are as follows :

1) Open Channel

- Type (1) : Trapezoidal shape with 1:2 slope protected by sodding
- Type (2) : Trapezoidal shape with 1:1 slope protected by brick

2) Covered Channel / or Pipe

- Type (1) : Brick pipe (Max. diameter : Ø 3,000)
- Type (2) : Concrete box culvert (Discharge capacity : more than $10m^3/s$)

Open channel type (1) is applied for khal sections situated in agricultural land where comparatively easy land acquisition is expected. Open channel type (2) are proposed for khal sections located in built-up areas where land acquisition is likely to be difficult. O & M roads with a minimum width of 4.0 m is proposed to provide for the both banks of each khal. Typical section of the khal improvement is shown in Fig.F.5.1 in Supporting Report F.

The covered channel type (1) is basically applied for trunk drains. However the type (2) is proposed for the trunk drains sections, of which the design discharge is estimated to be more than $10m^3/s$. Typical sections of the proposed trunk drain are shown in Fig. F.5.5 in Supporting Report F.

As related structures, construction of eleven (11) road bridges and three (3) railway bridges will be required for crossing of new khal and road/railway. Location of these structures are shown in Fig. E.5.12. Details are mentioned in Supporting Report F.

The proposed khal improvement works are shown in Table E.5.8 and Fig. E.5-13, and summarized below :

Zone	Khal Improvement (km)		Trunk Drain (km)		Bridge (Place)	
	Type (1)	Type (2)	Type (1)	Type (2)	Road	Railway
NB-1	1.20	0.40	---	---	1	---
NB-2	0.90	2.20	---	---	2	1
NB-3	---	2.60	0.90	0.50	---	2
NB-4	1.40	1.40	---	---	2	---
NB-5	0.80	4.90	---	---	6	---
Total :	4.30	11.50	0.90	0.50	11	3

TABLE E.2.1 PROJECT IMPLEMENTATION SCHEDULE OF RELATED PROJECT : FAP 8B

Year	'91		'92				'93				'94				'95				'96				Remarks
Quarter	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
Project Preparation																							
A.Flood Protection (Part A)																							
- Construction Works																							
- Incremental Maintenance																							
B.Drinage (Part B)																							
- Construction Works																							
- Incremental Maintenance																							
C.Enviromental Improvement																							
Program (Part C)																							
- Improvement Works																							
- Incremental Maintenance																							

Note:
1).Construction Works includes preparatory activities

TABLE E.3.1 MAIN FEATURES OF ALIGNMENT ALTERNATIVE

Description of Alternatives	Total Length of Embankment (km)	Average Ground Level (PWD)	Embankment Volume (x 1000 m^3)	Foundation Treatment Required (km)	No. of Sluice Gates (No)	Total Construction Cost (million taka)	Protected Area (ha)	Remarks
Alternative A	4.4	1.5 ~ 3.0	868	3.94	1	900	+ 215	Recommended
Alternative B	4.4	2.0 ~ 5.0	553	1.33	1	570	± 0	

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TABLE E.3.2 NAVIGATION SURVEY RESULT IN DHAKA EAST ZONE

(Unit : TK.)

Boat Terminals	Boat - Days per Year		Average No. of Trips per Day	Share of Commodity Transport Services	Total No. of Trips for Commodity Transport Services		Share by size of Boats				Value of Commodities per Trip		Valut of Commodities			Share
	Wet Season	Dry Season			Wet Season	Dry Season	Wet Season		Dry Season		Small Boat	Big Boat	Wet Season	Dry Season	Total	
							Small Boat	Big Boat	Small Boat	Big Boat			G1 = D1x(E11xF1+ E12xF2)	G2 = D2x(E21xF1+ E22xF2)	H = G1+G2	
	A1	A2	B	C	D1=A1xBxC	D2=A2xBxC	E11	E12	E21	E22	F1	F2				(%)
Rampura	17,850	2,700	1.5	50%	13,388	2,025	0.65	0.35	0.25	0.75	1,000	10,000	55,558,125	15,693,750	71,251,875	12.42
Meradia	308	0	11.0	20%	678	0	0.33	0.67	0.25	0.75	1,000	10,000	4,743,200	0	4,743,200	0.83
	546	0	11.0	20%	1,201	0	0.33	0.67	0.25	0.75	1,000	10,000	8,408,400	0	8,408,400	1.47
Madartek	12,600	2,700	2.5	50%	15,750	3,375	1.00	0.00	1.00	0.00	1,000	10,000	15,750,000	3,375,000	19,125,000	3.33
Shahjadpur	4,830	0	3.0	10%	1,449	0	0.00	1.00	1.00	0.00	1,000	10,000	14,490,000	0	14,490,000	2.53
Khilkhet	9,870	0	2.0	10%	1,974	0	0.00	1.00	1.00	0.00	1,000	10,000	19,740,000	0	19,740,000	3.44
Tongi	57,750	11,250	1.0	60%	34,650	6,750	0.45	0.55	0.00	1.00	1,000	10,000	204,750,000	39,150,000	243,900,000	42.51
Mainer Tek	2,310	900	11.0	10%	2,541	990	1.00	0.00	1.00	0.00	1,000	10,000	2,541,000	990,000	3,531,000	0.62
Kaskura	1,680	0	1.0	10%	168	0	1.00	0.00	1.00	0.00	1,000	10,000	168,000	0	168,000	0.03
Patira	4,200	1,400	3.5	70%	10,290	3,430	0.53	0.47	1.00	0.00	1,000	10,000	53,508,000	18,865,000	72,373,000	12.61
	1,232	880	3.5	70%	3,018	2,156	0.53	0.47	1.00	0.00	1,000	10,000	15,695,680	11,858,000	27,553,680	4.80
Bora Beraid	2,100	1,200	2.5	50%	2,625	1,500	0.53	0.47	1.00	0.00	1,000	10,000	13,650,000	8,250,000	21,900,000	3.82
	1,456	1,040	2.5	50%	1,820	1,300	0.53	0.47	1.00	0.00	1,000	10,000	9,464,000	7,150,000	16,614,000	2.90
Kaetpara	9,800	2,500	1.5	50%	7,350	1,875	0.64	0.36	1.00	0.00	1,000	10,000	30,975,000	8,906,250	39,881,250	6.95
	2,022	1,040	1.5	50%	1,517	780	0.64	0.36	1.00	0.00	1,000	10,000	6,327,750	3,705,000	10,032,750	1.75
Total	128,554	25,610											455,769,155	117,943,000	573,712,155	100.00

Note : Results of the interview survey towards boatmen.
Source : JICA

TABLE E.3.3 PROPOSED FLOOD MITIGATION FACILITY : DHAKA EAST

Compartment	Facility		Main Feautres
1. Northern Compt.			
(DC-1)	1. Embankment	L=	14.00 km (E.33+200~E.69)
	2. Sub-Embankment (SA)	L=	6.40 km (SA.0~SA.16)
	3. Flood Wall (R)	L=	5.85 km (R.16+150~R.22)
	4. Sluice Gate	No=	4 Places (Main Emb.3, Sub-Emb.1)
2. Central Compt.			
(DC-2)	1. Embankment	L=	6.00 km (E.18+200~E.33+200)
	2. Sub-Embankment (SA)	L=	-
	3. Flood Wall (R)	L=	4.85 km (R.11+300~R.16+150)
	4. Sluice Gate	No=	1 Place
3. Southern Compt.-1			
(DC-3)	1. Embankment	L=	2.97 km (E.11+150~E.18+200)
	2. Sub-Embankment	L=	4.71 km (SB.0~SB.12)
	3. Flood Wall (R)	L=	2.50 km (R.8+300~R.11+300)
	4. Sluice Gate	No=	1 Place
4. Southern Compt.-2			
(DC-4)	1. Embankment	L=	4.55 km (E.0~E.11+150)
	2. Sub-Embankment (SA)	L=	6.31 km (SC.0~SC.13)
	3. Flood Wall (R)	L=	8.07 km (R.0~R.8+800)
	4. Sluice Gate	No=	1 Place
Total			
(DC 1-4)	1. Embankment	L=	27.52 km (E.0~E.69)
	2. Sub-Embankment (SA)	L=	17.42 km (3 Sub-Embankments)
	3. Flood Wall (R)	L=	21.27 km (R.0~R.22)
	4. Sluice Gate	No=	7 Place

TABLE E.3.4 LAND USE AND POPULATION OF GREATER DHAKA EAST

Year / Item / Area		1990		2000		2010	
	Drainage Area (km2)	Built-up Area (km2)	Population (million people)	Built-up Area (km2)	Population (million people)	Built-up Area (km2)	Population (million people)
Greater Dhaka East (F/S Area)	118.62	23.11	0.638	50.27	1.151	85.50	2.202
Part of Greater Dhaka West (Drainage Related Area)	47.74	43.60	1.512	45.38	1.806	46.90	2.268
Total (Study Area)	166.36	66.71	2.150	95.65	2.957	132.40	4.470

TABLE E.3.5 MAIN HYDRAULIC FEATURES OF EXISTING MAJOR KHALS : GREATER DHAKA EAST

Dhaka East Zone (DC)

Khal No.	Length (m)	Max. Section Catchment Area (km2)	Width (m)	Depth (m)	Slope (%)	Discharge Capacity (m3/s)	Specific Discharge Capacity (m3/s/km2)	Min. Section Catchment Area (km2)	Width (m)	Depth (m)	Slope (%)	Discharge Capacity (m3/s)	Specific Discharge Capacity (m3/s/km2)
K 1	820	2.50	21.60	3.30	0.050	30.9	12.3	0.80	5.80	1.10	0.050	1.3	1.6
K 2	1,640	5.95	6.80	1.00	0.025	0.9	0.2	2.00	2.00	0.40	0.025	0.1	0.0
K 3	4,100	3.77	82.20	3.60	0.017	81.4	21.6	2.50	35.60	1.50	0.017	8.2	3.3
K 4	440	11.49	13.80	1.40	0.017	2.8	0.2	10.00	9.60	0.80	0.017	0.8	0.1
K 5	3,040	18.34	38.60	2.80	0.025	30.3	1.7	1.76	20.40	0.90	0.025	2.4	1.4
K 6	1,940	1.00	13.60	1.20	0.017	2.1	2.1	7.30	2.40	0.20	0.017	0.0	0.0
K 7	640	18.00	12.00	1.30	0.017	2.1	0.1	20.00	5.80	1.00	0.017	0.7	0.0
K 8	3,540	26.00	11.60	3.30	0.017	9.1	0.3	24.50	9.80	0.90	0.017	1.0	0.0
K 9	1,760	0.50	15.40	1.10	0.017	2.1	4.2	3.00	14.20	0.90	0.017	1.4	0.5
K 10	1,600	30.80	14.20	1.80	0.017	4.3	0.1	30.00	7.40	1.00	0.017	0.8	0.0
K 11	1,620	6.30	19.20	1.30	0.017	3.5	0.6	5.70	5.60	0.80	0.017	0.4	0.1
K 12	740	38.40	18.60	2.00	0.017	6.8	0.2	38.00	10.60	1.60	0.017	2.6	0.1
K 13	1,700	4.00	12.40	1.80	0.017	3.8	0.9	3.00	9.40	1.30	0.017	1.7	0.6
K 14	740	1.50	10.40	1.60	0.017	2.6	1.7	0.50	7.40	1.20	0.017	1.1	2.3
K 15	2,600	47.90	39.60	2.60	0.017	22.7	0.5	39.00	10.60	1.40	0.017	2.1	0.1
K 16	2,200	3.50	43.20	2.90	0.017	29.7	8.5	1.00	8.20	1.30	0.017	1.4	1.4
K 17	800	1.00	13.20	1.70	0.017	3.7	3.7	1.50	7.60	0.50	0.017	0.3	0.2
K 18	1,920	1.50	13.60	1.50	0.017	3.1	2.1	0.50	5.00	0.50	0.017	0.2	0.4
K 19	3,220	1.00	26.60	1.10	0.017	3.6	3.6	1.50	12.80	0.60	0.017	0.6	0.4
K 20	1,640	33.50	25.40	2.00	0.025	11.4	0.3	32.00	10.40	1.70	0.025	3.5	0.1
K 21	2,600	40.90	42.60	3.20	0.017	34.5	0.8	34.00	22.00	2.30	0.017	10.2	0.3
K 22	5,320	14.00	17.00	3.50	0.025	18.5	1.3	13.50	8.60	0.60	0.025	0.5	0.0
K 23	4,820	8.20	34.20	2.50	0.017	18.4	2.2	6.50	7.60	1.30	0.017	1.3	0.2
K 24	3,420	5.50	18.00	3.10	0.017	13.4	2.4	2.00	7.60	1.10	0.017	1.0	0.5
K 25	2,420	1.00	41.40	1.80	0.017	12.9	12.9	8.00	13.20	2.00	0.017	4.8	0.6
K 26	1,800	4.10	29.00	2.70	0.017	17.6	4.3	3.00	19.20	1.70	0.017	5.4	1.8
K 27	2,400	45.00	57.00	5.30	0.017	106.6	2.4	44.00	56.80	2.70	0.017	34.8	0.8

Note : Roughness Coefficient (n) = 0.035

TABLE E.3.6(1) HYDRAULIC REQUIREMENTS OF PROPOSED PUMPING STATION : GREATER DHAKA EAST

Proposed Pumping Station	Drainage Zone		Discharge Capacity (m^3/s)	Design Water Level (m, PWD)					Static Head (m)		Remarks
	No.	Area (km^2)		Outer			Inner		Design	Max.	
				H.H.W.L	H.W.L	L.W.L	H.W.L	L.W.L			
P 5	DC-1	22.11	25.60	8.15	6.25	3.00	4.00	3.00	3.25	5.15	
P 6	DC-2	47.88	54.60	7.90	6.15	3.00	4.00	3.00	3.15	4.90	
P 7A	DC-3	46.58	53.10	7.60	6.05	3.00	4.00	3.00	3.05	4.60	
P 7B	DC-4	41.34	47.20	7.55	6.00	3.00	4.00	3.00	3.00	4.55	

Note : 1. H.H.W.L. and H.W.L. of outer design water level means that of 100-year and 2-year frequency flood respectively

TABLE E.3.6(2) HYDRAULIC REQUIREMENTS OF PROPOSED RETARDING POND : GREATER DHAKA EAST

Proposed Retarding Pond	Drainage Zone	Pond Area (ha)	Storage Capacity (x $10^6 m^3$)	Design Water Level (m, PWD)		Remarks
				H.W.L	L.W.L	
RP 5-1	DC-1	138	1.38	4.00	3.00	
RP 5-2	DC-1	127	1.27	4.00	3.00	
RP 6	DC-2	575	5.75	4.00	3.00	
RP 7A	DC-3	339	5.59	4.00	3.00	
RP 7B-1	DC-4	199	1.99	4.00	3.00	
RP 7B-2	DC-4	297	2.97	4.00	3.00	

TABLE E.3.7 LAND USE AND POPULATION BY DRAINAGE ZONE IN 1990 AND 2010

Item \ Area		DC 1	DC 2				DC 3			DC 4			Total
			2-A	2-B	2-C	Total	3-A	3-B	Total	4-A	4-B	Total	
Area (km2)		30.56	5.71	10.13	32.04	47.88	32.01	14.57	46.58	10.02	31.32	41.34	166.36
	(I) Land Use (km2)												
	(1) Residencial (high)	0	0	0	0	0	4.06	0	4.06	2.58	1.68	4.26	8.32
	(2) Residencial (middle)	0.16	0	0.11	0.20	0.31	3.44	0.56	4.00	1.47	2.24	3.71	8.18
	(3) Residencial (low)	4.90	3.60	3.21	3.15	9.96	13.95	0.85	14.80	1.27	5.41	6.68	36.34
	(4) Commercial	0.08	0	0	0.01	0.01	1.42	0	1.42	1.57	0.31	1.88	3.39
	(5) Industry	0	0	0	0	0	2.69	0	2.69	0.28	0.01	0.29	2.98
	(6) Institution	0.02	0.44	0.01	0	0.45	4.68	0	4.68	2.15	0.20	2.35	7.50
	Sub-Total (buil-up area)	5.16	4.04	3.33	3.36	10.73	30.24	1.41	31.65	9.32	9.85	19.17	66.71
	(7) Agriculture	24.39	1.42	6.41	26.99	34.82	0.15	10.70	10.85	0.63	19.67	20.30	90.36
	(8) Water Body	1.01	0.25	0.39	1.69	2.33	1.62	2.46	4.08	0.07	1.80	1.87	9.29
	Sub-Total	25.40	1.67	6.80	28.68	37.15	1.77	13.16	14.93	0.70	21.47	22.17	99.65
	(II) Population (x10 6)	0.08	0.05	0.04	0.06	0.15	0.93	0.02	0.95	0.54	0.43	0.97	2.15
	(I) Land Use (km2)												
	(1) Residencial (high)	4.46	0.05	2.49	2.57	5.11	9.60	2.87	12.47	3.79	7.92	11.71	33.75
	(2) Residencial (middle)	8.44	0.05	3.51	6.65	10.21	6.58	2.70	9.28	0.93	8.66	9.59	37.52
	(3) Residencial (low)	5.33	0.05	0.93	0.88	1.86	1.58	0.59	2.17	0.12	1.17	1.29	10.65
	(4) Commercial	1.38	0.23	0.43	0.71	1.37	1.85	0.27	2.12	1.77	1.56	3.33	8.20
	(5) Industry	0.22	0.00	0.03	0.00	0.03	2.18	0.00	2.18	0.21	0.15	0.36	2.79
	(6) Institution	5.52	5.29	2.67	4.71	12.67	9.44	2.48	11.92	3.18	6.20	9.38	39.49
	Sub-Total (buil-up area)	25.35	5.67	10.06	15.52	31.25	31.23	8.91	40.14	10.00	25.66	35.66	132.40
	(7) Agriculture	2.40	0.00	0.00	10.70	10.70	0.00	0.00	0.00	0.00	0.00	0.00	13.10
	(8) Water Body	2.81	0.04	0.07	5.82	5.93	0.78	5.66	6.44	0.02	5.66	5.68	20.86
	Sub-Total	5.21	0.04	0.07	16.52	16.63	0.78	5.66	6.44	0.02	5.66	5.68	33.96
	(II) Population (x10 6)	0.55	0.00	0.22	0.26	0.48	1.49	0.21	1.70	0.78	0.96	1.74	4.47

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TABLE E.3.8 RUN-OFF COEFFICIENT : GREATER DHAKA EAST

Dhaka East Zone (DC)

(DC-1)

Block No.	Area	Run-off Coefficient	Land Use (%) Residential High Density	Residential Midium Density	Residential Low Density	Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
DC-1-1	2.53	0.39	12.03	24.05	24.05	5.70	1.11	17.50	14.25	1.31
DC-1-2	3.95	0.40	14.33	27.85	21.39	5.35	0.96	17.75	11.23	1.15
DC-1-3	5.01	0.44	21.88	40.30	12.64	4.19	0.45	18.57	1.35	0.62
DC-1-4	1.76	0.38	16.97	29.16	7.58	2.80	0.22	17.58	24.97	0.71
DC-1-5	5.09	0.33	10.07	19.70	11.79	2.81	0.49	11.78	42.42	0.96
DC-1-6	3.77	0.32	7.40	14.80	14.80	3.51	0.68	10.77	47.23	0.80
DC-1-7	3.38	0.39	12.03	24.05	24.05	5.70	1.11	17.50	14.25	1.31
DC-1-8	2.57	0.39	12.03	24.05	24.05	5.70	1.11	17.50	14.25	1.31
DC-1-9	2.50	0.42	26.63	25.87	8.09	4.82	0.15	33.09	1.17	0.19

(DC-2)

Block No.	Area	Run-off Coefficient	Land Use (%) Residential High Density	Residential Midium Density	Residential Low Density	Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
DC-2-1	5.71	0.38	18.18	13.92	3.57	4.08	0.00	59.43	0.00	0.82
DC-2-2	1.79	0.40	21.20	13.49	3.85	4.72	0.00	55.25	0.00	1.48
DC-2-3	4.08	0.44	24.03	38.41	10.38	4.19	0.31	22.23	0.00	0.45
DC-2-4	2.97	0.45	22.90	41.99	11.45	4.03	0.38	18.69	0.00	0.55
DC-2-5	1.29	0.42	21.99	26.78	7.40	4.40	0.18	38.20	0.00	1.05
DC-2-6	4.54	0.34	14.41	15.81	3.36	2.25	0.00	29.76	33.05	1.36
DC-2-7	3.52	0.40	19.31	21.27	4.51	4.24	0.00	41.18	8.09	1.40
DC-2-8	2.36	0.35	12.60	25.22	4.20	1.85	0.00	14.35	40.52	1.27
DC-2-9	3.33	0.40	16.76	33.57	5.59	3.64	0.00	20.40	18.77	1.29
DC-2-10	1.25	0.38	15.26	30.56	5.09	3.00	0.00	18.22	26.60	1.28
DC-2-11	4.98	0.38	15.26	30.56	5.09	3.00	0.00	18.22	26.60	1.28
DC-2-12	1.34	0.38	15.26	30.56	5.09	3.00	0.00	18.22	26.60	1.28
DC-2-13	1.23	0.35	12.03	24.10	4.01	2.36	0.00	14.37	42.11	1.01
DC-2-14	4.48	0.24	3.84	7.67	1.28	0.10	0.00	3.86	82.72	0.54
DC-2-15	5.01	0.25	3.94	7.88	1.31	0.10	0.00	3.96	82.24	0.56

(DC-3)

Block No.	Area	Run-off Coefficient	Land Use (%) Residential High Density	Residential Midium Density	Residential Low Density	Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
DC-3-1	8.81	0.47	40.87	9.45	0.32	10.51	6.63	30.02	0.00	2.20
DC-3-2	3.23	0.50	30.52	24.38	4.26	3.09	24.96	10.00	0.00	2.79
DC-3-3	5.54	0.42	24.81	21.06	7.71	3.47	0.00	35.98	4.67	2.30
DC-3-4	7.24	0.43	20.73	30.42	5.21	4.52	0.17	36.68	0.00	2.28
DC-3-5	6.29	0.43	23.28	20.27	4.06	4.81	7.16	38.88	0.00	1.55
DC-3-6	2.38	0.42	23.58	27.78	6.76	4.28	0.00	25.04	10.61	1.94
DC-3-7	3.42	0.38	14.89	29.84	4.96	3.24	0.00	18.13	27.79	1.14
DC-3-8	2.09	0.34	11.14	22.32	3.71	2.42	0.00	13.57	45.97	0.86
DC-3-9	1.86	0.30	8.55	16.16	2.28	2.42	0.10	9.98	59.98	0.52
DC-3-10	4.10	0.27	3.13	12.69	5.29	1.16	0.00	9.03	68.27	0.43
DC-3-11	0.69	0.40	8.69	35.22	14.70	3.21	0.00	25.08	11.92	1.19
DC-3-12	0.93	0.27	3.32	13.47	5.62	1.23	0.00	9.59	66.32	0.45

(DC-4)

Block No.	Area	Run-off Coefficient	Land Use (%) Residential High Density	Residential Midium Density	Residential Low Density	Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
DC-4-1	7.25	0.47	35.05	5.94	0.45	21.78	2.79	33.99	0.00	0.00
DC-4-2	2.11	0.48	61.10	16.61	2.41	5.68	0.61	12.84	0.00	0.74
DC-4-3	3.67	0.47	42.01	30.26	4.34	6.97	0.22	15.71	0.00	0.50
DC-4-4	1.03	0.43	34.67	24.97	3.58	5.75	0.18	12.97	17.48	0.41
DC-4-5	2.72	0.44	28.27	18.99	0.04	9.81	0.00	41.81	0.12	0.96
DC-4-6	0.61	0.44	28.27	18.99	0.04	9.81	0.00	41.81	0.12	0.96
DC-4-7	2.49	0.46	29.55	31.11	4.01	8.95	0.15	22.52	2.82	0.88
DC-4-8	0.70	0.29	4.27	18.28	5.48	1.55	0.13	9.77	60.00	0.52
DC-4-9	1.39	0.36	7.21	30.91	9.27	2.62	0.22	16.52	32.37	0.87
DC-4-10	5.30	0.37	28.38	12.54	1.38	2.73	0.79	19.16	34.15	0.87
DC-4-11	3.24	0.35	11.99	26.34	3.69	2.77	0.52	14.70	39.20	0.79
DC-4-12	2.91	0.44	27.04	29.90	3.97	4.79	1.13	31.90	0.00	1.28
DC-4-13	2.56	0.46	14.91	52.18	7.45	4.39	0.68	19.09	0.00	1.30
DC-4-14	0.30	0.29	3.91	16.76	5.03	1.42	0.12	8.96	63.33	0.47
DC-4-15	1.11	0.26	2.59	11.12	3.33	0.94	0.08	5.94	75.68	0.31
DC-4-16	1.10	0.43	11.23	44.16	10.47	3.73	0.42	20.62	8.18	1.19
DC-4-17	0.30	0.46	14.91	52.18	7.45	4.39	0.68	19.09	0.00	1.30
DC-4-18	1.96	0.44	27.04	29.90	3.97	4.79	1.13	31.90	0.00	1.28
DC-4-19	0.59	0.46	14.91	52.18	7.45	4.39	0.68	19.09	0.00	1.30

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TABLE E.3.9 DESIGN DISCHARGE : GREATER DHAKA EAST

Dhaka East Zone (DC)

(DC-1)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual a (km2)	Drainage Area Accumlated A (km2)	Run-off Coefficier Individual f	Run-off Coefficier Accumlated F	Length Individual l (km)	Length Accumlated L (km)	Velocity V (m/s)	Time of Concentration t (min)	Rainfal Intensity r (mm/hr)	Areal Reduction Factor (m3/s/km)	Design Discharge (m3/s)
DC-1-1	2.53	2.53	0.39	0.39	2.30	2.30	0.80	68	76.37	0.98	20.5
DC-1-2	3.95	6.48	0.40	0.40	1.70	4.00	0.80	103	58.73	0.96	40.3
DC-1-3	5.01	11.49	0.44	0.42	2.30	6.30	0.80	151	46.71	0.94	58.5
DC-1-4	1.76	1.76	0.38	0.38	2.00	2.00	0.80	62	80.64	0.99	14.9
DC-1-5	5.09	18.34	0.33	0.39	1.90	8.20	0.80	191	40.67	0.92	74.5
DC-1-6	3.77	22.11	0.32	0.38	0.50	8.70	0.80	201	39.33	0.91	83.2
DC-1-7	3.38	3.38	0.39	0.39	2.50	2.50	0.80	72	73.76	0.98	26.5
DC-1-8	2.57	5.95	0.39	0.39	1.30	3.80	0.80	99	60.37	0.96	37.3
DC-1-9	2.50	2.50	0.42	0.42	2.20	2.20	0.80	66	77.74	0.99	22.6

(DC-2)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual a (km2)	Drainage Area Accumlated A (km2)	Run-off Coefficier Individual f	Run-off Coefficier Accumlated F	Length Individual l (km)	Length Accumlated L (km)	Velocity V (m/s)	Time of Concentration t (min)	Rainfal Intensity r (mm/hr)	Areal Reduction Factor (m3/s/km)	Design Discharge (m3/s)
DC-2-1	5.71	5.71	0.38	0.38	3.20	3.20	0.80	87	65.89	0.96	38.5
DC-2-2	1.79	7.50	0.40	0.39	1.40	4.60	0.80	116	54.30	0.95	41.6
DC-2-3	4.08	4.08	0.44	0.44	2.10	2.10	0.80	64	79.16	0.97	38.6
DC-2-4	2.97	7.05	0.45	0.45	2.00	4.10	0.80	105	57.94	0.96	48.5
DC-2-5	1.29	15.84	0.42	0.42	1.00	5.60	0.80	137	49.42	0.92	83.2
DC-2-6	4.54	20.38	0.34	0.40	2.20	7.80	0.80	183	41.81	0.91	86.2
DC-2-7	3.52	3.52	0.40	0.40	3.10	3.10	0.80	85	66.91	0.97	25.2
DC-2-8	2.36	26.26	0.35	0.40	2.00	9.80	0.80	224	36.67	0.88	93.0
DC-2-9	3.33	3.33	0.40	0.40	2.40	2.40	0.80	70	75.04	0.98	27.5
DC-2-10	1.25	30.84	0.38	0.40	1.40	11.20	0.80	253	33.77	0.86	98.5
DC-2-11	4.98	4.98	0.38	0.38	2.20	2.20	0.80	66	77.74	0.97	40.1
DC-2-12	1.34	6.32	0.38	0.38	1.60	3.80	0.80	99	60.37	0.96	39.1
DC-2-13	1.23	38.39	0.35	0.39	0.70	11.90	0.80	268	32.48	0.85	115.5
DC-2-14	4.48	4.48	0.24	0.24	2.80	2.80	0.80	78	70.17	0.97	20.7
DC-2-15	5.01	47.88	0.25	0.36	2.50	14.40	0.80	320	28.59	0.83	114.6

(DC-3)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual a (km2)	Drainage Area Accumlated A (km2)	Run-off Coefficier Individual f	Run-off Coefficier Accumlated F	Length Individual l (km)	Length Accumlated L (km)	Velocity V (m/s)	Time of Concentration t (min)	Rainfal Intensity r (mm/hr)	Areal Reduction Factor (m3/s/km)	Design Discharge (m3/s)
DC-3-1	8.81	8.81	0.47	0.47	4.07	4.07	1.00	88	65.33	0.95	71.3
DC-3-2	3.23	12.04	0.50	0.48	2.40	6.47	1.00	128	51.22	0.94	77.0
DC-3-3	5.54	5.54	0.42	0.42	5.20	5.20	0.80	128	51.11	0.96	31.4
DC-3-4	7.24	7.24	0.43	0.43	4.60	4.60	0.80	116	54.30	0.96	45.5
DC-3-5	6.29	6.29	0.43	0.43	3.20	3.20	0.80	87	65.89	0.96	47.8
DC-3-6	2.38	33.49	0.42	0.45	2.30	8.77	0.80	203	39.15	0.86	139.6
DC-3-7	3.42	3.42	0.38	0.38	2.60	2.60	0.80	74	72.52	0.97	25.5
DC-3-8	2.09	5.51	0.34	0.36	1.80	4.40	0.80	112	55.70	0.96	29.8
DC-3-9	1.86	40.86	0.30	0.43	2.70	11.47	0.80	259	33.26	0.85	137.4
DC-3-10	4.10	44.96	0.27	0.41	2.20	13.67	0.80	305	29.63	0.83	127.1 (120.0)
DC-3-11	0.69	0.69	0.40	0.40	1.20	1.20	0.80	45	94.79	1.00	7.2
DC-3-12	0.93	1.62	0.27	0.33	1.20	2.40	0.80	70	75.04	0.99	10.9

(DC-4)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual a (km2)	Drainage Area Accumlated A (km2)	Run-off Coefficier Individual f	Run-off Coefficier Accumlated F	Length Individual l (km)	Length Accumlated L (km)	Velocity V (m/s)	Time of Concentration t (min)	Rainfal Intensity r (mm/hr)	Areal Reduction Factor (m3/s/km)	Design Discharge (m3/s)
DC-4-1	7.25	7.25	0.47	0.47	4.00	4.00	1.00	87	65.89	0.95	58.6
DC-4-2	2.11	9.36	0.48	0.47	1.40	5.40	1.00	110	56.28	0.94	64.5
DC-4-3	3.67	3.67	0.47	0.47	3.30	3.30	0.80	89	64.90	0.97	30.4
DC-4-4	1.03	14.06	0.43	0.47	2.20	7.60	0.80	178	42.40	0.93	71.9
DC-4-5	2.72	2.72	0.44	0.44	1.90	1.90	0.80	60	82.17	0.98	26.5
DC-4-6	0.61	3.33	0.44	0.44	1.30	3.20	0.80	87	65.89	0.98	26.0
DC-4-7	2.49	5.82	0.46	0.44	1.10	4.30	0.80	110	56.43	0.96	38.9
DC-4-8	0.70	20.58	0.29	0.45	1.00	8.60	0.80	199	39.59	0.91	93.6
DC-4-9	1.39	1.39	0.36	0.36	1.90	1.90	0.80	60	82.17	0.99	11.3
DC-4-10	5.30	5.30	0.37	0.37	2.70	2.70	0.80	76	71.33	0.96	36.8
DC-4-11	3.24	8.21	0.35	0.39	2.20	4.90	0.80	122	52.46	0.95	44.6 (25.0)
DC-4-12	2.91	2.91	0.44	0.44	3.00	3.00	0.80	83	67.96	0.98	23.8
DC-4-13	2.56	5.47	0.46	0.45	2.20	5.20	0.80	128	51.11	0.96	33.6
DC-4-14	0.30	14.31	0.29	0.39	0.30	5.50	0.80	135	49.83	0.93	72.5 (35.0)
DC-4-15	1.11	37.39	0.26	0.42	1.90	10.50	0.80	239	35.16	0.85	131.0 (115.0)
DC-4-16	1.10	1.10	0.43	0.43	1.70	1.70	0.80	55	85.42	0.99	11.0
DC-4-17	0.30	38.79	0.46	0.42	0.50	11.00	0.80	249	34.15	0.85	132.1 (120.0)
DC-4-18	1.96	1.96	0.44	0.44	1.60	1.60	0.80	53	87.15	0.99	20.8
DC-4-19	0.59	2.55	0.46	0.45	1.20	2.80	0.80	78	70.17	0.98	21.8

Note: The figures in parenthesis indicate the design discharge estimated in hydraulic simulation by Mike 11 model. considering the storage effect of the retarding area.

TABLE E.3.10 HYDRAULIC DESIGN OF KHAL IMPROVEMENT : GREATER DHAKA EAST

Dhaka East Zone (DC)

Khal No.	Design Discharge (m3/s)	Section Bottom Wid. (m)	Section Upper Wid. (m)	Section Height (m)	Roughness Coefficient	Slope i (%)	Velosity (m/s)	Discharge Capacity (m3/s)
(DC-1)								
KD-1-1	83.2	20.00	34.80	3.70	0.035	0.022	0.84	85.2
KD-1-2	74.6	17.50	32.30	3.70	0.035	0.022	0.83	76.2
KD-1-3	58.5	13.00	27.80	3.70	0.035	0.022	0.80	60.1
KD-1-4	40.3	7.50	22.30	3.70	0.035	0.022	0.74	40.8
KD-1-5	20.5	2.00	16.80	3.70	0.035	0.022	0.65	22.5
KD-2	14.9	2.00	16.32	3.58	0.035	0.025	0.67	22.1
KD-3-1	37.3	5.00	21.00	4.00	0.035	0.022	0.74	38.3
KD-3-2	26.5	2.00	18.00	4.00	0.035	0.022	0.68	27.1
KD-4	22.6	2.50	10.50	4.00	0.025	0.022	0.91	23.6
(DC-2)								
KD-5-1	115.5	27.50	43.50	4.00	0.035	0.018	0.82	117.0
KD-5-2	115.5	27.50	43.50	4.00	0.035	0.018	0.82	117.0
KD-5-3	98.5	23.00	39.00	4.00	0.035	0.018	0.81	100.1
KD-5-4	93.1	21.50	37.50	4.00	0.035	0.018	0.80	94.5
KD-5-5	86.2	19.50	35.50	4.00	0.035	0.018	0.79	87.0
KD-5-6	83.2	16.00	31.68	3.92	0.035	0.025	0.89	83.6
KD-5-7	41.6	6.50	21.70	3.80	0.035	0.025	0.78	41.9
KD-5-8	38.6	6.00	21.00	3.75	0.035	0.025	0.77	39.0
KD-6	20.7	2.00	17.40	3.85	0.035	0.025	0.70	26.3
KD-7-1	40.1	7.00	23.00	4.00	0.035	0.018	0.69	41.6
KD-7-2	40.1	6.00	21.28	3.82	0.035	0.025	0.78	40.5
KD-8	27.5	2.50	17.90	3.85	0.035	0.025	0.72	28.1
KD-9	25.2	2.00	17.68	3.92	0.035	0.025	0.71	27.4
KD-10-1	48.6	9.00	24.00	3.75	0.035	0.025	0.81	50.1
KD-10-2	38.6	7.00	14.16	3.58	0.025	0.025	1.07	40.7
(DC-3)								
KD-11-1	120.0	24.50	41.70	4.30	0.035	0.018	0.85	120.4
KD-11-2	139.6	29.00	46.20	4.30	0.035	0.018	0.86	139.5
KD-11-3	139.6	26.50	42.98	4.12	0.035	0.025	0.98	140.0
KD-12-1	10.9	2.00	17.20	3.80	0.035	0.025	0.70	25.5
KD-12-2	7.2	2.00	15.04	3.26	0.035	0.025	0.64	17.7
KD-13-1	29.8	2.00	18.60	4.15	0.035	0.025	0.74	31.5
KD-13-2	25.5	2.00	18.20	4.05	0.035	0.025	0.73	29.7
(DC-4)								
KD-14-1	120.0	24.50	41.70	4.30	0.035	0.018	0.85	120.4
KD-14-2	115.0	23.50	40.70	4.30	0.035	0.018	0.84	116.2
KD-14-3	93.6	18.50	35.70	4.30	0.035	0.018	0.82	95.2
KD-14-4	71.9	11.50	20.10	4.30	0.025	0.018	1.09	74.0
KD-14-5	71.9	10.00	18.36	4.18	0.025	0.025	1.23	73.0
KD-15-1	21.8	2.00	18.80	4.20	0.035	0.025	0.74	32.4
KD-15-2	20.8	2.00	16.48	3.62	0.035	0.025	0.68	22.7
KD-16	11.0	2.00	16.40	3.60	0.035	0.025	0.68	22.4
KD-17-1	35.0	3.00	20.00	4.25	0.035	0.025	0.77	37.6
KD-17-2	25.0	2.00	18.28	4.07	0.035	0.025	0.73	30.0
KD-17-3	36.8	5.00	20.36	3.84	0.035	0.025	0.76	37.2
KD-18-1	33.6	3.00	19.28	4.07	0.035	0.025	0.75	34.0
KD-18-2	23.8	2.00	16.80	3.70	0.035	0.025	0.69	23.9
KD-19	11.3	2.00	16.04	3.51	0.035	0.025	0.67	21.1
KD-20-1	38.9	3.50	20.34	4.21	0.035	0.025	0.78	38.9
KD-20-2	26.5	3.00	11.20	4.10	0.025	0.025	1.00	29.2
KD-20-3	26.5	3.00	11.00	4.00	0.025	0.025	0.99	27.7

TABLE E.3.11 PROPOSED KHAL IMPROVEMENT WORKS : GREATER DHAKA EAST

Dhaka East Zone (DC)

Zone	Khal No.	Khal Length (km)	Required Hydraulic Section Wb x Wu x H (m x m x m)	Open Channel Brick Protection (km)	Open Channel Sodding (km)	Covered Channel Box Culvert (km)	Covered Channel Brick Pipe (km)	Bridge (Places)	Aqueduct (Places)	Dredging (1000m3)	Maintenance Road (km)	Land Acquisition (ha)
	KD-1-1	0.50	20.0 34.8 3.7	-	0.50	-	-	-	-	25.10	0.50	1.88
	KD-1-2	1.90	17.5 32.3 3.7	-	1.90	-	-	-	-	36.90	1.90	2.35
	KD-1-3	2.30	13.0 27.8 3.7	-	2.30	-	-	-	-	65.95	2.30	7.47
	KD-1-4	1.70	7.5 22.3 3.7	-	1.70	-	-	-	-	32.30	1.70	6.72
DC-1	KD-1-5	1.00	2.0 16.8 3.7	-	1.00	-	-	-	-	22.90	1.00	2.93
	KD-2	1.40	2.0 16.3 3.6	-	1.40	-	-	-	-	1.86	1.40	1.66
	KD-3-1	1.30	5.0 21.0 4.0	-	1.30	-	-	-	-	0.00	1.30	3.88
	KD-3-2	1.40	2.0 18.0 4.0	-	1.40	-	-	-	-	0.00	1.40	3.85
	KD-4	1.20	2.5 10.5 4.0	1.20	-	-	-	-	-	3.86	1.20	1.63
	Sub-Total	12.70		1.20	11.50	0.00	0.00	0	0	188.87	12.70	32.37
	KD-5-1	2.50	27.5 43.5 4.0	-	2.50	-	-	-	-	148.44	2.50	8.01
	KD-5-2	0.70	27.5 43.5 4.0	-	0.70	-	-	-	-	49.47	0.70	3.18
	KD-5-3	1.40	23.0 39.0 4.0	-	1.40	-	-	-	-	79.81	1.40	5.55
	KD-5-4	2.00	21.5 37.5 4.0	-	2.00	-	-	-	-	81.70	2.00	6.80
	KD-5-5	2.20	19.5 35.5 4.0	-	2.20	-	-	-	-	61.03	2.20	8.67
DC-2	KD-5-6	1.00	16.0 31.7 3.9	-	1.00	-	-	-	-	32.40	1.00	4.40
	KD-5-7	1.40	6.5 21.7 3.8	-	1.40	-	-	-	-	18.80	1.40	5.18
	KD-6	1.80	2.0 17.4 3.9	-	1.80	-	-	-	-	13.62	1.80	3.08
	KD-7-1	1.60	7.0 23.0 4.0	-	1.60	-	-	-	-	27.68	1.60	3.53
	KD-7-2	2.20	6.0 21.3 3.8	-	2.20	-	-	-	-	23.40	2.20	4.54
	KD-8	1.80	2.5 17.9 3.9	-	1.80	-	-	-	-	6.91	1.80	2.85
	KD-9	1.00	2.0 17.7 3.9	-	1.00	-	-	-	-	1.59	1.00	1.59
	KD-10-1	2.00	9.0 24.0 3.8	-	2.00	-	-	3	-	39.34	2.00	7.06
	KD-10-2	2.10	7.0 14.2 3.6	2.10	-	-	-	5	-	154.25	2.10	7.29
	Sub-Total	23.70		2.10	21.60	0.00	0.00	8	0	738.44	23.70	71.73
	KD-11-1	2.20	24.5 41.7 4.3	-	2.20	-	-	-	-	135.81	2.20	2.38
	KD-11-2	2.70	29.0 46.2 4.3	-	2.70	-	-	-	-	155.96	2.70	5.49
	KD-11-3	1.70	26.5 43.0 4.1	-	1.70	-	-	-	-	110.73	1.70	6.66
DC-3	KD-12-1	1.20	2.0 17.2 3.8	-	1.20	-	-	-	-	37.82	1.20	2.97
	KD-12-2	1.30	2.0 15.0 3.3	-	1.30	-	-	-	-	35.89	1.30	4.44
	KD-13-1	1.80	2.0 18.6 4.2	-	1.80	-	-	-	-	14.81	1.80	2.73
	KD-13-2	1.20	2.0 18.2 4.1	-	1.20	-	-	-	-	4.01	1.20	1.23
	Sub-Total	12.10		0.00	12.10	0.00	0.00	0	0	495.03	12.10	25.90
	KD-14-1	0.50	24.5 41.7 4.3	-	0.50	-	-	-	-	159.04	0.50	5.60
	KD-14-2	1.90	23.5 40.7 4.3	-	1.90	-	-	1	-	153.30	1.90	8.62
	KD-14-3	1.00	18.5 35.7 4.3	-	1.00	-	-	-	-	117.04	1.00	6.41
	KD-14-4	0.70	11.5 20.1 4.3	0.70	-	-	-	-	-	45.15	0.70	1.27
	KD-14-5	1.50	10.0 18.4 4.2	1.50	-	-	-	1	-	111.59	1.50	4.32
	KD-15-1	1.20	2.0 18.8 4.2	-	1.20	-	-	-	-	61.56	1.20	2.96
	KD-15-2	1.40	2.0 16.5 3.6	-	1.40	-	-	-	-	86.64	1.40	5.05
DC-4	KD-16	1.70	2.0 16.4 3.6	-	1.70	-	-	-	-	78.98	1.70	5.14
	KD-17-1	0.60	3.0 20.0 4.3	-	0.60	-	-	-	-	6.40	0.60	0.36
	KD-17-2	2.20	2.0 18.3 4.1	-	2.20	-	-	1	-	81.88	2.20	3.46
	KD-17-3	2.70	5.0 20.4 3.8	-	2.70	-	-	-	-	117.99	2.70	4.47
	KD-18-1	2.20	3.0 19.3 4.1	-	2.20	-	-	-	-	56.14	2.20	4.23
	KD-18-2	0.90	2.0 16.8 3.7	-	0.90	-	-	-	-	19.80	0.90	1.87
	KD-19	1.90	2.0 16.0 3.5	-	1.90	-	-	-	-	14.16	1.90	1.65
	KD-20-1	1.10	3.5 20.3 4.2	-	1.10	-	-	1	-	47.40	1.10	3.45
	KD-20-2	1.30	3.0 11.2 4.1	1.30	-	-	-	-	-	34.40	1.30	3.14
	KD-20-3	1.30	3.0 11.0 4.0	1.30	-	-	-	-	-	46.24	1.30	4.53
	Sub-Total	24.10		4.80	19.30	0.00	0.00	4	0	1237.71	24.10	66.53
	Total	72.60		8.10	64.50	0.00	0.00	12	0	2660.05	72.60	196.53

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TABLE E.4.1 PROPOSED FLOOD MITIGATION FACILITY : DND AREA

Route (Total Length)	Facility		Main Features
1. Chasara to Buriganga Bridge (DW) (L= 10.63 km)	1) Flood Wall Construction	:	-
	2) Rehabilitation Work	:	
	(1) Foot Protection	:	L = 3.63 km
	(2) Flood Wall Raising	:	L = -
	3) Stop Log Structure	:	14 places
2. Buriganga Bridge to Demra (DN) (L= 8.58 km)	1) Flood Wall Construction	:	L = 0.58 km
	2) Rehabilitation Work	:	
	(1) Foot Protection	:	L = 5.60 km
	(2) Flood Wall Raising	:	L = 4.40 km
	3) Stop Log Structure	:	17 places
3. Chasara to Hajiganj (DS) (L= 2.15 km)	1) Flood Wall Construction	:	L = 1.75 km
4. Hajganj to Demra (DE) (L= 10.16 km)	1) Flood Wall Construction	:	L = 1.05 km
	2) Rehabilitation Work	:	
	(1) Foot Protection	:	L = 8.40 km
	(2) Flood Wall Raising	:	L = 3.20 km
	3) Stop Log Structure	:	27 places
	4) Sluice Gate	:	1 place
Total			
	1) Flood Wall Construction	:	3.38 km
	2) Rehabilitation Work	:	
	(1) Foot Protection	:	17.63 km
	(2) Flood Wall Raising	:	7.60 km
	3) Stop Log Structure	:	58 places
	4) Sluice Gate	:	1 place

TABLE E.4.2 LAND USE AND POPULATION OF DND

Drainage Area (km^2)	1990		2000		2100	
	Buil-up Area (km^2)	Population (million people)	Buil-up Area (km^2)	Population (million people)	Buil-up Area (km^2)	Population (million people)
56.79	21.74	0.449	36.14	0.880	42.70	1.314

TABLE E.4.3 MAIN HYDRAULIC FEATURES OF EXISTING MAJOR KHALS : DND

DND Project Area (NA)

Khal No.	Length (m)	Max. Section: Catchment Area (km2)	Width (m)	Depth (m)	Slope (%)	Discharge Capacity (m3/s)	Specific Discharge Capacity (m3/s/km2)	Min. Section: Catchment Area (km2)	Width (m)	Depth (m)	Slope (%)	Discharge Capacity (m3/s)	Specific Discharge Capaciiy (m3/s/km2)
K 1	3,200	2.80	5.60	1.20	0.017	0.8	0.3	0.80	3.20	0.60	0.017	0.2	0.2
K 2	3,280	1.50	23.80	2.80	0.050	26.2	17.4	7.00	3.60	0.90	0.050	0.6	0.1
K 3	2,200	9.50	10.20	2.00	0.017	3.6	0.4	10.60	5.60	1.40	0.017	1.1	0.1
K 4	1,660	21.00	14.00	2.00	0.017	5.1	0.2	21.30	12.00	0.90	0.017	1.2	0.1
K 5	1,200	24.00	43.20	4.80	0.017	68.2	2.8	25.00	19.20	2.70	0.017	11.5	0.5
K 6	900	25.00	58.40	6.90	0.017	168.4	6.7	25.00	31.40	2.30	0.017	14.7	0.6
K 7	3,600	1.00	15.60	2.40	0.017	7.6	7.6	2.30	10.40	0.90	0.017	1.0	0.4
K 8	1,000	1.40	18.60	3.00	0.050	22.6	16.1	0.70	6.40	1.40	0.050	2.1	3.0
K 9	2,480	7.00	14.40	2.90	0.017	9.5	1.4	8.00	8.60	1.40	0.017	1.7	0.2
K 10	820	11.00	11.80	1.50	0.017	2.7	0.2	11.30	10.60	1.30	0.017	1.9	0.2
K 11	3,000	25.00	26.60	3.60	0.017	25.8	1.0	1.50	13.60	1.00	0.017	1.6	1.1
K 12	2,240	13.50	7.60	1.90	0.017	2.4	0.2	12.50	7.00	1.00	0.017	0.8	0.1
K 13	320	55.80	2.40	0.40	0.017	0.1	0.0	55.80	2.40	0.40	0.017	0.1	0.0
K 14	1,380	1.80	6.80	1.80	0.017	2.0	1.1	0.80	4.60	0.70	0.017	0.3	0.4
K 15	2,200	10.00	23.00	1.00	0.017	2.7	0.3	12.80	4.80	0.70	0.017	0.3	0.0
K 16	1,400	5.00	10.20	3.00	0.017	6.8	1.4	7.60	6.20	0.60	0.017	0.3	0.0
K 17	2,600	2.50	29.40	2.90	0.025	24.4	9.7	3.70	10.40	1.10	0.025	1.7	0.5
K 18	1,600	0.20	16.00	3.00	0.050	19.2	96.2	1.00	13.00	2.20	0.050	9.4	9.4

Note : Roughness Coefficient (n) = 0.035

TABLE E.4.4 YEARLY OPERATION RECORD OF DEMRA PUMPING STATION

Year	Total operation of Pump in hour						Water level				(feet PWD)	
	A	B	C	A+B	B+C	A+B+C	River side		Country side		Main Canal	
	Gate	Gate	Gate	Gate	Gate	Gate	max.	min.	max.	min.	max.	min.
1970	2,166	327	3,995	2,493	4,322	6,488	18.70	2.00	8.80	2.30	15.60	13.50
1971	2,066	316	6,638	2,382	6,954	9,020	18.20	1.60	9.70	1.60	16.20	11.00
1972	3,654	528	2,160	4,182	2,688	6,342	16.00	1.20	7.60	1.60	15.40	10.50
1973	2,958	393	5,306	3,351	5,699	8,657	17.30	0.90	8.70	1.00	15.50	12.00
1974	2,944	481	6,370	3,425	6,851	9,795	19.70	1.70	8.20	1.40	15.60	13.20
1975	3,804	499	4,439	4,303	4,938	8,742	16.50	0.80	9.40	2.50	15.50	8.60
1976	3,623	712	4,588	4,335	5,300	8,923	16.30	1.00	8.80	1.60	15.80	9.00
1977	2,925	670	4,147	3,595	4,817	7,742	17.20	0.30	8.50	2.00	15.90	-
1978	3,824	604	4,873	4,428	5,477	9,301	16.10	0.05	8.40	2.70	15.90	11.40
1979	4,381	718	4,856	5,099	5,574	9,955	16.30	1.00	9.00	1.60	15.70	11.30
1980	3,597	653	4,530	4,250	5,183	8,780	18.30	1.00	7.50	0.00	15.80	11.50
1981	3,026	735	4,132	3,761	4,867	7,893	16.70	1.00	7.90	2.00	15.50	10.90
1982	3,404	528	2,703	3,932	3,231	6,635	15.90	0.00	7.90	1.40	15.90	11.50
1983	2,428	544	5,814	2,972	6,358	8,786	17.20	0.00	9.70	0.50	15.60	11.50
1984	3,168	332	7,921	3,500	8,253	11,421	18.10	0.00	9.40	0.00	15.70	11.00
1985	2,560	533	3,645	3,093	4,178	6,738	16.50	1.00	11.30	1.30	16.60	6.00
1986	3,483	237	5,216	3,720	5,453	8,936	15.40	0.20	10.00	0.80	16.00	9.00
1987	3,040	191	5,914	3,231	6,105	9,145	19.00	0.40	10.10	0.70	16.00	11.50
1988	2,272	191	6,712	2,463	6,903	9,175	20.90	0.80	9.80	1.00	15.25	12.80
1989	2,957	436	2,597	3,393	3,033	5,990	15.90	0.00	7.40	0.00	15.25	12.00
Average	3,114	481	4,828	3,595	5,309	8,423	17.31	0.75	8.91	1.30	15.74	10.41
	(49)	(366)	(4,223)	(415)	(4,589)	(4,638)						

Note :
1) Case A means irrigation supply by pump from the Lakhya River.
2) Case B means irrigation supply by pump from the drainage channel of country side.
3) Case C means pump drainage to the Lakhya River.
4) The figures in parenthesis show the value between June and October.

TABLE E.4.5(1) HYDRAULIC REQUIREMENTS OF PROPOSED PUMPING STATION : DND

Proposed Pumping Station	Drainage Zone		Discharge Capacity (m^3/s)	Design Water Level (m, PWD)					Static Head (m)		Remarks
	No.	Area (km^2)		Outer			Inner		Design	Max.	
				H.H.W.L	H.W.L	L.W.L	H.W.L	L.W.L			
P 10	NA-1	25.10	14.50	---	5.75	3.00	1.80	1.00	4.75	---	Existing Pumping Station
P 11	NA-2	31.69	50.20	7.10	5.65	3.00	4.00	3.00	2.65	4.10	

Note : 1. H.H.W.L. and H.W.L. of outer design water level means that of 100-year and 2-year frequency flood respectively

TABLE E.4.5(2) HYDRAULIC REQUIREMENTS OF PROPOSED RETARDING POND : DND

Proposed Retarding Pond	Drainage Zone	Pond Area (ha)	Storage Capacity (x $10^6 m^3$)	Design Water Level (m, PWD)		Remarks
				H.W.L	L.W.L	
RP 10-1	NA-1	196	1.96	4.00	3.00	
RP 10-2	NA-1	45	0.45	4.00	3.00	
RP 10-3	NA-1	60	0.60	4.00	3.00	
RP 11-1	NA-2	90	0.90	4.00	3.00	
RP 11-2	NA-2	225	2.25	4.00	3.00	
RP 11-3	NA-2	66	0.66	4.00	3.00	

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TABLE E.4.6 RUN-OFF COEFFICIENT : DND

DND Project Area (NA)

(NA-1)

Block No.	Area	Run-off Coefficient	Land Use (%)							
			Residential			Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
			High Density	Midium Density	Low Density					
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
NA-1-1	0.97	0.50	46.29	8.17	0.00	3.15	19.16	18.90	0.00	4.33
NA-1-2	1.17	0.50	50.88	8.98	0.00	3.87	15.42	16.21	0.00	4.63
NA-1-3	2.70	0.51	53.82	12.15	0.00	5.87	11.51	12.33	0.00	4.32
NA-1-4	2.15	0.40	23.40	14.46	2.79	2.76	7.85	20.21	25.60	2.92
NA-1-5	1.62	0.30	7.48	11.46	2.10	0.90	3.31	9.47	62.97	2.32
NA-1-6	0.71	0.29	10.68	5.76	1.03	1.10	4.08	8.64	67.35	1.36
NA-1-7	1.32	0.44	20.84	25.01	5.29	3.30	6.00	24.38	11.02	4.17
NA-1-8	1.15	0.48	36.01	17.80	2.43	4.77	10.76	21.88	2.45	3.90
NA-1-9	2.30	0.44	24.88	24.88	5.53	4.52	3.73	27.75	5.57	3.13
NA-1-10	3.43	0.44	24.88	24.88	5.53	4.52	3.73	27.75	5.57	3.13
NA-1-11	0.53	0.45	21.81	18.64	8.52	4.25	13.50	22.44	7.14	3.70
NA-1-12	1.62	0.44	24.88	24.88	5.53	4.52	3.73	27.75	5.57	3.13
NA-1-13	1.23	0.39	19.83	19.83	4.41	3.60	2.97	22.11	24.77	2.50
NA-1-14	0.69	0.40	17.11	13.90	7.01	3.41	11.41	17.30	27.01	2.86
NA-1-15	1.59	0.43	23.81	23.41	5.69	4.36	4.66	26.33	8.65	3.09
NA-1-16	0.94	0.45	21.38	16.63	9.50	4.33	16.32	21.21	6.90	3.75
NA-1-17	0.98	0.34	11.17	7.92	4.77	2.35	10.69	10.36	50.82	1.91

(NA-2)

Block No.	Area	Run-off Coefficient	Land Use (%)							
			Residential			Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
			High Density	Midium Density	Low Density					
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
NA-2-1	2.02	0.44	24.11	21.97	5.71	4.99	9.05	32.64	0.00	1.53
NA-2-2	1.67	0.45	23.97	23.36	5.26	4.40	8.66	32.29	0.00	2.06
NA-2-3	1.09	0.46	28.37	19.40	4.36	6.03	14.57	25.60	0.00	1.66
NA-2-4	2.77	0.38	14.91	14.18	2.61	1.98	10.54	15.38	36.90	3.50
NA-2-5	2.43	0.41	15.87	22.22	4.23	1.86	8.20	22.74	20.82	4.06
NA-2-6	1.57	0.35	10.85	13.56	2.71	1.32	6.16	12.00	49.13	4.26
NA-2-7	1.29	0.26	4.47	4.40	1.29	0.72	4.19	4.31	79.22	1.40
NA-2-8	1.36	0.45	23.66	20.22	3.29	1.87	12.02	21.66	12.06	5.23
NA-2-9	1.61	0.42	20.07	19.89	3.35	1.72	10.03	19.75	20.36	4.83
NA-2-10	1.19	0.43	16.43	25.82	4.69	1.89	7.62	20.99	17.23	5.32
NA-2-11	1.39	0.44	18.99	25.02	4.89	2.23	10.26	31.40	4.16	3.05
NA-2-12	0.71	0.43	16.76	25.72	4.72	1.94	7.96	22.32	15.57	5.03
NA-2-13	1.78	0.43	16.28	25.41	4.63	1.88	7.60	20.70	18.18	5.31
NA-2-14	2.63	0.40	14.94	20.43	3.93	1.77	7.89	19.24	27.07	4.73
NA-2-15	0.67	0.36	11.55	15.47	3.00	1.39	6.22	13.32	44.74	4.31
NA-2-16	1.25	0.34	10.52	15.62	3.19	1.31	5.22	13.11	47.79	3.24
NA-2-17	1.56	0.28	5.83	6.48	1.79	0.85	3.65	6.25	73.23	1.92
NA-2-18	0.90	0.41	18.29	14.22	8.13	3.70	13.96	18.14	20.35	3.20
NA-2-19	1.51	0.44	19.74	17.88	8.22	3.70	14.10	20.46	11.90	4.00
NA-2-20	1.76	0.41	16.59	9.74	6.58	3.74	21.63	13.48	25.50	2.72
NA-2-21	0.53	0.45	18.52	8.42	6.74	4.48	31.11	12.74	15.10	2.88

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TABLE E.4.7 DESIGN DISCHARGE : DND

DND Project Area (NA)

(NA-1)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual	Drainage Area Accumlated	Run-off Coefficier Individual	Run-off Coefficier Accumlated	Length Individual	Length Accumlated	Velocity	Time of Concentration	Rainfal Intensity	Areal Reduction Factor	Design Discharge
	a	A	f	F	l	L	V	t	r		
	(km2)	(km2)			(km)	(km)	(m/s)	(min)	(mm/hr)	(m3/s/km)	(m3/s)
NA-1-1	0.97	0.97	0.50	0.50	1.00	1.00	0.80	41	99.14	1.00	13.3
NA-1-2	1.17	2.14	0.50	0.50	1.20	2.20	0.80	66	77.74	0.99	23.0
NA-1-3	2.70	2.70	0.51	0.51	2.80	2.80	0.80	78	70.17	0.98	26.4
NA-1-4	2.15	6.99	0.40	0.47	1.40	4.20	0.80	108	57.17	0.96	50.5
NA-1-5	1.62	1.62	0.30	0.30	2.50	2.50	0.80	72	73.76	0.99	9.9
NA-1-6	0.71	2.33	0.29	0.30	1.70	4.20	0.80	108	57.17	0.99	10.9
NA-1-7	1.32	10.64	0.44	0.43	1.80	6.00	0.80	145	47.83	0.94	57.3 (30.0)
NA-1-8	1.15	1.15	0.48	0.48	1.80	1.80	0.80	58	83.77	0.99	12.7
NA-1-9	2.30	3.45	0.44	0.45	1.50	3.30	0.80	89	64.90	0.97	27.3
NA-1-10	3.43	6.88	0.44	0.45	1.50	4.80	0.80	120	52.97	0.96	43.5
NA-1-11	0.53	18.05	0.45	0.44	0.60	6.60	0.80	158	45.64	0.92	92.2 (50.0)
NA-1-12	1.62	1.62	0.44	0.44	1.60	1.60	0.80	53	87.15	0.99	17.1
NA-1-13	1.23	2.85	0.39	0.42	1.60	3.20	0.80	87	65.89	0.98	21.4
NA-1-14	0.69	21.59	0.40	0.43	1.00	7.60	0.80	178	42.40	0.91	100.4 (60.0)
NA-1-15	1.59	1.59	0.43	0.43	1.80	1.80	0.80	58	83.77	0.99	15.7
NA-1-16	0.94	24.12	0.45	0.43	0.70	8.30	0.80	193	40.39	0.90	105.8 (65.0)
NA-1-17	0.98	-	0.34	-	1.10	-	0.80	-	-	-	33.8

(NA-2)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual	Drainage Area Accumlated	Run-off Coefficier Individual	Run-off Coefficier Accumlated	Length Individual	Length Accumlated	Velocity	Time of Concentration	Rainfal Intensity	Areal Reduction Factor	Design Discharge
	a	A	f	F	l	L	V	t	r		
	(km2)	(km2)			(km)	(km)	(m/s)	(min)	(mm/hr)	(m3/s/km)	(m3/s)
NA-2-1	2.02	2.02	0.44	0.44	2.20	2.20	0.80	66	77.74	0.99	19.1
NA-2-2	1.67	3.69	0.45	0.44	1.80	4.00	0.80	103	58.73	0.97	25.9
NA-2-3	1.09	1.09	0.46	0.46	1.60	1.60	0.80	53	87.15	0.99	12.1
NA-2-4	2.77	7.55	0.38	0.42	1.50	5.50	0.80	135	49.83	0.95	42.1
NA-2-5	2.43	2.43	0.41	0.41	2.30	2.30	0.80	68	76.37	0.98	20.7
NA-2-6	1.57	11.55	0.35	0.41	1.20	6.70	0.80	160	45.29	0.94	56.1
NA-2-7	1.29	12.84	0.26	0.40	1.30	8.00	0.80	187	41.23	0.93	54.1
NA-2-8	1.36	1.36	0.45	0.45	2.20	2.20	0.80	66	77.74	0.99	13.1
NA-2-9	1.61	1.61	0.42	0.42	1.80	1.80	0.80	58	83.77	0.99	15.6
NA-2-10	1.19	4.16	0.43	0.43	1.40	3.60	0.80	95	62.10	0.97	30.1
NA-2-11	1.39	1.39	0.44	0.44	1.80	1.80	0.80	58	83.77	0.99	14.1
NA-2-12	0.71	2.10	0.43	0.44	1.50	3.30	0.80	89	64.90	0.99	16.4
NA-2-13	1.78	8.04	0.43	0.43	1.20	4.80	0.80	120	52.97	0.95	48.7
NA-2-14	2.63	2.63	0.40	0.40	2.60	2.60	0.80	74	72.52	0.98	20.8
NA-2-15	0.67	11.34	0.36	0.42	0.80	5.60	0.80	137	49.42	0.94	61.6
NA-2-16	1.25	1.25	0.34	0.34	1.60	1.60	0.80	53	87.15	0.99	10.2
NA-2-17	1.56	14.15	0.28	0.40	2.40	8.00	0.80	187	41.23	0.93	60.0
NA-2-18	0.90	25.02	0.41	0.43	1.00	9.30	0.80	214	37.83	0.89	71.5 (40.0)
NA-2-19	1.51	1.51	0.44	0.44	2.20	2.20	0.80	66	77.74	0.99	14.2
NA-2-20	1.76	28.29	0.41	0.43	1.80	11.10	0.80	251	33.96	0.88	71.6
NA-2-21	0.53	55.81	0.45	0.42	0.60	11.70	0.80	264	32.84	0.82	143.5

Note: The figures in parenthesis indicate the design discharge estimated in hydraulic simulation
by Mike 11 model. considering the storage effect of the retarding area.

TABLE E.4.8 HYDRAULIC DESIGN OF KHAL IMPROVEMENT : DND

DND Project Area (NA)

Khal No.	Design Discharge (m3/s)	Section: Bottom Wid. (m)	Section: Upper Wid. (m)	Section: Height (m)	Roughness Coefficient	Slope i (%)	Velosity (m/s)	Discharge Capacity (m3/s)
(NA-1)								
KN-1-1	33.8	5.50	13.50	4.00	0.025	0.017	0.89	33.8
KN-1-2	65.0	14.50	30.50	4.00	0.035	0.017	0.73	65.6
KN-1-3	60.0	13.00	29.00	4.00	0.035	0.017	0.72	60.4
KN-1-4	50.0	10.00	26.00	4.00	0.035	0.017	0.69	50.0
KN-1-5	30.0	10.00	26.00	4.00	0.035	0.017	0.69	50.0
KN-1-6	50.6	8.50	24.02	3.88	0.035	0.025	0.82	51.7
KN-1-7	23.0	3.50	17.02	3.38	0.035	0.025	0.68	23.7
KN-1-8	13.3	2.50	8.78	3.14	0.025	0.025	0.85	15.0
KN-2-1	21.4	2.00	17.48	3.87	0.035	0.025	0.71	26.6
KN-2-2	17.1	2.50	9.40	3.45	0.025	0.025	0.89	18.3
KN-3	10.9	2.00	17.44	3.86	0.035	0.025	0.70	26.4
KN-13	15.8	2.00	17.60	3.90	0.035	0.025	0.71	27.1
KN-14-1	43.5	6.50	22.02	3.88	0.035	0.025	0.79	43.8
KN-14-2	27.4	3.00	18.00	3.75	0.035	0.025	0.72	28.2
KN-14-3	12.7	2.00	8.16	3.08	0.025	0.025	0.81	12.7
KN-15	9.9	2.00	14.76	3.19	0.035	0.025	0.63	16.8
KN-16	26.4	4.00	11.40	3.70	0.025	0.025	0.99	28.3
(NA-2)								
KN-4-1	143.5	33.50	41.84	4.17	0.025	0.010	0.92	144.0
KN-4-2	56.1	10.50	27.18	4.17	0.035	0.017	0.72	56.7
KN-4-3	56.1	10.50	27.18	4.17	0.035	0.017	0.72	56.7
KN-4-4	42.1	5.50	21.66	4.04	0.035	0.025	0.79	43.5
KN-4-5	26.0	4.00	11.18	3.59	0.025	0.025	0.98	26.7
KN-4-6	19.1	3.50	10.04	3.27	0.025	0.025	0.91	20.2
KN-5-1	71.6	22.50	38.70	4.05	0.035	0.010	0.60	74.5
KN-5-2	40.0	9.50	17.50	4.00	0.025	0.010	0.76	40.8
KN-6	14.2	2.00	17.92	3.98	0.035	0.025	0.72	28.4
KN-7-1	61.6	12.00	28.68	4.17	0.035	0.017	0.73	62.3
KN-7-2	61.6	12.00	28.68	4.17	0.035	0.017	0.73	62.3
KN-7-3	48.7	7.00	15.14	4.07	0.025	0.025	1.14	51.6
KN-7-4	30.1	4.50	11.94	3.72	0.025	0.025	1.02	31.1
KN-7-5	13.1	2.00	8.82	3.41	0.025	0.025	0.86	15.9
KN-8	10.2	2.00	18.36	4.09	0.035	0.025	0.73	30.4
KN-9	20.8	2.00	18.28	4.07	0.035	0.025	0.73	30.0
KN-10	15.6	2.00	16.28	3.57	0.035	0.025	0.67	21.9
KN-11	20.7	2.00	18.20	4.05	0.035	0.025	0.73	29.7
KN-12	12.1	2.00	9.28	3.64	0.025	0.025	0.89	18.3
KN-17	16.4	2.00	15.80	3.45	0.035	0.025	0.66	20.2

TABLE E.9.9 PROPOSED KHAL IMPROVEMENT WORKS : DND

DND Project Area (NA)

Zone	Khal No.	Khal Length (km)	Required Hydraulic Section Wb x Wu x H (m x m x m)			Open Channel: Brick Protection (km)	Open Channel: Sodding (km)	Covered Channel: Box Culvert (km)	Covered Channel: Brick Pipe (km)	Bridge (Places)	Aqueduct (Places)	Dredging (1000m3)	Maintenance Road (km)	Land Acquisition (ha)
NA-1	KN-1-1	2.10	5.5	13.5	4.0	2.10	-	-	-	-	-	22.27	2.10	0.61
	KN-1-2	0.70	14.5	30.5	4.0	-	0.70	-	-	1	-	34.44	0.70	1.72
	KN-1-3	1.00	13.0	29.0	4.0	-	1.00	-	-	1	-	43.02	1.00	2.54
	KN-1-4	0.60	10.0	26.0	4.0	-	0.60	-	-	-	-	11.90	0.60	0.82
	KN-1-5	1.80	10.0	26.0	4.0	-	1.80	-	-	1	-	76.88	1.80	4.83
	KN-1-6	1.40	8.5	24.0	3.9	-	1.40	-	-	1	-	49.86	1.40	3.98
	KN-1-7	1.20	3.5	17.0	3.4	-	1.20	-	-	-	-	29.51	1.20	2.67
	KN-1-8	0.60	2.5	8.8	3.1	0.60	-	-	-	-	-	5.91	0.60	0.22
	KN-2-1	1.60	2.0	17.5	3.9	-	1.60	-	-	3	1	34.36	1.60	3.70
	KN-2-2	1.60	2.5	9.4	3.5	1.60	-	-	-	2	-	21.32	1.60	2.37
	KN-3	1.70	2.0	17.4	3.9	-	1.70	-	-	1	-	16.78	1.70	2.92
	KN-13	1.20	2.0	17.6	3.9	-	1.20	-	-	1	-	39.35	1.20	3.49
	KN-14-1	1.50	6.5	22.0	3.9	-	1.50	-	-	-	-	48.18	1.50	4.92
	KN-14-2	1.50	3.0	18.0	3.8	-	1.50	-	-	-	-	36.30	1.50	4.45
	KN-14-3	1.60	2.0	8.2	3.1	1.60	-	-	-	1	-	27.68	1.60	3.18
	KN-15	1.60	2.0	14.8	3.2	-	1.60	-	-	1	-	11.69	1.60	4.32
	KN-16	2.20	4.0	11.4	3.7	2.20	-	-	-	-	-	43.04	2.20	4.68
	Sub-Total	23.90				8.10	15.80	0.00	0.00	13	1	552.49	23.90	51.42
NA-2	KN-4-1	1.80	33.5	41.8	4.2	1.80	-	-	-	3	-	229.56	1.80	4.37
	KN-4-2	1.30	10.5	27.2	4.2	-	1.30	-	-	-	-	118.68	1.30	4.93
	KN-4-3	1.20	10.5	27.2	4.2	-	1.20	-	-	2	-	61.65	1.20	2.61
	KN-4-4	1.50	5.5	21.7	4.0	-	1.50	-	-	2	-	73.93	1.50	4.16
	KN-4-5	1.80	4.0	11.2	3.6	1.80	-	-	-	4	-	24.91	1.80	1.27
	KN-4-6	0.80	3.5	10.0	3.3	0.80	-	-	-	1	-	20.80	0.80	0.67
	KN-5-1	1.80	22.5	38.7	4.1	-	1.80	-	-	-	-	256.96	1.80	6.03
	KN-5-2	1.00	9.5	17.5	4.0	1.00	-	-	-	-	-	67.23	1.00	2.40
	KN-6	0.90	2.0	17.9	4.0	-	0.90	-	-	-	-	18.44	0.90	1.36
	KN-7-1	2.40	12.0	28.7	4.2	-	2.40	-	-	1	1	196.23	2.40	7.92
	KN-7-2	0.80	12.0	28.7	4.2	-	0.80	-	-	-	-	42.41	0.80	2.52
	KN-7-3	1.20	7.0	15.1	4.1	1.20	-	-	-	-	-	24.82	1.20	1.36
	KN-7-4	1.40	4.5	11.9	3.7	1.40	-	-	-	6	-	34.30	1.40	1.18
	KN-7-5	0.80	2.0	8.8	3.4	0.80	-	-	-	1	-	8.70	0.80	0.58
	KN-8	1.00	2.0	18.4	4.1	-	1.00	-	-	-	-	20.54	1.00	1.65
	KN-9	1.30	2.0	18.3	4.1	-	1.30	-	-	1	-	31.32	1.30	2.20
	KN-10	1.80	2.0	16.3	3.6	-	1.80	-	-	2	-	20.00	1.80	2.43
	KN-11	1.40	2.0	18.2	4.1	-	1.40	-	-	-	-	30.19	1.40	3.14
	KN-12	1.60	2.0	9.3	3.6	1.60	-	-	-	1	-	8.96	1.60	0.76
	KN-17	1.50	2.0	15.8	3.5	-	1.50	-	-	1	-	47.32	1.50	4.18
	Sub-Total	27.30				10.40	16.90	0.00	0.00	25	1	1336.95	27.30	55.72
	Total	51.20				18.50	32.70	0.00	0.00	38	2	1889.44	51.20	107.14

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TABLE E.5.1 PROPOSED FLOOD MITIGATION FACILITY : NARAYANGANJ WEST

Route (Total Length)		Facility		Main Features	
1. Narayanganj to					
Panchabati (NW) (L = 5.64 km)	1)	Road-Cum-Embankment	:	4.10 km	(NW.8+100~ NW.29)
	2)	Embankment	:	1.54 km	(NW.0~NW.8 +100)
	3)	Sluice Gate	:	2 places	
2. Narayanganj to					
Demra (NE) (L = 21.83 km)	1)	Flood Wall	:	11.48 km	(NE.0~NE.48, NE.55~NE.62, NE.87~NE.88)
	2)	Embankment	:	10.35 km	(NE.48~NE.55, NE.62~NE.87)
	3)	Sluice Gate	:	12 places	
	4)	Stop Log Structure	:	17 places	
Total	1)	Road-Cum-Embankment	:	4.10 km	
	2)	Embankment	:	11.89 km	
	3)	Flood Wall	:	11.48 km	
	3)	Sluice Gate	:	14 places	
	4)	Stop Log Structure	:	17 places	

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TABLE E.5.2 LAND USE AND POPULATION OF NARAYANGANJ WEST

Drainage Area (km^2)	1990		2000		2100	
	Buil-up Area (km^2)	Population (million people)	Buil-up Area (km^2)	Population (million people)	Buil-up Area (km^2)	Population (million people)
18.36	13.12	0.470	17.20	0.696	17.20	0.927

TABLE E.5.3
MAIN HYDRAULIC FEATURES OF EXISTING MAJOR KHAL : NARAYANGANJ WEST

Narayanganj West Zone (NB)

Khal No.	Length (m)	Max. Section Catchment Area (km2)	Width (m)	Depth (m)	Slope (%)	Discharge Capacity (m3/s)	Specific Discharge Capacity (m3/s/km2)	Min. Section Catchment Area (km2)	Width (m)	Depth (m)	Slope (%)	Discharge Capacity (m3/s)	Specific Discharge Capacity (m3/s/km2)
K 1	420	0.50	11.20	1.70	0.050	5.3	10.6	1.70	5.00	0.90	0.050	0.8	0.5
K 2		1.20	3.00	3.50	0.050	2.6	2.2	1.20	3.00	3.50	0.050	2.6	2.2
K 3	1,220	55.80	44.00	6.60	0.050	199.9	3.6	55.80	13.20	0.40	0.050	0.6	0.0
K 4	520	0.30	11.20	5.60	0.050	31.6	105.3	0.70	5.20	3.60	0.050	6.2	8.8
K 5	600	0.70	25.60	5.20	0.050	76.4	109.2	0.20	20.40	4.50	0.050	47.5	237.3
K 6	360	0.50	15.40	3.10	0.050	19.4	38.9	0.50	15.40	3.10	0.050	19.4	38.9
K 7	1,240	2.40	14.40	3.00	0.017	10.0	4.2	2.00	7.60	0.90	0.017	0.7	0.4
K 8	1,400	4.60	16.40	5.20	0.025	32.6	7.1	1.30	12.20	2.40	0.025	7.1	5.5

Note : Roughness Coefficient (n) = 0.035

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TABLE E.5.4(1) HYDRAULIC REQUIREMENTS OF PROPOSED PUMPING STATION : NARAYANGANJ WEST

Proposed Pumping Station	Drainage Zone		Discharge Capacity	Design Water Level (m, PWD)					Static Head (m)		Remarks
	No.	Area (km^2)	(m^3/s)	Outer			Inner		Design	Max.	
				H.H.W.L	H.W.L	L.W.L	H.W.L	L.W.L			
P 12	NB-1	1.73	2.00	7.35	5.80	3.00	4.20	3.00	2.80	4.35	
P 13	NB-2	1.92	2.20	7.25	5.70	3.50	4.60	3.50	2.20	3.75	
P 14-A	NB-4	2.36	2.70	7.10	5.50	3.00	4.50	3.00	2.50	4.10	
P 14-B	NB-5	4.65	5.30	6.97	5.45	3.50	4.60	3.50	1.95	3.47	

Note : 1. H.H.W.L. and H.W.L. of outer design water level means that of 100-year and 2-year frequency flood respectively

TABLE E.5.4(2) HYDRAULIC REQUIREMENTS OF PROPOSED RETARDING POND : NARAYANGANJ WEST

Proposed Retarding Pond	Drainage Zone	Pond Area (ha)	Storage Capacity (x $10^6 m^3$)	Design Water Level (m, PWD)		Remarks
				H.W.L	L.W.L	
RP 12	NB-1	21	0.21	4.20	3.00	
RP 13	NB-2	23	0.23	4.60	3.50	
RP 14-1	NB-4	28	0.28	4.50	3.00	
RP 14-2	NB-5	26	0.26	4.60	3.50	
RP 14-3	NB-5	30	0.30	4.60	3.50	

Off

TABLE E.5.5 RUN-OFF COEFFICIENT : NARAYANGANJ WEST

Narayanganj West Zone (NB)

Block No.	Area	Run-off Coefficient	Land Use (%) Residential High Density	Residential Midium Density	Residential Low Density	Commercial	Industrial	Institutionl	Open Space /Agrecultural	Waterbodies
	km2	f	0.50	0.50	0.30	0.65	0.55	0.30	0.20	1.00
NB-1-1	0.57	0.45	23.44	19.60	5.95	5.21	7.83	31.29	2.60	4.07
NB-1-2	1.73	0.42	20.60	17.22	5.23	4.58	6.88	27.49	14.43	3.57
NB-2-1	1.19	0.43	19.90	7.11	3.29	4.85	25.76	17.61	19.37	2.09
NB-2-2	0.73	0.49	24.67	8.82	4.08	6.02	31.93	21.83	0.05	2.59
NB-2-3	2.07	0.49	24.67	8.82	4.08	6.02	31.93	21.83	0.05	2.59
NB-3-1	0.95	0.45	29.94	8.84	6.30	3.61	19.18	30.37	0.18	1.59
NB-3-2	0.91	0.45	29.94	8.84	6.30	3.61	19.18	30.37	0.18	1.59
NB-3-3	0.73	0.45	29.94	8.84	6.30	3.61	19.18	30.37	0.18	1.59
NB-3-4	0.70	0.48	39.92	4.65	1.18	7.44	19.65	25.46	0.00	1.70
NB-3-5	0.89	0.48	39.92	4.65	1.18	7.44	19.65	25.46	0.00	1.70
NB-3-6	0.40	0.53	35.09	5.04	0.00	33.90	6.04	17.02	0.00	2.91
NB-3-7	0.51	0.53	35.09	5.04	0.00	33.90	6.04	17.02	0.00	2.91
NB-3-8	0.24	0.53	35.09	5.04	0.00	33.90	6.04	17.02	0.00	2.91
NB-4-1	1.07	0.49	34.34	13.20	2.48	10.02	12.28	22.71	0.41	4.56
NB-4-2	0.54	0.45	29.25	11.25	2.11	8.54	10.46	19.34	15.16	3.89
NB-4-3	0.75	0.41	25.18	9.68	1.82	7.35	9.01	16.65	26.96	3.35
NB-5-1	1.01	0.50	42.91	17.94	3.72	11.96	3.38	15.13	0.41	4.54
NB-5-2	0.75	0.40	28.04	11.72	2.43	7.82	2.21	9.89	34.93	2.97
NB-5-3	1.33	0.46	37.43	15.64	3.25	10.44	2.95	13.20	13.14	3.96
NB-5-4	1.39	0.48	38.90	16.26	3.38	10.85	3.07	13.72	9.72	4.12
NB-5-5	0.17	0.50	42.91	17.94	3.72	11.96	3.38	15.13	0.41	4.54

TABLE E.5.6 DESIGN DISCHARGE : NARAYANGANJ WEST

Narayanganj West Zone (NB)

Conditions: Inlet Time; 20min

Block No.	Drainage Area Individual a (km2)	Drainage Area Accumlated A (km2)	Run-off Coefficier Individual f	Run-off Coefficier Accumlated F	Length Individual l (km)	Length Accumlated L (km)	Velocity V (m/s)	Time of Concentration t (min)	Rainfal Intensity r (mm/hr)	Areal Reduction Factor (m3/s/km)	Design Discharge (m3/s)
NB-1-1	0.57	0.57	0.45	0.45	0.90	0.90	0.80	39	101.46	1.00	7.2
NB-1-2	1.73	1.73	0.42	0.42	1.80	1.80	0.80	58	83.77	0.99	16.7
NB-2-1	1.19	1.19	0.43	0.43	1.50	1.50	0.80	51	88.94	0.99	12.5
NB-2-2	0.73	0.73	0.49	0.49	1.80	1.80	0.80	58	83.77	1.00	8.3
NB-2-3	2.07	2.07	0.49	0.49	2.10	2.10	0.80	64	79.16	0.99	21.9
NB-3-1	0.95	0.95	0.45	0.45	1.50	1.50	0.80	51	88.94	1.00	10.5
NB-3-2	0.91	0.91	0.45	0.45	1.40	1.40	0.80	49	90.81	1.00	10.3
NB-3-3	0.73	0.73	0.45	0.45	1.10	1.10	0.80	43	96.91	1.00	8.8
NB-3-4	0.70	0.70	0.48	0.48	1.00	1.00	0.80	41	99.14	1.00	9.2
NB-3-5	0.89	0.89	0.48	0.48	1.50	1.50	0.80	51	88.94	1.00	10.5
NB-3-6	0.40	0.40	0.53	0.53	0.80	0.80	0.80	37	103.90	1.00	6.2
NB-3-7	0.51	0.51	0.53	0.53	1.20	1.20	0.80	45	94.79	1.00	7.2
NB-3-8	0.24	0.24	0.53	0.53	0.60	0.60	0.80	33	109.15	1.00	3.9
NB-4-1	1.07	1.07	0.49	0.49	1.70	1.70	0.80	55	85.42	0.99	12.4
NB-4-2	0.54	0.54	0.45	0.45	0.50	0.50	0.80	30	111.98	1.00	7.5
NB-4-3	0.75	2.36	0.41	0.46	0.90	1.40	0.80	49	90.81	0.99	27.0
NB-5-1	1.01	1.01	0.50	0.50	1.40	1.40	0.80	49	90.81	0.99	12.7
NB-5-2	0.75	1.76	0.40	0.46	0.80	2.20	0.80	66	77.74	1.00	17.4
NB-5-3	1.33	1.33	0.46	0.46	1.50	1.50	0.80	51	88.94	0.99	15.1
NB-5-4	1.39	1.39	0.48	0.48	2.00	2.00	0.80	62	80.64	0.99	14.6
NB-5-5	0.17	4.65	0.50	0.47	0.30	2.50	0.80	72	73.76	0.97	43.1

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TABLE E.5.7 HYDRAULIC DESIGN OF KHAL AND TRUNK DRAIN IMPROVEMENT : NARAYANGANJ WEST

Narayanganj West Zone (NB)

Khal No.	Design Discharge (m3/s)	Section Bottom Wid. (m)	Section Upper Wid. (m)	Section Height (m)	Roughness Coefficient	Slope i (%)	Velosity (m/s)	Discharge Capacity (m3/s)
(NB-1)								
KN-18	7.2	2.00	7.00	2.50	0.025	0.033	0.84	9.5
KN-19	16.7	2.00	14.00	3.00	0.035	0.033	0.70	16.8
(NB-2)								
KN-20	12.5	3.00	13.00	2.50	0.035	0.033	0.66	13.1
KN-21	8.3	2.00	7.00	2.50	0.025	0.033	0.84	9.5
KN-22	21.9	4.50	10.50	3.00	0.025	0.033	1.05	23.7
(NB-3)								
KN-23	10.5	2.50	7.50	2.50	0.025	0.033	0.87	10.9
KN-24	10.3	2.50	7.50	2.50	0.025	0.033	0.87	10.9
KN-25	8.8	2.00	7.00	2.50	0.025	0.033	0.84	9.5
KN-26	9.2	2.00	7.00	2.50	0.025	0.033	0.84	9.5
KN-27	7.2	2.00	7.00	2.50	0.025	0.033	0.84	9.5
S-1	10.5	3.00	-	3.00	0.015	0.033	1.22	11.0
S-2	6.2	-	2.50	-	0.015	0.067	1.26	6.2
S-3	3.9	-	2.20	-	0.015	0.067	1.16	4.4
(NB-4)								
KN-28-1	27.0	6.00	18.00	3.00	0.035	0.033	0.79	28.3
KN-28-2	7.5	2.00	13.32	2.83	0.035	0.033	0.68	14.7
KN-29	12.4	2.00	8.00	3.00	0.025	0.033	0.93	13.9
(NB-5)								
KN-30-1	43.2	9.50	15.50	3.00	0.025	0.033	1.19	44.7
KN-30-2	15.1	2.50	8.50	3.00	0.025	0.033	0.96	15.8
KN-31-1	17.4	2.50	14.50	3.00	0.035	0.033	0.71	18.2
KN-31-2	12.7	2.00	8.00	3.00	0.025	0.033	0.93	13.9
KN-32	14.6	2.50	8.50	3.00	0.025	0.033	0.96	15.8

TABLE E.5.8

PROPOSED KHAL AND TRUNK DRAIN IMPROVEMENT WORKS : NARAYANGANJ WEST

Narayanganj West Zone (NB)

Zone	Khal No.	Khal Length (km)	Required Hydraulic Section Wb x Wu x H (m x m x m)			Open Channel Brick Protection (km)	Open Channel Sodding (km)	Covered Channel Box Culvert (km)	Covered Channel Brick Pipe (km)	Bridge (Places)	Aqueduct (Places)	Dredging (1000m3)	Maintenance Road (km)	Land Acquisition (ha)
NB-1	KN-18	0.40	2.0	7.0	2.5	0.40	-	-	-	-	-	5.52	0.40	0.65
	KN-19	1.20	2.0	14.0	3.0	-	1.20	-	-	1	-	29.85	1.20	2.43
	Sub-Total	1.60				0.40	1.20	0.00	0.00	1	0	35.37	1.60	3.08
NB-2	KN-20	0.90	3.0	13.0	2.5	-	0.90	-	-	-	-	8.46	0.90	0.90
	KN-21	1.40	2.0	7.0	2.5	1.40	-	-	-	1	-	26.90	1.40	2.50
	KN-22	0.80	4.5	10.5	3.0	0.80	-	-	-	2	-	9.84	0.80	1.60
	Sub-Total	3.10				2.20	0.90	0.00	0.00	3	0	45.20	3.10	5.00
NB-3	KN-23	0.60	2.5	7.5	2.5	0.60	-	-	-	1	-	7.80	0.60	1.02
	KN-24	0.70	2.5	7.5	2.5	0.70	-	-	-	1	-	11.20	0.70	1.20
	KN-25	0.40	2.0	7.0	2.5	0.40	-	-	-	-	-	0.00	0.40	0.37
	KN-26	0.60	2.0	7.0	2.5	0.60	-	-	-	-	-	0.00	0.60	0.12
	KN-27	0.30	2.0	7.0	2.5	0.30	-	-	-	-	-	1.80	0.30	0.31
	S-1	0.90	3.0	-	3.0	-	-	0.90	-	-	-	21.69	0.90	1.50
	S-2	0.30		2.5		-	-	-	0.30	-	-	5.76	0.30	0.46
	S-3	0.20		2.2		-	-	-	0.20	-	-	2.44	0.20	0.29
	Sub-Total	4.00				2.60	0.00	0.90	0.50	2	0	50.69	4.00	5.27
NB-4	KN-28-1	0.90	6.0	18.0	3.0	-	0.90	-	-	-	-	10.25	0.90	1.65
	KN-28-2	0.50	2.0	13.3	2.8	-	0.50	-	-	-	-	4.33	0.50	1.04
	KN-29	1.40	2.0	8.0	3.0	1.40	-	-	-	2	-	35.40	1.40	2.70
	Sub-Total	2.80				1.40	1.40	0.00	0.00	2	0	49.98	2.80	5.39
NB-5	KN-30-1	0.30	9.5	15.5	3.0	0.30	-	-	-	1	-	13.52	0.30	0.41
	KN-30-2	1.50	2.5	8.5	3.0	1.50	-	-	-	-	-	13.67	1.50	1.26
	KN-31-1	0.80	2.5	14.5	3.0	-	0.80	-	-	1	-	22.80	0.80	1.53
	KN-31-2	1.30	2.0	8.0	3.0	1.30	-	-	-	2	-	33.30	1.30	3.01
	KN-32	1.80	2.5	8.5	3.0	1.80	-	-	-	2	-	37.60	1.80	3.45
	Sub-Total	5.70				4.90	0.80	0.00	0.00	6	0	120.89	5.70	9.66
	Total	17.20				11.50	4.30	0.90	0.50	14	0	302.13	17.20	28.40

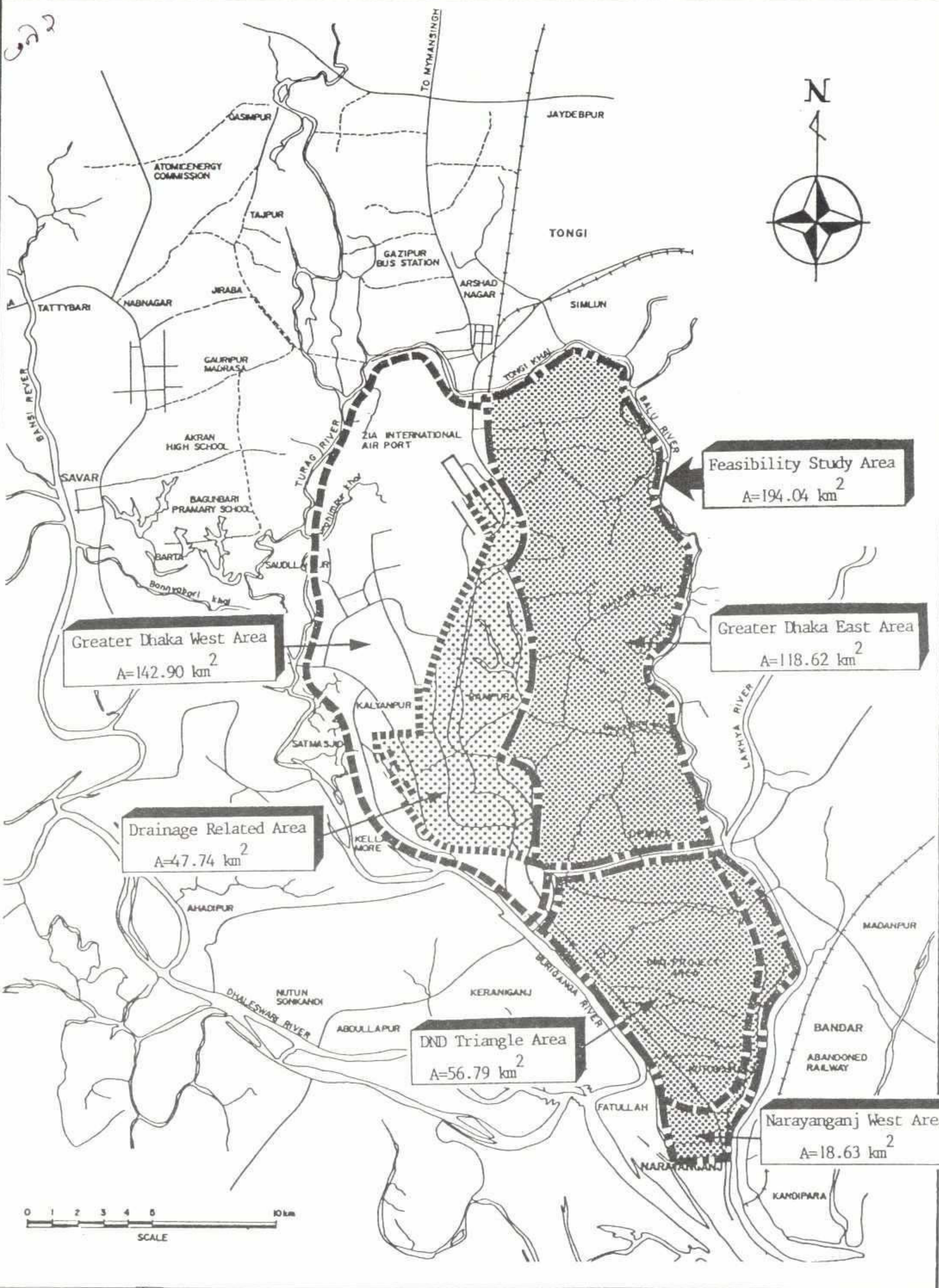

FIG. E.1.1 STUDY AREAS FOR FEASIBILITY STUDY

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

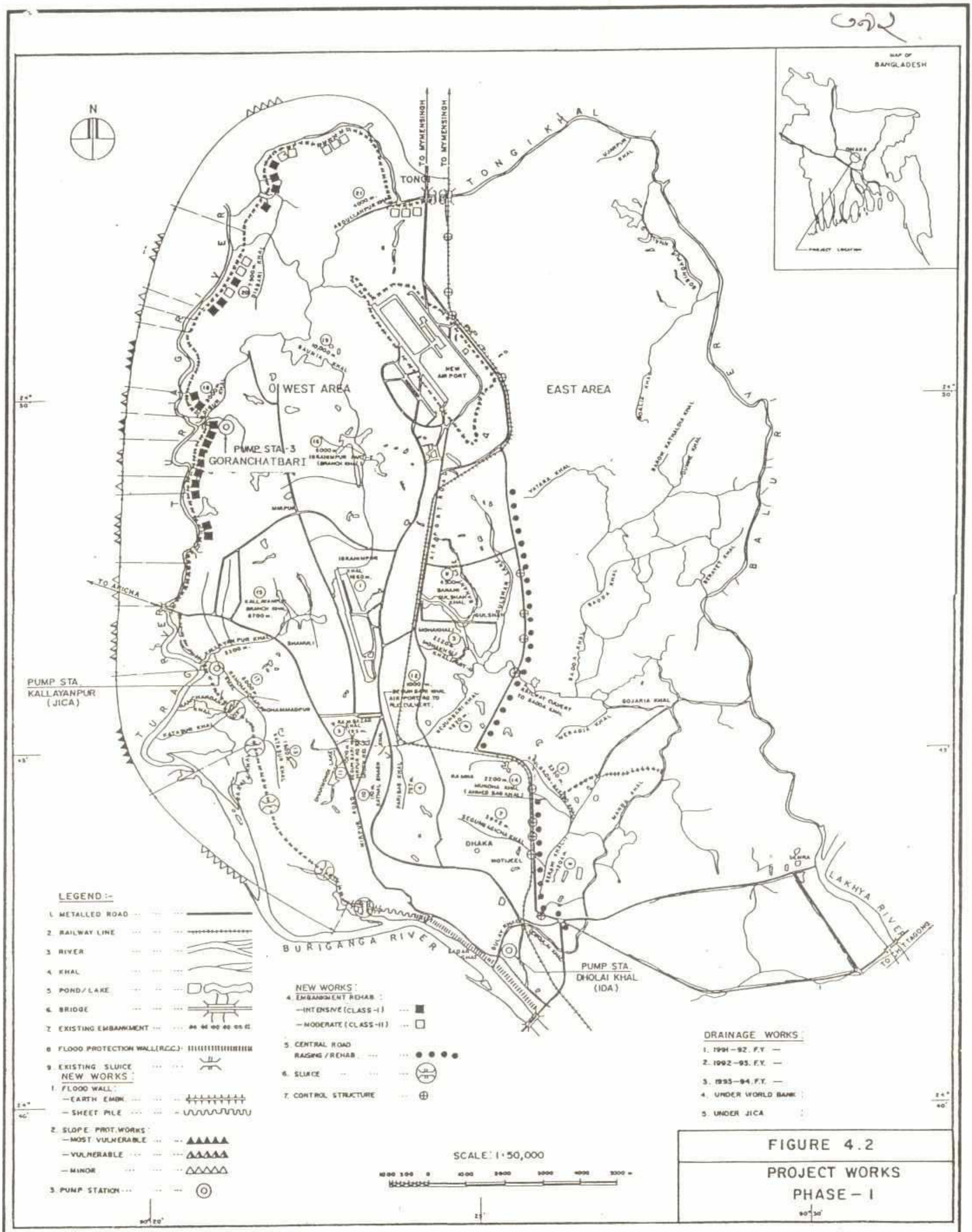

FIG. E.2.1 FLOOD CONTROL AND DRAINAGE WORKS PROPOSED BY FAP 8B

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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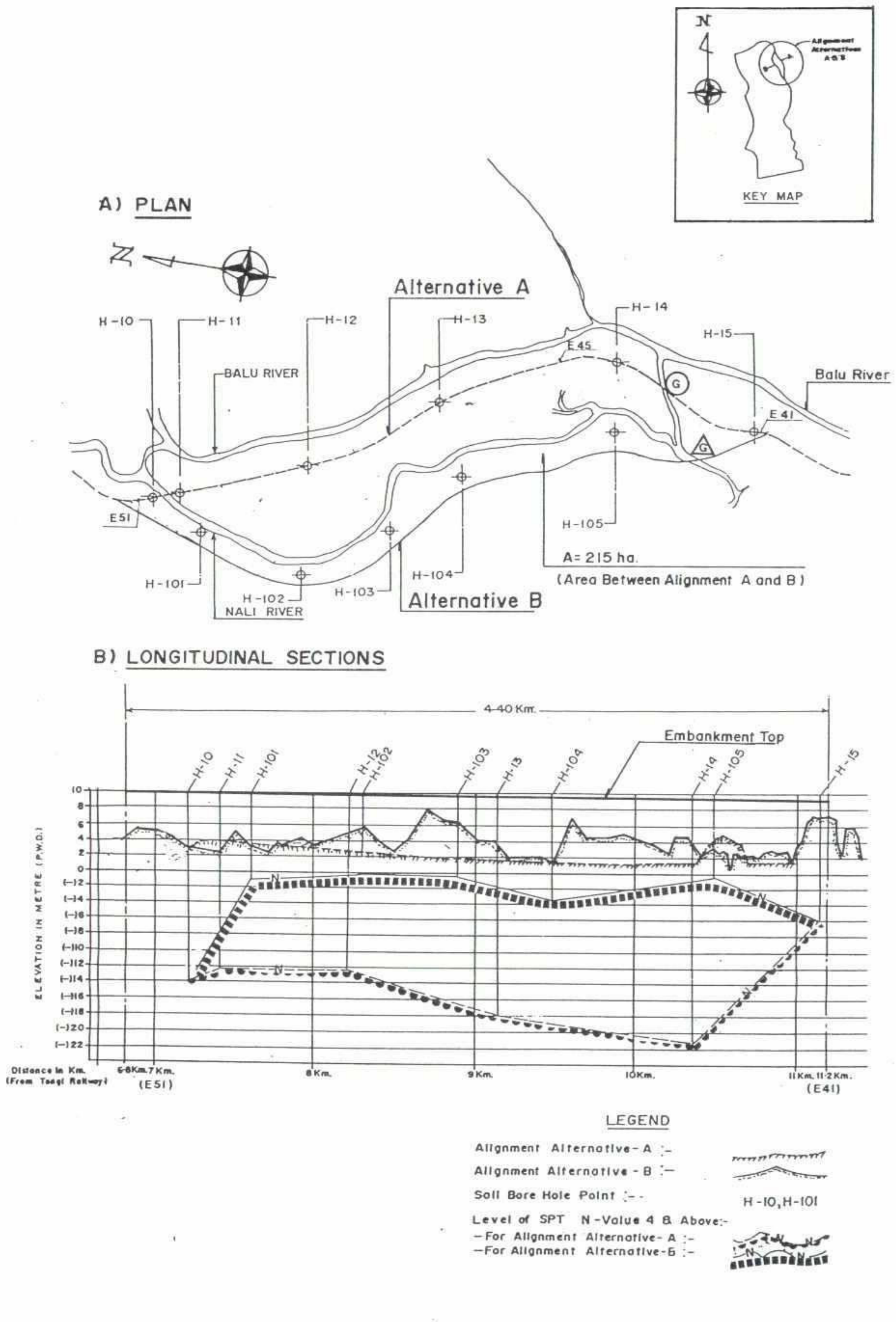

FIG. E.3.1 EMBANKMENT ALIGNMENT OF NALI RIVER PORTION

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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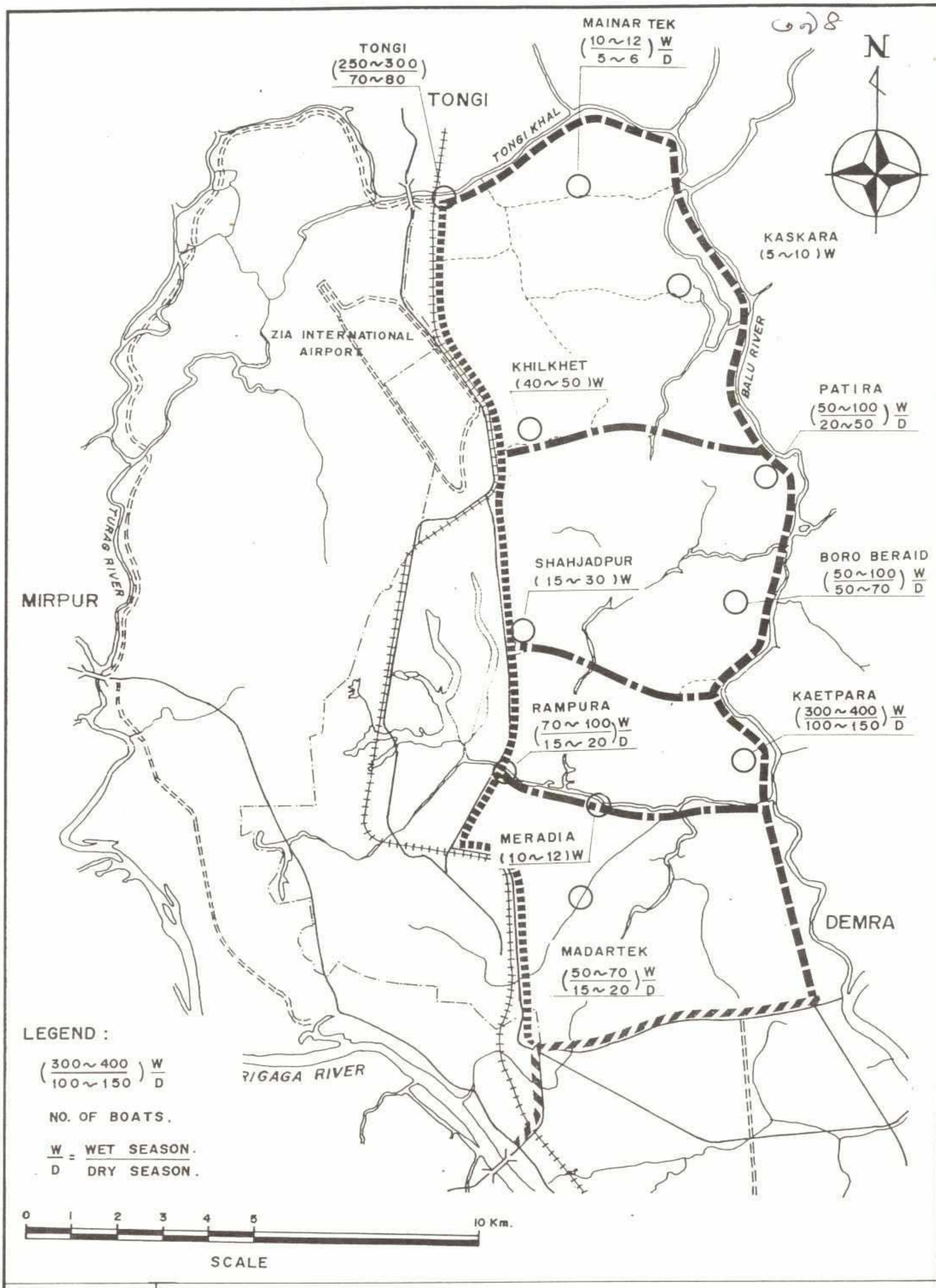

FIG. E.3.2 LOCATION OF NAVIGATION SURVEY POINTS & BOAT NUMBER

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

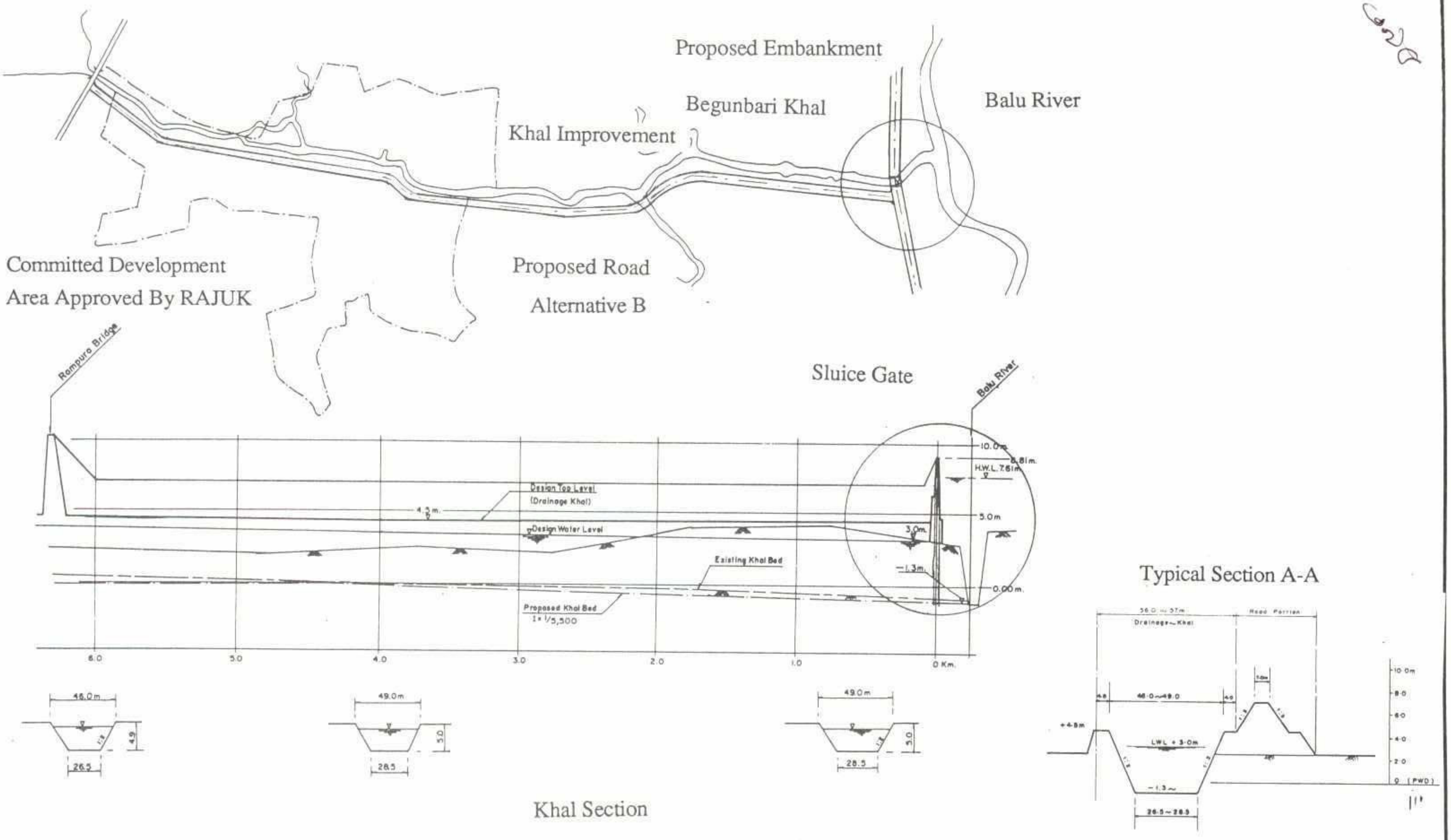

FIG. E.3.3(1) ALTERNATIVE A OF NAVIGATION SYSTEM OF BEGUNBARI KHAL

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

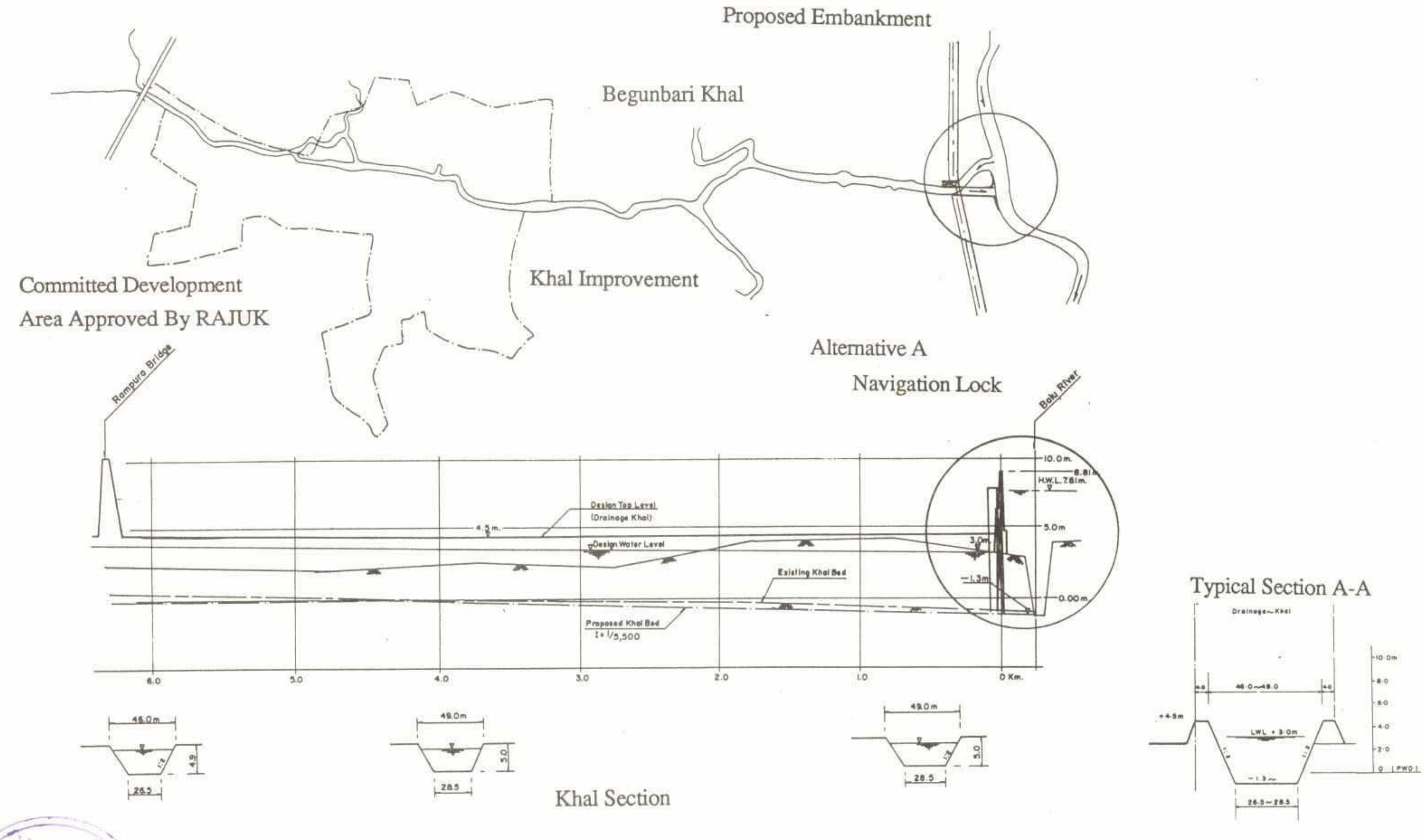

FIG. E.3.3(2) ALTERNATIVE B OF NAVIGATION SYSTEM OF BEGUNBARI KHAL

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

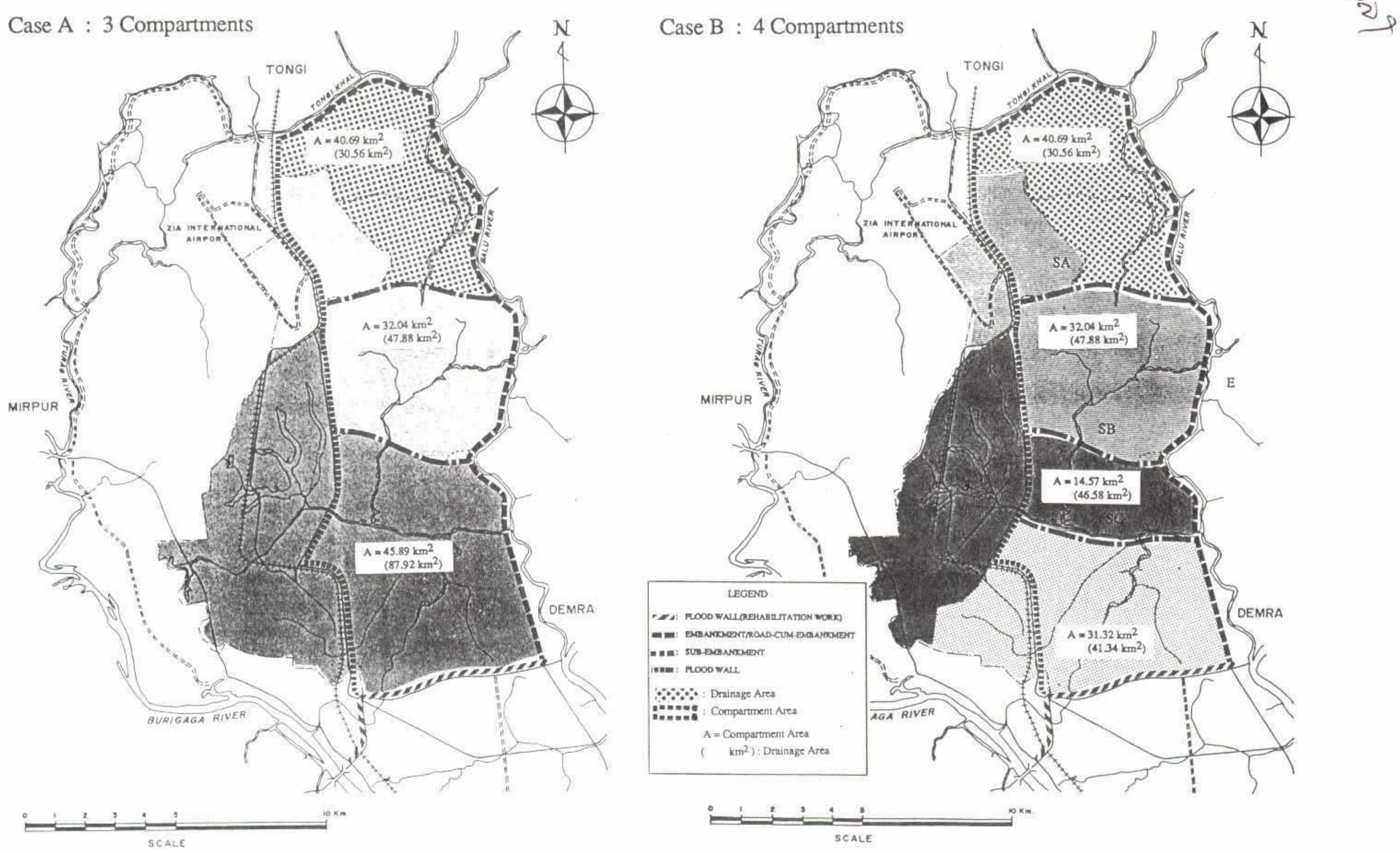

FIG. E.3.4 ALTERNATIVE OF COMPARTMENTALIZATION

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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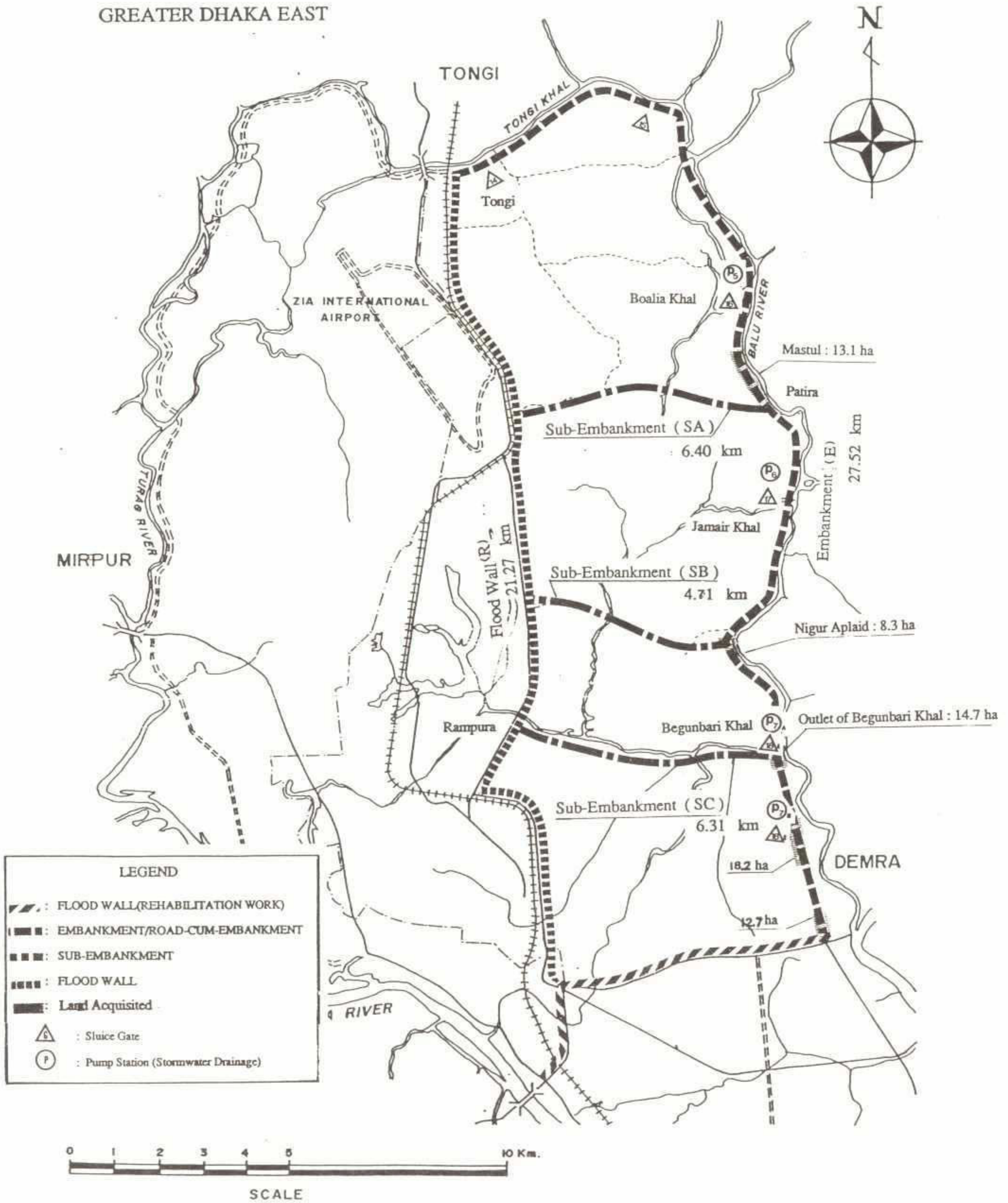
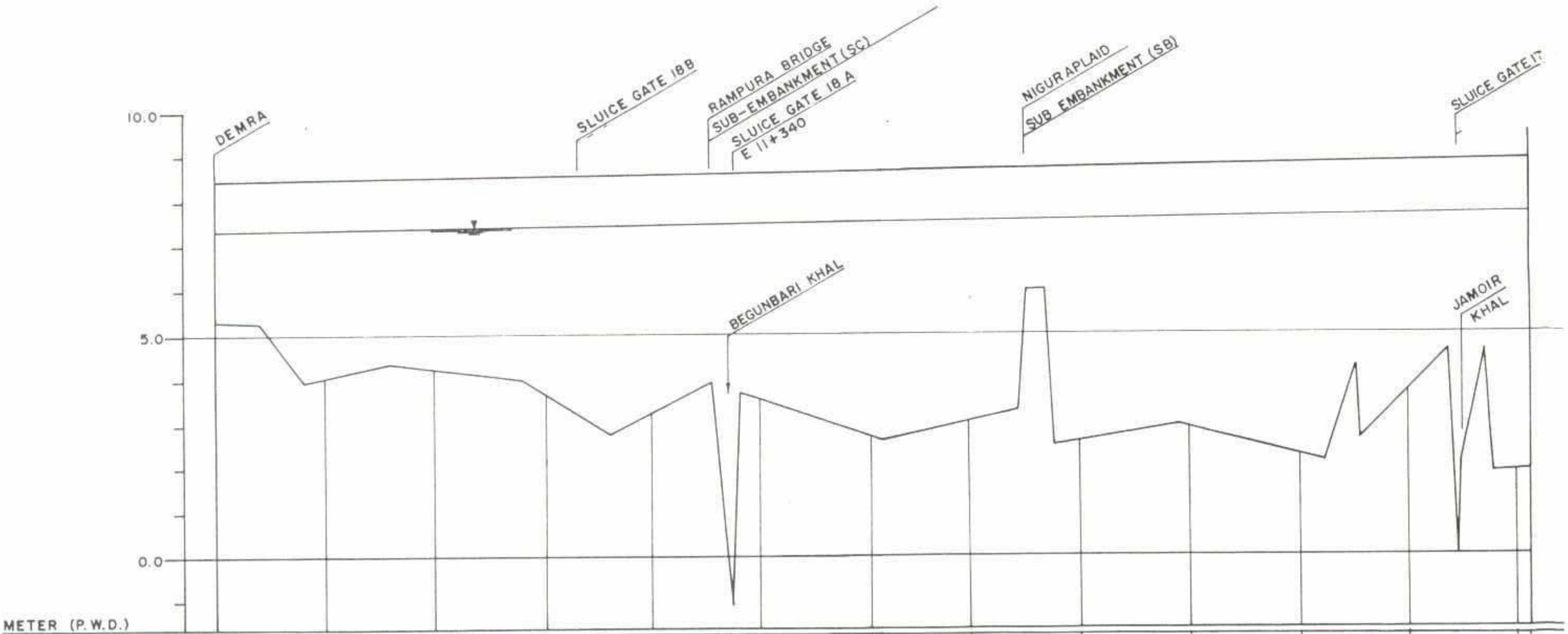


FIG. E.3.5 PROPOSED FLOOD MITIGATION FACILITIES

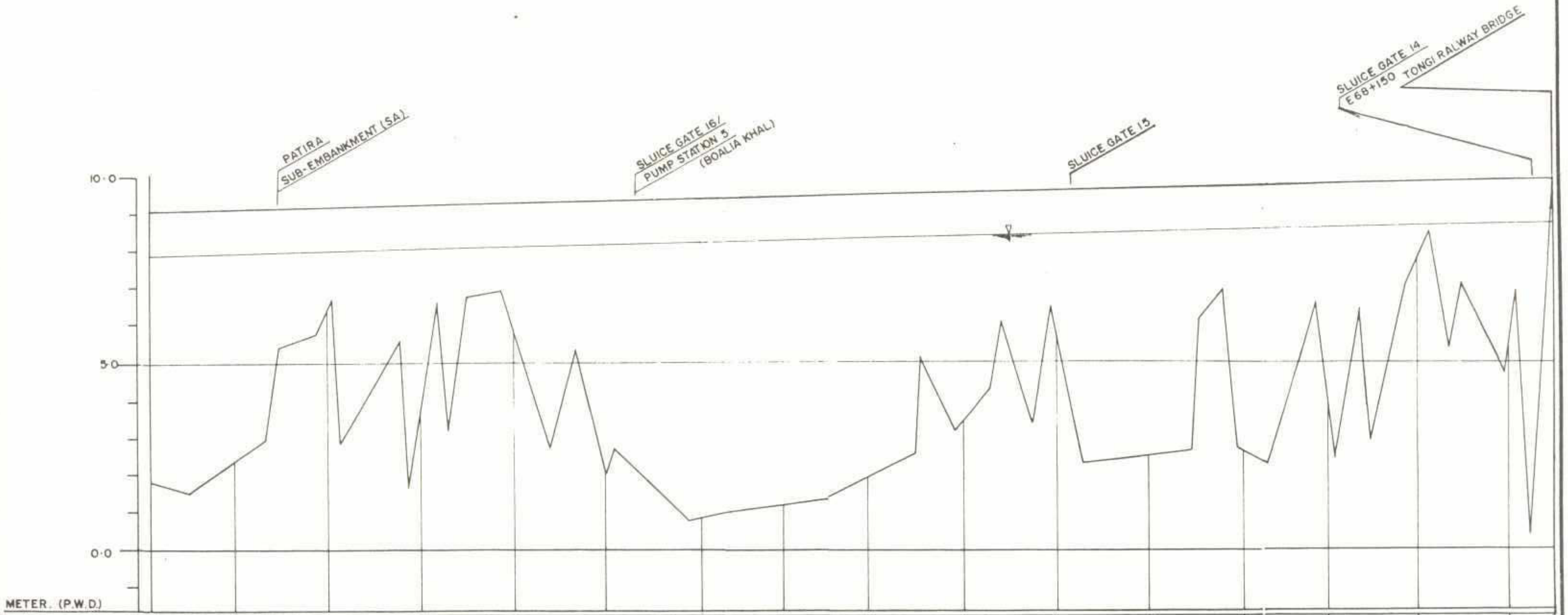
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DESIGNED	GRADIENT	I= 1/22,930													
	TOP OF EMBANKMENT	8.80	8.84	8.89	8.73	8.77	8.82	8.86	8.91	8.95	9.00	9.04	9.08	9.13	9.13
	H. W. L.	7.40	7.44	7.49	7.53	7.57	7.62	7.66	7.71	7.75	7.80	7.84	7.88	7.93	7.93
ACCUMULATED DISTANCE (KM)		0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	11.0	12.0	12.12

FIG. E.3.6(1)	LONGITUDINAL SECTION OF EMBANKMENT : DHAKA EAST (E_1)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DESIGNED	GRADIENT	1 = 1/22,930																
	TOP OF EMBANKMENT	9.13	9.17	9.21	9.25	9.30	9.34	9.38	9.43	9.47	9.52	9.56	9.60	9.64	9.69	9.72	9.75	9.80
	H.W.L.	7.93	7.97	8.01	8.05	8.10	8.14	8.18	8.23	8.27	8.32	8.36	8.40	8.44	8.49	8.52	8.55	8.60
ACCUMULATED DISTANCE (KM)		12.12	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	22.0	23.0	24.0	25.0	26.0	27.0	27.52

FIG. E.3.6(2) LONGITUDINAL SECTION OF EMBANKMENT : DHAKA EAST (E_2)

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GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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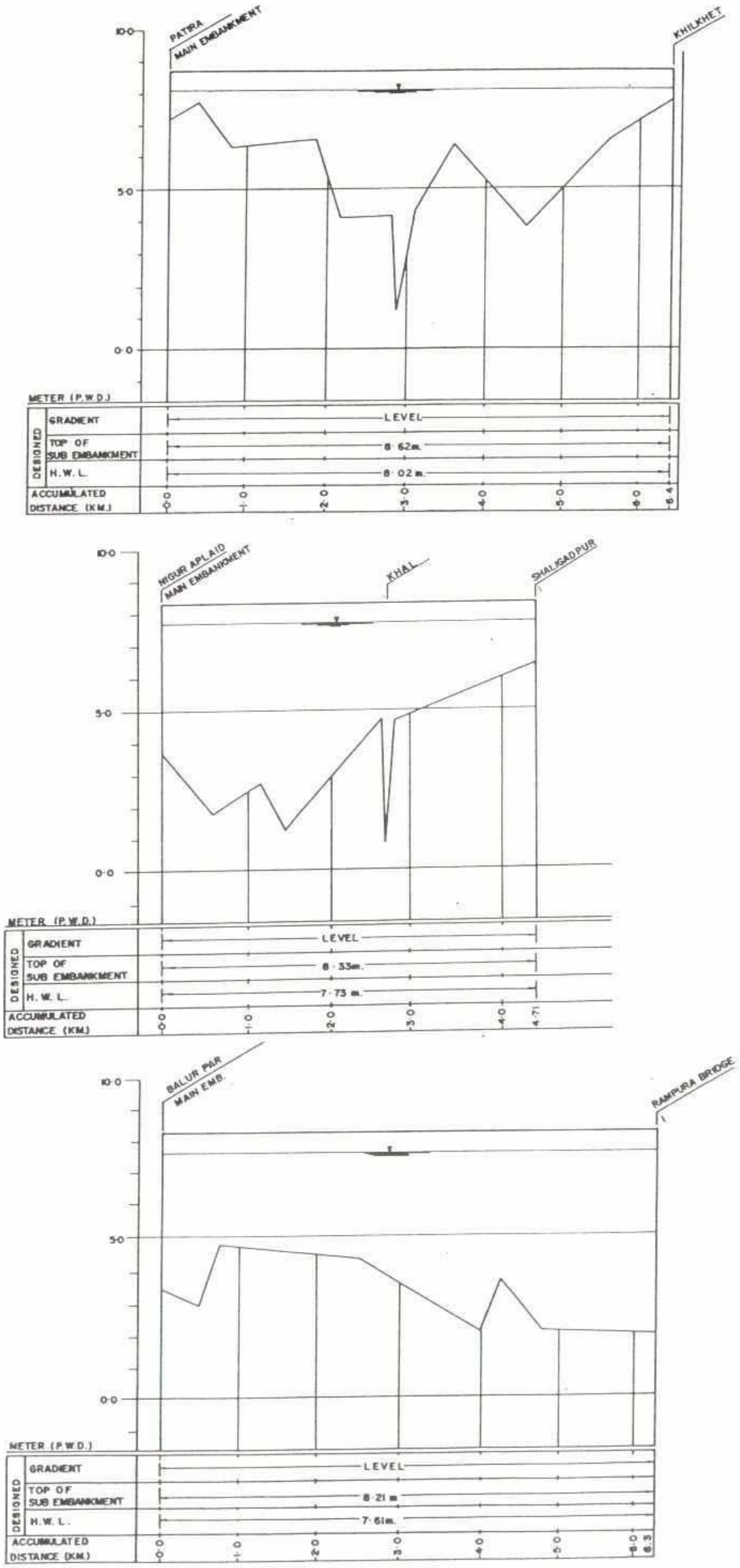


FIG. E.3.6(3) LONGITUDINAL SECTION OF EMBANKMENT : DHAKA EAST (SA, SB AND SC)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

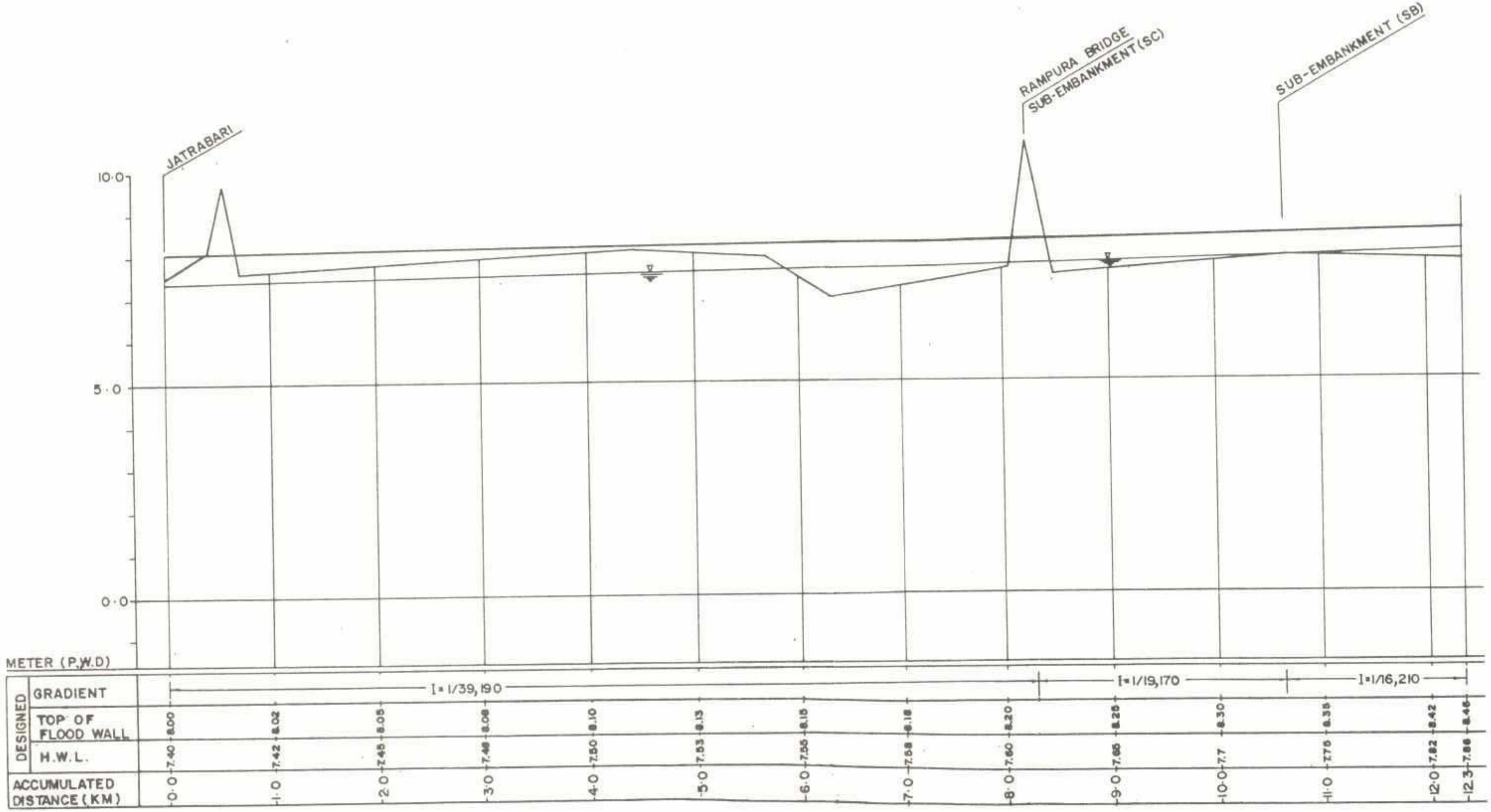
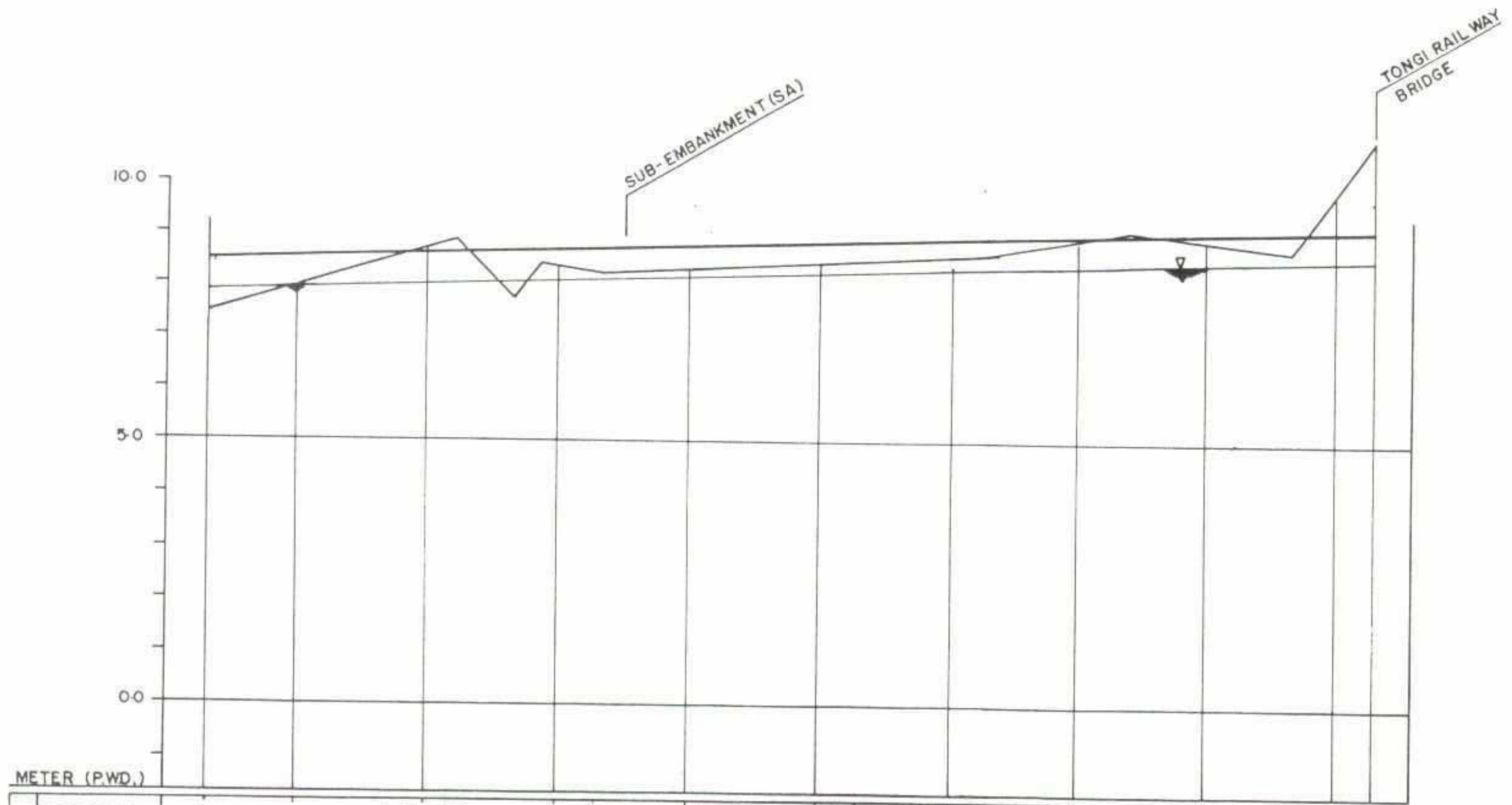


FIG. E.3.6(4) LONGITUDINAL SECTION OF FLOOD WALL : DHAKA EAST (R_1)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



GRADIENT		I = 1/16,210			I = 1/10,300							
DESIGNED	TOP OF FLOOD WALL	8.46	8.48	8.54	8.60	8.69	8.79	8.89	8.99	9.09	9.19	9.20
DESIGNED	H. W. L.	7.86	7.88	7.94	8.00	8.09	8.19	8.29	8.39	8.49	8.59	8.60
ACCUMULATED DISTANCE (KM.)		12.3	13.0	14.0	15.0	16.0	17.0	18.0	19.0	20.0	21.0	21.3

FIG. E.3.6(5) LONGITUDINAL SECTION OF FLOOD WALL : DHAKA EAST (R_2)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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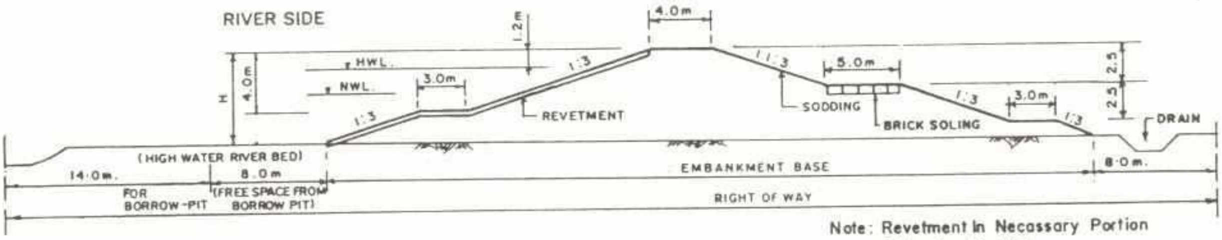
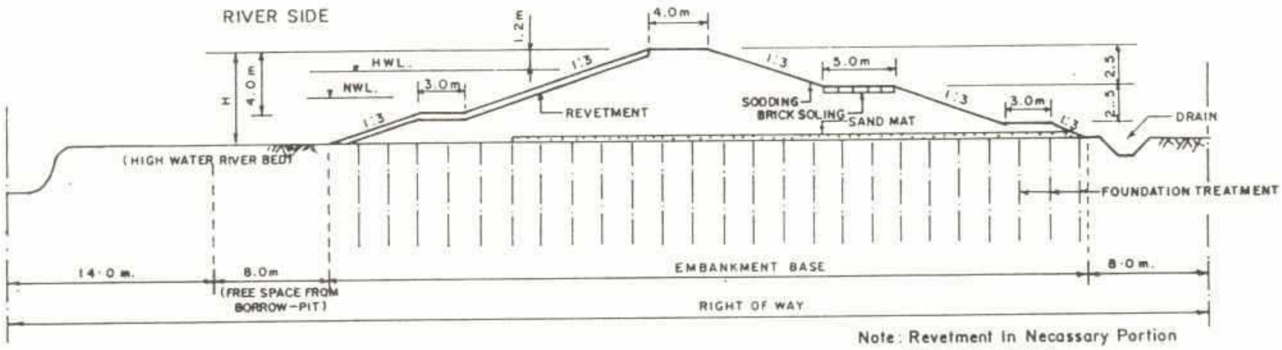
TYPICAL SECTION OF EMBANKMENT



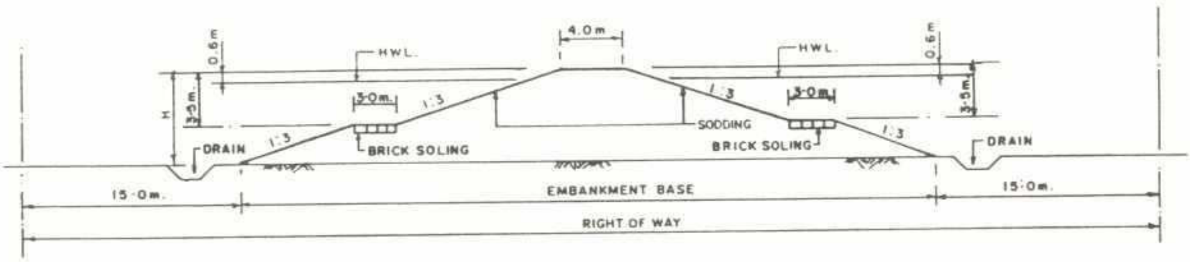
Note: Revetment In Necassary Portion
Otherwise Sodding

. TYPICAL SECTION OF EMBANKMENT WITH FOUNDATION TREATMENT



Note: Revetment In Necassary Portion
Otherwise Sodding.

TYPICAL SECTION OF SUB-EMBANKMENT



TYPICAL SECTION OF SUB-EMBANKMENT WITH FOUNDATION TREATMENT

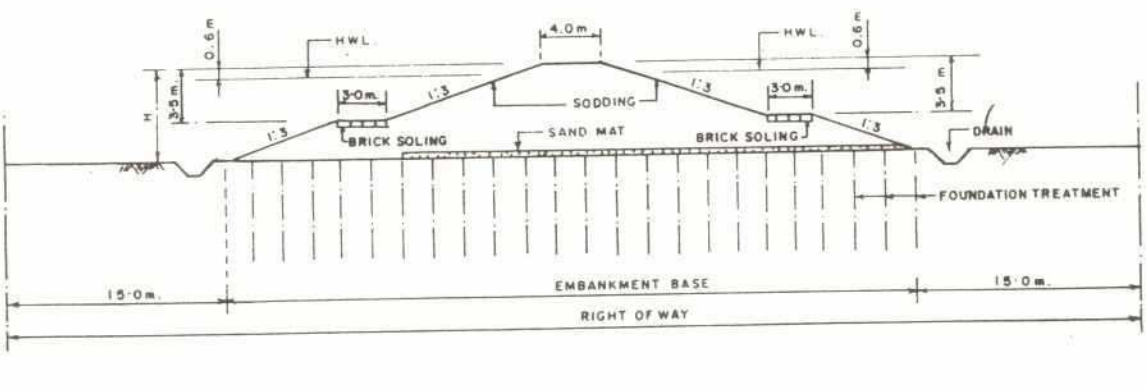


FIG. E.3.7 STANDARD CROSS-SECTION OF EMBANKMENT/SUB-EMBANKMENT : DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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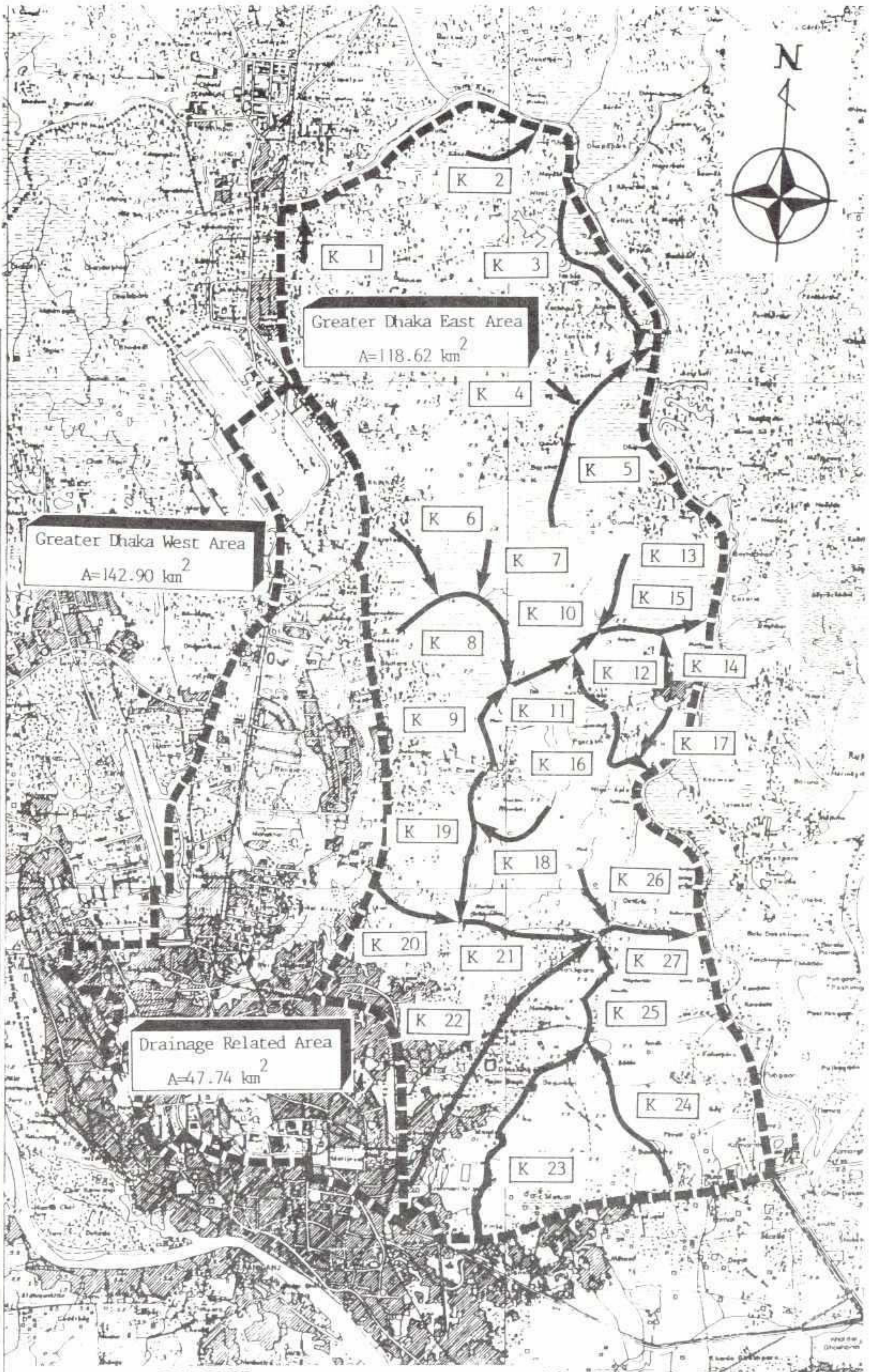
Khal Length

No.	Length(m)
K 1	820
K 2	1,640 ·
K 3	4,100
K 4	440
K 5	3,040
K 6	1,940
K 7	640
K 8	3,540
K 9	1,760
K 10	1,600
K 11	1,400
K 12	740
K 13	1,700
K 14	740
K 15	2,600
K 16	2,200
K 17	800
K 18	1,920
K 19	3,220
K 20	1,640
K 21	2,700
K 22	5,320
K 23	4,820
K 24	3,420
K 25	2,420
K 26	1,800
K 27	2,200
Total	59,160



LEGEND

: Drainage Zone Boundary

: Khal and Khal No.

K 1

0 1 2 3 4 5 Km.

Scale

FIG. E.3.8 EXISTING MAJOR KHALS : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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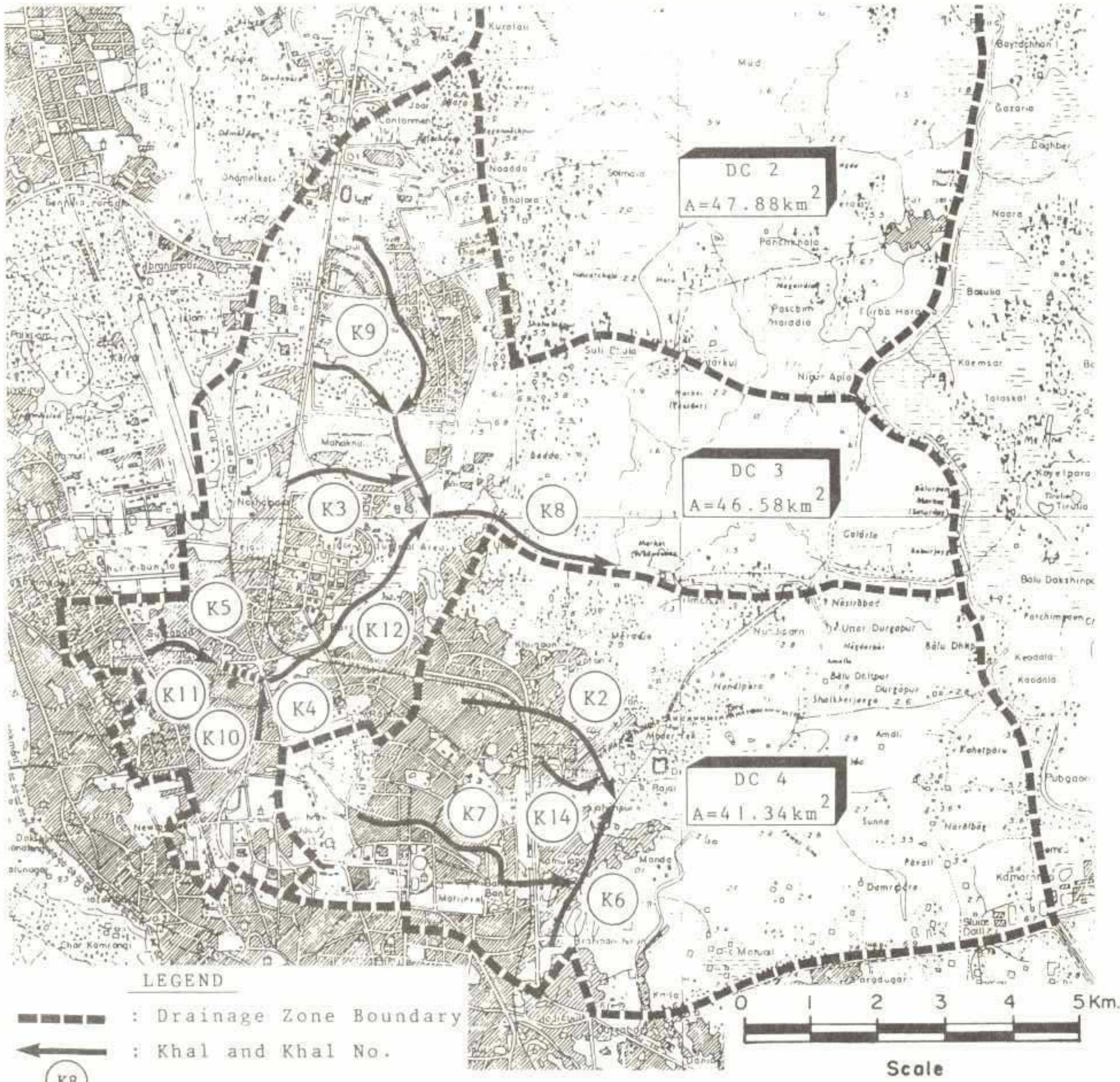

Sourse : ADB, Dhaka Integrated Flood Protection, FAP-8B, Sep. 1991

Phased Khal Improvement Work

Khal No.	Name of Khal	Improved Length(m)
Phase I Work (1991 - 1992)		
K 3	Mohakhali Khal	2,220
K11	BegunbariKhal	1,000
K 7	Segunbagicha Khal	2,366
K 5	Rajabazar Khal	195
K10	Kathalbagan Khal	110
	Sub-total	5,891
Phase II Work (1992 - 1993)		
K 2	Khilgaon-Basabo Khal	3,035
K 6	Gerani Khal	1,204
K 7	Segunbagicha Khal	1,576
K12	Begunbari Khal	1,000
K 9	Banani-Gulshan Khal	4,500
K 4	Paribagh Khal	767
	Sub-total	12,082
Phase III Work (1993 - 1994)		
K14	Mugda Khal	2,200
K 8	Begunbari Khal	4,820
	Sub-total	7,020
	Total	24,993

FIG. E.3.9 KHAL IMPROVEMENT WORKS PROPOSED IN DIFPP FINANCED BY ADB

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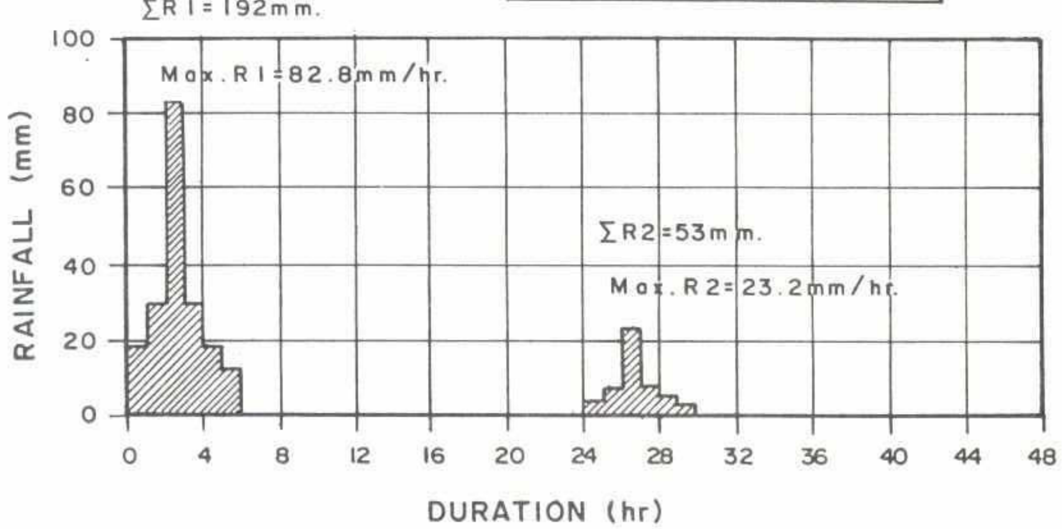
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

HOURLY DISTRIBUTION

hr	%	R1	R2
1	9	17.4	4.8
2	15	28.3	8.0
3	44	82.8	23.2
4	16	30.6	8.5
5	9	18.0	5.0
6	7	14.9	3.5
TOTAL	100	192.0	53.0



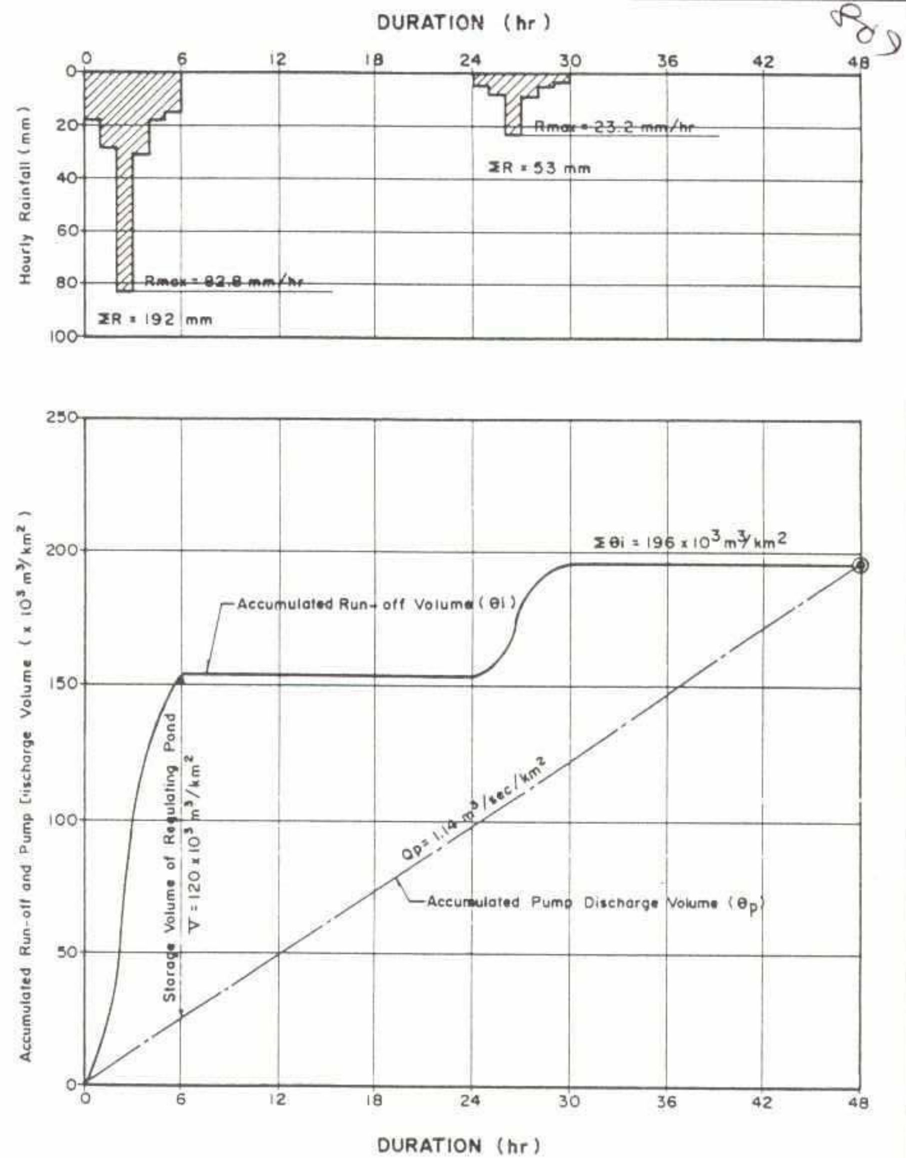
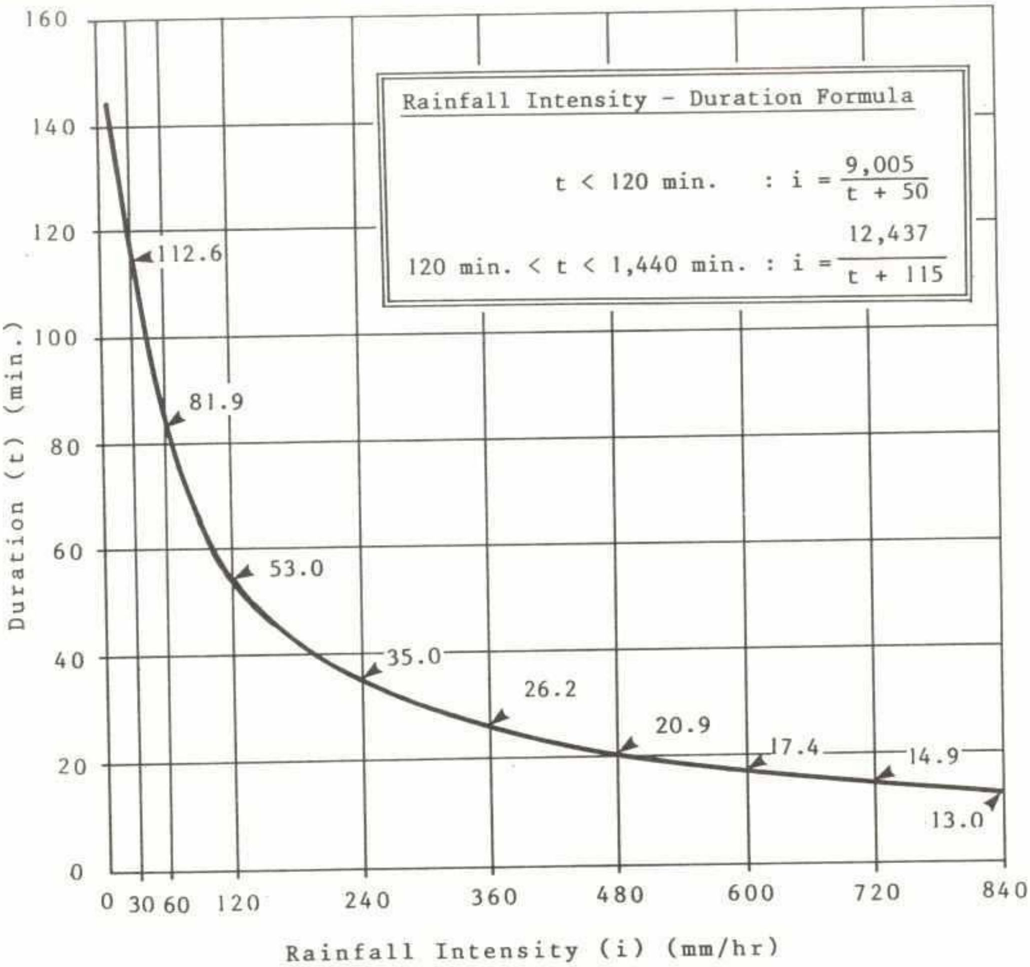
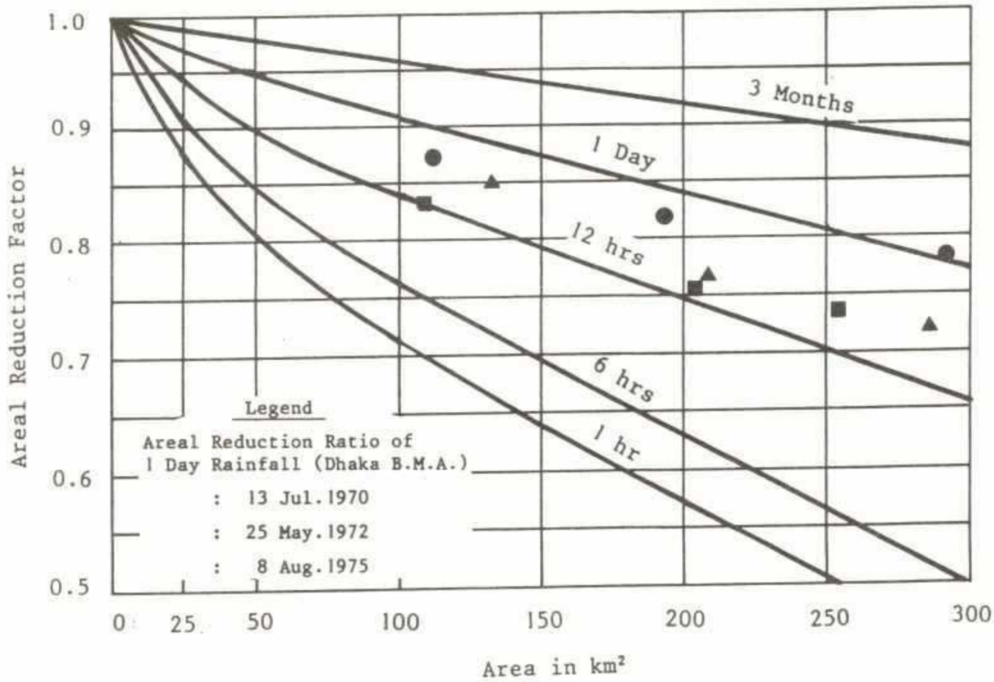


FIG. E.3.10 DESIGN RAINFALL FOR PUMP DRAINAGE PLAN AND DESIGN SPECIFIC REQUIREMENTS OF PUMP AND RETARDING POND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



Souece : JICA,Study on Storm Water Drainage System Improvement Project in Dhaka City,1987



Source : NEDECO,Master Plan for Drainage and Flood Control of Jakarta,1973

FIG. E.3.11 DESIGN RAINFALL AND AREAL REDUCTION CURVE FOR KHAL IMPROVEMENT PLAN

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

Drainage Zone Area

Area		
Greater Dhaka East Area		
- DC 1-A	:	A= 8.45 km²
- DC 1-B	:	A= 22.11 km²
- DC 2-B	:	A= 10.13 km²
- DC 2-C	:	A= 32.04 km²
- DC 3-B	:	A= 14.57 km²
- DC 4-B	:	A= 31.32 km²
Total	:	A=118.62 km²
Drainage Related Area		
- DC 2-A	:	A= 5.71 km²
- DC 3-A	:	A= 32.01 km²
- DC 4-A	:	A= 10.02 km²
Total	:	A= 47.74 km²
Combined Drainage Area		
- DC 1	:	A= 30.56 km²
- DC 2	:	A= 47.88 km²
- DC 3	:	A= 46.58 km²
- DC 4	:	A= 41.34 km²
Total	:	A=166.36 km²

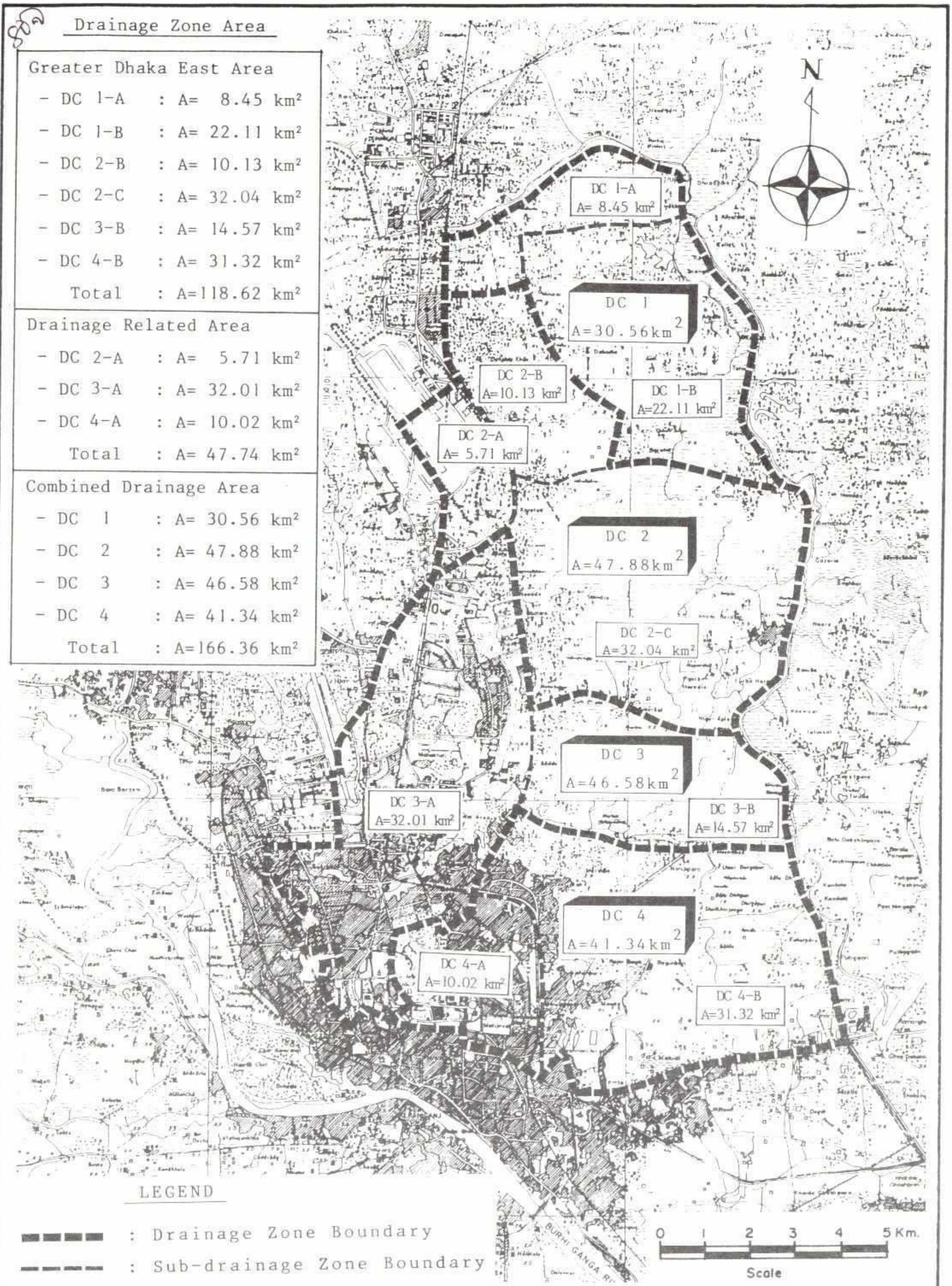


FIG. E.3.12 DRAINAGE ZONE : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

827

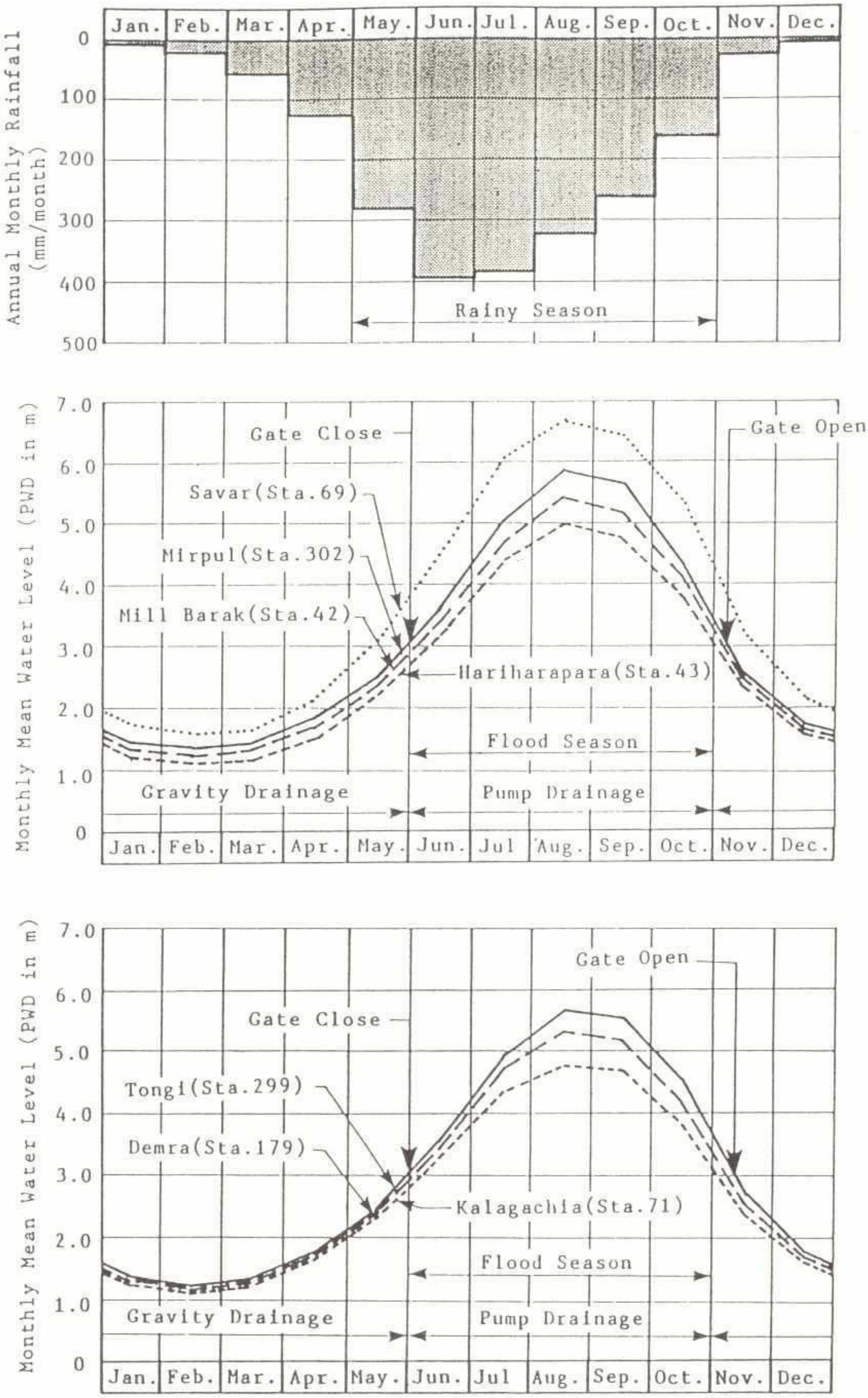
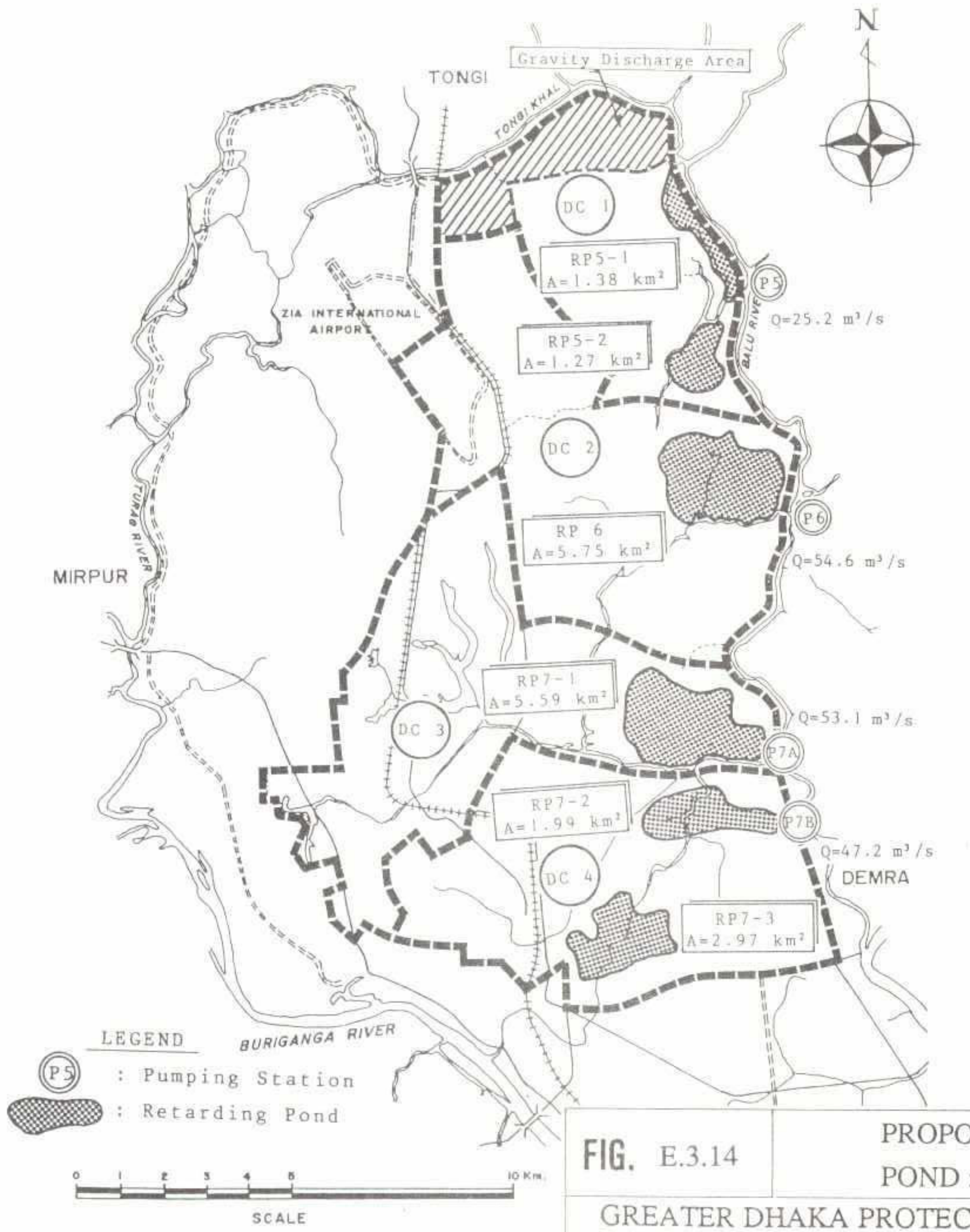


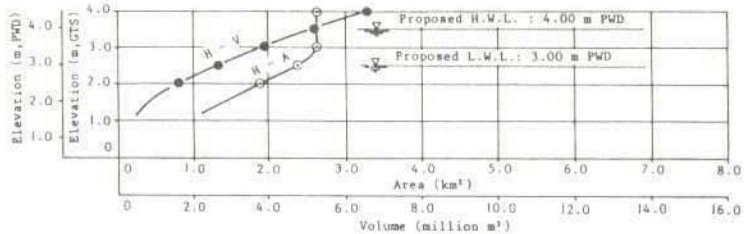
FIG. E.3.13 SEASONAL VARIATION OF RAINFALL AND FLOOD WATER LEVEL IN DHAKA METROPOLITAN AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

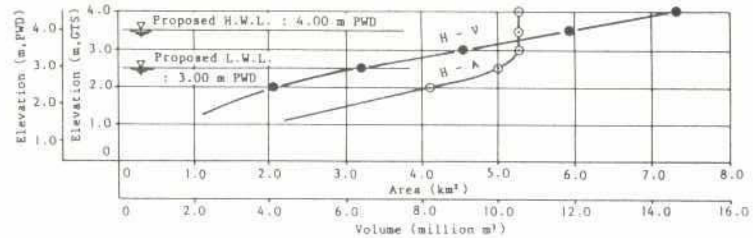
JICA

822

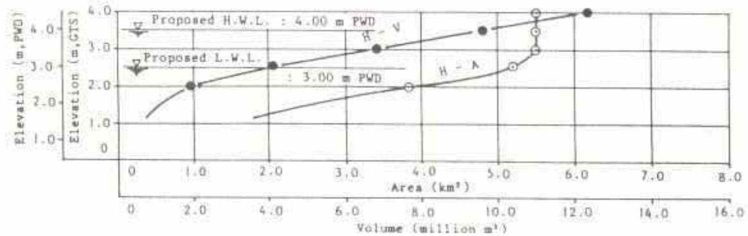




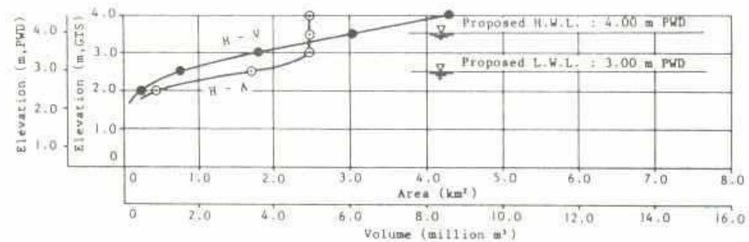
Retarding Pond : 5-1 and 5-2



Retarding Pond : 6



Retarding Pond : 7-1



Retarding Pond : 7-2 and 7-3

FIG. E.3.14 PROPOSED REQUIREMENTS OF PUMP AND RETARDING POND : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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Block No.	Drainage Area (km2)	Run-off Coefficient f
	(DC-1)	
DC-1-1	2.53	0.39
DC-1-2	3.95	0.40
DC-1-3	5.01	0.44
DC-1-4	1.76	0.38
DC-1-5	5.09	0.33
DC-1-6	3.77	0.32
DC-1-7	3.38	0.39
DC-1-8	2.57	0.39
DC-1-9	2.50	0.42
	(DC-2)	
DC-2-1	5.71	0.38
DC-2-2	1.79	0.40
DC-2-3	4.08	0.44
DC-2-4	2.97	0.45
DC-2-5	1.29	0.42
DC-2-6	4.54	0.34
DC-2-7	3.52	0.40
DC-2-8	2.36	0.35
DC-2-9	3.33	0.40
DC-2-10	1.25	0.38
DC-2-11	4.98	0.38
DC-2-12	1.34	0.38
DC-2-13	1.23	0.35
DC-2-14	4.48	0.24
DC-2-15	5.01	0.25
	(DC-3)	
DC-3-1	8.81	0.47
DC-3-2	3.23	0.50
DC-3-3	5.54	0.42
DC-3-4	7.24	0.43
DC-3-5	6.29	0.43
DC-3-6	2.38	0.42
DC-3-7	3.42	0.38
DC-3-8	2.09	0.34
DC-3-9	1.86	0.30
DC-3-10	4.10	0.27
DC-3-11	0.69	0.40
DC-3-12	0.93	0.27
	(DC-4)	
DC-4-1	7.25	0.47
DC-4-2	2.11	0.48
DC-4-3	3.67	0.47
DC-4-4	1.03	0.43
DC-4-5	2.72	0.44
DC-4-6	0.61	0.44
DC-4-7	2.49	0.46
DC-4-8	0.70	0.29
DC-4-9	1.39	0.36
DC-4-10	5.30	0.37
DC-4-11	3.24	0.35
DC-4-12	2.91	0.44
DC-4-13	2.56	0.46
DC-4-14	0.30	0.29
DC-4-15	1.11	0.26
DC-4-16	1.10	0.43
DC-4-17	0.30	0.46
DC-4-18	1.96	0.44
DC-4-19	0.59	0.46

LEGEND

: Drainage Zone Boundary

: Sub-drainage Zone Boundary

DC-2-14 : Block No. of Sub-drainage Zone

: Khal

0 1 2 3 4 5 Km.

Scale

FIG. E.3.15 SUB-DRAINAGE ZONE AND THEIR RUN-OFF COEFFICIENT : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

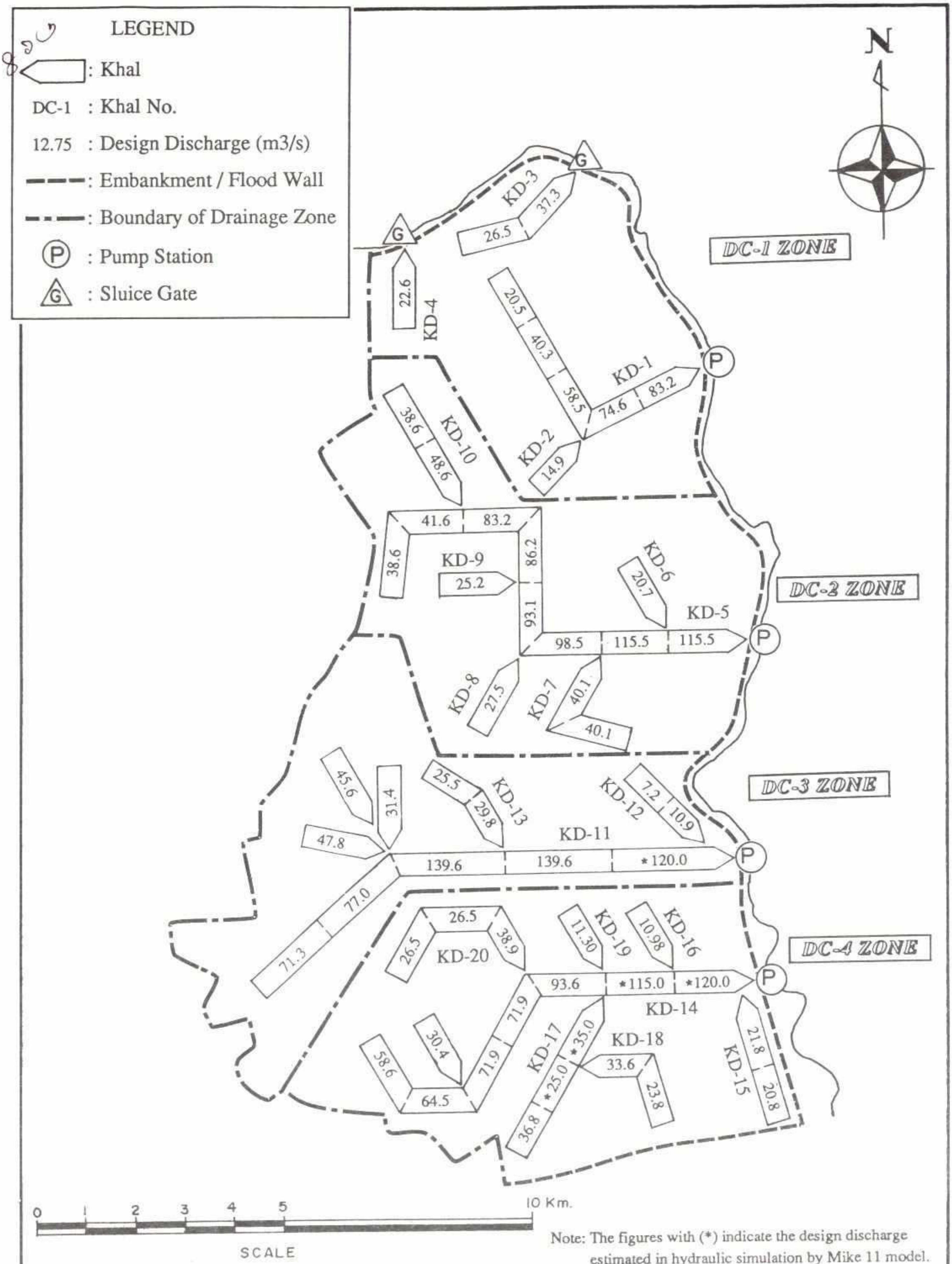

FIG. E.3.16 DESIGN DISCHARGE FOR KHAL IMPROVEMENTS : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

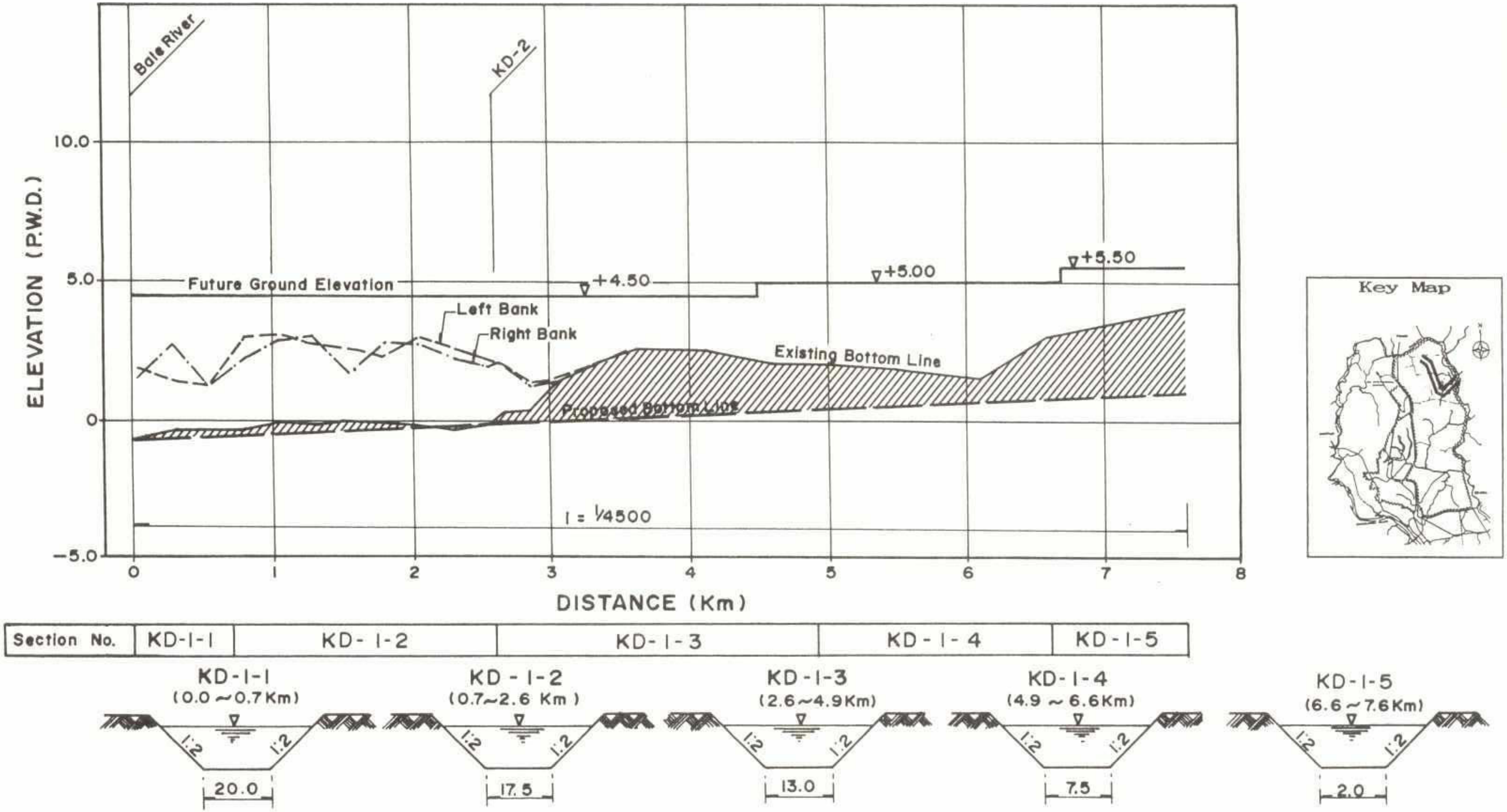

FIG. E.3.17(1) PROPOSED LONGITUDINAL AND CROSS SECTIONS (KD-1)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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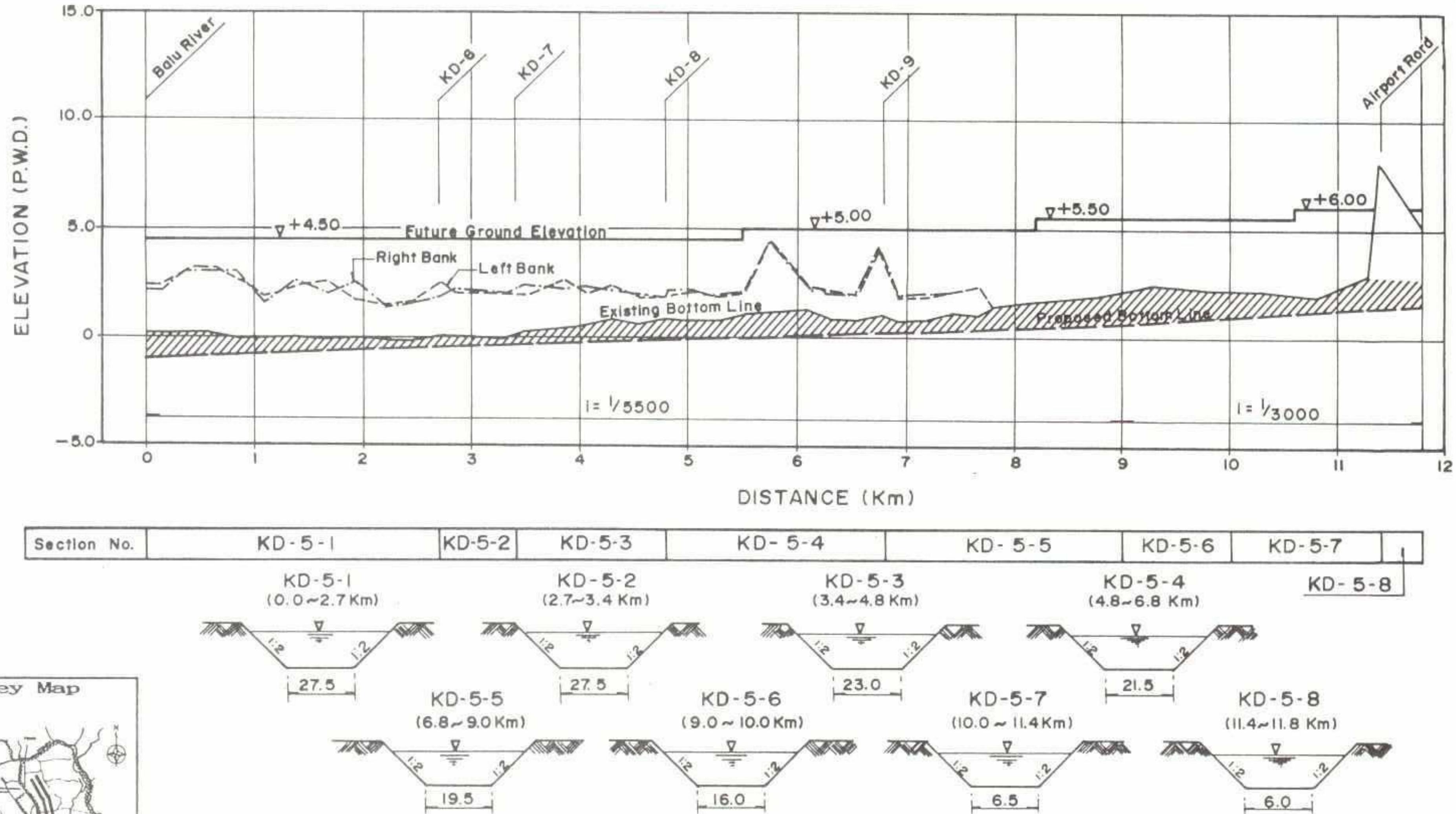


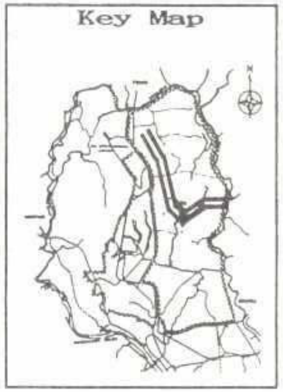
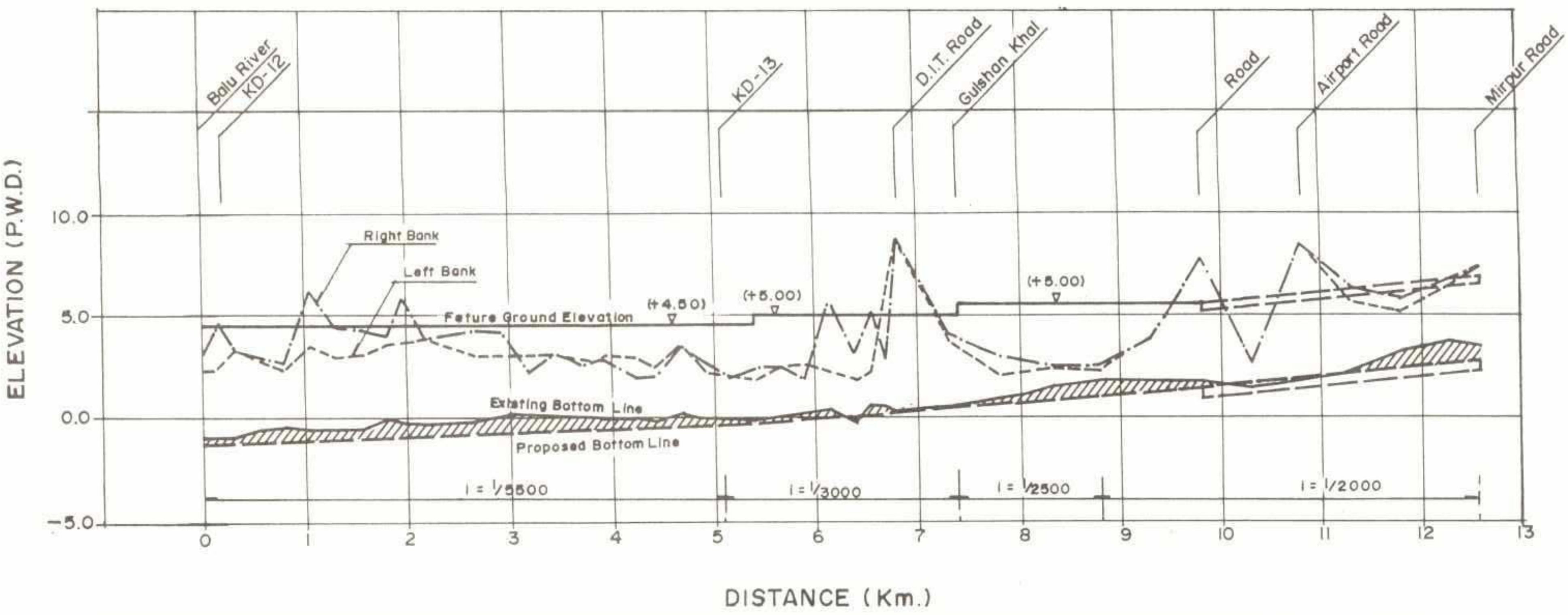
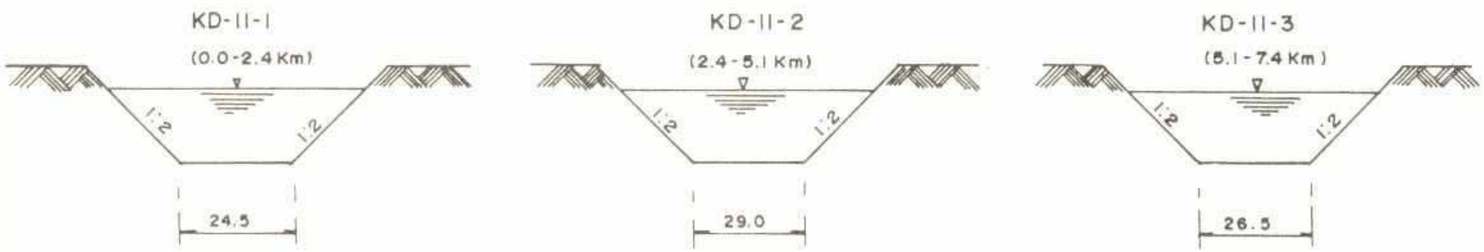


FIG. E.3.17(2) PROPOSED LONGITUDINAL AND CROSS SECTIONS (KD-5)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



Section No.	KD-11-1	KD-11-2	KD-11-3	(A.D.B. Project Area)



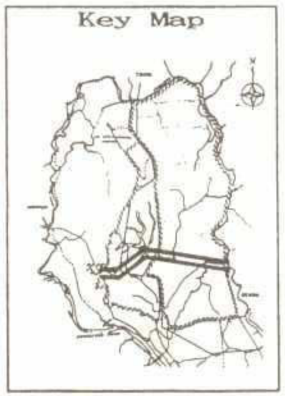
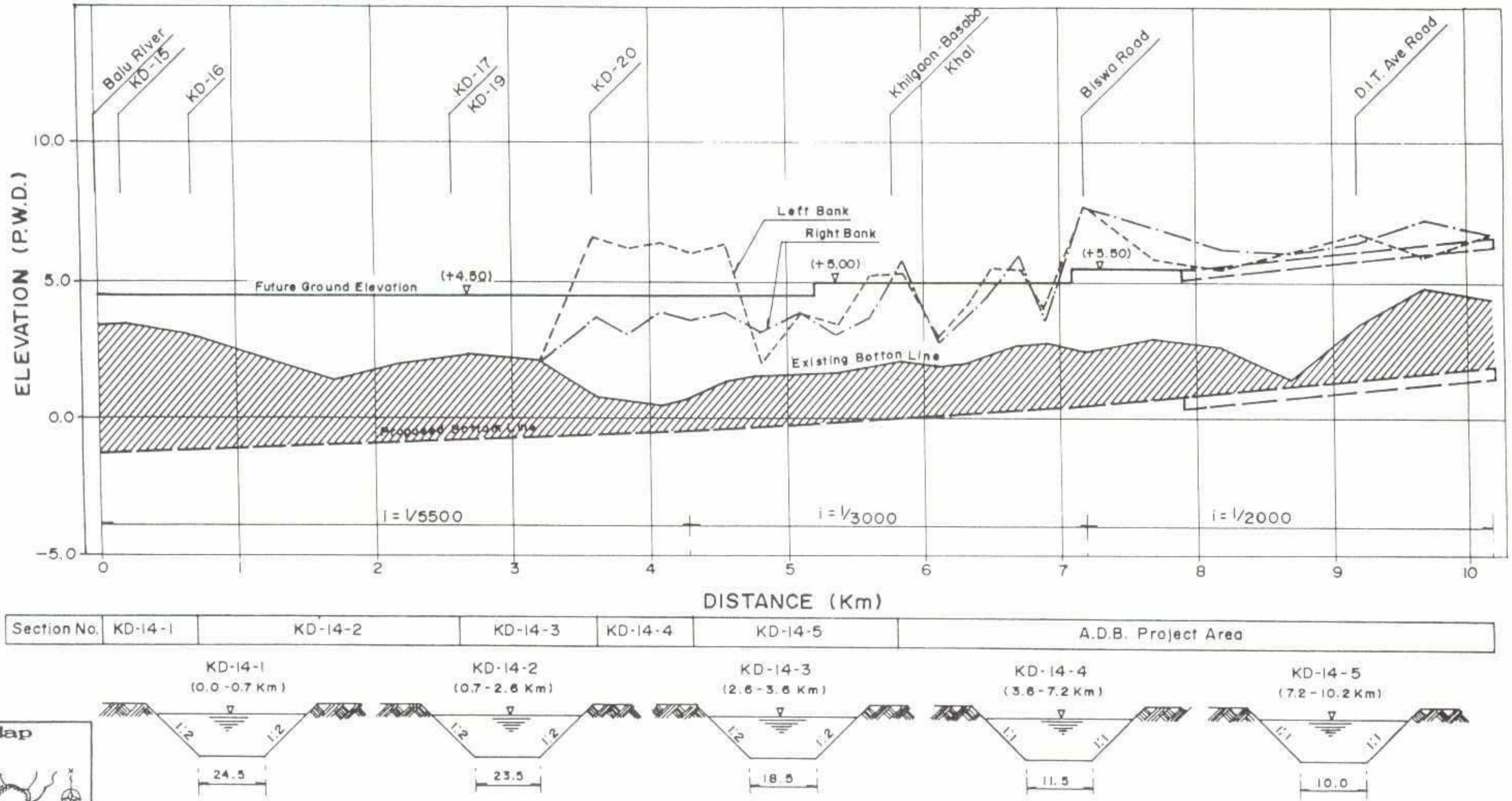


FIG. E.3.17(3) PROPOSED LONGITUDINAL AND CROSS SECTIONS (KD-11)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

85

829



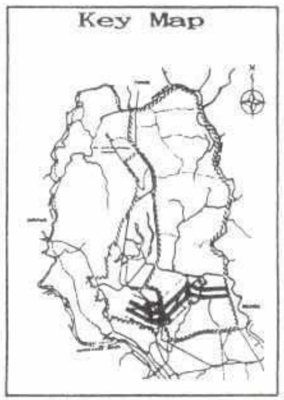


FIG. E.3.17(4) PROPOSED LONGITUDINAL AND CROSS SECTIONS (KD-14)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

8ɔ1

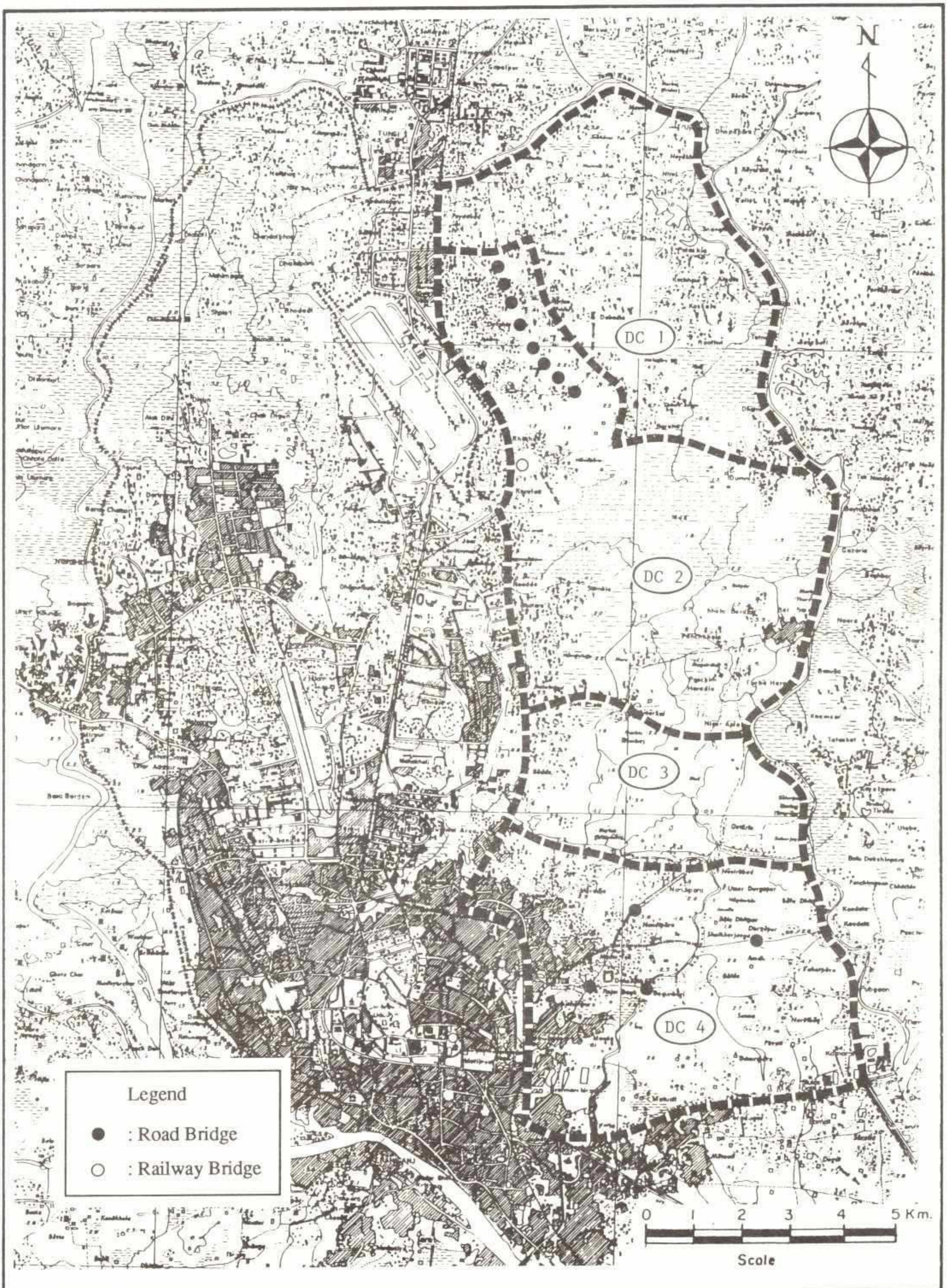


FIG. E.3.18 | LOCATION OF PROPOSED BRIDGES : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

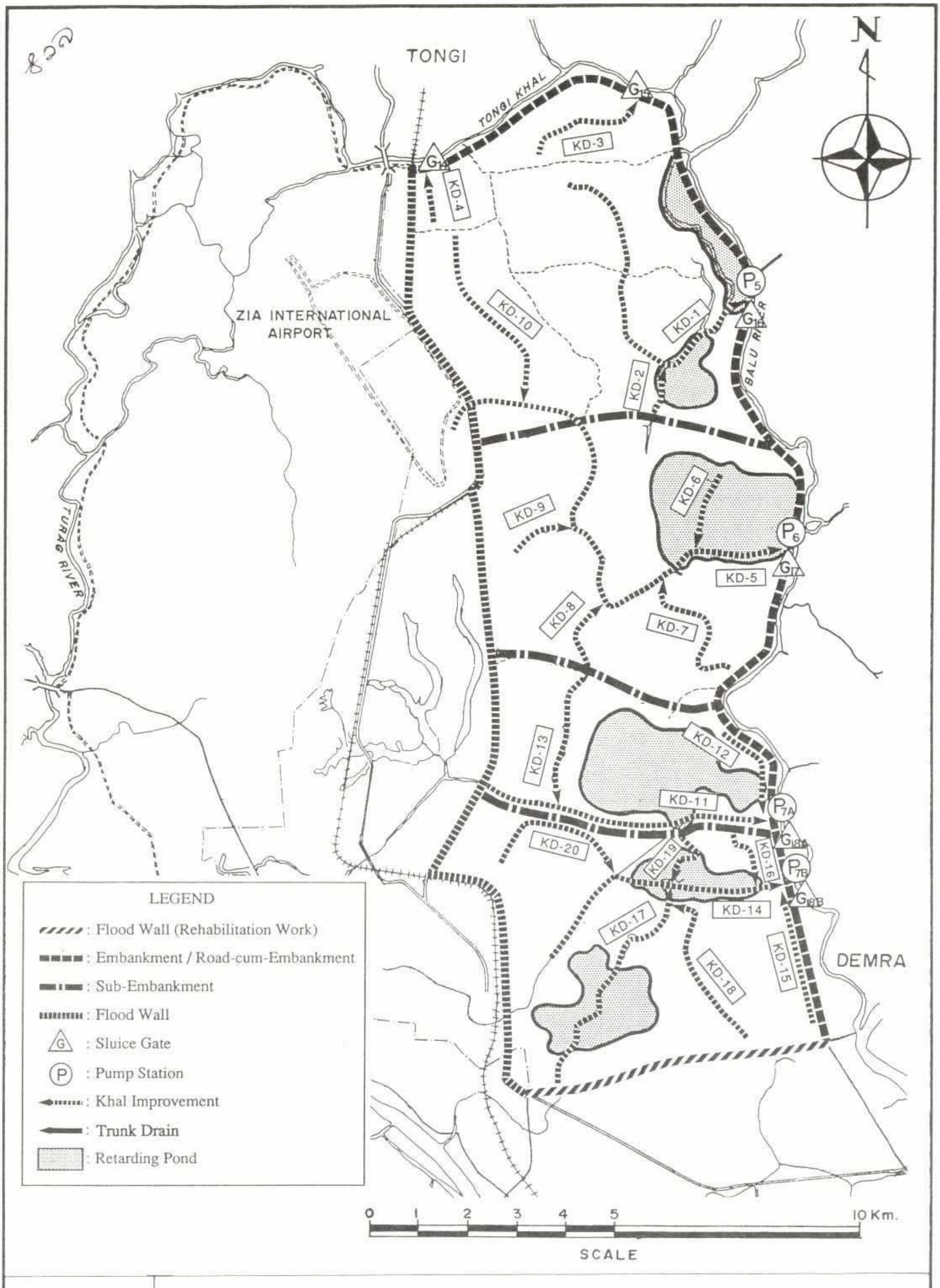


FIG. E.3.19 PROPOSED FACILITIES : GREATER DHAKA EAST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

820

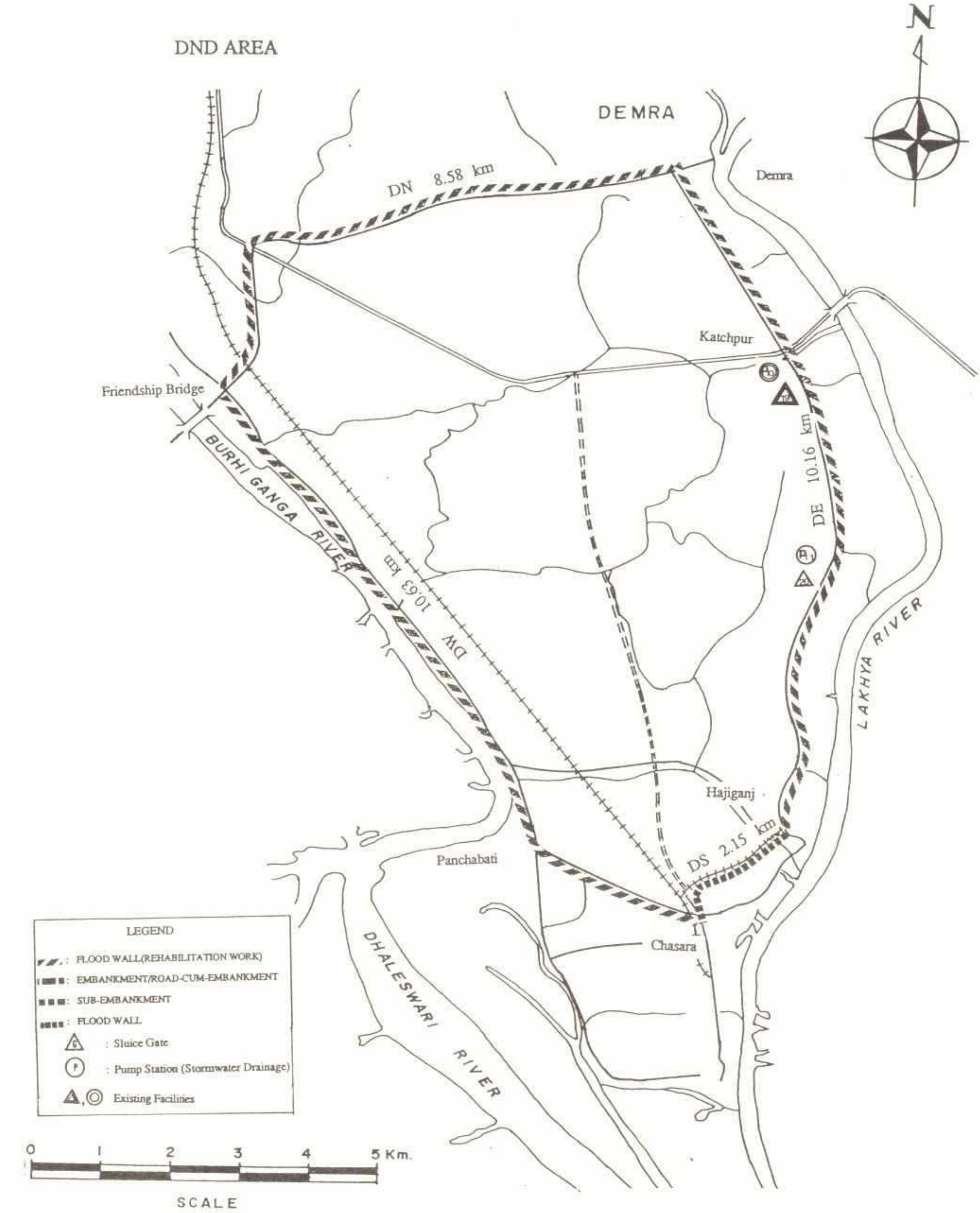
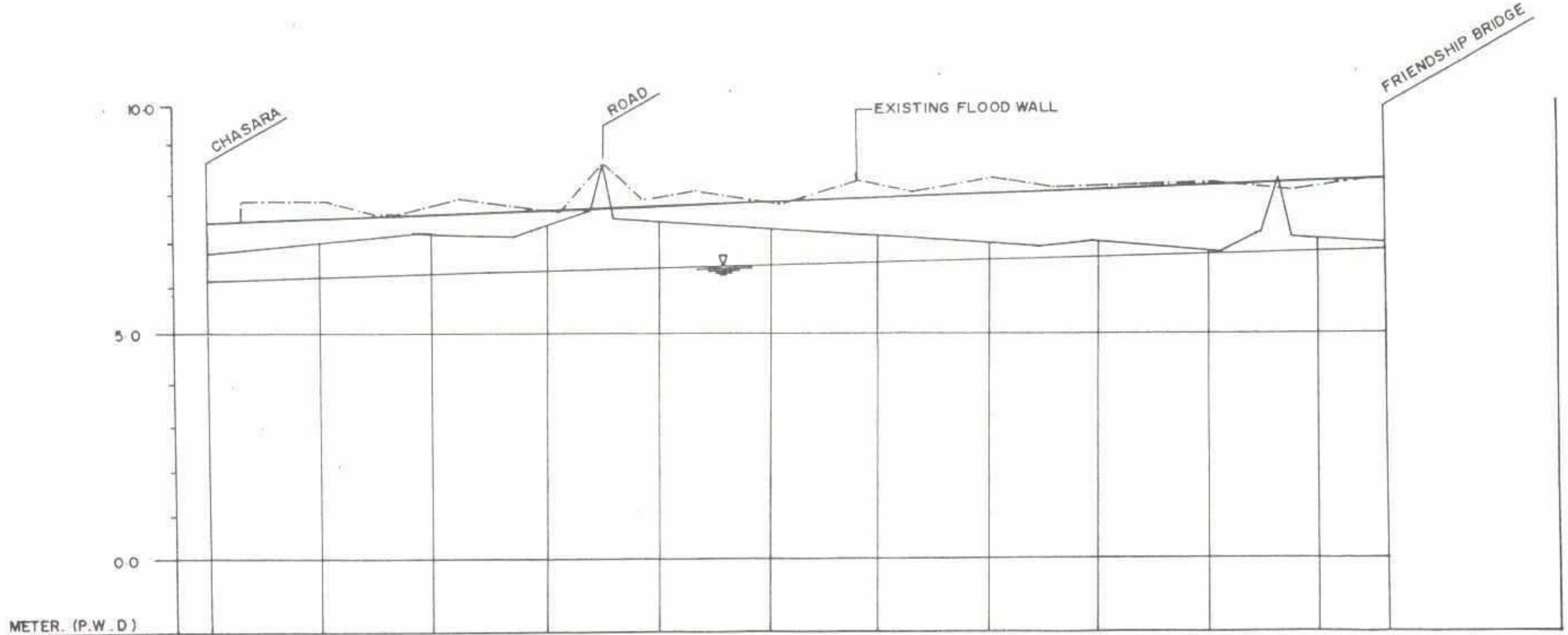


FIG. E.4.1 ALIGNMENT OF FLOOD WALL : DND AREA

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

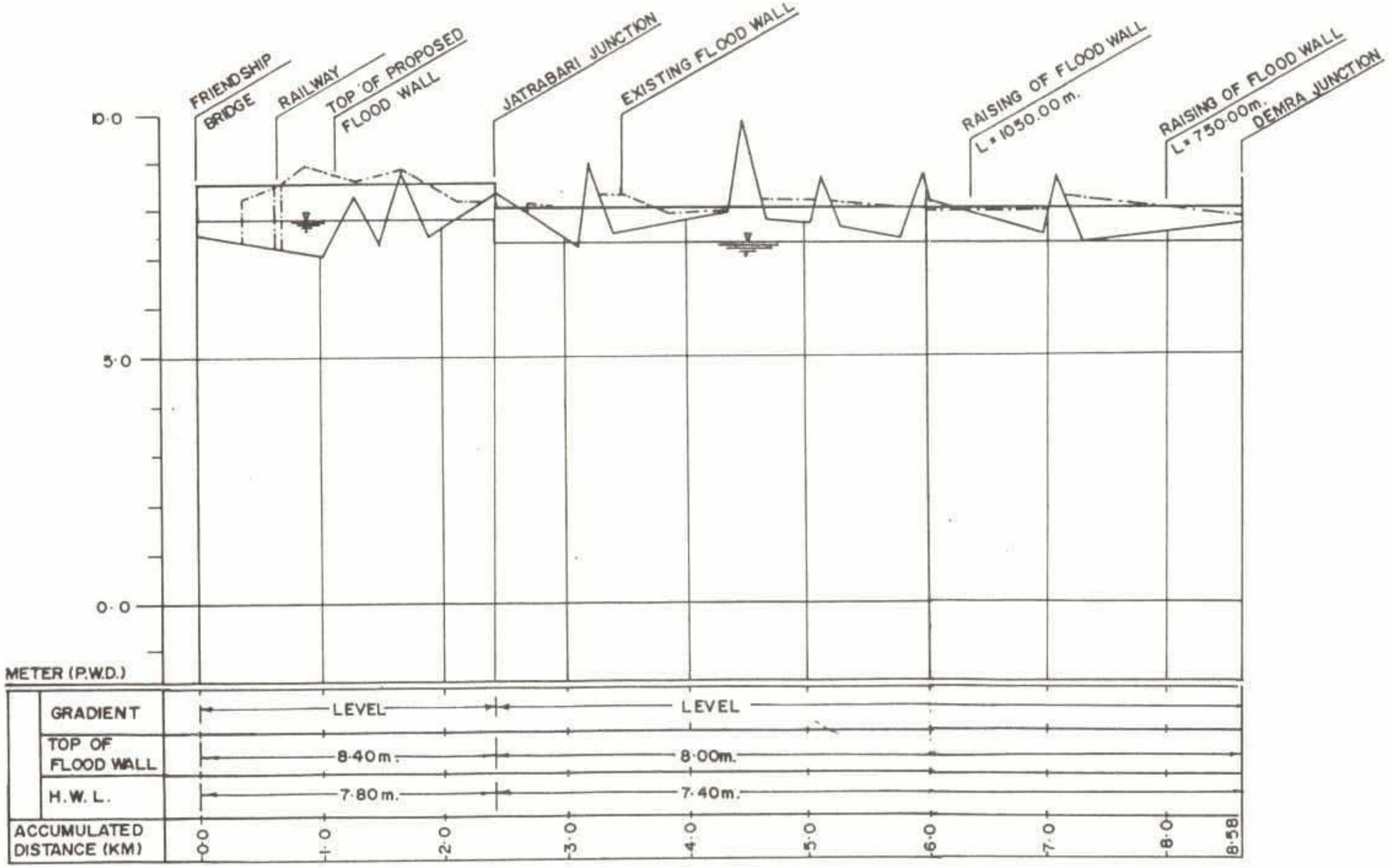
8R2



DESIGNED GRADIENT	I=1/10,420			I=1/13,540								
DESIGNED TOP OF FLOOD WALL	7.56	7.65	7.75	7.84	7.91	7.98	8.06	8.13	8.20	8.28	8.35	8.40
DESIGNED H. W. L.	6.96	7.06	7.15	7.24	7.31	7.38	7.46	7.53	7.60	7.68	7.75	7.80
ACCUMULATED DISTANCE (KM)	0.0	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0	10.63

FIG. E.4.2(1) LONGITUDINAL SECTION OF FLOOD WALL : DND (DW)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



822

FIG. E.4.2(2) LONGITUDINAL SECTION OF FLOOD WALL : DND (DN)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

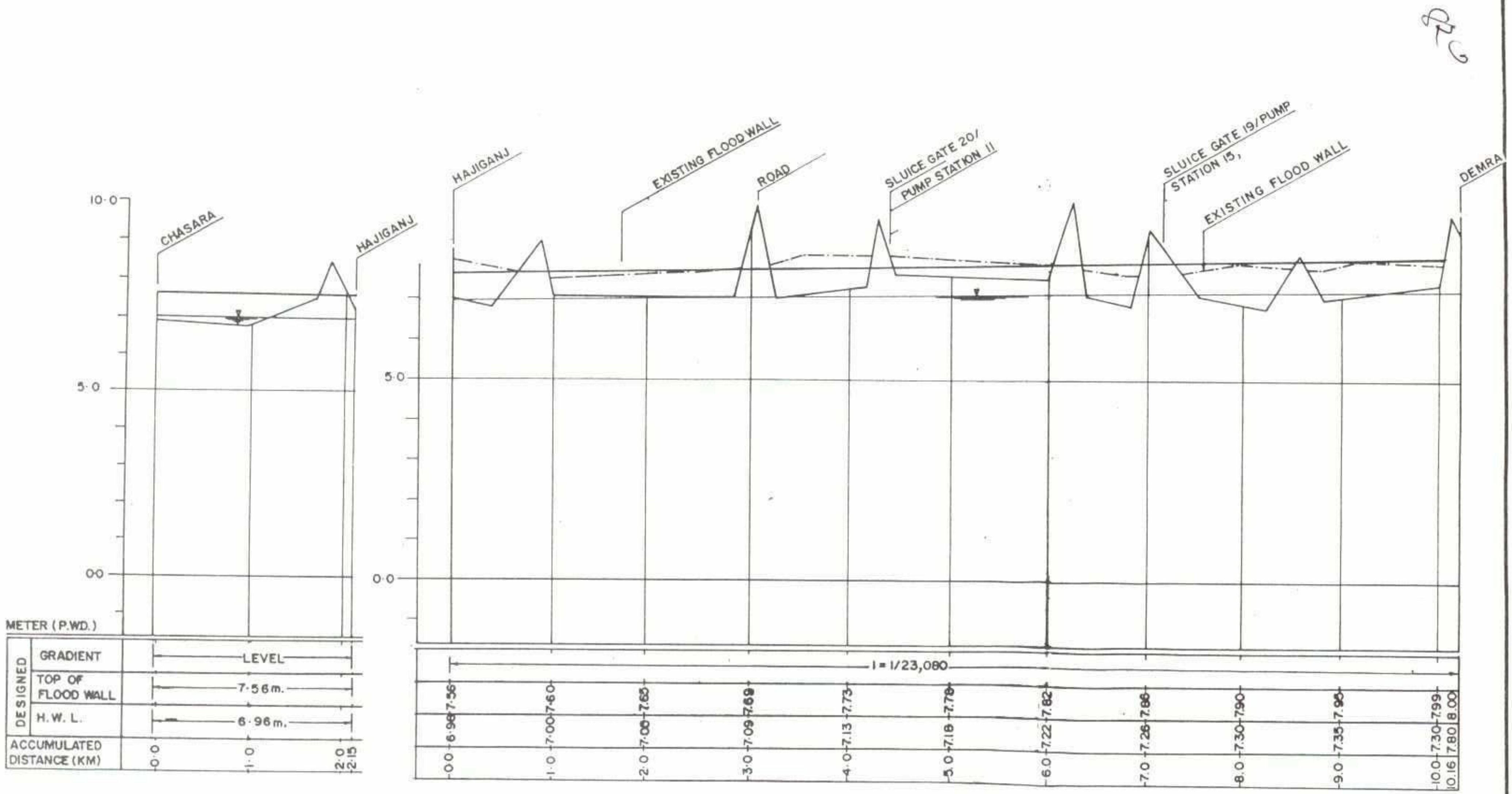


FIG. E.4.2(3) LONGITUDINAL SECTION OF FLOOD WALL : DND (DS AND DE)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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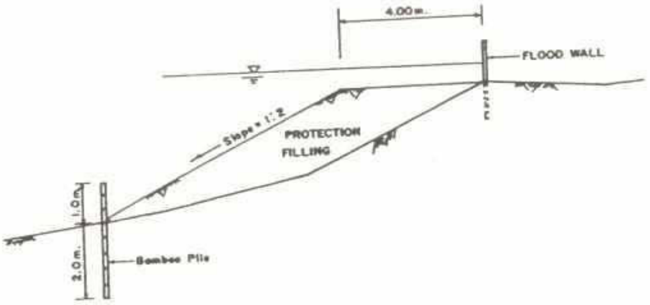
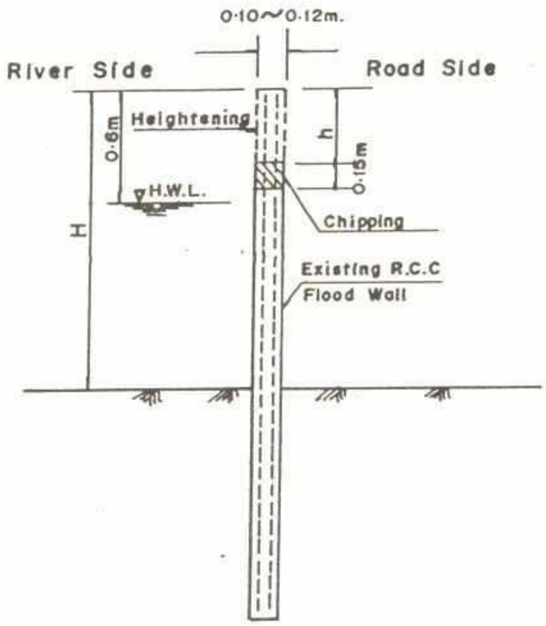
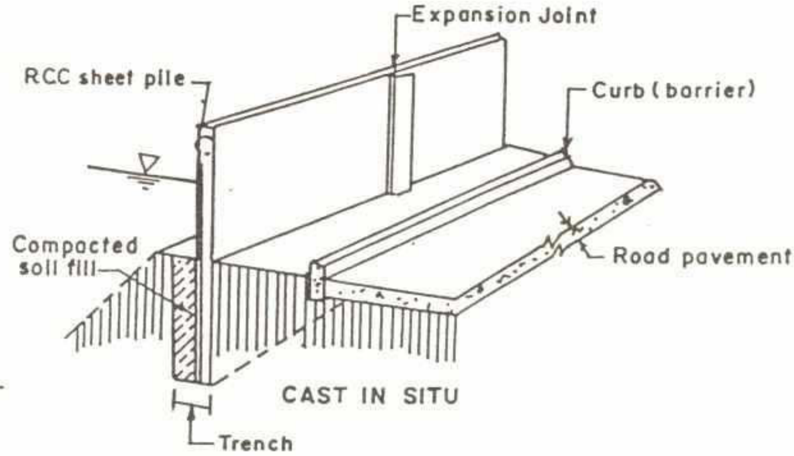
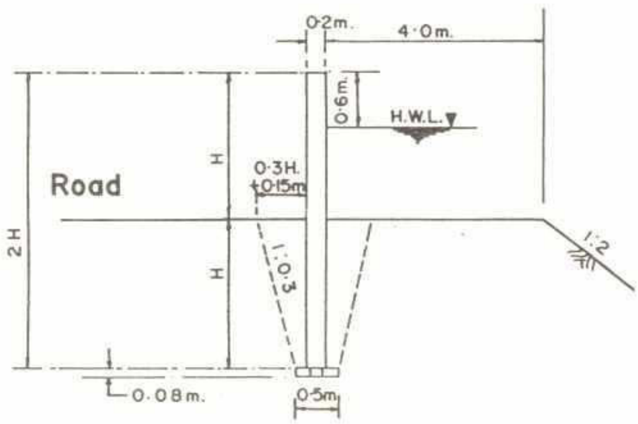






TYPICAL SECTION OF FLOOD WALL

TYPICAL SECTION OF FLOOD WALL



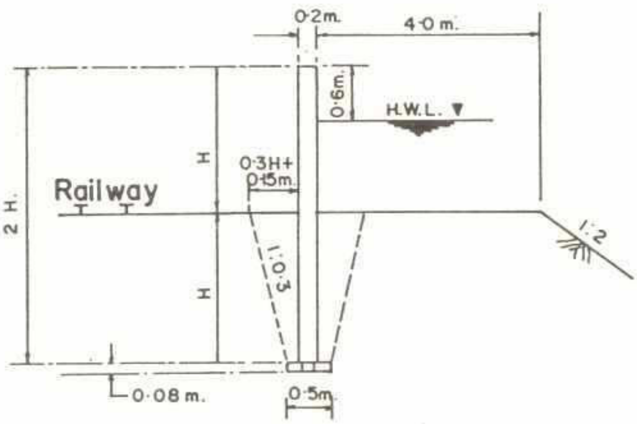


FIG. E.4.3	TYPICAL SECTIONS OF FLOOD WALL REHABILITATION WORKS

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

824

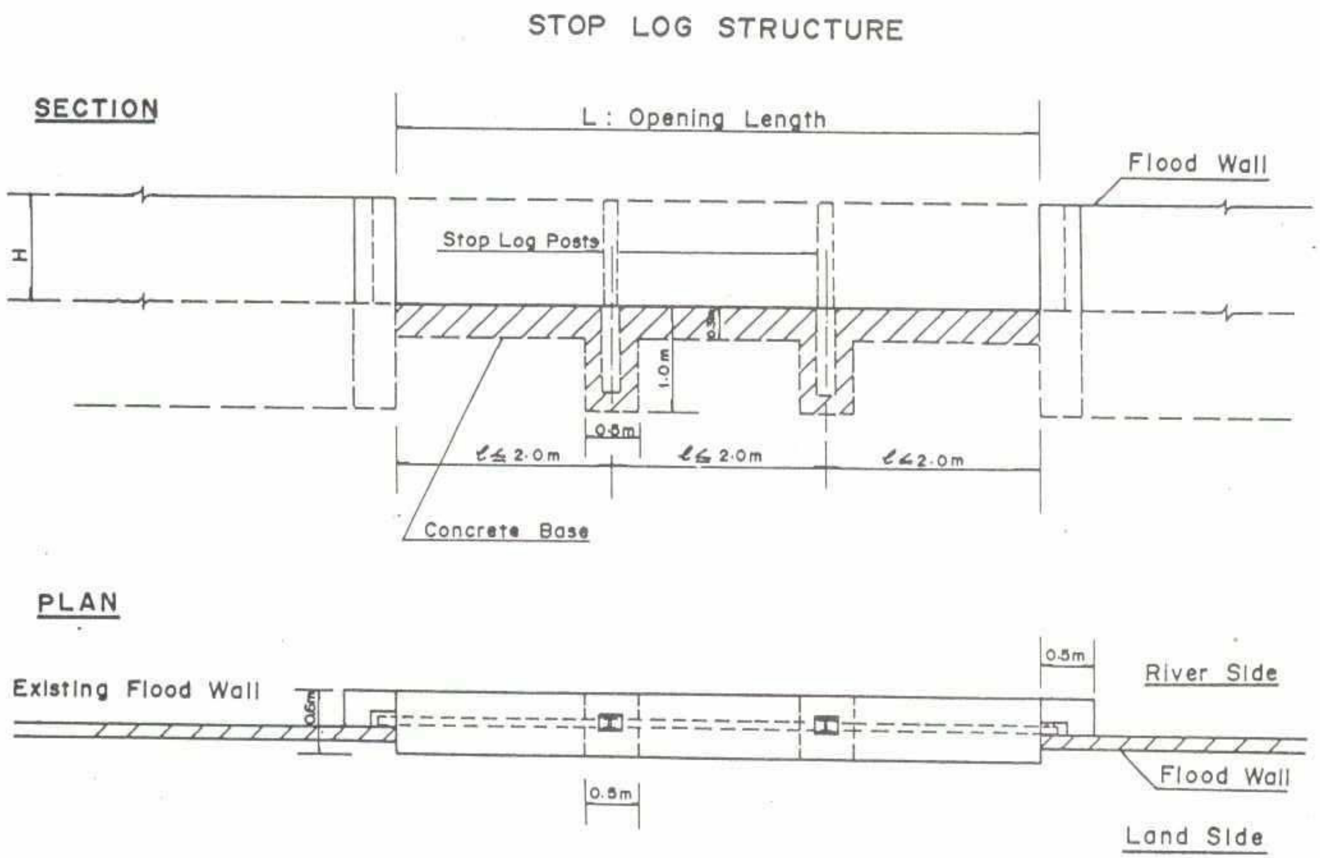
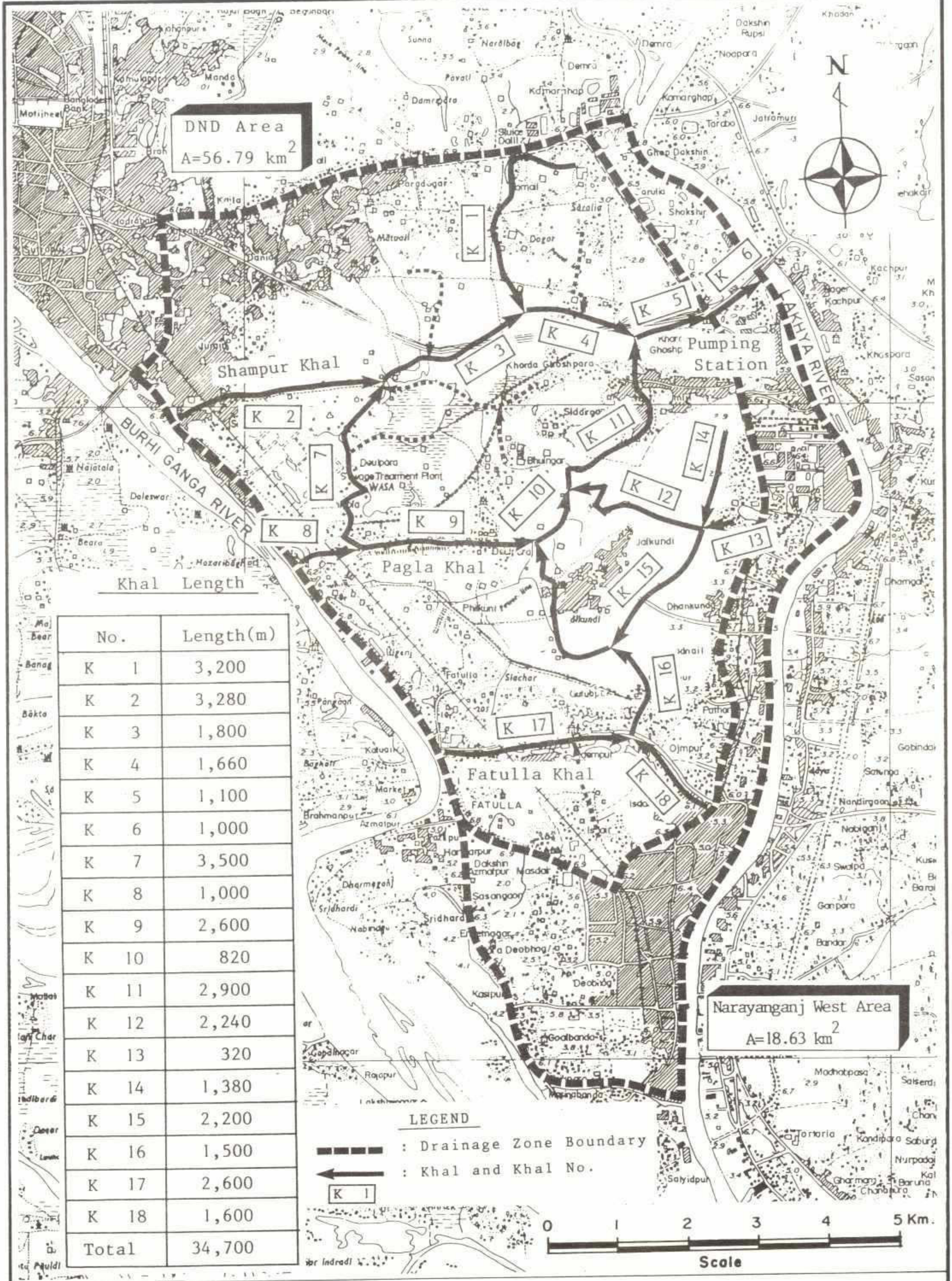


FIG. E.4.4 TYPICAL SECTION OF STOP LOG STRUCTURE

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

823



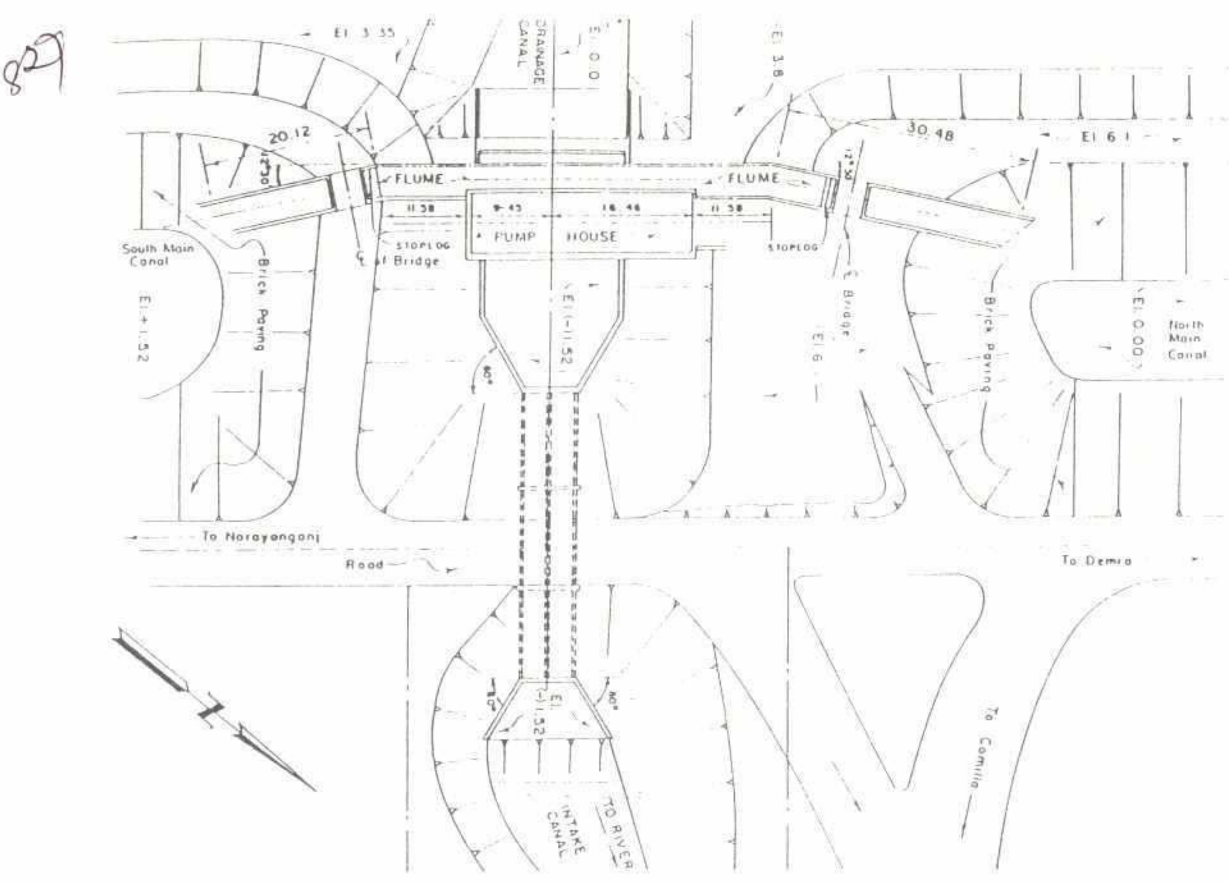
Khal Length

No.	Length(m)
K 1	3,200
K 2	3,280
K 3	1,800
K 4	1,660
K 5	1,100
K 6	1,000
K 7	3,500
K 8	1,000
K 9	2,600
K 10	820
K 11	2,900
K 12	2,240
K 13	320
K 14	1,380
K 15	2,200
K 16	1,500
K 17	2,600
K 18	1,600
Total	34,700

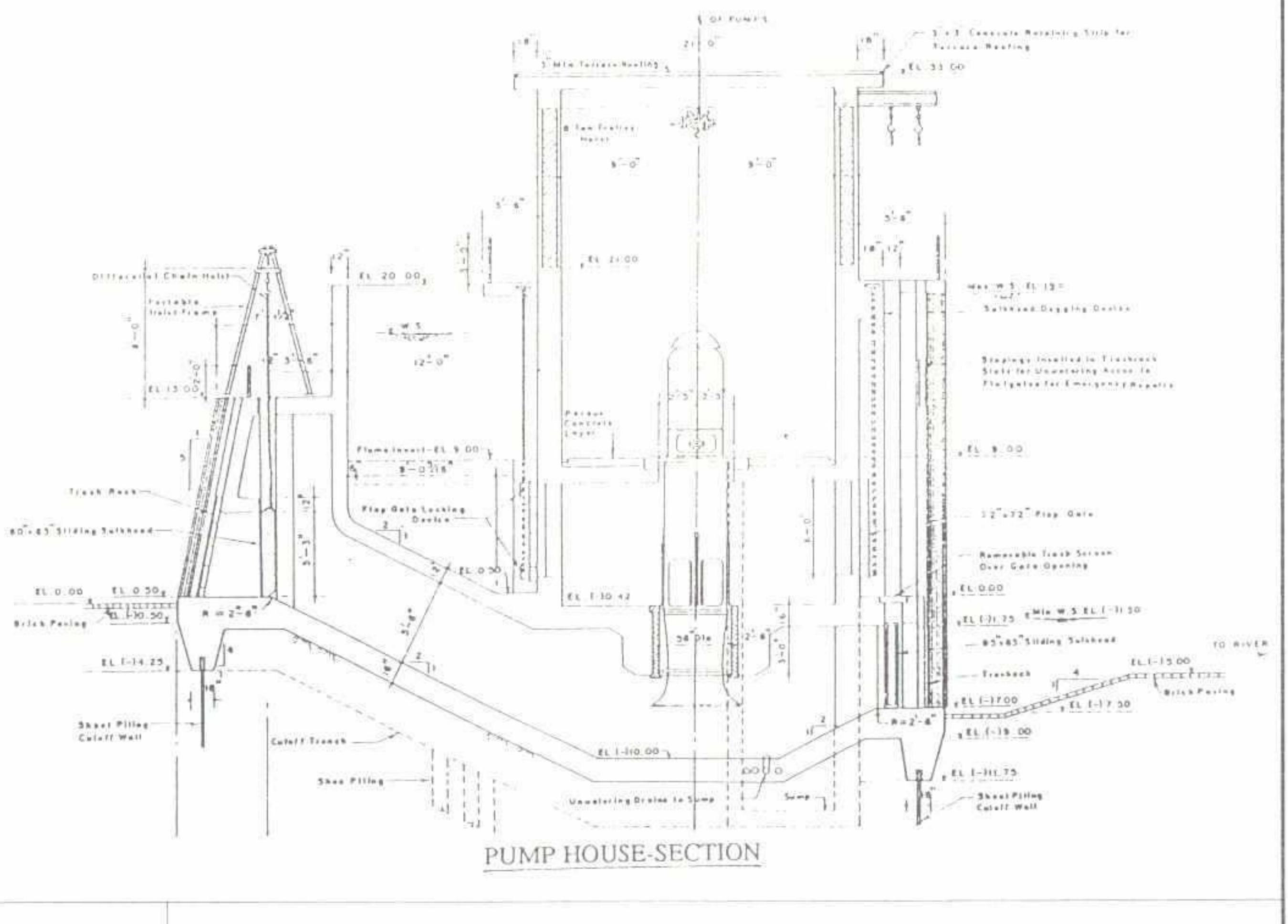
FIG. E.4.5 EXISTING MAJOR KHALS : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA



KEY PLAN FOR PUMPING PLANT



PUMP HOUSE-SECTION

FIG. E.4.6	EXISTING DEMRA PUMPING STATION

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

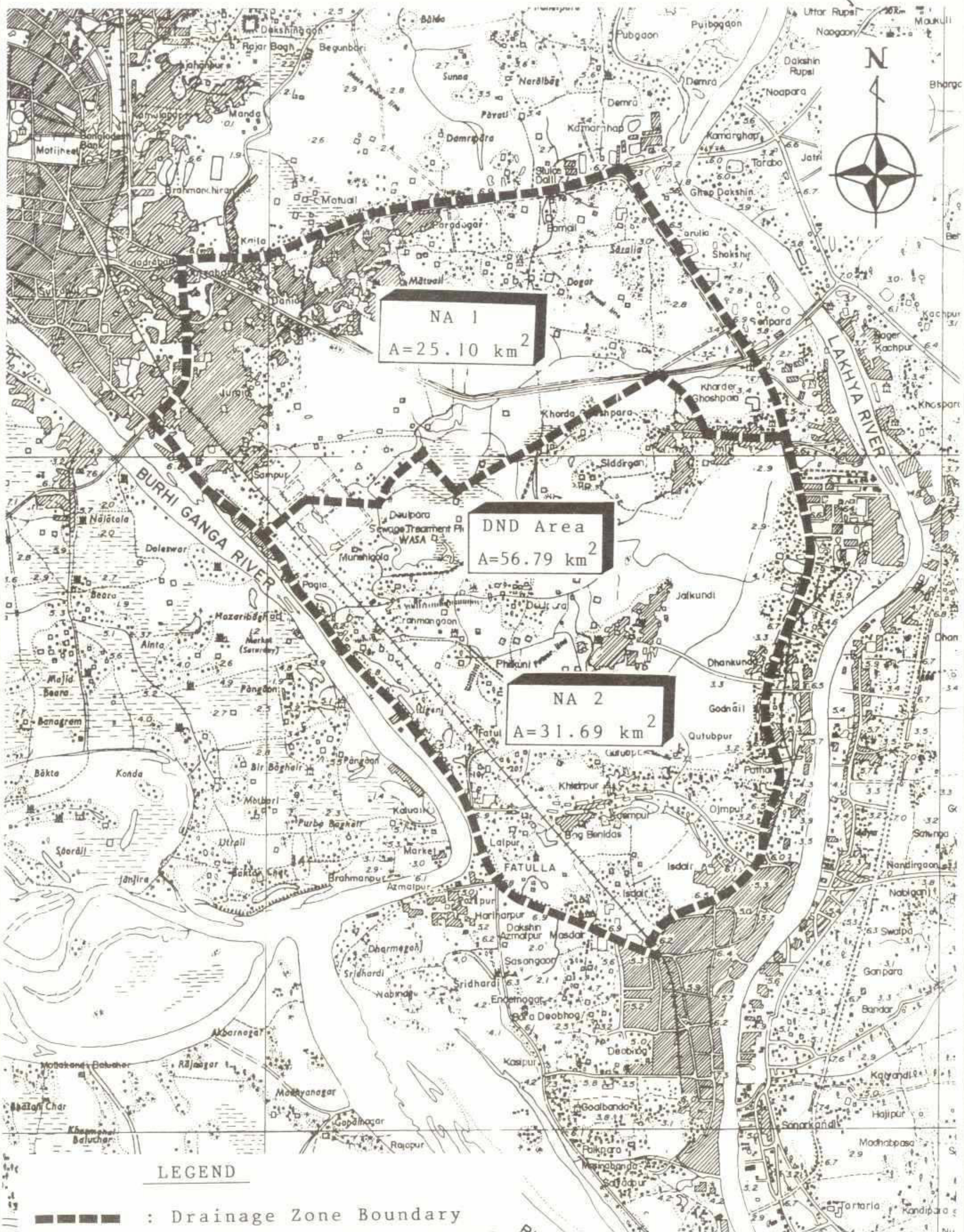


FIG. E.4.7 DRAINAGE ZONE : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

822

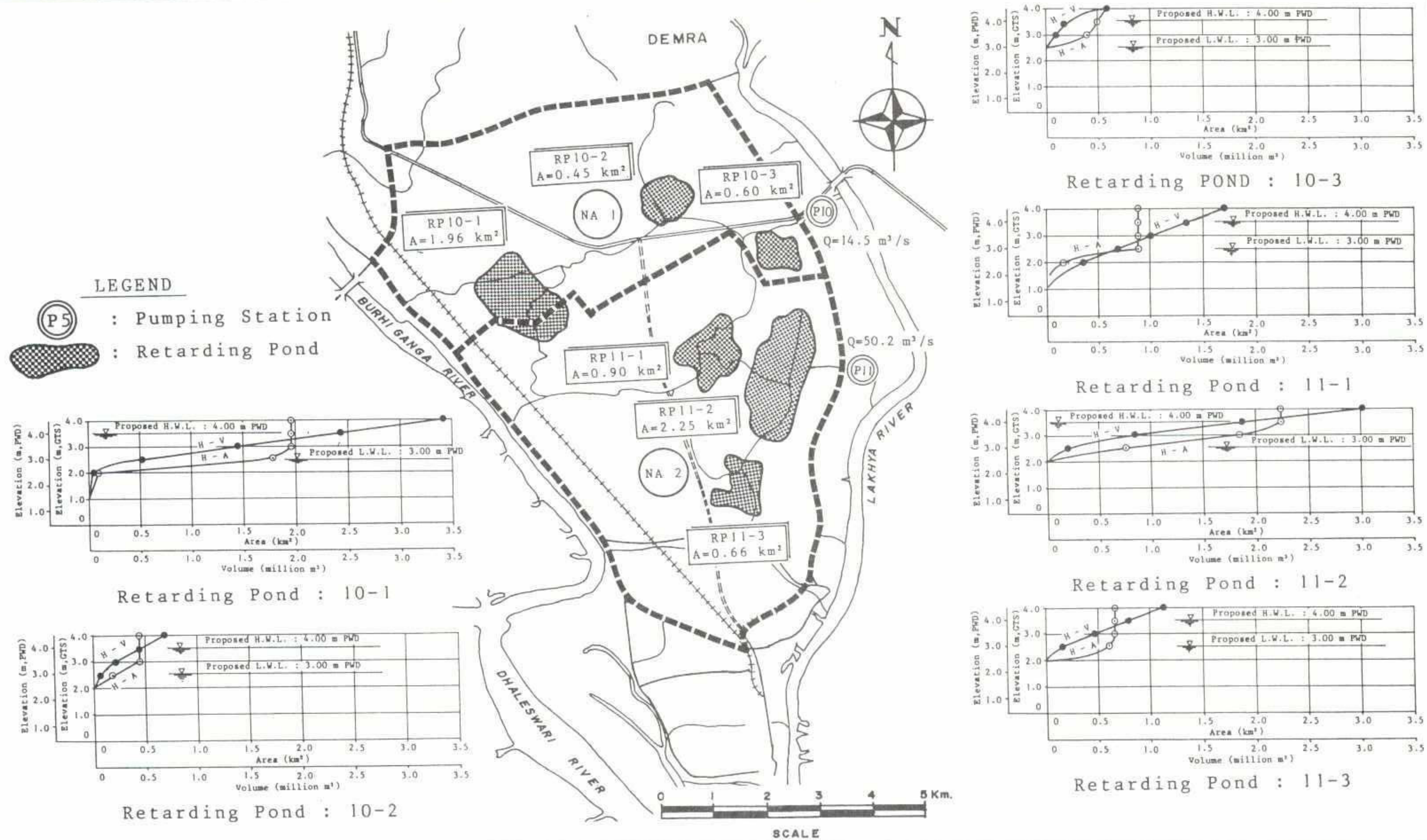
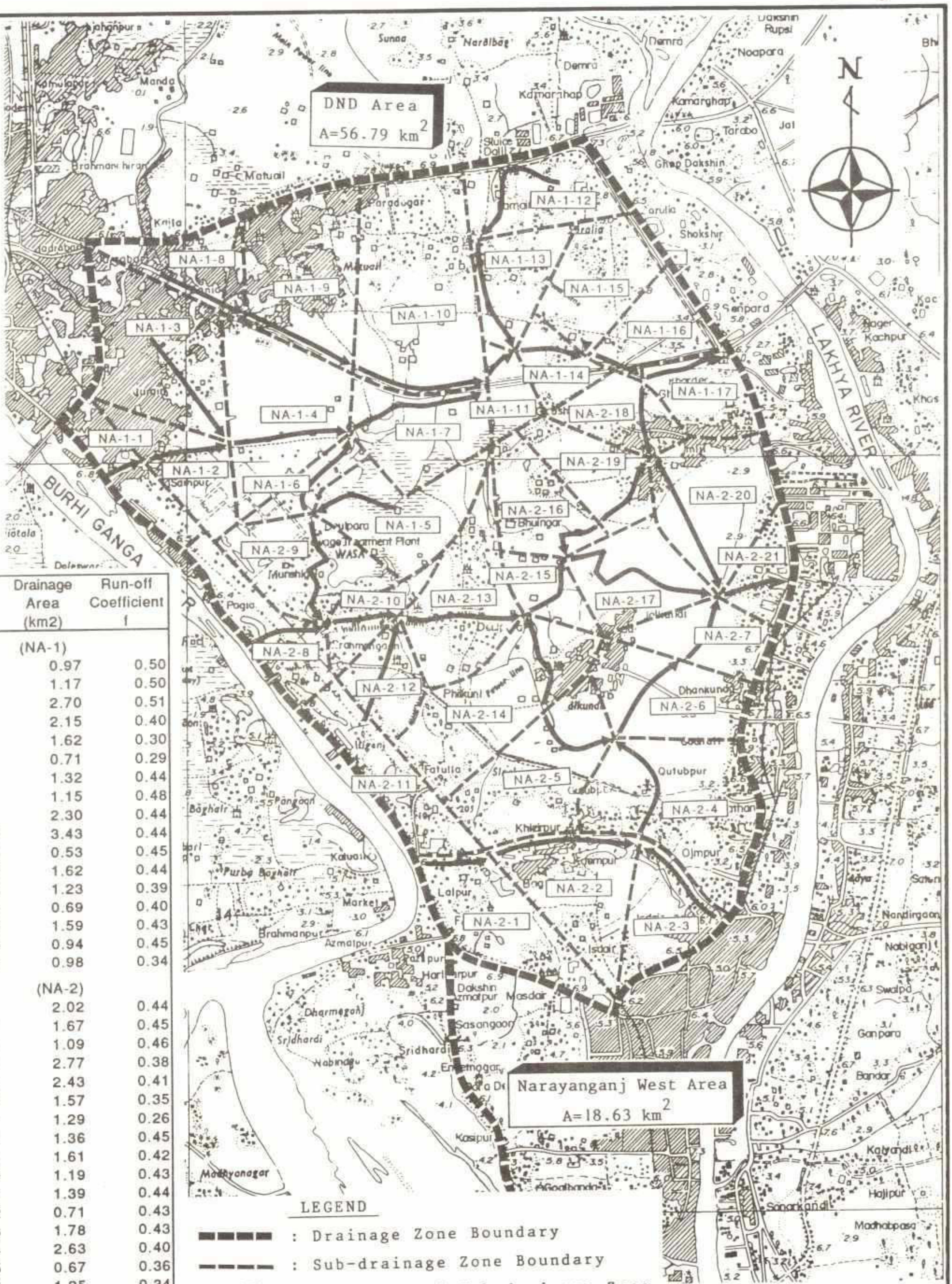


FIG. E.4.8 PROPOSED REQUIREMENTS OF PUMP STATION AND RETARDING POND : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

860



Block No.	Drainage Area (km2)	Run-off Coefficient f
	(NA-1)	
NA-1-1	0.97	0.50
NA-1-2	1.17	0.50
NA-1-3	2.70	0.51
NA-1-4	2.15	0.40
NA-1-5	1.62	0.30
NA-1-6	0.71	0.29
NA-1-7	1.32	0.44
NA-1-8	1.15	0.48
NA-1-9	2.30	0.44
NA-1-10	3.43	0.44
NA-1-11	0.53	0.45
NA-1-12	1.62	0.44
NA-1-13	1.23	0.39
NA-1-14	0.69	0.40
NA-1-15	1.59	0.43
NA-1-16	0.94	0.45
NA-1-17	0.98	0.34
	(NA-2)	
NA-2-1	2.02	0.44
NA-2-2	1.67	0.45
NA-2-3	1.09	0.46
NA-2-4	2.77	0.38
NA-2-5	2.43	0.41
NA-2-6	1.57	0.35
NA-2-7	1.29	0.26
NA-2-8	1.36	0.45
NA-2-9	1.61	0.42
NA-2-10	1.19	0.43
NA-2-11	1.39	0.44
NA-2-12	0.71	0.43
NA-2-13	1.78	0.43
NA-2-14	2.63	0.40
NA-2-15	0.67	0.36
NA-2-16	1.25	0.34
NA-2-17	1.56	0.28
NA-2-18	0.90	0.41
NA-2-19	1.51	0.44
NA-2-20	1.76	0.41
NA-2-21	0.53	0.45

FIG. E.4.9 SUB-DRAINAGE ZONE AND THEIR RUN-OFF COEFFICIENT : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

802

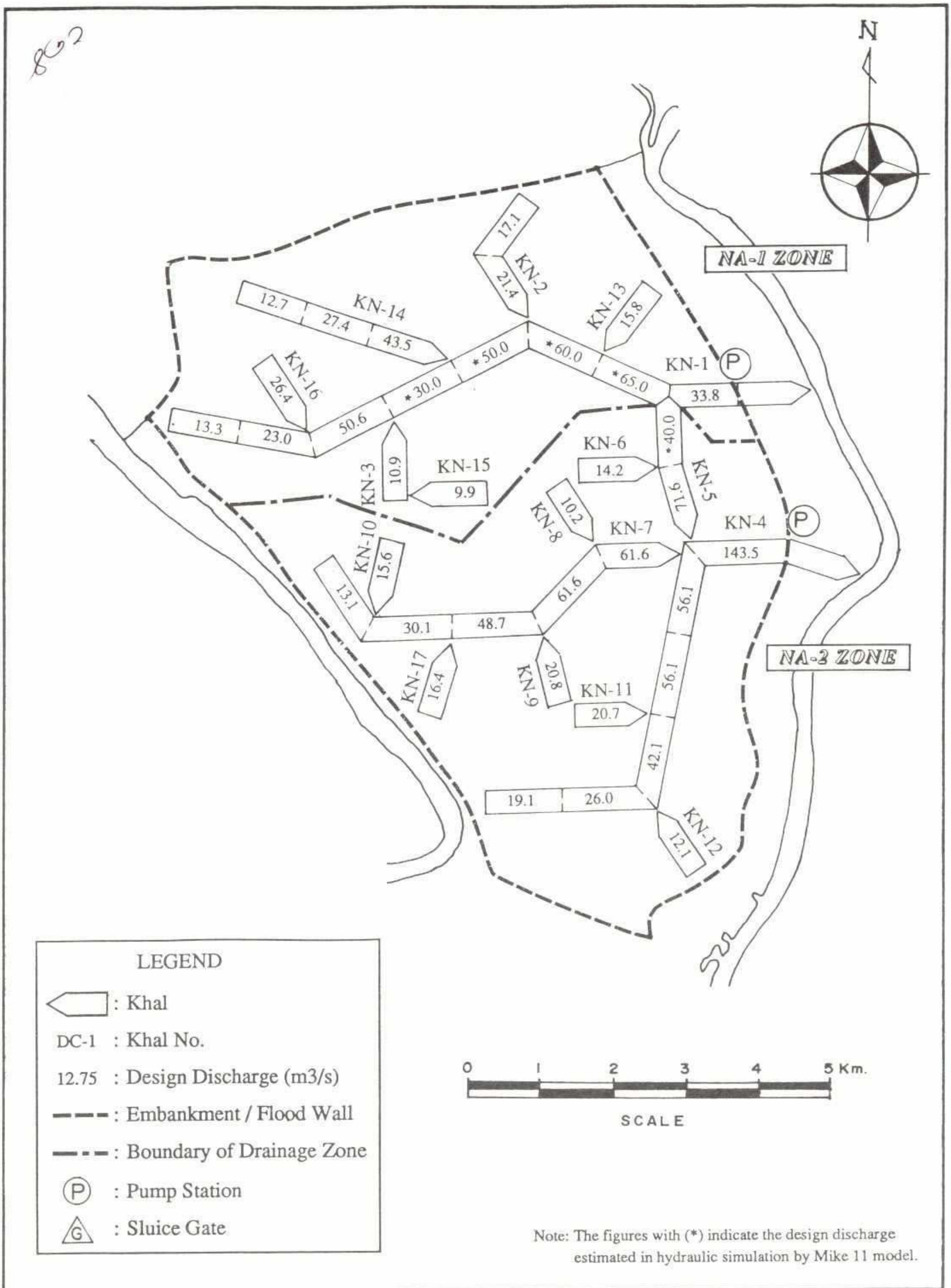
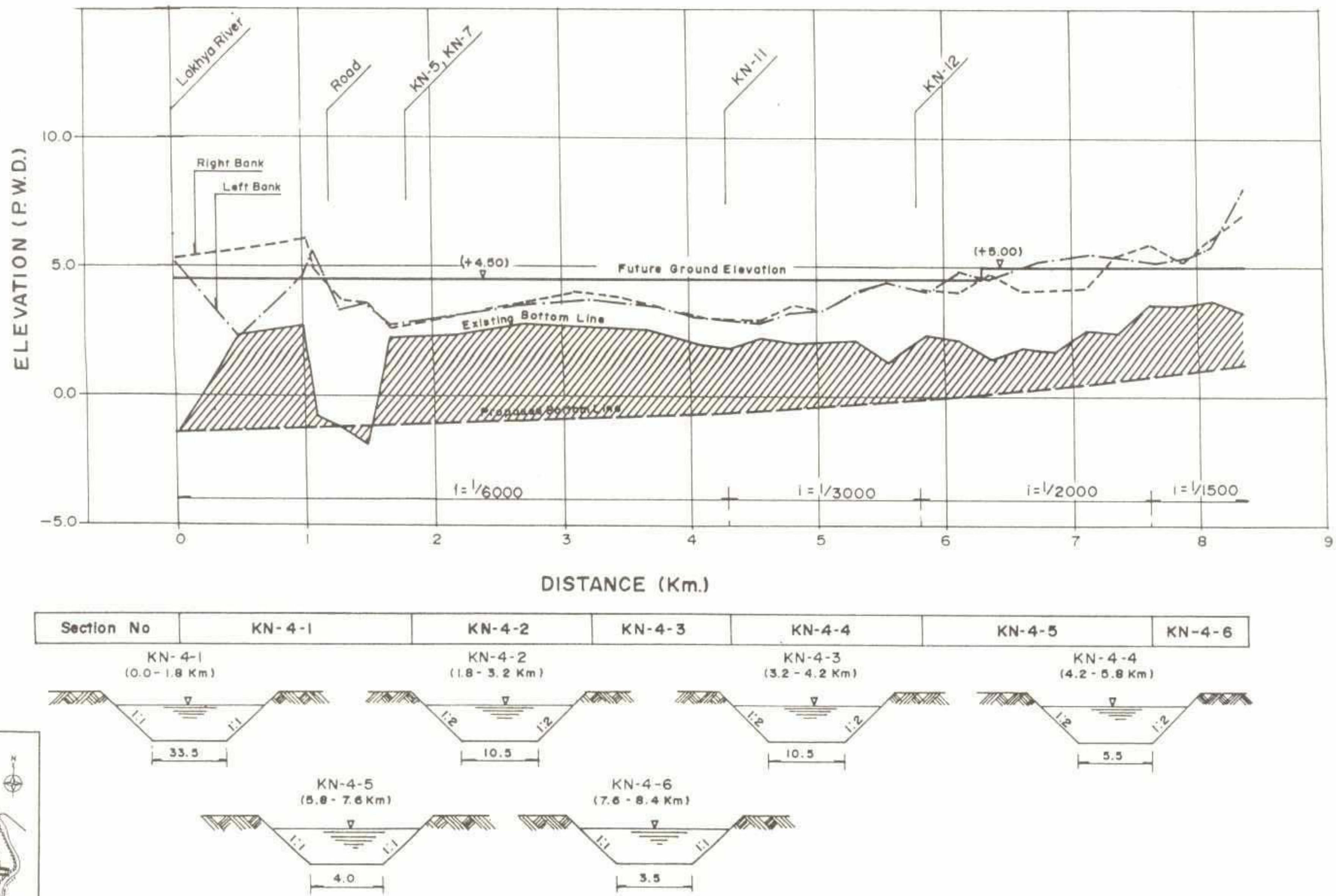
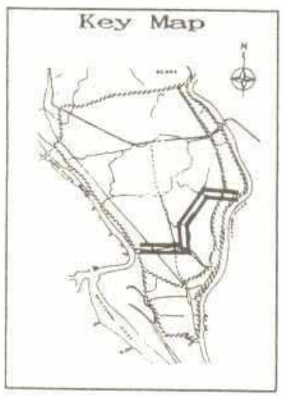


FIG. E.4.10 DESIGN DISCHARGE FOR KHAL IMPROVEMENT PLAN : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



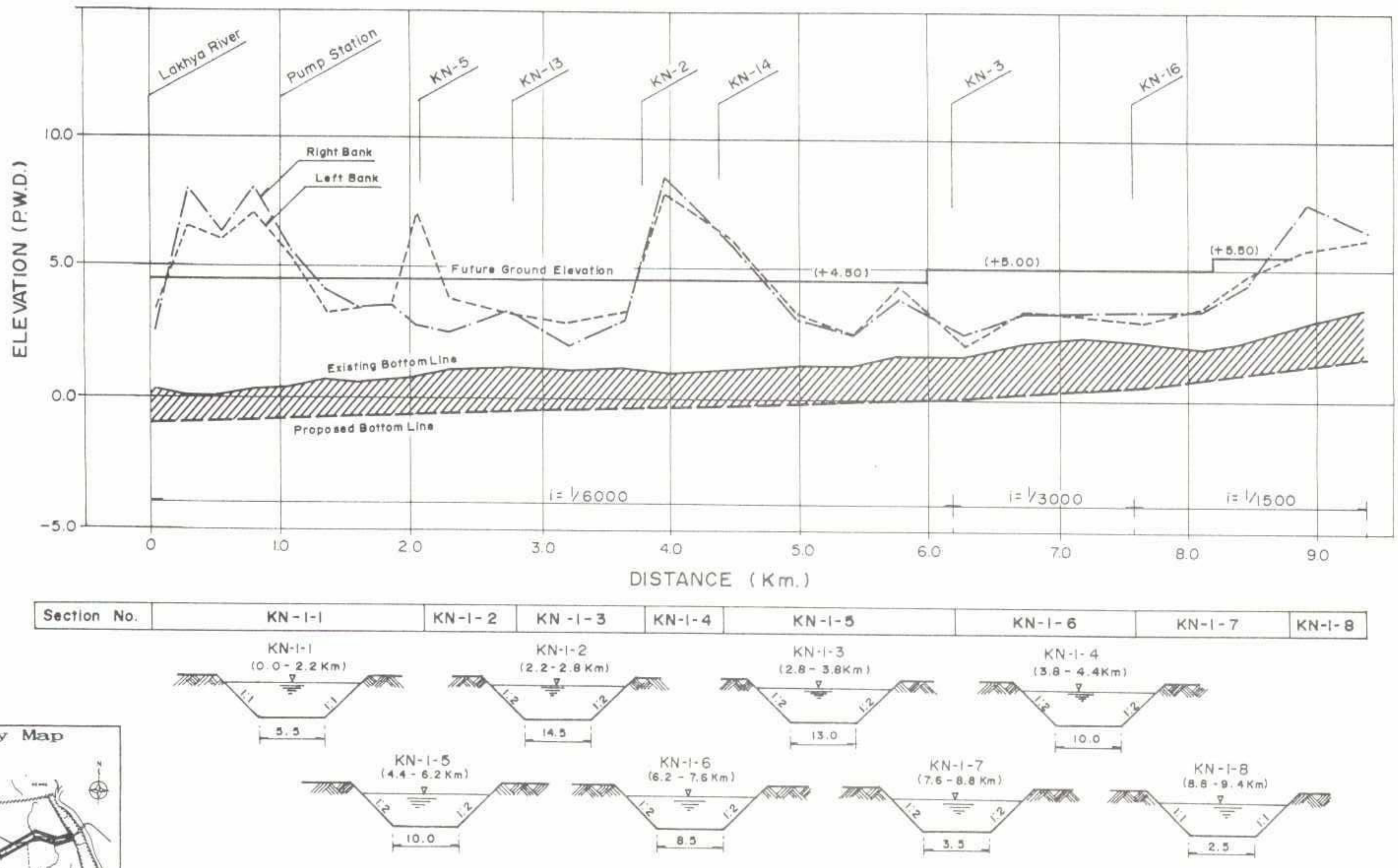


862

FIG. E.4.11(1) PROPOSED LONGITUDINAL AND CROSS SECTIONS (NK-4)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

866



Key Map

FIG. E.4.11(2) PROPOSED LONGITUDINAL AND CROSS SECTIONS (NK-1)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

808

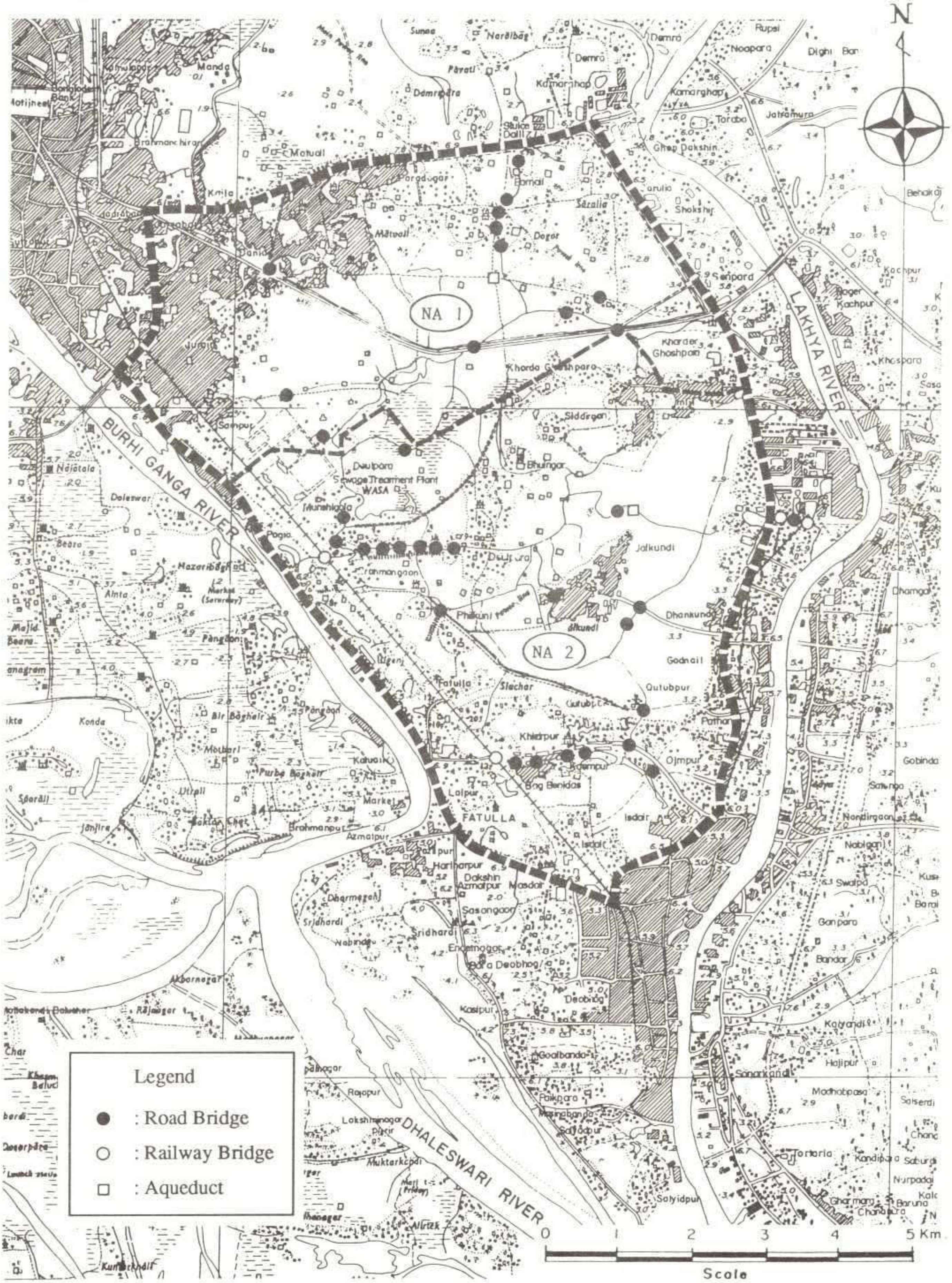


FIG. E.4.12 LOCATION OF PROPOSED BRIDGES AND AQUEDUCT : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

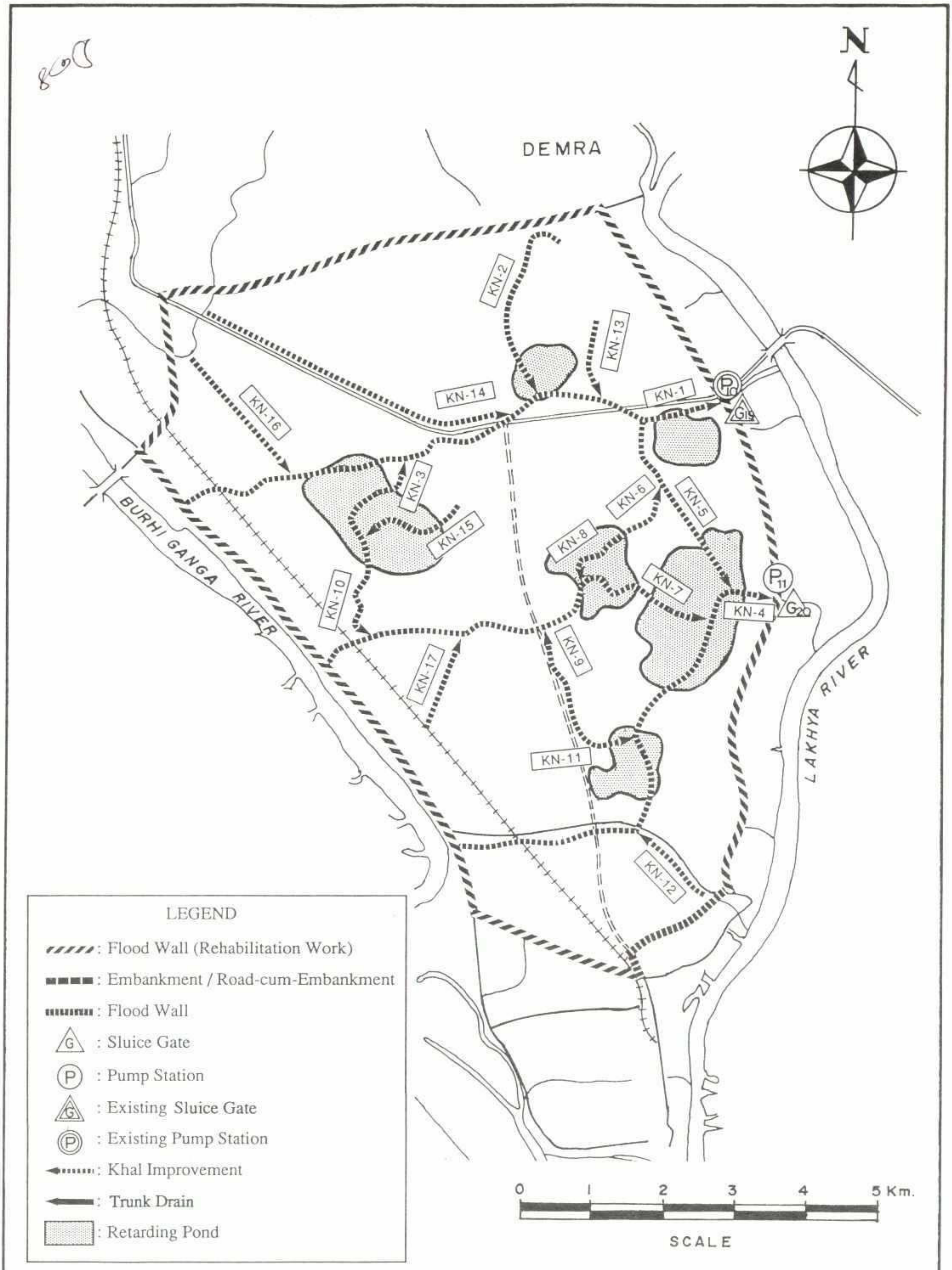


FIG. E.4.13 PROPOSED FACILITIES : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

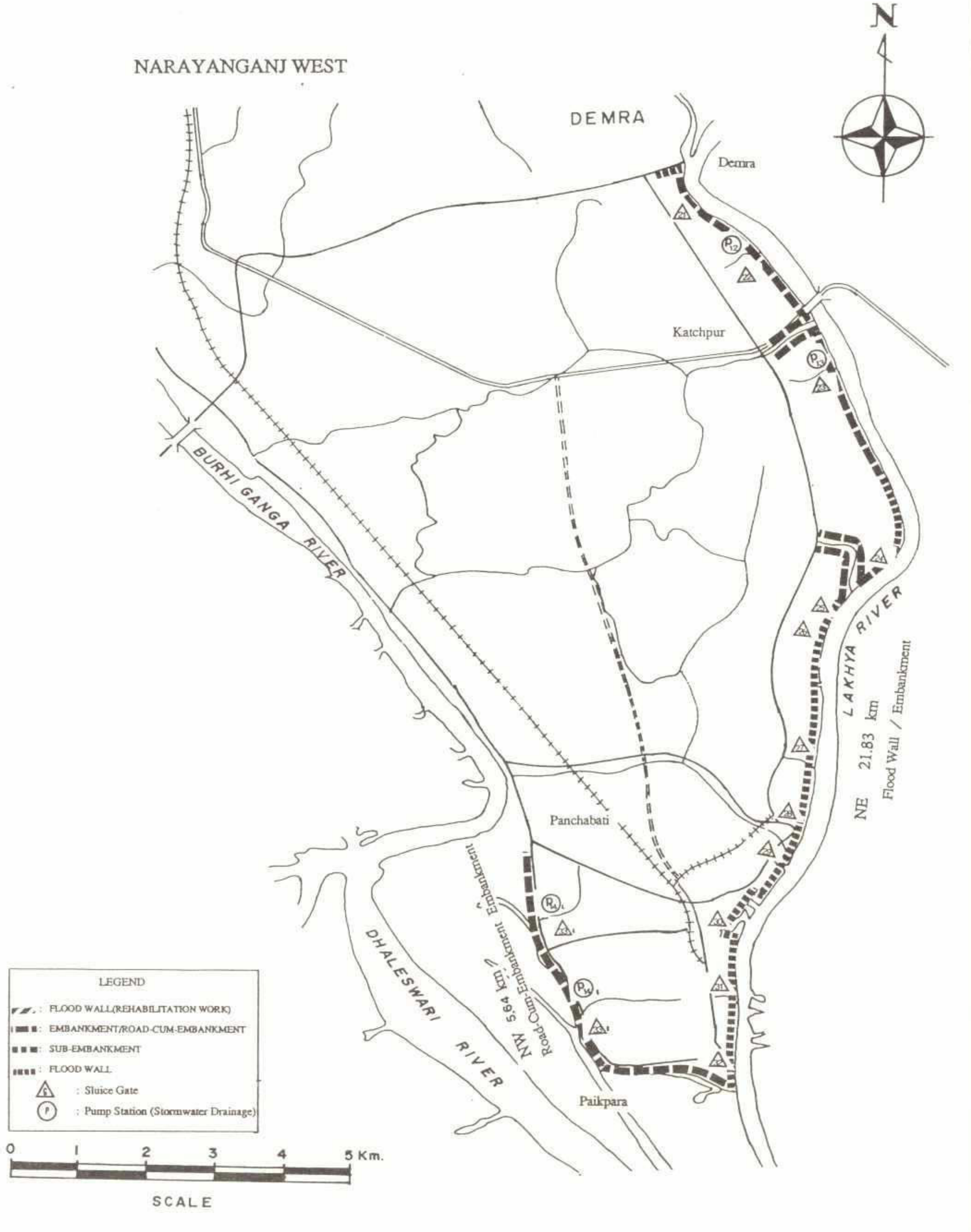
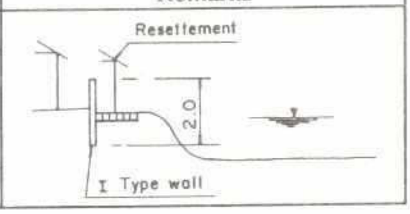


FIG. E.5.1 ALIGNMENT OF POLDER : NARAYANGANJ WEST

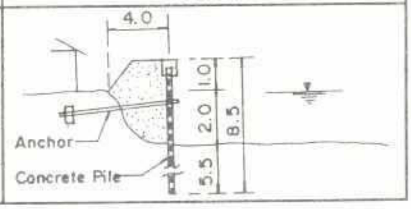
GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

86.9

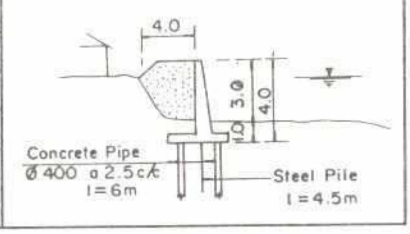
Type 1 : I type R.C Wall (H=2.0m) (Unit :TK)

Item	Unit	Quantity	Unit Cost	Cost	Remarks
1. R.C Concrete	m3	0.4	7,900	3,160	
2. Formworks	m2	4	600	2,400	
3. Excavation	m3	0.9	160	144	
4. Brick Soling	m2	4	590	2,360	
5. Resettlement	m2	5	5,000	25,000	
Total				33,064	

Type 2 : R.C Sheet Pile Wall (H=8.5m) (Unit :TK)

Item	Unit	Quantity	Unit Cost	Cost	Remarks
1. R.C Sheet Pile	m2	8.5	8,200	69,700	
2. Banking	m3	12	510	6,120	
3. Anchoring Etc	L.S	1		15,164	
Total				90,984	

Type 3 : R.C Retaining Wall (H=4.0m) (Unit :TK)

Item	Unit	Quantity	Unit Cost	Cost	Remarks
1. R.C Concrete	m3	3	7,900	23,700	
2. Formworks	m2	8	600	4,800	
3. R.C Pile	m	4.8	3,300	15,840	
4. Excavation	m3	5	160	800	
5. Banking	m3	12	510	6,120	
6. S.Sheet Pile	m2	4.5	6,100	27,450	
Total				78,710	

Type 4 : Concrete Block Wall (H=4.0m) (Unit :TK)

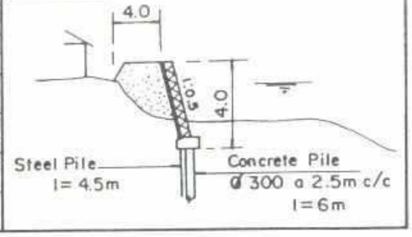
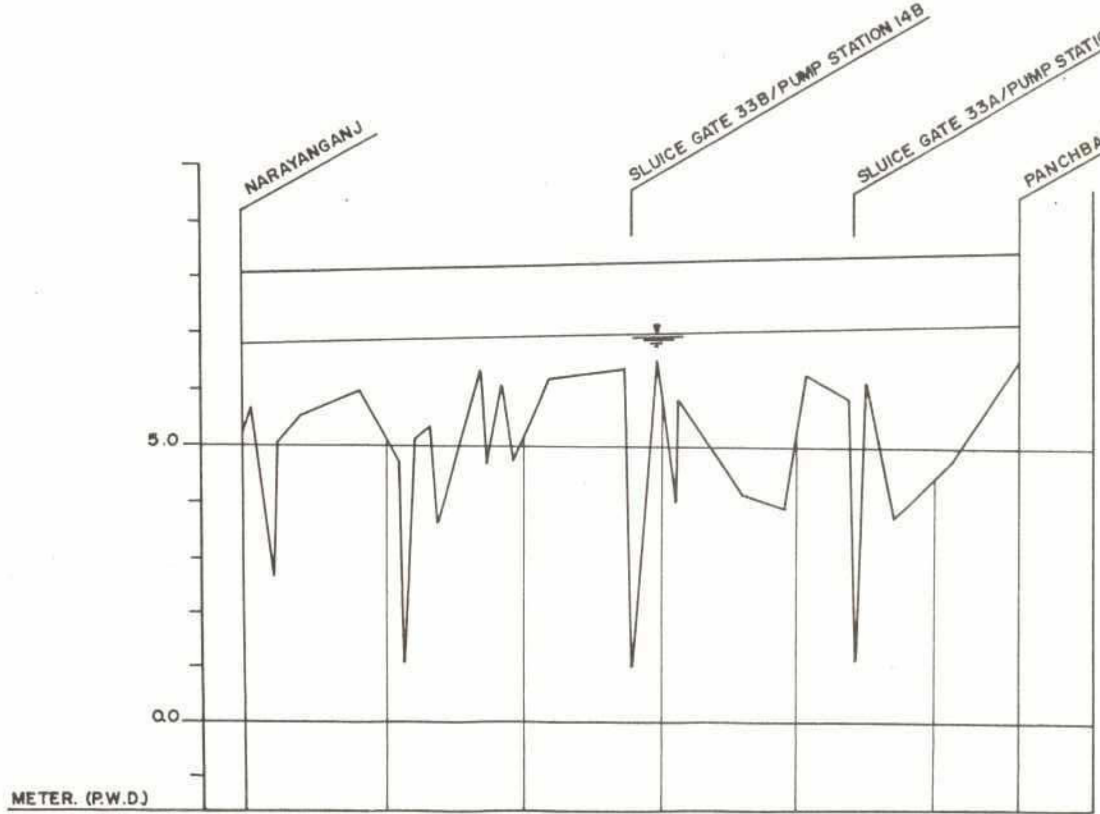
Item	Unit	Quantity	Unit Cost	Cost	Remarks
1. Concrete Block	m2	3.9	1,330	5,187	
2. R.C Concrete	m3	0.3	7,900	2,370	
3. R.C Pile	m	2.4	3,300	7,920	
4. Excavation	m3	1	160	160	
5. Banking	m3	12	510	6,120	
6. S.Sheet Pile	m	4.5	6,100	27,450	
Total				49,207	

FIG. E.5.2 ALTERNATIVE OF FLOOD WALL TYPES : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



DESIGNED	GRADIENT	1 = 1/20,390			1 = 1/12,000			
DESIGNED	TOP OF EMBANKMENT	8.00	8.05	8.10	8.18	8.27	8.35	8.40
DESIGNED	H.W.L.	6.80	6.85	6.90	6.98	7.07	8.15	7.20
ACCUMULATED DISTANCE (KM)		0.0	1.0	2.0	3.0	4.0	5.0	5.6

FIG. E.5.3(1) LONGITUDINAL SECTION OF EMBANKMENT ROAD-CUM-EMBANKMENT (NW) NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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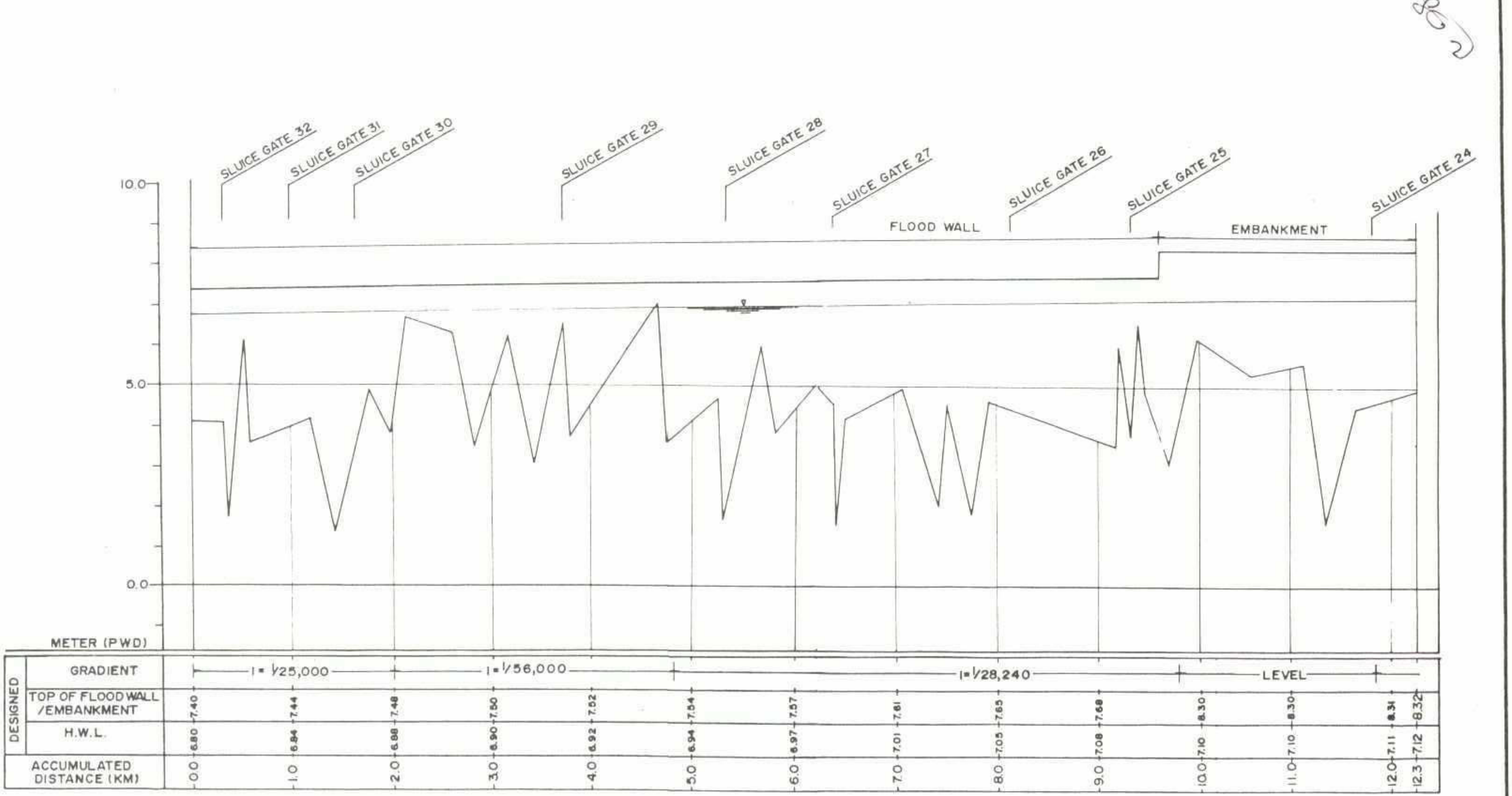

FIG. E.5.3(2) LONGITUDINAL SECTION OF FLOOD WALL/EMBANKMENT (NE-1): NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

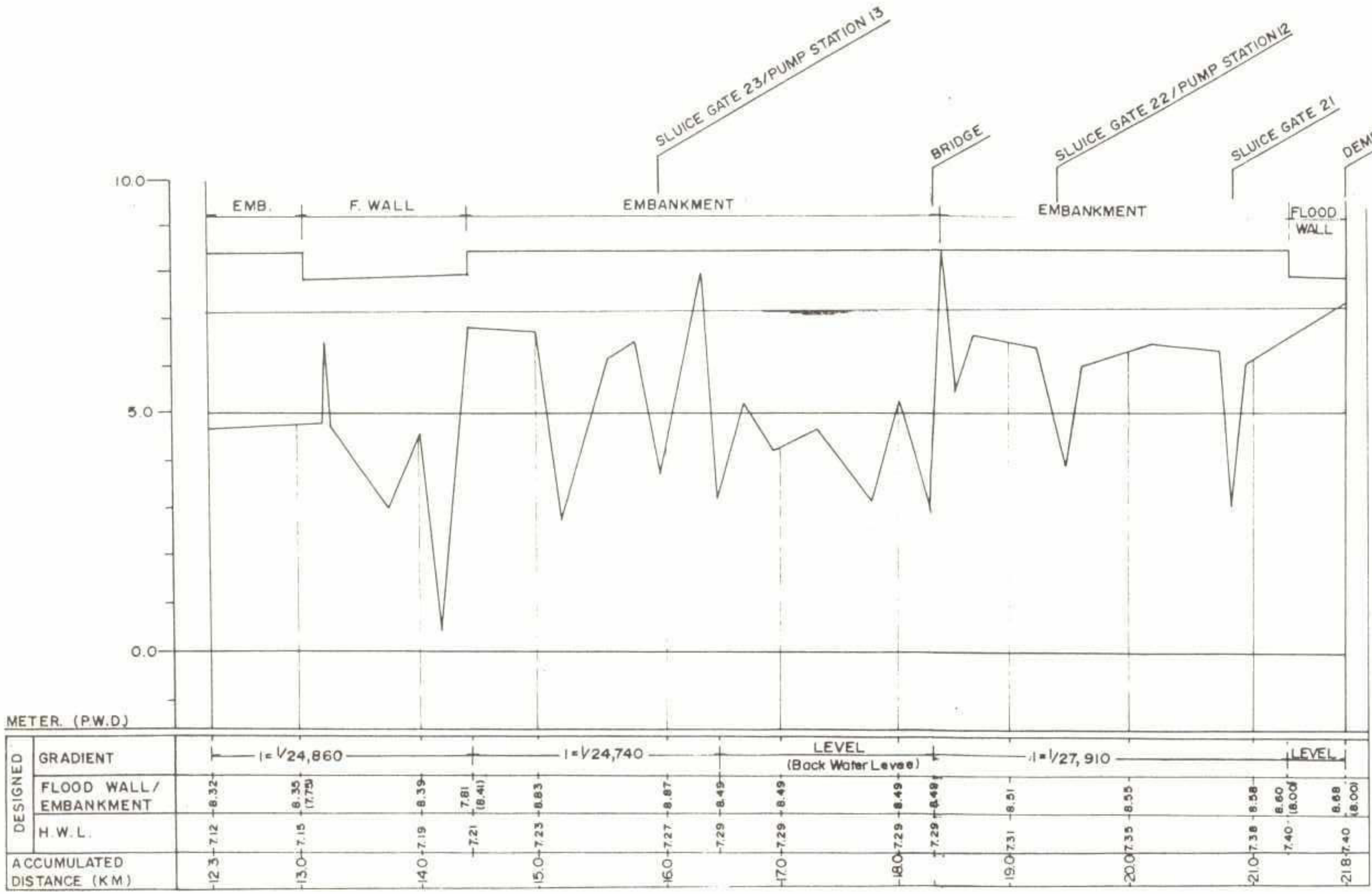

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FIG. E.5.3(3) LONGITUDINAL SECTION OF FLOOD WALL/EMBANKMENT (NE-2): NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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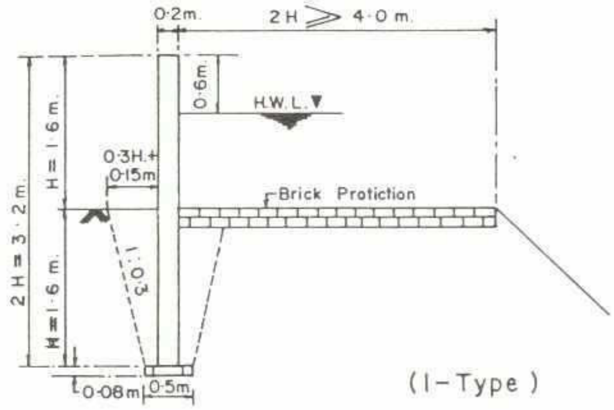
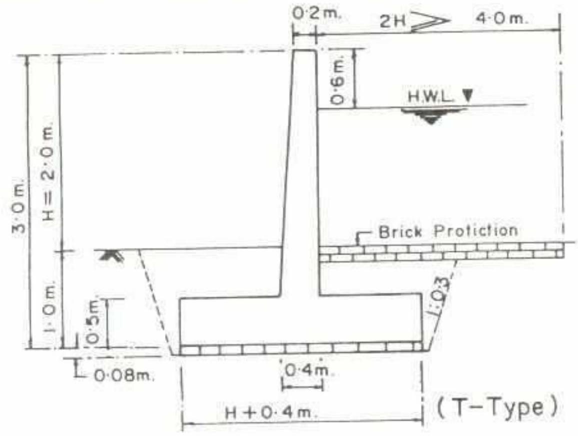
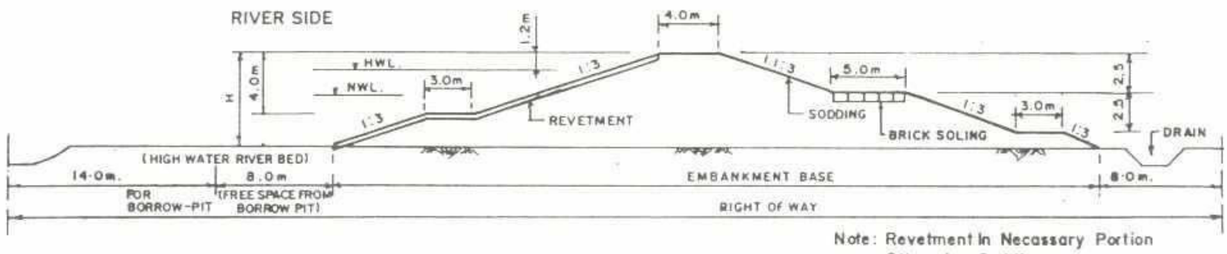
TYPICAL SECTION OF FLOOD WALL



TYPICAL SECTION OF FLOOD WALL

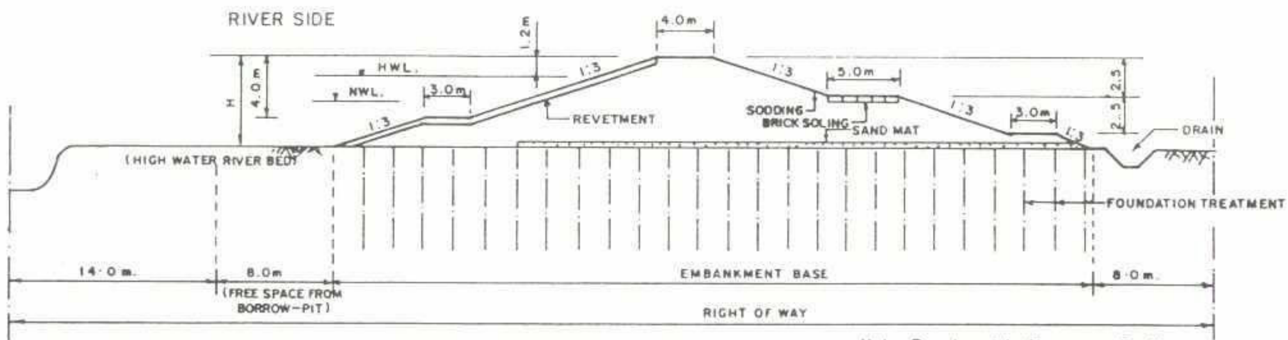


TYPICAL SECTION OF EMBANKMENT



Note: Revetment In Necessary Portion
Otherwise Sodding

. TYPICAL SECTION OF EMBANKMENT WITH FOUNDATION TREATMENT



Note: Revetment In Necessary Portion
Otherwise Sodding.

TYPICAL SECTION OF ROAD-CUM EMBANKMENT

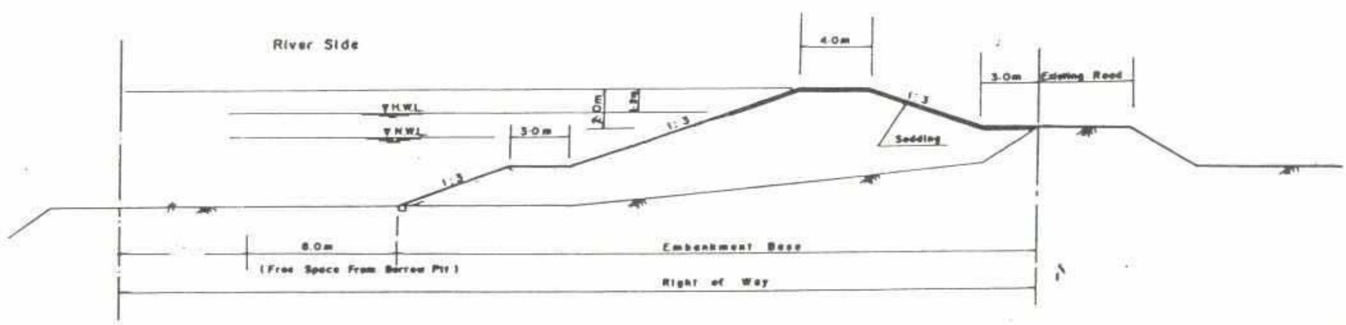


FIG. E.5.4	TYPICAL CROSS-SECTION OF ROAD-CUM-EMBANKMENT/ EMBANKMENT AND FLOOD WALL

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

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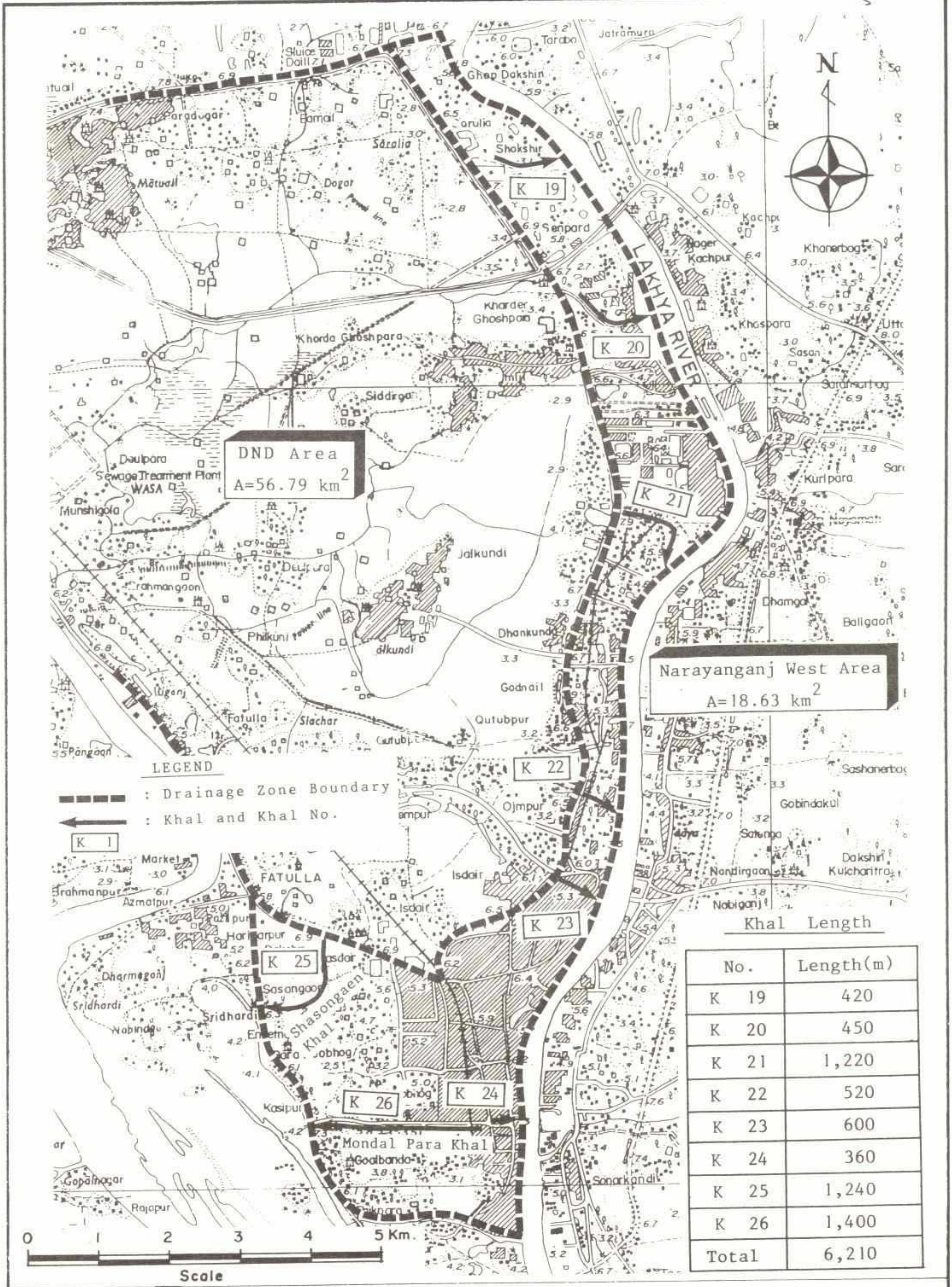

Khal Length

No.	Length(m)
K 19	420
K 20	450
K 21	1,220
K 22	520
K 23	600
K 24	360
K 25	1,240
K 26	1,400
Total	6,210

FIG. E.5.5 EXISTING MAJOR KHALS : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

JICA

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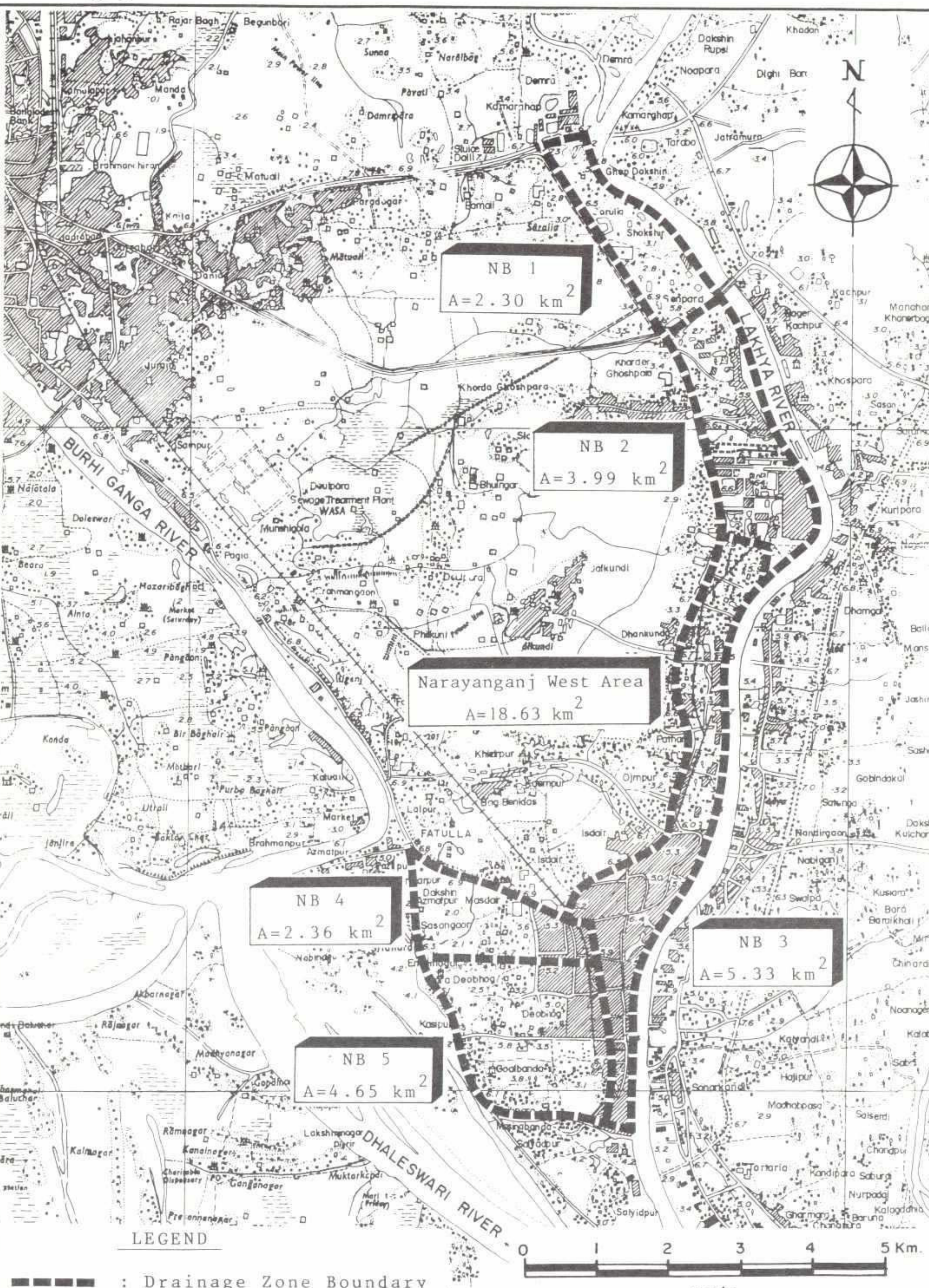
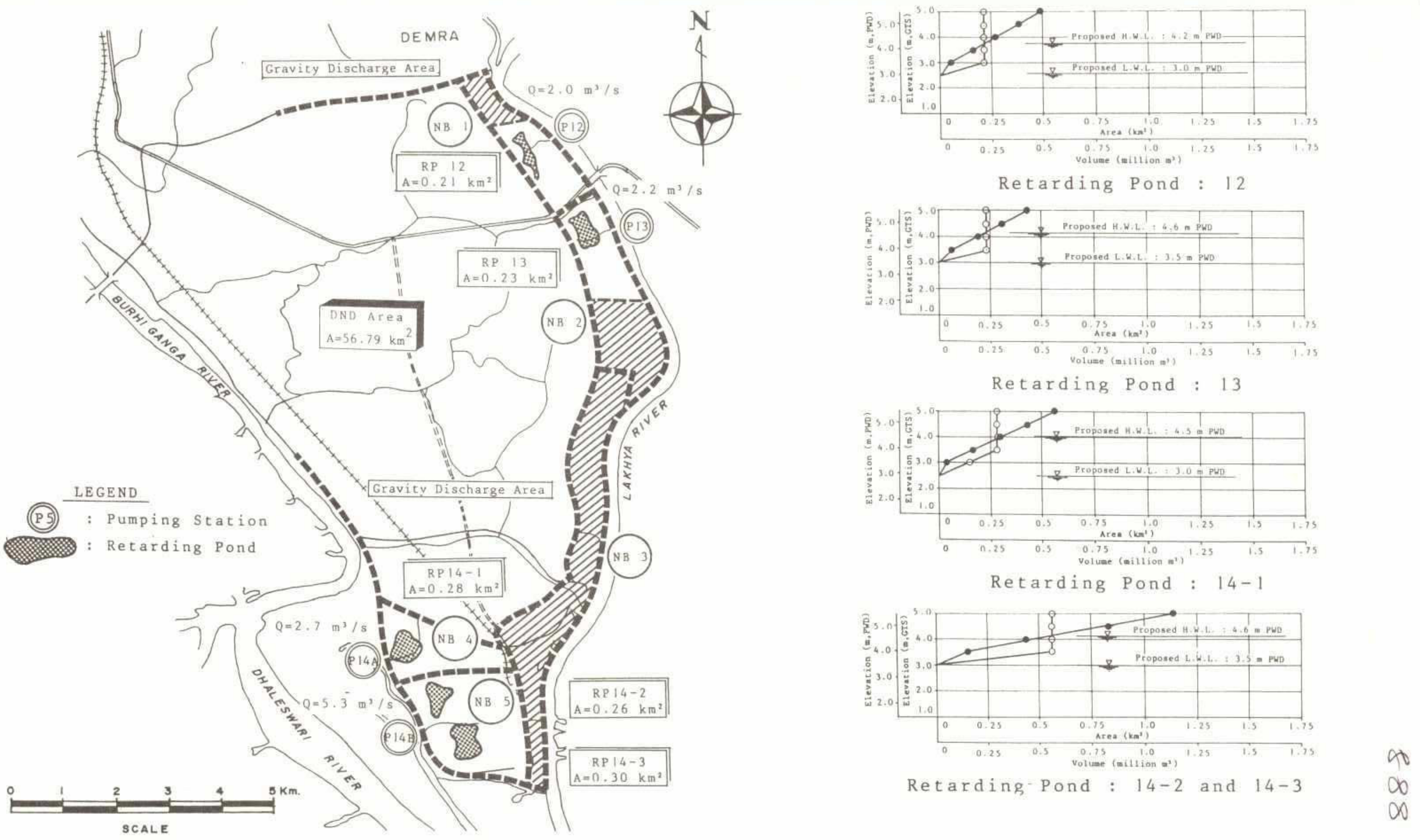


LEGEND

▬▬▬▬ : Drainage Zone Boundary

FIG. E.5.6	DRAINAGE ZONE : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH



888

FIG. E.5.7 PROPOSED REQUIREMENTS OF PUMP STATION AND RETARDING POND : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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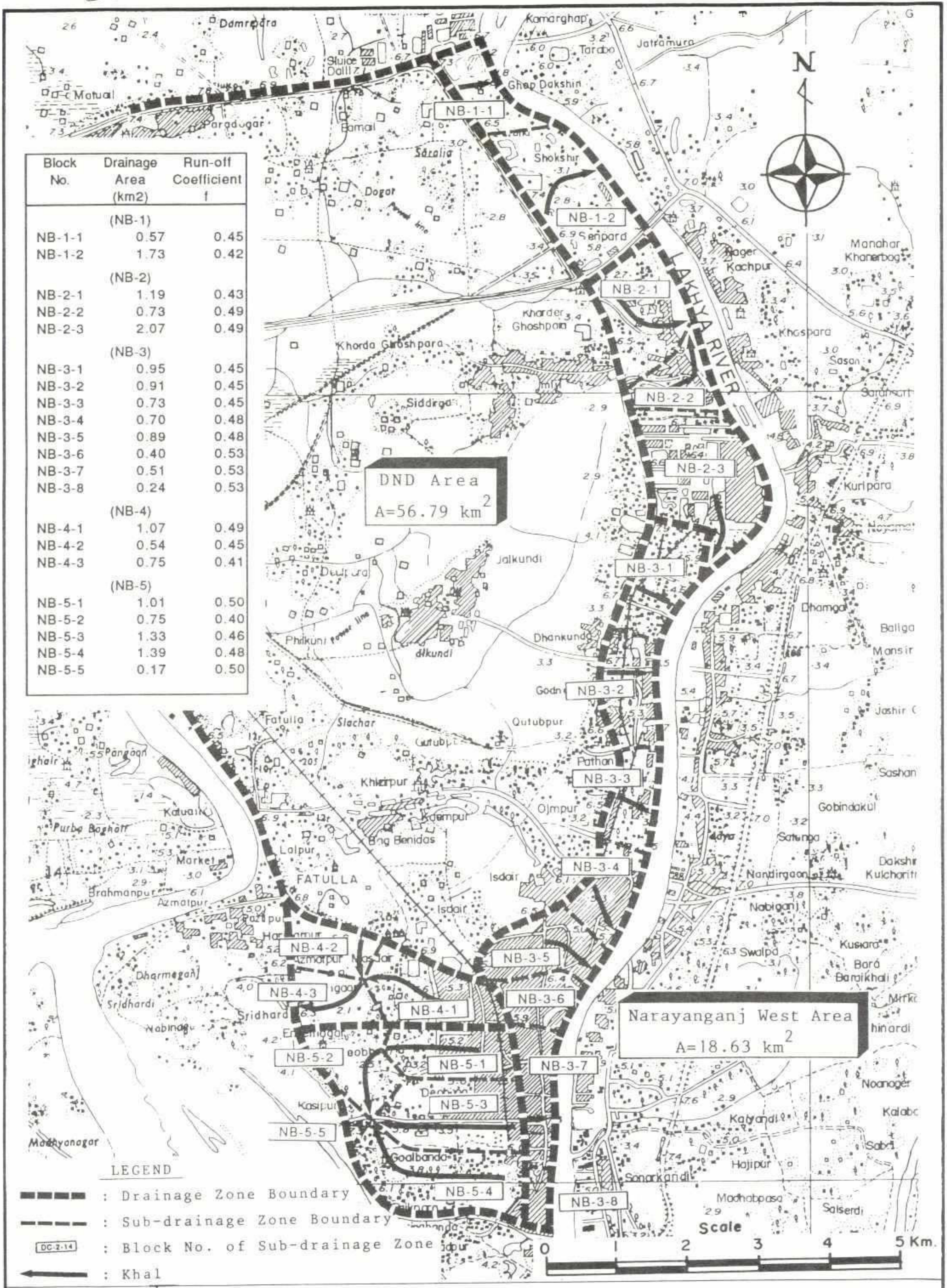

Block No.	Drainage Area (km2)	Run-off Coefficient f
	(NB-1)	
NB-1-1	0.57	0.45
NB-1-2	1.73	0.42
	(NB-2)	
NB-2-1	1.19	0.43
NB-2-2	0.73	0.49
NB-2-3	2.07	0.49
	(NB-3)	
NB-3-1	0.95	0.45
NB-3-2	0.91	0.45
NB-3-3	0.73	0.45
NB-3-4	0.70	0.48
NB-3-5	0.89	0.48
NB-3-6	0.40	0.53
NB-3-7	0.51	0.53
NB-3-8	0.24	0.53
	(NB-4)	
NB-4-1	1.07	0.49
NB-4-2	0.54	0.45
NB-4-3	0.75	0.41
	(NB-5)	
NB-5-1	1.01	0.50
NB-5-2	0.75	0.40
NB-5-3	1.33	0.46
NB-5-4	1.39	0.48
NB-5-5	0.17	0.50

FIG. E.5.8 SUB-DRAINAGE ZONE AND THEIR RUN-OFF COEFFICIENT : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

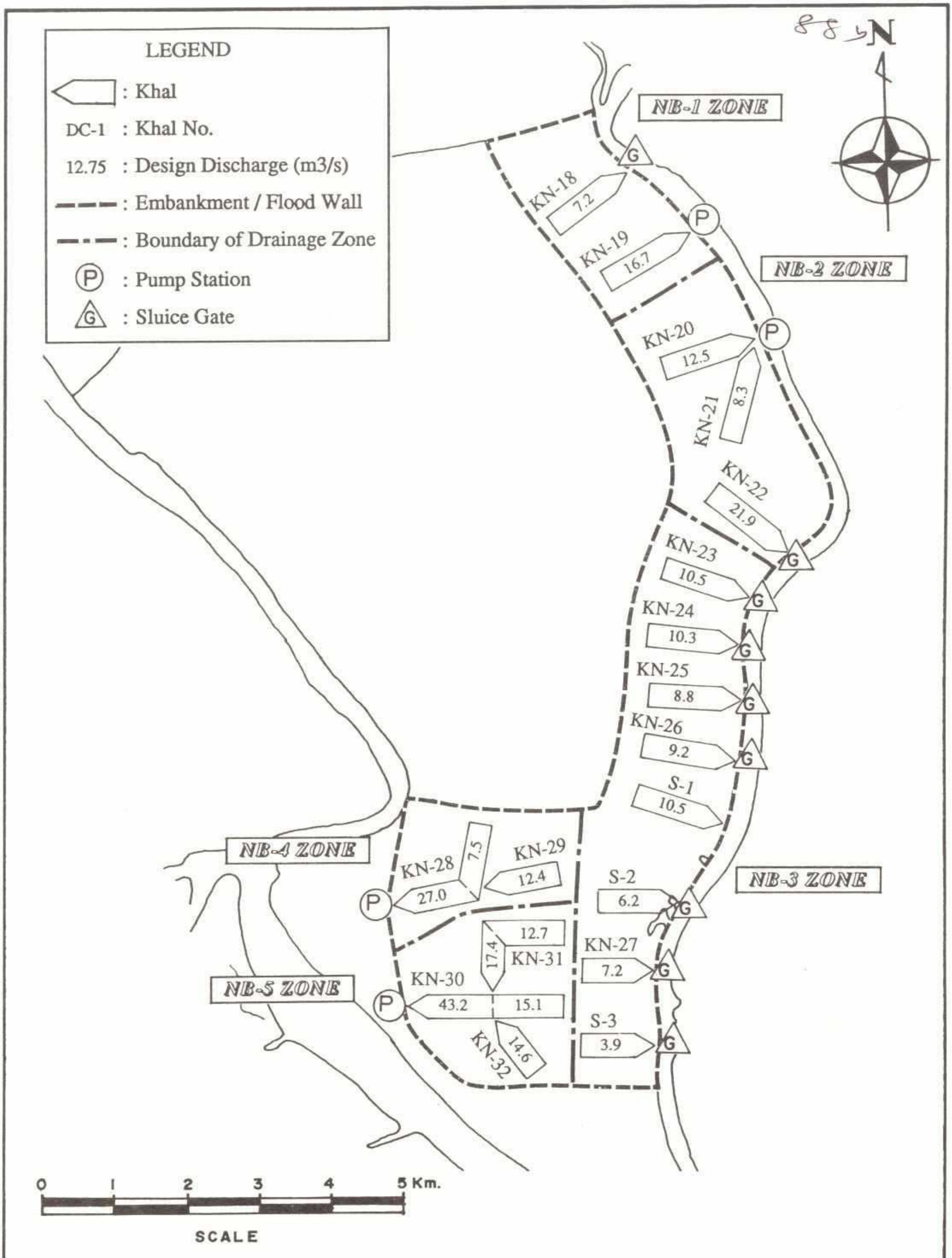

FIG. E.5.9 DESIGN DISCHARGES FOR IMPROVEMENTS OF KHAL AND TRUNK DRAIN : NARAYANGANJ WEST-

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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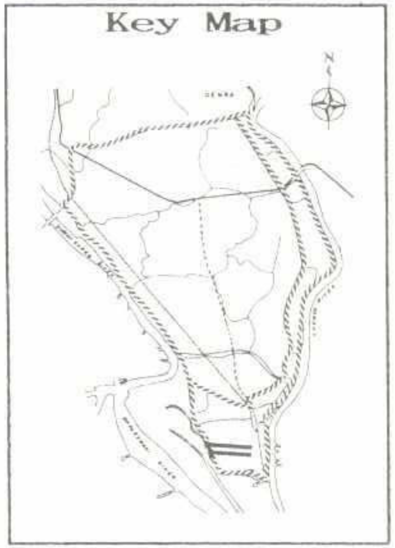

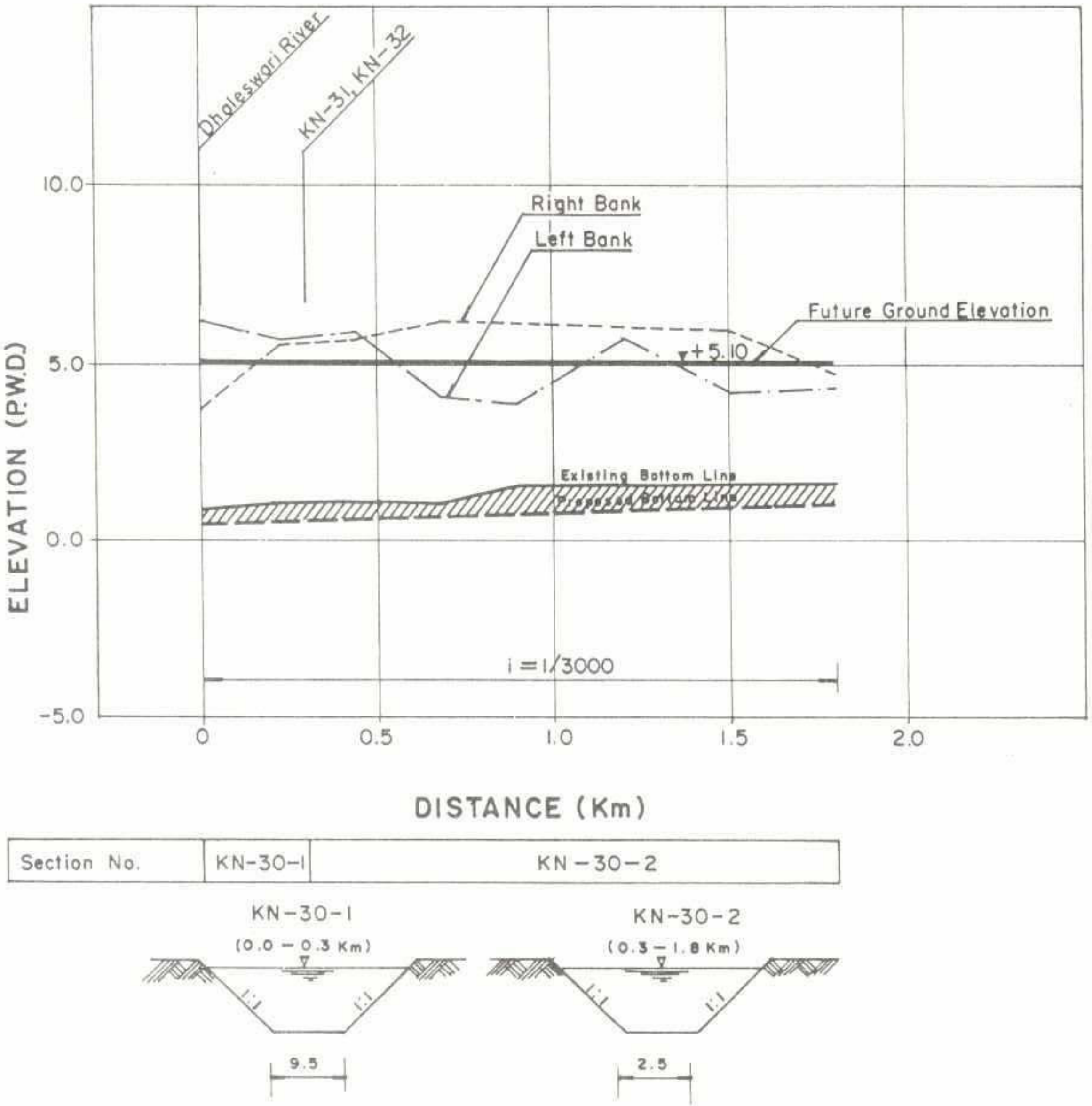

FIG. E.5.10	PROPOSED LONGITUDINAL AND CROSS SECTIONS (KN-30)

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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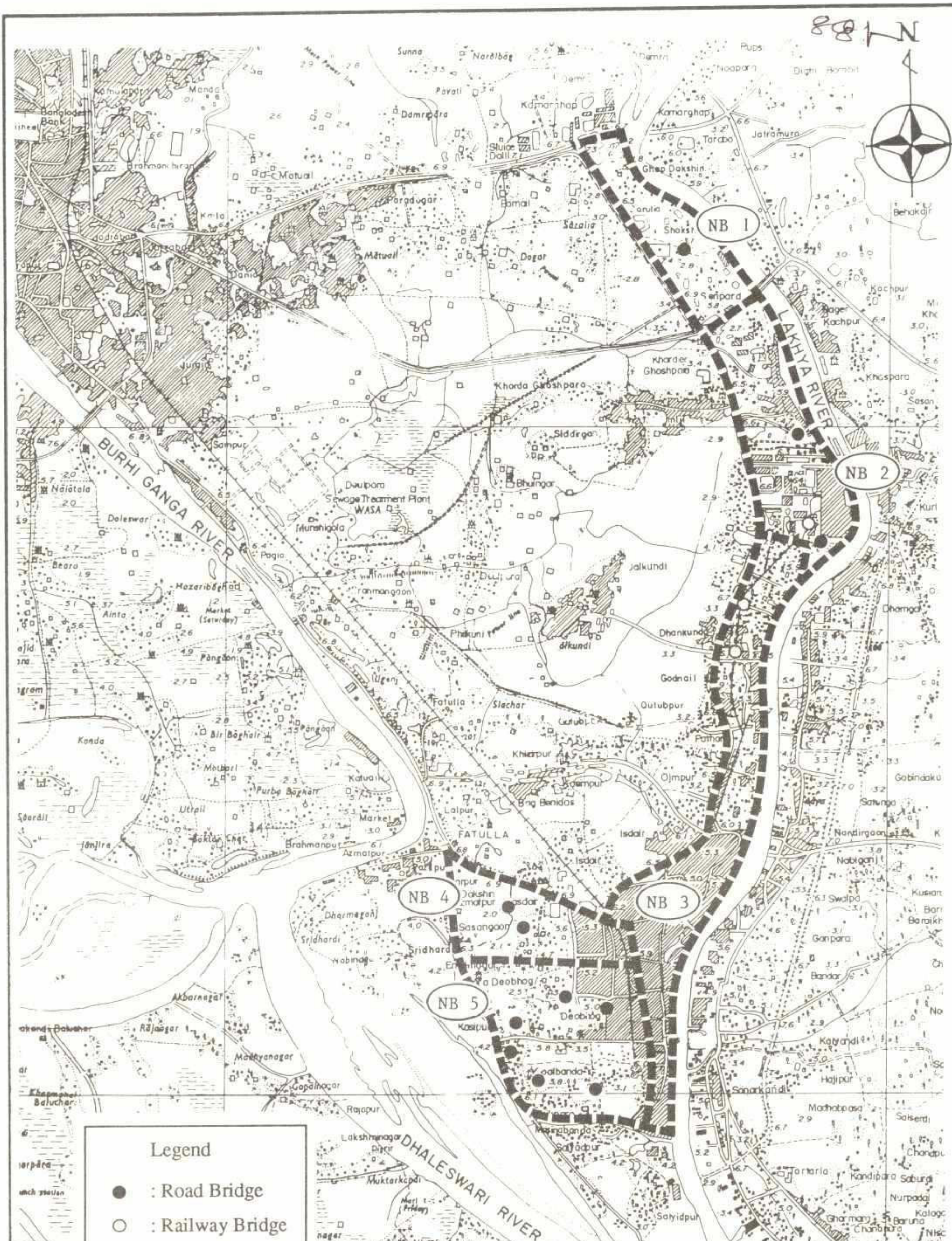

FIG. E.5.11 LOCATION OF PROPOSED BRIDGES: NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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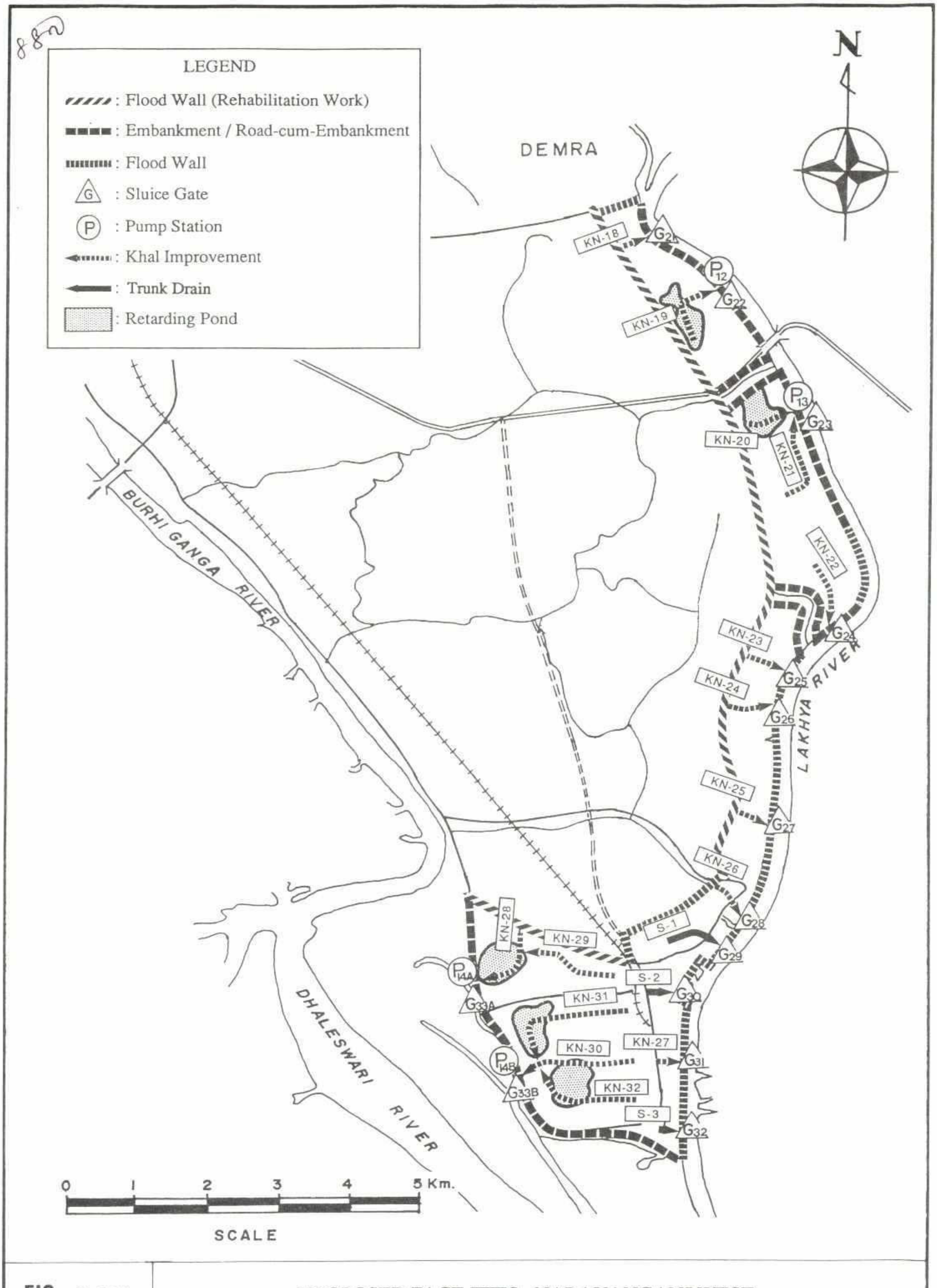

FIG. E.5.12 PROPOSED FACILITIES : NARAYANGANJ WEST

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROLOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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ANNEX I

Case Study on Compartmentalized Drainage System of DND Area

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ANNEX-I

1. General

As the results of the feasibility study on stormwater drainage of DND area, improvement works of pump drainage combined with the retarding basin are recommended under the existing drainage system, which is based on one basin with two drainage zones, taking into consideration of the following;

- DND area was developed as an agricultural land which was protected from the external floods by the embankments and also was provided suitable pump irrigation and drainage facilities under one basin system.

- Though a cultivated area of DND occuping almost 60% of the whole area (56.79 km^2) in 1990 is rapidly developing to the residential area, almost 20% of the area will be still remained as an agricultural land in 2010.

- So, if DND area is divided into some independent and compartmentalized drainage zones by sub-embankments of the spine roads, not only the stormwater drainage system but also the irrigation system shall be improved. This will be uneconomized.

It is, however, fact that DND area is surrounded and dividedd into some sub-areas by the existing and under constructing spine roads, such as Dhaka-Demra Road, Dhaka-Chittagong Highway, Dhaks Narayanganj road. Demra-Narayanganj Road, and etc.

So, in this Annex, a Case Study on Compartmentalized Drainage System of DND Area is carried out as an alternative study.

2. Zoning

DND area of 56.79 km^2 is surrounded by the existing major roads, Dhaka-Demra road to the north, Demra-Narayanganj Road to the east and Dhaka-Narayanganj Road to the west and south. As shown in Fig. EA.1, the area is mainly divided into three compartments by the spine roads such as Dhaka-Chittagong Highway and Dhaka-Narayanganj New Road being under construction. these areas are below:

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Zone (Compartment)	Area (km2)	Main Khal
NA-1	13.90	Shampur Khal
NA-2	21.85	Pagla Khal
NA-3	21.04	Fatuallah Khal
Total	56.79	

Note: Refer to Fig. EA.1

3. Countermeasures

Stormwater drainage countermeasures are proposed for the whole area of 56.79 km2. As almost 60% of the area is still un-urbanized, the proposed measures will consist of the following:

- All the required pumping stations with retarding ponds
- Khal improvements

However, lateral drains and tertiary drainage pipes are excluded in this project. Because a beneficial effect of these facilities will be expected only after the completion of the connected khals in newly developed areas.

Land acquisition of the proposed pumping station and khal improvement is required to prevent illegal land development by the private sector. For the retarding pond, however, land use regulation will be necessary to preserve their storage capacity and to limit the pump capacity.

4. Pump Drainage Plan

4.1 Required Pump and retarding Pond Capacity

For the three (3) compartment areas, a pump drainage system combined with retarding ponds is re commended to economize the pump drainage cost by reducing the required pump capacity.

The required pump and retarding pond capacities are estimated based on the both specific requirements, $P=1.14m^3/S/km^2$ and $V=0.0120x10^6m^3/km^2$ respectively as shown below:

Zone (Compartment)	Area (km^2)	Required Pump Capacity		Required Storage Volume of Retarding Pond	
		Specific ($m^3/s/km^2$)	Total (m^3/s)	Specific ($m^3/km2$)	Total ($x10^6m^3$)
NA-1	13.90	1.14	15.9	0.12	1.67
NA-2	21.85	1.14	24.9	0.12	2.62
NA-3	21.04	1.14	24.0	0.12	2.53
Total	56.79	-	64.8	-	6.82

Note: Fef. to Fig. EA.3

4.2 Proposed Pumping Station

4.2.1 Proposed Site

In view of the continuous demand for irrigation in DND and the economized pump drainage cost, the existing Demra pumping station will be utilized in the plan. The existing pump capacity of $14.5m^3/s$ is however, less than the required pump capacity of zone NA-1 (15.9 m^3/s).

Since it is difficult to get the construction space for additional pump facility at the Demra pumping station, the shortage pump capacity of 1.4 m^3/s is to be added to the new pumping station planned at Siddirganj in Zone NA-3, and also the khal connected between NA-1 and NA-3 is to be maintained. So, total pump capacity of zone NA-3 will increase from 24.0 m^3/s to 25.4 m^3/s.

Pump site of zone NA-2 is proposed at the Pagla Khal crossing with the Dhaka-Narayanganj road.

Location of the proposed pumping stations are shown in Fig. EA-2 and listed below:

Sub Zone	No. of pumping Station	Station No. of Embankment	Name of Khal
NA-1	P10 (Demra P.S.)	DE 17+350	KN-1
NA-2	P11A	DW 6+700	KN-4
NA-3	P11B	DE 10+300	KN-10

Note: Ref. to Fig. EA.4

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4.2.2 Design Water Level of Pumping Station

As topographic, hydrological and hydraulic conditions of DND area are very similar with those of Greater Dhaka East, the design water levels of pump station is planned to apply the same value as Greater Dhaka East pumping station, except the H.H.W.L. of the Lakhya River.

Hydraulic requirements of the proposed pumping stations are shown in Table EA-1(1).

4.3 Proposed Retarding Pond

4.3.1 Proposed Site

The Proposed sites of the retarding ponds are selected under the following concept.

- a vast low-laying area below 3.0m PWD
- a low potential area for urban development
- an area with necessary hydraulic effect
- an area with possibility of land use regulation

A number of the proposed site of the retarding pond for each drainage zone is follow:

NA-1 : 3 sites (RP10-1, RP10-2 and RP10-3)
NA-2 : one site (RP11A-1)
NA-3 : 2 sites (RP11B-1 and RP11B-2)

Location of the proposed six (6) sites are shown in Fig. EA.2.

4.3.2 Design Water Level and Area of Pond

The design L.W.L. of the retarding pond during flood season is planned to be 3.0m PWD due to the followings:

- to meet average ground elevation of the proposed site of the retarding pond
- to meet average water level of the Lakhya River and Buriganga River at the beginning and end of flood season.

On the other hand, the design H.W.L. of the retarding pond is proposed to be 40m PWD considering an effective storage depth of 1.0m which is same as that of Greater

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Dhaka East. Because topographic conditions of low-lying areas in DND and Greater Dhaka East are very similar.

Table EA.1(2) shows the hydraulic requirements of the retarding pond.

5. Khal Improvement Plan

5.1 Design Discharge

5.1.1 Division of Sub-drainage Zone

In order to calculate the design discharges at several distinct points for preparation of more deep khal sections, each drainage zone is divided into 37 sub-drainage zones based on the existing topographic condition and the proposed khal networks as shown in Fig. EA.3. the number of sub-drainage zones are.

NA-1	:	9	sub-zones
NA-2	:	15	sub-zones
NA-3	:	13	sub-zones
Total		37	sub-zones

5.1.2 Design Discharge

Design discharges for khal improvements are calculated by Rational method. The estimated design discharges are shown in Table EA.2 and Fig. EA.4.

5.2 Proposed Khal Improvement

The discharge capacities of the existing khals in the DND area mostly do not meet the design discharge. Khal improvement by widening and dredging are required.

Planning concept for longitudinal and cross sections of the improved khals is as follows:

1) Bed elevation at the mouth of khal is planned to be same or higher than that of Lakhya River and Buriganga River.

2) Khal bed slope is planned to be nearly same as the existing one.

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3) Ratio of upstream bed slope and downstream bed slope at inflection point is planned to be within 0.5.

4) The following two types of khal cross section are proposed:

- Type (1) : Trapezoidal shape with 1:2 slope protected by sodding
- Type (2) : Trapezoidal shape with 1:1 slope protected by brick

Type (1) is applied for khal sections situated in existing agricultural land where comparatively easy land acquisition is expected. Type (2) are proposed for khal sections located in existing built-up areas where land acquisition is likely to be difficult.

Table EA.4 shows the hydraulic design of khal improvements.

As related structures, road bridge, railway bridge and aqueduct are planned to be reconstructed or newly constructed at khal crossing with road, railway, and irrigation canal. The number of related structures are as follows:

- Road bridge : reconstruction; 29 places, new construction; 7 places
- Railway bridge : reconstruction; 3 places
- Aqueduct : reconstruction; 2 places

The proposed khal improvement works are shown in Table EA.5 and Fig. EA.5 and summarized below:

Zone	Open Channel (km)		Road Bridge (place)		Railway Bridge(place)	Aqueduct (place)
	Type (1)	Type (2)	Recons-truction	New Cons-truction	Reconstruction	Reconstruction
NA-1	7.50	5.30	8	3	0	1
NA-2	13.70	6.00	9	3	1	0
NA-3	12.40	6.40	12	1	2	1
Total:	33.60	17.70	29	7	3	2

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6. Cost Estimate

Construction cost, land acquisition/compensation cost and CDST for the imported materials/equipment of the proposed works are estimated in the same condition of the original plan.

6.1 Construction Cost

Total constriction cost is estimated at million Tk. 2,679, which is million Tk. 137 higher than that of the original plan

Construction cost by zone and facility is as follows;

	Pump Station			Khal Improvement			Bridge			
Zone	F/C	L/C	Total	F/C	L/C	Total	F/C	L/C	Total	Total
NA-1	229	10	239	119	142	261	28	42	70	570
NA-2	501	121	622	171	219	390	11	16	27	1,039
NA-3	510	121	631	175	218	393	19	27	46	1,070
Total:	1,240	252	1,492	465	579	1,044	58	85	143	2,679

Breakdown of the construction costs by drainage facility and zone are shown in Tables EA.6(1) to EA.8.

6.2 Land Acquisition/Compensation Cost

Land acquisition and compensation costs are estimated at million Tk. 431, which is million Tk. 31 higher than that of the original plan.

Land acquisition and compensation cost by zone and facility is as follows;

	Pump Station		Khal Improvement		
Zone	Area (ha)	Cost (million Tk.)	Area (ha)	Cost (million Tk.)	Total (million Tk.)
NA-1	-	-	29.1	107.7	106.7
NA-2	0.8	10.5	51.3	188.3	198.8
NA-3	0.8	7.0	32.3	118.4	125.4
Total	1.6	17.5	112.7	413.4	430.9

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6.3 CDST

CDST (Custom Duty and Sales Tax) for the imported materials and equipment is estimated at million Tk. 747 which is million Tk. 34 higher than that of the original plan.

CDST cost by zone and material or equipment is as follows;

Unit: Million Tk.(1991 price)

Zone	Pump Equipment	Gate Equipment	Steel Materials	Total
NA-1	168.5	5.8	-	174.3
NA-2	282.5	7.1	1.5	291.1
NA-3	273.2	7.1	1.7	282.0
Total:	724.2	20.0	3.2	474.4

TABLE E.A.1(1) : HYDRAULIC REQUIREMENTS OF PROPOSED PUMPING STATION : DND

Proposed Pumping Station	Drainage Zone		Discharge Capacity (m^3/s)	Design Water Level (m, PWD)					Static Head (m)		Remarks
	No.	Area (km^2)		Outer			Inner		Design	Max.	
				H.H.W.L	H.W.L	L.W.L	H.W.L	L.W.L			
P 10	NA-1	13.90	14.50	---	5.75	3.00	1.80	1.00	4.75	---	Existing Pumping Station
P 11A	NA-2	21.85	24.9	7.40	5.65	3.00	4.00	3.00	2.65	4.10	
P11B	NA-3	21.04	25.4	7.10	5.65	3.00	4.00	3.00	2.65	4.10	

Note : 1. H.H.W.L. and H.W.L. of outer design water level means that of 100-year and 2-year frequency flood respectively

TABLE EA . 1(2) : HYDRAULIC REQUIREMENTS OF PROPOSED RETARDING POND : DND

Proposed Retarding Pond	Drainage Zone	Pond Area (ha)	Storage Capacity (x $10^6 m^3$)	Design Water Level (m, PWD)		Remarks
				H.W.L	L.W.L	
RP 10-1	NA-1	62	0.62	4.00	3.00	
RP 10-2	NA-1	45	0.45	4.00	3.00	
RP 10-3	NA-1	60	0.60	4.00	3.00	
RP 11.A-1	NA-2	90	0.90	4.00	3.00	
RP 11.B-1	NA-3	225	2.25	4.00	3.00	
RP 11.B-2	NA-3	28	0.28	4.00	3.00	

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TABLE EA.2 DESIGN DISCHARGE

DND Project Area (NA)

(NA-1)

Conditions: Inlet Time; 20min

Block No.	Drainage Area		Run-off Coefficient		Length		Velocity	Time of Concentration	Rainfal Intensity	Areal Reduction Factor	Design Discharge
	Individual a (km2)	Accumlated A (km2)	Individual f	Accumlated F	Individual l (km)	Accumlated L (km)	V (m/s)	t (min)	r (mm/hr)	(m3/s/km)	(m3/s)
NA-1-1	1.15	1.15	0.48	0.48	1.80	1.80	0.80	58	83.77	0.99	12.7
NA-1-2	2.30	3.45	0.44	0.45	1.50	3.30	0.80	89	64.90	0.97	27.1
NA-1-3	3.63	7.08	0.44	0.45	2.00	5.30	0.80	130	50.68	0.96	43.1
NA-1-4	1.62	1.62	0.44	0.44	1.60	1.60	0.80	53	87.15	0.99	17.1
NA-1-5	1.23	2.85	0.39	0.42	1.60	3.20	0.80	87	65.89	0.98	21.5
NA-1-6	0.46	10.39	0.40	0.44	1.00	6.30	0.80	151	46.71	0.94	55.8
NA-1-7	1.59	1.59	0.43	0.43	1.80	1.80	0.80	58	83.77	0.99	15.7
NA-1-8	0.94	12.92	0.45	0.44	0.70	7.00	0.80	166	44.29	0.93	65.0
NA-1-9	0.98	13.90	0.34	0.43	1.10	8.10	0.80	189	40.94	0.93	63.2

(NA-2)

Conditions: Inlet Time; 20min

Block No.	Drainage Area		Run-off Coefficient		Length		Velocity	Time of Concentration	Rainfal Intensity	Areal Reduction Factor	Design Discharge
	Individual a (km2)	Accumlated A (km2)	Individual f	Accumlated F	Individual l (km)	Accumlated L (km)	V (m/s)	t (min)	r (mm/hr)	(m3/s/km)	(m3/s)
NA-2-1	0.97	0.97	0.50	0.50	1.00	1.00	0.80	41	99.14	1.00	13.4
NA-2-2	1.17	2.14	0.50	0.50	1.20	2.20	0.80	66	77.74	0.99	22.9
NA-2-3	2.70	2.70	0.51	0.51	2.80	2.80	0.80	78	70.17	0.98	26.3
NA-2-4	2.15	6.99	0.40	0.47	1.40	3.60	0.80	95	62.10	0.96	54.4
NA-2-5	1.32	1.32	0.44	0.44	1.80	1.80	0.80	58	83.77	0.99	13.4
NA-2-6	0.71	9.02	0.29	0.45	1.70	5.30	0.80	130	50.68	0.95	54.3
NA-2-7	1.62	1.62	0.30	0.30	2.50	2.50	0.80	72	73.76	0.99	9.9
NA-2-8	1.61	12.25	0.42	0.43	1.80	7.10	0.80	168	43.96	0.93	59.8
NA-2-9	1.42	1.42	0.41	0.41	1.40	1.40	0.80	49	90.81	0.99	14.5
NA-2-10	1.88	3.30	0.40	0.40	1.30	2.70	0.80	76	71.33	0.97	25.4
NA-2-11	1.65	4.95	0.43	0.41	1.00	3.70	0.80	97	61.22	0.96	33.1
NA-2-12	1.39	1.39	0.44	0.44	1.80	1.80	0.80	58	83.77	0.99	14.1
NA-2-13	0.71	2.10	0.43	0.44	1.50	3.30	0.80	89	64.90	0.99	16.5
NA-2-14	1.19	8.24	0.43	0.42	1.40	5.10	0.80	126	51.55	0.95	47.1
NA-2-15	1.36	21.85	0.45	0.43	2.20	9.30	0.80	214	37.83	0.91	89.8

(NA-3)

Conditions: Inlet Time; 20min

Block No.	Drainage Area		Run-off Coefficient		Length		Velocity	Time of Concentration	Rainfal Intensity	Areal Reduction Factor	Design Discharge
	Individual a (km2)	Accumlated A (km2)	Individual f	Accumlated F	Individual l (km)	Accumlated L (km)	V (m/s)	t (min)	r (mm/hr)	(m3/s/km)	(m3/s)
NA-3-1	2.02	2.02	0.44	0.44	2.20	2.20	0.80	66	77.74	0.99	19.0
NA-3-2	1.67	3.69	0.45	0.45	1.80	4.00	0.80	103	58.73	0.97	26.3
NA-3-3	1.09	1.09	0.46	0.46	1.60	1.60	0.80	53	87.15	0.99	12.0
NA-3-4	2.77	7.55	0.38	0.42	1.50	5.50	0.80	135	49.83	0.95	41.7
NA-3-5	1.09	1.09	0.41	0.41	2.30	2.30	0.80	68	76.37	0.99	9.4
NA-3-6	1.57	10.21	0.35	0.41	1.20	6.70	0.80	160	45.29	0.94	49.5
NA-3-7	1.49	11.70	0.26	0.39	1.00	7.70	0.80	180	42.10	0.94	50.2
NA-3-8	1.46	1.46	0.42	0.42	1.00	1.00	0.80	41	99.14	0.99	16.7
NA-3-9	1.92	3.38	0.44	0.43	2.20	3.20	0.80	87	65.89	0.98	26.1
NA-3-10	1.25	4.63	0.34	0.41	1.60	4.80	0.80	120	52.92	0.97	27.1
NA-3-11	1.40	1.40	0.38	0.38	3.40	3.40	0.80	91	63.94	0.99	9.4
NA-3-12	1.70	7.73	0.31	0.38	2.40	7.20	0.80	170	43.64	0.95	33.8
NA-3-13	1.61	21.04	0.41	0.39	0.90	8.60	0.80	199	39.59	0.91	82.1

TABLE EA.3 HYDRAULIC DESIGN OF KHAL IMPROVEMENT

DND Project Area (NA)

Khal No.	Design Discharge (m3/s)	Section Bottom Wid. (m)	Upper Wid. (m)	Height (m)	Roughness Coefficien	Slope i (%)	Velosit (m/s	Discharg Capacity (m3/s)
(NA-1)								
KN-1-1	65.0	12.50	20.50	4.00	0.025	0.017	1.02	67.2
KN-1-2	65.0	14.50	30.50	4.00	0.035	0.017	0.73	65.6
KN-1-3	55.8	12.00	28.00	4.00	0.035	0.017	0.71	56.9
KN-1-4	43.1	7.00	22.32	3.83	0.035	0.025	0.79	44.5
KN-1-5	27.1	3.00	17.80	3.70	0.035	0.025	0.71	27.3
KN-1-6	12.7	2.50	8.56	3.03	0.025	0.025	0.83	14.0
KN-2	15.7	2.00	17.60	3.90	0.035	0.025	0.71	27.1
KN-3-1	21.5	2.50	17.98	3.87	0.035	0.025	0.72	28.4
KN-3-2	17.1	2.50	9.40	3.45	0.025	0.025	0.89	18.3
(NA-2)								
KN-4-1	89.8	17.50	25.50	4.00	0.025	0.017	1.07	92.1
KN-4-2	59.8	13.00	29.00	4.00	0.035	0.017	0.72	60.4
KN-4-3	54.4	11.50	27.50	4.00	0.035	0.017	0.71	55.2
KN-4-4	54.4	9.50	25.02	3.88	0.035	0.025	0.83	55.6
KN-4-5	22.9	3.50	17.02	3.38	0.035	0.025	0.68	23.7
KN-4-6	13.4	2.50	8.76	3.13	0.025	0.025	0.85	14.9
KN-5-1	47.1	8.50	16.50	4.00	0.025	0.017	0.96	47.9
KN-5-2	33.1	5.50	13.50	4.00	0.025	0.017	0.89	33.8
KN-5-3	25.4	2.00	17.60	3.90	0.035	0.025	0.71	27.1
KN-5-4	14.5	2.00	15.24	3.31	0.035	0.025	0.64	18.3
KN-6	16.5	2.00	17.52	3.88	0.035	0.025	0.71	26.8
KN-7	9.9	2.00	17.48	3.87	0.035	0.025	0.71	26.6
KN-8	13.4	2.00	17.40	3.85	0.035	0.025	0.70	26.3
KN-9	26.3	4.00	11.40	3.70	0.025	0.025	0.99	28.3
(NA-3)								
KN-10-1	82.1	19.00	27.34	4.17	0.025	0.010	0.86	82.8
KN-10-2	50.2	9.00	25.68	4.17	0.035	0.017	0.71	51.1
KN-10-3	49.5	9.00	25.68	4.17	0.035	0.017	0.71	51.1
KN-10-4	41.7	5.50	21.66	4.04	0.035	0.025	0.79	43.5
KN-10-5	26.3	4.00	11.18	3.59	0.025	0.025	0.98	26.7
KN-10-6	19.0	3.50	10.04	3.27	0.025	0.025	0.91	20.2
KN-11-1	33.8	4.50	21.18	4.17	0.035	0.017	0.65	34.5
KN-11-2	27.1	2.00	18.36	4.09	0.035	0.025	0.73	30.4
KN-11-3	26.1	2.00	18.08	4.02	0.035	0.025	0.72	29.1
KN-11-4	16.7	2.00	16.40	3.60	0.035	0.025	0.68	22.4
KN-12	9.4	2.00	18.00	4.00	0.035	0.025	0.72	28.8
KN-13	9.4	2.00	18.20	4.05	0.035	0.025	0.73	29.7
KN-14	12.0	2.00	9.28	3.64	0.025	0.025	0.89	18.3

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TABLE EA.4 MAIN FEATURES OF PROPOSED RELATED STRUCTURES

Zone	Khal No.	Bridge No.	Existing		Required	Proposed			Remarks
			Type	Size (m x m)	Size (m x m)	Type	Size (m x m)	Width	
NA-1	KN-1-1	1	Girder bridge	12.50 x 5.00	11.55 x 5.00	-	-	-	Road bridge
	"	2	" "	8.40 x 5.00	" "	Girder bridge	11.60 x 5.00	3.66	" "
	KN-1-2	3	Box culvert	4.70 x 4.70	15.75 x 5.00	" "	15.80 x 5.00	40.00	Highway bridge
	KN-1-3	4	Girder bridge	11.00 x 3.00	11.50 x 5.00	" "	11.50 x 5.00	3.66	Road bridge
	KN-1-4	5	-	-	10.26 x 4.83	" "	10.30 x 4.90	40.00	Highway bridge
	KN-1-6	17	-	-	3.87 x 4.03	Slab bridge	3.90 x 4.00	7.00	Road bridge
	KN-2	16	-	-	6.86 x 4.90	Girder bridge	6.90 x 4.90	3.66	Road bridge
	KN-3-1	9	Aqueduct	4.00 x 0.61	7.17 x 0.61	Rect. Aqueduct	7.20 x 0.61	0.91	Rect. Aqueduct
		10	Pipe	0.91 x 2.00	7.17 x 4.87	Girder bridge	7.20 x 4.90	3.66	Road bridge
	"	11	Slab	1.09 x 1.57	" "	" "	" "	"	" "
	"	12	Pipe	0.91 x 1.00	" "	" "	" "	"	" "
	KN-3-2	13	Slab	0.91 x 1.35	4.17 x 4.45	Slab bridge	4.20 x 4.45	"	" "
	"	14	Pipe	0.91 x 1.00	" "	" "	" "	"	" "
NA-2	KN-4-1	43	Pipe	0.45 x 1.00	15.05 x 5.00	Deck Girder	15.10 x 5.00	1.70	Railway bridge
	KN-4-2	46	"	0.45 x 1.00	14.70 x 5.00	Girder bridge	14.70 x 5.00	3.66	Road bridge
	"	47	"	0.45 x 2.00	" "	" "	" "	"	" "
	KN-4-3	15	-	-	13.65 x 5.00	" "	13.70 x 5.00	"	" "
	KN-4-4	6	Slab bridge	4.85 x 2.30	12.08 x 4.88	" "	12.10 x 4.90	"	" "
	KN-4-5	7	Deck- Rly	11.00 x 4.88	7.18 x 4.38	-	-	-	Railway bridge
	"	8	Girder bridge	8.00 x 4.75	" "	-	-	-	Road bridge
	KN-5-1	37	Pipe	0.91 x 2.00	8.75 x 5.00	Girder bridge	8.80 x 5.00	3.66	" "
	"	38	Slab bridge	0.95 x 1.65	" "	" "	" "	"	" "
	"	39	Pipe	0.61 x 1.00	" "	" "	" "	"	" "
	"	40	-	-	" "	" "	" "	"	" "
	"	41	Pipe	0.91 x 1.00	" "	" "	" "	"	" "
	"	42	Slab bridge	2.30 x 2.00	" "	" "	" "	"	" "
	KN-6	49	-	-	6.83 x 4.88	" "	6.90 x 4.90	"	" "
	KN-7	18	-	-	6.82 x 4.87	" "	" "	"	" "
NA-3	KN-10-1	19	Deck-Rly	18.30 x 7.00	16.22 x 5.17	-	-	-	Railway bridge
	"	20	Pipe	0.45 x 2.00	" "	Cantilever	16.30 x 5.20	3.66	Road bridge
	"	21	"	0.91 x 1.00	" "	Deck Girder	" "	1.70	Railway bridge
	KN-10-3	22	"	0.91 x 1.00	12.14 x 5.17	Girder bridge	12.20 x 5.20	3.66	Road bridge
	"	23	"	0.61 x 1.00	" "	" "	" "	"	" "
	KN-10-4	24	Girder bridge	5.50 x 3.70	9.50 x 5.04	" "	9.50 x 5.10	"	" "
	"	25	Arch bridge	4.50 x 4.85	" "	" "	" "	"	" "
	KN-10-5	26	Pipe	0.91 x 1.00	5.31 x 4.59	" "	5.30 x 4.60	"	" "
	"	27	"	" "	" "	" "	" "	"	" "
	"	28	"	" "	" "	" "	" "	"	" "
	"	29	"	" "	" "	" "	" "	"	" "
	"	50	-	-	" "	" "	" "	40.00	Highway bridge
	KN-10-6	30	Box Culvert	0.70 x 0.80	4.24 x 4.27	Deck Girder	4.30 x 4.30	1.70	Railway bridge
	KN-11-1	35	Aqueduct	3.60 x 1.80	8.99 x 1.37	Rect. Aqueduct	9.00 x 1.37	0.91	Rect. Aqueduct
	"	36	Slab bridge	2.40 x 2.50	" "	Girder bridge	9.00 x 5.20	3.66	Road bridge
	KN-11-3	32	Girder bridge	10.8 x 5.10	7.03 x 5.02	-	-	-	" "
	"	33	" "	7.00 x 5.20	7.03 x 5.02	-	-	-	" "
	"	34	" "	10.7 x 5.15	" "	-	-	-	" "
	KN-11-4	31	" "	13.00 x 5.00	6.44 x 4.60	-	-	-	" "
	KN-12	44	Slab bridge	3.00 x 1.90	7.00 x 5.00	Girder bridge	7.00 x 5.00	3.66	" "
	"	45	Girder bridge	10.00 x 5.10	" "	-	-	-	" "
	KN-14	48	Slab bridge	1.70 x 2.25	3.95 x 4.64	Slab bridge	4.00 x 4.70	3.66	" "

TABLE EA.5 PROPOSED KHAL IMPROVEMENT WORKS

DND Project Area (NA)

Zone	Khal No.	Khal Length (km)	Required Hydraulic Section Wb x Wu x H (m x m x m)	Open Channel: Brick Protection (km)	Open Channel: Sodding (km)	Covered Channel: Box Culvert (km)	Covered Channel: Brick Pipe (km)	Bridge (Places)	Aqueduct (Places)	Dredging (1000m3)	Maintenance Road (km)	Land Acquisition (ha)
NA-1	KN-1-1	2.10	12.5 20.5 4.0	2.10	-	-	-	1	-	58.82	2.10	0.91
	KN-1-2	0.70	14.5 30.5 4.0	-	0.70	-	-	1	-	40.75	0.70	1.89
	KN-1-3	1.00	12.0 28.0 4.0	-	1.00	-	-	1	-	41.86	1.00	2.38
	KN-1-4	2.10	7.0 22.3 3.8	-	2.10	-	-	1	-	67.38	2.10	6.76
	KN-1-5	1.50	3.0 17.8 3.7	-	1.50	-	-	-	-	34.20	1.50	4.41
	KN-1-6	1.60	2.5 8.6 3.0	1.60	-	-	-	1	-	27.00	1.60	3.25
	KN-2	1.20	2.0 17.6 3.9	-	1.20	-	-	1	-	39.05	1.20	3.50
	KN-3-1	1.00	2.5 18.0 3.9	-	1.00	-	-	3	1	31.17	1.00	3.37
	KN-3-2	1.60	2.5 9.4 3.5	1.60	-	-	-	2	-	22.89	1.60	2.66
	Sub-Total	12.80		5.30	7.50	0.00	0.00	11	1	363.12	12.80	29.13
NA-2	KN-4-1	0.80	17.5 25.5 4.0	0.80	-	-	-	1	-	92.15	0.80	2.04
	KN-4-2	1.80	13.0 29.0 4.0	-	1.80	-	-	2	-	136.62	1.80	3.70
	KN-4.3	1.70	11.5 27.5 4.0		1.70	-	-	1	-	102.26	1.70	4.23
	KN-4-4	1.40	9.5 25.0 3.9	-	1.40	-	-	1	-	44.58	1.40	3.08
	KN-4-5	1.20	3.5 17.0 3.4	-	1.20	-	-	-	-	30.53	1.20	2.56
	KN-4-6	0.60	2.5 8.8 3.1	0.60	-	-	-	-	-	14.93	0.60	0.38
	KN-5-1	1.40	8.5 16.5 4.0	1.40	-	-	-	6	-	71.82	1.40	1.75
	KN-5-2	1.00	5.5 13.5 4.0	1.00	-	-	-	-	-	32.80	1.00	10.20
	KN-5-3	1.30	2.0 17.6 3.9	-	1.30	-	-	-	-	25.27	1.30	2.67
	KN-5-4	1.40	2.0 15.2 3.3	-	1.40	-	-	-	-	30.80	1.40	4.71
	KN-6	1.50	2.0 17.5 3.9	-	1.50	-	-	1	-	67.56	1.50	4.40
	KN-7	1.60	2.0 17.5 3.9	-	1.60	-	-	1	-	34.72	1.60	4.60
	KN-8	1.80	2.0 17.4 3.9	-	1.80	-	-	-	-	22.49	1.80	2.45
	KN-9	2.20	4.0 11.4 3.7	2.20	-	-	-	-	-	50.69	2.20	4.62
	Sub-Total	19.70		6.00	13.70	0.00	0.00	13	0	757.22	19.70	51.39
NA-3	KN-10-1	2.20	19.0 27.3 4.2	2.20	-	-	-	2	-	111.27	2.20	1.96
	KN-10-2	0.90	19.0 25.7 4.2	-	0.90	-	-	-	-	106.87	0.90	4.82
	KN-10-3	1.20	9.0 25.7 4.2	-	1.20	-	-	2	-	56.97	1.20	2.39
	KN-10-4	1.50	5.5 21.7 4.0	-	1.50	-	-	2	-	62.09	1.50	3.65
	KN-10-5	1.80	4.0 11.2 3.6	1.80	-	-	-	5	-	28.41	1.80	1.28
	KN-10-6	0.80	3.5 10.0 3.3	0.80	-	-	-	1	-	20.80	0.80	0.63
	KN-11-1	2.40	4.5 21.2 4.2	-	2.40	-	-	1	1	126.40	2.40	6.30
	KN-11-2	1.00	2.0 18.4 4.1	-	1.00	-	-	-	-	19.70	1.00	1.48
	KN-11-3	0.90	2.0 18.1 4.0	-	0.90	-	-	-	-	13.13	0.90	1.31
	KN-11-4	1.00	2.0 16.4 3.6	-	1.00	-	-	-	-	9.51	1.00	1.08
	KN-12	2.10	2.0 18.0 4.0	-	2.10	-	-	1	-	42.30	2.10	3.58
	KN-13	1.40	2.0 18.2 4.0	-	1.40	-	-	-	-	29.79	1.40	3.11
	KN-14	1.60	2.0 9.3 3.6	1.60	-	-	-	1	-	10.06	1.60	0.74
	Sub-Total	18.80		6.40	12.40	0.00	0.00	15	1	637.30	18.80	32.33
	Total	51.30		17.70	33.60	0.00	0.00	39	2	1757.64	51.30	112.85

TABLE EA.6(1) BREAKDOWN OF CONSTRUCTION COST OF PUMPING STATION (1)

A. DND Area

1) NA-1: P.10 (Q=14.50m3/s)

(1991 Price)

Item	Unit	Unit Cost (TK)			Quantity	Construction Cost (1000TK)		
		Total	F/C(%)	L/C(%)		F/C	L/C	Total
I. Preparation Work	LS	11,370,156	96	4	1	10,895	475	11,370
II. Mechanical & Electrical Work								
1. ø1200 Pump	Place	86,947,365	100	0	1	86,947	0	86,947
2. 170 kw Main Motor	Place	33,078,145	100	0	1	33,078	0	33,078
3. Pipe and Valve	Place	23,729,889	100	0	1	23,730	0	23,730
4. Electrical Facilities	LS.	40,000,000	100	0	1	40,000	0	40,000
5. Crane and Spare Parts	LS.	3,500,000	100	0	1	3,500	0	3,500
6. Gate Leaf and Sheet	LS.	2,496,823	100	0	1	2,497	0	2,497
7. Hoist Machine	LS.	1,664,548	100	0	1	1,665	0	1,665
8. Installation	LS.	19,141,677	90	10	1	17,228	1,914	19,142
9. Miscellaneous	LS	16,844,676	55	45	1	9,265	7,580	16,845
Subtotal			96	4		217,909	9,494	227,403
Total			96	4		228,804	9,969	238,773

2) NA-2: P.11A (Q=24.90m3/s)

(1991 Price)

Item	Unit	Unit Cost (TK)			Quantity	Construction Cost (1000TK)		
		Total	F/C(%)	L/C(%)		F/C	L/C	Total
I. Preparation Work	LS	29,628,749	81	19	1	23,869	5,760	29,629
II. Civil Work								
1. Excavation	m3	324	80	20	23780	6,164	1,541	7,705
2. Embankment	m3	509	70	30	18221	6,492	2,782	9,274
3. Backfill	m3	118	50	50	4546	268	268	536
4. R.C. Pile (0.4x0.4)	m	3,262	60	40	3629	7,103	4,735	11,838
5. Sheet Pile (Type II)	m2	6,117	60	40	264	967	645	1,612
6. Leveling Concrete	m2	3,777	60	40	328	742	495	1,237
7. Concrete	m3	4,786	60	40	4627	13,288	8,859	22,146
8. Form	m2	761	80	20	8666	5,276	1,319	6,595
9. Reinforcement Bar	t	44,717	60	40	455	12,198	8,132	20,331
10. Slope Protection	m2	1,579	40	60	1439	909	1,363	2,271
11. Bed Protection (Concrete Block)	m2	4,613	50	50	168	387	387	775
12. Bed Protection (brick)	m2	1,579	40	60	449	284	426	710
13. Sodding	m2	60	20	80	2380	29	114	143
14. Operation Bridge	m2	65,400	55	45	11	396	324	719
15. Building Works	LS	63,500,000	40	60	1	25,400	38,100	63,500
16. Miscellaneous	LS	14,939,274	53	47	1	7,990	6,949	14,939
17. Coffer Dam	LS	49,299,603	53	47	1	26,368	22,932	49,300
Subtotal			53	47		114,261	99,371	213,632
III. Mechanical & Electrical Work								
1. ø2000 Pump	Place	151,734,375	100	0	1	151,734	0	151,734
2. 560 kw Main Motor	Place	49,349,507	100	0	1	49,350	0	49,350
3. Pipe and Valve	Place	36,244,243	100	0	1	36,244	0	36,244
4. Electrical Facilities	LS.	38,906,250	100	0	1	38,906	0	38,906
5. Crane and Spare Parts	LS.	10,504,688	100	0	1	10,505	0	10,505
6. Automatic Trash Screen	LS.	27,136,842	100	0	1	27,137	0	27,137
7. Gate Leaf and Sheet	LS.	3,060,000	100	0	1	3,060	0	3,060
8. Hoist Machine	LS.	2,040,000	100	0	1	2,040	0	2,040
9. Installation	LS.	31,897,590	90	10	1	28,708	3,190	31,898
10. Miscellaneous	LS	28,069,880	55	45	1	15,438	12,631	28,070
Subtotal			96	4		363,122	15,821	378,943
Total			81	19		501,252	120,952	622,204

Note : Preparation work (site clearing, site office motor pool, survey works, soil boring, safety control, etc.)

TABLE EA.6(2) BREAKDOWN OF CONSTRUCTION COST OF PUMPING STATION (2)

A. DND Area

3) NA-3: P.11B (Q=25.40m3/s)

(1991 Price)

Item	Unit	Unit Cost (TK)			Quantity	Construction Cost (1000TK)		
		Total	F/C(%)	L/C(%)		F/C	L/C	Total
I. Preparation Work	LS	30,076,354	81	19	1	24,298	5,778	30,076
II. Civil Work								
1. Excavation	m3	324	80	20	23780	6,164	1,541	7,705
2. Embankment	m3	509	70	30	18221	6,492	2,782	9,274
3. Backfill	m3	118	50	50	4546	268	268	536
4. R.C. Pile (0.4x0.4)	m	3,262	60	40	3629	7,103	4,735	11,838
5. Sheet Pile (Type II)	m2	6,117	60	40	264	967	645	1,612
6. Leveling Concrete	m2	3,777	60	40	328	742	495	1,237
7. Concrete	m3	4,786	60	40	4627	13,288	8,859	22,146
8. Form	m2	761	80	20	8666	5,276	1,319	6,595
9. Reinforcement Bar	t	44,717	60	40	455	12,198	8,132	20,331
10. Slope Protection	m2	1,579	40	60	1439	909	1,363	2,271
11. Bed Protection (Concrete Block)	m2	4,613	50	50	168	387	387	775
12. Bed Protection (brick)	m2	1,579	40	60	449	284	426	710
13. Sodding	m2	60	20	80	2380	29	114	143
14. Operation Bridge	m2	65,400	55	45	11	396	324	719
15. Building Works	LS	63,500,000	40	60	1	25,400	38,100	63,500
16. Miscellaneous	LS	14,939,274	53	47	1	7,990	6,949	14,939
17. Coffer Dam	LS	49,299,603	53	47	1	26,368	22,932	49,300
Subtotal			53	47		114,261	99,371	213,632
III. Mechanical & Electrical Work								
1. ø2000 Pump	Place	154,732,500	100	0	1	154,733	0	154,733
2. 560 kw Main Motor	Place	50,324,605	100	0	1	50,325	0	50,325
3. Pipe and Valve	Place	36,960,395	100	0	1	36,960	0	36,960
4. Electrical Facilities	LS.	39,675,000	100	0	1	39,675	0	39,675
5. Crane and Spare Parts	LS.	10,712,250	100	0	1	10,712	0	10,712
6. Automatic Trash Screen	LS.	28,710,779	100	0	1	28,711	0	28,711
7. Gate Leaf and Sheet	LS.	3,237,480	100	0	1	3,237	0	3,237
8. Hoist Machine	LS.	2,158,320	100	0	1	2,158	0	2,158
9. Installation	LS.	34,544,899	90	10	1	29,386	3,265	32,651
10. Miscellaneous	LS	30,399,511	55	45	1	15,803	12,930	28,733
Subtotal			96	4		371,700	16,195	387,895
Total			81	19		510,259	121,344	631,603

Note : Preparation work (site clearing, site office motor pool, survey works, soil boring, safety control, etc.)

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TABLE EA.7(1) BREAKDOWN OF CONSTRUCTION COST OF KHAL IMPROVEMENT (1)

DND Project Area (NA)

(Unit: 1000Tk ,1991 Price)

Zone	Khal	Channel Works			Maintenance Road			Banking			Dredging			Total		
		F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL	F/C	L/C	TOTAL
NA-1	KN-1-1	17,585	26,378	43,963	6,668	741	7,409	3,469	3,469	6,938	1,870	7,482	9,352	29,593	38,069	67,662
	KN-1-2	93	372	465	2,223	247	2,470	1,156	1,156	2,313	1,296	5,183	6,479	4,768	6,959	11,727
	KN-1-3	133	531	664	3,175	353	3,528	1,652	1,652	3,304	1,331	5,325	6,656	6,291	7,861	14,152
	KN-1-4	279	1,116	1,395	6,668	741	7,409	3,469	3,469	6,938	2,143	8,571	10,713	12,559	13,897	26,455
	KN-1-5	199	797	996	4,763	529	5,292	2,478	2,478	4,956	1,088	4,350	5,438	8,528	8,154	16,682
	KN-1-6	13,398	20,097	33,495	5,080	564	5,645	2,643	2,643	5,286	859	3,434	4,293	21,980	26,739	48,720
	KN-2	159	638	797	3,810	423	4,234	1,982	1,982	3,965	1,242	4,967	6,209	7,194	8,011	15,204
	KN-3-1	133	531	664	3,175	353	3,528	1,652	1,652	3,304	991	3,965	4,956	5,951	6,501	12,452
	KN-3-2	13,398	20,097	33,495	5,080	564	5,645	2,643	2,643	5,286	728	2,912	3,640	21,850	26,216	48,066
	Sub-Total	45,378	70,557	115,935	40,643	4,516	45,158	21,146	21,146	42,291	11,547	46,189	57,736	118,713	142,407	261,120
NA-2	KN-4-1	6,699	10,048	16,747	2,540	282	2,822	1,322	1,322	2,643	2,930	11,721	14,652	13,491	23,373	36,864
	KN-4-2	239	956	1,196	5,715	635	6,350	2,974	2,974	5,947	4,345	17,378	21,723	13,273	21,943	35,216
	KN-4.3	226	903	1,129	5,398	600	5,998	2,808	2,808	5,617	3,252	13,007	16,259	11,684	17,319	29,003
	KN-4-4	186	744	930	4,445	494	4,939	2,313	2,313	4,626	1,418	5,671	7,088	8,362	9,221	17,583
	KN-4-5	159	638	797	3,810	423	4,234	1,982	1,982	3,965	971	3,883	4,854	6,923	6,927	13,850
	KN-4-6	5,024	7,537	12,561	1,905	212	2,117	991	991	1,982	475	1,899	2,374	8,395	10,639	19,034
	KN-5-1	11,723	17,585	29,308	4,445	494	4,939	2,313	2,313	4,626	2,284	9,136	11,419	20,765	29,527	50,292
	KN-5-2	8,374	12,561	20,934	3,175	353	3,528	1,652	1,652	3,304	1,043	4,172	5,215	14,244	18,738	32,982
	KN-5-3	173	691	863	4,128	459	4,586	2,148	2,148	4,295	804	3,214	4,018	7,252	6,511	13,763
	KN-5-4	186	744	930	4,445	494	4,939	2,313	2,313	4,626	979	3,918	4,897	7,923	7,468	15,392
	KN-6	199	797	996	4,763	529	5,292	2,478	2,478	4,956	2,148	8,594	10,742	9,588	12,398	21,986
	KN-7	213	850	1,063	5,080	564	5,645	2,643	2,643	5,286	1,104	4,416	5,520	9,040	8,474	17,514
	KN-8	239	956	1,196	5,715	635	6,350	2,974	2,974	5,947	715	2,861	3,576	9,643	7,426	17,069
	KN-9	18,423	27,634	46,056	6,985	776	7,762	3,634	3,634	7,269	1,612	6,448	8,060	30,654	38,492	69,146
	Sub-Total	52,062	82,643	134,706	62,551	6,950	69,502	32,544	32,544	65,089	24,080	96,318	120,398	171,238	218,456	389,694
NA-3	KN-10-1	18,423	27,634	46,056	6,985	776	7,762	3,634	3,634	7,269	3,538	14,154	17,692	32,581	46,198	78,779
	KN-10-2	120	478	598	2,858	318	3,175	1,487	1,487	2,974	3,398	13,594	16,992	7,863	15,876	23,739
	KN-10-3	159	638	797	3,810	423	4,234	1,982	1,982	3,965	1,812	7,247	9,058	7,764	10,290	18,054
	KN-10-4	199	797	996	4,763	529	5,292	2,478	2,478	4,956	1,974	7,898	9,872	9,415	11,702	21,117
	KN-10-5	15,073	22,609	37,681	5,715	635	6,350	2,974	2,974	5,947	903	3,614	4,517	24,665	29,831	54,496
	KN-10-6	6,699	10,048	16,747	2,540	282	2,822	1,322	1,322	2,643	661	2,646	3,307	11,222	14,298	25,520
	KN-11-1	319	1,275	1,594	7,620	847	8,467	3,965	3,965	7,930	4,020	16,078	20,098	15,924	22,165	38,088
	KN-11-2	133	531	664	3,175	353	3,528	1,652	1,652	3,304	626	2,506	3,132	5,587	5,042	10,629
	KN-11-3	120	478	598	2,858	318	3,175	1,487	1,487	2,974	418	1,670	2,088	4,882	3,953	8,834
	KN-11-4	8,374	12,561	20,934	3,175	353	3,528	1,652	1,652	3,304	302	1,210	1,512	13,503	15,775	29,278
	KN-12	279	1,116	1,395	6,668	741	7,409	3,469	3,469	6,938	1,345	5,381	6,726	11,761	10,706	22,468
	KN-13	186	744	930	4,445	494	4,939	2,313	2,313	4,626	947	3,789	4,737	7,891	7,340	15,231
	KN-14	13,398	20,097	33,495	5,080	564	5,645	2,643	2,643	5,286	319.908	1279.632	1599.54	21,442	24,585	46,026
	Sub-Total	63,480	99,006	162,486	59,694	6,633	66,326	31,058	31,058	62,115	20266.14	81064.56	101330.7	174,498	217,761	392,258
	Total	160,920	252,206	413,126	162,888	18,099	180,986	84,748	84,748	169,495	55,893	223,572	279,465	464,448	578,625	1,043,073

TABLE EA.7(2) BREAKDOWN OF CONSTRUCTION COST OF KHAL IMPROVEMENT(2)

DND Project Area (NA)

(1991 Price)

Zone	Khal	Length	Open Channel								Maintenance Road						
			Type	Area	Unit Construction Cost			Construction Cost (1000TK)			Area	Unit Construction Cost			Construction Cost (1000TK)		
		m		(m2)	Total	F/C(%)	L/C(%)	F/C	L/C	Total	(m2)	Total	F/C(%)	L/C (%)	F/C	L/C	Total
NA-1	KN-1-1	2,100	Brick	27,842	1579	40	60	17,585	26,378	43,963	12,600	588	90	10	6,668	741	7,409
	KN-1-2	700	Sodding	7,749	60	20	80	93	372	465	4,200	588	90	10	2,223	247	2,470
	KN-1-3	1,000	Sodding	11,070	60	20	80	133	531	664	6,000	588	90	10	3,175	353	3,528
	KN-1-4	2,100	Sodding	23,247	60	20	80	279	1,116	1,395	12,600	588	90	10	6,668	741	7,409
	KN-1-5	1,500	Sodding	16,605	60	20	80	199	797	996	9,000	588	90	10	4,763	529	5,292
	KN-1-6	1,600	Brick	21,213	1579	40	60	13,398	20,097	33,495	9,600	588	90	10	5,080	564	5,645
	KN-2	1,200	Sodding	13,284	60	20	80	159	638	797	7,200	588	90	10	3,810	423	4,234
	KN-3-1	1,000	Sodding	11,070	60	20	80	133	531	664	6,000	588	90	10	3,175	353	3,528
	KN-3-2	1,600	Brick	21,213	1579	40	60	13,398	20,097	33,495	9,600	588	90	10	5,080	564	5,645
	Sub-Total	12,800				39	61	45,378	70,557	115,935	76,800		90	10	40,643	4,516	45,158
NA-2	KN-4-1	800	Brick	10,606	1579	40	60	6,699	10,048	16,747	4,800	588	90	10	2,540	282	2,822
	KN-4-2	1,800	Sodding	19,926	60	20	80	239	956	1,196	10,800	588	90	10	5,715	635	6,350
	KN-4.3	1,700	Sodding	18,819	60	20	80	226	903	1,129	10,200	588	90	10	5,398	600	5,998
	KN-4-4	1,400	Sodding	15,498	60	20	80	186	744	930	8,400	588	90	10	4,445	494	4,939
	KN-4-5	1,200	Sodding	13,284	60	20	80	159	638	797	7,200	588	90	10	3,810	423	4,234
	KN-4-6	600	Brick	7,955	1579	40	60	5,024	7,537	12,561	3,600	588	90	10	1,905	212	2,117
	KN-5-1	1,400	Brick	18,561	1579	40	60	11,723	17,585	29,308	8,400	588	90	10	4,445	494	4,939
	KN-5-2	1,000	Brick	13,258	1579	40	60	8,374	12,561	20,934	6,000	588	90	10	3,175	353	3,528
	KN-5-3	1,300	Sodding	14,391	60	20	80	173	691	863	7,800	588	90	10	4,128	459	4,586
	KN-5-4	1,400	Sodding	15,498	60	20	80	186	744	930	8,400	588	90	10	4,445	494	4,939
	KN-6	1,500	Sodding	16,605	60	20	80	199	797	996	9,000	588	90	10	4,763	529	5,292
	KN-7	1,600	Sodding	17,712	60	20	80	213	850	1,063	9,600	588	90	10	5,080	564	5,645
	KN-8	1,800	Sodding	19,926	60	20	80	239	956	1,196	10,800	588	90	10	5,715	635	6,350
	KN-9	2,200	Brick	29,168	1579	40	60	18,423	27,634	46,056	13,200	588	90	10	6,985	776	7,762
	Sub-Total	19,700				39	61	52,062	82,643	134,706	118,200		90	10	62,551	6,950	69,502
NA-3	KN-10-1	2,200	Brick	29,168	1579	40	60	18,423	27,634	46,056	13,200	588	90	10	6,985	776	7,762
	KN-10-2	900	Sodding	9,963	60	20	80	120	478	598	5,400	588	90	10	2,858	318	3,175
	KN-10-3	1,200	Sodding	13,284	60	20	80	159	638	797	7,200	588	90	10	3,810	423	4,234
	KN-10-4	1,500	Sodding	16,605	60	20	80	199	797	996	9,000	588	90	10	4,763	529	5,292
	KN-10-5	1,800	Brick	23,864	1579	40	60	15,073	22,609	37,681	10,800	588	90	10	5,715	635	6,350
	KN-10-6	800	Brick	10,606	1579	40	60	6,699	10,048	16,747	4,800	588	90	10	2,540	282	2,822
	KN-11-1	2,400	Sodding	26,568	60	20	80	319	1,275	1,594	14,400	588	90	10	7,620	847	8,467
	KN-11-2	1,000	Sodding	11,070	60	20	80	133	531	664	6,000	588	90	10	3,175	353	3,528
	KN-11-3	900	Sodding	9,963	60	20	80	120	478	598	5,400	588	90	10	2,858	318	3,175
	KN-11-4	1,000	Brick	13,258	1579	40	60	8,374	12,561	20,934	6,000	588	90	10	3,175	353	3,528
	KN-12	2,100	Sodding	23,247	60	20	80	279	1,116	1,395	12,600	588	90	10	6,668	741	7,409
	KN-13	1,400	Sodding	15,498	60	20	80	186	744	930	8,400	588	90	10	4,445	494	4,939
	KN-14	1,600	Brick	21,213	1579	40	60	13,398	20,097	33,495	9,600	588	90	10	5,080	564	5,645
	Sub-Total	18,800				39	61	63,480	99,006	162,486	112,800		90	10	59,694	6,633	66,326
	Total	51,300				39	61	160,920	252,206	413,126	307,800		90	10	162,888	18,099	180,986

DND Project Area (NA)

TABLE EA.7(3) BREAKDOWN OF CONSTRUCTION COST OF KHAL IMPROVEMENT (3)

(1991 Price)

Zone	Khal	Length	Banking							Dredging							Land Acqisition						
			Volume	Unit Construction Cost			Construction Cost (1000TK)			Volume	Unit Construction Cost			Construction Cost (1000TK)			Area	Unit Price (1000Tk)			Cost (1000TK)		
		(m)	(1000m3)	Total	F/C(%)	L/C (%)	F/C	L/C	Total	(1000m2)	Total	F/C(%)	L/C (%)	F/C	L/C	Total	(ha)	Total	F/C(%)	L/C (%)	F/C	L/C	Total
NA-1	KN-1-1	2,100	58.80	118	50	50	3,469	3,469	6,938	58.82	159	20	80	1,870	7,482	9,352	0.91	3,100	0	100	0	2,821	2,821
	KN-1-2	700	19.60	118	50	50	1,156	1,156	2,313	40.75	159	20	80	1,296	5,183	6,479	1.89	3,100	0	100	0	5,859	5,859
	KN-1-3	1,000	28.00	118	50	50	1,652	1,652	3,304	41.86	159	20	80	1,331	5,325	6,656	2.38	3,100	0	100	0	7,378	7,378
	KN-1-4	2,100	58.80	118	50	50	3,469	3,469	6,938	67.38	159	20	80	2,143	8,571	10,713	6.76	3,100	0	100	0	20,956	20,956
	KN-1-5	1,500	42.00	118	50	50	2,478	2,478	4,956	34.20	159	20	80	1,088	4,350	5,438	4.41	3,100	0	100	0	13,671	13,671
	KN-1-6	1,600	44.80	118	50	50	2,643	2,643	5,286	27.00	159	20	80	859	3,434	4,293	3.25	3,100	0	100	0	10,075	10,075
	KN-2	1,200	33.60	118	50	50	1,982	1,982	3,965	39.05	159	20	80	1,242	4,967	6,209	3.50	3,100	0	100	0	10,850	10,850
	KN-3-1	1,000	28.00	118	50	50	1,652	1,652	3,304	31.17	159	20	80	991	3,965	4,956	3.37	3,100	0	100	0	10,447	10,447
	KN-3-2	1,600	44.80	118	50	50	2,643	2,643	5,286	22.89	159	20	80	728	2,912	3,640	2.66	3,100	0	100	0	8,246	8,246
	Sub-Total	12,800	358.40				21,146	21,146	42,291	363.12				11,547	46,189	57,736	29.13				0	90,303	90,303
NA-2	KN-4-1	800	22.40	118	50	50	1,322	1,322	2,643	92.15	159	20	80	2,930	11,721	14,652	2.04	3,100	0	100	0	6,324	6,324
	KN-4-2	1,800	50.40	118	50	50	2,974	2,974	5,947	136.62	159	20	80	4,345	17,378	21,723	3.70	3,100	0	100	0	11,470	11,470
	KN-4.3	1,700	47.60	118	50	50	2,808	2,808	5,617	102.26	159	20	80	3,252	13,007	16,259	4.23	3,100	0	100	0	13,113	13,113
	KN-4-4	1,400	39.20	118	50	50	2,313	2,313	4,626	44.58	159	20	80	1,418	5,671	7,088	3.08	3,100	0	100	0	9,548	9,548
	KN-4-5	1,200	33.60	118	50	50	1,982	1,982	3,965	30.53	159	20	80	971	3,883	4,854	2.56	3,100	0	100	0	7,936	7,936
	KN-4-6	600	16.80	118	50	50	991	991	1,982	14.93	159	20	80	475	1,899	2,374	0.38	3,100	0	100	0	1,178	1,178
	KN-5-1	1,400	39.20	118	50	50	2,313	2,313	4,626	71.82	159	20	80	2,284	9,136	11,419	1.75	3,100	0	100	0	5,425	5,425
	KN-5-2	1,000	28.00	118	50	50	1,652	1,652	3,304	32.80	159	20	80	1,043	4,172	5,215	10.20	3,100	0	100	0	31,620	31,620
	KN-5-3	1,300	36.40	118	50	50	2,148	2,148	4,295	25.27	159	20	80	804	3,214	4,018	2.67	3,100	0	100	0	8,277	8,277
	KN-5-4	1,400	39.20	118	50	50	2,313	2,313	4,626	30.80	159	20	80	979	3,918	4,897	4.71	3,100	0	100	0	14,601	14,601
	KN-6	1,500	42.00	118	50	50	2,478	2,478	4,956	67.56	159	20	80	2,148	8,594	10,742	4.40	3,100	0	100	0	13,640	13,640
	KN-7	1,600	44.80	118	50	50	2,643	2,643	5,286	34.72	159	20	80	1,104	4,416	5,520	4.60	3,100	0	100	0	14,260	14,260
	KN-8	1,800	50.40	118	50	50	2,974	2,974	5,947	22.49	159	20	80	715	2,861	3,576	2.45	3,100	0	100	0	7,595	7,595
	KN-9	2,200	61.60	118	50	50	3,634	3,634	7,269	50.69	159	20	80	1,612	6,448	8,060	4.62	3,100	0	100	0	14,322	14,322
	Sub-Total	19,700	551.60				32,544	32,544	65,089	757.22				24,080	96,318	120,398	51.39				0	159,309	159,309
NA-3	KN-10-1	2,200	61.60	118	50	50	3,634	3,634	7,269	111.27	159	20	80	3,538	14,154	17,692	1.96	3,100	0	100	0	6,076	6,076
	KN-10-2	900	25.20	118	50	50	1,487	1,487	2,974	106.87	159	20	80	3,398	13,594	16,992	4.82	3,100	0	100	0	14,942	14,942
	KN-10-3	1,200	33.60	118	50	50	1,982	1,982	3,965	56.97	159	20	80	1,812	7,247	9,058	2.39	3,100	0	100	0	7,409	7,409
	KN-10-4	1,500	42.00	118	50	50	2,478	2,478	4,956	62.09	159	20	80	1,974	7,898	9,872	3.65	3,100	0	100	0	11,315	11,315
	KN-10-5	1,800	50.40	118	50	50	2,974	2,974	5,947	28.41	159	20	80	903	3,614	4,517	1.28	3,100	0	100	0	3,968	3,968
	KN-10-6	800	22.40	118	50	50	1,322	1,322	2,643	20.80	159	20	80	661	2,646	3,307	0.63	3,100	0	100	0	1,953	1,953
	KN-11-1	2,400	67.20	118	50	50	3,965	3,965	7,930	126.40	159	20	80	4,020	16,078	20,098	6.30	3,100	0	100	0	19,530	19,530
	KN-11-2	1,000	28.00	118	50	50	1,652	1,652	3,304	19.70	159	20	80	626	2,506	3,132	1.48	3,100	0	100	0	4,588	4,588
	KN-11-3	900	25.20	118	50	50	1,487	1,487	2,974	13.13	159	20	80	418	1,670	2,088	1.31	3,100	0	100	0	4,061	4,061
	KN-11-4	1,000	28.00	118	50	50	1,652	1,652	3,304	9.51	159	20	80	302	1,210	1,512	1.08	3,100	0	100	0	3,348	3,348
	KN-12	2,100	58.80	118	50	50	3,469	3,469	6,938	42.30	159	20	80	1,345	5,381	6,726	3.58	3,100	0	100	0	11,098	11,098
	KN-13	1,400	39.20	118	50	50	2,313	2,313	4,626	29.79	159	20	80	947	3,789	4,737	3.11	3,100	0	100	0	9,641	9,641
	KN-14	1,600	44.80	118	50	50	2,643	2,643	5,286	10.06	159	20	80	320	1,280	1,600	0.74	3,100	0	100	0	2,294	2,294
	Sub-Total	18,800	526.40				31,058	31,058	62,115	637.30				20,266	81,065	101,331	32.33				0	100,223	100,223
	Total	51,300	1,436.40				84,748	84,748	169,495	1757.64				55,893	223,572	279,465	112.85				0	349,835	349,835

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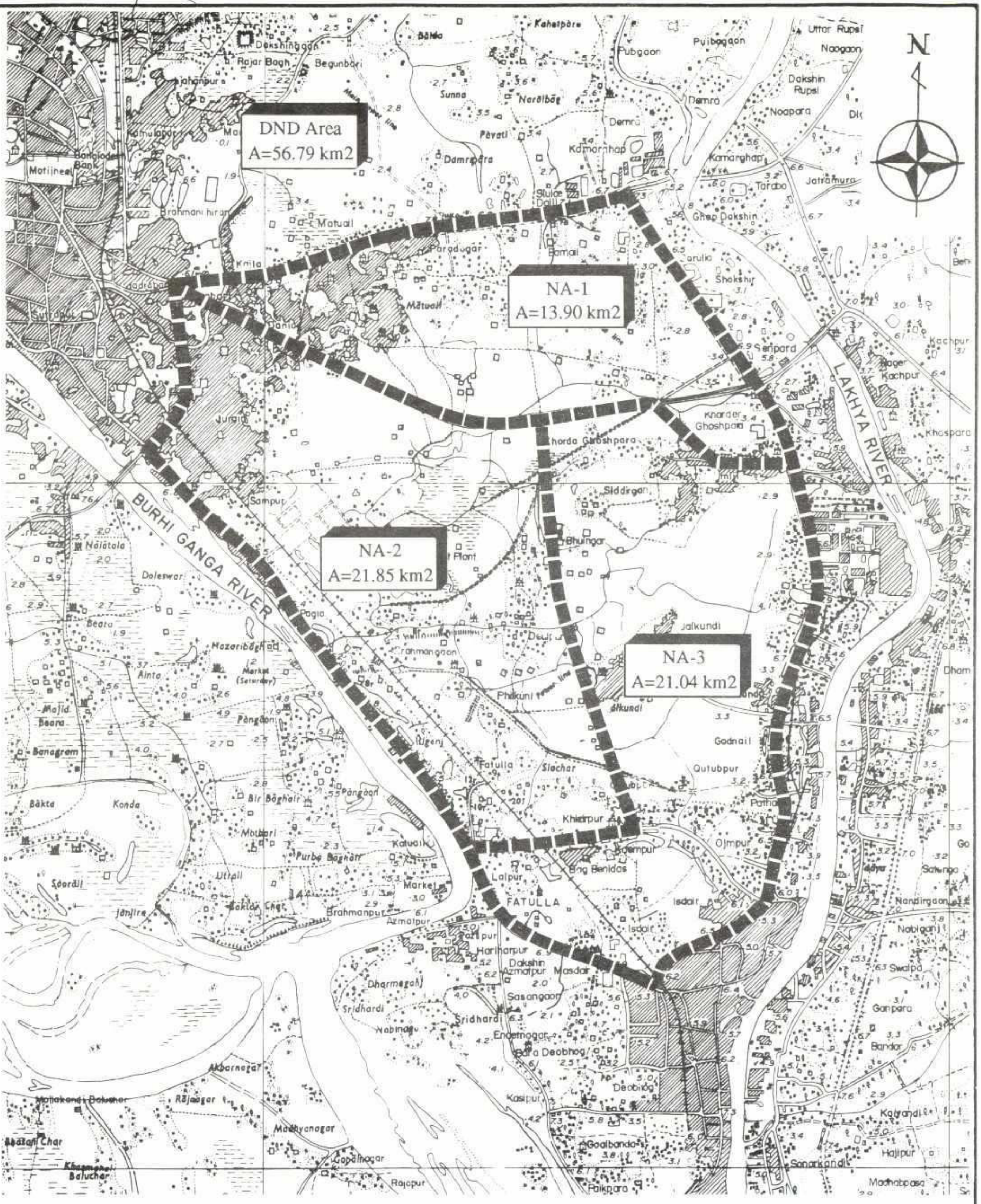
TABLE EA.8 BREAKDOWN OF CONSTRUCTION OF BRIDGE/AQUEDUCT

DND Project Area

(1991 Price)

Zone	Khal No.	Bridge No.	Length (m)	Type	Area (m2)	Unit Cost (TK) Total	F/C(%)	L/C(%)	Construction Cost (1000TK) F/C	L/C	Total	C.D.S.T. (1000Tk)	Remarks
NA-1	KN-1-1	2	11.60	Girder bridge	42.46	51.00	40	60	866	1,299	2,165	-	Road bridge
	KN-1-2	3	15.80	" "	632.00	43.00	40	60	10,870	16,306	27,176	-	Highway bridge
	KN-1-3	4	11.50	" "	42.09	51.50	40	60	867	1,301	2,168	-	Road bridge
	KN-1-4	5	10.30	" "	412.00	55.00	40	60	9,064	13,596	22,660	-	Highway bridge
	KN-1-6	17	3.90	Slab bridge	27.30	112.35	40	60	1,227	1,840	3,067	-	Road bridge
	KN-2	16	6.90	Girder bridge	25.25	72.00	40	60	727	1,091	1,818	-	Road bridge
	KN-3-1	9	7.20	Rect. Aqueduct	-	-	-	-	647	1,040	1,687	-	Rect. Aqueduct
		10	7.20	Girder bridge	26.35	70.00	40	60	738	1,107	1,845	-	Road bridge
	"	11	7.20	" "	26.35	70.00	40	60	738	1,107	1,845	-	" "
	"	12	7.20	" "	26.35	70.00	40	60	738	1,107	1,845	-	" "
	KN-3-2	13	4.20	Slab bridge	15.37	112.05	40	60	689	1,033	1,722	-	" "
	"	14	4.20	" "	15.37	112.05	40	60	689	1,033	1,722	-	" "
	Sub Total						40	60	27,860	41,860	69,720	0	
NA-2	KN-4-1	43	15.10	Deck Girder	-	-	-	-	963	852	1,816	506	Railway bridge
	KN-4-2	46	14.70	Girder bridge	53.80	45.00	40	60	968	1,453	2,421	-	Road bridge
	"	47	14.70	" "	53.80	45.00	40	60	968	1,453	2,421	-	" "
	KN-4-3	15	13.70	" "	50.14	46.50	40	60	933	1,399	2,332	-	" "
	KN-4-4	6	12.10	" "	44.29	50.50	40	60	895	1,342	2,236	-	" "
	KN-5-1	37	8.80	" "	32.21	61.00	40	60	786	1,179	1,965	-	" "
	"	38	8.80	" "	32.21	61.00	40	60	786	1,179	1,965	-	" "
	"	39	8.80	" "	32.21	61.00	40	60	786	1,179	1,965	-	" "
	"	40	8.80	" "	32.21	61.00	40	60	786	1,179	1,965	-	" "
	"	41	8.80	" "	32.21	61.00	40	60	786	1,179	1,965	-	" "
	"	42	8.80	" "	32.21	61.00	40	60	786	1,179	1,965	-	" "
	KN-6	49	6.90	" "	25.25	72.00	40	60	727	1,091	1,818	-	" "
	KN-7	18	6.90	" "	25.25	72.00	40	60	727	1,091	1,818	-	" "
	Sub Total						41	59	10,897	15,753	26,651	506	
NA-3	KN-10-1	20	16.30	Cantilever	59.66	42.00	40	60	1,002	1,503	2,506	-	Road bridge
	"	21	16.30	Deck Girder	-	-	-	-	1,014	879	1,893	546	Railway bridge
	KN-10-3	22	12.20	Girder bridge	44.65	50.00	40	60	893	1,340	2,233	-	Road bridge
	"	23	12.20	" "	44.65	50.00	40	60	893	1,340	2,233	-	" "
	KN-10-4	24	9.50	" "	34.77	58.00	40	60	807	1,210	2,017	-	" "
	"	25	9.50	" "	34.77	58.00	40	60	807	1,210	2,017	-	" "
	KN-10-5	26	5.30	" "	19.40	87.00	40	60	675	1,013	1,688	-	" "
	"	27	5.30	" "	19.40	87.00	40	60	675	1,013	1,688	-	" "
	"	28	5.30	" "	19.40	87.00	40	60	675	1,013	1,688	-	" "
	"	29	5.30	" "	19.40	87.00	40	60	675	1,013	1,688	-	" "
	"	50	5.30	" "	212.00	87.00	40	60	7,378	11,066	18,444	-	Highway bridge
	KN-10-6	30	4.30	Deck Girder	-	-	-	-	383	413	796	144	Railway bridge
	KN-11-1	35	9.00	Rect. Aqueduct	-	-	-	-	721	1,146	1,868	-	Rect. Aqueduct
	"	36	9.00	Girder bridge	32.94	60.00	40	60	791	1,186	1,976	-	Road bridge
	KN-12	44	7.00	Girder bridge	25.62	71.50	40	60	733	1,099	1,832	-	" "
	KN-14	48	4.00	Slab bridge	14.64	112.25	40	60	657	986	1,643	-	" "
	Sub Total						41	59	18,778	27,428	46,208	690	
	Total						40	60	57,535	85,041	142,578	1,196	



LEGEND

▬▬▬▬ : Drainage Zone Boundary

0 1 2 3 4 5 Km.

Scale

FIG. EA.1	DRAINAGE ZONE : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

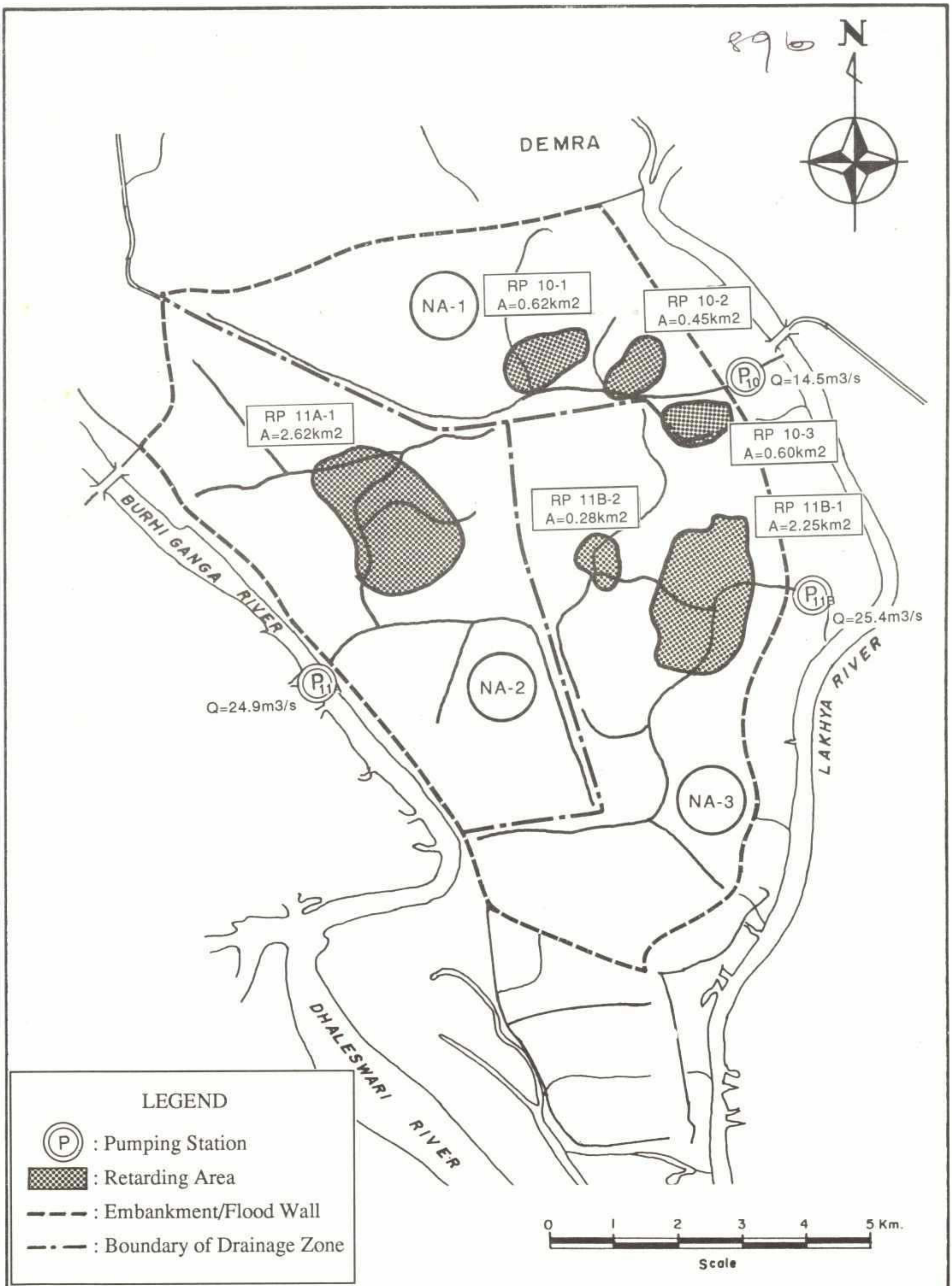


FIG. EA.2 PROPOSED REQUIREMENTS OF PUMP STATION AND RETARDING AREA : DND

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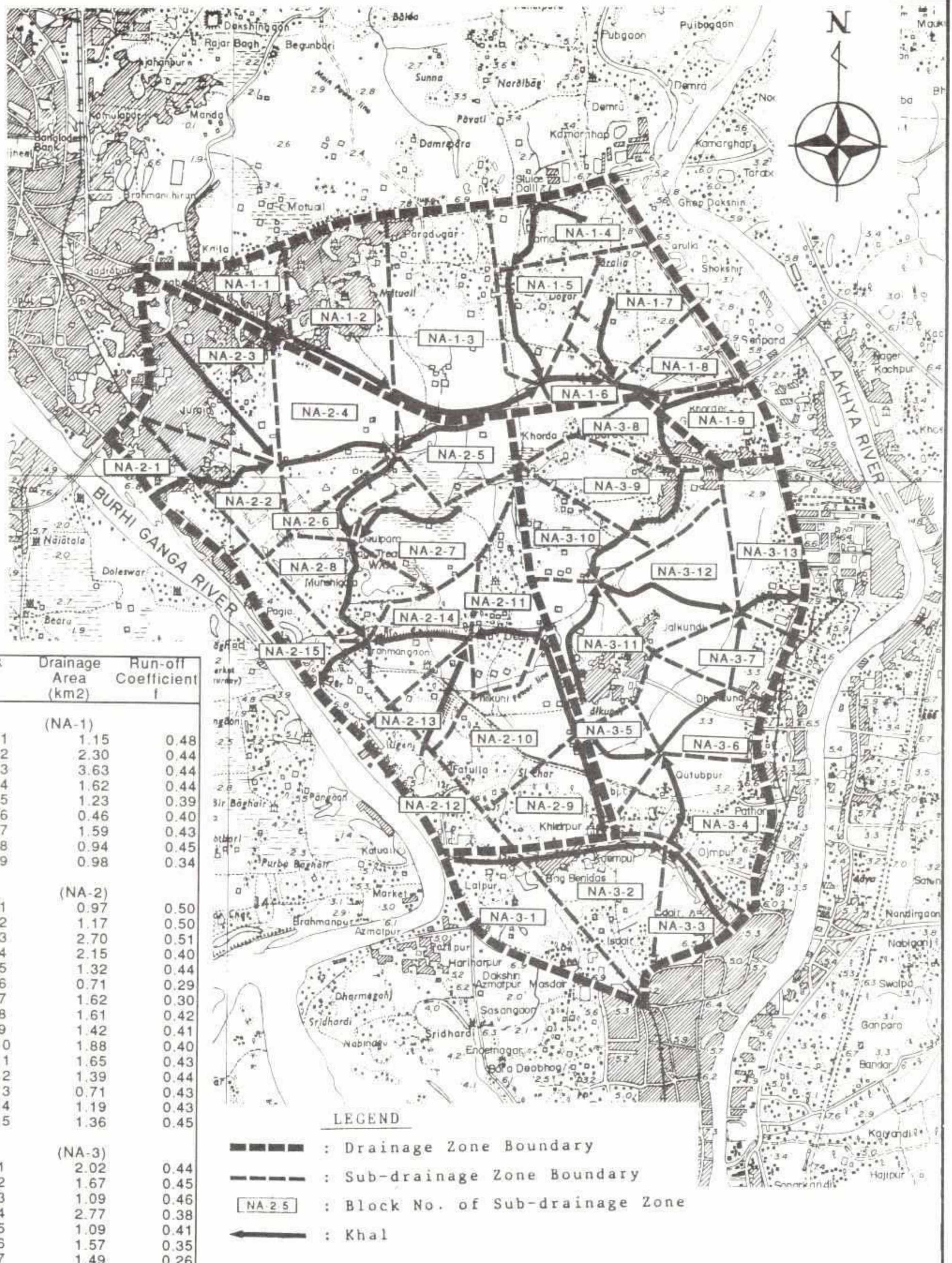

Block No.	Drainage Area (km2)	Run-off Coefficient f
(NA-1)		
NA-1-1	1.15	0.48
NA-1-2	2.30	0.44
NA-1-3	3.63	0.44
NA-1-4	1.62	0.44
NA-1-5	1.23	0.39
NA-1-6	0.46	0.40
NA-1-7	1.59	0.43
NA-1-8	0.94	0.45
NA-1-9	0.98	0.34
(NA-2)		
NA-2-1	0.97	0.50
NA-2-2	1.17	0.50
NA-2-3	2.70	0.51
NA-2-4	2.15	0.40
NA-2-5	1.32	0.44
NA-2-6	0.71	0.29
NA-2-7	1.62	0.30
NA-2-8	1.61	0.42
NA-2-9	1.42	0.41
NA-2-10	1.88	0.40
NA-2-11	1.65	0.43
NA-2-12	1.39	0.44
NA-2-13	0.71	0.43
NA-2-14	1.19	0.43
NA-2-15	1.36	0.45
(NA-3)		
NA-3-1	2.02	0.44
NA-3-2	1.67	0.45
NA-3-3	1.09	0.46
NA-3-4	2.77	0.38
NA-3-5	1.09	0.41
NA-3-6	1.57	0.35
NA-3-7	1.49	0.26
NA-3-8	1.46	0.42
NA-3-9	1.92	0.44
NA-3-10	1.25	0.34
NA-3-11	1.40	0.38
NA-3-12	1.70	0.31
NA-3-13	1.61	0.41

FIG. EA.3 SUB-DRAINAGE ZONE AND THEIR RUN-OFF COEFFICIENT : DND

GREATER DHAKA PROTECTION PROJECT (STUDY IN DHAKA METROPOLITAN AREA) OF BANGLADESH FLOOD ACTION PLAN NO.8A IN THE PEOPLE'S REPUBLIC OF BANGLADESH

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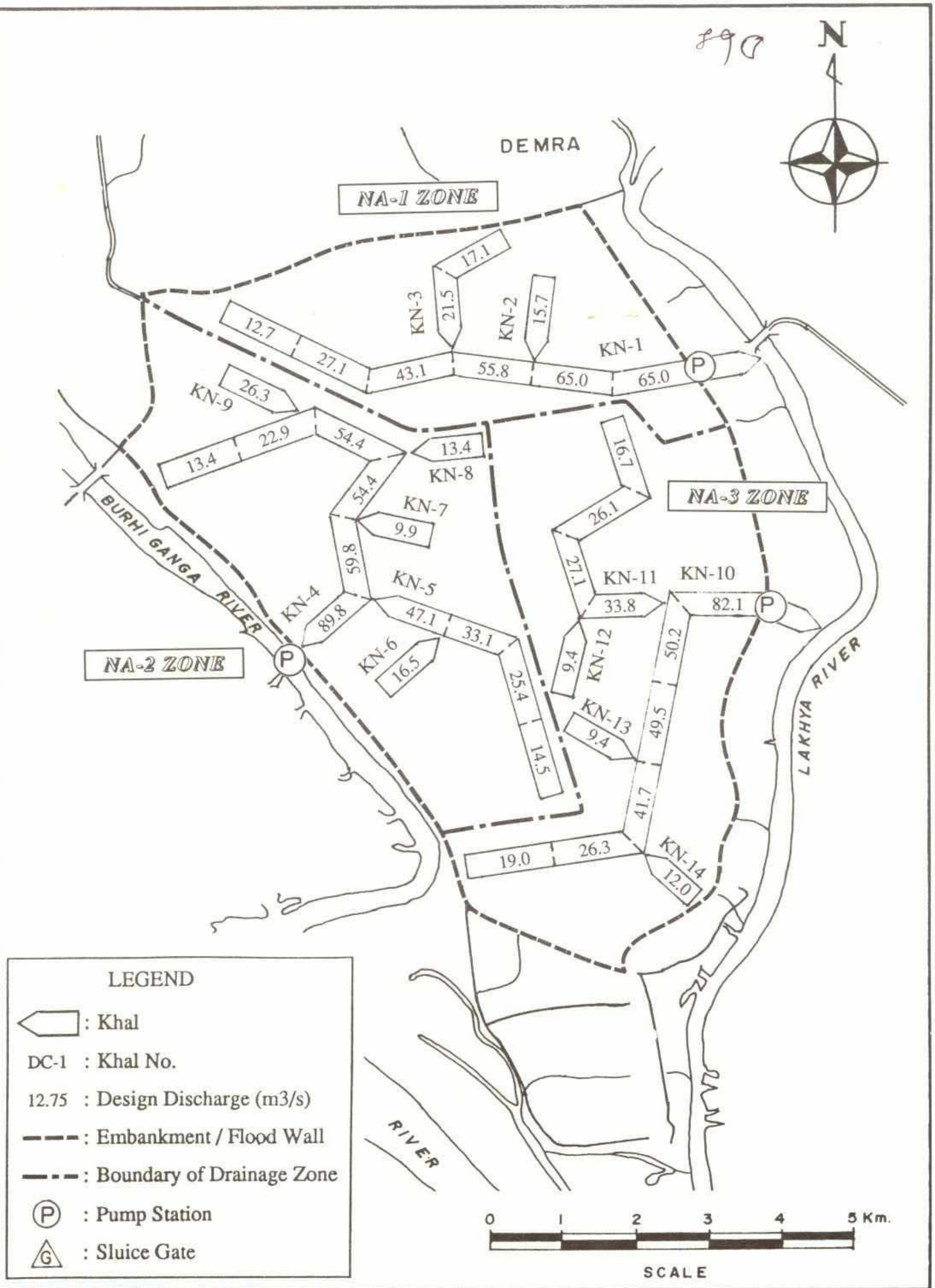

FIG. EA.4 — DESIGN DISCHARGE FOR KHAL IMPROVEMENT PLAN : DND

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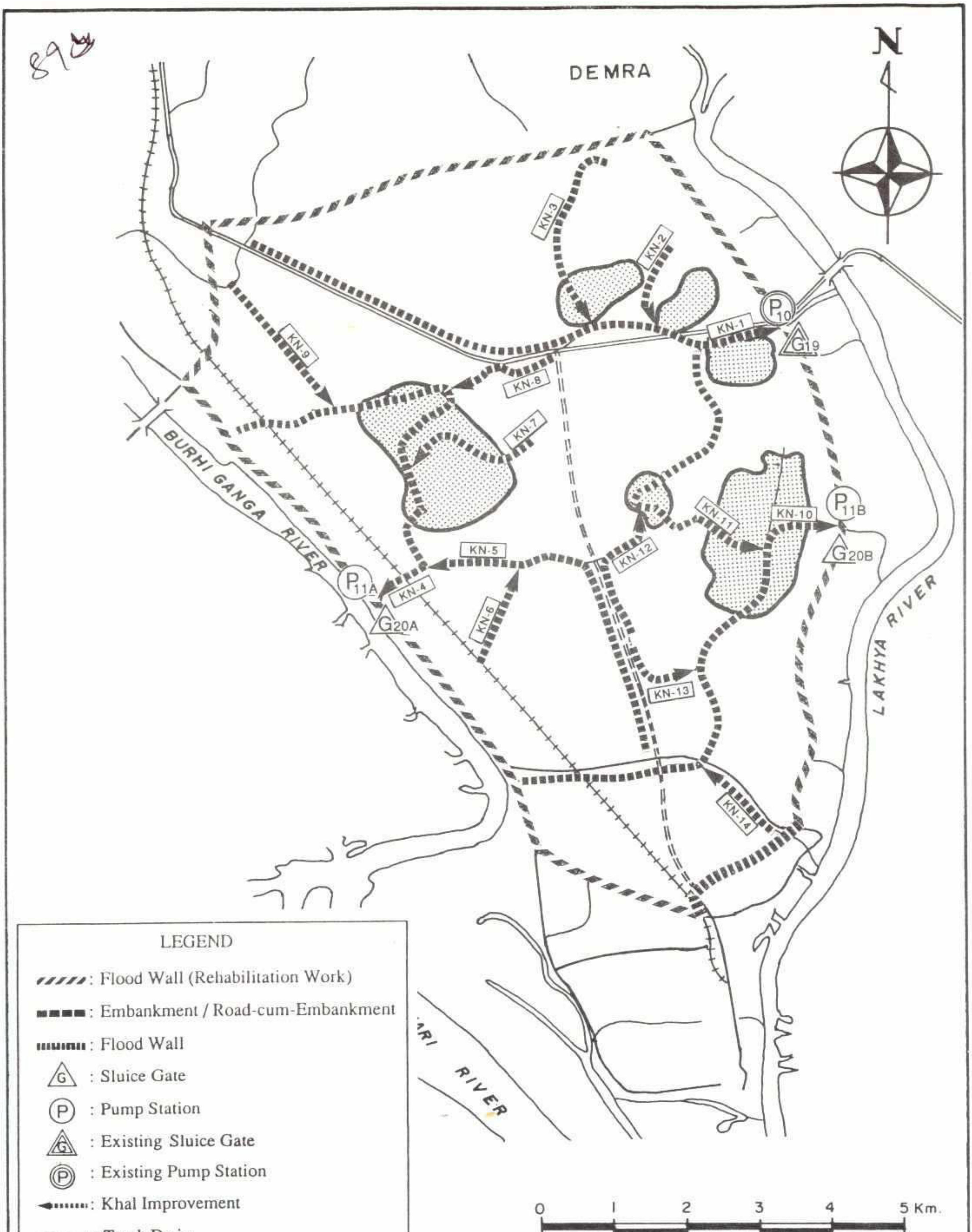

FIG. EA.5	PROPOSED FACILITIES : DND

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