Government of the People's Republic of Bangladesh
Bangladesh Water Development Board
Water Resources Planning Organization

FLOOD ACTION PLAN

NORTHEAST REGIONAL WATER MANAGEMENT PROJECT (FAP 6)

KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT FEASIBILITY STUDY

ANNEX I ENVIRONMENTAL IMPACT ASSESSMENT

Final Report
March 1998

SNC ♦ Lavalin International
Northwest Hydraulic Consultants

in association with

Engineering and Planning Consultants Ltd.
Bangladesh Engineering and Technological Services

Canadian International Development Agency

COVER PHOTO: A typical village in the deeply flooded area of the Northeast Region. The earthen village platform is created to keep the houses above water during the flood season which lasts for five to seven months of the year. The platform is threatened by erosion from wave action; bamboo fencing is used as bank protection but often proves ineffective. The single *hijal* tree in front of the village is all that remains of the past lowland forest. The houses on the platform are squeezed together leaving no space for courtyards, gardens or livestock. Water surrounding the platform is used as a source of drinking water and for waste disposal by the hanging latrines. Life in these crowded villages can become very stressful especially for the women, because of the isolation during the flood season. The only form of transport from the village is by small country boats seen in the picture. The Northeast Regional Water Management Plan aims to improve the quality of life for these people.

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ACRONYMS AND ABBREVIATIONS

AEZ	Agro Ecological Zone
ASA	Association for Social Advancement
AST	Agriculture Sector Team
BAU	Bangladesh Agricultural University
BBS	Bangladesh Bureau of Statistics
BFRSS	Bangladesh Fisheries Resources Survey System
BIWTA	Bangladesh Inland Water Transport Authority
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BUET	Bangladesh University of Engineering and Technology
BWDB	Bangladesh Water Development Board
CDN	Canadian
CEA	Canadian Executing Agency
CEAA	Canadian Environmental Assessment Act
cft	cubic feet
CHC	Canadian High Commission (Dhaka)
CIDA	Canadian International Development Agency
CITES	Convention on International Trade in Endangered Species of Flora and Fauna
cm	centimetre
CO	Community Organizer
DAE	Directorate of Agricultural Extension
DC	Deputy Commissioner
DDR	demographic dependency ratio
DOE	Department of Environment
DOF	Department of Fisheries
DPHE	Department of Public Health Engineering
DSSTW	Deep Set Shallow Tube Well
DTW	Deep Tube Well
EIA	Environmental Impact Assessment
EIP	Early Implementation Projects
EPP	Environmental Protection Plan
FA	Fisheries Association
FAO	Food and Agriculture Organization (United Nations Agency)
FAP	Flood Action Plan
FCDI	Flood Control Drainage and Irrigation
FPCO	Flood Plan Coordination Organization
FW	Future With Project
FWC	Family Welfare Centre
FWO	Future Without Project
GIS	Geographic Information System
GOB	Government of Bangladesh
ha	hectare
HH	Household
hr	hour

HTW	Hand Tube Well
HYV	High Yielding Variety
IEC	Important Environmental Components
IIM	Impact Identification Matrix
IWT	Inland water transportation
ISPAN	Irrigation Support Project for Asia and the Near East
IUCN	International Union for the Conservation of Nature
JMBA	Jamuna Multipurpose Bridge Authority
kg	kilogram
km	kilometre
KK	Kalni-Kushiyara
KKCDMP	Kalni-Kushiyara Community Development and Monitoring Project
KKRB	Kalni-Kushiyara River Basin
KKRMP	Kalni-Kushiyara River Management Project
LAD	Least Available Draught
LGED	Local Government Engineering Department
LGRDC	Local Government, Rural Development and Cooperative
LLP	Low Lift Pump
m	metre
MCH	Mother and Child Health
mg	milligram
MLGRD&C	Ministry of Local Government Rural Development and Co-operatives
mm	millimetre
Mm^3	Million cubic metres
MOA	Ministry of Agriculture
MOE&F	Ministry of Environment and Forestry
MOL	Ministry of Land
MOS	Ministry of Shipping
MOWR	Ministry of Water Resources
MPO	Master Plan Organization
mt	metric tonne
NCA	Net Cultivated Area
NERP	Northeast Regional Water Management Project
NFMP	New Fisheries Management Policy
NGO	Non-Governmental Organization
NSC	National Steering Committee
O&M	Operation and Maintenance
PAH	polyaromatic hydrocarbons
PAP	Project Affected Person
PCB	polychlorinated biphenyl
PIO	Project Implementation Office
POL	Petroleum, Oil, Lubricants
ppm	part per million
PRA	Participatory Rural Appraisal
PWD	Public Works Department
RBM	Result Based Management
RCC	reinforced cement concrete
RRA	Rapid Rural Appraisal

SOB	Survey of Bangladesh
SRDI	Soil Resources Development Institute
STW	Shallow Tube Well
Tk	Taka (Bangladesh currency. $1 CDN=approx. Tk 30)
TNO	Thana Nirbahi Officer
UNDP	United Nations Development Program
UNICEF	United Nations International Children's Emergency Fund
UP	Union Parishad
VP	Village Platform
WARPO	Water Resources Planning Organization

GLOSSARY

aar bandh	a traditional method of platform protection using a bamboo frame and vegetative packing
aman	monsoon rice crop
aus	pre-monsoon rice or rice grown in *kharif* I season.
b. aman	broadcast or deepwater aman rice grown in *Kharif* I and II seasons
barga	sharecropping system whereby the landowner and the operator share the inputs and the produce
beel	floodplain lake that may hold water perennially or dry up during the winter season
bhita	homestead
bisra	patch between homestead and crop land
bondh	crop land
boro	rice grown during the dry, winter season
bundh	earthen dam, closure
chailla	a grass (Hemarthria protensa) grown in low-lying floodplains
chukti	a type of leasing system for singled-cropped land whereby the operator pays a fixed amount of rent after harvest
class I channel	3.6 metre depth; 50 metre width perennial
class II channel	2.4 metre depth; 50 metre width perennial
class III channel	1.8 metre depth; 37 metre width perennial
class IV channel	1.5 metre depth; 37 metre width seasonal
country boat	wood hull boat of traditional design; capacity usually not more than 500 *maunds* (19 tonnes)
dhaincha	a leguminous plant (Sesbania sp.)
dhala	breaches across river banks
dhol kolmi	a woolly shrub (Ipomoea fistulosa)
dry season	5 months: December-April inclusive
duar	scour hole in river bed which provides habitat for fish and river dolphins
hat	riverine landing or assembly place
girost	farmer
gleaning	the collection of fallen rice kernels, from harvested fields
gopat	pathway
haal	unit of land measurement, 1 haal is equal to 1.5 ha (approx.)
haor	depression on the floodplain
hizol	type of water tolerant tree
household	a family unit, who share common resources for cooking and eating
ikor	a type of water-tolerant grass (Sclerostachya fusca)
IWT craft	steel-hull boat 350-500 tonne capacity; single screw
jal	fishing net
jalakhet	rice seed bed
jalmohal	waterbody used as fishery
kanda	high land on the *haor*, used for cattle grazing, cropping or rice threshing
kantha	quilt made of old cloth
kare	unit of land measurement, 1 kare is equal to 0.12 ha (approx.)

katha	unit of land measurement, equivalent to 0.08 acre
khal	channel
kharif	monsoon crop season, including the *aus* and *aman* crop
khas	government owned land or water bodies
koroch	a type of water-tolerant tree
lakh	100,000
logni karbar	usury or money-lending at high interest rates
maund	indigenous unit of weight, equivalent to 40 seers or 37.3 kg
mauza	lowest level of geo-administrative unit
mohajan	money-lender
pajubon	grasslands
rabi	dry season
rangjoma	type of leasing system where the operator pays a fixed rent in cash at the time of contract
saree	women's garment
t. aman	transplanted aman rice grown in *Kharif* II season or monsoon season
taka (Tk)	unit of currency, 1 US $ = 40 taka (approx.)
tarja wall	protection wall made from bamboo mat
thana	geo-administrative unit under a district comprising several unions
union	geo-administrative unit under a thana comprising several villages
union parishad	elected local government council at the union level
wet season	7 months: May-November inclusive

EXECUTIVE SUMMARY

The Project Area

The Kalni-Kushiyara River Management Project (KKRMP) covers a gross area of 335,600 ha and extends over the districts of Sylhet, Sunamganj, Moulvibazar, Habiganj and Kishoreganj in the Northeast region of Bangladesh. The Kalni-Kushiyara River has experienced ongoing channel instability and sedimentation problems over the last 30 years which has led to increased pre-monsoon flood damage to crops, deteriorating river navigation and loss of productive land and human settlements.

Objective of the Kalni-Kushiyara River Management Project

Given the nature of the problems facing the region, the Kalni-Kushiyara River Management Project has been formulated to meet multiple objectives, including:

- improving the river's stability and providing a more stable environment for development;
- reducing damage to agriculture by reducing pre-monsoon flood damage and improving post-monsoon drainage;
- improving living conditions along the river by reducing erosion damage to villages and by creating new flood-free village platforms, and
- improving navigation along the river during the dry season.

Environmental Impact Assessment Methodology

The methodology recommended in the Environmental Impact Assessment Guidelines and the Environmental Impact Assessment Manual of FPCO (presently WARPO) was followed in conducting the EIA of the Kalni-Kushiyara River Management Project.

Project Description

The project includes the following initiatives, undertaken over a 168 km reach of the Kalni-Kushiyara River:

- River Stabilization Works: construction of two loop cuts (7 km), channel excavation (31 km), channel re-alignment and river training at 3 locations;
- Flood Control Works: construction of levees at strategic locations for a total length of 20 km to minimize river over-bank spills and breaches;
- Navigation Channel Improvements: dredging at 5 locations to develop Class II navigation channel (Least Available Draft of 2.4 m);

- Village Homestead Platforms: construction of 247 ha of homestead platforms at 44 locations using dredged spoil and including protection measures against wave action and associated infrastructure during the implementation phase, as well as construction of another 40 locations (200 ha) during the operation and maintenance phase, and

- Implementation of an Environmental Management Plan: designed to enhance positive impacts and mitigate negative ones.

The construction initiatives are sequenced to avoid adverse downstream impacts and to minimize channel maintenance costs. The implementation program is scheduled for a period of 7 years, which includes 2 years for detailed design, floating of international tenders and land acquisition, and 5 years for the construction period.

Description of the Existing Environment
The channel's natural bankfull discharge capacity varies from 2,600 m^3/s in the upper reaches to 1,300-1,400 m^3/s in the lower reaches because of continuous channel bed aggradation. The bed material in the Kushiyara and Kalni reaches is typically fine to medium sand (median size between 0.30 and 0.16 mm). Banks are typically stiff clay or still clay. The sediment quality in the Kushiyara River can be considered as 'uncontaminated'.

Some 8.0% of the project area is under permanent water bodies either confined (*beels*) or open channels. Most of the floodplain in the lower reaches of the river, within the project area, consist of depressions, or *haors,* which are underwater during the monsoon season with only village platforms emerging. Most of the *haors* and *beels* are interconnected with channels through which water spills during the flood season and drains out at the end of the monsoon season.

The project area experiences the sub-tropical monsoon climate typical of Bangladesh, but with variations due to its location and topography. Three types of foods occur in the project area: winter floods, pre-monsoon flash floods, and monsoon season floods. Winter floods, which occur between December and February and pre-monsoon floods, which occur between March and May 15, are caused by storms in the outlying hills as well as by local rainfall. The pre-monsoon flood volume is sufficient to fill the *haor* depressions, and they are the cause of major crop damages in the region. Monsoon season floods are large and normally last from July to October.

The Kalni-Kushiyara River has experienced considerable channel instability and sedimentation problems over the last 20-30 years. Most of these problems arose because of a river avulsion. This began in the late 1950's and 1960's. The shift triggered channel aggradation along the lower reaches of the Kushiyara River in the later 1970s and the 1980s. Most of this aggradation has developed since 1975 and it is expected that this situation will continue in the future, resulting in decreasing channel depth and greater channel instability and more frequent avulsion events. Distributaries are also likely to suffer increasing channel sedimentation and decreasing channel depth.

Most of the land is cultivated. All of the land area has, to some extent, been altered by human activities and most of it is intensely used by humans or their domestics. Wetlands, both permanent and seasonal, constitute the major remaining natural habitat in the study area.

Several terrestrial and aquatic species occur within the project area, making the area internationally important in terms of biodiversity conservation. The Gangetic Dolphin is listed as a 'Vulnerable' species.

In 1995, the population of the project area was estimated at 1.89 million, with 90% living in the rural areas. The average population density is 526/km^2, which is much lower than the national figure of 755/km^2. The low population density reflects the unsuitability of large tracts of land for settlement, since these tracts are subject to pre-monsoon and monsoon flooding. Most of the rural population live in settlements along the river on raised earthen platforms, which are surrounded by water during the monsoon.

This region is one of the poorest of Bangladesh. Presently 65% of the population are considered below the absolute poverty level, 50% below the hardcore poverty level, compared to 48% and 28% respectively for the whole of Bangladesh.

Income distribution is highly skewed in favour of large landowners. The top 10% of households have an income share of 40% while the bottom 20% of households have an income share of 6%. Income inequality is higher than that of the country as a whole.

Approximately 75% of the area's population have never attended school. School dropout rates are high, particularly for female students.

The overall health situation is poor. The sanitation facilities used by 95% of households are below acceptable standards. Lack of space on eroded homestead platforms creates congested living conditions.

The economy of the project area mainly, based on agriculture, provides employment for 700,000 people. Although a variety of crops are grown, rice crops account for some 98% of the cultivated area. Farmers grow four main rice crops; *aus* (<3%) and deep water *aman* (9%) during the pre-monsoon, *aman* (<3%) during the monsoon and *boro* (84%) during the winter months. The figures clearly show that farmers are mainly dependent on the *boro* crop.

The area is also characterized by the presence of high quality fisheries habitat, which provides employment to some 100,000 persons. Fishing is the only source of income for landless people during the monsoon season.

Navigation is essential to the area's access and for goods transportation. Some 40% of the population depend solely on river communication. The majority of rural market places are located along the Kalni-Kushiyara River. Navigation provides employment to some 20,000 people.

The Kalni-Kushiyara River system is the life-line of the people, the resource base for their livelihood and the vehicle for their survival. Agriculture, fisheries, transportation, and the region's environmental sustainability are all dependent on the hydrological and geomorphic characteristics of this system. At the same time, most of the problems faced by the people are inextricably linked to the changes in the river's hydrological regime.

People's Participation

During the KKRMP feasibility study, extensive discussion took place at different stages with local people who put forward numerous suggestions to solve the area's problems. In general the local population is favourable to the proposed works. The main exception being the farmers living in two villages, who are owners of the land to be acquired in one loop cut area (known as the Issapur loop cut) and whose agricultural lands will be difficult to replace. Fisher households are also concerned that this same loop cut may cause disruption of the fish stock in a nearby channel. Traders and market owners in the vicinity of this loop cut insist that construction of the loop cut must be accompanied by annual dredging of a main channel whose discharge will be reduced as a result of the loop cut. There is no opposition to the construction of the second loop cut (known as Kathkal loop cut) or to other proposed works.

Environmental Impact Assessment

The Important Environmental Components (IECs) were identified through a scoping process on the basis of the baseline description data collected by the NERP multi-disciplinary team. The impact of each set of activities during Implementation and Operation and Maintenance (O&M) phases on each IEC has been assessed. The impacts of the project were predicted and described by assessing the difference between a "future without project" and a "future with project" scenario, taking into consideration the likely changes in the bio-physical and socio-economic IECs. A series of recommendations on mitigation, enhancement, compensation, and monitoring for the environmental management of the project area have been proposed.

<u>Impacts of Earthworks and Pre-dredging</u>: The main impacts of the earthworks and pre-dredging activities are related to the effects on land used and settlements as it is anticipated that several thousand workers will be involved in the construction phase of the project. Some agricultural activities, such as *boro* cultivation, will also be adversely impacted because of removal and storage of topsoil and construction activities. The work camps for temporary labourers are predicted to have significant adverse impacts on the quality of village life.

<u>Impacts of Excavation of River Bed and Loop Cuts</u>: Riverine habitat may be negatively impacted by the river bed excavation and by the discharge of effluent water during the dredging operations. However, the result of the water quality monitoring activities carried out during the pilot project indicate that the increase of turbidity related to the operation of the dredgers was negligible.

<u>Impacts of the Improved River Channel</u>: The presence of an improved channel (including loop cuts and bank protection structures) as well as the resulting hydraulic conditions will positively modify the environment in the long term, at the regional level. The proposed project interventions will stabilize the river. These improvements are expected to impact the existing infrastructure by reducing the current bank erosion rate of 55 ha/yr, by reducing homestead damage along the river due to the reduction of bank erosion, and by reducing high velocity spills and breaches in the river banks. The project will reduce pre-monsoon flooding of agricultural land and favour early planting, increasing cereal production by 14%, increase total fish production, provide a year round Class-II navigation channel and generally improve the overall quality of life of the local population.

<u>Impacts of New Setting and Settlement Pattern</u>: The impacts on land use and settlement at the site of the Issapur and Katkhal loop cuts are unavoidable and of mid-magnitude, affecting locally some communities in the long term.

Over the years, homestead land has been continuously eroded by waves and this is expected to continue once the project is completed. Whereas in the past the eroded material was of the same composition as the one present in farming plots, in the future sandy dredged river spoils will be eroded and deposited on those plots resulting in significant deterioration of agricultural spoils if no protection measure is taken to prevent erosion. Both soft and hard platform protection will be provided as a component of the project to prevent erosion and to protect land quality and productivity.

Improvement in the general economic condition of the people and better living conditions, including improved water supply and sanitation, will have positive impact on ability and attitude of the people toward education, and will have direct impact on the general state of health. Improved liveability of homestead platforms will facilitate more home-based activities for women.

Environmental Management Plan

The purpose of the proposed environmental management plan (EMP) is to provide specific action plans that will be carried out during the Implementation and Operation and Maintenance phases of the project in order to manage the anticipated impacts, reducing their effects to an acceptable level and making the project environmentally friendly. The management plan is comprised of six work packages:

Compensation Plan: Adequate compensation is proposed for the loss of agricultural land acquired for the construction of the loop cuts. As a further compensation for the effects of land loss as a primary source of income and economic resource, approximately 160 ha of high land on both sides of both loop cuts will be proportionately returned back to landowners in the loop cut areas for re-use in intensive agriculture after completion of the construction. Compensation is also proposed for crop damage, homestead loss and loss of fisheries ground.

Environmental Protection Plan: This plan is introduced to protect the environment from deterioration due to project construction. The loss of a portion of the landless households annual income through the loss of agricultural labour opportunities in the two loop cut areas will be mitigated by the provision of assured labour opportunities during the implementation and O&M phases. In addition, the contractor shall, to the maximum possible extent, employ local labour for manual earth works. Local female labour must comprise at least 20% of the work force. The contractor must provide secure overnight camp facilities, including adequate water and sanitation, for the local labourers. Other provisions include construction of boat landing facilities, market development, relocation of displaced households, replacement of affected infrastructure (roads, irrigation networks, latrines, wells) and control of turbidity releases.

Enhancement Measures: Enhancement measures are proposed to achieve long-term sustainability and to reduce the O&M cost of the new platforms against wave erosion through non-structural measures including plantation for platform protection, improvement of soil structure and productivity through green manuring, improvement of basic water supply and sanitation facilities on new or extended platforms and development of a fisheries management program.

Contingency Plan: This plan specifies the emergency response to any unplanned occurrence whose results are seriously detrimental. The following hazards have been identified: failure of confinement dykes, effluent leakage through pipes, accidental injury, oil spillage from dredges, and navigation lighting.

Monitoring Plan: This plan includes the follow-up and technical supervision activities that are carried out to ensure compliance of project execution with the specifications of the Implementation Plan. Those technical supervision activities include: baseline surveys and data collection programme, water quality monitoring, fisheries monitoring, agriculture monitoring and social and gender monitoring. Moreover, agriculture, fisheries, navigation, and employment and income will be monitored through a long-term benefits monitoring program to evaluate the long-term impacts of the project on the socioeconomic environment of the modified area.

Training Plan: This plan will be conducted throughout the project phases, pre-construction, construction and post-construction. Training and workshops are planned for the project participants at beneficiary, platform committee, *thana*, district and divisional levels. Topics will include project concept, land dedication procedure, responsibilities and obligations, environmental issues, land use planning, platform protection and maintenance, and organization and strengthening of beneficiary and village communities.

Cost of Environmental Management Plan

Total EMP cost during the implementation stage is estimated to be Tk 57.6 million including cost of mitigative measures, compensation plan and enhancement program.

EMP Implementation

Execution of the EMP will involve GOB agencies in their respective fields of expertise and land dedication procedures will be based on the experience of the pilot dredging project. At all times the project shall take into consideration the community's views within technical limitations.

Residual Impacts

Negative residual impacts left once the EMP is implemented are mostly associated with the construction phase and hence are of local and short-to medium-term duration. Only two negative impacts remain for the long-term. One associated with the loss of agricultural land at the Issapur loop cut site , an unavoidable and mid-magnitude impact affecting some local communities. The second associated with a decrease in the area cultivated with non-cereal crops as farmers will switch to cereals. However the overall impact on land productivity is positive. All other long term impacts are positive.

Conclusion

The Project will positively impact on a very large and diverse number of beneficiaries in terms of sources of income, increased employment opportunities, relative income, and gender. It is also explicitly designed to assist in empowering the "poorest of the poor" and promptly stop potentially irreversible environmental degradation. The project is institutionally, financially, and environmentally sustainable as long as careful monitoring and baseline data collection is carried out, peoples are consulted and involved in all the project implementation phases, and all proposed mitigation and enhancement programmes are conducted as integral constituents of the project.

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1. INTRODUCTION

1.1 Project Background

The Kalni-Kushiyara River Management Project (KKRMP) covers a gross area of 335,600 ha and extends over the districts of Sylhet, Sunamganj, Moulvibazar, Habiganj and Kishoreganj in the Northeast region of Bangladesh. The study area is shown in Figure I.1

The Kalni-Kushiyara River has experienced ongoing channel instability and sedimentation problems over the last 30 years which has led to increased pre-monsoon flood damage, deteriorating river navigation and loss of productive land and human settlements. Much of this instability has occurred in response to the avulsion of the Bibiyana River into Suriya Khal in the 1960's. Impacts from past FCD embankments upstream of Sherpur and closure of important drainage channels (such as Markuli) have also contributed to this situation. So far, past flood control initiatives in the project area have focused on constructing submersible embankments around individual *haors* on the floodplain, with the assumption that these areas could be developed independently from the main river system. However, channel instability and sedimentation on the main river impacts the floodplain through increased spills and breaches, increased frequency of flooding and reduced post-monsoon drainage. Measures to promote the development of a more stable channel regime are necessary for the long-term maintenance of the river system and for ensuring the operation of infrastructure and river-based transportation systems in the surrounding area. Simply continuing to raise the height of existing embankments throughout the project area may provide temporary benefits but long-term sustainable solutions will require remedial works to the main river.

With the financial assistance of the Canadian International Development Agency (CIDA), the pre-feasibility study of this project was completed in 1994. After review, CIDA together with the Flood Plan Coordination organization (FPCO) and the Bangladesh Water Development Board (BWDB) decided to proceed with the feasibility study.

Since the intervention proposed in the pre-feasibility study included an extensive dredging component, the study report recommended a Pilot Dredging Project to gain experience with dredging and the disposal of dredge spoil with minimum negative environmental impact.

1.2 Objectives of the Project

The overall goal of the project is to enhance economic activity and the quality of life on the Kalni-Kushiyara flood plain.

Given the nature of the problems facing the study area, the project was formulated to meet multiple objectives, including:

- improving the river's stability and providing a more stable environment for development;
- reducing damage to agriculture by reducing pre-monsoon flood damage and improving post-monsoon drainage;

- improving living conditions along the river by reducing erosion damage to villages, and by creating flood-free village platforms, and

- improving navigation and river transportation during the dry season.

The specific objectives of the Pilot Dredging Project now completed (Annex J-Pilot Dredging Project) were:

- to evaluate the effectiveness of dredging methods in terms of productivity, maintenance requirements, needs for environmental management and cost;

- to develop, test and demonstrate beneficial uses for dredged spoil, including potential to create new village platforms;

- to clarify social aspects of disposing spoil and identify constraints that may affect the site selection and design of future dredging programs;

- to develop a methodology for public participation activities in future dredging programs, and

- to develop a framework for institutional co-operation in Kalni-Kushiyara River dredging activities.

1.3 Objectives of the Environmental Impact Assessment

The objective of the KKRMP Environmental Impact Assessment (EIA) is to:

- identify the impacts of project activities on the bio-physical and socioeconomic environment;

- recommend enhancement measures for the positive impacts;

- recommend mitigation of negative impacts, and compensation measures as required;

- outline a contingency plan to manage hazards;

- outline a monitoring plan to evaluate the actual impacts of the project on the environment;

- propose a training plan for the various participants and stakeholders;

- propose an implementation plan, and

- identify the residual impacts once mitigation and enhancement measures have been implemented.

1.4 Methodology

The methodology recommended in the FPCO *Guidelines for Project Assessment* (FPCO, 1992(a)) and further detailed in the ISPAN *Manual for Environmental Impact Assessment* (ISPAN, 1994) has been followed in conducting the KKRMP EIA. In addition, the EIA has been prepared to meet the requirements of the *Canadian Environmental Assessment Act* (CEAA).

The Feasibility study of the Project was initiated at the time the Implementation Plan and the Environmental Management Plan (EMP) of the Pilot Dredging Project were prepared (NERP, 1996). This was followed by the implementation of the Pilot Dredging Project carried out at two locations, Kakailseo and Gazaria in the project area. The experience gained in the preparation and the implementation of the Pilot Dredging Project EMP was also integrated in the KKRMP EIA.

NERP team members reviewed the final pre-feasibility report of the Kalni-Kushiyara River Improvement Project and took into account the experience gained during, and the lessons learned from the Pilot Dredging Project in order to collect primary data. Several reconnaissance field visits were undertaken and several meetings and discussions were held with government officials and representatives of local communities as part of the scoping process to identify the Important Environmental Components (IECs). Methods for data collection included Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA), and various surveys for collecting field information and data on land use, vegetation cover, wildlife, fisheries, navigation and social characteristics of the project area.

Once field data were collected, NERP developed an environmental baseline description for the study area. This was followed by a bounding exercise to determine temporal, spatial, impact and monitoring boundaries. The assessment began with the establishment of an environmental 'future-without-project' scenario (FWO), by assuming that the past trend will continue in the future. This was followed by developing a 'future-with-project' scenario (FW). The impacts of the project were predicted by assessing the difference between the above two future scenarios, taking into consideration the likely changes in the bio-physical and socioeconomic environmental components. A series of recommendations on mitigation, enhancement, compensation, and monitoring for the environmental management of the project were proposed.

1.5 EIA Team

The NERP multi-disciplinary team carried out the EIA while conducting the KKRMP Feasibility study. The team included Water Resources Engineers, a River Morphology Engineer, an Agronomist, Fisheries Biologists, a Botanist, Navigation Specialists, Sociologists, an Economist, a Gender Specialist, a Wildlife Biologist, and Environmental Specialists. They were supported in the field by:

- Community Organizers, primarily responsible for collecting social data and assessing the local community perception of the project area's issues and problems and the impact of the proposed project;
- Junior Fisheries Biologists to collect information on fisheries;

- Land Use Surveyors to collect information on land use, and
- Navigation Field Assistants to obtain information on navigation and river transportation.

1.6 EIA Level of Effort

The data and investigations required for the feasibility study provided most of the data needed for the EIA. Some surveys and data collection programs were also collected specifically for the EIA. Data collection and analysis started in January 1995 and was completed by March 1997.

Two complete hydrologic cycles were covered, although the bulk of the data was collected during the dry seasons. Consultation with local people continued throughout the data collection period.

1.7 Relationship to Project Feasibility Report

The feasibility study and the EIA were conducted in parallel. It should be noted that, although the present report is a stand alone document, some aspects covered in detail in the feasibility study Main Report and annexes have been summarized in the EIA Annex. A detailed project description is provided in Annex C-Engineering. Detailed descriptions of the existing environment are provided in Annex D-Social, Annex F-Agriculture, Annex G-Navigation and Annex H-Fisheries. Annex D also contain a description of people's participation and their perception of the project. Finally the direct experience gained with environmental management during the course of the Pilot Dredging Project is reported in Annex J-Pilot Dredging Project.

1.8 Report Layout

The Environmental Impact Assessment (EIA) of the Kalni-Kushiyara River Management Project is issued as a separate, self contained Annex of the Main Feasibility Study Report.

The proposed project and its main components during implementation and O&M phases are described in Chapter 2. Chapter 3 presents a description of the existing environment, physical, biological and socioeconomic components. People's participation, including their perception about the problems, their suggested solutions and their perception of the project is presented in Chapter 4. Chapter 5 presents the environmental impact assessment. The chapter describes the scoping process leading to the identification of the IECs, the description and evaluation of the impact of each activity on the IECs associated with implementation and O&M, and the cumulative impact assessment of other projects planned for the project area. Chapter 6, Environmental Management Plan (EMP), proposes mitigation of negative impacts, compensation measures whenever necessary, enhancement measures of positive impacts, a contingency program to manage hazards, a monitoring program to evaluate actual environmental impacts of the project during and after implementation, a training plan, and EMP implementation. Residual impacts are described in Chapter 7. The cost of the EMP is provided in Chapter 8. Finally, Chapter 9 concludes the EIA.

2. PROJECT DESCRIPTION

The focus of the work in this project extends along the 168 km reach of the Kalni-Kushiyara River between Fenchuganj (Figure I.1) to the junction of the Dhaleswari-Baida River downstream of Kalma.

2.1 Project Alternatives

Various concepts for rehabilitating the River were developed during Pre-feasibility level investigations in 1993. The adopted project concept involves (1) constructing loop cuts at Issapur and Katkhal to achieve a more stable channel pattern, (2) re-excavating the channel downstream of Ajmiriganj (3) constructing river protective works and levees upstream of Ajmiriganj to reduce breaching and spills during the pre-monsoon season. It is also recognized that ongoing channel maintenance and monitoring would be required to successfully manage the river over the long-term. Without this component, the project can not be sustainable.

Subsequently, concerns were raised that the Issapur loop cut could adversely impact local communities whose cultivable land lay along the proposed route of the new channel. As a result, two alternatives were assessed:

Alternative 1: construct both loop cuts, and
Alternative 2: eliminate the Issapur loop cut and carry out additional channel re-excavation along the Dhaleswari River.

2.1.1 Alternative 1

Alternative 1 includes the following components:

(1) constructing loop cuts at Issapur and Katkhal;
(2) re-excavating the reach between Madna and Ajmiriganj by dredging;
(3) constructing flood-resistant village platforms from the dredged spoil;
(4) constructing bank protection works at various sites;
(5) constructing levees along low banks to reduce spills, and
(6) conducting maintenance dredging for improved navigation up to Fenchuganj.

The location of these work are summarized in Figures I.2 and I.3. Table I.1 summarizes the main components of this alternative.

2.1.2 Alternative 2

Figure I.4 shows the general arrangement of works in Alternative 2 and Table I.2 summarizes the main components of the alternative. With this alternative, the Issapur loop cut is eliminated and in its place, additional channel excavation would be carried out along the Kalni River and Dhaleswari River. All other elements of Alternative 2 are similar to Alternative 1.

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Table I.1: Primary Flood Control and Channel Stabilization Works - Alternative 1

Kilometre	Name	Proposed Works	Purpose	Other Beneficiaries
53.0-72.5	Issapur loop cut	• Shorten river by 16.5 km by excavating a new channel from Kalma to Issapur • Close entrance to old Kalni channel • Excavate Dhaleswari channel from Madna to Kalma	• Reduce sediment deposition in Dhaleswari channel; • Improve drainage in lower Ratna/Khowai system • Reduce pre-monsoon flood damage by lowering water levels and making the channel more self-scouring	• Navigation • Community development
72.5-83.0	Issapur-Kadamchal excavation	• Dredge Kalni River channel	• Restore channel capacity to reduce pre-monsoon flood damage • Reduce risk of avulsion at Cherapur Khal	• Navigation • Community development • Capture Fisheries
83.5-85.5	Kadamchal re-alignment	• Excavate accretion on right floodplain	• Re-align bend to reduce bank erosion near Kadamchal • Remove local constriction caused by floodplain accretion	• Community development • Capture Fisheries
86.5-96.5	Katkhal loop cut	• Shorten river by 5.5 km by excavating a new channel from Bishorikona to Shantipur	• Stabilize the river and prevent avulsion through Cherapur Khal • Lower pre-monsoon flood damage by lowering upstream water levels and making the channel more self-scouring	• Navigation • Community development
96.5-107.0	Ajmiriganj excavation	• Dredge Kalni River	• Restore channel capacity to reduce pre-monsoon flood damage	• Navigation • Community development • Capture Fisheries
114.0-114.5	Pituakandi revetment	• Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend	• Capture Fisheries • Existing project • Settlement
114.5-115.5	Koyer Dhala revetment	• Construct bank protection and regulator	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend • Restore irrigation water supply and boat access	• Capture Fisheries
125.0-142.0	Intermittent levees	• Construct low levees along low sections of banks	• Prevent pre-monsoon flood spills	• Capture Fisheries • Settlement
138.5-139.5	Akkilshah revetment	• Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend, reduce erosion damage	• Capture Fisheries • Settlement • Existing projects

Table I.2: Primary Flood Control and Channel Stabilization Works - Alternative 2

Kilometre	Name	Proposed Works	Purpose	Other Beneficiaries
55.0-72.0	Dhaleswari-Kalni excavation	Dredge channel	• Improve drainage in lower Ratna/Khowai system • reduce pre-monsoon flood damage	• Navigation • Community development
72.5-83.0	Issapur-Kadamchal excavation	Dredge Kalni River channel	• Restore channel capacity to reduce pre-monsoon flood damage • Lower risk of avulsion at Cherapur Khal	• Navigation • Community development • Fisheries
83.5-85.5	Kadamchal re-alignment	Excavate accretion on right floodplain	• Re-align bend to reduce bank erosion near Kadamchal • Remove local constriction caused by floodplain accretion	• Community development • Fisheries
86.5-96.5	Katkhal loop cut	Excavate a new channel from Bishorikona to Shantipur	• Stabilize river and prevent avulsion through Cherapur Khal • Lower pre-monsoon flood levels at Ajmiriganj by shortening river's length 5.5 km to increase the slope and make the channel more self-scouring	• Navigation, • Community development
96.5-107.0	Ajmiriganj excavation	Dredge Kalni River	• Restore channel capacity to reduce pre-monsoon flood damage	• Navigation • Community development • Fisheries
114.0-114.5	Pituakandi revetment	Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend	• Fisheries • Existing projects • Settlement
114.5-115.5	Koyer Dhala revetment	Construct bank protection and regulator	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend • Restore irrigation water supply and boat access	• Fisheries
125.0-142.0	Intermittent levees	Construct low levees along low sections of banks	• Prevent pre-monsoon flood spills	• Fisheries • Settlement
138.5-139.5	Akkilshah revetment	Construct bank protection	• Prevent bank breaching and pre-monsoon flood spills • Stabilize meander bend	• Fisheries • Settlement • Existing projects

2.1.3 Comparison of Alternative 1 and Alternative 2

There are 5 areas that will have a significant difference between Alternative 1 and Alternative 2: future evolution of the river both in terms of river morphology and hydrology, existing water resources infrastructure, agriculture and settlements. These topics are discussed below.

Future Evolution of the River

Discharges: Under Alternative 2, the magnitude of the discharges and the flow split between the Baida and Dhaleswari River channels will remain approximately the same as at present. Under the Future Without Project (FWO) scenario, the Dhaleswari branch will become essentially abandoned (due to the diversion through the Cherapur Khal). Therefore, the discharge regime in the Dhaleswari branch should be preserved at its present condition provided the ongoing dredging operations are continued.

River Morphology and Sedimentation: Without the Issapur loop cut, it is expected that the historical pattern of deposition will continue to occur in the Kalni-Dhaleswari reach. Hence, in Alternative 2, additional capital and maintenance dredging will be carried out to preserve the conveyance of the channel in the lower part of this reach. It is estimated that an additional volume of 23 million m^3 over the 30 year project period will need to be dredged. With this dredging, the Alternative 2 will stabilize the current regime, which means there should not be any significant downstream changes from the present situation. The main impact differences from Alternative 1 are as follows:

- the Baida channel will remain the dominant channel and will not be diminished;
- erosion along the left bank of the Dhaleswari will be potentially increased, and
- temporary deposition downstream of the Issapur loop cut will not occur.

Hydrological Characteristics - Water Levels and Flooding Extent: Impacts of Alternative 2 on pre-monsoon water levels will be similar to Alternative 1 except in the lower reach of the Kalni river between Madna and Kadamchal. In this reach, the pre-monsoon water levels will remain close to the present conditions, and will be up to 0.45 m higher than with Alternative 1.

Compared to the FWO scenario, Alternative 2 will increase the flood-free land by about 47,000 ha during a 1:5 year pre-monsoon flood. This value is roughly 8,000 ha lower than for Alternative 1, and mainly reflects lower benefits along the Ratna floodplain area north of Madna.

Water Resource Infrastructures

Without the Issapur loop cut, pre-monsoon water levels in the Khowai and Baulai rivers would be reduced to a lesser extent than for Alternative 1. Similarly, pre-monsoon drainage would be facilitated to a lesser extent in these rivers. Alternative 2 would, therefore, reduce or perhaps nullify potential benefits in the Khowai River project, as well as in some or all of the 17 submersible embankment projects in the right-bank floodplain of the Baulai River.

Agriculture
Compared to FWO project scenario, Alternative 2 will increase the flood-free land by about 47,000 ha during a 1:5 year pre-monsoon flood. This value is about 8,000 ha lower than for Alternative 1. Accordingly, agricultural benefits are less. The expected increase in annual rice production between FWO and Alternative 1 is 82,800 tonnes (13.4%); but between FWO and Alternative 2 this drops to 74,000 tonnes (12%).

Settlements
At present, 11 disposal sites have been identified in the area. The right river bank is already densely settled and has very little agriculture or *khas* land. The left bank is less populated with low, privately owned agriculture land but very little *khas* land. Stretches of the reach between Issapur and Laura have no villages along the right bank. Maintenance dredging in the Dhaleswari reach will require constructing 3 to 4 new platforms/year over the life of the project.

It could be problematic to dispose of the spoil in Alternative 2. The volume of dredging is higher than in Alternative 1 and there may not be sufficient nearby homestead sites to accommodate the spoil. This may require the acquisition of agricultural land for the disposal.

2.1.4 Selection of Preferred Alternative

Alternative 2 does not consider the Issapur loop cut and increases capital and maintenance dredging in the Dhaleswari River. Early on in the study, Alternative 2 was formulated to investigate an alternative to the Issapur loop cut and its adverse impact at Chowdanta and Bhatura (communities located in the general vicinity of the proposed loop cut channel), while achieving the same upstream benefits as Alternative 1.

After the study team's investigation of the physical, social and economic impacts of Alternative 2, several conclusions became apparent:

1. Alternative 2 can not achieve the same benefits as Alternative 1. Alternative 2 results in higher upstream, pre-monsoon water levels and less flood-free land, primarily in the Ratna River floodplain area north of Madna. This results in a decrease in the net flood-free land, and hence a reduction in agricultural production which is the main economic benefit of this project.

2. Alternative 2 requires increased capital dredging, but more importantly, it requires a commitment to increased maintenance dredging over the life of the project and beyond. Further, project benefits will be lost quicker and perhaps permanently if maintenance dredging is not done properly. Given that maintenance is key to the sustainability of this project, this is believed to be a serious constraint.

3. As a result of the increased maintenance dredging, there will be a need for more disposal sites in a localized area between Issapur and Madna. Although at this time, 11 additional village platform sites have been identified, obtaining sufficient platform disposal sites could become problematic in the future.

4. Field investigations concluded that the negative impacts of Alternative 1 to Chowdanta and Bhatura villages can be satisfactorily compensated and mitigated in an environmental management program.

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Considering the above, a decision was taken to conclude the study by focussing only on Alternative 1. Hence, the remainder of this Annex focus on Alternative 1.

2.2 Description of the Project (Alternative 1)

2.2.1 Loop Cuts

Two major loop cuts are planned:

- near Issapur at the Dhaleswari/Baida bifurcation, and
- near Katkhal village, where the river splits into several branches.

Previous loop cuts were constructed by local authorities by excavating a small pilot channel, then closing the old channel and diverting the flow into the new one. The pilot channel enlarged over a period of 10-15 years before it reached its full section. This caused a local flow constriction as well as erosion problems upstream and downstream of the cut. Consequently, in this project, the new channels will be excavated to their full cross section. The excavation will be completed in two stages - the first stage by surface excavation using manual labor and the second stage by dredging. The spoil from the excavation will be used mainly for construction of village platforms.

Both loop cuts will be provided with guide banks set-back from the river. The purpose of these embankments is to guide flood flows along the desired alignment and to reduce the risk of over-bank flow developing new channels or new avulsion paths. The guide banks will not confine the flood flows and should not raise water levels in the monsoon season.

The Issapur loop cut involves making a 2.75 km long excavation from near Kalma in the Dhaleswari River to Issapur in the Kalni River and will shorten the river by 16.5 km. After the new channel is opened a closure will be constructed across the old channel near Issapur. This closure will effectively block sediment laden water from entering the Dhaleswari channel and is intended to arrest further sediment deposition in this lower reach. The cutoff channel will remain open below Madna so that inflows from the Ratna-Khowai River are not obstructed. Drainage in this area will be improved by re-excavating the Dhaleswari channel from the Ratna River junction (Km 64) down to the outlet of the new channel near Shibpur (Km 56). This will involve dredging a 50 m wide Shibpur channel to El. -1.5 m. The excavation will also provide a minimum depth of 2.4 m in the dry season so that this reach can be maintained as a Class II navigation channel. Approximately 740,000 m^3 of material will be excavated and the spoil will be used to raise the low lying back channel between Adampur and an existing island and two homestead platforms at Shibpur. No work is planned on the Baida River channel.

The Katkhal loop cut is intended to prevent further channel instability and to reduce the risk of a major flow diversion into the Baulai River through Cherapur Khal. The loop cut will shorten the channel length by around 5.5 km through the reach. The former main channel leading from Katkhal towards Cherapur Khal will be closed. However, this *khal* will remain open through the southern branch leading to Nayakurar Kandi, so that it will provide post-monsoon drainage relief and can continue to be used for navigation.

2.2.2 Channel Re-excavation - Issapur to Ajmiriganj

Design parameters for the main channel re-excavation work are as follows:

- bottom width varies from 75 to 100 m, and
- design grade varies, from El. -3 m near Issapur to El. -2 near Ajmiriganj.

The total excavated volume during the first 2 years of construction amounts to 4.0 million m^3. It is expected that some degradation will occur once the loop cuts are opened up. Depending on the response of the channel to the loop cuts, an additional 2.3 million m^3 may have to be dredged as a second phase to the work. Suction cutter dredgers will be used for the excavation, with the spoil pumped into permanent disposal chambers on the floodplain.

2.2.3 Navigation Dredging

The channel stabilization work downstream of Ajmiriganj will produce an improved navigation channel up to Ajmiriganj. Additional dredging will be required upstream of Ajmiriganj at five locations in order to provide a Class II navigation channel to Fenchuganj. The dredging will be required at local shoals that develop in straight reaches between bends. Most of these occur between Manumukh (near the mouth of the Manu River) and Fenchuganj. Dredging at these sites will probably be required annually.

2.2.4 Village Platform Construction

Spoil from the dredging and channel re-excavation work will be pumped into dyked confinement chambers on land to minimize any chance of sediment return to the river. The size of the chambers has been designed so they will retain at least 95% of the pumped sediment. This method of handling dredge spoil disposal is very protective of the environment. After dredging is completed, the disposal chambers will be converted into new village platforms to benefit the local communities.

Based on initial planning and analysis, up to 44 new village platforms will be constructed during the capital dredging work excluding the navigation dredging. Figures I.5 through I.11 shows the tentative location and layout of these platforms. Due to limitations from pumping, the disposal sites will have to be relatively close to the dredging areas (generally less than 1.5 km). The two largest platforms are on the left and right bank of the Issapur loop cut and cover an area of 29 ha and 32 ha respectively. The remaining platforms range between 2-10 ha in size.

The civil works required at each village platform include the following components:

- constructing a confinement dyke around the disposal site;
- constructing an outlet structure to discharge the return flows from dredging;
- excavating an effluent outlet channel to convey the return flows back to the river, and
- installing temporary slope protection to prevent erosion during the filling operations

Based on the pilot project experience, the following components, which were once identified as mitigation measures, are now included in the platform construction and as O&M standard activities. These additional civil works are required before the disposal sites can be used as village platforms.

Levelling (top-grading)
Levelling, or top-grading, of dumped dredged spoil becomes a pre-requisite for the safety of platform during monsoon season and further re-use. Accumulated rainfall should not be allowed to over run the peripheral dykes. This might lead to dyke failure. Hence, levelling will be part of the standard construction activities and will be carried out by the dredging contractor immediately after the filling operations, or before the onset of monsoon rainfall.

Platform Drainage
Two types of drainage facilities are required to safely evacuate rainfall run-off from platform surface (1) temporary drains and (2) permanent drains.

The temporary drains will be needed during the first rainy season after the completion of the dredge filling operation and/or until a permanent protection of the platform slope is constructed. In a properly designed confinement chamber with sufficient freeboard, the risk of dyke overflow is reduced. With the internal drainage pattern flowing towards the chamber outlet, pipes can be utilized for drainage of local runoff. In case the steel outlet pipes are removed, and permanent drains are not yet constructed, PVC pipes with adequate capacity should be installed, before the onset of the rainy season, at the site of the original chamber outlet.

The permanent drains should be installed at the time of constructing the permanent slope protection works with concrete blocks. The drains should be incorporated into the concrete block platform slope protection by constructing a 0.30 m x 0.30 m gutters with sealed joints.

Green Manuring
The objective of this activity is to improve the soil structure and productivity of the dredged spoil in order to protect the site from erosion, health and environmental hazards and optimize the land use. These may include production of biomass on the platform by quick growing plants, ensuring a faster recycling and decay process. Other methods will involve creation of a biologically active living soil environment complemented with associated management practices. These activities are divided into short-term and long-term management practices.

Short-term activities mainly include plantation of quick growing plants (African *dhaincha*) immediately after the completion of filling operations. Following this, when plants are about 60 cm long, they are cut and mixed with the dredged spoil and covered by about 15 cm of topsoil. If the season does not permit *dhaincha* cultivation, straw or water hyacinth may be used.

Long-term activities include research and creation of a biologically active living soil environment and associated management practices. The need and the demand for village platforms could be limited in the long-term. Hence, a method should be developed for the quick conversion of dredged spoil for agricultural practices. Preliminary studies indicate that quick conversion is related to the depth of fill. It is proposed to carry out this research activity as a part of the project. Depth of filling in the navigation disposal chambers is limited to one meter, but the area of the chamber is quite large and will facilitate these research activities.

Platform Protection and Maintenance
This includes the following activities:

- slope protection, and
- dyke repair.

Newly constructed platforms must be adequately protected against wave erosion to provide a stable foundation for building a community. Based on the pilot project experience, field visits, local discussions at the proposed disposal sites and preliminary analysis of wave heights and fetch lengths, slope protection is divided into two categories; soft protection and hard protection. The location of these works are summarized in Figures I.5 through I.11.

Soft protection refers to a bio-physical method of protection for homestead platforms, adapted from traditional methods used in the *haor* areas. Soft protection methods require annual replacement and repair of dyke protection. Soft protection consists of the comprehensive use of a bamboo frame (locally called *aar bandh)* with *chailla* (Hemarthria Protensa) grass and *tarja* walling applied to the outside slope of the dyke. The bamboo frame and *chailla* grass are replaced each year. Trees, shrubs and grasses planted near the toe of the dyke serve as long-term protection to reduce the effect of wave erosion.

Platform protection and maintenance will be the responsibility of the contractor during the first year. In the following three years, the platform beneficiaries will be expected to contribute to platform protection through the contributions of material and labor. Community motivation practices will be carried out in platform communities. The enhanced production of *chailla* grass for use in traditional platform protection will be encouraged. Village-based nurseries will be established for the production and sale of adult-sized *koroch* saplings. It is expected that protection and maintenance will be assumed fully by platform landowners after 3 years.

On platforms likely to be severely affected by waves, permanent protection has been proposed with concrete blocks to be constructed in the second dry season, after the dyke fill material has attained a sufficient degree of settlement. The concrete block protection has been selected as the most economic protection, compared to RCC retention wall and brick gravity wall.

This work will be carried out in parallel with the execution of platform levelling and placement of topsoil cover, as either some or all topsoil will be taken from the exterior platform dyke.

The dyke, settled and partially eroded during the monsoon season, will be cut and re-sectioned to a 1:2.5 side slope. Topsoil for Issapur platforms will be available through this re-sectioning process. But for the remaining platforms, some amount of topsoil may have to be collected from the adjacent cultivable land.

The size of slope protection required to resist wave erosion was estimated from Hudson's formula. The 1:20 year design storm was adopted for exposed embankments and platforms (refer to Annex-C; Engineering). Typical design of platform slope protection with concrete blocks, including a brick wall toe protection is shown in Figure I.12.

Platform Access Facilities
The average height of the platforms is approximately 4-5 m above ground level. Turfing of the Gazaria dyke has been damaged by pedestrians and cattle climbing the dyke. Loss of turf reduces the dyke's capacity to withstand rain erosion. In addition, during the monsoon season, boats require a landing place to load and offload passengers and goods. At Kakailseo, boats using the unfinished drainage outlet located at the outlet channel caused some damage to the earthen dyke. Concrete steps and landing facilities will be built to provide access to the platform. The stairs will also be used as bathing sites (*ghat*) off the platform. The number and location of stairs cum *ghats* per platform will vary depending on the length of the platform, its configuration in relation to the old platform and the water routes used during the monsoon. The Issapur platforms will also require cattle access or bullock cart access ramps.

2.2.5 River Training Works

Temporary Protection
Temporary bank protection using bamboo 'porcupines' will be constructed immediately after project start-up at two locations:

- at the entrance to Cherapur Khal where the river is enlarging and diverting flows into the Baulai River, and

- near Shantipur, where rapid bank erosion is taking place near the entrance to the proposed Katkhal loop cut.

Bank Protection and Spill Closures
The main bank protection work will be carried out between Raniganj and Ajmiriganj. It is proposed to construct stone bank protection at three active breaches:

- right bank near Akkilshah Bazaar (Km 138.0);

- left bank at Koyer Dhala (Km 115.5), and

- right bank at Pituakandi (Km 114.5).

The bank protection will arrest further bank erosion and breaches that trigger damaging pre-monsoon spills. The protection will consist of a stone rip-rap revetment with a launching apron to prevent undermining. The protection will extend up to the top of the bank and will be overtopped during extreme high water. Two regulators have been incorporated into the protection to provide either access to irrigation water in the internal project area, re-open navigation routes, to facilitate fish migration between the river and the adjacent floodplain *beels* and *khals*, or a combination of these. One of the regulators is multi-purpose and includes three main components (1) a flushing/ drainage regulator (2) a fish pass and (3) a navigation pass. Figure I.13 shows a typical multi-purpose design.

Channel Re-alignment near Kadamchal
A channel constriction has developed in the large meander bend downstream of Katkhal as a result of land accretion along the right bank in the point bar opposite Kadamchal (Km 84.0). This accretion has reduced the width of the river from typically 250 m to only about 100 m which deflects the river towards the left bank, causing bank erosion between Kalimpur (Km

82.0) and Kadamchal (Km 85.0). The proposed work involves removing part of the accreted land along the right bank to eliminate the constriction and would involve manual excavation of 140,000 m^3 in the dry and dredging of approximately 300,000 m^3. The manually excavated material will be used to raise the ground level of the right bank.

2.2.6 Levees

Low levees and land grading will be required in localized reaches between Raniganj Bazar (Km 152.0) and Markuli (Km 132.0) to prevent spilling of pre-monsoon floods into cropped areas. The maximum height of the levees is 1.0 m, including 0.3 m of freeboard. The levees will replace the bunds constructed annually by local farmers to protect their crops from flood damage. The levees have been designed for the FW flood levels. Consequently, these works will not be required at many sections presently subjected to flood damage. In general, the levees will not impede the present drainage pattern as the slope of the land is away from the river channel.

2.2.7 Operation and Maintenance

Solutions to problems associated with channel instability and sedimentation generally require a long-term management approach. ***A crucial aspect of river management involves carrying out ongoing channel maintenance.*** In this context, "maintenance" involves more than routine repair of existing structures. In the KKRMP, the scope of the maintenance operations will extend along the entire length of the river. Systematic data collection and field observations will provide the direction and guidance for the maintenance work. An important requirement for this type of adaptive river management approach is the need for institutions with the capacity and the resources to carry out the monitoring and channel maintenance work. Institutional arrangements for both implementation and management are discussed in Chapter 6.

Channel Stabilization and Flood Control Works
The main types of channel maintenance that are described in this chapter include channel excavation, and work associated with bank protection, levees, embankments and village platforms.

<u>Bank Protection</u>: There will be a need for ongoing monitoring of channel shifting and bank erosion, and construction of bank protection works at strategic locations, particularly during the first five years after the main capital works have been constructed.

<u>Channel Maintenance Dredging</u>: Requirements for channel maintenance dredging were based on experience from the pilot project, results of long-term channel monitoring studies, and sediment transport modelling and analysis. The incoming coarse silt and sand load on the river presently amounts to around 3.5 million m^3/year (at Sherpur and Markuli). It is this bed material load that will create the primary need for ongoing maintenance dredging downstream of Ajmiriganj. At present, the reach below Katkhal can not transport all of the incoming sediment load. For example, morphologic studies showed approximately 1.2 million m^3 of material was deposited between Kadamchal and Issapur during 1995. In order to achieve a long-term equilibrium in this reach, the channel would have to transport all of this silt and sand load into the Meghna River.

Results of the pilot project monitoring near Gazaria and Kakailseo villages showed that deep, local excavations in the river bed filled-in within a matter of weeks. Overall, with a total excavation of approximately 450,000 m^3, the average bed level in the dredged reaches filled in by about 50% by the end of the monsoon season. However, the extent of the pilot dredging was very limited, (about 1 km at each location) and did not involve other measures to improve the self-scouring capacity of the river. The project's proposed channel improvements should reduce the need for future dredging along the river. For example, the loop cuts will shorten the river's length, which will initially steepen the river's gradient and increase the channel's transport capacity. Also, the closures and levees upstream of Ajmiriganj will increase the pre-monsoon velocities in the lower reach, since spills and losses into the floodplain will be reduced. This will increase the lower reach's capacity to transport sediment which will promote channel scouring before the monsoon season. Furthermore, assuming a major new avulsion can be prevented, the river should begin to establish a more stable configuration than it has in the last 30 years, which will reduce sediment production from bank erosion. A series of morphologic modelling simulations and sediment transport calculations were made to provide preliminary estimates of the future channel maintenance requirements along the river (Annex A - Sedimentation). On the basis of this analysis it was concluded that annual channel maintenance dredging will have to be carried out on the river to preserve the improved channel conveyance. Given the inherent uncertainties with sediment transport predictions, these computations can provide indicative results only.

Maintenance requirements will decrease over time as the channel adjusts to the two loop cuts. Over a 30 year planning period, the total maintenance dredging quantities amounts to 19.3 million m^3. This work will create an ongoing need to find disposal sites along the river as well as an opportunity to continue developing new village platforms.

Navigation Channel Maintenance
The additional dredging carried out for navigation improvement is located upstream of river training or channel improvement works. The shoals in this upper reach (Manumukh, Omarpur and Fenchuganj) are all located at "cross-overs" or "riffles" between bends. These shoals will re-form each year after excavation, so that it can be assumed the maintenance dredging volumes will be similar to the initial excavation amounts. Therefore, the initial navigation dredging of 125,000 m^3 upstream of Sherpur will require a total maintenance dredging effort of 3.7 million m^3 over the 30 year planning period.

Village Platform Maintenance
One of the main requirements for village platform maintenance involves sustaining the platforms' slope protection. While "hard" protection should not require substantial repair except possibly after major floods, "soft" protection requires annual replacement and repair. It will be carried out in much the same way as during the implementation phase. The enhanced production of *chailla* grass for use in traditional platform protection will be encouraged. Village-based nurseries will be established for the production and sale of adult-sized *koroch* saplings. Full protection and maintenance costs will be assumed by platform landowners after 3 years.

2.2.8 Phasing and Scheduling

Construction of the various components has been phased over a 7 year period. The tentative schedule of work is as follows:

- emergency remedial work at Cherapur Khal and Katkhal;

- construction of both loop cuts and associated village platforms, and Kadamchal re-alignment;

- channel re-excavation and navigation dredging with associated village platforms, and

- construction of levees, bank protection and spoil closures upstream of Ajmiriganj.

The proposed project implementation schedule is presented in Figure I.14. The loop cut at Issapur will be excavated in one season, with erosion protection placed in the second year. Katkhal loop cut will require two years for excavation and a third year for slope protection. Construction of upstream bank protection and levees should be carried out after the downstream works are completed in order to reduce the magnitude of downstream impacts.

3. DESCRIPTION OF THE EXISTING ENVIRONMENT

3.1 Physical Environment

The focus of the project is the 190 km reach of the lower Kushiyara and Kalni Rivers, extending from the town of Fenchuganj to the junction with the Upper Meghna River near Dilalpur (Figure I.1). The project area is bounded by the Kushiyara-Bijna-Ratna-Sutang River system to the south, the Surma-Baulai River floodplain to the west, the Old Surma-Dahuka River and Jaganathpur-Sylhet road to the north, and the Sylhet-Kaktai road to the east. The project covers a gross area of 335,600 ha.

3.1.1 Climate

The project area experiences the sub-tropical monsoon climate typical of Bangladesh, but with variations due to its location and topography. Rainfall is the most significant and variable aspect of the climate, causing severe floods and flooding in summer, and water demand for irrigation in winter. There are four, more or less, distinct seasons in the project area relative to the annual hydrological cycle, which reflects the seasonal distribution of annual rainfall. Mean annual rainfall increases from an average of 2,572 mm/yr at Habiganj in the south, to 5,641 mm/yr at Sunamganj in the north (Figure I.15). The seasonal distribution of annual rainfall is shown in Table I.3.

The most distinctive climatic events of the year are the onset and withdrawal of the monsoon. In the project area, onset occurs on average on 1 June, and withdrawal occurs on average on 7 October. The average duration of the monsoon is 122 days, but may vary from 112 to 139 days.

Maximum temperatures vary from about 27°C to 35°C with the highest temperatures experienced during the period April to June.

Table I.3: Seasonal Distribution of Annual Rainfall

Season	Hydrology	Calendar Period	% Annual Rainfall in Project Area		
			South (Habiganj)	Middle (Markuli)	North (Sunamganj)
Dry	Drought	Dec. - Mar.	4	3	2
Pre-monsoon	Flash Floods	Apr. and May	25	25	15
Monsoon	Flooding	June - Sept.	65	67	78
Post-monsoon	Drainage	Oct. and Nov.	6	5	5

Source: NERP, 1993 a)

3.1.2 Physiography

Three main landform units are found in the basin: Flood Basin, Lowland Floodplains, and Uplands (Figure I.16).

The Flood Basin landform unit is characterized by large saucer-shaped seasonally flooded, interfluvial areas known as *haors* within which small, permanent lakes, called *beels*, exist. Flood Basin is the dominant landform throughout the unit, occupying almost two-thirds of the project area. The basin is believed to have evolved as a result of alluvial and shallow lacustrine deposition into a rapidly subsiding trough. This unit is bounded by the Surma River on the north, the Surma/Kushiyara floodplain to the east, Ratna to the south and the Baulai River to the west. Land elevations typically range between 3 and 7 m PWD. Much of the land is traversed by distributary spill channels and other old partially infilled channels which at one time connected the Surma River system to the Kushiyara River.

The Lowland Floodplains have been created as a result of deposition and erosion from the Surma and Kushiyara Rivers. This landform unit covers more than one-third of the project area.

The Uplands landform occurs in the north-eastern part of the project area and covers 1% of the area.

3.1.3 Topography and Surface Water Bodies

Topography

The land generally slopes from the north-east to the south-west, but also slopes away from the river banks to the south and north floodplain of the Kalni-Kushiyara River. Elevations typically range from 1 to 16 m PWD. Approximately 50% of the land lies below 5 m PWD and 80% of the land lies below 7 m PWD. Terraces occupy about 1,162 ha and their elevation varies from 13 to 16 m PWD.

River Channels

The Kushiyara River originates at the international boundary near Amalshid where the Barak River bifurcates into the Surma and Kushiyara Rivers. The Kushiyara River flows south over a length of about 240 km from Amalshid to Astagram where it joins the Upper Meghna River. The river reach from Amalshid to Markuli is called the Kushiyara River. The reach between Markuli to Issapur is the Kalni River while reach the downstream of Issapur is called the Dhaleswari River (Figure I.1).

In addition to the Amalshid flow, the Kushiyara River has eight tributaries all originating in Tripura State, India and entering the Kushiyara from the south. Four of these tributaries enter the Kushiyara River upstream of Sherpur gauging station (Sonai Bardal, Juri, Manu, Dhalai) and flow throughout the year. The remaining four tributaries (Lungla, Karangi, Khowai and Sutang) are also perennial. These tributaries flow overland and enter the Kalni River downstream of Ajmiriganj during the monsoon season.

The Old Kalni River originates from the Old Surma River near Derai and flows southwards. It joins the Kushiyara River just north of Markuli. In 1978, a closure was constructed at the outfall of the Kalni River to prevent backflows of the Kushiyara River into the central depression. As a result, the Old Kalni River also flows into the Baulai River in the west near Dhanpur through the Chamti-Darain River systems.

In addition, the north floodplain of the project area is traversed by a maze of distributary channels. They convey flow from the Surma River and locally generated runoff into the Old Kalni River.

3.1.4 Hydrology and Hydraulics

Channel Morphology
The Upper Kushiyara River flows between natural alluvial levees that are between 3 to 4 m higher than the adjacent low lying flood basin land. The levees are cut by *khals* or spill channels which used to connect the main channel with Sada Khal, a large drain that flows along the lowest point in the flood basin. Downstream of Sherpur, the river enters the deeply flooded Central Basin. This low-lying land is scarred with abandoned channels, ox-bow lakes and *beels* and is drained by an intricate maze of spill channels and distributaries.

The Kushiyara River flows in a single, irregularly meandering sand-bed channel. Downstream of Markuli, the river sinuosity is reduced and the river flows in long straight reaches because of the recently constructed loop cuts. The Dhaleswari River is a transitional reach that links the Kalni River with the upper Meghna River. In this backwater controlled reach, the river splits around large permanent islands and displays large bars and sand shoals.

The bed material in the Kushiyara and Kalni reaches is typically fine to medium sand (median size varies from 0.16 mm to 0.30 mm). Banks are typically stiff clay or silty clay.

The channel has an average top width of 150 m between Amalshid and Fenchuganj, 225 m between Fenchuganj and Manumukh and 240 m between Manumukh and the Suriya Channel. The average depth at bankfull stage averages between 8 to 9 m in these reaches. However, deep scour holes have developed along the concave (outer) banks at most meander bends along the river. Surveys by NERP indicate maximum depths typically reached 28 m to 30 m during bankfull conditions at most sharp bends. The soundings indicate the side slopes in some bends are very steep and subject to slumping, which suggests the river has scoured down into cohesive sediments in some locations.

Figure I.17 shows a longitudinal profile of the Kalni-Kushiyara River.

Evolution of the River System
The Rennells survey of 1768 showed the upper Kushiyara River was a minor distributary of the Barak River and was much smaller than the Surma River. Rennells noted the upper Kushiyara River was navigable only by small boats during the flood season. Furthermore, the map showed the river flowed down Sonai Bardal channel, meeting its present-day course near Fenchuganj.

The Kalni River originated as a southward flowing distributary that connected the Surma River to the Kushiyara system at Markuli. The Surma River flowed into the Kalni/Kushiyara River at Ajmiriganj. The combined flow formed the Dhaleswari River and joined the Upper Meghna River.

The 1952 topographic maps show the Kushiyara River flowing in its present course between Amalshid and Sherpur. Downstream of Sherpur the river flowed through the Bibiyana River channel until Markuli, where it was joined by the Kalni River, a major southward flowing distributary that drained the low flood basin lying between the Surma/Kushiyara Rivers. Downstream of Markuli, the Kushiyara River was referred to as the Kalni River even though by that time most flows in this reach were derived from the Upper Kushiyara River. Previously, most flows would have come from the north through the Surma River system. The Old Surma River channel entered the Kalni River near the town of Ajmiriganj. At that time the Old Surma River was still an important branch of the Surma River.

During the 1960's the Kushiyara River shifted northwards out of the Bibiyana River channel and developed a new route between Sherpur and Markuli, called the Suriya River. This alignment has remained approximately unchanged over the last 20 years.

Hydraulics
Bankfull stage coincides closely to a mean annual flood condition between Amalshid and Sherpur. The channel's natural bankfull discharge capacity is around 2,100 m^3/s between Amalshid and Manumukh and 2,600 m^3/s at Sherpur. The river enters the Central Basin lowlands just downstream of Sherpur. Downstream from that point the bankfull level becomes lower and flood level flattens out appreciably so that the channel banks become submerged to a depth of 2 to 3 m during the monsoon season. Based on uniform flow calculations, the actual bankfull discharge capacity downstream of Markuli is approximately 1,400 m^3/s. This value is typical of pre-monsoon flood peaks and is less than half of some recent flood discharges. These calculations also indicate that during the height of the monsoon, when water levels are highest and water slopes are lowest, only about 40% of the total discharge will be carried by the main channel, with most flow conveyed over-bank on the floodplain or carried by adjacent spill channels.

Runoff Patterns
Discharges on the Kalni-Kushiyara River system are governed by inflows from the Barak River at Amalshid and from tributary streams (Juri, Manu, Khowai, Sonai-Bardal), by inflows or losses that occur through distributaries, spill channels and breaches along the river channel system, and by locally generated runoff from rainfall over the project area. In addition, backwater from the lower Meghna River controls river stages, which affects the distribution of flow carried in the main river channels and as over-bank flow onto the floodplain.

The seasonal distribution of runoff at Sheola and Sherpur are summarized in Table I.4. Studies show that the Kushiyara River has an available flow of about 44.0 m^3/s during the critical month of March. Although the flows in the Kushiyara River are substantial, its present irrigation use and requirements for navigation restrict further large scale abstractions. However, there is some scope for installation of additional LLPs along both banks of the Kushiyara River.

Table I.4: Seasonal Distribution of Runoff

Season	At Sheola		At Sherpur	
	Discharge (m^3/s)	% of Annual Runoff	Discharge (m^3/s)	% of Annual Runoff
Pre-monsoon	472	11.5	1,152	17.4
Monsoon	1,415	69.4	1,952	59.0
Post-Monsoon	555	13.6	1,175	17.8
Dry Season	111	5.5	197	5.8
Year	**682**	**100.0**	**1,101**	**100.0**

Source: NERP, 1993 a)

Flooding
Three types of floods occur in the project area: winter floods, pre-monsoon flash floods, and monsoon season floods.

Winter floods, which occur between December and February, are caused by winter storms in the outlying hills as well as by local rainfall. They occur suddenly and are of a relatively short duration and hence are characterized as 'flash floods'. They rarely overtop the river banks but water readily enters the *haors* because at this time of the year, there are numerous openings in the river banks including hydraulic structures with opened gates. Because the drainage system generally is inadequate, water remains in the lowlands and submerges crops to depths and for durations beyond their tolerance limits. As a result, the crops (usually *rabi* crops and *boro* rice at various early stages) are damaged. These floods do not occur every year and are very unpredictable.

Pre-monsoon floods, which occur between March and May 15, are a normal feature of the region. Low magnitude pre-monsoon floods usually stay within the channel banks and enter the adjacent flood basins and *haor* areas through the open spill channels and distributaries. Larger pre-monsoon floods overtop river banks and flood the back basins and floodplain by overland flow as well as through spills. These floods are very flashy and may last from a few days to about two weeks, depending on the time of occurrence. The pre-monsoon flood volume is sufficient to fill the *haor* depressions, and they are the cause of major crop damages in the region.

Monsoon season floods are large and normally last from July to October. The monsoon season floods are a combination of flood inflow from external rivers, seasonal rainfalls, and a lack of drainage due to backwater effects of the Lower Meghna River. Agricultural damage from these floods tends to be less since farmers either leave their land fallow during this time or they plant low yielding deep water *aman* rice capable of elongating with the gradual rise of flood levels.

Preliminary estimates of the extent of pre-monsoon flooding under present conditions for various return periods are summarized in Table I.5 (maps are provided in the Main Report). During the pre-monsoon, about 69,500 ha may be inundated during a 1:2 year flood. The inundated area increases substantially for higher return periods, ranging from 218,130 ha for the 1:5 year flood to about 290,073 ha for the 1:10 year flood.

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Table I.5: Pre-monsoon Flooded Areas

Return Period (year)	Flood Free (ha)	Gross Flooded Area (ha)				
	< 0.3 m	0.3 to 0.9 m	0.9 to 1.8 m	> 1.8 m	Total	% of Total
1:2	266,100	35,890	26,494	7,116	69,500	21
1:5	117,471	67,609	103,770	46,751	218,130	65
1:10	45,527	48,358	131,710	110,005	290,073	**86**

Drainage
Drainage patterns throughout the project area in general follow the land gradient particularly during the pre-monsoon and post-monsoon seasons. In the south floodplain, the land generally slopes from the Surma and Kushiyara Rivers towards the central depression and from east to west. The land also slopes from the Kushiyara River and the southern boundary towards the central part of northern floodplain and from east to west. During the monsoon season, drainage takes place from north to south and southwest.

Most of the distributary channels from the Surma left bank behave as spill channels, divert water out of the Surma system into the central part of the south floodplain which in turn flows to the Baulai River near Dhanpur through the Kamarkhali-Chamti-Darain River system. Furthermore, spills from the Upper Kushiyara River near Fenchuganj and Balaganj drain west through Sadipur Khal near Sherpur. Sadipur Khal does not have a direct outlet back into the Kushiyara River. Consequently, water accumulates in *beels* and *haors* until it overtops the Kushiyara right bank or finds its way into Kamarkhali-Chamti-Darain River system (Figure I.1).

Historically, most of these flows drained into the Kushiyara-Kalni River system between Markuli and Ajmiriganj and thence to the Upper Meghna. However, increasing water levels during the post-monsoon season have reduced the river's drainage capacity. Drainage has also been adversely affected after a closure dam was constructed across the right bank outlet channel near Markuli in 1978 to eliminate pre-monsoon spills from the Kalni/Kushiyara River into the Central Basin. A similar closure was also constructed near Ajmiriganj in 1993. Consequently, most spills and internal runoff from the basin are intercepted by the channels of the Darain River and Old Surma River which discharges into the Baulai River at Dhanpur (Figure I.1). However, since these channels are too small to convey the inflows, the drainage from the entire basin is delayed.

On the left bank (south side), the Bijna-Ratna River system collects most of the accumulated runoff through many collector drains. Previously, water drained towards the Kalni River above Ajmiriganj through the Old Kushiyara River channel.

3.1.5 Groundwater Resources

Based on MPO (WARPO) data, the estimated usable ground water recharge within the project area is 406 Mm^3 (MPO, 1991). Out of this, about 269 Mm^3 are available within the depth range accessible by force mode technology (DTW). Suction mode STW technologies could withdraw only about 7.0 Mm^3 which indicates STWs are probably not suitable due to aquifer constraints, but about 70 Mm^3 could be withdrawn by deep-set STW (DSSTW). The majority of the groundwater resource potential is located in Baniachang, Nabiganj, Biswanath and Jagannathpur.

3.1.6 Sedimentation and Erosion Processes

Lateral Instability

The Kushiyara River has undergone considerable channel instability over the last 40 years. Between 1955 and 1963, the Kushiyara shifted its course upstream of Markuli from the Bibiyana channel to the Suriya channel. The amount of sediment eroded from the 30 km reach below Sherpur during this shift was estimated to be approximately 25 million m^3. This volume of sediment represents about 10 times the annual sand load at Sheola. This shift induced further channel changes downstream which have continued to progress downstream of Ajmiriganj.

Vertical Stability

The Kalni-Kushiyara River has experienced considerable sedimentation problems over the last 20 to 30 years downstream of Ajmiriganj. Most of these problems arose because of the avulsion of the Bibiyana Channel to the Suriya Channel. The shift triggered channel widening and aggradation along the Kushiyara River between Ajmiriganj and Rahala. Most of this aggradation has developed since 1975. Independent estimates of channel siltation were obtained from residents of Ajmiriganj. Their estimates ranged from 4.5 to 6.0 m over the last 15 to 20 years. This is consistent with the values obtained from the BIWTA sounding charts. Since then, the instability has propagated further downstream. Bank erosion and channel shifting near Katkhal have caused enlargement of Cherapur Khal and flow diversion into the Baulai River system. These changes have been accompanied by further aggradation along the Kalni River downstream of Kadamchal. The aggradation is due to reduced discharges in this channel. Reduced flow in the Kalni River is also contributing to aggradation in the Dhaleswari River channel.

3.1.7 Water and Sediment Quality

Water Quality

Water samples were collected from the Kalni River on September 9, 1994 near Gazaria and just downstream of Kakailseo. The samples were analyzed at the Environmental Engineering Laboratory, Department of Civil Engineering, BUET. Results of the tests indicate the river water quality in all sections is relatively good and characterized by high turbidity and concentrations of suspended solids. The concentrations of oxygen consuming organics, nutrients, heavy metals and toxic elements are within the permissible limits for natural surface waters in Bangladesh.

Suspended sediment concentrations were measured in the Kalni River at Ajmiriganj and Markuli twice per week between April and October 1995. The sediment concentrations averaged from 500 to 1000 mg/l during the monsoon season, with peak values exceeding 1,400 mg/l at high flows. During the dry season, background suspended sediment concentrations were typically 50 to 100 mg/l. The total suspended sediment load carried by the Kalni River in 1995 was estimated to be approximately 8 million tonnes.

Sediment Quality

Twenty five bed material samples were collected along the Kalni-Kushiyara River to assess bulk physical properties. Upstream of Markuli, the river sediments are generally fine-medium sand with less than 5% silt content. Between Markuli and Katkhal, the sediments become finer and more variable in composition, ranging between clean medium-fine sand to silty sand and sandy silt. Downstream of Katkhal, the sediments are primarily sandy in nature. All of the sediments were essentially inorganic alluvial deposits, with no trace of oil or grease, decomposed organics or odours.

Samples of river bed material were also collected from the main channel on September 9, 1994 near Gazaria and below Kakailseo and sent to the Environmental Engineering Laboratory, BUET for an assessment of sediment quality.

Bulk properties of the sediments were as follows:

Gazaria:	sand 65%, silt 32%, clay 3%
Kakailseo:	sand 50%, silt 47%, clay 3%

Elutriate tests were performed on each sample. These tests were developed by the US Environmental Protection Agency as a means for assessing contaminant release from sediments during dredging. The test consists of mixing the sediments and water from the dredge site for a prescribed period in order to simulate the agitation produced by dredging, then separating the solids from the elutriate. The elutriate is then analyzed to evaluate whether nutrients and/or contaminants were released from the sediments into the water column. By comparing the concentrations in the elutriate water with those measured in the river water, it can be concluded that the dredging operation will not release additional nutrients or toxic elements to the river water.

Certain contaminants, such as pesticides and some heavy metals, could not be easily tested at BUET. Therefore, two additional samples were collected in March 1995 and sent to Chemex Laboratories, Vancouver, Canada for detailed testing. The sediment was collected from the main channel of the river with a grab sampler. Sample 1, located about 1 km downstream of Kakailseo village, consisted of fine-medium sand, with trace of silt. Sample 2, located about 1 km upstream of Gazaria village, consisted of silt and fine sand. Based on the results of earlier bed material sampling, these samples were representative of the range of sediments likely to be encountered in the Kalni-Kushiyara River. In fact, since the area is not under the influence of any point source major effluent or industrial discharge, it is clear that any contamination of the sediment would be the result of diffuse sources (agricultural or sanitation drainage for instance) that would affect the whole area all in the same way. Therefore, as there is no reason for any specific location to be significantly different in terms of sediment contamination, the results of the sediment quality from the two samples collected in the Kakailseo area can be generalized to the whole project area with maximum confidence.

Analysis were carried out to evaluate the chemical contamination of the bottom sediment. As to the metal contents, the results of a leaching test indicate that the sediments are not likely to release significant quantities of heavy metals, even in highly acidic conditions. In fact, the results show that for most heavy metals, like Arsenic, Cadmium, Chromium, Copper, Lead, and Nickel, concentrations are under detection limits while Zinc is found to leach in very low concentration (0.01 mg/l).

Organic compounds were found in very low total concentrations and, for most of them, under the detection limits. Polyaromatic Hydrocarbons (PAHs) were all under the limits of detection with the exception of only few compounds which concentrations were very low, below what is considered the Background Level or the No-Effect Level in many North-American and European countries. Polychlorinated Biphenyls (PCBs) and Organochloride Pesticides were all under the limits of detection.

Mineral oil and greases concentration was also very low (less than 0.025%), as was the Total Carbon content, 0.52% for sample 1 and 0.07% for sample 2.

Based on these results, the sediment quality in the Kushiyara River can be considered as 'uncontaminated'. Therefore, the use of this material for homestead or agricultural purposes would be permitted without limitations under the Canadian guidelines as well as under other known current North-American or European guidelines.

3.1.8 Soils

Soils in the project area are relatively uniform. Grey, heavy, silty clay loams predominate on the ridges; clay in the basins. Small areas of loamy soils occur alongside rivers, together with mixed sandy and silty alluvium. Peat occupies some wet *haor* centres. Except in *haor* centres, the cultivated layer of the predominant soils is lighter in texture than lower layers, and there is a strong ploughpan. Most soils have dark grey to black topsoil. In depression soils, the upper part or all of the subsoil is also dark coloured. In higher soils, the subsoil is grey-brown to yellow-brown with dark grey coatings on the faces of subsoil cracks.

3.2 Biological Environment

3.2.1 Aquatic Ecosystems

Agriculture is the main use of the land in the Northeast Region with perennial wetland constituting the major remaining natural habitat of the project area.

Wetland is a young and dynamic form of landscape. Within a particular climatic setting (insolation, temperature, precipitation), the geographical and temporal extent of wetland is governed by the timing and duration of inundation or soil saturation events. It is further influenced by the flow regime, the chemical and particulate concentrations in water and the soil characteristics. Wetland conditions range from virtually perennial aquatic lowland to seasonally dry uplands.

The Kalni-Kushiyara project area supports two types of wetland:

(1) permanent wetland, and
(2) seasonal wetland.

The permanent wetland includes rivers, canals, perennial water bodies and fish ponds. Most of the project area supports seasonal wetland.

While permanent wetland provides refuge and shelter for most of the aquatic flora and fauna, the seasonal wetland serves as the grazing ground for fish and other aquatic animals like freshwater turtles. It may also provide substratum for many species of turtles to lay eggs.

The changes in the physical characteristics of wetland has a direct impact on its dependent flora and fauna. The fluctuation or changes in the population dynamics of the biological diversity define the biomass productivity of the wetland.

Permanent Wetland
The project area includes many important perennial areas of wetland consisting of at least 35 major *haor* complexes. The total area of permanent wetland is 27,836 ha including rivers, channels, *beels* and ponds. The area covered by major and minor rivers are 10,780 ha and 1,250 ha respectably. The perennial water bodies (*beels* and *haors*) cover 13,340 ha. The total area covered by permanent wetland is 8% of the project area. This area reduces during the dry season when only the deepest pockets retain water. Likewise, some channels either dry out or become stagnant. Figure I.18 shows the perennial areas of wetland inside the project area.

Seasonal Wetland
The area which can be considered seasonal wetland varies as a function of flooding intensity. In a 1:2 year (1993) the average monsoon flood causes about 77%, or 260,200 ha, of the net project area to be inundated.

Most of the *haors* and *beels* are interconnected with channels. Through these water spills into the project area from the Surma, Baulai and Kalni-Kushiyara Rivers during the flood season and drains out at the end of the monsoon season.

Major areas of wetland and their importance for wildlife are given in Table I.6.

The wetland areas of the northeastern zone such as Majail Haor, Dubrir Haor, Damrir Haor and Muktarpur Haor are flat-shallow and have very few perennial water bodies. This situation creates very good habitat for numerous submerged and rooted floating plants. Ongoing siltation due to over bank spills and breaches in the river banks make the area unsuitable for both wild flora and fauna. This is further exacerbated by human interference through the encroachment of paddy fields. Moreover, in some areas, utilization of water from the *beels* for irrigation makes the area unsuitable for natural habitat. It should be emphasized that an important wetland is located next to the project area, in the northeastern section. Hakaluki Haor is a large area comprised of several *beels* that are of outstanding importance for wildlife, especially the waterfowl. The *haor* qualifies as a wetland of international importance according to the Ramsar criteria. (Bangladesh has been a contracting party to the Ramsar Convention since 1992, and the Sundarbans is the only Ramsar site of Bangladesh.)

Table I.6: List of Principal Wetland Areas and Wildlife Ranking

North Eastern Zone	Rank[1]	North Central Zone	Rank[1]	South Central Zone	Rank[1]	Western Zone	Rank[1]
Damrir	B	Baram	B	Dabhanga	C	Abdullahpur	C
Dubrir	B	Chaptir	B	Gardar	C	Garbhanga	B
Majail	B	Dhamalia	C	Haitola	D	Ghagrar	D
Muktapur	D	Kaliagota	D	Kodalia	C	Raoband	C
		Naluar	C	Mokar	B	Shibpurer	B
		Pagnar	B	Matikata	B		
		Pangasiar	B	Puber	C		
		Tangua	B	Pipir	C		

Note: 1. Rank:
A = Site of outstanding importance for wildlife (international)
B = Site of considerable importance for wildlife (national)
C = Site of only limited importance for wildlife (local)
D = Not ranked

Major wetland in the north central zone of the project area include, Chaptir Haor, Tangua Haor, Naluar Haor, Baram Haor, Pagnar Haor, Pangasiar Haor, Kaliagota Haor and Dhamalia Haor. All of these large *haors* have many perennial *beels*. However most have submersible embankment to prevent flooding during the pre-monsoon period. After overtopping the embankment, water level rises very rapidly which prevents any significant growth of aquatic flora.

Wetland in the south central some include Puber Haor, Mokar Haor, Dabhanga Haor, Matikata Haor, Kodalia Haor, Gardar Haor, Haitola Haor and Pipir Haor. They are deeply flooded and slope gradually towards the south-west boundary of the project. These deeper pockets and the vast floodplain represents very diverse habitat for wetland flora and fauna. In *haors* flooded even deeper, floating plants do not survive in the monsoon because of waves, but submerged plants grow very well, particularly when the water recedes. In the shallow floodplain, floating plants grow profusely, especially sedges and meadows.

The western zone of the project area, especially the southwest, is the deepest flooded portion of the project. This area includes some of the larger and deeper *haor* complexes. The major wetland areas are Abdullahpur Haor, Raoband Haor, Ghagrar Haor, Shibpurer Haor and Garbhanga Haor. These *haors* remain under deep flooding in the monsoon and cannot support a lot of natural vegetation. But when the water recedes, plants grow rapidly almost covering the entire area.

3.2.2 Aquatic Flora

Wetland habitat is characterized by anaerobic conditions. Continuous submergence inhibits normal plant growth. However, a group of plants known as hydrophyte are able to withstand these extreme conditions.

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The following types of aquatic flora exist in the Kalni-Kushiyara project area:

- Submerged plants;
- Free floating plants;
- Rooted floating plants;
- Sedges and meadows;
- Reed swamp;
- Freshwater swamp forest, and
- Marginal (on surrounding saturated soil).

Some types may be absent from a particular wetland due to disruption by human activities.

Submerged plants are prevalent in the project area, both in permanent and seasonal wetland. Almost all of these plants are monocotyledons and in closely related families like Aponogetonaceae, Hydrocharitaceae and Potamogetonacea. These plants start growing with the rise of water level and persist as long as water is present. The species composition of this plant community differs from permanent to seasonal wetland. Hydrilla, Myriophyllum and Najas are most common in *beels* while Aponogeton and Ottelia are dominant in seasonal flood plain.

Free floating plants are also very common throughout the project area. But their abundance depends much on the location of the wetland. They are not among the dominant plant communities in the *haor* area and include about 15 plant species from both Angiosperm and Pteridophytes. Eichhornia crassipes is the single most dominant species followed by Salvinia, Azolla and Lemna. Many fish ponds are also covered by this type of vegetation.

Rooted floating plants make one of the most dominant plant type in the project wetland areas. They include about 15 species with dominant families of Nymphaeaceae and Menyanthaceae. At the species level Nymphaea and Nymphoides are the most common. However their abundance is only in perennial and deeply flooded seasonal wetland. They are not found in shallow seasonal wetland due to inadequate time for their growth.

Sedges and meadows form an ecotone type consisting of amphibian plants. This type has the highest species diversity and is one of the most important wetland plant community in the project area. The most dominant families in this community are Cyperaceae and Gramineae. At the species level, Cyperus, Fimbristylis, Schoenoplectus and Scirpus are common in all the *beels* as well as seasonal flood plains. In some wetland areas, Ipomoea fistulosa and Monochoria hastata are also very common. Generally this vegetation type occupies the water margin and its population increases or decreases with the fluctuation of water level.

The elevated areas with gentle slopes are occupied by tall grasses or reeds. This type of vegetation is locally known as *Pajubon* and consists of grass such as the Phragmites karka, Saccharum spontaneum Vetiveria zizanioides, Sclerostachya fusca and Arundo donax. Other than grass, woody shrubs like Ficus heterophylla, Asparagus racemosus, Lippia javanica and Rosa involucrata are the dominant species. Another prominent species is Asclepias, a climber from Asclepidiaceae family. It is reported that this reed attains height of about 3-4 m.

Reeds also occur in deeply flooded channels locally known as *kanda* which remain submerged with 3 to 5 m water during the flood season and dries out thereafter. In the past, this type of vegetation occupied extensive areas of the region. Over exploitation of reeds for lime burning and the conversion of land to agriculture threaten the conservation of this vegetation.

The wooded areas, or freshwater swamp, consist of evergreen trees forming a closed canopy. The trees are 10 to 12 m high at maturity. The species present are Barringtonia acutangula (*Hizal*) and Pongamia pinnata (*Koroch*), Crataeva nurvala, Trewia nudiflora and Salix tetrasperma. Besides reed, Phyllanthus disticha and other woody shrubs like Ficus heterophylla, Rosa involucrata and Asclepias climbers are also found to occur in these areas. Wooded areas are located on village platforms, sheltering homesteads and on elevated ridges between *beels*. A single patch may cover an area ranging from a few plants to several hectares. The lower part of trees remains submerged under 2 to 3 m deep water for 3 to 4 months during the monsoon. The luxuriance of the vegetation varies greatly with local conditions and the extent of human interference. It can range from very open with undergrowth to dense closed canopy with poor undergrowth.

Abundance and Distribution

Distribution and relative abundance of wetland plants largely depend on the condition and location of a particular wetland area. In the Kalni-Kushiyara project area, wetland can be divided into several categories depending on the depth and duration of flooding. In the western zone where flooding is deeper and often produces high waves, water plants hardly survive waves and insufficient light. In the eastern zone of the project area, where land is shallowly flooded, water plants get a very good substratum for luxuriant growth. The use of wetland areas as a source of irrigation during the winter destroys natural seed beds and inhibits the regeneration process. Most of the rivers in the project area are devoid of vegetation.

Growing Period

Most of the wetland plant species are sensitive to seasonal water level fluctuations and their regeneration and growing are governed by these fluctuations. In the permanent water bodies the plants can survive and regenerate for the whole year. However, in the seasonally flooded areas, the rhizomes and seeds remain buried during the dry season and then start sprouting with the arrival of water. As water rises, they multiply and expand their vegetative growth attaining their maturity just after the flood peak. When the water begins to recede, most of these plants rapidly bear flowers and fruits.

Utilization

Utilization of wetland plant products is low. Currently wetland plant products and services include:

- Starch food;
- Other foods (vegetables);
- Fodder and forage;
- Medicine;
- Thatching and mat making;
- Fuel;
- Fisheries habitat, and
- Bio-fertilizer.

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3.2.3 Aquatic Fauna

The hydrological cycle and the presence of perennial and seasonal wetland provide a diversified habitat for all biota but especially for fish. The life cycle of the aquatic, or wetland, related fauna is dependent on the riverine ecosystem's natural fluctuations. Before April or May most wetland areas remain isolated. During the monsoon (June-September) all wetland areas join to become a single large water body.

During the pre-monsoon season, fish leave their dry season habitats (*beels* in the floodplain and *duars* in the river) and migrate upstream for spawning and breeding. Their spawning migration starts when early flash floods or rain water inundate areas rich in nutrients and the environment is favorable (temperature, suitable water velocity, water transparency, soil texture). Migration is generally counter-current. Perennial water bodies including shallow floodplains are the breeding ground for most of the floodplain species.

Nearly all of the small fish including *Pabda, Foli, Koi, Magur*, and *Lati* are usually localized breeders who swim only a short distance for spawning. Some long distance migratory fish such as *Ilish* (Hilsa ilisha) and the giant fresh water prawn, *Golda Chingri* (M. rosenbergii) are widespread in the rivers and floodplains of the western part of the project area. Prawn fry migrate towards the floodplain from the sea for grazing, while *Ilish* migrate primarily for spawning.

After spawning, with the increase of water level in the monsoon season, the fry disperse throughout the flooded area. Fish then have access to vast, rich habitats for grazing. At the same time plankton grows with favorable temperature, sunlight and oxygen conditions in the vast shallow wetland areas. In the post-monsoon season, when the water level drops, fish start migrating towards the over-wintering ground, the deeper parts of rivers (*duars*) and the perennial water bodies of the floodplain.

A total of 104 aquatic fauna species were observed in the project area. Of these, 68 species were totally dependent on wetland (*beels*, river, ponds), and 36 species partially dependent on wetland. The survey also showed a habitat preference for stretches abutting homestead backyards. Wetland areas are intensively exploited. Some species have not adapted to the altered environment whilst others have flourished.

A more detailed description of the fish populations and species is presented in section 3.4.4.

Among amphibians, the skipper frog (Rana cyanophlyctis) is common, found in most wetland habitats and has been the most successful in adapting to the altered habitat. The common roof turtle (Kachuga tecta), the flat-shelled spotted turtle (Lissemys punctata) and the peacock soft shell turtle (Aspideretes hurum) are the most common reptiles. These freshwater turtle species face migration problems during the summer when water levels are low.

Common aquatic snakes include the checkered keelback (Xenochrophis piscator) and the smooth water snake (Enhydris enhydris).

Aquatic and water-dependent birds have been severely affected by the alteration of the natural habitat. Wetland degradation has left virtually no sheltered place for waterfowl to roost or nest, in particular the lesser whistling ducks (Dendrocygna javanica) and the jacanas (Metopidius indicus).

Compared to the eastern part of the Northeast Region, concentrations of migratory waterfowl are scarce and are restricted to the larger *haors*. Noteworthy are the shoveller (Anas clypeata), the northern pintail (Anas acuta), the garganey (Anas querquedula) and the coot (Fulica atra). The waders comprise the Mongolian plover (Charadrius mongolus), the grey-headed lapwing (Vanellus cinereus) and the golden plover (Pluvialis fulva) among others.

Wetland related birds like kingfishers and birds of prey have little scope for adaptation. Some species (mostly piscivorous) have moved to areas more favorable to their needs. Among the kingfishers, the storkbilled kingfisher (Pelargopsis capensis) has not been observed even though the existing habitat can support this species. It has probably migrated elsewhere.

There are few aquatic mammals. There is evidence of the presence of the common otter (Lutra lutra) but the population is fast-declining.

The river is the habitat of the Gangetic dolphin, Platanista gangetica locally known as *susu* or *susuk*. Dolphins are found in river *duars* and feed on fish and benthos trapped in eddies. During the monsoon they move to the floodplain. These creatures have vestigial eyes and high turbidity does not affect them as they have lungs. The presence of dolphins in a river reach is an indicator of fish abundance.

3.2.4 Terrestrial Ecosystem

The terrestrial ecosystem and flora can be divided into two categories:

1) natural vegetation, and
2) human influenced vegetation.

Natural vegetation includes wooded areas, grassland and other natural habitats. Human influenced vegetation includes, homestead gardens, orchards, plantation, cropland and other planted or cultivated habitat. Within the project area, the area covered by natural vegetation is marginal and consists only of some small patches of grasslands. Natural forest is totally absent.

3.2.5 Terrestrial Flora

Terrestrial flora is classified according to their habitat. Each habitat supports a unique collection of plant species. The major habitat patterns in the project area are: homestead vegetation, orchard, grassland vegetation, roadside vegetation and crop field vegetation.

Homestead vegetation

Homestead vegetation is the single most important plant community. It includes two types of plants: those cultivated for their economic value and those that are self propagating. The net settlement area in the project is 14,779 ha, of which 5,910 ha (40%) is exclusively under this type of vegetation cover.

According to the vegetation survey, few tree species are present and their composition is very similar all over the project area. These trees are Mangifera indica, Artocarpus heterophyllus, Areca catechu, and Albizia procera. Table I.7 provides a list of major tree species with their corresponding canopy coverage. Vertical cross section profile follows a similar trend with a few trees leading in the upper canopy all over the project area. The upper canopy leaders are comprised by high trees such as the Alstonia scholaris, Albizia procera, Toona ciliata and Anthocephalus chinensis. Lower canopies are occupied by other trees, shrubs and herbs. Climbers are also quite common. Table I.8 shows the dominant species that typically occupy each layer of a homestead.

The average tree density is 1,650/ha. But tree concentration is relatively higher in the flood free zones, especially in areas close to the river from Latirkanda to Ghagra. The ratio of sapling to sub-adult and adult is 12:1:3.

Almost all tree species present on homestead platforms are sensitive to flood water. But the degree of their vulnerability varies widely. The number of flood insensitive species is low and represent only 15% of the total trees coverage. These insensitive species like Barringtonia, Crataeva and Pongamia are scattered over the project area. Except for one or two species, all shrubs and herbs are sensitive to flooding.

Table I.7: Major Tree Species

Tree species	% of Canopy coverage
Albizia procera	2.15
Areca catechu	4.96
Artocarpus heterophyllus	3.32
Barringtonia acutangula	2.85
Cocos nucifera	8.25
Crataeva nurvala	6.96
Lagerstromia speciosa	1.55
Mangifera indica	7.30
Pongamia pinnata	14.96
Samanea saman	6.75
Syzygium cumini	1.75
Trewia nudiflora	10.30
Zizyphus mauritiana	4.65

Source: NERP Vegetation Survey, 1995-96

The phenological cycle of most of the trees starts with flowering at the end of winter (March-April). However the whole reproductive period, which extends up to the maturation of seeds, varies from species to species and can continue until the following winter. The most critical part of this cycle is at the time of the early monsoon and any flooding at this time can cause extensive damage to their immature fruits.

With regard to utilization and annual return, the homestead habitat is the highest productive land. In addition to regular supply of food, fodder, medicine and other household requirements homestead vegetation is also the major source of timber and renewable biomass energy. The annual return from homestead vegetation stands at Tk 57,275 per hectare or Tk 338.5 million for the entire project area. The value of these plant resources, including tree, shrubs and herbs, totals Tk 314,468 per hectare or Tk 1858.5 million for the project.

Orchards

Orchards and economic plantations are practically non-existent in the project area, although there is land available for this type of activity. The area covered by orchards is about 250 ha with a value of about Tk 640,000/ha or Tk 160 million for the project area. The annual return from these plantations totals Tk 129,000/ha or Tk 32 million for the project area.

Grassland vegetation

Grassland is scattered throughout the project area covering about 2,500 hectares of land. This vegetation is composed of some reeds and other grass. This land is commonly used for grazing and is not in good natural condition. Tall grasses are scarce except for some *Vetiveria zizanioides*.

Table I.8: Major Plant Species in Different Layers of Homestead Vegetation

Layer	Height (m)	Plant species
Super	>20	Borassus flabellifer
		Alastonia scholaris
		Albizia procera
		Cocos nucifera
Upper canopy	20-15	Anthocephalus chinensis
		Samanea saman
		Mangifera indica
		Artocarpus heterophyllus
		Bambusa sp.
		Caryota urens
		Syzygium cumini
Lower canopy	15-10	Lagerstroemia speciosa
		Azadirachta indica
		Aegle marmelos
		Cassia fistula
		Diospyros peregrina
		Streblus asper
		Diospyros peregrina
		Trewia nudiflora
Upper bole	10-5	Ficus hispida
		Zizyphus mauritiana
		Psidium guajava
		Crataeva nurvala
		Erythrina sp.
		Pongamia pinnata
		Barringtonia acutangula
Shrub	<5	Clinogyne dichotoma
		Ipomoea fistulosa
		Phyllanthus reticulatus
		Sida cordifolia
		Phragmites karka
		Solanum sp.
		Saccharum spontaneum
Herb	<2	Alternanthera sp.
		Amaranthus sp.
		Colocasia sp.
		Solanum sp.
		Grasses

Source: NERP Vegetation Survey, 1995-96

Roadside vegetation
Except on some major roads, roadside tend to be devoid of trees. Some old trees can be found on both side of the Dhaka-Sylhet national highway. Recently, plantation has taken place along many roads, but in most cases, it consists of a monoculture of mulberry trees for silk production.

Crop field vegetation
Crop field vegetation extends over 279,850 hectares or 83% of the project area. This area is mostly utilized for rice monoculture. Different crops and cropping patterns are discussed in the agricultural section. The major weeds growing with the crop in this area are: Cyperus, Fimbristylis, Leersia, Scirpus, Cynodon and Schoenoplectus.

3.2.6 Terrestrial Fauna

A total of 182 terrestrial fauna species were observed within the project area. Of these, 130 species were birds and 52 species were mammals, reptiles and amphibians.

Terrestrial birds can be divided into two major groups; birds observed in floodplains and wetland, and birds observed in dry land habitat such as homestead, open woodland, secondary scrub and grass land. Birds of prey survive well in the area. Two species of kite are common and widespread, the brahminy kite (Haliastur indus) as a resident and the black kite (Milvus migrans) primarily as a winter visitor. The white-rumped vulture (Gyps bengalensis) is also common and widespread. Healthy populations of other bird species are found mainly in the non-flooded portion of the project area.

Mammals are scarce and all the bigger mammals have already disappeared. Small mammals such as fishing cat (Felis viverrina), jungle cat (Felis chaus), large Indian civet (Viverra zibetha), small Indian civet (Viverricula indica), Bengal fox (Vulpes bengalensis), common mongoose (Herpestes edwardsi) and bats are the major species. Among the reptiles, the yellow land tortoise (Indotestudo elongata) is the only terrestrial chelonian known to occur in the area. This species is very rare and on the verge of extinction. The common lizards found within the project area include the common skink (Mabuya carinata), the garden lizard (Calotes versicolor) and the wall lizard (Gecko gecko). Among other species that once were common but now are only occasionally seen are the yellow common lizard (Varanus flavescens) and the Bengal grey lizard (Varanus bengalensis). Snakes are not very common in the vast floodplain but they can be found in homestead groves. Amphibian species favor wetland areas and the marginal dried areas. Some species, like kaloula frog (Kaloula pulchra) prefer the cool, damp habitat of the bamboo grooves.

Several species listed in the IUCN *Red Data Book* occur within the project area. These species include Pallas's fish-eagle (Haliaeetus leucorhyphus), marsh babbler (Pellorneum palustre), Bengal fox (Vulpes bengalensis), yellow common lizard (Varanus flavescens) and freshwater dolphin (Platanista gangetica). In addition, some species found within the project area are listed in the Schedules of the *Convention on International Trade in Endangered Species of Flora and Fauna* (CITES). Those listed are, *baz pakhi* (Falco peregrinus), Bengal gray lizard (Varanus bengalensis), small Indian civet (Viverricula indica), jungle cat (Felis chaus), fishing cat (Felis viverrina). The yellow land tortoise (Indotestudo elongata) is the only terrestrial chelonian known to occur in the area. This species is very rare and on the verge of extinction. It is also included in the IUCN *Red Data Book*, the schedules of the *Convention on International Trade in Endangered Species of Flora and Fauna* (CITES) and the *Bangladesh Wildlife Act* of 1973.

3.3 Social Environment

3.3.1 Political, Jurisdictional and Institutional Features

The impacted area includes parts of the greater Sylhet and Mymensingh regions. Greater Sylhet accounts for as much as 80% of the total area. Among the districts, Habiganj has the highest proportion of project area and population, followed by Sylhet, Sunamganj, Kishoreganj and Moulvibazar (Table I.9). The project area includes 2 *thanas*, Ajmiriganj and Baniachang, in their entirety and parts of 16 other *thanas*.

Table I.9: Distribution of Project Area and Population

District	% in the project	
	Area	Population
Habiganj	35.7	34.7
Sylhet	22.2	31.6
Sunamganj	22.8	19.0
Kishoreganj	18.9	14.2
Moulvibazar	0.4	0.5
Total	**100.0**	**100.0**

Source: Estimates based on 1991 Population Census, BBS

Government administration is exercised through the Establishment Ministry with a Deputy Commissioner (DC) at the district level and a Thana Nirbahi Officer (TNO) at the *thana* level. Most service-oriented ministries and agencies have district and *thana* level offices. These are:

- Department of Fisheries (DOF);
- Directorate of Livestock Services (DOL);
- Forest Department;
- Directorate of Agriculture Extension (DAE);
- Directorate of Health and Family Planning;
- Department of Education;
- Department of Public Health Engineering (DPHE);
- Bangladesh Rural Development Board (BRDB);
- Directorate of Women's Affairs;
- Department of Cooperatives;
- Directorate of Youth Development;
- Local Government Engineering Department (LGED), and
- Bangladesh Water Development Board (BWDB).

The Union Parishad (UP) is the lowest level of self-government council. The UP is constituted with one Chairman and nine Members, who are directly elected every four years. The UP is under the Ministry of Local Government Rural Development and Cooperatives (LGRD&C) and reports to the TNO. The UP is responsible for the maintenance of rural markets, roads and small water bodies.

The BWDB, under the Ministry of Water Resources (MOWR) is responsible for the planning and implementation of flood control, drainage and irrigation projects. Within the project area, overall field supervision lies with two Chief Engineers, with offices located in Comilla and Dhaka. At the next level, BWDB Circles are headed by a Superintending Engineer, with offices located in Sylhet, Moulvibazar and Mymensingh. BWDB Divisions, headed by an Executive Engineer include the O&M Divisions of Moulvibazar and Habiganj under Moulvibazar Circle, Sylhet and Sunamganj under Sylhet Circle and Kishoreganj under Mymensingh Circle.

The BRDB is the government agency entrusted with rural development. The BRDB utilizes a two-tier cooperative structure, with a primary society at the village level and a federation of primary societies at the *thana* level. BRDB cooperatives are mainly composed of farmers. The rural poor are organized in male and female cooperatives under the RD-12 program.

Contrary to other parts of Bangladesh, non-government agencies (NGOs) have a limited presence in the project area. Within the larger study area, national NGOs such as the Grameen Bank, the Association for Social Advancement (ASA) and the Bangladesh Rural Advancement Committee (BRAC) have active programs. Within the proposed project area, the international NGO known as CONCERN have a limited field presence in Kisoreganj District.

3.3.2 Demographic and Social Context

According to the 1991 census, the population of the study area is 1.77 million. Based on projections from *thana* statistics on the basis of area, the population in 1995 was estimated at 1.89 million, living in 286,683 households. The Kalni-Kushiyara region accounts for 2.27 % of the area and 1.58 % of the population of Bangladesh. The population density is 526 people/km^2, much lower than that of the Northeast Region (707) and Bangladesh (755). The density decreases along the east-west direction.

The population in the project area increased at an annual rate of 5.35 % during the inter-census period between 1981 and 1991. The population having doubled in the first seventy years, from 1900 to 1970, tripled in the twenty years that followed. The growth rate in successive inter-census periods has been lower than that of the country. This implies that the region experienced net out-migration throughout the period.

The sex ratio, defined as the ratio of male population per 100 females is an indicator of the society's conditions for women in relation to men. A high sex ratio indicates that women are disadvantaged in the society. Population in the project area is 48.5% female and 51.5% male. The sex ratio for the project area in 1991 is 102.7. The sex ratio for the country is 106. The lower sex ratio in the project area reflects fewer urban centres , where proportionately, a greater population of working males live away from their families in the village.

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The average number of household members is 5.7, which is slightly higher than the country average of 5.5. The demographic dependency ratio (DDR) is the ratio of the dependent population (below 15 years and above 65 years) to the population of working age (15 to 64 years), expressed in percentage. In the project area, the DDR has been estimated to be 85%.

3.3.3 People and Settlement

The area is less urbanized than the rest of the country. Among urban centres, are the district and *thana* headquarters, although Habiganj is the only major urban centre located in the project area. The urban population in the project area, according to the 1991 census, is 8.9 % of the project population. This is much lower than the urban population in the country in the corresponding year (20%).

The majority of people live in villages. A village is the lowest-level geographic and social unit of settlement. There are an estimated 2,412 villages in the project area. The average number of households in a village is 119, while the average number of people is 732.

Village settlement is conditioned by the land elevation and the water regime. Historically, villages have been settled on high land along the river banks. Those villages within 100 m of the bank are particularly threatened by river bank erosion and over-bank spills. Between Sherpur and Kalma, over 5% of the platform area in vulnerable villages is subject to river erosion every year (Reconnaissance Survey, 1996).

The platform of a rural homestead is called a *bhita*. In upstream areas, the size of a *bhita* is larger than in downstream areas. The average size of a *bhita* in the villages along the Sherpur-Markuli reach is 0.05 ha, while homestead size averages only 0.02 ha in villages downstream of Markuli (Reconnaissance Survey, 1996). As platforms are eroded, either by the river or from *haor* waves, people have to live on whatever space is left. Those without homesteads often migrate to other areas. In *haor* areas, raising an earthen homestead platform is very costly. Many households find it impossible to raise a new platform once their homestead has been eroded. In the project area, one-fifth of households (19%) do not own their own homestead (Household Survey, 1996).

Each year, villagers try to protect their homesteads from monsoon wave erosion, using traditional platform protection methods. Only wealthy households can afford brick wall protection, which lasts from 10 to 40 years. Most householders can only afford a method that requires annual replacement, such as *aar bandh* or *matte bandh*.

The *aar bandh* method uses a bamboo frame, placed along the earthen slope of the platform. Various types of vegetative material are packed between the earthen platform and the bamboo frame. The height of the vertical bamboo frame exceeds the height of the platform being protected, allowing for additional vegetative layers to be added, as the lower layers decompose. The preferred vegetative material is *chailla* grass because of its capacity to withstand long periods of submersion without decay. *Chailla* bundles are placed parallel to the earthen wall to be protected. In 1996, the average cost of *aar bandh* protection, built on an old and settled platform was Tk 100/m^2 (PRA Erosion Study, 1996).

The *matte bandh* method uses *chailla* bundles, stacked at right angle to platform slope, and interspersed with layers of earth. Compared to the *aar bandh* method, no bamboo is required but twice as many *chailla* bundles are used because they are packed perpendicular to the earthen platform slope. In 1996, the average cost of *matte bondh* protection was Tk 785 for a height of 4.5 m and a width of one meter (PRA Erosion Study, 1996).

The costs of traditional platform protection has increased because of the scarcity of *chailla* grass. In the past, *chailla* grew without cultivation on fallow lands. With the increased availability of irrigation systems over the past few years, a greater portion of low *haor* land has been brought under HYV rice production, thus displacing the production of indigenous *chailla* (PRA Erosion Study, 1996).

3.3.4 Way of Life

The river (*nadi* or *gang*) is considered the lifeline of communities in the Kalni-Kushiyara area. A village (*gram*) is a cluster of houses. Each house is built on a homestead platform (*bhita*), which is raised from two to five meters above ground level. Most villages are located with the river in front and the *haor* behind. Usually there is a pathway (*gopat*) along the bank of the river. Low land adjoining the platform (*chara bisra*) is used for growing vegetables in the dry season. Some villages are located out on the *haor* itself. During the monsoon, these villages look like small islands in a shallow sea.

The *haor* is a vast bowl-shaped landmass. The bed of the *haor* has different names at different elevations. Narrow strips of land in the *haor* with relatively higher elevation is known as *kanda*. It is often *khas* land, used for cattle grazing, rice threshing or cultivation of secondary vegetable crops. People often use *kanda* to raise a new homestead or to plant rice seed beds (*jalakhet*). Crop land is locally known as *bondh* or *jomin*. Farmers grow *boro* rice on the *bondh*. *Beels* are the lowest parcels of land in the *haor*. Some *beels* dry early and then are used for growing dry season (*boro*) rice. Those *beels* that do not dry up are used for fishing in the dry season.

The farmer forms the nucleus of the agrarian society. Agricultural practices are related to the traditional farmer (*girost*), owning his own land and farming with plough and bullocks. A farmer usually engages some farm laborers during the peak seasons of transplantation and harvesting. Laborers are hired on a daily or on a seasonal basis. Daily wages fluctuate with the demand for labor, related to various agricultural tasks during the dry season.

3.3.5 Role of Women

Women in the project area have limited access to all resources, including education and income. In Kakailseo, 85% of adult women have never attended school, while 15% have had between one and two years of primary school. Women's exposure to education is nominal in Gazaria, where 98% have had no schooling and 2% have had between one and two years of primary school. The majority of women in the project area (76%) marry between the ages of 12 and 16 years while 20% of women were married below the age of 12 years (Women's Status Survey, 1996).

The main source of income for women willing to work outside the household compound is through agriculture labor. Women's earning capacity in agriculture is limited by the constraints of a single annual paddy crop, vulnerable to loss from frequent pre-monsoon flooding. Women's wages in agriculture are approximately half that of men's, ranging between Tk 15-30/day for y8

paddy transplantation and weeding. Very poor women earn an income that sustains their family for four months of the year by gleaning fallen rice kernels, from harvested fields on the *haor*. During the lean monsoon season, opportunities to earn are greatly reduced and women's daily wage averages Tk 10/day. Women have almost no access to earning in the fishing industry. Women are not directly engaged in trading. Women's earning capacity in homestead production is significantly limited by lack of space on crowded village platforms. The average homestead space in the project area is 26 square meters or 0.64 decimals. Women use homestead plots mainly for vegetable gardening, paddy processing and livestock rearing. Homestead production is for family consumption, as well as "labor-wage saved" for the family and sale of surplus produce (Women's Status Survey, 1996).

3.3.6 Education

Survey data show that about 75% of the population have never attended any school. Literacy is the ability to write a letter, as defined by the population census, 1991. The literacy rate is lower in *haor* areas, compared to high land areas. The female literacy rate is lower than male literacy rate in all districts.

In the region, the school/population ratio at the primary level is relatively high and that at the secondary level is low, compared to the rest of the country. There are less than 6 primary schools and less than one secondary school per 10,000 population. The enrolment statistics of 10 primary schools, between Sherpur and Ajmiriganj were studied. The enrolment of boys and girls is nearly the same in the lower grades. Among the total enrolled students in the lower grades, 49% are girls. However at successive stages of schooling, female participation is lower than male, in increasing proportions. The school dropout rates are high and increasingly more students drop out in each successive grade. The average number of students enrolled in grade one is 52, while it is only 15 in grade 5. The dropout rate is higher for girls (Reconnaissance Survey, 1996 and Table I.10).

Table I.10: Literacy of Population

Level of schooling	% of Population		
	Both sex	male	Female
No schooling	72.3	67.4	77.5
Primary (Grade I-V)	19.4	21.3	17.5
Secondary (Grade VI-X)	6.9	9.1	4.5
Above secondary	1.4	2.2	.5
Total	**100.0**	**100.0**	**100.0**

Source: NERP Household Survey, 1996

3.3.7 Public Health

Public health infrastructure in the area includes one health centre-cum-hospital in each *thana* headquarter, with limited laboratory facilities and a few beds for indoor patients. In addition, there is one Family Welfare Centre (FWC) at the union level which provides limited MCH (maternal and child health) services to villagers, supplies contraceptives to eligible couples and provides immunization to children and pregnant mothers. Many people in the villages still depend on traditional healers for their day to day health treatment. People mainly suffer from water-borne diseases, particularly diarrhoea. Of all the patients treated in government hospitals, about half come with diarrhoeal problems. The incidence of all diseases including diarrhoea is highest in the post-monsoon season.

Immunization of children against six killer diseases is a major thrust of the government. The immunization rate for children in the districts of greater Sylhet ranged from 50% to 55% in 1990 (Planning Commission, Population Development and Evaluation Unit (PDEU), Impact of Population Program Performance at District Level, 1990).

3.3.8 Drinking Water and Sanitation

Hand tubewells are the main source of safe drinking water in the project area. Hand tubewells are located on homestead land and therefore access to safe water is related to homestead land holding. Of landless households, 74% drink tubewell water, while the remainder use water from river and *haor* for drinking. Each functioning tubewell serves an average of 20 households (Household Survey 1996). The national standard for potable water coverage is one tubewell for 16 households (UNICEF 1993).

Sanitation facilities in the project area are well below the national standard. In villages of the project area, only 5% of households have a sanitary latrine, composed of 4% earthen pit latrines and 1% concrete water-seal latrines. The remaining 95% of households have an unacceptable standard of sanitation. Of these, the most common facility for 75% of households is an open latrine, hanging over ditches or canals. Twenty percent of households have no latrine and must defecate in open space during the dry season. During the monsoon season defecation in open space is widely practised by males and females (Household Survey 1996). Comparatively, national sanitation coverage indicates that only 52% of households use an unacceptable sanitation facility (hanging latrine and open space), while 48% of national households use a sanitary water-seal or earthen pit latrine (UNICEF 1996).

3.3.9 Nutrition

Household income is not sufficient to maintain a decent life for most of the households. The absolute and hard core poverty rates are much higher than that of the national rates. As much as 65% of households are below the absolute poverty line in terms of calorie intake. The extent of hard core poor is 50%. By WHO/UNICEF Bangladesh standards, the absolute poverty line is the required level of calorie intake of 2,122 cal per capita per day. Hard core poverty level is 85% of the required level, that is, 1,805 cal per capita per day.

3.3.10 Cultural and Heritage Sites

An old Hindu monastery (*akhra*), known as Dillir Akhra is located in Khoyerpur union, under Astagram thana of Kishoreganj district. The monastery was built about 400 years ago by a Hindu saint on 154 ha of land. The temple platform itself is built well above flood level. Farmers of the adjoining villages cultivate 30 ha of *akhra* land, under different contractual arrangements. There are three ponds which are used for pisciculture. There is an extensive plantation of water tolerant trees (*hizol*) around the *akra*, giving the area the appearance of an aquatic forest. Many devotees, both Hindu and Muslim assemble at the *akhra* to participate in religious-cultural festivals, celebrating different seasonal occasions, like the *Magh Uttarayan* (winter festival) and the *Choitra Sankranti* (festival on the last day of the *Bengali* calendar).

3.4 Economic Development

3.4.1 Land Use Patterns

According to NERP land use survey carried out in 1995/96, the Net Cultivated Area (NCA) accounts for 83% of the project area.

Based on NERP analysis about 96% of the project area is flooded during the monsoon season for the 1:2 year flood. Accordingly, crops are grown mainly in the dry season and harvested before the beginning of monsoon season. The proposed project does not have any impact on the monsoon flood. It confines pre-monsoon floods (1:5 year) within the river channel until about 15 May to facilitate safe harvest of *boro* crop. Therefore, all cultivated land in the project area is classified according to the depths of pre-monsoon flooding.

Analysis of the 1:2 year pre-monsoon flood for present conditions and land elevation in the project area shows that the cultivated land is dominated by flood free lands. These lands constitute 83% of the NCA. The flood free lands decreases significantly for the 1:5 year pre-monsoon flood to 30% of the NCA. Whilst for 1:10 year pre-monsoon flood the flood free lands constitutes only about 5% of the NCA.

Based on agroecological zoning (regions and sub-regions) of the FAO/UNDP (1988), the project area is occupied by the following agroecological zones (AEZ):

- Old Meghna Estuarine Floodplain (AEZ 19);
- Eastern Surma-Kushiyara Floodplain (AEZ 20);
- Sylhet Basin (AEZ 21);
- Northern and Eastern Piedmont Plains (AEZ 22), and
- Northern and Eastern Hill (AEZ 29).

The extent of each AEZ is presented in Figure I.19.

As to the land capability and land use associations, based on the SRDI's Reconnaissance Soil Survey Reports (Sunamganj and Habiganj subdivisions, 1973; Netrokona subdivision, 1968; and Kishoreganj subdivision, 1974-75), more than 80% of the project area is cultivable. Crop production is limited by flooding. Cropping patterns and the types of crops grown are also determined by flood depth, time and duration. Land use and cropping intensity are less in lowlands than in the highlands. More than two-thirds of the cultivable land is lowland. Depth of flooding in these lands is more than 0.9 m and the cropping patterns consist of one crop which is cultivated in the dry season. During the wet season, short stature rice varieties cannot be cultivated due to deep flooding.

3.4.2 Land Value and Ownership

According to the NERP household survey, 42% of the HHs do not own any cultivable land. Small farmers, owning up to one hectare of cultivable land, account for 36% of HHs. Medium farmers owning more than one ha but not more than 3 ha of cultivable land represent 14% of HHS. Only 8% HHs are large farmers who own more than 3 ha of cultivable land (Table I.11).

Table I.11: Land Ownership Pattern

Strata	Household		Area		Cumulative %		Average holding (ha)
	No.	%	ha	%	HH	Area	
Landless	242	42	0	0	42	0	
Small	203	36	88	14	78	14	0.4
Medium	79	14	142	23	92	37	1.8
Large	44	8	387	63	100	100	8.8
Total	**568**	**100**	**617**	**100**			**1.1**

Source: NERP Household Survey, 1996

Adhibhagi (commonly known as *barga* in many areas), *chukti* and *rangjoma* are major tenancy systems in the region and are indicative of the high extent of landlessness and high concentration of land in a few hands. These are described as follows:

- *Adhibhagi* or *barga* is a system of sharecropping where the cultivator and the land-owner share the cost of seed, fertilizer and water equally and divides the output among them equally. Other costs are borne by the cultivator;

- *Chukti* is a kind of leasing system of single-cropped land where the farmer pays a fixed amount of rent in crop, say, 4-5 *maunds* of rice per *kare* (0.11 ha), to the land-owner after the harvest, and

- *Rangjoma* is a leasing system where the cultivator pays a fixed rent in cash at the time of contract. The rent is Tk 1,000 for single-cropped land and Tk 1,200-1,500 for double-cropped land (1996 rate).

Many landless and small farmers cultivate others peoples land on the basis of *adhibhagi* (share-cropping) or *rangjoma* (lease) for subsistence. The proportion of *barga* land and land taken under the system of *rangjoma* is almost equal.

3.4.3 Agriculture

Of the net cultivated area, 94% is single cropped, 3% is double cropped and 3% is fallow. Cropping intensity, or ratio of the total cropped area to the net cultivated area, is 1.01. This shows that on average each unit of cultivated land in the project area supports one crop per year.

Crop cultivation is the main component of the present farming system in the project area. Rice dominates crop farming since it is well-suited to the agro-hydraulic regime. Livestock production forms a small component of the farming system, and consist mainly of cattle.

Rice

The land-use survey confirmed that rice dominates crop farming, accounting for 98% of the total cropped area. Thus, the major crop practices in the project area are rice based and almost all segments of the cultivated land are cropped with rice. The four main rice crops are; rain-fed upland (*B.aus*), deep water (*B.aman*), rain-fed lowland (*T.aman*) and irrigated (*boro*).

Boro is the major rice crop. The crop is grown in the dry season and covers 84% of the total cropped area. *T. aman* or monsoon rice occupies less than 3% of the total cropped area, and *aus* or pre-monsoon rice occupies less than 3%. Deep water *aman*, which is sown in the pre-monsoon season and harvested with *T. aman*, accounts for 9% of the total cropped area.

About 27% of the total rice area is under local varieties. The remaining rice area is under HYVs mainly grown in the *boro* season. The HYVs account for 82% of the area under *boro* rice and over 99% of the area under *T. aman*. A*us* and deep water *aman* varieties are all local.

HYV *boro* is grown on floodplain ridges. During the monsoon, deep water *aman* is grown along the periphery of the flooded area. Transplanted *aman* and wheat are grown on river banks. The transplanted *aman* is followed by HYV *boro*. Groundnut, sweet potato, vegetables and spices are grown on the highest land near rivers.

Non-rice
Spices and vegetables are the major non-rice crops. They account for about 0.7% of the total cropped area. The other non-rice crops occupy about 0.4% of the total cropped area.

Crop Seasons
There are 3 crop seasons in the project area. These are: *kharif* I (pre-monsoon to early monsoon season), *kharif* II (late monsoon season), and *rabi* (dry or winter season).

The characteristics of *kharif* I are unreliable rainfall, high temperature and evaporation, drought at the planting time, flash floods, and rapid rise of flood water. B. *aus* rice and photosensitive deep water *aman* rice are grown in this crop season. A relatively small area is cultivated in this season. *Boro* rice, which is transplanted in the *rabi* season, flowers and ripens in the *Kharif* I season.

Kharif II is characterized by high humidity, heavy rainfall and monsoon floods. Crop production in this season is limited by the variable flood depths. During the peak of the monsoon season, most of the study area may be inundated to a depth of 1 m or more. As a result, crops can not be grown in the *kharif* II season. Transplanted *aman* rice is grown in small areas. Deepwater *aman* also continues to grow through this season. Photosensitive crops flower when days get shorter.

The *rabi* season is characterized by low rainfall and low humidity, high solar radiation and evapotranspiration rate, low temperature, and a large variation in temperature between days and nights. The conditions during this season are very favorable for higher yields crops. Crop production is mainly governed by the availability of residual soil moisture or water for irrigation. Irrigated *boro* rice is extensively cultivated in vast areas. Short duration local *boro* is cultivated in lands where drainage is delayed after the monsoon, and HYV *boro* in better drained areas. Non rice crops are also grown in this season, such as wheat, potatoes, sweet potatoes, lentils, mustard, groundnuts, linseed, tomatoes, beans, *brinjal* (eggplant), chilies, coriander, and cucumbers. The limiting factors for crop production during the *rabi* season are: poor drainage which delay sowing or transplanting, inadequate residual soil moisture, low-moisture holding capacity of soils, plant stress from low temperatures when the crops are planted early and flash floods. Because the drainage is often delayed after the monsoon, crops are not planted on time. This in addition to early flash floods prevents full development of cultivable lands.

Irrigation
Surface water irrigation coverage includes about 125,00 ha by LLP's and traditional modes (AST, 1991). Of this there are 3,200 LLP's of various discharge capacities irrigating an area of 55,000 ha. The majority of the surface water irrigated area is concentrated in Astagram, Nabiganj, Baniachang, Balaganj, Derai Sullah, and Jagannathpur.

Present groundwater abstraction for irrigation is not significant. According to AST (1991), there are 191 shallow tube wells and 77 deep tube wells in the project area. The reported groundwater irrigated area is 4,000 ha, of which 1,700 ha is by shallow tube well and 2,300 ha is from deep tube wells. Groundwater abstraction is about 17.33 million m^3 based on MPO's (currently WARPO) estimated groundwater irrigation duty. According to AST, groundwater irrigation is mainly concentrated in Baniachong, Nabiganj, Astagram, Itna, Mitamain, Sylhet, Balaganj and Jagannathpur *thanas*.

3.4.4 Fisheries

Habitat
The project area is characterized by the presence of high quality fisheries habitats. The most important habitat, constituting 95.8% of the total, occurs on the extensive floodplain, in *beels* and ponds. The remainder of the fishery habitat includes the Kalni-Kushiyara River mainstream channel (which contains important river *duars*), other active rivers (the Baulai, Old Surma and Khowai rivers) and open and closed distributaries. Data on the principal aquatic habitat types in the project area are presented in Table I.12.

A total of 72 species of fish have been recorded in the project area (Annex H - Fisheries). Important groups are major carp, other carps, large catfish, knifefish, *ilish*, prawn, small catfish, small cyprinids and other small species.

Fish abundance in the project area was determined by NERP catch assessment surveys at 20 representative sites. The most fish-rich natural habitats were *beels*. All other natural habitats had significant lower standing crops (Table I.12). Variation of standing crop within a habitat was generally moderate, except for *beels* which ranged from 118.5 to 1,294.3 kg/ha/yr. This may be due to the degree of sedimentation of individual *beels* (Annex H).

Standing crop and species composition show seasonal variations for individual habitat types (Annex H). *Beel* and riverine habitats generally have peak catches during winter months, while floodplain peak during the mid-monsoon.

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Table I.12: Areas and Fish Production by Habitat Type - Present Conditions

Habitat group	Habitat type	Area (ha)	Area (%)	Standing Crop (kg/ha/yr)	Production (tonnes)	% of total
Riverine	Kalni-Kushiyara River	3,955	1.4	201.8	798	1.5
	Other flowing rivers	3,104	1.1	273.2	848	1.5
	Closed and dead rivers	3,721	1.3	121.7	453	0.8
	Distributaries	1,250	0.4	121.7	152	0.3
	Subtotal	**12,030**	**4.2**	**187.1**	**2,251**	**4.1**
Floodplain	Floodplain	260,200	90.3	159.7	41,554	76.2
	Beels	13,340	4.6	503.1	6,711	12.3
	Ponds	2,466	0.9	1,636.5	4,036	7.4
	Subtotal	**276,006**	**95.8**	**189.5**	**52,301**	**95.9**
	Total	**288,036**	**100.0**	**189.4**	**54,552**	**100.0**
	Urban areas, infrastructure	47,564				
	Grand Total	**355,600**				

Source: NERP Fisheries Survey, 1994-96

Mainstream River Channel: The Kalni-Kushiyara River is a principal migration route for certain high value commercial fish species (major carp, large catfish, *ilish* and *golda chingri*) in the Northeast Region. Biomass peaks during April and May in the Kushiyara River while further downstream in the Kalni, the highest biomass is observed in December, January or February. One interpretation is that migratory fish may congregate in the lower river section during the dry season, and then swim upstream during the pre-monsoon for spawning purposes. Peak month catches show a high proportion (30% - 88%) of large species (carp, catfish, *ilish*).

Mainstream Duars: Highest biomass in *duars* was recorded in the month of December and February. This suggests the use of *duars* as overwintering grounds. Peak month catches are heavily dominated by large species (83% - 100%) such as carp and catfish.

Other Rivers: Biomass peaks were highly variable among other rivers. This is probably due to the impact of river closures, connections to different remote mainstream channels and variations in timing of fish movements over a large floodplain basin area. Biomass peaks were recorded in January, June, August and November. Assuming that the other rivers act as transit routes, these differently timed peaks probably represent migration episodes to and from spawning, grazing, and overwintering grounds. Peak month species composition is dominated by small fish (58% - 76%). *Golda chingri* can be of some importance as well (5% - 11%, when present).

Floodplain: Fish only occur on flood lands when the habitat is flooded, thus floodplain production is entirely dependent on in-migration from other aquatic habitats (rivers and their *duars*, *beels*, *khals*). This paradox - that the most productive habitat in the project area is completely non-self-sustaining is a central and critical concept for analyzing and interpreting the potential project impact on fish production in the project area.

Highest biomass on the floodplain was recorded in August. Species composition in peak months is usually dominated by small finfish species (in most cases, 60% - 73%). Large catfish are also of some importance (14% - 36%). In one instance *golda chingri* accounted for 52% of catch. Project utilization areas consist mainly of ditches, lowlands and some floodplain area.

Beels: Highest biomass was recorded during the dry season (December to March). Carp are especially important in peak month catches (14% - 48%). Small fish form the largest component (34% - 68%), but both large catfish (18%) and *golda chingri* (10%) are significant.

The results of the field survey highlight the importance of the river *duars* and *beels* as critical overwintering habitats for carp and catfish broodstock. Moreover the productivity of the extensive floodplain habitat is entirely dependent on annual restocking with 'seed' from riverine and *beel* habitats.

Ponds: There are an estimated 29,399 ponds in the project area (Annex H) covering an area of 2,466 ha out of which nearly 25.2% are cultured, and 32.6% are culturable (may be used for fish culture without any major investment). In addition, 42% are derelict, these are not presently used and are lying fallow, in most cases they are covered with water hyacinth. The cultured ponds are generally larger and deeper than other ponds and are used for wild fish stock and fingerlings of cultured species. Those are mostly located in flood-free areas. Culturable ponds are shallow and are often located in areas subject to flooding.

Fish Production
Total fish production in the project area is estimated at 54,552 tonnes (Table I.12). Breakdown by habitat indicates that 76.2% of all fish production originates from the floodplain.

Fishing Practices
Diverse fishing practices are used in the region's floodplain and *beels*. During the dry season when fish are confined to the *beels* and in the drainage channels, fishing is very active with a wide variety of nets, traps and other gear. Boats used to operate gear and transport fish also vary in size, and are predominantly non-mechanized country boats.

Fishing Community
The traditional fishers of the project area are Hindus and belong to several castes, the most important being the *Kaibarta, Barman, Das, Rajbongshi, Malo.* There are also Muslim fishers who are predominantly landless or poor people with a low standard of living. Women in the fishing industry are employed mainly in fish processing and net making and repairing.

Fishers generally own the gear and boat either individually or as a group; wages are paid on a catch sharing basis. The distribution of catch, however, varies depending on the nature of the fishing effort and the water body types.

Fisheries Management
The open water fisheries of the project area are being managed by the owners to earn revenues from fishers and fish traders operating in the waters. In the past, the ownership of the rivers, *beels* etc. rested with private landlords. The rivers are divided into arbitrary segments with each segment being known as fisheries or *Jalmohal*. Similarly each seasonal or perennial *beel* is also a *jalmohal*. Presently, ownership of all *jalmohal* rests with the Ministry of Land and are leased out through auction. The owners of the lease then allow fisher access for a fee. Running rivers have been declared open fisheries since 1996.

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Although a licensing system (termed the New Fisheries Management Policy) was introduced in selected fisheries in the project area, the traditional leasing system is still the dominant management mechanism.

The revenue-oriented management system tends to encourage over-fishing of the fish stocks as both fishermen and lessees are motivated by the desire to maximize profit in the short-term. The lessees, during the tenure of lease, exercise monopoly privileges in so far as control and exploitation of real fishermen. The lessees charge exorbitant rents or fees for different fishing gear and units belonging to fishermen. In addition, the lessees also take the bigger share of the catch from the fishermen. Thus the role of lessees in the management of the fisheries of the project area has been exploitative and fishers working in the fishing grounds remain deprived and perpetually poor.

Fisheries Resource Development

A small portion of the fish catch in the project area is processed and exported. There are two processing plants situated in the area.

Ajmiriganj Fish Industries Ltd., Ajmiriganj: The plant started operation in 1980. It is a large fish processing plant with a daily freezing capacity of 4 tonnes/day. The ice plant has a capacity of 10 tonnes/day. The plant exported fish products within the range of 175 to 507 tonnes/year with an average of 327 tonnes/year during the period 1985 to 1992. About 70% of the supply of fish to the plant is harvested from the project area.

Kuliarchar Cold Storage Ltd: This is a large fish processing plant that was established in 1985. The maximum production capacity is 11.2 tonnes/day, but only 4 to 6 tonnes of fish and prawns are produced per day. The capacity of the cold store is 300 tonnes.

The major export items are prawns (65%) and table fish (35%). The plant exports about 2,660 tonnes per year to Belgium, Germany, Italy, UK, USA, and the Netherlands. About 80% of the fish are collected from the project area, particularly from Ajmiriganj, Sullah, Baniachang, Itna, Mitamain, Lakhai and Astagram.

There are also eight ice plants in the project area for fish preservation and marketing.

Sun-dried *(Shutki)* and fermented fish *(Shidol)* are the most common form of processed fish product. Ajmiriganj, Kakailseo, Khaliajuri and Derai are important dried fish marketing centres. Both products are marketed to other parts of the country from November to May.

3.4.5 Employment

The majority of households resort to more than one option for survival. Although the highest proportion of the households depend on field agriculture for their subsistence, many people live from wage labor on others' farms (Table I.13). Earthwork, fishing and trading are also important occupations for the people. *Lura tukani* (rice gleaning) and post-harvest rice processing are also important sources of household income, particularly for the poor women. Rice gleaning is a typical activity of the destitute women in the *haor* region during the harvesting period. Substantial quantity of rice is left out in the *haor* in the wake of harvesting as the farmers want to harvest the crop quickly to avoid pre-monsoon flood.

Table I.13: Occupational Distribution

Main household occupation	Number of households	%
Agriculture	241	42
Agricultural. labor	209	37
Fishing	33	6
Trading	29	5
Boat operating	16	3
Service	13	2
Others	27	5
Total	**568**	**100**

Source: NERP Household Survey, 1996

Labor opportunities are limited. Rice cultivation in the dry season is the main economic activity in the region. The poor mainly depend on wage labor for their survival. A number of labor contracting systems has evolved with varying wage rates characterized by fluctuating demand for labor at different stages of rice cultivation.

Boro is the main crop, and is characterized by high demand for labor and consequent in-migration of seasonal harvesting laborers engaged on contractual basis from other districts. Employment of local harvesting laborers is not favored by many farmers as they are less efficient than the outsiders. Migrant laborers mostly come from the greater Mymensingh district. In the *haor* areas, many farmers hire them for the harvesting and threshing of rice. As there is always the danger of early flood, harvesting has to be completed quickly. The laborers gets 10% of the harvest as wages.

3.4.6 Income

The NERP household survey (1995-1996) provides data on per capita income from all sources in 568 HHs from six villages selected from the upper, middle and lower reaches of the Kalni-Kushiyara River. Absolute poverty level is experienced by 65% of those HHs; 50% of HHs suffer from hardcore poverty. In the Kalni-Kushiyara area 42% of all HHs do not own cultivable land.

The NERP household survey assessed income distribution in the project area for comparison with national income distribution. In average rural areas of Bangladesh, the bottom 20% of HHs earn 7% of total income, while the top 10% of HHs earn 28% of income. In the Kalni-Kushiyara area, the bottom 20% of HHs earn 6% of the total income while the top 10% of HHs earn 40% of income. The remarkably greater income earned by top HHs in the *haor* area is related to their extensive control of rich agriculture and fishery resources.

Well-to-do farmers employ one or more laborers on a seasonal or yearly basis. A farmer usually engages one laborer per *haal* (about 1.5 ha) of cultivable land. A contractual seasonal laborer engaged for the months covering the entire *boro* season gets, in addition to 3 meals a day, about 30 *maunds* of rice, or Tk 6,000-8,000 in wages. Some are paid both wages and rice. Often a laborer is employed only for harvesting and transportation for a period of 1 to 2 months. In addition to 2 or 3 meals a day, one such laborer gets 7 to 9 *maunds* of rice for one month of work or about 15 maunds of rice for 2 months of work. The monthly wage rate for certain agricultural activities like boat operation, operation of LLP, etc., is about Tk 800-900 plus 3 meals a day. In the monsoon season, the demand for labor drops and wage rates also decreases.

Women get lower wages. A female laborer in the harvesting season usually gets 3 to 4 *maunds* of rice, 3 meals a day and a *saree* for a month of work.

The Sylhet basin is perceived by many as a rice surplus area characterized by relative prosperity. This is a myth in the project area. Large scale landlessness, limited labor opportunities owing to low intensity of cropping and frequent crop failures coupled with a feudal social power structure, have created the conditions which have accelerated the process of pauperization and marginalization.

Logni (usury) is a common practice. In the *haor* areas, the demand for capital reaches its peak from mid-December to mid-March when farmers start preparing land for *boro* cultivation, negotiate with the laborers, transplant rice, buy fertilizers and pay for irrigation. Most of the poor and medium farmers borrow money from the *mohajan* (professional money-lender) at this stage and repay the loan after the harvest in mid-April to mid-June.

The monopolistic credit market dominated by a small group of traditional money-lenders does not exist any more. Now there are many lenders. There are many who are not rich but have some surplus to invest in usury. The common practice is to pay 8 *maunds* of rice for borrowing Tk 1,000 for the *boro* season. In case of crop failure, the repayment period is usually extended by another year and interest for the first year is written off.

3.4.7 Transportation and Navigation

Of all the major market centres in the region, only Fenchuganj has both perennial road and rail access. Downstream of Sherpur, the only effective year-round access is the river. In general, poor transportation and communications, either in terms of reliability and/or cost, will be major inhibiting factors in economic development. Within the Northeast Region, particularly the *haor* areas, roads are expensive to build and maintain through successive floods. As a consequence, rivers are more likely to be the most cost effective mode of transportation.

The Kalni-Kushiyara river connects a host of growth centres with a vast hinterland. Given the water regime, river transport is the only mode of passenger and freight traffic for most parts of the year. The sector is serviced mainly by motor launches and mechanized boats for transportation of people and commodities.

An examination of the most recent navigation charts shows that there is very limited access to river communities above Ikardia. The communities of Shibpur, Nurpur, Madna and Adampur along of the Kalni are virtually inaccessible during the dry season due to river siltation. Indicative Least Available Draughts (LAD's) are about 1 m to Madna and then 0.6 m to Adampur. As a result, through traffic now takes the Baida channel (western loop), which offers better depths, or is diverted via the Baulai and the Dhaki-Kanchanpur Khal to enter the Kalni River above Kanchanpur. The reach above Ishapur is reasonably accessible although there is a shallow area below Abdullapur which would limit boats to a 1 m draft.

There are many shallow stretches of the river between Kanchanpur and Ajmiriganj that inhibit navigation during the dry season in anything bigger than a small country boat. The river is effectively blocked by a major drying shoal below Manumukh, and there are other limiting shoal areas at Omarpur and just below Fenchuganj. Thus, the river is not currently navigable to through traffic during the dry season, and given the extent of the shoal below Manumukh, the river may not be freely navigable during an extended period into the wet season.

The Kalni-Kushiyara River has many tributaries and distributaries, apart from various *khals* connecting the *haors* with the main river. Most notable among the existing routes are Bhairab to Ajmiriganj, Ajmiriganj to Sherpur, Bhairab to Lakhai and Bhairab to Astagram. During the monsoon, boats are the only mode of transportation for most of the villagers. In earlier days, these rivers and *khals* were navigable year round; thus the Kalni-Kushiyara River along with its network of feeder routes served as excellent waterways for the whole area where no road alternative exists. However, in the course of time, natural siltation of these smaller rivers and *khals* resulted in a drawdown of the navigable draft in several waterways.

Table I.14 provides the cargo and passenger traffic within the 110-km reach of the river from Madna to Sherpur (NERP navigation survey, Annex G-Navigation). The main goods transported are: paddy & rice (21%), fertilizer (19%), house building materials covering boulder, sand, cement, rod etc. (19%), fruits and vegetables (10%), and consumer goods (4%).

Table I.14: Water Transport Traffic at 12 River Stations of the K-K river, 1995

Seasons	Cargo ('000 tonne)	Passenger ('000)
Dry Season	179	3,333
Monsoon Season	292	6,355
Annual	471	9,688

Source: NERP Navigation Survey, 1994-95

3.4.8 Trade and Industry

The region has a surplus of rice and fish. These commodities are exported outside the region. Rice is mainly transported to Bhairab, while Bhairab and Kuliarchar are the most important fish outlets of the region.

The region has a poor industrial base. Although it accounts for more than 2% of the total area of Bangladesh, only about 1% of the manufacturing enterprises of the country are located in the region according to the BBS: Directory of Manufacturing Establishments 1989-90 (employing 10 or more persons). The highest proportion of enterprises are in food processing, followed by timber processing and wood products, and brick manufacturing. Most of the manufacturing plants are located in the highlands of Sylhet and Fenchuganj. In some *thanas*, Itna, Mitamain, Astagram, Baniachang and Sullah, there is not a single manufacturing plant.

Most of the household essentials and consumer goods are brought from outside, mainly from Bhairab. Ajmiriganj is the biggest trading centre in the region. Among other trading centres of significant importance are Adampur, Markuli, Derai, Raniganj and Sherpur.

3.5 Existing Environmental Issues and Future Trends

3.5.1 Physical Processes

Survey of Bangladesh (SOB) 4 inch to one mile maps (1962) and 1:50,000 scale satellite images (1989-90) were digitized and reduced to a common scale to compare physical characteristics. The comparison shows that 1,095 ha of the permanent water-bodies have been lost due to complete siltation over the last 30 years. Siltation of permanent water bodies has a direct impact on irrigation and fisheries resources. Studies show that siltation is mainly caused by over bank spills and breaches in the river banks during the pre-monsoon season. For example, Bhanda Beel was almost completely silted up in 1994 due to bank breaching of the Kalni River just downstream of Markuli (Annex H- Fisheries).

Traditional irrigation represents about 25% of total irrigation, and it is gradually decreasing due to *beel* and offtake siltation. In order to compensate, people will have to depend on the main river. For instance, over the last two years about 300 additional LLPs were installed in the river reach between Ajmiriganj and Madna. Most of these LLPs require long irrigation canals (over 2 km) which increases the cost of cultivation substantially.

Future Evaluation of the River

Given the history of channel instability over the last 30 years, it is difficult to accurately predict the future morphologic characteristics of the Kalni-Kushiyara River system. Avulsions and channel shifts are highly complex processes that may be triggered by chance occurrence and are not entirely deterministic. Therefore, any forecast will be somewhat speculative. Nevertheless, it is felt that a realistic scenario could be developed on the basis of the river's recent geomorphic evolution. The following comments summarize the main features of this scenario. Spills, river bank breaching and bank erosion will continue to occur between Sherpur and Ajmiriganj. However, the rate of bank erosion in this reach is expected to decline in comparison to the last 30 years. This is because most of the recent channel instability in this reach was related to channel adjustments following the Suriya avulsion (just below Sherpur) and Markuli closure. It is expected the channel has reached its equilibrium width so that further channel widening will be very minor. However, the meander pattern is still adjusting by eliminating short radius bends through natural loop cuts. This will cause some short-term bank erosion problems between Sherpur and Markuli.

Since 1993, the main instability on the river has occurred downstream of Ajmiriganj and it is expected that this situation will continue in the future. Cherapur Khal is enlarging rapidly and appears to be diverting a substantial amount of flow into the Baulai River system. A complete avulsion would result in the abandonment of the lower Kalni-Dhaleswari River and major erosion and sedimentation problems along the lower Baulai River. The magnitude of these impacts would be at least as large as the impacts resulting from the earlier Suriya avulsion. However, based on a comparison of channel lengths and slopes along the Baulai and Kalni Rivers, it appears unlikely that the Baulai route will capture all of the flow in the immediate future. It appears more likely that Cherapur Khal will enlarge until it forms a major distributary channel, carrying slightly less than half of the incoming flows on the Kalni River. Empirical Regime equations suggests the top width of Cherapur Khal could reach up to 200 m similar to the branch of the Kalni River that developed opposite Katkhal village in 1994. This development will produce significant channel adjustments on both the lower Baulai River and lower Kalni River systems.

Increased flows through Cherapur Khal (Dhakay-Kanchanpur route) will induce bank erosion and increased channel shifting along the 13.5 km length of the *khal*. Channel widening should produce bank erosion of approximate 280 ha and will add an additional sediment load of approximately 15 million tonnes to the Baulai River. Downstream of the diversion, Kalni River flows will be decreased substantially, particularly in the dry season and pre-monsoon season (effectively the channel-forming flows on this river). The reduced discharges will result in partial infilling of the channel and a reduction of the channel cross-section. Empirical Regime equations can be used as a guide for estimating the change in the channel geometry that will occur. However, more direct guidance can be provided from the observed channel changes that presently occur on the Kalni River immediately downstream of the Baida River bifurcation. At this point about 60% of the flow is carried by the Baida channel and about 40% continues down the Dhaleswari branch. Surveys along this reach show the cross sectional area at bankfull stage decreases by round 450 m^2 (about 50%) below the bifurcation. On this basis, it was estimated that the cross section of the Kalni River will be reduced by 400 m^2, downstream of Cherapur Khal. This corresponds to an increase in the average bed level of between 1.5 - 1.0 m. This would effectively cause the Dhaleswari branch between Issapur and Kalma to become abandoned in the dry season.

Analysis of FWO scenario shows that an area of about 99,700 ha (30% of gross area) will be inundated by the 1:2 year flood during the pre-monsoon season. The inundated area will increase substantially for higher return periods, ranging from 239,000 ha for the 1:5 year flood to about 294,700 ha for the 1:10 year flood (Table I.15). In addition, siltation of Khowai River outfall could have severe adverse impact on the Khowai River embankment.

Moreover, post-monsoon drainage will be impeded from its present level and plantation of *boro* crop will be delayed. Late plantation makes the crop more vulnerable to pre-monsoon floods and accumulated rainfall inundation. The magnitude of impacts will increase both inside and outside the project area as follows:

- the south floodplain will be impacted severely due to siltation of outfall channels of Khowai, Ratna and Sutang River. Impacts may extend outside the project particularly in Habiganj and Moulvibazar areas, and

- water levels in the Baulai River system will also increase (Itna-Sukdevpur reach) during the pre-monsoon and post-monsoon seasons. Both banks of the Baulai River will be affected. Water levels at Dhanpur will increase by about 0.3 m. Darain River is the main drainage channel from the north floodplain of the project area which drains at Dhanpur. This suggests that both depth and duration of flooding will increase in the north floodplain.

Table I.15: Pre-monsoon Gross Inundated Area Under FWO Scenario

Return Period	Flood Free (ha)	Gross Inundated Area (ha)				% Inundated Area	FWO Increase over Present (%)
	<0.3m	0.3-0.9 m	0.9-1.8 m	>1.8 m	Total		
1:2	235,867	53,352	37,252	9,131	99,734	30	9
1:5	96,215	69,793	113,863	55,729	239,385	71	6
1:10	40,886	44,430	121,482	128,802	294,714	88	2

Although of less immediate concern, it is also important to consider the effects of global warming on the future river regime. A series of papers have been published on the subject by Bangladesh Unnayan Parishad (BUP, 1993). The direct effects include sea-level rise, increasing cyclone activity, generally higher and more erratic rainfall, and more intensive rain storms. The net effect on the river regime would be to increase the backwater effect in the downstream reach of the project area and increase the frequency and magnitude of pre-monsoon floods. The net effect would be to worsen flooding conditions in the project area beyond those described in the preceding paragraphs.

3.5.2 Aquatic and Terrestrial Fauna Ecosystems

Changes in the hydrological regime, conversion of land for agricultural purposes, habitat alteration due to development activities and exploitation of wildlife for commercial purposes have all had deleterious effects on the local fauna. The resulting ecology has favored certain species while impairing others. For example, changes due to agricultural expansion have favored the propagation of rodents that, in turn, has supported an increase in the raptor population, particularly the crested serpent eagle (Spilornis cheela).

Among birds dependant on terrestrial habitat, the most common are the sub-species of *drongos* and *mynas*. These species thrive in the altered habitat. Conversely, frugivorous (fruit-eating) birds and grassland-dependant birds (warblers, etc.) are experiencing population decline due to the lack of fruit-bearing trees and grassland habitat.

Commercial exploitation of economically important species like the common otter (Lutra lutra), the Bengal lizard (Varanus bengalensis), the rat snake (Ptyas mucosus) and the bull frog (Rana tigerina) is widely practiced. Local people, particularly tribal groups, are engaged in the collection of local species. These are either sold locally or transported to Dhaka from where they are shipped overseas.

The negative effects of habitat alteration have had the greatest impact on the mammal population, particularly the large mammals, which have totally disappeared. Medium and small mammals are struggling to survive.

3.5.3 Social

Population
Population estimates for the future have been made on the basis of projections used in the World Bank literature. It has been assumed that the country will attain a Net Reproductive Rate of 1 (no increase in net population) by 2010. According to projections, the country will have an annual growth rate of 1.06% in 2025. Based on this assumption, the population of the project area will be 2.88 million in the year 2025.

Urbanization
Urban population increased at an annual rate of over 5% during the inter-census period from 1981 to 1991. An important feature of the 1980s was a heavy exodus of population from the villages to *thana* headquarters. It is expected that soon this phenomenon of high rural-urban migration at the *thana* level would be stabilized and the migration rate would be slowed down. It is assumed that the rate of urbanization in the project area will fall in a linear fashion and will be 2% in the year 2025. As a result, urban population will increase from the current (1995) figure of 0.19 million to 0.53 million in 2025. This means that urban population will increase at an average annual rate of 3.62% and rural population at 1.12% during the period up to 2025. In 2025, urban population will be 18.4% of the total project population compared to 8.9% in 1991.

Landlessness
The extent of landlessness is 43% in the project area according to the 1996 household survey of NERP. Landless population in Bangladesh increased annually at the rate of 1.5% during the period from 1977 to 1991. Assuming a similar rate in the future, landless population will be 1.73 million, or 74% of the total rural population, in 2025. On the other hand, farm population will decline as a result of increasing urbanization and landlessness.

Employment
Considering the 15 to 64 year age group as the working population, this age group will increase by 0.54 million within the next 30 years. There will be an additional demand for 18,000 jobs every year to maintain the current level of employment. Two-thirds of them are to be absorbed in the rural sector. This implies an average annual increase of job-seekers at the rate of 1.41%.

3.5.4 Agriculture

Pre-monsoon floods are the major cause of damage to the *boro* rice crop, the principal food grain grown in the project area. Low yields and complete loss of the *boro* crop leads to unstable food production and causes economic insecurity for the people. Recurring pre-monsoon flood damage has accelerated the process of pauperization among farm families.

After October, water levels in the project area usually start to decrease, and the water drains from the floodplain back to the main river channels. The timing of this recession is very important, since it governs when *boro* rice cultivation can begin. If drainage is delayed or obstructed, farmers can not transplant *boro* seedlings. Furthermore, the longer the delay in planting, the greater the risk of incurring damage from pre-monsoon floods before the next harvest.

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Cultivated Land
Present cultivated land will decrease by about 1% in FWO scenario due to the development of infrastructure, expansion of homestead area and river bank erosion. The increase in volume of pre-monsoon floods would diminish the flood-free cultivated area and cause greater damage to winter crops in low-lying areas. Increased siltation in the Kalni-Kushiyara River, higher river levels and the closing of major channel outlets through sedimentation could further delay drainage of flood water, impede irrigation and increase loss of crop production.

Under FWO conditions in the pre-monsoon season, the cultivated flood-free lands will be reduced by 13% at 1:2 year flood, 27% at 1:5 year flood, and 51% at 1:10 year flood compared to present conditions. Conversely, an extra 10% of the net cultivated area will be inundated during the pre-monsoon season from the present level at 1:2 year flood, 8% at 1:5 yr flood and 3% at 1:10 yr flood. The increased inundation will mainly aggravate losses of *boro* crops and decrease rice production in the project area.

Crop Pattern and Area
The crops will continue to be grown mainly in the winter season. The winter crops area could decrease from 86.3% of the net cultivated area at present to 85.6% in FWO scenario. The surface water irrigated area may decrease due to siltation of permanent water bodies, river channels. About 97.7% of the winter crops will be irrigated compared to 98.1% at present.

There will be no significant changes in crop patterns in FWO project. HYV *boro* rice area will continue replacing local *boro* in future. However, the rate of increase will be low compared to that in 1980s. The area irrigated by lifting water through traditional methods would decrease, and dependence on irrigation water from the perennial rivers would increase. The cropping intensity would increase slightly due to the cultivation of HYV *boro* after broadcast *aman* on lands raised by sediment deposition. The area of rainfed b.*aus* and t.*aman* would decrease due to the deposition of sediments, inadequate soil moisture and the increase in flooding extent.

There would be no significant changes in the area under non-rice crop. The area under wheat and pulse could increase due to unavailability of adequate irrigation water for potato cultivation. Similarly, vegetables and spices would replace HYV *boro* on lands where irrigation supply will not be adequate for *boro* production. Irregular deposition of sandy sediment will change the landscape, degrade the soil and diminish productivity in large areas. Non-rice crops will replace rice in these areas as sandy sediments will make the land unsuitable for rice cultivation.

Changes in Annual Food Production
The rice production would decrease due to increase in crop losses. Crop loss will result from the increase in inundated crop area in the pre-monsoon season.

Present cultivated land will decrease by about 1% in the FWO scenario due to the development of infrastructure, expansion of homestead area and river bank erosion. The increase in volume of pre-monsoon floods would diminish the flood-free cultivated area and cause greater damage to winter crops in the low-lying areas. Increased siltation in the Kalni-Kushiyara River, higher river levels and the closing of major channel outlets through sedimentation could further delay drainage of flood water, impede irrigation and increase loss of crop production.

3.5.5 Fisheries Issues and Trends

According to the fisheries statistics data collection system (BFRSS) operated by the DOF and to the data from Ajmiriganj Fish Industries Ltd, river fisheries have undergone a decline since reaching a peak in 1988/89. It is believed that fish production in the project area is subject to five principal negative risks: (1) sedimentation of key habitats (river channels, *duars*, *beels*), (2) poor water quality due to stagnation and contamination, (3) fish disease outbreaks, (4) overfishing with illegal fishing gear and (5) undermining of sound biological management due to lack of revenue collection.

At the same time, the increasing river discharge is exerting a positive impact region-wide on fishery production.

Sedimentation
Field studies have shown that the mainstream river channel, distributaries, *beels*, and *duars* are all undergoing relatively rapid aggradation in the project area downstream of Ajmiriganj. Average channel depth of the Kushiyara River between Fenchuganj and Sherpur (8 m) is greater than average channel depth of the Kalni River between Markuli and Katkhal (5 m). Fish standing crop index is also higher between Fenchuganj and Sherpur (263.1 kg/ha/yr) compared to the Kalni River (mean of 168.8 kg/ha/yr). It is reasonable to assume that this difference is in large part controlled by channel depth.

Bed load siltation due to bank overspill is causing a rapid in-filling of *beels* in the project area. Field studies indicate that *beel* area has declined on average by 28% during the last 15-20 years. However, *beel* depth has declined even more - by 44%. This indicates that as a *beel* fills in with sediment, it becomes shallower at a faster rate than it loses surface area. Maximum *beel* depth is strongly correlated with standing crop index. This suggests that actual loss of fish abundance from *beels* will be 1.6 times greater than indicated by the rate of loss of *beel* surface area.

In the future, sedimentation of the Kalni-Kushiyara River channel is likely to continue, resulting in decreasing channel depth, loss of *duars*, and greater channel instability and more frequent avulsion events. Distributaries are also likely to suffer increasing channel sedimentation and decreasing channel depth. This is likely to lead to decreasing catches of riverine species. Shallow habitats during the dry season will accelerate fishing out of broodstock.

Without project interventions, the structural quality of fish producing habitats, especially critical *beel* and *duar* habitats, is likely to continue to decline. Estimated *beel* area loss over the next 30 years is approximately 1,095 ha (21.2%). This is equivalent to 642 tonnes of fish production on an area basis, and 1,027 tonnes if adjusted for the likely loss in *beel* maximum depth.

Water Quality and Agrochemicals
Population increase is leading to an increase in domestic sewage. Almost all of the sewage enters the aquatic environment. This nutrient loading likely results in a general increase in primary and secondary production, and in turn fish production. This factor should therefore be generating a continuous increase in fish production, paralleling human population growth (1.8% per annum over the last 10 years).

Intensification of agriculture is leading to increasing application of fertilizer in the region. A portion of this fertilizer enters the aquatic environment, either directly or as nutrients from decomposing or otherwise transformed crop wastes. The increase in nutrients from fertilizers can then be expected to result in increases in fish production. High rates of application of nitrogen fertilizers might however over-eutrophicate the aquatic environment, leading to a depression of fish production.

Agricultural intensification invariably leads to increasing use of pesticides and residues in the environment. Lethal and sub-lethal impacts of pesticides will reduce fish production.

Inadequately treated effluent discharges from the Fenchuganj fertilizer plant cause lethal and sublethal toxicity in fish in the Kushiyara River. These losses in fish production began abruptly at start-up of the plant and will continue until such time as there is an improvement in effluent treatment or the plant closes.

Fish Disease

Severe outbreaks of epizootic ulcerative disease and massive fish mortalities appear to be induced by deteriorating water quality under stagnant water conditions in some *beels*, *khals* and borrow pits during the late monsoon and dry season.

Overfishing and Fisheries Management

The use of small mesh monofilament nets (*jal*) is a persisting problem in the area. Although the current *jal* is a highly efficient gear, it cannot distinguish between adults of small species (which would be an acceptable target species) and juveniles of large species (especially *ilish* and carp). Over-harvesting of juveniles depresses significantly stock abundance. Efforts to control current *jal* use have not been especially successful.

River fisheries have in the last year been declared open access fisheries by the GOB. This has resulted in a large increase in the number of fishermen. Both legal and illegal fishing gears now contribute to overfishing of stocks.

Increasing Discharge

River discharge (and its corollary - flood intensity) is known to be a direct determinant of fish production in floodplains. The general trend of increasing discharge in the region should in theory produce a trend of increasing fish production. Catch statistics from DOF and Ajmiriganj Fish Industries Ltd. however show a declining trend.

One possible explanation is that only very strong flood years are important for increasing fish production. Medium and low intensity flood years generally result in fishing out of broodstock from the critical *beel* and *duar* habitats. Strong flood years, such as 1988 (and again in 1994) result in strong recovery of major carp and large catfish, with large quantities of hatchlings recorded the same year of the flood, and broodstock appearing in catches 2 to 3 years later. The relationship between flood intensity and fish catch may thus be curvilinear rather than linear. In such a model, floodplain fish stocks are replenished during periodic strong flood years, and generally fished out during intervening medium and low flood years.

In the future, decreasing channel capacity and increasing discharge in the catchment will produce faster bank overspill and more prolonged flooding. Increased hectare-month of inundation of the floodplain will increase fish catch. This is likely to be accompanied by a shift in species composition to less migratory, more sedentary floodplain species. *Ilish, pangash* and some major carp species will possibly become extinct in the region (a trend which is already underway).

3.5.6 Navigation

The Kalni-Kushiyara River system will have the following hydromorphological changes under FWO condition:

- the average bed level of the Kalni-Kushiyara River below Cherapur Khal (Dhakey-Kanchanpur Route) will raise by about 1-1.5 m from its present level. This will effectively cause the Dhaleswari River between Issapur and Kalma to become totally unusable for navigation during the dry season, and

- the banks of Cherapur Khal will continue eroding and the channel will likely shift along its 13.5 km length. This process will erode an estimated 15 million tonnes of sediment load and deposit it on the lower reach of the Baulai River.

These hydromorphological changes are expected to impact water transport sector in the following way:

- water transportation will face set backs during the post-monsoon season for a longer period, may be starting from November. Length of critical dry period for navigation (February - March) may also increase to January - April;

- currently, LAD is about 0.25 m at Issapur and falls below 0.75 m at many places (Khajir Khola, Adampur, Madna, Shambazar, Manumukh) during the dry period. Further deterioration indicates BIWTA services (launch) between Ajmiriganj and Bhairab Bazar will be totally disrupted during the dry season. Moreover, medium and small size engine boats and non-mechanized country boats, may also be inactive from the Kalni-Kushiyara River for a longer period (January-April) particularly downstream of Cherapur Khal;

- the cost of transportation will increase considerably due to slow movement of cargo and passenger fleets including frequent stopping and several transhipment due to inadequate draught. Moreover, in many places the essential cargo items of daily life will have to take costlier, under-graded seasonal roads by availing a mix of head-loads and country boats. For example, about 295,000 persons in river communities between Cherapur Khal and Abdullahpur will be seriously affected based on NERP 1995 navigation survey (Table I.16 - sum of Abdullahpur and Kadamchal). Cost of Petroleum, Oil, Lubricants (POL), fertilizer, seeds will also be increased, which in turn may have adverse impact on *boro* production;

- Cherapur Khal (Dhakey-Kanchanpur route) will be perennial due to increase in depth during the dry season. But the navigation distances will be increased by 12 km to Bhairab Bazar for the residents living upstream of Cherapur Khal which will increase the cost of transportation. This will adversely impact 2.08 million passengers in the river reach between Katkhal and Ajmiriganj (Table I.16);

Table I.16: Present Dry Season Traffic-Lower Reach

Station	Total Traffic	
	Cargo (tonnes)	Passenger (no)
Madna	813	69,496
Kadamchal	688	74,684
Adampur	7,245	325,584
Abdullahpur	5,180	220,316
Katkhal	2,404	267,956
Kakailseo	57,163	157,452
Ajmiriganj	39,904	1,655,362
Total	**113,397**	**2,770,850**

Source: NERP Navigation Survey, 1994-95

- the bed level of Baulai will be increased due to the deposition of 15 million tonnes of eroded materials. This might disrupt the Baulai navigation system during the dry season, and
- feeder rivers will also suffer loss of navigability as siltation in them will be enhanced at their confluences with the main river.

From the above, it could be inferred that the cost of living will be increased significantly and all other activities will be slowed down to minimal level which is neither desirable nor acceptable. Moreover, people of the project area are already confined within their homesteads for three to five months in a year during the monsoon season. Disruption of navigation will leave them also confined during the winter months.

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4. PEOPLE'S PARTICIPATION

4.1 The Methodology

Over the past one and half years, male and female Community Organizers (COs), living in Madna, Ajmiriganj and Kakailseo have been collecting people's perceptions on selected socio-economic issues in communities between Ajmiriganj and Ikardia. Reflected in the social analysis used throughout the feasibility study, the COs' sketch maps and documentation has provided material on flood occurrence, disposal site ownership, village configurations, land prices, women's homestead practices, paddy gleaning, erosion history, traditional platform protection, gender-specific agricultural practices, fishing practices, *khas* land use, village institutional structures and social relationships, markets, navigation patterns, labor and wage and the case studies for Shahebnagar, Anandapur and the Cherapur Khal. Material for the community impact analysis has been obtained through a series of surveys.

Village Reconnaissance Survey
In the 1995-1996 dry season, a village reconnaissance survey was done in 115 villages, on the riverside and the floodplain, along both banks of the Kalni-Kushiyara River, from Sherpur to Kochuagaon. A check-list format was used to collect material on village, union and *thana* location, population, flood occurrence, erosion history, and *khas* land availability.

Household Survey
A socio-economic survey of households was carried out in April-June 1996. Based on the knowledge gained of villages in the Reconnaissance Survey, 6 villages, covering the Upper, Middle and Lower reaches between Sherpur and Kochuagaon were surveyed. Villages were selected to typify the pilot project communities, geographic diversity, village size, occupational and economic diversity, and water problems such as flood, erosion, and drainage congestion. In total, the male head of 568 households were sampled with a pre-tested questionnaire to obtain data on population characteristics, land ownership, tenancy conditions, occupation, income and water and sanitation coverage.

Womens Status Survey
In the dry season of 1996, a women's status survey was conducted by female community organizers (COs) in 5 villages, representing 4 *thanas*, located along the river between Ajmiriganj and Madna. Villages were selected to sample women's participation in the pilot communities and to represent villages with a typical range of women's issues related to flood, erosion and homestead agriculture. The senior woman in 408 households were surveyed with a structured questionnaire on household characteristics, marriage, education, literacy, land ownership, homestead production, income, wage and household decision-making.

Participatory Rural Appraisal
Participatory Rural Appraisal (PRA) is a research methodology, used by social scientists, to develop qualitative analysis on selected issues not captured in statistical surveys and hard data. Based on discussion, the analysis draws on people's experiences and knowledge of their life conditions. Over the past one and half years, the PRA method has been extensively used by the COs.

Having male and female COs living in the villages, over an extended period has provided them with the acceptability needed to gain depth on village social relationships, as well as adding a seasonal and gender dimension to the material. At the pilot dredging sites, as well as in remote project areas, people's perceptions have been gathered to provide the social context on a wide range of issues including agriculture and fishing practices, land and tenancy relationships, traditional platform protection, labor and wage contracts, paddy gleaning, markets and navigation patterns. Historical accounts and selected studies on erosion, *khas* land, channel changes, river avulsions and disposal sites have contributed to the study team's knowledge and utilization of social issues in water resource management.

4.2 People's Identification of Problems and Issues

4.2.1 Problems and Issues

Problems of the project area's population are inextricably linked with the river regime. The river is a lifeline of the people and a necessary condition for their survival. But it is also at time a nemesis.

The main problems and issues identified by local people through meetings and interviews are:

- river erosion, particularly in bends;
- damage to *boro* crops by flash flood in the pre-monsoon season and *aman* crops during the monsoon;
- late planting of *boro* rice after the monsoon as the land does not drain fast enough;
- erosion of village platform by waves during the monsoon. As a result affected villagers have to relocate;
- shifts in river courses (avulsions). Affected people have to relocate. They also become landless when the shifts occurs over their agricultural land;
- silting of *beels*, ponds and channels;
- silting of the navigation channel between Madna and Kakailseo, and
- general pauperization of medium and small farmers, as they cannot repay their loans and the mortgaged land is repossessed. Medium farmers become poor, small farmers become landless.

4.2.2 Proposed Solutions

Numerous suggestions were put forward by local people. However, some suggestions are meant for small and localised issues. The most common are:

- save *boro* rice crops from flash floods;
- increase drainage effectiveness;

- undertake projects to improve drainage;
- control water for rice production in the wet season.;
- protect land from intrusion of flood water;
- embank rivers at appropriate places with necessary sluice gates at appropriate locations, to ensure drainage as well as storage of flood water for irrigation;
- construct high embankments to resist wave action;
- excavate/re-excavate rivers, *khals*, *beels*, *haors* and channels to minimise floods and store water for irrigation in dry season;
- ensure availability of irrigation water in the dry season, and
- improve the navigation channel from Madna to Kakailseo.

4.3 People's Perception of the Proposed Project

In general the local population is favorable to the proposed project. Following are some of the main issues raised.

Issapur Loop Cut

Impacts on Chowdanta and Bhatura: The villages of Chowdanta and Bhatura will be seriously impacted because farmers in these two communities own 90% of the land to be acquired. They strongly oppose construction of the loop cut because loss of this agricultural land will mean loss of their primary source of livelihood.

Scarcity of high land in the area will make it difficult for Chowdanta and Bhatura farmers to replace their high quality agricultural land, even if they are well compensated. These farmers report that to farm efficiently, any replacement land must be located within 3 km of their homesteads. There is no *khas* land within this range. Shifting away from their traditional location is not viewed as a viable option by these minority communities.

Impacts on Kalma and Issapur: Issapur and Kalma are located respectively, on the north and south ends of the Issapur loop cut. Farmers in these two communities own about 10 per cent of the agriculture land to be acquired for the loop cut. They are willing to sell at market prices. Issapur and Kalma people anticipate economic growth as important transit centres along the new waterway and navigation route.

Impacts on People in the Baida Channel Area (Boithakhali - Maska River): The Kalni River becomes the Baida Channel when it loops south-west from Issapur. The villages of Chandipur, Shantipur, Kakoria and Sapanto are located along the Baida Channel, which people refer to as the Boithakhali or the Maska River. Farmers in this area are not opposed to the Issapur loop cut because they will not lose land for its construction. On the contrary, farmers favor the loop cut because their *boro* crop will be secure from pre-monsoon flood. The loop cut will provide people in this area with a direct north- south navigation route. However, fisher households are concerned that the Issapur loop cut may inhibit the flow in the Baida Channel, thereby reducing water in the large *beels* of the area. This will in fact not be the case because the backwater effect from the Meghna River will sustain the Baida Channel water levels.

The Dhaleshwari Channel

Adampur Bazar and Madna Impacts: Farmers in Madna report that over the years there has been an increase of siltation in the Dhaleswari River, resulting in reduced post-monsoon drainage capacity and a delay in plantation of the *boro* rice crop. Farmers insist that construction of the

Issapur loop cut must be accompanied by annual dredging of the Dhaleswari River. A deepened channel will improve post-monsoon drainage, enabling farmers to plant their *boro* crop on time and eliminate greater risk of crop loss from pre-monsoon floods.

Shopkeepers and traders in Adampur Bazar report that decreased flow and limited navigability in the dry season has seriously affected their business. Since 1992, passenger launches have been unable to navigate this portion of the river during the dry season. Between January and March, when larger boats are unable to pass in the Dhaleswari River, trading goods are off-loaded at Kalma and Issapur and transported on lighter crafts to Adampur Bazar and Madna. Business people are of the opinion that the increased costs for transporting goods during the dry season is threatening the viability of their markets in Adampur Bazar and Madna.

Traders and market owners in Madna and Adampur Bazar are opposed to the Issapur loop cut as a single initiative. They are of the opinion that the loop cut would result in even further siltation of the Dhaleswari River. If the Issapur loop cut is to be constructed, business people are adamant that dredging is essential to maintain navigability and retain the commercial viability of their markets.

The Katkhal Loop Cut

Farmers, homestead dwellers and business people in all villages in the vicinity of the Katkhal loop cut are overwhelmingly in favor of its construction.

In Santipur and Katkhal villages, many households have lost homestead land and buildings from river erosion each year. They feel that without measures to straighten the river, it will continue to erode on the north-west side of Santipur and will eventually make its own random loop cuts. In early April, 1996 landowners from Katkhal and Santipur, farming in Barabaira Beel and Bander Beel lost 1,200 acres of standing *boro* crop in a pre-monsoon flood.

In Shahebnagar village, people have become impoverished as a result of continuing river avulsion and bank erosion. The 1994 erosion at Shahebnagar resulted in the loss of 200 homesteads. Over the years, some households have shifted as often as four times to raise new homesteads. Siltation of their *haor* agricultural land has resulted in increased production costs for their *boro* rice cultivation.

Landowners in Katkhal and Shahebnagar anticipate that unless a loop cut is constructed within two years, the river itself will cut south through Doia Beel. People fear river avulsion and loss of crop in the Mora Gang Beel may occur in the future.

Landowners are in favor of the Katkhal loop cut because even though they will loose some land to its construction, their remaining land will be less vulnerable to pre-monsoon flood. For the same reason, farmers have given permission for loop cut spoils to be deposited on their low land, should sufficient excavated material be available. Farmers in the area expect to grow *boro* paddy after 1 or 2 years, on the land raised with good quality soil from the loop cut.

The Homestead Platforms in the Rahela to Ajmiriganj Reach

All landowners at these sites are willing to dedicate land for platform development.

5. ENVIRONMENTAL IMPACT ASSESSMENT

5.1 Assessment Methodology

The methodology recommended in the FPCO *Guidelines* (FPCO, 1992) and further detailed in the FAP-16 EIA Manual (ISPAN, 1994) for Environmental Impact Assessment (EIA) was followed with some adaptations to match the specific set of conditions of the KKRMP.

Relying on field data, the NERP multi-disciplinary team has developed an environmental baseline description of the study area. Then the Important Environmental Components (IECs) have been identified through a scoping process. The impact of each activity carried out during pre-construction, construction, or O&M on each different IEC has been assessed. Environmental characteristics of the FWO scenario have been assessed, by assuming that past trends will continue in the future (Section 3.5). Next, these characteristics have also been assessed for the FW scenario (Sections 5.7 to 5.10). Project impacts have been evaluated by taking into consideration the changes likely to occur under each future scenario in the bio-physical and socioeconomic IECs. Maps have been developed and analyzed to quantify spatial impacts related to agriculture, wetland and fisheries. Once project impacts were identified, recommendations have been made to mitigate negative impacts, compensate individuals or groups adversely impacted, enhance positive impacts whenever possible and monitor actual impacts during implementation and O&M phases.

5.2 Scoping

5.2.1 Scoping Process

Scoping has been carried out to identify the important environmental issues to arise from the project and the IECs. These have been evaluated in terms of distribution, quantity, quality, seasonality and socioeconomic and/or ecological importance.

The sources of information for the scoping process have been:

- work sessions and discussions among professionals of the various technical disciplines represented at NERP;
- information collected through interview of local community representatives (including key informants and knowledgeable persons) carried out by NERP Community Organizers (COs);
- information gathered through formal and informal meetings with officials of Government and Non-Government Organizations (NGOs), and
- direct experience with implementation of the Pilot Dredging Project EMP.

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5.2.2 Selection of Important Environmental Components

Through the scoping process, the IECs identified for the KKRMP are presented below. It should be noted that, in order to avoid repetition, some of the environmental components have been grouped based either on their similarity or on the fact that they are likely to be modified in a same way by the project.

- River Morphology;
- Hydrology and Hydraulics (water levels, flow velocities and flooding);
- Open Water Bodies (river, *haors* and secondary channels);
- Erosion and Sedimentation Processes;
- Drainage;
- Irrigation;
- Aquatic Habitat and Fisheries (water quality, fish production, fish migration, river dolphins, wetland);
- Terrestrial Habitat (flora and fauna);
- Land Use and Settlement (housing, homesteads, land ownership);
- Education and Health (sanitation, drinking water, nutrition, quality of life, and security);
- Status of Women;
- Land quality and productivity (crop production);
- Navigation;
- Employment and Economic Activity, and
- Equity.

It should also be noted that project impacts overlap some of the IECS, in particular river morphology, hydrology and hydraulics, and erosion and sedimentation processes.

5.3 Bounding

5.3.1 Temporal Bounding

Temporal bounding is the economic life of the project, 30 years.

5.3.2 Spatial Bounding

The area considered for spatial bounding is the project area, in particular the 168 km reach of the lower Kushiyara and Kalni Rivers, extending from the town of Fenchuganj to the junction with the Upper Meghna River near Astagram (Figure I.1). This river system affects much of the low-lying floodplain and flood basin lands in the Northeast region. The project area is bounded by the Kushiyara-Bijna-Ratna-Sutang River system to the south, the Surma-Baulai River floodplain to the west, the Old Surma-Dahuka River and Jaganathpur- Sylhet road to the north, and the Sylhet-Kaktai road to the east. The project gross area covers 335,600 ha and extends over the districts of Sylhet, Sunamganj, Habiganj, Moulvibazar and Kishoreganj.

5.3.3 Impact Bounding

For the purpose of impact assessment, different bounds have been defined for different IECs depending on the type of impact affecting an IEC and its duration. For most long term impacts, the whole project area was considered as the controlled area or the "benefited area", that is to say the entire area directly and indirectly affected by the impacts. This is the case for impacts on hydraulics, agriculture and fisheries. For some long term impacts, navigation for instance, a more extended area was considered in order to take into account the effects of the project on adjacent populations or on overall regional economy. This is also the case for sedimentation on the river reach Madna-Bhairab Bazar located downstream of the project boundary and for which the impact of the project has also been assessed. For short term impacts related to the construction of the different project components for example, smaller areas were generally considered.

5.3.4 Monitoring Bounding

As a general rule, the monitoring bounding was adjusted according to the impact bounding for a given IEC.

5.4 Project Main Components

In order to facilitate and simplify the impact assessment, the project is divided into its main components, which are distinct activities or group of activities. Only the activities likely to interfere with the environment are considered herein. The components are presented for the two project phases, implementation and O&M. The first phase basically includes 2 short to medium term components while the second phase consists of 2 long-term components.

Implementation Components
From an environmental viewpoint there are two components during the project implementation phase:

- Earthwork and Pre-dredging. This component refers to all earthen construction and project related human activities including mobilization and demobilization of equipment, removal and storage of topsoil, dyke construction, setting and dismantling of pipelines, effluent channel, outlets, work camps and so forth. It includes the presence of pipelines, effluent channels and outlets and the presence of a large number of laborers. It refers also to the construction of levees, bank protection, river training works and structures. It finally includes the early stage of the platform maintenance program (plantation, protection, drainage management, etc.).

- Excavation of River Bed and Loop Cuts. This component refers to the excavation, transportation and placing of material. It also refers to the operation of the dredges as well as to the pumping of material into disposal chambers, and the discharge of effluent. This component does not include the presence of the improved channel.

The implementation of each of these components includes two sub-phases; namely pre-construction and construction. Pre-construction which includes cadastral and social surveys, data collection and design is considered to contribute to the impacts identified for the component , as the two sub-phases constitute a continuous process.

O&M Components
This section includes the project's long term components once construction is completed and throughout the O&M phase:

- Improved River Channel (including loop cuts and levees and bank protection upstream of Ajmiriganj).This component mainly refers to the resulting new hydraulic conditions. Most of the effects are likely to modify the environment at the regional level.

- New Setting and Settlement Pattern. This component refers to the presence and use of the new platforms and upgraded land as well as to the settlement and land use pattern modifications due to loop cuts. It also refers to the presence of the protection structures upstream of Ajmiriganj. Most of the effects are likely to modify the environment at the community or local level.

5.5 Impact Identification Matrix

The Impact Identification Matrix (IIM) presented in Table I.17 identifies potential interactions between IECs and project's components. It should be emphasized that, given the extent of the project area and the number of interventions, the Land Use and Settlement component has been broken down into 5 sub-components in order to take into account some very site-specific impacts. The following sections present a description and evaluation of each identified impact. They also introduce mitigation, compensation and enhancement measures likely to improve the project, as well as related relevant monitoring activities.

5.6 Quantification and Scoring of Impacts

The EIA *guidelines* (FPCO 1992 b)) require scoring of the impacts. The methodology described in the EIA Manual (ISPAN, 1994) for project impact assessment and scoring was used in this study. The impact assessment of specific IECs was done by the multi-disciplinary team members. An uniform well defined and stepwise structured format and criteria were used for assessment and scoring. When an impact could not be quantified, qualitative judgement was used based on professional experience. The scoring was done within a 21 point score ranging from -1 to -10 for negative impacts and +1 to +10 for positive impacts while 0 was used in case of no impact (or neutral impact) based on the scoring charts presented in Table I.18.

The impact scoring charts were developed considering the following aspects:

- value of the IEC in terms of rarity, economic value, importance for human etc.
- magnitude of the change (low to high);
- scale of the change (site-specific, local, regional, national);
- frequency (occurs a few times or repetitively);
- duration (short, mid or long term);
- reversibility (through mitigation or natural processes);
- probability (unlikely, likely, unavoidable), and
- significance summarizing the magnitude, frequency, duration and reversibility of the predicted impacts.

Table I.17: Impact Identification Matrix

Important Environmental Components (IECs)	Project Component			
	Implementation		O&M	
	Earth Works and Pre-dredging	Excavation of River Bed and Loop Cuts	Improved River Channel	New Setting and Settlement Pattern
River Morphology			17	
Hydrology & Hydraulics			18	
Open Water Bodies			19	
Erosion & Sedimentation Process		10	20	32
Drainage	1		21	33
Irrigation	2		22	34
Aquatic Habitat & Fisheries	3	11	23	
Terrestrial Habitat	4		24	35
Land Use & Settlement	5	12	25	
Issapur Loop Cut Site				36
Dhaleswari Dredging & Fill Sites				37
Katkhal Loop Cut Site				38
Land Dedicated Platform Sites				39
Khas Land Platform Sites				40
Education and Health	6	13	26	41
Status of Women	7		27	42
Land Quality & Productivity	8	14	28	43
Navigation		15	29	
Employment & Economic activity	9	16	30	44
Equity			31	45

Scoring may vary from individual to individual as the score assigned to a given element of the chart would differ when done by two different persons. It should be emphasized that although any scoring method will prove to have some limitations, the important point about scoring is to make sure that any reviewer will understand the reasons behind a given assessment and will be able to reproduce this assessment.

Finally, the EIA guidelines (FPCO 1992 b)) suggest to weigh the impacts as products of the proportionate importance of the IECs and the proportionate magnitude of the predicted impacts, and to sum these products as a measure of the total impact of the project. This has not been done, for impact on each IEC has its own weight and can not be added or subtracted from the impact on another IEC. For instance, negative impact on open-water fisheries can hardly be quantitatively neutralized by a positive impact on culture fisheries.

The detailed impact analysis is presented in Table I.19 for the implementation phase and in Table I.20 for the O&M phase.

The following sections present a description and evaluation of each identified impact. Each impact description heading is followed by two numbers. The first one is the IIM identification number (Table I.17) and the second one is the impact scoring value.

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Table I.18: Impact Scoring Charts
Chart A. Magnitude of the Change

Intensity of the Modification	Probability of the Change		
	Unlikely	Likely	Unavoidable
No modification	No impact	No impact	No impact
Little modification	Low	Low	Medium
Mid	Low	Medium	High
Large modification	Medium	High	High

Chart B. Importance of the Change (function of magnitude and scale)

Magnitude of the Change as per Chart A.	Scale of the change		
	Site-specific	Local	Regional
Low	Very Little importance	Little importance	Much important
Medium	Little importance	Much important	Very important
High	Much important	Very important	Most important

Chart C. Value of IECs in Terms of Rarity, Economic Value and Cultural Importance

Value	IEC
Low	River Morphology Hydrology and Hydraulics Open Water Bodies Erosion and Sedimentation Processes
Medium	Drainage Irrigation Aquatic Habitat and Fisheries Terrestrial Habitat and Wetlands Land Quality and Productivity Navigation Employment and Economic Activity
High	Land Use and Settlement Education and Health Status of Women Equity

Chart D. Global Scoring Chart

Duration	Value of the IEC	Importance of the Change as per Chart B				
		Very Little Importance	Little Importance	Much Importance	Very Important	Most Important
Short-Term	Low	1	2	2	3	3
	Medium	2	3	3	4	4
	High	2	3	4	4	5
Mid-Term	Low	2	3	3	4	5
	Medium	3	4	4	5	6
	High	3	4	5	6	7
Long-Term	Low	3	4	5	6	8
	Medium	4	5	6	7	9
	High	5	6	7	8	10

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Table I.19: Detailed Impact Analysis - Implementation Phase

IIM No.	Impact on IEC	Inten-sity	Mag.	Prob.[1]	Scale[2]	Importance of the change[3]	Value of IEC[4]	Dur-ation	Impact Scoring
	EARTH WORK & PRE-DREDGING								
1.	Drainage	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2
2.	Irrigation	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2
3.	Aquatic Habitat & Fisheries	Little	Low	Like	Loc	Little Imp.	Med	Short	-3
4.	Terrestrial Habitat	Mid	Med	Like	Site	Little Imp.	Med	Short	-3
5.	Land Use & Settlements	Little	Med	Unav	Site	Little Imp.	High	Mid	-4
6.	Education & Health	Little	Low	Like	Loc	Little Imp.	High	Mid	-4
7.	Status of Women	Little	Low	Like	Reg	Much Imp.	High	Mid	+5
8.	Land Quality & Productivity	Little	Low	Like	Site	Very Little Imp.	Med	Mid	-3
9.	Employment & Economic Act.	Little	Med	Unav	Reg	Very Imp.	Med	Mid	+5
	EXCAVATION OF RIVER & LOOP CUTS								
10.	Erosion & Sedimentation		No						0
11.	Aquatic Habitat & Fisheries	Little	Low	Like	Loc	Little Imp.	Med	Short	-3
12.	Land Use & Settlements	Little	Med	Unav	Site	Little Imp.	High	Short	-3
13.	Education & Health	Large	Med	Unlik	Site	Little Imp.	High	Short	-3
14.	Land Quality & Productivity	Large	Med	Unlik	Site	Little Imp.	Med	Short	-3
15.	Navigation	Little	Low	Like	Loc	Little Imp.	Med	Short	-3
16.	Employment & Economic Act.	little	Low	Like	Reg	Much Imp.	Med	Mid	+4

Notes:

1. Like = Likely; Unlik = Unlikely; Unav = Unavoidable
2. Loc = Local; Reg = Regional
3. Imp = Importance
4. Med = Medium

Table I.20: Detailed Impact Analysis - O&M Phase

IIM No.	Impact on IEC	Intensity	Mag.	Prob.[1]	Scale[2]	Importance of the change[3]	Value of IEC[4]	Duration	Impact Scoring
	IMPROVED RIVER CHANNEL								
17.	River Morphology	Little	Low	Like	Reg	Much Imp.	Low	Long	+5
18.	Hydrology & Hydraulics	Little	Low	Like	Reg	Much Imp.	Low	Long	+5
19.	Open Water Bodies	Little	Low	Like	Reg	Much Imp.	Low	Long	+5
20.	Erosion & Sedimentation	Little	Low	Like	Loc	Much Imp.	Low	Long	+5
21.	Drainage	Little	Low	Like	Reg	Much Imp.	Med	Long	+6
22.	Irrigation	Little	Low	Like	Reg	Much Imp.	Med	Long	+6
23.	Aquatic Habitat & Fisheries	Little	Low	Like	Reg	Much Imp.	Med	Long	+6
24.	Terrestrial Habitat	Little	Low	Like	Site	Very Little Imp.	Med	Long	+4
25.	Land Use & Settlements	Little	Low	Like	Loc	Little Imp.	High	Long	+6
26.	Education & Health	Little	Low	Like	Reg	Much Imp.	High	Long	+7
27.	Status of Women	Little	Low	Like	Reg	Much Imp.	High	Long	+7
28.	Land Quality & Productivity	Mid	Med	Like	Reg	Very Imp.	Med	Long	+7
29.	Navigation	Little	Low	Like	Reg	Much Imp.	Med	Long	+6
30.	Employment & Economic Act.	Little	Low	Like	Reg	Much Imp.	Med	Long	+6
31.	Equity	Little	Low	Like	Reg	Much Imp.	High	Long	+7
	NEW SETTING AND SETTLEMENT PATTERNS								
32.	Erosion & Sedimentation		No						0
33.	Drainage	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2
34.	Irrigation	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2
35.	Terrestrial Habitat	Little	Low	Like	Site	Very Little Imp.	Med	Long	+4
36.	Issapur loop Cut Site	Little	Med	Unav	Loc	Much Imp.	High	Long	-7
37.	Dhaleswari Dredging & Fill Site	Mid	Med	Like	Loc	Much Imp.	High	Long	+7
38.	Kathkal Loop Cut Site	Little	Med	Unav	Loc	Much Imp.	High	Long	-7
39.	Land Dedicated Platform Sites	Little	Med	Unav	Loc	Much Imp.	High	Long	+7
40.	*Khas* Land platform Sites	Little	Med	Unav	Loc	Much Imp.	High	Long	+7
41.	Education & Health	Little	Low	Like	Reg	Much Imp.	High	Long	+7
42.	Status of Women	Mid	Med	Like	Loc	Much Imp.	High	Long	+7
43.	Land Quality & Productivity	Little	Low	Like	Site	Very Little Imp.	Med	Long	-4
44.	Employment & Economic Act.	Little	Low	Like	Loc	Little Imp.	Med	Long	+5
45.	Equity	Little	Low	Like	Loc	Little Imp.	High	Long	+6

5.7 Description, Evaluation and Management of Environmental Impacts Related to Earth Works and Pre-dredging Activities

This section refers to all construction and project related human activities including mobilization and demobilization of equipment and laborers, removal and storage of topsoil, dyke construction, setting and dismantling of pipelines, effluent channel, outlets, work camps and so forth. It includes the presence of pipelines, effluent channels and outlets and the presence of a large number of laborers. It refers also to the construction of levees, bank protection, river training and structures. It finally includes the early stage of the platform maintenance program (plantation, protection, drainage management, etc.).

5.7.1 Local Drainage (1) (-2)

The setting of pipelines and effluent channels could cause disruption of existing drainage. Adequate cross drainage will be provided and compensation will be paid wherever disruption is unavoidable. This is a short-term impact, low magnitude and site-specific.

5.7.2 Irrigation Network Systems (2) (-2)

Presence of pipeline and effluent channel may interfere with irrigation channels and irrigation activities. This is a short-term impact, low magnitude and site-specific. Alternative sources of irrigation will be provided as well as channel overpasses. Adequate compensation will be provided when disruption is unavoidable.

5.7.3 Aquatic Habitat and Fisheries (3) (-3)

Fisheries could be affected by an increase in poaching and over fishing related to the local and short-term increase of population. This is a short-term, low magnitude and local impact that is mitigable in part if local labor is favored and in part by effective management.

5.7.4 Terrestrial Habitat (4) (-3)

Presence of pipeline and effluent channel may interfere with terrestrial habitat. Both flora and fauna will generally suffer from these construction activities. This is a short-term impact, mid-magnitude and site-specific. Adequate compensation will be provided where disruption is unavoidable.

5.7.5 Land Use and Settlement (5) (-4)

It is anticipated that many workers will be involved in the implementation phase of the project. For instance, some 10,000 to 12,000 manual laborers will participate in the construction of loop cuts. Significant, but temporary, adverse impacts of construction activities include disruption in the quality of village life. Some agricultural activities such as *boro* cultivation will also be significantly adversely impacted because of removal and storage of topsoil and construction activities. The work camps for temporary laborers are likely to have significant adverse impacts on the quality of village life. Impacts on this IEC will occur through crowding, strain on infrastructure and services, noise and general disruption in association with the construction activities and the potential aggravation caused by so many workers and villagers placed in close proximity to each other. This is a mid-term impact, mid-magnitude and site-specific impact that is mitigable in part through proper management and deployment of local labor.

5.7.6 Education and Health (6) (-4)

Construction activities as well as the presence of several strangers could threaten local communities health and safety. The existing water supply will come under pressure from the influx of laborers and other contractor staff. Therefore, as part of the project mitigation plan, hand tubewells for drinking water will be installed near the sheds which will be built for temporary labor. Likewise sanitary latrines will also be installed.

There is a moderate but non-significant increase in health risk to the village population during the pre-dredging phase because of increased population levels. Sanitation, at present, is almost non-existent. The increased labor force will greatly increase the occurrence of human excreta in the waters around the village and this can almost certainly have a negative effect on village health. Stress on whatever limited sanitation facilities there are, will impact mostly on the poor.

Some negative effects on nutrition will arise from the temporary loss of agricultural land during construction. Village health is directly related to water, sanitation and nutrition. If these three variables change in a negative direction, so will health.

This is a mid-term, low magnitude and local impact that is mitigable in part if local labor is favored.

5.7.7 Status of Women (7) (+5)

As an enhancement measure, the international contract will specify that a minimum construction labor quota of females will be mandatory. On an annual basis, throughout the construction period, the percentage of female construction labor should be reviewed and revised as necessary. Penalty clauses are to be applied to the contractor for failure to meet these obligations. This is a mid-term, low magnitude and regional positive impact.

5.7.8 Land Quality and Productivity (8) (-3)

A temporary major increase of the local population may affect land productivity, namely those land adjacent to the project. This is a mid-term, low magnitude, site-specific, likely impact, mitigable in part. During the pre-dredging phase, in cases where farming disruption becomes unavoidable, adequate compensation will be provided. Cash compensation will be paid to the farmers whose land will be affected.

5.7.9 Employment and Economic Activity (9) (+5)

It is anticipated that the project will have both direct and indirect positive impact on employment and local economic activity. This is a mid-term, mid-magnitude, regional, unavoidable positive impact. As a mitigation measure for the local communities affected by the construction phase of the project, the international contract will specify that, to the maximum possible, all types of labor should be locally recruited.

5.8 Description, Evaluation and Management of Environmental Impacts Related to the Dredging of the River Bed and Excavation of the Loop Cuts

This component refers to the excavation of the river bed (and loop cuts) and to the transportation and pumping of material into disposal chambers and discharge of effluent. It does not include the presence of the improved channel.

5.8.1 Erosion and Sedimentation Processes (10) (0)

During the Pilot Dredging Project, the overall trap efficiency of the disposal chambers was typically 96% (range 87% - 99%). One way to assess the potential impacts of dredging is to compare the amount of sediment returned to the river with the amount of sediment being transported by the river during the same time period. Assuming an average trap efficiency of 96% and a total chamber volume of 133,000 m^3, about 5,000 m^3 (or 4,000 tonnes) of sediment was discharged to the river during dredging at Kakailseo for instance. Based on suspended sediment measurements at Ajmiriganj, the Kalni River transported about 100,000 tonnes of sediment during the three months of dredging (January-March). Therefore, the effluent from the dredging operations temporarily increased the suspended load in the river during this period by approximately 4%. By comparison, the total quantity of sediment transported by the Kalni River in 1995 was estimated to be about 10,000,000 tonnes; the overall impact of the sediment discharged from the disposal chamber is very small (0.04%) in comparison to the total annual quantity of sediment transported by the river.

Another way to interpret these results is to estimate the potential impacts of sediment re-deposition. If all of the sediment in the effluent was redeposited in a typical *duar* (roughly 400 m long by 300 m wide), which is highly unlikely to occur since *duars* are situated in bends where strong secondary currents cause scour and sediment erosion, the total thickness of the deposit would amount to about 5 cm. By comparison, the NERP river survey program has documented natural scour and fill in some bends of up to three meters over a single year. Evidently, concerns about *duars* being infilled with sediment from the dredging effluent are unfounded and physical changes to the river channel from effluent discharges are estimated to be negligible.

5.8.2 Aquatic Habitat and Fisheries (11) (-3)

Riverine habitat may be negatively impacted by the river bed excavation and by the discharge of effluent water during the dredging operations.

Dredging

Hydraulic dredges are usually mounted on barges equipped with diesel powered centrifugal pumps. They remove and transport sediment in the form of slurries, usually containing 10 to 20% solids by weight, using discharge pipelines.

Hydraulic suction dredges are equipped with a powerful rotating mechanical digging apparatus mounted at the intake end of the suction pipe. This cutterhead breaks up hard and/or cohesive material so it can be pumped up at the suction intake. There are many types of cutterheads adapted for different types of sediment.

The cutterhead hydraulic dredge is generally equipped with two spuds which serve to hold the dredge in working position. During operation, the cutterhead dredge swings from side to side, alternately using the port and starboard spuds as pivots. Cables attached to either side of the dredge control lateral movement. Forward movement is achieved by lowering the starboard spud after the port swing is made. This operation ensures the accurate and uniform removal of sediment.

Dredging efficiency depends on achieving a balance between the hydraulic suction and the mechanical action of the cutterhead. Production rate depends not only on the size and power of the dredge, but also on the grain size and compaction of the dredged material, the dredging depth and area, as well as the distance to which the material has to be pumped through the pipeline.

In general terms, a coarser material and a longer distance would reduce the production rate of a given hydraulic dredge. In addition, more dispersed and less deep material would reduce the yield due to frequent displacement and repositioning.

The results of the water quality monitoring activities carried out during the pilot project indicate that the increase of turbidity related to the operation of the dredgers was negligible. It is not surprising since hydraulic dredges generally have few environmental impacts at the dredging site if pump pressure, cutter rotation speed, dredge head advancing speed, and depth of cut are closely controlled. Specifically, sediment resuspension can be reduced to nothing by balancing cutter speed with pump capacity. This also improves dredge performance, since all loosened or dislodged sediment is sucked up at the intake of the dredge. A variety of simple operating techniques can be used to match cutterhead speed to pump capacity.

- As a general rule, cutterhead speed should always be kept to the minimum that yields an acceptable production rate cost-wise. Reduced speeds are frequently more efficient, both environmentally and economically.

- Slopes should be stepped rather than box cut. In fine noncohesive material, a box cut left alone to slough itself into an angle of repose could cause substantial sediment resuspension.

- On some dredging projects, it may be more economical to make rough cuts and then complete the project with a final cleanup. This technique is not generally recommended, because the layer of sediment left may be subject to resuspension by currents and shipping traffic. This technique should therefore be used only where sediment resuspension will not affect sensitive resources.

- Large sets, or distances between cuts, very thick cuts and very shallow cuts should be avoided. Deep cuts tend to bury the dredge head and may cause high levels of resuspension if suction is not strong enough. On the other hand, if cuts are too shallow, the cutter tends to throw the sediment beyond the intake of the dredge.

It should be emphasized that, above all, the training and skill of operators represents the most critical factor both in terms of environmental impacts and production rate.

Disposal of Effluent

Potential short-term effects are related to the discharge of suspended particulate matter from the disposal chambers. However, field observations in the river during the pilot project indicated that the mixing zone extended about one kilometre downstream of the outlet and that only a small portion along the shore was influenced by the turbidity plume. Except for some readings in inlet and pool waters, where there was a marked dissolved oxygen depletion, none of the readings from the river were indicative of significant environmental problems. Except for the turbidity readings along the shore in the first 400 to 500 meters downstream of the outlet, data were typical of any river in the Northeast region. During the pilot project, the effluent from the disposal chambers did not have significant impact on the aquatic ecosystem.

As a general rule, the dimension of a given disposal chamber should be designed and adjusted according to the type of material it is planned to be filled with. While fine sediment would require long detention time and, consequently, large disposal chambers, coarser material such as pure sand would settle within a very short period of time.

Tarja walling should be installed in the confinement chamber to ensure a sufficient detention time for the silt to settle out instead of going back to the river (Annex J-Pilot Dredging Project).

The size of the turbidity plume depends on the sediment load in the outlet as well as on hydrodynamic conditions at the outlet site. High turbidity levels are generally of short duration at any given point, lasting from a few minutes to several hours. The effects of sediment suspension depend on the quantity and particle size of the suspended sediment, its dispersion rate in the environment and the vulnerability of sensitive resources in the environment.

The main biological impacts of sediment suspension derive from the turbidity itself as well as sediment resettlement. The impact of an increase in turbidity and in suspended solids concentration will depend on the animal and plant species present and their stage of development as well as the characteristics of the environment in which the increase occurs. In general, organisms regularly subjected to increases in turbidity attributable to natural causes are better able to withstand increases generated by dredging activities. Natural phenomena in fact generate increases in turbidity and in suspended solids concentrations comparable to those caused by dredging activities (Kirby and Land, 1991). Storms, floods and large tides, for example, are natural phenomena that provoke substantial increases in turbidity, and they can affect much larger areas and last for much longer than dredging operations. Navigational traffic is another source of resuspension of large quantities of sediment (Pennekamp et al., 1991).

The Pilot Dredging project demonstrated that sediment resuspension typical of dredging activities is unlikely to produce substantial deterioration of the environment. In fact, turbidity levels generated by dredging activities are far below lethal thresholds for most species and, more importantly, they do not last as long as known lethal exposure times for larvae and adults.

According to Munawar et al. (1989), turbidity does not seem to be a limiting factor for primary production because plankton is relatively mobile and can move through the water column to find good light conditions. Dredging projects in large river systems are unlikely to have a major impact on primary production.

Experimental determinations of the effects of suspended sediment on shellfish (based on a literature review conducted by Palermo et al., 1990) show dredging activities generate concentrations and exposure times far below those reported to be harmful for shellfish. Palermo et al. (1990) conclude that shellfish living in estuaries can tolerate suspended sediment concentrations far greater than those generated by dredging operations and that it is highly unlikely that shellfish are significantly affected by the localized, temporary increases in suspended solids occasioned by dredging activities.

Palermo et al. (1990) and Appleby and Scarrat (1989) suggest that suspended sediment concentrations of 500 mg/l and even 1000 mg/l at a distance of 500 m from the dredge can be considered safe for fish, especially because fish are mobile organisms and can avoid unfavorable conditions. Total suspended solids of 20,000 parts per million (ppm) or more are considered lethal to fish.

Very little work has been done to evaluate the extent to which dredging and disposal of dredged material modify fish migration patterns and corridors. It cannot be concluded from the studies conducted by Palermo et al. (1990), though they are very detailed, that dredging has a major impact on fish migration. Drinnan and Bliss (1986) also state that most fish tend to avoid areas affected by dredging operations and that the impacts of dredging are generally very minor.

During the pilot project, a simple experiment was conducted in order to test the impact of turbidity in the effluent channels. Caged fish were placed in the river within the limits of the turbidity plume and periodically observed. Three fish species were selected for the experiment on account of their abundance in this section of the river: one pelagic fish species, *Puti* (Puntius sophore), and two bottom feeder fish species, *Gulsha* (Mystus cavasius), and *Tergra*. Fish were kept in four bamboo cages (1 m x 0.7 m x 0.7 m) and placed at four different locations in the river. A cage was set 500 m upstream of the outlet as a control to evaluate the baseline effect of the experimental setting. The other cages were set downstream of the outlet at various intervals to measure the effect of the turbidity plume. Five to ten of each type of fish were put together in each of the cages. The cages were placed within the turbidity plume for five to six consecutive hours and were lifted at intervals of approximately two hours to observe the fish. Very turbid water (10 m from outlet) was found intolerable only when the fish were subjected to extended exposure; this situation is unlikely since fish would naturally swim away from such areas. The turbidity tolerance tests conducted following a short conditioning time showed that for short exposure periods, a very high survival rate was observed: 98% of all fish exposed to different turbidity levels for 1 or 2 hours survived. Even exposed to high turbidity (10 m from outlet), 95% survived.

During the pilot project, no evidence of fish being caught by the dredger pumping action was observed. Fish can easily avoid disturbed areas in the same way they avoid the large number of motorized boats and other disturbances every day. In addition, the dredge suction head was deeply buried in the bottom sediment where the pumping action would be most efficient.

With regard to the river dolphins, no dolphin were seen in the river reach downstream of the dredging areas, either before or during the pilot project implementation. The dredging activities are carried out in shallow waters, while river dolphins concentrate their activities in the deeper sections of the river. There is no evidence that dolphin habitat was modified due to the pilot dredging works. High turbidity may not affect the vision of the dolphins as they have only vestigial eyes, nor their breathing as they have lungs and breath at the surface. These animals can easily avoid disturbed areas.

It is therefore anticipated that the project will have very minor impacts on aquatic fauna, for it is generally believed that aquatic fauna can easily avoid turbid and disturbed areas. However, the dredging activities could temporarily induce some very local fish population displacement and, as a result, locally affect fisheries yield, forcing fishermen to adapt locally to fish movements.

It is considered that the impact of the project on the aquatic habitat will be short-term, low magnitude and local. Disposing the dredged spoil in a properly designed containment chamber is the primary mitigation measure that will be used to control turbidity releases. In addition, bamboo barriers and silt curtains will be placed in the disposal chambers in such a way as to maximize the detention time of the turbid waters. If needed, some barriers could also be put in place at the location of effluent discharge in the river. This measure will be aimed at protecting sensible areas or usages at close proximity of the outlet.

5.8.3 Land Use and Settlement (12) (-3)

The excavation component of the project will have some temporary negative impacts due to different disturbances (noise, near-shore water quality alteration, etc.). These impacts will be short-term, mid-magnitude, site-specific, unavoidable, and mitigable in part if local labor is favored.

5.8.4 Health (13) (-3)

With regard to any accidental event that would result, for instance, from the failure of the containment dyke, the international contract will specify that a contingency plan complete with emergency response equipment and trained personnel will be mandatory. Penalty clauses are to be applied to the contractor for failure to meet these obligations. The contractor will also be responsible for keeping a safe workplace, for ensuring by-standers will be prevented from interfering with work at hand, and for limiting movement of people and cattle over the embankment. In addition, for the whole duration of operations, the contractor will be responsible for inspecting all earth structures, dykes and outlet channels for evidence of slope failure. This impact will be short-term, mid-magnitude, site-specific, unlikely, and mitigable.

5.8.5 Land Quality and Productivity (14) (-3)

Possible accidental events are related to the transportation of dredged material in pipelines and discharging through outlet channels (leakage, loss control, channel or pipeline failure). This impact will be short-term, medium magnitude, site-specific, unlikely, and mitigable. The contractor will be responsible to ensure that the joints between the different sections of the pipeline are watertight. Water quality alteration and soils modification may result from spillage of dredged slurry. Leaky pipeline joints will be replaced, to prevent spread of foreign material on agricultural plots.

With regard to any accidental event, the international contract will specify that a contingency plan complete with emergency response equipment and trained personnel will be mandatory. Penalty clauses are to be applied to the contractor for failure to meet these obligations.

5.8.6 Navigation (15) (-3)

As much as possible, dredging works will be planned in order to have minimal interference with navigation and fishing displacements and activities. However, the presence of the dredges and the pipelines are likely to cause temporary disruption of navigation activities. This may arise

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particularly during the dry season when the effective channel become rather narrow. These impacts are short-term, low magnitude, local, and mitigable in part by ensuring that appropriate signs and channel identification are put in place around the dredging area.

5.8.7 Employment and Economic Activity (16) (+4)

The project will certainly have both direct and indirect positive impact on employment and local economic activity during its construction phase. This is a mid-term, low magnitude, regional, very likely and positive impact. As a mitigation measure for the local communities affected by the construction phase of the project, the international contract will specify that, to the maximum possible, all labor should be locally recruited.

5.9 Description, Evaluation and Management of Environmental Impacts Related to the Improved River Channel

This project component mainly refers to the presence of a new channel (including loop cuts and bank protection structures) as well as the resulting new hydraulic conditions. Most of the effects relating to this component are likely to modify the environment at the regional level.

5.9.1 River Morphology (17) (+5)

The proposed project interventions will stabilize the river systems. For example, channel degradation upstream of the loop-cuts associated with maintenance dredging will eventually lower water levels further. Consequently, over a period of several years, flood levels at Kadamchal should be reduced by approximately the same amount as at Issapur (0.5 - 0.7 m). Water levels at Ajmiriganj will be reduced by the cumulative effects of degradation from both loop cuts, so the ultimate long-term water level lowering would be around 1 m (refer to Annex B - Hydrodynamic Model).

This suggests that the project will continue to improve the flooding situation even during the extreme events that exceed the adopted design criteria of confining the 1:5 year pre-monsoon flood within the river banks. This is because: (1) the overall channel conveyance is increased by the channel improvements for all flow conditions and (2) preventing breaches at the upstream spill channels will reduce overflows even during extreme floods when the water levels exceed the top of the bank. This impact will be long-term, low magnitude, regional, and very likely.

It should be emphasized that the project will also prevent the enlargement of Cherapur Khal to a size almost equal to the Kalni River's that would occur in the FWO condition in order to accommodate the upland flow. The Cherapur Khal is 13.5 km long. It has an average maximum width of 35 m for a length of about 13 km and the remaining portion is 250 m wide. There are about 570 homesteads along the river banks. Assuming a 250 m future width, the *khal* would erode about 280 ha of cultivable land, and about 150 of the homesteads would be eroded as a result of this enlargement.

5.9.2 Hydrology and Hydraulics (18) (+5)

Loop Cuts
The effect of the loop cuts on water levels was found to be greatest during the pre-monsoon and dry seasons, when the river slopes are steepest, and close to negligible during the monsoon and post-monsoon season, when the gradients are backwater controlled. The Issapur loop cut will lower the pre-monsoon flood levels by 0.5 - 0.7 m immediately upstream of the cut. Pre-monsoon flood levels at Madna will be lowered by 0.4 m and on the adjacent Ratna - Barak floodplain will be lowered by approximately 0.4 - 0.6 m. The upstream extent of the improvements will be relatively limited. By Kadamchal, 15 km upstream of Issapur, the peak pre-monsoon flood levels will be lowered by about 0.2 m. The Katkhal loop cut will lower the peak pre-monsoon flood levels by approximately 0.5 m near Rahala and by 0.25 m at 10 km upstream near Ajmiriganj. The simulations demonstrated that loop-cuts alone will reduce pre-monsoon flood levels upstream of the cuts, but will not eliminate flooding altogether.

Spill Closures
The longitudinal profile of the 1:5 year pre-monsoon flood levels and the bank levels shows the project will be able to maintain the water levels below the top of the bank except in localized areas upstream of Markuli. Consequently, all major upstream spills will be eliminated through the construction of levees at these locations (refer to Main Report).

Table I.21 summarizes the discharges at various points along the river with present, FWO and FW scenarios. Due to the flow confinement, the peak discharge at Ajmiriganj will increase above present conditions by 17% for the 2-year pre-monsoon flood and by 27% for the 5-year pre-monsoon flood condition. Flows in the Baida River channel below Issapur will be close to those in the FWO scenario. These flows are substantially lower than the existing condition since most discharge will be carried by the new channel.

Table I.21: Discharges along the Kalni-Kushiyara River

Location	2-year Pre-monsoon Flood Discharge (m^3/s)			5-year Pre-monsoon Flood Discharge (m^3/s)		
	Present	FWO	FW	Present	FWO	FW
Sherpur	1700	1,700	1,700	2,410	2,401	2,400
Markuli	1556	1,287	1,661	1,929	1,559	2,310
Below Koyer Dhala	1,417	1,153	1,625	1,798	1,433	2,283
Ajmiriganj	1,378	1,143	1,609	1,798	1,430	2,270
Below Cherapur Khal	976	330	1,311	1,429	521	1,998
Baida River channel	565	323	300	966	517	685

The net immediate impact on water level is that the pre-monsoon flood levels will be lowered by 0.35 - 0.45 m between Madna and Ajmiriganj in spite of the increased discharge carried by the main channel.

Monsoon flood levels will be only slightly lowered by the channel improvements. The project will have a major impact on post-monsoon and dry-season water levels on the Kalni - Kushiyara River, with levels lowering by up to 1.5 m near Ajmiriganj. Impacts to post-monsoon levels on

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the Ratna floodplain are estimated to be around 0.5 m in mid-December while on the Chamti-Darain floodplain will be around 0.4 m.

Table I.22 summarizes the extent of impacts of flooding on the net cultivated lands under FWO and FW scenarios in the project area for 1:2, 1:5, and 1:10 year pre-monsoon flood. Comparison of FWO and FW conditions shows that the project will increase the flood-free land by 63,100 ha (24%) during a 1:2 year pre-monsoon flood, 55,200 ha (20%) during a 1:5 year flood and by 44,450 ha (16%) during a 1:10 year flood. These impacts will be long term, low magnitude, regional, and very likely.

Table I.22: Impacts of Pre-Monsoon Flooding

Depth of Flooding	Net Cultivated Area (ha)					
	1:2 Year		1:5 Year		1:10 Year	
	FWO	FW	FWO	FW	FWO	FW
Flood Free	235,867	299,971	96,215	151,428	40,886	85,333
0.3-0.9 m	53,352	13,891	69,793	62,594	44,430	32,743
0.9-1.8 m	37,252	16,062	113,863	80,132	121,482	120,527
>1.8 m	9,131	5,586	55,729	41,446	128,802	96,997
Total Flooded Area	99,735	35,629	239,385	184,172	294,714	250,267
% Inundated Area	30	11	71	55	88	75
Total project area	**335,602**	**335,600**	**335,600**	**335,600**	**335,600**	**335,600**

5.9.3 Open Water Bodies (19) (+5)

Surface water availability in the main river and in the permanent water bodies will be improved with FW project condition. The depth of water will be increased over 2 m during the critical months of January and February. As the water surface profile is controlled by the backwater effect from the Upper Meghna River, this will allow better access for LLPs intakes.

Rates of high velocity spills and breaches through river banks will be reduced which in turn will reduce *haor*/beel siltation. It is expected that water availability will be maintained to its present level. These impacts will be long-term, low magnitude, regional, and very likely.

Tables I.23 and I.24 summarize the water levels of adjacent rivers during the pre-monsoon and post-monsoon seasons for the FWO and FW scenarios.

Table I.23: Pre-Monsoon Water Levels

River	Location	Water Level (m PWD)			
		1:2 Year		1:5 Year	
		FWO	FW	FWO	FW
Khowai	Habiganj	9.63	8.79	10.63	10.63
Baulai	Sukdevpur	5.13	5.09	5.91	5.84
	Khaliajuri	4.13	3.96	4.94	4.75
	Itna	3.91	3.60	4.82	4.59

Table I.23 shows that the Issapur loop cut could lower the pre-monsoon water level at Habiganj by as much as 0.84 m (1:2 year flood). There is no change predicted for the 1:5 year flood. However, the Madna channel water level will be lowered by 0.4 m in the 1:5 year flood during the pre-monsoon season due to the loop cut. This suggests that in the lower reaches of Khowai River the hydraulic slope will be steeper. As a result, proposed and planned submersible embankments on the Kowai River below Habiganj might receive substantial benefit from the KKRMP.

Table I.24 shows that the Baulai water level will also be lowered during the pre-monsoon and post-monsoon seasons under FW scenario. There are 17 submersible embankment projects on the right bank of the Baulai River. Currently, these projects are subjected to increased pre-monsoon flood levels and delayed post-monsoon drainage due to high water levels in the Baulai River. The project will have some positive impacts on these submersible embankments due to decrease in Baulai water levels during the pre-monsoon and post-monsoon seasons.

Table I.24: Post-Monsoon Water Levels

River	Location	Water Level (m PWD)					
		December		January		February	
		FWO	FW	FWO	FW	FWO	FW
Baulai	Sukdevpur	3.90	3.62	3.07	2.76	2.05	1.83
	Khaliajuri	3.47	3.05	2.69	2.26	1.88	1.62
	Itna	3.30	2.80	2.55	2.07	1.82	1.56

In this investigation, neither engineering analysis nor economic benefits have been made due to inadequate primary data. However, during the monitoring of the KKRMP, it is proposed to monitor the above outstanding issues in order to provide proper guidelines to the Government for the preparation of an improved water management plan of the region.

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5.9.4 Erosion and Sedimentation Processes (20) (+5)

The following summarize the expected impacts of the completed project on the erosion and sedimentation processes. These impacts also affect the channel morphology. The Kalni-Kushiyara River has been sub-divided into four main reaches and the discussion of impacts will be summarized by reach.

Upper Kushiyara - Amalshid to Sherpur

No construction will take place in this reach. However, water levels in the dry season will be lowered by as much as 1.0 m at Fenchuganj. This will return the water levels to comparable conditions that were experienced in the 1960's -70's. It is expected that the low flow channel will cut down through local shoals in some areas, particularly at the mid-channel "crossings" that occur in straight reaches between meander bends. Some aggradation may also take place in the lower reaches of tributaries such as the Juri River and the Manu River. No other morphologic impacts are anticipated.

Kushiyara River - Sherpur to Markuli

Levees and local bank protection work will be constructed along portions of this reach. Downstream improvements will lower pre-monsoon flood levels at Markuli by about 0.4 m. Water levels in the dry season will be lowered by up to 1.5 m.

The proposed flood control works will reduce the frequency and magnitude of pre-monsoon spills and breaches downstream of Raniganj (Km 152). This will reduce the deposition of sediment "splays" into the adjacent flood basins and distributary channels in this reach. Minor adjustments may occur in the meander pattern in response to the installation of bank protection. However, these changes will be very small in comparison to the natural pattern of channel shifting. The channel is already very deep in this reach. Therefore, no major impacts are expected as a result of lower water levels in the dry season.

Kalni River - Markuli to Ajmiriganj

Local bank protection and navigation dredging will be carried out in this reach. Downstream improvements will lower pre-monsoon flood levels by about 0.5 m. Under present conditions and FWO scenario, spills in the pre-monsoon season cause the discharges in the main channel to decrease in the downstream direction between Sherpur and Ajmiriganj. When the project is completed, these pre-monsoon spills will be virtually eliminated in most years. Consequently, the magnitude of pre-monsoon floods will increase somewhat downstream of Markuli. It is estimated that the dominant or channel-forming discharge will be increased from about 1,650 m^3/s to around 1,900 m^3/s. During the first decade of operations, the channel may tend to widen slightly. Simple Lacey "Regime Theory" equations indicate the increase in width could reach up to 15 m. Meander migration and bank erosion may be also be accelerated temporarily. However, once the river adjusts to the higher flows a new equilibrium will be established.

Kalni River - Ajmiriganj to Meghna River Confluence

This reach will be affected by the loop cuts and channel re-excavation and modified pre-monsoon discharge regime. The project will prevent the river from developing a new avulsion into the Baulai River through Cherapur Khal. Consequently, the drainage system in the lower Baulai/Ghorautra River system will not experience a major episode of channel instability and sedimentation. Furthermore, the lower Kalni River below Cherapur Khal will continue to carry most of the river's flow.

Sedimentation rates in the Dhaleswari branch of the lower Kalni River below Issapur should be reduced in comparison to the present conditions and FWO scenario. The closure below Issapur will prevent sediment laden water from depositing material in the reach. The 12 km long Dhaleswari channel between Madna and Kalma will gradually narrow over time in response to the lower discharge regime and the land filling along the right bank. The channel bottom will remain at around El. -1.5 m PWD as a result of maintenance dredging operations. Major deposition in this reach from the Khowai/Ratna River inflows is not expected since most of the sediment from those rivers is deposited far upstream on the floodplain near Habiganj.

Due to the low gradient of the river and the manner in which the loop cuts will be constructed (excavated full section rather than construction of a pilot channel) it is anticipated that the overall bed response will be relatively minor. Figure I.20 shows the predicted bed profile changes along the Kalni River after loop cutting. The predictions were made with a one-dimensional morphologic model. Shortening the channel will induce degradation upstream of the cuts (around 0.7 m at Issapur and 0.5 m at Katkhal) which will slowly progress upstream of Ajmiriganj in approximately 5-10 years.

The loop cuts will cause temporary aggradation in the first years of operations immediately downstream of the new channels. However, this deposition will be transient and the bed will eventually return to the initial conditions. The potential impacts downstream of Katkhal have been mitigated by over-dredging between Kadamchal and Kalimpur, so any potential deposition will not raise the bed above its pre-project conditions. The channel downstream of Kalma increases in size dramatically as the river joins the Upper Meghna River system. Therefore, this lower reach can easily accommodate temporarily increased sediment inflows without significantly reducing the channel's conveyance. Results of the morphologic model simulations show that impacts of the loop cuts on bed levels in the Meghna River will be undetectable.

This impact will be long-term, low magnitude, regional, and very likely.

5.9.5 Drainage (21) (+6)

Table I.25 summarizes the extent of impacts on the post-monsoon drainage in the project area. The analysis shows that the project will facilitate early plantation to an area of 14,104 ha in relation to FWO conditions particularly in the lower areas. Early plantation will make the crop less vulnerable to pre-monsoon floods and accumulated rainfall inundation. This impact will be long-term, low magnitude, regional, and very likely.

Table I.25: Impacts of Post-monsoon Drainage

Month	FWO (ha)	FW (ha)	Improved Area (ha)
November	102,863	69,107	33,756
December	34,279	20,175	14,104
January	11,070	8,187	2,883
February	8,085	7,320	765

5.9.6 Irrigation (22) (+6)

The project will make substantial positive impacts on irrigation water supplies by increasing the channel capacity, decreasing the risk of pre-monsoon spills through the distributaries and by installing flushing regulators. These impacts will be long-term, low magnitude, regional, and very likely.

Loop Cuts
The Issapur loop cut will reduce the cost of irrigation water. Currently, the cultivable area between the Dhaleswari and Baida channel is irrigated from these two channels. The new channel will be an additional source of water for irrigation. This new channel will reduce the length of irrigation canals and consequently the irrigation costs. The Dhaleswari River (Madna channel) will have a deeper channel section and will provide better access to LLP intakes.

The Katkhal loop cut will also have positive impact on existing irrigation systems. Because of its position, the cost of water will be reduced. In addition, a drainage cum flushing regulator is planned to be installed at the offtake of Barabaria Khal. This regulator will facilitate drainage and irrigation in the Barabaria area. Currently, the area suffers from an inadequate supply of water for irrigation during the dry season. NERP studies during the period 1991 through 1995 show that only 2-3 LLPs were used along left bank of Kalni River between Rahala and Alipur villages. Ponded water in the Kalni River will be more than adequate for this irrigation. Basically, this area is irrigated from the Bashira River.

The Kalni River spills through the Bashira River during the pre-monsoon season due to large scale channel bed siltation around the offtake of Bashira River. As a result, local people closed the Bashira offtake. This has adversely impacted *boro* cultivation in an area of about 3,600 ha. The project will facilitate revitalization of the Bashira River Project which was implemented by BWDB in 1988 with IDA Credit.

In this investigation, no estimates have been made on the economic benefits due to inadequate primary data. However, it is proposed that the economic value of these benefits be analyzed during the monitoring stage.

Koyer Dhala Multi-Purpose Regulator
The Koyer Dhala multi-purpose regulator will be installed with flushing facilities for irrigation during the dry season, a fishpass for fish migration during the pre-monsoon season and navigation facilities for medium size country boats.

The structure will provide irrigation water to the Old Kushiyara Irrigation Scheme, Jhingari Nadi Irrigation Scheme and fallow lands along the Baniachang-Ajmiriganj road during the dry season.

NERP case studies in 1996 show that the Old Kushiyara Irrigation Scheme has a command area of about 2,500 ha. The area is irrigated from the Old Kushiyara River with 189 LLPs and one floating pump. About half of the pumps are electrically driven. The project is almost ineffective due to offtake siltation of the Old Kushiyara River. The farmers can use ponded water up to February, then they have to rely on rainfall. As a result, *boro* cultivation has become extremely insecure.

The Jhingari Nadi Irrigation Scheme has a net area of about 3,600 ha and the Old Kushiyara River is the main source of supply for irrigation. The project also suffers from the same problem as indicated above.

The structure will also supply water for irrigation to a 1,200 ha fallow land area located along the southern side of the Baniachang-Ajmiriganj road. The area remains flood-free even under the 1:5 year pre-monsoon flood. Local people reported that the land is only suitable to grow *boro*.

Impact on LLPs

During the dry season, typically in January, the water surface will be some 4-5 m below the top of the river bank, on the Madna-Markuli reach. LLPs are capable of lifting water to 6 m, therefore should not be affected by the project. Upstream of Markuli, the head in most places is already above 6 m and only a few LLPs can operate. Those are likely to be affected by the lower water level.

Groundwater supply

There will be no reduction in ground water storage volume since the project does not alter the monsoon flooding condition. Currently, farmers do not use groundwater because the land is regularly flooded. The project will facilitate ground water irrigation on lands located at an altitude of 6 to 7 m PWD due to the reduction in pre-monsoon flooding.

5.9.7 Aquatic Habitat and Fisheries (23) (+6)

Open Water Fisheries

Interconnection between the various habitat types in the project area make it difficult to predict fisheries impacts with a high degree of certainty. Loss of a particular habitat result in direct losses of production from that habitat, as well as indirect or second order losses from other habitat types. The methodology for the estimation of these second order impacts is not precise enough to allow for a reliable evaluation. As a general operational guideline however, it may inferred that loss of *duar* or *beel* area will have a relatively large second order loss effect, while loss of river or floodplain habitat will have a smaller second order effect.

The project is expected to have the following <u>positive</u> impacts on fisheries:

- The improvement in channel depth from dredging, and alleviation of channel siltation due to self scouring, will increase fish production in the river channel. The impact of increased depth and wetted surface area will be especially favorable during the dry season. A new artificial *duar* will be created by the Katkhal loop cut at Kaisar, and

- The proposed installation of a fishpass at Koyer Dhala will allow fish to cross the existing *khal* closure. The impact will be greatest during the pre-monsoon floods period, when both adult broodstock searching for spawning grounds and hatchlings and fingerlings requiring nursery grounds will be able to access the Kodalia fishery grounds.

The expected <u>negative</u> impacts of the project are as follows:

- The two proposed loop cuts will affect six river *duars*, thus resulting in a some direct loss of fish production from *duar* harvesting and an indirect loss of fish production from

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the neighbouring floodplain and riverine habitats which are dependent on the *duar* for restocking. These *duars* are currently subject to siltation in conformity with general siltation of the river channel. The proposed channel dredging would serve to alleviate general *duar* siltation, and

- The inundated area of the floodplain will remain constant during the main monsoon flood period, but the duration and depth of flooding will be reduced due to flood protection during the pre-monsoon flood period and late monsoon drainage period. This will result in reduced pre-monsoon access to the floodplain and more crowding of fish and reduced growth during the late monsoon, both of which will lower fish production.

As noted above, quantification of impacts is problematic. The breakdown presented below should be considered provisional and indicative only.

Kalni River Channel: Dredging will deepen the channel and consequently increase the water surface area during the dry season by about 650 ha. The surface area increase alone should result in a nominal increase in fish production of about 131 tonnes. However the increased surface area will overlie a quality improved, deeper river channel, which can be expected to support higher fish biodiversity and production (measurable either as biomass per unit water surface area or unit water volume). Channel deepening can therefore expect to increase fish yields to a greater extent than predictable by marginal surface area increase, perhaps by 200-300 tonnes.

Some *duars* will be negatively impacted. With respect to the loss of *duars*, it should be mentioned that progressive morphological changes cause the aquatic habitat to be continuously modified over a period of years on alluvial rivers such as the Kalni-Kushiyara. For example, the shift from the Bibiyana channel into the Suriya River in the early 1960's caused sedimentation in the reach downstream of Ajmiriganj which in turn reduced the number of *duars* in this reach. A comparison of BIWTA charts over time shows that there were 14 deep scour holes in the reach in 1963 and only one in 1988.

Fish production in *duars* will be affected by loop cutting. A conservative approach has been taken herein to estimate the loss in fish production. At the Katkhal loop cut, all six *duars* will suffer decreases in maximum dry season depth (average of 27%), and three of them (Mathabpur, Cherapur, Kanchanpur) will become detached from the mainstream channel and semi-isolated in the loops. NERP analysis shows that Mathabpur Duar will experience significant infilling after the project. This site will effectively be cutoff by the loopcut. However, the closure near Shantipur should reduce the sedimentation rate in this *duar* so that it will not fill completely.

The new mainstream channel alignment created by the loop cut will create a new *duar* at Kaisar. The design grade for the 14 km long dredged cut between Issapur and Kadamchal varies between El. -2.5 and -3.0 m PWD which will be lower than the present *duar* at Kanchanpur. The re-aligned channel will create a new *duar* opposite Kaisar as a result of the flow along the right bank. This new *duar* will extend over an area approximately 500 m long by 100 m wide. In addition, under FW scenario, the river reach between Ajmiriganj and Madna will have a minimum depth of about 3 m during the dry season. This mitigation is expected to dampen the net loss in direct production from *duars* to about 10% (3 tonnes). The impact of *duar* modification extends to adjacent floodplain habitat, as the *duars* provide 'seed' to an area of approximately 1,300 ha. The expected loss in adjacent floodplain fish production is about 24 tonnes.

Loop cut impacts on fish production at the Issapur loop cut will be minimal. The *duar* at Issapur is likely to remain stable (or possible scour deeper), while the small shallow *duar* at Bangalpara (a recent unstable formation) will become detached from the mainstream channel and likely fill in again. No net change in fish production is expected.

The increase in fish production due to channel deepening will exceed the decrease due to *duar* modification and loss, resulting in a net gain in fish production from the mainstream river channel. A general improvement in self-scouring of the river channel could possible lead to more scouring of the mainstream *duars*, thus increasing their capacity to harbour broodstock during the dry season and further enhance production.

Other Rivers: The rate of channel bed siltation will be reduced from its present level, suggesting fish production will not be negatively affected. As there exists considerable fish traffic between the Kalni mainstream channel and smaller tributary rivers, any increase in Kalni River fish stocks should also result in an increase of fish stocks in other rivers.

Floodplain: As described in section 5.9.2 flooded area during the pre-monsoon will be reduced, and this will negatively affect fish production.

Studies have shown that pre-monsoon flooding is extremely important for breeding migrations and annual restocking of floodplain nursery and grazing habitats. Interference with pre-monsoon flooding can therefore have a major impact on the subsequent monsoon flood grow-out period, even if monsoon flood intensity is adequate.

The proposed fishpass at Koyer Dhala would act to mitigate the negative effect of pre-monsoon flood constriction on fish production on the left bank floodplain around Ajmiriganj by allowing *boal*, *kalibaush*, *gonia* and other important migratory species to enter the tributary system to spawn on the floodplain in greater numbers during the pre-monsoon. Passive drift of hatchlings and fingerlings through the fishpass from upstream areas would further enhance floodplain fish production. The degree to which this will compensate for the loss in pre-monsoon flooding during the average flood return period on both river bank floodplains is, however, unclear. It would be parsimonious to assume that the net benefit recovered might be in the order of 10% to 20%. Nonetheless, the marginal economic benefit is likely to exceed the cost of construction and operation of the fishpass structure and generate a robust internal rate of return.

More rapid drainage during the late monsoon will decrease flood intensity by reducing inundation duration and depth. The result would be reduced fish production due to a marginally shorter growing period and possibly more crowding. Because the open floodplain is the most productive environment for fisheries even small reductions in fish growth increments (i.e. 1% or 2%) can lower overall fish production significantly. The proposed project intervention will reduce flooded area progressively during November (33,756 ha), December (14,104 ha), January (2,883 ha) and February (765 ha), for a total loss of 51,508 ha-months of inundation. Normal pre-project inundation is 156,297 ha-months, indicating a 67% decrease in late monsoon flood intensity. Monsoon flooding from June to October covers some 260,200 ha of floodplain, and represents 1,301,000 ha-months of flood intensity. The overall loss in monsoonal flood intensity due to accelerated late monsoon drainage is thus 4%. Faster drainage would force a marginal fraction of fish off the floodplain and into overwintering refuge habitats where their growth rate is expected to decrease, resulting in some loss of fish production.

The net impact of the project on floodplain fish production is expected to be an approximate loss of 5%, or 2,078 tonnes.

Beels/Haors: The rate of bank overspill and breaches of the river banks during the pre-monsoon season will be reduced and consequently *beel/haor* siltation will also be reduced. *Beel* fish production will accordingly stop being negatively impacted by siltation, and would stabilize at present levels. Some of the increased fish biomass expected in the mainstream river channel would spill over into *beel* standing crop, as *beels* are suitable overwintering grounds for juveniles of some species. Stabilization of *beel* habitats will also have a positive benefit for floodplain production as overwintering *beel* fish stocks also provide 'seed' for annual restocking of the floodplain environment during the monsoon flood period (in a manner similar to river *duars*). It is expected that *beel* production will increase by 5%, or 1,363 tonnes.

Impacts on open water fisheries production were analyzed on the basis of catch assessment survey, fisheries effort survey and market survey (Annex H - Fisheries). The magnitude of the expected impacts are summarized in Table I.26

Table I.26: Areas and Fish Production of Habitat Types in the Project Area

Habitat group	Habitat Type	Production (million tonnes)			Impact (million tonnes)	
		Present	FWO	FW	FW vs Present	FW vs FWO
Riverine	Kalni-Kushiyara. River (without *Duars*)	480	404	780	300	376
	Kalni-Kushiyara River (*Duars* only)	318	303	315	(3)	12
	Other flowing rivers	848	848	1,018	170	170
	Closed and dead rivers	453	439	453	0	14
	Distributaries	152	147	182	30	35
	Sub-total	**2,251**	**2,141**	**2,748**	**497**	**607**
Floodplain	Floodplain	41,554	40,723	39,476	(2,078)	(1,247)
	Beels	6,711	5,684	7,047	336	1,363
	Ponds	4,036	3,834	4,440	404	606
	Sub-total	**52,301**	**50,241**	**50,963**	**(1,338)**	722
TOTAL		**54,552**	**52,382**	**53,711**	**(841)**	**1329**

Closed Water Fisheries: The project is expected to have a small positive impact on pond fisheries in so far as flood duration is expected to decrease, thus resulting in a longer growing period for pond fish and reduced risk of pond flooding.

The two proposed loop cuts will create six isolated river loops. The river loops will retain hydrological links to the Kalni River mainstream channel and will thus continue to be fish producing habitats, albeit greatly modified from their original qualities.

In conclusion, it is believed that the total fish production of the project area will increase from the FWO scenario. Aquatic flora will not be impacted during the monsoon season since the project does not change the monsoon season water level. However, channelization of pre-monsoon flow and early post-monsoon drainage might have some negative impact on wetland flora, because the time period for their life span could be reduced for a short time. These impacts are difficult to quantify. The impact on aquatic fauna would be insignificant. However, migratory waterfowls might have some problems due to early drainage in the post-monsoon season. On the contrary dolphins will be benefitted due to an increase in river water depth. The overall impact will be positive, very low magnitude, long term, and regional.

Wetland

It should be considered that the project may interfere with one important wetland area located next to the project area, in the northeastern section. Hakaluki Haor is a site of outstanding importance for wildlife, especially waterfowl, according to the Ramsar criteria (Bangladesh is a contracting party to the Ramsar Convention since 1992 and so far, Sundarban is the only country's Ramsar site). Hakaluki Haor consists of a group of several *beels* that are discharging into the Kushiyara river through a maze of small ditches. The *haor* acts as a natural reservoir and the water level remains high till the end of monsoon. The outflow is slow and, as water level falls during post-monsoon, the *beels* become isolated from one another for the whole duration of the dry season, surface water level being controlled by groundwater level. In the FW scenario, as the water level in the Kushiyara river will be lower by 0.5 to 1 m, it is likely that the water level in the entire *haor* region will fall a little more rapidly during the post-monsoon season. The effects of this modification on the water level variation are not expected to be important on fish and waterfowl. However, a close monitoring should be carried out over the first years and mitigative measures should be implemented if needed. The construction of very small retention structures on the main distributaries of the *haor* would easily prevent rapid post monsoon drainage of the area. It should be noted that monsoon and pre-monsoon water levels will not be modified significantly by the project.

Some wetland will be converted to crop land under FWO scenario

5.9.8 Terrestrial Habitat (24) (+4)

As indicated in Chapter 3, there is little of the project area that has not been significantly altered by human activity. As population increases and pressure on the existing system of production grows, biodiversity will continue to decrease and natural habitats will suffer alteration regardless of any intervention. Some wetlands and most of the grass and *khas* lands which are now being used as community pasture or grazing land will be converted to crop land under FWO scenario. But this conversion will be hindered and limited due to early water level drop and post-monsoon drainage. The improved hydraulic regime will undermine irrigation to these comparatively higher lands.

The project will have substantial positive local impacts on homestead vegetation (see section 5.10.4) and with respect to 'orchard' vegetation, the total area under this type of commercial plantation is expected to increase gradually because of its financial prospect. However, the project will have minimum impact on this kind of vegetation and most orchards will presumably expand in the flood free regions. Essentially the project will not impact on roadside vegetation nor on winter grazing area. These impacts will be long-term, low magnitude, site-specific, and very likely.

The project will not have any long-term negative impact on terrestrial fauna.

5.9.9 Land Use and Settlement (25) (+6)

The proposed project interventions will stabilize the river, eliminate over bank spills and breaches in the river banks. These improvements are expected to impact the existing infrastructures in the following ways:

- reduction of the current bank erosion rate of 55 ha/yr;
- reduction of homestead damage along the river banks due to the reduction of bank erosion, and
- elimination of high velocity spills and breaches in the river banks is expected to reduce the annual construction cost of closure at the breaching point and will also reduce the annual maintenance cost of submersible embankments located around Markuli particularly along the right bank.

Enhanced conditions will benefit the population. Improved irrigation and drainage of the deeply flooded areas will contribute to more valuable and profitable land use and will ensure a more secure and dependable settlement for many people, thus increasing the overall quality of life. These impacts will be long-term, low magnitude, local, and very likely.

5.9.10 Education and Health (26) (+7)

An increase in household income is expected as a result of the project. This will directly contribute to overall improvement in the conditions of living, particularly through improvement in the health and nutritional status of people. If a 10% increase in income is assumed for all households, the proportion of the population below the poverty line, both absolute and hard core poverty will be reduced by 5%. It is likely that with an increase in the household income, per capita expenditure on nutritious food, sanitation and health care will increase. Increased expenditure on food will contribute to ensure the minimum caloric intake for the vulnerable population. All these together will have positive impacts on life expectancy, particularly on the reduction of infant and child mortality. These impacts will be long-term, low magnitude, regional and very likely.

Enhanced production systems, including pond aquaculture in seasonally flooded areas and improved irrigation and drainage systems of the deeply flooded areas, will contribute to increased production of high nutrition crops, fish and livestock. This will increase their availability in the market. Availability of cereals will also increase. Raising fish production through aquaculture in safe areas will give dietary benefits to poorer groups.

5.9.11 Status of Women (27) (+7)

Poor women will use their earnings from project construction to invest in a variety of income-earning opportunities such as agricultural production on leased land, concrete latrine production, ownership of village nurseries and small trade. Further economic opportunities will be provided for poor women in increased post-harvest rice processing and gleaning when rice production is increased.

Women on flood-secure and expanded homestead platforms will contribute to increased household production of vegetables, fruits, livestock and poultry. The sale of surplus homestead production will accrue to women. Family welfare will be enhanced through improved nutrition and water and hygiene facilities. Women's enhanced income will contribute to children's educational opportunities.

5.9.12 Land Quality and Productivity (28) (+7)

Crop damage due to over bank spills, inundation and breaches in the river banks during the pre-monsoon season will be reduced and the flood-free land area will be increased. The existing flood control infrastructure will be more effective and production will be increased towards its optimal level under damage-free conditions. Reduced spills in the pre-monsoon season will enable farmers to harvest more local and high yielding varieties of *boro* rice. As a result, production is expected to increase at least to the level of what other farmers are obtaining under damage-free conditions. As flooding risks diminish, this may induce the farmers to replace some of the local *boro* by high yielding varieties of *boro* rice. However, pre-monsoon flooding will not be eliminated from the project area and it has been assumed that damage to local and high yielding varieties of *boro* rice will continue but at a reduced scale. Reduction in depth of flooding during the pre-monsoon season will, to some extent, reduce damage to local varieties of broadcast *aman* to some extent at the early growth stage and contribute to the establishment of this crop.

There will be no change in monsoon season flooding conditions after implementation of the project. Therefore, cropping patterns will remain similar to those under the FWO condition.

Drainage improvements in the post-monsoon season will make more land available for cultivation early in the *rabi* season facilitating timely plantation of *rabi* crops. Farmers are expected to utilize residual soil moisture by growing more *rabi* crops and the area under *rabi* crop cultivation is expected to increase. This would include fodder crops to meet the requirement of cattle feed.

Total crop production under present conditions, FWO and FW scenarios are presented in Table I.27.

Table I.27: Total Annual Crop Production for the Project Area

Food Group	Present (million tonnes)			FWO (million tonnes)			FW (million tonnes)		
	1:2 yr	1:5 yr	1:10 yr	1:2 yr	1:5 yr	1:10 yr	1:2yr	1:5yr	1:10 yr
Cereals	1,052	823	713	995	782	697	1,127	893	789
Non-Cereals	30	28	27	36	34	34	30	28	27
Total	**1,082**	**851**	**740**	**1,031**	**816**	**731**	**1,157**	**921**	**816**

Based on a 1:5 year pre-monsoon flood, the annual cereal production is expected to increase by about 111,000 tonnes, from 782,000 tonnes (FWO) to 893,000 tonnes (FW), as a result of the project, an increase of about 14%. Non-cereal production is expected to decrease from 34,000 tonnes (FWO) to 28,000 tonnes (FW), a reduction of about 17%. This results from a decrease of the non-cereal cultivated area and implies a decrease in the availability of non-cereals (Annex F-Agriculture). In spite of this negative effect, the overall impact on land productivity is positive long-term, mid magnitude, regional, and very likely.

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5.9.13 Navigation (29) (+6)

The most important impact of the project on navigation and water transport will be the improvement and upgrading of the present seasonal class-IV (LAD=1.5 m) navigation channel to a class-II (LAD=2.4 m) navigation channel from Fenchuganj down to Astagram. This will make the Kalni-Kushiyara river navigation route an integral part of the national waterways network.

Deepening of the presently silted-up bed of the Kalni-Kushiyara River under the proposed project will also enable feeder channels to become more effective for post-monsoon drainage of the flood plain, through natural scouring.

The growth of water transportation depends on two factors: the quality of waterways and navigable rivers and a demand for the transportation of passengers and goods. The Kalni-Kushiyara River will become a year round navigable waterway. This is expected to attract more long distance traffic, especially because waterways offer lower freight rates compared to roads and railways. Traffic, such as fertilizers, construction material, POL, paddy, rice, and bulk items can be carried by IWT fleet at cheaper cost than by trucks. The Shah Jalal fertilizer factory will provide an assured annual traffic of 150,000 tonnes from about year 2000 for transportation to Dhaka and North Bengal. Paddy traffic of 250,000-400,000 tonnes can be expected once the project is completed, for export to Ashuganj/Bhairab Bazar, Dhaka and Chittagong. More construction material will be required in the project area and in the Kalni-Kushiyara River Basin areas in general to meet the expected urban growth.

These impacts are positive, long-term, low magnitude, regional, and very likely.

5.9.14 Employment and Economic Activity (30) (+6)

The KKRMP will impact favorably on the activities of the water related production sector (agriculture and fisheries), service sector (water transportation), trade and commerce. The provision of flood free housing will impact sanitation, health and education.

The end result will be more production in all related fields, creating tradeable surpluses, leading to higher income, higher consumption and improvement in socioeconomic welfare of the Kalni-Kushiyara community. These impacts will be long-term, low magnitude and regional. The estimated economic benefits are summarized in the following section (Annex E - Economics).

Agriculture
The total physical cultivated areas are estimated to be, respectively, 279,850 hectares, 276,945 hectares and 277,424 hectares for the Present, FWO, and FW scenarios. This represents over 80% of the total study area.

The average annual project benefit to the agricultural sector should amount to about Tk 353 million per annum. On a per hectare basis, this translates into about Tk 1,272 per annum (or approximately US$ 30/year/ha). As a point of reference, this would be about 13% of a typical gross margin/ha/yr.

Agricultural benefits are expected to accrue beginning in Year 4 of the project (40%). These would climb by about 20% per year and reach their maximum in Year 7. This is a relatively quick start up and maturation of the anticipated agricultural benefit stream.

Navigation

Deepening of the Kalni-Kushiyara River will also create a minimum Class II (LAD=2.4m) navigation channel along the river from Fenchuganj to Astagram linking this transport route to the national arterial water transport routes through the Upper Meghna.

The potential navigation benefits of the project are based on estimated cost savings and estimated cargo volumes. The sum of the cost savings generated from different types of cargo movement is considered the total navigational impact of the project.

The expected cost savings are generally based on the estimated differences between wet and dry season freight rates. This is calculated as the differences between IWT type craft rates operating at 2.4m LAD versus dry season rates for country boats.

River transportation benefits are, accordingly, estimated to be Tk 21.9 million per annum; an estimate that would be expected to climb in conjunction with population growth over time. It is also assumed that it should be possible to capture 20% of this initial benefit in Year 5 of the project; 40% in Year 6 and all of it by Year 7.

Another important impact of the KKRMP after its completion will be an increase in employment in the water transport sector. However, under FW scenario and assuming full employment, no additional employment is created during the life time of the project, because the additional traffic will in fact eliminate current underemployment of existing boat crews. Their income is expected to more than double under FW scenario.

Fisheries

The principal benefit of the project to fisheries is that it will stop the sedimentation process in the Kalni-Kushiyara River and *beel* areas and hence the deterioration of fisheries. As an enhancement, it will also develop culture fishery. The net impact is expected to be an annual incremental production increase of 1,329 tonnes/year. The fisheries sector is overall expected to be slightly better off after the proposed project is implemented. The annual incremental net benefit is estimated as Tk 43.7 million per annum at project maturity (Year 9). About 20% of the fishery benefits are expected in Year 6; 40% in Year 7 and 80% in Year 8.

5.9.15 Equity (31) (+7)

The proposed interventions will have limited impact on the extent of urbanization. In the deeply flooded areas, the demand for labor will increase as a result of crop saving. This extra demand, as well as improved living conditions in rural settlements will restrict seasonal labor out-migration.

The project will have a favorable impact on the landless population, as the demand for labor, will increase during the harvesting and post-harvest periods. With increase in household income, marginalisation of the landless and small farmers as well as fragmentation of farm holdings are expected to slow down. All landowners will benefit from pre-monsoon flood protection and post-monsoon drainage improvement, but the magnitude of the accrued benefits will be in relation to the size of farms.

There are also possibilities that the relative advantage of the local poor will be offset by in-migration of laborers from outside the region, particularly during the harvesting period. Nevertheless, the existing status quo between the farm population and the landless population is likely to continue in the future without any significant change.

In conclusion, benefits from the project will accrue to different strata of society in varying proportions. The initiatives will benefit mostly the landowners. The upper echelon of the farm households will derive most benefits as this is determined by the existing land occupancy structure which is likely to remain unchanged. But the strategic thrusts on improved living conditions of rural settlements will benefit all strata of the population with optimum equity. Women will benefit more proportionately by initiatives on homestead protection. Increase in aggregate employment and income will contribute to attain a higher standard of living. On the other hand, the rich-poor gap with respect to income is likely to increase as a result of a disproportionate share of the incremental benefit accruing to the wealthy.

Enhanced production systems including pond aquaculture in seasonally flooded areas and improved irrigation and drainage systems of the deeply flooded areas will contribute to increased production of high value nutritious crops, fish and livestock and will thereby increase their availability in the market. Per capita availability of cereals will increase. The overall impact of the new conditions on equity is positive and will be long-term, low magnitude, regional, and likely.

5.10 Description, Evaluation and Management of Environmental Impacts Related to the New Setting and Settlement Pattern

This component refers to the presence and use of the new platforms and upgraded land as well as to the modifications of settlement and land use pattern due to loop cuts. It also refers to the presence of the protection structures upstream of Ajmiriganj. Most of the effects are likely to modify the environment at the community or local level. Given the extent of the project area and the number of interventions, it should be noted that the Land Use and Settlement component has been broken down into 5 sub-components in order to take into account the fact that the project has different site-specific impacts.

5.10.1 Erosion and Sedimentation Processes (32) (0)

Most of the area is underwater during the monsoon with only homesteads emerging. Over the years, homestead land has been continuously eroded by waves and this is expected to continue once the project is completed. Both soft and hard platform protection will be provided as a component of the project to prevent platform erosion. With this protection, the impact on erosion in considered negligible.

Some platforms will require extensive protection as they have long exposures to *haor* wave erosion. Hard protection, not requiring annual replacement will be provided for these platforms. Trees, shrubs and grasses will be planted at the toe of these dykes to reduce wave erosion.

5.10.2 Drainage from the Adjacent Land (33) (-2)

The presence of the new platforms may interfere locally with drainage patterns. Local mitigative works will be carried out to correct any disruption or modification that would negatively impact on drainage. As an example, the pilot project platform at Kakailseo was constructed between several *paras* of the village and the river (Annex J-Pilot Dredging Project). As a result, the platform obstructed the flow of water from a large ditch towards the river. This created water logging in the pre-and post-monsoon periods, thereby hindering the passage of persons from their houses and presenting a danger for children playing near the ditch. The mitigation measure undertaken for water-logging as a result of platform construction consisted of filling in the ditch.

These impacts are short-term, low magnitude and site-specific. These drainage problems will be addressed through thorough preparation and planning as well as through monitoring when the project is implemented.

5.10.3 Irrigation (34) (-2)

As for drainage, the presence of the new platforms may interfere locally with irrigation patterns. Local mitigative works will be carried out to correct any disruption or modification that would negatively impact on irrigation. These impacts are short-term, low magnitude and site-specific. These irrigation problems will be addressed through thorough preparation and planning as well as through monitoring when the project is implemented.

5.10.4 Terrestrial Habitat (35) (+4)

The project will have substantial positive impacts on homestead vegetation by offering increased security against flooding. About 90% of the homestead trees are vulnerable to flood damage. As a result, local people are reluctant to plant saplings in their homestead platforms. Increased flood protection and homestead areas will lead to increased tree plantation. These impacts are long-term, low magnitude, site-specific, and very likely.

The pilot project experience shows that homestead vegetable gardening will expand rapidly on the newly developed platforms and will occupy about 25% of the area. As well, about 173 ha including 61 ha from Issapur loop cut will be available for vegetable gardening. In addition, it is planned to re-use the set-back areas of the loop cuts for non-cereal crops. The set-back distance is 100 m between the bank of the new channel and the dyke. About 99 ha will be available for non-cereal crops keeping 10 m free space along the channel bank and toe of the dyke. In addition, the Madna channel filling will provide an additional 58 ha to grow non-cereal crops. This shows that a net area of 330 ha will be available for re-use. The flood-free homestead platforms will also facilitate plantation of about 120,000 water resistant saplings along the confinement dykes during the implementation period and 95,000 during the O&M period.

Economic and employment impacts on homestead vegetation were calculated from the primary data collected in the vegetation survey. Trees will be planted around disposal chambers and harvesting could start 8 years after planting. An annual economic production of Tk 50 per tree can generate Tk 10.8 million for the project area. Homestead vegetables will generate Tk 1.24 million assuming Tk 20,000 net income per hectare. Better living space and secured homestead platforms will also favor plantation of more fruit trees on the platforms. It is expected that each homestead will earn a minimum of Tk 1,000/year from these fruit trees which, will provide a total economic value of Tk 11.3 million/year.

5.10.5 Land Use and Settlement at Issapur Loop Cut Site (36) (-7)

A loop cut of approximately 2.75 km will be constructed off the Kalni River, west of Issapur, passing south through agricultural land to re-join the Dhaleswari River east of Kalma. The eastern flow of the Kalni River (the Dhaleswari River) will be closed at Issapur. The western flow of the Kalni River (Baida channel) will not be changed.

To accommodate the width of the loop cut, its embankments and set-back areas on either side, 216 ha of land is to be purchased from individual landowners. Soil from the loop cut will be used to build the embankments and two platforms. No homestead land will be affected. Hard protection will be provided on the new platforms dykes.

The villages of Chowdanta and Bhatura will be most seriously impacted by the construction of the Issapur loop cut. Farmers of these two communities own 90% of the land to be acquired. Of the 225 HHs in Chowdanta, approximately 105 HHs own land in the loop cut. Bhatura is composed of 95 HHs, of which approximately 55 own land in the loop cut. Approximately 50% of landowners in Chowdanta and Bhatura will loose land in the loop cut. Although they are not all land owners, all HHs in Chowdanta and Bhatura are dependant on agricultural as a primary source of income. The 216 ha to be acquired is good quality agricultural land used for HYV *boro* rice cultivation.

Farmers in Chowdanta and Bhatura have reported that if they are to be provided with replacement land it must be located within 3 km of their homesteads. There is no *khas* land in the area. Scarcity of high (pre-monsoon flood secure) land will make it difficult for farmers to replace their quality agricultural land. If it is at all available, replacement land will be costly.

Construction of the Issapur loop cut will effectively place the two communities on opposite sides of the channel and require each of them to cross the river for such essential facilities as markets, schools and administrative offices. Chowdanta on the right bank of the loop cut will be inconvenienced by having to cross the new channel to avail of market facilities at Adampur Bazar. Their high school and administrative communications to the west in Astagram Thana will not be disturbed by the loop cut. Bhatura on the left bank of the loop cut will be inconvenienced by having to cross the new channel to reach their high school and administrative services in Astagram Thana. Communications with their market at Adampur Bazar will remain intact. From both communities, some farmers will have to cross the new channel to farm their land on the other side.

The Kalni River becomes the Baida channel when it loops south-west from Issapur. In this area, most people in the villages of Chandipur, Shantipur, Kakoria and Sapanto are not opposed to the loop cut because they will not lose land for its construction. In addition the loop cut will reduce the risk of crop loss from pre-monsoon flood and provide local people with a more direct navigation route to the south.

Two other communities will be affected by the Issapur loop cut: Issapur and Kalma on the north and south ends respectively. People in these communities support the loop cut because their business opportunities as market and transit centres will be enhanced as a result of a new navigation route. Issapur on the left bank and Kalma on the right bank will maintain their existing communications for schools, markets and administrative services. Farmers in Issapur and Kalma own about 10% of the land to be acquired for the loop cut. They are willing to sell their land for this purpose.

The impacts of the new setting and settlement pattern on land use and settlement at the site of the Issapur loop cut are unavoidable and of mid-magnitude, affecting locally some communities on the long-term. In order to minimize those impacts, compensation is required for approximately 160 landowners in Chowdanta and Bhatura for loss of land as their primary economic resource.

In addition to compensation, the following mitigative measures will be implemented:

- To mitigate the loss of land as a primary source of income, landowners will be paid cash grants to either replace land at a higher cost or to convert to another income-earning opportunity, such as trading and small business;

- As a further mitigation for the effects of land loss as a primary source of income, approximately 106 ha out of 216 ha will be proportionately returned back to landowners (Chowdanta, Bhatura, Kalma and Issapur) for re-use in intensive agriculture;

- Landless households in the Issapur loop cut area may lose a portion of their annual income through loss of agricultural labor opportunities. However they will be mitigated by the provision of extensive labor opportunities in earth construction;

- To mitigate Chowdanta's loss of easy access to a market and to provide an opportunity for the development of trade and small business in the area, a market will be developed at Chowdanta, and

- To mitigate Bhatura's loss of access to a high school and administrative facility, two river *ghats* (landing) facilities will be provided at Chowdanta and at a place mid-way between Bhatura and Issapur.

Once the mitigative measures have been implemented, the following benefits will accrue:

- new cropping pattern on raised land, throughout the year, which could include high value vegetable crops;

- increased trading opportunities by having a market centre plus direct transportation facility to Bhairab Bazar, and

- extensive labour opportunities in diversified crops for landless labour presently engaged in only one season of rice cultivation.

5.10.6 Land Use and Settlement at Dhaleswari Dredging and Fill Sites (37) (+7)

When the Issapur Loop Cut is constructed and the Dhaleswari River is closed at Issapur, dredging will be required in the Dhaleswari Channel. With the dredged spoil, two homestead platforms will be constructed at Shibpur. A channel along the right bank of the Dhaleswari River at

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Noorpur and Baluchar will be filled. In a later period of maintenance dredging, several more homestead platforms will be constructed in this reach.

A large *char* of 58 ha has emerged in the middle of the Dhaleswari River, in front of Noorpur and Baluchar (right bank) and Madna (left bank). The Dhaleswari River flows on the east and west sides of the *char*. The western part of the Dhaleswari channel will be filled with spoil from river dredging. No disposal chamber will be constructed. The height of the filled channel will be lower than that of the centre *char*. The disposal area is not being prepared as agricultural land and no top soil will be provided. The filled channel will be closed at its north and south ends.

The *char* began emerging in the centre of the river in 1952. It is government-owned *khas* land, administered by the Ministry of Land Administration at Lakhai Thana, Habiganj District for the left bank and Astagram Thana, Kishoregonj District for the right bank. At the village and *thana* level, agreement on distribution of *char* land has been mediated over the years. Four hundred and fifty cultivators and four mosque committees in Noorpur and Baluchar farm paddy, chili, jute, *chailla* and *kaun* (sesame) on 58 ha of *char* land. None of the cultivators have land title, although many are trying to obtain deeds through the court.

Since 1990, the flow of water in the dry season has become so low that approximately 30% of land in the west channel is now cultivated. Customary land use rights in the west channel are an extension of those on the central *char*. The west channel is cultivated by the same group of 450 farmers and 4 mosque committees.

Disposal of river spoil in the Dhaleswari west channel will not require land acquisition because the land is river *khas* and the present farmers have no titled land holding. No social disruption is expected over use of the new *khas* land. As in the past, disputes arising over land use rights will be locally mediated on the basis of customary land use in the Dhaleswari *chars*.

No long-term economic loss will be suffered by cultivators in the area. To the contrary, filling of the west Dhaleswari Channel is supported by farmers because more land will become available. It is anticipated that after 3-4 years, the present cultivators will return to cropping on sandy soil in the west channel.

Farmers in Madna report that over the years there has been an increase of siltation in the Dhaleswari River, resulting in reduced post-monsoon drainage capacity and a delay in plantation of the *Boro* rice crop. Farmers and business persons insist that construction of the Issapur Loop Cut be accompanied by annual dredging of the Dhaleswari River. A deepened channel will improve post-monsoon drainage and increase navigability and trade.

The impact is positive, long-term, local and mid-magnitude. No land acquisition, compensation, mitigation or enhancement programs are required for this project component with regard to Land Use and Settlement.

5.10.7 Land Use and Settlement at Katkhal Loop Cut Site (38) (-7)

A loop cut of approximately 5.65 km. will be constructed between Shantipur and Bishorikona. Construction will be carried out in three sections: Shantipur to Katkhal, Kaisar and Shahebnagar.

To accommodate the width of the loop cut and its embankments and set-back areas on either side, 195 ha. of land is to be purchased from individual landowners. Spoil from the loop cut will be used to construct the embankments and 10 homestead platforms in the area. Embankments and village platforms will be protected by both soft and hard protection. River training works will be constructed at strategic locations. The homesteads of 20 households of Nayapara a *para* of Shahebnagar will be re-located.

People in all communities in the vicinity of the Katkhal Loop Cut are overwhelmingly in favor of its construction. Shantipur residents have lost homestead land and houses from river erosion each year. Their agricultural lands in Borobaira area and Bander Beel are vulnerable to pre-monsoon flood in most years. They feel that without measures to straighten the river, it will continue to erode on the north-west side of Shantipur and will eventually make its own random loop cuts.

Shahebnagar residents consider themselves most vulnerable to continuing river erosion and avulsion. The 1994 erosion at Shahebnagar resulted in the loss of 250 homesteads. Over the years, some households have had to move as often as 5 times to raise new homesteads on their agricultural land located in different *haors*.

Landowners in Katkhal and Shahebnagar anticipate that unless a loop cut is constructed within two years, the river itself will cut south through Doia Beel. People fear river bank avulsion and loss of crop in the Mora Gang Beel in the near future. Landowners are in favor of the Katkhal loop cut because even though they will loose some land to its construction, their remaining land will be less vulnerable to pre-monsoon flooding.

The homestead land of 20 HHs of Nayapara must be acquired for the construction of the Katkhal Loop Cut. These HHs are very vulnerable to severe river erosion, particularly in the pre-monsoon period. Despite the fact that they will loose homestead land, the 20 HHs of Nayapara support construction of the loop cut. They will accept re-location to flood-secure land as a highly desirable alternative to erosion.

An amount of 195 ha of agricultural land is to be acquired. Most of the landowners are found in the villages of Shantipur, Katkhal, Shahebnagar, Kaisar, Nayakurakandi and Bishorikona. The patterns of land distribution and *khas* land are as follows:

- Shantipur to Katkhal - 60% of the agricultural land in this section is owned by Shantipur HHs; 40% is owned by Katkhal HHs. A small portion of the former *khas* land of Bander Beel has been awarded to a large landowner in Katkhal. Therefore, there is no *khas* land remaining in this section;

- Kaisar - all agricultural land in this section is owned by Kaisar HHs in the paras of Purbo Hati, Dokkhin Hati and Uttor Hati. The required land along the riverbank is *khas* and is being used by Kaisar HHs without title, and

- Shahebnagar - all agricultural land in this area is owned by Shahebnagar HHs. There is no *khas* land in this section.

The impacts on land use and settlement at the site of the Katkhal loop cut are unavoidable and of mid-magnitude, affecting locally some communities on the long-term. In order to minimize those impacts, compensation is required for landowners in villages of Shantipur, Katkhal, Shahebnagar, Kaisar, Nayakurakandi and Bishorikona for loss of land as their primary economic resource.

In addition, those 20 relocated HHs will each be paid a temporary accommodation grant to shift to an area of their choice. When construction has been completed, the 20 Nayapara HHs will be permanently re-located near their original homesteads on the left bank. Each HH will be provided with re-used land and each will be paid a re-settlement grant to cover land raising, house and outbuilding construction, and water and sanitation facilities.

In addition to compensation, the following mitigative measures will be implemented:

- To mitigate the loss of land as a primary source of income, landowners will be paid cash grants to either replace land at a higher price or to convert to another income-earning opportunity, such as trading and small business;
- As a further mitigation for the effects of land loss as a primary source of income, approximately 54 ha of land on both sides of the loop cut will be proportionately returned back to landowners for re-use in intensive agriculture. After completion of the construction, it is anticipated that the set back area will be ready for re-use in 2-3 years, and
- Landless households in the Katkhal loop cut area may lose a portion of their annual income through loss of agricultural labor opportunities. However they will be mitigated by the provision of extensive labor opportunities in earth construction.

The enhancement measures for the Katkahl area will include *koroch* tree plantation and platform protection.

5.10.8 Land Use and Settlement at Land Dedicated Platform Sites (39) (+7)

In total, 31 platforms will be extended over dedicated land.

In the river reach between Kalma and Kadamchal, 12 platforms will be developed. This includes 2 at Shibpur, 4 at Abdullapur; 3 at Kalma; 2 at Samarchar and 1 at Hemantaganj.

A total of 10 homestead platforms are to be developed using dredged spoil from the Katkhal Loop Cut. Single platforms are to be constructed in Bishorikona, Nayakurakandi, Kaisar and Shantipur. Katkahl will receive 4 platforms and 2 platforms will be built in Shahebnagar. Katkhal will be benefitted by improved communication of all *paras* with the high school and the market, thus improving its commercial value.

River dredging will also be carried out in several locations from Rahala to Ajmiriganj. Dredged river spoil will be used to construct 9 homestead platforms at Rahala, Mahmoodpur, Shahabnagar, Nazrakanda, Solori, Kalnipara, Rania, Ajmiriganj (Samipur) and Ajmiriganj Bazar (Ganjerhati and Pukurpar). The platform at Mahmoodpur will provide a linkage and possible expansion of the Kakailseo market. The platform at Shahnagar will improve the school facility.

The impact on settlement pattern will be positive, long term, mid magnitude and will benefit local communities. The compensation, mitigation and enhancement plan has been documented and budgeted on the basis of the pilot project experience.

5.10.9 Land Use and Settlement at Khas Land Platform Sites (40) (+7)

Khas land platforms will be constructed at two sites. The impact on settlement pattern will be positive, long-term, mid-magnitude and will benefit local communities.

The Abdullahpur Dokkhin Char Platforms
Extensive river dredging will be conducted downstream of Abdullahpur village at a location known as Abdullapur Dokkhin Char (Issapur-Abdullahpur section). Dredged river spoil will be used to construct 12 new homestead platforms on the left bank. The total platform area will be approximately 44 ha.

These platforms will be exposed to considerable wave erosion. Permanent protection is planned for these platforms. In the first year immediately following construction, soft platform protection will be applied.

There are no nearby villages and the platforms will be constructed on *khas* land. The land is presently being cultivated by approximately 800 HHs from Abdullahpur village. A preliminary field survey indicates that none of the land users have title.

The Ministry of Land will be requested to obtain 44 ha. of *khas* land for the construction of 12 platforms and to re-settle destitute and landless HHs on the completed homestead platforms.

The 12 platforms of Abdullapur Dokkhin Char may be developed on the same basis as the EEC funded project 'Operation Thikana' carried out by the Ministry of Land in different areas of Bangladesh in the 1970's and '80's. The criteria used for homestead land allocation in this project will be followed. Those owning neither homestead nor agricultural land will be given priority. It is expected that poor households from eroded villages such as Anowarpur, Abdullahpur and Kalimpur will be resettled on the *khas* platform of Abdullahpur Dokkhin Char.

Anandapur Platform
River dredging will be conducted downstream of Kakailseo at a location adjacent to Anandapur village. There is no habitation at the site to be constructed. Dredged river spoil will be used to construct one new homestead platform of approximately 13 ha.

The freehold sides of the platform will be exposed to considerable wave erosion off the *haor*. Hard dyke protection is planned for the Anandapur platform in its second year. In the first year immediately following construction, soft platform protection will be applied. To dampen the impact of wave erosion, trees will be planted along the exposed freehold sides of the platform.

The Anandapur *khas* land is centred around 13 ha of *khas* land which was awarded, in 1989, by the government to 31 landless households, but to-date this land is occupied by local people. In the selection for the pilot sites, Anandapur was considered an excellent choice because it would provide benefits to poor people, but the landless group were unwilling to dedicate their legally owned land for platform construction because they were of the opinion that once the platform was developed, they would never succeed to claim their land. As a result, the Anandapur site was not included in the final selection for the pilot project.

In order to manage the dispute over Anandapur *khas* land, the Ministry of Land Administration would be requested to purchase the 13 ha of awarded land from the original 31 HHs for implementation of the project. The 31 landless HHs would be compensated at the market price of land. The EMP for Anandapur calls for land purchase from the 31 "Anandapur Landless" who technically own the land but are not able to occupy it and are therefore unwilling to dedicate it.

In an undeveloped state, the 13 ha of former *khas* is low land, unsuitable for homestead land. During the monsoon it is under 2 to 3 m. of water. If they ever were to gain occupancy, the "Anandapur Landless" can only use their land for cultivation of *Boro* vegetables during the dry season. However for settlement on a developed platform, an allocation of 100 decimals of homestead land is not a feasible settlement pattern. The average homestead holding in the feasibility study area and in Gazaria is 7 decimals. Therefore, on the new platform the Ministry of Land Administration will be requested to allocate 10 decimals of developed homestead land to approximately 250 destitute and landless HHs, including the original 31 "Anandapur Landless" HHs. It is expected that the criteria for land allocation will follow the precedent set for landless resettlement in other government projects (see Abdullahpur Dokkhin Char). Destitute and landless families from such eroded villages as Shantipur and Shahebnagar may be good candidates for re-settlement on the Anandapur platform.

Hard dyke protection will be provided for the widely exposed Anandapur platform. In addition, the enhancement measures include tree plantation, soil enrichment, latrines and tubewells for 250 HHs.

5.10.10 Education and Health (41) (+7)

Quality of life may be interpreted in terms of education, health, income and overall material standard of living. An improvement in all these areas will definitely contribute to attain a higher level of human security (human security, as defined in the Human Development Report 1996, represents safety from such chronic threats as hunger, disease and repression and protection from sudden and hurtful disruptions in the patterns of daily life).

The proposed initiatives will not have direct impact on the literacy situation. But the attainment of government's goal of universal primary education will be facilitated by a population responsive to the strategies and initiatives. Improvement in the general economic condition of the people and better living conditions will have positive impact on ability and attitude of the people toward education. Well-protected settlements will ensure uninterrupted functioning of educational institutions which is often disrupted during the monsoon months. Higher income will enable poorer households to spend more on education. The elasticity of income effect on education is believed to be more than one at the above-subsistence level. Once basic food requirements are met, people will spend more on education.

Improved liveability of settlements will contribute in achieving the national goal for universal coverage of potable water for drinking. With improved accessibility, the use of tube well water for all purposes can be expanded. This will help to reduce the incidence of water-borne diseases and will have positive impact on health and personal hygiene. Besides, increased accessibility will bring comfort to women who are the main drawers and users of water.

Protective measures for homestead platforms will allow more space for construction of latrine on a permanent basis. Thus the scope for more water-seal sanitary latrines will be expanded. This will also improve the state of sanitation through proper disposal of human waste and will have direct impact on the general state of health.

Income has a direct correlation with nutritional status of the people. With increased per capita income, extent of child malnutrition like stunting, wasting and underweight is expected to decline.

These positive impacts will be long-term, low magnitude and regional.

5.10.11 Status of Women (42) (+7)

Improved liveability of homestead platforms will facilitate more home-based activities for women, particularly in the fields of homestead gardening, poultry rearing, and cottage industries. Small farmers will prefer post-harvest threshing and winnowing of rice in courtyards rather than in farmyards. This will increase the participation of family labor instead of hired male labor. Homestead is literally the world of women. Safe platforms will enhance the security of women to a significant extent in both tangible and intangible terms in the sense that it will enhance the scope for more economic activities and also more comfort in performing household chores. These impacts are long-term, mid-magnitude and local.

5.10.12 Land Quality and Productivity (43) (-4)

About 938 ha of land (about 0.3% of the project gross area) will be required for storing dredged material and construction of loop cuts and levees. Out of this, 806 ha will be taken from cultivable areas. The impact of this land use change has been taken into consideration during calculation of Net Cultivable Area (NCA) under FW condition. Out of 938 ha, about 335 ha (75% of the platform area) will be used as homestead platform and 330 ha will be used for homestead vegetation and for home-based activities like gardening and poultry rearing. The net land use change is 273 ha which is not significant in relation to project area (0.08%). The impact is long-term, low magnitude and site-specific.

Over the years, homestead land has been continuously eroded by waves and this is expected to continue once the project is completed. Whereas in the past the eroded material was of the same composition as the one present in farming plots, in the future sandy dredged river spoils will be eroded and deposited on those plots resulting in significant deterioration of agricultural soils if no protection measure is taken to prevent erosion. Both soft and hard platform protection will be provided as component of the project to prevent erosion. In addition, a three year community program has been included to train the communities and develop the framework to insure effective maintenance of the platforms.

2G0

5.10.13 Employment and Economic Activity (44) (+5)

The expected benefits of the proposed project to the socioeconomic infrastructure of the region are numerous and varied. They include the following:

- Kalni-Kushiyara river bank flood protection;
- Additional river bank protection & related land development;
- Village platform (VP) flood and wave protection;
- VP homestead gardens, fruit trees and slope protection;
- VP homestead grain drying;
- Quality of life Improvement, and
- Reduction of O&M for existing projects.

Some of these expected benefits represent a "package" of attributes and therefore are only very imperfect proxy variables. Other variables are those which knowingly do not account for all of the expected benefits being quantified. The quantitative socioeconomic infrastructure benefits should only be treated as indication of order-of-magnitude values (Annex E-Economics).

For this study, 16 underlying benefits were quantified to reflect the total socioeconomic value of all benefits. These were subsequently grouped into 7 composite benefits which after analysis were found to contribute to the aggregate economic benefits estimate approximately as follows:

• Kalni-Kushiyara River bank flood protection;	16%
• Additional bank protection & related land development;	14%
• Village platform flood & wave protection;	23%
• Homestead gardens fruits, fruit trees and slope plantation;	26%
• Homestead grain drying;	4%
• Quality of life improvement, and	15%
• Additional protection to existing projects	2%
TOTAL	**100%**

The benefit gradually climb over the life of the project, ultimately levelling off in Year 26 at about Tk 76.3 million per year. As such, this would be the second largest direct benefit of the project at about 10% of total of the project benefits.

This positive impact will be very likely, long-term, low magnitude and local.

5.10.14 Equity (45) (+6)

It is expected that all strata of the population will benefit from the project. Observations show that the poor people use homestead land more intensively than the rich as the latter has more access to farm land. Hence, newly created platforms will benefit the poor to a greater extent. The impact is long-term, low magnitude and local.

5.11 Cumulative Impacts

Cumulative impacts are environmental impacts that result from actions that are added to other of the past, present or the foreseeable future, caused by multiple human activities and/or events that are either repeated or occur in combination.

5.11.1 Existing Water Resource Development Projects

There are 11 existing major FCD projects in the study area including seven completed projects and six ongoing projects (refer to Figure I.1). The total gross area of these projects is about 80,000 ha, and the net cultivable area is 55,200 ha (Table I.28).

Table I.28: Completed and Ongoing Projects

Name of Project	Area		Type	Length (km)	Structures (nos)	Remarks
	Gross (ha)	Net (ha)				
Kushiyara Left Bank						
Sutki River Embankment	12,146	9,710	E	34	-	Completed
Sutki River FCD	1,417	810	E	58	2 Regulators	Completed
Jhingari Nadi Drainage and Irrigation	7,150	1,900	D	15	2 Regulators	Under SRP
Basira River Re-excavation	4,260	3,600	D	11	-	Completed
Sub-Total:	**24,973**	**16,020**	**E** **D**	**92** **26**		
Kushiyara Right Bank						
Naluar Haor I	9,840	8,800	E	52	6 Regulators	Completed
Naluar Haor II	2,300	1,924	E	26	under construct.	Completed
Chaptir Haor	4,453	3,624	E	35	under construct	Completed
Udgal Beel	5,900	4,700	E	34	1 Reg; 3 Pipe sl.	Completed
Baram Haor	5,500	4,800	E	26	3 Reg.; 3 Pipe sl.; 34 inlets	Completed
Tangua Haor	5,000	4,500	E	20	2 Reg.; 6 Pipe sl.; 20 inlets	Completed
Bhanda Beel	4,000	3,600	E	32	1 Reg.; 5 Pipe sl; 20 inlets	Completed
Damrir Haor	18,212	7,285	D	-	-	Completed
Sub-Total:	**55,206**	**39,251**	**E**	**208**		
Total:	**80,179**	**55,271**	**E** **D**	**300** **26**		

Source: NERP, 1993 b)
Note: E - Embankment
D - Re-excavation for Drainage Improvement

There are 4 existing projects on the left bank of the Kushiyara with a gross area of about 25,000 ha. Two of these projects, Sutki River Embankment Project and Sutki River FCD Project, include about 92 km of submersible embankments and are designed to protect *boro* crops from pre-monsoon flooding. The remaining 2 projects, Jhingari Nadi Scheme and Bashira River Re-excavation, were designed to improve drainage and increase winter season irrigation and include about 26 km of re-excavated drainage channels. All these projects are located around Baniachang Thana.

There are 7 projects on the right bank of the Kushiyara River with a total gross area of about 55,000 ha. The Kushiyara right bank schemes are all submersible embankment projects which provide pre-monsoon flood protection to *boro* crops. The 6 submersible embankments projects

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around Markuli provide pre-monsoon flood protection to a gross area of 37,000 ha. The 7th project is the Damrir Haor project, a drainage project located close to Fenchuganj.

The total length of embankments for the 11 projects is about 300 km.

Boro cultivation has increased following completion of some of the projects, and it appears that there have been some agricultural benefits. However, pre-monsoon flooding still occurs and crops are damaged almost every year in parts of the schemes. Local people of the Tangua Haor and Bhanda Beel projects stated that in recent years, the Kushiyara River water levels have increased substantially. Now the banks of the Kalni-Kushiyara are frequently overtopped and breaches at several locations. The onrush of water through these breaches associated with high velocity over bank spills, damages the submersible embankments, and consequently damages the *boro* crops. Local information suggests that the design crest level of submersible embankments was in the range 6.6 to 6.9 m PWD. Due to recurring overtopping, EIP reviewed the pre-monsoon water levels and has revised the submersible embankment design crest levels to 7.4 m PWD. The new crest level for submersible embankments is now approaching the level of monsoon floods.

Under the FWO scenario, these submersible embankments will be damaged frequently due to overbank spills and breaches in the river bank around Markuli.

To protect *boro* crops under the FWO condition, it is conceivable that the embankment heights would have to be raised by approximately one metre in the future. Total earthwork cost for raising embankment heights by one metre is about Tk 148 million, based on 1995 prices. Moreover, this could require acquiring an additional 150 ha land for the embankments which would cost an additional Taka 27 million (assuming land costs of Tk 180,000/ha). These lands would mostly be taken from the existing cultivated areas. With this additional one metre height and a provision for freeboard, the submersible embankment crest level at some locations would begin to approach the annual monsoon flood level. As a result, these embankments could begin to affect monsoon flood levels in the north floodplain.

Some 13,563 ha are protected from pre-monsoon floods on the left bank of the Kushiyara River. Crop damage in the remaining unprotected areas will be increased from its present level. There are also two completed projects (Jhingari Nadi and Basira River). These projects are becoming totally ineffective due to siltation of the offtake channels.

The Jhingari Nadi Drainage and Irrigation Project (net area 3,600 ha) was conceived to enhance surface water availability for winter irrigation. This was accomplished in 1978 by re-excavating the Jhingari Nadi for a length of about 11 km. The Jhingari Nadi connects the old Kushiyara River in the north with Ratna River in the south. The Old Kushiyara River channel was the main source of irrigation water supplies which is completely silted up near Ajmiriganj.

The Bashira River Re-excavation project has the same objective as Jhingari Nadi but it became ineffective due to the construction of closure dam at the offtake of the Bashira River.

5.11.2 Effects of the Proposed Project on Existing Water Resource Development Projects

Elimination of high velocity spills and breaches in the river banks due to dredging and river training works is expected to have the following positive impacts on the existing projects:

- it will reduce the annual construction cost of closures dams at the breaching points;

- it will reduce the annual maintenance cost of the submersible embankments located around Markuli particularly along the right bank;

- the Jhingari Nadi Drainage and Irrigation scheme will be made effective through the installation of Koyer Dhala multi-purpose structure;

- the Bashira River Re-excavation scheme could be made effective through proper rehabilitation, and

- the Khowai River Project might have substantial benefit due to the development of the proposed project.

The Baulai water level will also be lowered during the pre-monsoon and post-monsoon seasons under FW scenario. There are 17 submersible embankment projects on the right bank of the Baulai River. Currently, these projects are subjected to increased pre-monsoon flood levels and delayed post-monsoon drainage due to high water levels in the Baulai River. The project will have some positive impacts on these submersible embankments due to decrease in Baulai water levels during the pre-monsoon and post-monsoon seasons.

None of the above project will have an impact on the KKRMP.

5.11.3 Assessment in Relation to other Proposed Projects

The KKRMP was conceived within the Northeast Regional Water Management Plan to be one of the initial components in an overall strategy of integrated development of the deeply flooded areas of the NE Region (NERP, 1993 c)). Initiatives, for which pre-feasibility level investigations have been completed, and with direct links to KKRMP, include:

- Kushiyara-Bijna-Inter-Basin Project;
- Surma-Kushiyara-Baulai Basin Project, and
- Upper Surma-Kushiyara Project.

Figure I.21 shows their location.

The Kushiyara-Bijna Inter-Basin Project includes flood protection with submersible embankments downstream of Markuli, and construction of nine drainage-cum-flushing regulators and five irrigation inlets along the Kalni-Kushiyara River. Therefore, this initiative relates synergistically to the KKRMP. Some components (such as the Koyer Dhala regulator, some levees) have been incorporated directly into the KKRMP. Implementation of the remaining structures could be carried out immediately following the project's completion.

The objectives of the Surma-Kushiyara-Baulai Basin Project were to protect *boro* crops grown in the *haor* areas from winter and pre-monsoon floods, to mitigate the effect of monsoon floods on *aus* and *aman* crops and to protect infrastructure in the higher areas in the eastern portion of the region. An important aspect of this project involves improving the internal drainage system in the inter-basin west of Ajmiriganj and Markuli through the re-excavation of key drainage channels. Ancillary structures (including regulators, fish passes and navigation passes) would be provided. This initiative would expand the post-monsoon drainage benefits from the KKRMP significantly, since it would re-open the internal drainage system on the river's north floodplain. Under the KKRMP, improvements to post-monsoon drainage are limited by the past closures (such as at Markuli and Bheramona) which essentially disconnect the river from the floodplain. Re-opening this drainage system would allow what would otherwise only be potential benefits of the KKRMP to be realized.

The Upper Surma-Kushiyara Project was proposed under the strategic thrust *"Enhanced Production Systems on Seasonally Flooded Lands"*. The initiative is located upstream of the KKRMP and involves flood control measures along the left bank of the Upper Surma River and right bank of the Kushiyara River. The western portion of the project area would be kept open for drainage, navigation and fish passage. Some components, such as the control of major spills from the Surma River into the Kushiyara River system through Kakura Khal, would have substantial benefits to the KKRMP. Controlling these spills would reduce the magnitude of flood flows in the monsoon season and reduce sediment inflows into the Kushiyara River. Therefore, initiating this development could substantially reduce maintenance costs on the KKRMP.

5.12 Summary of Environmental Impact Assessment

The Impact Evaluation Matrix presented in Table I.29 presents a summary of the impacts of the project. The scoring is based on the methodology described in section 5.6.

Table I.29: Impact Evaluation Matrix

Important Environmental Component (iEC)	Project Phase			
	Implementation		O&M	
	Earth Works and pre-dredging	Excavation of River Bed and Loop Cuts	New River Channel	New Setting and Settlement Pattern
	Score	Score	Score	Score
River Morphology			+5	
Hydrology & Hydraulics			+5	
Open Water Bodies			+5	
Erosion & Sedimentation Processes		0	+5	0
Drainage	-2		+6	-2
Irrigation	-2		+6	-2
Aquatic Habitat & Fisheries	-3	-3	+6	
Terrestrial Habitat & Wetlands	-3		+4	+4
Land Use and Settlement	-4	-3	+6	-7
Issapur Loop Cut Site				+7
Dhaleswari Dredging & Fill Sites				-7
Katkhal Loop Cut Site				+7
Land Dedicated Platform Sites				+7
Khas Land Platform Sites				+7
Education and Health	-4	-3	+7	+7
Status of Women	+5		+7	+7
Land Quality & Productivity	-3	-3	+7	-4
Navigation		-3	+6	
Employment & Economic activity	+5	+4	+6	+5
Equity			+7	+6

6. ENVIRONMENTAL MANAGEMENT PLAN

6.1 Purpose and Contents of EMP

The purpose of this Environmental Management Plan (EMP) is to provide specific environmentally-related action plans that will be carried out during the Implementation and O&M phases of the project. This action plan will manage the negative post-implementation, and the negative short-term (implementation) impacts discussed in Chapter 5. Actions taken under this EMP will reduce the negative impacts to an acceptable level and make the project environmentally friendly. The plan also includes monitoring. This is necessary to ascertain whether the measures taken for reducing the impacts are adequate, and to verify whether any unanticipated impacts occur. In order to capitalize on the positive impacts resulting from the project interventions, an enhancement program has also been included in this plan. The EMP has 6 components:

- Compensation Plan;
- Environmental Protection Plan;
- Enhancement Plan;
- Contingency Plan;
- Monitoring Plan, and
- Training Plan.

As indicated in Chapter 2, this EMP applies only to Alternative 1.

In this Chapter, the costs budgeted do not include contractor's nor consultant's (labor and expenses) costs. The contractor's costs are budgeted under the project Capital Infrastructure Costs and the consultant's costs are budgeted under the Project Study Costs.

Moreover, the long-term benefits monitoring program (Section 6.6.7) costs are also not budgeted in the EMP. The monitoring programs costs (Sections 6.6.1 to 6.6.6), during the implementation phase of the project, are budgeted in the EMP.

6.2 Compensation Plan

6.2.1 Land Acquisition

Impact
About 411 ha of agricultural land will be acquired for the construction of the Issapur (216 ha) and Katkhal (195 ha) loop cuts.

Compensation
The BWDB, in its pre-construction phase cadastral survey, will determine the registered land ownership and the value of land to be expropriated for the loop cuts. Values will be based on agricultural capability, location, recent land transactions and other parameters normally used for calculating the land values. Land acquisition will be discussed with individuals affected and

through participation, the most appropriate form of compensation for each affected landowner will be decided.

As a further compensation for the effects of land loss as a primary source of income and economic resource, a total of 160 ha of high land on both sides of each loop cut will be proportionately returned back to landowners in the loop cut areas for re-use in intensive agriculture. After completion of construction, it is anticipated that the set back areas will be ready for re-use within 2 to 3 years.

Based on the precedent set by the Jamuna Multipurpose Bridge (JMBA, 1993)) in resettling project affected persons (PAPs), the following compensation package plan is proposed for the landowners:

- allocate 106 ha of reusable land to Issapur affected landowners in compensation for the acquired land;
- similarly, allocate 54 ha of land to Katkhal affected landowners;
- allocate 20 % (appropriation value) cash grant to Issapur and Katkhal affected landowners to use in income generating activities;
- employ the affected poor in project's construction and O&M activities, and
- allocate nearby *khas* land to the affected landless persons.

Compensation should be carried out by an independent group attached to the BWDB, in a manner similar to that used for the Jamuna Multipurpose Bridge resettlement program. This approach ensures that each land owner will receive cash in hand that reflects the current market value of the land. One payment only should be made (not by instalments) immediately upon signing of the land title transfer.

An EMP cash grant of Tk 7.78 million for Issapur and Tk 4.88 million for Katkhal affected landowners has been budgeted based on current land prices obtained from field interviews. High agricultural land in Issapur was assumed to be priced at Tk 180,000/ha and agricultural land in Katkhal was priced at Tk 125,000/ha.

Another 80 ha of land also needs to be acquired for disposal sites downstream of Abdullahpur and Anandapur, for navigation, as well as for construction of levees and structures. These are *khas* lands and do not require to be budgeted in the EMP beyond the original cost of land acquisition.

At the beginning of the pre-construction phase, the experience of JMBA with resettlement will be reviewed and adapted to the KKRMP as required.

6.2.2 Crop Loss

Impact and Compensation

Land acquisition is scheduled to be completed within two years after the start of the project and some land may remain unused by the project for one or more seasons. Farmers will generally be able to harvest their crop growing at the time of the acquisition unless the land is required immediately for construction. In the latter case, farmers will be compensated for lost crop. Otherwise no compensation will be made for land acquired for the various project components.

Crop will either be damaged or prevented from cultivation during the installation of shore pipelines, construction and filling of effluent outlet channels, and collecting earth for the maintenance of dykes. Crop compensation is budgeted for the platforms where agricultural land is privately owned.

Responsibility
BWDB will be responsible for crop compensation except when it relates to dyke construction and maintenance. The earthwork contractors will be responsible for crop compensation for any work related to dyke construction and maintenance. The Consultant will select the pipeline route and effluent outlet route in association with the local people and will facilitate the compensation.

6.2.3 Homestead Loss

Impact and Compensation
Homestead loss includes loss of large fruit trees, latrines and ponds due to the extension of the existing homestead platforms. Homestead loss compensation has been budgeted at the rate of Tk 5,000 per platform based on the pilot project experience.

Responsibility
BWDB will ensure compensation to the affected landowners. The Consultant will facilitate the compensation process.

6.2.4 Fishers

Impact and Compensation
Fishers, particularly along the Issapur and Katkhal loop cuts may be partially impacted. They will be compensated. It is proposed to lease the new channel sections to these affected fishers.

Responsibility
BWDB and the Consultant will be responsible for this activity.

6.3 Environmental Protection Plan

The Environmental Protection Plan (EPP) includes specifically a mitigation plan. The EPP is designed to protect the environment from deterioration due to project construction. Responsibilities have been assigned to implement this mitigation plan.

6.3.1 People's Perception

Impact and Mitigation
As experienced in the Pilot Dredging Project, during the pre-construction phase, when the data collection program, the cadastral and social surveys take place and the final layout is agreed to, unrests cannot be discounted from those who will be affected by the project.

The following mitigation measures will be applied:

- problems and issues related to land dedication will be managed through the proposed institutional framework including district, *thana* and beneficiaries committees;

- on-going consultations with affected communities, and

- visits of beneficiary representatives to the platforms of Kakailseo and Gazaria.

Responsibility
The Consultant's social team will arrange the consultation with the local population and the visits to the pilot platforms. Issues will be negotiated with the assistance of the committees.

6.3.2 Local Employment

Impact and Mitigation
Landless households in the 2 loop cut areas may lose a portion of their annual income through the loss of agricultural labor opportunities. However, this will be mitigated by the provision of assured labor opportunities during the implementation and O&M phases. The pilot project experience indicates that labor contracting societies earn approximately 16% more than they can earn as sub-contracted labor. The following mitigation measures will be applied:

- the Contractor shall, to the maximum possible extent, employ local labor for manual earth works:

- local female labor must comprise at least 25% of the work force for earthwork;

- no children under the age of 14 shall be employed in heavy earthwork, in accordance with the Labour Code of Bangladesh, and

- during the O&M phase of the project, local labor should be provided with direct contracting opportunities through their own landless groups.

Responsibility
BWDB will be responsible for local employment: 1) through the contract documents during the implementation stage and 2) by providing contracts directly to the landless groups during the O&M stage. The Consultant will maintain liaison between the Project Engineer and the Contractor to obtain fair wage and working conditions.

6.3.3 Labor Camp

Impact and Mitigation
Considering the amount of labor which will be required, it is anticipated that local labor (both female and male) will travel long distances to the work sites. The Contractor must provide secure overnight camp facilities, including adequate water and sanitation, for the local laborers. BWDB standard rules relating to layout, water supply, canteen, sanitation and security both for the workers and the local population in labor camp must be strictly followed.

Responsibility
The Contractor will be responsible for these facilities. BWDB field officials and the Consultant will ensure the camp facilities are based on industry standard rules.

6.3.4 Landing Facilities

Impact and Mitigation
The Issapur loop cut will disrupt the easy access of Bhatura villagers to a high school and administrative installations. To mitigate their loss of access, landing facilities *(ghats)*, will be provided on both banks of the river. These will be at Chowdanta village and at a place mid-way between Bhatura and Issapur villages. The cost for the construction of 4 *ghats* is estimated at Tk 400,000.

Responsibility
BWDB will be responsible to install these *ghats* through the Contractor. The Consultant will facilitate the selection of locations in association with the local community people.

6.3.5 Market Facilities

Impact and Compensation
To mitigate the Chowdanta villagers' loss of easy access to the market and to provide an opportunity for the development of trade and small business in the area, a market will be developed at Chowdanta. The market area will be provided with drainage, water and sanitation facilities. Shopkeepers will be expected to develop their own structures.

An EMP cost of Tk 1.48 million is budgeted for this market facility based on the pilot project experience.

Responsibility
BWDB will carry out this activity through the Contractor. The market should be planned, designed and implemented with platform drainage and access facilities. The Consultant will facilitate selecting the location and the number of shops in association with the Chowdanta people.

6.3.6 Relocation of Households (HHs)

Impact and Mitigation
About 20 HHs will be displaced due to construction of the Katkhal loop cut particularly at the Shahebnagar section. The Nayapara HHs to be displaced, are vulnerable to severe river erosion, particularly in the pre-monsoon period. Despite the fact that they will lose homestead land, the Nayapara HHs support construction of the loop cut. They will accept relocation to flood-secure land as a highly desirable alternative to erosion. Loss of their homestead land, houses and outbuildings represents both an economic and social loss. This should be compensated and mitigated.

The Nayapara HHs will be permanently relocated on homestead platform No. 31 (Figure I.8). The platform will be constructed on the silted-up offtake of the Kalni River, located on the northeast corner of Shahebnagar village simultaneously with the guide embankment of the new channel. The platform is scheduled to be completed between Years 3 and 4. The proposed

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excavation plan and location of Nayapara HHs indicates that they can stay to their places till the completion of homestead platform 31. Each HH will be provided with 20 decimals of land and a cash grant of Tk 80,000. This will cover land raising, house and outbuilding construction, and drinking water supply and sanitation facilities.

An EMP cost of Tk 1.60 million is budgeted for this relocation program.

Responsibility
BWDB will facilitate the relocation plan and give the cash grant. In association with the appropriate local committee, the Consultant will execute the plan and will ensure land titles are secured for these relocated villagers.

6.3.7 Drainage from Adjacent Lands

Impact and Mitigation
Extension of an existing platform, when it is connected to more than one village *(para)*, may disrupt the existing surface drainage systems from the adjacent lands. For example, during the implementation of the pilot project, the Kakailseo platform disrupted the natural drainage system from the adjacent *paras*. It had to be re-established from the project budget. Costs to address this issue are budgeted at Tk 2.0 million. However, special attention should be given to avoid this issue as much as possible during the planning and selection of disposal sites.

Responsibility
BWDB and the Consultant will be responsible for this mitigation. The mitigation plan should be executed through the same contractor responsible for the construction of confinement dykes.

6.3.8 Irrigation Network Systems

Impact and Mitigation
The existing irrigation network systems (earthen canals) may be disrupted during the installation of shore pipelines and construction of effluent outlet channels. As a mitigative measure, the disrupted sections will be reinstalled by the project. In the pilot dredging project, the disrupted sections were temporarily rehabilitated by installing pipes across the effluent outlet.

A provision has been made in the cost estimate for pipeline installation.

Responsibility
The Contractor will be responsible for the reinstallation of irrigation network systems. BWDB and the Consultant will arrange land required for these activities.

6.3.9 Road Shifting

Impact and Mitigation
In some village, communication systems will be disrupted. All riverine communities have earthen, raised roads leading from the *haor* and river to their existing platforms. These roads are critical in transporting the harvested grain. Some village roads may require rerouting for the installation of shore pipelines and construction of the effluent channel and the confinement dykes. An EMP cost of Tk 500,000 has been estimated for road shifting based on the pilot project experience.

Responsibility
The Consultant will prepare and execute the mitigation plan in association with the local people. BWDB will facilitate the program. The mitigation plan should be executed through the same contractor responsible for the construction of confinement dykes.

6.3.10 House Shifting

Impact and Mitigation
To facilitate the construction of confinement dykes particularly along the existing platforms, some houses may require shifting. Based on the pilot dredging project experience, costs for shifting 6 houses per platform are budgeted at the rate of Tk 500 per house.

Responsibility
The Consultant will prepare and execute the house-shifting plan in association with the affected people. BWDB will facilitate the program.

6.3.11 Supplementary Tubewells

Impact and Mitigation
The extension of existing platforms will infill sources of domestic water supplies. These are generally ditches, located behind the houses. The disruption of domestic water supplies will be mitigated through the installation of supplementary tubewells.

Based on the pilot project experience, an EMP cost is estimated assuming 1 tubewell per 50 HHs. About 100 tubewells will be required for the project. Cost was estimated assuming Tk 8,000 per tubewell.

Responsibility
The Consultant will prepare the plan and install the tubewells in association with the local people. BWDB will facilitate the tubewell installation plan.

6.3.12 Water Quality Protection Measures

Impact and Mitigation
Disposing of the dredged spoil in a properly designed containment chamber is the primary mitigation measure that will be used to control turbidity releases. In addition, bamboo barriers and silt curtains will be placed in the disposal chambers in such a way as to maximize the retention time of the turbid waters. If needed, some barriers could also be installed at the place where the effluent discharges into the river.

An EMP cost of Tk 1.1 million is budgeted based on the pilot project experience.

Responsibility
The Contractor will be responsible to control turbidity through the specified methods. The Consultant will monitor turbidity at regular intervals. The Consultant will identify required mitigative measures at specific sites and execute them through the Contractor. BWDB will facilitate the program.

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6.4 Enhancement Plan

6.4.1 Platform Protection

The objective of this enhancement plan is to achieve long-term sustainability and to reduce the O&M cost of the new platforms against wave erosion through non-structural measures. The non-structural measures mainly include:

- plantation of water-tolerant trees;
- development of nurseries;
- protection and care of trees, and
- *chailla* production.

Plantation of Water-tolerant Trees
The long-term sustainability of the new platform will be greatly dependant on the plantation of water-tolerant trees, shrubs and grasses along the toe of platform dykes. These non-structural measures dissipate wave energy. They have been proven by the *haor* society to be one of the best methods of protection against wave action.

The water-tolerant trees, *hizol* and *koroch* species, were identified as the most suitable for protection against wave erosion. However, preference should be given for plantation of more *koroch* saplings since its pattern of branching is more effective in dissipating wave energy. Moreover, *koroch* trees are less likely to be harvested for fuel than *hizol*, which have a higher market value for use in constructing fish *kathas*.

Approximately 120,000 water-tolerant trees will be required for the project including the mortality rate based on pilot project experience. Most of the trees will be produced in the project nurseries, which may require about 4 to 5 years to produce initial supplies.

To meet the initial demand of trees at Katkhal, Kadamchal and Shibpur disposal sites in Years 3 and 4, particularly for the soft protected length, about 20,000 man-height trees will be purchased directly from the suppliers. An EMP cost of Tk 1.26 million is budgeted for these trees.

Nurseries
Two central and 8 village nurseries will be developed to produce the remaining 100,000 water-tolerant trees. The central nurseries will have the capacity to produce 20,000 saplings per year.

The 8 village nurseries will be established throughout the project area. Poor women will be targeted to work in the village nurseries. Year-old *koroch* saplings will be provided from the central nursery to the village nurseries for their growth up to 3 years. The project will purchase man-height trees from these village nurseries at the rate of Tk 10/tree.

An EMP cost of 2.60 million is budgeted for the plantation program. This includes Tk 0.85 million for the development and management of two central and eight village nurseries, Tk 0.75 million for initial purchase, management and maintenance of 100,000 saplings for the central nurseries and purchase cost of Tk 1.0 million for adult-size trees from the village nurseries.

Central and village nurseries should be established between Years 1 and 2 in order to meet the project requirements. However, one central nursery could be established on the relocated platform (Section 6.3.6) which can also be used during the O&M of the project.

New platform landowners will also be encouraged to plant shrubs and grasses at the toe and lower slopes on their own section of dyke to be protected. This includes mainly *ikor* (Sclerostachya Fusca), *dhol kolmi*, *murta* (Clinogyne dichotoma), and *nol kagra*. These plants can be partially harvested while leaving the main stock intact. However, to ensure that shrub and grass coverage is provided for all platforms, an EMP budget of Tk 50,000 is identified for this activity.

In all cases, a 3 to 5 m strip for plantation is required at the toe of the platform. Those who dedicate land for the platform will also be obliged to dedicate space outside the platform for plantation.

Responsibility: BWDB will be responsible for the purchase of water-tolerant trees, establishment of nurseries and quantity control of the plantation program. The Consultant will facilitate the purchase and establishment of the nurseries. They will also ensure training, management, the supply of trees and the execution of plantation program as per plan.

Protection and Care of Trees

The water-tolerant trees are subject to damage from animal grazing. These trees will be protected with bamboo baskets. Plantation must be done immediately after the post-monsoon drainage. To ensure their survival rate, these saplings will require watering for a period of about 4 months.

An EMP cost of Tk 2.08 million is budgeted for the protection and care of trees (bamboo baskets and watering).

Responsibility: The protection and watering of trees along the embankments of Issapur and Katkhal loop cuts will be done by appointing women workers. The dedicated platform owners will be responsible for care of the trees along their own section. The Consultant will be responsible for the execution of the program. BWDB will be responsible for payment and supervision.

Chailla Production

The vegetation preferred in traditional platform protection is *chailla* grass because of its capacity to withstand decay over a lengthy submersion period. NERP studies show that current *chailla* production is not sufficient to meet the project requirements.

Chailla production needs to be enhanced in order to fulfil the project demand. Farmers will be encouraged to grow more *chailla* through the provision of production grants.

An EMP cost of Tk 1.38 million was estimated based on 138 ha of land at the rate of Tk 10,000/ha.

Responsibility: The Consultant will be responsible for the *chailla* production plan, the execution of program and the availability of *chailla*. BWDB will facilitate the program through payment and supervision.

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6.4.2 Top Soil Cover and Green Manuring

The objective of this enhancement measure is to improve the soil structure and productivity of the dredged spoil in order to protect the site from erosion, health and environmental hazards and optimize the land use. One possible approach is to produce biomass on the platform by utilizing quick growing plants, ensuring a faster recycling and decay process. Other methods will involve creation of a biologically active living soil environment and management practices. These activities are divided into short-term and long-term management practices.

Short-term activities mainly include plantation of quick growing plants (African *dhaincha*), wherever the season permits immediately after the completion of filling operations. When they are about 60 cm long, the plants will be cut and mixed with the dredged spoil and covered by about 15 cm topsoil. *Dhaincha* plantation could be repeated for better soil enrichment. If the season does not permit *dhaincha* cultivation, straw/water hyacinth will be used. The topsoil will be taken from the exterior surface of confinement dykes, placed there in excess during the construction of the dykes (Annex C - Engineering). Extra topsoil will be be purchased from nearby field after the first monsoon season in order to dress any dyke eroded by wind and wave action despite the protection provided during the monsoon.

NERP's experience with green manuring, covering over one year and described in Annex J-Pilot Dredging Project shows that there is merit in this approach. Monitoring, to ensure the effectiveness of green manuring, will be carried out in 1998 and 1999 in the frame of the *Kalni-Kushiyara Community Development and Monitoring Project* (KKCDMP).

Long-term activities include research and creation of a biologically active living soil environment, along with associated management practices. The need and demand for village platforms could be limited in the long-term and consequently local people may not be interested to dedicate their land for homestead platforms. Therefore, the long-term research program concerning the agricultural use of dredge spoil becomes a prerequisite for the project. Preliminary studies indicate that depth of dredged spoil is a critical factor for its quick agricultural use. It is proposed to carry out this research activity as a part of the project. This research program could be carried out at the navigation disposal sites.

An EMP cost of Tk 4.20 million was estimated for the green manuring program. This includes costs for *dhaincha* for 247 ha at the rate of Tk 800/ha and straw for 148 ha at the rate of Tk 25,000/ha, as well as a long-term cost of Tk 30,000/year for a period of 10 years. The cost of topsoil is covered under construction costs.

Responsibility: The Consultant will be responsible for the execution of the short-term program in association with the beneficiaries. In the places where *dhaincha* cultivation is not possible due to seasonal constraints, the Consultant will prepare a joint venture plan to place straw and water hyacinth simultaneously with the activities of topsoil and dyke maintenance.

BWDB will provide their agronomists and soil experts for the long-term program. They will be guided by the Bangladesh Agriculture University (BAU) and Dhaka University experts. The Consultant will coordinate the program and will prepare the research plan in association with the BWDB, BAU and Dhaka University experts.

6.4.3 Drinking Water Supply

Approximately 1,250 landless households will be settled on 13 new homestead platforms (Sites 6 to 17 and 39) as a part of the project plan. To improve the basic water supply and sanitation facilities, the project will provide hand tubewells based on the standard criteria of 1 tubewell/10 HHs.

An EMP cost estimate is made for 135 hand tubewells including 10 tubewells in public locations at the rate of Tk 8,000/tubewell.

Responsibility: The Consultant will prepare and finalize the land use plan in association with the local people. Approval of the plan from the village platform committee and execution of the program will also be the responsibility of the Consultant. BWDB will facilitate the approval and execution of the program.

6.4.4 Sanitation

In the project area, about 95% of the households have an unacceptable standard of sanitation facilities (hanging latrine and open space). This is even far below the national standard of unacceptable (52%) and sanitary latrines (48%) based on 1996 UNICEF statistics.

Field studies show that the households are willing to install sanitary latrines on their extended platforms, but they need support. In order to improve sanitation facilities, the project plans to provide water-seal latrines in all the newly-built homestead platforms.

Each household will be provided with a water-seal latrine consisting of three masonry rings and a slab. The households will install the superstructure according to their capabilities and choice.

An EMP cost is budgeted for 6,275 water-seal latrines at the rate of Tk 600/latrine.

Responsibility: The Consultant will execute the program in association with the beneficiaries. BWDB will facilitate the program.

6.4.5 Landless Settlement Program

A 1,250 HHs landless settlement program, using the proposed 13 platforms at Abdullahpur Dokkhin Char and Anandapur, will be developed on the *khas* land, arranged by the Ministry of Land (MOL). The criteria for the 1,250 HHs to be settled will be based on similar projects executed by MOL. People owning neither homestead nor agricultural land will be given priority. Each household will be settled on 10 decimals of land and will be provided a cash grant of Tk 10,000 for housing..

The platforms will be enhanced with tree plantation, soil enrichment, latrines and tubewells (Sections 6.4.3 and 6.4.4). A cash grant of Tk 12.5 million is budgeted for the 1,250 HHs landless settlement.

Responsibility
The proposed landless settlement will be carried in association with MOL, and finally it could be a project of MOL. The deputed personnel from MOL and BWDB will prepare the settlement plan in consultation with the Deputy Commissioner. The Consultant will facilitate the preparation of settlement plans. Approval of the plan from the village platform committee and execution of the program will be the responsibility of the MOL through the Deputy Commissioner at Kishoreganj (Abdullapur Dokkhin Char) and Habiganj (Anandapur).

6.4.6 Fisheries Enhancement Measures

Important opportunities exist for enhancing fish production in the project area. These relate to fisheries management, creation of fish sanctuaries, introduction of floating cage culture practices and a rare species reintroduction program in the isolated river loops.

Fisheries Management Measures
These measures relate to the establishment of genuine fishers association (FA) which will have exclusive monopoly ownership of specific fishing grounds and transfer of said fisheries from leaseholding system to the NFMP *nitimala* regime. Assistance will be given by the project to train the FAs in biological fisheries management practices and developing fisheries harvesting and conservation plans.

Fish Sanctuaries
These will be created in critical habitats, especially overwintering habitats for broodstock (*duars, beels*) and fishpass access lanes.

Floating cage culture
This will be introduced in association with pond culture (as a measure to prevent losses during monsoon flooding and increase grow-out periods) and as fattening operations for wild caught fish or hatchery/nursery-sourced fingerlings. The advantage of floating cages in areas prone to intensive monsoon flooding over other types of aquaculture practices should be tested in a pilot project modality prior to dissemination.

Rare Species Reintroduction Program
The isolated river loops created by the loop cuts may retain regulated hydrological connections with the mainstream river channel. This may allow long-term utilization of these water bodies for fisheries enhancement purposes, and prevent encroachment for agricultural use. The river loops could be used as partial grow out facilities for selected fish species which have become rare or extinct in the region. The intention is to attempt to reintroduce these species into the Northeast Region. An on-site induced breeding hatchery could also be constructed where broodstock of *nandina*, *angrot*, *sarputi*, *pangas*, *mohasol* and other species will be kept. Fry from induced breeding will be raised in floating cages in the river loops and then liberated as juveniles (20 to 30 cm size class) into the mainstream river channel during the pre-monsoon and monsoon flood periods.

Due to inadequate data and information, costs for these enhancement programs are not budgeted in the EMP. For example, the morphological behaviour of isolated loops, and the right of use including institutional aspects need to be evaluated and finalized before preparation of enhancement programs. It is proposed to develop this program based on primary data. This data will be collected during the implementation stage under the monitoring plan.

Responsibility: The Consultant in consultation with DOF will prepare the enhancement program, mode of implementation and institutional aspects during the monitoring stage.

6.5 Contingency Plan

Any unplanned occurrence whose results are seriously detrimental to one or more of the Important Environmental Components (IECs) is considered a hazard. The following hazards have been identified:

- failure of confinement dykes;
- effluent leakage through pipes;
- accidental injury, and
- oil spillage from dredges.

With regard to these hazards, the international contract will specify that a contingency plan complete with emergency response equipment and trained personnel will be mandatory. Penalty clauses are to be applied to the Contractor for failure to meet these obligations.

6.5.1 Failure of Containment Dyke

Three times daily (start-up, mid-day and shut-down), for the whole duration of operations, all earth structures, dykes and outlet channels will be inspected for evidence of slope failure and piping and repairs will be made before operation resumes. Spills resulting from the failure of the embankment chamber or the (improbable) erosion of an outlet channel will be contained with sand bags. To that effect, a number of bags, depending on the size of the disposal chamber, will be stored on site. Jute bags will be used as they are inexpensive and environmentally sound.

6.5.2 Effluent Leakage

All operating pipelines will be visually inspected three times daily (start-up, mid-day and afternoon) along their whole length. If any spill is observed, immediate action will be taken to fix the leaking joint and remove the spoil. If warranted, temporary suspension of work will be requested until corrective measures are implemented. Leakage from pipeline joints will be prevented by ensuring that the Dredging Contractor has enough spares. A low range wireless communication system will be provided by the Contractor for communications between the observers in the field and the dredge operator.

6.5.3 Accidental Injury

The Contractor will be responsible for keeping a safe work place. By-standers will be prevented from interfering with work at hand. An efficient supervision of earthworks will be implemented to prevent unauthorized works on private properties outside the project area.

6.5.4 Oil Spillage from Dredgers

The Contractor will ensure that the dredge is in working order so as to prevent oil spills. Procedures for handling fuel are to be developed to that effect. Oil spills will be contained within the perimeter of the dredge by placing water hyacinths on a bamboo cum jute mat support.

6.5.5 Navigation Lighting

To prevent endangering to or obstruct of navigation, the Contractor will ensure placement of proper lights at night, between sunset and sunrise, on all dredges, barges. Floating pipeline markers will also be installed to warn river users during the day.

All costs for the contingency plan are the responsibility of the Contractor and therefore, they are not budgeted in the EMP as they are included in the project capital costs.

6.6 Monitoring Plan

The monitoring plan includes monitoring programs (Sections 6.6.1 to 6.6.6) carried out by the Consultant during the construction phase of the project . The monitoring plan also includes the long-term benefits monitoring program (Section 6.6.7) carried out by a monitoring consultant in association with GOB during the first 9 years of the project.

However, it should be noted that the long-term benefits monitoring program costs are not budgeted in the EMP.

The monitoring plan includes the following components:

- Baseline Surveys and Data Program;
- Water Quality Monitoring Program;
- Fisheries Monitoring Program;
- Agriculture Monitoring Program;
- Social and Gender Monitoring Program;
- Physical Process Monitoring Program, and
- Long-Term Benefits Monitoring Program.

6.6.1 Baseline Surveys and Data Program

The initial phase of the development of a comprehensive monitoring plan includes:

- design of the monitoring framework;
- identification of the parameters or indicators to be measured, and data sources;
- collection of baseline parameters from the data sources (surveys, etc.), and
- selection of parameters/indicators sampling frequency for monitoring.

As monitoring progresses, the current values of the parameters are compared to the baseline values and the impacts are inferred from the results of the analysis.

This process is not specific to EMP monitoring, but also to other project activities, such as progress of the project or of its individual components, since KKRMP project management will follow the Result Based Management (RBM) approach. This approach emphasizes results and products rather than activities and input in the management of the project. Results are measured by performance indicators which may be direct measures or indirect measures of the results. Data sources are also identified for each indicator.

With respect to baseline data and information, NERP has already collected and processed, in the context of the KKRMP feasibility study, a wealth of data and information. In the early phase of the project, it is proposed to evaluate the existing pre-project baseline data to determine its completeness and adopt for a particular parameter or indicator, an alternate data collection approach if the associated existing data is deemed insufficient or deficient. Baseline data and information readily available includes:

- river channel bathymetry for several pre-and post-monsoon seasons;
- profile of both banks of the Kalni River from Raniganj, upstream of Markuli to Madna, at the downstream end of the project area. This survey identified in particular *khals* through which water enters the *haor* agricultural lands during the pre-monsoon season and flood crops;
- land use, crop patterns and cropped areas of individual plots for ten sample areas which comprise the entire area of 34 *mauzas*, an area of 14,927 ha, including maps;
- pre-monsoon flood depth maps for different conditions, present, future without project (FWO) and future with project (FW), for the 1:2, 1:5 and 1:10 year pre-monsoon flood;
- data on agricultural input, yields and crop damage;
- data on project area's households, population, income and social stratification;
- data on location, number of households, land ownership of all village platforms which will be extended;
- fisheries catch assessment surveys, number and location of culture ponds;
- data on navigation and river transportation, and
- miscellaneous maps.

It is proposed to enter the data on a Geographic Information System (GIS) to keep consistency, centralize the baseline data, simplify processing and reporting. All mapping of NERP has been computerized in Auto-Cad format and the most popular commercial GIS software packages can readily accept this format. A GIS application will also simplify greatly the task of maintaining and updating the data base. Data associated with a particular indicator will be updated in the data base in order to evaluate this indicator status on the target date.

For example, the extent of flooding during the April 1996 flood was determined indirectly by NERP by first making a river bank breach survey during the flood, then introducing the breaches in the MIKE-11 hydrodynamic model and calculating the flooded area. Mapping the extent of flooded area will be an important element to assess crop damage during project and post-project phases. In mid-1996, RADARSAT was launched and the imagery of this satellite is ideal to identify water. The possibility of using the digital data of this satellite to map the extent of flooded areas should be investigated in the early phase of the project.

Another case in point relates to the Net Cultivated Area (NCA) of the project area (Annex F-Agriculture). This area was estimated from various sources. There is a need to confirm the size of the NCA by an area wide detailed land-use survey which would take 6 months for 12 groups of 4 land use surveyors each. This survey is the more important, because current topographic maps were produced in 1962-64. Since then and with due consideration to the relatively uniform topography (ie. small variation in elevation), this topography has changed as a result of sediment deposition in the *haor*. As a consequence actual crop patterns may, in some areas, be different than those estimated during the KKRMP feasibility study.

A third area where the baseline information is deficient is the measurement of river discharges. Currently there is only one permanent recording gauging station in the project area, at Sherpur. Markuli and Ajmiriganj have staff gauge. There is a need to upgrade these stations to permanent recording stations, to implement a regular discharge measurement program at the two stations and to develop rating curves.

Other baseline data include statistical data at the *thana* level. *Thana* GOB offices keep statistics of cropped areas, crop production, employment and others. During census all relevant data is recorded at the *mauza* level, checked, aggregated at the *thana* level, then published in BBS census statistics. In between census, this data is collected annually in theory at the *mauza* level, but is not checked and maintained. This information is difficult to access as a result. There is a need for structuring the collection and mainly the processing of this information if it is to be of any use for the monitoring program of the KKRMP. The Capacity Development component of the Project will address this issue.

Responsibility: The primary responsibility for the design of the baseline program and for the conduct of surveys and collection of data will rest with the Consultant who will be assisted by the concerned GOB agencies in their various fields of expertise

6.6.2 Water Quality Monitoring Program

During dredging operations, at each disposal site, turbidity, water temperature and oxygen content upstream and downstream of the effluent outlet will be measured regularly. Turbidity measurements will be carried out in situ, with a portable turbidimeter. At each site, four stations will be clearly identified in the river and respectively located 100 m, 500 m, 1000 m, and 2000 m downstream from each active outlet. These stations will be located within the visible turbidity plume originating from the outlet. One sampling station will be located 50 m upstream to evaluate the background level. Each station will be sampled (one integrated sample from the bottom to the surface) 3 times daily. Once a day, current speed and water depth will also be measured at each sampling station. Measurements at the four stations downstream of the work area will be regularly compared with background upstream observations. Boundaries and tolerance thresholds will be based on values measured in the surrounding environment, along with hydrodynamic characteristics that influence dispersion of suspended solids. As a general rule for all the sites, it is recommended that dredging operations be temporarily suspended when turbidity measured 500 m downstream of the outlet exceeds the mean upstream value by 4 times or more, or when the oxygen content decreases significantly, 75% or less. Temporary suspension of work will be requested until conditions return to normal. The dredging methods will be modified if the tolerance limits are frequently exceeded.

An EMP cost of Tk 500,000 is budgeted for the equipment and tests based on the pilot project experience.

Responsibility: The Department of Environment (DOE) will have primary responsibility for this activity which will also involve staff from the Department of Fisheries (DOF) at the *thana* level.

6.6.3 Fisheries Monitoring Program

The fisheries monitoring program, during construction, will consist of a follow up of fish catch and fish production in the river and in representative *beels* and floodplains, It will include the following main activities:

- monitoring of the Koyer Dhala fishpass structure;
- monitoring of siltation rate in selected *beels*, and
- monitoring of migratory fish movements.

In addition, behaviour and movement of dolphins will be documented through detailed monitoring.

An EMP cost of Tk 2.5 million is budgeted for the fisheries monitoring program. This estimate also includes the cost of a monitoring shed at Koyer Dhala multi-purpose structure.

Responsibility: The DOF will be responsible for this activity.

6.6.4 Agriculture Monitoring Program

Agriculture monitoring will focus on changes in land use and will consider changes in fertility status of the soils. NERP has already completed a semi-detailed land use survey where present use and crops presently grown in each plot have been recorded. The monitoring team will identify any changes in land use which would occur during the construction phase of the project. Mitigation measures will be suggested to the land users and an enhancement program will be proposed. Any change in soil fertility due to the spreading of dredged material will also be noted.

The soil structure, physical and chemical properties, habitat of abiotic complexes, environmental gradients and productivity of the dredged spoil should be examined and monitored. Accordingly, appropriate and cost efficient technologies should be developed on the basis of available resources for the improvement of soil structure and productivity and other environmental gradients.

An EMP cost of Tk 500,000 is budgeted for this activity, including analysis of physical and chemical soil properties.

Responsibility: This activity will be under the responsibility of the Department of Agricultural Extension (DAE).

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6.6.5 Social and Gender Monitoring Program

This component of the Monitoring Plan includes all activities related to socio-anthropological studies, gender assessment and programming, social surveys, public consultations, local institutional assessment, community participation, and social impact monitoring.

The Social and Gender Monitoring Program includes the following activities:

- analysis of social profiles of site communities;
- interaction with concerned communities in laying out platforms, land dedication and formation of village committees;
- implementation of elements of EMP that concern communities;
- application of surface and slope protection measures;
- creation of community-level institutions to maintain the platforms, and
- support of women labour groups in getting organized, in negotiating working conditions, and in establishing the value of work performed.

An EMP cost of Tk 1.5 million is budgeted for social monitoring, including cost of monitoring stations.

Responsibility: The Consultant will be responsible for this activity and will coordinate with the stakeholders committees and relevant GOB officials both at the *thana* and district levels.

6.6.6 Physical Process Monitoring Program

This program primarily involves monitoring physical impacts related to the channel excavation and re-alignment work. The main components include baseline measurements of river discharges, water levels and suspended sediment concentrations, and monitoring physical changes to key habitats. Knowledge of river discharges is a requirement for assessing impacts on water quality and dredging.

There are 3 main components of physical process monitoring:

- hydrometric measurements;
- hydrographic surveys, and
- morphology surveys.

Hydrometric Measurements
During the construction season, discharges and suspended sediment concentrations will be measured at 12 locations, 5 of which will be in addition to BWDBs regular program. These measurements will be continued until the water levels exceed the top of the bank in the monsoon season, and will be used to provide baseline data for assessing changes to water levels and the division of flow along the river before, during, and after the project is completed. The suspended sediment concentrations will be used to help assess the performance of the dredge spoil

confinement chambers. The sediment data will also be used for assessing sediment production from other construction activities such as the manual excavation work. Sediment measurements will be carried out as far downstream as Austagram, 40 km below the Issapur loop cut, in order to assess any potential downstream impacts from project implementation. Details on location, responsibility, type of measurements, duration, and purpose for each station are provided in Table I.30.

Table I.30: Hydrometric Monitoring for Environmental Management Plan

Location	Distance (km)	Status[1]	Measurements[2]			Duration	Purpose
			W	Q	S		
Sheola	269	BWDB	X	X	X	Annual	baseline conditions, dry season impacts
Fenchuganj	217	BWDB	X			Annual	baseline conditions, dry season impacts
Sherpur	177	BWDB	X	X	X	Annual	baseline conditions, dry season impacts
Markuli	133	BWDB	X	X	X	Annual	baseline conditions, dry season impacts
Ajmiriganj	106	BWDB	X	X	X	Seasonal	baseline conditions
Rahala	97	new	X			Seasonal	flow split
Cherapur Khal	90	new	X	X		Seasonal	flow split
Kadamchal	85	new	X	X	X	Seasonal	flow split, sediment impacts
Issapur	72.5	new	X	X	X	Seasonal	flow split, sediment impacts
Baida River	72	new	X	X		Seasonal	flow split
Madna	61	BWDB	X	X		Seasonal	flow split
Austagram	41	BWDB	X	X	X	Seasonal	sediment impacts

Note 1: Status refers to responsibility centre; new means a new centre is required.
Note 2: W=Water Lever; Q=discharge; S=suspended sediment

Hydrographic Surveys

Hydrographic surveys will be made at bi-weekly intervals during construction to assess changes in bottom topography at critical habitat sites downstream of dredging operations. Bed material samples will also be collected to assess possible alteration of the sediment composition. These surveys will be used to assess whether construction activities such as dredging, channel re-alignment or bank protection works are impacting on the extent and quality of important aquatic habitat. For example, it has been suggested that channel re-alignments at the loop cuts could cause deep *duars* to be in-filled, which could adversely affect fisheries habitat. This monitoring will provide the data for determining possible mitigation and compensation requirements.

This activity also includes monitoring the impact of the project on the post-monsoon drainage of the Hakaluki Haor. If it is determined that the drainage is too rapid, mitigative measures will be taken such as the construction of very small retention structures on the main distributaries of the *haor*.

Morphology Surveys
Morphologic monitoring will also be carried out in May and November of each year over the duration of the project's construction. This will involve preparing contour maps of the channel bottom from Markuli to Austagram. The surveys will be compared to assist in interpreting the overall morphologic impacts of the project over time. The surveys will be continued at least 40 km downstream from the Issapur loop cut in order to provide an adequate data for assessing the extent of downstream impacts.

An EMP cost allocation of Tk 1.9 million has been budgeted for the physical process monitoring plan.

Responsibility: This activity will be under the responsibility of the Consultant, assisted by the BWDB.

6.6.7 Long-Term benefits Monitoring Program

The long-term benefits monitoring program will be designed and implemented to monitor the long term impacts of the project on the socioeconomic environment of the KKRB. These impacts are related to benefits in agriculture, fisheries, navigation, employment and income. A tentative methodology, to be confirmed during the early phase of the implementation, is proposed as follow:

Agriculture
The expected outcome of the KKRMP with respect to agriculture is an increase in the production of *boro* paddy. Result indicators and data sources are:

- *boro* paddy estimates from sample area surveys (eg. sample sites considered in the KKRMP analysis on agriculture) and *thana* annual statistics on agriculture, and

- extent of inundated land during pre-monsoon floods. In the KKRMP feasibility study, this parameter has been evaluated indirectly, by hydraulic modelling and spot elevations surveys. In mid-1996, RADARSAT was launched and the imagery of this satellite is ideal to identify water. The possibility of using the digital data of this satellite to map the extent of flooded areas should be investigated in the early phase of the project.

Fisheries
The expected outcome of the KKRMP on fisheries is an increase in the fish catch in *beels* and *khals*. The result indicator is fish catch and the data sources are:

- sample surveys of selected *beels* and *khals*;
- market studies;
- volume of export of regional fish processing plants, and
- DOF annual catch assessment surveys and annual *thana* fisheries survey.

Navigation
Boat traffic (transportation volume of goods and number of passengers) is expected to increase as a result of the KKRMP implementation. The overall impact will be a reduction in river transportation costs. The result indicators to be monitored are:

- number and size of boats on the river network obtained from surveys of major landings;

- number of passengers and volume of cargo, obtained from BIWTA annual statistics and interviews with representatives of boat owners associations, and

- cost of trading good imports obtained from market studies for trading goods.

Employment and Income
One of the major expected benefits of the KKRMP is an increase in employment and income. A measure of this benefit is the number of agricultural labourers and labour rates. The sources of information are sample area surveys of agricultural labour and their pay rates, and *thana* statistics on employment and income.

Roles and Responsibilities
During the later stages of the Implementation Phase and the first two years of the O&M Phase, primary responsibility for monitoring long-term benefits will rest with a Monitoring Consultant who will liaise with and train staff seconded to the project from the following GOB agencies:

- DAE for agriculture monitoring;

- DOF for fisheries monitoring;

- Bangladesh Water Inland Transportation Authority (BIWTA) for the monitoring of navigation long term benefits;

- Bangladesh Bureau of Statistics (BBS) for the long term monitoring of employment and income.

These GOB agencies will in turn be responsible for long-term benefits monitoring in their respective areas of expertise over the remainder of the O&M Phase.

Long-Term Benefit Monitoring Costs
This component of the Monitoring Plan has been costed under the assumption that the program will run for a period of 9 calendar years. It will start with the start of the KKRMP implementation phase, when existing baseline data will be analyzed and supplementary data collected as required, and will end 2 years after the end of the intervention. Thereafter, it will be under the responsibility of GOB. The cost of the program under external funding is estimated as Tk 62.4 million. This cost is not included in the economic analysis as it is not offset by benefits. Detailed cost estimates are presented for this component in Annex L - Project Management Plan.

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6.7 Training Plan

The training plan will be conducted by the project team throughout the project phases. Training and workshops are planned for the project participants at beneficiary, platform committee, *thana*, district and divisional levels. Training and education will take place in pre-construction, construction and O&M phases. These mainly include the following:

- project concept, components and impacts;
- land dedication procedure, responsibilities and obligations;
- environmental issues, hazards, impacts and responsibilities;
- land use planning, topsoil management and productivity;
- establishment of nursery, plantation, reuse and responsibilities;
- platform protection, maintenance and responsibilities;
- development procedure of various committees and their functions;
- organization and strengthening of beneficiary and village committees, and
- relationship between local, *thana*, district and national level.

An EMP cost of Tk 500,000 is budgeted for the training plan.

6.8. EMP Implementation

6.8.1 Proposed Institutional Organization

In order to implement the project activities, including the EMP, an Institutional Organization is proposed. According to the existing institutional context, Bangladesh Water Development Board (BWDB) will be the lead implementing agency for the KKRMP. However, the BWDB is largely a civil engineering organization and it rests within a single ministry. Successful implementation of KKRMP will require coordination with other GOB Ministries, departments and agencies, as well as with NGOs and private organizations working in the area. These include the Bangladesh Inland Water Transportation Authority (BIWTA), the Ministry of Land (MOL), the Local Government Engineering Department (LGED), the Department of Public Health Engineering (DPHE), the Department of Fisheries (DOF),the Ministry of Environment and Forestry (MOEF), the Department of Environment (DOE) who will ensure that the construction activities are executed in accordance with the Project's EMP, the Department of Agricultural Extension (DAE) and the Bangladesh Bureau of Statistics (BBS). Each will be involved in their own area of expertise, but expected to liaise and coordinate with others. There is also a need for full stakeholders participation.

For implementation, it is proposed that the project institutional organization include the following components:

- a National Steering Committee (NSC) which is the highest level formation for overall policy planning, coordination and management of the KKRMP;

- a Project Implementation Office (PIO) which will be the focal point for day to day implementation of the project;

- three field offices located respectively in the lower, middle and upper reaches of the Kalni-Kushiyara River and who will be responsible for actual implementation of activities. Each Field Office will have one or more Sub-Divisions depending on the number of construction sites and the volume of work;

- advisors to the PIO and project offices;

- Project Committees at the district and *thana* levels as recommended in GOB *Guidelines on People's Participation* (MOWR, 1994), and

- Stakeholder Committees which will assume the form of a platform society at the village level for new platform development, or a beneficiary committee formed around a water management structure (e.g. Koyer Dhala), and

- Non Governmental Organization (NGOs) who, although their presence in the project area is at present minimal, will be approached to participate in the community development aspects of the project.

The proposed project organization chart is presented in Figure I.22.

The roles and responsibilities of the organizations associated with the execution of the EMP are presented in Table I.31.

6.8.2 Capacity Development

The economic life of KKRMP is 30 years. After 7 years, and at the end of the intervention phase, external support will be phased out. At that time, all Bangladesh stakeholders will take charge of the project for its O&M phase, from Project Years 8 to 30. The work to be carried out annually during the O&M phase including EMP implementation will in most respects be similar to the intervention itself, but at a reduced scale. It will consist of monitoring the river's behaviour and response to the project intervention; annual maintenance dredging of up to 1 million m^3; land dedication for new or extended platforms, followed by their construction and maintenance; and maintenance of bank protection, levees, and structures. However, there is a risk - or even a probability - that without a targeted capacity development approach, the organization that is developed for implementation is disbanded when the project intervention is completed.

The long-term KKRMP management structure must be designed to ensure that the relevant agencies and organizations continue to be represented, especially after external funding and assistance is withdrawn. In order to carry out both implementation and O&M, a coordinated approach between the institutions directly involved is imperative.

Based on experience with O&M of water resource development projects in Bangladesh, the structure of the project organization during the O&M phase must be defined before implementation. Failure to do this has resulted in lack of ownership by beneficiaries. Fortunately, the work to be carried out during the O&M phase is very much of the same nature as in the implementation, albeit much reduced, so the structure will likely keep the same components, less the funding agencies and consultants. Therefore, it is appropriate at this point to set priorities for capacity development. This will lay the initial groundwork for preparing a capacity development plan, which should be in place by the beginning of implementation.

Table I.31: Roles and Responsibilities for EMP Execution

Organization	Compensation Plan	Environmental Protection Plan	Enhancement Plan	Contingency Plan	Monitoring Plan
Bangladesh Bureau of Statistics (BBS)					Responsible for monitoring of long term employment & income benefits.
Bangladesh Inland Water Transport Authority (BIWTA)					Responsible for monitoring of long term navigation benefits.
Bangladesh Water Development Board (BWDB)	Responsible for: • compensation related to land acquisition; • homestead loss; • crop loss (except related to dyke construction & maintenance).	Responsible for: • local employment; • installation of landing facilities; • development of market facilities (through the contractor); • cash grant for relocation of households; • drainage from adjacent land.	Responsible for purchase of water tolerant trees.		Assist Consultant in physical processes monitoring.
Consultant	Jointly responsible with BWDB for compensation to fishers impacted by loop cuts.	Responsible for: • road shifting; • supplementary tubewells.	Responsible for: • execution of tree planting program; • execution of green manuring program; • drinking water supply; • sanitation program.		Responsible for: • baseline survey & data collection; • social & gender monitoring; • physical processes monitoring.
Contractor		Responsible for: • laying out labour camp in accordance with BWDB regulations; • reinstallation of irrigation networks; • water quality protection measures.		Overall responsibility for contingency plan.	
Department of Agricultural Extension (DAE)					Responsible for: • agriculture monitoring program during construction; • monitoring of long-term agricultural benefits.

Table I.31: Roles and Responsibilities for EMP Execution (Cont'd)

Organization	Compensation Plan	Environmental Protection Plan	Enhancement Plan	Contingency Plan	Monitoring Plan
Department Of Environment (DOE)		Ensure compliance of environmental protection plan with DOE regulations.		Ensure compliance of contingency plan with DOE regulations.	Responsible for water quality monitoring program during construction.
Department of Fisheries (DOF)					Assist DOE in water quality monitoring program during construction. Responsible for monitoring of long-term fisheries benefits.
Department of Public Health Engineering (DPHE)		Assist Consultant for installation of supplementary tubewells.	Assist Consultant for provision of drinking water & sanitation.		
District Commissioner (DC)					Assist Consultant in social & gender monitoring.
Local Government Engineering Department (LGED)			Assist Consultant for protection of new or extended platforms.		
Ministry of Land			Responsible for landless settlement program.		
Platform Owners			Responsible for care of tree planted for platform protection.		
Stakeholders Committees					Assist Consultant in social & gender monitoring.
Thana Nirbahi Officer (TNO)					Assist Consultant in social & gender monitoring.

Capacity development activities of the KKRMP will begin with initial assessments of the priorities for capacity development. These priority setting activities need to pay attention to the following functions:

- Overall coordination of management of water resources throughout the KKRMP, based on existing institutions as much as possible;

- Managing the deposition, development, utilization, protection and maintenance of large amounts of spoil from loop cut construction and river dredging. This function should identity the organizations and people involved, the systematic processes to be established, the skills and knowledge required;

- Continuous monitoring and reporting of river morphology and associated dredging to maintain the river channel depth and velocities required to reduce pre-monsoon flooding and increase river traffic;

- Decentralized effective protection and maintenance of various flood control structures, that along with a cleared river channel, are necessary and sufficient for stopping pre-monsoon flood destruction of crops at least 4 out of every 5 years, and

- Representative coordination through federation of village and other committees at community level to successively higher levels within the Kalni-Kushiyara river basin.

6.8.3 Beneficiaries Participation in the EMP

Based on the experience of the pilot dredging project both the project authorities and the landowners dedicating land for homestead platforms will sign project agreements, outlining the responsibilities and obligations of each party. The agreement shall specify the project's liability for failure of the dyke, in addition to other technical components which will be built during different phases of construction. At all times the project shall take consideration of the community's views within technical limitations. Beneficiary HHs shall assure provision of earth for chamber and outlet construction, top soiling and dyke repairing. Landowners shall provide 5 m of space outside the dyke for tree plantation. Beneficiary HHs shall assure their contribution of labour and materials to soft dyke protection for 3 years. Community beneficiaries shall assure protection of project materials during the implementation and O&M periods.

6.8.4 Institutional Aspects of Land Preparation

Land acquisition will require the assistance of government agencies. Following are the main issues related to land acquisition and proposed strategy.

Issapur Loop Cut
During the project preparation period, it is proposed that national and local elected representatives be invited to participate in a series of workshops, outlining the scope of the project including its preparation, construction and maintenance phases. The respective Member of Parliament and local politicians will be briefed and requested to discuss the project and its compensation, mitigation and enhancement packages with the people of Chowdanta, Bhatura, Issapur and Kalma. The Ministry of Land Administration under the District Commissioner (DC) of Kishoreganj with the concerned government departments at Astagram Thana will be requested to execute the land

acquisition through purchase from individual landowners. These offices should carry out a detailed survey of landowners, following the engineering survey to mark the required land within the loop cut. The Land and Water Use Directorate of the BWDB will be requested to appoint staff to work with field teams in land documentation, survey, community briefing and preparation.

Abdullapur Dokkhin Char Platforms

Twelve Khas Land Platforms are to be constructed at Abdullapur Dokkhin Char. There are no nearby villages. The platforms will be constructed mostly on *khas* land, which is presently being cultivated by approximately 800 households from Abdullapur village. A preliminary field survey indicates that none of the land users have title. The extent of court claims on this *khas* land is unknown at this time.

The respective Member of Parliament and local politicians will be briefed on the planned engineering intervention and its accompanying land and social development requirements.

The Kishoreganj Deputy Commissioner, under authorization from the Ministry of Land, with the concerned government departments at Astagram Thana, will be requested to take possession of 44 ha of *khas* land for the construction of twelve platforms at Abdullapur Dokkhin Char. When the detailed engineering survey has been completed, these offices should carry out a detailed survey of farmers using the *khas* land. Any land disputes or court cases in regards to this *khas* land should be settled. Elected representatives should be involved in dealing with occupants who are to be displaced from the *khas* land they have been farming. The Land and Water Use Directorate of the BWDB will be requested to field staff to work with the documentation and survey teams. It is anticipated that two years will be required to execute these land arrangements.

Platform land distribution and re-settlement of the Abdullapur Dokkhin Char homestead should be conducted by a committee under the Kishoreganj Deputy Commissioner, through the Ministry of Land, with the assistance of project personnel. Development of a poverty alleviation program for destitute and landless households could be implemented through the same government bodies with donor support for program funding and technical assistance.

Katkhal Loop Cut

During the project preparation period, it is proposed that national and local elected representatives will be invited to participate in a series of workshops, outlining the scope of the project including its preparation, construction and maintenance phases. The respective Member of Parliament and local elected representatives will be briefed and requested to discuss the project and its compensation, mitigation and enhancement packages with the people of Shantipur, Katkhal, Shahebnagar, Bishorikona and Nayakurakandi.

The Kishoreganj Deputy Commissioner, under authorization from the Ministry of Land, with the concerned government departments at Mitamain Thana, will be requested to execute the land acquisition through purchase from individual landowners or re-allocation of *khas* land. Following the engineering survey to mark the required land within the loop cut, these offices should carry out a detailed survey of landowners and *khas* land users. The Land and Water Use Directorate of the BWDB will be requested to work with field teams in land documentation, survey and community briefing.

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An Institutional Strategy to Obtain the Anandapaur Site

The Anandapur *khas* land problem is centred around 31 acres (equivalent to 13 ha) of *khas* land which has been awarded, in 1989, by the government to 31 landless households, but which has always been forcefully occupied by elite landlords, mainly from neighbouring Kakailseo village.

The project proposes to dredge the Kalni River and use the spoil to construct a new platform known as the Anandapur site. This platform will be used to settle destitute and landless households, including the "Anandapaur landless".

To achieve this, the Ministry of Land Administration would be requested to purchase the 13 ha of *khas* land from the 31 "Anandapur landless" who technically own the land but are not able to occupy it and are therefore unwilling to dedicate it. When government re-acquires the land, the 18 elite landowners will lose any claims they may have for occupancy.

In an undeveloped state, the 13 ha of former *khas* land is very low, unsuitable for habitation. During the monsoon, this land is under 2 to 3 m of water. If they ever were to gain occupancy, the "Anandapur landless" can only use their land for cultivation of vegetables and some local variety rice during the dry season. If the "Anandapur landless" are to re-settled on a flood-secure platform, an allocation of 100 decimals of homestead land per household is difficult to justify .

The Ministry of Land Administration will be requested to allocate 10 decimals of newly developed homestead land to approximately 250 destitute and landless households, including the original 31 "Anandapur landless" households. The criteria for land allocation can follow the precedent set for landless resettlement in other government projects. Destitute families, eroded from Shahebnagar may be candidates for re-settlement on the Anandapur platform.

The project will require extensive support from the Deputy Commissioner of Habiganj and the Ministry of Land Administration. They will be provided with institutional support to assist them in re-acquiring 13 ha of previously allocated *khas* land at Anandapur. It is anticipated that up to two years may be required for these arrangements.

To achieve settle landless households on *khas* land, the project will require the support of political parties at national, regional and local levels. The respective Member of Parliament and local politicians will be briefed on the planned engineering intervention and the project's requirements for the *khas* land at Anandapur. They will be requested to mediate with the landed groups at Kakailseo to withdraw the civil case and the landless group at Anandapur to agree to exchange 100 decimals of insecure, low land for 10 decimals of secure high land.

If the Ministry of Land Administration is unable to obtain land for the Anandapur site, proceedings to obtain alternative *khas* land at the Kamalpur site can be undertaken. The platform size and the allocation of land to poor households would be similar to the Anandapur site.

6.8.5 Implementation Schedule

The project implementation schedule, including EMP activities is presented in Figure I.14. In this figure, a rolled up task is one which is executed in stages, eg. ID 8, Stakeholders Surveys/Committee.

7. RESIDUAL IMPACTS

The Residual Impacts Evaluation Matrix presented in Table I.32 presents a summary of the residual impacts of the project. The residual scoring is based on the methodology described in Section 6.6, taking into account the proposed mitigation and compensation measures. The detailed residual impact analysis is presented in Tables I.33 and I.34. The following sections present a summary of the main anticipated negative and positive impacts of the projects.

The presence of an Improved Channel (including loop cuts and bank protection structures) as well as the resulting new hydraulic conditions are likely to positively modify the environment in the long-term at the regional level.

The presence and use of the new platforms and upgraded land as well as the settlement and land use pattern modifications due to loop cuts are likely to modify the environment at the community or local level.

River Morphology: The proposed project intervention will stabilize the Kalni-Kushiyara River. In particular, it will prevent the enlargement of Cherapur Khal, which would erode homestead, silt-up the Dhaleswari and Baida channels, and the lower reach of the Baulai River.

Hydrology and Hydraulics: The proposed project interventions will significantly improve the flooding conditions during the pre-monsoon. The analysis even suggest that the project will continue to improve the flooding situation during the extreme events that exceed the adopted design criteria of confining the 1:5 year pre-monsoon flood within the river banks.

Open Water Bodies: Surface water availability in the main river and in the permanent water bodies will improve in the future condition. The depth of water will increase over 2 m during the critical month of January and February. This suggests that the increased depth and increased cross-section will increase the shortage volume by the backwater effect of the Upper Meghna River. It is expected that water availability will be maintained to its present level.

Erosion and Sedimentation Process: River improvements are expected to impact the existing infrastructures by reducing the current bank erosion rate of 55 ha/yr, by reducing homestead damage along the river banks due to the reduction of bank erosion, by reducing high velocity spills and breaches through the river banks, and by reducing the siltation of *beels*.

Drainage: The project will facilitate post-monsoon drainage and as a result allow early plantation to an area of about 14,100 ha, particularly in the lower elevation, of the project area. Early plantation will make the crop less vulnerable to pre-monsoon floods and accumulated rainfall inundation.

Irrigation: The project will make substantial positive impacts on irrigation water supplies by increasing the channel capacity, decreasing the risk of pre-monsoon spills through the distributaries. The Issapur loop cut will reduce the cost of irrigation water supplies and the Katkhal loop cut will also have positive impact on the existing irrigation systems. In addition, the installation of two drainage and flushing regulators is proposed, the first at Koyer Dhala and the second at the offtake of Barabaria Khal. These regulators will facilitate drainage from and irrigation water supply to the Koyer Dhala and Barabaria areas. Currently, these areas suffer from inadequate dry season irrigation water supply, which can be easily met from the Kalni River.

Table I.32: Residual Impacts Evaluation Matrix

Important Environmental Component (IEC)	Impact Score before EMP				Residual Impact Score			
	Implementation		O&M		Implementation		O&M	
	Earth Work and Pre-dredging	Excavation of River Bed and Loop Cuts	New River Channel	New Setting and Settlement Pattern	Earth Work and Pre-dredging	Excavation of River Bed and Loop Cuts	New River Channel	New Setting and Settlement Pattern
River Morphology			+5				+5	
Hydrology & Hydraulics			+5				+5	
Open Water Bodies			+5				+5	
Erosion & Sedimentation Processes		0	+5	0		0	+5	0
Drainage	-2		+6	-2	0		+6	0
Irrigation	-2		+6	-2	0		+6	0
Aquatic Habitat & Fisheries	-3	-3	+6		-2	-2	+7	
Terrestrial Habitat	-3		+4	+4	0		+4	+4
Land Use & Settlement	-4	-3	+6		-3	-2	+6	
Issapur Loop Cut Site				-7				-4
Dhaleswari Dredging & Fill Sites				+7				+7
Katkhal Loop Cut Site				-7				-4
Land Dedicated Platform Sites				+7				+8
Khas Land Platform Sites				+7				+8
Education and Health	-4	-3	+7	+7	-3	-2	+7	+7
Status of Women	+5		+7	+7	+5		+7	+7
Land Quality & Productivity	-3	-3	+7	-4	0	-2	+7	-4
Navigation		-3	+6			-2	+6	
Employment & Economic activity	+5	+4	+6	+5	+5	+4	+6	+5
Equity			+7	+6			+7	+6

Table I.33: Detailed Residual Impact Analysis - Implementation Phase

IIM No.	Impact on IEC	Inten-sity	Mag.	Prob.	Scale	Importance of the change	Value of IEC	Dur-ation	Impact Scoring	Mit/Comp/ Enhance	Resid. Scoring	Comment
	EARTH WORK & PRE-DREDGING											
1.	Drainage	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2	Compens.	0	Residual value=0 through compensation.
2.	Irrigation	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2	Compens.	0	Residual value=0 through compensation.
3.	Aquatic Habitat & Fisheries	Little	Low	Like	(Loc) Site	(Little Imp.) Very little imp.	Med	Short	-3	Mit in part	-2	Mitigation modifies Scale from Local to Site specific.
4.	Terrestrial Habitat	Mid	Med	Like	Site	Little Imp.	Med	Short	-3	Compens.	0	Residual value=0 through compensation.
5.	Land Use & Settlements	Little	(Med) Low	(Unav) Like	Site	(Little Imp.) Very little imp.	High	Mid	-4	Mit in part	-3	Magnitude decreases from Med to Low, thus Scoring decreases.
6.	Education & Health	Little	Low	Like	(Loc) Site	(Little Imp.) Very little imp.	High	Mid	-4	Mit in part	-3	Mitigation modifies Scale from Local to Site specific.
7.	Status of Women	Little	Low	Like	Reg	Much Imp.	High	Mid	+5	N/A	+5	Project already includes recommendations.
8.	Land Quality & Productivity	Little	Low	Like	Site	Very Little Imp.	Med	Mid	-3	Compens.	0	Residual value=0 through compensation.
9.	Employment & Economic Act.	Little	Med	Unav	Reg	Very Imp.	Med	Mid	+5	Local Lab.	+5	Local labour is already included in the project.
	EXCAVATION OF RIVER & LOOP CUTS											
10.	Erosion & Sedimentation		No						0		0	
11.	Aquatic Habitat & Fisheries	Little	Low	Like	(Loc) Site	(Little Imp.) Very little imp.	Med	Short	-3	Mitigable	-2	Mitigation modifies Scale from Local to Site specific.
12.	Land Use & Settlements	Little	(Med) low	(Unav) like	Site	(Little Imp.) Very little imp.	High	Short	-3	Mit in part	-2	Prob. decreases from Unav. to Likely, Magnitude decreases from Med to Low, Scoring decreases.
13.	Education & Health	(Large) Mid	(Med) Low	Unlike	Site	(Little Imp.) Very little imp.	High	Short	-3	Mitigable	-2	Intensity decreases from Large to Mid, Magnitude decreases from Med to Low, Scoring decreases.
14.	Land Quality & Productivity	(Large) Mid	(Med) Low	Unlike	Site	(Little Imp.) Very little imp.	Med	Short	-3	Mitigable	-2	Intensity decreases from Large to Mid, Magnitude decreases from Med to Low, Scoring decreases.
15.	Navigation	Little	Low	Like	(Loc) Site	(Little Imp.) Very little imp.	Med	Short	-3	Mit in part	-2	Mitigation modifies Scale from Local to Site specific.
16.	Employment & Economic Act.	Little	Low	Like	Reg	Much Imp.	Med	Mid	+4	Local Lab.	+4	Local labour is already included in the project.

Table I.34: Detailed Residual Impact Analysis - O&M Phase (Page 1 of 2)

IIM No.	Impact on IEC	Inten-sity	Mag.	Prob.	Scale	Importance of the change	Value of IEC	Dur-ation	Impact Score	Mit/Comp/ Enhance	Resid. Score	Comment
IMPROVED RIVER CHANNEL												
17.	River Morphology	Little	Low	Like	Reg	Much Imp.	Low	Long	+5	N/A	+5	No change
18.	Hydrology & hydraulics	Little	Low	Like	Reg	Much Imp.	Low	Long	+5	N/A	+5	No change
19.	Open Water Bodies	Little	Low	Like	Reg	Much Imp.	Low	Long	+5	N/A	+5	No change
20.	Erosion & Sedimentation	Little	Low	Like	Loc	Much Imp.	Low	Long	+5	N/A	+5	No change
21.	Drainage	Little	Low	Like	Reg	Much Imp.	Med	Long	+6	N/A	+6	No change
22.	Irrigation	Little	Low	Like	Reg	Much Imp.	Med	Long	+6	N/A	+6	No change
23.	Aquatic Habitat & Fisheries	(Little) Mid	(Low) Med	Like	Reg	(Much Imp.) Very imp.	Med	Long	+6	Enhance	+7	Intensity increases from Little to Mid, Magnitude increases from Low → Med through enhancement
24.	Terrestrial Habitat	Little	Low	Like	Site	Very Little Imp.	Med	Long	+4	Monit.	+4	No change
25.	Land Use & Settlements	Little	Low	Like	Loc	Little Imp.	High	Long	+6	N/A	+6	No change
26.	Education & Health	Little	Low	Like	Reg	Much Imp.	High	Long	+7	N/A	+7	No change
27.	Status of Women	Little	Low	Like	Reg	Much Imp.	High	Long	+7	N/A	+7	No change
28.	Land Quality & Productivity	Mid	Med	Like	Reg	Very Imp.	Med	Long	+7	N/A	+7	No change
29.	Navigation	Little	Low	Like	Reg	Much Imp.	Med	Long	+6	N/A	+6	No change
30.	Employment & Economic Act.	Little	Low	Like	Reg	Much Imp.	Med	Long	+6	N/A	+6	No change
31.	Equity	Little	Low	Like	Reg	Much Imp.	High	Long	+7	N/A	+7	No change

Table I.34: Detailed Residual Impact Analysis - O&M Phase (Page 2 of 2)

IIM No.	Impact on IEC	Inten-sity	Mag.	Prob.	Scale	Importance of the change	Value of IEC	Dur-ation	Impact Score	Mit/Comp/ Enhance	Resid. Score	Comment
NEW SETTING AND SETTLEMENT PATTERNS												
32.	Erosion & Sedimentation		No						0		0	
33.	Drainage	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2	Mit/Monit	0	Residual value=0 through mitigation
34.	Irrigation	Little	Low	Like	Site	Very Little Imp.	Med	Short	-2	Mit/Monit	0	Residual value=0 through mitigation
35.	Terrestrial Habitat	Little	Low	Like	Site	Very Little Imp.	Med	Long	+4	N/A	+4	No change
36.	Issapur loop Cut Site	Little	(Med) Low	(Unav) Like	Loc	(Much Imp.) Little imp.	High	Long	-7	C/Mit/En	-4	Prob. decreases from Unav. to Likely, Magnitude decreases from Med to Low through mitigation, duration decreases from Long to Mid through enhancement
37.	Dhaleswari Dredging & Fill Site	Mid	Med	Like	Loc	Much Imp.	High	Long	+7	N/A	+7	No change
38.	Kathkal Loop Cut Site	Little	(Med) Low	(Unav) Like	Loc	(Much Imp.) Little imp.	High	Long	-7	C/Mit/En	-4	Prob. decreases from Unav. to Likely, Magnitude decreases from Med to Low through mitigation, duration decreases from Long to Mid through enhancement
39.	Land Dedicated Platform Sites	(Little) Mid	(Med) High	Unav	Loc	(Much Imp.) Very imp.	High	Long	+7	Enhance	+8	Intensity increases from Little to Mid, Magnitude increases from Med→ High through enhancement
40.	*Khas* Land platform Sites	(Little) Mid	(Med) High	Unav	Loc	(Much Imp.) Very imp.	High	Long	+7	Enhance	+8	Intensity increases from Little to Mid, Magnitude increases from Med to High through enhancement
41.	Education & Health	Little	Low	Like	Reg	Much Imp.	High	Long	+7	N/A	+7	No change
42.	Status of Women	Mid	Med	Like	Loc	Much Imp.	High	Long	+7	N/A	+7	No change
43.	Land Quality & Productivity	Little	Low	Like	Site	Very Little Imp.	Med	Long	-4	N/A	-4	No change
44.	Employment & Economic Act.	Little	Low	Like	Loc	Little Imp.	Med	Long	+5	N/A	+5	No change
45.	Equity	Little	Low	Like	Loc	Little Imp.	High	Long	+6	N/A	+6	No change, project is already aimed at poverty alleviation. Landless resettlement is already part of the project

The Koyer Dhala multi-purpose regulator will be installed with flushing facilities for irrigation during the dry season. The structure will provide irrigation water supplies to the Old Kushiyara Irrigation Scheme, Jhingari Nadi Irrigation Scheme and fallow lands along the Baniachang-Ajmiriganj road during the dry season.

Aquatic Habitat and Fisheries: The total fish production of the project area will increase compared to the FWO condition. An enhancement program aimed at increasing fish production in the project area is proposed.

The Koyer Dhala multi-purpose structure, includes a fishpass and will mitigate the affects of the project on fish migration from river to flood plain during the pre-monsoon season.

Terrestrial Habitat and Wetlands: The project will have substantial positive impacts on homestead vegetation by offering increased security against flooding. Homestead vegetable gardens are expected to occupy some 25% of the new platform areas. About 242 ha of new land will be available for vegetable gardening.

Land Use and Settlement: The project will create new or extend existing village platforms from the dredge spoil, providing extra space of homestead and improving living conditions. This IEC has been broken down into 5 sub-components in order to take into account some very site-specific impacts:

- When the Issapur Loop Cut is constructed and the Dhaleswari River is closed at Issapur, dredging will be required in the Dhaleswari Channel. With the dredged spoil, a channel along the right bank of the Dhaleswari River at Noorpur and Baluchar will be filled. This activity is supported by farmers because more land will become available;

- The impacts on land use and settlement at the site of the Issapur and Katkhal loop cuts are unavoidable and of mid-magnitude, affecting locally some communities on the long-term. In order to minimize those impacts, compensation is required for approximately 160 landowners in Chowdanta and Bhatura for loss of land as their primary economic resource. In addition to compensation, a certain number of mitigative measures will be implemented, reducing the magnitude of the negative impact;

- The impact on Land Dedicated Platforms will be positive, of mid-magnitude and will benefit local communities, and

- The project intends to relocate landless families on the *Khas* Land Platforms. This is a positive impact of high magnitude through of enhancement measures.

Over the years, homestead land has been continuously eroded by waves and this is expected to continue once the project is completed. Whereas in the past the eroded material was of the same composition as the one present in farming plots, in the future sandy dredged river spoils will be eroded and deposited on those plots resulting in significant deterioration of agricultural soils if no protection measure is taken to prevent erosion. Both soft and hard platform protection will be provided as component of the project to prevent erosion and to protect land quality and productivity.

Education and Health: Improvement in the general economic condition of the people and better living conditions will have positive impact on ability and attitude of the people toward education and will contribute in achieving the national goal for universal coverage of potable water. Protective measures for homestead platforms will allow more space for construction of latrine on a permanent basis. Thus the scope for more water-seal sanitary latrines will be expanded. This will also improve the state of sanitation through proper disposal of human waste and will have direct impact on the general state of health.

Status of Women: Improved liveability of homestead platforms will facilitate more home-based activities for women, particularly in the fields of homestead gardening, poultry rearing, and cottage industries. Homestead is literally the world of women. Safe platforms will enhance the security of women to a significant extent in both tangible and intangible terms in the sense that it will enhance the scope for more economic activities and also more comfort in performing household chores.

Land Quality and Productivity: Crop damage due to over bank spills inundation and breaches in the river banks during the pre-monsoon season will be reduced and the flood-free land area will be increased. Based on a 1:5 year pre-monsoon flood, the annual cereal production is expected to increase by about 111,000 tonnes, from 782,000 tonnes (FWO) to 893,000 tonnes (FW), as a result of the project, an increase of about 14%. Non-cereal production is expected to decrease from 34,000 tonnes (FWO) to 28,000 tonnes (FW), a reduction of about 17%. This results from a decrease of the non-cereal cultivated area and implies a decrease in the availability of non-cereal. In spite of this negative effect, the overall impact on land productivity is positive.

Navigation: One of the most important impact of the project is on navigation and water transport as it will improve and upgrade the presently seasonal class-IV (LAD=1.5 m) navigation channel to a class-II (LAD=2.4 m) navigation channel from Fenchuganj up to Astagram to meet the Upper Meghna. This will make the Kalni-Kushiyara river navigation route an integral part of the national waterways network.

The Koyer Dhala multi-purpose structure, includes navigation facilities for medium size country boat.

Employment & Economic Activity: With completion of the project there will be a chain of favourable impacts on the activities of various water related production sectors, agriculture, fisheries, etc. and also the service sectors, navigation and water transport services, trade and commerce, flood-free housing further impacting on sanitation and health, education and so on.

Enhanced conditions will benefit the population as improved irrigation and drainage of the deeply flooded areas will contribute to increase the overall quality of life, particularly through improvement in health and nutritional status of the people. If a 10% increase in income is assumed for all households, the proportion of the population below the poverty line, both absolute and hard-core poverty, will be reduced by 5%.

The end result will be more production in all concerned fields of activities creating tradable surpluses leading to higher income, higher consumption and improvement in socio-economic welfare of the communities in the area. Increase in aggregate employment and income will contribute to attain a higher standard of living.

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Equity: The benefits of the project will accrue to different sections of the society in varying proportions. The initiatives will benefit mostly the land-owners. However, the strategic thrusts on improved liveability of rural settlements will benefit all strata of the population with optimum equity.

8. EMP COSTS

Total EMP costs, during the implementation phase, are estimated to be Tk 57.6 million. A breakdown of the costs by component is shown in Table I.35. These costs were estimated on the basis of FPCO *Guidelines* (FPCO, 1992 a)) and pilot project experience.

Table I.36 shows that annual EMP costs, during the O&M phase, are estimated to be Tk 1.75 million during Years 8 to 10, Tk 1.58 million during Years 11 to 13 and Tk 1.40 million during Years 14 to 30. These costs were estimated by prorating implementation costs based on the number and size of disposal sites during the O&M phase of the project. It should be noted that the cost of topsoil acquisition has been estimated as part of the capital cost both for the implementation and the O&M phases (Annex E - Economics, Appendix E.1)

Table I.35: EMP Costs During the Implementation Stage

Item		Unit	Quantity	Unit Rate (Tk)	Total (millionTk)
1	**COMPENSATION**				
1.1	Crop loss (outlets)	Platform	51	5,000	0.25
1.2	Crop Loss (Shore pipelines)	Platform	51	5,000	0.25
1.3	Homestead loss (garden, latrine, pond)	Platform	32	5,000	0.16
	SUB TOTAL - COMPENSATION				**0.66**
2	**MITIGATION**				
2.1	Cash grants for land replacement and other vocations for Issapur L.C.	ha	216	180,000	7.78
2.2	Cash grants for land replacement and other vocations for Katkhal L.C.	ha	195	125,000	4.88
2.3	River *Ghats* for Bhatura& Chowdanta	*Ghat*	4	100,000	0.40
2.4	Market for Chowhanta	LS			1.48
2.5	Relocation of Shahebnagar HHs	HH	20	8,000	1.60
2.6	Drainage from adjacent lands	LS			2.00
2.7	Road shifting	LS			0.50
2.8	House shifting	LS			0.10
2.9	Supplementary tubewells	Tubewell	100	8,000	0.80
2.10	Water Quality Protection Measures Bamboo Barriers and Silt Curtains	LS			1.10
	SUB TOTAL - MITIGATION				20.63

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Table I.35: EMP Costs (continued)

	Item	Unit	Quantity	Unit Rate (Tk)	Total (million Tk)
3.0	**ENHANCEMENT**				
3.1	Plantation of purchased trees	Tree	20,000	63	1.26
3.2	Nurseries development				0.85
3.3	Purchase of saplings	Sapling	100,000	7.5	0.75
3.4	Adult-size tree purchase	Tree	100,000	10	1.00
3.5	Tree care	Tree	30,000	36	1.08
3.6	Bamboo baskets	Basket	100,000	10	1.00
3.7	Straw (Green manuring)	ha	148	25000	3.70
3.8	Dhaincha (soil enrichment)	ha	247	800.	0.20
3.9	Green manuring long-term cost	Year	10	30000	0.30
3.1	Shrubs & grasses	ha	9.5	5000	0.05
3.11	*Chailla* production	ha	138	10,000	1.38
3.12	Tubewells on new platforms	Tubewell	135	8,000	1.08
3.13	Latrines	Latrine	6,275	600	3.77
3.14	Landless Settlement	HH	1,250	10,000	12.50
	SUB TOTAL - ENHANCEMENT				**28.91**
4.0	**MONITORING**				
4.1	Fisheries Monitoring Program	LS			2.50
4.2	Water Quality Monitoring Program	LS			0.50
4.3	Agricultural Monitoring Program	LS			0.50
4.4	Social and Gender Monitoring Program	LS			1.50
4.5	Engineering Monitoring	LS			1.90
	SUB TOTAL - MONITORING				**6.90**
5.0	**TRAINING PLAN**				
5.1	Pre-construction, Construction and Post-construction	LS			0.50
	GRAND TOTAL - EMP				**57.60**

Table I.36: EMP Costs During the O&M Phase

Years	Dredged Volume (Mm^3/year)	Disposal Site Area (ha/year)	Mitigation (million Tk)	Compensation (million Tk)	Enhancement (million Tk)	Total (million Tk)
8-10	1.0	22.22	0.05	0.57	1.13	1.75
11-13	0.9	20.00	0.05	0.52	1.01	1.58
14-30	0.8	17.78	0.04	0.45	0.91	1.40

9. CONCLUSION

The potential benefits of the proposed project to the socio-economic infrastructure of the region are numerous and varied because it is designed to be a multiple-use project which will positively impact on a very large and diverse number of beneficiaries in terms of sources of income increased employment opportunities, relative incomes and gender. It is also explicitly designed to 1) assist in empowering the "poorest of the poor" 2) promptly stop potentially irreversible environmental degradation (which has an immeasurably high social cost).

We believe this project is environmentally sustainable under the following conditions:

- careful monitoring and baseline data collection is carried out;
- people is consulted and involved in all the project implementation phases;
- people negatively impacted by the project are adequately compensated, in particular the farmers of Chowdanta and Bhatura who will loose some of their land and the people who will have to be relocated, and
- all proposed mitigation and enhancement programs are conducted as integral constituents of the project.

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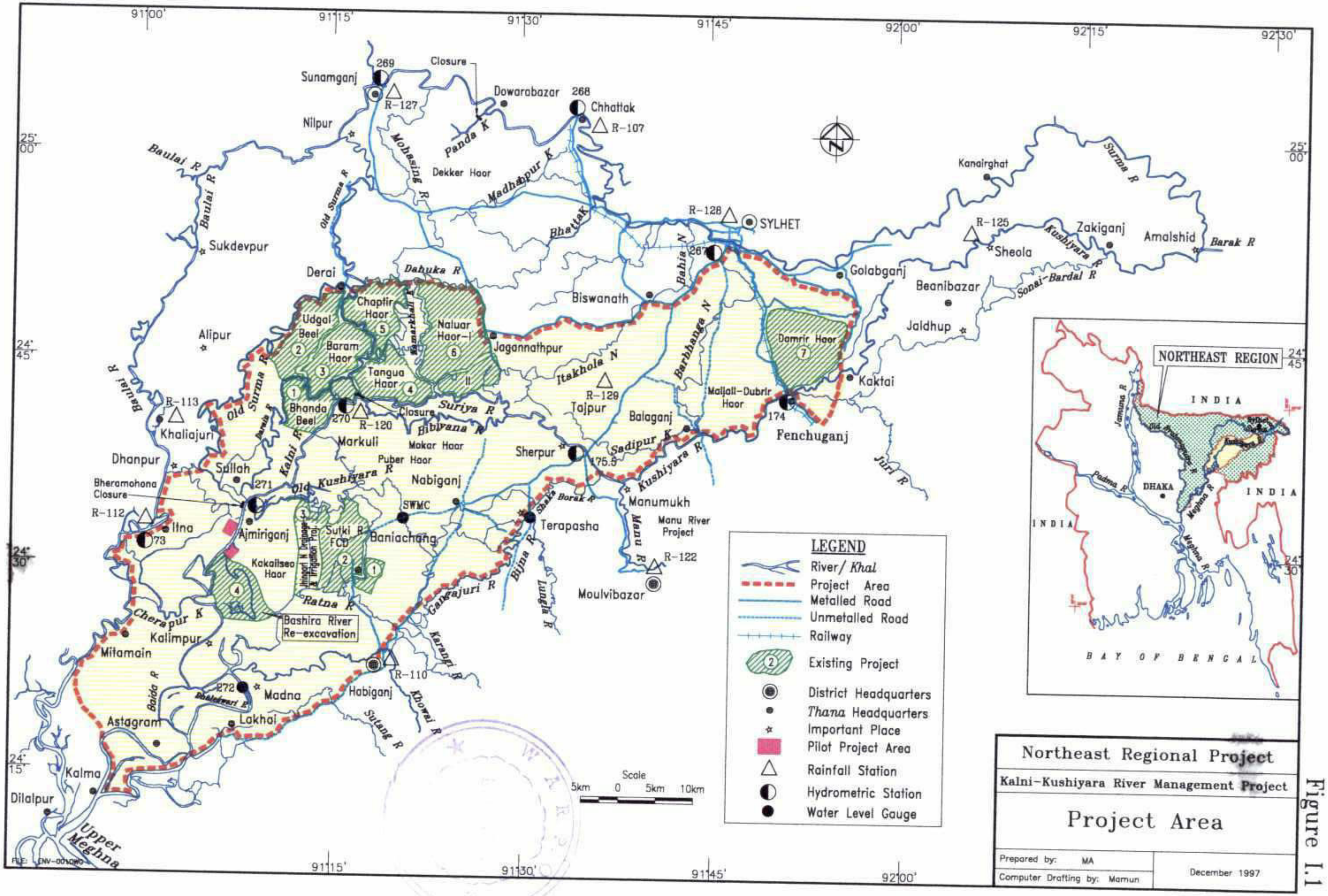
FIGURES

Figure I.1



Northeast Regional Project

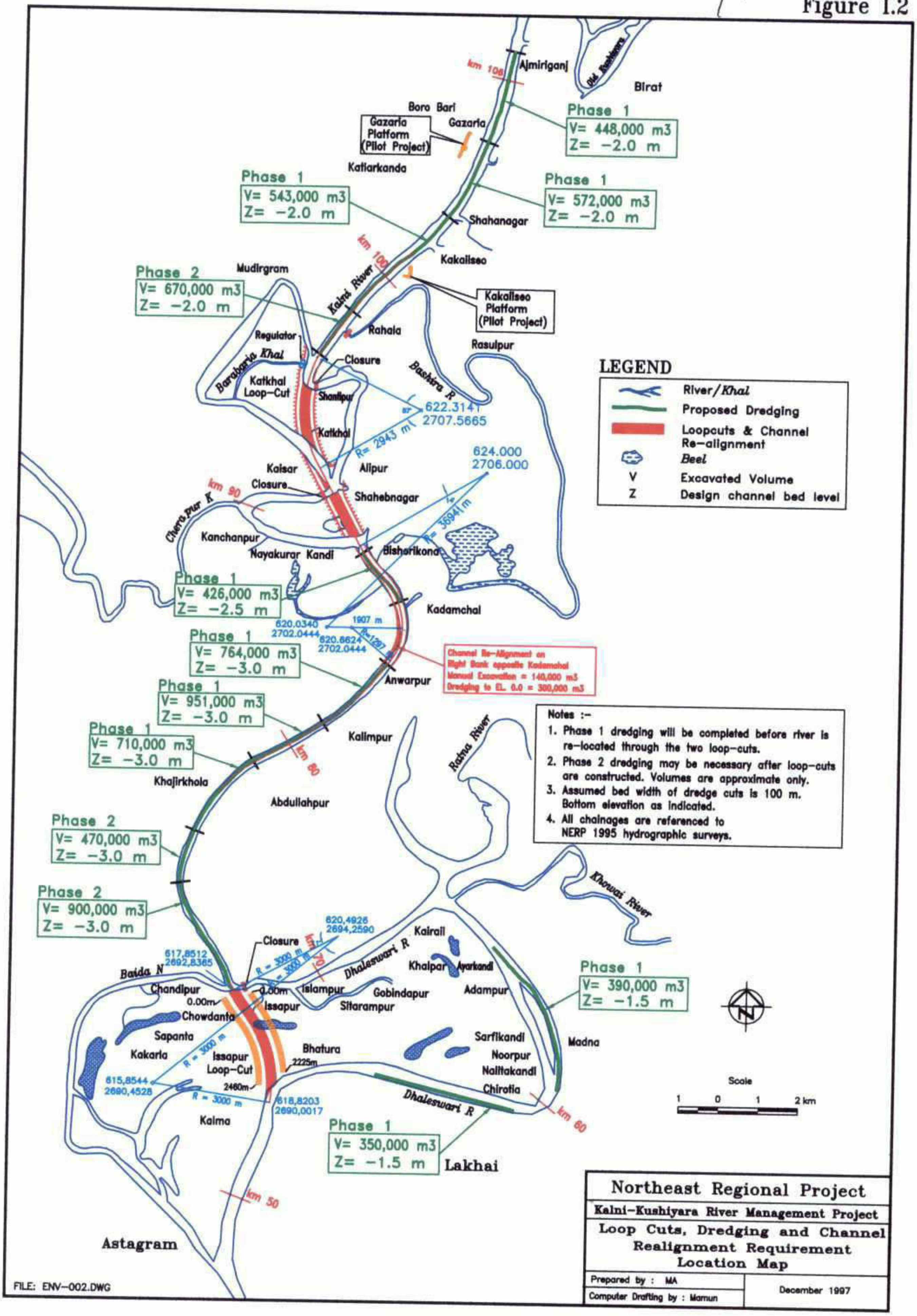
Kalni-Kushiyara River Management Project

Project Area

Prepared by: MA
Computer Drafting by: Mamun

December 1997

Figure I.2



Ajmiriganj
km 106
Old Kushiyara
Birat
Boro Bari
Gazaria
Gazaria Platform (Pilot Project)
Katiarkanda
Phase 1 V= 448,000 m3 Z= -2.0 m
Phase 1 V= 543,000 m3 Z= -2.0 m
Phase 1 V= 572,000 m3 Z= -2.0 m
Shahanagar
Kakaliseo
km 100
Kalni River
Kakaliseo Platform (Pilot Project)
Phase 2 V= 670,000 m3 Z= -2.0 m
Mudirgram
Rahala
Rasulpur
Regulator
Baraharia Khal
Closure
Bashira R
Katkhal Loop-Cut
Shantipur
Katkhal
622.3141 2707.5665
R= 2943 m
624.000 2706.000
Kaisar
Closure
Alipur
km 90
Cherapur K
Shahebnagar
R= 3694 m
Kanchanpur
Nayakurar Kandi
Bishorikona
Phase 1 V= 426,000 m3 Z= -2.5 m
Kadamchal
620.0340 2702.0444
1907 m
620.8624 2702.0444
Phase 1 V= 764,000 m3 Z= -3.0 m
Channel Re-Alignment on Right Bank opposite Kadamchal Manual Excavation = 140,000 m3 Dredging to EL 0.0 = 300,000 m3
Anwarpur
Phase 1 V= 951,000 m3 Z= -3.0 m
Kalimpur
Ratna River
Phase 1 V= 710,000 m3 Z= -3.0 m
km 80
Khajirkhola
Abdullahpur
Phase 2 V= 470,000 m3 Z= -3.0 m
Phase 2 V= 900,000 m3 Z= -3.0 m
Khowai River
620.4926 2694.2590
Kairail
Closure
km 70
R = 3000 m
617.8512 2692.8365
Baida N
Dhaleswari R
Khalpar
Ayarkandi
Chandipur
0.00m
Islampur
Gobindapur
Adampur
0.00m
Issapur
Sitarampur
Chowdanta
Phase 1 V= 390,000 m3 Z= -1.5 m
Sapanta
Sarfikandi
Kakaria
Issapur Loop-Cut
Bhatura
2225m
Madna
Noorpur
Nalitakandi
615.8544 2690.4528
2460m
Chirotia
R = 3000 m
618.8203 2690.0017
Dhaleswari R
km 60
Kaima
Phase 1 V= 350,000 m3 Z= -1.5 m
Lakhai
km 50
Astagram
LEGEND
River/Khal
Proposed Dredging
Loopcuts & Channel Re-alignment
Beel
V Excavated Volume
Z Design channel bed level
Notes :-
1. Phase 1 dredging will be completed before river is re-located through the two loop-cuts.
2. Phase 2 dredging may be necessary after loop-cuts are constructed. Volumes are approximate only.
3. Assumed bed width of dredge cuts is 100 m. Bottom elevation as indicated.
4. All chainages are referenced to NERP 1995 hydrographic surveys.
N
Scale
1 0 1 2 km
Northeast Regional Project
Kalni-Kushiyara River Management Project
Loop Cuts, Dredging and Channel Realignment Requirement Location Map
Prepared by : MA
Computer Drafting by : Mamun
December 1997
FILE: ENV-002.DWG

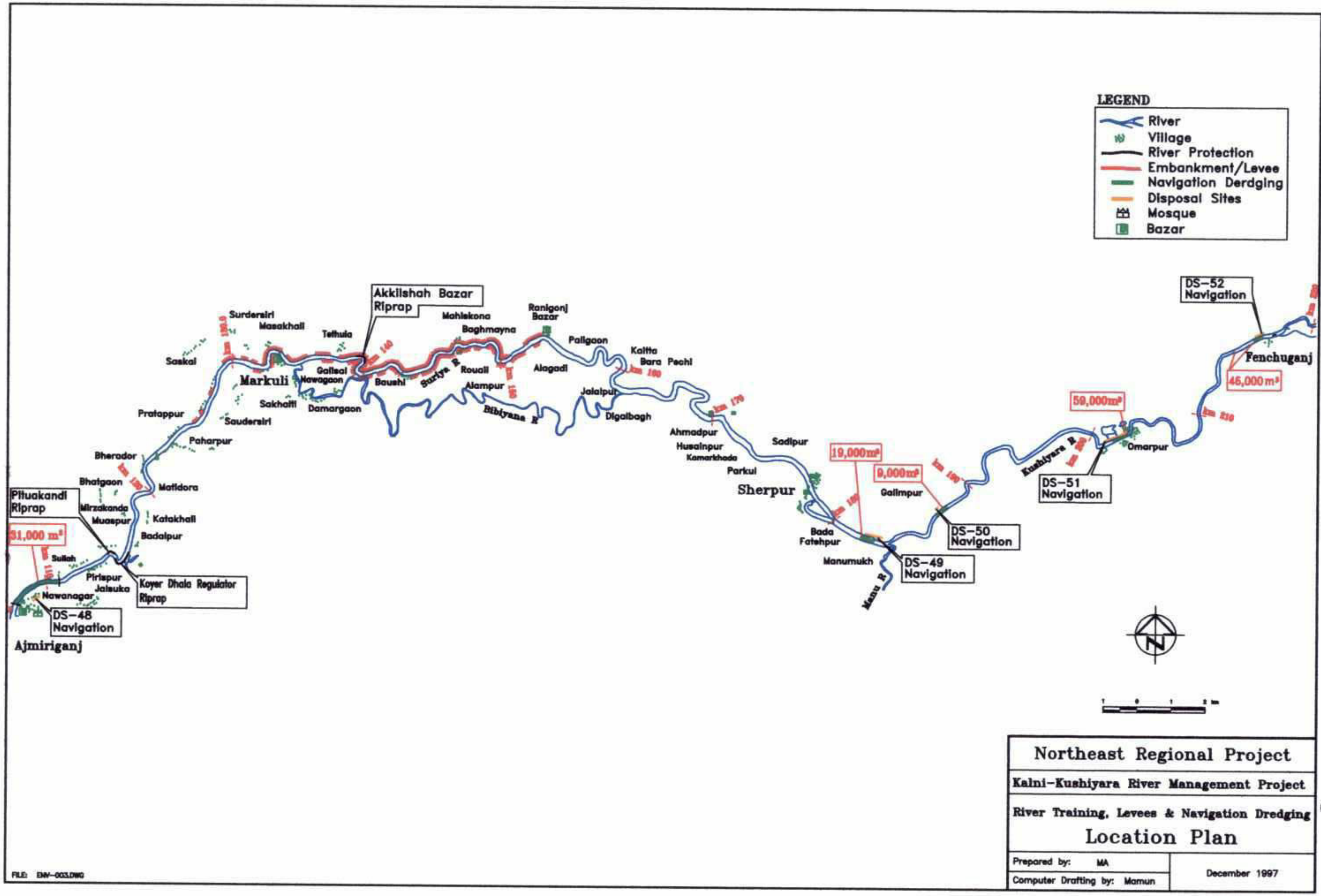
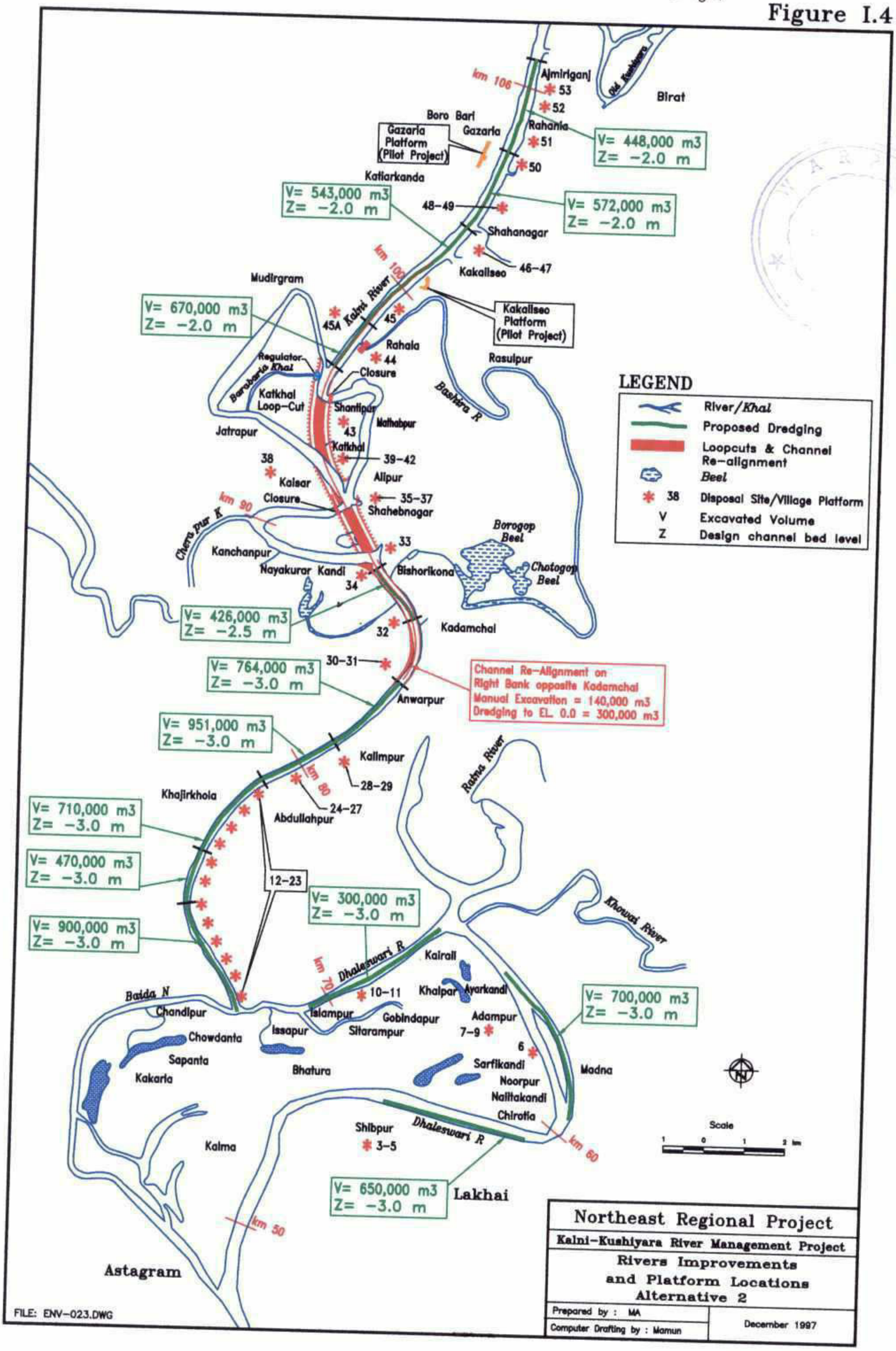

LEGEND
River
Village
River Protection
Embankment/Levee
Navigation Derdging
Disposal Sites
Mosque
Bazar
DS-52 Navigation
Fenchuganj
46,000 m³
59,000m³
Omarpur
Kushiyara R
DS-51 Navigation
DS-50 Navigation
9,000m³
Galimpur
DS-49 Navigation
19,000m³
Manu R
Manumukh
Bada Fatehpur
Sherpur
Sadipur
Parkul
Ahmadpur
Husainpur
Komarkhada
Kaitta
Bara Pechi
Digalbagh
Jalalpur
Paligaon
Ranigonj Bazar
Alagadi
Bibiyana R
Alampur
Rouail
Baghmayna
Mahiskona
Sariya R
Baushi
Akkilshah Bazar Riprap
Tethula
Galisal
Nawagaon
Damargaon
Masakhali
Surdersiri
Markuli
Sakhatti
Saudersiri
Saskai
Pratappur
Paharpur
Bherador
Matidora
Bhatgaon
Mirzakanda
Muaspur
Katakhali
Badalpur
Pituakandi Riprap
31,000 m³
Suliah
Pirispur
Jalsuka
Koyer Dhala Regulator Riprap
Nawanagar
DS-48 Navigation
Ajmiriganj
Northeast Regional Project
Kalni-Kushiyara River Management Project
River Training, Levees & Navigation Dredging
Location Plan
Prepared by: MA
Computer Drafting by: Mamun
December 1997
FILE: ENV-003.DWG

Figure I.3

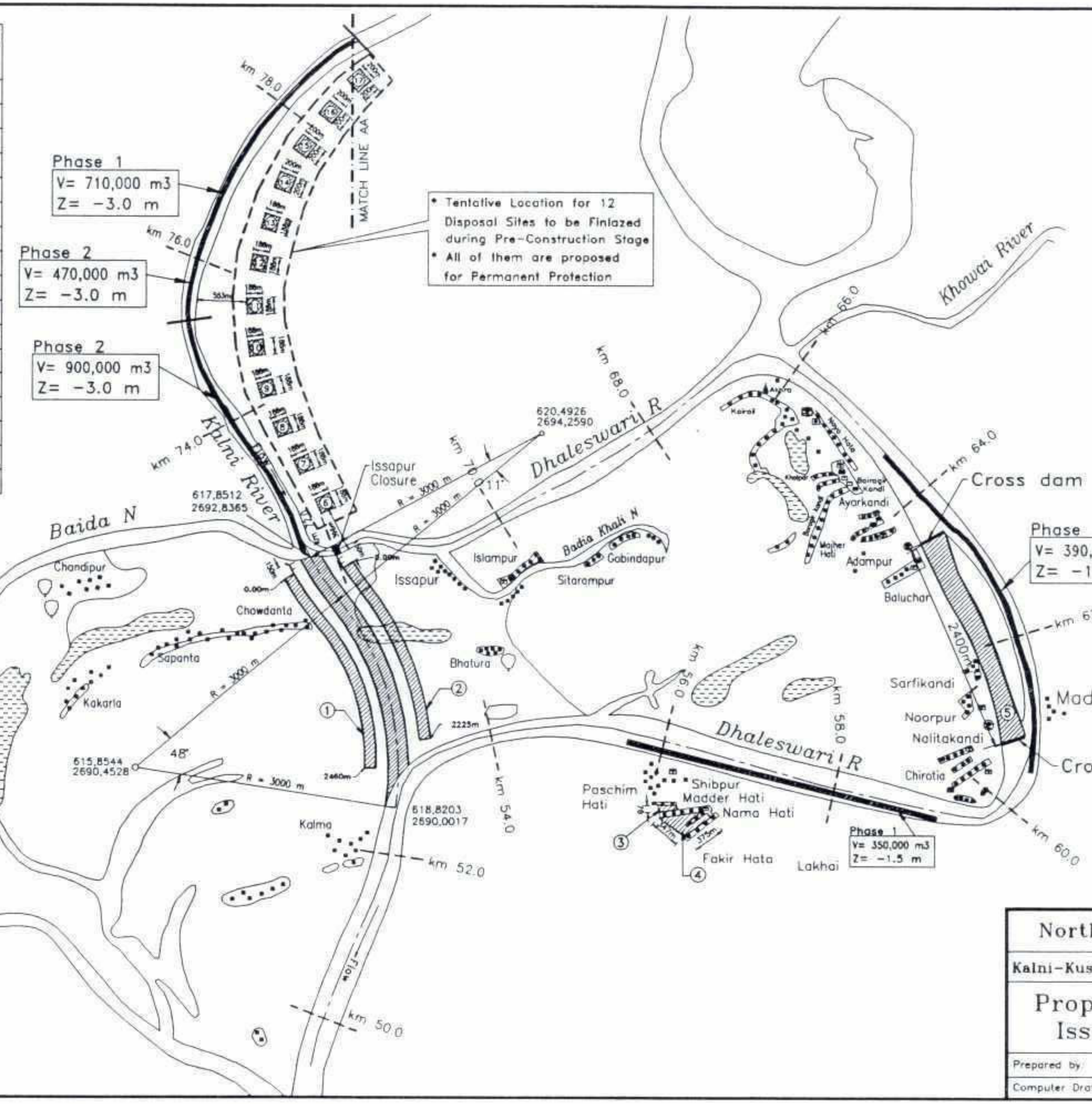
Figure I.4



Ajmiriganj
km 106
53
52
Birat
Boro Bari
Gazaria Platform (Pilot Project)
Gazaria
Rahania
51
V= 448,000 m3
Z= -2.0 m
50
Katiarkanda
V= 543,000 m3
Z= -2.0 m
48-49
V= 572,000 m3
Z= -2.0 m
Shahanagar
km 100
Kakailseo
46-47
Mudirgram
V= 670,000 m3
Z= -2.0 m
Kalni River
45A
45
Kakailseo Platform (Pilot Project)
Rahala
44
Rasulpur
Regulator
Barabaria Khal
Closure
Katkhal Loop-Cut
Shantipur
Mathabpur
Bashira R
43
Jatrapur
Katkhal
39-42
38
Kaisar
Alipur
35-37
km 90
Closure
Shahebnagar
Cherapur K
Kanchanpur
33
Borogop Beel
Nayakurar Kandi
Bishorikona
Chotogop Beel
34
V= 426,000 m3
Z= -2.5 m
32
Kadamchal
30-31
V= 764,000 m3
Z= -3.0 m
Channel Re-Alignment on Right Bank opposite Kadamchal
Manual Excavation = 140,000 m3
Dredging to EL. 0.0 = 300,000 m3
Anwarpur
V= 951,000 m3
Z= -3.0 m
Kalimpur
Ratna River
km 80
28-29
Khajirkhola
24-27
Abdullahpur
V= 710,000 m3
Z= -3.0 m
V= 470,000 m3
Z= -3.0 m
12-23
V= 300,000 m3
Z= -3.0 m
Khowai River
V= 900,000 m3
Z= -3.0 m
Dhaleswari R
Kairali
km 70
10-11
Khalpar
Ayarkandi
Baida N
Chandipur
Islampur
Gobindapur
Adampur
V= 700,000 m3
Z= -3.0 m
Chowdanta
Issapur
Sitarampur
7-9
6
Sapanta
Bhatura
Sarfikandi
Madna
Kakaria
Noorpur
Nalitakandi
Chirotia
Shibpur
Dhaleswari R
3-5
km 60
Kalma
V= 650,000 m3
Z= -3.0 m
Lakhai
km 50
Astagram
LEGEND
River/Khal
Proposed Dredging
Loopcuts & Channel Re-alignment
Beel
38 Disposal Site/Village Platform
V Excavated Volume
Z Design channel bed level
Scale
1 0 1 2 km
FILE: ENV-023.DWG
Northeast Regional Project
Kalni-Kushiyara River Management Project
Rivers Improvements and Platform Locations Alternative 2
Prepared by : MA
Computer Drafting by : Mamun
December 1997

Figure 1.5

Site No	Length (m)	Length (m)
1	2460	130
2	2225	130
3	207	76
4	347	375
5	2400	300
6	188	188
7	188	188
8	188	188
9	188	188
10	188	188
11	188	188
12	188	188
13	188	188
14	200	200
15	200	200
16	200	200
17	200	200



Northeast Regional Project

Kalni-Kushiyara River Management Project

Proposed Disposal Sites Issapur-Abdullahpur

Prepared by: MA | Computer Drafting by: Mamun | December 1997

FILE: ENV-004.DWG

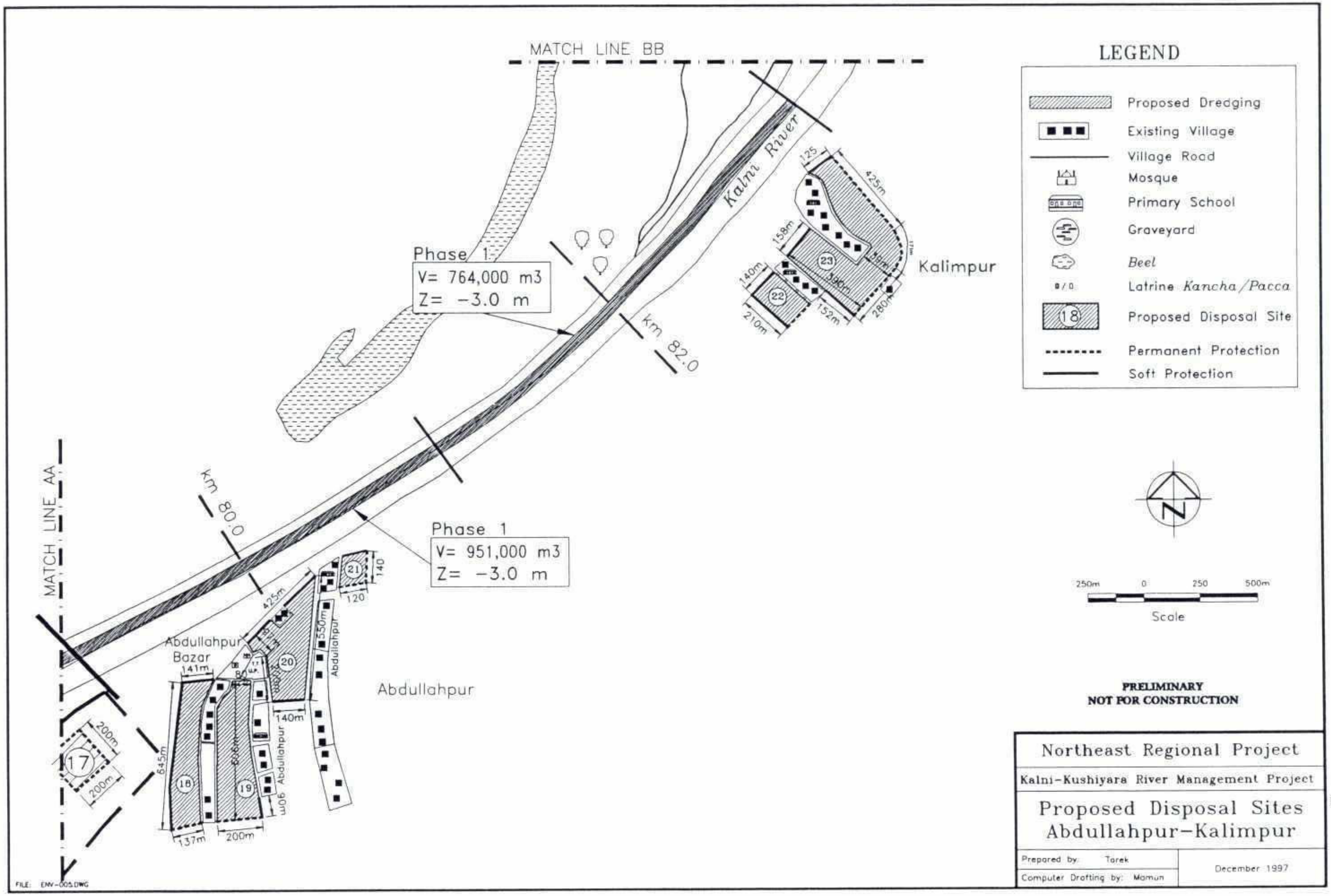
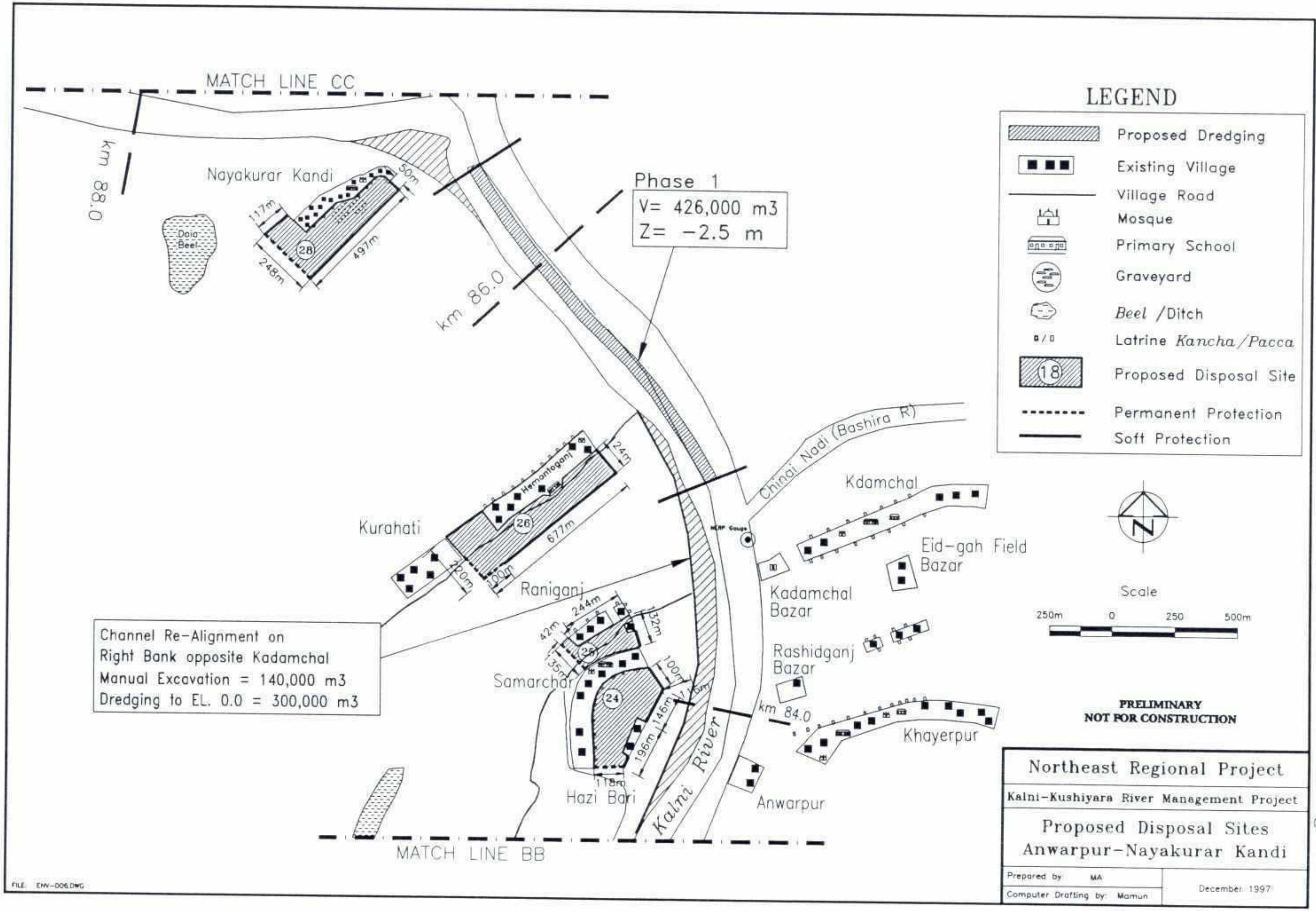

MATCH LINE BB
MATCH LINE AA
LEGEND
Proposed Dredging
Existing Village
Village Road
Mosque
Primary School
Graveyard
Beel
Latrine Kancha/Pacca
Proposed Disposal Site
Permanent Protection
Soft Protection
Phase 1
V= 764,000 m3
Z= -3.0 m
Phase 1
V= 951,000 m3
Z= -3.0 m
Kalni River
km 82.0
km 80.0
Kalimpur
Abdullahpur
Abdullahpur Bazar
Abdullahpur
250m 0 250 500m
Scale
PRELIMINARY
NOT FOR CONSTRUCTION
Northeast Regional Project
Kalni-Kushiyara River Management Project
Proposed Disposal Sites
Abdullahpur-Kalimpur
Prepared by: Tarek
Computer Drafting by: Mamun
December 1997
FILE: ENV-005.DWG

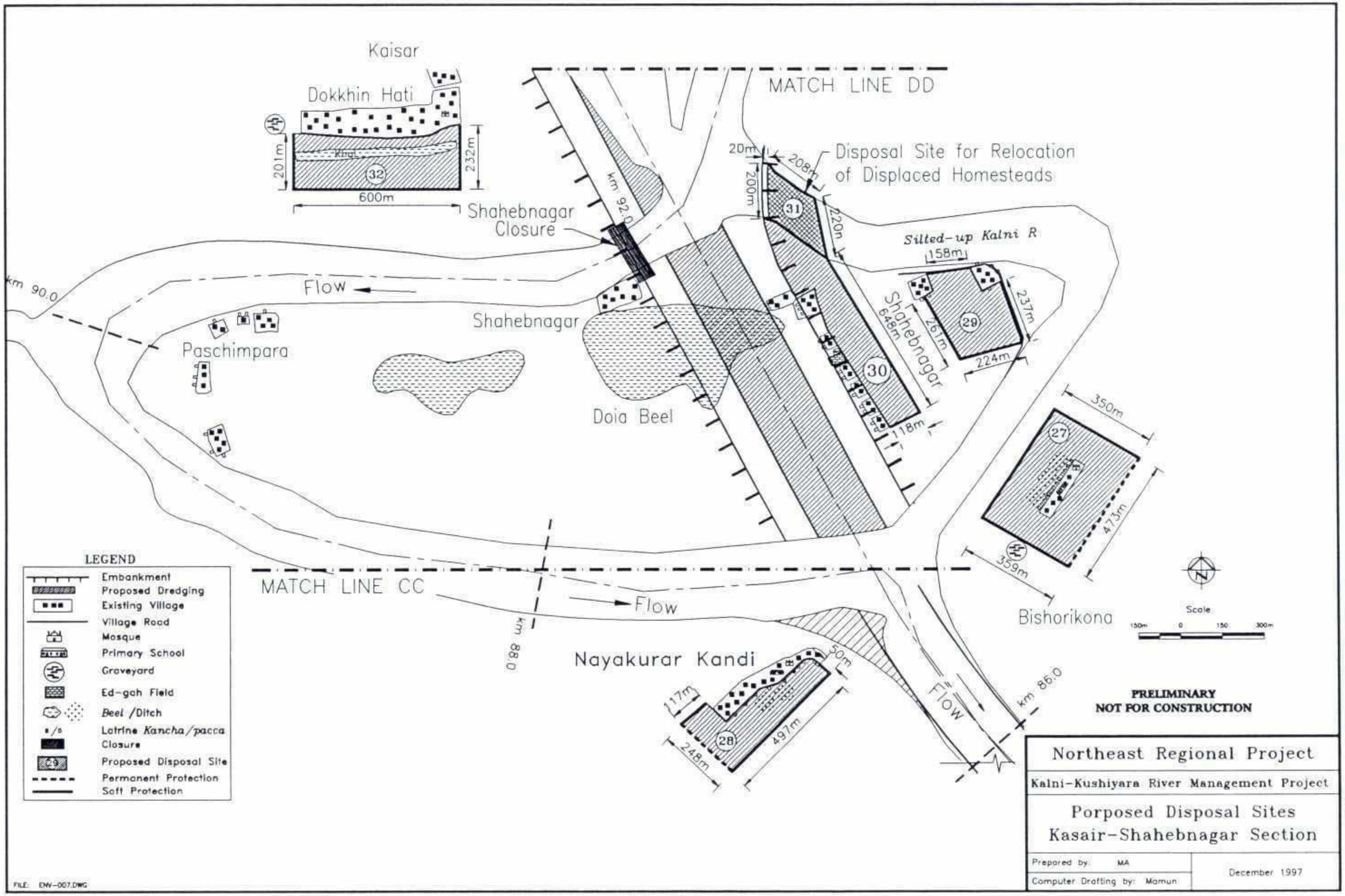
Figure I.6

Figure I.7



LEGEND
Proposed Dredging
Existing Village
Village Road
Mosque
Primary School
Graveyard
Beel /Ditch
Latrine Kancha/Pacca
Proposed Disposal Site
Permanent Protection
Soft Protection
Scale
250m 0 250 500m
PRELIMINARY
NOT FOR CONSTRUCTION
MATCH LINE CC
MATCH LINE BB
km 88.0
km 86.0
km 84.0
Phase 1
V= 426,000 m3
Z= -2.5 m
Nayakurar Kandi
Dola Beel
Kurahati
Hemontoganj
Raniganj
Samarchar
Hazi Bari
Kalni River
Chinai Nadi (Bashira R)
Kdamchal
Eid-gah Field
Bazar
Kadamchal
Bazar
Rashidganj
Bazar
Khayerpur
Anwarpur
Channel Re-Alignment on
Right Bank opposite Kadamchal
Manual Excavation = 140,000 m3
Dredging to EL. 0.0 = 300,000 m3
50m
117m
248m
497m
24m
677m
220m
100m
244m
42m
35m
132m
146m
196m
118m
Northeast Regional Project
Kalni-Kushiyara River Management Project
Proposed Disposal Sites
Anwarpur-Nayakurar Kandi
Prepared by: MA
Computer Drafting by: Mamun
December 1997
FILE: ENV-006.DWG

Figure I.8



Northeast Regional Project
Kalni-Kushiyara River Management Project
Porposed Disposal Sites
Kasair-Shahebnagar Section
Prepared by: MA
Computer Drafting by: Mamun
December 1997
PRELIMINARY
NOT FOR CONSTRUCTION
Scale
150m 0 150 300m
MATCH LINE DD
MATCH LINE CC
Disposal Site for Relocation of Displaced Homesteads
Silted-up Kalni R
Kaisar
Dokkhin Hati
Shahebnagar Closure
Shahebnagar
Paschimpara
Doia Beel
Nayakurar Kandi
Bishorikona
Flow
km 90.0
km 92.0
km 88.0
km 86.0
201m
232m
600m
20m
208m
200m
220n
158m
237m
261m
224m
648m
118m
350m
473m
359m
50m
117m
248m
497m
LEGEND
Embankment
Proposed Dredging
Existing Village
Village Road
Mosque
Primary School
Graveyard
Ed-gah Field
Beel /Ditch
Latrine Kancha/pacca
Closure
Proposed Disposal Site
Permanent Protection
Soft Protection
FILE: ENV-007.DWG

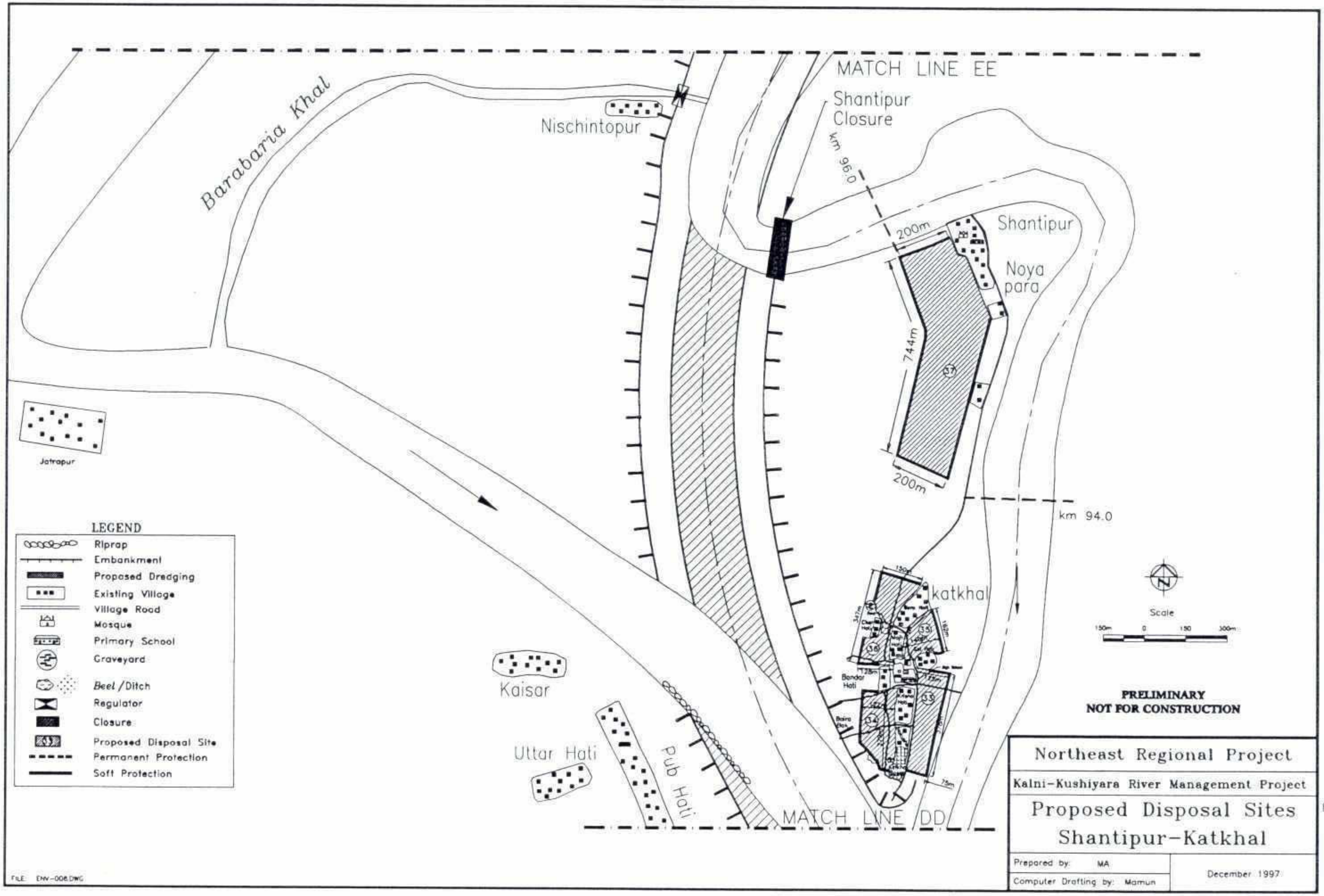
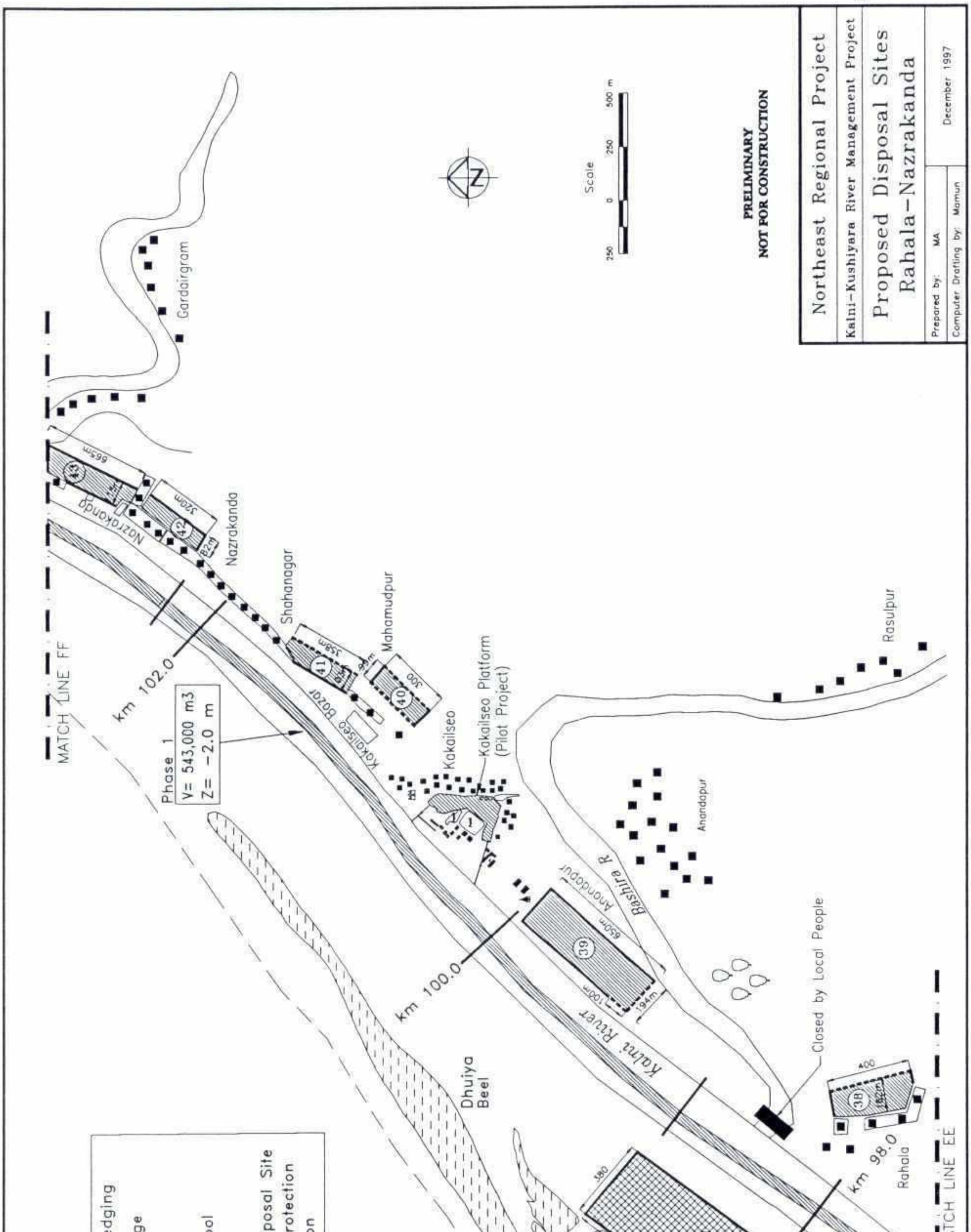

MATCH LINE EE
Shantipur Closure
km 96.0
Barabaria Khal
Nischintopur
Shantipur
Noya para
200m
744m
200m
km 94.0
katkhal
Bandar Hati
Jatrapur
Kaisar
Uttar Hati
Pub Hati
MATCH LINE DD
LEGEND
Riprap
Embankment
Proposed Dredging
Existing Village
Village Road
Mosque
Primary School
Graveyard
Beel / Ditch
Regulator
Closure
Proposed Disposal Site
Permanent Protection
Soft Protection
Scale
150m 0 150 300m
PRELIMINARY
NOT FOR CONSTRUCTION
Northeast Regional Project
Kalni-Kushiyara River Management Project
Proposed Disposal Sites
Shantipur-Katkhal
Prepared by: MA
Computer Drafting by: Mamun
December 1997
FILE: ENV-008.DWG
Figure I.9

Figure I.10



Northeast Regional Project
Kalni-Kushiyara River Management Project
Proposed Disposal Sites
Rahala-Nazrakanda
Prepared by: MA
Computer Drafting by: Mamun
December 1997
PRELIMINARY
NOT FOR CONSTRUCTION
Scale
250 0 250 500 m
LEGEND
Proposed Dredging
Existing Village
Village Road
Mosque
Primary School
Beel /Ditch
Proposed Disposal Site
Permanent Protection
Soft Protection
MATCH LINE FF
MATCH LINE EE
Phase 1
V= 543,000 m3
Z= -2.0 m
Phase 2
V= 670,000 m3
Z= -2.0 m
km 102.0
km 100.0
km 98.0
Kalni River
Dhuiya Beel
Gardairgram
Nazrakanda
Shahanagar
Mahamudpur
Kakailseo
Kakailseo Bazar
Kakailseo Platform (Pilot Project)
Anandapur
Bashira R
Rasulpur
Closed by Local People
Rahala
Kamalpur
665m
320m
358m
300
650m
100m
194m
400
380
1000m
43
42
41
40
39
39A
38
1
FILE: EN-009.DWG

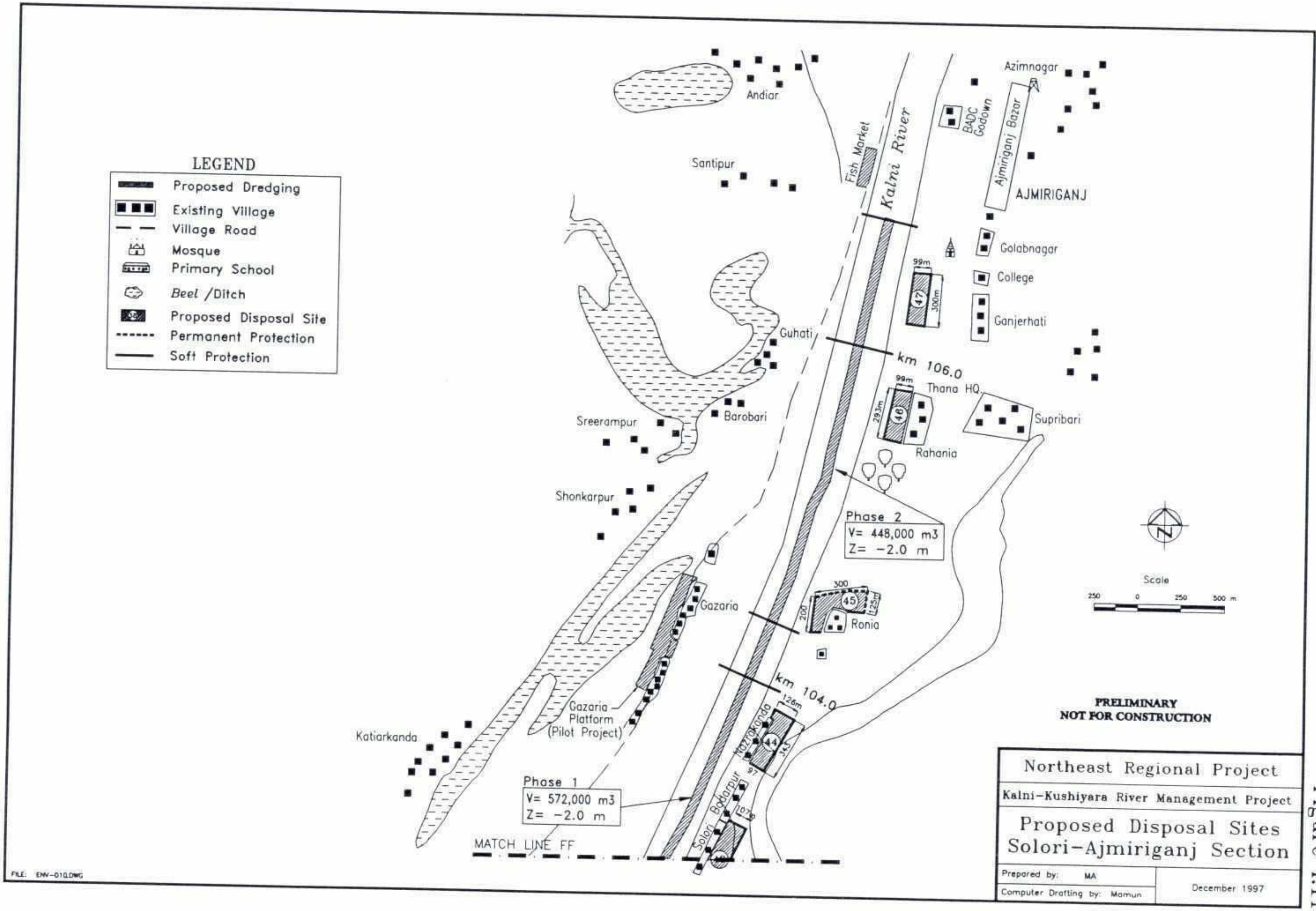
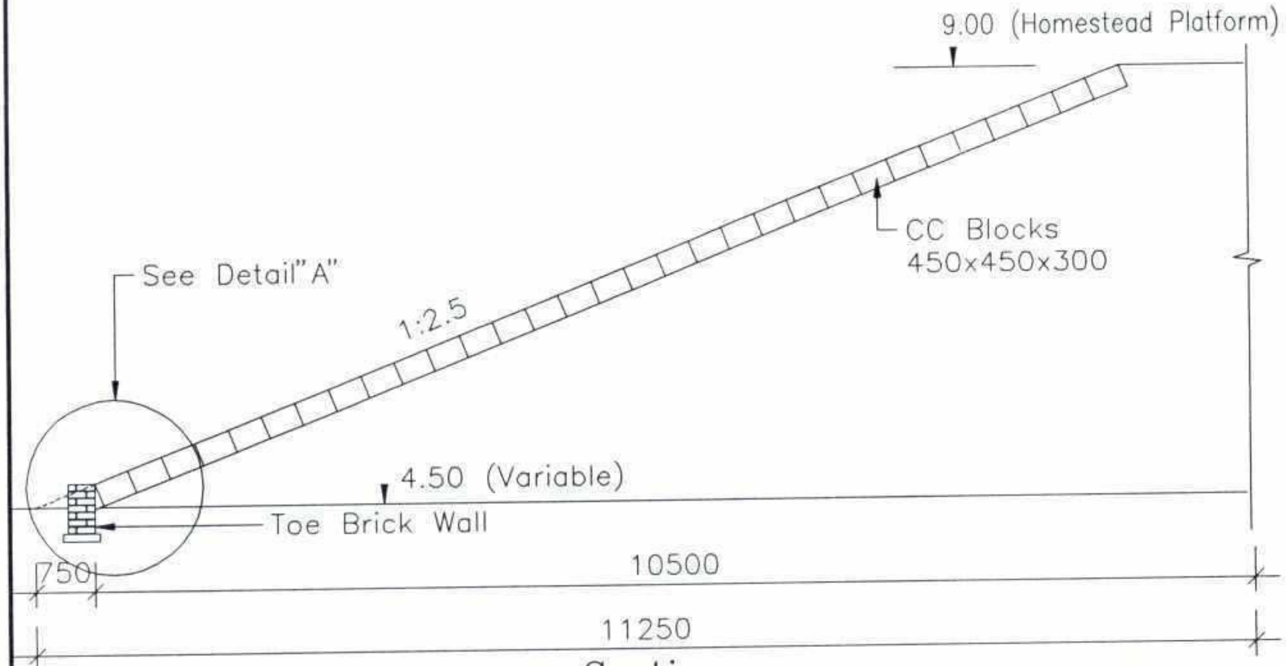
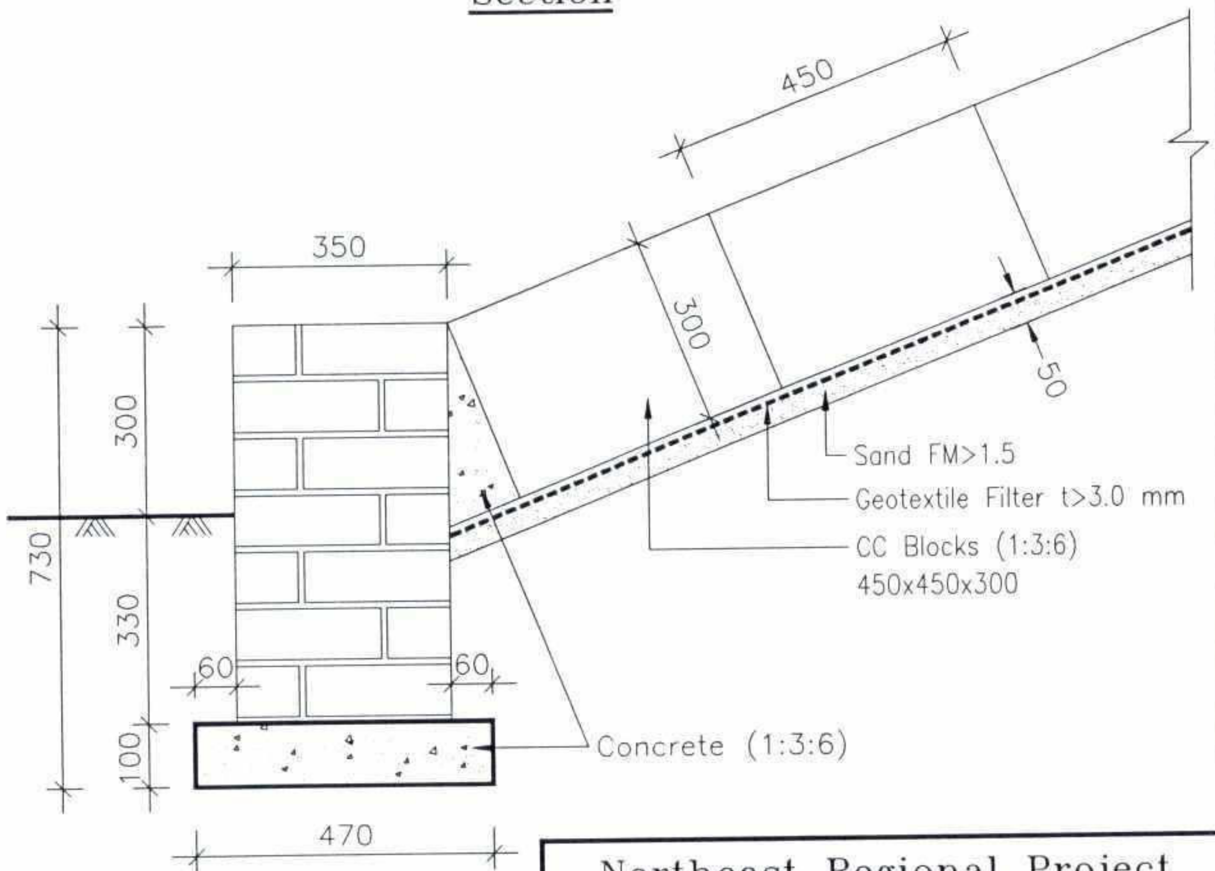

LEGEND
Proposed Dredging
Existing Village
Village Road
Mosque
Primary School
Beel /Ditch
Proposed Disposal Site
Permanent Protection
Soft Protection
Andiar
Santipur
Fish Market
Kalni River
Azimnagar
BADC Godown
Ajmiriganj Bazar
AJMIRIGANJ
Golabnagar
College
Ganjerhati
99m
300m
47
Guhati
km 106.0
99m
293m
46
Thana HQ.
Supribari
Rahania
Barobari
Sreerampur
Shonkarpur
Phase 2
V= 448,000 m3
Z= −2.0 m
300
200
125m
45
Ronia
Gazaria
km 104.0
126m
Nazirkanda
44
343
97
Gazaria Platform (Pilot Project)
Katiarkanda
Solori
Badarpur
107m
Phase 1
V= 572,000 m3
Z= −2.0 m
MATCH LINE FF
Scale
250 0 250 500 m
PRELIMINARY
NOT FOR CONSTRUCTION
Northeast Regional Project
Kalni-Kushiyara River Management Project
Proposed Disposal Sites
Solori-Ajmiriganj Section
Prepared by: MA
Computer Drafting by: Mamun
December 1997
FILE: ENV-010.DWG

Figure I.11

Figure I.12



Section



Detail "A"

Northeast Regional Project

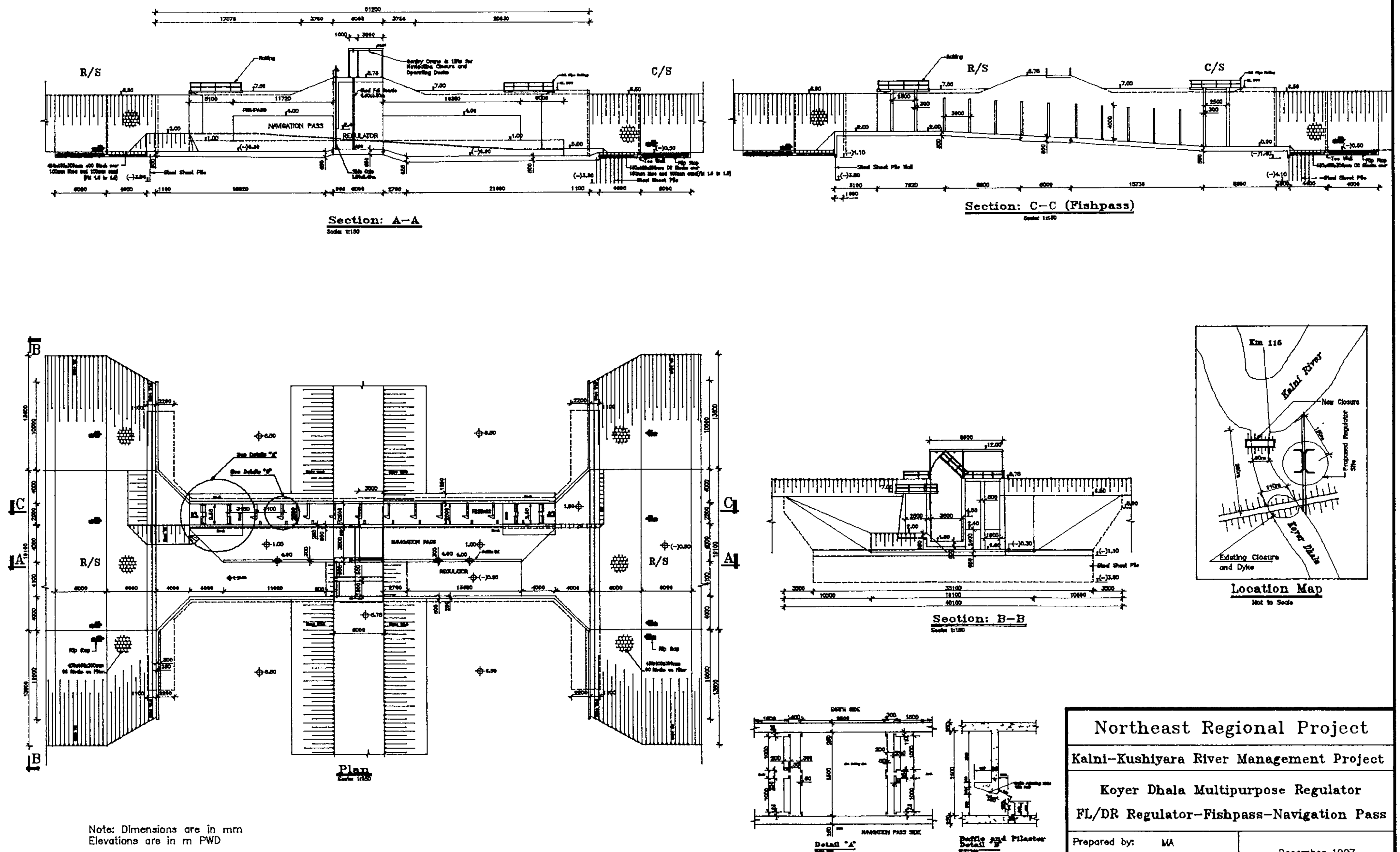
Kalni-Kushiyara River Management Project

Permanent Protection of Homestead Platform

Prepared by: MA	December 1997
Computer Drafting by: Jalal	

FILE: ENV-011.DWG

Figure I.13



Note: Dimensions are in mm
Elevations are in m PWD

FILE: ENV-012DWG

Northeast Regional Project	
Kalni-Kushiyara River Management Project	
Koyer Dhala Multipurpose Regulator	
FL/DR Regulator-Fishpass-Navigation Pass	
Prepared by: MA	December 1997
Computer Drafting by: Jalal	

ID	Task Name
1	CAPACITY DEVELOPMENT
2	Institutional Development
3	Assessment of priorities
4	Process - Phase 1
5	process - Phase 2
6	Community Development
7	Public Information
8	Stakeholder Surveys/Committee
17	Training & Workshops
18	Community in Project Activities
19	Platform Protection/Maintenance
20	Enhancement Program
21	
22	SURVEYS, DESIGN, TENDERS
23	Loop Cuts
24	Loop Cuts Survey
25	Loop Cuts Boreholes
26	Loop Cuts Design
27	Loop Cut Embankments Design
28	Construction Drawings

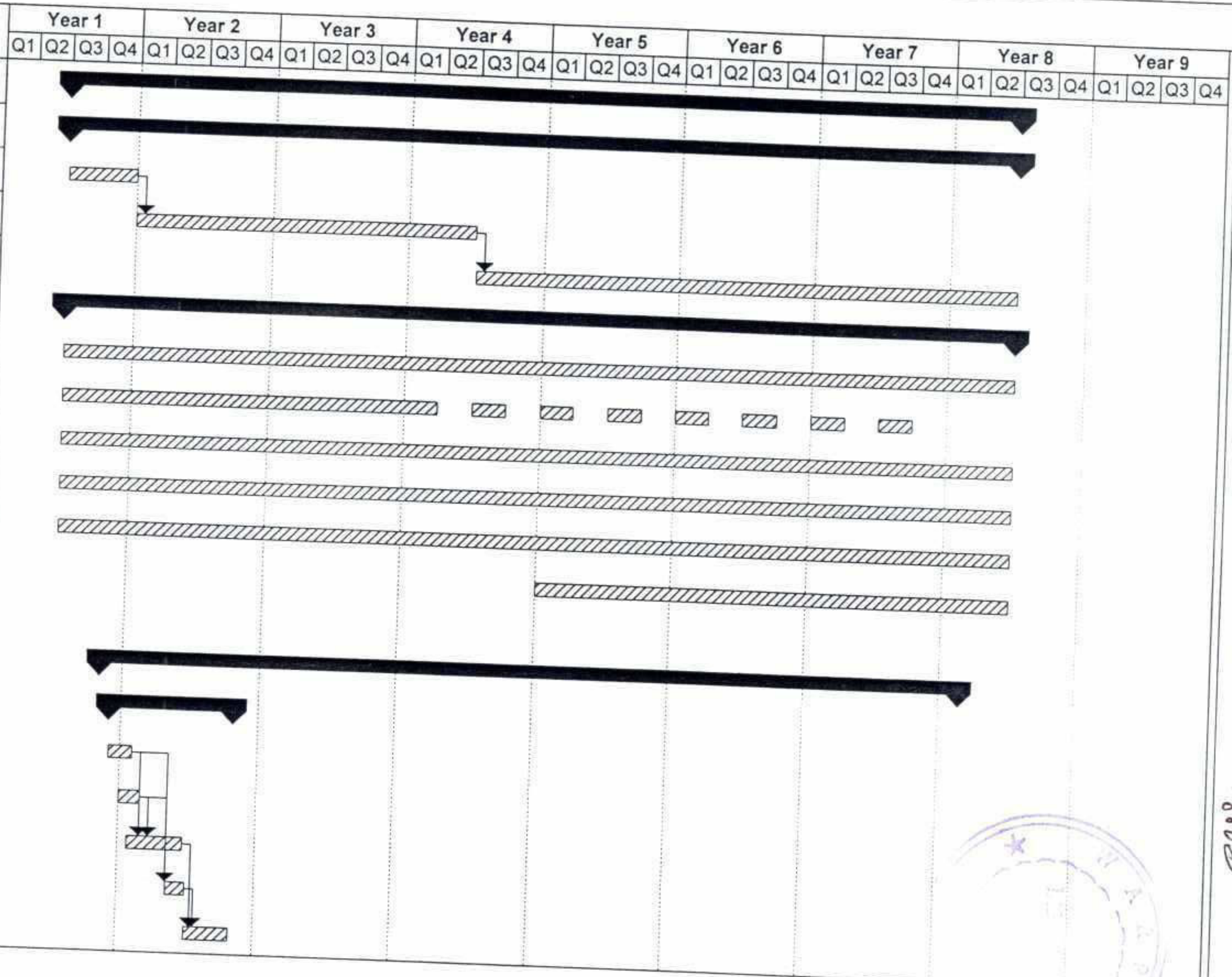


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

Task · Summary · Rolled Up Task

Figure I.14

Figure I.14

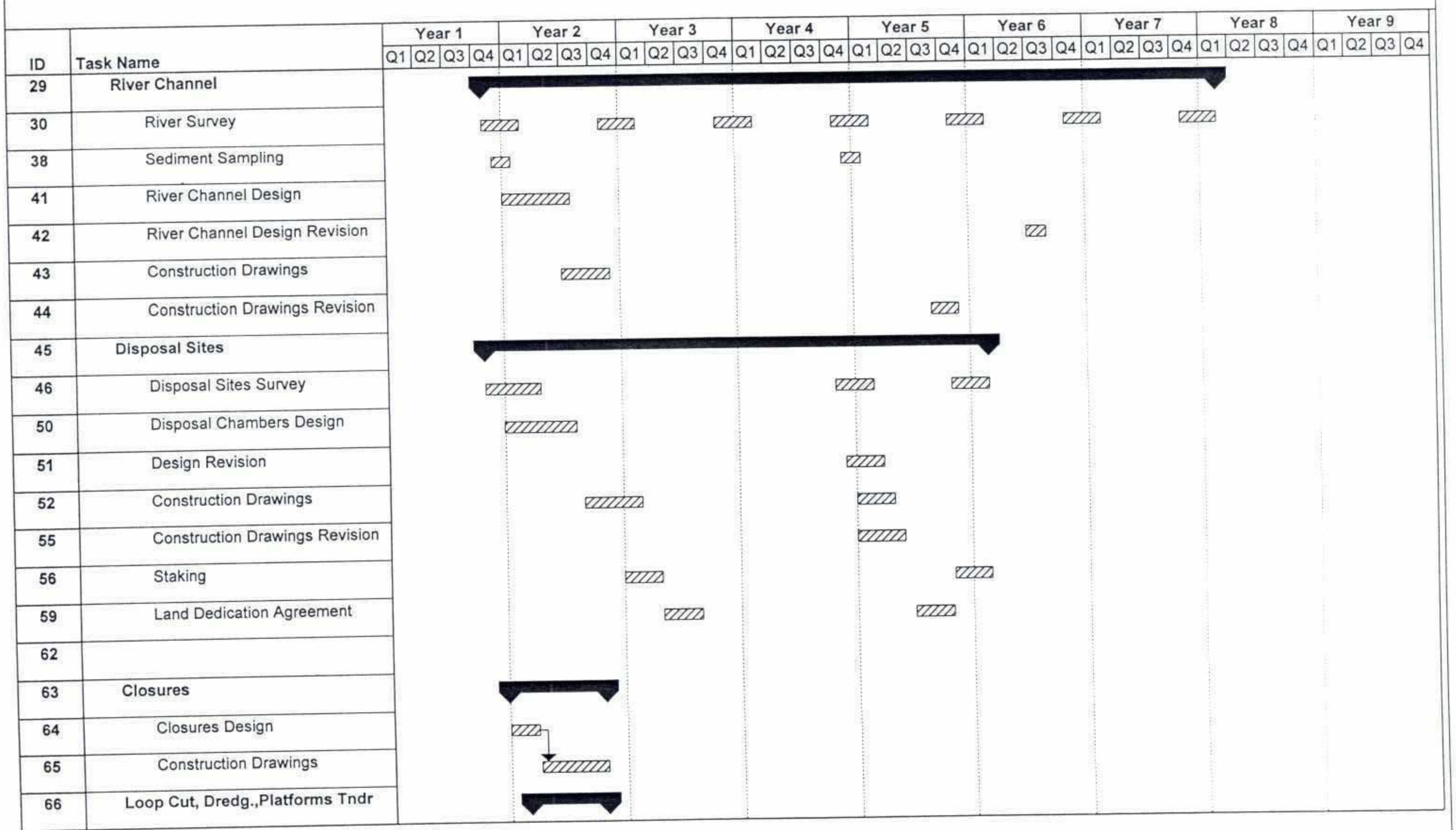


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

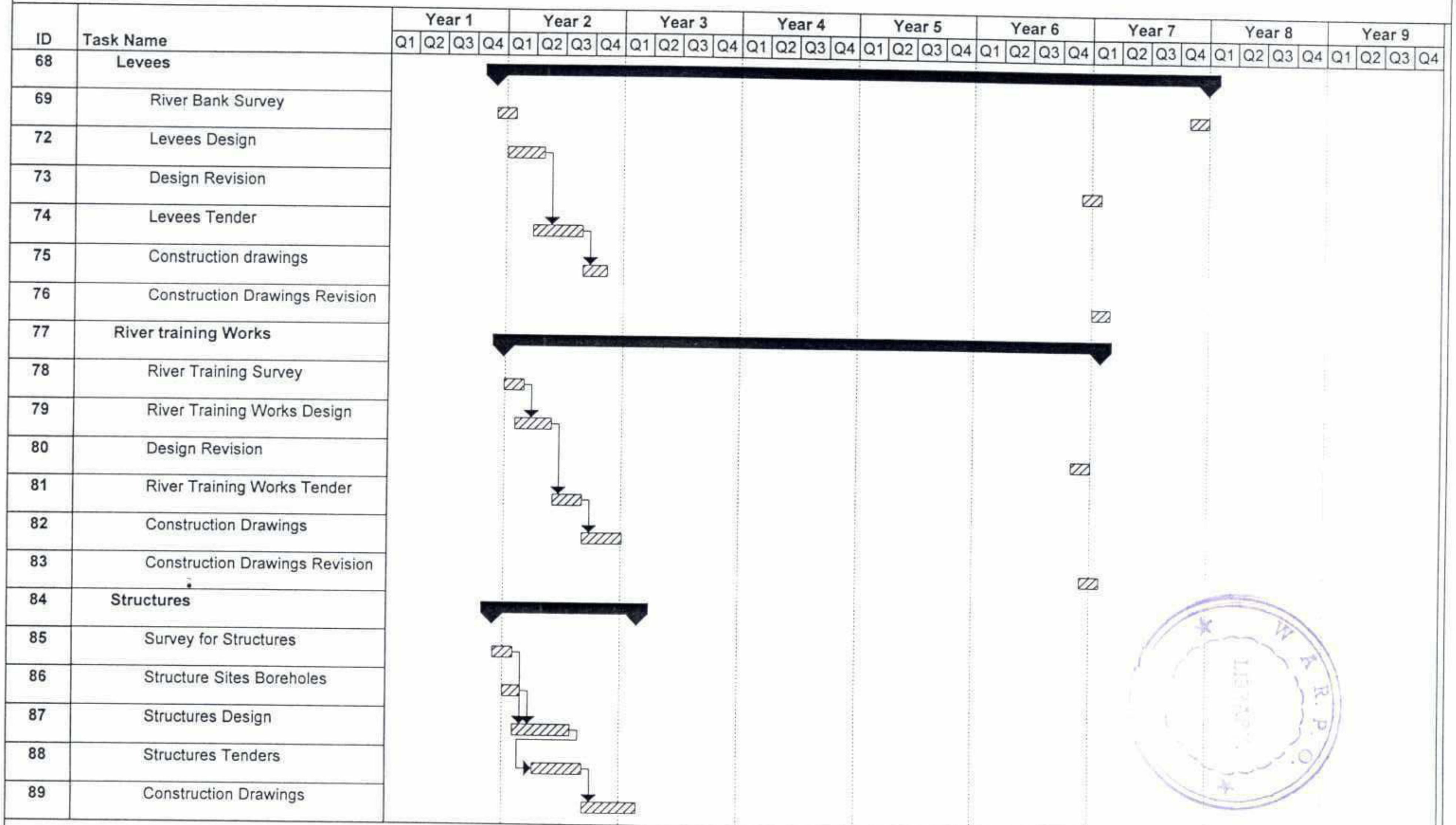


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

Task
Summary
Rolled Up Task

Figure I.14

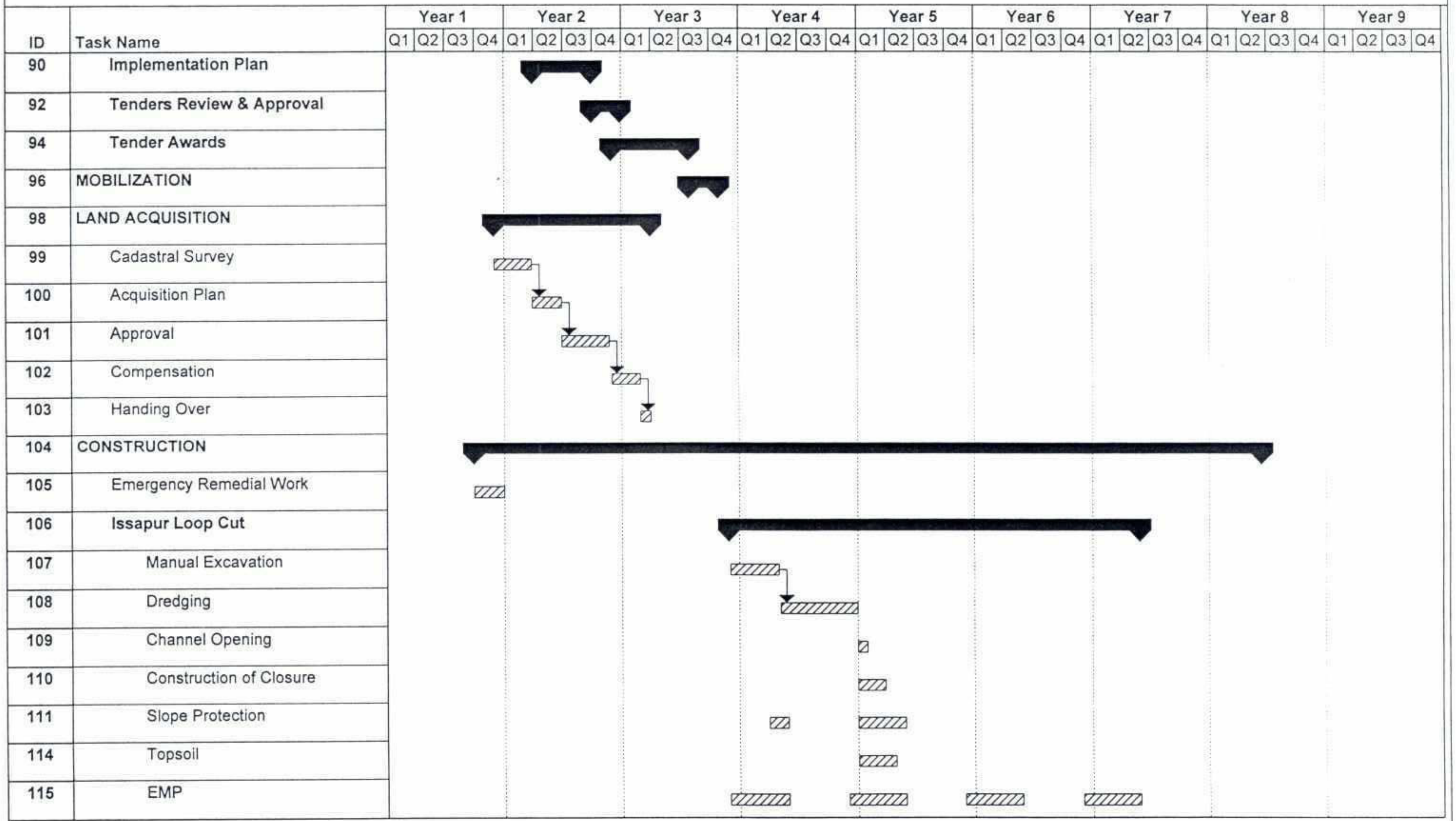


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

Task | Summary | Rolled Up Task

Figure I.14

ID	Task Name
120	
121	**Dhaleswari River**
122	Construction of Madna Closure
123	Constr. Confinement Dykes
124	Dredging at Madna
125	Dredging & Filling
126	Slope Protection
131	Top Soil
132	Slope Protection
137	EMP
142	**Katkhal Loop Cut**
143	Manual Excavation
144	Const. Confinement Dykes
145	Dredging & Filling
149	Channel Opening
150	Construction of Closures
151	Slope Protection
157	Top Soil
161	EMP
167	

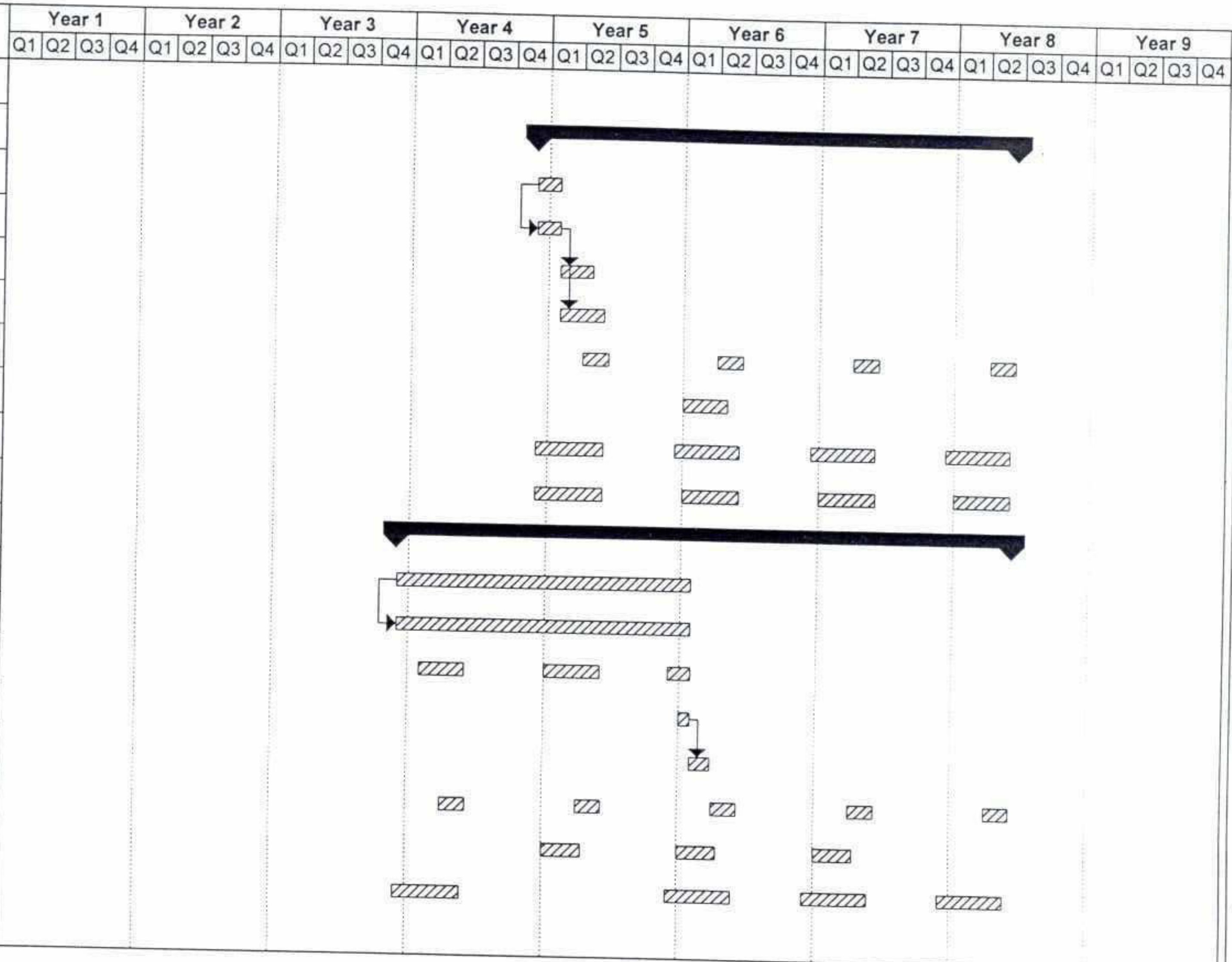


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

Task | Summary | Rolled Up Task

Figure I.14

Figure I.14

ID	Task Name
168	**Rahala-Ajmirganj Reach**
169	Constr. Confinenement Dykes
170	Dredging & Filling
171	Slope Protection
174	Top Soil
175	EMP
178	**Kachamdal Channel**
179	Manual Earthwork
180	Const. Confinement Dykes
181	Dredging & Filling
182	Slope Protection
186	EMP
190	**Issapur-Kalimpur Reach**
191	Confinement Dykes
195	Dredging & Filling
199	Slope Protection
203	Top Soil
206	EMP
210	
211	

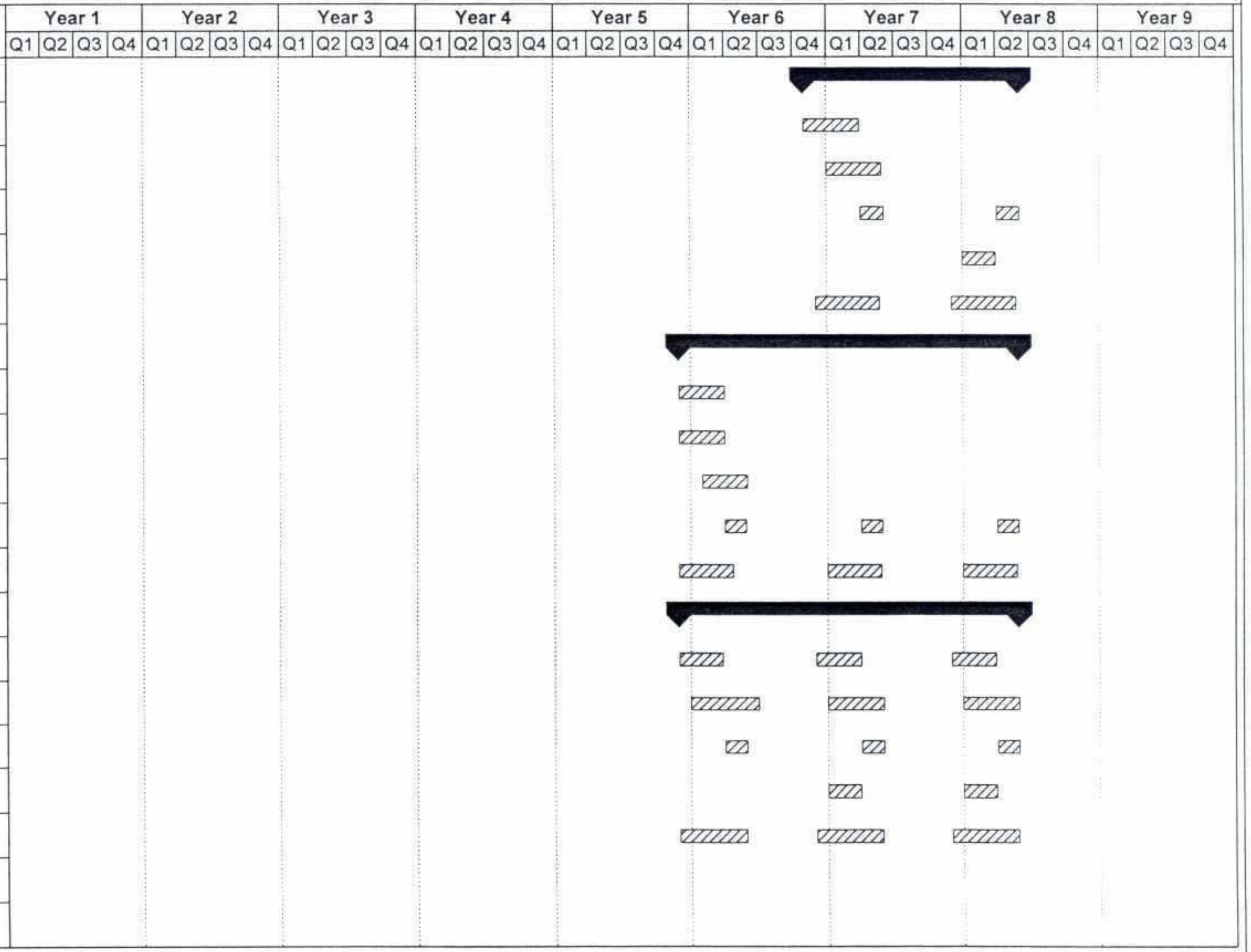


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

Task | Summary | Rolled Up Task

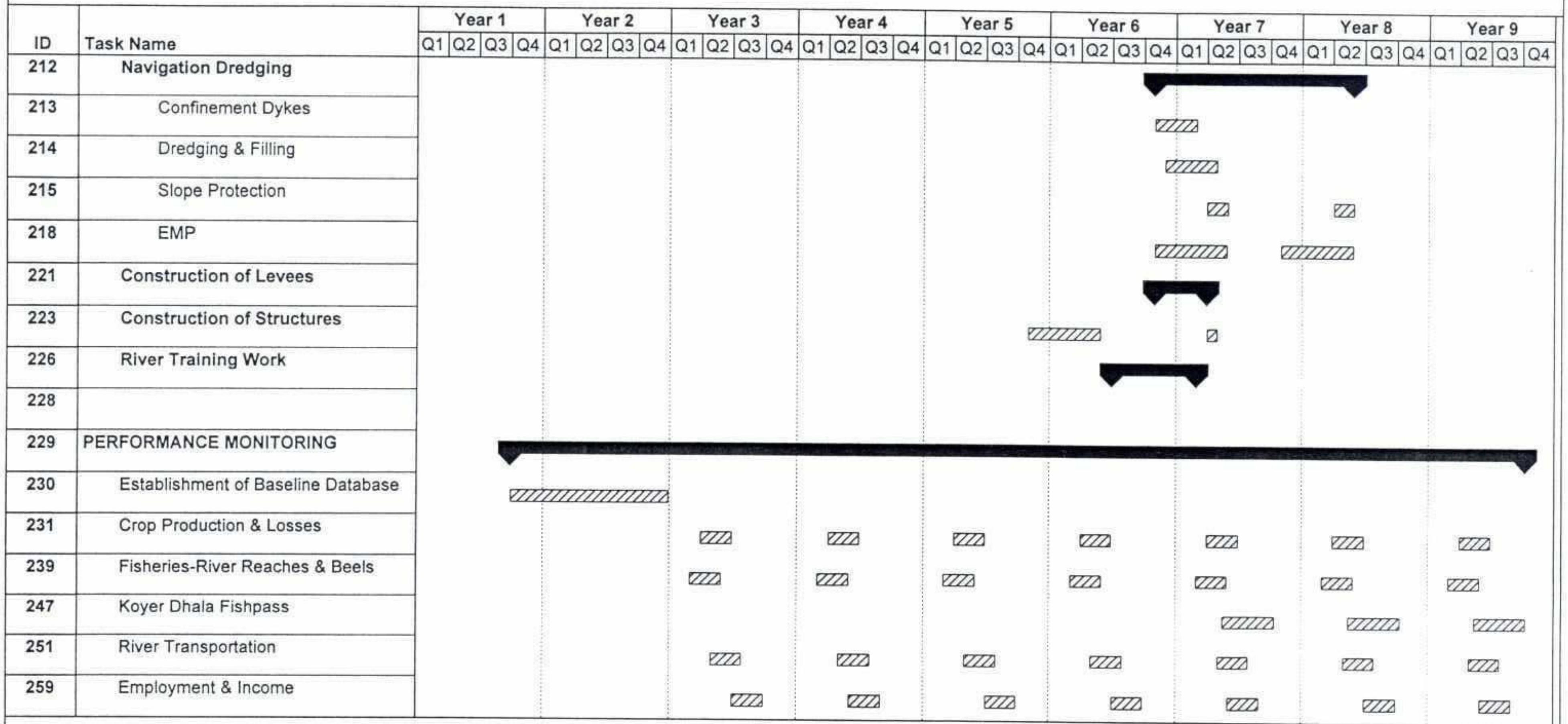


Figure I.14
KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
IMPLEMENTATION SCHEDULE

Task | Summary | Rolled Up Task

Figure I.14

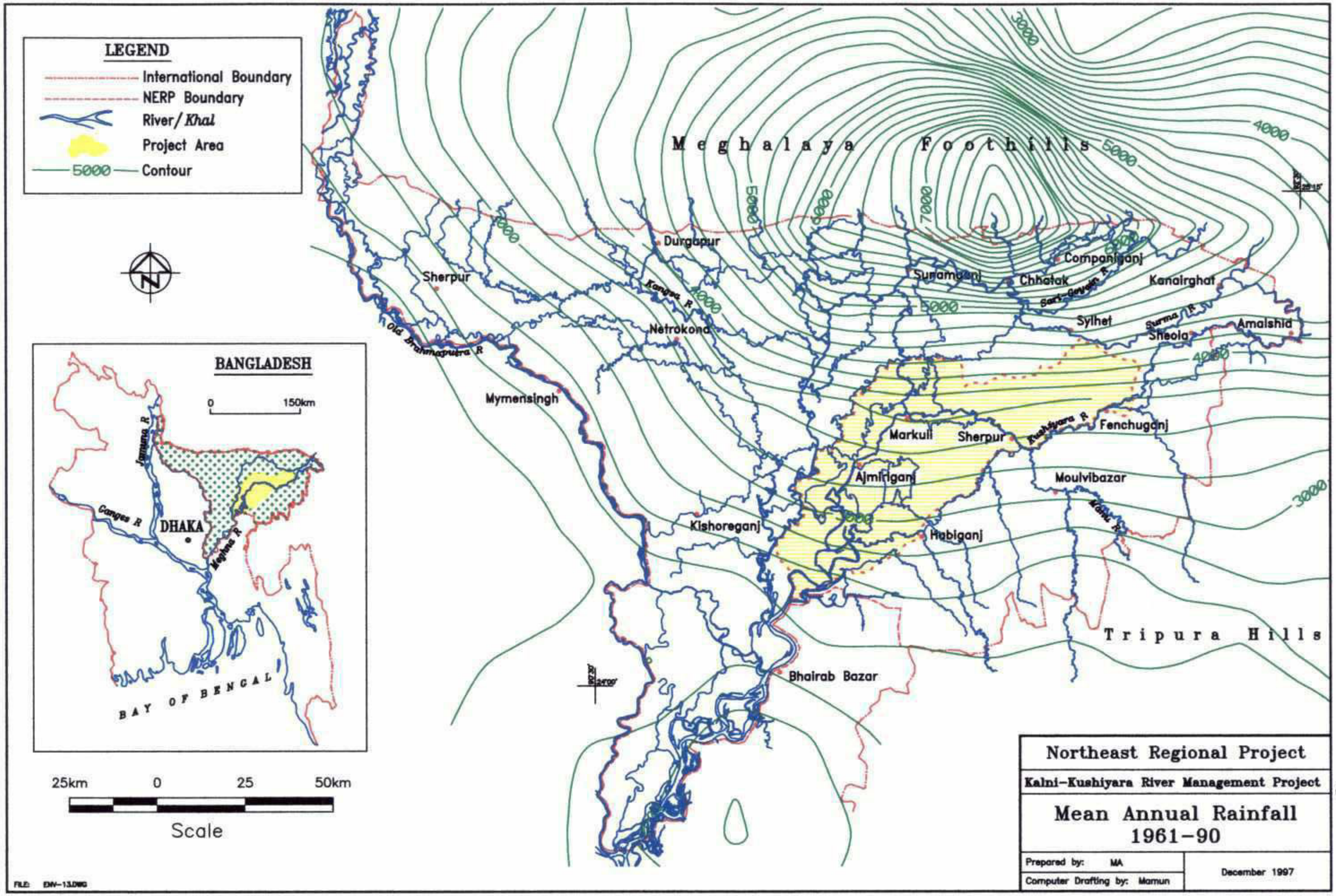
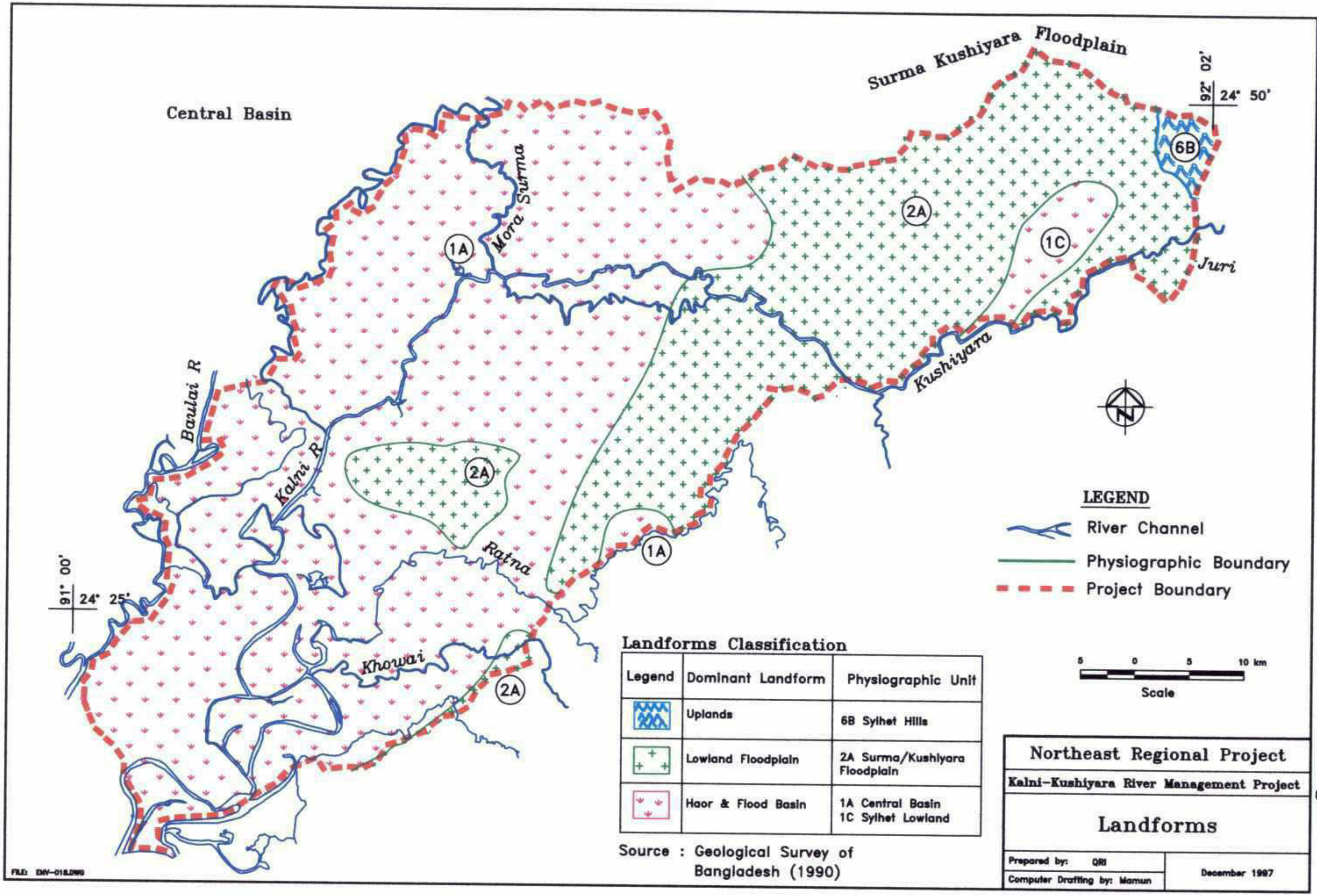

LEGEND
International Boundary
NERP Boundary
River/ Khal
Project Area
5000 Contour
Meghalaya Foothills
Tripura Hills
3000
4000
5000
6000
7000
Durgapur
Sherpur
Netrokona
Kangsa R
Old Brahmaputra R
Mymensingh
Kishoreganj
Sunamganj
Chhatak
Companiganj
Kanairghat
Sylhet
Surma R
Sheola
Amalshid
Markuli
Sherpur
Kushiyara R
Fenchuganj
Ajmiriganj
Moulvibazar
Manu R
Habiganj
Bhairab Bazar
BANGLADESH
0
150km
Jamuna R
Ganges R
DHAKA
Meghna R
BAY OF BENGAL
25km
0
25
50km
Scale
Northeast Regional Project
Kalni-Kushiyara River Management Project
Mean Annual Rainfall 1961-90
Prepared by: MA
Computer Drafting by: Mamun
December 1997
FILE: ENV-13.DWG

Figure I.15

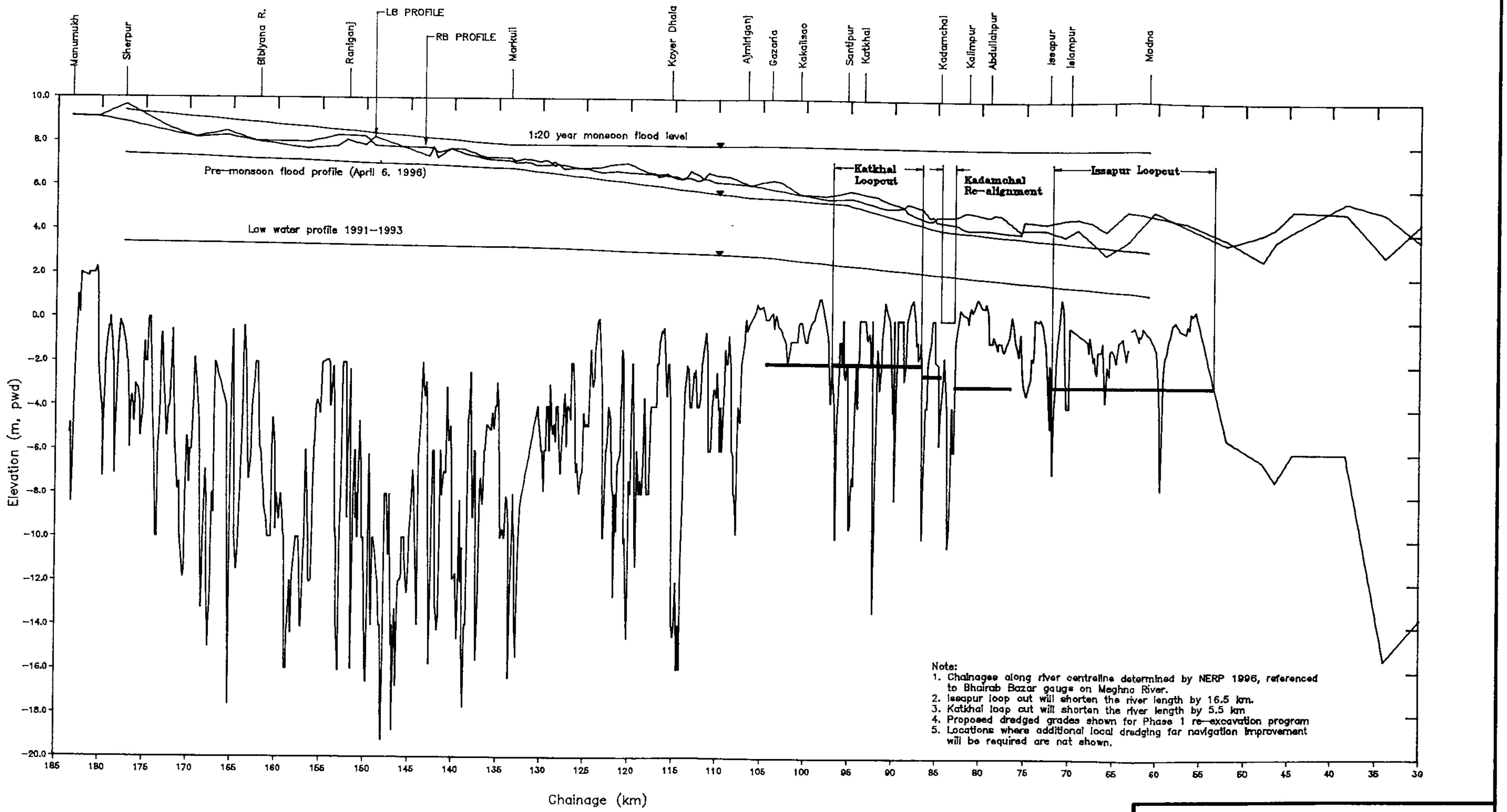
Figure I.16



Landforms Classification

Legend	Dominant Landform	Physiographic Unit
	Uplands	6B Sylhet Hills
	Lowland Floodplain	2A Surma/Kushiyara Floodplain
	Haor & Flood Basin	1A Central Basin 1C Sylhet Lowland

Figure I.17



Note:
1. Chainages along river centreline determined by NERP 1996, referenced to Bhairab Bazar gauge on Meghna River.
2. Issapur loop cut will shorten the river length by 16.5 km.
3. Katkhal loop cut will shorten the river length by 5.5 km
4. Proposed dredged grades shown for Phase 1 re-excavation program
5. Locations where additional local dredging for navigation improvement will be required are not shown.

Northeast Regional Project

Kalni-Kushiyara River Management Project

Longitudinal Profile of Kalni-Kushiyara River

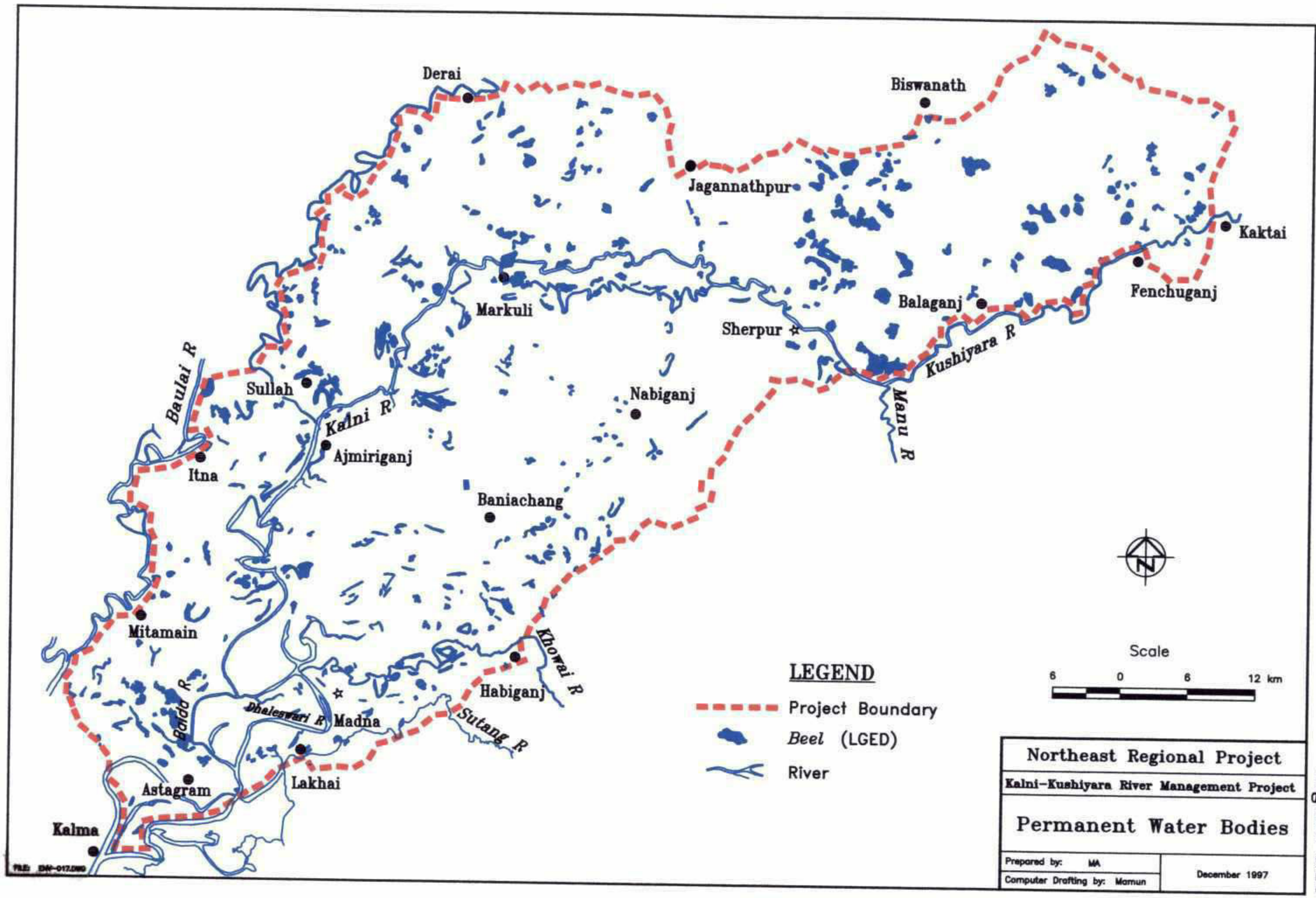
Prepared by: D.G.M.

Computer Drafting by: Mamun

December 1997

FILE: ENV-015.DWG

Figure I.18



Derai
Biswanath
Jagannathpur
Kaktai
Fenchuganj
Balaganj
Sherpur
Markuli
Kushiyara R
Manu R
Baulai R
Sullah
Kalni R
Ajmiriganj
Nabiganj
Itna
Baniachang
Mitamain
Khowai R
Habiganj
Baida R
Dhaleswari R
Madna
Sutang R
Lakhai
Astagram
Kalma
LEGEND
Project Boundary
Beel (LGED)
River
Scale
6 0 6 12 km
Northeast Regional Project
Kalni-Kushiyara River Management Project
Permanent Water Bodies
Prepared by: MA
Computer Drafting by: Mamun
December 1997

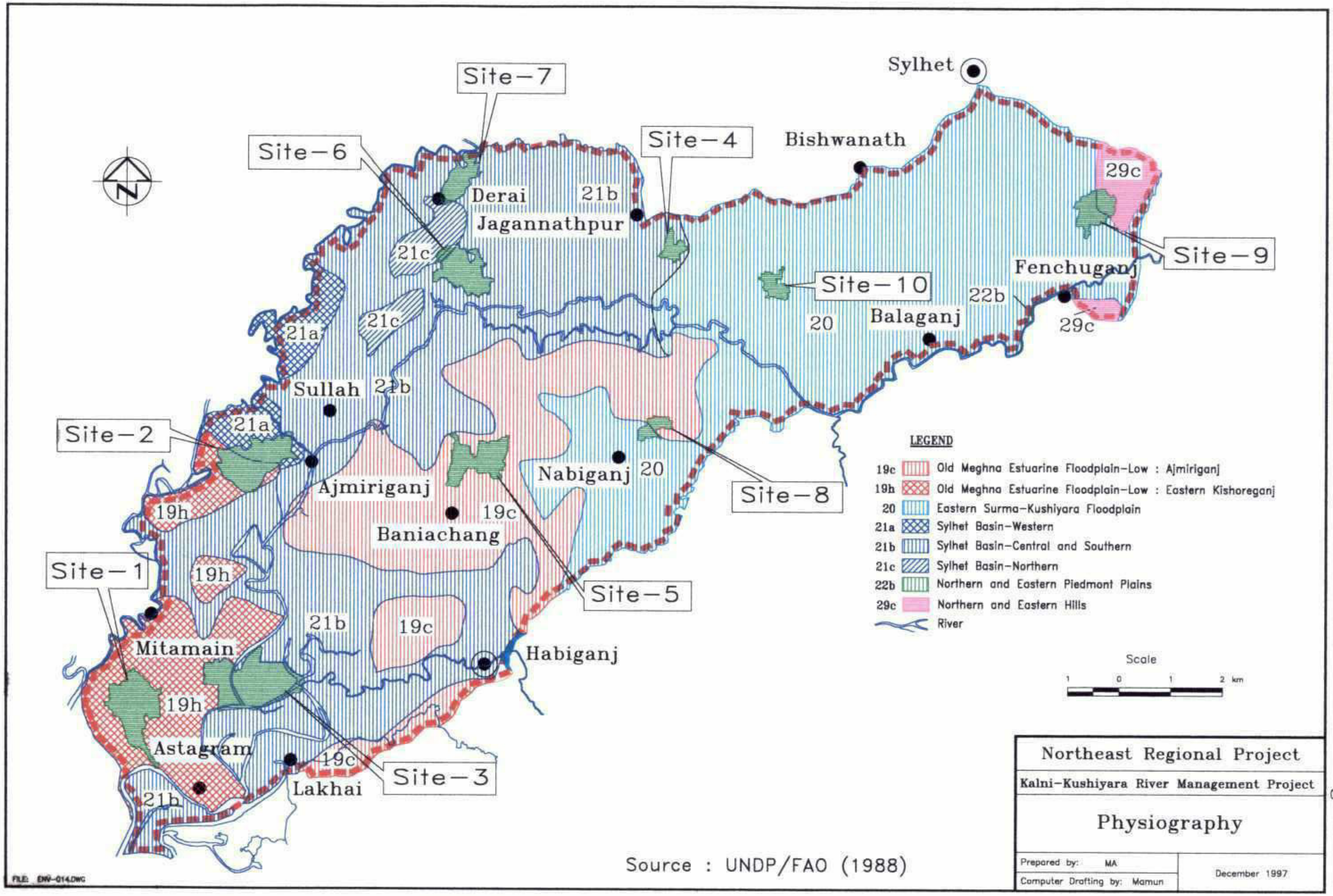
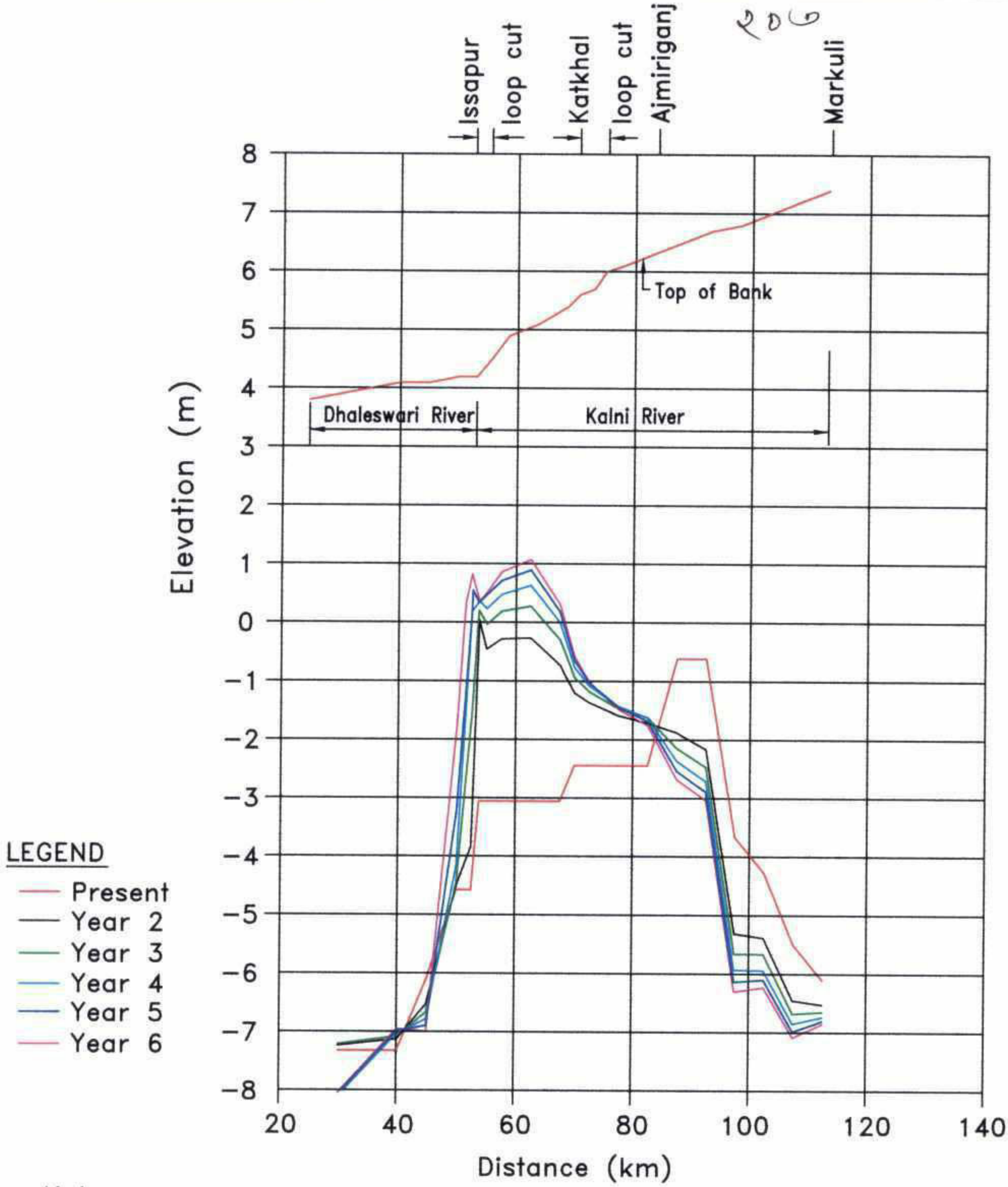

Sylhet
Bishwanath
Fenchuganj
Balaganj
Site-9
Site-10
Site-4
Site-7
Site-6
Site-8
Site-5
Site-2
Site-1
Site-3
Derai
Jagannathpur
Sullah
Ajmiriganj
Nabiganj
Baniachang
Habiganj
Mitamain
Astagram
Lakhai
29c
22b
20
21a
21b
21c
19c
19h
LEGEND
19c Old Meghna Estuarine Floodplain-Low : Ajmiriganj
19h Old Meghna Estuarine Floodplain-Low : Eastern Kishoreganj
20 Eastern Surma-Kushiyara Floodplain
21a Sylhet Basin-Western
21b Sylhet Basin-Central and Southern
21c Sylhet Basin-Northern
22b Northern and Eastern Piedmont Plains
29c Northern and Eastern Hills
River
Scale
1 0 1 2 km
N
Source : UNDP/FAO (1988)
Northeast Regional Project
Kalni-Kushiyara River Management Project
Physiography
Prepared by: MA
Computer Drafting by: Mamun
December 1997

Figure I.19



Note :

1. Simulated bed level response with Alternative 1, under a worst-case scenario of no maintenance excavation.
2. Bed profile shows mean bed levels along the channel.
3. Chainages have been adjusted to account for loop cuts.

Northeast Regional Project

Kalni–Kushiyara River Management Project

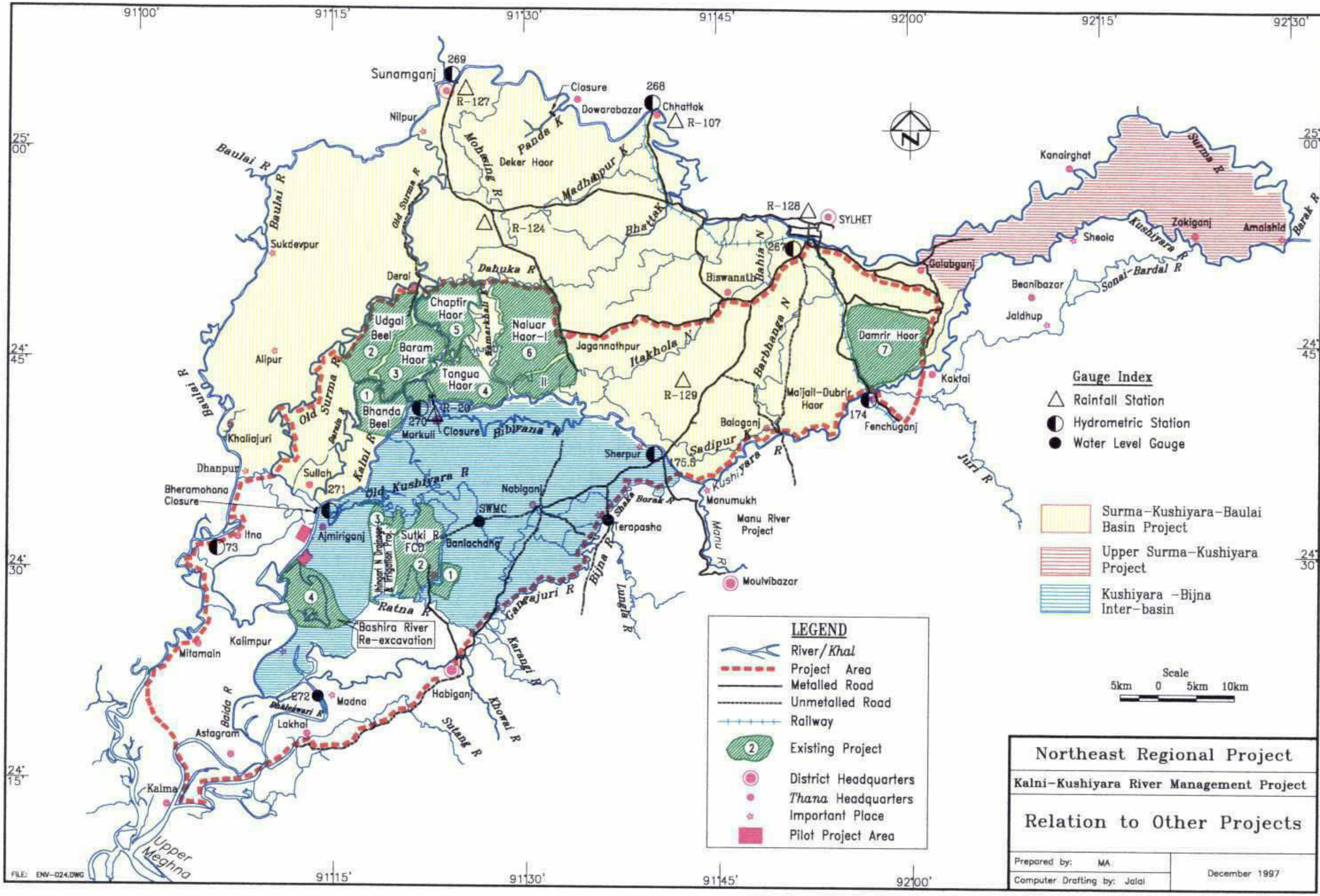
Long term Bed Profile Response–Alternative 1

Prepared by: D.G.M.

Computer Drafting by: Mamun

December 1997

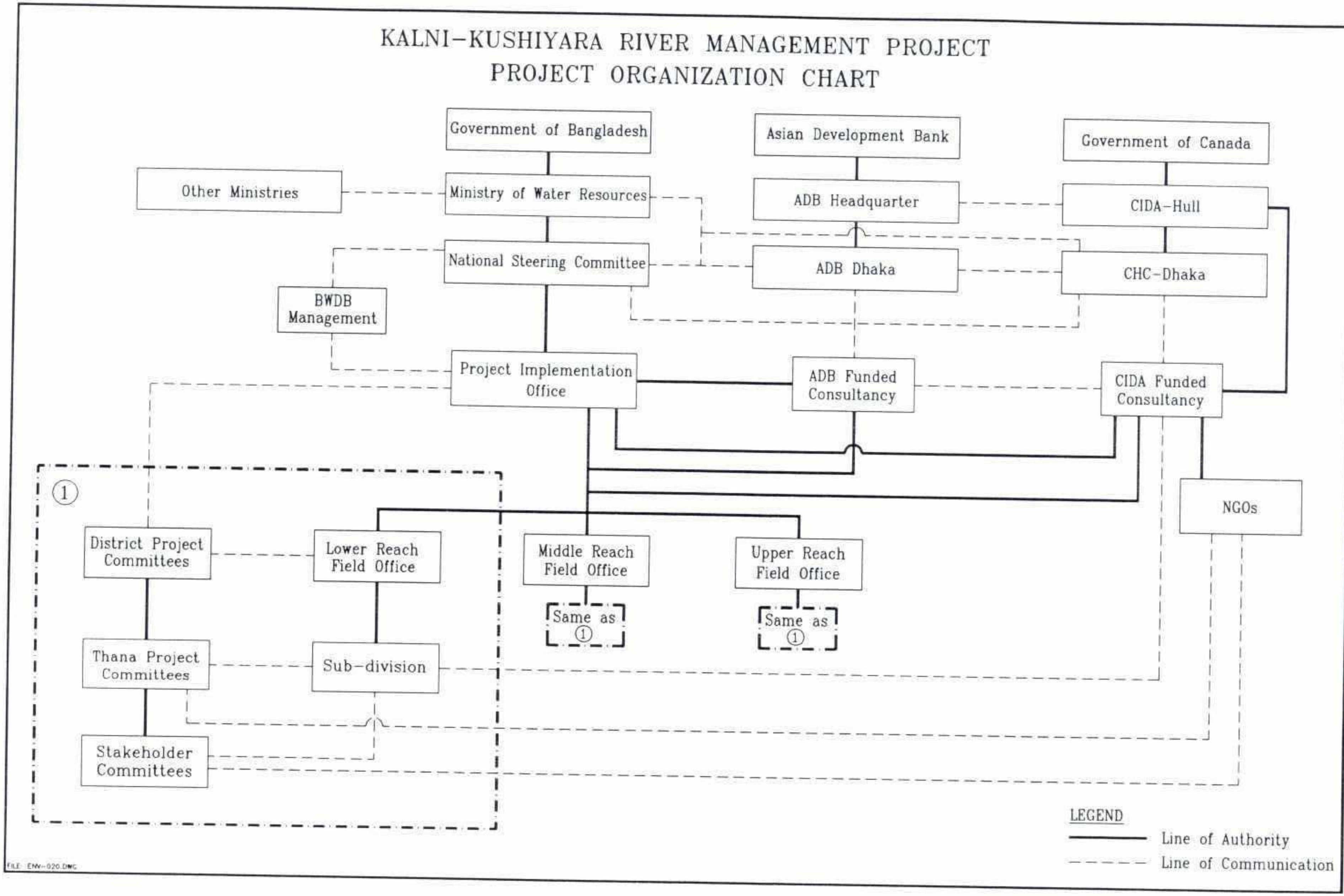
FILE: ENV-019.DWG



Northeast Regional Project
Kalni-Kushiyara River Management Project
Relation to Other Projects
Prepared by: MA
Computer Drafting by: Jalal
December 1997
LEGEND
River/Khal
Project Area
Metalled Road
Unmetalled Road
Railway
Existing Project
District Headquarters
Thana Headquarters
Important Place
Pilot Project Area
Gauge Index
Rainfall Station
Hydrometric Station
Water Level Gauge
Surma-Kushiyara-Baulai Basin Project
Upper Surma-Kushiyara Project
Kushiyara -Bijna Inter-basin
Scale
5km 0 5km 10km
91°00'
91°15'
91°30'
91°45'
92°00'
92°15'
92°30'
25°00'
24°45'
24°30'
24°15'
Sunamganj
Sylhet
Habiganj
Moulvibazar
Chhatak
Dowarabazar
Closure
Nilpur
Deker Haor
Sukdevpur
Alipur
Khaliajuri
Dhanpur
Bheramohona Closure
Itna
Mitamain
Kalimpur
Astagram
Kalma
Upper Meghna
Lakhai
Madna
Ajmiriganj
Sullah
Derai
Udgal Beel
Baram Haor
Chaptir Haor
Tangua Haor
Naluar Haor-I
Bhanda Beel
Markuli
Closure
Jagannathpur
Biswanath
Balaganj
Sherpur
Nabiganj
SWMC
Banlachang
Sutki R FCD
Jhingari N Drainage & Irrigation Proj.
Bashira River Re-excavation
Terapasha
Manumukh
Manu River Project
Damrir Haor
Maijail-Dubrir Haor
Fenchuganj
Kaktai
Golabganj
Beanibazar
Jaldhup
Kanairghat
Sheola
Zakiganj
Amalshid
R-127
R-107
R-124
R-128
R-129
R-20
269
268
267
270
271
272
73
174
75.5
Baulai R
Old Surma R
Mohasing R
Panda K
Madhabpur K
Bhatta K
Dahuka R
Bahia N
Itakhola N
Barbhanga N
Sadipur K
Kalni R
Baraia R
Bibiyana R
Old Kushiyara R
Kushiyara R
Ratna R
Gangajuri R
Bijna R
Lungla R
Shaka Barak R
Manu R
Juri R
Karangi R
Khowai R
Sutang R
Baida R
Bhaleswari R
Surma R
Barak R
Sonai-Bardal R
FILE: ENV-024.DWG

Figure I.21

Figure I.22


KALNI-KUSHIYARA RIVER MANAGEMENT PROJECT
PROJECT ORGANIZATION CHART
Government of Bangladesh
Asian Development Bank
Government of Canada
Other Ministries
Ministry of Water Resources
ADB Headquarter
CIDA-Hull
National Steering Committee
ADB Dhaka
CHC-Dhaka
BWDB Management
Project Implementation Office
ADB Funded Consultancy
CIDA Funded Consultancy
NGOs
1
District Project Committees
Lower Reach Field Office
Middle Reach Field Office
Upper Reach Field Office
Same as 1
Same as 1
Thana Project Committees
Sub-division
Stakeholder Committees
LEGEND
Line of Authority
Line of Communication
FILE: ENV-020.DWG