JAPAN INTERNATIONAL COOPERATION AGENCY

DEPARTMENT OF IRRIGATION
MINISTRY OF WATER RESOURCES
THE KINGDOM OF NEPAL

THE STUDY
ON
FLOOD MITIGATION PLAN
FOR
SELECTED RIVERS IN THE TERAI PLAIN
IN
THE KINGDOM OF NEPAL

FINAL REPORT

VOLUME III (4/9)

SUPPORTING REPORT

(A4: FMP/NARAYANI RIVER)

MAY 1998

NIKKEN Consultants, Inc.
NIPPON KOEI CO., LTD.

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A4. FLOOD MITIGATION PLAN:

NARAYANI RIVER BASIN

SUPPORTING REPORT
A4. FLOOD MITIGATION PLAN: NARAYANI RIVER BASIN

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1.1 Topography and Geology

The topography and geology of Nepal can be divided into the following zones (Fig. A1.1):

1) Inner Himalayan valleys
2) Higher Himalayan zone
3) Lesser Himalayan zone
   - Midland range
   - Mahabharat range
4) Siwalik (Churia) hills
5) Dun valleys
6) Terai plain

The Narayani river basin covers all the topographical and geological zones mentioned above. Principal features of these zones are presented below.

(1) Inner Himalayan Valleys

North of the Higher Himalayan zone and south of Tibetan plateau are called as Inner Himalayan valleys including Mustang and Langu. In these valleys the amount of annual rainfall is small below 250 mm. The rocks are of Tethys sediments with recent alluvium covering.

(2) Higher Himalayan Zone

Snow covered peaks and deep and "U" shaped glacial hanging valleys are the main topographic features in the Higher Himalayan zone. The mountains above 3,800 m,MSL are mostly barren of vegetation and above 4,800 m,MSL snow occurs at most places. Higher peaks are located mostly in the east Nepal as compared to the west. On mountain slopes, glacial moraines are found. Sometimes the moraines form glacial lakes which are found mostly in northern Nepal.

The topographic slope in this zone varies from vertical to 740 m/km. This slope makes rocks unstable. In Nepal the dip of rock is generally towards the north east. In places where river makes bend and dip is towards the valleys, exposed bedrock slips due to the

load pressure exceeding frictional force. The load increases with erosion of the valley and decreases with erosion of surface layer.

Rivers have gradient of 200 to 740 m/km and flow velocity increases at night summer when the snowmelt water reaches the river channel. Snow melts during the day and it takes about 5 to 6 hours to reach the river channel. In this zone, rockslides or mountain slides often happen. Gravity slides occur in the bed dips of 30° to 60°. Below or above this dip rocks are mostly stable, unless they are fractured.

(3) Lesser Himalayan Zone

Lesser Himalayan zone occupies the central part of the Himalayan Mountains. It consists of a series of mountain ranges rising abruptly above its low rolling hills.

The Lesser Himalayan zone is divided into two sub-ranges, namely the Midland and Mahabharat ranges from north.

Midland Range

The Midland range consists of low hills, river and tectonic valleys. The slope ranges from 100 to 400 m/km. In this range, generally the rocks consist of fissile phyllite and schist. The dip of the bed in this part is generally towards the north. In the areas where rivers have east-west course, landslides are seen on the southern bank of the river. Since the phyllite is a soft rock, the exposed bed in the bottom section of hill is found to be crushed in most places, indicating that the load is beyond its bearing capacity.

The Midland range is composed of soft rocks (phyllite, slate and dolomite) and thick soil covers this area, hence it is heavily populated. Because soft rocks weather easily, the Midland range forms low and mild slope hills. Nearly all the hill slopes are found to be formed from the talus of landslide and rock fall. Generally the hill slope appears to be stable for a period of 8 to 10 years after the slide till the talus is washed away by under-cutting of the river, and at the same time, this causes the development of gullies and erosion throughout valleys. Slowly the topography changes from flat to steeper terrain and sliding occurs again.

Mahabharat Range

The Mahabharat range consists of comparatively harder rock than the midland range.

The number of slides is found to be less even though the topography is steep. The topography is steeper on the southern slope comparing to the northern one of about 100 to 200 m/km. Slides take place on the northern slope and rock falls on the southern slope. The steep of the topography can be attributed to the Main Boundary Fault (MBF) which lies mostly at the southern foot of the ranges.

The Mahabharat ranges are the first set of high mountains facing the Terai plain, and affects much to the climate of Nepal during the monsoon.

(4) Siwalik (Churia) Hills

The Siwalik (Churia) hills are the lowest hills bordering the Indo-Gangetic plain in the north. Mostly it consists of rocks of alternating beds of clay, sandstone, sand and pebble. The rocks generally dip northwards. Alternately loose and hard rock beds have produced the escarpment feature. In many places rugged land with numerous gullies and mound of talus are found. The topographic slope varies from 200 to 400 m/km on the average. The Siwalik hills are divided into three layers, i.e., upper, middle and lower Siwaliks.

Upper Siwalik

The upper Siwalik is mainly conglomerate with pebbles and boulders of pale schistose quartzite, purple and white quartzite; dark phyllites; purple and dark pebbly quartzite and silt brown sandstone. The depth of upper Siwalik is about 2000 to 3000 meters.

Middle Siwalik

The layer of middle Siwalik is found in the form of thick deposits of sandstone. These are characterized by their feldspar and mica content. Apparently the sandstone has been derived from granite rocks. Calcareous concretions and seams of coal are found in the basal part. In many sections, the sandstone forms vertical cliffs. The depth of middle Siwalik is about 2000 to 2500 meters.

Lower Siwalik

The lower Siwalik is alteration of brown, weathered sandstone and chocolate colored clays. The alternation of beds is not thick as the sandstone. Beds of impure limestone also occur within the lower Siwalik. The depth of lower Siwalik is about 1200 to 1500

meters. All pebbles except those found in the brown sandstone are derived from rocks of Pre-tertiary age.

(5) Dun Valleys

The Siwalik hills make separate ranges from east to west except in some places where it merges with Mahabharat range. The separate ranges form Dun Valleys as seen in Trijunga, East Rapti-Nawalpur, Deokhuri (West Rapti), Dang Valley, Surkhet Valley, etc. The Dun Valleys are fertile and are similar to the Terai plain in nature. Hence they are sometimes classified as a part of the Terai plain.

(6) Terai Plain

The Terai plain is the continuation of Indo-Gangetic plain having an elevation from 50 to 300 m,MSL. Its width varies between 10 to 30 km with one exception at Koilabash narrow, and extends from east to west Nepal for about 900 km.

The Terai slopes toward south with steeper slope at the foot hill region and nearly flat at the southern end.

In the Terai plain the changes of river stream are often seen in places by the lateral erosion incorporated by much sediment from the mountainous area. On such rivers, artificial structure works such as bridge, roads and irrigation facilities have to be given careful consideration.

The Terai plain is divided into three zones, i.e., (1) Bhabhar zone (foot of hill), (2) Marshy area (spring line), and (3) Southern Terai (Indian border).

<u>Bhabhar Zone</u>

The Bhabhar zone lies at the foot of Siwalik hills and is about 12 km wide (Charkose Jhadi). It is composed of boulder, pebble, cobble and sand of Siwalik hills or Mahabharat range deposited by the present rivers. In most cases the rocks are sandstone, quartz or charty dolomite. The foot of hills is covered with evergreen forest.

Soils are mainly alluvium consisting of sand, silt, clay looms and silty clay. In the dry season almost all rivers in this zone have no flow on the surface and water flow underground only.

Marshy Area

The marshy area is found in the south of Bhabhar zone where two lithological units having different porosity and permeability meet or inter finger along with the change of elevation mainly resulting in spring lines, ponds, lakes, etc. The lithology is mostly composed of pebbles and sandy bed with a few clay partings. The lithology of the pebbles is similar to the boulder zone and sand beds are loose, brownish to greenish with black and red shale fragments. The clay is mostly blackish gray where a thick sequence is found, but yellow one is also observed at some places where there was a temporary hiatus in its deposition or because of a flood at that time. This is particularly true in Lumbini zone.

Southern Terai

This nearly flat and not well-drained area is found between middle Terai and the Indo-Nepal border. The area is composed of sand, clay and silt with less pebble.

(7) Narayani River Basin

The lower reaches of the Kali Gandaki and Trisuli river junction is called as the Narayani river. Major tributaries of the Narayani river are as presented below.

- The Kali Gandaki river drains the area from central Nepal to higher Himalaya. The Kali Gandaki river rises in the trans-Himalayan tract beyond Mamang Bhot and joins many rivers in the upper region. The river cuts across the higher Himalayan range through a gorge between the Dhoulagiri and the Annapurna massifs.
- The Seti Gandaki river rises in the base of the Annapurna Himal massif. The river flows through the Pokhara valley and joins with the Trisuli river.
- The Marsyangdi river flows on the north of Annapurna Himal massif and turns toward south on the west of Manaslu Himal.
- The Trisuli river rises from the Ganesh Himal and flows down to south, southwest and then joins the Marsyangdi river, Seti river, and finally the Kali Gandaki river.

Since in the upper basin before these rivers enter to the Narayani river, these rivers flow through the longitudial valley or gentle slope, large materials such as boulders and

cobble stones first deposit in the valley and they are transported to lower reaches by river flow during large flood.

The Narayani river is located in Dun area and surrounded by the Siwalik hills. The East Rapti river joins to the Narayani river in the Dun area. The Narayani river receives much sediment such as gravel, sand and clay through the East Rapti river and other tributaries from the Siwalik hills.

Geological map of the Narayani river basin is shown in Fig. A1.2.

1.2 Meteorology and Hydrology

1.2.1 Meteo-Hydrological Observation

Responsibilities for meteo-hydrological data collection and analysis in Nepal have been born mainly by the Department of Hydrology and Meteorology (DHM), the Ministry of Science and Technology. Other authorities such as the Department of Irrigation (DOI), Nepal Electricity Authority (NEA), and International Center for Integrated Mountain Development (ICIMOD) also conduct meteo-hydrological observations. In principle, all of these data observed by other authorities are also sent to the DHM. The DHM publishes data in yearbooks after basic checking has been completed.

The Meteorology Section of DHM is responsible for compilation and analysis of meteorological observation records such as precipitation, temperature, humidity, vapor pressure, sunshine, wind, evaporation and soil temperature. And the Hydrology Section of DHM is responsible for compilation and analysis of hydrological observation records such as water level and sediment.

Based on the DHM's data, a list of meteorological and hydrometric stations in the Central and Western Development Regions is shown in Tables A1.1 and A1.2, and their locations are shown in Figs. A1.3 and A1.4.

In order to supplement the existing observatory, the Study Team installed recording rain gauge at the following site:

River basin	Caretaker	Serial Number
Narayani	Chitwan District Irrigation Office (Bharatpur)	Gauge: 232746 Recorder: 244191

1.2.2 Meteo-Hydrological Features of Basin

Climate of the Narayani river basin varies wide range depending on the location from Tundra monsoon subtropical zone in Terai plain and Siwalik hills to Tundra in higher Himalayan zone. The dry season (from October to May) and rainy season (from June to September) are clear in the inner Terai. The dry and rainy seasons due to monsoon are the major cause of climatic contrasts in the inner Terai. Figure A1.5 shows the meteo-hydrological features of the basin based on the monthly average data at Mustang and Pokhara airport (sta. code: 0612 and 0804).

(1) Temperature

Altitude affects much the temperature. The annual average temperature is 5.7℃ at Mustang and 20.9℃ at Pokhara airport, ranging from –2.5℃ in the coldest month to 13.9℃ in the hottest month at Mustang and ranging from 13.5℃ to 25.9℃ at Pokhara airport. The coldest month is in January and the hottest falls in between June and July. The temperature rises from March to June-July while it decreases from October to January.

(2) Relative Humidity

According to Fig. A1.5, annual average relative humidity is 82.9% at Mustang and 80.9% at Pokhara airport, ranging from 70.2% in June to 94.4% in January at Mustang and from 60.9% in April to 90.2% in January at Pokhara airport.

(3) Rainfall

The study area receives the southeast monsoon during the months from June to September. The monsoon air-stream is forced to rise as it meets the Himalayas and causes heavy rainfall on the south facing slopes (Fig. A1.6).

According to Fig. A1.5, annual rainfall at Pokhara airport is 3,733mm on average ranging from 3,073 to 4,217mm depending on the year. The maximum rainfall is 4,217mm in 1993. The 81% of annual rainfall is concentrated in rainy season from June to September.

(4) Runoff

Figure A1.7 shows the monthly average flow of the Narayani river at Narayan Ghat station (No. 450).

According to Fig. A1.7, The runoff increases from May to August while it decreases from August to November and the most of runoff is concentrated in rainy season from June to September. The annual average runoff at Narayan Ghat station is approximately 1,600m^3/s. The maximum monthly average flow is approximately 5,100m^3/s in August. The monthly average flow exceeds the annual average during the period from July to September.

1.3 Environment

1.3.1 Environmental Organizations and Institutions

The Environmental Division of the Ministry of Population and Environment has overall responsibility for environmental matters in Nepal. In June of 1997, Environmental Conservation Rules were issued under section 24 of the 1997 Environmental Conservation Act. These rules lay down procedure to be followed when new projects are proposed or existing projects extended.

1.3.2 Environmental Overview

The Narayani river is a class-I river rising in the Himalayan mountains and has many tributaries joining it. It has a basin area of some 35,780 km^2, (nearly 3.6 million hectares) of which just less than 2% are in the Terai. It flows year round and has a length of 360 km. In the Terai plains, its length is about 83 km., with a basin area of some 705 km^2 (70,500 hectares). It is joined by the East Rapti river and these rivers form two boundary lines of the Chitwan National Park, one of the few remaining areas of natural vegetation in the Terai.

The national park in Chitwan is fully protected from encroachment. There is also a buffer zone round this (and every other) park, with restrictions on the use of forest land and the river bank zones. The total area of Chitwan N.P. is 93,200 ha., 80% being forest and the remaining 20% grasslands. The river Narayani runs along the park's western border, with the East Rapti river forming the park's northern border. Much of the park is

elevated, thus, during the monsoons, river water tends to flow on farm and forest land opposite the park. Some dikes and gabions etc. have been erected to prevent this from happening, but this protection is incomplete.

The flora and fauna in the Chitwan national park and wetlands in the vicinity of the Narayani river include 43 species of mammals and over a hundred species of birds. Some notable mammals and reptiles are *Rhinoceros uniceroni* (rhino), *Panthera tigris* (tiger), *Axis axis* and *A. pircinus* (deer), *Gavialis gangeticus* (gharial crocodile), *Crocoylus palustris, Plantanista gangetica* (Gangetic dolphin) and many migratory birds. The fauna include *Saccharum spontaneum* (elephant grass), *Imperata cylindrica* (imperata grass), *Bombax ceiba* (simal [false kapok]) *Dalbergia sissoo* (sisoo) *Acacia catechu* (khair), *Terminalia tormentosa* (saj) and *Trewia nudiflora*. The trees on the floodplain include, khair, sal, simal, sisoo, *Ficus glomerata* (gular), *Engenia jambolana* (kyamuno) and *Terminalia tomentosa* (saj).

The existing land use and population density of the Narayani river basin in the Terai is shown below.

(Land Area, Land Use and Population Excluding the Chitwan National Park: 1998)

Items	Agri-culture	Forest	Barren/ sand	Other	Total	Population
Area (ha)	51,310	16,280	950	1,960	70,500	(257,000)*
Ratio (%)	72.8	23.1	1.3	2.8	100	(3.6)**

(Note)*: Population (persons), **: Population density (per/ha)

Over 70% of the Narayani basin area in the Terai is now farmed, but there is still about one-quarter of the land under trees. According to the Inventory of Wetlands (IUCN 1996), there are 3 wetlands in the vicinity of this river. It is still to be determined if the proposed flood mitigation interventions will affect these areas. However, with such a high population density, the protection of the farmland and property is important.

Every year, sand, silt and/or floodwater on average covers on average over 5,000 hectares of which about 1,000 ha. are covered with sand and soil. Some of this soil cover is a result of human activity, especially in the Siwalik hills. In addition, over 1% of the land is barren or covered with sand, principally due to flooding and inundation.

This is why flood mitigation measures, including watershed activities are essential to protect the environment. With appropriate flood mitigation measures, such land could

be reclaimed and soil/sand inundation should be reduced. Also, farmers knowing their land is safe from flooding and inundation, could invest in irrigation and increase their productivity. This may relieve the pressure on the remaining forestlands, curtail deforestation and boost grain production.

1.4 Socio Economy

(1) Economic Activities

Land Use: The Narayani river flows in Chitwan and Nawalparasi districts. According to the district data, agricultural and forestland most of the total plain area in the two districts (81.9%/96.4% respectively).

unit: hectare

District	Agriculture	Forest	Sand/Gravel /Boulder	Others
CHITWAN	49,272 59.5%	18,500 22.4%	0 ---	15,000 18.1%
NAWALPARASI	71,310 86.0%	8,588 10.4%	2,239 2.7%	773 0.9%
10 Districts (where M/P rivers flow)	800,591 64.1%	352,508 28.2%	43095 3.5%	52,449 4.2%

Source: Land Resources Mapping Project 1986, Department of Survey
Forest Survey 1993, Department of Forest

Economically Active Population (10 Years of Age and Over) by Major Occupation: A ratio of 75.8%/83.8% of the labor force is engaged in agriculture, as opposed to 5.3%/2.9% in manufacturing and 12.9%/9.0% in service sectors.

District	Agriculture Worker	Service Worker	Production Worker	Sales Worker and Others
CHITWAN	105,498 75.8%	17,949 12.9%	7,377 5.3%	8311 6%
NAWALPARASI	145,290 83.8%	15,669 9.0%	5,104 2.9%	7,292 4.2%
10 Districts (where M/P rivers flow)	1,123,328 73.9%	215,393 14.2%	73,937 4.9%	107522 7%

Source: Population Census 1991, Central Bureau of Statistics

Crop Area and Productivity of Agriculture Crop: Chitwan and Nawalparasi districts produce a wide range of crops, with major crops of paddy, maize, wheat, pulse, and oilseed. These major crops but wheat, pulse and oilseed are grown during the monsoon. Although there are also winter paddy and maize, most of the paddy and maize are grown in summer.

unit: hectare. (metric ton/ha.)

District	Paddy	Maize	Wheat	Pulses	Oilseeds	Sugarcane	Vegetables
CHITWAN	45,000 (2.70)	27,127 (2.00)	9,100 (1.70)	---	19,550 (0.75)	40 (27.00)	---
NAWALPARASI	46,100 (3.06)	7,700 (2.40)	19,000 (2.36)	7,870 (0.43)	---	7,100 (43.5)	950 (12.00)
10 Districts (where M/P rivers flow)	537671 (27.79)	145489 (18.14)	174589 (19)	98536 (4.9)	102720 (7.92)	17331 (233.06)	11930 (52.58)

Source: Annual Agricultural Development Programme 1995/96, District

(2) Land Holding

Land Ownership & Holding: In Chitwan/Nawalparasi districts, the average land holding size has declined in recent years like other districts in the Terai plain. The average size is far below the 16.4 hectare ceiling imposed by the 1964 Lands Act. More than 90% of the agricultural land is under owner-cultivation. With regard to the agricultural land under "formal" tenancy, the most dominant form is sharecropping.

District	Owner-Cultivated (%)		Average Holding Size (ha.)	
	1981/82	1991/92	1981/82	1991/92
CHITWAN	97.0	93.4	1.67	0.80
NAWALPARASI	98.1	94.7	1.45	1.11
Terai	91.8	87.6	1.47	1.22

Tenure Arrangements: However, that since informal arrangements of land tenancy are not recorded in the official census, the above figure of owner-cultivation should be treated with caution. Underlying the sharecropping category is a commonly known phenomenon of "dual ownership". To undertake flood mitigation works for land under "dual ownership", it will be imperative to involve both land owners and tenants, both of whom are entitled to certain shares of the proceeds of the land.

District	Tenure Arrangement – 1991/92 (%)		
	Fixed Rent	Share Crop	Others
CHITWAN	15.3	6.9	77.8
NAWALPARASI	14.5	66.4	19.1
Terai	30.6	62.7	6.7

Source: Nepal Sample Census of Agriculture 1991/92, Department of Agriculture

(3) Population

From nation-wide viewpoint, in-migration in the east is approaching to zero, as new lands available for cultivation are being closed. On the other hand, the western districts continue to exhibit high population growth, since the land frontiers are relatively open. In a similar vein, the original inhabitants of the Terai constitute nearly or more than half

the population towards the west, while the proportion of indigenous groups makes up less than half in most of the eastern districts.

Population of Chitwan and Nawalparasi districts is 354,000 and 436,000 as of 1991 with population growth rates of 3.1% and 3.4% (1981-1991) respectively. The population growth ratios have gradually been declining since 1970s, just as the national average. The current pace of population growth rates are slightly higher than the national average, i.e., 2.3% (1981-1991).

Demographic Records of Flood-Prone VDCs: The following table shows the population trends of the VDCs affected by Narayani floods. The 1981-91 population growth rate of the affected VDCs is 6.3%. This indicates that the population pressure is higher in the flood-risk VDCs, than other localities in Chitwan/ Nawalparasi districts.

District	VDC	1971	1981	1991	1996
Chitwan	Divyanagar	-	6,662	7,001	8,160
	Gunjnagar	5,190	5,701	11,067	12,909
	Mangalpur	6,502	10,480	13,488	15,720
	Meghauli	6,987	9,374	12,363	14,401
Nawal Parasi	Parsauni	2,335	-	4,709	5,579
	Pithauli	3,044	7,673	5,957	7,058
	Kumarvatti	-	-	4,155	4,923
	Rajahar	-	-	7,839	9,288
	Koluwa	4,583	7,542	6,292	7,455
	Mukundpur	-	-	7,631	9,041
	Narayani	-	-	7,234	8,571
Total		28,641	47,432	87,736	103,105

Source: Population Census 1991, Central Bureau of Statistics
Nepal District Profile 1997, National search Associates

(4) Human Development Index (HDI)

In terms of the Human Development Index (which is a development indicator based on life expectancy, adult literacy, and GDP), the districts in eastern areas of the country receive, in general, higher performance, and become lower toward the west. Whil the HDI of Chitwan district is one of the highest (16th of all 75 districts), the HDI of the neighboring Nawalparasi district is ranked among the lower strata (51st among all 75 districts).

1.5 River and Basin Conditions

1.5.1 Principal Basin Features

The Narayani river basin extends from 27°15'N to 29°15'N and from 83°00'E to 85°45'E. The Narayani river originates in the Higher Himalayan zone. The river is classified as a class I river. Administratively the inner Terai of the Narayani river falls under Chitwan district of Central Development Region (left bank) and Nawalparasi district of Western Development Region (right bank).

Basin area of the Narayani river is 35,780 km^2 in total, consisting of 35,075 km^2 of mountainous basin and 705 km^2 of plain area. General basin maps of the Narayani river is shown in Fig. A1.8. Topographic maps of 1/50,000 were used to prepare overall basin maps. The basin map of the inner Terai was prepared based on the topographic maps of scale 1/25,000 (Eastern Nepal topographic mapping series and Lumbini zone mapping series). Boundaries of the river basin and sub-basins were drawn on the basin map. Basin boundary in the inner Terai was delineated in consideration of existing drainage channels, irrigation canals, road networks and other ground objects.

Notable features of the Narayani river basin are as follows:

1) The Narayani river forms a valley called inner Terai in the downstream area from E-W Highway bridge, having narrow gorge in the lower end near Indian border
2) River is braided in the plain area and has islands in the river area.
3) Major tributaries in the inner Terai are the East Rapti and Rewa rivers. Numerous tributaries from the Siwalik hills flow into the Narayani.
4) At the gorge section, Narayani barrage was constructed and managed by India. Nepal Gandak Western Canal Project is operated for the lower areas of the gorge getting water from the barrage.
5) Bharatpur city is located in the riverine area near the outlet from the mountainous basin.

1.5.2 Characteristics of River Channel

Channel slope and width of the existing river are shown in Fig. A1.9 for the plain reaches. These were prepared based on the topographic map of scale 1/25,000, since river survey results were not available. In order to obtain the river profile, spot elevation data on the topographic map were used and the river width was measured on

the map at the intervals of 1 km along the river. The river width includes perennial river sections and sandbars of the meandering and braided river section.

According to the figure, principal features of the existing river in the Terai plain are summarized below.

River	Class	Length(km)	Slope	Width(m)
Narayani R.	I	83.0(80.6)	1/720~1/1560	400~2500

Note: River length in ( ) indicates that downstream from E-W Highway

1.5.3 River Course Shifting

It is generally said that rivers in the Terai plain have tendency to shift westwards. If it is true the existing talweg might take closer to west or right side bank as a whole. To confirm this hypothesis, the location of talweg in the river section was measured at every 1 km and shown in the Fig. A1.9. The clear tendency of westward shifting was not seen.

In order to look into the actual shifting of river course in the past, topographic maps prepared in 1953/54 (scale: 1/50,000) and those in 1992 (scale: 1/25,00) were superimposed and shown in Fig. A1.10.

According to the figure showing river course change during the past 38 years, the following features are considered:

1) Meander of river channel is not sever for the main Narayani river and the shifting of river course seems to remain within the meander belt.
2) Meandering of the East Rapti and Rewa rivers is rather severe and the river course shifting is large.

1.5.4 Riverbed Materials

The Study Team investigated riverbed materials along the plain reaches of the river. The investigation includes the following outdoor and indoor works:

1) Sampling of river bed materials at site
2) Grain size analysis at site field and in laboratory
3) Specific gravity test in laboratory

Bed materials of the Narayani river were sampled at 23 sites (Fig. A1.11) among which outdoor analyses were carried out at 20 sites. Results of riverbed material tests are shown in Table A1.3 and the grading curves in Fig. A1.12

Principal features of the riverbed materials are summarized below. In the descriptions below, UI denotes uniformity index defined as a ratio of d_{84} to d_{16}, SG stands for specific gravity, and classification of grain size is principally based on classification by AGU.

1) Samples: Riverbed materials were sampled from the main course of the Narayani river except for the following:
   - Anabranch of Narayani R: Na-9, Na-9A, Na-13, Na-14
   - East Rapti R: Na-11, Na-16, Na-17
   - Tributaries: Na-1, Na-3, Na-4, Na-8
2) Grain size:
   - Main river: d_{60} = 7.39 to 77.96 mm (distribute in wide range from fine gravel to small cobbles) except Na-2
   - Right anabranch: d_{60} = 0.10 to 5.93 mm (very fine sand to fine gravel)
   - E. Rapti R: d_{60} = 24.36 to 47.91 mm (coarse to very coarse gravel)
   - Tributaries from Siwalik hill: d_{60} = 20.27 to 39.70 mm (coarse gravel)
3) Uniformity index: All samples distribute in wide range UI>38 except for anabranch samples and Na-21.
4) Specific gravity
   - SG = 2.65 g/cc on average ranging from 2.60 to 2.70 g/cc
5) Longitudinal distribution: Significant change in grain sizes is not clear.

Based on the investigation result, grain size distribution along the river is shown in the Fig. A1.9.

1.5.5 Land Use

Land utilization map and land capability map (scale: 1/50,000) are available. These maps have been prepared by Topographic Survey Section of Survey Department under the Canadian assistance program.

Mapping details are based on aerial photos taken in 1978 and 1979 and extensive field truthing and sampling during the year 1980 and 1981. The maps were published in

1982.

Existing land use of the plain area is shown in Fig. A1.13 based on the land utilization map. These maps were prepared rearranging the classifications into five categories, i.e., (1) rice field, (2) diversified cropland, (3) grazing land, (4) forest, and (5) settlement.

Land capability map is also available, which shows the land capability for agricultural development mainly based on the land system such as topography, land slope, soil and drainage conditions. Future land use would be prospected from the land capability.

1.5.6 Existing Basin Development Projects and Plans

(1) Gandaki Irrigation Project

The Gandaki barrage is located at the outlet of narrow gorge of inner Terai plain, and service area covers western lands of the Narayani river. Therefore the project area is located outside of the flood prone area for the Study.

(2) Other Water Resources Development Projects

There exist nine major hydropower plants over the country of Nepal. Out of these 6 plants (136.5 MW in total) are located in the Narayani river, while others are in the Sunkosi and Bagmati rivers as listed below (Fig. A1.14).

Plant	Proposed capacity (MW)	River
Panauti	2.4	Sunkosi R.
Trisuli	21.0	Narayani R./Trisuli R.
Sunkosi	10.0	Sunkosi R.
Gandak	15.0	Narayani R.
Kulekhani No.1	60.0	Bagmati R.
Devighat	14.1	Narayani R./Trisuli R.
Kulekhani No.2	32.0	Bagmati R.
Marsyangdi	69.0	Narayani R./Marsyangdi R.
Andi Khola (BPC)	5.1	Narayani R./Kaligandaki R.
Jhimruk (BPC)	12.3	Narayani R./Kaligandaki R.
Total	240.9	

NEA has conducted Phase-I study of Medium Hydropower Study Project with an aid of Canadian International Water and Energy Consultants. The medium hydropower is defined as those ranging 10 to 300 MW. In this study, a total of 138 sites were inventoried. Through the several stages of screening, 7 priority sites were selected as

follows:

Plant	Installed capacity (MW)	River
Upper Karnali (KR-1A)	240	Karnali R.
Dudh Koshi (DD-1)	134	Sunkosi R.
Kabeli A (KB-A)	35	-
Likhu Khola (LK-4)	34	Kamala R.
Rahughat Khola (RH-0)	24	Narayani R.
Budhi Ganga (BG-0)	22	Karnali R.
Tamur (TM-3)	72	-

1.6 Vegetation in Watershed Area

General features of vegetation in the watershed area are presented here. Sediment yield from the watershed was not estimated for the Narayani river, since the watershed area is large and the sediment yield in the watershed does not directly affect the sediment flows in the plain area. Most of the sediments in the plain area are secondary or tertiary sediment deposit transported by river flows.

Watershed of the Narayani river is classified as the climate and vegetation divisions of Terai and Outer Himalaya, Middle Mountain, Himalaya Inner Valleys and Alpine Deserts.

(1) Terai and Outer Himalaya

The Terai plain is composed of an alluvial fan and an alluvial plain of elevation ranging from 50 m to 300 m,MSL extending from the foot of Siwalik hills to the Indian border. The climate of this area belongs to the monsoon subtropical zone, and the dry season is from October to May with the rainy season from June to September. The Terai plain was covered widely by Sal forests (*Shorea robusta*). But, recently farmers from Middle Mountains cleared the forests rapidly for agricultural land and villages.

The Siwalik hills were formed by upheaval of sediment bed carried from Himalaya. Forests are left in the Siwalik hills, because of too steep inclination for settlement and farming. But, clearing forest takes place recently even in the Siwalik hills.

(2) Middle Mountain

The Middle Mountain is the area of 1000 to 2500 m,MSL between the Mahabharat and High Himalaya mountain. The Middle Mountain is the central place of Himalayan

mountain residents. In the eastern and central part of the Middle Mountain, population is large and forest changed to cultivated lands and residential areas.

Large forest area shall remain in the western part of the country where population is sparse. Generally the forests are left in the areas such as (1) steep slope area which is hard to approach, (2) community forest managed by village, (3) forest with small shrine of native belief, and (4) northern slope which is not suitable for agriculture.

Vegetation changes according to the changes of elevation. Sal forest continues from the Terai plain up to 1000 to 1200 m,MSL, followed by laurel forest from 1000 to 2500 m,MSL. These vegetation zones are recognized throughout the Middle Mountain, and forest species changes from humid type in eastern part to dry type in western part.

(3) Himalaya Inner Valleys

Himalaya Inner Valley is located in the main ridges of High Himalayas. Because the Middle Mountain interrupts monsoon from the south, rainfall in this area is less than that in the Middle Mountain area.

The area forms Alpine zone of elevation ranging from 3800 to 5500 m,MSL. Forest of Himalaya Inner Valley are formed *Abies spectabilis* forest (3000 to 3800 m,MSL), *Betula utilis* forest (3700 to 3800 m,MSL) and the high mountain scrub (3800 to 3900 m,MSL).

(4) Alpine Deserts

Annapurna and Dhaulagiri mountains interrupt monsoon from south, and make the southern mountain areas rainy with annual rainfall amounting to 5000 mm. On the other hand, the northern mountain area ranging from 3000 to 5000 m,MSL is arid with annual precipitation of 500 mm or less.

Plants which grow scattering in this zone are Genus *Caragana,* Genus *Nepeta,* Genus *Ephedra* , *Rosa sericea* and *Artemisia gmelinii.* Vegetation of arid zone also has variety of plants as in Tibet Highland, Central Asia and Iran-Turan region.

1.7 Past Flood and Sediment Disasters

The Study Team investigated conditions of past flood and sediment disasters in January

1998. On the basis of the information obtained from the District Irrigation offices and District Development Committee offices, a total of 11 VDC/Municipality offices were selected for the investigation. Furthermore, a total of 101 residents in the flood prone areas were selected for the interview using questionnaire form.

Questionnaires to the residents are summarized in Table A1.4. In recent 10 years, the Narayani river experienced big floods in 1988, 1993 and 1995. Bank erosion sedimentation and flooding over farmland are the major types of disasters. Among these, bank erosion is the most serious problem. Frequent flooding occurs in the low-lying lands on the right bank in the lower reaches from the East Rapti rivers junction.

According to the data and information obtained from DDC and DIO of Chitwan and Nawal Parasi districts, areas suffering from bank erosion and flooding are summarized as shown below.

(Areas Suffering from Bank Erosion and Flooding)

VDC	Village/Ward
(Nawal Parasi)	
Mukundpur	Pitauji
Rajahar	Bote Tole, Kujauli (Tallo), Kujauli (Mathillo), Kotetadi
Pithauli	Rudauli, Gairi
Kumarvarti	Amaltari
Kolhuwa	Kolhuwa (No.4), Nandpur, Ratanpur, Bharmsthan
Narayani	Dhajaha, Sitapur, Sehari, Bhandara
Parsauni	Somara, Parsauni (No.3), Kulcutta, Tole, Buduwa
Naya Vehani	Tamaspur (No.1, No.2)
(Chitwan)	
Mangalpur	Bharampur, Jhanjhan,
Gunjanagar	Gajipur, Gobareni
Divyanagar	Hirapur, Koila, Padariya, Sishait, Bhagedi
Meghauli	Bardaha, Parsabazar, Loukure, Sisabash, Jogitole, Bhatatpur, Salbash, Pahadi, Jitpur, Baluwa, Dadreni, Pipara, Pathreni, Bancatta

Loss of life and damage to properties are shown in Table A1.5, mainly based on data during 1993-flood. According to the field investigation and interviews of residents, flood-suffering areas during the 1993-flood are shown in Fig. A1.15.

1.8 Flood Mitigation Activities

1.8.1 Existing River Facilities

According to the result of investigation conducted by the Study Team in January 1998, major river facilities of the Lakhandei river are as follows:

1) Embankment: none
2) Spur : 65 sites
3) Revetment : 4 sites
4) Head work : none
5) Bridge : 1 site

Location of these facilities is shown in Fig. A1.16. As seen in the above, spur (groin) works share by far the majority of the facilities followed by revetment works. Almost all the spur and revetment works are made of gabion by boulder and galvanized iron (G.I.) wire net.

The existing facilities are located sporadically along the river course. Some of these spur and revetment works are damaged already probably due to inappropriate foot protection. In some sites single spur was seen, though the spur works can function effectively, in general, when they are installed as a series. The types of existing spur or bank protection works are monotonous. Variety of works should be introduced taking account the river condition and availability of materials. Photos of typical river facilities are shown in Fig. A1.17.

1.8.2 Policy Framework

There are various laws and policies governing and orientating the flood mitigation activities. The followings are the major ones, among others:

1) Approach to the Ninth Plan (1997-2002)
2) National Action Plan on Disaster Management
3) Draft Flood Mitigation Policy
4) Watershed Development Policy

1.8.3 Organizations Involved in Flood Mitigation

The Department of Irrigation (DOI) is responsible for flood mitigation in the downstream areas. At the same time, there are other agencies that can make significant contributions to the implementation of flood mitigation project, both within and outside the central Government.

The Water-induced Disaster Prevention Technical Center (DPTC) has developed technologies and methodologies which can be applied to the project.

The Department of Soil Conservation and Watershed Management (DOSCWM), with an increasing number of branch offices in the Terai plain, also contributes to the project implementation through soil conservation which is also a crucial factor in promoting flood mitigation in the target areas.

As indicated by the experience of the efforts for small-scale infrastructure development by the Ministry of Local Development (MLD), the local governing institutions (LGIs) can play a significant role in facilitating community mobilization and also in coordinating different organizations operating in their own jurisdictions. There exists an NGO-led disaster preparedness network (DPNET), an association of organizations concerned with community-based disaster management can participate in implementing community development components of the flood mitigation project.

Table A1.1 (1/3)

LIST OF METEOROLOGICAL STATIONS

Station No.	Station Name	Type of Station	Reg.	Latitude			Longitude			Elevation (m)	Start of Record	Remarks
				°	'	"	°	'	"			
0601	Jomsom	Climatology	W	28	47	00	83	43	00	2,744	07-1957	Narayani
0604	Thakmarpha	Agrometeology	W	28	45	00	83	42	00	2,566	12-1966	Narayani
0605	Baglung	Climatology	W	28	16	00	83	36	00	984	05-1969	Narayani
0606	Tatopani	Precipitation	W	28	29	00	83	39	00	1,243	05-1969	Narayani
0607	Lete	Precipitation	W	28	38	00	83	36	00	2,384	05-1969	Narayani
0608	Ranipauwa (M Nath)	Precipitation	W	28	49	00	83	53	00	3,609	05-1969	Narayani
0609	Beni Bazar	Climatology	W	28	21	00	83	34	00	835	02-1956	Narayani
0610	Ghami (Mustang)	Precipitation	W	29	03	00	83	53	00	3,465	11-1972	Narayani
0612	Mustang (Lomangtang)	Climatology	W	29	11	00	83	58	00	3,705	09-1973	Narayani
0613	Karki Neta	Precipitation	W	28	11	00	83	45	00	1,720	02-1977	Narayani
0614	Kushma	Climatology	W	28	13	00	83	42	00	891	05-1969	Narayani
0615	Bobang	Precipitation	W	28	24	00	83	06	00	2,273	12-1977	Narayani
0616	Gurja Khani	Precipitation	W	28	36	00	83	13	00	2,530	12-1978	Narayani
0619	Gharapani	Precipitation	W	28	24	00	83	44	00	2,742	03-1975	Narayani
0620	Tribeni	Precipitation	W	28	02	00	83	39	00		*	Narayani
0621	Darbang	Precipitation	W	28	23	00	83	24	00		*	
0622	Rangkhani	Precipitation	W	28	09	00	83	34	00		*	
0701	Ridi Bazar	Precipitation	W	27	57	00	83	26	00	412	07-1956	Narayani
0702	Tansen	Climatology	W	27	52	00	83	32	00	1,067	07-1956	Tinau
0703	Butwal	Climatology	W	27	42	00	83	28	00	205	07-1956	Tinau
0704	Beluwa (Girwari)	Precipitation	W	27	41	00	83	03	00	150	02-1957	Narayani
0705	Bhairhawa Airport	Agrometeology	W	27	31	00	83	26	00	109	09-1966	Tinau
0706	Dunkauli	Agrometeology	W	27	41	00	84	13	00	154	10-1965	Narayani
0707	Bhairhawa (Agric)	Agrometeology	W	27	32	00	83	28	00	120	01-1968	Tinau
0708	Parasi	Precipitation	W	27	32	00	83	40	00	125	05-1971	
0710	Dumkibas	Precipitation	W	27	35	00	83	52	00	164	05-1970	Narayani
0715	Khanchikot	Climatology	W	27	56	00	83	09	00	1,760	11-1970	Narayani
0716	Taulihawa	Climatology	W	27	33	00	83	04	00	94	11-1970	
0721	Pattharkot (West)	Precipitation	W	27	46	00	83	03	00	200	03-1973	
0722	Musikot	Precipitation	W	28	10	00	83	16	00	1,280	06-1956	Narayani
0723	Bhagwanpur	Precipitation	W	27	41	00	82	48	00	80	01-1975	
0724	Paklihawa	Precipitation	W	27	29	00	83	27	00	100	01-1970	
0725	Tamghas	Climatology	W	28	01	00	83	15	00	1,530	11-1979	Narayani
0726	Gagarkot	Precipitation	W	27	52	00	83	48	00	500	11-1979	Narayani
0727	Lumbini	Precipitation	W	27	28	00	83	17	00	95	10-1980	Tinau
0728	Simari	Climatology	W	27	32	00	83	45	00	154	04-1981	Narayani
0801	Jagat (Setibas)	Precipitation	W	28	20	00	84	54	00	1,334	07-1957	Narayani
0802	Khudi Bazar	Climatology	W	28	17	00	84	22	00	823	07-1957	Narayani
0803	Pokhara (Hospital)	Precipitation	W	28	14	00	84	00	00	866	06-1956	Narayani
0804	Pokhara Airport	Agrometeology	W	28	13	00	84	00	00	827	10-1965	Narayani
0805	Syangja	Climatology	W	28	06	00	83	53	00	868	11-1972	Narayani
0806	Larke Sando	Precipitation	W	28	40	00	84	37	00	3,650	06-1978	Narayani
0807	Kunchha	Precipitation	W	28	08	00	84	21	00	855	06-1956	Narayani
0808	Bandipur	Precipitation	W	27	56	00	84	25	00	965	06-1956	Narayani
0809	Gorkha	Agrometeology	W	28	00	00	84	37	00	1,097	06-1956	Narayani
0810	Chapkot	Climatology	W	27	53	00	83	49	00	460	02-1957	Narayani
0811	Malepatan (Pokhara)	Agrometeology	W	28	13	00	83	57	00	856	04-1966	Narayani
0813	Bhadaure Deurali	Precipitation	W	28	16	00	83	49	00	1,600	05-1969	Narayani
0814	Lumle	Agrometeology	W	28	18	00	83	48	00	1,740	11-1969	Narayani
0815	Khairini Tar	Agrometeology	W	28	02	00	84	06	00	500	03-1969	Narayani
0816	Chame	Climatology	W	28	33	00	84	14	00	2,680	07-1974	Narayani
0817	Damauli	Precipitation	W	27	58	00	84	17	00	358	01-1974	Narayani
0818	Lamachaur	Precipitation	W	28	16	00	83	58	00	1,070	01-1972	Narayani
0820	Manang Bhot	Precipitation	W	28	40	00	84	01	00	3,420	06-1975	
0821	Ghandruk	Precipitation	W	28	23	00	83	48	00	1,960	05-1976	Narayani
0822	Khuldi	Precipitation	W	28	26	00	83	50	00	2,440	09-1973	
0823	Gharedhunga	Precipitation	W	28	12	00	84	37	00	1,120	07-1976	Narayani
0824	Sikles h	Precipitation	W	28	22	00	84	06	00	1,820	06-1977	Narayani
0825	Begnas Tal	Precipitation	W	28	12	00	84	06	00	900	07-1981	
0826	Walling	Precipitation	W	27	59	00	83	46	00	750	*	
0827	Rumjakot	Precipitation	W	27	52	00	84	08	00	660	*	
0902	Rampur	Agrometeology	C	27	37	00	84	25	00	256	01-1967	Narayani
0903	Jhawani	Precipitation	C	27	35	00	84	32	00	270	02-1957	Narayani
0904	Chisapani Gadhi	Precipitation	C	27	33	00	85	08	00	1,706	05-1956	Narayani
0905	Daman	Climatology	C	27	36	00	85	05	00	2,314	09-1965	Narayani
0906	Hetaunda N.F.I	Climatology	C	27	25	00	85	03	00	474	08-1966	Narayani

Table A1.1 (2/3)

LIST OF METEOROLOGICAL STATIONS

Station No.	Station Name	Type of Station	Reg.	Latitude	Longitude	Elevation (m)	Start of Record	Remarks
				° ' "	° ' "			
0907	Amlekhganj	Precipitation	C	27 17 00	85 00 00	396	06-1955	
0909	Simara Airport	Agrometeology	C	27 10 00	84 59 00	130	09-1965	
0910	Nijgadh	Precipitation	C	27 17 00	85 10 00	244	06-1955	
0911	Parwanipur	Agrometeology	C	27 04 00	84 58 00	115	01-1967	
0912	Ranoli Bairiya	Precipitation	C	27 01 00	85 23 00	152	01-1956	
0915	Karkhu Gaun	Precipitation	C	27 37 00	85 09 00	1,530	12-1971	
0917	Hetaunda (Ind Dis)	Precipitation	C	27 26 00	85 02 00	466	01-1974	Narayani
0918	Birgunj	Precipitation	C	27 00 00	84 52 00	91	02-1974	
0919	Makwanpur Gadhi	Precipitation	C	27 25 00	85 10 00	1,030	12-1974	Narayani
0920	Beluwa	Precipitation	C	27 30 00	84 45 00	274	12-1974	Narayani
0921	Kalaiya	Precipitation	C	27 02 00	85 00 00	140	02-1976	
0922	Gaur	Climatology	C	26 46 00	85 18 00	90	03-1983	
1001	Timure	Precipitation	C	28 17 00	85 26 00	1,900	06-1957	Narayani
1002	Aru Ghat D.Bazar	Precipitation	C	28 03 00	84 49 00	518	06-1957	Narayani
1003	Trishuli	Precipitation	C	27 55 00	85 09 00	595	12-1955	Narayani
1004	Nuwakot	Climatology	C	27 55 00	85 10 00	1,003	05-1956	
1005	Dhading	Precipitation	C	27 52 00	84 56 00	1,420	05-1956	Narayani
1006	Gumthang	Precipitation	C	27 52 00	85 52 00	2,000	07-1947	
1007	Kakani	Agrometeology	C	27 48 00	85 15 00	2,064	01-1962	Narayani
1008	Nawalpur	Precipitation	C	27 48 00	85 37 00	1,592	06-1959	
1009	Chautara	Precipitation	C	27 47 00	85 43 00	1,660	07-1947	
1011	Kathmandu (US AID)	Precipitation	C	27 42 00	85 20 00	1,335	01-1954	
1012	Sundarijal (Pwr.House)	Precipitation	C	27 45 00	85 25 00	1,364	05-1940	
1013	Sundarijal (Water Res.)	Precipitation	C	27 47 00	85 26 00	1,576	05-1940	
1014	Kathmandu (I.E.)	Precipitation	C	27 44 00	85 20 00	1,324	01-1921	
1015	Thankot	Precipitation	C	27 41 00	85 12 00	1,630	09-1966	
1016	Sarmathang	Climatology	C	27 57 00	85 36 00	2,625	11-1970	
1017	Dubachaur	Precipitation	C	27 52 00	85 34 00	1,550	11-1970	
1018	Baunepati	Precipitation	C	27 47 00	85 34 00	845	11-1970	
1020	Mandan	Precipitation	C	27 42 00	85 39 00	1,365	07-1947	
1022	Godavari	Climatology	C	27 35 00	85 24 00	1,400	05-1952	
1023	Dolal Ghat	Precipitation	C	27 38 00	85 43 00	710	07-1947	
1024	Dhulikhel	Climatology	C	27 37 00	85 33 00	1,552	06-1947	
1025	Dhap	Precipitation	C	27 55 00	85 38 00	1,240	12-1976	
1027	Bahrabise	Precipitation	C	27 47 00	85 54 00	1,220	12-1965	
1028	Pachuwar Ghat	Precipitation	C	27 34 00	85 45 00	633	01-1966	
1029	Khumaltar	Agrometeology	C	27 40 00	85 20 00	1,350	05-1967	
1030	Kathmandu Airport	Agrometeology	C	27 42 00	85 22 00	1,336	06-1949	
1035	Sankhu	Precipitation	C	27 45 00	85 29 00	1,419	09-1970	
1036	Panchkhal	Agrometeology	C	27 41 00	85 38 00	865	11-1970	
1038	Dhunibesi	Climatology	C	27 43 00	85 11 00	1,085	04-1971	Narayani
1039	Panipokari (Kathmandu)	Climatology	C	27 44 00	85 21 00	1,335	04-1971	
1043	Nagarkot	Climatology	C	27 42 00	85 31 00	2,163	05-1971	
1047	Pharping	Precipitation	C	27 37 00	85 18 00	1,500	05-1971	
1049	Khopasi (Panauti)	Precipitation	C	27 35 00	85 31 00	1,517	06-1971	
1052	Bhaktapur	Precipitation	C	27 44 00	85 25 00	1,330	05-1971	
1054	Thamachit	Precipitation	C	28 10 00	85 19 00	1,847	11-1971	Narayani
1055	Dhunche	Climatology	C	28 06 00	85 18 00	1,982	11-1971	Narayani
1056	Tokha	Precipitation	C	27 48 00	85 26 00	1,790	12-1972	
1057	Pansayakhola	Climatology	C	28 01 00	85 07 00	1,240	01-1973	
1058	Tarka Ghyang	Precipitation	C	28 00 00	85 33 00	2,480	01-1974	
1059	Changu Narayan	Precipitation	C	27 45 00	85 25 00	1,543	05-1974	
1060	Chapa Gaun	Precipitation	C	27 36 00	85 20 00	1,448	10-1975	
1061	Lubhu	Precipitation	C	27 39 00	85 23 00	1,341	11-1975	
1062	Sangachok	Climatology	C	27 42 00	85 43 00	1,327	05-1979	
1063	Thokarpa	Precipitation	C	27 42 00	85 47 00	1,750	07-1979	
1071	Buddhanilakantha	Climatology	C	00	00	1,360	*	
1072	Paigutang	Climatology	C	28 13 00	85 11 00	4,091	*	
1101	Nagdaha	Precipitation	C	27 41 00	86 06 00	850	01-1977	
1102	Charikot	Precipitation	C	27 40 00	86 03 00	1,940	06-1959	
1103	Jiri	Agrometeology	C	27 38 00	86 14 00	2,003	08-1961	
1104	Melung	Precipitation	C	27 31 00	86 03 00	1,536	06-1959	
1106	Ramechhap	Precipitation	C	27 19 00	86 05 00	1,395	04-1948	
1107	Sindhuli Gadhi	Climatology	C	27 17 00	85 58 00	1,463	06-1955	
1108	Bahun Tilpung	Precipitation	C	27 11 00	86 10 00	1,417	05-1958	
1109	Patthar kot (East)	Precipitation	C	27 05 00	85 40 00	275	01-1956	Lakhandehi

LIST OF METEOROLOGICAL STATIONS

Station No.	Station Name	Type of Station	Reg.	Latitude			Longitude			Elevation (m)	Start of Record	Remarks
				°	'	"	°	'	"			
1110	Tulsi	Precipitation	C	27	02	00	85	55	00	457	12-1955	
1111	Janakpur Airport	Climatology	C	26	43	00	85	58	00	90	06-1968	
1112	Chisapani Bazar	Precipitation	C	26	55	00	86	10	00	165	07-1955	
1114	Hardinath	Precipitation	C	26	48	00	85	59	00	93	11-1968	
1115	Nepal Thok	Precipitation	C	27	27	00	85	49	00	1,098	04-1948	
1116	Hariharpur Gadhi	Precipitation	C	27	20	00	85	30	00	880	06-1955	
1117	Hariharpur Gadhi Valley	Precipitation	C	27	20	00	85	30	00	250	03-1978	
1118	Manusmara	Climatology	C	26	53	00	85	25	00	100	02-1979	
1119	Gausala	Precipitation	C	26	53	00	85	47	00	200	02-1979	
1120	Malangwa	Precipitation	C	26	52	00	85	34	00	150	03-1983	Lakhandchi
1121	Karmaiya	Climatology	C	27	07	00	85	28	00	131	08-1983	
1122	Jalesore	Climatology	C	26	39	00	85	47	00		03-1989	

(Note) Reg. W: Western and C: Central Region (All the stations of these region are listed.)

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation	Drainage Area	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "	(m)	(km^2)						
120.	Chamelia	Karkale Gaon	29 40 20	80 33 30	-	1,150				01/01/65		
150.	Mahakali	Pancheshwor	29 26 45	80 15 30	-	12,236	C	R		01/01/62		
169.8	Surnagad	Gujar Gaon	29 31 00	80 35 00	-	(66)	C			-		
170.	Surnagad	Patan near Baitadi	29 27 30	80 33 10	1,110	118	C			01/01/66	01/04/88	
190.5	Kandr Khola	Amsara	28 36 00	80 56 00	-	(313)				-		
190.8	Khutiya Khola	Boladevi Gaon	28 53 00	80 44 00	-	-				-		Khutiya
205.	Kharpu Khola	Kharpu	29 57 00	81 52 00	-	1,310				14/05/78		
206.	Humla Karnali	Bihi Chhara	29 38 00	81 52 00	-	(8,447)				17/06/79		
208.	Mugu Karnali	Surkhet	29 37 00	81 52 00	-	5,300	C			13/06/79		
209.	Kawadi Khola	Kawadi Ghat	29 36 16	81 45 28	-	795				17/01/89		
210.	Rara Daha	Nizal	29 31 00	82 04 00	-	1,150				08/11/65		
215.	Humla Karnali	Thuldada	29 09 00	81 36 00	-	15,200	C			06/02/66		
220.	Tila Nala	Nagina	29 12 00	81 55 00	-	1,870	C			19/03/64		
225.	Sinja Khola	Diware	29 12 00	81 55 00	-	824	C			17/03/64		
230.	Tila Nadi	Seti Ghat	29 08 00	81 36 00	-	3,470	C			08/03/64		
240.	Karnali	Asara Ghat	28 57 10	81 26 30	629	19,260	C	R	S	01/01/61		
241.	Lohare Khola	Tallo Dungeswat	28 41 00	81 36 00	-	1,060	C			24/05/65		
245.	Chhamghat Khola	Gitachaur	28 56 00	81 41 30	-	(108)	C			20/03/78		
250.	Karnali	Benighat	28 57 40	81 07 10	320	21,240	C	R		01/02/63		
251.	Seit	Chainpur	29 33 30	80 12 40	-	2,040	C			-		
255.	Bhdhi Ganga	Kakarsant	29 11 00	81 13 00	-	1,340	C			28/04/78		
259.2	Seit	Gopaghat Gaon	29 18 00	80 46 30	-	4,420	C			-		
260.	Seit	Banga near Belgaon	28 58 40	81 08 40	328	7,460	C	R	S	06/02/63		
262.	Tuli Gad	Khanayatal	28 56 00	80 54 00	314	896	C	R		17/06/65		
265.	Thulo Bheri	Rimna	28 42 30	82 17 30	-	6,720	C			18/06/72		
267.	Sano Bheri	Simli Ghat	28 39 30	82 21 30	-	2,620	C			18/06/76		
269.5	Bheri Nadi	Samaiji Ghar			-	-	C	PR		16/12/89		
270.	Bheri	Jamu	28 45 20	81 21 00	246	12,290	C	R	S	23/01/63		
280.	Karnali	Chisapani	28 38 40	81 17 30	191	42,890	C	R	S	01/01/62		

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
284.	Sarda Khola	Shyalpani-Sita Pall	28 22 30	82 11 45	-	295				17/06/77		Babai
285.	Mohana	Kalakunta	28 27 00	81 00 30	-	(623)				22/04/76		
286.	Sarada Khola	Daradhunga	28 17 58	82 01 30	-	816	C	R	S	01/01/72		Babai
287.	Kauriala Karnali	Sattar Farm	28 24 30	81 05 00	-	-				17/03/80		
288.	Geruwa Karnali	Kothiya Ghat	28 22 30	81 12 00	-	(14,853)				18/03/80		
289.	Babai River	Gangate Gaon	28 15 00	81 57 00						06/01/72		
289.5	Gohar Khola	Sirchaur Gaon	28 09 15	82 22 45	-	-	C			21/06/77		Babai
289.9	Babai Nadi	Gangata			-	-				-		Babai
289.95	Babai Nadi	Chepang			-	-	C	R		01/10/89		Babai
290.	Babai	Bargadha	28 25 20	81 22 10	192	3,000	C	R		16/07/66	13/04/89	Babai
291.	Babai Nadi	Bhada			-	-				-		Babai
327.	Lungri Khola	Khungree Gaon	28 13 30	82 42 30	-	467	C			26/12/76		West Rapti
330.	Mari Khola	Nayagaon	28 04 20	82 48 00	536	1,980	C			01/01/64		West Rapti
333.	Arun Khola	Devistan	28 02 00	82 45 30	-	136	C			--/--/68		West Rapti
339.5	Jhimruk Khola	Tigra Gaon	28 03 00	82 49 40	-	683	C			22/05/71		West Rapti
340.	Jhimruk Khola	Kalimati Ghat	28 02 10	82 53 00	692	696	C			01/01/65	21/05/71	
350.	Rapti	Bagasoti Gaon	27 54 00	82 51 00	381	3,380	C	R	S	08/05/75		West Rapti
350.5	Rangsing Khola	Tinkhanne Gaon	27 47 30	82 49 00	-	(92)	C			03/01/83		West Rapti
360.	Rapri	Jalkundi	27 56 50	82 13 30	218	5,150	C	R	S	08/04/64		West Rapti
380.	Rapti River	Sindhania	28 01 00	81 44 45						06/03/83		
385.2	Rapti River	Farinda			-	-				-		West Rapti
387.4	Dumre Khola	Kalimati	27 47 47	83 32 09	595	90	C			18/06/80		Tinau
387.5	Madi Tinau	Charchare	27 47 29	83 33 08	570	103	C	R		17/06/80		Tinau
387.8	Jhumsa Khola	Dumahi Bari	27 45 00	83 30 46	335	99	C			15/02/85		Tinau
390.	Tinau Khola	Butwal	27 42 10	83 27 50	184	554	C			09/12/63		Tinau
403.	Kali Gandaki	Jomsom	28 47 30	83 45 00	-	(3,060)				07/06/69		Narayani
403.5	Kali Gandaki	Tatopani	28 29 00	83 39 00	1,239	-		R		--/03/92		
404.6	Kali Gandaki	Kalipul Beni	28 21 30	83 34 30	-	(4,581)				05/04/71		Narayani
404.7	Myagdi Khola	Mangla Ghat	28 21 30	83 32 00	-	(1,112)	C			19/05/75		Narayani

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
406.	Kali Gandaki	Modi Beni	28 12 00	83 42 00	667	-		R		--/03/92		
406.5	Modi Khola	Nayapul	28 13 30	83 42 15	-	(635)	C			25/05/75		Narayani
409.5	Seti Khola	Seti Beni	28 00 40	83 37 10	-	(138)				22/02/76		Narayani
410.	Kali Gandaki	Seti Beni	28 00 30	83 36 10	546	6,630	C	R	S	21/02/64		Narayani
413.2	Danab Khola				-	-	C			27/05/90		
414.1	Dararun Khola	Arjun Chaupari			-	-				01/01/90		
415.	Andhi Khola	Dumrichaur Andhimuhan	27 58 20	83 35 20	543	476	C			06/04/89		Narayani
416.2	Daram Khola	Wamitaksar	28 11 45	83 18 15	-	(239)	C			18/12/78		Narayani
417.	Badigad Khola	Rudrabeni Gulmi	27 58 20	83 28 10	-	1,990	C			24/05/67		Narayani
419.1	Kali Gandaki	Ansigh-AndhiGhat			-	-	C			13/04/89		Narayani
420.	Kali Gandaki	Kotagaon Shringe	27 45 00	84 20 50	198	11,400	C	R		15/04/64		Narayani
428.	Mardi Khola	Lahachok	28 18 30	83 55 30	-	160	C			07/06/70		Narayani
430.	Seti Khola	Phoolbari	28 14 00	84 00 00	830	582	C			01/01/89		Narayani
438.	Madi	Shisa Ghat	28 06 00	84 14 00	-	858	C			08/02/73		Narayani
439.3	Khudi Khola	Khudi Bazar	28 17 15	84 21 45	-	(151)	C			04/07/81		Narayani
439.4	Dordi Khola	Amote Bazar-Sera Besi	28 10 45	84 27 30	-	(341)	C			09/02/76		Narayani
439.7	Marsyangdi	Bimal Nagar	27 57 00	84 25 48	354	(4,088)	C	R	S	31/03/87		Narayani
439.8	Marsyangdi	Gopling Ghat	27 55 35	84 29 42	320	3,850	C	R	S	01/06/73	21/05/88	
440.	Chepe Khola	Garam Besi	28 03 41	84 29 23	442	308	C	PR		20/11/63		Narayani
441.	Daraundi Khola	Nayasanghu Gorkha	28 01 00	84 35 15	-	386	C			13/10/67		Narayani
441.5	Daraundi Khola	Ramdi								26/12/86		
445.	Burhi Gandaki	Arughat	28 02 37	84 48 59	485	4,270	C	R	S	28/11/63		Narayani
445.3	Ankhu Khola	Ankhu Bridge	27 58 20	84 49 10	-	768	C			--/--/67		Narayani
446.15	Lirung Khola	Kyangjin								-		
446.2	Langtang Khola	Shyaprubesi	28 09 30	85 20 45	-	(540)	C			-		Narayani
446.25	Bhote Kosi	Syaprubesi			-	-				-		
446.3	Trisuli Khola	Dhunche	28 07 10	85 17 40	-	49	C	R		--/--/63		Narayani
446.8	Phalankhu Khola	Betrawati	27 58 25	85 11 15	630	162				24/04/69		Narayani
447.	Trisuli	Betrawati	27 58 08	85 11 00	600	4,110	C	R	S	01/04/67		Narayani

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
447.4	Tadi Khola	Rautar Nuwakot	27 55 00	85 17 10	-	254				-		Narayani
447.9	Likhu Khola	Pattawari Nuwakot	27 53 30	85 14 45	-	(145)				-		Narayani
448.	Tadi Khola	Tadipul Belkot	27 51 35	85 08 18	475	653				14/06/68		Narayani
449.9	Trisuli	Mugling	27 51 00	84 34 30	-	-				-		Narayani
449.91	Trishuli	-			-	-				-		
449.95	Trisuli	Bhorletar	27 49 00	84 26 45	-	(14,500)	C			26/02/82		Narayani
450.	Narayani	Narayan Ghat	27 42 30	84 25 50	180	31,100	C	R	S	10/02/62		Narayani
460.	Rapti	Rajaiva	27 26 30	84 58 15	332	579	C			01/01/63		Narayani
465.	Manahari Khola	Manahari	27 33 00	84 48 10	305	427	C	R		15/06/63		Narayani
470.	Lothar Khola	Lothar	27 35 40	84 43 00	336	169	C			30/11/63		Narayani
505.	Bagmati	Sundarijal	27 46 30	85 25 40	1,600	17	C	R		07/12/62		
507.	Nagmati	Sundarijal	27 46 20	85 26 10	1,660	13				00/11/63		
510.	Sialmati	Syamdado	27 46 10	85 25 10	1,660	3				00/11/63		
511.	Dhakal Khola	Gagalgau	27 44 45	85 26 15	-	-				-		
520.	Bagmati River	Gokarna	27 43 45	85 23 30		56				-		
525.5	Manahara River	Shakyu Salmutar			-	-				04/03/00		
530.	Bagmati	Gauri Ghat	27 42 30	85 21 00	1,300	68				15/11/64		
536.2	Bishnumati Khola	Budhanilkantha	27 46 49	85 21 32	1,454	4				27/05/68	27/08/98	
540.	Nakhu Khola	Tika Bhairab	27 34 30	85 18 50	1,400	43				23/11/62		
548.	Nakhu Khola	Nakhu Jail Near Patan	27 39 40	85 18 30	-	56				01/01/87		
550.	Bagmati River	Chovar	27 39 40	85 17 50	1,280	585	C	R	S	01/07/62	--/--/80	
550.05	Bagmati	Khokana	27 16 00	85 13 00	1,255	607		PR		01/06/91		
550.1	Bagmati River	Sampkhel	27 33 30	85 15 45	-	-	C	R	S	15/06/85		
565.	Kulekhani Khola	Lamichaur	27 36 13	85 09 39	1,514	122	C	R		01/07/75	09/12/78	
570.	Kulekhani Khola	Kulekhani	27 35 10	85 09 30	1,480	126	C	R	S	01/12/62	15/11/77	
586.	Bagmati	Rai Gaon			-	-				01/02/88		
589.	Bagmati	Pandhera Dobhan	27 06 20	85 28 30	180	2,700	C	R	S	28/01/79		
590.	Bagmati	Karmaiya - Mangalpur	27 06 20	85 28 30	177	2,720		R	S	21/06/64	17/10/84	
592.	Bagmati	Bramhapuri	26 45 30	85 20 00	-	(13,790)				-		

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
595.	Jamuni	Chyutaha	26 57 00	85 20 00	-	-				19/03/92		
598.	Kamala	Chisapani	26 55 15	86 10 30	-	(1,595)				-		
599.	Kamala	Inarawa	26 36 45	86 09 00	-	-				-		
600.05	Barun Khola	Seksila Hatiya	27 41 00	87 21 00	1,500	352				22/12/86		
600.1	Arun	Uwa Gaon	27 36 00	87 20 06	1,294	26,750	C	R	S	11/05/72		
601.8	Pangtha Khola	Kurle Besi	27 24 00	87 13 30	-	(26)				01/09/98		
601.9	Pangma Khola	Kurle Besi	27 24 00	87 12 45	-	(38)				01/09/98		
602.	Sabhaya Khola	Tumlingtar	27 18 20	87 13 15	-	375	C	R		02/01/74		
602.5	Hinwa Khola	Pipletar	27 17 45	87 13 30	-	110	C			-		
604.	Arun	Leguwa Ghat	27 09 00	87 16 30	-	(4,183)				01/06/68		
604.5	Arun	Turkeghat	27 20 00	87 11 30	414	28,200	C	R		23/05/75		
605.	Pikhuwa Khola	Parapani Phedi	27 05 00	87 07 00		337				0/0/64		
606.	Arun	Simle	26 55 30	87 09 30	-	30,380	Br			-		
610.	Bhote Kosi	Barabise	27 47 10	85 53 20	840	2,410				17/02/65		
612.	Sun Kosi	Barabise	27 46 30	85 54 30	-	(84)				-		
620.	Balephi Khola	Jalbire	27 48 20	85 46 10	793	629	C			25/12/63		
625.	Sun Kosi	Dolalghat	27 38 30	85 43 00	-	(1,375)	C			-		
627.5	Melamchi Khola	Helambu	28 02 30	85 32 00	-	-				-		
627.55	Melamchi Khola	Sajhaya			-	-				-		
629.1	Indrawati	Dolalghat	27 38 20	85 42 30	-	1,225	C			17/09/72		
630.	Sunkosi	Pachuwar Ghat	27 33 30	85 45 10	589	4,920	C			26/03/64		
640.	Rosi Khola	Panauti	27 34 50	85 30 50	1,480	87				17/10/63		
641.	Rosi Khola	Lold Khola			-	-				-		
647.	Tamakosi	Busti	27 38 05	86 05 12	849	2,753	C	R		14/01/70		
650.	Khimti Khola	Rasnalu Village	27 34 30	86 11 50	1,520	313	C			06/04/64		
652.	Sunkosi	Khurkot	27 20 00	86 00 00	455	10,000	C			01/07/67		
660.	Likhu Khola	Sanghu Khola	27 20 10	86 13 10	543	823	C			24/03/64		
665.	Sun Kosi	Ahrkapur (Tokselghat)	27 10 30	86 22 00	-	(8,736)	C			20/02/86		
668.4	Taktor Khola	Beni	27 31 45	86 33 30	2,350	(87)	Br			-		

LIST OF HYDROMETRIC STATIONS

Station No.	Name of River	Name of Site	Latitude	Longitude	Elevation (m)	Drainage Area (km^2)	Instrument			Start of Record	End of Record	Remarks
			° ' "	° ' "								
668.5	Solua Khola	Salme	27 30 30	86 33 15	1,800	(324)	Br			-		
669.5	Rawa Khola	Gaikhure	27 16 00	86 40 30						-		
670.	Dudh Kosi	Rabuwa Bazar	27 16 00	86 39 50	460	4,100	C	R	S	10/03/64		
680.	Sun Kosi	Kampughat	26 52 30	86 49 20	200	17,600				28/06/65		
681.	Sun Kosi	Hampuachuwar	26 55 15	87 08 45	-	-	C			-		
684.	Tamur	Majhitar	27 09 30	87 42 45	-	-	C			-		
685.3	Maiwa Khola	Maiwa Dovan	27 22 10	87 36 50		194				-		
685.9	Hima Khola	Thapatar (Phidim)	27 09 45	87 46 15						0/0/74		
688.5	Madhu Khola	Dhankuta	26 59 30	87 22 15						-		
688.6	Banchare Khola	Dhankuta	26 59 00	87 22 30		13				-		
688.7	Nibuwa Khola	Dhankuta	26 59 00	87 23 15	-	(28)				-		
689.	Tankhuwa Khola	Biretar Near Dhankuta	26 58 30	87 22 15	-	51				--/--/64		
690.	Tamur	Mulghat	26 55 50	87 19 45	276	5,640	Br	PR	S	11/03/65		
691.	Tamur	Tribeni	26 55 00	87 10 00	-	(6,146)	C			-		
695.	Sapta Koshi	Chatara-Kothu	26 52 00	87 09 30	140	54,100	C		S	01/01/77		
698.	Sardu Khola	Mathilo Sardu-Dharan	26 51 00	87 18 05		7				0/0/71		
715.	Mai Khola	Mai Beni	26 53 25	87 57 20		210				0/0/71		
720.	Jog Mai Khola	Mai Beni	27 53 40	87 59 20		140				0/0/67		
728.	Mai Khola	Rajdwail	26 52 45	87 55 45	-	377	C		S	01/01/83		
730.	Puwa Khola	Sajbote (Ilam)	26 55 00	87 54 40	802	107	C			18/01/65		
738.	Deo Mai Khola	Angdang	26 54 00	87 46 15	-	(199)	C			-		Ratuwa ?
795.	Kankai Mai	Mainachuli	26 41 12	87 52 44	125	1,148	C	R		01/05/71		
799.	Kankai	Kumarkhod-Jhapa			-	-				30/10/87		
848.4	Siddhi Khola	Kajeni	26 51 15	88 07 00	-	-				-		

Note:

C: Cable way for discharge measurement

Br: Bridge available for discharge measurement

R: Recording gauge for water level observation

PR: Pressure type gauge for water level observation

GRAIDING OF RIVERBED MATERIALS

Sample code	Cumulative percentage of passing materials (%)														
	<0.075 (mm)	<0.106 (mm)	<0.25 (mm)	<0.425 (mm)	<0.85 (mm)	<2 (mm)	<4.75 (mm)	<9.5 (mm)	<19 (mm)	<26.5 (mm)	<37.5 (mm)	<53 (mm)	<100 (mm)	<200 (mm)	<400 (mm)
	0.075	0.106	0.250	0.425	0.850	2.00	4.75	9.50	19.0	26.5	37.5	53.0	100.0	200.0	400.0
Narayani River															
Na-1	0.8	1.7	7.6	13.3	17.0	22.1	28.7	34.3	41.9	49.6	58.5	67.5	78.4	100.0	100.0
Na-1	0.8	1.7	7.6	13.3	17.0	22.1	28.7	34.3	41.9	49.6	58.5	67.5	78.4	100.0	100.0
Na-2	2.4	4.8	30.3	53.8	61.7	62.8	64.9	67.0	70.9	73.8	80.3	87.6	100.0	100.0	100.0
Na-3	0.4	0.9	6.4	14.5	25.9	33.9	39.5	46.2	56.9	64.3	72.6	82.5	95.9	100.0	100.0
Na-4	0.4	1.0	5.8	11.2	15.6	22.1	31.0	38.5	51.0	57.6	66.4	77.9	97.2	100.0	100.0
Na-5	1.4	2.4	5.8	9.5	12.5	13.7	17.3	23.4	31.8	36.9	43.5	48.2	67.6	100.0	100.0
Na-6	3.8	4.9	7.0	9.4	14.3	20.0	27.8	39.4	57.5	69.2	82.0	88.4	91.4	100.0	100.0
Na-7	0.5	0.7	1.7	8.5	23.0	25.8	28.7	32.8	38.9	44.4	52.1	58.5	80.6	100.0	100.0
Na-8	0.3	0.6	2.9	5.3	10.7	22.6	34.8	42.9	58.2	67.4	78.0	86.7	100.0	100.0	100.0
Na-9	40.5	60.6	94.6	98.7	99.5	99.9	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Na-9A	34.3	50.8	77.0	85.0	91.6	96.9	99.7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Na-10	0.7	1.1	4.5	14.2	25.8	31.4	37.7	44.8	56.9	66.0	82.6	93.0	100.0	100.0	100.0
Na-11	4.6	7.0	10.4	13.2	16.9	20.3	24.2	28.0	34.7	40.1	52.4	63.3	81.9	100.0	100.0
Na-12	0.5	0.8	4.7	16.2	32.0	43.1	55.8	62.4	70.8	75.7	82.0	89.0	94.1	100.0	100.0
Na-13	2.3	4.3	19.3	30.9	49.1	54.3	58.4	63.3	71.2	77.2	82.3	86.7	100.0	100.0	100.0
Na-14	1.7	4.6	42.0	74.4	91.4	96.5	98.1	99.2	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Na-15	2.1	2.5	5.8	14.4	25.5	32.4	38.5	45.6	57.8	63.5	68.0	73.3	81.9	100.0	100.0
Na-16	0.7	1.3	6.4	12.7	21.3	24.5	27.1	33.2	48.4	63.9	78.5	90.7	100.0	100.0	100.0
Na-17	1.8	2.7	8.8	18.2	23.6	25.7	27.4	30.0	37.3	45.4	56.3	75.3	100.0	100.0	100.0
Na-18	4.2	6.3	18.0	27.8	32.8	35.3	39.7	45.6	63.0	73.3	81.6	88.9	100.0	100.0	100.0
Na-19	3.9	5.1	10.0	17.3	29.5	36.5	41.4	44.8	55.5	62.1	64.3	67.9	70.4	100.0	100.0
Na-20	0.9	1.3	2.6	6.4	14.5	24.1	35.8	49.1	66.3	75.1	82.6	89.6	91.8	100.0	100.0
Na-21	1.8	2.4	4.9	6.9	8.0	8.8	10.4	13.5	19.1	24.3	31.7	44.4	72.7	100.0	100.0
Na-22	13.6	19.5	29.6	32.5	34.1	35.6	38.8	42.9	48.6	53.4	61.0	65.1	89.7	100.0	100.0

REPRESENTATIVE GRAIN SIZES AND SPECIFIC GRAVITY

Sample code	Representative grain size					Specific gravity(g'cc)		
	16 (%)	60 (%)	65 (%)	84 (%)	d84 / d16	S.G.1 (g'cc)	S.G.2 (g'cc)	S.Gave (g'cc)
Narayani River								
Na-1	0.70	39.70	48.10	119.69	170.45	2.61	2.65	2.63
Na-1	0.70	39.70	48.10	119.69	170.45	2.61	2.65	2.63
Na-2	0.15	0.73	4.87	44.68	289.44	2.68	2.63	2.66
Na-3	0.46	21.82	27.25	57.01	122.71	2.68	2.68	2.68
Na-4	0.89	29.15	35.46	64.84	72.75	2.68	2.70	2.69
Na-5	3.49	77.96	91.84	142.03	40.65	2.66	2.65	2.66
Na-6	1.10	20.41	23.52	41.71	37.94	2.69	2.70	2.70
Na-7	0.61	55.35	63.90	112.92	185.79	2.59	2.63	2.61
Na-8	1.24	20.27	24.30	47.63	38.26	2.68	2.63	2.66
Na-9	#N/A	0.10	0.12	0.19	#N/A	2.65	2.63	2.64
Na-9A	#N/A	0.14	0.17	0.40	#N/A	2.68	2.63	2.66
Na-10	0.47	21.26	25.51	39.29	83.06	2.68	2.65	2.67
Na-11	0.72	47.71	56.10	108.37	151.46	2.64	2.61	2.63
Na-12	0.42	7.39	11.79	41.44	98.55	2.63	2.65	2.64
Na-13	0.21	5.93	11.00	42.80	206.73	2.65	2.68	2.67
Na-14	0.14	0.34	0.36	0.63	4.57	2.59	2.63	2.61
Na-15	0.47	21.63	29.75	108.37	230.41	2.68	2.65	2.67
Na-16	0.55	24.36	27.17	43.80	79.14	2.59	2.61	2.60
Na-17	0.38	40.12	43.95	66.30	176.58	2.63	2.59	2.61
Na-18	0.22	16.74	20.27	42.08	195.34	2.68	2.63	2.66
Na-19	0.39	23.88	39.99	137.50	356.02	2.68	2.70	2.69
Na-20	0.97	14.74	18.04	40.24	41.47	2.65	2.68	2.67
Na-21	12.87	75.19	84.12	133.23	10.35	2.63	2.58	2.61
Na-22	0.09	35.82	52.37	86.30	1000.3	2.58	2.61	2.60
							Average	2.65

SUMMARY OF QUESTIONNAIRES BY RIVER

Name of river: NARAYANI RIVER(1/2)

No.	Questions/items	Summary of answers
1. FLOOD EVENTS		
1.1	Year of most severe flood in past 10 years (nop)	1993(51), 1988(46), 1989(1)
1.2	Floods in a year (times)	Average(4) ranging(2 to 9)
1.3	Severe floods in past 10 years (times)	Average(3) ranging(2 to 6)
1.4	(Cancelled)	(Cancelled)
1.5	Cause of flood (nop)	• Too much rain(62) • Sediment flow(36) • Bank erosion(48) • Others(0)
2. EFFECT DUE TO SEVERE FLOOD IN PAST		
2.1	Loss of human life (nop)	2 (excluding those due to epidemic disease)
2.2	Loss of livestock/husbandry (nos)	• Cow(23) • Buffalo(0) • Sheep/Goat(13) • Poultry(134)
2.3	Damage to farm land (ha)	• Irrigated land: Average(1.9) ranging(1.0 to 6.2) • Non-irrigated land: Average(1.7) ranging(0.2 to 7.7)
2.4	Extent of damage to farm land	• Simple inundation (nop): 30 • Loss of crops (nop): Paddy(72), Sugarcane(1), Maize(52), Others(0) • Total washout (ha): Average(3.1) ranging(0.2 to 11.6)
2.5	Extent of damage to dwelling and asset	• Flooding duration (days): Average(6.0) ranging(2 to 12) • Flooding depth in (m): Average(1.6) ranging(03 to 3.0) • Damage to house (nop): Severe(15), Moderate(21), Ordinary(44) • Loss of cash (Rs): Average(5,000) ranging(0 to 8,600) • Loss of food grains (kg): Paddy: Average(710) ranging(0 to 2,500) • Clothing (nos): Average(2) ranging(1 to 4) • Other valuables: Average(2) ranging(0 to 2)
2.6	Problems during flood (nop)	• Erosion of river bank(79) • Sediment in the river(66) • Sediment in irrigation canal(51) • Drinking water problem(43) • Sanitary problem(28) • Salinity(0) • Flooding over farm land(64) • Others(1)
2.7	Epidemic disease after flood? (nop)	• Yes(38) • No(63)
2.8	If yes, kind of epidemic disease (nop)	• Cholera(0) • Dysentery(35) • Typhoid(16) • Others(0)
2.9	Fatal causality? (nop)	• Yes(0) • No(69)
2.10	Reason of flood(nop)	• Too much rain(37) • Lack of flood protection works(93) • Weak river training works(0) • Sediment load in the flood water(20) • Flood from adjoining rivers(6)
2.11	Total amount of damage (Rs)	Average(160,000) ranging(0 to 3,000,000)

(Remarks) nop: Number of persons who answer to the item.

SUMMARY OF QUESTIONNAIRES BY RIVER

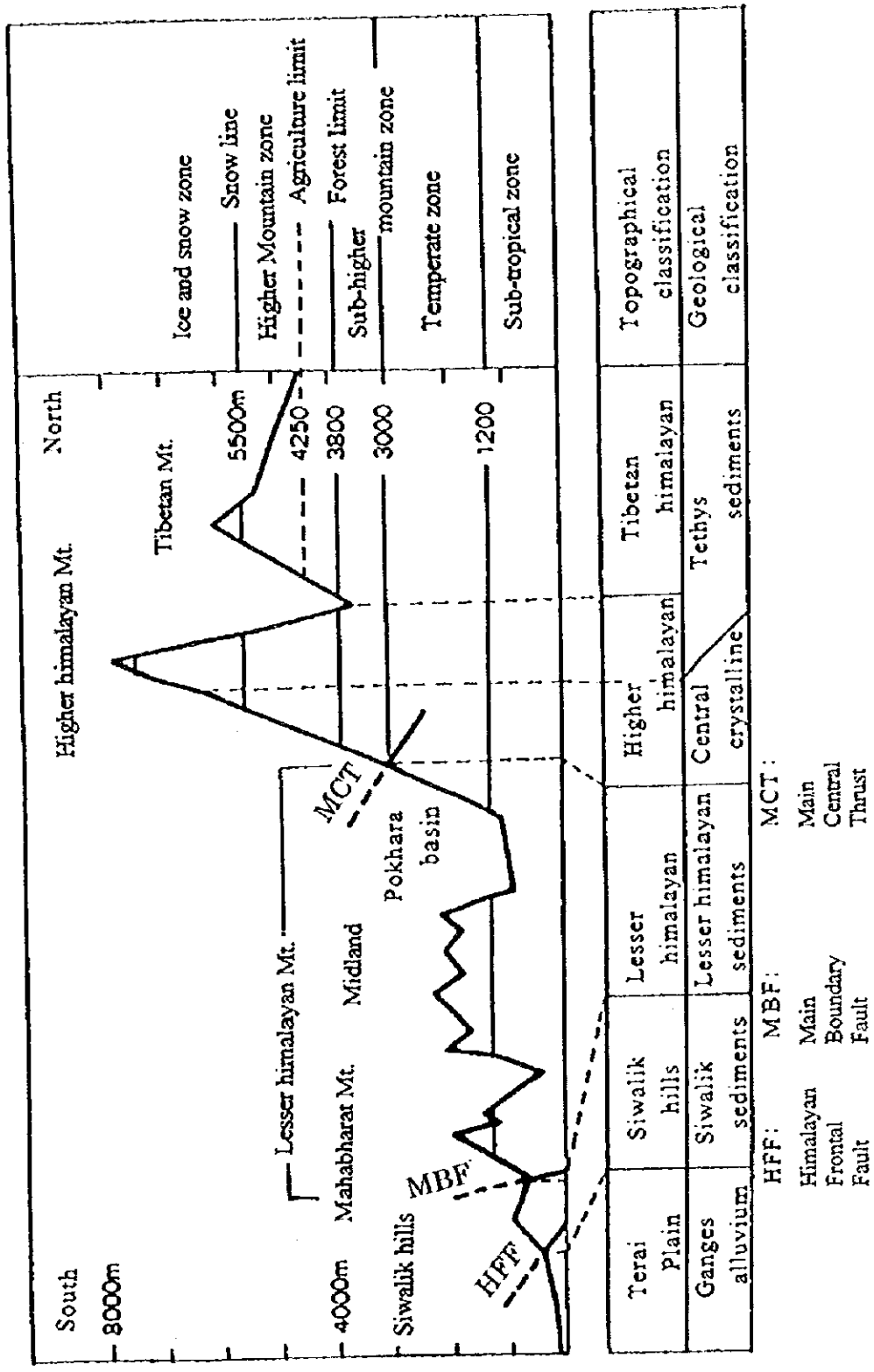
Name of river: **NARAYANI RIVER(2/2)**

No.	Questions/items	Summary of answers
3. FLOOD WARNING SYSTEM		
3.1	(Cancelled)	(Cancelled)
3.2	Self warning (nop)	• Heavy rain/High flood level(56) • Bank erosion(19) • Smelled mud(6) • Unusual sound(5) • Others(0)
3.3	Warning by others (nop)	• Neighbors(0) • Institutions(0) • Others(0)
4. FLOOD RELIEF MEASURES		
4.1	Evacuation experience? (nop)	• Yes(72) • No(29)
4.2	If yes, place of evacuation (nop)	• High ground(8) • Public building(19) • Others houses(27) • Other sites(14)
4.3	Being relieved? (nop)	• Yes(43) • No(57)
4.4	If yes, how?(nop)	• In cash(13) • Kind(43)
4.5	Organization/individual giving relief (nop)	• Central government(0) • DDC(24) • VDC(8) • Other institutions(4) • NGO(0) • Individuals(31)
4.6	(Cancelled)	(Cancelled)
5. PREVENTIVE MEASURES AGAINST FLOOD		
5.1a	Current preparedness/ measures (nop)	• Warning(0) • Evacuation(35) • Settlement(38)
5.1b	Proposed preparedness/ measures (nop)	• Warning(12) • Evacuation(50) • Settlement(39)
5.2a	Current non-structural measures (nop)	• Seed storage(0) • Cash pools(0) • Informal insurance(0) • Others(0)
5.2b	Proposed non-structural measures (nop)	• Seed storage(55) • Cash pools(16) • Informal insurance(16) • Others(0)
5.3a	Current structural measures (nop)	• Embankment(0) • Spur(13) • Simple gabion(3) • Plantation(0) • Others(0)
5.3b	Proposed structural measures(nop)	• Embankment(75) • Spur(37) • Simple gabion(40) • Plantation(0) • Others(0)
6. PARTICIPATION ACTIVITIES		
6.1	Experience of Participation in activities? (nop)	• Yes(43) • No(58)
6.2	If yes, type (nop)	• Cash(1) • Labor(26) • Kind(0) • Care taker(6) • Others(8)
6.3	If no, reason (nop)	• Being affected badly(13) • Financially weak(1) • Being out of the area(2) • No willingness(6) • Others(35)
6.4	Willing to participate in future? (nop)	• Yes(95) • No(0)
6.5	If yes, type (nop)	• Cash(6) • Labor(93) • Kind(0) • Care taker(13) • Others(0)
6.6	If no, reasons (nop)	• No time(0) • No benefit(0) • No Willingness(0) • Not known how to participate(0) • Others(0)

(Remarks) nop: Number of persons who answer to the item.

LOSS OF LIFE AND DAMAGE TO PROPERTIES (NARAYANI RIVER)
(1993-FLOOD)

VDC/Municipality	Loss of Life	Loss of Cattle (nos.)			Damage of Crops (hac)		Damage of Crops (ton)		Damage of Land (nos.)		Damage of Houses (nos.)		Remarks
	(nos.)	Cow	Goat	Polutry	Paddy	Maize	Paddy	Maize	Agricultural	Barren	Damage	Washout	
A. Chitwan District													
Meghauli	-	15	-	-	20	80	70	160	130	30	10	135	
Divyanagar	3	60	-	-	52	-	156	-	52	-	50	200	
Gungnagar	-	-	-	-	12	6	42	9	18	3	20	35	
Manglapur	-	-	-	-	100	-	300	-	-	-	50	-	
sub total	3	75	0	0	184	86	568	169	200	33	130	370	
B. Nawal Parasi District													
Mukundpur	-	-	-	-	3	3	9	5	6	-	35	-	
Pitihauli	-	-	-	-	-	-	-	-	0.1	1.3	-	-	
Rajahar	-	-	-	-	7	8	25	8	8	5	25	-	
Kumar Varti	-	-	-	-	20	8	90	12	28	-	-	65	
Koluwa	-	-	-	-	215	-	968	-	180	-	30	150	
Narayani	-	12	40	500	45	35	68	23	23	-	150	35	
Parsauni	-	100	35	1,000	525	8	1,575	12	200	-	100	45	
Naya Belahani	-	-	7	-	200	133	600	100	30	-	-	-	
sub total	0	112	82	1,500	1,015	195	3,335	160	475.1	6.3	340	295	
Total	3	187	82	1,500	1,199	281	3,903	329	675.1	39.3	470	665	

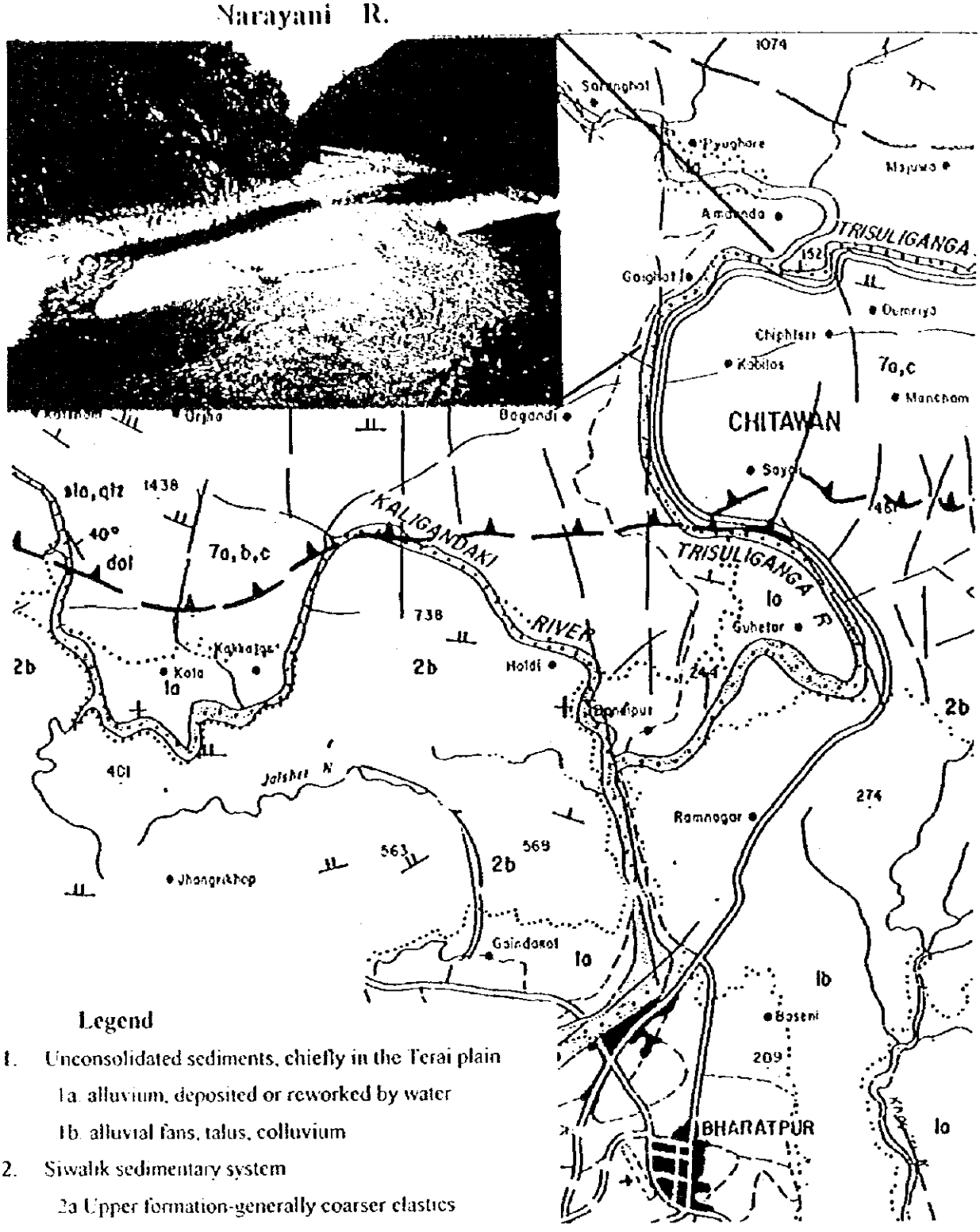


TOPOGRAPHICAL AND GEOLOGICAL CLASSIFICATION(N-S PROFILE)

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

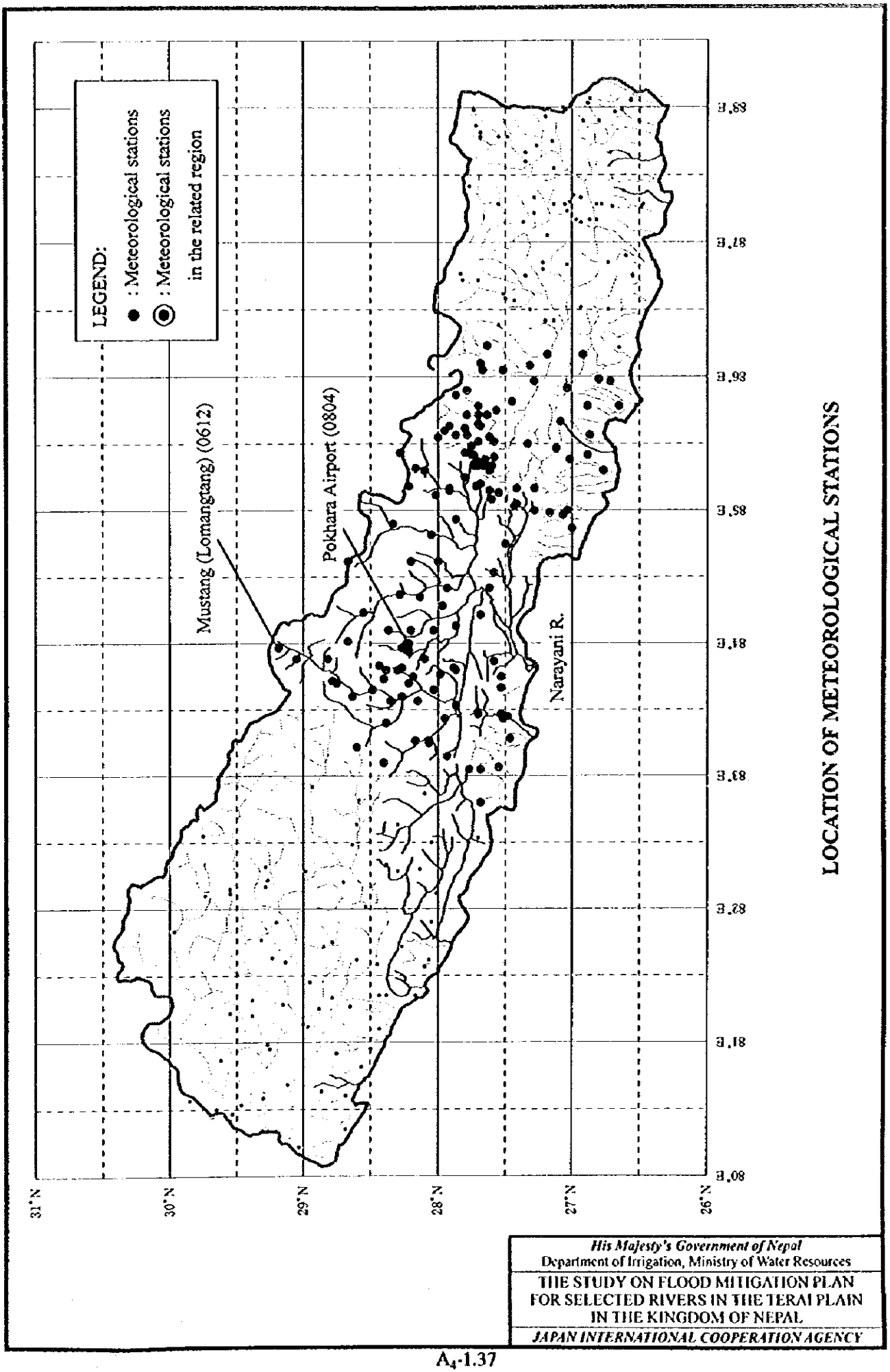
JAPAN INTERNATIONAL COOPERATION AGENCY



GEOLOGICAL MAP(NARAYANI R.)

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A1.3



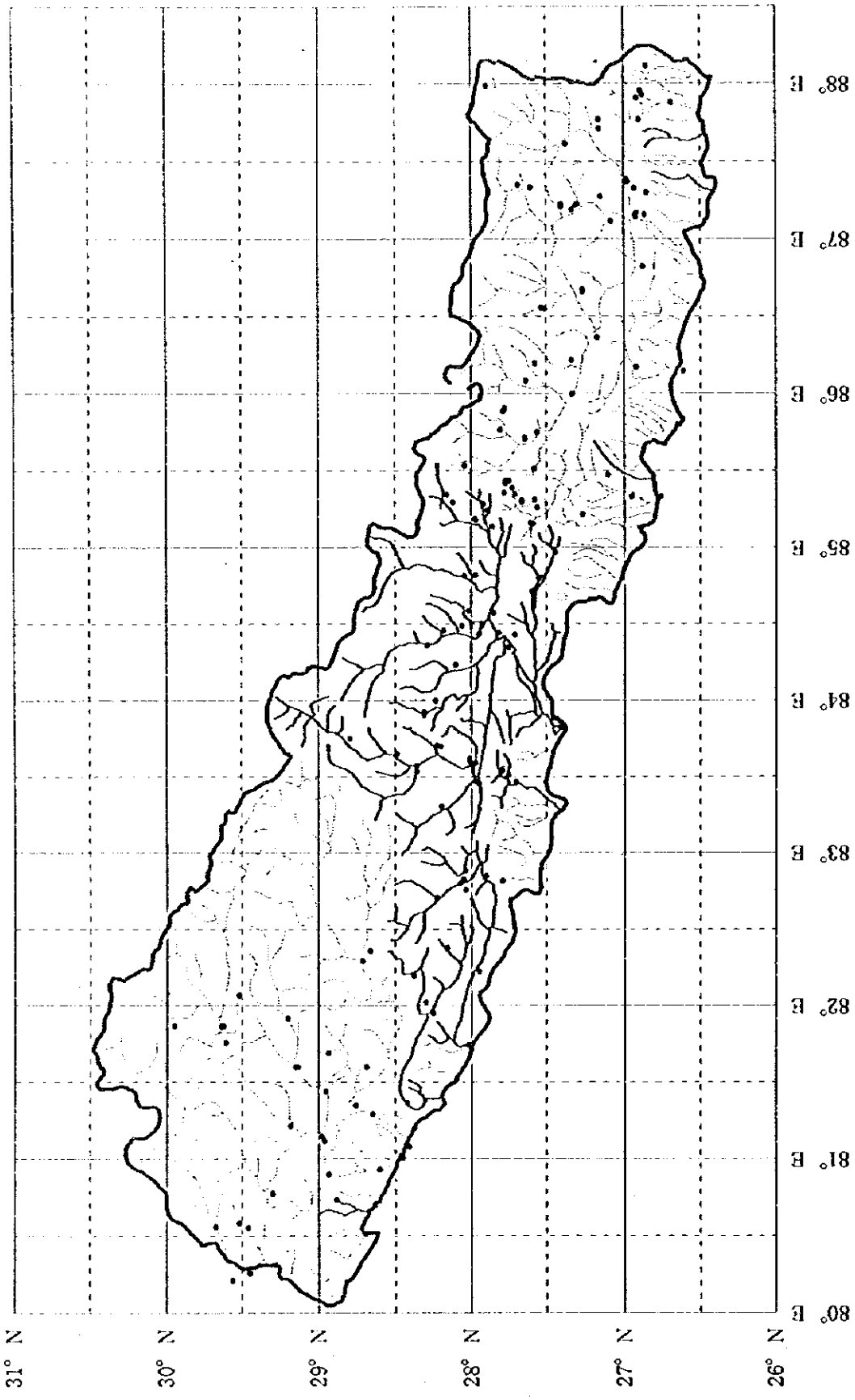
LOCATION OF METEOROLOGICAL STATIONS

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. A1.4



His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources

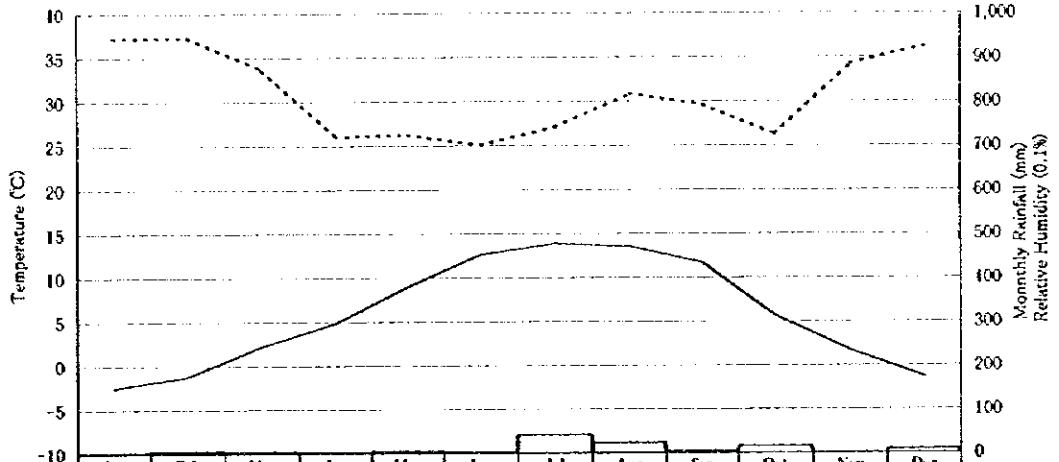
THE STUDY ON FLOOD MITIGATION PLAN
FOR SELECTED RIVERS IN THE TERAI PLAIN
IN THE KINGDOM OF NEPAL

JAPAN INTERNATIONAL COOPERATION AGENCY

Code: 0612
Station: Mustang (Lomangtang)

Latitude: 29°11'
Longitude: 83°58'
Elevation: 3,705 m

Mustang (Lomangtang) (0612)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation, Total	3.3	5.4	4.8	2.9	5.4	3.3	42.1	24.6	5.1	16.6	1.8	9.0
Air Temperature, Mean	-2.5	-1.2	2.2	4.9	9.0	12.7	13.9	13.6	11.8	5.7	1.8	-1.3
Relative Humidity, 08:45	911	917	874	724	726	702	743	818	792	726	888	924

Air Temperature, Mean (Unit °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	-6.0	-0.8	6.5	5.8	8.2	11.5	12.6	12.7	11.9	5.7	2.4	0.4	5.9
1986	-2.8	-1.9	0.9	4.5	7.8	13.0	14.0	13.5	11.2	5.2	2.8	-3.6	5.4
1987	-3.5	-1.4	2.9	4.7	6.5	13.4	14.6	13.9	12.4	5.3	3.3	-0.5	6.0
1988	-1.3	-0.8	-0.1	6.3	10.1	12.3	14.1	13.2	11.2	6.1	1.2	-	-
1989	-4.9	-1.9	2.1	4.4	8.7	10.5	13.0	13.0	11.2	6.1	1.3	-2.0	5.1
1990	1.3	-1.9	-0.7	5.1	10.4	14.6	14.0	13.7	12.0	5.3	1.8	-0.7	6.2
1991	-	-	5.5	5.0	9.9	12.6	14.5	14.3	11.5	5.2	1.0	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	0.4	5.4	9.7	13.0	14.4	14.7	12.6	7.2	2.2	-1.3	-
1994	-0.3	0.4	2.7	3.0	10.1	13.5	14.2	13.6	12.1	5.8	0.0	-	-
Ave.	-2.5	-1.2	2.2	4.9	9.0	12.7	13.9	13.6	11.8	5.7	1.8	-1.3	5.7

Relative Humidity, 08:45 (Unit %)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	-	88	84	78	85	83	82	95	77	85	91	92	-
1986	-	-	-	64	54	71	74	67	70	68	83	88	-
1987	95	97	83	74	80	60	69	77	83	66	82	91	79.8
1988	93	94	91	67	64	63	70	79	81	70	95	96	80.4
1989	92	98	94	87	78	70	70	97	96	97	97	92	89.0
1990	96	95	96	65	61	80	76	75	85	72	94	95	82.5
1991	-	-	90	63	87	77	86	77	65	81	90	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	84	72	63	67	76	97	94	60	74	93	-
1994	94	96	77	79	81	61	66	72	62	54	91	-	-
Ave.	94.4	94.7	87.4	72.1	72.6	70.2	74.3	81.8	79.2	72.6	88.6	92.4	82.9

Precipitation, Total (Unit mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	14	1	0	0	4	9	103	53	5	67	0	20	276
1986	1	10	0	17	0	0	103	36	9	2	0	31	209
1987	0	3	0	0	10	0	5	27	8	80	0	18	151
1988	2	5	9	9	2	20	38	29	0	0	0	0	114
1989	2	2	3	0	30	0	28	21	0	0	1	0	87
1990	0	14	1	0	1	1	34	7	24	0	10	3	95
1991	-	-	1	0	2	0	23	48	0	0	5	-	-
1992	-	-	-	-	-	-	-	-	-	-	-	-	-
1993	-	-	27	0	0	0	0	0	0	0	0	0	-
1994	4	3	2	0	0	0	45	0	0	0	0	0	54
Ave.	3.3	5.4	4.8	2.9	5.4	3.3	42.1	24.6	5.1	16.6	1.8	9.0	131

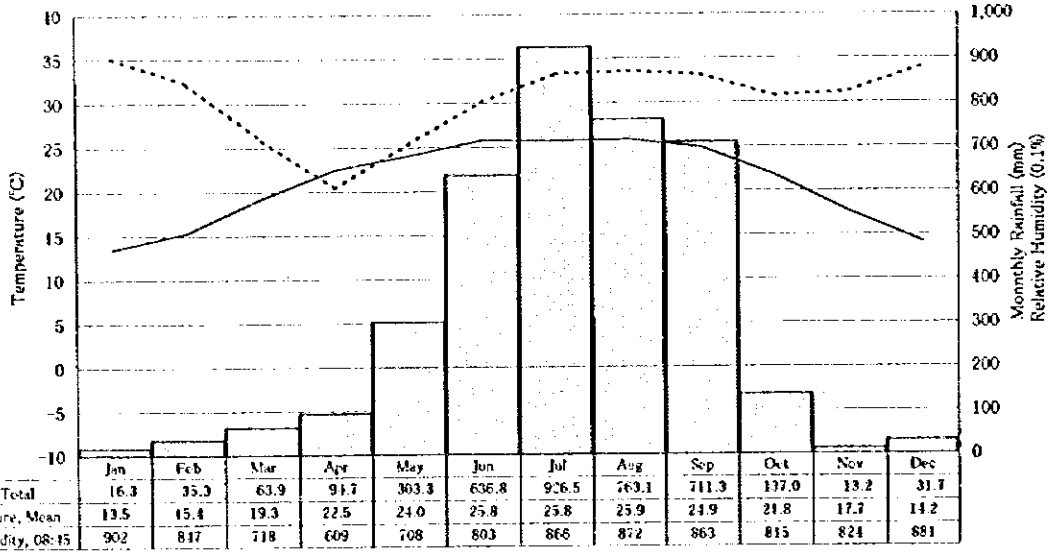
METEOROLOGICAL CONDITIONS

His Majesty's Government of Nepal
Department of Irrigation, Ministry of Water Resources
THE STUDY ON FLOOD MITIGATION PLAN FOR SELECTED RIVERS IN THE TERAI PLAIN IN THE KINGDOM OF NEPAL
JAPAN INTERNATIONAL COOPERATION AGENCY

Code: 0804
Station: Pokhara Airport

Latitude: 28°13'
Longitude: 84°00'
Elevation: 827 m

Pokhara Airport (0804)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation, Total	16.3	35.3	63.9	94.7	303.3	636.8	926.5	763.1	711.3	137.0	13.2	31.7
Air Temperature, Mean	13.5	15.4	19.3	22.5	24.0	25.8	25.8	25.9	24.9	21.8	17.7	14.2
Relative Humidity, 08:45	902	847	718	609	708	803	866	872	863	815	824	881

Air Temperature, Mean (Unit: °C)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	13.3	15.7	21.8	24.4	23.8	25.9	25.0	26.3	24.6	21.4	17.2	14.7	21.2
1986	13.3	15.3	19.2	21.3	22.7	25.9	25.8	26.2	24.2	21.2	18.1	13.5	20.5
1987	13.8	16.0	19.0	22.0	23.8	26.1	25.3	25.5	25.4	21.8	18.2	15.0	21.0
1988	14.3	16.3	19.0	23.1	24.7	25.8	26.1	25.8	25.4	22.4	17.8	15.4	21.3
1989	12.6	14.2	18.9	22.7	25.2	25.5	24.8	25.5	25.0	22.0	17.3	13.4	20.6
1990	15.0	15.2	17.2	21.7	23.9	26.1	25.7	25.7	25.1	21.4	18.3	14.6	20.8
1991	12.9	16.4	19.8	22.4	24.5	25.5	26.4	26.0	25.3	22.3	17.0	13.6	21.0
1992	13.0	13.8	20.6	24.3	23.4	25.8	25.8	26.0	25.3	21.8	17.8	13.6	20.9
1993	13.5	16.4	17.6	21.7	23.8	25.8	26.5	25.7	24.3	22.2	18.5	15.2	20.9
1994	13.7	14.4	20.1	22.0	24.9	25.8	26.4	26.4	25.1	21.3	16.8	13.6	20.8
Ave.	13.5	15.4	19.3	22.5	24.0	25.8	25.8	25.9	24.9	21.8	17.7	14.2	20.9

Relative Humidity, 08:45 (Unit: %)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	86	83	66	57	73	80	89	87	87	86	86	90	80.8
1986	89	87	72	74	75	85	88	87	89	84	88	87	83.8
1987	88	85	76	63	61	76	88	85	87	79	80	85	79.4
1988	89	85	72	60	71	80	87	88	84	75	73	87	79.3
1989	91	83	70	52	63	79	88	85	86	76	84	90	78.9
1990	93	86	76	66	72	83	86	87	86	77	75	86	81.1
1991	90	79	69	61	75	83	87	88	85	82	85	91	81.3
1992	93	89	67	48	71	74	82	86	80	85	84	92	79.3
1993	93	86	69	65	77	82	86	91	90	87	88	86	83.3
1994	89	84	81	63	70	81	85	88	89	84	81	87	81.8
Ave.	90.2	84.7	71.8	60.9	70.8	80.3	86.6	87.2	86.3	81.5	82.4	88.1	80.9

Precipitation, Total (Unit: mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
1985	22	26	27	63	299	373	905	525	696	204	51	58	3,249
1986	1	47	64	191	159	726	768	574	1,164	130	14	69	3,907
1987	3	63	86	117	111	656	1,213	742	728	167	5	28	3,919
1988	2	26	73	136	241	783	1,094	811	794	15	4	55	4,034
1989	68	14	66	12	518	594	974	872	807	58	44	43	4,070
1990	9	60	115	45	361	932	733	743	530	100	0	3	3,622
1991	10	22	78	64	358	496	798	603	994	57	1	35	3,516
1992	13	25	1	54	247	469	794	799	397	246	2	26	3,073
1993	9	20	56	205	358	652	966	1,168	479	295	9	0	4,217
1994	35	50	73	60	381	687	1,020	794	524	98	2	0	3,724
Ave.	16.3	35.3	63.9	94.7	303.3	636.8	926.5	763.1	711.3	137.0	13.2	31.7	3,733

METEOROLOGICAL CONDITIONS

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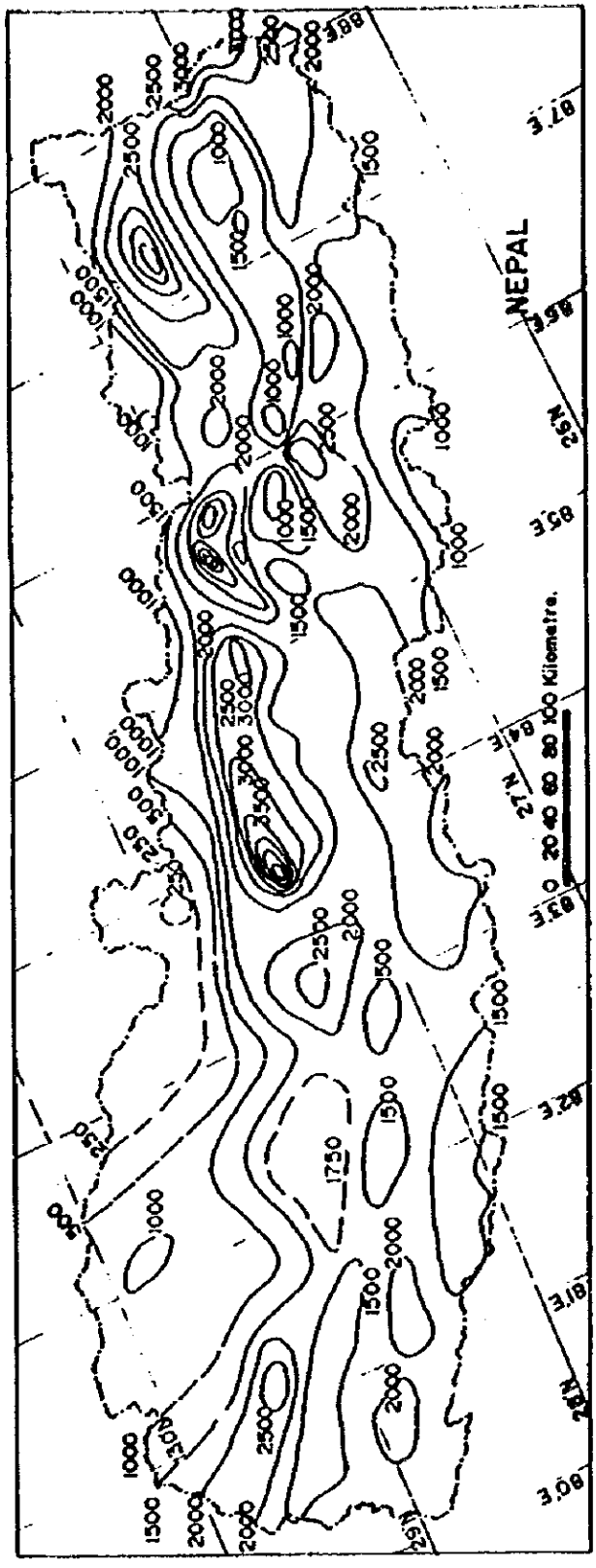
MEAN ANNUAL PRECIPITATION (mm) 1971-1985



Source: Natural Hazards and Man Made Impacts in The Nepal Himalaya, C.K.Sharman, 1988

ANNUAL RAINFALL DISTRIBUTION OF NEPAL

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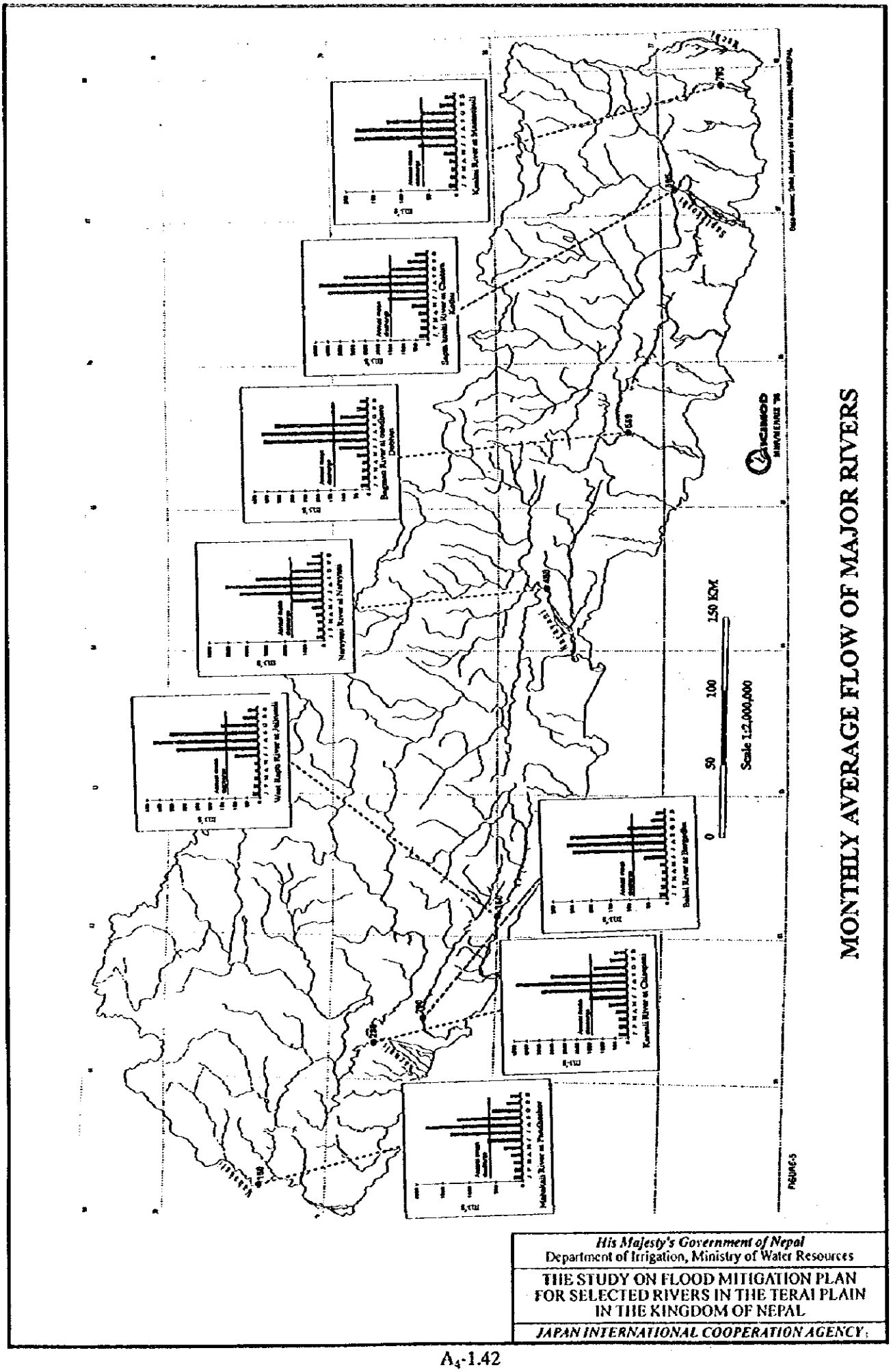
Fig. A1.7


MONTHLY AVERAGE FLOW OF MAJOR RIVERS
Scale 1:2,000,000
0
50
100
150 KM
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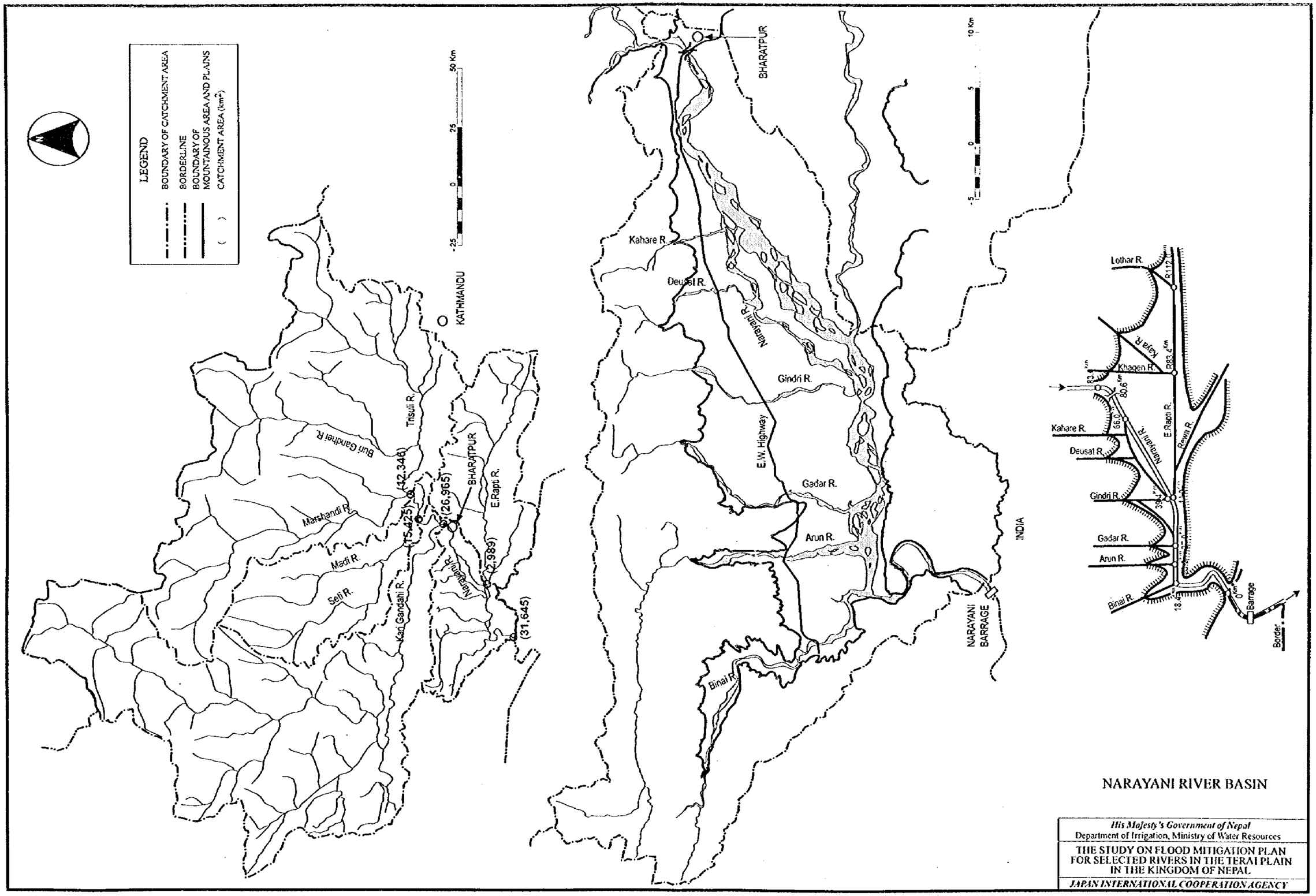
LEGEND
BOUNDARY OF CATCHMENT AREA
BORDERLINE
BOUNDARY OF MOUNTAINOUS AREA AND PLAINS
( ) CATCHMENT AREA (km²)
50 Km
25
0
-25
KATHMANDU
BHARATPUR
Bun Gandhari R.
Trisuli R.
Marshandi R.
Madi R.
Seti R.
Kali Gandaki R.
(42,348)
(15,425)
(26,965)
(12,989)
(31,645)
E.Rapti R.
Narayani R.
Kahare R.
Deusil R.
Gindri R.
E.W. Highway
Gadar R.
Arun R.
Binai R.
NARAYANI BARRAGE
INDIA
10 Km
5
0
-5
Lothar R.
Khageri R.
Kahare R.
Deusat R.
Gindri R.
Gadar R.
Arun R.
Binai R.
Rewa R.
R112
R83.4km
83.4km
80.6km
66.0
39.4km
18.4km
0km
Barrage
Border
NARAYANI RIVER BASIN
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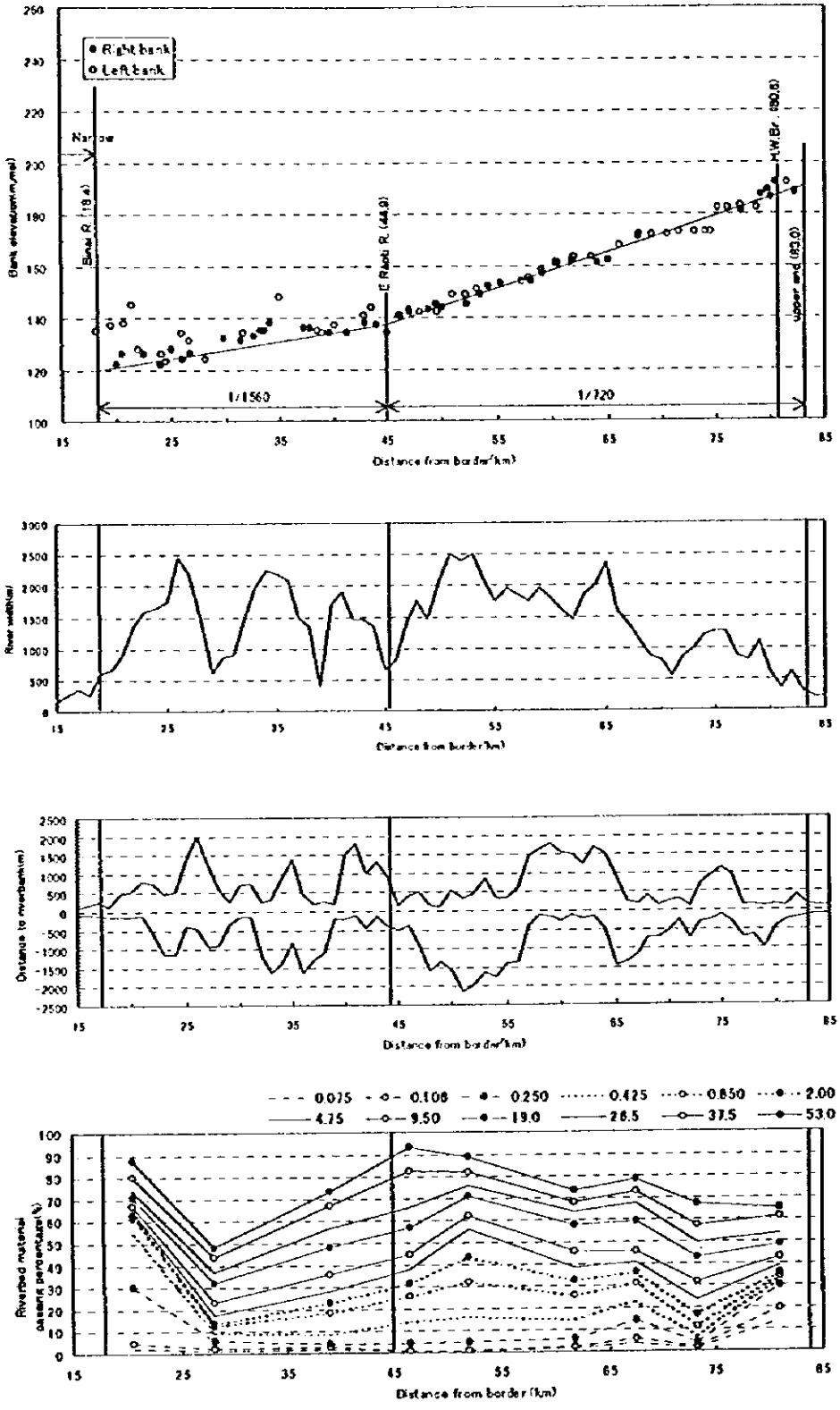
NARAYANI RIVER



CHARACTERISTICS OF EXISTING CHANNEL

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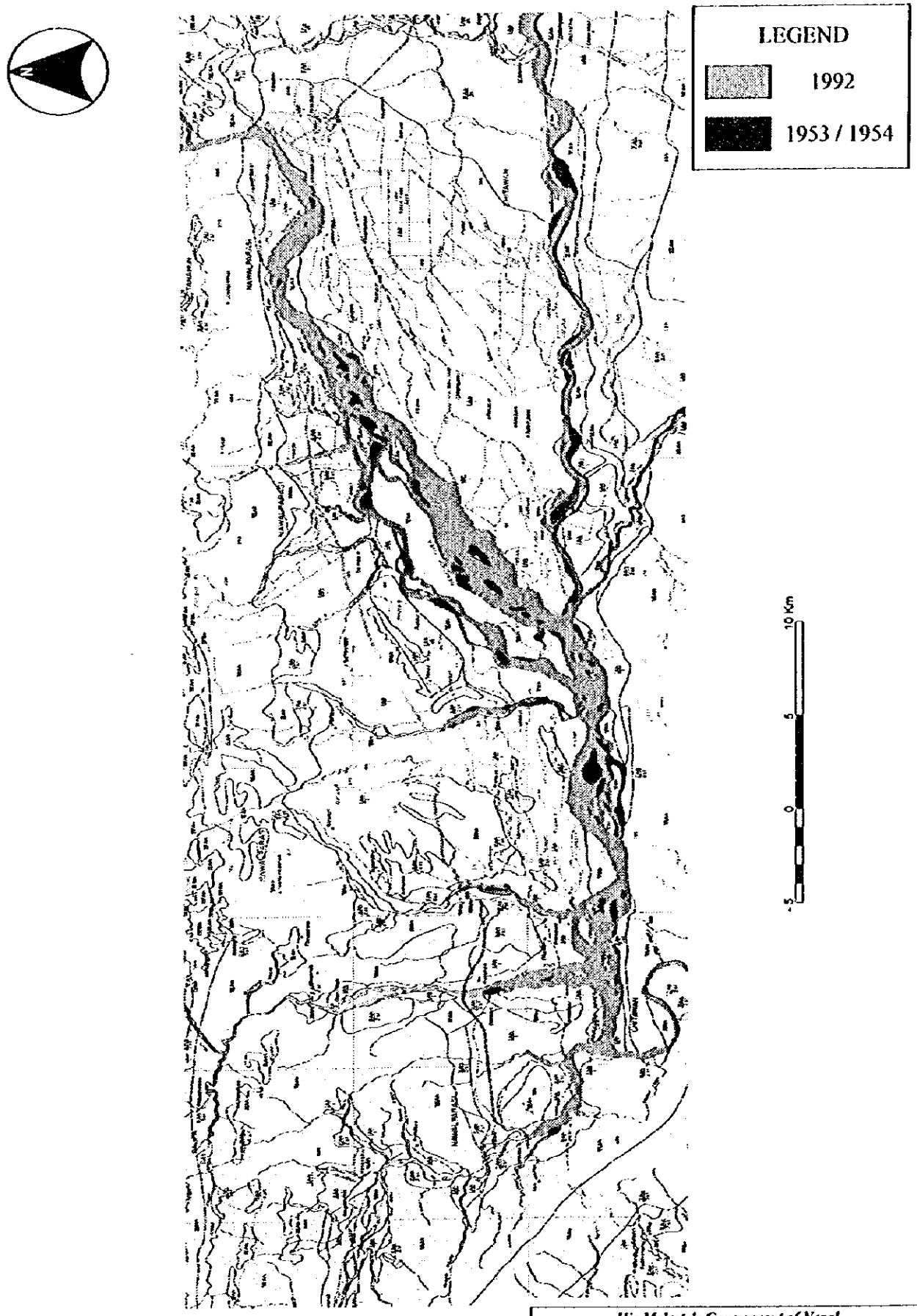

CHANGE OF NARAYANI RIVER COURSE

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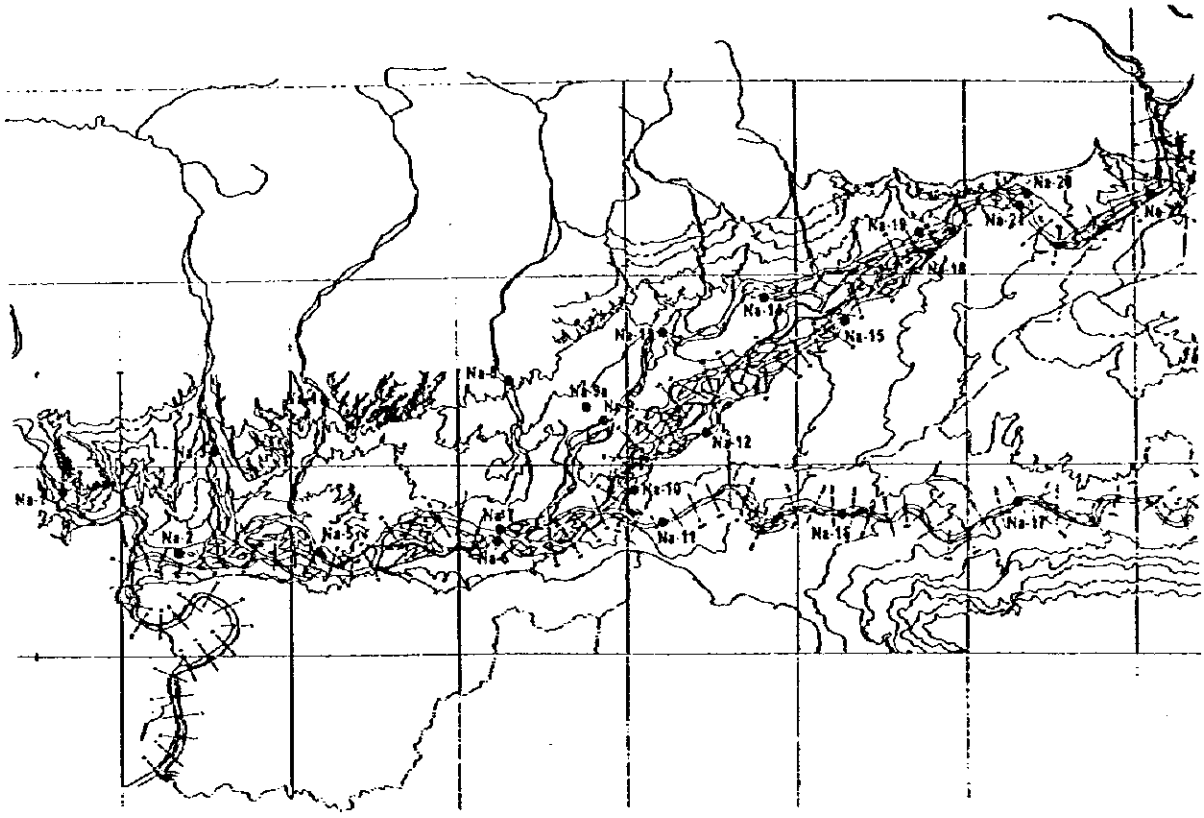

SN	Sample code	Soil classification by eye	Description of sampling place	GPS Reading N	GPS Reading E	FGA (Y/N)
1	Na-1	Boulder mixed sand	Dumkibas WN 6	27°34.057'	83°53.203'	Y
2	Na-2	Boulder mixed sand	Naya Belani WN 2	27°32.802'	83°56.756'	Y
3	Na-3	Boulder mixed sand	Belani WN 8	27°36.882'	83°57.428'	Y
4	Na-4	Boulder mixed sand	Tamasaria WN 7	27°36.943'	84°00.971'	Y
5	Na-5	Boulder mixed sand	Narayani WN 3	27°33.274'	84°00.607'	Y
6	Na-6	Boulder mixed sand	Kumarwarti	27°33.126'	84°06.017'	Y
7	Na-7	Boulder mixed sand	Kumarwarti, Amaltari	27°33.229'	84°06.008'	Y
8	Na-8	Boulder mixed sand	Agauli WN 9	27°37.427'	84°06.189'	Y
9	Na-9	Silty sand	Kawaswoti WN 1	27°36.771'	84°09.421'	N
9a	Na-9a	Silty sand	Kawaswoti WN 1	27°37.055'	84°09.001'	N
10	Na-10	Boulder mixed sand		27°34.442'	84°10.186'	Y
11	Na-11	Boulder mixed sand		27°33.848'	84°11.643'	Y
12	Na-12	Boulder mixed sand		27°36.781'	84°13.507'	Y
13	Na-13	Boulder mixed sand	Pithauli	27°38.547'	84°10.964'	Y
14	Na-14	Silty sand	Rajaur WN 2	27°39.762'	84°14.094'	N
15	Na-15	Boulder mixed sand		27°38.502'	84°16.296'	Y
16	Na-16	Boulder mixed sand		27°33.686'	84°16.241'	Y
17	Na-17	Boulder mixed sand		27°34.023'	84°21.434'	Y
18	Na-18	Boulder mixed sand	Mangalpur WN 8, Magargaon	27°40.403'	84°18.882'	Y
19	Na-19	Boulder mixed sand	Mukundpur WN 8	27°41.016'	84°18.578'	Y
20	Na-20	Boulder mixed sand	Gaindakot WN 5	27°42.239'	84°21.823'	Y
21	Na-21	Boulder mixed sand	Mangalpur WN 5, Barampur	27°41.694'	84°21.663'	Y
22	Na-22	Boulder mixed sand	Near highway bridge	27°42.074'	84°25.259'	Y

SAMPLING SITES OF RIVERBED MATERIALS (NARAYANI RIVER)

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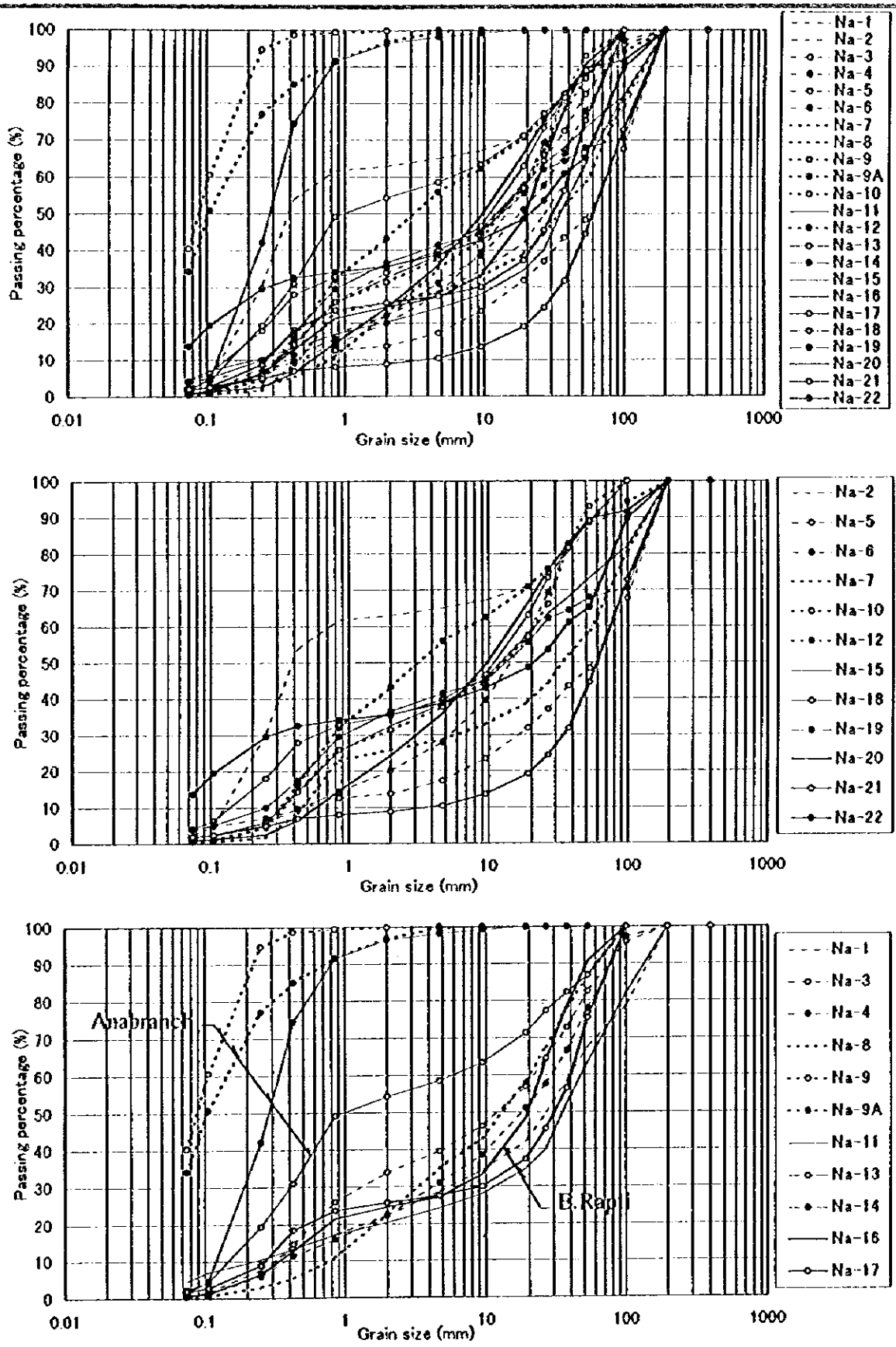

GRADING CURVES OF RIVERBED MATERIALS (NARAYANI R.)

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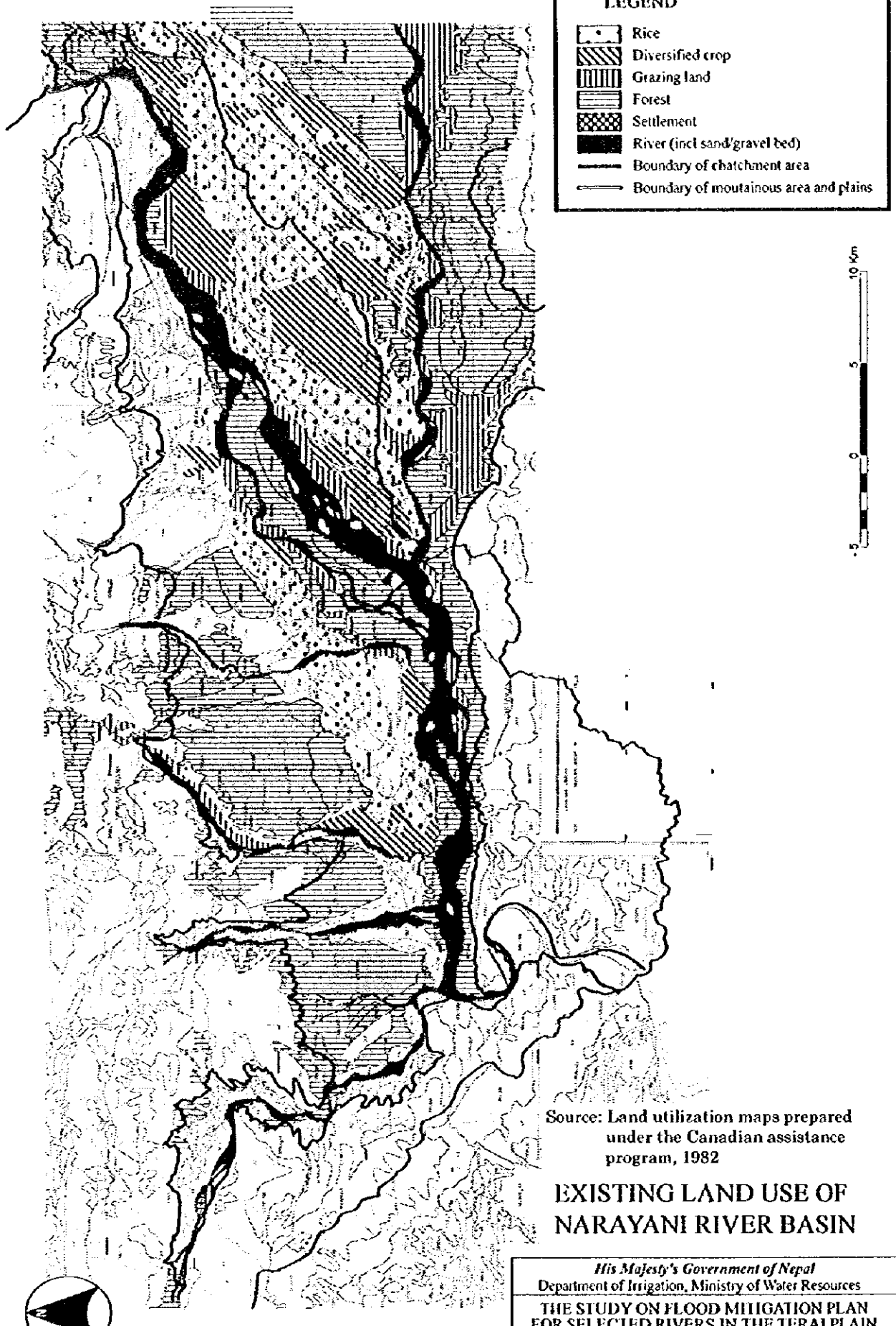
Fig. A1.13



Source: Land utilization maps prepared under the Canadian assistance program, 1982

EXISTING LAND USE OF NARAYANI RIVER BASIN

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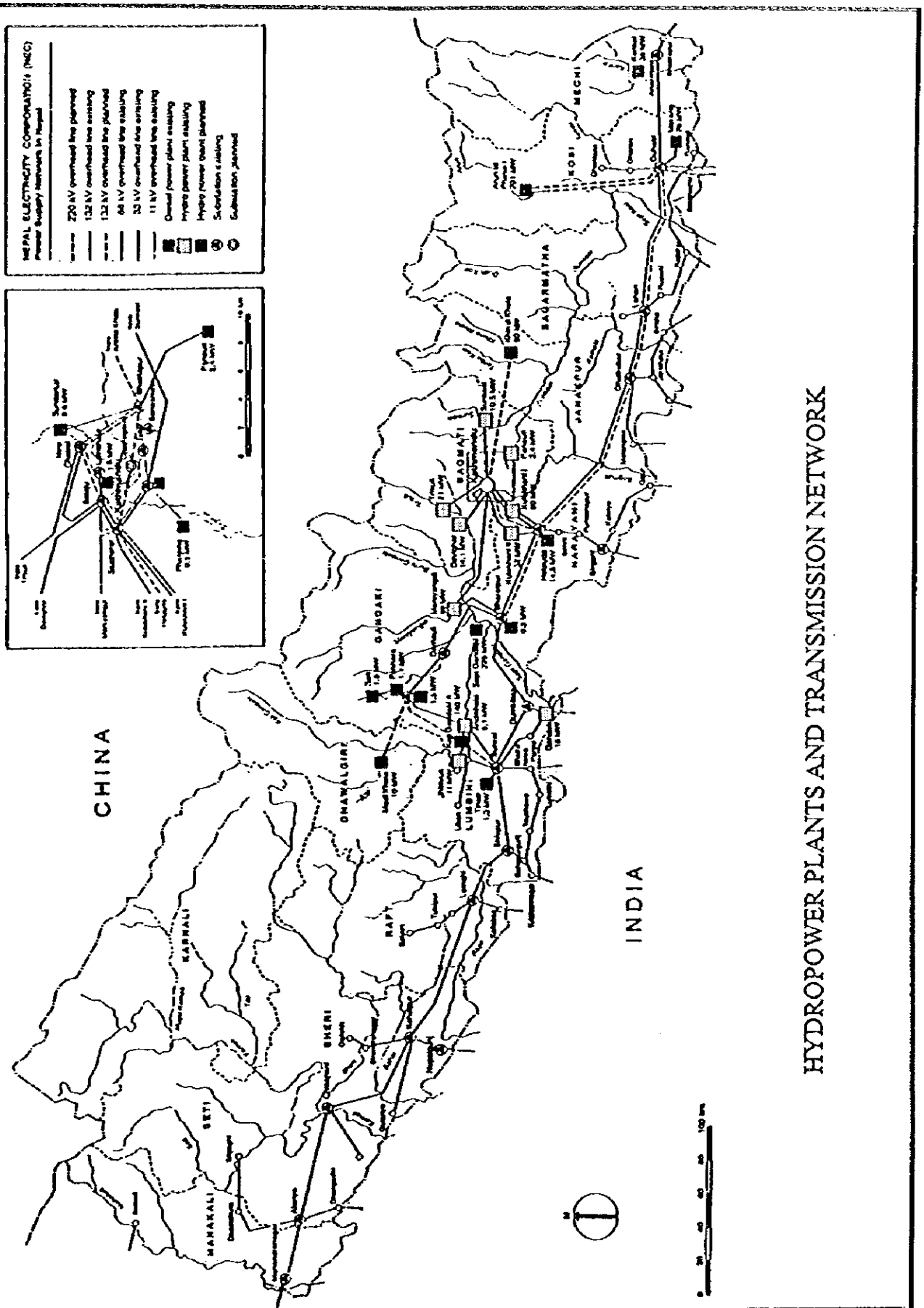
HYDROPOWER PLANTS AND TRANSMISSION NETWORK
CHINA
INDIA
KOSHI
SAGARMATHA
JANAKPUR
BAGMATI
NARAYANI
GANDAKI
DHAWALGIRI
LUMBINI
RAPTI
KARNALI
BHERI
SETI
MAHAKALI
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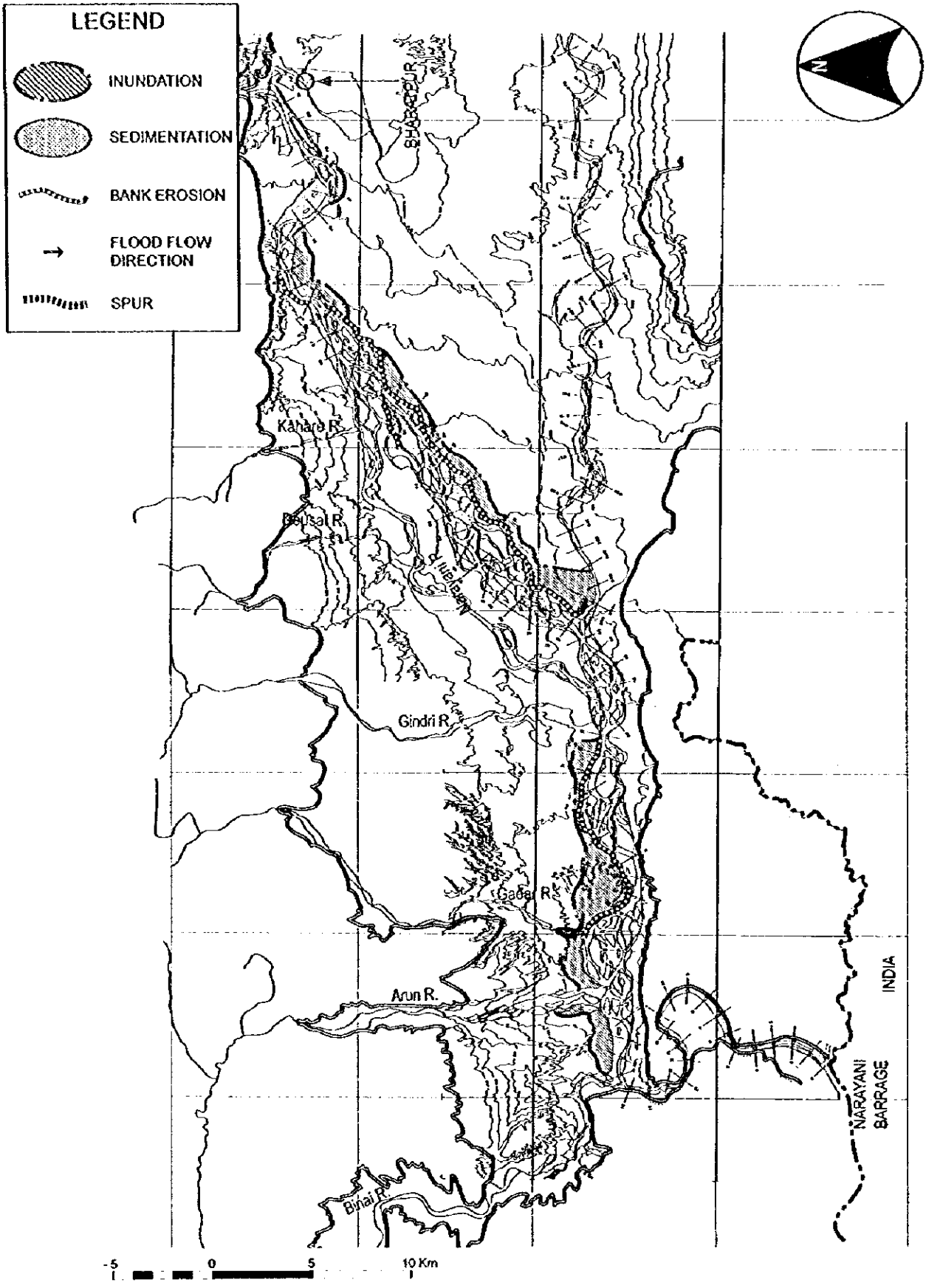
Fig. A1.15



FLOOD SUFFERING AREA (NARAYANI RIVER, 1995)

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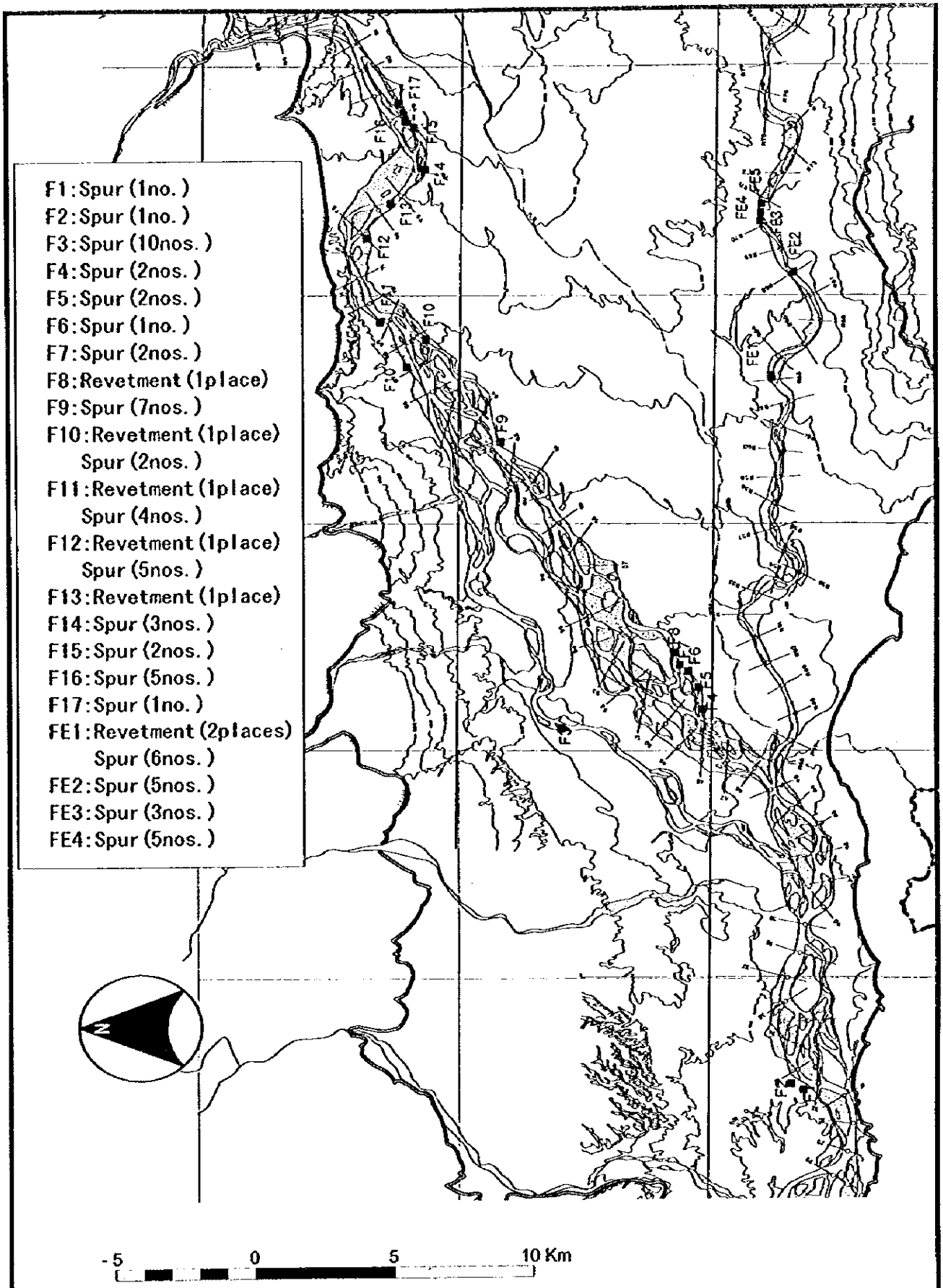

LOCATIONS OF RIVER FACILITIES

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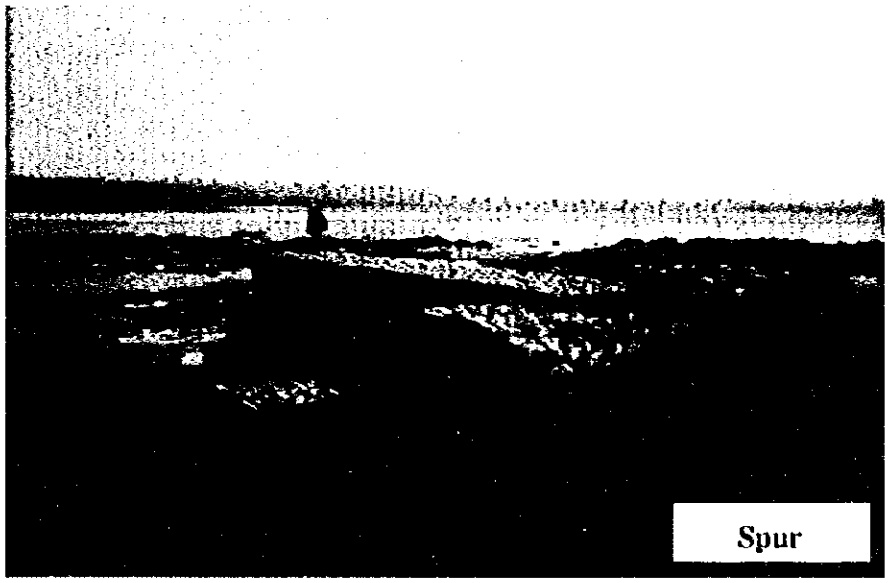

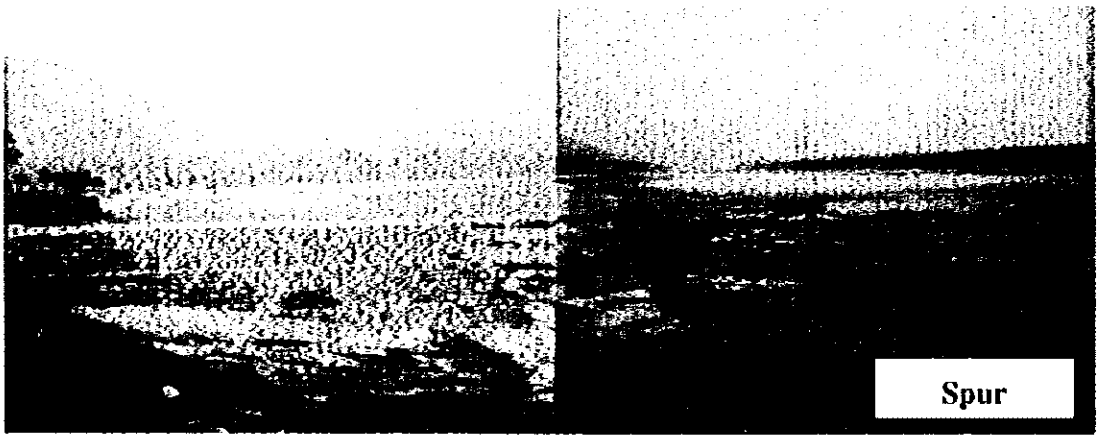

TYPICAL RIVER FACILITIES (1/2)

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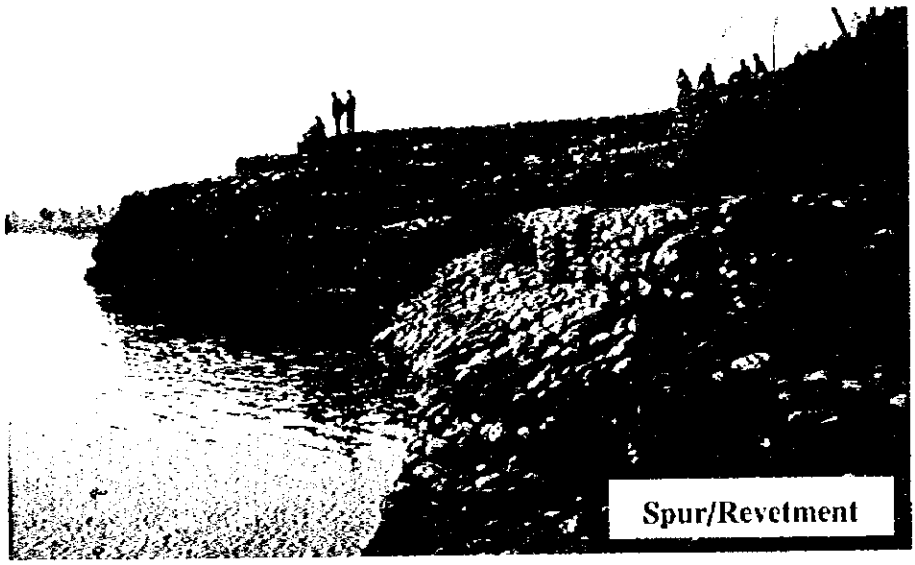

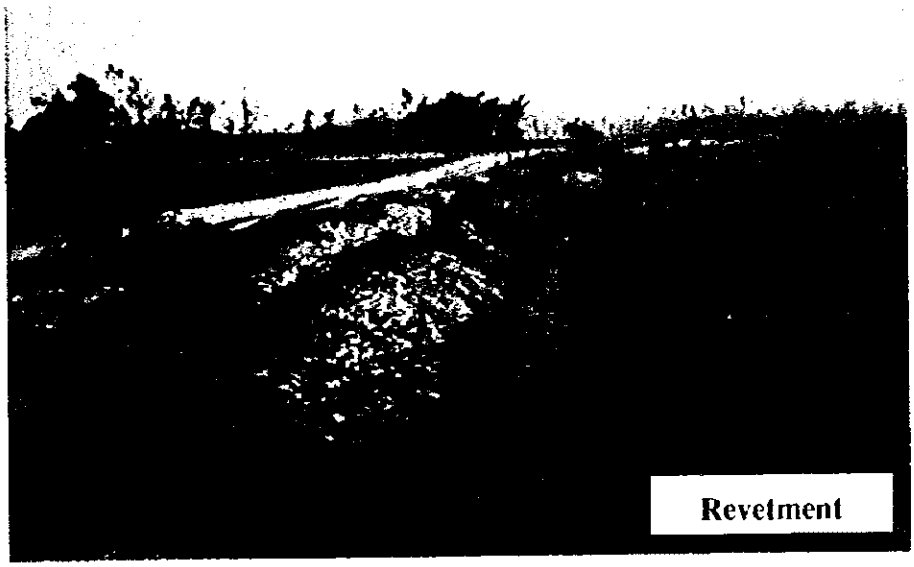

TYPICAL RIVER FACILITIES (2/2)

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