No.

Japan International Cooperation Agency

Federal Flood Commission
Ministry of Water and Power
The Islamic Republic of Pakistan

The Study on Comprehensive Flood Mitigation and Environmental Improvement Plan of Lai Nullah Basin in The Islamic Republic of Pakistan

Final Report
Volume 2 Main Report

September 2003

CTI Engineering International Co., Ltd.
Pacific Consultants International

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PREFACE

In response to a request from the Government of Islamic Republic of Pakistan, the Government of Japan decided to conduct a development study on Comprehensive Flood Mitigation and Environmental Improvement Plan of the Lai Nullah Basin in the Islamic Republic of Pakistan, and entrusted the Study to the Japan International Cooperation Agency (JICA).

JICA selected and dispatched a study team, headed by Mr. MATSUMOTO Yoshiharu of CTI Engineering International Co., Ltd. to Pakistan three (3) times between August 2002 and August 2003. In addition, JICA set up an Advisory Committee chaired by Mr. MIYAGAWA Yuji of the Ministry of Land, Infrastructure and Transport between May 2002 and September 2003, which examined the Study from specialist and technical points of view.

The Team held a series of discussions with the officials concerned of the Government of Islamic Republic of Pakistan and conducted field surveys at the Study area. Upon returning to Japan, the Team conducted further studies and prepared this final report.

I hope that this report will contribute to the promotion of this project and to the enhancement of friendly relationship between our two countries.

Finally, I wish to express my sincere appreciation to the officials concerned of the Government of Islamic Republic of Pakistan for their close cooperation extended to the Study.

September 2003

KAWAKAMI Takao
President
Japan International Cooperation Agency

September 2003

Mr. KAWAKAMI Takao
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

Sir:

We are pleased to submit herewith the final report of a Study on Comprehensive Flood Mitigation and Environmental Improvement Plan of the Lai Nullah Basin in the Islamic Republic of Pakistan.

Under a contract with the Japan International Cooperation Agency, the study was conducted by CTI Engineering International Co., Ltd. in association with Pacific Consultants International during the period from May 2002 to September 2003.

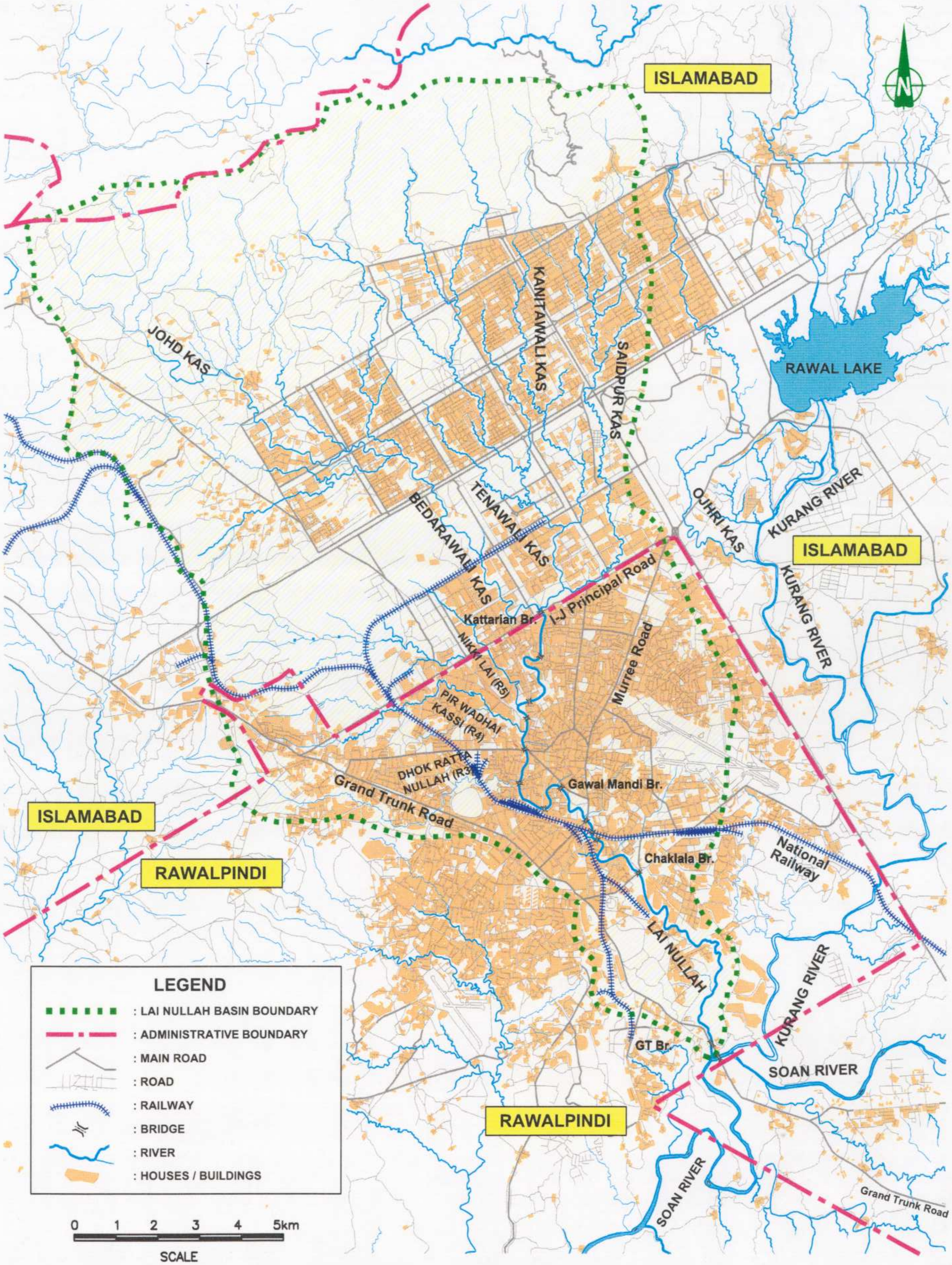
This final report presents a formulation of a master plan for comprehensive flood mitigation and environmental improvement of Lai Nullah. The principal component of the overall plan is placed in the structural flood mitigation plan, which aims at producing the immediate effect and ultimately making Lai Nullah free from overflow by the probable flood runoff discharge of 100-year return period. As the principal structures, a community pond, a flood diversion channel and supplementary works to the on-going river channel improvement are proposed. In addition to the above, non-structural flood mitigation plan such as flood forecasting and warning system, related environmental improvement plan and strengthening of institutional setup are proposed.

We wish to take this opportunity to express our sincere gratitude to the officials concerned of JICA, the Ministry of Foreign Affairs, and the Ministry of Land, Infrastructure and Transport. We would also like to extend our deep appreciation to the officials concerned of the Government of the Islamic Republic of Pakistan, Federal Flood Commission, the JICA Pakistan Office and the Embassy of Japan in Pakistan for their cooperation and assistance throughout our field survey.

Finally, we hope that this report will contribute to comprehensive flood mitigation and environmental improvement of Lai Nullah and sustainable development of the Islamic Republic of Pakistan.

Very truly yours,

MATSUMOTO Yoshiharu
Team Leader
The Study on Comprehensive Flood Mitigation
and Environmental Improvement of Lai Nullah Basin
in The Islamic Republic of Pakistan


ISLAMABAD
JOHD KAS
KANITAWALI KAS
SAIDPUR KAS
RAWAL LAKE
BEDARAWALI KAS
TENAWALI KAS
OJHRI KAS
KURANG RIVER
ISLAMABAD
KURANG RIVER
Kattarian Br.
I-J Principal Road
Murree Road
NIKKI LAI (R5)
PIR WADHAI KASSI (R4)
DHOK RATTA NULLAH (R3)
Gawal Mandi Br.
Grand Trunk Road
ISLAMABAD
RAWALPINDI
Chaklala Br.
National Railway
LAI NULLAH
KURANG RIVER
GT Br.
SOAN RIVER
RAWALPINDI
SOAN RIVER
Grand Trunk Road
LEGEND
: LAI NULLAH BASIN BOUNDARY
: ADMINISTRATIVE BOUNDARY
: MAIN ROAD
: ROAD
: RAILWAY
: BRIDGE
: RIVER
: HOUSES / BUILDINGS
0 1 2 3 4 5km
SCALE

GENERAL MAP

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ABBREVIATION

Organization

ADB	:	Asian Development Bank
AMC	:	Rawalpindi Agromet Center
CDA	:	Capital Development Authority
CIW	:	Commissioner for Indus Waters
DHI	:	Danish Hydraulic Institute
ECNEC	:	Executive Center of National Economic Council
FFC	:	Federal Flood Commission
FFD	:	Flood Forecasting Division
JBIC	:	Japan Bank for International Cooperation
JOCV	:	Japan Overseas Cooperation Volunteer
MES	:	Military Engineering Services
MMP	:	Mott MacDonald Pakistan
MWP	:	Ministry of Water and Power
NFFD	:	National Flood Forecasting Division
OECF	:	Overseas Economic Cooperation Fund
PCIW	:	Pakistan Commissioner for Indus Waters
PID	:	Punjab Irrigation and Power Development
PMD	:	Pakistan Metrological Department
RCB	:	Rawalpindi Cantonment Board
RDA	:	Rawalpindi Development Authority
RMC	:	Rawalpindi Municipal Corporation
SDO	:	Small Dams Organization, Irrigation and Power Development, Punjub
TMA	:	Tehsil Municipal Administration Rawalpindi
WAPDA	:	Water and Power Development Authority
WASA	:	Rawalpindi Water and Sanitation Authority

Unit

℃	:	Degree Centigrade
cusec	:	Cubic feet per second (1 cusec = 0.0283 m^3/s, or 1 m^3/s = 35.3 cusec)
dia.	:	Diameter
g	:	Gram
Ghz	:	Gigahertz
ha	:	Hectare
Kg, kg	:	Kilogram
Km, km	:	Kilometer
L. l. lit.	:	Liter
m	:	Meter
m^3	:	Cubic meter
m^3/s	:	Cubic meter per second
mil.	:	Million
Mhz	:	Megahertz
MLD	:	Million Liter per Day
MGD	:	Million Gallon per Day (1 MGD = 4.546 MLD)
Rs.	:	Pakistan Rupee
sec	:	second
t, ton	:	Tonnage
US$	:	American Dollar
W	:	Watt

Others

CEA	:	Chief Engineering Advisor
CFFC	:	Chairman, Federal Flood Commission
CN	:	Curve Number
ERC	:	Emergency Cell
EIRR	:	Economic Internal Rate of Return
FFWS	:	Flood Forecasting and Warning System
IEA	:	Initial Environmental Analysis
LAA	:	Land Acquisition Act
PST	:	Pakistan Standard Time
SCS	:	Soil Conservation of Services
SME	:	Small and Medium Enterprise
SWM	:	Solid West Management
Sweep	:	Solid Waste Management & Environmental Enhancement Project
UNDP	:	United Nation's Development Programme
UWSSP-R	:	Urban Water Supply and Sanitation Project for Rawalpindi City
WTP	:	Wastewater Treatment Plant

CHAPTER 1. INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Lai Nullah has a catchment area of 234.8 km^2 and a length of about 30 km, stretching from the Margalla Hills at the northwestern edge until Soan River at the southeastern edge. The catchment area is administratively divided into Islamabad in the upper reaches of 144.4 km^2 and Rawalpindi in the lower reaches of 90.5 km^2. Rawalpindi has been almost fully urbanized with the extremely high population, while Islamabad is the relatively new city established in 1961 and still less populated as compared with Rawalpindi.

Lai Nullah Basin receives a heavy rainfall of about 500mm during the monsoon from July to September, which could lead to the large flood runoff discharge. The recent intensive urban development in the City of Islamabad also tends to increase the peak flood runoff discharge. At the same time, the flow capacity of downstream of the Lai Nullah in the City of Rawalpindi has been remarkably reduced due to the illegal encroachment of buildings into the river course and the pile of garbage indiscriminately dumped into the river.

Due to the metrological conditions and river channel conditions as described above, the floods frequently overtop the Lai Nullah inflicting sever flood damages particularly in Rawalpindi. The flood in July 2001 caused the worst damage in the basin including death of 74 people[1] and the complete or partial destruction of about 3,000 houses. Public facilities such as transportation and electric power supply had also been completely paralyzed.

To cope with the flood problems of Lai Nullah, the Study on Comprehensive Flood Mitigation and Environmental Improvement Plan of the Lai Nullah Basin (hereinafter referred to as “the Study”) was undertaken through technical cooperation by the Japan International Cooperation Agency (JICA) during a period from May 2002 to September 2003.

1.2 OBJECTIVE OF THE STUDY

As stipulated in the Scope of Works, the objectives of the Study are:

(1) To formulate a master plan for comprehensive flood mitigation and environmental improvement in the Study area; and,

(2) To transfer skills and technology of comprehensive flood mitigation and environmental improvement to counterpart personnel of the Federal Flood Commission (FFC), and other government agencies concerned.

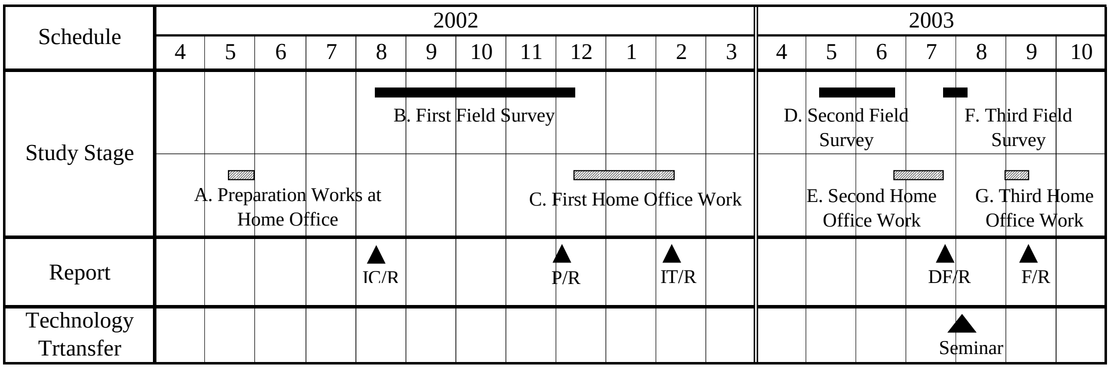
[1] The number of death was based on the information from Emergency Relief Cell of the Federal Government.

1.3 STUDY AREA

The Study Area covers the whole of the Lai Nullah basin of 234.8 km^2. A supplementary clarification is further made to the adjacent Kurang river basin, which is proposed as the outlet of the flood diversion channel.

1.4 OVERALL STUDY SCHEDULE

The Study is carried out through the phased field surveys in Pakistan and home office works in Japan within the entire study period of from May 2002 up to September 2003, as shown in Fig. R 1.4.1.



IC/R: Inception Report, P/R: Progress Report, IT/R: Interim Report, DF/R: Draft Final Report, F/R: Final Report

Fig. R 1.4.1 Tentative Study Schedule

CHAPTER 2. PHYSICAL CONDITIONS OF THE STUDY AREA

2.1 TOPOGRAPHY

The ground elevation of the Lai Nullah Basin ranges from EL. 420 m at the downstream end of the basin (i.e., the confluence with Soan River) to EL. 1,240 m at the upstream end (i.e., a mountaintop in the Margalla range) as shown in Fig. 2.1.1, and the Basin could be broadly divided to the following four (4) areas in view of topography; the Margalla range, the higher plain, the lower plain and the valley area in the north to south direction. The detailed topography of these four areas as described hereinafter:

2.1.1 Margalla Range

The Margalla range stands behind Islamabad City area as a wall, which forms the north boundary of the Lai Nullah Basin. The foot of the Margalla range is about EL. 620m, while the top of the mountain, which is only 3km away from the foot, is about EL. 1,200m. There are three (3) major tributaries of Lai Nullah namely Saidpur Kas, Tenawali Kas and Bedarawali Kas, which originate from the Margalla Range forming a very steep channel bed slope of about 1/10.

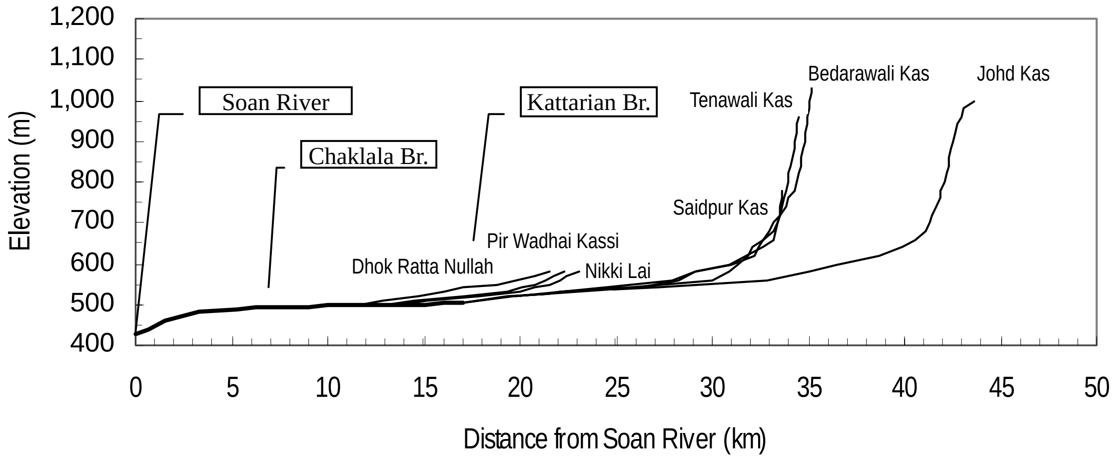


Fig. R 2.1.1 River Profiles

2.1.2 Higher Plain

The higher plain expands over the built-up area of Islamabad City with a gradual slope from North to South. Saidpur Kas, Tenawali Kas and Bedarawali Kas run southward in the plain with a slope of 1/100 to 1/500 weaving the build-up areas of Islamabad and finally flow into Lai Nullah just upstream of Kattarian Bridge.

2.1.3 Lower Plain

The lower plain extends over the upper part of the Rawalpindi area above Chaklala Bridge. This area is flatter than the upper Higher Plain and the lower Valley Area forming a bowl-shaped topography as shown in Fig. 2.1.2. The lowest area along Lai Nullah from Gawal Mandi Bridge to Chaklala Bridge is the bottom of the bowl, towards which all floodwater gathers from tributaries as well as the main stream. This bottom area was deeply submerged in the floodwater in 2001.

2.1.4 Valley Area

Below Chaklala Bridge, the topography changes into a definite valley. The river turns steeper with several cascades, falling down to Soan River. The river channel is deeper than 10 m, and the average river slope between Chaklala Bridge and Soan River is about 1/70.

2.2 CLIMATE

The climate of the Study Area is classified as "Subtropical Triple Season Moderate Climate Zone", which is characterized by single rainfall season from July to September and its moderating influence on temperature.

The Study Area has hot summers and cold winters. In June the daily maximum temperature reaches 40˚C, while the daily minimum temperature falls near 0℃ in December and January. Between July and September, the temperature is slightly moderate due to humidity.

The Study Area receives rains in all seasons but the monsoon rain is pronounced and constitutes a definite rain season between July and September. The total rainfall during the rain season is about 600 mm, accounting for 60% of the annual rainfall of about 1,000 mm. These monsoons bring heavy downpours in the Lai Nullah Basin, resulting in flooding of Lai Nullah and the tributaries. In the monsoon season, the thunderstorm often occurs 12 or 13 days in a month in Rawalpindi.

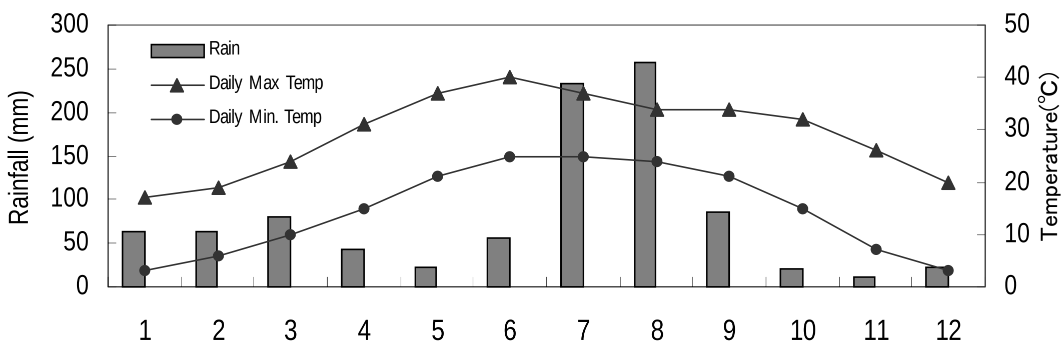


Fig. R 2.2.1 Rainfall and Temperature (Rawalpindi)

2.3 RIVER CONDITIONS

2.3.1 River System

In the jurisdiction area of Islamabad (i.e., the upper reaches of the Lai Nullah), the river system is composed of three (3) major tributaries (i) "Saidpur Kas", (ii) "Tenawali Kas" and (iii) "Bedarawali Kas" (refer to Fig. 2.3.1). These tributaries originate from Margalla hills and flow into the mainstream of Lai Nullah just upstream from Kattarian Bridge (RD17+210)[2], which was built on Khayaban-I-Sir Syed (or I-J Principal Road) forming the administrative boundary between Islamabad and Rawalpindi.

Below Kattarian Bridge (i.e., the jurisdiction area of Rawalpindi), the mainstream meets other three (3) major tributaries, namely (i) Nikki Lai, (ii) Pir Wadhai Kas and (iii) Dhok Ratta Nullah one after another, then flows down through the center of Rawalpindi City and finally pours into Soan River (refer to Fig. 2.3.1). In addition to these major tributaries, there are other six (6) tributaries or drainage/sewage channels, which joins the mainstream between the confluences of Dhok Ratta Nullah and Soan River. The name and the catchment area of the whole tributaries are as listed in Table R 2.3.1.

Table R 2.3.1 Tributaries of Lai Nullah

Location of Confluence with Main Stream	No. and Name of Tributary		Catchment Area (km^2)
	No[*1]	Name[*2]	
Islamabad	-	Saidpur Kas	24.7
	-	Tenawali Kas (Including Kanitawali Kas as the secondary tributary)	39.7
	-	Bedarawali Kas (Including Johd Kas as the secondary tributary)	79.9
	Sub-total		144.3
Rawalpindi	R5	Nikki Lai Kas	20.9
	R4	Pir Wadhai Kassi	11.2
	R3	Dhok Ratta Nullah	10.8
	R2	Unknown	22.8
	R1	Saddar Tributary	
	L2	Arya Nullah	
	L1	Dhok Chiraghdin Tributary	
	L4	Workshop Tributary	6.8
	L3	Unknown	
	-	Residual Area	18.0
	Sub-total		90.5
Grand Total			234.8

*1: Identification numbers assumed by the Study Team (The numbers corresponds to those shown in Fig. 2.3.1).
*2: Refer to "Feasibility Report on Flood Control of Lai Nullah in Rawalpindi City" by NESPAK-NDC in 1987.

The tributaries as well as the mainstream of Lai Nullah are the natural stream but also used as the channels for drainage/sewage disposal from the built-up areas in Islamabad and Rawalpindi without any treatment. As the results, the tributaries and the mainstream are significantly polluted giving off a stench during a period of low flow discharge in particular.

2 The figure with RD at the head hereinafter means the distance from New G.T. Road Bridge located 320m upstream from the confluence of Soan River. That is, RD17+210 is the point 17,210m upstream from G..T. Road Bridge.

2.3.2 River Features

The Lai Nullah shows the distinctly different river features among the following four (4) stretches; (i) the upstream from Kattarian Bridge (RD17+210), (ii) the middle stream from Kattarian Bridge to Chaklala Bridge (RD6+251) (iii) the middle stream from Chaklala Bridges to the waterfall below Murree Brewery (RD3+800), and (iv) the downstream from the waterfall to the confluence with Soan River (RD0-310). The principal river features of these stretches are as described below:

1) Upstream from Kattarian Bridge (RD17+210)

As described above, the river system of Lai Nullah is divided into three (3) major tributaries, namely Bedarawali Kas, Tenawali Kas and Saidpur Kas in the upper reaches from Kattarian Bridge. These tributaries have the rather spacious channel cross-sections with less meandering alignment. The channel bed-slopes of the lower stretches of Bedarawali Kas, Tenawali Kas and Saidpur Kas are more than 1/500, which is far steeper than that of 1/1,250 of the mainstream of Lai Nullah located downstream from Kattarian Bridge.

Due to the spacious and rather steep channels, the upper stretches of the tributaries, which are out of the extent of backwater effect of Lai Nullah, have the large channel flow capacity, and have never caused any extensive and serious river flood overflow since establishment of Islamabad in 1961, although minor flood inundation locally occurs due to inadequate drainage capacity and/or encroachment of houses into the habitual flood inundation area.

On the other hand, the lower stretches of the tributaries is under influence of the backwater effect by the water level of Lai Nullah, because all flood runoff discharge from the tributaries concentrates into the mainstream of Lai Nullah at Kattarian Bridge raising its water level of the mainstream. This backwater effect occasionally causes the serious flood overflow and the extensive flood inundation along the lower stretches of the tributaries. In the flood 2001, the water level of mainstream at Kattarian Bridge rose above EL. 508m, which is far higher than the bank level of the mainstream (i.e., EL. 500m). Due to such high water level, the extensive flood inundation occurred in the area along the lower reaches of the tributaries administratively called Block Nos. I-8 and I-9 of Islamabad.

2) Middle Stream between Kattarian Bridge and Chaklala Bridge (RD6+251)

Below Kattarian Bridge, Lai Nullah passes through the area of Rawalpindi. The area is on the flat alluvium plain, and the section of Lai Nullah in the area has the gentle riverbed slope of about 1/1,250 with several meandering portions.

The river channel improvement for this stretch is now in progress (the detailed clarification of the channel improvement is as described in the following subsection 2.3.3). Before the channel improvement, the stretch had a single cross-section with a narrow channel width; the width of several bottlenecks in the stretch is less than 20m. Moreover, there have been many encroachments of structure in the river channel. Due to these river conditions, the stretch has frequently caused the flood overflow.

According to the simulation by non-uniform calculation, the bank level of the stretch before the on-going channel improvement could confine the flood water level for only less than 300 m^3/s which corresponds to recurrence probability of less than 3-years (refer to Fig. 2.3.2). On the other hand, the channel flow capacity is expected to increase to more than 600 m^3/s upon completion of the on-going river channel improvement. Detailed clarification of this incremental channel flow capacity is as described in the following subsection 2.3.4.

3) Middle Stream from Chaklala Bridge to Waterfall below Murree Brewery (RD3+800)

Below Chaklala Bridge, the Lai Nullah passes through the residential area of the Cantonment Area. This stretch has the gentle channel bed-slope, which is almost same as that of the upper on going channel improvement section (i.e., 1/1,250) as shown in Fig. 2.3.3.

There were heavily meandering sections of about 1,150m in length around Murree Brewery Area from RD4+077 to RD5+227 (i.e., about 2.1km to 1.0km downstream from Chaklala Bridge). The meandering section had a limited channel width causing a rather frequent flood overflow. According to the interview survey with the residents, Askari Estate located at the left bank of meandering section had the flood inundation depth therein reached 1.5m above ground level in the flood in 2001. In order to offset the flood overflow, realignment (short-cut) together with widening of the river channel has been made by PMU, RDA as an extension of the aforesaid on-going channel improvement of Lai Nullah from Chaklala Bridge to Kattarian Bridge. Through this channel improvement, the short-cut section has a channel flow capacity of more than 1,800 m^3/s.

The section of about 1.0km in length sandwiched between the aforesaid realignment/widening of the meandering section and the on-going channel improvement above Chaklala Bridge is, however, left behind without any channel. The section contains the several bottlenecks, the cross-sections of which are far smaller than the design cross-section at Chaklala Bridge. As the results, the floodwater level tends to abruptly rise just upstream of the section due to the water head swelled at the bottlenecks of the section. The floodwater level thus abruptly raised causes the adverse backwater effect to the upper on-going channel improvement sections. The backwater effect would extend to the upstream section near to Gunj Mandi Bridge, which is about 6km upstream from Chaklala Bridge. Should the existing bottleneck section remain as it is without any improvement, the actual channel flow capacity within the extent of the backwater effect would be decreased to be below the design flow capacity of the on-going channel improvement project (refer to section 2.3.4 in detail).

4) Downstream from Waterfall to Confluence with Soan River (RD0-310)

The Lai Nullah meets the first waterfall about 3,800 m upstream from New G.T. Road Bridge (RD0+000). Below the water fall, the Lai Nullah passes through less populated area, having the rather large channel width and channel depth with steep channel slope of about 1/70 as shown in Fig. 2.3.3. Due to these conditions, the flood damage along this stretch could be evaluated to be nil.

2.3.3 On-going River Improvement Works for Middle Stream from Kattarian Bridge to Chaklala Bridge

As described above, the channel improvement is currently in progress for the stretch from Chaklala Bridge to Kattarian Bridge. The heavily meandering section around Murree Brewery Area (RD4+077 to RD5+227) has also been realigned (short-cut) and widened as a part of the on-going channel improvement. This channel improvement started, on experiencing the disastrous flood damage in 2001, as a part of the project of the on going "Urban Water Supply and Sanitation Project Phase-1 for Rawalpindi City" under the financial assistance of ADB Loan {Loan No. 1260 Pak (SF)}.

The project is composed of (i) widening and realignment of the section of 10.96km from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210), (ii) reconstruction of the three (3) bridges, namely: Dhoke Chiragh Din Bridge (RD8+050), Gawal Mandi Bridge (RD12+976), and Pir Wadhai Bridge (RD13+760) and (iv) realignment/widening of meandering section around Murree Brewery Area from RD4+077 to RD5+227 (i.e., about 2.1 km to 1.0 km downstream from Chaklala Bridge).

The actual construction works had started upon award of contract in January 2002, but demolishing of the structures for securing of the right of way could not start until July 2002 in spite of efforts of the relevant government agencies. Due to difficulties in demolishing, the actual work progress was much delayed, and the target completion time was extended to September 2003 from January 2003. The salient features of the improvement works as well as the dimensions of the design cross-sections are as listed in the following Tables R 2.3.2 and R 2.3.3, respectively:

Table R 2.3.2 Salient Features of On-going Channel Improvement of Lai Nullah

Item	Description
Design scale	25-year return period at non-bridge sections, and 100-year return period for bridge sections
Design discharge	About 600 to 1,000m^3/s
Improvement section	(a) Section of 10,959m from Kattarian Bridge (RD17+210) to Chaklala Bridge (RD6+251) (b) Meandering Section of 1,150 m from around Murree Brewery Area from RD4+077 to RD5+227 (Short-cut to 775m)
Shape of cross-section	Single cross-section with the side slope of 1 to 1.5
Side protection	Stone pitching for the sections of 50m in length along twelve (12) bridges
Depth of cross-section	6.5m at the design high water level (HWL) and 7.5m at the top of the bank (i.e., height of free board is 1m)
Width of cross-section	Top width of 47.0 to 69.7 m within the Right of Way of 56 to 79m
Reconstruction of bridge	Three (3) bridges; namely, Dhoke Chiragh Din Bridge (RD8+050), Gawal Mandi Bridge (RD12+976), and Pir Wadhai Bridge (RD13+760)
Side drain	The concrete drain with its top width of 0.37m placed along the bank of the river channel as required.

Source: Design Report Vol.1, Urban Water Supply and Sanitation Project Phase 1 for Rawalpindi City, March 2002., and interview from PMU, RDA

Table R 2.3.3 Typical Cross-section Designed in the On-going River Channel Improvement

Section				Design Flow Capacity (m^3/s)	Channel Width (m)		Channel Depth (m)	Width of Right of Way (m)
Downstream		Upstream						
Description	RD	Description	RD		Bottom	Top		
Short-cut section	4+077	Short-cut section	5+277	N.A*	47.3	69.7	7.5	N.A*
Chaklala Bridge	6+215	Dhoke C. Din Bridge	8+060	1,009	44.4	66.9	7.5	79.0
Dhoke C. Din Bridge	8+060	Railway Road Bridge	8+325	968	42.4	64.9	7.5	77.0
Railway Road Bridge	8+325	Murree Road Bridge	8+628	962	42.2	64.7	7.5	76.0
Murree Road Bridge	8+628	Gawal Mandi Bridge	9+814	957	41.9	64.4	7.5	76.0
Gawal Mandi Bridge	9+814	City S. Road Bridge	10+790	942	41.2	63.7	7.5	75.0
City S. Road Bridge	10+790	Ratta A. Road Bridge	11+780	934	40.8	63.3	7.5	75.0
Ratta A. Road Bridge	11+780	Gunj Mandi Bridge	12+630	923	40.3	62.8	7.5	74.0
Gunj Mandi Bridge	12+630	Pir Wadhai Bridge	14+428	873	37.9	60.4	7.5	72.0
Pir Wadhai Bridge	14+428	Khayaban S.S. Bridge	14+100	819	35.4	57.9	7.5	69.0
Khayaban S.S. Bridge	14+100	Parrian Bridge	16+178	633	26.4	48.9	7.5	58.0
Parrian Bridge	16+178	Kattarian Bridge	17+210	594	24.5	47.0	7.5	56.0

Source : Design Report Vol.1, Urban Water Supply and Sanitation Project Phase 1 for Rawalpindi City, March 2002, and Variation Order No.05 Contract No. CW/LCB/DW-08A on Straightening of Chaklala Loop, PMU RDA.
Note* : Not specified

2.3.4 River Channel Flow Capacity

The river channel flow capacity of Lai Nullah and its major tributaries were estimated by non-uniform calculation method with using the channel cross-sections and the probable runoff discharges as the basic data. Among others, the probable runoff discharges are derived from the results of the hydrological analysis (refer to chapter 5), while the channel cross-sections are from the results of the river channel survey carried out in the Study and/or the construction drawing for the on-going river channel improvement. The extent and the Manning’s Roughness Coefficient adapted to the estimation of channel flow capacity are as listed below.

Table R 2.3.4 Stretches for Estimation of Channel Flow Capacity

Name of River	Extent	Length (km)	Manning's Coefficient	Source of cross-sections
Bedarawali Kas	From Kattarian Bridge to 2.3km upstream	2.2	0.035	Results of river channel survey carried out in the Study
Tenawali Kas	From confluence with Saidpur Kas to 2.2km upstream*	2.2	0.035	- ditto -
Saidpur Kas	From confluence from Kattarian Bridge to 2.2km upstream	3.5	0.035	- ditto -
Lai Nullah	From Waterfall (RD3+800) to outlet of short-cut section (RD4+077)	0.3	0.035	Variation Order No.05 on Straightening of Chaklala Loop, PMU RDA.
	Short-cut section (RD4+077 to RD5+277)	0.8	0.030	Construction drawing for the on-going river channel improvement
	From inlet of short-cut sec. (RD5+277) to Chaklala Bridge (RD6+251)	1.0	0.035	Results of river channel survey carried out in the Study
	Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210)	10.1	0.030	Construction drawing for the on-going river channel improvement

*: The confluence of Tenawali Kas and Saidpur Kas is located about 600m upstream from Kattarian Bridge

1) Tributaries in Islamabad

The probable water levels of Lai Nullah at Kattarian Bridge were first estimated by the non-uniform calculation from waterfall (RD 3+800) up to Kattarian Bridge based on the critical flow at the waterfall as the boundary condition at the downstream end. The results of the estimation are as listed in Table R 2.3.5.

Table R 2.3.5 Probable Water Level and Discharge at Kattarian Bridge

Return Period	Probable Discharge (m^3/s)*				Water Level of Lai Nullah at Kattarian Bridge (EL. m)
	From Tributaries			Lai Nullah at Kattarian Bridge	
	Bedarawali Kas	Tenawali Kas	Saidpur Kas		
5	180	95	55	330	498.0
10	340	175	105	620	499.8
25	640	315	195	1150	502.1
50	930	450	280	1660	503.7
100	1270	620	380	2270	505.3

* Estimated by the flood runoff simulation (refer to Chapter 5)

The profile of water level along the tributaries, Bedarawali Kas, Tenawali Kas and Saidpur Kas was further estimated applying the above probable water level of Lai Nullah at Kattarian Bridge as the initial water stage (i.e., the boundary condition) at the downstream end of the tributaries. The probable water level of the tributaries thus estimated were then compared with their existing bank levels, and the channel flow capacity of the tributaries were estimated through the comparison as listed below (refer to Fig. 2.3.4):

Table R 2.3.6 Channel Flow Capacities of Tributaries in Islamabad

Name of Tributaries	Length of Channel Surveyed	Flow Capacity	Flood Scale to be coped by Flow Capacity*
Bedarawali Kas	2.2 km	730 m^3/s	30-year return period
Tenawali Kas	2.2 km	320 m^3/s	25-year return period
Saidpur Kas	3.5 km	200 m^3/s	25-year return period

*: The values are estimated by interpolation of the flow capacity into the probable runoff discharges listed in Table R.2.3.5.

As listed above, the channel flow capacity of the lower stretch of Bedarawali Kas is about 730 m^3/s, which could cope with the probable flood discharge of 30-year return period. As for Tenawali Kas and Saidpur Kas, their channel flow capacities are estimated at 320 m^3/s and 200 m^3/s, respectively, which would correspond to the probable flood runoff discharges of 25-year return floods, respectively.

As described in the following item 2), the on-going channel improvement section of Lai Nullah has the channel flow capacity of 640 m^3/s at Kattarian Bridge, which corresponds to the probable runoff discharge of about 10-year return period[3]. Accordingly, it is evaluated that the tributaries of Bedarawali Kas, Tenawali Kas and Saidpur Kas have the larger channel flow capacity than the mainstream of Lai Nullah, even after completion of the on-going channel improvement of the mainstream.

2) Mainstream of Lai Nullah from Waterfall (RD3+800) to Kattarian Bridge (RD17+210)

The profile of the water levels for probable flood flow discharges along Lai Nullah from waterfall to Kattarian Bridge was estimated through the aforesaid non-uniform calculation based on the critical flow at the waterfall (RD 3+800) as the boundary condition at the downstream end of the stretch. As the results, the probable flood discharge, which has its corresponding water level below the bank level, was estimated as the channel flow capacity of Lai Nullah. The results of the estimation are as listed below (refer to Fig. 2.3.5):

Table R 2.3.7 Estimated Channel Flow Capacity of Lai Nullah
{In case of Non-Channel Improvement of the Section (RD5+277 to RD6+215)}

Section				Flow Capacity (m^3/s)
Downstream		Upstream		
Description	RD	Description	RD	
Short-cut section	4+077	Short-cut of mender	5+277	1,810
Non improvement section	5+277	Non improvement section	6+215	800
Chaklala Bridge	6+215	Dhoke C. Din Bridge	8+060	620
Dhoke C. Din Bridge	8+060	Railway Road Bridge	8+325	770
Railway Road Bridge	8+325	Murree Road Bridge	8+628	780
Murree Road Bridge	8+628	Gawal Mandi Bridge	9+814	800
Gawal Mandi Bridge	9+814	City S. Road Bridge	10+790	850
City S. Road Bridge	10+790	Ratta A. Road Bridge	11+780	880
Ratta A. Road Bridge	11+780	Gunj Mandi Bridge	12+630	890
Gunj Mandi Bridge	12+630	Pir Wadhai Bridge	14+428	890
Pir Wadhai Bridge	14+428	Khayaban S.S. Bridge	14+100	880
Khayaban S.S. Bridge	14+100	Parrian Bridge	16+178	690
Parrian Bridge	16+178	Kattarian Bridge	17+210	640

As described above there are bottlenecks along non-improvement section of 1.0 km in length below Chaklala Bridge (RD5+277 to RD6+215). The bottlenecks swells the water head and

[3] According to the design report of the on-going channel improvement, the design channel flow capacity was assumed to meet a probable flood runoff discharge of 25-year return period but it was reevaluated to be nearly equal to a probale discharge of only 10-year return period in this Study (refer to Table R 5.2.3).

brings about the abrupt rise of the flood water level just upstream of the bottlenecks and, its backwater effect extends about 6km upstream near to Gunj Mandi Bridge as shown in Fig. 2.3.5. The backwater effect causes the unfavorable conditions such that the channel flow capacity of the lower section reversibly drops below that of the upper section within an extent from Chaklala Bridge up to Gunj Mandi Bridge; the channel flow capacity of at Gunj Mandi is 890 m^3/s, while the flow capacity drops to 620 m^3/s at Chaklala Bridge as listed in Table R 2.3.7.

The reversal of the channel flow capacities from the upper to lower sections inflicts the risk of flood overflows and therefore, should be unconditionally dispelled. In order to offset the reversal of the channel flow capacities, it is indispensable to improve the bottlenecks. The necessary channel improvement could be made through enlargement of the cross-sections. Designed channel profile, typical cross-sections and alignment for the bottlenecks are as described in Item 3) of subsection 6.2.1

On the premises that the channel improvement of the bottlenecks, the channel flow capacity of the Lai Nullah could be recovered and almost compatible to the design discharge adapted to the on-going channel improvement project as listed in Table R 2.3.8 (refer to Fig. 2.3.6).

Table R 2.3.8 Estimated Flow Capacity of Lai Nullah and Design Discharge adopted to the On-going River Channel Improvement

{In case of Channel Improvement of the Section (RD5+277 to RD6+215)}

Section				(1) Estimated Flow Capacity*1	(2) Design Discharge*2
Downstream		Upstream			
Description	RD	Description	RD		
Short-cut section	4+077	Short-cut section	5+277	1,810	-
Proposed improvement section	5+277	Proposed improvement section	6+215	1,010	-
Chaklala Bridge	6+215	Dhoke C. Din Bridge	8+060	1,010	1,000
Dhoke C. Din Bridge	8+060	Railway Road Bridge	8+325	1,010	970
Railway Road Bridge	8+325	Murree Road Bridge	8+628	1,000	960
Murree Road Bridge	8+628	Gawal Mandi Bridge	9+814	970	960
Gawal Mandi Bridge	9+814	City S. Road Bridge	10+790	960	940
City S. Road Bridge	10+790	Ratta A. Road Bridge	11+780	950	930
Ratta A. Road Bridge	11+780	Gunj Mandi Bridge	12+630	940	920
Gunj Mandi Bridge	12+630	Pir Wadhai Bridge	14+428	910	870
Pir Wadhai Bridge	14+428	Khayaban S.S. Bridge	14+100	890	830
Khayaban S.S. Bridge	14+100	Parrian Bridge	16+178	690	630
Parrian Bridge	16+178	Kattarian Bridge	17+210	640	590

Note

*1: The flow capacity estimated by non-uniform calculation assuming widening of the sections below Chaklala Bridge (RD5+227 to RD6+215)

*2: The rounded values of design discharge adopted to the on-going channel improvement (Source: Design Report Vol.1, Urban Water Supply and Sanitation Project Phase 1 for Rawalpindi City, March 2002)

As listed above, the flow capacities adapted to the design of the on-going channel improvement (i.e., the values under the column of (2) in Table R 2.3.8) tend to be slightly lower than the values estimated in the Study (i.e., those under the column of (1) in Table R 2 3.8), which are subject to the widening of the existing channel section below Chaklala Bridge (RD5+227 to RD6+215).

The channel flow capacity adapted to the on-going channel improvement is estimated by the uniform calculation method, where considered is not given to the possible increment of the flow capacity due to the downward expansion of the designed typical cross-sections (refer to Fig. 2.3.7).

Taking the above conditions into consideration, the values estimated by non-uniform calculation in this Study (i.e., the values under column of (1) in Table R 2.3.8) are assumed as the design channel flow capacity of the on-going channel improvement section from Chaklala Bridge to Kattarian Bridge. As described above, however, the design flow capacity adapted in the Study is on conditions that the channel improvement of the existing non-channel improvement section below Chaklala Bridge (RD5+227 to RD6+215) is made in accordance with the proposed channel profile and cross-sections as specified in subsection 6.2.1.

2.4 GEOLOGY

2.4.1 General

The study area is located at the northwestern extension of the Himalayan mountain system developed in a series of stages 30 to 50 million years ago. The Himalayan range was created from powerful earth movement that occurred as the Indian plate pressed against the Eurasian continental plate (Plate Tectonics). This collision raised the deposits laid down in the ancient to form the Himalayan ranges from Pakistan eastward across northern India, and from Nepal and Bhutan to the Myanmar border.

Major tectonic activity has shaped the geologic structures observed in northern Pakistan. The main sutures among the Indian and Eurasian continents, and the others are clearly outlined. As shown in the following figure, the major contact, which over a vast area separates lower crustal or upper mantle rocks from the sialic crust of the Indian Plate, can be referred to as the Main Muntle Thrust (MMT), the Main Karakorum Thrust (MKT) and the Main Bundary Thrust (MBT).

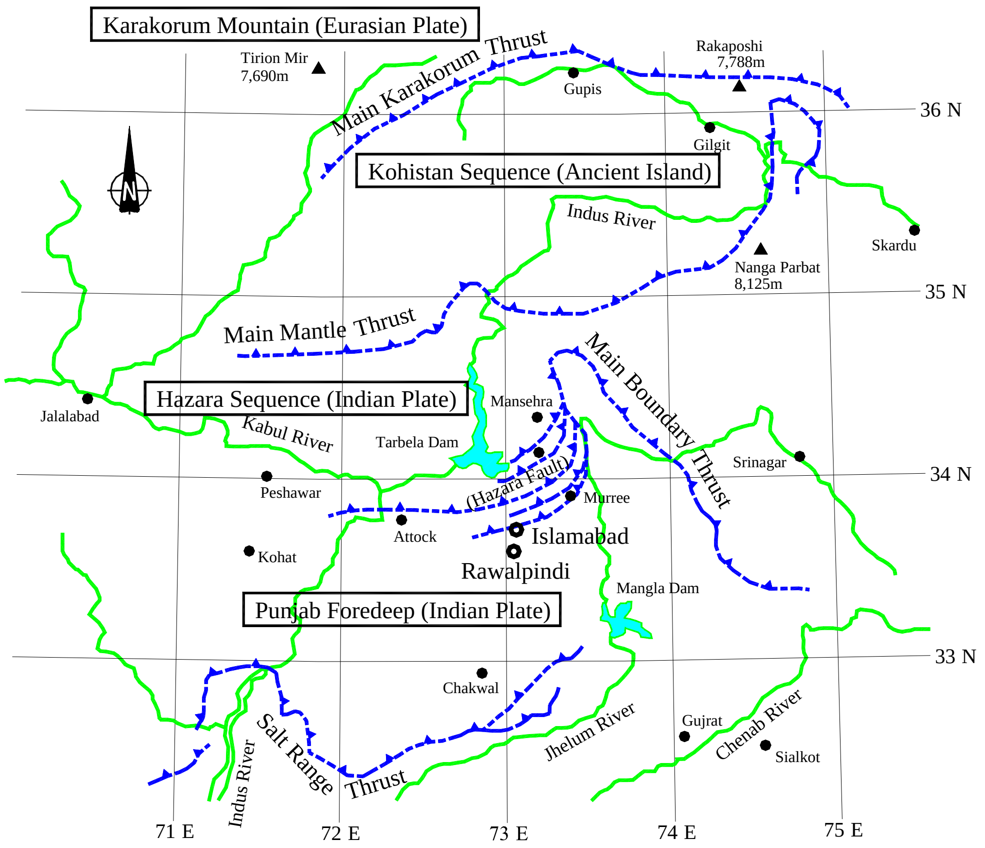


Fig. R 2.4.1 Tectonic Boundary observed in Northern Pakistan

2.4.2 Geology in the Study Area

The study area is located near the trace of the Hazara fault that corresponds to the Main Boundary Thrust (MBT). The area forming the northeastern Potwar Plateau and adjacent hills is in its geological condition largely Tertiary in age and with smaller areas of formations belonging to Cretaceous age. The following stratigraphical sequence is seen in the area.

Table R 2.4.1 Stratigraphical Sequence in Study Area

Formation	Constitution	Epoch	Period	Time Boundaries
Surficial Deposit	Loessic Silt (Loam), Older Alluvium,	Holocene	Quaternary	1.6 mil. years ago
	Gravelly Conglomerate	Pleistocene		
Siwalik Formation	Sandstone, Conglomerate	Miocene-Pliocene	Tertiary	65 mil. to 1.6 mil. years ago
Murree Formation	Sandstone, Shale	Miocene		
Kuldana Beds	Sea Deposits, Fluvial Deposits	Eocene		
Upper Nummulitics	Limestone, Shale			
Lower Nummulitics	Limestone, Shale			
Giumal Formation	Quartzitic Sandstone, Calcareous Shale, Limestone	-	Cretaceous	138 mil. to 65 mil. years ago

The details of geological constitution mentioned in the above table are explained hereinafter.

1) Giumal Formation

The oldest formation outcropping in the study area belongs to Cretaceous age and is represented by the Giumal Formation. It comprises dark colored quarzitic sandstone, calcareous shale and limestone. These rocks are thinly developed, but make a conspicuous appearance in the Margalla hill slopes bordering the north margin of the Potwar Plateau. The rocks are very much folded and squeezed. The sequence is greatly disturbed by reversed faulting.

2) Lower and Upper Nummulitics

The Lower Nummulitics comprises a massive gray or dark colored limestone of great thickness with intercalation of shale containing nummulite fossils. The Lower Nummulitics outcrops forming the Margalla hill range in the northwestern corner of the study area.

The Lower Nummulitics is succeeded by Upper Nummulitics variegated limestone and shale. Outcrops of this series are seen as thin zones with the Lower Nummulitics in the Margalla hill range and have some calcareous conglomerates and red shale toward its top.

3) Kuludana Beds

These passage beds denoting recession of sea deposits and beginning of fluvial deposits.

4) Murree Formation

A thick group of red and purple sandstone and shale sequence over lying the Kuldana Beds are designated the Murree Formation. The strata are red and purple shale veined by calcite, sandstone and concretionary clay pseudo conglomerates. Apart from the Margala hill range, the entire region is formed by the Murree Formation. Regular outcrops are, however, seen only in the small ridges at the base of the Margalla hill range, in the Murree hills and in lower reaches of Lai Nullah (downstream from RD 3+600). Rest of the area is covered by surficial deposits.

5) Siwalik Formation

The rock formations succeeding the Murree Formation in conformable sequence have been called the Siwalik Formation. It can be divided into three groups; namely, Lower Siwalik, Middle Siwalik and Upper Siwalik, which is the youngest and terminates the Tertiary formations.

The lowest beds of the Lower Siwalik indicate clear transitional passage into the upper Murree Formation. It is formed of hard, dark colored and massive sandstone. The Upper Siwalik overlies the previous formation in a transitional manner, but often with overlapping margin, sometimes appearing as fault contact. The lower one of this formation is composed of red earthy clay with massive beds of coarse, loosely cemented and pebbly sandstones. The upper one is composed of pebbly beds, which gradually increase in size to form a regular siliceous conglomerate. The Siwalik Formation outcrops southeast and south of Rawal Pindi

6) Surficial Deposits

In upper reaches (upstream from RD 4+050), Lai Nullah cuts through the surficial deposits, which generally consists of Potwar loessic silt. It deposits forming a thick mantle overlying Lai Conglomerates as per stratigraphical sequence. However, in lower reaches of Lai Nullah (downstream from RD 3+600), the surficial deposits are found to be present directly over older formation, the Murree Formation, where the Lai Conglomerate has been removed by the degradation.

The loessic silt deposits are massive and comprises well-sorted silt with some clay and very fine sand. Below RD 4+50, these silts have been eroded in the river and older alluvium has been exposed.

The Lai Conglomerate, which is the oldest among Quaternary deposits in the study area, is exposed along the course of Lai Nullah between RD 3+600 and RD 4+50. The Lai Conglomerate is poorly graded, well cemented and quite hard. It is of varying composition, consisting of limestone, sedimentary rock, quartzite and igneous rock.

7) Folds and Faults

Due to the measure tectonic activity, the study area forms a part of the northern limb of a big geosyncline. The rock formations from the Murree to the Upper Siwalik have been folded and striking approximately in a northeast-southwest direction. The angle of inclination of the main fold axis varies considerably, but is about 20 degree.

According to the report, “Active Fault Systems in Pakistan”, some of the active faults were revealed in Pakistan by the study of aerial photographs and Landsat images. The Attock and Campbellpur Active Faults were observed in or near the Margalla hill region of the study area. There are two parallel E-W trending faults, which cut through recent alluvium and form fault terraces. It will be desirable to conduct further ground checks and detailed field studies.

2.5 FLOOD

Details of the past flood disasters are unfortunately not available, but scraps of descriptions about past floods could be collected from several study reports. According to them, the flood has occurred with the frequently of 19 years at least in 59 years from 1944 to 2002 as listed in Table R 2.5.1. In other words, flood damage broke out almost once in every three years.

Table R 2.5.1 Flood Years

Year	Date	Year	Date
1944	August 13	1985	No Data
1957	No Data	1988	No Data
1966	July 31	1890	No Data
1970	No Data	1994	July 3
1972	No Data	1995	July 24
1976	No Data	1996	July 29
1977	No Data	1997	August 27
1978	No Data	2001	July 23
1981	No Data	2002	August 13
1982	August 10	N/a	N/a

2.5.1 Habitual Flood Inundation Areas

Habitual inundation areas have been identified by the relevant administrations such as CDA, RDA and TMA. The low-lying areas along Lai Nullah and the tributaries in Rawalpindi suffer from even small floods. The serious flood tents to occur particularly along the mainstream between Gunj Mandi Bridge and Railway Bridge, and the tributaries of Arya Nullah, Dhok Ratta Nullah and Donk Charaghdin. According to TMA, flood overflow of Lai Nullah starts along these areas once the water level of Lai Nullah reaches 18 feet (491.5 m) at Gawal Mandi Bridge. In order to disseminate the risk of flood over flow, TMA blow sirens over the low-lying areas when the water revel reaches the alert water level at 16 feet (491.3 m).

Due to the geophysical features, Islamabad is safer against floods than Rawalpindi. Residential areas in Islamabad are generally placed on the relatively high ground level and surrounded by extensive green spaces, which might function as retention ponds or buffers from flood water. Nevertheless, the localized flood inundation still occurs in the low-lying areas along the tributaries of Lai Nullah such as Saidpur Kas and Tenawali Kas in I-Block areas in Islamabad. The community called “Kachi Abadi” in particular, who live in the right-of-way of the tributaries, is exposed to the frequent flood inundation.

2.5.2 Flood Discharges

The flood marks at Gawal Mandi Bridge have been recorded by TMA for these 13 years, although the records do not contain the dates of their occurrences. Table R 2.5.2 gives the maximum water levels and their corresponding discharges estimated from the water level-discharge relationship by the non-uniform flow calculation in Section 2.3. Among others, however, the discharge of the flood in 2001 (2,560 m^3/s) was estimated through the flood simulation model instead of the water level-discharge relationship due to the massive volume of flood inundation. This discharge thus estimated is subject to an assumption that all the floodwater had been confined in the river.

Table R 2.5.2 Observed Max. Water Levels and Estimated Discharges at Gawal Mandi Bridge

Year	Maximum Water Level		Discharge (m^3/s)
	(ft)	(m)	
1966	25	494.02	450
1970	30	495.54	700
1972	26	494.32	500
1976	25	494.02	450
1977	30	495.54	700
1978	25	494.02	450
1981	29	495.24	650
1982	32	496.15	850
1994	31	495.85	770
1995	26	494.32	500
1996	20	492.50	270
2001	41	498.90	2,560*
2002	22	493.10	320

Note: * by the flood simulation model confining flood water in the river (refer to Chapter 5).

2.5.3 2001 Flood

The flood in 2001 would be the largest among the recorded floods. On 23 July 2001, the rainfall depth was recorded at 620 mm in 10 hours from 0600 to 1600 hours (in Pakistan Standard Time) at the Islamabad Station. The water level of Lai Nullah and its tributaries remarkably rose and all houses and some road bridges along them were swept away.

Heavy rainfall in this South Asian region is generally associated with monsoon depressions formed over Bay of Bengal during summer. The rainfall experienced in the flood in 2001 is, however, exceptionally not associated with any depression. According to PMD, the rainfall was caused by a freak combination of disastrous weather events including: (a) intense heating on the surface, (b) presence of mid latitude westerly trough and (c) moisture feeding through monsoon flow along Himalayas.

A meso-scale rainfall was firstly developed a day before about 50 km north of Islamabad producing more than 200 mm around the origin during the night. It moved in south and southeast direction. In Islamabad, rain started at 0600 hours and attained peak intensity at 1200 hours lasting till 1600 hours. The intensity as well as amount of rainfall was more in Islamabad than in Rawalpindi. The swollen flow of Lai Nullah invaded Rawalpindi causing several times more damages than Islamabad. Loss of 74 human lives has been reported in this disaster.

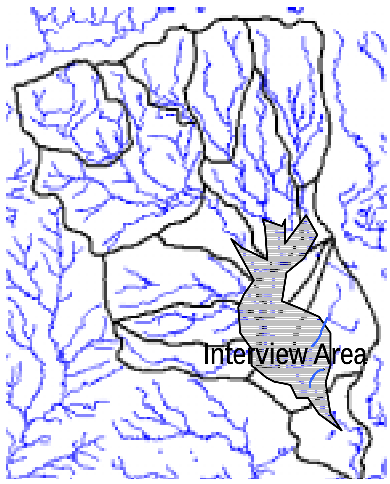


Fig. R 2.5.1 Interview Area

Interviews were conducted between September and October 2002 at 500 points in Rawalpindi and Islamabad, to clarify the conditions of the 2001 flood in particular that people still remember well.

The 500 interview points spread over the low-lying areas and their surroundings along Lai Nullah and the tributaries that were specified in advance through a preliminary study on topography, interviews to officials concerned and site-inspections. The results of interview survey results are summarized as below:

1) Inundation Depth, Duration and Causes

The results of interview on the 2001 flood are plotted on three maps in Fig. 2.5.1. The first map indicates the maximum inundation depths, the second the duration of the inundation, and the third the causes of the flood inundation that the interviewees believed. The maximum inundation depths are as deep as 4 m or over in the low-lying areas along Lai Nullah and the tributaries, where the inundation duration is also as long as 6 hours or over. As for the causes of the flood damage, the overflow of Lai Nullah was raised by more interviewees, followed by the overflow of the tributaries and the combination of the overflow of Lai Nullah and the local rainfall. In some low-lying spots, the local rainfall was also raised as one of the principal causes of the flood.

2) Evacuation Activities

Out of the 500 interviewees, 152 interviewees evacuated somewhere during the 2001. Most of the evacuation places were the rooftops of their houses followed by the neighbors' houses. It is noted that almost none of evacuees was given any advice on the evacuation by the administrations but they acted by themselves. In addition, about 130 interviewees answered that the flood was too fast to allow them to evacuate.

3) Request on Flood Mitigation and Environment Measures

Fig. R 2.5.2 shows requests from the interviewees for the future flood mitigation and environmental improvement. As shown in the figure., the garbage control and river improvement are more prefered by them. Flood Forecasting and Warning System is also desired by nealy half of the interviewees. Not a few interviewees mentioned flood diversion of Lai Nullah in the upper reaches as a conceivable flood mitigation measure that was not included in the questionnaire list.

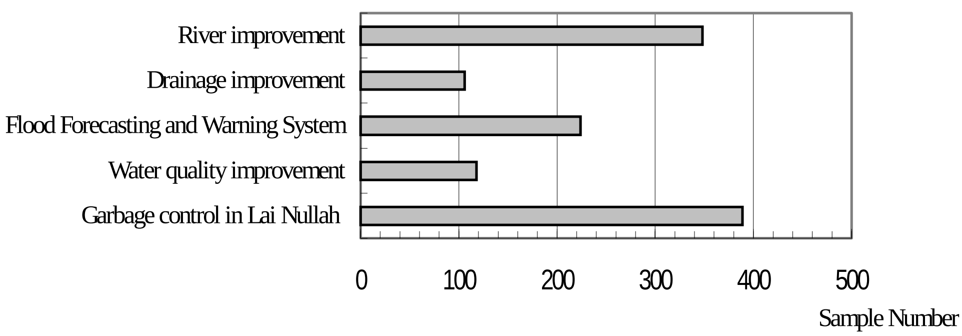


Fig. R 2.5.2 Requests from Interviewees

CHAPTER 3. SOCIO-ECONOMIC CONDITIONS OF THE STUDY AREA

3.1 SOCIAL CONDITIONS

3.1.1 Administrative Boundary of the Study Area

The Study Area extends over three (3) jurisdiction/administration units of Islamabad, Rawalpindi and Cantonment positioning on the northern most edge of the tract known as Potohar plateau in the range of about 22 km long and 19 km wide.

1) Islamabad

Islamabad is a new Capital City for Pakistan, which was finally decided in late 1950's and started the construction in 1961 based on the Master Plan of a Greek consultant, Konstantinos Doxiadis. CDA (Capital Development Authority) is the implementing agency for the new Capital administered under direct jurisdiction of the Federal Government. After two years of the construction start, Islamabad started its functions as the Capital in 1963. The construction itself is still on-going to develop mainly in the Western direction.

According to the Master Plan, the large area of Islamabad was divided into five zones, of which Zone 1 is urban area. Some part of Zone 2 will be urbanized in the future. Zone 3 basically consists of the forest in the North and a National Pak in the South, including some residential areas in the vicinity with Zone 1. Zone 4 and 5 are sparsely populated and basically rural areas (refer to Fig. 3.1.1). Accordingly, the urban area will be developed up to C-16, namely from I-8 and H-8 to 16, G-6, F-6 to 16, E-7 to 16, D-10 to 16 and C-13 to 16. Now the development has been almost completed around E-11, F-11, G-9 and H-10. But there are some spots left vacant without any buildings, meaning that there are no concrete plans to development. CDA is to implement the areas according the demand from public and private sectors. The area size of each Zone is given in the table below. The total area is 910.6 km^2, which is more than tree times of the Study Area.

Table R 3.1.1 Zones of Islamabad

Zone	Area (acre)	Area (km^2)
1	54,958.26	222.4
2	9,804.92	39.7
3	50,393.01	203.9
4	69,814.35	282.5
5	39,029.46	158.0
Total	225,000.00	910.6

Source: Master Plan of Islamabad

2) Rawalpindi

In Rawalpindi area a mixed land use is predominant in the central areas of the City. There is no segregation of compatible land uses, which have not been related to overall transportation system, thereby creating congestion, chaotic traffic hazards environmental problems. The concentration of the commercial activity and its linear growth has created complex problems, such as inadequate parking places, poor accessibility due to encroachments on roads/foot paths and presence vendors/hawkers. The areas between the main streets, forming pockets, are filled with residential use.

Rawalpindi is defined, in a narrow sense, as the jurisdiction area of RDA, which is sandwiched by those of CDA and RCB. The whole jurisdiction area of RDA and RCB could be also called as Rawalpindi. Moreover, the jurisdiction area of TMA, which is far larger than those of RDA and RCB, is again called as Rawalpindi. The administrative boundaries of the areas of RDA, RCB and TMA are as shown in Fig.3.1.2. In this Study, the first definition is used in most cases, if otherwise defined.

3) Cantonment

Cantonment is a part of Rawalpindi and it is called as “Rawalpindi Cantonment”, because there are many cantonments in Pakistan. Most of the administration for the area is ruled by the RCB (Rawalpindi Cantonment Board). The area is characterized not only by the general headquarter of the Pakistan Army and its relevant offices but also by many Government offices, residential and commercial area. The Cantonment area is in the southern side of Murree Road and main railway track, connecting the City with Lahore and Karachi. The other physical barrier between the Municipal and Cantonment areas is complex and intermixed at some locations. The industrial area of the City is situated in Western ridge and near Kohinoor Textile Mills along with Peshawar Road. The best residential area of the Cantonment is also located in this area. The largest owners of the lands are private with 63.2%, which is followed by Armed Forces with 16.8% as listed in Table R 3.1.2. The remaining owners have only small shares of less than 5%. The land values are widely different in a range of about five times, reflecting the localities, specialties or traditional values.

Table R 3.1.2 Land Ownership

Sr.Nr.	Ownership	Area (in Acre)	Area (km^2)	Percentage
1	Central Government	971	3.93	4.10
2	Provincial Government	1,056	4.27	4.46
3	Armed Forces	3,986	16.13	16.83
4	Cantonment Board	959	3.88	4.05.
5	Pakistan Railways	817	3.31	3.45
6	Airport	933	3.78	3.94
7	Private	14,965	60.56	63.17
	Total:	23,687	95.86	100.00

3.1.2 Land Use

The present and the future land use maps were prepared applying the following seven (7) categories of the land use.

(1) Agricultural area: to be used for agricultural purposes

(2) Residential area/densely populated: like the congested area in Rawalpindi

(3) Residential area/moderately populated: like the planned area in Islamabad

(4) Residential area/suburbs: like ones located in the suburbs, or village centers.

(5) Forest area

(6) Green area and bare land

(7) Water body

The present land use map as of 2001 was produced based on the Landsat image taken in 2001. The future land use maps in 2012 and 2030 are based on the Urban Master Plan 2030 by the relevant government agencies and the population projected in the Study (refer to the under-mentioned subsection 3.1.2). The land use maps thus prepared are as shown in Figs. 3.1.3 to 3.1.5, which are summarized as shown in Table R 3.1.3.

Table R 3.1.3 Summary of the Land Use

Land Use	Present (2001)		2012		2030	
	(km^2)	(%)	(km^2)	(%)	(km^2)	(%)
Agricultural Area	33.4	14.2	29.1	12.4	11.4	4.9
Residential Area/ Densely Populated	31.2	13.3	35.2	15.0	38.8	16.5
Residential Area/ Moderately Populated	53.3	22.7	68.6	29.2	95.2	40.5
Residential Area in the Suburbs	6.1	2.6	5.6	2.4	2.3	1.0
Forest	34.9	14.8	32.3	13.8	32.0	13.6
Green and Bare Land	74.3	31.6	62.4	26.6	53.5	22.8
Water Body	1.6	0.7	1.6	0.7	1.6	0.7
Total	234.8	100.0	234.8	100.0	234.8	100.0

Source: JICA Study Team 2002

As listed above, it is clear that residential areas will increase in the future, while agricultural area and green/bare land decrease. The forest area will also slightly decrease to provide more residential areas, as the population increases.

As the development of the study area continues, the land use pattern will change to adjust it and accommodate the population increase. The moderately populated residential area of Islamabad will increase from 53.3 km^2 in 2001 to 68.6 km^2 in 2012 and reach 95.2 km^2 in 2030. The densely populated residential area, most of which is located in Rawalpindi, will also increase from 31.2 km^2 in 2001 to 35.2 km^2 in 2012 and 38.8 km^2 in 2030, respectively. These incremental rates are not lager than those of the moderately populated residential area, which could explain that the population density in Rawalpindi have reached the maximum level, and there will be almost no room to take in new residents.

In order to compensate the increase of the residential area, the green and bare land will decrease from 74.3 km^2 in 2001 to 62.4 km^2 in 2012and 53.5 km^2 in 2030, respectively. Likewise, the agricultural area will decrease from 33.4 km in 2001 to 29.1 km^2 in 2012and 11.4 km^2 in 2030, respectively.

3.1.3 Population

The population for the study area is clarified based on the census and other relevant data/information as described hereinafter:

1) Present Population in the Concerned Administrative Units

As shown in the present population in the concerned administrative listed on Table R 3.1.4, the present population density of Islamabad City is 2,383 persons per km^2, while those of Rawalpindi City and Cantonment Area are 27,436 and 8,636, respectively. If the population density of Islamabad is assumed at 1, that of Cantonment Area is 3.6 times more than that of Islamabad. Under the same assumption, the population density of Rawalpindi City is 11.5 times more than that of Islamabad City.

Table R 3.1.4 Population of the Concerned Governing Bodies as of 1998

Area	Population	Area (km^2)	Density (person/km^2)
1. Islamabad District*4	805,235	906	889
(1) Islamabad City	529,180	222*1	2,383
(2) Islamabad Rural	276,055	684	404
2. Rawalpindi District	3,364,000	5,286	636
(1) Tehsil Rawalpindi	1,409,768	686*2	2,055
(2) Rawalpindi City	781,927	28.5*3	27,436
(3) Cantonment Area	627,841	72.7*3	8,636

Source : Provincial Census Report of Punjab, 1998, District Census Report of Islamabad, 1998 and District Census Report of Rawalpindi, 1998

Note*1 : The land area for urban part of Islamabad is defined herein as Zone 1 of the Master Plan of Islamabad, while, the area for the rural corresponds to the rest of the area of Islamabad Capital District.

Note*2 : Initial enumeration by JICA study team

Note*3 : Measured by GIS software

Note*4 : The term ‘Islamabad District’ is identical to ‘Islamabad Tehsil’, under which the urban area is called as Islamabad City

2) Present Population within the Study Area

The Study Area is demarcated by natural settings of the Lai Nullah watershed; therefore, the boundary of the Area does not correspond to administrative division. The Table below shows the estimated present population within the Study Area.

Table R 3.1.5 Estimated Present Population within the Study Area

Area	Population	Households	Area (km²)	Density (/km²)		Average Household Size
				Population	Households	
Islamabad City	432,678	72,086	161.3	2,682	446.9	6.0
Zone 1 (urban)	432,678	72,086	74.0	5,847	974.1	6.0
Rawalpindi City	724,311*1	107,219*1	26.4	27,436	4,061	6.8
Cantonment Area	407,622*1	62,770*1	47.2*2	8,636	1,330	6.5
Total	1,564,611	242,075	234.9	6,661	1,031	6.5

Note *1 : The population of Islamabad in the following areas was excluded from the population of the Study Area:. C-16, D-15, D-16, E-14, E-16, F-5, G-6(ExG-6/2), I-15, I-16, Mochi Mphra, Noorpur Shahan, Ojhri Khud & Kalan, Poona Faqiran, Qauid-E-Azam Univ., Rawal Town

*2 : Approximate population in the Study Area is enumerated by proportional distribution to the land area.

*3 : The Cantonment Area includes a small strip of land, 2.1km^2 administered by TMA.

3) Population Growth and Projection

The national population growth until the year 2030 was firstly project by assessing the past patterns of growth and extrapolating the recent trends as: (a) 2.60% up to 2002, (b) 2.50% for 2003-2015 and (c) 2.40% for 2016-2030. Based on this projection, the population for the Study Area is projected under assumptions that national level growth rate corresponds to natural birthrate and, therefore, gaps between the growth rate at the national level and that of respective administrative division, Islamabad City, Rawalpindi City and Rawalpindi Cantonment Area, are proportional either to social inflow or outflow of population. Other major assumptions are presented below.

(a) Islamabad City : Population growth rate converges with the projected national growth rate in the year 2030.

(b) Rawalpindi City : Outflow of migrants begins from the year 2015.

(c) Rawalpindi Cantonment : Social inflow and outflow of population would balance until the year 2030 with a growth rate converging with that of the national average.

Historically the population density, which allows a human-like living standard, is said to be about 20,000 persons per km^2 at maximum. That of Rawalpindi City has reached the level (27,346 at present). Most likely the population pressure would work emigration from the area to Islamabad Cit and Cantonment. Therefore the table below, showing rather mathematical figures, presents the summary of the projection.

Table R 3.1.6 Summary of Population Projection within the Study Area

Jurisdiction Area	Population (persons)			Population Density (p/km²)		Household Density (p/km²)	
	1998	2012	2030	2012	2030	2012	2030
Islamabad City	432,678	715,151	1,020,697	4,434	6,328	739	1,055
Rawalpindi City	724,311	1,111,802	1,496,339	42,114	56,680	6,230	8,385
Cantonment Area	407,622	676,354	979,562	14,330	20,753	2,208	3,198
Total	1,564,611	2,503,307	3,496,598	10,657	14,885	1,650	2,304

3.2 SOCIO-ECONOMIC CONDITIONS

3.2.1 Twin City in Sub-regional Economy

The Twin City of Islamabad and Rawalpindi constitutes a vital nodal point of emerging east-west economic corridor of the country connecting Peshawar and Lahore and further extending to Kabul in Afganistan on the west and to New Dehli in Inida on the east through the Asian Highway. The corridor extends to the south forming a north-south economic corridor from Lahore, the landlocked Punjab capital, to the country's international port in Karachi. The nodal point of the Twin City is further connected toward the north with Xinjiang province in China running through northern areas by the new all-weather road of the Karakoram Highway. The city of Rawalpindi is, in addition, connected to Trans-Asian Railway in the southern corridor of Asia-Europe Routes, which is expected to contribute to development of the subregional economy through improving industrial and commercial efficiency and export competitiveness.

Although about 80% of Pakistan's economic activity and population currently live within 50 to 100 km of the 1,700 km north-south corridor linking Lahore to Karachi[4], the Twin City is becoming strategically important in terms of pivotal and catalytic role in promoting sub-regional economic development and reducing poverty in the sub-region through emerging trade opportunity with neighboring counties and increasing presence in the domestic business development.

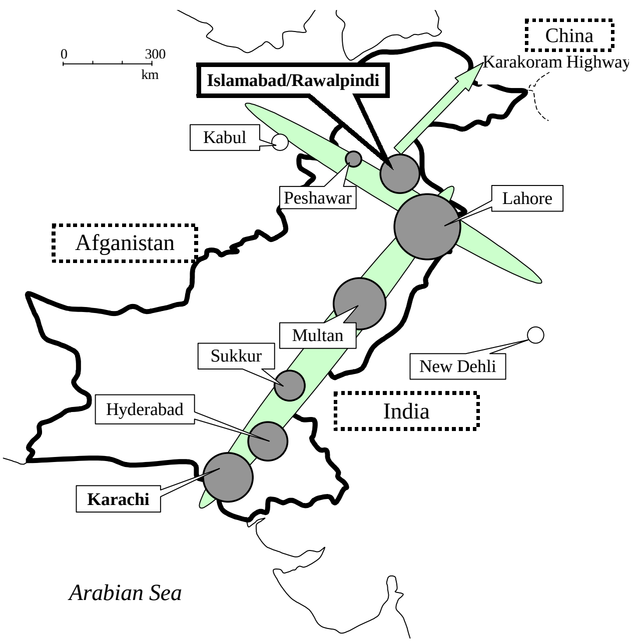


Fig. R 3.2.1 Strategic Position of the Study Area

Table R 3.2.1 compares population size, and hence size of potential market, of the major administrative bodies lying along the corridors. Social increment of population indicates polarized urbanization of Karachi, the south most metropolitan with an international port and the cities in emerging east-west corridor.

Among the cities, Islamabad has achieved the highest population growth rate in the last decade. With 2.5% annual growth rate, the population would be doubled within three decades. The population has slightly increased in other cities along the east-west corridor except Rawalpindi.

[4] Project Information Document: Pakistan-Pakistan Railways Privatization Project, World Bank

Although Karachi has undergone slight increase in the last decade, other cities along the north-south corridor such as Multan, Hyderabad and Sukkur have been subject to slightly declining population in contrast with cities along the east-west corridor.

The said bipolar urbanization may have been resulted from migration of population from rural area as well as other urban part of the country seeking for new economic opportunity created in the last decade.

Table R 3.2.1 Demographic Data of the Major Bodies lying along the Corridors

Corridor	Division	Households	Population in 1998	Social Increment per annum from 1981 to 1998
East-West Corridor	Islamabad	128,753	805,000	2.5%
	Rawalpindi	1,065,486	6,659,528	-0.4%
	Peshawar	474,634	3,915,855	0.5%
	Lahore	2,010,471	14,248,641	0.3%
North-South Corridor	Karachi	1,457,096	9,856,318	0.9%
	Multan	1,655,474	11,577,431	-0.1%
	Hyderabad	1,212,859	6,829,537	-0.4%
	Sukkur	936,756	5,584,613	-0.3%

Source: Economic Survey 2001-2002, Finance Division

Due to geographical advantage in proximity to the border with Afghanistan, the Twin City is expected to contribute to enhancing economic development of landlocked Afghanistan through border trade, though comprehensive statistical data on border trade is currently considerably limited.

3.2.2 Economic Structure of the Study Area

Islamabad is the core of the politics and public administration of the country with emerging private sector. Comprising five zones including the diplomatic enclave, the commercial district, the educational sector and the industrial area, the city of Islamabad has evolved into an urbanized modern city with development history of 40 years, which is spacious and carefully planned with tree-lined streets, large houses, elegant public buildings and well organized bazaars.

Rawalpindi, on the other hand, has rather versatile dimensions consisting of thriving commercial operation in the city and military base in the Cantonment. The city has undergone sprawling peripheral expansion with basic infrastructure facilities concentrated in and around a few big urban centers. Traffic system of the city was originally designed to accommodate animal drawn vehicles and pedestrians, which resulted in prevalent over-crowding and choking bottleneck of city roads.

1) Employment and Structure of the Economy

Reflecting region's structure of the economy, occupational structure differs between two cities. In Islamabad, high paying professionals predominate Islamabad's residents including professionals in science, education, technicians and associated professionals, those of which are mostly paid by public sector as presented below. It is noteworthy that there are poor people in Islamabad with subsistence level of income. They live in low-lying flood prone area of the Lai Nullah, generally referred to as Kachi Abadi, with poor infrastructure accessibility. This will be further described in the succeeding part of the report.

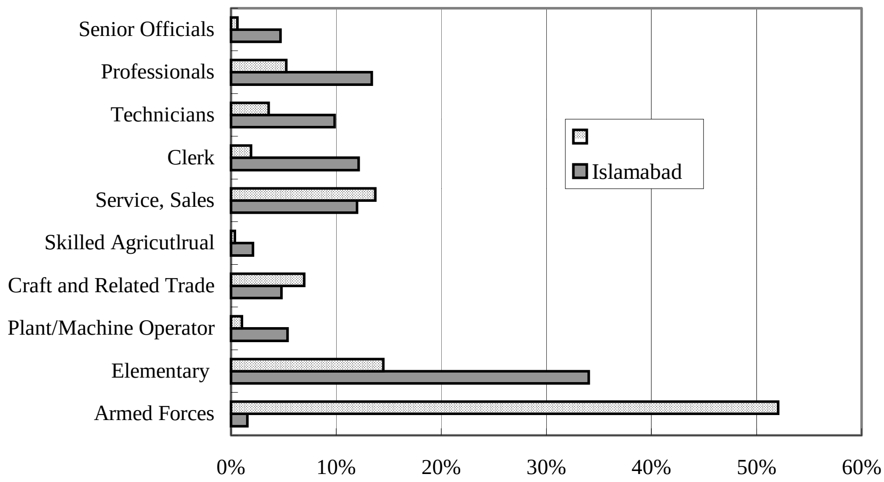


Fig. R 3.2.2 Comparison of Occupational Group
Source: District Census Report of Islamabad/Rawalpindi 1998

In Rawalpindi, more than 50 % of the employed rely on various occupations within the armed force of Cantonment. The rest of the occupation includes service workers and market sales agents and other elementary occupation.

In addition to the people holding Pakistnni's nationality, there are a large number of refugees living in a large camp locating in the western part of Islamabad. Detailed statistic on refugee is not available, though statistics of UNHCR indicated that total population in the country has risen from 1.2 million to 2 million in the year 2001.

a) Public Sector

Being the core of the politics and public administration of the country, more than a half of the employed population in Islamabad serves as governmental officers of the federal bodies as well as CDA. Contribution of public sector to employment opportunity in Rawalpindi is more accentuated in contrast with Islamabad due to presence of the armed force, which provides various positions to military officers as well as civilian bureaucrats contributing more than 50% of the total employment.

Table R 3.2.2 Total employed Population in Urban Area

District	Sector	Employed Population in the Urban Area	
Islamabad	Public Sector	61,656	54%
	Private Sector	52,326	46%
	Self Employed	20,799	18%
	Total	113,982	100%
Rawalpindi	Public Sector	250,594	64%
	Private Sector	141,441	36%
	Self Employed	90,089	23%
	Total	392,035	100%

Source: District Census Report Islamabad / Rawalpindi 1998

Note: Public sector includes government employee and autonomous body employee. Unpaid family helper was excluded from the statistics.

b) Private Sector

Endowed with geographical advantage in commercial and industrial activity, the economy of the Twin City is bolstered with a large number of small and medium size enterprises dealing with a wide range of products including household chores, utensils, foods and furniture.

In Islamabad, private sector has emerged providing employment opportunity to 52,326 people including employees at private establishments and those of self employment, while robust business entities operating in Rawalpindi provide 141,441 people.

The Cantonment of Rawalpindi is also dominated with small and medium enterprises accompanied by industries including petroleum refinery, an ordnance factory, an arsenal factory, engineering workshops, a steel-rolling mill, gasworks, and a brewery.

2) Small and Medium Enterprises (SME)

An enterprise with total assets of up to Rs. 20 million is defined as a small enterprise, while that exceeding Rs.20 million up to Rs.100 million is defined as a medium enterprise in the country. Most of the business entities operating within the Study Area are deemed categorized either small or medium size enterprise.

Number of enterprises operating within the Study Area was estimated assuming a homogeneous land use pattern within the Study Area. Total number of enterprises within the Study Area is estimated to be nearly 620,000.

Table R 3.2.3 Estimated Number of Enterprises within the Study Area

Enterprise	Number of enterprises
Commercial operation	600,000
Industrial Operation	20,000
Total	620,000

Source: JICA Study Team 2002

As presented in the table above, total number of employees in the private sector amounts to nearly 200,000, which therefore indicates merely three employees at one enterprise reflecting presence of a large proportion of small-scale enterprises.

Due to non-availability of concrete data on the SME sector such as financial statements and accounts, financial appraisals of SMEs become an arduous task for the formal lending organizations and banks and thus SMEs have always been termed as non-bankable and risky. The unavailability of the financial statement of SMEs constrains sector's further development and, in the flood in 2001, limited capability to cope with risks of the business, due to inaccessibility to formal financial market.

3) Dimensions of Poorer Segment

a) Wage Laborer in Urban Sector

Wages of urban construction workers in the cities along the East-West economic axis increase have grown in a similar pattern in contrast with those in other cities such as Karachi and Quetta. This may indicate possible migration of labors among the cities lying along the East-West axis and resultant equilibrium of wage labor market. Wages is highest in Lahore among the cities along the East-West Axis, which generally seems to decline towards the west to Islamabad, 82%, and Peshawar, 58% of Lahore.

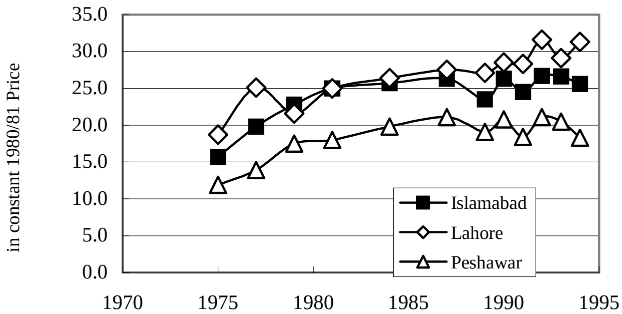


Fig. 3.2.3 Wages of unskilled Urban Construction Workers
Source: Federal Bureau of Statistics Monthly Bulletins, Economic Survey for construction workers wage data

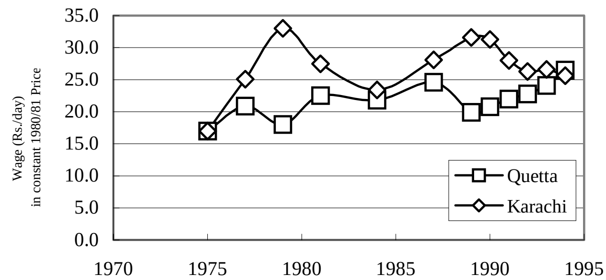


Fig. 3.2.4 Wages of unskilled Urban Construction Workers
Source: Federal Bureau of Statistics Monthly Bulletins, Economic Survey for construction workers wage data

b) Dimensions of Women

There is a significant gender gap in labor participation rate. Number of female employed in private sector is lower particularly in Rawalpindi where it is frequently referred as a city of conservative Muslim culture. Domestic works are the major form of employment for poor female in the area. In some cases, however, domestic work provides a substantial income, and pays better wages than professional work or casual work done by males. Women domestic workers in Dhok Naddi, Rawalpindi make Rs. 600 to 1,000 per month, while unskilled male casual workers make Rs. 700 to 1,000. But men are only guaranteed regular work at this rate during the peak summer season.

Table R 3.2.4 Gender Comparison of Labor Market

District	Sector	Male	Female	Female/Male (%)
Islamabad	Public Sector	54,438	7,218	13%
	Private Sector	48,485	3,841	8%
	Self Employed	19,895	904	5%
	Total	102,923	11,059	11%
Rawalpindi	Public Sector	241,496	9,098	4%
	Private Sector	138,835	2,606	2%
	Self Employed	89,758	331	0%
	Total	380,331	11,704	3%

Source: District Census Report Islamabad / Rawalpindi 1998
Note: Public sector includes government employee and autonomous body employee. Unpaid family helper was excluded from the statistics.

c) Kachi Abadi and Encroachment

In the city of Islamabad, several communities are extensively developed within the existing right-of-way of the river, which are seemingly poorer settlers than the rest of the communities. The term “encroachment” herein is defined as the settlements that are referred to as “Kachi Abadi” in Urudu with the meaning of non-brick housing units.

Reported population living in Kachi Abadi in Islamabad corresponds to nearly 3 % of the total population of the city. Kachi Abadis are dispersedly present in the certain sectors of Islamabad city including the sectors of E-9, F-6, F-7, G-7 and G-8. There are other Kachi Abadis that are not recorded in the statistics, which include, for instance, those in I-9 section of the city. The combined figure of the total population in Islamabad’s Kachi Abadi is roughly estimated to be 7 % of the total population. A structured interview survey conducted during the Fist Field Study Period covering 160 households in Islamabad and Rawalpindi indicated more than double dense population in Kachi Abadi with larger average family size in smaller residential plot.

Table R 3.2.5 Population and Number of Household residing in Kachi Abadi in Islamabad

Area	Population	Number of Houses	Average Household Size
Islamabad city total	529,180	86,575	6.1
Kachi Abadi Total in Islamabad city	17,263	2,689	6.4

Source: District Census Report of Islamabad, 1998

The statistical definition of Kachi Abadi of housing unit is non-brick structure, however, there are variations in housing structure among residents in Kachi Abadi including low quality brick structures as well as those with/without stone floor. Those of stone floored structure constitutes 55% of the total Kachi Abadi, while corresponding value for Islamabad city and rural Islamabad is 89% and 86% respectively. Structure without floor still remain about 32 % of the total Kachi Abadis. In terms of structure, the area of Kachi Abdi is less developed than the rural part of Islamabad. On the other hand, accessibility to potable water is higher than the rural part of Islamabad due to availability of hand pumps or community tap water installed by CDA.

Table R 3.2.6 Structure and Housing Facility

Study Area	Floored structure	Structure with semi- earth floor	Structure with earth floor	Potable water	Electricity
Islamabad city	89%	5%	6%	75%	91%
Rural Islamabad	86%	7%	7%	21%	92%
Kachi Abadi Total in Islamabad city	55%	13%	32%	62%	84%

Source: District Census Report of Islamabad, 1998
Note: Floored structure, structure with semi-earth floor and structure with earth floor corresponds to PACCA, Semi-PACCA and KACHA respectively in Urudu.

The dweller of Kachi Abadi is predominantly non-Muslim people with lower literacy rate. They include Protestant as well as Catholic Christians, overwhelmingly minority groups in the Islamic society, while there are some Muslim communities of Kachi Abadi including those in I-9.

Table R 3.2.7 Literacy Rate and Religion

Study Area	Literacy Rate (%)	Religion	
		Muslim	Others
Islamabad city	77%	94%	6%
Rural Islamabad	63%	99%	1%
Kachi Abadi Total in Islamabad city	45%	8%	92%

Source: District Census Report of Islamabad, 1998

4) Development of Kachi Abadi in Islamabad and Present Livelihood

There are many reasons why the poor encroach upon the publicly owned right-of-way. The settlement in Islamabad began with the inception of development of Islamabad, which was initiated nearly 40 years back when the Government decided to move the Capital to Islamabad. During the early period of Islamabad development, a large number of construction workers were recruited from nearby cities and villages including Faisalabad and Lahore.

Although dynamic demographical data of Islamabad is unavailable, an informant of Kachi Abadi dweller in G-7/2, a former sharecropper in a small village of Faisalabad, revealed that he came to Islamabad as a construction worker nearly 35 years ago when the construction of the city was still under its initial stage. His nephew also settled in, thereafter, at the age of fifteen and started working as an officer in the lower echelons of the government. He found the position through his aunt who was working as a maid at a wealthy household of a high official. The sources of income in the area varies from sweepers of offices, hospitals, housekeepers of wealthy Islamabad residents to unskilled laboring on a daily wage basis, all of which are low paying job without secure terms of employment. The family of the said informant subsists on or below the international poverty line with total estimated daily expenditure nearly equal to US$ 1.0/capita[5].

3.3 ORGANIZATION SETUP FOR MANAGEMENT OF LAI NULLAH

The management and/or administration of Lai Nullah is currently undertaken by the following six (6) organizations (1) Federal Flood Commission (FFC), (2) Capital Development Authority (CDA), (3) Small Dam Organization (SDA), (4) Rawalpindi Development Authority (RDA), (5) Tehsil Municipal Authority (TMA) in Rawalpindi and (6) Rawalpindi Cantonment Board (RCB). The functions and role of these organizations are as described hereinafter:

3.3.1 Federal Flood Commission (FFC)

Up to the end of 1976, Provincial Irrigation and Power Departments were responsible for the planning and execution of flood protection works. Upon occurrence of the disastrous flood in the country in the year 1973 and 1976, which caused heavy losses of life and infrastructures, it was recognized that the flood protection facilities were inadequate to provide effective measures for the country. This resulted in the creation of Federal Flood Commission in January 1977 (refer to Fig. 3.3.1). The major responsibilities and duties assigned to FFC are:

(1) Preparation of National Flood Protection Plan (NFPP);

(2) Approval of provincial flood mitigation schemes;

(3) Reviews of plans for restoration and reconstruction works;

(4) Measures for improvements in the flood forecasting and warning system;

(5) Evaluation and monitoring of the progress of implementation of National Flood Protection Plan, and;

(6) Preparation of research program for flood mitigation and other flood management measures.

Since its creation, FFC has coordinated implementation of flood works over Rs. 10 billion under a number of programs (i.e. Normal ADP, FPSP-I, 1988 FDRP, FPSP-II, etc.) financed by Government of Pakistan and various donor agencies.

Regarding Lai Nullah development projects, ECNEC in its meeting held on 30th May, 1984 decided to set up a Technical Committee under the Chairmanship of the Secretary Water and Power, Chairman WAPDA, Chairman CDA, representative of Punjab Irrigation and Power

[5] The family with eight members monthly spends Rp.10,000, which is equivalent to daily expenditure of US$ 0.73/capita. The ownership of the residence that resides in CDA rents the unit at free charge, therefore, it can be regarded as income transfer from the public sector to the poor household with estimated market value of US$ 0.29 /capita/day. The family subsists on or below the international poverty line with total estimated daily expenditure nearly equal to US$ 1.0/capita.

Department and Chief Water, Planning Commission to go into the technical issues raised and come up with an agreed plan on the flood mitigation measures of Lain Nullah. Later on, the Technical Committee held several meetings regarding the issues. In the Technical Committee meeting held on August 20, 1985, a sub committee chaired by CEA/CFFC had been appointed to supervise the feasibility study for the Pacca Canalization of Lai Nullah and furthermore, National Economic Council decides that Federal Flood Commission may act as lead agency for the project.

Keeping in view the above recommendations and the flood passed in July 2001, FFC feels very seriously necessity of strengthening of coordination among the responsible agencies like CDA, RDA, and RCB regarding Lai Nullah management. As a part of institutional strengthening Chairman FFC has decided to constitute a steering committee to supervise the future development and management works of Lai Nullah. After getting the approval from Ministry of Water and Power, Steering Committee has been constituted for the stakeholders of Lai Nullah vide office No. FC-I(5)34-2001-XIX dated October 10, 2001 with the following setup.

Table R 3.3.1 Members of Steering Committee for Development and Management of Lai Nullah

Agencies Concerned/Person in Charge	Role of Steering Committee
CEA/CFFC	Chairman
Chief Engineer (DSC) / Floods	Member / Secretary
Member of Eng. Directorate, GHQ, Rawalpindi	Member
Representative of 10 Corps	Member
Representative from CDA, RDA, TMA & PID	Member

3.3.2 Capital Development Authority (CDA)

Capital Development Authority (CDA) was constituted on 14th June 1960 under CDA act, as a corporate body for the purpose of planning development and construction of the Federal Capital of Pakistan. The Authority shall prepare a master plan and the phased master program for the development of the Capital sites and may prepare a similar plan and program for the rest of the specified areas and all such plans and programs shall be submitted to the Central Government for approval. The authority may, pursuant to the master plan and master program, call upon any local body or agency operating in the specified areas to prepare, in consultation with the Authority, a scheme or schemes in respect of matters ordinarily dealt with by such local body or agency and there upon the local body or agency shall be responsible for the preparation of the scheme or schemes with a reasonable time. Such Schemes may relate to, land use, zoning and land reservation, public buildings, industry, transportation, communications, highways, roads, streets, railways, aerodromes and tele-communications. The organization chart showing the major staffing setup is shown in Fig. 3.3.2.

During July, 2001 exceptionally high rain took place and due to very heavy storm Lai Nullah channel overflowed and inundated in I – 9 Sector of Islamabad along the I.J principle road. After the severe damages took place during July 2001, CDA was forced to realize the importance of operational plan to fight against the expected rainwater storm in future. For this purpose a meeting was held on July 1st, 2002 under the chairmanship of Chairman CDA and operational plan was discussed in detail how to face the expected flood in future. After the meeting a notification was issued for this purpose, vide No. CDA/DS-2(2)/2002/38 Dated July 9, 2002. According to the operational plan Chairman informed in the meeting that un-precedent rain in the last year and above average rain predicted for the coming monsoon in 2002 necessitates the preemptive measures to ensure against damage to life and infrastructures. The meeting also discussed the last year's experience and the actions that could be taken to avoid repetition of the situation. Chairman also designated the Director Sanitation as the focal person / co-coordinator on behalf of CDA for the arrangements to pass the storm water safely from Capital city. It is true that CDA has realized the importance of storm water but according to the office of Director Sanitation that no budget was allocated additionally for this purpose. Director Sanitation has made all the arrangements by his existing staff and from his normal budget.

3.3.3 Small Dam Organization (SDO)

SDO is the subordinate office of the PID, presently responsible for the operation and maintenance of Rawal Dam. After the dissolution of West Pakistan Agricultural Development Corporation in January 1972, SDO was established by the Central Government but finally it was decided to entrust its functions to respective provinces from February 1st, 1973. This office has the vast experience for flood mitigation projects for the rivers and hill torrents and construction of small dams throughout the Punjab Province and especially in Potohar Platuo around Islamabad. About 31 small dams have already been constructed by the organization in Pothohar area during last thirty years and operation and maintenance for all of those constructed dams is also being done by SDO office very successfully. The existing organization setup is as shown in Fig. 3.3.3.

After the exceptionally high flood passed from Lai Nullah during July 2001, Secretary of the PID has been asked by the Army Head Quarter Rawalpindi to give the technical opinion for the management of Lai Nullah to avoid future damages. The secretary has given a briefing at the core commander office at Rawalpindi on 2nd of August 2001. The secretary has explained that PID through its subordinate office located at Islamabad (SDO), has conducted so many studies regarding flood management of Lai Nullah time to time since 1973.

3.3.4 Rawalpindi Development Authority (RDA)

Rawalpindi Development Authority (RDA) was established in 1989 (total area of jurisdiction is 311 km^2), under the Punjab Development of Cities ACT-1976. Its existing organization setup is shown at Fig. 3.3.4. The major responsibilities of RDA are, to plan, guide, control and implement major and long-term development works for the followings,

(1) To control construction of structures in its controlled areas.

(2) To launch housing schemes and other similar projects and to control private housing schemes.

(3) To execute land development and estate management.

(4) To preserve the environment.

(5) To evolve policies and plans including their implementation.

(6) To undertake provision and maintenance of water supply & sewerage services in the city.

(7) To undertake improvement, beautification, operation and maintenance of parks.

(8) To construct major roads and advertisement boards etc.

As a part of institutional strengthening, Water and Sanitation Agency (WASA) was established in 1992 as an agency of RDA to deal with the water supply and sewerage services for the areas under the control of RDA. It became partially operational after taking over the Rawal Lake Filtration Plant from Public Health Engineering Department in 1996 and further became fully operational in 1998 after taking over the charge of water supply and sewerage services from Rawalpindi Municipal Corporation (RMC).

According to the responsibilities mentioned above, it seems that RDA plays a role to deal with surface drainage or flood mitigation projects relates to Lai Nullah in the context of water supply, sewerage, land development and management within the city. A network of sewers covers the central city area bounded by Lai Nullah, Kassi Nullah and Asghar Mall road. Most of the system discharges untreated sewage to Kassi Nullah, which ultimately flows into Lai Nullah. In addition to the above, Lai Nullah is prone to occasional short period of flooding during the summer/rainy season every year and due to the tight sections, Channel overflowed and causes severe inundation during these flood events and damages to peoples living close to the banks of Lai Nullah, particularly those in Kachi Abadies.

3.3.5 TEHSIL Municipal Administration (TMA) in Rawalpindi

Keeping in view the present institutional strengthening, Punjab Government has issued new Act during the year 2001 to devolve the political power and decentralize administrative and financial authority in a manner of setup of District Tehsil and Union Administration (refer to Fig. 3.3.5). As a result of the above, Gazette Notification issued by the Government of Punjab, Rawalpindi Tehsil Municipal Administration (TMA) was also established. According to the notification it is a corporate body and consist of a Tehsil Nazim, Tehsil Municipal officer, Tehsil officer, Chief officer and other officials of the local council services, as shown in Fig.3.3.6. The Major duties assigned to TMA Rawalpindi under the new act are,

(1) To prepare spatial plans for the Tehsil in collaboration with the union councils, including plans for land use and zoning.

(2) To seek approval of the Tehsil Council to the spatial plans prepared by it after due process of dissemination and public enquiry, incorporating modifications on the basis of such enquiry.

(3) To execute and manage development plans.

(4) To exercise control over land-use, land-subdivision, land development and zoning by public and private sectors for any purpose including agriculture, industry, comers market, shopping and other employment centers, residential, recreation, park entertainment, passenger and other transport freight and transit stations.

(5) To enforce all municipal laws, rules and byelaws governing the function.

(6) To prevent encroachment.

(7) To regulate affixing of signboards and advertisements.

(8) To provide, manage, operate, maintain and improve the municipal infrastructure and services.

(9) To compile information provided by the union and village councils of prioritized projects in the Tehsils.

(10) To prepare budget, long term and annual municipal development programs in Collaboration with the union councils under the direction of Tehsil Nazim.

(11) To maintain with the assistance of District Governments, Union and village Councils, a comprehensive data base and information system for Tehsil Municipal Administration and provide public assess to it on nominal charges.

(12) To propose and notify taxes, user fee, rates, rents, tolls, charges, levies, fines, and penalties after approval of Tehsil Council.

(13) To collect approved taxes, user fee, rates rents, tolls, charges, fines and penalties.

(14) To organize sports cultural and recreational events, fair and shows.

(15) To coordinate and support municipal functions amongst unions and villages.

3.3.6 Rawalpindi Cantonment Board (RCB)

Rawalpindi city had the population about 1.4 million in 1998 of which approximately 45% reside in the Cantonment areas under the Jurisdiction of Military Engineering Services (MES) and Rawalpindi Cantonment Board (RCB), while the remaining 55% live in the jurisdiction of RDA. Organization set up shown in Fig. 3.3.7. The major charter of duties for Cantonment Board is explained as,

(1) Municipal Administration

(2) Provision of Civic Amenities i.e., water supply, sanitation, roads/streets/lanes, street lights and surface drainage

(3) Fire Fighting

(4) Taxation

(5) Building Control

(6) Land Management

(7) Horticulture

(8) Primary Education

(9) Acquiring and maintaining Cantonment Property

(10) Registration of Births and Deaths

(11) Maintaining Public Markets / Slaughter Houses/Public toilets

(12) Regulating trade and professions

(13) Enforcing pure food act

(14) Enforcing Muslim Family Laws

By the discussion and interview with the cantonment board staff, it has been observed that cantonment board does not have any kind of precautionary measures arrangement against the floodwater flowing through Lai Nullah in the jurisdiction of Rawalpindi Cantonment Board. In addition to that it has also been pointed out that there is no proposed project available at the moment and never any kind of funds have been allocated and spent for the purpose of flood mitigation measures in Lai Nullah, because the Lai Nullah channel passing within the jurisdiction of cantonment board is almost safe and there were very few complaints about the inundation of the areas and no serious damages have been recorded during flood season. After 2001 exceptionally high flood Board has been forced to think about the flood mitigation measures in future.

CHAPTER 4. ENVIRONMENTAL CONDITIONS AND PRACTICES FOR ENVIRONMENTAL IMPROVEMENT

4.1 DRAINAGE AND SEWERAGE

At present the services of drainage and sewerage systems of the study area are managed by four organizations: Capital Development Authority (CDA), Water and Sanitation Authority (WASA)/Tehsil Municipal Administration (TMA) of Rawalpindi, and Rawalpindi Cantonment Board (RCB), based on their administrative jurisdictions. The drainage system of the Study Area is shown in Fig. 4.1.1, while the sewerage system is shown in Fig. 4.1.2.

4.1.1 Drainage and Sewerage in Islamabad

Islamabad had been developed from Sector 3, located in the East with the governmental offices and foreign embassies. This area is called as Diplomatic Enclave. The urbanized areas had been gradually developed toward West. Presently almost half of the projected urban areas have been developed until around Sectors of 10/11. According to the Urban Master Plan of Islamabad, the ultimate development will reach Sectors of 16. In accordance with the progressive expansion of the urban area in Islamabad, the drainage and sewerage system were designed and set-up from East to West employing the separate system for drainage and sewerage.

1) Drainage System in Islamabad

The drainage system has been installed in the existing urbanized area in CDA step by step, and the present whole built-up areas of Islamabad are in principle served with the drainage system. The Study Team obtained that of Sector I-8 as an example, as shown in Fig. 4.1.3.

According to an officer of CDA, the drainage system of the urbanized area in Islamabad was designed on the rainfall intensity of 75mm/hr, while the actual structural sizes of the existing drainage system were evaluated in the Study to be below the designed scales. However, Islamabad is located on the gradual slope from North to South, and due to the existing drainage system together with the favorable geophysical condition, its storm rainfall could be rather well drained into Lai Nullah. In fact, Islamabad never experienced any serious/disastrous inundation by the storm rainfall flooded except in 2001 flood. The 2001 flood caused the serious river overflow from Tenawali Kas and Saidpur Kas in Sectors I-8 and I-9, but the principal reason of the overflow in 2001 could be attributed to the backwater effect from the mainstream of Lai Nullah to drainage system, but not to shortage of the drainage capacity.

2) Sewerage System in Islamabad

The sewerage system was designed, as the urban development was prepared from East to West in the same way as the above design of the drainage system. Fig. 4.1.4 shows the sewerage system with trunk sewers in Islamabad. They were designed along the rivers to intercept the wastewater generated at households, institutions or others, to convey it to the treatment plant (activated sludge process), located at Sector I-9. The operational condition of the treatment plant is, however, so poor and beside other waster water is discharged without treatment. As a result the water quality of Lai Nullah is heavily polluted at about 100 mg/l of BOD.

The sewerage system in the flat plain may usually need some pumping stations between the generation points and the treatment plant. In Islamabad such pumping stations are, however, not required due to favorable geological conditions of the gradual slope form North to South.

The wastewater generated in the urbanized areas is collected and conveyed to the treatment plant located in Sector of I-9. The Service Department is not monitoring the plant at the regular basis, so the detailed data of water quality (influent and effluent) was not given to the Study Team. It was, however, observed that, due to lack of the treatment capacity and its poor maintenance, most of the collected wastewater is discharged into the Lai Nullah without proper treatment. This may be causing further pollution of the river. According to CDA, the present capacity of treatment plant is only 25% of the total wastewater generated in the area.

At the urbanized areas without direct connections with the sewerage system, on-site systems such as a septic tank are used. This system holds the wastewater from individual house within its premise and discharge into gutter after some kind of treatment. However this system does not work effectively, and discharges almost raw sewage. The French Government decided to provide with a low-interest loan in 2002 for renovation of the existing treatment plant and/or the new treatment plant of CDA. The design capacity of the existing and planned treatment plant is shown in Table R 4.1.1.

Table R 4.1.1 Design Capacity of the Water Treatment Plant of CDA.

Phase	Design capacity		Construction Year	Remark	No. of Served sectors
	MGD	m^3/day			
I	3	13,638	1964-1965	Operational	7
II	3	13,638	1966-1967	Operational	
III	6	27,276	1975-1985	Out of order	10
IV	15	68,190	from 2004	In Planning	9
V	N.A	N.A	N.A	Future Planning	N.A
Total	27	122,742			26

Source: Master Plan of Islamabad (1960)

The existing treatment plants had been completed through Phase I and II from 1964 to 1967. Based on the record of 11th September 2002, the total wastewater flow at the existing treatment plants is estimated at only 1.5 MGD (6,819 m^3/day), which corresponds to only 25% of the total design capacity of 6 MGD (27,276m^3/day).

The quality of influent and treated wastewater at the existing treatment plants has not been analyzed on regular basis since 1995 because of lack of chemicals, according to the persons in charge. Based on the results of the wastewater quality analysis of 30 October 1994, BOD of the influent was 220 mg/l, while that of the effluent was 104 mg/l. This means that the removal rate was only 53%, which is obviously too law for the activated sludge process. The reason is that the aeration time of just 1.5 hours seems to be too short for the expected removal achievement of more than 80%. It is suggested at least to conduct frequent water quality analysis to monitor the existing treatment conditions. The sludge generated at the water treatment plant is dried in the drying bed for sale as fertilizer.

4.1.2 Drainage and Sewerage in Rawalpindi

The Rawalpindi Development Authority (RDA) has commenced the “Urban Water Supply & Sanitation Project Phase 1-Rawalpindi (UWSSP-R)” in 1996 through the budgetary allocation in the Eighth (8th) Five-Year Plan (1993-1998) together with the financial assistance from the Asian Development Bank (ADB). At the early stage of the UWSSP-R, the RDA formulated the Sewerage and Drainage Master Plan to improve the sewerage and drainage system in all the jurisdiction area of WASA. This objective area of the Master Plan covers an area bounded by Shahrah-e-Islamabad and Kahyaban-e-sir roads in the northeast and northwest of the project area (refer to Fig. 4.1.5)

The Master Plan consists of two (2) components of the Sewerage Master Plan and the Drainage Master Plan. The Sewerage Master Plan proposed to check the inflow of sewage from the area of WASA to the Lai Nullah through the following three (3) components of measures. The Master Plan is projected to complete in 2020, and upon the completion, the Lai Nullah would be no longer the outlet of the sewage, and its water quality would be remarkably improved.

(1) Improvement/expansion of the Sewerage Collection Systems, which collects all sewage throughout the aforesaid objective area of the Master Plan to a downstream point of the objective area, (near the point of “Moti Mahar Cinema”),

(2) Construction of the Transfer Sewer, which transfers all collected sewage as described above to the under-mentioned treatment plant about, and

(3) Construction of the Sewage Treatment Plant located at the north bank of Soan River.

As for the Drainage Master Plan, proposed was the following drainage improvement for the area of WASA of RDA, the east side catchment of the Lai Nullah in particular on the premises of the project implementation period of 14 year from 1996 to 2010.

(1) Channel improvement of Lai Nullah as the ultimate destination of the drainage water,

(2) Diversion of the existing primary drains called "Kassi East" and "Kassi West" running the center of the east catchment of the Lai Nullah.

(3) Improvement of secondary and tertiary collection

(4) Transfer strategy options for the primary drains

(5) Construction of pounding and pumping schemes for protection of low lying areas from the rainwater inundation

(6) Clean Drainage Campaign

1) Drainage System in Area of Rawalpindi Water and Sanitation Authority

There are the following three groups of major drains: (a) the drains of 13.2km in length with a top width over 1000 mm, (b) the drains of 5.3 km in length with a top width between 750 mm and 1000 mm and (c) the drains of 52.4 km in length with a top width between 500 mm and 700 mm. The total length of all types of drains is approximately 71.0 km. The drainage system and the typical cross section of drainage channel in Rawalpindi are as shown in Figs. 4.1.5 and 4.1.6, respectively.

Under UWSSP-R Phase I funded by ADB, new drainage system of Satellite Town area was constructed and diverted into Lai Nullah. The Asghar Mall Drain also needs to be constructed to improve the drainage system. The west side of the City area drains directly to Lai Nullah from the boundary of the central catchment, which is approximately close to Saidpur Road/ Circular Road/ Murree Road (South). Whereas the side of the City drains to the tributaries of Lai Nullah both called Kassi Nullah. One runs from Satellite Town and the other from Dhoke Kashmirian and they both outfall to Lai Nullah near RDA offices having come together at or near Nadeem Colony.

In the event of 2001 flood, large areas in Rawalpindi were inundated and some low–laying areas are always subject to inundation. As the detailed information of the design criteria was not available to the Study Team, it would be hard to judge how much the ADB-financed drainage improvement works could cope with the magnitude of the 2001 flood. It is, however, obvious that the present drainage system is far from satisfactory for the purpose.

2) Sewerage System in Area of Rawalpindi Water and Sanitation Authority

Sewerage in the City has been developed since 1953 but more progressively during the last fifteen years following proposals in 1971. Under UWSSP-R Phase I, trunk sewers are being laid to cater for the eastern part of the City and finally discharge into Lai Nullah. A portion of area sewers (lateral sewers) is also to be completed. Besides this land acquisition is being done for Sewage Treatment Plant, which will be executed under Phase-II of the Project. The sewerage system in Rawalpindi is delineated in accordance with the information collected through the Study as shown in Fig. 4.1.7

There are the main gravity sewers of about 11 km in length with more than 300 mm diameter in the City area and 4 km in length in the adjacent Satellite Town. A network of sewers now covers the central city area bounded by Lai Nullah, Ashar, Mall Road and Kassi Nullah, about 30 % of the City area. Sizes of principal sewers range from 225 mm diameter to 1200 mm diameter. The system discharges untreated sewage to Kassi Nullah, which flows into Lai Nullah from the east, just upstream of the confluence of the two Nullahs. The Cantonment is also served by a limited sewerage system. In UWSSP-R Phase-II, the outfall sewers will be designed taking into account the load of Cantonment area for the sewage treatment plant.

Under the Phase-I priority was given to sewer cleaning equipment and basic rehabilitation of the existing sewerage system, mainly by means of repairs to manholes. Provincial allowance is also included in the main sewerage cleaning packages for replacement of damaged sections of sewers as these are identified during the course of the cleaning works.

The scope of the Phase-II sewerage development proposals is to include the following components:

(a) Further rehabilitation of the existing sewerage system at key locations throughout the City. Area. New trunk sewers will be constructed in the following areas:

(i)	Central Sewerage District	: C-1 South East Area
(ii)	West 1 Sewerage District	: W1-1 City Saddar
(iii)	West 2 Sewerage District	: W2-2 South
(iv)	Trunk Sewer serving Satellite Town	: C-2
(v)	North Eastern Sewerage District	: NW-1 and NW-2

(b) New sewerage system in the above areas (excluding Satellite Town, where the adequate sewerage system has been completed)

(c) New house connections in the above areas (except Satellite Town)

4.1.3 Drainage and Sewerage in Rawalpindi Cantonment Area

The Sewerage Master Plan for Rawalpindi Cantonment Board was given to the Study Team. It discusses the present and future (up to year 2030) sewerage production, its collection, transportation, treatment and final disposal. It also discusses the problem in monitoring and maintenance of such services so as to maximize the public health, safety & welfare and to minimize any adverse environmental impact. This Master Plan will help to provide the basis for improvements to the necessary facilities for proper disposal of wastewater in the Cantonment area. Without such improvements, the incidents of water-related diseases and the occurrence of diarrhea, dysentery etc. may be expected to increase.

1) Drainage System in Rawalpindi Cantonment Area

No planned drainage system has been built in the Cantonment area. Surface drainage includes the network of man-made channels within the built-up areas that are intended to convey storm water with the natural channels draining the region within which the Cantonment lies.

The storm wastewater and effluent from households flows in small drains discharging into natural deep rivers. The storm water drains on the North- Eastern side falls into Lai Nullah, which discharges into the Soan River as shown in Fig. 4.1.5. The existing surface drainage system in the Cantonment area deemed to be adequate to drain normal storm water except for floods in Lai Nullah during heavy monsoon rains. In terms of management, however, more adequate maintenance on the facilities would be required

Management of the surface drainage requires knowledge of drainage patterns, a record of drainage assets, control of development to prevent encroachment of buildings into the drainage channels, and a citizenship awareness of their responsibilities regarding use of drainage facilities. Prior to the annual monsoon period (July-August) and campaign of drain cleaning is generally carried out by RCB to overcome the built-up of silt or debris that has accumulated in the drainage channels.

2) Sewerage System in Rawalpindi Cantonment Area

There is no definite plan about the drainage system in the Cantonment area. Rawalpindi Cantonment Board (RCB) puts a high priority on the sewerage system development than the drainage system. RCB completed “Sewerage Master Plan for Rawalpindi Cantonment Board” in February 2002. According to the Master Plan, it is proposed to install sewers and a wastewater treatment plant as shown in Fig. 4.1.7. RCB has a concept to convey wastewater collected in the Western side of the RCB area, to WASA sewers. It is likely that WASA will accept the concept.

RCB has not provided any areas within its jurisdiction with underground piped sewerage system. Where as some residents and army establishments are making use of septic tanks for disposal of wastewater, a major problem in the Cantonment area is addressed to the practice of disposing of untreated wastewater into Lai Nullah and its tributaries. Materials disposed of in this way reduce the self-purification capacity of the rivers and results in ultimate blockage. In addition to the above the presence of uncontrolled wastewater generates various adverse environmental impacts including the following:

(a) Attracts flies and encourages the communication of diseases thus reducing the likely improvement in general health brought about by improved water supplies.

(b) Encourages a poor standard of cleanliness throughout the Cantonment area.

(c) Detracts from the attractiveness of the Cantonment area.

(d) Decrease the aesthetic charm of the Cantonment area

(e) Creates a safety hazard.

(f) Creates a smell nuisance.

According to the Master Plan, the project area comprises the Cantonment area covering about 75.2 km^2, which is bounded by Rawalpindi City on Northeastern side and Islamabad on Northern side. The main two proposed sewerage systems located east and west of the GT Road, each discharging into an independent sewage treatment plant are identified as WTP EAST and WTP WEST. There is a plan to switch the existing septic tank areas to a centralized sewerage system, which will be discharging into an independent plant identified as the Treatment Plant at Chaklala. The sewage flows are summarized in the table below. The flows of ADF and PDF are predicted for three sewerage systems in year 2030.

Table R 4.1.2 Flow Prediction of Water Treatment Plant in Year 2030

Sewerage System	ADF (m^3/day)	PDF (m^3/day)
WTP West	82,944	165,890
WTP East	188,610	377,220
WTP Chaklala	4,086	8,172

Source: Sewerage Master Plan of RCB (Phase-III)(Feb. 2002)
Note: ADF = average daily flow, PDF= peak daily flow

WTP East is the largest among the three systems, and WTP Chaklala is the smallest. For the prediction of the daily flow the three systems are applied with the same PF (Peak Factor) of 2, reflecting the almost the same development stage within the Cantonment area.

The effluent quality is proposed as follows:

(a) BOD : 40 mg / l

(b) Fecal Coli forms : Less than 1000 organisms /100 ml

For this requirements the following treatment process is proposed for WTP WEST and WTP Chaklala on small area: 1) screening, 2) raw sewage pumping, 3) grit chamber, primary settling tank, 5) aeration tank, 6) secondary settlement, 7) sludge pumping, 8) sludge digester, and 9) sludge drying and disposal. On the other hand, the oxidation ditch treatment (followed by maturation lagoon) is considered for the site of WTP East, because wider area is available here and cost saving is possible. This site also offers a greater buffer distance from anaerobic lagoons to the existing planned communities. The cost of the project proposed by the Master Plan is shown in the table below. The project is proposed for implementation in five stages up to year 2018.

Table R 4.1.3 Summary of Cost for Sewerage Development System in RCB

S. No	Component		Amount (Rs million)
1	Sewer Construction	• West • East • Chaklala	159.77 825.31 21.72
2	Treatment Plant Construction	• West • East • Chaklala	247.00 558.00 30.00
3	House Connections (175,000 Nos)		1225.00
4	Land Acquisition	• West (6.5 ha) • East (232 ha) • Chaklala (1.6 ha)	25.60 69.00 8.00
5	Subtotal		3169.40
6	Contingency (5%)		158.47
7	Consultancy (3%)		95.08
8	Total		3422.96

4.1.4 River Water Quality

The river water around the Study Area is generally heavily polluted due to garbage dumping and discharge of untreated wastewater. The pollution level is very high especially in Rawalpindi area, because Lai Nullah and its tributaries are receiving a large volume of polluted wastewater generated in the urbanized area and huge amount of solid waste dumped, which has been deteriorated in the rivers. Those pollutions are accumulated in down streams in Rawalpindi.

In Pakistan it is not common and regulated by law to take water samples in the systematic way to monitor the water quality of the rivers. So, no series of water quality analysis of Lai Nullah and its tributaries was available to the Study Team. A sample of the river water quality around the Study Area was analyzed in April 2000: the sampling points and their water quality data are as shown in Fig. 4.1.8 and Table 4.1.1, respectively. According to the data, the worst water quality was almost as polluted as raw sewage.

4.2 SOLID WASTE MANAGEMENT (SWM)

4.2.1 Law and Organization for SWM

The Study Area is covered by three authorities related to the SWM: CDA (Capital Development Authority), TMA (Tehsil Municipal Authority) and RCB (Rawalpindi Cantonment Board). The SWM service for Islamabad and Rawalpindi areas are described basically in the following laws and regulations:

(1) “The Local Government Act 2001”, to describe the roles of Province (Zila Nazim), Tehsil on execution of SWM, and Union on support for execution of SWM.

(2) “The Punjab Local Government Act 2002”.

In addition CDA is ruled by “Islamabad Capital Territory Municipal Byelaw 1968”. The SWM for RCB is described in “The Cantonment Act, 1924”. However, CDA and TMA have no specified law/regulation for SWM. RCB has a special section called as Sanitary Section to collect and dispose of solid waste.

Since the situations concerning the solid wastes have been changing largely in quality and quantity, a long-term strategic policy for SWM is required and upgraded at regular basis. However at present there is no such a long-term plan for these three authorities. They are just involved in the daily collection, transportation and disposal of solid wastes without long-term plan for SWM. They are not aware of how much solid wastes are generated, what kinds of components they are consisted of, and how their characteristics are changing. Due to lack of the collection capacity, they are just collecting some of the generated solid wastes and transporting them to an open dumping site. Only in the jurisdiction area of TMA, some of the solid wastes are transported to the disposal site located near to the airport and covered with soil. It is obvious that the remaining wastes are disposed of in empty lands or into rivers.

4.2.2 Solid Waste Collection Ratio and Served Population

The collection service area of CDA and TMA are limited to the urban centers not covering the remote rural areas, informal administrative villages and communities like “ Kachi Abadis” as shown in Fig. 4.2.1. As the results, the collection rations of CDA and TMA are limited to about only 41% and 66%, respectively The non-SWM service areas, therefore, are forced to dispose their own solid waste by themselves causing inappropriate dumping of solid wastes anywhere in and around their communities. As there is no commitment of SWM services by the local government in these areas, the sanitation section officials of CDA and TMA are not almost aware of the present conditions of the service level. The “laissez-faire” policy on SWM has been deteriorating the environment, including the conditions of Lai Nullah and its tributaries. The dumped solid wastes are accumulated in the riverbeds, and the smooth flow is disturbed eventually. In case of a flood, the accumulated wastes may resist the smooth flow of the river and cause the overflow from the bank. Based on the information from three relevant authorities, the total volume of solid waste generated in the jurisdiction area of CDA, TMA and RCB is estimated at 2,150 ton per day, while the volume collected is 1,800 ton per day, which corresponds to only 83% of the generated solid waste as below.

Table R 4.2.1 Solid Waste Collection Ratio and Served Population

Authority	CDA	TMA	RCB	Total
Estimate solid waste generation (t/day)	550	700	900	2,150
Unit generation (kg/c/d)	0.92	0.47	1.00	0.72
Amount of collection (t/day)	500	600	700	1,800
Collection ratio (% , area-wise)	90%	85	78	83
Population (1,000)	600	1,500	900	3,000
Served population (1,000)	250	1,000	900	2,150
Served population ratio (%)	41	66	100	71

Source: JICA Study Team 2002

4.2.3 Functions of Solid West Management (SWM)

"The Local Government Act 2001" describes the functions of SWM to local governments, as follows:

(1) Sweeping（street, road, park, public space）

(2) Door to door collection of waste from residential to commercial areas.

(3) Transportation and disposal of garbage

(4) Removal of dead animals.

(5) Maintenance of public toilet.

(6) Maintenance of six weekly bazaars.

In the line with the concept, the Sanitation Directorate of CDA has started, in 2000, the "New Management Plan" to give additional works beyond the regulated functions including: (1) Sweeping of major/service road in Monday, (2) Cleanliness in one private sector in Tuesday, (3) Cleanliness/inspection of private sector in Wednesday, (4) Collective cleanliness program in Thursday, (5) Cleanliness of marks and public places in Friday and (6) Claening of streets and weekly bazaars in Saturday.

4.2.4 Categorization of Solid Wastes

It is clear that the solid wastes contain a wide variety of wastes: from relatively safe one to highly dangerous one. This is the reflection of the real life, which uses many different kinds of materials. Therefore it is a common practice to define the solid wastes according to the characteristics in many developing or developed countries.

However CDA, TMA and Cantonment at present have no special classification of dangerous solid wastes such as industrial waste, hazardous waste and infectious hospital waste. They are just collecting these wastes together with other usual wastes and dispose of them on the same dumping site. The hospital is responsible for safe disposal of the infectious hospital waste disposal. In spite of the "Medical Waste Guidelines" prepared by Ministry of Health, medical doctors and workers of small clinics and hospitals are reluctant to follow the guideline in their daily works due to financial reasons or lack of facilities. The authorities concerned are not taking any effective measures to stop such unfavorable activities.

As mentioned above, it is essential to understand what kinds of components are contained in the solid waste. In Japan there is a large volume of the database concerning the matter. When the database is available, it becomes quite easy to compare the differences of components of solid waste among the cities, and to assess their historical trends as well as the future forecasting. However in Pakistan, as these kinds of data are not accumulated, it is difficult to conduct simple things in the SWM services. The Study Team had attempted to collect some data for the waste components, and based on them, the components of solid wastes in Pakistan are preliminarily estimated as listed below:

Table R 4.2.2 Component of Solid Waste (TMA)

Component	House	Restaurant	Hotel	Shop	Market	Office	Road sweeping
Paper	5.3	2.6	19.5	16.8	7. 1	48.0	2.6
Kitchen waste	59.3	80.6	43.1	14.1	48.2	15.5	69.7
Plastics	5.2	0.9	6.7	20.0	3.9	3.9	3.5
Textile	3.0	0.0	4.6	4.0	16.2	3.9	4.4
Wood, grass	9.7	0.0	0.3	26.9	22.4	1.1	5.8
Rubber, leather	0.2	0.0	0.0	0.1	0.0	7.1	0.1
Metal	0.7	0.7	0.1	0.5	0.1	1.4	0.3
Glass, stone, bones	7.7	15.2	25.6	0.4	2.1	12.0	3.8
Earth & sand	8.2	0.0	0.0	17.2	0.0	7.1	9.8
Others	0.7	0.0	0.1	0.0	0.0	0.0	0.0
Combustible Waste (%)	83.4	84.1	74.3	81.9	97.8	79.5	86.1
Incombustible Waste (%)	16.6	15.9	25.7	18.1	2.2	20.5	13.9
Density (kg/l)	0.3 1	0.07	0.24	0.10	0.21	0.03	0.27

Source: Solid waste management improvement study in Rawalpindi 1995(JICA)

4.2.5 Collection, Transportation and Disposal System

A sanitary worker collects bags of solid wastes at doors of the houses (door to door collection system) and transports them to the primary collection place (such as containers or concrete bins). CDA, TMA or RCB then collect and transport the solid wastes from the primary collection place to the final disposal site. The owners of markets, factories and offices are, however, obligated to transport their generating wastes directly to the disposal site. A handcart (20 to 25 kg) is used for collection of the bags of the wastes from houses, and a handcart and/or a mechanical road sweeper are for transportation of the solid wastes on the roads to the primary collection place. A garbage trolley (500 kg), a skip, a skip lifter, collector truck, and tractor trolleys are further used for transportation of the bulky solid wastes accumulated at the primary collection place to disposal site.

4.2.6 Recycling by Scavengers

The scavenger is called as the person, who finds and collects valuable materials in the solid waste and sells them. The work itself is simple and anybody including children can scavenge and secure a minimum level of income. Therefore the scavenging is a method with which unskilled people can live in urban areas. They are in a meaning contributing to the recycling and reuse of materials by reducing the solid waste amount. However the working as well as living conditions shall be considered carefully, because they are always facing quite dangerous wastes such as glasses, syringes and infectious wastes. It would be necessary to understand their living conditions from the viewpoint of social welfare and poverty alleviation. In this Study the existing conditions of scavengers are investigated. There are about 200 scavengers in Islamabad, and about half of them work at the dumping site of H-12. There are also some 900 to 1,000 scavengers in Rawalpindi (in the jurisdiction area of TMA not including the area of RCB).

Interview survey to the scavengers was carried out through the Study in both Islamabad and Rawalpindi. According to the results of interview survey, they are collecting wastes of about 25 kg per day. Their income is estimated in the range of Rs 150 to 300 per day, which is a quite low securing only minimum level of living in the urban area. In terms of their contribution to the material recycling, however, the figure of 1.5~2% of the wastes is estimated to be recycled in Islamabad and about 4% in Rawalpindi.

4.2.7 Equipment and Facilities for Collection of Solid Waste

Vehicles are usually used to collect solid wastes from generators. The existing vehicles for collection of SW for the Study Area (CDA, TMA and Cantonment) are listed below:

Table R 4.2.3 Vehicles for Collection of Solid Waste

Authority/Board	Collection Vehicle	Number
CDA (Capital Development Authority)	Refuse compactor	15
	Skip lifter	5
	Bedford vehicle	8
	Tractor trolley	8
TMA (Tehsil Municipal Authority)	Mazda T-3500	16
	Tractor	5
	Container truck	30
	Dumper	4
	Recovery vehicle	1
	Front end loader	1
RCB (Rawalpindi Cantonment Board)	Truck	23
	Tractor blade	2
	Road mechanical sweepers	4
	Pickup truck	5
	Auto loader tractor	5

The facilities required for an effective SWM are the workshop to maintain and repair the machines, parking site, and the dumping site to dispose of solid wastes. In a large service area the transfer station may be required to load solid wastes to larger vehicles by reloading solid wastes in case it is proven to be more economical. Utilities like electricity and water are also important to operate and maintain these facilities.

In the jurisdiction area of CDA, electricity and water are available for the workshop and parking sites at G7/1. At present there is no designed damping site, but a site of about 1 km^2 in Block H-12 is being used as the tentative damping area. For the future a site at Kuri is selected, which is located 22 km from Zero Point (about 25 min). The area is about 100 acres (40 ha).

In Rawalpindi the workshop is located at Mukhsigah State with both electricity and water available. The parking site is located at the Community Center in Satellite Town. The present dumping site is located at Dhoke Gangal (25 Acre, or 10 ha), which is near to Air Force Airport, distanced by 5 to 8 km from the center of the City. Neither electricity nor water is available for the present site. TMA is planning to construct a new dumping site (85 Acres, or 34 ha), which is located about 25 km far from the center of the City. For the new site electricity is planned and water will be supplied from a well.

In Cantonment area the workshop and parking site are located at Gawal Mandi with electricity and water available. The present dumping site (23 acres, or 9 ha) is located along Mistral Road with distance of 10 km from the Cantonment Board Office. There is no plan to construct a new dumping site.

4.2.8 Other Information on Solid Waste Management

Composting and incineration technologies are not introduced in the study area. It is known that the hazardous wastes such as the used medical squirts; hypodermic needles, scalpels, and tweezers are sold in Bazaars of Rawalpindi. In order to improve the present unfavorable solid waste management system, the Government of Japan donated collection vehicles for collection and transportation of the solid wastes to TMA through grant aid program in 1996, and two (2) JOCVs in the field of SWM and one JICA short-term expert of SWM were dispatched to TMA in 2001 and to EPA in 2002, respectively.

Community based SWM Improvement Project in Rawalpindi was also carried out through UNDP fund from 1996 to 2000. This project was called as SWEEP (Solid Waste Management & Environment Enhancement Project). The Project aimed at nurturing community leaders so that the leaders could enlighten the community members on SWM improvement in each district by discussion. The relevant activities posterior to the Project could not be well prevailed, but it was evaluated that the Project gave a certain impact on the concept of “Community Participation to SWM” and “Source Garbage Reduction Method”.

4.3 WATER USE AND WATER RESOURCES

4.3.1 Present Water Supply Capacity in the Study Area

The present water supply in the study area is administrated by the three (3) independent entities; namely, (1) Capital Development Authority (CDA), (2) Water & Sanitation Agency (WASA) under Rawalpindi Development Authority (RDA), and (3) Rawalpindi Cantonment Board (RCB). Islamabad is wholly under jurisdiction of CDA. On the other hand, Rawalpindi is divided into jurisdiction areas of WASA and RCB.

The present water supply capacity for the study area is about 172.8 MGD (785.5 MLD) in total. Out of the total water supply, the service area of CDA (i.e., Islamabad) shares 111.6 MGD (64.6%), while the service areas of WASA and RCB share 27.0 MGD (15.7%) and 34.2 MGD (19.8%), respectively as listed in Table R 4.3.1.

Table R 4.3.1 Water Supply Capacity for the Study Area

Service Area	Water Source	Treatment Plant	Dam Reservoir	Supply Capacity as of '02	
				MGD	MLD
Area of CDA[*1]	Kurang River	Korang	-	4.0	18.2
		Shadhara	-	1.6	7.3
	Soan River	Simly	Simply	42.0	190.9
	Haro River	Sangjani	Khanpur	16.5	75.0
	Lai Nullah	Said Pur	-	0.8	3.6
		Noor Pur	-	0.7	3.2
	Surface and groundwater	Augmentation		12.0	54.6
	Groundwater	-	-	34.0	154.6
	Sub-total for Area of CDA			111.6	507.3
Area of WASA[*2]	Kurang	Rawal	Rawal	8.0	36.4
	Haro River	Sangjani	Khanpur	1.0	4.5
	Groundwater	-	-	18.0	81.8
	Sub-total for Area of WASA			27.0	122.7
Area of RCB[*3]	Kurang	Rawal	Rawal	10.0	45.5
	Haro River	Sangjani	Khanpur	19.7	89.6
	Groundwater	-	-	4.5	20.5
	Sub-total for Area of RCB			34.2	155.5
Total of Study Area	Surface Water			116.3	528.7
	Ground Water			56.5	256.8
	Grand Total			172.8	785.5

Source:
*1: Water Manage Directorate, CDA, 2002
*2: PC-1 for Project Improvement of Water Supply and Sewerage & Drainage System of Rawalpindi City, WASA, RDA, 2002
*3: Sewerage Master Plan for Rawalpindi Cantonment Board (Phase III), 2002

The source of the above water supply capacity is divided into the surface water and groundwater. The groundwater in the study area is abstracted by about 450 tube wells (i.e., 182 wells in the area of CDA, 194 wells in the area of WASA and 74wells in the area of RCB). A particular attention is herein given to the high percentage of the groundwater as the water source, which takes about 33% of the total water supply in the study area: the service area of WASA in particular high percentage of about 67%, as shown in Table R 4.3.2.

Table R 4.3.2 Share of Surface Water and Groundwater as Water Supply Source for the Study Area

Supply Source	Area of CDA		Area of WASA		Area of RCB		Whole Study Area	
	Capacity	Share	Capacity	Share	Capacity	Share	Capacity	Share
	MGD	%	MGD	%	MGD	%	MGD	%
Surface	77.6	69.5	9.0	33.3	29.7	86.8	116.3	67.3
Groundwater	34.0	30.5	18.0	66.7	4.5	13.2	56.5	32.7
Total	111.6	100.0	27.0	100.0	34.2	100.0	172.8	100.0

The surface water supply capacity of 116.3 MGD (528.7 MLD) for the study area is defined as the total capacity of the existing seven (7) treatment plans, which abstract the raw water from the dam reservoirs, or directly from the natural flow discharge of the small tributaries. Among others, the principal surface water sources are Simly Dam on Soan River, Khanpur Dam on Haro River, Rawal Dam on Kurang River, which has a supply capacity of 97.2 MGD (441.9 MLD) or 84% of the total surface water supply capacity as listed Table R 4.3.3.

Table R 4.3.3 Water Supply Capacity from Dam Reservoirs

Dam Reservoir as Surface Water Source	Service Area	Supply Capacity	
		MGD	MLD
Simly	Area of CDA	42.0	190.9
Khanpur	Area of CDA	16.5	75.0
	Area of WASA	1.0	4.5
	Area of RCB	19.7	89.6
	Sub-total	37.2	169.1
Rawal	Area of WASA	8.0	36.4
	Area of RCB	10.0	45.5
	Sub-total	18.0	81.9
Grand Total		97.2	441.9

4.3.2 Present Actual Supply Capacity and Per-capita Consumption

As described above, the present water supply capacity for the study area is 172.8 MGD. On the other hand, the actual daily water supply for sale to customers is limited to 85.9 MGD (390.5 MLD) or 49.7% of the supply capacity as listed in Table R 4.3.4.

Table R 4.3.4 Water Supply Capacity vs. Actual Water Supply for Sale to Customers

Service Area	(1) Supply Capacity		(2) Actual Supply to Customers		(1)/(2)
	MGD	MLD	MGD	MLD	%
Area of CDA	111.6	507.3	55.0*1	250.0	49.3
Area of WASA	27.0	122.7	19.4*2	88.2	71.9
Area of RCB	34.2	155.5	11.5*3	52.3	33.6
Total	172.8	785.5	85.9	390.5	49.7

Source *1: Water Management Directorate, CDA, 2002
*2: Water Supply Distribution System, Design Report, UWSSP-R, MMP, 1998
*3 Results of interview from RCB

The difference between the supply capacity and supply volume for sale could be attributed to several factors such as; (a) unaccounted water including leakage of water and water tapping, and (b) non-operation of the water supply facilities including part-time operation of tube-wells, troubles of supply facilities, and power cut. The present urban population of Islamabad and Rawalpindi is estimated at over 2 million, whereby its average per-capita water consumption is estimated at about 221 liter/person/day based on the aforesaid actual water supply for sale to customers as listed in Table R 4.3.5.

Table R 4.3.5 Gross Per-capita Consumption for Domestic, Public, Commercial and Industrial Use

Item	Unit	Islamabad	Rawalpindi	Whole Study Area
Average Daily Supply	(MLD)	250	161	411
Population	(persons)	621,000*1	1,455,000*2	2,076,000
Service Ratio	(%)	100*1	85*2	90
Served Population	(persons)	621,000	1,236,750	1,857,750
Gross Per-capita Consumption	(lit/person/day)	403	130	221

Source: *1: The Regional Study for Water Resources Development Potential for the Metropolitan Area of Islamabad-Rawalpindi, JICA, 1987.
*2: PC-1 for Project of Improvement of Water Supply and Sewerage & Drainage System of Rawalpindi City, WASA, RDA, July 2002

The above per-capita consumption includes the domestic, public, commercial and industrial use. Accordingly, the net-per capita consumption purely for the domestic use would be far smaller than the estimated value of 221 liter/person/day. According to results of the Study by JICA in 1988, the share of per-capita consumption for the domestic use to the total consumption in 2000 was estimated at 40% for Islamabad and 57% for Rawalpindi. Assuming these rates, the per-capita consumption for the domestic use is estimated as below:

Table R 4.3.6 Per-capita Consumption for Domestic Use

Item	Islamabad	Rawalpindi	Whole Study Area
Gross Per-capita Consumption	403 lit./person/day	130 lit./person/day	221 lit./person/day
Share of Domestic Use	40%	57%	47%
Per-capita Consumption for Domestic Use	161 lit./person/day	74 lit./person/day	103 lit./person/day

Source: *: The Regional Study for Water Resources Development Potential for the Metropolitan Area of Islamabad-Rawalpindi, JICA, 1987.

4.3.3 Forecast of Future Water Demand and Deficit

Islamabad and Rawalpindi have recorded the annual population growth of 5.7% and 3.4%, in the recent ten (10) years, respectively. The population growth of Islamabad is the highest among the major cities in the country, and even the growth rate of Rawalpindi is the ninth highest. Such high urban population growth together with expansion of the government offices and other industrial/commercial entities would bring out the substantial increment of water demand year by year in the future. The future water demand for Islamabad and Rawalpindi was estimated in the previous relevant studies and/or the water supply development plans. According to them, the present water supply capacity for Rawalpindi (i.e., the area of WASA and RCB) falls below the present potential water demand leading to the chronic water shortage as listed in Table R 4.3.7. On the other hand, the supply capacity for Islamabad (i.e., the jurisdiction area of CDA) could apparently meet the future incremental water demand for the time being. Nevertheless, the infrastructures for urban water supply in Islamabad have mostly completed their useful life and a lot of water leakage problems become abundantly visible in the city. Moreover the groundwater level is seriously dropping and causing difficulties in abstracting the water through tube-wells (refer to the following subsection 4.3.2). As the results, the CDA also could hardly secure the reliable water supply.

Table R 4.3.7 Comparison between Average Daily Water Production and Water Demand

Area	Present Supply Capacity		Water Demand (Daily Max.)					
			In 2001		In 2003		In 2010	
	MGD	MLD	MGD	MLD	MGD	MLD	MGD	MLD
Area of CDA*1	112	507	102	461	105	478	119	541
Area of WASA*2	27	123	50	227	56	255	78	355
Area of RCB*3	36	165	44	200	n.a.	n.a.	n.a.	n.a.

*1: The Regional Study for Water Resources Development Potential for the Metropolitan Area
*2: PC-1 for Project of Improvement of Water Supply and Sewerage & Drainage System of Rawalpindi
*3: Sewerage Master Plan for Rawalpindi Cantonment Board (Phase –III)

4.3.4 Degradation of Groundwater as Water Resources

As described in the foregoing subsection 4.3.1, about 30% of the present water supply to the study area relies on the groundwater as the water source, which is abstracted through about 450 tube-wells. Thus, the groundwater is the major water source for the study area. According to the results of interview surveys with CDA, however, the groundwater level has seriously dropped with an annual average rate of about 2m for the recent five (5) year, and the present level has reached 35 to 40 m below the surface ground level. It is also reported by WASA[6] that the groundwater level has dropped from 12m to 45m below ground level during a period of 1982-2001. As the results, the quantity as well as quality of groundwater as the important water source is close to a crisis.

The major reasons of the dropping of the groundwater levels would be attributed to the degradation of recharge capacity, and the excessive abstraction of the groundwater in the study area as enumerated hereinafter:

1) Degradation of Recharge Capacity by Unfavorable Human Activities in Upstream Watershed

The natural forests in the Margalla Hills are regarded as the significant source for recharge of the groundwater in the study area. However, the excessive quarrying works eroded the substantial extent of the forest. Moreover, the inhabitants also make unauthorized use of wood for cooking and heat in the area, and domestic cattle heads overgraze endangering the

6 "Brief on Water & Sanitation Agency Rawalpindi for Tehsil Nazim/Chairman RDA, dated on August 22, 2002"

natural environment of the forest[7]. These unfavorable activities are likely to aggravate the recharging capacity by the forest in the Margalla Hills.

2) Degradation of Recharge Capacity due to Reduction of Unsealed Infiltration Area in Downstream Watershed

According to the estimates in the previous report[8], about 68% (70 km^2) of the area in Islamabad is remained as the unsealed natural infiltration area in 1981, while the natural infiltration area is being reduced due to the intensive urbanization and going to be reduced to 30% in 2030 due to progress of urbanization. This dynamic reduction of infiltration area is obviously enumerated as one of the principal causes for reduction of recharge capacity of the groundwater.

3) Excessive Exploitation of Groundwater as Water Source

The exploitation of tube-wells has been made with less consideration on the recharge capacity of the groundwater. Any reliable hydraulic investigation on the present states of groundwater has never been made in the study area, and therefore, the appropriate rate of abstraction volume of the groundwater is unknown. Judging from the serious dropping of the groundwater level, however, the current abstraction volume of the groundwater would exceed the allowable limit.

4.3.5 Water Resources and Water Supply Development Project

The on-going and proposed bulk water supply development projects for the study area are such as: (1) Metropolitan Water Supply Project, Phase-1 and 2 (Khanpur-I and II), and (2) the Urban Water Supply & Sanitation Project Rawalpindi, Phase I (UWSSP-R). Through these projects, the study area could increase the present water supply capacity of 172.8 MGD (785.5 MLD) to 265.9 MGD (1,208.8 MLD) in total as listed below:

7 There exist about 56 quarries and 34 villages in and around the Natural Park with over 26,000 inhabitants.

8 Refer to “Sustainable Groundwater Exploitation of the Lei-Nullah in 24th WEDC Conference” by Dr. Amir Haider Malic, 1998.

Table R 4.3.8 Present and Future Water Supply Capacity for the Study Area

Year	Supply Capacity (MGD)				Remarks
	Islamabad	Rawalpindi		Total	
	CDA	WASA	RCB		
Present (2002)	111.6 MGD (507.3 MLD)	27.0 MGD (122.7 MLD)	34.2 MGD (155.5 MLD)	172.8 MGD (785.5 MLD)	Refer to Table R 4.3.1
Future (2003)	111.6 MGD (507.3 MLD)	49.6 MGD (225.5 MLD)	53.9 MGD (245.1 MGD)	215.1 MGD (977.9 MLD)	- Increment of 13.6 MGD for WASA and 19.7MGD for RCB by expansion of Khanpur filtration plant under Khanpur-I - Increment of 8MGD for WASA by expansion of Rawal dam filtration plant under UWSSP-1 - Increment of 2MGD for WASA by expansion of tub-well capacity under UWSSP-I
Future (Indefinite)	128.1 MGD (582.3 MLD)	64.2 MGD (291.9 MLD)	73.7 MGD (334.6 MLD)	265.9 MGD (1,208.8 MLD)	Following increment of supply capacity would be made by expansion of Khanpur filtration plant under Khanpur II - Increment of 16.5MGD for CDA - Increment of 14.6MGD for WASA - Increment of 19.7MGD for RCB

The Metropolitan Water Supply Project (Khanpur-I) was proposed to have the daily water supply capacity of 51 MGD from the source of Khanpur dam reservoir to Islamabad and Rawalpindi. Out of the supply capacity, 16.5 MGD was shared to Islamabad, and its treatment plan as well as water distribution system was completed in 2000 with the financial assistance from Overseas Economic Cooperation Fund (OECF), Japan and now under operation.

The remaining 34.5 MGD is shared to Rawalpindi, and its treatment plant/distribution system is going to be completed by 2003 through the Urban Water Supply & Sanitation Project Rawalpindi, Phase I (UWSSP-I) by WASA with financial assistance from ADB.

Succeeding to Khanpur-I, Khanpur-II is now being proposed to expand the water supply capacity for Islamabad and Rawalpindi, although its completion time has not been fixed yet. Upon completion, Islamabad and Rawalpindi would have the supply capacity of 102 MGD. The share of water supply capacity under Khanpur-I and II is as listed in Table R 4.3.9.

Table R 4.3.9 Phased Development of Water Supply Capacity from Khanpur Dam Reservoir

Supply Area	Water Supply Capacity				Remarks
	Phase-1		Phase II		
	(MGD)	(MLD)	(MGD)	(MLD)	
Islamabad	16.5	75.0	33.0	150.0	Phase-I was completed in 1996
Rawalpindi (Area of WASA)	14.8	67.3	29.6	134.6	Phase I is to be completed by 2003
Rawalpindi (Area of RCB)	19.7	89.6	39.4	179.1	Phase I is to be completed by 2003
Total	51.0	231.8	102.0	463.7	

Source: PC-1 for Project of Improvement of Water Supply and Sewerage & Drainage System of Rawalpindi City, WASA, RDA, July 2002

The treatment capacity of the Rawal Lake Filtration Plant is now expanded as a component of the aforesaid UWSSP-I. This project component is scheduled to complete in 2002, and upon completion, the service area of WASA would increase the water supply capacity from Rawal dam reservoir from the present 8 MGD to 15 MGD. Installation of 20 new tube-wells and rehabilitation of 100 existing tube-wells are also being implemented through UWSSP-1. Moreover, WASA further intends to install the new tube-wells year by year with using the WASA’s own fund. Through these installations/rehabilitations of tube-wells, the groundwater supply capacity is projected to increase from 18MGD in 2002 to 22 MGD in 2010.

CHAPTER 5. HYDROLOGICAL AND HYDRAULIC STUDY

5.1 RAINFALL ANALYSES

5.1.1 Rain Gauge Stations

In the Study Area, there exist four (4) rain gauge stations, all of which are all being operated by PMD. They are the Chaklala (Islamabad International Airport), Islamabad (National Agromet Centre), Rawalpindi Agromet Center (RAMC) and Saidpur (Seismological Observatory) Stations.

According to "the Feasibility Report on Flood Control of Lai Nullah in Rawalpindi City, NESPAK – NDC Joint Venture, January 1987", five self-recording rain gauges were installed by CDA in 1960s, but they were very shortly closed after 3.5 to 5 years of operation. The present Islamabad Station used to be called Rawalpindi Station before it was moved from a place near the present RAMC Station to the present location in 1967.

1) Rainfall Observation

Locations and main features of the existing four stations are presented in Fig. 5.1.1 and Table R 5.1.1 respectively. The four (4) stations line up along the eastern boundary of the Lai Nullah Basin with an order of Saidpur, Islamabad, RAMC, and then Chaklala in the north to south direction. The Chaklala and Islamabad Stations have comparatively long operation period of more than 30 years, but the Saidpur and RAMC Stations are so new that they started measurement only 8 and 14 years back respectively.

Table R 5.1.1 Existing Rainfall Stations in Study Area

Station	Location			Year of Establi-shment	Frequency of Measurement	Year of Installation of Self-recorder	Remarks
	Latitude (North)	Longitude (East)	Altitude (m)				
Chaklala	33°37’	73°06’	500	1931	Every 3 hours	(1951)**	Islamabad International Airport
Islamabad	33°41.00’	73°03.87’	520	1967*	Every 3 hours	1999	National Agromet Centre
RAMC	33°38.88’	73°05.13’	500	1989	Three times a day	1989	Rawalpindi Agromet Centre
Saidpur	33°44.56’	73°03.91’	660	1994	Once a day	N/a	Seismological Observatory

Note: * The Islamabad Station (National Agromet Center) moved in 1967 to the present location, Zero Point, Islamabad from Rawalpindi.

** According to the Feasibility Report by NESPAK – NDC Joint Venture, at the Chaklala Station was installed in 1951 a self recording gauge, which no longer exists although it was reportedly operational until 1987 at least.

The frequency of rainfall measurement differs according to the purposes of each station. Rainfall measurement is made every three hours at 0200, 0500, 0800, 1100, 1400, 1700, 2000 and 2300 hours (PST) at the Chaklala and Islamabad Stations, three times a day at 0800, 1400 and 1700 hours at the RAMC Station, and once a day at 0800 hours at Saidpur

Station. A self-recording rain gauge is annexed to two stations, Islamabad and RAMC. In addition, the Chaklala Station also used to have a self-recording gauge between 1951 and 1980s.

2) Data Availability

The Study Team tried to collect short-time rainfall data such as hourly and 3-hourly data recorded during selected heavy rainstorms as well as all available daily rainfall data, visiting PMD Headquarter in Islamabad, Regional Meteorological Center in Lahore and the four stations. etc. Unfortunately the data availability does not correspond to the operation periods of the stations as shown in Tables 5.1.1 and 5.1.2. Considerable parts of precious old data are missing or were already lost, according to PMD officials.

The Chaklala Station is the richest in rainfall data with daily data of 58 years, 3-hourly data of 32 years, and hourly data of 21 years, followed by the Islamabad Station of which daily and 3-hourly data are available since 1983. The RAMC Station has daily rainfall data and self-recorder charts of 13 years since 1989. The new Saidpur Station is the poorest with daily data of 7 years.

Focusing on short-time rainfall data, especially hourly data during heavy rainstorms that are indispensable for analyses of flash floods like the 23 July 2001 Flood, the data availability is too low, mostly due to instrument troubles caused by such rainfall intensities. As seen in Table 5.1.2, hourly data are available only for a few rainstorms among the selected 53 storms since 1970. Due to inadequacy of the hourly rainfall data, the rainfall analyses are alternatively based on the 3-hourly rainfall data as described hereinafter.

5.1.2 Rainfall Characteristics

Using the collected rainfall data, rainfall analyses was made to know general characteristics of the rainfall in the Study Area in terms of duration and distribution in space and time.

1) Duration

First, accumulated rainfall curves of the Chaklala and Islamabad Stations during past major rainstorms were drawn in Fig. 5.1.2, where the accumulated rainfalls were converted in percentages of the total rainfalls. As seen in the figure, the rain duration was generally short. Almost all the rainstorms ended within 12 hours except for that of 27 August 1997, which lasted 24 hours.

2) Distribution in Space

The spacious distribution of storm rainfall in the Study Area was clarified based on the rainfall records of the recent floods on 29 July 1996, 27 August 1997 and 23 July 2001. As shown in Fig. 5.1.3, it is obvious that the three floods show different distribution patterns. The 1997 flood rainfall seems fairly uniform along the eastern basin boundary. The 1996 flood rainfall was biased towards the south. In the 2001 flood, the rainfall of 620.7 mm at Islamabad Station overwhelms those at the other three stations located within a radius of only 8 km. The differences are as big as 300 to 450 mm.

The 3-hourly rainfall data of the Islamabad Station were also plotted against those of the Chaklala Station in the right figure to examine correlation between the two stations. The result shows that no clear correlation is found between them. From the above analyses, it might be concluded that the localization of rainfall is quite significant and the spatial distribution pattern is different from flood to flood.

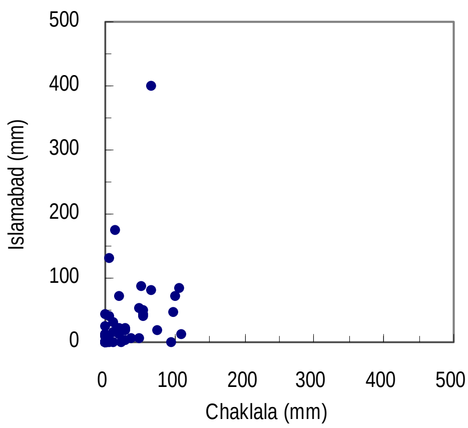


Fig. R 5.1.1 Correlation of 3-hourly Rainfalls

3) Distribution in time

Hyetographs were also drawn for the recent three floods as shown in Fig. 5.1.4 to know rainfall distribution in time. The hydrographs were based on the collected 3-hourly data except for the Chaklala Station of the 1997 flood and the Islamabad Station of the 2001 flood for which hourly data are by chance available. The same scales of graph axes were commonly employed for the three floods to facilitate comparison of the rainfall intensities.

First of all, surprisingly intensive rainfall is found at the Islamabad Station in the 2001 flood. Intensive rainfall over 130mm/hr continued 3 hours between 1000 and 1300 hours on 23 July 2001. The hourly rainfall intensity of 180mm between 1200 and 1300 hours is the recorded maximum in Pakistan according to PMD. Intensity of 90mm/hr was also recorded between 1300 and 1400 hours at the RAMC Station during the same flood.

As for the other floods, the rainfall intensity was quite lower than the exceptional 2001 flood, while the intensive 3-hourly rainfalls of more than 35mm/hr (corresponding to 105mm in three hours) were also observed in the 1996 flood at the Chaklala Station and in the 1997 flood at the Chaklala and RAMC Stations.

5.1.3 Frequency Analysis

As discussed in Subsection 5.1.2, the spatial variation of rainfall is very significant in the Study Area and the spatial distribution pattern also differs from flood to flood. In order to correctly evaluate such rainfall in relation to flood discharges on Lai Nullah, therefore, basin mean rainfalls are more important than point rainfalls observed at each station. In this sense basin mean rainfalls were estimated based on the collected rainfall data, and then a frequency analysis was made to estimate probable basin mean rainfalls for several return periods, as follows:

1) Reference Point

As the first step, Gawal Mandi Bridge that is located in the middle of the habitual flood inundation area between Gunj Mandi and Railways Bridges was defined as a reference point for the estimation of the basin mean rainfalls. In other words, the basin mean rainfalls were estimated not for the whole river basin of 234.8 km^2 but for the catchment area of 199.2 km^2 (85% of the whole basin catchment area) upstream of the bridge, taking it into consideration that flood discharges in the habitual flood inundation area are mostly generated by rainfalls falling in the 199.2 km^2 area.

It is noted that Gawal Mandi Bridge is very meaningful for the present flood warning system of TMA too. As explained in subsection 2.5.2, the water level at this bridge is an indicator for the flood warning issuance. Once the water level rises over the 18 feet level, sirens are to be blown at several warning posts in Rawalpindi.

2) Basin Mean Rainfall

The Thiessen Method was applied to estimate the basin mean rainfalls. Fig. 5.1.5 presents divisions of the Lai Nullah Basin by the Thiessen polygon lines according to the rainfall data availability, and the Thiessen coefficients are summarized below:

Table R 5.1.2 Thiessen Coefficients

Station	Number of Stations of which rainfall data are available			
	4 Stations	3 Stations	2 Stations	1 Station
Saidpur	0.30	N/a	N/a	N/a
Islamabad	0.47	0.77	0.85	N/a
RAMC	0.12	0.13	N/a	N/a
Chaklala	0.11	0.10	0.15	1.00

Using the collected 3-hourly data observed at the stations, 3-hourly basin mean rainfall data were calculated to create a basin mean rainfall database for the selected heavy rainstorms of 32 years from 1970 to 2001.

3) Probable Rainfalls

The annual maximum basin mean rainfalls of four (4) different durations (3, 6, 9, 12-hourly rainfalls) were plotted on the different probability distribution curves including the Gumbel, Log-normal, Pearson Type 3 and Log-Pearson Type 3 (refer to Table 5.1.3 and Fig. 5.1.6). As the results, it is evaluated that the Log-Pearson Type 3 gives good fitting to all the four extreme rainfalls and selected as the optimum distribution. The probable basin mean rainfalls are thus estimated through that the Log-Pearson Type 3 and summarized in Table R 5.1.3, which also shows the actual basin mean rainfalls of the 2001 flood, the probable basin mean daily rainfalls additionally estimated in this Study and the probable daily rainfalls by the on-going ADB Lai Nullah Project so as to facilitate the comparison with the obtained probable rainfalls. As discussed in Section 5.2.3, design hyetographs with different return periods are created from these probable 3, 6, 9 and 12-hourly rainfalls.

Table R 5.1.3 Probable Rainfalls

(mm)

Rainfall	Data Period	Return Period (years)						2001 Flood
		5	10	25	50	100	200	
3-hourly	32 years(1970 – 2001)	105	134	177	216	260	311	239
6-hourly	32 years(1970 – 2001)	128	167	230	287	355	437	349
9-hourly	32 years(1970 – 2001)	146	194	272	346	435	542	401
12-hourly	32 years(1970 – 2001)	151	203	291	376	481	611	444
Daily (This Study)	32 years(1970 – 2001)	152	196	263	324	395	478	411
	42 years(1960 – 2001)	136	175	239	298	371	459	
	58 years(1944 – 2001)	145	186	247	300	361	432	
Daily (ADB)	42 years(1960 – 2001)	136	162	193	215	236	N/a	

*: Annual maximum basin mean daily rainfall data are tabulated in Table 5.1.4 and their probability plotting for three different data periods is given in Fig. 5.1.7.

It is important to evaluate the exceptional flood on 23 July 2001 in terms of return period of rainfall. The 3, 6, 9 and 12-houly rainfalls of the 2001 flood are all slightly smaller than those of the 100-year return period, and the flood could be evaluated at 75 to 90 years of return period.

4) Comparison of Design Rainfall with ADB Project

According to the Design Report of the ADB Project, design rainfalls with duration of 3 hours, which almost corresponds to the concentration time of the La Nullah catchments on the project stretch, were applied to estimate design peak discharges for the river improvement. The design rainfalls were created by converting probable daily rainfalls that were estimated from daily rainfall records of 42 years observed at the Chaklala Station. Since no information of the probable 3-houly design rainfalls is presented in the Design Report, it is virtually difficult to compare them with those of this Study. Instead, the probable daily rainfalls that are luckily presented in the report are compared with the probable basin mean daily rainfalls estimated additionally in this Study by applying the same methodologies as for the 3, 6, 9 and 12-houly rainfalls.

The ADB's daily rainfalls are generally smaller than those of this Study as seen in Table R 5.1.3. The gap is bigger as the return period becomes longer, for example the ADB's 100-year daily rainfall of 236 mm is smaller by 135 mm than this Study's daily value of the same 42 years. This gap is mainly because the ADB estimation was grounded on only the Chaklala Station data that recorded the smallest rainfall among the four stations during the 2001 flood while this Study considers all the four stations to estimate the basin mean rainfalls.

It is also guessed that the ADB design 3-hourly rainfalls are significantly smaller than those of this Study, because they were based on smaller daily rainfalls. In other words, the ADB project might have underestimated the design rainfalls. This rainfall gap seems to further lead to a gap of design discharges between this Study and the ADB project as discussed in subsection 5.2.3.

5.2 HYDROLOGICAL AND HYDRAULIC SIMULATION

Following the above rainfall analyses, hydrological and hydraulic flood simulation analyses are discussed in this section. Objectives of the simulation analyses are as follows:

(1) To clarify the flood inundation mechanism in the Lai Nullah River Basin;

(2) To determine the basic hydrological parameters for designing countermeasures, such as design discharge and design water level; and

(3) To examine effects of conceivable countermeasures.

5.2.1 Software and Model-Set up

The flood simulation is generally made in two steps, namely calculation of runoff from the sub-basins and flood routing along the rivers. For some special cases, flood inundation maps are additionally generated for the purposes of verification of the established simulation model, estimation of flood damages or just simply generation of flood risk maps. Mike11 software that is an integrated software developed by DHI Water & Environment for river management was used for all the above procedures, selecting appropriate methods for each procedure among a variety of optional methods provided in the software.

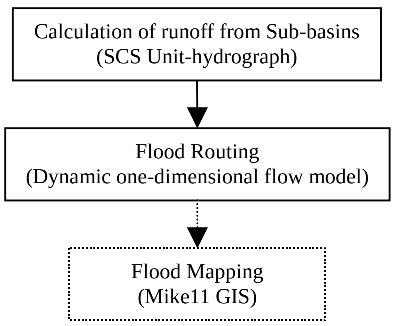


Fig. R 5.2.1 Flow of Flood Simulation

A unit-hydrograph method based on the SCS Curve Number that were used often in the previous studies for Lai Nullah was again selected to estimate runoff discharges from the 15 sub-basins presented in Fig. 5.1.1. The estimated runoff discharges were further used as inflow data to the river network for the flood routing as shown in Fig. R 5.2.2.

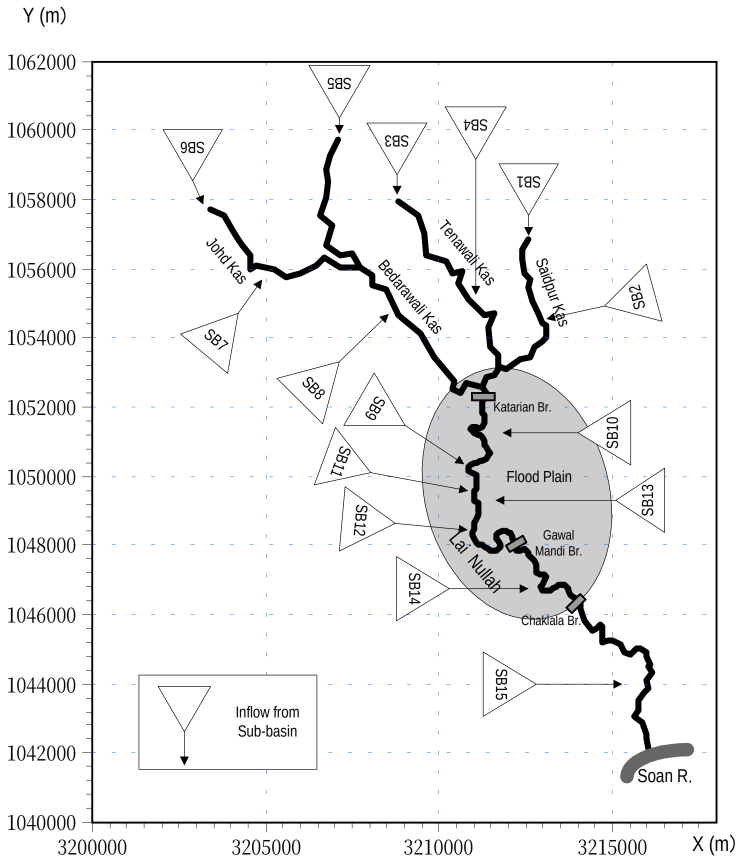


Fig. R 5.2.2 River Network

The main river, Lai Nullah, and four major tributaries, Saidpur Kas, Tenawali Kas, Bedarawali Kas and Johd Kas were considered to build the river network for the flood routing. A dynamic one-dimensional flow model of Mike11 that can simulate hydraulic phenomena more precisely was applied to estimate discharges and water levels in the river network.

The estimated water levels were further exported for the flood map generation to Mike11 GIS, which is an interface module of Mike11 with Arcview GIS software. Flood inundation depths were calculated in Mike11 GIS by interpolating and extrapolating the river water levels over the digital elevation models (DEM) of the flood plain.

1) Runoff Calculation by SCS Unit-hydrograph Method

The US Soil Conservation Service developed a method for computing abstraction from storm rainfall, introducing a concept of the Curve Number. The Curve Number CN is a kind of runoff parameter representing soil, land use and antecedent moisture conditions. The Curve Number is generally defined for normal antecedent moisture conditions (AMC II) and further modified to those for dry conditions (AMC I) or wet conditions (AMC III) according to the antecedent rainfall conditions. Using the Curve Number CN, the depth of excess precipitation P_e is given as follows:

$$P_e = (P - 0.2S)^2/(P + 0.8S) \tag{5.1}$$

$$S = 25.4 \times (1000/CN - 10) \tag{5.2}$$

where:

P: depth of precipitation.

S: potential maximum retention in mm.

The excess precipitation is converted into runoff discharge by the SCS triangular unit-hydrograph. The lag time t_l is calculated from the catchment characteristics using the standard SCS formula:

$$t_l = (L \times 3.28 \times 10^3)^{0.8} \times (1000/CN - 9)^{0.7}/(1900 \times Y^{0.5}) \tag{5.3}$$

where:

L: hydraulic length of the catchment area in km.

Y: slope.

CN: SCS Curve Number (AMC II).

2) Dynamic One-dimensional Flow Calculation

The dynamic one-dimensional flow calculation module that is based on the 'Saint Venant' equations is a core of Mike11. The equations of continuity and momentum are:

$$\frac{\partial Q}{\partial x} + \frac{\partial A}{\partial t} = q \tag{5.4}$$

$$\frac{\partial Q}{\partial t} + \frac{\partial \left(\alpha \frac{Q^2}{A} \right)}{\partial x} + gA\frac{\partial h}{\partial x} + \frac{gQ|Q|}{C^2 AR} = 0 \tag{5.5}$$

where:

Q: discharge.

A: flow area.

Q: lateral inflow.

h: water level.

C: Chezy resistence coefficient ($C=R^{1/6}/n$).

n : Manning roughness coefficient.

R : hydraulic radius

α : momentum distribution coefficient

The flood routing is made along the river network consisting of the five rivers. Pre-defined water levels at the confluence with Soan River and the estimated runoff discharge from the sub-basin at each of the four upstream ends are given as the boundary data of the river network.

Table R 5.2.1 Rivers in River Network

River	Stretch	Length (km)
Lai Nullah	Kattarian Br. to Soan River	17.5
Saidpur Kas	Zero Point to Tenawali Kas	5.8
Tenawali Kas	Jinnah Avenue to Bedarawali Kas	8.7
Bedarawali Kas	E-9 to Lai Nullah	12.7
Johd Kas	Golra Village to Bedarawali Kas	7.3

3) Flood Mapping

The flood mapping covers some 100 km^2 including the lower Islamabad area (H and I blocks) and the Rawalpindi area as the flood inundation interview survey. A DEM (Digital Elevation Model) is essential for the flood mapping and accuracy of the flood map greatly depends upon that of the DEM. In this Study topographical data obtained from the GPS survey were used to divide the 100 km^2 area into 40,000 square cells of 50 m x 50 m size, each of which was assigned a ground elevation value. Fig. 2.1.2 is the elevation map created from the 50 m DEM.

Mike11 GIS has the function for calculating water levels over each of the DEM cells by interpolating or extrapolating the water levels in the rivers. Finally the water level of each cell is converted to the inundation depth by subtracting the ground elevation.

5.2.2 Reproduction of 2001 Flood and Model Verification

The flood on 23 July 2001 that could provide the richest hydrological data, was selected as the target flood for the model verification, and reproduced to clarify the flood mechanism.

1) Model Calibrations and Model Parameters

The river cross-sectional data was availed from the results of survey by the ADB Project and this JICA Study. The survey by the ADB Project that was carried out immediately after the 2001 flood covers the project stretch between Kattarian and Chaklala Bridges on Lai Nullah. In this Study, the supplementary cross-sectional surveys were conducted between October and November 2002 for lower Lai Nullah downstream of Chaklala Bridge, several tributaries, and Soan and Kurang Rivers. These cross-sectional survey data were incorporated into the river network model.

To express the retarding effects by flood inundation, additional off-stream storage areas, of which area-elevation data were extracted from the generated DEM, were connected to the

Lai Nullah cross sections between Kattarian Bridge and Chaklala Bridge, where inundation was so extensive in the 2001 flood.

The rainfall data observed at the four stations, of which hyetographs are presented in Fig. 5.1.4, were applied for the runoff calculation of the 15 sub-basins. The basin mean rainfalls were firstly estimated for each of the sub-basins based on the Thiessen polygons, and the basin mean rainfalls were input to the SCS unit-hydrograph method.

Trial runs of runoff calculation were made until acceptable accuracy was attained, changing and adjusting model parameters including the SCS Curve Numbers and the Manning's roughness coefficients of the rivers. The SCS Curve Number by land use was finally determined as given in Table R 5.2.2 and those of the 15 sub-basins were estimated as shown in Table 5.2.1 based on the 2001 land use map given in Fig. 3.1.3. The roughness coefficients of all the rivers were determined at 0.035 for the low water channels and at 0.050 for the high water channels.

Table R 5.2.2 SCS Curve Number by Land Use

Land Use	Curve Number CN
Agricultural area	70
Residential area/Densely populated	90
Residential area/Moderately populated	75
Residential area in the Suburbs	70
Forest (Mountain area)	70
Forest (Flat area)	65
Green and grass area	65
Water Body	100

Note: under normal antecedent moisture condition (AMC II)

2) Reproduction Results

Fig. 5.2.1 presents the discharge and water level hydrographs at Kattarian, Gawal Mandi and Chaklala Bridges. As shown in the Fig., the temporal variation of the water level and discharge in the hydrographs is gradual, which could be attributed to the flood retarding effects of the river basin. The peak water level appears around 1400 hours at Kattarian Bridge and around 1800 hours at Gawal Mandi and Chaklala Bridges. The duration of flood Inundation around Gawal Mandi Bridge is estimated at about 10 hours judging from the temporal variation of water level in the hydrograph. These timings and the inundation duration agree with the memories of inhabitants and officials concerned.

Fig. 5.2.2 compares the estimated maximum water levels along Lai Nullah with the elevations of flood marks left at several bridges. It can be said that the estimated water levels match the flood marks very well.

In addition, the flood map is simulated to overview the maximum extent and depth of flood inundation and, it is confirmed that the simulated flood map could well accord with the results of the interview survey as shown in Fig. 5.2.3. As shown in the simulated flood map as well as the results of interview survey in Fig. 5.2.3, the flood inundation expands over low-lying areas along Lai Nullah and the tributaries. The extent of the whole flood inundation area and its corresponding inundation volume were estimated at 9.2 km^2 and 23 million m^3 respectively from the generated flood map.

As discussed above, the reproduction of the 2001 flood is satisfactory enough for the Master Plan Study. In conclusion, the established model is considered acceptable and applicable for estimation of the standard flood discharge described in the following subsection 5.2.3.

5.2.3 Flood Simulation for Future Scenarios

Using the established simulation model, the standard flood discharge was estimated as described hereinafter:

1) Simulation Conditions

The flood simulation is made on the premises of the without-project, which is subject to no flood mitigation effect by any new flood mitigation structure other than the on-going ADB river improvement project. The discharges estimated under this condition are called "standard flood discharge".

a) Rainfall

100-year, 50-year 25-year, 10-year and 5-year design hyetographs with 12 hours of duration were created for the future scenario flood simulation, based on the frequency analysis of 3-hourly, 6-hourly, 9-hourly and 12-hourly rainfalls discussed in Subsection 5.1.3.

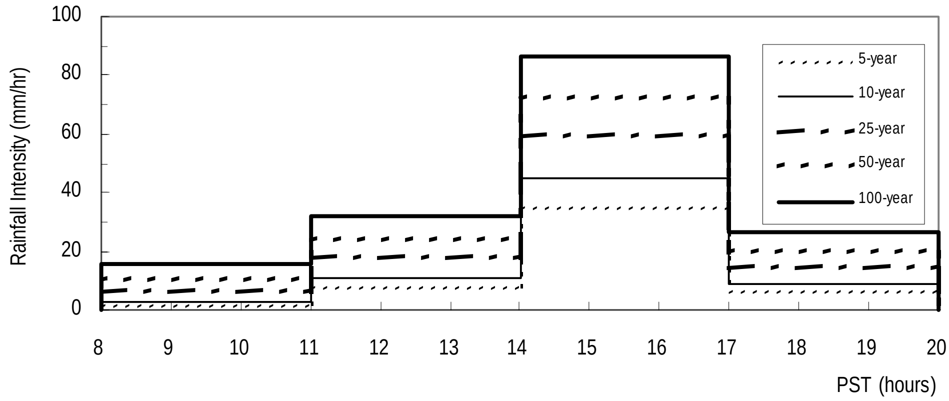


Fig. R 5.2.3 Design Hyetograph

b) Land Use

The 2012 land use condition shown in Fig. 3.1.4 was applied for this calculation. The SCS Curve Numbers of the sub-basins were modified accordingly.

c) Consideration of On-going ADB River Improvement Project

The Lai Nullah improvement project that is now in progress under the financial assistance of ADB is scheduled to complete in early 2003. The Lai Nullah will be widened by 20 to 30 m in the project.

The completion of this on-going river improvement was premised for the flood simulation, and the existing cross sections of Lai Nullah that were used for the reproduction of the 2001 flood were replaced by cross sections designed by the project, of which roughness coefficient were set at 0.030 as designed.

d) Confinement of Flood Discharges in Rivers

The additional off-stream storage areas connected to the cross sections of the simulation model for the 2001 flood were removed to confine all the flood water in the rivers not allowing any spillage because this future scenario simulation aimed to estimate river discharges under no flood inundation.

2) Simulation Results of the Standard Flood Discharge

The aforesaid standard flood discharges under the without-project condition were estimated through a model slightly modified from the simulation model for the 2001 flood. The standard flood discharges thus estimated at the two principal reference points, namely Kattarian Bridge and Gawal Mandi Bridge are compared with the probable discharges estimated from the observed water level as well as those estimated in the ADB Project as shown in Table R 5.2.3.

Table R 5.2.3 Standard Flood Discharge by Return Period

Reference Point	By	Description	5 years	10 years	25 years	50 years	100 years
Kattarian Br.	This Study	Simulated as Standard Flood Discharge	330	620	1,150	1,660	2,270
	ADB project	Estimated by Runoff Analysis	324	425	571	682	784
Gawal Mandi Br.	This Study	Simulated as Standard Flood Discharge	390	720	1,340	1,940	2,640
		Estimated From observed Water levels	490	840	1,500	2,200	3,000
	ADB project	Estimated byRunoff Analysis	563	719	942	1,109	1,264

As listed above, it could be evaluated that the values simulation as the standard flood discharge well accords with the value estimated from the observed water level. As expected in Subsection 5.1.3, however, the considerably big gaps are seen between the values simulated in the Study and estimated in the ADB Projects. These gaps become bigger as the return period is longer. The values simulated for the 100-year return period in the Study are about three times of the values estimated in the ADB project.

3) Increase of Discharge by Urbanization

Land use is also an important factor affecting flood discharges. Urbanization that is generally accompanied by pavement, building and drain installation leads to an increase of flood discharges, as experienced all over the world. It is very important to know the extent of such discharge increase caused by land use change.

In this Study, the basin average Curve Numbers reflected by the land use maps in 2001, 2012 and 2030 were estimated to gradually increase from 72 to 74 as shown in Table 5.2.1. In accordance with the increment of the Curve Numbers, the probable maximum discharge would also increase as listed below:

Table R 5.2.4 Maximum Discharges by Land Use

Reference Point	100-year Discharge (m^3/s)			25-year Discharge (m^3/s)		
	2001	2012	2030	2001	2012	2030
Kattarian Br.	2,200	2,270	2,300	1,110	1,150	1,180
Gawal Mandi Br.	2,551	2,640	2,711	1,260	1,340	1,375

4) Flood Map under Future Land Use

The flood maps were developed for the five (5) cases as shown in Table R 5.2.5. Among the cases, the Case1-2 presents the probable maximum extent and depth of the flood inundation caused by the flood 2001 assuming the flood occurs immediately after the completion of the ADB Project. This flood map will be useful to let inhabitants know what will happen if the awful 2001 flood occurs again.

Cases 2-1, 2-2 and 2-3 presents the maximum extent and depth of the flood inundation caused by the probable flood of 25, 50 and 100-year return period assuming any flood mitigation structures other than the on-going ADB Project is not given to Lai Nullah. These flood maps could be used to estimate flood damages according to the return periods. The generated flood maps and the extents of the flood inundation area are as shown in Fig. 5.2.4, and Table 5.2.2, respectively.

Table R 5.2.5 Summary of Flood Mapping

Case No	Facility Condition	Land Use	Rainfall	Estimated Inundation Area (km2)	Remarks
1-1	Existing Condition	2001	2001 Flood	9.2	Reproduction of 2001 Flood
1-2	After Completetion of ADB Project	2001	2001 Flood	7.2	Flood Risk Map
2-1	After Completetion of ADB Project	2012	100yr Rain	7.6	Without-project Condition
2-2	After Completetion of ADB Project	2012	50yr Rain	4.5	Without-project Condition
2-3	After Completetion of ADB Project	2012	25yr Rain	2.6	Without-project Condition

CHAPTER 6. FORMULATION OF FLOOD MITIGATION PLAN

6.1 PLANNING FRAMEWORKS FOR FLOOD MITIGATION

The principal objective of the Study is to formulate the comprehensive flood mitigation plan and further extend to clarification of the relevant environmental issues. Among others, the flood mitigation plan would be composed of the various structural and non-structural measures such as; channel improvement, flood diversion channel, flood retention/detention facilities, and flood forecasting/warning system. The relevant environmental improvement issues would also cover the various aspects including solid waste management, drainage/sewage management and watershed conservation.

Due to the above natures, the proposed plan would involve the various government agencies as well as private organizations/communities requiring the quantitative work volume and land acquisition. As the results, the plan would lead to the long implementation period and the project investment cost that may take up a substantial share of the annual national development budget. On the other hand, the flood mitigation effects are urgently and at the same time, progressively required to prevent the target areas (i.e., Islamabad and Rawalpindi) from the recurrent disastrous flood damage and enhance the better urban environments. Accordingly, the proposed project would need to be implemented through the phased programs in line with the national development strategies.

6.1.1 Relevant National Development Plan

The updated national development strategies in Pakistan are formulated through "Three-year Plans (2001-2004)" and the "Ten Year Perspective Plan (2001-2011)" drafted by the Planning Commission taking into account the recommendations and suggestions from the relevant federal and provincial government agencies. These two (2) national development plans involve the various sectors and, among others, the sector of flood mitigation is derived from the "National Flood Mitigation Plan (NFPP)" prepared by the Federal Flood Commission (FFC).

Before establishment of NFPP, the Provincial Irrigation Departments and the relevant federal agencies used to prepare their own flood protection plans only within their jurisdiction areas without inter-provincial coordination. Such localized plans tended to cause the unnecessary disputes between the upstream and downstream provinces, and the inefficient project investment. Hence, the NFPP was established to implement the nation-wide flood mitigation plans unifying the proposals from various provinces and federal government agencies.

Two (2) phases of NFPP have been implemented during the recent two decades (1978 to 1998); namely Phase I (NFPP-I) for 1978-1988 and Phase II (NFPP-II) for 1988-1998. The draft of Phase III (NFPP-III) has further been prepared for the project implementation from 1998 to

2012. The investment cost for the NFPPs had remarkably increased from Rs. 1,630 million for NFPP-I to Rs. 16,360 million for NFPP-II. The investment cost in NFPP-III is further scheduled to increase to Rs. 25,965million as listed below.

Table R 6.1.1 Investment Cost and Schemes Implemented under NFPP

Phase of NFPP	Classification	Investment Cost		Number of Schemes
		By Local Fund (Rs. Million)	By Foreign Fund (US$ Million)	
NFPP-1 (1978-88)	Normal Annual Development Program	1,630	0	311
NFPP-II (1988-98)	Normal Annual Development Program	2,541	0	170
	Flood Protection Sector Project-I (FPSP-1)	4,860	131	257
	1988 Flood/Rain Damage Restoration Project	2,300	200	2,065
	1924-94 Flood/Rain Damage Restoration Project	6,659	193	1980
	Total of NFPP-II	16,360	524	4,472
NFPP-III (1998-12)	Normal Annual Development Program (2000-2012)	2,400	Not fixed	Not fixed
	Flood Protection Sector Project-II (FPSP-I1) (1998-2004)	16,184	Not fixed	Not fixed
	Flood Protection Sector Project-III (FPSP-II1) (2005-2012)	7,381	Not fixed	Not fixed
	Total of NFPP-III	25,965	Not fixed	Not fixed

Note (1) : The investment cost and number of schemes for NFPP-I and II are the value actually invested, while the investment cost for NFPP-III are the proposed value as of 2001.

Note (2) : The investment cost for local fund under NFPP-III could be reduced provided that the financial assistance by the foreign fund could be induced.

Source : Annual Flood Report 2001, by FFC for NFPP-I and II
National Flood Protection Plan-III for NFPP-III

A particular attention in the above Table R 6.1.1 is given to the phased programs applied to NFPP-II and III. That is, the projects in NFPP-I were implemented solely through the "Normal Annual Development Program", which is based on the actual annual requirement, while those in NFPP-II and III are implemented through not only the "Normal Annual Development Program" but also phased developments programs called "Flood Protection Sector Project (FPSP)". Thus, the importance of the flood protection projects in Pakistan is being recognized and the strategic nation-wide flood protection projects are steadily being implemented through the phased programs.

The structures as the primary output of the NFPP-I, II, III consist of the flood protection bunds (embankment), the channel protective spurs and the hill torrents structures. The length of the flood protection bunds and number of spurs so far constructed has reached 5,822km and 363 lots in total, respectively as listed in Table R 6.1.2.

Table R 6.1.2 Length of Existing Flood Protection Bund and Spurs

Name of Province	Length of Flood Bund (km)	Number of Spurs
(a) Punjub	2,749	151
(b) Sindh	2,422	36
(c) Northern West Frontier Province	290	176
(d) Balochistan	361	-
Total	5,822	363

Source: National Flood Protection Plan-III (1998-2012), May 2001 by FFC

The outputs of the NFPPs also cover the non-structural measures such as improvement of flood forecasting/warning system through expansion of the weather radar gauging system and data processing system to facilitate the flood management works. An attempt in the NFPP was further made to create public awareness so to enhance participation of beneficiary to the relevant flood prevention works.

The outputs of NFPPs are, however, oriented to flood protection and channel conservation for the nation-wide large rivers such as Indus River and its principal tributaries Chenab, Ravi, Sutlej and Jhelum Rivers. On the other hand, NFPP has given less attention to protection of the urban flood, particularly to the flood overflow from the small rivers similar to the Lai Nullah. That is, the urban flood tends to be regarded as the issue of urban drainage under jurisdiction of a local government, and the urban flood protection plan has been formulated and/or implemented by each of the competitive local government authorities on the ad-hoc basis with less compliance to the national development strategy.

The flood overflow in the urban areas tends to cause the disastrous damage with death of people as the progress of the intensive urbanization, and seriously inflict the national socio-economic deteriorations. Accordingly, it is indispensable to delineate the nation strategy for urban flood mitigation, and the NFPP should cover this category as the further challenge. From these viewpoints, the Study will be made on the premises that the proposed flood mitigation plan for Lai Nullah should be newly programmed in the NFPP-III and further incorporated into the national development plans of the aforesaid “Three-year Plans (2001-2004)” and the “Ten Year Perspective Plan (2001-2011)”.

6.1.2 Target Design Flood Scale of the Project

The target design flood scale is proposed at 100-year return period as the ultimate goal of the project from viewpoints of the following items (1) to (3).

(1) The flood in July 2001 is regarded as the recorded maximum flood, and its recurrence probability is evaluated to be little under 100-year return period (refer to Chapter 5). The target design flood level should cover this recurrence probability of the recorded maximum flood.

(2) The Steering Committee for the Study through the meeting on the Inception Report preferred that the target design level of the long-term flood mitigation for the Lai Nullah should reach 100-year return period at least.

(3) There does not exist any definitive guideline for the design flood scale to be applied to the urban centers in Pakistan. Nevertheless, the flood damage of the Study area, which encompasses the twin cities of Islamabad and Rawalpindi, could bring out the significant adverse effect to the national development. In order to avoid such nation-wide adverse effect, the Asian countries apply the design flood scales of 100-year

return period for their capitals or major cities as listed below:

Table R 6.1.3 Design Flood Level for River running through Capital and/or Major Cities of Asian Countries

Country	River	Major City in River Basin	Population of the City (million)	Design Flood (return period)	Remarks
Japan	Tone	Tokyo	12.0	200	Completed
Thailand	Chao Phraya	Bangkok	7.6	100	Planned
Philippines	Pasig-Marikina	Manila	9.5	100	Planned
Indonesia	Ciliwung	Jakarta	10.0	100	Completed
Malaysia	Klang	Kuala Lumpur	1.5	100	Planned
Vietnam	Red	Hanoi	2.1	100	Planned

The on-going river channel improvement for the Lai Nullah with financial assistance from ADB aimed at achieving the design flood level of 25-year return period, while the substantial channel flow capacity given by the on-going channel improvement is still limited to only at about 10-year return period according to verification based on the probable flood runoff discharges as simulated in the foregoing Chapter 5. Under such condition, it is virtually difficult to achieve the ultimate goal of 100-year return period all at once. In due consideration of these conditions, it is also proposed that the design flood scale of 25-year return period should be applied as the mid-term target of the objective flood mitigation plan.

6.1.3 Phased Programs and Target Project Completion Time

The proposed flood mitigation plan is divided into the three (3) phased programs in order to achieve the immediate flood mitigation effects and at the same time to achieve the long-term sustainable flood mitigation effect. The target structural design level and the target completion year for the phased programs are as listed in Table R 6.1.4.

Table R 6.1.4 Proposed Phased Flood Mitigation Program

Phased Program	Target Structural Design Level	Target Completion Year
Urgent Project	Indefinite*1	2005
Short-term Project	25-year return	2007
Lon-term Project	100-year return	2012

Note: *1: Regardless to the design level, the urgent project is implemented as the priority component of the short-term project in order to produce the immediate flood mitigation effect

*2; The project would need to continue even after completion of the long-term project until the basin stops its urbanization.

1) Urgent Project

The urgent project would be proposed among the components of the under-mentioned short-term project taking urgency and easiness of project implementation into account. The urgent project is assumed to complete by the year of 2005 to produce the immediate flood mitigation effect.

2) Short-term Project

As described in the foregoing subsection 6.1.2, the on-going channel improvement for Lai Nullah from Kattarian Bridge to Chaklala could hardly achieve its original design flood level of 25-year return flood, and a certain supplementary and/or reinforcement works are required to reach the original design level. Hence, the short-term project is proposed to fulfill the design level of 25-year return period. The on-going channel improvement is scheduled to complete by September 2003, and, thereby target completion year of the entire the short-term project is provisionally assumed at 2007 considering that the components of the short term project would require the further detailed field investigations and clarification of technical and economical viability.

3) Long-term Project

The ultimate target design level of 100-year return period for the flood mitigation of Lai Nullah would be achieved through the long-term project. The objective flood mitigation plan for the Lai Nullah contains the significant effect to the national and regional socio-economy, and it should be implemented in line with the relevant national development plans. In this connection, the flood mitigation plan for Lai Nullah proposed in this Study should be newly programmed in the NFPP-III (1998-2012) and further incorporated into the national development plans of the “Ten Year Perspective Plan (2001-2011)” (refer to in the foregoing subsection 6.1.1). Taking the implementation period of these relevant national development plans into consideration, the target completion year for the long-term project is preliminarily assumed at 2012.

As stated above, the whole phased programs are to complete by the year of 2012, while the Lai Nullah basin, Islamabad in particular may expand the urban area even after the completion year of 2012. The progress of urbanization would curtail the non-built-up area such as vacant land and natural forest, which are not sealed by pavement and contain many low pits contributing to the natural flood retarding effect. As the results, Islamabad (i.e., the upper reaches of Lai Nullah above Kattarian Bridge) may gradually increase its basin peak flood runoff discharge.

CDA has projected to complete the urban development plan of Islamabad by the year of 2030. According to the urban development plan of Islamabad, however, the upper reaches of Lai Nullah basin above Kattarian Bridge (i.e., the jurisdiction area of Islamabad) would have the relatively slow progress of urbanization from present up to 2030, that is: the urbanized area of the basin will increase from 32.4% in 2001 to 42.7% in 2012 and 49.6% in 2030. Due to such limited extent of urbanization, any significant difference is not seen in the probable peak runoff discharges in 2001, 2012 and 2030 as shown in Table R 6.1.5. Accordingly, it is expected that the flood safety level achieved by the long-term project would be ever sustained even after completion of the long-term project, and any flood mitigation program posterior to the long-term project would not be required. From these viewpoints, the design discharge estimated under the land use states of year 2012 is applied to the whole of the urgent project, the short-tem project as well as the long-term project.

Table R 6.1.5 Probable Flood Runoff Discharge and Urbanized Ration of Lai Nullah Basin

Description		Year 2001	Year 2012	Year 2030
1. Probable Flood Discharge of Lai Nullah at Kattarian Bridge	5-year return period	310 m^3/s	330 m^3/s	350 m^3/s
	25-year return period	1,110 m^3/s	1,150 m^3/s	1,180 m^3/s
	100-year-return period	2,200 m^3/s	2,270 m^3/s	2,290 m^3/s
2. Urbanized Ratio* of Lai Nullah Basin above Kattarian Bridge		32.4%	42.7%	49.6%

Note*: Urbanized Ration means the share of built up area (=residential area + commercial area + industrial Area) to the total extent

6.2 POTENTIAL STRUCTURAL FLOOD MITIGATION MEASURES

As the results of field reconnaissance, interview survey on the extent of the past floods, and review on the previous relevant studies, the followings are preliminarily scrutinized as the potential structural measures for the flood mitigation of Lai Nullah (refer to Fig. 6.2.1):

(1) River channel Improvement of Lai Nullah and its tributaries;

(2) Community pond at Fatima Jinnah Park in Islamabad;

(3) Flood mitigation dam to be placed in the area administratively called Block E-11 of Islamabad;

(4) Flood diversion channel to divert the flood discharge from tributaries of Bedarawali Kas, Tenawali Kas and Saidpur Kas to Kurang river;

(5) On site-flood detention facilities such as (i) the rainfall storage tank installed at individual house lot, (ii) the on-site flood detention pond and (iii) the infiltration facility.

Among others, the structural measures of the above items (1) to (4) are called the off-site structures and to be completed through a series of the urgent project, the short-term project and the long-term project by 2012 so as to cope with the design discharge from the whole catchment area. Each of the off-site structures has the large structural scales and produce immediate and large flood mitigation effect. Details of the off-site structural measures are as described in the following subsections 6.2.1 to 6.2.4.

The structural measure of the above item (5) is called the on-site structure to cope with the local flood/drainage problems and/or the increment of the peak runoff discharge inflicted by the land development as required. Each of the on-site structures has the far smaller flood mitigation effect as compared with the aforesaid off-site structures, and it is installed as supplement to the off-site structure, as required. The typical structural features of the on-site structures are introduced in the following subsection 6.2.5, but the definitive structural plan for the on-site structure, which is dominated by the local geophysical conditions, is not formulated in this Study.

6.2.1 River Channel Improvement

As described above, the on-going channel improvement of Lai Nullah above Chaklala Bridge could cope with the probable flood peak discharge of only 10-year return period, which is below the target design level of the aforesaid short-term project (i.e., 25-year return period). Hence, the further channel improvement is considered as one of the potential flood mitigation measures.

1) Extent of Channel Improvement

Judging from the river features and channel flow capacities as evaluated in the foregoing subsection 2.3, the maximum extent of the channel improvement may cover the following stretches of the mainstream and tributaries:

(a) *Mainstream of about 11.0 km from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210)*: The channel improvement is required to increase the channel flow capacity of the on-going river channel improvement;

(b) *Mainstream of about 1.1 km (RD4+077–RD5+227) below Chaklala Bridge*: This stretch is out of the extent of the on-going river channel improvement, but unconditionally requires enlargement of the cross-sections at the bottleneck in order to avoid the unfavorable adverse backwater effect to the channel flow conditions of the stretch of above item (a) (refer to the following subsection 2.3 in detail)

(c) *Three (3) tributaries of Bedarawali Kas, Tenawali Kas, and Saidpur Kas, which concentrate to the mainstream of Lai Nullah at Kattarian Bridge*: the flood flow of these tributaries are influenced by the backwater from the mainstream at Kattarian bridge, and may require a certain extent of channel improvement; and

(d) *Eight (8) tributaries, which flow into the mainstream between Chaklala Bridge and Kattarian Bridge*: these may require a certain extent of channel improvement associated with the channel improvement of the mainstream (refer to Table R 2.3.1).

The necessity of channel improvement for the above stretches are evaluated, and the channel improvement plans are proposed as described in the following items 2) to 5).

2) Channel Improvement Plan for Mainstream from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210)

Through the on-going channel improvement, the substantial extent of land acquisition has been made in the densely populated area of Rawalpindi. The further land acquisition has to require demolishing of the tremendous number of house/buildings closely packed along the river, which would cause the extremely serious frictions with the residents.

Judging from these social problems anticipated, the Steering Committee Meeting for the Study concluded in August 2002 that the right-of-way secured for the on-going channel improvement should be the maximum limit, and that the further widening of the river channel is no longer applicable. In accordance with this conclusion, the possible measure posterior to the on-going channel improvement is to be oriented to deepening of the riverbed instead of the river widening.

Deepening of the riverbed had been already proposed by the Rawalpindi Electric Supply Company in 1944 by blasting of the waterfall located about 2.5km downstream from Chaklala Bridge, while the proposal was finally ruled out due to adverse effects to the upstream bridges as well as the buildings along the river. Nevertheless, the adverse effects to the bridges and buildings could be offset by reconstruction and/or reinforcement for them, controlling of the flood flow velocity and/or providing of the bank protection and, therefore would not be the critical issue to rule out the proposal.

The proposed alignment, longitudinal profile, typical cross-sections and the relevant works for the channel deepening are as described hereinafter:

a) Alignment

The channel deepening is made on the designed riverbed of the on-going channel improvement. Accordingly, the proposed channel improvement follows the alignment of the on-going channel improvement.

b) Longitudinal Profile

The ongoing channel improvement maintains the existing channel bed slope of about 1/1,250. This bed slope has been formed by the long-term flow regime, and judged to be stable minimizing sedimentation and/or erosion. From these viewpoints, the existing channel slope of 1/1,250 is preferred as the optimum channel bed slope even after deepening of the channel improvement.

Partial deepening of the channel with using the groundsill will not be applicable to increase the overall channel flow capacity, and, the channel bed of the entire target river stretch should be lowered by a uniform depth with maintaining the channel bed slope 1/1,250.

On the premises of the above conditions, the optimum depth for lowering is assumed as 2m taking the following conditions into account:

(i) The on-going channel improvement is now in progress with its designed channel depth of 7.5m, which causes the maximum channel flow capacity of more than 3m/s. The excessive channel deepening would increase the unfavorable channel flow velocity far faster than 3m/s, causing difficulties in maintaining the river channel. In this connection, the allowable maximum channel velocity is provisionally assumed as 4m/s, and the allowable extent of channel deepening is assumed at 2m to control the channel flow velocity below the allowable limit.

(ii) The consistent channel bed slope of 1/1,250 would need to be maintained up to waterfall (RD3+800) about 2.5km downstream from Chaklala Bridge (refer to the following item 3). Under this condition, the channel deepening of more than 2m would require removal of waterfall and the extensive excavation of hard rocks, which outcrops below Murree Brewery (located about 700m upstream of the waterfall).

(iii) The channel deepening of 2m could avoid channel improvement of the upper tributaries of Bedarawali Kas, Tenawali Kas, and Saidpur Kas, as well as reconstruction of 11 bridges crossing over the tributaries.

The longitudinal profile for channel deepening is delineated, on the premises of the channel deepening by 2m with the channel bed slope of 1/1,250 as shown in Fig. 6.2.2.

c) Typical Cross-Sections

A compound section with high and low water channels is preferable in general due to advantages such as minimizing of embankment height and assuring of channel stability. The on-going channel improvement, however, adopted a single cross-section with a side-slope of 1 to 1.5, and the further channel improvement would also need to follow the same shape of cross-section due to difficulties of land acquisition. The dimensions of the typical cross-sections for the proposed channel deepening of Lai Nullah are as listed in the following Table R 6.2.1 (refer to Fig. 6.2.3):

Table R 6.2.1 Typical Cross-section of Proposed Channel Deepening

Section (Name of Bridge)				Width (m)		Depth (m)
Downstream		Upstream		Bottom	Top	
Name of Bridge	RD	Name of Bridge	RD			
Chaklala	6+215	Dhoke C. Din	8+060	38.4	69.9	9.5
Dhoke C. Din	8+060	Railway Road	8+325	36.4	67.9	9.5
Railway Road	8+325	Murree Road	8+628	36.2	67.7	9.5
Murree Road	8+628	Gawal Mandi	9+814	35.9	67.4	9.5
Gawal Mandi	9+814	City S. Road	10+790	35.2	66.7	9.5
City S. Road	10+790	Ratta A. Road	11+780	34.8	66.3	9.5
Ratta A. Road	11+780	Gunj Mandi	12+630	34.3	65.8	9.5
Gunj Mandi	12+630	Pir Wadhai	14+428	31.9	63.4	9.5
Pir Wadhai	14+428	Khayaban S.S.	14+100	29.5	60.9	9.5
Khayaban S.S.	14+100	Parrian	16+178	20.4	51.9	9.5
Parrian	16+178	Kattarian	17+210	18.5	50.0	9.5

d) Side Slope Protection

The on-going river channel improvement provides the side slope protection by stone pitching only along right and left banks of 100 feet (about 30m) upstream and 200 feet (about 60m) of each of the existing nine (9) bridges and reconstructed three (3) bridges. Other substantial parts of the stretch are left unlined without any side slope protection. According to the site inspection by the Study Team, however, the gully erosion has appeared on the surface of side slope along the unlined stretch, and it may develop further serious bank erosion and lead to collapse of riverbank.

The necessity of the side protection all along the stretch was once acknowledged in the design meetings for the on-going channel improvement, but finally turned down considering compatibility with the further channel improvement proposed in this Study. Thus, the side protection works for the on-going channel improvement could be regarded as the expedient, and it is indispensable to provide side slope protection all along the stretch for channel improvement as the permanent measure. Considering the current progress of bank erosion observed and the other channel conditions such as the channel depth of 9.5m and the expected maximum channel flow capacity of about 4m/s, the bolder concrete should be preferable as the type of the side protection instead of the stone pitching as proposed in the on-going river channel improvement.

e) Reconstruction and Reinforcement Works of Bridges

There exist nine (9) bridges crossing over the target river stretches (refer to Fig. 6.2.4). According to interview survey, the depth of their foundations, although it is unknown, is likely to be very shallow. Moreover, the top level of foundation is rather high as compared with the riverbed level and will be exposed by the channel deepening. Due to the these unfavorable conditions, all of the existing bridges would need to be reconstructed, should the channel deepening be implemented. The approximate length and width of these bridges to be reconstructed are as listed in Table 6.2.1.

In addition to the existing bridges, reconstruction works are now being undertaken for the following three (3) bridges through the on-going channel improvement: namely, (a) Dhoke Chiragh Din, (b) Gawal Mandi and (c) Pir Wadhai. All of these new bridges have the adequate foundation depth of more than 18m. However, as for Dhoke Chiragh Din, and Pir Wadhai Bridge, their top foundation would be exposed above the proposed riverbed level, should the riverbed be lowered by 2m as listed in Table R 6.2.2. Accordingly, these two (2) bridges would require the reinforcement works for their foundations.

Table R 6.2.2 Foundation of Bridges Reconstructed in On-going Channel Improvement

Name of Bridge	Riverbed Level after Deepening*	Number of Foundation	Level of Foundation		Foundation Depth	Exposure of Foundation
			Top	Tip		
Pir Wadhai	EL. 488.5m	4	EL. 490.5 m	EL. 471.3 m	20.2 m	2.0 m
Gawal Mandi	EL. 485.6m	4	EL. 483.6 m	EL. 464.4 m	20.2 m	-2.0 m
Dhoke Chiragh Din	EL. 484.1m	6	EL. 484.0 m	EL. 467.0 m	18.0 m	0.1 m

Source: Drawings for Reconstruction of Bridge, Urban Water Supply and Sanitation Project-Phase 1 for Rawalpindi, Mott Macdonald, 2002

3) Channel Improvement Plan for Main Stream (RD5+277-RD6+215) below Chaklala Bridge

As described in the foregoing section 2.3, realignment (short-cut)/enlargement of the meandering section (RD4+077 to RD5+277) has been completed by PMU, RDA (refer to Figs. 6.2.5 and 6.2.6), which could accommodate an adequate channel flow capacity, even when the channel above Chaklala Bridge is deepened by 2m. The existing channel from waterfall (RD3+800) to the short-cut section has also extensive cross-sectional flow area, which is far larger than the design cross-section of the above short-cut section. The channel improvement is, however, required to the section of about 1.0km in length (RD5+227 to RD6+215) sandwiched between the short-cut section around Murree Brewery Area and the on-going channel improvement above Chaklala Bridge in order to offset adverse backwater effect to the upper river section regardless to aforesaid channel deepening of the upper stretch from Chaklala Bridge.

a) Alignment

The objective channel improvement section (RD5+227 to RD6+215) has almost strait alignment, and any realignment is not required to the section (refer to Fig. 6.2.5).

b) Longitudinal Profile

The channel bed slope from waterfall (RD3+800) to the upstream end of short cut section (RD5+277) is about 1/1,250, almost same as that of the on-going channel improvement section from Chaklala Bridge (RD6+251) to Kattarian Bridge (RD17+210) (refer to Figs. 6.2.2 and 6.2.6). On the other hand, the channel depth from waterfall to the upstream end of short cut section is about 2m deeper than that of the on-going channel improvement section (refer to Fig. 6.2.2).

The objective improvement section has a steep bed slope of 1/180 forming a transition of the channel bed profile from the on-going channel section above Chaklala Bridge to the short-cut section as shown in Fig.6.2.2. It is also recognized that an extent of about 20 to 50m in width along the right and left bank of the objective channel improvement section (RD5+227 to RD6+215) is currently remained as vacant land.

Taking these river features into consideration, widening of the channel is preferred as the optimum channel improvement rather than channel deepening, and the existing channel bed profile should be remained with a minimal excavation.

c) Typical Cross-section

The typical cross-sections were prepared for the following two (2) cases: (a) the on-going channel improvement section above Chaklala Bridge is remained without further channel deepening; and (b) the on-going channel improvement section is further deepened by 2m as described in the above item 2).

The typical cross-sections should have the channel flow capacity to offset the aforesaid adverse backwater effect to the upstream section. On the premises of this required channel flow capacity and the above proposed longitudinal profile, the dimensions of the typical cross-sections for the above two cases are determined as listed in the following Table R 6.2.3 (refer to Figs. 6.2.7 and 6.2.8):

Table R 6.2.3 Typical Cross-section for Section from Waterfall to Chaklala Bridge

Case	States of Upstream from Chaklala Bridge	Dimensions of Cross-section		
		Width (m)		Depth (m)
		Bottom	Top	
Case A	The on-going channel improvement section remains without channel deepening	20.0	48.5	9.5
Case B	The on-going channel improvement section is further deepened by 2m	44.4	72.9	9.5

Note: (1) A single cross-section with a side-slope of 1 to 1.5 was adapted in the same way as the upstream of Chaklala Bridge.

(2) High water level is set at 1m below the bank level assuming 1m depth of free board

d) Side Slope Protection

Considering the channel depth of 9.5m and the expected maximum channel flow capacity of about 4m/s, the bolder concrete is adapted as the type of the side protection in the same way as the upper stretch from Chaklala Bridge.

4) Potential Channel Flow Capacity and Design Discharge of Lai Nullah

As described above, two (2) cases of channel improvement is proposed for the bottleneck section (RD5+277 to RD6+215) of about 1km in length below Chaklala Bridge. The first case is on the premises that the on-going channel improvement section above Chaklala Bridge remains without further channel deepening. This first case is unconditionally required to offset the adverse backwater effect and secure the design discharge of the on-going channel improvement.

The second case is subject to channel deepening of the on-going channel improvement above Chaklala Bridge. In this second case, the typical cross-section of the bottleneck section below Chaklala Bridge is enlarged as shown in Table R 6.2.3, and the riverbed of the on-going channel improvement is deepened by 2m. Due to these channel enlargements, the channel flow capacity would increase from 640 m^3/s to 900 m^3/s at Kattarian Bridge and from 1,000 m^3/s to 1,400 m^3/s at Chaklala Bridge as listed below.

Table R 6.2.4 Potential Channel Flow Capacity of Lai Nullah before and after Proposed Channel Improvement

Section of Lai Nullah				Potential Channel Flow Capacity (m^3/s)	
Downstream		Upstream		Before Deepening	After Deepening
Description	RD	Description	RD		
Short-cut section	4+077	Short-cut section	5+277	1,810	1,810
Proposed improvement section	5+277	Proposed improvement section	6+215	1,010	1,500
Chaklala Bridge	6+215	Dhoke C. Din Bridge	8+060	1,010	1,400
Dhoke C. Din Bridge	8+060	Railway Road Bridge	8+325	1,010	1,400
Railway Road Bridge	8+325	Murree Road Bridge	8+628	1,010	1,400
Murree Road Bridge	8+628	Gawal Mandi Bridge	9+814	970	1,370
Gawal Mandi Bridge	9+814	City S. Road Bridge	10+790	960	1,350
City S. Road Bridge	10+790	Ratta A. Road Bridge	11+780	950	1,330
Ratta A. Road Bridge	11+780	Gunj Mandi Bridge	12+630	940	1,320
Gunj Mandi Bridge	12+630	Pir Wadhai Bridge	14+428	910	1,290
Pir Wadhai Bridge	14+428	Khayaban S.S. Bridge	14+100	890	1,260
Khayaban S.S. Bridge	14+100	Parrian Bridge	16+178	690	960
Parrian Bridge	16+178	Kattarian Bridge	17+210	640	900

5) Necessity of Channel Improvement for Tributaries above Mainstream of Lai Nullah

As described above, the channel flow capacity of Lai Nullah is expected to increase to 900 m^3/s at Kattarian Bridge by the proposed channel deepening. It is estimated from the results of the hydrological analysis in Chapter 5 that the increased channel flow capacity of 900 m^3/s corresponds to the flood runoff discharges of 504 m^3/s from Bedarawali Kas, 244 m^3/s from Tenawali Kas and 152 m^3/s from Saidpur Kas. On the other hand, the existing flow capacities of the tributaries are estimated at 730 m^3/s for Bedarawali Kas, 320 m^3/s for Tenawali Kas and 200 m^3/s for Saidpur Kas (refer to the foregoing Table R.2.3.6). Thus, all of the tributaries have the adequate channel flow capacities larger that the runoff discharges equivalent to the increased flow channel capacity of Lai Nullah at Kattarian Bridge (refer to Table R 6.2.5). Accordingly, as long as the design discharge of Lai Nullah is set below 900 m^3/s at Kattarian Bridge, any channel improvement associated with the channel deepening of the mainstream is not required to the tributaries.

Table R 6.2.5 Existing Channel Flow Capacity and Probable Runoff Discharge of Tributaries above Kattarian Bridge

Name of Tributaries	Existing Channel Flow Capacity of Tributaries	Probable Runoff Discharge Equivalent to Design Discharge of 900m^3/s for Lai Nullah at Kattarian Bridge
Bedarawali Kas	730 m^3/s	504 m^3/s
Tenawali Kas	320 m^3/s	244 m^3/s
Saidpur Kas	200 m^3/s	152 m^3/s
Total	1,250 m^3/s	900 m^3/s

6) Necessity of Channel Improvement for Tributaries below Kattarian Bridge

As described in the foregoing section 2.3, there are nine (9) tributaries flowing into the mainstream of Lai Nullah from Kattarian Bridge to Chaklala Bridge. Among others, the channel cross-sectional survey was carried out for eight (8) tributaries during the first field survey. The field reconnaissance was further carried out to crosscheck the results of cross-section survey with using the results of GPS survey on the ground level along the tributaries. As the results, it was finally clarified that almost all part of the whole tributaries has the adequate bank level above the design high water level of the on-going channel improvement of the mainstream as shown in Fig. 6.2.9. Accordingly, any major flood protection work for the tributaries would not be required. Nevertheless, necessity of some minor bank protection is detected at the downstream end of the tributaries of Pir Wadhai Kassi (No. R4), Workshop Tributary (No. L4), Saddar Tributary (No. R1) and Dhok Churaghdin Tributary (No. L1).[9]

6.2.2 Community Pond

The possible site and the detailed structural plans for the proposed community pond are as described hereinafter:

1) Possible Site

A community pond has the function of temporarily storing runoff discharge on the way to the upper or middle reaches of a river and thus flattening the peak runoff discharge. This measure is very effective for mitigation of flood with a short flood concentration time and it

[9] The location of the tributaries are as shown in Fig. 2.3.1.

is technically managed to detain runoff discharge before joining into the lower rivers that do not have sufficient flow capacities. However, its applicability definitely depends on a suitable site that technically and regionally allows temporary inundation, because this type of facility requires large flood regulation capacity and a rather extensive land acquisition.

In the study area, possible sites for the community pond are very limited. In Rawalpindi, the land along the river course is fully and disorderly utilized as built-up area with dense population. In Islamabad, urbanization has been neatly promoted in the form of square lots, each of which is used for a specific purpose such as administration, commercial and residential areas.

Under the above land use conditions in the study area, the Fatima Jinnah Park covering an extent of 3 km^2 located in the north of the study area is a strong candidate of the site for the community pond (refer to Figs. 6.2.10 and 6.2.11). It was planned and constructed at administratively called Block F-9 as the National Park in the capital city in 1960's. The substantial part of it still remains as the vacant land without any major permanent structure.

Taking the above into consideration, the community pond is proposed to construct at the Fatima Jinnah Park. The principal advantages of the proposed pond are as enumerated below:

(a) Any land acquisition and house evacuation is not required,

(b) CDA, the administrator of the park has given the provisional consent to use the park as the community pond in view of the function of community pond to improve the amenity of the park,

(c) The community pond can widely produce the benefits such as leading to effective land use, lowering of land development cost and creating of the urban scenery through introduction of greening and water-based beautification.

2) Flood Diversion from Tributary of Bedarawali Kas

The catchment area of the community pond proposed on the tributary of the Tenawali Kas is about 16.6 km^2, which is equivalent to only 7 % of the Lai Nullah River Basin. Generally, the larger catchment area brings out the higher effectiveness of the flood mitigation function and the greater the cost advantage of the facilities. From this point of view, it is proposed to divert the flood discharge of the Bedarawali Kas to the community pond as shown in the following figure.

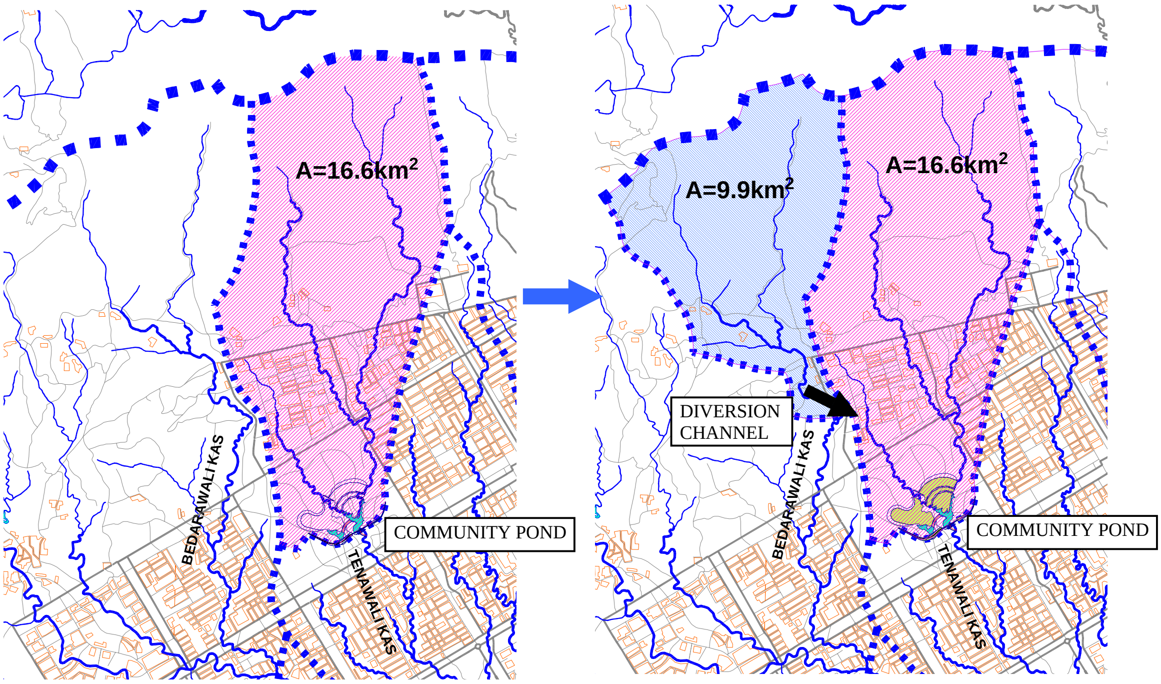


Fig. R 6.2.1 Flood Diversion from Tributary of Bedarawali Kas to Community Pond

The total catchment area of the community pond becomes about 26.5 km^2, which is equivalent to 11.3 % of the Lai Nullah River Basin. The length of the diversion channel is about 1,340 m (refer to Fig. 6.2.12).

3) Layout of Community Pond

The community pond should be designed hydraulically to have the flood mitigation function as described in the previous section. In the Fatima Jinnah Park, small dam with flood mitigation function is planed on the waterway immediately downstream of the confluence of two tributaries. The crest level of the small dam should be set below EL. 557.0 m so as to limit the temporally flood inundation area in the park. In addition to the flood mitigation function, those facilities contain a potential to provide the public amenity space and improve the scenery in the urban area. Accordingly, the environmental conditions of pond area would be improved so that the residents will easily and safely access and use the area. A community pond with some stages made through excavation is proposed to use the lower stage for water area and the higher stage for a recreation purpose such as garden, play ground, tennis courts and so on.

The plan and the cross sectional layout of the community pond is as shown in the following Fig. R 6.2.2 (refer to Fig. 6.2.13):

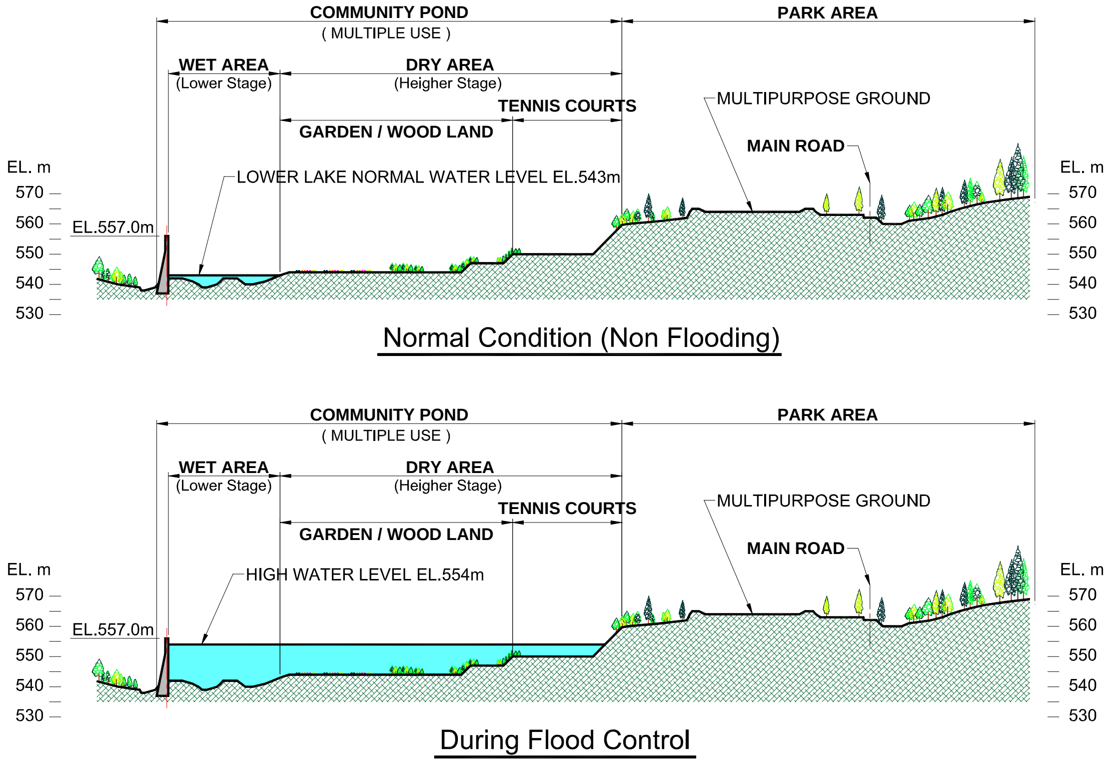


Fig. R 6.2.2 Cross Sectional Layout of Community Pond

4) Flood Mitigation Plan and Reservoir Capacity Allocation

As mentioned in the previous section, the flood mitigation capacity of the community pond is planned as the maximum development so as to limit the temporally flood inundation area in the park. Based on this concept, the proposed community pond is proposed to have a storage capacity to cut almost all the probable peak runoff discharge of 25-year return period, and reduce about 35% of the peak flood discharge even in case of 100-year return period at site.

These functions could increase the flood safety level of the downstream of Lai Nullah. Calculation results of flood mitigation effect at dam site are given in Fig. 6.2.14 and summarized as below:

Table R 6.2.6 Flood Mitigation Effect of Community Pond at Site

Return Period	Inflow			Regulated Peak Outflow Discharge (m^3/s)	Pond Surface Level (EL. m)	Pond Surface Area (km^2)	Peak Discharge Reduction Rate (%)
	Diverted Flood Discharge (m^3/s)	Flood Discharge (m^3/s)	Total (m^3/s)				
5-year	24	44	68	11	547.0	0.16	84
10-year	39	81	120	14	549.9	0.29	88
25-year	59	148	207	16	552.2	0.60	92
50-year	71	213	284	94	553.5	0.67	67
100-year	78	290	368	232	554.0	0.70	37

Pond storage curve of community pond is shown in Fig. 6.2.15, which is estimated using the topographic map of 1:5,000, which is newly prepared by the study.

5) Water Quality of Community Pond

The water quality of Tenawali Kas, which runs through the site of the community pond, is seriously deteriorated giving an offensive odor because of the polluted wastewater generated in the urbanized area. According to site investigation, however, the water quality diverted from the tributary of the Bedarawali Kas to the community pond is relatively good as compared with that of Tenawali Kas. Under these circumstances, the following measures were adopted as the structures to maintain the better water quality of the community pond:

(a) To construct the oxidation ponds to improve the water quality of inflow to the community pond;

(b) To construct the check dams to stop the garbage flowing into the pond;

(c) To construct the diversion channel to bring the clean discharge from the adjacent river (i.e., Bedarawali Kas) into the pond; and

(d) To alternate the existing route of low flow of Tenawali Kas, which now gives an offensive odor, and not connect it to the pond.

6) Design Features of Facilities

From the aforesaid consideration, diversion channel from the tributary of the Bedarawali Kas, detention dam including dam body, spillway and outlet facilities, and facilities of multiple use of community pond shall be designed. Design features of the necessary facilities summarized as follows:

a) Pond

Catchment Area	:	26.5 km^2 (= 16.6 + 9.9 km^2)
Pond Surface Area	:	0.64 km^2
Maximum Water Surface	:	EL. 555.000 m
Surcharge Water Surface	:	EL. 553.000 m
Low Water Surface	:	EL. 543.000 m
Gross Storage Capacity	:	2,950,000 m^3
Effective Storage Capacity	:	2,900,000 m^3
Dead Storage Capacity	:	50,000 m^3

b) Dam Body on Waterway

Dam Type	:	Combined Dam
Dam Height above Foundation	:	20.0 m
Crest Elevation	:	EL. 557.000 m
Foundation Elevation	:	EL. 537.000 m

Crest Length	:	1,550.0 m Embankment Type L = 1,260 m Concrete Type L = 290 m
Crest Width	:	6.0 m
Concrete Gravity Portion	:	Upstream Vertical, Downstream 1:0.8
Embankment (Homogeneous) Portion	:	Upstream 1:3.5, Downstream 1:3.0

c) Spillway and Outlet Facilities for Dam

Design Flood (Inflow Peak Discharge)		
Emergency Spillway Design Flood	:	560 m^3/s (200-year probability x 120 %)
Flood Mitigation Capacity	:	210 m^3/s (25-year Probability)
Overflow Crest	:	Crest EL. 553.000 m, 100 m in length
Flood Control Outlet	:	H 1.0 m x W 1.0 m x 2, EL. 543.0 m
Outlet for Draw Down	:	H 1.0 m x W 1.0 m x 1, EL. 540.0 m

d) Check Dam upstream of Pond

Weir (Wet Stone Masonry)	:	H 1.5m x L 20 m x 1
Weir (Wet Stone Masonry)	:	H 1.5m x L 30 m x 1

e) Diversion Facilities

Fixed Weir on Tributary	:	2.5 m in height, 37 m in length Overflow Crest L = 16 m Orifice H 1.0 m x W 1.0 m x 2
Diversion Weir with Orifice	:	5.2 m in height, 20 m in length Orifice H 1.0 m x W 1.0 m x 1 Orifice H 1.5 m x W 1.5 m x 7
Diversion Channel (Wet Stone Masonry)	:	8 m in width, 1,340 m in length Water Depth D = 2.4 m

f) Facilities for Multiple Use of Community Pond

Public Facilities (Road, Bridge, Car Parking, Backfilling, etc.)
Sports and Recreation facilities (Multipurpose Ground, Tennis Court, etc.)
Amenity and Landscape (Water Front Open Space, Gardening, etc.)

g) Major Work Quantities

Surface Excavation		
Foundation Excavation	:	140,000 m^3
Reservoir Excavation	:	2,000,000 m^3
Dam Embankment	:	160,000 m^3
Backfilling (as Spoil Area)	:	700,000 m^3
Common Embankment (as Spoil Area)	:	300,000 m^3
Dam Concrete	:	27,000 m^3
Reinforced Concrete	:	4,000 m^3
Bridge	:	2 bridges
Main Road	:	L = 4,700 m, W = 20 m

6.2.3 Flood Mitigation Dam

The results of clarification on the possible flood mitigation dams are as described hereinafter:

1) Identification of Potential Dam Sites

A flood mitigation dam has also the function of temporarily storing runoff discharge on the way to the upper reaches of a river and thus flattening the peak runoff discharge. In the same way as the community pond, stored flows are subsequently returned to the downstream river at a reduced rate of flow. It is the core structure for flood regulation in contrast with channel improvement as a core structure for quick disposal of flood discharge.

Generally, the larger the catchment area of a flood mitigation dam, the more effective the flood peak cut. However, potential sites for flood mitigation dam are very limited in the study area due to its topographic condition. Almost all parts of the study area are classified into flat land formed on the Potwar plateau, and the mountainous area located at the northern end of the study area is only 15 % of the Lai Nullah basin.

In this study, the potential dam sites were preliminary identified regardless of their catchment area through the review of the previous report, the field reconnaissance and the study on the topographic map newly developed from data of IKONOS. The following six (6) dams are enumerated. Locations of potential dam sites are shown in Fig. 6.2.16.

2) Selection of Optimum Flood Mitigation Dam

Salient features of the six (6) potential dam sites identified in this study are summarized in the following table:

Table R 6.2.7 Features of Potential Dam Sites for Flood Mitigation

Item	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6
1. River	Bedarawali Kas	Bedarawali Kas	Bedarawali Kas	Bedarawali Kas	Tenawali Kas	Tenawali Kas
2. Location	Flat Land	Mountainside	Mountainside	Mountainside	Mountainside	Mountainside
3. Geology	Loessic silt, Limestone	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed	Limestone, Sandstone, Shale, Much folded, Many joints, Thick Riverbed
4. Land Use in Reservoir Area	Belonging to Block E-11, Being illegally developed by Private Developer	Unused Land such as Forest	Unused Land such as Forest	Unused Land such as Forest	Unused Land such as Forest	Unused Land such as Forest
5. Catchment Area (km^2)	19.7	1.6	2.5	3.7	1.9	4.0

In case that each flood mitigation dam has a capacity to cut the probable peak discharge of 100-year return period as much as possible, the design features of each dam and the cost effectiveness are given as below:

Table R 6.2.8 Design Features of Alternative Flood Mitigation Dams

<table>
<tr><th>Item</th><th>Site-1</th><th>Site-2</th><th>Site-3</th><th>Site-4</th><th>Site-5</th><th>Site-6</th></tr>
<tr><td>1. Required Total Storage Capacity (m^3) *1</td><td>3,040,000</td><td>250,000</td><td>390,000</td><td>560,000</td><td>290,000</td><td>610,000</td></tr>
<tr><td>2. Dam Height (m)</td><td>20.0</td><td>34.4</td><td>28.6</td><td>42.5</td><td>26.4</td><td>29.7</td></tr>
<tr><td>3. Crest Length (m)</td><td>840</td><td>150</td><td>155</td><td>180</td><td>130</td><td>230</td></tr>
<tr><td>4. Area below Maximum Water Level (km^2)</td><td>0.80</td><td>0.04</td><td>0.07</td><td>0.07</td><td>0.06</td><td>0.11</td></tr>
<tr><td>5. Embankment Volume (m^3)</td><td>300,000</td><td>358,000</td><td>217,000</td><td>521,000</td><td>164,000</td><td>378,000</td></tr>
<tr><td rowspan="2">6. Estimated Peak Cut Discharge (100-year) at Kattarian Bridge (m^3/s)</td><td rowspan="2">300</td><td>26</td><td>41</td><td>59</td><td>30</td><td>64</td></tr>
<tr><td colspan="5">220</td></tr>
<tr><td>7. Cost (million Rs.)
- Construction Cost
- Compensation Cost
- Total Cost</td><td>
477
1,620
2,097</td><td>
569
4
573</td><td>
344
7
351</td><td>
827
7
834</td><td>
260
6
266</td><td>
601
11
612</td></tr>
<tr><td rowspan="2">8. Cost / Peak Cut Discharge (7./6.) (Rs. / m^3/s) *2</td><td rowspan="2">7,000,000</td><td>22,000,000</td><td>8,600,000</td><td>14,100,000</td><td>8,900,000</td><td>9,600,000</td></tr>
<tr><td colspan="5">12,000,000</td></tr>
</table>

*1 The required total storage capacity is estimated on the premise that the flood mitigation dam has a capacity to cut the probable peak discharge of 100-year return period as much as possible at site.

*2 Figures in this column show the cost effectiveness of flood mitigation dam. The smaller figure brings out the higher effectiveness of the flood mitigation function and the greater cost advantage of the facility.

The following matters can be seen in the above table:

(a) Among the identified six (6) potential dam sites, Site-1 located at Block E-11 is greatest advantage in terms of total cost per peak cut discharge in spite of its high compensation cost.

(b) The alternative dams identified at mountainside (Sites-2, 3, 4, 5, 6) have extremely large figures of total cost per peak cut discharge. The reasons are:

(i) Low efficiency of dam reservoir due to their steep riverbed slope,

(ii) Low efficiency of flood peak cut discharge due to their small catchment area,

(iii) High cost of foundation treatment due to their weathered and folded foundation.

From the above discussion, Site-1 was selected as the optimum site for flood mitigation dam.

3) Flood Mitigation Plan and Reservoir Capacity Allocation

The proposed flood mitigation dam could have a storage capacity to cut almost all the probable peak runoff discharge of 25-year return period, and reduce about 44% of the peak flood discharge at site even in case of 100-year return period.

These functions could increase the flood safety level of the downstream of Lai Nullah. The results of calculation on flood mitigation effect at dam site are given in Fig. 6.2.17 and summarized as below:

Table R 6.2.9 Flood Mitigation Effect of Flood Mitigation Dam at Site

Return Period	Inflow (m^3/s)	Regulated Peak Outflow Discharge (m^3/s)	Reservoir Surface Level (EL. m)	Peak Discharge Reduction Rate (%)
5-year	45	4	567.1	91
10-year	86	5	568.5	94
25-year	162	6	570.8	96
50-year	236	65	572.2	72
100-year	325	183	572.8	44

Reservoir storage curve of the flood mitigation dam is shown in Fig. 6.2.18, which is estimated using the topographic map of 1:5,000 newly developed by the Study.

4) Design Features of Flood Mitigation Dam

From the aforesaid consideration, flood mitigation dam including dam body, spillway and outlet facilities shall be designed. The plan is shown in Fig. 6.2.19. Design features of the necessary facilities are summarized as follows:

a) Reservoir

Catchment Area	:	19.7 km^2
Reservoir Surface Area	:	0.62 km^2
Maximum Water Surface	:	EL. 574.000 m
Surcharge Water Surface	:	EL. 571.600 m
Low Water Surface	:	EL. 565.300 m
Gross Storage Capacity	:	3,040,000 m^3
Effective Storage Capacity	:	2,640,000 m^3
Dead Storage Capacity	:	400,000 m^3

b) Dam Body on Waterway

Dam Type	:	Fill Dam
Dam Height above Foundation	:	20.0 m
Crest Elevation	:	EL. 576.000 m
Foundation Elevation	:	EL. 556.000 m
Crest Length	:	840.0 m
Crest Width	:	5.0 m
Embankment Slope	:	Upstream 1:3.5, Downstream 1:3.0

c) Spillway

Design Flood (Inflow Peak Discharge)		
Emergency Spillway Design Flood	:	520 m^3/s (200-year probability x 120 %)
Flood Mitigation Capacity	:	170 m^3/s (25-year Probability)
Overflow Crest	:	Crest EL. 571.600 m, 70 m in length

d) Major Work Quantities

Surface Excavation	:	250,000 m^3
Dam Embankment	:	330,000 m^3
Mass Concrete	:	5,000 m^3
Reinforced Concrete	:	35,000 m^3

6.2.4 Flood Diversion Channel

The results of clarification on the possible flood diversion channel are as described hereinafter:

1) Preliminary Screening of Potential Diversion Channel Routes

As the final solution of the flood problem, diversion channel to adjacent rivers has been studied somewhere upstream of Rawalpindi city so that no flood passes through the city area. The routs of the diversion channel examined in the previous study and in this study are shown in the following Fig. R 6.2.3 and Table R 6.2.10.

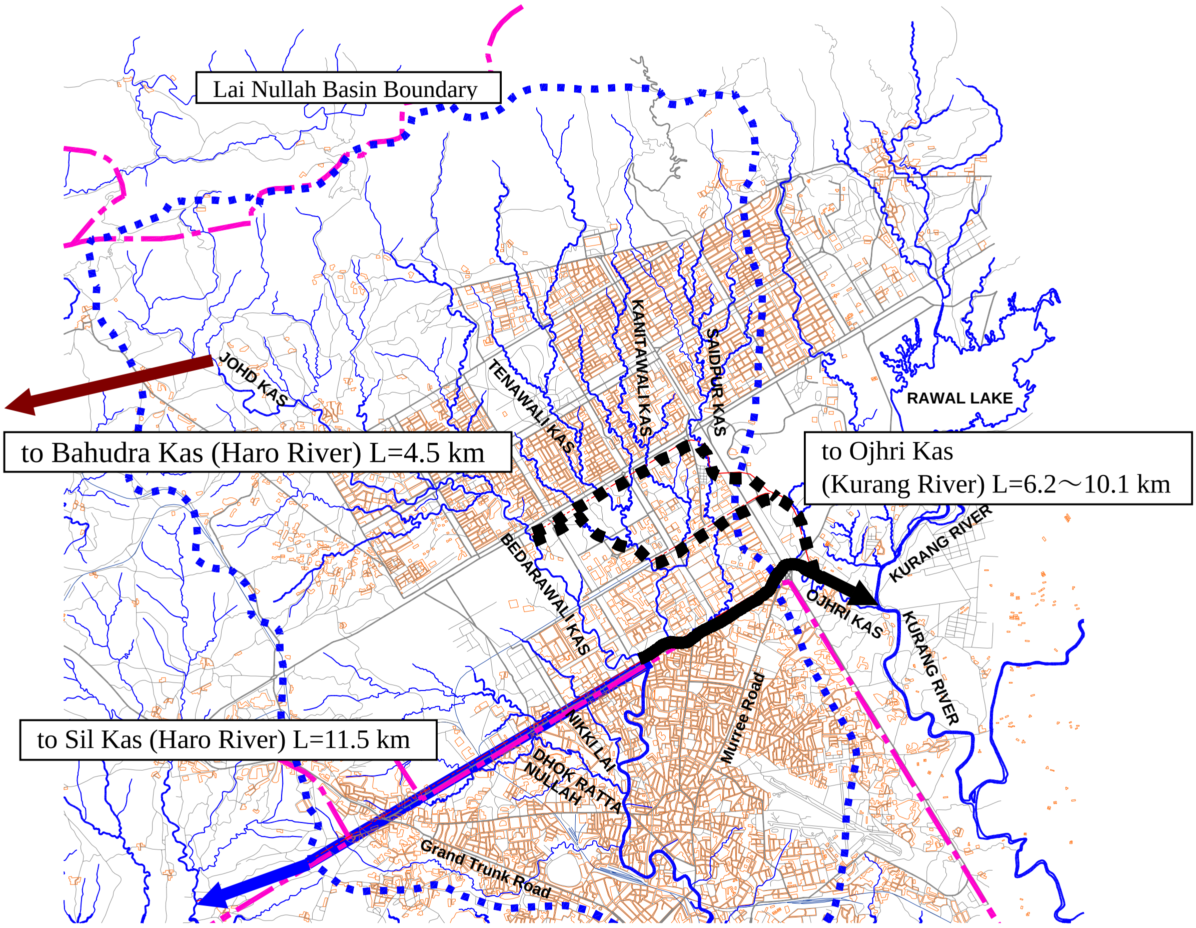


Fig. R 6.2.3 Potential Routes of Flood Diversion Channel

Table R 6.2.10 Potential Routes of Flood Diversion Channel

Routes of Diversion Channel	Diverted River/Tributary	Catchment Area (km^2)	Length of Channel (km)
to Bahudra Kas of Haro River	Johd Kas (Bedarawali Kas)	12	4.5
to Sil Kas of Haro River	Bedarawali Kas, Nikki Lai Dhok Ratta Nullah	103	11.5
to Ojhri Kas of Kurang River	Bedarawali Kas, Tenawali Kas Kanitawali Kas, Saidpur Kas	122 to 144	6.2 to 10.1

The diversion channel to the Bahudra Kas of the Haro River does not have any difficulties of land acquisition. However, its possible catchment area of tributary to be diverted is limited to only 12 km^2, equivalent to about 5 % of the Lai Nullah basin, and therefore, this diversion could not provide adequate relief.

The diversion channel to the Sil Kas of the Haro River planed to cut across hill area. Difference of land level among tributaries to be diverted and top of hill area is not less than 60 m. Thus, the extremely large excavation volume is required and, therefore this route is not practicable.

After exclusion of inappropriate routes, the diversion channel to the Ojhri Kas of the Kurang River remains as alternative routes to be studied.

2) Features of Alternative Routes

Three (3) alternative routes to divert flow into the Kurang River can be considered. They divert the flow of the four (4) main tributaries, namely, Bedarawali Kas Tenawali Kas, Kanitawali Kas and Saidpur Kas, and run through the urbanized area of Islamabad along the road and finally outfall into the Kurang River. Plan and longitudinal profiles of alternatives are shown in Fig. 6.2.20 and 6.2.21. Features of these alternatives are summarized as follows:

Table R 6.2.11 Features of Alternative Routes to Kurang River

No.	Route of Diversion Channel	Catchment Area (km^2)	Riverbed Level (EL. m)		Possible Riverbed Slope	Channel Length (m)
			Bedarawali Kas	Kurang River		
Route-1	Along Kashimir Highway	122	515.0	488.0	1/700	10,155
Route-2	Along Khayaban-E-Johar Road (one block south from Route-1)	129	515.0		1/700	9,726
Route-3	Along Khyaban-E-Siryed Road (called I-J Principal Road)	144	495.0		1/1000	6,233

3) Selection of Optimum Route

The allowable maximum capacity of flood diversion channel is estimated at about 1,700 m^3/s taking the following factors into account: (a) the allowable limit of the right-of-way for the diversion channel, (b) the possible bed of the diversion channel and (c) the required improvement works of Kurang River as the outlet of the diversion channel[10]. The study on the optimum route of the diversion channel is carried out on the assumption that the capacity of flood diversion is fixed at 1,480 m^3/s, which corresponds to the design discharge of the diversion channel, if the proposed community pond (assumed as the strongest candidate of the priority project component) is constructed in the upper reaches. The required cross sectional area of each alternative is given in Fig. 6.2.22. Measure work quantities and compensation works are summarized as follows:

Table R 6.2.12 Measure Work Quantities and Compensation Works for Alternative Diversion Route

Measure Work Quantities

No.	Excavation (m^3)	Dike Embankment (m^3)	Side Slope Protection (m^2)	Sodding (m^2)	Bridge (bridges)
Route-1	7,900,000	70,000	158,000	295,000	12
Route-2	4,000,000	131,000	164,000	167,000	20
Route-3	5,000,000	16,000	106,000	153,000	16

Compensation Works

No.	Land Acquisition (m^2)			House Evacuation (houses)		
	Residential Area	Others	Total	in I-8, I-9	Along Ojhri Kas	Total
Route-1	5,700	312,000	317,700	0	19	19
Route-2	6,000	342,000	348,000	0	20	20
Route-3	41,900	176,000	217,900	76	13	89

From the above studies, cost of each alternative route is estimated as below:

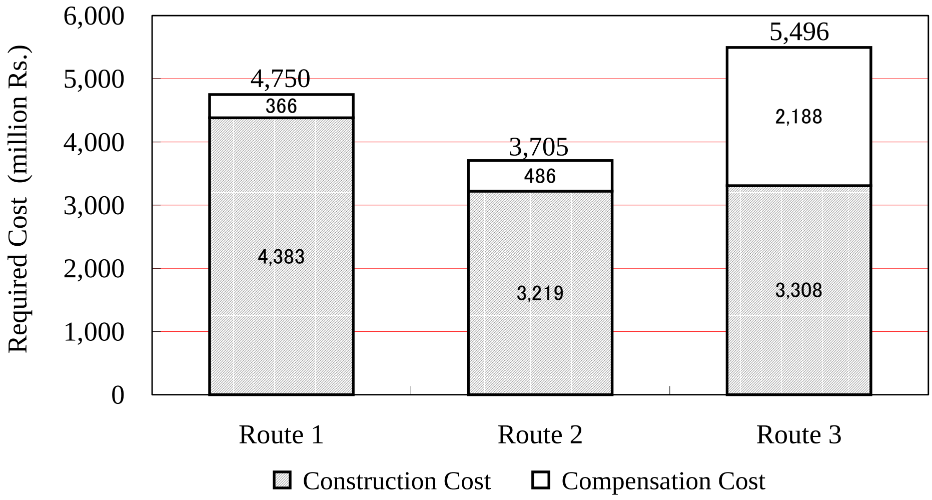


Fig. R 6.2.4 Cost Comparison of Alternative Routes

[10] CDA commented in the Steering Committee Meeting on the Draft Final Report that the right-of-way for the route-2 of the diversion channel should be restricted to be a certain width. Due to the comment, the possible maximum diversion discharge for the alternative route-2 may fall below 1,700m^3/s. After detailed discussions, it is finally agreed by the Steering Committee that this matter would be clarified in the succeeding Feasibility Study (refer to item 2 in the Minutes of Steering committee Meeting on the Draft Final Report as attached to this Main Report).

It is concluded that the route-2 is the most suitable alternative for diversion channel to divert flood into Kurang River due to the following reasons:

(a) The route-2 is the most economical alternative, when their construction cost and compensation cost are contrasted.

(b) It is deemed to be difficult to implement construction of route-3 channel due to difficulties in evacuating many permanent houses located in Blocks I-8 and I-9.

(c) In case of route-2, no house evacuation in Blocks I-8 and I-9 is necessary.

It is proposed that the diversion channel would increase its flow capacity through the short-term project and the long-term project. The diversion channel will divert the flood runoff discharges of 25-year return period from Tenawali Kas and Saidpur Kas to Kurang River upon completion of the short-term project, and those of 100-year return period from Bedarawali Kas, Tenawali Kas and Saidpur Kas upon completion of the long-term project (refer to Figs. 6.2.23 to 6.2.25).

4) Necessary Treatment for Kurang River

The proposed flood diversion channel flows into Kurang River through its tributary named Ojhri Kas and finally pours into Soan River. Between these two (2) outlet rivers, Soan River has unquestionably the adequate channel flow capacity to accommodate the flood discharge from Kurang River as well as Lai Nullah. On the other hand, there are the bottleneck stretches along Kurang River, which even now cause the frequent flood overflow. In order to safely divert the proposed flood discharge into Kurang River, the necessary treatment works for the River was preliminarily evaluated taking its present channel flow capacity and the flood runoff discharge from the river basin into account.

a) Flood Discharge of Kurang River

There exists Rawal Dam on Kurang River about 5.6 km upstream from the outlet point of the flood diversion (i.e., at the confluence of Ojhri Kas). The dam reservoir is used as the major source for water supply to Rawalpindi, but at the same time, it has a certain effect on the flood mitigation for the downstream of Kurang River. That is, the water stage of the dam reservoir drops to EL. 531 m in the early of July from the normal water

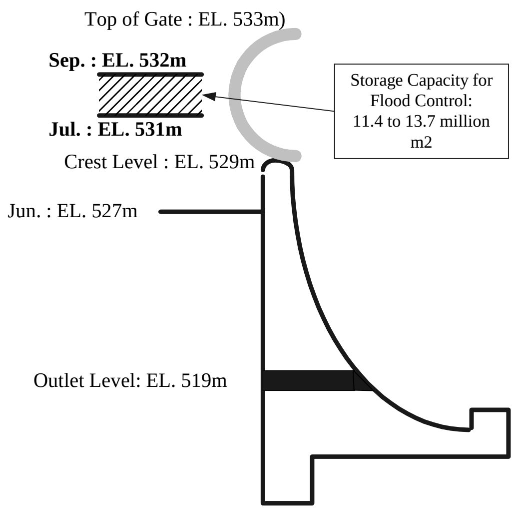


Fig. R 6.2.5 Water Stage of Rawal Dam Reservoir level of EL 532 m, and then it gradually rises finally recovering to the normal level in the end of September. The drop of water stage in the early of July could create a stage capacity of 13.7 million m^3 for flood mitigation (refer to Fig. R 6.2.5). This flood mitigation capacity could reduce the peak flood runoff discharge from the upper reaches of the dam and delay the time of occurrence of the peak discharge. In the flood of July 2001, the dam reservoir released its peak discharge of only 220 m^3/s after the flood of downstream is subsided.

The above flood mitigation capacity is, however, not always expected due to the gradual raise of the reservoir water stage as stated above. Depending on the timing of flood occurrence, the dam may possibly release the substantial discharge. According to the record of the dam outflow discharge, the annual maximum dam outflow discharge fluctuates year-by-year, and the largest value of about 1,300 m^3/s was recorded in 1988 as shown in Fig. R 6.2.6.

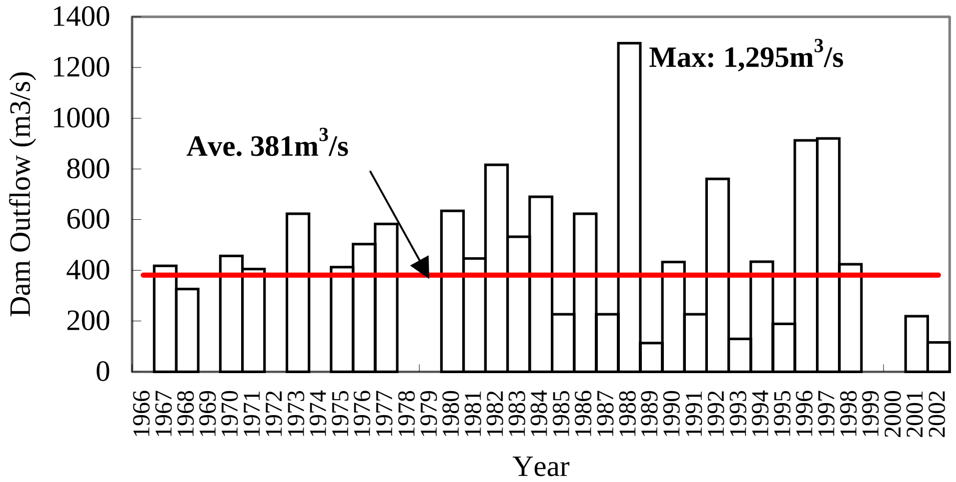


Fig. R 6.2.6 Annual Maximum Outflow Discharge from Rawal Dam

Thus, the peak dam outflow discharge is changeable depending on the complex factors of dam water stage, timing of flood occurrence and volume of the runoff discharge from the upper reaches of the dam reservoir.

Due to the above complex factors, it is virtually difficult to determine the designed dam outflow discharge through hydrological simulation. In this Study, however, the maximum dam outflow of about 1,300 m^3/s recorded in 1988 is provisionally assumed as the design discharge released from Rawal dam. The following items are further assumed, and it is concluded that the maximum peak discharge to be accommodated by Kurang River would be about 3,240 m^3/s at outlet point of the diversion channel (i.e., the confluence point with Ojhri Kas) (refer to Fig. R. 6.2.7):

(i) The peak flood runoff discharge of 100-year return period from the catchment area of Ojhri Kas is estimated at 310 m^3/s through the hydrological simulation.

(ii) The maximum discharge from the diversion channel would be about 1,630 m^3/s in the flood of 100-year return period assuming that any flood storage structures (i.e., the community pond in Fatima Jinnah Park and/or flood mitigation dam in Block E-11) are not constructed in the catchment area of the diversion channel.

(iii) It is assumed as the worst case, that the peak discharge from the diversion discharge could coincide with the peak discharge from Rawal dam and the catchment area of Ojhri Kas. In this case, the peak discharge to be accommodated by Kurang River is estimated to at about 3,240 m^3/s as the total of 1,630 m^3/s from the diversion channel, 1,300 m^3/s from Rawal Dam and 310 m^3/s the catchment area of Ojhri Kas.

b) Existing Channel Flow Capacity of Kurang River

The upstream channel of about 4.4 km in length from the outlet point of the proposed diversion channel to the confluence of Gumreh Kas (tributary of Kurang River) has U-shape cross-sections with the small channel depth of only about 2 m, although it has the rather large channel width of more or less 100 m. Moreover, the upstream channel has the very gentle channel bed slope of about 1/1,500. Due to these characteristics, the channel flow capacity of the upper reaches is limited to about 200 m^3/s, which is far smaller than the aforesaid expected maximum flow discharge of 3,240 m^3/s for Kurang River as listed below.

Table R 6.2.13 Hydraulic Channel Dimensions and Channel Flow Capacity of Kurang River

Name of Point	Distance from Rawal Dam Site (km)	Channel Bed Slope	Max. Depth (m)	Max. Width (m)	Hydraulic Radius (R) (m)	Max. Discharge (m^3/sec)
Soan Village	5.6	1/750	5.8	130	3.0	960
Shikrial Village	7.3	1/1500	2.1	110	1.3	140
Khanna Bridge	10.0	1/140	2.9	96	1.8	730
Karal Village	12.5	1/140	11.0	75	6.8	5,300

Source : Results of river channel survey by Small Dam Organization in 2001
Note : The villages of Soan, Shakrial and Khanna are located upstream from the confluence of Gumreh Kas, while Karal Village is downstream from the confluence of Gumreh Kas.

In contrast with the upstream, the downstream of Kurang River with a length of about 16 km between the confluences of Gumreh Kas (the tributary of Kurang River) and Soan River has the steep cliff at both of the left and right banks, and the steep channel bed slope of about 1/140. According to the results of the field reconnaissance and the uniform calculation based on the channel survey by the Small Dam Organization, the channel flow capacity of the downstream stretch is evaluated to be more than 5,300 m^3/s as listed above, which could adequately accommodate the above peak discharge of 3,240 m^3/s, even if the flood runoff discharge from the catchment area of Gumreh Kas is added.

It is, however, herein noted that the land development for the new residential area is now in progress at and around the confluence of Kurang River and Soan River. Through the land development, the river channel of Kurang along the residential has been filled-up, and the new short-cut channel has been constructed. According to the site investigation, the short-cut channel deems to have far lower channel flow capacity than its upstream channel, and the residential area itself becomes the great hindrance to discharge the flood flow of Kurang River into Soan River. In order to offset such unfavorable conditions, it is indispensable to immediately suspend the on-going land development and restore the channel flow capacity as in the past, regardless of construction of the flood diversion channel from Lai Nullah to Kurang River.

c) The Areas to be protected against Flood Overflow of Kurang River

There exist three (3) settlement areas, namely, Soan, Shikrial and Khanna Dak, along the upstream channel of Kurang River. These villages currently suffer the habitual flood inundation by the overflow from Kurang River. Should the proposed flood diversion channel be constructed, the flood flow discharge of Kurang River definitely increases and accretes the present flood damage to the villages in particular (refer to Fig. R 6.2.7).

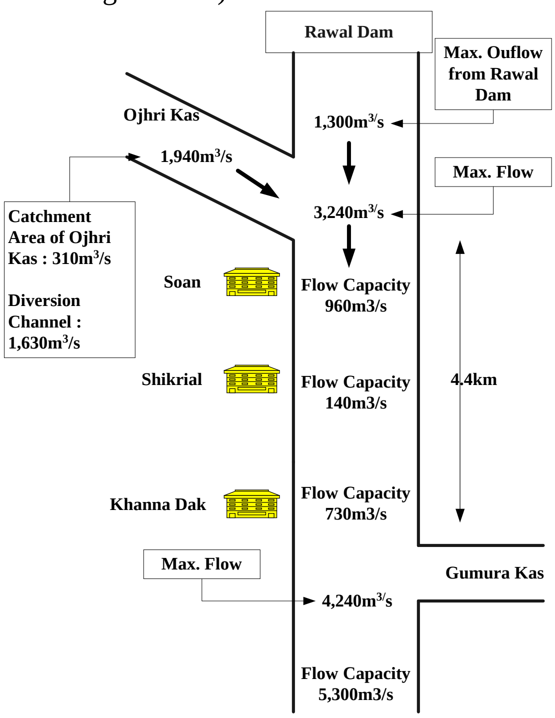


Fig. R 6.2.7 Channel Flow Capacity and Design Flow Discharge of Kurang River

Hence, the certain flood protection for the villages would become an indispensable precondition for selection of the flood diversion option. Nevertheless, apart from the settlement area of the villages, the substantial part of the rive-side along the upstream of Kurang is remained as the natural unused land and/or agricultural land. Accordingly, the major target of the objective flood mitigation could be limited to the settlement areas of the three (3) villages.

d) Flood Mitigation Measures Required to Kurang River

In order to offset the increment of flood damage potential of Kurang River inflicted by construction of the proposed flood diversion channel, establishment of the river reserve area and construction of the ring dike is proposed as shown in Fig. 6.2.26. The required work volumes for these proposed flood mitigation works are preliminarily estimated as listed in Table R 6.2.14. These are, however, subject to revision based on the further detailed topographic survey and hydrological analysis on the flood runoff discharge and the flood inundation.

Table R 6.2.14 Required Work Volume for Proposed River Reserve Area Ring Dike

Work Item	Work Volume
1. Length Ring Dike	
1.1 Right Dike for Soan Village	1,300 m
1.2 Right Dike for Shikrial Village	1,570 m
1.3 Right Dike for Khanna Dak Village	1,430 m
1.4 Left Dike for other dotted settlement areas	2,200 m
Total	6,500 m
2 Extent of Land Acquisition for Establishment of River Reserve Area and Construction of Ring Dike	334,000 m^2
3. Number of Necessary House Evacuation	220 houses

Details of the proposed river reserve area and ring dike are as described in the following items (i) to (iii):

(i) The area long the section of 10,930 m from Rawal Dam to the confluence of Gumura Kas should be delineated and gazetted to be the river reserve area as the buffer against the flood overflow and the right-of-way for the future river channel improvement works. Any unfavorable land development within the river reserve area should be prohibited.

The CDA has already declared the left and right bank of 1,000 feet in width each from the center of the river course as the river reserve area. However, the width of 2,000 feet (about 600m) in total covers the substantial part of the existing settlement area, and at the same time, it deems to be too spacious as compared with the potential extent of the flood inundation and the necessary extent for the future river improvement. From these viewpoints, the extent of the river reserve area is provisionally proposed at 200m in width from the center of the river cause (refer to Fig. 6.2.26).

(ii) A certain structural flood mitigation measures for the aforesaid three (3) villages namely Soan, Shikrial and Khanna Dak along Kurang River would be required to relive the villages from the adverse effect inflicted by construction of the proposed flood diversion channel. The villages are, however, rather sparsely dispersed along Kurang River, and therefore, the river channel improvement for the entire river stretch is not required. Instead, the ring dike is proposed to besiege the villages and prevent them from flood overflow of Kurang River.

(iii) Execution of the above river reserve area and the ring dike would require evacuation of about 220 houses. Such substantial number of house evacuation may create a social conflict and therefore would be addressed as the important issue for achievement of the proposed flood mitigation works for Kurang River. Nevertheless, the houses as the objectives of evacuation are even now exposed to the frequent flood damage and, any measure other than evacuation is not practical to get rid of such unfavorable conditions. Moreover, urban population of Rawalpindi is now being spilled over the possible flood inundation area particularly along right bank of Kurang River. Should the area along Kurang River be left behind without clearance of houses within the extent of the proposed river reserve area, the riverside along Kurang River would be finally saturated with the house and buildings like the current situation of Lai Nullah and remarkably increase the flood damage potential. In order to avoid such unfavorable conditions, the house evacuation would be indispensable even regardless to construction of the proposed flood diversion channel.

6.2.5 On-site Flood Detention Facilities

The on-site structures will involve the various structural types as described in the following items 1) to 4) which are individually installed at each new land development sites i.e., the new residential area, commercial area, or government office quarter (refer to Fig. 6.2.27 and Table 6.2.2)

1) Rainfall Storage Tank Installed at Individual House Lot

The rainfall storage tank is installed on the ground or in the building to collect rainwater from rooftop through roof gutters/pipes and store it so as to delay and reduce the peak runoff discharge. The standard type of the storage tank has a storage capacity of 2,000 liters, which could collect the rainfall from rooftop of $50m^2$ in average. Accordingly, the maximum rainfall depth to be stored in the rainfall tank is limited to only 40 mm (=2,000 liters $\div$ 50 m^2), which is fulfilled by even 5-year return flood before its peak rainfall intensity occurs as shown in Fig R 6.2.8. Thus, the rainfall storage tank could hardly effect to reduce the peak runoff discharge, unless it is adopted in combination with the under-mentioned on-site flood detention pond and/or the infiltration facility. Moreover, the substantial flood mitigation effect could be achieved only when the rainfall storage tanks are installed at considerable parts of individual house lots in the basin.

Nevertheless, the rainfall storage tank has a potential function to be a subsidiary water resources (the rainfall harvesting) in addition to the function of flood mitigation (refer to subsection 8.5.5). In order to prevail the rainfall storage tanks, the following various expedients would be required:

(a) Dissemination of the effect of rainfall storage tank on water use among the residents;

(b) Preparation/revision of the byelaw and the Building Code to accommodate the rainfall storage tank at the individual house lot;

(c) Establishment of subsidiary system for installation of the rainwater tank; and

(d) Concession of property tax to the residents who install the rainwater tank.

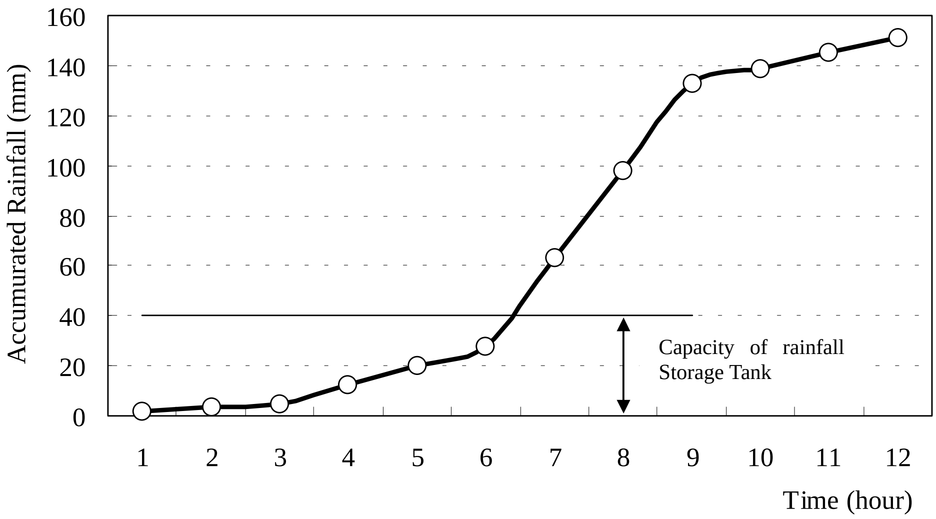


Fig. R 6.2.8 Design Storm Rainfall of 5-year Return Period

2) On-site Flood Detention Pond

The on-site flood detention pond is usually placed at the downstream end of the new land development area in order to offset the increment of the peak runoff discharges inflicted by the land development. The flood regulation effect by the on-site flood detention pond could extend to both of the following middle and large-scale floods (refer to Fig. 6.2.28):

(a) The small-scale floods (say in a rage of 5 to 10-year return period) to offset the excessive flood runoff over the flow capacity of the drainage channels immediately downstream from the land development area; and

(b) The large-scale floods (say in a rage of 25 to 100-year return period) to offset the excessive flood runoff over the flow capacity of the river channel, which is situated as the final outlet of the basin flood runoff discharges.

In order to perform the above regulation effect, the on-site flood detention ponds may have two (2) outlet holes as illustrated in Fig. 6.2.29. The small-scale floods are discharged through only the lower outlet, while the large-scale floods are discharged through both of the lower and upper holes.

When the vacant grass land and/or the natural forest of $1km^2$ in extent is developed to the residential area (the moderately populated area like those in Islamabad), the probable peak discharge of 10-year return period is estimated to increase from 4 $m^3/s/km^2$ to 10 $m^3/s/km^2$ and that of 100-year return period from 16 $m^3/s/km^2$ to 23 $m^3/s/km^2$ as shown in Fig. 6.2.28.

The necessary storage capacity of the on-site flood detention pond to offset the above increments of peak flood runoff discharge is estimated at about 150,000 m^3 per $1km^2$ of land development area assuming 4 to 7m as the average depth of pond. This on-site flood pond would have an extent of 30,000 to 50,000 m^2, which takes about only 3 to 5% of the entire land development area. The storage capacity as well as the extent of pond would increase in proportion to extent of the land development.

When the land development in the river basin is judged to cause the excessive peak flood runoff discharge over the flow capacity of the downstream drainage channel and/or river channel, the river administrator (or the land administrator) may be required to enforce the land developer, through bylaw, to provide the above on-site flood detention pond. Through construction of the on-site flood detention pond, the flood safety level of the river basin could be maintained irrespectively of land development in the basin.

3) Infiltration Facilities

Infiltration facilities are used to collect the rainfall and/or the flood runoff discharge and make them infiltrate into the ground so as to mitigate the flood runoff discharge. There are various types of the infiltration facilities as shown in Table 6.2.2. The facilities are, however, applicable only to the subsurface of gravel deposits and other permeable soil. Moreover, the infiltration capacity of the facilities easily drops due to clogging by sediments, and therefore, the facility could be installed only at paved areas and green belt, where little suspended solids is yielded.

4) Flood Detention Wall at Public Open Space

The storage measure of this type is such that a public open space (such as a sport ground and a car parking area) is enclosed by a low wall with a surrounding side drain and an outlet to collect the rainfall from an entire public compound (refer to Fig. 6.2.27). The maximum storage depth and storage time length should be limited in due consideration of the original purpose of the storage space as public utility.

Most of the facilities of this type are designed to have the maximum storage depth of 30 cm and the maximum storage time of 2 to 12 hours due to the original purpose of the storage space as the public utility. The size of the outlet should be determined on the premises that the storage will meet to the requirement of the maximum storage depth and storage time against the design hydrograph of the target design scale for urban drainage not allowing any overflow.

6.3 COMPARATIVE STUDY ON ALTERNATIVE COMBINATIONS OF STRUCTURAL MEASURES

The flood mitigation capacity of each of the possible off-site flood mitigation measures proposed in the foregoing subsections 6.2.1 to 6.2.4 is limited to a certain level due to the topographic conditions, hydrological conditions and various social/environmental conditions. Accordingly, the single measure may not cope with the target design flood of the short-term as well as the long-term project. Hence, a combination of the measures would be required to achieve the target flood mitigation, and the optimum combination would be selected among the alternative combinations of the measures. From these points of view, the following issues are clarified as the first approach to selection of the optimum combination.

(1) Necessary discharge to be regulated as expressed by difference between the present channel flow capacity of Lai Nullah and the probable peak flood runoff discharge corresponding to the target design scales;

(2) Potential maximum flood mitigation capacity expected to each of the above flood mitigation measures;

(3) Eligible alternative flood mitigation schemes composed of the above flood mitigation measures taking the above items (1) and (2); and

(4) Flood mitigation capacity required to each of components of eligible alternative flood mitigation schemes to cope with the required disposal discharge of the above item (1).

6.3.1 Necessary Discharge to be Regulated

Kattarian Bridge, among the reference points of Lai Nullah, is located at the inflow point of the on-going channel improvement. The probable peak flood runoff discharges at Kattarian Bridge are estimated at 1,150 m^3/s for the target design level of the short-term project (25-year return period) and 2,270m^3/s for the long-term project (100-year return period), respectively. On the other hand, the channel flow capacity of Lai Nullah upon completion of the on-going river channel is limited only to 640 m^3/s at Kattarian Bridge. The difference between the probable peak flood discharge and the channel flow capacity is 510 m^3/s and 1,630m^3/s, which need to be offset by the followings (refer to Fig. R 6.3.1):

(1) Reduction of the peak runoff discharge by the proposed community pond or flood detention dam; or

(2) Increment of channel flow capacity by the further river channel improvement (by deepening of the riverbed) or the flood diversion.

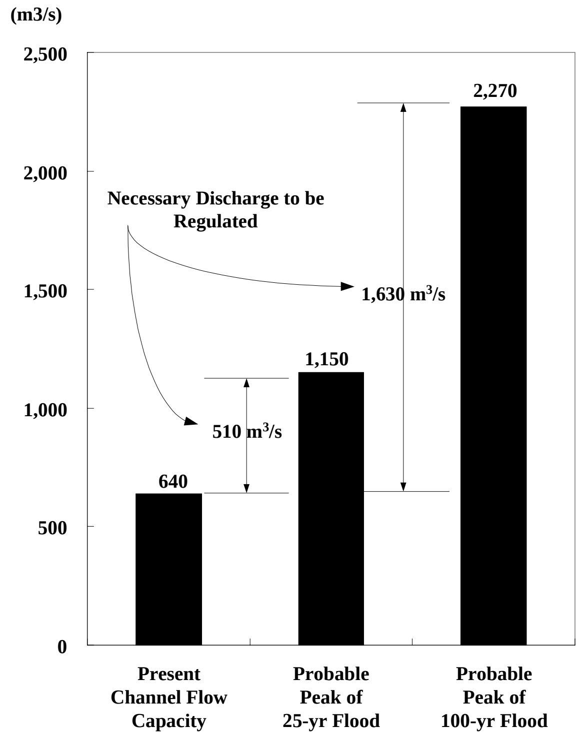


Fig. R 6.3.1 Concept of Necessary Discharge to be regulated

6.3.2 Potential Maximum Capacity of Each Flood Mitigation Measure

The maximum possible reduction of probable peak discharges by the community pond and/or the flood mitigation dam was estimated through the hydrological simulation (refer to Chapter 5). As shown in the Table R 6.3.1, the probable peak discharges of 25-year return period at Kattarian Bridge could be reduced from about 1,150 m^3/s to 830 m^3/s by 320 m^3/s (28%), should both of the community pond and flood mitigation dam be constructed on the premises of their maximum development of storage capacities (i.e., 2.90 million m^3 for the community pond and 2.64 million m^3 for the flood mitigation dam). The peak discharge of 100-year return period could be also reduced from 2,270 m^3/s to 1,730 m^3/s by 540 m^3/s (24%). Thus, the community pond and the flood mitigation dam have the substantial effect to reduce the probable peak discharge of Lai Nullah at Kattarian Bridge by more than 20%.

Table R 6.3.1 Maximum Reduction of Probable Peak Flood Discharge of Lai Nullah at Kattarian Bridge by Proposed Flood Detention Facility

Flood Detention Facility Applied		Live Storage Capacity (million m^3)	Catchment Area of Facility (km^2)	Flood Mitigation Effect at Kattarian Bridge (m^3/s)			
				25-year return period		100-year return period	
				Peak (m^3/s)	Reduction (m^3/s)	Peak (m^3/s)	Reduction (m^3/s)
1	No facility	0	0	1,150	0	2,270	0
2	Community Pond	2.90	26.5	960	190	2,030	240
3	Dam	2.64	19.7	1,000	150	1,970	300
4	2 + 3	5.54	46.2	830	320	1,750	520

The river channel improvement is made by channel bed deepening, and upon its completion, the channel flow capacity at Kattarian Bridge could be increased from 640 m^3/s to 900 m^3/s by 260 m^3/s (refer to the foregoing Table R 6.2.4). As for the flood diversion channel, the possible channel flow capacity is preliminarily evaluated to cover about 1,630 m^3/s taking the following factors into account: (a) the allowable limit of the right-of-way along the diversion route, (b) the possible channel bed slope of the diversion route and (c) the required improvement works of Kurang River, the outlet of diversion channel (refer to subsection 6.2.4). Based on these clarifications, the maximum flood mitigation capacities of the components for the alternative flood mitigation schemes are summarized as Table R 6.3.2.

Table R 6.3.2 Summary on Maximum Flood Mitigation Capacity of Each Potential Measure at Kattarian Bridge

Return Period	Maximum Flood Mitigation Capacity of Potential Flood Mitigation Measure (m^3/s)				
	Reduction of Peak Discharge			Increment of Flow Capacity	
	Community Pond	Flood Mitigation Dam	Community Pond ＋ Dam	River Improvement	Flood Diversion
25-year	190	150	320	260	1,700
100-yer	240	300	520		

6.3.3 Alternative Flood Mitigation Schemes

As described in the above 1), the necessary discharges to be regulated at Kattarian Bridge are 510 m^3/s for 25-year return period and 1,630 m^3/s for 100-year return period. On the other hand, the maximum flood mitigation capacity as the total by the community pond, the flood mitigation dam and the river channel improvement is 580 m^3/s for 25-year return flood and 800 m^3/s for 100-year return flood. Accordingly, the flood diversion would not be necessarily required to cover the aforesaid disposal discharge of 25-year return period, while the flood diversion would be indispensable for the design discharge of 100-year return period. Taking all possible combinations of the flood mitigation measures based on the conditions into account, the alternative flood mitigation schemes are preliminarily delineated as listed below.

Table R 6.3.3 Eligible Alternative Flood Mitigation of Measures

Alt. No.	Measures to be included and not included into the Alternatives			
	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity	
	Community Pond	Flood Mitigation Dam	River Improvement	Flood Diversion
Alt. 1	○	○	○	○
Alt. 2	○	×	○	○
Alt. 3	×	○	○	○
Alt. 4	○	○	×	○
Alt. 5	×	×	○	○
Alt. 6	○	×	×	○
Alt. 7	×	○	×	○
Alt. 8	×	×	×	○

Note (1): ○= Included as the component of the alternative, × = Excluded as the component of the alternative

(2): All alternative schemes include the supplementary works to the on-going channel improvement in common in addition to the flood mitigation measures as listed above. The supplementary works are (a) the side-protection for the entire stretch of the on-going river improvement section from Chaklala Bridge to Kattarian Bridge (RD6+251-RD17+210), and (b) improvement of the existing channel of Lai Nullah (RD5+277-RD6+215) below Chaklala Bridge.

6.3.4 Flood Mitigation Capacities Required to Components of Each Alternative Scheme

The flood mitigation capacities required to each of flood mitigation measures, which compose the alternative flood mitigation schemes are estimated based on (1) the necessary discharge to be regulated as described in subsection 6.3.1 and (2) the potential maximum capacity of each flood mitigation measures. The results of estimation are as summaries below:

Table R 6.3.4 Flood Discharge Disposed at Kattarian Bridge by Alternative Flood Mitigation Schemes

Channel Flow Capacity	Probable Peak Discharge	Required Disposal Discharge*	Discharge Disposed by Alternative Combinations of Measures (m^3/s)				
			Alt. No.	Reduction of Peak Discharge by		Increment of Flow Capacity by	
				Community Pond	Flood Mitigation Dam	River Improvement	Flood Diversion
25-year Return Period	1,150	510	Alt. 1	320		190	-
			Alt. 2	190	-	260	60
			Alt. 3	-	200	260	50
			Alt. 4	320		-	190
			Alt. 5	-	-	260	250
			Alt. 6	190	-	-	320
			Alt. 7	-	200	-	310
			Alt. 8	-	-	-	510
100-year Return Period	2,270	1,630	Alt. 1	450		260	920
			Alt. 2	150	-	260	1,220
			Alt. 3	-	300	260	1,070
			Alt. 4	450		-	1,180
			Alt. 5	-	-	260-	1,370
			Alt. 6	150	-	-	1,480
			Alt. 7	-	300	-	1,330
			Alt. 8	-	-	-	1,630

*: Required Disposal Discharge = Probable peak discharge – Channel flow capacity upon completion of the on-going channel improvement (=640 m^3/s)

As listed above, it is concluded that the design level of 25-year return period for the short-term project could be achieved by the potential capacity of the community pond, the flood mitigation dam and the river channel improvement without dependence to the flood diversion. As for the design level for 100-year return period, however, the flood diversion is indispensable, and the share of the disposal discharge by the flood diversion would be more than half of the total disposal discharge.

6.3.5 Optimum Flood Mitigation Scheme

The optimum flood mitigation plan was determined through comparison of the alternative schemes based on the project cost, the compensation works, the immediate flood mitigation effect, and other relevant social/natural environmental impacts by the project into consideration. As the results, the following evaluation was made, and the Alternative 6, which is principally composed of the community pond in Fatima Jinnah Park and the flood diversion, was selected as the alternative scheme. The detailed viewpoints of each evaluation items are as described in the following items 1) to 4).

Table R 6.3.5 Evaluation of the Alternative Flood Mitigation Schemes

Alt. No.	Evaluation ○ : Preferable × : Not preferable △ : Fair				Remarks
	Project Cost	Compensation	Immediate Flood Mitigation Effect	Social/Natural Environmental Impacts	
Alt. 1	×	×	○	×	
Alt. 2	△	△	○	×	
Alt. 3	×	×	×	×	
Alt. 4	×	×	○	×	
Alt. 5	△	△	×	×	
Alt. 6	○	△	○	△	Optimum Scheme
Alt. 7	×	×	×	×	
Alt. 8	○	△	×	△	

1) Project Cost

Among others, the Alt. 6 has the least cost of long-term project below Rs. 7,500 million followed by Alt. 8 as listed in Table R 6.3.6. In contrast to the above Alts 6 and 8, other alternatives require the comparatively high cost of about Rs. 8,000 to 11,000 million. They contain the flood mitigation dam and the river channel improvement as their components of flood mitigation structures, and the relatively high cost could be attributed to the land acquisition for the flood mitigation dam and the re-construction cost of bridges for the river channel improvement.

The flood mitigation dam in particular would require the land acquisition of about 80ha. The land belongs to the private owner and it is located at Block 11 adjacent to the center of Islamabad. Due to these conditions, the land acquisition cost for the flood mitigation is evaluated to be almost same market value as the residential area of Islamabad, and therefore, the flood mitigation dam would require the high project cost as compared with its limited flood effect.

As for the river channel improvement, the proposed channel deepening from Chaklala Bridge to Kattarian Bridge would require reconstruction of the existing ten (10) bridges and reinforcement of the new bridges, which are now in progress through the on-going channel improvement by RDA. Due to the cost for reconstruction/reinforcement of these bridges, the entire project cost for the proposed channel deepening becomes comparatively high.

Table R 6.3.6 Project Cost of Alternative Flood Mitigation Schemes for Long-Term Project

(Unit: million Rs.)

Alt. No.	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity		Supplementary to On-going River Improvement*	Total
	Community Pond	Flood Mitigation Dam	River Improvement (Deepening of Channel)	Flood Diversion		
Alt. 1	851	2,792	1,948	4,239	873	10,702
Alt. 2	851	-	1,948	4,901	873	8,573
Alt. 3	-	2,792	1,948	4,486	873	10,099
Alt. 4	851	2,792	-	4,803	873	9,319
Alt. 5	-	-	1,948	5,178	873	7,999
Alt. 6	851	-	-	5,605	873	7,330
Alt. 7	-	2,792	-	5,068	873	8,733
Alt. 8	-	-	-	6,574	873	7,448

*: Includes the side-protection for the entire stretch of the on-going river improvement section from Chaklala Bridge to Kattarian Bridge (RD6+251-RD17+210), and the improvement of the existing channel of Lai Nullah (RD5+277-RD6+215) below Chaklala Bridge

2) Compensation Works

When the flood mitigation dam is included as one of the components for the alternative flood mitigation schemes, the extent of land acquisition tends to remarkably increase as shown in Table R 6.3.7. Moreover, the private land developer had commenced development of the residential area in and around the proposed dam reservoir in October 2002, and a substantial progress of development has been achieved, although the development is being illegally made without approval by CDA, the land administrator for the subject area. Difficulties are also foreseeable in acquiring land, because the land acquisition is subject to consent of many private owners for the subject land.

As for the house evacuation required to the project, all alternatives require the relatively small number of houses of less than about 270 houses to be evacuated (refer to Table R 6.3.8). Out of the 270 houses, 220 houses are required to all of the alternatives in common due to necessity of the proposed channel improvement of Kurang River as the outlet of the proposed diversion channel. All of these houses are, however, built within the habitual flood inundation area, and the limits of the river reserve area declared by CDA Moreover, most of the houses are the temporary structures/the shanties. Due to these backgrounds, the fewer disputes on the house evacuation are expected.

There also exist about 30 houses to be evacuated for construction of the flood mitigation dam. In contrast to the above houses to be evacuated for improvement of Kurang River, these houses are located in the on-going residential development area, and difficulties are foreseeable in relocating them. From viewpoints of the foreseeable difficulties in relocating the houses as well as the aforesaid difficulties of land acquisition, the alternatives, which include the flood mitigation dam, would not be preferable as the component of the optimum scheme.

Table R 6.3.7 Land Acquisition Required to Alternative Flood Mitigation Schemes for Long-term Project

(Unit: m^2)

Alt. No.	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity		Supplementary to On-going River Improvement*	Total
	Community Pond	Flood Mitigation Dam	River Improvement (Deepening of Channel)	Flood Diversion		
Alt. 1	0	798,000	13,000	290,000	8,000	1,109,000
Alt. 2	0	-	13,000	321,000	8,000	342,000
Alt. 3	-	798,000	13,000	301,000	8,000	1,120,000
Alt. 4	0	798,000	-	315,000	8,000	1,121,000
Alt. 5	-	-	13,000	333,000	8,000	354,000
Alt. 6	0	-	-	348,000	8,000	356,000
Alt. 7	-	798,000	-	329,000	8,000	1,135,000
Alt. 8	-	-	-	366,000	8,000	374,000

*: For the improvement of the existing channel of Lai Nullah (RD5+277-RD6+215) below Chaklala Bridge

Table R 6.3.8 Number of House Evacuation Required to Alternative Flood Mitigation Measures for Long-term Project

(Unit: houses)

Alt. No	Measure to reduce the peak flood discharge		Measures to increase the flood flow capacity			Total
	Community Pond	Flood Mitigation Dam	River Improvement (Deepening of Channel)	Flood Diversion		
				Construction of Diversion	Improvement of Kurang River	
Alt. 1	0	30	0	20	220	270
Alt. 2	0	-	0	20	220	240
Alt. 3	-	30	0	20	220	270
Alt. 4	0	30	0	20	220	270
Alt. 5	-	-	0	20	220	240
Alt. 6	0	-	0	20	220	240
Alt. 7	-	30	0	20	220	270
Alt. 8	-	-	0	20	220	240

3) Immediate Flood Mitigation Effect

Among the components of the flood mitigation measures, the community pond would not cause any social problem (such as dispute on house evacuation/land acquisition, traffic disruption and splits of the local communities) in nature, and therefore the early commencement of its construction is expected. Moreover, the required construction period is estimated at only 2 years, which is far shorter than those for other proposed structural measures.

Lai Nullah below Kattarian Bridge would have a channel flow capacity to cope with the probable peak flood runoff discharge of 10-year return period through the on-going river channel improvement by RDA, which is scheduled to complete by September 2003. Upon completion of the community pond, the channel flow capacity would be lifted up to meet the probable peak runoff discharge of 13-year return period. Moreover, even in case of the probable flood runoff of more than 13-year return period, the probable flood inundation area as well as inundation depth would be substantially reduced due to the flood detention effect of the community pond.

From the above viewpoints, the alternatives, which include the community pond as their component of the structural measures, are preferable in the aspect of the immediate effect of the flood mitigation.

4) Relevant Social and Natural Environment Influenced by the Project

Each of the structural measures included into the alternative flood mitigation schemes would contain potentials of adverse impact to the social and natural environments as enumerated below.

(a) Traffic disruption by the river channel improvement and the flood diversion;

(b) Dispute over house evacuation/land acquisition by the flood mitigation dam;

(c) Replacement of the underground public facilities such as cables and water pipes by the flood diversion;

(d) Change of flow regime of Lai Nullah by the flood diversion; and

(e) Deterioration of the water quality in the community pond.

The flood diversion is indispensable to all of the alternatives, and its potential adverse effects could be avoided through the countermeasures; such as:

(a) Construction temporary bypasses to minimize traffic disruption;

(b) Progressive replacement of the underground public facilities for a long-term so as to minimize the adverse effect of the interruption of the facilities; and

(c) Securing of the maintenance flow for Lai Nullah by construction of the appropriate diversion structures and maintenance channel so as to minimize the change of the flow regime of Lai Nullah.

Deterioration of the water quality in community pond could be also minimized and/or improved better than the present through the following designs:

(a) To construct the oxidation ponds to improve the water quality of inflow;

(b) To construct the check dams to stop the garbage flowing to the pond;

(c) To construct the diversion channel to bring the clean discharge from the adjacent river (i.e., Bedarawali Kas) into the pond; and

(d) To alternate the existing route of low flow of Tenawali Kas, which now gives an offensive odor, and not connect it to the pond.

As stated above, the potential adverse effects of the flood diversion and the community pond could be minimized by adopting the several practical countermeasures. On the other hand, the flood mitigation dam and the river channel improvement are likely to have the fatal adverse social effects. That is, the flood mitigation dam would cause the serious dispute over the house evacuation and/or land acquisition as described above. As for the river channel improvement, the proposed channel deepening from Chaklala Bridge to Kattarian Bridge would require reconstruction/ reinforcement of the thirteen (13) bridges as mentioned above. These bridges currently take an important role for traffic of Rawalpindi, and interruption of these bridges due to river improvement would cause the serious traffic disruption and further deterioration of the regional economy.

6.3.6 Operation, Maintenance and Management Works for the Proposed Flood Mitigation Structures

The major works required to the operation, maintenance and management for the proposed structural measures, which consists of community pond, the river channel and the diversion channels, are as described hereinafter:

1) Community Pond

The principal works for operation, maintenance and management of the community pond would include the following items:

(a) Removal of deposits in the pond: This would be periodically required during a flood season from July to September in order to secure the designed storage capacity of the pond. In this connection, one (1) backhoe with bucket capacity of 0.45 m^3 and two (2) 10-ton capacity dump trucks were proposed as the required equipments to facilitate the objective control of the deposits.

(b) Safety control: The area of 0.16km^2 with a ground level below EL.545 m in and around the pond is subject to the probable flood inundation area of 10-year return period. In order to avoid the eventuality of visitors to be exposed to danger of flood, the area would need to be placed off limits during a flood season.

(c) Sanitary control: The water quality of the pond would be preserved by various facilities such as the oxidation ponds, the check dams and the bypass pipe not to allow the polluted water to flow into the community pond. Nevertheless, the periodical inspection on the water quality of the pond would be required and, in case of the unfavorable water quality detected through inspection, the pond would need to be dried up through the outlet of orifice.

2) River Channel and Flood Diversion Channel

The most critical issue on the maintenance for the river and diversion channel is addressed to removal of sediment, solid wastes and any other deposits in the channels particularly at the hydraulic critical points such as inlet of diversion points and piers of bridges. In order to cope with the issue, periodical removal of the deposits would be required throughout a year, and the emergency inspection/retrieval works be further required after a flood. The inspection and retrieval works on the side slope of the river channel would be also enumerated as an important issue for maintenance of the river channel, and the side protection works particularly against erosion of the side slope would be required according to the results of inspection.

6.4 POSSIBLE NON-STRUCTURAL FLOOD MITIGATION MEASURES

6.4.1 Flood Forecasting and Warning

The Pakistan Metrological Department PMD has monitored the storm rainfall of Lai Nullah through the existing four rainfall gauging stations and one weather surveillance radar installed in the compound of PMD Headquarter near Zero Point. TMA had also previously operated two (2) manual (off-line) water level gauging station at Gawal Mandi Bridge and Ratta Amral Bridge to monitor the flood water level of Lai Nullah. The existing rainfall gauging stations operated by PMD are, however, not equipped with the automatic data transmittal system, which cause difficulties in collecting the accurate gauged data in real-time base. The water level gauging stations used by TMA were also abandoned due to reconstruction of the bridges after the July 2001 flood.

The storm rainfall observed by PMD has been informed to by the relevant authorities (such as TMA, RDA and CDA) through the public telephone lines. Based on the information of storm rainfall and the flood water level of Lai Nullah, TMA in particular has disseminated the flood warning to the residents through the patrol cars and the sirens. However, the patrol cars hardly achieved the immediate dissemination of the flood warning, and the warning sires are decrepit decreasing reliability of function.

In the event of July 2001 flood, PMD observed an extra-ordinary scale of rainfall intensity in Lai Nullah through its weather surveillance radar and rainfall gauging. Judging from the results of the observation, PMD predicted a possibility of serious flood overflow along Lai Nullah a few hours before its actual occurrence. In spite of the advanced awareness of the flood, the flood caused the death of 74 people.

Should the existing flood gauging, communicating and warning system be strengthened, the more accurate and immediate flood information could be systematically collected, and the death calamity as experienced in 2001 flood would be relieved. From these viewpoints, the improvement of the existing flood forecasting and warning system is proposed as an eligible measure to immediately effect mitigation of the flood damage, the calamity of death in particular.

1) Proposed Organization Set-up for FFWS

For smooth operation of FFWS, the following improvement for existing organization is proposed (refer to Fig. 6.4.1):

(a) PMD would be the most eligible agency to undertake the integrated hydrological observation of the storm rainfall as well as the water level and the flood prediction. PMD would also take responsibilities to inform the results of the flood prediction to the relevant local government agencies such as TMA, RDA and RDB.

(b) The above local government agencies would take the responsibilities of flood dissemination to the residents in their respective jurisdiction areas based on the flood prediction by PMD.

(c) FFC should be the coordination body for PMD and other relevant government agencies to facilitate the daily overall maintenance and management for the whole facilities/equipment of FFWS and the basin-wide flood fighting and/or evacuation works as required.

2) Proposed Equipment and Telecommunication Network for FFWS

The proposed FFWS is composed of (a) rainfall/water level gauging stations, (b) Master Control Station, (c) Monitoring Station, (d) Executive Warning Control Room and, (e) Warning Posts. Location map of these gauging stations are as shown in Fig. 6.4.2. The proposed telecommunication network for these stations and the equipment required are as shown in Fig. 6.4.3 and Table 6.4.1**,** respectively. Briefs of the these stations/posts are further described hereinafter:

a) Rainfall Gauging Station

All of the existing four (4) rainfall stations are biased to eastern side of Lai Nullah Basin and, therefore, the western side of the basin is now situated as the hydrological blind area. In order to retrieve such unfavorable conditions, two additional rainfall gauging stations are proposed to be newly installed at the western side of the basin. Thus, the proposed FFWS is composed of the following six (6) rainfall gauging stations in total. All of the rainfall gauging stations would be equipped with the telemetry system, and the gauging data are automatically transferred from the rainfall stations to the Master Control Station through 400 MHz telemetry line.

Name of Station	Existing or New	Location		
		Latitude	Longitude	Located at
Chaklala	Existing	Lat.: 33^0 37'	Long: 73^0 37'	Islamabad International Airport
Islamabad	Existing	Lat.: 33^0 41'	Long: 73^0 03	National Agronomical Center
RAMC	Existing	Lat.: 33^0 37'	Long: 73^0 37'	Rawalpindi Agronomical Center
Saidpur	Existing	Lat.: 33^0 88'	Long: 73^0 05'	Seismological Observatory
Golra	New	Lat.: 33^0 41'	Long: 72^0 58'	Modern Veterinary Health Center
Bokra	New	Lat.: 33^0 33'	Long: 73^0 00'	Construction Machinery Training Institute

b) Water Level Gauging Station

The telemetry water level gauging station would be installed at five (5) following locations and the gauging data are automatically transferred to the Master Control Station through 400Mhz telemetry line. Among others, two water level gauging stations are installed along the mainstream of Lai Nullah at Kattarian Bridge and beside the Rawalpindi Fire Brigade Office (about 500m downstream from Gawal Mandi Bridge) in order to monitor the flood water level of the mainstream. Other three water level gauging stations would be installed in and around the proposed Community Pond in Fatima Jinnah Park to monitor the water level of the pond: two gauging stations for the water level of the two inlets channels of the pond and one for the water level of the pond itself. The overall location of the water level gauging stations are as listed below:

Name of Station	Existing or New	Location
Kattarian Bridge	New	At Kattarian Bridge on Khayaban-I-Sir Syed (I-J Principal Road)
Rawalpindi Fire Brigade	New	In the compound of Rawalpindi Fire Brigade Headquarter
Park-A	New	North inflow point of Tenawali Kas within the compound of Fatima Jinnah Park
Park-B	New	East inflow point of Tenawali Kas within the compound of Fatima Jinnah Park
Park-C	New	Community Pond proposed in Fatima Jinnah Park

c) Master Control Station

The Master Control Station is installed within the compound of PMD Headquarter at Zero Point. All rainfall and water level gauging data are transmitted to and processed by a sever installed at the Master Control Center on real-time base through 400MHz telemetry line connected between the Master Control Center and the aforesaid rainfall and water level gauging stations.

d) Monitoring Station

The Monitoring Station is installed at FFC, WASA of RDA and the control office of the community pond proposed in Fatima Jinnah Park. All flood information collected and processed by the Master Control Center is monitored by the client personnel computer at Monitoring Stations on real-time base through WAN with using excusive 5.2 GHz Wireless LAN. The Monitoring Stations would decide and arrange the necessary issues of the basin-wide flood warning, flood evacuation/rescuer, and control of community pond as required. Based on the monitors of the basin-wide flood conditions.

e) Executive Warning Control Room

The Executive Warning Control Room is installed at Rawalpindi Fire Brigade Headquarter. All flood information collected and processed by the Master Control Center is monitored by the client personnel computer at the Executive Warning Control Room on real-time base through WAN with using excusive 5.2 GHz Wireless LAN. The Executive Warning Control Room would evaluate the flood risk based on the monitored flood information and disseminate the flood warning to the residents through the under-mentioned warning sirens.

f) Warning Post

The warning posts would be distributed into the habitual flood inundation areas in Rawalpindi. The required number of the warning posts was provisionally estimated at ten (10) to cover the whole extent of the flood inundation areas. Out of the proposed ten (10) waning posts, the four (4) would be installed at the following locations. Other six (6) warning posts would be determined during the time for detailed design of the system.

Name of Station	Location		Remarks
Gawal Mandi	Lat.: 33^0 60’	Long. : 73^0 05’	Gawal Mandi Fire Office
Pir Wadhai	Lat.: 33^0 63’	Long. : 73^0 03	Pir Wadhai Fire Office
Warning Post C	Lat.: 33^0 60’	Long. : 73^0 07’	Waqar-un-Nisa College
Fatima Jinnah Park	Lat.: 33^0 43’	Long. : 73^0 04’	Within the compound of Fatima Jinnah Park

All of the warning posts are connected to the Executive Warning Control Room by telemetry line (400MHz). The Executive Warning Control Room will send the signals to the warning posts, as required, to blow warning sirens to the residents. The Executive Warning Control Room will also receive the signals from the warning post so as to confirm the execution of warning sirens

g) Configuration of Telecommunication Network

The telemetry line of remote transmission unit (RTU) with UHF band (400Mhz) would be connected between the rainfall/water level gauging stations and the Master Control Station in order to automatically transmit the flood information gauged by the rainfall gauging stations and the water level gauging to a server installed at Master Control Station. The telemetry line would be also linked between the Executive Warning Control Room and warning posts in order to transmit the signal to blow warning sirens to the residents. The Wide Area Network (WAN) with using excusive 5.2 GHz Wireless LAN would be further linked among the Master Control Station, the Monitor Station and Executive Warning Control Room in order to monitor the flood information collected and processed by the Master Control Station.

6.4.2 Flood Risk Map

Dissemination of the flood risk map is broadly adapted in the world as one of the useful non-structural flood mitigation measures. Through dissemination of the flood risk map, the residents could aware the extent of the possible flood inundation area and the available evacuation routes during a flood.

The flood risk map could also be the guidance for appropriate urban planning and land development. The flood risk map, in general, contains the information on: (1) the probable extent and depth of flood inundation and (2) the evacuation centers and evacuation routes to be taken during a flood. The base maps for the extent and depth of the probable flood inundation was delineated as shown in Fig. 6.4.4. The available evacuation centers as well as evacuation routes for each unit of the local communities should be further selected by the relevant local government agencies based on the base maps, and the flood risk map should be finalized. The flood risk map thus prepared should be disseminated to the public through a bulletin, an information board and other available information tools.

The total inundation area deeper than 0.3 m is estimated about 7.2 km^2, and deep inundation over 4 m is still anticipated in 1.3 km^2 low-lying areas along Lai Nullah and the tributaries even after the completion of the on-going ADB's Lai Nullah improvement project.

Table R 6.4.1 Flood Inundation Area

Inundation Depth	Inundation area by city (km^2)		
	Islamabad	Rawalpindi	Total
0.3 – 1m	0.26	1.57	1.84
1 – 2m	0.30	1.54	1.84
2 – 3m	0.15	1.11	1.26
3 – 4m	0.13	0.81	0.94
Greater than 4m	0.34	0.98	1.31
Total	1.18	6.01	7.18

6.5 STRENGTHENING OF INSTITUTIONAL SETUP AND CAPACITY BUILDING FOR FLOOD MITIGATION AND RIVER MANAGEMENT

There are several agencies concerned with flood mitigation and river management, while there is no agency to exclusively manage and/or administrate the entire Lai Nullah basin for flood mitigation. All of the agencies other than FFC are concerned with their own jurisdiction areas. As the results, it is difficult to have the consistent basin-wide river management from upstream to downstream. Under these conditions, the following issues on the present organization setup are pointed out:

(1) Flood mitigation plans may be formulated independently in each territory or control area by each agency with different scales and measures.

(2) In such plans, there may be some discrepancy or gap in the strategy of river management among territories or control areas, especially between upstream and downstream.

(3) As the results, flood mitigation plans could be hardly promoted especially when the coordination among agencies concerned is required.

(4) There are too many laws, acts and acts related to flood mitigation and river management, which causes difficulties in fully understanding the whole of the relevant legal arrangements.

(5) The statements in the laws, acts and acts related to flood mitigation and river management are relatively brief, and it may be difficult to cope with detailed issues on river management based on the statements laws, acts and acts related to flood mitigation and river management.

6.5.1 Strengthening of Organization Set-up

Strengthening of the organization setup would be achieved through (1) establishment of a new authority for the entire river management/administration or and (2) strengthening of the existing authorities relevant to the river management/administration. However, the establishment of a new authority in the above item (1) is evaluated to be virtually difficult, since there exist several authorities in charge of the river administration and/or administration, such as CDA and RDA, and establishment of a new authority may cause the serious conflict of roles with these existing authorities. From these viewpoints, the strengthening of the existing relevant river authorities is preferable, and the following items are proposed:

1) Establishment of Management Committee

The ECNEC had constituted a technical committee in 1984, under the Chairmanship of the Secretary of Ministry of Water and Power (MPW) for the smooth implementation of development projects in Lai Nullah, and another sub-committee was constituted in 1985 under the Chairmanship of CEA/CFFC and it was decided that FFC would act as lead agency for the Lai Nullah Project.

In order to strengthen the institutional setup for the river management/administration of Lai Nullah, there is dire need of reactivation of the Management Committee in the Ministry chaired by MWP with the principal members of FFC, CDA, RDA, TMA, RCB and SDO. The Management Committee may have monthly coordinate the issues regarding Lai Nullah, and through the coordination, the Management Committee would have the following principal functions:

(a) Support to financial arrangement of implementation of the master plan;

(b) General monitoring of progress of the Master Plan for flood mitigation of Lai Nullah; and

(c) Coordination on issues beyond control of FFC's Task Force between Federal and Provincial agencies, i.e., FFC, CDA, RDA, TMA, RCB and SDO.

2) Establishment of Task Force for Lai Nullah

FFC will shoulder the principal duty for implementation of Master Plan in Lai Nullah, while it has also a huge role to manage and coordinate the other major rivers in Pakistan as the routine works. In order to cope with the large work volume for implementation for Lai Nullah without fewer disturbances to the present routine works, it is recommended to set up a task force (or a project unit), which will exclusively handle the works for coordination for implementations relevant to Lai Nullah basin. The basic function of the proposed Task Force includes the following works (refer to Fig. 6.5.1):

(a) Review and modification of the Master Plan for flood mitigation and environmental improvement of Lai Nullah including implementation schedule.

(b) Explanation of the Master Plan to the agencies concerned and public.

(c) Financial arrangement for implementation of the Master Plan.

(d) Implementation of F/S for the project components included in the Master Plan if necessary.

(e) Allocation and instruction of the works including land acquisition and house evacuation of the project components to each agency responsible.

(f) Supervision and coordination for the works.

(g) Overall management and instruction of operation and maintenance works to the agencies concerned.

3) Preservation of the Existing Roles of the Relevant Authorities

On the premises of the above establishment of the Management Committee and the Task Force, the river management and administration should be jointly undertaken in principal by the existing relevant authorities, which include CDA, RDA, TMA, RCB and FFC. The major functions and/or responsibilities for these authorities are as proposed below:

Table R 6.5.1 Major Functions for Project Implementation

Agencies concerned	Major Functions/Responsibilities
FFC	Coordination for financing, planning, design, supervision, O&M* and others (land acquisition, logistics, etc)
CDA, RDA, TMA, RCB	Implementation of planning, design, supervision, O&M* and others in their territory or control area

*: Among the proposed flood mitigation structures, the community pond is placed in the jurisdiction area of CDA, and the usual operation and maintenance would be undertaken by CDA. However, the emergency removal of sediments in and around the pond after a flood may need to be undertaken by FFC

6.5.2 Strengthening of Legal Setup

There are many laws, acts and acts for the land administration but less for the river administration in Pakistan. As the results, when the river basin extends over more than two different jurisdiction areas, the river is administrated by the different land administrators, and the consistent river basin administration is hardly achieved. In order to improve such unfavorable conditions, it is indispensable to enact the “River management law or Water law”, which prescribes (a) the definitive unified river administrator, (b) the river reserve area to be administrated by the prescribed river administrator, (c) the authorities and responsibilities given to the administrator and (d) all other necessary items related to the river administration.

6.5.3 Capacity Building

Judging from the technical capacity of the staffs of the relevant agencies, the capacity building for the following programs would be required through the on-the-job trainings, the seminar/work shops and other relevant opportunities:

(1) Development of key management capability

(2) Financial and legal management capability

(3) Planning and design management capability including environmental knowledge

(4) S/V, O&M and Contract management capability

(5) Logistic support including public relation and coordination capability

The period for the on-the-job-training in particular would require one year before commencement of implementation of the proposed flood mitigation project for Lai Nullah and, other capacity building programs will be continued in parallel with the progress of the project implementation.

CHAPTER 7. CONSTRUCTION PLAN AND COST ESTIMATION

7.1 SUMMARY OF CONSTRUCTION WORKS

The plan for construction works are prepared for all structures proposed as the components of the optimum structural flood mitigation plan and the flood forecasting and warning system proposed as the eligible non-structural flood mitigation plan.

7.1.1 Community Pond

The community pond is scheduled to complete through the urgent project (2004-2005) as described in the following chapter. The major works are broadly divided into the following three (3) portions: (1) Diversion works, (2) Construction of the flood mitigation facilities and (3) Construction of the amenity facilities. The works items and work volumes for these portions are as listed below:

Table R 7.1.1 Major Construction Works of Community Pond

Work Item		Specification	Unit	Quantity
1. Diversion Facilities	1.1 Intake			
	Fixed Weir	H=2.5m	set	1
	Diversion Weir	H=5.2m	set	1
	Wet Stone Pitching		m^2	2,500
	Wet Stone Masonry		m^2	2,800
	1.2 Diversion Channel	L=1,340m, W=8m	set	1
	1.3 Box Culvert, etc.		L.S.	1
2. Flood Control Facilities	2.1 Detention Dam	Mixed type		
	Foundation Excavation		m^3	90,000
	Earth Fill	Homogeneous	m^3	160,000
	Concrete		m^3	31,000
	2.2 Pond Excavation		m^3	2,000,000
3. Amenity Facility	3.1 General Facilities			
	Entrance Gate		set	4
	Car Park		set	4
	Main Road	Asphalted	m	4,700
	3.2 Sports & Recreation			
	Multipurpose Ground		set	2
	Tennis Court		set	6
	Basket Court		set	4
	Other Facilities		set	1
	3.3 Landscape			
	Water-front Open Area		m^2	15,000
	Entrance Open Area		m^2	4,000
	Flower Bed		m^2	75,000
	Forest Park		m^2	417,000

7.1.2 Flood Diversion Channel

Construction of the flood diversion channel would be made through two (2) phases, namely: the short-term project (2005-2007) and the long-term project (2008-2012) as described in the following chapter. The major works for the construction are also divided into the following four (4) portions: (1) Diversion channel from Bedarawali Kas to Tenawali Kas, (2) Diversion Channel from Tenawali Kas to Saidpur Kas, (3) Diversion channel from Saidpur Kas to Kurang

River and (4) Improvement Kurang River. The works items and work volumes for these portions are as listed below:

Table R 7.1.2 Major Construction Works of Diversion Channel

Work Item		Unit	Quantity (Short term)	Quantity (Long term)
1. Diversion Channel (Bedarawali Kas - Tenawali Kas)	1.1 Fixed Weir	place	0	1
	1.2 Diversion Weir	place	0	1
	1.3 Diversion Channel			
	Common Excavation	m^3	0	1,148,000
	Revetment (wet stone masonry, wet stone pitching)	m^2	0	76,200
	Concrete (reinforced concrete & floor concrete)	m^3	0	33,840
	1.4 Bridge	place	0	4
2. Diversion Channel (Tenawali Kas - Saidpur Kas)	2.1 Hydraulic Drop (Tenawali Kas & Kanitawali Kas)	place	2	2
	2.2 Intake Weir (Tenawali Kas)	place	1	1
	2.3 Diversion Weir (Saidpur Kas)	place	1	1
	2.4 Diversion Channel (L=2,150m)			
	Common Excavation	m^3	184,000	443,000
	Dike Embankment	m^3	26,000	47,000
	Revetment	m^2	0	30,400
	Concrete (Floor Concrete)	m^3	0	21,390
	Drainage Outlet	place	40	50
	2.5 Bridge	place	8	8
3. Diversion Channel (Saidpur Kas - Kurang River)	3.1 Hydraulic Drop (Ojhri Kas)	place	2	2
	3.2 Diversion Channel (L=5,126m)			
	Common Excavation	m^3	1,542,000	2,430,000
	Dike Embankment	m^3	49,000	84,000
	Revetment (wet stone masonry, wet stone pitching)	m^2	0	107,300
	Concrete (Floor Concrete)	m^3	0	18,400
	3.3 Hydraulic Drop (Diversion Channel)	place	1	1
	Common Excavation	m^3	9,000	9,000
	Concrete (Mass Concrete)	m^3	11,000	11,000
	Gabion Mattress W 1.0m x B 1.5m x T 0.5m	m^3	11,300	11,300
	3.4 Bridge	place	8	8
4. Improvement of Kurang River	4.1 Excavation and Embankment Works			
	Common Excavation	m^3	82,000	164,000
	Dike Embankment	m^3	82,000	164,000
	4.2 Slope Protection (sodding)	m^2	37,000	74,000
	4.3. Drainage Outlet	place	30	70
5. Compensation	5.1 House Evacuation (for diversion channel)			
	For diversion channel	house	15	20
	For Improvement of Kurang River	house	110	220
	5.2 Land Acquisition (for Improvement of Kurang River	m^2	211,500	348,000

7.1.3 Supplementary Works for On-going Channel Improvement by RDA

The supplementary works are broadly divided in to the following two (2) portions, namely: (1) river improvement of Lai Nullah below Chaklala Bridge ((RD5+277-RD6+215) and (2) side slope protection works for the on-going channel river section of Lai Nullah from Chaklala Bridge to Kattarian Bridge (RD6+251-RD17+210). The river improvement of Lai Nullah below Chaklala Bridge of the above item (1) is scheduled to complete through the urgent project (2004-2005), while the side slope protection works of the item (2) is through the short-term project (2005-2007), as described in the following chapter. The works items and work volumes for these portions are as listed below:

Table R 7.1.3 Major Construction Works of Supplementary Works for On-going River Channel Improvement of Lai Nullah

Work Item		Unit	Quantity
1. Downstream River Improvement	1.1 Earth Work (Common Excavation)	m^3	31,000
	1.2 Slope Protection (Wet stone pitching)	m^2	41,000
	1.3. Compensation		
	Land Acquisition	m^2	8,000
	House Evacuation	house	0
2 Slope Protection	2.1 Revetment (Wet Stone Pitching)	m^2	302,000
	2.2 Compensation		
	Land Acquisition	m^2	0
	House Evacuation	House	0

7.1.4 Flood Forecasting and Warning System (FFWS)

The flood forecasting and warning system is to be completed through the urgent project (2004-2005) same as the aforesaid community pond. The principal equipment to be installed for the system are as listed below:

Table R 7.1.4 Major Equipment to be Installed for FFWS

Station	Principal Equipment	Quantity (unit)
1. PMD Master Control Station	Telemetry Supervisory Equipment	1
	Radio Equipment for 5.2 GHz and 400MHz	2
	Antenna System	1
	Display System & PC type Operation Console	1
	Printer & Processing System (FFWS Server)	1
	Emergency Power Supply System	1
2. Monitoring Station (FFC, WASA, Jinnah Park)	Radio Equipment for 5.2 GHz Wireless LAN	3
	Antenna System	3
	Display System	3
	Emergency Power Supply System	3
3. Rawalpindi Warning Control Station	Warning Supervisory/Control System	1
	Radio Equipment for 5.2 GHz ad 400MHz	1
	Antenna System	1
	Printer	1
	PC type Operation Console	1
	Display System	1
	Emergency Power Supply System	1
4. Rainfall Gauging Station	Remote Terminal Unit (RTU)	5
	Radio Equipment for 400MHz	5
	Antenna System	5
	Sensor Rainfall Gauge with Data Memory Pack	5
	Emergency Power Supply System	5
5. Water Level Gauging Station	Remote Terminal Unit (RTU)	5
	Radio Equipment for 400MHz	5
	Antenna System	5
	Sensor Water Level Gauge with Data Memory Pack	5
	Emergency Power Supply System	5
6. Warning Post	Warning Equipment	10
	Siren Equipment	10
	Audio Amplifier	10
	Laud Speaker and Sound Collector	10
	Radio Equipment for 400MHz	10
	Antenna System	10
	Emergency Power Supply System	10
7. Repeater Station (Telemetry System)	Repeater Equipment	1
	Radio Equipment for 400MHz	2
	Antenna System	1
	Power Supply	1
8. Repeater Station (Wireless LAN)	Radio Equipment for 5.2 GHz Wireless LAN	4
	Antenna System	2
	Emergency Power Supply System	2

7.2 BASIC CONDITIONS OF CONSTRUCTION PLAN

7.2.1 Earth Work

The performance of the construction machines is assumed as listed in Table R 7.2.1 taking the most suitable machine combination and the reuse of the excavation soil. Based on the performance of the construction machine, the construction period of earthwork was estimated.

Table R 7.2.1 Performance of Construction Machines

Earthwork	Machine	Performance Capacity	Remarks
Excavation	Bulldozer (32 ton)	146.21 m^3/hr.	
Loading	Backhoe (1.0m^3)	104.00 m^3/hr.	
Carrying	Dump truck (10 ton)	30.86 m^3/hr.	Materials handling distance : 0.5km
	Dump truck (10 ton)	8.00 m^3/hr.	Materials handling distance：8km
	Dump truck (10 ton)	6.70 m^3/hr.	Materials handling distance：12km
Grading & compaction	Bulldozer (21 ton)	100.00 m^3/hr.	Disposal Area
Spreading material for fill work	Bulldozer (21 ton)	119.60 m^3/hr.	Dam Work
Spreading material for fill work	Backhoe (0.7m^3)	53.50 m^3/hr.	Dam Work
Compaction of material for fill work	Tamping Roller (20. 7 to 34.5 ton)	55.00 m^3/hr.	Dam Work

7.2.2 Mass Concrete Placing Work

The construction period of mass concrete of the dam body is estimated on the basis of the following assumptions:

(1) The daily concrete placing capacity is 225 m^3 (15m in width x 10m in depth x 1.5m in height).

(2) The maximum casting height of 1.5m.

(3) One cycle of the daily concrete placing works will take 8 days, which include 2 days of form fabrication, 5 days for concreting and curing, and 1 day for dismantling.

7.2.3 Available Working Days

Construction works are much influenced by rainfall. The works related to soil materials in particular could be performed in the non-rainy days. Taking these conditions into account, the number of the available construction-days in a month is assumed at 25 days. It is also assumed that each of the preparation, the temporary work and the clearing works would take 0.5 months.

7.2.4 Dumping Sites

The dumping sites for the excavated materials are provisionally assumed at Block H-12 and F-13 in Islamabad (refer to Fig. 7.2.1).

7.3 CONSTRUCTION SCHEDULE

In accordance with the phased program, the entire construction/installation period for the major work components of the proposed structural plan as well as the flood forecasting and warning system proposed as the non-structural plan was assumed as shown in Table R 7.3.1. The detailed construction schedule for the structural plan was further prepared based on the aforesaid work volumes and basic conditions for construction as shown in Table 7.3.1.

Table R 7.3.1 Entire Construction Period of Major Works

Classification	Work Item		Construction and/or Installation Period
Structural	Community Pond		Urgent (2004-2005)
	Diversion Channel	Channel (Tenawali Kas-Kurang River, Qmax= 470 m^3/s)	Short-term (2005-2007)
		Channel (Bedarawali Kas-Kurang River, Qmax=1,790m^3/s)	Long-term (2008-2012)
		Improvement of Kurang River	Short/Long-term (2005-2012)
	Supplementary Works for River Improvement of Lai Nullah	River improvement below Chaklala Bridge	Short-term (2004-2005)
		Side slope protection of the on-going improvement section	Short-term (2005-2007)
Non-structural	Flood Forecasting and Warning System		Urgent (2004-2005)

7.4 COST ESTIMATION

7.4.1 Project Cost

The project cost, which consists of the direct construction cost, indirect construction cost and compensation cost, is estimated base on the following assumptions.

(1) All costs expressed in the Study are based on the average prevailing market prices in 2002, and the exchange rate of currency of US$ 1.0 =120.06 yen (Japanese currency) = Rs. 58.0.

(2) Direct construction cost consists of material cost, labor cost and plant cost.

(3) Indirect construction cost consists of the following common temporary work cost, management cost and overhead cost:

  (a) Common temporary work cost: 5% of the direct cost,

  (b) Management cost: 10% of the total of the direct cost and the common temporary cost, and

  (c) Overhead cost: 10% of the total of the direct cost, the common temporary cost and the management cost.

(4) The physical contingency and price contingency are included in the construction cost. The physical contingency is assumed at 5% of direct cost and indirect cost. Estimation of the price contingency is based on the inflation rate of 4% per year inflicted to the local currency portion of the direct cost and indirect cost.

(5) Compensation cost is given to the land acquisition and house evacuation, and it is based on the following unit prices:

Item	States	Unit Price
Land Acquisition	Urban Area	Rs. 5,500 to 11, 000/m^2
	Rural Area	Rs. 1,600 to 2, 000/m^2
	Forest	Rs.500/m^2
House Evacuation	Urban Area	Rs.8,000,000/house
	Rural Area	Rs.50,000 to 100,000/house

(6) Cost for engineering service estimated at 10% of the construction cost.

(7) Administration service is estimated at 1% of the construction and compensation cost.

(8) Duty and tax are estimated as the with-holding tax (6.4%) on the construction cost and the cost for engineering service.

Based on the above assumptions, the project cost estimated for the optimum structural flood mitigation plan is estimated at Rs. 7,615 million in total, which is divided into (1) Rs. 1,137 million for the community pond, (2) Rs. 5,605 million for the flood diversion and (3) Rs. 873 million for the supplementary works for the on-going channel improvement of Lai Nullah. The project cost is also divided into (1) Rs. 1,267 million for the urgent project, (2) Rs. 2,857 million for the short-term project and (3) Rs. 3,492 million for the long-term project. As for the flood forecasting and warning system proposed as the non-structural flood mitigation plan, the project cost is estimated at Rs. 302 million, which would be invested during the term of the urgent project cost. The breakdown of these project costs is as tabulated in Table R 7.4.1.

Table R 7.4.1 Project Cost for the Proposed Structural and Non-structural Flood Mitigation Plan

(Unit: Rs. million)

Work Item			Urgent Project	Short-term Project	Long-term Project	Total
Structural	Community Pond		1,137	-	-	1,137
	Diversion Channel	Channel (Tenawali Kas-Kurang River)	-	2,059	-	2,059
		Channel (Bedarawali Kas-Kurang River)	-	-	3,433	3,433
		Improvement of Kurang River	-	55	59	114
		Sub-total	-	2,113	3,492	5,605
	Supplementary Works for Lai Nullah	River improvement below Chaklala Br.	130	-	-	130
		Side slope protection of the river channel	-	743	-	743
		Sub-total	130	743	-	873
	Grand Total of Structural Plan		**1,267**	**2,857**	**3,492**	**7,615**
Non-structural	Flood Forecasting and Warning System	(1) Equipment Cost	248	-	-	248
		(2) Installation Cost	28	-	-	28
		(3) Cost for Civil Works	10	-	-	10
		(3) Materials/ other miscellaneous	16	-	-	16
	Grand-total of Non-structural Plan		**302**	**-**	**-**	**302**

7.4.2 Operation and Maintenance Cost

The operation and maintenance cost for the components of the proposed structural plan is assumed to consist of (1) the machine operation cost, (2) the machine maintenance cost, (3) the cost for the administrative and logistic support, (4) cost for repair of the structures and office running cost, and (5) the miscellaneous expenses. Based on these items assumed, the annual operation and maintenance cost is estimated at Rs. 3,256 thousand upon completion of the urgent project, Rs. 4,784 thousand upon completion of the short-term project and Rs. 5,373 thousand upon completion of the long-term project as listed in Table R 7.4.2.

Table R 7.4.2 Annual Operation and Maintenance Cost for the Components of the Structural Plan

(Unit: Rs. Thousand)

Item	Upon Completion of Urgent Project	Upon Completion of Short-term Project	Upon Completion of Long-term Project
(1) Machine operation cost	696	1,006	1,006
(2) Machine maintenance cost*	1,404	1,404	1,404
(3) Cost for administrative and logistic support	542	1,160	1,160
(4) Cost for repair of the structures and office running cost	460	986	1,547
(5) Miscellaneous expenses**	155	228	256
Total	3,256	4,784	5,373

*: Includes cost for regular maintenance, repair of the machineries, supply of spare parts
**: Assuming 5% of the items (1) to (4)

As for the flood forecasting and warning system, the necessary annual operation and maintenance cost is estimated at about Rs. 3 million, which is composed of Rs. 2.3 million for maintenance of equipment and Rs. 0.7 million for administrative/logistic support as listed in Table R 7.4.3. This operation and maintenance cost would accrue immediately after completion of the urgent project in 2005.

Table R 7.4.3 Annual Operation and Maintenance Cost for the Flood Forecasting and Warning System in the Proposed Non-structural Plan

(Unit: Rs. Thousand)

Item	Cost
Maintenance cost for equipment, office running cost, etc.	2,258*
Cost for administrative and logistic support	700
Total	2,958

*: 1% of procurement & installation cost of the equipment, civil works and other miscellanies direct cost.

CHAPTER 8. ENVIRONMENTAL IMPROVEMENT PLAN RELATED TO FLOOD MITIGATION

8.1 IMPROVEMENT OF DRAINAGE AND SEWERAGE SYSTEM

8.1.1 General

The Lai Nullah is currently used as the principal outlet for drainage of storm water and sewerage in Islamabad and Rawalpindi. Islamabad is located on the gradual slope toward Lai Nullah. Due to the favorable geophysical condition as well as the rather adequate existing drainage network in the built-up area, most of the jurisdiction area of Islamabad is likely to not have any significant drainage problem. On the other hand, the drainage conditions in Rawalpindi are deteriorated due to low-lying ground and the backwater effects of the high water level of Lai Nullah. Moreover, due to poor capacity of the existing sewage treatment plants both in Islamabad and Rawalpindi, the river water of Lai Nullah is seriously polluted giving off a stench during a period of low flow discharge

In order to retrieve Lai Nullah from the current sewage problems, improvement of the existing sewage treatment plant for Islamabad has been launched out in 2003 through a financial assistance from the French Government. The sewerage and drainage master plan for the city center of Rawalpindi has been also formulated in 2002 and, in accordance with the master plan, the improvement works are now being implemented through a financial assistance from ADB funding.

The sewerage master plan and the drainage master plan for Rawalpindi are, however, projected to be completed in 2020, and 2014, respectively. Thus, it would still take some time more to be free from drainage and sewerage problems. Moreover, the drainage and sewage improvement work in Rawalpindi is limited to the jurisdiction area of WASA, RDA, and the Cantonment Area in Rawalpindi (i.e., the jurisdiction area of RCB) is left behind from any drainage and sewerage improvement. Taking these conditions into account, the following items would be given as the principal issues on the drainage and sewage.

8.1.2 Clarification of Phased Improvement Programs for On-going of Drainage and Sewage Improvement

The phased improvement programs are likely to have been already formulated in the on-going plan.

1) Improvement of Islamabad Sewage Treatment Project (STP)

Joint project by CDA and French government, consisting of newly completion of STP Phase IV, besides improvement and repair of the other STP Phase I, II and III, will start abound first of

2004 and construction period is about 30 months. After the completion, it is expected river water quality at downstream of the STP located at I-9 will be improved. It would be, however necessary to retrieve leakage of sewage from the trunk sewer and to complete the house connection system with sewers. A system for regular monitoring on the water quality of the river as well as the inflow/outflow at the STP would be also required.

2) Improvement of TMA-R Sewerage and Drainage System

After the "Urban Water Supply & Sanitation Project, Phase 1", "Rawalpindi Environmental Improvement Project" is now under preparation as a phase 2. The components are (a) water supply, (b) sewerage, (c) drainage, (d) solid waste management, and (e) institutional strengthening. A feasibility study will start in September 2003 and the detailed components of the project (Phase II) will be decided five (5) months after commencement of the feasibility study. The project will be subject to the financial assistance with a loan amount of US$ 50 million from ADB.

The components of the sewerage system are roughly classified into (a) construction of lateral sewers, (b) construction of trunk and outfall sewers, (c) construction of sewerage treatment plant, (d) purchase of equipment and machinery for operation and maintenance of the system. The components of the drainage are also classified into (a) Lai Nullah improvement works – phase 2, which includes channel lining, deepening and construction of maintenance roads on both banks and (b) rehabilitation of Kassi East, Kassi West and other main drains.

8.1.3 Implementation of Drainage and Sewerage Improvement for Jurisdiction Area of RCB

The master plan for improvement of sewerage system in the jurisdiction area of RCB has been formulated by Engineers 10 Corps, Rawalpindi, while the drainage system in the area is left behind without any definitive improvement plan. The master plan for the sewage plan should be updated, as required. Effluent quality at STP is proposed as 40 mg/L in BOD and less than 1000 organisms/100 ml in fecal coli-form, and the figure is relatively high, especially in fecal coli-form. Effluent quality with activated sludge sewage treatment process is regulated in Japan as BOD is less than 20mg/l, fecal coli-form is less than 3000 organisms/ml and SS is less than 70 mg/l. And the necessary budgetary arrangements as well as other relevant necessary works for implementation should be taken immediately. At the same time, the drainage master plan should be formulated in the earliest opportunity taking the on-going river improvement of Lai Nullah, the on-going drainage improvement works for the jurisdiction area of TMA and other relevant flood mitigation works into consideration.

8.2 SOLID WASTE MANAGEMENT

It is common that most of the residents living close to Lai Nullah and its tributaries are apt to dump solid wastes into the river. The residents are taking an easy way to dump their solid wastes, instead of bringing them to the nearest containers. This kind of activities would deteriorate the water quality and sanitary conditions of the rivers. However, the residents usually complain about lack of containers in their vicinity, or that the containers are always full of solid waste. What the residents want is simply to get rid of their solid wastes from their premises without considering any environmental impacts.

In order to relieve these unfavorable conditions, CDA, TMA and RCB shall take necessary actions to remove these habits, attitudes and kind of social customs. A realistic SWM policy shall be formulated and the following measures be urgently proposed:

8.2.1 Collection of Accurate Solid Waste Data in a Scientific Way

The authorities in charge of the solid waste management are not aware of how much solid wastes are generated what kinds of components they are consisted of, and how the characteristics are changing, etc. Due to lack of the collection capacity, they just collect some of the generated solid wastes and transport them to dumping site. It is Obvious that the remaining wastes are dumped into empty lands or rivers.

The volume of the solid waste is presently estimated by visual judgment without measurement of the actual weight, whereof it is virtually difficult to get accurate reliable data. The method is unreliable and shall be converted to a scientific one. The authority shall accumulate the basic data on the weights and components of the collected, disposed solid waste and generated solid waste. To formulate a scientific and efficient long-term plan of SWM, the measurement by the truck scale (measuring equipment for the truck weight) shall be conducted soon. Moreover to formulate a future plan concerning the SWM, the data collection is essential to calculate the capacity and lifetime of the landfill site, or to estimate the required numbers of collection vehicles and so on.

8.2.2 Legislation of Act of Solid Waste Management

There currently exits no definite and independent regulation for solid waste management in Pakistan. No treatment of solid wastes is given before transporting them to the dumping sites, and open dumping is made with inadequate landfills, which causes serious environmental problems in and around the dumping site. The strategic plan needs to be prepared comprising both long term strategy, vision of how municipal solid waste management service in the city will be developed in the future, and action plan, how the city is going to get there.

Therefore to improve the situations related to solid wastes in Islamabad and Rawalpindi, “the Solid Waste Management Act” shall be legislated. “The Solid Waste Management Act” shall be designed to protect the living environment and promote public health. The residents (citizens), enterprises and the municipalities (government) play their respective rolls in promoting appropriate waste management.

The act shall clarify what kind of roles the residents (citizens), enterprises and the municipalities (government) are to play in the daily activities. Important considerations for improving the SWM in the study area are summarized in the following Table R 8.2.1.

Solid Waste Management Act (assumed name, hereafter referred to as “the Act”) shall promote the creation of “source reduction of waste and recycling system”. People, enterprises and government shall cooperate together to reduce, reuse and recycling the waste. The Act shall provide their respective roles in promoting appropriate waste management.

Municipalities are responsible for management of domestic waste, such as garbage from households. Municipalities shall set solid waste management plan in respective administrative area. And the plan includes the following matters:

(1) Estimation of the volume of domestic waste to be generated and to be treated

(2) Estimation of fundamentals of proper domestic waste management and fundamentals relating to authorities carrying out such management

(3) Evaluation on the matters pertaining to improvement of expansion of domestic waste treatment facilities and landfill site.

Enterprises are in charge of their own industrial waste such as construction waste, cinders, sludge and waste oil etc. generated from their own business activities. And each enterprise shall treat and dispose their waste by themselves consulting with the municipalities. Regardless of industrial waste, business must recycle waste produced from their activities and make effort for waste reduction. The following measures relating to products and by-products are the way of source reduction of waste.

(1) Measures for reducing waste by designing long-life products

(2) Measure for reusing parts

(3) Measures for manufacturers to recover and recycle end-of life products

(4) Measures for reduction and recycling of by-products.

The owners of large office buildings and market directors may carry out the reduction of solid waste and recycling. First of all they shall set the reduction numerical target (goal) in the offices or markets for solid. The volume of garbage may be measured or counted by numbers of bags baled in waste. And owners or the directors shall direct to reduce the garbage, which is generated by each tenant of the buildings or every small market owner in the market.

People should separate waste according to their types. Moreover, in order to promote effective reduction, reuse and recycling waste. For example community residents gather and separate the garbage to dispose and resource to use from the waste and have the resources collected by recycling company.

Table R 8.2.1 Items to be considered for Preparation of the SWM Act

Items to be considered	Explanation
To organize recycle system and to reduce the solid waste generation.	• To formulate source reduction, reuse and recycling system for solid wastes.
To define the solid waste	• To clarify the definition of domestic waste, hazardous wastes, infectious hospital waste and industrial wastes.
To clarify the duty and roll of central government, municipality, citizen and enterprise.	• Central Governments; To provide guidance and financial assistance from central government to municipalities • Municipalities; to collect, transport and dispose domestic waste. • Citizen and community; To separate and reduce their wastes To use the recycled products. • Enterprise and factories; to be in charge of their own industrial wastes (such as construction waste, factory waste) i.e. each enterprise shall treat and dispose industrial waste by themselves consulting with municipalities.
To make solid waste management planning	• To make solid waste management planning, consisting prediction of solid waste generation, future plan for landfill site and other solid waste treatment facilities.
To dispose hospital waste	• To collect, transport and dispose the infectious hospital waste by hospitals by themselves consulting with municipalities.

8.2.3 Reduction of Waste Generation by Community-based Organization or Private Enterprise Partnership

By the discussion and interview with the staff of TMA and CDA, after the SWEEP project had been completed, it was found that this kind of activity could not be sustained without large efforts required to maintain it. However JICA Study Team have come to a conclusion that this project would be useful to give substantial impacts, such as introducing the concept of Community-based Organization (CBO) or Private Enterprise Partnership (PEP) to participate in solid waste management, to reduce the public cost and enlighten the importance of the social awareness.

Both the municipality and the citizen shall be responsible for solid waste management with the cooperation in order to effectively solve the solid waste management problem.

At the garbage generation point, citizens (or community) can segregate and reduce the garbage. Community cooperation needs to be carried out the source reduction measures.

To formulate solid waste reduction programs, the municipality shall formulate a feasible strategy: 1) to promote the waste reduction program with community and enterprise participation, because of the high effectiveness of source reduction by the citizen, and 2) to introduce waste separation to make an easy waste recycling.

8.2.4 Gradual Prohibition of Scavenging Activity

The scavenging activity might contribute to the reduction and recycling of solid wastes to be collected to some degree. However negative impacts would not be negligible such as scattering the wastes or aesthetic disturbances. On the other hand there are a certain number of people, who are living on scavenging. A sudden prohibition would cause social problems related to the scavenging activity. In light of avoiding sudden major change, JICA Study Team would propose to prohibit the scavenging gradually or only limited places. To this end a social survey will be required on the method and timing toward the prohibition of the scavenging activity.

8.3 CONTROL AND REMOVAL OF ENCROACHMENT

8.3.1 Overview

In the study area, there remain several communities developed within the existing right-of-way (ROW) of various tributaries of Lai Nullah River as well as those of Kurang River. The communities are in situations where no proper solid or sanitary waste collection or disposal programs exist. Therefore many of the residents are forced to dispose of their waste directly to watercourse, resulting eventually in degradation of their living environment and nearby watercourse environment.

In this context, a possible resettlement of the community was initially considered in the urban settings for improving living environment of the community. The residents in rural setting such as those in Kurang River was subsequently incorporated into potential target population for resettlement program when potential needs of relocation was recognized in the course of project designing. In parallel with the formation of the project concept, Capital Development Authority (CDA) should initiate the debate on relocation of Kachi Abadi dwellers in Islamabad whose abodes were destroyed in the flood.

The intervention through the resettlement program will involve two-dimensional consequences such as significant beneficial impacts to the living environment of the people and adverse socio-economical impacts such as disruption of community, loss of employment opportunity as a result of distant relocation sites from the current community unless appropriate measures are designed for restoring and improving their livelihood.

In this study, legislative aspects of relocation was briefly examined, which led to development of proposal for modification of resettlement program of the government to minimize adverse impacts and to maximize project benefit by incorporating mitigation measures. Total lack of the legal framework for rehabilitation and those for informal squatters will necessitate development of a set of the project-specific guidelines for resettlement assistance incorporating principal elements stipulated in the guidelines of potential funding sources.

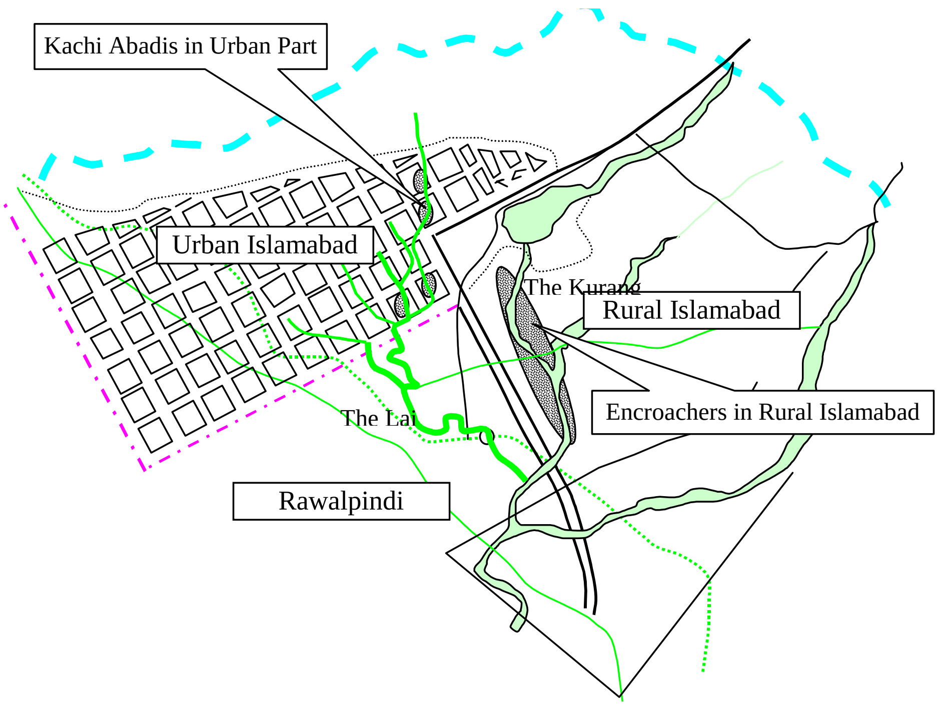


Fig. R 8.3.1   Location of Encroachments

8.3.2 Issues to be addressed in the Program

The principal issues are addressed to the existing encroachments in the right-of-way for the river as described hereinafter

1) History and Current Encroachers

The government has emerged at the time of Islamabad development as "provider" of housing assistance, sometimes in ad-hoc built "satellite towns" sited nearby that is generally referred to as Kachi Abadi in the area. In this context, most housing within Kachi Abadi was property of the government with decent level of infrastructure in its early period. However, it has sprawled across the low-lying area as a result of increased migration of people seeking for increased opportunity in the urban area.

Residents currently live in overcrowded dwelling environment where no proper solid and sanitary waste collection, and disposal programs exist, which therefore render them to dispose directly to watercourse resulting eventually in degradation of their living environment and nearby watercourse environment. The incidence of flood in the year 2001 indicated that direct disposal of solid waste has disturbed water flow and hence lowered flow velocity of the watercourse, which is deemed to be the underlying cause of the substantial damage incurred to the whole community within the Study Area.

Kachi Abadis are located on marginal and prone to natural and man-made disasters as have seen in the year 2001. The lack of basic environmental infrastructure and locations on marginal land often translate the residents into higher rates of disease and lower life spans. In addition, they are most affected group of people by increased flooding due to changes in land use by others upstream yet they generally have the least power to enact change or to compel government to intervene on their behalf due to their fragile legal position.

2) Governmental Proposal for Relocation of Kachi Abadi

Due to unclear tenure system of Kachi Abadi, there is the fear of imminent eviction among the residents. This has been debated in a recent meeting of All-Pakistan Alliance of Kachi Abadis. The agenda debated in the meeting includes eviction notices issued to the residents of Railway Colony in Peshawar. The eviction operation was called off due to pressure from the residents, however, there is an indication that the Pakistan Railways has restarted its eviction drives all over again. In the Study Area, it is being debated in the context of rehabilitation of Kachi Abadi dwellers in Islamabad whose abodes were destroyed in the flood. The flood victims of Kachi Abadi in G sectors such as G-7/1, G-7/2 and G-8/1 have been granted permission to rebuild their houses at the same place where they were originally constructed. However, there is still not much clarity on how the residents of I-sector Kachi Abadi will be rehabilitated. Capital Development Authority has proposed recently to relocate the Kachi Abadis to a site in Alipur Farash.

3) Adverse Impact of Resettlement

An interview with several informants within Kachi Abadis in Islamabad indicated that forced displacement for those affected means not only the loss of their homes, but also the loss of their prior jobs. The distance of the relocation site from the original place and jobs will become an obstacle to maintaining prior employment and thus result in possible escalation of wages in Islamabad for low-paying job. Furthermore, those who lacked legal title to their shelters and house plots are regarded as ineligible for compensation. Tenants are also ineligible for compensation, even though they may be unable to find elsewhere equally affordable tenancy arrangements. The social and cultural disruptions in neighborhood ties and kinship networks will also have deep effects, which are additional to the tangible economic losses. Such non-quantifiable but real social and economic costs are the loss of access to site-related mutual help networks, to exchange and borrowing opportunities and to services such as schools, churches, etc.

4) Legislative Aspects of Encroachment Removal and Recommendations

The current government relocates encroachment on the ground of the Land Acquisition Act, LAA that was enacted originally in 1894, more than 100 years ago, when the role of the public sector in promoting economic development was negligible and was based on the doctrine of laissez-faire. The Act allows the Government to acquire privately owned land for public purpose such as river improvement, highway and building construction. Compensation is in cash for the loss of land, other productive assets such as standing crop, house plots and residence.

There seems to be deficiencies in the LAA in view of the internationally accepted procedure for land acquisition such as the latest environmental guidelines of JBIC, the Guidelines for Environmental Social Consideration, as well as OP 4.12 and BP 4.12 “Involuntary Resettlement” of the World Bank. A major gap is the absence of any law, regulation or policy guidelines governing “resettlement” and “rehabilitation”. Restoration of community and household productive assets, or standard or quality of life, is not covered by the LAA. In addition, no legal framework is available to pay compensation to informal settlers, encroachers or illegal occupants.

The Bank policy states that ‘where displacement is unavoidable, resettlement programs should be conceived and executed as development programs, providing sufficient investment resources to give the persons displaced by the project the opportunity to share in project benefits’. It also mandates that the affected people should be ‘offered opportunities to participate in planning and implementing resettlement programs’; and that ‘displaced persons should be assisted in their efforts to improve their former production levels, income earning capacity and living standards, or at least to restore the production levels, income earning capacity and living standards they would have achieved in the without-project case’ (World Bank 1998:1).

In order to reduce the economic losses, social trauma and psychological pain inflicted on displaced people, the country must develop guidelines that will explicitly regulate displacement and relocation with due consideration on the fact that the deprivation suffered by displaced people raises vital issues of constitutional norms and human rights, including the right to survival, and the basic right to live with dignity.

8.3.3 Resettlement Program of Encroachers

The details of the resettlement programs of encroachments are as described hereinafter:

1) Objectives of Resettlement Program

The major objectives of the resettlement program are the following:

(a) To improve living environment;

(b) To reduce environmental degradation of the watercourse;

(c) To increase flow velocity by reducing direct disposal of solid waste to the watercourse; and

(d) To empower poor people by participatory program planning.

2) Target Population of Resettlement Program

The target population of the program includes those living in communities developed within the existing right-of-way of various tributaries of Lai Nullah River as well as Kurang River in Islamabad. They are generally poorer than other segment of the society, which is the common dimension of the target population, though; they are diverse in environmental settings as they encompass those living in urban as well as rural settings. The target population in urban environment includes residents of Kachi Abadis in Islamabad developed inside the riverbank of the Lai Nullah, while that in rural environment is the settlement extending along the Kurang River. Resettlement in urban or pre-urban settings, usually referred to as urban resettlement, is differentiated from rural resettlement since the types of problems involved and the strategies proposed to address them are substantially different from those in rural resettlement. Due to limited range of information on socio-economy of the community along the Kurang River available as of the time of report prepared, this part of the report temporally address the issues of Kachi Abadi community resettlement in urban settings.

3) Proposal for Modification of Resettlement Program

Efforts must be made to examine all possible ways to avoid involuntary resettlement and loss of means of livelihood. When involuntary resettlement is unavoidable even after such examination, effective measures to minimize impacts and compensate losses shall be agreed upon with the parties concerned.

Residents who are forced to relocate involuntarily or forfeit their means of livelihood shall be sufficiently compensated and supported by the project proponent for an appropriate duration of time. Sufficient compensation and support should not stop at preventing the deterioration of the quality of life, but may mean improving it as well. Measures to achieve this purpose may include providing monetary and land compensation (to cover monetary and land losses), as well as support the means for an alternative sustainable livelihood, the expenses necessary for relocations, and the re-establishment of a community at relocation sites.

Meaningful participation of relevant stakeholders, such as affected people and communities, shall be promoted in planning, implementation, and monitoring of resettlement and rehabilitation plans.

In the development of resettlement plan, principal elements that should be included are (a) a census survey of displaced persons and valuation of assets; (b) description of compensation and other resettlement assistance to be provided; (c) consultations with displaced people about acceptable alternatives; (d) institutional responsibility for implementation and procedures for grievance redress; (e) arrangements for monitoring and implementation; and (f) a timetable and budget.

8.4 LAND USE CONTROL IN THE HABITUAL FLOOD INUNDATION AREA

The land use control, which is adopted as the non-structural flood mitigation measure, would generally require less cost than the structural flood mitigation measures and essentially bring about environmentally beneficial in that it does not attempt to regulate the natural flooding pattern of a river.

With installation of proposed structural measures, on the other hand, local pre-project adaptations to flood would be relaxed or abandoned or increased development on the flood-prone area would occur in the post-project period, which might increase risk to life and property when structural failure could occur and floodwaters would exceed the capacity of control structures/measures.

The target flood protection area in the Twin City of Islamabad/Rawalpindi is a developed urban part of the country where use of non-structural flood control is imperative in conjunction with structural facilities to minimize investment cost and to ensure realization of project objectives in an environmentally sound and socially acceptable manner.

In this context, zoning as an effective means of controlling floodplain development will provide basis to enable sustainable development of flood prone urban area. Zoning the land for such things as residential areas, parks and conservation areas is compatible with floodplain protection, and prevention of land uses which are vulnerable to flood damage.

The objectives and tools of land use control are: (1) to prohibit or to regulate development on the floodplain or watershed areas or flood-proof existing structures; and (2) to reduce the potential for loss from flooding. In order to achieve these objectives, the following acts for the land use control would be required:

1) Zoning Act

Regulations in zoning acts can prohibit or specify the types and function of structures that can be built on the floodway and flood plain to minimize the flood risk. For example, the disposal of sewage, toxic and other harmful materials can be prohibited, and flood protection of structures shall be required. The construction of buildings and private roads, that may exacerbate the effects of floods, shall not be allowed.

2) Sanitary Act

Sanitary acts and building acts can make further specifications on floodplain management. Sanitary acts reduce the risk of health problems which could arise from contamination of water supplies when sewage disposal systems are disrupted by flooding, or when contaminated groundwater is infiltrated into the pipes. The acts can prohibit the installation of soil absorption systems (e.g., septic tanks, absorption fields, etc.) or require that a permit be obtained prior to installation with appropriate specification by the government.

3) Building Act

Building acts can specify structural requirements of new buildings to reduce their vulnerability to flooding, reduce health and safety hazards to occupants (e.g., regulations on electrical wiring and floor elevations), and minimize the extent that the building could impede the flow of floodwaters.

Relevant land use plans are included in the Master Plan of Islamabad and that of Rawalpindi. Future land use of Rawalpindi, where a significant economic damage incurred in 2001, with objectives of (1) achieving sustainable and systematic growth of the city, (2) achieving convenience, aesthetic and healthy environmental for the residents, and (3) creating a compact city within the existing built up area.

As represented in the objectives, the future plan aims at bolstering economic development by streamlining transportation and improving convenience of the people rather than creating flood-proof community. The problem in the city’s land use plan may underlie in (1) lack of flood hazard information among urban planner, (2) lack of tools for land use control reflecting flood hazard and (3) inadequate information about plans to citizens. Flood hazard information will become available upon the completion of this study. Therefore, development of concrete zoning, sanitary and building acts will be necessary and a sort of awareness program may be required.

8.5 WATERSHED MANAGEMENT IN LAI NULLAH BASIN

In Lai Nullah basin, the land development associated with exploitation of water sources has been promoted for a long term covering the whole basin. As the results of such activity, the following issues are pointed out, though the specific data to identify such conditions are very limited:

(1) Deterioration of water quality;

(2) Reduction of water conservation capacity of forest;

(3) Increase of sediment runoff from the river basin;

(4) Increase of the peak flood runoff discharges as well as flood damage;

(5) Decrease of the low flow discharge; and

(6) Lowering of grand water level.

As noted from the above conditions, it is necessary to practice the watershed management in Lai Nullah basin, which would contribute to reduction of the water problems. To successfully practice the watershed management, coordination among agencies concerned and also public participation are essential. The necessity of the watershed management might have been discussed among the agencies concerned and it has been practiced so far by several agencies. The following activities are enumerated as the typical examples of the watershed management in Lai Nullah basin and its adjacent river basin:

Table R 8.5.1 Activities of Watershed Management

Project	Implementation Agency	Location	Major contents of the Project
Watershed Management of Rawal Dam*	Small Dams Organization	Catchment area of Rawal dam (Out of Lai Nullah)	355 check structures and 25 Nos. bed bars (The works were completed at the end of 2002 October.)
Watershed Management of Lai Nullah	CDA	CDA Territory in Lai Nullah basin	Construction of check dam, landscaping, and afforestation**, land use control in the upstream and along the river course
Watershed Management of Silly dam***	CDA	Catchment area of Silly dam (Out of Lai Nullah)	Construction of check dam, terracing, retaining wall, silt detention dam afforestation,

*: Source: PC1 for watershed management of Rawal Dam

**: Afforestation has been practiced since 1960's. Recent work volume is plantation of about 200,000 trees (the area of about200 ha/year). (Source: Environment, CDA)

***: As the effectiveness of the watershed management, annual sedimentation volume remarkably reduced as follows: from 0.37 million m^3/year ('83 – '94) to 0.19 million m^3/year. (Source: Simly Dam Project, CDA)

In case of Lai Nullah Basin, CDA has undertaken several works in the territory as shown in the above table. On the other hand, TMA, RDA and Cantonment area have not undertaken any concrete action for the watershed management within their jurisdiction area of Rawalpindi. Furthermore, at present, there may not exist a responsible agency, which handles basin-wide watershed management. Thus, judging from the present water issues as above-mentioned, it seems to be necessary to strengthen watershed management currently being practiced. As the major reasons not to be undertaken such activities, the following are considered:

(1) Necessity of basin-wide watershed management may not be well recognized among agencies concerned as well as inhabitants in the basin.

(2) It may not be clear which agency should have responsibility of basin-wide watershed management together with the coordination among agencies concerned.

(3) There is no law to specify the responsibility of agencies concerned on the matter.

1) Watershed Management for Flood Problems

The following flood problems relating to watershed management are pointed out: (i) increase of flood discharge, (ii) decrease of river channel flow capacity and (iii) increase of flood damage. In order to relive these problems, the watershed management for alleviation of flood problems is considered as described hereinafter:

a) Alleviation of Increase of Flood Discharge

As one of the main causes of increase of flood peak discharge, the land development in a manner of deforestation in the upper reaches and urbanization in the middle and lower reaches are pointed out. In principle, the followings measures and activities are considered to cope with the situation:

(i) Restriction of deforestation and implementation of afforestation in the upper reaches.

(ii) Land use control and introduction of detention facilities to compensate the increase of flood discharge due to land development in the middle and lower reaches.

b) Alleviation of Decrease of River Channel Flow Capacity

As the main causes of alleviation of decrease of river channel flow capacity, the followings are pointed out; encroachment to the river channel in a manner of construction of houses, buildings, etc., and dumping of garbage. It may be understood that these issues are related to rather river management than watershed management. As for the measures to cope with the situation, control and removal of encroachment and control of garbage dumping into the river are conceived.

c) Alleviation of Flood Damage

In combination with the increase of flood peak discharge and decrease of river channel capacity, the flood damage naturally increases. Furthermore, land development in flood prone area and encroachment to the river channel also cause the increase of flood damage. To alleviate the situations, land use control and control and removal of encroachment are pointed out.

2) Watershed Management for the Other Water Issues

As the remaining major water issues, water resources development and utilization and environment are pointed out. Needless to say, to identify the detailed issues and measures to cope with the issues, further studies including arrangement of the necessary data are required. Nevertheless such works are too wide to be covered in this study, and instead of them, only basic process for the further study on watershed management are clarified as below:

(a) The necessity of basin-wide watershed management on water resources development and utilization and environment should be highly recognized among the agencies concerned as well as inhabitants considering the current conditions relating to water utilization.

(b) Agencies responsible for the watershed management should be confirmed.

(c) The major water issues on water resources development and utilization and environment in Lai Nullah basin should be identified through arrangement and monitoring of necessary data to indicate the issues.

(d) Necessary measures to cope with the major water issues should be analyzed and examined.

(e) The watershed management plan should be formulated to implement the necessary measures. As the typical urgent issues, lowering of ground water level and deterioration of water quality in Lai Nullah should be examined and take an action to settle down the issues in a manner of watershed management.

8.6 DEVELOPMENT OF WATER RESOURCES BY THE PROPOSED FLOOD MITIGATION FACILITIES

As described in subsection 4.3, the study area is now suffering from the chronic water shortage, and the competent agencies (i.e., CDA, WASA and RCB) have an attempt to increase the water supply capacity. However, the service area of WASA in particular could not meet the full water demand in 2001 even after completion of the on-going water supply project under UWSSP-I.

Moreover, the current practices for water supply are oriented more to expansion of the treatment capacity and/or the abstraction capacity of tube-wells, but less to development of the new water resources. Such unbalanced way of water resources development brings out a big gap between the treatment capacity and the actual water supply capacity. Difficulties in abstracting the groundwater also occur due to the serious drawdown of the groundwater level.

Under the above conditions, a particular attention is given to the subsidiary effects of flood mitigation facilities on water resources development. That is, among the potential flood mitigation facilities as identified in the foregoing subsection 6.2, the reservoir of the flood control dam proposed at Block E-11 in Islamabad could be used as the water supply sources, and the community pond at the Fatima Jinnah Part in Islamabad may have a potential function for recharging to the groundwater. The on-site flood detention facilities would have also the function of rainwater harvesting and/or recharging to the groundwater. From these viewpoints, the potentials of water resources development by the flood mitigation facilities and the major issues for development are preliminarily clarified at this study stage.

8.6.1 Flood Control Dam proposed at Block E-11 in Islamabad

The present water quality of the dam inflow discharge is kept to be non-polluted, and the water stored in the dam reservoir could be the water source particularly for domestic use in Islamabad and Rawalpindi. The following major issues and/or difficulties are, however, identified in developing the dam reservoir as the water supply source:

(1) The dam site is located adjacent to the urban center of Islamabad, and the upper catchment of the dam site is likely to have the significant land value for urban development. In fact, the land development around the dam site is in progress, although it is not legally approved by CDA. In order to maintain the present suitable water quality of the dam inflow, however, it is indispensable to reserve the upper catchment (19.7km^2) of the dam site as the “Controlled Area” to prohibit any type of land development.

(2) The maximum live storage capacity and the catchment area of the proposed dam reservoir are about 1.5 million m^3 and 19.7km^2, respectively which are far smaller than those of the existing three (3) dam used as the present water supply source for the study area as listed below. Accordingly, the proposed dam reservoir could not be the fundamental solution for the current serious water shortage of the study area.

Table R 8.6.1 Comparison of Existing and the Proposed Dam Reservoir

Name of Dam	Catchment Area (km^2)	Live Storage (MCM)
Khanpur	778	113
Simply	153	25
Rawal	275	53
The proposed dam at Golra	**19.7**	**1.5**

8.6.2 Community Pond at Fatima Jinnah Park

The proposed community pond receives the flow discharge of Tenawali Kas, and the diverted discharge from the adjacent eastern tributary of Bedarawali Kas. The water quality of the discharge from Tenawali Kas is seriously polluted getting off an offensive odor due to effluent of the non-treated wastewater from the upper built-up area. On the other hand, the substantial part of the catchment area of Bedarawali Kas is remained as the non-built up area, and the water quality of the tributary is not aggravated.

In due consideration of the water quality of the inflow discharges, the proposed community pond is designed to impound the inflow only from Bedarawali Kas but not from Tenawali Kas during a dry season. The water impounded in the pond could be used as the source for recharge to groundwater. In order to sustain the present water quality from the eastern tributary of Bedarawali Kas, however, it is required to reserve the catchment area of the tributary (9.9km^2) as the non-built-up area just like the aforesaid case of the dam catchment area of Golra.

8.6.3 Channel Deepening of Lai Nullah

The channel deepening of Lai Nullah is considered as one of possible flood mitigation measures. The channel deepening drops the riverbed level by 2m, which would cause lowering of the river water stage during low flow discharge.

Lowering of river water stage during low flow discharge may cause, in general, the adverse effect on the groundwater level. Nevertheless, the present groundwater level in the study area is 40m below the ground level, while the depth of the river channel upon completion of the channel deepening is 9.5m, which is far higher the present groundwater level. Accordingly, the adverse effect on the groundwater level by channel deepening could be evaluated to be minimal.

8.6.4 Flood Diversion Channel

The proposed flood diversion aims at diverting the flood runoff discharge from Lai Nullah basin to the external Kurang river basin. Should the whole of the basin runoff discharge be diverted to the external basin during the non-flooding period, the present natural recharging capacity to the groundwater in the basin may be dropped. In order to avoid such adverse effect, the flood diversion structure is designed to divert only the flood discharge over the channel flow capacity of the downstream channel but to remain the non-flood discharge within Lai Nullah basin.

8.6.5 On-site Flood Detention Facility

Among the various types of the on-site flood detention facility, the storage tank installed at an individual house lot and the infiltration facility would be useful to the water resources development as the supplementary effect of flood mitigation.

1) Storage Tank Installed at Individual House Lot

The storage tank could effect the reduction of runoff discharge from each of house lots. At the same time, the rainwater stored in the tank could be used for washing, watering to garden and other various secondary water uses other than use for drinking.

According to the rainfall records at Chaklala gauging station, the Lai Nullah basin could receive about 49 mm per month in average even during a dry season from October to June. Assuming a roof top of 50m^2 as the space to collect the rainfall, the daily average rainwater volume to be stored in the tank is estimated at about 80 litters/day/house (=49 mm x 50m^2÷30 days). The standard type of the storage tank has a capacity of 2,000 litters, which would be enough for storage and use of the whole rainwater during a dry season.

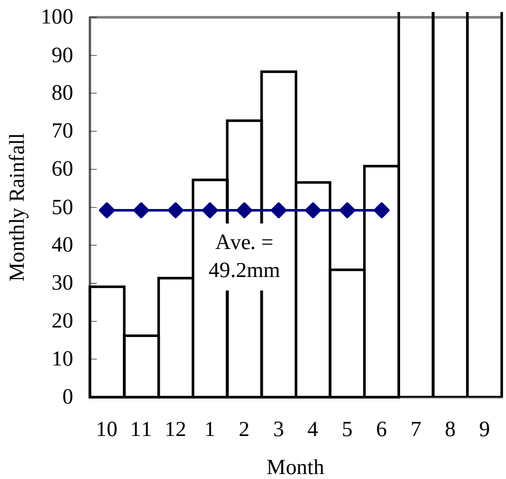


Fig. R 8.6.1 Monthly Average Rainfall at Chaklala

If the number of residents per one unit of house is assumed at 5 personnel, the daily average rainwater volume of 80 litters/day/house could cover the water consumption of about 16 litters/person/day (=80 litters/day/house÷5 personnel/house). This consumption fed by the rainwater harvesting corresponds to 22% of the present per capita water consumption in the service area of WASA (=74 litters/day/person). Thus, the significant rate of the water consumption could be fed by the rainwater harvesting, and therefore, the storage tank installed at individual house lot would be useful as the subsidiary water supply source.

2) Infiltration Facility

There are various infiltration facilities to retain the flood runoff discharge such as soak pit, infiltration gutter and trench as proposed in the foregoing subsection 6.2.5. These infiltration facilities are also expected to effect on recharging to the groundwater. Nevertheless, the difficulties are foreseeable in estimating the definitive infiltration capacity of the facilities. The infiltration capacity of the facilities also easily drops down due to clogging of the filter. In order to clarify the definitive infiltration capacity and maintain the infiltration effect of the facilities, the field infiltration test together with the soil mechanical test as well as the sustainable maintenance works for the facilities are indispensable.

CHAPTER 9. IMPLEMENTATION PROGRAM

9.1 IMPLEMENTATION PROGRAM FOR FLOOD MITIGATION PROJECT

The proposed flood mitigation projects involve the structural and non-structural measures. The structural measures are proposed to progressively complete through three (3) phased programs of the urgent project, the short-term project and the long-term project with the ultimate target completion year of 2012. Hence, the implementation program is prepared to divide each of the structural measures into the three (3) phased programs taking the period physically required to completion of the components and significance of flood mitigation effects.

The implementation program is also prepared for the proposed non-structural flood mitigation measures such as the flood forecasting and warning system and the dissemination of the flood risk maps. These non-structural flood mitigation measures could effect to mitigate the flood damage together with the structural measures, particularly for those caused by the extra-ordinary floods over the design scale of the structural measures. The non-structural flood mitigation measures are provisionally assumed to progressively complete by the target year of 2012 in parallel with implementation of the structural measures so as to fulfill the maximum flood mitigation effect.

The overall implementation program for the flood mitigation projects is as summarized in Table R 9.1.1, and the details of the program are as described in the following subsection 9.1.1 to 9.1.3.

Table R 9.1.1 Implementation Program for Flood Mitigation Project

Sector	Scheme	Phased Program		
		Urgent (2004-05)	Short-term (2005-07)	Long-Term (2008-12)
1. Structural Flood Mitigation Project	1.1 Community Pond at the Fatima Jinnah Park	○		
	1.2 Flood Diversion			
	(1) Flood diversion from Bedarawali Kas to Tenawali Kas			○
	(2) Flood diversion from Tenawali Kas to Kurang River		○	○
	(3) Improvement of Kurang River		○	○
	1.3 Supplementary works for on-going river channel improvement			
	(1) River improvement below Chaklala Bridge	○		
	(2) Side slope protection works of the on-going improvement section		○	
2. Non-structural Flood Mitigation Project	2.1 Establishment of flood forecasting and warning system	○		
	2.2 Establishment of flood risk map		○	○

9.1.1 Flood Mitigation Measures for Urgent Project

Among the proposed flood mitigation measures, the following two structural measures {items (1) and (2)} and one non-structural measure (item (3)) are selected as the components of the Urgent Project considering the immediate mitigation of flood damage and the possible completion within the target implementation period by the year of 2005.

1) Improvement of the section of Lai Nullah (RD5+277-RD6+216) below Chaklala Bridge

The river improvement of the section of Lai Nullah between Chaklala Bridge and Kattarian Bridge (RD6+216-17+210) is now in progress and scheduled to complete by September 2003. The realignment/enlargement of the meandering section around Murree Brewery Area (RD4+077-RD5+277) has also been completed as the supplementary work of the river improvement.

However, the section (RD5+277-RD6+216) sandwiched between the above river improvement sections is left behind without any channel improvement. It is verified that the section forms bottleneck causing the adverse backwater effect to the on-going river improvement section above Chaklala Bridge. Accordingly, the river improvement of the section is urgently required to offset the adverse backwater effect and to preserve the design flow capacity of the on-going channel improvement.

2) Construction of Community Pond

The substantial part of the park Fatima Jinnah Park as the construction site of the community pond still remains as the vacant land without any major permanent structure. CDA, the administrator of the park has given the provisional consent to use the park as the flood detention facility, in view of the function of community pond to improve the amenity of the park. Due to these conditions, construction of the community pond would not require any house evacuation and land acquisition, which avail the early commencement of construction. Moreover, the required construction period is provisionally estimated at about 2 years, whereof the community pond could be completed by the target year of 2005 for the Urgent Project. Moreover, The community pond could have cut almost all the probable peak runoff discharge of 25-year return period, and reduce about 35% of the park flood discharge even in case of 100-year return period. These functions could increase the flood safety level of the downstream of Lai Nullah. Thus, the proposed community pond would contribute the significant flood mitigation effect to the downstream of Lai Nullah.

3) Reinforcement and Expansion of the Existing Flood Forecasting and Warning System

In the event of July 2001 flood, Pakistan Metrological Department (PMD) observed an extra-ordinary scale of rainfall intensity in Lai Nullah through its weather surveillance radar and rainfall gauging. Judging from the results of the observation, PMD predicted a possibility of serious flood overflow along Lai Nullah a few hours before its actual occurrence. In spite of the advanced awareness of the flood, the flood caused the death of 75 people.

Should the existing flood gauging, communicating and warning system be strengthened, the more accurate and immediate flood information could be systematically collected, and the death calamity as experienced in 2001 flood would be relieved. From these viewpoints, the improvement of the existing flood forecasting and warning system is proposed as an eligible measure to immediate effect mitigation of the flood damage, the calamity of death in particular.

9.1.2 Flood Mitigation Measures for Short-term Project

The Short-term Project with its target completion year of 2007 would include the flood diversion channel for the design scale of 25-year return period as the structural measure and the establishment of the flood risk maps as the non-structural measures.

1) Flood Diversion Channel for Short-term Project

The flood diversion channel for the design scale of 25-year return period would be completed by the year 2007 as the provisional flood mitigation measure for the under-mentioned flood diversion channel with the design scale of 100-year return period. The diversion channel will divert the flood runoff discharge from Tenawali Kas and Saidpur Kas into Kurang River. In addition, the flood runoff discharge from the tributary of Bedarawali Kas would be indirectly diverted, through Community Pond, Tenawali Kas, and the diversion channel. The design discharges of the diversion channel are as listed below (refer to Fig. R 9.1.1):

Table R 9.1.2 Design Discharge of Diversion Channel in Short-term Project

Section	Design Flow Capacity (m^3/s)
Tributary of Bedarawali Kas to Tenawali Kas (Community Pond)	70
Tenawali Kas to Saidpur Kas	70-140
Saidpur Kas to Ojhri Kas	320
Ojhri Kas to Kurang River	470

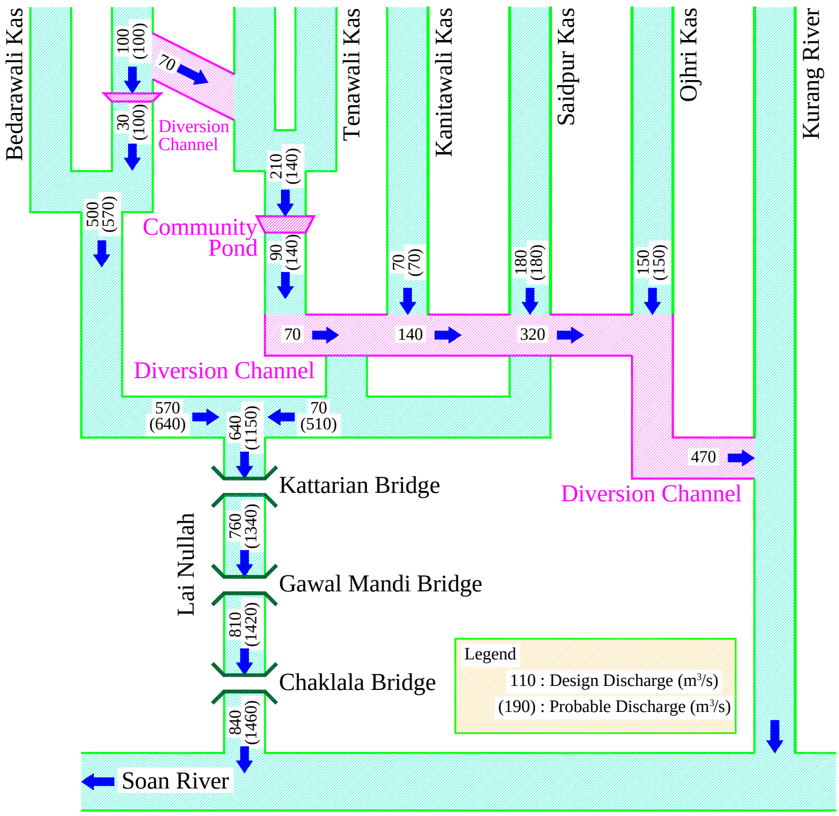


Fig. R 9.1.1 Design Discharge for Short-term Project (25-year Return Period)

2) Establishment of Flood Risk Map

As described in the foregoing subsection 6.4.2, the base maps for the extent and depth of the probable flood inundation was delineated in this Study. The flood risk map thus prepared should be disseminated to the public through a bulletin, an information board and other available information tools. However, the available evacuation centers as well as evacuation routes for each unit of the local communities need to be selected by the relevant local government agencies based on the base maps, and the flood risk map should be finalized. Accordingly, establishment of the flood risk map would require a substantial period. Moreover, the evacuation centers and the evacuation routes would need to be progressively modified in accordance with expansion of the built-up area. From these viewpoints, establishment of the flood risk map is assumed to complete in the period of short-term period and need to be revised through the period of the long-term project.

9.1.3 Flood Mitigation Measures for Long-term Project

The Long-term Project with its target completion year of 2012 would include the flood diversion channel for the design scale of 100-year return period as the structural measure and the establishment of the flood risk maps as the non-structural measures continued from the above short-term Project. Through the Long-term Project, a new diversion channel will connect a channel with a flow capacity of 600 m^3/s from Bedarawali Kas to Tenawali Kas. Moreover, the diversion channel from Tenawali Kas to Kurang River completed in the Short-term Project will be also expanded as listed below (refer to Fig. R 9.1.2):

Table R 9.1.3 Comparison of Design Discharges of Diversion Channel for Short-term and Long-term Project

Section	Design Flow Capacity (m^3/s)	
	Short-term Project	Long-term Project
Tributary of Bedarawali Kas to Tenawali Kas (Community Pond)	70	80
Bedarawali Kas to Tenawali Kas	-	600
Tenawali Kas to Saidpur Kas	70-140	980-1,120
Saidpur Kas to Ojhri Kas	320	1,480
Ojhri Kas to Kurang River	470	1,790

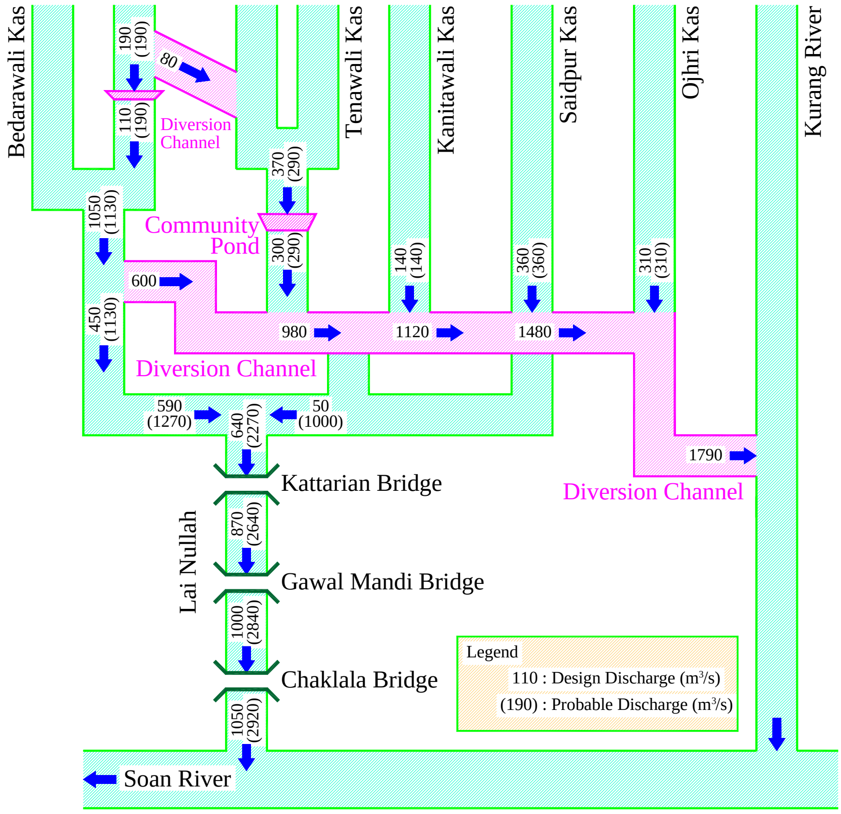


Fig. R 9.1.2 Design Discharge for Long-term Project (100-year Return Period)

9.2 IMPLEMENTATION PROGRAM FOR RELEVANT ENVIRONMENTAL IMPROVEMENT AND STRENGTHENING OF ORGANIZATION SETUP

The implementation program covers the phased action programs for the relevant environmental improvement measures such as the removal of encroachment along the river course, the control of garbage dumped into the river and the drainage and sewerage improvement. These environmental improvement measures would effect to sustain the design capacity of the structural measures and create the appropriate environmental conditions of Lai Nullah. There are several on-going and projected environmental implement plans such as improvement of sewerage treatment plant in Islamabad City and the Urban Water Supply & Sanitation Project, Phase –1 and 2 (UWSSP-1 & 2), Rawalpindi City. Therefore, the implementation programs for the environmental improvement measures are prepared taking the implementation schedules committed and/or proposed for these on-going and projected projects into consideration.

The strengthening of the institutional setup would be also raised as an important issue to facilitate the overall river administration and management. Among the proposed components for strengthening of the institutional setup, establishment of Management Committee and Task Force for the integrated administration of Lai Nullah is urgently required to enhance execution of the project. Demarcation of roles and authorities of the relevant land administrators is also urgently required likewise. On the other hand, long-term efforts would be required to strengthening of the legal setup and capacity building. From the viewpoints, the implementation program is prepared for the strengthening of institutional setup aspect.

Table R 9.2.1 Implementation Program for Environmental Improvement and Strengthening of Organization Setup

Sector	Scheme	Phased Program		
		Urgent	Short-term	Long-Term
1. Related Environmental Improvement Project	1.1 Land use control			
	(1) Formulation of a step-wise resettlement plan	○		
	(2) Execution of the resettlement plan and demolishing of the site		○	○
	1.2 Control of solid wastes dumped into the river			
	(1) Apprehension of the volume of solid wastes	○		
	(2) Legislation of the acts for the solid waste management		○	○
	(3) Formulation and execution for reduction and recycle and solid waste			○
	1.3 Improvement of drainage and sewerage			
	(1) Improvement of sewerage treatment plant in Islamabad	○		
	(2) UWSSP-I	○		
	(3) UWSS-2		○	
	(4) Drainage and sewerage improvement for area of RCB		○	○
2. Strengthening of Institutional Setup	2.1 Establishment of Management Committee for the integrated administration of Lai Nullah	○		
	2.2 Establishment of Task Force for implementation of flood mitigation project of Lai Nullah	○		
	2.3 Demarcation of roles and authorities of the relevant land administrators	○		
	2.4 Strengthening of Legal-setup			○
	2.5 Capacity building	○	○	○

CHAPTER 10. PROJECT EVALUATION

10.1 ECONOMIC EVALUATION

10.1.1 Project Economic Benefit

The project economic benefit accrues from the amount of flood damage progressively reduced by the phased structural flood mitigation plans, namely, the urgent project, the short-term project, and the long-term project. The economic benefit would also accrue from the non-structural flood mitigation plans such as the flood forecasting and warning system and the dissemination of the flood risk maps. However, the principal benefit of the non-structural flood mitigation plans is oriented to securing of human life, but its monetary term is not generally accepted. Due to these backgrounds, the economic benefit by the non-structural flood mitigation plans was not incorporated into this evaluation.

In order to assess the project economic benefit, the economic damages by the Flood 2001 were initially assessed based on the interview survey conducted in the first field survey. The table below indicates that the Flood 2001 resulted in enormous amounts of economic damages corresponding to Rs. 28 billion, which is shared by the residential damage of 46% an the damage in business of 54%.

Table R 10.1.1 Estimated Economic Damages in the Flood 2001

(Unit: Rs. Million)

Sector			Damage Item	Damage/Expense		
Private	Residential	Direct Damage	Structure	7,681	12,852 (45.6%)	28,193 (100%)
			Household effects	4,976		
		Indirect Damage	Loss of Income	124		
			Emergency Measures	17		
			Other*	54		
	Business	Direct Damage	Structure	4,485	15,153 (53.7%)	
			Loss of merchandise stock	7,823		
		Indirect Damage	Business suspension	2,681		
			Emergency Measures	5		
			Flood Proofing Activity	159		
Public	Infrastructure			153	187 0.7%)	
	Emergency Assistance**			34		

Source: JICA Study Team 2002
* The expenses on the flood fighting/evacuations, the medical expenses, ets.
**Expenses as emergency assistance includes that from a NGO.

As listed above, the flood damage is classified into (1) the residential damage which covers the damage of the private house structures and household effects and other indirect damage, (2) the damage in business, which accrues from the damages of the structures and stocks as well as loss of business suspension, and (3) the damage in the public sector, which includes the damage of the public infrastructures such as road and bridges, and the expenses for public rescue operation.

The probable and annual average flood damage was further estimated based on (1) the probable flood inundation area/depth as estimated in the hydrological simulation, (2) the assets within the probable flood inundation area as estimated in the Study and (3) the flood damage rates as estimated in the aforesaid field survey on the damage of the Flood 2001.

As the results, the annual average flood damage is estimated at about Rs. 597 million when any proposed flood mitigation structure is implemented (i.e., without-project). On the other hand, the annual average flood damage could be reduced to Rs. 397 million upon completion of the urgent project and further reduced to Rs. 167 million upon completion of the short-term project as listed in Table R10.1.2. Moreover, the long-term project could make free from any damage by the probable flood of less than 100-year return period. The annual average economic benefit is expressed as the difference between the annual average damages of the without-project and the with-project, and therefore estimated at Rs. 218 million with-the urgent project, Rs. 430 million with-the short-term project and Rs. 597 million with the long-term project as listed below:

Table R 10.1.2 Estimation of Annual Average Flood Damage and Annual Average Benefit

States	Frequency Return Period (year)	Probable Damage (Rs billion)	Annual Average Damage (Rs million)	Annual Average Benefit (Rs million)
Without Project*	Less than 10	0	597	-
	25	7.09		
	50	13.46		
	100	22.44		
Upon Completion of Urgent Project	Less tan 13	0	379	218
	25	4.35		
	50	10.55		
	100	19.37		
Upon Completion Short-term Project	Less than 25	0	167	430
	50	6.21		
	100	14.70		
Upon Completion of Long-term Project	Less than 100	0	0	597

* The completion of the on-going channel improvement work by RDA is assumed as the Without Project Case.

10.1.2 Project Economic Cost

The economic costs of projects were derived by subtracting price contingencies and taxes from the financial costs of the projects, then, adjusting it by the opportunity cost of labor and land for the construction cost as described bellow. Estimation of the economic cost is further subject to subtracting of the cost for the amenity facilities for the community pond, since the amenity facilities contribute to enhancement of aesthetic and recreational value of the land but not mitigation of the flood damage. The economic costs of local materials were based on the prevailing market prices assumed to remain unchanged in real terms at constant 2002 price.

(1) Opportunity cost of labor: The opportunity cost of unskilled labor was derived by adjusting the prevailing market wage rate by a factor of 0.75 in line with estimated level

of seasonal unemployment and underemployment in the subproject areas[11].

(2) Cost of land acquisition: The lands acquired for the project include those owned by the government as well as personally owned lands. As for the land owned by the government, it is currently used as a central reservation of the road network in Islamabad City, and therefore, the cost of land is not included in the economic analysis considering the opportunity cost of the land. On the other hand, the land owned by private individuals is assessed at its market price with consideration on the urban and/or pre-urban settings where land market is rather competitive.

As the results of the above assumptions, the project economic cost was estimated as listed below:

Table R 10.1.3 Project Cost and Disbursement Period of Project Cost

Description	Urgent Project		Urgent Project + Short-term Project		Urgent Project + Short-term Project + Long Term Project	
	Initial Investment	Annual O & M	Initial Investment	Annual O & M	Initial Investment	Annual O & M
Financial Cost (Rs. Million)	895.5	3.3	3,337.2	4.8	5,900.7	5.4
Economic Cost (Rs. Million)	835.8	3.1	3,129.8	4.6	5,535.6	5.1
Disbursement Period	2003-2005	2006-2052	2003-2007	2008-2052	2003-2012	2013-2052

Note: The financial cost and the economic cost exclude the cost of the amenity facilities for the Community Pond. The financial cost further excludes the price contingency.

10.1.3 Economic Internal Rate of Return

The economic internal rate of return (EIRR) was estimated assuming the aforesaid project economic benefit and economic cost. The sensitivity analysis was further made assuming 10% reduction of the economic benefit or the economic cost. The results of the estimation are as listed below:

Table R 10.1.4 EIRR and B/C Ratio of the Proposed Structural Measures

Progress of the Project	EIRR			B/C Ratio*
	Base Case	10% Reduction in Benefit	10% Reduction in Cost	**Base Case**
1 Urgent Project	**22.4 %**	20.4 %	20.5 %	**2.3**
2 Urgent + Short-term Project	**12.8 %**	11.6 %	11.7 %	**1.3**
3 Whole (Urgent + Short-term + Long-term Project)	**10.4 %**	9.3 %	9.4 %	**1.0**

*: Assuming the discount ratio of 10%

As estimated above, the proposed structural flood mitigation plans could be evaluated to be economically viable indicating the EIRR over the capital opportunity cost of 10%. Moreover, the population of about 183,000 could be relieved by the structural flood mitigation measures as a whole. However, as the EIRR of the Long-term Project is marginally beyond the opportunity

[11] Report and Recommendation of the President to the Board of Directors on a Proposed Loan to the Islamic Republic of Pakistan for the Second Flood Protection Sector Project, October 1997 (PRP:PAK28165)

cost 10 %, and the reduction in benefit or 10 % overrun in project cost pushes EIRR below the threshold. The flood mitigation effect begins in nature to accrue as soon as the measures are installed. Therefore, a delay in benefit realization may take place when completion of construction is overdue. The preparation and construction of the structures of the project would, therefore, need to be closely monitored during the supervision with particular reference to timely resource mobilization of the Pakistan side by facilitated interagency coordination.

10.2 FINANCIAL EVALUATION

The cost for flood mitigation is subsidized in most case, and not recovered directly from beneficiaries. From these viewpoints, the financial analysis was made to clarify the fiscal capacity of the government to afford the project with referring to the results of the recent public expenditures.

10.2.1 Review on the Public Expenditure Reviews

Table below summarizes the consolidated national revenue and expenditure in 2001. The total revenue amounts to Rs 625.4 billion against Rs 837.6 billion in total expenditure. An overall fiscal deficit of Rs.212.2 billion is financed through external and domestic sources.

Table R 10.2.1 Consolidated National Revenue and Expenditure in 2001

Item		Amount (Rs. Billion)
1. Revenue	1.1 Tax Revenue	486.0 (78%)
	1.2 Non-Tax Revenue	139.4 (22%)
	Total Revenue	625.4 (100%)
2. Expenditure	2.1 Current Expenditure	705.5 (84%)
	(1) Federal	535.4 (64%)
	(2) Provincial	170.1 (20%)
	2.2 Development Expenditure	132.1 (16%)
	(1) Public Sector Development Program (PSDP)	127.0 (15%)
	(2) Others	4.1 (1%)
	Total Expenditure	837.6 (100%)
3. Overall Fiscal Deficit	3.1 External	148 (70%)
	3.2 Domestic	64.2 (30%)
	Total Deficit	212.2 (100%)

Source: Economic Survey 2001-2002 (Modified Budget Estimated)

Among the above items, the budget for expenditure of the Public Sector Development Programme (PSDP) is expected as the eligible financial source for implementation of the proposed flood mitigation plans. The budget of PSDP for 2001 is Rs 127 billion, which accounts for 15% of the total expenditures. Out of Rs. 127 million for the budget of PSDP in 2001-02, about Rs 9 billion or 7% has been allocated to water sector.

According to the “Ten Year Perspective Development Plan 2001-2011”, the whole budget of PSDP is projected to increase from to Rs. 127 billion in 2001 to Rs. 418 billion in 2010 with an annual growth rate at 14%. In parallel with increment of the whole budged of PSDP, the budget for the water sector is also raised to Rs. 60 million in 2010 (refer to Table R 10.2.2).

Table R 10.2.2 Projected Whole and Water Sector Budget of PSDP
(Ten Year Perspective Development Plan 2001-2011)

(Unit: Rs. Billion)

Sector \ Year	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	Total
Water Sector	9	29	47	41	42	44	46	51	58	60	426
Whole Budget of PSDP	130	150	180	202	227	255	287	324	367	418	2,540

Source: Ten Year Perspective Development Plan 2001-11 and Three Year Development Programme 2001-04, Planning Commission, September, 2001

10.2.2 Fiscal Impact of the Proposed Flood Mitigation Project

The initial investment cost of the proposed flood mitigation project is Rs. 7,615 million in total, while the annual O & M cost for the proposed project will gradually increase to Rs. 3.3 million upon completion of the Urgent Project in 2004 to Rs 5.4 million upon completion of the Long-term Project in 2012, which would imposes a fiscal burden during the entire project life as listed below:

Table R 10.2.3 The Project Initial Investment Cost and Annual O & M Cost

Project	Initial Investment Cost (Rs. million)	O & M cost (Rs. million/ year)
Urgent Project	1,267	3.3
Urgent + Short-term Project	4,124	4.8
Urgent + Short-term + Long-term Project	7,615	5.4

In order to firstly clarify the fiscal burden of the initial investment cost to the government budget, the annual disbursement schedule of the project investment cost is compared with the whole budget of PSDP and its budget in the water sector as listed below.

Table R 10.2.4 Project Investment and Ten Year Perspective Development Plan 2001-2011

Item	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
(1) Whole Budget of PSDP (Rs. million)	130,000	150,000	180,000	202,000	227,000	255,000	287,000	324,000	367,000	418,000	-	-
(2) Budget of Water Sect. in PSDP (Rs. million)	9,000	28,500	47,100	41,100	41,500	44,300	46,000	50,700	57,600	59,800	-	-
(3) Project Cost (Rs. million)	-	-	69	813	1,194	1,066	1,084	658	677	680	707	666
(4) (3)/(1)	-	-	0.04%	0.40%	0.53%	0.42%	0.38%	0.20%	0.18%	0.16%	-	-
(5) (3)/(2)	-	-	0.15%	1.98%	2.88%	2.41%	2.36%	1.30%	1.17%	1.14%	-	-

Source: Ten Year Perspective Development Plan 2001-11 and Three Year Development Programme 2001-04

As compared above, the project will have the maximum increment of only 2.88% of the budget for water sector programs. The corresponding figure for the PSDP up to 2012 in total is merely

0.53%. As far as the current size of the expenditure is concerned, there will be a negligible incremental fiscal burden on the federal governments. Additional annual expense with implementation of the project is, therefore, generally deemed to fall within the capacity of the government. In addition, recent development in tax reform including broadened tax base has increased tax revenue of the central government by 13% from 2001-02 to the 2002-03, which is expected to contribute to balanced budget in the future.

In addition to the above clarification the fiscal burden of the initial investment cost, the fiscal burden of the annual O & M cost to the government budget was also clarified. The eligible budgetary source for the annual O & M cost would accrue from the budget for the Normal Annual Development Program (NADP) in the National Flood Protection Plan (NFPP), which is allocated as a part of the budget of the aforesaid water sector in PSDP. According to the draft National Flood Protection Plan-III issued on May 2001, it is planned to invest Rs 2,400 million in total for the NADP for a period from 1998 to 2012. The annul average budget for NADP is estimated at about Rs. 185 million, while the project would require the annual O & M cost of Rs. 5.4 million, which will results in 3% increase on the annual base budget of NADP and deemed to be affordable within the limit of the budget.

10.3 INITIAL ENVIRONMENTAL EVALUATION

The proposed flood mitigation plan consists of the two principal structural measures, that is: (1) the Community Pond constructed in the Fatima Jinnah Park and (2) the Flood Diversion Channel, which runs across the upper reaches of Lai Nullah Basin. The initial environmental evaluation (IEE) for these structural measures was carried out based on information collected during this Master Plan Study, and consultation with concerned government, the NGOs and other project stakeholders. The major assessment given below is a cross impact matrix, with the major environmental resources as rows, and the activities for implementation of the proposed plan as the columns.

Table R 10.3.1 Activities for Each Project Phase.

Phase	Project Activity
Planning and Design Stage	Land Acquisition
Construction Phase	Construction camp establishment
	Equipment servicing and fuelling
	Site preparation and clearing
	Earthworks
	Quarries and borrow sites
Operation Phase	Operation

In the matrix, assessment of impacts was made in terms of magnitude, duration or time framework, causal relationship and probability. The result of the assessment was presented following the categories.

Table R 10.3.2 Assessment Category

Magnitude of Impact	A	Major impact is anticipated. Mitigation measure is judged required.
	B	Potential major impact is anticipated. Detailed study required in EIA.
	C	Some impact is anticipated.
		Blank represents no anticipated impact.
Duration of Impact	L	Long-term impact
	S	Short-term impact
Causal relationship	D	Direct Impact
	I	Indirect impact
Probability	H	Highly probable,
	M	Moderately probable,
	U	Unpredictable

The checklists for each of the project phase as well as the above assessment categories were clarified as shown in Tables R 10.3.3 and 10.3.4. As the results of the checklists, it is evaluated that the flood mitigation plan proposed in the Master Plan will induce relatively insignificant adverse impacts as compared with the flood mitigation projects in alluvial area in rural setting where flooding recharges soil moisture, replenishes soil nutrients and thus enhances productivity of natural resources such as wildlife, livestock and fisheries. Several potential adverse impacts were, nevertheless, identified in the evaluation, and it is concluded that the Environmental Impact Assessment (EIA) is required in the succeeding study period. The particular evaluations for each of the Community Pond and the Flood Diversion Channel are as described below:

1) Community Pond

The community pond poses far less adverse environmental impact as compared with the flood diversion in the initial screening level, in addition, it will have a significant beneficial impact on improvement of the living environment by increased aesthetic, recreational and partly educational value of the park. However, one of the adverse environmental impacts would be addressed to *waste* of construction during the construction phase, whereby a special attention should be given to selection of disposal site of excavated soil during the construction phase. The adverse impacts on *fauna and flora* in the existing park are also expected during the construction phase, whereby it is necessary to confirm that there exist no threatened or rare species of fauna and flora in the park. The adverse impact during the operation phase would be further brought about through *water pollution* of the pond, resulting in increase of *offensive odor* and emergence of water-borne disease. Increased waste disposal from visitors of the park needs to be properly collected to maintain cleanliness of the park. These adverse impacts should be the principal items for the succeeding EIA. Nevertheless, it is preliminarily evaluated that these adverse impacts would be minimized by construction of: (1) the oxidation pond, (2) the check dam to stop the inflow of garbage, (3) diversion channel to bring the clean discharge from the adjacent Bedarawali Kas and (4) alternative sewerage channel of the polluted low flow from Tenawali Kas.

Table R 10.3.3 Checklist for Community Pond

Category of Environmental Impact	Overall Assess.	Planning and Design Phase				Construction Phase				Operation Phase				Beneficial		
		Magnitude	Duration	Causal	Probability	Magnitude	Duration	Causal	Probability	Magnitude	Duration	Causal	Probability	Magnitude	Duration	Causal
Social Environment																
Involuntary Resettlement																
Economic Activity																
Traffic and Public facilities																
Split of Communities																
Cultural Properties																
Water and Common Rights																
Public Health Conditions																
Waste	B					B	S	D	H	B	L	I	M			
Hazards (risk)																
Other social impacts														A	L	D
Natural Environment																
Topography and Geology																
Soil Erosion																
Groundwater																
Changes in Hydrology																
Fauna and Flora	B					B	S	D	H							
Metrology																
Landscape																
Other natural impacts																
Pollution																
Air pollution	C					C	S	D	M							
Water Pollution	B					B	S	D	M	B	L	I	M			
Soil contamination	C					C	S	D	M							
Noise and vibration	C					C	S	D	M							
Land subsistence																
Offensive odor	B					C	S	D	M	B	L	I	M			
Other impact in pollution control																

2) Flood Diversion Channel

The flood diversion channel will require ***involuntary resettlement*** along Kurang River as the outlet of the diversion channel during the planning and design phase, which would be enumerated as one of the principal objectives of the succeeding EIA. The resettlement would be, however, indispensable regardless to construction of the diversion channel, because the objective houses for resettlement are located within the present habitual flood inundation area and the great impediments to the flow of flood discharge. The number of house to be resettled is about 220, which is far less than 2,000 houses evacuated by RDA for the on-going river channel implement. Accordingly, the objective resettlement associated with construction of the diversion channel would be realizable provided that the stepwise resettlement plan and the support by micro financing are formulated and executed as described in the foregoing subsection 6.3. Interaction with *traffic and public facilities* will be also a potential impact in construction phase. Due to linear alignment of the diversion channel, it will result in *split of community* as well as damage on *cultural properties.* In order to cope with these adverse affects, it would be necessary to construct temporary bypasses and several permanent bridges. Adverse impacts in *waste disposal* will occur in two distinct occasions in construction and operation phases, and control of the garbage dumped into the channel should be carefully made based on legislation of the Act for Solid Waste Management and formulation/execution of the program for reduction and recycle of solid waste (refer to subsection 8.2).

Table R 10.3.4 Checklist for Flood Diversion Channel

Category of Environmental Impact	Overall Assess.	Planning and Design Phase				Construction Phase				Operation Phase				Beneficial		
		Magnitude	Duration	Causal	Probability	Magnitude	Duration	Causal	Probability	Magnitude	Duration	Causal	Probability	Magnitude	Duration	Causal
Social Environment																
Involuntary Resettlement	A	A	L	D	M											
Economic Activity	B	B	L	D	M											
Traffic and Public facilities	B					B	S	D	H	B	L	D	H			
Split of Communities	A					B	S	D	H	A	L	D	H			
Cultural Properties	A					A	S	D	M							
Water and Common Rights																
Public Health Conditions																
Waste	A					B	S	D	H	A	L	I	H			
Hazards (risk)																
Other social impacts																
Natural Environment																
Toporaphy and Geology																
Soil Erosion																
Groundwater																
Changes in Hydrology	A									A	L	I	M			
Fauna and Flora	C					C	S	D	H	C	L	D	M			
Meteology																
Landscape	C									C	L	D	M			
Other natural impacts																
Pollution																
Air pollution	B					C	S	D	M							
Water Pollution	B					B	S	D	M							
Soil contamination	B					C	S	D	M							
Noise and vibration	B					C	S	D	M							
Land sussistence																
Offensive odor	B					C	S	D	M							
Other impact in pollution control																

CHAPTER 11. CONCLUSION AND RECOMMENDATION

The low-lying area along Lai Nullah has suffered the chronic flood inundation, and occasionally encountered the disastrous flood damage potential including death of human life as experienced in 2001 Flood. Thus, the flood of Lai Nullah calls the serious social malaise and at the same time, hinders the regional economy as well as the urban environment. In order to get rid of these significant flood problems, it is indispensable to implement the proposed flood mitigation and relevant river environmental improvement plan.

Among the proposed plan components, the proposed structural flood mitigation plan is confirmed to be economically and financially viable. The environmental adverse impacts caused by implementation of the plan could be also minimized by the several practical countermeasures attached to the proposed structural plan. Accordingly, implementation of the proposed structural plan is recommended in accordance with the proposed phased programs, where the year of 2012 is set as the target completion year.

The overall proposed plan further includes the non-structural flood mitigation plan, the environmental improvement plan and the plan for strengthening of the institutional setup for project implementation and management. These are essential to ensure and/or supplement the functions of the proposed structural measures and need to be implemented in parallel with the phased programs for the structural flood mitigation plan. The principal recommendations in implementation of these proposed overall plans are as summarized hereinafter:

1) Implementation of the Proposed Urgent Project

Lai Nullah would cause the serious flood overflow by the comparatively small probable flood, even upon completion of the on-going river channel improvement above Chaklala Bridge by RDA, due to the limited right-of-way availed to the on-going improvement and the bottlenecks left behind below Chaklala Bridge. Thus, Lai Nullah still has the high flood damage potential, and it is strongly recommended to take the early implementation of the proposed urgent project and produce the immediate flood mitigation effect.

2) Implementation of the Phased Short-term and Long-term Project

Lai Nullah Basin has experienced the disastrous damage by 2001 Flood including death of 74 people and destruction of about 3,000 houses. The 2001 Flood is the recorded maximum flood, and the design scale of the above urgent project is still far less than the scale of 2001 Flood. The flood damage potential would further increase with the expansion of population in the basin as projected from 1.0 million in 1998 to 2.3 million in 2030.

Under the above conditions, it is inevitable to implement the drastic flood mitigation plan, which could cope with even the scale of 2001 Flood. Nevertheless, the plan would take a long implementation period of about 10 years due to its huge work volume. Accordingly, the plan would be progressively implemented through the phased short-term and long-term project. In order to complete these phased programs within due time, the close monitoring on implementation would be indispensable.

3) Feasibility Study on Flood Diversion Plan

The flood diversion channel is proposed as the principal structural measure for the long-term project. A feasibility study would be, however, required to clarify the further details of the proposed diversion structures with a particular attention to a comment given from CDA on the allowable width of the diversion channel (refer to item 2 in the Minutes of Steering committee Meeting on the Draft Final Report as attached to this Main Report). The objectives of the feasibility study should further include clarification on the detailed river improvement works required to Kurang River, which is proposed as the outlet of the diversion.

4) Involvement of the Federal Government in Implementation and Management of the Project

The principal beneficiary of the proposed flood mitigation plan is biased to the lower reaches of Lai Nullah in Rawalpindi City, while the major flood mitigation structures such as the community pond and the diversion structure are placed in the upper reaches in Islamabad City. This contradiction may lead to conflicts between the regional administrators for the two cities in implementation and management of the proposed flood mitigation. In order to minimize the conflicts, the federal government as represented by the Ministry of Water and Power and/or the Federal Flood Commission would be required to coordinate the overall project implementation and management works, and/or further directly undertake a part of them.

5) Implementation of Environmental Improvement Works of Lai Nullah

The environmental improvement particularly in the aspect of control of the garbage dumped into the river and the encroachment in the right-of-way of the river would be the important issues to sustain the flood mitigation capacity and the appropriate river environment of Lai Nullah. From these viewpoints, it is necessary to urge the relevant on-going environmental improvement projects such as enlargement of the capacity of the existing sewerage treatment capacity for Islamabad and the UWSSP-I and II for Rawalpindi

City. At the same time, legislation of the new act and enforcement for control of garbage dumping and encroachment in the waterway of the river would be required.

6) Budgetary Arrangement

According to the recent national policy in Pakistan, the public development investment is deemed to tend toward the regions other than the capital territory of Islamabad. This national policy may lead to difficulties in securing the necessary budget for the proposed flood mitigation plan. The budgetary arrangement would need, therefore, to be deliberated thoroughly by the federal agency as represented by the Ministry of Water and Power and the relevant local government agencies such as CDA and the provincial government of Punjabi, TMA, RDA and RCB.

7) Strengthening of Hydrological Data

The existing hydrological gauging data including the rainfall and water level data in Lai Nullah Basin is quite inadequate and less orderly prepared, which is a great hindrance for formulation of the flood mitigation plan as well as other various water resources development plan. In order to retrieve such unfavorable conditions, it is recommended to increase the hydrological gauging stations and at the same time, an attempt should be given to orderly arrange the gauged data.

8) Coordination with CDA on Layout of Amenities as Attached to Community Pond

The community pond proposed as a component of the urgent project would have the multiple functions as flood mitigation facility during a flood and as the amenity of the existing Fatima Jinnah Park during a non-flood time. CDA is quite concerned with the layout of the amenity facilities attached to the community pond, and therefore, a close coordination with CDA on this matter would be required during the succeeding detailed design stage.

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