TABLE E-13. QUESTIONNAIRE USED FOR THE FARMER INTENTION SURVEY

Q. 1. Do you plan to pursue your current farming activities?

Check	Answer/Explanation
	(1) 'Yes'
	(2) 'No' (Specify:

Q. 2. Which of the following do you foresee as the major source of family income in the future? (Select one or several of the items listed below)

Check	Answer/Explanation
	(1) Crop production (Specify:
	(2) Livestock production (Specify:
	(3) Work as a farm laborer for other farmers
	(4) Other source of income (Specify:

Q. 3. Do you plan to increase the acreage of the land you cultivate?

Check	Answer/Explanation
	(1) 'Yes' (Specify the possible source of land:
	(2) 'No'

Q. 4. Do you currently have a sufficient supply of irrigation water?

Check	Answer/Explanation
	(1) Sufficient in both the Kharif and the Rabi seasons
	(2) Insufficient in the Rabi season
	(3) Insufficient in both the Kharif and the Rabi seasons
	(4) Insufficient in the Kharif season

Q. 5. Do you currently have difficulties in distributing water to each plot in your farm?

Check	Answer/Explanation
	(1) 'Yes' (Specify:
	(2) 'No'

Q. 6. Do you currently have difficulties in transporting farm inputs and outputs to your farm?

Check	Answer/Explanation
	(1) 'Yes' (Specify:
	(2) 'No'

Q. 7. Which crops and cropping intensities would you adopt if additional irrigation water were available?

Season	Priority Crops			Cropping Intensity (%)		
	1st Crop	2nd Crop	3rd Crop	0-30	30-60	60-100
Kharif						
Rabi						

Q. 8. Do you want to be allocated additional irrigation water through the present project?

Check	Answer/Explanation
	(1) 'Yes'
	(2) 'No' (Specify:

TABLE E-14. RESULTS OF THE FARMER INTENTION SURVEY CONDUCTED IN THE STUDY AREA BY HILL TORRENT (percentage of respondents)

	Kaura	Vehowa	Sanghar	Sori Lund	Vidore	Sakhi Sarwar	Chachar	Zangi	Sori Janubi
Q. 1 [1]	100	100	100	100	100	100	100	100	100
[2]	0	0	0	0	0	0	0	0	0
Q. 2 [1]	100	100	100	100	83	100	100	100	100
[2]	22	0	25	45	75	55	66	33	78
[3]	0	0	0	0	8	0	33	22	11
[4]	45	33	67	0	25	89	33	89	33
Q. 3 [1]	55	78	100	100	92	89	100	100	100
[2]	45	22	0	0	8	11	0	0	0
Q. 4 [1]	45	0	25	11	17	0	0	0	0
[2]	0	0	8	0	0	0	0	0	0
[3]	55	100	67	89	83	100	100	100	100
[4]	0	0	0	0	0	0	0	0	0
Q. 5 [1]	55	78	67	100	100	67	100	89	100
[2]	45	22	33	0	0	33	0	11	0
Q. 6 [1]	89	33	50	100	67	89	100	78	11
[2]	11	67	50	0	33	11	0	22	89
Q. 7	See text	See text	See text	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Q. 8 [1]	100	100	100	100	100	100	100	100	100
[2]	0	0	0	0	0	0	0	0	0

Note: Question 2 was misunderstood by all respondents, who chose to indicate all their sources of income. In this case, therefore, the results of the Survey refer to the percentage of respondents who also engage in the other activities mentioned, i.e. crop production, livestock production, work as a farm laborer for other farmers, and others.

TABLE E-15. (1) RESULT OF FARMER INTENTION SURVEY; KAURA HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	* Specification of the other source of income: services.
	(2)	2	22	
	(3)	0	0	
	(4)	*4	45	
Q. 3.	(1)	*5	55	* Specification of the possible source of land: fallow and waste land, if water is available; in one case, plan to purchase land; in one case, plan to intensify cultivation.
	(2)	4	45	
Q. 4.	(1)	4	45	
	(2)	0	0	
	(3)	5	55	
	(4)	0	0	
Q. 5.	(1)	*5	55	* Specification of the reason for difficulties: not available.
	(2)	4	45	
Q. 6.	(1)	*8	89	* Specification of the reason for difficulties: absence of roads; in one case, high cost of transportation.
	(2)	1	11	
Q. 7.	Refer to Crop Selection in Farmer Intention Survey for Kaura hill torrent.			
Q. 8.	(1)	9	100	
	(2)	0	0	

TABLE E-15. (2) CROP SELECTION IN FARMER INTENTION SURVEY; KAURA HILL TORRENT

Crop	Priority						Total	
	1st Crop		2nd Crop		3rd Crop			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Kharif								
(1) Cotton	4	80	0	0	0	0	4	50
(2) Jowar	1	20	2	100	0	0	3	37.5
(3) Bajra	0	0	0	0	1	100	1	12.5
(4) Total	5	100	2	100	1	100	8	100
Rabi								
(1) Wheat	5	100	0	0	0	0	5	71.4
(2) Gram	0	0	1	100	0	0	1	14.3
(3) Oilseeds	0	0	0	0	0	0	1	14.3
(4) Total	5	100	1	100	1	100	7	100

TABLE E-15. (3) RESULT OF FARMER INTENTION SURVEY; VEHOWA HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	* Specification of the other source of income: services.
	(2)	0	0	
	(3)	0	0	
	(4)	*3	33	
Q. 3.	(1)	*7	78	* Specification of the possible source of land: fallow and waste land, if water is available.
	(2)	2	22	
Q. 4.	(1)	0	0	
	(2)	0	0	
	(3)	9	100	
	(4)	0	0	
Q. 5.	(1)	*7	78	* Specification of the reason for difficulties: field erosion; in three cases, because of field erosion and distance.
	(2)	2	22	
Q. 6.	(1)	*3	33	* Specification of the reason for difficulties: absence of roads.
	(2)	6	67	
Q. 7.	Refer to Crop Selection in Farmer Intention Survey for Vehowa hill torrent.			
Q. 8.	(1)	9	100	
	(2)	0	0	

TABLE E-15. (4) CROP SELECTION IN FARMER INTENTION SURVEY; VEHOWA HILL TORRENT

Crop	Priority						Total	
	1st Crop		2nd Crop		3rd Crop			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Kharif								
(1) Cotton	2	67	0	0	0	0	2	33.3
(2) Jowar	1	33	1	50	0	0	2	33.3
(3) Bajra	0	0	1	50	1	100	2	33.3
(4) Total	3	100	2	100	1	100	6	100
Rabi								
(1) Wheat	2	100	0	0	0	0	2	67
(2) Gram	0	0	1	100	0	0	1	33
(3) Total	2	100	1	100	0	0	3	100

TABLE E-15. (5) RESULT OF FARMER INTENTION SURVEY; SANGHAR HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	12	100	
	(2)	0	0	
Q. 2.	(1)	12	100	* Specification of the other source of income: services.
	(2)	3	25	
	(3)	0	0	
	(4)	*8	67	
Q. 3.	(1)	*12	100	* Specification of the possible source of land: fallow and waste land, if water is available.
	(2)	0	0	
Q. 4.	(1)	3	25	
	(2)	1	8	
	(3)	8	67	
	(4)	0	0	
Q. 5.	(1)	*8	67	* Specification of the reason for difficulties: field erosion.
	(2)	4	33	
Q. 6.	(1)	*6	50	* Specification of the reason for difficulties: absence of roads.
	(2)	6	50	
Q. 7.	Refer to Crop Selection in Farmer Intention Survey for Sanghar hill torrent.			
Q. 8.	(1)	12	100	
	(2)	0	0	

TABLE E-15. (6) CROP SELECTION IN FARMER INTENTION SURVEY; SANGHAR HILL TORRENT

Crop	Priority						Total	
	1st Crop		2nd Crop		3rd Crop			
	Nos.	%	Nos.	%	Nos.	%	Nos.	%
Kharif								
(1) Cotton	4	57	1	25	0	0	5	38.5
(2) Jowar	3	43	2	50	0	0	5	38.5
(3) Bajra	0	0	1	25	2	100	3	23.0
(4) Total	7	100	4	100	2	100	13	100
Rabi								
(1) Wheat	8	100	0	0	0	0	8	53.3
(2) Gram	0	0	5	100	0	0	5	33.3
(3) Oilseeds	0	0	0	0	2	100	2	13.3
(4) Total	8	100	5	100	2	100	15	100

TABLE E-15. (7) RESULT OF FARMER INTENTION SURVEY; SORI LUND HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	
	(2)	4	45	
	(3)	0	0	
	(4)	0	0	
Q. 3.	(1)	*9	100	* Specification of the possible source of land: fallow and waste land, if water is available; in one case, plan to lease land; in one case, plan to work additionally as a tenant.
	(2)	0	0	
Q. 4.	(1)	1	11	
	(2)	0	0	
	(3)	8	89	
	(4)	0	0	
Q. 5.	(1)	*9	100	* Specification of the reason for difficulties: field erosion.
	(2)	0	0	
Q. 6.	(1)	*9	100	* Specification of the reason for difficulties: absence of roads.
	(2)	0	0	
Q. 7.	This question was unanswered by all respondents.			
Q. 8.	(1)	9	100	
	(2)	0	0	

TABLE E-15. (8) RESULT OF FARMER INTENTION SURVEY; VIDORE HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	12	100	
	(2)	0	0	
Q. 2.	(1)	10	83	* Specification of the other source of income: services.
	(2)	9	75	
	(3)	1	8	
	(4)	*3	25	
Q. 3.	(1)	*11	92	* Specification of the possible source of land: fallow and waste land, if water is available; in three cases, plan to lease land.
	(2)	1	8	
Q. 4.	(1)	2	17	
	(2)	0	0	
	(3)	10	83	
	(4)	0	0	
Q. 5.	(1)	*12	100	* Specification of the reason for difficulties: field erosion.
	(2)	0	0	
Q. 6.	(1)	*8	67	* Specification of the reason for difficulties: absence of roads.
	(2)	4	33	
Q. 7.	This question was unanswered by all respondents.			
Q. 8.	(1)	12	100	
	(2)	0	0	

TABLE E-15. (9) RESULT OF FARMER INTENTION SURVEY; SAKHI SARWAR HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	* Specification of the other source of income: services.
	(2)	5	55	
	(3)	0	0	
	(4)	*8	89	
Q. 3.	(1)	*8	89	* Specification of the possible source of land: fallow and waste land, if water is available; in one case, plan to lease land.
	(2)	1	11	
Q. 4.	(1)	0	0	
	(2)	0	0	
	(3)	9	100	
	(4)	0	0	
Q. 5.	(1)	*6	67	* Specification of the reason for difficulties: field erosion; in one case, distance to plots.
	(2)	3	33	
Q. 6.	(1)	*8	89	* Specification of the reason for difficulties: absence of roads.
	(2)	1	33	
Q. 7.	This question was unanswered by all respondents.			
Q. 8.	(1)	9	100	
	(2)	0	0	

TABLE E-15. (10) RESULT OF FARMER INTENTION SURVEY; CHACHAR HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	* Specification of the other source of income: services.
	(2)	6	66	
	(3)	3	33	
	(4)	*3	33	
Q. 3.	(1)	*9	100	* Specification of the possible source of land: fallow and waste land, if water is available.
	(2)	0	0	
Q. 4.	(1)	0	0	
	(2)	0	0	
	(3)	9	100	
	(4)	0	0	
Q. 5.	(1)	*9	100	* Specification of the reason for difficulties: field erosion.
	(2)	0	0	
Q. 6.	(1)	*9	100	* Specification of the reason for difficulties: absence of roads.
	(2)	0	0	
Q. 7.	This question was unanswered by all respondents.			
Q. 8.	(1)	9	100	
	(2)	0	0	

TABLE E-15. (11) RESULT OF FARMER INTENTION SURVEY; ZANGI HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	* Specification of the other source of income: services.
	(2)	3	33	
	(3)	2	22	
	(4)	*8	89	
Q. 3.	(1)	*9	100	* Specification of the possible source of land: fallow and waste land, if water is available.
	(2)	0	0	
Q. 4.	(1)	0	0	
	(2)	0	0	
	(3)	9	100	
	(4)	0	0	
Q. 5.	(1)	*8	89	* Specification of the reason for difficulties: field erosion.
	(2)	1	0	
Q. 6.	(1)	*7	78	* Specification of the reason for difficulties: absence of roads.
	(2)	2	22	
Q. 7.	This question was unanswered by all respondents.			
Q. 8.	(1)	9	100	
	(2)	0	0	

TABLE E-15. (12) RESULT OF FARMER INTENTION SURVEY; SORI JANUBI HILL TORRENT

Question		Response		Specification
		Nos.	%	
Q. 1.	(1)	9	100	
	(2)	0	0	
Q. 2.	(1)	9	100	* Specification of the other source of income: services.
	(2)	7	78	
	(3)	1	11	
	(4)	*3	33	
Q. 3.	(1)	*9	100	* Specification of the possible source of land: fallow and waste land, if water is available.
	(2)	0	0	
Q. 4.	(1)	0	0	
	(2)	0	0	
	(3)	9	100	
	(4)	0	0	
Q. 5.	(1)	*9	100	* Specification of the reason for difficulties: field erosion.
	(2)	0	0	
Q. 6.	(1)	*1	11	* Specification of the reason for difficulties: absence of roads.
	(2)	8	89	
Q. 7.	This question was unanswered by all respondents.			
Q. 8.	(1)	9	100	
	(2)	0	0	

CHAPTER III. HOUSEHOLD QUESTIONNAIRE

TABLE E-16. HOUSEHOLD QUESTIONNAIRE

1. Members of Household

(1) What is your family make-up?
(Sex, Age, and Occupation for each member of your household)

(2) Who is the head of the household?

2. Farm Land

(3) What is your farm size?
(Hectares for the last 12 months, and maximum and minimum Net Sown Area in the past 10 years)

(4) Who has the tenure of your farm land?

(5) How many separate farm plots do you have?

(6) Respectively in acres, what is your maximum and minimum plot size?

(7) Respectively, what is the maximum and minimum distance between the farm plot and your house?

(8) What is the major soil texture in your farm land?

3. Livestock

(9) What kinds of, and how many heads of domestic animals are you raising?

4. Farm Inputs and Crop Yield

(10) How much farm input have you used during the past 12 months?
(Seeds, Fertilizers, and Agro-Chemicals for each crop)

(11) What was your crop yield?
(kg/ha of each crop harvested in the past 12 months, and maximum and minimum crop yield during the past 10 years)

5. Machinery

(12) What kind of machinery have you used during the past 12 months?

(13) If you have used a tractor on your farm, how have you used it during the past 12 months?

6. Cropping Pattern and Labor Requirement

(14) How was the cropping pattern in your farm during the past 12 months? (Crop Acreage, Proportion, and Cropping Calendar)

(15) How many days have you used laborers and draft animals for cropping during the past 12 months?

HOUSEHOLD QUESTIONNAIRE 1 [DISTRICT :] [HILL TORRENT :]

1. Member of Household

Total Persons : _____ persons

(1) Male			(1) Female		
	Age	Occupation		Age	Occupation
i.			i.		
ii.			ii.		
iii.			iii.		
iv.			iv.		
v.			v.		
vi.			vi.		
vii.			vii.		
viii.			viii.		
ix.			ix.		
x.			x.		

2. Farm Land

(1)	Farm Size	Total Area: _____ ha	
i.	Net Sown Area	:	Max:
	(Irrigated)	:	
	(Non-Irrigated)	:	
ii.	Current Fallow	:	
iii.	Grazing Area	:	
iv.	Culturable Waste	:	
v.	Others	:	
(2)	Land Tenure		
(3)	Number of Farm Plot		
(4)	Plot Size,	Max: acre,	Min: acre
(5)	Distance to the Farm,	Max: m,	Min: m
(6)	Soil, Sandy: %,	Loamy: %,	Clayey: %

3. Livestock

	adult	(heads) young
(1) Cattle		
(2) Buffaloes		
(3) Sheep		
(4) Goats		
(5) Horses		
(6) Mules		
(7) Donkeys		
(8) Camels		
(9) Poultry		

4. Farm Imputs & Crop Yield

Crop	Seeds		Fertilizers (kg/ha)				Agro-Chemicals (kg/ha)			Crop Yield (kg/ha)	
	Variety	(kg/ha)	N	P	K	Others				*Present	**Max.
Jowar											
Bajra											
Wheat											
Pulses											
Oilseed											

5. Machinery

(1) Tractor
- i. Owner :
- ii. Type & Hp :
- iii. Average Use : ***d/y
- iv. Purposes :
- v. Area Covered : ha
- vi. Attachments :

(2) Thresher

(3) Pump

(4)

(5)

* Present: The last 12 months, ** Max.: maximum during the past 10 years, *** d/y: days/year

HOUSEHOLD QUESTIONNAIRE 2 [DISTRICT :] [HILL TORRENT :]

6. Cropping Pattern & Labor Requirement (day/year)

Crop Acreage ha (%)	Cropping Pattern & Labor Requirement													Total
		May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	
( )	*c. m. d.													
( )	*c. m. d.													
( )	*c. m. d.													
( )	*c. m. d.													
( )	*c. m. d.													
( )	*c. m. d.													
Total ( )	*c. m. d.													

* c: cropping pattern (put marks on the dotted line), m; mandays, d: draft animal days

ANNEX F. IRRIGATION

LIST OF TABLES

LIST OF FIGURES

ANNEX F. IRRIGATION

1) Existing Irrigation Facilities

The salient features of the major existing irrigation facilities located in the hill torrents are shown in Table F - 1.

2) Cross-drainage Works

The existing D.G. Khan Canal Dajal Branch and the proposed Dajal Branch Extension run along the lower boundaries of the Pachad areas. The location and capacity of cross-drainage works in the D.G. Khan Canal Dajal Branch are summarized in Table F - 2.

3) Pachad Area of Main Hill Torrents

The general maps of the Pachad areas of 12 Hill Torrents, excluding the Kaha Hill Torrent from the major 13 Hill Torrents, are illustrated in Figures F - 1 to F - 12. The water rights conditions are also indicated in the Figures.

TABLE F-1. EXISTING MAIN IRRIGATION STRUCTURES

Name of Hill Torrent	Existing Main Irrigation Structure			
	Name of Structure		Scale	
1. VEHOWA	- Pick Up Weir	Height:	0.9 m	(3 feet)
		Length:	91.4 m	(300 feet)
	- Gang Channel	Capacity:	5.7 m3/sec	(200 cusec)
2. SANGHAR	- Diversion Bund	Height:	2.4 m	(8 feet)
	(JAT WAH)	Length:	274.3 m	(900 feet)
	- Diversion Bund	Height:	2.3 m	(7.6 feet)
	(VEGWARI JADID)	Length:	310.9 m	(1,020 feet)
	- Diversion Bund	Height:	1.5 - 4.6 m	(5 - 15 feet)
	(SAD WANDA)	Length:	457.2 m	(1,500 feet)
	- Diversion Bund	Height:	4.9 m	(16 feet)
	(3 Nos, Taunsa Villiage)	Length:	76.2 - 53.3 m	(250 - 175 feet)
3. SORI LUND	- Jhal Hotwani Embankment	Height:	5.8 m	(19.1 feet)
		Length:	115.8 m	(380 feet)
	- Godi Wali Ganda	Height:	3.4 m	(11 feet)
		Length:	356.6 m	(1,170 feet)
	- Kande Wali Ganda	Height:	1.7 m	(5.5 feet)
		Length:	579.1 m	(1,900 feet)
4. VIDORE	- Ganda Khoh Kalan	Height:	3.0 m	(10 feet)
		Length:	273.4 m	(900 feet)
5. ZANGI	- Ganda Dilbar	Height:	2.8 m	(9.1 feet)
		Length:	533.4 m	(1,750 feet)
	- Bund Chak Mat	Height:	1.8 - 2.4 m	(6 - 8 feet)
		Length:	502.9 m	(1,650 feet)

TABLE F-2. LOCATION AND CAPACITY OF CROSS-DRAINAGE WORKS

No.-	Hill Torrnets	Location 'RD'	Individual Capacity (cms)	Total Capacity for each Torrent (cms)	Remarks
	I. D.G.KHAN CANAL (EXISTING)				
1-	Sori lund	51+000	140		Direct outfall into River Indus.
		69+500	790		〃
		82+400	140		〃
				1,200	
		108+857	60		Enters Canal Commanded Area.
		144+000	30		〃
		156+750	40		〃
2-	Vidore	185+500	60		〃
				340	
		242+215	280		〃
3-	Sakhi Sarwar	279+370	60	60	〃
4-	Mithawan	316+430	60		〃
	II. DAJAL BRANCH (EXISTING)				
				270	
		19+213	40		〃
		32+166	170		〃
5-	Kaha	79+700	280		〃
		95+280	20		〃
		109+770	30		〃
				730	
		123+650	140		〃
		145+760	200		〃
		165+760	60		〃
6-	Chachar	177+300	60		〃
				340	
		186+100	280		〃
	III. DAJAL BRANCH EXTENSION (PROPOSED)				
		205+000	60	60	Proposed on Dajal Extension & affect Canal Command Area.
7-	Pitok	290+500	140		〃
				250	
		307+000	110		〃
8-	Sori Shumali	322+000	60		〃
9-	Zangi	437+000	280		〃
				390	
		448+000	110		
10-	Sori Janubi	519+975	280		
				450	
		529+303	170		
	IV. CHASHMA RIGHT BANK CANAL (PROPOSED)				
11-	Kaura		1,260		These will affect Chashma Right Bank Canal and its command area. These have direct outfall into Indus River.
12-	Vehowa		3,130		
13-	Sanghar		3,960		

(SOURCE: FLOOD MANAGEMENT OF D.G.KHAN HILL TORRENTS MAIN REPORT)

FIGURE F - 1. GENERAL MAP OF KAURA HILL TORRENT

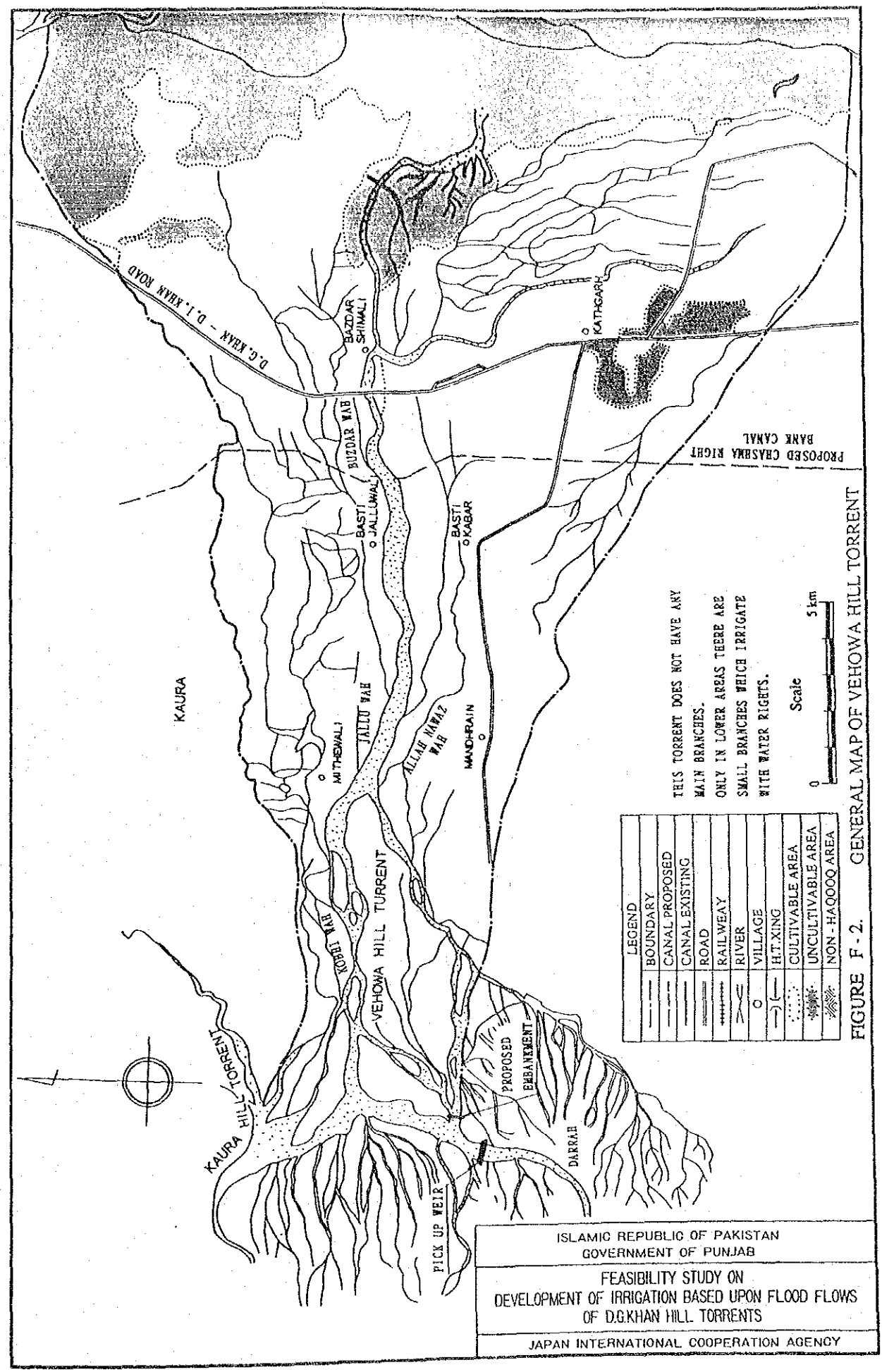

FIGURE F-2. GENERAL MAP OF VEHOWA HILL TORRENT

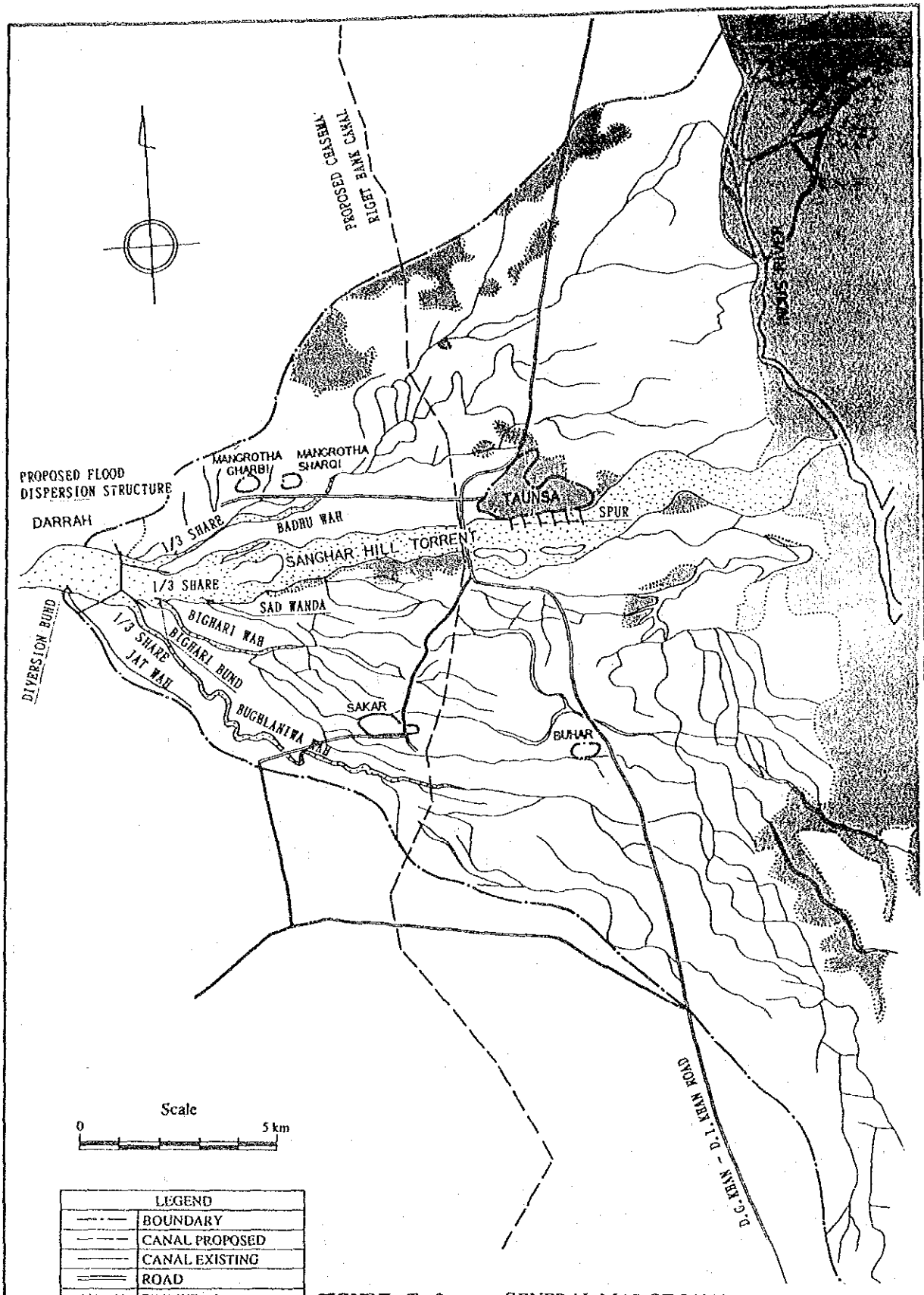

FIGURE F - 3. GENERAL MAP OF SANGHAR HILL TORRENT

ISLAMIC REPUBLIC OF PAKISTAN
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DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
OF D.G.KHAN HILL TORRENTS

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE F-4. GENERAL MAP OF SORI LUND HILL TORRENT

ISLAMIC REPUBLIC OF PAKISTAN
GOVERNMENT OF PUNJAB

FEASIBILITY STUDY ON
DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
OF D.G.KHAN HILL TORRENTS

JAPAN INTERNATIONAL COOPERATION AGENCY

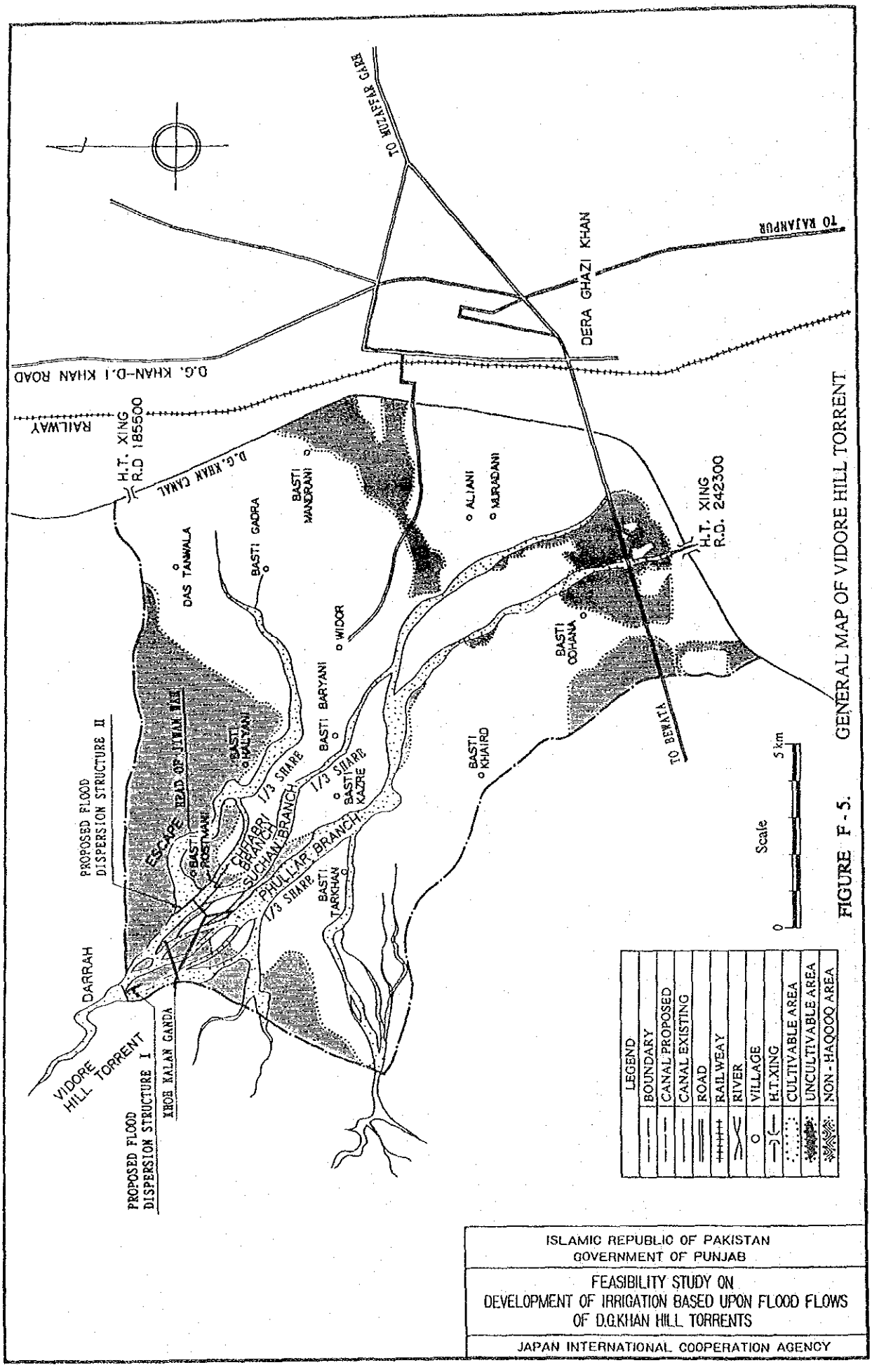

FIGURE F - 5. GENERAL MAP OF VIDORE HILL TORRENT

ISLAMIC REPUBLIC OF PAKISTAN
GOVERNMENT OF PUNJAB

FEASIBILITY STUDY ON
DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS
OF D.G.KHAN HILL TORRENTS

JAPAN INTERNATIONAL COOPERATION AGENCY

FIGURE F-6. GENERAL MAP OF SAKHI SARWAR HILL TORRENT

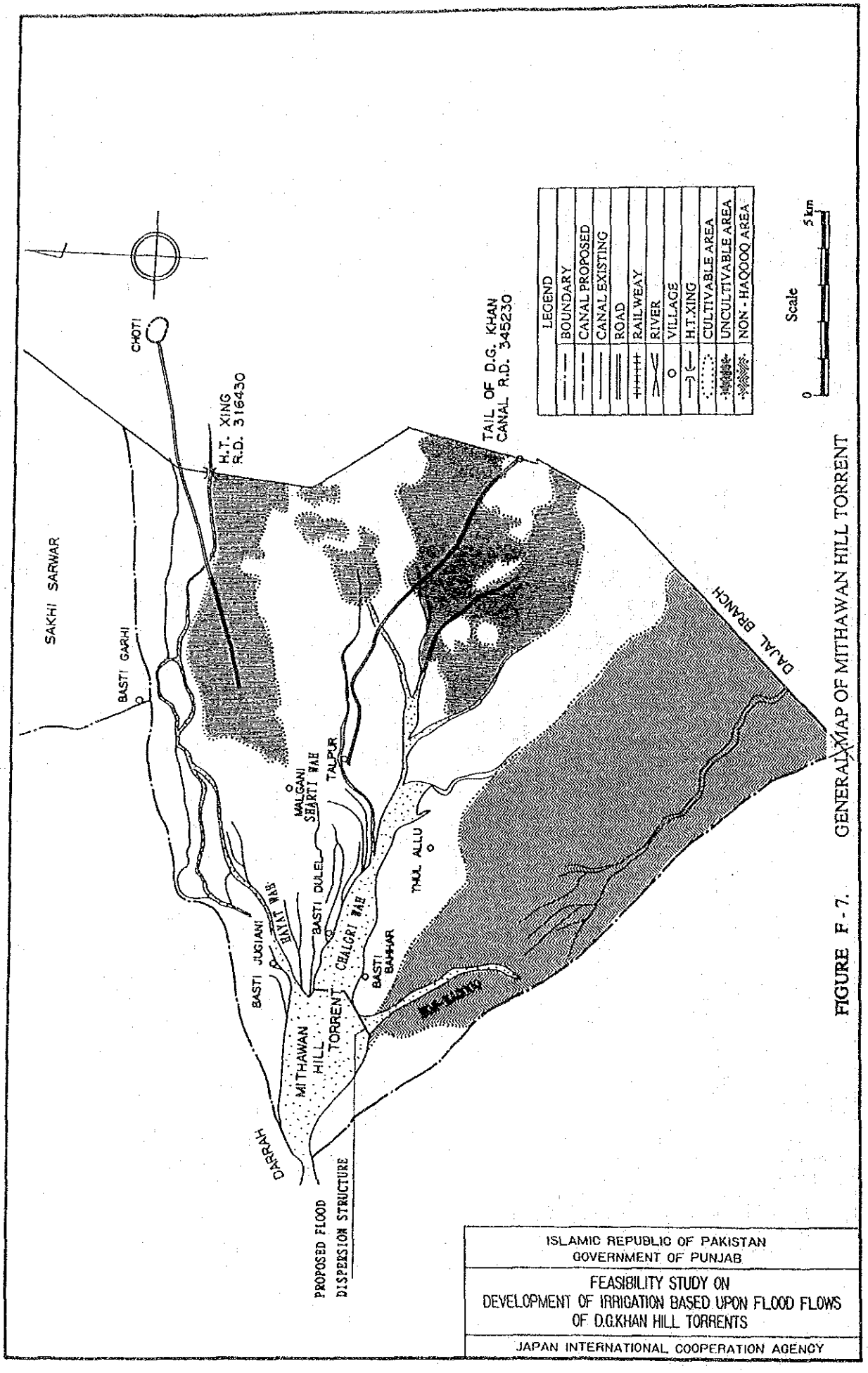

FIGURE F-7. GENERAL MAP OF MITHAWAN HILL TORRENT

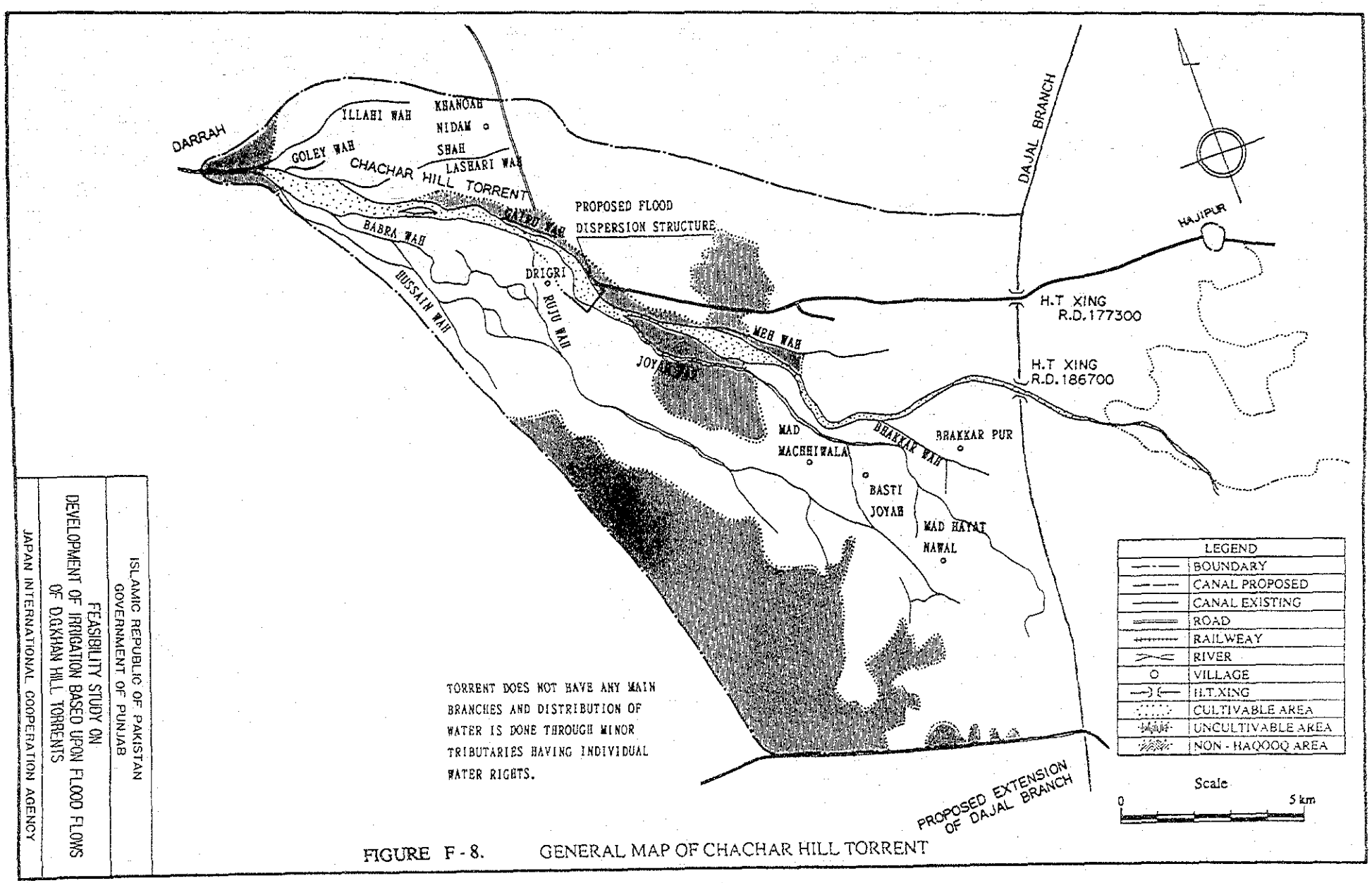

FIGURE F - 8. GENERAL MAP OF CHACHAR HILL TORRENT

FIGURE F-9. GENERAL MAP OF PITOK HILL TORRENT

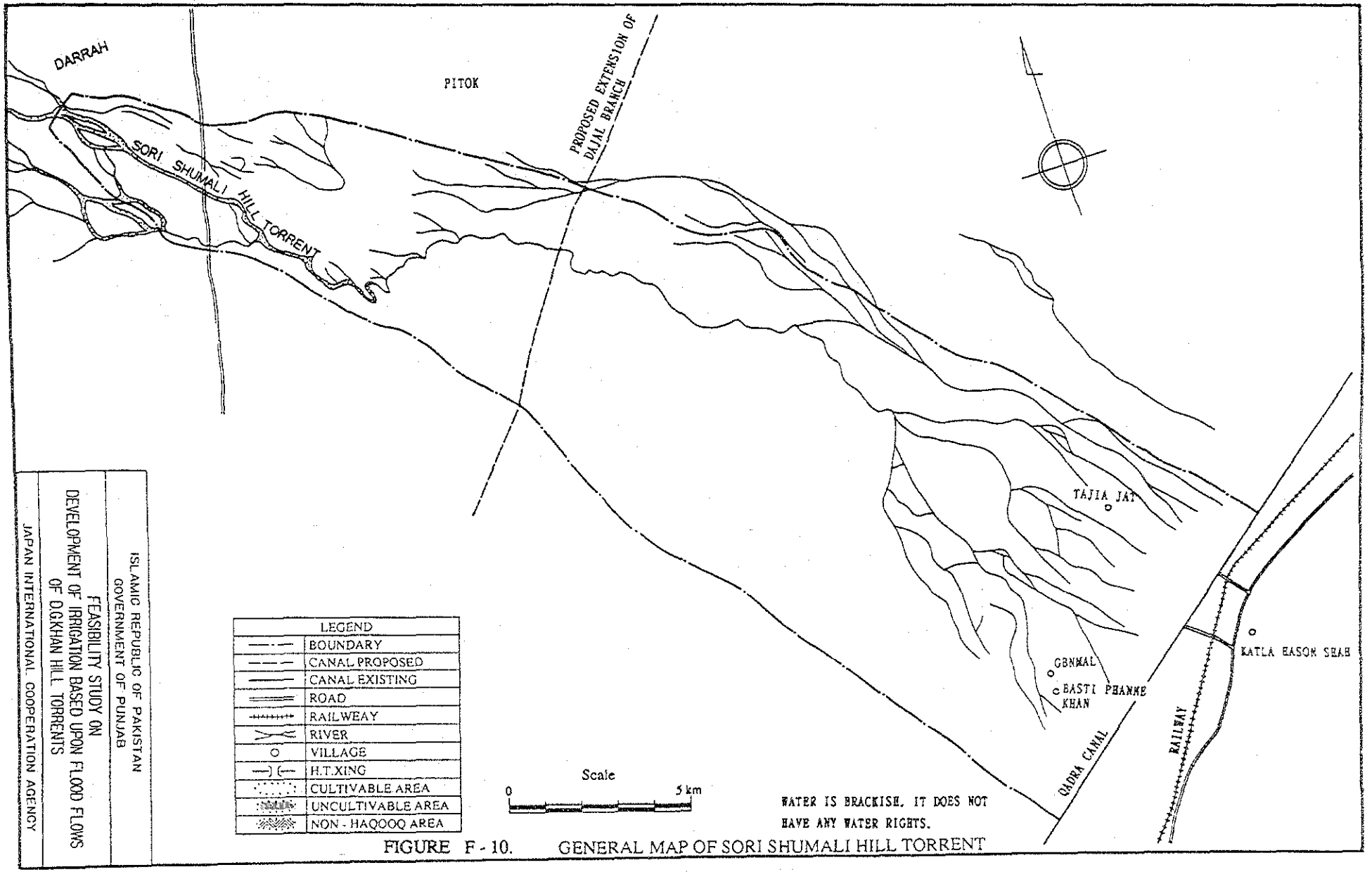

FIGURE F - 10. GENERAL MAP OF SORI SHUMALI HILL TORRENT

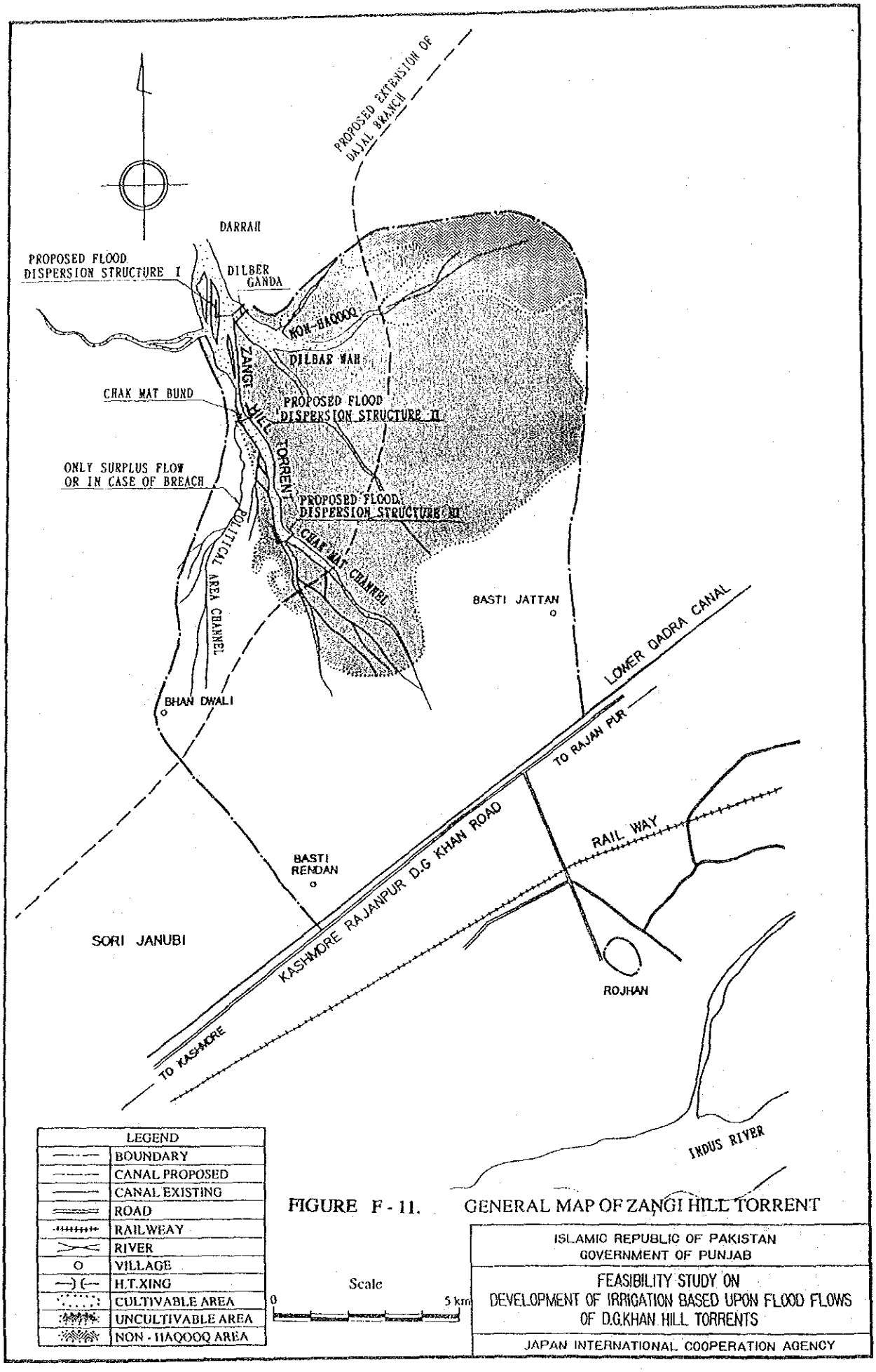

FIGURE F - 11. GENERAL MAP OF ZANGI HILL TORRENT

ISLAMIC REPUBLIC OF PAKISTAN
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FEASIBILITY STUDY ON
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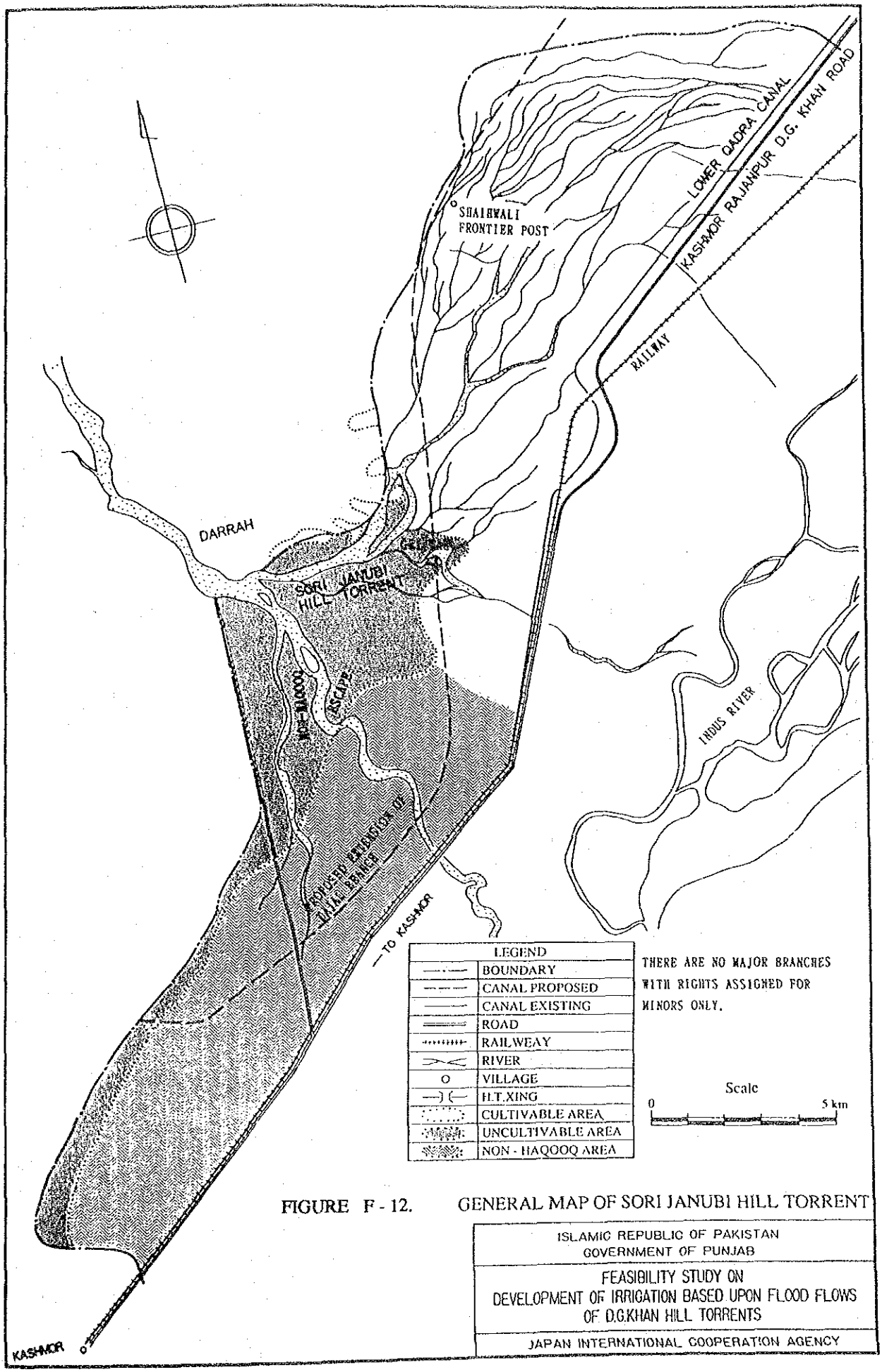


FIGURE F - 12. GENERAL MAP OF SORI JANUBI HILL TORRENT

ISLAMIC REPUBLIC OF PAKISTAN GOVERNMENT OF PUNJAB
FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G.KHAN HILL TORRENTS
JAPAN INTERNATIONAL COOPERATION AGENCY

PART II. VIDORE HILL TORRENT AREA

ANNEX G. METEOROLOGY / HYDROLOGY

LIST OF TABLES

LIST OF FIGURES

ANNEX G. METEOROLOGY / HYDROLOGY

1) Rainfall

There are 5 rain gauge stations within the watershed of Vidore hill torrent of which 2 stations (Bandukh and Bandlukh) are located very close to each other. The areal rainfall of the watershed is calculated for 10 years (1975 - 1984) using data of 4 stations excluding Bandukh station and applying the Thiessen Method. The annual and monthly rainfall of 4 stations (Mard Bun, Beira, Sanga Sluf and Bandlukh) are presented in Table G-1 and Table G-2. The Thiessen Polygon is shown in figure G-1. Monthly areal rainfall of Vidore hill torrent is presented in Table G-3.

2) Runoff Volume

The grassland area of present and plans are shown in Table G-4. Daily mean runoff is calculated for 10 years (1975 - 1984) using daily areal rainfall and applying Tank Model Method as shown in Figure G-2. Monthly runoff of Vidore, Dalana and Zai are shown in Table G-5, Table G-6 and Table G-7. Annual runoff and probable runoff are presented in Table G-8.

3) Flood Peak Discharge

The probable flood peak discharges are calculated using probable hourly rainfall and applying Characteristic Curve Method. According to this method, the watershed area of Vidore hill torrent is divided into 13 blocks as shown in figure G-3. The probable flood peak discharges of present and plans are presented in Table G-9. The hydrographs of present and plans are shown in Figure G-4.

Table G-1 Annual Observated Rainfall in Vidore Hill Torrent

(Unit: mm)

Year	Mard Bun	Beira	Sanga Sluf	Bandlukh
1975	476.2	320.5	395.2	345.7
1976	552.2	426.3	550.0	514.4
1977	366.4	238.1	347.2	277.0
1978	238.8	267.7	270.6	228.8
1979	236.5	313.7	285.4	192.2
1980	220.2	249.2	223.3	204.4
1981	266.6	259.0	222.3	198.8
1982	277.4	297.3	330.7	196.9
1983	428.7	416.2	474.6	382.5
1984	228.0	275.1	321.0	163.8
Average	329.1	306.3	342.0	270.5

Table G-2 Monthly Observated Rainfall in Vidore Hill Torrent (1/2)

< Mard Bun Station> (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.0	0.0	0.0	26.7	24.7	63.8	52.1	195.7	113.2	0.0	0.0	0.0	476.2
1976	0.0	22.9	47.3	33.8	5.1	36.1	95.8	150.5	152.8	7.9	0.0	0.0	552.2
1977	0.0	0.0	0.0	101.2	11.4	50.3	146.8	21.6	35.1	0.0	0.0	0.0	366.4
1978	0.0	0.0	0.0	24.4	0.0	0.0	138.4	27.0	40.9	0.0	8.1	0.0	238.8
1979	17.8	31.3	13.7	17.6	16.1	4.3	72.2	22.1	30.7	6.6	0.0	4.1	236.5
1980	23.4	2.3	21.4	2.3	4.1	45.3	61.4	47.0	6.6	6.4	0.0	0.0	220.2
1981	28.5	6.6	50.8	6.1	18.3	0.0	91.6	62.9	0.0	0.0	1.8	0.0	266.6
1982	1.8	15.7	58.5	27.7	10.7	22.9	24.7	75.0	6.8	16.1	3.0	14.5	277.4
1983	0.0	0.0	4.3	62.2	77.6	30.7	113.9	70.3	69.7	0.0	0.0	0.0	428.7
1984	0.0	7.6	13.2	0.0	0.0	0.0	63.3	126.6	17.3	0.0	0.0	0.0	228.0
Mean	7.2	8.6	20.9	30.2	16.8	25.3	86.0	79.9	47.3	3.7	1.3	1.9	329.1

< Beira Station> (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.0	0.0	0.0	36.9	19.1	30.6	75.0	96.7	62.2	0.0	0.0	0.0	320.5
1976	3.0	1.8	30.5	20.1	2.8	59.4	134.4	73.5	78.2	22.6	0.0	0.0	426.3
1977	17.8	0.0	0.0	75.9	19.6	38.9	65.8	6.6	10.2	0.0	3.3	0.0	238.1
1978	9.7	27.7	17.3	18.7	0.0	0.0	138.0	28.7	23.3	0.0	4.3	0.0	267.7
1979	12.7	33.5	66.6	24.4	22.2	11.7	72.2	44.7	16.0	4.6	0.0	5.1	313.7
1980	20.3	1.8	25.1	3.3	4.8	45.3	88.4	36.1	5.1	16.0	3.0	0.0	249.2
1981	19.6	8.6	52.4	8.1	13.7	0.0	106.8	47.0	0.0	0.0	2.8	0.0	259.0
1982	2.8	20.8	60.9	27.7	14.2	22.9	29.7	67.8	6.8	25.6	4.6	13.5	297.3
1983	0.0	12.5	5.1	53.8	76.2	29.7	94.8	74.4	69.7	0.0	0.0	0.0	416.2
1984	6.4	6.4	13.7	5.8	0.0	15.5	65.6	143.4	18.3	0.0	0.0	0.0	275.1
Mean	9.2	11.3	27.2	27.5	17.2	25.4	87.1	61.9	29.0	6.9	1.8	1.8	306.3

Table G-2 Monthly Observated Rainfall in Vidore Hill Torrent (2/2)

< Sangha Sluf Station> (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.0	0.0	0.0	32.8	20.1	66.3	109.7	100.3	66.0	0.0	0.0	0.0	395.2
1976	2.5	4.8	11.0	19.5	0.0	99.8	105.6	168.2	136.6	2.0	0.0	0.0	550.0
1977	0.0	0.0	0.0	94.0	30.7	89.5	39.1	60.1	20.6	0.0	13.2	0.0	347.2
1978	0.0	11.4	38.6	8.6	0.0	0.0	138.2	42.4	23.3	0.0	8.1	0.0	270.6
1979	8.6	22.2	38.4	11.5	31.5	9.9	52.5	61.8	38.6	5.3	0.0	5.1	285.4
1980	14.7	0.0	18.5	10.7	7.4	0.0	88.4	68.9	0.0	12.4	2.3	0.0	223.3
1981	12.2	8.8	29.0	10.4	21.0	0.0	82.6	40.1	4.3	13.9	0.0	0.0	222.3
1982	6.1	31.7	61.0	27.7	37.4	16.5	29.7	67.8	0.0	27.7	4.8	20.3	330.7
1983	0.0	16.8	0.0	76.2	94.1	61.7	94.8	60.9	65.3	0.0	0.0	4.8	474.6
1984	7.4	13.7	6.4	43.2	0.0	31.8	65.6	143.5	9.4	0.0	0.0	0.0	321.0
Mean	5.2	10.9	20.3	33.5	24.2	37.6	80.6	81.4	36.4	6.1	2.8	3.0	342.0

< Bandlukh Station> (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.0	0.0	0.0	1.3	22.9	40.6	75.0	96.7	109.2	0.0	0.0	0.0	345.7
1976	0.0	0.0	24.7	21.6	0.0	83.8	114.3	135.4	134.6	0.0	0.0	0.0	514.4
1977	13.9	0.0	0.0	80.2	0.0	78.8	75.6	9.9	18.6	0.0	0.0	0.0	277.0
1978	2.8	2.0	25.4	29.2	0.0	6.4	143.0	11.4	8.6	0.0	0.0	0.0	228.8
1979	0.0	25.2	15.2	12.4	44.2	9.9	22.6	50.0	8.9	0.0	0.0	3.8	192.2
1980	8.9	0.0	29.4	33.8	14.7	0.0	87.6	5.1	12.7	7.9	0.0	4.3	204.4
1981	7.9	0.0	30.5	15.2	10.2	0.0	61.6	67.3	0.0	0.0	6.1	0.0	198.8
1982	0.0	11.4	36.9	33.8	9.4	0.0	24.2	51.3	0.0	21.6	0.0	8.3	196.9
1983	0.0	2.5	0.0	65.3	72.4	42.0	102.6	43.1	54.6	0.0	0.0	0.0	382.5
1984	0.0	0.0	8.9	2.5	0.0	6.9	63.2	75.9	6.4	0.0	0.0	0.0	163.8
Mean	3.4	4.1	17.1	29.5	17.4	26.8	77.0	54.6	35.4	3.0	0.6	1.6	270.5

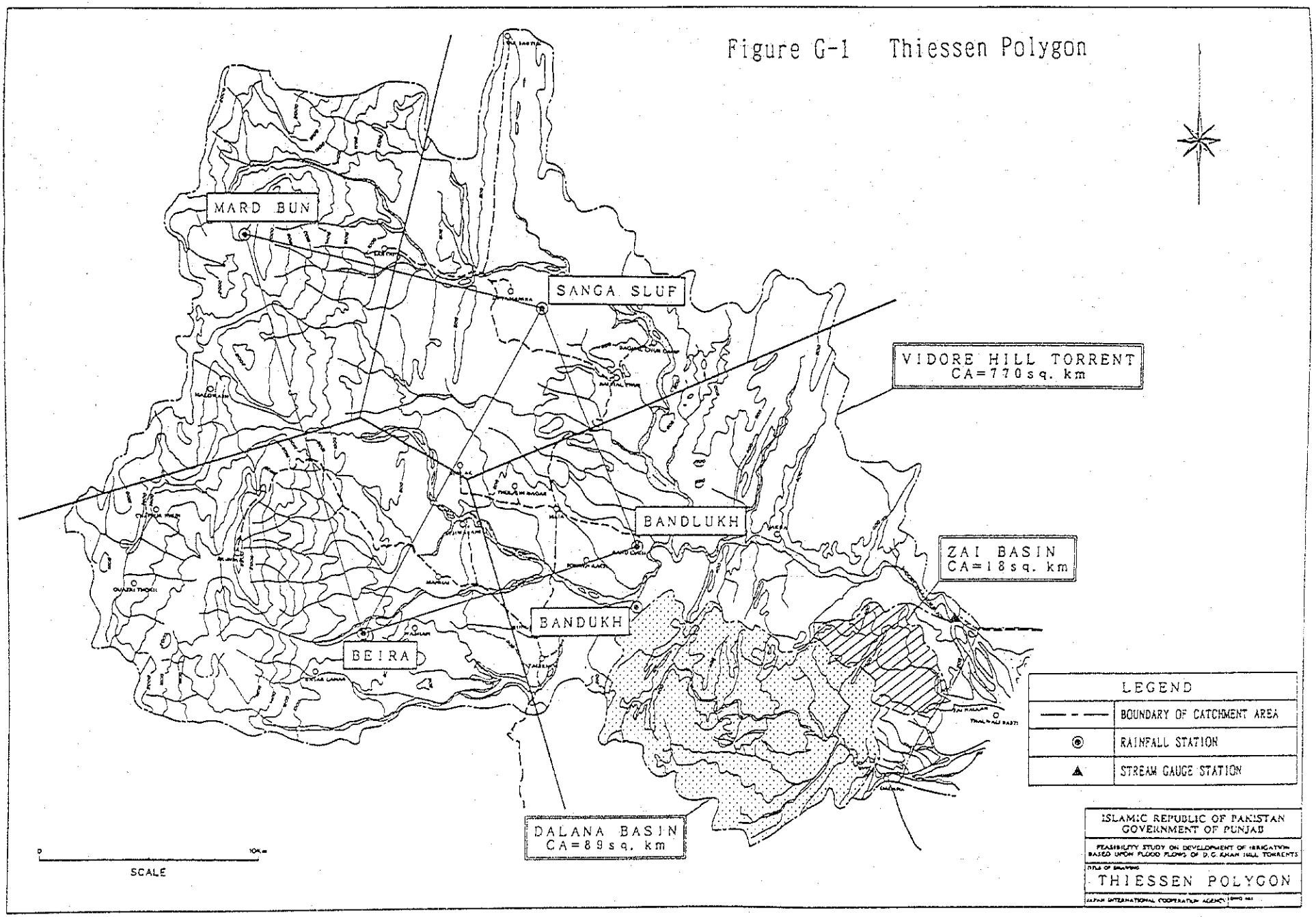


Figure G-1 Thiessen Polygon
MARD BUN
SANGA SLUF
VIDORE HILL TORRENT
CA=770sq. km
BANDLUKH
ZAI BASIN
CA=18sq. km
BANDUKH
BEIRA
DALANA BASIN
CA=89sq. km
LEGEND
BOUNDARY OF CATCHMENT AREA
RAINFALL STATION
STREAM GAUGE STATION
SCALE
ISLAMIC REPUBLIC OF PAKISTAN
GOVERNMENT OF PUNJAB
FEASIBILITY STUDY ON DEVELOPMENT OF IRRIGATION BASED UPON FLOOD FLOWS OF D.G. KHAN HILL TORRENTS
THIESSEN POLYGON

Table G-3 Monthly Areal Rainfall of Vidore

(Catchment Area : 770 sq.km) (Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.0	0.0	0.0	23.7	21.7	49.6	78.6	119.4	87.5	0.0	0.0	0.0	380.5
1976	1.4	6.7	27.7	23.4	1.8	71.2	113.1	131.4	125.0	7.9	0.0	0.0	509.6
1977	8.4	0.0	0.0	87.2	15.1	65.2	79.7	24.2	20.6	0.0	4.1	0.0	304.5
1978	3.2	10.3	21.1	20.4	0.0	1.8	139.5	26.9	23.1	0.0	4.9	0.0	251.2
1979	9.2	27.9	33.5	16.3	29.4	9.1	53.4	45.5	22.9	3.9	0.0	4.5	255.6
1980	16.4	1.0	23.8	13.5	8.1	21.3	82.2	38.0	6.3	10.7	1.3	1.2	223.8
1981	16.4	5.8	40.1	10.2	15.6	0.0	84.7	54.5	1.1	3.5	2.8	0.0	234.7
1982	2.6	19.8	53.7	29.4	17.9	14.9	27.0	64.8	3.2	22.9	3.0	14.0	273.2
1983	0.0	8.0	2.2	64.5	79.9	41.4	101.2	61.3	64.4	0.0	0.0	1.2	424.1
1984	3.5	6.7	10.4	13.0	0.0	13.8	64.4	120.8	12.5	0.0	0.0	0.0	245.1
Mean	6.1	8.6	21.2	30.2	18.9	28.8	82.4	68.7	36.7	4.9	1.6	2.1	310.2

Areal Rainfall : To be Computed by THIESSEN METHOD

Rainfall Station	Areal Ratio by THIESSEN
Mard Bun	0.22
Beira	0.25
Sanga Sluf	0.25
Bandlukh	0.28

Table G-4 Grassland Area of Present and Alternative Plan

Basin	Zone	C.A. sq.km	Grassland Area: Present sq.km	(%)	Plan: CaseA sq.km	(%)	CaseB-1 sq.km	(%)	CaseB-2 sq.km	(%)
Vidore	I	250	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
-do-	II	125	2	(1.6)	2	(1.6)	72	(57.6)	72	(57.6)
-do-	III	138	4	(2.9)	4	(2.9)	67	(48.6)	67	(48.6)
-do-	IV	110	4	(3.6)	4	(3.6)	4	(3.6)	74	(67.3)
-do-	V	147	3	(2.0)	3	(2.0)	3	(2.0)	30	(20.4)
Vidore Total		770	13	(1.7)	13	(1.7)	146	(19.0)	243	(31.6)
Dalana	V	89	0	(0.0)	0	(0.0)	0	(0.0)	36	(40.4)
Zai	V	18	0	(0.0)	0	(0.0)	0	(0.0)	10	(55.6)
Total		877	13	(1.5)	13	(1.5)	146	(16.6)	289	(33.0)

C.A. : Catchment Area

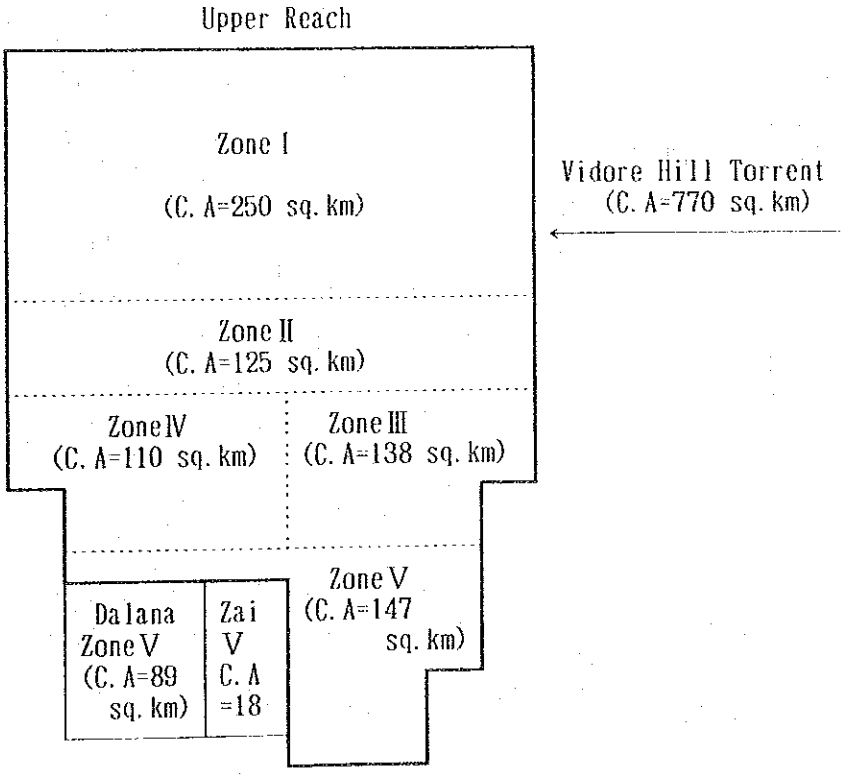
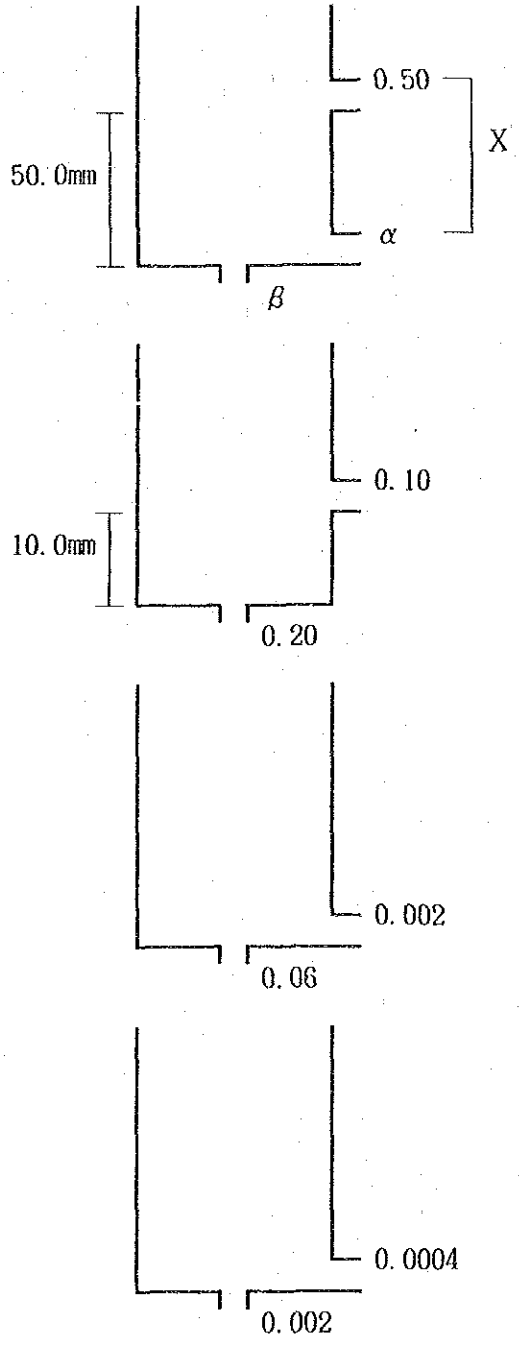


Figure G-2 Structure of Tank



Basin	Zone	Present		Plan		
		α	β	R %	α	β
Vidore	I	0.40	0.10	0.0	0.40	0.10
	II	0.35	0.15	57.6	0.23	0.27
	III	0.30	0.20	48.6	0.20	0.30
	IV	0.30	0.20	67.3	0.17	0.33
	V	0.35	0.15	20.4	0.31	0.19
Dalana	V	0.35	0.15	40.4	0.22	0.28
Zai	V	0.35	0.15	55.6	0.24	0.26

Zone	R= 0 %	R= 100%	Relation Line
I	X= 0.90	X= 0.70	X= -0.002R+ 0.90
II	X= 0.85	X= 0.65	X= -0.002R+ 0.85
III	X= 0.80	X= 0.60	X= -0.002R+ 0.80
IV	X= 0.80	X= 0.60	X= -0.002R+ 0.80
V	X= 0.85	X= 0.65	X= -0.002R+ 0.85

R : Ratio of Grassland (%)

$X = \alpha + 0.50$

$\alpha + \beta + 0.50 = 1.0$ (fixed)

Table G-5 Monthly Runoff Volume of Vidore (1/2)

<Present and Plan CaseA> (Catchment Area : 770 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	8.87	7.36	16.87	26.36	49.83	39.81	0.03	0.00	0.00	149.13
1976	0.43	3.04	10.62	6.75	0.53	29.15	47.24	49.32	71.29	2.48	0.06	0.04	220.95
1977	3.44	0.01	0.01	37.35	4.69	28.24	29.51	8.16	6.93	0.00	1.49	0.00	119.83
1978	1.12	3.42	6.91	5.79	0.00	0.46	59.76	8.60	8.20	0.00	1.83	0.00	96.09
1979	3.80	12.96	14.21	4.75	8.96	2.54	20.66	15.81	8.69	1.32	0.00	1.39	95.09
1980	6.67	0.28	8.03	3.80	2.11	6.56	30.22	13.50	1.74	4.02	0.35	0.35	77.63
1981	6.73	1.98	14.97	3.50	4.69	0.00	31.89	19.18	0.27	0.91	0.81	0.00	84.93
1982	0.71	6.52	21.59	9.72	5.28	5.25	8.25	22.78	0.94	7.53	0.93	5.25	94.74
1983	0.00	2.65	0.64	27.89	30.21	12.93	41.75	22.47	26.18	0.00	0.00	0.32	165.04
1984	1.07	2.42	3.20	3.84	0.00	4.07	21.10	59.78	4.41	0.00	0.00	0.00	99.89
Mean	2.40	3.33	8.02	11.22	6.38	10.61	31.67	26.94	16.85	1.63	0.55	0.73	120.33

Year	Apr. - Sep. Runoff (MCM)	Oct. - Mar. Runoff (MCM)	Annual Runoff (MCM)	(1)R.P. (Year)	(2)R.P. (Year)
1975	149.10	0.03	149.13	5.36	1.48
1976	204.28	16.67	220.95	25.48	1.28
1977	114.88	4.95	119.83	2.68	1.73
1978	82.81	13.28	96.09	1.75	3.00
1979	61.41	33.68	95.09	1.72	3.18
1980	57.93	19.70	77.63	1.38	13.60
1981	59.53	25.40	84.93	1.49	5.94
1982	52.22	42.52	94.74	1.70	3.24
1983	161.43	3.61	165.04	7.75	1.40
1984	93.20	6.69	99.89	1.78	2.70
Average	103.68	16.65	120.33		

R.P.	(MCM)	(MCM)
2-Years	108.56	108.56
5-Years	146.35	87.10
10-Years	176.44	79.87
15-Years	195.12	76.99
20-Years	208.93	75.32
25-Years	220.02	74.19

(1)R.P. : Return Period (Probability of Exceedance)
(2)R.P. : Return Period (Probability of Unexceedance)

Table G-5 Monthly Runoff Volume of Vidore (2/2)

< Plan CaseB-1 > (Catchment Area : 770 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	8.07	6.83	15.50	24.01	47.58	38.67	0.09	0.04	0.02	140.81
1976	0.38	2.96	10.23	6.34	0.52	27.32	44.84	46.36	70.89	2.48	0.19	0.16	212.67
1977	3.42	0.10	0.08	35.34	4.09	26.58	28.27	6.97	6.52	0.00	1.19	0.00	112.56
1978	1.08	3.08	6.00	5.54	0.00	0.45	56.78	7.68	7.72	0.02	1.65	0.00	90.00
1979	3.58	12.15	12.96	4.48	8.15	2.31	19.37	14.45	7.78	1.22	0.00	1.28	87.73
1980	6.22	0.27	7.56	3.57	1.96	6.39	27.80	12.06	1.70	3.64	0.31	0.34	71.82
1981	6.37	1.79	14.07	3.21	4.29	0.00	29.79	18.24	0.21	0.70	0.79	0.00	79.46
1982	0.61	5.80	20.30	9.05	4.60	4.88	7.60	21.10	0.90	6.88	0.84	4.71	87.27
1983	0.00	2.26	0.62	25.95	28.06	11.77	39.35	20.91	24.64	0.05	0.02	0.26	153.89
1984	0.90	2.10	3.03	3.14	0.00	3.42	19.49	56.89	4.23	0.04	0.01	0.00	93.25
Mean	2.26	3.05	7.49	10.47	5.85	9.86	29.73	25.22	16.33	1.51	0.50	0.68	112.95

< Plan CaseB-2 > (Catchment Area : 770 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	7.72	6.51	14.93	22.74	46.37	37.66	0.12	0.06	0.03	136.14
1976	0.36	2.94	9.72	6.05	0.51	26.18	43.16	44.68	70.38	2.41	0.26	0.22	206.87
1977	3.11	0.13	0.10	33.86	3.98	25.58	27.08	6.85	6.30	0.00	1.17	0.00	108.16
1978	0.95	2.83	5.66	5.21	0.00	0.41	54.67	7.43	7.50	0.02	1.62	0.00	86.30
1979	3.47	11.51	12.25	4.23	7.65	2.16	18.61	13.61	7.55	1.20	0.00	1.20	83.44
1980	5.95	0.26	7.04	3.26	1.82	6.10	26.33	11.76	1.57	3.41	0.29	0.31	68.10
1981	6.10	1.73	13.37	2.99	4.11	0.00	28.45	17.22	0.21	0.70	0.72	0.00	75.60
1982	0.59	5.55	19.39	8.52	4.41	4.70	7.19	20.13	0.86	6.49	0.81	4.53	83.17
1983	0.00	2.15	0.58	24.85	26.78	11.20	37.89	19.91	23.52	0.07	0.03	0.27	147.25
1984	0.86	2.06	2.85	3.07	0.00	3.27	18.44	55.48	4.08	0.06	0.02	0.01	90.20
Mean	2.14	2.91	7.09	9.98	5.58	9.45	28.46	24.34	15.96	1.45	0.50	0.66	108.52

Table G-6 Monthly Runoff Volume of Dalana

<Present and Plan CaseA> (Catchment Area : 89 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	0.04	0.91	1.70	3.16	4.48	5.21	0.00	0.00	0.00	15.50
1976	0.00	0.00	0.93	0.67	0.00	3.83	6.35	6.03	9.38	0.01	0.00	0.00	27.20
1977	0.70	0.00	0.00	3.89	0.00	3.66	2.94	0.31	0.65	0.00	0.00	0.00	12.15
1978	0.11	0.06	0.97	0.91	0.00	0.20	6.53	0.40	0.27	0.00	0.00	0.00	9.45
1979	0.00	1.23	0.54	0.44	1.56	0.31	0.76	1.98	0.30	0.00	0.00	0.12	7.24
1980	0.40	0.00	1.26	1.18	0.46	0.00	3.68	0.16	0.40	0.28	0.00	0.16	7.98
1981	0.33	0.00	1.12	0.65	0.32	0.00	2.10	2.99	0.00	0.00	0.23	0.00	7.74
1982	0.00	0.35	1.70	1.57	0.29	0.00	0.76	1.99	0.00	0.84	0.00	0.31	7.81
1983	0.00	0.08	0.00	3.21	2.91	1.60	3.83	1.78	2.45	0.00	0.00	0.00	15.86
1984	0.00	0.00	0.33	0.08	0.00	0.21	2.16	4.00	0.20	0.00	0.00	0.00	6.98
Mean	0.15	0.17	0.69	1.26	0.65	1.15	3.23	2.41	1.89	0.11	0.02	0.06	11.79

< Plan CaseB-2 > (Catchment Area : 89 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	0.03	0.64	1.22	2.28	3.59	4.09	0.02	0.01	0.00	11.88
1976	0.00	0.00	0.65	0.47	0.00	2.91	5.35	4.57	8.79	0.05	0.04	0.03	22.86
1977	0.52	0.02	0.01	2.81	0.00	2.82	2.08	0.22	0.47	0.00	0.00	0.00	8.95
1978	0.08	0.04	0.68	0.64	0.00	0.14	4.79	0.30	0.19	0.00	0.00	0.00	6.86
1979	0.00	0.88	0.38	0.31	1.11	0.22	0.53	1.40	0.21	0.00	0.00	0.08	5.12
1980	0.29	0.00	0.90	0.83	0.32	0.00	2.62	0.11	0.28	0.20	0.00	0.11	5.66
1981	0.23	0.00	0.80	0.46	0.22	0.00	1.48	2.16	0.00	0.00	0.16	0.00	5.51
1982	0.00	0.25	1.21	1.12	0.21	0.00	0.54	1.40	0.00	0.59	0.00	0.22	5.54
1983	0.00	0.06	0.00	2.41	2.07	1.13	2.72	1.27	1.79	0.00	0.00	0.00	11.45
1984	0.00	0.00	0.23	0.06	0.00	0.15	1.52	3.15	0.15	0.00	0.00	0.00	5.26
Mean	0.11	0.13	0.49	0.91	0.46	0.86	2.39	1.82	1.60	0.08	0.02	0.04	8.91

Table G-7 Monthly Runoff Volume of Zai

<Present and Plan CaseA> (Catchment Area : 18 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	0.01	0.18	0.34	0.64	0.91	1.05	0.00	0.00	0.00	3.13
1976	0.00	0.00	0.19	0.14	0.00	0.77	1.28	1.22	1.90	0.00	0.00	0.00	5.50
1977	0.14	0.00	0.00	0.79	0.00	0.74	0.60	0.06	0.13	0.00	0.00	0.00	2.46
1978	0.02	0.01	0.20	0.19	0.00	0.04	1.32	0.08	0.05	0.00	0.00	0.00	1.91
1979	0.00	0.25	0.11	0.09	0.32	0.06	0.15	0.40	0.06	0.00	0.00	0.02	1.46
1980	0.08	0.00	0.26	0.24	0.09	0.00	0.74	0.03	0.08	0.06	0.00	0.03	1.61
1981	0.07	0.00	0.23	0.13	0.06	0.00	0.42	0.60	0.00	0.00	0.05	0.00	1.56
1982	0.00	0.07	0.34	0.32	0.06	0.00	0.16	0.40	0.00	0.17	0.00	0.06	1.58
1983	0.00	0.02	0.00	0.65	0.59	0.32	0.78	0.36	0.49	0.00	0.00	0.00	3.21
1984	0.00	0.00	0.07	0.01	0.00	0.04	0.44	0.81	0.04	0.00	0.00	0.00	1.41
Mean	0.03	0.03	0.14	0.26	0.13	0.23	0.65	0.49	0.38	0.02	0.01	0.01	2.38

< Plan Caseß-2 > (Catchment Area : 18 sq.km) (Unit : MCM)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1975	0.00	0.00	0.00	0.00	0.14	0.27	0.52	0.80	0.92	0.03	0.00	0.00	2.68
1976	0.00	0.00	0.15	0.11	0.00	0.66	1.19	1.03	1.91	0.01	0.00	0.00	5.06
1977	0.12	0.00	0.00	0.64	0.00	0.63	0.48	0.05	0.11	0.00	0.00	0.00	2.03
1978	0.02	0.01	0.16	0.15	0.00	0.03	1.09	0.07	0.04	0.00	0.00	0.00	1.56
1979	0.00	0.20	0.09	0.07	0.25	0.05	0.12	0.32	0.06	0.00	0.00	0.02	1.18
1980	0.07	0.00	0.20	0.19	0.07	0.00	0.60	0.03	0.06	0.05	0.00	0.03	1.30
1981	0.05	0.00	0.18	0.11	0.05	0.00	0.34	0.49	0.00	0.00	0.04	0.00	1.26
1982	0.00	0.06	0.28	0.25	0.05	0.00	0.12	0.32	0.00	0.14	0.00	0.05	1.27
1983	0.00	0.01	0.00	0.55	0.47	0.26	0.63	0.29	0.41	0.00	0.00	0.00	2.62
1984	0.00	0.00	0.05	0.01	0.00	0.04	0.35	0.71	0.03	0.00	0.00	0.00	1.19
Mean	0.03	0.03	0.11	0.20	0.10	0.19	0.55	0.41	0.36	0.02	0.01	0.01	2.02

Table G-8 Annual Runoff Volume (1/3)

< Present and Plan CaseA > (Unit : MCM)

Year	Vidore CA=770sq.km	Dalana CA= 89sq.km	Zai CA= 18sq.km	Total CA=877sq.km
1975	149.13	15.50	3.13	167.76
1976	220.95	27.20	5.50	253.65
1977	119.83	12.15	2.46	134.44
1978	96.09	9.45	1.91	107.45
1979	95.09	7.24	1.46	103.79
1980	77.63	7.98	1.61	87.22
1981	84.93	7.74	1.56	94.23
1982	94.74	7.81	1.58	104.13
1983	165.04	15.86	3.21	184.11
1984	99.89	6.98	1.41	108.28
Mean	120.33	11.79	2.38	134.50
<Runoff Coefficient %>				
Mean	50.4	49.0	49.0	50.2

<Probable Runoff Volume>

Return Period	Vidore	Dalana	Zai	Total
2years	108.56	9.58	1.94	120.08
5years	146.35	14.48	2.93	163.76
10years	176.44	19.28	3.90	199.62
15years	195.12	22.60	4.58	222.30
20years	208.93	25.20	5.11	239.24
25years	220.02	27.39	5.55	252.96

Table G-8 Annual Runoff Volume (2/3)

< Plan CaseB-1 > (Unit : MCM)

Year	Vidore CA=770sq.km	Dalana CA= 89sq.km	Zai CA= 18sq.km	Total CA=877sq.km
1975	140.81	15.50	3.13	159.44
1976	212.67	27.20	5.50	245.37
1977	112.56	12.15	2.46	127.17
1978	90.00	9.45	1.91	101.36
1979	87.73	7.24	1.46	96.43
1980	71.82	7.98	1.61	81.41
1981	79.46	7.74	1.56	88.76
1982	87.27	7.81	1.58	96.66
1983	153.89	15.86	3.21	172.96
1984	93.25	6.98	1.41	101.64
Mean	112.95	11.79	2.38	127.12

<Runoff Coefficient %>

Mean	47.3	49.0	49.0	47.5

<Probable Runoff Volume>

Return Period	Vidore	Dalana	Zai	Total
2years	101.30	9.58	1.94	112.82
5years	137.79	14.48	2.93	155.20
10years	167.15	19.28	3.90	190.33
15years	185.48	22.60	4.58	212.66
20years	199.06	25.20	5.11	229.37
25years	209.99	27.39	5.55	242.93

Table G-8 Annual Runoff Volume (3/3)

< Plan CaseB-2 >

(Unit : MCM)

Year	Vidore CA=770sq.km	Dalana CA= 89sq.km	Zai CA= 18sq.km	Total CA=877sq.km
1975	136.14	11.88	2.68	150.70
1976	206.87	22.86	5.06	234.79
1977	108.16	8.95	2.03	119.14
1978	86.30	6.86	1.56	94.72
1979	83.44	5.12	1.18	89.74
1980	68.10	5.66	1.30	75.06
1981	75.60	5.51	1.26	82.37
1982	83.17	5.54	1.27	89.98
1983	147.25	11.45	2.62	161.32
1984	90.20	5.26	1.19	96.65
Mean	108.52	8.91	2.02	119.45
<Runoff Coefficient %>				
Mean	45.4	37.0	41.5	44.6

<Probable Runoff Volume>

Return Period	Vidore	Dalana	Zai	Total
2years	97.09	6.87	1.56	105.52
5years	132.91	10.78	2.43	146.12
10years	161.76	14.97	3.38	180.11
15years	179.78	18.01	4.06	201.85
20years	193.14	20.46	4.62	218.22
25years	203.88	22.56	5.09	231.53

Figure G-3 Division of Vidore Hill Torrent Basin
(for the Flood Runoff Analysis)

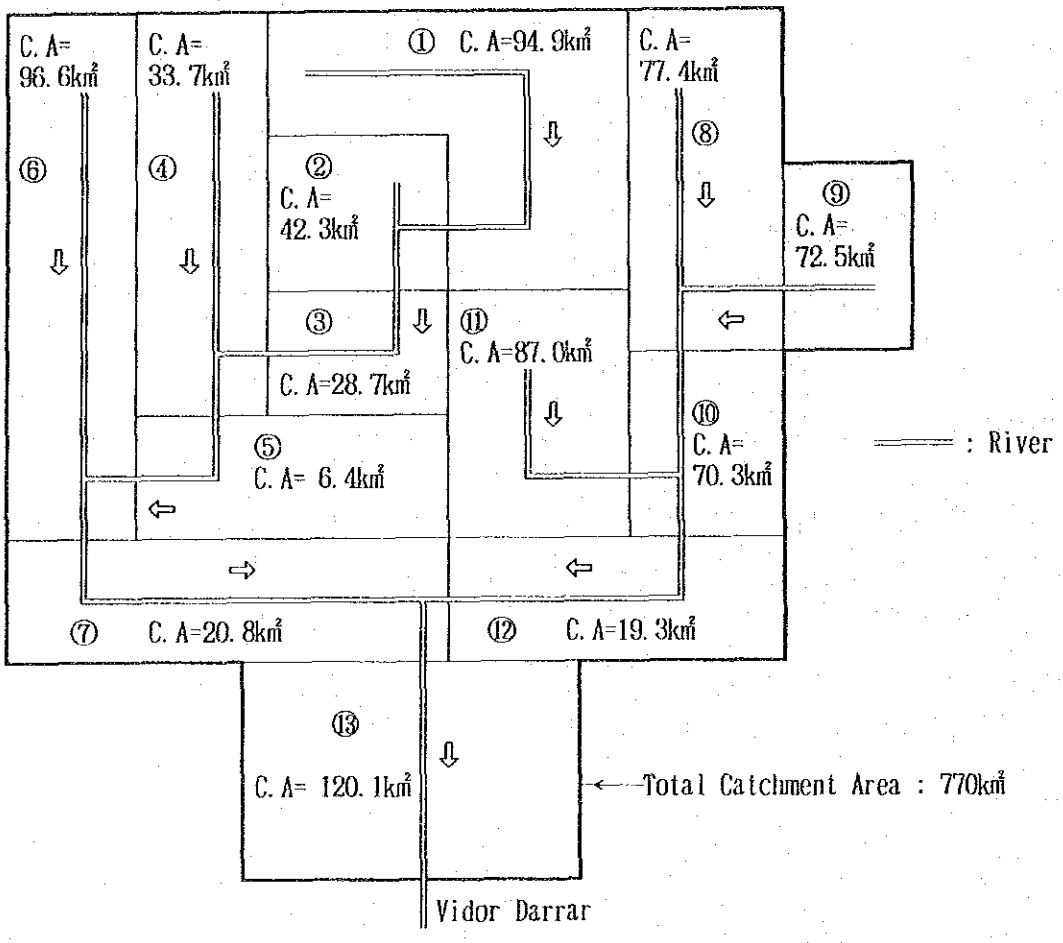


Table G-9 Probable Flood Peak Discharges

(Unit : cu.m/s)

Return Period	Present	Plan		
		CaseA	CaseB-1	CaseB-2
Vidore (CA=770sq.km)				
2years	688	688	484	418
5years	1,109	1,109	789	665
10years	1,405	1,405	1,031	880
25years	1,795	1,795	1,306	1,103
Dalana (CA=89sq.km)				
2years	86	86	86	32
5years	136	136	136	52
10years	178	178	178	70
25years	215	215	215	92
Zai (CA=18sq.km)				
2years	32	32	32	13
5years	46	46	46	21
10years	66	66	66	27
25years	77	77	77	34
Vidore + Dalana + Zai (CA=877sq.km) by Composite Hydrograph				
2years	777	777	553	452
5years	1,262	1,262	908	720
10years	1,618	1,618	1,194	953
25years	2,048	2,048	1,498	1,195

Figure G-4 Flood Hydrograph of Vidore (1/5)

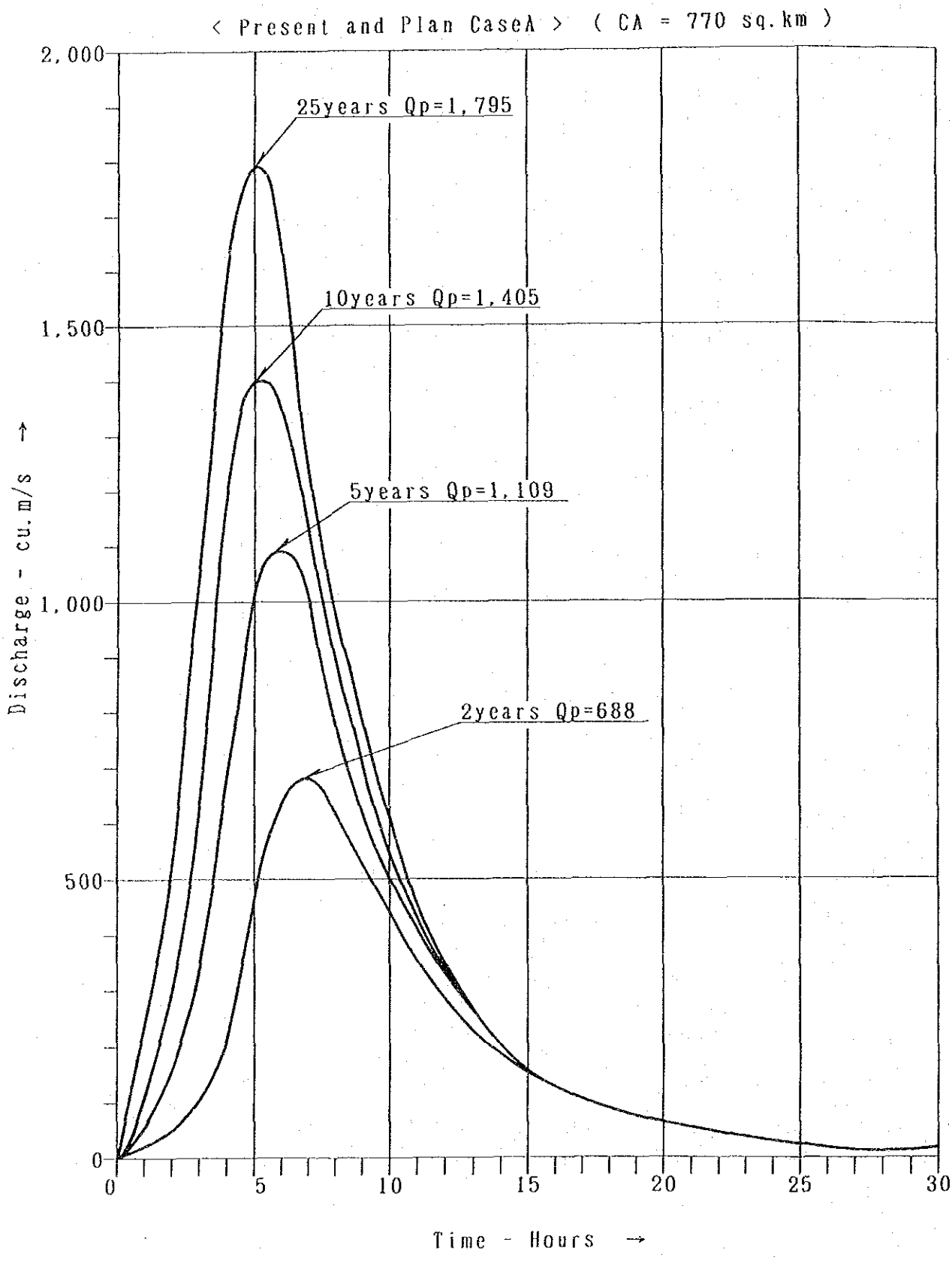


Figure G-4 Flood Hydrograph of Vidore (2/5)

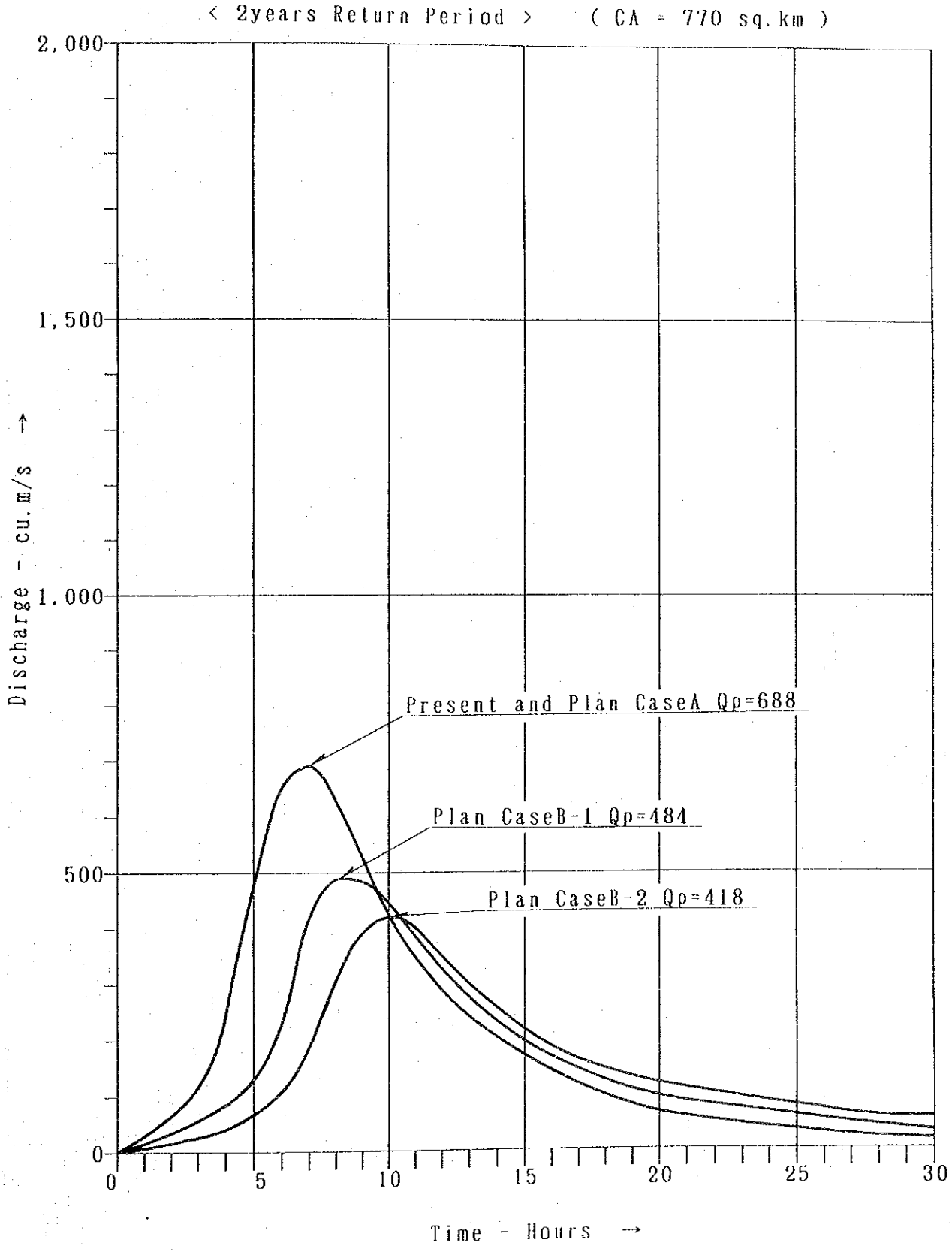


Figure G-4 Flood Hydrograph of Vidore (3/5)

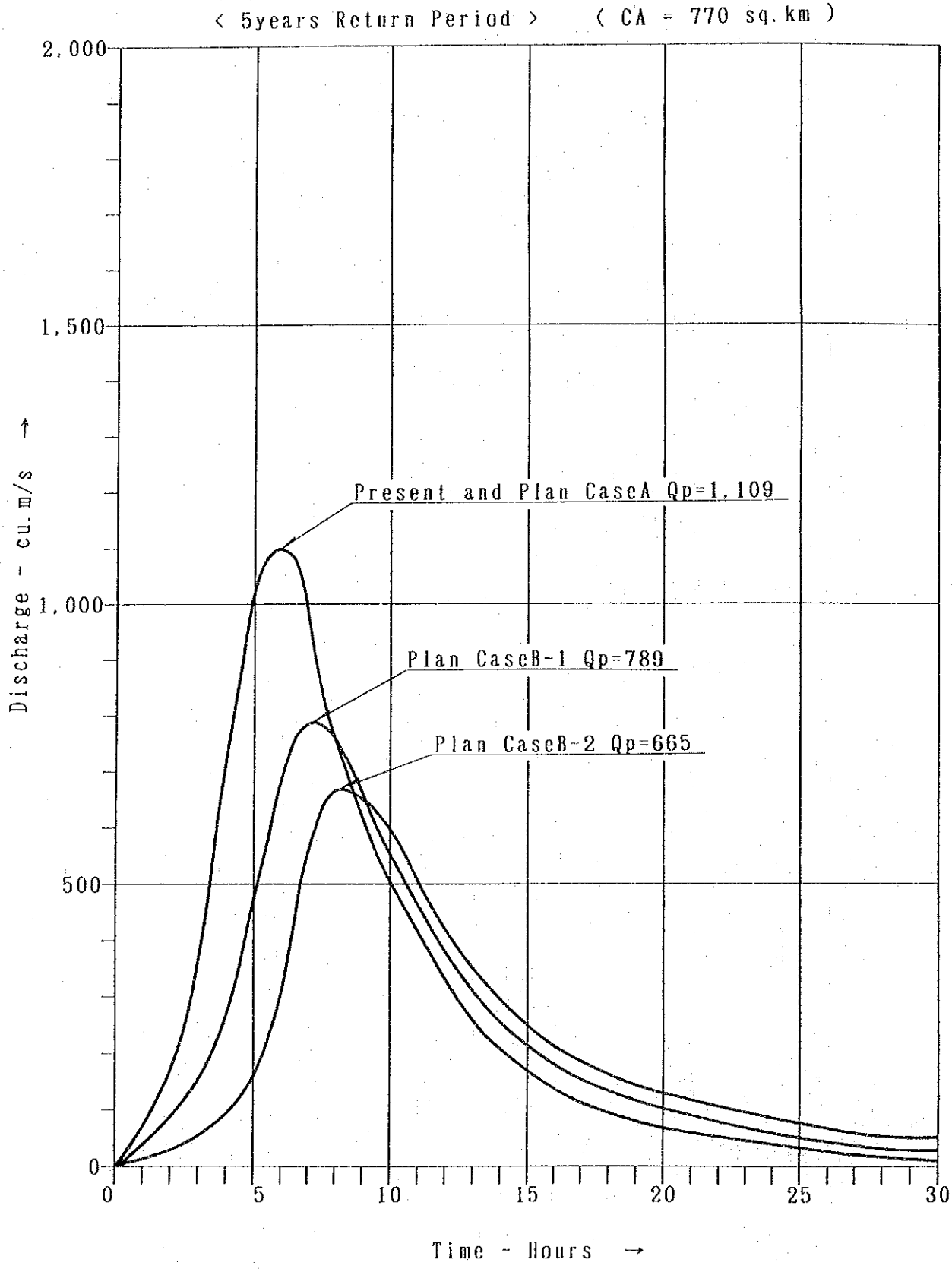


Figure G-4 Flood Hydrograph of Vidore (4/5)

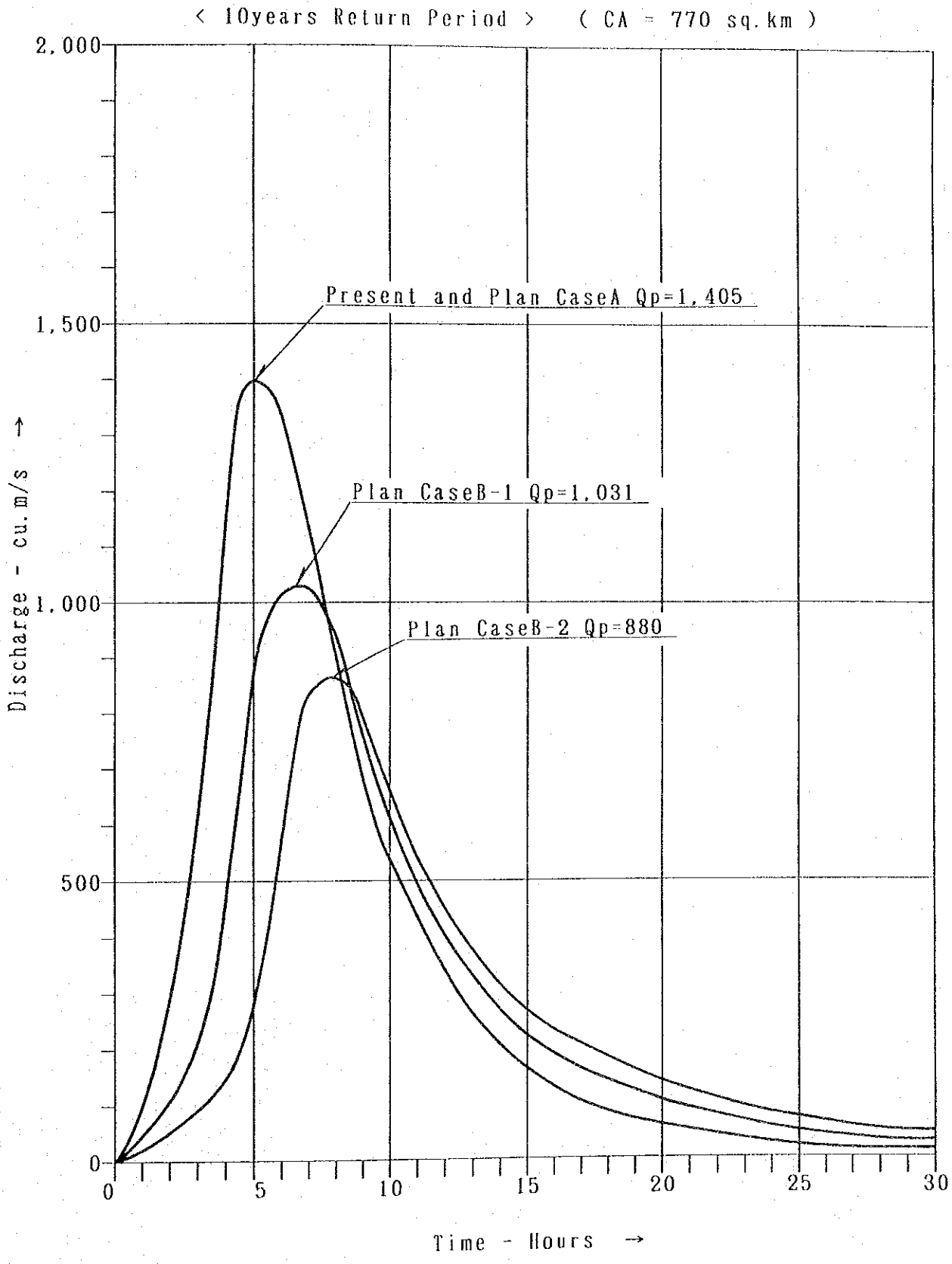
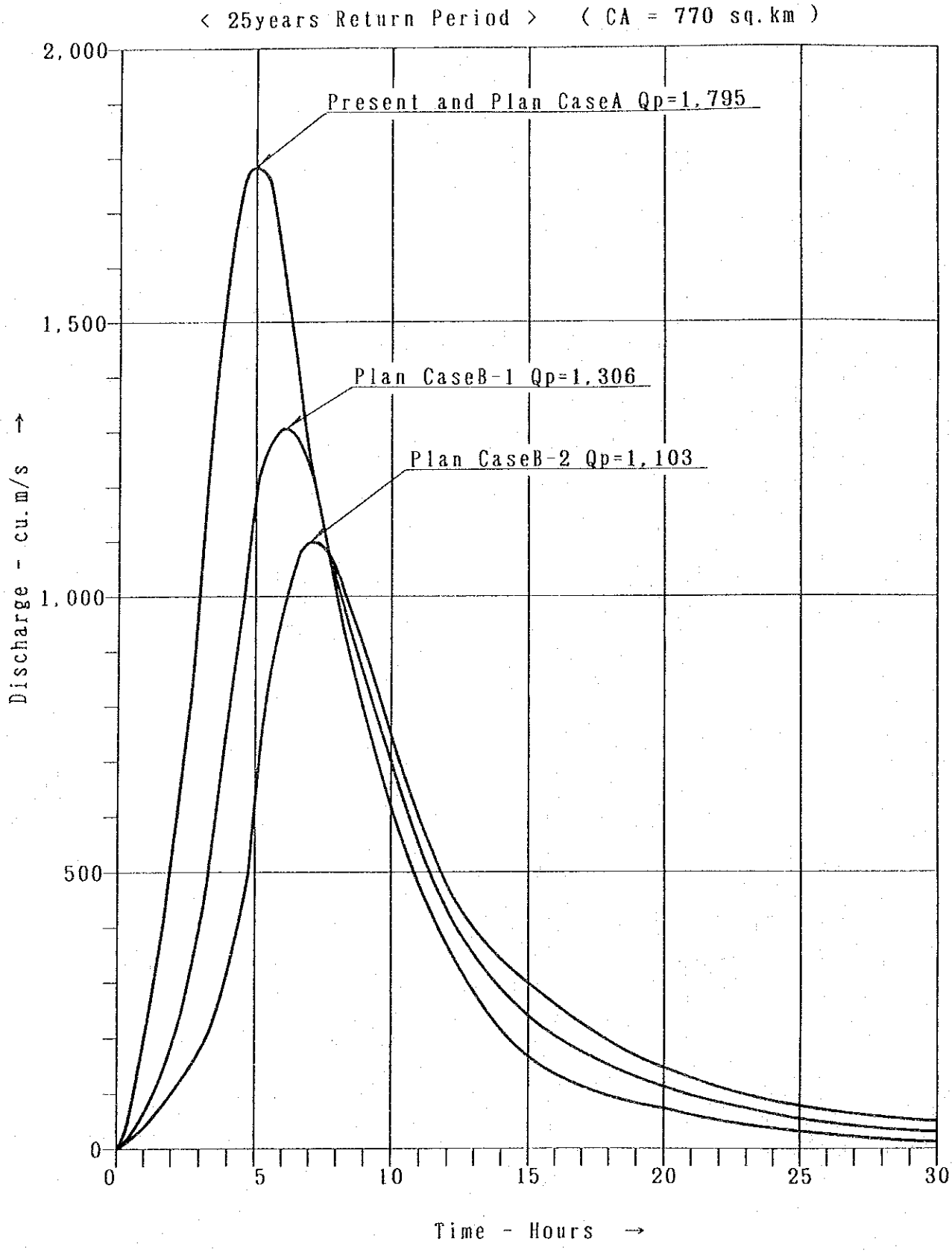


Figure G-4 Flood Hydrograph of Vidore (5/5)



ANNEX H. SOIL / LAND USE

ANNEX H. SOIL / LAND USE

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CHAPTER I. METHOD OF SOIL SURVEY

The soil survey was carried out to explore and evaluate the land and soil resources of the Project area aiming at the following points:

1) To review the existing data and check the validity of the existing soil map for use in agricultural development planning,
2) To make the supplementary soil survey to identify, classify and describe properly the major kinds of soils occurring in the project area,
3) To evaluate the soils in terms of land suitability under the current flood irrigation condition.

The survey in the Project area was carried out in association with the Soil Survey of Pakistan officers. The field work was started on January 18th and completed on January 31st, 1992. A topographic map of 1:50,000 scale prepared by the Survey of Pakistan was used as a field map. The locations of auger holes and soil pits were noted and marked on the map by a Global Satellite Receiver. The locations are shown in Figures H-1 and H-2.

Soil association mapped by the Soil Survey of Pakistan in the area were taken into consideration in the study, and soil series encountered in these associations were studied and delineated on the present scale. The soils were studied along the selected traverses with 2 to 3km distance between the observation points. The soils were checked by opening small pits supplemented by auger holes. Fifteen(15) soil pits up to one meter in depth were excavated in the selected locations, and described properly according to FAO guidelines. Three pits out of fifteen were located in the catchment area. Thirty-six(36) soil samples from the Pachad area and eight(8) samples from the catchment area were collected for laboratory analysis.

The soil samples collected for laboratory analysis were properly analyzed by the NARC (National Agricultural Research Center) laboratory in Islamabad. The analysis includes determination of pH, electrical conductivity, organic carbon, nitrogen, phosphorus, CEC, and exchangeable cations for chemical properties. Physical properties tests consist of soil texture, bulk density, water retentivity and hydraulic conductivity.

CHAPTER II. METHODS OF SOIL ANALYSIS

The soil samples collected for laboratory analysis were analyzed by NARC (National Agricultural Research Center) in Islamabad.

(1) Chemical analysis

1) pH : pH meter with glass electrode (soil:water=1:5).
2) EC : Electrical conductivity meter (soil:water=1:5).
3) Organic matter : Wet oxidation method.
4) Total nitrogen : Kjelgahl method.
5) Cationexchange capacity(CEC):Ammonium saturation method.
6) Exchangeable cations:Flame photometer and titration method.
7) Available phosphate : Olsen method.

(2) Physical analysis

1) Soil texture : Hydrometer.
2) Bulk density : Direct oven drying of soil core.
3) Moisture retention(pF) : Pressure plate method.
4) Hydraulic conductivity : Constant head method.

CHAPTER III. CHEMICAL PROPERTIES OF THE SOILS

The analysis of chemical properties includes the determination of pH, EC, organic matter, total nitrogen, CEC, exchangeable cations and available phosphate. The result is shown in Table H-1.

(1) pH :

The pH of soils ranges from 7.6 to 8.2 which indicates that the soils belong to the slightly alkali to neutral group. There is little difference in pH value among different soil series.

(2) Electrical conductivity (EC) :

The EC of the topsoils varies from 0.16 to 0.80mS/cm. The EC of subsoils is generally lower than that of topsoils in major soil series. It appears to be no hazard of salinity in the Project area.

(3) Organic matter :

Organic matter content is generally low, ranging from 0.21 to 0.80%. The soils in the catchment area have relatively higher content.

(4) Total nitrogen :

Nitrogen content is generally low to very low, ranging from 0.01 to 0.09%. The content usually falls gradually with depth.

(5) Cation exchange capacity (CEC) :

CEC of soils reflects a difference in clay mineralogy as well as both content and type of organic matter. CEC in the Project area is, however, mainly according to clay content. CEC of topsoils varies from 24.6 to 35.0 me/100g for clayey soils, while that ranges from 9.5 to 15.3 me/100g for sandy soils.

(6) Exchangeable cations :

Calcium content in topsoil is medium to high ranging from 16.6 to 21.8 me/100g in clayey soils. The higher calcium content is a reflection of the calcareous soil

characteristics. The calcium content is, however, low to medium in sandy soil ranging from 4.5 to 7.1 me/100g. The contents of other cations such as potassium, sodium and magnesium are generally low to medium in most soils.

(7) **Available phosphate :**

Available phosphate content is low to very low in most soils. The content varies from 0.1 to 3.4ppm in topsoils.

CHAPTER IV. PHYSICAL PROPERTIES OF THE SOILS

The analysis of physical properties includes the determination of soil texture, bulk density, water retentivity and hydraulic conductivity. The result is shown in Table H-2.

(1) Soil texture :

According to the soil survey, three major soil series (Katohar, Chatter and Kallarwala) were identified in the Project area. They were classified as loam to clay loam, sand to loamy sand and sand to sandy loam, respectively.

(2) Bulk density :

Katohar has the highest bulk density among the three major soil series with an average of 1.57g/cc. The density is 1.32g/cc for Chatter, and 1.42g/cc for Kallarwala on average, respectively.

(3) Moisture retention(pF) :

There is a clear difference in available water amount among the soils. The amount ranges from 8.5 to 24.7%(vol.), from 5.5 to 10.2%, and from 7.1 to 18.1% for Katohar, Chatter and Kallarwala, respectively. The difference is mainly due to their texture.

(4) Hydraulic conductivity :

Hydraulic conductivity of clayey soil is smaller than that of sandy soil, which also reflects the difference in soil texture.

CHAPTER V. DESCRIPTION OF SOIL MAPPING UNIT

A soil mapping unit consists of one or more named and defined taxonomic units, which is called "soil association". Description of each mapping unit comprises location of occurrence, area, soil characteristics, present land use, limitations and development possibilities.

(1) Mapping unit 1 (Katohar association)

This unit mainly occurs in the west to south-west part of the area and occupies 7,650ha (39.5%). A considerable part consists of the Katohar series, which is deep, moderately well drained, slowly permeable, and silty clay loam in texture. This unit also includes small parts of Kundi, Hadwar and Bolan series. A large part of the unit is used for flood irrigation cropping. Yields are moderate to low due to traditional management and inadequate supplies of irrigation water. With sufficient irrigation water and use of fertilizers along with improved seeds and cultural practices, high economic return is expected.

(2) Mapping unit 2 (Katohar-Kundi association)

This unit occurs in the east to north-east part of the area and occupies 5,250ha (27.1%). Major soil series of the unit are Katohar and Kundi including small part of Bolan and Chatter. The soils are deep, moderately well drained, slowly to very slowly permeable, and silty clay to silty clay loam in texture. This unit is mainly used for flood irrigation and/or tube well irrigation cropping. Small areas along the D.G.Khan canal are irrigated by the canal water. Areas far away from torrent beds provide poor grazing only. Yields are variable depending upon the availability of water. Under irrigation along with modern management, most of this unit has high potential for crop production.

(3) Mapping unit 3 (Chatter association)

This unit occurs along with torrent beds and old river beds. The unit occupies 2,140ha (11.1%). The unit mainly consists of Chatter series including small parts of Katohar and Hadwar. The soils are deep, excessively well drained, moderately permeable, and sand to loamy sand in texture. Most of the unit is not cultivated and is poor for grazing. Locally, small areas are irrigated by flood or tube well.

The major limitations of the unit are sandy soil texture, undulating relief and poor availability of water. Proper range management measures are necessary to improve grazing potential. The unit has low to moderate potential for crop production with the introduction of irrigation and modern management.

(4) Mapping unit 4 (Kallarwala association)

This unit occurs in the west and north-west part of the area and occupies 2,490ha (12.9%). Major soil series of the unit is Kallarwala including small part of Talai and Katohar. The soils are deep, well drained, moderately permeable, and sand to loamy sand in texture. Most of the unit is not cultivated and is poor for grazing. The major limitations of the unit are sandy soil texture, higher and undulating relief, and poor availability of water. Proper range management measures are necessary to improve grazing potential.

(5) Mapping unit 5 (Torrent bed)

This unit consists of hill torrents having mappable beds, and occupies 1,480ha (7.7%). The area belongs to miscellaneous areas because it has little agricultural potential. The beds are stony or gravelly in the upper reaches but are sandy in the lower parts. The torrent beds are usually dry but rain water rushes through them following heavy rainfall in the catchment area.

(6) Mapping unit 6 (Gravelly and stony land)

This unit also belongs to miscellaneous areas and occupies 330ha (1.7%). The unit is mainly covered by gravels and stones, and has a sparse vegetational cover. Some parts are poor for grazing.

CHAPTER VI. DESCRIPTION OF SOIL SERIES

a) Pachad area

1)Katohar series (1)

Katohar series consist of deep and very deep , moderately well drained, calcareous, fine textured soils formed in recent piedmont alluvium derived from the Suleiman range. The series occupies gently sloping areas along torrent courses in the recent piedmont plains. It has a brown/dark brown firm, moderately calcareous, silty clay, massive topsoil underlain by stratified, yellowish brown or brown/dark brown, firm, calcareous, silty clay to about 90 to 150cm.

Pit No.	:	1
Location	:	30°10"N, 70°35'53"E
Physiography	:	Level to nearly level sub-recent piedmont plain.
Land use	:	Sorghum, wheat, oilseeds and gram.
Drainage	:	Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-10	Brown/dark brown(10YR 4/3)moist, massive and stratified silty clay loam; sticky plastic, firm moist, hard dry; few slightly sticky medium and common fine vesicular pores, moderately calcareous, common fine and very fine roots; clear smooth boundary.
Bw	10-20	Brown/dark brown (10YR 4/3) moist, few distinct yellowish brown (10YR 5/6) mottles, silty clay loam; stratified; sticky, plastic friable moist, hard dry; few medium and fine tubular pores; moderately calcareous; common fine and very fine roots;clear smooth boundary.

C1	20-36	Brown/dark brown (10YR 5/4), few yellowish brown (10YR 5/4) mottles, moist silty clay loam, massive; sticky, plastic, friable moist, hard dry; few fine tubular pores; moderately calcareous, few fibrous roots; abrupt smooth boundary.
C2	36-72	Brown/dark brown (10YR 4/3) moist, silty clay loam; very weak coarse subangular blocky, platy, sticky, plastic; friable moist, hard dry; few fine and medium tubular pores; moderately calcareous; few fibrous roots, abrupt smooth boundary.
Bwb	72-100	Brown/dark brown (10YR 4/3) moist; silty clay, weak medium subangular blocky; very sticky, very plastic, very hard dry; few very fine tubular pores; moderately calcareous, clear smooth boundary.

2) Katohar series (2)

Pit No. : 10
Location : 30°04'36"N, 70°30'26"E
Physiography : Level to nearly level sub-recent piedmont plain.
Land use : Sorghum, wheat, oilseeds and gram.
Drainage : Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-15	Dark greyish brown(10YR 4/2)moist, silty clay loam; stratified; very sticky, very plastic, firm moist, hard dry; few fine tubular pores; moderately calcareous, many very fine and few fine roots; clear smooth boundary.

C1	15-32	Brown/dark brown (10YR 4/3) moist, silty clay loam, very weak, subangular blocky and plain platy; very sticky, very plastic, friable moist, hard dry; few fine and very fine tubular pores; moderately calcareous, few fine fibrous roots; gradual smooth boundary.
C2	32-69	Brown/dark brown (10YR 4/3) moist, common distinct yellowish brown (10YR 5/6) mottles; silty clay loam; stratified with some specks of sand; very sticky, very plastic; friable moist, hard dry; few medium and common fine ubular pores; moderately calcareous; gradual smooth boundary.
C3	69-100	Dark yellowish brown (10YR 4/9) moist, silty clay loam; stratified; very sticky, very plastic, friable moist, hard dry; few very fine tubular pores; moderately calcareous; no roots; clear smooth boundary.

3) Chatter series

The Chatter series consists of excessively drained, calcareous, coarse textured soils formed in recent piedmont alluvium derived from the Suleiman range. It has no B horizon. The series occupies gently undulating areas along torrent courses in the recent piedmont plains. It has a yellowish brown, very friable, moderately calcareous, massive, loamy sand topsoil underlain by a brown, loose, moderately calcareous, single grain loamy sand and sand, stratified subsoil with thin layers of other textures.

Pit No.	:	5
Location	:	30°01'15"N, 70°32'07"E
Physiography	:	Gently undulating sub-recent piedmont plain.
Land use	:	Wheat and oilseeds.
Drainage	:	Well drained.

Horizon	Depth (cm)	Description
Ap	0-3	Brown/dark brown (10YR 4/3) moist, sandy loam; massive; slightly sticky, slightly plastic, very friable moist, hard dry; few fine and very fine tubular pores; moderately calcareous; few fine and many very fine roots; abrupt wavy boundary.
C1	3-72	Greyish brown (10YR 5/2) moist, loamy sand, massive single grain; non-plastic, loose moist, loose dry; no pores; moderately calcareous; no roots; abrupt wavy boundary.
C2	72-100	Yellowish brown (10YR 5/4) moist; very fine sandy loam; weak thin platy; slightly sticky, slightly plastic, very friable moist, soft dry; no pores; moderately calcareous; no roots; gradual smooth boundary.

4) Kallarwala series (1)

The Kallarwala series consists of deep, well drained, calcareous, medium textured soils developed in Pleistocene piedmont mountain outwash deposits derived from the Suleiman range. It has a cambic B horizon. The series occupies nearly level and gently undulating piedmont plains with a recent erosional surface. It has a brown to dark brown, friable, moderately to strongly calcareous loam with weak coarse subangular blocky structure. A few fine lime specks and nodules occur in the B horizon. The substratum is massive and texture becomes gradually coarser at lower depths.

Pit No. : 7
Location : 30°07'39"N, 70°32'00"E
Physiography : Gently undulating recent piedmont plain.

Land use : Barren.
Drainage : Moderately well drained.

Horizon	Depth (cm)	Description
A1	0-20	Brown/dark brown(10YR 4/3)moist, loamy sand, massive, slightly sticky, slightly plastic, friable moist, slightly hard dry; moderately calcareous; few fine roots; clear smooth boundary.
Bw1	20-45	Yellowish brown(10YR 5/4)loam, very weak common and subangular blocky, slightly sticky, slightly plastic, friable moist; slightly hard dry; few lime specks at places, moderately to strongly calcareous, many fine fibrous roots; gradual smooth boundary.
Bw2	45-100	Yellowish brown(10YR 5/4)loam, weak, coarse subangular blocky, slightly sticky, slightly plastic, friable moist; slightly hard dry; moderately calcareous, few fine roots; gradual smooth boundary.

5) Kallarwala series (2)

Pit No. : 8
Location : 30°07'56"N, 70°29'00"E
Physiography : Nearly level, gently undulating sub-recent piedmont plain.
Land use : Barren.
Drainage : Moderately well drained.

Horizon	Depth (cm)	Description

A1	0-10	Brown/dark brown(10YR 4/3)moist, loam, massive, slightly sticky, slightly plastic, friable moist, slightly hard dry; moderately calcareous; few fine roots; clear smooth boundary.
Bw1	10-55	Yellowish brown(10YR 5/4)loam, very weak coarse sub-angular, blocky, slightly sticky, slightly plastic, friable moist; slightly hard dry; few fine tubular pores; moderately calcareous, very fine fibrous roots; clear smooth boundary.
Bw2	55-100	Yellowish brown(10YR 5/4)loam, weak, subangular blocky, slightly plastic, friable moist; hard dry; few fine tubular pores; moderately calcareous, no roots; clear smooth boundary.

6) Kundi series (1)

Kundi series consists of moderately deep and deep, moderately well drained, calcareous, fine texture soils, developed in subrecent alluvium derived from the Suleiman range. It has a cambic B horizon about 75cm thick. The series occupies gently sloping subrecent piedmont plains. It has a brown/dark brown very firm, calcareous, massive and laminated silty clay surface horizon, underlain by brown/dark brown to yellowish brown, very firm, moderately calcareous, silty clay B horizon with weak coarse and medium subangular blocky structure. The substratum has yellowish brown to brown stratified layers of different textures.

Pit No.	:	4
Location	:	30°02'30"N, 70°32'10"E
Physiography	:	Level to nearly level sub-recent piedmont plain.
Land use	:	Sorghum, wheat, oilseeds and gram.
Drainage	:	Moderately well drained.

Horizon	Depth (cm)	Description
A1	0-14	Brown/dark brown(10YR 4/3)moist, silty clay loam, weak coarse, subangular blocky and stratified; sticky, plastic, very firm moist, very hard dry; few fine tubular pores; moderately calcareous; many fine fibrous roots; clear smooth boundary.
Bw	14-83	Brown/dark brown(10YR 4/3)moist, silty clay, weak coarse and medium sub-angular blocky, few distinct non-intersecting slicken sides; very sticky, very plastic, firm moist; very hard dry; common very fine and few fine ubular pores; moderately calcareous, few fine fibrous roots; clear smooth boundary.
C1	83-100	Brown/dark brown(10YR 4/3)moist, silt loam; very weak, coarse subangular blocky, thin platy, slightly sticky, slightly plastic, friable moist; slightly hard dry; few fine tubular pores; moderately calcareous, no roots; abrupt smooth boundary.

7) Kundi series (2)

Pit No. : 6
Location : 30°02'37"N, 70°34'29"E
Physiography : Level to nearly level recent piedmont plain.
Land use : Sorghum, wheat, oilseeds and gram.
Drainage : Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-15	Brown/dark brown (10YR 4/3) moist, silty

		clay loam, weak coarse, subangular blocky; very sticky, very plastic, friable moist, very hard dry; few fine and common very fine tubular pores; moderately calcareous; common fine and very fine roots; clear smooth boundary.
Bw1	15-52	Brown/dark brown (10YR 4/3) moist, silty clay, very sticky, very plastic, friable moist; very hard dry; few fine tubular pores; moderately calcareous, no roots; clear smooth boundary.
Bw2	52-100	Brown/dark brown (10YR 4/3) moist, silty clay; weak, coarse and medium subangular blocky, very sticky, very plastic, friable moist; very hard dry; few fine tubular pores; moderately calcareous, no roots; abrupt smooth boundary.

8) Bolan series

The Bolan series consists of very deep and deep, well drained, calcareous, medium textured soils, formed in recent piedmont alluvium derived from the Suleiman range. The series occupies gently sloping areas along torrent courses in the recent piedmont plains. It has a yellowish brown, friable, calcareous, massive, silt loam topsoil underlain by stratified layers of various textures, predominantly yellowish brown or brown, friable, calcareous, silt loam and very fine sandy loam.

Pit No.	:	2
Location	:	30°03'37"N, 70°36'18"E
Physiography	:	Nearly level recent piedmont plain.
Land use	:	Sorghum, wheat and fodder.
Drainage	:	Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-10	Yellowish brown (10YR 5/4) moist, clay loam, very weak massive and coarse subangular blocky; slightly sticky, slightly plastic, friable moist; slightly hard dry; few fine and very fine tubular pores, moderately calcareous, few medium roots, clear smooth boundary.
Bw	10-57	Yellowish brown (10YR 5/4) moist, silt loam; coarse subangular blocky and stratified; slightly sticky, slightly plastic, friable moist, hard dry; few fine and common very tubular pores, moderately calcareous; few very fine roots, abrupt smooth boundary.
C2	57-100	Yellowish brown (10YR 5/4) moist, silt clay loam; stratified and massive; sticky, plastic, friable moist, hard dry; very fine tubular pores, moderately calcareous; no roots, clear smooth boundary.

9) Talai series (1)

The Talai series consists of excessively drained, calcareous, deep, coarse textured soils, developed in Pleistocene mountain outwash deposits derived from the Suleiman range. The series occupies undulating sandy areas in the Pleistocene piedmont plains. It has a brown/dark brown, very friable, moderately calcareous, massive, loamy sand topsoil underlain by dark yellowish brown, very friable, calcareous, massive loamy sand subsoil. The substratum is brown to dark brown, loose, calcareous, massive sand.

Pit No. : 9
Location : 30°07'55"N, 70°33'38"E

Physiography : Gently undulating piedmont plain.
Land use : Wheat and oilseeds.
Drainage : Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-20	Brown/dark brown (10YR 4/3) moist, sandy loam, massive, slightly sticky, slightly plastic, very friable moist, hard dry, common fine and few medium pores, moderately calcareous, few fine and common very fine fibrous roots; gradual smooth boundary.
C1	20-62	Greyish brown (10YR 5/2) moist, loamy sand, massive, non-sticky, non-plastic, loose (h moist, loose dry, silty clay layer at 50cm, moderately calcareous, no roots, abrupt) smooth boundary.
C2	62-100	Brown/dark brown (10YR 4/3)moist, silty clay loam, stratified; very sticky, very plastic, 4 very firm moist, very hard dry; no pores, moderately calcareous, no roots, clear smooth boundary.

10) Talai series (2)

Pit No. : 12
Location : 30°03'27"N, 70°26'48"E
Physiography : Undulating recent piedmont plain.
Land use : Grazing.
Drainage : Extensively well drained.

Horizon	Depth (cm)	Description

A1	0-22	Dark greyish brown (10YR 4/2) moist, loamy sand, massive, non-sticky, non-plastic, friable moist, soft dry, common fine tubular pores, moderately calcareous, many fine and very fine fibrous roots; gradual smooth boundary.
C1	22-72	Brown/dark brown (10YR 4/3) moist, loamy sand, massive, slightly sticky, slightly plastic, friable moist, soft dry, fine tubular pores, moderately calcareous, few fine fibrous roots, clear smooth boundary.
C2	72-100	Dark yellowish brown (10YR 4/4) moist, loamy sand, massive/very weak subangular blocky; non-sticky, non-plastic, very loose moist, soft dry; medium lime specks; strongly calcareous, clear smooth boundary.

11) Hadwar series

The Hadwar series consists of deep, well drained,calcareous, medium textured loamy soils formed in recent piedmont alluvium derived from the Suleiman range. It has a brown/dark brown, friable, massive, calcareous, sandy loam topsoil underlain by a brown/dark brown stratified or massive loam in the subsoil. The substratum consists of stratified layers of various textures from sand to clay.

Pit No.	:	3
Location	:	30°00'37"N, 70°37'18"E
Physiography	:	Nearly level recent piedmont plain.
Land use	:	Sorghum and wheat.
Drainage	:	Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-5	Greyish brown (10YR 5/2) moist, sandy

		loam, massive, very slightly sticky, very slightly plastic, very friable moist, hard dry, few fine and very fine tubular pores, moderately calcareous, abrupt smooth boundary.
Bw1	5-30	Yellowish brown (10YR 5/4) moist, silt loam; very weak subangular blocky/ laminated; sticky, plastic; friable moist, hard dry; few fine and common very fine tubular pores, moderately calcareous, common very fine and few fine roots, abrupt smooth boundary.
C1	30-77	Brown (10YR 5/3) very pale brown (10YR 7/3), loamy sand/sand, single grain, non-sticky, non-plastic, loose moist, loose dry, no pores, moderately calcareous, few very fine fibrous roots, clear smooth boundary.
C2	77-100	Brown/dark brown (7.5YR 4/4) moist, silty clay loam, stratified/massive; very sticky, very plastic, firm moist, very hard dry; few fine and very fine tubular pores; moderately calcareous, clear smooth boundary.

b) Catchment area

Soils in the catchment area consist of shallow to moderately deep, moderately well drained, moderately calcareous, medium textured sandy loam soils formed in recent piedmont alluvium derived from the Suleiman range. It has a brown/dark brown, friable, massive, moderately calcareous sandy loam topsoil underlain by a brown/dark brown massive sandy loam in the subsoil.

Pit No. : 13

Location	:	30°16'40"N, 70°14'30"E
Physiography	:	Nearly level to level recent piedmont plain.
Land use	:	Sorghum, wheat and oilseeds.
Drainage	:	Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-5	Brown/dark brown (10YR 4/3) moist, sandy loam, massive, very slightly sticky, very slightly plastic, very friable moist, hard dry, few fine and common very fine tubular pores, moderately calcareous; many fine fibrous roots; clear smooth boundary.
Bw	5-35	Greyish brown (10YR 5/4) moist, sandy loam with infills of silt loam; very weak subangular blocky; slightly sticky, slightly plastic; friable moist, hard dry; common very fine tubular pores, moderately calcareous, few very fine roots, abrupt smooth boundary.
C	35-65	Dark greyish brown (10YR 4/2) moist, sandy loam to loam, massive, slightly sticky, slightly plastic, friable moist, hard dry, few fine tubular pores, moderately calcareous, few fine fibrous roots, gradual smooth boundary. small gravels present below 65cm.

Pit No.	:	14
Location	:	30°10'13"N, 70°17'38"E
Physiography	:	Nearly level to undulating recent piedmont plain.
Land use	:	Wheat, fodder and oilseeds.
Drainage	:	Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-15	Dark greyish brown (10YR 4/2) moist, loamy sand, massive, very slightly sticky, very slightly plastic, very friable moist, hard dry, porous, moderately calcareous; fine medium fibrous roots; gradual smooth boundary.
C	15-52	Brown/dark brown (10YR 4/3) moist, loamy sand, massive/stratified; very slightly sticky, very slightly plastic; friable moist, very hard dry; porous, moderately calcareous, very few fibrous roots, abrupt wavy boundary.
Bwb	52-100	Brown/dark brown (10YR 4/3) moist, loam, massive/weak coarse subangular, blocky; slightly sticky, slightly plastic, friable moist, hard dry, few fine tubular pores, strongly calcareous, few fine fibrous roots, clear smooth boundary.

Pit No. : 15
Location : 30°07'50"N, 70°15'07"E
Physiography : Nearly level to undulating recent piedmont plain.
Land use : Wheat.
Drainage : Moderately well drained.

Horizon	Depth (cm)	Description
Ap	0-12	Brown/dark brown (10YR 4/3) moist, loamy sand, massive, slightly sticky, slightly plastic, friable moist, hard dry, few fine and common very fine tubular pores; moderately calcareous; many fine fibrous

		roots; clear smooth boundary.
Bw	12-40	Dark brown(10YR 4/4)moist, sandy loam, very weak subangular, blocky; sticky, slightly plastic; friable moist, hard dry; common very fine tubular pores, moderately calcareous, common fine and few medium fibrous roots, gradual smooth boundary.
C1	40-100	Dark brown (10YR 4/4)moist, loamy sand, massive, slightly sticky, slightly plastic, friable moist, hard dry, few lime specks, strongly calcareous, few fibrous roots, gradual wavy boundary.

TABLE H-1. SOIL ANALYSIS DATA (SOIL CHEMICAL PROPERTIES)

Soil Series	Sample No.	Depth (cm)	pH (1:5) KCL	pH (1:5) H2O	EC (1:5) (ds/m)	OM (%)	Total-N (%)	P (ppm)	Exchangeable cation (me/100g)				CEC (me/100g)	Sand (%)	Silt (%)	Clay (%)	Soil texture
									K	Na	Ca	Mg					
KATOHAR	P1-1	10-20	7.6	7.8	0.80	0.35	0.06	0.00	0.33	1.70	16.60	3.90	24.6	32	40	28	Clay loam
	P1-2	20-36	7.6	8.1	0.30	0.21	0.04	0.10	0.24	1.30	12.60	3.30	21.6	68	16	16	Sandy loam
	P1-3	36-72	7.7	7.9	0.40	0.21	0.04	0.00	0.35	1.40	15.80	4.10	30.4	40	34	26	Loam
BOLAN	P2-1	15-27	7.8	8.2	0.40	0.55	0.05	0.10	0.47	2.40	10.10	5.20	22.5	62	22	16	Sandy loam
	P2-2	27-43	7.7	7.6	0.30	0.73	0.05	0.00	0.47	1.40	17.10	3.80	28.3	32	36	32	Clay loam
	P2-3	43-66	7.8	8.0	0.80	0.73	0.05	0.90	0.40	3.00	12.00	5.30	28.9	22	54	24	Silt loam
HADWAR	P3-1	05-30	7.7	8.0	0.30	0.69	0.03	2.30	0.40	1.20	12.50	2.40	21.2	58	20	22	Sandy clay loam
	P3-2	30-77	7.9	8.0	0.20	0.41	0.01	1.80	0.19	1.00	10.10	0.90	11.4	92	2	6	Sand
	P3-3	77-100	7.7	7.9	0.40	0.60	0.03	0.90	0.40	1.10	16.40	3.80	30.8	40	34	26	Loam
KUNDI	P4-1	0-14	8.2	8.0	0.23	0.80	0.09	2.60	0.60	1.20	21.80	3.00	27.2	34	32	34	Clay loam
	P4-2	14-44	8.3	8.0	0.20	0.70	0.06	0.60	0.50	1.20	17.00	2.80	29.6	34	32	34	Clay loam
	P4-3	44-55	8.2	8.0	0.30	0.30	0.02	0.70	0.33	1.50	12.00	3.40	23.7	57	20	23	Sandy clay loam
CHATTER	P5-1	00-03	8.2	8.0	0.28	0.55	0.01	3.40	0.28	1.20	5.50	2.90	13.6	81	9	10	Sandy loam
	P5-2	03-72	8.2	8.1	0.22	0.48	0.01	1.90	0.10	1.00	12.40	1.30	9.1	42	8	6	Sand
	P5-3	72-100	8.2	8.1	0.21	0.35	0.02	0.80	0.26	1.30	7.60	1.80	15.0	86	6	8	Loamy sand
KUNDI	P6-1	00-15	8.0	7.7	0.75	0.62	0.06	1.90	0.73	1.90	20.80	1.50	35.0	11	49	40	Silty clay
	P6-2	15-52	8.0	8.0	0.44	0.76	0.04	0.60	0.50	1.90	17.80	4.20	32.8	22	30	48	Clay
	P6-3	52-100	7.9	7.7	1.50	0.60	0.06	0.50	0.30	3.90	21.30	5.40	34.8	12	42	46	Silty clay
KALLARWALA	P7-1	00-20	7.8	8.0	0.16	0.41	0.02	1.30	0.19	0.84	4.50	1.70	9.5	90	4	6	Sand
	P7-2	20-45	8.0	8.0	0.24	0.48	0.01	1.50	0.42	0.80	4.90	0.90	11.3	84	6	10	Loamy sand
	P7-3	45-100	8.0	8.0	0.14	0.48	0.01	2.40	0.42	0.90	10.80	0.80	18.9	78	9	13	Sandy loam
KALLARWALA	P8-1	00-10	8.1	8.0	0.19	0.45	0.01	2.30	0.45	0.90	7.10	0.70	9.6	82	9	9	Loamy sand
	P8-2	10-55	8.0	8.0	0.17	0.55	0.02	1.40	0.45	1.40	7.30	0.90	15.4	78	9	13	Sandy loam
	P8-3	55-100	8.0	8.0	0.18	0.35	0.01	1.90	0.40	1.00	8.80	1.50	25.9	76	11	13	Sandy loam
TALAI	P9-1	00-20	8.0	8.0	0.33	0.52	0.03	1.70	0.26	1.70	12.40	1.70	15.3	78	9	13	Sandy loam
	P9-2	20-62	8.1	8.0	0.24	0.52	0.00	1.40	0.16	1.20	13.90	3.60	12.2	90	4	6	Sand
	P9-3	62-100	7.9	8.0	0.38	0.30	0.04	2.10	0.38	1.70	21.50	3.20	27.0	50	27	23	Sandy clay loam
KATOHAR	P10-1	03-15	7.8	7.9	0.39	0.55	0.07	1.10	0.54	1.60	18.90	5.70	29.2	34	35	31	Clay loam
	P10-2	15-32	8.0	8.1	0.58	0.60	0.03	1.20	0.42	2.80	12.50	5.10	31.5	50	30	20	Loam
	P10-3	55-69	8.3	7.8	0.29	0.60	0.04	1.70	0.28	1.60	15.50	3.00	10.1	37	27	36	Clay loam
KATOHAR	P11-1	02-22	7.8	7.9	0.26	0.80	0.06	1.10	0.71	1.50	20.60	3.80	29.2	24	37	39	Clay loam
	P11-2	22-48	7.9	7.9	0.24	0.35	0.06	3.50	0.42	1.00	17.60	3.20	31.9	26	39	35	Clay loam
	P11-3	48-70	8.0	8.0	0.21	0.60	0.03	7.60	0.24	1.30	13.50	1.10	22.8	58	25	17	Sandy loam
TALAI	P12-1	00-22	8.2	7.9	0.16	0.35	0.04	2.80	0.14	0.90	7.80	2.30	11.6	90	3	7	Sand
	P12-2	22-72	8.0	8.0	0.15	0.40	0.02	1.10	0.24	1.00	7.10	2.40	19.6	70	17	13	Sandy loam
	P12-3	72-100	8.1	7.8	0.18	0.35	0.01	1.00	0.21	3.40	8.90	3.40	21.0	76	11	13	Sandy loam
Catchment-1	P13-1	05-35	8.0	8.0	0.25	1.77	0.04	0.90	0.35	1.30	11.80	3.60	21.6	56	25	19	Sandy loam
	P13-2	35-60	8.0	8.1	0.28	1.00	0.06	1.40	0.21	1.20	5.90	0.80	13.5	62	19	19	Sandy loam
Catchment-2	P14-1	00-15	8.1	7.9	0.17	0.90	0.04	1.00	0.33	0.70	5.60	0.60	12.4	80	11	9	Loamy sand
	P14-2	15-35	8.2	8.0	0.19	0.76	0.03	0.90	0.40	0.50	6.30	0.60	20.2	76	13	11	Loamy sand
	P14-3	35-52	7.9	8.0	0.14	0.76	0.03	1.70	0.28	1.00	13.10	1.10	14.4	76	13	11	Loamy sand
Catchment-3	P15-1	00-12	8.1	8.1	0.17	0.76	0.01	2.00	0.24	1.00	11.80	1.40	17.8	82	5	13	Loamy sand
	P15-2	12-40	7.9	7.8	1.66	0.90	0.07	1.00	0.10	1.10	24.30	1.20	18.9	72	18	10	Sandy loam
	P15-3	40-100	7.7	7.8	2.58	0.60	0.03	2.60	0.14	1.70	62.90	3.20	18.1	80	10	10	Loamy sand