Annex H
Irrigation and Drainage

ANNEX H

IRRIGATION AND DRAINAGE

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ANNEX H IRRIGATION AND DRAINAGE

H.1 EXISTING IRRIGATION SCHEMES

Though there is no irrigation system providing surface water with dam and reservoir due to lack of economic site for construction, numerous number of small irrigation schemes have been completed and operated.

Irrigation schemes implemented in the Study Area by the Irrigation Department so far, are listed in Table H.1.1 to Table H.1.3.

H.2 RESULT OF CALCULATED IRRIGATION WATER REQUIREMENT

During Phase I Study, present irrigation water requirement was estimated in each district in the Study Area. As a basic factor, reference evapo-transpiration (ETo) in the Study Area was calculated by modify PENMAN method. The ETo was obtained at 1,548.5 mm par year as shown in Table H.2.1, in which estimations calculated by other methods were attached.

Irrigation water requirement in each district concerning the Study Area were calculated in consideration with present cropping pattern. Tables from H.2.2 to H.2.5 are results of the irrigation water requirement calculation, at which irrigation efficiency of 0.5 was adopted as assuming traditional surface irrigation method. In Table H.2.6, irrigation water requirement in each crop of Quetta district is shown as a reference.

Table H.1.1 List of Completed Irrigation Schemes (Quetta Irrigation Division)

Name of Schemes	Year of Completion	Construction cost (M.Rs)	Design dischg.(Cusecs)	Irrigation Area (Acres)	Remarks
(Perennial Irrigation Schemes)					
Seragurg(I)	1973-1974	0.140	3.00	200.0	Weir 225ft, Channel 26,900ft
Zawar Kan(I)	1983-1984	1.570	2.00	150.0	Weir 140ft, Channel 11,150ft
Saran Tangi(I)	1985-1986	0.500	1.25	80.0	Weir 26ft, Channel 450ft
Weir Metharzai Viala	1990-1991	0.979	3.00	1,050.0	Weir 100ft, Channel 3,500ft
				1,480.0	
(Flood Irrigation Schemes)					
Dinar Mana Flood(I)	1974-1975	0.200	300.00	150.0	Bund 280ft, Channel 5,300ft
Kuram Manda Flood(I)	1983-1984	1.050	650.00	800.0	Weir 200ft, Channel 4,200ft, Bund 600ft
Remodelling of Hashim Rud	1984-1985	0.850	500.00	300.0	Weir 278ft, Channel 7,700ft, Bund 220ft
Abd-i-kas Flood(I)	1986-1987	13.500	350.00	1,200.0	Weir 170ft, Canal 13,500ft
				2,450.0	
(Delay Action Dam Schemes)					
Murghi Kotal	1967-1968	0.450	2,000.00	-	270ft long dam
Wali Dad	1973-1974	0.159	500.00	-	125ft long dam
Habib Nullah	1980-1981	0.150	600.00	-	125ft long dam
Zawar Kan	1986-1987	1.454	800.00	-	540ft long dam
Marium	1994	3.000		-	
Habib Dara (II)	1994	3.000		-	
(Flood Protection Bund Schemes)					
Pashtoonabad&Kakar Colony	1983-84	0.800	4,142.00	-	Bund 2,100ft
Hudda Village Jail Road	1986-1987	4.147	5,000.00	-	Nullah linning 1,700ft

Table H.1.2 List of Completed Irrigation Schemes (Pishin Irrigation Division)

Name of Schemes	Year of Completion	Construction cost (M.Rs)	Design dischg.(Cusecs)	Irrigation Area (Acres)	Remarks
(Perennial Irrigation Schemes)					
Kassi	1989-1990	0.452	2.00	200.0	
Poti Essazai	1989-1990	1.000	1.00	100.0	
Gawal Channel	1989-1990	1.104	5.00	293.0	
Warjaroba	1989-1990	0.365	0.25	50.0	
Toshkan	1990-1991	1.600	0.85	75.0	
Surhhab Sub-surface (II)	1986-1987	3.765	6.00	1,000.0	
Walang Khushdil	1982-1983	2.319	1.50	300.0	
Farakhi	1985-1986	1.123	1.50	270.0	
Hyderzai Viala(II)	1987-1988	1.262	2.00	270.0	
Tore Murgha	1985-1986	1.392	3.00	300.0	
Tore Murgha(II)	1994	14.800	-	-	
				2,858.0	
(Flood Irrigation Schemes)					
Khudadzai Flood	1982-1983	1.725	250.00	1,000.0	
Jungle Pir Alizai Flood(I)	1982-1983	1.862	500.00	1,000.0	
Popalazi Flood	1982-1983	1.500	150.00	1,000.0	
Balozai Flood	1990	1.640	400.00	250.0	Channel 34,250ft
				3,250.0	
(Delay Action Dam Schemes)					
Chachobi	1986-1987	0.922	1,550.00	300.0	34ft height, 500ft long dam
Shiker Gat	1987-1988	1.200	1,000.00	200.0	30ft height, 700ft long dam
Shadak	1982-1983	0.697	825.00	120.0	49ft height, 300ft long dam
Zohri	1986-1987	1.054	2,700.00	600.0	34ft height, 270ft long dam
Busaid	1986-1987	0.551	1,000.00	250.0	34.6ft height, 440ft long dam
Khushab	1985-1986	2.000	1,000.00	500.0	50ft height, 547ft long dam
Sabooni	1985-1986	2.000	3,075.00	250.0	37ft height, 300ft long dam
Surtal	1983-1984	1.125	6,000.00	250.0	40ft height, 150ft long dam
Ghargi	1985-1986	1.042	1,500.00	250.0	40ft height, 470ft long dam
Kar Manda	1985-1986	2.515	3,000.00	259.0	40ft height, 240ft long dam
Obdeki	1982-1983	1.000	1,700.00	80.0	32.2ft height, 760ft long dam
Bogha(II)	1982-1983	0.909	3,000.00	100.0	26.2ft height, 390ft long dam
Khusro	1982-1983	0.900	500.00	150.0	40ft height, 1860ft long dam
Ghunza	1989-1990	0.719	-	-	50ft height, 285ft long dam
Khaiz	1983-1984	0.235	-	-	39ft height, 1080ft long dam
Injanani	1982-1983	0.824	-	-	15.7ft height, 480ft long dam
Ghadak	1983	0.697	-	-	
Mahal	1985-1986	0.460	-	-	37ft height, 340ft long dam
Gavgi Tangi	1985-1986	0.430	-	-	30ft height, 200ft long dam
Granag	1989	1.700	-	-	38ft height, 450ft long dam
Tora Khulla	1989	1.980	-	-	36ft height, 470ft long dam
Balozai	1982-1983	1.000	-	-	40ft height, 2800ft long dam
Khanozai	1982-1983	1.200	-	-	38ft height, 2200ft long dam
Bostan	1990	6.000	-	-	40ft height, 400ft long dam
Khushdil Khan	1980	1.000	-	-	38ft height, 3000ft long dam
Takhoi Malagzai	1981	1.200	-	-	36ft height, 350ft long dam
Aghbergi	1980	0.800	-	-	36ft height, 350ft long dam
Dera Toghi	1994	7.030	-	-	
Inzargai	1994	2.000	-	-	
(Flood Protection Bund Schemes)					
Inayatullah Karez	1983-1984	3.840	-	-	Bund 12,000ft
Qilla Viala Flood Protection	1983-84	1.196	-	-	
Poti Mangalzai Flood Prot.	1989-1990	6.120	12,400.00	-	
Manzaki Flood Prot.	1989-1990	7.406	27,200.00	-	Bund 12,000ft
Killi Lamran Flood Prot.	1989-1990	3.019	3,600.00	-	Bund 11,400ft
Afgan refuges tented villag.	1988-1989	9.609	26,000.00	-	Bund 18,500ft
Manzaki extension	1989-1990	2.647	27,000.00	-	Bund 5500ft
Quila Majak Flood Prot.	1990-1991	3.539	5,050.00	-	Bund 4500ft
Surkhab h/w Flood Prot.	1988-1989	1.286	26,000.00	-	Bund 2200ft
Gulistan Karez Flood Prot.	1870-1988	0.600	2,500.00	-	Bund 1200ft
Chaman town Flood Prot.	1986-1987	2.557	2,000.00	-	Bund 7400ft
Chaman area Flood Prot.	1994	2.500	-	-	

Table II.1.3 List of Completed Irrigation Schemes (Mastung Irrigation Division)

Mastung Sub-Division

Name of Schemes	Year of Completion	Construction cost (M Rs)	Design dischg.(Cusecs)	Irrigation Area (Acres)	Remarks
(Perennial Irrigation Schemes)					
Khaisar (I)	1984	1.900	5.00	427.0	
(Flood Irrigation Schemes)					
Sherinab	1964-1965	0.300	200.00	1,500.0	
(Delay Action Dam Schemes)					
Kad Kocha	1984	3.600	-	5,000.0	
Amach	1986-1987	3.130	-	1,358.0	
Duz Dar	1984	1.500	-	400.000	
Kanak	1986-1987	3.140	-	500.000	
Tooth	1991	1.940	-	675.000	
Eri Kalag	1994	1.980	-	-	
Zaloo Chakul	1994	1.500	-	-	
(Flood Protection Bund Schemes)					

Kalat Sub-Division

Name of Schemes	Year of Completion	Construction cost (M Rs)	Design dischg.(Cusecs)	Irrigation Area (Acres)	Remarks
(Perennial Irrigation Schemes)					
Sarawan (I)	1979-1980	0.670	2.00	241.0	
Dasht-e-Goran (I)	1984	0.470	5.00	200.0	
Sheikhari	1989-1990	4.100	3.00	450.0	
				891.0	
(Flood Irrigation Schemes)					
Surma Sung	1965-1966	0.290	5.00	1,360.0	
Dhalo Chapper	1990	0.850	1400.00	3,000.0	
Chashuma Iskalkoo	1969-1970	0.790	200.00	640.0	
				5,000.0	
(Delay Action Dam Schemes)					
Hyder Kach	1981-1982	0.950	7400.00	1,770.0	
Gur	1982	0.500	-	300.0	
Tori Kafta	1982	0.740	-	1,400.0	
Gorpad	1982	0.500	-	400.000	
Baste-e-Goran	1991	2.690	-	750.000	
Dhalo Chaper	1990	0.853	-	-	
Laghamgir	1993	2.500	-	-	
Daber	1993	1.607	-	-	
Loveri	1993	0.755	-	-	
Sarband	1993	2.800	-	-	
(Flood Protection Bund Schemes)					
Kalat F/P Bund	1980-1981	2.500	-	-	

Table II.2.1 Estimated Referance Evapo-Transpiration (ETo) in the Study Area

Evapotranspiration Estimated by Ovserved Pan Evaporation (for reference)

Station: Quetta

Items	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Epan (Monthly)	116.0	138.0	183.0	240.0	265.0	297.0	427.0	384.0	250.0	150.0	121.0	109.0	2,680.0
Epan (Daily)	3.74	4.93	5.90	8.00	8.55	9.90	13.77	12.39	8.33	4.84	4.03	3.52	
RHmean (%)	50.0	50.0	43.0	35.0	27.0	21.0	26.0	24.0	22.0	24.0	29.0	43.0	
Wind verosity*(Km/day	133.4	155.6	173.3	177.8	168.9	195.6	235.6	168.9	124.5	97.8	111.1	97.8	
Kp	0.65	0.65	0.65	0.5	0.55	0.5	0.5	0.55	0.55	0.55	0.55	0.65	
ETo (Daily)	2.43	3.20	3.84	4.00	4.70	4.95	6.89	6.81	4.58	2.66	2.22	2.29	
ETo (Monthly)	75.4	89.7	119.0	120.0	145.8	148.5	213.5	211.2	137.5	82.5	66.6	70.9	1480.4

Evapotranspiration Estimated by FAO's Blaney-Criddle Method (for reference)

Station: Quetta

Items	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
Temperature	3.7	6.0	11.1	16.6	21.1	25.6	27.9	26.4	21.2	14.7	9.2	5.1	
P	0.24	0.25	0.27	0.29	0.31	0.32	0.31	0.30	0.28	0.26	0.24	0.23	
P(0.46T+8.13)(=F)	2.36	2.72	3.57	4.57	5.53	6.37	6.50	6.08	5.01	3.87	2.97	2.41	
Monthly Total(F)	73.2	76.2	110.8	137.2	171.4	191.1	201.5	188.5	150.2	120.0	89.0	74.7	1583.8
RHmin	50.0	50.0	43.0	35.0	27.0	21.0	26.0	24.0	22.0	24.0	29.0	43.0	
n	7.1	7.4	7.5	9.1	10.8	10.9	10.1	10.1	9.8	9.9	9.3	7.7	
N	10.4	11.1	12.0	12.9	13.6	14.0	13.9	13.2	12.4	11.5	10.6	10.2	
n/N	0.68	0.67	0.63	0.71	0.79	0.78	0.73	0.77	0.79	0.86	0.88	0.75	
Wind verosity (m/sec)	1.54	1.80	2.01	2.06	1.95	2.26	2.73	1.95	1.44	1.13	1.29	1.13	
ETo (Daily)	0.63	1.06	2.78	4.16	4.44	6.64	6.82	5.10	3.81	2.90	1.67	0.69	
ETo (Manthly)	19.5	29.7	86.2	124.8	137.6	199.2	211.4	158.1	114.3	89.9	50.1	21.4	1242.2

Evapotranspiration Estimated by Modify PENMAN Method

Station: Quetta

Items	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
ea	7.95	9.30	13.20	18.90	25.10	32.80	37.60	34.40	25.20	16.70	11.70	8.80	
ed	3.98	4.65	5.68	6.62	6.78	6.89	9.78	8.26	5.54	4.01	3.39	3.78	
(ea-ed)	3.97	4.65	7.52	12.28	18.32	25.91	27.82	26.14	19.66	12.69	8.31	5.02	
Wind verosity (Km/day	133.4	155.6	173.3	177.8	168.9	195.6	235.6	168.9	124.5	97.8	111.1	97.8	
f(Wind verosity)	0.63	0.69	0.74	0.75	0.73	0.80	0.91	0.73	0.61	0.53	0.57	0.53	
(1-W)	0.50	0.46	0.39	0.31	0.27	0.23	0.20	0.22	0.27	0.35	0.40	0.47	
(1-W)f( )(ea-ed)	1.25	1.48	2.17	2.86	3.61	4.77	5.06	4.20	3.24	2.35	1.89	1.25	
Ra	8.80	10.70	13.10	15.20	16.50	17.00	16.80	15.70	13.90	11.60	9.50	8.30	
n	7.1	7.4	7.5	9.1	10.8	10.9	10.1	10.1	9.8	9.9	9.3	7.7	
N	10.4	11.1	12.0	12.9	13.6	14.0	13.9	13.2	12.4	11.5	10.6	10.2	
n/N	0.68	0.67	0.63	0.71	0.79	0.78	0.73	0.77	0.79	0.86	0.88	0.75	
(1-a)(0.25+0.5n/N)	0.44	0.44	0.42	0.45	0.49	0.48	0.46	0.47	0.48	0.51	0.52	0.47	
Ra(1-a)(0.25+0.5n/N)	3.90	4.68	5.53	6.87	8.01	8.15	7.73	7.45	6.73	5.92	4.91	3.91	
f(t)	11.66	12.00	12.92	13.92	14.82	15.80	16.30	15.98	14.84	13.61	12.58	11.87	
f(ed)	0.26	0.25	0.24	0.24	0.24	0.24	0.21	0.23	0.25	0.26	0.27	0.26	
f(n/N)	0.71	0.70	0.66	0.73	0.81	0.80	0.75	0.79	0.81	0.87	0.89	0.78	
f(t)f(ed)f(n/N)	2.17	2.13	2.09	2.43	2.85	2.97	2.64	2.84	2.96	3.09	2.98	2.43	
W( )	0.87	1.38	2.09	3.07	3.77	3.99	4.07	3.60	2.75	1.84	1.16	0.78	
ETo (Daily) *	1.69	2.28	3.41	4.74	5.90	7.00	7.31	6.24	4.79	3.35	2.44	1.63	
ETo (Manthly)	52.5	63.9	105.7	142.1	183.0	210.1	226.5	193.3	143.7	103.9	73.2	50.5	1,548.5

* : C=0.8

Table H.2.2 Present Unit Water Requirement in Quetta District

Irrigation Efficiency: 0.5 (Unit:mm)

	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco
Jan.	28.7	28.59	0.00	0.00	20.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb.	41.7	41.67	0.00	0.00	32.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar.	86.8	74.40	80.30	45.61	75.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr.	87.1	39.40	121.76	102.71	111.59	0.00	0.00	0.00	0.00	46.69	9.93	14.00	0.00	0.00
May	28.5	0.00	94.16	120.33	50.91	64.19	45.47	39.00	51.66	183.59	56.37	143.64	114.13	0.00
Jun.	0.00	0.00	26.84	0.00	0.00	168.92	132.02	149.86	149.65	215.49	155.58	197.40	185.94	0.00
Jul.	0.00	0.00	0.00	0.00	0.00	214.84	181.31	192.19	209.75	91.14	203.08	87.09	156.64	93.60
Aug.	0.00	0.00	0.00	0.00	0.00	185.02	165.33	157.10	132.47	0.00	0.00	0.00	0.00	169.54
Sep.	0.00	0.00	0.00	0.00	0.00	120.81	112.79	96.86	9.62	0.00	0.00	0.00	0.00	67.46
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov.	24.2	7.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec.	27.1	25.67	0.00	0.00	6.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	323.99	217.14	323.06	268.65	297.43	753.79	636.92	635.01	553.15	536.90	424.97	442.13	456.72	330.60
Gross	647.98	434.28	646.12	537.29	594.85	1,507.58	1,273.83	1,270.02	1,106.29	1,073.80	849.93	884.26	913.43	661.19

Present Irrigation Water Requirement in Quetta Area

Total Crop Intensity: 95.8

Crops Areal Percentage	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco	Total	Total
	21.9	1.7	1.3	2.5	1.6	20.0	20.0	1.6	3.6	0.8	12.1	6.4	2.3	0.0	(mm)	(lt/sec/ha)
Jan.	12.55	0.97	0.00	0.00	0.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	14.19	0.053
Feb.	18.25	1.42	0.00	0.00	1.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	20.70	0.086
Mar.	38.03	2.53	2.09	2.28	2.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	47.35	0.177
Apr.	38.15	1.34	3.17	5.14	3.57	0.00	0.00	0.00	0.00	0.75	2.40	1.79	0.00	0.00	56.30	0.217
May	12.46	0.00	2.45	6.02	1.63	25.68	18.19	1.25	3.72	2.94	13.64	18.39	5.25	0.00	111.60	0.417
Jun.	0.00	0.00	0.70	0.00	0.00	67.57	52.81	4.80	10.77	3.45	37.65	25.27	8.55	0.00	211.56	0.816
Jul.	0.00	0.00	0.00	0.00	0.00	85.94	72.52	6.15	15.10	1.46	49.14	11.15	7.21	0.00	248.67	0.928
Aug.	0.00	0.00	0.00	0.00	0.00	74.01	66.13	5.03	9.54	0.00	0.00	0.00	0.00	0.00	154.71	0.578
Sep.	0.00	0.00	0.00	0.00	0.00	48.33	45.12	3.10	0.69	0.00	0.00	0.00	0.00	0.00	97.23	0.375
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
Nov.	10.60	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	10.85	0.042
Dec.	11.87	0.87	0.00	0.00	0.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.94	0.048
	141.91	7.38	8.40	13.43	9.52	301.52	254.77	20.32	39.83	8.59	102.84	56.59	21.01	0.00	986.10	

Table H.2.3 Present Unit Water Requirement in Pishin District

Irrigation Efficiency: 0.5 (Unit:mm)

	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco
Jan.	28.7	28.59	0.00	0.00	20.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb.	41.7	41.67	0.00	0.00	32.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar.	86.8	74.40	80.30	45.61	75.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr.	87.1	39.40	121.76	102.71	111.59	0.00	0.00	0.00	0.00	46.69	9.93	14.00	0.00	0.00
May	28.5	0.00	94.16	120.33	50.91	64.19	45.47	39.00	51.66	183.59	56.37	143.64	114.13	0.00
Jun.	0.00	0.00	26.84	0.00	0.00	168.92	132.02	149.86	149.65	215.49	155.58	197.40	185.94	0.00
Jul.	0.00	0.00	0.00	0.00	0.00	214.84	181.31	192.19	209.75	91.14	203.08	87.09	156.64	93.60
Aug.	0.00	0.00	0.00	0.00	0.00	185.02	165.33	157.10	132.47	0.00	0.00	0.00	0.00	169.54
Sep.	0.00	0.00	0.00	0.00	0.00	120.81	112.79	96.86	9.62	0.00	0.00	0.00	0.00	67.46
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov.	24.2	7.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec.	27.1	25.67	0.00	0.00	6.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	323.99	217.14	323.06	268.65	297.43	753.79	636.92	635.01	553.15	536.90	424.97	442.13	456.72	330.60
Gross	647.98	434.28	646.12	537.29	594.85	1,507.58	1,273.83	1,270.02	1,106.29	1,073.80	849.93	884.26	913.43	661.19

Present Irrigation Water Requirement in Pishin Area

Total Crop Intensity: 90.3

Crops Areal Percentage	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco	Total	Total
	34.0	2.2	2.1	1.0	1.1	10.0	10.0	5.7	0.7	4.2	3.7	9.4	1.6	4.6	(mm)	(lt/sec/ha)
Jan.	19.48	1.26	0.00	0.00	0.46	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	21.20	0.079
Feb.	28.34	1.83	0.00	0.00	0.71	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.88	0.128
Mar.	59.05	3.27	3.37	0.91	1.67	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	68.27	0.255
Apr.	59.22	1.73	5.11	2.05	2.45	0.00	0.00	0.00	0.00	3.92	0.74	2.63	0.00	0.00	77.87	0.300
May	19.35	0.00	3.95	2.41	1.12	12.84	9.09	4.45	0.72	15.42	4.17	27.00	3.65	0.00	104.18	0.389
Jun.	0.00	0.00	1.13	0.00	0.00	33.78	26.40	17.08	2.10	18.10	11.51	37.11	5.95	0.00	153.17	0.591
Jul.	0.00	0.00	0.00	0.00	0.00	42.97	36.26	21.91	2.94	7.66	15.03	16.37	5.01	8.61	156.76	0.585
Aug.	0.00	0.00	0.00	0.00	0.00	37.00	33.07	17.91	1.85	0.00	0.00	0.00	0.00	15.60	105.43	0.394
Sep.	0.00	0.00	0.00	0.00	0.00	24.16	22.56	11.04	0.13	0.00	0.00	0.00	0.00	6.21	64.10	0.247
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
Nov.	16.45	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.78	0.065
Dec.	18.43	1.13	0.00	0.00	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	19.69	0.074
	220.31	9.55	13.57	5.37	6.54	150.76	127.38	72.39	7.74	45.10	31.45	83.12	14.61	30.41	818.33	

Table H.2.4 Present Unit Water Requirement in Mastung District

Irrigation Efficiency: 0.5 (Unit:mm)

	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco
Jan.	28.7	28.59	0.00	0.00	20.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb.	41.7	41.67	0.00	0.00	32.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar.	86.8	74.40	80.30	45.61	75.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr.	87.1	39.40	121.76	102.71	111.59	0.00	0.00	0.00	0.00	46.69	9.93	14.00	0.00	0.00
May	28.5	0.00	94.16	120.33	50.91	64.19	45.47	39.00	51.66	183.59	56.37	143.64	114.13	0.00
Jun.	0.00	0.00	26.84	0.00	0.00	168.92	132.02	149.86	149.65	215.49	155.58	197.40	185.94	0.00
Jul.	0.00	0.00	0.00	0.00	0.00	214.84	181.31	192.19	209.75	91.14	203.08	87.09	156.64	93.60
Aug.	0.00	0.00	0.00	0.00	0.00	185.02	165.33	157.10	132.47	0.00	0.00	0.00	0.00	169.54
Sep.	0.00	0.00	0.00	0.00	0.00	120.81	112.79	96.86	9.62	0.00	0.00	0.00	0.00	67.46
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov.	24.2	7.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec.	27.1	25.67	0.00	0.00	6.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	323.99	217.14	323.06	268.65	297.43	753.79	636.92	635.01	553.15	536.90	424.97	442.13	456.72	330.60
Gross	647.98	434.28	646.12	537.29	594.85	1,507.58	1,273.83	1,270.02	1,106.29	1,073.80	849.93	884.26	913.43	661.19

Present Irrigation Water Requirement in Mastung Area

Total Crop Intensity: 99.9

Crops Areal Percentage	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco	Total	Total
	42.9	11.6	8.1	0.4	7.2	5.0	5.0	1.3	11.3	2.9	1.5	0.8	1.8	0.0	(mm)	(lt/sec/ha)
Jan.	24.58	6.63	0.00	0.00	3.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	34.23	0.128
Feb.	35.75	9.67	0.00	0.00	4.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.04	0.207
Mar.	74.50	17.26	13.01	0.36	10.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	116.04	0.433
Apr.	74.73	9.14	19.73	0.82	16.07	0.00	0.00	0.00	0.00	2.71	0.30	0.22	0.00	0.00	123.71	0.477
May	24.41	0.00	15.25	0.96	7.33	6.42	4.55	1.01	11.67	10.65	1.69	2.30	4.11	0.00	90.36	0.337
Jun.	0.00	0.00	4.35	0.00	0.00	16.89	13.20	3.90	33.82	12.50	4.67	3.16	6.69	0.00	99.18	0.383
Jul.	0.00	0.00	0.00	0.00	0.00	21.48	18.13	5.00	47.40	5.29	6.09	1.39	5.64	0.00	110.43	0.412
Aug.	0.00	0.00	0.00	0.00	0.00	18.50	16.53	4.08	29.94	0.00	0.00	0.00	0.00	0.00	69.06	0.258
Sep.	0.00	0.00	0.00	0.00	0.00	12.08	11.28	2.52	2.17	0.00	0.00	0.00	0.00	0.00	28.05	0.108
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
Nov.	20.76	1.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	22.48	0.087
Dec.	23.25	5.95	0.00	0.00	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	30.10	0.112
	277.99	50.38	52.34	2.15	42.83	75.38	63.69	16.51	125.01	31.14	12.75	7.07	16.44	0.00	773.67	

Table H.2.5 Present Unit Water Requirement in Kalat District

Irrigation Efficiency: 0.5 (Unit:mm)

	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco
Jan.	28.7	28.59	0.00	0.00	20.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Feb.	41.7	41.67	0.00	0.00	32.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Mar.	86.8	74.40	80.30	45.61	75.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Apr.	87.1	39.40	121.76	102.71	111.59	0.00	0.00	0.00	0.00	46.69	9.93	14.00	0.00	0.00
May	28.5	0.00	94.16	120.33	50.91	64.19	45.47	39.00	51.66	183.59	56.37	143.64	114.13	0.00
Jun.	0.00	0.00	26.84	0.00	0.00	168.92	132.02	149.86	149.65	215.49	155.58	197.40	185.94	0.00
Jul.	0.00	0.00	0.00	0.00	0.00	214.84	181.31	192.19	209.75	91.14	203.08	87.09	156.64	93.60
Aug.	0.00	0.00	0.00	0.00	0.00	185.02	165.33	157.10	132.47	0.00	0.00	0.00	0.00	169.54
Sep.	0.00	0.00	0.00	0.00	0.00	120.81	112.79	96.86	9.62	0.00	0.00	0.00	0.00	67.46
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Nov.	24.2	7.41	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Dec.	27.1	25.67	0.00	0.00	6.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	323.99	217.14	323.06	268.65	297.43	753.79	636.92	635.01	553.15	536.90	424.97	442.13	456.72	330.60
Gross	647.98	434.28	646.12	537.29	594.85	1,507.58	1,273.83	1,270.02	1,106.29	1,073.80	849.93	884.26	913.43	661.19

Present Irrigation Water Requirement in Kalat Area

Total Crop Intensity: 99.9

Crops	Wheat	Barley	Cumin	R.Veg.	R.Fodder	Apples	Grapes	Other Fruits	Onion	Potato	K.Veg.	Melon	K.Fodder	Tobacco	Total	Total
Areal Percentage	37.1	4.6	5.7	0.5	8.4	10.0	5.0	1.4	16.3	7.0	1.4	0.8	1.7	0.0	(mm)	(lt/sec/ha)
Jan.	21.26	2.63	0.00	0.00	3.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	27.40	0.102
Feb.	30.92	3.83	0.00	0.00	5.39	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	40.14	0.166
Mar.	64.43	6.84	9.15	0.46	12.72	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	93.61	0.349
Apr.	64.62	3.62	13.88	1.03	18.75	0.00	0.00	0.00	0.00	6.54	0.28	0.22	0.00	0.00	108.94	0.420
May	21.11	0.00	10.73	1.20	8.55	12.84	4.55	1.09	16.84	25.70	1.58	2.30	3.88	0.00	110.38	0.412
Jun.	0.00	0.00	3.06	0.00	0.00	33.78	13.20	4.20	48.78	30.17	4.36	3.16	6.32	0.00	147.03	0.567
Jul.	0.00	0.00	0.00	0.00	0.00	42.97	18.13	5.38	68.38	12.76	5.69	1.39	5.33	0.00	160.02	0.597
Aug.	0.00	0.00	0.00	0.00	0.00	37.00	16.53	4.40	43.19	0.00	0.00	0.00	0.00	0.00	101.12	0.378
Sep.	0.00	0.00	0.00	0.00	0.00	24.16	11.28	2.71	3.14	0.00	0.00	0.00	0.00	0.00	41.29	0.159
Oct.	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
Nov.	17.95	0.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	18.63	0.072
Dec.	20.11	2.36	0.00	0.00	1.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.51	0.088
	240.40	19.98	36.83	2.69	49.97	150.76	63.69	17.78	180.33	75.17	11.90	7.07	15.53	0.00	872.09	

Table H.2.6 Irrigation Water Requirement Calculation for Quetta Area (1/4)

Wheat:

Month	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.			Apr.			May		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	0.4	0.4	0.46	0.54	0.70	0.86	1.02	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.98	0.81	0.64	0.47	0.30			
		0.4	0.4	0.46	0.54	0.70	0.86	1.02	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.98	0.81	0.64	0.47	0.30		
			0.4	0.4	0.46	0.54	0.70	0.86	1.02	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.98	0.81	0.64	0.47	0.30	
				0.4	0.4	0.46	0.54	0.70	0.86	1.02	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.98	0.81	0.64	0.47	0.30
Kc(10days)		0.40	0.42	0.45	0.52	0.64	0.78	0.92	1.02	1.08	1.10	1.10	1.10	1.10	1.10	1.10	1.07	1.00	0.88	0.72	0.56	0.47	0.39	0.30
Kc		0.41			0.54			0.91			1.09			1.10			1.06			0.72			0.39	
Area %(10days	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25
Area %		0.50			1.00			1.00			1.00			1.00			1.00			1.00			0.50	
ETo		103.9			73.2			50.5			52.5			63.9			105.7			142.1			183.0	
Req.(1)		*21.3*			*39.4*			*45.8*			*57.4*			*70.3*			*111.5*			*102.3*			*35.3*	
Rainfall		2.8			6.1			28.2			49.8			49.5			40.4			21.1			9.4	
Effective rain		2.0			4.5			18.7			28.7			28.6			24.7			15.2			6.9	
S.M.C		30.0			10.8			0.0			0.0			0.0			0.0			0.0			0.0	
Wate requirement		0.0			24.2			27.1			28.7			41.7			86.8			87.1			28.5	
harvested area:21.9%		*0.0*			*5.3*			*5.9*			*6.3*			*9.1*			*19.0*			*19.1*			*6.2*	

Total 324.0 mm; *71 mm*

Barley:

Month	Oct.			Nov.			Dec.			Jan.			Feb.			Mar.			Apr.			May		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
		0.4	0.40	0.49	0.63	0.82	1.01	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.91	0.71	0.51	0.31					
			0.4	0.40	0.49	0.63	0.82	1.01	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.91	0.71	0.51	0.32				
				0.4	0.40	0.49	0.63	0.82	1.01	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.91	0.71	0.51	0.32			
					0.4	0.40	0.49	0.63	0.82	1.01	1.10	1.10	1.10	1.10	1.10	1.10	1.10	1.10	0.91	0.71	0.51	0.32		
Kc(10days)		0.40	0.40	0.43	0.48	0.59	0.74	0.89	1.01	1.08	1.10	1.10	1.10	1.10	1.10	1.05	0.95	0.81	0.61	0.51	0.41	0.32		
Kc		*0.40*			*0.50*			*0.88*			*1.09*			*1.10*			*0.94*			*0.51*			*0.32*	
Area %(10days	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25	0.00	0.00
Area %		0.25			0.92			1.00			1.00			1.00			1.00			0.75			0.08	
ETo		103.9			73.2			50.5			52.5			63.9			105.7			142.1			183.0	
Req.(1)		10.4			33.5			44.4			57.3			70.3			99.1			54.6			4.8	
Rainfall		2.8			6.1			28.2			49.8			49.5			40.4			21.1			9.4	
Effective rain		2.0			4.5			18.7			28.7			28.6			24.7			15.2			6.9	
S.M.C		30.0			21.7			0.0			0.0			0.0			0.0			0.0			0.0	
Wate requirement		0.0			7.4			25.7			28.6			41.7			74.4			39.4			0.0	
harvested area:1.7%		*0.0*			*0.1*			*0.4*			*0.5*			*0.7*			*1.3*			*0.7*			*0.0*	

Total 217.1 mm; *4 mm*

Cumin:

Month	Dec.			Jan.			Feb.			Mar.			Apr.			May			June			July		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	0.5	0.5	0.56	0.73	0.88	1.00	1.10	1.10	1.10	1.10	1.10	0.98	0.83	0.62	0.39									
		0.5	0.5	0.56	0.73	0.88	1.00	1.10	1.10	1.10	1.10	1.10	0.98	0.83	0.62	0.39								
			0.5	0.5	0.56	0.73	0.88	1.00	1.10	1.10	1.10	1.10	1.10	0.98	0.83	0.62	0.39							
				0.5	0.5	0.56	0.73	0.88	1.00	1.10	1.10	1.10	1.10	1.10	0.98	0.83	0.62	0.39						
					0.5	0.5	0.56	0.73	0.88	1.00	1.10	1.10	1.10	1.10	1.10	0.98	0.83	0.62	0.39					
						0.5	*0.5*	*0.56*	*0.73*	*0.88*	*1.00*	*1.10*	*1.10*	*1.10*	*1.10*	*1.10*	*0.98*	*0.83*	*0.62*	*0.39*				
							0.5	0.5	0.56	0.73	0.88	1.00	1.10	1.10	1.10	1.10	1.10	0.98	0.83	0.62	0.39			
Kc(10days)		0.50	0.52	0.57	0.63	0.69	0.75	0.84	0.92	1.00	1.05	1.07	1.04	0.97	0.87	0.84	0.78	0.70	0.61	0.50	0.39			
Kc		0.51			0.63			0.84			1.04			0.96			0.77			0.50			0.00	
Area %(10days	0.14	0.29	0.43	0.57	0.71	0.86	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.71	0.57	0.43	0.29	0.14	0.13	0.00	0.00
Area %		0.29			0.71			1.00			1.00			1.00			0.71			0.29			0.04	
ETo		50.5			52.5			63.9			105.7			142.1			183.0			210.1			226.5	
Req.(1)		7.3			23.8			53.6			110.0			136.9			101.0			30.0			0.0	
Rainfall		28.2			49.8			49.5			40.4			21.1			9.4			4.3			11.2	
Effective rain		18.7			28.7			28.6			24.7			15.2			6.9			3.1			8.2	
S.M.C		30.0			30.0			30.0			5.1			0.0			0.0			0.0			0.0	
Wate requirement		0.0			0.0			0.0			80.3			121.8			94.2			26.8			0.0	
harvested area:1.3%		*0.0*			*0.0*			*0.0*			*1.0*			*1.6*			*1.2*			*0.3*			*0.0*	

Total 323.1 mm; *4 mm*

Rabi.Vegetable:

Month	Dec.			Jan.			Feb.			Mar.			Apr.			May			June		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	0.5	0.5	0.50	0.50	0.55	0.65	0.77	0.92	1.00	1.00	0.99	0.96									
		0.5	0.5	0.50	0.50	0.55	0.65	0.77	0.92	1.00	1.00	0.99	0.96								
			0.5	*0.5*	*0.50*	*0.50*	*0.55*	*0.65*	*0.77*	*0.92*	*1.00*	*1.00*	*0.99*	*0.96*							
				0.5	0.5	0.50	0.50	0.55	0.65	0.77	0.92	1.00	1.00	0.99	0.96						
					0.5	0.5	0.50	0.50	0.55	0.65	0.77	0.92	1.00	1.00	0.99	0.96					
						0.5	0.5	0.50	0.50	0.55	0.65	0.77	0.92	1.00	1.00	0.99	0.96				
							0.5	0.5	0.50	0.50	0.55	0.65	0.77	0.92	1.00	1.00	0.99	0.96			
Kc(10days)	0.50	0.50	0.50	0.50	0.51	0.53	0.57	0.63	0.70	0.77	0.84	0.90	0.94	0.97	0.99	0.98	0.97	0.96			
Kc		0.50			0.51			0.63			0.84			0.97			0.97			0.00	
Area %(10days	0.14	0.29	0.43	0.57	0.71	0.86	1.00	1.00	1.00	1.00	1.00	1.00	0.86	0.71	0.57	0.43	0.29	0.14	0.00	0.00	0.00
Area %		0.29			0.71			1.00			1.00			0.86			0.71			0.29	
ETo		50.5			52.5			63.9			105.7			142.1			183.0			210.1	
Req.(1)		7.2			19.3			40.4			88.5			117.9			127.2			0.0	
Rainfall		28.2			49.8			49.5			40.4			21.1			9.4			4.3	
Effective rain		18.7			28.7			28.6			24.7			15.2			6.9			3.1	
S.M.C		30.0			30.0			30.0			18.2			0.0			0.0			0.0	
Wate requirement		0.0			0.0			0.0			45.6			102.7			120.3			0.0	
harvested area:2.5%		*0.0*			*0.0*			*0.0*			*1.1*			*2.6*			*3.0*			*0.0*	

Total 268.6 mm; *7 mm*

Table H.2.6 Irrigation Water Requirement Calculation for Quetta Area (2/4)

Fodders:

Month		Oct.			Nov.			Dec.			Jan.			Feb.			Mar.			Apr.			May	
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
				0.50	0.54	0.75	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.85	0.43			
					0.50	0.54	0.75	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.85	0.43		
						0.50	0.54	0.75	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.85	0.43	
							0.50	0.54	0.75	0.90	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.94	0.85	0.43
Kc(10days)				0.50	0.52	0.60	0.67	0.79	0.89	0.94	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.92	0.80	0.76	0.66	0.48
Kc					0.54			0.78			0.95			0.95			0.95			0.89			0.63	
Area %(10days	0.00	0.00	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25
Area %		0.00			0.50			1.00			1.00			1.00			1.00			1.00			0.50	
ETo		103.9			73.2			50.5			52.5			63.9			105.7			142.1			183.0	
Req.(1)		0.0			19.8			39.6			49.7			60.7			100.4			126.8			57.8	
Rainfall		2.8			6.1			28.2			49.8			49.5			40.4			21.1			9.4	
Effective rain		2.0			4.5			18.7			28.7			28.6			24.7			15.2			6.9	
S.M.C		30.0			30.0			14.7			0.0			0.0			0.0			0.0			0.0	
Wate requirement		0.0			0.0			6.2			20.9			32.1			75.7			111.6			50.9	
harvested area:1.6%		*0.0*			*0.0*			*0.1*			*0.3*			*0.5*			*1.2*			*1.8*			*0.8*	

Total 297.4 mm; *5 mm*

Apples:

Month		Apr.			May			June			July			Aug.			Sep.			Oct.			Nov.	
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	0.4	0.40	0.40	0.47	0.55	0.63	0.73	0.83	0.90	0.95	1.00	1.00	1.00	0.99	0.97	0.94	0.85	0.75						
Kc(10days)	0.40	0.40	0.40	0.47	0.55	0.63	0.73	0.83	0.90	0.95	1.00	1.00	1.00	0.99	0.97	0.94	0.85	0.75						
Kc		0.40			0.55			0.82			0.98			0.99			0.85			0.00			0.00	
Area %(10days	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*	*1.00*
Area %		1.00			1.00			1.00			1.00			1.00			1.00			1.00			1.00	
ETo		142.1			183.0			210.1			226.5			193.3			143.7			103.9			73.2	
Req.(1)		56.8			101.1			172.1			223.0			190.4			121.5			0.0			0.0	
Rainfall		21.1			9.4			4.3			11.2			7.4			1.0			2.8			6.1	
Effective rain		15.2			6.9			3.1			8.2			5.4			0.7			2.0			4.5	
S.M.C		90.0			30.0			0.0			0.0			0.0			0.0			0.0			2.0	
Wate requirement		0.0			64.2			168.9			214.8			185.0			120.8			0.0			0.0	
harvested area:20%		*0.0*			*12.8*			*33.8*			*43.0*			*37.0*			*24.2*			*0.0*			*0.0*	

Total 753.8 mm; *151 mm*

Grapes:

Month		Apr.			May			June			July			Aug.			Sep.			Oct.			Nov.	
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
				0.45	0.45	0.45	0.55	0.65	0.73	0.79	0.85	0.87	0.89	0.89	0.87	0.85	0.79	0.73						
Kc(10days)				0.45	0.45	0.45	0.55	0.65	0.73	0.79	0.85	0.87	0.89	0.89	0.87	0.85	0.79	0.73						
Kc		0.00			0.45			0.64			0.84			0.88			0.79			0.00			0.00	
Area %(10days	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Area %		1.00			1.00			1.00			1.00			1.00			1.00			1.00			1.00	
ETo		142.1			183.0			210.1			226.5			193.3			143.7			103.9			73.2	
Req.(1)		0.0			82.4			135.2			189.5			170.7			113.5			0.0			0.0	
Rainfall		21.1			9.4			4.3			11.2			7.4			1.0			2.8			6.1	
Effective rain		15.2			6.9			3.1			8.2			5.4			0.7			2.0			4.5	
S.M.C		30.0			30.0			0.0			0.0			0.0			0.0			0.0			2.0	
Wate requirement		0.0			45.5			132.0			181.3			165.3			112.8			0.0			0.0	
harvested area:20%		*0.0*			*9.1*			*26.4*			*36.3*			*33.1*			*22.6*			*0.0*			*0.0*	

Total 636.9 mm; *127 mm*

Aprict and others:

Month		Apr.			May			June			July			Aug.			Sep.			Oct.			Nov.	
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	0.4	*0.40*	*0.40*	*0.45*	*0.51*	*0.58*	*0.66*	*0.73*	*0.80*	*0.85*	*0.90*	*0.90*	*0.90*	*0.85*	*0.77*	*0.70*	*0.68*	*0.66*						
Kc(10days)	0.40	0.40	0.40	0.45	0.51	0.58	0.66	0.73	0.80	0.85	0.90	0.90	0.90	0.85	0.77	0.70	0.68	0.66						
Kc		0.40			0.51			0.73			0.88			0.84			0.68			0.00			0.00	
Area %(10days	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Area %		1.00			1.00			1.00			1.00			1.00			1.00			1.00			1.00	
ETo		142.1			183.0			210.1			226.5			193.3			143.7			103.9			73.2	
Req.(1)		56.8			94.2			153.0			200.4			162.5			97.6			0.0			0.0	
Rainfall		21.1			9.4			4.3			11.2			7.4			1.0			2.8			6.1	
Effective rain		15.2			6.9			3.1			8.2			5.4			0.7			2.0			4.5	
S.M.C		*90.0*			*48.3*			*0.0*			*0.0*			*0.0*			*0.0*			*0.0*			*2.0*	
Wate requirement		0.0			39.0			149.9			192.2			157.1			95.9			0.0			0.0	
harvested area:1.6%		*0.0*			*0.6*			*2.4*			*3.1*			*2.5*			*1.5*			*0.0*			*0.0*	

Total 635.0 mm; *10 mm*

Table H.2.6 Irrigation Water Requirement Calculation for Quetta Area (3/4)

Onion:

Month	Mar.			Apr.			May			June			July			Aug.			Sep.		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
				0.35	0.35	0.35	0.43	0.55	0.67	0.79	0.91	0.98	1.00	1.00	1.00	0.86					
					0.35	0.35	0.35	0.43	0.55	0.67	0.79	0.91	0.98	1.00	1.00	1.00	0.86				
						0.35	0.35	0.35	0.43	0.55	0.67	0.79	0.91	0.98	1.00	1.00	1.00	0.86			
							0.35	0.35	0.35	0.43	0.55	0.67	0.79	0.91	0.98	1.00	1.00	1.00	0.86		
Kc(10days)				0.35	0.35	0.35	0.37	0.42	0.50	0.61	0.73	0.84	0.92	0.97	0.99	0.97	0.95	0.93	0.86		
Kc		0.00			0.35			0.43			0.73			0.96			0.95			0.86	
Area %(10days)	0.00	0.00	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25	0.00	0.00
Area %		0.00			0.50			1.00			1.00			1.00			0.75			0.08	
ETo		105.7			142.1			183.0			210.1			226.5			193.3			143.7	
Req (1)		0.0			24.9			78.9			152.8			217.9			137.9			10.4	
Rainfall		40.4			21.1			9.4			4.3			11.2			7.4			1.0	
Effective rain		24.7			15.2			6.9			3.1			8.2			5.4			0.7	
SMC		30.0			30.0			20.3			0.0			0.0			0.0			0.0	
Wate requirement		0.0			0.0			51.7			149.6			209.7			132.5			9.6	
harvested area:3.6%		*0.0*			*0.0*			*1.9*			*5.4*			*7.6*			*4.8*			*0.3*	

Total 553.1 mm; *14.8 mm*

Poteto:

Month	Mar.			Apr.			May			June			July			Aug.			Sep.		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	0.4	0.4	0.48	0.70	0.95	1.09	1.10	1.10	1.10	1.07	0.94	0.82									
		0.4	0.4	0.48	0.70	0.95	1.09	1.10	1.10	1.10	1.07	0.94	0.82								
			0.4	0.4	0.48	0.70	0.95	1.09	1.10	1.10	1.10	1.07	0.94	0.82							
				0.4	0.4	0.48	0.70	0.95	1.09	1.10	1.10	1.10	1.07	0.94	0.82						
Kc(10days)	0.40	0.40	0.43	0.50	0.63	0.81	0.96	1.06	1.10	1.09	1.05	0.98	0.94	0.88	0.82						
Kc		0.00			0.65			1.04			1.04			0.88			0.00			0.00	
Area %(10days)	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Area %		0.50			1.00			1.00			1.00			0.50			0.00			0.00	
ETo		105.7			142.1			183.0			210.1			226.5			193.3			143.7	
Req (1)		0.0			91.9			190.5			218.6			99.3			0.0			0.0	
Rainfall		40.4			21.1			9.4			4.3			11.2			7.4			1.0	
Effective rain		24.7			15.2			6.9			3.1			8.2			5.4			0.7	
SMC		30.0			30.0			0.0			0.0			0.0			0.0			5.4	
Wate requirement		0.0			46.7			183.6			215.5			91.1			0.0			0.0	
harvested area:1%		*0.0*			*0.5*			*1.8*			*2.2*			*0.9*			*0.0*			*0.0*	

Total 536.9 mm; *5.4 mm*

Kharif Vegetables:

Month	Mar.			Apr.			May			June			July			Aug.			Sep.		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
				0.35	0.35	0.38	0.47	0.57	0.72	0.85	0.90	0.95	0.95	0.95	0.95	0.95	0.89	0.80			
					0.35	0.35	0.38	0.47	0.57	0.72	0.85	0.90	0.95	0.95	0.95	0.95	0.95	0.89	0.80		
						0.35	0.35	0.38	0.47	0.57	0.72	0.85	0.90	0.95	0.95	0.95	0.95	0.95	0.89	0.80	
							0.35	0.35	0.38	0.47	0.57	0.72	0.85	0.90	0.95	0.95	0.95	0.95	0.95	0.89	0.80
Kc(10days)				0.35	0.35	0.36	0.39	0.44	0.53	0.65	0.76	0.85	0.91	0.94	0.95	0.95	0.94	0.90	0.88	0.84	0.80
Kc		0.00			0.35			0.46			0.76			0.93			0.00			0.00	
Area %(10days)	0.00	0.00	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25
Area %		0.00			0.50			1.00			1.00			1.00			1.00			0.50	
ETo		105.7			142.1			183.0			210.1			226.5			193.3			143.7	
Req (1)		0.0			25.1			83.3			158.7			211.3			0.0			0.0	
Rainfall		40.4			21.1			9.4			4.3			11.2			7.4			1.0	
Effective rain		24.7			15.2			6.9			3.1			8.2			5.4			0.7	
SMC		30.0			30.0			20.1			0.0			0.0			0.0			5.4	
Wate requirement		0.0			0.0			56.4			155.6			203.1			0.0			0.0	
harvested area:1%		*0.0*			*0.0*			*0.6*			*1.6*			*2.0*			*0.0*			*0.0*	

Total 415.0 mm: *4.2 mm*

Melon:

Month	Mar.			Apr.			May			June			July			Aug.			Sep.		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
		0.35	0.35	0.45	0.60	0.78	0.98	0.98	0.98	0.98	0.93	0.78									
			0.35	0.35	0.45	0.60	0.78	0.98	0.98	0.98	0.98	0.93	0.78								
				0.35	0.35	0.45	0.60	0.78	0.98	0.98	0.98	0.98	0.93	0.78							
					0.35	0.35	0.45	0.60	0.78	0.98	0.98	0.98	0.98	0.93	0.78						
Kc(10days)		0.35	0.35	0.38	0.44	0.54	0.70	0.83	0.93	0.98	0.97	0.92	0.90	0.85	0.78						
Kc		0.00			0.45			0.82			0.95			0.84			0.00			0.00	
Area %(10days)	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25	0.00	0.00	0.00	0.00	0.00	0.00
Area %		0.25			0.92			1.00			1.00			0.50			0.00			0.00	
ETo		105.7			142.1			183.0			210.1			226.5			193.3			143.7	
Req (1)		0.0			59.2			150.5			200.5			95.3			0.0			0.0	
Rainfall		40.4			21.1			9.4			4.3			11.2			7.4			1.0	
Effective rain		24.7			15.2			6.9			3.1			8.2			5.4			0.7	
SMC		30.0			30.0			0.0			0.0			0.0			0.0			5.4	
Wate requirement		0.0			14.0			143.6			197.4			87.1			0.0			0.0	
harvested area 6.4%		*0.0*			*0.9*			*9.2*			*12.6*			*5.6*			*0.0*			*0.0*	

Total 442.1 mm; *28.3 mm*

Table H.2.6 Irrigation Water Requirement Calculation for Quetta Area (4/4)

Kharif Fodder:

Month	Mar.			Apr.			May			June			July			Aug.			Sep.		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
				0.35	0.47	0.74	0.90	0.90	0.90	0.90	0.90	0.90	0.81	0.48							
					0.35	0.47	0.74	0.90	0.90	0.90	0.90	0.90	0.90	0.81	0.48						
						0.35	0.47	0.74	0.90	0.90	0.90	0.90	0.90	0.90	0.81	0.48					
							0.35	0.47	0.74	0.90	0.90	0.90	0.90	0.90	0.90	0.81	0.48				
Kc(10days)				0.35	0.41	0.52	0.61	0.75	0.85	0.90	0.90	0.90	0.88	0.77	0.73	0.65	0.48				
Kc		0.00			0.43			0.74			0.90			0.79			0.00			0.00	
Area %(10days	0.00	0.00	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25	0.00	0.00	0.00	0.00
Area %		0.00			0.50			1.00			1.00			0.92			0.25			0.00	
ETo		105.7			142.1			183.0			210.1			226.5			193.3			143.7	
Req.(1)		0.0			30.3			135.9			189.1			164.8			0.0			0.0	
Rainfall		40.4			21.1			9.4			4.3			11.2			7.4			1.0	
Effective rain		24.7			15.2			6.9			3.1			8.2			5.4			0.7	
S.M.C		30.0			30.0			14.9			0.0			0.0			0.0			5.4	
Wate requirement		0.0			0.0			114.1			185.9			156.6			0.0			0.0	
harvested area:2.3%		*0.0*			*0.0*			*2.6*			*4.3*			*3.6*			*0.0*			*0.0*	

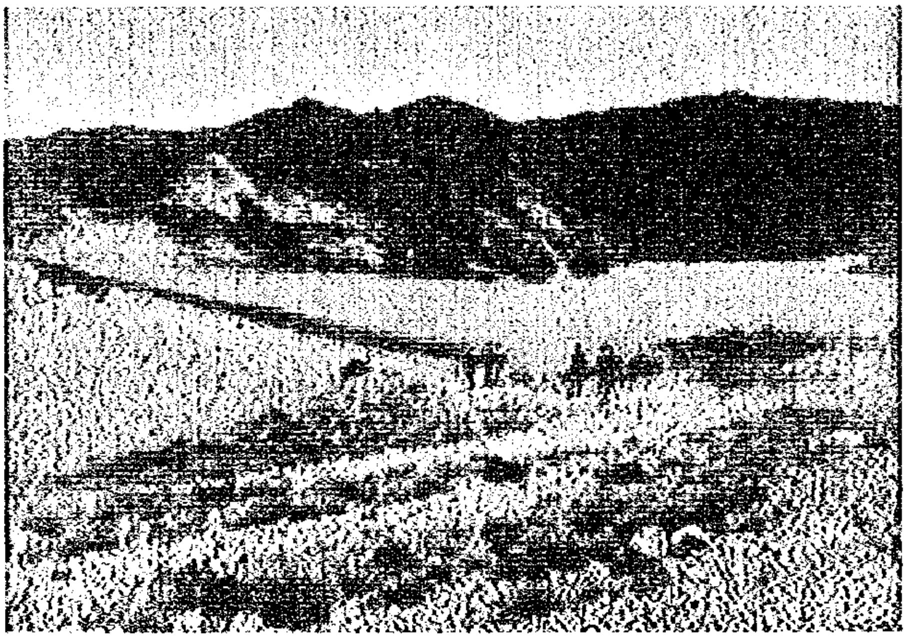
Total 456.7 mm; *10.5 mm*

Tobocco:

Month	Mar.			Apr.			May			June			July			Aug.			Sep.		
10days	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
										0.25	0.25	0.31	0.53	0.75	0.97	1.00	1.00	0.92			
											0.25	0.25	0.31	0.53	0.75	0.97	1.00	1.00	0.92		
												0.25	0.25	0.31	0.53	0.75	0.97	1.00	1.00	0.92	
													0.25	0.25	0.31	0.53	0.75	0.97	1.00	1.00	0.92
Kc(10days)										0.25	0.25	0.27	0.33	0.46	0.64	0.81	0.93	0.97	0.97	0.96	0.92
Kc		0.00			0.00			0.00			0.26			0.48			0.91			0.95	
Area %(10days	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.50	0.75	1.00	1.00	1.00	1.00	1.00	1.00	0.75	0.50	0.25
Area %		0.00			0.00			0.00			0.50			1.00			1.00			0.50	
ETo		105.7			142.1			183.0			210.1			226.5			193.3			143.7	
Req.(1)		0.0			0.0			0.0			26.9			108.0			175.0			68.2	
Rainfall		40.4			21.1			9.4			4.3			11.2			7.4			1.0	
Effective rain		24.7			15.2			6.9			3.1			8.2			5.4			0.7	
S.M.C		30.0			30.0			30.0			30.0			6.2			0.0			0.0	
Wate requirement		0.0			0.0			0.0			0.0			93.6			169.5			67.5	
harvested area:0%		*0.0*			*0.0*			*0.0*			*0.0*			*0.0*			*0.0*			*0.0*	

Total 330.6 mm; *0.0 mm*

Annex I
Delay Action Dam Structure



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ANNEX I DELAY ACTION DAM STRUCTURE

I.1 General Information of Delay Action Dams

(1) Delay action dam projects

Delay action dam constructions have been commenced since 1971, and 110 dams were operated and 84 dams are presently proposed to be implemented in the Balochistan Province. Dam locations and the inventory of the completed and proposed dams are plotted in Fig. I.1.1 and I.1.2 in the whole of the Balochistan Province and in and around Study Area. Presently 64 delay action dams have been constructed in the Study Area as shown in Fig. I.1.2. These dams are however distributed within the limited area, and also lack in the absolute quantity to work out the groundwater decline.

Delay action dam construction is increasing in and around the Quetta valley where severe decline of the groundwater surface has been observed. Constructive dam planning (Shagai I, II, Hingi and Tabai dams) is proposed in the four tributaries of Sariab and Hanna rivers out of their 14 tributaries. Potential river basin in the Quetta valley is shown in Fig. I.3.1.

Delay Action Dams in Pishin Lora Basin

Cap.: Reservoir capacity (1,000m³)

Districts	Qila Abdullah		Pishin		Quetta		Mastung		Kalat		Total	
Basin/Sub-Basin	Nos.	Cap.	Nos.	Cap.	Nos.	Cap.	Nos.	Cap.	Nos.	Cap.	Nos.	Cap.
Pishin Lora Basin												
Pishin	0	0.0	22	20,518.5	0	0.0	0	10.0	0	0.0	22	20,528.5
Kuchlagh	0	0.0	12	15,262.6	1	2,073.2	0	10.0	0	0.0	13	17,345.8
Quetta	0	0.0	0	0.0	8	1,685.5	1	12.2	0	0.0	9	1,697.7
Kolpur	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Mastung	0	0.0	0	0.0	0	0.0	2	1,572.8	0	0.0	2	1,572.8
Shirinab	0	0.0	0	0.0	0	0.0	1	60.0	0	0.0	1	60.0
Mangochar	0	0.0	0	0.0	0	0.0	0	0.0	1	159.1	1	159.1
Sardar Khel	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Patki Shah Nawaz	0	0.0	0	0.0	0	0.0	0	0.0	1		1	0.0
Kalat	0	0.0	0	0.0	0	0.0	0	0.0	7	954.8	7	954.8
Kopoto	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
<u>Sub-total</u>	0	0.0	34	35,781.1	9	3,758.7	4	1,665.0		91113.9	56	42,318.7
Other Basin	0	0.0	6	15,262.6	0	0.0	2	84.2	0	0.0	8	15,346.8
Total	0	0.0	40	51,043.7	9	3,758.7	6	1,749.2		91113.9	64	57,665.5

The K.K.Bund (Pishin) having reservoir capacity of 55,507,500m³ was not considered in above table.

Table I.1.1 Inventry of Constructed Delay Action Dam

Dam Name	Division	District	Completion of Dam	Construction Cost (Million-Rs)	Dam Dimensions: Dam Height (m)	Crest Length (m)	Catchment Area (sq.km)	Storage Capacity (1000cum)	Desig Flood Discharge (cum/s)	Embank. Volume (1000cum)	Latitude			Longitude		
Daber	KALAT	Kalat	12/31/93	1.6	9.4	762.2	17.19	190.0	226.70	286.2	29	25	53	66	31	28
Dasht-e-Goran	KALAT	Kalat	12/31/91	2.7	14.0	271.3	3.04	146.0	74.63	50.5	28	59	13	66	17	27
Gar	KALAT	Kalat	12/31/82	0.5	15.2	115.9	2.43	123.1	9.29	33.8	29	6	4	66	35	9
Gorpad	KALAT	Kalat	12/31/82	0.5	9.8	244.0	0.90	181.3	39.67	38.8	28	58	24	66	31	10
Laghamgir	KALAT	Kalat	12/31/93	2.5	12.2	135.0	29.20	254.5	153.02	77.4	29	23	51	66	27	53
Loveri	KALAT	Kalat	12/31/93	0.8	6.1	332.3	1.52	60.0	13.66	13.9	29	40	38	66	40	5
Tori Kafta	KALAT	Kalat	12/31/82	0.7	13.7	265.2	4.57	159.1	17.07	55.4	29	19	38	66	34	17
Zaloo	KALAT	Kalat	12/31/93	1.5	8.0	500.0	2.00	50.9	19.63	30.1	29	5	41	66	33	50
Eri Kalag	KALAT	Kharan	12/31/93	2.0	13.8	147.0	11.89	112.8	37.78	35.9	28	41	39	65	7	5
Hazarganji	KALAT	Khuzdar	12/31/81	0.5							27	31	6	66	11	14
Amach	KALAT	Mastung	12/31/87	2.8	15.2	762.0	25.70	1,050.0	83.27	136.0	29	46	55	66	54	39
Duzd Darra	KALAT	Mastung	6/30/84	1.5	15.2	111.3	2.48	12.2	25.11	52.5	29	58	59	66	50	21
Kanak	KALAT	Mastung	12/31/87	3.1	6.1	2225.0	7.01	2,073.2	33.29	124.2	30	10	29	66	46	17
Khad Kucha I	KALAT	Mastung	12/31/84	3.6	15.2	636.0	21.00	522.8	35.22	198.2	29	39	12	66	48	7
Nishpa	KALAT	Mastung	30/6/95	2.9	15.2	204.0	3.84	114.9	53.78	35.7	29	59	14	66	52	41
Sarband	KALAT	Mastung	12/31/93	2.8	12.8	412.0	34.80	-	145.60	60.8	29	32	18	66	27	20
Gori	QUETTA	Chagai	6/30/85	2.5							29	39	10	66	7	46
Khaisar	QUETTA	Chagai	6/30/83	1.6							29	37	35	66	3	55
Adu	QUETTA	Pishin	12/31/87	0.6	11.9	137.5	3.89	2,343.7	50.98	403.7						
Aghberg Kach Hassanzai	QUETTA	Pishin	6/30/93	2.1	12.2	84.7	9.82	764.8	24.78	220.9	30	55	41	67	19	53
Aghbergai	QUETTA	Pishin	12/31/94	0.8	9.4	99.1	6.48	752.4	46.73	118.5	30	48	16	67	18	8
Aghbergi	QUETTA	Pishin	6/30/80	0.3	11.6	91.4	6.48	616.8	42.48	393.1	30	46	17	67	14	34
Amozai	QUETTA	Pishin	12/31/96	2.2	11.0	152.4	6.40	59.3	45.34	26.4	30	52	44	67	19	1
Bachak	QUETTA	Pishin	6/30/94	1.6	7.6	169.8	16.54	1,134.8	44.75	280.4	30	61	0	67	30	45
Balozai	QUETTA	Pishin	6/30/83	1.0	12.2	853.4	6.48	3,022.1	79.30	950.0	30	39	1	67	23	1
Biana	QUETTA	Pishin	6/30/89	0.8	13.7	152.4	10.00	863.5	62.30	298.1	30	45	54	66	50	59
Boghra Secondary	QUETTA	Pishin	6/30/83	0.9	8.1	118.9	24.61	320.7	87.79	268.3						
Bostan Dara	QUETTA	Pishin	6/30/89	6.0	16.0	272.0	23.40	210.0	114.00	164.0	30	24	0	67	2	0
Bund Khushdil Khan	QUETTA	Pishin	12/31/80	1.0	11.6	914.4	1165.54	55,507.5	141.60	573.8	30	41	9	67	3	53
Chachobi	QUETTA	Pishin	12/31/87	0.9	10.4	147.8	10.00	1,110.2	66.01	254.7	30	61	17	67	25	20
Dara Toghai	QUETTA	Pishin	6/30/94	7.0	11.6	259.1	72.52	3,416.8	84.96	977.3	30	49	32	66	58	2
Garang	QUETTA	Pishin	6/30/89	1.7	11.6	137.2	6.48	1,850.3	70.80	391.8	30	45	46	66	49	35
Ghargi	QUETTA	Pishin	6/30/86	1.0	12.2	76.2	19.43	1,233.5	42.48	403.1	30	60	48	67	20	59
Ghez	QUETTA	Pishin	6/30/84	0.2	11.9	329.2	10.10	2,615.0	59.47	351.4	30	54	51	67	22	17
Ghunza	QUETTA	Pishin	12/31/90	0.7	15.2	86.9	3.20	148.1	21.16	23.4	30	55	50	67	17	8

Dam Name	Division	District	Completion of Dam	Construction Cost (Million-Rs)	Dam Dimensions: Dam Height (m)	Crest Length (m)	Catchment Area (sq.km)	Storage Capacity (1000cum)	Desig Flood Discharge (cum/s)	Embank. Volume (1000cum)	Latitude			Longitude		
Injani	QUETTA	Pishin	6/30/83	0.8	4.8	146.3	5.44	986.8	94.90	398.1	31	10	30	67	26	60
Inzargai	QUETTA	Pishin	6/30/94	2.0	11.6	106.7	6.48	1,800.9	28.32	301.7	30	46	32	67	10	13
Kar Manda	QUETTA	Pishin	6/30/86	2.5	13.7	73.2	16.03	1,763.9	84.96	352.3	30	56	51	67	34	23
Khanozai	QUETTA	Pishin	6/30/83	1.2	11.6	670.6	3.89	3,207.1	87.79	1,034.0	30	38	29	67	21	54
Khushab	QUETTA	Pishin	6/30/86	2.0	15.4	164.0	15.20	392.9	75.12	52.2	30	33	34	67	19	52
Khusro	QUETTA	Pishin	6/30/83	0.9	12.2	91.4	16.84	2,713.7	141.60	790.8	31		41	67	35	53
Mahal Tangi	QUETTA	Pishin	6/30/86	0.5	9.1	170.7	10.36	3,022.1	55.22	345.1	31	9	57	67	27	24
Nadira Check detention	QUETTA	Pishin	6/30/93	2.0	2.3	85.3	3.24		49.16	96.3						
Nareen Jahlak	QUETTA	Pishin	6/30/93	1.7	13.7	75.3	10.36	1,800.9	31.15	356.8	30	43	36	67	22	4
Obeki	QUETTA	Pishin	6/30/83	1.0	9.8	231.6	11.66	616.8	56.64	236.0						
Sabnai	QUETTA	Pishin	6/30/86	2.0	11.3	91.4	11.66	740.1	87.08	210.1	30	38	44	67	36	27
Savgi	QUETTA	Pishin	6/30/81	0.4	8.1	118.9	24.61	320.7	39.59	90.2	30	58	39	67	27	13
Shadak	QUETTA	Pishin	6/30/83	0.7	15.1	91.4	9.19	493.4	56.64	349.7						
Sharan Manda	QUETTA	Pishin	6/30/93	2.0	10.4	210.3	14.89	1,196.5	50.98	391.5	30	45	45	66	46	7
Shikar Gat	QUETTA	Pishin	12/31/88	1.2	9.1	213.4	4.53	616.8	30.44	362.5	30	25	27	67	5	5
Spinkai	QUETTA	Pishin	6/30/93	1.6	11.6	85.3	13.80	814.1	29.74	271.9	30	48	28	67	25	9
Surtal	QUETTA	Pishin	6/30/84	1.1	12.2	493.8	19.68	3,083.8	169.92	1,041.6	31	4	38	67	42	35
Temrak	QUETTA	Pishin	12/31/96	7.6	1524.0	189.0	28.06	377.7	119.02	94.7	30	44	57	67	13	41
Tikha	QUETTA	Pishin	6/30/93	3.2	10.7	417.6	10.75	2,578.0	84.96	531.0						
Tokhai Malagzai	QUETTA	Pishin	6/30/81	1.2	11.0	106.7	12.95	1,171.8	53.52	241.9	30	55	34	67	20	55
Tore Khulla	QUETTA	Pishin	6/30/90	2.0	11.0	143.3	11.66	1,048.5	53.81	395.1	30	36	41	67	22	38
Uch Bianzai	QUETTA	Pishin	6/30/93	3.1	13.4	147.8	15.49	2,269.6	101.95	576.5	30	57	4	67	15	10
Ush Tara	QUETTA	Pishin	6/30/93	2.3	12.9	119.5	15.85	1,171.8	42.48	433.3	30	34	56	67	36	16
Zohri	QUETTA	Pishin	6/30/87	1.1	9.4	164.6	11.66	3,083.8	77.46	392.6	30	36	13	67	38	8
Habib Dara I	QUETTA	Quetta	6/30/72	0.1	9.2	54.9	10.36	493.4	16.99	72.5	30	12	42	67	4	45
Habib Dara II	QUETTA	Quetta	12/31/93	2.1	12.2	81.7	12.43	727.8	107.62	263.5	30	12	55	67	4	46
Khora Manda	QUETTA	Quetta	6/30/93	3.4	10.4	238.0	12.20	144.3	129.40	45.7	30	12	46	66	52	15
Marium	QUETTA	Quetta	12/31/93	3.0	14.5	122.0	0.50	43.5	52.71	42.3	30	16	10	67	12	36
Murghi Kotal	QUETTA	Quetta	6/30/79	1.0	8.5	45.7	19.70	493.4	56.64	122.7	30	19	31	66	57	27
Wali Dad	QUETTA	Quetta	6/30/73	0.2	7.7	31.5	5.40	161.6	14.16	56.5	30	17	56	67	16	19
Zawar Kan	QUETTA	Quetta	6/30/86	2.2	12.2	164.6	12.95	1,652.9	72.22	365.4	30	26	60	67	9	40
Akram Tangi	SIBI	Ziarat	12/31/76	0.2	7.6	137.2	5.18	36.6	5.60	8.5	30	23	50	67	45	35
Ghundi	SIBI	Ziarat	12/31/93	2.7	14.3	100.6	12.96	91.8	35.70	28.3	30	28	56	67	34	49
Gogi	SIBI	Ziarat	12/31/81	1.5	18.3	277.4	6.48	487.9	67.20	85.9	30	31	29	67	28	24
Kadi Kach	SIBI	Ziarat	12/31/91	3.0	12.9	114.3	3.88	32.6	23.81	59.0	30	28	2	67	20	59
Mana Storage	SIBI	Ziarat	12/31/92	10.0	36.9	41.8	72.70	1,924.7	275.00	-	30	27	27	67	45	50
Mangi Storage Dam	SIBI	Ziarat	12/31/82	1.0	12.2	125.6	46.74	134.2	126.00	-						
Nazi Tangi	SIBI	Ziarat	12/31/93	2.2	10.8	250.0	11.66	85.4	47.60	37.9	30	27	11	67	39	42

Dam Name	Division	District	Completion of Dam	Construction Cost (Million-Rs)	Dam Dimensions: Dam Height (m)	Crest Length (m)	Catchment Area (sq.km)	Storage Capacity (1000cum)	Desig Flood Discharge (cum/s)	Embank. Volume (1000cum)	Latitude			Longitude		
Pechi	SIBI	Ziarat	12/31/74	0.4	13.1	289.6	18.14	526.9	22.40	32.6	30	25	52	67	42	24
Pinakai	SIBI	Ziarat	12/31/91	2.1	12.8	167.7	15.55	326.9	19.60	35.3	31	35	5	67	26	58
Sasnak Mana Storage	SIBI	Ziarat	6/30/95	4.0	18.9	48.1	16.85	179.3	10.64	2.4	30	30	6	67	47	24
Sharan Storage Bund	SIBI	Ziarat	12/31/75	0.3	10.7	152.4	3.24	157.3	2.80	14.0	30	28	56	67	37	51
Storage Bund at Jungle	SIBI	Ziarat	12/31/79	0.5	10.1	135.7	7.78	36.6	8.40	8.5	30	29	34	67	22	18
Tangi	SIBI	Ziarat	12/31/93	4.9	14.8	126.5	20.74	334.2	31.20	24.0	30	32	21	67	29	51
Verchume Storage Bund	SIBI	Ziarat	12/31/75	0.2	12.2	152.4	-	158.6	5.60	27.6	30	29	19	67	32	40
Zargi Storage Bund	SIBI	Ziarat	1947	0.3	13.7	57.9	90.72	442.7	260.13	22.6	30	30	52	67	42	50
Zindra	SIBI	Ziarat	12/31/71	0.3	7.6	22.9	5.83	41.5	7.00	9.2	30	29	52	67	38	33
China Khundi	ZHOB	Loralai	12/31/93	2.2	9.4	152.4	10.53	38.0	119.00	19.3	31	9	33	69	55	42
Dabri	ZHOB	Loralai	12/31/80	0.3	8.1	30.0	7.77	17.0	14.00	18.2	30	26	7	68	56	24
Gadobra	ZHOB	Loralai			6.0	173.7	25.89	160.0	184.00	37.8	29	49	22	69	25	44
Ghara	ZHOB	Loralai	8/31/93	2.9	10.1	268.2	14.23	131.0	85.00	32.9	30	32	14	69	17	28
Gewari	ZHOB	Loralai	12/31/76	0.7	11.4	60.0	23.30	123.0	156.00	19.0	30	17	3	68	15	56
Gurmi	ZHOB	Loralai	12/31/71	0.3	7.5	41.2	13.30	55.0	42.46	4.5	30	31	16	67	51	56
Kuncha	ZHOB	Loralai	12/31/88	2.1	11.9	164.6	10.36	78.0	52.30	53.8	30	21	12	67	55	19
Mando Kara	ZHOB	Loralai	12/31/85	1.0	9.1	91.4	7.77	58.0	48.13	12.0	30	22	51	67	54	50
Sur Gund	ZHOB	Loralai	6/30/93	1.8	12.2	126.8	9.77	58.0	48.13	12.0	30	35	22	67	48	50
Tirkha Lahri Small (I)	ZHOB	Loralai	6/30/93	5.0	2.7	29.9	12.95	1,095.0	92.55	95.3	30	5	41	68	57	56
Wahvi Small (I)	ZHOB	Loralai	12/31/90	1.9	9.1	60.0	10.36	247.0	92.55	95.3	30	3	41	68	56	19
Bahana	ZHOB	Qilla Saifullah	6/30/91	2.3	12.2	106.7	14.23	163.4	171.63	47.0	30	41	48	68	19	20
Gaati	ZHOB	Qilla Saifullah	12/31/75	0.1	10.7	40.4	2.58	22.0	22.40	13.9	31	2	13	67	48	31
Ghunda Mana	ZHOB	Qilla Saifullah	12/31/92	2.4	11.0	159.3	14.23	107.3	140.00	61.0	30	39	10	68	6	46
Inder Bes	ZHOB	Qilla Saifullah	5/31/85	1.0	15.2	51.8	20.71	109.1	140.00	34.7	31	1	30	67	47	53
Kafir Toi	ZHOB	Qilla Saifullah	6/30/90	2.1	12.5	115.9	38.83	279.3	168.00	56.7	30	39	58	68	33	46
Kan Mehterzai	ZHOB	Qilla Saifullah	12/31/75	0.9	12.8	198.2	9.06	256.1	84.00	95.1						
Kandil	ZHOB	Qilla Saifullah	6/30/93	2.7	15.2	161.6	12.94	137.8	140.00	115.0	30	50	6	67	44	4
Khajir	ZHOB	Qilla Saifullah	6/30/91	6.8	15.2	219.6	25.89	487.9	196.00	156.2	31	14	15	67	29	49
Khushkalwai	ZHOB	Qilla Saifullah	6/30/93	2.8	10.7	122.0	20.71	76.8	84.00	31.0	31	21	6	68	48	31
Mandak	ZHOB	Qilla Saifullah	4/30/81	1.0	12.5	335.4	12.94	208.6	70.00	115.9	30	52	27	67	44	33
Mulazai	ZHOB	Qilla Saifullah	5/31/76	0.6	12.2	122.0	7.76	134.2	70.00	35.0	30	47	51	67	36	8
Murgha Bakarzai	ZHOB	Qilla Saifullah	4/30/85	0.5	7.6	114.3	1.96	108.6	38.64	21.7	30	51	57	67	31	33
Pinakai	ZHOB	Qilla Saifullah	6/30/94	1.9	15.2	115.9	6.47	47.6	72.80	77.1	30	4	49	67	19	45
Sangar	ZHOB	Qilla Saifullah	12/31/83	1.5	14.3	129.6	90.65	170.8	98.00	76.9	30	41	43	67	31	45
Shinshobi	ZHOB	Qilla Saifullah	12/31/74	0.4	11.0	82.3	6.47	329.3	72.80	29.9	30	56	22	67	41	7
Tore Skhur	ZHOB	Qilla Saifullah	12/31/75	0.1	9.1	115.2	3.88	45.1	58.80	30.2						

Table I.1.2 Dam Name of Delay Action Dam around Study Area

Constructed Delay Action Dams				Proposed Dealy Action Dams	
1	Daber	41	Temrak	1	Chapchal
2	Dasht-e-Goran	42	Tokhai Malagzai	2	Iskalku
3	Gar	43	Tore Khulla	3	Ziarat
4	Gorpad	44	Uch Bianzai	4	Isplanji
5	Laghmgir	45	Ush Tara	5	Khad Kucha II
6	Loveri	46	Zohri	6	Chinar Monda
7	Tori Kafta	47	Habib Dara I	7	Habibzai
8	Zaloo	48	Habib Dara II	8	Jigda
9	Amach	49	Khora Manda	9	Nari kach
10	Duzd Darra	50	Marium	10	Pasta Manda
11	Kanak	51	Murghi Kotal	11	Peshi
12	Khad Kucha I	52	Wali Tangi	12	Sanzalai
13	Nishpa	53	Zawar Kan	13	Sher Ghundi
14	Sarband	54	Akram Tangi	14	Spingolona
15	Gori	55	Ghundi	15	Tirkha Manda
16	Khaisar	56	Gogi	16	Zar Tangi
17	Aghberg Kach	57	Kadi Kach	17	Arambi (Ghazlona)
18	Aghbergai	58	Mana Storage	18	Arambi (Mando Lakela)
19	Aghbergi	59	Nazi Tangi	19	Brewary
20	Amozai	60	Pechi	20	Dara
21	Balozai	61	Sasnak Man Storage	21	Murghi Kotal
22	Biana	62	Sharan Storage Bund	22	Nobisar
23	Bostan Dara	63	Storage Bund at	23	Wali Dad
24	Bund Khushdil Khan	64	Tangi	24	Bekok
25	Dara Toghai	65	Verchume Storage	25	Ghary Manda
26	Garang	66	Zargi Storage Bund	26	Sara Berki
27	Ghez	67	Zindra	27	Sara Ghar
28	Ghunza	68	Gurmi	28	Shinmaghzai
29	Inzargai	69	Kuncha	29	Dana
30	Kar Manda	70	Mando Kara	30	Naik
31	Khanozai	71	Sur Gund	31	Srakbula
32	Khushab	72	Kafir Toi	32	Urgasi
33	Khusro	73	Kandil	33	Wrazrumba
34	Nareen Jahlak	74	Mandak	34	Kach
35	Sabnai	75	Mulazai		
36	Savgi	76	Murgha Bakarzai		
37	Shadak	77	Pinakai		
38	Sharan Manda	78	Sangar		
39	Shikar Gat	79	Shinshobi		
40	Spinkai				

Note: Dam location is shown in Fig. I.1.2 by No. in the table.

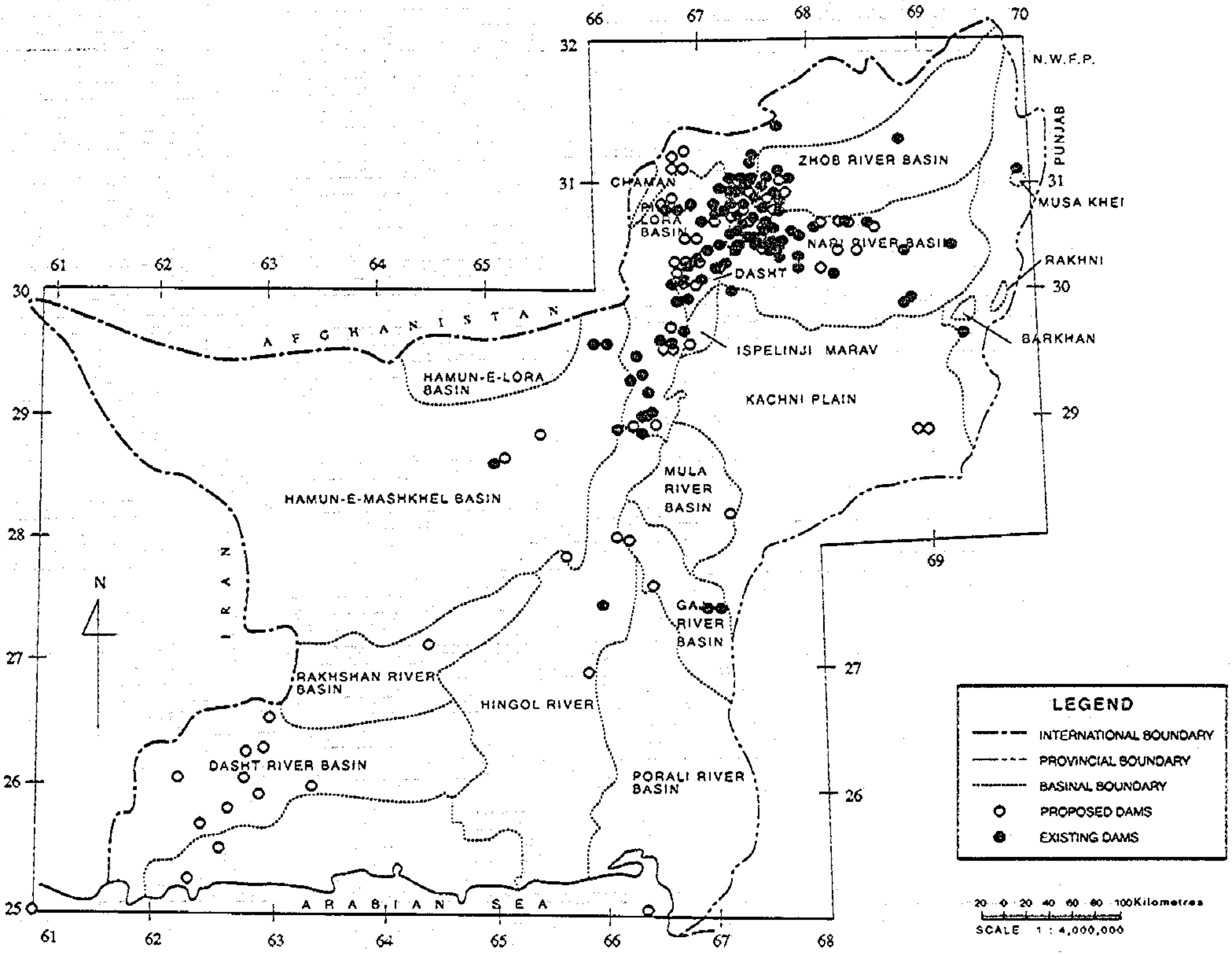


Fig. I.1.1 Dam Location of Delay Action Dams in Balochistan

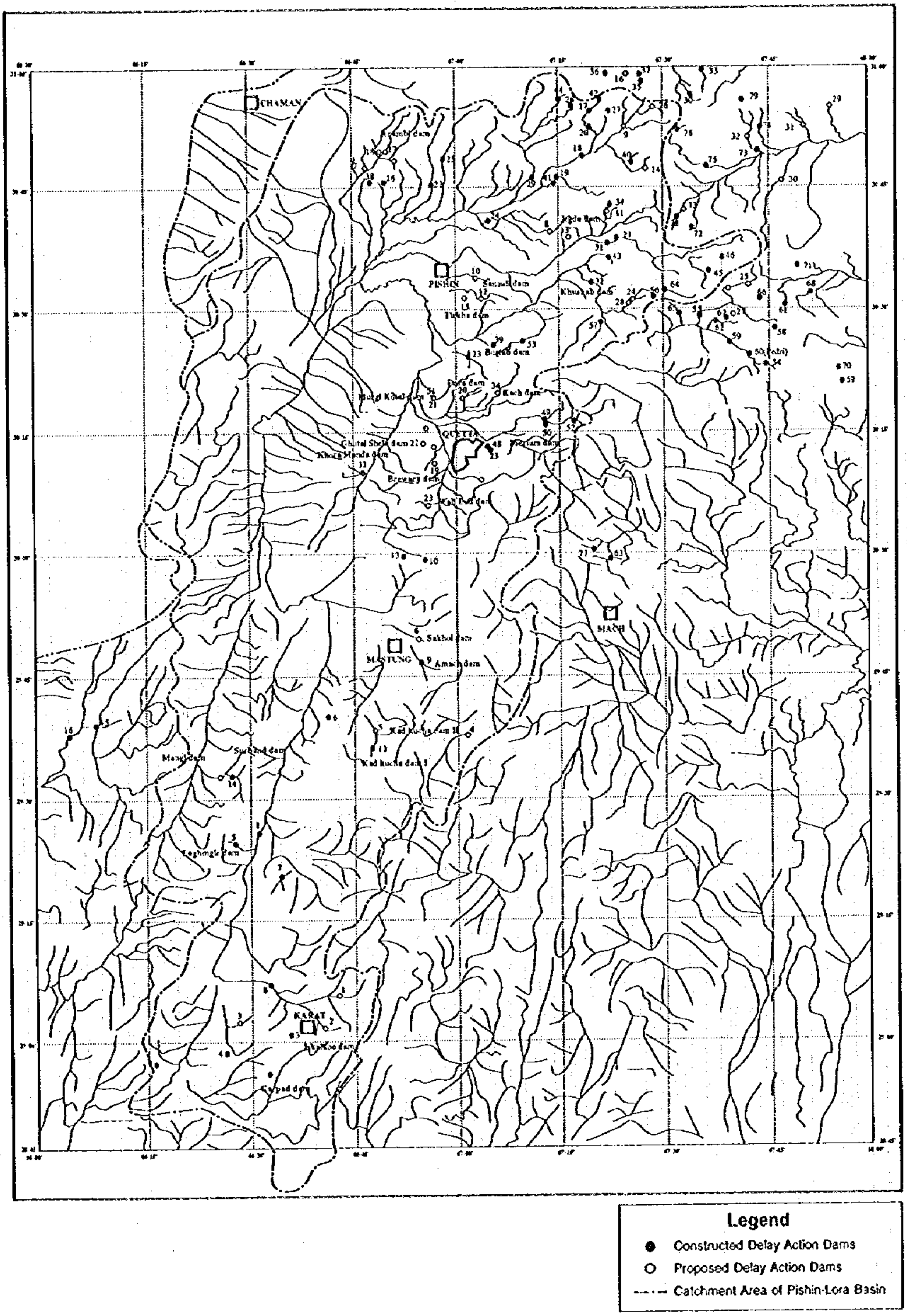


Fig. 1.1.2 Dam Location of Delay Action Dams around Study Area

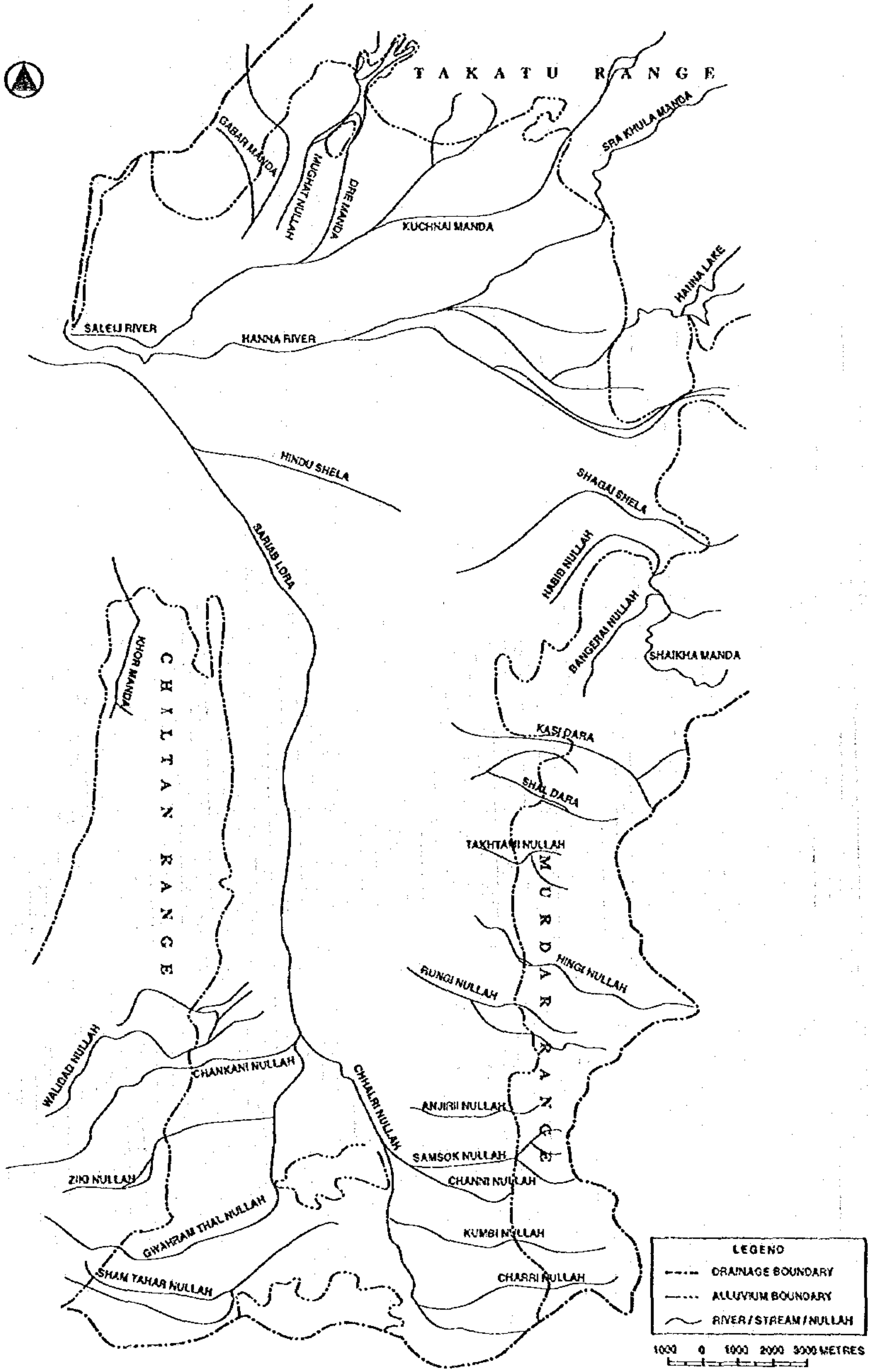


Fig. I.1.3 Potential River Basin for Delay Action Dam Construction in Quetta Valley

I.2 Evaluation of Existing Delay Action Dams

Ten (10) of completed delay action dams have been evaluated in view points of design, construction, operation and maintenance aiming at feedback for further improvement of the proposed dams. Location of these dams are shown in Fig. I.1.2. Controversial points of the dam planning, design construction and O&M are summarized in Table I.2.1 and Details of these dam are listed in Table I.2.2.

Table I.2.1 Observations of Existing Delay Action Dams

	Dam Name	Year Comp.	Dam Type	Catchment Area (sq.km)	Dam Height (m)	Planning	Design	Construction	O&M	Others
1	Khora Manda	1993	Earth	12.23	10.40	Spillway canal is susceptible to erosion because of its unconsoli-dated talus core deposits foundation. Flood flow through the spillway caused flood damages at the left side alluvial fan concentrately.	Spillway forms step configuration in longitudinal section to dissipate water energy. Masonry protection thorough canal surface shall be attained to prevent erosion of scouring by flood.	Rehabilitation of the spillway has been carrying out by the Irrigation Department. Gabion protection of the spillway channel is susceptible to scouring during floods, so that concrete protection is preferable to prevent scouring.	It is suggested to remove siltation which has been accumulated in 0.6m thick in the reservoir.	Flood flow through the spillway located left side abutment caused flood damages at the left side area of alluvial fan concentrately.
2	Marium Manda	1994	Earth	0.45	14.51	Inadequate inflow due to small catchment area has not contributed to the groundwater recharge.	Widening of the canal downstream of the spillway is required to improve flow capacity.	A few borrow materials of river deposits was available at the dam site. Weathered soil which had prominent clayey gradation on the hillside was utilized for embank-ment. Breakout of seepage line may observed on the downstream slope of embankment.	Water quality becomes worse due to long time stagnancy of the water. Water treatment is required for the domestic use.	In planning, diverted water from adjacent catchment area was supplied to the reservoir through conduits. Few water was storaged in the reservoir due to shortly diverted through conduits.
3	Bostan	1990	Earth	23.4	16.00	Inadequate inflow due to small catchment area has not sufficiently contributed to the groundwater recharge.	Large amount of sediment is expected because of steep river gradient. Sediment control device, e.g. detention bund should be constructed.	Spillway is located on the rock foundation composed of limestone. It is however necessary to protect spillway at the inflow portion and downstream with certain materials at where weathered soil is exposed.		
4	Khushab	1986	Earth	15.2	15.00	Recharge ability through the reservoir is insufficient. In addition, no intake device was installed to drain the water in the reservoir. Spillway was eroded by flood due to its unconsolidated talus core deposits foundation.	Spillway was constructed on the unconsolidated talus core deposits. Canal surface should be completely protected with stone riprap to prevent erosion and scouring by flood.	Temporary rehabilitation work for spillway is being carried out at present. Further protection shall be completed through the spillway canal.	Small slope collapse of natural soil was observed in around the impounding area. Siltation composed of fine materials has been deposited at the upstream of the impounding area because the water level of the dam was kept in full water level of the dam.	It is expected that the natural groundwater levels at the dam site and the catchment area are relatively high.
5	Tirkha		Earth	6.7	10.50	Inadequate groundwater recharge was expected due to siltation composed of fine materials in the reservoir. Recharge through recharge pit was not effective owing to its poor recharge capacity.	Dam axis is curved perpendicularly. Curved portion may have defect on stability of the embankment against water pressure. Poor recharge capacity of the pit installed at the downstream of the embankment shall be improved.	It was assumed that the embankment materials were composed of fine gradation materials, e.g. silt, sand. Drain was not installed. Because of low permeability of the dam foundation, periodical observation for piping is required.	Existing recharge pit shall be improved to accelerate recharge capacity. Due to poor permeability of the foundation, groundwater recharge from the river deposits is proposed.	Water conveyance by conduits or open canal is effective to supply irrigation water from dam to beneficial area due to low permeability of the aquifer.
6	Amach	1987	Earth	25.65	15.20	Full water level storage is attained once in 40 years because of its excessively large storage volume of 1.05 million cu.m. Less run-off is expected from ordinary rainfall.	Downstream of the spillway canal is located closing to the dam embankment. Guide wall or retention wall should be constructed to prevent inundation at the toe of the downstream slope of the embankment.	High groundwater recharge is expected through 500m crest length of dam. Ground surface upstream of dam has an inclination to the right abutment corres-ponding to natural terrain. Proper excavation of borrow material contributes effective recharge.	Constant monitoring of karezes is required to evaluate a quantitative effect of the groundwater recharge along with dam construction.	Accumulation of siltation in the storage area is less expected because rivers extend radially, accordingly flood flows down in small creeks distributed in the catchment area.

	Dam Name	Year Comp.	Dam Type	Catchment Area (sq.km)	Dam Height (m)	Planning	Design	Construction	O&M	Others
7	Kad Kocha I	1984	Earth	20.95	15.24	Efficiency of dam storage is low as same that as Amach dam.	Spillway was constructed by the use of a natural undulation. Insufficient leveling of the spillway canal extremely harms flow capacity of the spillway. Guide wall or retention wall should be constructed to prevent inundation downstream of embankment.	Leveling of the spillway canal is required to ensure smooth flow during flood.	Excessive infiltration is observed in particular area in the reservoir during floods. Piping of the embankment materials may cause dam failure.	Accumulation of siltation in the storage area is less expected because rivers extend radially, accordingly flood flows down in small creeks and distributed in the catchment areas.
8	Gorpad I	1982	Earth	0.93	9.75	Impounding water has been contaminated with salinity, accordingly the water is not suitable for irrigation purpose. Salinity accumulation in the impounding area and downstream of the dam embankment shall be worked out. Catchment area is small.	Intake conduit should have been installed to drain storaged water.	Poor compaction of spall layer accelerates gully erosion on the downstream slope of the dam.	Salinity accumulation may be accelerated because of inflow of saline water to the reservoir. Drainage device shall be installed.	
9	Laghmgir	1993	Earth	29.2	12.19	Because spillway was constructed on the unconsolidated talus core deposits, canal base is susceptible to erosion by flood.	Considerable scouring of spillway canal has occurred because of poor protection of the canal. Canal must be completely protected with stone riprap or concrete lining.	Downstream of the embankment forms steep gradient of 1:2. Additional earth work is required to reshape coinciding to specified gradient.	Lowering of spillway canal bed is being carried out to enlarge flow capacity of the spillway. Guideline to determine free board of the dam should be observed.	
10	Sarbund	1993	Earth	34.79	12.80	Because spillway was constructed on the unconsolidated talus core deposits, canal base is susceptible to erosion by flood.	A free board between dam crest and spillway is too deep. Regulation regarding free board shall be required.	Crest elevation is insufficient at the left side abutment. Crest width and downstream gradient of the embankment also dose not satisfy the requirement in specification.	Gully erosion is observed on the downstream slope of the embankment. Spewl layer shall be rehabilitated.	
A	Wali Dad	1973	Earth	5.35	10.50	Siltation has been developed because the narrow and deep valley was selected for the dam site. Gravity dam was also recommended from the geo-topographical points of view. Overflow of dam embankment caused dam collapse.	Concentration of flood flow and increase of flow velocity are induced in the case that the dam is located at a narrow portion of the river. Relatively wider portion of the river be selected for the dam construction.	Concentration of seepage line might be observed at the boundary of clayey and sandy materials in th embankment.	Storage area has been completely filled up with siltation. Embankment was also washed out by flood.	Siltation is composed fine materials. These materials has been consolidated, so not be completely washed out toward downstream during flood flows.
B	Murgi Kotal	1969	Earth	19.65	11.62	Alluvial fans were widely developed at the south and east of the dam site. From this observation, there is abundant sediments production from the catchment area. Sediment control device should be constructed during the planning.	Insufficient flow capacity of the spillway was obtained due to a difficulty of widening of the spillway owing to steep and massive rock abutment at the dam site. Concentration of the seepage line along gravel layers might induce piping in embankment.	Collapse located at the center of the embankment has not rehabilitated. Rehabilitation is urgently required to eliminate further damages. Supplemental embankment of 1.5m was made corresponding to siltation development.	Storage area has been completely filled up with siltation. Embankment was also damaged at the center of the dam crest by flood. Recharge ability was lost due to siltation.	Proposed dam is planned to be located at the same position or 100m upstream of the existing dam. Removal of siltation in the existing reservoir is inevitable either dam site be selected at upstream or downstream of existing dam.
C	Kach	1968	Earth	56.45	26.20	Soil of the catchment area is composed of sand stone, shale and limestone strata. The reservoir has been totally silted up by excessive sediment production at the catchment area. Sufficient sediment capacity should be ensured during the dam planning.	Concrete cut-off wall was heavily damaged by mud pressure of sediment. Poor reinforcement of the wall did not tolerate the pressure. Heavy erosion is observed in the spillway canal.	Assuming that compaction was carried out by roller, an anisotropy of permeability might observed and consequently caused piping.	Storage area has been completely filled up with siltation. Embankment was also heavily damaged at the center of the dam crest by flood. Recharge ability was lost due to siltation. Spillway canal was also heavily eroded by flood.	Existing dam crest was elevated with stone materials to prevent overflow of flood water.

Table I.2.2 Structural Observation of the Existing Dams

(1/13)

1	Dam name	Khora Manda delay action dam
2	Dam location	Quetta district (30-12'-46"N, 66-52'-15"E)
3	Dam type	Earth dam
4	Geological condition	Limestone strate, and talus core deposits
5	Catchment area	12.23 sq.km
6	Resrvoir/ siltation	Siltation composed of fine materials, sand and silt is observed in the reservoir with its thickness of around 0.6 m. Upstream of the dam catchment area is composed of limestone strate. River deposits have been developed in the river bad. Talus core deposits were accumulated at the dam site. River bed slope is relatively gentle in the catchment area. Abutment of the dam site is composed of talus core deposits comprising of consolidated sand and gravel.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: No protection (spall layer only) Crest width: 6.0m (20 feet) Free board: 3.1 m (10 feet) from spillway Overflow head: 1.53 m (5 feet)
8	Spillway	Spillway is located at the left side abutment. Spillway has been heavily eroded at chute canal portion by flood in August 1995. Rehabilitation works is being carried out at present. Longitudinal section forms step shape with its fall depth of around 2.4 m (8 feet). Diversion works are simulteously being carried out at the downstream of the spillway to protect flood damages on the alluvial fan. Comperatively unconsolidated gravel deposits are susceptible to erosion, so that all canal surface shall be protected by stone masonry.
9	Intake/ recharge device	No intake device was constructed. Recharge to the ground water was attained by means of the seepage through the reservoir foundation. Reservoir had adequate storages approaching to full water level for several times during operation. Run-off during monsoon period brings adequate storage water, on the other hand, excessive water flowed out through spillway caused flood damages at the downstream area specified. Lowering of river bed at the downstream of the spillway due to no turbidity water shall be causes flood water concentration in specified area.
10	Recharge condition	Flood water was impounded in the reservoir 7 times during winter rainy seasons. However, adequate ground recharge was not observed during flood according to the information of IPD.

1	Dam name	Marium delay action dam
2	Dam location	Quetta district, (30-16'-01"N, 67-11'-25"L)
3	Dam type	Earth dam
4	Geological condition	Limestone, sandstone and conglomerate (no vegetation on the mountain slope)
5	Catchment area	0.45 sq.km
6	Resrvoir/ siltation	Little water is impounded in the reservoir. (April 15, 1996) Preminant siltation is not observed in the reservoir. Run-off from the adjacent catchment area is diverted to the reservoir through conduits. (Diverted water was not supplied in April, 1996)
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: Protected with stone riprap with 0.225m (0.75 feet) thick. Talus core deposits were utilized for the dam embankment. Embankment may have impermeability.
8	Spillway	Spillway is located at the left side abutment, and constructed on the natural foundation. Canal base and side slope of the spillway canal are protected with the dry stone masonry. Masonry cut-off with gabion-wired has applied for the upstream and down stream ends. Flood has not flowed through the spillway. Canal at the downstream of the spillway is not properly widened.
9	Intake/ recharge device	Any intake structure has not installed. Recharge for the ground water is attained by means of seepage flow through reservoir foundation. Leading pipe line of 153 m of RCC dia. 600mm has been installed to divert water from adjacent catchment area of the dam.
10	Recharge condition	Inadequate inflow dut to small catchment area has not contributed the recharge function. Small springs are located near the reservoir area. It was also planned to shave off the peak floods and minigate flood losses in Urak valley where a lot of damages occur to the precious fruit orchards.

1	Dam name	Bostan Dara delay action dam
2	Dam location	Pishin district (30-23'-30"N, 67-02'-53"E)
3	Dam type	Earth dam
4	Geological condition	Limestone strate
5	Catchment area	23.4 sq.km
6	Resrvoir/ siltation	Water is not impounded in the reservoir (May 1996). Few siltation is observed. Small run-off was onserved compared with its storage capacity.
7	Dam embankment	Embankment materials: River deposits comprised of gravel, sand and silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: Protected with stone riprap with 0.225m (0.75 feet) thick.
8	Spillway	Spillway is located at the right side abutment, and constructed on the natural foundation. Canal base is composed of hard limestone, and no protection was constructed at the downstream of the spillway. Flood water is diversed into the natural river valley adjacent to the dam embankment. Flood has not flowed out through the spillway. Canal protection at the downstream portion of the spillway is necessary to prevent erosion during flood.
9	Intake/ recharge device	No intake structure was not installed. Recharge of the ground water is attained by means of seepage flow through the dam foundation.
10	Recharge condition	Groundwater recharge was in poor condition due to insufficient run-off from the catchment area. Alluvial fan located at te downstream of the dam is composed of high permeability.

1	Dam name	Khushab delay action dam
2	Dam location	Pishin district (30-33'-16"N, 67-19'-32"E)
3	Dam type	Earth dam
4	Geological condition	Shale strate
5	Catchment area	15.20 sq.km
6	Resrvoir/ siltation	Reserver is fully impounded with water (May 1996) Siltation comprised of sand/silt was observed at the upstream of the impounding area. Water level in full water was continued for three to six months every year due to poor seepage capacity of the dam foundation. Land slides around the impounding area were observed. Vegetation in the catchment area is considerably abundant comparing with other dam sites in the study area.
7	Dam embankment	Embankment materials: River deposits comprised of gravel, sand and silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: Protected with stone riprap with 0.225m (0.75 feet) thick.
8	Spillway	Spillway is located at the left side abutment, and constructed on the natural foundation. There are rock foundation exposed at the middle portion of the spillway canal. Inlet portion of the spillway is protected with stone riprap with gabion wire. Besides, heavy erosion caused by flood flow was observed at the downstream of the spillway canal because erozed portion is composed of talus core sediment which has very poor strength against water scouring. Rehabilitation work has been already carried out by the Irrigation Department.
9	Intake/ recharge device	Any intake device has planned to divert the impounding water to downstream. Poor recharge for the groundwater is attained by means of the seepage flow through the dam foundation. Water level is periodically recorded by the Irrigation Department.
10	Recharge condition	Saturated portion was observed at the downsteam of the dam embankment. It is however concluded that the seepage capacity through the dam foundation was insufficient.

1	Dam name	Tirkha delay action dam
2	Dam location	Pishin district
3	Dam type	Earth dam
4	Geological condition	Bostan clay, and talus core deposits
5	Catchment area	6.70 sq.km
6	Resrvoir/ siltation	Full of the water is impounded in the reservoir (April 13, 1996). Siltation with red clay prevents seepage through the reservoir foundation. Catchment area forms undulated configuration composed of thickly accumulated talus core deposits.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: no protection (spall layer only) Dam crest curves perpendicular corresponding to the topography at the dam site.
8	Spillway	Spillway is located at the left side abutment at where natural foundation exists. Spillway canal is protected with the stone masonry. A head between reservoir and downstream river bed is small because of gentle gradient of the river bed at the dam site.
9	Intake/ recharge device	Steel pipe of 150mm (6') diameter has been installted to accerelate recharge to the ground water. Recharge well with 3mx3mx2m length has been constructed at the toe of the embankment downstream slope. Foundation around the recharge well is moistened or saturated with seepage water.
10	Recharge condition	Recharge capacity has declined by 60% by the red clay siltation according to the engineer of IPD. It is proposed to install recharge trench with its length of 300 meters or more to accelerate groundwater recharge. Permeable foundation exists along the river bed. Water diversion to the river is also recommended.

1	Dam name	Amach delay action dam (Completed in June 1986)
2	Dam location	Mastung district (29-46'-55"N, 66-54'-39"E)
3	Dam type	Earth dam
4	Geological condition	Limestone strate
5	Catchment area	25.65 sq.km
6	Resrvoir/ siltation	Little water is impounded in the reservoir (April 23, 1996) Dam was constructed in 1986. Predominant siltation is not observed at the dam site. Tributaries extend radially with gentle gradient. Thick talus core deposits are developed in the catchment area.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1 feet) thick. Slope: 1:2.5 Downstream slope: Protected with stone riprap with 0.225m (0.75 feet) thick. Slope: 1:2.0 Downstream slope of 1:2.0 was applied. Free board: 2.44m (8 feet) Crest length: 756m (2,473 feet) Crest width: 6.0m Horizontal drain of 12.2m x 1.22m thick was installed.
8	Spillway	Spillway is located at the right side abutment at where natural undulation of the lime stone foundation was observed. No protection for the spillway canal was constructed. Retaining wall with the stone masonry was constructed at the downstream of the spillway. Spillway width: 18.0m (60 feet)
9	Intake/ recharge device	No intake device was constructed. Recharge to the ground water is attained by means of the seepage through the reservoir foundation. Reservoir storage capacity of around 1.05 million cu.m is considerably adequate comparing with expected run-off from the catchment area.
10	Recharge condition	Threre exist 9 karezes at the downstream of the dam. 2 to 3 karezes are maintained at present. Obvious recharge effects have not been recorded at these karezes. Depth of water table below the ground level is between 50 - 150 m.

1	Dam name	Kad Kocha (I) delay action dam
2	Dam location	Mastung district (29-39'-12"N, 66-48'-07"E)
3	Dam type	Earth dam
4	Geological condition	Sedimentary rocks of limestone, sand stone, silt stone conglomerate
5	Catchment area	20.95 sq.km
6	Resrvoir/ siltation	Water is not impounded in the reservoir (April 22, 1996) Dam was constructed in 1982. Siltation at the dam site is estimated at less than 50,000cum.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: Protected with stone riprap with 0.225m (0.75 feet) thick. Drain was not installed in the dam body. Crest length: 636m Crest width: 6.0m Dam height: 15.24m
8	Spillway	Spillway is located at the left side abutment at where natural undulation of the rock foundation was observed. No protection for the spillway canal was constructed. Flood water which flows through the spillway may inundates at the downsteam of the embankment because the spillway is located closed to the embankment. Canal bed shall be smoothly excavated to improve flow capacity and flow condition during flood. Crest width: 30.48m, Flood head: 1.22m during design discahrge of 35.22 m3/sec
9	Intake/ recharge device	No iatake device was constructed. Recharge to the ground water is attained by means of the seepage through the reservoir foundation.
10	Recharge condition	Obvious recharge effects have not been recorded at the observation well located at 2km downstream of the dam. Small run-off has been recorded compared with its relatively large catchment area.

1	Dam name	Gorpad delay action dam (I & II) (Completed in 1986)
2	Dam location	Kalat district (28-57'-03"N, 66-32'-13"E)
3	Dam type	Earth dam
4	Geological condition	Mud stone strate
5	Catchment area	0.93 sq.km
6	Resrvoir/ siltation	(Gorpad DAD I, downstream of II dam) Water depth of around 2m was observed (April 25, 1996). Predominat siltation was not observed at the dam site. Saline water was impounded (EC:3,000) (Gorpad DAD II, detention dam for I dam located at upstream of I dam) Water depth of around 0.5m was observed (April 25, 1996). Predominat siltation was not observed at the dam site. Saline water was not impounded.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope is protected with stone riprap with 0.22m (9 inches) thick. Downstream slope is not protected by the riprap, but protected with spall layer. (Gorpad DAD I) Crest length: 244m Crest width: 6.0m Upstream protection: 0.22m (9") (Gorpad DAD II) Crest length: 160m Crest width: 4.6m Upstream protection: 0.22m (9")
8	Spillway	(Gorpad DAD I) Spillway is located at the right side abutment at where natural foundation exists. Spillway canal is protected with the stone masonry. (Gorpad DAD II) Spillway is located at the left side abutment at where natural foundation exists. Spillway canal is protected with the stone masonry.
9	Intake/ recharge device	(Gorpad DAD I) Steel pipe of 150mm (6') diameter was installted to divert water to the downstream.by siphon principle. It was removed due to saline water. Recharge is attained by means of seepage through reservoir foundation. (Gorpad DAD II) Gorpad DAD II was constructed at upstream of Gorpad DAD I to storage pure water instead of Gorpad I dam, no intake device was found.
10	Recharge condition	Impounding water in the Gorpad I has been contaminated with salinity. Salinity accumulation in the impounding area and downstream of the dam embankment shall be worked out.

1	Dam name	Laghamgir delay action dm
2	Dam location	Kalat district (29-22'-56"N, 66-26'-53"E)
3	Dam type	Earth dam
4	Geological condition	Limestone strate
5	Catchment area	29.20 sq.km
6	Resrvoir/ siltation	Dam was constructed in the hilly area composed of limestone strate. Meters of impounding was observed in May 1996. Fine materials were accumulated at the full water level at the upstream of the resrvoir area.
7	Dam embankment	Embankment materials: River deposits comprised of gravel, sand and silt, and talus core deposits. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: No protection (0.3m of stone pitching) Crest length: 135m, width: 20m Seepage line may emerge on the downstream slope of the embankment due to its steep slope gradient (1:2)
8	Spillway	Spillway is located at the left side abutment. Canal slope on the embankment side was protected with grouted stone masonry, however, canal bed and mountain side slope are not protected, so that annual repair works for soil exposed portion are inevitable to prevent erosion. Furthermore, lowering of the spillway canal elevation is being conducted to secure free board between spillway crest and dam crest. Original plan of 36.6m crest width located at right abutment was modified to left abutment. Canal at the embankment side was constructed on the embankment, protecion work shall be additionally achieved to prevent erosion and slope collapse.
9	Intake/ recharge device	No intake device was planned in the reservoir. Recharge of the groundwater is attained by means of the seepage through the dam foundation.
10	Recharge condition	Competatively sufficient recharge was achieved through the dam foundation. Adequate run-off was expected judging from the flood marks remained on the elevated slope of the dam embankment.

1	Dam name	*Sarband delay action dam*
2	Dam location	Mastung district (29-22'-32"N, 66-26'-53"E)
3	Dam type	Earth dam
4	Geological condition	Limestone, shale, sand stone, alluvial soil
5	Catchment area	34.79 sq.km
6	Resrvoir/ siltation	Few water is impounded in the reservoir (May 1996) Siltation is estimated at around hundreds cubic meters only. Tributaries exist radially in the catcment area. River bed slopes are relatively gentle. Existing road in the impounding area will be inundated during flood, furthermore, crop field also damaged during flood. Silt trap by the dam contributes to reducing siltation of the Mangi dam which is proposed to be constructed at the downstream of the Sarband dam.
7	Dam embankment	Embankment materials: River deposits comprised of gravel, sand and silt, and talus core deposits at the both side abutment of the embankment. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) Downstream slope: No protection (spall pitching) Crest width of around 4 m is comperatively narrow compering with other delay action dams. Furthermore, steep slope of the downstream slope may induce emerge of seepage line on the slope. Seepage line may emerge on the downstream slope of the embankment due to its steep slope gradient (1:2)
8	Spillway	Spillway is located at the right side abutment of the embankment. Spillway canal bed is not *protected except its downstream end, so that huge erosion may occur during the flood.* Considerably abundant free board between spillway bed and dam crest was obtained. Flood control capacity of the dam contributes to reducing flood discharge of the Mangi dam which is proposed to be constructed at the downstream of the Sarband dam.
9	Intake/ recharge device	No intake device was installed in the reservoir. Recharge of the groundwater is attained by means of seepage flow through the dam foundation.
10	Recharge condition	Predominat permeability of the dam foundation contributes to high recharge ability through the dam foundation.

1	Dam name	Wali Dad delay action dam
2	Dam location	Quetta district (30-17'-56"N, 67-16'-19"E)
3	Dam type	Earth dam
4	Geological condition	Limestone strate
5	Catchment area	5.4 sq.km
6	Resrvoir/ siltation	Existing embankment has heavily damaged by flood. Impounding area has fully silted up. Elevated river bed by siltation incurred overflow of flood. Siltation is comprised of fine materials (silt, clay) at the dam embankment, and coarse materials (gravel, cobble stone) at 100m upstream of the dam embankment.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: No protection
8	Spillway	Spillway was located at the left side abutment. It is expected that overflow of floods was caused by an inadequate flow capacity of the spillway and its poor structural reinforcement.
9	Intake/ recharge device	No iatake device was constructed. Recharge to the ground water was attained by means of the seepage through the reservoir foundation.
10	Recharge condition	There is effectiveness for the groundwater recharge.

1	Dam name	Murgi Kotal delay action dam
2	Dam location	Quetta district (30-19'-31"N, 66-57'-29"E)
3	Dam type	Earth dam
4	Geological condition	Limestone strate
5	Catchment area	19.7 sq.km
6	Resrvoir/ siltation	*Existing embankment has heavily damaged by flood in July 1977.* Impounding area has fully silted up. Elevated river bed by siltation incurs overflow of flood even though additional embankment of 1.5m height at the dam crest was attained. *Siltation is comprised of fine materials (sand, silt) at the dam embankment, and coarse materials* (gravel, stone) at 100m upstream of the dam embankment.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: Protected with stone riprap with 0.30m (1.0 feet) thick. Crest length: 88.7 m Crest width: 4.0 m (after 1.5 m stone embankment for rehabilitation) Dam height: 11.62 m (after 1.5 m stone embankment for rehabilitation) Dam was completed in 1969, but was washed away in July 1977.
8	Spillway	Spillway is located at the right side abutment. Spillway canal was constructed on the base rock, and delineated with the dam mebankment by the retaining wall of the bricks. It is expected that overflow of floods was caused by an inadequate flow capacity of the spillway and elevated river bed despite of 0.3m (1 feet) cutting of the base during rehabilitation work. Spillway width: 9.79 m
9	Intake/ recharge device	No intake device was constructed. Recharge to the ground water was attained by means of the seepage through the reservoir foundation.
10	Recharge condition	Recharge is unaffordable owing to fully siltation in the impounding area.

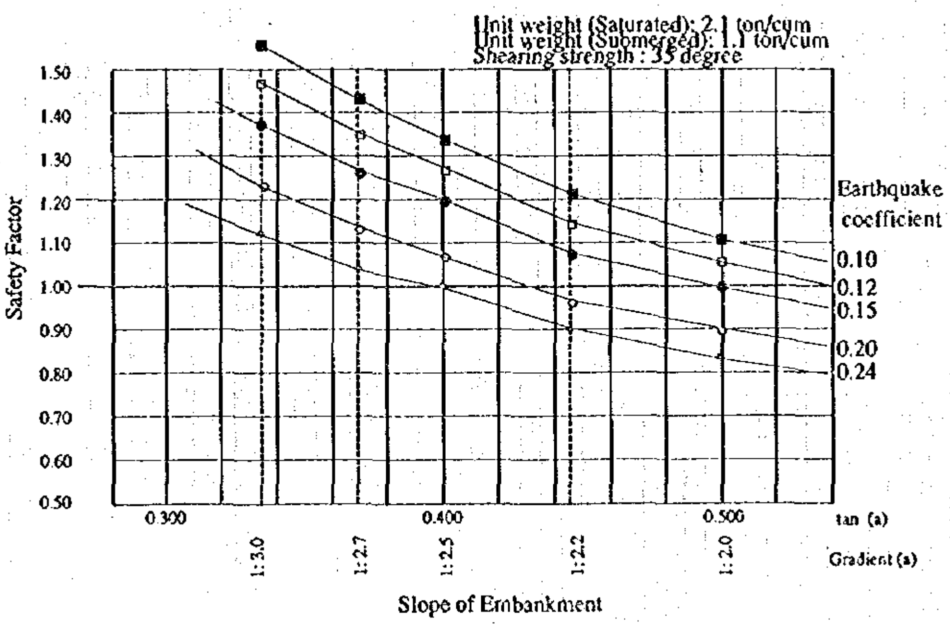
1	Dam name	Kach delay action dam (Completed in 1968)
2	Dam location	Quetta district
3	Dam type	Earth dam (with concrete cut-off wall at the center)
4	Geological condition	Limestone, shale, sandstone strate
5	Catchment area	56.45 sq.km
6	Resrvoir/ siltation	Existing embankment has heavily damaged by flood in 1990. Impounding area has fully silted up after 4 years of compeletion. Total sedimentation was estimated at around 1.05 MCM at present. Elevated river bed by siltation incurred overflow of flood. Siltation is comprised of fine materials (sand, silt, clay) at the dam embankment, and coarse materials (gravel, stone) at 750m upstream of the dam embankment. Dam site is composed of weathered shale (CL class),but it is available for the fill dam foundation.
7	Dam embankment	Embankment materials: River deposits comprised of gravel and sand, silt. Upstream slope: Protected with stone riprap with 0.45m (1.5 feet) thick. Downstream slope: Protected with limestone spall (eroded) Concrete cut-off wall (B=0.5m in average) was constructed at the center of the dam embankment. Crest length: 190.5 m Crest width: 6.0 m Dam height: 26.2 m
8	Spillway	Spillway is located at the right side and upstream of the dam embankment. Spillway canal was not protected for erosion, so that the channel was entirely, heavily erozed. It is expected that overflow of floods was caused by elevated river bed or up-lift force incurred by seepage flow in the dam embankment because the embankment collapse was occurred at the deepest portion of the dam embankment.
9	Intake/ recharge device	Intake devices were composed of circular wet type R.C.C of 3.35m diameter and 23m height, and 450mm diameter RCC pipe for water conveyance. Recharge to the ground water was attained by means of the intake devices above. Seepage through dam foundation was not expected because of its quite low hydrualic conductivity of $1x10^{-5}$cm/sec.
10	Recharge condition	Recharge is unaffordable owing to fully siltation in the impounding area.

I.3 Basic Study on Dam Stability and Seepage through Dam Foundation

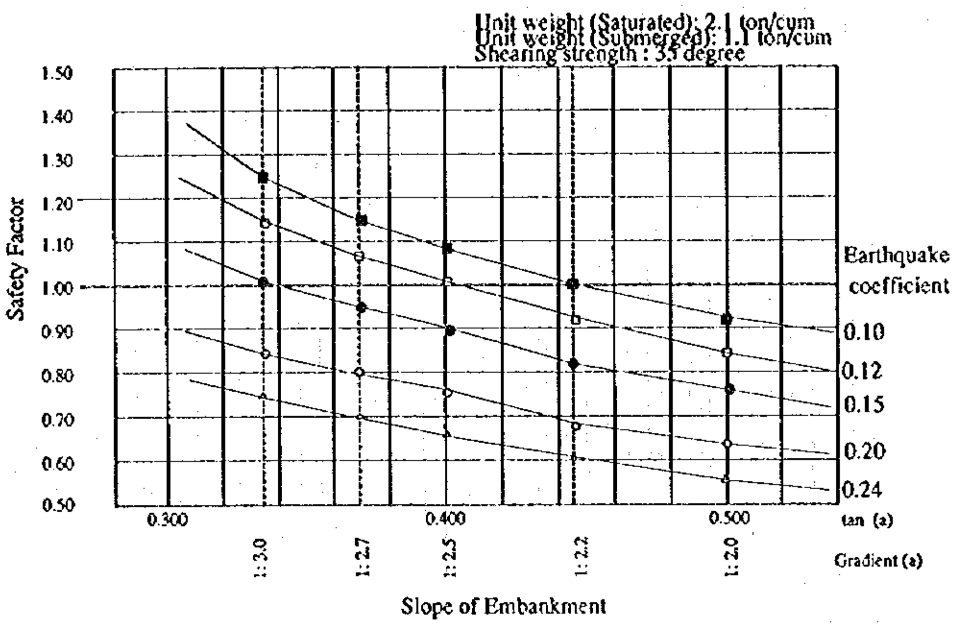
I.3.1 Dam Stability

(1) Stability Analysis of Dam Embankment

Embankment slopes of the upstream and downstream of the existing dams were determined at 1:2.00 and 1:3.00, respectively. Stability of the upstream slope is roughly examined referring to the safety factor against surface sliding in dam empty and submerged condition. The following figure shows relation between slope, earthquake coefficient and safety factor, assuming saturated unit weight of material of 2.1 ton/m^3, and shearing strength of 35° in all cases. Resulting from this, safety factor of 1.0 is attained when the slope is 1:2.50 or more gentle on condition that dam is empty and earthquake coefficient is 0.24. Besides, safety factor of 1.0 is attained when the slope is 1:2.00 or more gentle in the case of earthquake coefficient of 0.12. Assuming embankment slope of 1:2.0, the embankment is collapsed with earthquake coefficient of 0.08 or more in submerged condition. As gravel - sand materials, which cohesion is not expected, are generally placed on the slope surface, it is recommended that the upstream slope is to be 1:2.50 or more gentle on condition that earthquake coefficient can be reduced by 50 % of the design coefficient for the reason that an earthquake of design coefficient is not probably occurred when reservoir is impounding.



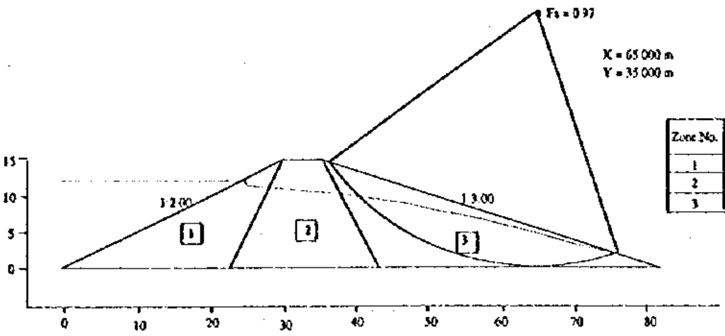
Relation between Dam Slope and Safety Factor in Different Earthquake Coefficient (Dam empty)



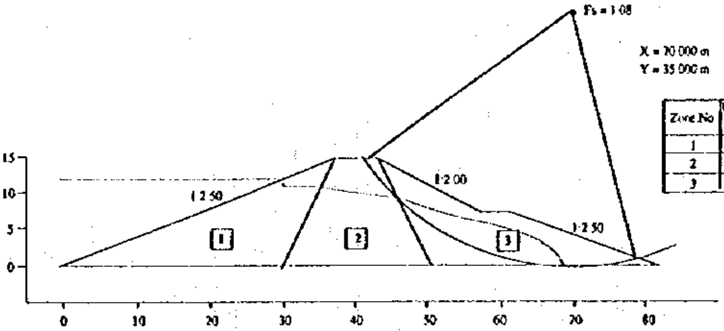
Relation between Dam Slope and Safety Factor in Different Earthquake Coefficient (Impounding)

Discussing the downstream slope, 1:3.0 is applied for the most of existing delay action dams so as not to allow a seepage water broken out from the downstream slope. Stability analysis was conducted for the cases of the gradients of 1:3.0 and 1:2.5 downstream slopes. Resulting from these analyses, it was concluded that the stability factors of both cases were estimated at almost the same because of the different seepage line elevations due to installation of the toe drain on the slope of 2.5. Accordingly, it is recommended concerning to the minimization of the embankment volume that the slope gradient downstream of the dam embankment is to be 1:2.5 for the dams of its dam height of around 15 to 20 m on condition that the toe drain or horizontal drain is installed.

On the other hand, in the case that the dam height is 20 m or higher, upstream slope must be more gentle, e.g. 1:2.7 to 1:3.0 or more because of a reduction of the resistance force due to an increase of the submerged area in the embankment section.



Zone No.	Unit weight of saturated (t/m3)	Unit weight of compacted (t/m3)	Internal angle	Cohesion (t/m2)	Earthquake Coefficient
1	2.18	1.90	38.0	0.0	0.20
2	2.18	1.90	38.0	0.0	0.20
3	2.18	1.90	38.0	0.0	0.20



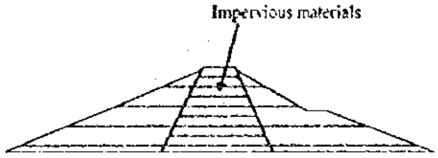
Zone No	Unit weight of saturated (t/m3)	Unit weight of compacted (t/m3)	Internal angle	Cohesion (t/m2)	Earthquake Coefficient
1	2.18	1.90	38.0	0.0	0.20
2	2.18	1.90	38.0	0.0	0.20
3	2.18	1.90	38.0	0.0	0.20

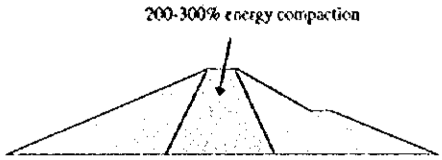
(2) Zoning of Embankment

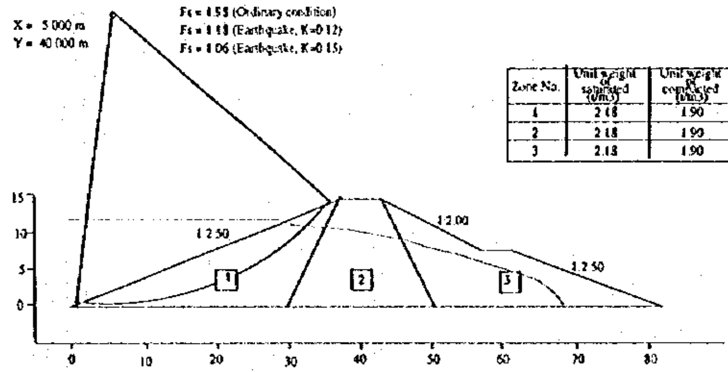
1) Slope gradient

Most of dams have been constructed as a homogeneous fill type dam with their sandy, soil materials mixture ratio of 3:2. Heavily weathered materials or talus core deposits around the dam abutment were utilized for soil materials. Because of the difficulty to uniformly mix the sandy materials and clayey materials with proper moisture content, two types of the zoning of embankment are proposed. One is composed of two zonings, i.e. upstream and downstream zones with permeable materials (shear materials), and center core zone with semi-permeable materials. The other is composed of not obviously different materials, but the center portion of the embankment is compacted with larger energy rather than the upstream and downstream portion aiming at improvement of permeability, accordingly the lowering of the seepage line at the center portion is attained.

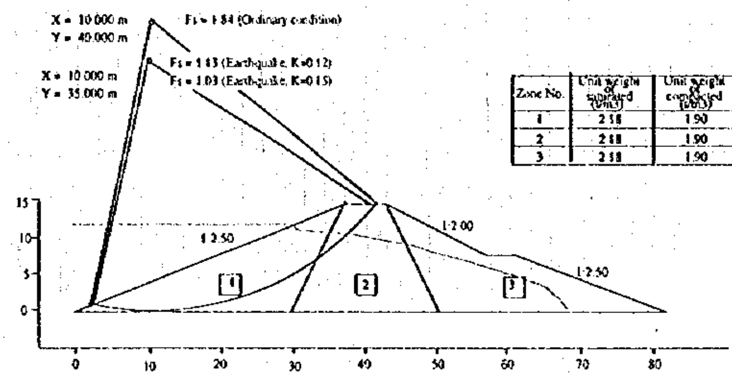
Stability analyses of above alternatives were carried out with proper physical parameters which provided appropriate shear strengths and unit weights of the river bed materials available around the dam site. It was concluded that the stability factors of the upstream were almost the same, however, stability of the downstream of which sand-gravel materials are placed is more effective against sliding, especially during earthquake.



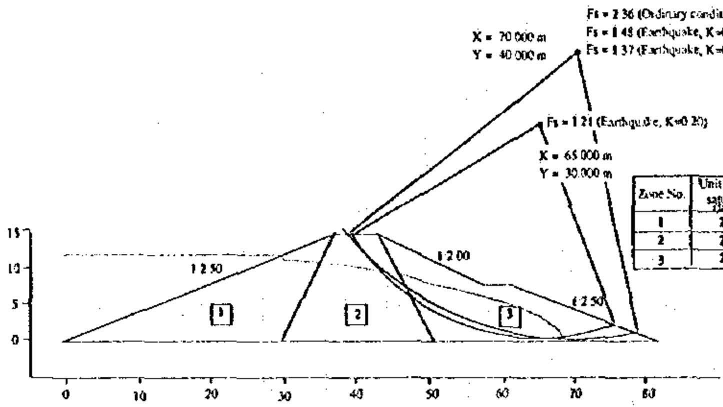




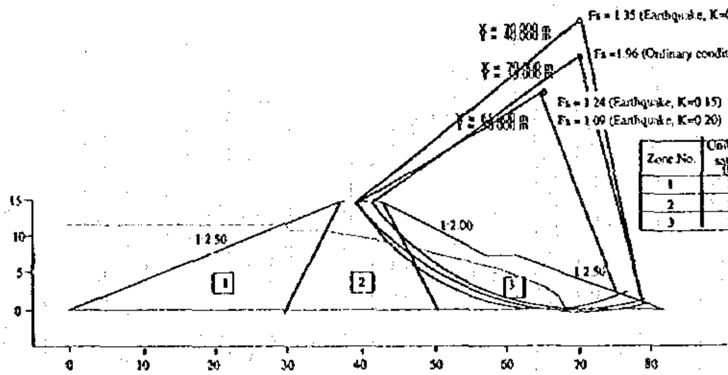
Zone No.	Unit weight of saturated (t/m3)	Unit weight of compacted (t/m3)	Internal angle	Cohesion (t/m2)	Earthquake Coefficient
1	2.18	1.90	38.0	0.0	0.12-0.15
2	2.18	1.90	28.0	0.5	0.12-0.15
3	2.18	1.90	38.0	0.0	0.12-0.15



Zone No.	Unit weight of saturated (t/m3)	Unit weight of compacted (t/m3)	Internal angle	Cohesion (t/m2)	Earthquake Coefficient
1	2.18	1.90	32.0	0.5	0.12-0.15
2	2.18	1.90	32.0	0.5	0.12-0.15
3	2.18	1.90	32.0	0.5	0.12-0.15



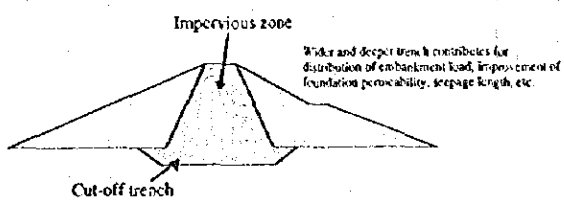
Zone No.	Unit weight of saturated (t/m3)	Unit weight of compacted (t/m3)	Internal angle	Cohesion (t/m2)	Earthquake Coefficient
1	2.18	1.90	38.0	0.0	0.12-0.20
2	2.18	1.90	28.0	0.5	0.12-0.20
3	2.18	1.90	38.0	0.0	0.12-0.20



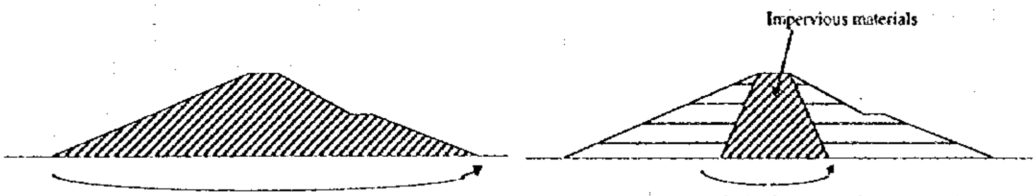
Zone No.	Unit weight of saturated (t/m3)	Unit weight of compacted (t/m3)	Internal angle	Cohesion (t/m2)	Earthquake Coefficient
1	2.18	1.90	32.0	0.5	0.12-0.20
2	2.18	1.90	32.0	0.5	0.12-0.20
3	2.18	1.90	32.0	0.5	0.12-0.20

2) Safety against seepage flow of foundation

River deposits have been thickly accumulated at the dam sites. These river deposits have high permeability due to several unconsolidated layers, and voids in the layers. In this regard, homogeneous type fill dam with proper impermeable materials is recommended to attain sufficient seepage length, which contributes to decline hydraulic gradient in the foundation. Furthermore, wider and deeper cut-off trench are also effective to maintain the above, and also to attain high bearing capacity from the view point of dam stability and elimination of irregular settlement of embankment.

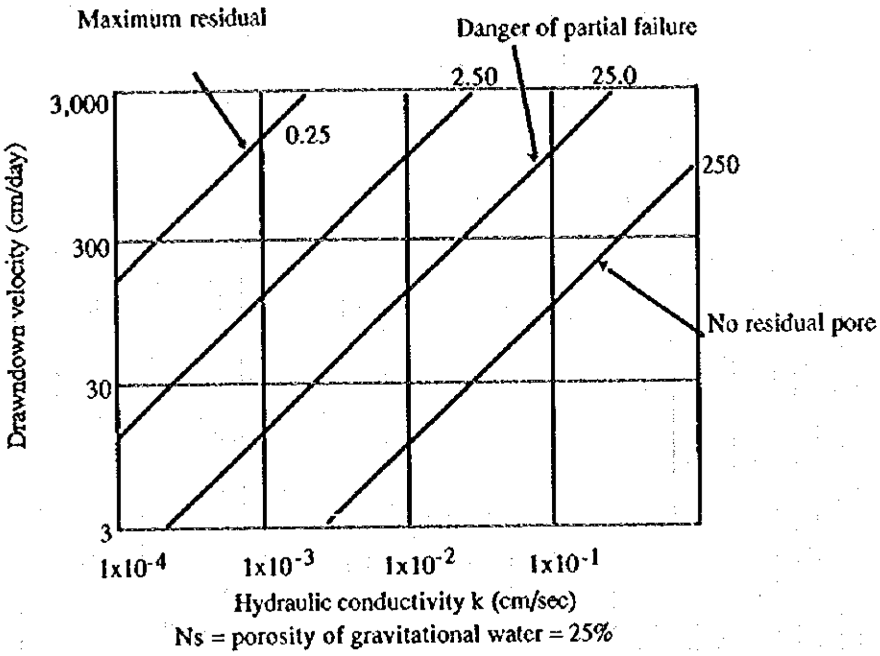


In general, zone type fill dam is designed for the high dams in order to secure dam stability. Zone type fill dam is, however, composed of high shear strength but pervious materials at the zones of upstream and downstream, hydraulic gradient at impervious zone becomes steep without proper foundation treatment such as grouting. In this connection, it is recommended that the homogeneous type fill dam is constructed at where dam foundation is composed of permeable material, and zone type fill dam is allowable at where impermeable foundation exists with proper foundation and abutments treatment by means of grouting and clogging cracks by proper materials.



3) Rapid drawndown

Rapid drawndown of the water level implies the situation where internal water level of the embankment does not decrease following drawndown of the reservoir level. In such case, upstream water pressure is reduced and water level difference becomes great between the reservoir and internal part of the embankment, resulting in a very dangerous condition in dam stability due to a seepage flowing towards the reservoir side. When hydraulic conductivity of the embankment material is less than 10^{-7} cm/sec, internal water level exhibits almost no change. Therefore, generally, 100 % of the pore pressure before drawndown at full reservoir level remains in the case of the impervious materials. Safety factor for the various slopes can be obtained from the table developed by Morgensstern. The relationship between the drawndown velocity of the reservoir level and stability of the slope when hydraulic conductivity "k" is 10^{-1} to 10^{-3} cm/sec and slope is 1:3. If drawndown velocity is 30 cm/day and the hydraulic conductivity is less than 10^{-2} to 10^{-3} cm/sec, the slope failure may occur even for such a slope with gradient of 1:3.



The drawndown velocity of 25 - 30 cm/day is expected for the delay action dams assuming that the storage water is drained within 60 days. Referring to the figure above, the materials having hydraulic conductivity of $1x10^{-3}$ cm/sec shall be placed at the upstream of the embankment.

The zoning is determined taking account of the stability of the dam embankment, embankment height and volume, availability of the materials including its natural moisture content, permeability and bearing strength of the foundation, and construction machinery as well.

I.3.2 Seepage through Dam Foundation

Seepage analysis was conducted to determine:

1) seepage rate through dam embankment and foundation,
2) reduction of seepage discharge due to sedimentation in the reservoir,
3) effectiveness of drain installation for dam embankment, and
4) application for embankment planning.

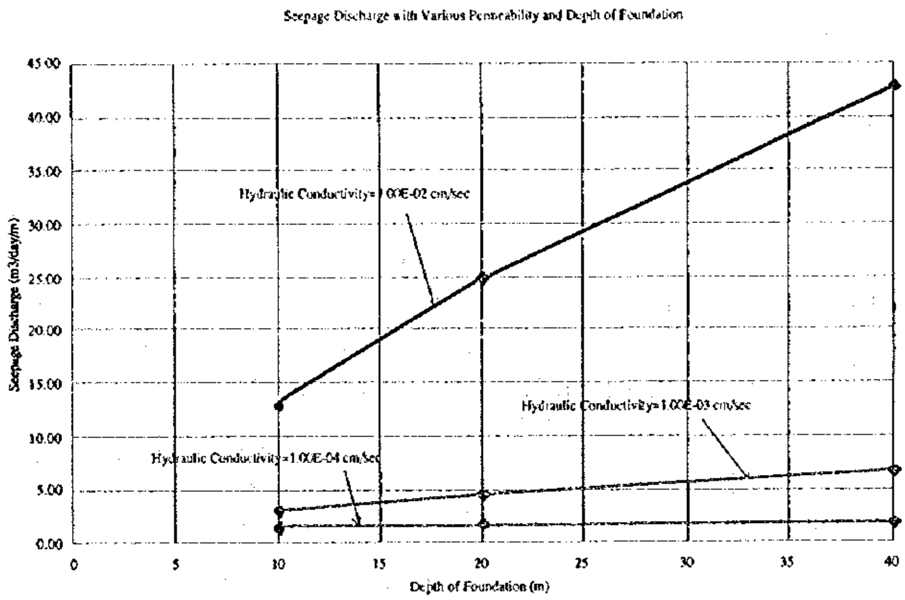
Hydraulic parameter and model is shown in Table I.3.1, Fig. I.3.1, I.3.2.

Case	Descriptions
Case-1	**Quantitative seepage flow discharges** Hydraulic conductivity and thickness of aquifer are assumed based on the geological investigation in proposed dam site during the Study. Hydraulic conductivity of foundation: 1×10^{-2} - 1×10^{-4} cm/sec Hydraulic conductivity of embankment: 5×10^{-4} cm/sec (Hydraulic conductivity of toe drain: 1×10^{-1} cm/sec) Thickness of aquifer: 40 - 10 m
Case-2	**Reduction of seepage flow discharges by sediment accumulation in the reservoir** *Hydraulic conductivity of sediment: 5×10^{-4} cm/sec* Hydraulic conductivity of foundation: 1×10^{-2} - 1×10^{-3} cm/sec Hydraulic conductivity of embankment: 5×10^{-4} cm/sec (Hydraulic conductivity of toe drain: 1×10^{-1} cm/sec) Thickness of sediment: 5, 10 m Thickness of aquifer: 40, 10 m
Case-3	**Reduction of seepage flow discharges by sediment accumulation in the reservoir with period** *Hydraulic conductivity of sediment: 5×10^{-4} cm/sec* 1. Immediately after completion of the embankment 2. 5m development of sediment 3. 10m development of sediment
Case-4	**Lowering of seepage line due to center core establishment** Hydraulic conductivity of foundation: 2.5×10^{-4} - 1×10^{-4} cm/sec Hydraulic conductivity of other zone: 5×10^{-4} cm/sec
Case-5	**Lowering of seepage line due at horizontal drain installation**

Result of these cases are listed in Table I.3.2.

(1) Quantitative seepage flow discharges

The following shows relation of seepage discharge through dam embankment and foundation. Resulting from this, it is concluded that the seepage discharge increases mostly linear relation together with increase of aquifer thickness, however, it exponentially decreases together with lowering of the hydraulic conductivity. Because the hydraulic conductivity of the proposed dams range between 1×10^{-3} to 1×10^{-4} cm/sec, small quantity, is expected through the foundation.



(2) Reduction of seepage flow discharges by sediment accumulation in the reservoir

With 5 m sedimentation of its hydraulic conductivity of 5×10^{-5} cm/sec, around 50 to 60 % of the the seepage discharge reduction is observed, and around 70 to 75 % of the the seepage discharge reduction is observed when the sediment reaches 10 m depth. Reduction of seepage discharge is obviously caused by decrease of hydraulic gradient due to head loss in the sediment, other word by increase of seepage path length, given by following equation:

$$Lr = ((Kf \times Zf \times Zb)/Kb)^{0.5}$$

where:

Lr:	increase of seepage path length
Kf:	hydraulic conductivity of foundation
Zf:	foundation thickness
Zb:	sediment thickness
Kb:	vertical hydraulic conductivity of sediment

(3) Reduction of seepage flow discharges by sediment accumulation in the reservoir with period

Case-3 explains seepage reduction together with sediment development including upstream portion of embankment. As a result, the seepage discharge is reduced by 30 % compared with that of before the sediment accumulated in the reservoir.

(4) *Lowering of seepage line due to center core establishment*

Establishment of core zone in the center of the embankment is proposed to maintain dam stability as explained in Annex "Standard Section of Dam Embankment". Improvement of the hydraulic conductivity of the core zone is achieved by embankment of the impervious materials or compaction with larger energy. In the analysis, improvement effect of hydraulic conductivity by means of latter method is applied. It is concluded that the 1.0 m and 3 m lowering of the seepage line is expected on condition that the conductivity is reduced from $5x10^{-5}$ to $2.5x10^{-5}$ cm/sec, and to $1x10^{-5}$ cm/sec, respectively.

(5) Lowering of seepage line due at horizontal drain installation

To improve the stability of the downstream of the embankment, horizontal drain is installed, especially for the dams of their height of more than 25 m. The obvious changes of the seepage flow is as follows:

1) seepage line in the embankment is remarkably drawndown
2) seepage discharge increases around 60 to 70 % comparing with non installation of the drain.
3) hydraulic gradient near the horizontal drain is around 0.85 to 0.90.

Resulting from the results above, the following must be achieved during the planning and construction:

1) filter materials of proper grain distribution must be placed around the drain materials to prevent piping.
2) recharge device is planned because seepage flow through horizontal drain is remarkably increased.

(6) Seepage analysis of high dam

Seepage lines in the embankment of the homogeneous type and zone type fill dams were analyzed according to the several combinations of the hydraulic conductivity of the materials and thickness of the dam foundation. Analysis results are illustrated in next sheets, and the following are concluded:

1) In the case that the embankment is composed of semi-pervious materials, breakout point on the downstream slope is elevated comparing with embankment of impervious materials due to low hydraulic loss. (Case-1&2)

2) Lowering of seepage line is not obviously observed according to the depth of the permeable dam foundation. (Case-3&4)

3) Impervious zone contributes to lowering of seepage line in the embankment. Deference of the seepage lines of Case-5 and 6 corresponds to the specified hydraulic conductivity of pervious and impervious zones. (Case-5&6)

4) Horizontal drain is mostly effective to lower seepage line in the embankment. (Case-7&8)

Table I.3.1 Material Permeability

(unit: cm/sec)

Case		Foundation (1)	Foundation (2)	Foundation (3)	Foundation (4)	Upstream zone	Center core	Horizontal drain	Downstream zone	Sediment (1)	Sediment (2)	Toe drain
1-1	Permeable foundation with 40m depth	1.00E-02	1.00E-02	1.00E-02	1.00E-02	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-2	Permeable foundation with 20m depth	-	-	1.00E-02	1.00E-02	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-3	Permeable foundation with 10m depth	-	-	-	1.00E-02	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-4	Semi-permeable foundation with 40m depth	1.00E-03	1.00E-03	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-5	Semi-permeable foundation with 20m depth	-	-	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-6	Semi-permeable foundation with 10m depth	-	-	-	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-7	Impermeable foundation with 40m depth	1.00E-04	1.00E-04	1.00E-04	1.00E-04	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-8	Impermeable foundation with 20m depth	-	-	1.00E-04	1.00E-04	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
1-9	Impermeable foundation with 10m depth	-	-	-	1.00E-04	5.00E-04	5.00E-04	-	5.00E-04	-	-	1.00E-01
2-1	Permeable foundation and 10m sediment	1.00E-02	1.00E-02	1.00E-02	1.00E-02	5.00E-04	5.00E-04	-	5.00E-04	5.00E-05	5.00E-05	1.00E-01
2-2	Permeable foundation and 5m sediment	1.00E-02	1.00E-02	1.00E-02	1.00E-02	5.00E-04	5.00E-04	-	5.00E-04	5.00E-05	-	1.00E-01
2-3	5m sediment and Semi-permeable foundation with 40m depth	1.00E-03	1.00E-03	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	5.00E-05	-	1.00E-01
2-4	5m sediment and Semi-permeable foundation with 20m depth	-	-	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	5.00E-05	-	1.00E-01
2-5	10m sediment and Semi-permeable foundation with 40m depth	1.00E-03	1.00E-03	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	5.00E-05	5.00E-05	1.00E-01
2-6	10m sediment and Semi-permeable foundation with 20m depth	-	-	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	5.00E-05	5.00E-05	1.00E-01
3-1	40m semi-permeable foundation without sedimentation	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-05	5.00E-04	-	5.00E-04	-	-	1.00E-01
3-2	40m semi-permeable foundation with 5m sedimentation	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-05	5.00E-04	-	5.00E-04	1.00E-05	-	1.00E-01
3-3	40m semi-permeable foundation with 10m sedimentation	1.00E-03	1.00E-03	1.00E-03	1.00E-03	5.00E-04	5.00E-04	-	5.00E-04	1.00E-05	1.00E-05	1.00E-01
4-1	20m semi-permeable foundation and impervious core zone	-	-	1.00E-03	1.00E-03	5.00E-04	1.00E-04	-	5.00E-04	-	-	1.00E-01
4-2	20m semi-permeable foundation and impervious core zone	-	-	1.00E-03	1.00E-03	5.00E-04	2.50E-04	-	5.00E-04	-	-	1.00E-01
5-1	20m semi-permeable foundation and horizontal drain	-	-	1.00E-03	1.00E-03	5.00E-04	5.00E-04	1.00E-01	5.00E-04	-	-	5.00E-04
5-2	10m semi-permeable foundation and horizontal drain	-	-	-	1.00E-03	5.00E-04	5.00E-04	1.00E-01	5.00E-04	-	-	5.00E-04

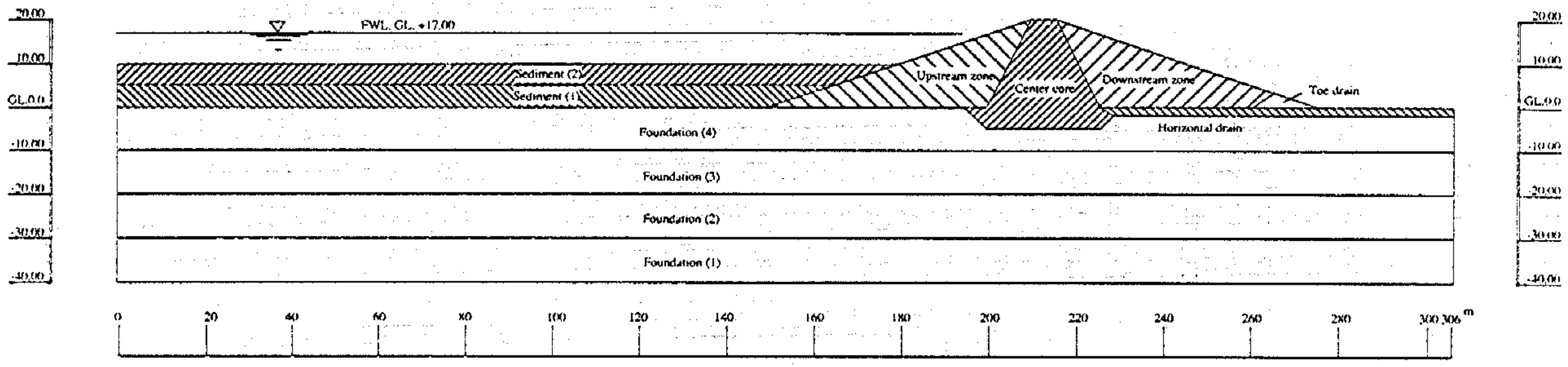


Fig. I.3.1 Model of Seepage Flow Analysis

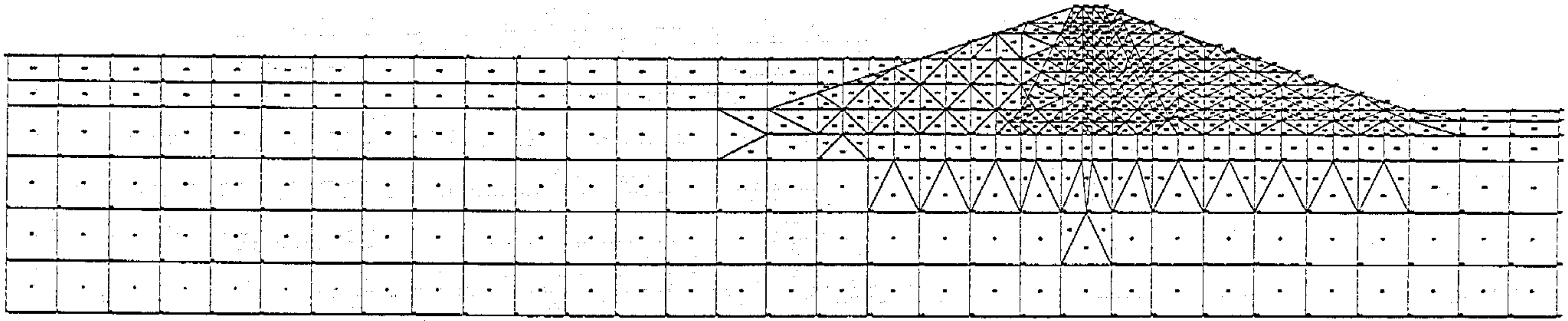
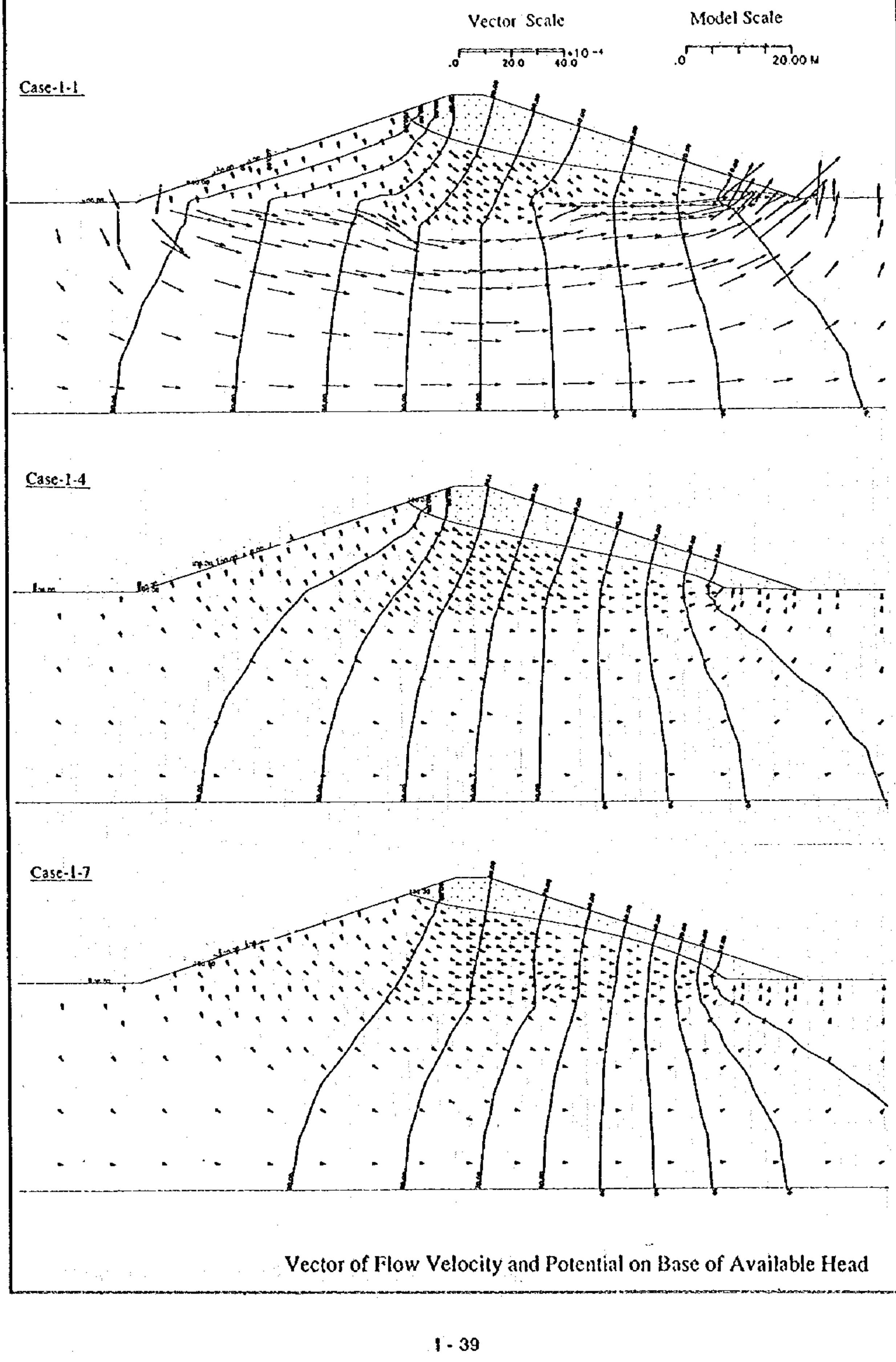


Fig. I.3.2 Element and Node Number of Model

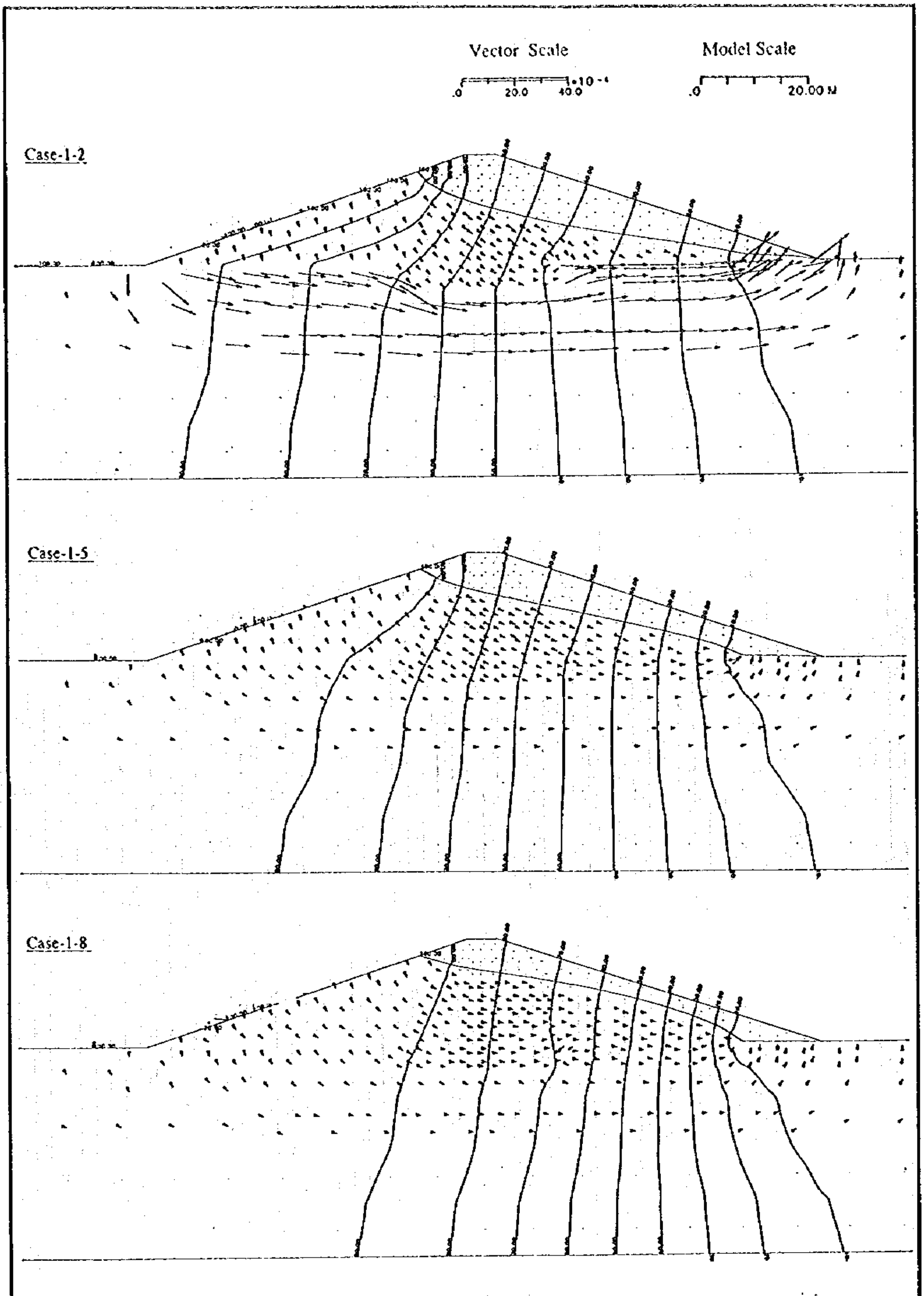
Table I.3.2 Results of Seepage Flow Discharge

Case	Depth of foundation (m)	Hydraulic conductivity (Foundation) (cm/sec)	Sediment depth (m)	Hydraulic conductivity (Sediment) (cm/sec)	Outflow foundation (A) (m3/day/m)	Outflow embankment (B) (m3/day/m)	Outflow total (A)+(B) (m3/day/m)	Remarks
1 - 1	40	1.00E-02	-	-	42.37	0.56	42.93	
2	20	1.00E-02	-	-	23.95	1.04	24.99	
3	10	1.00E-02	-	-	12.13	0.94	13.07	
4	40	1.00E-03	-	-	4.98	1.83	6.81	
5	20	1.00E-03	-	-	2.93	1.77	4.70	
6	10	1.00E-03	-	-	1.45	1.76	3.22	
7	40	1.00E-04	-	-	0.78	1.27	2.06	
8	20	1.00E-04	-	-	0.54	1.27	1.81	
9	10	1.00E-04	-	-	0.34	1.29	1.63	
2 - 1	40	1.00E-02	10	5.00E-05	21.16	0.58	21.74	Hydraulic conductivity of the enbankment merains 5.00E-04 cm/sec.
2	40	1.00E-02	5	5.00E-05	28.07	0.76	28.83	- ditto -
3	40	1.00E-03	5	5.00E-05	5.78	0.90	6.68	- ditto -
4	20	1.00E-03	5	5.00E-05	3.80	0.88	4.68	- ditto -
5	40	1.00E-03	10	5.00E-05	4.70	1.73	6.43	- ditto -
6	20	1.00E-03	10	5.00E-05	2.87	1.73	4.60	- ditto -
3 - 1	40	1.00E-03	-	-	4.98	1.83	6.81	
2	40	1.00E-03	5	1.00E-05	1.88	0.67	2.55	Hydraulic conductivity in upstream zone is reduced to 1.00E-5 by silt clogging.
3	40	1.00E-03	10	1.00E-05	1.43	0.51	1.94	- ditto -
4 - 1	20	1.00E-03	-	-	3.13	0.72	3.84	Hydraulic conductivity in center core zone is reduced to 1.00E-4
2	20	1.00E-03	-	-	2.69	1.62	4.31	Hydraulic conductivity in center core zone is reduced to 2.50E-4
5 - 1	20	1.00E-03	-	-	0.70	6.65	7.35	Horizontal drain (k=1.00E-1) is installed
2	10	1.00E-03	-	-	0.21	5.41	5.62	- ditto -

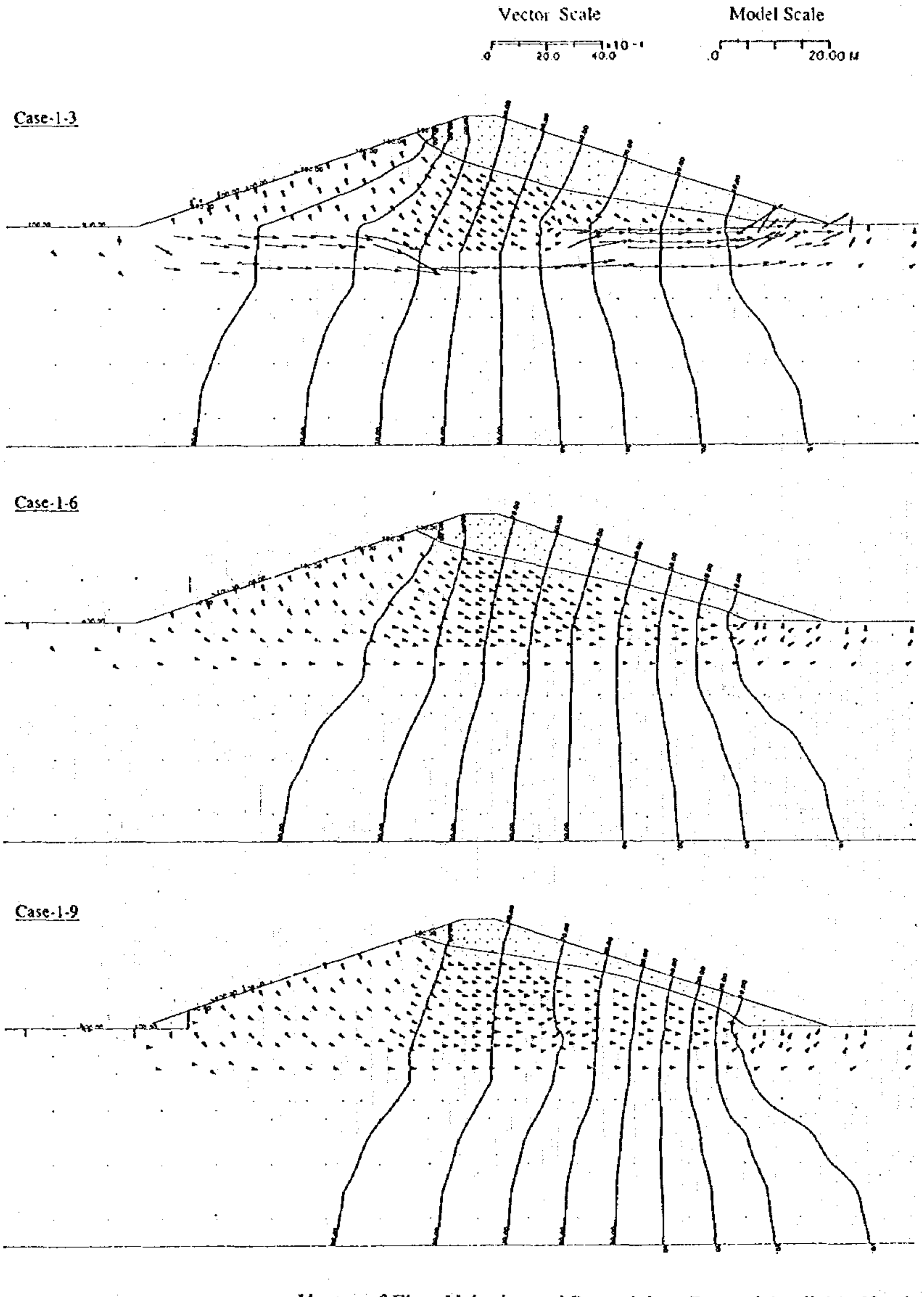
Notes: Vector of seepage velocity and potential line in each case are shown in attached below.



Vector of Flow Velocity and Potential on Base of Available Head

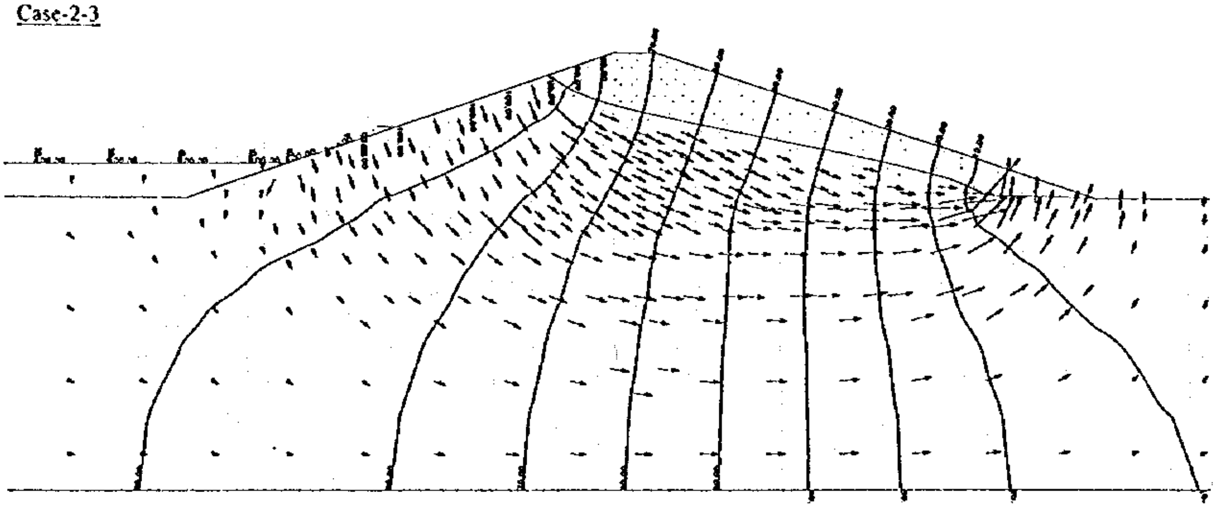


Vector of Flow Velocity and Potential on Base of Available Head

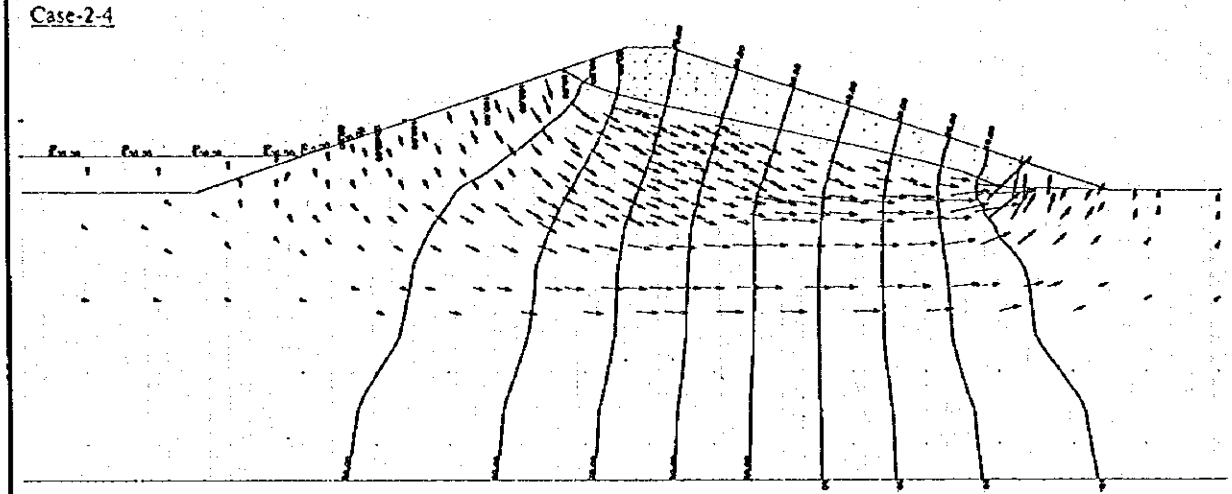


Vector of Flow Velocity and Potential on Base of Available Head

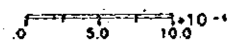
Case-2-3



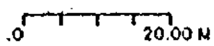
Case-2-4



Vector Scale

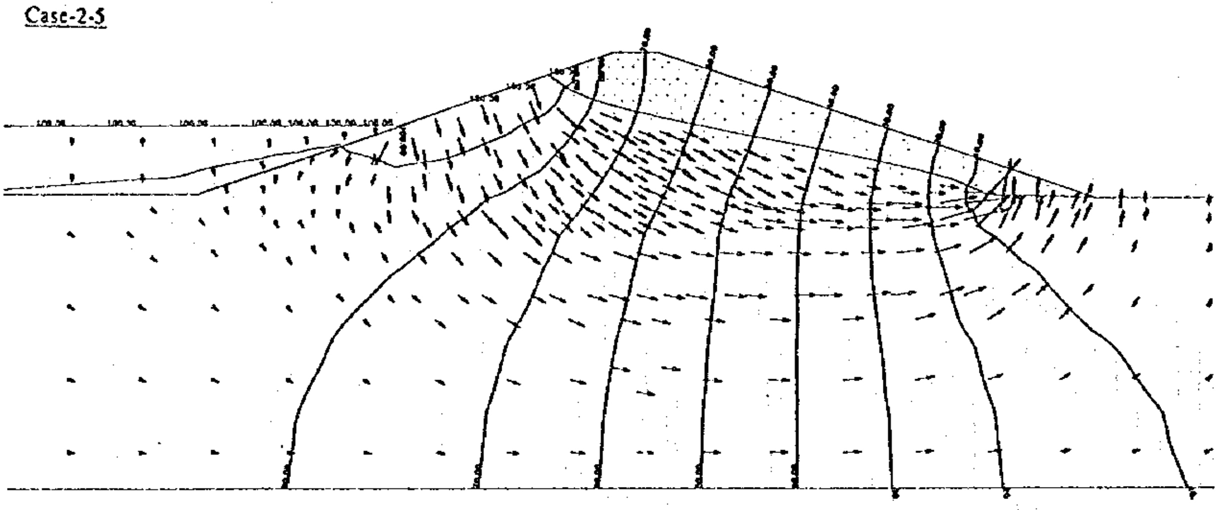


Model Scale

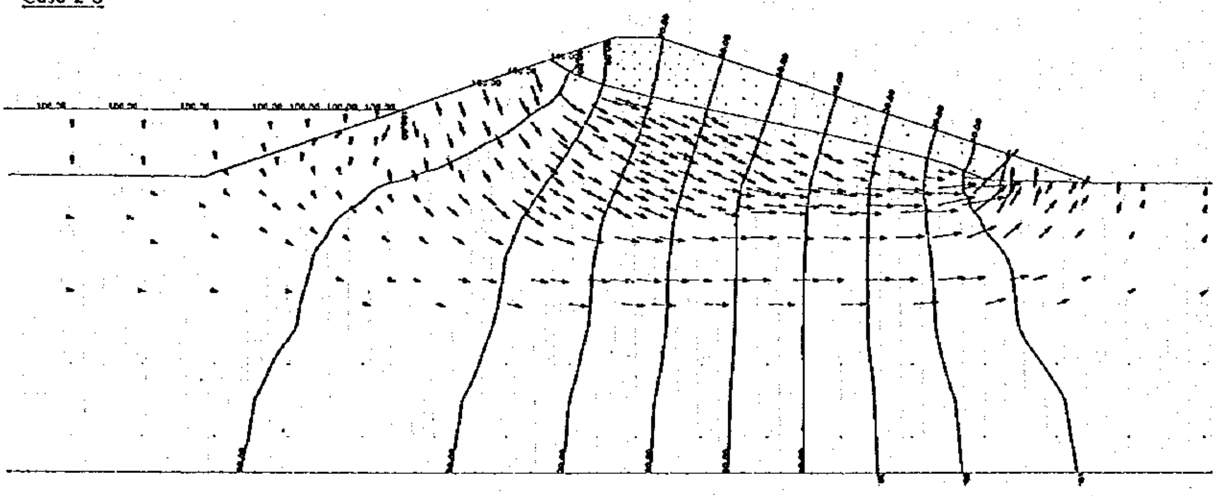


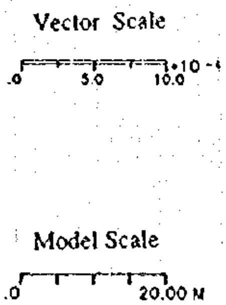
Vector of Flow Velocity and Potential on Base of Available Head

Case-2-5



Case-2-6

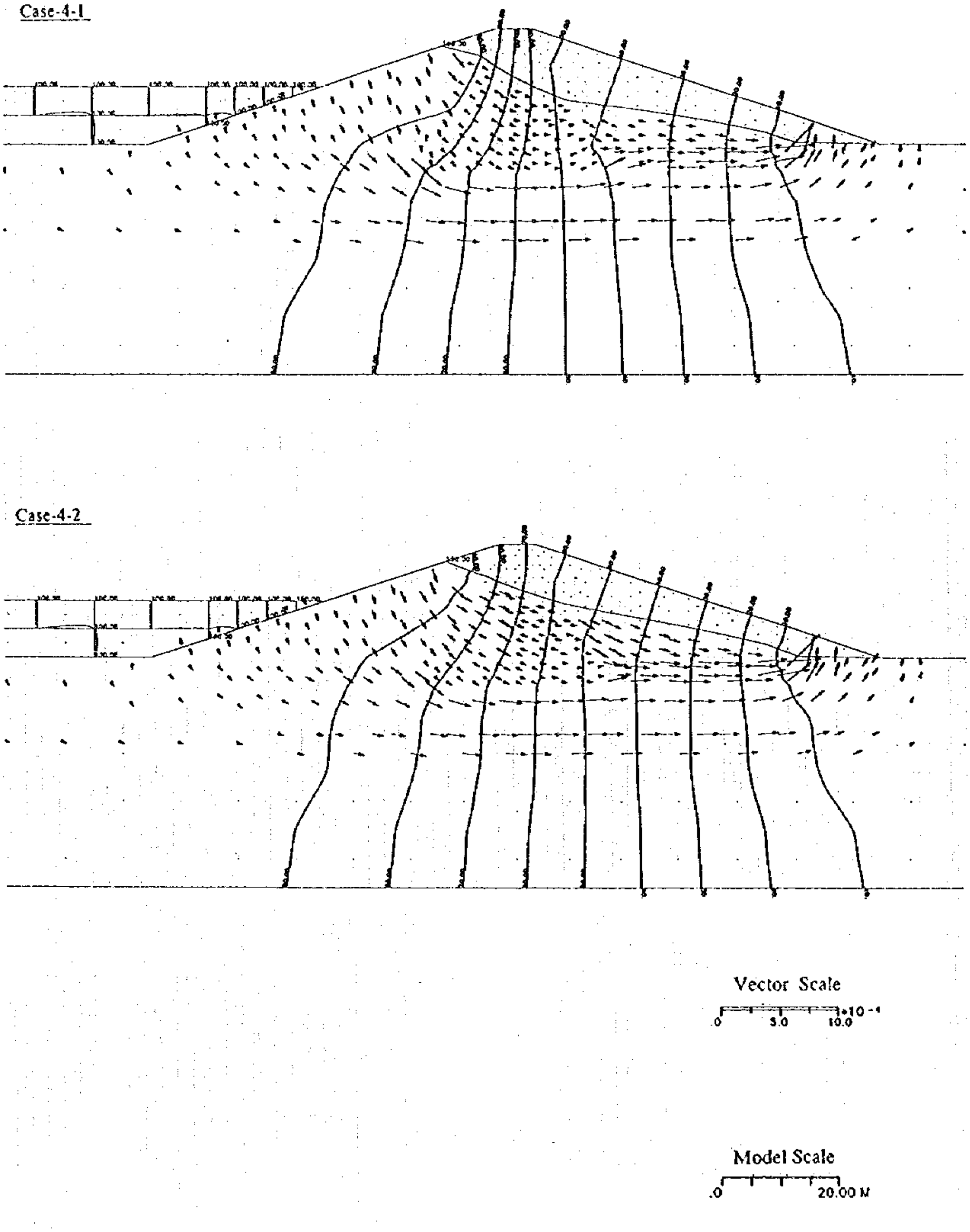




Vector of Flow Velocity and Potential on Base of Available Head

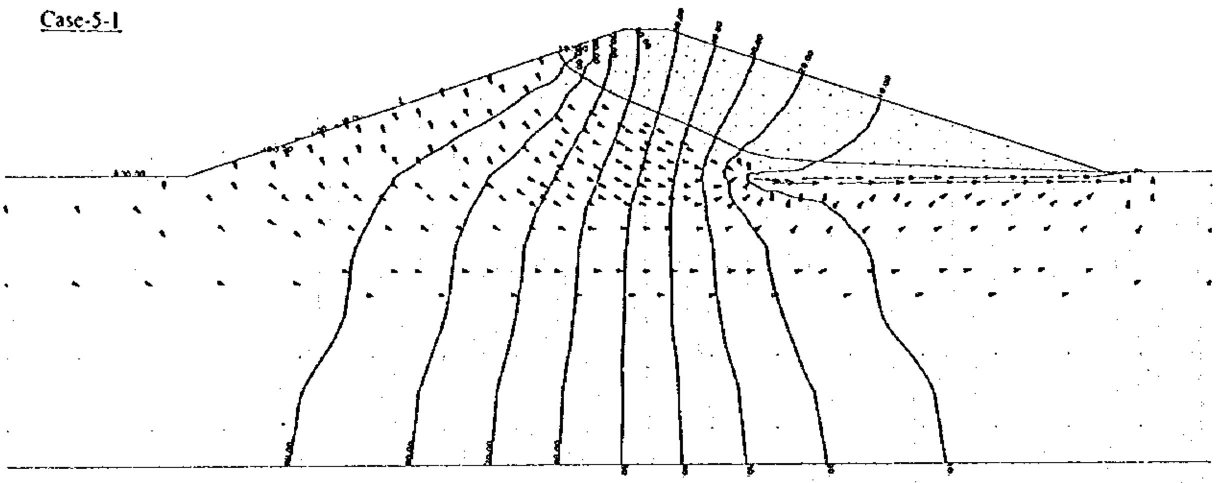
Case-4-1

Case-4-2

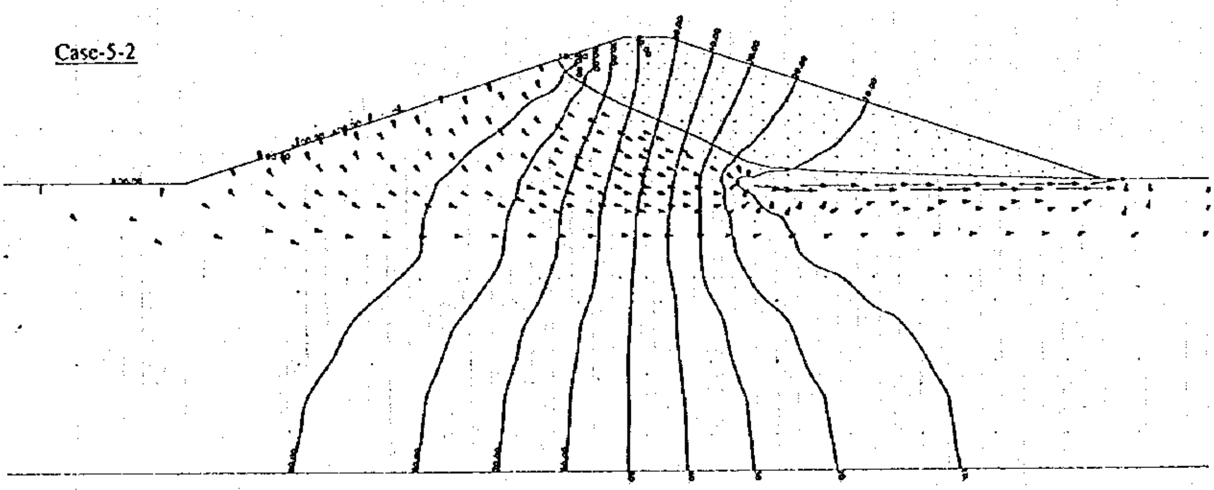


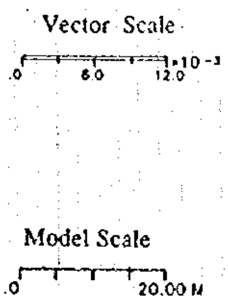
Vector of Flow Velocity and Potential on Base of Available Head

Case-5-1

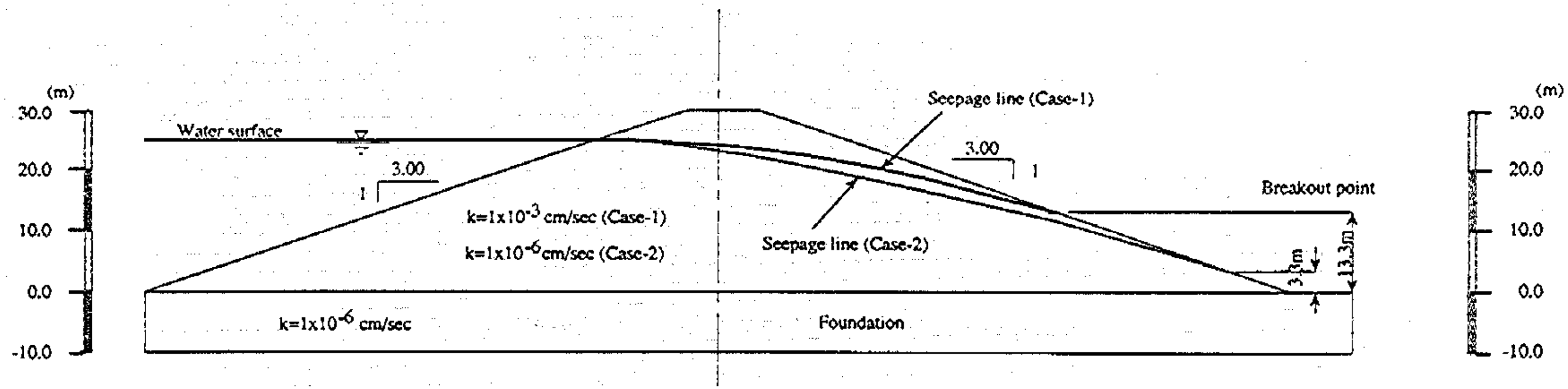


Case-5-2

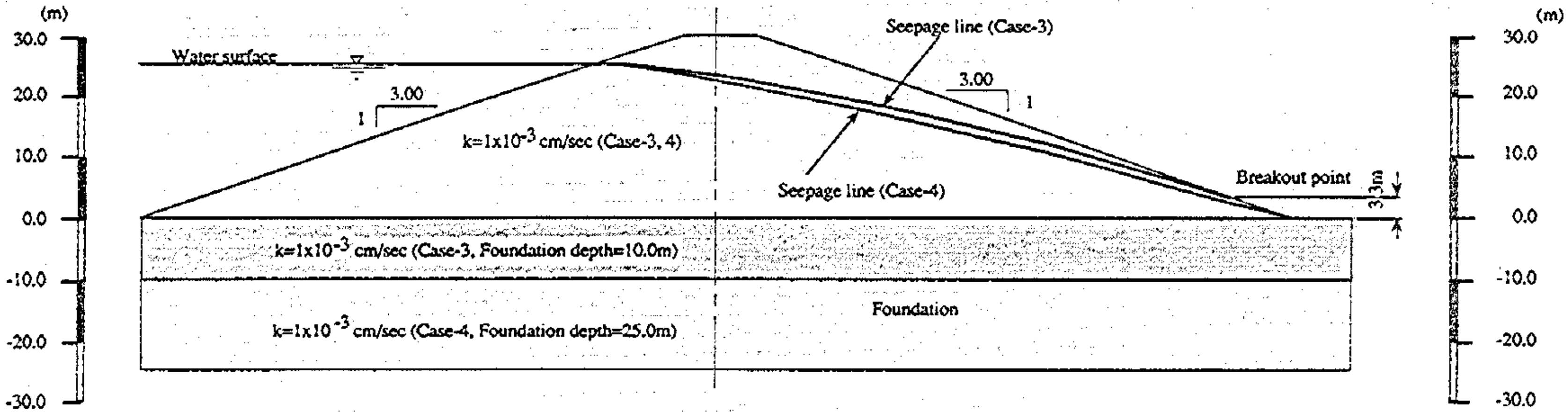




Vector of Flow Velocity and Potential on Base of Available Head

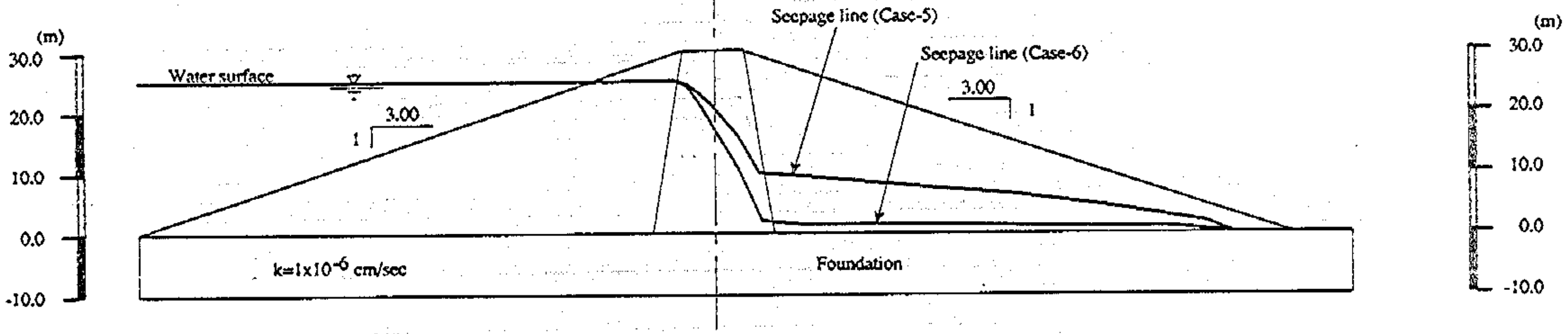


Case-1, 2 Seepage Lines with Specified Hydraulic Conductivities (Homogeneous Type)



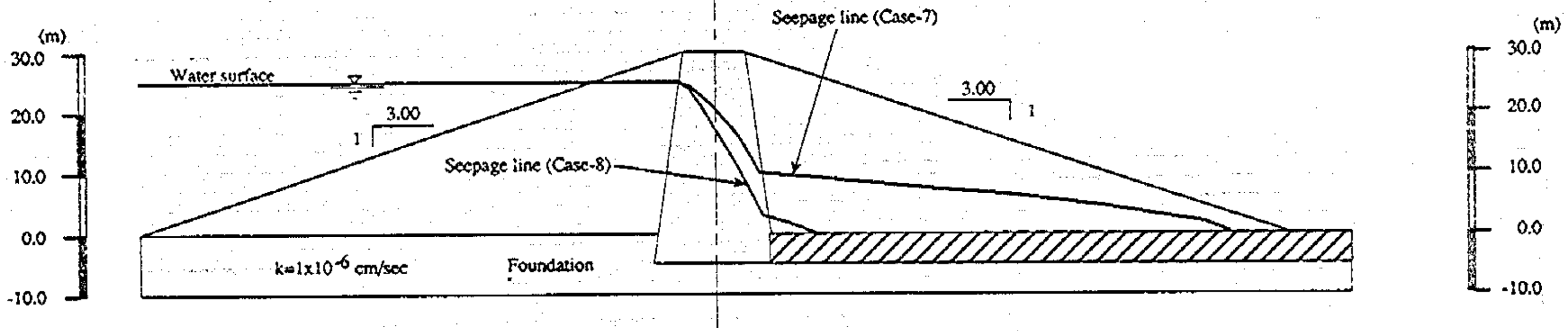
Case-3, 4 Seepage Lines with Specified Depth of Foundation (Homogeneous Type)

	Impervious zone	Pervious zone
Case-5	$k=1x10^{-6}$ cm/s	$k=1x10^{-4}$ cm/s
Case-6	$k=1x10^{-7}$ cm/s	$k=1x10^{-3}$ cm/s



Case-5, 6 Seepage Lines with Specified Hydraulic Conductivity (Zone Type)

	Impervious zone	Pervious zone	Drain
Case-7	$k=1x10^{-6}$ cm/s	$k=1x10^{-4}$ cm/s	not installed
Case-8			$k=1x10^{-2}$ cm/s



Case-7, 8 Seepage Lines with/without Drain (Zone Type)

I.4 Design of Delay Action Dam and Sediment Control Facilities

I.4.1 Dam Design

(1) Design flood

In line with the Planning and Design Guideline for Delay Action Dams (Annex M), the design flood discharges of 14 delay action dams are estimated as shown in Table I.4.1.

(2) Sediment

In line with the Planning and Design Guideline for Delay Action Dams, the sediment volume of 14 delay action dams are estimated as shown in Table I.4.2.

(3) Dam section

In line with the Planning and Design Guideline for Delay Action Dams, the dam section of 14 delay action dams are determined considering the following conditions. Calculation of dam sliding is conducted for the Kach dam, and dams of its height of 20 m and 15 m. Calculation results are shown in Fig. I.4.1.

Coefficient of Earthquake

		Kach dam	20m, 15m height
Full water surface	(U/S)	K=0.24	K=0.12 (ordinary seepage line in embankment)
Full water surface	(D/S)	K=0.24	K=0.12 (ordinary seepage line in embankment)
Low water surface	(D/S)	-	K=0.24 (seepage line is under the dam foundation)

Note: (U/S) Upstream slope, (D/S) Downstream slope

Material Properties

Kach dam

Zone	Saturated weight (t/m^3)	Compacted weight (t/m^3)	Cohesion (t/m^2)	Internal Angle (degree)
1. Sediment	1.800	1.600	2.0	0.0
2. Impervious soil	2.100	2.000	10.0	18.0
3. Pervious materials	2.100	1.900	0.0	35.0

Dam height of 20m, 15m

Zone	Saturated weight (t/m^3)	Compacted weight (t/m^3)	Cohesion (t/m^2)	Internal Angle (degree)
1,2,3 Pervious materials	2.100	1.900	0.0	35.0

Note: Zone number is referred to Fig. I.4.1.

Dam Section

Dam Name	Dam Type	Upstream Slope	Downstream Slope	Drain
Brewary dam	Gravity dam	Vertical	0.9	-
Dara dam	Homogeneous type fill dam	2.5	2.25	Toe Drain
Murgi Kotal dam (Upstream)	Homogeneous type fill dam	3.0	2.5	Horizontal Drain
Murgi Kotal dam (Downstream)	Homogeneous type fill dam	3.0	2.5	Vertical Drain
Kach dam (Rising of crest)	Zone type fill dam	3.0	2.8	Vertical Drain
Kach dam (Downstream)	Zone type fill dam	3.0	2.8	Vertical Drain
Jigda dam	Homogeneous type fill dam	3.0	2.75	Toe Drain
Sanzali dam	Homogeneous type fill dam	2.5	2.25	Toe Drain
Sakhol dam	Homogeneous type fill dam	2.5	2.0	Toe Drain
Mangi dam	Homogeneous type fill dam	2.5	2.0	Toe Drain
Kad Kocha II dam	Homogeneous type fill dam	2.5	2.0	Toe Drain
Ghazlona dam	Homogeneous type fill dam	2.5	2.25	Toe Drain
Ghutai Shela dam	Homogeneous type fill dam	2.5	2.25	Toe Drain
Wali Dad dam	Gravity dam	Vertical	0.9	Toe Drain
Samaki dam	Homogeneous type fill dam	2.5	2.25	Toe Drain
Iskalkoo dam	Homogeneous type fill dam	2.5	2.25	Toe Drain

Note: Dam section of the Brewary dam is determined refering to the Feasibility Studies, Brewary Dam, March 1996.
Downstream slope is in average.

(4) Dam feature

In line with the Planning and Design Guideline for Delay Action Dams, the details of dam section of 14 delay action dams are determined as shown in Table I.4.2. Elevation-capacity curves of the proposed delay action dams are shown in Fig. I.4.2.

(5) Outlet Facilities

Outlet facilities consist of the intake section, driving canal and regulating section.

a) Intake section

Inclined conduit should be selected for the intake section of the outlet device in consideration of advantages as follows.

- The construction cost of inclined conduit is less than intake tower's.
- Large bearing stress capacity is not necessary on foundation.
- Structure is stable and easy to maintain and operate.

Diameter of intake pipe is designed as small orifice and strainer should be attached to prevent inflow of sediment. And also intake pipes are planed to be set at two meters intervals in vertical from low water revel to the bottom of reservoir. Standard diameter of inclined pipe is recommended as follows according to the size of intake pipe.

Standard Combination of Intake pipe and Inclined pipe

Intake pipe (mm)	ø100	ø125	ø150	ø200	ø250	ø300	ø350
Inclined pipe (mm)	ø200	ø200	ø250	ø300	ø400	ø500	ø600

Inclined pipe should be rolled up by reinforced concrete to resist water pressure, buoyant force and other forces.

Standard Dimension of Concrete Block

Inclined pipe (mm)	ø200	ø250	ø300	ø400	ø500	ø600
Width & Height (mm)	550	600	650	800	1,000	1,200

It is indispensable to attach air vent pipe (gas iron pipe ø50) and stairs for maintenance. In the case that inclined pipe is long, it is necessary to set up the anchor for the stability of facility. Furthermore, it is recommended to compare and adopt inclined pipe/collecting conduit type from the economical point of view in the case that slope gradient is gentler than 15 degrees.

b) Driving Canal

Driving Canals are categorized into three types (see "Drawings"). Type A conduit is provided as conduit for the purpose of collecting water. This type is composed of perforated steel pipe and gravel trench. Collected water through inclined pipe and perforated pipe is lead to Type B conduit. Type B conduit is adopted in the section under dam body and composed of steel pipe rolled up by reinforced concrete. And also, in the downstream section of dam, Type C conduit which is ductile iron pipeline is adopted.

c) Regulating section

At the end of Type C conduit, discharge pit and sluice valve should be installed to regulate water into link canal and river bed (see "Drawings"). It is important to operate these valves within the limit that discharge doesn't exceed design discharge.

I.4.2 General Concept of Recharge Devices

(1) Proposed facility

Groundwater is recharged through the foundation of the delay action dam reservoir and the river bed where storage water is discharged through the conduit. It is estimated the amount of rechargeable water through the river bed is much larger than that through the foundation of reservoir. Further, it is supposed that the percolation rate through reservoir foundation is reduce gradually by sedimentation. Then it is necessary to set up the system for sustainable groundwater recharge.

In Balochistan, there are some dams with the infiltration device by utilizing conduit and recharge pit. Generally, the scale of these facilities are rather small and it is difficult to infiltrate adequate water for groundwater recharge. Then it is desirable to improve the groundwater recharge system for the accerelation of infiltration. The infiltration system is functionally composed of two facilities, link canal and infiltration facility.

1) Link canal

Storage water in the reservoir is lead to infiltration facility through the link canal. The link canal is classified into two types as the method of utilizing river bed and lining canal. In the case of conveying storage water through the river bed, the main of storage water flows downstream as surface flow, because the amount of under-flow is estimated to be small for the reason that permeability of river bed is less than 10^{-3} cm/s and depth to water table is less than 10m at most dam sites. And it is anticipated that storage water will be reduced by evaporation and water use for the purpose of irrigation or domestic water supply. In addition, it is also apprehended that water sometimes flows downstream wastefully in reduction of infiltration rate due to saturated soil caused by precipitation and flood. Then it is recommended to utilize artificial canal for water conveyance in principle.

Open canal, pipeline and trench system are supposed to be popular for link canal. Here, open canal means concrete lined canal. Topographic condition at the downstream of the dams indicates that earth canal is not recommendable for the reason that canal slope is supposed to be easily eroded by streamflow/fluctuation of water level and heavy maintenance will be frequently required. Furthermore, gradient of hill side is steep and it is supposed water flows in high velocity. In that case, it is anticipated canal bank will be heavily eroded.

Open canal system is the most popular to convey water to infiltration facility. However, its alignment is limited by topographical feature and it is not easy to set alignment in undulate area.

And it is necessary to set up cross structure in the case of crossing small tributary/valley. In addition, in the case of utilizing river area, it is necessary to select the route on higher part of area to avoid flood damage.

According to infiltration trench system, it is possible to be aligned in river bed. However it is also desirable to be set on higher part of river area to prevent from being clogged with silt and fine sand brought by flood. On the other hand, pipeline system are possible to be set alignment not only in undulate area but also in the river bed. It is unnecessary to set up cross structures as well as trench system.

Annual construction costs including operation/maintenance cost are estimated roughly. As the result, it is recommended to adopt open canal for link canal. And in the case that it is difficult to adopt open canal, it is preferable to select pipeline system.

2) Infiltration Facility

Infiltration trench, injection well and infiltration pond/dike are generally selected for artificial infiltration facility. It is recommended that these facilities should be located on the higher part of alluvial fan.

Infiltration pond and dike are available to accelerate large amount water infiltration but it requires large area coresponding to an infiltration amount. Then it is difficult to adopt, then in case that there are problems of land acquisition and compensation. Both systems are possible to be built in river area. However, in the case that infiltration dike which is necessarily dammed up on river bed, it is naturally suffered from flood. On the other hand, it becomes expensive to set up spillway.

Regarding infiltration trench, it is profitable compared to infiltration pond in the case of difficulty to acquire land, because it is possible to be aligned in river area. However trench system also requires very long length and it needs heavy maintenance to remove silt and fine sand in trench which brought by not only storage water but also flooding regularly. In addition, it is anticipated that water flows downstream wastefully in the case of reduced infiltration by clogged silt/sand.

Injection well is possible to infiltrate aquifer certainly. However it is supposed to be easily clogged by silt and requires expensive cost to construction. It is reported that injection well had become functional disorder in 10 years after construction by clog with silt.

Annual construction costs of facilities are estimated roughly under consideration of factors mentioned above. In this study, according to infiltration dike, it is assumed that flood frequency is once in two years and collapse of dike by flood occurs at the ratio of 30 percent in whole dike body. As the result, it is realized that infiltration pond is profitable from the aspect of recharging ability and economical efficiency. Then it is recommended to adopt infiltration pond as infiltration facility.

I.4.3 General Concept of Sediment Control Facilities

(1) General

Devastation is proceeding especially in some river basins where delay action dams are planed to be constructed. And also it is anticipated that huge amount of thick sediment in the river bed would be flown toward reservoir area by the flood in some basins. In those river basins, washout of sediment is supposed to increase year by year. Therefore it is necessary to take proper countermeasures to eliminate washout of sediment from basins.

- <u>Management in devastation area</u>

The yield of sediment is the most important factor to establish sediment prevention scheme. The yield mainly depends on the scale of catchment area, topo-geological conditions, density of vegetation, hydrological feature and land use. Countermeasure to eliminate sediment yield should be taken up in top priority.

It is supposed that management of conserving watershed in the upstream area is mostly necessary to prevent sediment yield. That is to say, forestation and hillside works should be operated for the purpose of preventing sediment yield in the devastation area. At present, conservation works by contour trenches, loose stone check dams and other methods are proceeded in a small scale within Brewary, Kach, Jigda and Ghazlona river basin by the Forestry Department in the Study Area. These works should be proceeded covering whole area of river basins. It is also necessary to prepare an implementation plan on the basis of the long-term strategy and the deliberate studies in each river basin. In addition, there needs continuous implementation for long term. Therefore, in this study, it is unavoidable to renounce implementation plan of watershed conservation management.

- <u>Sediment transportation control</u>

It is effective to construct erosion control dam, ground sill, revetment to control sediment movement in the river. However, the rise of river bed elevation and water level during flood will be come up by the result of sedimentation in upstream area by these schemes. Then, the deliberate study is be necessary to prevent flood damage and functional disorder of intake facilities by backwater/sediment in the case that there are cultivating lands or villages in the upstream area. In Pakistan, earth dam, gabion and stone masonry structure are generally utilized for sediment transportation control.

The site of erosion control facility should be proposed in accordance with the Planning and Design Guideline for the Delay Action Dams. In this site selection, following items are especially considered.

- site where valley is narrow and large pocket for storage exist.
- site where riverbed slope is gentle less than 1/20~1/15.

Earth dam/bund and gabion bund are nominated as an erosion control facility. Spillway should be constructed for an earth dam type to avoid break of embankment by flood. However, in that case, construction cost will be much higher compared to gabion structure of which overflow is acceptable during flood. Then, it is supposed to be profitable to set up gabion structure.

Stone masonry type and gabion type are selected as a ground sill and revetment. In these types, gabion type is selected in the aspect of easiness in construction and economical point of view in a construction cost. Gabion structure which maximum height is not exceeding 3 m should be adopted. In the case that the height of gabion structure is beyond 3m, geophysical study, e.q. bearing capacity of the foundation and structural stability should be examined.

(2) Observation of the watershed and facility planning

(a) Brewary DAD

The catchment area of the Brewary dam is composed of Brewary limestone, Dungan formation in Chiltan range, and Ghazing formation comprising of mudstone, sandstone and conglomerate. The catchment area are formed of mountainous hilly and rolling terrains which are mostly devoid of vegetation or have sparse vegetal cover, especially at the downstream of the area.

Perennial flow has not been observed at the middle and upstream areas of the catchment area, however observed upstream of the proposed dam site. The flow discharge has been reduced by 10 to 30 lit./sec in October, November, and utilized for the irrigation and domestic water use, so that it was difficult to divert the water for the use of vegetation.

Reforestation program has been implemented in the whole of the area by the Forest Department. As for reforestation, transplanting of the nursery trees has been commenced, while soil conservation by means of vegetation cover has successfully achieved with restriction of grazing under the program.

Relatively narrow gorges located at the 5 km upstream of the dam and ground depression at 6 km upstream are available for the construction of the detention bunds for silt trap. Mostly upstream of the catchment area forms valley, however the soil production is small because of the gentle slope of the valley.

(b) Dara DAD

The catchment area is mostly composed of limestone, and mudstone and conglomerate layers exists at the upstream of the dam site. The catchment is broadly divided by the tributaries of Kazha Shela nullah, Nauda Takai nullah.

Nullah upstream of the dam site is around 100 m width, and sand, gravel and cobble stone are deposited. Water course has been changes by floods. Nauda Takai nullah has its river width of 50 to 100 m from the dam site to 2.5 km upstream, and upper stream reduces its width to around 10 m. Steep limestone walls of the both sides produces narrowest valley of its width of 3 m and that is preferable to detention bund construction. Talus along the nullah have relatively adequate vegetation cover. Upstream area of the Kazha Shela nullah is composed of outcrop of the limestone, and sandstone, mudstone layers are observed at the middle, downstream of the nullah with sparse vegetation cover. Talus deposits of these layers are accumulated in the river bed, however the outflow of soil seems not so high.

Proposed dam site is located at the confluence of these nullahs. Because of its steep river bed slope of 1:30 at the site, the thickly deposited river materials is susceptible to flowing down into the reservoir area by floods. In this connection, river bed consolidation works, which is effective to settle and storage sediment, are available to prevent the movement of the river materials.

(c) Murgi Kotal DAD

Dam site forms narrow gorge composed of limestone at the both abutments, and river deposits composed of sand, gravel are thickly accumulated upstream of the reservoir area. Talus deposits around the reservoir area has no vegetation cover due to heavy surface erosion. Sediment production from the upstream of the catchment area is expected not so large, however, adequate river deposits and talus deposits around the reservoir may flow down into reservoir by heavy floods.

Detention bunds are proposed at upstream of the dam site of 1.5 to 3.0 km at where the narrow gorges exists. However, the storage volume of sediments is insufficient because of the steep slope of the river bed. Adequate river width together with sufficient storage volume is attained at 7 km upstream from the dam site. Furthermore, detention bund site 4 km upstream is alternatively available at where narrow gorge exists.

(d) Kach DAD

The catchment area is composed of shales at and around the reservoir area, limestone area and Urak formation comprised of sand, gravel at the upstream of the area. The reservoir area had been fully silted up with in four years immediately after the completion of the existing dam due to excessively high soil production of shales around the reservoir. Specific sediment volume was estimated at around 2,100 $m^3/km^2/year$.

Chundak Rud flows down at the center of the catchment area, and catchment area is broadly divided into the catchment areas of Kuchnai Mangala nullah, Mari Chak nullah, Inzar, Shpol nullah. Vegetation cover is scarcely observed at and around the reservoir area due to high erosion susceptibility and land slide of shales. Surface of shales have drying shrinkage of 50 cm depth or more and it incurs high erosion. River bed width is 30 to 40 m at the middle portion of the catchment area, and partly reduces its width. Slope failures of the height of 30 m are observed along the river, however the talus composed Urak formation have broadly gentle slope in the catchment area. Vegetation cover is relatively in good condition.

The catchment area of Mari Chak nullah is located at limestone area, and its tributary has steep slope. The catchment area is composed of outcrop of the limestone, that few soil production is expected. Soil erosion control facilities, such as detention bund is not planned for the reasons above. The catchment area of Kuchnai Mangala nullah is composed of limestone wall of more than 50 m height at the right side and steep slope of Urak formation comprising of gravel and sand at the left side. Hundreds of small creek are developed on the gentle slope toward the nullah, however, heavy erosion is not observed, thus soil productivity is small. Series of the sand trap bund with its height of around 0.75 m were constructed by the Forest Department.

Most upstream of the catchment area is composed of denuded limestone at the right side and talus deposits at the left side. Rivers or creeks has not been developed. Vegetation cover is in good condition in the area.

(e) Jigda DAD

The catchment area is composed of Murgha Faquirzai Shale, and Subrecent deposits is accumulated in the river bed. The catchment area forms of hilly and rolling terrains. Jigda nullah flows in the center of the catchment area. Several tributaries are located 4 km upstream of the proposed dam site. Surface of shale is weathered, and vegetation cover is scarce.

River bed slope is gentle at the middle of the catchment area and weathered shale of 5 to 50 mm grain are accumulated in the river bed. Both sides of the river have gentle slope. Numerous fine shale materials are deposited in the two major steep tributaries 1.5 to 2.0 km upstream of the dam site. These deposits are susceptible to flowing down toward downstream by floods because of steep slope of these tributaries. It is not recommended to construct the detention bunds along the tributaries due to deep and unconsolidated foundations. It is alternatively preferable to construct them downstream of their confluences. Vegetation cover is poor in the middle of the catchment area.

The middle and upstream catchment area also forms of hilly and rolling terrains. Vegetation cover is sparse due to thin topsoil on the shales. Weathered shales of their sieve size of 5 to 10 mm are deposited in the river bed.

(f) Sanzali DAD

Rolling terrains comprised of clay and silt Bostan Formation are located on the most upstream of the catchment area. River deposits were originated from alluvial soil formed by process of deposition. Sandstone layers have been eroded by the river flow and large slope failures are observed along the river. Vegetation cover is sparse on the river deposits, however is not observed on the hill slope due to heavy erosion. Alluvial soil has sparse vegetation cover at the upstream of the catchment area. Hilly terrains composed of Bostan Formation has no vegetation due to susceptibility to erosion.

River deposits has plainly accumulated in the river bed with their depth of 1.5 to 3.0 m. Fine materials originated from clay and sand of Bostan Formation is easily transported by the flood and subject to be accumulated in the reservoir area. These fine materials are not be captured by means of the detention bunds or other structures, so that sediment accumulation in the reservoir obstructs smooth dam operation. Bund composed of cobble stone with its height of 50 to 75 cm on the hill slopes may be effective to mitigate surface soil erosion. However, eminent effectiveness is not expected as long as whole of the catchment is covered with the bund. On contrary to this, river bed consolidation works may be proposed to control sediment flow by means of loosening river bed slope.

(g) Sakhol DAD

Two of large tributaries located at the left and right side of the catchment area have confluence at the proposed dam site. Both tributaries are located at limestone area (Chiltan limestone), and have alluvium in the river beds. Talus deposits are accumulated on the alluvium. Vegetation cover is well observed on the talus deposits and alluvium.

Earth bunds have been constructed by inhabitants for the basin irrigation at the proposed reservoir area and also upstream of the catchment area, especially along the right side tributaries. Series of earth bunds in small creeks are effective for silt trap during floods. High permeability of the foundation in the catchment area is also mitigate flood run-off, consequently reduces soil erosion in accordance with the sediment observation of the adjacent Amachi dam catchment area.

(h) Mangi DAD

The catchment area is composed of Shirinab Formation at the left side and Nimargh Limestone at the right side, and alluvium are deposited in the river bed. Shirinab Formation is composed of limestone and interlogged shales. The catchment area of the Sarbund dam is composed of Nimargh limestone and alluvium is thickly accumulated in the widely spreaded valley of the catchment area. Vegetation cover is in good condition in the catchment area of the Sarbund dam and several bunds constructed in the valley for the basin irrigation contribute to trap silt and turbid water in them during floods. Siltation volume is slightly observed in the reservoir of the Sarbund dam.

Plain river bed with its width of 500 to 700 m is formed in the downstream area of the Mangi dam catchment area. Vegetation cover is sparse on the alluvium and talus deposits. Several bunds with their length of more than 200 m are constructed for the basin irrigation in the river and it contributes for silt trap during floods. River forms gorge configuration in the middle of the catchment area. Gorge width ranges 15 to 20 m. Outcrop of limestone is observed at the both sides of the river. Vegetation cover is sparse. Perennial flow (groundwater) is observed at the mountain foot located at the left side of the river.

Upstream of the catchment area forms wide basin with sparse vegetation cover. Groundwater flow is observed at the shallow depth through the year. Vegetation cover is in good condition on the alluvium located at the mostly upstream and left side of the catchment area. Basin irrigation is cultivated on the gentle slope on the talus deposits and also on the alluvium deposits in the whole of the basin. Several rows of earth bunds for the basin irrigation contributes to capture fine silt, clay eroded by precipitation inside of the bunds.

(i) Kad Kocha II DAD

The catchment area is composed of Chiltan limestone, and alluvium comprising of sand, gravel and cobble stone is thickly deposited in the river bed. Vegetation cover is well observed on the alluvium deposits and talus deposits. River deposits are thickly accumulated, however accumulation of siltation in the reservoir area is less expected because tributaries extend radically, accordingly floods flow down through small creeks distributed in the catchment area.

(j) Ghazlona DAD

The whole catchment area is composed of Murgha Faquirzai Shale, and forms rolling terrains at the proposed dam site. Upstream of the catchment area forms mountainous hilly and most upstream is located at Arambi Range at where severe erosion has developed. Ghazlona nullah flows in the center of the catchment area.

Rolling terrains composed of shale is located at the downstream of the catchment area. Weathered shale covers the shale foundation. Vegetation cover is sparse. Small trenches with their length of 2 m, and depth of 0.5 m are constructed in the slopes of the surrounding hills aiming at erosion control, however, erosion control is not effectively induced because of their short duration after the construction. Gravel, sand deposits produced from the surface erosion of the shales and cobble stone of rectangular plate or bar shapes originated by slope failures are accumulated in the river bed. River bed has 60 to 70 m width.

The river is distributed in several tributaries at the middle of the catchment area. River reduces its width around 20 to 30 m and it is suitable to construct the detention bunds. Vegetation cover is scarce, however soil production is not so high because surface soil is thin on the slope. River deposits has 1 to 2 m depth and shale foundation is partly exposed on the river bed.

River width is around 15 m at the upstream of the catchment area. The gorge forms deep valley due to severe land failure and erosion. Vegetation is not observed. River deposits are accumulated in the river bed with their depth of about 1 m.

(k) Ghutai Shela dam

Catchment area is situated in Piedomont deposits (Fanglomerate). Gravel and cobble stone are deposited in the river bed. Piedomont deposits have been eroded by precipitation and form undulated terrains. Vegetation is scarce in whole of the catchment area due to heavy erosion and also over grazing.

Series of lower height detention bunds are proposed to control erosion by loosening riverbed slope and to prevent the movement of riverbed deposits.