D.2 Preliminary Design of the Facilities

D.2.1 Storage Dams

D.2.1.1 Selection of Proposed Damsites

(1) Basic Concepts Used in Selection

The study area has been basically restricted to the Dor River, Haro River and Soan River basin. In the first step, suitable damsites were found using 1/50,000 topographic maps keeping in mind runoff records in the river basin and operation records for existing dams. In the second step, dam axises were considered based on geological and topographical reconnaissance in the field.

The following procedures and methodology were considered preliminarily to the determination of suitable damsites and sizings.

(a) Reservoir Size

The respective storage capacity of respective dams has been studied on three or four sizes to find the optimum dam size in consideration of annual runoff at the damsite.

(b) Dambody and Volume of Dam

The shape of dams, including dam top elevation, slope and top width of dambodies, is determined using the design criteria described in D.2.1.2.

The volume of a dambody is calculated roughly using the values for dam height, dam top length and river bed excavation width.

(c) Construction Costs

The total cost of a proposed dam can be divided into dam construction cost and compensation cost.
Dam construction costs are estimated using the specific unit cost of the dambody. In this preliminary study, specific unit costs per dam volume are assumed based on those of recently constructed dam projects in Pakistan.

(d) Water Costs Curve

At the first stage of the study, "construction costs/effective storage capacity curves" are worked out for the comparison of proposed damsites.

(2) Preliminary Study of Proposed Damsites

The preliminary study was carried out for twenty five proposed damsites in the three river basins shown in Figure D-2-1. The results of the preliminary study are shown in follwing Tables and Figures.

Table D-2-2 Reservoir Storage Capacity [First Stage] (1)--(3)
Table D-2-3 Geology and Topograpy of Proposed Damsites (1)--(4)
Table D-2-4 Dimension for Dam Sizing [First Stage] (1)--(6)
Figure D-2-3 Schematic Geological Cross Section of Proposed Damsites (1)--(4)

Figure D-2-2 shows the relation between raw water costs and effective storage capacities for each damsite.

(3) Selected Damsites

Selection of optimum dams would be confirmed after future study in which water demand patterns, relations to existing storage dams and intake facilities (diversion dams and pumping stations), and the operation plans of a series of dams in the same river basin were investigated.

The result of the study mentioned above give seven suitable damsites, namely D-1, H-4, N-1, S-1, M-1, L-1 and SL-1. These were selected tentatively for study work and field surveys.

Table D-2-1 Proposed Damsites [First Stage]

River Basin	1st Stage	2nd Stage
Dor River	8 damsites (D-1--D-8)	1 damsite (D-1)
Haro River	9 damsites (H-1--H-8, N-1)	2 damsites (H-4, N-1)
Soan River	8 damsites (S-1--S-3, M-1) (L-1--L-3, SL-1)	4 damsites (S-1, M-1) (L-1, SL-1)
TOTAL	25 damsites	7 damsites

(4) Revision of Proposed Damsites on the Second Stage

On the second phase of the field survey and study, two new damsites were proposed as alternatives to N-1 and M-1.

(a) Suspension of N-1 Dam Scheme

After careful surveying N-1 Dam on the Nandna Kas proved to have serious demerits. These included:

- Submergence of a part of Shahpur Dam and CCA of the project.
- Removal of 500 KV extra high voltage transmission line.
- High dam construction costs.

In consequence, as an alternative to the development of Nandna Kas, the heightenning of Shahpur Dam has been studied and proposed.

(b) Removal of M-1 Damsite

Among these proposed damsites, site M-1 on Malal Kas does not have favourable topographical and geological conditions, making the dam high in cost. An alternative damsite was searched for along Malal Kas and it was finally founded at the former gauging station of Lohi Bher, near the Panwal village, on the Kurang River.

The site has been named KL-1 (Kurang Lower Site No. 1).

Figure D-2-1 Location of Proposed Damsites

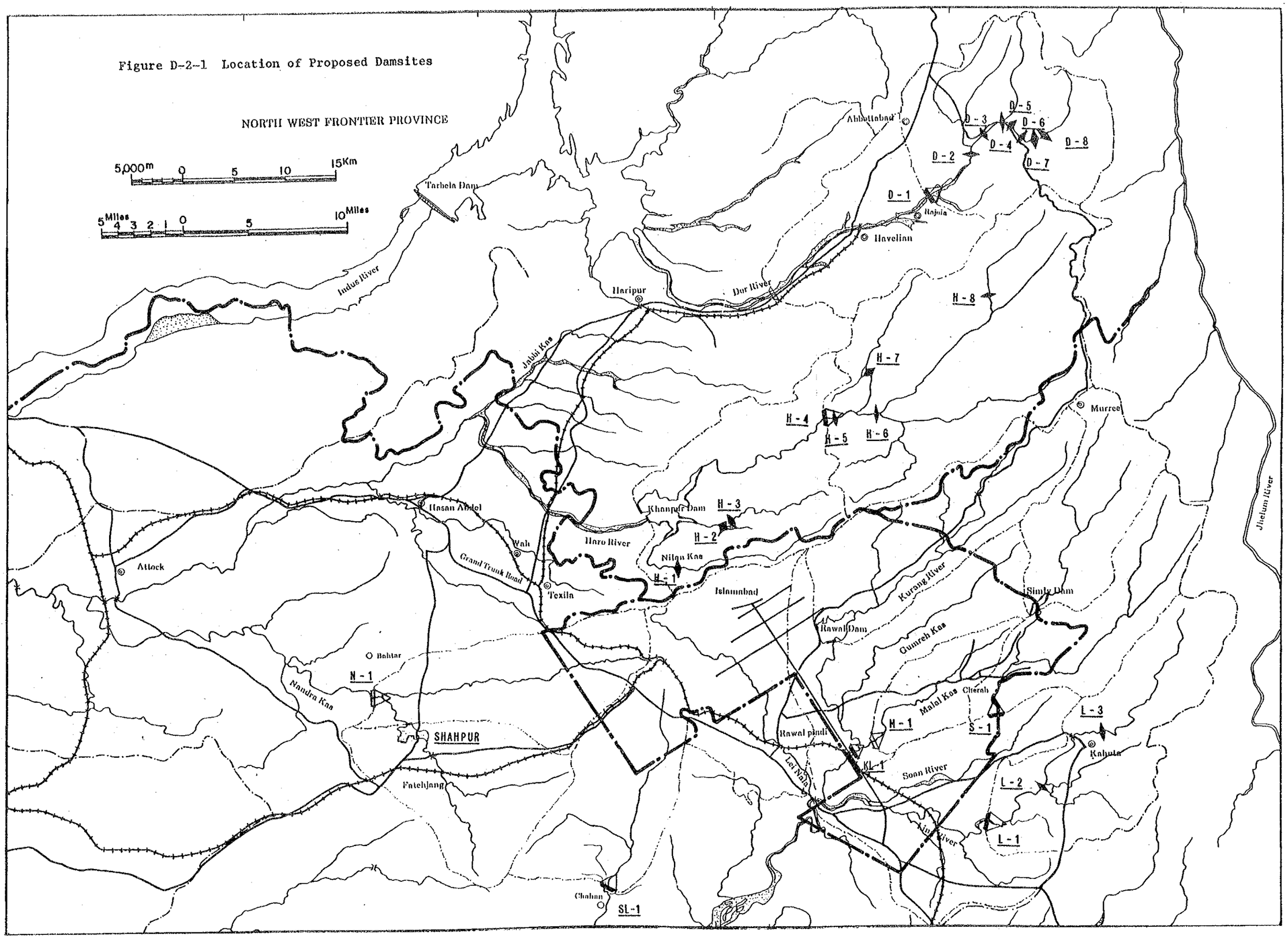


Figure D-2-2. Unit Cost and Storage Capacity

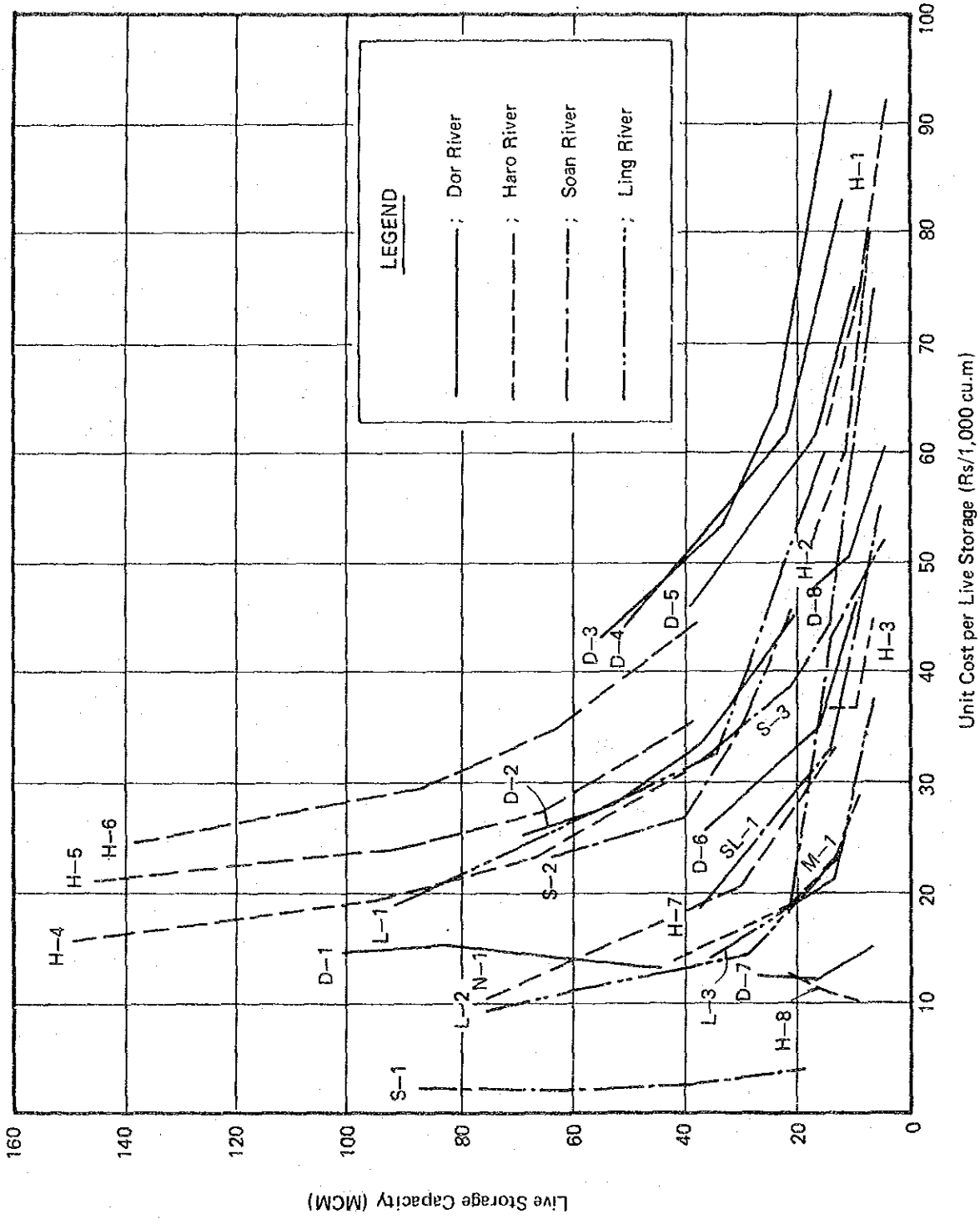


Table D-2-2 (1) Reservoir Storage Capacity (First Stage) (1)

DAMSITE ; D-1

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
3,133	955	0	0	0	0	0
3,150	960	342,000	5	5	570,000	570,000
3,200	975	938,000	15	20	9,600,000	10,170,000
3,250	991	1,650,000	15	35	19,410,000	29,580,000
3,300	1,006	2,725,000	15	50	32,813,000	62,393,000
3,350	1,021	3,817,000	15	65	49,065,000	111,458,000
3,400	1,036	4,913,000	15	80	65,475,000	176,933,000
3,450	1,052	6,425,000	15	95	85,035,000	261,968,000

DAMSITE ; D-2

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
3,494	1,065	0	0	0	0	0
3,500	1,067	6,000	2	2	4,000	4,000
3,550	1,082	142,000	15	17	1,110,000	1,114,000
3,600	1,097	425,000	15	32	4,253,000	5,367,000
3,650	1,113	750,000	15	47	8,813,000	14,180,000
3,700	1,128	1,158,000	15	62	14,310,000	28,490,000
3,750	1,143	1,683,000	15	77	21,308,000	49,798,000
3,800	1,158	2,400,000	15	92	30,623,000	80,421,000

DAMSITE ; D-3

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
3,740	1,140	0	0	0	0	0
3,750	1,143	15,000	3	3	15,000	15,000
3,800	1,158	108,000	15	18	933,000	948,000
3,850	1,173	225,000	15	33	2,498,000	3,446,000
3,900	1,189	533,000	15	48	5,685,000	9,131,000
3,950	1,204	941,000	15	63	11,055,000	20,186,000
4,000	1,219	1,305,000	15	78	16,845,000	37,031,000
4,050	1,234	1,648,000	15	93	22,148,000	59,179,000
4,100	1,250	2,159,000	15	108	28,553,000	87,732,000
4,150	1,265	2,560,000	15	123	35,393,000	23,125,000

DAMSITE ; D-4

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
3,881	1,183	0	0	0	0	0
3,900	1,189	125,000	6	6	250,000	250,000
3,950	1,204	358,000	15	21	3,623,000	3,873,000
4,000	1,219	513,000	15	36	6,533,000	10,406,000
4,050	1,234	723,000	15	51	9,270,000	19,676,000
4,100	1,250	971,000	15	66	12,705,000	32,381,000
4,150	1,265	1,197,000	15	81	16,260,000	48,641,000
4,200	1,280	1,506,000	15	96	20,273,000	68,914,000
4,250	1,295	1,897,000	15	111	25,523,000	94,437,000

Table D-2-2 (2) Reservoir Storage Capacity (First Stage) (2)

DAMSITE ; D-5

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
3,976	1,212	0	0	0	0	0
4,000	1,219	30,000	7	7	70,000	70,000
4,050	1,234	140,000	15	22	1,275,000	1,345,000
4,100	1,250	288,000	15	37	3,210,000	4,555,000
4,150	1,265	380,000	15	52	5,010,000	9,565,000
4,200	1,280	573,000	15	67	7,148,000	16,713,000
4,250	1,295	814,000	15	82	10,403,000	27,116,000
4,300	1,311	983,000	15	97	13,478,000	40,594,000
4,350	1,326	1,437,000	15	112	18,876,000	59,470,000

DAMSITE D-7

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
4,311	1,314	0	0	0	0	0
4,350	1,326	232,000	12	12	928,000	928,000
4,400	1,341	500,000	15	27	5,490,000	6,418,000
4,450	1,356	663,000	15	42	8,722,500	15,140,500
4,500	1,372	905,000	15	57	11,760,000	26,900,500
4,550	1,387	1,050,000	15	72	14,662,500	41,563,000
4,600	1,402	1,263,000	15	87	17,347,500	58,910,500
4,650	1,417	1,500,000	15	107	20,722,500	79,633,000

DAMSITE ; D-6

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
4,127	1,258	0	0	0	0	0
4,150	1,265	13,000	7	7	30,000	30,000
4,200	1,280	90,000	15	22	773,000	803,000
4,250	1,295	256,000	15	37	2,595,000	3,398,000
4,300	1,311	350,000	15	52	4,545,000	7,943,000
4,350	1,326	720,000	15	67	8,025,000	15,968,000
4,400	1,341	1,100,000	15	82	13,650,000	29,618,000
4,450	1,356	1,421,000	15	97	18,908,000	48,526,000
4,500	1,372	1,805,000	15	112	24,195,000	72,721,000

DAMSITE D-8

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
4,334	1,321	0	0	0	0	0
4,350	1,326	45,000	5	5	75,000	75,000
4,400	1,341	225,000	15	20	2,025,000	2,100,000
4,450	1,356	313,000	15	35	4,035,000	6,135,000
4,500	1,372	463,000	15	50	5,820,000	11,955,000
4,550	1,387	550,000	15	65	7,597,500	19,552,500
4,600	1,402	668,000	15	80	9,285,000	28,837,500
4,650	1,417	800,000	15	95	11,160,000	39,997,500
4,700	1,433	1,025,000	15	110	13,687,500	53,685,000

Table D-2-2 (3) Reservoir Storage Capacity (First Stage) (3)

DAMSITE ; II-1

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,287	697	0	0	0	0	0
2,300	702	60,000	5	5	100,000	100,000
2,350	717	155,000	15	20	1,613,000	1,713,000
2,400	732	282,000	15	35	3,278,000	4,991,000
2,450	747	480,000	15	50	5,715,000	10,706,000
2,500	762	772,000	15	65	9,390,000	20,096,000
2,550	777	1,212,000	15	80	14,880,000	34,976,000
2,600	792	1,617,000	15	95	21,218,000	56,194,000
2,650	806	2,275,000	15	110	29,190,000	85,384,000

DAMSITE ; II-2

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,192	668	0	0	0	0	0
2,200	671	25,000	3	3	25,000	25,000
2,250	686	75,000	15	18	750,000	775,000
2,300	701	233,000	15	33	2,310,000	3,085,000
2,350	717	425,000	15	48	4,935,000	8,020,000
2,400	732	850,000	15	63	9,563,000	17,583,000
2,450	747	1,150,000	15	78	15,000,000	32,583,000
2,500	762	1,656,000	15	93	21,045,000	53,628,000
2,550	777	2,125,000	15	108	28,358,000	81,986,000

DAMSITE ; II-3

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,329	710	0	0	0	0	0
2,350	717	50,000	7	7	117,000	117,000
2,400	732	275,000	15	22	2,437,000	2,554,000
2,450	747	475,000	15	37	5,625,000	8,179,000
2,500	762	775,000	15	52	9,375,000	17,554,000
2,550	777	1,050,000	15	67	13,688,000	31,242,000

DAMSITE ; II-4

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,543	775	0	0	0	0	0
2,550	777	14,000	2	2	9,000	9,000
2,600	792	350,000	15	17	2,730,000	2,739,000
2,650	808	950,000	15	32	9,750,000	12,489,000
2,700	823	1,675,000	15	47	19,688,000	32,177,000
2,750	838	2,713,000	15	62	32,910,000	65,087,000
2,800	853	3,763,000	15	77	48,570,000	113,657,000
2,850	869	5,050,000	15	92	66,098,000	179,755,000
2,900	884	6,600,000	15	107	87,375,000	267,130,000
2,950	899	8,425,000	15	122	112,688,000	379,818,000
3,000	914	11,372,000	15	137	148,478,000	528,296,000

Table D-2-2 (4) Reservoir Storage Capacity (First Stage) (4)

DAMSITE ; H-5

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,589	789	0	0	0	0	0
2,600	792	75,000	3	3	75,000	75,000
2,650	808	550,000	15	18	4,688,000	4,763,000
2,700	823	1,175,000	15	33	12,938,000	17,701,000
2,750	838	2,113,000	15	48	24,660,000	42,361,000
2,800	853	3,038,000	15	63	38,633,000	80,994,000
2,850	869	4,225,000	15	78	54,473,000	135,467,000
2,900	884	5,625,000	15	93	73,875,000	209,342,000
2,950	899	7,200,000	15	108	96,188,000	305,530,000
3,000	914	9,884,000	15	123	128,130,000	433,660,000

DAMSITE ; H-6

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,694	821	0	0	0	0	0
2,700	823	40,000	2	2	27,000	27,000
2,750	838	575,000	15	17	4,612,000	4,639,000
2,800	853	1,225,000	15	32	13,500,000	18,139,000
2,850	869	2,025,000	15	47	24,375,000	42,514,000
2,900	884	3,150,000	15	62	38,813,000	81,327,000
2,950	899	4,025,000	15	77	53,813,000	135,140,000
3,000	914	5,859,000	15	92	74,130,000	209,270,000
3,050	930	8,437,000	15	107	107,220,000	316,490,000
3,100	945	11,650,000	15	122	150,653,000	467,143,000

DAMSITE ; H-7

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
3,133	955	0	0	0	0	0
3,150	960	2,000	5	5	5,000	5,000
3,200	975	29,000	15	20	233,000	238,000
3,250	991	320,000	15	35	2,617,000	2,855,000
3,300	1,006	907,000	15	50	9,203,000	12,058,000
3,350	1,021	1,445,000	15	65	17,640,000	29,698,000
3,400	1,036	2,560,000	15	80	30,038,000	59,736,000
3,450	1,051	3,794,000	15	95	47,655,000	107,391,000
3,500	1,066	5,716,000	15	110	71,325,000	178,716,000

DAMSITE ; H-8

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
4,327	1,319	0	0	0	0	0
4,350	1,326	175,000	7	7	408,000	408,000
4,400	1,341	425,000	15	22	4,500,000	4,908,000
4,450	1,356	575,000	15	37	7,500,000	12,408,000
4,500	1,372	800,000	15	52	10,313,000	22,721,000
4,550	1,387	1,275,000	15	67	15,563,000	38,284,000
4,600	1,402	1,850,000	15	82	24,438,000	62,722,000
4,650	1,417	2,475,000	15	97	32,437,000	95,159,000

Table D-2-2 (5) Reservoir Storage Capacity (First Stage) (5)

DAMSITE ; S-1

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
1,811	552	0	0	0	0	0
1,850	564	700,000	12	12	2,800,000	2,800,000
1,900	579	3,675,000	15	27	32,813,000	35,613,000
1,950	594	6,900,000	15	42	79,313,000	114,926,000

DAMSITE ; S-3

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
2,116	645	0	0	0	0	0
2,150	655	75,000	10	10	250,000	250,000
2,200	671	300,000	15	25	2,813,000	3,063,000
2,250	686	963,000	15	40	9,473,000	12,536,000
2,300	701	1,775,000	15	55	20,535,000	33,071,000
2,350	716	2,575,000	15	70	32,625,000	65,696,000
2,400	732	3,438,000	15	85	45,098,000	110,794,000

DAMSITE S-2

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
1,890	576	0	0	0	0	0
1,900	579	68,000	3	3	68,000	68,000
1,950	594	713,000	15	18	5,858,000	5,926,000
2,000	610	2,125,000	15	33	21,285,000	27,211,000
2,050	625	4,913,000	15	48	52,785,000	79,996,000

DAMSITE ; M-1

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
1,660	506	0	0	0	0	0
1,675	511	175,000	5	5	88,000	88,000
1,700	518	1,092,000	7.5	12.5	4,751,000	4,839,000
1,725	526	4,825,000	7.5	20.0	22,189,000	27,028,000
1,750	533	12,000,000	7.5	27.5	63,094,000	90,122,000

Table D-2-2 (6) Reservoir Storage Capacity (First Stage) (6)

DAMSITE ; L-1

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
1,581	482	0	0	0	0	0
1,600	488	158,000	6	6	316,000	316,000
1,650	503	433,000	15	21	4,433,000	4,749,000
1,700	518	817,000	15	36	9,375,000	14,124,000
1,750	533	1,892,000	15	51	20,318,000	34,442,000
1,800	548	8,350,000	15	66	76,815,000	111,257,000
1,850	563	17,700,000	15	81	132,850,000	244,107,000

DAMSITE ; L-2

CONTOUR (ft)	CONTOUR (m)	AREA OF CONTOUR (sq.m)	HEIGHT INTERVAL (m)	HEIGHT PROGRESSIVE (m)	CAPACITY BETWEEN CONTOUR (cu.m)	CAPACITY PROGRESSIVE (cu.m)
1,808	551	0	0	0	0	0
1,850	564	2,650,000	13	13	11,483,000	11,483,000
1,900	579	9,650,000	15	28	92,250,000	103,733,000
1,950	594	23,025,000	15	43	245,063,000	348,796,000

DAMSITE ; N - 1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
395	0		0	0
400	0.200	5	0.500	0.500
410	0.600	10	4.000	4.500
420	2.776	10	16.880	21.380
430	6.640	10	47.080	68.460
440	13.407	10	100.235	167.695
450	22.259	10	178.330	347.025

DAMSITE ; S L - 1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
428	0		0	0
430	0.110	2	0.110	0.110
440	0.600	10	3.850	3.960
450	1.543	10	11.015	14.975
460	3.300	10	24.215	39.190
470	6.900	10	51.000	90.190
475	11.460	5	45.900	136.090

Table D-2-3 (1) Geology and Topography of the Proposed Damsites (1)

River	Site No.	Geology			Topography			Remarks
		Lithology	Weathering	Overburden	River Width	Slope Inclination	W/H 1)	
Dor River	D-1	Bedrock : Paleozoic Conglomerate Overburden : Terrace gravel layer	Moderate	Terrace grave l 40-50m River dep. less than 10 m	20-30m	Very gentle	22.3	- Thick and widely spread terrace deposits on both flanks. - Very wide valley
	D-2	Bedrock : Mesozic limestone Overburden : River dep.	Moderate	River dep. 30-40m	River - 130m	Right : 35° Left : 60°	3.4	- Highly Permeable limestone - Thick overburden
	D-3	Bedrock : Mesozoic limestone Overburden : River dep. Terrace gr.	Moderate	River dep. 30-40m Terrace gr. 30-40m	River - 150m Terrace 150m	Right : 50°-60° Left : 55°	4.2	- Highly Permeable limestone - Thick overburden
	D-4	Bedrock : Tertiary limestone Overburden : River dep. Terrace gr.	Moderate	River dep. 30-40m Terrace gr. 20-30m	River - 200m Terrace 80m	Right : 65° Left : 35	5.1	- Highly Permeable limestone - Thick overburden
	D-5	Bedrock : Mesozoic limestone Overburden : River dep.	Moderate	River dep. 20-30m	70m	Right : 30° Left : 45°	3.5	- Highly Permeable limestone
	D-6	Bedrock : Mesozic limestone Overburden : River dep.	Relatively fresh	River dep. 10-20m	50m	Right : 45° Left : 45°	2.4	- Highly permeable limestone
	D-7	Bedrock : Mesozic limestone Overburden : Terrace dep.	Moderate	Terrace dip 10m	River 20 Terrace 140m	Right : 45° Left : 15-30°	4.4	- Highly Permeable limestone - Thin ridge in left bank
	D-8	Bedrock : Mesozoic Shale Terrace Overburden : River Dep. Dep.	Highly Weathered	River dep. 10-20m Terrace gr. 10m	River dep 10-20m Terrace gr.	Right : 30° Left : 30°	5.1	- Highly weathered and sheared shale

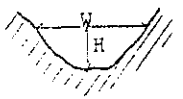
1) 

Table D-2-3 (2) Geology and Topography of the Proposed Damsites (2)

River	Site No.	Geology			Topogarapny			Remarks
		LITHOLOGY	Weathering	Overburden	River Width	Slope Inclination	W/H	
HARO RIVER	H-1	Bedrock : Tertiary limestone. Overburden : River dep. Terrace gr.	Moderate	River dep. 20-30m Terrace gr. 10m	River 110m Terrace 70m	Right 35° Left 45°	7.9	- Highly Permeable limestone
	H-2	Bedrock : Tertiaty limestone Overburden : River dep. Terrace gr.	Moderate	River dep. 10-20m Terrace gr. less than 10m	River 60m Terrace 50m	Right 30° Left 20°	6.4	- Highly Permeable limestone
	H-3	Bedrock : Tertiary limestone Overburden : River dep. Terrace gr.	Moderate	River dep. less than 10m Terrace gr. less than 10m	River 36m Terrace 90m	Right 35° Left 30°	6.9	- Highly Permeable limestone
	H-4	Bedrock : Mesozoic limestone Overburden : River dep. Terrace gr.	Moderate to Highly	River dep. 30-40m Terrace gr. 20-30m	River 150m Terrace 60m	Right 30° Left 40°	4.5	- Highly Permeable limestone - Thick overburden - Weathered bedrock
	H-5	Bedrock : Mesozic limestone Overburden : River dep. Terrace gr.	Moderate to Highly	River dep. 30m-40m	River 160m Terrace 430m	Right 30° Right 30°	8.6	- Highly Permeable limestone - Thick overburden - Weathered bedrock - Wide valley
	H-6	Bedrock : Mesozic limestone Overburden : River dep.	Moderate to Highly	River dep. 40-50m	230m	Right 25° Left 25°	7.0	- Highly Permeable limestone - Thick overburden - Weathered bedrock - Thin ridge in left bank
	H-7	Bedrock : Tertiary limestone	Fresh	Negligible	20m	Right 30° Left 30°	3.6	- Highly Permeable limestone
	H-8	Bedrock : Tertiary limestone	Fresh	Negligible	10m	Right 80°-25° Left 80°-30°	3.3	- Highly permeable limestone

Table D-2-3 (3) Geology and Topography of the Proposed Damsites (3)

River	Site No.	Geology			Topography			Remarks
		Lithology	Weathering	Overburden	River Width	Slope Inclination	W/H	
Soan River	S-1	Bedrock : Tertiary Sandstone	Fresh	Negligible	River 10-20m Terrace 30m	Right 40° Left 35°	4.5	No major problem for dam construction could not found in this survey
	S-2	Bedrock : Tertiary Sandstone Overburden : River dep.	Moderate	River dep. 10-20m Terrace gr. 20-30m	River 70-80m Terrace 450m	Right 10° Left 5-10°	15.6	- Thick overburden - Very wide valley
	S-3	Bedrock : Tertiary Sandstone Overburden : River dep. Terrace gr.	Moderate	River dep. 10-20m Terrace gr. 10-20m	River 70-80m Terrace 150m	Right 20°-40° Left 25°	6.4	- Thick Overburden
Malal Kas	M-1	Bedrock : Tertiary Sandstone ridge Overburden : Alluvial dep. (Silt)	Moderate	Thick allurium silt surrouds the sandstone ridge	River 10m	Very gentle	48.8	- Very thin sandstone ridge - Very wide valley
Ling River	L-1	Bedrock : Tertiary Sandstone and Claystone Overburden : Alluvial dep. River dep.	Moderate	Alluvial dep. 0m-10m ? River dep. 0-5m ?	River 80m Terrace 190m	Right 10°-40° Left 15°	21.5	- Very wide valley
	L-2 L-2	Bedrock : Tertiary Sandstone Claystone Overburden : Alluvial dep. River dep.	Moderate	Alluvial dep. 10-20m ?	River 100m	Very gentle	52.9	- Very wide valley
	L-3	Bedrock : Tertiary sandstone and claystone Overburden : Alluvial dep. River dep.	Moderate	Alluvial dep. 10-20m ?	River 60m	Very gentle	45.4	- Very wide valley

Table D-2-4 (1) Demension for Dam Sizing (First Stage) (1)

D - 1

		D - 1 ①	②	③	
① NUMBER OF DAM					
② NAME OF DAM		Bajoia			
③ CATCHMENT AREA	sq. km	292.3			
④ RECEABLE SEDIMENT	m.c.m.	11.2			
⑤ RETENTION WATER LEVEL	El. m	1,020.0	1,009.0	1,002.0	
⑥ GROSS STORAGE	m.c.m.	114.0	76.0	37.0	
⑦ LIVE STORAGE	do	100.8	62.8	43.8	
⑧ TYPE OF DAM		Concrete Gravity with Embankment Flank			
⑨ RIVER BED ELEVATION	El. m	933.0			
⑩ FOUNDATION LEVEL	do	947.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	2,830.0			
⑫ WEIR LENGTH	m	120.0			
⑬ OVERFLOW DEPTH	do	3.0			
⑭ HIGH WATER LEVEL	El. m	1,025.0	1,014.0	1,007.0	
⑮ FREEBOAD	m	3.0	3.5	3.5	
⑯ DAM TOP ELEVATION	El. m	1,028.0	1,016.5	1,009.5	
⑰ DAM HEIGHT	m	81.0	69.5	62.5	
⑱ TOP WIDTH	do	C: 8.0 , F: 12.0	C: 8.0 , F: 10.0	C: 8.0 , F: 10.0	
⑲ TOP LENGTH	do	C: 130 , F: 1,430	C: 130 , F: 1,270	C: 130 , F: 870	
⑳ RIVER WIDTH EXCAVATED	do	C: 40 , F: 0			
㉑ U/S SLOPE OF DAM		C: 0.1 , F: 3.0			
㉒ D/S SLOPE OF DAM		C: 0.9 , F: 2.5			
㉓ DAM VOLUME	1000 cu.m	C: 234.3 , F: 9,358.0	C: 175.8 , F: 6,067.8	C: 146.3 , F: 3,386.8	
㉔ DAM COST	10^6 Rs.	1,428.0	939.1	579.8	
㉕ ARTICLE - ROAD	Km				
㉖ TO BE - HOUSE	Number	42	31	17	
㉗ SUBMER- - MILL	do	2	2	2	
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	7.3	5.6	3.5	
㉛ WATER CONVEYANCE COST	do	1,433.3	944.7	583.3	
㉜ OTHER COST	do				
㉝ TOTAL COST	do				
㉞ UNIT COST PER LIVE STORAGE	Rs/1000 cu.m	14.24	15.04	13.32	

D - 2

		D - 2 ①	②	③	④
① NUMBER OF DAM					
② NAME OF DAM		Dorse Gali			
③ CATCHMENT AREA	sq. km	244.5			
④ RECEABLE SEDIMENT	m.c.m.	11.1			
⑤ RETENTION WATER LEVEL	El. m	1,157.0	1,149.0	1,141.0	1,129.0
⑥ GROSS STORAGE	m.c.m.	80.0	64.0	48.0	32.0
⑦ LIVE STORAGE	do	48.9	32.9	16.9	20.9
⑧ TYPE OF DAM		Concrete Gravity			
⑨ RIVER BED ELEVATION	El. m	1,045.0			
⑩ FOUNDATION LEVEL	do	1,029.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	2,350.0			
⑫ WEIR LENGTH	m	129.0			
⑬ OVERFLOW DEPTH	do	4.5			
⑭ HIGH WATER LEVEL	El. m	1,161.5	1,153.5	1,145.5	1,133.5
⑮ FREEBOAD	m	3.0	3.0	3.0	3.0
⑯ DAM TOP ELEVATION	El. m	1,164.5	1,156.5	1,148.5	1,136.5
⑰ DAM HEIGHT	m	135.5	127.5	119.5	107.5
⑱ TOP WIDTH	do	4.0	4.0	4.0	4.0
⑲ TOP LENGTH	do	360.0	340.0	320.0	290.0
⑳ RIVER WIDTH EXCAVATED	do	12.0			
㉑ U/S SLOPE OF DAM		0.1			
㉒ D/S SLOPE OF DAM		0.9			
㉓ DAM VOLUME	1000 cu.m	1,435.7	1,233.7	1,033.3	736.0
㉔ DAM COST	10^6 Rs.	1,722.8	1,468.4	1,240.0	943.2
㉕ ARTICLE - ROAD	Km				
㉖ TO BE - HOUSE	Number	50	29	16	6
㉗ SUBMER- - MILL	do	1	1	1	1
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	3.0	3.0	2.9	1.4
㉛ WATER CONVEYANCE COST	do	1,719.5	1,473.3	1,242.9	944.6
㉜ OTHER COST	do				
㉝ TOTAL COST	do				
㉞ UNIT COST PER LIVE STORAGE	Rs/1000 cu.m	33.12	27.85	33.68	45.20

Table D-2-4 (2) Demension for Dam Sizing (First Stage) (2)

D - 3

			①	②	③	④
① NUMBER OF DAM		0 - 1				
② NAME OF DAM		Thai				
③ CATCHMENT AREA	sq. km	138.6				
④ PECEABLE SEDIMENT	m.c.m.	7.1				
⑤ RETENTION WATER LEVEL	El. m.	1,235.0		1,220.0	1,213.0	1,206.0
⑥ GROSS STORAGE	m.c.m.	62.0		41.0	31.0	21.0
⑦ LIVE STORAGE	do	54.9		33.9	23.9	13.9
⑧ TYPE OF DAM		Concrete Gravity				
⑨ RIVER BED ELEVATION	El. m	1,140.0				
⑩ FOUNDATION LEVEL	do	1,100.0				
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	2,000.0				
⑫ WEIR LENGTH	m	119.0				
⑬ OVERFLOW DEPTH	do	4.0				
⑭ HIGH WATER LEVEL	El. m	1,239.0		1,224.0	1,216.0	1,208.0
⑮ FREEBOAD	m	3.0		3.0	3.0	3.0
⑯ DAM TOP ELEVATION	El. m	1,242.0		1,227.0	1,219.0	1,211.0
⑰ DAM HEIGHT	m	142.0		127.0	119.0	111.0
⑱ TOP WIDTH	do	4.0		4.0	4.0	4.0
⑲ TOP LENGTH	do	440.0		410.0	390.0	370.0
⑳ RIVER WIDTH EXCAVATED	do	70.0				
㉑ U/S SLOPE OF DAM		0.1				
㉒ D/S SLOPE OF DAM		0.8				
㉓ DAM VOLUME	1000 cu.m	1,899.1		1,452.5	1,233.3	1,040.3
㉔ DAM COST	10^6 Rs.	2,278.9		1,743.0	1,482.4	1,248.4
㉕ ARTICLE - ROAD	Km	(Type A) 3.5		2.15	1.7	1.35
㉖ TO BE - HOUSE	Number	35		32	27	19
㉗ SUBMER- - MILL	do					
㉘ GED - MOSQUE	do					
㉙ - POST OFFICE	do					
㉚ COMPENSATION COST	10^6 Rs.	92.8		58.6	36.5	41.6
㉛ WATER CONVEYANCE COST	do					
㉜ OTHER COST	do					
㉝ TOTAL COST	do	2,371.7		1,801.6	1,518.9	1,290.0
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	43.20		53.14	63.97	92.80

D - 4

			①	②	③	
① NUMBER OF DAM		0 - 4				
② NAME OF DAM		Oisai				
③ CATCHMENT AREA	sq. km	149.1				
④ PECEABLE SEDIMENT	m.c.m.	8.7				
⑤ RETENTION WATER LEVEL	El. m.	1,271.0		1,245.0	1,232.0	
⑥ GROSS STORAGE	m.c.m.	58.0		29.0	19.0	
⑦ LIVE STORAGE	do	51.3		22.3	12.3	
⑧ TYPE OF DAM		Concrete Gravity				
⑨ RIVER BED ELEVATION	El. m	1,183.0				
⑩ FOUNDATION LEVEL	do	1,148.0				
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,930.0				
⑫ WEIR LENGTH	m	96.0				
⑬ OVERFLOW DEPTH	do	4.5				
⑭ HIGH WATER LEVEL	El. m	1,275.5		1,249.5	1,236.5	
⑮ FREEBOAD	m	3.0		3.0	2.5	
⑯ DAM TOP ELEVATION	El. m	1,278.5		1,252.5	1,239.0	
⑰ DAM HEGHT	m	130.5		104.5	91.0	
⑱ TOP WIDTH	do	4.0		4.0	4.0	
⑲ TOP LENGTH	do	460.0		430.0	405.0	
⑳ RIVER WIDTH EXCAVATED	do	90.0				
㉑ U/S SLOPE OF DAM		0.1				
㉒ D/S SLOPE OF DAM		0.8				
㉓ DAM VOLUME	1000 cu.m	1,834.8		1,107.9	818.8	
㉔ DAM COST	10^6 Rs.	2,201.5		1,329.5	980.2	
㉕ ARTICLE - ROAD	Km	(Type A) 2.5		1.7	1.5	
㉖ TO BE - HOUSE	Number	23		20	16	
㉗ SUBMER- - MILL	do					
㉘ GED - MOSQUE	do					
㉙ - POST OFFICE	do					
㉚ COMPENSATION COST	10^6 Rs.	65.9		43.3	42.4	
㉛ WATER CONVEYANCE COST	do					
㉜ OTHER COST	do					
㉝ TOTAL COST	do	2,267.7		1,375.0	1,022.6	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	44.20		61.66	83.13	

Table D-2-4 (3) Demension for Dam Sizing (First Stage) (3)

D - 5

		D - 5		
① NUMBER OF DAM				
② NAME OF DAM		Harna ①	②	③
③ CATCHMENT AREA	sq. km	113.6		
④ RECEABLE SEDIMENT	m.c.m.	5.1		
⑤ RETENTION WATER LEVEL	El. m	1,348.0	1,287.0	1,274.0
⑥ GROSS STORAGE	m.c.m.	44.0	22.0	13.0
⑦ LIVE STORAGE	do	38.9	16.9	9.9
⑧ TYPE OF DAM		Concrete Gravity		
⑨ RIVER BED ELEVATION	El. m	1,212.0		
⑩ FOUNDATION LEVEL	do	1,184.0		
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,640.0		
⑫ WEIR LENGTH	m	82.0		
⑬ OVERFLOW DEPTH	do	4.5		
⑭ HIGH WATER LEVEL	El. m	1,316.5	1,291.5	1,278.5
⑮ FREEBOAD	m	3.0	3.0	2.5
⑯ DAM TOP ELEVATION	El. m	1,319.5	1,294.5	1,281.0
⑰ DAM HEIGHT	m	133.5	110.5	98.0
⑱ TOP WIDTH	do	4.0	4.0	4.0
⑲ TOP LENGTH	do	410.0	330.0	280.0
⑳ RIVER WIDTH EXCAVATED	do	40.0		
㉑ U/S SLOPE OF DAM		0.1		
㉒ D/S SLOPE OF DAM		0.8		
㉓ DAM VOLUME	1000 cu.m	1,471.5	832.7	581.3
㉔ DAM COST	10^6 Rs.	1,765.8	999.2	697.6
㉕ ARTICLE - ROAD	Km	(Type A) 1.9	1.3	1.3
㉖ TO BE - HOUSE	Number	24	16	10
㉗ SUBMER- - MILL	do	2	1	0
㉘ GED - MOSQUE	do			
㉙ - POST OFFICE	do			
㉚ COMPENSATION COST	10^6 Rs.	52.1	40.4	34.0
㉛ WATER CONVEYANCE COST	do			
㉜ OTHER COST	do			
㉝ TOTAL COST	do	1,817.9	1,039.6	731.6
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	46.73	61.52	73.89

D - 6

		D - 6 ①	②	③
① NUMBER OF DAM				
② NAME OF DAM		Kalra		
③ CATCHMENT AREA	sq. km	103.9		
④ RECEABLE SEDIMENT	m.c.m.	4.8		
⑤ RETENTION WATER LEVEL	El. m.	1,349.0	1,330.0	1,321.0
⑥ GROSS STORAGE	m.c.m.	41.0	21.0	14.0
⑦ LIVE STORAGE	do	36.2	16.2	9.2
⑧ TYPE OF DAM		Concrete Gravity		
⑨ RIVER BED ELEVATION	El. m	1,238.0		
⑩ FOUNDATION LEVEL	do	1,240.0		
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,570.0		
⑫ WEIR LENGTH	m	78.0		
⑬ OVERFLOW DEPTH	do	4.5		
⑭ HIGH WATER LEVEL	El. m	1,353.5	1,338.5	1,325.5
⑮ FREEBOAD	m	3.0	3.0	2.5
⑯ DAM TOP ELEVATION	El. m	1,356.5	1,337.5	1,328.0
⑰ DAM HEIGHT	m	116.5	97.5	88.0
⑱ TOP WIDTH	do	4.0	4.0	4.0
⑲ TOP LENGTH	do	275.0	225.0	200.0
⑳ RIVER WIDTH EXCAVATED	do	30.0		
㉑ U/S SLOPE OF DAM		0.1		
㉒ D/S SLOPE OF DAM		0.8		
㉓ DAM VOLUME	1000 cu.m	753.1	456.1	342.5
㉔ DAM COST	10^6 Rs.	903.7	547.3	411.0
㉕ ARTICLE - ROAD	Km	(Type A) 0.8	0.7	0.6
㉖ TO BE - HOUSE	Number	33	15	9
㉗ SUBMER- - MILL	do	2	1	1
㉘ GED - MOSQUE	do			
㉙ - POST OFFICE	do	1	0	0
㉚ COMPENSATION COST	10^6 Rs.	27.8	20.3	16.9
㉛ WATER CONVEYANCE COST	do			
㉜ OTHER COST	do			
㉝ TOTAL COST	do	931.5	567.6	427.9
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	25.73	35.04	46.51

Table D-2-4 (4) Demension for Dam Sizing (First Stage) (4)

D - 7

		D - 7		
① NUMBER OF DAM		Dakhoa ①	②	③
② NAME OF DAM				
③ CATCHMENT AREA	sq. km	77.8		
④ PECEABLE SEDIMENT	m.c.m.	3.5		
⑤ RETENTION WATER LEVEL	El. m	1,374.0	1,362.0	1,346.0
⑥ GROSS STORAGE	m.c.m.	30.0	20.0	10.0
⑦ LIVE STORAGE	do	26.5	16.5	6.5
⑧ TYPE OF DAM		Concrete Gravity with Embankment Flank		
⑨ RIVER BED ELEVATION	El. m	1,314.0		
⑩ FOUNDATION LEVEL	do	1,309.0		
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,290.0		
⑫ WEIR LENGTH	m	53.0		
⑬ OVERFLOW DEPTH	do	5.0		
⑭ HIGH WATER LEVEL	El. m	1,379.0	1,367.0	1,351.0
⑮ FREEBOAD	m	2.5	2.5	2.0
⑯ DAM TOP ELEVATION	El. m	1,381.5	1,369.5	1,353.0
⑰ DAM HEIGHT	m	72.5	60.5	44.0
⑱ TOP WIDTH	do	C: 4.0 ,F: 12.0	C: 4.0 ,F: 10.0	C: 4.0 ,F: 8.0
⑲ TOP LENGTH	do	C: 70 ,F: 300	C: 70 ,F: 220	C: 70 ,F: 160
⑳ RIVER WIDTH EXCAVATED	do	C: 30 ,F: 0		
㉑ U/S SLOPE OF DAM		C: 0.1 ,F: 3.0		
㉒ D/S SLOPE OF DAM		C: 0.8 ,F: 2.5		
㉓ DAM VOLUME	1000 cu.m	C: 117.0 ,F:1,576.5	C: 83.5 ,F: 805.0	C: 46.8 ,F: 312.2
㉔ DAM COST	10^6 Rs.	329.6	196.8	93.6
㉕ ARTICLE - ROAD	Km			
㉖ TO BE - HOUSE	Number	23	16	11
㉗ SUBMER- - MILL	do	1	1	1
㉘ GED - MOSQUE	do			
㉙ - POST OFFICE	do	1	1	1
㉚ COMPENSATION COST	10^6 Rs.	5.4	4.4	3.7
㉛ WATER CONVEYANCE COST	do			
㉜ OTHER COST	do			
㉝ TOTAL COST	do	335.0	201.2	97.3
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	12.64	12.19	14.97

D-8

		D - 8		
① NUMBER OF DAM		Thorati ①	②	③
② NAME OF DAM				
③ CATCHMENT AREA	sq. km	51.6		
④ PECEABLE SEDIMENT	m.c.m.	2.3		
⑤ RETENTION WATER LEVEL	El. m.	1,387.0	1,373.0	1,358.0
⑥ GROSS STORAGE	m.c.m.	20.0	13.0	7.0
⑦ LIVE STORAGE	do	17.7	10.7	4.7
⑧ TYPE OF DAM		Concrete Gravity		
⑨ RIVER BED ELEVATION	El. m	1,321.0		
⑩ FOUNDATION LEVEL	do	1,303.0		
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	990.0		
⑫ WEIR LENGTH	m	90.0		
⑬ OVERFLOW DEPTH	do	3.0		
⑭ HIGH WATER LEVEL	El. m	1,390.0	1,376.0	1,361.0
⑮ FREEBOAD	m	2.5	2.5	2.0
⑯ DAM TOP ELEVATION	El. m	1,392.5	1,378.5	1,363.0
⑰ DAM HEIGHT	m	89.5	75.5	60.0
⑱ TOP WIDTH	do	4.0	4.0	4.0
⑲ TOP LENGTH	do	450.0	390.0	300.0
⑳ RIVER WIDTH EXCAVATED	do	30.0		
㉑ U/S SLOPE OF DAM		0.1		
㉒ D/S SLOPE OF DAM		0.8		
㉓ DAM VOLUME	1000 cu.m	698.7	446.2	233.8
㉔ DAM COST	10^6 Rs.	838.4	537.6	280.6
㉕ ARTICLE - ROAD	Km			
㉖ TO BE - HOUSE	Number	11	9	6
㉗ SUBMER- - MILL	do	1	1	1
㉘ GED - MOSQUE	do			
㉙ - POST OFFICE	do	1	1	1
㉚ COMPENSATION COST	10^6 Rs.	3.7	3.4	2.9
㉛ WATER CONVEYANCE COST	do			
㉜ OTHER COST	do			
㉝ TOTAL COST	do	842.1	541.2	283.5
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	47.58	50.58	60.31

Table D-2-4 (5) Demension for Dam Sizing (First Stage) (5)

H-1

① NUMBER OF DAM		H - 1			
② NAME OF DAM		Chanba Dhok ①	②	③	
③ CATCHMENT AREA	Sq. km	41.4			
④ ERODABLE SEDIMENT	m.c.m.	1.4			
⑤ RETENTION WATER LEVEL	El. m	756.0	740.0	740.0	
⑥ GROSS STORAGE	m.c.m.	16.0	11.0	8.0	
⑦ LIVE STORAGE	do	14.6	9.6	6.8	
⑧ TYPE OF DAM		Rockfill			
⑨ RIVER BED ELEVATION	El. m	697.0			
⑩ FOUNDATION LEVEL	do	675.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	850.0			
⑫ WEIR LENGTH	m	144.0			
⑬ OVERFLOW DEPTH	do	2.0			
⑭ HIGH WATER LEVEL	El. m	738.0	730.0	742.0	
⑮ FREEBOAD	m	3.0	3.0	3.5	
⑯ DAM TOP ELEVATION	El. m	761.0	753.0	744.5	
⑰ DAM HEIGHT	m	86.0	78.0	69.5	
⑱ TOP WIDTH	do	14.0	12.0	10.0	
⑲ TOP LENGTH	do	500.0	470.0	460.0	
⑳ RIVER WIDTH EXCAVATED	do	60.0			
㉑ U/S SLOPE OF DAM		3.0			
㉒ D/S SLOPE OF DAM		2.5			
㉓ DAM VOLUME	1000 cu.m	4,542.0	3,539.6	2,749.0	
㉔ DAM COST	10^6 Rs.	908.4	707.9	549.9	
㉕ ARTICLE - ROAD	Km				
㉖ TO BE - HOUSE	Number	5	3	3	
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	0.8	0.5	0.5	
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	909.2	708.4	550.4	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	62.27	73.79	81.39	

H-2

① NUMBER OF DAM		H - 2			
② NAME OF DAM		Ranjha ①	②	③	
③ CATCHMENT AREA	sq. km	49.8			
④ ERODABLE SEDIMENT	m.c.m.	1.7			
⑤ RETENTION WATER LEVEL	El. m.	732.0	724.0	711.0	
⑥ GROSS STORAGE	m.c.m.	19.0	13.0	8.0	
⑦ LIVE STORAGE	do	17.3	11.3	4.3	
⑧ TYPE OF DAM		Rockfill			
⑨ RIVER BED ELEVATION	El. m	668.0			
⑩ FOUNDATION LEVEL	do	646.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	970.0			
⑫ WEIR LENGTH	m	89.0			
⑬ OVERFLOW DEPTH	do	3.0			
⑭ HIGH WATER LEVEL	El. m	735.0	727.0	714.0	
⑮ FREEBOAD	m	3.0	3.0	2.5	
⑯ DAM TOP ELEVATION	El. m	738.0	730.0	716.5	
⑰ DAM HEIGHT	m	90.0	82.0	68.5	
⑱ TOP WIDTH	do	14.0	12.0	10.0	
⑲ TOP LENGTH	do	480.0	430.0	380.0	
⑳ RIVER WIDTH EXCAVATED	do	40.0			
㉑ U/S SLOPE OF DAM		3.0			
㉒ D/S SLOPE OF DAM		2.5			
㉓ DAM VOLUME	1000 cu.m	4,487.1	3,375.8	2,030.3	
㉔ DAM COST	10^6 Rs.	897.4	675.2	406.1	
㉕ ARTICLE - ROAD	Km				
㉖ TO BE - HOUSE	Number	9	8	6	
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	1.4	1.2	0.9	
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	898.9	676.4	407.0	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	51.95	59.83	94.64	

Table D-2-4 (6) Demension for Dam Sizing (First Stage) (6)

H-3

		H - 3 ①	②	③	
① NUMBER OF DAM					
② NAME OF DAM		Chas Karan			
③ CATCHMENT AREA	Sq. km	41.9			
④ RECOVERABLE SEDIMENT	m.c.m.	1.5			
⑤ RETENTION WATER LEVEL	El. m	760.0	751.0	747.0	
⑥ GROSS STORAGE	m.c.m.	16.0	11.0	8.0	
⑦ LIVE STORAGE	do	14.5	9.5	6.5	
⑧ TYPE OF DAM		Concrete Gravity			
⑨ RIVER BED ELEVATION	El. m	710.0			
⑩ FOUNDATION LEVEL	do	705.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	860.0			
⑫ WEIR LENGTH	m	63.0			
⑬ OVERFLOW DEPTH	do	3.5			
⑭ HIGH WATER LEVEL	El. m	763.5	754.5	750.5	
⑮ FREEBOAD	m	2.5	2.0	2.0	
⑯ DAM TOP ELEVATION	El. m	766.0	756.5	752.5	
⑰ DAM HEIGHT	m	61.0	51.5	47.5	
⑱ TOP WIDTH	do	4.0	4.0	4.0	
⑲ TOP LENGTH	do	450.0	380.0	360.0	
⑳ RIVER WIDTH EXCAVATED	do	110.0			
㉑ U/S SLOPE OF DAM		0.1			
㉒ D/S SLOPE OF DAM		0.8			
㉓ DAM VOLUME	1000 cu.m	442.3	289.2	241.0	
㉔ DAM COST	10^6 Rs.	330.8	347.0	289.2	
㉕ ARTICLE - ROAD	Km				
㉖ TO BE - HOUSE	Number	10	8	7	
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	1.5	1.2	1.1	
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	332.3	348.2	290.3	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	36.71	36.66	44.65	

H-4

		H - 4			
① NUMBER OF DAM					
② NAME OF DAM		Pine ①	②	③	④
③ CATCHMENT AREA	Sq. km	420.6			
④ RECOVERABLE SEDIMENT	m.c.m.	14.7			
⑤ RETENTION WATER LEVEL	El. m.	863.0	851.0	843.0	833.0
⑥ GROSS STORAGE	m.c.m.	164.0	110.0	82.0	55.0
⑦ LIVE STORAGE	do	149.3	95.3	67.3	40.3
⑧ TYPE OF DAM		Rock fill			
⑨ RIVER BED ELEVATION	El. m	775.0			
⑩ FOUNDATION LEVEL	do	735.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	3,450.0			
⑫ WEIR LENGTH	m	147.0			
⑬ OVERFLOW DEPTH	do	5.0			
⑭ HIGH WATER LEVEL	El. m	868.0	856.0	848.0	838.0
⑮ FREEBOAD	m	4.0	4.0	3.5	3.5
⑯ DAM TOP ELEVATION	El. m	872.0	860.0	851.5	841.5
⑰ DAM HEGHT	m	137.0	125.0	116.5	106.5
⑱ TOP WIDTH	do	20.0	20.0	18.0	16.0
⑲ TOP LENGTH	do	490.0	460.0	420.0	380.0
⑳ RIVER WIDTH EXCAVATED	do	60.0			
㉑ U/S SLOPE OF DAM		3.0			
㉒ D/S SLOPE OF DAM		2.3			
㉓ DAM VOLUME	1000 cu.m	11,252.3	8,960.3	7,721.8	6,199.4
㉔ DAM COST	10^6 Rs.	2,250.5	1,792.1	1,544.4	1,239.9
㉕ ARTICLE - ROAD	Km	(Type A) 1.5	0.8	0	0
㉖ TO BE - HOUSE	Number	39	33	24	16
㉗ SUBMER- - MILL	do	1	1	1	1
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	43.8	25.4	4.1	3.2
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	2,294.3	1,817.5	1,548.5	1,243.1
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	15.37	19.07	23.01	30.85

Table D-2-4 (7) Demension for Dam Sizing (First Stage) (7)

H-5

① NUMBER OF DAM		H - 5	①	②	③	④
② NAME OF DAM		Tilar				
③ CATCHMENT AREA	Sq. km	411.0				
④ PECEABLE SEDIMENT	m.c.m.	14.4				
⑤ RETENTION WATER LEVEL	El. m.	873.0	859.0	851.0	841.0	
⑥ GROSS STORAGE	m.c.m.	160.0	107.0	80.0	33.0	
⑦ LIVE STORAGE	do	145.6	92.6	65.6	38.6	
⑧ TYPE OF DAM		Rockfill				
⑨ RIVER BED ELEVATION	El. m	789.0				
⑩ FOUNDATION LEVEL	do	757.0				
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	3,410.0				
⑫ WEIR LENGTH	m	203.0				
⑬ OVERFLOW DEPTH	do	4.0				
⑭ HIGH WATER LEVEL	El. m	877.0	863.0	855.0	845.0	
⑮ FREEBOAD	m	4.0	3.5	3.0	3.0	
⑯ DAM TOP ELEVATION	El. m	881.0	866.5	858.0	848.0	
⑰ DAM HEIGHT	m	124.0	109.5	101.0	91.0	
⑱ TOP WIDTH	do	18.0	18.0	18.0	14.0	
⑲ TOP LENGTH	do	830.0	780.0	750.0	700.0	
⑳ RIVER WIDTH EXCAVATED	do	70.0				
㉑ U/S SLOPE OF DAM		3.0				
㉒ D/S SLOPE OF DAM		2.5				
㉓ DAM VOLUME	1000 cu.m	14,681.2	10,860.1	8,987.9	6,870.2	
㉔ DAM COST	10^6 Rs.	2,936.2	2,172.0	1,797.6	1,374.0	
㉕ ARTICLE - ROAD	Km	(Type A) 3.0	1.0	0	0	
㉖ TO BE - HOUSE	Number	36	24	18	11	
㉗ SUBMER- - MILL	do	1	1	0	0	
㉘ GED - MOSQUE	do					
㉙ - POST OFFICE	do					
㉚ COMPENSATION COST	10^6 Rs.	80.9	29.1	2.7	1.7	
㉛ WATER CONVEYANCE COST	do					
㉜ OTHER COST	do					
㉝ TOTAL COST	do	3,017.1	2,201.1	1,800.3	1,375.7	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000Cu.m	20.72	23.77	27.44	35.63	

H-6

① NUMBER OF DAM		H - 6				
② NAME OF DAM		Docara	①	②	③	④
③ CATCHMENT AREA	sq. km	329.8				
④ PECEABLE SEDIMENT	m.c.m.	11.5				
⑤ RETENTION WATER LEVEL	El. m.	901.0	888.0	881.0	871.0	
⑥ GROSS STORAGE	m.c.m.	150.0	100.0	75.0	50.0	
⑦ LIVE STORAGE	do	138.5	88.5	63.5	38.5	
⑧ TYPE OF DAM		Rockfill				
⑨ RIVER BED ELEVATION	El. m	821.0				
⑩ FOUNDATION LEVEL	do	776.0				
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	3,000.0				
⑫ WEIR LENGTH	m	98.0				
⑬ OVERFLOW DEPTH	do	6.0				
⑭ HIGH WATER LEVEL	El. m	907.0	894.0	887.0	877.0	
⑮ FREEBOAD	m	4.0	4.0	3.5	3.5	
⑯ DAM TOP ELEVATION	El. m.	911.0	898.0	890.5	880.5	
⑰ DAM HEIGHT	m	135.0	122.0	114.5	104.5	
⑱ TOP WIDTH	do	20.0	18.0	18.0	16.0	
⑲ TOP LENGTH	do	740.0	660.0	650.0	610.0	
⑳ RIVER WIDTH EXCAVATED	do	90.0				
㉑ U/S SLOPE OF DAM		3.0				
㉒ D/S SLOPE OF DAM		2.5				
㉓ DAM VOLUME	1000 cu.m	16,495.8	12,730.7	10,740.9	8,496.2	
㉔ DAM COST	10^6 Rs.	3,299.2	2,546.1	2,148.2	1,699.2	
㉕ ARTICLE - ROAD	Km	(Type A) 2.1	2.0	1.9	1.8	
㉖ TO BE - HOUSE	Number	51	35	29	23	
㉗ SUBMER- - MILL	do	2	2	2	2	
㉘ GED - MOSQUE	do					
㉙ - POST OFFICE	do					
㉚ COMPENSATION COST	10^6 Rs.	61.1	56.3	52.6	49.5	
㉛ WATER CONVEYANCE COST	do					
㉜ OTHER COST	do					
㉝ TOTAL COST	do	3,360.3	2,602.4	2,201.0	1,748.7	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000Cu.m	24.25	29.41	34.66	45.42	

Table D-2-4 (8) Demension for Dam Sizing (First Stage) (5)

H-7

		H-7 ①	②	③	④
① NUMBER OF DAM					
② NAME OF DAM		Kar Kai			
③ CATCHMENT AREA	Sq. km	36.8			
④ FECEABLE SEDIMENT	m.c.m.	2.0			
⑤ RETENTION WATER LEVEL	El. m	1,023.0	1,011.5	1,005.0	1,001.5
⑥ GROSS STORAGE	m.c.m.	44.0	22.0	13.0	11.0
⑦ LIVE STORAGE	do	42.0	20.0	13.0	9.0
⑧ TYPE OF DAM		Concrete Gravity			
⑨ RIVER BED ELEVATION	El. m	993.0			
⑩ FOUNDATION LEVEL	do	993.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,060.0			
⑫ WEIR LENGTH	m	97.0			
⑬ OVERFLOW DEPTH	do	3.0			
⑭ HIGH WATER LEVEL	El. m	1,028.0	1,014.5	1,008.5	1,004.5
⑮ FREEBOAD	m	2.5	2.5	2.5	2.0
⑯ DAM TOP ELEVATION	El. m	1,030.5	1,017.0	1,011.5	1,006.5
⑰ DAM HEGHT	m	79.5	62.0	56.0	51.5
⑱ TOP WIDTH	do	4.0	4.0	4.0	4.0
⑲ TOP LENGTH	do	360.0	320.0	290.0	280.0
⑳ RIVER WIDTH EXCAVATED	do	40.0			
㉑ U/S SLOPE OF DAM		0.1			
㉒ D/S SLOPE OF DAM		0.8			
㉓ DAM VOLUME	1000 cu.m	433.5	273.2	251.6	176.2
㉔ DAM COST	10^6 Rs.	320.3	330.2	253.2	211.4
㉕ ARTICLE - ROAD	Km	(Type A) 2.0	1.9	1.8	1.7
㉖ TO BE - HOUSE	Number	60	33	24	14
㉗ SUBMER- - MILL	do	2	2	2	2
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	60.0	53.5	49.6	45.6
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	380.3	383.7	302.8	257.0
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	13.82	19.18	23.29	28.56

H-8

		H - 8 ①	②	③	
① NUMBER OF DAM					
② NAME OF DAM		Chiver Gali			
③ CATCHMENT AREA	Sq. km	41.7			
④ FECEABLE SEDIMENT	m.c.m.	2.2			
⑤ RETENTION WATER LEVE	El. m.	1,372.0	1,361.0	1,356.0	
⑥ GROSS STORAGE	m.c.m.	24.0	16.0	12.0	
⑦ LIVE STORAGE	do	21.8	13.8	9.8	
⑧ TYPE OF DAM		Concrete Gravity			
⑨ RIVER BED ELEVATION	El. m	1,319.0			
⑩ FOUNDATION LEVEL	do	1,314.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/Sec	1,110.0			
⑫ WEIR LENGTH	m	55.0			
⑬ OVERFLOW DEPTH	do	4.5			
⑭ HIGH WATER LEVEL	El. m	1,376.5	1,365.5	1,360.5	
⑮ FREEBOAD	m	2.5	2.5	2.0	
⑯ DAM TOP ELEVATION	El. m	1,379.0	1,368.0	1,362.5	
⑰ DAM HEGHT	m	65.0	54.0	48.5	
⑱ TOP WIDTH	do	4.0	4.0	4.0	
⑲ TOP LENGTH	do	260.0	190.0	150.0	
⑳ RIVER WIDTH EXCAVATED	do	20.0			
㉑ U/S SLOPE OF DAM		0.1			
㉒ D/S SLOPE OF DAM		0.8			
㉓ DAM VOLUME	1000 cu.m	226.5	123.3	83.5	
㉔ DAM COST	10^6 Rs.	271.8	148.0	100.2	
㉕ ARTICLE - ROAD	Km				
㉖ TO BE - HOUSE	Number	8	6	4	
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	1.2	0.9	0.6	
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	273.0	148.9	100.8	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	12.52	10.79	10.29	

Table D-2-4 (9) Demension for Dam Sizing (First Stage) (6)

S-1

		S - 1 ①	②	③	④
① NUMBER OF DAM					
② NAME OF DAM		Cherah			
③ CATCHMENT AREA	sq. km	349.0			
④ PERCABLE SEDIMENT	m.c.m.	27.9			
⑤ RETENTION WATER LEVEL	El. m.	594.0	590.0	586.0	582.0
⑥ GROSS STORAGE	m.c.m.	113.0	93.0	70.0	47.0
⑦ LIVE STORAGE	do	87.1	65.1	42.1	19.1
⑧ TYPE OF DAM		Concrete Gravity			
⑨ RIVER BED ELEVATION	El. m	551.0			
⑩ FOUNDATION LEVEL	do	551.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	3,120.0			
⑫ WEIR LENGTH	m	113.0			
⑬ OVERFLOW DEPTH	do	3.5			
⑭ HIGH WATER LEVEL	El. m	599.5	595.5	591.5	587.5
⑮ FREEBOAD	m	2.0	2.0	2.0	2.0
⑯ DAM TOP ELEVATION	El. m	601.5	597.5	593.5	589.5
⑰ DAM HEIGHT	m	49.5	45.5	41.5	37.5
⑱ TOP WIDTH	do	4.0	4.0	4.0	4.0
⑲ TOP LENGTH	do	180.0	165.0	145.0	125.0
⑳ RIVER WIDTH EXCAVATED	do	30.0			
㉑ U/S SLOPE OF DAM		0.1			
㉒ D/S SLOPE OF DAM		0.8			
㉓ DAM VOLUME	1000 cu.m	100.9	80.3	61.5	43.7
㉔ DAM COST	10^6 Rs.	121.1	96.6	73.8	34.8
㉕ ARTICLE - ROAD	Km	(Type C) 3.3	3.2	3.0	2.8
㉖ TO-BE - HOUSE	Number	268	167	121	74
㉗ SUBMER- - MILL	do	3	3	3	3
㉘ GED - MOSQUE	do	3	4	1	0
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	59.7	42.2	30.2	21.0
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	180.0	138.8	104.0	75.8
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	2.08	2.13	2.47	3.97

S-2

		S - 2 ①	②	③	④
① NUMBER OF DAM					
② NAME OF DAM		Chaper			
③ CATCHMENT AREA	sq. km	215.8			
④ PERCABLE SEDIMENT	m.c.m.	17.3			
⑤ RETENTION WATER LEVEL	El. m.	624.0	618.0	614.0	610.0
⑥ GROSS STORAGE	m.c.m.	80.0	58.0	43.0	29.0
⑦ LIVE STORAGE	do	62.7	40.7	25.7	11.7
⑧ TYPE OF DAM		Rockfill			
⑨ RIVER BED ELEVATION	El. m	576.0			
⑩ FOUNDATION LEVEL	do	558.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/Sec	2,390.0			
⑫ WEIR LENGTH	m	77.0			
⑬ OVERFLOW DEPTH	do	6.0			
⑭ HIGH WATER LEVEL	El. m	630.0	624.0	620.0	615.0
⑮ FREEBOAD	m	2.5	2.5	2.5	2.5
⑯ DAM TOP ELEVATION	El. m	632.5	626.5	622.5	617.5
⑰ DAM HEIGHT	m	74.5	68.5	64.5	59.5
⑱ TOP WIDTH	do	12.0	10.0	10.0	10.0
⑲ TOP LENGTH	do	1,200.0	1,050.0	950.0	800.0
⑳ RIVER WIDTH EXCAVATED	do	50.0			
㉑ U/S SLOPE OF DAM		3.0			
㉒ D/S SLOPE OF DAM		2.5			
㉓ DAM VOLUME	1000 cu.m	7,175.3	5,325.0	4,328.0	3,174.7
㉔ DAM COST	10^6 Rs.	1,433.1	1,065.0	865.6	634.9
㉕ ARTICLE - ROAD	Km	(Type B) 1.0	1.0	0.9	0.8
㉖ TO-BE - HOUSE	Number	70	58	45	46
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	23.5	23.7	20.3	11.4
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	1,460.6	1,088.7	885.9	646.3
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	23.29	26.75	34.47	55.24

Table D-2-4 (10) Demension for Dam Sizing (First Stage) (10)

S-3

① NUMBER OF DAM		S - 1	①	②	③	④
② NAME OF DAM		Satyidan				
③ CATCHMENT AREA	sq. km	117.9				
④ PERCABLE SEDIMENT	m.c.m	9.4				
⑤ RETENTION WATER LEVEL	El. m	706.0	698.0	693.0	687.0	
⑥ GROSS STORAGE	m.c.m.	47.0	31.0	24.0	16.0	
⑦ LIVE STORAGE	do	37.6	21.6	14.6	6.6	
⑧ TYPE OF DAM		Rockfill				
⑨ RIVER BED ELEVATION	El. m	665.0				
⑩ FOUNDATION LEVEL	do	627.0				
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,680.0				
⑫ WEIR LENGTH	m	54.0				
⑬ OVERFLOW DEPTH	do	6.0				
⑭ HIGH WATER LEVEL	El. m	712.0	704.0	699.0	693.0	
⑮ FREEBOAD	m	3.0	3.0	2.5	2.5	
⑯ DAM TOP ELEVATION	El. m	715.0	707.0	701.5	695.5	
⑰ DAM HEIGHT	m	88.0	80.0	74.5	68.5	
⑱ TOP WIDTH	do	14.0	12.0	12.0	10.0	
⑲ TOP LENGTH	do	670.0	600.0	480.0	430.0	
⑳ RIVER WIDTH EXCAVATED	do	50.0				
㉑ U/S SLOPE OF DAM		3.0				
㉒ D/S SLOPE OF DAM		2.5				
㉓ DAM VOLUME	1000 cu.m	5,911.3	4,126.7	3,188.9	2,444.9	
㉔ DAM COST	10^6 Rs.	1,182.3	825.3	637.8	449.0	
㉕ ARTICLE - ROAD	Km	(Type B) 1.8	0	0	0	
㉖ TO BE - HOUSE	Number	46	37	27	23	
㉗ SUBMER- - MILL	do					
㉘ GED - MOSQUE	do					
㉙ - POST OFFICE	do					
㉚ COMPENSATION COST	10^6 Rs.	33.9	5.6	4.0	3.4	
㉛ WATER CONVEYANCE COST	do					
㉜ OTHER COST	do					
㉝ TOTAL COST	do	1,216.2	830.9	641.8	492.4	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	32.35	38.47	43.96	74.61	

M-1

① NUMBER OF DAM		M - 1	①	②	③	
② NAME OF DAM		Dhok Bangla				
③ CATCHMENT AREA	sq. km	70.2				
④ PERCABLE SEDIMENT	m.c.m.	5.6				
⑤ RETENTION WATER LEVEL	El. m.	525.0	522.0	521.0		
⑥ GROSS STORAGE	m.c.m.	23.0	15.0	11.0		
⑦ LIVE STORAGE	do	17.4	9.4	5.4		
⑧ TYPE OF DAM		Concrete Gravity with Embankment Flank				
⑨ RIVER BED ELEVATION	El. m	506.0				
⑩ FOUNDATION LEVEL	do	506.0				
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,210.0				
⑫ WEIR LENGTH	m	110.0				
⑬ OVERFLOW DEPTH	do	3.0				
⑭ HIGH WATER LEVEL	El. m	528.0	525.0	524.0		
⑮ FREEBOAD	m	2.0	2.0	2.0		
⑯ DAM TOP ELEVATION	El. m	530.0	527.0	526.0		
⑰ DAM HEIGHT	m	24.0	21.0	20.0		
⑱ TOP WIDTH	do	C: 4.0 ,F: 8.0	C: 4.0 ,F: 8.0	C: 4.0 ,F: 8.0		
⑲ TOP LENGTH	do	C: 120 ,F: 1,010	C: 120 ,F: 830	C: 120 ,F: 680		
⑳ RIVER WIDTH EXCAVATED	do	C: 10.0 ,F: 0				
㉑ U/S SLOPE OF DAM		C: 0.1 ,F: 3.0				
㉒ D/S SLOPE OF DAM		C: 0.8 ,F: 2.5				
㉓ DAM VOLUME	1000 cu.m	C: 18.3 ,F: 642.9	C: 14.8 ,F: 405.3	C: 13.6 ,F: 303.9		
㉔ DAM COST	10^6 Rs.	99.1	66.4	52.8		
㉕ ARTICLE - ROAD	Km	(Type B) 2.8	1.5	0		
㉖ TO BE - HOUSE	Number	47	25	5		
㉗ SUBMER- - MILL	do					
㉘ GED - MOSQUE	do					
㉙ - POST OFFICE	do					
㉚ COMPENSATION COST	10^6 Rs.	49.1	26.2	0.7		
㉛ WATER CONVEYANCE COST	do					
㉜ OTHER COST	do					
㉝ TOTAL COST	do	148.2	92.6	53.5		
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	8.51	9.86	9.91		

Table D-2-4 (11) Demension for Dam Sizing (First Stage) (11)

L-1

① NUMBER OF DAM	-	L - 1 ①	②	③	
② NAME OF DAM		Dadhochhat			
③ CATCHMENT AREA	Sq. km	281.3			
④ ESCAPABLE SEDIMENT	m.c.m.	22.6			
⑤ RETENTION WATER LEVE	El. m	548.0	538.0	534.0	
⑥ GROSS STORAGE	m.c.m.	114.0	57.0	38.0	
⑦ LIVE STORAGE	do	91.2	34.2	15.2	
⑧ TYPE OF DAM		Concrete Gravity with Embankment Flank			
⑨ RIVER BED ELEVATION	El. m	482.0			
⑩ FOUNDATION LEVEL	do	472.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	2,800.0			
⑫ WEIR LENGTH	m	119.0			
⑬ OVERFLOW DEPTH	do	3.0			
⑭ HIGH WATER LEVEL	El. m	553.0	543.0	539.0	
⑮ FREEBOAD	m	3.0	2.5	2.5	
⑯ DAM TOP ELEVATION	El. m	556.0	545.5	541.5	
⑰ DAM HEIGHT	m	84.0	73.5	69.5	
⑱ TOP WIDTH	do	C: 4.0 ,F: 12.0	C: 4.0 ,F: 12.0	C: 4.0 ,F: 10.0	
⑲ TOP LENGTH	do	C: 130 ,F: 1,470	C: 130 ,F: 1,270	C: 130 ,F: 1,120.0	
⑳ RIVER WIDTH EXCAVATED	do	C: 70.0 ,F: 0			
㉑ U/S SLOPE OF DAM		C: 0.1 3.0			
㉒ D/S SLOPE OF DAM		C: 0.8 ,F: 2.5			
㉓ DAM VOLUME	1000 cu.m	C: 319.4 ,F:10,232.3	C:248.2 ,F:6,851.5	C:223.4 ,F: 5,350.1	
㉔ DAM COST	10^6 Rs.	1,613.4	1,120.0	910.1	
㉕ ARTICLE - ROAD	Km	(Type C) 0.3	0	0	
㉖ TO BE - HOUSE	Number	30	1	0	
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do				
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	3.4	0.2	0	
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	1,919.0	1,120.2	910.1	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	17.73	32.75	59.87	

L-2

① NUMBER OF DAM		K - 2 ①	②	③	
② NAME OF DAM		Thathi Satyidan			
③ CATCHMENT AREA	Sq. km	237.9			
④ ESCAPABLE SEDIMENT	m.c.m.	19.0			
⑤ RETENTION WATER LEVE	El. m.	578.0	570.0	568.0	
⑥ GROSS STORAGE	m.c.m.	95.0	48.0	32.0	
⑦ LIVE STORAGE	do	76.0	29.0	13.0	
⑧ TYPE OF DAM		Rockfill			
⑨ RIVER BED ELEVATION	El. m	551.0			
⑩ FOUNDATION LEVEL	do	545.0			
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	2,330.0			
⑫ WEIR LENGTH	m	93.0			
⑬ OVERFLOW DEPTH	do	3.5			
⑭ HIGH WATER LEVEL	El. m	583.5	575.5	573.5	
⑮ FREEBOAD	m	2.0	2.0	2.0	
⑯ DAM TOP ELEVATION	El. m	585.5	577.5	575.5	
⑰ DAM HEIGHT	m	40.5	32.5	30.5	
⑱ TOP WIDTH	do	8.0	8.0	8.0	
⑲ TOP LENGTH	do	1,850.0	1,650.0	1,300.0	
⑳ RIVER WIDTH EXCAVATED	do	100.0			
㉑ U/S SLOPE OF DAM		3.0			
㉒ D/S SLOPE OF DAM		2.5			
㉓ DAM VOLUME	1000 cu.m	3,399.3	2,019.4	1,450.8	
㉔ DAM COST	10^6 Rs.	680.0	403.9	290.2	
㉕ ARTICLE - ROAD	Km	(Type C) 3.0	1.7	1.0	
㉖ TO BE - HOUSE	Number	66	47	39	
㉗ SUBMER- - MILL	do				
㉘ GED - MOSQUE	do	1	1	1	
㉙ - POST OFFICE	do				
㉚ COMPENSATION COST	10^6 Rs.	20.4	13.6	10.3	
㉛ WATER CONVEYANCE COST	do				
㉜ OTHER COST	do				
㉝ TOTAL COST	do	700.3	417.5	300.5	
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	9.21	14.40	23.12	

Table D-2-4 (12) Demension for Dam Sizing (First Stage) (12) L-3

		L - 3 ①	②	③
① NUMBER OF DAM				
② NAME OF DAM		Pandaul		
③ CATCHMENT AREA	sq. km	109.7		
④ ERODABLE SEDIMENT	m.c.m.	8.8		
⑤ RETENTION WATER LEVEL	El. m	825.0	616.0	616.0
⑥ GROSS STORAGE	m.c.m.	44.0	27.0	15.0
⑦ LIVE STORAGE	do - -	35.2	13.2	6.2
⑧ TYPE OF DAM		Rockfill		
⑨ RIVER BED ELEVATION	El. m	595.0		
⑩ FOUNDATION LEVEL	do	589.0		
⑪ SPILLWAY DESIGN FLOOD	cu.m/sec	1,600.0		
⑫ WEIR LENGTH	m	116.0		
⑬ OVERFLOW DEPTH	do	3.5		
⑭ HIGH WATER LEVEL	El. m	628.5	619.5	617.3
⑮ FREEBOAD	m	2.0	2.0	2.0
⑯ DAM TOP ELEVATION	El. m	630.5	621.5	619.5
⑰ DAM HEIGHT	m	41.5	32.5	30.5
⑱ TOP WIDTH	do	8.0	8.0	8.0
⑲ TOP LENGTH	do	1,270.0	1,150.0	1,080.0
⑳ RIVER WIDTH EXCAVATED	do	50.0		
㉑ U/S SLOPE OF DAM		3.0		
㉒ D/S SLOPE OF DAM		2.5		
㉓ DAM VOLUME	1000 cu.m	2,382.7	1,366.7	1,144.5
㉔ DAM COST	10^6 Rs.	476.5	273.3	228.9
㉕ ARTICLE - ROAD	Km	(Type B) 0.6	0.2	0
㉖ TO BE - HOUSE	Number	38	22	18
㉗ SUBMER- - MILL	do			
㉘ GED - MOSQUE	do			
㉙ - POST OFFICE	do			
㉚ COMPENSATION COST	10^6 Rs.	14.7	8.3	2.4
㉛ WATER CONVEYANCE COST	do			
㉜ OTHER COST	do			
㉝ TOTAL COST	do	491.2	279.6	231.3
㉞ UNIT COST PER LIVE STORAGE	Rs/1000cu.m	13.96	21.18	37.31

Table D-2-4 (13) Demension for Dam Sizing (First Stage) (13)

N - 1

		①	②	③	④	⑤
(1) NUMBER OF DAM						
(2) NAME OF DAM		Dhok BALOCH				
(3) CATCHMENT AREA	sq. km	462.0	(258.1 ---- Excluding Shahour Dam Catchment Area)			
(4) DEAD STORAGE	m. c. m.	10.32				
(5) LIVE STORAGE	do	140.00	105.00	76.00	54.00	42.00
(6) GROSS STORAGE	do	150.32	115.32	86.32	64.32	52.32
(7) LOW WATER LEVEL	El. m.	416.0				
(8) NORMAL WATER LEVEL	do	438.5	435.0	432.0	429.5	427.0
(9) HIGH WATER LEVEL	do	443.5	440.0	437.0	434.5	432.0
(10) RIVER BED ELEVATION	El. m.	395.0				
(11) FOUNDATION LEVEL	do	385.0				
(12) TYPE OF DAM		Rockfill				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	3,630.0				
(14) OVERFLOW DEPTH	m	5.0				
(15) WEIR LENGTH	m	155.0				
(16) FREEBOAD	m	2.5	2.5	2.5	2.5	2.5
(17) DAM TOP ELEVATION	El. m.	446.0	442.5	439.5	437.0	434.5
(18) DAM HEIGHT	m	61.0	57.5	54.5	52.0	49.5
(19) TOP WIDTH	m	10.0	10.0	10.0	10.0	8.0
(20) TOP LENGTH	m	1,615.0	1,585.0	1,545.0	1,520.0	1,495.0
(21) RIVER WIDTH, EXCAVATED	m	20.0				
(22) U/S SLOPE OF DAM		1:3.0				
(23) D/S SLOPE OF DAM		1:2.5				
(24) DAM VOLUME	10^6 cu. m	8.247	7.049	6.080	5.345	4.572
(25) DAM COST	10^6 Rs	1,649.40	1,409.80	1,216.00	1,069.00	914.40
(26) — ROAD	km	(B) Type 4.3	3.8	3.1	2.5	2.0
(27) ARTICLE — HOUSE	Number	192	181	160	141	122
(28) TO BE — MILL	do					
(29) SUBMER- — MOSQUE	do					
(30) GED — POST OFFICE	do					
(31) — TRANSMITTION	do	20	20	19	19	18
(32) COMPENSATION COST	10^6 Rs	293.30	284.15	260.50	248.65	228.30
(33) DAM CONSTRUCTION COST	do	1,942.70	1,693.95	1,476.50	1,317.65	1,142.70
(34) OTHER COST	do					
(35) TOTAL COST	do					
(36) UNIT COST PER LIVE STORAGE	Rs/1000cu. m	(13.88)	(16.13)	(19.43)	(24.40)	(27.21)

SL - 1

		①	②	③	④	⑤
(1) NUMBER OF DAM						
(2) NAME OF DAM		Dhok Parlanwali				
(3) CATCHMENT AREA	sq. km	237.6				
(4) DEAD STORAGE	m. c. m.	21.38				
(5) LIVE STORAGE	do	100.00	60.00	37.00	13.00	5.00
(6) GROSS STORAGE	do	121.38	81.38	58.38	34.38	26.38
(7) LOW WATER LEVEL	El. m.	452.5				
(8) NORMAL WATER LEVEL	do	471.0	465.5	462.5	457.0	454.0
(9) HIGH WATER LEVEL	do	475.0	469.5	466.5	461.0	458.0
(10) RIVER BED ELEVATION	El. m.	428.0				
(11) FOUNDATION LEVEL	do	418.0				
(12) TYPE OF DAM		Rockfill				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	2,550.0				
(14) OVERFLOW DEPTH	m	4.0				
(15) WEIR LENGTH	m	151.0				
(16) FREEBOAD	m	2.5	2.5	2.5	2.0	2.0
(17) DAM TOP ELEVATION	El. m.	477.5	472.0	469.0	463.0	460.0
(18) DAM HEIGHT	m	59.5	54.0	51.0	45.0	42.0
(19) TOP WIDTH	m	10.0	10.0	10.0	8.0	8.0
(20) TOP LENGTH	m	450.0	380.0	350.0	300.0	270.0
(21) RIVER WIDTH, EXCAVATED	m	60.0				
(22) U/S SLOPE OF DAM		1:3.0				
(23) D/S SLOPE OF DAM		1:2.5				
(24) DAM VOLUME	10^6 cu. m	1.707	1.317	1.136	0.814	0.686
(25) DAM COST	10^6 Rs	341.40	263.40	227.20	162.80	137.20
(26) — ROAD	km					
(27) ARTICLE — HOUSE	Number	8	6	5	3	2
(28) TO BE — MILL	do					
(29) SUBMER- — MOSQUE	do					
(30) GED — POST OFFICE	do					
(31) — OTHERS	do					
(32) COMPENSATION COST	10^6 Rs	1.20	0.90	0.75	0.45	0.30
(33) DAM CONSTRUCTION COST	do	342.60	264.30	227.95	163.25	137.50
(34) OTHER COST	do					
(35) TOTAL COST	do					
(36) UNIT COST PER LIVE STORAGE	Rs/1000cu. m	(3.43)	(4.41)	(6.16)	(12.56)	(27.50)

Figure D-2-3 (1) Schematic Geological Cross Section of Proposed Damsites (1)

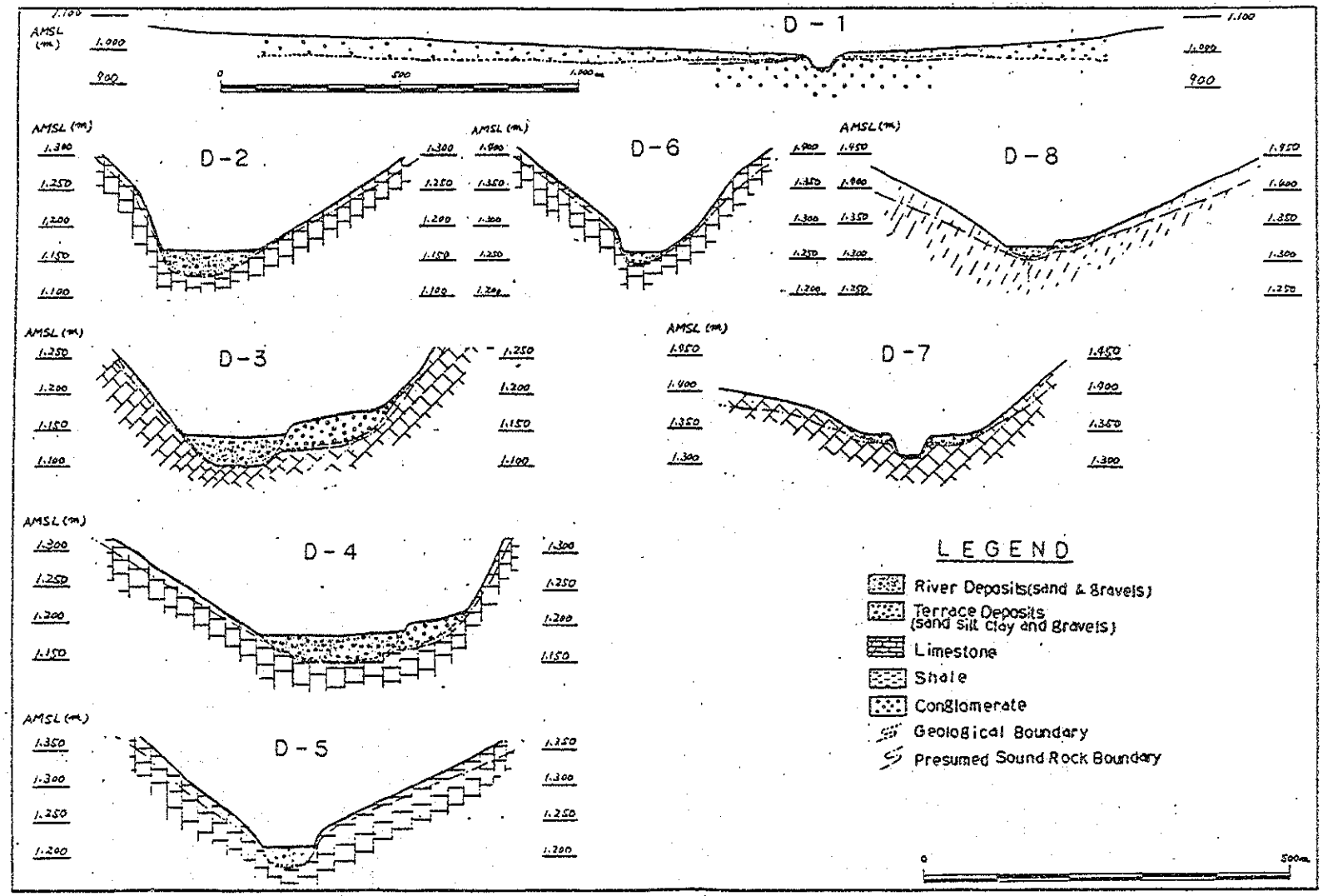


Figure D-2-3 (2) Schematic Geological Cross Section of Proposed Damsites (2)

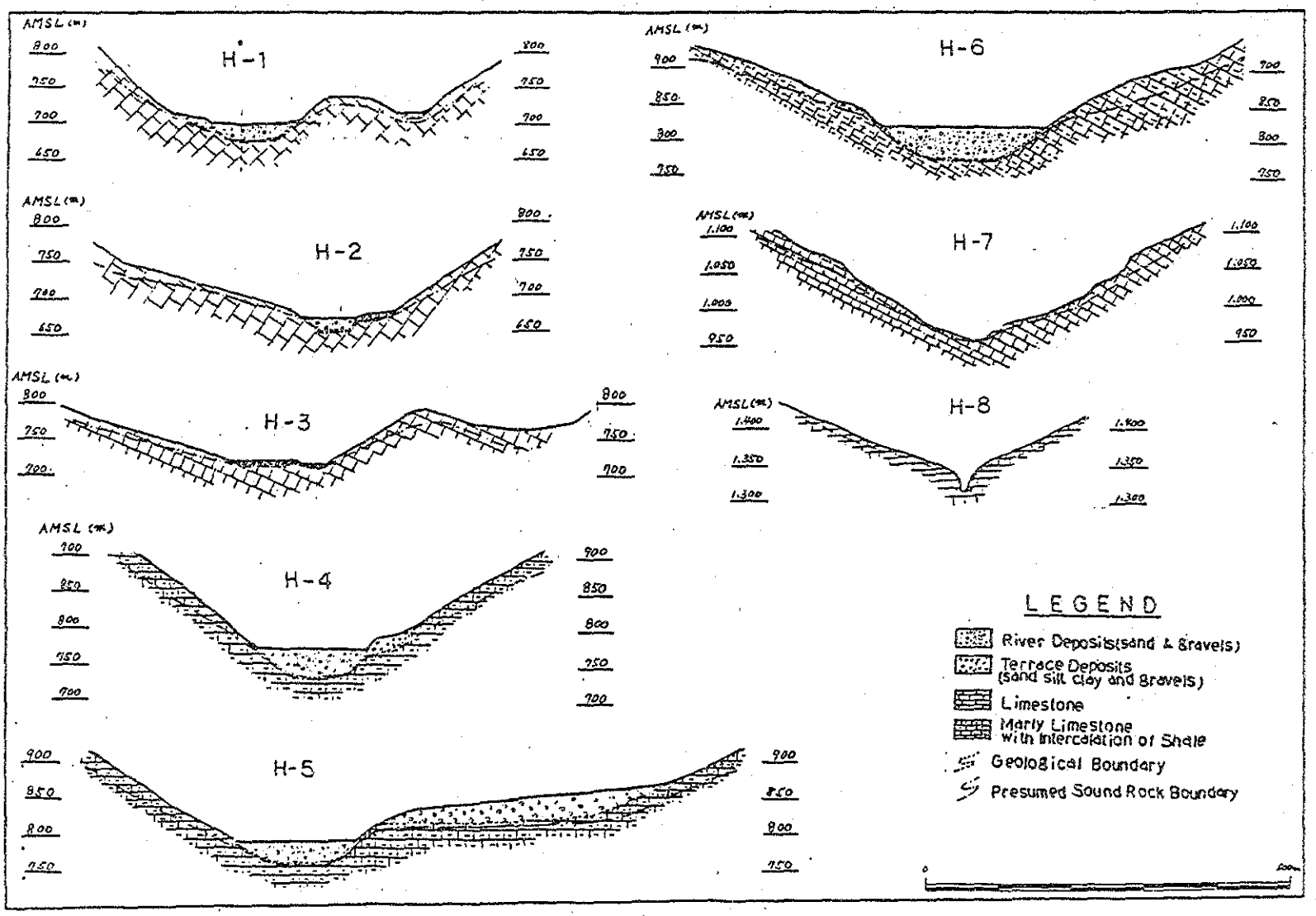


Figure D-2-3 (3) Schematic Geological Cross Section of Proposed Damsites (3)

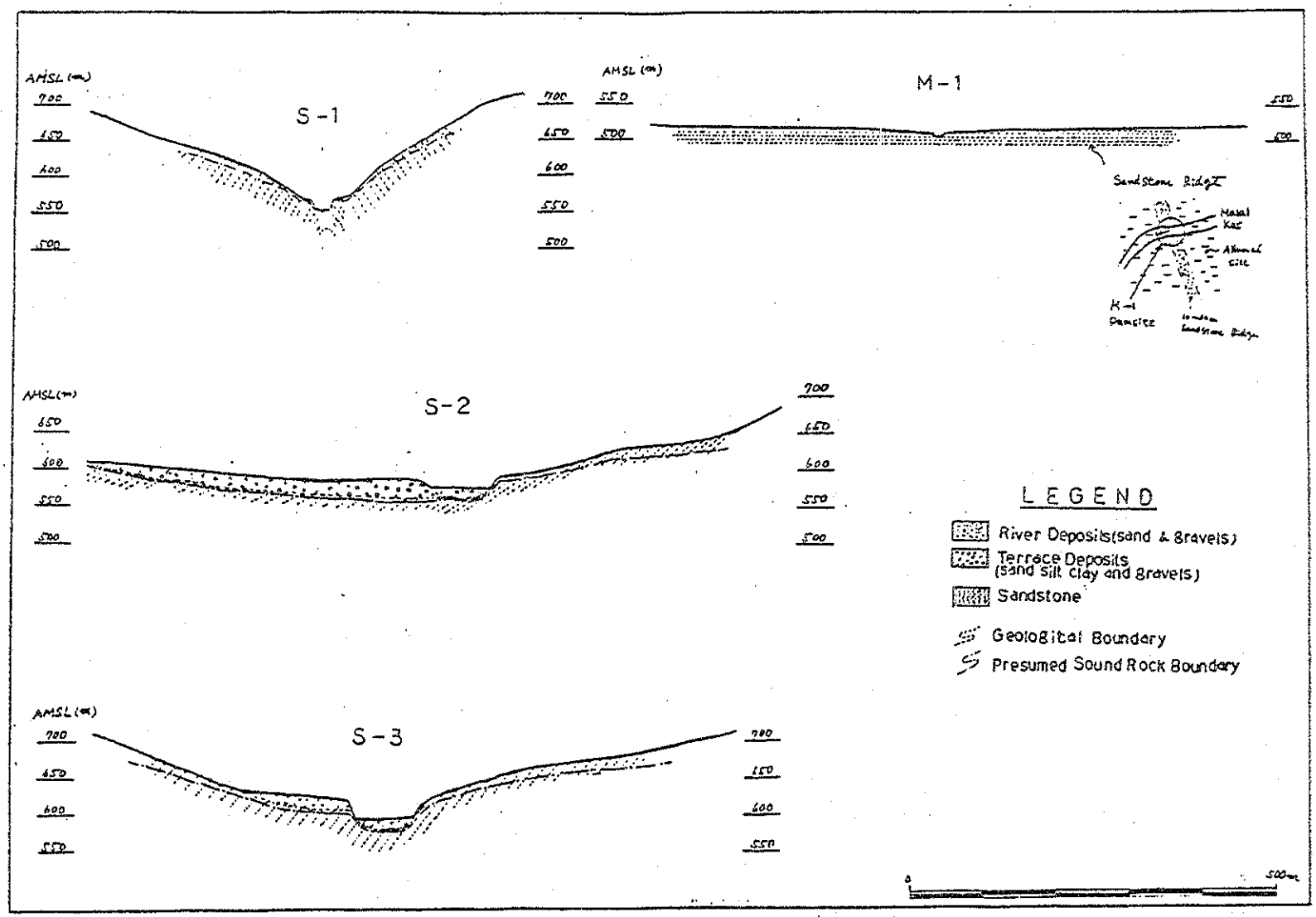
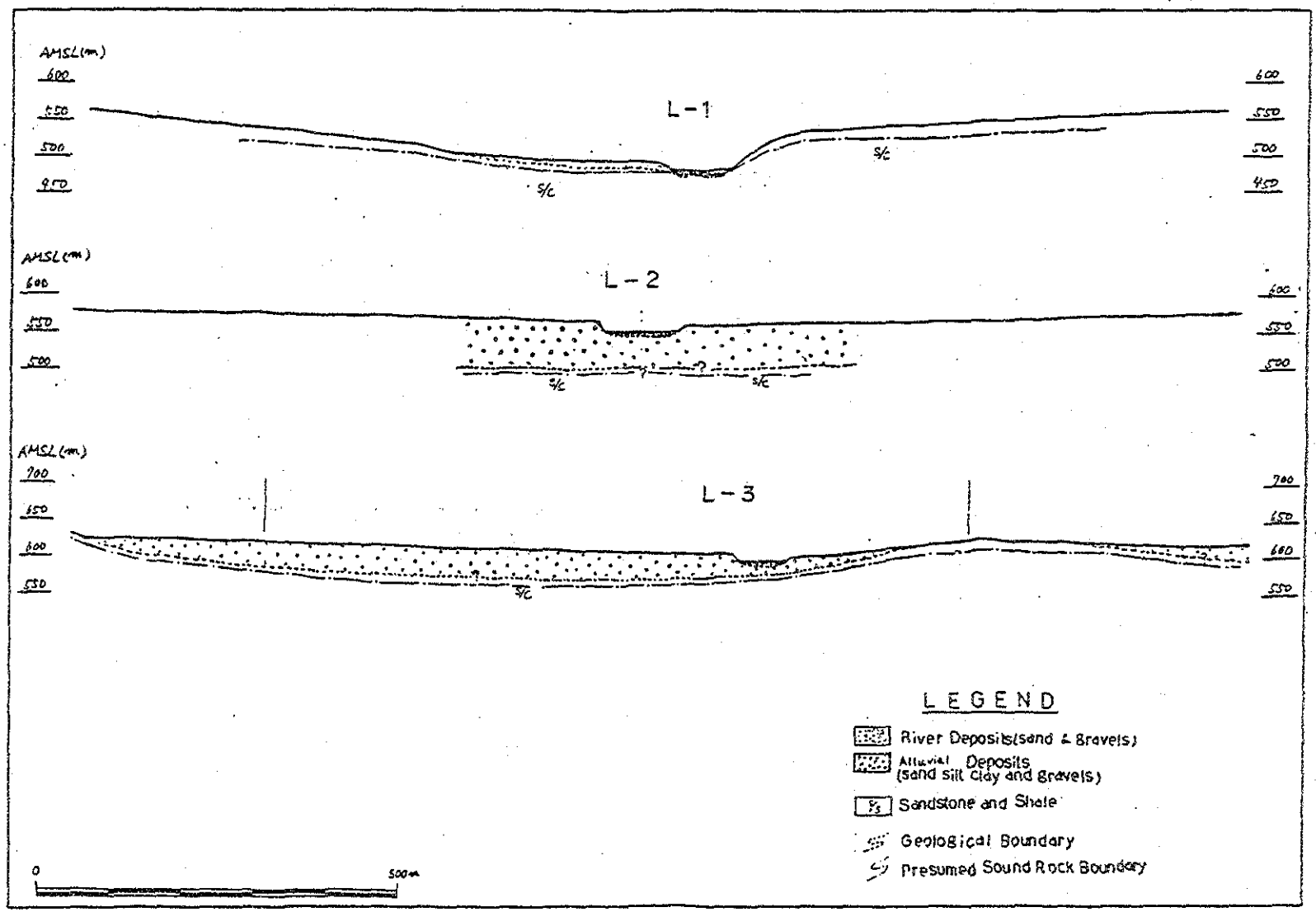


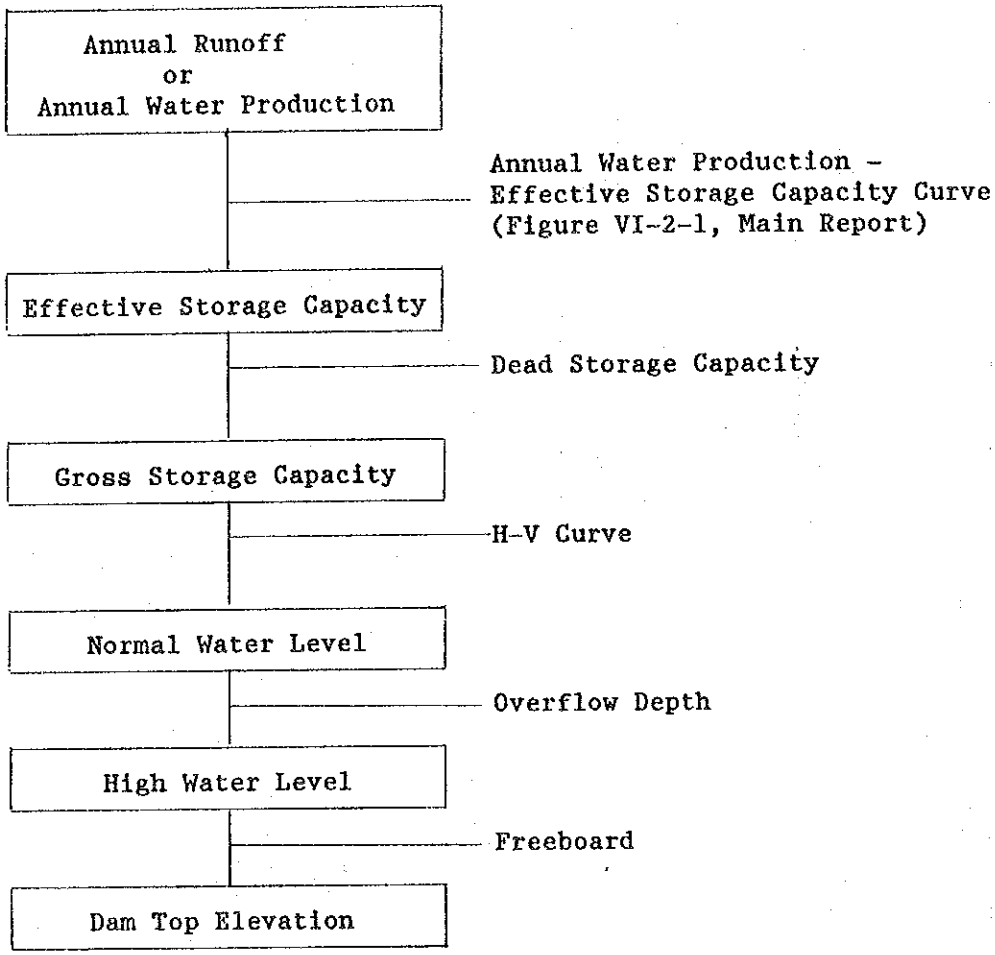
Figure D-2-3 (4) Schematic Geological Cross Section of Proposed Damsites (4)



D.2.1.2 Design Criteria of Storage Dams

(1) Determination of Dam Top Elevation

The following procedures and methodology are applied to determine reservoir water levels and dam top elevations.



(2) Dambody

(a) Type of Dam

The type of dam is selected upon consideration of the topographical, geologic and hydrological conditions of the damsites. From a topographical point of view, the shape of the valley is the most important factor in the selection.
On the other hand, geological conditions such as the thickness of river deposits and weathered rock foundation, the strength and permeability of the bedrock, the distribution of construction materials are also very important factors in the selection.
Such informations corresponding to this study are obtained through field reconnaissance.

(b) Freeboard

In determining the dam top elevation a certain freeboard is necessary above the High Water Level of the reservoir for safety purposes.
The freeboard should be determined upon considering such factors as extraordinary flood discharge, waves due to wind and earthquakes, rises in the water surface level caused by unexpected accidents in the operation of the spillway and the operation method of the reservoir.
In this preliminary study, approximately 4% of the dam height is adopted for the freeboard of a dam, as shown in the followings;

Dam Height (m)	Freeboard above High Water Level (m) Concrete Dam	Embankment Dam
$H < 50$	2.0	2.0
$50 \leq H < 75$	2.5	2.5
$75 \leq H < 100$	2.5	3.0
$100 \leq H < 120$	3.0	3.5
$120 \leq H$	3.0	4.0

(c) Dam Slopes and Top Widths

The slopes of dambodies are one of the most important factors influencing not only the safety of dams but also the volume of dambodies. The shape of dams should be determined after thoroughly studying the topographical conditions of the damsites, the nature of the bed rock, construction materials to be used and the type of spillway to be adopted.

The slopes of dambodies are tentatively determined according to the following criteria.

	Slope (Horizontal Ratio)	
Type of Dam	Upstream	Downstream
Concrete Gravity Dam	1:0.1	1:0.8
Embankment Dam	1:3.0	1:2.5

Top width of dambodies is adopted as follows;

	Top Width of Dambody	
Dam Height (m)	Concrete Dam	Embankment Dam
$H < 50$	4.0	8.0
$50 \leq H < 75$	4.0	10.0
$70 \leq H < 85$	4.0	12.0
$85 \leq H < 100$	4.0	14.0
$100 \leq H < 110$	4.0	16.0
$110 \leq H < 120$	4.0	18.0
$120 \leq H$	4.0	20.0

(3) Spillway

(a) Design Flood Discharge

Specific runoff of peak flood discharges can be studied using such empirical formula as Creager's Formula, Logarithmic Formula, Ingli's Formula, Dicken's Formula, Ration Method, and so on.
In this study, Creager's Formula (c=75) is adopted in consideration of the fact that Creager's Formula (c=100) would be the maximum value of peak flood discharge. The design flood discharge of Khanpur Dam (Q=150,000 cusec) is very similar to that of Creager's Formula (c=70).

$$Q = 46 \times C \times A^{0.894} \times A^{-0.048}$$

or

$$Q' = 1.303 \times C \times (A'/2.59)^{0.9358} \times A'^{-0.048}$$

Where,

Q : Design flood discharge in cusec.
Q' : Design flood discharge in cu.m/sec.
A : Catchment area in sq. miles
A' : Catchment area in sq. km
C : Coefficient = 75

(b) Overflow Water Depth of Spillway

In this study, the overflow water depth is calculated using the following simple equation, taking no account of reservoir surcharge effects which are usually considered in the design of spillways in Pakistan.

$$Q = C \times L \times H^{1.5}$$

Where,

Q : Design flood discharge (cu.m/sec.)
C : Coefficient of overflow = 2.1
L : Length of overflow weir (m)
H : Overflow water depth (m)

(c) Type of Spillway

The type of spillway studied prelimiarily would be the ungated type. The major reasons for this are summarized as follows;

- Ungated spillways do not suffer from any operation and maintenance problems.

- The only demerit an ungated spillway would have is that it requires additional dam height to keep overflow water depth. This is not so serious at this stage. Additional dam height may be considered to be a margin.

D.2.1.3 Preliminary Design of Storage Dams

(1) General Features of Selected Dams

The preliminary design were carried out for the seven selected damsites, namely D-1, H-4, S-1, SL-1, KL-1, and Shahpur Dam Heightenning Scheme.

The reservoir storage capacity were revised considering the results of field topographical survey, and are shown in Table D-2-7. The demension for the selected dams are studied based on the procedures and methodologies described in D.2.1.2, and are shown in Table D-2-8 and D-2-9.

The general features of the seven selected dams which have the optimum sizes described in Appendix D.3.2, are shown in Table D-2-5, and their preliminary design drawings are shown DWG. NO. 1 to 7.

(2) Engineering Considerations

Preliminary designs of storage dams are carried out based on the design criteria described in D.2.1.2. This chapter describes the engineering considerations of the preliminary designs, based on topographical, geological and soil mechanical, reconnaissance.

(a) Selection of Dam Type

The type of dam is selected taking into account the topographical, geologic and hydrological conditions of the damsites. Such technical characteristics as the dam foundation and the distribution of construction materials are especially important factors in the selection of the dam type.

The result of the geological surveys and the construction materials for selected damsites are described in Appendix B.3 and B.4 and are summarized in Table D-2-6.

Judging from the technical characteristics of dam foundations, only the S-1 damsite, comprised of Rawalpindi group sandstone and shale, has enough strength for the foundation of a concrete gravity dam. The bedrock of the H-4 damsite consists of limestone and might have enough strength for a concrete gravity dam of moderate size, but an embankment dam would be more suitable when the existence of thick river deposits and terrace deposits is taken into account.
The foundation of other damsites consist of thick terrace deposits (the D-1 damsite) or highly sheared and weathered bedrock (the L-1, SL-1 and KL-1 damsites). These foundations are not strong enough for concrete gravity dams, but will support embankment type dams.

As for the construction materials, concrete aggregate and embankment materials, quality materials are expected to be available in the near vicinity of each of the proposed damsites. However, there are some materials for some damsites which must be brought from a distance of 10 km.

(b) Foundation Treatment

The foundations of selected damsites can be classified into three groups by foundation treatment.

(1) Rock foundations [S-1, L-1, KL-1, SL-1]
(2) Pervious gravel foundations [D-1]
(3) Combinations of (1) and (2) [H-4].

(i) Rock Foundations

Grouting is usually performed to seal fissures, joints and other cracks in the foundation rock and to improve their watertightness. In the case of limestone layers, it is very important to select injection materials and perform the injections gradually using coarse to fine materials.
As for soft rock foundations, injections using low pressures are adequate and do not destroy the foundation rock.

(ii) Pervious Gravel Foundations

If a sand or gravel layer in the foundation is not very thick and a sufficient impervious layer underlies it, the impervious zone or cut-off wall is designed to reach the impervious layer.
When there is a thick sand or gravel layer foundation, seepage may generally be controlled by providing an upstream impervious blanket to reduce the hydraulic gradient.
The blanket method is not a direct measure to insure the watertightness of pervious foundations, but and indirect measure to prevent high velocity and large quantity seepage through the foundation by reducing the hydraulic gradient.

(c) Types of Spillways

In this study ungated and overflow type spillways are adopted for the damsites proposed in Appendix D.2.1.
It is necessary to adopt not only center overflow types but also side overflow types. This is decided upon consideration of the topographical conditions of each damsite.

Table D-2-5 General Feature of Selected Dams Series

Number of Dam		D - 1	H - 4	S - 1	L - 1	SL - 1	KL - 1	Shahpur
Name of River		Dor River	Haro River	Soan River	Soan River	Soan River	Soan River	Haro River
Name of Tributary		-	-	-	Ling River	Sil River	Kurang River	Nandna Kas
Name of Dam		Rajoia	Pina	Cherah	Dadhochai	Dhok Shaban	Lohi Bher	Shahpur
Catchment Area *	(sq.km)	292.3	498.5	341.1 (188.3)	285.0	237.6	558.8 (283.7)	203.9
Reservoir Area	(sq.km)	2.9	4.2	6.1	8.4	6.5	4.7	8.6
Gross Storage	(m.c.m)	74.62	144.94	82.95	116.65	83.38	41.80	47.28
Live Storage	(m.c.m)	60.00	125.00	66.00	91.00	62.00	16.30	40.00
Dead Storage	(m.c.m)	14.62	19.94	16.95	25.65	21.38	25.50	7.28
High Water Level	(El.m)	1,017.0	869.0	591.5	554.5	473.0	480.0	449.58
Normal Water Level	(do)	1,012.0	864.0	586.0	549.5	469.0	480.0	449.58
Low Water Level	(do)	981.5	815.0	570.0	529.0	453.0	475.5	440.40
Type of Dam **		E	E	C&F	E	E	E	G (Heightening)
Dam Top Elevation	(El.m)	1,020.0	872.5	594.0	557.5	475.5	482.0	450.8
Dam Height	(m)	85.0	132.5	C;65.0 F;14.0	92.5	55.5	42.0, 18.0	30.59 32.61
Dam Length	(m)	1,590	510	C;260 F;1750	1,570	420	300 + 910 = 1,210	256.0
Dam Volume	(m.c.m)	5.469	7.477	C;0.236 F;0.453	7.360	1.943	0.797 + 0.506 = 1.306	-
Initial Cost	(10^6Rs)	1,172.65	1,689.31	381.52	1,575.89	415.50	303.44	60.00
Annual O/M Cost (10^6Rs/Yr)		5.5	7.1	2.5	6.7	2.5	2.5	2.5
Water Production (m.c.m/yr)		107.0	80.0	60.0	70.0	40.0	34.0	17.25
Unit Water Cost (Rs/cu.m)		0.65	1.25	0.39	1.33	0.63	0.56	0.34

* ( ) ... Direct Catchment Area ** Type of Dam G; Concrete Gravity, E; Embankment, F; Embankment Flank

Table D-2-6. Dam Foundation and Construction Materials

Dam	Foundation			Construction Materials			Remarks
	Lithology	Weathering	Overburden	Impervious	Pervious	Aggregate	
D-1	Bedrock : Mesozoic limestone Overburden: Partially cemented terrace gravel layer	Moderate	Terrace gravel more than 50 m River dep. less than 10 m	Terrace	Limestone River dep.	Limestone River dep.	
H-4	Bedrock : Mesozoic limestone Overburden: River dep. Terrace gr.	Moderate	River dep. 30-40 m Terrace gr. 20-30 m	Terrace (12 km)*	Limestone River dep.	Limestone River dep.	*Near Battal, left tributary of Dhund Haro
S-1	Bedrock : Tertiary Sandstone and some Shale layers	Fresh	Negligible	Alluvial dep.	Sandstone	Sandstone	
L-1	Bedrock : Tertiary Sandstone and Shale Overburden: Alluvial dep. River dep.	High	Alluvial dep. 0-5 m River dep. 0-5 m	Alluvial dep.	Sandstone (moderate)	Sandstone (12 km)*	*South-west of S-1
KL-1	Bedrock : Tertiary Sandstone and Shale Overburden: Alluvial dep. (Silt)	High	Alluvial dep. 0-20 m River dep. 0-5 m	Alluvial dep.	Sandstone (moderate)	Sandstone (12 km)*	*Near Rawal Lake
SL-1	Bedrock : Tertiary Sandstone and Shale Overburden: Alluvial dep. River dep.	High	Alluvial dep. 0-10 m	Alluvial dep.	Sandstone (moderate)	Limestone (4 km)*	*North of SL-1

Table D-2-7 (1) Reservoir Storage Capacity (Second Stage) (1)

DAMSITE ; D − 1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
945	0		0	0
950	0.103	5	0.257	0.257
960	0.308	10	2.055	2.312
970	0.665	10	4.865	7.177
980	1.058	10	5.615	12.792
990	1.485	10	12.715	25.507
1,000	2.130	10	18.075	43.582
1,010	2.780	10	24.550	68.132
1,020	3.435	10	31.075	99.207
1,030	4.093	10	37.640	136.847
1,040	4.875	10	44.840	181.687
1,050	5.782	10	53.285	234.972

DAMSITE ; S − 1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
540	0	—	0	0
550	0.170	10	0.850	0.850
560	0.600	10	3.350	4.200
570	2.000	10	13.000	17.200
580	4.300	10	31.500	48.700
590	7.300	10	58.000	106.700
600	10.400	10	88.500	195.200
605	11.700	5	55.250	250.450

DAMSITE ; L − 1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
482	0		0	0
490	175	8	0.700	0.700
500	340	10	2.575	3.275
510	551	10	4.455	7.730
520	867	10	7.075	14.805
530	1,509	10	11.865	26.670
540	4,415	10	29.620	56.290
550	8,637	10	65.260	121.550
560	14,247	10	114.420	235.970

Table D-2-7 (2) Reservoir Storage Capacity (Second Stage) (2)

DAMSITE ; H－4

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
768	0		0	0
770	0.003	2	0.003	0.003
780	0.073	10	0.380	0.380
790	0.274	10	1.735	2.118
800	0.585	10	4.295	6.413
810	0.942	10	7.635	14.048
820	1.376	10	11.590	25.638
830	1.943	10	16.595	42.233
840	2.568	10	22.555	64.788
850	3.197	10	28.825	93.613
860	3.893	10	35.450	129.063
870	4.638	10	42.655	171.718
880	5.568	10	51.030	227.748
890	6.597	10	60.825	283.573
900	7.759	10	71.780	355.353
910	9.527	10	86.430	441.783

DAMSITE ; SL－1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
428	0		0	0
430	0.110	2	0.110	0.110
440	0.600	10	3.850	3.960
450	1.543	10	11.015	14.975
460	3.300	10	24.215	39.190
470	6.900	10	51.000	90.190
475	11.460	5	45.900	136.090

DAMSITE ; KL－1

ELEVATION OF RESERVOIR (m)	AREA OF RESERVOIR (sq.km)	HEIGHT (m)	STORAGE CAPACITY BETWEEN CONTOUR (m.c.m.)	STORAGE CAPACITY PROGRESSIVE (m.c.m.)
449.6	0		0	0
457.2	0.186	7.6	0.707	0.707
464.8	0.672	7.6	3.260	3.967
472.4	2.244	7.6	11.081	15.048
480.1	4.696	7.7	26.719	41.767

Table D-2-8 Demension for Optimum Dam Series

		D − 1	H − 4	S − 1	L − 1	SL− 1	KL− 1	Shahpur
(1) NUMBER OF DAM								
(2) NAME OF DAM		Rajoia	Pina	Cherah	Dadhochai	Dhok Shaban	Lohi Sher	Shahpur
(3) CATCHMENT AREA *	sq. km	292.3	498.5	341.1 (188.3)	285.0	237.6	558.8 (283.7)	203.9
(4) DEAD STORAGE	m. c. m.	14.62	19.94	16.95	25.65	21.38	25.50	7.28
(5) LIVE STORAGE	do	60.00	125.00	66.00	91.00	62.00	16.30	40.00
(6) GROSS STORAGE	do	74.62	144.94	82.95	116.65	83.38	41.80	47.28
(7) LOW WATER LEVEL	El. m.	981.5	815.0	570.0	529.0	453.0	475.5	440.4
(8) NORMAL WATER LEVEL	do	1,012.0	864.0	586.0	549.5	469.0	480.0	449.58
(9) HIGH WATER LEVEL	do	1,017.0	869.0	591.5	554.5	473.0	480.0	449.58
(10) RIVER BED ELEVATION	El. m.	945.0	768.0	534.0	475.0	428.0	448.0	
(11) FOUNDATION LEVEL	do	935.0	728.0	530.0	465.0	420.0	440.0	
(12) TYPE OF DAM		Earthfill	Earthfill	Gravity & Flank	Earthfill	Earthfill	Earthfill	Gravity
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	2,840.0	3,780.0	3,090.0	2,800.0	2,530.0	2,800.0	1,473.0
(14) OVERFLOW DEPTH	m	5.0	5.0	5.5	5.0	4.0	4.5	4.0
(15) WEIR LENGTH	m	121.0	161.0	114.0	120.0	151.0	140.0	60.0
(16) FREEBOAD	m	3.0	4.0	2.5	3.0	2.5	2.0	1.22
(17) DAM TOP ELEVATION	El. m.	1,020.0	872.5	594.0	557.5	475.5	482.0	450.8
(18) DAM HEIGHT	m	85.0	132.5	C;65.0, F;14.0	92.5	55.5	E;42.0, F;18.0	30.5→32.61
(19) TOP WIDTH	m	14.0	18.0	C; 4.0, F; 8.0	14.0	10.0	8.0	
(20) TOP LENGTH	m	1,590.0	510.0	C;260 , F;1750	1,570.0	420.0	E;300 , F;910	
(21) RIVER WIDTH, EXCAVATED	m	30.0	30.0	30.0	70.0	60.0	E;60.0, F;300	
(22) U/S SLOPE OF DAM		1 : 3.0	1 : 3.0	1 : 0.1 & 3.0	1 : 3.0	1 : 3.0	1 : 3.0	
(23) D/S SLOPE OF DAM		1 : 2.5	1 : 2.5	1 : 0.8 & 2.5	1 : 2.5	1 : 2.5	1 : 2.5	
(24) DAM VOLUME	10^6 cu. m	5.469	7.477	C;0.236 F;0.453	7.360	1.943	1.306	
(25) DAM COST	10^6 Rs	1,166.55	1,645.31	350.47	1,569.89	414.45	287.39	58.00
(26) — ROAD	km		(A) 1.5	(C) 3.0	(C) 0.3		(B) 0.2	
(27) ARTICLE — HOUSE	Number	35	40	127	34	7	27	
(28) TO BE — MILL	do	2	1	3				
(29) SUBMER- — MOSQUE	do			1			1	
(30) GED — POST OFFICE	do							
(31) — OTHERS	do						5	
(32) COMPENSATION COST	10^6 Rs	6.10	44.00	31.05	6.00	1.05	16.05	2.00
(33) DAM CONSTRUCTION COST	do	1,172.65	1,689.31	381.52	1,575.89	415.50	303.44	60.00
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	5.5	7.1	2.5	6.7	2.5	2.5	2.5
(35) ANNUAL WATER PRODUCT	m. c. m./yr	107.0	80.0	60.0	70.0	40.0	34.0	17.25
(36) UNIT WATER COST	Rs/cu. m	0.65	1.25	0.39	1.33	0.63	0.56	0.34

* ; ( )---Direct Catchment Area

Table D-2-9 (1) Demension for Dam Sizing (Second Stage) (1)

D - 1

		①	②	③	④	⑤
(1) NUMBER OF DAM						
(2) NAME OF DAM		Rajola				
(3) CATCHMENT AREA	sq. km	292.3				
(4) DEAD STORAGE	m. c. m.	14.62				
(5) LIVE STORAGE	do	100.00	80.00	60.00	50.00	43.00
(6) GROSS STORAGE	do	114.62	94.62	74.62	64.62	57.62
(7) LOW WATER LEVEL	El. m.	981.5				
(8) NORMAL WATER LEVEL	do	1,024.0	1,018.5	1,012.0	1,009.0	1,006.0
(9) HIGH WATER LEVEL	do	1,029.0	1,023.5	1,017.0	1,014.0	1,011.0
(10) RIVER BED ELEVATION	El. m.	945.0				
(11) FOUNDATION LEVEL	do	935.0				
(12) TYPE OF DAM		Earthfill				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	2,840.0				
(14) OVERFLOW DEPTH	m	5.0				
(15) WEIR LENGTH	m	121.0				
(16) FREEBOAD	m	3.0	3.0	3.0	3.0	3.0
(17) DAM TOP ELEVATION	El. m.	1,032.0	1,026.5	1,020.0	1,017.0	1,014.0
(18) DAM HEIGHT	m	97.0	91.5	85.0	82.0	79.0
(19) TOP WIDTH	m	14.0	14.0	14.0	12.0	12.0
(20) TOP LENGTH	m	1,890.0	1,780.0	1,590.0	1,510.0	1,390.0
(21) RIVER WIDTH, EXCAVATED	m	30.0				
(22) U/S SLOPE OF DAM		1:3.0				
(23) D/S SLOPE OF DAM		1:2.5				
(24) DAM VOLUME	10^6 cu. m	9.232	7.340	5.469	4.744	4.837
(25) DAM COST	10^6 Rs	1,969.19	1,565.62	1,166.55	1,011.90	864.50
(26) — ROAD	km					
(27) ARTICLE — HOUSE	Number	46	41	35	31	26
(28) TO BE — MILL	do	2	2	2	2	2
(29) SUBMER- — MOSQUE	do					
(30) GED — POST OFFICE	do					
(31) — OTHERS						
(32) COMPENSATION COST	10^6 Rs	7.90	7.15	6.10	5.65	4.90
(33) DAM CONSTRUCTION COST	do	1,977.09	1,572.77	1,172.65	1,017.55	869.40
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	7.9	6.7	5.5	5.1	4.3
(35) ANNUAL WATER PRODUCT	m. c. m./yr	109	108.5	107	103	96
(36) UNIT WATER COST	Rs/cu. m	1.07	0.86	0.65	0.59	0.54

Table D-2-9 (2) Demension for Dam Sizing (Second Stage) (2)

H - 4

		①	②	③	④	⑤
(1) NUMBER OF DAM						
(2) NAME OF DAM		Pina				
(3) CATCHMENT AREA	sq. km	498.5				
(4) DEAD STORAGE	m. c. m.	19.94				
(5) LIVE STORAGE	do	200.00	144.00	125.00	92.00	62.00
(6) GROSS STORAGE	do	219.94	163.94	144.94	111.94	81.94
(7) LOW WATER LEVEL	El. m.	815.0				
(8) NORMAL WATER LEVEL	do	879.0	868.5	864.0	855.5	846.0
(9) HIGH WATER LEVEL	do	884.0	873.5	869.0	860.5	851.0
(10) RIVER BED ELEVATION	El. m.	768.0				
(11) FOUNDATION LEVEL	do	728.0				
(12) TYPE OF DAM		Earthfill				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	3,780.0				
(14) OVERFLOW DEPTH	m	5.0				
(15) WEIR LENGTH	m	161.0				
(16) FREEBOAD	m	4.0	4.0	3.5	3.5	3.0
(17) DAM TOP ELEVATION	El. m.	888.0	877.5	872.5	864.0	854.0
(18) DAM HEIGHT	m	148.0	137.5	132.5	124.0	114.0
(19) TOP WIDTH	m	20.0	20.0	18.0	16.0	14.0
(20) TOP LENGTH	m	560.0	530.0	510.0	480.0	445.0
(21) RIVER WIDTH, EXCAVATED	m	30.0				
(22) U/S SLOPE OF DAM		1:3.0				
(23) D/S SLOPE OF DAM		1:2.5				
(24) DAM VOLUME	10^6 cu. m	10.554	8.449	7.477	6.059	4.617
(25) DAM COST	10^6 Rs	2,322.41	2,540.40	1,645.31	1,332.84	1,015.97
(26) — ROAD	km	(A) Type 2.4	1.8	1.5	1.1	0.3
(27) ARTICLE — HOUSE	Number	47	42	40	35	28
(28) TO BE — MILL	do	1	1	1	1	1
(29) SUBMER- — MOSQUE	do					
(30) GED — POST OFFICE	do					
(31) — OTHERS						
(32) COMPENSATION COST	10^6 Rs	67.55	51.80	44.00	33.25	12.20
(33) DAM CONSTRUCTION COST	do	2,389.96	1,911.00	1,689.31	1,366.09	1,028.17
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	8.4	7.7	7.1	6.1	5.1
(35) ANNUAL WATER PRODUCT	m. c. m./yr	91	84	80	67	51
(36) UNIT WATER COST	Rs/cu. m	1.53	1.34	1.25	1.21	1.20

Table D-2-9 (3) Demension for Dam Sizing (Second Stage) (3)

S - 1

		①	②	③	④	⑤
(1) NUMBER OF DAM						
(2) NAME OF DAM		Cherah				
(3) CATCHMENT AREA	sq. km	341.1 (188.3…Excluding Simly Dam Catchment Area)				
(4) DEAD STORAGE	m. c. m.	16.95				
(5) LIVE STORAGE	do	180.00	130.00	88.00	66.00	43.00
(6) GROSS STORAGE	do	196.95	146.95	104.95	82.95	59.95
(7) LOW WATER LEVEL	El. m.	570.0				
(8) NORMAL WATER LEVEL	do	600.5	595.0	590.0	586.0	582.0
(9) HIGH WATER LEVEL	do	606.0	600.5	595.5	591.5	587.5
(10) RIVER BED ELEVATION	El. m.	534.0				
(11) FOUNDATION LEVEL	do	530.0				
(12) TYPE OF DAM		Concrete Gravity & Embankment Flank				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	3,090.0				
(14) OVERFLOW DEPTH	m	5.5				
(15) WEIR LENGTH	m	114.0				
(16) FREEBOAD	m	2.5	2.5	2.5	2.5	2.5
(17) DAM TOP ELEVATION	El. m.	608.5	603.5	598.0	594.0	590.0
(18) DAM HEIGHT	m	C; 79.5, F; 28.5	C; 74.5, F; 23.5	C; 69.0, F; 18.0	C; 65.0, F; 14.0	C; 61.0, F; 10.0
(19) TOP WIDTH	m	C; 4.0, F; 8.0	C; 4.0, F; 8.0	C; 4.0, F; 8.0	C; 4.0, F; 8.0	C; 4.0, F; 8.0
(20) TOP LENGTH	m	C; 300, F; 2070	C; 290, F; 1990	C; 275, F; 1910	C; 260, F; 1750	C; 250, F; 1050
(21) RIVER WIDTH, EXCAVATED	m	30.0				
(22) U/S SLOPE OF DAM		C; 1:0.1, F; 1:3.0				
(23) D/S SLOPE OF DAM		C; 1:0.8, F; 1:2.5				
(24) DAM VOLUME	10^6 cu. m	C; 0.407, F; 2.660	C; 0.343, F; 1.674	C; 0.279, F; 0.867	C; 0.236, F; 0.453	C; 0.198, F; 0.171
(25) DAM COST	10^6 Rs	883.41	660.19	463.55	350.47	262.99
(26) — ROAD	km	(C) Type 4.0	3.7	3.2	3.0	2.8
(27) ARTICLE — HOUSE	Number	445	319	180	127	80
(28) TO BE — MILL	do	3	3	3	3	3
(29) SUBMER- — MOSQUE	do	5	5	4	1	0
(30) GED — POST OFFICE	do					
(31) — OTHERS						
(32) COMPENSATION COST	10^6 Rs	87.75	67.95	44.10	31.05	21.90
(33) DAM CONSTRUCTION COST	do	971.16	728.13	507.65	381.52	284.89
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	4.9	3.6	2.5	2.5	2.5
(35) ANNUAL WATER PRODUCT	m. c. m./yr	78	74	67.5	60	44.5
(36) UNIT WATER COST	Rs/cu. m	0.74	0.59	0.45	0.39	0.41

Table D-2-9 (4) Demension for Dam Sizing (Second Stage) (4)

L - 1

(1) NUMBER OF DAM		①	②	③	④	⑤
(2) NAME OF DAM		Dadhochai				
(3) CATCHMENT AREA	sq. km	285.0				
(4) DEAD STORAGE	m. c. m.	25.65				
(5) LIVE STORAGE	do	120.00	91.00	70.00	50.00	35.00
(6) GROSS STORAGE	do	145.65	116.65	95.65	75.65	60.65
(7) LOW WATER LEVEL	El. m.	529.0				
(8) NORMAL WATER LEVEL	do	552.5	549.5	546.0	543.0	541.0
(9) HIGH WATER LEVEL	do	557.5	554.5	551.0	548.0	546.0
(10) RIVER BED ELEVATION	El. m.	475.0				
(11) FOUNDATION LEVEL	do	465.0				
(12) TYPE OF DAM		Earthfill				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	2,800.0				
(14) OVERFLOW DEPTH	m	5.0				
(15) WEIR LENGTH	m	120.0				
(16) FREEBOAD	m	3.0	3.0	3.0	3.0	3.0
(17) DAM TOP ELEVATION	El. m.	560.5	557.5	554.0	551.0	549.0
(18) DAM HEIGHT	m	95.5	92.5	89.0	86.0	84.0
(19) TOP WIDTH	m	14.0	14.0	12.0	12.0	12.0
(20) TOP LENGTH	m	1,870.0	1,570.0	1,470.0	1,340.0	1,270.0
(21) RIVER WIDTH, EXCAVATED	m	70.0				
(22) U/S SLOPE OF DAM		1:3.0				
(23) D/S SLOPE OF DAM		1:2.5				
(24) DAM VOLUME	10^6 cu. m	8.342	7.360	6.335	5.605	5.161
(25) DAM COST	10^6 Rs	1,779.35	1,569.89	1,341.26	1,195.55	1,100.84
(26) — ROAD	km	(C) Type 0.4	0.3	0.2	0.2	0.1
(27) ARTICLE — HOUSE	Number	42	34	24	16	11
(28) TO BE — MILL	do					
(29) SUBMER- — MOSQUE	do					
(30) GED — POST OFFICE	do					
(31) — OTHERS						
(32) COMPENSATION COST	10^6 Rs	7.50	6.00	4.20	3.00	1.95
(33) DAM CONSTRUCTION COST	do	1,786.85	1,575.89	1,355.46	1,198.55	1,102.79
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	7.4	6.7	6.1	5.6	5.3
(35) ANNUAL WATER PRODUCT	m. c. m./yr	73.5	70	60.5	49	40
(36) UNIT WATER COST	Rs/cu. m	1.43	1.33	1.33	1.45	1.64

Table D-2-9 (5) Demension for Dam Sizing (Second Stage) (5)

S L - 1

(1) NUMBER OF DAM		①	②	③	④	⑤
(2) NAME OF DAM		Dhok Shaban				
(3) CATCHMENT AREA	sq. km	237.6				
(4) DEAD STORAGE	m. c. m.	21.38				
(5) LIVE STORAGE	do	100.00	62.00	37.00	13.00	5.00
(6) GROSS STORAGE	do	121.38	83.38	58.38	34.38	26.38
(7) LOW WATER LEVEL	El. m.	453.0				
(8) NORMAL WATER LEVEL	do	473.5	469.0	464.0	458.0	454.0
(9) HIGH WATER LEVEL	do	477.5	473.0	468.0	462.0	459.0
(10) RIVER BED ELEVATION	El. m.	428.0				
(11) FOUNDATION LEVEL	do	420.0				
(12) TYPE OF DAM		Earthfill				
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	2,530.0				
(14) OVERFLOW DEPTH	m	4.0				
(15) WEIR LENGTH	m	151.0				
(16) FREEBOAD	m	2.5	2.5	2.5	2.0	2.0
(17) DAM TOP ELEVATION	El. m.	480.0	475.5	470.5	464.0	461.0
(18) DAM HEIGHT	m	60.0	55.5	50.5	44.0	41.0
(19) TOP WIDTH	m	10.0	10.0	10.0	8.0	8.0
(20) TOP LENGTH	m	470.0	420.0	345.0	305.0	280.0
(21) RIVER WIDTH, EXCAVATED	m	60.0				
(22) U/S SLOPE OF DAM		1:3.0				
(23) D/S SLOPE OF DAM		1:2.5				
(24) DAM VOLUME	10^6 cu. m	2.324	1.943	1.562	1.113	0.956
(25) DAM COST	10^6 Rs	495.71	414.45	333.17	237.40	203.91
(26) — ROAD	km					
(27) ARTICLE — HOUSE	Number	9	7	6	3	2
(28) TO BE — MILL	do					
(29) SUBMER- — MOSQUE	do					
(30) GED — POST OFFICE	do					
(31) — OTHERS	do					
(32) COMPENSATION COST	10^6 Rs	1.35	1.05	0.90	0.45	0.30
(33) DAM CONSTRUCTION COST	do	497.06	415.50	334.07	237.85	204.21
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	2.5	2.5	2.5	2.5	2.5
(35) ANNUAL WATER PRODUCT	m. c. m./yr	43.5	40	33	19.5	4
(36) UNIT WATER COST	Rs/cu. m	0.68	0.63	0.63	0.80	2.28

Table D-2-9 (6) Demension for Dam Sizing (Second Stage) (6)

KL-1 | Shahpur

(1) NUMBER OF DAM							
(2) NAME OF DAM		Lohi Bher				Shahpur	
(3) CATCHMENT AREA	sq. km	558.8 (283.7…Excluding Rawal Dam Catchment Area)				203.9	
(4) DEAD STORAGE	m.c.m.	25.50				7.28	
(5) LIVE STORAGE	do	16.30				40.00	
(6) GROSS STORAGE	do	41.80				47.28	
(7) LOW WATER LEVEL	El. m.	475.5				440.4	
(8) NORMAL WATER LEVEL	do	480.0				449.58	
(9) HIGH WATER LEVEL	do	480.0				449.58	
(10) RIVER BED ELEVATION	El. m.	448.0					
(11) FOUNDATION LEVEL	do	440.0					
(12) TYPE OF DAM		Earthfill				Masonry Gravity	
(13) SPILLWAY DESIGN FLOOD	Cu. m/sec	2,800.0				1,473.0	
(14) OVERFLOW DEPTH	m	4.5				4.0	
(15) WEIR LENGTH	m	140.0				60.0	
(16) FREEBOAD	m	2.0				1.22	
(17) DAM TOP ELEVATION	El. m.	482.0				450.8	
(18) DAM HEIGHT	m	E; 42.0 , F; 18.0				30.59 → 32.61	
(19) TOP WIDTH	m	8.0					
(20) TOP LENGTH	m	300 910					
(21) RIVER WIDTH, EXCAVATED	m	60.0 300					
(22) U/S SLOPE OF DAM		1:3.0					
(23) D/S SLOPE OF DAM		1:2.5					
(24) DAM VOLUME	10^6 cu. m	0.797+0.506=1.306					
(25) DAM COST	10^6 Rs	287.39				58.00	
(26) — ROAD	km	(B) Type 0.2					
(27) ARTICLE — HOUSE	Number	27					
(28) TO BE — MILL	do						
(29) SUBMER- — MOSQUE	do	1					
(30) GED — POST OFFICE	do						
(31) — OTHERS		5					
(32) COMPENSATION COST	10^6 Rs	16.05				2.00	
(33) DAM CONSTRUCTION COST	do	303.44				60.00	
(34) OPERATION/MAINTENANCE COST	10^6 Rs/yr	2.5				2.5	
(35) ANNUAL WATER PRODUCT	m.c.m./yr	34				17.25	
(36) UNIT WATER COST	Rs/cu. m	0.56				0.34	

D.2.2. Diversion Dams and Intake Tower

(1) Diversion Dam

The main functions of diversion dams are to intake surface water from rivers, to intake water released from upstreams dams and to stabilize stream flow for pumping-up.

In this study diversion dams are planned to be constructed by one each on the Dor river, the Jhablat Kas and the Soan river respectively. A few prospective sites are selected on the topographical map in the scale at 1 to 50,000 in consideration of selection criteria described in D.2.2.(1)(a). The detailed field investigation clarifies that a proposed sites are at Nikapah 12.5 km east of Haripur on the Dor, at 4 km downstream of Hassan Abdal on the Jhablat Kas and on the upstream of the Grand Trunk road along the Soan respectively.

A floating type diversion dam is planned on the Dor and Jhablat Kas and a fixed type on the Soan.

Selection of the prospect site, geology and basic approach to structural design can be referred to D.2.2.(1)(b) and (c).

The intake point of the irrigation water to the Soan river right bank suburban areas of the Capital shall be located about 8.0 km downstream of the confluence with Lei Nala. It is recommended, however, that the percolation conduit system should be adopted for collecting infiltrating water due to heavy river water pollution by urban sewage.

(a) Selection Criteria for Diversion Damsites

The dams shall be so constructed as to take water in keeping always the stable discharges. Consequently, successful selection of the dam sites requires to give prudent consideration on the following criteria.

- A site is located so as to secure sufficient water head for water supply as well as possibly close to commanded areas, so that water conveyance networks can be economical in construction cost and easy in operation/maintenance services.

- A site, commanding a possibly vast area, is located along a part as narrow as possible in river width with flow center close to the bank and stable in discharge.

- A site is located not along with meandering of a river course but a straight part in considerable distance and not affected in river bed shift by flood.

- A Site has a reasonable river cross-section and slope to smoothly discharge a designed flood and to effectively eliminate deposited sand.

- A site has sufficient bearability to structures in stable, although acceptable with some permeable foundation.

- A site is less affected in submergence in the upstream area of a weir by daming-up of water and gives less adverse effect to structures such as bridges, embankment, etc. in the immediate downstream.

- A site requires less construction costs and is easy in implementation of construction works.

(b) Design of Diversion Dam

The proposed diversion dams will be designed for the site with 200 - 300 m river width and with intake capacity by 0.5 - 5.0 m^3/sec (20 - 180 cusec), and the foundation rocks of the structure are found both considerably deep and rather shallow depend upon the site conditions. In view of construction cost economy, a floating type structure will be adopted on sufficiently bearable sand and gravel foundation in the case that suitable foundation rocks are found deep from the river bed surface, while the fixed type with concrete structures directly constructed on foundation rocks shall be adopted in the case that sufficiently bearable foundation rocks are found shallow.

The designed flood discharge is estimated by Creager's Formula

$$Q = 46 \times C \times A^{0.894 \times A^{-0.048}}$$

Where;

Q : Designed flood discharge (cusec)

C : Region Coefficient
(The coefficient of 50 shall be applied as that for Punjab province)

A : Catchment Area (sq. miles)

Items		Dw-1	Jw-1	Sw-1
Area of River Basin	(sq.km)	517.7	248.6	1,472.8
	(sq.mile)	99.9	96.0	568.6
Flood Discharge	(cu.m)	2,570	1,730	4,270

Since the weir type with flood gates on the crest is expensive in construction cost, the weir is designed with table concrete body providing the flushing gate only.

For the floating type weir on the permeable foundation, a sufficient length of seepage route shall be secured in the dam body because the water dam-up will bring a considerable difference in the water levels between upstream and downstream of the dam body so that the piping phenomena may not take place in the weir body materials. And the necessary seepage route length can be obtained by Bly and Rein's Equation.

(c) Appurtenant Structures

i) Water Intake

The intake mouth shall be provided on the river bank immediately upstream of the dam body with about 1.0 meter higher sill height than that of the flushing gates. And the water intake velocity is designed in a range between 0.6 m/s and 0.8 m/sec so as to prevent sand from flowing in.

A gate will be provided immediately upstream of the intake mouth for regulating the intake amount, and a screen will be placed immediately upstream of the regulating gate for preventing floating materials from running into the intake mouth.

ii) Desilting Basin

A silting basin will be provided very closely in the downstream of the intake mouth in order to eliminate sand materials from the water conveyance networks for their easy operation and maintenance works. The desilting basin is so designed as to flush the sedimented sand materials out of the basin by gravity.

iii) Spillway, Control Gates and Regulating Facilities

A head regulator will be placed between the desilting basin and the conveyance canal for controlling regulating the amount of water take into the canal, and a spillway will be constructed upstream of the head regulator so as to return flood water or excess water into the river.

iv) Fish Ladder and Lock Gate

Fish ladders and lock gates will not be constructed on the proposed facilities since there are no fisheries nor navigation practised in the objective river and streams of the Project.

(d) Consideration of Each Diversion Dam Site

i) Diversion Dam Site on the Dor River

A diversion dam is constructed on the Dor river for the purpose of water conducting to the Khanpur dam. The prospecting sites are at Kalanwan 8 km east of Haripur and at Nikapah 12.5 km east of Haripur. The both sites are suitable for construction of diversion dam because the river width is small and current stream runs close to the left bank at both sites.

The riverbed elevation at the Kalanwan site is 616.6 m (2,020 ft), and the retention water level of the Khanpur dam is 604.5 m (1,982 ft).

The difference in elevation between the above two is 12.1 m (38 ft). The examination of topographical map and field investigation have revealed that the conduction main is about 22 km in length.

Since many streams and rivers run along the route, a fairly large number of crossing structures for such as aqueducts, syphons are needed. In addition, two tunnels (one for 2 km and the other for 4.5 km in length) are needed. The length of these structures will reach 50 percent of the total length. The rule of the conduction main is 1 to 1900 in average gradient. The gradient of the open canal, however, will be about 1 to 4,000 because some water head will be consumed by these costly structures. This fact indicates that the flow section will become large, accordingly and the construction cost will became fairly high. As for the Nikapah site, the difference in elevation between river bed of the Dor and retention water level of the Khanpur dam is 84 m. the length between them is about 26.5 km.

Even though the tunnels, siphons, aqueducts and open canals are constructed, and their dimensions are determined by allowable maximum velocity. The head over 30 m will still remain consumable. This remaining water head will be consumed by constructing of drops and shutes.

The properly designed drops and shutes will allow the open canal to be constructed on the elevation well-suited to the topography and the construction cost to be reduced to some extent.

Although the Nikapah conduction main is 16 percent longer than the Kalawan, the water head on the Nikapah can be consumed more than seven times that on the Kalawan. This fact shows that the scale of the structures such as tunnels, siphons, aqueducts and the cross-section of the open canal can be reduced to 70 percent.

For references, these costly structures occupy about 30 percent of the total length.

From a viewpoint of the cost, it is recommended that a diversion dam should be constructed at the Nikapah.

The terrace plain spreads on the both banks in this site. The relative height of the high terrace in the right bank is around 30 to 50 m and the recent lower terrace is 2 to 3 m from the river floor. In the left bank middle terrace whose relative height is approximately 15 m from the river floor widely spreads. The terrace plain has been cultivated on both flanks.

The deposits at the high-and middle-lying terrace are composed of compactly and moderately consolidated sand and gravels (cobble to pebble size) whose bearing capacity and permeability coefficient are supposed to be more than 50 tons per square meter and 10^{-3} cm/sec in magnitude, respectively.

The present river deposits and the recent low terrace deposits consist of loose sand and gravels in size ranging from cobble to pebble including some boulders. The sorting of these deposits is so fair that their permeability may have lower value by around 10^{-3} cm/sec and their bearing capacity is estimated at 15 to 20 tons per square meter excepting 1 to 2 m deep looser portion from the surface.

The thickness of the high-middle-lying terrace deposits may be considerable but the recent terrace and present river deposits are assumed to be around 10 m in thickness.

ii) Diversion Dam on the Jhablat Kas

Since one of the major water sources of the Jhablat Kas is springs found around Wah and Hassan Abdal, a favourable pumping station site in the downstream of this springing zone is selected at the point about 4 km located near the proposed irrigation area. Although the Jhablat Kas meanders heavily around this point the river discharge is comparatively stable and smooth for the proposed diversion damsite, and the proposed pumping site provides a sufficiently spacious land for a pumping station as well as appropriately elevated hilly land for constructing a delivery tank.

Besides, the proposed site is located closely to Hasar which has the highest elevation of 472.5 m (1,550 ft) in the irrigation area.

(e) Surveying

For the preliminary design on the diversion dam, a cross section of the river at the proposed dam center, riverbed gradient, discharge condition and so on need to be examined.

At one prospect diversion dam site for the Dor longitudinal and cross sections of the rivers was surveyed.

(2) Intake Facilities for the Suburban Irrigation Area

The cultivable area spreads to the southern part of Dahgal and the western part of Gorakupur. A pump station and concrete lined canal with cross-section of 1.0 sq.m exist at 0.8 km north of the Dahgal village, which was constructed about 10 years ago. The intake facilities were damaged by flood, so that they have not been used since these six years. The field investigation has fund that the existing canal is still in good condition.

This canal system should be rehabilitated and utilized for irrigation.

Due to water pollution of the Soan, the intake facilities are forced to be changed in type from the surface water intake to percolated water intake.

In consideration of the above-mentioned facts it is recommended that wells should be dug at the starting point of the canal on the right bank of the Soan and connected with collecting conduit which is laid crossing through the river.

In comparison with a plan for irrigation water taken at the upstream of GT Bridge by pump-up to supply by 10 km conduction main, the above plan is lower by 50 percent in both construction cost and O/M cost.

(3) Intake Tower

The water stored in the Khanpur reservoir is conveyed out through intake facilities provided at the right saddle. The intake capacity of the facilities is 15.57 cu.m (550 cu.sec), which is equal to the total capacity of water conveyance through the canals for the both banks.

Consequently, new intake facilities must be provided to meet the increased urban water and irrigation water requirements for the commanded areas to be developed.

The construction of the new intake tower, however, will be technically intricated and trouble some as the works must be implemented with the reservoir storing water. And the new

facilities will be provided at the inlet about 500 m east of the left saddle and the water taken out of the reservoir will be conveyed through 700 m long pressure tunnel to cross the river to the southern side. (Refer to the Feasibility Study Report on the Water Conduction from the Khanpur to Islamabad/Rawalpindi)

D.2.3. Pumping Station

Nine pumping stations will be provided in the beneficiary area, of which six is for supplying urban water to the Metropolitan area, three is for supplying irrigation water.

(1) Type of Pump

The pumping heads more than 30 m are mostly required for the Project. In view of required discharge and head, double suction volute pump is selected.

(2) Control Method

Considering operational and economic advantages as well as operation and maintenance, flow control is primarily based on the simplest method of control by charge of operating pump number and on-off control in terms of water level control in the discharge pool. Accordingly HWL and LWL are to be established in both suction and discharge pools, providing proper capacities which are determined as 30 minutes capacity of the maximum design discharge.

(3) Number of Pump Units

The number of pump units is determined in consideration of the following factors;