8.3 Design Seismic Coefficient

8.3.1 Design Seismic Coefficient for Existing Dams

To determine the design seismic coefficient for the Project, the correlation between seismic risk and adopted design seismic coefficient for the existing and planned dams in Turkey was studied. The design seismic coefficients (horizontal ground level seismic coefficients) for the 45 dam sites were in hand out of 184 dam sites (Dams and Hydroelectric Power Plant in Turkey, 1990).

Available seismic risk map for Turkey was prepared in 1972 by the Government of Turkey (IMAR ve ISKAN BAKANLIGI). Then, the correlation between seismic risk and the design seismic coefficient was studied by comparing the seismic risk map with the dam location. The seismic risk map for Turkey which shows the 5 zones relating to the degree of risk covering the whole of Turkey is given in Figure 8-6. The result of the survey is also given in Figure 8-7.

Consequently, the results can be summarized by item as follows;

- The maximum value of adopted design seismic coefficient was 0.18,
- The minimum value of adopted design seismic coefficient was 0.05,
- The value of 0.18 as design seismic coefficient was adopted for 1 site out of 45 sites, similarly 0.15 for 18 sites, 0.12 for 4 sites, 0.10 for 16 sites and 0.05 for 6 sites,
- The coefficient 0.15 is noticeable in 1st degree zone given in Figure 8-6,
- The coefficient 0.12 or 0.10 is noticeable in 2nd degree zone,
- The coefficient 0.15 or 0.10 is noticeable in 3rd degree zone, and
- The coefficient 0.05 is noticeable in 4th degree zone.

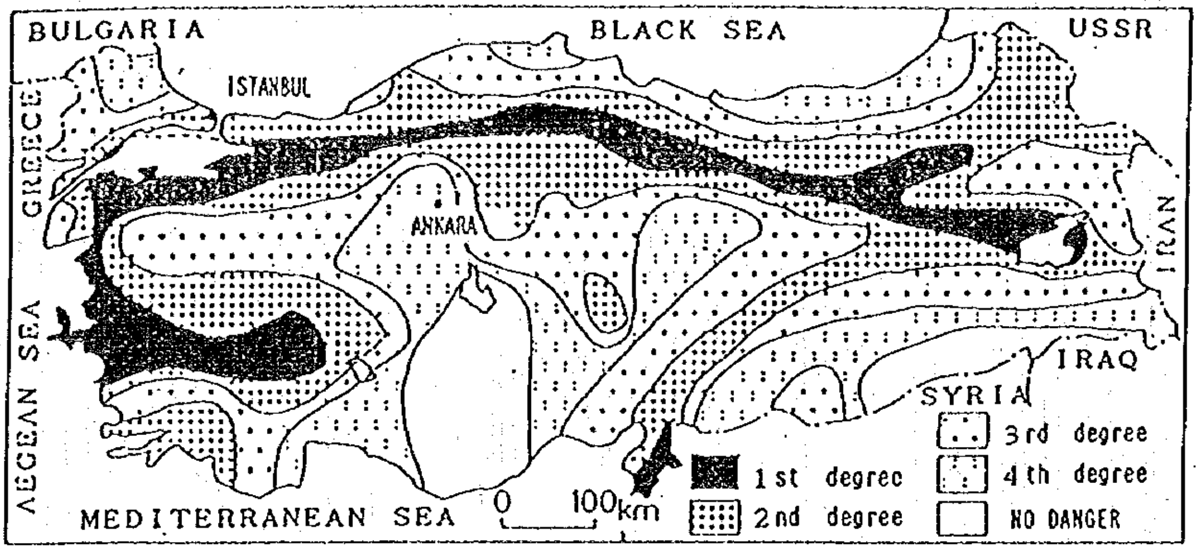


Figure 8-6 Seismic Risk Map for Turkey (1972)

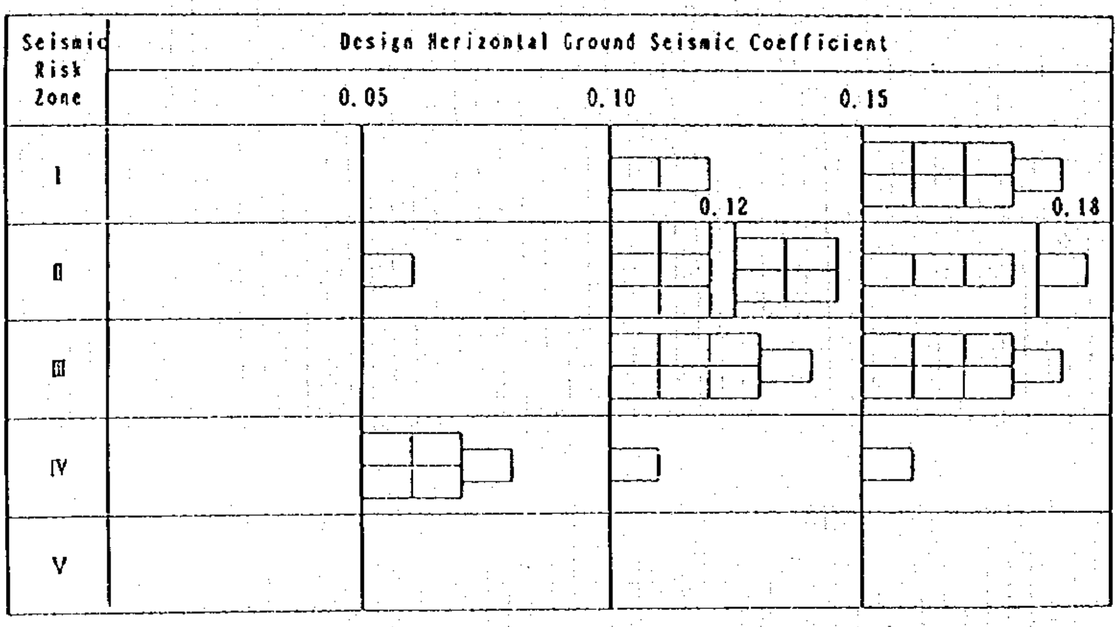


Figure 8-7 Design Seismic Coefficient used for Dams in Turkey

In this study, the reasonable results are obtained, that the high coefficient was adopted for the hazardous zone, and on the contrary the low coefficient for the safer zone.

Considering above-mentioned tendency, it can be standardized as follows from the viewpoint of earthquake-resistant design for dams in Turkey.

- The design seismic coefficient 0.15 can be applied for the 1st degree zone
- The coefficient 0.15 - 0.12 for the 2nd degree zone
- The coefficient 0.12 - 0.10 for the 3rd degree zone
- The coefficient 0.10 - 0.05 for the 4th degree zone

8.3.2 Estimation of Maximum Acceleration at the Sites

(1) Analysis Method

The estimation of the maximum ground acceleration at the Bayram and the Bağlık dam site by statistical probability analysis was performed to determine the design seismic coefficient. The seismicity data used in this study are those compiled by NOAA (National Oceanic and Atmospheric Administration Environmental Data Service). The number of earthquakes which occurred within the radius of 800 km from the site during the period from 1880 to 1997 is 11,118 for the Bayram dam site, and 11,126 for the Bağlık dam site. Of previously proposed attenuation models which express maximum ground acceleration A (gal), in terms of earthquake magnitude M and epicentral distance R (km), four models shown below are used in this study.

$\text{Log } A = 3.090 + 0.347 M - 2 \text{ Log } (R+25)$ .... (1) proposed by C. Oliveira 1)

$\text{Log } A = 2.674 + 0.278 M - 1.301 \text{ Log } (R+25)$ ....(2) proposed by R.K. McGuire 2)

$\text{Log } A = 2.041 + 0.347 M - 1.6 \text{ Log } R$ .... (3) proposed by L. Esteva and E. Rosenblueth 3)

$\text{Log } A = 2.308 + 0.411 M - 1.637 \text{ Log } (R+30)$ ....(4) proposed by T. Katayama 4)

The maximum ground accleration for several return periods were estimated with the third-type asymptotic distribution based on the "Theory of Extreme Values".

Estimation were made with the data in the period 1880-1987 by taking an equal time interval of one year.

(2) Results of Seismic Risk Analysis at the Bayram Dam Site

The distributions of magnitudes and epicentral distances regarding seismological data used in the seismic risk analysis at the Bayram dam site (42°09' east longitude, 41°15' north latitude) are given in Table 8-1 and Figure 8-8. The number of earthquakes yearly from 1880 to 1997 are given in Table 8-2, while the estimated values of maximum accelerations in the earthquakes with the greatest effects on the site in each of the years are given in Table 8-3.

The seismic risk analysis results based on the statistical probability theory technique concerning the Bayram dam site are shown in Figures 8-9 to 8-12.

(3) Results of Seismic Risk Analysis at the Bağlık Dam Site

The distributions of magnitudes and epicentral distances regarding seismological data used in the seismic risk analysis at the Bağlık dam site (42°03' east longitude, 41°13' north latitude) are given in Table 8-4 and Figure 8-13. The number of earthquakes yearly from 1880 to 1997 are given in Table 8-5, while the estimated values of maximum accelerations in the earthquakes with the greatest effects on the site in each of the years are given in Table 8-6.

The seismic risk analysis results based on the statistical probability theory technique concerning the Bağlık dam site are shown in Figures 8-14 to 8-17.

(4) Maximum Accelerations Assumed for the Bayram and the Bağlık Dam Sites

The maximum accelerations at the ground surface assumed for the Bayram and the Bağlık dam sites can be put together in Tables 8-7 and 8-8 from the previously-mentioned seismic risk analysis.

As can be comprehended from the tables, the results of estimation of maximum acceleration vary greatly depending on the attenuation equation applied. Since such uncertainties exist in the seismic risk analysis, and as evaluations are on the conservative side, a value enveloping Table 8-7 or Table 8-8 is to be considered as the assumed maximum acceleration for each site.

In effect, 150 gal is to be taken as the maximum acceleration at the ground surface during earthquake for the Bayram dam site, and 190 gal for the Bağlık dam site.

Further, the 150 gal for the Bayram dam site and the 190 gal for the Bağlık dam site approximately correspond to a return period of 1000 years.

Table 8-1 Distribution of Magnitude and Epicentral Distance of Seismicity Data used for the Bayram Dam Site

	0<=D<50	<100	<200	<300	<400	<500	<600	<700	<800	Total
0<M<3.0	1	39	633	8	0	0	0	0	12	743
<3.5	18	70	1254	248	104	24	15	10	84	1827
<4.0	9	130	622	628	776	515	220	62	53	3015
<4.5	8	82	307	367	500	295	166	98	111	1934
<5.0	7	40	222	286	313	236	182	127	127	1540
<5.5	4	26	142	220	238	134	135	91	97	1087
<6.0	4	12	101	135	118	85	76	58	95	684
<6.5	2	5	26	46	32	19	18	19	46	213
<7.0	0	0	6	11	6	10	3	0	13	49
<7.5	0	1	0	4	2	10	0	3	3	23
<8.0	0	0	0	1	1	0	0	0	0	2
8.0<=	0	0	1	0	0	0	1	1	0	1
Unknown	0	0	0	0	0	0	0	0	0	0
Total	53	405	3364	1954	2090	1328	815	468	641	11118

D: Epicentral Distance (km)

M: Magnitude

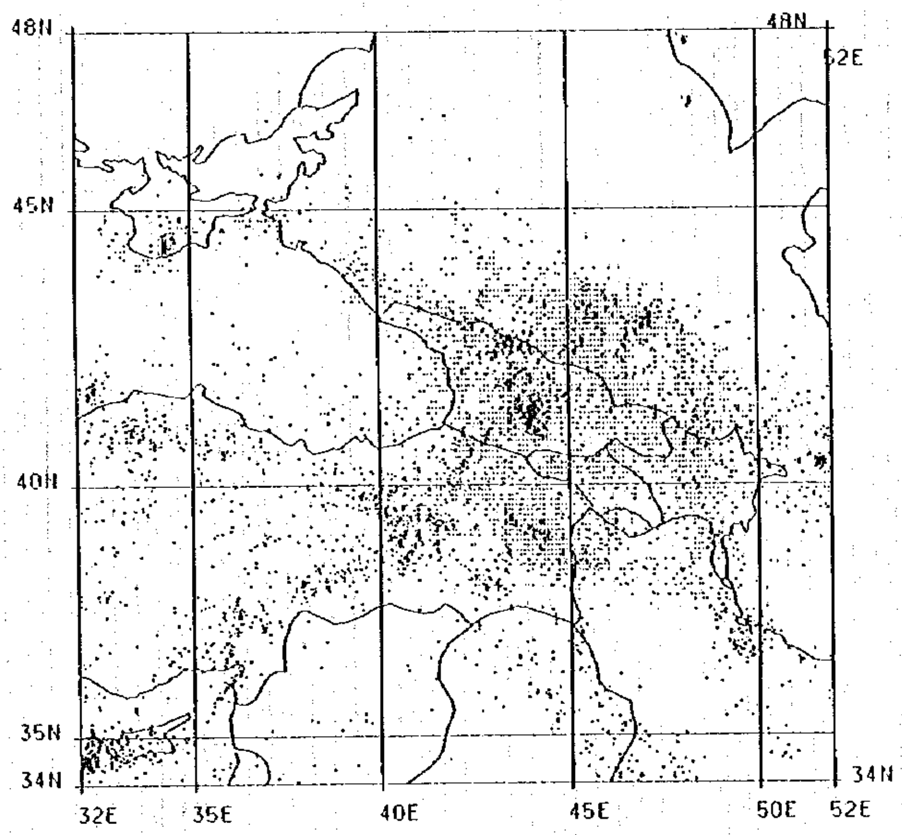


Figure 8-8 **Distribution of Magnitude and Epicentral Distance of Seismicity Data used for the Bayram Dam Site**

Table 8-2 Number of Earthquakes in a Year during the Period from 1880 to 1997 for the Bayram Dam Site (1/2)

Year	N	Sum of N	Year	N	Sum of N
1880	2	2	1930	61	780
1881	11	13	1931	54	834
1882	6	19	1932	34	868
1883	2	21	1933	22	890
1884	3	24	1934	29	919
1885	4	28	1935	45	964
1886	3	31	1936	45	1009
1887	1	32	1937	31	1040
1888	5	37	1938	49	1089
1889	6	43	1939	34	1123
1890	7	50	1940	65	1188
1891	7	57	1941	29	1217
1892	4	61	1942	18	1235
1893	5	66	1943	18	1253
1894	4	70	1944	20	1273
1895	3	73	1945	22	1295
1896	6	79	1946	36	1331
1897	8	87	1947	32	1363
1898	1	88	1948	32	1395
1899	4	92	1949	53	1448
1900	6	98	1950	39	1487
1901	6	104	1951	28	1515
1902	31	135	1952	39	1554
1903	27	162	1953	67	1621
1904	15	177	1954	46	1667
1905	26	203	1955	27	1694
1906	22	225	1956	19	1713
1907	24	249	1957	33	1746
1908	26	275	1958	43	1789
1909	40	315	1959	31	1820
1910	19	334	1960	40	1860
1911	8	342	1961	32	1892
1912	25	367	1962	899	2791
1913	24	391	1963	761	3552
1914	15	406	1964	690	4242
1915	17	423	1965	625	4867
1916	22	445	1966	815	5682
1917	12	457	1967	254	5936
1918	8	465	1968	371	6307
1919	11	476	1969	271	6578
1920	7	483	1970	656	7234
1921	7	490	1971	310	7544
1922	5	495	1972	238	7782
1923	16	511	1973	196	7978
1924	32	543	1974	290	8268
1925	14	557	1975	451	8719
1926	27	584	1976	625	9344
1927	64	648	1977	443	9787
1928	32	680	1978	412	10199
1929	39	719	1979	31	10230

Table 8-2 Number of Earthquakes in a Year during the Period from 1880 to 1997 for the Bayram Dam Site (2/2)

Year	N	Sum of N
1980	31	10261
1981	40	10301
1982	40	10341
1983	49	10390
1984	52	10442
1985	34	10476
1986	59	10535
1987	24	10559
1988	58	10617
1989	34	10651
1990	64	10715
1991	121	10836
1992	60	10896
1993	41	10937
1994	51	10988
1995	54	11042
1996	73	11115
1997	3	11118

Table 8-3 Maximum Accelerations of the Year at the Bayram Dam Site during the Period from 1880 to 1997 (1/3)

(gal)

Year	Attenuation Equation			
	Oliveira's Eq. ACC.	McGuire's Eq. ACC.	Esteva & Rosenblueth's Eq. ACC.	Katayama's Eq. ACC.
1880	0.30	3.66	0.33	0.84
1881	1.38	11.90	1.44	4.60
1882	0.26	3.71	0.32	1.02
1883	0.23	3.55	0.30	0.97
1884	0.74	7.59	0.81	2.49
1885	0.37	4.12	0.38	1.08
1886	3.43	20.64	3.14	8.57
1887	6.16	28.76	5.43	12.01
1888	11.67	44.32	10.54	20.70
1889	1.19	10.38	1.22	3.67
1890	1.56	11.75	1.49	4.02
1891	2.25	15.69	2.14	6.12
1892	38.29	85.94	99.10	36.75
1893	1.46	13.57	1.66	6.08
1894	1.31	10.24	1.25	3.29
1895	0.52	6.06	0.60	1.88
1896	1.32	10.81	1.31	3.76
1897	0.43	5.32	0.51	1.60
1898	2.57	14.81	2.26	4.70
1899	5.67	28.43	5.02	12.57
1900	1.02	9.39	1.07	3.24
1901	4.61	26.15	4.22	12.16
1902	2.42	16.08	2.25	6.12
1903	25.13	78.75	23.44	46.08
1904	8.18	35.48	7.22	16.05
1905	24.08	87.23	21.21	63.18
1906	13.94	54.52	12.30	30.39
1907	3.17	21.45	3.10	10.12
1908	5.32	28.06	4.76	12.87
1909	3.02	18.57	2.76	7.30
1910	2.00	14.21	1.90	5.26
1911	2.92	16.24	2.57	5.32
1912	5.27	27.56	4.70	12.39
1913	4.91	26.85	4.44	12.32
1914	2.18	14.03	1.97	4.72
1915	3.31	17.58	2.92	5.84
1916	2.60	18.44	2.43	9.59
1917	3.43	16.98	3.07	5.14
1918	1.03	8.69	1.00	2.65
1919	16.35	55.66	15.29	27.50
1920	4.81	27.72	4.46	13.62
1921	3.72	21.73	3.38	9.13
1922	1.57	12.60	1.57	4.75
1923	3.26	18.08	2.88	6.37
1924	48.18	113.24	65.17	63.63

Table 8-3 **Maximum Accelerations of the Year at the Bayram Dam Site during the Period from 1880 to 1997 (2/3)**

(gal)

Year	Attenuation Equation			
	Oliveira's Eq. ACC.	McGuire's Eq. ACC.	Esteva & Rosenblueth's Eq. ACC.	Katayama's Eq. ACC.
1925	22.61	72.22	21.14	40.43
1926	6.08	31.76	5.48	15.76
1927	2.24	13.44	1.98	4.12
1928	5.81	27.76	5.12	11.54
1929	6.13	27.87	5.41	11.11
1930	2.92	18.01	2.62	9.15
1931	2.97	19.35	2.80	8.24
1932	8.18	35.48	7.22	16.05
1933	1.27	9.48	1.13	3.28
1934	12.39	45.76	11.32	21.27
1935	8.00	35.79	8.23	18.63
1936	2.93	19.16	2.76	8.14
1937	2.48	16.20	2.28	6.18
1938	2.96	17.89	2.67	6.80
1939	5.73	35.59	5.75	22.13
1940	16.00	56.16	14.62	30.73
1941	5.82	29.10	5.16	13.04
1942	1.38	13.39	1.62	6.15
1943	2.84	17.81	2.60	6.93
1944	2.44	15.77	2.23	5.79
1945	1.92	14.78	1.92	6.02
1946	5.92	31.23	5.35	15.44
1947	4.41	24.86	4.00	11.10
1948	4.26	23.21	3.80	9.59
1949	5.65	29.20	4.99	15.72
1950	1.76	12.74	1.63	4.60
1951	4.55	25.35	4.12	11.37
1952	6.24	32.31	5.62	16.09
1953	4.56	21.88	4.03	8.80
1954	3.89	22.89	3.56	10.03
1955	2.64	16.60	2.40	6.17
1956	14.69	47.66	15.25	19.97
1957	4.63	24.69	4.13	10.45
1958	3.58	20.49	3.21	8.10
1959	11.66	46.05	10.35	22.95
1960	1.85	14.76	1.90	6.19
1961	5.94	27.72	5.24	11.27
1962	6.12	22.66	7.07	6.27
1963	24.33	67.96	39.07	31.52
1964	4.15	17.92	4.18	6.71
1965	3.53	17.19	3.23	6.44
1966	5.66	27.15	6.33	14.23
1967	4.58	20.69	4.17	8.98
1968	17.65	56.30	17.68	26.21
1969	15.13	47.32	16.90	18.95

Table 8-3 **Maximum Accelerations of the Year at the Bayram Dam Site during the Period from 1880 to 1997 (3/3)**

(gal)

Year	Attenuation Equation			
	Oliveira's Eq. ACC.	McGuire's Eq. ACC.	Esteva & Rosenblueth's Eq. ACC.	Katayama's Eq. ACC.
1970	6.92	30.19	6.15	12.23
1971	4.60	20.70	4.40	10.27
1972	6.99	29.69	6.28	11.58
1973	8.62	31.24	8.87	10.76
1974	6.26	24.18	6.45	7.37
1975	11.66	39.95	11.91	15.55
1976	13.00	48.00	11.79	23.10
1977	5.80	23.02	5.85	6.95
1978	19.99	84.78	18.28	69.34
1979	1.47	10.24	1.32	3.00
1980	3.49	17.44	3.10	5.44
1981	0.93	7.57	0.87	2.04
1982	1.51	10.92	1.38	3.68
1983	9.89	42.67	8.71	21.91
1984	19.65	60.59	20.14	28.73
1985	5.54	24.14	5.04	8.32
1986	4.48	24.31	4.01	10.33
1987	1.90	11.91	1.69	3.49
1988	8.19	32.28	7.59	12.43
1989	2.41	13.39	2.12	3.82
1990	3.01	17.65	2.69	6.44
1991	3.99	23.94	3.71	11.00
1992	2.18	14.78	1.93	6.07
1993	3.04	15.96	2.69	4.89
1994	1.55	10.54	1.39	3.06
1995	3.65	17.97	3.25	5.64
1996	3.31	17.27	2.92	5.57
1997	0.16	2.69	0.21	0.66

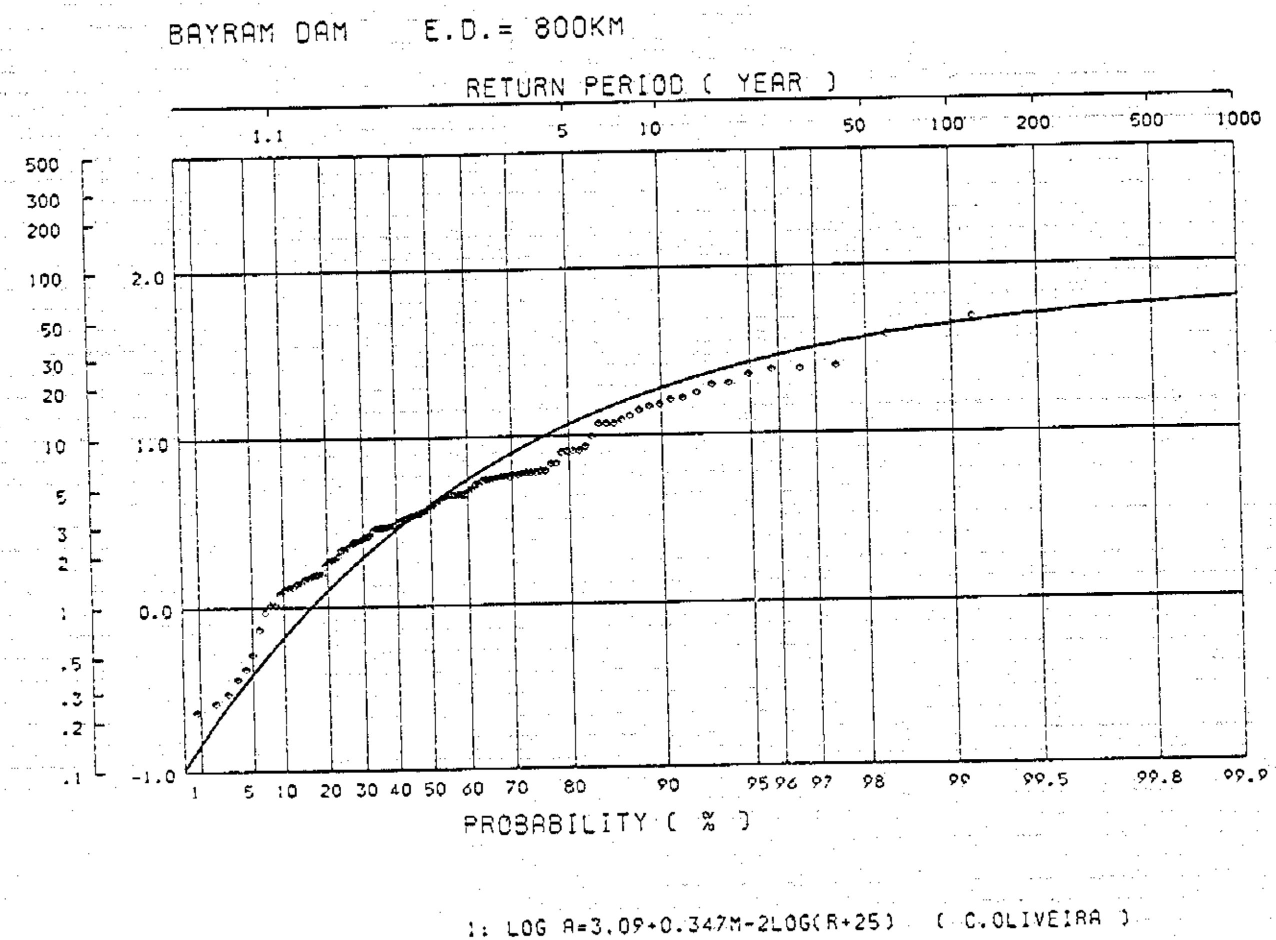


Figure 8-9 Maximum Acceleration for Return Peirod at the Bayram Dam Site Estimated by Oliveira's Equation

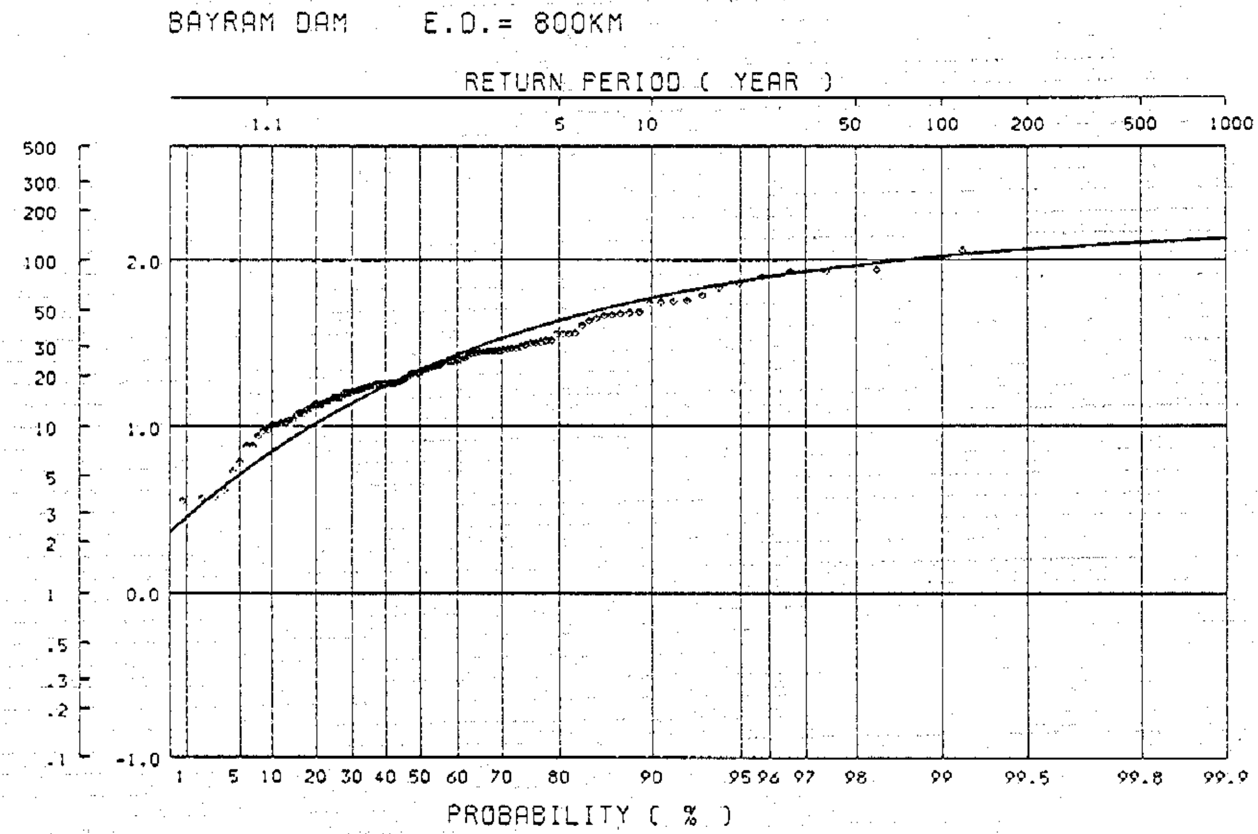


Figure 8-10 Maximum Acceleration for Return Period at the Bayram Dam Site Estimated By McGuire's Equation

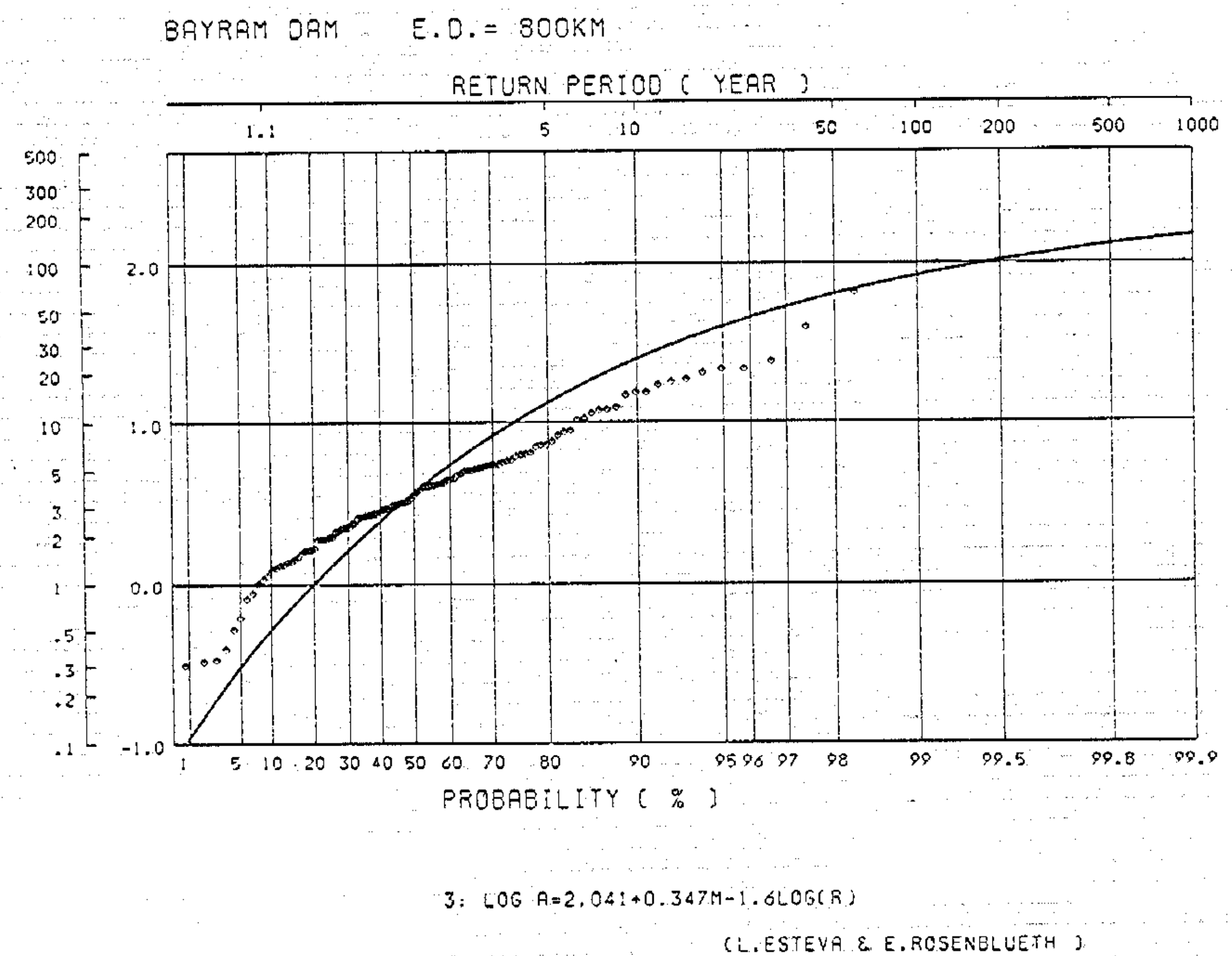
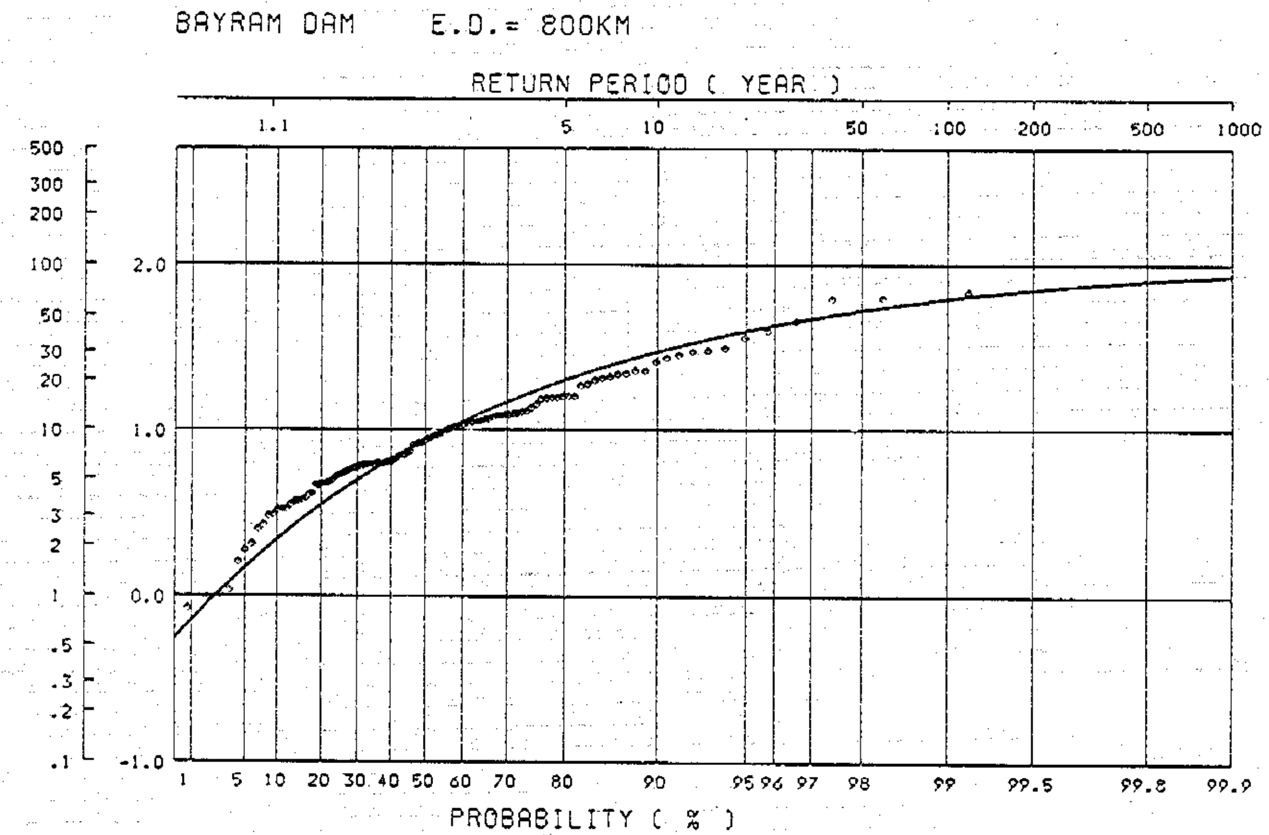


Figure 8-11 Maximum Acceleration for Return Period at the Bayram Dam Site Estimated by Esteva & Rosenblueth's Equation



4: LOG A=2.308+0.411M-1.637LOG(R+30)

(T.KATAYAMA)

Figure 8-12 Maximum Acceleration for Return Period at the Bayram Dam Site Estimated by Katayama's Equation

Table 8-4 **Distribution of Magnitude and Epicentral Distance of Seismicity Data used for the Bağlık Dam Site**

	0<=D<50	<100	<200	<300	<400	<500	<600	<700	<800	Total
0<M<3.0	1	28	689	13	0	0	0	1	12	744
<3.5	17	65	1224	275	109	27	16	14	83	1830
<4.0	12	124	594	625	771	543	223	69	54	3015
<4.5	12	72	307	360	500	304	164	104	113	1936
<5.0	12	36	214	282	314	241	183	134	122	1538
<5.5	6	24	143	219	227	136	141	98	95	1089
<6.0	2	15	96	134	121	88	75	61	96	688
<6.5	0	8	25	50	26	23	18	17	44	211
<7.0	0	0	6	13	4	10	3	0	13	49
<7.5	0	1	0	4	2	10	0	5	1	23
<8.0	0	0	0	1	1	0	0	0	0	2
8.0<=	0	0	1	0	0	0	0	0	0	1
Unknown	0	0	0	0	0	0	0	0	0	0
Total	62	373	3299	1976	2075	1382	823	503	633	11126

D: Epicentral Distance (km)

M: Magnitude

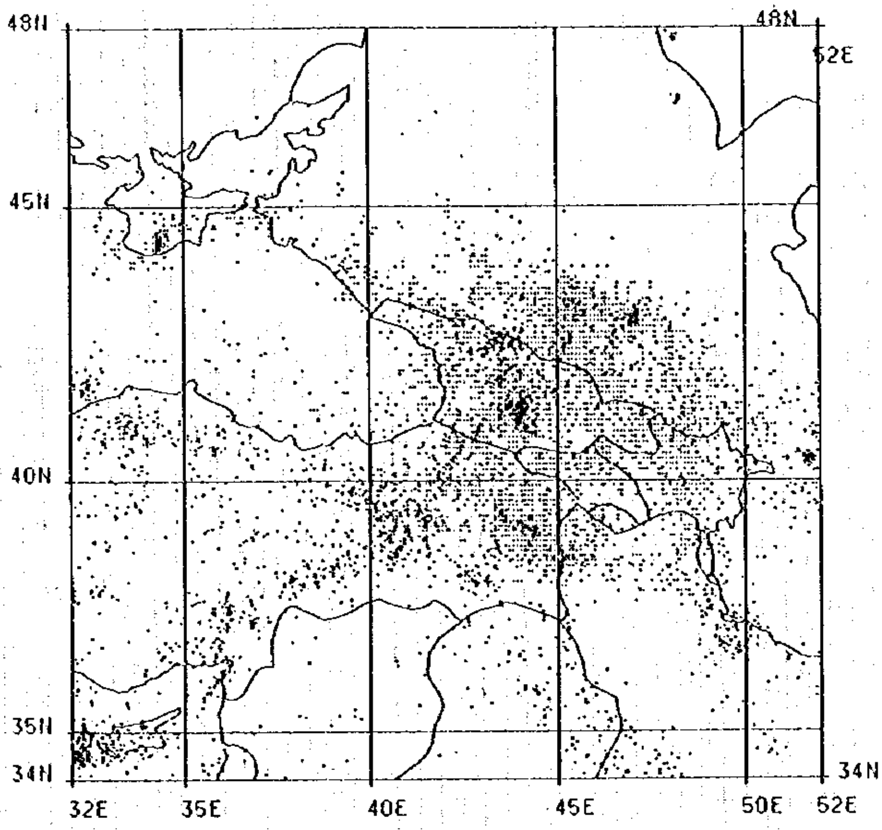


Figure 8-13 Distribution of Magnitude and Epicentral Distance of Seismicity Data used for the Bağlık Dam Site

Table 8-5 **Number of Earthquakes in a Year during the Period from 1880 to 1997 for the Bağlık Dam Site (1/2)**

Year	N	Sum of N	Year	N	Sum of N
1880	2	2	1930	61	782
1881	11	13	1931	54	836
1882	6	19	1932	35	871
1883	2	21	1933	22	893
1884	3	24	1934	29	922
1885	4	28	1935	45	967
1886	3	31	1936	45	1012
1887	1	32	1937	31	1043
1888	5	37	1938	49	1092
1889	6	43	1939	34	1126
1890	7	50	1940	65	1191
1891	7	57	1941	29	1220
1892	4	61	1942	18	1238
1893	5	66	1943	18	1256
1894	4	70	1944	20	1276
1895	3	73	1945	23	1299
1896	6	79	1946	36	1335
1897	8	87	1947	33	1368
1898	1	88	1948	32	1400
1899	4	92	1949	53	1453
1900	6	98	1950	39	1492
1901	6	104	1951	28	1520
1902	31	135	1952	39	1559
1903	27	162	1953	67	1626
1904	15	177	1954	46	1672
1905	26	203	1955	27	1699
1906	22	225	1956	19	1718
1907	24	249	1957	34	1752
1908	27	276	1958	43	1795
1909	40	316	1959	31	1826
1910	19	335	1960	40	1866
1911	8	343	1961	32	1898
1912	25	168	1962	899	2797
1913	24	392	1963	761	3558
1914	15	407	1964	691	4249
1915	17	424	1965	630	4879
1916	22	446	1966	815	5694
1917	12	458	1967	254	5948
1918	8	465	1968	372	6320
1919	11	477	1969	272	6592
1920	7	484	1970	656	7248
1921	8	492	1971	310	7558
1922	5	497	1972	238	7796
1923	16	513	1973	196	7992
1924	32	545	1974	290	8282
1925	14	559	1975	451	8733
1926	27	586	1976	624	9357
1927	64	650	1977	443	9800
1928	32	682	1978	412	10212
1929	39	721	1979	31	10243

Table 8-5 Number of Earthquakes in a Year during the Period from 1880 to 1997 for the Bağlık Dam Site (2/2)

Year	N	Sum of N
1980	31	10274
1981	40	10314
1982	40	10354
1983	48	10402
1984	52	10454
1985	34	10488
1986	55	10543
1987	25	10568
1988	58	10626
1989	32	10658
1990	61	10719
1991	123	10842
1992	60	10902
1993	41	10943
1994	52	10995
1995	55	11050
1996	73	11123
1997	3	11126

Table 8-6 **Maximum Accelerations of the Year at the Bağlık Dam Site during the Period from 1880 to 1997 (1/3)**

(gal)

Year	Attenuation Equation			
	Oliveira's Eq. ACC.	McGuire's Eq. ACC.	Esteva & Rosenblueth's Eq. ACC.	Katayama's Eq. ACC.
1880	0.29	3.56	0.31	0.81
1881	1.38	11.92	1.44	4.61
1882	0.25	3.77	0.33	1.04
1883	0.23	3.60	0.31	0.98
1884	0.75	7.64	0.82	2.51
1885	0.36	4.07	0.38	1.11
1886	3.68	21.58	3.34	9.05
1887	5.90	27.98	5.20	11.62
1888	10.46	41.27	9.36	19.01
1889	1.25	10.68	1.27	3.80
1890	1.45	11.21	1.39	3.80
1891	2.43	16.48	2.29	6.50
1892	41.24	90.20	122.15	38.76
1893	1.52	13.90	1.71	6.26
1894	1.22	9.77	1.17	3.10
1895	0.54	6.20	0.62	1.94
1896	1.24	10.39	1.24	3.57
1897	0.44	5.44	0.52	1.64
1898	2.26	13.64	2.00	4.25
1899	5.03	26.29	4.47	11.42
1900	1.03	9.41	1.07	3.25
1901	4.94	27.35	4.49	12.85
1902	2.43	16.48	2.29	6.50
1903	21.58	71.32	19.72	40.96
1904	7.85	34.54	6.92	15.54
1905	23.32	85.44	20.55	61.62
1906	14.92	56.99	13.19	32.05
1907	3.22	21.67	3.14	10.25
1908	4.89	26.58	4.40	12.05
1909	2.76	17.49	2.53	6.78
1910	1.88	13.65	1.79	5.00
1911	2.57	14.94	2.27	4.81
1912	4.74	25.74	4.26	11.40
1913	4.49	25.32	4.08	11.46
1914	2.01	13.28	1.82	4.41
1915	3.05	16.66	2.69	5.60
1916	2.43	18.89	2.51	9.88
1917	2.92	15.27	2.58	4.52
1918	0.97	8.33	0.95	2.52
1919	16.74	56.53	15.72	28.01
1920	4.42	26.24	4.13	12.73
1921	3.39	20.46	3.10	8.48
1922	1.52	12.31	1.53	4.62
1923	2.89	16.71	2.56	5.84

Table 8-6 **Maximum Accelerations of the Year at the Bağlık Dam Site during the Period from 1880 to 1997 (2/3)**

(gal)

Year	Attenuation Equation			
	Oliveira's Eq. ACC.	McGuire's Eq. ACC.	Esteva & Rosenblueth's Eq. ACC.	Katayama's Eq. ACC.
1924	35.47	92.79	40.66	50.62
1925	18.72	63.87	17.07	34.94
1926	5.58	30.07	5.07	14.74
1927	2.02	12.57	1.80	3.80
1928	5.67	27.33	5.00	11.33
1929	5.32	25.42	4.69	9.94
1930	2.74	17.94	2.51	9.11
1931	3.22	20.39	3.01	8.79
1932	7.85	34.54	6.92	15.54
1933	1.17	9.18	1.04	3.15
1934	14.77	51.28	13.82	24.35
1935	6.94	34.69	6.87	17.93
1936	2.91	19.10	2.75	8.11
1937	2.28	15.41	2.12	5.81
1938	2.82	17.33	2.55	6.58
1939	6.08	36.98	6.05	23.20
1940	13.51	50.31	12.14	28.23
1941	5.58	28.29	4.95	12.60
1942	1.43	13.70	1.67	6.33
1943	3.03	18.60	2.76	7.31
1944	2.60	16.47	2.37	6.11
1945	1.92	14.77	1.92	6.01
1946	6.33	32.64	5.70	16.29
1947	4.48	25.10	4.06	11.23
1948	4.02	22.34	3.60	9.16
1949	5.33	30.35	4.84	16.48
1950	1.77	13.12	1.70	4.76
1951	4.72	25.97	4.26	11.71
1952	6.62	33.60	5.94	16.88
1953	4.17	22.70	3.72	9.23
1954	3.56	21.63	3.29	9.36
1955	2.52	16.13	2.30	5.96
1956	12.45	42.80	12.35	17.61
1957	4.36	23.73	3.89	9.95
1958	3.26	19.28	2.94	7.52
1959	11.38	45.31	10.08	22.51
1960	1.95	15.28	1.99	6.46
1961	5.57	26.58	4.90	10.71
1962	6.22	22.88	7.23	6.35
1963	19.67	59.18	21.23	26.86
1964	4.52	19.05	4.91	7.23
1965	4.08	18.30	3.82	6.72
1966	4.85	27.82	5.12	14.67
1967	5.24	22.61	4.86	9.42

Table 8-6 **Maximum Accelerations of the Year at the Bağlık Dam Site during the Period from 1880 to 1997 (3/3)**

(gal)

Year	Attenuation Equation			
	Oliveira's Eq. ACC.	McGuire's Eq. ACC.	Esteva & Rosenblueth's Eq. ACC.	Katayama's Eq. ACC.
1968	18.79	58.62	19.13	27.48
1969	13.38	43.67	14.27	17.26
1970	6.60	29.27	5.85	11.78
1971	3.99	21.27	3.72	10.62
1972	6.96	29.61	6.25	11.55
1973	7.69	29.00	7.67	10.67
1974	6.18	23.97	6.33	7.29
1975	12.47	41.72	12.99	16.36
1976	11.68	44.79	10.50	21.27
1977	6.53	24.84	6.80	7.60
1978	18.25	79.91	16.81	64.49
1979	1.44	9.93	1.29	2.80
1980	3.48	17.41	3.09	5.43
1981	1.00	7.95	0.93	2.16
1982	1.53	11.14	1.39	3.78
1983	10.30	43.82	9.07	22.62
1984	20.10	61.48	20.73	29.23
1985	5.21	23.20	4.71	7.97
1986	4.13	22.68	3.74	9.50
1987	2.15	12.90	1.90	3.85
1988	10.03	36.82	9.62	14.52
1989	2.13	12.37	1.88	3.47
1990	2.71	16.52	2.44	5.94
1991	3.70	22.79	3.46	10.35
1992	2.02	15.36	2.02	6.36
1993	3.41	17.20	3.03	5.35
1994	1.50	10.32	1.35	2.98
1995	3.38	17.09	3.00	5.31
1996	3.11	16.58	2.74	5.30
1997	0.16	2.73	0.22	0.67

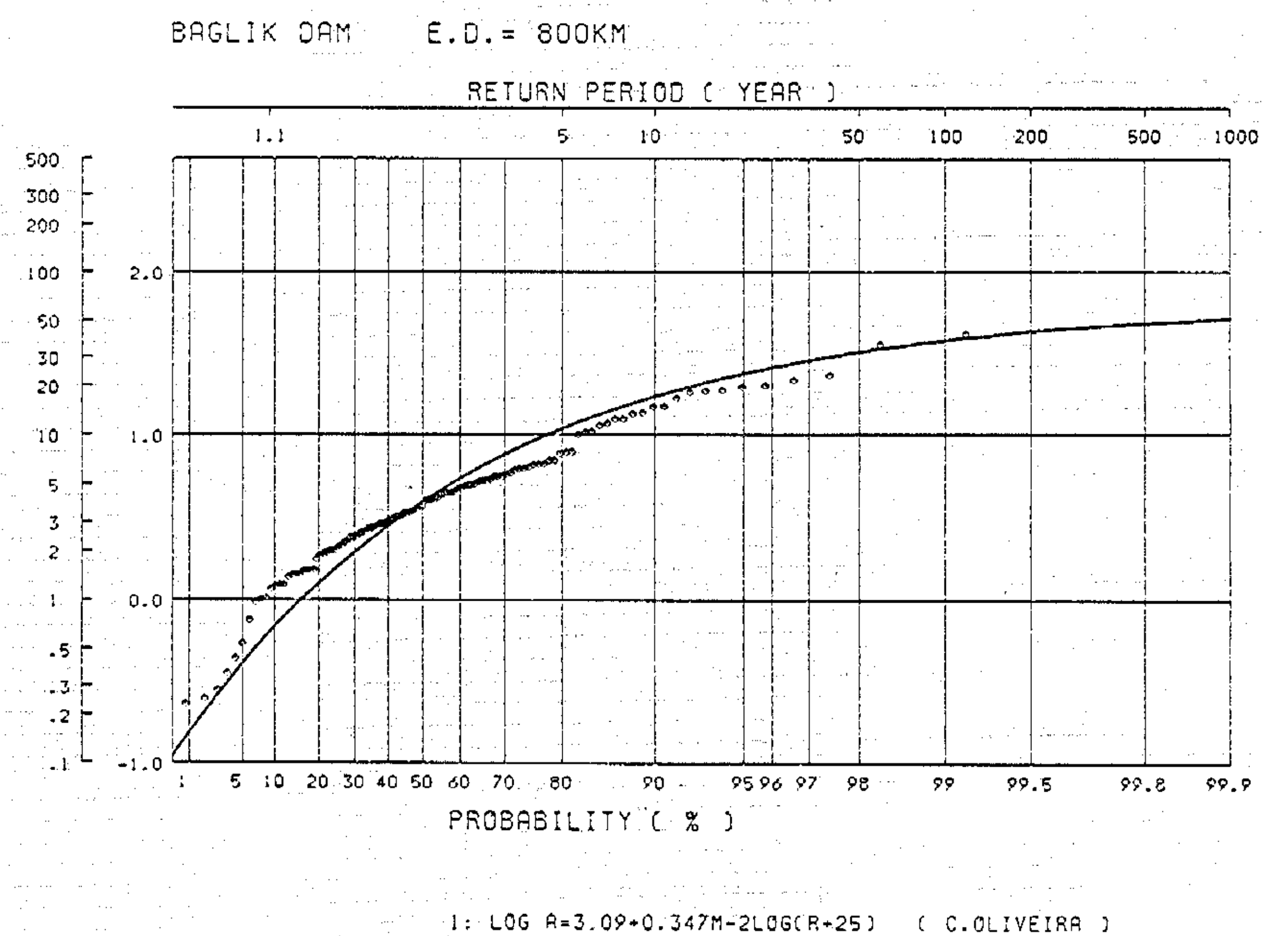


Figure 8-14 Maximum Acceleration for Return Peirod at the Bağlık Dam Site Estimated by Oliveira's Equation

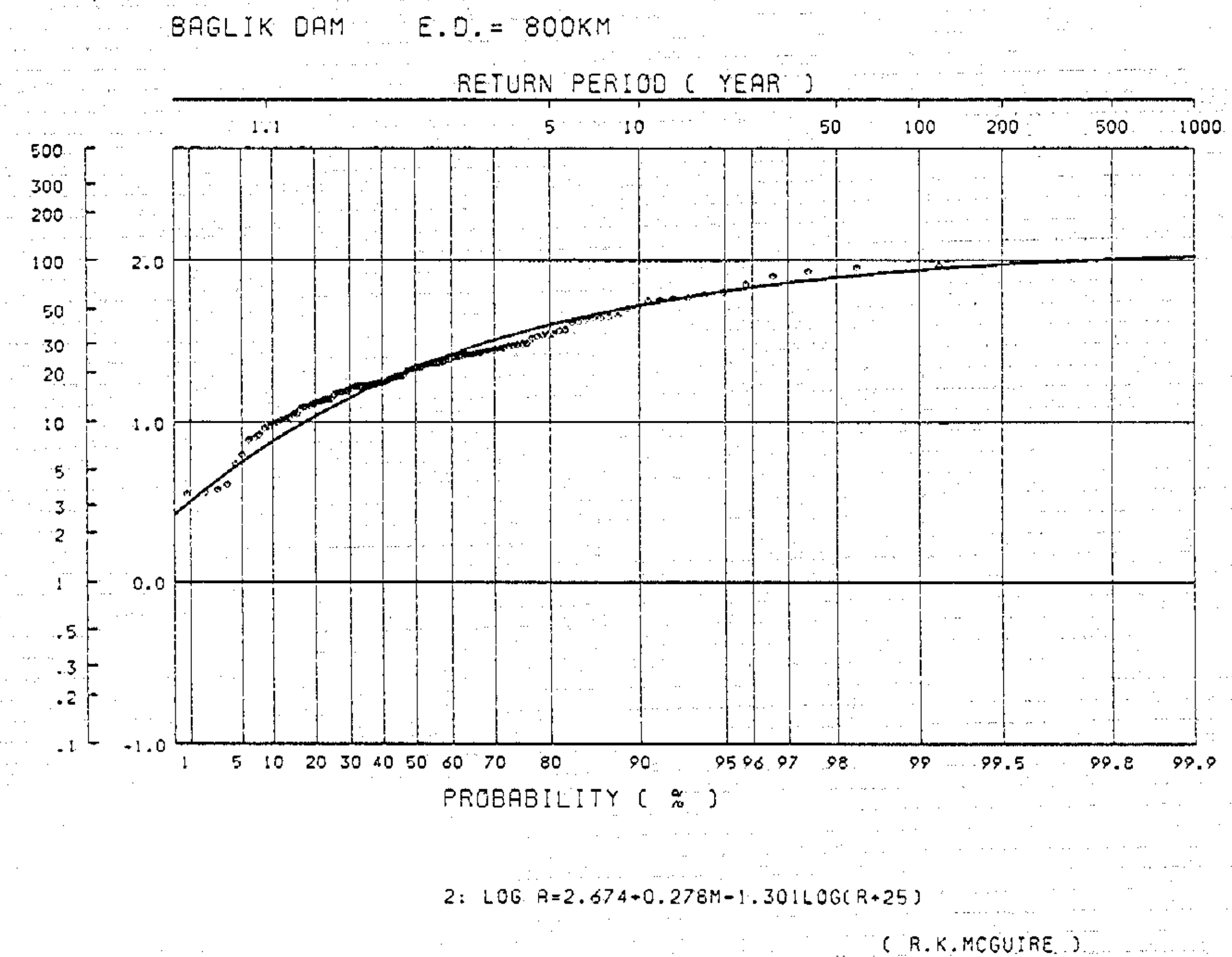


Figure 8-15 Maximum Acceleration for Return Period at the Bağlık Dam Site Estimated By McGuire's Equation

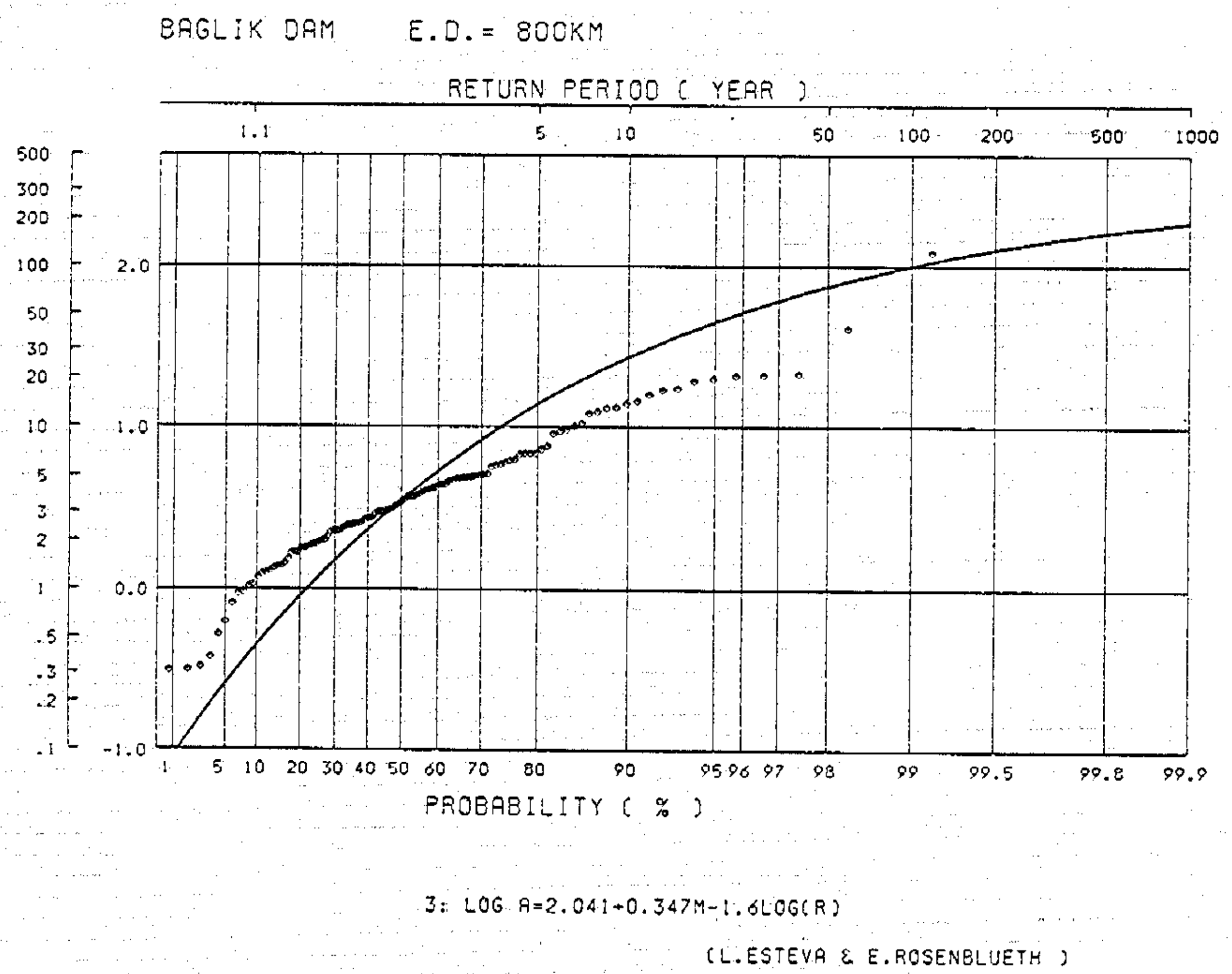


Figure 8-16 Maximum Acceleration for Return Period at the Bağlık Dam Site Estimated by Esteva & Rosenblueth's Equation

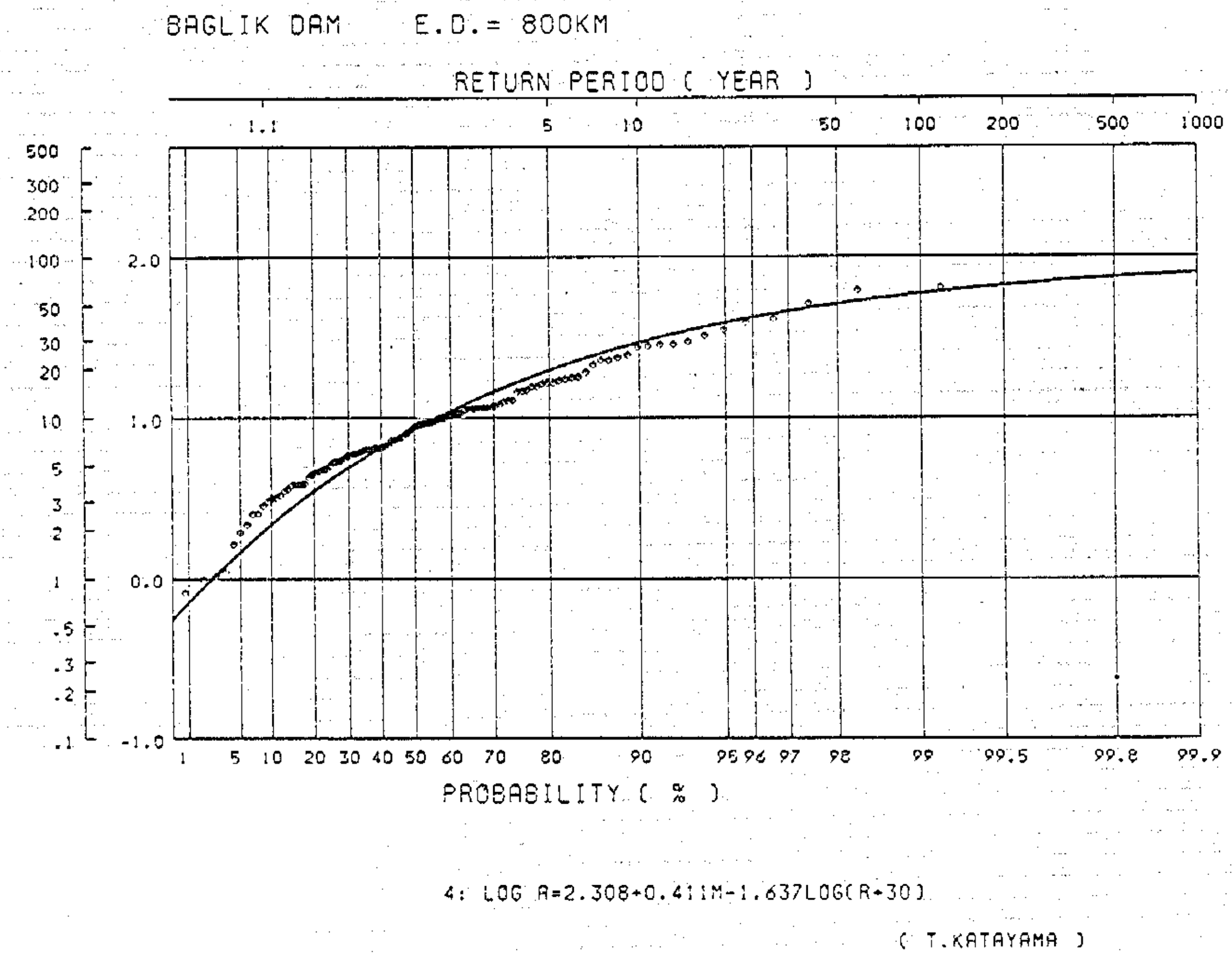


Figure 8-17 Maximum Acceleration for Return Period at the Bağlık Dam Site Estimated by Katayama's Equation

Table 8-7 **Maximum Accelerations Expected at the Bayram Dam Site for Five Return Periods**

Attenuation Equation	Return Period (Year)				
	50	100	200	500	1000
Oliveira Equation	37	44	50	57	61
McGuire Equation	93	106	116	128	134
Esteva & Rosenblueth Equation	64	84	104	130	148
Katayama Equation	54	63	72	81	87
Probability	0.98	0.99	0.995	0.998	0.999

Table 8-8 **Maximum Accelerations Expected at the Bağlık Dam Site for Five Return Periods**

Attenuation Equation	Return Period (Year)				
	50	100	200	500	1000
Oliveira Equation	32	38	43	48	51
McGuire Equation	79	88	95	102	107
Esteva & Rosenblueth Equation	75	101	129	165	191
Katayama Equation	51	59	67	75	79
Probability	0.98	0.99	0.995	0.998	0.999

Table 8-9 Supposed Maximum Acceleration for the Bayram Dam Site and the Bağlık Dam Site

Dam Site	Maximum Acceleration at Ground Surface (gal)
Bayram	150 gal
Bağlık	190 gal

8.3.3 Design Horizontal Seismic Coefficient Used in Aseismic Design

(1) Design Horizontal Seismic Coefficient of Ground at Project Sites

Regarding the relationship between the maximum horizontal acceleration of earthquake motion and the design horizontal seismic coefficient, the following equation will generally be valid:

$$Kh = R \cdot \frac{A_{max}}{980} \quad \text{......} \quad (5)$$

where, Kh: Design horizontal seismic coefficient

R: Conversion factor

Amax: Maximum horizontal acceleration of earthquake motion (gal)

The design horizontal seismic coefficient of the above equation is what is called effective seismic coefficient or equivalent seismic coefficient, and the following proposals have been made in research in Japan.

1) Kh =(0.35 ~ 0.42) Amax/980 (effective value of steady sine wave) .... (6)
2) Kh =0.33 (Amax/980)1/3 (Noda 5), 1975) .... (7)
3) Kh =0.072 + 0.332 (Amax/980) (Matsuo 6), 1984).................... (8)
4) Kh =(0.13 ~ 0.34) Amax/980 (Hakuno 7), 1984) .... (9)
5) Kh = (0.50 ~ 0.60) Amax/980 (Watanabe 8), 1984).................... (10)

In the Technical Guide of Aseismic Design of Nuclear Power Plants 9) published in 1987, the following equation is proposed as a result of overall evaluation and taking into account these cases of study.

Kh = (0.40 ~ 0.60) Amax/980 .... (11)

The concept of effective seismic coefficient (equivalent seismic coefficient) was derived so that the largeness of stresses produced in ground and structures by earthquake motions will be equivalent for cases of handling dynamically (dynamic analysis by input of earthquake motion) and for cases of handling statically (static analysis using design seismic coefficient). The conversion factor which will be required for calculating effective seismic coefficient (equivalent seismic coefficient) is thought to be largely dependent on the frequency characteristics of design input earthquake motions. That is, for an earthquake motion with long-period components predominant, a large value (for example; 0.6) should be taken for the conversion factor. And for an earthquake motion with short-period components predominant, a small value (for example; 0.4) can be taken for the conversion factor.

As described before, the maximum acceleration assumed at the Bayram dam site and the Bağlık dam site is to be 150 gal and 190 gal, respectively. Consequently, applying Eq. (11), the design horizontal seismic coefficient of ground at the Bayram dam site and the Bağlık dam site will be 0.06 ~ 0.10 and 0.07 ~ 0.12, respectively.

Since the frequency characteristics of earthquake motions during earthquakes at the sites cannot necessarily be estimated distinctly at the present time, it is judged to be reasonable to take the design horizontal seismic coefficient of ground at the dam site as 0.15 for an evaluation on the conservative side.

(2) Design Horizontal Seismic Coefficient for Dam

Regarding the design horizontal seismic coefficients for dam, as shown in Table 8-10, the same value as the design horizontal seismic coefficient of ground is to be adopted for rockfill dam and concrete gravity dam. For concrete arch dam, a value twice the design horizontal seismic coefficient of ground is to be adopted.

Table 8-10 Design Horizontal Seismic Coefficient for Dam

Dam Type	Design Horizontal Seismic Coefficient
Rockfill Dam	0.15
Concrete Gravity Dam	0.15
Concrete Arch Dam	0.30

(3) Afterward

The determination of optimum configuration and cross section of a dam, and the basic stability evaluation of the dam during earthquake are normally made according to the seismic coefficient method. The design seismic coefficient to be used in the seismic coefficient method, is evaluated considering a conversion factor for the maximum acceleration of earthquake motion assumed for the site. The value of the conversion factor can be thought to depend on the frequency characteristics of the earthquake motions assumed. It is desirable to ascertain the seismic stability of the dam by dynamic analysis at the stage of detailed design. Namely, the appropriateness of the design seismic coefficient would be verified by comparison of dynamic and static analysis.

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(9) Japan Electric Association, "Technical Guide to Aseismic Design of Nuclear Power Stations," 1987.

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9.1 Review of Existing Development Plan

9.1.1 Outline of Berta River Development Plan

The Berta river which is the second largest tributary of the Çoruh river next to the Oltu river, is located at the northeast part of the Çoruh river basin. It is surrounded by the Karçal mountain range in the northwest, the Savsetskij mountain range in the northeast, and the Yalnizcam mountain range in the southeast and connects to the Çoruh river mainstream in the southwest for a catchment of rectangular shape in the northeast-southwest direction with a catchment area of 2,315 km^2. The Berta river runs from northeast to southwest through the middle of this catchment.

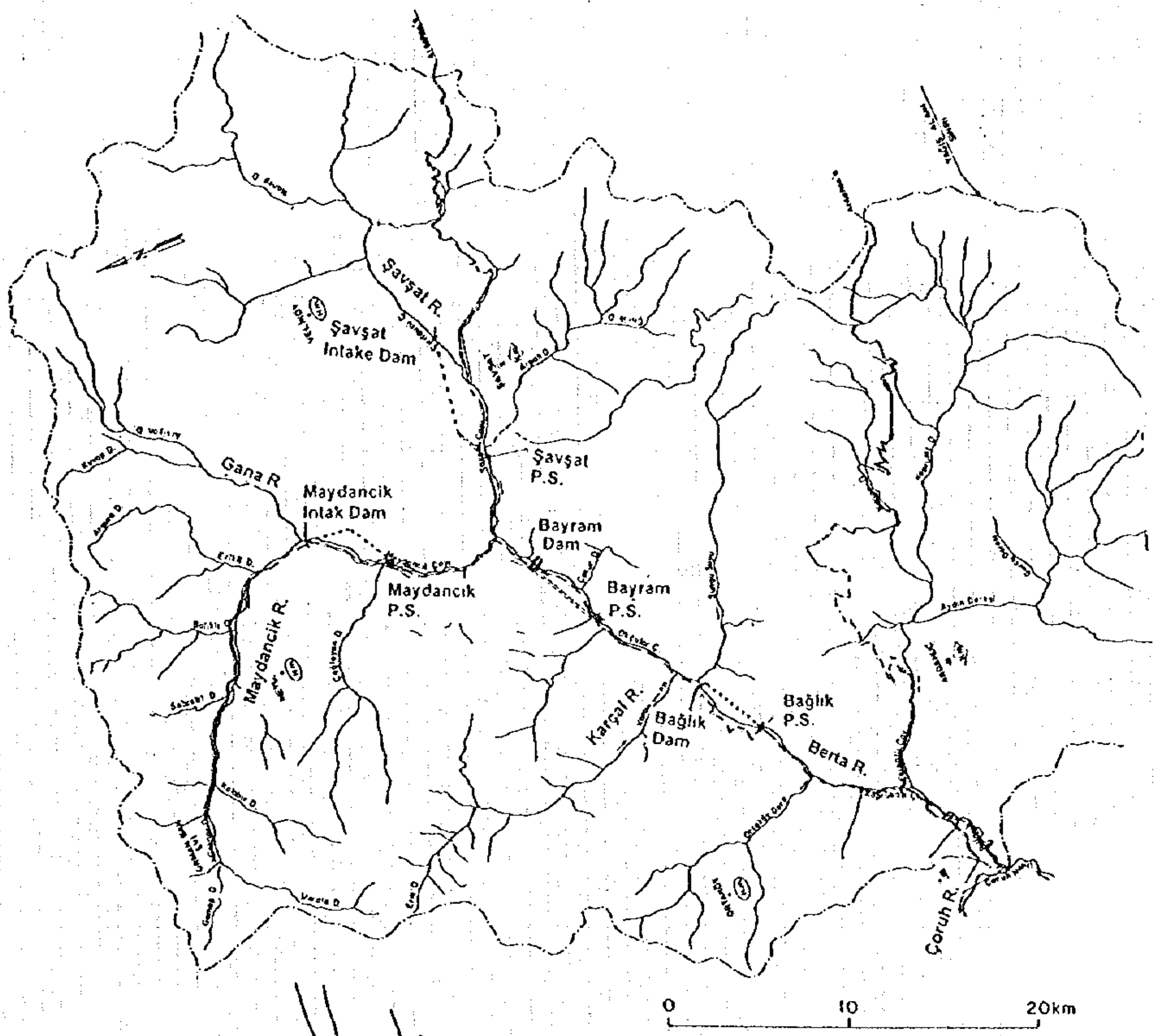
The upstream of Berta river consists of the Meydancık river of catchment area 577 km^2 which rises from the Karçal Mountain range at the northwest part of the basin and flows south, and the Şavşat river of catchment area 580 km^2 which rises from the Yalnizcam mountain range at the southeast part of the basin, which merge at EL. 665m to become the Berta river to flow southwest. After being joined by middle and small-size tributaries, the Sungu river from the left-bank side at EL 470, and the Karçal river and the Ortakoy river at EL. 515 m and EL. 340 m, respectively, the Berta is joined from the right-bank side at EL. 276 m by the Ardanuç river which springs from the Yalniz mountain range at the southern part of the basin, flows down in the northwest direction with a catchment area of 572 km^2, and at EL. 212 m the Berta river merges with the Çoruh river from the right-bank side.

Up to the present, there has been no development of hydroelectric power in the Berta river basin, but in the Çoruh-Berta river basin the master plan report prepared by EİE in 1992, as shown in Table 9.1 and Fig. 9.1, there are 2 sites on the Berta river mainstream and one each on the tributary Meydancık river and the Şavşat river, a total of 4 sites to comprise the Berta river basin hydroelectric power development scheme.

Table 9-1 Hydroelectric Power Development Project in Berta River in the Master Plan

Name of Project	Unit	Bayram	Bağlık	Sub Total	Meydancık	Şavşat
Reservoir						
Catchment Area	km^2	1,173	1,521		200.3	331
Annual Inflow	m^3/s	17.80	21.20		8.50	3.80
High Water Level	m	720.00	570.00		855	900
Low Water Level	m	680.00	567.22		-	-
Gross Storage Capacity	$10^6 m^3$	71.50	40.34		-	-
Effective Storage Capacity	$10^6 m^3$	57.60	30.34		-	-
Dam						
Type		Rockfill	Arch		Gravity	Gravity
Height	m	120	125		5.00	5.00
Gross Head	m	150	175		135	180
Installed Capacity	MW	40.0	55.0	95.0	17.0	11.0
Annual Average Energy	GWh	148.22	215.30	363.52	65.87	41.14
Annual Firm Energy	GWh	65.70	78.84	144.54	5.25	5.08
Total Investment Cost	10^9TL	181.35	177.30	385.65	56.42	40.41
Annual Cost	10^9TL	19.10	18.70	37.80	5.64	4.04
Annual Benefit	10^9TL	18.07	27.50	45.57	5.14	3.21
Annual Surplus Benefit	10^9TL	- 1.03	8.80	7.77	- 0.50	- 0.83
Benefit Cost Ratio		0.95	1.47	1.21	0.91	0.79

* 1 US$ = 2600 TL



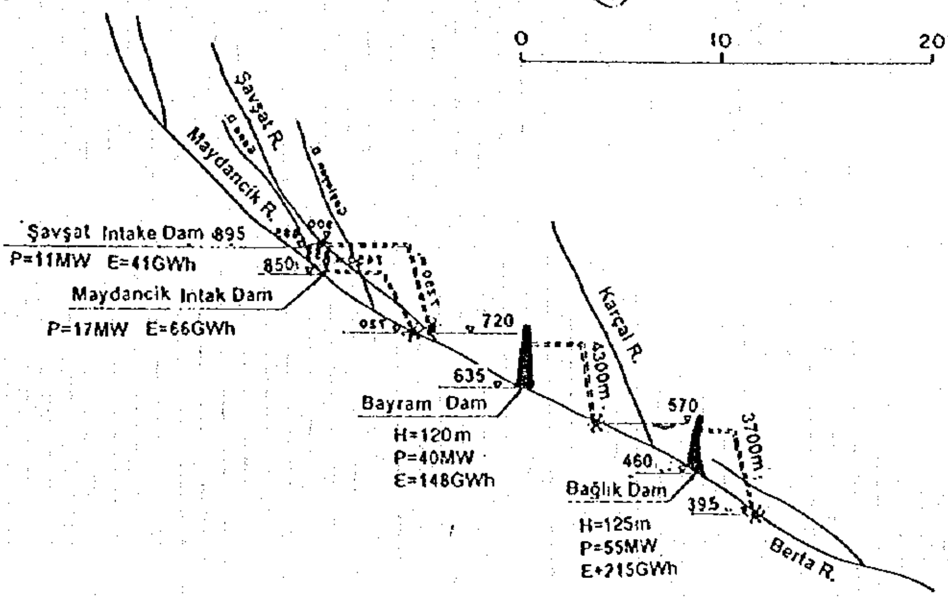


Figure 9-1 Hydroelectric Power Development Project in Berta River in Master Plan

The hydroelectric power development on the Berta river mainstream would consist of a two-step development scheme at the 2 sites of Bayram and Bağlık making use of the head from the confluence of the two large upstream tributaries of Şavşat river and Meydancık river to the downstream Deriner project reservoir.

The Meydancık project and the Şavşat project located on the Meydancık river and the Şavşat river, respectively, are run-of-river type development schemes which discharge into Bayram reservoir, and according to the master plan, these two projects are both of minus annual surplus benefits while unit costs of electric power are higher than the fuel costs of alternative thermal plants, and thus the two are deemed unfeasible.

In the master plan report the upstream Bayram project will have a minus annual surplus benefit, but is feasible when considered overall with the downstream Bağlık project.

According to the master plan report, as shown in Table 9-2 and Figure 9-2, the Erikli project at the upstream part of the tributary Meydancık river, the Karçal project at the downstream part of the tributary Karçal river, and the Ardanuç project at the downstream part of the tributary Ardanuç river have been contemplated as run-of-river type schemes, but all have been abandoned as not being visible as hydroelectric power development schemes.

Table 9-2 Alternative Hydroelectric Power Development Project in Berta River in the Master Plan

Project Name	Unit	Balıklı	Karçal	Ardanuç	Kaledüzü
Normal Water Level	m	1,360	900	465	720
Tail Water Level	m	970	570	395	395
Installed Capacity	MW	35.3	23.6	8.3	112.0
Annual Energy Production	GWH	125.00	62.10	21.70	380.27
Annual Benefit	10^9TL	7.25	4.84	1.69	53.94
Total Investment Cost	10^9TL	181.35	60.00	30.00	471.34
Annual Cost	10^9TL	19.10	6.00	3.00	49.37
Annual Surplus Benefit	10^9TL	-1.03	-1.16	-1.31	4.57
Benefit Cost Ratio		0.58	0.81	0.56	1.09

US$ = 2,600 TL

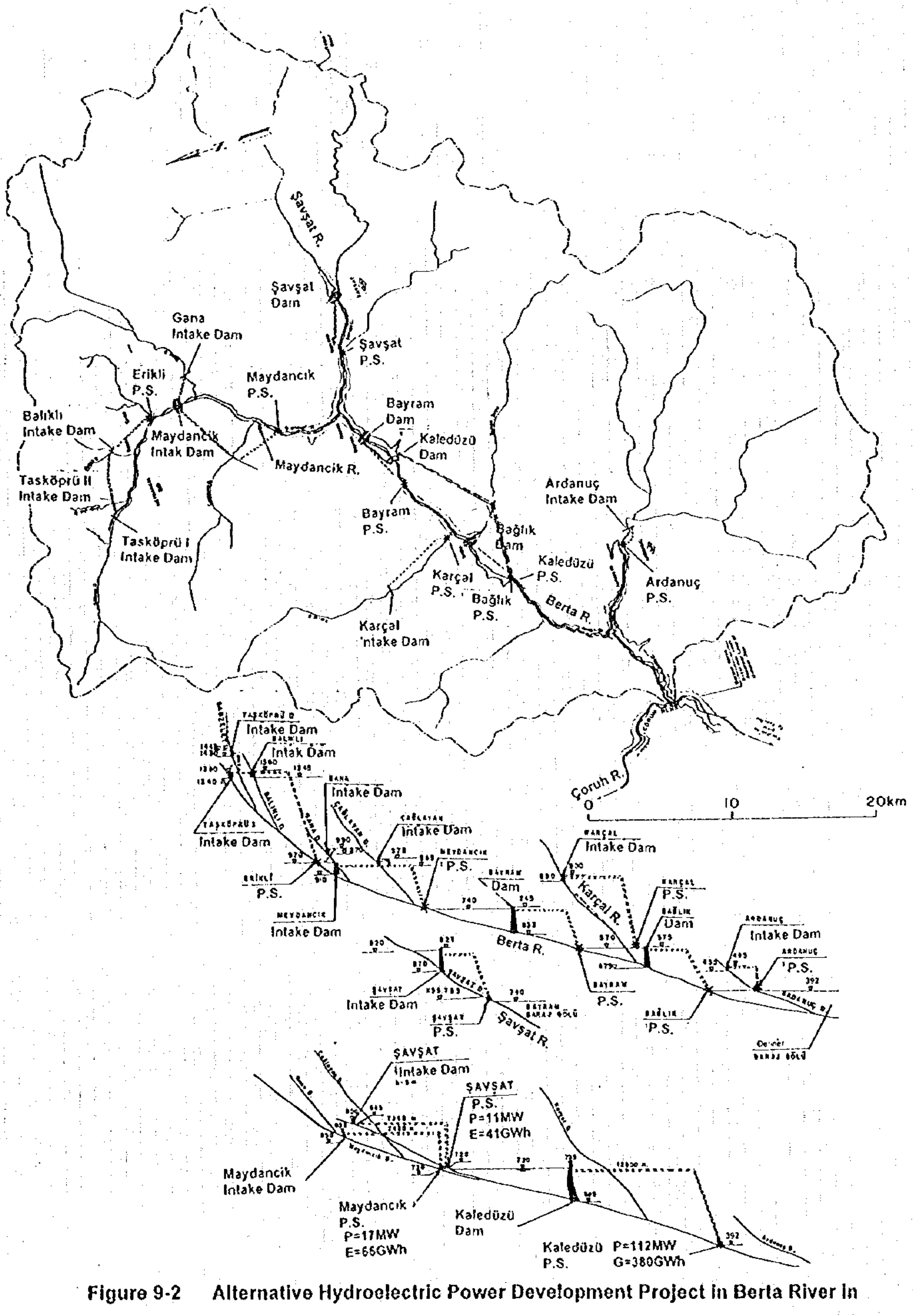


Figure 9-2 Alternative Hydroelectric Power Development Project in Berta River in Master Plan

9.1.2 Reexamination of Existing Development Plans

(1) Confirmation of Project Sites

In the master plan report, only the Bayram and Bağlık projects on the Berta river mainstream are said to be feasible, and because of this the object project sites in this present survey have been made the two sites of the Bayram project and the Bağlık project. The results of reexamination of the existing development schemes in the master plan report based on the results of studies by 1/25,000 topographical maps and field reconnaissances carried out on the object project sites are as described below.

(a) Meydancık Project, Şavşat Project

With both projects, if the intake dam sites were to be moved upstream, intake streams would be divided into numerous small tributaries so that the number of intake dams would be increased, the lengths of waterways would be sharply increased and the economics of the projects will not be improved. Further upstream, streams would be divided into even more small tributaries with stream discharges being small so that they will not be suitable for development projects.

In both projects the river gradients between the intake dam sites and powerhouse sites are uniform, while there are no inflows of major tributaries, so that even if intake dam sites and powerhouse sites were to be moved, the economic natures of the projects will not be improved.

Furthermore, the powerhouse sites of the two projects are locate near the reservoir backwater end of the Bayram project which is a downstream project, and if the powerhouse locations were to be move downstream, it would mean the reservoir high water level of the Bayram project would be lowered. In this case, the added benefit of the two power stations would be much smaller than the reduced benefit of Bayram Power Station, and the economics of the projects will not be improved.

Consequently, the Meydancık project and the Şavşat project have no room for improvement of the economics from the standpoints of layout and the conclusion of the master plan report which said these were unfeasible was reasonable.

(b) Ardanuç Project

The Ardanuç river is a tributary next in size to the Meydancık river and the Şavşat river. This river's downstream part constitutes the reservoir of the Deriner project located on the Çoruh river mainstream and as far as 9 km upstream from the confluence with the Berta river comes within this reservoir.

The Ardanuç river is further divided into three tributaries near EL. 450 m, which is 55 m higher than the flood water level of Deriner reservoir of EL. 395 m, and the stream discharges of these tributaries are small. Accordingly, areas further upstream than around EL. 450 m are not suitable for development projects.

The Ardanuç project was examined in the master plan between the vicinity of EL. 450 m at the confluence of the Ardanuç river and a tributary and the end of the backwater of Deriner reservoir, and it was abandoned as being unfeasible.

The Deriner project is a scheme the implementation of which has already been decided, and because of this there is no room for improvement of the Ardanuç project. Therefore, the conclusion in the Master plan report is reasonable.

(c) Karçal Project

The Karçal river with a catchment area of 126 km^2 is the fourth largest tributary of the Berta river basin which joins the Berta at the right bank 12 km downstream of the confluence of the Meydancık river and the Şavşat river and makes up 36% of the catchment area between the Bayram project and the Bağlık project.

In the master plan report, the Karçal project was contemplated between river-bed elevation 890 m in the vicinity of Coge village and the confluence with the Berta river, but the economics could not be assured, and the project was abandoned as unfeasible.

In the master plan report, the runoff in the catchment between the Bayram project site and the Bağlık project site average 3.4 m^3/s, while the discharge water level of the Karçal project is put at the reservoir high water level of 570 m of the Bağlık project. According to the results of the present study, this runoff has increased to 5.7 m^3/s, and it may be considered that about 78% of this runoff is discharge from the Karçal river. The high water level of the Bağlık project will be 530 m, and the ratio of the head to the headrace length will be 1:14.

Because of this, there is room for the economics of the Karçal project to be greatly improved compared with the result given in the master plan report and there is a possibility that the project will be feasible.

At the confluence with the Çermik river 4.5 km upstream from the intake site of the Karçal project, there is little reduction of catchment area while the river gradient is about 1:10, and it is possible that a run-of-river scheme in this stretch will also be viable.

Upstream of the confluence with the Çermik river, the Karçal river is divided into numerous tributaries, runoffs are sharply reduced, and it is not suitable for a power development project.

Concerning the power development scheme for the Karçal river, if it were to be feasible, the project area would not overlap with the Bayram and Bağlık projects which are schemes on the Berta river mainstream, and will not directly affect the schemes for the mainstream, and it will be reasonable to consider it as a future object of study.

(d) Other Tributaries

Besides the tributaries described in (a) to (c) above, there are a number of other tributaries such as the Sungu river and the Cağlayan river, but these tributaries all have small runoffs, while there are no sites where high heads can be obtained with short waterways, and so they are not suitable for power development projects.

(e) Bayram Project, Bağlık Project

The Berta river mainstream begins from the confluence of the Meydancık river and the Şavşat river at river-bed elevation EL 665 m and joins the Çoruh river mainstream 35 km downstream at river-bed elevation EL 212 m, but the downstream part of the Berta river is a part of the reservoir of the Deriner project situated on the Çoruh river mainstream which is already at the stage of implementation.

The high water level of Deriner reservoir will be EL. 392 m and the end of the backwater on the Berta river will be 17 km upstream from the confluence with the Çoruh river mainstream.

The Berta river between the confluence of the Meydancık river and the Şavşat river and the end of the Deriner river backwater, although weaving a little locally, runs down more or less in a straight line from a broad point of view, while the river gradient is roughly uniform at about 1:66 throughout the entire stretch.

According to the master plan report, a dam site for a reservoir would be selected at a point of river-bed elevation 635 m, 2.5 km downstream of the confluence between the Meydancık river and the Şavşat river, and it is proposed for a two-step development consisting of a Bayram project and a Bağlık project for development of the entire head between this point and the end of the Deriner reservoir backwater at EL. 392 m.

That the dam site of the Bayram project has been selected downstream of the confluence of the Meydancık river and the Şavşat river, the two largest tributaries of the Berta river, is reasonable from the viewpoints of securing storage capacity and effective regulation of inflow. Also, that the reservoir high water level of the Deriner project was made the tail water level of the Bağlık project is reasonable from the point of view of eliminating idle head.

That development of the Berta river mainstream was made a 2-step development scheme consisting of the Bayram project and the Bağlık project is reasonable from the fact that the Berta river between the dam site of the Bayram project and the powerhouse site of the Bağlık project is more or less a straight-line flow with a number of tributaries coming in from the right and left sides so that a route for a headrace would be discontinuous on both right- and left-bank sides and, therefore, is reasonable. However, that the downstream Bağlık project is planned to have a reservoir made with a dam 125 m in height would result in a reservoir of small storage capacity compared with the scale of the dam, while differing from the reservoir in the Bayram project, which would be effective for both the Bayram and Bağlık projects, the reservoir of the Bağlık project would be effective for only the Bağlık project, so that there is room for reconsideration of the scale of Bağlık dam from the standpoints of storage efficiency and investment efficiency.

(f) Kaledüzü Project

On the Berta river mainstream, as an alternative to the 2-step development scheme with the Bayram project and the Bağlık project, there is the Kaledüzü project contemplated for development in a single step of the head obtained by a dam of 150 m height at a site of river-bed elevation 585 m, 3 km downstream from the Bayram dam site, down to the end of the Deriner reservoir backwater. However, since the economics is poorer than the 2-step development with the Bayram and Bağlık projects, while due to Kaledüzü reservoir, there is a slope failure area in the vicinity of Savail village located at the left bank of the Berta river 2 km upstream from Kaledüzü dam and 1 km downstream from the Bayram dam site, it is not proposed as an object of this survey. According to the plan, there is only one suitable place from a topographical point of view where a work adit or vertical shaft can be provided for the headrace tunnel which will exceed 14 km in length, and this will be a problem in construction of the tunnel.

Consequently, the conclusion in the master plan report may be considered to be reasonable.

(g) Object Projects of Study

In view of (a) to (e) above, it was decided that the projects to be considered in this study should be the Bayram project and the Bağlık project. The conclusion in the master plan report is reasonable.

(2) Reexamination of Development layout

(a) Formulation of Alternative Layout

The Bayram project and the Bağlık project proposed in the master plan report consist of so-called headrace-type layouts in which water is drawn by an intake provided immediately upstream of the dam with the water conducted to a surge tank by a pressure tunnel-type headrace, and further to a surface-type powerhouse by a surface-type penstock for power generation to be carried out.

The dam of the Bağlık project is planned to be 125 m in height, roughly the same scale as the dam in the Bayram project, so that the location of the powerhouse of the Bayram project is at riverbed elevation of 570 m near the end of the Bağlık reservoir backwater, and if the height of Bağlık dam were to be lowered, the location of the Bayram project powerhouse would be moved downstream with lowering of the high water level of Bağlık reservoir. The headrace tunnel in this case would become long as it will need to detour around gullies running into the Berta river.

Furthermore, at the powerhouse site proposed in the master plan report, it is considered unavoidable for both the penstock and the powerhouse to be made underground types from the standpoint of the topography.

Because of such a situation, in contrast to the headrace-type layout proposed in the master plan report, a so-called tailrace-type layout in which an underground powerhouse is provided immediately downstream of the dam with a tailrace of non-pressure type arranged in a straight line between this powerhouse site and the outlet site was set up as an alternative layout.

In this case, the high water level of Bayram reservoir would be made EL. 740 m, and that of Bağlık reservoir EL. 530 m.

In comparison with the 2-step development scheme proposed in the master plan report, a single-step development scheme consisting of the Kaledüzü project and a single-step development scheme with Bayram dam absorbing the Bağlık project into the Bayram project were also set up as alternative layout. The outline of the alternatives are shown in the Figure 9-3, 9-4 and Table 9-3.

(b) Results of comparison Studies of Alternative Layouts

The comparison studies of the alternative layouts were made with the peak operating times of the power-stations to be 6 hours and using the benefit-cost method. The unit price of benefit and the unit construction prices of the alternative layouts are as described in 9.2.1.

The results of comparison studies of the various alternative layouts are as given in Table 9-4 and 9-5.

For the 2-step development scheme of the Bayram project and the Bağlık project of tailrace-type layout, power station output, annual energy production, annual surplus benefit, benefit ratio, cost ratio, all will be maximum with unit energy cost minimum.

Accordingly, it was decided that the study of the development plan should be of a 2-step development scheme consisting of the Bayram project, the Bağlık project, and a tailrace-type layout.

Table 9-3 Outline of Alternative Layout

Bayram Headrace, Tailrace and One Stage, Kaleduzu Headrace and Tailrace Type Layout

Reservoir	Damsite Layout	Bayram Headrace	Baglik Headrace	Bayram Tailrace	Baglik Tailrace	Bayram One Stage	Kaleduzu Headrace	Kaleduzu Tailrace
Catchment Area	KM^2	1,159	1,509	1,159	1,509	1,159	1,214	1,214
Annual Inflow	M^3/S	19.20	24.90	19.20	24.90	19.20	20.10	20.10
High Water Level	M	740.00	530.00	740.00	530.00	740.00	720.00	720.00
Normal Water Level	M	722.00	528.50	722.00	528.50	722.00	703.33	703.33
Low Water Level	M	686.00	527.00	686.00	527.00	686.00	670.00	670.00
Available Drawdown	M	54.00	3.00	54.00	3.00	54.00	50.00	50.00
Gross Capacity	10^6M^3	133.00	7.30	133.00	7.30	133.00	186.80	186.80
Effective Capacity	10^6M^3	113.00	1.00	113.00	1.00	113.00	140.00	140.00
Dam								
Type		Rockfill	Con-Gra.	Rockfill	Con-Gra.	Rockfill	Rockfill	Rockfill
Height from Found.	M	145	74	145	74	145	140	140
Crest Length	M	415	190	415	190	415	450	450
Volume	10^3M^3	6,144	195	6,144	195	6,144	8,990	8,990
Headrace Tunnel								
Type		Pressure	Pressure				Pressure	
Diameters	M	4.3	4.7				4.5	
Length	M	8,100	4,300				14,150	
Penstock								
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.3	3.6	3.3	3.6	3.3	3.5	3.5
Length	M	460	160	321	213	437	540	443
Powerhouse								
Type		Surface	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel								
Type		Hosesho.	Hosesho.	Hosesho.	Hosesho.	Hosesho.	Hosesho.	Hosesho.
Diameters	M	4.6	4.9	4.6	4.9	4.6	4.8	4.8
Length (Tunnel)	M	500	150	7,930	4,454	15,530	150	11,250
(Channel)	M							
Firm Discharge	M^3/S	10.70	13.00	10.70	13.00	10.70	12.00	12.00
Maximum Dischaerge	M^3/S	43.00	52.00	43.00	52.00	43.00	48.00	48.00
Tail Water Level	M	530.00	392.00	530.00	392.00	392.00	392.00	392.00
Gross Head								
Maximum Head	M	210.00	138.00	210.00	138.00	348.00	328.00	328.00
Normal Head	M	192.00	136.50	192.00	136.50	330.00	311.33	311.33
Minimum Head	M	156.00	135.00	156.00	135.00	294.00	278.00	278.00
Loss of Head	M	17.10	8.40	9.10	5.60	15.10	26.00	11.90
Effective Head								
Maximum	M	192.90	129.60	200.90	132.40	332.90	302.00	316.10
Normal	M	174.90	128.10	182.90	130.90	314.90	285.33	299.43
Minimum	M	138.90	126.60	146.90	129.40	278.90	252.00	266.10
Installed Capacity	MW	65	57	68	59	117	118	124
Firm Peak Power	MW	56.1	56.1	58.0	56.4	104.4	108.0	112.4
Annual Energy								
Average	GWh	240.1	220.4	247.9	221.4	421.1	412.8	428.1
Firm	GWh	136.8	123.6	141.4	124.2	243.5	251.9	262.2
Secondary	GWh	103.3	96.8	106.5	97.2	177.6	160.9	166.0

Table 9-4 Cost Estimate of Alternative Layout

Bayram Headrace, Tailrace and One Stage, Kaleduzu Headrace and Tailrace Type Layout **Unit: 10^3US$**

Description Dam Site / Layout Type	Bayram Headrace	Baglik Headrace	Bayram Tailrace	Baglik Tailrace	Bayram One Stage	Kaleduzu Headrace	Kaleduzu Tailrace
High Water Level (m)	740	530	740	530	740	720	720
Reservoir Area (km^2)	3.38	0.37	3.38	0.37	3.38	4.18	4.18
Dam Volume (10^6m^3)	6,144	195	6,144	195	6,144	8,990	8,990
Dam Height (m)	145	74	145	74	145	140	140
Maximum Head (m)	210	138	210	138	348	328	328
Maximum Discharge (m^3/s)	43	52	43	52	43	48	48
Relocation Road	11,655	6,759	11,655	6,759	11,655	14,414	14,414
Camp Facilties	800	800	800	800	1,600	800	1,600
Land Acquisition	2,242	598	2,242	598	2,242	2,773	2,773
Civil Work	87,967	28,635	83,113	25,984	106,445	130,583	121,037
Diversion	2,421	0	2,421	0	2,421	2,421	2,421
Care of River	1,082	0	1,082	0	1,082	1,082	1,082
Dam	47,281	9,983	47,281	9,983	47,281	70,220	70,220
Spillway	7,523	780	7,523	780	7,523	7,080	7,080
Outlet Works	1,018	0	1,018	0	1,018	1,018	1,018
Intake	1,087	40	1,087	40	1,087	912	842
Headrace Tunnel	22,275	13,330	0	0	0	41,460	0
Surge Tank	0	0	0	0	0	0	0
Penstock	787	288	546	376	1,211	1,572	1,291
Acces Tunnels	0	0	3,980	2,478	10,105	0	9,608
Power House	3,049	3,413	3,049	3,413	5,249	4,012	4,350
Tailrace Tunnel	944	300	14,965	8,914	29,307	306	22,963
Switchyard	500	500	161	0	161	500	161
Pre-Subtotal	102,664	36,791	97,810	34,141	121,942	148,569	139,823
Contingency (15%)	15,063	5,429	14,335	5,031	17,955	21,869	20,558
Eng. and Admi. (10%)	17,323	4,162	10,990	3,857	20,648	25,150	23,641
Sub Total	135,049	46,383	123,136	43,030	160,545	195,588	184,022
I.D.C (9.5%/Year)	26,981	11,586	24,601	10,748	32,075	39,078	36,765
Total	162,031	57,968	147,737	53,778	192,620	234,664	220,787
Hydraulic Equipment	8,368	2,526	5,203	2,884	8,416	10,215	8,856
Spillway	856	870	856	870	856	856	856
Outlet Works	528	0	528	0	528	528	628
Intake Gate	763	170	763	170	763	789	789
Penstock	3,459	1,074	2,400	1,400	5,321	6,909	5,674
Draft Gate	122	121	122	121	122	136	136
Tailrace Gate	61	61	61	61	61	68	68
Pre-Subtotal	5,789	2,296	4,730	2,622	7,651	9,266	8,051
Contingency (10%)	579	230	473	262	765	929	805
Electro-Mechanical Equipment	15,137	18,938	15,780	19,216	25,223	28,219	34,507
Equipment	14,416	18,036	15,029	18,301	24,022	26,876	32,863
Contingency (5%)	721	902	751	915	1,201	1,344	1,643
Eng. and Admi. (10%)	2,151	2,146	2,098	2,210	3,364	3,843	4,336
Sub Total	23,656	23,610	23,082	24,310	37,003	42,277	47,699
I.D.C (9.5%/Year)	1,272	1,337	1,241	1,377	1,989	2,273	2,565
Total	24,928	24,947	24,323	25,687	38,993	44,550	50,264
Grand Total	186,958	82,916	172,060	79,464	231,613	279,214	271,051

Table 9-5 Comparison Study on Alternative Layout

Tailrace Type Underground Powerhouse Layout Bayram H.W.L.=735m L.W.L.=585m-730m and Baglik H.W.L.=530m — by Mixed Alternative Thermal Power Plant

Description Dam Site	Bayram Headrace	Baglik 530C	Total	Bayram Tailrace	Baglik Tailrace	Total	Bayram One Stage		Total	Kaleduzu Headrace		Total	Kaleduzu Tailrace		Total
High Water Level	740.00	530.00		740.00	530.00		740.00			720			720		
Normal Water Level	722.00	528.50		722.00	529.50		722.00			703.3333			703.3333		
Low Water Level	686.00	527.00		686.00	527.00		686.00			670			670		
Available Drawdown	54.00	3.00		54.00	3.00		54.00			50			50		
Gross Storage Capacity	133.00	7.30		133.00	7.30		133.00			186.8			186.8		
Effective Storage Capacity	113.00	1.00		113.00	1.00		113.00			140			140		
Dam Type	Rockfill	Con-Gra		Rockfill	Con-Gra		Rockfill			Rockfill			Rockfill		
Dam Hight	145	74		145	74		145			140			140		
Dam Volume	6,144	195		6,144	195		6,144			8,900			8,900		
Tailwater Level	530.00	392.00		530.00	392.00		392.00			392.00			392.00		
Effective Head	174.90	128.10		182.90	130.90		314.90			285.33			299.43		
Maximum Discharge	43.00	52.00		43.00	52.00		43.00			48.00			48.00		
Installed Capacity	65.00	57.00	122.00	68.00	59.00	127.00	117.00		117.00	118.00		118.00	124.00		124.00
Firm Peak Power	56.11	56.14	112.24	58.00	56.40	114.40	104.40		104.40	108.00		108.00	112.40		112.40
Energy Production															
Average Energy	240.10	220.38	450.49	247.90	221.40	469.30	421.10		421.10	412.79		412.79	428.12		428.12
Firm Energy	136.79	123.62	260.41	141.40	124.20	265.60	243.50		243.50	251.90		251.90	262.16		262.16
Secondary Energy	103.31	96.76	200.08	106.50	97.20	203.70	177.60		177.60	160.90		160.90	165.96		165.96
Unit Benefit Value	0.00	0.00		0.00	0.00		0.00			0.00			0.00		
Firm Peak Power	180.45	180.45		180.45	180.45		180.45			180.45			180.45		
Firm Energy	0.027	0.027		0.027	0.027		0.027			0.027			0.027		
Secondary Energy	0.022	0.022		0.022	0.022		0.022			0.022			0.022		
Benefit															
Firm Peak Power	9.66	9.66	19.32	9.98	9.71	19.69	17.97		17.97	18.59		18.59	19.34		19.34
Firm Energy	3.63	3.28	6.91	3.75	3.30	7.05	6.46		6.46	6.69		6.69	6.96		6.96
Secondary Energy	2.22	2.08	4.31	2.29	2.09	4.39	3.82		3.82	3.46		3.46	3.57		3.57
Total	15.51	15.02	30.54	16.03	15.09	31.12	28.25		28.25	29.74		29.74	29.87		29.87
Investment Cost															
Civil Facilities	162.03	57.97	220.00	147.74	53.78	201.51	192.62		192.62	234.66		234.66	220.79		220.79
Hydrau. and Ele.-Mech Eq	24.93	24.95	49.87	24.32	25.69	50.01	38.99		38.99	44.55		44.55	50.26		50.26
Total	186.96	82.92	269.87	172.06	79.46	251.52	231.61		231.61	279.21		279.21	271.05		271.05
Annual Cost															
Civil Facilities	16.37	5.85	22.22	14.92	5.43	20.35	19.45		19.45	23.70		23.70	22.30		22.30
Hydrau. and Ele.-Mech Eq	2.84	2.84	5.69	2.77	2.93	5.70	4.45		4.45	5.08		5.08	5.73		5.73
Total	19.21	8.70	27.91	17.69	8.36	26.05	23.90		23.90	28.78		28.78	28.03		28.03
Annual Surplus Benefit(B-C)	-3.70	6.33	2.63	-1.67	6.74	5.07	4.35		4.35	-0.04		-0.04	1.84		1.84
Benefit Cost Ratio(B/C)	0.81	1.73	1.09	0.91	1.81	1.19	1.18		1.18	1.00		1.00	1.07		1.07
Unit Annual Cost (Firm)	0.140	0.070	0.107	0.125	0.067	0.098	0.098		0.098	0.114		0.114	0.107		0.107
Unit Annual Cost (Average)	0.080	0.039	0.061	0.071	0.038	0.056	0.057		0.057	0.070		0.070	0.065		0.065

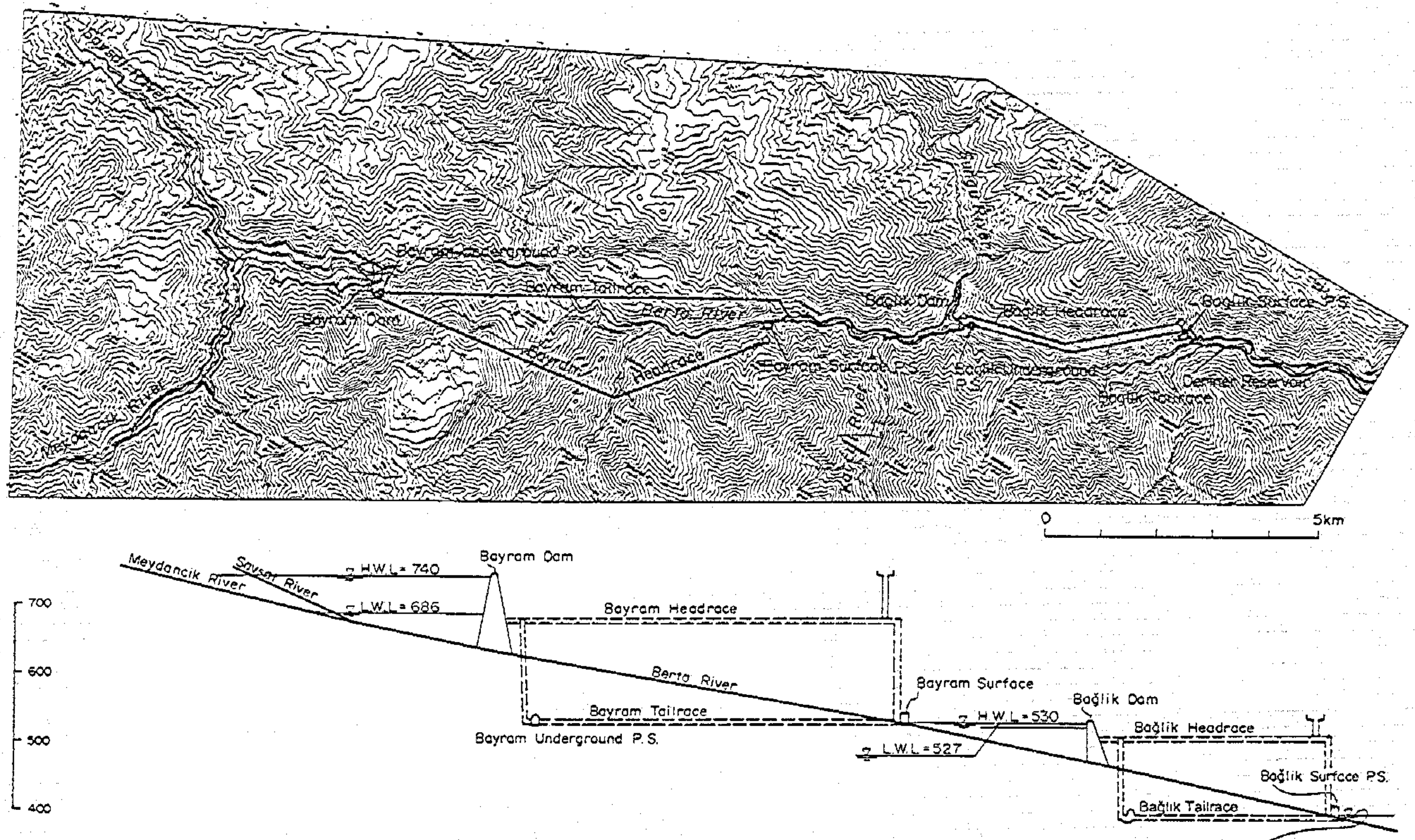


Figure 9-3 Outline of Alternative Layout for Headrace and Tailrace Type

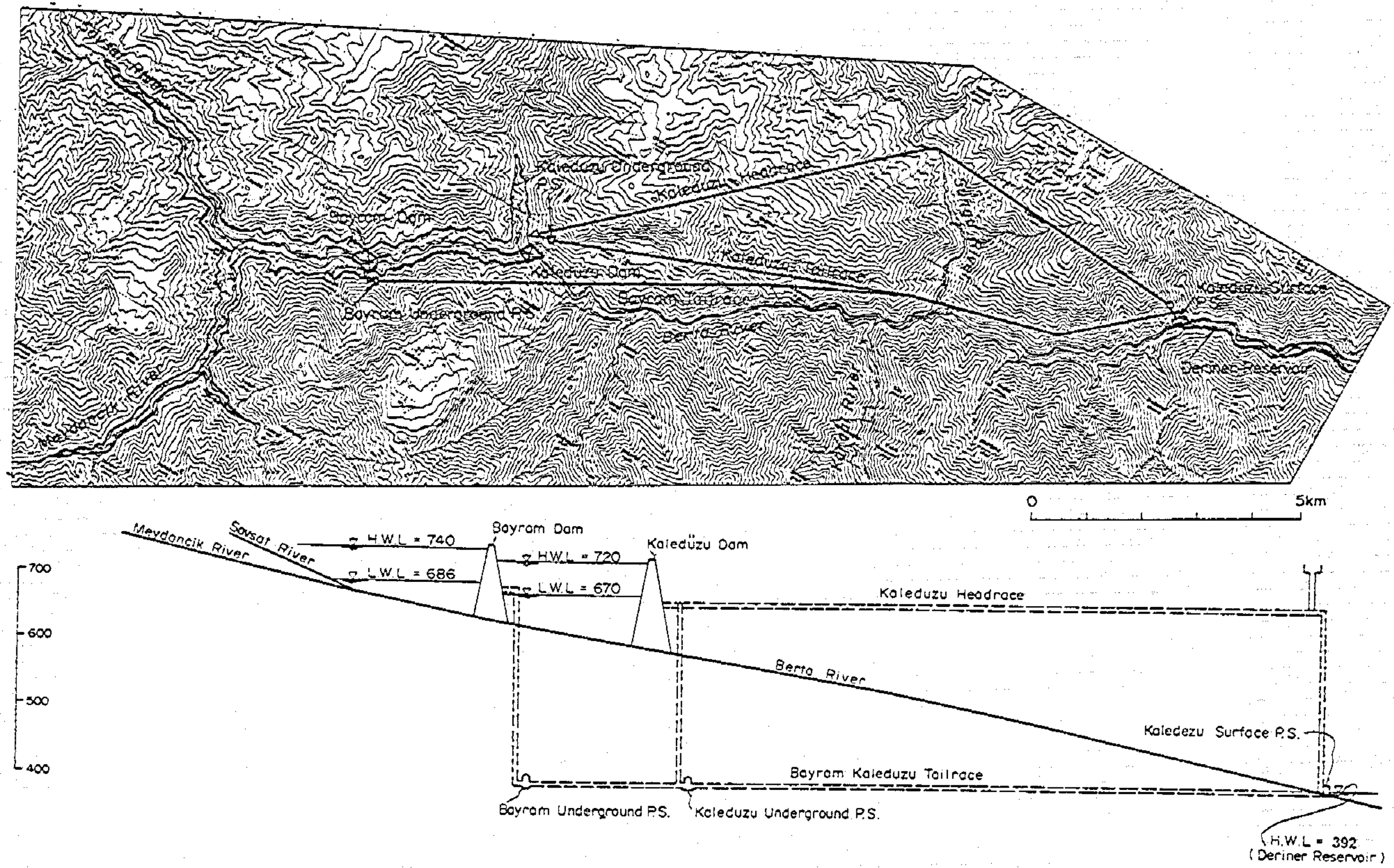
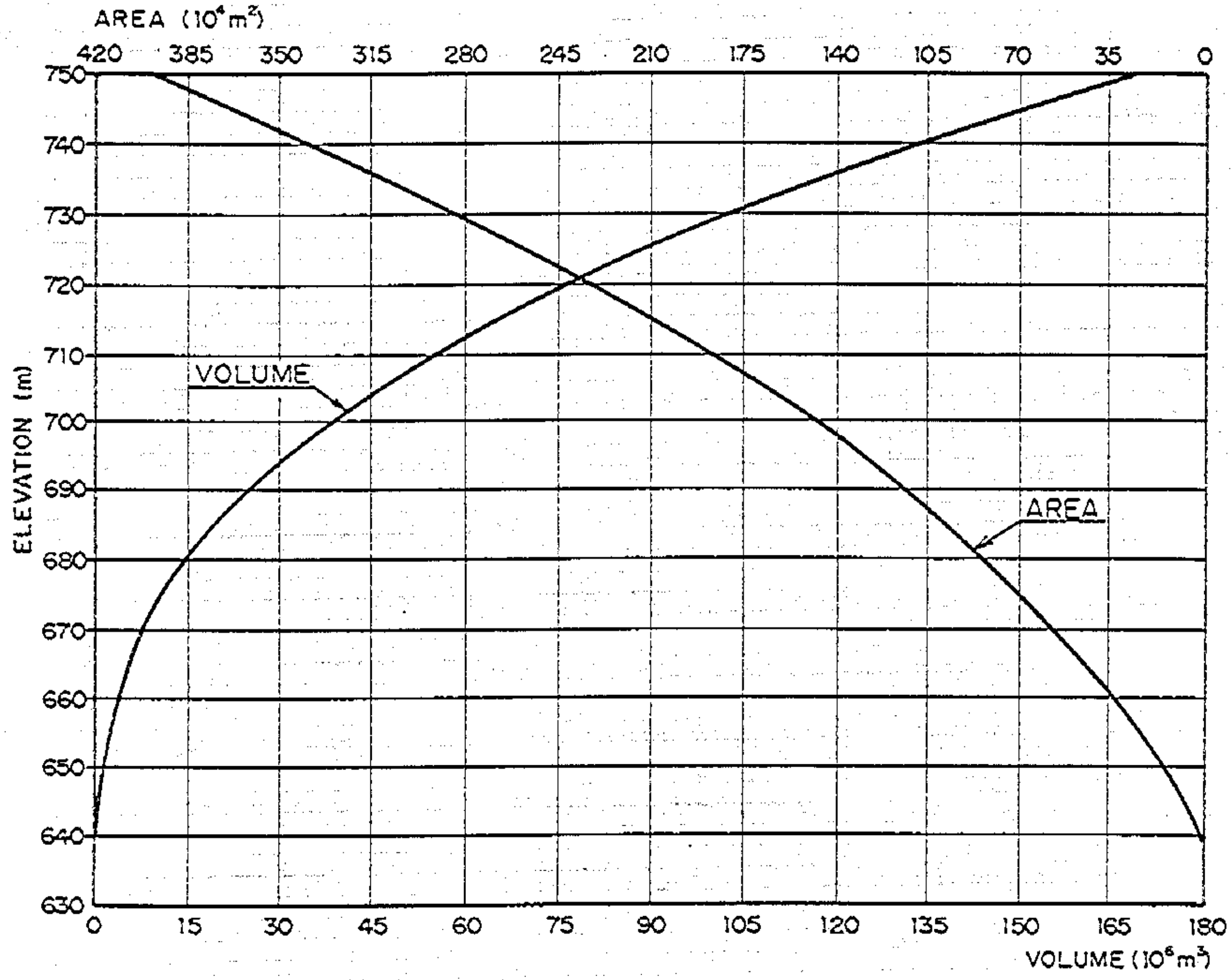
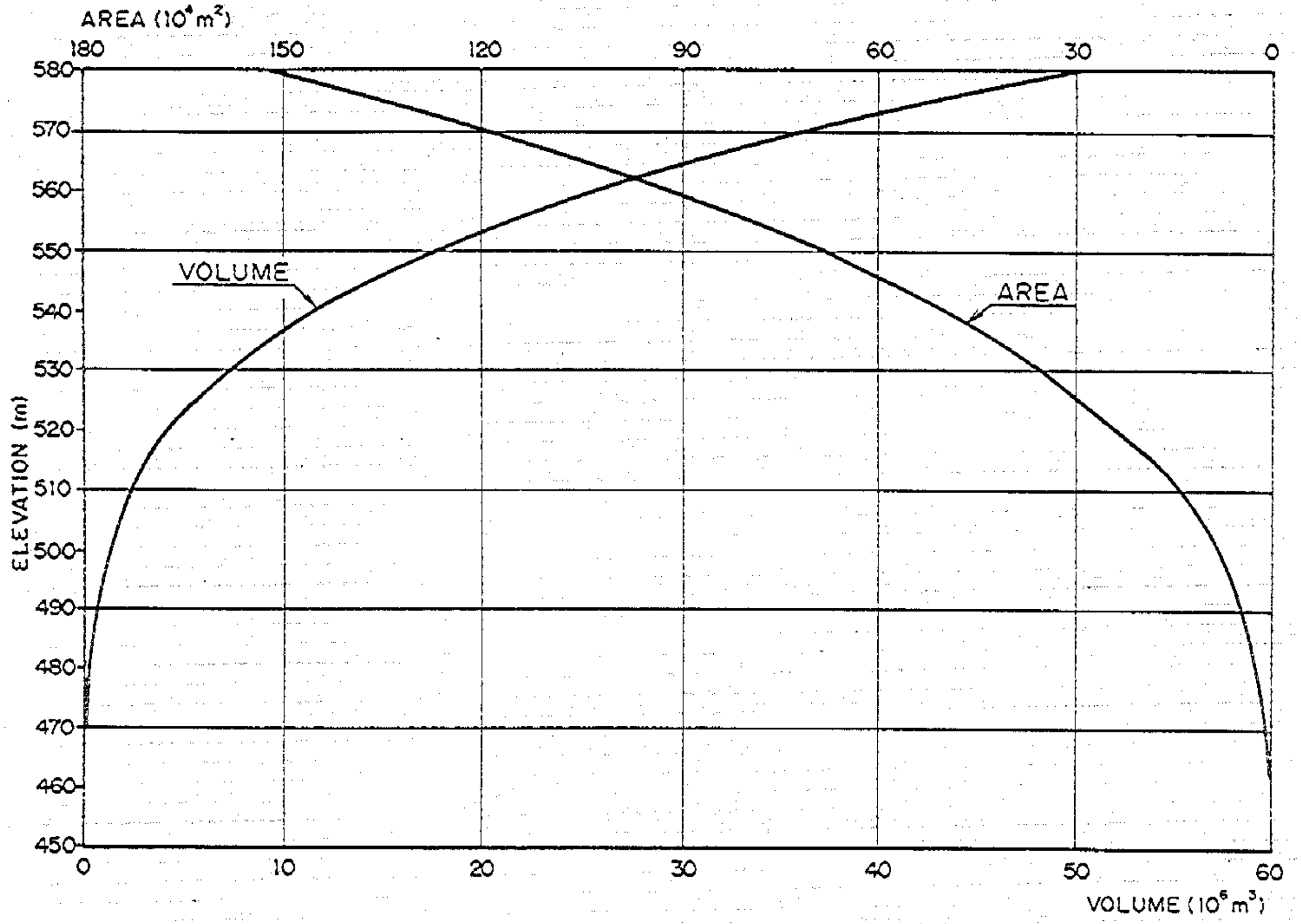


Figure 9-4 Outline of Layout for 1 Stage Development



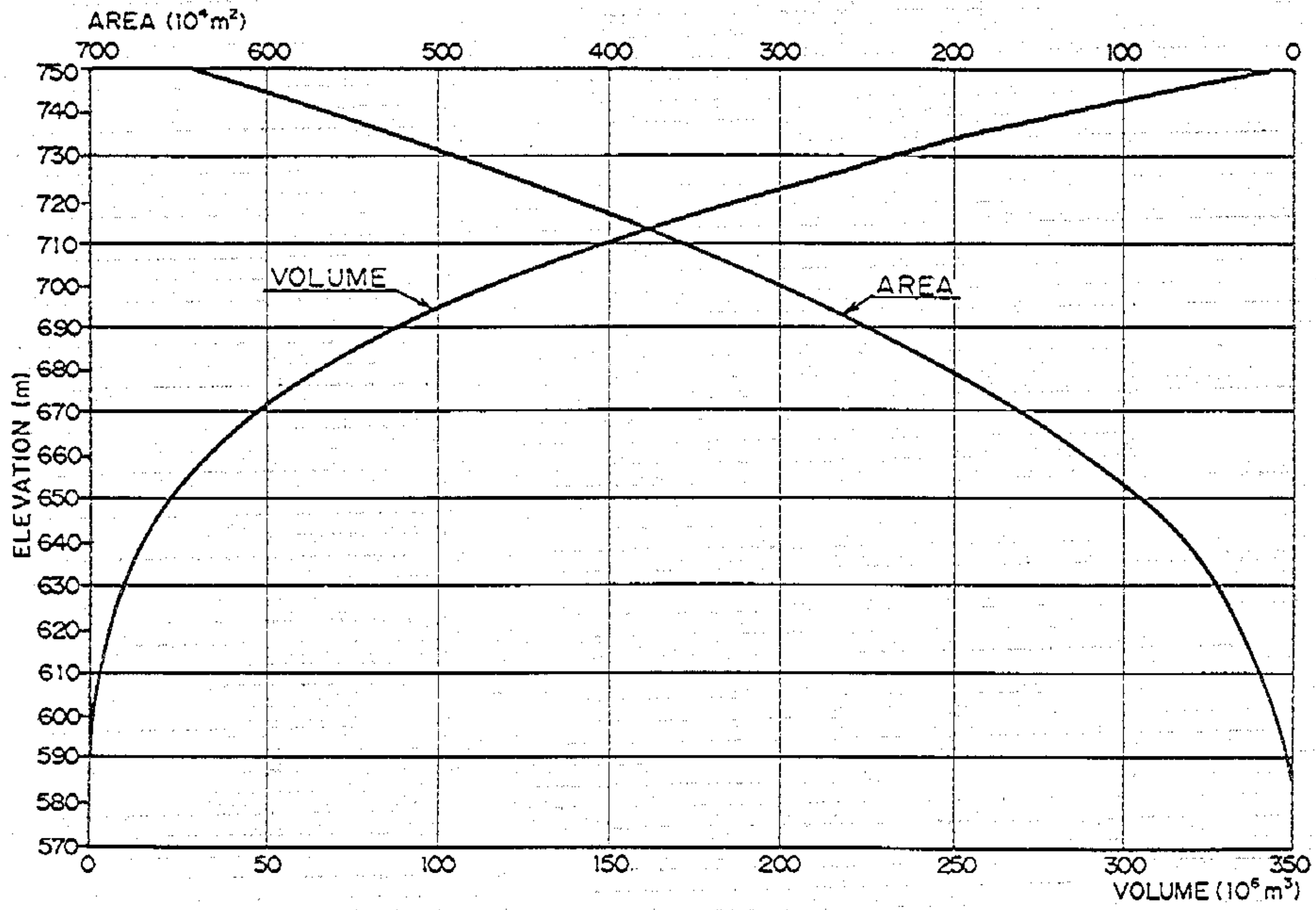
ELEVATION (m)	AREA ($10^4 m^2$)	TOTAL VOLUME ($10^6 m^3$)
640	0	0
650	14.130	0.707
660	32.230	3.025
670	58.570	7.565
680	87.190	14.853
690	115.640	24.995
700	146.560	38.105
710	188.310	54.849
720	231.740	75.852
730	282.690	101.574
740	337.860	132.602
750	398.380	169.414

Figure 9-5 Area-Capacity Curve of Bayram Reservoir



ELEVATION (m)	AREA ($10^4 m^2$)	TOTAL VOLUME ($10^6 m^3$)
468	0	0
470	0.912	0.009
480	2.572	0.183
490	4.739	0.549
500	7.954	1.184
510	13.685	2.266
520	24.833	4.192
530	37.278	7.298
540	50.948	11.709
550	69.366	17.725
560	92.339	25.810
570	119.989	36.426
580	152.251	50.038

Figure 9-6 Area-Capacity Curve of Bağlık Reservoir



ELEVATION (m)	AREA ($10^4 m^2$)	TOTAL VOLUME ($10^6 m^3$)
580	0	0
590	2.875	0.144
600	10.825	0.829
610	20.563	2.398
620	28.850	4.869
630	46.888	8.656
640	62.175	14.109
650	88.880	21.662
660	121.565	32.184
670	162.025	46.363
680	207.070	64.818
690	250.545	87.699
700	300.073	115.230
710	359.048	148.186
720	418.103	187.044
730	487.210	232.310
740	561.478	284.744
750	644.168	345.026

Figure 9-7 Area-Capacity Curve of Kaledüzü Reservoir

9.2 Comparison Study of Alternative Development Plan

9.2.1 Method of Comparative Study

(1) Basic Condition

The method used for a comparative study of the alternative development plan for optimization of the Çoruh-Berta project is the benefit cost method (BC Method) considering an alternative thermal power plant that would be built without the Çoruh-Berta project and taking the cost of the thermal power plant as the benefit of the project.

In order to select the optimum development plan an combination of imported coal-fired thermal power plant and natural gas combined cycle power plant which is supposed to be the future one of the main thermal power plants is used as the alternative facility to be installed in some sea coast region with an installed capacity of 300 MW.

Alternative development plans of the Çoruh-Berta project concerning dam site, waterway route, location of powerhouse and scale of reservoir are formulated and the optimum development plan is selected by comparison of these alternatives.

The annual surplus benefit (B-C) obtained from equalized annual costs (C) for the project life (50 years) of the hydropower facility, and the equalized annual cost (B) of the alternative thermal facility having an ability equivalent to the hydropower facility is used in the study as the indices. Prices in 1996 without import taxes are used in the comparisons.

The cost of the transmission line between the Powerhouse of the Çoruh-Berta project and the load center which should be born by the Çoruh-Berta project and the cost of transmission line between the alternative thermal power plant and load center are omitted.

Parameters of the alternative thermal power plant are as shown in Table 9-6.

(2) Equalized Annual Cost

The equalized annual cost of a hydropower facility consists of depreciation and operation-maintenance cost. This is estimated by multiplying the annual cost factor by the investment cost.

Equalized Annual Cost = Annual Cost Factor x Investment Cost
= Depreciation + Interest + Operation and Maintenance Cost

Depreciation + Interest = Investment Cost x Capital Recovery Factor

$$\text{Capital Recovery Factor} = \frac{i(1+i)^n}{(1+i)^n - 1}$$

n: Service Life

Civil Facility	50 years
Hydro-mechanical Facility	35 years
Electro-mechanical Facility	35 years

i: Discount Rate 9.5%

Civil Facility	9.6%
Hydro-mechanical Facility	9.9%
Electro-mechanical Facility	9.9%

- Operation and Maintenance Cost (Rate to Direct Cost)

Civil Facility	0.5%
Hydro-mechanical Facility	1.5%
Electro-mechanical Facility	1.5%

Accordingly annual cost ratios of facilities are as follows:

Civil Facility	10.1%
Hydro-mechanical Facility	11.4%
Electro-mechanical Facility	11.4%

(3) Benefit

The benefits of the Berta project are summarized according to the project cost, maintenance and operation costs, and the fuel cost of an alternative thermal-power plant as shown in Table 9-6. The effective power output and effective energy that are used in calculating the advantages of the project, are given according to the below conditions.

(a) The effective power output at the receiving end is expressed by the below equation. This equation reduces the station service rate by 0.3%, the forced outage rate by 0.3%, the scheduled outage rate by 2.0%, and the transmission loss rate by 2.1% from the firm peak output. The firm peak output is defined as the 95% probable output for the 53 year period.

Effective power output = (1 - 0.003) x (1 - 0.003) x (1 - 0.02) x (1 - 0.021) x Firm peak output

(b) The effective energy at the receiving end is expressed by the below equation that reduces the station service rate by 0.3% and transmission loss rate by 1.4% from the average energy for the 53 year period.

Effective Energy = (1 - 0.003) x (1 - 0.004) x Average annual energy

Table 9-6 Alternative Thermal Power Plant for Comparison Study

Item Type	Unit	Coal Thermal		Gas Combined Cycle	
Installed Capacity	MW	300*1=300 * 0.5		150*2=300 * 0.5	
Annual Plant Factor	%	70.0		70.0	
Thermal Efficiency	%	38.3		40.0	
Annual Energy Production	GWh	1,839.6 * 0.7 =	1,287.7	1,839.6 * 0.3 =	551.9
Investment Cost	10^6US$	420 * 0.5 =	210.00	198 * 0.5 =	99.00
Service Life	Year	25		15	
Construction Period	Year	4		3	
Capital Recovery Factor		0.10596		0.127744	
Coal Calorific Value	kcal/kg	6,500			
Coal Surface Moisture	%	7		7	
Oil Calorific Value	kcal/kg	10,500			
Fuel Consumption Rate(Coal 95%))	kg/kWh	0.353			
Fuel Consumption Rate (Oil 5%)	kg/kWh	0.011			
Fuel Consumption Rate (Gas 100%%)	kcal/kWh	2,200		2,200	
O & M Cost,Administration Cost	%	3		3	
Unit Fuel Cost (Coal)	US$/kg	0.055			
Unit Fuel Cost (Oil)	US$/kg	0.013			
Unit Fuel Cost (Gas)	US$/10^6kcal			0.001646	
Annual Cost		Fixed Cost	Variable Cost	Fixed Cost	Variable Cost
Capital Recovery	10^6US$	22.25	0.00	12.65	
O & M Cost,Administration Cost	10^6US$	5.67	0.63	2.67	0.30
Fuel Cost	10^6US$	0.00	25.19		19.99
Total	10^6US$	27.92	25.82	15.32	20.29
Annual Cost At Reciving End					
kW Cost 1)	US$/kW			180.45	
Firm KWh Cost 3)	US$/kWh			0.0270	
Secondary KWh Cost 4)	US$/kWh			0.0217	

1) ((27.92*10^6/300,000)*1.252)+((15.32*10^6/3000,000)*1.252) = 180.45 US$

2) ((25.82/1,287.7)*1.084*0.7)+(25.82/1,839.6)*1.084*0.3)= 0.0270 US$

3) (25.82/1,287.7)*1.085= 0.0217 US$

4) Ajustment Factor for kW & kWh

Item	Thermal Power Plant kW	Thermal Power Plant kWh	Hydro Power Plant kW	Hydro Power Plant kWh
Transmission Loss Rate (%)	3.0	2.5	2.1	1.4
Station Service Rate (%)	7.0	7.0	0.3	0.3
Forced Outage Rate (%)	4.0	-	0.3	-
Scheduled Outage Rate (%)	12.0	-	2.0	-

kW Adjustment Factor = (1-0.021)*(1-0.003)*(1-0.003)*(1-0.02) / (1-0.003)*(1-0.07)*(1-0.04)*(1-0.12) = 1.252

kWh Adjustment Factor = (1-0.014)*(1-0.003) / (1-0.025)*(1-0.07) = 1.084

9.2.2 Alternative Plan

As described in 9.2.1(2) regarding the Bayram and Bağlık projects, alternative plans for the projects consisting of tailrace-type layouts in which underground powerhouses are provided immediately below the respective dams with discharge made by non-pressure tunnels in the vicinities of the ends of downstream reservoir backwaters were formulated.

(1) Dam Sites

(a) Bayram Dam

The location of Bayram dam must be selected between the Meydancık river-Şavşat river confluence and the Savail slope site 3.5 km downstream of the confluence due to conditions required of a reservoir. From the standpoint of topography, there are no sites other than the dam axis selected in the master plan of 2.5 km from the confluence, while it has been confirmed in this study that geologically, there is no decisive defect with this dam axis.

Consequently, it was decided not to select an alternative dam axis other than the other selected in the master plan.

(b) Bağlık Dam

In the master plan, the dam axis is selected at a narrows 300 m downstream from the confluence with the Sungu river, one of the important tributaries of the Berta river. Downstream of this site there is no inflow of an important tributary, while the river-bed gradient is more or less constant at about 1/66 down to the end of the Deriner reservoir backwater, while moreover, the valley width is broader compared with the narrows and moving the dam site further downstream than the narrows will be of no merit. Furthermore, because of theeffective storage capacity, if the dam site were to be moved downstream, it will be unavoidable for idle head to result in the inflow from the Karçal river which makes up the major part of inflow from the remaining catchment between Bayram dam and Bağlık dam.

On the other hand, if the dam site were to be moved upstream of the confluence with the Sungu river, not only will the inflow be reduced, but also the storage capacity will be greatly lowered.

Because of this, unless the narrows downstream of the Sungu river possesses a decisive defect geologically for a dam site, it will be unnecessary to select an alternative dam site.

The dam axis selected in the master plan is the point of smallest valley width in this narrows, and as mentioned in 7.2, it is not necessarily a favorable dam axis geologically, so that in the present study, a dam axis was newly selected at a point 200 m upstream of this dam axis. Since these two dam axes, new and old, can be considered to be the same site from the standpoint of studying the project, the upstream new dam axis was considered as the Bağlık dam site, and no other alternative was set up for the dam.

A comparison study of the new and old dam axes and the results are as described in 11.2.

(2) Tail Water Level

(a) Bayram Project

The tail water level of the Bayram project will depend on the reservoir high water level of the downstream Bağlık project so that the tail water level and the alternative tailrace tunnel route proposal will be in combination with the alternative storage capacity proposal for the Bağlık project.

(b) Bağlık Project

The tail water level of the Bağlık project, according to the master plan, will be the reservoir high water level of the Deriner project, which is already at the stage of development, since it is to make use of the entire head between it and the Deriner project.

The Berta river between the Bayram dam site and the end of the Deriner reservoir backwater flows down in a roughly straight line with the river gradient more or less a constant 1/66. Accordingly, there is no necessity consider an alternative plan which sets the tail water level at higher than the high water level of the Deriner project.

It will be possible for the tailrace tunnel of the Bağlık project to be made a non-pressure tunnel even if the tail water level of the Bağlık project were to be about 10 m lower to take advantage of the head produced by the fall in the water level of Deriner reservoir, but it is scheduled for Deriner reservoir to already have been completed when the Bağlık project is to be constructed, and in this case, it will be necessary for a cofferdam to be provided inside Deriner reservoir for construction work on the outlet part of the tailrace tunnel. Therefore, it was decided not to consider an alternative plan to make the tail water level lower than the high water level of EL. 392 m of the Deriner project.

(3) Effective Storage Capacity, High water Level of reservoir

(a) Effective Storage Capacity

According to the master plan, the Bayram project will have a dam 120 m in height with which a reservoir of high water level 720 m and effective storage capacity of 57.6 x 20^6 m^3 will be made, while the Bağlık project would have a dam 125 m in height with which reservoir of high water level 570 m and effective storage capacity of 30.34 x 10^6 m^3 will be provided.

The regulating effect of the reservoir in the Bayram project will be effective for the Bağlık project also. The regulating effect of the reservoir of the Bağlık project will be effective only for the Bağlık project itself, but the tail water level and the tailrace tunnel route of the Bayram project will be decided by the scale of Bağlık reservoir.

Consequently, the alternative proposal concerning storage capacity was made a combination of the respective storage capacities of the Bayram project and the Bağlık project.

For the Bayram project, effective storage capacities of 11 cases at 5 m intervals in a range from high water level 750 m and effective storage capacity 149 x 10^6 m^3 to high water level 700 m and effective storage capacity 18 x 10^6 m^3 were set up.

For the Bağlık project, in addition to the two cases of high water level 570 m, effective storage capacity 30 x 10^6 m^3 and high water level 550 m, effective storage capacity 11 x 10^6 m^3, a case of high water level 530 m and effective storage capacity 1 x 10^6 m^3 consisting of daily regulating capacity for the generating discharge of the Bayram project and the residual runoff between Bayram dam and Bağlık dam was considered for a total of three cases.

Consequently, the alternative plans for storage capacities in the Bayram project and Bağlık project were the 33 combinations of cases given in below.

Bağlık Project Low Water Level = 527 m High Water Level (m)	Bayram Project Low Water Lvel = 686 m High Water Level (m)			
570	750 - 700	5 m	pitch	total 11 cases
550	750 - 700	5 m	pitch	total 11 cases
530	750 - 700	5 m	pitch	total 11 cases

These alternatives, as shown below, were based on minimum water level taking into consideration sediment volume and static draft head of intake. Since Bağlık project is planned together with Bayram project and not be constructed before Bayram project, therefor catchment area between Bayram project and Bağlık project is taken into account for calculation of sediment volume of Bağlık project.

		Bayram Project	Bağlık Project
Annual Sediment Volume	10^6m^3	0.235	0.071
Project Lift	Year	50	50
Design Sediment Volume	10^6m^3	11.76	3.55
Design Sediment Elevation	m	676.00	517.00
Intake Draft Head	m	10.00	10.00
Minimum Low Water Level	m	686.00	527.00

Outline of alternative plans for storage capacities in the Bayram project and Bağlık project are shown in Table 9-7.

(b) Reservoir Low Water Level

The alternative plans for the comparison studies regarding combinations of storage capacity of the Bayram and Bağlık projects were formulated with the minimum low water levels determined from low water levels and sedimentation volumes as the low water levels, following which alternative plans with low water levels set above these minimum low water levels were formulated for making the comparison studies.

For the Bayram project, alternative plans were set up for the storage capacity which was determined as optimum in the comparison studies of alternative reservoir plans described in (a) and storage capacities around that storage capacity.

Here, as a result of comparative study of effective storage volume as mentioned in (a), an alternative with storage volume of Bağlık Project being minimum (daily regulation), i.e. an alternative with minimum dam became optimum. Therefore, various cases of Bayram project were compared setting a case with HWL 530 m for Bağlık Project as tentatively optimum as given in below.

Bayram Project High Water Level (m)	Bayram Project (with Baglik project High Water Lvel = 530 m two Low Water Level = 527 m)			
750	686	705-745	5 m pitch	total 10 cases
745	686	700-740	5 m pitch	total 10 cases
740	686	700-735	5 m pitch	total 9 cases
735	686	700-730	5 m pitch	total 8 cases
730	686	700-725	5 m pitch	total 7 cases

Optimum high water level and low water level of the Bağlık Project is to be determined after determination of optimum high water level and low water level of Bayram project as described in 9.2.3(2).

Table 9-8 shows outline of alternative plan concerning low water level of reservoir.

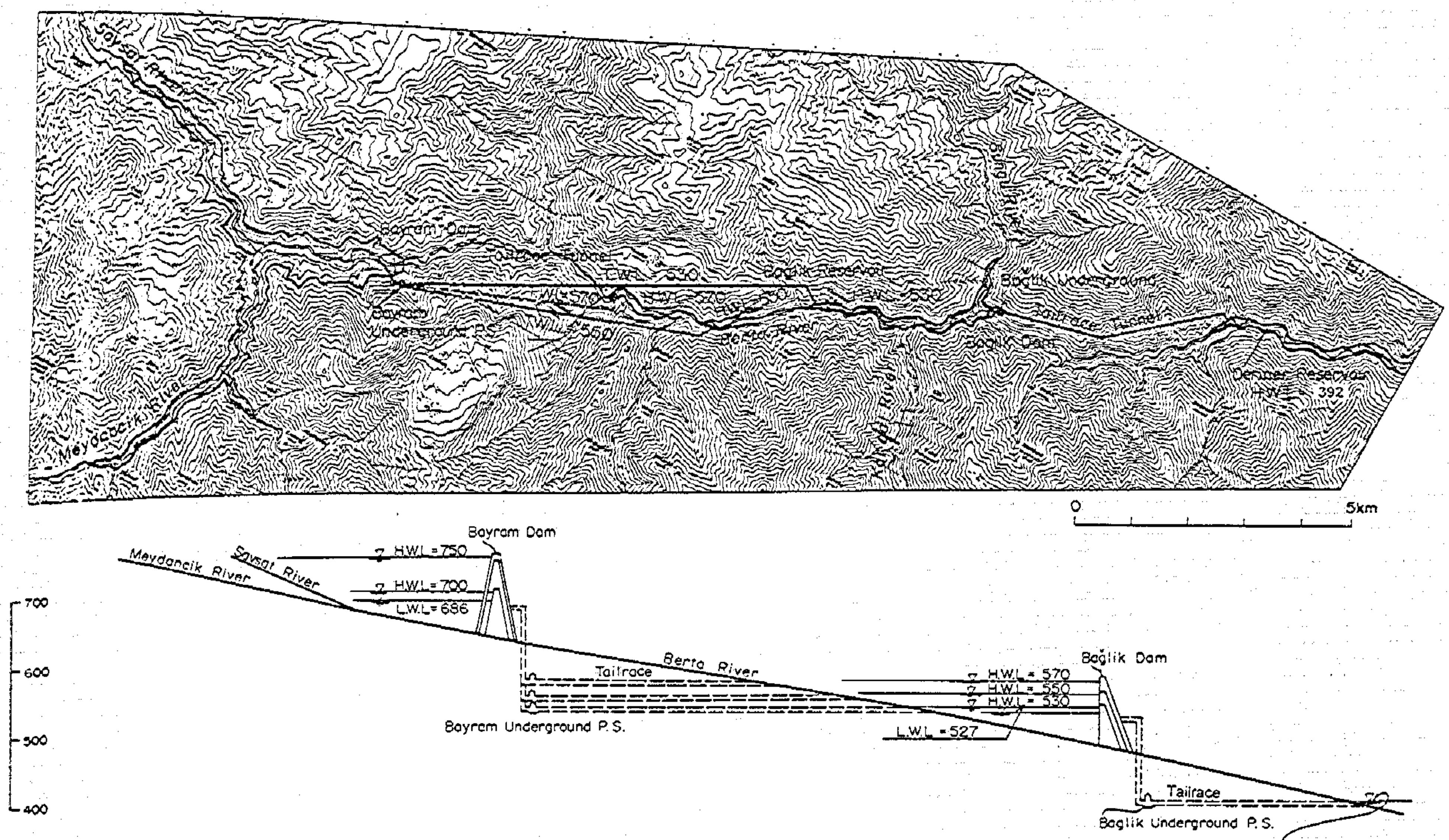


Figure 9-8 Outline of Alternative Development Plan

Table 9-7(1) Outline of Alternative Plan for Reservoir Capacity

Bayram Project Tailrace Type Undergro. P/S Layout H.W.L.=750m-700m With Baglik H.W.L.=570m

Reservoir	Damsite Layout	Bayram 750M.P	Bayram 745M.P	Bayram 740M.P	Bayram 735M.P	Bayram 730M.P	Bayram 725M.P	Bayram 720M.P	Bayram 715M.P	Bayram 710M.P	Bayram 705M.P	Bayram 700M.P
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	750.00	745.00	740.00	735.00	730.00	725.00	720.00	715.00	710.00	705.00	700.00
Normal Water Level	M	728.67	725.33	722.00	718.67	715.33	712.00	708.67	705.33	702.00	698.67	695.33
Low Water Level	M	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00
Available Drawdown	M	64.00	59.00	54.00	49.00	44.00	39.00	34.00	29.00	24.00	19.00	14.00
Gross Capacity	10^6M^3	169.00	150.00	133.00	116.00	102.00	88.00	76.00	65.00	55.00	46.00	169.00
Effective Capacity	10^6M^3	149.00	130.00	113.00	96.00	82.00	68.00	56.00	45.00	35.00	26.00	149.00
Dam												
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	155	150	145	140	135	130	125	120	115	110	105
Crest Length	M	462	442	415	395	379	363	351	337	324	311	292
Volume	10^3M^3	8,500	7,200	6,144	5,400	4,800	4,300	3,900	3500	3100	2700	2400
Headrace Tunnel												
Type												
Diameters	M											
Length	M											
Penstock												
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5
Length	M	268	267.99	267.99	267.99	267.99	267.99	267.99	267.99	267.99	267.99	267.99
Powerhouse												
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel												
Type		Hosesho	Non-Pre.	Non-Pre	Non-Pre	Non-Pre	Non-Pre	Non-Pre.	Non-Pre	Non-Pre.	Non-Pre	Non-Pre.
Diameters	M	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.8
Length (Tunnel)	M	4,550	4,550	4,550	4,550	4,550	4,550	4,550	4,550	4,550	4,550	4,550
(Channel)	M											
Firm Discharge	M^3/S	12.20	11.40	10.70	10.10	9.50	8.90	8.30	7.70	7.20	6.60	6.10
Maximum Dischaerge	M^3/S	49.00	46.00	43.00	40.00	38.00	36.00	33.00	31.00	29.00	26.00	24.00
Tail Water Level	M	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00
Gross Head												
Maximum Head	M	180.00	175.00	170.00	165.00	160.00	155.00	150.00	145.00	140.00	135.00	130.00
Normal Head	M	158.67	155.33	152.00	148.67	145.33	142.00	138.67	135.33	132.00	128.67	125.33
Minimum Head	M	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00
Loss of Head	M	6.30	6.30	6.30	6.40	6.40	6.50	6.60	6.60	6.70	6.80	6.90
Effective Head												
Maximum	M	173.70	168.70	163.70	158.60	153.60	148.50	143.40	138.40	133.30	128.20	123.10
Normal	M	152.37	149.03	145.70	142.27	138.93	135.50	132.07	128.73	125.30	121.87	118.43
Minimum	M	109.70	109.70	109.70	109.60	109.60	109.50	109.40	109.40	109.30	109.20	109.10
Installed Capacity	MW	64	59	54	49	45	42	37	34	31	27	24
Firm Peak Power	MW	52.4	48.8	44.8	40.7	37.2	34.5	30.2	27.6	26.2	23.8	21.1
Annual Energy												
Average	GWh	215.0	207.6	199.5	188.2	178.9	170.9	158.4	149.8	139.7	127.3	117.3
Firm	GWh	135.0	123.9	113.2	102.3	93.5	87.2	78.5	70.5	64.4	56.2	51.8
Secondary	GWh	80.0	83.7	85.3	85.0	84.6	83.7	79.8	79.3	75.3	71.1	65.5

Baglik Project Tailrace Type Undergro. P/S Layout H.W.L.=570.00m With Bayram H.W.L.=750m-700m

Reservoir	Damsite Layout	Baglik 750M.P	Baglik 745M.P	Baglik 740M.P	Baglik 735M.P	Baglik 730M.P	Baglik 725M.P	Baglik 720M.P	Baglik 715M.P	Baglik 710M.P	Baglik 705M.P	Baglik 700M.P
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00	570.00
Normal Water Level	M	555.67	555.67	555.67	555.67	555.67	555.67	555.67	555.67	555.67	555.67	555.67
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00	43.00
Gross Capacity	10^6M^3	36.40	36.40	36.40	36.40	36.40	36.40	36.40	36.40	36.40	36.40	36.40
Effective Capacity	10^6M^3	30.10	30.10	30.10	30.10	30.10	30.10	30.10	30.10	30.10	30.10	30.10
Dam												
Type		Con-Gra	Con-gra	Con-gra	Con-gra	Con-gra	Con-gra	Con-gra	Con-gra	Con-gra	Con-gra	Con-gra
Height from Found.	M	114	114	114	114	114	114	114	114	114	114	114
Crest Length	M	284	284	284	284	284	284	284	284	284	284	284
Volume	10^3M^3	680	680	680	680	680	680	680	680	680	680	680
Headrace Tunnel												
Type												
Diameters	M											
Length	M											
Penstock												
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	4.0	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.3	3.2	3.1
Length	M	213.01	213	213	213	213	213	213	213	213	213	213
Powerhouse												
Type		Undergr	Undergr	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel												
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	5.2	5.2	5.1	5.0	4.9	4.8	4.7	4.6	4.6	4.5	4.4
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M											
Firm Discharge	M^3/S	15.50	15.00	14.30	13.50	12.75	12.25	11.50	11.00	10.50	10.00	9.50
Maximum Dischaerge	M^3/S	62.00	60.00	57.00	54.00	51.00	49.00	45.00	44.00	42.00	40.00	38.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head												
Maximum Head	M	178.00	178.00	178.00	178.00	178.00	178.00	178.00	178.00	178.00	178.00	178.00
Normal Head	M	163.67	163.67	163.67	163.67	163.67	163.67	163.67	163.67	163.67	163.67	163.67
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.50	5.50	5.50	5.60	5.60	5.60	5.70	5.70	5.70	5.80	5.80
Effective Head												
Maximum	M	172.50	172.50	172.50	172.40	172.40	172.40	172.30	172.30	172.30	172.20	172.20
Normal	M	158.17	158.17	158.17	158.07	158.07	158.07	157.97	157.97	157.97	157.87	157.87
Minimum	M	129.50	129.50	129.50	129.40	129.40	129.40	129.30	129.30	129.30	129.20	129.20
Installed Capacity	MW	85	82	78	74	69	67	63	60	57	54	52
Firm Peak Power	MW	72.5	70.8	67.6	67.8	66.2	62.5	60.1	56.8	53.2	47.9	43.4
Annual Energy												
Average	GWh	287.0	285.6	282.1	279.5	276.3	269.6	263.1	257.1	251.3	243.4	233.3
Firm	GWh	178.0	172.2	163.7	156.2	147.9	141.1	132.7	126.1	121.5	114.6	108.0
Secondary	GWh	109.0	113.4	115.4	123.3	128.4	128.5	130.4	131.0	129.8	128.8	125.3

Table 9-7(2) Outline of Alternative Plan for Reservoir Capacity

Bayram Project Tailrace Type Undergro. P/S Layout H.W.L.=750m-700m with Baglik H.W.L.=550.00m

Reservoir	Damsite Layout	Bayram 750A	Bayram 745A	Bayram 740A	Bayram 735A	Bayram 730A	Bayram 725A	Bayram 720A	Bayram 715A	Bayram 710A	Bayram 705A	Bayram 700A
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	750.00	745.00	740.00	735.00	730.00	725.00	720.00	715.00	710.00	705.00	700.00
Normal Water Level	M	728.67	725.33	722.00	718.67	715.33	712.00	708.67	705.33	702.00	698.67	695.33
Low Water Level	M	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00
Available Drawdown	M	64.00	59.00	54.00	49.00	44.00	39.00	34.00	29.00	24.00	19.00	14.00
Gross Capacity	10^6M^3	169.00	150.00	133.00	116.00	102.00	88.00	76.00	65.00	55.00	46.00	38.00
Effective Capacity	10^6M^3	149.00	130.00	113.00	96.00	82.00	68.00	56.00	45.00	35.00	26.00	18.00
Dam												
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	155	150	145	140	135	130	125	120	115	110	105
Crest Length	M	462	442	415	395	379	363	351	337	324	311	292
Volume	10^3M^3	8,500	7,200	6,141	5,400	4,800	4,300	3,900	3,500	3,100	2,700	2,400
Headrace Tunnel												
Type												
Diameters	M											
Length	M											
Penstock												
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5
Length	M	294	294	294	294	294	294	294	294	294	294	294
Powerhouse												
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel												
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.8
Length (Tunnel)	M	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700	6,700
(Channel)	M											
Firm Discharge	M^3/S	12.20	11.40	10.70	10.10	9.50	8.90	8.30	7.70	7.20	6.60	6.10
Maximum Discharge	M^3/S	49.00	46.00	43.00	40.00	38.00	36.00	33.00	31.00	29.00	26.00	24.00
Tail Water Level	M	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00
Gross Head												
Maximum Head	M	200.00	195.00	190.00	185.00	180.00	175.00	170.00	165.00	160.00	155.00	150.00
Normal Head	M	178.67	175.33	172.00	168.67	165.33	162.00	158.67	155.33	152.00	148.67	145.33
Minimum Head	M	136.00	136.00	136.00	136.00	136.00	136.00	136.00	136.00	136.00	136.00	136.00
Loss of Head	M	8.00	8.00	8.10	8.20	8.20	8.30	8.40	8.40	8.50	8.60	8.70
Effective Head												
Maximum	M	192.00	187.00	181.90	176.80	171.80	166.70	161.60	156.60	151.50	146.40	141.30
Normal	M	170.67	167.33	163.90	160.47	157.13	153.70	150.27	146.93	143.50	140.07	136.63
Minimum	M	128.00	128.00	127.90	127.80	127.80	127.70	127.60	127.60	127.50	127.40	127.30
Installed Capacity	MW	72	66	60	55	51	47	42	39	35	31	28
Firm Peak Power	MW	60.4	55.9	51.4	46.7	42.6	38.7	33.9	32.2	30.6	27.8	25.8
Annual Energy												
Average	GWh	226.7	233.0	223.3	213.2	203.3	194.2	182.7	171.4	161.0	146.4	135.4
Firm	GWh	143.2	139.2	126.4	115.3	106.4	99.7	89.1	81.2	75.0	64.9	58.6
Secondary	GWh	83.5	63.6	57.7	97.9	96.9	94.5	93.6	90.2	86.0	81.5	76.8

Baglik Project Tailrace Type Undergro. P/S Layout H.W.L=550.00m With Bayram H.W.L=750m-700m

Reservoir	Damsite Layout	Baglik 750A	Baglik 745A	Baglik 740A	Baglik 735A	Baglik 730A	Baglik 725A	Baglik 720A	Baglik 715A	Baglik 710A	Baglik 705A	Baglik 700A
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00	550.00
Normal Water Level	M	538.50	538.50	538.50	538.50	538.50	538.50	538.50	538.50	538.50	538.50	538.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00	23.00
Gross Capacity	10^6M^3	17.70	17.70	17.70	17.70	17.70	17.70	17.70	17.70	17.70	17.70	17.70
Effective Capacity	10^6M^3	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40	11.40
Dam												
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	94	94	94	94	94	94	94	94	94	94	94
Crest Length	M	240	240	240	240	240	240	240	240	240	240	240
Volume	10^3M^3	420	420	420	420	420	420	420	420	420	420	420
Headrace Tunnel												
Type												
Diameters	M											
Length	M											
Penstock												
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.9	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9
Length	M	213.01	213	213	213	213	213	213	213	213	213	213
Powerhouse												
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel												
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	5.1	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.3	4.2
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M											
Firm Discharge	M^3/S	14.80	14.25	13.50	13.00	11.75	11.25	10.50	10.00	9.50	8.75	8.25
Maximum Discharge	M^3/S	59.00	57.00	54.00	52.00	47.00	45.00	42.00	40.00	38.00	35.00	33.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head												
Maximum Head	M	158.00	158.00	158.00	158.00	158.00	158.00	158.00	158.00	158.00	158.00	158.00
Normal Head	M	146.50	146.50	146.50	146.50	146.50	146.50	146.50	146.50	146.50	146.50	146.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.50	5.50	5.60	5.60	5.70	5.70	5.70	5.80	5.80	5.90	5.90
Effective Head												
Maximum	M	152.50	152.50	152.40	152.40	152.30	152.30	152.30	152.20	152.20	152.10	152.10
Normal	M	141.00	141.00	140.90	140.90	140.80	140.80	140.80	140.70	140.70	140.60	140.60
Minimum	M	129.50	129.50	129.40	129.40	129.30	129.30	129.30	129.20	129.20	129.10	129.10
Installed Capacity	MW	72	69	66	63	57	54	51	48	46	42	40
Firm Peak Power	MW	65.8	63.0	59.8	57.8	55.0	53.0	50.0	47.0	44.7	41.0	39.4
Annual Energy												
Average	GWh	255.0	252.9	250.5	245.8	240.2	235.2	227.5	221.0	214.0	203.5	196.9
Firm	GWh	152.0	145.5	139.0	132.3	120.2	115.7	107.0	102.6	98.1	89.5	85.1
Secondary	GWh	103.0	107.4	111.5	113.5	120.0	119.5	120.5	118.4	115.2	114.0	111.5

Table 9-7(3) Outline of Alternative Plan for Reservoir Capacity

Bayram Project Tailrace Type Undergro. P/S Layout H.W.L.=750m-700m with Baglik H.W.L.= 530.00m

Reservoir	Damsite Layout	Bayram 750C	Bayram 745C	Bayram 740C	Bayram 735C	Bayram 730C	Bayram 725C	Bayram 720C	Bayram 715C	Bayram 710C	Bayram 705C	Bayram 700C
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	750.00	745.00	740.00	735.00	730.00	725.00	720.00	715.00	710.00	705.00	700.00
Normal Water Level	M	728.67	725.33	722.00	718.67	715.33	712.00	708.67	705.33	702.00	638.67	695.33
Low Water Level	M	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00	686.00
Available Drawdown	M	64.00	59.00	54.00	49.00	44.00	39.00	34.00	29.00	24.00	19.00	14.00
Gross Capacity	10^6M^3	169.00	150.00	133.00	116.00	102.00	88.00	76.00	65.00	55.00	46.00	38.00
Effective Capacity	10^6M^3	149.00	130.00	113.00	96.00	82.00	68.00	56.00	45.00	35.00	26.00	18.00
Dam			9.95	8.73	7.74	6.91	6.13	5.45	4.85	4.28	3.76	3.22
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	155	150	145	140	135	130	125	120	115	110	105
Crest Length	M	462	442	415	396	379	363	351	337	324	311	292
Volume	10^3M^3	8,500	7,200	6,144	5,400	4,800	4,300	3,900	3,500	3,100	2,700	2,400
Headrace Tunnel												
Type												
Diameters	M											
Length	M											
Penstock												
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8	2.7	2.6	2.5
Length	M	321	321.14	321.14	321.14	321.14	321.14	321.14	321.14	321.14	321.14	321.14
Powerhouse												
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel												
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.1	4.0	3.9	3.8
Length (Tunnel)	M	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930
(Channel)	M											
Firm Discharge	M^3/S	12.20	11.40	10.70	10.10	9.50	8.90	8.30	7.70	7.20	6.60	6.10
Maximum Dischaerge	M^3/S	49.00	46.00	43.00	40.00	38.00	36.00	33.00	31.00	29.00	26.00	24.00
Tail Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Gross Head												
Maximum Head	M	220.00	215.00	210.00	205.00	200.00	195.00	190.00	185.00	180.00	175.00	170.00
Normal Head	M	198.67	195.33	192.00	188.67	185.33	182.00	178.67	175.33	172.00	168.67	165.33
Minimum Head	M	156.00	156.00	156.00	156.00	156.00	156.00	156.00	156.00	156.00	156.00	156.00
Loss of Head	M	9.00	9.00	9.10	9.20	9.20	9.30	9.40	9.50	9.50	9.70	9.80
Effective Head												
Maximum	M	211.00	206.00	200.90	195.80	190.80	185.70	180.60	175.50	170.50	165.30	160.20
Normal	M	189.67	186.33	182.90	179.47	176.13	172.70	169.27	165.83	162.50	158.97	155.53
Minimum	M	147.00	147.00	146.90	146.80	146.80	146.70	146.60	146.50	146.50	146.30	146.20
Installed Capacity	MW	80	74	68	62	57	53	48	44	40	35	32
Firm Peak Power	MW	67.4	63.0	58.0	52.4	48.5	43.6	39.0	36.9	35.0	31.8	29.5
Annual Energy												
Average	GWh	266.8	257.7	247.9	237.0	227.0	216.6	204.9	193.3	180.8	167.3	154.4
Firm	GWh	168.5	154.4	141.4	128.2	119.5	110.7	100.1	92.0	83.9	75.3	67.2
Secondary	GWh	98.3	103.3	106.5	108.8	107.5	105.9	104.8	101.3	96.9	92.0	87.2

Baglik Project Tailrace Type Undergro. P/S Layout H.W.L= 530.00m with Bayram H.W.L.=750m-700m

Reservoir	Damsite Layout	Baglik 750C	Baglik 745C	Baglik 740C	Baglik 735C	Baglik 730C	Baglik 725C	Baglik 720C	Baglik 715C	Baglik 710C	Baglik 705C	Baglik 700C
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Normal Water Level	M	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Gross Capacity	10^6M^3	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
Effect Capacity	10^6M^3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dam												
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	74	74	74	74	74	74	74	74	74	74	74
Crest Length	M	190	190	190	190	190	190	190	190	190	130	190
Volume	10^3M^3	195	195	195	195	195	195	195	195	195	195	195
Headrace Tunnel												
Type												
Diameters	M											
Length	M											
Penstock												
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.8	3.7	3.6	3.5	3.4	3.3	3.2	3.1	3.0	2.9	2.8
Length	M	213.01	213.01	213.01	213.01	213.01	213.01	213.01	213.01	213.01	213.01	213.01
Powerhouse												
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel												
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	5.1	5.0	4.9	4.8	4.7	4.6	4.5	4.4	4.3	4.2	4.1
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M											
Firm Discharge	M^3/S	14.50	13.75	13.00	12.00	11.25	10.75	10.00	9.50	9.00	8.25	7.75
Maximum Dischaerge	M^3/S	58.00	55.00	52.00	48.00	45.00	43.00	40.00	38.00	36.00	33.00	31.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head												
Maximum Head	M	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00
Normal Head	M	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.50	5.60	5.60	5.60	5.70	5.70	5.80	5.80	5.80	5.90	6.00
Effective Head												
Maximum	M	132.50	132.40	132.40	132.40	132.30	132.30	132.20	132.20	132.20	132.10	132.00
Normal	M	131.00	130.90	130.90	130.90	130.80	130.80	130.70	130.70	130.70	130.60	130.50
Minimum	M	129.50	129.40	129.40	129.40	129.30	129.30	129.20	129.20	129.20	129.10	129.00
Installed Capacity	MW	65	62	59	54	51	48	45	43	40	37	35
Firm Peak Power	MW	62.9	59.6	56.4	52.0	49.0	47.0	44.0	41.0	39.0	36.0	34.0
Annual Energy												
Average	GWh	227.0	224.0	221.4	215.7	210.6	206.8	200.6	192.6	185.9	176.9	170.4
Firm	GWh	139.2	130.7	124.2	113.6	107.1	102.5	96.1	89.5	85.1	78.6	74.2
Secondary	GWh	87.8	93.3	97.2	102.1	103.5	104.3	104.5	103.1	100.8	95.3	96.2

Table 9-8(1) Outline of Alternative Plan for Bayram Reservoir Water Level

Bayram Project Tailrace Undergro. P/S Layout H.W.L.=750m L.W.L.=688-745m With Baglik H.W.L.= 530.00m

Reservoir	Damsite Layout	Bayram 750-686	Bayram 750-705	Bayram 750-710	Bayram 750-715	Bayram 750-720	Bayram 750-725	Bayram 750-730	Bayram 750-735	Bayram 750-740	Bayram 750-745
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00	750.00
Normal Water Level	M	728.67	735.00	736.67	738.33	740.00	741.67	743.33	745.00	746.67	748.33
Low Water Level	M	686.00	705.00	710.00	715.00	720.00	725.00	730.00	735.00	740.00	745.00
Available Drawdown	M	64.00	45.00	40.00	35.00	30.00	25.00	20.00	15.00	10.00	5.00
Gross Capacity	10^6M^3	169.00	169.00	169.00	169.00	169.00	169.00	169.00	169.00	169.00	169.00
Effective Capacity	10^6M^3	149.00	123.00	114.00	104.00	93.00	81.00	67.00	53.00	36.00	19.00
Dam	(m^3/s-d)	1,724.5	1,423.6	1,319.4	1,203.7	1,076.4	937.5	775.5	613.4	416.7	219.9
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	155	155	155	155	155	155	155	155	155	155
Crest Length	M	462	462	462	462	462	462	462	462	462	462
Volume	10^3M^3	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500	8,500
Headrace Tunnel											
Type											
Diameters	M										
Length	M										
Penstock											
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.5	3.4	3.3	3.3	3.2	3.1	3.0	2.9	2.7	2.5
Length	M	321	321	321	321	321	321	321	321	321	321
Powerhouse											
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel											
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.8	4.7	4.6	4.6	4.5	4.4	4.3	4.2	4.0	3.8
Length (Tunnel)	M	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930
(Channel)	M										
Firm Discharge	M^3/S	12.20	11.20	10.70	10.40	10.00	9.40	8.80	8.20	7.20	6.10
Maximum Dischaerge	M^3/S	49.00	45.00	43.00	42.00	40.00	38.00	35.00	33.00	29.00	24.00
Tail Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Gross Head											
Maximum Head	M	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00	220.00
Normal Head	M	198.67	205.00	206.67	208.33	210.00	211.67	213.33	215.00	216.67	218.33
Minimum Head	M	156.00	175.00	180.00	185.00	190.00	195.00	200.00	205.00	210.00	215.00
Loss of Head	M	9.00	9.10	9.10	9.10	9.20	9.20	9.30	9.40	9.50	9.80
Effective Head											
Maximum	M	211.00	210.90	210.90	210.90	210.80	210.80	210.70	210.60	210.50	210.20
Normal	M	189.67	195.90	197.57	199.23	200.80	202.47	204.03	205.60	207.17	208.53
Minimum	M	147.00	165.90	170.90	175.90	180.80	185.80	190.70	195.60	200.50	205.20
Installed Capacity	MW	80	76	73	72	69	66	61	58	51	43
Firm Peak Power	MW	67.4	66.4	64.1	62.4	60.2	58.6	54.7	52.1	48.6	40.3
Annual Energy											
Average	GWh	266.8	266.0	265.2	264.5	263.5	259.5	253.9	245.0	232.7	199.8
Firm	GWh	168.5	166.6	161.4	156.0	149.4	141.8	128.9	120.2	110.2	88.3
Secondary	GWh	98.3	99.4	103.8	108.5	114.1	117.7	125.0	124.8	122.5	111.5

Baglik Project Tailrace Undergro. P/S Layout H.W.L.= 530.00m With Bayram H.W.L.=750m L.W.L.=688-745m

Reservoir	Damsite Layout	Baglik 750-686	Baglik 750-705	Baglik 750-710	Baglik 750-715	Baglik 750-720	Baglik 750-725	Baglik 750-730	Baglik 750-735	Baglik 750-740	Baglik 750-745
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Normal Water Level	M	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Gross Capacity	10^6M^3	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
Effect Capacity	10^6M^3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dam											
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	74	74	74	74	74	74	74	74	74	74
Crest Length	M	190	190	190	190	190	190	190	190	190	190
Volume	10^3M^3	195	195	195	195	195	195	195	195	195	195
Headrace Tunnel		1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
Type											
Diameters	M										
Length	M										
Penstock											
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.8	3.7	3.6	3.6	3.5	3.3	3.3	3.2	3.0	2.8
Length	M	213	213	213	213	213	213	213	213	213	213
Powerhouse											
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel											
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	5.1	5.0	4.9	4.9	4.8	4.7	4.6	4.5	4.4	4.1
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M										
Firm Discharge	M^3/S	14.50	13.40	13.00	12.40	11.80	11.10	10.50	9.70	8.90	7.80
Maximum Dischaerge	M^3/S	58.00	54.00	52.00	50.00	47.00	44.00	42.00	39.00	36.00	31.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head											
Maximum Head	M	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00
Normal Head	M	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.50	5.60	5.60	5.60	5.70	5.70	5.70	5.80	5.80	6.00
Effective Head											
Maximum	M	132.50	132.40	132.40	132.40	132.30	132.30	132.30	132.20	132.20	132.00
Normal	M	131.00	130.90	130.90	130.90	130.80	130.80	130.80	130.70	130.70	130.50
Minimum	M	129.50	129.40	129.40	129.40	129.30	129.30	129.30	129.20	129.20	129.00
Installed Capacity	MW	65	61	59	56	53	49	47	44	40	35
Firm Peak Power	MW	62.9	58.0	56.4	55.0	51.0	48.0	46.0	42.0	39.0	34.0
Annual Energy											
Average	GWh	227.0	223.0	221.9	219.0	216.5	212.0	206.4	198.0	186.1	169.0
Firm	GWh	139.2	127.0	124.1	120.5	111.7	105.1	100.7	92.0	85.1	74.5
Secondary	GWh	87.8	96.0	97.8	98.6	104.8	106.9	105.7	106.0	101.0	94.5

Table 9-8(2) Outline of Alternative Plan for Bayram Reservoir Water Level

Bayram Project Tailrace Undergro. P/S Layout H.W.L.=745m L.W.L.=686-740m With Baglik H.W.L.= 530.00m

	Damsite Layout	Bayram 745-686	Bayram 745-700	Bayram 745-705	Bayram 745-710	Bayram 745-715	Bayram 745-720	Bayram 745-725	Bayram 745-730	Bayram 745-735	Bayram 745-740
Reservoir											
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	745.00	745.00	745.00	745.00	745.00	745.00	745.00	745.00	745.00	745.00
Normal Water Level	M	725.33	730.00	731.67	733.33	735.00	736.67	738.33	740.00	741.67	743.33
Low Water Level	M	686.00	700.00	705.00	710.00	715.00	720.00	725.00	730.00	735.00	740.00
Available Drawdown	M	59.00	45.00	40.00	35.00	30.00	25.00	20.00	15.00	10.00	5.00
Gross Capacity	10^6M^3	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00	150.00
Effective Capacity	10^6M^3	130.00	112.00	104.00	95.00	85.00	74.00	62.00	48.00	34.00	17.00
	(m^3/s-d)	1,504.6	1,296.3	1,203.7	1,099.5	983.8	856.5	717.6	555.6	393.5	196.8
Dam											
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	150	150	150	150	150	150	150	150	150	150
Crest Length	M	442	442	442	442	442	442	442	442	442	442
Volume	10^3M^3	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200	7,200
Headrace Tunnel											
Type											
Diameters	M										
Length	M										
Penstock											
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.4	3.3	3.3	3.2	3.1	3.0	2.9	2.9	2.7	2.5
Length	M	321	321	321	321	321	321	321	321	321	321
Powerhouse											
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel											
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.7	4.6	4.6	4.5	4.4	4.3	4.2	4.2	4.0	3.8
Length (Tunnel)	M	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930
(Channel)	M										
Firm Discharge	M^3/S	11.40	10.70	10.40	10.00	9.60	9.10	8.50	7.90	7.10	6.00
Maximum Dischaerge	M^3/S	48.00	43.00	42.00	40.00	38.00	36.00	34.00	32.00	28.00	24.00
Tail Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Gross Head											
Maximum Head	M	215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00	215.00
Normal Head	M	195.33	200.00	201.67	203.33	205.00	206.67	208.33	210.00	211.67	213.33
Minimum Head	M	156.00	170.00	175.00	180.00	185.00	190.00	195.00	200.00	205.00	210.00
Loss of Head	M	9.00	9.10	9.10	9.20	9.20	9.30	9.40	9.40	9.60	9.80
Effective Head											
Maximum	M	206.00	205.90	205.90	205.80	205.80	205.70	205.60	205.60	205.40	205.20
Normal	M	186.33	190.80	192.57	194.13	195.80	197.37	198.93	200.60	202.07	203.53
Minimum	M	147.00	160.90	165.90	170.80	175.80	180.70	185.60	190.60	195.40	200.20
Installed Capacity	MW	74	70	69	67	64	61	58	55	48	42
Firm Peak Power	MW	63.0	60.9	60.1	58.3	56.2	54.2	52.3	50.5	45.4	40.3
Annual Energy											
Average	GWh	257.7	257.1	256.5	253.6	249.4	246.5	241.2	235.2	221.1	199.8
Firm	GWh	154.4	148.9	151.4	149.8	139.5	130.7	124.2	112.4	99.3	88.2
Secondary	GWh	103.3	108.2	105.1	103.8	109.9	115.8	117.1	122.8	121.8	111.6

Baglik Project Tailrace Undergro. P/S Layout H.W.L.= 530.00m Bayram H.W.L.=745m L.W.L.=688-740m

	Damsite Layout	Baglik 745-686	Baglik 745-700	Baglik 745-705	Baglik 745-710	Baglik 745-715	Baglik 745-720	Baglik 745-725	Baglik 745-730	Baglik 745-735	Baglik 745-740
Reservoir											
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Normal Water Level	M	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Gross Capacity	10^6M^3	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
Effect Capacity	10^6M^3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dam											
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	74	74	74	74	74	74	74	74	74	74
Crest Length	M	190	190	190	190	190	190	190	190	190	190
Volume	10^3M^3	195	195	195	195	195	195	195	195	196	195
Headrace Tunnel											
Type											
Diameters	M										
Length	M										
Penstock											
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.7	3.6	3.5	3.5	3.4	3.3	3.2	3.1	3.0	2.8
Length	M	213	213	213	213	213	213	213	213	213	213
Powerhouse											
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel											
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	5.0	4.9	4.8	4.8	4.7	4.6	4.5	4.4	4.3	4.1
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M										
Firm Discharge	M^3/S	13.75	13.00	12.30	12.00	11.30	10.80	10.30	9.50	8.70	7.50
Maximum Dischaerge	M^3/S	55.00	52.00	49.00	48.00	45.00	43.00	41.00	38.00	35.00	30.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head											
Maximum Head	M	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00
Normal Head	M	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.60	5.60	5.60	5.60	5.70	5.70	5.80	5.80	5.90	6.00
Effective Head											
Maximum	M	132.40	132.40	132.40	132.40	132.30	132.30	132.20	132.20	132.10	132.00
Normal	M	130.90	130.90	130.90	130.90	130.80	130.80	130.70	130.70	130.60	130.50
Minimum	M	129.40	129.40	129.40	129.40	129.30	129.30	129.20	129.20	129.10	129.00
Installed Capacity	MW	62	59	55	54	51	48	45	43	39	33
Firm Peak Power	MW	59.6	56.4	54.0	52.0	49.0	47.0	45.0	41.0	38.0	33.0
Annual Energy											
Average	GWh	224.0	220.7	218.5	215.6	212.5	208.5	203.5	192.0	185.0	169.0
Firm	GWh	130.7	123.5	118.3	113.9	107.3	102.9	95.6	89.8	83.2	72.3
Secondary	GWh	93.3	97.2	100.2	101.7	105.2	105.6	105.0	102.2	101.8	96.7

Table 9-8(3) Outline of Alternative Plan for Bayram Reservoir Water Level

Bayram Project Tailrace Undergro. P/S Layout H.W.L.=740m L.W.L.=686m-735m With Baglik H.W.L.= 530.00m

Reservoir	Damsite Layout	Bayram 740-686	Bayram 740-700	Bayram 740-705	Bayram 740-710	Bayram 740-715	Bayram 740-720	Bayram 740-725	Bayram 740-730	Bayram 740-735
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	740.00	740.00	740.00	740.00	740.00	740.00	740.00	740.00	740.00
Normal Water Level	M	722.00	726.67	728.33	730.00	731.67	733.33	735.00	736.67	738.33
Low Water Level	M	686.00	700.00	705.00	710.00	715.00	720.00	725.00	730.00	735.00
Available Drawdown	M	54.00	40.00	35.00	30.00	25.00	20.00	15.00	10.00	5.00
Gross Capacity	10^6M^3	133.00	133.00	133.00	133.00	133.00	133.00	133.00	133.00	133.00
Effective Capacity	10^6M^3	113.00	95.00	87.00	78.00	68.00	57.00	45.00	31.00	17.00
Dam										
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	145	145	145	145	145	145	145	145	145
Crest Length	M	415	415	415	415	415	415	415	415	415
Volume	10^3M^3	6,144	6,144	6,144	6,144	6,144	6,144	6,144	6,144	6,144
Headrace Tunnel										
Type										
Diameters	M									
Length	M									
Penstock										
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.30	3.19	3.15	3.07	3.03	2.90	2.81	2.62	2.47
Length	M	321	321	321	321	321	321	321	321	321
Powerhouse										
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel										
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.6	4.5	4.5	4.4	4.3	4.2	4.1	3.9	3.8
Length (Tunnel)	M	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930
(Channel)	M									
Firm Discharge	M^3/S	10.70	10.00	9.70	9.30	8.90	8.30	7.70	6.80	6.00
Maximum Dischaerge	M^3/S	43.00	40.00	39.00	37.00	36.00	33.00	31.00	27.00	24.00
Tail Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Gross Head										
Maximum Head	M	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00	210.00
Normal Head	M	192.00	196.67	198.33	200.00	201.67	203.33	205.00	206.67	208.33
Minimum Head	M	156.00	170.00	175.00	180.00	185.00	190.00	195.00	200.00	205.00
Loss of Head	M	9.10	9.20	9.20	9.30	9.30	9.40	9.50	9.60	9.80
Effective Head										
Maximum	M	200.90	200.80	200.80	200.70	200.70	200.60	200.50	200.40	200.20
Normal	M	182.90	187.47	189.13	190.70	192.37	193.93	195.50	197.07	198.53
Minimum	M	146.90	160.80	165.80	170.70	175.70	180.60	185.50	190.40	195.20
Installed Capacity	MW	68	64	63	61	59	55	52	48	41
Firm Peak Power	MW	58.0	55.6	54.0	52.1	51.0	49.0	46.5	42.9	39.3
Annual Energy										
Average	GWh	247.9	246.5	244.9	242.8	240.0	235.2	225.8	212.6	193.8
Firm	GWh	141.4	134.6	130.8	126.3	122.2	116.0	107.8	97.4	85.1
Secondary	GWh	106.5	111.9	114.1	116.5	117.8	119.2	118.0	115.2	107.8

Baglik Project Tailrace Undergro. P/S Layout H.W.L= 530.00m With Bayram H.W.L.=740m L.W.L.=686m-700m

Reservoir	Damsite Layout	Baglik 740-686	Baglik 740-700	Baglik 740-705	Baglik 740-710	Baglik 743-715	Baglik 740-720	Baglik 740-725	Baglik 740-730	Baglik 740-735
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Normal Water Level	M	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Gross Capacity	10^6M^3	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
Effect Capacity	10^6M^3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dam										
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	74	74	74	74	74	74	74	74	74
Crest Length	M	190	190	190	190	190	190	190	190	190
Volume	10^3M^3	195	195	195	195	195	195	195	195	195
Headrace Tunnel										
Type										
Diameters	M									
Length	M									
Penstock										
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.60	3.5	3.4	3.3	3.3	3.2	3.1	2.9	2.8
Length	M	213	213	213	213	213	213	213	213	213
Powerhouse										
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel										
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.9	4.8	4.7	4.6	4.6	4.5	4.4	4.3	4.1
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M									
Firm Discharge	M^3/S	13.00	12.00	11.50	11.00	10.50	10.00	9.30	8.50	7.50
Maximum Dischaerge	M^3/S	52.00	48.00	46.00	44.00	42.00	40.00	37.20	34.00	30.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head										
Maximum Head	M	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00
Normal Head	M	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.70	5.60	5.70	5.70	5.70	5.80	5.80	5.90	6.00
Effective Head										
Maximum	M	132.30	132.40	132.30	132.30	132.30	132.20	132.20	132.10	132.00
Normal	M	130.80	130.90	130.80	130.80	130.80	130.70	130.70	130.60	130.50
Minimum	M	129.30	129.40	129.30	129.30	129.30	129.20	129.20	129.10	129.00
Installed Capacity	MW	59	54	52	49	47	45	42	38	33
Firm Peak Power	MW	56.4	51.5	50.0	48.0	46.0	44.0	40.0	37.0	33.0
Annual Energy										
Average	GWh	221.4	216.3	213.5	210.7	206.8	201.0	192.6	180.8	169.5
Firm	GWh	124.2	113.6	109.5	104.9	100.7	96.1	87.6	80.8	72.3
Secondary	GWh	97.2	102.7	104.0	105.8	106.1	104.9	105.0	100.0	97.2

Table 9-8(4) Outline of Alternative Plan for Bayram Reservoir Water Level

Bayram Project Tailrace Undergro. P/S Layout H.W.L.=735m L.W.L=686m-730m With Baglik H.W.L.= 530.00m

Damsite Layout		Bayram 735-686	Bayram 735-700	Bayram 735-705	Bayram 735-710	Bayram 735-715	Bayram 735-720	Bayram 735-725	Bayram 735-730
Reservoir									
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	735.00	735.00	735.00	735.00	735.00	735.00	735.00	735.00
Normal Water Level	M	718.67	723.33	725.00	726.67	728.33	730.00	731.67	733.33
Low Water Level	M	686.00	700.00	705.00	710.00	715.00	720.00	725.00	730.00
Available Drawdown	M	49.00	35.00	30.00	25.00	20.00	15.00	10.00	5.00
Gross Capacity	10^6M^3	116.00	116.00	116.00	116.00	116.00	116.00	116.00	116.00
Effective Capacity	10^6M^3	96.00	78.00	70.00	61.00	51.00	40.00	28.00	14.00
Dam									
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	140	140	140	140	140	140	140	140
Crest Length	M	395	395	395	395	395	395	395	395
Volume	10^3M^3	5,400	5,400	5,400	5,400	5,400	5,400	5,400	5,400
Headrace Tunnel									
Type									
Diameters	M								
Length	M								
Penstock									
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.2	3.1	3.0	2.9	2.9	2.8	2.6	2.4
Length	M	321	321	321	321	321	321	321	321
Powerhouse									
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel									
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.5	4.4	4.3	4.2	4.2	4.1	3.9	3.4
Length (Tunnel)	M	7,930	7,930	7,930	7,930	7,930	7,930	7,930	7,930
(Channel)	M								
Firm Discharge	M^3/S	10.10	9.30	8.90	8.50	8.10	7.40	6.70	5.80
Maximum Dischaerge	M^3/S	40.00	37.00	36.00	34.00	32.00	30.00	27.00	23.00
Tail Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Gross Head									
Maximum Head	M	205.00	205.00	205.00	205.00	205.00	205.00	205.00	205.00
Normal Head	M	188.67	193.33	195.00	196.67	198.33	200.00	201.67	203.33
Minimum Head	M	156.00	170.00	175.00	180.00	185.00	190.00	195.00	200.00
Loss of Head	M	9.20	9.30	9.30	9.40	9.40	9.50	9.60	9.90
Effective Head									
Maximum	M	195.80	195.70	195.70	195.60	195.60	195.50	195.40	195.10
Normal	M	179.47	184.03	185.70	187.27	188.93	190.50	192.07	193.43
Minimum	M	145.80	160.70	165.70	170.60	175.60	180.50	185.40	190.10
Installed Capacity	MW	62	58	57	55	52	49	44	38
Firm Peak Power	MW	52.4	50.5	49.6	49.5	47.3	46.1	43.1	37.6
Annual Energy									
Average	GWh	237.0	235.1	233.2	228.9	233.3	215.8	204.8	184.7
Firm	GWh	128.2	110.5	108.6	108.4	103.6	100.9	94.4	82.4
Secondary	GWh	108.8	124.6	124.6	120.5	129.7	114.9	110.3	102.3

Baglik Project Tailrace Undergro. P/S Layout H.W.L= 530.00m with Bayram H.W.L.=735m L.W.L=686m-730m

Damsite Layout		Baglik 735-686	Baglik 735-700	Baglik 735-705	Baglik 735-710	Baglik 735-715	Baglik 735-720	Baglik 736-725	Baglik 735-730
Reservoir									
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Normal Water Level	M	528.50	528.50	528.50	528.50	528.50	528.50	528.50	528.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Gross Capacity	10^6M^3	7.30	7.30	7.30	7.30	7.30	7.30	7.30	7.30
Effect Capacity	10^6M^3	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dam									
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	74	74	74	74	74	74	74	74
Crest Length	M	190	190	190	190	190	190	190	190
Volume	10^3M^3	195	195	195	195	195	195	195	195
Headrace Tunnel									
Type									
Diameters	M								
Length	M								
Penstock									
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.50	3.35	3.27	3.23	3.15	3.03	2.90	2.72
Length	M	213	213	213	213	213	213	213	213
Powerhouse									
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel									
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.8	4.7	4.6	4.5	4.5	4.4	4.2	4.0
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M								
Firm Discharge	M^3/S	12.00	11.00	10.60	10.20	9.70	9.10	8.30	7.30
Maximum Dischaerge	M^3/S	48.00	44.00	42.00	41.00	39.00	36.00	33.00	29.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head									
Maximum Head	M	138.00	138.00	138.00	138.00	138.00	138.00	138.00	138.00
Normal Head	M	138.50	136.50	136.50	136.50	136.50	136.50	136.50	136.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.60	5.70	5.70	5.80	5.80	5.80	5.90	6.00
Effective Head									
Maximum	M	132.40	132.30	132.30	132.20	132.20	132.20	132.10	132.00
Normal	M	130.90	130.80	130.80	130.70	130.70	130.70	130.60	130.50
Minimum	M	129.40	129.30	129.30	129.20	129.20	129.20	129.10	129.00
Installed Capacity	MW	54	49	47	45	44	40	37	32
Firm Peak Power	MW	52	45	45	45	42	39	36	31
Annual Energy									
Average	GWh	215.7	210.1	207.2	203.2	197.5	189.5	180.0	166.0
Firm	GWh	113.6	105.1	100.7	98.6	92.0	85.4	78.8	67.9
Secondary	GWh	102.1	105.0	106.5	104.7	105.5	104.1	101.2	98.1

Table 9-8(5) Outline of Alternative Plan for Bayram Reservoir Water Level

Bayram Project Tailrace Undergro. P/S Layout H.W.L.=730m L.W.L=686m-725m With Beglik H.W.L.= 530.00m

Reservoir	Damsite Layout	Bayram 730-686	Bayram 730-700	Bayram 730-705	Bayram 730-710	Bayram 730-715	Bayram 730-720	Bayram 730-725
Catchment Area	KM^2	1,159	1,159	1,159	1,159	1,159	1,159	1,159
Annual Inflow	M^3/S	19.20	19.20	19.20	19.20	19.20	19.20	19.20
High Water Level	M	730.00	730.00	730.00	730.00	730.00	730.00	730.00
Normal Water Level	M	715.33	720.00	721.67	723.33	725.00	726.87	728.33
Low Water Level	M	686.00	700.00	705.00	710.00	715.00	720.00	725.00
Available Drawdown	M	44.00	30.00	25.00	20.00	15.00	10.00	5.00
Gross Capacity	10^6M^3	102.00	102.00	102.00	102.00	102.00	102.00	102.00
Effective Capacity	10^6M^3	82.00	64.00	56.00	47.00	34.00	26.00	14.00
Dam								
Type		Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill	Rockfill
Height from Found.	M	135	135	135	135	135	135	135
Crest Length	M	379	379	379	379	379	379	379
Volume	10^3M^3	4,800	4,800	4,800	4,800	4,800	4,800	4,800
Headrace Tunnel								
Type								
Diameters	M							
Length	M							
Penstock								
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.1	3.0	2.9	2.8	2.7	2.6	2.4
Length	M	321	321	321	321	321	321	321
Powerhouse								
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel								
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.4	4.3	4.2	4.1	4.0	3.9	3.7
Length (Tunnel)	M	7,930	7,930	7,930	7,930	7,930	7,930	7,930
(Channel)	M							
Firm Discharge	M^3/S	9.50	8.70	8.30	7.80	7.10	6.60	5.80
Maximum Dischaerge	M^3/S	38.00	35.00	33.00	31.00	28.00	26.00	23.00
Tail Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Gross Head								
Maximum Head	M	200.00	200.00	200.00	200.00	200.00	200.00	200.00
Normal Head	M	185.33	190.00	191.67	193.33	195.00	196.67	198.33
Minimum Head	M	156.00	170.00	175.00	180.00	185.00	190.00	195.00
Loss of Head	M	9.10	9.20	9.30	9.40	9.50	9.60	9.80
Effective Head								
Maximum	M	190.90	190.80	190.70	190.60	190.50	190.40	190.20
Normal	M	176.23	180.80	182.37	183.93	185.50	187.07	188.53
Minimum	M	145.90	160.80	165.70	170.60	175.50	180.40	185.20
Installed Capacity	MW	57	54	52	49	44	42	37
Firm Peak Power	MW	48.5	46.3	45.0	43.6	42.4	39.5	36.3
Annual Energy								
Average	GWh	227.0	223.9	221.0	215.4	206.5	187.8	160.0
Firm	GWh	119.5	110.8	107.1	103.2	97.1	87.3	79.4
Secondary	GWh	108.8	113.1	113.9	112.2	109.4	100.5	80.6

Beglik Project Tailrace Undergro. P/S Layout H.W.L= 530.00m with Bayram H.W.L.=730m L.W.L=686m-725m

Reservoir	Damsite Layout	530.00 730-686	530.00 730-700	530.00 730-705	530.00 730-710	530.00 730-715	530.00 730-720	530.00 730-725
Catchment Area	KM^2	1,509	1,509	1,509	1,509	1,509	1,509	1,509
Annual Inflow	M^3/S	24.90	24.90	24.90	24.90	24.90	24.90	24.90
High Water Level	M	530.00	530.00	530.00	530.00	530.00	530.00	530.00
Normal Water Level	M	528.50	528.50	528.50	528.50	528.50	528.50	528.50
Low Water Level	M	527.00	527.00	527.00	527.00	527.00	527.00	527.00
Available Drawdown	M	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Gross Capacity	10^6M^3	7.30	7.30	7.30	7.30	7.30	7.30	7.30
Effect Capacity	10^6M^3	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Dam								
Type		Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra	Con-Gra
Height from Found.	M	74	74	74	74	74	74	74
Crest Length	M	190	190	190	190	190	190	190
Volume	10^3M^3	195	195	195	195	195	195	195
Headrace Tunnel								
Type								
Diameters	M							
Length	M							
Penstock								
Type		Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel	Tunnel
Diameters	M	3.4	3.2	3.2	3.1	3.0	2.9	2.7
Length	M	213	213	213	213	213	213	213
Powerhouse								
Type		Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.	Undergr.
Tailrace Tunnel								
Type		Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho	Hosesho
Diameters	M	4.7	4.5	4.5	4.4	4.3	4.2	4.0
Length (Tunnel)	M	4,454	4,454	4,454	4,454	4,454	4,454	4,454
(Channel)	M							
Firm Discharge	M^3/S	11.25	10.30	9.90	9.50	8.70	8.10	7.30
Maximum Dischaerge	M^3/S	45.00	41.00	40.00	38.00	35.00	32.00	29.00
Tail Water Level	M	392.00	392.00	392.00	392.00	392.00	392.00	392.00
Gross Head								
Maximum Head	M	138.00	138.00	138.00	138.00	138.00	138.00	138.00
Normal Head	M	136.50	136.50	136.50	136.50	136.50	136.50	136.50
Minimum Head	M	135.00	135.00	135.00	135.00	135.00	135.00	135.00
Loss of Head	M	5.70	5.80	5.80	5.80	5.90	5.90	6.00
Effective Head								
Maximum	M	132.30	132.20	132.20	132.20	132.10	132.10	132.00
Normal	M	130.80	130.70	130.70	130.70	130.60	130.60	130.50
Minimum	M	129.30	129.20	129.20	129.20	129.10	129.10	129.00
Installed Capacity	MW	51	46	45	43	39	36	32
Firm Peak Power	MW	49	45	44	41	38	35	31
Annual Energy								
Average	GWh	210.6	204.0	200.0	193.3	183.0	171.7	152.0
Firm	GWh	107.1	99.3	96.4	89.5	83.2	76.4	67.9
Secondary	GWh	103.5	105.7	103.6	103.8	99.8	95.3	84.1