(E) Connection of waiting factories

Large power demands are expected from factories which have waited for connection to the power system, and which are being connected in the three years from 1987 to 1989. These are listed in Table 2.2.3, and are summarized as follows:

	Effective power (MW)	Annual energy (GWh)
Grid system	6.10 *	135.08
Isolated systems	26.89	118.51
Total	32.97	253.59

(Note): * Load of the Mufindi boiler (25 MW) is not included, as the boiler is to be operated during off-peak hours.

Energy consumption in the industrial sector in 1986 was 545.49 GWh. Thus, the load of industrial consumers waiting for connection over the subsequent three (3) years amounts to 46.5% of the 1986 load.

In general, GDP growth in the industrial sector includes demand growth caused by new plant construction and facilities expansion. The load forecast here, however, also takes into the load magnitude of the waiting consumers, and the expected new loads have been to the forecast by use of regression models.

2.2.3 Result of Power Demand Forecast

(1) Forecast for the Whole Power System

Using the regression models shown in Section 2.2.2 (2), and based on the assumptions described in Section 2.2.2 (2), forecasts of electricity demand for 1987 to 2005 were carried out for the following two growth scenarios:

Year	GDP growth rate: Base scenario	Low growth scenario
1984-1986	3.1%	3.1%
1986-1990	4.6%	4.6%
1990-2005	4.5%	4.0%

The forecast results are shown in Tables 2.2.4 to 2.2.9 and in Fig. 2.2.2. A Comparison of these results with those for the high-growth Scenario A of the "TANESCO Power Sector Master Plan" is summarized below:

Forecast		1990	1995	2000	2005
JICA Team's forecast					
- Base scenario:					
Consumption	(GWh)	1,470	1,843	2,299	2,872
Generation	(GWh)	1,755	2,195	2,744	3,428
Peak load	(MW)	292	404	502	629
- Low growth scenario:					
Consumption	(GWh)	1,470	1,795	2,190	2,670
Generation	(GWh)	1,755	2,143	2,614	3,188
Peak load	(MW)	292	349	480	585
Master Plan forecast (Scenario A)					
- Updated in 1987:					
Consumption	(GWh)	1,544	1,964	2,562	3,342
Generation	(GWh)	1,926	2,451	3,199	4,175
Peak load	(MW)	316	408	540	712
- Original in 1985:					
Consumption	(GWh)	1,175	1,548	2,045	2,692
Generation	(GWh)	1,390	1,843	2,423	3,189
Peak load	(MW)	262	342	449	588

(2) Forecast for the Arusha-Kilimanjaro Regions

The power demand forecast for the Arusha-Kilimanjaro regions is shown in Tables 2.2.5 to 2.2.9.

The results may be summarized as follows:

Year	Energy consumption (GWh) Arusha	Moshi	Total	Peak load (MW) Arusha	Moshi	Total
Base scenario						
1987	70.42	45.53	115.95	17.3	11.4	27.0
1990	83.09	54.13	137.22	20.4	13.6	32.0
1995	104.73	68.37	173.10	28.2	18.9	44.3
2000	131.48	85.83	217.31	35.4	23.8	55.6
2005	164.82	107.59	272.41	44.4	29.8	69.7
Low growth scenario						
1987	70.42	45.53	115.95	17.3	11.4	27.0
1990	83.09	54.13	137.22	20.4	13.6	32.0
1995	102.16	66.69	168.85	27.5	18.5	43.2
2000	125.14	81.69	206.83	33.7	22.6	52.9
2005	153.10	99.94	253.04	41.2	27.7	64.8

(Note): * Total of peak loads include a diversity factor of 0.94.

2.2.4 Power Development Program and Demand and Supply Balance

(1) Power Development Program

The Power Sector Master Plan (updated in 1987) considers two types of power development projects: (1) Hydroelectric Expansion Sequence, and (2) Gas Expansion Sequence. Considering the problems, uncertainties, and required time in developing offshore natural gas, it is more be appropriate to base the power development program, at least up to around 2005, on the Hydroelectric Expansion Sequence.

The expected commissioning dates and generating capacities of the projects considered in the Master Plan are as follows:

Commissioning	Project name	Installed capacity (MW)	Energy generation (GWh)
1990	Ubungo Gas turbine	20	–
1992	Pangani Falls redevelopment	60	305
1995	Downstream Kihansi	162	945
1999	Upstream Kihansi (Retire existing diesel)	45 (-123)	438 (-)
2001	Masigira	80	491
2003	Rumakali	204	1185

As shown above, the development projects of the Master Plan are limited to big projects concentrated mainly in the 220 kV system.

From the standpoint of power system planning, however, special attention should be paid to the difficult conditions of the Arusha-Kilimanjaro regions. Because of the growing electricity demand in these regions as well as the need to alleviate the immediate problem of large voltage drop, the JICA team's study added the following regional hydropower projects to those in the Master Plan.

Commissioning	Project name	Installed capacity (MW)	Energy generation (GWh)
1991	Kikuletwa No. 1 (rehabilitation)	1.5	10.53
1994	Kikuletwa No. 2	11.0	67.09

(2) Power Demand and Supply Balance

(i) Reserve Capacity

The power system must have a reserve capacity, to be able to meet forced outages, shutdowns for scheduled maintenance, and unforeseen growth in power demand. Various criteria are available regarding reserve capacity, but the most commonly adopted are:

- Capacity equivalent to the largest and second largest generating units.

- Capacity equivalent to a certain percentage of peak load (in general, 15% to 20% of peak load).

- The larger of the above two criteria.

In the TANESCO grid system, the power supplied comes almost completely from hydro power stations. Most of load centers in the isolated systems, where power is supplied by diesel power stations, are expected to be incorporated into the grid system within one or two years.

From the standpoint of maintenance cycle and forced outage ratio of hydropower stations, a 10% reserve margin will be sufficient to maintain normal operation of the power system. Thus, the JICA team's power development program for the study period from 1987 to 2005 was formulated using the following reserve margin criteria:

- Until 1995, when Downstream Kihansi is expected to enter service, the present total capacity of diesel power stations, 122.6 MW, shall serve as standby.

- When the Downstream Kihanshi project is completed, the diesel power stations shall be retired.

- From 1995 on, the reserve margin of hydropower stations shall be kept at over 10% of peak load or required energy generation.

(ii) Commissioning Time Schedule and Demand and Supply Balance

Tables 2.2.10 and 2.2.11 and Figs. 2.2.3 and 2.2.4 show the power and energy demand and supply balance for the whole power system (excluding JICA team's proposed hydropower projects in the Kilimanjaro region).

Tables 2.2.12 and 2.2.13 and Figs. 2.2.5 and 2.2.6 show the power and energy demand and supply balance for the Arusha-Moshi-Tanga regions.

All of the figures are based on the JICA team's forecast and the reserve margin criteria mentioned above.

The results of study are summarized below:

a) For the 220 kV system

Commissioning	Project name	Installed capacity (MW)	Energy (GWh)
1990	Ubungo gas turbine	20	-
1995	Downstream Kihansi (retire diesel)	162	945
2000	Upstream Kihansi	45	438
2002	Masigira	80	491
2005	Rumakali	204	1,185

Hydropower capacity and energy generation are insufficient to meet the demand up to 1995. During this period, the shortage must be covered by the existing diesel power stations.

b) For the northeastern 132 kV system

Commissioning	Project name	Installed capacity (MW)	Energy (GWh)
1991	Kikuletwa No. 1 (rehabilitation)	1.5	10.53
1992	Pangani Falls redevelopment	60.0	305.00
1994	Kikuletwa No. 2	11.0	67.09

In this system, a shortage of both power and energy will continue to 1992 when the Pangani Falls redevelopment project is expected to be completed. The power shortage in 1991 will be 22.7 MW. The shortage must be covered by importing from the 220 kV power system.

If the Study Team's proposed hydropower projects Kikuletwa No. 1 (rehabilitation) and Kikuletwa No. 2 are not implemented, a power shortage will reappear in 1996 even if the Pangani Falls redevelopment project is commissioned in 1992. If the team's proposed projects are implemented, however, a power shortage would not arise until 1999, with an energy shortage from 2001.

2.3 HYDROPOTENTIAL STUDY IN KILIMANJARO REGION

The Study Team, taking into account the forecast power deman through 2005, made a preliminary study and project priority study of nine (9) small hydropower schemes that were proposed by TANESCO at Kilimanjaro Region sites that TANESCO considered promising. The features of each potential site are listed in Table 2.3.1.

As a result of discussions between TANESCO and JICA based on the study, Kikuletwa No. 1 and No. 2 sites were selected, out of the nine (9) potential sites, for carrying forward into the feasibility study stage. The reasons for this selection were :

- Evaluation by B/C and EIRR revealed Kikuletwa No. 1 Project to have the highest priority, followed by the No. 2 Project. (See Table 2.3.1).

- Kikuletwa No. 1 Project has a great advantage that the existing civil structures can be used following the repair or rehabilitation. This will greatly economize the construction costs.

- Considerable power discharge and potential head will be made available by the Kikuletwa No. 2 Project. Its sizable generating capacity - the largest among the nine potential sites, should effectively strengthen the power supply in the Kilimanjaro region. The Same area sites, by contrast, provided smaller potential scale.

- The runoff conditions of the Kikuletwa River are very advantageous for hydropower development.

- The potential sites in the Same area located far from the Moshi and Arusha load center, and are, therefore, deemed to be less effective than the Kikuletwa No. 1 and No. 2 projects for reinforcing the Kilimanjaro region's power supply.

Table 2.1.1 CHARACTERISTICS OF GENERATING FACILITIES

(1987)

Power station	Capacity x unit (MW)	Installed capacity (MW)	Peak generation 1986 (MW)	Commissioning year
Interconnected system				
(1) Hydro				
Pangani river basin:				
Kikuletwa	0.6 x 1			1950
	0.4 x 1			1937
	0.16 x 1	1.16	0.20	1935
Nyumba Ya Mungu	4.0 x 2	8.00	8.00	1969
Hale	10.5 x 2	21.0	15.75	1964
Pangani Falls	3.5 x 5	17.50	15.50	1934
Sub-total		47.66	39.45	
Great Ruaha river basin				
Kidatu	51.0 x 4	204.00	163.00	1975/1980
Others				
Tosamaganga	-	1.22	-	-
Mbalizi	-	0.34	-	-
Total hydro		253.22	202.45	
(2) Thermal (Diesel)				
Arusha			3.16	
Dodoma			2.85	
Iringa			0	
Iyunga			6.40	
Singida			0.84	
Ubungo			6.90	
Total thermal		81.65	20.05	
Total grid system		334.87	222.50	
Isolated system				
Total		63.47		
Whole power system		398.34		

Note: Mtera hydro power station is now on line with an installed capacity of 80 MW (40 MW x 2 units). The No. 1 unit was commissioned in June 1988, and the No. 2 unit in December, 1988

Table 2.1.2 ENERGY CONSUMPTION BY CATEGORY OF CONSUMERS

(GWh)

Category	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Interconnected system														
Domestic	64.74	65.45	74.73	74.17	80.33	95.76	111.27	131.76	143.12	151.84	145.88	154.61	173.89	208.25
Commercial **	39.55	42.25	41.19	41.64	44.58	46.98	57.90	68.37	58.66	60.95	50.60	50.82	55.56	69.96
Industrial **	265.14	281.92	295.79	299.60	313.34	344.04	374.19	422.03	423.85	391.49	357.71	361.39	423.40	499.49
Public lighting	2.86	2.99	3.25	2.87	3.12	4.09	3.46	4.36	4.29	3.55	3.36	2.07	3.48	2.99
Zanzibar	-	-	-	-	-	-	15.73	13.47	25.18	27.92	32.13	34.54	39.27	41.59
Total	372.29	392.61	414.96	418.25	441.38	490.28	562.56	639.98	655.09	635.74	587.68	603.42	695.59	822.28
Isolated system														
Domestic	8.89	9.98	11.41	11.64	12.89	17.10	19.38	24.18	25.34	25.86	28.39	32.30	23.94	25.80
Commercial **	13.73	14.79	15.32	15.78	15.82	17.17	17.74	19.14	18.83	23.20	16.71	19.21	13.69	14.44
Industrial **	34.97	39.93	42.85	42.66	43.92	39.70	68.07	60.38	76.10	54.64	65.04	71.20	48.62	46.00
Public lighting	1.54	1.57	1.71	1.73	1.61	1.49	1.30	1.91	1.67	1.38	0.70	1.84	1.15	0.59
Total	59.14	66.26	71.29	71.81	74.24	75.46	106.48	105.60	121.94	105.08	110.84	124.54	87.39	86.83
Whole power system														
Domestic	73.63	75.43	86.14	85.78	93.23	111.27	130.65	155.94	168.45	117.70	174.27	186.90	197.83	234.05
Commercial **	53.28	57.03	56.61	57.42	60.40	64.15	75.64	87.50	77.49	84.15	67.31	70.03	69.24	84.40
Industrial **	300.11	321.85	338.64	342.26	357.26	383.75	442.25	482.41	499.94	446.13	422.75	432.58	472.05	545.49
Public lighting	4.40	4.56	4.96	4.60	4.73	5.58	4.76	6.26	5.97	4.92	4.06	3.91	4.62	3.58
Zanzibar	-	-	-	-	-	-	15.73	13.47	25.18	27.92	32.13	34.54	39.27	41.59
Total	431.43	458.87	486.25	490.05	515.61	565.74	669.04	745.58	777.03	740.82	700.52	727.96	782.98	909.11

Note: Based on the existing interconnected system as of 1986
** Corrected to the 1970 to 1979 base tariff structure.
Source: Power Sector in Tanzania - TANESCO Planning Directorate.

Table 2.1.3 ENERGY GENERATION AND PEAK LOAD BY POWER SYSTEM

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
Interconnected system														
Consumption (GWh)	372.29	392.61	414.96	418.25	441.38	490.28	562.56	639.98	655.09	635.74	587.68	603.42	716.19	822.28
Generation (GWh)	448.18	462.18	479.93	510.13	536.75	592.75	652.31	686.53	715.33	720.20	740.10	773.67	914.93	1041.09
Peak load (MW)	65.7	67.1	80.2	84.9	91.4	98.6	110.9	117.6	124.0	122.8	127.8	139.2	176.4	183.1
System losses (%)	16.9	15.1	13.5	18.0	17.8	17.3	13.8	6.8	8.6	11.7	20.6	22.0	21.7	21.0
Load factor (%)	77.9	78.6	68.3	68.6	67.0	68.6	67.1	66.5	65.9	67.0	66.1	63.4	59.2	64.9
Isolated system														
Consumption (GWh)	59.14	66.26	71.29	71.81	74.24	75.46	106.48	105.60	121.94	105.08	110.84	124.54	87.39	86.83
Generation (GWh)	66.93	73.78	77.68	80.81	82.27	89.63	105.06*	105.57*	108.45*	109.76	117.78	149.03	102.49	105.07
Peak load (MW)	-	-	-	-	-	-	-	24.0	25.4	25.6	31.1	36.1	23.1	25.3
System losses (%)	11.6	10.2	8.2	11.1	9.8	15.8	na	na	na	4.3	5.9	16.4	14.7	17.4
Load factor (%)	-	-	-	-	-	-	-	50.2	48.7	48.9	43.2	47.1	50.6	47.4
Whole power system														
Consumption (GWh)	431.43	458.87	486.25	490.05	515.61	565.74	669.04	745.58	777.03	740.82	700.52	727.96	803.58	909.11
Generation (GWh)	515.10	535.96	557.62	590.95	619.02	682.41	757.36	792.10	823.78	829.96	857.88	922.71	1017.42	1146.16

Note: * Excludes imports.
The isolated peak generation includes a diversity factor of 90%.

Source: Power Sector in Tanzania - TANESCO Planning Directorate.

Table 2.1.4 ENERGY DISTRIBUTED AND PEAK LOAD BY REGION
(Interconnected System)

Region	1980	1981	1982	1983	1984	1985	1986
Energy distributed (GwH)							
Arusha-Kilimanjaro Region	83.08	87.43	95.27	101.54	112.66	125.21	158.07
Tanga and District	82.62	92.72	86.44	87.09	91.27	88.66	126.71
Dar es Salaam and District	427.07	430.78	429.01	438.11	452.38	468.80	511.40
Zanzibar	13.47	25.18	27.91	32.13	34.74	39.98	42.10
Morogoro Retion	36.37	36.92	33.61	31.23	32.96	45.28	55.21
Iringa	-	-	-	-	-	42.82	65.93
Dodoma	-	-	-	-	-	3.57	17.60
Singida	-	-	-	-	-	-	0.66
Mufindi	-	-	-	-	-	-	-
Mbeya	-	-	-	-	-	-	-
Total	642.61	673.03	672.25	690.09	724.00	814.32	977.68
Peak load (MW)							
Arusha-Kilimanjaro Region	14.9	14.7	19.5	18.5	20.1	21.9	26.7
Tanga and District	18.9	23.8	22.6	19.4	22.0	23.7	24.3
Dar es Salaam and District	73.1	75.0	75.8	75.8	79.7	85.7	91.0
Zanzibar	4.6	5.2	5.6	6.6	6.6	8.0	8.6
Morogoro Retion	7.3	7.6	7.3	9.1	9.2	10.0	11.6
Iringa	-	-	-	-	-	2.6	2.6
Dodoma	-	-	-	-	-	3.5	4.2
Singida	-	-	-	-	-	-	1.6
Mufindi	-	-	-	-	-	19.3	15.2
Mbeya	-	-	-	-	-	5.5	9.0
Coincident peak load	117.6	124.0	122.8	127.8	139.2	176.4	183.1

Note: Iringa interconnected in March 1985.
Mbeya interconnected in July 1985.
Dodoma interconnected in October 1985.
Singida interconnected in October 1985.

Source: Power Sector in Tanzania - TANESCO Planning Directorate.

Table 2.2.1 ECONOMIC AGGREGATES

Sector	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
GDP at 1976 prices (T.Shs million)												
Agriculture	8,934	8,683	9,491	10,014	10,038	10,179	10,297	10,606	10,854	11,140	11,259	11,546
Service sector:	6,987	7,646	8,012	8,478	8,833	9,363	9,720	10,065	10,057	10,303	10,531	11,037
Commercial	5,436	5,794	5,950	6,136	6,206	6,415	6,359	6,510	6,227	6,170	5,993	6,205
Trade	2,627	2,739	2,783	2,839	2,915	2,984	2,884	2,734	2,595	2,478	2,467	2,453
Transport, communication	1,435	1,541	1,621	1,685	1,652	1,699	1,633	1,818	1,652	1,693	1,475	1,643
Finance and insurance	1,794	1,950	1,996	2,036	2,101	2,217	2,343	2,489	2,529	2,666	2,767	2,831
Bank service charge	(-)420	(-)436	(-)450	(-)424	(-)462	(-)485	(-)501	(-)531	(-)549	(-)667	(-)716	(-)722
Public administration	1,551	1,852	2,062	2,342	2,627	2,948	3,361	3,555	3,830	4,133	4,538	4,832
Industrial sector:	3,664	3,744	3,728	4,128	4,386	4,391	4,212	3,761	3,252	3,032	2,578	2,389
Mining	197	194	163	214	231	189	200	189	193	193	181	185
Manufacturing	2,285	2,348	2,381	2,811	2,984	3,127	2,809	2,288	1,804	1,482	1,351	1,171
Electricity and water	179	202	224	219	256	292	324	352	365	427	420	446
Construction	1,003	1,000	960	884	915	783	879	932	890	930	626	587
Total GDP	19,585	20,073	21,231	22,620	23,257	23,933	24,229	24,432	24,163	24,475	24,368	24,972
Population (Million)	14.37	14.76	15.31	16.41	16.92	17.44	17.98	18.58	19.17	19.78	20.41	21.06
GDP/capita (T. Shs)	1,363	1,360	1,387	1,378	1,374	1,372	1,348	1,315	1,260	1,237	1,194	1,186

Source: Statistical Abstract 1984 - Bureau of Statistics, Ministry of Finance, Planning and Economic Affairs.

Table 2.2.2 FORECAST OF ECONOMIC GROWTH

(Tsh million - 1976 constant prices)

Year	Base Scenario				Low Growth Scenario			
	Agriculture	Service	Industries	Total	Agriculture	Service	Industries	Total
1984*	11,546	11,037	2,389	24,872				24,972
1985*	11,835	11,618	2,389	25,842				25,842
1986*	12,131	12,920	2,508	26,559				26,559
1987	12,434	12,230	2,859	27,523				27,523
1988	12,806	12,597	3,259	28,662				28,662
1989	13,255	13,101	3,748	30,104				30,104
1990	13,719	13,756	4,310	31,785				31,785
1991	14,332	14,306	4,577	33,215	14,254	14,237	4,565	33,056
1992	14,952	14,876	4,882	34,710	14,809	14,735	4,835	34,379
1993	15,610	15,473	5,189	36,272	15,387	15,251	5,116	35,754
1994	16,298	16,092	5,514	37,904	15,987	15,785	5,511	37,183
1995	17,014	16,736	5,860	39,610	16,611	16,337	5,723	38,671
1996	17,763	17,405	6,224	41,392	17,259	16,909	6,050	40,218
1997	18,544	18,101	6,610	43,225	17,932	17,501	6,393	41,826
1998	19,360	18,826	7,015	45,201	18,631	18,114	6,755	43,500
1999	20,212	19,579	7,445	47,236	19,358	18,748	7,134	45,240
2000	21,102	20,362	7,897	49,361	20,113	19,404	7,533	47,050
2001	22,030	21,176	8,376	51,828	20,897	20,083	7,952	48,932
2002	23,000	22,023	8,881	53,904	21,712	20,786	8,391	50,889
2003	24,012	22,904	9,413	56,329	22,559	21,513	8,852	52,924
2004	25,068	23,820	9,976	58,864	23,439	22,266	9,336	55,041
2005	26,171	24,773	10,569	61,513	24,353	23,046	9,844	57,243

. * Actual record

Table 2.2.3 WAITING INDUSTRIAL CONSUMERS

Location	Plant	Requested power (MW)	Start date	Effective load (MW)	Energy (GWh)
Arusha	A-Z Clothing	1.30	1987	0.78	3.42
Dae es Salaam	Brewery Expansion	1.50	1988	0.90	3.94
	Sheet Glass	1.50	1987	0.90	5.52
	Terry Towels	0.40	1988	0.24	1.05
	Sewing Thread	0.40	1987	0.24	1.05
Morogoro	Water Treatment	0.50	1989	0.35	2.45
	Textile Institute	0.50	1988	0.30	1.31
	Textile Expansion	0.50	1989	0.25	1.10
Iringa	Mufindi Boiler	50.00	1988-90	(Off-peak)	109.50
	Mufindi Tea Estates	1.00	1989	0.80	2.10
Dodoma	Grain Mill	0.50	1988	0.20	0.70
Mbeya	Tea Estates	1.40	1989	1.12	2.94
	Total Grid			6.08	25.58
					+109.50
Mwanza	Glass Containers	1.20	1988	0.60	3.68
	Oxygen	0.20	1987	0.10	0.61
	Leather Workshop	1.50	1987	0.75	2.63
	Ginneries	6.30	1989	5.04	17.66
Shinyanga	Mwadui	9.00	1989	9.00	51.25
	Ningwa Dam	0.40	1987	0.24	1.05
	Ginneries	11.60	1989	9.28	32.51
Tabora	Textile Mill	2.00	1989	1.20	6.31
	T.R.C. Depot	0.40	1987	0.24	1.05
	SIDO	0.50	1987	0.20	0.70
	LocoShed	0.40	1987	0.24	1.05
	Total Isolated			26.89	118.51
	Grand total			32.97	253.59

Table 2.2.4 POWER DEMAND FORECAST BY POWER SYSTEM (LOW GROWTH SCENARIO)

Year	Interconnected system: Identified consumption (GWh)	Interconnected system: Total consumption (GWh)	Interconnected system: Generation (GWh)	Interconnected system: Peak load (MW)	Isolated systems: Identified consumption (GWh)	Isolated systems: Total consumption (GWh)	Isolated systems: Generation (GWh)	Isolated systems: Peak load (MW)	Whole power system: Identified consumption (GWh)	Whole power system: Total consumption (GWh)	Whole power system: Generation (GWh)	Whole power system: Peak load (MW)
1986*	828.28	874.52	1041.09	183.1	86.83	ditto	105.07	25.3	909.11	963.35	1146.16	206.3
1987	869.01	924.01	1100.07	192.8	100.34	ditto	121.62	28.7	969.35	1024.35	1221.63	219.3
1988	1007.00	1070.73	1274.68	204.0	111.59	ditto	135.26	31.5	1118.59	1182.32	1409.94	233.1
1989	1158.13	1231.43	1465.99	218.6	228.92	ditto	277.48	58.7	1387.05	1460.35	1743.47	274.5
1990	1156.48	1229.68	1463.90	232.8	240.10	ditto	291.03	62.0	1396.58	1469.78	1754.93	291.9
1991	1204.92	1281.18	1525.22	267.9	248.56	ditto	301.29	71.7	1453.48	1529.74	1826.50	336.1
1992	1255.30	1334.75	1588.99	279.1	257.36	ditto	311.95	74.2	1512.66	1592.10	1900.93	349.7
1993	1307.69	1390.46	1655.31	290.7	266.51	ditto	323.04	76.8	1574.20	1656.96	1978.34	363.9
1994	1362.18	1448.39	1724.28	302.8	276.02	ditto	334.57	79.6	1638.20	1724.42	2058.85	378.6
1995	1418.85	1508.65	1796.01	315.4	286.92	ditto	346.57	82.4	1704.77	1794.57	2142.58	393.9
1996	1477.78	1571.31	1870.61	328.5	296.21	ditto	359.04	86.4	1773.99	1867.52	2229.18	409.8
1997	1539.08	1636.49	1948.20	342.1	306.91	ditto	372.01	88.5	1845.99	1943.40	2320.21	426.3
1998	1602.82	1704.26	2028.89	356.3	318.04	ditto	385.51	91.7	1920.86	2022.31	2414.39	443.5
1999	1669.11	1774.75	2112.80	371.1	329.62	ditto	399.54	95.0	1998.73	2104.37	2512.34	461.4
2000	1738.06	1848.06	2200.08	386.4	341.66		414.13	98.5	2079.72	2189.72	2614.21	480.0
2001	1809.75	1924.31	2290.84	402.3	354.18	ditto	429.31	102.1	2163.94	2278.48	2720.15	499.4
2002	1884.34	2003.60	2385.23	418.9	367.20	ditto	445.09	105.9	2251.53	2370.80	2830.32	519.5
2003	1961.89	2086.06	2483.40	436.1	380.74	ditto	461.51	109.8	2342.63	2466.80	2944.91	540.4
2004	2042.55	2171.82	2585.50	454.0	394.83	ditto	478.58	113.8	2437.37	2566.65	3064.08	562.2
2005	2126.43	2261.01	2691.68	472.7	409.47	ditto	496.33	118.0	2535.90	2670.49	3188.01	584.9

Note: Diversity factor of peak loads between interconnected system and isolated systems was estimated to be 0.99 based on the operation records in 1986.
* Actual record

Table 2.2.5 ENERGY DEMAND FORECAST (LOW GROWTH SCENARIO)
- Interconnected System -

(GWh)

	Identified energy consumption												
Year	Arusha	Moshi	Tanga	Dar es S.	Zanzibar	Morogoro	Iringa	Dodoma	Singida	Mbeya	Total	Total con-sumpiton	Gene-ration
1986*	64.03	43.79	85.88	415.11	41.59	65.69	63.56	13.38	3.08	26.17	822.28	874.52	1041.09
1987	70.42	45.53	89.34	440.38	43.81	68.72	66.14	13.74	3.44	27.49	869.01	924.01	1100.01
1988	73.81	47.83	93.85	467.28	46.02	73.50	157.09	15.14	3.60	28.88	1007.00	1070.73	1274.68
1989	78.09	50.74	99.56	496.02	48.82	81.45	251.02	16.02	3.83	33.58	1158.13	1231.43	1465.99
1990	83.09	54.13	106.22	527.37	52.09	86.57	190.25	17.04	4.10	35.62	1156.48	1229.68	1463.90
1991	86.75	56.63	110.85	549.44	54.22	90.37	197.61	18.07	4.82	36.15	1204.92	1281.18	1525.22
1992	90.38	59.00	115.49	572.42	56.49	94.15	205.87	18.83	5.02	37.66	1255.30	1334.75	1588.99
1993	94.15	61.46	120.31	596.31	58.85	98.08	214.46	19.62	5.23	39.23	1307.69	1390.46	1656.31
1994	98.08	64.02	125.32	621.15	61.30	102.16	223.40	20.43	5.45	40.87	1362.18	1448.39	1724.28
1995	102.16	66.69	130.53	646.99	63.85	106.41	232.69	21.28	5.68	42.57	1418.85	1508.65	1796.01
1996	106.40	69.46	135.96	673.87	66.50	110.83	242.36	22.17	5.91	44.33	1477.78	1571.31	1870.61
1997	110.81	72.34	141.59	701.82	69.26	115.43	252.41	23.09	6.16	46.17	1539.49	1636.49	1948.20
1998	115.40	75.33	147.46	730.89	72.13	120.21	262.86	24.04	6.41	48.08	1602.82	1704.26	2028.89
1999	120.18	78.45	153.56	761.12	75.11	125.18	273.73	25.04	6.68	50.07	1669.11	1774.75	2112.80
2000	125.14	81.69	159.90	792.56	78.21	130.35	285.04	26.07	6.65	52.14	1738.06	1848.06	2200.08
2001	130.30	85.06	166.50	825.25	81.44	135.73	296.80	27.15	7.24	54.29	1809.76	1924.31	2290.84
2002	135.67	88.56	173.36	859.26	84.80	141.33	309.03	28.27	7.54	56.53	1884.34	2003.60	2386.23
2003	141.26	92.21	180.49	894.62	88.29	147.14	321.75	29.43	7.85	58.86	1961.89	2086.06	2483.40
2004	147.06	96.00	187.91	931.40	91.91	153.19	334.98	30.64	8.17	61.28	2042.55	2171.82	2585.50
2005	153.10	99.94	195.63	969.65	95.69	159.48	348.73	31.90	8.51	63.79	2126.43	2261.01	2691.68

* Actual record

Table 2.2.6 PEAK LOAD FORECAST (LOW GROWTH SCENARIO)
- Interconnected System -

(GWh)

Year	Peak load by region Arusha	Moshi	Tanga	Dar es S.	Zanzibar	Morogoro	Iringa	Dodoma	Singida	Mbeya	Total	Coincident peak load
1986*	15.8	10.9	24.3	91.0	8.6	11.6	17.8	4.2	1.6	9.0	194.8	183.1
1987	17.3	11.4	25.4	96.0	8.9	12.2	18.5	4.5	1.6	9.3	205.1	192.8
1988	18.1	12.0	26.7	102.0	9.4	13.1	19.3	4.5	1.7	9.8	217.0	204.0
1989	19.1	12.7	28.3	108.0	10.0	14.5	21.4	5.2	1.8	11.5	232.5	218.6
1990	20.4	13.6	30.2	115.1	10.6	15.4	22.8	5.5	1.9	12.2	247.7	232.8
1991	23.4	15.7	24.8	132.5	12.3	17.7	26.2	6.3	2.3	14.0	285.0	267.9
1992	24.3	16.3	36.2	138.0	12.8	18.4	27.3	6.5	2.4	14.5	296.9	279.1
1993	25.4	17.0	37.7	143.8	13.3	19.2	28.5	6.8	2.5	15.2	309.3	290.7
1994	26.4	17.7	39.3	149.8	13.9	20.0	29.6	7.1	2.6	15.8	322.2	302.8
1995	27.5	18.5	40.9	156.0	14.4	20.8	30.9	7.4	2.7	16.4	335.6	315.4
1996	28.7	19.2	42.0	162.5	15.0	21.7	32.2	7.7	2.8	17.1	349.5	328.5
1997	29.8	20.0	44.4	169.3	15.7	22.6	33.5	8.0	2.9	17.8	364.0	342.1
1998	31.1	20.8	46.2	176.3	16.3	23.5	34.9	8.3	3.0	18.6	379.1	356.3
1999	32.4	21.7	48.2	183.6	17.0	24.5	36.3	8.7	3.2	19.3	394.7	371.1
2000	33.7	22.6	50.1	191.1	17.7	25.5	37.8	9.0	3.3	20.1	411.0	386.4
2001	36.1	23.5	52.2	199.0	18.4	26.5	39.4	9.4	3.4	21.0	428.0	402.3
2002	36.5	24.5	54.4	207.2	19.2	27.6	41.0	9.8	3.6	21.8	445.6	418.9
2003	38.0	25.5	56.6	215.8	20.0	28.8	42.7	10.2	3.7	22.7	464.0	436.1
2004	39.6	26.6	58.6	224.6	20.8	29.9	44.4	10.6	3.9	23.7	483.1	454.0
2005	42.1	27.7	61.4	233.8	21.6	31.2	46.3	11.1	4.0	24.6	502.9	472.7

Note: Loads of Mufindi boilers (25 MW x 2 units) is not included considering that they are off-peak use.

Values in the above table from 1986 to 1990 are the same for both "Base scenario" and "Low growth scenario".

* Actual record

Table 2.2.7 POWER DEMAND FORECAST BY POWER SYSTEM (BASE SCENARIO)

Year	Interconnected system: Identified consump-tion(GWh)	Interconnected system: Total consump-tion(GWh)	Interconnected system: Genera-tion(GWh)	Interconnected system: Peak load (MW)	Isolated systems: Identified consump-tion(GWh)	Isolated systems: Total consump-tion(GWh)	Isolated systems: Genera-tion(GWh)	Isolated systems: Peak load (MW)	Whole power system: Identified consump-tion(GWh)	Whole power system: Total consump-tion(GWh)	Whole power system: Genera-tion(GWh)	Whole power system: Peak load (MW)
1986*	822.28	874.52	1041.09	183.1	86.83	ditto	105.07	25.3	909.11	961.35	1146.16	2063
1987	869.01	924.01	1100.07	192.8	100.34	ditto	121.62	28.7	969.35	1024.35	1221.63	219.3
1988	1007.00	1070.73	1274.68	204.0	111.59	ditto	135.26	31.5	1118.59	1182.32	1409.94	233.1
1989	1158.13	1231.43	1465.99	218.6	228.92	ditto	277.48	58.7	1387.05	1460.35	1743.47	274.5
1990	1156.48	1229.68	1463.90	232.8	240.10	ditto	291.03	62.0	1396.58	1469.78	1754.93	291.9
1991	1210.98	1287.62	1532.88	269.2	249.62	ditto	302.57	72.0	1460.60	1537.24	1853.45	337.8
1992	1267.92	1348.17	1604.97	281.9	259.56	ditto	314.62	74.8	1527.49	1607.73	1919.59	353.1
1993	1327.43	1411.45	1680.30	295.1	269.95	ditto	327.22	77.8	1597.39	1681.40	2007.51	369.2
1994	1389.62	1477.57	1759.01	308.9	280.81	ditto	340.38	81.0	1670.43	1758.39	2099.39	386.0
1995	1454.61	1546.67	1841.28	323.4	292.16	ditto	354.13	84.2	1746.77	1838.83	2195.41	4035
1996	1522.52	1618.88	1927.24	338.5	304.02	ditto	368.51	87.6	1826.54	1922.90	2295.75	421.8
1997	1593.49	1694.34	2017.07	354.2	316.41	ditto	383.53	91.2	1909.90	2010.75	2400.60	441.0
1998	1667.64	1773.19	2110.95	370.7	329.36	ditto	399.23	94.9	1997.00	2102.56	2510.17	461.0
1999	1745.45	1855.60	2209.04	388.0	342.89	ditto	415.63	98.8	2088.04	2198.49	2624.67	481.9
2000	1826.13	1941.71	2311.56	406.0	357.04	ditto	432.77	102.9	2183.17	2298.74	2744.33	503.8
2001	1910.76	2031.69	2418.68	424.8	371.81	ditto	450.68	107.2	2282.57	2403.51	2869.37	526.6
2002	1999.20	2125.73	2530.63	444.4	387.26	ditto	469.40	111.6	2386.46	2512.99	3000.03	550.5
2003	2091.62	2224.00	2647.62	465.0	403.39	ditto	488.96	116.3	2495.01	2629.39	3136.58	575.5
2004	2188.19	2326.69	2769.86	486.5	420.26	ditto	509.40	121.2	2608.45	2746.94	3279.27	601.5
2005	2289.11	2434.00	2897.61	508.9	437.88	ditto	530.77	126.2	2727.00	2871.88	3428.38	628.8

Note: Diversity factor of peak loads between interconnected system and isolated systems was estimated to be 0.99 based on the operation records in 1986.

* Actual record

Table 2.2.8 ENERGY DEMAND FORECAST (BASE SCENARIO)
- Interconnected System -

(GWh)

Year	Arusha	Moshi	Tanga	Dar es S.	Zanzibar	Morogoro	Iringa	Dodoma	Singida	Mbeya	Total	Total consumption	Generation
	Identified energy consumption												
1986*	64.03	43.79	85.88	415.11	41.59	65.69	63.56	13.38	3.08	26.17	822.28	874.52	1041.09
1987	70.42	45.53	89.34	440.38	43.81	68.72	66.14	13.74	3.44	27.49	869.01	924.01	1100.01
1988	73.81	47.83	93.85	467.28	46.02	73.50	157.09	15.14	3.60	28.88	1007.00	1070.73	1274.68
1989	78.09	50.74	99.56	495.02	48.82	81.45	251.02	16.02	3.83	33.58	1158.13	1231.43	1465.99
1990	83.09	54.13	106.22	527.37	52.09	86.57	190.25	17.04	4.10	35.62	1156.48	1229.68	1463.90
1991	87.19	56.92	111.41	552.20	54.49	90.82	198.60	18.16	4.84	36.33	1210.98	1287.62	1532.88
1992	91.29	59.59	116.65	578.17	57.06	95.09	207.94	19.02	5.07	38.04	1267.92	1348.17	1604.97
1993	95.58	62.38	122.12	605.31	59.73	99.56	217.70	19.91	5.31	39.82	1327.43	1411.45	1680.30
1994	100.05	65.31	127.85	633.67	62.53	104.22	227.90	20.84	5.56	41.69	1389.62	1477.57	1759.01
1995	104.73	68.37	133.82	663.30	65.46	109.10	238.56	21.82	5.82	43.64	1454.61	1546.67	1841.28
1996	109.62	71.56	140.07	694.27	68.51	114.19	249.69	22.84	6.09	45.68	1522.52	1618.88	1927.24
1997	114.73	74.89	146.60	726.63	71.71	119.51	261.33	23.90	6.37	47.80	1593.49	1694.34	2017.07
1998	120.07	78.38	153.42	760.45	75.04	125.07	273.49	25.01	6.67	50.03	1667.64	1773.19	2110.95
1999	125.65	82.02	160.56	795.79	78.53	130.89	286.20	26.18	6.98	52.35	1745.15	1855.60	2209.04
2000	131.48	85.83	168.00	832.72	82.18	136.96	299.49	27.39	7.30	54.78	1826.13	1941.71	2311.56
2001	137.57	89.81	175.79	871.31	85.98	143.31	313.36	28.66	7.64	57.32	1910.76	2031.69	2418.68
2002	143.94	93.96	183.93	911.63	89.96	149.94	327.87	29.99	8.00	59.98	1999.20	2125.73	2530.63
2003	150.60	98.31	192.43	953.78	94.12	156.87	434.03	31.37	8.37	62.75	2091.62	2224.00	2647.62
2004	157.56	102.85	201.31	997.82	98.47	164.11	358.86	32.82	8.75	65.65	2188.19	2326.69	2769.86
2005	164.82	107.59	210.60	1043.84	103.01	171.68	375.41	34.34	9.16	68.67	2289.11	2434.00	2897.61

* Actual record

Table 2.2.9 PEAK LOAD FORECAST (BASE SCENARIO)
- Interconnected System -

(GWh)

Year	Peak load by region										Total	Coincident peak load
	Arusha	Moshi	Tanga	Dar es S.	Zanzibar	Morogoro	Iringa	Dodoma	Singida	Mbeya		
1986*	15.8	10.9	24.3	91.0	8.6	11.6	17.8	4.2	1.6	9.0	194.8	183.1
1987	17.3	11.4	25.4	96.0	8.9	12.2	18.5	4.5	1.6	9.3	205.1	192.8
1988	18.1	12.0	26.7	102.0	9.4	13.1	19.3	4.5	1.7	9.8	217.0	204.0
1989	19.1	12.7	28.3	108.0	10.0	14.5	21.4	5.2	1.8	11.5	232.5	218.6
1990	20.4	13.6	30.2	115.1	10.6	15.4	22.8	5.5	1.9	12.2	247.7	232.8
1991	23.5	15.8	34.9	133.2	12.3	17.8	26.3	6.3	2.3	14.0	286.39	269.2
1992	24.6	16.5	36.6	139.4	12.9	18.6	27.6	6.6	2.4	14.7	299.9	281.9
1993	25.7	17.3	38.3	146.0	13.5	19.5	28.9	6.9	2.5	15.4	313.9	295.1
1994	26.9	18.1	40.1	152.8	14.1	20.4	30.2	7.2	2.6	16.1	328.6	308.9
1995	28.2	18.9	42.0	160.0	14.8	21.3	31.6	7.6	2.8	16.9	344.0	323.4
1996	29.5	19.8	43.9	167.4	15.5	22.3	33.1	7.9	2.9	17.6	360.1	338.5
1997	30.9	20.7	46.0	175.2	16.2	23.4	34.7	8.3	3.0	18.5	376.9	354.2
1998	32.3	21.7	48.1	183.4	17.0	24.5	36.3	8.7	3.2	19.3	394.4	370.7
1999	33.8	22.7	50.4	191.9	17.7	25.6	38.0	9.1	3.3	20.2	412.7	388.0
2000	35.4	23.8	52.7	200.8	18.6	26.8	39.7	9.5	3.5	21.2	431.9	406.0
2001	37.1	24.9	55.1	210.1	19.4	28.0	41.6	9.9	3.6	22.1	451.9	424.8
2002	38.8	26.0	57.7	219.9	20.3	29.3	43.5	10.4	3.8	23.2	472.8	444.4
2003	40.6	27.2	60.3	230.0	21.3	30.7	45.5	10.9	4.0	24.2	494.7	465.0
2004	42.4	28.5	63.1	240.6	22.3	32.1	47.6	11.4	4.1	25.4	517.5	486.5
2005	44.4	29.8	66.0	251.7	23.3	33.6	49.8	11.9	4.3	26.5	541.3	508.9

Note: Loads of Mufindi boilers (25 MW x 2 units) is not included considering that they are off-peak use.

* Actual record

Table 2.2.10 POWER DEMAND AND SUPPLY BALANCE FOR THE WHOLE COUNTRY (Base Scenario)

Item		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	(MW) 2000
Maximum power demand															
Grid + Isolated	(A)	219.3	233.1	274.5	291.9	337.8	353.1	369.2	386.0	403.5	421.8	441.0	461.0	481.9	503.8
Existing supply capacity (Hydro)															
Kidatu		204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0	204.0
Mtera		-	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0	80.0
Pangani Falls		17.5	17.5	17.5	17.5	17.5	-	-	-	-	-	-	-	-	-
Hale		17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Nyumba Ya Mungu		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Total hydro	(B)	246.5	326.5	326.5	326.5	326.5	309.0	309.0	309.0	309.0	309.0	309.0	309.0	309.0	309.0
Balance (B)-(A)	= (C)	27.2	93.4	52.0	36.4	-11.3	-44.1	-60.2	-77.0	-94.5	-112.8	-132.0	-152.0	-172.9	-194.8
Planned new projects															
Ubungo gas turbines					20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
Pangani Falls redevelopment							60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Dowstream Kihansi										162.0	162.0	162.0	162.0	162.0	162.0
Upstream Kihansi															45.0
Total	(D)				20.0	20.0	80.0	80.0	80.0	242.0	242.0	242.0	242.0	242.0	287.0
Balance (C)+(D)	= (E)	27.2	93.4	52.0	56.4	8.7	35.9	19.8	3.0	147.5	129.2	110.0	90.0	69.1	92.2
Hydro reserve margine (Inclu. GT)															
(E)/(A)	(%)	12.4	40.1	18.9	19.3	2.6	10.2	5.4	0.8	36.6	30.6	24.9	19.5	14.3	18.3
Existing diesel P.S. (Reserve for standby use)															
Grid system		67.5	67.5	67.5	67.5	67.5	67.5	67.5	67.5	-	-	-	-	-	-
Isolated system		55.5	55.5	55.5	55.5	55.5	55.5	55.5	55.5	-	-	-	-	-	-
Total diesel		123.0	123.0	123.0	123.0	123.0	123.0	123.0	123.0	-	-	-	-	-	-

Note: Existing mini hydro (Kikuletwa, Tosamaganga, Mbalizi) and proposed small hydro (Kikuletwa No. 2 and Ndungu) are not included.

Table 2.2.10 POWER DEMAND AND SUPPLY BALANCE FOR THE WHOLE COUNTRY (Base Scenario)

(MW)

Item		2001	2002	2003	2005	2005
Maximum power demand						
Grid + Isolated	(A)	526.6	550.5	575.5	601.5	628.8
Existing supply capacity (Hydro)						
Kidatu		204.0	204.0	204.0	204.0	204.0
Mtera		80.0	80.0	80.0	80.0	80.0
Pangani Falls		-	-	-	-	-
Hale		17.0	17.0	17.0	17.0	17.0
Nyumba Ya Mungu		8.0	8.0	8.0	8.0	8.0
Total hydro	(B)	309.0	309.0	309.0	309.0	309.0
Balance (B)-(A)	= (C)	-217.6	-241.5	-266.5	-292.5	-319.8
Planned new projects						
Ubungo gas turbines		20.0	20.0	20.0	20.0	20.0
Pangani Falls redevelopment		60.0	60.0	60.0	60.0	60.0
Dowstream Kihansi		162.0	162.0	162.0	162.0	162.0
Upstream Kihansi		45.0	45.0	45.0	45.0	45.0
Masigira			80.0	80.0	80.0	80.0
Rumakali						204.0
Total	(D)	287.0	367.0	367.0	367.0	571.0
Balance (C)+(D)	= (E)	69.4 100	125.5 100	100.5 100	74.5 100	251.2 100
Hydro reserve margine (Inclu. GT)						
(E)/(A)	(%)	13.2	22.8	17.5	12.4	39.9

Table 2.2.11 ENERGY DEMAND AND SUPPLY BALANCE FOR THE WHOLE COUNTRY (Base Scenario)

(GWh)

Item		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Required energy generation															
Grid + Isolated	(A)	1221.6	1409.9	1743.5	1754.9	1835.5	1919.6	2007.5	2099.4	2195.4	2295.8	2400.6	2510.2	2624.7	2744.3
Existing supply capability (Hydro)															
Kidatu		1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0	1009.0
Mtera			303.0	303.0	303.0	303.0	303.0	303.0	303.0	303.0	303.0	303.0	303.0	303.0	303.0
Pangani Falls		110.0	110.0	110.0	110.0	110.0	-	-	-	-	-	-	-	-	-
Hale		143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0	143.0
Nyumba Ya Mungu		48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0	48.0
Total hydro	(B)	1310.0	1613.0	1613.0	1613.0	1613.0	1503.0	1503.0	1503.0	1503.0	1503.0	1503.0	1503.0	1503.0	1503.0
Banance (B)-(A)	= (C)	88.4	203.1	-130.5	-141.9	-222.5	-416.6	-504.5	-596.4	-692.4	-792.8	-897.6	-1007.2	-1121.7	-1241.3
Planned new projects															
Ubungo gas turbine					105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0	105.0
Pangani Falls redevelopment							305.0	305.0	305.0	305.0	305.0	305.0	305.0	305.0	305.0
Downstream Kihansi										945.0	945.0	945.0	945.0	945.0	945.0
Upstream Kihansi															438.0
Total	(D)				105.0	105.0	410.0	410.0	410.0	1355.0	1355.0	1355.0	1355.0	1355.0	1838.0
Balance (C)+(D)	= (E)	88.4	203.1	130.5	36.9	117.5	6.6	94.5	186.4	662.6	562.5	457.4	347.8	233.3	596.7
Energy to be supplied by standby diesel P.S.				130.5	36.9	117.5	6.6	94.5	186.4	-	-	-	-	-	-
Hydro reserve margine (Inclu. GT) (E)/(A)	(%)														

Note: 1. For Ubungo gas turbine power plant a plant factor of 60% was estimated.
2. Existing mini hydro (Kikuletwa, Tosamaganga, Mbalizi) and proposed small hydro (Kikuletwa No. 2 and Ubungo) are not included.

Table 2.2.11 ENERGY DEMAND AND SUPPLY BALANCE FOR THE WHOLE COUNTRY (Base Scenario)

(GWh)

Item		2001	2002	2003	2004	2005
Required energy generation						
Grid + Isolated	(A)	1221.6	1409.9	1743.5	1754.9	1835.5
Existing supply capability (Hydro)						
Kidatu						
Mtera						
Pangani Falls						
Hale						
Nyumba Ya Mungu						
Total hydro	(B)	1310.0	1613.0	1613.0	1613.0	1613.0
Banance (B)-(A)	= (C)					
Planned new projects						
Ubungo gas turbine						
Pangani Falls redevelopment						
Downstream Kihansi						
Upstream Kihansi						
Total	(D)					
Balance (C)+(D)	= (E)					
Energy to be supplied by standby diesel P.S.						
Hydro reserve margine (Inclu. GT) (E)/(A)	(%)					

Table 2.2.12 POWER DEMAND AND SUPPLY BALANCE FOR ARUSHA-MOSHI-TANGA REGIONS

(MW)

Item		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Maximum power demand															
Arusha		17.3	18.1	19.1	20.4	23.5	24.6	25.7	26.9	28.2	29.5	30.9	32.3	33.8	35.8
Moshi		11.4	12.0	12.7	13.6	15.8	16.5	17.3	18.1	18.9	19.8	20.7	21.7	22.7	23.8
Tanga		25.7	26.7	28.3	30.2	34.9	36.6	38.3	40.0	42.0	43.9	46.0	48.1	50.4	52.7
Aggregated total		54.4	56.8	60.1	64.2	74.2	77.7	81.3	85.1	89.1	93.2	97.6	102.1	106.9	111.9
*Coincident peak load	(A)	51.1	53.4	56.5	60.3	69.7	73.0	76.4	80.0	83.8	87.6	91.7	96.0	100.5	105.2
Existing supply capability															
Arusha (Diesel)		3.4	3.4	3.4	3.4	3.4	3.4	3.4	-	-	-	-	-	-	-
Kikuletwa		0.5	0.5	0.5	0.5	-	-	-	-	-	-	-	-	-	-
Nyumba Ya Mungu		8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Hale		17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0	17.0
Pangani Falls		17.5	17.5	17.5	17.5	17.5	-	-	-	-	-	-	-	-	-
Existing total	(B)	46.4	46.4	46.4	46.4	45.9	28.4	28.4	25.0	25.0	25.0	25.0	25.0	25.0	25.0
Balance (B)-(A)	= (C)	-4.7	-7.0	-10.1	-13.9	-23.8	-44.6	-48.0	-55.0	-58.8	-62.6	-66.7	-71.0	-75.5	-80.2
Planned new projects															
Pangani Falls redevelopment (D)							60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0	60.0
Balance (C)+(D)	= (E)	-4.7	-7.0	-10.1	-13.9	-23.8	15.4	12.0	5.0	1.2	-2.6	-6.7	-11.0	-15.5	-20.0
Proposed new projects															
Kikuletwa rehabilitation						1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Kikuletwa No. 2									11.0	11.0	11.0	11.0	11.0	11.0	11.0
Total	(F)					1.1	1.1	1.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
Banance (E)+(F)	= (G)	-4.7	-7.0	-10.1	-13.9	-22.7	16.5	13.1	17.1	13.3	9.5	5.4	1.1	-3.4	-8.1

Note: * Calculated using a diversity factor of 0.94.

Table 2.2.12 POWER DEMAND AND SUPPLY BALANCE FOR ARUSHA-MOSHI-TANGA REGIONS

(MW)

Item		2001	2002	2003	2004	2005
Maximum power demand						
Arusha		37.1	38.8	40.6	42.4	44.4
Moshi		24.9	26.0	27.2	28.5	29.8
Tanga		55.1	57.9	60.3	63.1	66.0
Aggregated total		117.1	122.5	128.1	134.0	140.2
*Coincident peak load	(A)	110.1	115.2	120.4	126.0	131.8
Existing supply capability						
Arusha (Diesel)		-	-	-	-	-
Kikuletwa		-	-	-	-	-
Nyumba Ya Mungu		8.0	8.0	8.0	8.0	8.0
Hale		17.0	17.0	17.0	17.0	17.0
Pangani Falls		-	-	-	-	-
Existing total	(B)	25.0	25.0	25.0	25.0	25.0
Balance (B)-(A)	= (C)	-85.1	-90.2	-95.4	-101.0	-106.8
Planned new projects						
Pangani Falls redevelopment	(D)	60.0	60.0	60.0	60.0	60.0
Balance (C)+(D)	= (E)	-25.1	-30.2	-35.4	-41.0	-46.8
Proposed new projects						
Kikuletwa rehabilitation		1.1	1.1	1.1	1.1	1.1
Kikuletwa No. 2		11.0	11.0	11.0	11.0	11.0
Total	(F)	12.1	12.1	12.1	12.1	12.1
Balance (E)+(F)	= (G)	-13.0	-18.1	-23.3	-28.9	-34.7

Table 2.2.13 ENERGY DEMAND AND SUPPLY BALANCE FOR ARUSHA-MOSHI-TANGA REGIONS (Base Scenario)

(GWh)

Item		1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Energy consumption															
Arusha		70.42	73.81	78.09	83.09	87.19	91.29	95.58	100.05	104.73	109.62	114.73	120.07	125.65	131.48
Moshi		45.53	47.83	50.74	54.13	56.92	56.59	62.38	65.31	68.37	71.56	74.89	78.38	82.02	85.83
Tanga		89.34	93.85	99.56	06.22	111.41	116.65	122.12	127.85	133.82	140.07	146.60	153.42	160.55	168.00
Total consumption		205.29	215.49	228.39	243.44	255.52	264.53	280.08	293.21	306.92	321.25	336.22	351.87	368.22	386.31
Required energy generation*	(A)	301.90	316.90	335.87	358.00	375.76	393.43	411.88	431.19	451.35	472.43	494.44	517.46	541.50	566.63
Existing supply capability															
Arusha		4.75	4.75	4.75	4.75	4.75	4.75	4.75	-	-	-	-	-	-	-
Kikuletwa		3.50	3.50	3.50	3.50	-	-	-	-	-	-	-	-	-	-
Nyumba Ya Mungu		48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00	48.00
Hale		143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00	143.00
Pangani Falls		110.00	110.00	110.00	110.00	110.00	-	-	-	-	-	-	-	-	-
Existing total	(B)	309.25	309.25	309.25	309.25	305.75	195.75	195.75	191.00	191.00	191.00	191.00	191.00	191.00	191.00
Balance (B)-(A)	= (C)	7.35	-7.65	-26.62	-48.75	-70.01	-197.60	-216.13	-240.19	-260.35	-281.43	-303.44	-326.46	-350.50	-375.63
Planned new projects															
Pangani Falls redevelopment	(D)						305.00	305.00	305.00	305.00	305.00	305.00	305.00	305.00	305.00
Balance (C)+(D)	= (E)	7.35	-7.65	-26.62	-48.75	-70.01	107.32	88.87	64.81	44.65	23.57	1.56	-21.46	-45.50	-70.63
Proposed new projects															
Kikuletwa rehabilitation						10.53	10.53	10.53	10.53	10.53	10.53	10.53	10.53	10.53	10.53
Kikuletwa No. 2									67.09	67.09	67.09	67.09	67.09	67.09	67.09
Total	(F)					10.53	10.53	10.53	77.62	77.62	77.62	77.62	77.62	77.62	77.62
Banance (E)+(F)	= (G)	7.35	7.65	26.62	48.75	59.48	117.85	99.40	142.43	122.27	601.19	79.18	56.16	32.12	6.99

Note: * *Energy loss factor of the above regions in 1986 is calculated to be 32% as shown below.*
This facotr was used for this study.

Table 2.2.13 ENERGY DEMAND AND SUPPLY BALANCE FOR ARUSHA-MOSHI-TANGA REGIONS (Base Scenario)

(GWh)

Item		2001	2002	2003	2004	2005
Energy consumption						
Arusha		137.57	143.94	150.60	157.55	168.82
Moshi		89.81	93.96	98.31	102.85	107.59
Tanga		175.79	183.93	192.43	201.31	210.60
Total consumption		403.17	421.83	441.34	461.71	487.01
Required energy generation*	(A)	592.90	620.34	649.03	678.99	716.19
Existing supply capability						
Arusha		-	-	-	-	-
Kikuletwa		-	-	-	-	-
Nyumba Ya Mungu		48.00	48.00	48.00	48.00	48.00
Hale		143.00	143.00	143.00	143.00	143.00
Pangani Falls		-	-	-	-	-
Existing total	(B)	191.00	191.00	191.00	191.00	191.00
Balance (B)-(A)	= (C)	-401.90	-429.34	-458.03	-487.99	-525.19
Planned new projects						
Pangani Falls redevelopment	(D)	305.00	305.00	305.00	305.00	305.00
Balance (C)+(D)	= (E)	-96.6	-124.34	-153.03	-182.99	-220.19
Proposed new projects						
Kikuletwa rehabilitation		10.53	10.53	10.53	10.53	10.53
Kikuletwa No. 2		67.09	67.09	67.09	67.09	67.09
Total	(F)	77.62	77.62	77.62	77.62	77.62
Banance (E)+(F)	= (G)	-18.98	-46.72	-75.41	-103.37	-142.57

Table 2.3.1 MAIN FEATURES OF SMALL HYDROPOWER IN THE KILIMANJARO REGION

	Kikuletwa No.1 (Re-habilitat.)	Kikuletwa No.2	Himo No.1 (Rehabi-litat.)	Himo No. 2	Bombo (Rehabi-litat.)	Hingilili	Ndungu	Ihindi	Gulutu
1. Name of river	Kikuletwa	Kikuletwa	Himo	Himo	Hingilili	Hingilili	Yongoma	Sesseni	Sesseni
2. Catchment area (km^2)	2,200	2,280	174	183	1.8	53.5	57.0	181.3	190.0
3. Annual inflow ($10^6 m^3$)	410	421	52	54.6	0.56	28.3	30.1	64.3	67.4
4. H.W.L. (m)	830.47	818	1,025.5*	885	1,470	900	1,071	690	600
5. Headrace length (km)		3.20	1	1.6	0.4	0.4	0.9	1.8	1.0
6. Penstock length (m)	20	834.5	82	200	400	1,600	1,100	120	220
7. T.W.L. (m)	817.4	730.9	954.2	837	1,380	585	532	617	545
8. Gross head (m)	13.07	87.10	71.20	48	90	315	539	73	55
9. Effective head (m)	12.70	78.20	67.6	43.7	84.5	299	512	67	51.2
10. Max. discharge (m^3/m)	15.4	17.9	0.43	0.43	0.085	0.8	1.00	0.96	1
11. Firm discharge (m^3/m)	10.53	17.9	0.13	0.14	-	0.12	0.15	1.24	0.25
12. Type of turbine	S-Type Tubuler	Francis	Cross Flow	Cross Flow	Cross Flow	Pelton	Pelton	Francis	Francis
13. Installed capacity (kW)	1,500	11,000	220	140	50	1,830	3,940	480	380
14. Firm capacity (kW)	1,055	11,000	66	43	0	270	575	120	96
15. Annual energy (GwH)	10.53	67.09	1.499	1.02	0.06	10	21.5	3.6	2.9
16. Transmisison lien length (km)	-	9	1	1.5	0.5	1	13.5	17	12
17. Total project cost (10^6US$)	7.2	49.4	1.07	3.71	0.44	9.56	16.29	7.29	5.11
18. Energy unit cost ($/kwh)	0.68	0.73	0.69	2.43	7.08		0.73	1.83	1.61
19. Benefit/Cost ratio	1.267	1.174	1.08	0.21	-	0.70	0.87	0.34	0.39
20. EIRR (%)	13.30	12.03	11.03	less than 0.1	-	6.63	8.52	0.96	1.97

Note: * High water level at head tank.

Fig. 2.1.1. ORGANISATION OF TANESCO

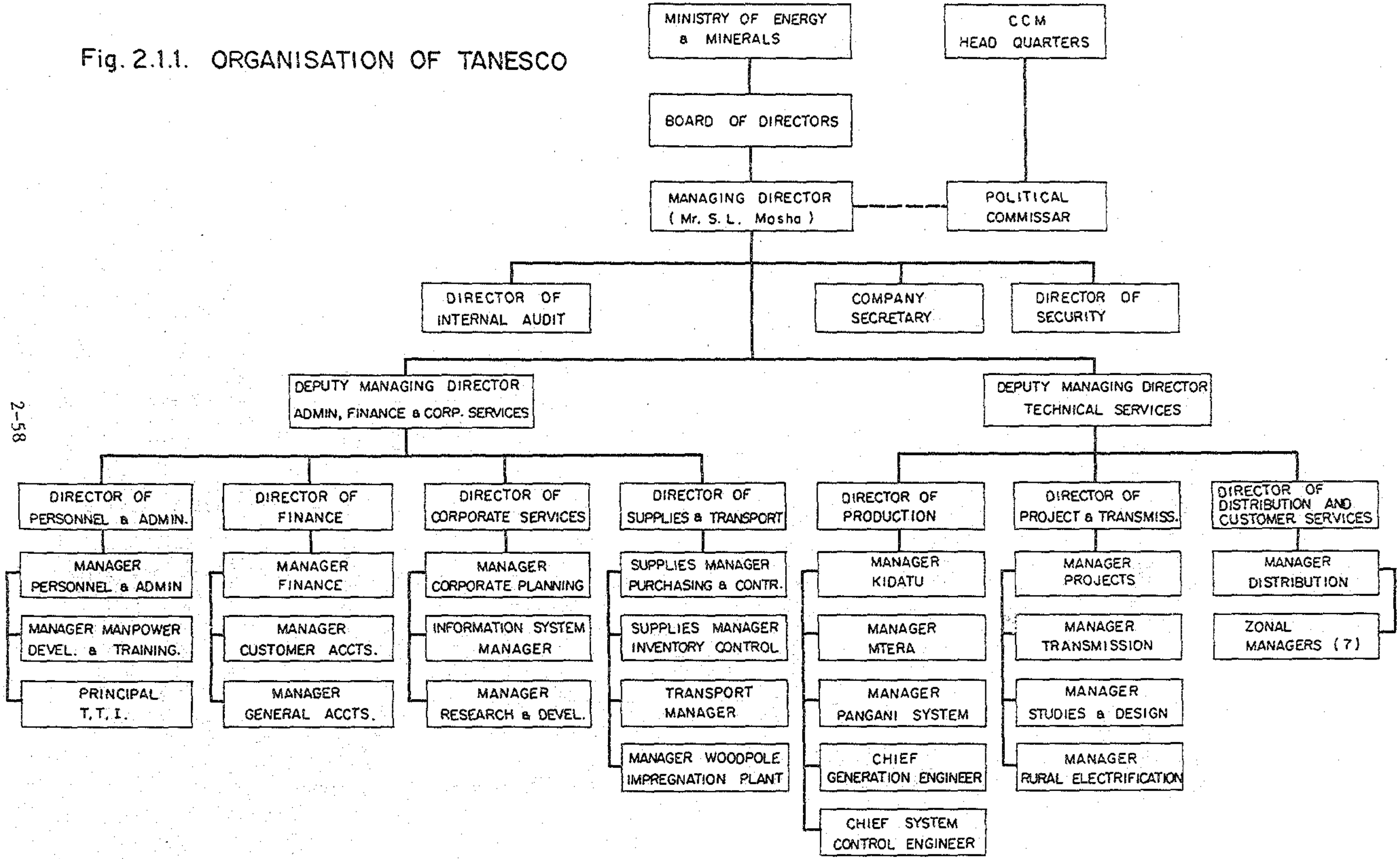


Fig. 2.1.2. POWER SYSTEM MAP

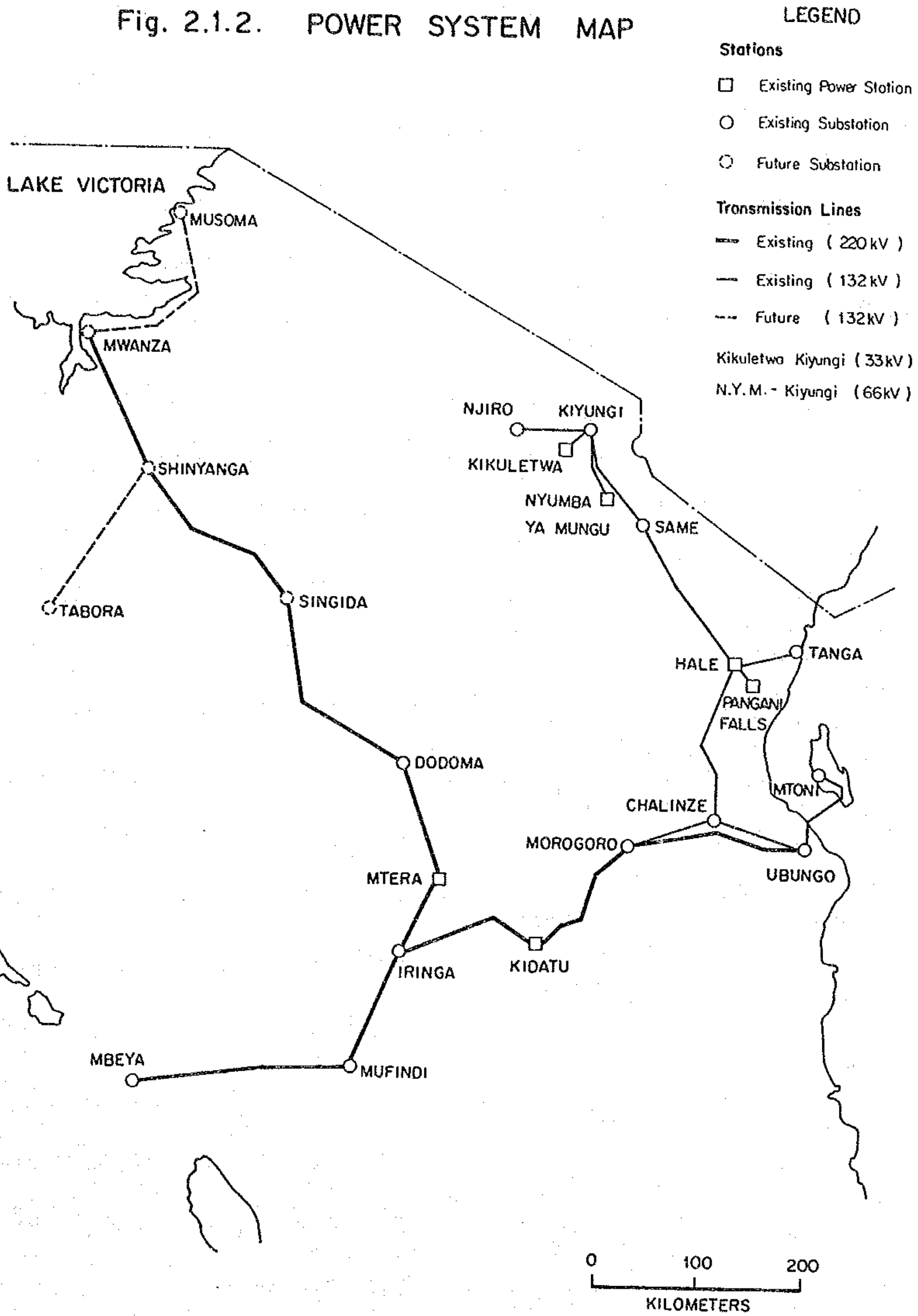


Fig. 2.1.3 GRID SYSTEM ONE LINE DIAGRAM (EXISTING)

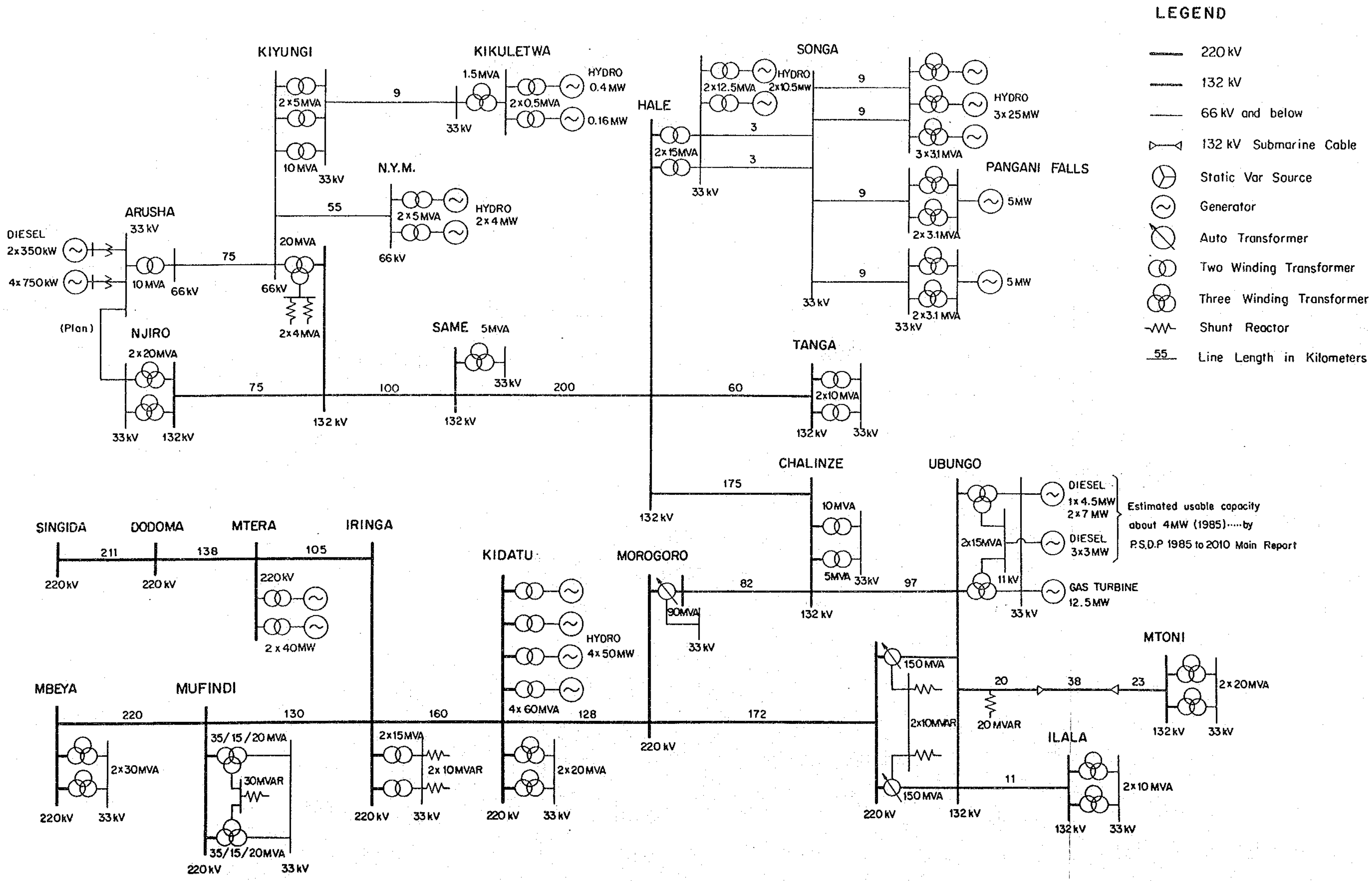


Fig. 2.1.4 TYPICAL DAILY LOAD CURVE

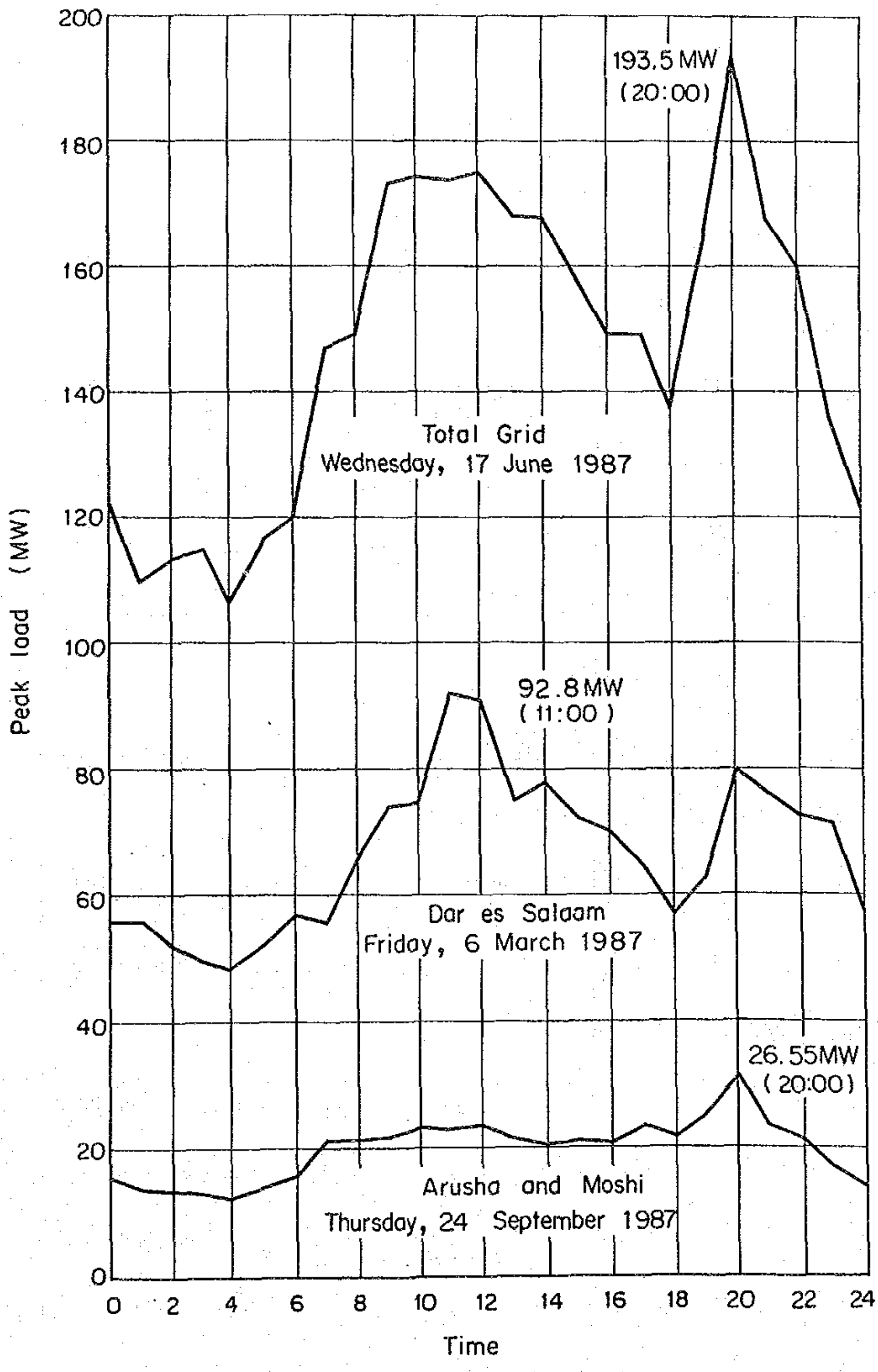


Fig. 2.2.1. DEMAND RELATIONSHIP

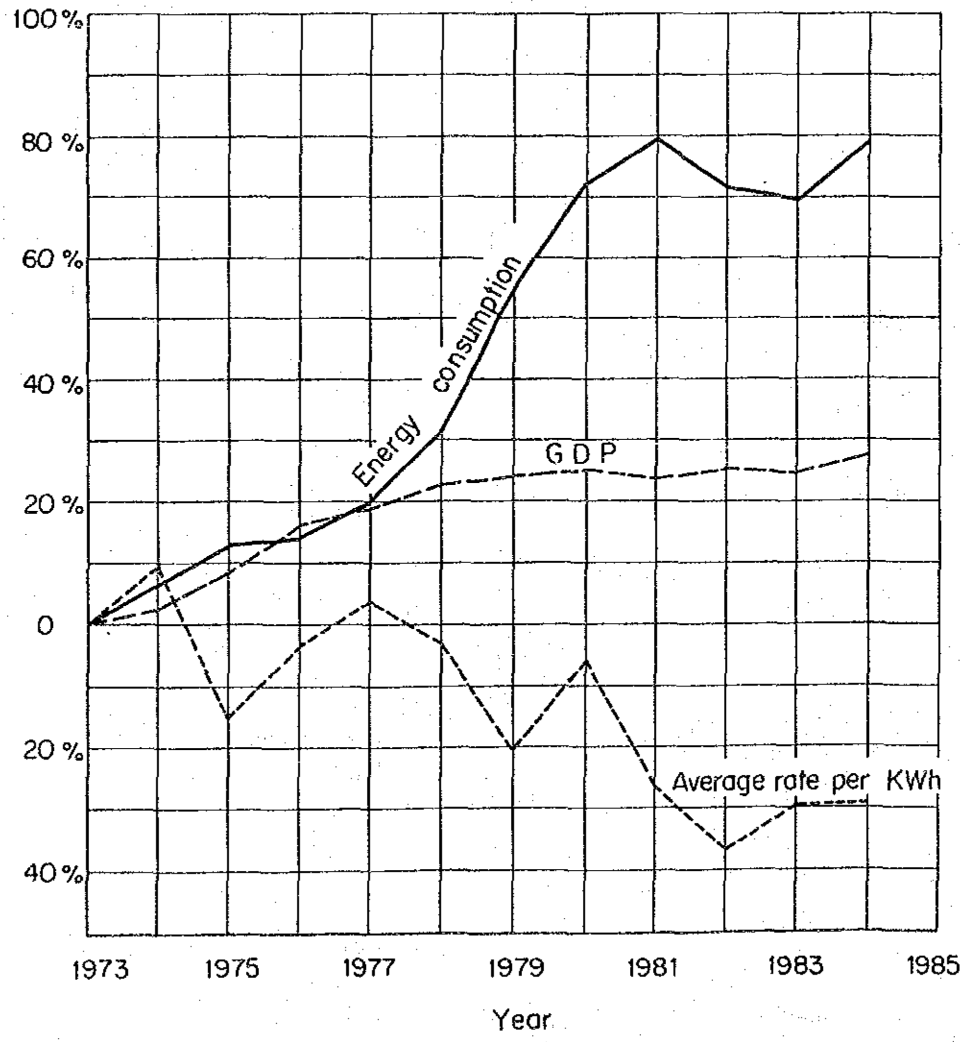


Fig. 2.2.2. COMPARISON OF LOAD FORECASTS (WHOLE POWER SYSTEM)

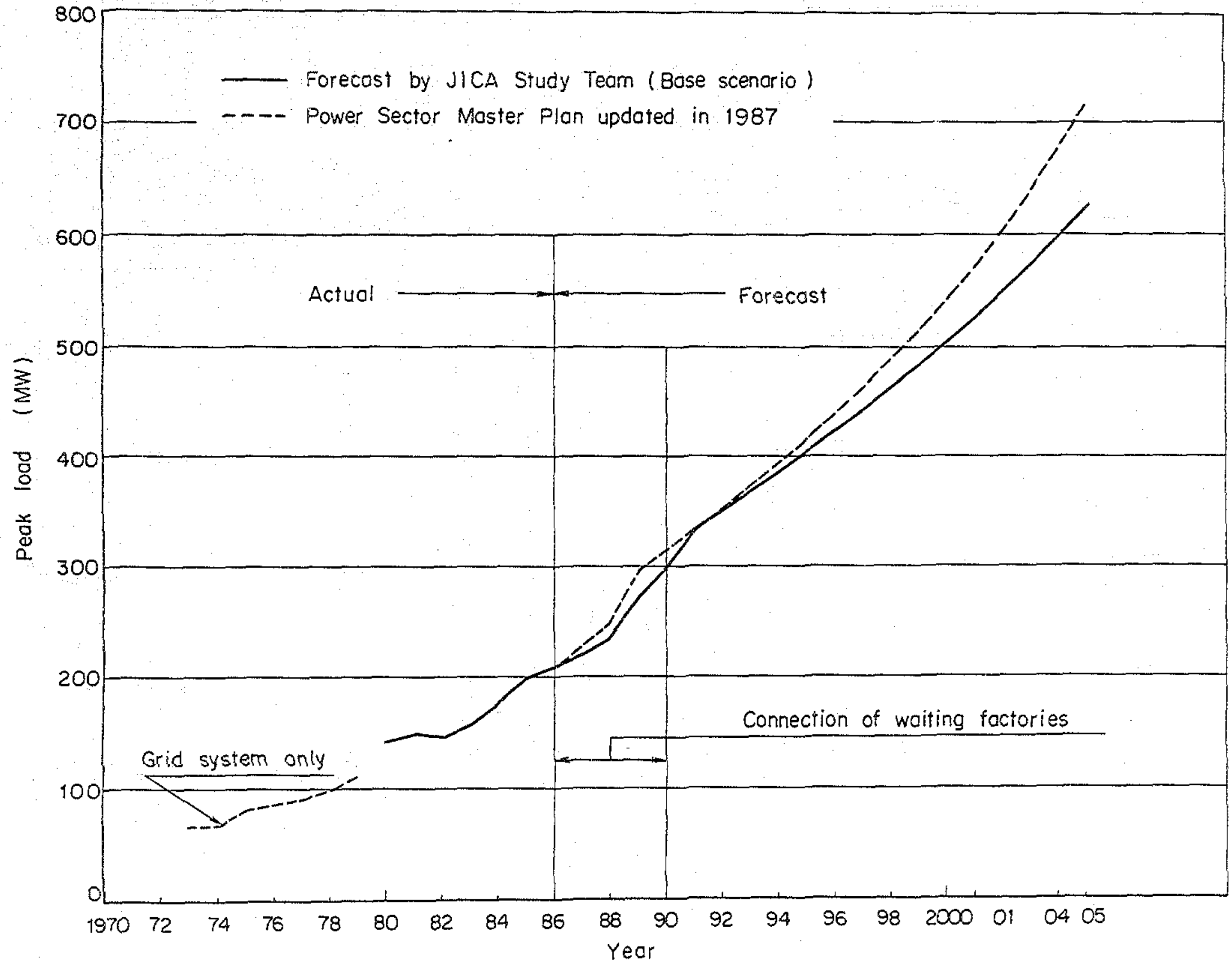


Fig. 2.2.3. POWER DEVELOPMENT PROGRAM AND DEMAND AND SUPPLY BALANCE FOR THE WHOLE COUNTRY (Base Scenario)

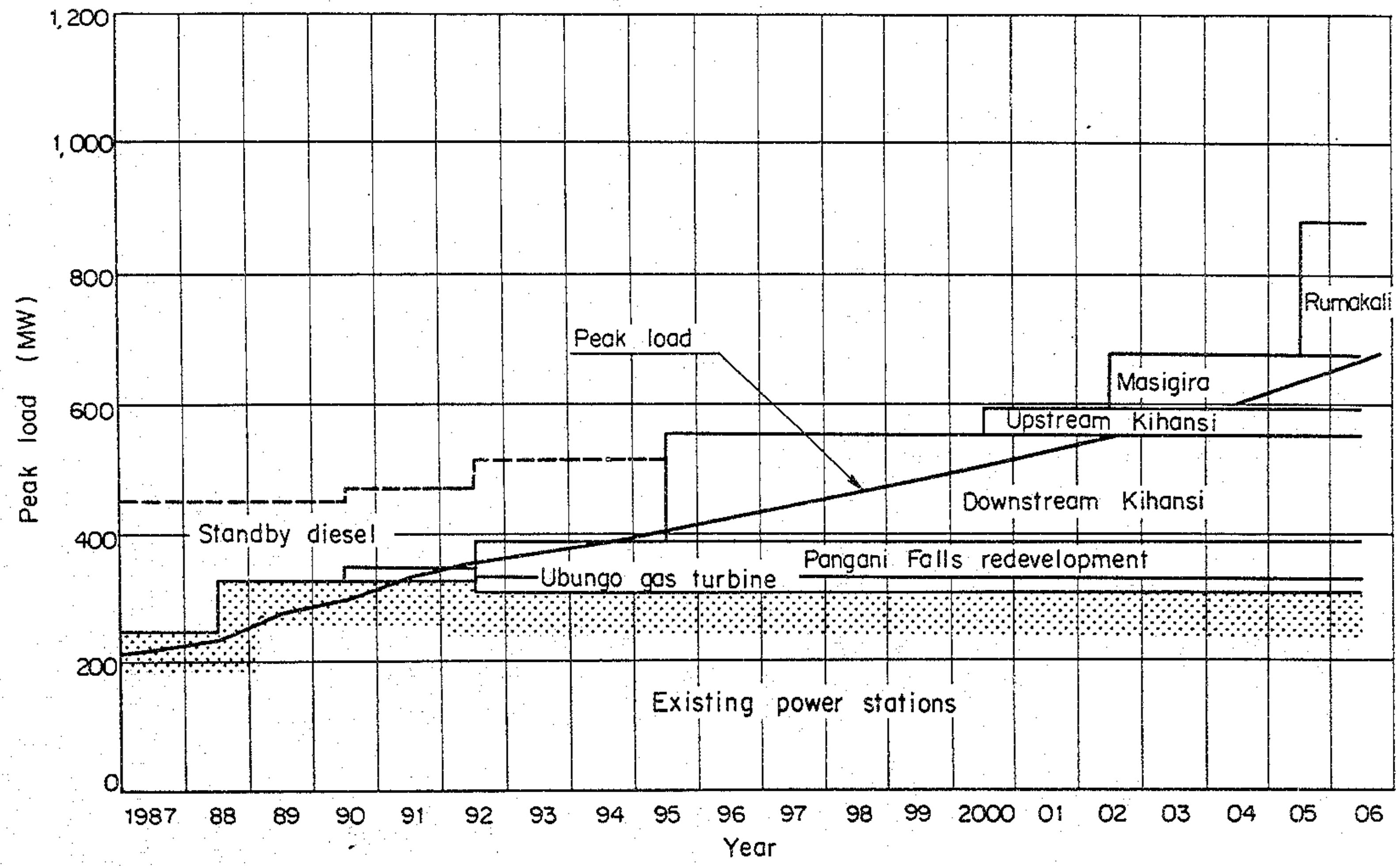


Fig. 2.2.4. ENERGY DEMAND AND SUPPLY BALANCE FOR THE WHOLE COUNTRY (Base Scenario)

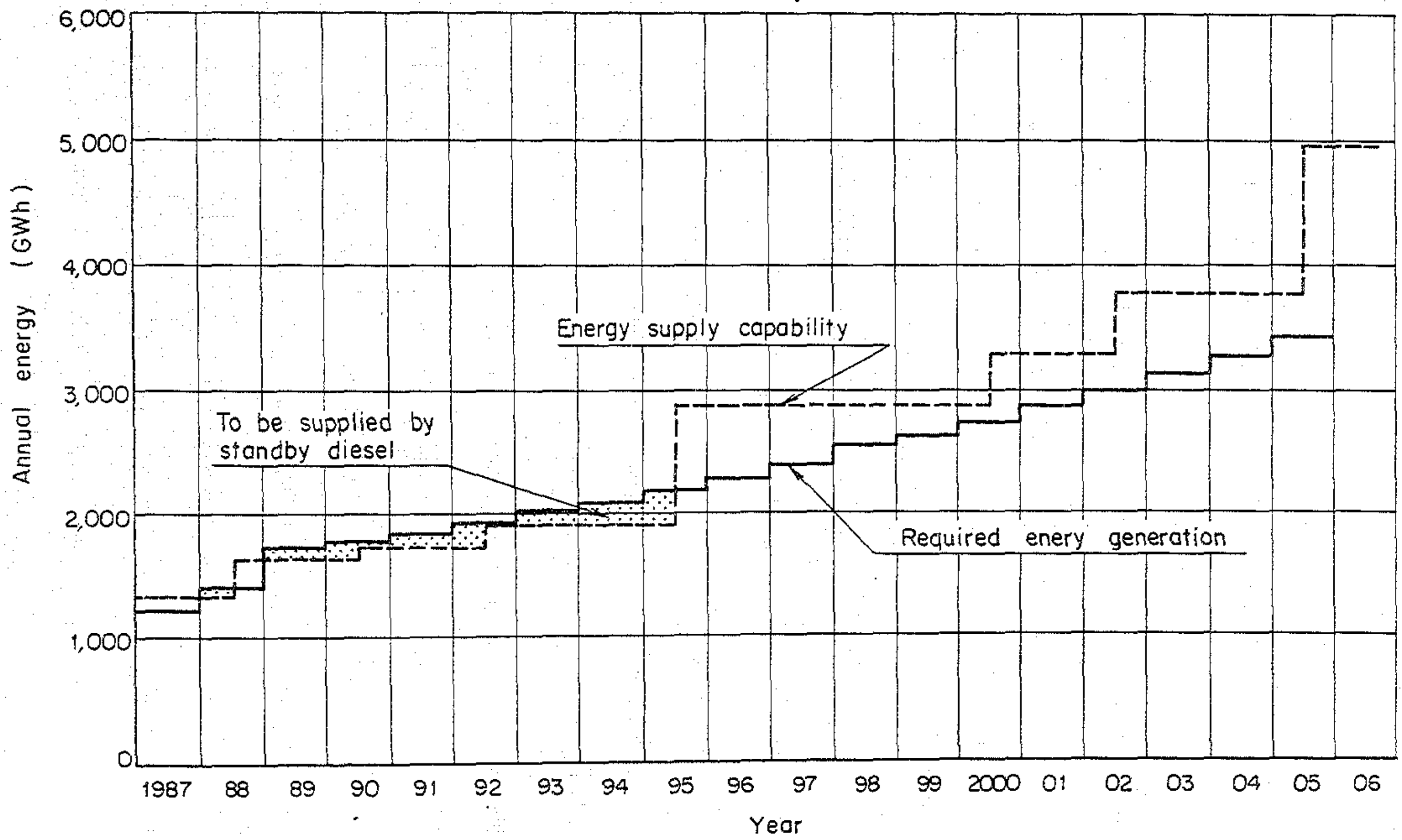


Fig. 2.2.5. ENERGY DEMAND AND SUPPLY BALANCE FOR THE ARUSHA-MOSHI-TANGA REGIONS (Base Scenario)

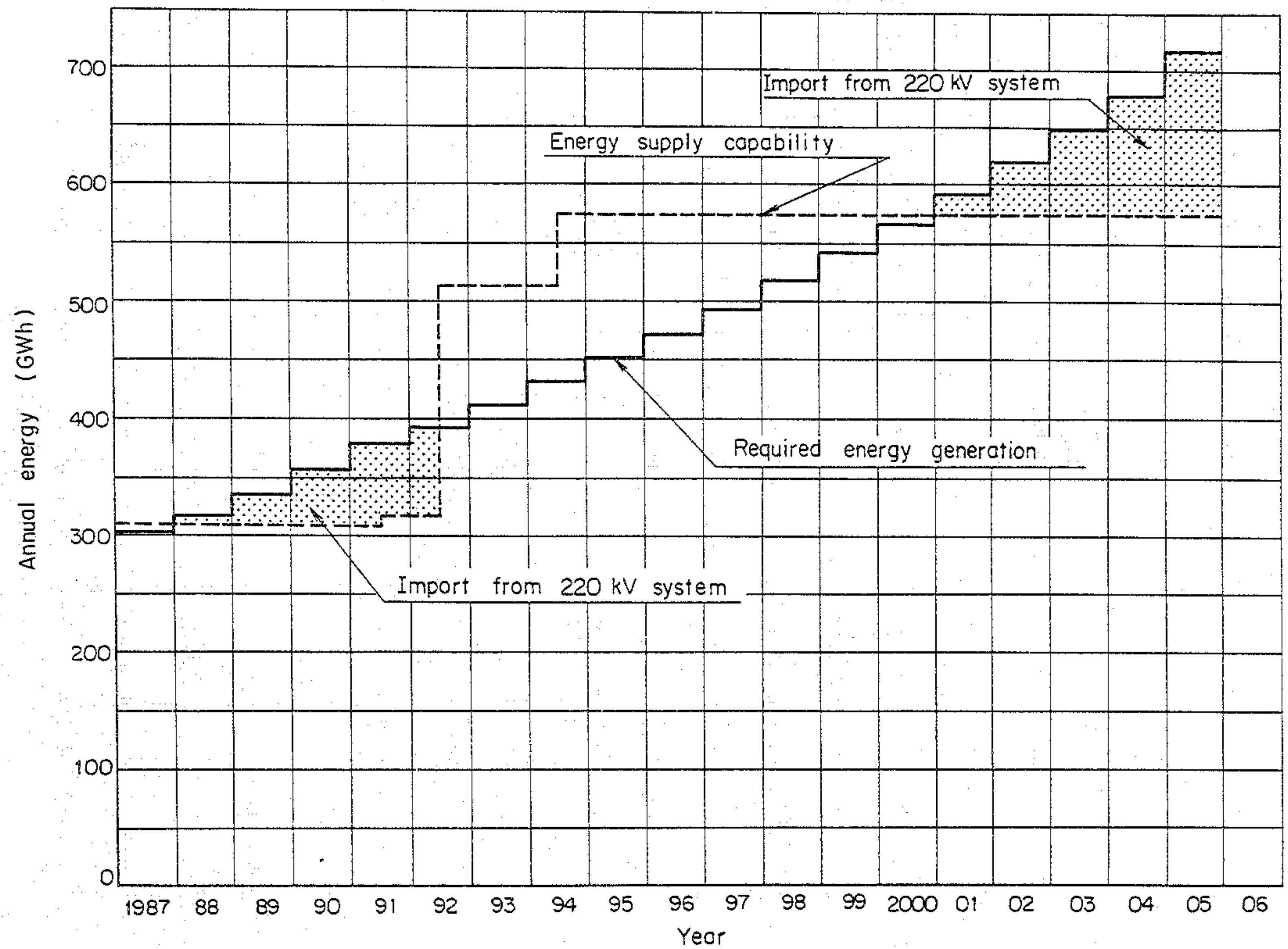
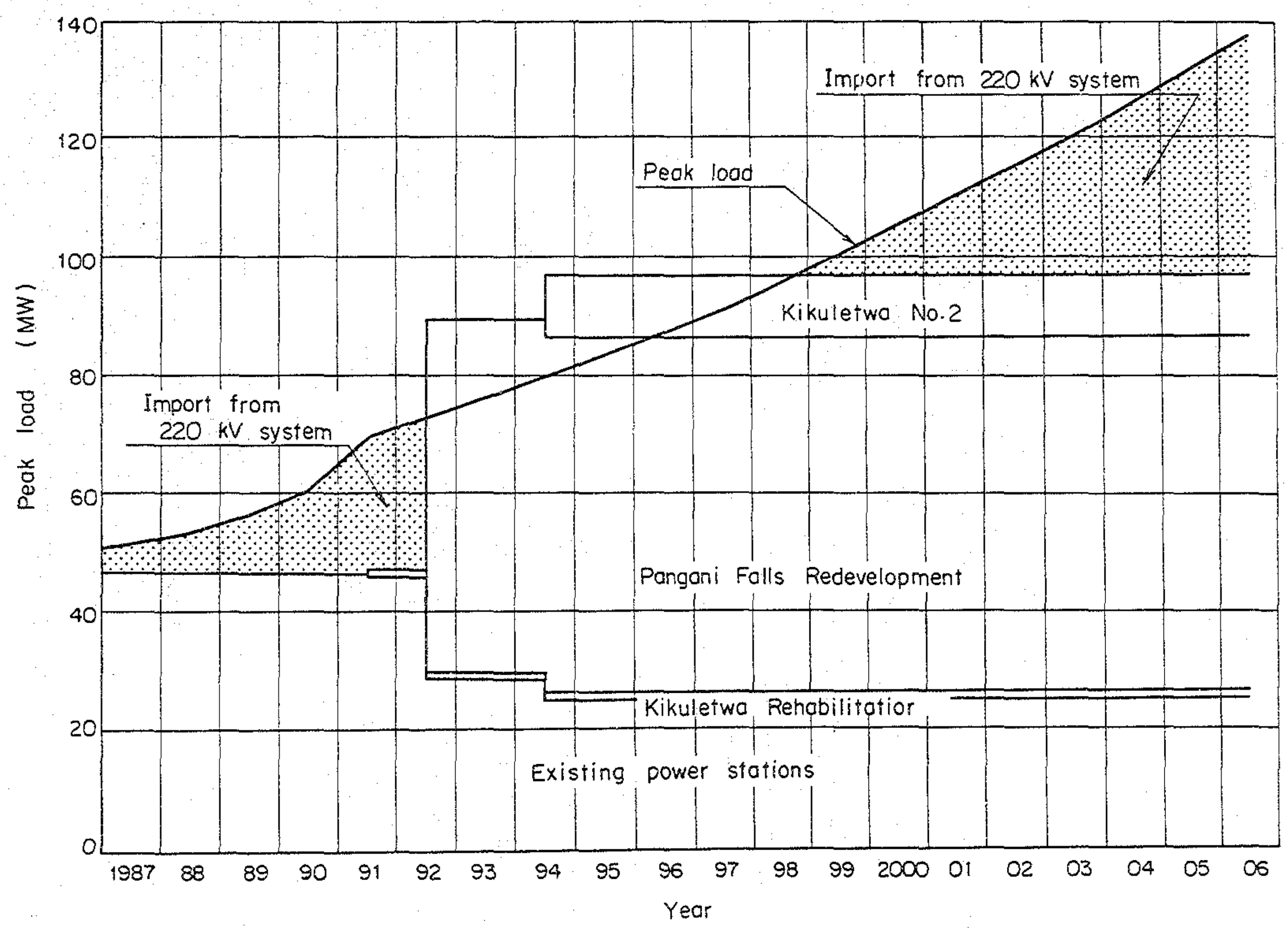


Fig. 2.2.6. POWER DEVELOPMENT PROGRAM AND DEMAND AND SUPPLY BALANCE FOR THE ARUSHA-MOSHI-TANGA REGIONS (Base Scenario)



CHAPTER 3
FIELD INVESTIGATION FOR KIKULETWA NO.1 AND NO.2 HYDROPOWER DEVELOPMENT PROJECTS

CHAPTER 3 FIELD INVESTIGATION FOR KIKULETWA NO.1 AND NO.2 HYDROPOWER DEVELOPMENT PROJECTS

CHAPTER 3 FIELD INVESTIGATIONS FOR KIKULETWA NO. 1 AND NO. 2 HYDROPOWER DEVELOPMENT PROJECTS

3.1 GENERAL

In order to collect the basic data required for the feasibility studies of the projects concerned, the JICA team carried out the following work in Tanzania. The work was carried out from January to March 1988.

(1) Aerial photographic surveying and preparation of topographical maps

(2) Preparation of topographical maps of main structure sites

(3) Core drilling investigations and detailed surface reconnaissances

(4) Concrete aggregate investigations

(5) Hydrological investigations

(6) Environmental investigations

3.2 TOPOGRAPHICAL SURVEYING

3.2.1 Aerial Photographic Surveying and Mapping

The aerial photographic surveying and mapping carried out by the JICA team was as follows:

(1) Photography (including film development): app. 300 sq. km

(2) Flight courses: 9 courses

(3) Photographic scales : 1/20,000 for mapping, 1/8,000 for longitudinal and transverse profiles

(4) Scope of mapping: approximately 30 sq. km and 9 km of longitudinal and transverse profiles

(5) Topographical scales: 1/5,000 for topographical map, 1/1,000 for longitudinal and transverse profiles

3.2.2 Preparation of Topographical Maps of Main Structure Sites

The surveying carried out by the TANESCO survey team with the advice of the JICA team was as follows:

(1) Control point surveying (including levelling) ... 13 points

(2) 1/500 topographical surveying

- Topographical surveying of vicinity of powerhouse of Kikuletwa No. 1 project site ... 32,500 sq.m
- Topographical surveying of vicinity of Kikuletwa No. 2 intake dam site ... 30,000 sq.m
- Topographical surveying of vicinity of Kikuletwa No. 2 Power Station ... 120,000 sq.m

3.3 BY CORE DRILLING INVESTIGATION

Core drilling investigation and permeability tests utilizing drill-holes, were carried out by the Study Team between January and March 1988. The extent and locations of this work are as shown in Table 3.3.1 and Fig. 3.3.1.

These investigation and test results are described in Chapter 4.

3.4 CONCRETE AGGREGATE INVESTIGATION

The Study Team and TANESCO selected five sites in the project area to serve as sources for concrete aggregates. Excavation of test pits, sampling, and laboratory tests were then carried out at these sites.

The locations of the concrete aggregate sources are shown in Fig. Fig. 3.4.1. Information on test pits, sampling quantities, and test items is provided given in Tables 3.4.1 and 3.4.2.

The results of these tests are described in Chapter 4.

Table 3.3.1 LIST OF DRILL HOLES AND PERMEABILITY TESTS

	Coordinate X	Coordinate Y	Elevation (EL.m)	Length (m)	Direction	Permeability test (times)	Remarks
K-1	8,693.84	12,339.33	828.72	25.0	Vertical	4	
KD-1	7,688.70	13,405.00	822.39	20.0	Vertical	4	
KD-2	7,658.50	13,433.60	812.41	15.0	Vertical	1	
KD-3	7,635.40	13,456.40	817.45	20.0	Vertical	2	
KD-4	6,925.37	14,152.01	825.89	20.0	Vertical	2	
KD-5	6,264.63	14,842.87	829.68	20.0	Vertical	4	
KD-6	5,813.64	15,290.85	811.33	20.0	Vertical	4	
KD-7	5,210.07	16,201.66	807.59	20.0	Vertical	4	
KD-8	4,458.82	16,837.42	779.57	30.0	Vertical	6	
KD-9	4,407.68	17,049.50	730.74	20.0	Vertical	3	
TOTAL	10 holes		-	210.0	-	34	

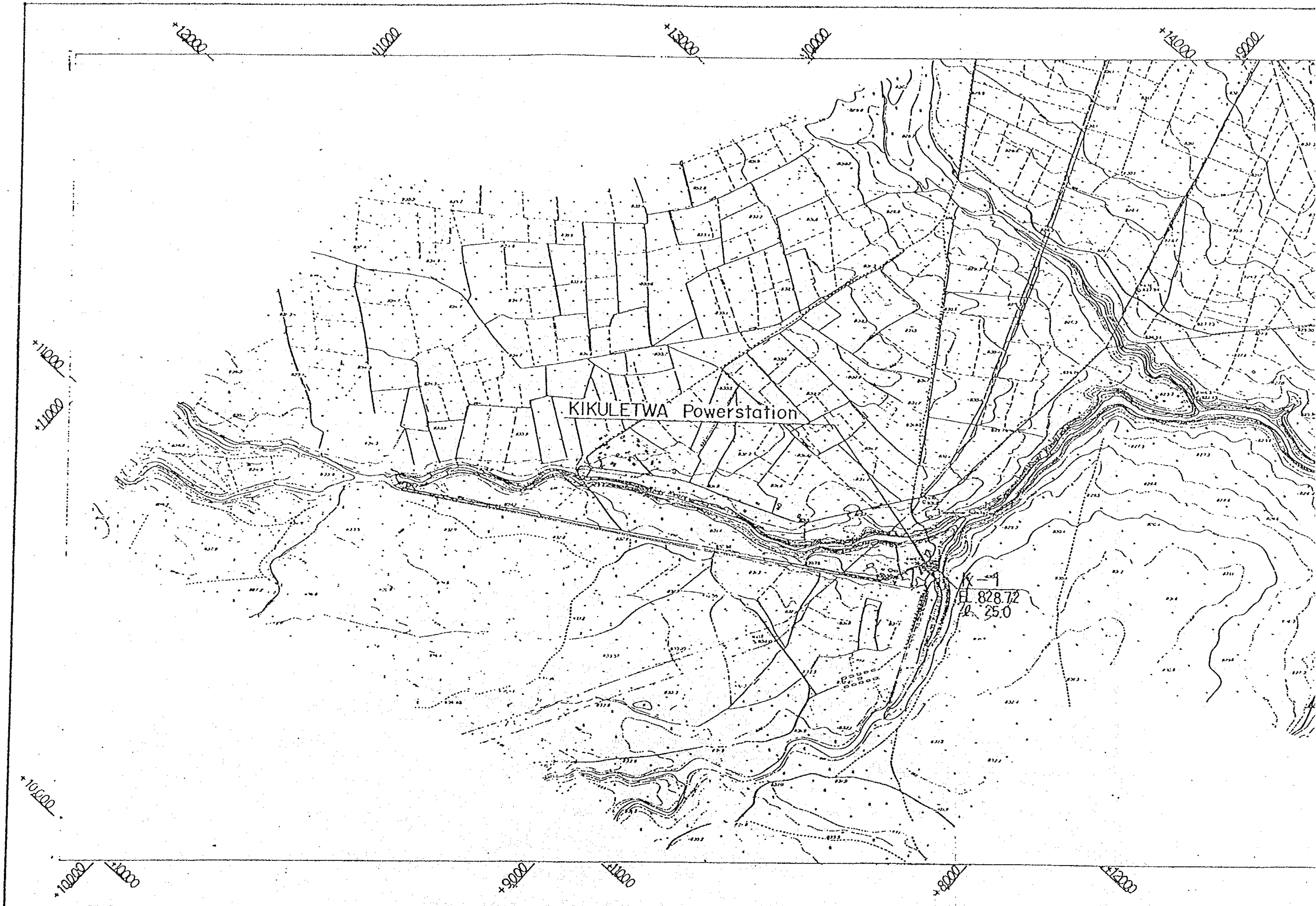
Table 3.4.1 LIST OF PITS

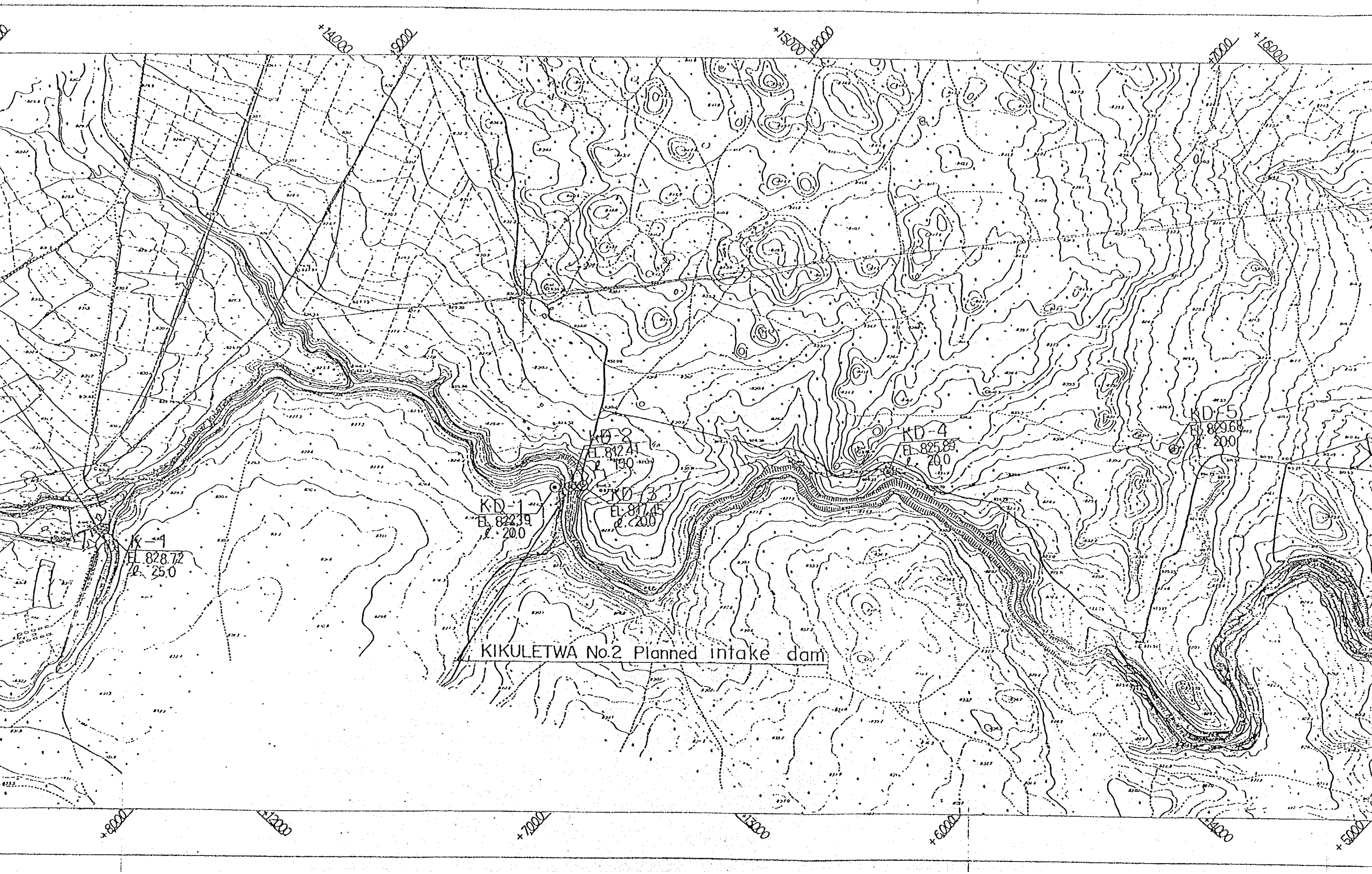
	Number of pits	Remarks
R. Karanga No. 1	4	For coarse and fine materials
" No. 2	1	For coarse and fine materials
" No. 3	3	For coarse and fine materials
" No. 4	3	For coarse and fine materials
" No. 5	2	For coarse and fine materials
Kiteto	15	Fine material
T.P.C.	1	Fine material
Hai (Crusher plant)	-	Coarse material
Nyumba ya Mungu	-	Fine material
Total	29	

Table 3.4.2 QUANTITY OF LABORATORY TEST FOR CONCRETE AGGREGATE

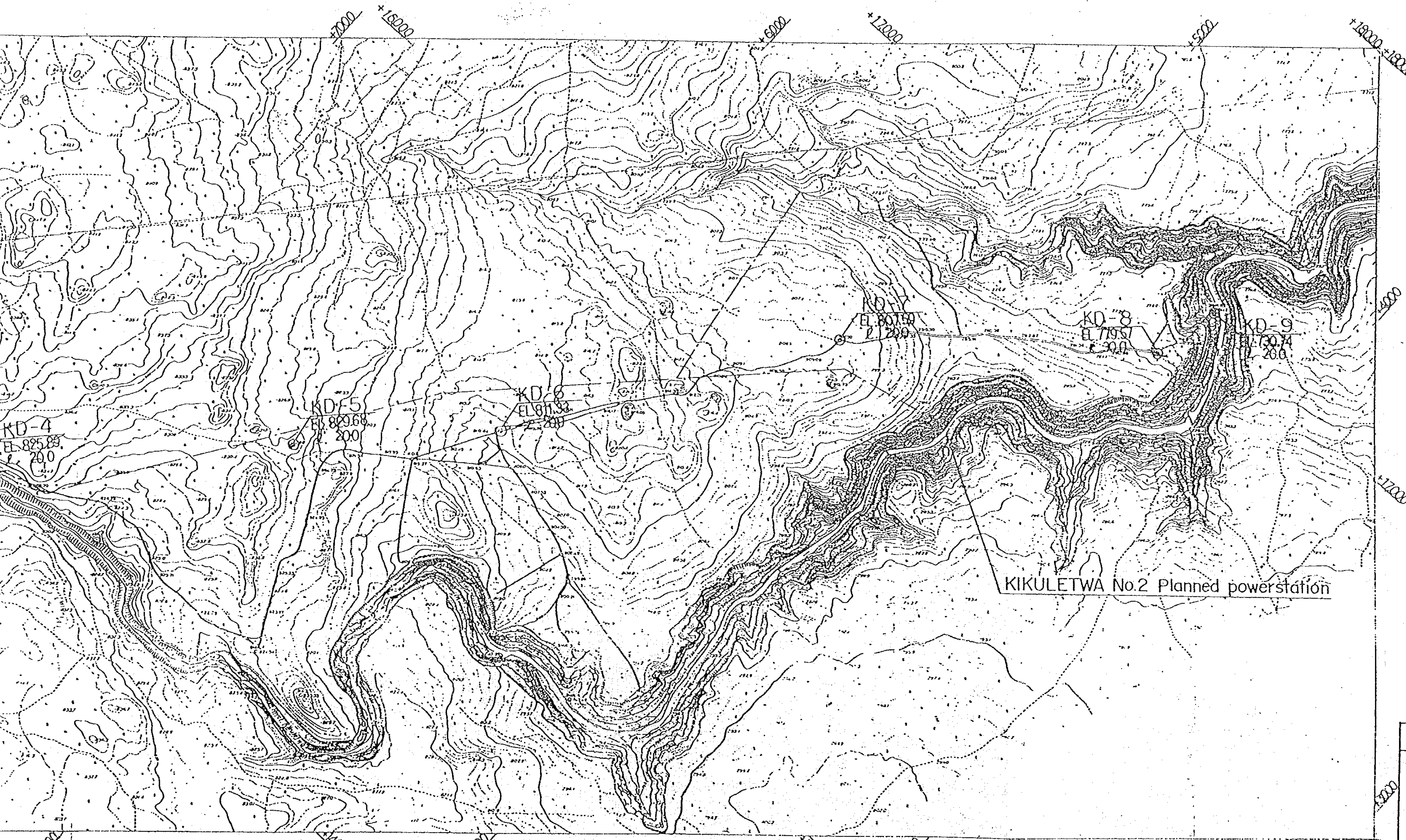
Item / Location	*1 Classification of Aggregate	*2 Grain-size Analysis	*3 Specific Gravity	*4 Absorption	*5 Abrasion	*6 Soundness	*7 Unight Weight	*8 Voids	Clay Lumps		*9 Organic Impurities	*10 Crushing Value	*11 Alkali Aggregate Reaction
									ASTMC142	BS812			
R.Karanga No. 1	1	3	0	0	1	3	0	0	0	0	0	0	0
No.2	1	0	0	0	0	0	0	0	0	0	0	1	0
No.3	1	1	1	1	1	2	1	1	1	0	1	0	1
No.4	1	0	0	0	0	0	0	0	0	0	0	0	0
No.5	1	1	1	1	1	1	1	1	1	1	1	0	0
T.P.C.	1	1	1	1	0	1	1	1	1	1	1	0	1
Hai	1	5	4	4	4	4	3	3	3	1	0	1	1
Kiteto	1	4	6	6	0	3	5	5	5	2	5	0	1
Nyumba ya Mungu	1	1	1	1	0	1	1	1	0	1	1	0	1
TOTAL	9	16	14	14	7	15	12	12	11	6	9	2	5

*1: Microscopic observation
*2: BS812
*3: ASTM C127/128
*4: ASTM C127/128
*5: AASHOTO T96
*6: ASTM C88
*7: ASTM C88
*8: ASTM C88
*9: ASTM C40
*10: BS812
*11: TZS58 (Tanzania standard)


KIKULETWA Powerstation
K-1
EL.828.72
ℓ. 25.0
+12000
+11000
+13000
+10000
+14000
+9000
+11000
+11000
+10000
+10000
+10000
+9000
+11000
+8000
+12000



KIKULETWA No.2 Planned intake dam
K-1
EL. 828.72
ℓ 25.0
KD-1
EL. 822.39
ℓ 20.0
KD-2
EL. 812.41
ℓ 15.0
KD-3
EL. 817.45
ℓ 20.0
KD-4
EL. 825.89
ℓ 20.0
KD-5
EL. 829.69
ℓ 20.0
+14000
+9000
+15000
+8000
+7000
+16000
+8000
+12000
+7000
+13000
+6000
+14000
+5000

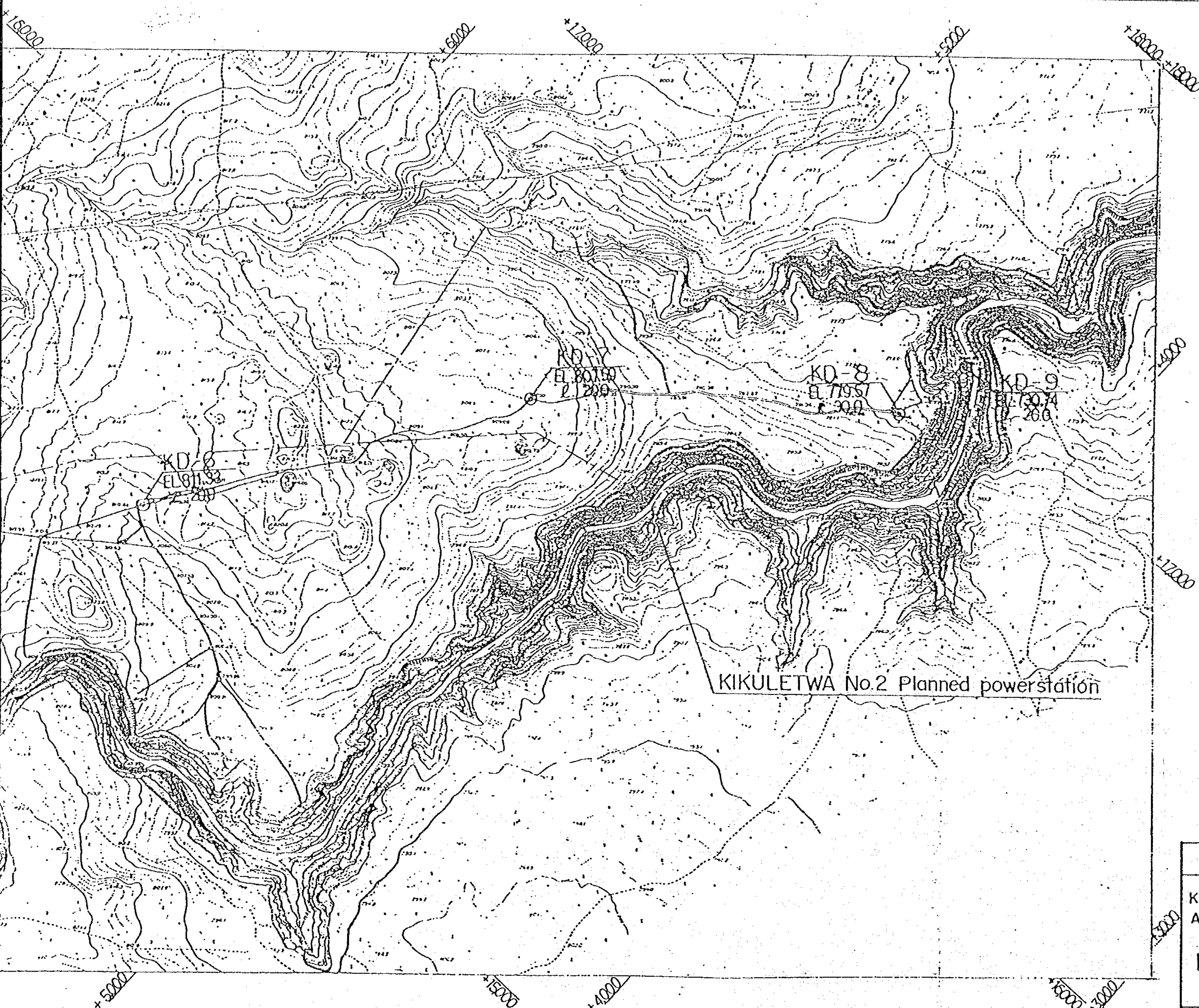


JA

KIKUL
AND

LO

Fi



LEGEND

◎ Drill hole

EL : Elevation (m)

ℓ : Length (m)

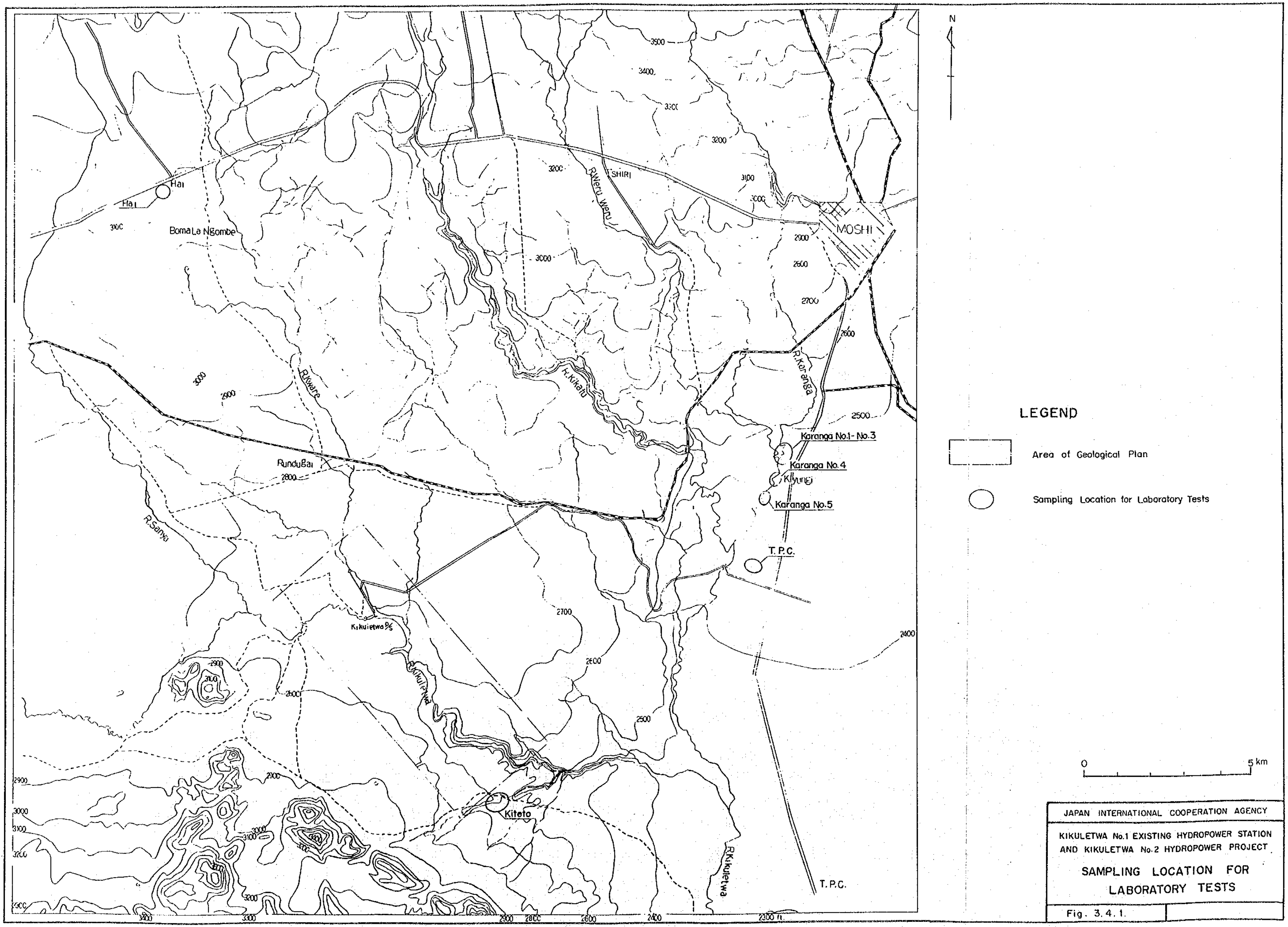
0 500m

JAPAN INTERNATIONAL COOPERATION AGENCY

KIKULETWA No.1 EXISTING HYDROPOWER STATION AND KIKULETWA No. 2 HYDROPOWER PROJECT

LOCATION OF DRILLHOLES

Fig. 3.3.1.



JAPAN INTERNATIONAL COOPERATION AGENCY

KIKULETWA No.1 EXISTING HYDROPOWER STATION AND KIKULETWA No.2 HYDROPOWER PROJECT

SAMPLING LOCATION FOR LABORATORY TESTS

Fig. 3.4.1.

CHAPTER 4
GEOLOGY

CHAPTER 4 GEOLOGY

CHAPTER 4 GEOLOGY

4.1 GENERAL GEOLOGY OF PROJECT AREA

4.1.1 Topography

The nine (9) potential sites are located in the following topographical areas.

- Mt. Kilimanjaro Area : Kikuletwa No. 1, Kikuletwa No. 2, Himo No. 1 and Himo No. 2 potential sites.
- Mt. South Pare Area : Ihindi, Gulutu, Ndungu, Hingilili and Bombo potential sites

The sites in the Mt. Kilimanjaro area are all distributed along the south foot of Mt. Kilimanjaro. The potential sites in the Mt. South Pare Area are on the east slope of the 2000-m high Mt. South Pare.

The topographical conditions of the Mt. Kilimanjaro Area, where the geological investigation work was undertaken for Kikuletwa No. 1 and Kikuletwa No. 2 sites, are described below.

The sites of the Kikuletwa No. 1 Hydropower Station (which would be rehabilitated under the proposed project) and the proposed Kikuletwa No. 2 Hydropower Project are located on a vast plain, which has an elevation of 700 to 800 m, at the south-southwest foot of Mt. Kilimanjaro (EL. 5,895 m). The two sites are approximately 45 km from the peak.

The Himo River, Karanga River, Weru Weru River and Kware River, the sources of which are near the summit, flow down the southern slope of the mountain in a fan-like pattern. These streams ultimately drain into the Kikuletwa River south of the city of Moshi. The Kikuletwa River, after passing the Nyumba Ya Munga Reservior, becomes the Pangani River which empties into the Indian Ocean at Tanga.

Mt. Meru (EL. 4,566 m) is located about 70 km west of Mr. Kilimanjaro, and also has a fan-like pattern of streams flowing down its slope. One of these streams is the main tributary of the upstream portion of the Kikuletwa River.

The Kikuletwa No. 1 and Kikuletwa No. 2 sites are both located in the vicinity of the confluence of the Kware River, flowing from Mt. Kilimanjaro and the Kikuletwa River, flowing from Mt. Meru.

The topographical conditions of the other seven potential sites are described in APP. III.

4.1.2 Regional Geology

The nine (9) potential sites can be broadly divided geologically into the following areas.

- Volcanic Rock Area : Kikuletwa No. 1, Kikuletwa No. 2, Himo No. 1 and Himo No. 2 sites
- Gneissic Rock Area : Ihindi, Gulutu, Ndungu, Hingilili and Bombo sites

Volcanic products of Mt. Kilimanjaro are spread widely over the volcanic rock area; gneissic rocks of the Usangaran System of the Pre-Cambrian Age are distributed widely over the gneissic rock area. The geological conditions in the volcanic rock area, where the geological investigation work was performed for the Kikuletwa No. 1 and Kikuletwa No. 2 sites, are described below.

Radiometric dating of volcanic rocks in Kenya has yielded a value of 13 to 15 x 10^6 years BP, so that Mr. Kilimanjaro's volcanic activity is thought to have started between the Miocene and Pliocene eras. It is thought that the frequency of activity gradually decreased from the Pleistocene to the Holocene eras. In present times, volcanic activity is limited to localized eruption.

Past activity can be divided into three stages, which were respectively involved in forming Kilimanjaro's three main peaks, known as Shira, Mawenzi, and Kibo. Shira, composed predominantly of lava with pyroclastic rocks, is considered the result of the first of these stages. Mawenzi developed at the next stage, with volcanic products - chiefly basaltic lava accompanied by tuff breccia and agglomerate - flowing mainly down Kilimanjaro's southern and eastern faces.

Kibo is the formation of the most recent activity, during which volcanic products were released mainly on the northern and southern sides. The lava of Kibo is divided into the following 10 groups.

Inner Crater Group
Caldera Rim Group
Small Rhomb Porphyry Group
Lent Group
Rhomb Porphyry Group
Upper Rectangle Porphyry Group
Upper Trachyandesite Group
Lower Rectangle Porphyry Group
Lava Tower Trachyte Group
Lower Trachyandesite Group

These lavas mainly consist of volcanic rocks or porphyry such as trachyandesite, trachyte, phonolite, and rhomb porphyry. In addition, a volcanic deposit known as "Lahar" is also present where the Kibo volcanic products are distributed.

The Kikuletwa No. 1 and No. 2 sites are located both in the area of the Kibo volcanic product distribution. For both sites, the volcanic products are of the Rhomb Porphyry Group partially overlayed with Lahar.

A regional geological map* showing Mt. Kilimanjaro, and the Kikuletwa No. 1 and No. 2 sites is provided in Fig. 4.1.1. The geological conditions of the other sites are described in App. III.

* "Geological Map of Kilimanjaro" by Ministry of Industries, Mineral Resources and Power (Geological Survey Division), 1965.

4.1.3 Geology of Kikuletwa No. 1 and No. 2 Project Area

The results of the JICA team's aerial photo interpretation, detailed geological field surveys, and core drillings indicate that the geology of the Kikuletwa No. 1 and No. 2 Project Area may be summarized as follows:

(a) The sub-area upstream of the proposed site for the Kikuletwa No. 2 intake dam. This area includes Kikuletwa No. 1 project area.

(b) The sub-area from the proposed site for the intake dam to the proposed powerhouse site for Kikuletwa No. 2.

(c) The sub-area downstream of the proposed site for the Kikuletwa No. 2 powerhouse.

The topographical differences of these sub-areas are considered to be due to the geologies which formed them. The geologies concerned are those of the Kibo "Rhomb Porphyry Group" and of the "Lahar". The former within the project area, consists of dark grey tuff breccia, with part of the top layer containing limestone. The "Lahar" is itself of reddish brown color; the "Lahar" studied in the surface reconnaissance and core drilling, however, had a high degree of consolidation, and presented the appearance of tuff breccia. This consolidated Lahar contains numerous blocks, which appear to be phonolite characterized by mega-phonocrysts.

In this report, the Rhomb Porphyry Group will be referred to Tuff Breccia (2); and the geology containing Lahar will be referred to as Tuff Breccia (1).

Sub-areas of (a) and (c) are composed of Tuff Breccia (2); sub-area (b) is composed of Tuff Breccia (1).

Origins and Stratigraphies

It is estimated that Tuff Breccia (2) was accumulated in the volcanic activity of Mt. Kilimanjaro and was subsequently subjected in part to the sedimentary environment of limestone. Tuff Breccia (1) is considered to be a secondary deposit of volcanic products and is thought to have covered Tuff Breccia (2) in the form of filling valley topography when flowing down the slopes. In the area studied, the thickness of Tuff Breccia (2) is greatest in the vicinity of the midpoint of the headrace planned for Kikuletwa No. 2, where it is estimated to exceed 50 m.

Hydrogeological Conditions

Springs which flow into the Kikuletwa River are located about 2 km upstream of the existing TANESCO Hydropower Station, in an area of Tuff Breccia (2) distribution. The volume of spring water is comparatively stable throughout the year. This, together with the fact that the existence of confined water has been recognized in Tuff Breccia (2) through core drilling investigations at the Kikuletwa No. 2 intake dam site, downstream of the spring location, make it seem quite likely that some part of the Tuff Breccia (2) layer is an aquifer.

Talus deposits and alluvium are present as unconsolidated deposits overlying the basement rocks. These deposits are either distributed over small areas, or are thinly and widely distributed.

No prominent fault structures, landslides or slope failures have been recognized in the project area.

The geological plan of this project area is presented in Fig. 4.1.2, and the geological logs of all drillholes are shown in Fig. 4.1.3.

4.2 TOPOGRAPHY AND GEOLOGY OF KIKULETWA NO.1 SITE

4.2.1 Topography

Kikuletwa No. 1 Hydropower Station is located adjacent to the existing TANESCO power station, on the left bank of the Kikuletwa River immediately upstream of the confluence of the Kikuletwa and Kware Rivers. The topography of the area from the intake dams on both the Kikuletwa and the Kware to the powerhouse site, is that of a flat table at an elevation of approximately 830 m. A head of approximately 15 m from this tableland to the bed of the Kikuletwa River is used for power generation.

From the intake dams to the powerhouse, the average river gradients are 1/30 for the Kikuletwa River, and 1/110 for the Kware River.

4.2.2 Geology along Canals

The existing Kikuletwa and Kware canals are located in Tuff Breccia (2) interbedded with thin tuff layers and tuffaceous sand layers. The tuff breccia is generally fresh and hard, although slight weathering can be seen near the ground surface. The tuff layers are associated with the tuffaceous sand layers, and the maximum combined thickness of the two is 1.5 m. The two are horizontally distributed only in the upstream area of the Kware Canal. A very thin layer, (less than 1 m), of talus deposits covers these basement rocks.

Geological Engineering Assessment

Judging by the geologies of the canal routes, there seems little possibility of natural water leakage from the rock layers along the canals. Nevertheless, canal repair will probably be necessitated as a result of leakage from bedrock due to scouring, and leakage from embankment due to long-term water flow. The geological profiles of the existing Kware and Kikuletwa canals are shown in Figs. 4.2.1(1-2) and (2-2).

4.2.3 Geology of Powerhouse Site

The powerhouse site consists of a 10-m thick lens of limestone interbedded between Tuff Breccia (2) and Tuff Breccia (1). Core drilling has revealed that both rock masses are fresh and hard, and that except for the limestone lens, there are few cracks. The permeability coefficient of the limestone lens is 10^{-3} cm/sec, but that of the underlying Tuff Breccia (2) is 10^{-5} cm/sec. The groundwater level is found in the limestone lens at EL. 820 m, approximately 3 m above the river-bed elevation.

Unconsolidated deposits consisting of talus deposits and alluvium, cover the basement rocks. These deposits, however, are very thin.

Geological Engineering Assessement

It is believed that Tuff Breccia (2) is distributed at the foundation of the proposed powerhouse site. The Tuff Breccia (2) possesses ample bearing capacity to serve as the foundation rock for the powerhouse. No problems are anticipated in construction of the powerhouse.

As for slope stability in foundation excavation, the bedrock is massive and hard, while unconsolidated deposits are very thin. It, therefore, appears that ample stability can be secured.

The geological section of the power station site is shown in Fig. 4.2.2.

4.3 TOPOGRAPHY AND GEOLOGY OF KIKULETWA NO.2 SITE

4.3.1 Topography

The intake dam and the powerhouse site for the Kikuletwa No. 2 Hydropower Project are located approximately 2 km and approximately 6 km, respectively, downstream of the existing TANESCO power station.

The topography from the intake dam site (including the regulating reservoir area) to the powerhouse site is that of a gently sloped tableland, of elevation from 800 to 840 m. The section from the intake dam site to the powerhouse site excluding the reservoir area shows a predominance of small mounds on the tableland.

The Kikuletwa River flows down the tableland from the intake dam site toward the powerhouse site, gradually descending to form a "V" shaped valley, and meandering slightly. The average river bed gradient in the regulating reservoir area (including the intake dam site) is 1/500. The gradient between the intake dam and powerhouse site is 1/50.

4.3.2 Geology of Regulating Reservoir and Intake Dam Site

The regulating reservoir and intake dam site are composed of Tuff Breccia (1), Tuff Breccia (2) and limestone. The Tuff Breccia (1) thinly overlies the Tuff Breccia (2) almost horizontally, with limestone interbedded at the boundary between the two. The limestone lens is limited to the vicinity of the intake dam site.

All of the bedrocks are generally hard, and except for Tuff Breccia (1) at the surface layer of the right bank of the intake dam, the permeability coefficients are 10^{-4} to 10^{-5} cm/sec. The groundwater level at the intake dam site is EL. 813 m, approximately 2 m above the water surface on both banks of the Kikuletwa River. Unconsolidated deposits, consisting of talus deposits and alluvium overlie the basement rocks. These deposits, however, are extremely thin.

Geological Engineering Assessment

Tuff Breccia (1), comprising the left and right abutments of the intake dam, appears fully satisfactory with regard to bearing capacity and watertightness. A high permeability coefficient of 10^{-3} cm/sec is found on the right-bank. However, the test site was located above the proposed high water level, and does not provide data to determine whether or not watertightness may be endangered.

In regard to the Tuff Breccia (2) in the riverbed of the intake dam, slimy core samples were recovered from long sections, and there remain many unknowns regarding the distribution of fissures and the hardness of the bedrock. However, investigation has clarified the following points.

- The slimy core and rock cores in the same drill hole are of the same petrographical quality. Accordingly, there is little possibility that the slimy cores are unconsolidated deposits such as sand layers.

- According to permeability test results, the Tuff Breccia (2) shows small permeability coefficients of 10^{-4} to 10^{-5} cm/sec, indicating that there are no large leakage seams.

For these reasons, it appears that the Tuff Breccia (2) will satisfactorily serve as the foundation for the intake dam, and as problems will arise.

It should be noted that spring water, of about 5 lit/min, was observed at the top of Drillhole KD-2. Attention will, therefore, be required regarding the handling of this water, during excavation for the dam foundation.

There is no risk of landslide or collapse of the surroundings of the regulating reservoir; nor does there seem to be any geological insufficiency in this respect. Considering the geology and the results of permeability tests at the intake dam site, there also appears to be no problem regarding the watertightness of the regulating reservoir.

The geological section of the intake dam site is shown in Fig. 4.3.1.

4.3.3 Geology along Headrace

The geology along the headrace route is Tuff Breccia (1) overlain at parts by very thin talus deposits of not more than 1 m. So far as ascertained in core drilling, the Tuff Breccia (1) is well-consolidated and hard to a depth of 20 m from the ground surface. Blocks thought to be phonolite, which exist in large numbers in the bedrock, are very hard, and their hardness differs from that of the fine material surrounding them.

For all drill holes, permeability coefficients at depths over 10 m from the ground surface were found to be 10^{-5} cm/sec or less. The groundwater level is highest near the midpoint of the proposed headrace, while it is about the same as or lower than the headrace elevation in the vicinities of the intake dam, located upstream, and the head tank, located downstream.

Geological Engineering Assessment

It is expected that excavated high slopes will be formed at the proposed headrace because of topographical features of the route. The properties of the Tuff Breccia (1) indicate that the cut slopes will be stable. As the headrace route runs through a gently-sloped tableland, there is little risk that of debris and loose soil from the surrounding ground surface will slide into the canal.

If a tunnel were to be proposed for the headrace, however, the following two problems would have to be faced:

- The rock cover to the ground surface is thin for tunnel excavation.

- The midpoint of the tunnel would pass below the groundwater table.

A geological section of the headrace is shown in Fig. 4.3.2

4.3.4 Geology of Penstock and Powerhouse Sites

The geology of the penstock and powerhouse sites consists of Tuff Breccia (1), Tuff Breccia (2), and limestone. The Tuff Breccia (1) overlies the Tuff Breccia (2) more or less horizontally. There is 10-m of limestone interbedded at the boundary.

The Tuff Breccia (1) is well-consolidated, and, at depth of 10-m and more, the permeability is a low 10^{-5} cm/sec. The limestone and Tuff Breccia (2) are hard, but, are also brittle in many places. The groundwater table along the slope is approximately 10 m below the ground surface.

The unconsolidated deposits covering the basement rocks are very thin with talus deposits several tens of centimeters thick observed on the tableland.

Geological Engineering Assessment

Along the penstock route, the basement rocks are of Tuff Breccia (1), limestone, and Tuff Breccia (2). The powerhouse site will be located on Tuff Breccia (2) basement rock. All the rocks here are thought to possess ample bearing capacity. Bedrock is exposed at the penstock slope, and there is no risk that unconsolidated deposits will slide.

The geological sections of the penstock and powerhouse sites are shown in Fig. 4.3.3.

4.4 CONCRETE AGGREGATE

4.4.1 Test Results

The test results are shown in Table 4.4.1 and Fig. 4.4.1 The test items and results are described below.

(1) Classification of Aggregates

The samples subjected to aggregate tests may be broadly classified as follows: pyroclastic materials, such as alkaline-basaltic sand and sand-gravel, which are of Mt. Kilimanjaro volcanic origin and which were taken from R. Karanga, T.P.C., and Hai; and deposits of quartz, feldspar, and limestone, which are of Precambrian sedimentary origin, and which were taken from Nyumba ya Mungu and Kiteto.

(2) Sieve Tests

Silt and clay fines of less than 0.074 mm which were contained in the samples, were washed away, and sieve tests were carried out on the larger sizes, which would actually be used as aggregates. Test results revealed the following:

- The natural materials from borrow pits for fine aggregates at Kiteto (No. 5, No. 7, No. 8, No. 12) and from Nyumba ya Mungu, and the 1/4-inch crushed material of Hai, show very similar gradations.

- The natural materials containing fine and coarse aggregates show a greater value than that of the gradation curve. These materials can be broadly divided into the two groups of R. Karanga (No. 2, No. 1-3 [1] , No. 1-3 [2]) and R. Karanga

(No. 3-3, No. 5-1), T.P.C. (No. 1), the former being higher in coarse material content.

(3) Specific Gravity

Specific gravity figures obtained on samples were 2.60 to 2.73 for Kiteto, 2.71 for Nyumba ya Mungu, 2.54 to 2.57 for Hai, 2.43 to 2.46 for R. Karanga, and 2.52 for T.P.C. The values for the samples collected in R. Karanga and T.P.C. are on the low side, as there was a high content of fines below 0.074 mm.

(4) Absorption

Absorption tests revealed values of 10.7 to 14.2% for fine aggregates (Kiteto, Nyumba ya Mungu, Hai 1/4"), 1.9 to 2.8% for coarse aggregates (Hai 1/2", 3/4", 1"), and 15.2 to 24.1% for mixed materials (R. Karanga and T.P.C.). Thus, for fine aggregates and mixed materials, the values were large.

(5) Abrasion

Abrasion tests of coarse aggregates yielded average values of 22.3 to 24.9% for Hai, and 25.2 to 27.2% for R. Karanga.

(6) Soundness

Soundness tests on fine aggregates yielded values of 4.6% to 7.2% for samples from R. Karanga, and 5.2% for Nyumba ya Mungu - indicating that these materials would strongly resist weathering. Values of 6.4% to 14.1% were found for Kiteto suggesting some slight weakness in weathering resistance.

For coarse aggregates, the values for Hai were 2.3% to 3.2%; the values for R. Karanga were 2.7% to 3.0%. These materials will strongly resist weathering.

(7) Unit Weight and Voids

The results of unit weight and void ratio tests on samples were as follows.

	Unit weight (kg/cu.m)	Void (%)	Remarks
Kiteto	1,942.2 - 1,994.7	24.4 - 26.7	Fine aggregate
Nyumba Ya Mungu	1,890.0	29.2	"
Hai (1/4")	1,698.4	33.6	"
Hai (1/2")	1,542.7	39.0	Coarse aggregate
Hai (3/4")	1,542.7	39.2	"
R. Karanga No. 3	1,739.3	29.8	Fine and coarse materials
R. Karanga No. 5	1,990.5	17.7	"
TPC	2,040.6	18.7	"

(8) Clay Lumps

Tests were performed by two methods: ASTM C 142, for material coarser than 1.2 mm; and BS 812, for material coarser than 0.075 mm.

The test results were as follows.

	ASTM-C142	BS 812	Remarks
Kiteto	1.3 - 2.8	4.1 - 4.6	Fine aggregate
Nyumba Ya Mungu	-	2.5	"
Hai (1/4")	0.7	6.3	"
Hai (1/2")	0.5	-	Coarse aggregate
Hai (3/4")	0.8	-	"
R. Karanga	1.5 - 1.9	20.6	Fine and coarse materials
T.P.C No. 1	1.4	16.9	"

The BS-method tests yielded larger values. The difference between the two methods was particularly large in the case of mixed materials from R. Karanga and T.P.C.

(9) Organic Impurities

Tests of samples from Kiteto and Nyumba ya Mungu produced light yellow colors close to the standard; samples from R. Karanga and T.P.C., however, showed dark brown. This indicates that the latter samples contain large quantities of organic impurities.

(10) Crushing Test

Crushing tests yielded values of 22.0% for the Hai samples, and 15.0% for the R. Karanga samples.

(11) Alkali-Aggregate Reactivity

Alkali-aggregate reactivity was tested by Tanzanian Standards (TZS 58). The test results indicated that fine aggregates of 5 mm and under T.P.C., Hai, and R. Karanga were slightly high in reactivity when compared with other samples. However, all the coarse and fine aggregates tested were within the allowable limits.

(12) Concrete Tests

Tests on fresh concrete and hardened concrete were performed on the aggregate combinations shown in Table 4.4.2

Table 4.4.2 COMBINATION OF AGGREGATES

Coarse aggregate	Hai (1/2 + 1")	Hai (1/2 + 1")	Karanga	Hai (3/4 + 1")
Fine aggregate	Kiteto	Nyumba ya Mungu	Karanga	T.P.C.

(a) Tests on Fresh Concrete

Tests on fresh concrete were performed for slump, compaction value, air pore content, and density. The test results are given in Table 4.4.3.

Table 4.4.3 RESULTS OF TEST FOR FRESH CONCRETE

Aggregates in concrete	KITETO/HAI Values for:		NYM/HAI Values for:		KARANGA Values for:		TPC/HAI Values for:	
Test	Fresh Concrete	Mix Design	Fresh Concrete	Mix Design	Fresh Concrete	Mix Design	Fresh Concrete	Mix Design
WORKABILITY:	medium	medium	medium	medium	medium	medium	medium	medium
-Slump mm*1	36	30-60	39	30-60	40	30-60	34	30-60
-Compaction value*2	1.11	1.1-1.24	1.12	1.1-1.25	1.12	1.1-1.25	1.13	1.1-1.25
AIR PORES%*3	3.0	1.5	2.4	1.5	1.8	1.5	2.0	1.5
DENSITY t/m^3	2.37	2.32	2.43	2.33	2.24	2.42	2.36	2.29

*1: BS 1818 *2: BS 1048 *3: BS 1881

(b) Tests on Hardened Concrete

Compressive strength tests were carried out for hardened concrete. The results are given in Table 4.4.4.

Table 4.4.4 RESULTS OF TEST FOR HARDENED CONCRETE

AGGREGATES IN CONCRETE	MEAN COMPRESSIVE STRENGTH (N/mm^2) After 7 days		After 28 days	
	Measured	Target	Measured	Target
KITETO/HAI	20.2	19.0	26.9	31.6
NYM/HAI	18.4	19.0	28.2	31.6
KARANGA	8.6	19.0	15.9	31.6
TPC/HAI	19.0	19.0	27.1	31.6