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KAJAKAI

110KV TRANSMISSION LINE STUDY
AND
REVISED COST COMPARISON OF
TRANSMISSION LINE VOLTAGE ALTERNATES

April, 1971

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This report incorporates the results of a study made in response to the request contained in the letter dated February 15, 1971, from Mr. Hamidullah Hamid, General President of Da Afghanistan Breshna Moassessa, to International Engineering Company, Inc. Its purpose is twofold:

- To investigate the technical feasibility of using 110 kV for transmission of Kajakai power to the Lashkar Gah-Girishk area and to Kandahar and, if feasibility is proven, to determine the necessary conditions for successful operation under increasing loads. These conditions include the location of the substation serving Lashkar Gah/Girishk, the number, routing, and timing of 44 kV circuits terminating at that substation, the quantity of shunt capacitance, transformer tap settings and bus voltages.

- To revise the cost comparison between alternate transmission voltages and transmission schemes. The latest previous comparison is part of a report entitled PRELIMINARY PLANS KAJAKAI HYDROELECTRIC POWER PLANT, issued in May 1970. Since that time three concepts have changed, resulting in a significantly changed basis for evaluation. These concepts are: first, the direct route from Kajakai to Kandahar has been abandoned and all transmission schemes under consideration use the same route; second, the high voltage substation serving Lashkar Gah/Girishk has been moved from Girishk to a nearby location on the Kajakai-Kandahar line, thereby eliminating the 20 km high voltage tap

which was part of all previous schemes; third, application of switchable shunt capacitors at the load substations makes possible the transmission of over 50 MW on a single 110 kV circuit and over 100 MW on a single 161 kV circuit. These line capacities and the feasibility of the substation location mentioned above are established by the 110 kV transmission line study described herein and the 161 kV transmission line study which was the subject of the February, 1971 report.

Consistent with its twofold purpose, this report is divided into two parts: Part I is concerned with a technical evaluation of the 110 kV transmission voltage, similar to the previous study on 161 kV; Part II is concerned with the economic comparison of a number of transmission schemes involving one or more of three voltages: 110 kV, 161 kV and 220 kV.

PART I: 110 KV TRANSMISSION LINE STUDY

SUMMARY AND CONCLUSIONS

The purpose of the 110 kv transmission line study is to determine:

1. The feasibility of using 110 kV for transmission of Kajakai power and, if feasibility is proven:
2. The transmission capacity per circuit.
3. The quantity of shunt capacitance required as a function of the load.
4. Whether the new stepdown substation serving Lashkar Gah/Girishk can be located at a point called the Junction, where the Kajakai-Kandahar line turns east, approximately 2 km north of the Herat-Kandahar road, with 44 kV feeders to the load centers; or whether the substation should be located closer to the load centers and connected to the Kajakai-Kandahar line with a 110 kV tap.
5. The number, routing and timing of 44 kV circuits terminating at the above substation.
6. Transformer tap settings and bus voltages as the load is varied from minimum to maximum.

To investigate these questions, digital computer load flow calculations were made for system loads as given in the USAID letter of November 11, 1970, as given in the ABM letter of December 21, 1970, and as given by increasing the loads proportionately up to the practical capacity of two 110 kV circuits, which is approximately equal to that of one 161 kV circuit. The calculations culminated in 19 load flow cases which represent realistic operating conditions.

An evaluation of the data from these cases leads to the following conclusions:

- By applying switchable shunt capacitors at the load substation low voltage buses and by making use of standard transformer fixed taps, 110 kV can be used for transmission of Kajakai power to Lashkar Gah/ Girishk and to Kandahar. To transmit the full output of the Kajakai power plant at stage IA (2 machines, 33 MW total generation) one circuit and 6 MVA of shunt capacitance at Kandahar are required; for full Phase I output (3 machines, 50 MW) one circuit and 18 MVA capacitance at Kandahar and 3 MVA capacitance at Lashkar Gah are required. For higher loads, two circuits and the levels of capacitance given on Table 1 are needed.

- The Junction is an acceptable location for the Lashkar Gah/Girishk substation from an operational standpoint. Since this is the most economical location (it involves the least length of high voltage 110 kV line), it is not necessary to investigate the technical feasibility of installing this substation at other locations.

- A 44 kV tie from Girishk to the Junction substation should be installed when the demand at Girishk reaches about 3 MW.

- A second 44 kV circuit between Lashkar Gah and the Junction substation should be installed when the demand at Lashkar Gah reaches 13 MW.

- Transformer fixed taps should be set as shown on Table 1.

- Comparison of 110 kV with 161 kV and 220 kV on the basis of system performance under normal conditions leads to the conclusion that the three are very nearly equal. The choice of voltage therefore depends on an economic evaluation as presented in detail in Part II.

On succeeding pages 7 through 13 there is a general discussion of the load flow work followed by a description of individual cases. Pages 14 and 15 are respectively a plan and single line diagram of the network studied and Table 1, which is a summary of load flow data, is on page 16. On Appendix pages B 1 through B 76 are reproduced the computer results.

General

For the 110 kV transmission voltage to be feasible for this application it must be capable of transmitting some minimum power level from Kajakai to the load centers at Kandahar, Lashkar Gah and Girishk with acceptable bus voltages and transmission system losses. This minimum power level for a single circuit is taken to be the output of the power plant at the completion of Phase I of its development (50 MW+). Two circuits should be capable of transmitting Kajakai Phase II generation (110 MW+, the capacity of one 161 kV circuit) and, by extension, three circuits should be capable of transmitting the ultimate plant capacity (150 MW+, the capacity of one 220 kV circuit).

To test the 110 kV transmission voltage on the basis of these criteria and to investigate the other questions listed on page 4, a series of digital computer load flow calculations was made on the network consisting of the Kajakai power plant, the high voltage (110 kV) transmission line(s), the load centers at Kandahar, Lashkar Gah and Girishk and associated 44 kV feeders, under increasing loads up the the practical limit of two high voltage circuits.*

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*The capacity of two circuits as determined from this load flow study is in the order of 110 MW, which is almost equal to the 115 MW temporary overload capability of the Kajakai power plant at the completion of Phase II of its development. At greater loads than this (see Case 9T, on Table 1 on Page 15 and as described below) the power angles are good but the voltage at Kandahar is extremely sensitive to the power factor of the load. Since shunt capacitors are switched in discreet steps, they would not provide adequate control over the receiving end voltage. For greater power transfer over these two circuits, either a generator or a synchronous condenser is required at Kandahar.

In Cases 1 and 2, without the tie to Girishk, and Cases 1T and 2T, with the tie, the loads assumed are those given in the USAID and ABM letters, respectively. In subsequent cases the loads are increased in even increments of the ratings of the generators at Kajakai (see columns 5 and 9 of Table 1). The load distribution among the three load centers is assumed to continue in approximately the same proportion: Lashkar Gah demand is 1-1/2 times Girishk demand and the Kandahar demand is three times the sum of the other two substations.

In all cases 477 MCM ACSR is assumed for the 110 kV line conductor and 266.8 MCM ACSR is assumed for the conductor of the new 44 kV lines.

The operating conditions considered acceptable are as follows:

1. Voltage - Receiving substation voltages may vary from 95% to 105% of the rated value (110 kV, 44 kV and 13.2 kV). For the protection of the equipment, voltages may not exceed 105% of rate value, except on the high voltage side of the Kajakai step-up transformers, which have 5% above-rated voltage taps. The upper limit here is 105% of the tap rating (i.e., 1.05 x 1.05 = 110% of 110 kV) in accordance with NEMA standard C57.12.00, Section 2.4. The minimum voltage at the Kajakai generator terminals is limited to 90% of rated value because of the necessity of maintaining adequate voltage to the plant auxiliaries.

2. Equipment Loading - Transformer capacity is added when the loading exceeds the rating of the installed equipment. The generators are loaded to their rating for 80°C temperature rise (115% of rated capacity at 60°C temperature rise).

3. The transformer fixed taps used to provide acceptable voltages at peak load may cause over-voltages at minimum load. Therefore, for each incremental peak load which requires a change in tap setting, a minimum load case is investigated. The minimum loads are assumed to be 10% of the peak loads. In all minimum load cases it is assumed that only one generator is on line at Girishk.

To produce acceptable operating conditions the following system parameters are controlled:

1. The Kajakai generator terminal voltage is varied between 103% to 105% under peak load to from 95% to 92% under minimum load to maintain acceptable voltages at the receiving substations. In practice this would be done either by manually adjusting the voltage regulator rheostats at Kajakai upon receipt of voltage information from Kandahar or automatically by means of Load Drop Compensators connected to the Kajakai voltage regulators.

2. Transformer fixed taps are adjusted. Since the transformer must be de-energized to make this change, it is assumed that the taps can be modified to conform with peak load changes from one year to the next

but not to conform to the change in load that occurs from minimum to peak within any given year.

3. Shunt capacitance is added as required to reduce the transmission of reactive power, thereby limiting the voltage drop in the transmission system. This capacitance is switched on and off incremently to conform with the requirements of the daily load cycle.

4. Transmission capacity in the form of a 44 kV tie from the Junction substation to Girishk and a second 44 kV circuit from the Junction substation to Lashkar Gah are added when needed.

Pertinent data on each load flow case is given on Table 1. The significance of individual cases is briefly explained below.

Load Flow Case 1 (Appendix pages A1-A4)

Load Flow Case 2 (Appendix pages A9-A12)

Load Flow Case 3 (Appendix pages A17-A20)

These cases investigate the network without the tie from the Junction substation to Girishk. Case 1 is based on the loads projected for 1975 in the USAID letter and Case 2 is based on the 1967 Beck Report projection for 5 years subsequent to Kajakai construction (recommended in the ABM letter). Case 3 represents loads corresponding to 100% loading of two generators at Kajakai.

From the appendix pages and from the summary on the table, it is seen that conditions are acceptable in Cases 1 and 2. In case 3, however, the voltage at Girishk (Column 33) is excessively low. Since the Kajakai generator voltage (Column 28) is at its upper limit and the Kajakai and Junction transformer taps (Columns 13 and 15, respectively) are set to produce the highest voltages at the load substations, these parameters cannot be further adjusted improve the voltage at Girishk.

Load Flow Case 1T (Appendix pages A21-A24)

Load Flow Case 2T (Appendix pages A29-A32)

Load Flow Case 3T (Appendix pages A37-A40)

These cases are analagous to Cases 1,2, and 3, above, except that a 44 kV, 13 mile tie between the Junction substation and Girishk has been installed. It can be seen that all the voltages are within acceptable limits.

This tie therefore solves the low voltage condition at Girishk shown in Case 3, above. Because this circuit provides a second path for Kajakai power to the entire Lashkar Gah-Girishk area, it increases the reliability of supply to these loads. It may therefore be advisable to install this tie before the time required as indicated by the load flow study.

Load Flow Case 4T (Appendix pages A45-A48)

Load Flow Case 5T (Appendix pages A49-A52)

Load Flow Case 6T (Appendix pages A57-A60)

Load Flow Case 7T (Appendix pages A65-A68)

Load Flow Case 8T (Appendix pages A69-A72)

Load Flow Case 9T (Appendix pages A73-A76)

These cases continue the investigation of network performance as loads are progressively increased. Operating conditions are acceptable through Case 9T, which represents Kajakai generation at close to the maximum capability of Phase II development. Load flow calculations with greater loads were made, but, as stated above, the voltage at Kandahar becomes very sensitive to the power factor of the load (and/or the amount of shunt capacitance connected). Therefore, we consider this a conservative loading limit.

Three points indicated on the table are worthy of note:

1. As the loading is increased, transformer capacity is added and changes are made in the transformer taps.

2. Starting with Cases 3 and 3T, shunt capacitance is added at the loads.

3. When the Lashkar Gah load reaches 14 MW, Case 7T, a second circuit is required from that substation to the Junction substation.

Load Flow Case 1A (Appendix pages A5-A8)

Load Flow Case 2A (Appendix pages A13-A16)

Load Flow Case 1TA (Appendix pages A25-A28)

Load Flow Case 2TA (Appendix pages A33-A36)

Load Flow Case 3TA (Appendix pages A41-A44)

Load Flow Case 5TA (Appendix pages A53-A56)

Load Flow Case 6TA (Appendix pages A61-A64)

These are the minimum load cases corresponding to the peak load cases having the same numbers. They indicate that the transformer fixed tap settings required for acceptable voltages under peak load conditions do not produce excessive over-voltages under minimum load conditions.

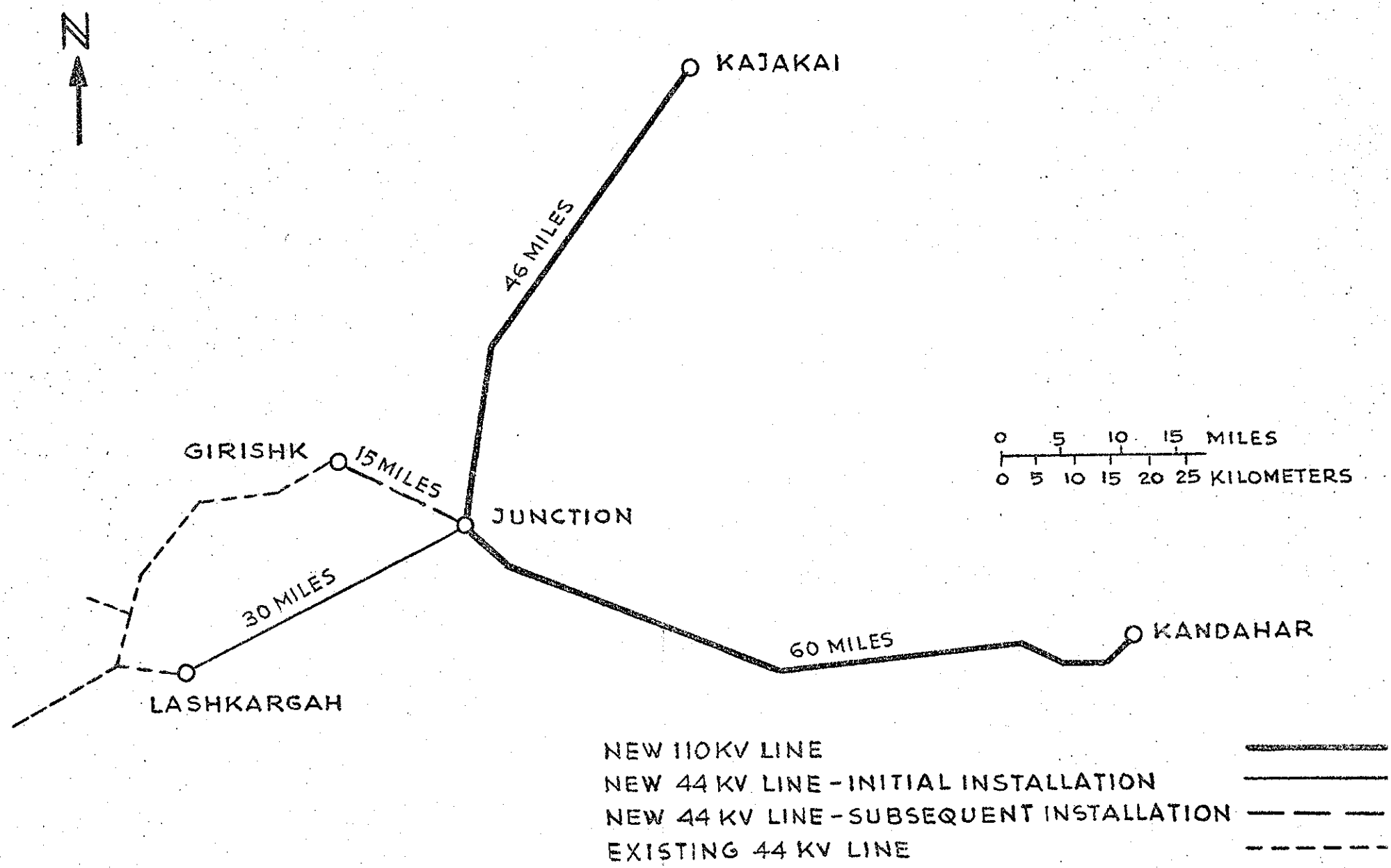

FIGURE 1 : KAJAKAI TRANSMISSION SYSTEM PLAN

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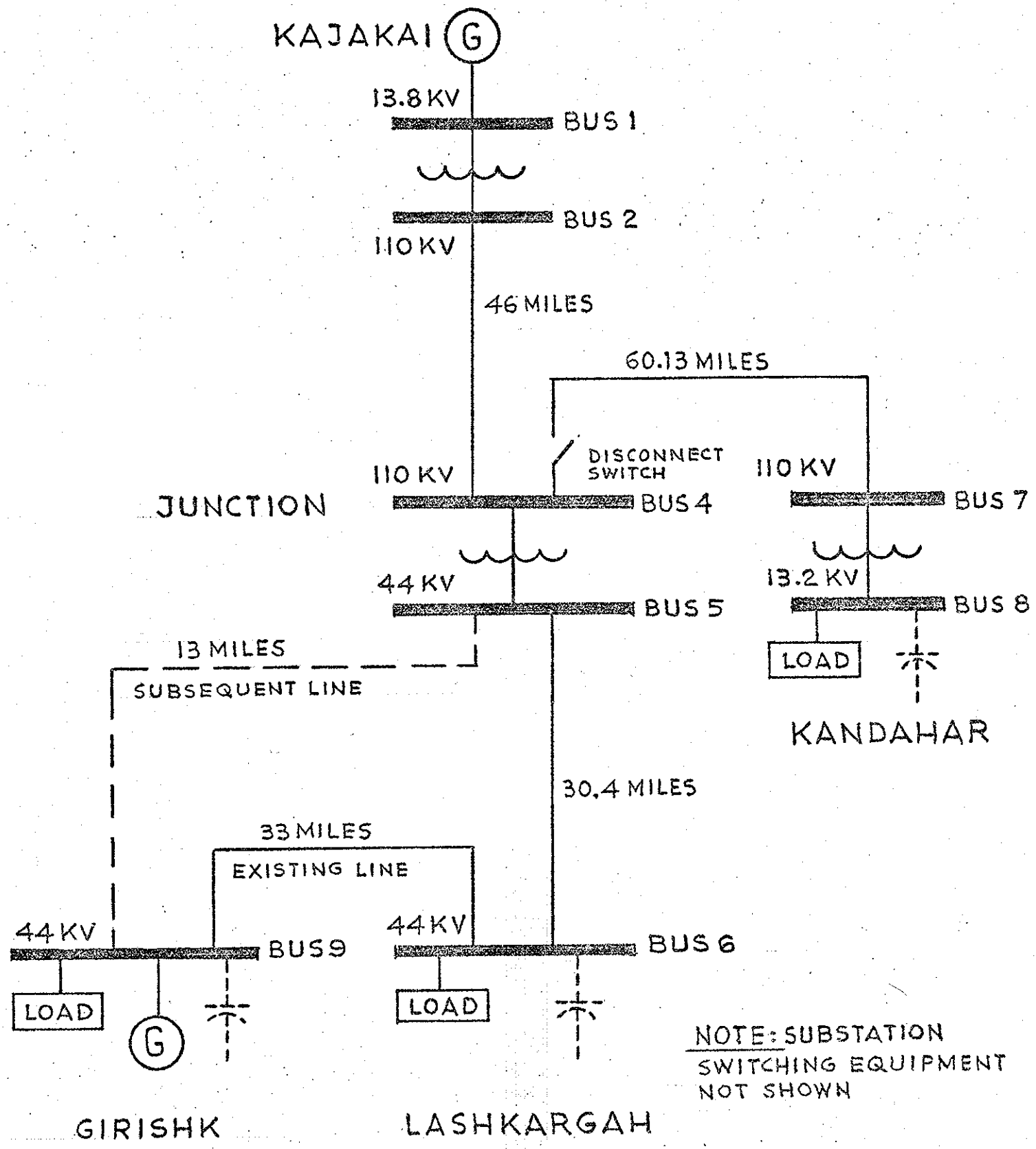

FIGURE 2 : KAJAKAI TRANSMISSION SYSTEM SIMPLIFIED SINGLE LINE DIAGRAM

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CASE	PRINTOUT NO FW	PRINTOUT DATE 1971	NO 110KV CTS	GEN UNITS	K A J A K GENERATING CAPACITY MW	MVAR	MVA	GEN % CAPACITY	ACTUAL GENERATION MW+MVAR
1	2	3	4	5	6	7	8	9	10
WITHOUT JUNCTION - GIRISHK TIE									
1	560	3-15	1	2				60	17.72+6.43
1A			1	2				6	0.80-5.49
2			1	2				80	25.20+14.16
2A			1	2				8	1.46-5.06
3	560	3-15	1	2	33.00	24.75	41.25	100	32.53+15.75
WITH JUNCTION - GIRISHK TIE									
1T	560	3-15	1	2				60	17.72+6.26
1TA			1	2				6	0.78-6.18
2T			1	2				80	25.17+13.92
2TA			1	2				8	1.44-5.59
3T			1	2	33.00	24.75	41.25	100	32.36+15.20
3TA			1	2				10	2.09-5.33
4T			1	3	49.50	37.12	61.87	100	49.90+18.46
5T			2	5				60	59.07+12.82
5TA			2	5				6	4.68-9.96
6T			2	5				80	81.55+30.25
6TA			2	5				8	6.63-8.09
7T			2	5	99.50	74.62	124.37	100	102.29+37.35
8T			2	5				105	107.87+35.93
9T	560	3-15	2	5				110	113.25+31.17

NOTES :

1. LASHKARG AND GIRISHK LOADS PE
2. LASHKARG AND GIRISHK LOADS PE
3. SHUNT CAPACITANCE ADDED ON TH
4. SECOND LINE ADDED FROM BUS 5 TC

A	I		JUNCTION		KANDAHAR				
P.F.	TRANSFORMER		TRANSFORMER		TRANSFORMER		LOAD 0.85 P.F. MW + MVAR	SH. CAP. MVAC	
	CAPACITY MVA	TAP SETTING	CAPACITY MVA	TAP SETTING	CAPACITY MVA	TAP SETTING			
11	12	13	14	15	16	17	18	19	
0.940	54/72	1.050	7.5/9.375	1.000	21/28	1.000	14.40+8.92		
0.144				1.000		1.000	1.44+0.89		
0.872				0.975		0.950	19.20+11.90		
0.277				0.975			1.92+1.19		
0.900	54/72	1.050	7.5/9.375	0.950	21/28	0.950	24.00+14.87	6.0	
0.943	54/72	1.050	7.5/9.375	1.000	21/28	1.000	14.40+8.92		
0.125						1.000	1.44+0.89		
0.875						0.950	19.20+11.90		
0.250				1.000			1.92+1.19		(
0.904				0.975			24.00+14.87	6.0	5
0.364			7.5/9.375		21/28		2.40+1.49		C
0.938	54/72		15/18.75		42/56	0.950	36.00+22.31	18.0	7
0.977	108/144					0.975	43.20+26.80	18.0	9.
0.425			15/18.75		42/56	0.975	4.32+2.68		0
0.937			22.5/28.12		63/84	0.950	57.60+35.70	19.5	12.
0.633							5.76+3.57		1.
0.939							72.00+44.62	39.0	14.
0.949							75.60+46.90	42.0	14.
0.964	108/144	1.050	22.5/28.12	0.975	63/84	0.950	79.20+49.10	48.0	15.

ER LETTER OF USAID (NOV. 11 1970)
ER LETTER OF ABM (DEC. 21 1970)
115 AND SUCCEEDING CASES WITH GREATER LOADS
) BUS6 (JUNCTION-LASHKARGAH)

AR		LASHKARG		GIRISHK			ACTUAL GENERATION TOTAL KAJAKAI+GIRISHK MW + MVAR
LOAD 0.85 P.F. W + MVAR	SH. CAP. MVAC	LOAD 0.85 P.F. MW + MVAR	SH. CAP MVAC	ACTUAL GENERATION MW + MVAR	LOAD 0.85 P.F. MW + MVAR	SH. CAP MVAC	
18	19	20	21	22	23	24	25
.40+8.92		3.00+1.86		2.40+1.80	2.00+1.24		20.12+8.23
.44+0.89		0.30+0.19		1.20+0.34	0.20+0.12		2.00-5.15
.20+11.90		4.12+2.55		2.40+1.80	2.75+1.70		27.60+15.96
.92+1.19		0.41+0.26		1.20+0.46	0.28+0.17		2.66-4.60
.00+14.87	6.0	5.15+3.18	—	2.40+1.80	3.44+2.12	—	34.93+17.55
.40+8.92		3.00+1.86		2.40+1.80	2.00+1.24		20.12+8.06
.44+0.89		0.30+0.19		1.20+0.90	0.20+0.12		1.98-5.28
.20+11.90		4.12+2.55		2.40+1.80	2.75+1.70		27.57+15.72
92+1.19		0.41+0.26		1.20+0.90	0.28+0.17		2.64-4.69
.00+14.87	6.0	5.15+3.18	—	2.40+1.80	3.44+2.12	—	34.76+17.00
.40+1.49		0.52+0.32		1.20+0.90	0.34+0.21		3.29-4.43
.00+22.31	18.0	7.20+4.47	3.0	2.40+1.80	4.80+2.97	—	52.30+20.26
.20+26.80	18.0	9.00+5.58	3.0	2.40+1.80	6.00+3.72	—	61.47+14.62
32+2.68		0.90+0.56		1.20+0.90	0.60+0.37		5.88-9.06
60+35.70	19.5	12.00+7.44	7.2	2.40+1.80	8.00+4.96	2.4	83.95+32.05
76+3.57		1.20+0.74		1.20+0.90	0.80+0.50		7.83-7.19
00+44.62	39.0	14.00+8.68	6.0	2.40+1.80	9.60+5.95	2.4	104.69+39.15
60+46.90	42.0	14.70+9.11	8.1	2.40+1.80	10.08+6.25	5.1	110.27+37.73
20+49.10	48.0	15.42+9.55	9.0	2.40+1.80	10.56+6.55	6.0	115.65+32.97

ADS

TABLE 1

SUMMARY OF LOAD FLOW STUDY

110/44 KV.

YSTEM LOSS		PER UNIT BUS VOLTAGES								NOTES
		KAJAKAI		JUNCTION		LASH.	GIR.	KANDAHAR		
MW	% GEN.	B1 LV	B2 HV	B4 HV	B5 LV	B6	B9	B7 HV	B8 LV	
26	27	28	29	30	31	32	33	34	35	36
0.72	3.6	1.030	1.072	1.042	1.033	1.010	1.029	1.000	0.965	NO.1
0.06	3.0	0.930	0.984	0.994	1.001	1.009	1.040	0.995	0.992	NO.2
1.53	5.5	1.050	1.083	1.032	1.035	0.990	0.983	0.971	0.974	
0.05	1.9	0.920	0.973	0.982	1.013	1.021	1.050	0.981	1.028	
2.34	6.7	1.050	1.081	1.023	1.039	0.972	0.939	0.961	0.971	NO.3
0.72	3.6	1.030	1.072	1.043	1.035	1.010	1.036	1.001	0.965	NO.1
0.04	2.0	0.930	0.985	0.997	1.010	1.010	1.016	0.998	0.995	NO.2
1.50	5.5	1.050	1.083	1.033	1.011	0.974	1.008	0.971	0.975	
0.03	1.1	0.920	0.974	0.984	0.996	0.995	1.001	0.983	1.031	
2.17	6.3	1.050	1.081	1.025	1.016	0.968	1.009	0.963	0.974	NO.3
0.03	0.9	0.930	0.984	0.993	1.029	1.027	1.034	0.990	1.037	
4.30	8.2	1.050	1.077	1.007	1.016	0.964	1.003	0.939	0.973	
3.27	5.3	1.040	1.082	1.046	1.046	0.977	1.026	1.009	1.014	
0.06	1.0	0.950	1.004	1.012	1.041	1.036	1.044	1.010	1.031	
6.35	7.6	1.050	1.081	1.022	1.035	0.959	1.015	0.956	0.980	
0.07	0.9	0.930	0.982	0.986	1.013	1.004	1.015	0.983	1.030	
9.09	8.7	1.050	1.077	1.006	1.007	0.950	0.979	0.939	0.971	NO.4
9.89	9.0	1.050	1.078	1.008	1.022	0.972	1.002	0.938	0.969	
0.47	9.1	1.050	1.081	1.016	1.033	0.985	1.016	0.953	0.991	

PART II: REVISED COST COMPARISON OF TRANSMISSION LINE VOLTAGE ALTERNATES

Because of the changes in basic design concepts described on page 1, the transmission line costs given on Table VIII-2 of PRELIMINARY PLANS KAJAKAI HYDROELECTRIC POWER PLANT are no longer applicable. A revised set of costs is needed to provide a valid comparison and to make possible an economic analysis based on the latest design concepts. The detailed studies just completed of the 110 kV and 161 kV transmission voltages provide the necessary data on circuit capacities and equipment ratings for cost estimates of these alternates. The equivalent data for the 220 kV alternate was derived by extrapolation of data from these studies and from our experience with this voltage on other applications.

If the transmission line and substations are financed with a loan whose interest rate is less than 3%, price escalation of equipment with time will exceed the discount rate and no advantage is gained by deferring expenditures. The lowest cost for the project results from the maximum initial investment. Therefore, the decision on making an incremental initial investment beyond the minimum necessary should be based on the optimum allocation of available investment funds between alternate projects. The optimum allocation is the one which yields the highest overall rate of return. Estimated rates of return on incremental initial investments in this project have been calculated for various price escalation and load growth rates. These rates of return can be compared with rates of return on investments in other projects to provide a basis for a decision on whether or not to provide more than the minimum capacity for initial operation.

The price escalation rates assumed were 0%, 3% and 5%. Load growth rates were 5% and 8%. We recommend a price escalation value of 3% and a load growth rate of 5% for use in the economic analyses of this project.

To transmit the ultimate capacity of the Kajakai powerplant (150 MW +) to the Lashkar Gah-Girishk area and to Kandahar, there are three feasible alternates: (1) three 110 kV circuits, (2) one 110 kV circuit and one 161 kV circuit, (3) one 220 kV circuit. The operating performance of the three alternates under normal conditions is very similar. Assuming that the Kajakai plant will eventually be developed to 150 MW and that this power will be transmitted to Lashkar Gah/Girishk and Kandahar, the choice between transmission alternates is therefore an economic one.

Based on an economic analysis of the above transmission alternates, we come to the following conclusions:

- If the highest rate of return on an alternate project of equal risk which requires financing is less than 4½%, the transmission line should be 220 kV.
- If the highest rate of return on the above alternate project lies between 4½% and 7%, the line should be 161 kV.
- If the highest rate of return on the above alternate project is greater than 7%, the line should be 110 kV on single circuit towers.

On succeeding pages 21 through 28, there is a more detailed exposition of the theory behind the economic analysis of the transmission alternates and the assumptions made regarding price escalation and load growth, a technical description of the transmission alternates, and an analysis of

the calculated rates of return on incremental investments. Figures 3, 4 and 5, pages 29 through 31, are single line diagrams of the transmission alternates for Kajakai Phase IA output. Table 2, a listing of the relevant cost components of each transmission alternate, is contained on pages 32 through 35. Table 3 on pages 36 and 37 shows the derivation of the rates of return on incremental investments. Figure 6, page 38, shows the load growth curves used in the rate of return calculations.

Because of the time value of money, it is often advantageous to defer the installation of certain project features or production capacity until those features or that capacity are required. Deferred installation may entail significantly increased cost due to the added cost inherent in more than one construction period, due to foregoing economy of scale, * and due to price escalation. Nevertheless, it may be economically justifiable because the higher future cost, when discounted at the interest rate applicable to the project, may be less than the equivalent initial cost. If there are two or more methods for developing a project which are equal in terms of performance, the method having the lowest sum of initial plus discounted future costs is chosen. Note that all costs applicable to the ultimate development of the project must be included.

However, if the transmission line and substations are to be financed at an interest rate of 3% or less, the cost increase of equipment with time due to price escalation is greater than the discount rate, hence it is not advantageous to defer investment. Instead, the lowest cost for this project will result from the maximum initial investment. Is it therefore justified to make the incremental investment over the minimum required for transmission capacity for delivery of Kajakai Phase I output ($3.5 million) to the minimum required for Kajakai Phase III output ($5.7 million)? If investment to provide capacity for Phase III output is not justified, is any incremental investment over the minimum required for Phase I or Phase IA output justified?

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* Economy of scale is the reduction in the per unit cost of a product due to increased production unit capacity. For instance, the cost per kilowatt generated by one 100 MW unit is less than the cost per kilowatt generated by four 25 MW units; the cost per megawatt of power transmitted by one 161 kV circuit is less than the cost per megawatt of power transmitted by two 110 kV circuits.

The answer to these questions is based on the optimum allocation of available investment funds between alternate projects. The optimum allocation is the one which yields the highest overall rate of return. Therefore, to evaluate the desirability of an incremental investment on this project, its rate of return should be compared with projected rates of return for other projects of approximately equal risk. For instance, if the 161 kV and double circuit 110 kV alternates had been eliminated for technical or other reasons, would investment in a 220 kV line be justified, or should a minimum investment be made consisting of a single 110 kV line followed by additional 110 kV lines as needed to meet the loads? Assuming annual rates of load growth and price escalation to be 5% and 3% respectively, the rate of return on the incremental investment in the 220 kV alternate ($5.7 million - $3.5 million = $2.2 million) is 5.4%. If there is another equally low risk project requiring investment funds (for instance, electric power development in some other area of the country) whose rate of return is greater than this, the money should be spent on that project. Conversely, if such a project does not exist, the incremental investment in this project is justified.

The rate of return on incremental investments in this project depends on the rate of price escalation and the rate of load growth. Since an accurate prediction of the rate of price escalation is impossible, rates of return were calculated for three values: 0%, 3% and 5%. Unless there are cost records in Afghanistan which lead to a different conclusion, we

recommend 3% for evaluating alternates on this project.* Likewise, the rate of growth in demand for electric power is uncertain. Therefore, investment rates of return calculated herein are based on two growth rates represented by the curves on Figure 6. For the next ten years the demand is assumed to increase as forecasted in the 1967 Beck Report. Thereafter, demand is increased at compound annual rates of 5% and 8%. Although 8% is not a high rate for a developing country undergoing electrification, the recent records indicating that the Beck forecast may be somewhat optimistic favor the 5% assumption.

All the transmission alternates considered herein use the same route, i.e. south from Kajakai along the Helmand River to a point about 2 km north of the Herat-Kandahar road, from whence it turns east and runs parallel to the road to Kandahar, a total distance of 106 miles. The Junction substation serving the Lashkar Gah-Girishk area is located at the turning point.

Tables 2A, 2B, 2C and 2D present cost estimates for transmission of Kajakai phase IA, phase I, phase II and phase III power, respectively, at the three voltage levels considered. Only the high voltage system components whose cost is a function of this voltage are included. Where a circuit of a given voltage has capacity for more than one phase of Kajakai output, the incremental cost of the highest phase for that voltage over the lower phases is due to differences in transformation capacity. For instance, the difference in cost between Alternate 161-II (Table 2C)

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* Price escalation in the Western United States between January 1960 and January 1971 averaged 3.3% for 230 kV steel tower transmission lines and 3.2% for switchyards and substations (from U.S. Bureau of Reclamation records quoted in ENGINEERING NEWS-RECORD).

and 161-I (Table 2B) is due to added transformers at Kajakai, the Junction and Kandahar. The cost of shunt capacitance required as indicated by the load flow studies for the 110 kV and 161 kV and as estimated for the 220 kV is included. The cost of shunt reactance and transfer tripping of circuit switchers for overvoltage protection (essential for safe operation of the line at 220 kV) are included in the 220 kV costs.

The costs of five transmission alternates are estimated for Phase IA (33 MW generation). From a comparison of the totals on Table 2A, the following conclusions can be drawn:

- Circuit voltage, transmission capacity and cost vary together. The capacities of the 161 kV and 220 kV circuits are respectively twice and three times that of the 110 kV single circuit. The costs are respectively 27% and 65% higher.
- The capacity of two 110 kV circuits (Alternate 110B-IA) is the same as that of one 161 kV circuit (Alternate 161-IA), but the cost is considerable higher. Therefore the 161 kV is preferable on the basis of cost. Examination of the applicable single line diagrams, pages 29 and 30, shows the 110 kV to have somewhat more than 50% capacity in the event of failure of one circuit on either line section (Kajakai - Junction and Junction-Kandahar) whereas failure of any portion of the 161 kV circuit would result in complete loss of load at Kandahar. On the other hand, the additional switching and control equipment of this alternate over the 161 kV would result in more frequent equipment failures. Taking both these factors into consideration, we conclude that the 110 kV would be marginally more reliable than the 161 kV, but this advantage is not sufficient in itself to justify the extra cost.

Tables 2B, 2C and 2D list the costs of transmission alternates having capacities for Kajakai output at Phase I (50 MW+), Phase II (100 MW+), and Phase III (150 MW+), respectively. It is obvious from these data that the cheapest voltage for the phase I output is 110 kV and, as would be expected from a consideration of economy of scale, for Phase II and Phase III it is 161 kV and 220 KV, respectively. To derive any significance from these costs, they must be converted to rates of return as described below.

Although the minimum transmission system investment estimated herein is for Phase IA, to reduce the number of options studied to a workable number, rates of return were calculated only on incremental investments in transmission above Phase I capacity. Transformer capacity was added as needed in integral multiples of the Phase I capacity. Seven options were considered:

1. One 110 kV circuit on double circuit towers installed now and the second circuit installed when needed versus a 110 kV single circuit tower line installed now and an identical line installed when needed. This Option presents the rate of return on double circuit towers for 110 kV.

2. One 161 kV circuit installed now versus a 110 kV single circuit tower line installed now and an identical line installed when needed.

3. One 161 kV circuit installed now versus a 110 kV circuit on double circuit towers installed now and a second circuit installed when needed. Options 2 and 3 present the rate of return on investment in 161 kV over 110 kV.

4. One 220 kV circuit installed now versus a 110 kV single circuit tower line installed now and identical lines added one at a time as needed. The advantage of this scheme is that at all stages of project development there is a minimum of excess transmission capacity. If there is uncertainty as to whether Kajakai will be developed to Phase III or whether all of Phase III power will

be used in the Helmand Valley, this scheme has merit.

5. One 220 kV circuit installed now versus a 110 kV single circuit line installed now and a 110 kV double circuit line installed complete when the load exceeds the capacity of the initial 110 kV circuit. This combination offers the advantage of lower cost than the 110 kV scheme above while not introducing a second transmission voltage as in the schemes below. It could be considered if after initial installation of a 110 kV single circuit line the load grew faster than expected and it was desired to add all at once the capacity for the ultimate output of the powerplant.

6. One 220 kV circuit installed now versus a 161 kV circuit installed now and a 110 kV single circuit line installed when the load exceeds the capacity of the 161 kV circuit or

7. One 220 kV circuit installed now versus a 110 kV single circuit installed now and a 161 kV line installed when needed. These two 161/110 kV schemes cost less than three 110 kV circuits but more than one 220 kV circuit. The 161/110 kV scheme of Option 6 is a possibility if an examination of the rates of return on alternate projects reveals that incremental expenditure is justified for 161 kV but not for 220 kV. In this case, addition of a 110 kV circuit when the capacity of the initial 161 kV circuit was exceeded would be the cheapest means of providing for the ultimate plant output. The 161/110 kV scheme of Option 7 is a possibility if a single 110 kV circuit is installed initially and it is later desired to add transmission capacity for ultimate plant output all at once and the objection of having two trans-

mission voltages is overcome. There are three disadvantages to operating with two transmission voltages: (1) In case of outage of a line section, say the 161 kV between the Junction and Kandahar, the 161 kV section between Kajakai and the Junction could not be connected to the 110 kV circuit, thereby sharing the load to the Junction. Instead, all the load would have to be transmitted over the single 110 kV circuit. (2) A greater quantity of spare parts would have to be kept locally. (3) Repair and maintenance would be somewhat more complex. However, it is moot whether these disadvantages outweigh the cost savings of this scheme over three 110 kV circuits.

As would be expected, the higher load growth rate of 8% after the first ten years results in slightly higher rates of return on incremental initial investment: 1.6% to 29.4% versus 1.2% to 22.8% for 5% growth rate. We believe the latter rate is the more likely, but the rates of return for the former should be kept in mind in case the growth rate is higher than expected.

As is also obvious, the rate of return on incremental initial investment increases with increasing price escalation. In fact, the increase is almost proportionate, varying from 1% to 17% at no escalation to 6% to 23% at 5% escalation (depending on the option, 5% growth rate). The remaining discussion is concerned only with 3% escalation and 5% load growth.

The rate of return on the incremental investment in a double circuit 110 kV tower line with one circuit strung initially over a single circuit 110 kV tower line, Option 1, is 5.7%. This incremental investment is of the same magnitude and has a lower return than investment in a 161 kV circuit, therefore this scheme is not economic.

The rates of return on incremental investment in 161 kV are 7% over the 110 kV single circuit tower line and 20% over the 110 kV double circuit tower line. The latter return is high because, although the future savings resulting from the 161 kV scheme are small, the incremental initial investment is only $9000. Since the 110 kV double circuit tower line is not recommended (see above), the rate of return on the 161 kV should be based on the 110 kV single circuit scheme as an alternate. This rate is 7%.

If it is decided not to consider use of circuits of different voltages (110 kV and 161 kV) for transmission of Kajakai power to Kandahar, the investment decision regarding 220 kV is based on Options 4 and 5. Option 4 represents the stronger 110 kV alternate and determines the rate of return on the 220 kV, which is 5.4%. If the use of circuits of different voltages is acceptable, the strongest alternate to the 220 kV is the scheme of Option 7. This establishes the rate of return on incremental investment in the 220 kV circuit at 4½%.

Therefore if the highest rate of return in an alternate project requiring financing is less than 4½%, Kajakai transmission should be at 220 kV. If the alternate project return is between 4½% and 7%, the 161 kV voltage should be used. If the alternate project return is greater than 7%, only the minimum investment in Kajakai transmission is justified, i.e. 110 kV.

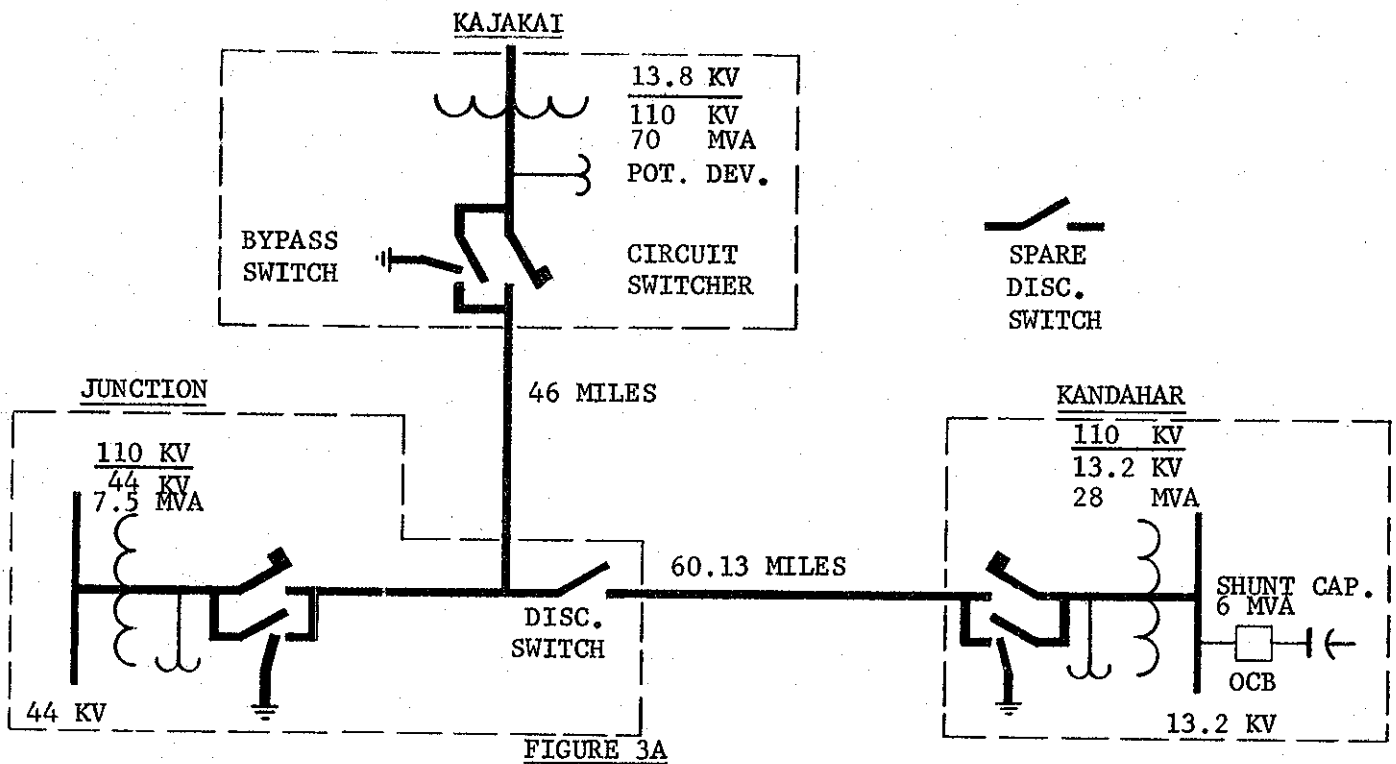

FIGURE 3A
ALTERNATES 110-IA AND 110A-IA

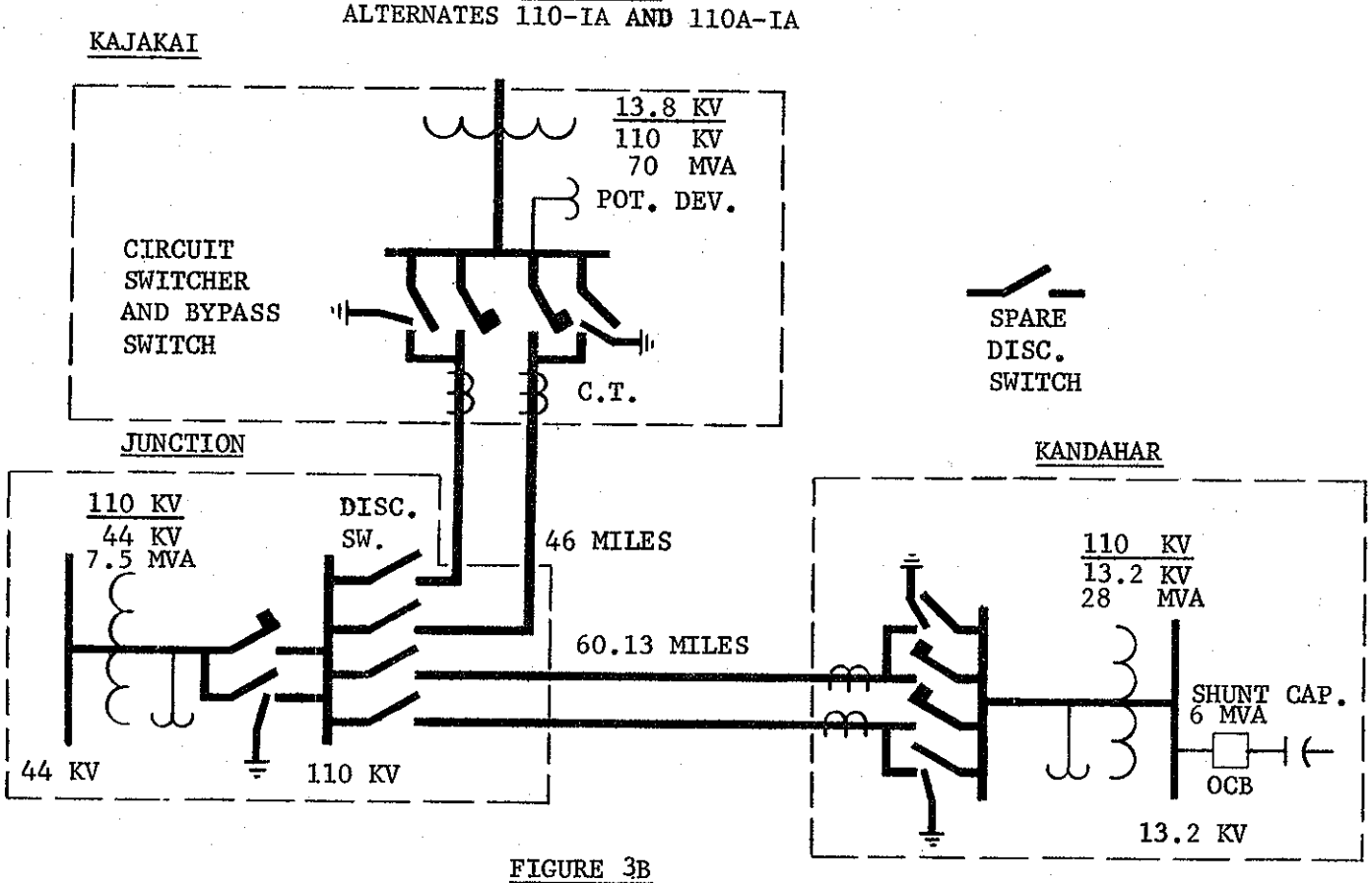

FIGURE 3B
ALTERNATE 110B-IA

110 KV KAJAKAI TRANSMISSION SYSTEM
SINGLE AND DOUBLE CIRCUIT LINE - SIMPLIFIED SINGLE LINE DIAGRAMS

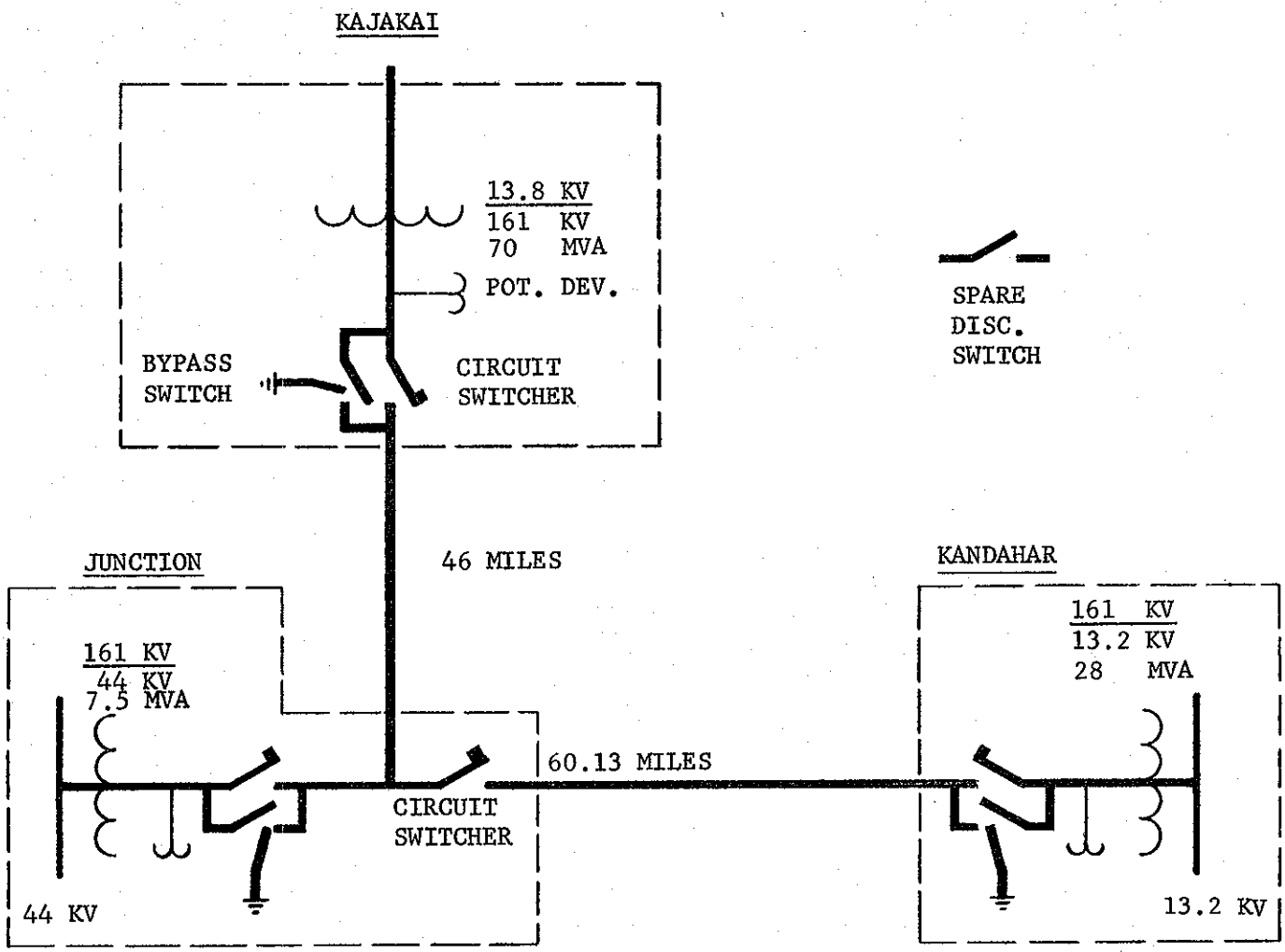

FIGURE 4
ALTERNATE 161-IA

161 KV KAJAKAI TRANSMISSION SYSTEM
SIMPLIFIED SINGLE LINE DIAGRAM

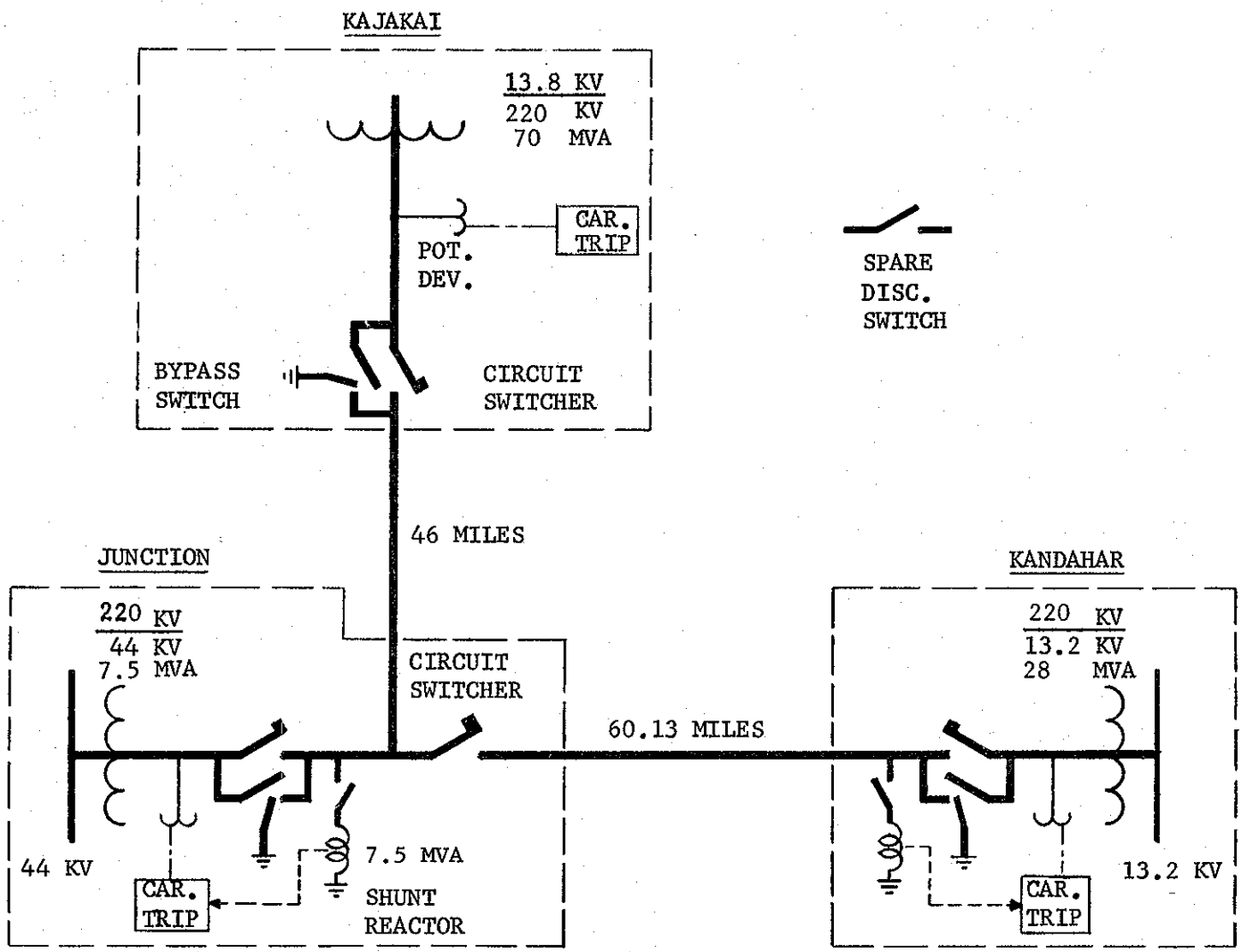

FIGURE 5
ALTERNATE 220-IA

220 KV KAJAKAI TRANSMISSION SYSTEM
SIMPLIFIED SINGLE LINE DIAGRAM

TABLE 2A

COST COMPARISON OF TRANSMISSION ALTERNATES FOR KAJAKAI PHASE IA OUTPUT

ALTERNATE	110-IA	110A-IA	110B-IA	161-IA	220-IA
			LINE CHARACTERISTICS		
VOLTAGE (KV)	110	110	110	161	220
NUMBER CIRCUITS/ON SINGLE CIRCUIT (SC) OR DOUBLE CIRCUIT (DC) TOWERS	1/SC	1/DC	2/DC	1/SC	1/SC
TRANSMISSION CAPACITY (MW)	55	55	110	115	165±
SHUNT CAPACITANCE REQUIRED (MVA)	6	6	0	0	0
SHUNT REACTANCE REQUIRED (MVA)	0	0	0	0	20
SIMPLIFIED SINGLE LINE ON FIGURE	1A	1A	1B	2	3
COST ITEM			LINE COSTS IN $1000		
TRANSMISSION LINE					
FOOTINGS	71	81	81	77	85
TOWERS	1250	1875	1875	1595	2060
INSULATORS	70	70	140	97	132
CONDUCTOR	545	545	1090	761	761
TOTAL	1936	2571	3186	2530	3038
TRANSFORMERS					
KAJAKAI (70 MVA)	232	232	232	276	364
JUNCTION (7.5 MVA)	65	65	65	77	102
KANDAHAR (28 MVA)	99	99	99	118	156
TOTAL	396	396	396	471	622
CIRCUIT SWITCHERS	57	57	95	85	131
DISCONNECT SWITCHES	21	21	47	20	42
POTENTIAL DEVICES	9	9	9	11	13
SHUNT CAPACITANCE	27	27	0	0	0
SHUNT REACTANCE	0	0	0	0	185
RELAYING & CONTROLS FOR 2ND 110 KV CIRCUIT	0	0	75	0	0
EXTRA CARRIER FOR 220 KV REACTORS	0	0	0	0	11
SPARE PARTS	6	6	6	8	10
SUBTOTAL 1	2452	3087	3814	3125	4052
GENERAL EXPENSES (23% SUB 1)	564	710	877	719	932
SUBTOTAL 2	3016	3797	4691	3844	4984
PROFIT (10% SUB 2)	302	380	470	385	499
GRAND TOTAL	3318	4177	5161	4229	5483

TABLE 2B
COST COMPARISON OF TRANSMISSION ALTERNATES FOR KAJAKAI PHASE I OUTPUT

ALTERNATE	110-I	110A-I	161-I	220-I
VOLTAGE (KV)	110	110	161	220
NUMBER CIRCUITS/ON SINGLE CIRCUIT (SC) OR DOUBLE CIRCUIT (DC) TOWERS	1/SC	1/DC	1/SC	1/SC
TRANSMISSION CAPACITY	55	55	115	165
SHUNT CAPACITANCE REQUIRED (MVA)	24	24	0	0
SHUNT REACTANCE REQUIRED (MVA)	0	0	0	15
COST ITEM	LINE COSTS IN $1000			
TRANSMISSION LINE				
FOOTINGS	71	81	77	85
TOWERS	1250	1875	1595	2060
INSULATORS	70	70	97	132
CONDUCTOR	545	545	761	761
TOTAL	1936	2571	2530	3038
TRANSFORMERS				
KAJAKAI (MVA)	232 (70)	232 (70)	276 (70)	364 (70)
JUNCTION (MVA)	95 (12)	95 (12)	122 (13)	160 (13)
KANDAHAR (MVA)	130 (37)	130 (37)	180 (43)	237 (43)
TOTAL	457	457	578	761
CIRCUIT SWITCHERS	57	57	85	131
DISCONNECT SWITCHES	21	21	20	42
POTENTIAL DEVICES	27	27	33	39
SHUNT CAPACITANCE	108	108	0	0
SHUNT REACTANCE	0	0	0	185
RELAYING & CONTROLS FOR ADDITIONAL CIRCUITS	0	0	0	0
EXTRA CARRIER FOR 220 KV REACTORS	0	0	0	11
SPARE PARTS	6	6	8	10
SUBTOTAL 1	2612	3247	3254	4217
GENERAL EXPENSES (23% SUB 1)	601	747	748	970
SUBTOTAL 2	3213	3994	4002	5187
PROFIT (10% SUB 2)	321	399	400	519
GRAND TOTAL	3534	4393	4402	5706

TABLE 2C
COST COMPARISON OF TRANSMISSION ALTERNATES FOR KAJAKAI PHASE II OUTPUT

ALTERNATE	110-II	110B-II	161-II	220-II
VOLTAGE (KV)	110	110	161	220
NUMBER CIRCUITS/ON SINGLE CIRCUIT (SC) OR DOUBLE CIRCUIT (DC) TOWERS	2/SC	2/DC	1/SC	1/SC
TRANSMISSION CAPACITY (MW)	110	110	115	165
SHUNT CAPACITANCE REQUIRED (MVA)	54	54	54	0
SHUNT REACTANCE REQUIRED (MVA)	0	0	0	15
COST ITEM		LINE COSTS IN $1000		
TRANSMISSION LINE				
FOOTINGS	142	81	77	85
TOWERS	2500	1875	1595	2060
INSULATORS	140	140	97	132
CONDUCTOR	1090	1090	761	761
TOTAL	3872	3186	2530	3038
TRANSFORMERS				
KAJAKAI (MVA)	464 (140)	464 (140)	552 (140)	728 (140)
JUNCTION (MVA)	190 (24)	190 (24)	244 (26)	320 (26)
KANDAHAR (MVA)	260 (74)	260 (74)	360 (86)	474 (86)
TOTAL	914	914	1156	1522
CIRCUIT SWITCHERS	95	95	85	131
DISCONNECT SWITCHES	74	74	60	76
POTENTIAL DEVICES	45	45	33	39
SHUNT CAPACITANCE	244	244	244	0
SHUNT REACTANCE	0	0	0	185
RELAYING & CONTROLS FOR ADDITIONAL CIRCUITS	75	75	0	0
EXTRA CARRIER FOR 220 KV REACTORS	0	0	0	11
SPARE PARTS	6	6	8	10
SUBTOTAL 1	5325	4639	4116	5012
GENERAL EXPENSES (23% SUB 1)	1225	1067	947	1153
SUBTOTAL 2	6550	5706	5063	6165
PROFIT (10% SUB 2)	655	571	506	617
GRAND TOTAL	7205	6277	5569	6782

TABLE 2D

COST COMPARISON OF TRANSMISSION ALTERNATES FOR KAJAKAI PHASE III OUTPUT

ALTERNATE	110-III	110 & 110B-III	110 & 161-III	220-III
VOLTAGE (KV)	110	110	110 & 161	220
NUMBER CIRCUITS/ON SINGLE CIRCUIT (SC) OR DOUBLE CIRCUIT (DC) TOWERS	3/SC	1/SC & 2/DC	1/SC & 1/SC	1/SC
TRANSMISSION CAPACITY (MW)	165	165	165	165
SHUNT CAPACITANCE REQUIRED (MVA)	84	84	84	77
SHUNT REACTANCE REQUIRED (MVA)	0	0	0	15
COST ITEM		LINE COSTS IN $1000		
TRANSMISSION LINE				
FOOTINGS	213	152	148	85
TOWERS	3750	3125	2845	2060
INSULATORS	210	210	167	132
CONDUCTOR	1635	1635	1306	761
TOTAL	5808	5122	4466	3038
TRANSFORMERS				
KAJAKAI (MVA)	696 (210)	696 (210)	784 (210)	1092 (210)
JUNCTION (MVA)	285 (36)	285 (36)	339 (38)	480 (39)
KANDAHAR (MVA)	390 (111)	390 (111)	490 (123)	711 (129)
TOTAL	1371	1371	1613	2283
CIRCUIT SWITCHERS	133	133	142	131
DISCONNECT SWITCHES	110	110	81	101
POTENTIAL DEVICES	63	63	60	39
SHUNT CAPACITANCE	378	378	378	347
SHUNT REACTANCE	0	0	0	185
RELAYING & CONTROLS FOR ADDITIONAL CIRCUITS	100	100	0	0
EXTRA CARRIER FOR 220 KV REACTORS	0 0	0	0	11
SPARE PARTS	6	6	14	10
SUBTOTAL 1	7969	7283	6754	6145
GENERAL EXPENSES (23% SUB 1)	1833	1675	1553	1413
SUBTOTAL 2	9802	8958	8307	7558
PROFIT (10% SUB 2)	980	896	831	756
GRAND TOTAL	10,782	9854	9138	8314

RATE OF RETURN ON INCREMENTAL TRANSMISSION INVESTMENT
5% LOAD GROWTH RATE

Option Number	Investment Options (High Cost Initial Investment Option Listed First	Initial Invest. High Cost Option ($M)	Initial Invest. Low Cost Option ($M)	Diff. in Initial Invest. ($M)	Diff. in First Future Invest. ($M)	First Future Invest. Period (Years)	Diff. in First Future Investment ($M) Escalated at 3%	Diff. in First Future Investment ($M) Escalated at 5%	Ratio of Difference in First Future Invest. to Difference in Initial Investment Escalation at 0%	Ratio of Difference in First Future Invest. to Difference in Initial Investment Escalation at 3%	Ratio of Difference in First Future Invest. to Difference in Initial Investment Escalation at 5%	Diff. in Second Future Invest. ($M)	Second Future Invest. Period (Years)	Diff. in Second Future Investment ($M) Escalated at 3%	Diff. in Second Future Investment ($M) Escalated at 5%	Ratio of Difference in Second Future Invest. to Difference in Initial Investment Escalation at 0%	Ratio of Difference in Second Future Invest. to Difference in Initial Investment Escalation at 3%	Ratio of Difference in Second Future Invest. to Difference in Initial Investment Escalation at 5%	Rate of Return on Incremental Investment (%) Escalation at 0%	Rate of Return on Incremental Investment (%) Escalation at 3%	Rate of Return on Incremental Investment (%) Escalation at 5%
1	One 110 kv Circuit on DC Tower plus installed later second circuit on same towers (110A-I then 110B-II) vs Two 110 kv Lines (110-I then 110-II	4.393	3.534	859	1,787	28	4,092	7,005	2.080	4.764	8.155	none	--	--	--	--	--	--	2.6	5.7	7.8
2	One 161 kv Line (161-I then 161-II) vs Two 110 kv Lines (110-I then 110-II)	4.402	3.534	848	2,504	28	5,734	9,816	2.953	6.762	11.575	none	--	--	--	--	--	--	3.9	7.1	9.1
3	One 161 kv Line (161-I then 161-II) vs One 110 kv Circuit on DC Tower plus installed later second circuit on same towers (110A-I then 110B-II)	4.402	4.393	9	717	28	1,642	2,811	79.7	182.4	312.3	none	--	--	--	--	--	--	16.9	20.4	22.8
4	One 220 kv Line (220-I then 200-II then 220-III) vs Three 110 kv Lines (110-I then 110-II then 110-III)	5.706	3.534	2,172	2.595	28	5,943	10,172	1.195	2.736	4.683	2.045	42	7.076	15,869	0.942	3.258	7.306	2.3	5.4	7.4
5	One 220 kv Line (220-I then 220-II then 220-III) vs One 110 kv SC Line plus installed later one 110 kv DC line (110-I then 110 & 110A-II then 110 & 110B-III)	5,706	3,534	2,172	4,415	28	10,110	17,307	2.033	4.655	7.968	373	42	1,291	2,894	0.172	0.594	1.332	2.8	5.9	7.9
6	One 220 kv Line (220-I then 220-II then 220-III) vs One 110 kv DC Line plus installed later one 161 kv line (110-I then 110 & 161-II then 110 & 161-III)	5,706	3,534	2,172	3,326	28	7,617	13,038	1.531	3.507	6.003	126	43	450	1,027	0.058	0.207	0.473	1.6	4.7	6.7
7	One 220 kv Line (220-I then 220-II then 220-III) vs One 161 kv Line plus installed later one 110 kv line (161-I then 161-II then 110 & 161-III)	5,706	4,402	1,304	91	28	208	357	0.070	0.160	0.274	2,037	43	7,272	16,602	1.562	5.577	12.731	1.2	4.3	6.4

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RATE OF RETURN ON INCREMENTAL TRANSMISSION INVESTMENT
8% LOAD GROWTH RATE

Option Number	Investment Options (High Cost Initial Investment Option Listed First)	Initial Invest. High Cost Option ($M)	Initial Invest. Low Cost Option ($M)	Diff. in Initial Invest. ($M)	Diff. in First Future Invest. ($M)	First Future Invest. Period (Years)	Diff. in First Future Investment ($M) Escalated at 3%	Diff. in First Future Investment ($M) Escalated at 5%	Ratio of Difference in First Future Invest. to Difference in Initial Investment Escalation at 0%	Ratio of Difference in First Future Invest. to Difference in Initial Investment Escalation at 3%	Ratio of Difference in First Future Invest. to Difference in Initial Investment Escalation at 5%	Diff. in Second Future Invest. ($M)	Second Future Invest. Period (Years)	Diff. in Second Future Investment ($M) Escalated at 3%	Diff. in Second Future Investment ($M) Escalated at 5%	Ratio of Difference in Second Future Invest. to Difference in Initial Investment Escalation at 0%	Ratio of Difference in Second Future Invest. to Difference in Initial Investment Escalation at 3%	Ratio of Difference in Second Future Invest. to Difference in Initial Investment Escalation at 5%	Rate of Return on Incremental Investment (%) Escalation at 0%	Rate of Return on Incremental Investment (%) Escalation at 3%	Rate of Return on Incremental Investment (%) Escalation at 5%
1	One 110 kv Circuit on DC Towers plus one installed later second circuit on same towers (110A-1 then 110B-II) vs Two 110 kv Lines (110-I then 110-II)	4,393	3,534	859	1,787	21	3,324	4,977	2.080	3.870	5.794	none	--	--	--	--	--	--	3.5	6.6	8.7
2	One 161 kv Line (161-I then 161-II) vs Two 110 kv Lines (110-I then 110-II)	4,402	3,534	848	2,504	21	4,657	6,974	2.953	5.492	8.224	none	--	--	--	--	--	--	5.3	9.3	10.6
3	One 161 kv Line (161-I then 161-II) vs One 110 kv Circuit on DC Towers plus installed later second circuit on same towers (110A-I then 110B-II)	4,402	4,393	9	717	21	1,334	1,997	79.7	148.2	221.9	none	--	--	--	--	--	--	23.2	26.9	29.4
4	One 220 kv Line (220-I then 220-II then 220-III) vs Three 110 kv Lines (110-I then 110-II then 110-III)	5,706	3,534	2,172	2,595	21	4,827	7,227	1.195	2.222	3.327	2,045	30	4,969	8,834	0.942	2.288	4.067	3.06	6.08	8.00
5	One 220 kv Line (220-I then 220-II then 220-III) vs One 110 kv SC Line plus installed later one 110 kv DC line (110-I then 110 & 110A-II then 110 & 110B-III)	5,706	3,534	2,172	4,415	21	8,212	12,296	2.033	3.781	5.661	373	30	906	1,611	0.172	0.417	0.742	3.71	6.81	8.88
6	One 220 kv Line (220-I then 220-II then 220-III vs One 110 kv SC Line plus installed later one 161 kv line (110-I then 110 & 161-II then 110 & 161-III)	5,706	3,534	2,172	3,326	21	6,186	9,263	1.531	2.848	4.265	126	30	306	544	0.058	0.141	0.250	2.18	5.25	7.30
7	One 220 kv Line (220-I then 220-II then 220-III) vs One 161 kv Line plus installed later one 110 kv line (161-I then 161-II then 110 & 161-III)	5,706	4,402	1,304	91	21	169	253	0.070	0.130	0.194	2,037	31	5.093	9,248	1.562	3.906	7.092	1.59	4.58	6.43

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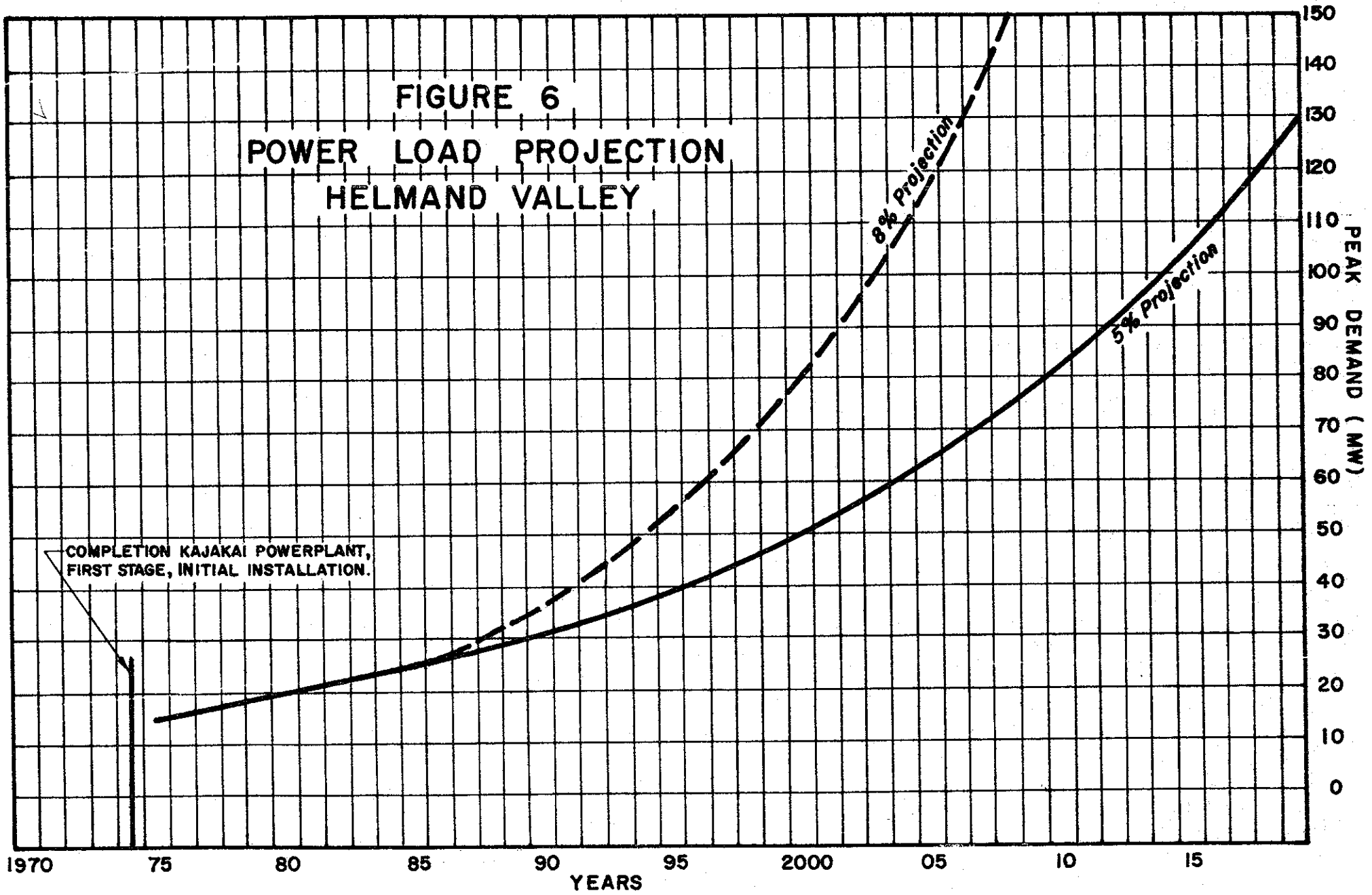
FIGURE 6
POWER LOAD PROJECTION
HELMAND VALLEY
8% Projection
5% Projection
COMPLETION KAJAKAI POWERPLANT,
FIRST STAGE, INITIAL INSTALLATION.
PEAK DEMAND (MW)
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1970
75
80
85
90
95
2000
05
10
15
YEARS

KAJAKAI HYDROELECTRIC PROJECT - CASE 1
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	1.030	30.0	17.72	6.435									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	17.72	6.43	19				5
				SHNT	0.00	0.00									
				RESD	.00	.00									
2	KAJAKAI	0	1.072	28.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-17.70	-6.00	19			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	17.70	6.00	19	14			1
				RESD	.00	-.00									
4	JUNCTION	0	1.042	26.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-17.44	-8.11	19	15			1
				SHNT	0.00	0.00	5	JUNCTION	2.67	.80	3			1.000	6
				RESD	.00	-.00	7	KANDAHAR	14.77	7.30	16	12			2
5	JUNCTION	0	1.033	25.6	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-2.66	-.74	3				6
				SHNT	0.00	0.00	6	LASHKARG	2.66	.74	3	7			3
				RESD	-.00	-.00									
6	LASHKARG	0	1.010	24.6	.00	.00									
		-0		LOAD	3.00	1.86	5	JUNCTION	-2.62	-1.00	3	8			3
				SHNT	0.00	0.00	9	GIRISHK	-.38	-.86	1	6			4
				RESD	-.00	-.00									
7	KANDAHAR	0	1.000	24.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-14.47	-9.95	18	13			2
				SHNT	0.00	0.00	8	KANDAHAR	14.47	9.95	18			1.000	7
				RESD	.00	-.00									
8	KANDAHAR	0	.965	22.2	.00	.00									
		-0		LOAD	14.40	8.92	7	KANDAHAR	-14.40	-8.92	17				7
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

38A

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KAJAKAI HYDROELECTRIC PROJECT - CASE 1
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S - D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	O L	TAP	BR. NO.
9	GTPISHK	0	1.029	23.8	2.40	1.304									
		-0		LOAD	2.00	1.24	6	LASHKARG	.40	.56	1	4			4
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A2

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39.

KAJAKAI HYDROELECTRIC PROJECT - CASE 1
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.264	.298	.045	.018	.022	.006	.071		
		-2.112	-2.544	-.259	-.304	.434	.067	1.027		

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40

KAJAKAI HYDROELECTRIC PROJECT - CASE 1
11KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
20.12	8.23	19.40	12.02	.72	-3.79	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

A4

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KAJAKAI HYDROELECTRIC PROJECT - CASE 1A
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 3. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	.930	30.0	.80	-5.495									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	.80	-5.49	6				5
				SHNT	0.00	0.00									
				RESD	.00	.00									
2	KAJAKAI	0	.994	29.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-.79	5.53	6			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	.79	-5.53	6	4			1
				RESD	-.00	-.00									
4	JUNCTION	0	.994	29.5	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-.78	3.06	3	2			1
				SHNT	0.00	0.00	5	JUNCTION	-.67	-.63	1			1.000	6
				RESD	.00	.00	7	KANDAHAR	1.44	-2.43	3	2			2
5	JUNCTION	0	1.001	29.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	.67	.64	1				6
				SHNT	0.00	0.00	6	LASHKARG	-.67	-.64	1	2			3
				RESD	.00	.00									
6	LASHKARG	0	1.004	30.1	.00	.00									
		0		LOAD	.30	.19	5	JUNCTION	.67	.33	1	2			3
				SHNT	0.00	0.00	9	GIRISHK	-.97	-.52	1	7			4
				RESD	.00	.00									
7	KANDAHAR	0	.993	29.3	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-1.44	-.90	2	1			2
				SHNT	0.00	0.00	8	KANDAHAR	1.44	.90	2			1.000	7
				RESD	.00	-.00									
8	KANDAHAR	0	.992	29.0	.00	.00									
		0		LOAD	1.44	.89	7	KANDAHAR	-1.44	-.89	2				7
				SHNT	0.00	0.00									
				RESD	-.00	.00									

A5

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KAJAKAI HYDROELECTRIC PROJECT - CASE 1A
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 3. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 9 CAP L	TAP	BR. NO.
9	GIRISHK	0	1.040	30.2	1.20	.342								
		0		LOAD	.20	.12	5	LASHKARG	1.00	.22	1	7		4
				SHNT	0.00	0.00								
				RESD	-.00	-.00								

NOTE * UNDER 2 OL COLUMN INDICATES LINE % PCT. CAP. IS GREATER THAN 100 P.C.

A6

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43

KAJAKAI HYDROELECTRIC PROJECT - CASE 1A
11KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.016	.003	.004	.029	.002	.001	.001		
		-2.478	-3.326	-.307	-.302	.046	.008	.010		

A7

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KAJAKAI HYDROELECTRIC PROJECT - CASE 1A
115KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
2.00	-5.15	1.94	1.20	.06	-6.35	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	.000
MVAR	.000	.000

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	O L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	25.20	14.165									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	25.20	14.16	29				5
				SHNT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAI	0	1.083	29.3	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-25.15	-13.17	28			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	25.15	13.17	28	22			1
				RESD	.00	-.00									
4	JUNCTION	0	1.032	25.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-24.56	-14.32	28	22			1
				SHNT	0.00	0.00	5	JUNCTION	4.64	2.28	5			.975	6
				RESD	.00	-.00	7	KANDAHAR	19.92	12.04	23	18			2
5	JUNCTION	0	1.035	23.7	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-4.62	-2.06	5				6
				SHNT	0.00	0.00	6	LASHKARG	4.62	2.06	5	14			3
				RESD	.00	-.00									
6	LASHKARG	0	.990	22.2	.00	.00									
		0		LOAD	4.12	2.55	5	JUNCTION	-4.48	-2.16	5	14			3
				SHNT	0.00	0.00	9	GIRISHK	.36	-.39	1	3			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.971	23.1	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-19.32	-13.69	24	18			2
				SHNT	0.00	0.00	8	KANDAHAR	19.32	13.69	24			.950	7
				RESD	.00	-.00									
8	KANDAHAR	0	.974	19.6	.00	.00									
		0		LOAD	19.20	11.90	7	KANDAHAR	-19.20	-11.90	23				7
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	0 L	TAP	BR. NO.
9	GIRISHK	0	.963	21.5	2.40	1.404									
		0		LOAD	2.75	1.70	6	LASHKARG	-.35	.10	0	2			4
				SHUT	0.00	0.00									
				REST	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A 10

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47

KAJAKAI HYDROELECTRIC PROJECT - CASE 2
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW. LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.594	.642	.148	.005	.051	.021	.123		
		-1.148	-1.649	-.104	-.290	.982	.223	1.791		

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48

KAJAKAI HYDROELECTRIC PROJECT - CASE 2
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
27.60	15.96	26.07	16.15	1.53	-.19	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A12

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49

KAJAKAI HYDROELECTRIC PROJECT - CASE 2A
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 2, SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	0 L	TAP	BR. NO.
1	KAJAKAI	0	.920	30.0	1.46	-5.065									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	1.46	-5.06	5				5
				SHNT	0.00	0.00									
				RESD	.00	.00									
2	KAJAKAI	0	.973	29.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-1.46	5.10	5			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	1.46	-5.10	5	4			1
				RESD	.00	-.00									
4	JUNCTION	0	.982	29.4	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-1.45	2.68	3	2			1
				SHNT	0.00	0.00	5	JUNCTION	-.48	-.65	1			.975	6
				RESD	.00	-.00	7	KANDAHAR	1.93	-2.03	3	2			2
5	JUNCTION	0	1.013	29.7	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	.48	.66	1				6
				SHNT	0.00	0.00	6	LASHKARG	-.48	-.66	1	2			3
				RESD	-.00	-.00									
6	LASHKARG	0	1.021	29.7	.00	.00									
		0		LOAD	.41	.26	5	JUNCTION	.48	.34	1	1			3
				SHNT	0.00	0.00	9	GIRISHK	-.89	-.60	1	7			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.941	29.1	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-1.92	-1.21	2	1			2
				SHNT	0.00	0.00	8	KANDAHAR	1.92	1.21	2			.950	7
				RESD	-.00	-.00									
8	KANDAHAR	0	1.021	28.7	.00	.00									
		0		LOAD	1.92	1.19	7	KANDAHAR	-1.92	-1.19	2				7
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

A13

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50

KAJAKAI HYDROELECTRIC PROJECT - CASE 2A
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 2, SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	0 L	TAP	BR. NO.
9	GIRISHK	0	1.050	29.7	1.20	.462									
		0		LOAD	.28	.17	6	LASHKARG	.92	.29	1	6			4
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

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A14

51

KAJAKAI HYDROELECTRIC PROJECT - CASE 2A
115KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.015	.004	.003	.026	.002	.001	.001		
		-2.422	-3.233	-.317	-.310	.042	.006	.016		

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2A
[illegible] TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
2.66	-4.6[illegible]	2.61	1.52	.05	-6.22	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

A16

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53

KAJAKAI HYDROELECTRIC PROJECT - CASE 3
11024 TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	32.53	15.755								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	32.53	15.75	36			5
				SHNT	0.00	0.00								
				RESD	.00	.00								
2	KAJAKAI	0	1.021	27.8	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-32.45	-14.21	35		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	32.45	14.21	35	27		1
				RESD	.00	-.00								
4	JUNCTION	0	1.023	24.4	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-31.53	-14.39	35	27		1
				SHNT	0.00	0.00	5	JUNCTION	6.58	3.94	8		.950	6
				RESD	.00	-.00	7	KANDAHAR	24.95	10.55	27	21		2
5	JUNCTION	0	1.039	21.5	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-6.53	-3.37	7			6
				SHNT	0.00	0.00	6	LASHKARG	6.53	3.37	7	21		3
				RESD	.00	-.00								
6	LASHKARG	0	.972	19.5	.00	.00								
		0		LOAD	5.15	3.19	5	JUNCTION	-6.22	-3.24	7	20		3
				SHNT	0.00	0.00	9	GIRISHK	1.07	.05	1	7		4
				RESD	-.00	-.00								
7	KANDAHAR	0	.981	20.6	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-24.16	-11.55	27	20		2
				SHNT	0.00	0.00	8	KANDAHAR	24.16	11.55	27		.950	7
				RESD	.00	-.00								
8	KANDAHAR	0	.971	16.1	.00	.00								
		0		LOAD	24.00	14.87	7	KANDAHAR	-24.00	-9.21	26			7
				SHNT	0.00	5.66								
				RESD	-.00	-.00								

A17

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54

KAJAKAI HYDROELECTRIC PROJECT - CASE 3
11KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
9	GIRISHK	0	.939	19.0	2.40	1.80H									
		0		LOAD	3.44	2.12	6	LASHKARG	-1.04	-.32	1	7			4
				SHNT	0.00	0.00									
				2FSD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

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A/00

55

KAJAKAI HYDROELECTRIC PROJECT - CASE 3
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

RANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.914	.794	.309	.035	.079	.044	.160		
		-.180	-.994	.133	-.259	1.535	.467	2.336		

A19

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KAJAKAI HYDROELECTRIC PROJECT - CASE 3
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
34.93	17.55	32.59	20.17	2.34	3.04	0.00	5.66

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.001	-.000
MVAR	.001	-.001

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A20

57

KAJAKAI HYDROELECTRIC PROJECT - CASE II
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	BUS DATA -- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	1.030	30.0	17.72	6.265									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	17.72	6.26	19				5
				SHNT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAI	0	1.072	28.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-17.70	-5.83	19			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	17.70	5.83	19	14			1
				RESD	-.00	-.00									
4	JUNCTION	0	1.043	26.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-17.44	-7.95	19	14			1
				SHNT	0.00	0.00	5	JUNCTION	2.67	.65	3			1.000	6
				RESD	.00	-.00	7	KANDAHAR	14.77	7.30	16	12			2
5	JUNCTION	0	1.035	25.6	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-2.66	-.59	3				6
				SHNT	0.00	0.00	6	LASHKARG	2.16	1.29	3	7			3
				RESD	-.00	.00	9	GIRISHK	.51	-.70	1	2			8
6	LASHKARG	0	1.010	25.1	.00	.00									
		0		LOAD	3.00	1.85	5	JUNCTION	-2.12	-1.56	3	7			3
				SHNT	0.00	0.00	9	GIRISHK	-.88	-.30	1	6			4
				RESD	-.00	-.00									
7	KANDAHAR	0	1.001	24.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-14.47	-9.95	18	13			2
				SHNT	0.00	0.00	8	KANDAHAR	14.47	9.95	18			1.000	7
				RESD	.00	-.00									
8	KANDAHAR	0	.965	22.2	.00	.00									
		0		LOAD	14.40	8.92	7	KANDAHAR	-14.40	-8.92	17				7
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

A21

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KAJAKAI HYDROELECTRIC PROJECT - CASE 1T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- BUS DATA ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
9	GTRISHK	0	1.036	25.4	2.40	1.80H								
		0		LOAD	2.00	1.24	5	JUNCTION	-.50	.57	1	2		8
				SHNT	0.00	0.00	6	LASHKARG	.90	-.01	1	6		4
				REQD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE % PCT. CAP. IS GREATER THAN 100 P.C.

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A22

59

KAJAKAI HYDROELECTRIC PROJECT - CASE 1T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.262	.297	.038	.022	.022	.006	.070	.002	
		-2.119	-2.650	-.269	-.305	.431	.065	1.026	-.137	

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A23

KAJAKAI HYDROELECTRIC PROJECT - CASE 1T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.6 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
20.12	8.06	19.40	12.02	.72	-3.96	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A24

61

KAJAKAI HYDROELECTRIC PROJECT - CASE 1TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
1	KAJAKAI	0	.930	30.0	.78	-6.185								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	.78	-6.18	6			5
				SHNT	0.00	0.00								
				RESD	.00	.00								
2	KAJAKAI	0	.955	29.9	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-.77	6.24	6		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	.77	-6.24	6	4		1
				RESD	-.00	.00								
4	JUNCTION	0	.997	29.6	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-.75	3.76	4	2		1
				SHNT	0.00	0.00	5	JUNCTION	-.69	-1.32	1		1.000	6
				RESD	.00	-.00	7	KANDAHAR	1.44	-2.44	3	2		2
5	JUNCTION	0	1.010	29.9	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	.69	1.34	2			6
				SHNT	0.00	0.00	6	LASHKARG	.11	-.28	0	0		3
				RESD	-.00	.00	9	GIRISHK	-.80	-1.06	1	3		8
6	LASHKARG	0	1.010	29.8	.00	.00								
		0		LOAD	.30	.19	5	JUNCTION	-.11	-.03	0	0		3
				SHNT	0.00	0.00	9	GIRISHK	-.19	-.16	0	1		4
				RESD	-.00	-.00								
7	KANDAHAR	0	.995	29.3	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-1.44	-.90	2	1		2
				SHNT	0.00	0.00	8	KANDAHAR	1.44	.90	2		1.000	7
				RESD	.00	-.00								
8	KANDAHAR	0	.995	29.0	.00	.00								
		0		LOAD	1.44	.89	7	KANDAHAR	-1.44	-.89	2			7
				SHNT	0.00	0.00								
				RESD	.00	-.00								

A25

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KAJAKAI HYDROELECTRIC PROJECT - CASE 1TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
8	GIRISHK	0	1.016	28.9	1.20	.90H									
		0		LOAD	.20	.12	5	JUNCTION	.81	.93		1	3		8
				SHNT	0.00	0.00	6	LASHKARG	.19	-.15		0	1		4
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A26

63

KAJAKAI HYDROELECTRIC PROJECT - CASE 1TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.022	.003	.000	.001	.003	.002	.001	.004	
		-2.472	-3.344	-.316	-.307	.058	.021	.010	-.127	

A27

6of

KAJAKAI HYDROELECTRIC PROJECT - CASE LTA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.06 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
1.98	-5.28	1.94	1.20	.04	-6.48	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A28

65

KAJAKAI HYDROELECTRIC PROJECT - CASE 2T
11OKV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	25.17	13.925									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	25.17	13.92	29				5
				SHNT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAI	0	1.083	28.3	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-25.12	-12.95	28			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	25.12	12.95	28	22			1
				RESD	.00	-.00									
4	JUNCTION	0	1.033	25.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-24.53	-14.12	28	22			1
				SHNT	0.00	0.00	5	JUNCTION	4.62	2.09	5			1.000	6
				RESD	.00	-.00	7	KANDAHAR	19.91	12.03	23	18			2
5	JUNCTION	0	1.011	23.6	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-4.60	-1.86	5				6
				SHNT	0.00	0.00	6	LASHKARG	3.10	2.03	4	10			3
				RESD	-.00	.00	9	GIRISHK	1.50	-.17	2	4			8
6	LASHKARG	0	.974	22.8	.00	.00									
		0		LOAD	4.12	2.55	5	JUNCTION	-3.01	-2.22	4	10			3
				SHNT	0.00	0.00	9	GIRISHK	-1.11	-.33	1	8			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.971	23.1	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-19.32	-13.69	24	18			2
				SHNT	0.00	0.00	8	KANDAHAR	19.32	13.69	24			.950	7
				RESD	.00	-.00									
8	KANDAHAR	0	.975	19.6	.00	.00									
		0		LOAD	19.20	11.90	7	KANDAHAR	-19.20	-11.90	23				7
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

A29

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
9	GIRISHK	0	1.008	23.2	2.40	1.80H								
		0		LOAD	2.75	1.70	5	JUNCTION	-1.50	.04	1	4		8
				SHNT	0.00	0.00	6	LASHKARG	1.15	.06	1	8		4
				RFSD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A30

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67

KAJAKAI HYDROELECTRIC PROJECT - CASE 2T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.508	.591	.085	.037	.050	.021	.123	.006	
		-1.149	-1.559	-.182	-.278	.973	.225	1.787	-.124	

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A.31

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68

KAJAKAI HYDROELECTRIC PROJECT - CASE 2T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.8 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
27.57	15.72	26.07	16.15	1.50	-.43	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A 32

KAJAKAI HYDROELECTRIC PROJECT - CASE 2TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0.	.920	30.0	1.44	-5.595									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	1.44	-5.59	6				5
				SHNT	0.00	0.00									
				RESD	.00	.00									
2	KAJAKAI	0	.974	29.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-1.44	5.64	6			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	1.44	-5.64	6	4			1
				RESD	-.00	.00									
4	JUNCTION	0	.984	29.4	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-1.42	3.22	4	2			1
				SHNT	0.00	0.00	5	JUNCTION	-.50	-1.18	1			1.000	6
				RESD	.00	-.00	7	KANDAHAR	1.93	-2.04	3	2			2
5	JUNCTION	0	.996	29.6	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	.50	1.20	1				6
				SHNT	0.00	0.00	6	LASHKARG	.20	-.21	0	0			3
				RESD	-.00	.00	9	GIRISHK	-.70	-.99	1	3			8
6	LASHKARG	0	.995	29.5	.00	.00									
		0		LOAD	.41	.26	5	JUNCTION	-.20	-.10	0	0			3
				SHNT	0.00	0.00	9	GIRISHK	-.21	-.16	0	1			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.983	29.0	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-1.92	-1.21	2	1			2
				SHNT	0.00	0.00	8	KANDAHAR	1.92	1.21	2			.950	7
				RESD	.00	-.00									
8	KANDAHAR	0	1.031	28.7	.00	.00									
		0		LOAD	1.92	1.19	7	KANDAHAR	-1.92	-1.19	2				7
				SHNT	0.00	0.00									
				RESD	.00	-.00									

A33

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP L	TAP	BR. NO.
9	GIRISHK	0	1.001	29.7	1.20	.90H								
		0		LOAD	.28	.17	5	JUNCTION	.71	.87	1	3		8
				SHNT	0.00	0.00	6	LASHKARG	.21	-.14	0	1		4
				RESD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A 34

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.019	.004	.000	.001	.003	.002	.001	.004	
		-2.418	-3.247	-.307	-.298	.051	.016	.016	-.124	

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A 35

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.019	.004	.000	.001	.003	.002	.001	.004	
		-2.418	-3.247	-.307	-.298	.051	.016	.016	-.124	

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KAJAKAI HYDROELECTRIC PROJECT - CASE 2TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.08 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
2.64	-4.69	2.61	1.62	.03	-6.31	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A 36

74

KAJAKAI HYDROELECTRIC PROJECT - CASE 3T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	32.36	15.20S								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	32.36	15.20	36			5
				SHNT	0.00	0.00								
				RESD	0.00	.00								
2	KAJAKAI	0	1.081	27.8	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-32.28	-13.70	35		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	32.28	13.70	35	27		1
				RESD	.00	-.00								
4	JUNCTION	0	1.025	24.5	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-31.39	-13.95	34	26		1
				SHNT	0.00	0.00	5	JUNCTION	6.44	3.47	7		.975	6
				RESD	.00	-.00	7	KANDAHAR	24.95	10.48	27	21		2
5	JUNCTION	0	1.015	21.4	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-6.40	-3.02	7			6
				SHNT	0.00	0.00	6	LASHKARG	3.97	2.71	5	13		3
				RESD	-.00	-.00	9	GIRISHK	2.43	.31	2	6		8
6	LASHKARG	0	.968	20.4	.00	.00								
		0		LOAD	5.15	3.13	5	JUNCTION	-3.83	-2.81	5	13		3
				SHNT	0.00	0.00	9	GIRISHK	-1.32	-.37	1	9		4
				RESD	-.00	-.00								
7	KANDAHAR	0	.953	20.7	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-24.16	-11.50	27	20		2
				SHNT	0.00	0.00	8	KANDAHAR	24.16	11.50	27		.950	7
				RESD	.00	-.00								
8	KANDAHAR	0	.976	18.2	.00	.00								
		0		LOAD	24.00	14.87	7	KANDAHAR	-24.00	-9.18	26			7
				SHNT	0.00	5.69								
				RESD	-.00	-.00								

A37

75

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KAJAKAI HYDROELECTRIC PROJECT - CASE 3T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
9	GIRTSHK	0	1.000	20.9	2.40	1.80H								
		0		LOAD	3.44	2.12	5	JUNCTION	-2.41	-.42	2	6		8
				SHNT	0.00	0.00	6	LASHKARG	1.37	.10	1	9		4
				RESD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A 38

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KAJAKAI HYDROELECTRIC PROJECT - CASE 3T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.894	.789	.140	.053	.078	.043	.159	.015	
		-.245	-1.023	-.103	-.270	1.503	.452	2.321	-.111	

A39

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77

KAJAKAI HYDROELECTRIC PROJECT - CASE 3T
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI-FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
34.76	17.00	32.59	20.17	2.17	2.52	0.00	5.69

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A40

78

KAJAKAI HYDROELECTRIC PROJECT - CASE 3TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.1 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	.930	30.0	2.09	-5.335									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	2.09	-5.33	6				5
				SHNT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAI	0	.984	29.8	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-2.09	5.38	6			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	2.09	-5.38	6	4			1
				RESD	-.00	.00									
4	JUNCTION	0	.993	29.3	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-2.07	2.92	4	2			1
				SHNT	0.00	0.00	5	JUNCTION	-.33	-1.14	1			.975	6
				RESD	.00	-.00	7	KANDAHAR	2.41	-1.78	3	2			2
5	JUNCTION	0	1.029	29.4	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	.34	1.15	1				6
				SHNT	0.00	0.00	6	LASHKARG	.29	-.18	0	0			3
				RESD	-.00	.00	9	GIRISHK	-.62	-.97	1	3			8
6	LASHKARG	0	1.027	29.3	.00	.00									
		0		LOAD	.52	.32	5	JUNCTION	-.28	-.15	0	0			3
				SHNT	0.00	0.00	9	GIRISHK	-.24	-.17	0	2			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.990	29.4	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-2.40	-1.51	3	2			2
				SHNT	0.00	0.00	8	KANDAHAR	2.40	1.51	3			.950	7
				RESD	.00	-.00									
8	KANDAHAR	0	1.037	28.4	.00	.00									
		0		LOAD	2.40	1.49	7	KANDAHAR	-2.40	-1.49	3				7
				SHNT	0.00	0.00									
				RESD	-.00	-.00									

A41

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KAJAKAI HYDROELECTRIC PROJECT - CASE 3TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.1 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	O L	TAP	BR. NO.
9	GIRISHK	0	1.034	29.4	1.20	.904									
		0		LOAD	.54	.21	5	JUNCTION	.62	.84	1	2			8
				SHNT	0.00	0.00	6	LASHKARG	.24	-.15	0	1			4
				REST	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A-42

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KAJAKAI HYDROELECTRIC PROJECT - CASE 3TA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.1 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.118	.006	.000	.001	.003	.001	.002	.003	
		-2.467	-3.294	-.327	-.318	.049	.013	.025	-.134	

A 43

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81

KAJAKAI HYDROELECTRIC PROJECT - CASE 3EA
110KV TRANSMISSION LINE-2 UNITS AT KAJAKAI 0.1 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
3.29	-4.43	3.26	2.02	.03	-6.45	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

A44

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82

KAJAKAI HYDROELECTRIC PROJECT - CASE 4T
110KV TRANSMISSION LINE-3 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	49.90	18.465									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	49.90	18.46	53				5
				SHNT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAI	0	1.077	25.5	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-49.73	-15.13	52			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	49.73	15.13	52	40			1
				RESD	.00	-.00									
4	JUNCTION	0	1.007	21.0	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-47.79	-12.24	49	38			1
				SHNT	0.00	0.00	5	JUNCTION	9.99	3.03	10			.975	6
				RESD	.00	-.00	7	KANDAHAR	37.80	9.21	39	30			2
5	JUNCTION	0	1.015	13.5	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-9.94	-2.55	10				6
				SHNT	0.00	0.00	6	LASHKARG	5.94	1.89	6	17			3
				RESD	-.00	-.00	9	GIRISHK	4.00	.67	4	11			8
6	LASHKARG	0	.964	16.2	.00	.00									
		0		LOAD	7.20	4.47	5	JUNCTION	-5.71	-1.86	6	17			3
				SHNT	0.00	2.79	9	GIRISHK	-1.49	.17	2	10			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.939	14.5	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-36.16	-7.61	37	28			2
				SHNT	0.00	0.00	8	KANDAHAR	36.16	7.61	37			.950	7
				RESD	.00	-.00									
8	KANDAHAR	0	.973	11.0	.00	.00									
		0		LOAD	36.00	22.31	7	KANDAHAR	-36.00	-5.28	36				7
				SHNT	0.00	17.03									
				RESD	-.00	-.00									

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KAJAKAI HYDROELECTRIC PROJECT - CASE 4T
110KV TRANSMISSION LINE-3 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
9	GIRISHK	0	1.003	17.8	2.40	1.80H								
		0		LOAD	4.80	2.97	5	JUNCTION	-3.96	-.74	4	11		8
				SHUT	0.00	0.00	6	LASHKARG	1.56	-.43	2	11		4
				RESD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A46

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84

KAJAKAI HYDROELECTRIC PROJECT - CASE 4T
110KV TRANSMISSION LINE-3 UNITS AT KAJAKAI-FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW. LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		1.946	1.638	.231	.069	.172	.045	.161	.042	
		2.494	1.503	.030	-.260	3.328	.477	2.332	-.072	

A47

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85

KAJAKAI HYDROELECTRIC PROJECT - CASE 4T
110KV TRANSMISSION LINE-3 UNITS AT KAJAKAI-FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
52.30	20.26	48.00	29.75	4.30	10.33	0.00	19.82

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.002	-.000
MVAR	.001	-.001

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A48

86

KAJAKAI HYDROELECTRIC PROJECT - CASE 5T
110KV TRANSMISSION LINES UNITS AT KAJAKAI 0.6 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 3. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP. L	TAP	BR. NO.
1	KAJAKAI	0	1.040	30.0	59.07	12.825								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	59.07	12.82	60			5
				SHNT	0.00	0.00								
				RESO	-.00	.00								
2	KAJAKAI	0	1.022	29.0	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-58.96	-10.63	60		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	29.48	5.32	30	23		1
				RESO	.00	-.00	4	JUNCTION	29.48	5.32	30	23		9
4	JUNCTION	0	1.046	24.7	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-28.84	-6.36	30	23		1
				SHNT	0.00	0.00	2	KAJAKAI	-28.84	-6.36	30	23		9
				RESO	.00	-.00	5	JUNCTION	13.23	5.40	14		.975	6
							7	KANDAHAR	22.22	3.66	23	17		2
							7	KANDAHAR	22.22	3.66	23	17		10
5	JUNCTION	0	1.046	21.6	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-13.15	-4.58	14			6
				SHNT	0.00	0.00	6	LASHKARG	7.51	3.05	8	23		3
				RESO	-.00	-.00	9	GIRISHK	5.54	1.53	5	16		8
6	LASHKARG	0	.977	19.0	.00	.00								
		0		LOAD	0.00	5.58	5	JUNCTION	-7.14	-2.83	8	21		3
				SHNT	0.00	2.85	9	GIRISHK	-1.86	.11	2	13		4
				RESO	-.00	-.00								
7	KANDAHAR	0	1.009	21.2	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-21.71	-5.72	22	17		2
				SHNT	0.00	0.00	4	JUNCTION	-21.71	-5.72	22	17		10
				RESO	.00	-.00	8	KANDAHAR	43.42	11.43	45		.975	7

A49

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87

KAJAKAI HYDROELECTRIC PROJECT - CASE 5T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.6 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 3. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
8	KANDAHAR	0	1.014	17.3	.00	.00								
		0		LOAD	43.20	26.80	7	KANDAHAR	-43.20	-8.29	44			7
				SHNT	0.00	18.51								
				RESD	-.00	-.00								
9	GIRISHK	0	1.025	20.7	2.40	1.80H								
		0		LOAD	6.00	3.72	5	JUNCTION	-5.56	-1.55	6	16		8
				SHNT	0.00	0.00	6	LASHKARG	1.96	-.37	2	14		4
				RESD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

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A50

88

KAJAKAI HYDROELECTRIC PROJECT - CASE 5T
11KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.6 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW. LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.642 -1.044	.514 -2.058	.369 .216	.102 -.257	.115 2.189	.078 .827	.216 3.137	.081 -.022	.642 -1.044
1-	.514 -2.058									

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A51

89

KAJAKAI HYDROELECTRIC PROJECT - CASE 5T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.6 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
51.47	14.62	53.20	35.10	3.27	-.11	0.00	21.37

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A52

90

KAJAKAI HYDROELECTRIC PROJECT - CASE 5TA
161KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.06 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP	L	TAP	BR. NO.
1	KAJAKAI	0	.950	30.0	4.68	-9.965									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	4.68	-9.96	11				5
				SHNT	0.00	0.00									
				RESD	.00	.00									
2	KAJAKAI	0	1.004	29.3	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-4.67	10.05	11			1.050	5
				SHNT	0.00	0.00	4	JUNCTION	2.34	-5.02	6	4			1
				RESD	-.00	.00	4	JUNCTION	2.34	-5.02	6	4			9
4	JUNCTION	0	1.012	29.3	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-2.32	2.45	3	2			1
				SHNT	0.00	0.00	2	KAJAKAI	-2.32	2.45	3	2			9
				RESD	.00	-.00	5	JUNCTION	.31	-.76	1			.975	6
							7	KANDAHAR	2.17	-2.07	3	2			2
							7	KANDAHAR	2.17	-2.07	3	2			10
5	JUNCTION	0	1.041	29.2	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-.31	.76	1				6
				SHNT	0.00	0.00	6	LASHKARG	.59	.04	1	1			3
				RESD	-.00	-.00	9	GIRISHK	-.29	-.81	1	2			8
6	LASHKARG	0	1.035	26.0	.00	.00									
		0		LOAD	.59	.56	5	JUNCTION	-.59	-.37	1	1			3
				SHNT	0.00	0.00	9	GIRISHK	-.31	-.19	0	2			4
				RESD	-.00	-.00									
7	KANDAHAR	0	1.010	28.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-2.16	-1.36	3	1			2
				SHNT	0.00	0.00	4	JUNCTION	-2.16	-1.36	3	1			10
				RESD	.00	-.00	8	KANDAHAR	4.32	2.72	5			.975	7

A53

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KAJAKAI HYDROELECTRIC PROJECT - CASE STA
132KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.06 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP L	TAP	BR. NO.
8	KANDAHAR	0	1.031	28.5	.00	.00								
		0		LOAD	4.32	2.68	7	KANDAHAR	-4.32	-2.68	5			7
				SHNT	0.00	0.00								
				RESD	.00	-.00								
9	GIRISHK	0	1.044	38.2	1.20	.508								
		0		LOAD	.60	.37	5	JUNCTION	.29	.67	1	2		8
				SHNT	0.00	0.00	6	LASHKARG	.31	-.14	0	2		4
				RESD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

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A 54

91A

KAJAKAI HYDROELECTRIC PROJECT - CASE 5IA
161KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.06 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.016 -2.575	.005 -3.429	.002 -.331	.003 -.323	.005 .087	.000 .003	.003 .041	.001 -.139	.016 -2.575
1-	.005 -3.429									

A55

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92

KAJAKAI HYDROELECTRIC PROJECT - CASE STA
TAIPA TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.06 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
5.98	-9.05	5.92	3.61	.06	-12.67	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A56

93

KAJAKAI HYDROELECTRIC PROJECT - CASE 6T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.8 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION

TOTAL ITERATIONS = 4. SWING BUS = 1.

FROM BUS	NAME	BUS DATA AC VOLTS		ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
1	KAJAKAI	0.	1.050	30.8	81.55S	30.25S								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	81.55	30.25	87			5
				SHNT	0.00	0.00								
				REST	-.00	.00								
2	KAJAKAI	0	1.050	27.3	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-81.32	-25.80	85		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	40.66	12.90	43	33		1
				REST	.00	-.00	4	JUNCTION	40.66	12.90	43	33		9
4	JUNCTION	0	1.022	22.4	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-39.35	-11.93	41	32		1
				SHNT	0.00	0.00	2	KAJAKAI	-39.35	-11.93	41	32		9
				REST	.00	-.00	5	JUNCTION	18.56	3.02	19		.975	6
							7	KANDAHAR	30.02	10.42	32	24		2
5	JUNCTION	0	1.035	19.8	0.00	0.00	7	KANDAHAR	30.02	10.42	32	24		10
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-18.57	-2.00	19			6
				SHNT	0.00	0.00	6	LASHKARG	10.40	2.05	11	30		3
				REST	-.00	-.00	9	GIRISHK	8.17	-.05	8	23		8
6	LASHKARG	0	.959	18.3	.00	.00								
		0		LOAD	12.00	7.44	5	JUNCTION	-9.76	-1.44	10	28		3
				SHNT	0.00	6.52	9	GIRISHK	-2.24	.61	2	16		4
				REST	-.00	-.00								
7	KANDAHAR	0	.956	18.0	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-28.94	-10.56	31	24		2
				SHNT	0.00	0.00	4	JUNCTION	-28.94	-10.56	31	24		10
				REST	.00	-.00	8	KANDAHAR	57.88	21.12	62		.950	7

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KAJAKAI HYDROELECTRIC PROJECT - CASE 6T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.8 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP	L	TAP	BR. NO.
8	KANDAHAR	0	.983	14.6	.00	.00									
		0		LOAD	57.60	35.70	7	KANDAHAR	-57.60	-16.95	60				7
				SHUT	0.00	18.75									
				RESD	-.00	-.00									
9	GRISHK	0	1.014	18.1	2.49	1.984									
		0		LOAD	8.10	4.96	5	JUNCTION	-8.01	.14	8	22			8
				SHUT	0.00	2.47	6	LASHKARG	2.41	-.83	3	18			4
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A 5T 8

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95

KAJAKAI HYDROELECTRIC PROJECT - CASE 6T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.8 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW. LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		1.306 .971	1.079 -.139	.638 .413	.168 -.219	.233 4.447	.095 1.013	.285 4.166	.162 .097	1.306 .971
1-	1.079 -.139									

A59

96

KAJAKAI HYDROELECTRIC PROJECT - CASE 6T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.8 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
83.95	32.05	77.60	48.10	6.35	11.78	0.00	27.83

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

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A60

97

KAJAKAT HYDROELECTRIC PROJECT - CASE 6TA
THREE TRANSMISSION LINES-5 UNITS AT KAJAKAT 0.08 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

FROM BUS	NAME	SC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT CAP	L	TAP	BR. NO.
1	KAJAKAT	0	.930	30.0	6.63	-8.095									
		0		LOAD	-0.00	-0.00	2	KAJAKAT	6.63	-8.09	10				5
				SHUT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAT	0	.942	30.7	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAT	-6.62	8.17	11			1.050	5
				SHUT	0.00	0.00	4	JUNCTION	3.31	-4.08	5	4			1
				RESD	-.00	-.00	4	JUNCTION	3.31	-4.08	5	4			9
4	JUNCTION	0	.926	24.1	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAT	-3.30	1.63	4	2			1
				SHUT	0.00	0.00	2	KAJAKAT	-3.30	1.63	4	2			9
				RESD	.00	-.00	5	JUNCTION	.81	-.40	1			.975	6
							7	KANDAHAR	2.89	-1.43	3	2			2
							7	KANDAHAR	2.89	-1.43	3	2			10
5	JUNCTION	0	1.013	28.9	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-.81	.40	1				6
				SHUT	0.00	0.00	6	LASHKARG	.83	.24	1	2			3
				RESD	-.00	-.00	9	GIRISHK	-.02	-.65	1	1			8
6	LASHKARG	0	1.004	23.7	.00	.00									
		0		LOAD	1.20	.74	5	JUNCTION	-.83	-.55	1	2			3
				SHUT	0.00	0.00	9	GIRISHK	-.37	-.19	0	2			4
				RESD	-.00	-.00									
7	KANDAHAR	0	.983	28.6	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-2.88	-1.81	3	2			2
				SHUT	0.00	0.00	4	JUNCTION	-2.88	-1.81	3	2			10
				RESD	.00	-.00	8	KANDAHAR	5.76	3.62	7			.950	7

A61

98

KAJAKAI HYDROELECTRIC PROJECT - CASE 6TA
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.08 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4, SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	O L	TAP	BR. NO.
8	KANDAHAR	0	1.030	22.2	.00	.00									
		0		LOAD	5.76	3.57	7	KANDAHAR	-5.76	-3.57	7				7
				SHNT	0.00	0.00									
				RESD	.00	-.00									
9	GIRISHK	0	1.015	28.6	1.28	.90m									
		0		LOAD	.28	.50	5	JUNCTION	.02	.52	1	1			8
				SHNT	0.00	0.00	6	LASHKARG	.38	-.12	0	2			4
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

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A 62

99

KAJAKAI HYDROELECTRIC PROJECT - CASE 6TA
110KV TRANSMISSION LINE--5 UNITS AT KAJAKAI 0.06 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		.016 -2.452	.009 -3.239	.005 -.309	.004 -.304	.004 .082	.000 .002	.003 .048	.001 -.132	.016 -2.452
1-	.009 -3.239									

A63

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KAJAKAI HYDROELECTRIC PROJECT - CASE 6TA
115KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 0.08 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
7.83	-7.14	7.76	4.81	.07	-12.00	0.00	0.00

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

A64

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KAJAKAI HYDROELECTRIC PROJECT - CASE 7T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT CAP	0 L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	102.29	37.35S									
		0		LOAD	-0.00	-0.00	2	KAJAKAI	102.29	37.35	109				5
				SHUT	0.00	0.00									
				RESD	-.00	.00									
2	KAJAKAI	0	1.077	26.5	0.00	0.00									
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-101.93	-30.38	106			1.050	5
				SHUT	0.00	0.00	4	JUNCTION	50.96	15.19	53	41			1
				RESD	.00	-.00	4	JUNCTION	50.96	15.19	53	41			9
4	JUNCTION	0	1.005	26.2	0.00	0.00									
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-48.93	-12.03	50	39			1
				SHUT	0.00	0.00	2	KAJAKAI	-48.93	-12.03	50	39			9
				RESD	.00	-.00	5	JUNCTION	22.17	6.83	23			.975	6
							7	KANDAHAR	37.84	8.61	39	30			2
							7	KANDAHAR	37.84	8.61	39	30			10
5	JUNCTION	0	1.007	17.1	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-22.02	-5.26	23				6
				SHUT	0.00	0.00	6	LASHKARG	6.75	1.81	7	19			3
				RESD	-.00	-.00	6	LASHKARG	6.75	1.81	7	19			11
							9	GIRISHK	8.51	1.63	9	24			8
6	LASHKARG	0	.957	14.3	.00	.00									
		0		LOAD	14.00	3.68	5	JUNCTION	-6.46	-1.69	7	19			3
				SHUT	0.00	3.42	5	JUNCTION	-6.46	-1.69	7	19			11
				RESD	-.00	-.00	9	GIRISHK	-1.08	.11	1	7			4
7	KANDAHAR	0	.939	14.2	0.00	0.00									
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-36.21	-7.03	37	28			2
				SHUT	0.00	0.00	4	JUNCTION	-36.21	-7.03	37	28			10
				RESD	.00	-.00	8	KANDAHAR	72.42	14.05	74			.950	7

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KAJAKAI HYDROELECTRIC PROJECT - CASE 7T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI-FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 4. SWING BUS = 1.

X---------- P U L S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP	L	TAP	BR. NO.
8	KANDAHAR	0	.971	9.5	.00	.00									
		0		LOAD	72.00	44.52	7	KANDAHAR	-71.99	-7.87	72				7
				SHNT	0.00	36.75									
				RESD	-.01	-.00									
9	GIRISHK	0	.979	18.5	2.49	1.408									
		0		LOAD	9.60	5.88	5	JUNCTION	-8.32	-1.48	8	24			8
				SHNT	0.00	2.30	6	LASHKARG	1.12	-.37	1	8			4
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

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KAJAKAI HYDROELECTRIC PROJECT - CASE 7T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI-FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		2.035	1.632	.295	.038	.366	.148	.423	.193	2.036
		3.162	1.586	.130	-.263	6.970	1.573	6.184	.151	3.162
1-	1.632	.295								
	1.586	.130								

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KAJAKAI HYDROELECTRIC PROJECT - CASE 7T
11KV TRANSMISSION LINE-5 UNITS AT KAJAKAI-FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
104.69	39.15	95.60	59.25	9.09	24.37	0.00	44.47

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.011	-.001
MVAR	.003	-.003

A68

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105

KAJAKAI HYDROELECTRIC PROJECT - CASE 3T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.05 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 2, SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
1	KAJAKAI	0	1.050	30.0	107.87	35.935								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	107.87	35.93	114			5
				SHNT	0.00	0.00								
				RESD	0.00	.00								
2	KAJAKAI	0	1.079	26.3	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-107.47	-28.33	111		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	53.74	14.17	56	43		1
				RESD	.00	-.00	4	JUNCTION	53.74	14.17	56	43		9
4	JUNCTION	0	1.008	20.2	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-51.52	-10.49	53	41		1
				SHNT	0.00	0.00	2	KAJAKAI	-51.52	-10.49	53	41		9
				RESD	.00	-.00	5	JUNCTION	23.37	2.52	24		.975	6
							7	KANDAHAR	39.84	9.23	41	31		2
							7	KANDAHAR	39.84	9.23	41	31		10
5	JUNCTION	0	1.022	16.3	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-23.22	-.91	23			6
				SHNT	0.00	0.00	6	LASHKARG	7.07	.89	7	20		3
				RESD	-.00	-.00	6	LASHKARG	7.07	.89	7	20		11
							9	GIRISHK	9.07	-.87	9	26		8
6	LASHKARG	0	.972	13.1	.00	.00								
		0		LOAD	14.70	9.11	5	JUNCTION	-6.78	-.77	7	19		3
				SHNT	0.00	7.85	5	JUNCTION	-6.78	-.77	7	19		11
				RESD	-.00	-.00	9	GIRISHK	-1.14	.09	1	8		4
7	KANDAHAR	0	.939	13.3	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-38.03	-7.14	39	30		2
				SHNT	0.00	0.00	4	JUNCTION	-38.03	-7.14	39	30		10
				RESD	.00	-.00	8	KANDAHAR	76.07	14.29	77		.950	7

A-69

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KAJAKAI HYDROELECTRIC PROJECT - CASE 8T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.05 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 2. SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT CAP	O L	TAP	BR. NO.
8	KANDAHAR	0	.969	0.3	.00	.00									
		0		LOAD	75.60	46.90	7	KANDAHAR	-75.60	-7.46	76				7
				SHNT	0.00	39.44									
				RESD	-.00	-.00									
9	GIRISHK	0	1.002	14.3	2.40	1.004									
		0		LOAD	10.08	6.25	5	JUNCTION	-8.86	1.03	9	25			8
				SHNT	0.00	5.12	6	LASHKARG	1.18	-.36	1	8			4
				RESD	-.00	-.00									

NOTE * UNDER OL COLUMN INDICATES LINE S PCT. CAP. IS GREATER THAN 100 P.C.

A70

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KAJAKAI HYDROELECTRIC PROJECT - CASE 8T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.05 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW. LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		2.215	1.804	.295	.040	.399	.152	.467	.206	2.215
		3.676	2.086	.120	-.275	7.598	1.609	6.828	.165	3.676
1-	1.804	.296								
	2.086	.120								

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A 71

108

KAJAKAI HYDROELECTRIC PROJECT - CASE 8T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.05 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
110.27	37.73	100.38	52.26	9.89	27.69	0.00	52.22

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.000	-.000
MVAR	.000	-.000

A72

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109

KAJAKAT HYDROELECTRIC PROJECT - CASE 9T
110kV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.1 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION — TOTAL ITERATIONS = 2, SWING BUS = 1.

FROM BUS	NAME	AC	VOLTS	ANGLE	GEN/LOAD MW	GEN/LOAD MVAR	TO BUS	NAME	MW	MVAR	LOG	PCT 0 CAP L	TAP	BR. NO.
1	KAJAKAI	0	1.050	0.0	113.25	31.175								
		0		LOAD	-0.00	-0.00	2	KAJAKAI	113.25	31.17	117			5
				SHNT	0.00	0.00								
				RESD	-.00	.00								
2	KAJAKAI	0	1.081	26.2	0.00	0.00								
		-0		LOAD	-0.00	-0.00	1	KAJAKAI	-112.82	-23.06	115		1.050	5
				SHNT	0.00	0.00	4	JUNCTION	56.41	11.53	58	44		1
				RESD	-.00	.00	4	JUNCTION	56.41	11.53	58	44		9
4	JUNCTION	0	1.015	19.6	0.00	0.00								
		-0		LOAD	-0.00	-0.00	2	KAJAKAI	-54.06	-7.47	55	42		1
				SHNT	0.00	0.00	2	KAJAKAI	-54.06	-7.47	55	42		9
				RESD	.00	-.00	5	JUNCTION	24.65	1.32	25		.975	6
							7	KANDAHAR	41.73	6.81	42	33		2
							7	KANDAHAR	41.73	6.81	42	33		10
5	JUNCTION	0	1.033	15.6	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-24.48	.43	24			6
				SHNT	0.00	0.00	6	LASHKARG	7.43	.60	7	21		3
				RESD	-.00	-.00	6	LASHKARG	7.43	.60	7	21		11
							9	GIRISHK	9.62	-1.62	10	27		8
6	LASHKARG	0	.988	12.2	.00	.00								
		0		LOAD	15.42	9.55	5	JUNCTION	-7.12	-.46	7	20		3
				SHNT	0.00	8.74	5	JUNCTION	-7.12	-.46	7	20		11
				RESD	-.00	-.00	9	GIRISHK	-1.19	.10	1	8		4
7	KANDAHAR	0	.953	12.4	0.00	0.00								
		-0		LOAD	-0.00	-0.00	4	JUNCTION	-39.84	-4.55	40	31		2
				SHNT	0.00	0.00	4	JUNCTION	-39.84	-4.55	40	31		10
				RESD	.00	-.00	8	KANDAHAR	79.69	9.11	80		.950	7

A73

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110

KAJAKAI HYDROELECTRIC PROJECT - CASE 9T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.1 OF FULL LOAD

REPORT OF LOAD-FLOW CALCULATION TOTAL ITERATIONS = 2. SWING BUS = 1.

X---------- B U S D A T A ----------X

FROM BUS	NAME	AC	VOLTS	ANGLE	-- GEN/LOAD -- MW	MVAR	TO BUS	NAME	MW	MVAR	LDG	PCT 0 CAP L	TAP	BR. NO.
8	KANDAHAR	0	.991	7.3	.00	.00								
		0		LOAD	79.20	49.10	7	KANDAHAR	-79.20	-2.00	79			7
				SHNT	0.00	47.10								
				RESD	-.00	-.00								
9	GIRISHK	0	1.016	13.4	2.40	1.808								
		0		LOAD	10.56	6.55	5	JUNCTION	-9.39	1.82	10	27		8
				SHNT	0.00	6.19	6	LASHKARG	1.23	-.38	1	9		4
				RESD	-.00	-.00								

NOTE * UNDER OL COLUMN INDICATES LINE'S PCT. CAP. IS GREATER THAN 100 P.C.

A74

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111

KAJAKAI HYDROELECTRIC PROJECT - CASE 9T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.1 OF FULL LOAD

SUMMARY OF LINE LOSSES -- LINE 1 = MW, LINE 2 = MVAR

BRANCH	--0	--1	--2	--3	--4	--5	--6	--7	--8	--9
0-		2.356 4.060	1.888 2.258	.316 .141	.042 -.282	.425 8.109	.165 1.747	.486 7.107	.231 .197	2.356 4.060
1-	1.888 2.258	.316 .141								

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A 75

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KAJAKAI HYDROELECTRIC PROJECT - CASE 9T
110KV TRANSMISSION LINE-5 UNITS AT KAJAKAI 1.1 OF FULL LOAD

GENERATION		LOAD		LOSSES		SHUNT	
MW	MVAR	MW	MVAR	MW	MVAR	MW	MVAR
115.65	32.97	105.18	65.20	10.47	29.80	0.00	62.02

MISMATCH TOTALS FOR SYSTEM

	ABSOLUTE TOTAL	ALGEBRAIC TOTAL
MW	.001	-.000
MVAR	.000	-.000

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A76

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