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THE COOPERATIVE REPUBLIC OF GUYANA

THE MASTER PLAN STUDY
ON
ELECTRIC POWER DEVELOPMENT PROJECT
IN
THE COASTAL AREA

FINAL REPORT
SUMMARY

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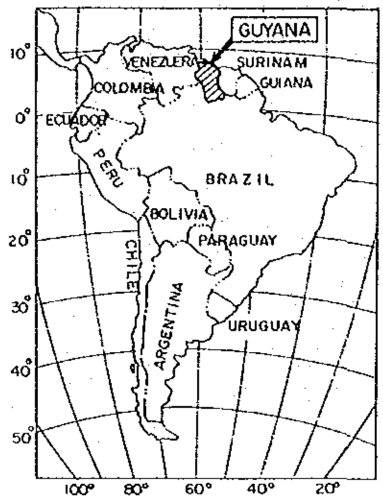
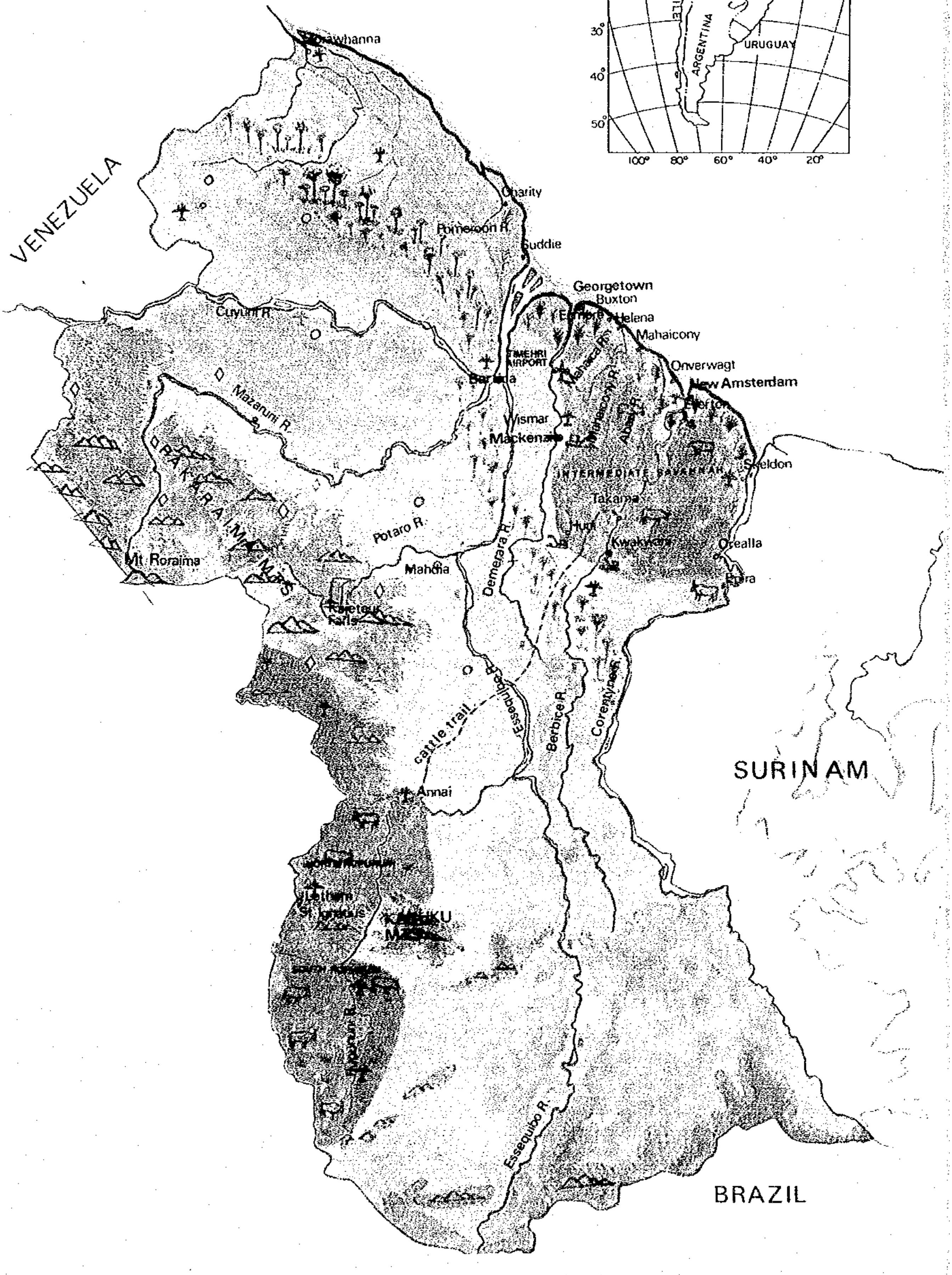
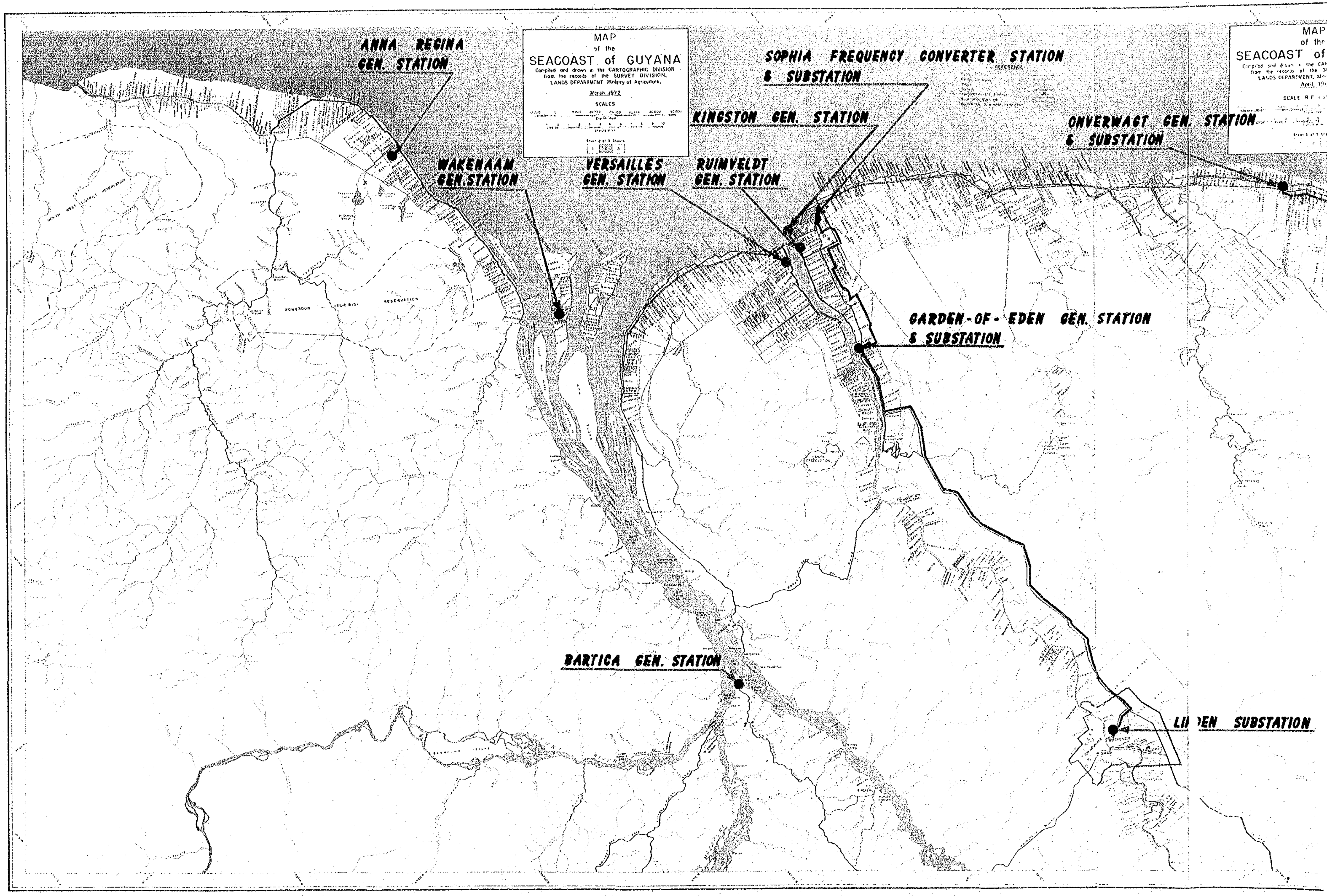
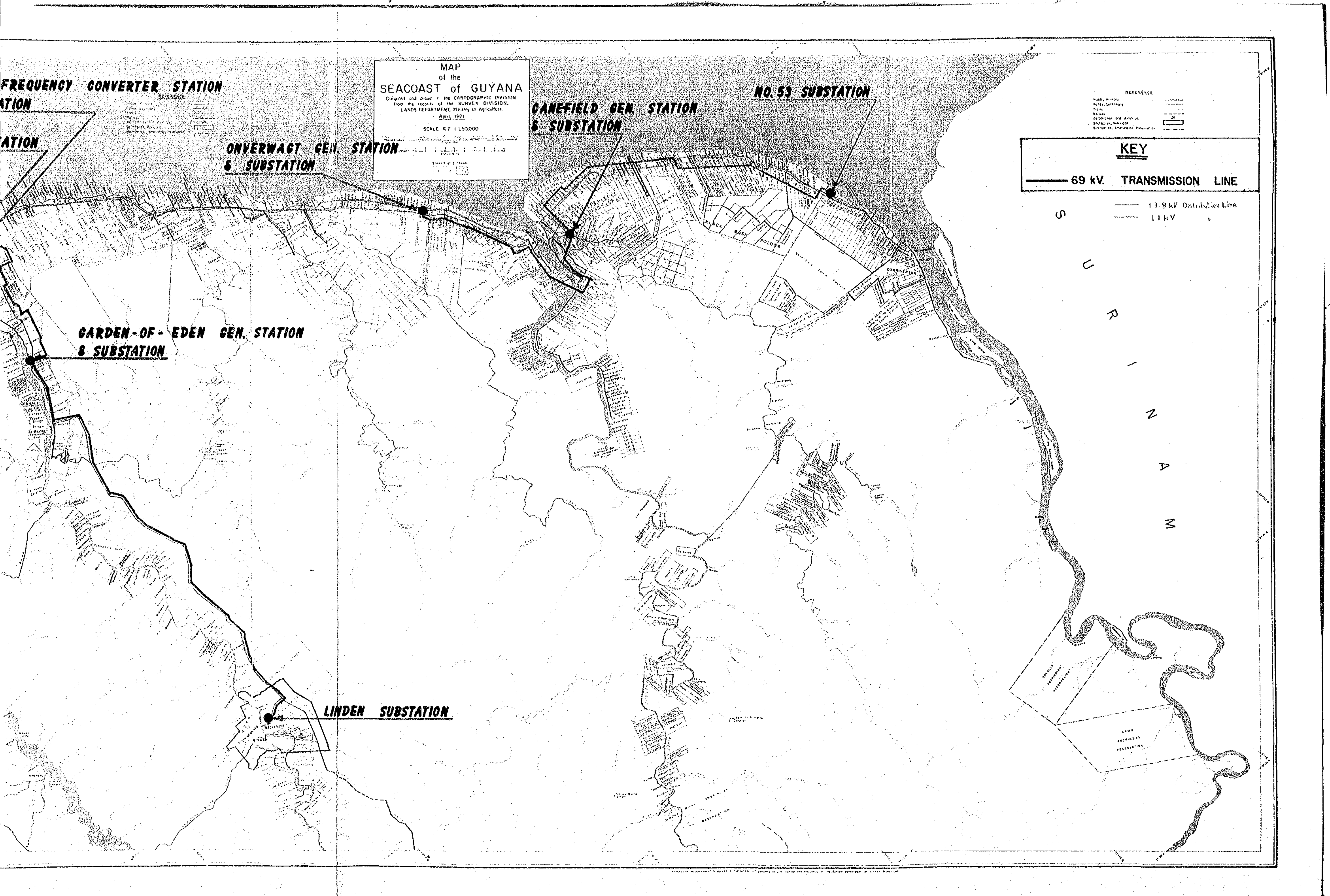
THE COOPERATIVE REPUBLIC OF GUYANA






MAP
of the
SEACOAST of GUYANA
Compiled and drawn in the CARTOGRAPHIC DIVISION
from the records of the SURVEY DIVISION,
LANDS DEPARTMENT Ministry of Agriculture.
March 1972
SCALES
ANNA REGINA
GEN. STATION
WAKENAAM
GEN.STATION
VERSAILLES
GEN. STATION
RUIMVELDT
GEN. STATION
KINGSTON GEN. STATION
SOPHIA FREQUENCY CONVERTER STATION
& SUBSTATION
ONVERWAGT GEN. STATION
& SUBSTATION
GARDEN-OF- EDEN GEN. STATION
& SUBSTATION
BARTICA GEN. STATION
SUBSTATION


FREQUENCY CONVERTER STATION
MAP
of the
SEACOAST of GUYANA
April, 1971
ONVERWAGT GEN. STATION
& SUBSTATION
CANEFIELD GEN. STATION
& SUBSTATION
NO. 53 SUBSTATION
KEY
69 kV. TRANSMISSION LINE
13.8 kV Distribution Line
11 kV
S U R I N A M
GARDEN-OF-EDEN GEN. STATION
& SUBSTATION
LINDEN SUBSTATION

SUMMARY

STUDY REPORT

ON

POWER DEVELOPMENT PLAN FOR COASTAL AREA

OF

REPUBLIC OF GUYANA

SUMMARY

1. BACKGROUND AND OBJECTIVE OF STUDY

(1) Background of Study

For the past several years, the Guyana Electricity Corporation (GEC) has experienced serious shortfall in its electric power supply capability, and is compelled to enforce scheduled blackouts on its customers as a matter of daily practice. To relieve this situation, the rehabilitation of aged power plants presently possessed by GEC, and the development of new electric power supply sources is vital.

Under these circumstances, the Government of the Republic of Guyana requested the Government of Japan to conduct studies for the formulation of an Electric Power Development Master Plan.

In response to this request the Japan International Cooperation Agency (JICA), which is the executing agency for international Cooperation of the Government of Japan, dispatched a study mission to Guyana for 10 weeks, starting from July 14 to September 20 of 1988.

(2) Objective of Study

i) Formulation of Master Plan for Electric Power Development in the Coastal Area of the Republic of Guyana.

Areas of study: The coastal area of Guyana where most electric power is consumed (including Demerara, Berbice, Corentyne, Anna Regina, Wakenaam, Bartica).

Time Period Covered by Study: Next 10 years (1988 to 1998).

ii) Recommendation on the improvement of Operation/Maintenance Management

(3) Study Mission

The Study Mission was composed of eight (8) expert staff members of EPDC International, Inc. Their names and professional fields are listed below.

Name	Assignment
Masashi KOIKE	Team Leader; Power system planning
Tetsuo KOBAYASHI	Load forecast; Economic evaluation
Akio MASUKI	Thermal power plant planning & design
Noriyuki KOHORI	Power plant design (thermal & hydro)
Kunio KURODA	Transmission system planning
Minaichi TAKEOKA	Hydro power planning
Kaname SOBUE	Geological evaluation
Shozo YUZAWA	Hydro power planning (in Japan)

2. ECONOMIC STATUS OF THE REPUBLIC OF GUYANA

(1) Geographical Conditions

Facing the Atlantic Ocean and with a total land area of 215,000 km^2, the Republic of Guyana is situated in the north-eastern part of the South American continent. As of 1984, the population of this nation was about 800,000.

The Republic of Guyana gained independence from Great Britain in 1966, but is still a member of the British Commonwealth of Nations.

The capital city is Georgetown.

The climate is typically tropical and rainy, with temperatures ranging from 23 to 31 degrees C.

(2) Industry and Economy

The major industry is bauxite, sugar and rice, with bauxite accounting for half the national total exports.

As of 1985, Guyana's gross domestic products (GDP) amounted to US$1,964 million. In that year, the nation exported US$215 million and imported US$262 million. The GDP per capita was US$493.

3. GENERAL STATUS OF ELECTRIC POWER SUPPLY

Although the Guyana Electricity Corporation (GEC) is responsible for power generation and distribution for the entire country, industries such as bauxite and sugar have their own generating facilities and therefore purchase no power from GEC. Contrarily, GEC purchases power when the bauxite mine (owned by GUYMINE) has surplus electric power.

The nation's major electric power supply systems are the Demerara Power System and Berbice Power System, which supply power to the capital city of Georgetown and the second largest city, New Amsterdam. There are also 3 small, isolated power systems near the mouth of the Essequibo River.

According to the nameplate ratings, the Demerara Power System and Berbice Power System, which are the major subjects of study for the formulation of this Master Plan, provide a total 66 MW supply capability. In reality, however, only a 37.2 MW output is actually available (as of August, 1988).

Georgetown is the nation's largest load center and where most loads are supplied with 50 Hz.

Guyana's major power networks are 60 Hz systems composed of 69 kV transmission lines. Of the major power stations under GEC, the largest, the Kingston Power Station, generates 50 Hz, while the second largest, the Garden of Eden Power Station and other smaller plants generate 60 Hz. Providing different operating frequencies, these stations are interconnected by a frequency converter station installed at Sophia, which has a nominal capacity of 30 MW, of which 10 MW is actually available today.

4. CURRENT CONDITIONS OF ELECTRIC POWER FACILITIES

(1) Generating Facilities

GEC operates a total of 8 power stations. The total generating capacity of its diesel powered stations is 42.6 MW, and that of the steam powered station, 30 MW. These power stations are badly aged except for the Versailles Power Station which was constructed in 1985 under grant cooperation of the Japanese Government. The current generation capability of these power stations for all of Guyana is approximately 40.3 MW.

Table 3.1.1. shows the power generation facilities presently owned by GEC.

Table 3.1.1 Existing Thermal Power Stations

Name of PS	Type	Unit	Freq. (HZ)	Installed Capacity (MW)	Guaranteed Capacity (MW)	Commission year
1. Demerara System						
Kingston "B"	Steam	1	50	10	8.5	1963
		2	50	10	8.5	1964
		3	50	10	8.5	1967
Versailles	H.Diesel	1	60/50	2.0/1.6	1.4	1985
		2	60/50	2.0/1.6	1.4	1985
		3	60/50	2.0/1.6	1.4	1985
Gaden of Eden	M.Diesel	2	60	5.7	*(3.0)	1975
		3	60	5.7	3.0	1975
		4	60	5.7	*(3.0)	1976
	Demerara total			53.1/51.9	32.7	
2. Berbice System						
Canefield	M.Diesel	3	60	5.8	4.5	1978
		4	60	5.8	*(4.5)	1978
Onverwagt	H.Diesel	5	60	2.5	*(1.8)	1981
	Berbice total			14.1	4.5	
(1+2) Demerara & Berbice total				67.2/66	37.2	
3. Independent System						
Anna Regina	H.Diesel	1	50	1.04	0.65	1972
		2	50	1.04	0.60	1972
		4	50	2.0	1.0	1986
Wakenaam	H.Diesel	3	60	0.5	0.5	1980
Bartica	H.Diesel	1	60	0.39	0.34	1978
		2	60	0.39	*(0.20)	1978
	Independent total			5.36	3.09	
(1+2+3) Whole system total				72.5/71.3	40.3	

Note: *( ) shows generating unit which are out of order as of Aug.1988

(2) Transmission and Distribution Facilities

i) Transmission Facilities

The highest voltage used for power transmission is 69 kV. Transmission lines of this voltage in Demerara run from Linden, a bauxite mine, to the Garden of Eden Power Station and the Sophia Frequency Converter Station, and it is being planned to extend the line to the Berbice Area in the near future. When this line is completed, an interconnection will be established with another 69 kV system covering the Berbice and Corentyne Areas, to complete interconnection nation-wide.

Power system diagram in Guyana is shown in Fig. 3.2.1.

ii) Substation Facilities

Table 3.2.2-1 shows an outline of existing substations.

Table 3.2.2-1 Existing Substation Facilities

(as of August, 1988)

Name of Substation	Voltage (kV)	Capacity (MVA)	Commissioning Year
Garden of Eden	69/13.8	2 x 16.7	1976
Linden	69/13.8	1 x 16.7	1976
Sophia	69/13.8	1 x 16.7	1977
Canefield	69/13.8	1 x 16.7	1984
Onverwagt	69/13.8	1 x 16.7	1986
No. 53 Corentyne	69/13.8	1 x 16.7	1987
New Amsterdam	13.8/2.3	2 x 1.5	
Total		119.9	

iii) System Interconnection Facility

There is a frequency converter station at Sophia, on the outskirts of Georgetown. The main equipment in this converter station is a set of synchronous motor-generators. 3 units providing a 10 MW capacity each have been installed, but only one of these is in operation at present.

iv) Distribution Facilities

The main distribution voltage is 13.8 kV in 60 Hz systems and 11 kV in 50 Hz systems. These main distribution voltages are stepped down to 240 V or 418 kV for customer supply by pole transformers.

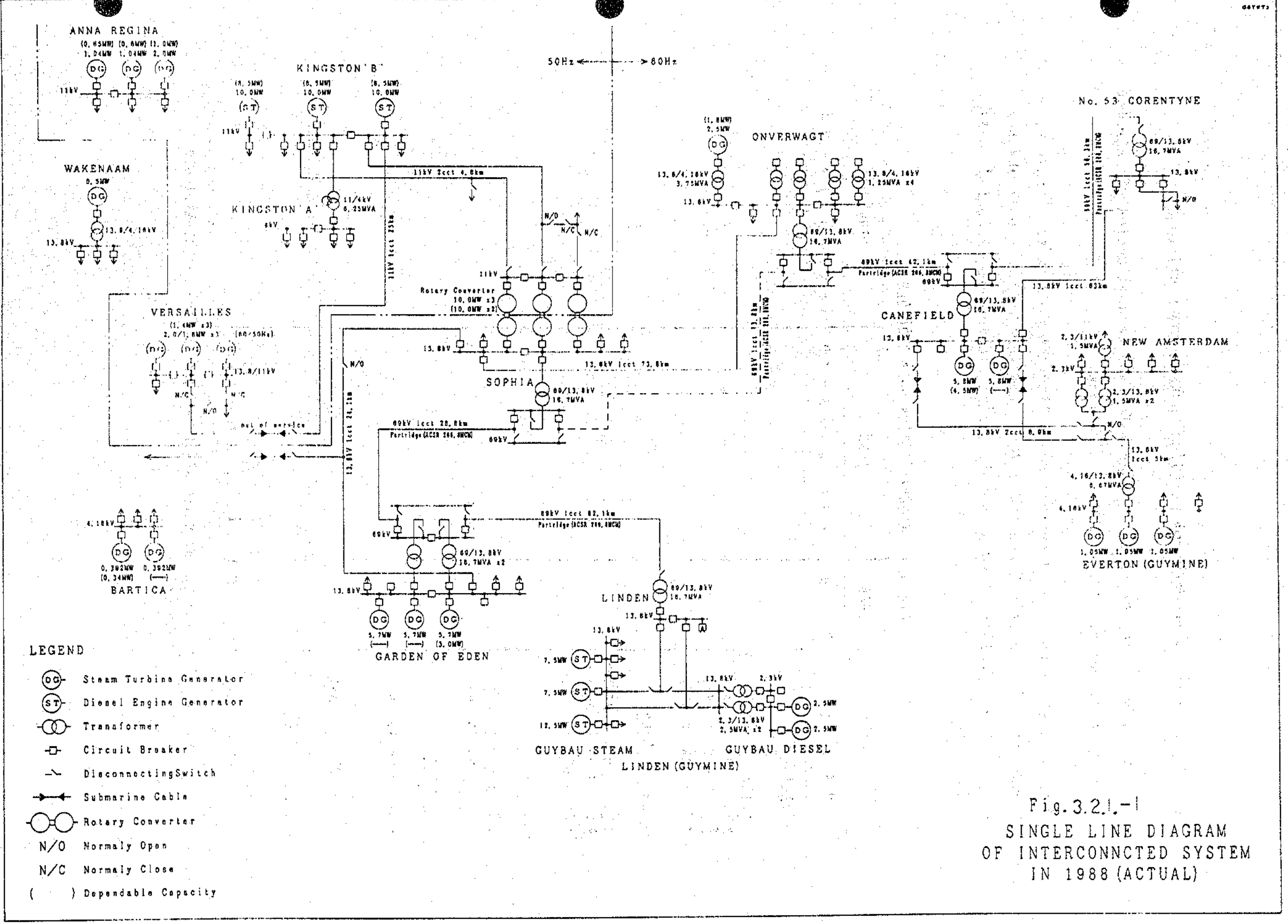


Fig. 3.2.1.-1
SINGLE LINE DIAGRAM
OF INTERCONNCTED SYSTEM
IN 1988 (ACTUAL)

5. REHABILITATION PROGRAM FOR EXISTING THERMAL POWER STATIONS

GEC is currently implementing a program for the rehabilitation of existing power generation facilities under an IDB loan.

The power stations covered by this rehabilitation program are Kingston, Garden of Eden, Canefield and Onverwagt. The schedule of repair and the output to be attained by this rehabilitation program are presented in Fig. 4.1.

Fig. 4. 1 REHABILITATION WORK SCHEDULE

	1988			1989												1990											
Power plant	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
<u>Kingston</u>																											
Actual (Expected)																											
# 1: 8.5MW (8.5MW)									===	===	===	===															
# 2: 8.5MW (8.5MW)																			===	===	===						
# 3: 8.5MW (8.5MW)																						===	===	===			
<u>Garden of Eden</u>																											
# 2: 0 MW (4.0MW) *						4 ===																					
# 3: 0 MW (5.0MW) *										5 ===																	
# 4: 3.0MW (5.0MW)													2 ===														
<u>Canefield</u>																											
# 3: 4.5MW (4.5MW)								===																			
# 4: 0 MW (5.0MW) *				===		5																					
<u>Onverwagt</u>																											
# 5: 0 MW (2.0MW) *			2 ===																								
Total: 33 MW (51 MW)																											
<u>Increase of capacity</u>																											
- Annual:			2		5			4			5			2													
- Accumulated total			2		7			11			16			18													

Note: * shows generating units which are out of order at present due to troubles.

6. POWER DEMAND FORECAST

(1) Methodology of Demand Projection

Power demand forecast was made based on detailed studies of past records about GDP, average rate per unit sold of electricity and number of consumers to find out correlation among these factors.

The studies showed that a linear regression model which uses number of consumers as the explanatory variable would be the most appropriate due to its highest correlation coefficient. Accordingly, this model was used to make power demand forecast for the project.

(2) Conditions for demand forecast

i) Increase of consumers

The electricity consumers was estimated to increase at an average rate of 3.75% per annum.

ii) Share of power demand by system

Demerara system	85.5%
Berbice system	10.8%
Anna Regina/Wakenaam system	3.0%
Bartica system	0.7%
Total	100.0%

iii) Potential power demand

From data on restricted applications, the potential power demand was estimated to be:

5.5 GWh in Demerara system
3.4 GWh in Berbice system

iv) Load factor

Demerara system	65.9% (Average in the recent years)
Berbice system	40.1% (Average in the recnet years)

v) System loss factor

The system loss factor at present is very high at 27 to 37%. GEC estimates that the loss factor in each power system will decline to 18% by 1994. Therefore, a system loss factor of 18% was used in this power demand forecast.

vi) Reserve capacity

In each power system, the reserve margin equivalent to capacity of one largest generating unit is to be secured. (The reason will be described later).

vii) Retirement schedule of superannuated power plants

Most of all existing power plants are superannuated, and their service lives will expire in the near future, although rehabilitation works for these plants are on-going at pesent. In this study, the service life was estimated to be 30 years for steam power plant and 20 years for diesel power plant.

(3) Result of power demand forecast

The results of power demand forecast made on the above-mentioned conditions are shown in Table 5.4.(2) and Fig. 5.1, together with balance of existing supply capability against power demand in the future.

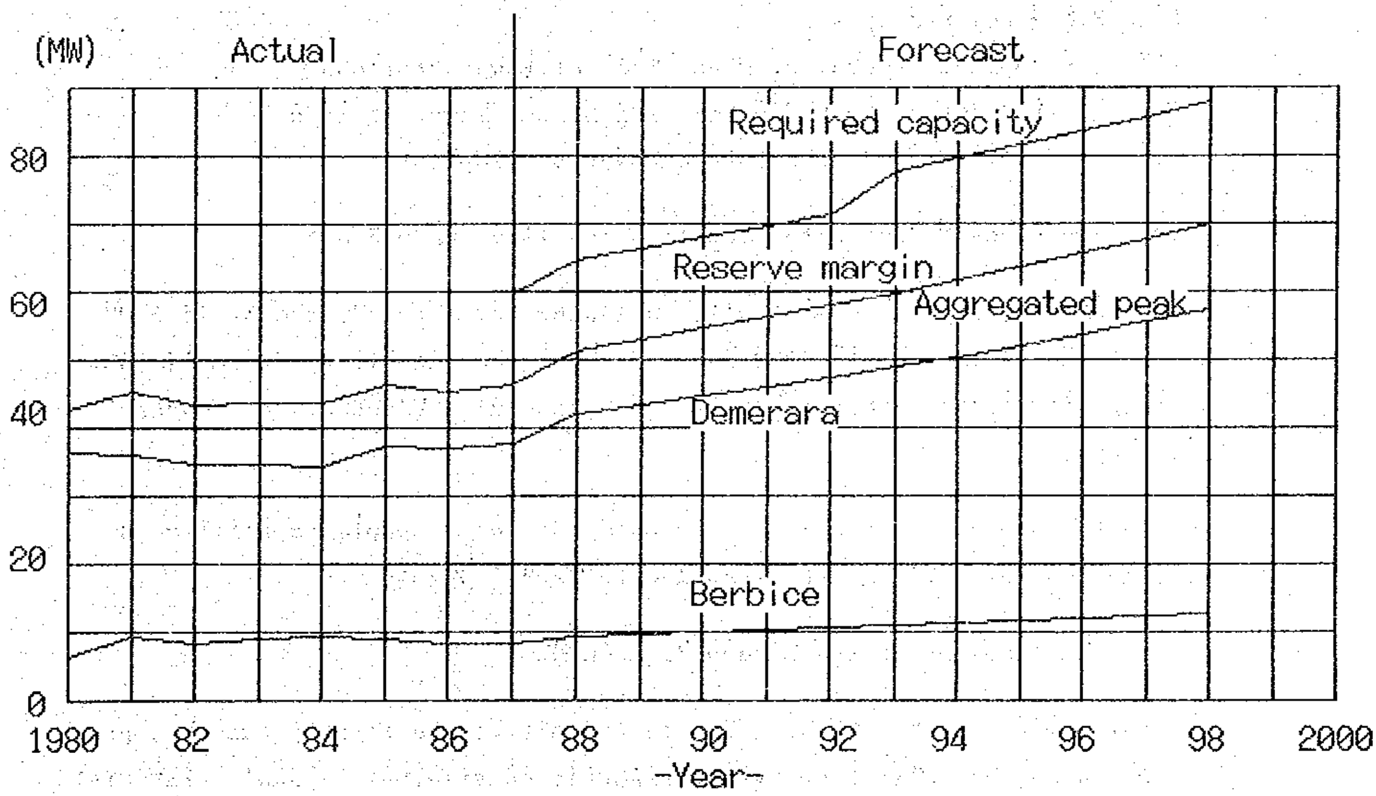
Table 5.4.(2) LOAD FORECAST & SUPPLY BALANCE
(By Existing Power Plants)

Demerara & Berbice System

Year (AD)	Energy sold (GWh)	Energy sent out (GWh)	Peak load (MW)	Reserve margin (MW)	Required capacity (MW)	Existing capacity (MW)	Retire-ment (MW)	Supply balance (MW)
1988	196.6	274.9	51.3	13.5	64.8	39.2	0.0	-25.6
1989	209.4	283.4	52.9	13.5	66.4	55.2	0.0	-11.2
1990	222.1	292.2	54.5	13.5	68.0	55.2	0.0	-12.8
1991	234.1	301.3	56.2	13.5	69.7	55.2	0.0	-14.5
1992	246.1	310.8	58.0	13.5	71.5	55.2	0.0	-16.3
1993	258.7	320.6	59.8	18.0	77.8	55.2	-8.5	-31.1
1994	271.2	330.8	61.7	18.0	79.7	55.2	-17.0	-41.5
1995	279.9	341.3	63.7	18.0	81.7	55.2	-26.0	-52.5
1996	288.9	352.3	65.7	18.0	83.7	55.2	-31.0	-59.5
1997	298.2	363.6	67.8	18.0	85.8	55.2	-39.5	-70.1
1998	307.9	375.4	70.0	18.0	88.0	55.2	-49.0	-81.8

Note: Overall load factor = 61,4%

Fig. 5.1 LOAD FORECAST FOR DEMERARA & BERBICE SYSTEMS



7. SUPPLY CAPABILITY ENHANCEMENT PLAN (POWER DEVELOPMENT PLAN)

(1) General

Even were the rehabilitation program which is now in progress to be fully implemented and be 100% effective, the power supply capability would still fall seriously short of meeting the nation's energy demands, and therefore, urgent measures are required.

Also, most generation facilities now in operation will have to be retired during the time span for which this Master Plan was formulated (10 years), leaving only the Versailles and Onverwagt Power Stations (total capacity of 6.2 MW).

This interprets that the scope of this Power Development Plan must include: i) emergency measures to circumvent the current pressing situation, and ii) a power development program for supply capabilities able to compensate for the retirement of existing major power stations and future load growth.

Our Supply Capability Enhancement Program is discussed below under the following headings;

i) Emergency Measures
ii) Development Program of Major Thermal Power Stations
iii) Replacement Program for Existing Diesel Power Stations
iv) Possibility of Hydroelectric Power Development

(2) Emergency Measures for Supply Capability Enhancement

As the total supply capability will fall short of total demand by 25.6 MW in 1988, and by 11.2 MW in 1989 even if the rehabilitation program is 100% realized, it will be necessary to enforce scheduled blackouts of substantial scope.

Emergency measures are required to expand the power supply capability as early as possible. These are discussed in detail below.

1) Replacement of the Garden of Eden Unit

The replacement of the Garden of Eden #5 Unit is the first promisable project which can be realistically implemented, considering Guyana's financial situation.

The plan calls for the replacement of this station's No. 5 Unit, which has been damaged to an extent beyond any rehabilitation, with a new unit and by using the existing foundation. The capacity of the new unit will be 5.7 MW. [Details of this plan are described later.]

2) Installation of New Unit at Onverwagt Power Station

As illustrated in Table 6-2(2), the shortage in power supply capability will amount to 7.1 MW even if a 5.7 MW unit is added to the Garden of Eden Power Station by 1990 according to the plan discribed above, and additional measures are urgently required.

Based on the following considerations, the Study Mission concluded that the most appropriate measure is to install three 2.6 MW, high-speed diesel generator units on the three foundations remaining at Onverwagt Power Station since three 1 MW units were removed.

i) A new generating capacity must be provided in the Berbice Area where power supply shortage is most pronounced.

ii) The plan should exert as little financial burden as possible.

iii) Existing facilities should be utilized effectively.

High-speed diesel generators are employed in the Versailles Power Station and have demonstrated high performance. As this plan is relatively inexpensive, it is recommended that this would be realized as soon as possible.

(3) Development Program of New, Major Thermal Power Stations

The Kingston Power Station, which is the key supply source in Guyana's power system, is a steam power station consisting of three 10 MW units. This station has operated for 20 plus years since its commissioning and its facilities are badly aged, resulting in aggravated equipment inefficiency and unreliability. The units experience frequent failures to cause extended blackouts in Georgetown City. Although these units should be replaced immediately, if only the economic efficiency of the plant is considered, it was assumed in this study that a conventional 30-year service life of the steam power plant be applied to these units, considering the financial constraints and expecting a good success of the rehabilitation program which is already in progress.

According to this schedule, No. 1 Unit will retire in 1993, No. 2 Unit in 1994, and No. 3 Unit in 1997.

The development of new power plants has been planned to coincide with the retirement of the Kingston units, and the following schedule is the main plan proposed for a new power station.

i) New Power Station Plan (Main Plan)

New Kingston Power Plant Phase I:
Two 13 MW units, commissioned in 1993.

New Kingston Power Plant Phase II:
Two 13 MW units, commissioned in 1995.

Type of main Unit:
60 Hz, synchronous generators driven by low speed diesel engines.

Fuel: Heavy oil only.

Location: Site of old Kingston "A" Power Station.

ii) Evaluation of Plan

* The evaluation of the timing of construction is discussed in Paragraph 5) below.

* Evaluation of power plant capacity:
The optimal combination of generation units operating in 1998 was studied (see Chapter 12 of the main report), and it was concluded that a maximum of 57 MW or so would be appropriate for a base-load station of this type. The balance between supply capacity and demand was then studied and four 13 MW units, providing a total station capacity of 52 MW was selected. (See Table 6-2(2).)

* Study of unit capacity:
It is generally economical to adopt large unit capacity and reduce the number of units. Considering the power system capacity (of approximately 90 MW) in 1998, a 13 MW unit capacity is practically the upper limit.

* Study of engine type:
The logical choice is either low-speed diesel or steam turbine. A low-speed diesel engine was selected based on economic evaluations. (Refer Table 8.4.1 of the main report.)

* Fuel: C-heavy oil.

* Plant location:
The site of the old Kingston "A" Power Station will be the best candidate site considering its proximity to the load center, fuel supply, available transportation facilities, and favorable ground conditions, all proven by the construction of the old power plant.

(4) Replacement Program for Existing Diesel Generators

In planning the replacement of existing diesel generators, the construction of a new major generation source, as discussed above, was first selected based on the possible timing of the retirement of the Kingston "B" Power Station. The replacement schedules for existing diesel units were then decided to substitute the retiring units and supplement further demand growth in the power systems.

Replacement Plan:

Garden of Eden	5.7 MW x 1, medium speed diesel,	1997
Canefield	5.7 MW x 1, medium speed diesel,	1998

(5) Evaluation of Development Plans

In order to develop an optimum power development plan, the three alternatives presented in Table 6.1, each satisfying the necessary supply/demand balance of power and energy, were analyzed and reviewed.

As there is no freedom of choice during the period of the emergency development plan and until the completion of Phase I of the New Kingston Power Station, the content of these alternatives are the same until 1993.

* Alternative 1: (Figure 6-1)
This is the most orthodox plan in that the number of units in each power station is not changed, and the unit capacities are expanded according to growth in demand.

There are only 3 units in the New Kingston Power Station and additional supply capability meeting the demand growth is created by the replacement of medium-speed diesel units.

* Alternative 2: (Figure 6-2)
Nos. 3 and 4 Units of the New Kingston Power Station are commissioned in 1995. The replacement of the Garden of Eden unit in Alternative 1 is not included here.

Large capacity thermal units are commissioned into the power system as base supply at an earlier time.

* Alternative 3: (Figure 6-3)
The Garden of Eden Power Station units are replaced in 1995, and the commissioning of the New Kingston Phase II units is delayed from the timing in Alternative 2, with one unit commissioned in 1996 and another in 1998. In this plan, the supply surplus in 1995, as observed in Alternative 2, is improved.

* Evaluation Results
Alternative 1 provides the lowest total construction cost and Alternative 2, the highest. However, Alternative 3 provides the best total economy including operating expenses, followed by Alternative 2. Whichever is considered, the difference is slight.

Table 12.3.(1) Optimum Sequence of Power Development
(Operation for entire service lives)

Discount rate: 7.0%

Item	Discounted Total costs (US$ thousand) Plan I	Plan II	Plan III
Investment cost	61556.5	64032.0	62963.9
Operation & maintenance cost	19685.8	20477.5	20136.0
Fuel cost	83379.4	76673.8	77245.8
Total cost	164622.0	161183.0	160346.0

Note: A plant factor of 60% is used.

The basic premises adopted in this Report are somewhat optimistic in terms of the service lives of existing facilities and the effect of rehabilitation. Considering this, it is important to attempt to provide certain ample power supply capability by adopting Alternative 2, so that, in the event that reduction in output and efficiency of existing diesel units is encountered earlier than expected, flexible measures can be provided to deal with that situation.

In summary, considering the relative economy and power system reliability, this Report recommends that Alternative 2 be adopted.

Table 6-1 Alternatives for Development Plan

Commissioning Year	Plan I			Plan II			Plan III		
	Power Plant	Capacity (MW)	Area/Type	Power Plant	Capacity (MW)	Area/Type	Power Plant	Capacity (MW)	Area/Type
1988									
1989									
1990	GOE	5.7	D, M	GOE	5.7	D, M	GOE	5.7	D, M
1991	OVW	7.8	B, H	OVW	7.8	B, H	OVW	7.8	B, H
1992									
1993	N.KGS1	26.0	D, L	N.KGS1	26.0	D, L	N.KGS1	26.0	D, L
1994									
1995	N.KGS2	13.0	D, L	N.KGS2	26.0	D, L	GOE	11.4	D, M
1996	GOE	11.4	D, M				N.KGS2	13.0	D, L
1997	GOE	5.7	D, M	GOE	5.7	D, M	GOE	5.7	D, M
1998	CF	13.0	B, M	CF	11.4	B, M	N.KGS3	13.0	D, L
Total		82.6			82.6			82.6	

Breakdown by areas (MW)			
DEMERARA	61.8	61.8	74.8
BERBICE	20.8	20.8	7.8

Breakdown by types						
	(MW)	Share	(MW)	Share	(MW)	Share
High Speed Diesel	7.8	9.4%	7.8	9.4%	7.8	9.4%
Middle Speed Diesel	35.8	43.3%	22.8	27.6%	22.8	2[illegible].6%
Low Speed Diesel	39.0	47.2%	52.0	63.0%	52.0	63.0%

Index of area
- D: Demerara
- B: Berbice & Corentyne

Index of plant type
- H: High speed diesel
- M: Middle speed diesel
- L: Low speed diesel

Index of power plant name
- GOE: Garden of Eden
- OVW: Onverwagt
- N.KGS1: New Kingston 1st stage
- N.KGS2: New Kingston 2nd stage
- N.KGS3: New Kingston 3rd stage
- CF: Canefield

Table 6-2 (1)

Study on Power Balance of each Development Plan

For Plan I

(MW)

Year	Peak Load	Reserve Margin	Required capacity	Rha. & Retire-ment	Develop-ment	Develop-ment (sum)	System capacity	Power Balance
1988	51.3	13.5	64.8	2.0		0.0	39.2	-25.6
1989	52.9	13.5	66.4	16.0		0.0	55.2	-11.2
1990	54.5	13.5	68.0	0.0	5.7	5.7	60.9	-7.1
1991	56.2	13.5	69.7	0.0	7.8	13.5	68.7	-1.0
1992	58.0	13.5	71.5	0.0		13.5	68.7	-2.8
1993	59.8	18.0	77.8	-8.5	26.0	39.5	86.2	8.4
1994	61.7	18.0	79.7	-8.5		39.5	77.7	-2.0
1995	63.7	18.0	81.7	-9.0	13.0	52.5	81.7	0.0
1996	65.7	18.0	83.7	-5.0	11.4	63.9	88.1	4.4
1997	67.8	18.0	85.8	-8.5	5.7	69.6	85.3	-0.5
1998	70.0	18.0	88.0	-9.5	13.0	82.6	88.8	0.8

Fig.6-1 POWER BALANCE AND REQUIRED DEVELOPMENT PLAN-I

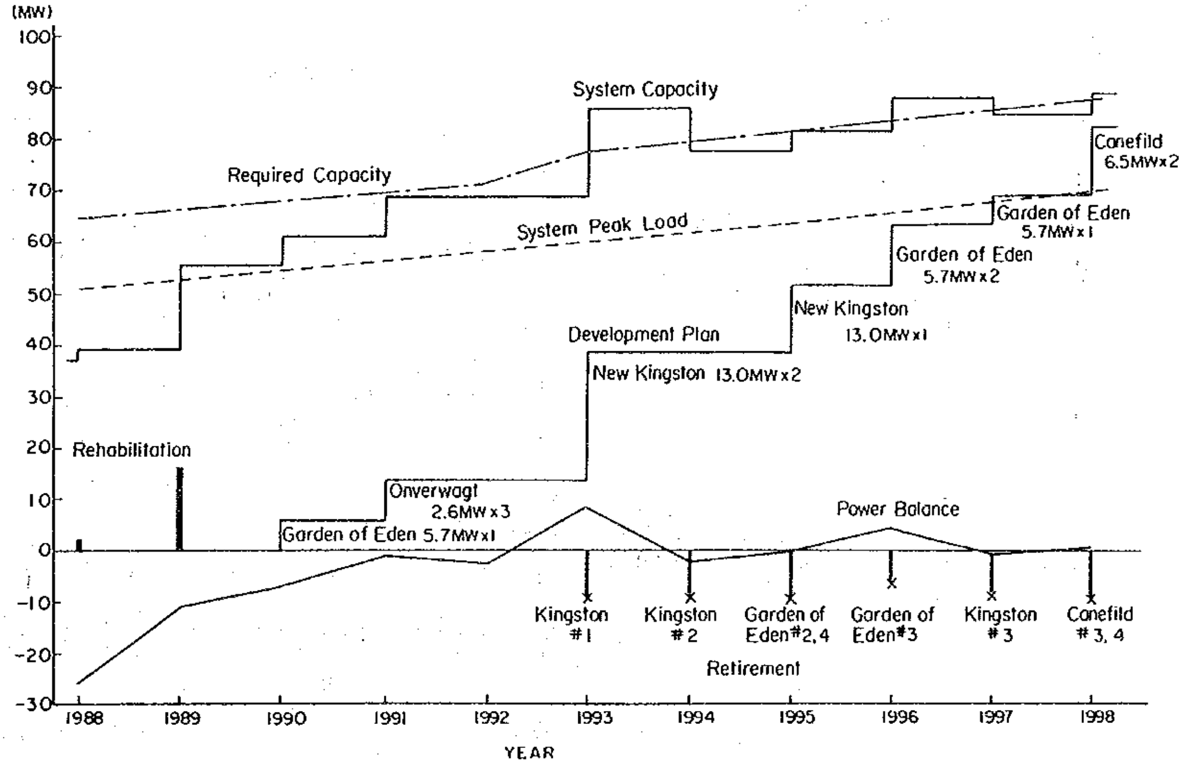


Table 6-2 (2)

Study on Power Balance of each Development Plan

For Plan II

(MW)

Year	Peak Load	Reserve Margin	Required capacity	Rha. & Retire-ment	Develop-ment	Develop-ment (sum)	System capacity	Power Balance
1988	51.3	13.5	64.8	2.0		0.0	39.2	-25.6
1989	52.9	13.5	66.4	16.0		0.0	55.2	-11.2
1990	54.5	13.5	68.0	0.0	5.7	5.7	60.9	-7.1
1991	56.2	13.5	69.7	0.0	7.8	13.5	68.7	-1.0
1992	58.0	13.5	71.5	0.0		13.5	68.7	-2.8
1993	59.8	18.0	77.8	-8.5	26.0	39.5	86.2	8.4
1994	61.7	18.0	79.7	-8.5		39.5	77.7	-2.0
1995	63.7	18.0	81.7	-9.0	26.0	65.5	94.7	13.0
1996	65.7	18.0	83.7	-5.0		65.5	89.7	6.0
1997	67.8	18.0	85.8	-8.5	5.7	71.2	86.9	1.1
1998	70.0	18.0	88.0	-9.5	11.4	82.6	88.8	0.8

Fig.6-2 POWER BALANCE AND REQUIRED DEVELOPMENT PLAN - II

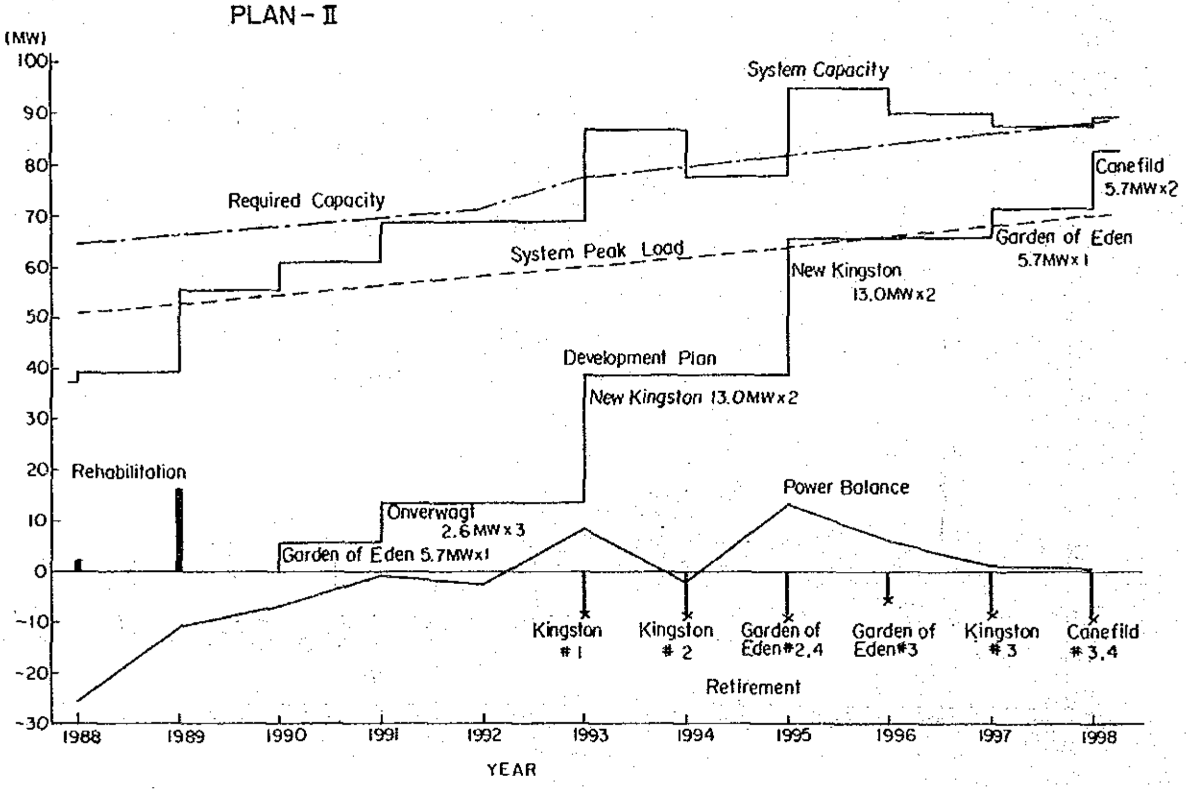


Table 6-2 (3)

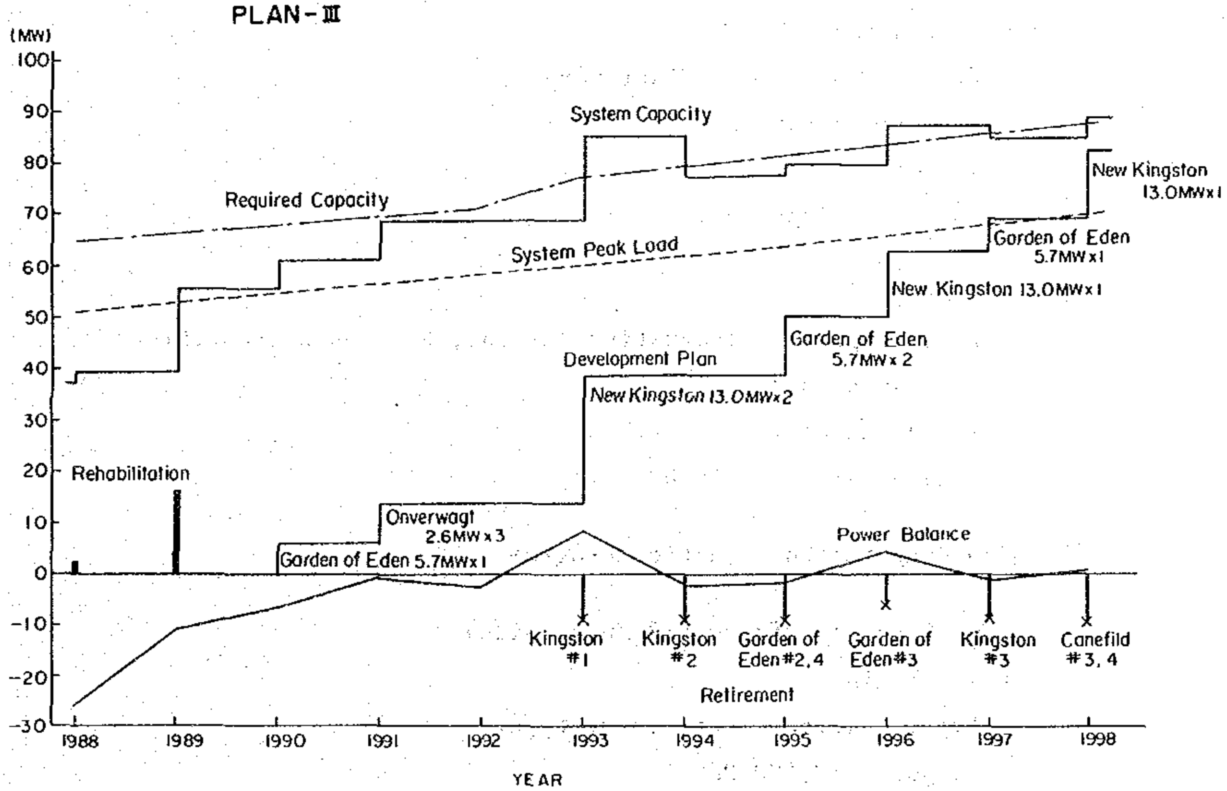
Study on Power Balance of each Development Plan

For Plan III

(MW)

Year	Peak Load	Reserve Margin	Required capacity	Rha. & Retire-ment	Develop-ment	Develop-ment (sum)	System capacity	Power Balance
1988	51.3	13.5	64.8	2.0		0.0	39.2	-25.6
1989	52.9	13.5	66.4	16.0		0.0	55.2	-11.2
1990	54.5	13.5	68.0	0.0	5.7	5.7	60.9	-7.1
1991	56.2	13.5	69.7	0.0	7.8	13.5	68.7	-1.0
1992	58.0	13.5	71.5	0.0		13.5	68.7	-2.8
1993	59.8	18.0	77.8	-8.5	26.0	39.5	86.2	8.4
1994	61.7	18.0	79.7	-8.5		39.5	77.7	-2.0
1995	63.7	18.0	81.7	-9.0	11.4	50.9	80.1	-1.6
1996	65.7	18.0	83.7	-5.0	13.0	63.9	88.1	4.4
1997	67.8	18.0	85.8	-8.5	5.7	69.6	85.3	-0.5
1998	70.0	18.0	88.0	-9.5	13.0	82.6	88.8	0.8

Fig.6-3 POWER BALANCE AND REQUIRED DEVELOPMENT PLAN-III



8. OUTLINE OF POWER PLANT FACILITIES INCORPORATED INTO THE POWER DEVELOPMENT PLAN

(1) Garden of Eden Replacement Program

Plant Capacity (added) 5.7 MW 1 unit

Diesel Engine

- Type: 4-stroke, stationary type.
- Output: 8,070 PS
- Speed: 720 rpm
- Fuel: diesel oil

Generator

- Type: 3-phase, alternating current, horizontal, synchronous generator
- Rated capacity: 7,125 kVA
- Voltage: 13.8 kV
- Frequency: 60 Hz

(2) Onverwagt Expansion Program

Plant Capacity (added) 7.8 MW (2.6 MW 3 untis)

Diesel Engine

- Type: 4-stroke, stationary type.
- Output: 3,680 PS
- Speed: 900 rpm
- Fuel: diesel oil

Generator

- Type: 3-phase, alternating current, horizontal, synchronous generator
- Rated capacity: 3,250 kVA
- Frequency: 60 Hz

(3) New Kingston Construction Program

Plant Capaicty 52 MW (13 MW 4 units)

Diesel Engine

- Type: 2-stroke, stationary type.
- Output: 18,400 PS

Speed: 129 rpm

Fuel: C-fuel oil

Generator

Type: 3-phase, alternating current, horizontal, synchronous generator

Rated capacity: 16,250 kVA

Voltage: 13.8 kV

Frequency: 60 Hz

Interconnection Transformer

Type: Outdoor, 3-phase, self cooled, 3-winding transformer

Rated capacity: 16.7 MVA x 2 Banks

Voltage: primary; 13.8 kV, secondary; 69 kV

Neutral: directly grounded

9. POWER SYSTEM PLAN

The power development programs incorporated into the Master Plan require no revision of existing power systems, except that for the construction of the New Kingston Power Station.

For New Kingston, the following power system plan must be formulated and implemented.

(1) Connection of 69 kV System to Power Station

The New Kingston Power Station will be operated at 60 Hz to bear the base load of Guyana's entire power systems, making it the nation's main power station.

This power station must, therefore, be connected to the main 69 kV power system which covers the nation's major load centers, for efficient power system operation as well as for reduced transmission loss.

i) Construction of New 69 kV Transmission Line

Section: From New Kingston to Sophia

Route: The shortest possible route should be selected.

Design: 69 kV transmission line on wooden or steel poles.

Number of circuits: 1

Length: Approximately 6 km.

ii) Substation Design

Function: To transmit approximately one half of the power generated at the New Kingston Power Station to a centralized power grid.

Transformer capacity: 16.7 MVA x 2

(2) Unification of Georgetown's Distribution Frequency to 60 Hz

The New Kingston Power Station will be constructed with 60 Hz rating in accordance with the laws of the Republic of Guyana.

All Georgetown consumers, now currently supplied with 50 Hz power, will have to be converted to 60 Hz consumers. It is mandatory that GEC provide new 60 Hz distribution systems, that it has its customers convert their equipment to 60 Hz, thereby taking the first step toward the unification of the country's power system frequency which was postulated in 1972.

As the commissioning of the New Kingston Power Station is quite close, in 1993, specific work plans for frequency unification must be formulated promptly.

As the scope of this Master Plan is limited to the formulation of power development plans, specific matters concerning frequency conversion of the distribution system are not reported here. (Only concepts of frequency conversion procedures which have been studied are described.)

We do recommend generally, however, that it is urgent that GEC conduct detailed surveys and formulate precise work plans.

(See Fig. 10-4, 10-5)

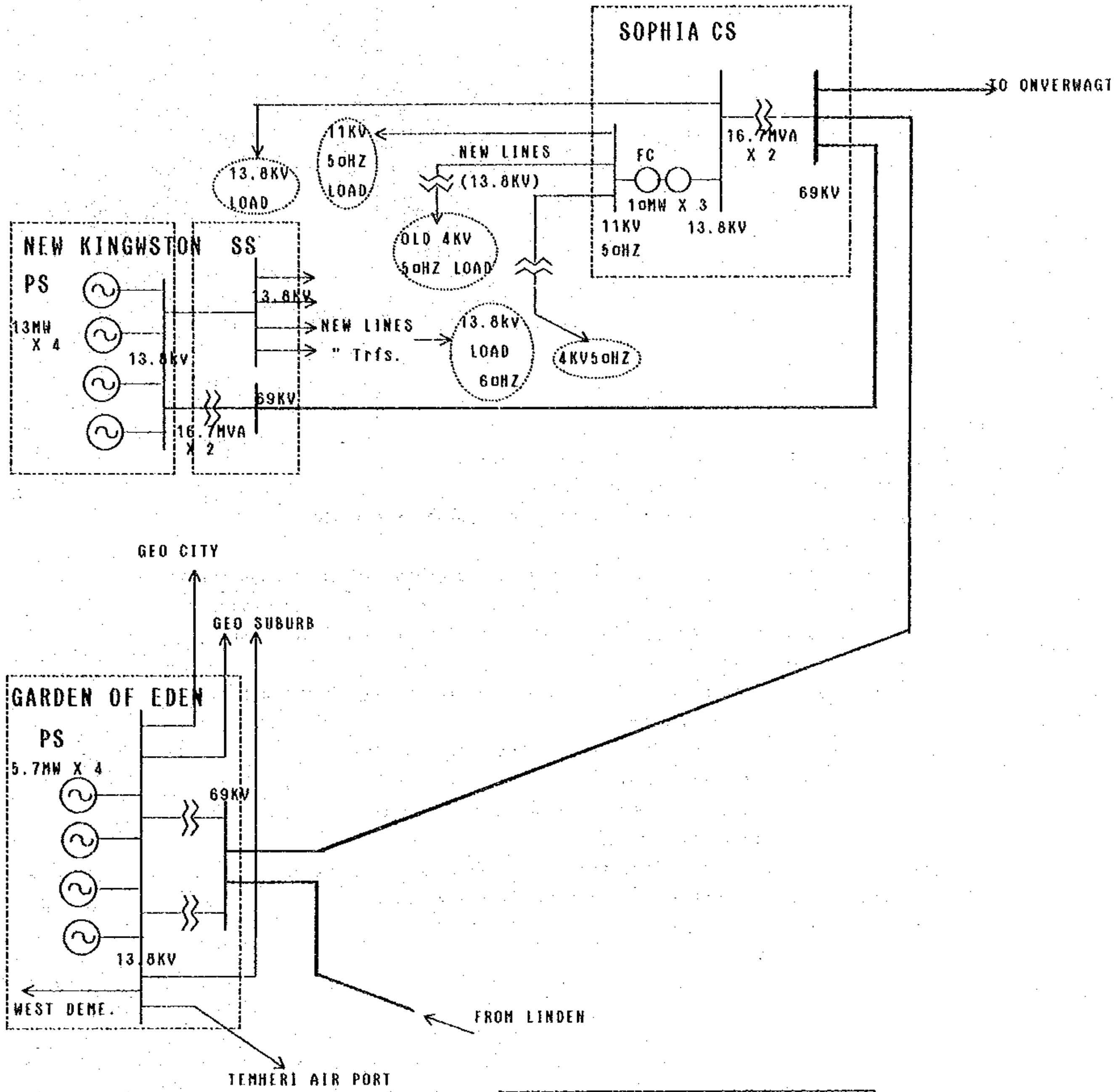
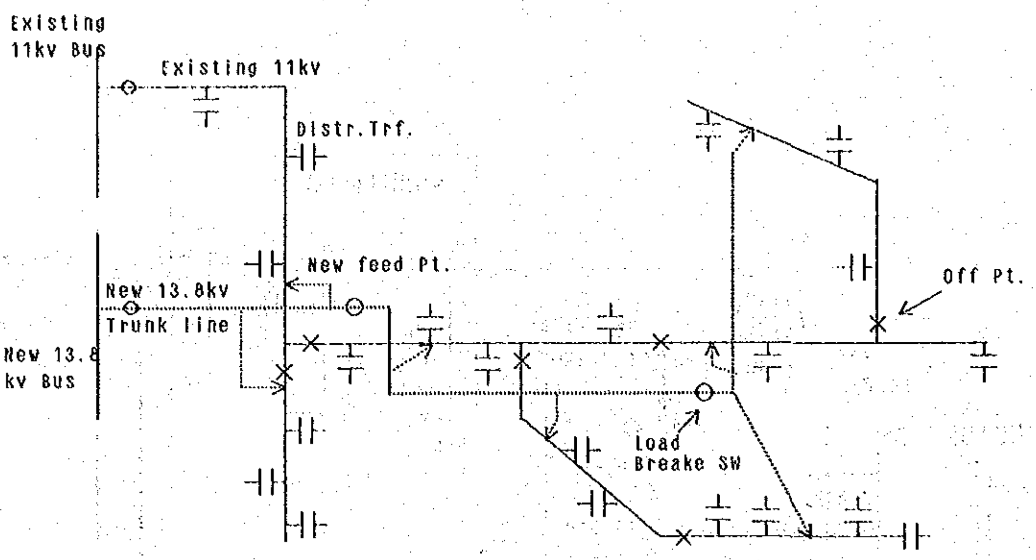


Fig. 10-4

SYSTEM DIAGRAM
AS OF 1995

EPDC INTERNATIONAL JAN.1989



Work order

1)Determination of breake points of existing lines
in order to use these parts as the branch lines.

2)Construction of new 13.8kv trunk lines along appropriate routes.

3)Test of freq. change work.

i) Replace of distribution transformers of a designated suitable model area from existing 11kv to new 13.8 kv within short hours supply-stoppage.

ii) Connection of the above portion of existing line to new trunk line at a suitable point.

iii) Supply 60HZ power to the consumers of the area through new trunk line and a part of existing line.

iv) Investigation of influence of freq. change for consumers.
Pointing out improvement points.
If necessary, tentative 50HZ power be supplied again, by mobile diesel generator etc.

4)Suitable counter measures aginst troubles cleared up by the test.

5)Execution of 60HZ conversion work successively for other areas by same manner as test case.

Fig. 10-5
Conceptual Drawing for Frequency Conversion in Georgetown
EPDC International Ltd.

10. TENTATIVE ESTIMATE OF CONSTRUCTION COST

As this Report only presents a Master Plan, detailed surveys for individual projects were not conducted. Although construction costs should be calculated based on detailed studies of individual projects, this Report provides only tentatively estimated construction cost for the purpose of economic comparison of alternatives. One exception is the replacement of the Garden of Eden Unit. As this program has been identified as the top priority project among emergency measures for supply capability enhancement, the project cost has been estimated in detail.

Tentative estimate of construction cost is shown below:

(1,000US$)

Items	Foregin currency	Local currency	Total
Power station	81,923	14,457	96,380
Transmission & substation facilities	2,484	851	3,335
Total	84,407	15,308	99,715

11. ECONOMIC EVALUATION

(1) Methodology

To select optimum type of power plant which is best adapted for load pattern of power system, it would be appropriate to use a method which consists of drawing cost-time curves of net 1 kW at sending-end of all types of power plants to obtain break-even points for economic operation of these power plants, and then projecting these break-even points on a forecasted load duration curve for the future to determine an optimum scale of their development. The types of power plant studied for this purpose are as follows:

- High speed diesel power plant, burning diesel oil
- Medium speed diesel power plant, burning diesel oil
- Low speed diesel power plant, burning Bunker C
- Gas turbine power plant, burning diesel oil
- Steam power plant, burning Bunker C

(2) Result of evaluation

The results of analysis conducted at the discount rate of 7% and 9% shows that the optimum structure of power source in 1998 would be as follows:

Optimum structure of power source (in 1998)	Discount rate 7% (MW)	Discount rate 9% (MW)
Low speed diesel (Bunker C)	57.2	55.4
High speed diesel (Diesel oil)	24.6	26.4
Remaining capacity of eixting P.S.	6.2	6.2
Total required capacity	88.0	88.0

(3) Relation with power development plan

Notwithstanding the above results, the power development plan described in Section 7 consists of 52 MW (13 MW x 4) for low speed diesel power plant and 29.8 MW for high speed and meidum speed diesel power plants, taking into account effective utilization of foundations of existing power plants and probable rise of interest rate in the future.

12. TIGER HILL HYDRO POWER DEVELOPMENT

(1) Necessity of hydroelectric power development

Toward attaining self-sufficiency in energy supply, it is recommended in general that, as soon as may be possible, the Government of the Republic of Guyana formulate a plan for the development of its hydroelectric potential, of which it has an abundance. In this context, the Study Mission conducted surveys of pre-feasibility levels on the Tiger Hill site, currently considered the most promising site for power supply to the coastal area, and subsequently formulated a recommendation plan.

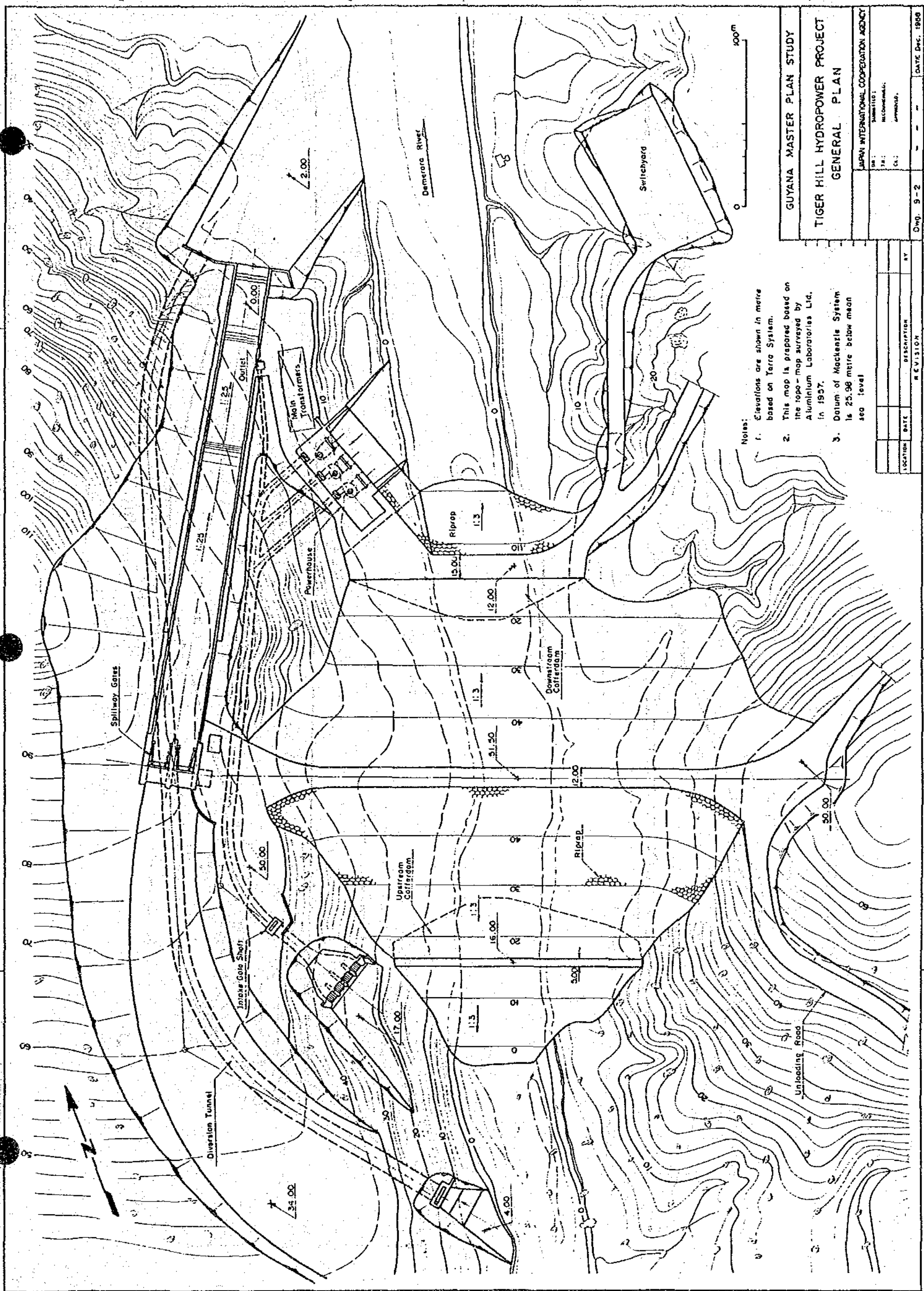
However, it appears difficult to incorporate a hydroelectric development program into this Master Plan, both in terms of lead time and the scale of financing. Therefore, only the surveys to be conducted for the realization of the Tiger Hill hydroelectric development project, as well as their proposed schedules, are presented in this Report.

(2) Outline of Tiger Hill hydroelectric power scheme

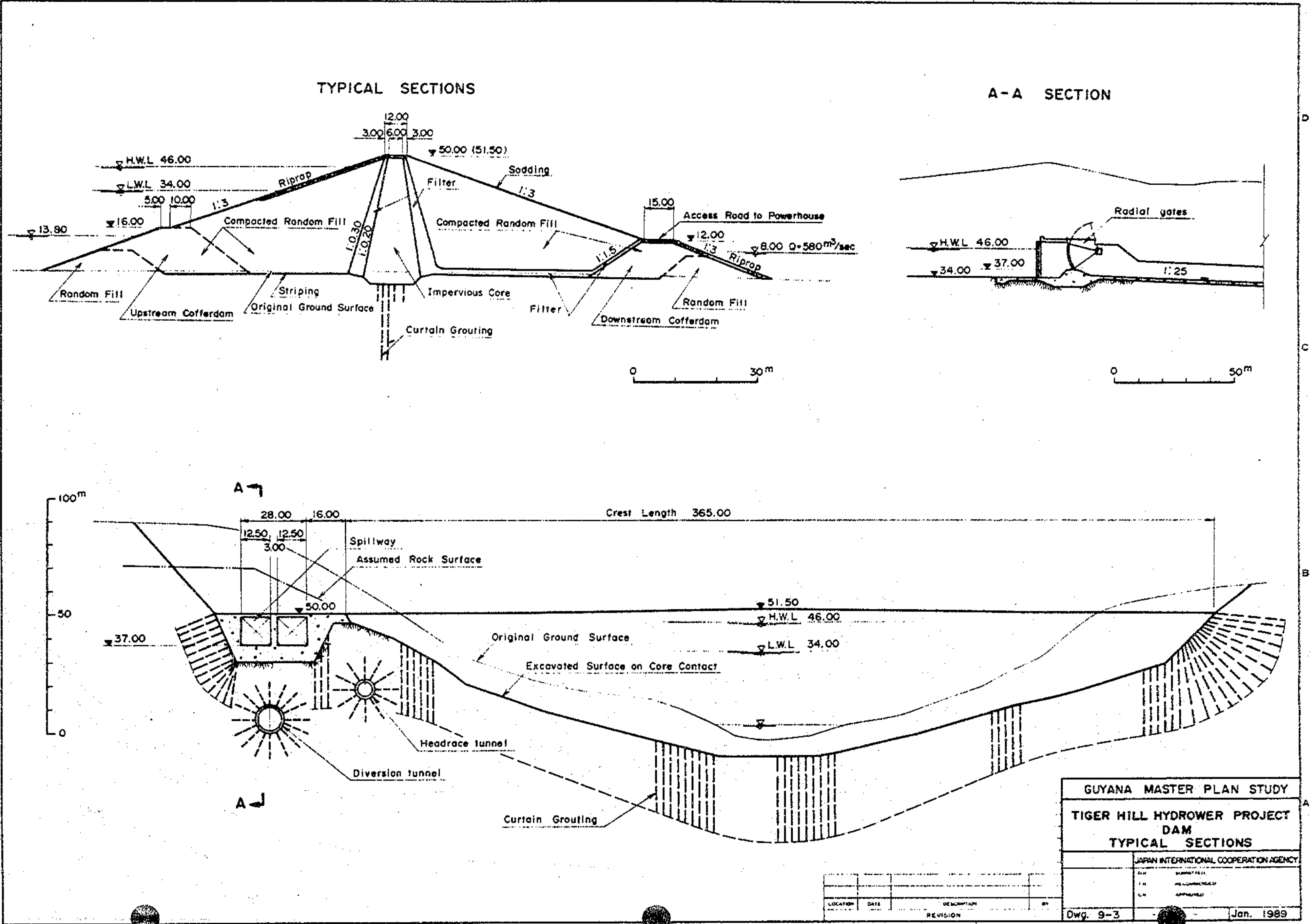
General features of Tiger Hill Project are shown below:

Power generation system	Dam type
Installed capacity	56,000 kW (28,000 kW x 2 units) Another 28 MW unit will be added in future
Annual energy production	265 GWh
Catchment area	4,100 km^2
Reservoir area (at HWL)	534 km^2
Average annual inflow	36×10^8 m^3
Recorded maximum runoff	454 m^3/sec
Recorded minimum runoff	12 m^3/sec
Average annual runoff	113.7 m^3/sec
High water level	EL. 46 m
Low water level	EL. 34 m
Available drawdown	12 m
Total storage capacity	5760×10^6 m^3
Effective storage capacity	4220×10^6 m^3
Normal intake level	EL. 41.5 m
Normal tailrace level	EL. 4.1 m

Gross head	37.4 m
Head loss	1.4 m
Normal effective head	36.0 m
Maximum available discharge	186 m^3/sec
Maximum output	56,000 kW
Annual energy production	265 GWh
Primary energy	237 GWh
Secondary energy	28 GWh
Evaporation loss	480 mm/yr
Equivalent peak duration time	12 hr
Peak duration	8 hr
25% load duration	16 hr
Dam	Fill-type
Dam height	62 m
Dam volume	1,498,000 m
Dam crest length	365 m
Spillway	Surface chute type
Design discharge	960 m^3/sec
Spillway gates	Radial gate, 2 units
Headrace tunnel length	235 m
Headrace diameter	8 m, 1 line
Penstock	Dia. 4.5 m, 3 lines, length 215 m
Turbine	
Type, capacity	Kaplan-type turbine, 29.3 MW x 2 units 29.3 MW x 1 unit (future)
Maximum discharge	186 m^3/sec
Normal effective head	36 m
Speed	212 rpm
Generator	
Capacity	32.3 MVA x 2 units
Frequency	60 Hz
Transmission line	
Length	135 km, 2 cct
Voltage	138 kV



GUYANA MASTER PLAN STUDY
TIGER HILL HYDROPOWER PROJECT
GENERAL PLAN
JAPAN INTERNATIONAL COOPERATION AGENCY
Dwg. 9-2
SHEET NO.
OF
REVISION
LOCATION
DATE
DESCRIPTION
BY
Notes:
1. Elevations are shown in metre based on Tarra System.
2. This map is prepared based on the topo-map surveyed by Aluminium Laboratories Ltd. in 1957.
3. Datum of Mackenzie System is 25.98 metre below mean sea level
Switchyard
Demerara River
Main Transformers
Outlet
Powerhouse
Spillway Gates
Downstream Cofferdam
Upstream Cofferdam
Riprap
Intake Gate Shaft
Diversion Tunnel
Unloading Road
100m

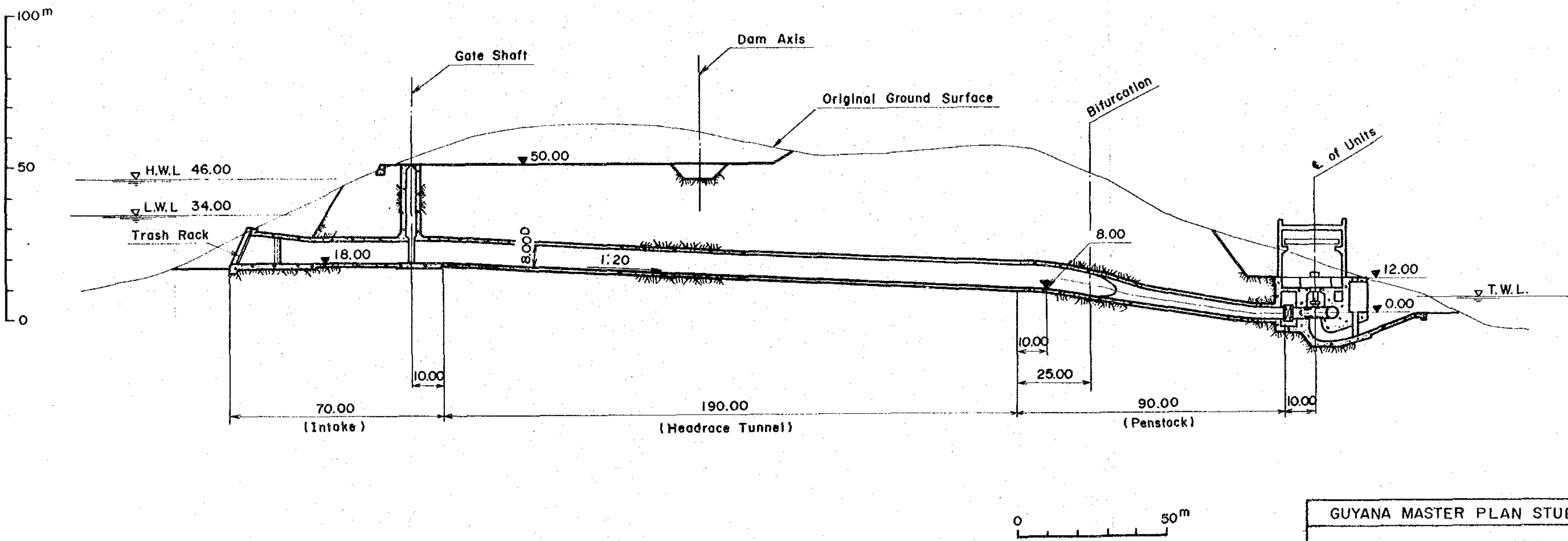


GUYANA MASTER PLAN STUDY

TIGER HILL HYDROWER PROJECT
DAM
TYPICAL SECTIONS

JAPAN INTERNATIONAL COOPERATION AGENCY

Dwg. 9-3 | SHEET NO. OF | Jan. 1989



GUYANA MASTER PLAN STUDY

TIGER HILL HYDROPOWER PROJECT

PROFILE OF WATERWAY

JAPAN INTERNATIONAL COOPERATION AGENCY

LOCATION	DATE	DESCRIPTION	BY
		REVISION	

Dwg. 9-4 | Jan. 1989

SHEET NO. 1 OF

13. ADVICE ON IMPROVEMENT OF OPERATION/MAINTENANCE MANAGEMENT

Various advice and recommendations are presented in the main text of this Report concerning technical and managerial improvements on the operation and maintenance of power facilities. The essential points of these recommendations are noted here.

(1) Securing Appropriate Maintenance Budget

All GEC officers and employees should be made clearly aware that expense is required to keep facilities in good condition. GEC must strongly request its Government to create a budgetary framework by which yearly funds for maintenance (in particular, foreign currency funds) can be appropriated regularly.

(2) Proper Management of Operation Records

Standardized formats must be established for fault records, maintenance and inspection records and facility repair records. It is vital that all personnel are encouraged to provide exact written record of all operations. Such records should be kept in the office in charge and the content should also be reported to supervisory offices according to properly established rules. (It may be difficult for some plant employees to keep complete records at first, but it must be noted that practice in compulsory record keeping could be used to provide basic training, arouse the interest of employees in the facilities for which they are responsible, and also aid in establishing working discipline within plants.)

CONCLUSION AND RECOMMENDATION

CONCLUSION AND RECOMMENDATION

(1) Prompt Realization of Garden of Eden Unit Replacement Program

This program has been identified as the top priority project among Emergency Measures for supply capability enhancement. It is recommended that GEC will promptly accelerate the realization of this program.

Program Outline:

Installation of a new, 5.7 MW, medium speed diesel generator. (The foundation and building of existing power station will be utilized as such.)

Scheduled commissioning; end of 1990.
Total construction cost; approximately 700 million yen.

(2) Authorization of Onverwagt Power Station 3 Units Replacement

The supply capacity of Berbice System must be expanded by some 7 MW as the second step of Emergency Measures for supply capability enhancement. It is recommended that GEC reviews the plan proposed in this Report immediately, finalize the plan, forward the plan to the Government, and take necessary actions for realization of plan including procurement of funds.

Program Outline:

Installation of three, new, 2.6 MW, high speed diesel generators. (The foundation and building of existing power station will be utilized as such.)

Scheduled commissioning; end of 1991.
Total construction cost; approximately 800 million yen.

(3) Preparation of Construction of New Kingston Power Station

Construction of New Kingston Power Station is the key project in Power Development Plan of Guyana. Existing Kingston B Power Station is approaching the end of plant life. Since it is inevitable for GEC to construct a new power station, it is necessary to start planning right now. In this context, it is recommended that the feasibility study of this project should be started immediately.

Program Outline:

Installation of a new power station having low speed diesel generators with total capacity of 52 MW.

Unit capacity; 13 MW, 4 units
Location; premise of old Kingston "A" Power Station
Scheduled commissioning; Phase I, 13 MW x 2, 1993
Phase II, 13 MW x 2, 1995
Total construction cost; approximately 8 billion yen.

(4) Preparation of Hydroelectric Development Plan

Since the Republic of Guyana is blessed with abundant hydroelectric power resources, it is recommended that hydroelectric power plants are constructed as soon as practicable to secure energy self-sufficiency of the nation.

Although Tiger Hill Site has not been incorporated in this Master plan as a realistic power supply source which can improve supply shortage by 1998, this project has been verified as an excellent hydroelectric potential. Therefore, it is recommended that GEC authorizes its willingness to take up this project and start preparations which are recommended in this Report.

Recommended Project Plan:

Power Station capacity; 56 MW (to be expanded to 84 MW in future)
Rockfill dam with effective storage capacity of 4220 x $10^6 m^3$.
Effective head; 36 m, maximum discharge; 186 m^3/s
Generator capacity 28 MW x 2 (1 unit added in future)
Annual generation; 265 GWh.

(5) Improvement of Operation/Maintenance Management

Various recommendations presented in the main text of this Report are those that can be implemented immediately. It is advised that GEC examine these recommendations carefully.

(6) Accelerating 60 Hz Conversion of Georgetown Loads

As Kingston B Power Station, currently being operated at 50 Hz, will soon retire, and power will be supplied by 60 Hz New Kingston Power Station, all customers in Georgetown must be converted to 60 Hz. This could be a complicated task. Since this is inevitable, however, detailed studies must be started immediately to establish a realistic program as soon as possible.