

the rainy season (June to September), in particular, traffic routes are often out of service. It will therefore be essential to carefully program an early delivery and stocking of major equipment and materials.

Civil works are expected to concentrate on narrow time band as this part of the works, river works, must be executed in the dry season. It will therefore be necessary to execute adequate preliminary works. It is important, as stated above, to draw out and examine adequate plans in advance for both the preliminary and the permanent works so that they will be free from any frustration after entering in the execution stage.

#### 5-6 Tentative Implementation Schedule

It is recommended, taking into consideration the request from the Government of Bhutan and results of our consultations with Government representatives during our site investigation, at that, in view of the scale and time schedule for the project, the project should be carried out in two stages.

The project shall be phased as follows:

- . Stage-1 project : Damphu area  
Dagana area
- . Stage-2 project : Shemgang area (include a part of the transmission  
and distribution lines in Dagana)

##### 5-6-1 Stage-1 Project

The execution program for stage 1 shall start with the Exchange of Note (E/N) between the governments of Japan and Bhutan.

Subsequently, the Department of Power shall conclude a contract with a Japanese consultant for consulting services necessary for the procurement of equipment and materials and for the implementation of the project.

After the signing of such a contract, the consultant shall prepare detailed designs and tender documents, and conduct tendering activities for the Japanese contractors on behalf of the Bhutanese

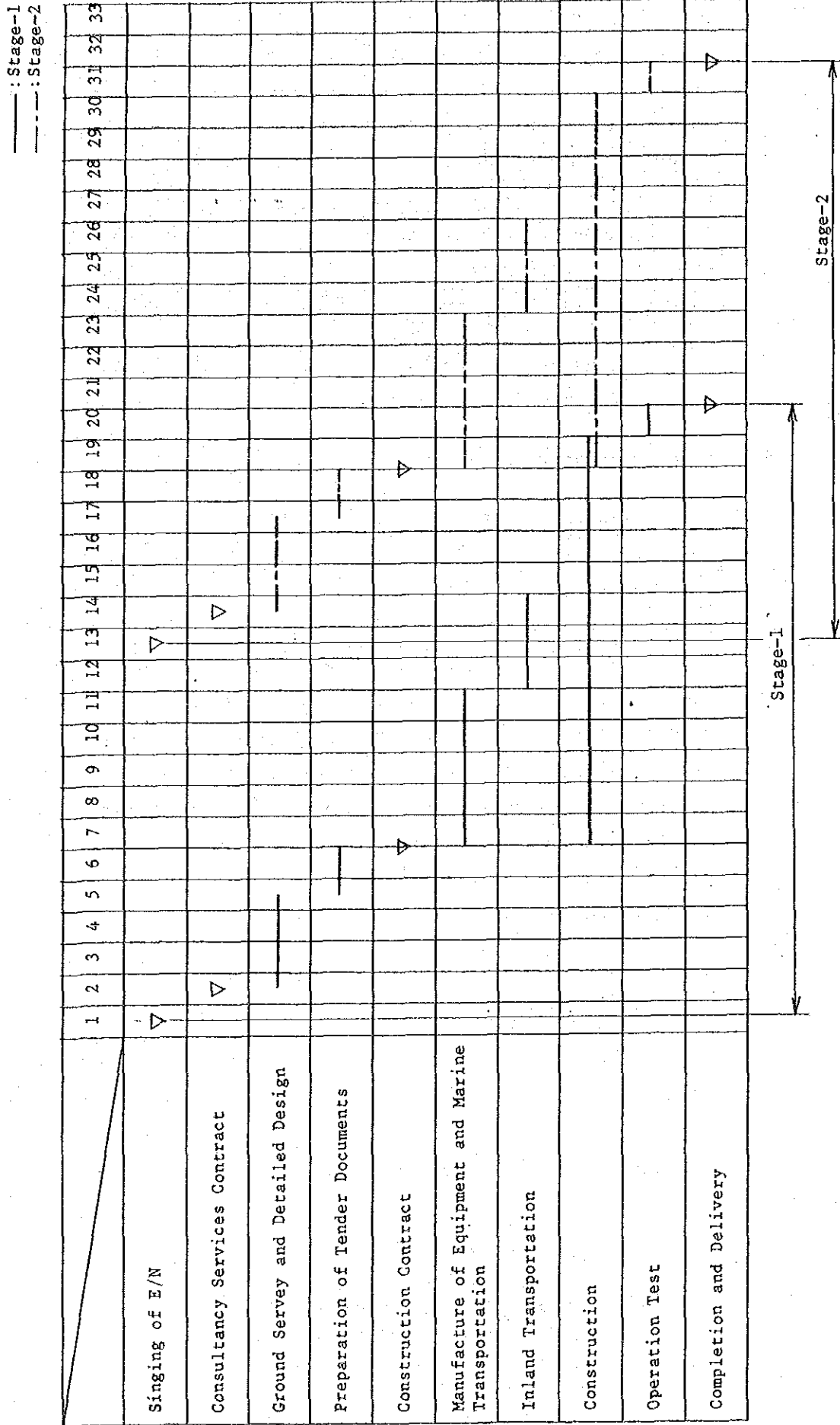
Government and witness the signing of the contract. It is expected that the period required from the signing of E/N to that of construction contract will be approximately 5.5 months while the manufacture of hydraulic turbines and power generators and the procurement, packing and sea transport of other equipment and materials will take approximately 5 months. Inland transportation is expected to take about 3 months. The period required for the works has been estimated as 13-months, considering the decline of work efficiency in the rainy season, after the signing of construction contract.

Shown in Table 5.6-1 is the time schedule for the execution of Stage 1 project.

#### 5-6-2 Stage 2 Project

The execution program of Stage 2 shall start with the signing of the Exchange of Note (E/N) between the Governments of Japan and Bhutan. This is expected to take place in the fiscal year following the execution of Stage 1. The period required for the contractual procedures after the signing of E/N, detailed design and tendering is expected to take 5.5 months, similar to Stage 1. The period required for the works has been estimated as 12 months after the signing of construction contract since the amount of rainfall at the project site is smaller than Damphu and Dagana areas, and the conditions of road for the transport of equipment and materials are better. The time schedule for the execution of Stage 2 project is shown in Table 5.6-1.

Table 5.6-1 Implementation Schedule



5-7 Estimated Project Cost

In implementing this Project, the estimated cost to be borne by the Government of Bhutan are as follows:

(1) Conditions of estimation

(a) Time of estimation: As of February, 1989

(b) Exchange rate: US\$1 = ¥133

(c) Construction period: . Stage-1 13-month

. Stage-2 12-month

(2) Amount of cost to be borne by the Government of Bhutan

The amount of cost to be borne by the Government of Bhutan are as follows;

(Unit: Thousand Nu.)

Items	Stage-1			Stage-2	Grand Total
	Damphu	Dagana	Total	Shemgang	
a) Acquisition of lands (@15 Nu/m <sup>2</sup> )	600	210	810	320	1,130
b) Compensation for the clearance of interfering and dange trees etc. (@5 Nu/m <sup>2</sup> )	550	840	1,390	1,800	3,190
Total	1,150	1,050	2,200	2,120	4,320



**CHAPTER 6**  
**MAINTENANCE AND MANAGEMENT PLAN**



## CHAPTER 6 MAINTENANCE AND MANAGEMENT PLAN

### 6-1 Organization for Maintenance and Management

#### 6-1-1 Maintenance and management system

Upon completion of this construction work, and after the test run is successfully completed, the Department of Power will start power supply from this power station to each area.

Engineers from the Department of Power will periodically patrol and check service and maintenance; daily checks and maintenance will be performed by residents, who are to be trained, in each area.

The daily operation and maintenance of facilities shall be performed by the groups consisting of three local nationals each, and the periodical patrol and inspection of facilities including ten power generation plants constructed in the previous Phase I shall be covered by two groups of engineers from the Department of Power, a group comprising two persons.

For the central control of these activities, a senior engineer shall be stationed at the Department of Power. Fig. 6-1 shows the organization

Technical guidance shall be provided by the contractor to the personnel in charge of the operation and maintenance during the construction and test run period.

The following are considered as the subjects of technical guidance:

- (1) Technology for daily operation and maintenance
- (2) Methods of coping with abnormalities including accidents, and remedial measures
- (3) Methods of facility management (including the arrangement of records)
- (4) Procedures for safe work



## 6-1-2 Maintenance and management costs

The annual maintenance and management costs were trially computed by assuming the following conditions since no data are available in Bhutan.

### (1) Repair costs

The standard costs applicable to public corporation in Japan (2,000 kW class power generation plant) have been allowed for.

### (2) Miscellaneous cost

As for the costs for consumables, communication and transport and traveling, the unit cost of 220 Nu/kW was adopted, assuming increase in the future, since the areas to be covered by the engineers of the Department of Power for the technical inspection and repair are total 13 areas including 10 areas previously constructed in Phase I, and much broader as compared with the similar case in Japan.

### (3) Personnel costs

Daily inspection shall be performed by a group of three local nationals per an installation while the patrol and inspection by the engineers of a total 13 areas including 10 previously constructed in Phase I will be done by two groups with a group consisting of two persons. In addition, this budget has been appropriated for the management personnel and assistants of the Department of Power.

### (4) Cost of lubricating oil

A percentage of the repair cost was appropriated, judging from the practices in Japan.

The annual maintenance and mangement costs resultant from the above assumption amount to Nu.575,185 as shown in Table 6-1. This is equivalent to Nu.0.23/kWh in term of power available for sale.

Applying the nationally unified present tariff, shown in paragraph 2-2-6 above, the total revenue from the sale will amount to

Nu.878,200 per year. Therefore, it will not be too difficult to raise the above maintenance and management cost as these account for only 65% of the total revenue from the power sale. Given below are the annual power generation and the revenue from the power sale, which are obtainable from the completion of the plan at three areas.

. Annual power generation

$$\begin{aligned}
 \text{(kWh)} &= \text{Output at power generation plant (kW)} \times \\
 & \quad 365 \text{ (days)} \times 24 \text{ (hours)} \times \text{power plant uti-} \\
 & \quad \text{lization rate} \times (1 - \text{loss ratio in the plant}) \\
 &= 600 \times 365 \times 24 \times 0.5 \times (1 - 0.05) \\
 &= 2,496,600 \text{ (KWh)}
 \end{aligned}$$

. Power demand

	Shengang	Damphu	Dagana	Total
Bulb (W)	139,440	174,960	205,380	519,780
Fluorecent (W)	42,960	37,540	15,860	96,360
Heater, X-Ray & & Others (W)	53,350	54,290	14,450	122,090
<b>Total</b>	<b>235,750</b>	<b>266,790</b>	<b>235,690</b>	<b>738,230</b>

Revenue from power sale

$$\begin{aligned}
 \text{Bulb} &= (519,780 \text{ W} \div 60 \text{ W}) \times 5 \text{ Nu./ea./month} \times 12 \text{ month} \\
 &= \text{Nu.519,780}
 \end{aligned}$$

$$\begin{aligned}
 \text{Fluorescent} &= (96,680 \text{ W} \div 40 \text{ W}) \times 5 \text{ Nu./ea./month} \times 12 \text{ month} \\
 &= \text{Nu.144,540}
 \end{aligned}$$

$$\begin{aligned}
 \text{Heater, X-Ray, Refrigerator} \\
 \text{\& othes} &= 122,090 \text{ W} \times 365 \text{ day} \times 12\text{h/day} \times 0.4 \text{ Nu./kWh} \\
 &= \text{Nu.213,900}
 \end{aligned}$$

$$\text{Total} \quad \text{Nu.878,220}$$

Fig. 6-1 Operation and Maintenance System

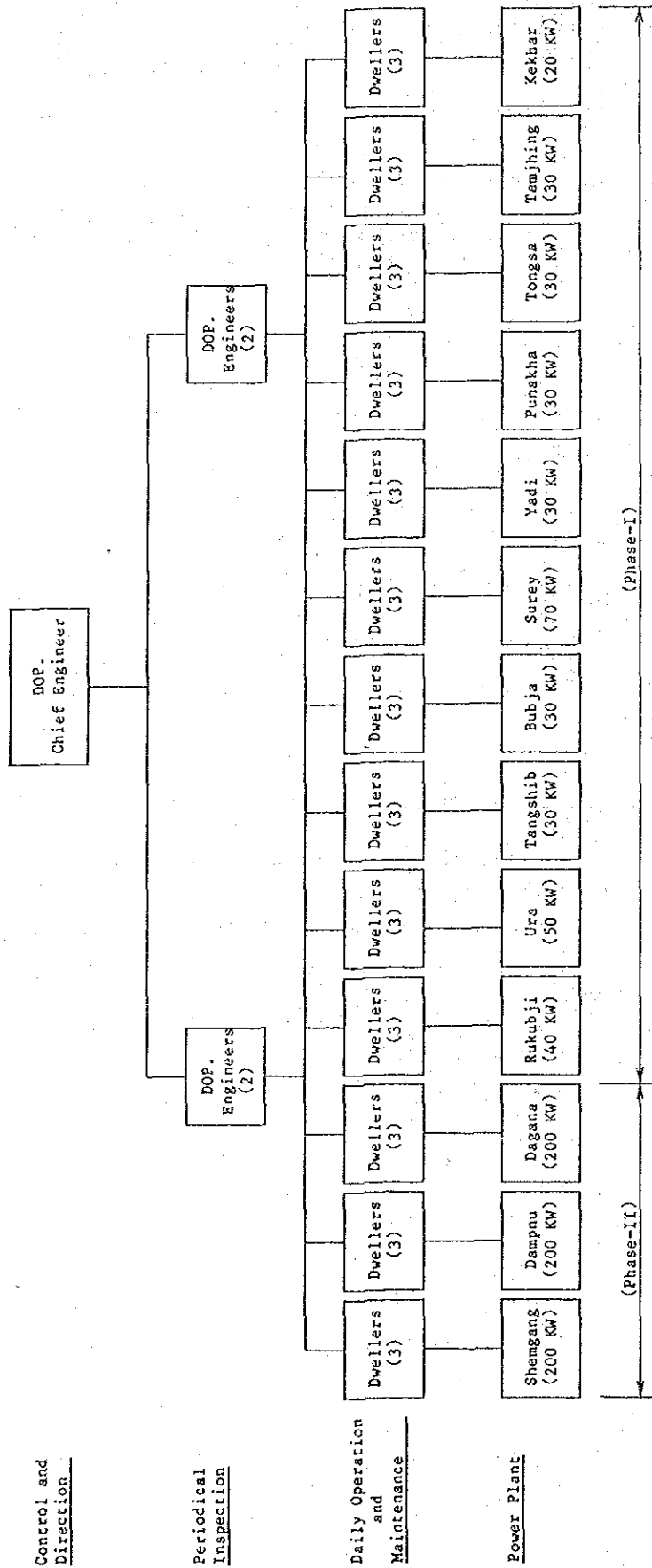


Table 6-1 Calculation of Annual O/M Expenses

Annual Expenses	Amount (in Nu)	Remarks
Repair Cost	318,000	<p>600 kW x 530 Nu = 318,000 Nu which is 3,191 ¥/kW in case of a plant with an installed capacity of 2,000 kW or less in Japan.</p> <p>But, increased by 50%, considering that the power plant is of small scale.</p> <p><math>(3,191\text{¥/kW} \div 9\text{¥/Nu}) \times 1.5 \doteq 530 \text{ Nu/kW}</math></p>
Miscellaneous Cost	30,460	<p>600 kW x 220 Nu x 3/13 = 30,460 Nu</p> <p>Yen 1,000/kW for costs of office supplies and stationary, communication and transportation and travelling expenses</p> <p>But if increased by 100% in view of the distance to the site.</p> <p><math>(1,000\text{¥/kW} \div 9\text{¥/Nu}) \times 2.0 \doteq 220 \text{ Nu/kW}</math></p>
Personnel Cost	147,225	<p>1) Daily inspection (inhabitants)</p> <p>3 persons/site x 3 sites x 12 months = 108 man months @450 Nu x 1.2 = 540 Nu 108 man months x 540 = 58,320 Nu</p> <p>2) Periodical inspection (engineers)</p> <p>by 2 groups composed of 2 technical persons each 2 persons x 2 x 12 months x 3/13 = 11 persons-months @4,300 Nu/m. x 1.3 (local salary) = 5,590 Nu/month 11 persons-months x 5,590 Nu/month = 61,490 Nu</p> <p>3) Other staff-members of Dept. of Power</p> <p>(1) Manager 1 man x 6,500 Nu/month x 12 months x 3/13 = 18,000 Nu</p> <p>(2) Assistants to Manager (typist, accountant, etc.) 2 persons x 550 Nu/month x 12 months x 3/13 = 9,415 Nu</p>
Lubricant Cost	79,500	Estimated at 25% of the maintenance cost.
Total	575,185	



**CHAPTER 7**  
**PROJECT EVALUATION**



## CHAPTER 7 PROJECT EVALUATION

A characteristic feature of Bhutan is that the majority of people live in small towns and villages in mountainous regions, except for the relatively flat regions in Thimphu, Phuntsholing and Gaylegphug.

For this reason, supply of electricity to rural areas has depended on isolated small diesel generators which is impossible to connect supply system of electricity in the respective areas.

On the other hand, Bhutan has an abundance of water resources with hydro-potential estimated at 6,000 MW. However, sites suitable for large reservoir type power generation schemes are scarce due to the steep gradient of river and the extremely complicated geological condition. It can be regarded, however, that steep river gradient is suitable for the development of medium and small scale hydro-power generation project of run-of-river-type.

Taking the above facts into consideration, the construction of small hydro-electric power plants to meet the power demand of respective regions may be regarded as a perfectly feasible.

The direct and indirect benefits of the projects are as follows.

### 7-1 Direct Benefit

- (1) It can be expected that the annual power production amounts to about 5.0 GWh.
- (2) Electrification to be realized by the project in each area is as follows.

	<u>Shemgang</u>	<u>Damphu</u>	<u>Dagana</u>
Public Institution (Nos.)	30	20	21
Household (Houses)	346	550	565



- (3) The operation of the existing diesel generators can be replaced by that of the project, which will reduce import of fuel oil and save foreign currency.

Estimated cost of fuel required for the existing and additional diesel generators which would be equivalent to the project is as shown below.

	Shemgang (80kW)	Damphu (48 kW)	Dagana (40 kW)	Additional equivalent to Project (200 kW x 3)
Annual power generation (KWh)	$80\text{kw} \times 365\text{day} \times 4\text{h} \times (1-0.25) = 87,600$	$48\text{kw} \times 365\text{day} \times 4\text{h} \times (1-0.25) = 52,560$	$40\text{kw} \times 365\text{day} \times 4\text{h} \times (1-0.25) = 43,800$	$600\text{kw} \times 365\text{day} \times 12\text{h} \times (1-0.25) = 1,971,000$
Fuel consumption (lit/kWh)	0.24	0.24	0.24	0.24
Unit fuel cost (Nu./lit)	3.91	3.91	3.91	3.91
Annual fuel cost (Nu.)	82,204	49,322	41,102	1,849,586

- (4) It will become possible by the project to supply electric power all day long. This can be expected to improve living standard by allowing use of electric lamps and heaters at any time, extending learning time by lighting in houses and dormitories, improving medical services by use of various electric medical equipment such as X-ray diagnostic devices and refrigerators for storing serum, and improving public security and order by enabling use of electric lamps along streets.

#### 7-2 Indirect Benefits

- (1) Advanced technology will be transferred from Japan to Bhutan through this project. Also people working in the Department of Power will be trained and their technological capability improved, which means development of human resources. This will much contribute to the future economic development plans of Bhutan.

(2) Upon completion of the construction, engineers of the Department of Power will make periodical patrol and check for services and maintenance of the system, while daily operation and maintenance will be performed by residents, which will contribute to enhance their technical skill through the said activities.

(3) Distribution of electric heaters will reduce consumption rate of firewood, which will prevent devastation of forests and woods.

Also small scale industrial activities will become more active, which will increase employment opportunities.

(4) People will be able to gather in public facilities at night, which will promote communication among residents. Promotion of community activities and improvement of social life can be greatly expected.

When considering the above benefits, it may be said that this project will largely contribute to the economic and social development of the Kingdom of Bhutan.



**CHAPTER 8**  
**CONCLUSIONS AND RECOMMENDATIONS**



## CHAPTER 8 CONCLUSIONS AND RECOMMENDATIONS

### 8-1 Conclusion

Taking into account the topographical conditions, social characteristics, and demand for power in each area, and the extensive requirements for transmission and distribution of power, the Government of Bhutan has planned, as part of its electrification project to modernize towns and villages in the country, to construct small-scale hydro power stations at 150 sites throughout the country. The Government considers this to be as the most efficient and economical means for developing and modernizing the country.

The three project areas, Shemgang, Damphu and Degana selected from among these 150 sites for the present project, are towns and villages playing an important role in their respective areas containing public facilities such as schools and hospitals. Each of the three areas has a diesel power generating facility. But electricity is either not supplied or else is supplied only at night. This is the reason that these areas have been selected.

The basic design and investigation report has now been completed after examining the results of the field investigations in the said three areas and after consulting with the Japanese government authorities. The following conclusions may thus be drawn:

- (1) Construction of small-scale hydro power facilities in the project areas will allow electrification of the areas where electricity was once supplied but is not supplied now, or is supplied for only a very short time each day. This would improve daily life, education and medical services, and also raise the level of public peace and order.

Also, small-scale industrial activities will become more active, which will create more opportunities for employment and promote economic activity in each project area.

Additionally, the existing diesel power generating facilities will be replaced by the hydro power project, which will reduce

import of fuel oil and save foreign currency. These satisfy the need to improve social and economic conditions, as well as to help the country achieve independence, which have been set up as the goals of the Sixth 5-year plan.

- (2) Rainfall in the three (3) project areas is relatively high (about 1,600 mm per year), and river water required for small-scale hydro power generation project can be secured. Also, the topographical conditions as well as geological conditions are very suited to construction of hydro power stations. Additionally, the condition of the roads required to transport equipment and machines for the construction is extremely good, as these roads are periodically maintained under assistance by India. These conditions suggest that it is technologically possible to construct hydro power stations at the proposed sites.

Also, the actual operation results of the ten (10) power stations constructed in phase I suggests that engineers in Bhutan will be fully capable of operating and controlling the new hydro power stations once this project is completed.

- (3) The costs to be borne by the Government of Bhutan include those for acquisition of land for the project, for lumbering, and for building or improving roads necessary for transporting equipment and materials. These costs are estimated to be about 4,320 thousand ngultrums.

In view of the scale of the national budget of the Kingdom of Bhutan, the Government will be able to meet these costs.

Also, it is estimated that the cost required for operation and maintenance of each power station after its completion will be less than the revenue from the sale of the generated electricity, and no additional expenditure will be required.

This project will provide many benefits for the residents in the project areas, and will contribute to improvement of their social life and living standard. For this reason, it is worthy that this project should be carried out by all means.

A comprehensive consideration of foregoings leads to the judgement that the implementation of the project is very significant and the provision of grant by the Japanese Government is well justifiable.

## 8-2 Recommendations

### 8-2-1 Recommendations for This Project

The small scale hydro power facilities constructed in this project will become a basis for the future economic and social development of Bhutan. The Government of Bhutan are required to take necessary measures regarding the following points.

- (1) The engineers concerned in the Government of Bhutan shall participate in the construction of the project throughout its entire period and acquire the technological skill for running hydro electric power generation plants from the Japanese engineers and consultants.
- (2) Bhutan's engineers should learn the techniques for operating and maintaining hydro power stations from engineers from Japan, and should establish a concrete policy for operating and maintaining the hydro power stations to be constructed under this project.
- (3) As soon as possible, the Government of Bhutan should acquire, at its own expense, the land required for the construction of each hydro power station; should build or improve the roads necessary for carrying equipment and materials required for the construction; and should remove the trees which would block or interfere with the construction works.





**APPENDIX**

**PERTINENT DATA AND INFORMATION**



APPENDIX

PERTINENT DATA AND INFORMATION

<u>NUMBER</u>	<u>DATA NAME</u>
1.	Key Personnel with whom the Survey Team Met
2.	Member List of Survey Team
3.	Survey Schedule
4.	Minutes of Discussions
5.	Table and Figure
6.	List of Received Data and Information
7.	Discharge Data
8.	Hydraulic Calculations for Open Channel



1. Key Personnel with whom the Survey Team Met



Key Personnel with whom the Survey Team Met

Full Name	Position of Title	Organization Name & Address
His Excellency Eijiro Noda	Ambassador Extraordinary and plenipotentiary of India	Embassy of Japan, Plot No. 4 & 5, 50-G, Chanakyapuri, New Delhi, India
Mr. Masamichi Saigo	First Secretary Embassy of Japan	- ditto -
Mr. Taro Kurabayashi	Representative of JICA Office in India	- ditto -
Mr. Bhim Subba	Director	Department of Power, Ministry of Trade Industry & Power, Thimphu, Bhutan
Mr. Jigmi Karchung	Divisional Engineering Officer	- ditto -
Mr. C. Ringin	Assistant Engineer	Rural Energy (Project), Dept. of Power
Mr. R.N. Adhikari	Assistant Engineer	Office of the Director, Dept. of Power.
Mr. Dorji Namgyel	Section Officer	- ditto -
Mr. Dasho Nagchung	Dzonda Shemgang	Shemgang District
Mr. Dasho Sheral Dorji	Dzongrab (Administra- tion), Chirang	Dzongkhag Administration, Chirang
Mr. Sangay Dorji	Officiating Dzongrab	Daga Dzong
Mr. Lok Pradhae	Engineer	- ditto -
Mr. S.B. Gurung	Engineer	- ditto - (Hydrology Division)
Mr. N. Silveraji	Accounts Officer	Dzongkhag Administration, Chimng
Mr. Y. Gurung	Head Cleak	- ditto -





## 2. Member List of Survey Team



Member List of Survey Team

Name	Designation	Organization
Kenji Nakato	Leader	Deputy Director, Construction Dept., Kyushu Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries. (MAFF)
Hiroaki Nakagawa	Project Coordinator	Grant Aid Planning & Survey Department, Japan International Cooperation Agency (JICA)
Tadao Sekizawa	Electric Power Planner & Hydrologist	EPDC International Limited
Keizo Nakagawa	Civil Engineer for Electric Power	EPDC International Limited
Mitsukiyo Naito	Electric & Mechanical Engineer	EPDC International Limited
Takanori Omori	Transmission & Distribution Engineer	EPDC International Limited
Hideo Sato	Civil Engineer for Cost Estimate	EPDC International Limited



### 3. Survey Schedule



Survey Schedule

No. 1

Ordinal No. of Days	Date	Day of week	Description
1	Nov. 20	Sun.	Leave Narita (Tokyo) International Airport. Arrive in Delhi (Stay at Delhi)
2	21	Mon.	Courtesy calls at the Embassy of Japan and JICA office in India, briefing the contents of an Inception Report. Leave Delhi and arrive in Calcutta.
3	22	Tue	Leave Delhi arrive in Calcutta (Calcutta)
4	23	Wed.	Leave Calcutta and arrive in Thimphu via Paro. (Thimphu)
5	24	Thu.	Courtesy calls at the government agencies of Bhutan. Discussions with the Department of Power the final itinerary for field surveys. (Thimphu)  Collection of data including maps and briefing of the questionnaire.  Arrangement for survey instruments and detailed discussion of field surveys.
6	25	Fri.	Leave Thimphu arrive in Tongsa. (Tongsa)
7	26	Sat.	Leave Tongsa arrive in Shemgang. Arrangement for field study with a Dzongdag of Shemgang Dzongkhang (Shemgang)
8	27	Sun.	Survey for Wangdi river site (Shemgang area) (Shemgang)
			<u>Group A</u> (Mr. K. Nakato, Mr. H. Nakagawa, Mr. T. Sekizawa) <u>Group B</u> (Mr. K. Nakagawa, Mr. T. Omori, Mr. M. Naito)
9	28	Mon.	Leave Shemgang arrive in Tongsa (Stay at Tongsa) Survey for Wangdi (Shemgang) river site, line routes and demand
10	29	Tue.	Leave Tongsa arrive in Thimphu (Thimphu) - ditto - (Shemgang)
11	30	Wed.	Discussion with the Department of Power (Thimphu) It rained. Arrangement of data (Shemgang)



Ordinal No. of Days	Date	Day of week	Description
12	Dec. 01	Thu.	Signing of the Minutes of Discussion (Mr. K. Nakato, Mr. H. Nakagawa) Leave Thimphu arrive in Tongsa (Mr. T. Sekizawa) (Stay at Thimphu) Survey for Wangdi river site, line routes and demand (Stay at Shemgang)
13	02	Fri.	Leave Thimphu arrive in Calcutta via Paro (Mr. K. Nakato, Mr. H. Nakagawa) Leave Tongsa arrive in Shemgang (Mr. T. Sekizawa) (Calcutt) - ditto - (Shemgang)
14	03	Sat.	Leave Calcutta arrive in Bangkok. (Mr. K. Nakato, Mr. H. Nakagawa) (Bangkok) Survey for Burumda site, line routes and demand. Mr. T. Sekizawa joined into Group B (Shemgang)
15	04	Sun.	Leave Bangkok arrive in Narita (Mr. K. Nakato, Mr. Nakagawa) (Tokyo) - ditto - (Shemgang)
16	05	Mon.	Survey for Burumda river site (Tintibi area) Discussion with a Dzongdag about the results of field survey (Shemgang)
17	06	Tue.	Leave Shemgang arrive in Gaylegphug (Gaylegphug)
18	07	Wed.	Leave Gaylegphug arrive in Damphu Courtesy calls on second Dzongday of Chiran Dzongkhang Survey for Chang river site (Damphu area) (Damphu)
19	08	Thu.	Survey for Chang river site, line routes and demands (Damphu)

Ordinal No. of Days	Date	Day of week	Description	
20	Dec. 09	Fri.	Survey for Chang river site, line routes and demands	(Stay at Damphu)
21	10	Sat.	Survey for Chang river site Discussion with second Dzongdag about results of field survey	(Damphu)
22	11	Sun.	Leave Damphu arrive in Dagana  Discussion of field survey with a secretary of Dzongdag	(Dagana)
23	12	Mon.	Survey for Dara river site (Dagana area)	(Dagana)
24	13	Tue.	Survey for Dara chu site (Dagana area), line routes and demand	(Dagana)
25	14	Wed.	- ditto -	(Dagana)
26	15	Thu.	Survey for Dara river site Discussion with Dzongdag of Dagana Dzongkhag about the result of field survey	(Dagana)
27	16	Fri.	Leave Dagana arrive in Damphu	(Damphu)
28	17	Sat.	Leave Damphu arrive in Thimphu	(Thimphu)
29	18	Sun.	Arrangement of data	(Thimphu)
30	19	Mon.	Discussion with D.O.P. about the results of the field survey. Collection data	(Thimphu)
31	20	Tue.	Making of field report Collection and arrangement of data	(Thimphu)
32	21	Wed.	- ditto -	(Thimphu)
33	22	Thu.	Collection and arrangement of data Discussion and confirmation for field report with D.O.P.	(Thimphu)
34	23	Fri.	Leave Thimphu arrive in Phuntsholing Inspection of Chukha generation plant on the way to Phuntsholing	(Phuntsholing)

Ordinal No. of Days	Date	Day of week	Description
35	Dec. 24	Sat.	Market Survey Inspection of Phutsholing Substation (Stay at Phuntsholing)
36	25	Sun.	Leave Phuntsholing arrive in Thimphu (Thimphu)
37	26	Mon.	Leave Thimphu arrive in Delhi via Paro (Delhi)
38	27	Tue.	Explain to the Embassy of Japan and JICA in India, the results of the field study. (Delhi)
39	28	Wed.	Arrangement of collection data (Delhi)
40	29	Thu.	Leave Delhi arrive in Narita (Tokyo)

#### 4. Minutes of Discussions



MINUTES OF DISCUSSIONS  
ON  
THE ESTABLISHMENT PROJECT FOR  
THE MICRO HYDROPOWER FACILITIES  
(PHASE-II)  
IN  
THE KINGDOM OF BHUTAN

In response to the request of the Government of the Kingdom of Bhutan, the Government of Japan decided to conduct a Basic Design Study on the Establishment Project for micro hydropower facilities (Phase-II), in the Kingdom of Bhutan (hereinafter referred to as "the Project") and entrusted the study to the Japan International Cooperation Agency, (hereinafter referred to as "JICA"). JICA sent to the Kingdom of Bhutan a Study Team headed by Mr. Kenji Nakato from November 20 to December 29, 1988.

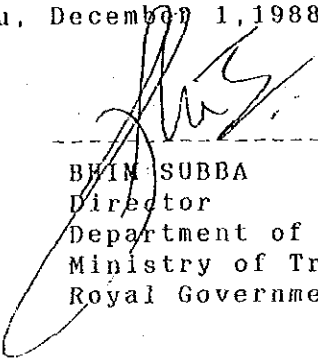
The Japanese study team had a series of discussions and exchanged views with the concerned authorities of the Government of the Kingdom of Bhutan and conducted a field survey in the proposed project areas.

As a result of the study and discussions, both parties mutually agreed to recommend to their respective Governments that the major points of understanding reached between them, attached herewith, should be examined toward the realization of the Project.

Thimphu, December 1, 1988

中戸堅持

KENJI NAKATO  
Leader  
JICA Basic Design Study Team

  
-----  
BHIM SUBBA  
Director  
Department of Power,  
Ministry of Trade & Industry,  
Royal Government of Bhutan.

## ATTACHMENT

1 : Objective of the Project

The objective of the project is to establish micro hydropower facilities on the sites where the people around the area need supply of electric power urgently for their living.

2 : Implementation Agency responsible for the Project

Ministry of Trade and Industry (Department of Power)

3 : Project Sites

The proposed sites of the Project are located in the three (3) towns which are the headquarters of the respective Dzongkhags (district) as shown Fig.1.

4 : Request

The project components requested by the Bhutanese side are shown in Annex I.

5 : The basic concept of the project implementation plan shall be described in the field report which will be submitted to the Bhutanese side at the end of this field survey.

6 : The Bhutanese side has understood that the Japanese grant aid system, explained by the team, includes the principle of use of a Japanese consulting firm and Japanese general contractors for the implementation of the Project.

7 : The Government of the Kingdom of Bhutan will take necessary measures as listed in Annex II on condition that grant aid by the Government of Japan would be extended to the Project.

8 : The Government of the Kingdom of Bhutan has agreed to provide the necessary budget and personnel for operation and maintenance of the micro hydro power facilities after completion of the Project.

9 : Final Report ( 10 copies, in English) will be submitted to the Bhutanese side before the end of March, 1989.

ANNEX -I

The contents and scope of the cooperation for the Project will be decided after technical and financial viability study. Requested facilities and equipment are as follows:

1 : The following sites are requested by the Government of the Kingdom of Bhutan to be established with micro-hydro facilities :-

<u>Name of Site</u>		<u>Name of District</u>
(1) Shemgang	:	Shemgang
(2) Damphu	:	Chirang
(3) Dagana	:	Dagana

2 : The following items are requested by the Government of the Kingdom of Bhutan as grant aid assistance.

- (1) Micro hydropower equipment for the three (3) sites
  - 1) Turbine, Generator
  - 2) Control Panel
  - 3) Penstock and Gates
  - 4) Transmission line (high voltage), distribution line (low voltage), Electric poles, Step-up and Step-down transformers.
- (2) Civil and building works for all the micro hydropower facilities for the three (3) project sites are listed below:
  - 1) Intake dam and sedimentation basin
  - 2) Conduit water way
  - 3) Head tank and related facilities
  - 4) Foundation of penstock, turbine & generator
  - 5) Foundation of transmission line (high voltage), distribution line (low voltage), electric poles and transformers.
  - 6) Power house building and related facilities
  - 7) Other necessary structures for the micro hydro power facilities
- (3) Transportation and installation of all equipments
- (4) Transportation equipment for maintenance
- (5) Measuring instruments and equipment for maintenance

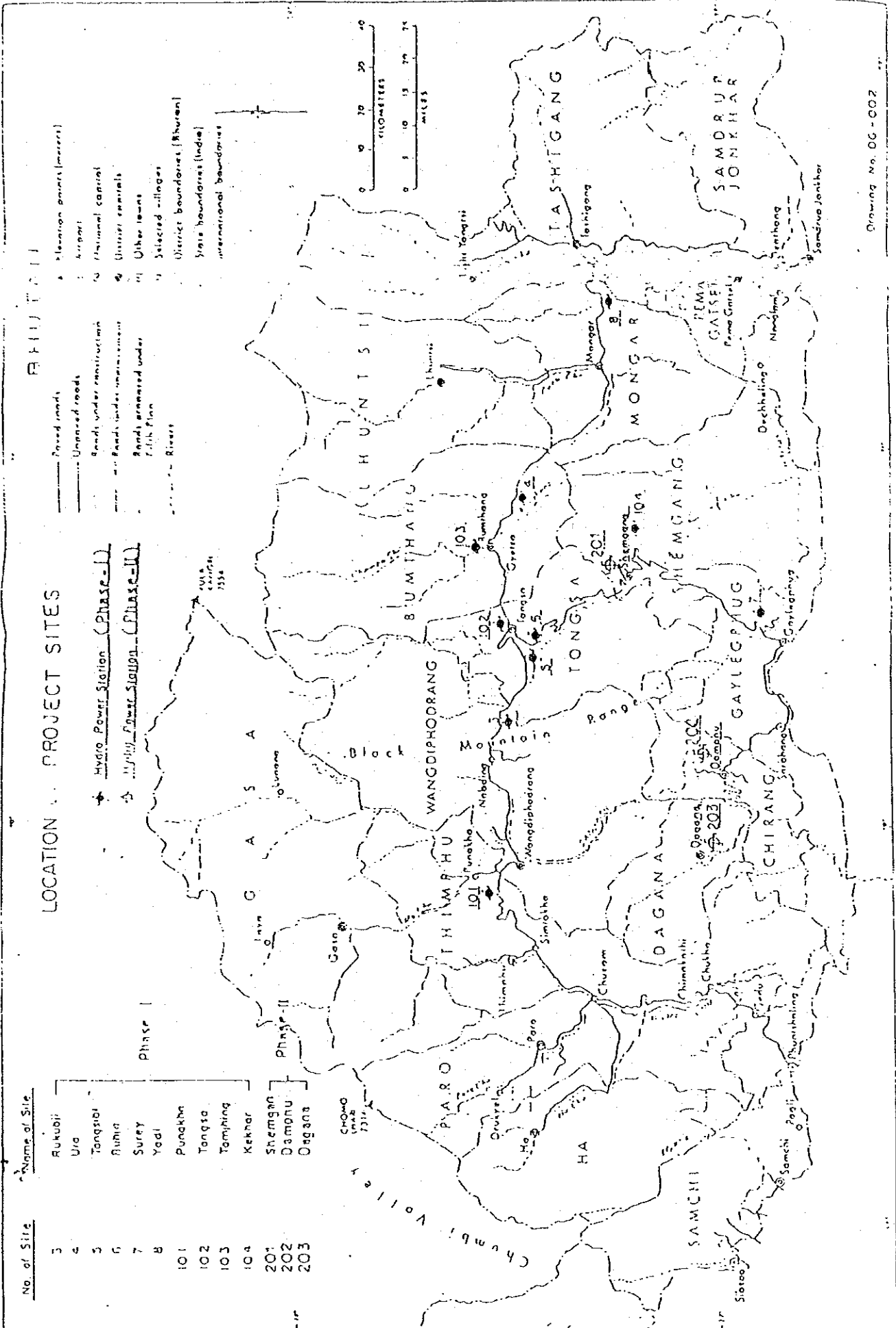


ANNEX -II

1. To acquire land and right of way (The legal right, established by usage, of a person or persons to pass and repass through grounds or property belonging to another) required for the Project implementation.
2. To ensure land and right of way necessary for construction of the temporary access roads from existing rural footpaths to the proposed construction sites.
3. To ensure speedy unloading, tax exemption, customs clearance at a port of disembarkation in the Republic of India and the Kingdom of the Bhutan, of the products purchased under the grant aid.
4. To allow transportation of vehicles, machinery and construction equipment on the existing national and rural roads.
5. To exempt from import duties and incidental expenses and to take necessary measures for customs clearance of the materials, equipment and spare parts brought into Bhutan for the implementation of the Project. These exemption shall be subject to the existing Bhutanese rules and regulations which are applicable to similar grant aid programs.
6. To assume the following commissions on the Japanese foreign exchange bank for banking services based on the banking arrangement:
  - (1) Advising commission of authorization to pay
  - (2) Payment commission
7. To accord Japanese nationals and other nationals whose services may be required in connection with the supply of the products and the services under the verified contract such facilities as may be necessary for their entry into the Kingdom of the Bhutan and stay therein for the performance of their works.
8. To exempt the Japanese and other nationals involved in the project from any customs duties, internal taxes, and other fiscal levies which may be imposed in Bhutan with respect to the supply of the product and services under the verified contract.

9. To bear all expenses, other than those to be borne by the grant.
10. To maintain and use properly and effectively the facilities constructed and equipment purchased under the grant.
11. To provide service connections from the distribution lines and internal wiring in the houses and other facilities.
12. To provide disposal places for excavated material during construction of the civil works.
13. To provide necessary data and information for detailed design.
14. To take necessary actions to expedite approval by the Government of the Kingdom of Bhutan for the execution of this Project.
15. To grant permission for import of skilled labour as required for the implementation of the Project and to make unskilled labour available as required for the Project.

*Handwritten signature/initials*



Handwritten signature or initials.

Field Report

THE BASIC DESIGN STUDY

ON

ESTABLISHMENT PROJECT FOR  
MICRO HYDROPOWER FACILITIES

( PHASE - II )

IN

THE KINGDOM OF BHUTAN

FIELD REPORT

DECEMBER 22, 1988

JAPAN INTERNATIONAL COOPERATION AGENCY

( JICA )

## CONTENTS

1.	Introduction .....	1
2.	Summary of Scope for Basic Design Study .....	1
3.	Present Situations of the Project Site .....	2
4.	3.1 Shengang Site .....	2
	3.2 Damphu site .....	3
	3.3 Dagana site .....	3
4.	Field Survey in the Project Sites .....	4
	4.1 Shengang site .....	4
	4.2 Damphu site .....	4.5
	4.3 Dagana site .....	4.5
5.	Conceptual Plan for the Project Components .....	6
6.	Items to be Prepared by the Department of Power (DOP)....	7
	6.1 Item to be done immediately .....	7
	6.2 Items for the Project implementation .....	7
7.	Tentative Implementation Schedule .....	7

Attachment : Requirement list for spare parts, transportation equipment and instruments for maintenance.

## 1. Introduction

This report is prepared by the basic design study team ( hereinafter referred to as " team ") based on the field survey and thorough discussions with the authorities concerned of the Government of Bhutan.

This report describes the preliminary technical findings obtained through the field survey of the establishment project for micro hydropower facilities ( hereinafter referred to as "the Project").

This report also includes some items to be confirmed between both parties during the field survey.

The final report will be prepared based on this field report as well as data and information collected during the field survey, in consultation with Japanese authorities concerned.

The report will consist of the following items:

- Urgency, propriety and effects of the Project
- Basic design
- Operation and maintenance plan
- Proposal for undertakings and necessary measures by the authorities concerned of the Government of Bhutan for the Project.

## 2. Summary of Scope for Basic Design Study

Scope of the basic design study is summarized as follows :

- (1) To perform the basic design for the establishment Project for micro hydropower facilities.
- (2) To estimate the project cost in the foreign and local portion.
- (3) To prepare the most effective plan for the Project implementation.
- (4) Maintenance and operation plan.

### 3. Present Situation of the Project Site

#### 3.1 General Situation of the Project Site

The proposed sites of the Project belong to the central and southern districts of Bhutan and have major towns at the centre of their districts. These towns are also collecting and distributing centres for agricultural products in the district. They have public institutions; such as schools, hospitals, veterinary clinics, dispensaries, post offices, etc. The inhabitants of these towns are desirous of being supplied with electricity as soon as possible. In these towns and the surrounding areas, most of the inhabitants are independent farmers.

If electricity is provided to these areas, the inhabitants will be relieved of the daily routine of collecting firewood as fuel, and instead will be in a position to undertake more productive work.

#### 3.1 Present situations of the Project site

##### (1) Project locations

The project sites are located at the following three places:

- a) Dagana - 633 Km from Thimphu and  
- 210 Km from Gaylegphug
- b) Shemgang - 293 Km from Thimphu and 130 Km from Gaylegphug
- c) Damphu - 523 Km from Thimphu and 100 Km from Gaylegphug

##### 2) Shemgang

Shemgang in Central Bhutan has a population of 44,516 mostly located off the Gaylegphug -Tongsa highway which traverses this Dzongkhag. Shemgang town as the dzongkhag headquarter has schools, hospital and other facilities befitting its status. In addition, in the Sixth five year National Economic Development Plan (1987-1992), the Bhutanese Government has planned to establish a Rural Development Center at Tintibi. Electric demand for Shemgang Dzongkhag area will be forecasted to increase in the near future. Main agricultural production consist if rice and maize.



The project site for Micro hydro power station was considered on the Wangdi river and the Burumda river.

At present, Shemgang town receives electricity from a 100 KVA diesel generating set which is operated between 5:00 Pm and 8:30 Pm.

In terms of project location from the town, this scheme is similar to the one at Dagana with the power station at the bottom of the hill on which the Dzong stands. The transmission line distance to the town will be around 10 Km although the road distance is about 30 Km.

### (3) Damphu

Damphu, the headquarter of Chirang dzongkhag is located in the south central foothills of the country. The population density in this region is one of the highest in the country. Fertile fields and suitable climate for cash crops such as oranges and cardamom contribute to the concentration of people. Statistics for 1985 indicates a population of 108,807.

Damphu presently has a well equipped hospital, high school, bank and other service facilities. A planned township at the existing site and the completion of the internal highway from Thimphu via Wangdiphodrang is likely to increase the importance of Damphu.

The proposed site for the micro hydro for Damphu is 15 Km below the town on Chancheu river and the transmission line distance will be about 9 Km. A 50 KVA diesel generating set was in operation between 5:00 and 9:00 Pm until March 1986.

### (4) Dagana

Dagana dzongkhag with a population of 28,352 is situated in south central Bhutan. The dzongkhag is relatively backward and comprises a number of villages as yet unconnected by motorable roads. Dagana, the headquarter of this dzongkhag was itself till recently unapproachable by motor vehicles. Permanent roadworks are still being undertaken.

Present facilities at Dagana include a Junior High school, Wireless Station, Basic Health Unit, Food Corporation outlet, etc. The proposed project site for the Micro hydro power station is on the Darachu river which is 10 Km via motorable road from the Dagana town. A 50 KVA diesel generating set was in operation between 5 pm and 9 pm until March 1986.

#### 4. Field survey in the Project Sites

As a result of field survey of the project sites and data obtained through this survey, outline of schemes for the micro hydropower facilities are supposed to be as follows:

##### 4.1 Shemgang site

The wangdi river runs at a river gradient about 1/10-1/15 and many large stones are deposited. In particular, many land slips are conspicuous on the left bank and very steep gradient are continuous on the right bank. Therefore, there is technically no suitable site for construction of micro hydro power station on Wangdi river.

On the other hand, the Burumda river runs at a river gradient about 1/15 and land slips are not observed on both the banks. It is considered appropriate that the Project site be selected on the Burumda river.

At the time, the daily discharge record of the Burumda river is not available. It is recommended that the daily discharge of the Burumda river near the proposed <sup>site</sup> be taken with immediate effect.

A suitable location for the power house is approximately 600 meters upstream of the right bank from the road along the Burumda river. Access to this site seems to be easily made for the transportation of materials and equipment therefor.

Thus, it is believed appropriate that the route of the water way be along the river on the right side of the Burumda river and that the canal, about 700 meters long, be constructed to obtain a head of 40 meters, and an installed capacity of 300 KW. Survey result of power demand, transmission line, distribution line and transformers will be considered as per attached sheets (Table -1, Fig-1).

#### 4.2 Damphu site

The Chanche~~n~~ river runs at a river gradient of about 1/15 and is found suitable for the construction of a run-off-river type hydro power plant.

A suitable location for the power house is approximately 500 meters downstream of the Damphu chu and Chanche~~n~~ river confluence on the right bank. At this time the daily discharge record of the Chanche~~n~~ river is not available. It is recommended that the daily discharge of the Chanche~~n~~ river on the site be measured with immediate effect. It is considered that the intake be located approximately 200 meters up stream of the Damphu river - Chanche~~n~~ river confluence. In the neighbourhood of the proposed intake, there is a great deal of gravel and large stones.

Access to this site seems to be easily made for transportation of materials and equipment along the left bank from the lapcheybotay village. However, it is considered that the transportation from the left bank to the right bank be done utilizing a simple ropeway.

The proposed waterway route is along the gently sloped rice fields on the right bank of the river. A canal, around 700 meters long, will be able to obtain a head of <sup>40</sup>~~35~~ meters and an installed capacity of 200 KW. Survey result of power demand, transmission line, distribution line and transformers will be considered as per the attached sheets ( Table -2, Fig-2).

#### 4.3 Dagana site

The Darachu river runs at a river gradient of about 1/15 and is found suitable for construction of a run - off - river type hydro power plant on it .

A suitable location for the power house is approximately 100 meters downstream from the existing road bridge on the right bank. It is considered that the intake be located approximately <sup>500</sup>~~200~~ meters upstream of the gauging station where stream flow observations are

b being conducted by the Department of Power.  
 The river bed is fairly narrow and out crops of rock exist on both banks.

The right bank of the stream, along the waterway route, is very stable, and access to the site seems to be not so difficult thus facilitating in the transportation of materials and equipment.

Thus, it is considered appropriate that the route of the water way be along the right bank of Dara Chu river, and that a canal, about 600 meters long, be constructed to obtain a head of ~~30~~<sup>25</sup> meters and an installed capacity of 200 KW.

Survey result of power demand, transmission line, distribution line and transformers will be considered as per attached sheets ( Table-2, Fig -3).

## 5. Conceptual Plan for the Project

### 5.1 Tentative plan for the micro hydro power plant

	<u>Shengang</u>	<u>Damphu</u>	<u>Dagana</u>
(1) Name of River	Burumda	Chanche	Dara chu
(2) Catchment Area (KM <sup>2</sup> )	60	40	220
(3) Gross Head (M)	35	49	25
(4) Available Discharge (K/S)	1.2	1.0	1.0 (2.0)
(5) Installed capacity (KW)	200	200	100 (200)
(6) Transmission line (Km)	<del>28</del> 18	9	16
(7) Distribution line (km)	5	5	5

### 5.2 Spare parts supply.

The items and quantities of spare parts for stock will be determined in the final report in accordance with study results of the field survey and spare parts requirement list prepared by DOP, subject to confirmation with Japanese authorities.

5.3 Transportation equipment and measuring instruments for maintenance. The items and quantities of above equipment and instruments for maintenance will be determined in the final report in accordance with study results of the field survey and requirement list prepared by DOP, subject to confirmation with Japanese authorities.

6. Items to be prepared by the Department of Power (DOP)

6.1 Item to be done immediately.

1) Gauging station.

At this time the daily discharge record of the Chanchay river and the Burumda river, at the Damphu site and the Shengang site, are not available. Since the discharge of river data and the precipitation record are most important for the Basic design of this projects, it is recommended that the daily discharge and the precipitation data on the Chanchay river and the Burumda river be recorded immediately.

6.2 Items for the Project Implementation

Based on the minutes of discussions agreed between both parties on December 1, 1988, DOP shall arrange or undertake the necessary actions to the each items mentioned in the annex-II of the minutes of discussions.

7. Tentative Implementation Schedule

The project may be executed in accordance with the attached (Table -3 ) tentative implementation schedule, subject to confirmation with Japanese authorities concerned.

\*1. Shemgang site

TOWN or Village Name	House holds	Population	Public Facilities	Reference
Shemgang	62	1,032	16	* Include high school student (850)
Tong Village	57	550	1	
Dakpai	27	180		
Tintibi (include Tama)	34	650	4	
Vebilapcha	30	5 persons x 30	1	* include primary school students in 1992 (300)
SUB - TOTAL	210	2,562	26	
Pam (Wangdigang)	43	370	-	
Pankhar: Dungbi)	14	138	-	
Birthey	32	416	-	
Coling	17	109	-	
Tshenglajong	30	5 persons x 30	-	
Tali				
Sub Total	136	1,183	0	
Total	346	5	26	

NO: "2" Demand Survey Result (Table -2)

"2" DAMPHU SITE

Town or Village Name	Households	Population	Public Facilities	Reference
Damphu town area	$9,000 \times \frac{1}{3} = 3,000$	$9,000 \times \frac{1}{2} = 4,500$	19	9,000:Goseling population 9:Average family
Salami (KIRKORHANG) AND near power Station (CHIRANE DARA)	50	$9 \times 50 = 450$	1	
TOTAL	550	4,950	20	

"3" DAGANA SITE

TOWN OR VILLAGE NAME	HOUSE HOLDS	POPULATION	PUBLIC FACILITIES	REFERENCE
TSEZA (CHEZANG) same, Tashigang, changlaykha, Daga Town area )	$110 \times \frac{2}{3} = 75$	$663 \times \frac{2}{3} = 442$	11	110:Tseza house holds 663:Tseza population
Nindugang, Kalijjinkha, Kanakha, Thalgean, Goshi	$475 \times \frac{1}{3} = 160$ $500 \times \frac{2}{3} = 330$	$2,744 \times \frac{1}{3} = 900$ person x 330 = 2,640	0 9	475:Kali house holds 2,744:Kali Population 500: Goshi house holds
Total	565	3,982	20	

Fig.-1.  
Transmission & Distribution Lines (Shemgang Site)

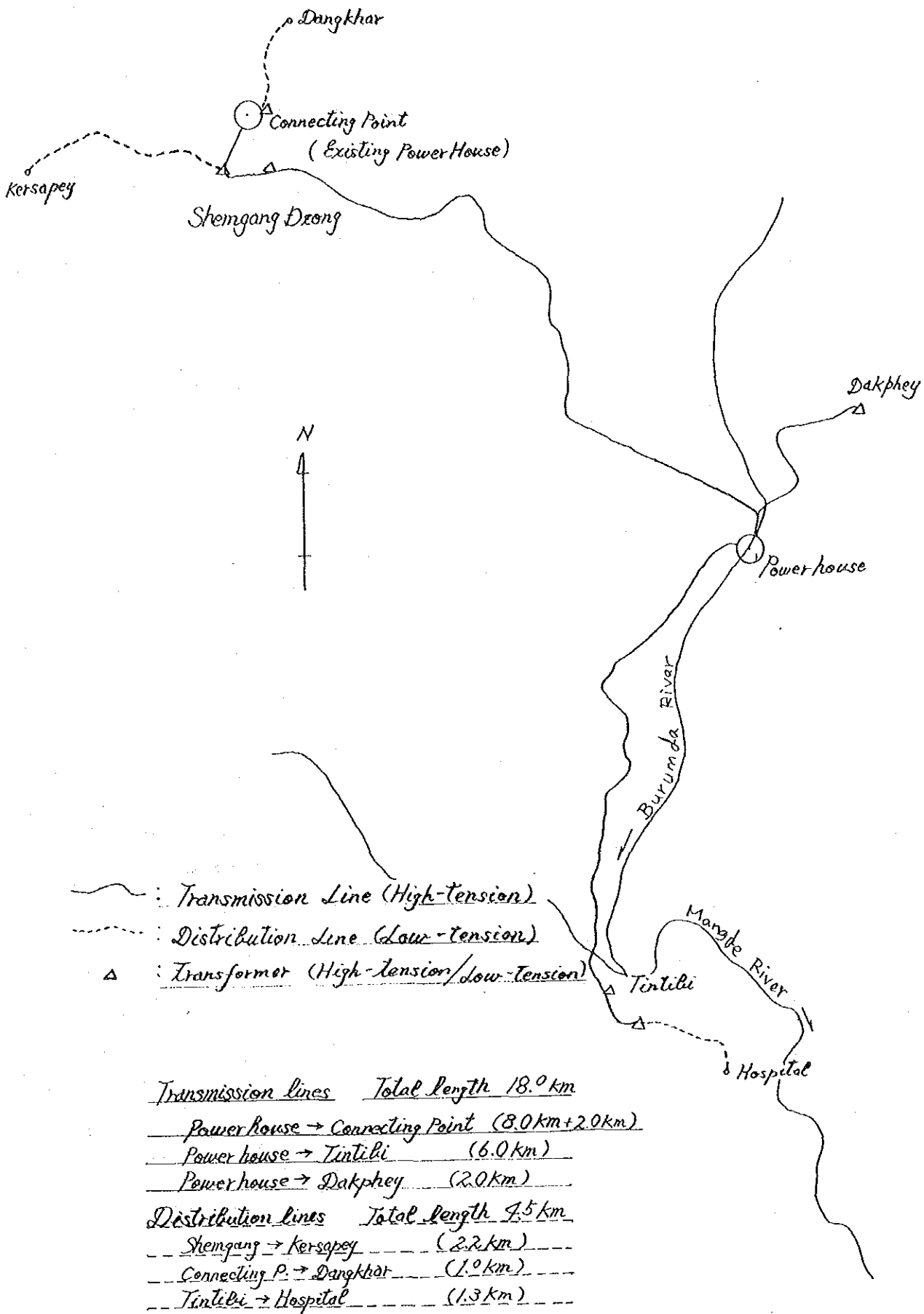
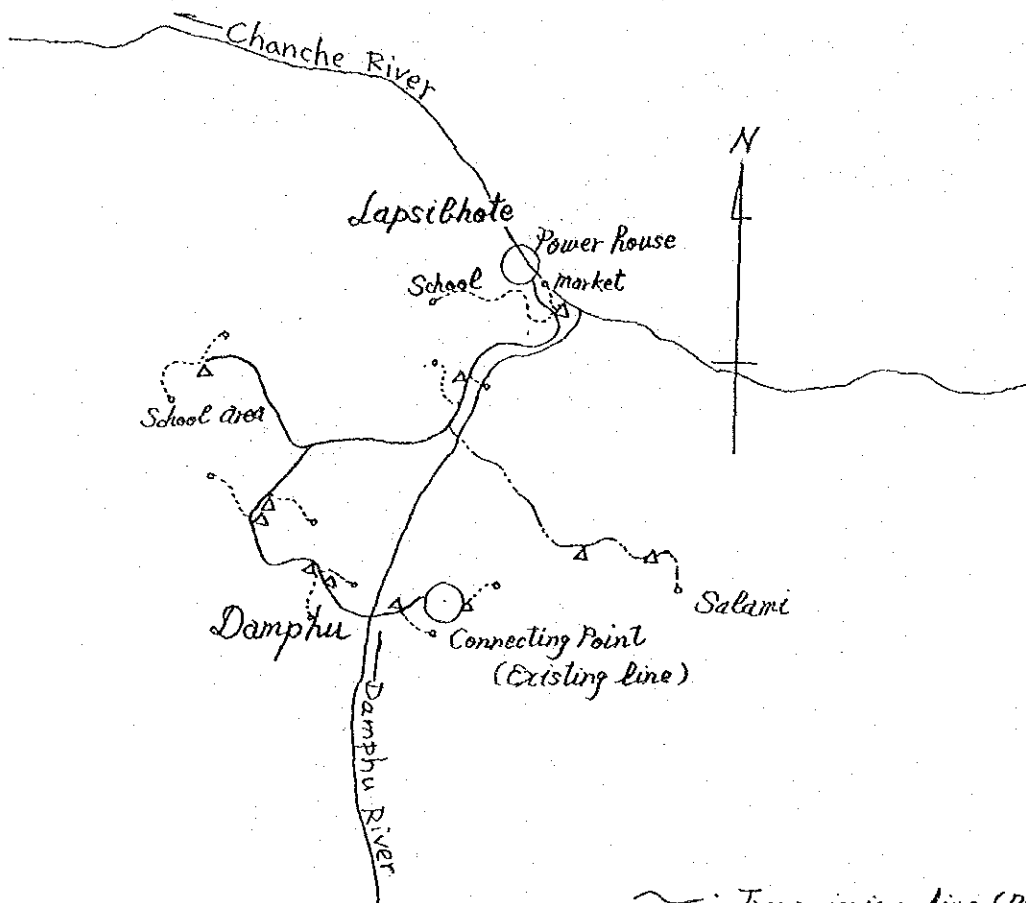




Fig-2.

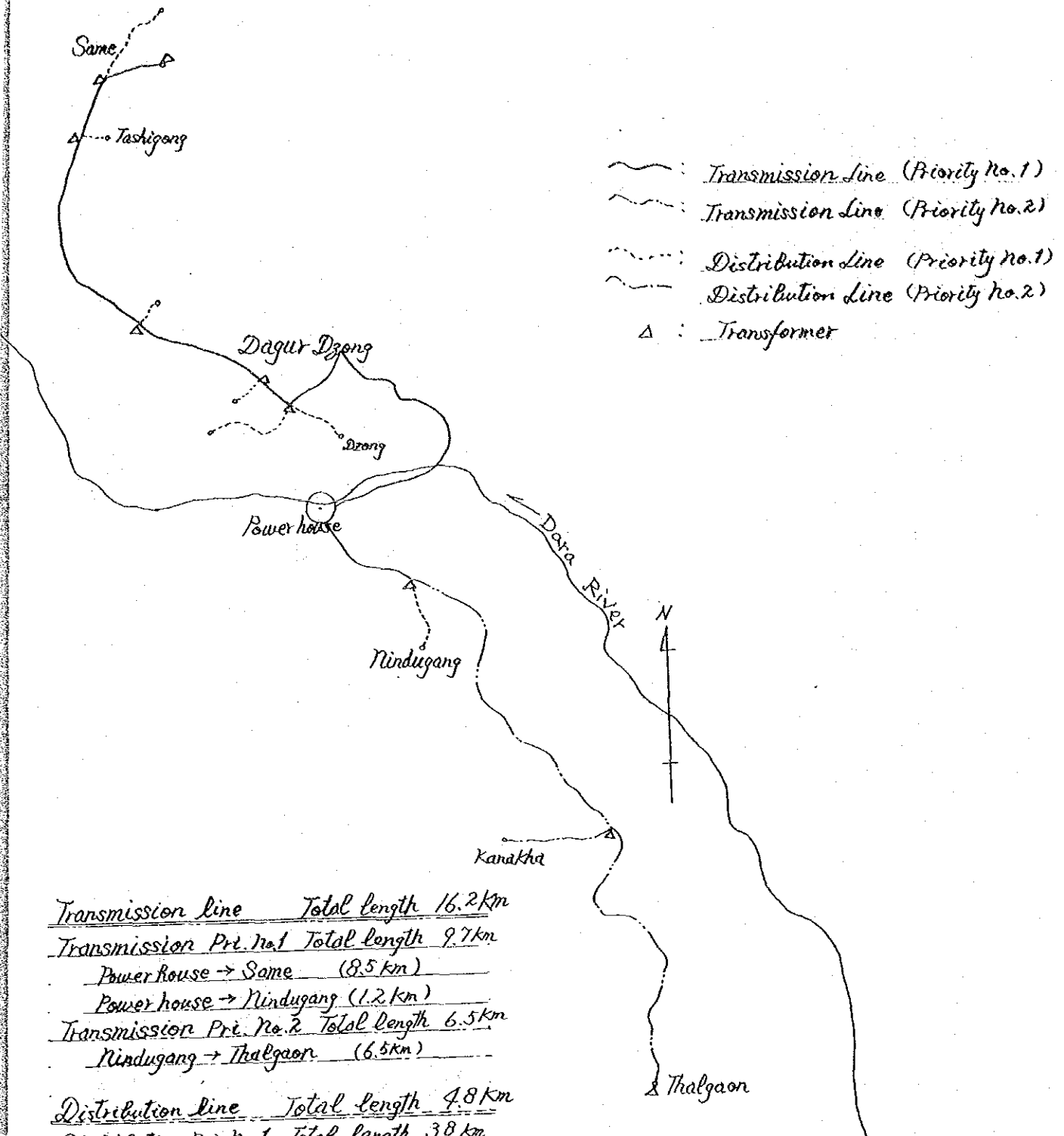
Transmission & Distribution Lines (Dampfu Site)

- ~~~~~ : Transmission line (Priority No.1)  
 - - - - : Transmission line (Priority No.2)  
 ..... : Distribution line (Priority No.1)  
 - . - . : Distribution line (Priority No.2)  
 Δ : Transformer

Transmission line Total length 8.5 km  
Transmission L. Pri. No.1 Total length 6.7 km  
 Power house → Connecting P. (5.5 km)  
 Dampfu → School Area (1.2 km)  
Transmission L. Pri. No.2 Total length 1.8 km  
 Lapsibhote → Salami (1.8 km)

Distribution line Total length 5.0 km  
Distribution L. Pri. No.1 Total length 4.6 km  
 Lapsibhote Area (1.6 km)  
 Dampfu and School Area (3.0 km)  
Distribution L. Pri. No.2 Total length 0.4 km  
 Salami Area (0.4 km)

Fig-3  
Transmission & Distribution Lines (Dagana Site)



<u>Transmission line</u>	<u>Total length 16.2km</u>
<u>Transmission Pri. No.1</u>	<u>Total length 9.7km</u>
Power house → Same	(8.5 km)
Power house → Nindugang	(1.2 km)
<u>Transmission Pri. No.2</u>	<u>Total length 6.5km</u>
Nindugang → Thalgaon	(6.5km)
<u>Distribution line</u>	<u>Total length 4.8km</u>
<u>Distribution Pri. No.1</u>	<u>Total length 3.8 km</u>
Dagur Dzong Area	(2.0 km)
Same Area	(1.2 km)
Nindugang Area	(0.6 km)
<u>Distribution Pri. No.2</u>	<u>Total length 1.0 km</u>
Kanakha Area	(1.0 km)

The Establishment Project for  
the Micro Hydropower Facilities

Tentative Implementation Schedule. (Table-3)

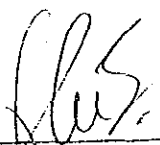
Item.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
- Conclusion of Exchange of Notes.												▽																									
- Conclusion of Contract for the Consultant.													▽																								
- Detailed survey and Design (Preparation of Tender Documents)																																					
- Tendering.																																					
- Tender Evaluation and Conclusion of Contract.																																					
- Construction and Installation.																																					

Note : (1) ——— Damphu and Dagana. (1st. stage)

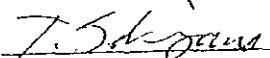
(2) - - - - - Shengang. (2nd. stage.)

Correction of Field Report in the Minutes of Discussion.

<u>Page</u>	<u>Original</u>	<u>Collected.</u>
- 5 -	4.3. Dagara site, (last phrase) ... approximately <u>200</u> meters ...	... approximately <u>500</u> meters ...
- 6 -	(third phrase) ... a head of <u>30</u> meters ...	... a head of <u>25</u> meters ...
- 6 -	5.1. Tentative plan for ----- (6) Transmission line (km) <u>28</u> .	(6) Transmission line (km) <u>18</u> .
- 6 -	None.	- Add the last phrase in 5.1. - <u>Installed capacity of the Dagara site will be determined in the final report in accordance with study results of the field survey, subject to confirmation with Japanese authorities.</u>
- 5 -	4.2. Damphu site, (fourth phrase) ... a head of <u>35</u> meters ...	... a head of <u>40</u> meters ...

  
 BHIM SUBBA  
 Director  
 Department of Power

Thimphu, December 24, 1988.

  
 TADAO SEKIZAWA  
 JICA Basic Design Study  
 Team.



Tel. -2505  
Cable -Bhutanpower

**DEPARTMENT OF POWER**  
**Office of the Director**  
TASHICHHODZONG : P. BOX 106  
THIMPHU : BHUTAN

REC/II-Phase/88-89/3802

Date 23/12/'88

To

Mr.K. Nakato,  
JICA team leader,  
Micro Hydro II-Phase  
Basic Design Team.

Sub : Spare parts and maintenance equipment for I-Phase  
and II-Phase.

Sir,

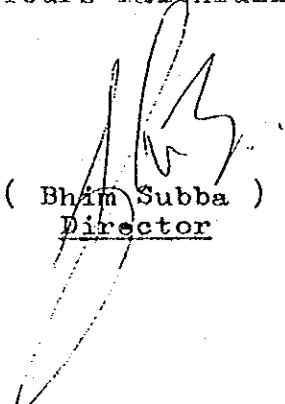
Please find attached herewith the following spare parts  
and maintenance equipment that the Department of Power  
would like to request the Government of Japan to supply  
under Grant Aid.

1. Spare parts for first phase,
2. Maintenance equipment/spare parts for second phase.

The final requirement of spare parts and maintenance  
equipment for II-Phase may kindly be determined by the  
Japanese authorities concerned.

Thanking you,

Yours faithfully,

  
( Bhim Subba )  
Director

## Spare Parts - First Phase

### 1. Electromechanical

#### a) Electrical

- module card for governor	4 Nos.
- AVR	5 Nos.
- AC/DC Converter	5 Nos.
- Aux relay 84X/86X	5 Nos.
- Magnetic contactor 88F	2 Nos.
- Voltage sensor 84	5 Nos.
- Over Voltage relay 59	1 No.
- Over Current relay 51	1 No.
- MCCBL/MCCBG 4P 100 AF/75AT F: 415V	2 Each
4P 50 AF/50 AT F: 415V	1 Each
4P 100AF/100AT F: 415V	1 Each
4P 225AF/150AT F: 415V	1 Each
- Over speed relay 12	3 Nos.
- Thermostat for dummy load	10 (one for each site)
- Wiring materials (assorted) for control panel	10 coils

#### b) Mechanical

- Gear coupling	10 (one for each site)
- Runner	10 ( " )
- Bearings	20 (two for each site)
- Gear oil for increaser ( Ura )	100 lts.
- Grease	40 kgs.

### 2. Transmission/Distribution/House Wiring

#### a) Transmission

- lightning arrester	6
- cutout switch	6
- 6.6 KV strain insulator with bracket	50
- 6.6 KV pin type insulator with bracket	100

#### b) Distribution

- shackle insulators with accessories	400
- photosensors for street lights	50

### 3. Miscellaneous

- chains for engine chain saw supplied for maintenance of Transmission line	10 Nos.
--	---------

Maintenance Equipments - II Phase

1. Double cabin, 4WD, diesel pick-up	2
2. Double cabin, 3-Tonner truck	1
3. Copy machine	1
4. Portable electric typewriter	1
5. Computer or electric typewriter	1
6. Electric chain saw	3
7. Engine (gasoline) chain saw	2
8. Aggregate/sand crusher	1
9. Electric circular saw, table mounted, 12 inch diameter	1
10. Electric rouster with assorted bits	1
11. Electric hammer drill with concrete drill bits, 500 W, 13 mm diameter	1
12. Cable fault locator with search coil	1
13. Socket wrench sets	5
14. LN key set	5
15. Long range communication system (portable)	4 sets
16. Video camera	1
17. Video cassette recorder	1
18. Color television (video adaptable)	1

Spare parts - II Phase

Spare parts for all the equipments to be brought for the project and the maintenance equipments listed above may kindly be decided by the Japanese authorities concerned.

For the purpose of further transmission line extensions to be carried out by the Department of Power, three (3) Nos. 6.6KV/11KV step-up transformers may be supplied as spare part.

## 5. Table and Figure





## 5. Table and Figure Lists

- 5.1 Outlays of Development plans, First Plan to Fifth Plan
- 5.2 Outlays of Development Percentage by Category, First Plan to Fifth Plan
- 5.3 Summary of Budgetary Operations, 1981/82 to 1986/87
- 5.4 Proposed Outlays by Sector, Sixth Plan (1976 - 1992)
- 5.5 Organizationn of the Department of Power
- 5.6 Bhutan Transmission Line
- 5.7 Energy Sold and Peak Load (1987.4 -1988.6)
- 5.8 Details of Generation (1987.4 - 1988.6)
- 5.9 Details of Purchase of Energy by DOP (1987.4 - 1988.6)
- 5.10 Details of Sales of Energy (1987.4 - 1988.6)
- 5.11 Areawise and Regionwise Sales of Energy During 1987.4 - 1988.6
- 5.12 Load Forecast -Dzongkagwise
- 5.13 Outline of Diesel Power Station
- 5.14 List of Consumer of Shemgang, Damphu, Dagana Power Plant
- 5.15 Typical Consumption (kW)
- 5.16 Survey Results of Numbers of Household and Public Facilities
- 5.17 Demand Forecast of Shemgang Site
- 5.18 Demand Forecast of Damphu Site
- 5.19 Demand Forecast of Danaga Site
- 5.20 Location of Gauging Station
- 5.21 Estimation of Monthly Average Discharge (Daily Average Discharge)
- 5.22 Estimation of Monthly Average Discharge (Daily Minimum Discharge)
- 5.23 Flow Duration Curve at Mandge River
- 5.24 Flow Duration Curve at Dagana River

- 5.25 Characteristics of Turbines (for small hydroelectric power generators)
- 5.26 Selection Figure of Water Turbine Type
- 5.27 Typical Single Line Diagram for Transmission
- 5.28 Calculation Results of Cable Sag
- 5.29 Supporting Structure Arrangement of Transmission and Distribution Line (1/2)
  - " Supporting Structure Arrangement of Transmission and Distribution Line (2/2)
- 5.30 Structure of Government

5.1 OUTLAYS OF DEVELOPMENT PLANS, FIRST PLAN TO FIFTH PLAN

(Nu. in millions)

Sector	First Plan (actual)	Second Plan (actual)	Third Plan (actual)	Fourth Plan (actual)	Fifth Plan (a) (revised)
Agriculture	1.9	21.6	58.3	259.0	419.4
Food Corporation of Bhutan	-	-	-	-	135.5
Animal Husbandry	1.5	5.6	24.2	61.5	162.4
Forestry	3.2	6.9	28.4	110.3	229.9
Power	1.5	9.1	30.1	50.5	340.5
Industry and Mines (including Trade and Commerce)	1.1	1.0	25.2	175.0	323.5
Public Works Department	62.9	70.5	84.6	128.3	787.5
Road Transport/Aviation	7.5	12.0	9.5	-	26.3
Post & Telegraph	0.5	5.9	11.4	16.9	65.0
Telecommunications	-	-	14.8	37.3	33.7
Tourism	-	-	14.1	12.5	29.1
Education	9.4	35.7	90.0	134.6	519.1
Health	3.1	16.7	38.1	54.6	237.5
Information and Publicity	0.1	1.4	4.0	11.0	36.1
Urban Development	-	-	-	-	187.3
General Development	-	-	-	-	1,114.9
Other	14.4	15.6	42.5	54.7	-
<b>Total Outlays</b>	<b>107.2</b>	<b>202.2</b>	<b>475.2</b>	<b>1,106.2</b>	<b>4,646.3</b>

(a) For the Fifth Plan the figures are revised allocations as presented in the Interim Review of the Fifth Plan. Figures exclude Chhukha Hydel Project (Fifth Plan Outlay Nu. 2,430 million).

Source: Fifth Plan documents produced by Planning Commission.

## 5.2

## OUTLAYS OF DEVELOPMENTS PERCENTAGE BY CATEGORY, FIRST PLAN TO FIFTH PLAN

(per cent)

Sector	First Plan	Second Plan	Third Plan	Fourth Plan	Fifth Plan (a)
Agriculture	1.8	10.7	12.3	23.4	9.0
Food Corporation of Bhutan	-	-	-	-	2.9
Animal Husbandry	1.4	2.9	5.1	5.6	3.5
Forestry	3.0	3.4	6.0	10.0	4.9
Power	1.4	4.5	6.3	4.6	7.3
Industry and Mines (including Trade and Commerce)	1.0	0.5	5.3	15.8	7.0
Public Works Department	58.7	34.95	17.8	11.6	16.9
Road Transport/Aviation	7.0	5.9	2.0	-	0.6
Post & Telegraph	0.5	2.9	2.4	1.5	1.4
Telecommunications	-	-	3.1	3.4	0.7
Tourism	-	-	3.0	1.1	0.6
Education	8.8	17.7	18.9	12.2	11.2
Health	2.9	8.3	8.0	4.9	5.1
Information and Publicity	0.1	0.7	0.8	1.0	0.8
Urban Development	-	-	-	-	4.0
General Development	-	-	-	-	24.0
Other	13.4	7.7	8.9	4.9	-
Total Outlays	100.0	100.0	100.0	100.0	100.0

(a) See footnotes to Table 5.1

Source: Fifth Plan documents produced by Planning Commission.

### 5.3 SUMMARY OF BUDGETARY OPERATIONS, 1981/82 TO 1986/87

Item	(Nu. in millions)					
	1981/82 (revised)	1982/83 (actual)	1983/84 (actual)	1984/85 (actual)	1985/86 (actual)	1986/87 (revised)
<b>Revenue</b>						
Tax revenue	65.1	75.7	113.7	133.7	135.9	172.2
Non-tax revenue	23.7	52.2	63.2	116.2	97.3	140.9
Other	30.8	9.8	19.1	26.3	24.8	22.1
Total revenue	119.6	137.7	196.0	276.2	258.0	335.2
<b>Grants</b>						
India	195.3	259.7	256.2	355.6	339.1	611.6
Others	104.9	100.6	222.1	156.5	170.0	223.9
Total grants	300.2	360.3	478.3	512.1	509.1	835.5
Total revenue and grants	419.8	498.0	674.3	788.3	767.1	1,170.7
<b>Expenditure</b>						
Current	169.7	213.1	223.2	304.0	339.2	363.0
Development	267.1	274.7	476.0	454.4	562.5	1,064.3
Total expenditure	436.8	487.8	699.2	758.4	901.7	1,427.3
<b>OVERALL SURPLUS/DEFICIT</b>	<b>(17.0)</b>	<b>10.2</b>	<b>(24.9)</b>	<b>29.9</b>	<b>(134.6)</b>	<b>(256.6)</b>

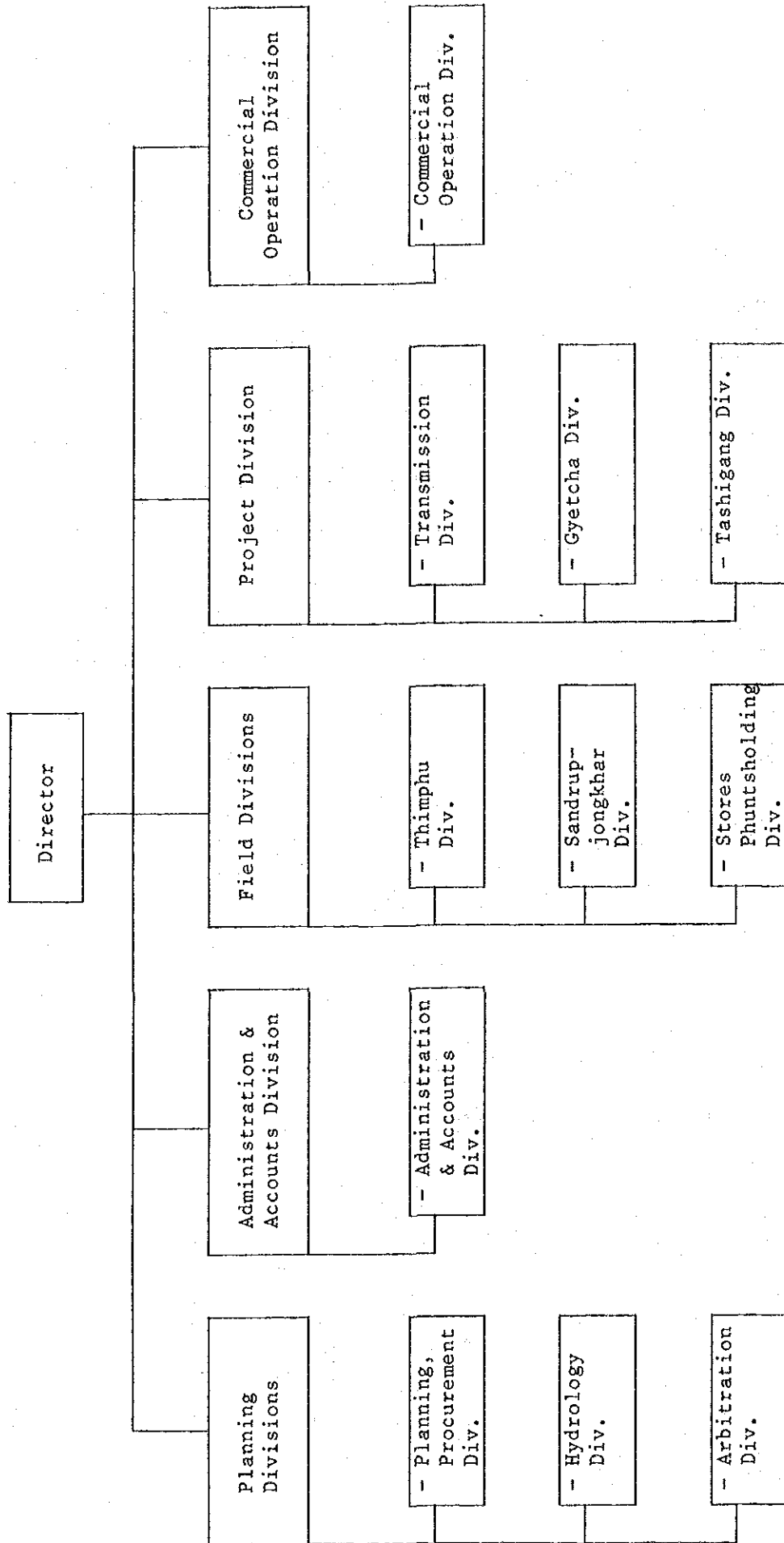
Source : Ministry of Finance

### 5.4 PROPOSED OUTLAYS BY SECTOR, SIXTH PLAN (1987 - 1992)

Sector	(Nu. in millions)			
	Current	Capital	Total	% of Total Outlay
<b>Ministries</b>				
Agriculture	760.9	717.7	1,478.6	15.6
Communication and Tourism	155.5	344.1	499.5	5.3
Trade and Industry	87.4	2,672.4	2,759.8	29.1
Social Services	1,064.7	1,519.1	2,583.8	27.2
Finance	487.1	240.2	727.3	7.7
Foreign affairs	200.9	9.7	210.6	2.2
Home Affairs	383.3	90.4	473.7	5.0
<b>Non Ministerial Organizations</b>				
Special Commission	43.4	16.2	59.6	0.6
Central Monastic Affairs	83.2	5.4	88.6	0.9
Others	231.8	372.0	603.8	6.4
<b>All Sectors</b>	<b>3,498.2</b>	<b>5,987.2</b>	<b>9,485.3</b>	<b>100.00</b>

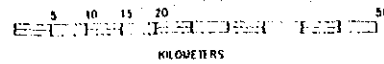
Source : Planning Commission

5.5 ORGANIZATION OF THE DEPARTMENT OF POWER



# 5.6 BHUTAN TRANSMISSION LINE

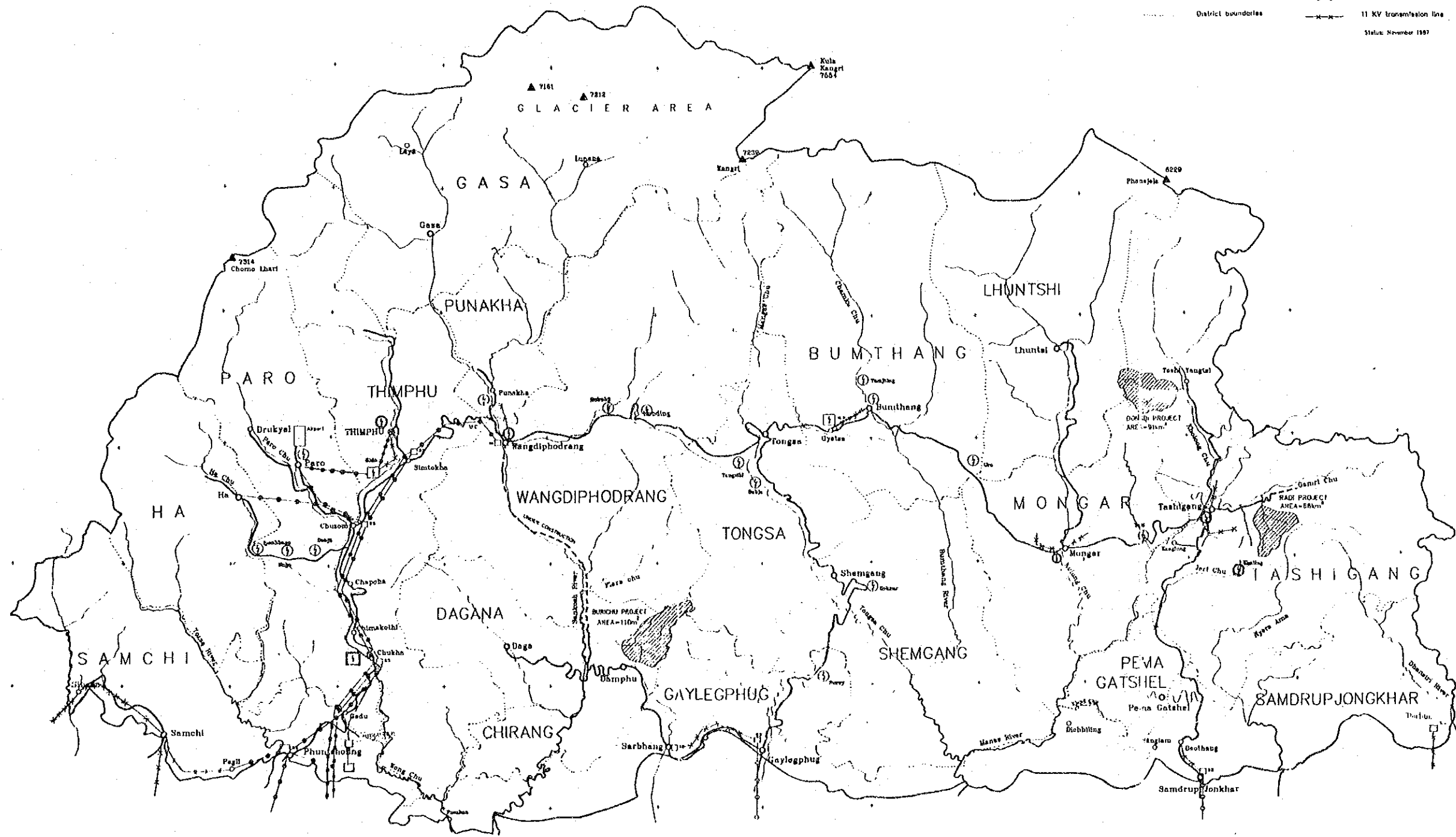
SCALE 1 : 600 000



## LEGEND:

- |  |                           |                              |                          |
|--|---------------------------|------------------------------|--------------------------|
|  | Paved roads               |                              | 1-100 KW hydro plant     |
|  | Unpaved roads             |                              | 100-1000 KW hydro plant  |
|  | Rivers                    |                              | 1-10 MW hydro plant      |
|  | National capital          | >10 MW hydro plant symbol"/> | >10 MW hydro plant       |
|  | District capitals         |                              | Substation               |
|  | Other capitals            |                              | 220 KV transmission line |
|  | Elevation points (meters) |                              | 66 KV transmission line  |
|  | International boundaries  |                              | 33 KV transmission line  |
|  | District boundaries       |                              | 11 KV transmission line  |

Status: November 1987



Remarks: This map is prepared from the existing map 1:250,000 and from the LANDSAT MAP 1:250,000





## 5.7

ENERGY SOLD AND PEAK LOAD (1987.4 - 1988.6)  
(Excl. local areas under CHP)

	Gross Genera- tion in GWh	Auxili- ary con- sumption in GWh	*1 Export if any in GWh	*4 Import if any in GWh	Net energy available in GWh	Total energy sold in GWh	Losses in GWh	% of loss on avail- ability	Peak Load	*3 % of load factor
<b>UPPER WESTERN REGION</b>										
Thimphu	3.054	0.125	2.19	17.929	18.667	11.523	7.144	38.271	4.000	26.27
Paro	0.007	0.000	0.000	2.190	2.197	1.983	0.214	9.741	0.500	36.16
W/Phodrang	0.707	0.025	0.000	0.000	0.681	0.634	0.047	6.902	0.208	27.79
<b>TOTAL UPPER REGION</b>	<b>3.768</b>	<b>0.152</b>	<b>2.190</b>	<b>20.119</b>	<b>21.545</b>	<b>14.140</b>	<b>7.405</b>	<b>34.370</b>	<b>4.708</b>	<b>27.38</b>
<b>LOWER WESTERN REGION</b>										
Phuntsholing	0.033	0.003	0.000	18.807	16.498	16.498	2.309	12.277		
Samchi	0.072	0.005	0.000	30.670	30.737	25.801	4.936	15.059	9.736	39.60
Sibsoo	0.000	0.000	0.000	0.096	0.096	0.109	-0.013	-13.542	0.200	5.97
<b>REGION</b>	<b>0.105</b>	<b>0.008</b>	<b>0.000</b>	<b>49.543</b>	<b>49.640</b>	<b>42.408</b>	<b>7.232</b>	<b>14.569</b>	<b>9.936</b>	<b>38.91</b>
<b>CENTRAL &amp; SOUTH CENTRAL REGION</b>										
Gaylegphug	0.000	0.021	0.000	1.976	1.955	1.572	0.383	19.591	0.873	16.42
Damphu	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	-
Tongsa	0.235	0.000	0.000	0.000	0.235	0.235	0.000	0.000	0.200	10.71
Shemgang	0.044	0.000	0.000	0.000	0.044	0.044	0.000	0.000	0.000	-
<b>CENTRAL REGION</b>	<b>0.279</b>	<b>0.021</b>	<b>0.000</b>	<b>1.976</b>	<b>2.234</b>	<b>1.851</b>	<b>0.383</b>	<b>0.000</b>	<b>1.073</b>	<b>15.73</b>
<b>EASTERN REGION</b>										
S/Jongkhar	0.000	0.000	0.000	1.190	1.190	1.323	-0.133*2	-11.176	0.350	34.46
Diafam	0.000	0.000	0.000	0.113	0.113	0.087	0.026	23.009	0.050	15.86
Tashigang	1.056	0.043	0.000	0.000	1.013	0.526	0.487	48.075	0.250	19.08
Mongar	0.485	0.044	0.000	0.000	0.441	0.318	0.123	27.891	0.133	21.80
<b>REGION</b>	<b>1.541</b>	<b>0.087</b>	<b>0.000</b>	<b>1.303</b>	<b>2.757</b>	<b>2.254</b>	<b>0.503</b>	<b>18.244</b>	<b>0.783</b>	<b>26.25</b>
<b>GRAND TOTAL</b>	<b>5.593</b>	<b>0.268</b>	<b>2.190</b>	<b>72.941</b>	<b>76.176</b>	<b>60.653</b>	<b>15.523</b>	<b>20.378</b>	<b>16.500</b>	<b>33.52</b>

\*1 Export to paro

\*2 Defective Metering

\*3 Load Factor (%) =  $\frac{\text{Total Energy Sold}}{24^h \times 457^D \times \text{Peak Load}} \times 100$  (457<sup>D</sup> = 366<sup>D</sup> + 30<sup>D</sup> + 31<sup>D</sup> + 30<sup>D</sup>)

\*4 Include CHP's Energy product

5.8 DETAILS OF GENERATION (1987.4 - 1988.6)

Name of Generating Stations	Peak Generation (in MW)	Energy Generation (MWh)	Auxiliary consumption (MWh)	Fuel consumption in (k.Ltrs)	Fuel per KWH (In Ltrs)
<b>HYDRO</b>					
1. Gidakom	1.200	2.485	0.033	-	-
2. Thimphu	0.520	0.412	0.037	-	-
3. W/Phodrang	0.238	0.707	0.026	-	-
4. Paro	0.000	0.000	0.000	-	-
5. Tashigang	0.230	1.056	0.043	-	-
6. Mongar	0.133	(0.485)	0.044	-	-
7. Nagu	0.000	0.000	0.000	-	-
8. Micros	0.000	0.235	0.000	-	-
Total Hydro	2.321	5.280	0.183	-	-
<b>DIESEL</b>					
1. Phuntsholing	1.967	0.033	0.003	14.583	0.442
2. Samchi	0.441	0.072	0.005	31.562	0.438
3. Paro	0.000	0.007	0.000	2.343	0.331
4. Thimphu	2.600	0.157	0.056	63.931	0.407
5. Damphu	0.000	0.000	0.000	0.000	0.000
7. Shemgang	0.000	0.044	0.000	0.000	0.000
Total Diesel	5.008	0.313	0.064	112.419	1.618
Grand Total	7.329	5.693	0.247	112.419	1.618

5.9 DETAILS OF PURCHASE OF ENERGY BY DOP (1987.4 - 1988.6)

Purchased from	Receiving Point	Maximum Demand in (MW)	Energy Purchased in MWh
1. Through WBSEB from India	Samchi - 11 kV	0.480	0.744
	Sibsóo - 11 kV	0.081	0.098
	Total	0.561	0.842
2. Through ASEB from India	Gaylegphug 33 kV	0.873	1.803
	S/Jongkhar 11 kV	0.350	0.909
	Diafam 11 kV	0.050	0.113
	Total	1.273	2.825
3. CHUKHA DYDEL PROJECT	Phuntsholing	*17.900	*18.775
	Samchi	-	25.250
	Simtokha	4.000	17.929
	Total	21.900	61.954
Total Purchase of Power by D.O.P.		23.734	65.621

\* Include local areas under CHP

5.10 DETAILS OF SALES OF ENERGY (1987.4 - 1988.6) (BY DOP)\*

Category of Consumers	Energy sold GWh	Percentage of total sales
Domestic	10.211	16.84
Comm. & Govt Offices	8.882	14.64
Industrial	38.720	63.839
Bulk Supply	2.70	4.45
Public Lightng	0.14	0.23
Total Sales	60.653	100.00

\* Exclude local sales by CHP

5.11 AREA WISE AND REGION WISE SALES OF ENERGY DURING 1987.4 - 1988.6  
(GWh)

	Domestic	Commercial and Govt. Offices	Industrial	Bulk Supply	Public Lighting	Total
<b>UPPER WESTERN REGION</b>						
Thimphu (% of Total)	4.291 37.239	24.255 36.926	0.452 3.923	2.457 21.323	0.068 0.590	11.523 100.000
Paro (% of Total)	0.485 24.458	1.385 69.844	0.109 5.497	0.000	0.004 0.202	1.983 100.000
W/Phodrang (% of Total)	0.215 33.912	0.362 57.098	0.057 8.991	0.000	0.000	0.534 100.000
Total for Upper Western Region A: (% of Total)	4.991 35.297	6.002 42.447	0.618 4.371	2.457 17.376	0.072 0.509	14.140 100.000
<b>LOWER WESTERN REGION</b>						
Phuntsholing (% of Total)	2.928 17.141	1.523 9.231	12.147 73.627	0.000 0.000	0.000 0.000	16.498 100.000
Samchi (% of Total)	0.435 1.586	0.055 0.213	25.311 98.101	0.000 0.000	0.000 0.000	25.801 100.000
Sibsoo (% of Total)	0.065 59.633	0.041 37.615	0.003 2.752	0.000 0.000	0.000 0.000	0.109 100.000
Total for Lower Western Region B: (% of Total)	3.328 7.848	1.619 3.817	37.462 88.335	0.000 0.000	0.000 0.000	42.408 100.000
<b>CENTRAL &amp; SOUTH CENTRAL REGION</b>						
Gaylegphug (% of Total)	0.615 39.122	0.448 28.499	0.498 31.679	0.000 0.000	0.011 0.700	1.572 100.000
Damphu (% of Total)	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000
Tongsa (% of Total)	0.235 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.235 0.000
Shengang (% of Total)	0.044 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.000 0.000	0.044 0.000
Total for Central & South Central D: (% of Total)	0.894 48.298	0.448 24.203	0.498 26.904	0.000 0.000	0.011 0.594	1.851 100.000
<b>EASTERN REGION</b>						
S/Jongkhar (% of Total)	0.758 57.294	0.443 33.485	0.099 7.483	0.000 0.000	0.023 1.738	1.323 100.000
Diafam (% of Total)	0.025 28.736	0.032 36.782	0.022 25.287	0.000 0.000	0.000 9.195	0.087 100.000
Tashigang (% of Total)	0.129 24.525	0.139 26.426	0.004 0.760	0.243 46.198	0.011 2.091	0.526 100.000
Mongar (% of Total)	0.086 27.044	0.199 62.579	0.018 5.660	0.000 0.000	0.015 4.717	0.318 100.000
Total for Eastern Region E: (% of Total)	0.998 44.277	0.813 36.069	0.143 6.344	0.243 10.781	0.057 2.529	2.254 100.000
Sub-Total F=D+E	1.892	1.261	0.641	0.243	0.068	4.105
Grand Total (Sub-Total C+F) (% of Total)	10.211 16.835	8.882 14.644	28.720 63.839	2.700 4.451	0.140 0.231	60.653 100.000

5.12 LOAD FORECAST - DZONGKAG WISE

DZONGKAG	1987 - 1988		1988 - 1989		1989 - 1990		1990 - 1991		1991 - 1992		Load Factor in 1991-92
	Energy (GWh)	Demand (MW)	Energy (GWh)	Demand (MW)	Energy (GWh)	Demand (MW)	Energy (GWh)	Demand (MW)	Energy (GWh)	Demand (MW)	
Thimphu	14.40	3.288	16.32	3.726	18.31	4.180	20.04	4.575	21.07	4.811	0.5
Paro	1.50	0.428	1.72	0.491	1.84	0.525	1.97	0.562	2.10	0.599	0.4
Wangdi/punakha	0.67	0.191	1.48	0.422	1.60	0.457	1.80	0.514	1.93	0.551	0.4
Chukha	6.91	1.315	82.97	15.786	90.14	17.149	94.46	17.972	96.42	18.345	0.6
Haa	-	-	0.27	0.117	0.45	0.171	0.54	0.205	0.63	0.240	0.3
Samchi	20.29	5.791	20.64	5.890	20.93	5.973	21.27	6.070	21.59	6.161	0.4
Gaphug	1.49	0.425	1.64	0.468	2.55	0.728	2.68	0.765	2.80	0.799	0.4
Damphu	-	-	-	-	-	-	0.45	0.171	0.90	0.342	0.3
Dagana	-	-	-	-	-	-	0.18	0.068	0.19	0.072	0.3
Shemgang	-	-	-	-	-	-	0.27	0.103	0.27	0.103	0.3
Bunthang	-	-	0.30	0.114	0.45	0.171	0.51	0.194	0.56	0.213	0.3
Tongsa	-	-	0.30	0.114	0.34	0.129	0.43	0.164	0.47	0.179	0.3
S/Jongkhar	1.17	0.325	1.26	0.359	1.93	0.522	1.94	0.554	2.05	0.585	0.4
Pema Gatsbel	-	-	-	-	-	-	-	-	-	-	-
Tashigang	0.72	0.273	0.88	0.335	0.95	0.361	1.02	0.389	1.08	0.411	0.3
Mongar	0.30	0.114	0.32	0.122	0.34	0.129	0.34	0.129	0.36	0.136	0.3
Lhuntsni	-	12.145	-	-	-	-	-	-	-	-	-
Total	47.45	12.16	128.1	27.944	184.28	30.495	147.9	32.434	152.42	33.547	0.5

5.13 Outline of Diesel Power Station

	Item	Shemgang	Damphu	Dagana
Diesel	Output (kW) Manufacturer Y.M.D Manufacturer Co. Model No. Fuel Consumption Fuel Cost Operation hour Country Fuel Oil Stop in Y.M.D.	No Data '82-8-17 KIRLOSKAR CUMMINS LTD. NT-495-G 21 L/hour 3.91 Nv/L PM 5.00 - PM 9.00 INDIA Light Oil Working	No Data ditto ASHOK LEYLAND POWER PLUS No Data 13 L/hour No Data PM 6.00 - 11.00 INDIA Light Oil '86-2-27	75.5 No Data KIRLOSKAR OIL ENGINES LTD. RB66 No Data ditto ditto INDIA Light Oil No Data
Gene- rator	Commissioning Year Capacity Voltage (Output) Ampere Rotation Power factor phase frequency Ex Voltage Ex Ampere Manufacturer Co. Country Insulation class	No Data 100 kVA 415 V 139.5 A 1500 rpm 0.8 3 50 Hz 260 V 5.0 A KIRLOSKAR ELECTRIC CO. INDIA No Data	No Data 60 kVA 420 V 82.5 A 1500 rpm 0.8 3 50 Hz 260 V 3.5 A KIRLOSKAR ELECTRIC CO. INDIA E	No Data 50 kVA 415V 69.8 A 1500 rpm 0.8 3 50 Hz 300 V 5.4 A KIRLOSKAR ELECTRIC CO. INDIA No Data

5.14 List of Consumers of Shemgang, Damphu, Dagana Power Plant

	Name of Consumer.	Shemgang		Damphu		Dagana	
		Light Point	Power Point	Light Point	Power Point	Light Point	Power Point
1.	Hospital		10	200*2			
2.	Dispensary	22	1	0		11	
3.	Animal Husbandry						
4.	Primary School	0					
5.	Junior High School	96	10			24	
6.	High School						
7.	Boys Dormitory	131		200*2			
8.	Girls Dormitory	83					
9.	Administration Office	131	3	200			
10.	Agriculture Dept. Office						
11.	Wireless Station	8					
12.	Post Office	36	2	150			
13.	Police Office	24					
14.	Forest Office	4					
15.	Food Corporation of Bhutan						
16.	Guest House	71	7			43	
17.	Oil Corporation	6					
18.	Monk	24		50			
19.	Tourist Lodge	13*1					
20.	Bank of Bhutan	15					
21.	Justice						
22.	DOP Office						
	Private House	767	12	1780		100	
	<b>Total</b>	<b>1431</b>	<b>45</b>	<b>2580</b>	<b>-</b>	<b>178</b>	<b>-</b>

\*1 Situated in Tong Village

\*2 include staff quarters



5.15 Typical Consumption (kW)

	Shemgang	Damphu	Dagang
Year. Month	1988.12	1986.2	No Data
Hour			
17H - 18H	59	-	ditto
18H - 19H	66	35	ditto
19H - 20H	69	31	ditto
20H - 21H	67	32	ditto
21H - 22H	-	31	ditto
22H - 23H	-	31	ditto

5.16 Survey Results of Numbers of  
Household and Public Facilities

1/2

TOWN or Village Name	Households	Population	Public Facilities	Reference
"Shemgang site	62	1,032	16	* Include high school student (850)
Tong Village	57	550	1	
Dakpai	27	180	4	
Tintibi (include Tama)	34	650	9	* Include primary school students in 1992 (300)
Yebilapcha	30	5 persons x 30	1	
Sub-Total	210	2,562	31	
Pam (Wangdigang Pankar Dungbi)	43	370	-	
Birthey	14	132	-	
Goling	32	416	-	
Tsanglajong	17	109	-	
Tali	30	5 persons x 30	-	
Sub-Total	136	1,177	0	
Total	346	3,739	31	

5.16 Survey Result of Number of Household and Public Facilities

2/2

TOWN or Village Name	Households	Population	Public Facilities	Reference
"2" <u>Damphu Site</u> Damphu town area Salami and near Power Station	9,000x1/2+9=500 50	9,000x1/2=4,500 9x50=450	19 1	9,000: Goseling population 9: Average family
Total	550	4,950	20	
"3" <u>Dagana Site</u> Daga Town same, Tashigang, changlaykha, Ningugang, Kalijingkha Kanakha, Thalgoan Goshi	110x2/3=75 475x1/3=160 500x2/3=330	663x2/3=442 2,744x1/3=900 personx330=2,640	11 0 9	110: Chezang households 663: Chezang population 475: Kali households 2,744: Kali population 500: Goshi households
Total	565	3,982	20	

5.17 Demand Forecast of Shemgang Site

(1/3)

No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)
1.	[Public Houses of Shemgang Town]				
(1)	Dispensary	Fluorescent Lamp	40	8	320
		Lamp	60	4	240
		Room Heater	5,000	2	10,000
		Water Heater	3,600	1	3,600
		Refrigerator	200	1	200
		Germicidal Lamp	20	1	20
(2)	Animal Husbandry	Fluorescent Lamp	40	3	120
		Lamp	60	3	180
(3)	Primary School	Fluorescent Lamp	40	24	960
		Public Address System	100	1	100
(4)	High School	Fluorescent Lamp	40	275	11,000
		Lamp	60	14	840
		Public Address System	100	1	100
		Video & Television	140	1	140
(5)	Dormitory of High School	Fluorescent Lamp	40	140	5,600
		Lamp	60	12	720
(6)	Administration Office	Fluorescent Lamp	40	40	1,600
		Lamp	200	10	2,000
(7)	Wireless Station	Lamp	60	8	480
		Power Supply Equipment	1,000	1	1,000
(8)	Post Office	Fluorescent Lamp	40	18	720
		Lamp	60	18	1,080
(9)	Police Office	Fluorescent Lamp	40	6	240
		Lamp	60	8	480
(10)	Forest Office	Fluorescent Lamp	40	2	80
		Lamp	60	2	120
(11)	Food Corporation of Bhutan	Fluorescent Lamp	40	1	40
		Lamp	60	1	60
(12)	Guest House	Fluorescent Lamp	40	12	480
		Lamp	60	58	3,480
(13)	Oil Corporation	Lamp	60	6	360
(14)	Monk	Fluorescent Lamp	40	81	3,240

## 5.17 Demand Forcast of Shemgang Site

(2/3)

No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)
(15)	Bank of Bhutan	Fluorescent Lamp	40	10	400
		Lamp	60	10	600
(16)	D.O.P. Office	Fluorescent Lamp	40	4	160
		Lamp	60	4	240
(17)	Street Light	Fluorescent Lamp	40	150	6,000
2.	[Public Houses of Tong Villagel]				
(1)	Lodging Office	Fluorescent Lamp	40	3	120
		Lamp	60	10	600
(2)	Street Light	Fluorescent Lamp	40	20	800
3.	[Public House of Dakpai Villagel]				
(1)	Agriculture Dept. Office	Fluorescent Lamp	40	2	80
(2)	Post Office	Fluorescent Lamp	40	2	80
(3)	Monk	Fluorescent Lamp	40	8	320
		Lamp	60	8	480
(4)	Street Light	Fluorescent Lamp	40	20	800
4.	[Public Houses of Tintibi Villagel]				
(1)	Primary School (in the future)	Fluorescent Lamp	40	24	960
		Public Address System	100	1	100
(2)	Dormitory of Primary School (in the future)	Fluorescent Lamp	40	20	800
		Lamp	60	10	600
(3)	Agriculture Dept. Office (in the future)	Fluorescent Lamp	40	2	80
(4)	Wireless Station (in the future)	Fluorescent Lamp	40	2	80
		Power Supply Equipment	1,000	1	1,000
(5)	Post Office	Fluorescent Lamp	40	2	80
(6)	Forest Office (in the future)	Fluorescent Lamp	40	2	80

5.17 Demand Forecast of Shemgang Site

(3/3)

No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)	
(7)	Guest House	Fluorescent Lamp	40	12	480	
		Lamp	60	6	360	
(8)	Sub-District Administration	Fluorescent Lamp	40	2	80	
(9)	Hydro met DIV	Fluorescent Lamp	40	2	80	
(10)	Power Station	Lamp	60	2	120	
(11)	Street Light	Fluorescent Lamp	40	100	4,000	
5.	[Public Houses of Yebilapcha Village]					
(1)	Hospital	Fluorescent Lamp	40	57	2,280	
		Operation Lamp	200	6	1,200	
		Lamp	60	9	540	
		Room Heater	5,000	6	30,000	
		Water Heater	3,600	1	3,600	
		Refrigerator	200	2	400	
		Germicidal Lamp	20	4	80	
		Vacuum Pump	750	1	750	
(2)	Street Light	Fluorescent Lamp	40	20	800	
6.	[Private Houses]					
	Shemgang Town	62	Lamp	60	6x346	124,560
	Tong Village	57	Radio	10	1x346	3,460
	Dakpai	"	27			
	Tintibi	"	34			
	Yebilapcha	"	30			
	Pam	"	43			
	Birthey	"	14			
	Goling	"	32			
	Ishanghajong"	17				
	Tali	"	30			
	Total	346				
7.	Total	Fluorescent Lamp			42,960	
		Lamp			139,440	
		Heater			47,200	
		Power			6,150	
		Total				

Calculation of Maximum Demand Forecast of Shengang Site

$$\begin{aligned} P_{\geq} & \left( \frac{139,440}{1.0} + \frac{42,960}{0.8} \right) \times 0.75 \times \frac{1.1}{1.2} \\ & + \left( \frac{47,200}{1.0 \times 1.0} + \frac{6,150}{0.8 \times 0.8} \right) \times 0.5 \times \frac{1.1}{1.1} \\ & = 132,784 + 28,405 = 161,189 \text{ (VA)} \end{aligned}$$

Then, Required Power Plants Output is as follows;

$$P_p = P \times K = 161 \times 1.2 = 193.2 = 200 \text{ (kVA)}$$

where, k is Transmission & Distribution Loss Factor.

5.18 Demand Forecast of Damphu Site

					(1/2)
No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)
1.	[Public Houses of Damphu Town]				
(1)	Hospital	Fluorescent Lamp	40	27	1,080
		Lamp	60	23	1,380
		Operation Lamp	200	12	2,400
		Room Heater	5,000	2	10,000
		Water Heater	3,600	1	3,600
		Refrigerator	200	2	400
		Germicidal Lamp	20	4	80
		Vacuum Pump	750	1	750
		X-Ray	25,000	1	25,000
(2)	Animal Husbandry	Fluorescent Lamp	40	12	480
(3)	Primary School	Fluorescent Lamp	40	133	5,320
		Public Address System	100	1	100
(4)	Junior High School	Fluorescent Lamp	40	246	9,840
		Lamp	60	28	1,680
		Public Address System	100	1	100
		Video & Television	140	1	140
(5)	Dormitory of Junior High School	Fluorescent Lamp	40	165	6,600
		Lamp	60	25	1,500
(6)	Administration Office	Fluorescent Lamp	40	30	1,200
		Lamp	60	2	120
(7)	Agriculture Dept. Office	Fluorescent Lamp	40	7	280
		Lamp	60	11	660
(8)	Wireless Station	Fluorescent Lamp	40	3	120
(9)	Post Office	Fluorescent Lamp	40	5	200
		Lamp	60	2	120
(10)	Police Station	Fluorescent Lamp	40	5	200
		Lamp	60	2	120
(11)	Forest Office	Fluorescent Lamp	40	2	80
(12)	Food Corporation of Bhutan	Lamp	60	4	240
(13)	Royal Guest House	Fluorescent Lamp	40	6	240
		Lamp	60	10	600



5.18 Demand Forecast of Damphu Site

(2/2)

No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)
(14)	Guest House	Fluorescent Lamp	40	6	240
		Lamp	60	10	600
(15)	Bank of Bhutan	Fluorescent Lamp	40	12	480
(16)	Justice	Fluorescent Lamp	40	4	160
(17)	Street Light	Fluorescent Lamp	40	200	8,000
2.	[Public Houses of Lapsibhete Village]				
(1)	Dispensary	Fluorescent Lamp	40	8	320
		Lamp	60	2	120
		Room Heater	5,000	1	5,000
		Water Heater	3,600	1	3,600
		Refrigerator	200	1	200
		Germicidal Lamp	20	1	20
(2)	Goseling Primary School	Fluorescent Lamp	40	31	1,240
		Public Address System	100	1	100
(3)	Agriculture Center	Fluorescent Lamp	40	2	80
(4)	Power Station	Lamp	60	2	120
3.	[Public House of Salami Village]				
(1)	Primary School	Fluorescent Lamp	40	32	1,280
		Lamp	60	5	300
4.	[Private Houses]				
	Damphu Town	Lamp	60	5x550	165,000
	(include Lapsibhote)	Radio	10	1x550	5,500
	Salami				
	Total				
5.	Total	Fluorescent Lamp			37,540
		Lamp			174,960
		Heater			22,200
		Power			7,090
					(25,000)

Calculation of Maximum Demand Forecast of Damphu Site

$$\begin{aligned} P > \left( \frac{174,960}{1.0} + \frac{37,540}{0.8} \right) \times 0.75 \times \frac{1.1}{1.2} \\ + \left( \frac{22,200}{1.0 \times 1.0} + \frac{7,090}{0.8 \times 0.8} + 25,000 \right) \times 0.5 \times \frac{1.1}{1.2} \\ = 152,546 + 29,139 = 181,685 \text{ (VA)} \end{aligned}$$

Then, Required Power Plants Output is as follows;

$$P_p = P \times K = 181.7 \times 1.2 = 218.04 = 220 \text{ (kVA)}$$

where, K is Transmission & Distribution Loss Factor

5.19 Demand Forecast of Dagana Site

(1/2)

No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)
	[Public Houses of Dagana Town]				
(1)	Dispensary	Fluorescent Lamp	40	13	520
		Lamp	60	6	360
		Room Heater	5,000	1	5,000
		Water Heater	3,600	1	3,600
		Refrigerator	200	1	200
		Germicidal Lamp	20	1	20
(2)	Animal Husbandry	Fluorescent Lamp	40	6	240
(3)	Same Primary School	Fluorescent Lamp	40	2	80
		Lamp	60	2	120
(4)	Junior High School	Fluorescent Lamp	40	87	3,480
		Lamp	60	3	180
		Public Address System	100	1	100
(5)	Dormitory of Junior High School	Fluorescent Lamp	40	43	1,720
		Lamp	60	14	840
(6)	Administration	Fluorescent Lamp	40	192	7,680
(7)	Wireless Office	Fluorescent Lamp	40	1	40
		Lamp	60	4	240
(8)	Post Office	Flourescent Lamp	40	4	160
(9)	Police Office	Fluorescent Lamp	40	10	400
(10)	Forest Office	Fluorescent Lamp	40	6	240
(11)	Food Corporation	Fluorescent Lamp	40	4	160
		Lamp	60	1	60
(12)	Street Light	Fluorescent Lamp	40	20	800
(13)	Power House	Lamp	60	2	120
2.	[Public House]				
(1)	Lhaling Primary School	Fluorescent Lamp	40	8	320
		Lamp	60	1	60

5.19 Demand Forecast of Dagana Site

(2/2)

No.	Consumer	Kind of Load (Power Facility)	Unit Capacity (W)	No. of Unit	Installed Capacity (W)
3.	[Private Houses]	Lamp	60	6x565	203,400
		Radio	10	1x565	5,650
	Dagana Town				
	Nindugang Village etc.				
	Goshi				
	<u>Total</u>				
4.	Total	Fluorescent Lamp			15,860
		Lamp			205,380
		Heater			8,600
		Power			5,950

Calculation of Maximum Demand Forecast of Dagana Site

$$\begin{aligned} P &= \left( \frac{205,380}{1.0} + \frac{15,860}{0.8} \right) \times 0.75 \times \frac{1.1}{1.2} \\ &+ \left( \frac{8600}{1.0 \times 1.0} + \frac{5,950}{0.8 \times 0.8} \right) \times 0.5 \times \frac{1.1}{1.1} \\ &= 154,828 + 8,948 = 163,776 \text{ (VA)} \end{aligned}$$

Then, Required Power Plants Output is as follows;

$$P_p = P \times K = 163.8 \times 1.2 = 196.6 = 200 \text{ (kVA)}$$

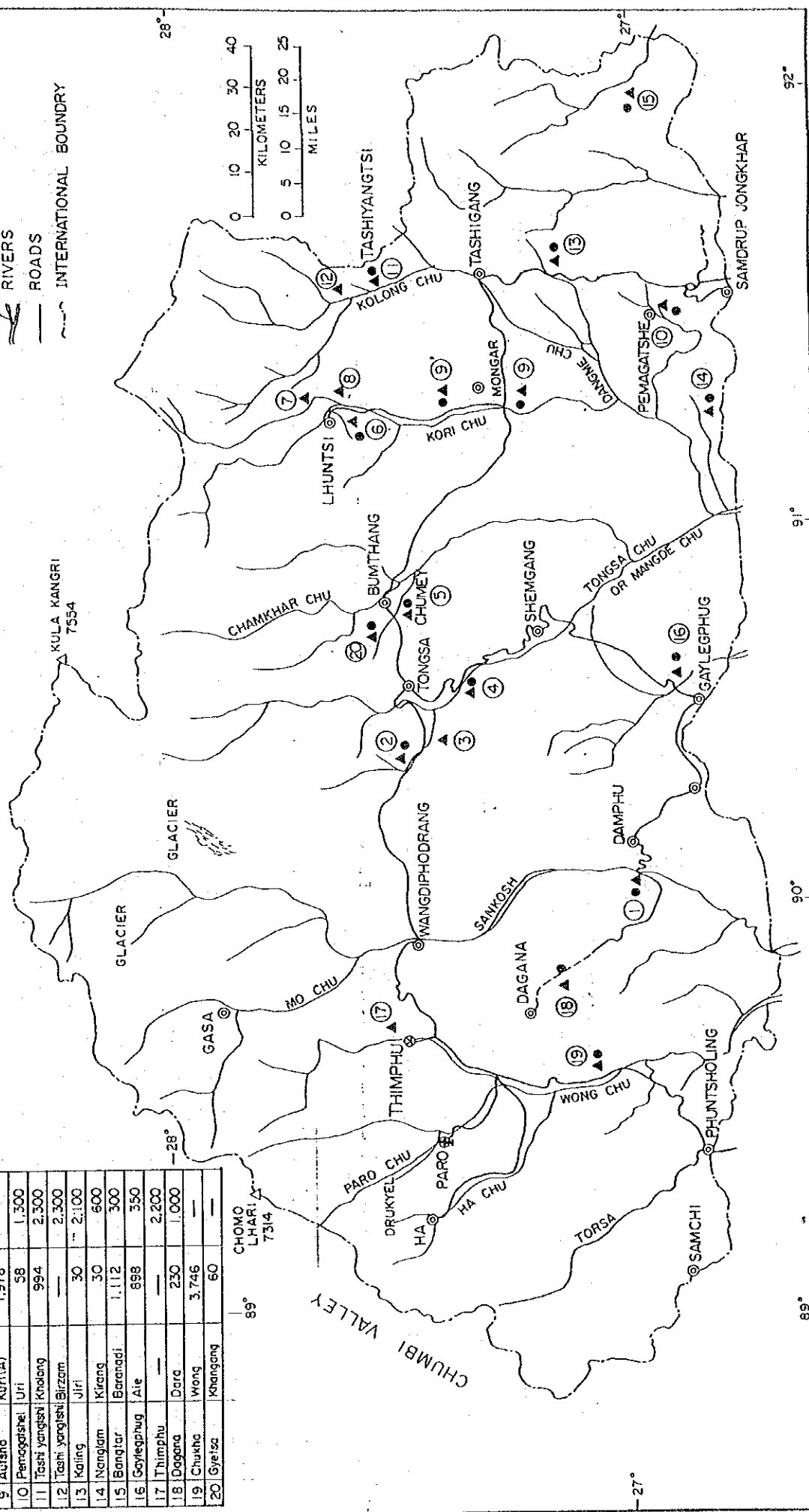
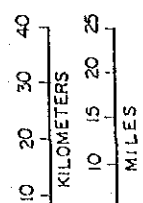
where, K is Transmission & Distribution Loss Factor

92° 91° 90° 89° 88° 87°

### 5.20 Location of Gauging Station

#### LEGEND

- ▲ ELEVATION POINTS (METERS)
- ✈ AIRPORT
- ⊙ NATIONAL CAPITALS
- ⊙ DISTRICT CAPITALS
- ▲ HYDROMET STATION
- RIVERS
- ROADS
- INTERNATIONAL BOUNDARY



Code No.	Name of G. Station	Name of River	Catchment Area (km <sup>2</sup> )	Elevation of G. Station (m)
1	Dubani	Sankoshi	10,452	300
2	Tangsebi	Nangste	—	—
3	Tangsebi	Chendeji	444	2,319
4	Rafe	Mangse	1,266	1,200
5	Chumey	Donkhar	60	2,850
6	Luntshi	Gargzoor	9	1,300
7	Luntshi	Kuri (S)	1,518	1,300
8	Luntshi	Xhoma	703	1,300
9	Kurbampa	Kuri(M)	3,089	470
9	Autsha	Kuri(A)	1,978	—
10	Panagatshel	Uri	58	1,300
11	Tashi yangtshi	Kholang	994	2,300
12	Tashi yangtshi	Birzam	—	2,300
13	Kaling	Jiri	30	2,100
14	Nanglam	Kirang	30	600
15	Bangtar	Baragdi	1,112	300
16	Goyegphug	Aie	898	350
17	Thimphu	Dara	—	2,200
18	Dagana	Wong	230	1,000
19	Chukha	Wong	3,746	—
20	Gyetsa	Khangang	60	—

5.21 Estimation of Monthly Average Discharge  
(Daily Average Discharge)

Unit. m<sup>3</sup>/sec

Gauging St. and Project Site	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remark
Refe GS. (Mongde Rv.) CA=1,266 km <sup>2</sup>	23.1	17.3	21.2	31.6	38.8	70.8	191.2	145.6	117.5	88.3	40.3	27.0	1986 data
	1.8	1.4	1.7	2.5	3.1	5.6	15.1	11.5	9.3	7.0	3.2	2.1	
Dagana GS (Dara Rv.) CA=230 km <sup>2</sup>	10.7	8.1	6.3	5.4	6.3	7.3	27.8	22.1	25.1	19.6	16.3	11.8	1986 data
	4.6	3.5	2.7	2.3	2.7	3.2	12.1	9.6	10.9	8.5	7.1	5.1	
Shemgang Site (Burumda Rv.) CA=108 km <sup>2</sup>	1.9	1.5	1.8	2.7	3.3	6.0	16.3	12.4	10.0	7.6	3.5	2.3	
	1.8	1.4	1.7	2.5	3.1	5.6	15.1	11.5	9.3	7.0	3.2	2.1	
Dampfu Site (Chanche Rv.) CA=53 km <sup>2</sup>	2.4	1.9	1.4	1.2	1.4	1.7	6.4	5.1	5.8	4.5	3.8	2.7	
	4.6	3.5	2.7	2.3	2.7	3.2	12.1	9.6	10.9	8.5	7.1	5.1	
Dagana Site (Dara Rv.) CA=225 km <sup>2</sup>	10.4	7.9	6.1	5.2	6.1	7.2	27.2	21.6	24.5	19.1	16.0	11.5	
	4.5	3.5	2.7	2.3	2.7	3.2	12.1	9.6	10.9	8.5	7.1	5.1	

Note: Upper line are daily discharge  
Under line are daily discharge per 100 km<sup>2</sup> of the catchment area

5.22 Estimation of Monthly Average Discharge  
(Daily Minimum Discharge)

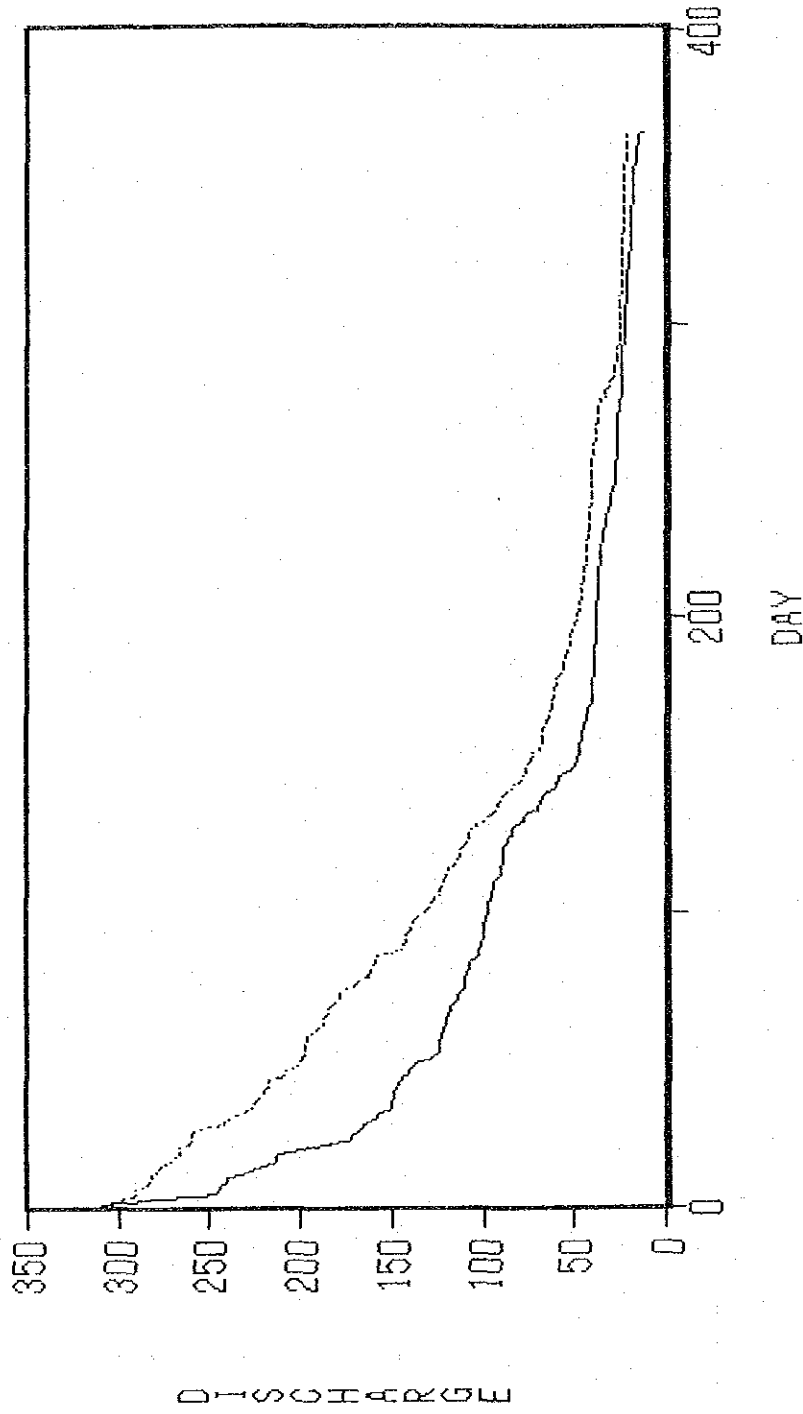
Unit. m<sup>3</sup>/sec

Gauging St. and Project Site	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Remark
Refe GS. (Mongde Rv.) CA=1,266 km <sup>2</sup>	14.4	11.7	15.6	15.5	33.6	40.3	109.6	109.3	84.6	64.4	30.8	22.1	1986 data
	1.1	0.9	1.2	1.2	2.7	3.2	8.7	8.6	6.7	5.1	2.4	1.7	
Dagana GS (Dara Rv.) CA=230 km <sup>2</sup>	8.6	6.5	4.4	4.9	4.9	4.7	20.4	15.6	19.5	16.5	14.7	10.4	1986 data
	3.7	2.8	1.9	2.1	2.1	2.0	8.9	6.8	8.5	7.2	6.4	4.5	
Shemgang Site (Burumda Rv.) CA=108 km <sup>2</sup>	1.2	1.0	1.3	1.3	2.9	3.4	9.4	9.3	7.2	5.5	2.6	1.8	
	1.1	0.9	1.2	1.2	2.7	3.2	8.7	8.6	6.7	5.1	2.4	1.7	
Dampu Site (Chanche Rv.) CA=53 km <sup>2</sup>	2.0	1.5	1.0	1.1	1.1	1.1	4.7	3.6	4.5	3.8	3.4	2.4	
	3.7	2.8	1.9	2.1	2.1	2.0	8.9	6.8	8.5	7.2	6.4	4.5	
Dagana Site (Dara Rv.) CA=225 km <sup>2</sup>	8.3	6.3	4.3	4.7	4.7	4.5	20.0	15.3	19.1	16.2	14.4	10.1	
	3.7	2.8	1.9	2.1	2.1	2.0	8.9	6.8	8.5	7.2	6.4	4.5	

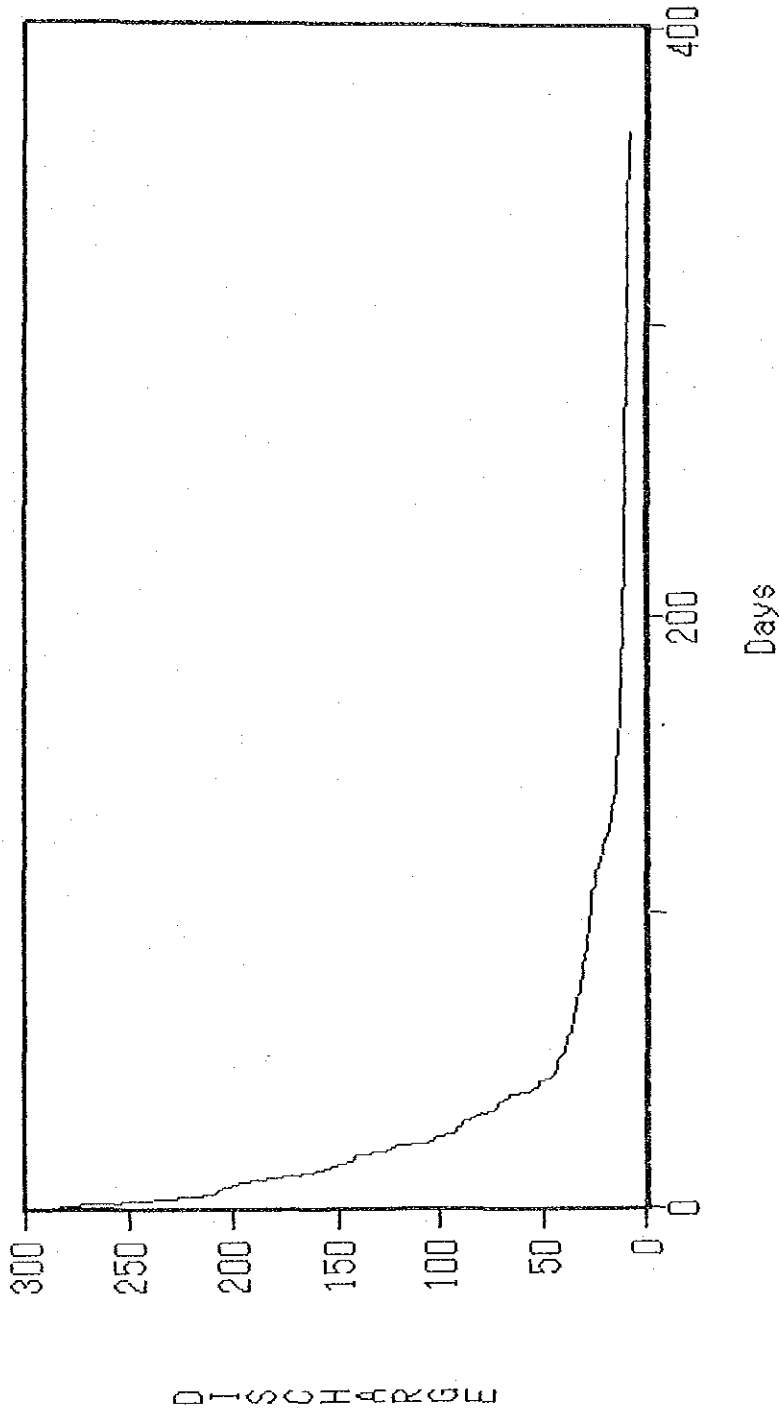
Note: Upper line are daily discharge  
Under line are daily discharge per 100 km<sup>2</sup> of the catchment area



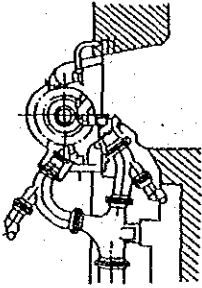
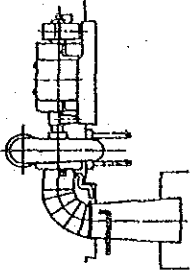
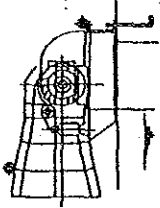
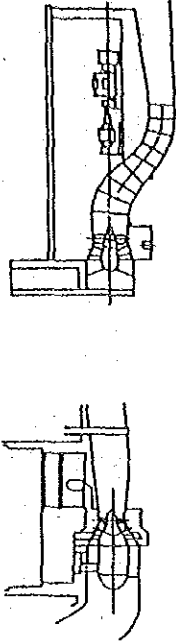
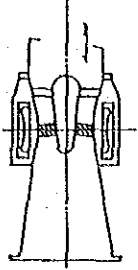
5.23 - FLOW DURATION CURVE  
AT MANGDE RIVER (m<sup>3</sup>/sec)



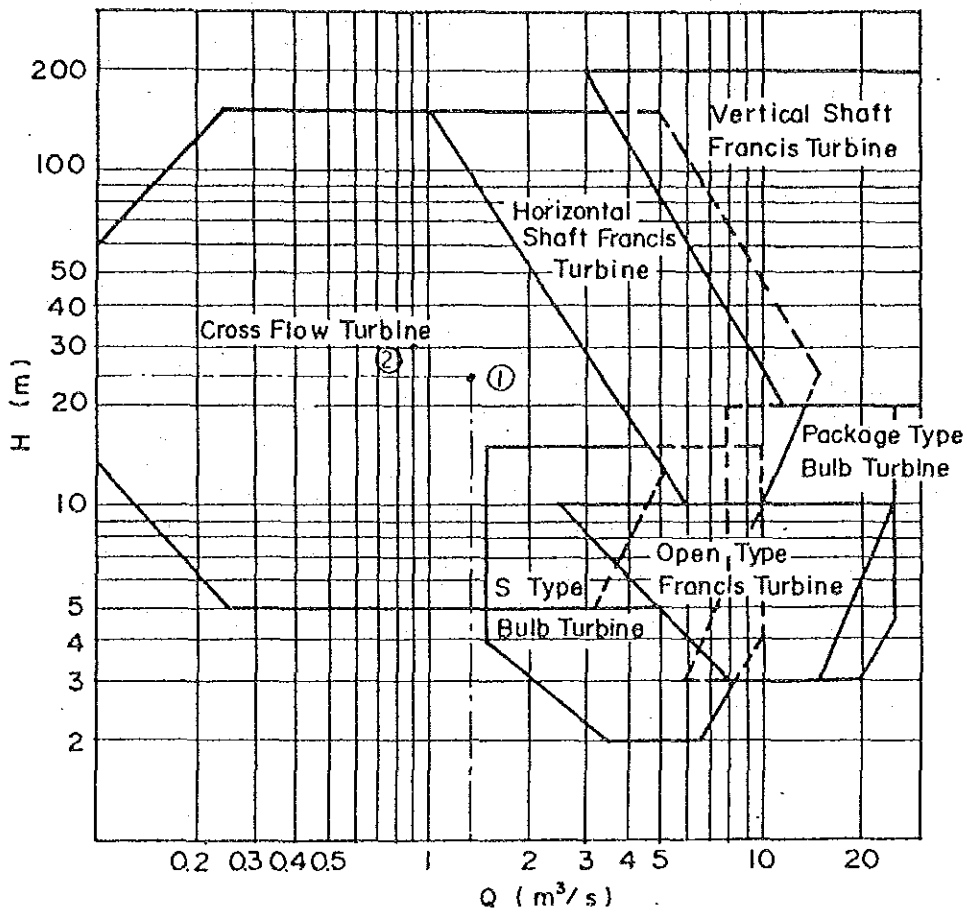
5.24 - FLOW DURATION CURVE  
AT DAGANA RIVER ( $m^3/sec$ )



5.25 Characteristics of Turbines (for small hydroelectric power generators)

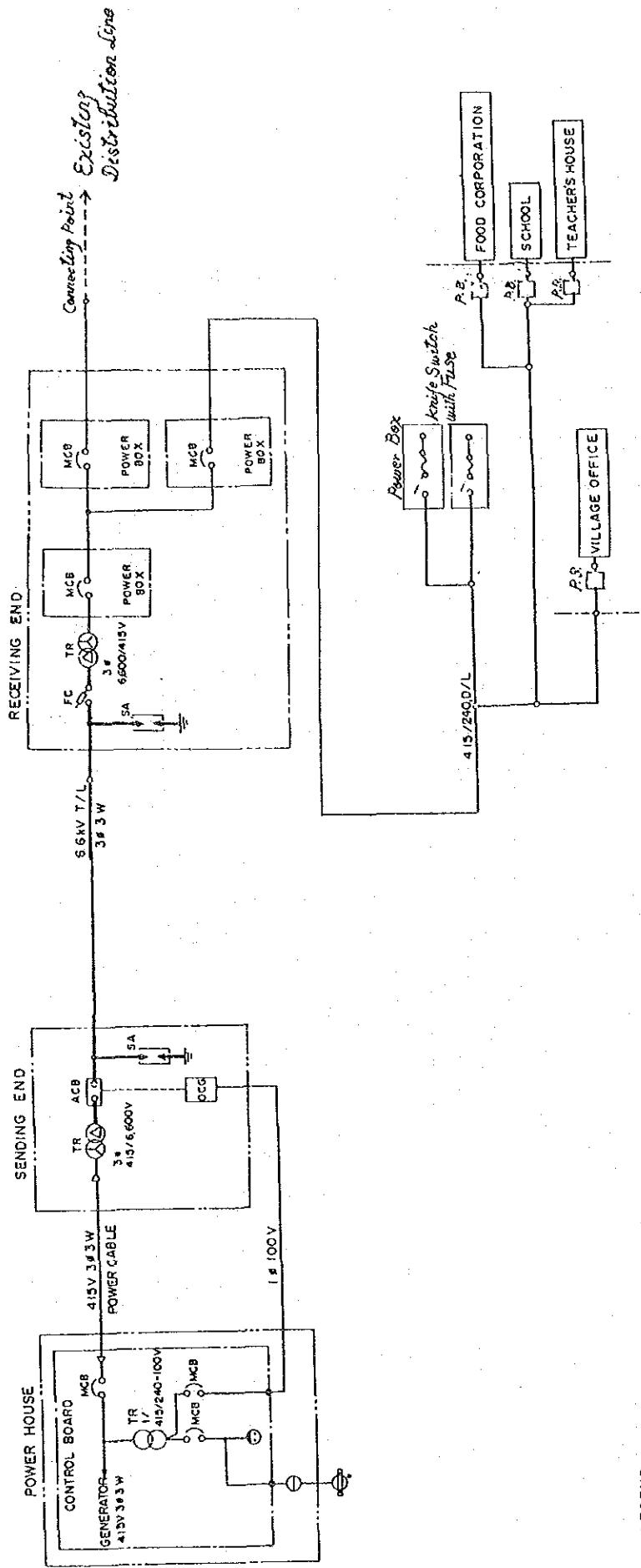
Type of Turbine	Difference in heads	General characteristics	Example of Turbines
Pelton Turbine	for higher head (more than 75 m)	Usable for dams, channels or for discharge water. High efficiency in change of stream volume.	
Francis Turbine	for medium height head (15 m - 200 m)	Most popular ones (for medium capacity) Able to match the change in stream volume by use of partial load runner.	
Cross-Flow Turbine	for medium height head (8 m - 100 m)	Suitable for small capacity (1,000 kW) and lowest in cost. Efficiency is not highest but least influence by change in stream water volume.	
Kaplan Turbine Tubular Turbine	for lower head (less than 25 m)	Suitable for channel (low head). Edest operability by use of movable wing runner.	
Fixed wing propeller turbine (including one piece turbine)	for lower head (less than 18 m)	Smallest equipment with diameter smaller than 1,000 mm. Able to meet changes in stream volume by means of changing number of equipment.	

## 5.26 Selection Figure of Water Turbine Type



- ① : Design Point of Dägana Project
- ② : Design Point of Shemgang and Damphu Project

5.27 Typical Single Line Diagram  
for Transmission and Distribution Line



LEGEND

- MCB : MOLDED CASE CIRCUIT BREAKER
- TR : TRANSFORMER
- ACB : AIR CIRCUIT BREAKER
- SA : SURGE ARRESTER
- OCG : OVERCURRENT-GROUND RELAY
- FC : FUSE CUTOUT

5.28 Calculation Results of Cable Sag (1/2)

Conductor (ACSR-OE 25 )

$T_{max} = 300\text{kg}$

$h = 0(\text{m})$

Span (m)	40		60		80		100	
	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)
40°C, 50kg/m <sup>2</sup>	149	0.72	164	1.48	172	2.50	177	3.80
0.9 3mmloe -10°C, 50kg/m <sup>2</sup>	300	0.57	300	1.29	300	2.29	300	3.57
15°C No wind	95	0.33	69	1.01	62	2.01	59	3.29

Conductor (ACSR-OE 25 )

$T_{max} = 300\text{kg}$

Span (m)	70 h=25m		60 h=20m		80 h=30m		100 h=30m	
	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)
40°C, 50kg/m <sup>2</sup>	175	2.17	169	1.62	179	2.81	183	4.11
0.9 3mmloe -10°C, 50kg/m <sup>2</sup>	307	1.97	306	1.42	309	2.60	309	3.89
15°C No wind	63	1.76	68	1.18	61	2.44	60	3.74

Conductor (ACSR-OE 25 )

$T_{max} = 400\text{kg}$

$h = 0(\text{m})$

Span (m)	40		60		80		100	
	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)
40°C, 50kg/m <sup>2</sup>	206	0.52	221	1.1	230	1.88	237	2.86
0.9 3mmloe -10°C, 50kg/m <sup>2</sup>	401	0.43	401	0.97	402	1.72	403	2.68
15°C No wind	218	0.14	154	0.45	112	1.11	94	2.06

Calculation Results of Cable Sag (2/2)

Conductor (ACSR-0E 25 )

$T_{max} = 400\text{kg}$

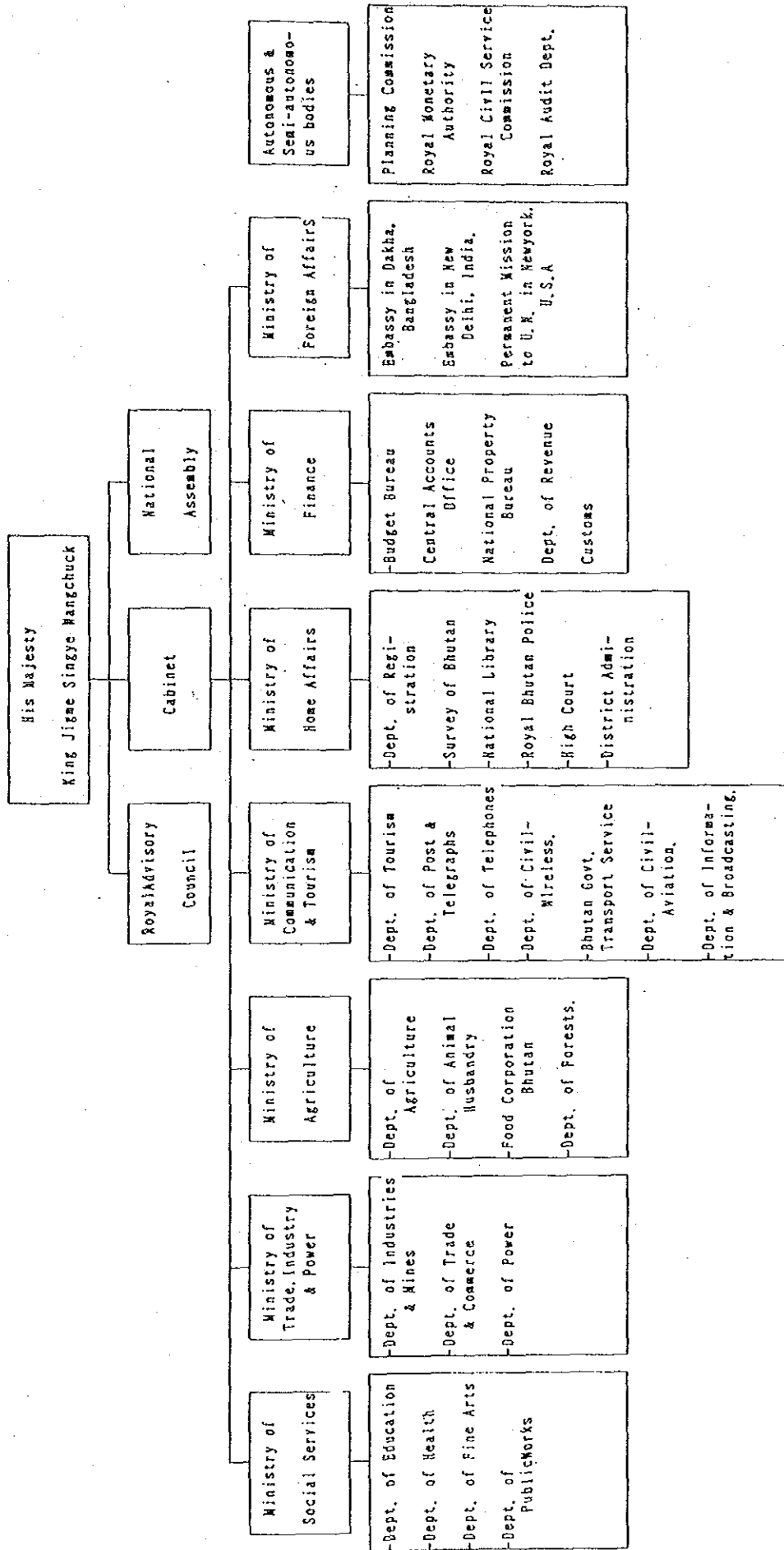
Span (m)	40 h=15m		60 h=20m		80 h=30m		100 h=30m	
Tension & Dip(Sag)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)
40°C, 50kg/m <sup>2</sup>	211	0.59	226	1.21	236	2.11	241	3.1
0.9 3mmloe -10°C, 50kg/m <sup>2</sup>	405	0.49	406	1.07	409	1.95	409	2.91
15°C No wind	214	0.17	147	0.53	105	1.38	93	2.36

Conductor (ACSR-0W 58 )

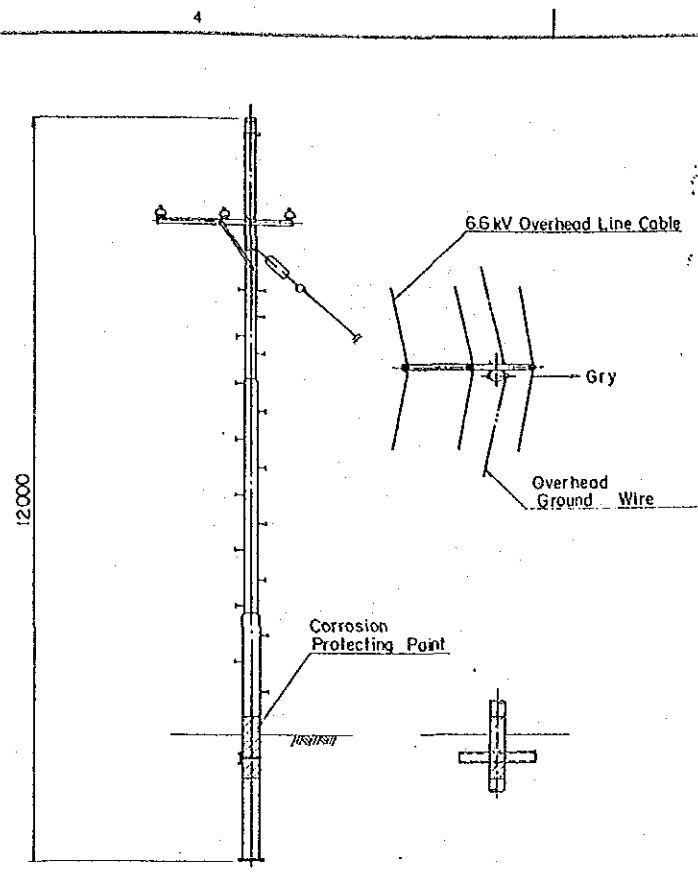
$T_{max} = 400\text{kg}$

Span (m)	40		60		80		100	
Tension & Dip(Sag)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)	T(kg)	D(m)
40°C, 50kg/m <sup>2</sup>	181	0.77	214	1.47	233	2.40	244	3.57
0.9 3mmloe -10°C, 50kg/m <sup>2</sup>	400	0.51	400	1.15	400	2.05	400	3.20
15°C No wind	123	0.50	122	1.14	122	2.04	121	3.19

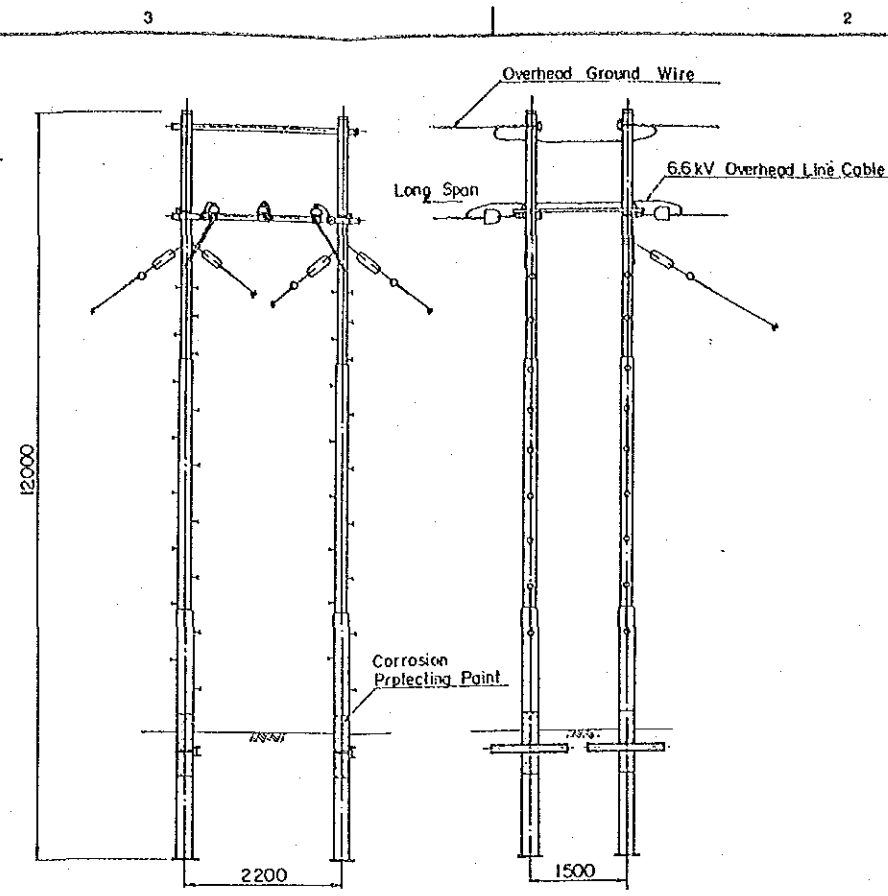
## 5.30 STRUCTURE OF GOVERNMENT



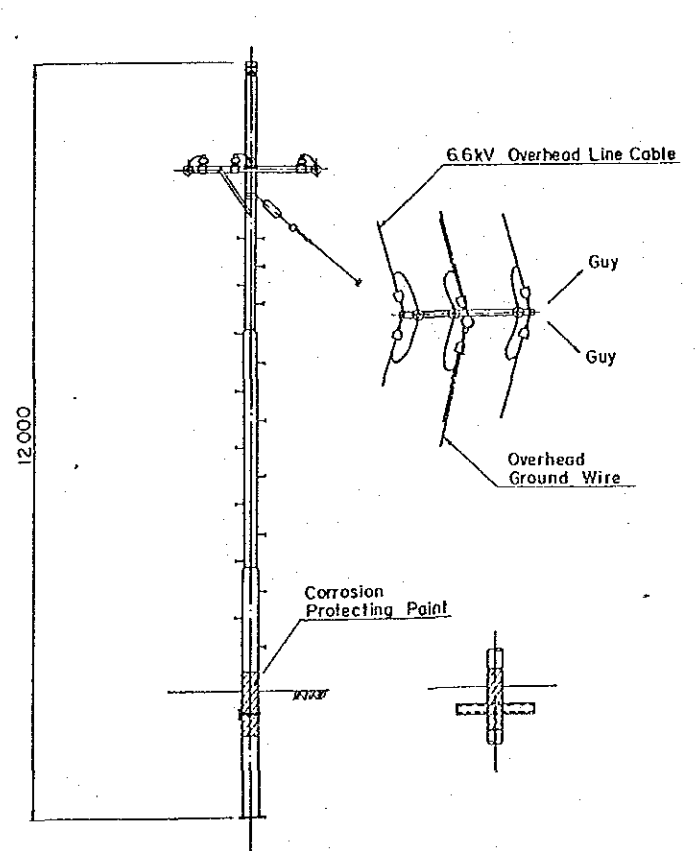




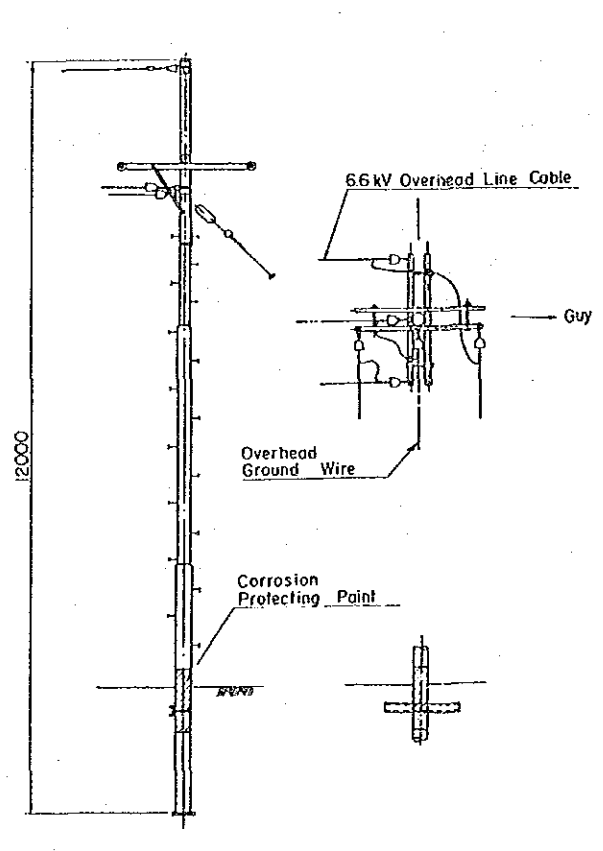
TYPE - A



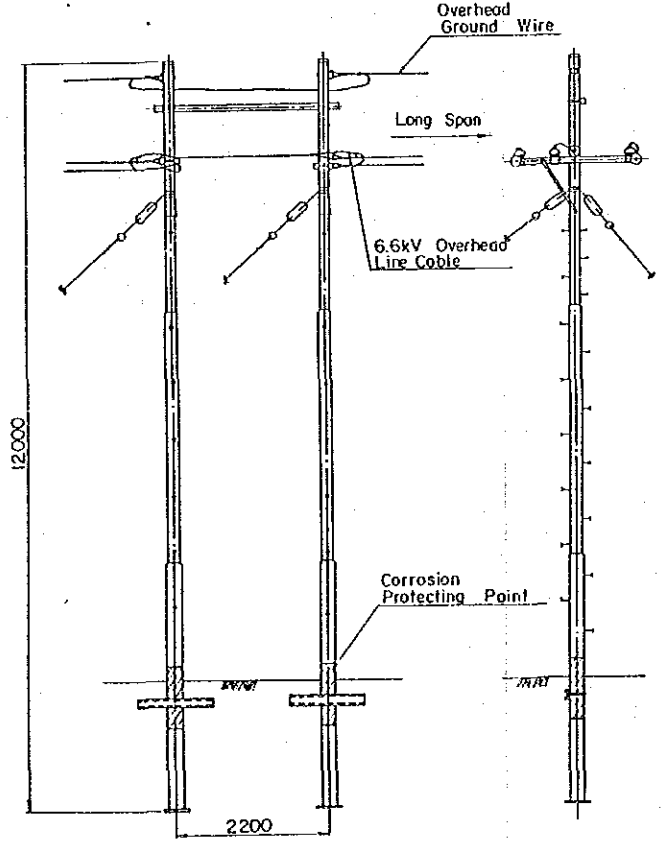
TYPE - B



TYPE - C

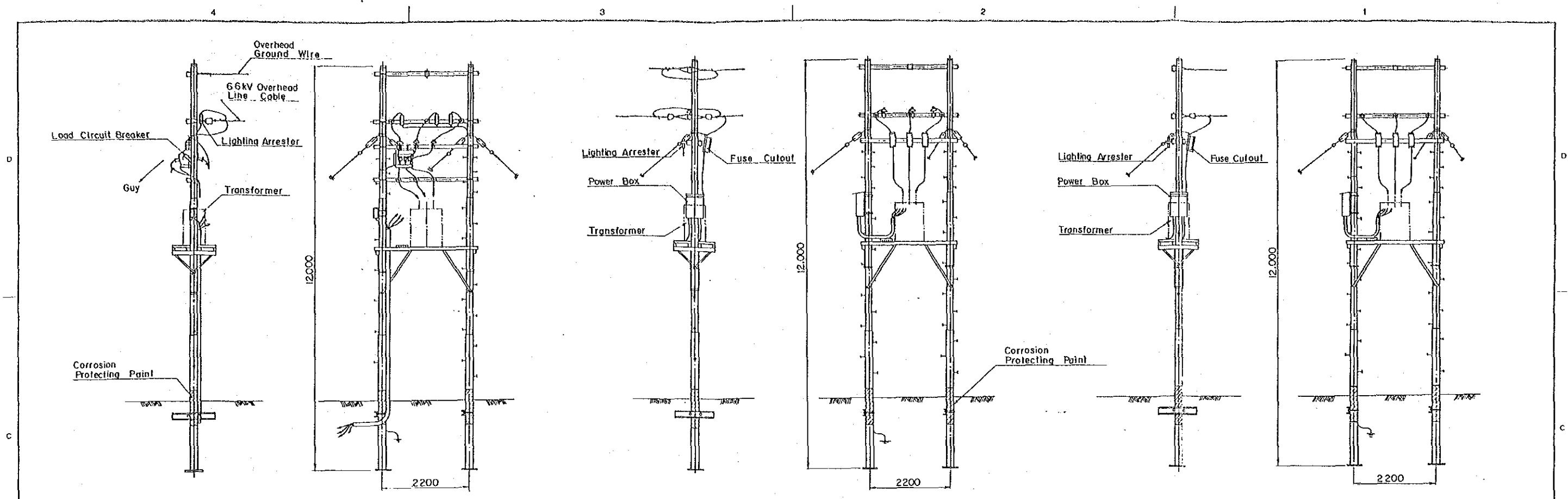


TYPE - D



TYPE - E

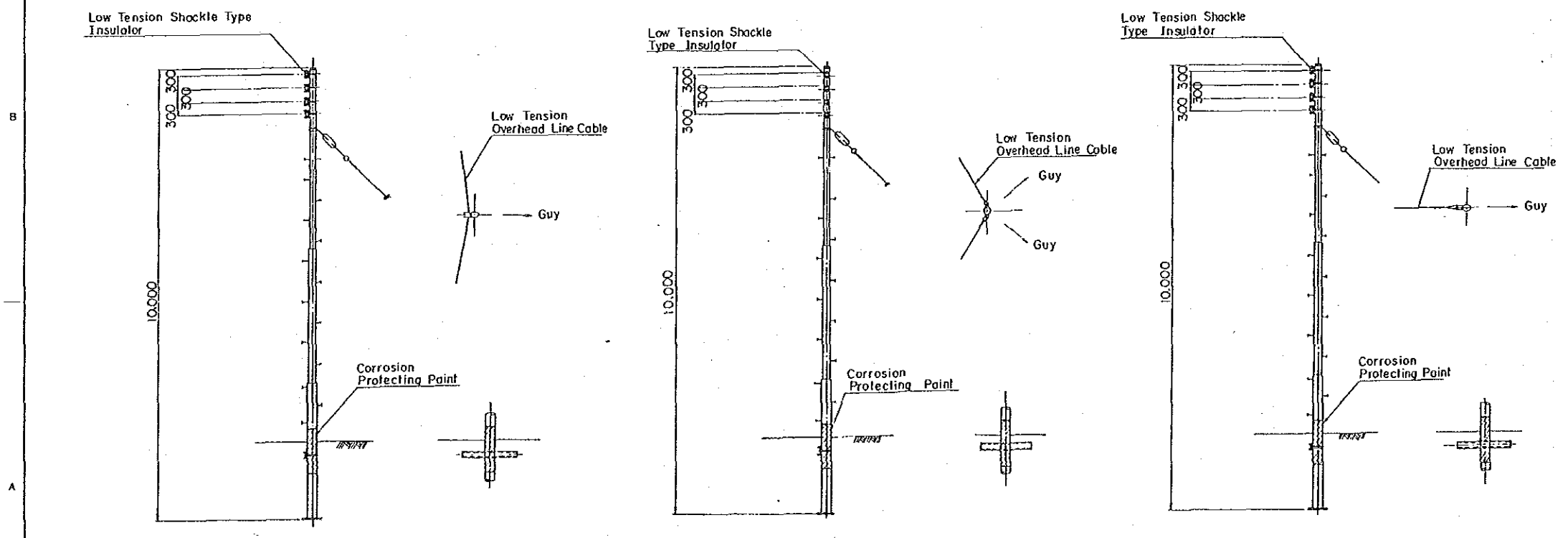
5.29 SUPPORTING STRUCTURE ARRANGMENT OF TRANSMISSION AND DISTRIBUTION LINE (1/2)



TYPE - F

TYPE - G

TYPE - H



TYPE - a

TYPE - b

TYPE - g

5.29 SUPPORTING STRUCTURE ARRANGMENT OF TRANSMISSION AND DISTRIBUTION LINE (2/2)



## 6. List of Received Data and Information



6. List of Received Data and Information

No.	Title	Note
1	Annual Report 1987	
2	Statistical Yearbook of Bhutan 1987	
3	Revised Series on Gross Domestic Product of Bhutan 1980 to 1987	
4	Department of Power Ministry of Trade & Industry Royal Govt. of Bhutan Sixth Five Year Plan (1987 - 1992)	
5	Kuri chu Hydro electric Project, Bhutan, Detailed Project Report Volume-I Engineering Part-1)	
6	Subtransmission and Distribution System for Thimphu and Paro Final Report Sep. 1984	
7	Bhutan Schedule of Rates 1987, P.W.D. 3ea. (Thimphu. Gayleghug. Phuntsholing)	
8	Application for Enlistment as Class A Contractors	
9	Application for Enlistment as Class B Contractors	
10	Rainfall & Temperature in Shemgang 1987	
11	Rainfall & Temperature in Dagana 1987	
12	Organization of Department of Power	
13	Map took from Landsat (Second Edition Ag' 87) 3ea.	
14	Specifications for Building & Road Works	
15	Statistical Handbook of Bhutan (1985)	
16	Statistical Handbook of Bhutan (1986)	
17	Hydrology data	
18	Micro Hydro Projects in the Kingdom of Bhutan	
19	Topographic Maps (1/50,000) 11 sheets	



## 7. Discharge Data





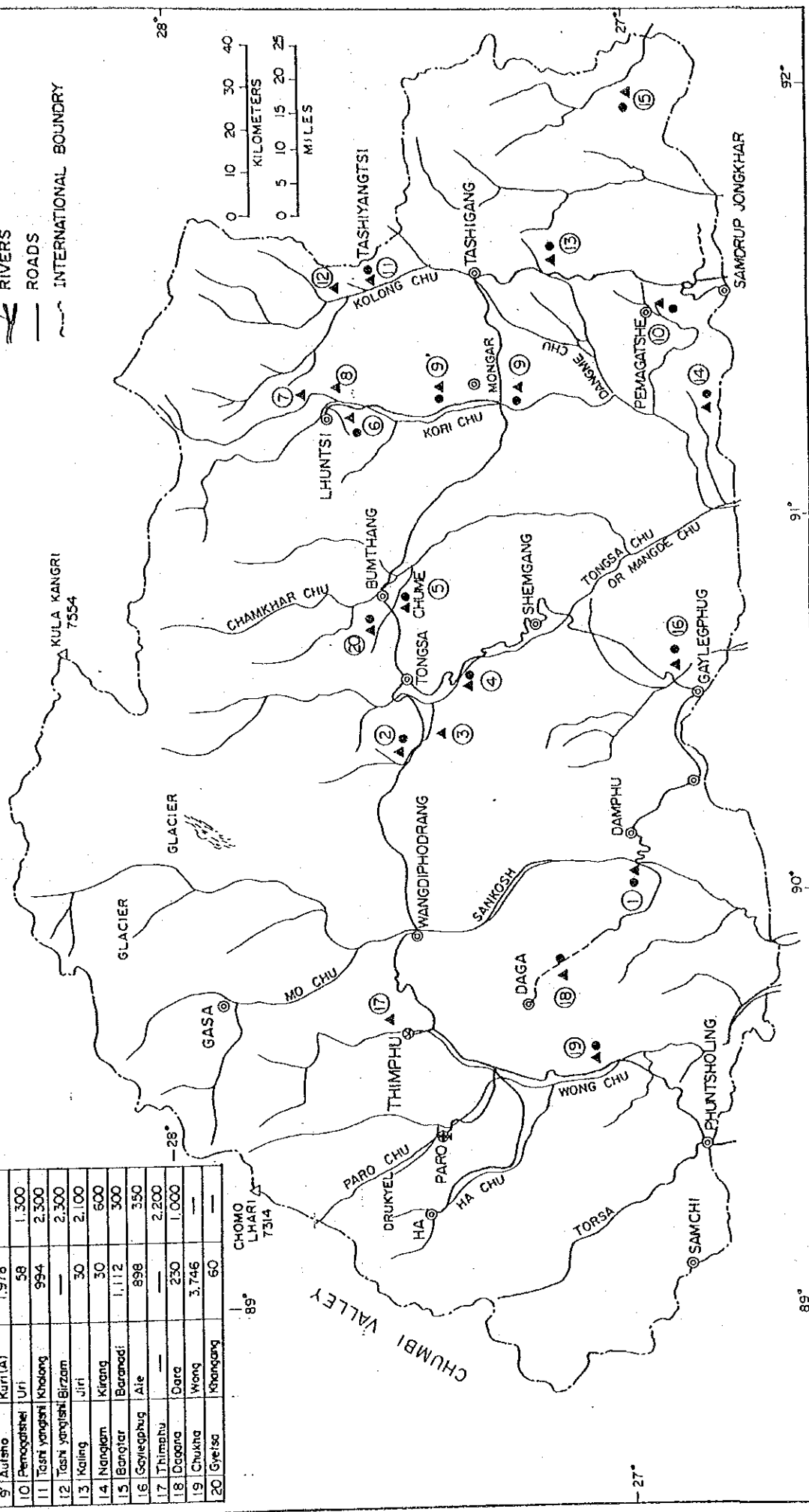
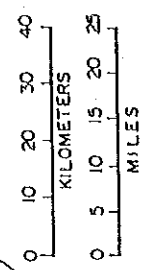
List of Gauging Station

Code No.	Name of G. Station	Name of River	Catchment Area (km <sup>2</sup> )	Elevation of Station (m)
1	Dabani	Sankosh	1,043	300
2	Tangsebi	Narayani	—	—
3	Tangsebi	Chandebji	444	2,319
4	Rate	Mangde	1,266	1,200
5	Churney	Donkhar	60	2,850
6	Lumtshi	Gangzoor	9	1,300
7	Lumtshi	Kuri (S)	1,518	1,300
8	Lumtshi	Khoma	703	1,300
9	Kurtzampa	Kuri (M)	3,089	470
9'	Auteno	Kuri (A)	1,978	—
10	Pemagatshé	Uri	58	1,300
11	Tashi yangtshi	Kholang	994	2,300
12	Tashi yangtshi	Birzom	—	2,300
13	Kaling	Jiri	30	2,100
14	Nanglam	Kirang	30	600
15	Bangtar	Baramedi	1,112	300
16	Goyisapghu	Ale	898	350
17	Thimphu	—	—	2,200
18	Dagana	Dara	230	1,000
19	Chukha	Wang	3,746	—
20	Gyetse	Khangang	60	—

LOCATION OF GAUGING STATION

LEGEND

- ▲ ELEVATION POINTS (METERS)
- ✈ AIRPORT
- ⊙ NATIONAL CAPITAL
- ⊙ DISTRICT CAPITALS
- ▲ HYDROMET STATION
- RIVERS
- ROADS
- INTERNATIONAL BOUNDARY



## Meteorological and Hydrological Data Lists

Code No.	Name of G. Station	Name of River	Catchment Area (km <sup>2</sup> )	Elevation of G. Station (m)	Observation Record
1	Dubani	Sankosh	10,452	300	1982-1987
2	Tangsebi	Nanganie	-		1984-1986
3	Tangsebi	Chendebji	444	2,319	1981-1987
4	Refe	Mangde	1,266	1,200	1983-1989
5	Chumey	Donkhar	60	2,850	(Non)
6	Luntshi	Gangzoor	9	1,300	1984-1986
7	Luntshi	Kuri (s)	1,518	1,300	Sumpa river 1984-1987
8	Luntshi	Khoma	703	1,300	1984-1987
9	Kurizampa	Kuri (M)	3,089	470	Mangar river 1983-1987
9'	Autsho	Kuri (A)	1,979		Autsho river 1987
10	Pemagatshel	Uri	58	1,300	1982-1987
11	Tashiyangtshi	Kholong	994	2,300	1983-1987
12	Tashiyangtshi	Birzam	-	2,300	1982-1986
13	Kaling	Jiri	30	2,100	1980-1985
14	Nanglam	Kirang	30	600	1982-1987
15	Bangtar	Baranadi	1,112	300	1982-1987
16	Gaylegphug	Aie	898	350	1985-1987
17	Thimphu	-	-	2,200	Meteorological st. Non
18	Dagana	Dara	230	1,000	1986-1988
19	Chukha	Wong	3,746	-	Chukha dam C.A.=6,854 1977-1985
20	Gyetsa	Khargang	60	-	1981-1986
21	Shemgang	-	-	1,900	Meteorological st. 1987-1988

(4) MANDOCCHU

Dechign and Rainfall Records

RIVER NAME : MANDOCCHU  
DISCHARGE STA. NAME: REFF  
RAINFALL STA. NAME : REFF

YEAR 1983

CA = 1/265.5 Km<sup>2</sup>

Month	Jan 1983		Feb 1983		Mar 1983		Apr 1983		May 1983		Jun 1983		Jul 1983		Aug 1983		Sep 1983		Oct 1983		Nov 1983		Dec 1983		
	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	
1																									
2																									
3																									
4																									
5																									
6																									
7																									
8																									
9																									
10																									
Sub Total	0.000	0.000	0.000	0.000	0.000	0.000	449.370	0.000	919.920	0.000	1299.320	0.000	2199.490	0.000	0.000	0.000	0.000	0.000	0.000	0.000	510.820	0.000	395.900	0.000	
Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	44.937	#DIV/0!	91.992	#DIV/0!	129.932	#DIV/0!	219.949	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	51.082	#DIV/0!	39.590	#DIV/0!	
11																									
12																									
13																									
14																									
15																									
16																									
17																									
18																									
19																									
20																									
Sub Total	0.000	0.000	0.000	0.000	0.000	0.000	424.750	0.000	837.430	0.000	1289.730	0.000	1826.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000	424.570	0.000	436.390	0.000	
Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	42.475	#DIV/0!	83.743	#DIV/0!	128.973	#DIV/0!	182.605	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	42.457	#DIV/0!	43.639	#DIV/0!	
21																									
22																									
23																									
24																									
25																									
26																									
27																									
28																									
29																									
30																									
31																									
Sub Total	0.000	0.000	0.000	0.000	0.000	0.000	346.800	0.000	1122.680	0.000	1858.720	0.000	2577.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	346.800	0.000	489.820	0.000	
Average	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	34.680	#DIV/0!	112.268	#DIV/0!	185.872	#DIV/0!	257.719	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	34.680	#DIV/0!	48.982	#DIV/0!	
TOTAL	0.000	0.000	0.000	0.000	0.000	0.000	1391.870	0.000	2678.340	0.000	4448.770	0.000	7577.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1281.370	0.000	1437.130	0.000	
AVERAGE	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	46.399	#DIV/0!	92.850	#DIV/0!	144.182	#DIV/0!	190.947	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	42.813	#DIV/0!	47.904	#DIV/0!	
MAX	0.000	0.000	0.000	0.000	0.000	0.000	92.120	0.000	137.680	0.000	233.100	0.000	392.570	0.000	0.000	0.000	0.000	0.000	0.000	0.000	119.560	0.000	84.540	0.000	
MIN.	0.000	0.000	0.000	0.000	0.000	0.000	37.330	0.000	68.320	0.000	97.860	0.000	119.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	58.080	0.000	33.700	0.000	

(A) MANDOCCHU

RIVER NAME : MANDOCCHU  
 DISCHARGE STA. NAME: REFF  
 RAINFALL STA. NAME : REFF

YEAR 1984

CA 1265.5 km<sup>2</sup>

Month	Jan 1984	Feb 1984	Mar 1984	Apr 1984	May 1984	Jun 1984	Jul 1984	Aug 1984	Sep 1984	Oct 1984	Nov 1984	Dec 1984
Date	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)	Dis. (Cumecs) Rainfall (mm)
1	35.830	28.650	28.950	42.710	48.830	87.710	10.600	174.800	135.350	92.380	82.980	52.820
2	35.830	28.650	28.950	48.830	48.830	87.710	10.600	174.800	135.350	92.380	82.980	52.820
3	36.350	32.570	29.910	50.900	41.670	88.450	1.400	150.160	158.440	75.520	78.960	35.190
4	38.350	29.970	29.910	46.750	40.750	88.450	1.400	150.160	158.440	75.520	78.960	35.190
5	35.450	29.950	29.130	34.350	40.840	92.220	1.200	128.340	113.920	86.630	104.660	32.430
6	33.710	30.980	28.700	34.350	40.840	92.220	1.200	128.340	113.920	86.630	104.660	32.430
7	33.710	30.980	28.700	34.350	40.840	92.220	1.200	128.340	113.920	86.630	104.660	32.430
8	32.440	30.980	29.190	32.240	35.040	110.230	14.800	93.330	179.850	81.010	54.990	30.490
9	34.040	30.970	29.040	34.230	34.000	85.710	10.200	105.020	145.690	77.520	40.740	36.770
10	34.500	29.950	29.030	34.450	34.000	102.960	10.200	105.020	145.690	77.520	40.740	36.770
Sub Total	348.230	302.710	292.550	375.540	329.430	642.350	82.700	1247.890	1455.920	815.360	634.840	334.840
Average	34.823	30.271	29.255	37.554	32.943	64.235	8.270	124.789	145.592	81.536	63.484	33.484
11	35.560	29.370	29.300	29.400	29.400	135.330	0.000	132.150	152.290	114.380	37.260	32.180
12	34.400	32.950	29.190	34.400	34.400	120.110	1.800	159.000	172.690	98.970	37.470	31.230
13	33.550	31.700	31.220	34.790	34.790	98.220	2.000	119.590	133.450	92.240	40.500	31.010
14	34.770	31.700	30.220	33.810	34.790	91.980	0.000	172.620	183.420	111.430	40.220	31.910
15	32.050	31.050	30.350	34.960	34.960	90.210	0.000	98.340	176.930	14.800	38.020	36.770
16	32.050	30.780	28.980	35.910	35.910	97.360	30.000	113.130	148.930	92.640	39.820	31.850
17	32.370	33.180	30.040	42.930	42.930	92.350	4.200	130.910	209.860	85.070	38.370	29.130
18	30.640	35.390	30.400	45.780	45.780	105.070	0.000	143.900	198.940	104.600	35.920	30.820
19	32.300	30.660	37.900	47.890	47.890	164.450	1.800	129.410	170.370	91.760	38.170	30.730
20	31.400	30.700	34.090	41.350	41.350	95.570	9.800	119.870	144.280	86.980	35.840	31.270
Sub Total	329.290	310.860	323.890	390.350	390.350	1092.860	119.600	1318.620	1693.330	844.550	384.800	317.650
Average	32.929	31.086	32.389	39.035	39.035	109.286	11.960	131.862	169.333	84.455	38.489	31.765
21	31.410	28.790	31.280	44.540	44.540	77.880	5.600	115.660	193.780	79.660	38.180	30.550
22	30.500	29.370	31.220	44.580	44.580	96.990	15.400	115.770	122.900	105.740	36.840	28.280
23	33.850	26.230	28.680	43.270	43.270	91.980	0.000	113.660	156.130	95.740	38.510	31.540
24	33.850	25.230	29.630	43.190	43.190	100.840	0.000	148.310	159.150	76.380	32.870	27.370
25	30.450	28.620	25.650	46.520	46.520	145.720	15.000	147.590	103.570	92.090	37.490	27.550
26	30.240	27.610	26.700	46.550	46.550	109.120	4.000	158.040	123.900	92.510	36.510	27.550
27	30.240	29.220	30.000	45.350	45.350	153.010	4.200	192.040	132.150	91.300	40.880	25.060
28	30.950	26.880	31.220	48.190	48.190	118.910	3.800	119.910	116.710	90.880	38.430	28.490
29	30.310	29.400	33.570	44.510	44.510	103.800	0.000	145.690	76.240	90.880	38.410	25.470
30	30.310	29.400	34.390	55.170	55.170	122.220	0.000	175.220	111.620	96.200	32.970	26.960
31	30.350	35.940	35.940	90.590	90.590	205.780	0.000	193.350	183.350	84.010	30.140	30.140
Sub Total	348.130	321.400	345.420	465.910	465.910	1275.040	71.600	1622.700	1308.150	899.750	367.050	310.940
Average	34.813	32.140	34.542	46.591	46.591	127.504	7.160	162.270	130.815	89.975	36.709	31.094
TOTAL	1023.650	870.990	970.660	1231.820	1231.820	2810.300	254.100	4189.410	4449.070	2630.680	1386.820	965.730
AVERAGE	33.021	30.034	31.312	41.061	41.061	104.885	8.476	135.142	148.302	84.861	46.221	31.153
MAX	36.350	35.390	36.220	55.170	55.170	164.450	26.200	193.350	209.860	114.380	104.960	36.770
MIN.	30.240	25.280	25.850	29.460	29.460	77.880	0.000	87.280	76.240	51.200	32.870	25.060

CA: 1.2655 km<sup>2</sup>

(A) MANGECHU

RIVER NAME : MANGECHU  
DISCHARGE STA. NAME: REF  
RAINFALL STA. NAME : REF  
YEAR 1985

Month	Jan 1985	Feb 1985	Mar 1985	Apr 1985	May 1985	Jun 1985	Jul 1985	Aug 1985	Sep 1985	Oct 1985	Nov 1985	Dec 1985
Date	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)
	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)
1	31.900	25.424	0.000	0.000	81.600	141.300	0.000	231.900	15.600	237.110	3.000	241.600
2	35.340	27.155	4.000	0.000	88.830	181.870	3.000	227.850	2.200	224.920	14.000	92.220
3	34.870	0.000	0.000	0.000	102.670	15.000	0.000	227.850	18.000	198.450	2.200	37.200
4	38.610	0.000	0.000	0.000	102.670	35.610	0.000	219.040	1.900	252.680	6.600	54.040
5	37.030	0.000	0.000	0.000	102.670	58.270	3.600	230.870	6.000	234.080	11.600	30.360
6	35.560	0.000	0.000	0.000	102.670	88.230	3.100	231.990	22.000	185.750	4.400	30.680
7	33.780	0.000	0.000	0.000	88.230	124.900	0.000	231.990	20.000	184.150	27.800	40.710
8	37.850	0.000	0.000	0.000	88.230	151.230	2.200	243.600	20.000	190.820	0.000	48.860
9	35.560	0.000	0.000	0.000	73.310	155.000	6.000	243.600	9.600	184.150	10.000	39.340
10	31.300	26.370	0.000	0.000	83.050	145.050	0.000	231.990	2.200	185.750	5.000	39.970
Sub Total	349.300	256.378	15.300	0.000	800.630	1322.330	28.200	1837.300	113.100	2065.240	69.200	2237.410
Average	34.930	25.638	1.530	0.000	80.069	132.233	2.820	183.730	11.310	206.524	6.900	223.741
11	31.190	25.770	0.000	0.000	72.050	150.140	0.000	305.700	0.000	216.920	0.000	41.680
12	31.510	25.740	0.000	0.000	72.550	127.200	0.000	301.700	6.200	211.970	0.000	36.420
13	31.080	25.820	0.000	0.000	101.180	117.170	0.000	282.650	14.000	187.000	0.000	114.100
14	31.300	25.240	0.000	0.000	97.460	150.750	0.000	273.510	13.400	187.520	0.000	111.500
15	31.470	24.240	0.000	0.000	96.060	135.220	3.000	237.300	21.200	206.250	1.200	189.020
16	32.970	25.820	0.000	0.000	100.180	165.330	10.100	280.700	10.200	230.850	4.800	180.840
17	32.190	24.840	0.000	0.000	102.870	158.520	8.000	288.010	21.200	230.770	0.000	134.120
18	32.780	25.180	0.000	0.000	97.980	243.390	25.000	254.450	9.000	237.370	0.000	223.880
19	31.630	25.770	0.000	0.000	94.950	203.370	0.000	289.430	11.000	226.730	32.800	87.840
20	31.930	25.890	0.000	0.000	89.270	158.730	6.000	287.870	4.800	232.760	8.200	81.170
Sub Total	313.400	242.850	10.800	0.000	927.690	1671.900	49.200	2630.850	116.800	2246.030	56.000	2118.410
Average	31.340	24.285	1.080	0.000	92.769	167.190	4.920	263.085	11.680	224.563	5.600	211.841
21	28.710	24.380	0.000	0.000	97.460	155.500	0.000	288.850	10.600	219.770	21.600	167.170
22	29.020	32.850	0.000	0.000	112.280	185.850	0.000	248.140	1.000	247.370	48.200	176.790
23	29.250	33.370	0.000	0.000	94.720	284.100	8.000	303.630	7.600	212.210	2.400	170.480
24	27.440	48.830	0.000	0.000	90.160	254.330	3.000	315.480	27.600	203.180	6.000	158.470
25	25.010	48.610	0.000	0.000	91.280	207.450	5.800	262.600	3.400	249.810	4.000	170.460
26	22.810	38.560	0.000	0.000	146.650	198.720	1.600	237.740	10.600	210.630	15.800	154.980
27	24.480	34.300	0.000	0.000	150.880	224.360	0.000	344.280	33.200	203.180	0.000	152.010
28	23.840	47.780	0.000	0.000	142.970	299.740	9.000	224.360	6.200	247.080	0.000	152.010
29	25.850	47.780	0.000	0.000	142.970	172.570	27.200	278.710	13.200	197.080	0.000	160.520
30	25.010	0.000	0.000	0.000	115.050	224.440	19.600	240.710	0.600	213.280	0.000	147.520
31	24.370	94.840	2.000	0.000	138.150	227.150	2.800	257.120	2.800	227.450	8.000	147.520
Sub Total	290.500	308.480	4.300	0.000	489.970	1304.100	22.200	3004.320	110.800	2431.060	108.600	1598.460
Average	26.417	33.560	0.391	0.000	44.543	130.410	2.018	273.120	10.618	221.065	8.873	159.846
TOTAL	955.790	817.609	26.100	44.400	3092.480	5441.550	150.000	7582.470	348.700	6767.230	234.400	6004.260
AVERAGE	30.832	42.763	0.932	1.480	99.757	181.535	5.000	200.143	8.647	218.298	7.581	200.143
MAX	37.850	48.630	10.200	14.400	150.880	299.740	37.200	344.280	33.200	288.220	48.200	261.820
MIN.	22.810	24.240	0.000	0.000	72.050	117.170	0.000	204.130	0.000	187.520	0.000	147.520

(4) MANDGECHU

RIVER NAME : MANDGECHU  
DISCHARGE STA NAME: REFF  
RAINFALL STA NAME : REFF

YEAR 1988

C.A. 1.265.5 Km<sup>2</sup>

Month	Jan 1988	Feb 1988	Mar 1988	Apr 1988	May 1988	Jun 1988	Jul 1988	Aug 1988	Sep 1988	Oct 1988	Nov 1988	Dec 1988
Day	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)	Dis (Cumec)
	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)	Rainfall (mm)
1	14.930	11.880	16.680	34.140	38.370	46.840	308.460	138.870	104.810	84.820	59.320	29.880
2	14.930	16.320	16.360	22.810	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
3	14.930	15.810	18.270	23.080	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
4	14.930	15.810	18.270	23.080	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
5	23.250	18.600	18.320	23.400	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
6	25.870	18.500	18.410	23.400	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
7	25.760	20.180	17.010	20.590	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
8	26.340	19.150	17.940	21.320	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
9	26.530	16.580	18.180	21.900	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
10	17.940	16.580	18.320	22.200	38.350	46.840	308.460	138.870	104.810	84.820	59.320	29.880
Sub Total	194.350	170.510	176.050	227.620	373.940	447.540	2294.410	1546.140	1281.930	937.530	643.660	307.850
Average	19.435	17.051	17.605	22.762	37.394	44.754	229.441	154.614	128.193	93.753	64.366	30.785
11	27.700	17.440	21.850	26.330	37.010	59.520	105.900	120.230	148.590	101.660	39.400	29.870
12	23.210	16.470	26.350	23.980	31.230	59.520	203.910	109.300	146.710	101.660	37.450	28.170
13	27.320	17.310	23.540	27.140	34.910	66.100	194.200	119.510	129.760	95.320	37.730	26.280
14	20.400	15.700	24.170	10.400	34.370	51.200	280.450	122.980	122.980	97.310	36.920	25.920
15	23.250	21.340	23.600	22.200	38.180	57.880	16.000	120.230	108.710	100.510	36.920	25.920
16	74.360	19.200	23.650	37.190	50.540	37.290	239.810	123.780	101.880	95.230	35.020	25.540
17	22.930	19.220	21.630	39.000	47.660	70.330	282.270	123.780	88.560	92.830	35.000	25.380
18	22.930	18.580	21.560	38.680	43.420	76.300	163.080	121.840	113.540	91.050	37.600	26.010
19	22.980	17.690	21.630	39.590	43.650	123.470	243.920	118.670	109.960	90.290	37.120	27.040
20	20.470	17.690	20.810	40.130	40.130	100.210	212.840	121.230	114.000	89.640	36.860	25.830
Sub Total	290.060	180.440	229.450	324.640	403.750	754.260	2237.640	1594.680	1178.930	949.560	370.720	243.140
Average	29.006	18.044	22.945	32.464	40.375	75.426	223.764	159.468	117.893	94.956	37.072	24.314
21	23.030	16.330	21.580	40.130	37.770	98.070	147.850	138.040	107.190	89.840	36.450	25.810
22	19.060	15.890	21.490	38.590	35.980	92.160	127.230	142.030	97.270	86.730	34.910	25.240
23	20.520	16.630	21.810	42.720	36.750	90.120	156.870	223.080	87.270	84.570	34.910	25.510
24	20.230	16.310	21.250	44.600	41.860	139.340	122.840	172.480	99.490	84.150	37.400	24.370
25	20.770	16.660	20.810	40.210	37.850	120.470	125.530	27.400	101.880	77.540	39.090	22.090
26	21.150	17.630	22.750	37.500	36.460	98.470	123.550	162.000	110.200	81.040	31.900	23.840
27	20.370	17.470	22.750	37.540	36.760	26.400	114.970	158.430	125.780	67.810	37.980	23.840
28	24.100	17.300	22.330	36.510	36.620	63.100	116.980	149.780	109.060	83.170	34.300	22.720
29	18.780	17.300	26.140	40.390	39.400	44.880	116.980	148.790	109.870	66.590	35.780	23.040
30	17.840	17.300	26.680	36.510	45.540	25.800	112.050	148.540	106.960	65.840	30.750	22.900
31	17.800	13.420	26.340	36.510	45.540	25.800	109.570	144.500	106.960	64.340	30.750	22.900
Sub Total	223.690	134.220	222.330	384.030	426.370	830.570	1394.280	1700.320	1084.880	850.980	353.470	261.700
Average	20.335	16.778	22.957	39.403	38.779	106.595	126.793	166.575	106.486	77.360	35.347	26.796
TOTAL	714.890	485.370	656.030	948.890	1204.230	1841.170	5926.330	4515.140	3525.740	2739.950	1207.870	837.850
AVERAGE	23.061	17.328	21.257	31.630	38.846	70.814	191.172	143.585	117.525	86.324	40.262	27.027
MAX	74.360	21.340	26.680	44.600	50.540	139.340	308.460	223.080	255.380	187.120	60.310	33.470
MIN.	14.370	11.660	15.560	10.400	15.480	40.260	109.570	64.360	84.580	30.750	30.750	22.900

CA = 1.265 S km<sup>2</sup>

RIVER NAME : MANDGECHU  
 DISCHARGE STA. NAME : REFF  
 RAINFALL STA. NAME : REFF

YEAR 1987

Month	Jan 1987	Feb 1987	Mar 1987	Apr 1987	May 1987	Jun 1987	Jul 1987	Aug 1987	Sep 1987	Oct 1987	Nov 1987	Dec 1987
Day	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)	Dis. (Cumec)	Rainfall (mm)
1	22.860	0.000	24.240	0.000	23.450	2.200	32.820	0.000	53.930	3.200	142.480	4.200
2	22.860	0.000	22.860	0.000	23.780	0.000	38.290	0.000	53.330	0.000	168.060	4.200
3	22.330	0.000	22.860	0.000	22.656	0.000	39.540	2.400	46.340	1.800	191.350	7.000
4	22.900	0.000	23.040	0.000	23.156	3.000	33.570	3.000	23.970	12.800	178.120	5.800
5	22.400	0.000	22.310	0.000	23.776	0.000	52.090	0.000	48.640	0.000	168.830	6.000
6	22.610	0.000	22.300	7.200	22.080	0.000	41.380	0.000	118.190	0.000	200.380	4.000
7	22.260	0.000	25.310	0.000	22.470	0.000	40.460	0.000	197.550	12.200	187.540	7.400
8	22.280	0.000	24.770	0.000	21.280	0.000	49.920	1.800	181.730	4.400	184.630	1.200
9	22.330	0.000	26.320	0.000	21.470	4.800	40.940	1.200	200.770	6.000	185.170	15.000
10	22.330	0.000	20.510	0.000	22.470	1.200	59.060	0.200	169.870	10.000	185.170	15.000
Sub Total	225.000	0.000	234.800	7.200	226.670	11.200	405.180	5.800	2350.330	141.800	1081.870	10.000
Average	22.500	0.000	23.480	0.720	22.667	1.120	40.518	0.580	235.033	14.180	108.187	1.080
11	21.680	0.000	24.840	0.000	24.010	1.000	43.080	2.800	195.540	4.000	226.130	21.000
12	21.770	2.200	24.840	0.000	24.410	5.800	42.860	0.000	225.330	26.000	226.220	26.000
13	20.890	0.000	24.720	0.000	24.830	3.200	41.390	0.000	241.180	16.000	235.680	34.000
14	21.700	0.000	24.720	0.000	24.830	0.300	40.190	0.000	198.260	10.400	188.780	10.400
15	22.840	0.000	24.420	0.000	24.260	4.000	38.570	0.000	259.330	0.000	142.140	0.400
16	21.680	0.000	24.420	0.000	25.190	0.000	40.190	0.000	221.540	9.800	132.970	10.000
17	21.510	0.000	23.680	0.000	24.610	1.100	41.750	15.600	223.700	7.200	122.410	1.400
18	20.980	0.000	23.980	0.000	24.610	0.000	41.020	0.000	207.650	2.000	76.120	0.000
19	20.980	0.000	23.550	0.000	25.400	3.400	41.020	2.900	206.510	18.000	126.470	7.800
20	20.500	0.000	23.350	0.000	27.020	9.800	49.150	0.000	197.640	8.800	188.850	23.000
Sub Total	214.510	2.200	242.540	0.000	243.230	19.800	413.260	21.800	2462.030	98.000	1757.240	126.280
Average	21.451	0.220	24.254	0.000	24.322	1.980	41.326	2.100	246.203	9.900	175.724	12.628
21	21.150	0.000	23.040	0.000	27.450	7.200	40.180	0.000	189.810	18.200	138.910	1.000
22	21.660	0.000	22.860	0.000	27.820	0.000	39.370	0.000	255.480	0.600	199.870	0.600
23	19.400	0.000	27.740	0.000	27.740	0.000	39.370	0.000	181.920	5.000	135.870	5.000
24	21.770	0.000	22.250	0.000	27.020	0.000	43.590	6.200	178.740	0.000	184.440	24.800
25	22.480	0.000	21.870	0.000	26.870	0.000	42.480	0.000	182.480	0.400	178.900	5.000
26	22.340	0.000	25.440	0.000	28.270	0.800	42.770	0.000	156.810	0.000	174.320	0.600
27	21.770	0.000	25.000	0.000	29.105	0.300	42.310	2.400	268.950	4.000	182.220	2.600
28	21.770	0.000	25.000	3.200	28.400	1.800	40.190	0.000	197.320	6.800	150.960	4.800
29	20.890	0.000	25.000	0.000	32.400	0.000	39.570	0.000	218.700	5.800	136.580	6.600
30	20.890	0.000	32.400	0.000	32.400	0.000	67.400	1.200	209.730	8.800	128.340	1.800
31	20.540	0.000	30.400	0.000	20.400	0.000	76.220	1.800	219.510	6.800	83.900	0.800
Sub Total	235.840	0.000	188.320	3.200	316.975	10.100	409.840	18.800	2400.300	77.200	1326.220	83.200
Average	21.422	0.000	23.540	0.400	28.789	0.918	40.984	1.880	240.030	7.720	132.622	8.320
TOTAL	675.250	2.200	665.660	10.400	792.465	40.900	1223.280	45.800	5034.390	331.280	2766.060	74.800
AVERAGE	21.782	0.071	23.774	0.371	25.563	1.319	40.943	1.520	187.811	11.042	90.280	2.413
MAX	23.480	2.200	26.320	7.200	32.400	7.200	52.090	15.900	307.200	34.800	170.270	55.800
MIN.	19.400	0.000	20.510	0.000	21.280	0.000	32.820	0.200	122.410	0.000	63.900	0.000
32	21.150	0.000	23.040	0.000	27.450	7.200	40.180	0.000	189.810	18.200	138.910	1.000
33	21.660	0.000	22.860	0.000	27.820	0.000	39.370	0.000	255.480	0.600	199.870	0.600
34	19.400	0.000	27.740	0.000	27.740	0.000	39.370	0.000	181.920	5.000	135.870	5.000
35	21.770	0.000	22.250	0.000	27.020	0.000	43.590	6.200	178.740	0.000	184.440	24.800
36	22.480	0.000	21.870	0.000	26.870	0.000	42.480	0.000	182.480	0.400	178.900	5.000
37	22.340	0.000	25.440	0.000	28.270	0.800	42.770	0.000	156.810	0.000	174.320	0.600
38	21.770	0.000	25.000	0.000	29.105	0.300	42.310	2.400	268.950	4.000	182.220	2.600
39	21.770	0.000	25.000	3.200	28.400	1.800	40.190	0.000	197.320	6.800	150.960	4.800
40	20.890	0.000	32.400	0.000	32.400	0.000	67.400	1.200	209.730	8.800	128.340	1.800
41	20.540	0.000	30.400	0.000	20.400	0.000	76.220	1.800	219.510	6.800	83.900	0.800
Sub Total	235.840	0.000	188.320	3.200	316.975	10.100	409.840	18.800	2400.300	77.200	1326.220	83.200
Average	21.422	0.000	23.540	0.400	28.789	0.918	40.984	1.880	240.030	7.720	132.622	8.320
TOTAL	675.250	2.200	665.660	10.400	792.465	40.900	1223.280	45.800	5034.390	331.280	2766.060	74.800
AVERAGE	21.782	0.071	23.774	0.371	25.563	1.319	40.943	1.520	187.811	11.042	90.280	2.413
MAX	23.480	2.200	26.320	7.200	32.400	7.200	52.090	15.900	307.200	34.800	170.270	55.800
MIN.	19.400	0.000	20.510	0.000	21.280	0.000	32.820	0.200	122.410	0.000	63.900	0.000

(4)

MANDGECHU



DAILY DISCHARGE in 1986

(18) Station : Darachu - Degana

Unit : m<sup>3</sup>/sec.

DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1		8.916	6.528	5.123	6.585	5.081	-	27.822	22.641	24.818	17.003	14.252
2		8.916	6.629	4.968	6.067	5.053	23.260	29.887	21.973	22.314	16.546	13.061
3		9.864	6.948	4.858	6.296	4.752	20.370	24.401	21.908	21.368	17.323	13.457
4		8.848	6.513	5.261	6.207	4.752	21.857	22.598	20.276	21.251	17.694	13.575
5		8.597	6.315	5.203	5.812	4.724	24.421	15.571	19.692	21.711	17.694	13.575
6		8.916	6.773	5.444	5.817	4.683	32.980	26.233	20.516	19.603	17.570	13.028
7		8.791	6.528	5.240	6.161	5.195	24.662	25.811	23.179	22.267	17.570	13.028
8		8.369	6.649	5.622	6.805	4.802	32.097	23.618	23.293	22.400	16.688	12.767
9	13.003	7.771	6.365	5.851	5.539	5.077	33.747	24.908	30.173	21.527	17.730	12.287
10	10.451	7.901	6.567	5.270	6.156	5.033	30.586	22.833	40.998	21.588	17.574	12.528
11	12.181	8.172	6.261	5.369	5.883	5.124	30.207	19.452	51.959	20.564	17.419	12.230
12	10.369	7.502	6.011	5.336	5.841	5.264	28.272	21.439	34.609	20.332	16.583	11.421
13	12.119	8.152	5.908	5.105	6.300	5.706	27.892	19.553	26.665	22.264	15.950	12.230
14	12.081	8.141	9.082	5.201	6.415	5.838	28.284	22.498	24.073	20.216	15.423	11.365
15	11.880	7.406	7.715	5.864	7.657	5.591	24.953	20.050	23.040	21.714	14.831	11.520
16	11.896	8.990	6.936	5.541	15.458	5.596	27.555	24.364	26.504	18.669	15.900	11.520
17	16.984	8.152	7.125	5.656	8.088	5.443	29.545	34.766	22.724	17.469	15.470	10.767
18	10.542	8.193	6.528	5.557	6.415	8.766	38.947	24.899	21.294	17.142	15.230	11.421
19	11.896	7.983	6.913	6.088	5.990	7.893	28.519	16.943	23.293	17.142	16.537	11.520
20	10.263	7.824	6.261	5.346	6.827	12.864	28.620	22.542	20.850	21.776	14.685	12.804
21	9.684	6.533	5.944	5.402	5.860	6.842	24.117	18.656	20.276	18.522	15.368	11.225
22	9.532	7.543	5.920	5.319	5.864	6.087	24.848	18.505	19.705	17.110	15.119	10.577
23	9.486	7.490	5.980	5.600	5.835	11.414	22.121	31.401	19.995	17.110	15.691	10.990
24	9.864	8.331	5.705	5.376	5.482	12.587	28.245	24.418	19.538	17.754	15.691	10.939
25	9.532	7.149	5.134	5.088	5.458	12.824	35.937	18.070	21.718	18.316	15.691	11.133
26	9.526	7.654	5.200	5.434	5.259	22.664	26.937	18.114	25.575	16.906	15.628	10.939
27	9.177	6.784	5.233	5.088	5.236	-	30.053	16.699	29.529	17.577	15.256	11.387
28	8.916	7.113	5.100	5.434	4.926	-	25.998	16.066	28.368	16.710	15.256	10.537
29	9.177		4.394	5.783	4.916	-	26.320	17.595	23.965	16.458	15.059	10.695
30	9.063		4.394	6.827	4.875	-	25.260	18.114	23.886	17.539	19.538	10.351
31	8.585		-		-	-	28.184	18.455		17.431		10.351
TOTAL	246.207	225.971	187.559	163.254	190.030	189.657	834.794	686.281	752.217	607.568	489.717	367.480
AVERAGE	10.705	8.070	6.252	5.442	6.334	7.264	27.826	22.138	25.074	19.599	16.324	11.854
MAX.	13.003	9.864	9.082	6.827	15.458	22.664	38.947	31.401	51.959	24.818	19.538	14.252
MIN.	8.585	6.533	4.394	4.858	4.875	4.683	20.370	15.571	19.538	16.458	14.685	10.351

Unit : m<sup>3</sup>/sec.

(18) Station : Darachu - Dagana

DAILY DISCHARGE in 1987

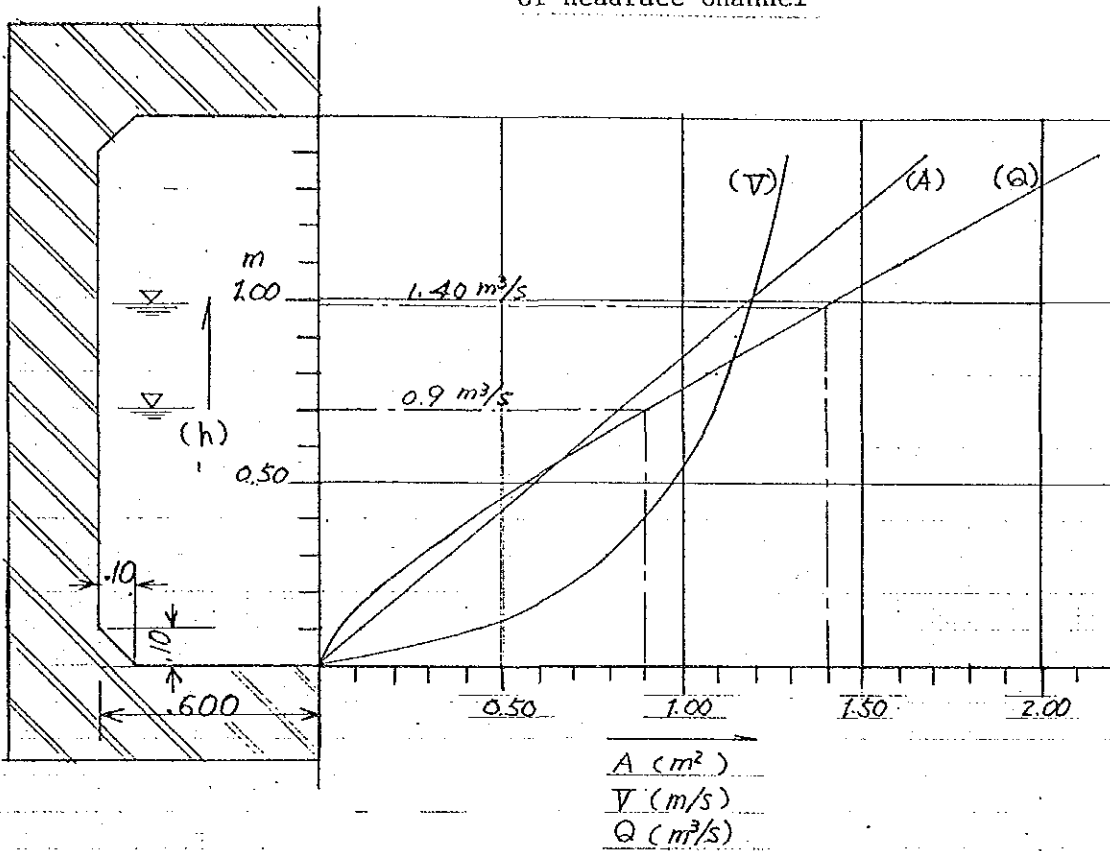
DATE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	10.180	8.410	9.095	9.483	9.878	8.863	23.674	126.16	32.532	28.297	14.107	11.773
2	10.180	8.410	8.996	9.685	9.596	9.244	19.030	245.29	30.833	27.059	14.224	11.926
3	10.316	8.542	8.874	10.469	10.861	8.991	14.194	180.02	27.903	24.995	13.949	12.123
4	9.906	8.165	8.752	10.054	14.452	8.846	13.308	162.32	31.577	24.655	14.071	11.189
5	10.005	10.515	8.460	9.854	13.337	10.537	16.811	154.22	29.617	24.633	13.954	12.509
6	10.040	9.790	8.608	9.685	12.404	14.267	24.848	142.78	28.380	24.973	13.476	9.941
7	10.455	9.506	8.726	9.445	11.270	15.043	24.279	199.21	28.366	23.614	13.249	11.306
8	10.248	9.241	8.874	10.075	10.801	19.418	27.060	209.29	26.625	21.855	12.249	11.422
9	10.528	9.432	8.996	9.410	11.270	21.650	29.083	202.29	27.536	21.489	13.105	11.875
10	10.491	9.828	9.370	9.410	10.669	22.981	30.996	232.98	27.536	21.418	12.894	11.968
11	10.785	9.638	9.221	9.221	10.537	25.822	32.832	195.63	43.761	20.566	12.905	12.141
12	10.304	9.542	9.370	8.874	9.497	26.853	35.270	153.29	56.084	19.447	12.447	11.646
13	10.404	9.542	8.996	8.606	9.221	29.159	34.957	283.62	44.601	18.334	12.680	12.265
14	10.062	9.506	9.749	9.008	9.092	34.101	38.318	207.28	38.783	17.651	12.549	13.171
15	10.373	9.506	9.370	9.221	9.194	45.731	39.567	139.29	33.940	17.352	11.754	12.152
16	10.656	9.506	9.221	8.948	9.244	52.155	35.696	221.39	30.342	16.272	13.171	10.897
17	10.254	9.355	9.638	8.747	8.702	86.108	36.374	172.45	27.731	16.426	12.148	11.238
18	9.604	8.922	10.356	8.177	8.971	100.522	38.583	121.47	26.912	17.791	12.152	9.768
19	9.533	9.319	9.345	8.127	9.466	120.093	39.572	102.74	30.832	27.731	11.740	9.868
20	9.479	9.041	9.095	7.600	9.595	146.91	42.237	92.134	28.509	21.418	12.040	9.982
21	9.463	9.241	9.365	7.487	10.028	141.671	42.700	92.134	26.912	17.025	11.740	9.868
22	9.738	9.319	9.509	8.177	10.480	106.035	40.622	79.41	27.189	16.141	12.522	9.438
23	9.080	9.319	9.573	11.329	9.244	93.587	42.758	73.95	27.648	15.673	11.282	10.236
24	9.235	9.338	9.221	12.166	8.579	73.369	46.007	66.27	31.645	15.926	11.861	9.775
25	9.046	7.650	8.864	10.933	8.579	54.985	52.390	53.59	29.211	17.035	10.993	10.236
26	8.509	7.847	9.095	11.886	8.143	42.881	67.429	37.59	31.808	14.715	11.767	10.933
27	8.642	9.117	8.726	11.438	7.900	36.169	69.651	32.15	35.882	14.341	11.482	10.443
28	8.322	10.010	9.877	10.205	7.767	33.929	71.844	40.09	31.046	14.719	10.993	10.514
29	8.542		9.118	9.419	8.022	33.929	80.774	36.90	31.640	14.719	11.963	10.443
30	8.297		8.864	8.971	8.088	32.404	89.108	34.09	26.739	14.598	12.264	10.329
31	8.297		8.864		8.211			30.36		14.598		10.372
TOTAL	300.974	257.557	284.178	286.110	303.098	1,456.253	1,199.972	4,120.388	952.120	605.466	675.731	341.727
AVERAGE	9.709	9.198	9.167	9.537	9.777	48.572	39.999	132.916	31.737	19.531	12.524	11.023
MAX.	10.785	10.515	10.356	12.166	14.452	146.91	89.108	283.62	56.084	28.297	14.224	12.509
MIN.	8.297	7.847	8.460	8.127	7.767	8.846	13.308	30.36	26.739	14.341	10.993	9.775



## 8. Hydraulic Calculation for Open Channel



Hydraulic Characteristic Curve  
of Headrace Channel



$$V = \frac{1}{n} \times R^{2/3} \times I^{1/2}$$

$$Q = A \times V$$

$$n = 0.014$$

$$I = 1/1,000$$







JICA