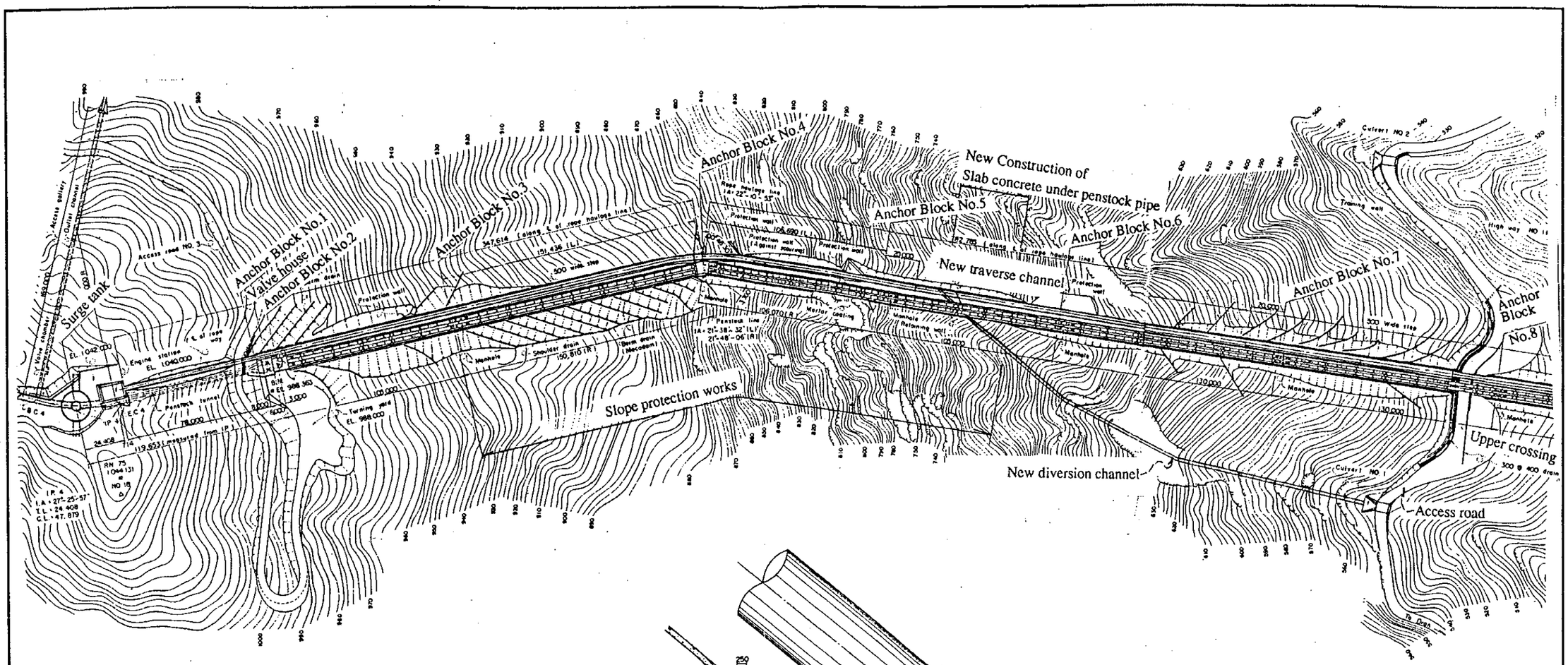
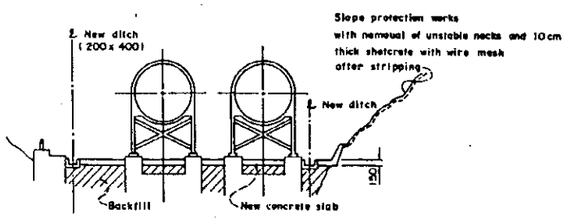
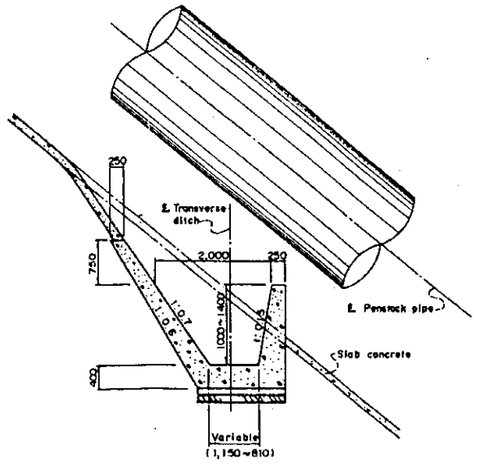
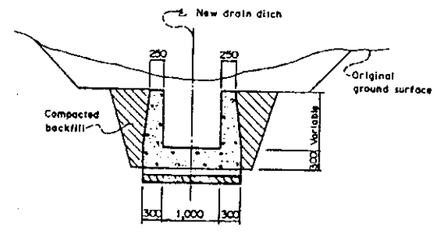




TYPICAL SECTION OF NEW SLAB CONCRETE
UNDER PENSTOCK LINE

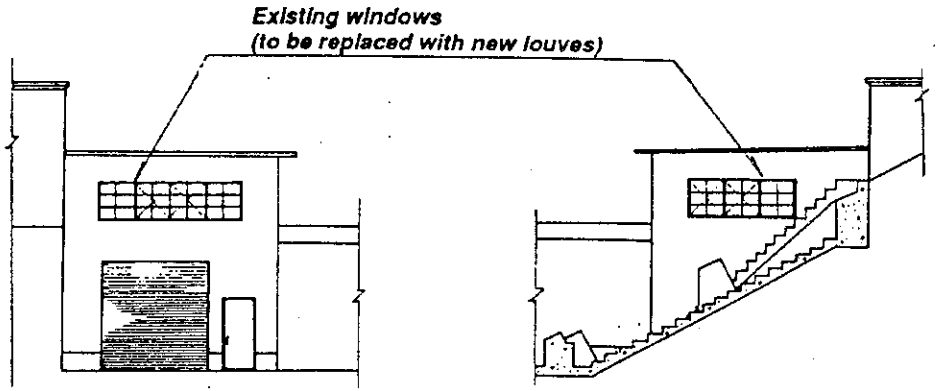


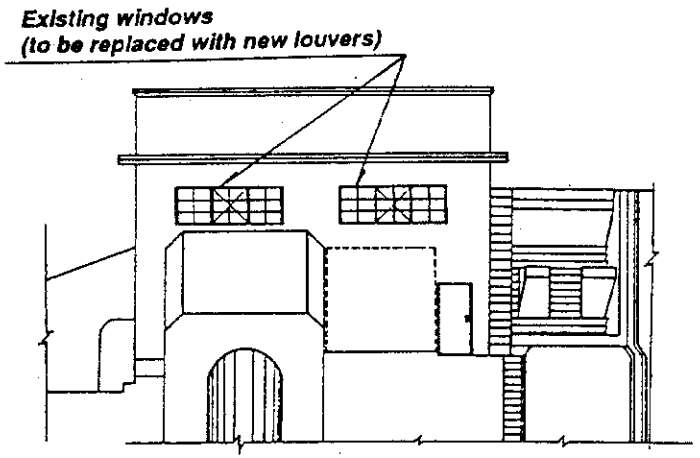
TYPICAL SECTION OF NEW TRANSVERSE CHANNEL

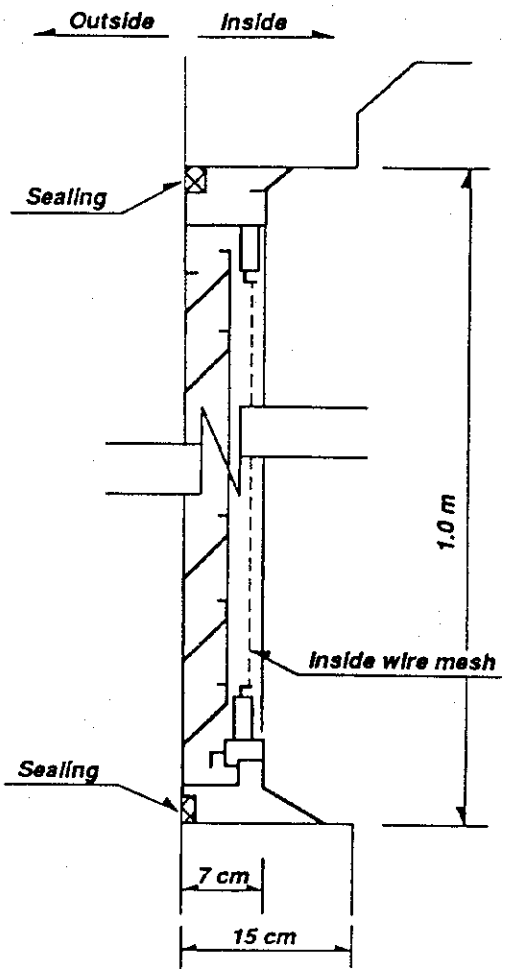


TYPICAL SECTION OF NEW DIVERSION CHANNEL

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 6.20 Urgent Rehabilitation Works for Penstock Line

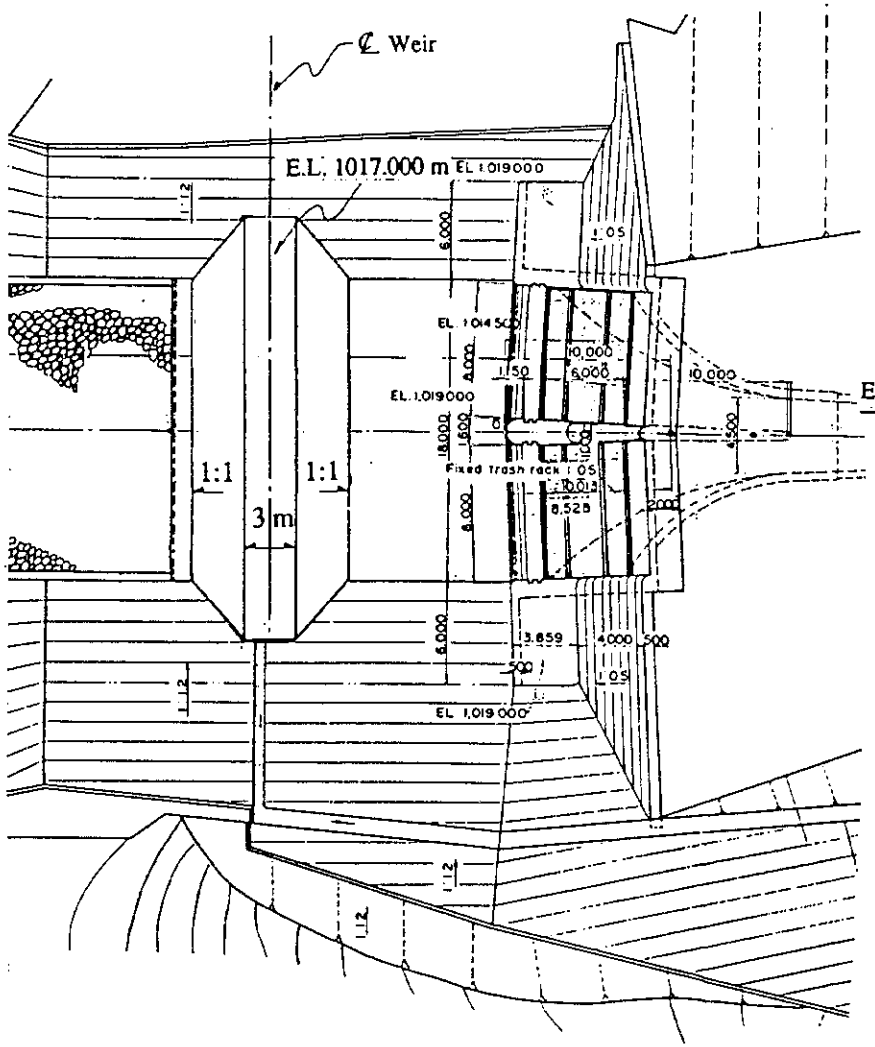




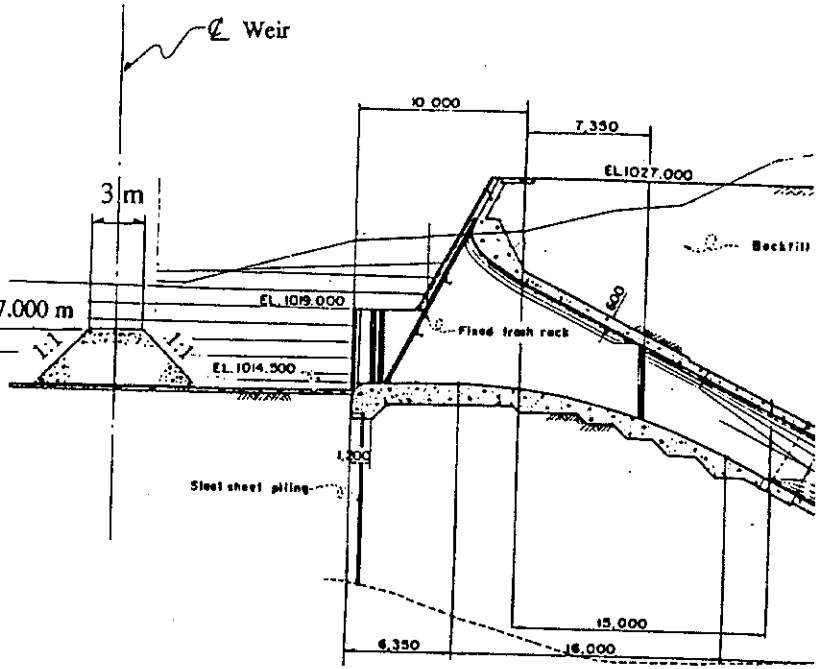


TYPICAL SECTION OF NEW LOUVER

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 6.21 Urgent Rehabilitation Works for Valve House



PLAN



TYPICAL SECTION

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 6.22 Long Term Rehabilitation Works to Cope with Sediment Deposit in Reservoir

CHAPTER 7

HYDROLOGICAL DATA ACQUISITION SYSTEM

CHAPTER 7 HYDROLOGICAL DATA ACQUISITION SYSTEM

7.1. Approach and Results of Study

7.1.1 Study Method

The Study Team has conducted the field study on each facility of the hydrological data acquisition system in the following way.

(1) Rainfall Data Acquisition System

The existing rainfall gauging stations had been designed and constructed by local staffs. The field survey started in a hearing of existing facilities from the counter-parts, examination of collected data and documents followed by the actual field survey of each existing facility and the detailed examination on the plan formulation.

1) Hearing

The hearing to and explanation from the engineers of the Da Nhim Power Station were mainly made on the details of construction and operation of the facilities including the future development plan. In addition, the detailed explanation on equipment and facilities was obtained from local designers of the rainfall gauging stations.

2) Examination of Data and Documents

The following documents were collected and examined.

* " The Hydrological Acquisition System of Da Nhim P/S (summary)"

* "Rainfall Gauging Station Complete Document"

3) Field Survey

The field survey and detailed inspection were made on the following stations;

Central Station	1 station
Rainfall Gauging Stations (Xuan Tho, Da Sa, Da Chay)	3 stations
Total	4 stations

Note : The repeater station could not be inspected because the entrance thereto was not allowed.

4) Map Survey

The checking and investigation were made one by one on the map of 1:50,000 scale for each location of four (4) existing stations and several additional stations newly proposed, access ways thereto and obstruction of propagation path, etc.

5) Examination on alternative locations

During the field investigation stage to the existing stations, their alternative locations for better operation in future were also investigated referring to the map, including access ways.

(2) Data Acquisition, Transmission Method and Management System

The following activities were done mainly for utilization of the data collected.

1) Hearing

a) Functions of the existing Central Station (hereinafter called as CS) and the reservoir management were discussed with the counterparts at site in attendance of hydrological engineers of the Study Team.

b) The explanation for the existing data transmission system by power line carrier (hereinafter called as PLC) was obtained from the counterparts, including the future plan. The detailed explanation on the system was also made by the Power System Control Center (hereinafter called as PSCC) of PC-2 in Ho Chi Minh city.

c) The present situation of frequency allocation to the proposed radio stations was explained by the PSCC.

d) The available hydrological data were obtained from the Southern Region Hydro Meteorological Center.

2) Examination on Documents

According to the results of the above hearing, the drawing of PLC network system received at site was revised by the Study Team to suit for the existing system including those under commissioning test and improvement.

3) Discussion

The Study Team discussed with the counterparts on the most preferable system configuration including the data transmission method between the CS and the Da Nhim Power Station (hereinafter called as P/S) and radio system with relay stations as well as the PLC system. Possibility of the future transmission method by microwave network system and/or optical fiber system was also discussed.

7.1.2 Results of Survey

The existing rainfall gauging stations (hereinafter called as RS) had been designed, manufactured and constructed by The Army Academy of Technology in 1983. After then an extensive modification of the system was made under the responsibility of P/S in 1989 and the system has been operated until now as it is.

(1) Data Acquisition System of Rainfall and Water Level

1) Data acquisition method

a) The RSs are located at three (3) places, i.e. Xuan Tho, Da Sa, and Da Chay, all of which are set on the west side of the Da Nhim river. The CS is in the observation room near the spillway gate of the main dam, and the water level gauging station (hereinafter called as WL) is located at the right side the spillway gates of the dam.

b) Rainfall data are transmitted by Frequency Shift Keying (hereinafter called as FSK) - Frequency Modulation (hereinafter called as FM) method through VHF radio (146.575 MHz).

c) The rainfall data from the RS are to be sent when the accumulated rainfall reaches 3.5 mm and/or every specified time (every hour :00).

d) The RS is designed to check the communication status between the CS and another RS before sending data, and to suspend its transmission until another communication has been completed.

e) The CS is designed to send the receiving signal to the RS after satisfactory receiving of data. If the receiving is failed, the CS instructs the RS to re-send the data to the CS.

f) The water level gauge is of float type and the measurement is sent to the CS by Selsyn motor system.

2) Rainfall Gauging Station (RS)

a) The RS consists of rainfall gauge, micro computer system, transmitter and receiver, antenna, battery, solar panel, outdoor type cubicle and antenna tower. There are buildings at Da Sa and Da Chay but they are not used at present.

b) The rainfall gauge is of tipping bucket type and the resolution is 0.5 mm.

c) When the RS finds the situation change of gauge, the RS sends at first the signal " interruption " to micro computer (8 bit CPU(Z80)) for "switch-on" of transmitter and then send the data when the change reaches up to 3.5 mm.

d) At presetting period (every hour: 00), the RS sends the data through the micro computer in the same procedure as above (c).

e) All the data of not only rainfall but also ID (Identification No. of Station), observation time, condition of battery, condition of solar panel, etc. after all these data are changed to FSK signal by computer.

f) These FSK signals are sent to receiver through voice-input terminal of the transmitter (VHF-FM) i.e. this modulation is FSK - FM method. The out-put of this transmitter is 10W/50W, and the frequency is 146.575 MHz.

g) All the antennas are of Yagi-antenna with 9 elements. The present direction of each station are as follows;

Da Chay	to CS	Directly
Xuan Tho	to South	Not to CS
Da Sa	to East	Not to CS

h) The height of antenna at each station is as follows;

Xuan Tho Station	9 m
Da Sa Station	9 m
Da Chay Station	17 m
CS Station	21m

All antennas are mounted on the triangular supports as horizontally polarized wave.

i) Rainfall gauge and outdoor box (Micro computer, transmitter and receiver, battery, etc. are contained), and solar panel are mounted within several meters above ground level on the antenna supports.

j) Approach to the RS at Da Sa and Da Chay is very difficult during the rainy season.

3) Central Station (CS)

a) The CS is provided in a room of the observation house located on a hill near the spillway gate of the reservoir.

b) The CS consists of indoor equipment such as Personal Computer (IBM-AT, compatible facility, display, printer, etc.), FM transceiver, water level indicator, and outdoor equipment such as rainfall gauge, antenna, etc.

c) The CS is operated by AC power source with back-up of UPS (Uninterruptible Power Source), but the UPS is now out of order and not used.

d) The CS is operated throughout 24 hours for observing the transmission and receiving of the RS. The water level of reservoir is always shown on the indicator.

e) The personal computer (internal de-corder board) demodulates the signal received from RS and display them on CRT (Cathode Ray Tube). The data are also printed out and saved in the hard disk.

f) When the data are not received correctly due to weak electrical field, etc. or the received data can not be demodulated due to receiving at the same time from both stations, the system re-calls the RS and instructs it to send the data again. When the data is received correctly, the RS sends a signal of its confirmation to the RS.

g) The printed out sheet is exampled in Figure 7.1.

(2) Utilization of Acquired Data

1) Data Acquisition and Display of Rainfall and Water Level

All the data of rainfall and water level are now collected at the CS. The data of rainfall are stored in the hard disk of the personal computer and are also displayed on CRT and printed out if required.

2) Transference of rainfall and water level data

All the data are stored in the CS, and transferred to the P/S in voice through the PLC telephone channel if required.

(3) PLC Telephone System

As the PLC for this system is designed mainly for voice channel, the PLC telephone channel is used as voice communication between the CS and the P/S, i. e., the data are transferred from the CS to the P/S in voice if necessary. The transmission of the data from the CS to the PSCC is scarcely made. The existing system of the PLC networks is shown in Figure 7.2, referring to the collected drawings and the results of hearing.

7.1.3 Analysis of Study Results

Taking into consideration that the water stored and/or to be stored is a valuable property and should be used most effectively, the water control and utilization are the most important proposition at present. The Study Team analyzed the present data acquisition system carefully.

(1) Data Acquisition System

1) Acquisition Method

The present "Event Reporting System" may be suitable for present number of stations, i.e., three RSs and one WL. However, 6 or 7 additional RS may be required for the future system, making about 10 stations in total. If the present system will be continuously applied, the possibility of disturbance of communication will increase due to collision of preset period system (same time interfacing of other station) and the effective data acquisition can not be kept.

Considering such situation, the polling system which all stations are under the control of the CS and data acquisition becomes smooth is recommended for this network. In applying the polling system, capacities of solar panels and battery

should be examined for the continuous operation throughout a day. The present event reporting system is effectively done on the polling system by applying "sending permission method" before sending data in case of rainfall reaching the specified value.

2) Location of Data Acquisition Stations

The present RSs are located only on the west side of the catchment area of the reservoir. The reason why these stations are on the west side only is that the access way is available on the west side. According to the meteorological data at Dalat city, the rainy season is from middle of April to middle of December and almost of the annual rainfall is concentrated in this period. The direction of wind in the rainy season is the west wind and that in the dry season is the east wind. Therefore, the rainfall by the west wind in the rainy season should be measured. The rainfall in the east side of the catchment area is more important for measuring of rainfall than that in the west side of the catchment area, because it is general to judge that the west wind blows on the west side of mountains (east side of catchment area) and make rainfall on that area.

Judging from the point of view, 2 or 3 RSs should be added on the east side of the catchment area, in addition to the existing 3 RSs on the west side. The measurement of water level at present is made only at the point near spillway gates.

On the other hand for the purpose of water control, water inflow into and outflow from the reservoir should be observed. Therefore, additional WLs should be provided for observing inflow and outflow. The location of WLs for inflow should be selected at the position of two rivers (Da Nhim and Klang Klet) where water level of the reservoir does not affect but nearer to the reservoir as possible. One WL should be also provided near the down stream of the reservoir for the checking of spillout.

3) Hardware

The rainfall gauge, data process, transmitter and receiver, battery, solar panel and antenna at the existing RS can be used practically. The combination of personal computer and transceiver can also be put to practical use.

The existing transceiver, however, is a product for the amateur radio and can be used for speech communication without any trouble, but seems not to be suitable

for data transmission facility. The production technique during design and fabrication seems to be a little poor for the permanent use. It is required generally to apply a cycle test of temperature and humidity on the equipment, which is normally applied to the outdoor box at tropical area with high temperature and high humidity. It was not, however, confirmed that such test had been applied to the existing equipment.

It is recommended to apply utilization of micro-processor in view of power consumption. Though the existing event reporting method does not require power source throughout a day and can reduce the capacity of battery, the polling system requires large power consumption at the receiving period. Therefore, it is required that the power source for micro-computer system should be put on only at the time when receiving of calling sign in order to save power.

4) Radio Wave Propagation

The design philosophy of the existing data acquisition system is that the data from the RS may be sent to the CS within a half day because the reservoir water level is changed with some delay after the rainfall and prompt information of data is not required. However, there is the possibility of delayed information when they are definitely necessary if the reliability of communication becomes worse, e.g., if the link reliability is 99%, it means that in the worst case there are 3.5 days of non-communication condition in a year. In order to make an effective operation such as preliminary spill-out in case of flood, non-delay communication is required.

Referring to the profile of communications route of the existing RS, it is judged that link reliability is very low, because antennas of both stations are not faced each other, i. e., it seems to use mountains as reflector of wave. The profile are shown in Figures 7.3, 7.4 and 7.5.

5) Data Transmission

MODEM for the computer communication is adopted for the data transmission. Though the transmission speed of this system is designed for 9600 BPS (Bit Per Second), the speed used actually is around 300 BPS.

As the information for the rainfall and water level is very small comparing with computer communication, it is more important to keep high S/N (Signal to Noise

ratio). A priority should be given to increase S/N ratio even if the transmission speed is depressed to 50 BPS according to the result of circuit design.

(2) Utilization of Acquired Data

1) Role of CS

The present CS executes the data acquisition of rainfall, supervision of reservoir water level and the control of spillway gates. Considering operation of the complete water control system, it is preferable that the role of the present CS is to be continued. In point of generating management, it is necessary to grasp dam data at P/S (hereinafter called as PS-S) where it was collected in CS, and all information should be transferred to the P/S. For this purpose, the current function of CS will be modified.

From such point, the following are recommended;

a) To collect water level and rain fall data
b) To announce discharge warning
c) To manage collection data
d) To transmit data to PS-S

2) Radio Station in the Power Station (PS-S)

As no such station is at present, PS-S and the communication network between the PS-S and the CS should be newly constructed in this urgent rehabilitation project.

Outline of the PS-S is as follows;

a) To comprehend water level and rain fall data where are transmitted form CS
b) To comprehend current condition in CS
c) To manage collection data

It is preferable equip with expandable function to transmit the above data when whole energy development plane in PC-2 will be done in future.

3) Communications Network between CS and PS-S

As the present communication between the CS and the P/S is made only voice through the telephone channel of PLC but, it is not leased circuit. Thus, data transmission circuit and leased circuit of water management by radio system will be installed in this urgent rehabilitation project. Normally radio system is called stronger than wire telecommunication system against disaster.

4) Warning of Water Discharge

After the precise water control will be introduced, the possibility of preliminary spillout from the reservoir would increase more frequently than that in the present, and the spillout should be warned to the down stream for safety of inhabitant. The power source for such warning may be available from commercial source, but a back-up system by battery will be provided for emergency case.

5) Communication to PSCC

Such data in the P/S as frequency, output, power factor, etc. are, at present, transferred to the PSCC in voice through the PLC communication network. In the same way, all the hydrological data collected in the PS-S can be sent to the PSCC.

However, the following should be settled in future, including the function and work sharing of the PSCC and the PS-S.

a) To send all the hydrological data collected in the PS-S to the PSCC, or
b) To send only selected data after management at the PS-S to the PSCC.

7.2 Urgent Rehabilitation Plan

The following rehabilitation work will be planned for the effective water control at the Da Nhim power station.

7.2.1 Outline of Rehabilitation Plan

The target of urgent rehabilitation plan are described as bellows:

(1) To comprehend overall rainfall in the catchment area of the Da Nhim reservoir by the effective location of the RS.

(2) To comprehend inflow and outflow of the Da Nhim reservoir by additional WLs.

(3) To provide the function of real time data acquisition by improvement of the radio transmission characteristics including installation of repeater station

(4) To provide the function of water management at CS.

(5) To comprehend water management condition at PS-S which will be installed data transmission circuit and water management leased telephone circuit between CS and PS-S.

(6) To provide the warning facility to secure safe living against inhabitant in the down stream.

The proposed station sites are shown on Figure 7.6.

7.2.2 Rehabilitation Plan of RS

The locations of the existing three (3) RSs should be re-examined in consideration of access road, radio wave propagation, robbery prevention of facility, etc. and if more suitable place would be found, the RS should be shifted there. Two or three new RSs will be constructed on the east side of the catchment area. As it is very difficult to find out the most suitable places in the jungles, three (3) locations of the new RS are selected on the top of mountains tentatively on map referring to the above three (3) check points, i.e., access road, wave propagation and robbery prevention. The power sources are to be solar panel.

7.2.3 Rehabilitation Plan of WL

As the existing WL is located near the spillway of dam and the indicator by Selsyn motor is installed in the spillway observation room, it is required to convert the signal to the one suitable for transmission through communications network in order to send it to the PS-S. Two new WLs are to be located just above the back water level of the reservoir in order to measure inflow from the rivers. Though the distance between the WL and the CS is around 10 km, the wave propagation seems to be somewhat difficult, because the locations of the WLs are at a lower place equivalent to the elevation of the river bed. In the case required, repeater stations may be located inside of the nearest RS which are to be constructed on or near the top of mountain. In addition, it is recommended to add the function of rainfall

gauging station in the WL. The WL for downstream is to be located at the place of around 100 m downstream from the dam. The power sources for the WL are solar panels.

7.2.4 Rehabilitation Plan of CS

CS is provided the function of water management for dam control such as collection of water level , rain fall and announcement of discharge warning.

And moreover, all information including collection data and warning status will be transferred to PS-S which will be installed data transmission circuit and water management leased telephone circuit. The data acquired are displayed on a wide CRT and/or mosaic panel so as to be confirmed by the operator visually. The operator executes effectively the water control based on these data after information process. The power source is to be a AC power source with UPS (Uninterruptible Power Source).

7.2.5 Radio Station in the Power Station (PS-S)

The PS-S is to be located in the Da Nhim Power Station for comprehension of condition as to water management. The data where collected CS concentrate at PS-S to use whole power station management. The data acquired are displayed on a wide CRT and/or mosaic panel so as to be confirmed by the operator visually. The operator executes effectively the water control based on these data after information process.

Furthermore, data transmission circuit and water management leased telephone are newly installed. The power source is AC with UPS.

7.2.6 Communications Network between CS and PS-S

Multiplex radio system which consists of data transmission and water management leased telephone circuit are newly provided. If necessary, the repeater station will be provided in view of wave propagation. It is expected difficulty to get commercial power where the repeater station is considerably installed top of mountain. Therefore, the power source is solar panels.

7.2.7 Warning Station (WS) for Water Discharge

Some radio stations for alarm of water discharge are to be constructed at downstream of the dam. The signal for warning of discharge is sent to all the WSs from the CS through the repeater station No. 1 (hereinafter called CS-R) at the same time. The power source is AC with the UPS.

7.2.8 System Configuration

System configurations are mentioned bellows:

(1) All the data will be collected by the polling method.

(2) Polling will be automatically made from the CS on set up time.

(3) The data transmission by the event reporting method will be applied to this system in the condition that the transmitting station has received the permit of sending from the CS.

(4) Solar panels are used for the RS and the WL as power source except that of the WL at the near spillway. AC power source will be used for other stations.

(5) All the WLs will provide with a function of rainfall gauging.

(6) The communications will be made by simplex or full duplex system.

(7) The radio communications among the RS and WL will be made by VHF radio wave. The frequencies used will be 5 bands consisting of the present 146.575 MHz, newly allocated 143.350 MHz and other three frequencies.

For radio communications between CS and PS-S will be made by UHF (400MHz) multiplex band. Four frequencies will be provided.

(8) FSK-FM method will be applied for the modulation and HDLC (High Level Data Link Control) procedure will be applied for the data control. ID code of the existing stations will be replaced by the new address code.

(9) Considering difficulty of access to the location of each station, all facilities provided should be fully reliable even under the severe condition of the tropical area, in order to reduce the burden for maintenance as possible.

(10) All the facilities and materials should be smaller and lighter as possible, low energy type, and of interchangeable unit construction for the easy maintenance in case of damage or malfunction.

7.3 Basic Design of the Urgent Rehabilitation Plan

This clause discusses the basic design for the facilities examined in the Section 7.2. The catchment area of the Da Nhim reservoir is covered by dense jungles on the mountains in altitude of 1,000m to 2,300m. Observation of the rainfall and water level is performed in this area, and the basic design should be achieved taking account of such geographical condition, which seriously restricts the fundamental specifications of the facilities. The major purpose of the basic design is to establish the adequate gauging and warning stations for the hydrological data acquisition system of the Da Nhim reservoir in account of the propagation characteristics.

7.3.1 Configuration of System

The conceptual arrangement and outline of the configuration of the system concluded by the basic design are shown in Figures 7.7 and 7.8.

General functions of each station are as follows:

(1) At every fixed time, the CS will order all the gauging stations to send data to the CS. To the particular station, CS will send particular calling command when gauging station is selected by manual.

(2) According to order form CS, gauging stations will send observation data to the CS automatically.

(3) To the gauging stations that sends the data through the repeater stations, the CS sends the call signal after switching ON of the repeater station. After finish of data transmission the repeater station will be automatically turned switch off.

(4) In failure of the collection of data, the CS will try to collect the observation data twice. After the second failure if occurred, the fact will be indicated with alarm by buzzer to the operators. In case of failure of the warning, the operators should take an alternative.

(5) After completion of data collection, the data will be immediately saved at CS and transmitted to PS-S

(6) Test or measurement other than the predetermined time will be made in the same manner as the above (1) to (5) except the case of manual starting. In addition, such function as calling of the particular station or particular groups is provided.

(7) The warning signal for water discharge is sent by the CS in the same manner as for calling the gauging stations.

(8) After confirmed sending of warning signal by a microphone, the warning station will send a reporting signal to the CS.

(9) The CS confirms the warning from all the warning stations and then report the fact to the PS-S.

(10) In failure of the warning procedure, the CS will try to control the warning stations twice. After the second failure if occurred, the fact will be indicated with alarm by buzzer to the operators. In case of failure of the warning, the operators should take an alternative.

(11) All of information and data where are comprehended in CS will be transferred to PS-S on real time.

(12) In order to save the charge of batteries as far as possible, the stations provided with solar batteries will have, in the waiting period, a function to make the power source ON after detecting so calling.

7.3.2 Design of the Facilities

(1) Site of the Existing Rainfall Gauging Stations

Figures 7.3 to 7.5 show the profile between the existing RS and the CS.

Following are pointed out from the profile.

- Elevation of the CS is low, and ridges of the hills around the station disturb the path of radio wave.
- The existing RSs are located at comparatively low sites, and the lines of sight are not properly provided.

Under the situation, the repeater station No. 1 (CS-R) will be installed between CS and gauging station, and the existing RSs also should be shifted to higher locations so that the line of sight is cleared. The examination of map survey, between CS and CS-R confirmed to take line of sight, and between CS-R and each gauging station was confirmed as bellows.

1) The Xuan Tho rainfall gauging station (RS-1) is provided with a line of sight to the CS-R.

2) The Da Sa rainfall gauging station (RS-2) is propagated to the CS-R with one diffraction at a ridge.

3) The Da Chay rainfall gauging station (RS-3) is propagated to the CS-R with one diffraction at a ridge.

The profile maps are shown in Figures 7.9 to 7.11

(2) New Rainfall Gauging Station (RS)

Four recommended locations were selected on the east side of the Da Nhim reservoir and their profile maps were prepared and examined by the Study Team.

Proposed Site	Elevation	North Latitude	East Longitude
A	1,788 m	12° 01' 15"	108° 36' 47.7"
B	1,836 m	11° 59' 42.1"	108° 38' 30.3"
C	2,287 m	12° 05' 21.2"	108° 39' 58.3"
D	1,562 m	11° 56' 08.9"	108° 39' 29.7"

The examination results that the proposed sites A and B(hereinafter called as RS-4) will have a satisfactory transmission characteristics between CS-R, and the sites C(hereinafter called as RS-5) and D(hereinafter called as RS-6) may be not suitable locations. While, the path connecting the RS-5 and RS-6 with the CS-R relaying at the RS-4 is satisfactory.

In point of hydrological, it is satisfactory to obtain merely one rain fall station site A or RS-4.

Accordingly, the sites for the new RSs will be selected at the recommended RS-4, and the RS-5 and RS-6 that will be relayed through the RS-4.

1) The RS-4 has a path of approximate line of sight. (loss of 6 to 10 dB added to that for the complete line of sight)

2) The RS-5 has a path of line of sight to the RS-4.

3) The RS-6 has also a path of line of sight to the RS-4.

The profiles for each site are shown on Figures 7.12 to 7.15.

(3) Water Level Gauging Station (WL)

Water level is indicated on a meter installed in the CS being transmitted through a cable from the existing water level gauging station (WL-1). The data are converted into the signal format and transmitted to the CS. The new WL (WL-4) planned to connect CS by cable where is located at the immediate down stream of the Dam

Sites of two new WLs are selected along the Da Nhim river and the Klong Klet river at the locations of at least 15 meters higher than the maximum high water level of the reservoir. The Study Team examined alternative locations for the new upper stream WLs. However it is found that the existing WL-2 and WL-3 are selected at more suitable locations. Profiles of the CS-WL-2 and the CS-WL-3 are shown on Figures 7.16 and 7.17.

Site	North Latitude	East Longitude
WL-2	11° 55' 07.9"	108° 34' 47"
WL-3	11° 55' 21.7"	108° 37' 32.5"

(4) Radio Station in the Power Station (PS-S) and Central Station (CS)

The PS-S is planned to be established in the premises of the power station. Since the power station is located at the bottom of the steep, an adequate propagation is not expected between the Dam site and the PS-S. Several locations for the alternative repeater station were examined by the Study Team. It is concluded that the most suitable site (hereinafter called as PS-R) for the PS-S will be at the elevation of 420m in latitude 11° 48'21.8"N and longitudinal 108° 42'00"E. As seen on Figures 7.18(1) and 7.18(2), there is a ridge between the CS-R and the PS-R, and loss due to the ridge is estimated at about 23 dB. The line of sight is kept in the path between the PS-R and the PS-S.

(5) Discharge Warning Station (WS)

The transmission of radio wave between the CS-R and the WS will be directly made in the line of sight or in the allowable extent even if the path is out of the line of sight. Otherwise, the repeater station is required. Service area of a warning station will be in several kilometers because of the propagated distance of sound waves. It will be not difficult to find suitable paths for the warning system.

7.3.3 Basic Design

(1) Radio Station in the Power Station (PS-S)

For the whole management of power station, PS-S are provided function that comprehend the all data such as observating data and status data where were collected in CS. Furthermore, water management leased telephone circuit will be installed between CS and PS-S. The block diagram of the system is shown on Figure 7.19.

Main equipment in the station and their functions are as follows:

1) Antenna and Duplexer

The antenna is a directive YAGI antenna facing the PS-R. The duplexer is used for the simultaneous operation of wave sending and receiving.

2) Transmitter and Receiver

The equipment are those of FM multiplex radio for transmitting frequency of F1 and receiving frequency of F2 for data transmission and water management leased telephone.

3) MODEM (modulator and demodulator)

The data signal speed of the MODEM will be for 9,600 BPS (Bit Per Second).

4) EWS (Engineering Work Station)

The EWS will be used for data management where were transmitted form CS and the data transmission control between PS-S and CS.

The other futures are bellows:

a) To record the data on the hard disk and also to process and then show the results on the display or indicating board.

b) To take back up to the magnetic tape

c) To process the database such as searching and printing out from stored data.

7) Uninterruptible Power Source (UPS)

For continuous power supply to the system, the UPS should be provided.

(2) Repeater Station No. 2(PS-R)

PS-R will be provided multiplex repeater equipment to use for relay station between PS-S and CS. Figure 7.20 shows the block diagram of the PS-R and their functions are as follows:

1) Antenna and Duplexer

Two antennas will be provided, one for the PS-S and another for the CS-R. The duplexer will enable the station to transmit and receive the radio wave at the same time.

2) Transmitter and Receiver

Two sets will be required, one for the PS-S and another for the CS-R. The set for the PS-S receives the frequency F1 and transmits the frequency F2. The set for the CS-R receives the frequency F3 and transmits the frequency F4.

3) Solar Panel

The solar panel will be provided with the solar batteries as the main power source. Design criteria for the panel are presented in Subsection 7.3.5.

(3) Repeater Station No. 1(CS-R)

CS-R will be provided multiplex repeater equipment between CS and PS-S, and repeater equipment for gauging stations and warning stations. Figure 7.20 shows the block diagram of the CS-R and their functions are as follows:

1) Antenna and Duplexer

a) For the multiplex radio circuit to PS-R and CS

Two antennas will be provided, one for the PS-R and another for the CS-R. The duplexer will enable the station to transmit and receive the radio wave at the same time.

b) For the gauging stations and warning stations

Four antennas will be provided, two for the observation and another for the warning.

2) Transmitter and Receiver

a) For the multiplex radio circuit to PS-R and CS

Two sets will be required, one for the PS-R and another for the CS. The set for the CS receives the frequency F1 and transmits the frequency F2. The set for the PS-R receives the frequency F4 and transmits the frequency F3.

b) For the observation stations and warning stations

Two sets will be required, one for the gauging and another for warning. The set for the gauging use the frequency f3 between CS and use the frequency f1 between stations. The set for the warning use the frequency f5.

3) Solar Panel

The solar panel will be provided with the solar batteries as the main power source. Design criteria for the panel are presented in Subsection 7.3.5.

(3) Central Station (CS)

CS will be provided the function to manage whole water control against gauging stations and warning stations.

Storing data and control of data transmission to the PS-S are used by Engineering Work Station (EWS). Furthermore, multiplex radio circuit consists of water management leased telephone circuit and data transmission circuit will be installed between CS and PS-S for data transmission where were collected CS and liaison work. The block diagram of CS is shown on Figure 7.19. Major equipment in the station and their functions are as follows:

1) Antenna and Duplexer

a) For the multiplex radio circuit to CS-R

One antenna system will be provided for the CS-R and the duplexer will enable the station to transmit and receive the radio wave at the same time.

b) For the observation stations and warning stations

Three antenna systems will be provided for the observation and warning.

2) Transmitter and Receiver

a) For the multiplex radio circuit to CS-R

One set of multiplex radio will be provided for CS-R. The set for the CS-R receives the frequency F2 and transmits the frequency F1.

b) For the gauging stations and warning stations

Three sets will be required for the observation and warning. The set for the gauging use the frequency f3 among CS-R and use the frequency f2 for gauging stations. The set for the warning use the frequency f4.

3) MODEM

For the data transmission, three sets of MODEM will be provided one for the observation , one for the warning and another one for the data transmission between CS and PS-S.

4) Telemetering supervisory and control equipment for WL and RS, and Warning supervisory and control equipment for warning

The supervisory and control equipment will be controlled data transmission between CS and each station(gauging and warning stations).

5) Operation console

The operation console will be connected the above supervisory and control equipment and its operate and indicate following items.

a) Selection of stations

b) Set up of calling interval

c) Manual calling

d) Voice communication

e) Status indication

f) Selection of control items for warning

g) Monitoring for warring

6) EWS and Ancillaries

The EWS which connects with the above supervisory and control equipment will be used for the data transmission control for CS and data storing. The other futures are bellows:

a) To record the data on the hard disk and also to process and then show the results on the display or indicating board.

b) To take back up to the magnetic tape

c) To process the database such as searching and printing out from stored data.

7) Uninterruptible Power Source (UPS)

For continuous power supply to the system, the UPS should be provided.

(4) Rainfall Gauging Station (RS) and Water Level Gauging Station (WL)

The stations will transfer data of rainfall, water level of the reservoir or water level of the rivers into the reservoir. These stations will function as the secondary station of the CS sending data to the CS by the HDLC protocol. In case of the measured data beyond the preset values, the stations will send the data to the CS after obtaining permission of the CS. Figure 7.22 shows the block diagrams of the stations.

Main equipment in the stations and their functions are as follows:

1) Antenna and Antenna Switch

An antenna will be installed at a station. However, the stations functioning as the repeater station will have the plural number of antenna to the related station and the switch for exchange of the antenna.

2) Transmitter (TX) and Receiver (RX)

The system will be designed for simplex system to use one radio frequency. In case of to equip with repeater function, this station using two frequencies but its will be also designed simplex system.

3) MODEM

The device will modulate and demodulate the transmitting and receiving signals, and exchange the codes with the telemetering equipment.

4) Telemetering equipment for gauging station

The equipment will function as the secondary station of the CS and send the measured data to the CS. They will also work for connection of the circuits, establishment of the data link, transfer of the data, release of the data link, disconnection of the circuits. The station provided with the plural number of antenna will switch the necessary antenna toward the opposite station. The equipment will send to the MODEM the codes transferred from the measured data and other data being input through the interface. In case of the data measured beyond the preset values, the equipment will send the data directly to the CS under acceptance of the CS.

5) Rainfall Gauge and Water Level Gauge

The rainfall gauge and water level gauge will measure the amounts of rainfall and water level of the rivers into the reservoir.

6) Power Controller (PW.C)

The receiver will be in the waiting condition at all the hours. In response to the signal for switching ON sent by the PS-S or the CS, the controller will make the switch for the power source ON for the two-way communication.

7) Power Source

Solar batteries will be used as the power sources in the stations. Data concerning the solar and storage batteries will be transferred to the CS together with the data of hours of sunshine. Those data will be utilized for the maintenance of the stations.

(5) Warning Station (WS)

The station will warn its surrounding by sounding of speaker in response to the warning signal. The station will report completion of the warning to the CS after confirming completion of the warning. Figure 7.23 shows the block diagram of the WS. Major equipment in the station are as follows:

1) Antenna

The antenna is used for transmitting and receiving the frequency f5.

2) Transmitter and Receiver

The stations will be provided with one set each of the transmitters and receivers.

3) Warning equipment

The equipment will be provided function as the secondary station of the CS under HDLC protocol, and the warning station will report the success or failure of the performance to the CS.

7.3.4 Basic Design of Frequency Allocation

Among the CS, gauging stations and warning stations will be performed simplex communication system which use function of change over transmitting and receiving.
Since simultaneous operation, the frequency f1, f2 and f3 should be used between CS and gauging stations and frequency f4 and f5 should be used between CS and warning stations. Address of each station will be discriminated by the ID code given to the station.

Where necessary of repeater station, the frequency f2 should be used for relay frequency. It is necessary to make radio link consists of data transmission circuit and leased telephone circuit between CS and PS-S constantly, full duplex multiple radio system by UHF band should be provided. In point of restriction of radio propagation, repeater station named PS-

R will be installed between PS-S and CS. Except the basic design criteria mentioned above, the following restrictions are also taken into account:

(1) An antenna having the sharp F/B (Front-Back Ratio) characteristics will not be applied, because the radio wave used for the project is not microwave but VHF.

(2) An intervention is unavoidable in the same frequency even if the wave is horizontally or vertically polarized.

(3) There are the CS-R and the PS-S located in the angle of 30° viewing from the PS-R. In order to avoid the intervention, separation should be set between the frequency bands from the CS and the PS-S to the PS-R.

(4) Similarly, the common frequency from the PS-R to the CS-R and PS-S will cause an intervention between the CS-R and the PS-S.

To avoid such restrictions, five VHF frequencies and four UHF frequency should be used for the Project. Figure 7.8 shows the recommended frequency allocation to the project.

7.3.5 Basic Design of Solar Battery, Storage Battery, and UPS

Power supply by the solar batteries should carefully be designed taking into account the tropical climatic condition at the project site. Figure 7.24 shows the average hours of sunshine to be 6.47 hours a day in the period of 11 years till the year 1993. The hour during a period of December to May (dry season) is more than the annual average hours, and the least hours of sunshine appear during August to be 2.4 hours/day (72 hours/month).

In order to maintain the reliable power supply, the design of the power source will be performed on the basis of the least hours of sunshine per month, namely, capacity of the batteries will be determined by conditions of an average hour of sunshine per day at 4.5 hours/day and capacity of the storage battery at non-sunshine days of 30 per month. Capacity of the UPS used together with AC power source in the stations will be determined for use of 24 hours per day.

7.4 Implementation Program of the Urgent Rehabilitation Plan

Following particulars will further be examined at the site before the manufacturing and installation. These examinations will be carried out by the contractor selected for implementation of the project.

(1) Field survey

(2) Wave propagation test

(3) Confirmation on facility design

(4) Reexamination of the system plan

(5) Detailed design

7.4.1 Field Survey

The Field survey will be performed to the gauging stations, repeater stations, and warning stations. The Study Team found some differences between the actual land features and the topographical maps (issued in 1965) obtained at the site. There might exist some alterations on the artificial structures, roads, streams, land configuration during a long period.

Since the access roads are the important factor for construction and maintenance of the facilities, the careful survey for the accessibility is required. The survey will be performed in the following procedure.

(1) Examination on Accessibility to the Proposed Sites

Access roads to the recommended sites are very important. In case that access roads to approach the site are not found in the available maps, it will be investigated on the aerial photograph if available. Otherwise the investigation may be carried out by a helicopter.

(2) Proof of Accessibility by Site Reconnaissance

Conditions of the access roads found in (1) above will be explored. The exploration will mainly be performed for proof of easiness of approach to the site for wave propagation tests and construction of the stations.

(3) Investigation of the CS-R and PS-R Site

The Study Team has confirmed that the newly proposed CS-R will be located near the CS and it is accessible and CS-R is located at the walkable distance from the CS. The field investigation will mainly be made to find availability of about 10m x 10m premises for construction of 6 antennas and a route of power supply, and to confirm the line of sight from the antennas. Since the new station is planned to be unstaffed,

confirmation on the transportation of maintenance equipment and materials is also an important factor of the investigation. It is also necessary to do same investigation concerning with PS-R.

7.4.2 Wave Propagation Test

The mirror test instead will be adequate to a path that the line of sight is certainly kept. While, the wave propagation will be tested on the transmitting and receiving of the radio wave of the frequency allocated for the actual facilities. The propagation test is important for confirming a communication path. The receiving equipment used for the wave propagation test is more complicated than the transmitting equipment. Since the CS-R is accessible, the receiving equipment will be set at the CS-R. The expected receiving level will be calculated in advance of the test from the profile obtained from the maps.

When the measured level is near the calculated value or fading of the radio wave is anticipated to be sufficiently low, the test will be done in a short period. In either case of a great difference of the measured value from the calculation or a large amount of fading assumed, the test will be continued for such a long period as one week. The basic design results that some sections covered by the jungle will need a repeater station for the test.

Although the CS-R will be designed for an unstaffed station, a firm communication route should be secured between the testing site (CS-R) and the base station as a lifeline during executing the propagation test in such a manner as arranging necessary persons at the site and the base station in addition to the communication between the base station and the PS-S.

7.4.3 Confirmation of Facility Design

The basic design of the facilities will be re-evaluated on the basis of the results of the propagation tests. Shorter antenna and less transmitting power are desired for the easy operation and maintenance of the system. If an alternative site that may give more satisfactory result than the proposed site will be found during the field survey, the site should also be subject to the wave propagation test. The facility design will be finalized taking into account the results of the tests.

7.4.4 Re-examination of the System Plan

It is concluded from the map survey and examination of the Study Team that the proposed system plan is justifiable and realizable. The reexamination will be done for confirmation of the plan or for finding out the better alternative plan for the possibly efficient system.

7.4.5 Detailed Design

On the basis of the final system plan established as above, the detailed design of the facilities will be performed. Following the design, the facilities will be manufactured, installed and tested for commissioning.

7.5 Long Term Plan

Implementation of the urgent rehabilitation plan for the existing facilities will result in the efficient water management and control of the Da Nhim reservoir.

While, know-how of the hydrological data acquisition system should be accumulated over a long term. After the urgent rehabilitation of the system, a great volume of data will be collected, from which the relation of the water inflow to the forecasted inflow, the relation of the water inflow to discharge and leakage, and others will be gradually and more accurately saved. In order to utilize these data for efficient water management, it is necessary to accumulate and analyze the data systematically and continuously. The Study Team recommends to enforce the subject as the long term plan.

7.6 Recommendation of Operation and Maintenance

(1) Gauging and Warning Stations

Following operation and maintenance procedures are recommended to the rehabilitated facilities.

Most of the stations are located in the jungle on the steep mountains making difficult approach. Accordingly, the stations to be rehabilitated are to be provided with reliable and durable equipment and devices. Under the situation, it is recommended to carry out the periodical inspection to the facilities twice a year, once during the dry season and another immediately before the rainy season.

The stations will not be provided with consumable materials, but provided with the solar batteries and storage batteries. Dust and birds' droppings contaminated on the solar panels should be cleaned twice a year at least. The storage batteries will be replaced in order of deterioration with new equipment, since efficiency of the batteries will remarkably decline in 3 to 5 years. Such outdoor used materials and equipment as

antenna feeders, arresters, etc. will naturally be superannuated, and frequent inspection on them will be needed. Spares in sufficient quantity will be required.

(2) Central Station (CS)

The station will be staffed and inspected once a week.

(3) Radio Station in the Power Station (PS-S)

The station will be staffed and inspected once a week.

(4) Repeater station No. 1(CS-R)

The CS is staffed station, while the CS-R is planned to be unstaffed and constructed near the CS. The CS-R will be inspected once a month by operators of the CS.

(5) Repeater Station to PS-S (PS-R)

Facilities installed in the station are same as those in the gauging station. Since accessibility to the stations will be much better, inspection to the station is recommended once a month.

(6) Warning Stations

Inspection of once a month is recommended. Trial sounding for the warning is also recommended once a month.

7.7 Preliminary Hydrological Analysis

7.7.1 Availability of Meteo-hydrological Data

The existing meteo-hydrological stations in and around the catchment covered by the Dran dam are shown in Figure 7.25. The catchment area of 755 km^2 is largely divided into two tributary basins, namely the Da Nhim and Klong Klet River basins, which cover approximately 600 km^2 and 155 km^2, respectively.

Of the existing five (5) rainfall gauging stations shown in the Figure, the three (3) ones are situated in the upper Da Nhim River basin, while the Dalat station is located outside the catchment and the other one is at the Dran dam site. At present, there exists no rainfall gauging station in the Klong Klet River basin.

The complete data of annual rainfall at these five rainfall stations for the period from 1977 to 1993 are shown in Table 7.1, which reveals that the complete rainfall data for the latest years are available only from the Dran dam site and Dalat rainfall stations. The annual mean rainfall at these two are estimated to be about 1,400 mm and 1,770 mm, respectively. For the time being, it is too hard to estimate the annual basin average rainfall for the entire project catchment with an area of 755 km^2, since no rainfall stations lie in the eastern part of the project catchment. Hence, it is essential to install new rainfall stations in and around the Klong Klet tributary basin in near future so as to make the flood forecasting with accuracy.

The reservoir water levels have been observed by the water level gauge installed at the Dran dam site. The observed water level data are being processed by the Da Nhim P/S office to be utilized for operation of the spillway gates in the event of the major floods as well as scrutinizing the long-term reservoir inflow.

The monthly evaporation and rainfall records at the Dran dam site are tabulated in Tables 7.2 and 7.3. The long term mean daily evaporation is derived to be about 5.2 mm. The daily evaporation becomes comparatively large in the dry period of March and April when the annual mean monthly evaporation is over 6 mm/day.

7.7.2 Ratio of Spillout Volume to Reservoir Inflow Volume

The reservoir inflow data observed after the completion of the Dran dam are summarized in Table 7.12 together with the streamflow data gauged before that. The annual mean discharge at the Dran dam site is estimated to be around 21.4 m^3/sec for the period from 1934 to 1993.

Table 7.4 shows the annual inflow and spillout volumes between 1978 and 1993. These records are plotted in Figure 7.26. On the basis of the records, the ratios of water utilized for power and water spilled out to the reservoir inflow are estimated to be around 10% and 92% on the average, respectively, as summarized in the Table. From the figure, it can be said that the Da Nhim P/S has been operated by utilizing so effectively the inflow discharge into the reservoir.

7.7.3 Characteristics of Floods

The hydrographs of the latest major floods, which were configurated based on the reservoir water level records as well as those of the spillout discharge, are illustrated in Figure 7.26 and Table 7.5. The rainfall records corresponding to those major floods were observed at Dalat as shown in Table 7.6, although the Dalat station is located outside the catchment as

aforesaid. On the other hand, the hourly rainfall data at the five rainfall stations are available for the 1993 flood only.

The records on the 1993 flood including the reservoir water level are summarized in Table 7.7. The hydrograph of the 1993 flood constructed based on the data related thereto such as the reservoir water level records is illustrated in Figure 7.26. The hourly rainfall records on the 1993 flood, which were observed at the aforesaid five rainfall stations, are tabulated in Table 7.8 and depicted in Figure 7.27. As seen in the Figure, it appears that the recorded hourly rainfall, especially those at the Dachay station which are shown in Figure 7.27, responds favorably to the hydrograph. Based on these flood records, the following characteristics are derived in terms of the floods in the catchment:

- The lag time of flood ranges between 4 and 5 hours, assuming that the basin rainfall can be represented by that at the Dachay station,

- At the Xuan Tho and Dalat stations, both of which are located far downstream of the Dachay station in the east, the rain storm occurs later than the Dachay station.

For the purpose of examining whether or not it is possible to forecast the occurrence of the flood based on the rainfall records at existing rainfall stations, the preliminary flood analysis was made for the 1993 flood applying the Nakayasu's synthetic unit hydrograph shown in Figure 7.28. It is generally understood that the formula which was developed in Japan works out the comparatively higher peak discharge. The flood hydrographs are generated with the formula applying the rainfall records at Dachay for the 1993 flood.

Assuming the runoff coefficient at 70% and the base flow at 50 m^3/sec, the hydrographs are constructed applying the rainfall records at Dachay on December 8 and 9, 1993 to the Nakayasu's synthetic unit hydrograph as shown in Figure 7.29. As a result, the peak discharge is calculated to be about 1,200 m^3/sec, which is considerably less than the observed one of 1,600 m^3/sec as sown in the Figure, although the shapes of the observed and estimated hydrographs are very similar. It is judged that this is responsible for the fact that there exist no rainfall stations in the eastern part of the project catchment. Therefore, it is recommended through the preliminary analysis that it is essential to install new rainfall stations in the eastern part of the catchment so as to exactly forecast the flood at the dam site.

7.7.4 Preliminary Frequency Analysis

In the present Study, the frequency analysis was made to estimate the probable floods at the Dran dam site adding the latest annual maximum discharge records. The annual maximum

records at the Dran dam site are shown in Tables 7.9. The frequency analysis is made by using the following distributions:

(1) Iwai

(2) Log Pearson type III, and

(3) Gumbel

The results of the frequency analysis are listed below:

Probable Flood at the Dran Dam Site

(Unit : m3/sec)

Return Period	Distribution		
(Year)	Iwai	Log Pearson Type III	Gumbel
5	730	730	890
10	1,110	1,130	1,200
20	1,570	1,600	1,500
50	2,320	2,380	1,890
100	3,010	3,100	2,180
200	3,820	3,950	2,470
500	5,090	5,290	2,850
10,000	11,340	11,950	4,090

As seen in the table above, there are a large difference between the probable floods estimated by the Gumbel method and other two ones concerning the higher return periods. This is a reason why the samples applied to the frequency analysis are skewed to the right side on the Gumbel's probability paper.

In the design stage of the project, the design flood and critical flood for the Dran dam are determined to be 4,500 m^3/sec and 5,500 m^3/sec, respectively. The critical flood corresponds to around the 500-year probable flood estimated by the Log Pearson Type III method and to over 10,000-year flood by the Gumbel method.

The adequacy of the critical flood of 5,500 m^3/sec is preliminary assessed by the Creager's coefficient derived by the following formulas:

$$Qp = 46 \times C \times A^{a}$$

$$a = 0.894 \times A^{-0.048} - 1$$

where,

C : Creager's coefficient

A : Catchment area in miles^2

Qp : Specific discharge in feet^3/sec/miles^2

Consequently, the Creager's coefficient is estimated to be about 89 for the critical flood. It is generally accepted that the Creager's coefficient comes to 100 in the catchment which suffers from the severe rain storm. Hence, it is considered that the critical flood adopted in the design stage would be in a reasonable range as the maximum limit.

Nevertheless, it is advisable to carry out the hydrological analysis to estimate the probable maximum flood (PMF) for the project catchment in the additional study stage as stated in the foregoing Section 6.5.

Table 7.1 Annual Rainfall in and around the Project Catchment

(Unit : mm)

Year	Rainfall Station				
	Don Duong (Dran Dam Site)	Dachay	Xuan Tho	Dasa	Dalat
1977	988	-	-	-	-
1978	1,507	-	-	-	1,547
1979	1,005	-	-	-	2,029
1980	1,631	-	-	-	1,938
1981	1,448	-	-	-	1,356
1982	1,424	-	-	-	1,763
1983	1,383	-	-	-	1,749
1984	1,578	-	-	-	1,706
1985	1,593	1,802	-	-	1,919
1986	1,541	1,270	-	-	1,714
1987	1,546	-	-	-	1,625
1988	1,233	1,795	-	-	1,807
1989	1,355	-	-	-	2,020
1990	1,459	-	-	-	1,934
1991	1,148	-	-	-	1,707
1992	1,639	-	-	-	1,734
1993	1,372	-	-	-	1,767
Mean	1,403	1,623	-	-	1,770

Note
"-" means that the rainfall data are not available.

Table 7.2 Annual Mean Monthly Evaporation at Dran Dam Site

(Unit : mm/day)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
1980	4.3	5.1	6.1	6.0	5.1	4.7	5.0	4.1	4.2	3.5	3.4	3.6	4.6
1981	4.4	5.3	7.0	6.2	5.0	3.9	4.9	4.8	3.5	3.3	3.0	2.6	4.5
1982	4.5	5.6	5.7	4.8	5.0	4.1	5.1	5.1	3.2	3.8	3.7	4.4	4.6
1983	4.4	5.6	6.5	6.7	4.8	4.2	4.9	4.5	4.0	3.2	4.4	4.0	4.8
1984	4.5	4.8	5.9	5.9	5.4	5.3	5.0	4.4	4.4	3.8	4.2	4.8	4.9
1985	4.8	5.4	6.6	5.2	4.9	5.7	5.6	6.9	4.7	4.9	3.4	3.8	5.2
1986	4.1	5.5	6.4	7.0	6.7	5.9	5.4	4.7	4.2	3.9	3.7	4.3	5.1
1987	5.2	5.7	6.6	5.6	5.9	5.3	6.1	5.4	5.0	5.3	4.1	5.2	5.5
1988	5.0	5.4	6.6	6.2	5.8	4.9	5.0	5.8	4.4	4.1	3.5	5.5	5.2
1989	6.0	6.1	5.7	5.9	5.1	5.1	5.0	5.3	5.4	4.5	5.2	5.6	5.4
1990	6.2	6.2	6.4	5.7	6.2	4.9	5.9	4.5	5.4	4.8	4.5	5.6	5.5
1991	6.1	6.5	6.2	6.1	5.8	6.1	5.8	5.7	5.0	5.2	5.9	6.4	5.9
1992	6.2	6.5	6.5	5.8	6.1	5.1	6.0	4.0	5.0	3.6	4.8	5.6	5.4
1993	6.1	6.4	6.5	6.5	6.4	6.2	6.6	6.5	5.9	4.9	5.2	4.4	6.0
Mean	5.1	5.7	6.3	6.0	5.6	5.1	5.5	5.1	4.6	4.2	4.2	4.7	5.2

Table 7.3 Annual monthly Rainfall at Dran Dam Site

(Unit : mm)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1977	0	0	0	59	138	110	174	114	269	8	116	0	988
1978	15	2	1	169	284	169	214	98	194	285	71	6	1,507
1979	0	4	17	120	83	228	83	0	215	93	128	34	1,005
1980	24	2	3	2	129	387	141	164	244	361	147	26	1,631
1981	2	2	0	43	235	71	127	31	282	333	249	72	1,448
1982	1	0	158	58	230	194	22	124	187	278	155	18	1,424
1983	3	0	0	18	100	200	137	240	309	249	124	5	1,383
1984	0	0	30	58	245	89	190	47	314	472	109	24	1,578
1985	10	8	1	212	254	46	228	12	261	364	166	30	1,593
1986	0	9	0	24	57	114	193	135	459	293	157	101	1,541
1987	0	0	4	139	87	121	75	105	391	270	345	10	1,546
1988	3	2	18	26	19	119	205	165	330	202	146	0	1,233
1989	0	0	32	130	146	164	159	221	279	190	36	0	1,355
1990	0	0	14	165	147	162	146	106	363	78	278	2	1,459
1991	0	0	63	4	192	58	124	59	363	252	19	16	1,148
1992	1	0	15	168	250	308	125	171	141	417	26	18	1,639
1993	0	0	43	1	279	105	69	35	277	310	122	135	1,372
Average	3	2	23	82	169	155	142	107	287	262	141	29	1,403

Table 7.4 Ratio of Annual Spillout Volume to Annual Inflow Volume

Year	Annual Volume (million m3)		Ratio of Spillout to Inflow (%)
	Inflow (Vi)	Spillout (Vs)	(=Vs / Vi x 100)
1978	490.1	0.0	0.0
1979	592.2	0.5	0.1
1980	702.6	81.6	11.6
1981	742.0	158.6	21.4
1982	484.1	0.0	0.0
1983	704.2	95.0	13.5
1984	658.4	5.6	0.9
1985	554.7	0.0	0.0
1986	585.6	14.6	2.5
1987	473.4	0.0	0.0
1988	587.2	99.5	17.0
1989	626.6	199.5	31.8
1990	642.4	168.7	26.3
1991	382.8	0.0	0.0
1992	663.1	66.5	10.0
1993	746.5	178.4	23.9
Mean	602.3	66.8	9.9

Table 7.5 Latest Major Flood Records at Dran Dam Site

Year	Date of Flood Occurrence	Duration of Flood (hours)	Reservoir Inflow Volume (million m3)	Peak Discharge (m3 /sec)
1979	Nov. 15	36	64.0	800
1980	Oct. 5	9	11.5	373
1981	Oct. 14	14	53.8	933
	Nov. 10	24	31.1	542
	Dec. 2	25	25.4	340
1982	-			
1983	Aug. 12	26	15.5	381
	Sep. 25	14	7.0	224
	Oct. 9	20	15.0	303
	Oct. 17	19	32.0	856
1984	Oct. 12	10	14.0	416
1985	-			
1986	Oct. 1	30	16.0	308
	Dec. 12	24	32.2	810
1987	Nov. 8	19	16.5	474
1988	Sep. 26	22	17.2	436
	Nov. 6	39	72.5	1,375
1989	-			
1990	Nov. 11	35	70.0	505
				489
1991	-			
1992	Oct. 23	71	72.0	530
1993	Oct. 4	36	23.7	309
	Nov. 22	58	36.5	264
	Dec. 5	12	14.0	409
	Dec. 9	19	43.8	1,625
	Dec. 14	5	9.8	276

Note : "-" means that no major flood took place in the year.

Table 7.6 Hourly Rainfall Records at Dalat for major Floods (1/2)

(Unit: mm)

Time	Year	1979		1980		1981		1983		1983	1983	1983	1986		1986	
(hour)	Date	Nov.17	Nov.18	Oct.5	Oct.6	Nov.9	Nov.10	Aug.12	Aug.13	Sep.25	Oct.9	Oct.17	Sep.30	Oct.1	Dec.1	Dec.2
1			1.3		0.4		0.1		5.4							0.1
2			12.3		0.0		0.7		6.4							
3			5.3		0.0		0.4		0.2							0.1
4			9.2			0.0	2.2				40.8*					
5			7.4			0.2	2.0									1.5
6			6.3			0.4	4.2									3.7
7			2.2			0.9	3.0									7.6
8			0.1			5.1	3.3									
9			0.4			6.9	1.6									
10			2.6	2.0		3.4	1.0					72.5*				
11			0.3	2.0		3.8	0.8									
12			2.4	6.0		0.5	1.7	1.7								
13			4.4			0.3	0.4	1.5								54.8*
14			2.6	37.1*		1.4	0.0	1.3	0.2							
15			3.4			0.8	4.6	0.2		59.4*						
16			3.0			0.6	0.4	0.6							0.2	
17		1.5	3.0	0.5		0.5	0.0	0.2	1.1				0.0	62.1*	0.9	
18		6.5	8.7	5.3		0.4			0.6				5.0		1.9	
19		2.0	2.6	2.2		0.4			0.9				3.0		1.1	
20		10.2	0.8	0.3		0.6		0.8	0.4				18.9	2.6	1.0	9.0*
21		3.2		1.2		0.6		1.5	0.2				1.1	2.2	0.5	
22		5.4		0.1		0.3		2.3	0.1				0.0	0.4	0.1	
23		3.7		0.0		0.3		8.5	0.3				0.0	0.1	0.2	
24		1.8		0.3		0.4		9.6	0.1				0.0		0.1	
Max.:		10.2	12.3		0.4	6.9	4.6	9.6	6.4				18.9		1.9	
Total:		34.3	78.3	57.0	0.4	27.8	26.4	28.2	15.9	59.4	40.8	72.5	28.0	67.4	6.0	76.8

Note : * ; shows the total rainfall amount for the duration shown by the arrows. The hourly rainfall data are not available for the duration.

Table 7.6 Hourly Rainfall Records at Dalat for Major Floods (2/2)

(Unit: mm)

Time	Year	1987	1988		1988	1992		1993		1993	1993	1993		1993
(hour)	Date	Nov.8	Sep.25	Sep.26	Nov.6	Oct.22	Oct.23	Oct.3	Oct.4	Nov.22	Dec.5	Dec.8	Dec.9	Dec.14
1				0.0	3.0		2.8	0.8	1.5	0.0			4.9	
2				2.9	4.0		1.8	1.1	3.5	0.2	0.2		5.2	
3				4.6	2.0		1.7	0.3	5.7	0.0	1.8		27.1	
4				4.1	0.6		2.2	0.5	2.5	0.0	2.0		32.9	
5				4.7	0.0		2.8	1.8	4.7	0.2	4.2		2.9	
6				3.5	0.0		1.3	2.3	1.9	0.1	1.0		0.7	
7		0.4			0.0		1.6	1.7	5.0	0.0	1.6		0.0	
8							0.4	0.5	5.3		3.8		0.0	0.0
9							1.2	1.6	0.7		0.0			
10							0.8	1.4	0.7					
11							1.3	2.0	1.0					
12							0.9	1.0	0.5		0.2			0.9
13		34.4*					0.5	0.1	0.5		2.5			2.3
14							2.2	0.9			4.7			0.2
15					50.0*		5.4	1.2	0.0		3.7			4.5
16							3.0	0.1	0.2		1.1			1.0
17			0.3				4.9	0.1			1.8			4.4
18			0.2	19.3		0.0	5.5	1.8			0.4			0.1
19						0.0	5.7	0.4			1.8			4.4
20						0.1	2.9	0.2			8.3			0.1
21				30.4*		0.2	1.6	1.2			3.1			0.3
22			2.2			0.2	1.0	0.5			1.3	0.4		
23			3.0			0.3	0.3	0.1	0.2		0.5	1.8		0.1
24			1.6			2.0	0.6	0.1	0.1		0.0	1.8		
Max.:			3.0			2.0	5.7	2.3	5.7	0.2	8.3	1.8	32.9	4.5
Total:		34.8	7.3	69.5	59.6	2.8	52.4	21.7	34.0	0.5	44.0	4.0	73.7	18.3

Note : * ; shows the total rainfall amount for the duration shown by the arrows. The hourly rainfall data are not available for the duration.

Table 7.7 Records of the 1993 Flood

Date/Time	Time Interval (min.)	Reservoir Water Level (EL. m)	Inflow Discharge		Spillout Discharge	
			Discharge (m3/sec)	Volume (million m3)	Discharge (m3/sec)	Volume (million m3)
Dec. 9, 1993 - 0:00	0	1,042.468	45		160	
0:30	30	1,042.460	49	0.08	160	0.29
1:00	60	1,042.445	107	0.14	160	0.29
1:30	90	1,042.425	80	0.17	160	0.29
2:00	120	1,042.415	133	0.19	208	0.33
2:30	150	1,042.405	181	0.28	208	0.37
3:00	180	1,042.405	233	0.37	208	0.37
3:30	210	1,042.395	179	0.37	304	0.46
4:00	240	1,042.400	355	0.48	360	0.60
4:30	270	1,042.395	385	0.67	400	0.68
5:00	300	1,042.395	418	0.72	393	0.71
5:30	330	1,042.445	687	0.99	452	0.76
5:45	345	1,042.500	1,285	0.89	684	0.51
6:00	360	1,042.520	1,434	1.22	1,200	0.85
6:15	375	1,042.454	1,434	1.29	1,400	1.17
6:30	390	1,042.435	1,426	1.29	1,600	1.35
6:45	405	1,042.435	1,625	1.37	1,600	1.44
7:00	420	1,042.425	1,520	1.42	1,600	1.44
7:15	435	1,042.405	1,415	1.32	1,600	1.44
7:30	450	1,042.385	1,400	1.27	1,600	1.44
7:45	465	1,042.378	1,536	1.32	1,600	1.44
8:00	480	1,042.362	1,446	1.34	1,600	1.44
8:15	495	1,042.340	1,395	1.28	1,600	1.44
8:30	510	1,042.320	1,415	1.26	1,600	1.44
8:45	525	1,042.295	1,363	1.25	1,600	1.44
9:00	540	1,042.280	1,367	1.23	1,500	1.40
9:15	555	1,042.245	1,157	1.14	1,500	1.35
9:30	570	1,042.290	1,198	1.06	1,010	1.13
9:45	585	1,042.290	1,025	1.00	1,000	0.90
10:00	600	1,042.288	1,004	0.91	1,000	0.90
10:15	615	1,042.282	962	0.88	1,000	0.90
10:30	630	1,042.298	993	0.88	800	0.81
10:45	645	1,042.338	965	0.88	520	0.59
11:00	660	1,042.380	725	0.76	260	0.35
11:15	675	1,042.425	758	0.67	260	0.23
11:30	690	1,042.458	632	0.63	260	0.23
11:45	705	1,042.495	674	0.59	260	0.23
12:00	720	1,042.520	548	0.55	260	0.23
12:15	735	1,042.550	600	0.52	260	0.23
12:30	750	1,042.572	516	0.50	260	0.23
12:45	765	1,042.598	558	0.48	260	0.23
13:00	780	1,042.615	516	0.48	312	0.26
13:15	795	1,042.620	390	0.41	312	0.28
13:30	810	1,042.625	421	0.36	312	0.28
13:45	825	1,042.635	411	0.37	312	0.28
14:00	840	1,042.642	411	0.37	312	0.28
14:15	855	1,042.648	400	0.36	312	0.28
14:30	870	1,042.648	337	0.33	312	0.28
14:45	885	1,042.650	358	0.31	312	0.28
15:00	900	1,042.650	337	0.31	312	0.28
15:15	915	1,042.648	316	0.29	312	0.28
15:30	930	1,042.634	305	0.28	312	0.28
15:45	945	1,042.640	285	0.27	312	0.28
16:00	960	1,042.635	285	0.26	312	0.28
16:15	975	1,042.630	285	0.26	312	0.28
16:30	990	1,042.625	285	0.26	312	0.28
16:45	1,005	1,042.618	264	0.25	312	0.28
17:00	1,020	1,042.610	253	0.23	312	0.28
17:15	1,035	1,042.602	253	0.23	312	0.28
17:30	1,050	1,042.592	232	0.22	312	0.28
17:45	1,065	1,042.584	253	0.22	312	0.28
18:00	1,080	1,042.572	211	0.21	312	0.28
18:15	1,095	1,042.558	190	0.18	312	0.28
18:30	1,110	1,042.550	253	0.20	312	0.28
18:45	1,125	1,042.540	243	0.22	312	0.28
19:00	1,140	1,042.530	232	0.21	312	0.28
19:15	1,155	1,042.515	206	0.20	312	0.28
19:30	1,170	1,042.500	180	0.17	312	0.28
19:45	1,185	1,042.490	206	0.17	312	0.28
20:00	1,200	1,042.480	232	0.20	312	0.28
20:15	1,215	1,042.465	206	0.20	312	0.28
20:30	1,230	1,042.450	180	0.17	312	0.28
20:45	1,245	1,042.438	194	0.17	312	0.28
21:00	1,260	1,042.425	207	0.18	312	0.28
21:15	1,275	1,042.413	207	0.19	312	0.28
21:30	1,290	1,042.400	207	0.19	312	0.28
21:45	1,305	1,042.385	194	0.18	312	0.28
22:00	1,320	1,042.370	180	0.17	312	0.28
22:15	1,335	1,042.350	154	0.15	312	0.28
22:30	1,350	1,042.330	127	0.13	312	0.28
22:45	1,365	1,042.315	154	0.13	312	0.28
23:00	1,380	1,042.300	180	0.15	312	0.28
Total				43.51		43.46

Table 7.8 Hourly Rainfall Data in and around the Project Catchment for the 1993 Flood

(Unit: mm)

Date / Time		Rainfall Station				
		Dachay	Dasa	Don Duong	Xuan Tho	Dalat
Dec. 8	18:00					
	19:00	1.00				
	20:00	2.50				
	21:00	4.00	2.00	5.00		
	22:00	4.00	2.00	2.50		0.40
	23:00	9.00	3.50	6.00	0.17	1.80
Dec. 9	0:00	2.00	3.00	4.00	0.17	1.80
	1:00	4.50	18.00	2.50	0.16	4.90
	2:00	48.00	25.00	28.00	7.00	5.20
	3:00		2.50	5.50	27.00	27.10
	4:00	3.50		1.50	20.00	32.90
	5:00			2.50		2.90
	6:00			2.00		0.70
	7:00			0.50		
	8:00			0.50		
	9:00					
	10:00					
Max.		48.00	25.00	28.00	27.00	32.90
Total		78.50	56.00	60.50	54.50	77.70

Table 7.9 Annual Maximum Discharge at Dran Dam Site

No.	Year	Date	Discharge (m3/sec)
1	1932	4 May	2,500
2	1934	10 Oct.	155
3	1935	10 Nov.	235
4	1936	11 Oct.	250
5	1937	12 Oct.	550
6	1938	12 Oct.	650
7	1939	1 Dec.	800
8	1940	15 Sep.	210
9	1941	4 Nov.	120
10	1942	29 Oct.	900
11	1943	27 Oct.	700
12	1944	13 Dec.	280
13	1949	10 Dec.	435
14	1950	19 Nov.	150
15	1951	22 Sep.	190
16	1952	21 Oct.	1,160
17	1953	23 Nov.	290
18	1954	3 Dec.	520
19	1955	5 Nov.	360
20	1956	3 Oct.	122
21	1957	10 Oct.	133
22	1958	29 Oct.	135
23	1959	14 Oct.	318
24	1960	1 Oct.	750
25	1961	3 Oct.	46
26	1962	22 Oct.	1,434
27	1965	28 Nov.	201
28	1966	6 Dec.	91
29	1967	28 Nov.	161
30	1968	20 Oct.	820
31	1969	5 Oct.	78
32	1970	29 Oct.	380
33	1971	26 Nov.	167
34	1972	5 Dec.	124
35	1979	18 Nov.	800
36	1980	5 Oct.	373
37	1981	14 Oct.	933
38	1982	25 Mar.	67
39	1983	17 Oct.	856
40	1984	12 Oct.	146
41	1985	2 Oct.	146
42	1986	2 Dec.	810
43	1987	8 Nov.	474
44	1988	6 Nov.	1,375
45	1989	10 Jul.	65
46	1990	11 Nov.	505
47	1991	22 Sep.	70
48	1992	23 Oct.	530
49	1993	9 Dec.	1,625

Data Source

Between 1932 and 1960 : Design Report on DaNhim Hydroelectric Project Part I 1962
Between 1961 and 1972 : Report on Observation and Study on the Dran Dam and Reservoir of Da Nhim Hydroelectric Project 1973
Between 1979 and 1993 : Da Nhim P/S office

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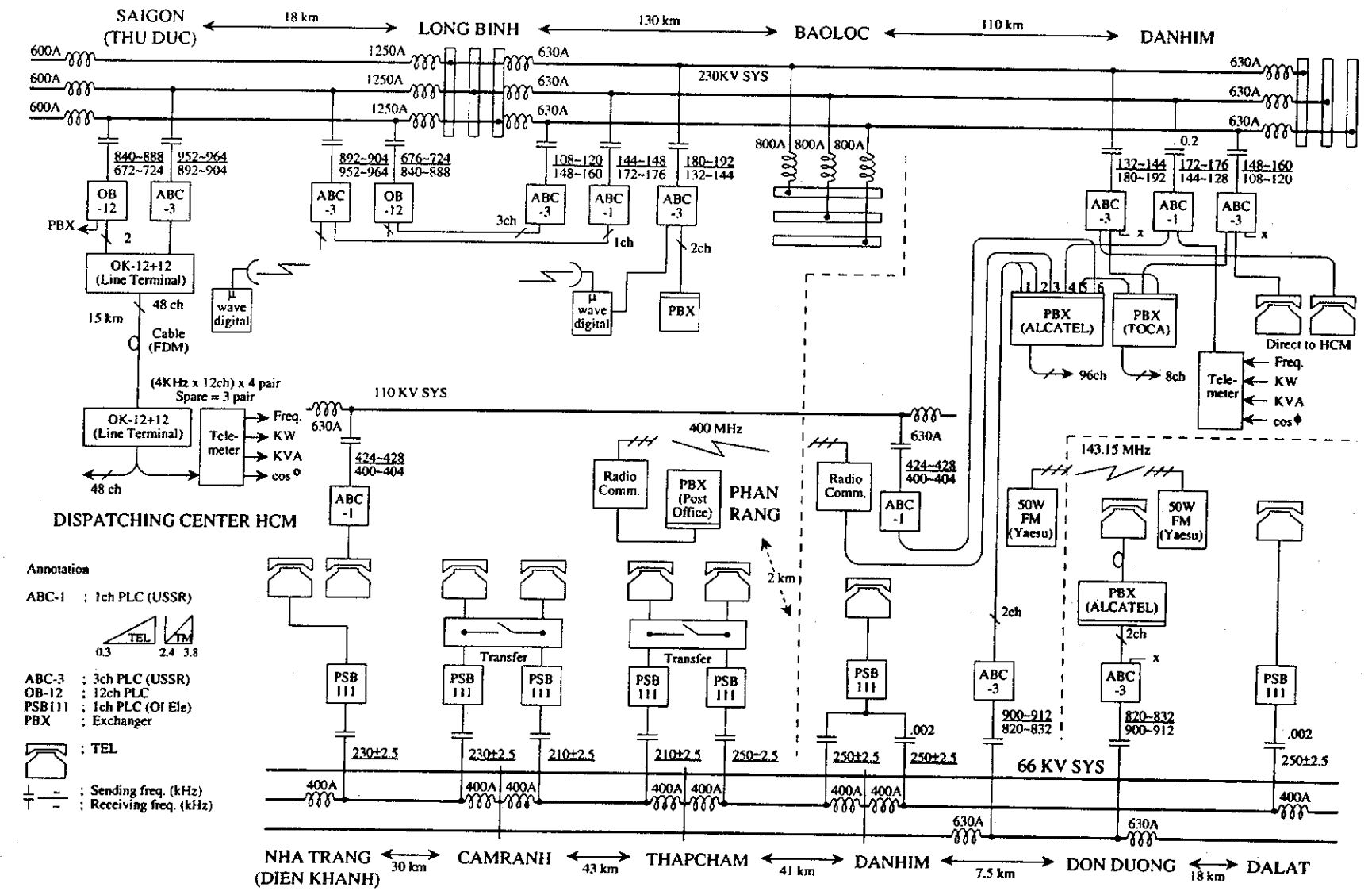
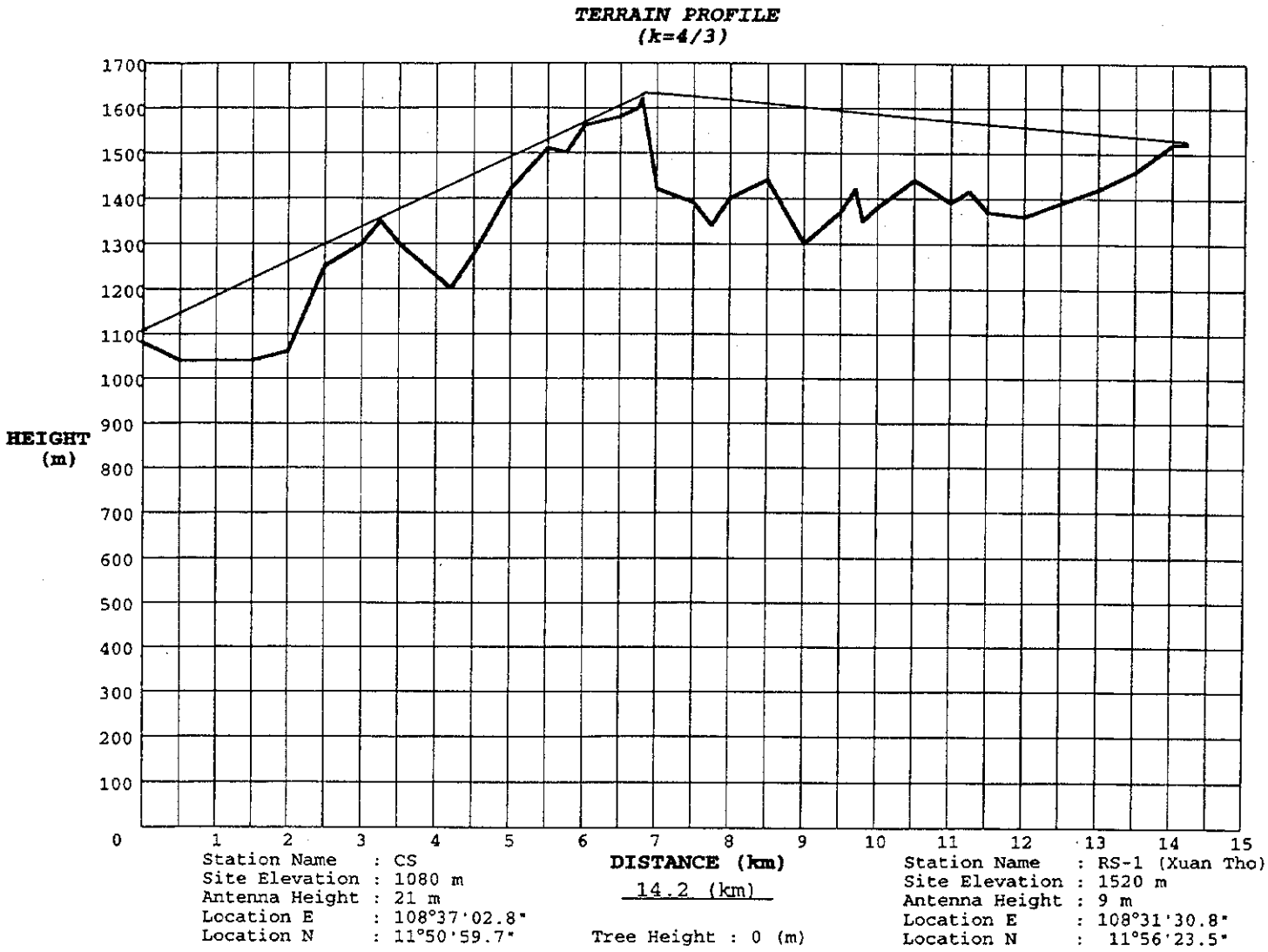
Ten tram	Ngay	Gio-Phut	So lieu mua	AC1	AC2	AC3	AC4	AC5	AC6	AC7	AC8	AC9	AC10	AC11	AC12	SOLAR1	SOLAR9
DASA	11/7/94	11 - 31	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	11 - 41	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	11 - 50	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	12 - 2	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	13 - 1	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	14 - 1	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	15 - 1	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 1	0.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 4	1.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 13	1.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 16	2.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 21	2.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 27	3.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 38	3.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	16 - 48	4.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	17 - 2	4.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	17 - 1	4.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	17 - 16	5.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	17 - 38	5.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	17 - 48	6.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DASA	11/7/94	19 - 0	6.00	T	T	T	T	T	F	T	T	T	T	T	T	F	F
DASA	11/7/94	19 - 0	6.50	T	T	T	T	T	F	T	T	T	T	T	T	F	F
DASA	11/7/94	21 - 1	6.50	T	T	T	T	T	F	T	T	T	T	T	T	F	F
DASA	11/7/94	22 - 1	6.50	T	T	T	T	T	F	T	T	T	T	T	T	F	F
DASA	11/7/94	23 - 1	6.50	T	T	T	T	T	F	T	T	T	T	T	T	F	F
DONDUONG	11/7/94	16 - 51	1.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DONDUONG	11/7/94	16 - 58	1.50	T	T	T	T	T	T	T	T	T	T	T	T	T	T
DONDUONG	11/7/94	17 - 42	2.00	T	T	T	T	T	T	T	T	T	T	T	T	T	T
XUANTHO	11/7/94	22 - 44	2,021.00	T	T	F	T	T	F	T	T	T	T	T	T	F	T
XUANTHO	11/7/94	22 - 48	2,021.50	T	T	F	T	T	F	T	T	T	T	T	T	F	T
XUANTHO	11/7/94	22 - 57	2,022.00	T	T	F	T	T	F	T	T	T	T	T	T	F	T
XUANTHO	11/7/94	22 - 28	2,022.50	T	T	F	T	T	F	T	T	T	T	T	T	F	T
XUANTHO	11/7/94	22 - 48	2,023.00	T	T	F	T	T	F	T	T	T	T	T	T	F	T

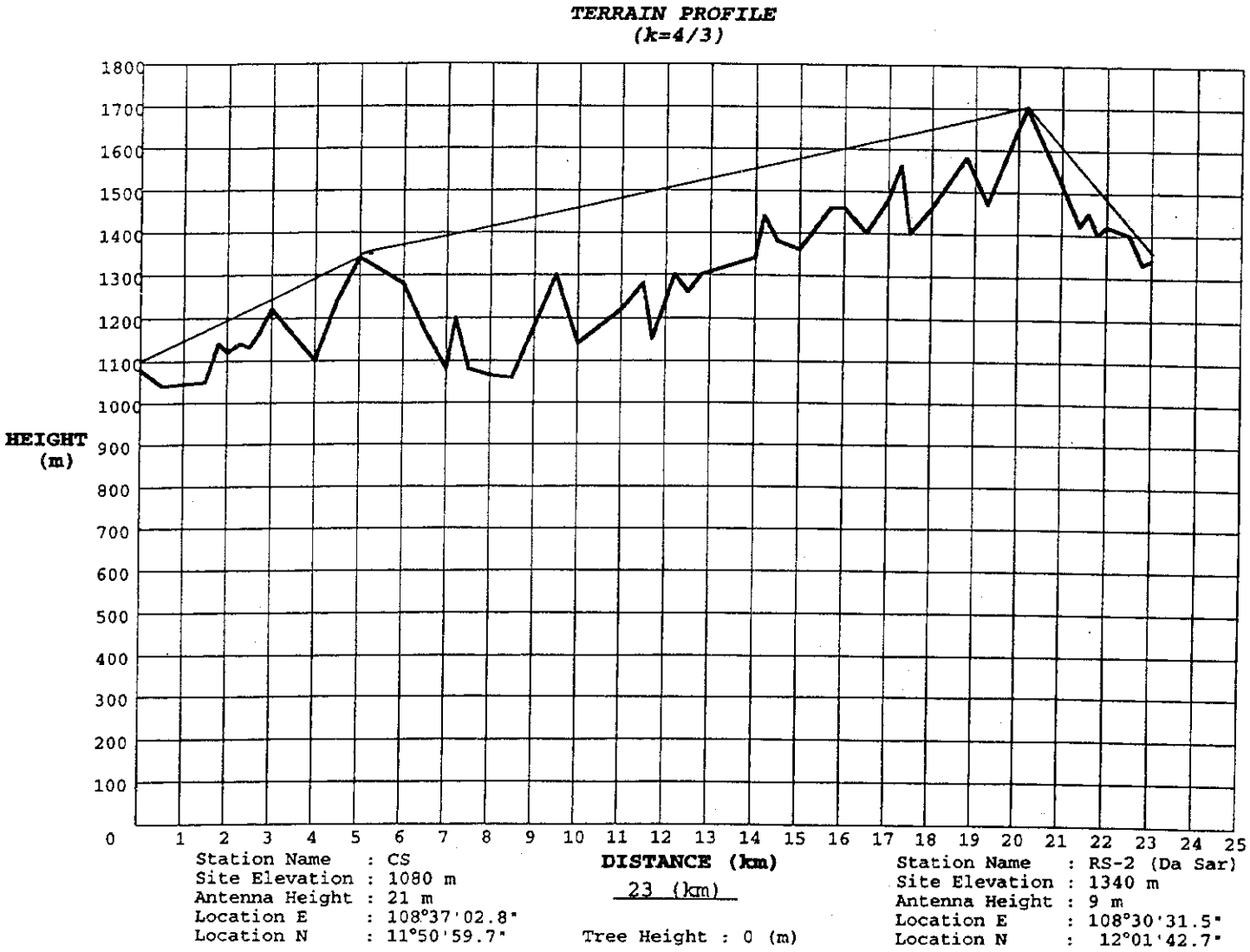
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.1 Example of Printed Out Sheet of Received Data



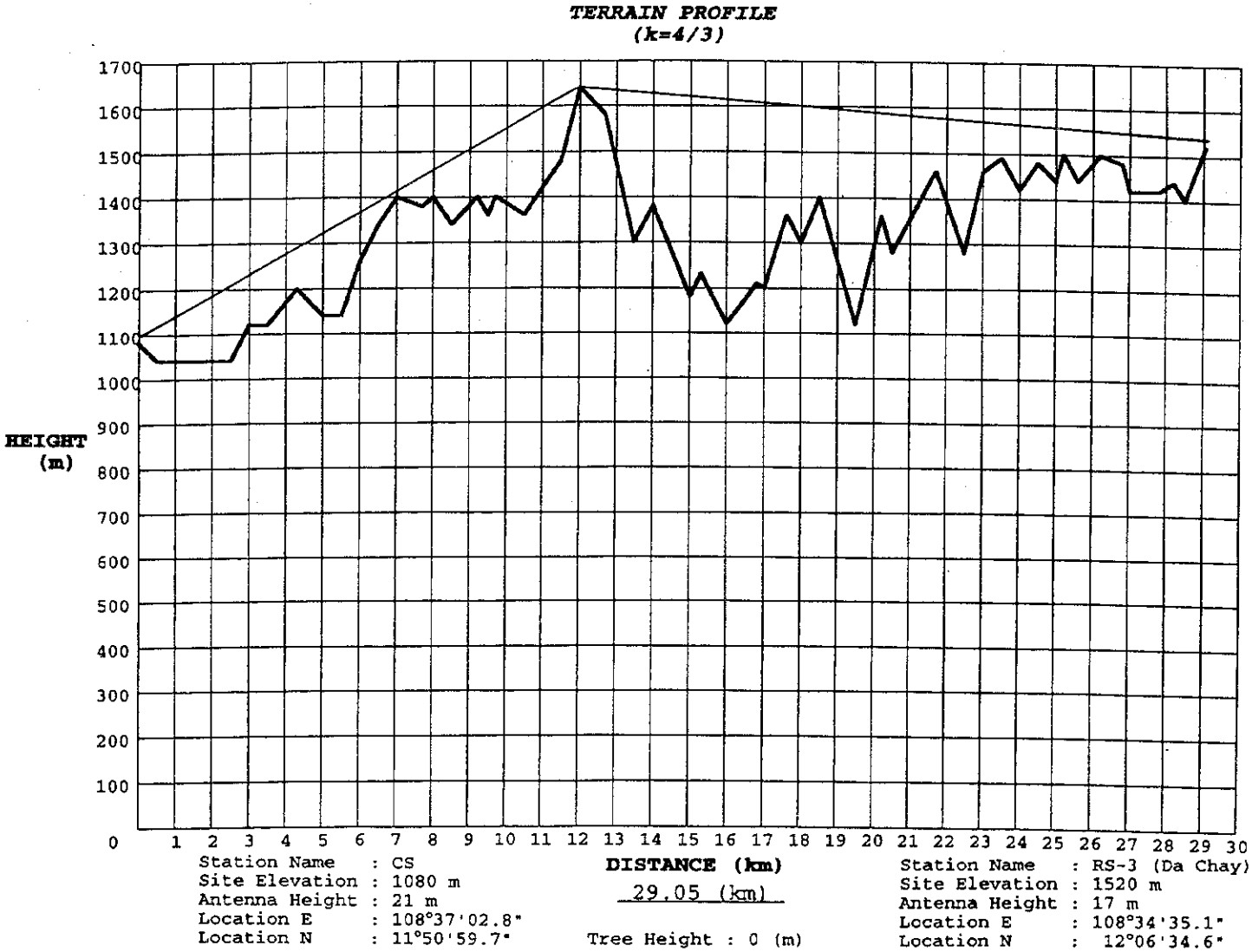
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.2 Present System of PLC Networks



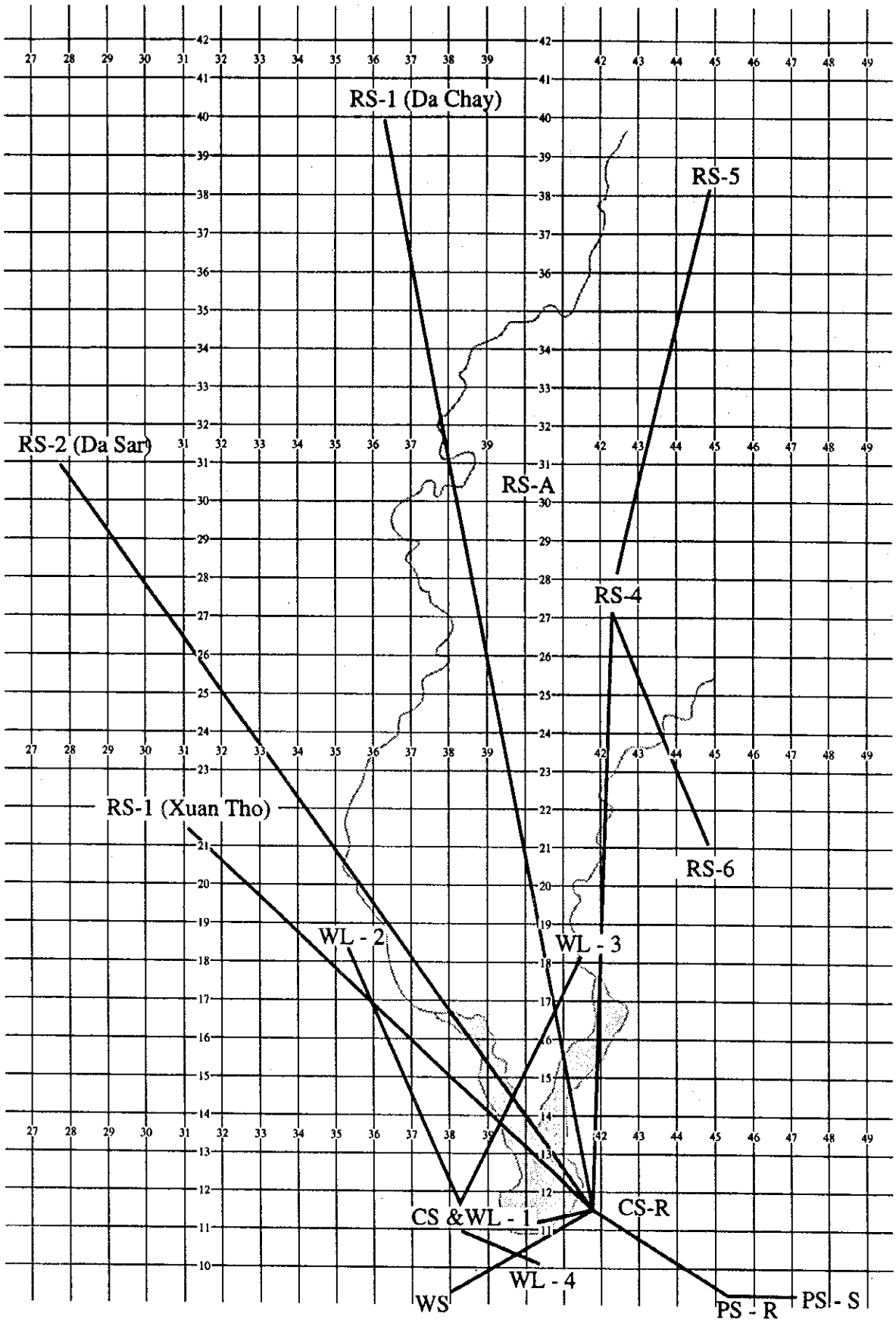
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.3 Profile Map



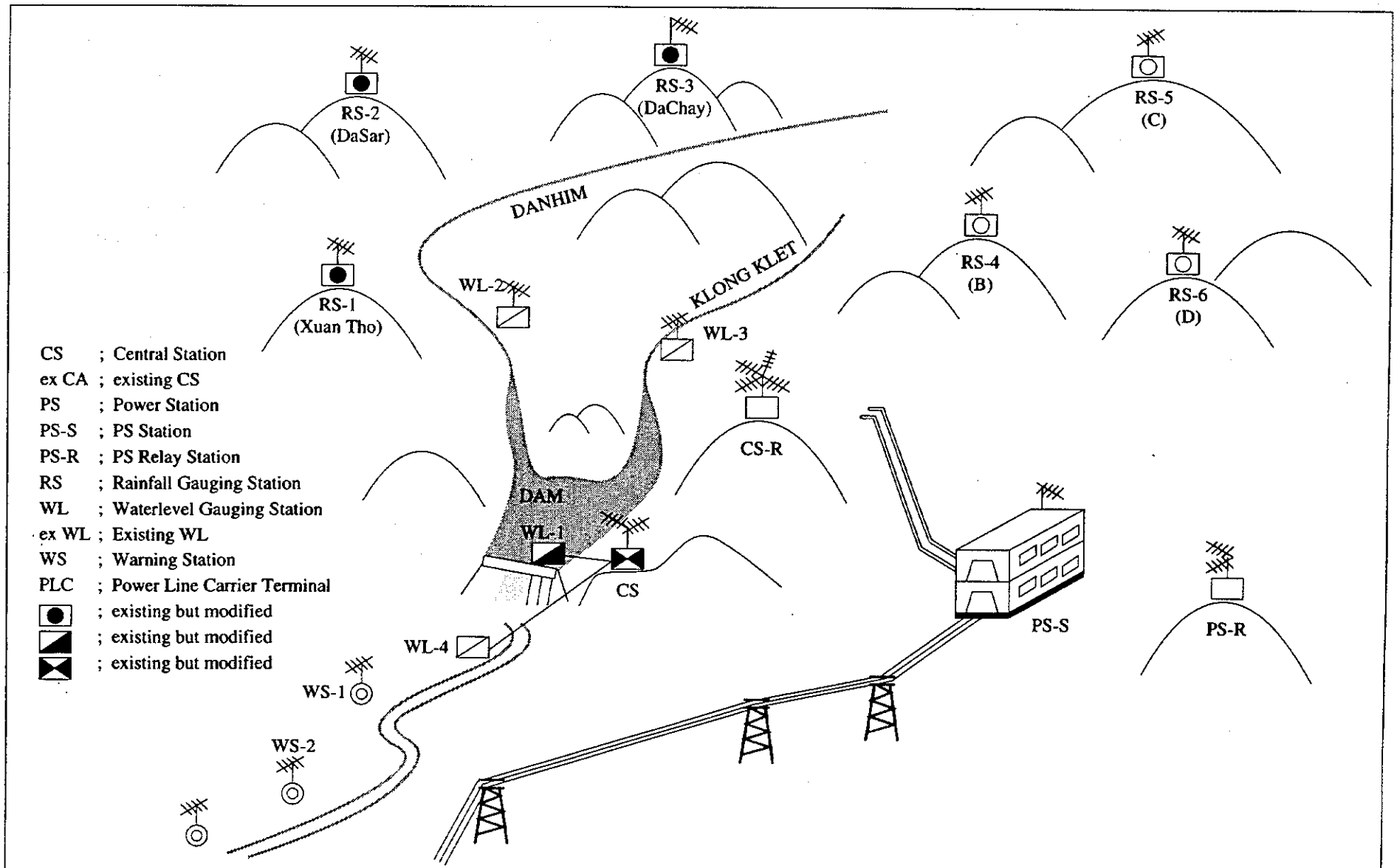
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.4 Profile Map



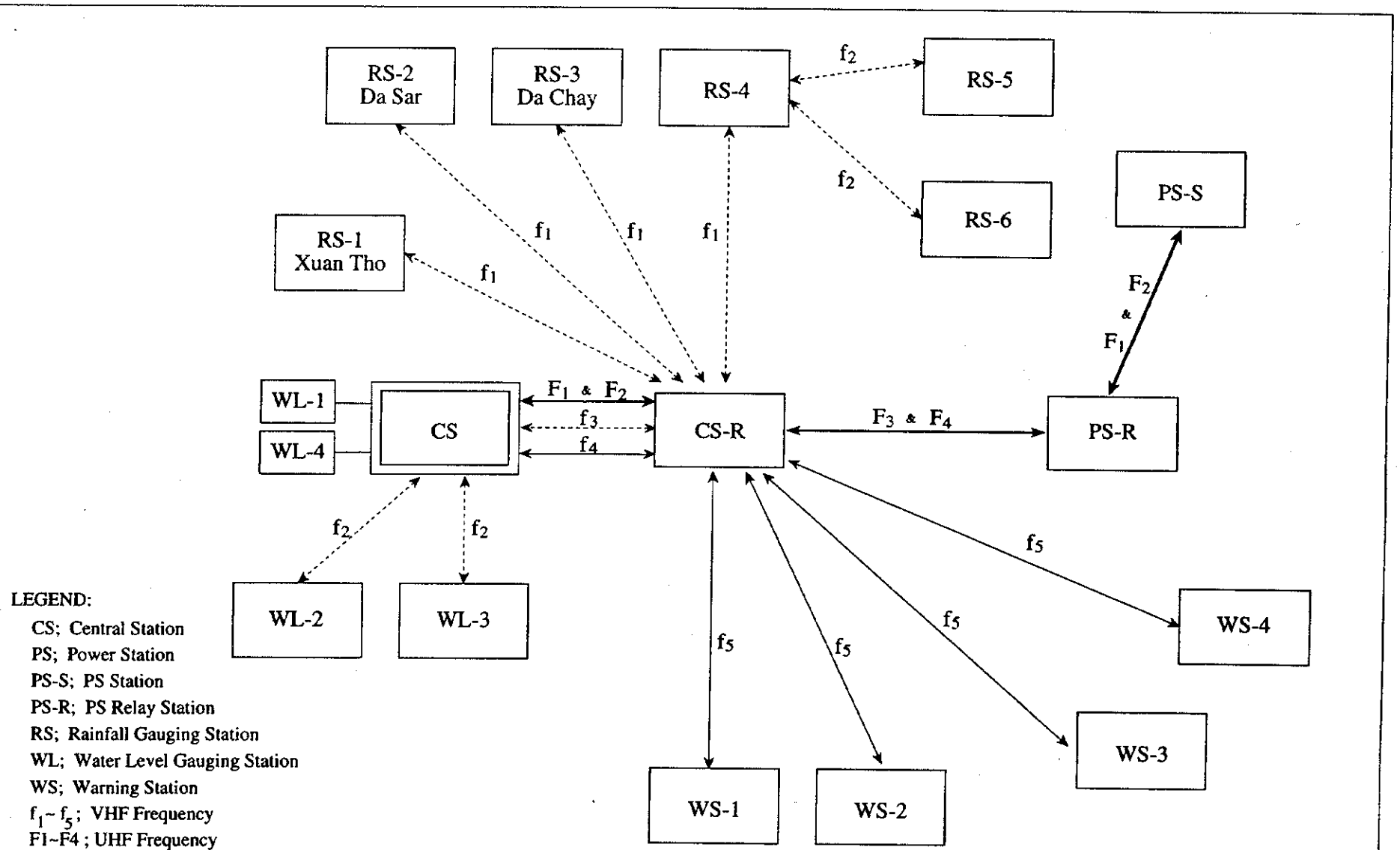
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.5 Profile Map



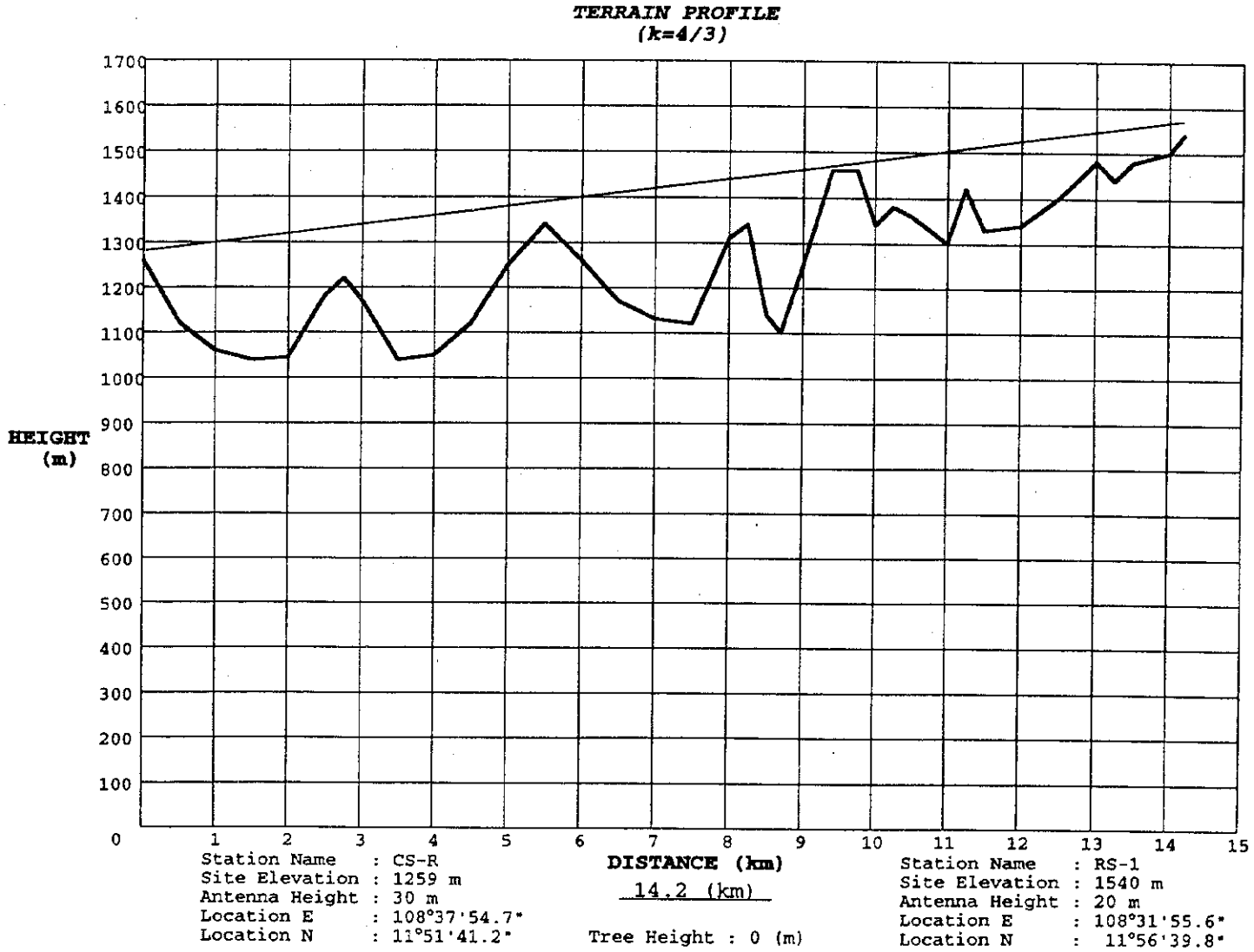
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.6 Proposed Station Site



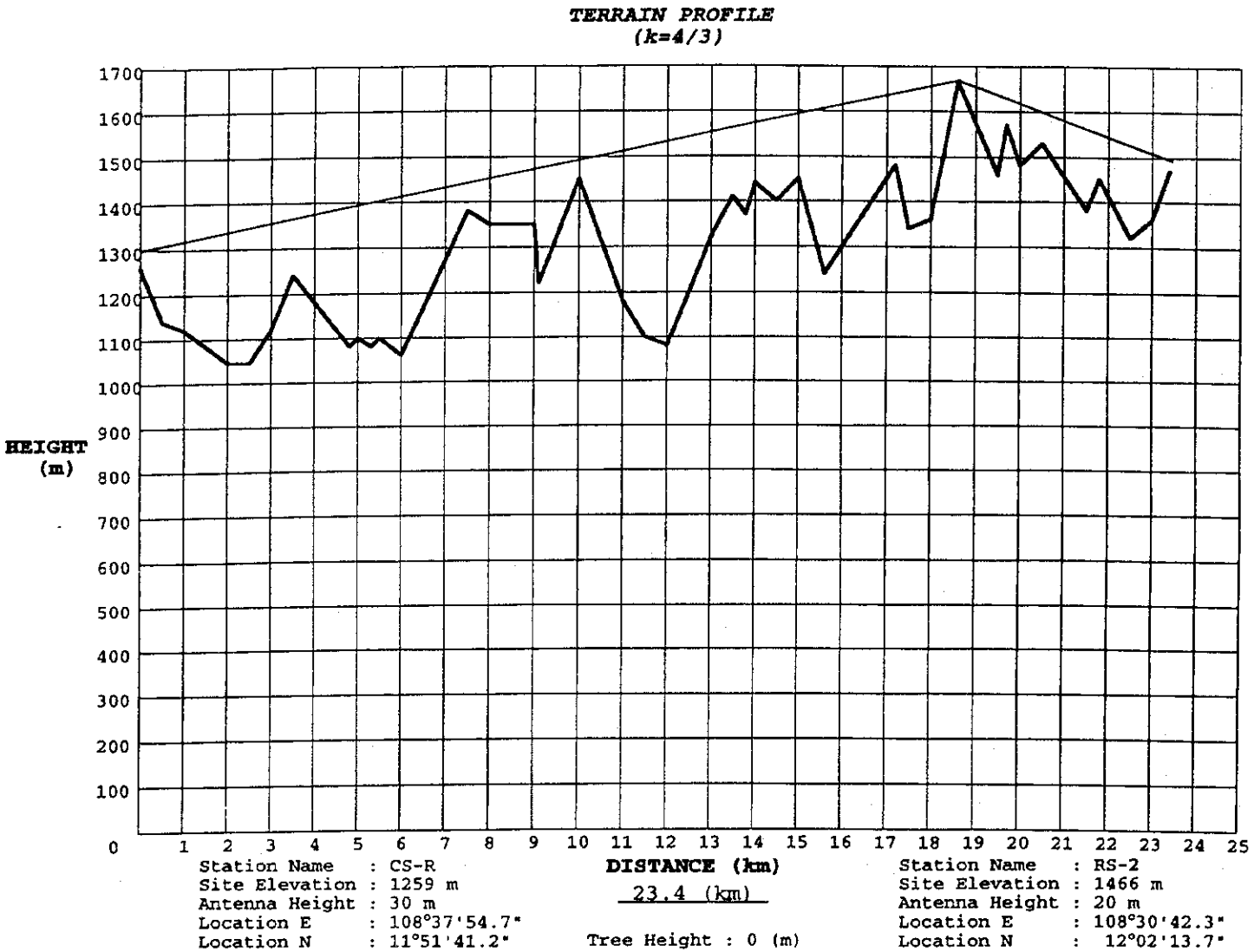
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.7 Conceptual Arrangement of Configuration of System



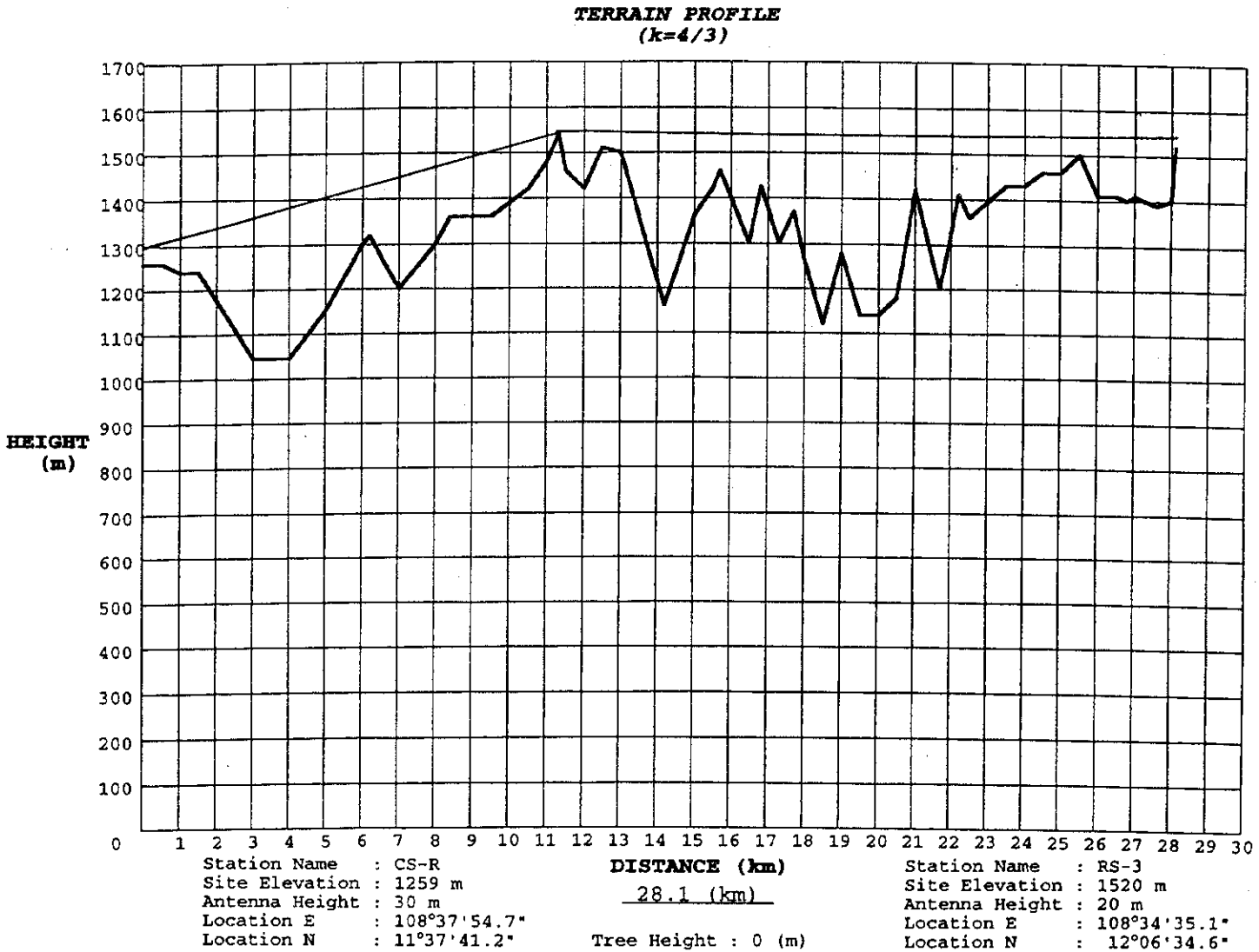
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.8 Outline of Configuration of System



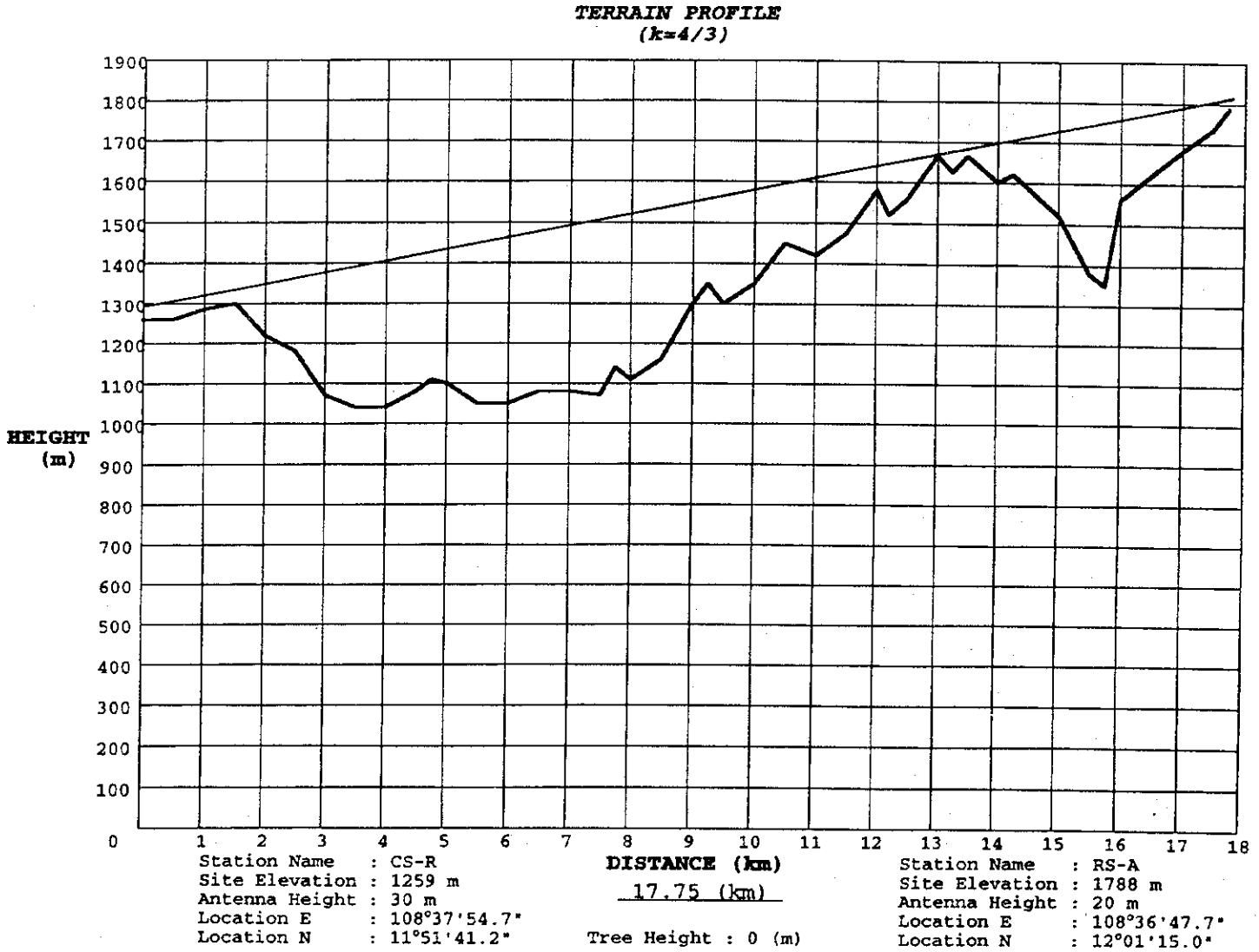
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.9 Profile Map



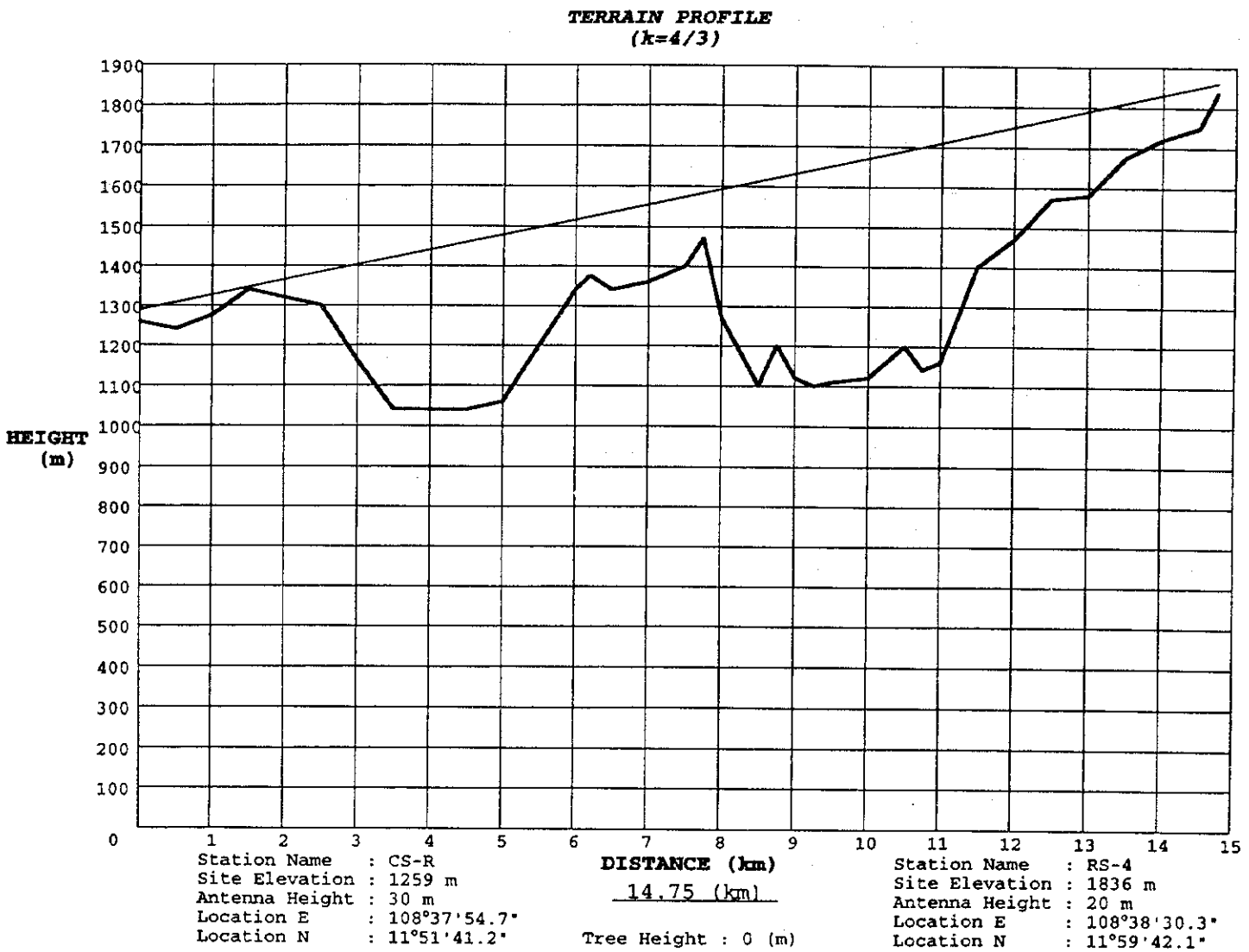
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.10 Profile Map



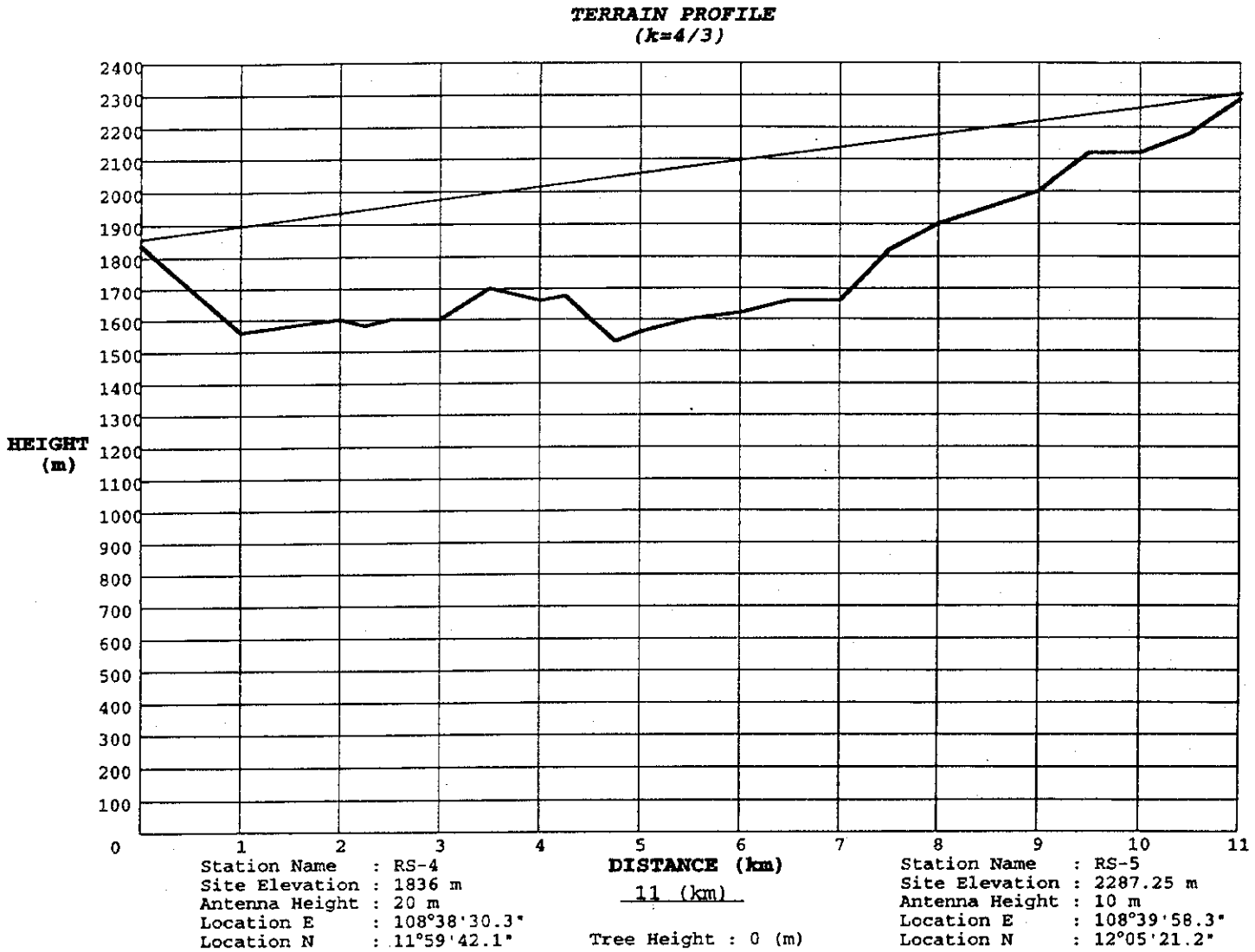
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.11 Profile Map



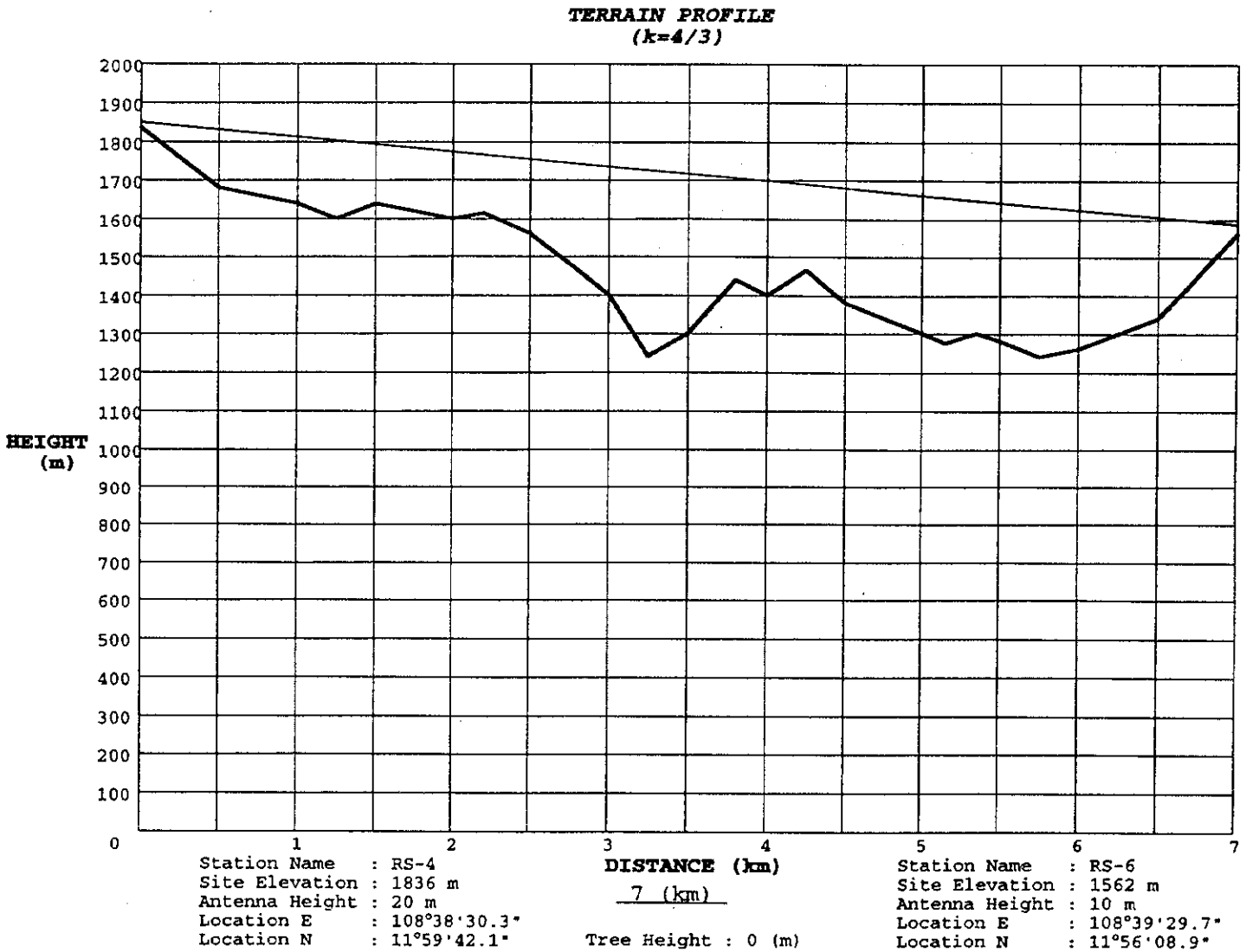
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.12 Profile Map



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.13 Profile Map

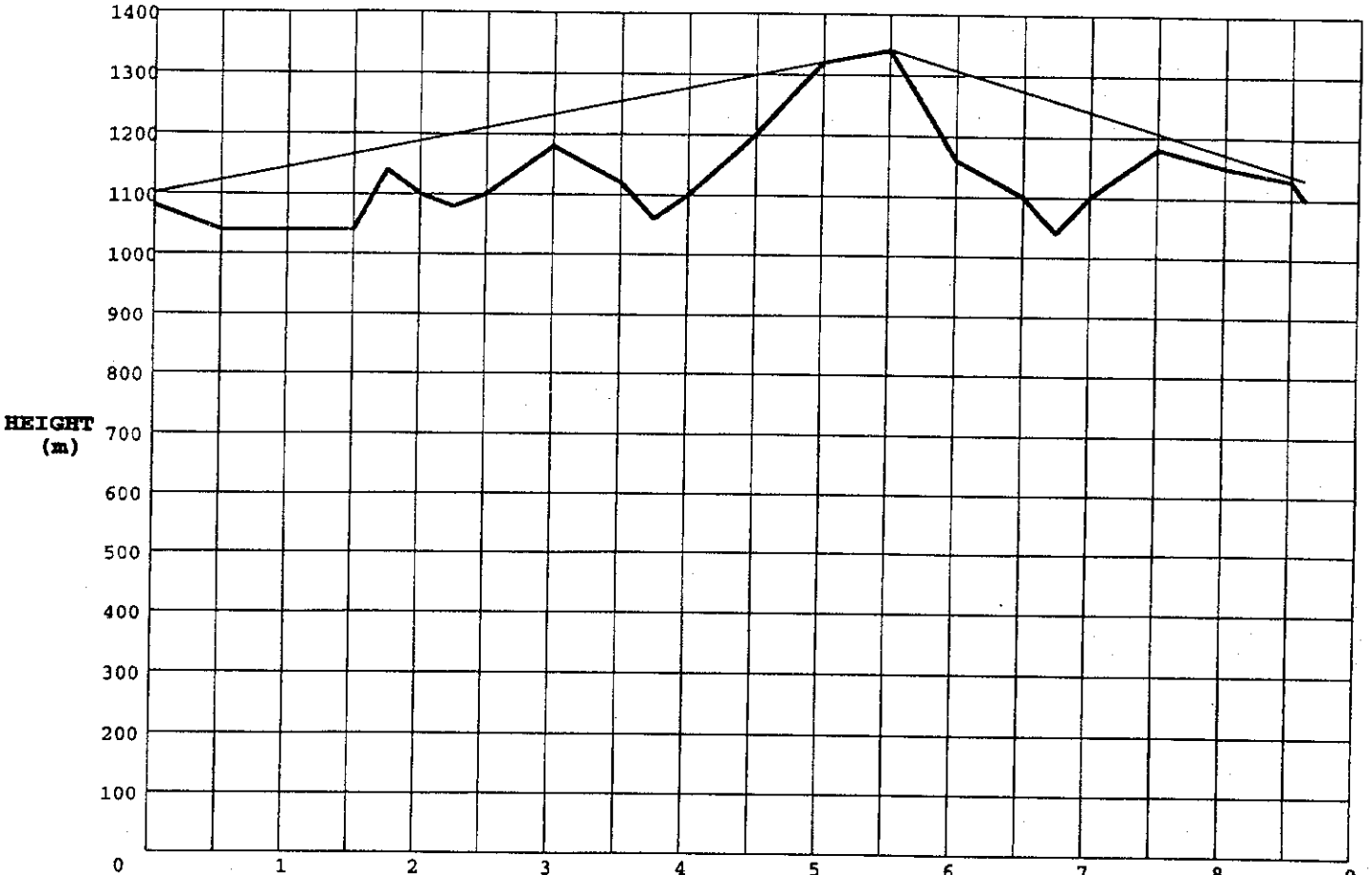


FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.14 Profile Map



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.15 Profile Map

TERRAIN PROFILE
(k=4/3)

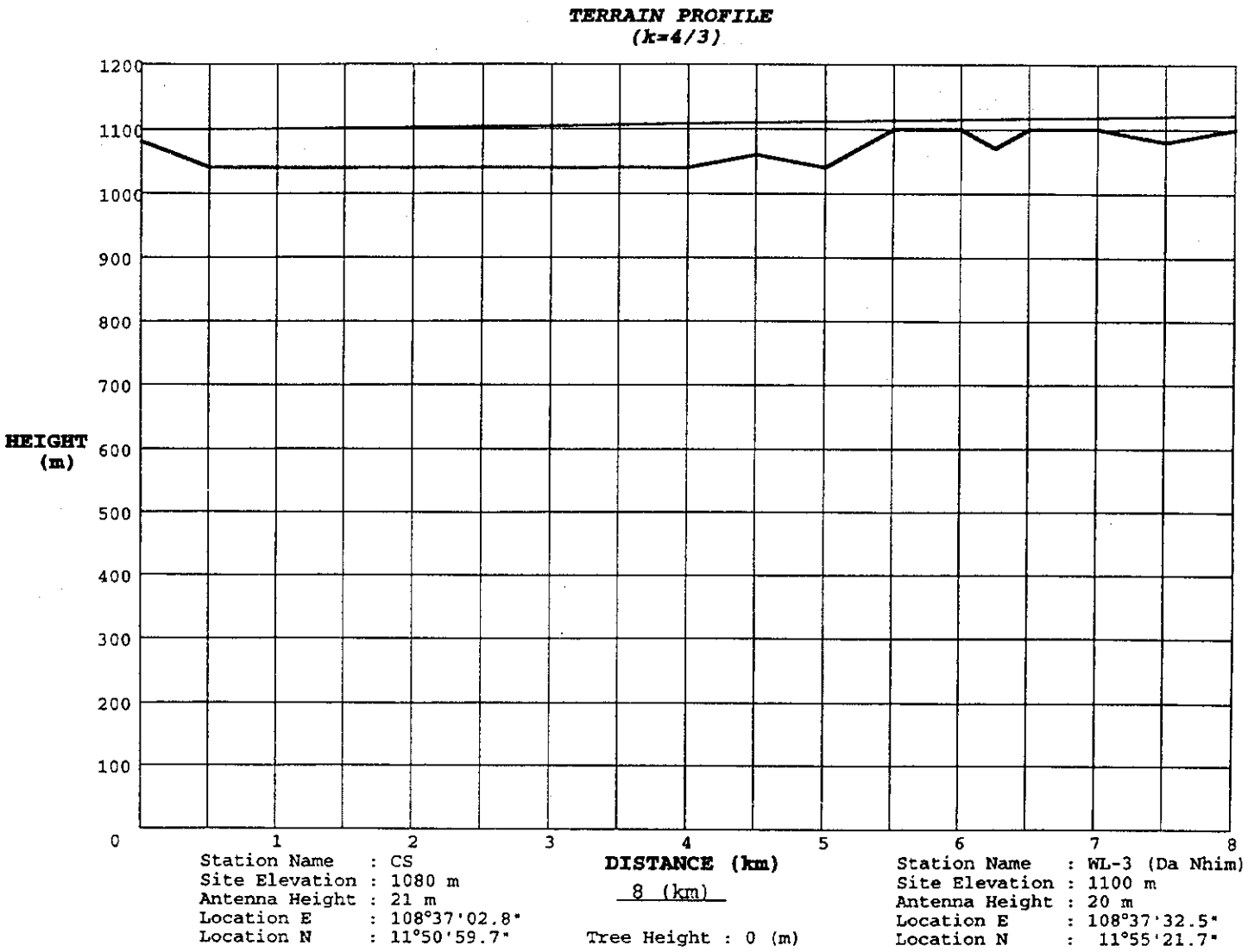


Station Name : CS
Site Elevation : 1080 m
Antenna Height : 21 m
Location E : 108°37'02.8"
Location N : 11°50'59.7"

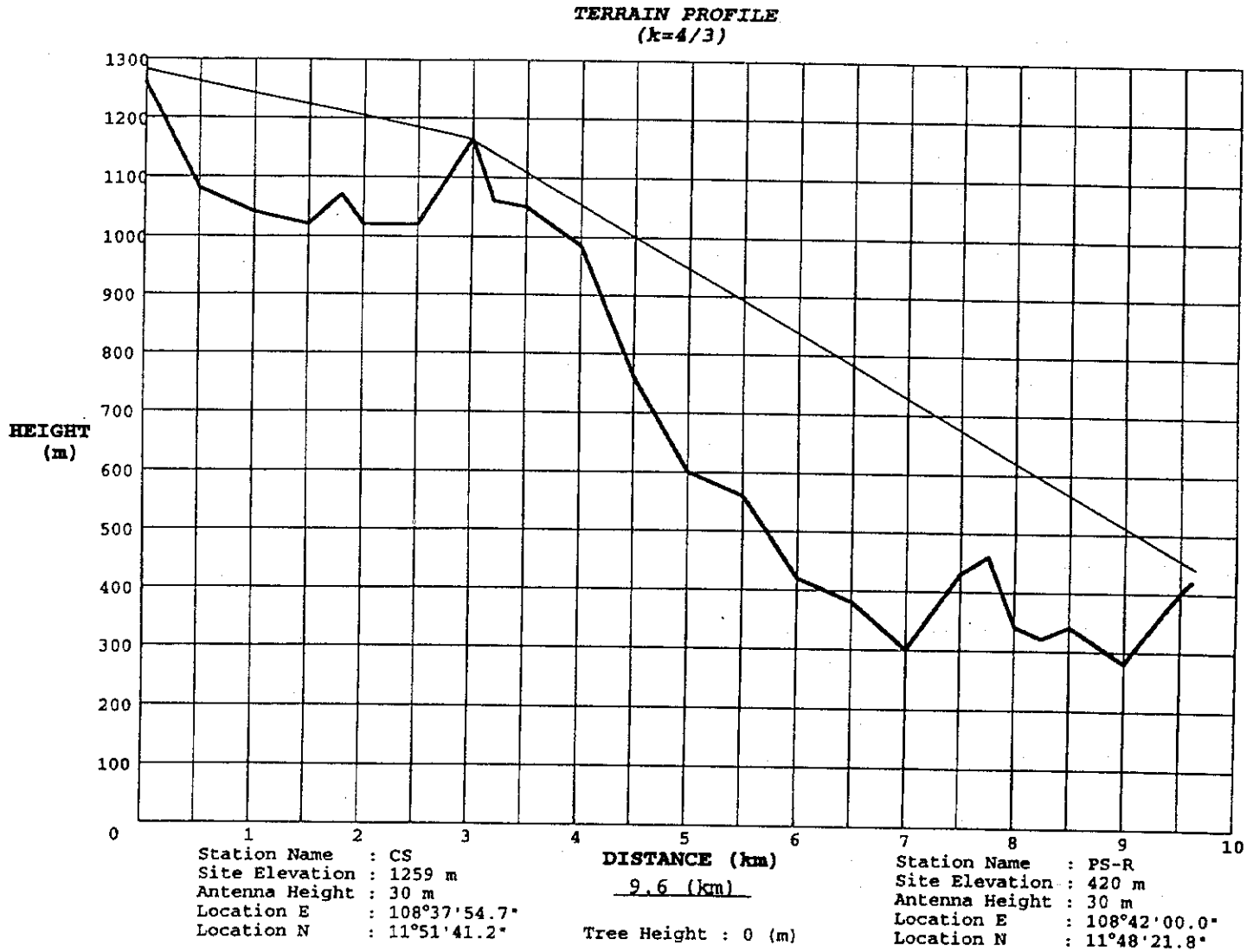
Tree Height : 0 (m)

Station Name : WL-2 (Da Nhim)
Site Elevation : 1100 m
Antenna Height : 40 m
Location E : 108°34'44.0"
Location N : 11°55'07.9"

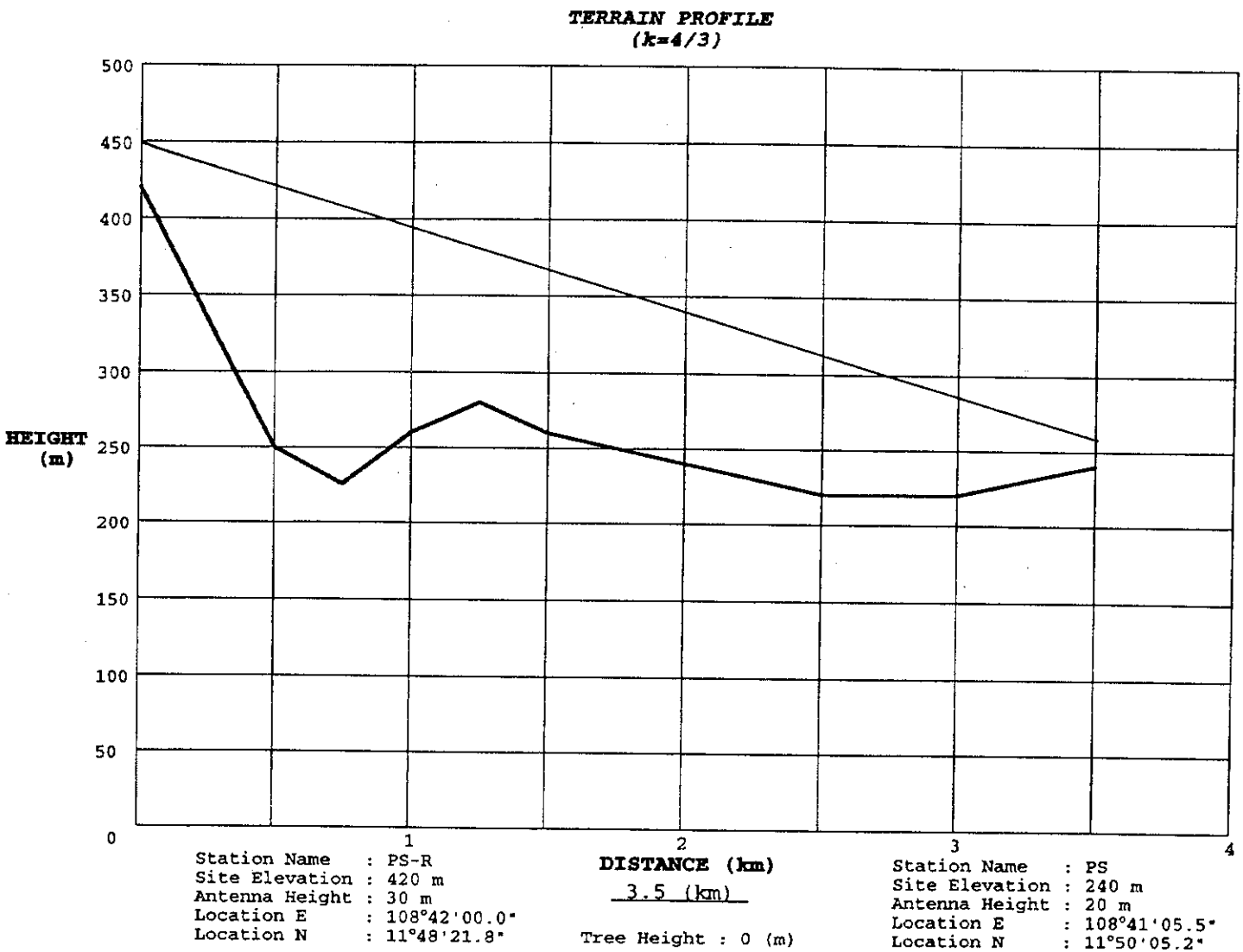
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.16 Profile Map



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.17 Profile Map



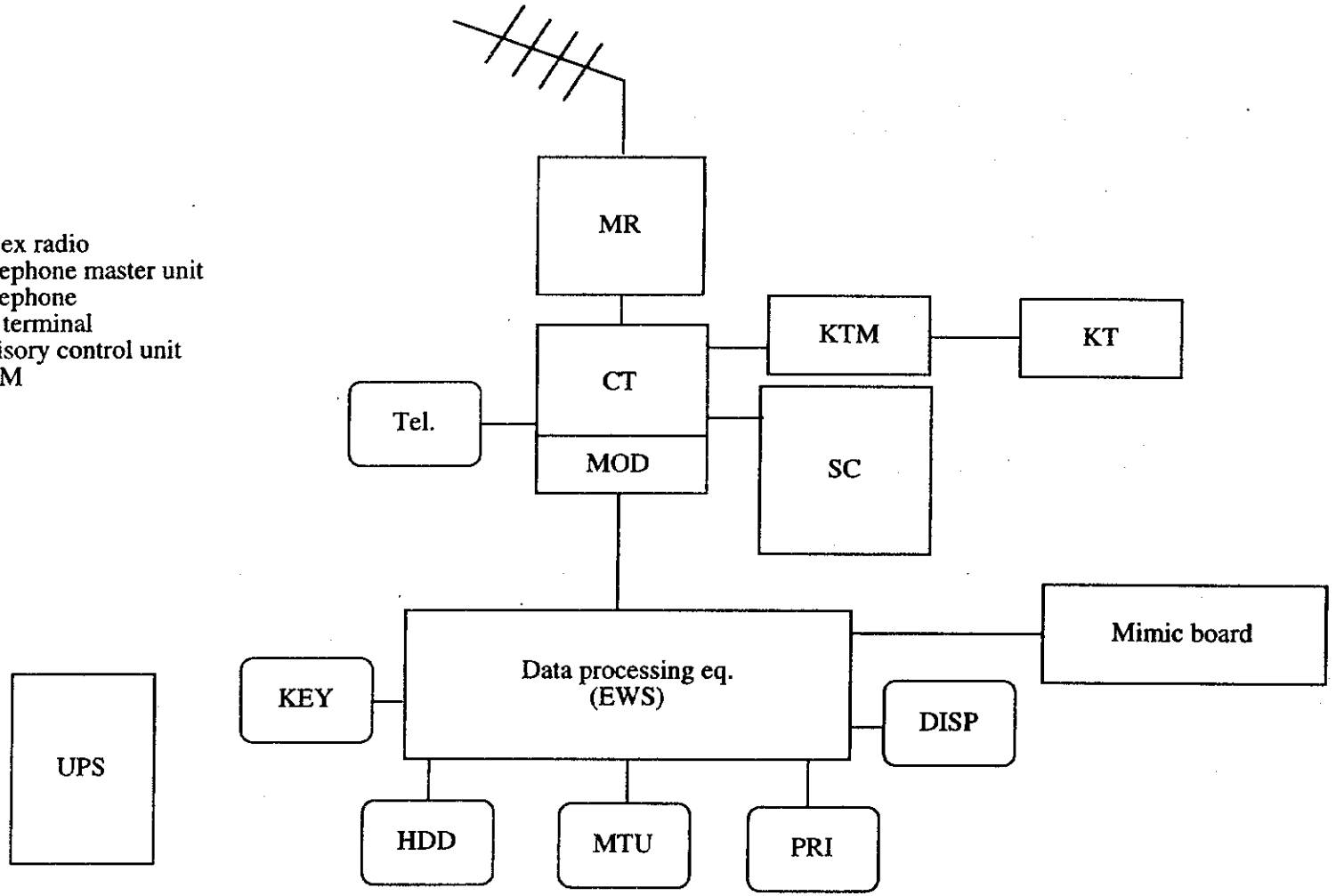
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.18 (1) Profile Map



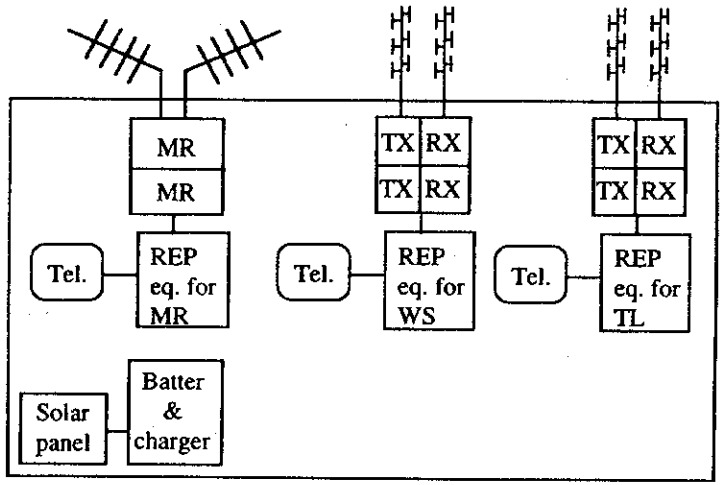
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.18 (2) Profile Map

LEGEND:

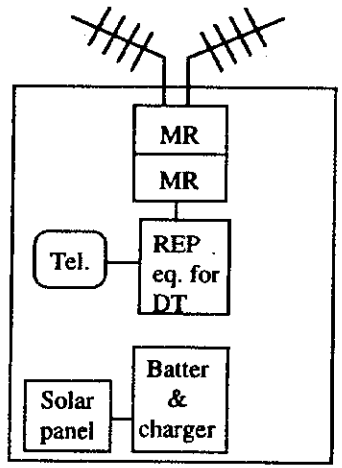
MR : Multiplex radio
KTM : Key telephone master unit
KT : Key telephone
CT : Carrier terminal
SC : Supervisory control unit
MOD : MODEM



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.19 Block Diagram of PS-S



CS-R

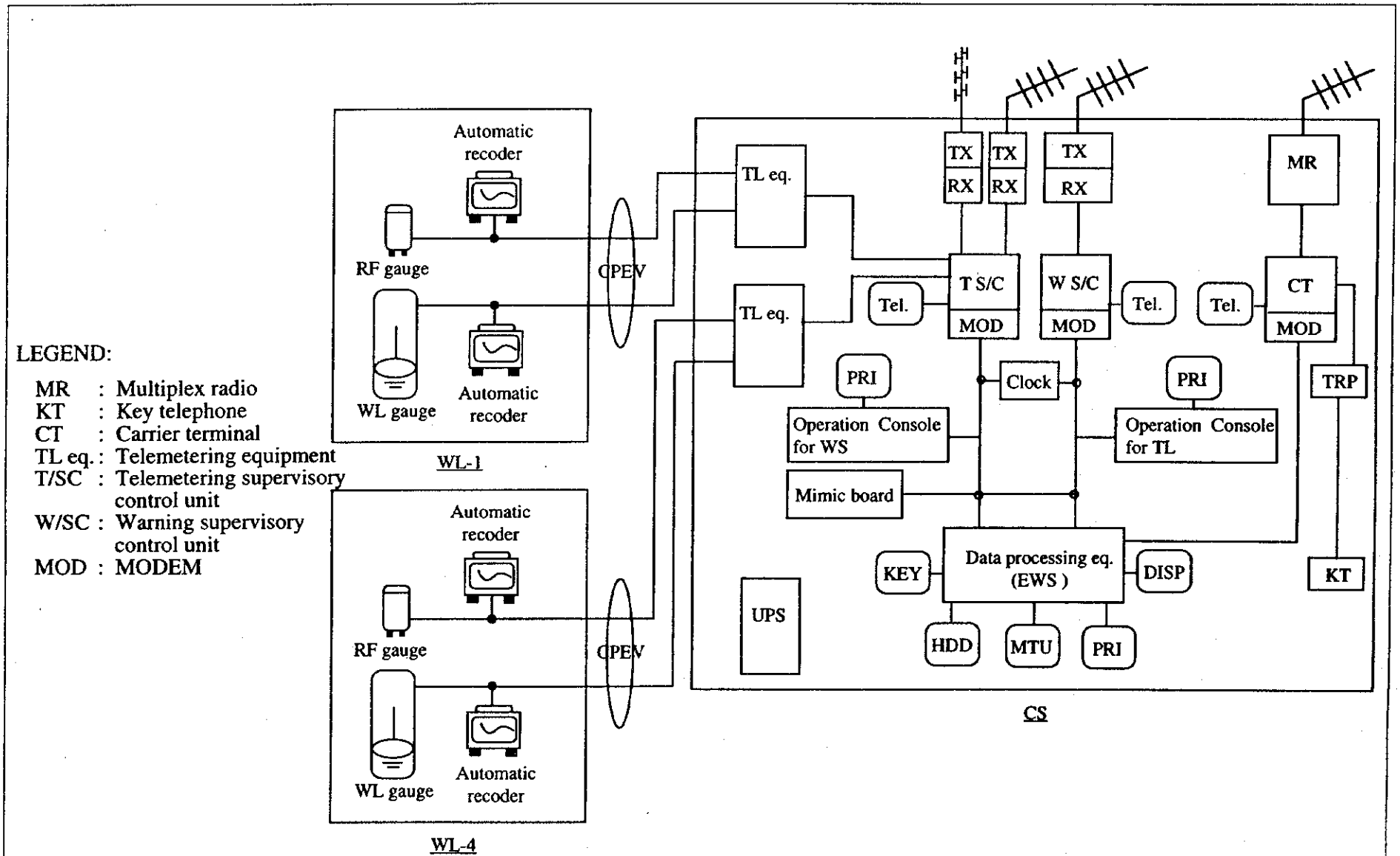


PS-R

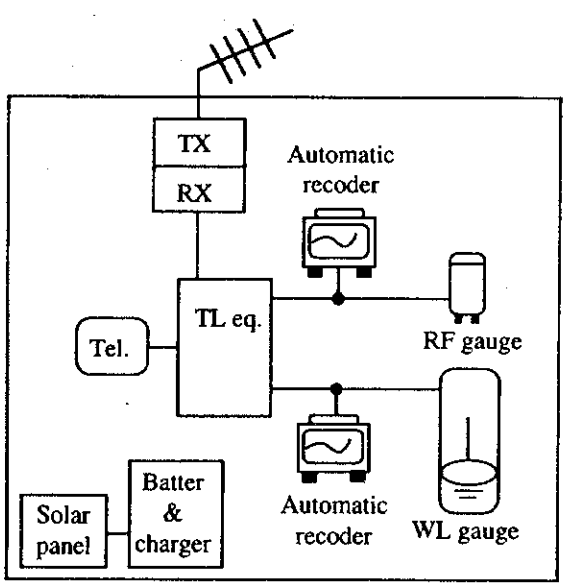
LEGEND:

TX : Transmitter
RX : Receiver
MR : Multiplex radio
REP : Repeater equipment

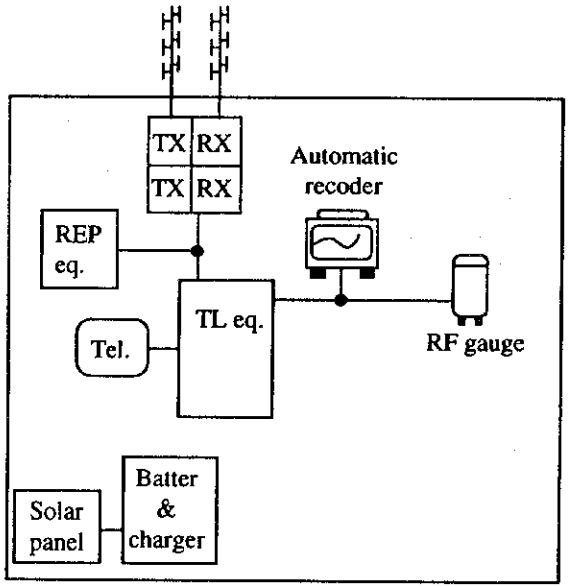
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.20 Block Diagram of PS-R and CS-R



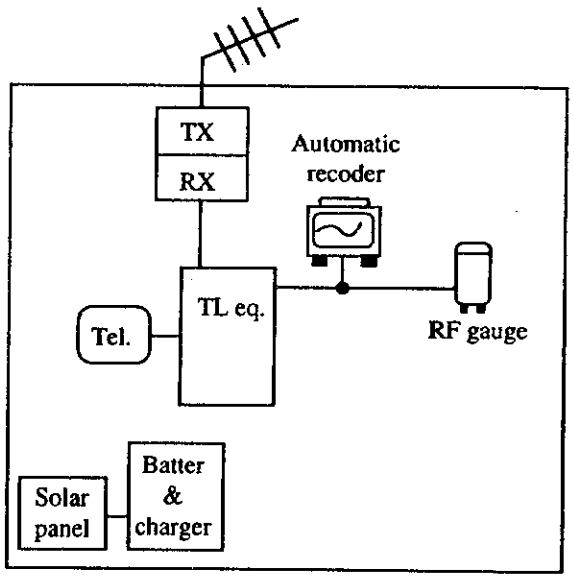
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.21 Block Diagram of CS, WL-1 and WL-2



WL



RS (Repeater type)

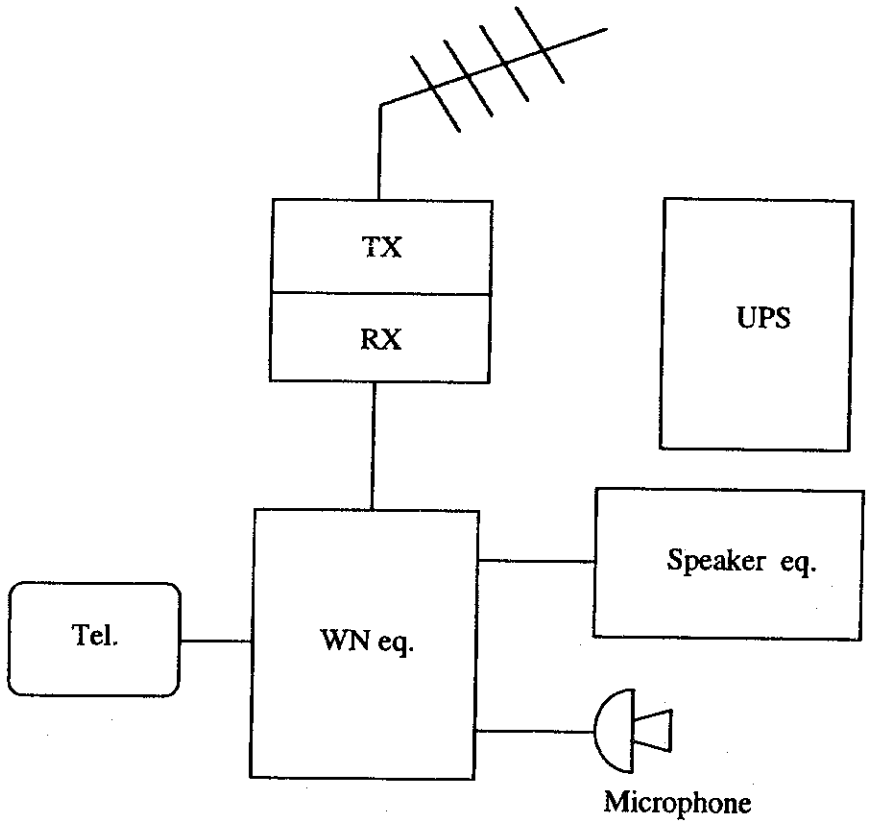


RS (Normal type)

LEGEND:

TX : Transmitter
RX : Receiver
REP eq. : Repeater equipment
TL eq. : Telemetering equipment

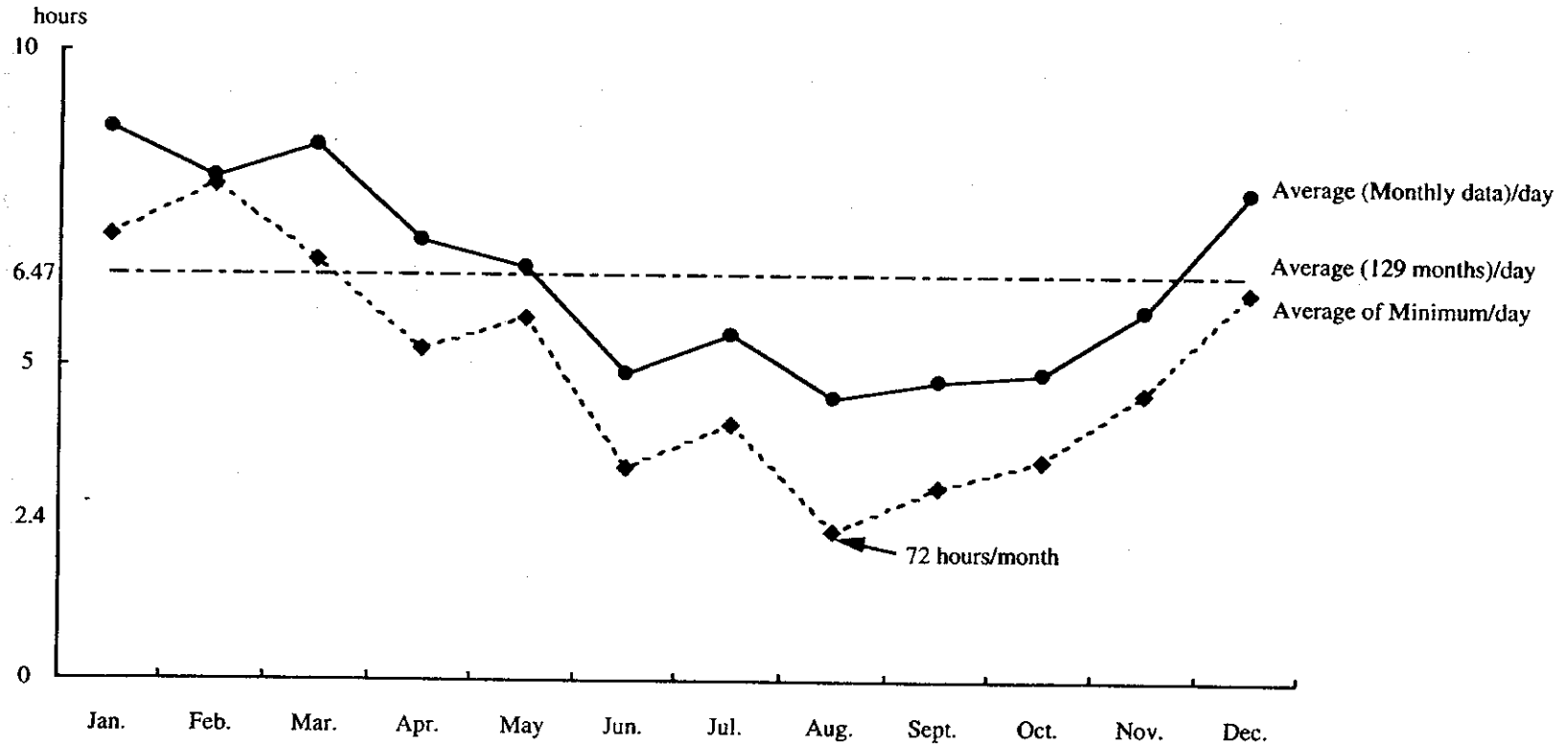
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.22 Block Diagram of RS and WL



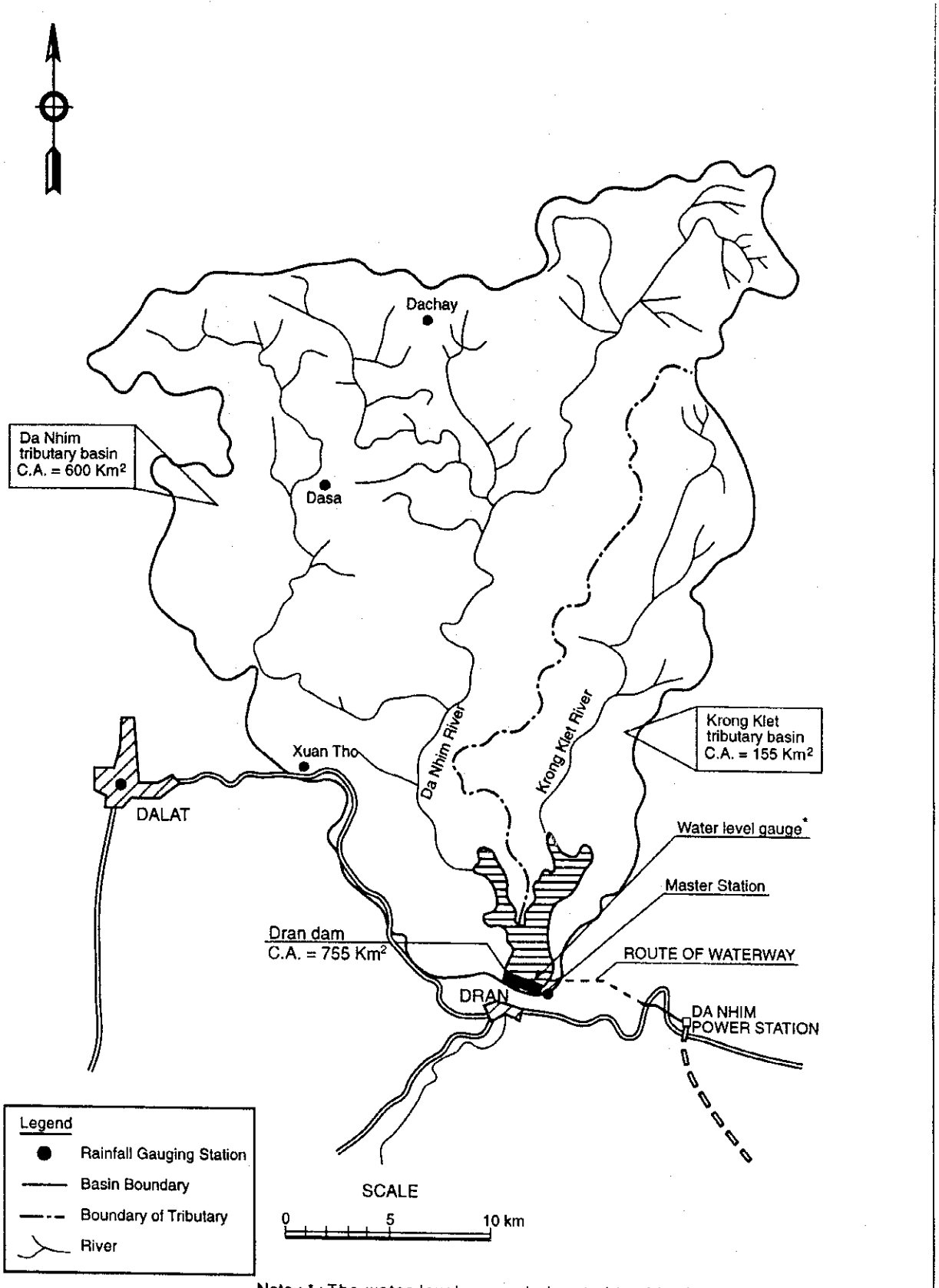
LEGEND:

TX : Transmitter
RX : Receiver
REP eq. : Repeater equipment
TL eq. : Telemetering equipment

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.23 Block Diagram of WS

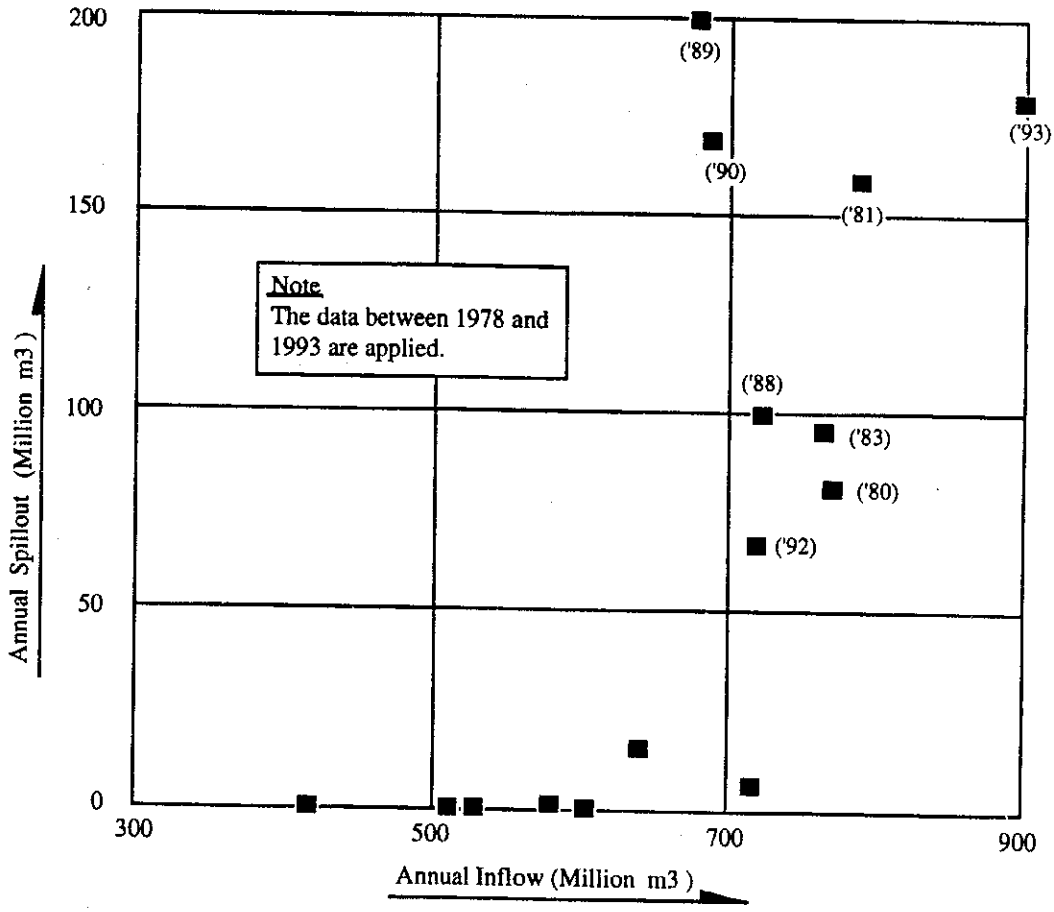


FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.24 Sunshine Hours a Day in Period of 11 Years



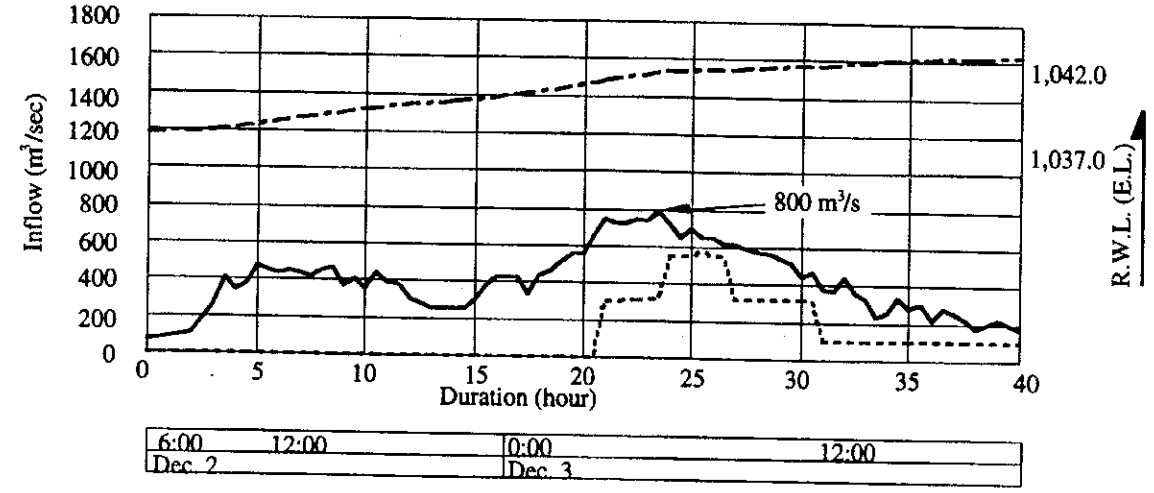
Note : * ; The water level gauge is located beside the spillway for gauging the reservoir water level.

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.25 Location Map of Existing Rainfall Stations and Tributary Basins

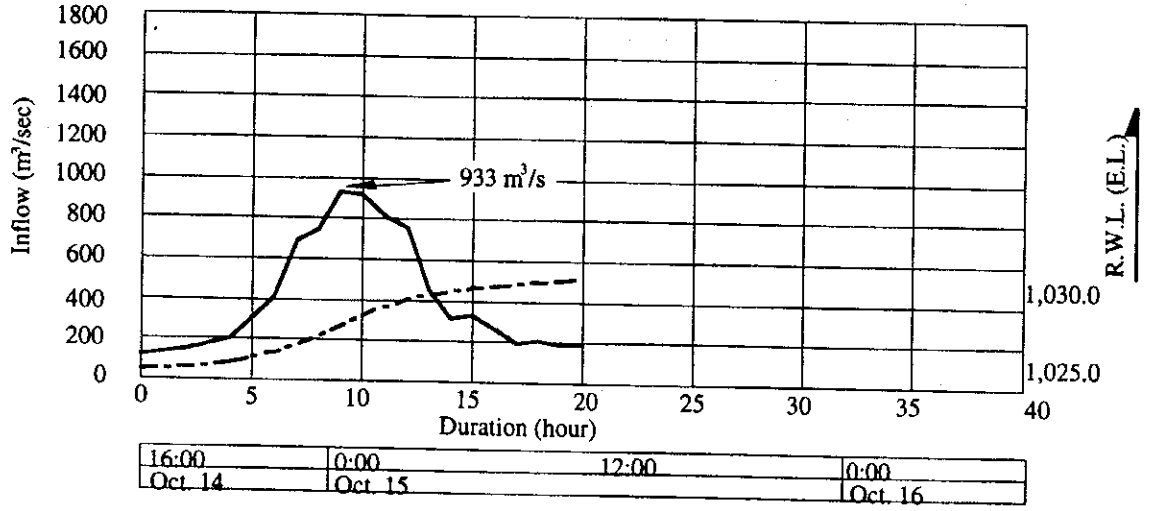


FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.26 Relationship between Annual Inflow and Spillout

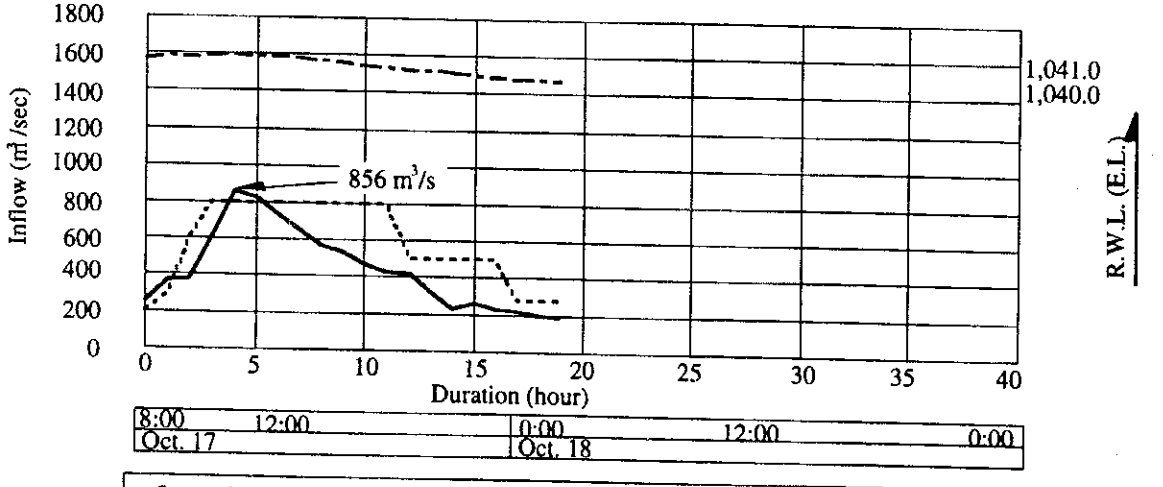
Nov. 17-19. 1979



Oct. 14-15. 1981



Oct. 17-18. 1983

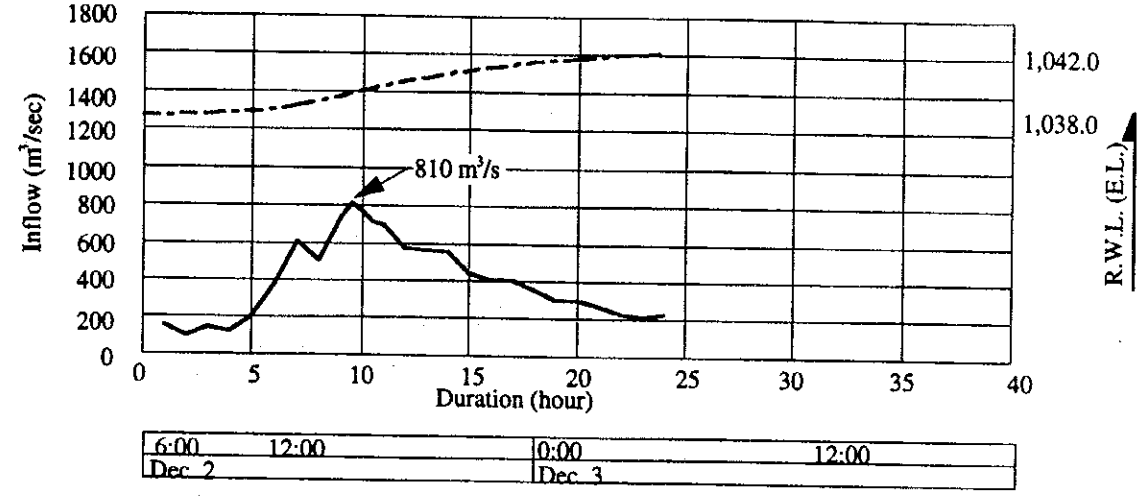


Legend

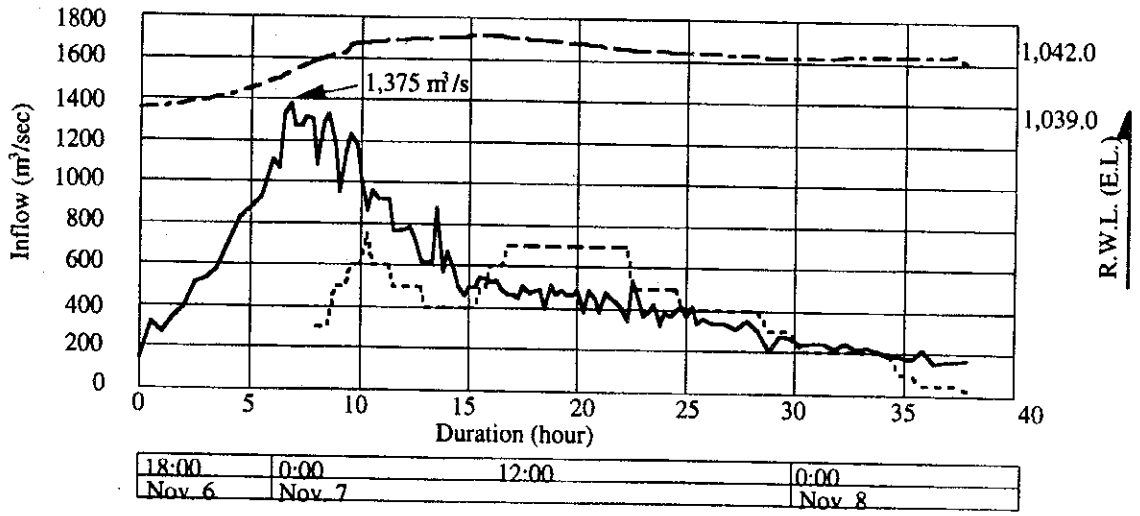
Inflow ····· Spillout - - - - Reservoir Water Level (R.W.L.)

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.27 (1) Observed Flood Hydrographies

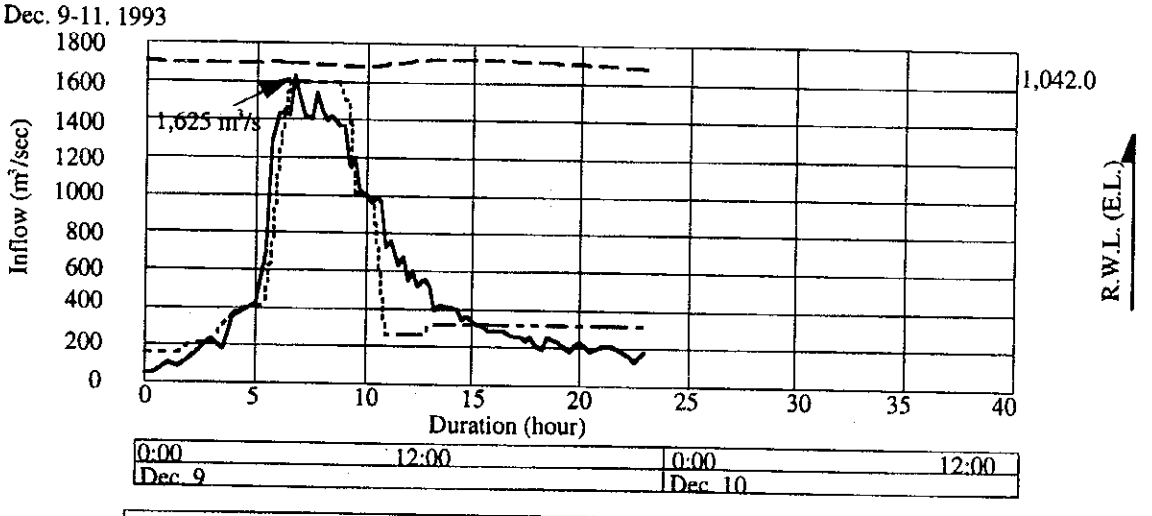
Dec. 2-3. 1986



Nov. 6-8. 1988



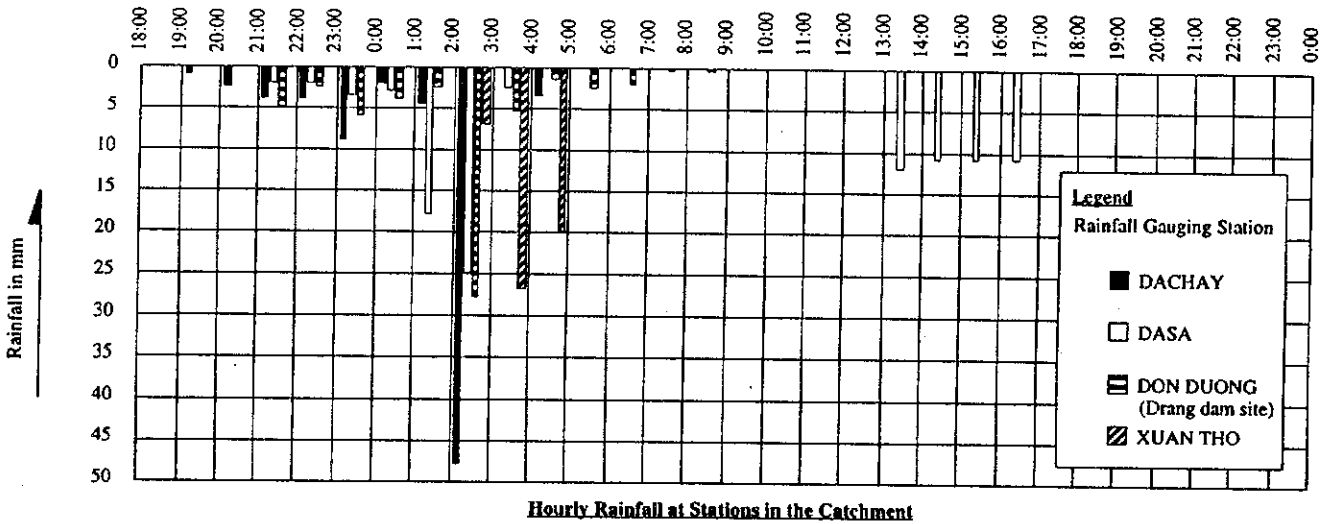
Dec. 9-11. 1993



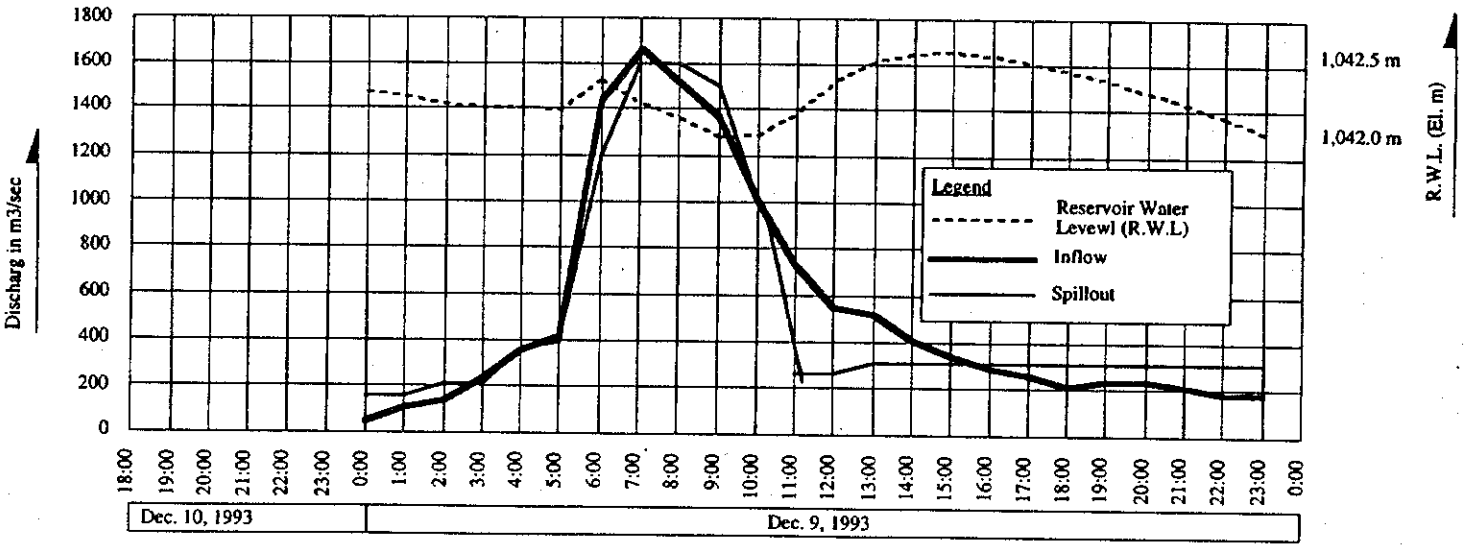
Legend

Inflow ····· Spillout - - - - Reservoir Water Level (R.W.L.)

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.27 (2) Observed Flood Hydrographies

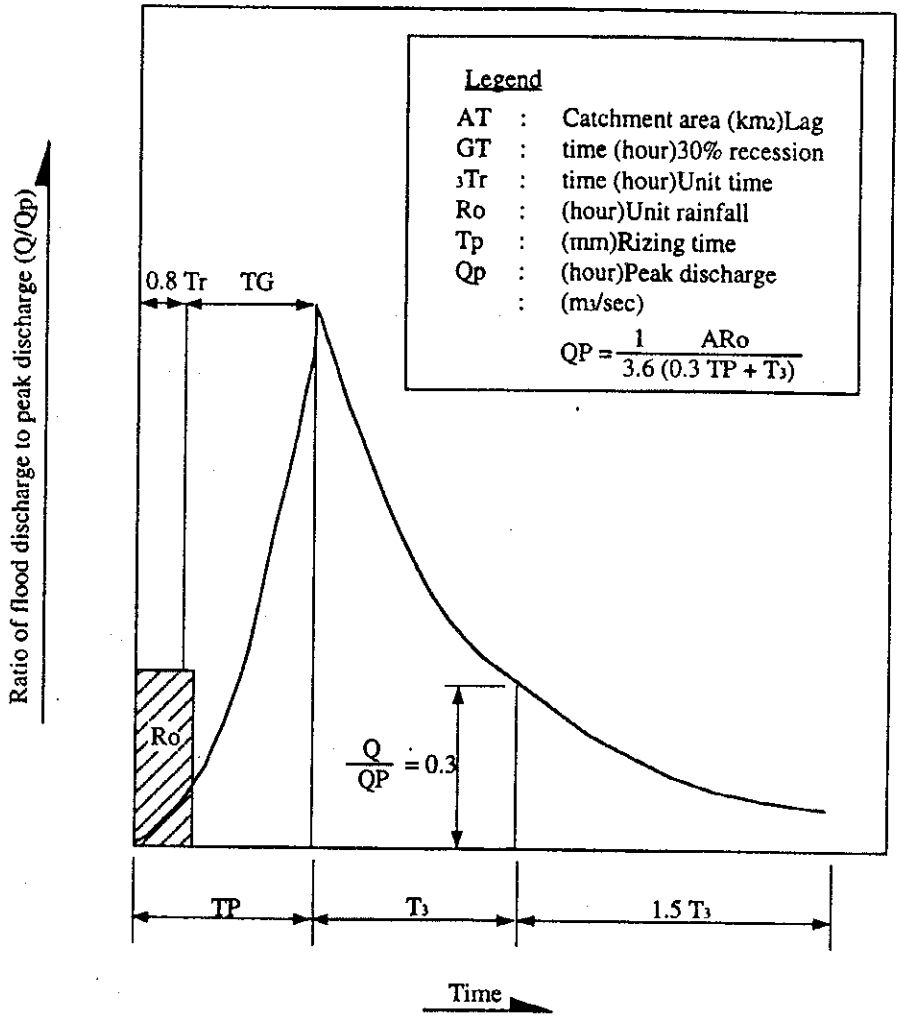


Hourly Rainfall at Stations in the Catchment



Flood Hydrograph

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.28 Meteo-Hydrological Records on the 1993 Flood



Nakayasu's Synthetic Unit Hydrograph

Formula

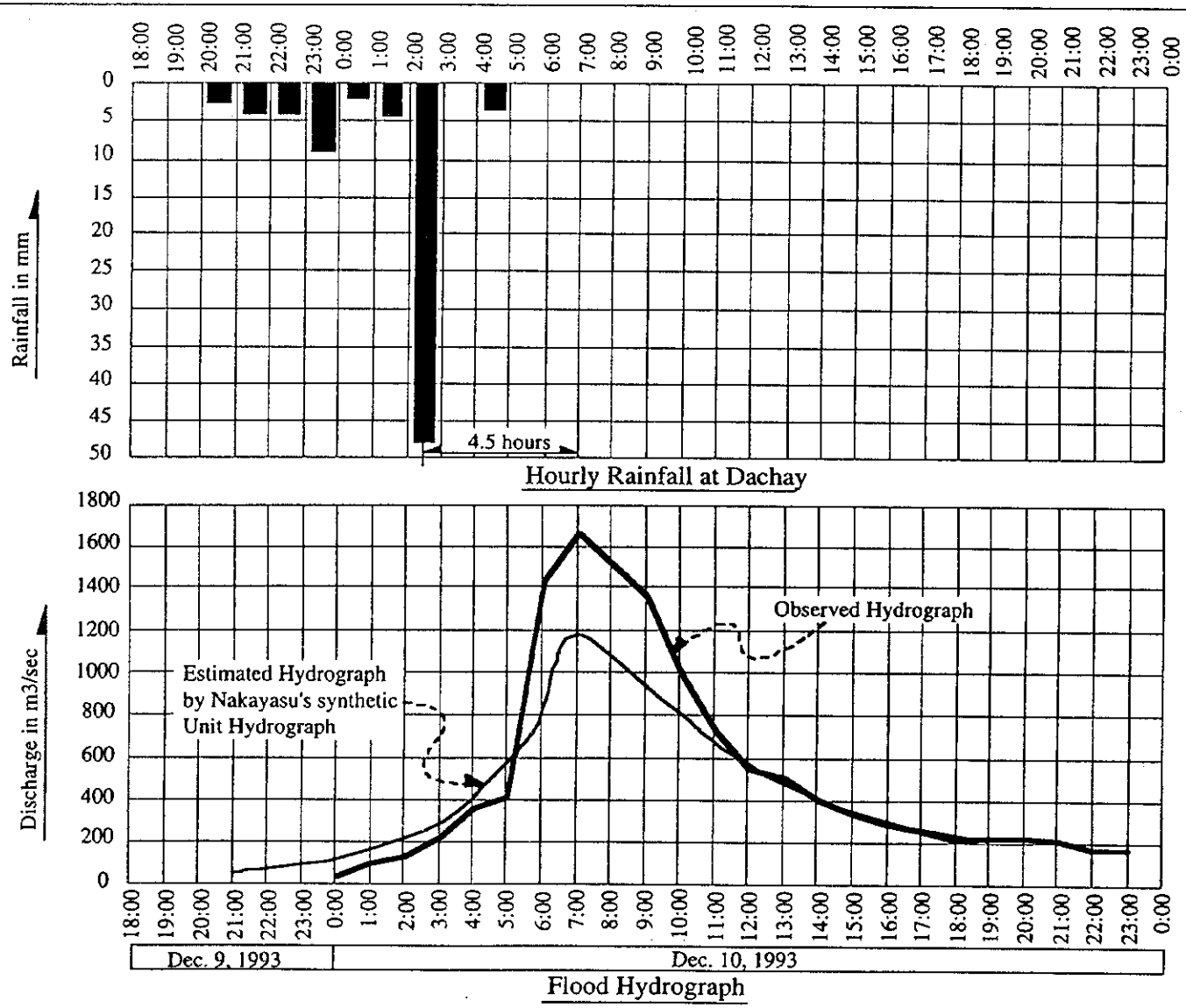
Rising Curve : $\frac{Q}{Qp} = \left(\frac{T}{Tp}\right)^{2.4}$

Receding Curve : $1 \geqq \frac{Q}{Qp} \geqq 0.3 \quad : \frac{Q}{Qp} = 0.3^{\frac{T-Tp}{Tk}}$

$0.3 \geqq \frac{Q}{Qp} \geqq 0.3^2 : \frac{Q}{0.3\,Qp} = 0.3^{\frac{T-(Tp+Tk)}{1.5Tk}}$

$0.3^2 \geqq \frac{Q}{Qp} \quad : \frac{Q}{0.3^2 Qp} = 0.3^{\frac{T-(Tp+Tk+1.5Tk)}{2.0Tk}}$

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.29 Concept of Nakayasu's Synthetic Unit Hydrograph



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 7.30 Comparison of Observed Hydrography of the 1993 Flood and Estimated One Applying Rainfall Record at Dachay to Nakayasu's Synthetic Unitgraph Method

CHAPTER 8

SUBSTATION FACILITIES

CHAPTER 8 SUBSTATION FACILITIES

8.1 Field Investigation, Results and Analysis

8.1.1 Field Investigation

This Clause describes the objectives and methods of the field investigation executed by the Study Team of the Da Nhim Power System.

(1) Objectives of Field Investigation

At the first discussion held with PC-2, the Study Team confirmed that the objectives of the field investigation on the substation facilities for the Da Nhim Power Station and the Saigon Substation. The objectives of the field investigation were the same as agreed upon between the GOV and the JICA Study Team for the Scope of Works for the rehabilitation of the Da Nhim Power System. However, the Study Team executed additionally some investigation upon request by PC-2.

Also, the Study Team executed the field investigation for the main transformers for the Thap Cham Substations and the Phan Thiet Substations that are planned to be upgraded.

Da Nhim Power Station

The field investigation was made for the following substation facilities including the control and relaying equipment in the Da Nhim Power Station. The single line diagram for the main circuits of the Da Nhim Power Station is shown in Figure 8.1.

1) Transformers

a) Four (4) main transformers; 45 MVA, 13.2/230 kV (1T, 2T, 3T, 4T)

b) Four (4) house-service transformers; 500 kVA, 13.2/0.38 kV (11T, 12T, 13T, 14T)

c) One (1) 31.5 kV transformer; 2 MVA, 13.2/31.5 kV (6T)

d) One (1) 31.5 kV transformer; 3 MVA, 13.2/31.5 kV (7T)

e) One (1) 66 kV transformer; 22.5 MVA, 13.2/66 kV (5T)

f) Three (3) 66 kV transformers; 16 MVA, 13.2/66 kV (8T-A, 8T-B, 8T-C)

g) One (1) 110 kV transformer; 63 MVA, 230/110 kV (9T)

2) Switchgear

a) 230 kV outdoor switchgear

Seven (7) air-blast circuit breakers, eighteen (18) disconnecting switches, twelve (12) current transformers, three (3) voltage transformers, twelve (12) lightning arresters, compressed air supply equipment, steel structures and busbars

b) 110 kV outdoor switchgear

One (1) gas circuit breaker, two (2) disconnecting switches, three (3) current transformers, three (3) voltage transformers and three (3) lightning arresters

c) 66 kV outdoor switchgear

Two (2) air-blast circuit breakers, one (1) oil circuit breaker, nine (9) disconnecting switches, nine (9) current transformers, six (6) voltage transformers and three (3) lightning arresters

d) 31.5 kV outdoor switchgear

One (1) air-blast circuit breaker, two (2) disconnecting switches, three (3) current transformers, three (3) voltage transformers and three (3) lightning arresters

e) One (1) lot of 13.2 kV indoor switchgear

f) One (1) lot of 6.6 kV indoor switchgear

3) Control and relay boards

a) One (1) lot of main control and relay boards

b) One (1) lot of generator automatic control boards, including one (1) automatic synchronizer panel

Saigon Substation

The field investigation was made for the following substation facilities in the Saigon Substation. The single line diagram for the main circuits of the Saigon Substation is shown in Figures 8.2, 8.3 and 8.4.

1) Two (2) synchronous condensers, 19,000 kVA

2) Transformers

   a) Two (2) banks of main transformers; 26/28/13 MVA x 3, 230/66/11 kV (1T, 2T)

   b) Two (2) house-service transformers; 300 kVA, 11/0.38 kV (5T, 7T)

   c) One (1) starting transformer for the synchronous condensers; 7 MVA, 11/2.75 kV (6T)

   d) Two (2) 66 kV transformers; 20 MVA, 66/15 kV (3T, 4T)

   e) One (1) bank of 66 kV transformer; 2 MVA x 3, 66/15 kV (9T)

   A spare single phase transformer (# 13188A) for the main transformer could not be investigated because it was under repair.

3) Switchgear

   a) 230 kV outdoor switchgear

      Three (3) air-blast circuit breakers, one (1) gas circuit breakers, ten (10) disconnecting switches, twelve (12) current transformers, seven (7) voltage transformers, six (6) lightning arresters, compressed air supply equipment, steel structures and busbars

   b) 66 kV outdoor switchgear

      Fifteen (15) air-blast circuit breakers, three (3) oil circuit breakers, forty (40) disconnecting switches, fifty-seven (57) current transformers, six (6) voltage transformers, compressed air supply unit, four (4) banks of static condensers, steel structures and busbars

c) 15 kV outdoor switchgear

Ten (10) oil circuit breakers, five (5) gas circuit breakers, thirty-three (33) disconnecting switches and six (6) voltage transformers

d) 11 kV outdoor switchgear

Three (3) oil circuit breakers, three (3) gas circuit breakers and four (4) disconnecting switches

4) Control and relay boards

a) One (1) lot of main control and relay boards

b) One (1) lot of station power distribution boards

c) One (1) lot of automatic starting control boards for the synchronous condensers

d) One (1) fault locator

Thap Cham Substation

1) One (1) main transformer; 18 MVA, 72/5.5 kV (4T)

Phan Thiet Substation

1) One (1) main transformer; 10 MVA, 66/16.5 kV (1T)

At the meeting held with the Transmission Department of PC-2 after completion of the field investigation, the Study Team confirmed that all the 230 kV switchgear for the Saigon Substation should be excluded from the Scope of Works for the rehabilitation of the Da Nhim Power System because they would be replaced with the new ones by the end of 1994 by the other project.

(2) Methods of Field Investigation

1) Synchronous condensers

The field investigation of the synchronous condensers were executed by the following inspection and tests under the deenergizing conditions.

All subsidiary works for the investigation, including the disassembling and re-assembling works, were done by the staff of PC-2.

a) External inspection

The external inspection was done for the main machines, exciters and auxiliary equipment. The external inspection for the main machines was made after removal of their coil end covers.

b) Insulation test

Measurement of insulation resistance was applied to each winding of the stator, rotor and main exciter for each unit. DC current absorption test and measurement of loss angle (tan δ) were applied to the stator windings only.

As for Unit 1, there was a time interval of about three weeks between the date of the insulation test and the date of the unit shutdown due to the ground fault on the brush holder. On the other hand, the insulation test for Unit 2 was carried out shortly after the unit shutdown.

c) Non-destructive test for bearings

Non-destructive test for the bearings was additionally executed in reply to request of PC-2.

Non-destructive test of liquid penetrant method was applied to the upper and lower half bearing metals of the main bearings for each unit. However, the non-destructive test for the lower half bearing metals for Unit 2 could not be done because Unit 2 was not allowed to be stopped in every night for the network operational reasons and there was no time to dismantle them.

2) Transformers

The transformers were investigated by the following inspection and analysis.

All subsidiary works for the investigation, including the terminal disconnection and re-connection works and the grounding connection works, were done by the staff of PC-2.

a) External inspection

The external inspection was basically done during the deenergizing period of the transformers. As for the transformers that could not be deenergized

for the network operational reasons, only visual check was done from the ground level.

b) Measurement of insulation resistance

Measurement of insulation resistance was applied only to the transformers that could be deenergized and disconnected from the busbars.

c) Laboratory analysis of insulating oil

The insulating oils of the transformers were analyzed by a Japanese laboratory for the amount of the gases dissolved in the oil to diagnose the insulation degradation of the transformers. The oil samples were taken from the following transformers and brought back to Japan for the analysis.

Da Nhim Power Station

Four (4) main transformers (1T, 2T, 3T, 4T)
One (1) house-service transformer (1T)
One (1) 31.5 kV transformer (6T)
Three (3) 66 kV transformers (8T-A, 8T-B, 8T-C)

Saigon Substation

Six (6) phases of main transformers (1T-A, 1T-B, 1T-C, 2T-A, 2T-B, 2T-C)
One (1) starting transformer (6T)
Two (2) 66 kV transformers (3T, 4T)

Thap Cham Substation

One (1) 66 kV transformer (4T)

Phan Thiet Substation

One (1) 66 kV transformer (1T)

3) Switchgear

The field investigation for the switchgear was executed by the following inspection.

All subsidiary works for the investigation, including the operation of the switchgear, the terminal disconnection and re-connection works and the grounding connection works, were done by the staff of PC-2.

a) External inspection

The external inspection was basically done during the deenergizing period of the transformers and the related circuits. As for the switchgear on the circuits that could not be deenergized for the network operational reasons, only visual check was done from the ground level.

b) Measurement of insulation resistance

Measurement of insulation resistance was applied to the switchgear that could be deenergized and disconnected from the busbars.

c) Operation check

The 230 kV air-blast circuit breakers were checked for opening and closing operations and confirmed their operating characteristics with an oscillograph recorder. This operation check of the 230 kV circuit breakers was requested by PC-2.

The disconnecting switches were checked for their operations and closing status.

4) Control and relay boards

The control and relay boards were investigated by the following inspection and test.

a) External inspection

The external inspection was applied to the control and relay boards to check the board construction, painting, wiring, instruments' fitting and cable connections, etc.

b) Calibration check of measuring instruments

Calibration check of the measuring instruments was carried out by sampling inspection under energizing conditions.

c) Characteristic tests for protective relays

The operating characteristic tests were applied only to the overcurrent relays.

8.1.2 Results of Field Investigation and Analysis for Da Nhim Power Station

(1) Transformers

The results of the external inspection and analysis of insulating oils are as shown below.

1) Main transformers (1T, 2T, 3T, 4T)

Remarkable vibration was observed on each main transformer. The vibration may be attributed to looseness of the transformer core due to ageing of the transformer.

No oil leakage was observed on each bushing. Oil leakage on the bushings, which had been reported previously, was already repaired by PC-2. However, it was observed that the oil levels in some bushings were lowered down. The lowering of the oil level will be resulted from the deterioration of the oil tight construction of the bushing. Judging from the standard service life of bushings and gaskets, which are generally considered as 30 years and 15 years respectively, it can be estimated that all the bushings for the main transformers have already been deteriorated.

The oil circulating pumps for each main transformer were aged and some of them had oil leakage.

The following mechanical protective relays on the main transformers were troubled.

a) Buchholtz relays for T3 and T4
b) Oil flow relays for T1, T2, T3 and T4.
c) Water flow relays for T1 and T2

The nitrogen gas sealing equipment for each main transformer was aged, so that its oil-preservation function might have been deteriorated.

The result of the laboratory analysis of the insulating oils for the main transformers are as shown in Table 8.1.

TABLE 8.1 Result of Transformer Oil Analysis for Main Transformers

Gas Component (ppm)	Criteria	1T (#131872A) 45,000 kVA	2T (#131873A) 45,000 kVA	3T (#131874A) 45,000 kVA	4T (#131875A) 45,000 kVA
Hydrogen (H_2)	400 ≥	1,042	55	47	40
Methane (CH_4)	150 ≥	4,625	86	134	58
Ethane (C_2H_6)	150 ≥	1,224	109	123	97
Ethylene (C_2H_4)	200 ≥	9,175	32	7	9
Acetylene (C_2H_2)	0	99	0	0	0
Carbon Monoxide (CO)	300 ≥	56	52	54	55
Total Combustible Gas	700 ≥	16,221	334	365	259
Moisture	30 ≥	8.8	9.9	5.3	6.6
Breakdown Volt.		43.0 kV	61.8 kV	83.7 kV	68.6 kV
Volume Resistivity	$5 \times 10^{12} \leq$	1.2×10^{13}	1.9×10^{13}	1.7×10^{13}	9.2×10^{12}

The result of the analysis showed that each of methane, ethane, ethylene and acetylene gases and the total amount of combustible gases dissolved in the oil exceeded seriously their normal values. Judging from the amount of the ethylene and acetylene gases, it was certain that the main transformer "1T" was subject to local heat problem due to imperfect contact and leakage current. The transformer with such condition was quite dangerous for the further operation.

As for the main transformers of "2T", "3T" and "4T", no special abnormality was recognized.

2) House-service transformers (11T, 12T, 13T, 14T)

Oil leakage was observed on all the bushings and top covers for each bank. This oil leakage was caused by deterioration of their gaskets. The paint of the transformer tank and radiators came off and some surfaces rusted.

As for the house-service transformer, the laboratory analysis of the insulating oil was made for "11T" only. The results of the insulating oil analysis for "11T" is shown in Table 8.2.

TABLE 8.2 Result of Transformer Oil Analysis for House-Service Transformer and 31.5 kV Transformer

Gas Component (ppm)	Criteria	11T (#R96302F) 500 kVA	6T 2,000 kVA		
Hydrogen (H_2)	400 ≥	3	23		
Methane (CH_4)	200 ≥	19	61		
Ethane (C_2H_6)	150 ≥	43	103		
Ethylene (C_2H_4)	300 ≥	10	44		
Acetylene (C_2H_2)	0	0	2		
Carbon Monoxide (CO_2)	300 ≥	34	87		
Total Combustible Gas	1,000 ≥	109	334		
Moisture	30 ≥	43.1	17.7		
Breakdown Volt.		43.0 kV	71.7 kV		
Volume Resistivity	$5 \times 10^{12} \leq$	3.4×10^{12}	1.3×10^{12}		

The result of the analysis showed that there was no special abnormality for the insulation of the house-service transformer "11T". Judging from the moisture and low volume resistivity of the oil, it was estimated that the insulating oil for "11T" had been degraded.

The house-service transformers "12T", "13T" and "14T" were not examined by the oil analysis, but their insulating oil are estimated to be deteriorated similarly to "11T".

3) 31.5 kV transformer (6T, 7T)

The external inspection resulted that no special abnormality was found out on the 31.5 kV transformer "6T".

As shown in Table 8.2, the insulating oil analysis for the 31.5 kV transformer "6T" resulted that the acetylene gas was dissolved in the oil. Judging from a

quantitative ratio between the acetylene gas and the total combustible gas, there is a great possibility of local heat inside "6T" due to imperfect contact or other causes. Meanwhile, it is estimated that the insulating oil for "6T" has been degraded because the volume resistivity is lower than the standard value.

As for the 31.5 kV transformer "7T", it was observed that a little oil was leaked from the bushings due to deterioration of their gaskets. No other abnormality was found out by the external inspection. The 31.5 kV transformer "7T" was not examined by the oil analysis, but its insulating oil is estimated to be deteriorated similarly to "6T".

4) 66 kV transformers (8T-A, 8T-B, 8T-C)

Oil leakage was observed on the bushings for the 66 kV transformer "8T-A". The oil leakage on the bushings for "8T-B" and "8T-C", which had been reported previously, was already repaired by PC-2. The buchholtz relays for all "8T-A", "8T-B" and "8T-C" were damaged seriously.

TABLE 8.3 Results of Transformer Oil Analysis for 66 kV Transformers

Gas Component (ppm)	Criteria	8T-A 16,000 kVA	8T-B 16,000 kVA	8T-C 16,000 kVA	
Hydrogen (H_2)	400 ≥	4	13	6	
Methane (CH_4)	200 ≥	2	8	2	
Ethane (C_2H_6)	150 ≥	trace	1	trace	
Ethylene (C_2H_4)	300 ≥	3	3	2	
Acetylene (C_2H_2)	0	trace	1	trace	
Carbon Monoxide (CO)	300 ≥	168	244	93	
Total Combustible Gas	1,000 ≥	177	265	103	
Moisture	30 ≥	13.5	21.8	12.0	
Breakdown Volt.		65.1 kV	40.5 kV	83.2 kV	
Volume Resistivity	$5 \times 10^{12} \leq$	1.3×10^{13}	1.4×10^{13}	1.6×10^{13}	

As the result of the insulating oil analysis for "8T" is shown in Table 8.3, a small quantity of the acetylene gas was detected on all the three transformers.

However, judging from the dissolved amount of the other gases, the insulation of the transformers was still good under the present conditions.

5) 66 kV transformer (5T)

The air breather was broken and the cooling fan control unit was troubled. The paint on the some parts came off. Although small quantity of oil leakage was observed on the radiators, this leakage was not so serious to need urgent repair under the present conditions.

6) 110 kV transformer (9T)

The 110 kV transformer "9T" was manufactured by Ex-Soviet in 1990. Excessive oil leakage was observed near the hand hole for the on-load tap changer. This oil leakage may be attributed to the defective construction of the gaskets for the hand hole. No special abnormality other than the oil leakage problem was recognized.

(3) Switchgear

On the whole, the outdoor switchgear incurred discoloration on the conductive parts and terminals, and rust on many steel members. The dash-pot parts of almost all the air-blast circuit breakers and the current transformers had a little oil leakage. The discoloration, rust and oil leakage may be attributed to ageing of the equipment. The interior of the local control boxes for almost all the circuit breakers and disconnecting switches was corroded due to dampness because the control boxes had no gaskets on the doors and no seals on the cable holes.

These problems and abnormalities on the switchgear were not so serious to interfere the operation of the switchgear under the present conditions.

Details of the result of the field investigation was as follows:

1) 230 kV air-blast circuit breakers

The following abnormalities were observed on all the 230 kV air-blast circuit breakers.

a) Discoloration of the conducting parts
b) Deterioration of the cables for the pressure switches
c) Corrosion in the local control boxes

2) 230 kV disconnecting switches

The following abnormalities were observed on all the 230 kV disconnecting switches.

a) Discoloration of the terminals
b) Rust on the bolts and spring washers
c) Corrosion in the local control boxes

The operation test resulted that six 230 kV disconnecting switches of "231-1", "232-2", "271-2", "271-3", "200-1" and "200-2" could not be closed perfectly.

3) 230 kV current transformers

A little oil leakage was observed on the primary terminals of the current transformer for phase-B on the main transformer "2T" circuit. However, the oil level was normal and the insulation resistance was still good. That is why it can be judged that this leakage was not so serious condition for the time being.

The discoloration was observed on the primary terminals of the current transformers.

4) 230 kV voltage transformers

The voltage transformers on the 230 kV transmission line circuit were deteriorated due to ageing and their terminal bolts have rusted.

5) 230 kV lightning arresters

The terminal bolts have rusted. No other special abnormalities were recognized.

6) 110 kV switchgear

All the 110 kV switchgear were made in ex-Soviet. No special abnormality was recognized on the 110 kV switchgear.

The operation test could not be executed for the network operational reasons.

7) 66 kV switchgear

On the whole, the corrosion and rusts were observed on the conductive parts and terminals for the 66 kV switchgear. The interiors of the local control boxes for the circuit breakers and disconnecting switches have been corroded due to dampness.

No other special abnormalities were recognized on the 66 kV switchgear.

8) 31.5 kV switchgear

A little oil leakage was observed on the dash-pot of the air-blast circuit breakers, and the surfaces of the air pipes was corroded. These problems do not seem to be serious under the present conditions.

No other special abnormalities were recognized on the 31.5 kV switchgear.

9) 13.2 kV indoor switchgear

The parallel resistance for the air-blast circuit breaker "543" for phase-C was broken. No other special abnormalities were recognized on the 13.2 kV switchgear.

10) 6.6 kV indoor switchgear

The pilot contacts for the magnetic-blast circuit breakers "636" and "672" were not in good conditions. No other special abnormalities were recognized on the 6.6 kV switchgear.

11) Compressed air supply equipment

There were two compressed air supply systems; namely, one was for the operational air supply to the outdoor air-blast circuit breakers of 230 kV, 66 kV and 31.5 kV and another was for the indoor 13.2 kV air-blast circuit breakers.

In both compressed air supply systems, the time for air charging into the primary air tanks became longer and the time interval for operation of the air compressors became shorter, as compared with the past data. Judging from this fact, the air displacement volume of the air compressors seems to be deteriorated due to aging of the air compressors.

12) 230 kV steel structures and busbars

The bus conductors and connectors have been discolored in black and all the insulators for the 230 kV busbars have been contaminated.

(4) Control and Relay Boards

The control and relay boards in the Da Nhim Power Station were almost manufactured in 1962 and they are, as a whole, still maintained in good condition, even though some of them were modified and additionally installed.

The result of the field investigation showed that there were no serious defects and rust on the panel, cables and terminals and that almost all the wiring and terminal connections were still in good condition.

Among the control instruments on the control deskboard, some switches such as # 7-65, # 7-77 and # 7-43 were loosen and rattling due to frequent operation. The selector switches for the temperature indicators were also defective.

Six recording instruments were mounted on the main control boards. Four of them were frequently troubled and the remaining two could not work because they had no papers at all.

The fault indicators were of the flag type. Most of them were troubled and could not be operated well.

The measuring instruments and the electrical protective relays were periodically inspected by the staff of PC-2 and they were still maintained in good condition without serious problems at present. However, since almost all the instruments and relays were used exceeding their standard service life, it is expected that such problems as mechanical troubles, imperfect contact, accuracy degradation and wrong operating characteristics will be arisen increasingly in the future. Indeed, many measuring instruments were beyond their accuracy and could not indicate the zero point correctly. The operating time characteristics of the induction disc type relays altered because of the deterioration of the helical springs of the relays. By the way, according to Japanese Standards of JEC - 174 (1968) and JEC - 2500 (1987) for "Protective Relays for Electric Power System", a standard service life of the protective relays is considered as 15 years.

As for the automatic control boards for the generators, no special abnormality was recognized. However, almost all the auxiliary relays, which make the automatic control sequence, seem to be aged and deteriorated. The automatic synchronizer was of vacuum tube type and the automatic synchronizing function was still in good condition. However, the automatic speed balancing and the automatic voltage matching functions could not be worked well any longer. Also, there were no spare parts for the synchronizer.

Furthermore, the surge tank water level gauging system was also troubled so that the surge tank water level could not be supervised from the control room in the powerhouse.

8.1.3 Results of Field Investigation and Analysis for Saigon Substation

(1) Synchronous Condensers

Two unit of the synchronous condensers were commissioned in 1964 but their operation was forced to be suspended from 1965 to 1978 because the 230 kV transmission line between the Da Nhim Power Station and the Saigon Substation was destroyed at the civil war. In addition, the synchronous condensers were damaged by the fire accident on the 11 kV circuits, the burning-out of the main bearing metals and other troubles. Also, it was reported that the synchronous condensers have not been overhauled at all.

As the results of the external inspection, insulation test and non-destructive test for the bearings are shown below, relatively serious defects and abnormalities were found out on the synchronous condensers.

1) Stators

The stator windings for both units were covered with heavy dusts and their insulation resistance was too low as shown below.

Result of Measurement of Insulation Resistance (Each Phase-to-Ground)

Unit 1:	30 ~ 60 MΩ	(Criteria: > 11.6 MΩ, At completion: 250 MΩ)
Unit 2:	35 ~ 42 MΩ	(Criteria: > 11.6 MΩ, At completion: 120 MΩ)

The insulation resistance of the insulation materials generally consists of specific volume resistance and surface resistance. That is why the heavy dust on the winding insulation surfaces caused the surface resistance to lower, so that the insulation resistance of the winding was deteriorated.

Meanwhile, the DC current absorption test was resulted as follows:

Result of DC Current Absorption Test (Each Phase-to-Ground)

Unit 1:	PI = 1.0 ~ 1.12	(Criteria: > 1.5)
Unit 2:	PI = 0.95 ~ 0.97	(Criteria: > 1.5)

(Note) Index of porosity (PI) is to estimate the degree of moisture absorption of insulation materials. In case PI is more than 1.5, the insulation materials are estimated to be enough dry.

Since the result of the DC current absorption test indicated that the figure of PI were about 1.0, the stator windings can be estimated to be in highly higroscopic condition. What is worse, PI for Unit 2 was less than 1.0, although the test was carried out shortly after the unit shutdown. Generally speaking, the material with good insulation is hard to absorb the moisture and the aged insulation is easy to absorb the moisture. That is why the insulation material for the stator windings is estimated to be aged and degraded so as to absorb moisture easily.

Also, the measurement of tan δ was resulted as follows.

Result of Measurement of Tan δ

Unit 1: 7.0 % (at 2 kV) ~ 7.4 % (at 8 kV)
Unit 2: 3.3 % (at 2 kV) ~ 3.4 % (at 8 kV)

In usual case, the figure of tan δ for a winding in higroscopic condition will be increased as the test voltage is increased. The result of the above test did not indicate this usual characteristics for a higroscopic winding. However, this phenomenon sometimes appears on a winding of highly higroscopic condition. Judging from the result of tan δ measurement, it can be estimated that the stator winding have been in highly higroscopic condition. The difference of tan δ values between Unit 1 and Unit 2 may be caused from the difference of a period of unit shutdown.

Some spacers for the stator windings for both units are slid out a little from the slots.

As for the stator core, it was observed that the fastening bolts for the stator core for Unit 1 was loosen a little. This looseness is not so serious problem under present condition. No other special abnormalities were observed on the stator core.

No special abnormalities were recognized on the stator frame.

The stator for each unit was equipped with twelve temperature detectors of resistance type having a resistance of 25 ohm at 0 °C of copper element. No abnormality was observed on each temperature detector.

2) Rotors

The rotor coils for both units were covered with heavy dusts and the insulation resistance of the rotor coils for both units were too low as shown below.

Result of Insulation Resistance

Unit 1:	0.002 MΩ	(Criteria: > 0.1 MΩ, At completion: 65 MΩ)
Unit 2:	2.7 MΩ	(Criteria: > 0.1 MΩ, At completion: 125 MΩ)

A small gap about 1 mm was observed on the rotor coil for Unit 1; No. 7 pole at the PMG side, between the lower insulation collar and the rotor spider. The rotor coil showed no traces of having been moved yet. No abnormality was observed on the other rotor coils.

The threads of the slip rings for both units have been worn down a lot especially at the center.

One support insulator of the brush holder for Unit 1 was damaged by the ground fault, which was attributed to a decrease of the insulation effect of the insulator due to coverage of the brush carbon dusts. The result of the insulation check on the brush holder showed that the insulation of the other support insulators was also deteriorated.

3) Main shafts

The fretting corrosion was observed on the main shaft at the PMG side of Unit 1. The fretting corrosion may be caused by looseness of the connection between the main shaft and the rotor spider. The looseness will make a gap around the shaft. The shaft will be swinging in the gap during operation and then the shaft surface will be worn out to produce metallic powders. The fretting corrosion can be detected because the metallic dusts rusted will be appeared in a radial manner on the rotor spider. Since the fretting corrosion is possible to become worse to more serious damage of the main shaft in several years, the main shaft needs to be replaced as soon as possible.

4) Main bearings

Almost all the babbit metal linings of the bearing metals for both units were detached and some of them were separated deeply. Also, the main shaft had some traces of having been rubbed with the bearing metals. Meanwhile, there were no spare bearing metals longer.

The cooling water pipe for the bearing at the exciter side for Unit 1 was broken at the inlet of the bearing metal. It was reported that the bearing metal at the exciter side for Unit 1 had been burnt out two times because of the water entrance into the oil due to the breakage of the cooling water pipe.

Much oil was leaked from the cover and labyrinth parts of each bearing for both units because of high oil level and the deterioration of the gaskets.

The lead wire of each temperature detector were much deteriorated. Also, a temperature detector for the bearing at the PMG side for Unit 1 was missing.

Excessive oil leakage was observed on the four oil circulating pumps and two oil lift pumps. As for the cooling water pumps, heavy rust, corrosion and oil leakage were observed on the three pumps, their piping and valves. The coupling part for either one cooling water pump was defective and the fretting corrosion was observed on it. Since these pumps were installed more than 30 years ago, their moving parts may also be deteriorated.

The cooling water pipes and valves were rusted and corroded. The corrosion of some valves were in serious conditions. The water level switch for automatic start/stop control of the cooling water pumps was also corroded.

5) Main and pilot exciters

The main and pilot exciters for both units were covered with heavy dust and the insulation resistance of the armature winding for the main exciter for Unit 1 was too low as show below.

Result of Insulation Resistance

Unit 1: 0.067 ~ 0.12 MΩ (Criteria: > 0.1 MΩ, At completion: 30 MΩ)

The commutator surfaces for both main and pilot exciters were still good. Some brushes on the brush holders for both main and pilot exciters do not work smoothly. The field pole terminals, lead wires and lead wire terminals for the pilot exciter were deteriorated remarkably.

6) Main conductors

The terminal conductors for both units were covered with heavy dusts and bore traces of having been locally heated. Also, their terminal connectors were corroded.

The 11 kV power cables bore traces of having been locally heated. The insulation compounds of the cable heads in the 11 kV cubicles were leaked out.

7) Air dampers

The air dampers for both units could not be operated automatically because of the troubles on the control circuits. The air damper was designed to be operated in the event of a fire occurrence only.

8) Automatic voltage regulator (AVR)

The AVR units were troubled and were not used since 1985. Only manual voltage regulation was available by manual operation of the field rheostat.

9) Automatic control boards

The automatic starting operation of the synchronous condenser was frequently failed due to some troubles on the automatic sequence circuits. Such troubles may be caused by the degradation and obsolescence of some control instruments and devices due to their ageing.

10) Air filters

The air filters at the air inlet of each unit were partly torn so that the dust could enter into the machines.

11) Overhead traveling crane

The brakes for traveling could not work well and therefore it can be estimated that all the brake shoes were worn out. The limit switches to stop traveling were also defective.

(2) Transformers

The results of the external inspection and laboratory analysis of insulating oils are shown as follows:

1) Main transformers (1T-A, 1T-B, 1T-C, 2T-A, 2T-B, 2T-C)

Oil leakage was observed at various parts of each main transformer as shown in Table 8.4.

Table 8.4 Oil Leaked Parts on Main Transformers

(Number of oil leaked parts)	1T-A	1T-B	1T-C	2T-A	2T-B	2T-C
Transformer Tank					1	
230 kV Neutral Bushing	1	1	1	1	1	1
66 kV Bushing	2	2	2	2	1	
11 kV Bushing		2				
Oil Circulation Pump	3	2	4	4	1	4
Radiator Valve	4	2	5	4		
Oil Flow Relay		2				1

Such oil leakage may be caused by ageing of the relevant parts and their gaskets.

Oil leakage on the 230 kV bushings, which had been reported previously, was already repaired by PC-2.

Judging from the standard service life of bushings and gaskets, which are generally considered as 30 years and 15 years respectively, it can be estimated that all the bushings for the main transformers have already been deteriorated.

The following mechanical protective relays on all the main transformers were troubled.

a) Buchholtz relays
b) Dial thermometers
c) Oil flow relays
d) Dial oil level gauges

The nitrogen gas sealing equipment for each main transformer was aged, so that its oil-preservation function might have been deteriorated.

The paint of the transformer tank and radiators came off and some surfaces rusted.

The result of the laboratory analysis of the insulating oils for each phase of the main transformer "1T" are as shown in Table 8.5.

TABLE 8.5 Result of Transformer Oil Analysis for Main Transformer "1T"

Gas Component (ppm)	Criteria	1T-A (#131878A) 28,000 kVA	1T-B (#131879A) 28,000 kVA	1T-C (#131877A) 28,000 kVA	
Hydrogen (H_2)	400 ≥	34	1,018	38	
Methane (CH_4)	150 ≥	91	186	76	
Ethane (C_2H_6)	150 ≥	162	258	157	
Ethylene (C_2H_4)	200 ≥	6	13	7	
Acetylene (C_2H_2)	0	0	0	0	
Carbon Monoxide (CO)	300 ≥	191	171	153	
Total Combustible Gas	700 ≥	484	1,646	431	
Moisture	30 ≥	14.1	25.7	14.9	
Breakdown Volt.		77.2 kV	62.6 kV	88.7 kV	
Volume Resistivity	$5 \times 10^{12} \leq$	6.0×10^{13}	4.2×10^{12}	2.4×10^{12}	

The result of the oil analysis for "1T-A" and "1T-C" showed that the discharge of ethane gas exceeded the normal value. However, judging from the dissolved amount of the other gases, the insulation of "1T-A" and "1T-C" was still good under the present conditions. Also, judging from the low volume resistivity of the oil , the insulating oil for "1T-C" was estimated to have been degraded.

As for "1T-B", judging from the hydrogen gas and total combustible gas being exceeded the abnormal level, there was a great possibility of the partial discharge being appeared in "1T-B". Also, judging from the low volume resistivity of the oil, the insulating oil for "1T-B" was estimated to be degraded.

The result of the laboratory analysis of the insulating oils for each phase of the main transformer "2T" are as shown in Table 8.6.

The result of the oil analysis for "2T-C" showed that not only the ethane gas exceeded the normal level but also the acetylene gas was dissolved in the oil. Judging from this result, there was a great possibility of local heat in "2T-C" due to imperfect contact or other causes. Also, since the volume resistivity was too low, the insulating oil for "2T-C" was estimated to be degraded.

As for "2T-A" and "2T-B", the amount of the all gases dissolved in the oil was lower than the normal level. However, judging from the low resistivity of the oil, the insulating oil for "2T-A" and "2T-B" was estimated to be degraded.

TABLE 8.6 Result of Transformer Oil Analysis for Main Transformer "2T"

Gas Component (ppm)	Criteria	2T-A (#131880A) 28,000 kVA	2T-B (#131882A) 28,000 kVA	2T-C (#131883A) 28,000 kVA	
Hydrogen (H_2)	400 ≥	13	27	60	
Methane (CH_4)	150 ≥	47	35	95	
Ethane (C_2H_6)	150 ≥	103	56	180	
Ethylene (C_2H_4)	200 ≥	6	9	10	
Acetylene (C_2H_2)	0	0	0	1	
Carbon Monoxide (CO)	300 ≥	158	299	178	
Total Combustible Gas	700 ≥	327	426	524	
Moisture	30 ≥	8.8	11.0	7.9	
Breakdown Volt.		86.7 kV	83.6 kV	90.2 kV	
Volume Resistivity	$5 \times 10^{12} \leq$	2.8×10^{12}	1.2×10^{12}	1.3×10^{11}	

2) House-service transformers (5T, 7T)

Oil leakage was observed on the top covers of the transformer tanks for "5T" and "7T", and on the primary and secondary bushings for "7T". The paint on some parts of the transformer tanks and radiators for both "5T" and "7T" came off and some surfaces rusted remarkably.

Since the oil analysis was not applied to "5T" and "7T", the degradation of the transformer insulation and oil for "5T" and "7T" could not be confirmed.

3) Starting transformer (6T)

A little oil leakage was observed on one bushing but this oil leakage was not a serious problem under this condition. Also, the dial thermometer was hard to read because of the window glass being blurred.

The result of the oil analysis for "6T" is shown in Table 8.7. Judging from the amount of the gases dissolved in the oil, the insulation degradation of the starting transformer "6T" was not recognized. However, since the volume resistivity was lower than the normal value, the insulating oil was judged to be degraded.

TABLE 8.7 Result of Transformer Oil Analysis for Starting Transformer and 66 kV Transformers

Gas Component (ppm)	Criteria	6T (#535188) 7,000 kVA	3T (#6994743) 20,000 kVA	4T (#6994736) 20,000 kVA	
Hydrogen (H_2)	400 ≥	23	89	3	
Methane (CH_4)	200 ≥	2	12	3	
Ethane (C_2H_6)	150 ≥	2	124	4	
Ethylene (C_2H_4)	300 ≥	10	11	0	
Acetylene (C_2H_2)	0	0	3	0	
Carbon Monoxide (CO)	300 ≥	218	531	32	
Carbon Dioxide (CO_2)		2,248	9,853	414	
Total Combustible Gas	1,000 ≥	255	770	42	
Moisture	30 ≥	17.5	28.9	6.8	
Breakdown Volt.		47.9 kV	82.4 kV	91.8 kV	
Volume Resistivity	$5 \times 10^{12} \leq$	9.5×10^{11}	8.5×10^{11}	1.3×10^{12}	

4) 66 kV transformers (3T, 4T)

Oil leakage was observed on the on-load tap changer for "3T" and on two oil circulating pumps for "4T".

Some paint on the tanks and radiators for both "3T" and "4T" came off and rusted.

The result of the oil analysis for "3T" and "4T" is shown in Table 8.7.

The result of the oil analysis for "3T" showed that a large quantity of the carbon monoxide gas, carbon dioxide gas and acetylene gas were dissolved in the oil. Judging from the amount of the carbon monoxide gas, there was a great possibility of the solid insulation materials such as the insulation papers and bakelite being burnt. Also, the existence of the acetylene gas suggested the possibility of local heat in "3T". Furthermore, the low volume resistivity of the oil suggested that the insulating oil was deteriorated too.

As for "4T", the degree of the insulation degradation could not be judged from the oil analysis because it was proved that the insulating oil for "4T" had just changed by PC-2 two months before the field investigation. It was quite certain that the oil change was made because the operating condition of "4T" was too bad. That is why the insulation condition of "4T" was possible to be deteriorated similarly to "3T".

5) 66 kV transformers (9T-A, 9T-B, 9T-C)

Oil leakage was observed on the top covers of the tanks for "9T-A" and "9T-B", the 66 kV bushings for "9T-A" and "9T-B", and the radiator valves for "9T-A", "9T-B" and "9T-C".

The following relays and instruments on all the transformers are troubled.

a) Buchholtz relays
b) Dial type thermometers
c) Rod type thermometers
d) Oil level gauges on the nitrogen gas sealing equipment

Since the oil analysis was not applied to "9T", the degradation of the transformer insulation could not be confirmed.

(3) Switchgear

Discoloration was observed on the conductive parts and terminals of the outdoor switchgear and heavy rust was observed on the whole steel members of the switchgear supports and the gantry structures. The discoloration and rust may be attributed to not only ageing but also a harmful effect of the air pollution by the thermal power plant and factories located nearby the Saigon Substation. Also, a little oil leakage was observed on the dash-pot of almost all the air-blast circuit breakers and the current transformers. Such oil leakage may be mainly caused by ageing of the gaskets. Furthermore, the interior of the local control boxes for almost all the air-blast circuit

breakers and disconnecting switches were corroded due to dampness because the control boxes had no gaskets on the doors and no seals on the cable holes.

These problems and abnormalities on the switchgear were not so serious to interfere the operation of the switchgear under the present conditions.

Details of the results of the field investigation are as follows:

1) 230 kV circuit breakers

The following abnormalities were observed on all the 230 kV air-blast circuit breakers.

a) Oil leakage from the dash-pot
b) Trouble of the operating counter
c) Corrosion of the interior of the local control box

The cable for the pressure switch for the 230 kV air-blast circuit breaker "232" was deteriorated.

The operating oil was leaked from the hydraulic pressure unit for the 230 kV gas circuit breaker "272".

2) 230 kV disconnecting switches

The following abnormalities were observed on all the 230 kV disconnecting switches.

a) Discoloration of blades and contacts
b) Rust on the steel parts such as terminal bolts and supporting structure
c) Corrosion of the interior of the local control box

Phase-C of the 230 kV disconnecting switch "233-1" could not be closed perfectly.

3) 230 kV current transformers, voltage transformers and lightning arresters

Excessive oil leakage was observed on the lower tank of the 230 kV current transformer for phase-B on the main transformer "2T" circuit.

Rust was observed on the terminal bolts and the supporting structures for the 230 kV current transformers, voltage transformers and lightning arresters.

4) 66 kV circuit breakers

The following abnormalities were observed on all the 66 kV air-blast circuit breakers.

a) Oil leakage from the dash-pot
b) Rust and corrosion of the steel parts such as the tank and supporting structure
c) Deterioration of the cables for the pressure switches
d) Trouble of the operating counter
e) Corrosion of the interior of the local control box

The following abnormalities were observed on all the 66 kV oil circuit breakers.

a) Oil leakage from the oil tanks
b) Rust and corrosion of the steel parts such as the tank and supporting structure
c) Corrosion of the interior of the local control box

5) 66 kV disconnecting switches

The following abnormalities were observed on almost all the 66 kV disconnecting switches.

a) Discoloration of the blades and contacts
b) Rust on the steel parts such as the supporting structure and operating rod
c) Corrosion of the interior of the local control box

The operation test resulted that eight 66 kV disconnecting switches of "734-2", "751-1", "773-2", "773-7", "774-2", "774-7", "776-7" and "700-2" could not be closed perfectly.

6) 66 kV current transformers and voltage transformers

Oil leakage was observed on the primary terminals and the flange parts of the tanks for almost all 66 kV current transformers. Especially, the current transformer "777" for Phase-A had excessive oil leakage so that the oil level was lowered down. The current transformer "772" was defective.

Heavy rust was observed on the steel parts such as the terminals, tanks and supporting structures for all the 66 kV current transformers.

7) 66 kV voltage transformers

The existing voltage transformers on the 66 kV bus No. 1 was defective and now the voltage transformers borrowed from the other substation was used. Heavy rust was observed on the steel parts such as the terminals, tanks and supporting structures for all the 66 kV voltage transformers.

8) 66 kV lightning arresters

The 66 kV lightning arresters for three 66 kV transformer circuits of "3T", "4T" and "9T" and eight feeder circuits were deteriorated by ageing. The lightning arresters for the 66 kV bus circuits were removed for relocation to another circuits and left as they were removed.

9) Compressed air supply equipment

In the compressed air supply system for the operational air supply to the 66 kV air-blast circuit breakers, the time for air charging into the primary air tank became longer and the time interval for operation of the air compressor became shorter, as compared with the past data. Judging from this fact, the air displacement volume of the air compressor seems to be deteriorated due to ageing of the air compressor.

10) 15 kV switchgear

Some oil leakage was observed on six 15 kV oil circuit breakers among ten.

Corrosion due to dampness was observed in the local control boxes for all the 15 kV oil circuit breakers.

Six 15 kV disconnecting switches of "577-1", "577-7", "579-1", 579-7", "581-1" and "581-7" were deteriorated remarkably, especially, "577-7" and "581-7" were damaged and failed to be operated.

Rust and corrosion were observed on the contacts and blades for almost all 15 kV disconnecting switches and on the steel structures and other steel parts for almost all the 15 kV switchgear.

11) 11 kV switchgear

Deterioration such as some oil leakage and rust on the steel parts was observed on the five 11 kV oil circuit breakers of "532", "561", "562", "536" and "536-B".

The 11 kV metal-enclosed switchgear was originally designed for indoor installation but was now relocated outdoors. Therefore, it was deteriorated on the whole.

12) Steel structures and busbars

Almost all the steel structures for 230 kV, 66 kV and 15 kV bays heavily rusted in red. The metallic parts for all the insulator strings also rusted.

All the bus conductors and connectors have been discolored in black.

13) 66 kV static condenser banks

Five (5) banks of the static condensers were installed in the Saigon Substation. However, one 5,000 kVA bank was demolished because it had been broken at the civil war. The remaining four banks of each 10,000 kVA were also damaged at the civil war and their post insulators and steel structures are left as they were broken. A little oil leakage was observed on some shunt reactor.

(4) Control and Relay Boards

The control and relay boards for the Saigon Substation were almost manufactured in 1962 and some of them were modified, relocated and additionally installed in company with the extension of the circuits.

Each board partly rusted and damaged, and were covered with soot due to overheat of the resistors for the indicators. The inside of each board were very dirty with dusts and spider's webs. The cables and wires were discolored by soot and insecticide. The wiring and terminal connection become untidy and got confused by the repeated modification works of the boards. Some parts of the boards seemed to be in danger for electrical accidents, especially at the inside of the AC and DC distribution boards for the station-service power distribution. However, there were no serious defects and abnormalities to interfere with the ordinary operation of the substation facilities, on the whole.

The measuring instruments and the electrical protective relays were periodically inspected by PC-2 and they were still maintained in good condition without serious problems at present. However, since almost all the instruments and relays were used exceeding their standard service life, it was expected that such problems as mechanical troubles, imperfect contact, accuracy degradation and wrong operating characteristics will be arisen increasingly in the near future. Indeed, many measuring instruments were beyond their accuracy and could not indicate the zero point correctly. The

operating time characteristic of the induction disc type relays altered because of the deterioration of the helical springs of the relays. By the way, according to Japanese Standards of JEC - 174 (1968) and JEC - 2500 (1987) for "Protective Relays for Electric Power System", a standard service life of the protective relays is considered as 15 years.

The fault locator for the 230 kV transmission line was installed in the Saigon Substation but it was long out of use because of its failure.

8.1.4 Results of Field Investigation and Analysis for Thap Cham Substation and Phan Thiet Substations

(1) 66 kV Transformer (4T) for Thap Cham Substation

The result of the oil analysis for the 66 kV transformer "4T" is shown in Table 8.8.

TABLE 8.8 Result of Transformer Oil Analysis for 66 kV Transformers for Thap Cham Substation and Phan Thiet Substation

Gas Component (ppm)	Criteria	Thap Cham 18,000 kVA	Phan Thiet 10,000 kVA		
Hydrogen (H_2)	400 ≥	17	67		
Methane (CH_4)	200 ≥	15	30		
Ethane (C_2H_6)	150 ≥	3	11		
Ethylene (C_2H_4)	300 ≥	7	11		
Acetylene (C_2H_2)	0	0	0		
Carbon Monoxide (CO)	300 ≥	741	717		
Total Combustible Gas	1,000 ≥	783	836		
Moisture	30 ≥	29.0	54.0		
Breakdown Volt.		74.2 kV	36.7 kV		
Volume Resistivity	$5 \times 10^{12} \leq$	6.2×10^{11}	8.7×10^{11}		

The result of the oil analysis for "4T" showed that the carbon monoxide gas dissolved in the oil exceeded the normal level and reached the abnormal level of more than 600

ppm. Judging from this result, there was a great possibility of the solid insulation materials such as the insulation papers and bakelite being burnt.

That is why it is recommendable that the 66 kV transformer "4T" should not be used any longer.

(2) 66 kV Transformer (1T) for Phan Thiet Substation

The result of the oil analysis for the 66 kV transformer "1T" is shown in Table 8.8.

The result of the oil analysis for "1T" shows that the carbon monoxide gas dissolved in the oil exceeded the normal level and reached the abnormal level of more than 600 ppm. Judging from this result, there was a great possibility of the solid insulation materials such as the insulation papers and bakelite being burnt.

That is why it is recommendable that the 66 kV transformer "1T" should not be used any longer.

8.2 Recommendation of Top Urgent Rehabilitation

The urgent rehabilitation work for the Substation Facilities, which is briefly described in Clause 8.3, is expected to be completed in 1998 or later taking into account the necessary procedures for the implementation of the project. As the result of the site investigation, it was found that the main transformer No. 1 (1T) for the Da Nhim Power Station and the synchronous condensers for the Saigon Substation were seriously deteriorated. In order to enable these facilities to continue their operation further until the urgent rehabilitation sets to work, the following top urgent rehabilitation work is recommended to be done immediately.

(1) Top Urgent Rehabilitation of Main Transformer "1T" for Da Nhim Power Station

1) Inside inspection of transformer

Judging from the result of the oil analysis, there was a great possibility of local heat in the main transformer due to imperfect contact, leakage current or other reasons. That is why the inside of the main transformer needs to be inspected immediately.

In case any serious defect, which is hard to be repaired, is found upon the inside inspection, the main transformer "1T" should preferably be replaced with new one as soon as possible.

Even though no special abnormalities are found, it is recommended that the following countermeasure should be taken for the main transformer "1T".

2) Countermeasure against vibration and load regulation

The main transformer "1T" was subject to the remarkable vibration that will possibly make worse the internal defects such as imperfect contact. Since such vibration is supposed to be caused by the looseness of the core, it is expected to be improved by re-tightening the core.

3) Adjustment of transformer load

To relieve excessive electrical and mechanical stresses on the main transformer "1T", the operation under high temperature condition should be avoided. Therefore, the operating hour and the output of the generating unit No. 1 is required to be adjusted for such purpose.

(2) Rehabilitation of Synchronous Condensers for Saigon Substation

1) Overhaul of synchronous condenser

Overhaul inspection is required to be carried out immediately to improve the present condition of the synchronous condensers.

The synchronous condensers were now in very dangerous condition to continue the operation further because the insulation resistance of each winding was extremely deteriorated. The low insulation resistance was certainly attributed to heavy dusts covered on the insulation surfaces of each winding. That is why the insulation resistance is expected to be improved by the removal of the dust on each winding. It is recommendable that the removal of the dusts should be done in order of brushing, cleaning with a volatile solvent, drying and varnishing over the insulation surfaces. This cleaning should be applied to all the windings of the synchronous condensers, especially to the rotor windings.

Also, the carbon dusts covered on the support insulators needs to be removed by cleaning, since one support insulator of the brush holder for Unit 1 was damaged by the ground fault due to coverage of the brush carbon dusts on the support.