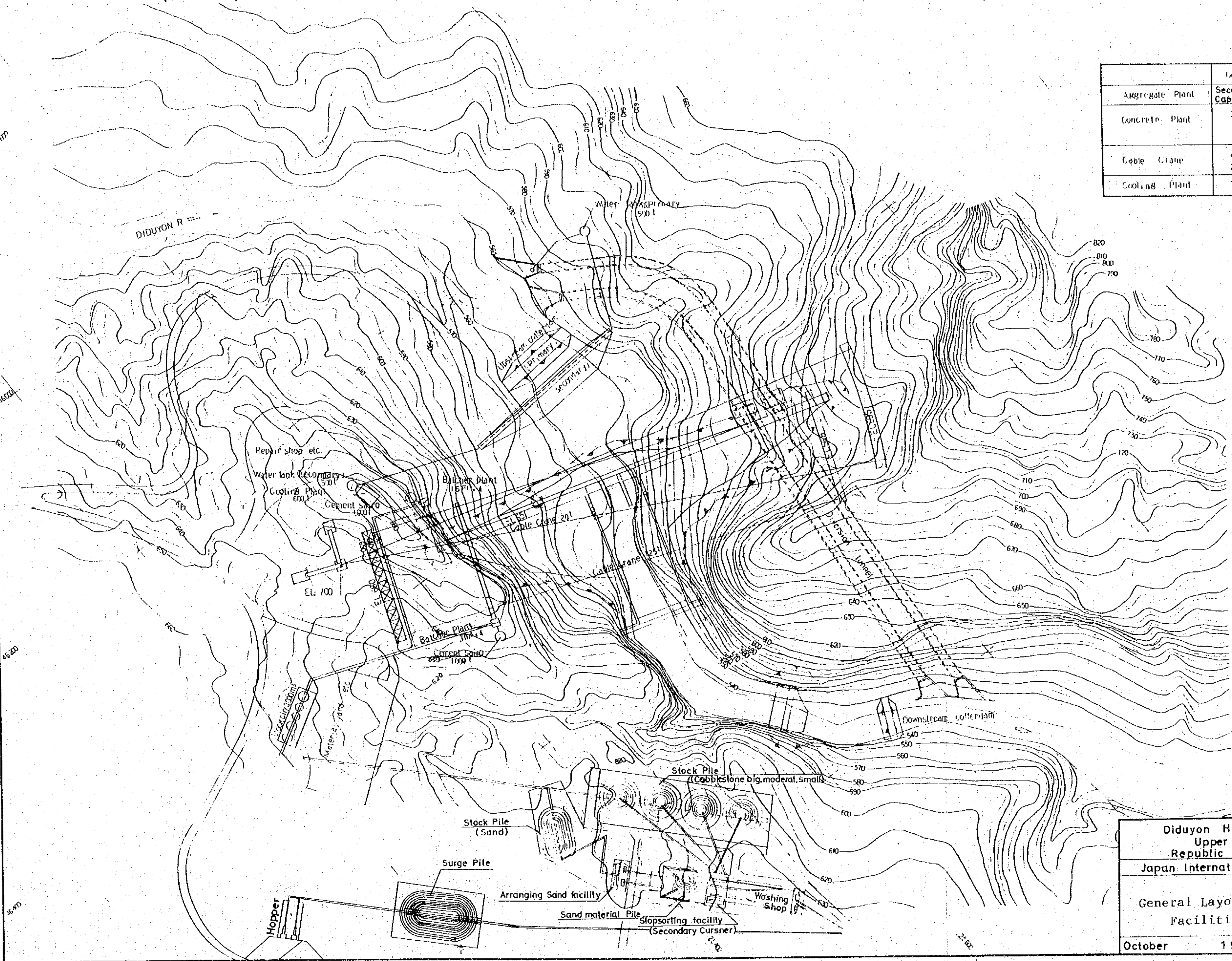
General Layout of Construction Facilities (Damsite)



	Capacity
Aggregate Plant	Secondary Crushing Cap. 750 ton/h
Concrete Plant	3 m³ × 4 15 " × 4
Cable Crane	25 ton × 1 20 " × 1
Cooling Plant	300 ton × 2

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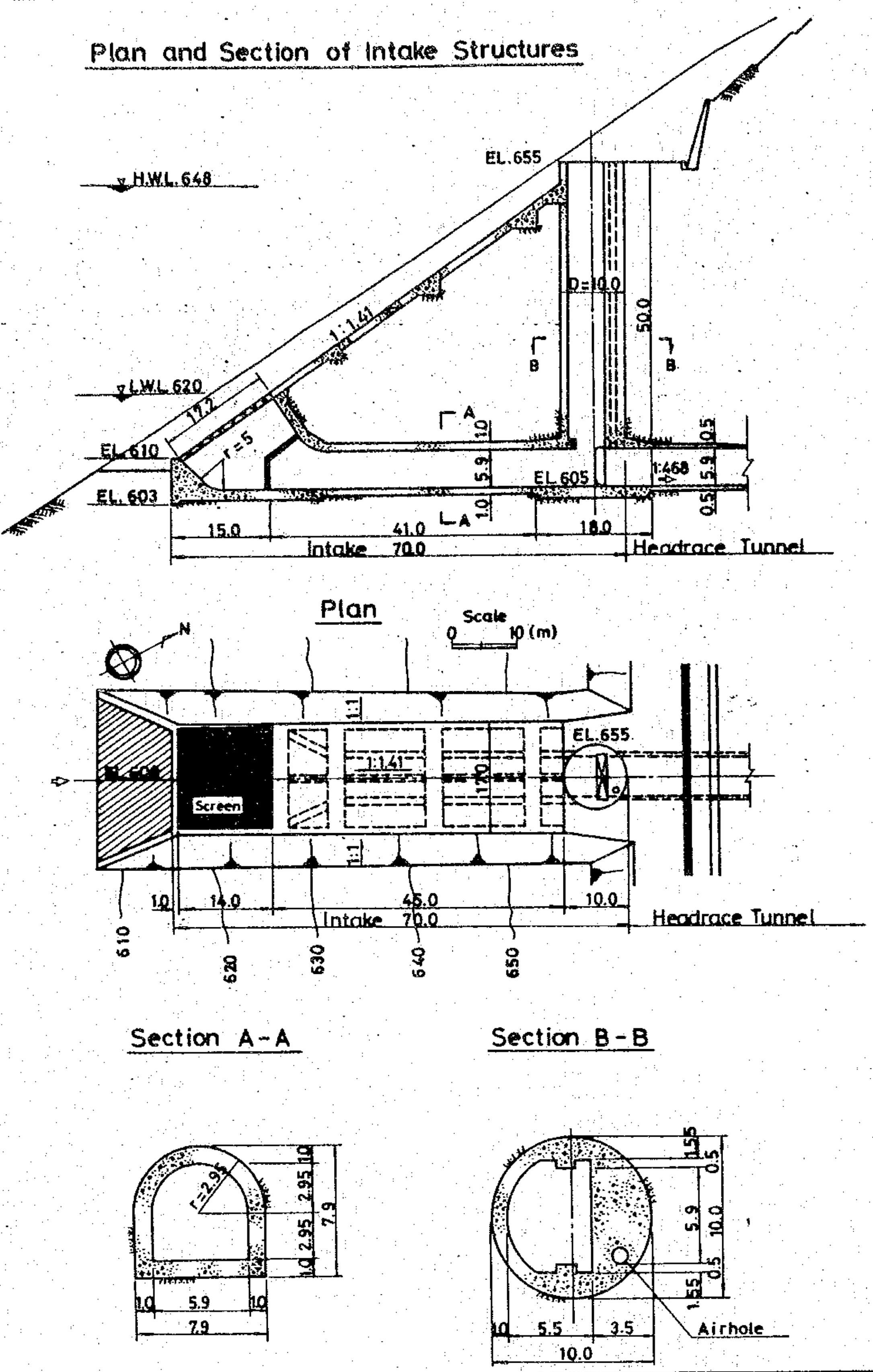
Japan International Cooperation Agency
General Layout of Construction Facilities (Damsite)
October 1980 Fig. 3-12

3.4.3. Intake

The intake of side inclined type will be installed on the left bank side. The intake will be located at El. 605 m which is equal to 15 m below the low water level of the reservoir, in order to avoid air entrainment into the pressure tunnel at the time of the low water level.

The general layout of the intake is given on Fig. 3-13.

Plan and Section of Intake Structures



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines		
Japan International Cooperation Agency		
Plan and Section of Intake Structures		
October	1980	Fig. 3 - 13

3.4.4. Waterway (Headrace)

(1) Selection of Waterway Route

In this connection the description in 3.3.2. should be referred to.

The Diduyon River, after it passes the damsite, turns its river course to the eastnorth and flows in a rapid stream with a riverbed gradient of 1/34 down to the powerhouse site.

The catchment area on the right bank in the river section from the damsite to the powerhouse site is so narrow that the watershed on the right bank is only 5 km distant from the river course. The mountain slope of the right bank is 1/2 to 1/3, cut by mountain streams.

The left bank in the same river section is the eastern tip of the Manparang Mountain Range. And the 1,000 m class high mountains come close to the Diduyon River on the left bank. The Didipio River joins the Diduyon River in a hanging valley from the left side at the middle point between the damsite and the powerhouse site. The river course in the same river section is narrow and the mountain streams present like hanging valleys.

The valley becomes slightly wider at the point 3 km downstream of the confluence with the Didipio River. Downstream from the point at the riverbed EL 170 m the mountain slopes of both banks become as gentle as 1/5, the gradient of the riverbed becomes also 1/120, and the river follows a northerly course.

The contour line of 800 m on the left bank comes, in the shape of a ridge, close to 2 km distant from the river course at the riverbed EL 150 m where there is the confluence with the Dibiowan River 13.5 km downstream of the Damsite. The ridge stands away from the river course as the river flows farther downstream and the elevation of the summit near the river course becomes as low as 500 m.

Along the left bank side just upstream of the confluence with the Dibiowan River there is a river terrace 1,000 m long and 100 m wide which will provide enough space for the construction of a powerhouse and a switchyard.

In the river section from the Damsite to this river terrace, the mountain slopes of both banks are adjacent directly to the river. Accordingly, it is difficult to find any adequate space for the construction of a powerhouse.

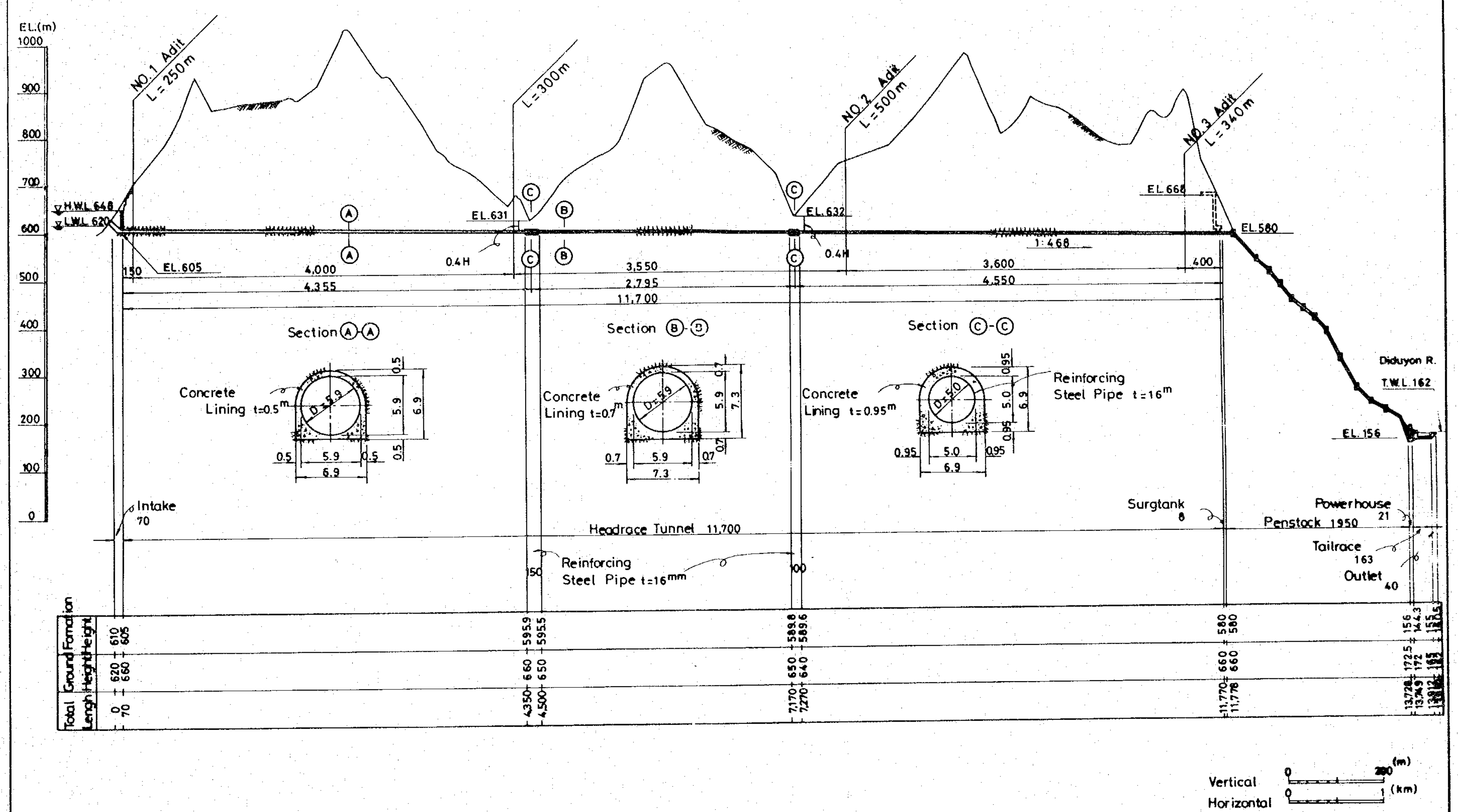
The right bank has a steep mountain slope and is undulated by the small mountain streams cut on the right bank. Moreover, the right bank is on the outer side of the bending Diduyon River. Accordingly, the alignment of the waterway on the right bank is questionable.

In contrast, the Didipio River flows in a hanging valley on the left bank. In order to keep away from the Didipio River, the waterway route will have to take an appreciable roundabout route. But the topography of the waterway route on the left bank is such as construction adits will be excavated at the intervals less than 4 km on the route, which will make it easier to drive tunnels for the waterway.

(2) Headrace Tunnel

The headrace tunnel will consist of one line, and is designed as pressure tunnel. The tunnel, 11.7 km long in total, will be divided into three segments — approximately 4 km, 3.6 km and 3.6 km respectively. For construction of the tunnel there will be driven two adits, 300 m and 500 m long respectively.

Profile and Section of Waterway, Headrace and Tailrace



Diduyon Hydroelectric Project
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Profile and Section of Waterway, Headrace & Tailrace

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The tunnel route and elevation is chosen on a principle that the mountain depth above the tunnel is at least 0.2, preferably as much as 0.4, of the total water head imposed on the spot.

The tunnel will be of concrete-lined circular section with a diameter of 5.9 m. The average thickness of concrete lining will be 0.5 m. For the limited portions intersecting the adits around the Didipio River and its tributary, the tunnel section will be reinforced with steel pipes with a diameter of 5.0 m, concreted and grouted around the pipes. The thickness of concrete lining should be reviewed during construction and will be decided by experienced engineers well versed in the design and local geology of the tunnel. A method of grouting for pressure tunnels should be established, based upon the elastic modulus and rock strength of the tunnel route.

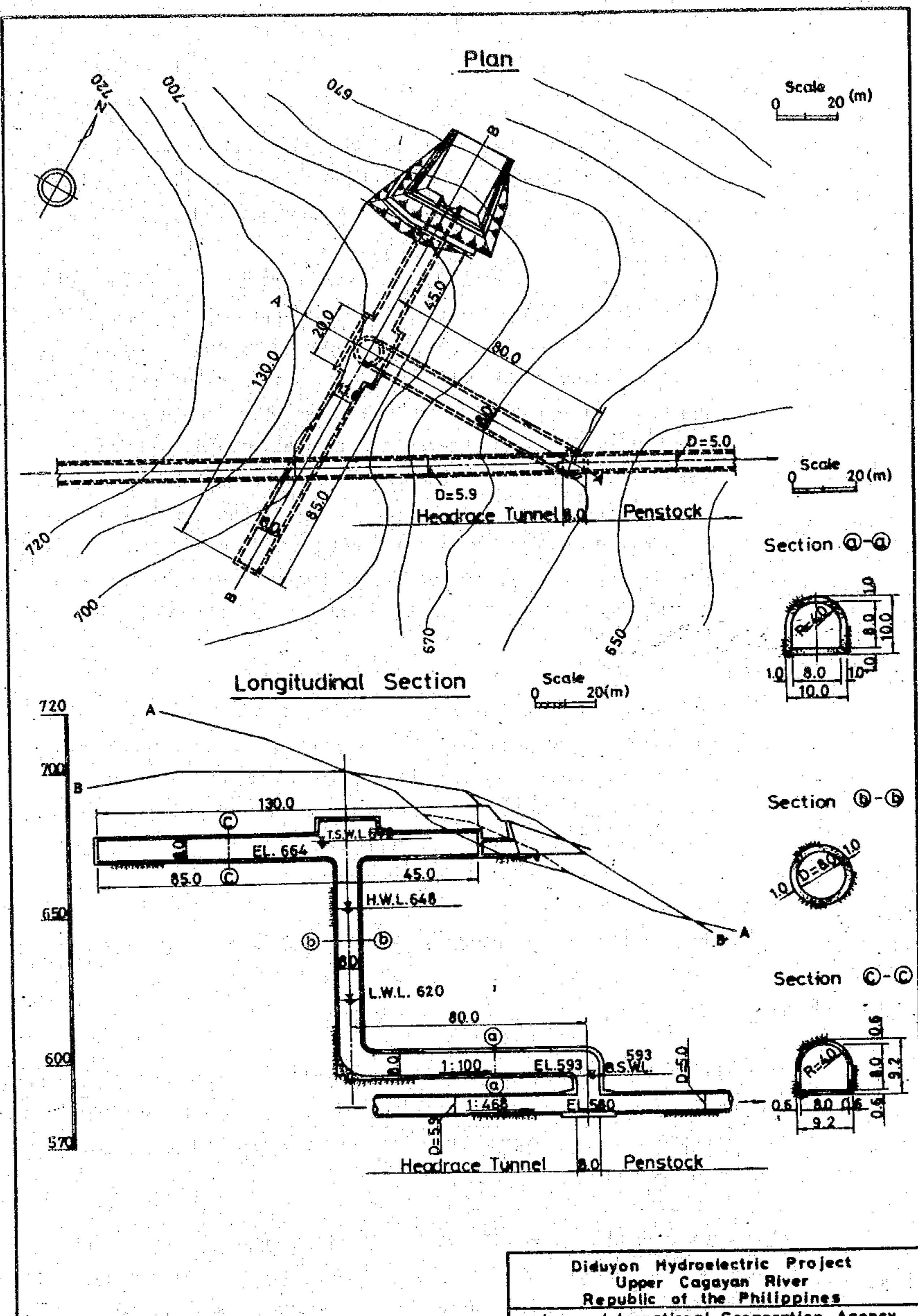
The tunnel section has been optimized, after analyses of the varied annual expenses of the pressure tunnel and the energy lost by the head loss with the change in the tunnel diameter. The velocity of flow inside the pressure tunnel will be 3 m/sec. The roughness coefficient (n) for concrete lining is taken 0.013 in this design.

The profile of the headrace tunnel is shown on Fig. 3-14.

3.4.5. Surge Tank

A surge tank of chamber type will be suitable for the project, because the available drawdown of reservoir is considerably deep and the hydrodynamic system including the headrace tunnel and penstock is very long.

The output of the Diduyon Power Station will share an appreciably large portion of the total output in the Luzon Grid. Accordingly, the stable section of the surge tank is desirably made larger. The



Diduyon Hydroelectric Project
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Surge Tank

October 1980 Fig. 3 - 15

section was determined with necessary allowance added to the computed stable section.

The surge tank, thus designed, will have the dimensions as shown below and in Fig. 3-15.

Vertical shafts	:	77 m high, with a circular section of D=8 m
Chambers	:	Upper - 130 m long tunnel with a cross-section of 57 m^2
		Lower - 80 m long tunnel with a cross-section of 57 m^2

The roughness coefficients used for the design of this surge tank are as follows:

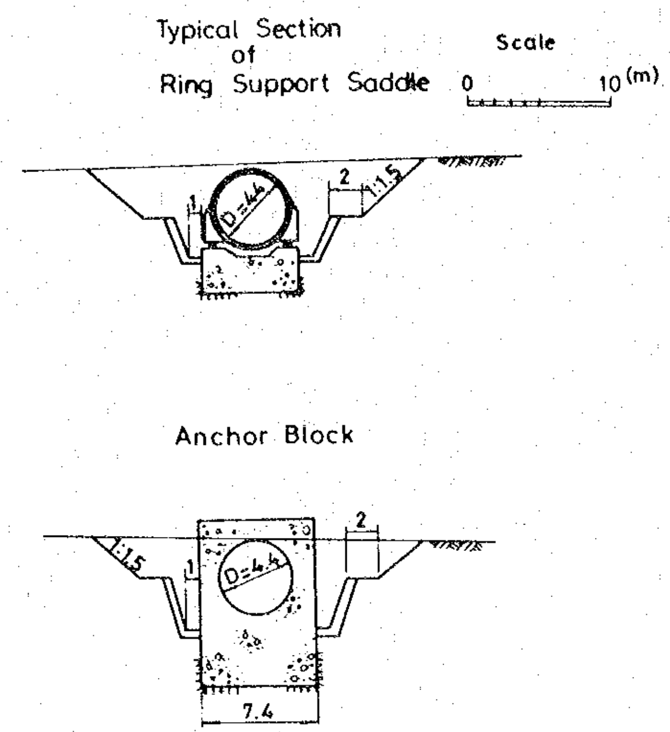
For the determination of the section and
the interruption of the load .... n = 0.0115
For the increase of the load .... n = 0.0145

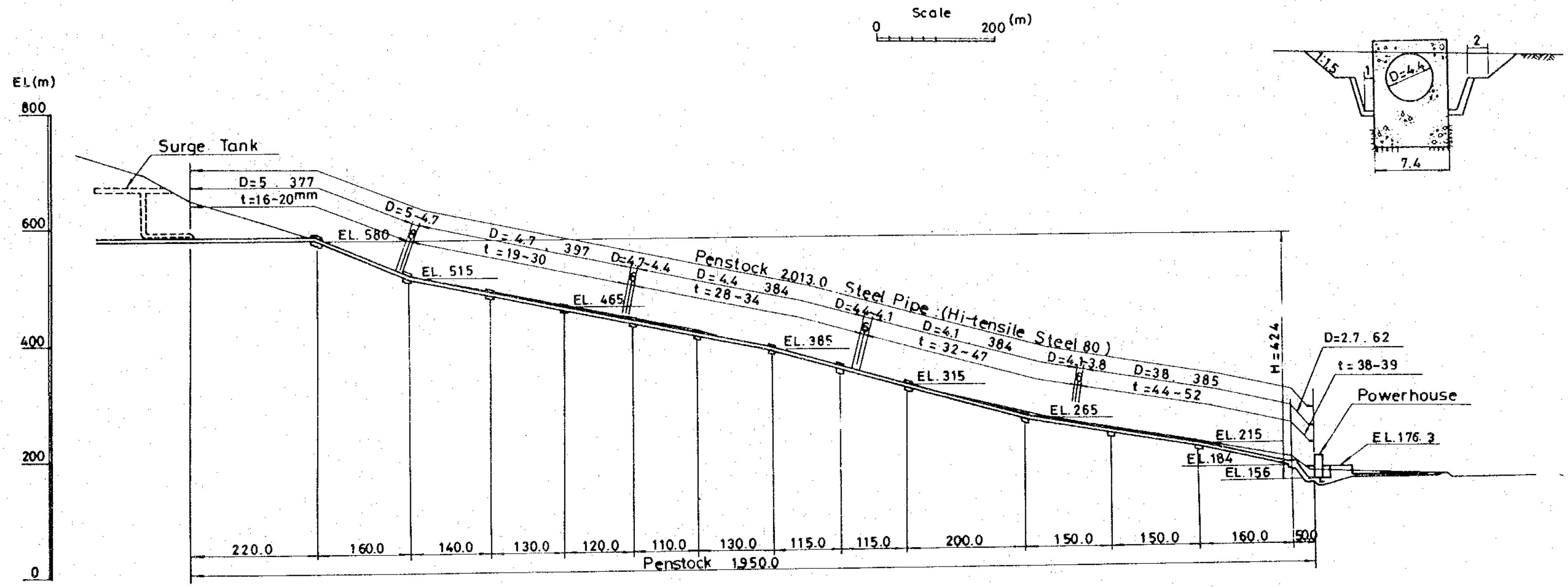
3.4.6. Penstock

The penstock consists of one welded steel pipe-line, and will bifurcate just before the hydraulic turbines as shown in Fig. 3-16. The use of high tensile steel plate of HT-80 kg/mm^2 class is totally adopted for the rationalization of design and the economization of steel weight.

The diameter of the penstock will be 5.0 to 2.7 m, and its length is 2,013 m. The water velocity inside the penstock will be 4.3 to 7.4 m/sec. The diameter of the penstock has been optimized, after analyzing the varied annual expenses of the penstock and the energy lost by the head loss with the change of the diameter.

Longitudinal Plofile and Typical Section of Penstock





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Penstock

October 1980 Fig. 3-16

The thickness of the steel pipe plates will gradually change from 16 mm to 52 mm, according to the hydrodynamic pressure.

The total weight of steel pipes for the penstock will reach 8,200 t. The use of high tensile steel will greatly decrease the thickness of steel plates and consequently the whole weight of pipe-line, because the penstock is considerably long and high-pressured.

3.4.7. Powerhouse

A conventional open type powerhouse will be adopted for the Project. It will be 29.6 m wide, 60 m long and 37 m high. The general layout of the powerhouse is as shown on Fig. 3-17.

The finish elevation around the powerhouse is designed on EL. 176.3m, which will keep the powerhouse perfectly free from the possible maximum flood water level of the Diduyon River.

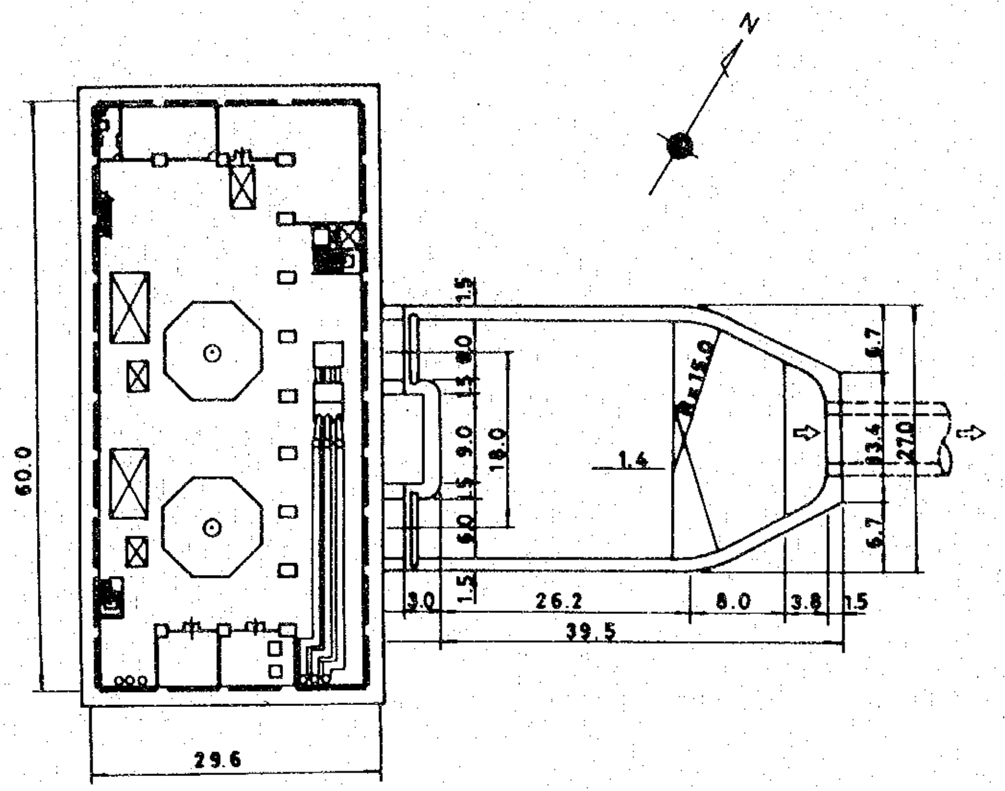
Aesthetic aspect of the powerhouse is a problem to be further studied at the definite design stage, because the structure will no doubt be of a conspicuous magnitude to call forth the general attention.

3.4.8. Tailrace

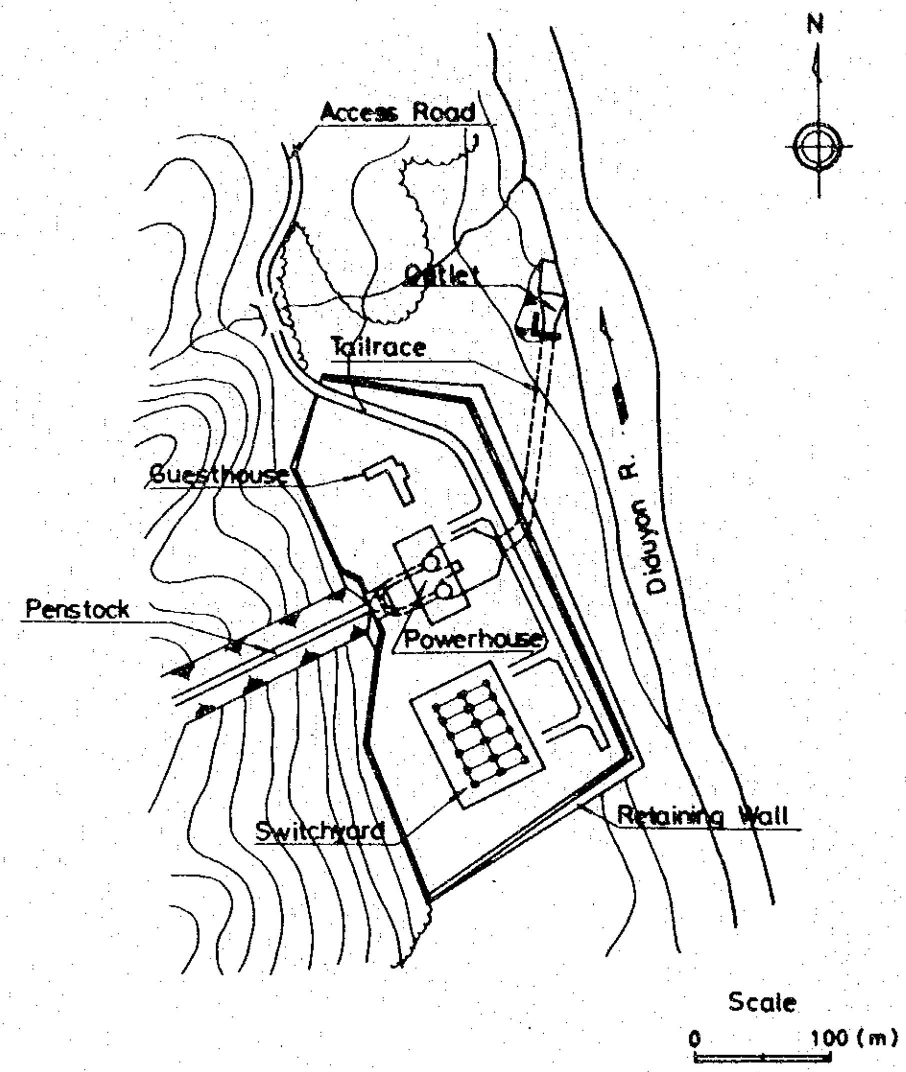
The tailrace consists of an afterbay, a short tunnel and outlet structures.
The water discharged from two hydraulic turbines will converge and be regulated at the afterbay. Then the water flows down the concrete-lined free-flow tunnel, 110 m long, with a circular section of D=5.9 m, and passing through the outlet to join the Diduyon River.

The general layout of the tailrace is also shown on Fig. 3-17.

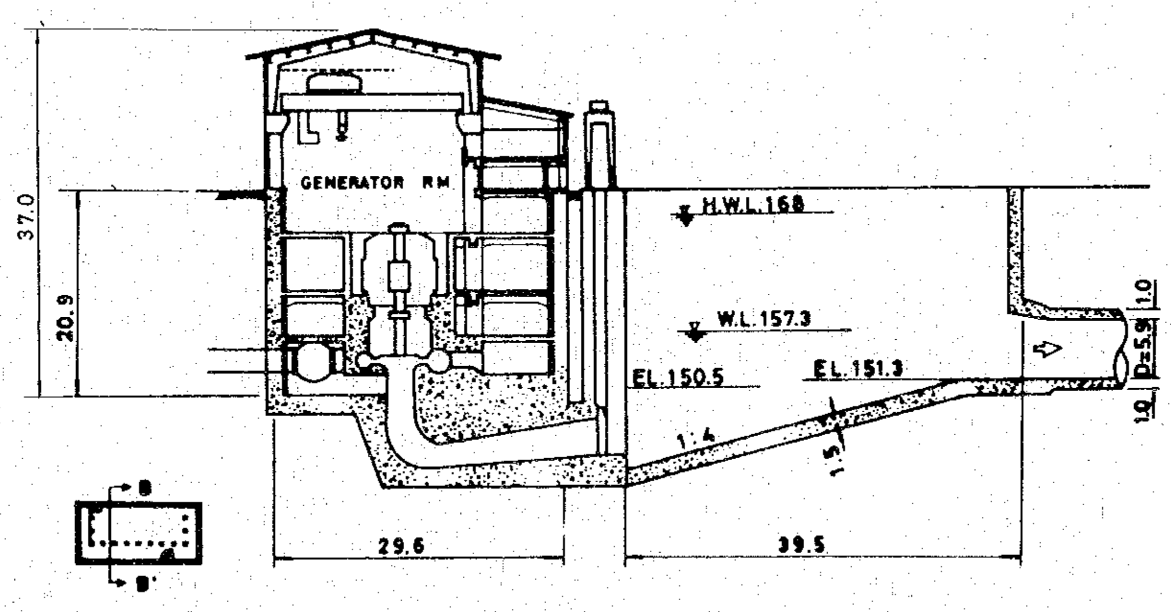
Plan of Powerhouse



Plan Around Powerhouse

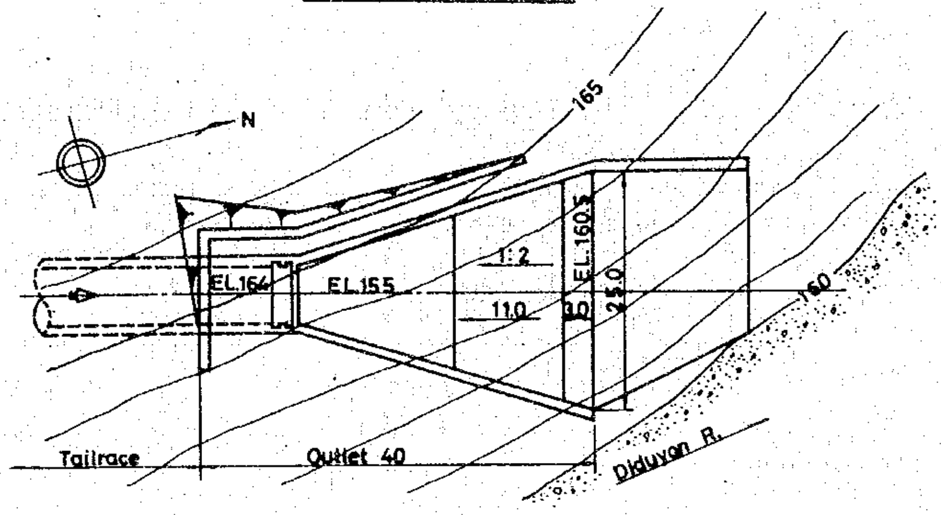


Longitudinal Section

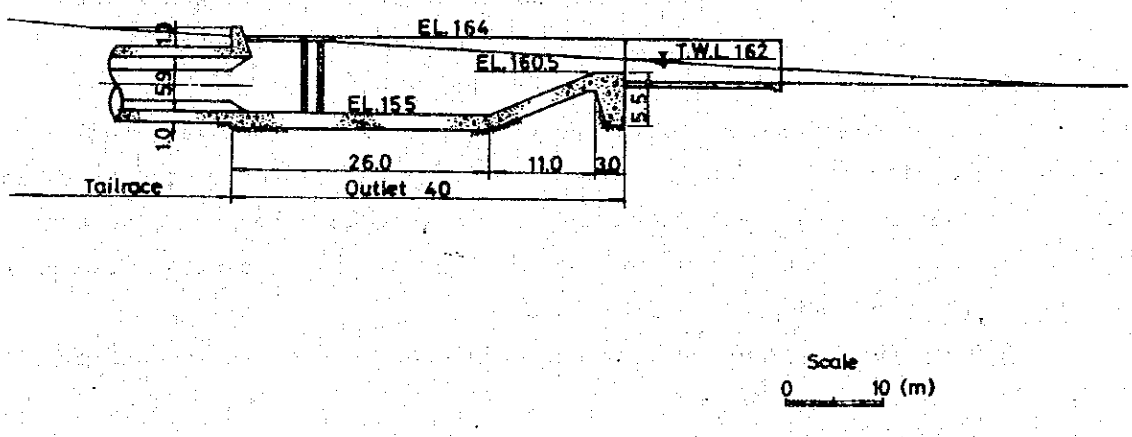


Diduyon Hydroelectric Project **Upper Cagayan River** **Republic of the Philippines**
Japan International Cooperation Agency
Powerhouse and Tailrace
October 1980 Fig. 3-17

Plan of Outlet



Longitudinal Section



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Tailrace Outlet
October 1980 Fig. 3 - 18

3.4.9. Hydraulic Turbines and Generators

The main features of hydraulic turbines and generators are shown in Table 3-6.

Table 3-6 Main Features of Hydraulic Turbines and Generators

Item	Hydraulic turbine	Generator
Type	Vertical shaft Francis	3-phase AC Generator
Maximum output	176 MW x 2 = 352 MW	191.7 MVA x 2 = 383.4 MVA
Revolution (r.p.m.)	360	360
Number of units	2	2

As the type of hydraulic turbines for a effective head of 451 m and a turbine discharge of 85.2 m^3/sec., either Francis or Pelton type be adopted. For the reasons of economics and easiness of maintenance, the Francis type is adopted in this Project.

To decide the number of units of water turbines and generators, several conditions were taken into consideration: weight of equipments for transportation to the site, conditions of the access road leading to the powerhouse site, percentage of unit capacity of the project in the total system capacity, and operation program of the storage reservoir, as well as a techno-economical study on the division into several units. As a result, a two-unit system was adopted for this project.
The general layout of turbines and generators is shown on Fig. 3-19.

3.4.10. Switchyard

The Diduyon Power Station and the Santiago Substation will be connected with two (2) 230 kV transmission lines. Thus, as stated above, this power station will include 2 banks of main transformers and 2 circuits of transmission line each at 230 kV. For such combination, the use of a simple ring bus will be optimum for adoption. Especially in this project, the use of wide space for the switchyard is quite limited from the topographical reason; the use of the simple ring bus satisfies this need also.

The layout of the switchyard is as shown on Fig. 3-20, while the one line diagram is shown on Fig. 3-21.

3.4.11. Transmission Line

As described in 3.3.6., the transmission line route for the project was selected from three alternative routes. The recommended route is a route of two-circuit 230 kV transmission line, 45 km long, connecting the Diduyon Power Station with the existing Santiago Substation of NAPOCOR.

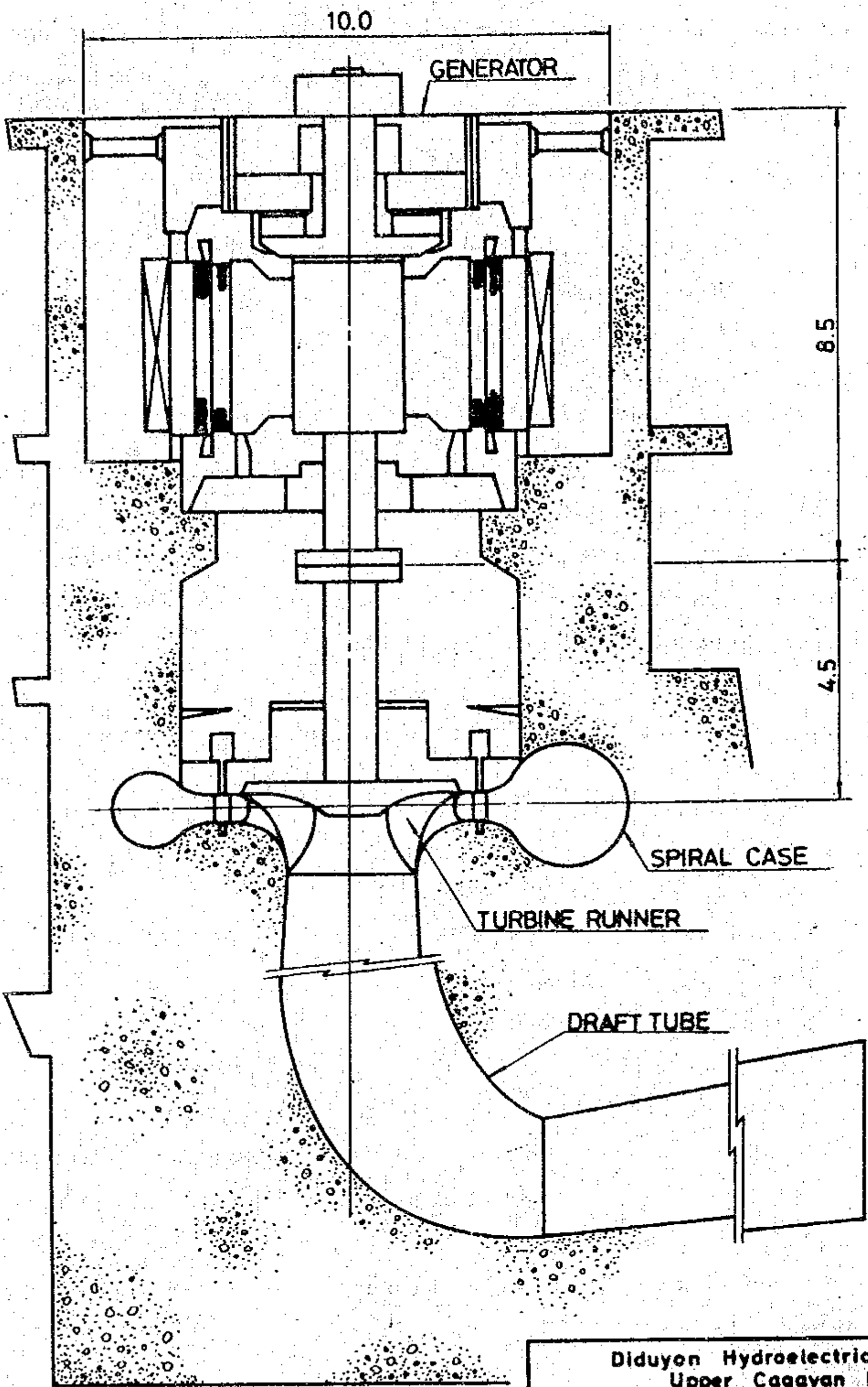
The general outline of the transmission line is given below:

Voltage	:	230 kV
Circuit	:	2
Conductor	:	795 MCM ACSR
Ground Wire	:	3/8" EHS
Wind Span	:	400 m
Weight Span	:	600 m
Tower	:	Double Circuit Steel Tower
Receiving End	:	To be equipped in a lot adjacent to the existing Santiago Substation with necessary facilities.

The general view of the typical suspension tower is given on Fig. 3-22.

The detailed design and survey will be made at the definite design stage.

Cross-Section of Turbine and Generator



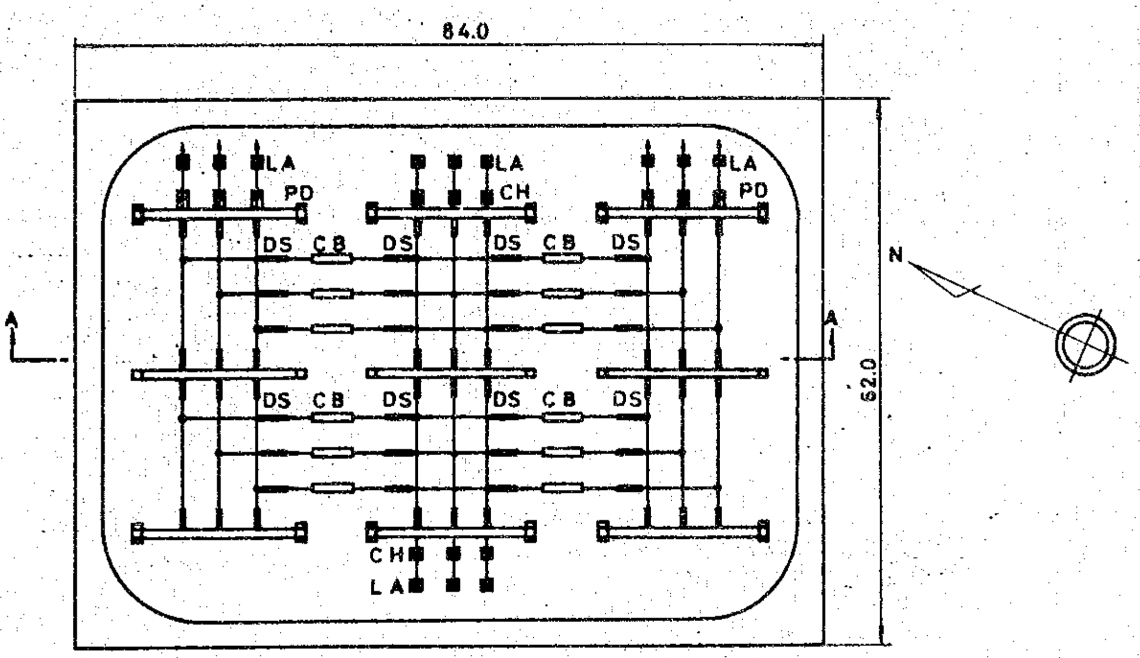
Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines		
Japan International Cooperation Agency		
Cross-Section of Turbine and Generator		
October	1980	Fig. 3 - 19

Plan and Section of Switchyard Equipment

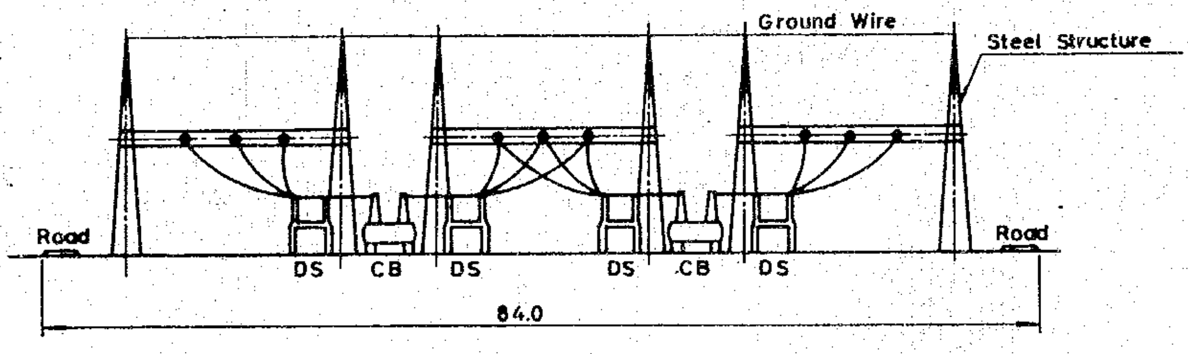
Legend

LA : Lightning Arrestor
PD : Potential Device
DS : Disconnecting Switch
CB : Circuit Breaker
CH ; Cable Head

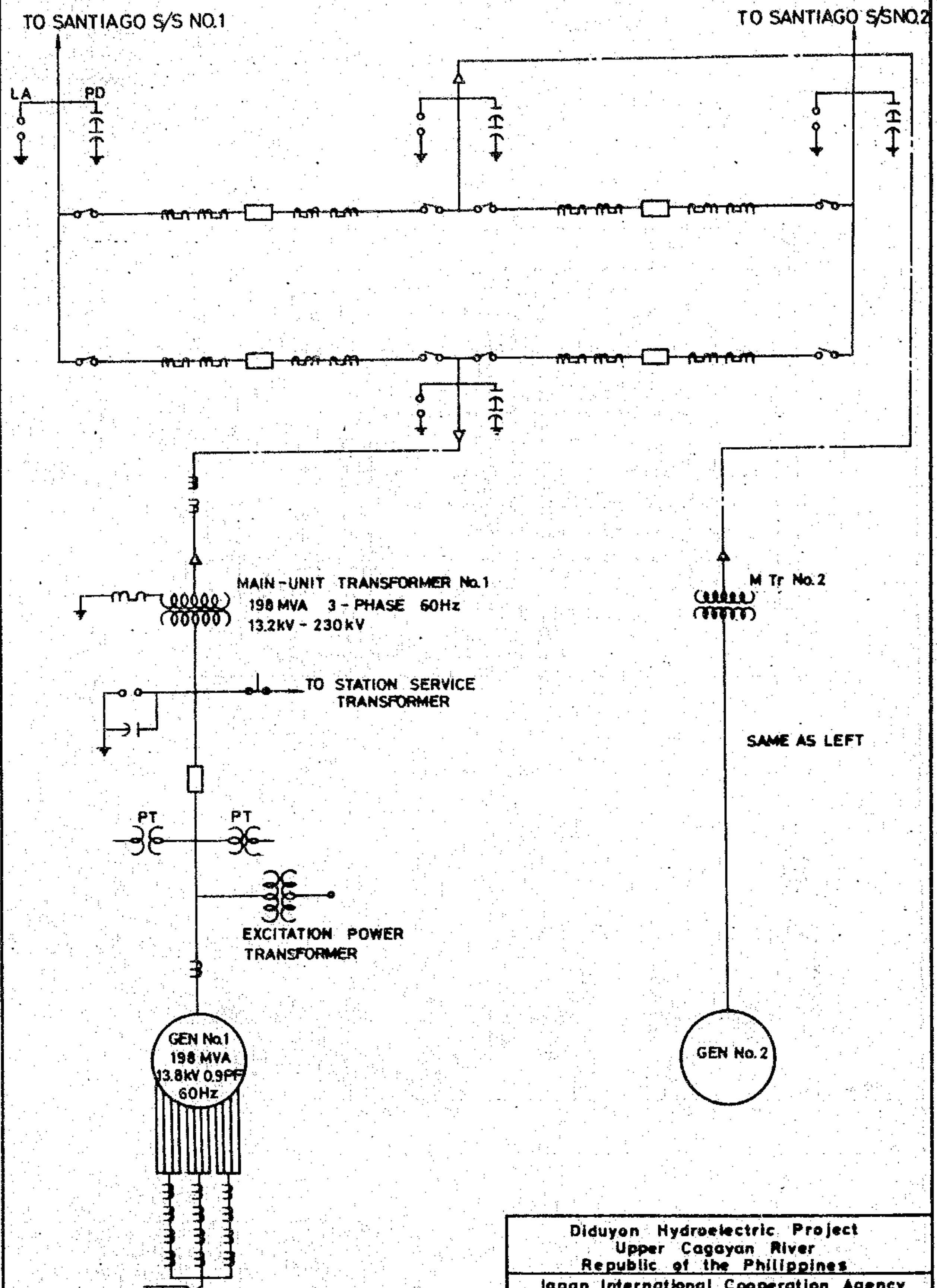
Plan



A - A Section

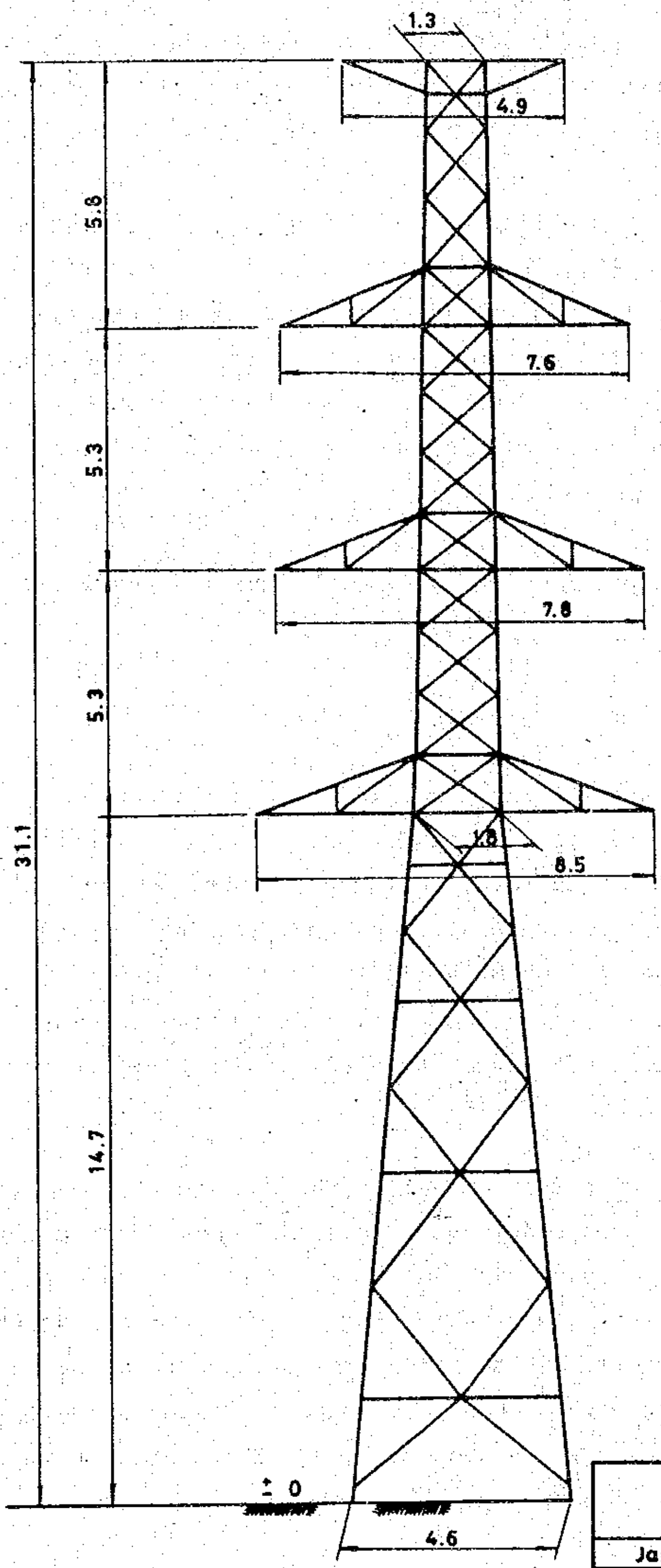


Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Plan and Section of Switchyard Equipment
October 1980 Fig. 3 - 20



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
One Line Diagram of Switchyard	
October 1980	Fig. 3 - 21

Scale : 1/150



Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines

Japan International Cooperation Agency

Suspension Tower for
Transmission Line

October	1980	Fig. 3-22

3.4.12. Construction Road

Besides the existing roads stated earlier, the construction roads connecting the terminals of the existing roads with the main structures of the dam, power station, quarry site, intake, tunnel adits and surge tank will be required.

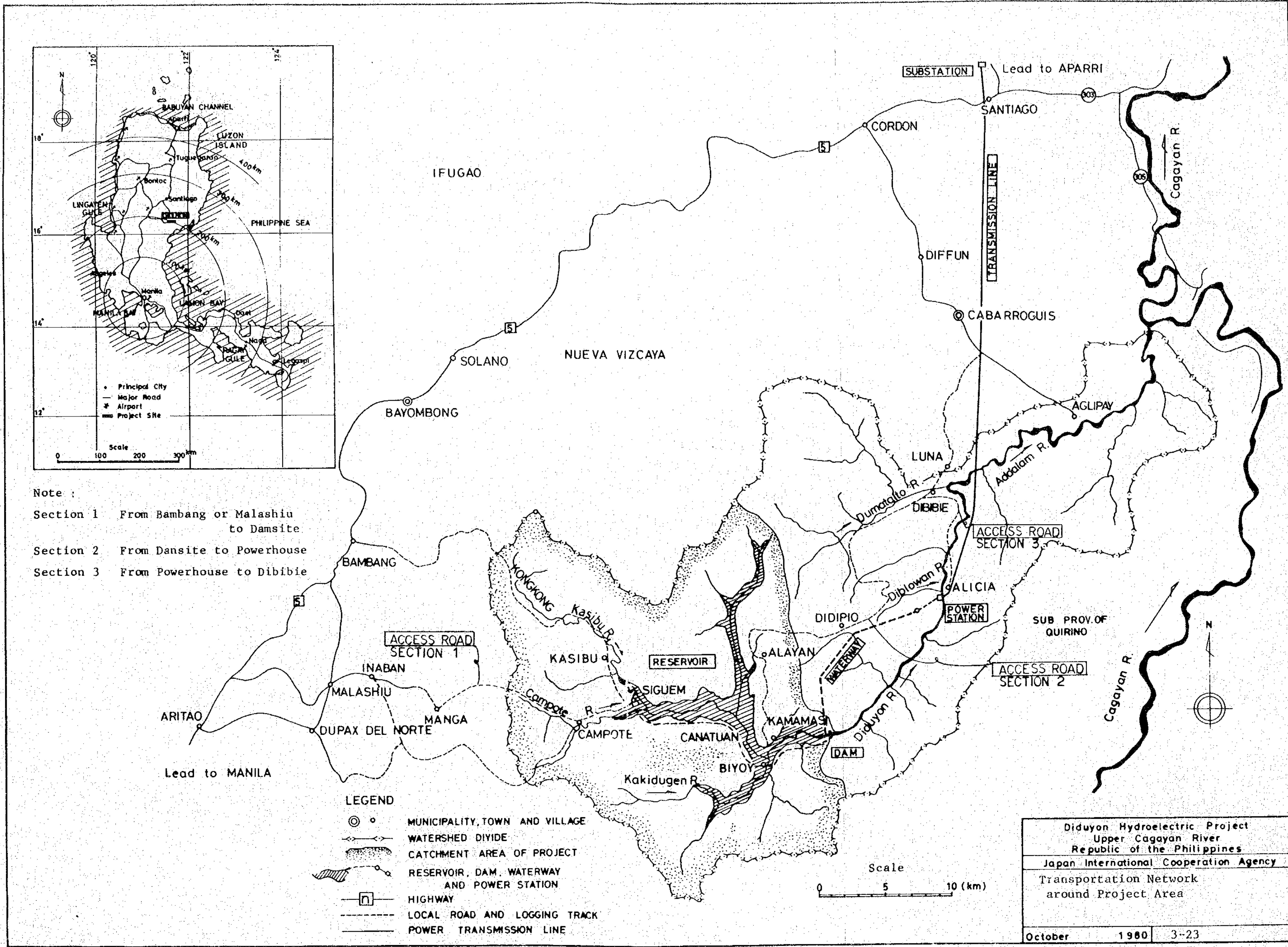
The length of road construction depends upon the route to be taken to and in the site, but it will be around 105 km; from Malashiu to the Damsite - 55 km, including all the necessary relocation of logging tracks along the reservoir, from the Damsite to the Powerhouse - 38 km, and from the Powerhouse to Dibibie - 12 km. The relation between the Project and its access roads is shown on Fig. 3-23.

In the above-stated construction roads are included the following three sections:

Section 1 From Bambang or Malashiu to Damsite.

There exists a local road from Bambang to Kasibu. To avoid any traffic difficulty owing to the relocation of this existing road, it is recommended to study the improvement and relocation of the existing logging track leading from Malashiu to Siguem via Manga. The latter route, 55 km long, seems worth studying into because of apparently good topographical features of the route.

In the portion from Siguem to the Damsite, the existing logging tracks should be relocated in time before the completion of the reservoir dam. This portion will be constructed on a suitable elevation above the reservoir H.W.L., and it may contain a few bridges to be built across the rivers such as Campote and Biyoy as well as other minor riverlets or streams. The Section 1 will be of gravel-paved type, 8 m wide.



Note :

Section 1 From Bambang or Malashiu to Damsite

Section 2 From Damsite to Powerhouse

Section 3 From Powerhouse to Dibibie

Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines

Japan International Cooperation Agency

Transportation Network around Project Area

October 1980 3-23

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Section 2 From Damsite to Powerhouse

This section, 38 km long, includes the following portions:- 6 km around the damsite on the right bank of the Diduyon River, 25 km from the damsite to the surge tank via Didipio along the waterway, and 7 km from the surge tank to the powerhouse. This section, will also be of gravel-paved type, 8 m wide.

Section 3 From Powerhouse to Dibibie

This section, 12 km long, is designed not only for construction but also for the future service road to the powerstation, and accordingly it is recommended that finally the surface be asphalt-paved and the road width be made wider.

In this section will be built a few bridges, crossing the Dumatalto River and other minor streams.

3.4.13. Local Materials for Construction

(1) Aggregates for concrete

As briefly stated in 2.6.3., all concrete aggregates were expected to be supplied from the riverbed deposits and the quarry on and around the site.

As a result of the field surveys carried out during a period of the feasibility study, it follows that they are available at Aglipay, the Addalam River, and at Bambang, the Magat River, but that the previously proposed quarry just downstream of the right bank of the damsite No. 3 is not fit for use.

The proposed dam is of considerably ample volume up to 1.2 million m^3 concrete. If the natural river deposits on the downstream river are used for the dam, their transportation to the damsite will need every day a caravan of hundreds of lorries over a distance of 80 km, resulting in very high cost of construction and extraordinary traffic jam on the access road.

It is recommended, therefore, that a suitable quarry site be acquired in the vicinity of the damsite.

The newly proposed quarry site is located on the left bank of the Diduyon River, 2 km upstream of the damsite. The surface geological reconnaissance carried out at the feasibility study stage shows that the basic geology of the site is andesite, very hard and sound, with seemingly thin topsoils on the rock body of large magnitude.

In the present study of dam consturction, cost estimates are premised on the condition that the above-mentioned quarry site is suitable for the purpose. On the next definite design stage, it is necessary to make a comprehensive survey of this quarry site to justify the premise.

The problem of alkali-aggregate reaction must also be checked, because quarry-made aggregates sometimes show an adverse quality of this kind.

(2) Cement

As explained in 2.6.3., the cement supply is sufficient for the Philippine home demand at present. But many giant construction works are and will be going on there. Especially in Northern Luzon, the Gened Project, with a 175 m high concrete arch dam of 2 million m^3, will be pushed forward prior to the Diduyon Project. It is well expected that the cement supply will increase according to the general construction program in the Philippines.

In case of the Diduyon Project, the supply capability provided for these projects will be fully utilized.

It must also be noted that not only the quantity of supply but also the quality of cement be tested and counted into the design of structures.

(3) Materials for access road

The access road to and in the project area is 105 km long in total. The road will be paved with a great volume of pebbles. For its pavement only, for example, nearly 200,000 m^3 of pebbles and gravels should be procured in the near-by riverbed deposits or quarries along the road route, as roughly estimated as follows:

8 m wide x 0.25 m thick x 105,000 m long = 210,000 m^3

Extra pebbly materials for construction of road-base section shall be added to the above figures.

7.5 m wide x 0.5 m thick x 105,000 m long = 390,000 m^3

Besides, aggregates and steel structures for bridges have also to be taken into account. Furthermore, the time of their procurement of such vast quantity is chiefly concentrated during the first few years of preliminary works.

It is stressed, therefore, the necessary field surveys should be made in the succeeding definite design stage of study to assess the procurement of the road materials.

3.5. Environmental Assessment

3.5.1. Sociological and Environmental Consequences

(1) Social Aspect

a) Resettlement of Inhabitants to be inundated by the reservoir.

With the creation of the reservoir 9 barrios in the Kasibu Village will be inundated. And 50% of the housing lots in the proposed reservoir, assumed at 500 households, and most of the irrigated rice field cultivated on the flats near the river will be submerged.

The resettlement of the people residing at the Kasibu Village, part of which will be inundated, should be planned very carefully. The reorganization of resettlers' villages and the transportation in and into these villages must also be guaranteed firmly.

b) Short-term Effects

The most remarkable short-term effect is the concentration of the population into the Diduyon area. The construction of large-scaled dam and power station requires a lot of labourers, engineers, technicians, administration staff and managers to engage in the works. These people and their families residing temporarily at the sites will form a town. This will bring sociological and environmental problems at the secluded place in the mountain.

c) Long-term Effects

Upon the completion of the access roads to the project area, Diduyon will be connected to the National Road Route No.5; on the route will be Bambang - Kasibu - Diduyon - Cabarroguis - Cordon. The connection with the National Road will activate and diversify the transport of agricultural products from the area and the inflow of consumable goods thereto.

Besides, there will be expected in the future the latent benefits such as irrigation, flood control and tourism.

i) Irrigation

About 3,000 ha of irrigable land will be made available in the future on both banks of the Lower Diduyon River. But the benefit to be obtained from the Project through the regulated river-flow at the Reservoir will be reaped only in the future, because all of the expected irrigable land lie distant from the Diduyon Project site and on higher elevation than the riverbed, which call forth the necessity of costly pumping facilities and waterways.

ii) Flood Control

It is likely that large-scaled floods have occured in the Diduyon River Basin. The flood control effect achieved by the Diduyon Reservoir will no doubt improve the downstream conditions in a broad conception.

iii) Tourism

The Diduyon Region is situated in the center of Northern Luzon. Being on a high altitude of about 700 m above sea level, the Diduyon Reservoir area will have a mild, cool climate very rare in the Philippines; it will provide an opportunity to attract tourists with its mild climate, presence of a large man-made lake and access roads associated with the construction of the Project.

3.5.2. Countermeasures for Environmental Setbacks

(1) Plan for Resettlement

With the creation of the reservoir at H.W.L. 648, about 500 households in the 9 villages will be affected. The land proposed for the relocation of the affected households should fulfil the following requirements;

a) The land shall be suitable to reconstruct the agricultural activities.

b) The land shall facilitate the intercommunications inside the resettled community.

c) The land shall be located so as to promote the economic interchanges with the society outside the community.

d) Allocation of land to the resettlers should include a deliberate consideration of the tribal feeling existing among the inhabitants living in the area. The resettlers may be from several tribes, quite different in respect of living standard, customs, dialect, religion and so on. The success or failure of resettlement greatly relies upon the grasping of the tribal problem in the area.

Following the concept mentioned above, three plans were worked out for study (See Fig. 3-24).

a) Plan 1 (Dispersion Type Relocation)

The land for resettlement will be developed dispersedly upstream of the damsite.

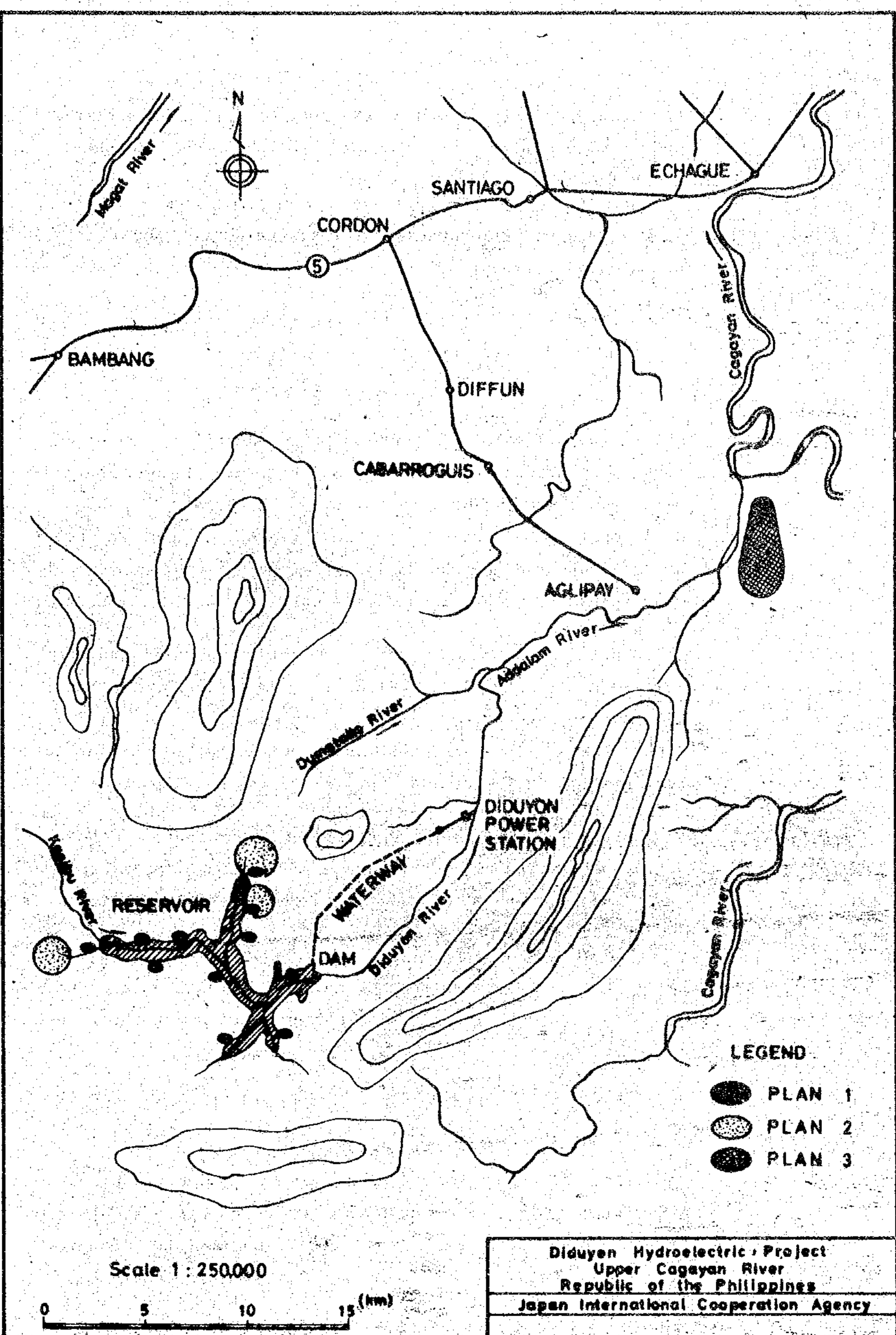
b) Plan 2 (Intension Type Relocation)

The land for resettlement will be developed in rather instensive lots upstream of the damsite.

c) Plan 3 (Complete Removal Type Relocation)

The area on the right bank 5 km upstream of the confluence of the Diduyon River with the Cagayan River will be developed for the land for resettlement. This area will be enriched with water for irrigation by the regulation of the riverflow at the dam.

The Plan 3 will produce a drastic change of the mode of life to the resettlers who are composed of different tribes and socio-economic conditions. The Plan 2 will serve to reconstruct and strengthen the Municipality of Kasibu. The Plan 1 will



Diduyen Hydroelectric Project Upper Cagayan River Republic of the Philippines	
Japan International Cooperation Agency	
Proposed Resettlement Plans	
October 1980	Fig. 3-24

not make a drastic reform of the mode of life of resettlers and provide similar condition of life to that before the resettlement.

Approximate costs for these three resettlement plans were computed as follows:

Plan 1	:	94 million
Plan 2	:	101 million
Plan 3	:	127 million

Before the selection of the final plan, detailed studies should be carried out, not only on the costs of the resettlements under those plans, but also on the actual, feasible measures to be accepted by the resettlers. Though the number of the inundated households is appreciably few as compared to other projects, countermeasures should be planned deliberately.

All that are concerned in this matter must bear in mind the commitment of NAPOCOR for all of the families that may be affected by the project, as stated in the letter of Mr. G.Y. Itchon, President of NAPOCOR, dated October 9, 1979. The letter confirms the following basic principles to be adopted.

a) Relocation shall be designed to bring progress to the people living along the rivers whose houses, farm lands and/or other properties shall be adversely affected by the project.

b) The people to be relocated shall be represented and shall participate in the decision-making process for their resettlement; and

c) The resettlement program shall be implemented within the context of existing laws.

The letter also assures the people in the project area that NPC will consult them about their relocation plans should the project prove to be feasible before NPC decides on its construction.

It is well expected that the above-mentioned basic principles and policy guidelines will lead to a successful and peaceful solution of settlement and compensations related to the Diduyon project.

As for the selection of the optimum relocation plan, it seems most practical and economical at this stage to adopt Plan 1 or Plan 2, depending upon the settlers' choice.

In respect of the affected households, farms and other properties around the powerhouse, penstock, waterway and transmission line, the compensation problems will also be solved on the same guidelines and treatment, because the range is limited and/or the affecting time is temporary.

(2) Environmental Consequences

a) Change of Riverflow

i) Downstream of the Powerhouse

A sudden rise of the water level downstream of the power station which will sometimes be caused by abrupt water discharge released from the power station, jeopardizes the safety of people working at and animals pastured at the river. To prevent this kind of accidents, countermeasures as discussed later should be taken in connection with the operation rules of the powerstation as well as with the establishment of adequate alarming system in the lower reaches of the river.

A sudden shut-out of the peak discharge will also cause difficulties in taking water in the downstream facilities. But in case of the Diduyon River, difficulties of this kind apparently do not arise even in the dry season, because the catchment area at the damsite is appreciably small (477 km^2) as compared with the residual catchment area at the downstream intakes, and there are few intakes that take water directly from the downstream river.

ii) Between the Dam and the Powerhouse

In the dry season, the river course between the dam and the powerhouse will be fed only by the small discharge from the mountain creeks in the river section. But this will not cause serious effects on the portion of river course, because there was neither any past practice of boating or rafting due to the torrential flow of the Diduyon River and to the presence of rapids, nor any system of water utilization from the Diduyon River.

b) Reservoir Problems

In the Diduyon Project is included the building of a 111 m high concrete dam and a storage reservoir impounding 0.58 billion m^3 of water.

Problems which may be caused by the construction of the Diduyon Reservoir will be summarized in the following three.

i) Drawdown of Storage Water Level

The drawdown in the reservoir is 28 m. The variation of reservoir water stages will have the possibility to cause the erosions of the slopes in the reservoir area and the exposure of remnants along the water shoreline in the dry season when the water level is drawndown.

The impoundment of a reservoir on a river expands the waterside line of the river and sometimes causes soil erosions and landslides along the waterside of the reservoir. The vegetation in the Diduyon River Basin is in good condition. Furthermore, hourly or daily speed of waterlevel drawdown in the Diduyon Reservoir is quite small and neglegible owing to its big storage capacity.

Accordingly, soil erosions and landslides on the water-side line of the reservoir to be created by the Diduyon Dam will not be so serious.

The aesthetic aspect of the reservoir shoreline in the dry season must be remedied by clearing of falling trees or construction materials before and after the completion of the dam. As a whole, this problem, if cautiously treated by the administration and contractors, will be compensated by the appearance of gigantic, beautiful landscapes around the reservoir.

In case of the Diduyon Reservoir, the projected drawdown is limited to 28 m, and it is projected to keep the water stage of reservoir as high as possible for the maximum generation of electricity. The aesthetic aspect of the Reservoir will, therefore, be not seriously affected by the drawdown.

ii) Water Quality and Water Temperature

The problem will be divided into two stages during construction and after construction.

The former will be treated successfully with technical-engineering considerations such as stilling basins and chemical adhesives, regulation of sanitary facilities for camps and dwellings, control of dumping soil into the river and so forth.

The latter has a rather long-durated character. The annual inflow into the reservoir is estimated to be about 1.5 times of the gross storage capacity of the reservoir. This will result in the formation of cold water layer at the bottom part of the reservoir. The movement of water will be considerably active in the live storage of reservoir for the available drawdown of 28 m between H.W.L. and L.W.L.

The contruction of a dam generally causes slight contamination of the river water on the lower reaches for a long term. However, this matter will not become an important issue in connection with the development of the Diduyon River, because the dense vegetation in the Diduyon River Basin keeps the water quality of the Diduyon in considerably good condition.

The water stored in the reservoir will be nourished by dissolution of organic matters and inflow of fertilizer, agricultural chemicals, and sewerage. However, the nourishment of the reservoir will not bring serious environmental problems because the living conditions seemingly will not change suddenly.

In a long term, animals and plants, submerged under the reservoir will rot, which will result in the aggravation of the water quality within the reservoir.

iii) Aquatic Life

The nourishment of the water stored in the reservoir will result in the extinction of the organism apt to live at the bottom of the water; the growth of aquatic plants and the generation of aquatic insects will in turn give influences to fishes.

The river flow will be cut by the construction of the dam. This will make it impossible for fishes to go up and down the stream. The environment for the life of adhesive duckweeds and aquatic insects growing in the shallows and in the coast will be changed after the completion of the dam. However, the creation of the reservoir will result in the propagation of fishes suitable to live in the stationary water.

The environment for the aquatic life at the riverbed and in the course downstream of the powerstation will be made unstable by the extreme change in the discharge downstream of the power station. The aquatic life will be able to adjust themselves to the change in the circumstance, considering the fact that they adjust themselves to the seasonal and daily variations of the water discharge including flood.

There are some successful examples of fish culture and seeding as well as projected plans of this kind in North-Eastern Luzon. Adverse effect of the dam on aquatic life, if any, will be liquidated by adopting such countermeasures.

c) Influence of logging industry

As stated above, the project development will not cause serious effect on the vegetation in the project area. But the logging of trees not directly related to the project development will give more influence on the vegetation. Accordingly, the vegetation control should be studied considering the plans of logging.

The animals resident in the project area will not be affected seriously by the project development. They will be affected more by the change in the vegetation which will result from the logging.

(3) Countermeasures for Environmental Consequences

In the following are enumerated the necessary countermeasures to avoid or lessen adverse effects due to the Project, other than the problem of resettlement as described in the previous section.

a) To avoid accidents due to the change of riverflow downstream of the powerhouse, an adequate system of gradually increasing peak discharge from the powerhouse should be stipulated before operating power station, and discharge announcing system should be installed to give adequate warnings to the people downstream of the reservoir.

b) The mountain sides around the reservoir seem at this time very stable, and there is little anxiety about future landslides. But any potential sites of landslides in the reservoir area should be investigated and necessary countermeasures should be taken.

c) All necessary methods and regulations for all people engaged in the construction to prevent deteriorating water quality of the riverflow during the construction works must be studied beforehand; these regulations must be strictly observed by all concerned.

d) A preliminary study on the possibility of future forming of cold-water mass in the reservoir is recommended to be carried out, and the arrangement to record the temperature distribution in the reservoir is inevitable.

e) A study of suitable fish culture and seeding plans in the reservoir is recommended.

f) It is widely admitted very much effective for success of the Project that NAPOCOR will prepare job-finding and livelihood promotion programs for the inhabitants in the region as well as for the resettlers from the would-be inundated area of the reservoir.

C H A P T E R 4

COST, CONSTRUCTION SCHEDULE AND ECONOMICS OF THE PROJECT

4. Cost, Construction Schedule and Economics of the Project

4.1. Estimated Construction Cost

4.1.1. Total Estimated Construction Cost

The total construction cost of the project development excluding interest during construction is estimated to be :-

The Diduyon Hydroelectric Power Station	-	US$384.3 million
Associated transmission lines and substation	-	US$8.6 million
Total		US$392.9 million

Out of the total estimated construction cost, the offshore cost is US$182 million and the local cost is US$211 million. Table 4-1 is the detailed breakdown of the total estimated construction cost of the project development, excluding interest during construction.

4.1.2. Basis of Estimates

Items noted in the estimates are defined as follwos:

1) Preliminary Work

a) Road construction and improvement :

Constructing and/or improving roads of 105 km between the nearest terminals of the existing roads and the Diduyon site, and between the Dam and the Powerhouse.

b) Temporary facilities :

Preparing power supply and communications, water supply facilities, camp site, and housing accommodations required for the construction.

2) Civil Engineering Work

Extension of unit prices determined at early 1980 by an evaluation of labour, materials and construction plant equipment required to perform the work, applied to approximately estimated quantities computed from the layout studies of the structures.

3) Electrical and Mechanical Works

Manufacture, delivery and installation of hydraulic equipment (including turbines, valves, gates), electrical equipment (including generators, transformers, switchgear) and mechanical equipment (including cranes, hoists and station service equipment).

4) Transmission and Substations

Manufacture, delivery, erection and commissioning of equipment and materials necessary for the associated transmission line and substation.

5) Land Acquisition and Compensations

All expenditures needed for acquiring land lots and resettlement of the households and farmlands to be submerged in the reservoir area or affected by the construction works.

6) Contingencies during the Construction

a) An allowance of 10% on the respective total estimated construction costs of the power station and the associated transmission line and substation, excluding the following items.

b) An allowance of 5% on the respective total estimated construction costs of the penstock and gates, as well as the electrical and mechanical works under paragraph 3) hereabove.

7) Costs for Engineering Work

a) Engineering at the Definite Design Stage:
Engineering cost for field investigation and office studies which will be required for the preparation of the tender documents.

b) Survey and design cost for construction roads.

c) Engineering at the Construction Phase:
Engineering cost for tender evaluations and construction supervision.

8) NPC Administration

An allowance of 3.5% on the total estimated costs of the power station and the associated transmission line and substations under paragraphs 1) to 6) hereabove.

9) Interest during the Construction

For both offshore and local expenditures computed at the prevailing rate of 8%.

Table 4 - 1 Estimated Construction Cost

(Excluding Interest during Construction)

(US$$10^6$ equivalent)

Item	Offshore Cost	Local Cost	Total
1. Preliminary Work	20.3	33.0	53.3
1.1. Road construction and improvement	13.8	23.2	37.0
1.2. Temporary facilities	6.5	9.8	16.3
2. Civil Engineering Work	111.8	113.8	225.6
2.1. Dam	60.8	53.9	114.7
2.2. Waterway	47.6	55.8	103.4
2.3. Powerhouse	3.4	4.1	7.5
3. Electrical and Mechanical Works	21.9	5.4	27.3
Sub-total (1 - 3)	154.0	152.2	306.2
4. Land Acquisition and Compensations	0	13.2	13.2
5. Contingencies during Construction	14.2	14.2	28.4
6. Cost for Engineering Work	8.5	15.8	24.3
7. NPC Administration	0	12.2	12.2
Sub-total (1 - 7)	176.7	207.6	384.2
8. Transmission/Substations	4.3	2.9	7.2
9. Contingencies during Construction	0.5	0.2	0.7
10. Cost for Engineering Work	0.4	0	0.4
11. NPC Administration	0	0.3	0.3
Sub-total (8 - 11)	5.2	3.4	8.6
Total (1 - 11)	181.9	211.0	392.9

4.2. Construction Schedule

4.2.1. Construction Schedule

The Diduyon Hydroelectric Power Project Development will be completed in 5 years in accordance with Fig. 1-5 assuming that the necessary steps of planning, design, and construction are taken within the specified time.

4.2.2. Preparatory Construction Works

(i) Transportation of Equipment and Materials into the site

There are practically two possible routes of the transportation of necessary equipment and materials for the Project site. One is an inland transportation in a distance of 310 ∿ 460 km from Manila to the site. Another is to unload the equipment and materials at San Fernando Port and transport them to the site in an inland route in a distance of 390 ∿ 480 km. The transportation distance differs owing to the intermediate routes.

After comparative study of these two routes, the first route, from Manila to the site, is recommended as an adequate one for transportation.

a) Improvement of Local Roads

In case of the above-mentioned transportation route, it is 310 km long from Manila to Kasibu and 410 km long from Manila to Dibibie.

Some portion of this route includes unpaved or poorly paved local roads, that is, 34 km from Bambang to Kasibu and 12 km from the powerhouse to Dibibie respectively. They need improvement of the road conditions such as surface pavement and bridges as well as the relocation of route as the case may be. The detailed survey and design of these roads will be made at the Definite Design Stage.

b) Construction Roads

Access to the Project site can be made through either Kasibu, Nueva Vizcaya or Dibibie, Quirino. For further access to the Project site, a 27 km long logging road leads from Kasibu to the damsite, and a 15 km long logging road from Dibibie to the powerhouse site.

Besides the existing roads, the construction roads connecting the existing logging roads with the main structures of the dam, power station, quarry site, intake, tunnel adits and surge tank will be constructed. It will be around 105 km; from Kasibu to the damsite - 55 km, from the damsite to the Powerhouse - 38 km, and from the Powerhouse to Dibibie - 12 km.

Any difficulties in the construction are not expected judging from the topographic and geologic conditions of the road routes. The maintenance work of the roads after construction, however, may be difficult, considering the characteristics of the mountain covered by heavily weathered zones and the unstable ground surface due to the deforestation. Therefore, careful attention should be paid to the drainage as well as surface protection and stability of the cut slopes when the design of the construction roads are made.

(ii) Other Preparatory Works

a) Power Facilities

A diesel generator will be required as a power source during the first period of the preparatory works, for there exists no power station nearby having a sufficient capacity. The required capacity will be around 1,500 kVA. As main construction works begin, supply of more power will be needed, say 15,000 kVA in total. For this purpose, a greater part of the service transmission line, at 230 kV and 45 km long, will be extended in time from Santiago to a substation at the powerhouse site. Electric power will be distributed from the substation to the dam and other construction sites by means of a 14 kV transmission line.

b) Temporary Facilities

Main temporary facilities required for the main construction works will be aggregate plants, concrete plants, telecommunication facilities and water supply facilities, which should be completed in accordance with the progress of the main construction works.

c) Temporary Structures

Temporary structures required for the main construction works will be construction office, site office, aggregate plant office, warehouse, housing, lodging facilities for labourers, repairing shop, lumber mill, etc., all of which should be completed before the main construction works are commenced.

d) Other Facilities

Security and welfare facilities will be important factors for the successful completion of the Project with smooth progress.

4.2.3. Main Construction Works

The construction of the Project consists of the total excavation volume of 2.4 million m^3 and the total concreting volume of 1.6 million m^3. The construction period will be 4 and half years from the commencement of the preparatory works excluding construction roads through the commencement of operation of the power station.

The construction works will include open-air works, which will be equivalent to 70% of the total volume of construction, and pit works, which will be equivalent to 30% of the total volume of construction.

All construction works should be carried out orderly on a merchanized system. In order to accomplish all these works successfully, construction facilities with a sufficient capability should be prepared in time on the site.

For building the concrete reservoir dam, for example, there will be needed a combination of construction facilities around the damsite as follows:

Aggregate plant, secondary ------------	750 ton/hour
Concrete mixing plant -----------------	4 @3 m^3 and 4 @1.5 m^3
Cable crane --------------------------	1 @25 t and 1 @20 t
Cooling plant ------------------------	2 @300 t

The detailed descriptions of construction equipment and procedures will be given in Vol. II.

4.3. Economics

4.3.1. Estimated Construction Cost

The main parameters used for the economic analysis of the project are shown as follows:

Installed capacity	345 MW
Firm capacity	308 MW
Annual energy production	956.8 GWh
Utility factor	97 %
Construction cost excluding interest during construction	US\$392.9 x 10^6
For power station	US\$384.2 x 10^6
For associated transmission facilities	US\$8.6 x 10^6

The construction cost was estimated on the basis of prices in early 1980, and an exchange rate among US Dollars, Pesos, and Japanese Yen was US$1.00 = ₱7.5 = ¥250.

Using the construction cost as mentioned above, the construction cost of the project per kW excluding interest during construction was calculated to be as follows:

Only power station	US$1,114/kW
Power station including transmission facilities	US$1,139/kW

And the construction cost per kWh was calculated to be as follows:

Only power station	US$0.402/kWh
Power station including transmission facilities	US$0.411/kWh

4.3.2. Generating Cost

Assuming that the utility factor of the Diduyon Power Station is 97%, the generating cost per kWh was calculated to be 44.59 Mills.

Taking account of a transmission loss of 3%, the generating cost at the receiving end is estimated at 45.81 Mills per kWh.

In the calculations, the following assumptions were used:

Annual OM cost of hydro-electric power plant, including administration and general costs	₱45.7/kW
Annual OM cost of the transmission facilities	2.5% of the construction cost
Interest rate per annum	8%
Service life	50 years
Capital recovery factor	0.08174

4.3.3. Cost-benefit Analysis

The results of cost-benefit analysis of the project is shown in Table 4-2.

This table shows that the net benefit in case of the power station only is US$30.3 x 10^6 per annum and US$29.3 x 10^6 in case of the transmission facilities being included. And it also indicates that the cost-benefit ratio is 1.79 in case of the power station only and 1.74 in case of the transmission facilities being included.

The benefit was assessed by an equivalent alternative coal-fired steam power station, because the annual cost of the coal-fired steam power station calculated at a rate of 8% is considered more economical than the oil-fired plant.

4.3.4. Sensitivity Tests and Internal Economic Rate of Return

Under the present conditions that oil conservation is an overwhelming tendency in the world, it is proper that steam power additions will be coal-fired steam power stations. However, it is practical to compare the price of coal with the price of oil. Accordingly, sensitivity tests were made for the case of adopting an oil-fired steam power station as an alternative power plant on the assumption that the price of oil is US$28 per barrel. Sensitivity tests were also made with respect to the case of increasing the construction cost of the project by 20% and the case of the construction cost of an alterrative coal-fired steam power station being cheaper than expected. The results of these sensitivity tests are shown in Table 4-3 and Fig. 4-1.

The table and figure show the followings.

(1) The cost-benefit ratios become 1.74 for the case of the coal-fired plant being adopted, and 1.79 for the case of the oil-fired, all of which demonstrate the sound econommics of the project.

Table 4-2 Cost - Benefit Calculation at an Discount Rate of 8%

1. Cost

Construction cost (excluding interest during construction)	
Power station only	384.3 x US$$10^6$
Transmission facilities	8.6 x US$$10^6$
Total	392.9 x US$$10^6$
Annual capital cost (including transmission facilities)	37.2 x US$$10^6$
Annual OM cost (including transmission facilities)	2.3 x US$$10^6$
Total annual cost (Total)	39.5 x US$$10^6$
(Power station only)	(38.5 x US$$10^6$)

2. Benefit - cost of coal-fired thermal plant

Construction cost	302.2 x US$$10^6$
(Constuction cost per kW)	(US$790)
Annual capital cost	31.2 x US$$10^6$
Annual cost of fuel	22.5 x US$$10^6$
(Coal price)	(US$45/T)
Annual cost of O & M	15.1 x US$$10^6$
Annual benefit	68.8 x US$$10^6$

3. Net annual benefit (B - C)

Power station only	30.3 x US$$10^6$
Including transmission cost	29.3 x US$$10^6$

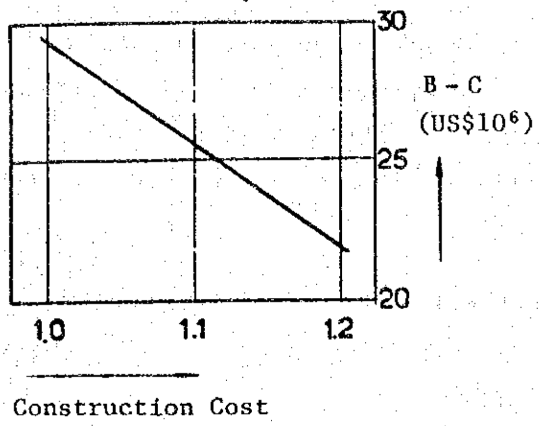
4. Benefit-cost ratio

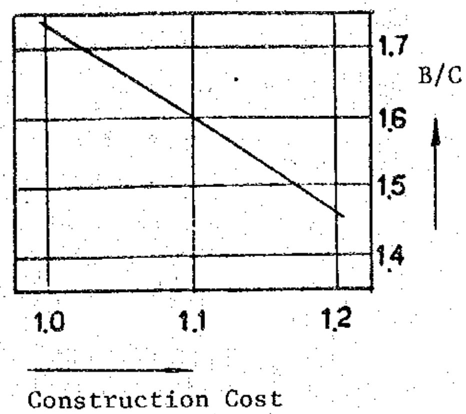
Power station only	1.79
Including transmission cost	1.74

Table 4-3 Sensitivity Tests of Cost-Benefit Analysis

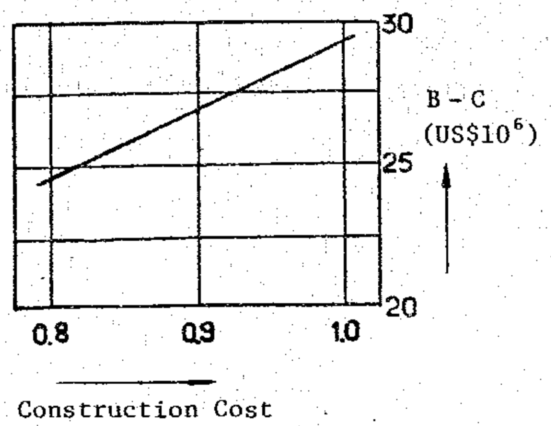
	Construction Cost of the Project		Alternative Thermal				Net Annual Benefit at 8%	B/C ratio at 8%	IRR
			Construction Cost		Fuel Cost				
	Ratio	US$$10^6$	Ratio	US$/kW	Ratio	Mills/kWh	US$$10^6$	Ratio	%
Case 1 Base case Coal-fired	1.0	393	1.0	790	1.0	22.15	29.3	1.74	24.1
Case 2	1.2	472	1.0	790	1.0	22.15	21.8	1.46	15.7
Case 3	1.0	393	0.9	711	1.0	22.15	24.6	1.62	19.3
Case 4	1.0	393	1.0	790	1.1	24.37	31.5	1.80	25.1
Case 5 Excl. T/L	0.97	384.3	1.0	790	1.0	22.15	30.3	1.79	25.3
Case 6 Oil-fired	1.0	393	0.8	630	1.8	40.01	33.0	1.84	20.3

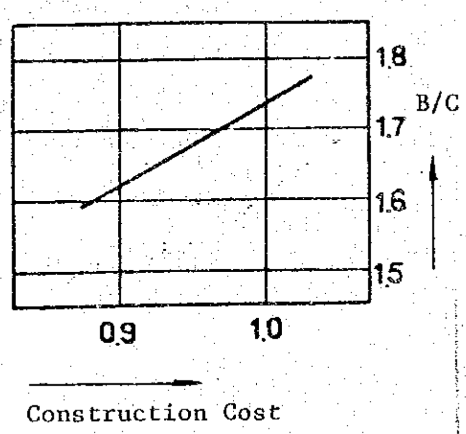
Varied Construction Cost of The Project



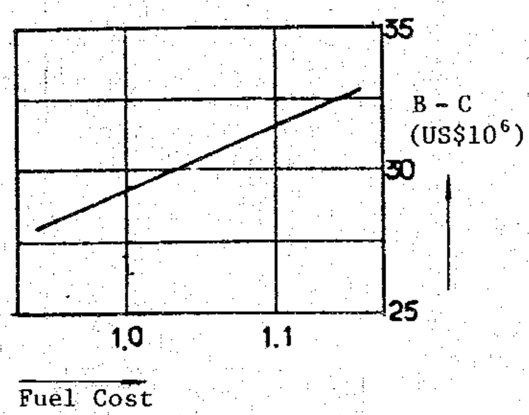


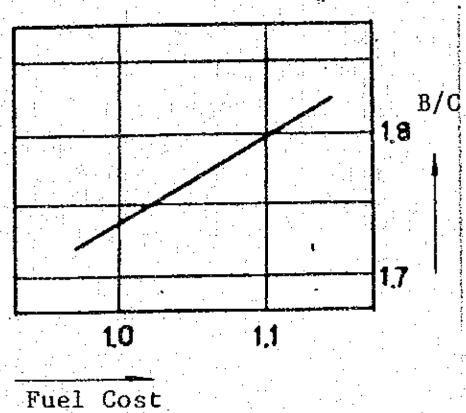
Varied Unit Construction Cost of Steam Powerstation





Varied Fuel Cost





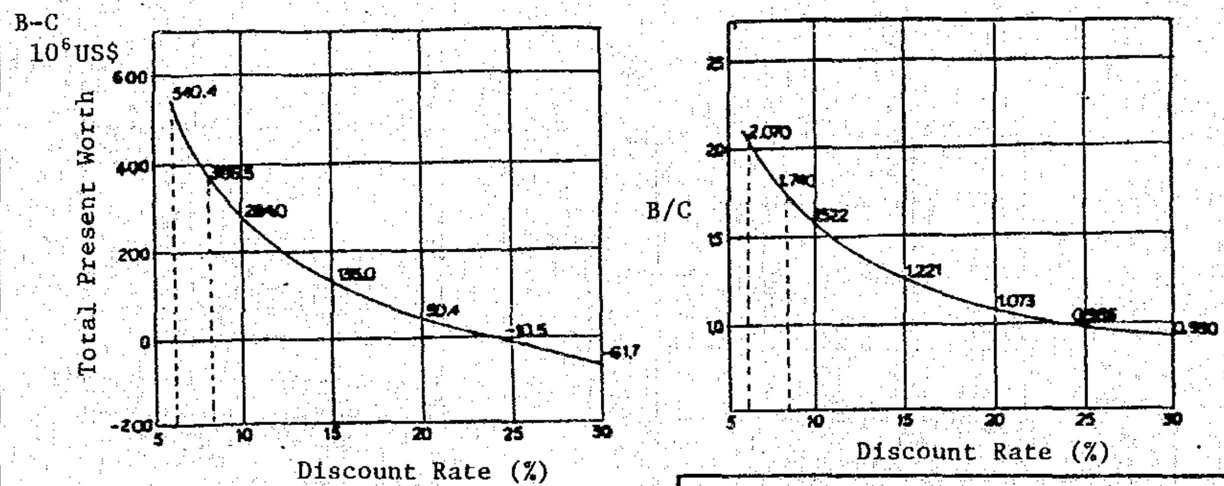
Discount Rate : 8 %

Diduyan Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Sensitivity Test of Benefit and Cost
October 1980 Fig. 4-1

(2) If the construction cost of the project is increased by 20%, the cost-benefit ratio will be reduced to 1.46. And if the construction cost of the coal-fired steam power plant is decreased by 10%, the cost-benefit ratio will be reduced to 1.62.

But in any event, the economics of the project will be still maintained even if variations in the construction costs are in such a range.

(3) The internal economic rate of return of the project will be 24.1% in case of the coal-fired steam plant, and 20.3% in case of the oil-fired plant. In any case, the internal economic rate of return exceeds 15%, an opportunity cost of capital in the Philippines, which justifies the project economically.



Powerstation with associated Transmission Line and Substation

Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines

Japan International Cooperation Agency

Present Worth with Varied Discount Rates

October 1980	Fig. 4-2

4.3.5. Financial Analysis

(1) Financial cost without cost escalation counted

a) Capital cost (Constant price in early 1980)

The disbursement schedule of the capital cost is shown in Table 4-4. The foreign currency requirement is US$182 x 10^6, and the local currenty US$211 x 10^6, which amount to US$393 x 10^6. The cost will be disbursed from 1985 to 1989.

b) Condition of Loan of Foreign Exchange Cost

The financing sources of the foreign exchange cost are not decided yet. But the following assumptions were used for the financial analysis.

i) Rate of interest per annum - 8.5%

ii) Period of repayment - 20 years, excluding a grace period of 5 years

iii) Repayment will be done by equal installments of the principal

c) Financial cost for Foreign Loan duing construction in constant price

As shown in Table 4-7, interest during construction are estimated at US$43.6 x 10^6.

d) Financial cost in constant price after start of commercial operation

The principal will be repaid for an annual amount of US$9.1 x 10^6 from 1990 to 2009. The interest will be paid, starting from 1990 to 2009. The amount of interest to be paid is estimated at US$15.5 x 10^6 in 1990 and will be reduced by US$0.80 x 10^6 every year.

Table 4-4 Disbursement Schedule

(Unit: US$ x 10^3)

No.	Year	Investment - Original			Financial Cost - Eslacated		
		Foreign	Local	Total	Foreign	Local	Total
		(1)	(2)	(3)	(4)	(5)	(6)
1	1985	22,097	25,940	48,037	35,587	45,715	81,302
2	1986	26,516	31,128	57,644	46,975	61,441	108,416
3	1987	54,041	62,975	117,016	105,311	139,218	244,529
4	1988	55,078	63,665	118,743	118,065	157,632	275,697
5	1989	24,170	27,322	51,492	56,992	75,766	132,758
Total		181,902	211,030	392,932	362,930	479,772	842,702

Table 4-5 Financial Costs for Foreign Loan during Construction

(Unit: US$ x 10^3)

No.	Year	Drawdown	Year End Balance	Outstand-ing Loan	Commit-ment Fee	IDC	Total
		(1)	(2)	(3)	(4)	(5)	(6)
1	1985	35,587	327,343	35,587	0	3,025	3,025
2	1986	46,975	280,368	82,562	0	7,018	7,018
3	1987	105,311	175,057	187,873	0	15,969	15,969
4	1988	118,065	56,992	305,938	0	26,005	26,005
5	1989	56,992	0	362,930	0	30,849	30,849
Total		362,930				82,866	82,866

(2) Financial cost with cost escalation counted

a) Rate of cost escalation

Accelerated by the sudden increase in oil price in 1979, it is expected that the prices in 1980 will mark a remarkable increase. Forecast of price increase in the future is a difficult task. But the following assumptions were used herein:

Cost escalation of foreign exchange cost - 10% p.a.

Cost escalation of local currency cost - 12% p.a.

Table 4-6 Financial Costs for Foreign Loan Payment Schedule

(US$ x 10^3)

No.	Year	Year End Principal	Principal Payment	Interest Payment	Total Payment
		(1)	(2)	(3)	(4)
5	1989	362,930			
6	1990	344,783	18,147	30,849	48,996
7	1991	326,636	18,147	29,307	47,454
8	1992	308,489	18,147	27,764	45,911
9	1993	290,342	18,147	26,222	44,369
10	1994	272,195	18,147	24,679	42,836
11	1995	254,048	18,147	23,137	41,284
12	1996	235,901	18,147	21,594	39,741
13	1997	217,754	18,147	20,052	38,199
14	1998	199,607	18,147	18,509	36,656
15	1999	181,460	18,147	16,967	35,114
16	2000	163,313	18,147	15,424	33,571
17	2001	145,166	18,147	13,882	32,029
18	2002	127,019	18,147	12,339	30,486
19	2003	108,872	18,147	10,797	28,944
20	2004	90,725	18,147	9,254	27,401
21	2005	72,578	18,147	7,712	25,859
22	2006	54,431	18,147	6,169	24,316
23	2007	36,284	18,147	4,627	22,774
24	2008	18,137	18,147	3,084	21,231
25	2009	0	18,137	1,542	19,679

b) Escalated financial cost

The financial cost with the cost escalation at the above rate counted is estimated as shown in Tables 4-4 ∿ 4-6, and Table 4-7 shows the comparison between nonescalated and escalated financial costs.

These tables indicate that the foreign exchange cost, local currency cost and total cost of the capital cost with the cost escalation counted will be increased by 99%, 127%, and 115% respectively. It also shows that the interest during construction, repayment of principal and annual amount of paid interest will also be increased by 90%, 100%, and 99% respectively.

(3) Power Sales

In case the local currency cost is financed by the NPC internal reserves and equity contribution, the power rate at the 1980 constant price that will be able to pay for the financial cost required for the foreign loan and the O & M cost, keeping a financial rate of return of 8%, is estimated to be US$41.5 x 10^6 in a year and 47.75 Mills per kWh. If the cost escalation is taken into account, such power rate will be increased to US$87.40 x 10^6 in a year and 94.16 Mills per kWh.

(4) Cash Flow and Debt Service Ratio

The projected cash flow statement of the project with the cost escalation as mentioned in Item (2) above-counted is presented in Table 4-8. This table indicates that the debt service ratio is 1.7 in the initial year of the commercial operation, thereafter increasing gradually with a decrease in the yearly payment of interest. Accordingly, if the power rate of 94.16 Mills per kWh at the 1990 price is secured, the income derived from this power rate will generate funds necessary for payment of principal and payment of financial costs.

Table 4-7 Comparison of Financial Costs bewteen Nonescalated and Escalated

Item	Original cost	Escalated cost	Ratio of escalated cost to original cost
1. Capital cost			
Foreign	182	363	1.99
Local	211	480	2.27
Total	393	843	2.15
2. Financial cost of foreign loan			
Interest during construction	43.6	83	1.9
Principal	181.9	363	2.0
(annual repayment)	(9.1)	(18.1)	
3. Paid interest			
Initial year	15.5	30.8	1.99
(Yearly decreased amount of paid interest)	(0.8)	(1.5)	

Table 4 - 8 PROJECTED CASH FLOW STATEMENT (1985 - 1995)

(Unit: US$ x 10^3)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
I. SOURCE OF FUNDS											
A. Internal Cash Generation											
Net Income before Interest						64290	64290	64290	64290	64290	64290
Depreciation						18511	18511	18511	18511	18511	18511
TOTAL						82801	82801	82801	82801	82801	82801
B. Foreign Borrowing	35587	46975	105311	118065	56992	0	0	0	0	0	0
C. Equity Contributions	48740	68459	155187	183637	106615	0	0	0	0	0	0
TOTAL SOURCES OF FUNDS	84327	115434	260498	301702	163607	82801	82801	82801	82801	82801	82801
II. APPLICATION OF FUNDS											
A. Addition to Plant	81302	108416	244529	275697	132758	0	0	0	0	0	0
B. Int. during Construction	3025	7018	15969	26005	30849	0	0	0	0	0	0
C. Operating Interest	0	0	0	0	0	30849	29307	27764	26222	24679	23137
D. Principal Repayment	0	0	0	0	0	18147	18147	18147	18147	18147	18147
E. Inc./Dec. in Working Capital	0	0	0	0	0	0	0	0	0	0	0
TOTAL APPLICATION OF FUNDS	84327	115434	260498	301702	163607	48996	47454	45911	44369	42826	41284
Cash Excess (Deficit)	0	0	0	0	0	33805	35347	36890	38432	39975	41517
Cash Bal., Beg. of the Yr.	0	0	0	0	0	0	33805	69152	106042	144474	184449
Cash Bal., End of the Yr.	0	0	0	0	0	33805	69152	106042	144474	184449	225966
Debt Service Ratio						1.7	1.7	1.8	1.9	1.9	2.0

C H A P T E R 5

FOLLOWING ENGINEERING WORK FOR IMPLEMENTATION OF THE PROJECT

5. Following Engineering Work for Implementation of the Project

5.1. Requirement

As stated in the preceding sections, the Project is technically and economically feasible. It is recommended that the Philippine Government will decide to develop the Project through NAPOCOR, the executing agency. Following a normal international procedure for the development of a hydroelectric power project, the engineering services (the Services) of the Project until preparation of bid documents are required to carry forward the Project implementation, subsequent to the feasibility study.

The Services proposed herein should be started before the end of 1980 and completed by the middle of 1983 in order to suit the schedule time for completion of the Project in 1989.

5.2. Scope of the Services

The scope of the Services at the Definite Design Stage will include the following items.

(1) Survey and Mapping

a) Aerophotogrammetric survey and mapping for access roads, transmission line route and waterway route.

b) Additional ground topographic survey for damsite, surge tank to powerhouse, access roads, and transmission line route.

c) Surveys related to geologic investigations and hydrologic study.

The proposed tentative quantities of the above surveys and mapping are given on Table 5-1.

(2) Hydrology

Data collection and observation of hourly rainfall inside the catchment area and runoff with automatic water stage gauge at the damsite for check and review of the runoff characteristics analyzed in the feasibility study.

(3) Sedimentation

Measurement of suspended load and bed load at and in the vicinity of the damsite, and investigation of riverbed materials for check and review of the characteristics of sediment load and the characteristics of riverbed evolution in the upper reaches.

(4) Further Investigation for Optimization of the Project

Check and review of the optimization of the Project based on the up-to-date information on power demand and power resources development, and based on the physical characteristics of the site newly obtained by the survey.

(5) Assistance of Preparation of Relocation Plan and Mitigative Measure

Assistance of preparation of relocation program for the people to migrate due to construction of reservoir and power station and mitigative measure for the people to remain around the Project site.

(6) Definite Design and Preparation of Tender Documents

Definite design of project components and access roads including hydraulic and laboratory tests, and preparation of tender documents based on the definite design.

(7) Preparation and Updating of the Project Cost with Necessary Breakdown

(8) Assistance for Preparing Implementation Program

5.3. Estimated Engineering Cost for the Definite Design Stage

Since the Diduyon Project is a large-scaled hydroelectric development, it is recommended that the engineering work as specified in the Subsection 5-2 will be carried out by qualified international consulting engineers, in association with local consultants.

The estimated foreign exchange cost for the Definite Design Stage is US$5.2 million, provided that NPC will provide the following facilities and services at its own expense (See Table 5-2).

1) Suitably furnished and airconditioned offices with adequate floor space at the project site and at or near NPC headquarters.

2) All local transportation in the Philippines.

3) Free access and use of lands in performing the next study.

4) Communications in and from the Philippines.

5) Back-up support of NPC or local engineers, geologists, technicians and draftsmen in an adequate number of manmonths.

6) Provision of clerks, typists and messengers in an adequate number of manmonths.

7) Field investigations.

   a) Topographic surveying work and preparation of the pertinent maps.

   b) Exploratory field work and pertinent field and laboratory tests for the geologic investigations.

Table 5-1 Field Investigations of the Project in the Definite Design Stage

Item	Object	Quantity	Description
Aerographic survey	Photographing	475 km	
	Aero-photo mapping	475 km	Scale: 1/5,000
	Aerotriangulation	40 pts	
	Total	475 km^2 & 40 points	
Ground topo-survey	Damsite	1 km^2	Scale: 1/500
	Surge tank - powerhouse	2 km^2	- ditto -
	Access road, alignment survey with cross sections	420 km	- ditto -
	Others	1 km^2	- ditto -
	Total	4 km^2 & 420 km	
Seismic prospecting	Damsite	2 km	
	Surge tank - tailrace	2 km	
	Waterway	4 km	
	Quarries	4 km	
	Total	12 km	
Drilling	Damsite	1,500 m	
	Waterway	300 m	
	Surge tank	300 m	
	Powerhouse	330 m	
	Quarry	1,500 m	
	Access road	300 m	
	Others	270 m	
	Total	4,200 m	
Test aditting	Damsite	400 m	
	Quarries	300 m	
	Total	700 m	
Dam foundation test		A series of test	
Test pit trench material test		- ditto -	

Table 5-2 Estimated Cost of Engineering Services

(Unit : ¥10^6 & ₱10^6)

(a)	Foreign Currency Portion	¥1,287 x 10^6	(US$5.2 x 10^6)
i)	Base salaray, overhead charge and fixed fee	¥714 x 10^6	
ii)	Direct cost	¥193 x 10^6	
iii)	Purchase of equipment & instruments	¥135 x 10^6	
iv)	Field Investigations Contract	¥180 x 10^6	
v)	Contingency	¥65 x 10^6	
(b)	Local Currency Portion	₱17.2 x 10^6	(US$2.3 x 10^6)
i)	Fees of local experts & sub-consultants	₱6.5 x 10^6	
ii)	Cost of field surveys & investigations	₱6.5 x 10^6	
iii)	Local supporting facilities	₱2.6 x 10^6	
v)	Contingency	₱1.6 x 10^6	

Disbursement Schedule of Estimated Cost

Year	Yen Portion	Peso Portion
1981	¥855 x 10^6	₱11 x 10^6
1982	¥245 x 10^6	₱3.1 x 10^6
1983	¥122 x 10^6	₱1.5 x 10^6

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