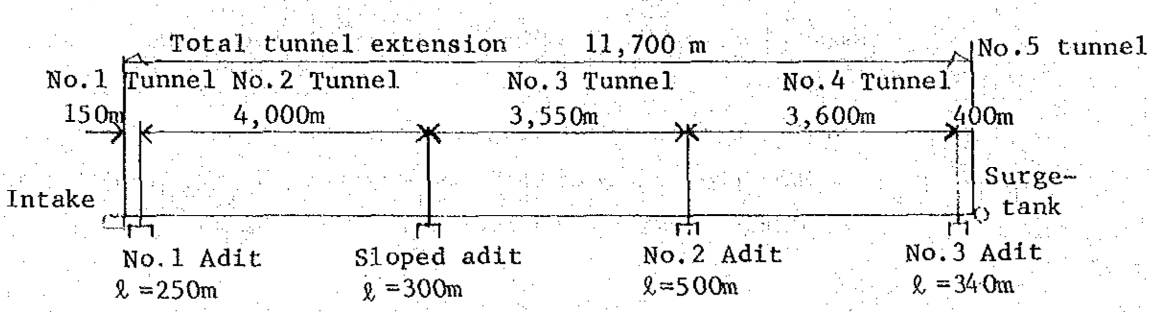


1) Excavation

Tunnel excavation shall be done through construction adits as illustrated above.

The excavation length covered by each construction adits shall be as follows:

No. 1 construction adit 250 m	150 m of tunnel section No. 1
	2,000 m of tunnel section No. 2
Sloped adit 300 m	2,000 m of tunnel section No. 2
	1,750 m of tunnel section No. 3
No. 2 construction adit 500 m	1,800 m of tunnel section No. 3
	1,700 m of tunnel section No. 4
No. 3 construction adit 340 m	1,900 m of tunnel section No. 4
	400 m of tunnel section No. 5

Excavation shall be made by the full face driving process. For drilling, a drill jumbo (8 drill bits mounted) shall be used, and muck shall be loaded by two 0.4 m^3 class muck loaders on 6 m^3 side dump type steel cars towed by a battery locomotive. A double line track of 30 kg rail shall be laid in the adit for the steel cars. Muck transported from the adit shall be discharged into a muck bin by dump trucks to the specified spoil banks.

For supportings, H-150x150 steel members shall be erected at a standard spacing of 1.2 m. This spacing may be adjusted depending on the character of the rock encountered.

The average cycle time for tunnel excavation work is shown in the table below. According to this table, the average progress of work shall be 90 m/month or 3.6 m/day. Operation shall be carried out in the two shifts of day and night, with the number of hours as shown below. The maximum excavation for tunnels shall be 2,300 m including 2,000 m for the lower portion and 300 m for the sloped portion of No. 2 tunnel, and 2,300 m including 1,800 m for the lower portion of No. 3 tunnel and 500 m for No. 2 construction adit.

Following table shows working hours.

Shift time	Compulsory hours	Paid labor hours	Actual labor hours
1st shift 7:00 - 19:00	12 hrs	11 hrs	10 hrs
2nd shift 19:00 - 7:00	12 hrs	11 hrs	10 hrs

Table showing cycle time for tunnel excavation

(Computation made on tunnel with B = 7.3 m and H = 7.3 m.)

Conditions for execution			
1.	Cross section	m^2	47.58
2.	Support spacing	m	1.2
3.	Progress made per blasting	"	1.2
4.	Performance per blasting (1) x (3)	m^3	57.1
5.	Standard number of holes	holes/m	2.5
6.	Number of holes (1) x (5)	hole	119
7.	Number of rock drills	unit	8
8.	Number of holes per unit (6) ÷ (7)	holes/unit	15
9.	Hole length per hole	m/hole	1.3
10.	Hole length per unit (8) x (9)	m/unit	19.5
11.	Drilling performance	m/min	0.5
12.	Shovel		RS85 x 2 units
13.	Shovel capacity	m^3/hr	23.7 x 2 units
14.	Truck capacity, original bedrock	m^3/unit	3.8
	blasted muck	"	6.0
15.	Number of trucks per blasting $\frac{(4)}{(14)}$	unit	15
16.	Train formation		3
Cycle			
17.	Preparations for rock drilling	min	15
18.	Drilling holes (10) ÷ (11)	"	39
19.	Moving rock drills [(18) - 1] x 1	"	14
20.	Clearing	"	10
21.	Charging with powder and connecting fuse 1.5 x (8)	"	23
22.	Taking shelter and blasting	"	5
23.	Ventilation	"	15
24.	Chiselling and chopping	"	30
25	Preparations for loading muck	"	20
26.	Loading muck $\frac{(14)}{(13)}$ x 60	"	72
27.	Shunting trucks [(15) - 1] x 1	"	14
28.	Shunting train [(16) - 1] x 7	"	14
29.	Supporting	"	100
30.	Surveying, etc.	"	10
31.	Sub-total	"	381
32.	Loss (31) x 0.05	"	19
33.	Total	"	400

Yield			
34.	Daily progress $\frac{1,200}{(33)}$ x (3)	m/day	3.6
35.	Monthly progress (34) x 25	m/month	90
36.	Daily performance $\frac{(35) \times (1)}{30}$	m^3/day	142

2) Concrete lining

The arch and side walls shall be lined with concrete following the progress of excavation and keeping a distance of about 200 m from the face of excavation. Concrete lining shall be performed as a rule with the use of sliding form covering a length of 9.0 m. The sliding form shall be the 70 - percent lining form. Concrete shall be placed by a concrete placer equipped with an agitator. Concrete forms shall be removed 12 hours after concrete lining as the standard practice.

The concrete placing cycle shall be:

Assembly of reinforcing bars and forms	1 day
Concrete placing and curing	1 day
Total	2 days

The number of concreting operations per month will be 25/2 = 12.5 times,but shall be set as 10 times/month, taking into account placing loss and other factors. Therefore, the monthly progress for each portal will become

9 x 10 times = 90 m/month

The monthly progress for invert concrete lining will be as follows based on 30 m/day:

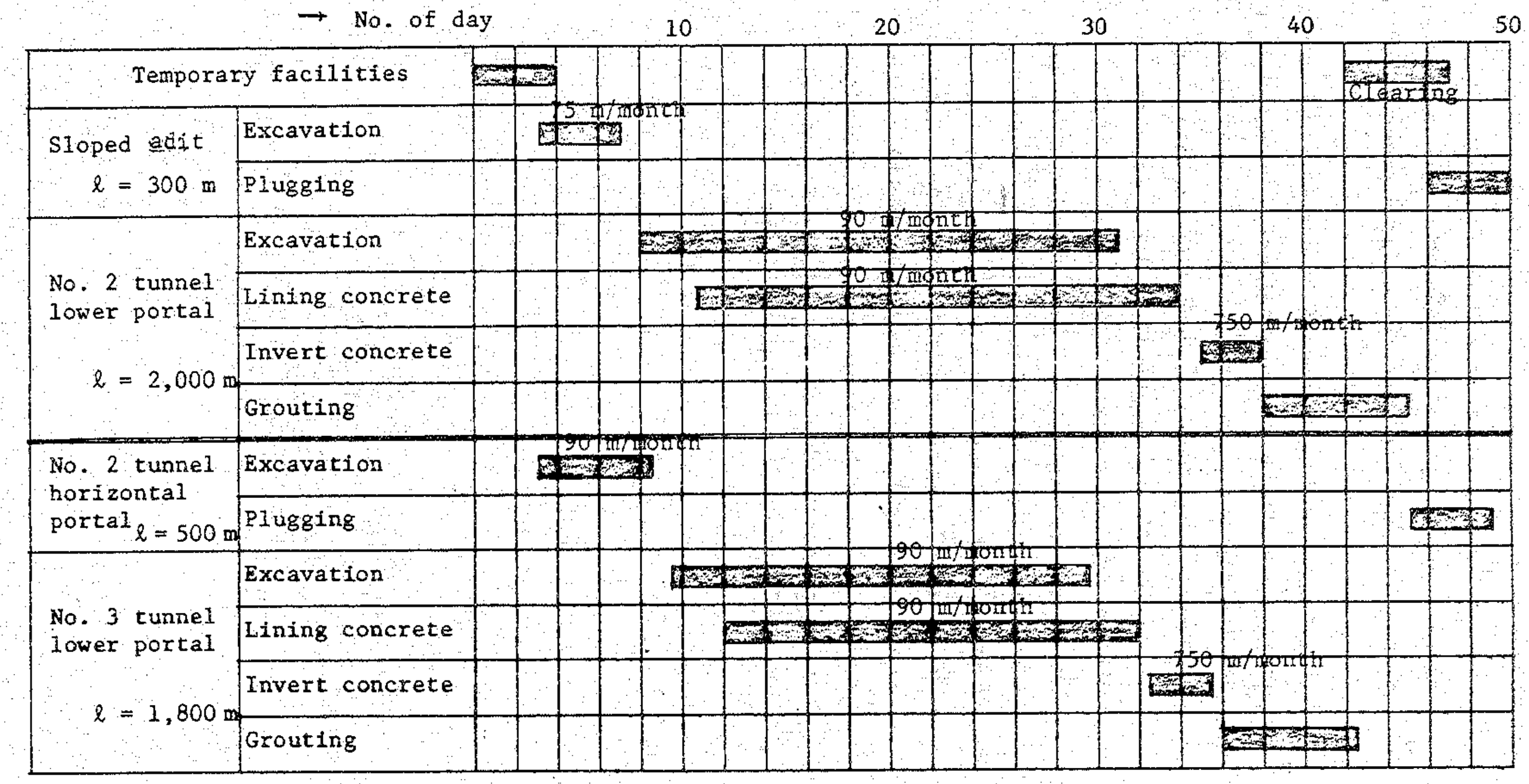
30 x 25 times = 750 m/month

3) Grouting

Mortar injection shall be conducted with the main emphasis on the arch section under a pressure of 5 kg/m^2.

Grouting under high pressure in use of cement milk to improve the foundation and watertightness shall be applied after a lapse of more than 2 weeks from the time mortar has been injected. Grout holes shall be drilled in six to eight directions per cross section with an average spacing of 6 m. Holes shall be drilled by percussion to 46 mm diameter and a depth of 1.5 m (after reaching the rock). Grouting shall be made under a pressure of about 7 to 10 kg/m^2 at the collar of hole. The mixture of grout material shall be started with 1 part cement to 6 parts water (by weight) and the consistency shall gradually be increased. When the injection amount has dropped to less than 0.5 liter/min, application shall be completed in 30 minutes thereafter.

Preliminary Schedule for Work on Longest Waterway Tunnel



(4) Surge tank

The surge tank shall consist of an upper water chamber, lower water chamber, upper riser 8 m in inner diameter and 70 m in height connecting both chambers, and lower riser 8 m in inner diameter and 7 m in height connecting the lower water chamber with the penstock tunnel.

1) Excavation

Work on the upper water chamber shall begin with cut-off up to its entrance and excavation of the horizontal pit. Cutting operation shall be conducted by combined use of a D-8 class bulldozer and a 2 m^3 class tractor shovel. The horizontal pit shall be excavated under the full face driving process. The upper water chamber tunnel shall be worked from the entrance by excavating the upper cross section first. Holes shall be drilled with a crawler drill, and materials shall be loaded on dump trucks by 1.5 m^3 class crawler side dump for removal.

Since earth covering for the upper water chamber is shallow, it is anticipated that covering has been weakened due to weathering of rock. Therefore, upon excavation, H-150 x 150 mm supports shall be erected at a spacing of 1 m to 1.2 m and they shall be anchored either with rock bolts or by placing concrete. A temporary concrete lining may be applied as required. When the upper half cross section has been excavated, the lower half cross section shall be excavated with the same combination of machinery, in the sequence of the third enlargement and both sides.

Excavation of the upper riser shall be conducted after completion of the upper water chamber by dividing work into the excavation of the heading from the adit of the upper water chamber and the enlargement of this heading. A Big Man shall be used for excavating the heading. For drilling, a ϕ250 mm pilot shall be made penetrating from the upper water chamber through the lower water chamber and reaching a work pit. Upon penetration of this pilot,the heading shall be cut upward from the working pit with a ϕ1,450 mm roller bit.

Prior to penetration of the pilot, a horizontal pit for muck removal (hood type cross section with 4.7 m in width, 4.7 m in height and 40 m in length) shall be excavated from the penstock tunnel to a point immediately below the upper riser. The heading shall be enlarged by dropping muck into it from above. When a section of about 10 m has been excavated, a scaffold shall be assembled for use as the work bench. An excavation cycle of 2 m shall be used as the standard and a temporary lining of concrete shall be applied as required. Muck shall be loaded on steel cars from a muck hopper to be installed in the horizontal working pit and shall be removed from No. 3 horizontal adit. The lower water chamber shall be excavated, following excavation of the upper riser. Heavy equipment shall be introduced by a crane (rated at 20 t) installed in the upper chamber after the scaffold facilities in the upper riser have been removed. Excavation shall be performed by first working the upper half cross section according to the process used for the upper chamber. Muck shall be transported by a dozer shovel to the muck removing heading in the upper riser. When the lower chamber has been excavated, the lower riser shall be excavated by a heading and then enlarging method as in the case of the upper riser. Muck shall be dropped directly into the penstock tunnel.

2) Concrete

Concrete shall be transported by concrete mixer cars from the batcher plant at the site of the power station. Both the upper and lower water chambers shall be concreted by a concrete placer with agitator. Concrete for the lower chamber shall be supplied with a 6-inch steel pipe to be described later.

Concrete for the upper riser shall be placed in the specified location from a ground hopper (20 m^3 capacity) provided on the upper chamber level through a 6-inch steel pipe and a rotary concrete districutor chute provided on the scaffold. Concrete shall be placed at a height of 2 m for each operation as the standard practice.

3) Grouting

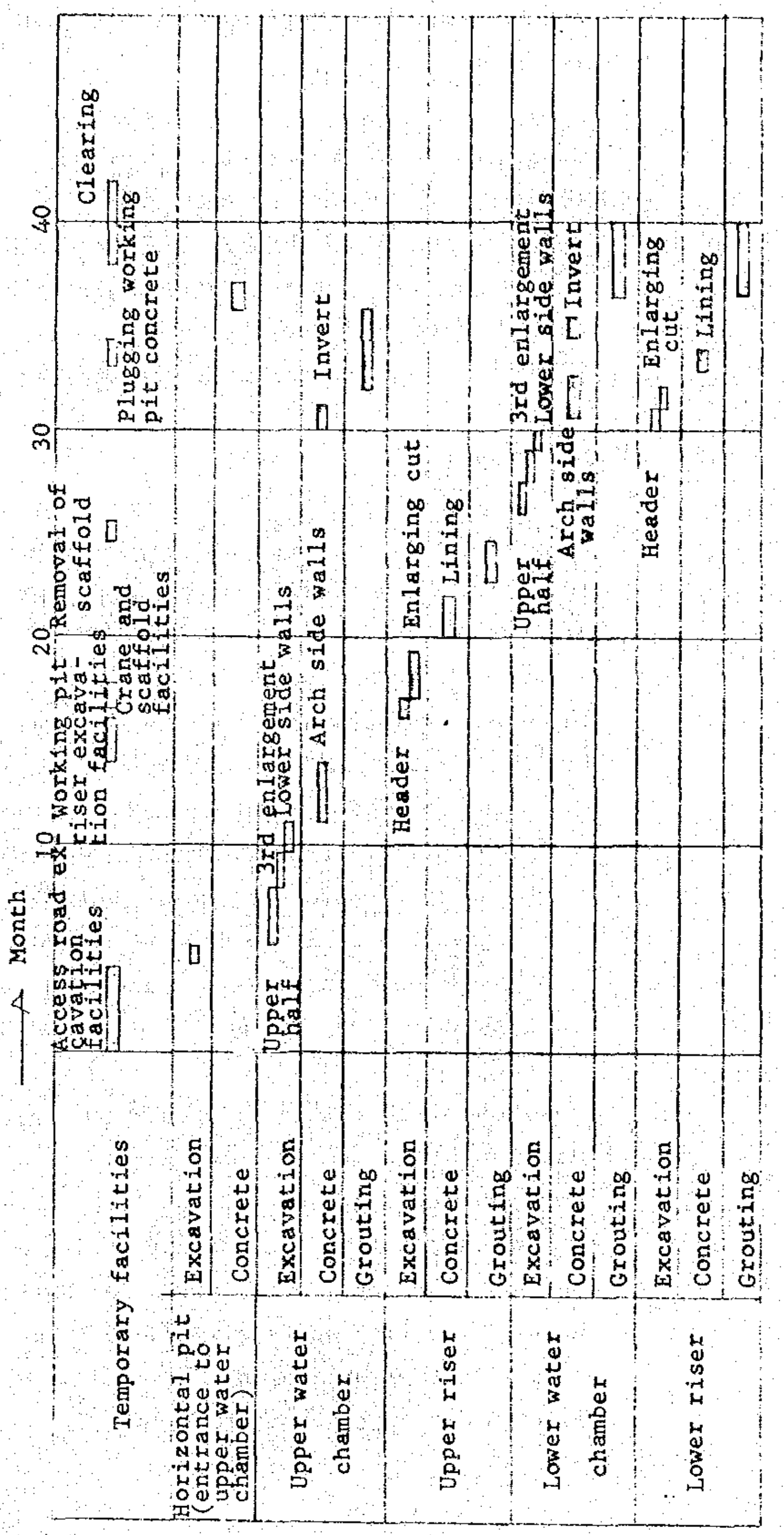
After concrete has been placed, grouting shall be applied for filling the voids (mortar) and improving foundation (cement milk).

The upper chamber shall be provided with mortar filler grouting and consolidation grouting according to the method used for the penstock. Mortar filler grouting shall be applied to the lower chamber in the same manner as the penstock tunnel. However, holes for consolidation grouting shall be made at a depth of 5 m and at a spacing of 3 m in a zigzag pattern in eight directions. Grout shall be filled under a pressure of 10 kg/m^2.

Consolidation grouting holes for the upper riser shall be made 1.5 m deep in the upper portion and 5. m in the lower portion. These holes shall be arranged in eight directions toward the center of a circle with a 3 m zigzag spacing. The application pressure shall be 1 kg/cm^2 in the upper portion and shall gradually be raised as grouting is applied to lower holes. At the bottom, it shall be filled under a pressure of 10 kg/cm^2.

Grouting shall be applied to the lower riser by the same procedure as that for the lower portion of the upper riser.

Rough Schedule of Work for Surgetank



(5) Penstock

The Penstock shall extend about 2,000 m from the end of the surgetank to the entrance valve in the power station. Its inner diameter shall be 5 m at the starting point and shall gradually be tapered down to 3.8 m at the bifurcating point near the powerstation. The pipe line after bifurcating shall be in two lines of 2.7 m in inner diameter. The pipe shall be made of HT-80 kg/mm high tensile steel with its thickness increasing from 16 mm in the upper horizontal tunnel section to 52 mm at the point immediately before the bifurcation. The total amount of steel to be used will amount to about 8,200 tons.

1) Excavation

The upper horizontal tunnel section (hood shaped, 6.9 m in both width and height and 220 m in extension) shall be provided with a portal on the penstock side, and shall be excavated toward the surgetank by top heading and bench cut method. A crawler drill shall be used for making holes in rock, and excavated materials shall be loaded on dump trucks by a 1.5 m^3 class crawler side dump for removal from the pit. Supports and the excavation of the lower half cross section shall be done according to the procedures followed for the upper chamber of the surgetank.

The open section of the sloped line (about 10 m in width and about 1,730 m in extension) shall be excavated with a combination of 1.2 m^3 class backhoes and 11 t dump trucks after the construction road for introduction of heavy equipment has been completed. A D-7 class bulldozer shall be used for excavation, pushing and collecting materials. Rock shall be excavated with a 2.8 m^3/min class leg drill and shall be finished with pick hammers.

Excavation for the bifurcated section shall be performed along with excavation for the power station.

2) Installation and welding of steel pipes

Steel pipes for the upper tunnel section shall be transported from a temporary shop to the portal by trucks, where they shall be loaded on a temporary pipe laying carriage for delivery to the installation point in the tunnel, and installed in the designated place using winch, chain block, etc. Pipes shall be installed, starting on the surgetank side.

Steel pipes for the open-laid section shall be transported by trucks to the inclined car where they will temporarily be laid, according to the progress of construction on the penstock. Pipes shall then be loaded on an inclined truck and delivered alongside the installation area and laid in the designated location.

Steel pipes shall be installed beginning with the section at each anchor block. When pipes have been installed in the designated place, concrete shall be placed. When concrete has attained the required strength, straight pipes shall be laid one after another toward the upper level. The pipe length shall be adjusted by means of adjusting pipe. Two 6 m unit pipes shall be considered one cycle and shall be installed at two points of the upper and lower ends.

Assuming one cycle will consist of:

Delivery and temporary installation	3 days
Welding	4 days
Inspection	1 day
Total	8 days

then an installation speed of 3 m/day can be obtained.

Steel pipes shall be supplied from the steel mill as semi-finished product to the temporary shop (with an area of 3,000 m^2) where they shall be processed to unit length pipes (6 m in length). As main equipment, the temporary shop will require a 20 m span, 35 t portal travelling crane, 1,500 t press, etc. For welding operation, shielded electrode arc welding and automatic welding shall jointly be used both at the temporary shop and in the field. Complete quality control is required because of use of HT-80 as steel material.

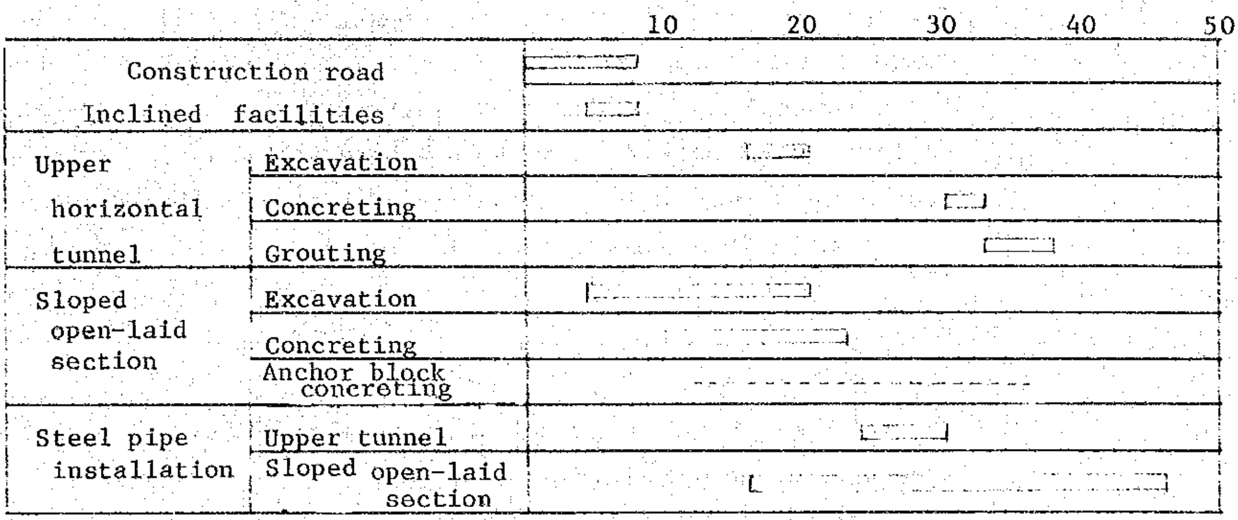
3) Concrete

Concrete for the upper tunnel shall be placed from the surgetank side toward the open-laid penstock side. Concrete shall be transported by concrete mixer cars from the concrete plant in the vicinity of the power station to the entrance of the penstock tunnel and shall be placed by concrete pump.

Concrete for the open-laid section shall be placed by combined use of pump, chute and bucket with track crane.

a preliminary schedule of work for excavation, concreting and steel pipe installation is shown on the following chart.

Preliminary Schedule of Work



(6) Powerhouse foundation and tailrace

This powerhouse is designed as a conventional open type. Its ground finish level is established at EL 176.3 m so that the structures will never be submerged by flooding. The powerhouse will be a structure 29.6 m in width, 63 m in length and 48 m in height. The deepest part of its foundation will be about 32 m below the ground level.

The tailrace will consist of an afterbay (27 m in width and 53 m in length), tunnel (closed conduit) (5.9 m in inner diameter and 110 m in length), and outlet works (40 m in length). Water discharge from two hydraulic turbine units will joint in the afterbay and flow through the tunnel at a reduced speed of current and rejoin with the Diduyon River through the outlet.

The foundation work for the powerhouse constitutes a major factor affecting the whole construction schedule for the powerhouse because work on buildings and installation of electromechanical equipments must immediately follow completion of the foundation work.

1) Excavation

The foundation work for the powerhouse and forebay shall be started by drilling rock with DC-45 class crawler drills and rock breakers. Overburdens and drilled rock shall then be removed by D-7 class bulldozers and 1 m^3 class backhoes and loaded on 11 t dump trucks by 2 m^3 class tractor shovels for removal from the site. Under the small bench cut process with about 2.5 m per lift, 12 lifts shall be excavated. The excavation surface shall be sloped at about 1:0.5 and a small step shall be provided every 5 m. The slope shall be stabilized either by spraying mortar or with rock bolts, as required. Muck shall be removed by building an access road from the tailrace side.

The overburdens and terrace deposits in the tailrace culvert and outlet sections shall be excavated by a combination of bulldozers, tractor shovels and dump trucks. The base rock shall be drilled and broken with crawler drills and rock breakers, and shall be removed by the combination of equipment described above. Prior to excavation of the outlet, a temporary coffer dam shall be made with cribwork, gabions, etc.

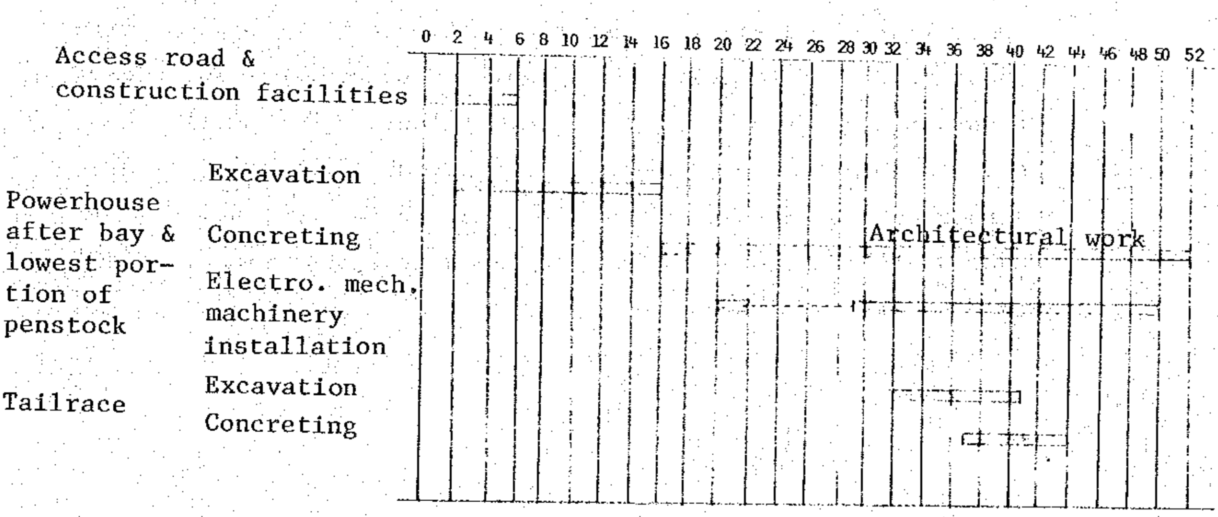
2) Concreting

Batches of concrete shall be delivered to the site by truck mixers along a construction road to be built on the tailrace side and shall be placed by concrete pump and chute. Concrete pumps shall also be mainly used for placing concrete on the architectural work portion.

All this work shall be completed in about four years and four months under the work schedule outlined below:

Schedule for Work on Powerhouse Foundation & Tailrace

(Month)



(7) Removal, clearing and restoration of environment on the site

When work has been completed and before the powerhouse starts its operation, the temporary facilities, construction equipment and temporary buildings shall promptly be removed, and the construction site shall be all cleared up and cleaned. Landscape gardening shall be provided around the powerhouse as well as other pertinent areas. Broken or damaged sections of the roads shall be repaired, and the environment shall be restored to original conditions and bettered.

(8) Work schedule

Preparatory work and provision of temporary facilities will be commenced in January, 1984, and the main work will be started in January, 1985. Under this schedule, the power station is expected to commence operation around December, 1989, when the approximate progress of each work is studied with the construction at an economical speed in mind. The stages of work have been compiled in Fig. 4-2-2.

4.2.5. Plan for construction facilities

Major construction facilities planned for the main work shall be as listed below. The layout of the aggregate plant and concrete facilities to be built at the damsite shall be listed in Table 4-2-1.

Construction Facilities for Major Works

(Refer to Fig. 4-3-1 as to the general layout of these facilities around the damsite)

Class	No.	Name of Work for Temporary Facilities	Specification	Remarks
Dam and Powerstation	1	Batcher plant installation " "	1.5 m^3 x 4 units 3 m^3 x 4 units 1.5 m^3 x 4 units	for power station for dam proper for dam spillway
	2	Cable crane "	25 t 20 t	both end travelling type, 600 m span, for dam proper and spillway
	3	Turbid water treatment plant	treatment capacity 800 m^3/hour	
	4	Cement storage and conveying facilities	1,000 t x 1 unit 1,000 t x 2 units	for power station for dam proper and spillway
	5	Concrete transport facilities	transfer car 9.0 m^3 and 6.3 m^3	including shuttle train line
	6	Cooling plant	300 t x 2 units in refrigeration tons	
Aggregate Plant	7	Aggregate plant turbid water treatment facilities	treatment capacity 800m^3/hour x 2 units	
	8	Aggregate production and storage facilities	primary crushing capacity 1,200 t/hour	secondary crushing capacity 750 t/hour
	9	Construction of settlement basin	1 set	settlement basin for dam turbit water treatment plant
Common Temporary Facilities	10	Incline facilities	1 set	for installation of hydraulic iron pipe line
	11	High voltage wiring and substation	1 set	
	12	Air supply facilities for work	1 set	
	13	Water supply facilities for work	1 set	

Common Temporary Facilities	14	Lighting facilities for work	1 set	
	15	Communications facilities	1 set	
	16	Temporary buildings for construction work	1 set	
	17	Security and welfare facilities	1 set	
	18	Temporary shop for hydraulic iron pipes	1 set	

Table 4-2-1 Tentative Construction Schedule of Diduyon Hydroelectric Development Proje

Description of Main Construction Works				Quantity	Unit
Preparatory Works	Improvement of Existing Road & Bridges			1	Lump Sum
	Access Road			105	km
	Power and Communication Facilities			1	Lump Sum
Temporary Facilities	Camp and Housing Facilities			1	Lump Sum
	Construction Facilities			1	Lump Sum
Dam	Cofferdam	Primary (Upstream)		1	Lump Sum
		Secondary (Upstream)		1	Lump Sum
		Downstream		1	Lump Sum
		Diversion Tunnel	Excavation	90,000	m^3
			Concrete Lining	26,000	m^3
	Main Dam	Excavation		445,300	m^3
		Concrete Placing		1,198,000	m^3
		Grouting		1	Lump Sum
		Gates		5	Gates
Waterway	Intake	Excavation		25,300	m^3
		Concreting		5,300	m^3
		Grouting		1	Lump Sum
		Gates		1	Gate
	Headrace Tunnel	Excavation		510,000	m^3
		Concrete Lining		195,000	m^3
		Grouting		1	Lump Sum
	Surgetank	Excavation		26,000	m^3
		Concreting		8,100	m^3
		Grouting		1	Lump Sum
		Others		1	Lump Sum
	Penstock	Excavation		1020,000	m^3
		Concreting		56,000	m^3
		Penstock		2013	m
	Tailrace	Excavation		81,300	m^3
		Concreting		7,500	m^3
		Gates		1	Lump Sum
Powerhouse	Faundation	Excavation		79,400	m^3
		Concreting		20,800	m^3
	Archtectural Finish			1	Lump Sum
	Electrical and Mecanical Works			1	Lump Sum

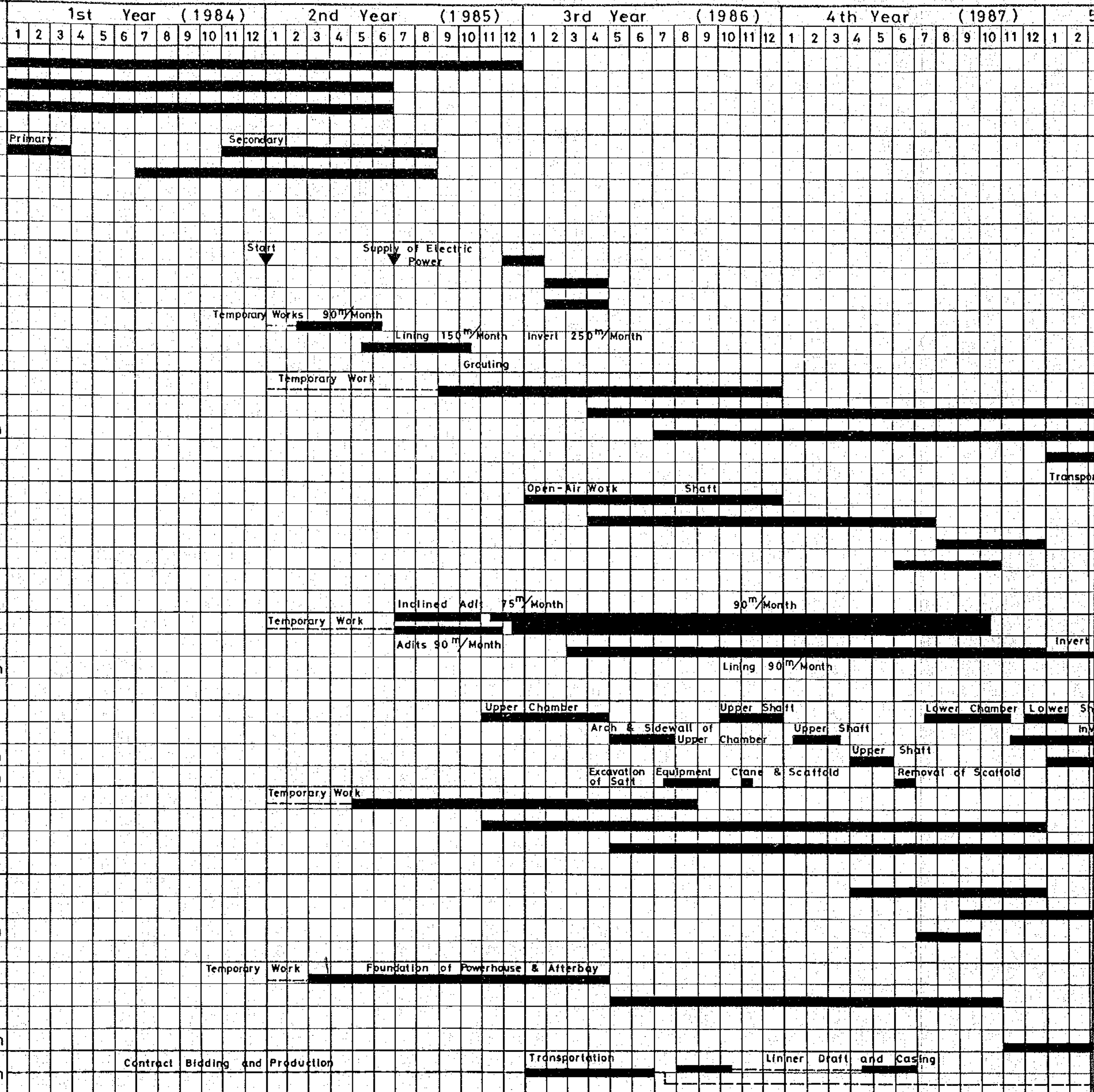
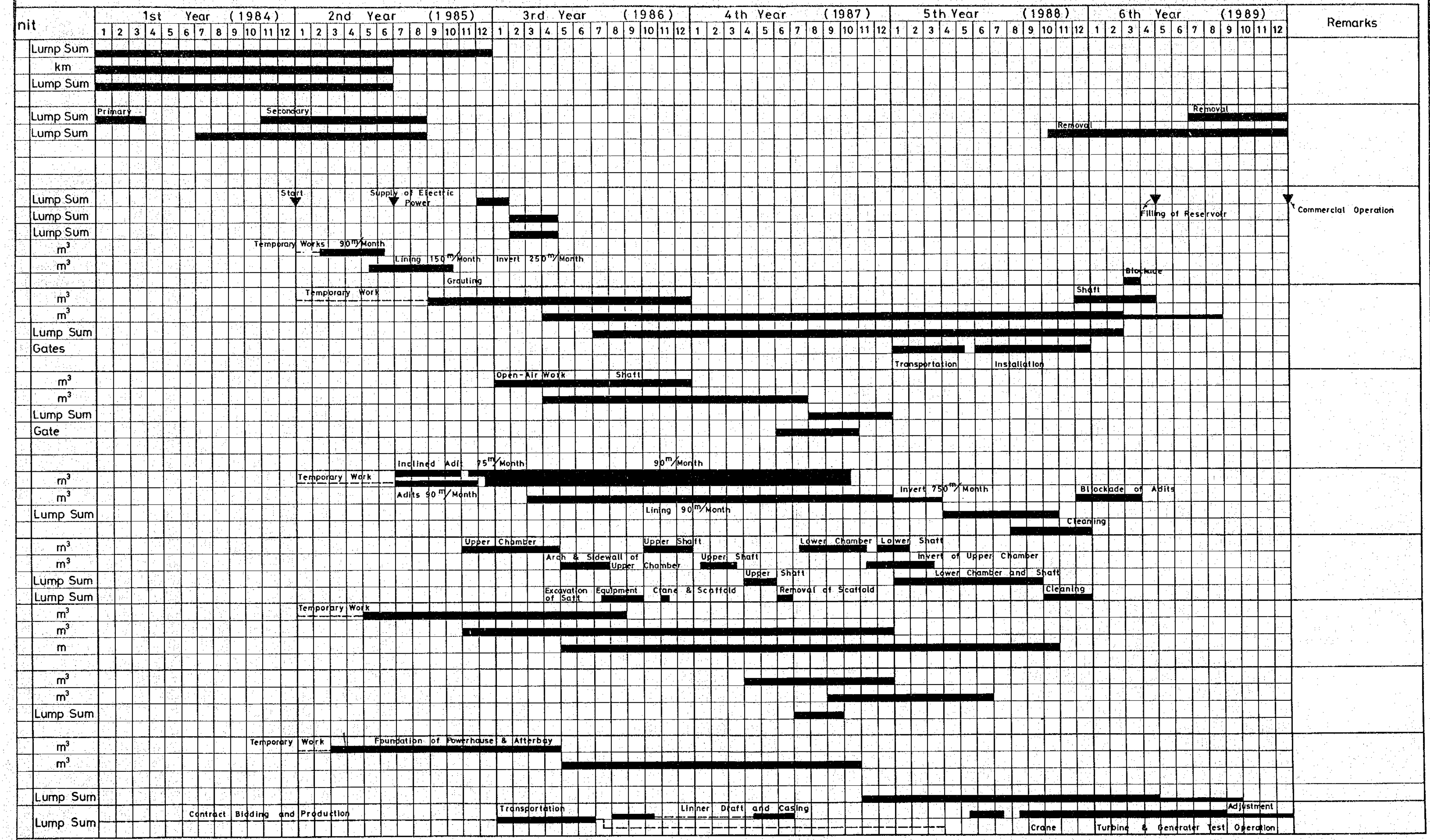
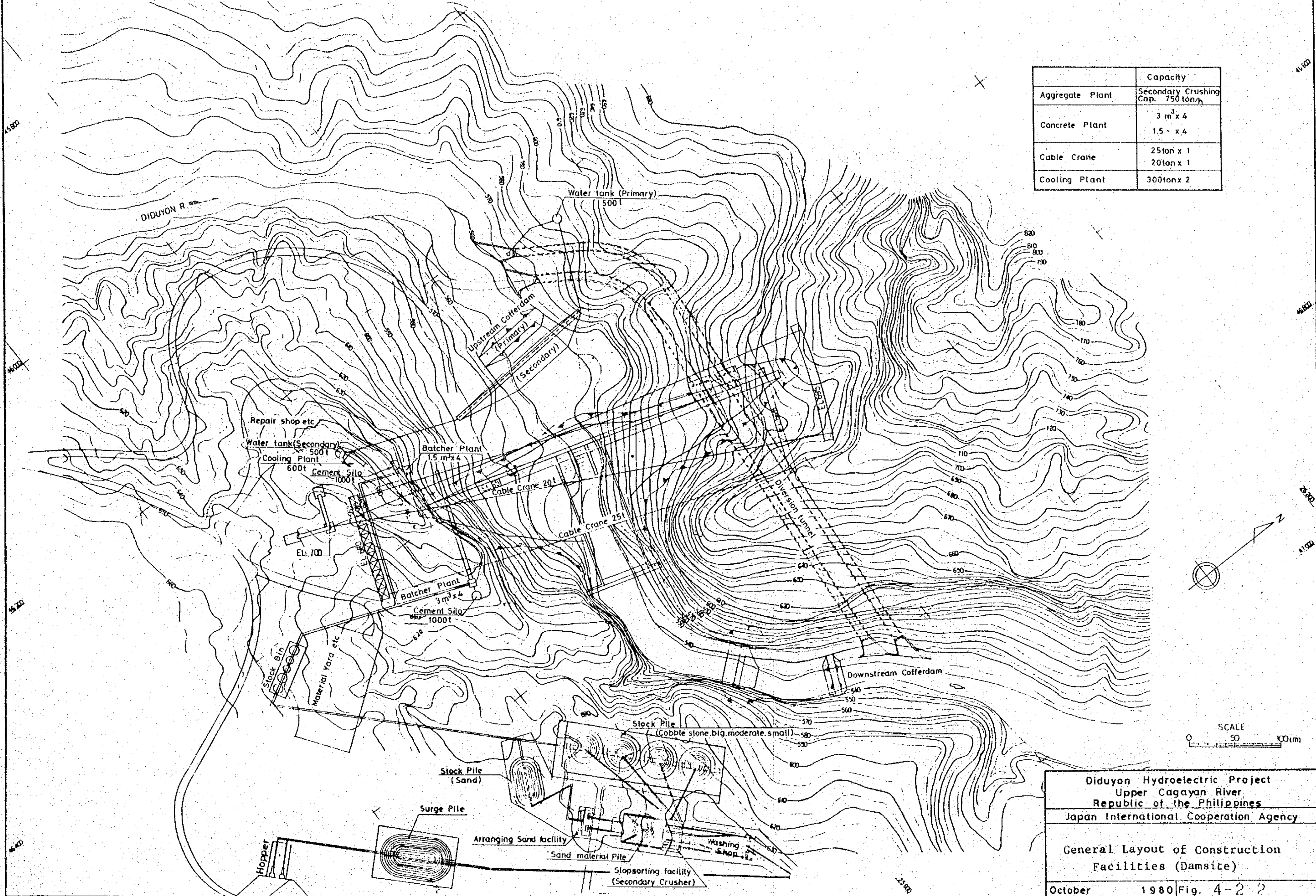


Table 4-2-1 Tentative Construction Schedule of Diduyon Hydroelectric Development Project



General Layout of Construction Facilities (Damsite)



	Capacity
Aggregate Plant	Secondary Crushing Cap. 750 ton/h
Concrete Plant	3 m³ x 4 1.5 ~ x 4
Cable Crane	25ton x 1 20ton x 1
Cooling Plant	300ton x 2

Diduyon Hydroelectric Project
Upper Cagayan River
Republic of the Philippines

Japan International Cooperation Agency

General Layout of Construction Facilities (Damsite)

October 1980 Fig. 4-2-2

(1) Production and Transportation of aggregate

As described earlier, the aggregates, both coarse and fine, shall be produced at the quarry site located on the left bank of the Diduyon River, 2 km upstream of the damsite.

Prior to actual production of aggregates for the project structures, the quarry site shall be stripped of vegetation and topsoil. For this opeation, a pilot road shall be built in two stages of upper and lower.

The topsoil shall be excavated by two units of D-8 class bulldozer which shall push and collect the soild for loading on dump trucks by a tractor shovel (2.3 m^3 class in capacity). The soil shall be dumped at a topsoil disposal site. After the topsoil has been removed, an access road for transporting the produced aggregate materials shall be built utilizing the pilot road. Stone shall be extracted by blasting under the bench cut process. The height of benches shall be 5 m as the standard. The quarrying method shall consist of drilling holes at about 75° to 80° to the vertical direction with a crawler drill and cutting rock downward in steps. Fragmented stone shall be collected by D-8 class bulldozers for loading on 20 to 32 ton dump trucks by a 3.8 m^3 capacity class tractor shovel.

1) Required amount of stone

Total aggregate tonnage (including the dam and other concrete structures) will be:

$2.2\ t/m^3 \times 1.6$ million m^3 = 3.52 million m^3

Loss at each work stage :

Secondary and tertiary loss	8 %
Quarry loss	22 %
Total	30 %

Processing volume at each stage will be estimated as follows:

Secondary processing volume

3.52 million tons ÷ 0.92 = 3.83 million tons

Volume to be charged into jaw crusher

= 3.83 million tons

Volume of rock to be extracted

3.83 million tons ÷ 0.78 = 4.91 million tons

Assuming the specific gravity of rock is 2.6, the volume of rock (bedrock) required will be;

4.91 million tons ÷ $2.60\ t/m^3 = 1.89$ million m^3

And loss of rock will be :

1.89 million $m^3 \times 0.30$ million m^3

2) Maximum required volume of aggregates per day

If concrete is placed at a rate of $3,325\ m^3$/day (see sub-section (2) Aggregate production and storage plan), the volume of aggregate required with an estimated loss of 30% will be :

$3,325\ m^3/\text{day} \times 2.2\ t/m^3 \times 1.30 = 9,510$ t/day

Assuming the rock has a specific gravity of 2.6, required volume of rock (bedrock) will be

$9,510$ t/day ÷ $2.6\ t/m^3 = 3,658\ m^3$/day

If the specific gravity of crushed rock is assumed to be $1.6\ t/m^3$, the volume of aggregate available for delivery will be ;

$9,510$ t/day ÷ $1.6\ t/m^3 = 5,944\ m^3$/day

3) Bench cut quarrying method

Bit gauge : 3" (75 mm)

Explosive : No. 3 "KIRI" dynamite with ANFO booster

Bench height : 5 m

Hole spacing : 2.3 m

Minimum resistance line: W = 0.87xB = 0.87 x 2.3 = 2 m

Sub-drilling: ℓs = 2.0 m x 0.35 = 0.7 m

Hole length : ℓh = 5.0 m + 0.7 m = 5.7 m

Filling up length : ℓn = W = 2.0 m

Charge length: $\ell c = \ell h - \ell n$ = 5.7 m - 2.0 m = 3.7 m

Charge per hole : L = (3.7/0.43) x 750 g/stick
= 9 sticks x 750 g/ℓ = 6.75 kg

Crushing volume : V = 2.0 x 2.3 x 5.0 = 23.0 m^3

Volume of explosive : F = 6.75 kg ÷ 23.0 m^3 = 0.29 kg/m^3

4) Calculation of crushing volume

Holes shall be made in rock by DC-45 class crawler drills.

(i) Drilling per hole : 5.7 m

(ii) Drilling time per hole : 20 minutes
Net drilling time per hole : 17 minutes
Moving and set-up time per hole : 3 minutes

(iii) Actual working hours is assumed: 7 hours per day

No. of holes drilled per 7 hours/day: 7 hr÷20 min = 21 holes,
21 holes x 2.3 m x 2.3 m
x 5.0 = 555 m^3/day/unit

Crushing volume per day with

8 units of DC-45 class crawler drill :

$555\ m^3$/day/unit x 8 units = $4,440\ m^3$/day/unit

$3,658\ m^3$/day/unit

For drilling machines, 8 sets of crawler drill (DC-45 class) combined with an engine-driven portable compressor ($17\ m^3$) shall be used for drilling holes for blasting. Preliminary cuts shall be carried out by combined use of leg hammers and bulldozers primarily intended for successive bench cuts.

Machines for Production of Aggregate

Drilling :	Crawler drill	DC-45	9 units with 1 unit stand-by
Accumulation:	Bulldozer	D-8	3 "
Loading :	Tractor shovel	$3.8\ m^3$ class	3 "
Transporting:	Dump truck	15 t class	20 "
Crushing :	Rock breaker		3 "

Rock breakers will be used when it is necessary to break rock into gravel of about 700 mm for charging into grizzly.

As the quarry shall be located on the left bank of the Diduyon River 2 km upstream of the damsite, only the primary aggregate plant shall be established near the quarry.

Aggregate materials crushed at the primary plant shall be transported by dump trucks to the secondary plant to be located near the damsite for production of aggregate products.

(2) Aggregate production and storage plan

1) Criteria for plan

The plan shall be formulated based on the volume of concrete to be placed per hour at the peak of concreting work.

Maximum volume of concrete to be placed per month :	64,470 m^3 (dam body) + 12,000 m^3 (other structures)
	= 76,470 m^3/month
Average concreting work days per month :	23 days
Volume of conrete to be placed per day :	3,325 m^3/day
Volume of concrete to be placed per hour :	Max. 235 (dam) + 45 (others) = 280 m^3/hr

As for the criteria of the plan for construction facilities, the required capacity of each machine shall be determined so as to meet the hourly concrete placement volume, 280 m^3/hr. This calculation is made on the assumption that the main equipment of the aggregate plants will be operated 12 hours per day.

Operation of aggregate plants

Average operating days per month :	24 days
Operating hours per day	
Primary :	12 hours
Secondary and tertiary:	16 hours

Volume of the necessary aggregates per hour classified by grade is given as follows:

Consumption of Aggregate

Concrete	Coarse aggregate 150-80 mm	Coarse aggregate 80 - 40 mm	Coarse aggregate 40 - 20 mm	Coarse aggregate 20 - 5 mm	Fine aggregate less than 5mm	Total
Dam (kg/m^3)	490	362	380	410	608	2,250
(%)	22	16	17	18	27	100
(t/hr)	116	85	90	95	143	529
Other structures (kg/m^3)			450	550	800	1,800
(%)			25	31	44	100
(t/hr)			20	25	36	81
Total (kg/m^3)	116	85	110	120	179	610
(%)	19	14	18	20	29	100

Note: 529 t/hr = 2.25 t/m^3 x 235 m^3/hr
81 t/hr = 1.8 t/m^3 x 45 m^3/hr

2) Required capacity of aggregate plants

Assuming that an all-crushing system will be employed, the capacity will be calculated backward from the sand production plant to the primary plant.

a) Capacity of sand production plant

C_3	: sand production plant capacity	t/hr
Q_3	: monthly production of fine aggregate	48,331 t/m
d_3	: No. of days plant is operated	24 days
t_3	: No. of hours plant is operated per day	16 hours
fs	: falling stone coefficient	1.02
fw	: loss factor of classifier	1.25
e	: rate of operation	75%

$$C_3 = \frac{Q3 \cdot fs \cdot fw}{d_3 \cdot t_3 \cdot e_3} = \frac{48,331 \times 1.02 \times 1.25}{24 \times 16 \times 0.75} = 214 \text{ t/h}$$

b) Secondary plant

$C_2 = C_2' + C_2''$: capacity of secondary plant

C_2'	: capacity required for production of fine aggregate	
C_2''	: capacity required for production of coarse aggregate	
C_3	: capacity of sand production plant	214 t/h
Q_2	: monthly production of coarse aggregate	118,327 t/m
fw	: coefficient of loss by washing	1.05
e_2	: rate of operation	75%

$$C_2' = \frac{C3 \cdot fs \cdot fw}{e_2} = \frac{214 \times 1.02 \times 1.05}{0.75} = 306 \text{ t/h}$$

$$C_2'' = \frac{Q2 \cdot fs \cdot fw}{d_2 \cdot t_2 \cdot e_2} = \frac{118,327 \times 1.02 \times 1.05}{24 \times 16 \times 0.75} = 440 \text{ t/h}$$

$$C_2 = C_2'' + C_2'' = 306 + 440 = 746 \text{ t/h}$$

c) Capacity of primary plant

C_1 : capacity of primary plant

C_2 : capacity of secondary plant 746 t/h

e_1 : rate of operation 80%

f_f : coefficient of variation in supply volume of stone 1.25

$$C_1 = \frac{C_2 \cdot f_f \cdot fs}{e_1} = \frac{746 \times 1.25 \times 1.02}{0.8} = 1{,}189 \text{ t/h}$$

From the foregoing, the required capacity of each plant is:

Primary plant	1,189 t/h
Secondary plant	746 t/h
Sand production plant	214 t/h

Name of machine to be used	Specification	Q'ty	Max. dimensions (Thick x W x L mm)	Standard crushing capacity (t/hr/unit) Outlet clearance (mm)							
				11	13	19	22	25	115	125	150
Jaw crusher	42 - 48	4	700x950x1,400						290	310	350
Cone crusher	12 - 60	4	150x210x300			180	190	195			
"	4 - 60	4	50x70x100	100	110	135					
Rod mill	9 - 12	2	30 ∿ 5	122							

The primary plant of the aggregate plant facilities shall be built at the quarry, and the other plants including the secondary plant are all established at the damsite.

(3) Aggregate storage facilities

1) Primary surge pile

Aggregate produced by the primary crusher shall temporarily be stocked in the surge pile. Although the primary and secondary plants are operated under separate operating systems, this surge pile will afford flexible operation of these plants and, is either one of the plants should fail, can prevent adverse effect of failure on the other plant. The machines of the secondary plant can efficiently be operated by keeping constant the volume of withdrawal from the surge pile. A quantity sufficient to meet three days' requirements shall be piled in the open storage area, as estimated as follows:

$$Q = V \times W \times \ell \div \gamma \times 3 = 3{,}325 \times 2.2 \times 1.20 \div 1.60 \times 3$$
$$= 16{,}459 \text{ m}^3 \text{ (effective)}$$

where

V : daily average placement of concrete in peak concreting month

W : volume of aggregate per cubic meter of concrete

ℓ : loss in production process

γ : apparent specific gravity of aggregate

Piling radius will be: $0.388\ L^3 = 16{,}459\ m^3 (L = 35\ m)$

2) Sand pile

For the capacity, a quantity sufficient to meet two days' requirements shall be piled in the open storage area, as stated below,

$$Q = V \times w \times y \times \ell \times r$$
$$= 3,325 \times 2.2 \times 0.29 \times 1.2 \div 1.6 \times 2$$
$$= 3,182\ m^3$$

y : ratio of fine aggregate

ℓ : loss in production process

Piling radius : $0.388L^3 = 3,182\ m^3$ (L = 20 m)

3) Product stockpile

For large, medium, small and fine aggregates, a quantity meeting rrquirements for five days shall be stocked. For sand, a quantity for eight days' consumption shall be stocked to allow drainage of water. From the above, each size of aggregate by ratio is shown in the table below.

Daily aggregate requirements

$$3,325 \times 2.2 \div 1.6 = 4,572\ m^3$$

	Grade (mm)	Composition(%)	Req. volume (m^3)	Req. storage (m^3)	Supply capacity	Radius of open piles (m)
Large gravel	150 - 80	19	(869) 2,607	3,000	about 3 days	20
Medium gravel	80 - 40	14	(640) 1,920	2,500	- " -	19
Small gravel	40 - 20	18	(823) 2,469	3,000	- " -	20
Fine gravel	20 - 5	20	(914) 2,742	3,000	- " -	20
Sand	less than 5	29	(1,326) 6,630	7,000	about 5 days	26

4) Adjusting bin

The distance from the product stockpile to the batcher plant is designed to be about 200 to 300 m. Therefore, steel adjusting bins shall be installed to minimize loss in time in case of trouble in transportation of products. A total of five adjusting bins shall be installed to store about half day's requirements of gravel and sand.

(4) Cement silo

The capacity of the cement silo for the dam concrete shall be calculated from the following formula:

$$C_s = \frac{V \times C \times D}{d \times rc}$$

$$= \frac{64,470 \times 200 \times 3}{23 \times 1,300} \approx 1,294 \ m^3 = 1,682 \ t$$

where,

C_s	:	capacity of silo (m^3)
r	:	maximum monthly volume of concrete to be placed for dam body (m^3)
C	:	volume of cement in 1m^3 of concrete (kg/m^3)
D	:	Storage capacity (day)
γ_c	:	apparent specific gravity of cement
d	:	working days per month

Two units of 1,000 t capacity cement silo shall be installed.

(5) Batcher plant

The following batcher plants shall be installed:

For dam body	:	3 m^3 x 4	1 unit
For spillway, etc.:		1.5 m^3 x 4	1 unit

Concrete production facilities shall be established at a place as close to the damsite as possible. This place shall be conveneiently located for transportation of products, and the production facilities shall be installed on stable ground.

An access road for trucks shall be built on the ground on which the concrete production facilities stand. This road shall be used not only for installation and removal of facilities but also for production of concrete, delivery and shipment of test pieces, and removal of rejected concrete.

The concrete production facilities can broadly be divided into manual and automatic operating methods. In this case, individual weighing, fully automatic production facilities shall be used for prompt and continuous production of concrete in large quantities according to the prescribed mixture formulation. The production facilities shall also be equipped with an electric type sand moisture content compensation device with a neutron moisture meter as well as a printer recording device.

The following points shall carefully be taken into account when the detailed structure of the concrete production facilities is designed and supplied:

(i) Rock ladders shall be provided in the cobble stone and large gravel bins to prevent segregation and crushing under load.

(ii) At the outlet of each bin, the following devices shall be provided to prevent weighing difficulty due to clogging of materials or overweighing due to trapping of materials at closing of the gate:

For bins for coarse aggregates	:	weighted blind
For bins for fine aggregates	:	vibration device, finger gate
For cement bins	:	aeration device

(iii) A sampling and transport device shall be provided for sampling concrete.

(iv) Piping shall be provided for supply of washing water to mixers, hoppers, etc. and for drainage of waste water.

(6) Concrete placing equipment

The maximum hourly placement of concrete shall be set as 235 m^3/hr. Buckets shall be provided in two capacities of 9 m^3 and 6 m^3. If the cycle time for the maximum hourly placement of concrete is set as:

Loading	:	1 minute
Travelling, both ways	:	1 minute
Hoisting and lowering	:	1.3 minutes
Bucket opening and closing	:	0.5 minute
Total	:	3.8 minutes

The concrete placing capacity will be

$$(9 + 6) \times 60/3.8 = 237 \text{ m}^3/\text{hr}$$

The cable cranes as detailed in the following table shall be used for transportation of concrete:

<u>Cable Cranes</u>

	25-ton Cable Crane	20-ton Cable Crane
Rated capacity (t)	25	20
Bucket capacity (m^3)	9	6
Traveling speed (m/min)	500	370
Lowering speed of loaded bucket (m/min)	160	150
Hoisting speed of empty bucket (m/min)	200	180
Type	Both ends traveling type	Arc traveling type around 45m high stationary tower built on the right bank side

(7) Turbid water treatment plant

The sources of turbid water in dam construction can be classified into two; one is washing water used in the aggregate production process as well as in concrete production and transport facilities, and the other is washing water used in removing laitance, cleaning rockbed, drilling, etc.

Turbid water from aggregate production are generally highly turbid and in great volume, while that from production of concrete, removal of laitance and from other damsite works are low in turbidity and volume, but of alkaline quality.

1) Turbid water treatment plant for the aggregate production facilities

Water used in washing, etc. in the process of aggregate production is about 1.3 to 2.3 m^3 per ton of aggregates. If aggregate production is set as the secondary plant capacity of 750 t/hr, the required capacity of turbid water treatment will be:

$$1.3 \text{ to } 2.3 \times 750 = 975 \text{ to } 1{,}723 \ m^3/hr$$

Thus, a turbid water treatment plant with a capacity of 800 m^3/hr x 2 units shall be installed.

If the unit weight per volume of 50,000 ppm SS deposits is assumed to be 1.3 t/m^3 for 1,600 t/hr of turbid water, the hourly production of deposits will be:

$$S = \frac{1{,}600 \times 0.05}{1.3} = 62 \ m^3/hr$$

Because the total production of aggregate is 1,660,000 x 2.2 = 3,520,000 m^3, the total volume of deposits will be:

$$Sa = 62 \times \frac{3{,}520{,}000}{750} \fallingdotseq 291{,}000 \ m^3$$

A grit chamber shall be provided to commonly handle deposits for the aggregate plant and damsite, and shall be adequate in capacity for this common use.

2) Turbid water treatment plant for damsite

Since both the turbidity and volume are low, a turbid water treatment plant of 800 m^3/hr shall be installed.

This plant shall consist of a neutralization tank, chemcial feed device, sedimentation and separation tanks, and de-waterring device. The effluent shall be less than 60 ppm in SS and about 7 in pH.

For a turbid water volume of 600 t/hr (see Sub-item 4.3.5. (7) Water supply facilities) with 20,000 ppm in SS and a unit weight per volume of 1.3 t/m^3, the maximum hourly production of settlements will be:

$$S = \frac{600 \times 0.02}{1.3} = 10 \, m^3/hr$$

(8) Water supply facilities

Service water is required for the dam construction work as follows:

Service water for construction works
In this category is involved the water used for cleaning foundation bedrock, and concrete joints, concrete curing and cooling, drilling and grouting washing aggregate and producing sand, mixing concrete, cooling compressors, etc.

Water supply for human consumption
Drinking water for workers and staff, miscellaneous service water, etc. will be necessary to be supplied in a separate system.

Designed service water supply

(i) Water supply to batcher plant

From experience, it is known that a relationship of roughly y = 0.0025 (x -40) exists between the batcher plant production capacity: x m^3/hr. and the plant's water supply requirement: y t/min.

For the batcher plants with capacities of

3 m^3 x 4	:production capacity of		280 m^3/hr
1.5m^3 x 4:	- ditto -		140 m^3/hr
Total :	- ditto -		420 m^3/hr

y = 0.0025 x (420 - 40) = 0.95 m^3/min ≑ 60 m^3/hr

of this 60 m^3/gr, 20% to 30% (approx. 20 m^3/hr) will be used as service water for washing the plant and buckets.

(ii) Water supply requirement of aggregate plant

From experience, it is known that 1.3 to 2.3 tons of water will be used for one ton of aggregate.

∴ 1.3 to 2.3 x 750 t/hr = 975 to 1,725 t/hr

where the capacity of the secondary aggregate pant is assumed to be 750 t/hr.

(iii) Water for cooling dam concrete by pipe cooling

Annual average placement of concrete:
1.2 million m^3 ÷ 2.9 = 410,000 m^3/year

Cooling water requirement:
410,000 m^3 ÷ 376 m^3/coil x 18 l/min = 20 m^3/min

If cooling water is supplied from a cooling plant, water will be recirculated. Assuming that the make-up water will be 10%, we obtain the following supply of water as necessary one.

$20 \times 0.1 \times 60 = 120\ m^3/hr$

(iv) Service water requirements for curing concrete and cleaning

Since about 2 to 3 m^3/min of water is needed for cleaning rockbed, disposing of laitance, and curing concrete, 120 to 180 m^3/hr shall be supplied.

(v) Water consumption for drilling, grouting, etc.

According to practical examples, 100 to 300 t/hr will be needed.

All these water supply requirements are summarized in the following table :

Use of Water	Water Supply Capacity (t/hr)	Turbid Water Output (t/hr)	Capacity of Turbid Water Treatment Facilities
Batcher plant	60	20	800t/hr - 1 unit
Cooling plant	120	120	
Curing concrete and cleaning	180	180	
Drilling, etc.	300	300	
Aggregate plant	1,600	1,600	800t/hr - 2 units
Total	2,260	-	800t/hr - 3 units

To meet these requirements for service water, the following water supply facilities shall be provided:

Aggregate plant	:	1,600 m^3/hr
Damsite	:	700 m^3/hr

(9) Lighting facilities

1) Requirement

The dam construction work woll involve night work. Lighting facilities shall be provided for efficient and safe operations during the night.

The damsite is vast in area and the construction field will change in three dimensions as progress is made in work. For this reason, it is common practice to provide both general and localized lighting facilities for economical installation. As specific lighting methods, the following two methods shall be jointly used. One method is to erect steel poles at strategic positions and install the source of lighting on these poles. The other is to stretch cables over the construction field and suspend an adequate number of floodlights from these.

Luminosity is defined as follows:

Concrete placement surface for the concrete dam -

Localized lighting	100 to 150 lux
General lighting	20 to 30 lux

Quarry -

General lighting	10 to 15 lux

2) Lighting plan for damsite

Both general lighting and suspension type lighting are used. The average illumination intensity over a flat surface on an average at 100 m below the source of lighting shall be 20 lux. Flood light shall be suspended from the cable both upstream and downstream of the cable crane.

Area illuminated : 200 x 100 = 20,000 m^2

No. of floodlights is given as follows:

$$N = \frac{EAD}{FV}$$

where, E = required illumination (lux)

A = work area to be illuminated (m^2)

D = Rate of compensation for reduced light

F = Beam flux per floodlight (m)

U = Utilization rate

$$\therefore \quad N = \frac{20 \times 20,000 \times 1.4}{19,000 \times 0.7} = 42.1 \text{ units}$$

Hence, 21 units each shall be installed on the upstream and downstream sides.

Major lighting applicances are as follows in general.

High-pressure mercury bulb : GS-H, 1,000 A

Outdoor suspension type floodlight : Special GFM-1,000 A

Stabilizer : HC-1,000 CA

Suspension spacing : 10 m

(10) Aritificial cooling plan

When concrete is placed, it will generate heat as it hardens. This heat build-up will gradually slow down due to dissipation from the surface, etc. After the concrete reaches a peak temperature by a certain time, it will begin to cool and will eventually attain the final stabilized temperature. Tensile stress will develop inside the concrete as the temperature drops. To prevent this tensile stress, the concrete shall be cooled artificially. The capacity of the cooling plant shall be calculated from the following formula:

$$R = \frac{M \cdot S \cdot W \cdot (Tu - Te)}{24 \times 3,300}$$

where,

M : volume of concrete to be placed per day - 2,800 m^3/day

S : Specific heat - 0.22 kcal/kg°C

W : density of concrete - 2,500 kg/m^3

Tu : initial maximum temperature of concrete - 45°C

Te : temperature of concrete at end of cooling - 20°C

Hense,

$$R = \frac{2,800 \times 0.22 \times 2,500 \times (45° - 20°)}{24 \times 2,300}$$

$\doteqdot$ 486 refrigeration tons

Two units of 300 refrigeration ton capacity plant shall be installed. It is to be noted that 1 refrigeration ton refers to the theoretical value needed to produce 1 ton of ice of 0°C from 1 ton of water of 0°C in 24 hours.
In other words,

One refrigeration ton = 1,000 kg x 80 kcal/day/kg
= 80,000 kcal/24 hrs
= 3,300 kcal/hr

(11) Communications facilities

The dam construction field will become a complex system where various elements of work are interrelated with each other. These elements include the quarry, aggregate plants, batcher plant, concrete placement facilities, drilling and grouting works, finish excavation work etc. Close communications among these elements of work are essential to achieve increased safety and higher efficiency of operations. To accomplish these objectives, the following communications facilities shall be installed:

1) Telephone system in the construction field

Mutual direct telephone by automatic exchange

Office - each station in the field

" - damsite

" - batcher plant

" - aggregate plant

" - quarry supervisor's office

" - each laboratory

" - substation

" - subcontractor's office - subcontractor's station

2) Public address system

Office - field stations - damsite

3) Field warning systems

Motor sirens for blasting alarm

Location : quarry and damsite

4) Transceiver

Cable crane - -oncrete placement site

5) Closed-circuit television

Office - damsite

(12) Temporary facilities

Buildings and structures for the dam construction work shall be provided and arranged in such manner as to satisfy the required capacity at the peak of construction.. For this purpose, an adequare plan shall be made and an adequate plot of land shall be secured. For living quarters in particular, due consideration shall be given to safety, health and recreation so that the living quarters will give sufficient rest and comfort to workers for improved work efficiency and safety supervision. When designing buildings for construction work, consideration shall also be given to sanitation, including sewage and garbage disposal. The major temporary buildings planned for this construction are shown in the following table:

Major Temporary Buildings

	Name of Building	Scale		Remarks
Office	Headquarter office	1 house	450 m^2	Including meeting rooms
	Damsite office	1 house	150 m^2	
	Quarry office	1 house	100 m^2	
	Supervisor's office	2 houses	100 m^2	
	Contractor's office	4 houses	400 m^2	
	Ambulance	3 houses	150 m^2	
NPC	Living quarters	10 houses	1,500 m^2	
	Dormitory	3 houses	1,500 m^2	
	Guest house	1 house	200 m^2	
	Hospital	1 house	300 m^2	Including living rooms
	Police station	1 house	250 m^2	Including living rooms
Contractor	Living quarters	5 houses	500 m^2	
	Dormitory	1 house	1,000 m^2	
	Laborers' houses	20 houses	1,500 m^2	
	Laborors' bunkhouse		5,000 m^2	
Others	Warehouse		1,500 m^2	On the lot with area 15,000 m^2, warehouses and repair shop
	Site post	7 houses	350 m^2	
	Laboratory	2 houses	200 m^2	For concrete test and water quality test

Of the temporary buildings shown in this table, the offices and company facilities shall be built so as to be ready for use when the main constructionwork starts. The facilities for subcontractors and the facilities for construction work shall be built or enlarged according to the progress of each type of work. Buildings shall be designed so that local building materials may be used.

4.2.6. Plan for security and welfare facilities

For this large-scale hydroelectric power development project involving a long construction period, the plan for security and welfare facilities and provisions is one of the most important measures for execution of the project with steady progress according to the schedule as well as for its successful completion.

The major plans and provisions in this regard are described below.

(1) Organizations for safety supervision

For safety supervision, the folloowing organizations and meeting shall be established:

1) Safety liaison council	To meet once a month
Members	Supervisors and representatives of contractors
Main responsibility	To establish targets for safety and formulate measures against accidents and disasters
2) Safety sanitation committee	To meet once a week
Members	Representatives of contractors and subcontractors
Main responsibility	To establish measures against accident and disaster and implement education and traning programs

3) Safety conference — To meet once a month

Members	All personnel engated in construction work
Object	To announce safety targets for the month

4) Preliminary meeting for work and safety — Meeting everyday

Members	All personnel engated in construction work
Object	To make preliminary arrangements for work on the following day and confirm safety requirements

5) Tool-box meeting

Members	Foreman and subordinate workers
Object	To give safety instructions to front line workers and remind them of importance of following these instructions

(2) Safety supervision implementation plan

For safety supervision, the following systems and education shall be implemented:

1) Safety inspection system

a) Safety check by turns

b) Safety patrol

2) Promotion of safety and sanitation education

a) Safety and sanitation education for workers when they are recruited

b) Safety and sanitation education for foremen

(3) Medical check-ups

Prescribed medical check-ups shall be carried out for all employees at the time of recruitment and at least once a year.

(4) Installation of safety signs, etc.

(5) Measures against pollution from construction work

To prevent pollution from construction work, the following measures shall be taken:

1) Prevention of water pollution

A turbid water treatment plant and water quality laboratory shall be established.

2) Prevention of dust

Dust protective masks and goggles shall be worn, and sprinkler facilities shall be installed in aggregate plants.

3) Prevention of noise and vibration

Low-noise type machines shall be used and vibration protective gloves and ear plugs shall be worn.

4) Fire prevention

Fire extinguishers shall be installed and watchman shall be posted where fire is used.

(6) Road traffic safety facilities and measures

Along the entire 105 km extension which will become the main construction road, adequate traffic and safety signs shall be installed, measures taken to prevent collapse of sloped surfaces, falling rock prevention fences established, traffic safety patrol made, and periodical safety education conducted.

(7) Security at construction site

An orderly and disciplined labor environment shall be created at the construction site. Police branch posts shall be established at the two places of the damsite and powerhouse site, and patrols shall be carried out by bigilance groups.

(8) Measures against disease and injury (particularly epidemic disease)

A clinic manned a doctor and nurse shall be established at the damsite. Also, knowledge of labor safety and hygience shall be disseminated to the workers.

(9) Measures against labor accidents

Skilled workers shall be distributed among ordinary workers. Education in the handling of equipment and materials shall be given to operators in advance. Thorough measures shall be taken to prevent collapse of cut sloped surfaces and fall of men over cliffs.

(10) Entertainment and recreation facilities

Movies, TV and radio sets shall be installed in places for recreation of the workers. Assembly halls shall be provided to give workers place for entertainment and recreation.

4.2.7. Implementation plan

(1) Labor market and construction worker recruitment plan

There is no problem in recruiting ordinary workers in the Philippines for construction of the Diduyon Hydroelectric Power Station. However, very few skilled workers are available in the vicinity of Diduyon and these must be either recruited in Manila or brought in from some other regions upon completion of other construction project.

The manpower requirement of this construction work will be roughly estimated as follows:

Ordinary workers (ordinary construction workers)	1,629 persons	(45 %)
Skilled workers (carpenters, mechanical or electrical engineers, and others)	905 persons	(25 %)
Machine operators (Drivers of trucks, bulldozers, etc.)	1,086 persons	(30 %)
Total	3,620 persons	(100%)

This construction project is large in scale and mainly consists of dam and tunnel construction. Thus, the use of a mechanized system is imperative from the standpoint of both shorter construction period and safety.

As a means of securing skilled workers and machine operators, recruitment outside the region, or training of the necessary number of personnel by the time the main work commences may be considered. As a workable method, it would be better to train workers during road building for construction work, survey work, or other preparatory works.

(2) Plan for power station operating staff

The Diduyon Power Station will be operated under the control of NPC. This sub-section will be devoted to discussion of the operating staff required for management and operation of the power station.

The field management organization and number of personnel will be as given in the following table:

Diduyon Power Station Operating Staff

Division	Function	Number	Remark
Manager		1	
Deputy Manager		1	
Operation	Operation of station	13	1 chief, 3 operators x 4 in 3 shifts
Maintenance	1. Electrical maintenance	3	1 chief, 2 engrs. (daily duty)
	2. Maintenance of transmission and substation facilities	3	1 chief, 2 engrs. (- " -)
	3. Maintenance of civil works	9	1 chief, 4 engrs. on 3 shift daily duly 4 engrs. on 3 shifts
General Affairs	Clerks	6	1 chief, 2 clerks, 3 workers
	Club workers	3	1 clerk, 2 cooks
	Drivers	2	2 drivers
Number of Staff	Manager and Deputy - 2	Total 41 persons	Electrical engrs.
	Operation -13		- " -
	Maintenance -15		6 electr. engrs. and 9 civil engrs.
	General Affairs -11		9 clerks and 2 drivers

Note: The number of staff listed above is subject to modification according to the NPC's personnel plan and the local conditions.

For scheduled maintenance and repairs or in an emergency due to accident, under NPC's direct control and supervision, operating engineers and maintenance crew shall jointly perform with various required operations with the help of personnel dispatched by NPC.

Operating personnel shall be assigned to the switchboard room in teams of 3 men in 3 shifts.

Among the maintenance personnel, waterway maintenance staff shall work in a waterway control office to be established close to the dam and intake, and shall be mainly responsible for observation of intake level and inspection and operation of the gates. These personnel shall work 8 hours a day in 3 shifts.

Other maintenance personnel and clercial workers shall perform their duties in the control office to be built in or near the powerhouse.

4.3. Economics

4.3.1. Methodology and Basic Figures for Economic and Financial Evaluations

In respect of methodology and basic figures to be used in the economic and financial evaluations, both parties of NPC and JICA Team discussed and agreed on the following items at the meeting held on June 13, 1980 in Manila.

(1) For Economic Evaluation

1) The construction costs shall be estimated for two cases of economic cost and financial cost.

2) Benefit Estimation

The following unit construction costs and fuel costs shall be applied for estimation of the costs of power and energy generated by the alternative thermal plants:

	Plant Type	Const. Cost	Fuel Cost
a)	Oil-Fired Plant	$630/kW	$28/barrel (Bunker C)
b)	Coal-Fired Plant	$790/kW	$45/ton
c)	Gas-Turbine Plant	$370/kW	$31/barrel (Bunker A)

Fuel price of gas-turbine was confirmed by the recent NPC data.

The benefit by water supply shall be evaluated at ₱1.00/m^3 as agreed by PICOREM and NPC.

3) Economic Evaluation Method

All the cost and benefit estimation shall be made based on the price level in early 1980, around March 1980.

The economic evaluation shall be made by the following calculations:

a) Benefit Cost Ratio (B/C)
b) Net Benefit (B - C)
c) Economic Internal Rate of Return (EIRR)
d) Production Cost per kWh
e) Sensitivity Analysis

(2) For Financial Evaluation

1) Investment Cost Estimate

a) Price escalation ratio for estimation of investment cost shall be 10% for foreign currency portion and 12% for local currency portion with due reasons.

b) The terms and conditions of finance for foreign currency shall be as follows: (based on IBRD base)

- Annual interest rate = 8.5%
- Grace period = same as construction period
- Repayment term = 20 years after grace period

c) The local currency portion shall be considered as the Government contribution.

2) Estimation of Revenue

a) Revenue by energy supply shall be estimated based on the projected tariff in the commissioning year.

b) 3% transmission loss shall be used for estimating power revenue.

3) Operation and Maintenance Expenses

a) The operation and maintenance expense in October 1979 for hydro power plant is 45.70₱/kW including actual operation and maintenance cost of ₱35.43/kW and additional 29% administration cost. The O & M Cost of transmission line shall be estimated at 2.5% of the construction cost. The O & M cost, to be applied for financial analysis, shall be calculated by applying the price escalation rate for local currency projected for the price level of the commissioning year.

b) Annual depreciation rate shall be on a straight line with 2% per annum.

4) Interest Cost

Interest cost shall be calculated on the basis of the assumed financial conditions.

5) Financial Study

The financial internal rate of return shall be calculated and a cash flow statement with debt service ratio shall be prepared and attached to the Feasibility Report.

The general description and the conclusions in each analysis of the Diduyon Project are all stated in Vol. I, 4.3., Economics.

In this section will be given the necessary procedures of the analysis as well as the supplementary explanation of the figures and coefficients which are used in the computation.

Construction cost of the project is as shown on the table below and from this Table the construction cost to be used in the analysis is summarized as follows:

Construction Cost

(including interest during construction)

(Unit: US$ x 10^3)

	1985	1986	1987	1988	1989	Total
Powerstation						
Original cost	48,040	57,640	115,290	115,290	48,040	384,300
$K = (1+0.08)^n$	1.469	1.360	1.260	1.166	1.08	
n	5	4	3	2	1	
Construction cost including I.D.C.	70,571	78,390	145,265	134,428	51,883	480,537
Transmission line and substation						
Original cost	-	-	1,740	3,450	3,450	8,640
$K = (1+0.08)^n$	1.469	1.360	1.260	1.166	1.08	
n			3	2	1	
Construction cost including I.D.C.			2,192	4,023	3,726	9,941
Total construction cost						490,478

4.3.2. Power generating cost and cost at receiving end

The Diduyon Power Station's annual average generating capacity will be 956.8 GWh. Assuming that the rate of hydraulic utilization will be 93 %, the average annual power generation will be 928 GWh.

If the interest rate is assumed to be 8 % per annum, the useful life of the hydraulic facilities 50 years and the operating cost 45.7 pesos per kilowatt per year, the operating and maintenance cost on the annual average throughout the useful life will be:

Annual running cost of powerhouse =

$$= \$480{,}537 \times 10^3 \times \text{crf}\ (0.08,\ 50) +$$

$$45.7\ (\frac{₱}{kW}) \times 345 \times 10^3\ (kW) \times \frac{1}{7.5}\ (\frac{\$}{₱})$$

$$\fallingdotseq \$\ 39{,}279 \times 10^3 + \$2{,}100 \times 10^3$$

$$\fallingdotseq \$\ 41{,}379 \times 10^3$$

Consequently, the generating cost will become $\$44.59 \times 10^{-3}$ per kWh. Provided, crf (0.08, 50): capital recovery factor at 8 % interest over a period of 50 years = 0.08174.

The original construction cost of the associated transmission line is $\$\ 8{,}640 \times 10^3$. Assuming that the interest rate will be 8 %, the useful life 30 years, and the running cost 2.5 % of the total construction cost, the average annual running cost for the useful life will be as follows:

Associated transmission line

Annual running cost

$$= \$\ 9{,}941 \times 10^3 \times [\text{crf}\ (0.08,\ 30) + 0.025]$$

$$= 1{,}132 \times 10^3\ (\$)$$

where,

crf (0.08, 30) : capital recovery factor at 8% interest over a period of 30 years = 0.08883

If the transmission loss is assumed to be 3 %, the power cost at the receving end will be as follows:

Power cost per kWh at the receiving end

$$= \$41,379 \times 10^3 + \$1,132 \times 10^3 / 928\ (\text{kWh}) \times 10^6 \times 0.97$$

$$\fallingdotseq \$45.81 \times 10^{-3}$$

4.3.3. Cost-benefit analysis

Cost-benefit analysis will be made by the present worth conversion process which is commonly used for economic assessment of hydroelectric power generation projects.

(1) Assumption of alternative energy sources

The benefit of a hydroelectric project is generally assessed by means of costing an alternative energy source which has a value equivalent to that of the hydroelectric power.

Alternative power sources include thermal power generated by oil-fired, coal-fired and gas turbine thermal electric palnts. Particulars of all these thermal power plants have been assumed as shown in the following table:

Assumption of Particulars of Alternative Thermal Power Plants

	Oil-fired	Coal-fired	Gas turbine
Unit construction cost	630$/kW	790$/kW	370$/kW
Service life	30 years	30 years	25 years
Unit fuel cost	28$/barrel	45$/ton	31$/barrel
Thermal efficiency	38%	37%	25%
Percentage of running cost	3 %	5 %	2.5%

(2) Selection of alternative power source

From Sub-section (1) above, the annual cost per kWh of each alternative power source based on the plant factor as a parameter will be shown in Fig.4-3-1.

As is evident from this Figure, the coal-fired power plant is most competitive as an alternative energy source with about 30% plant factor. The coal-fired power plant is also considered the most reasonable alternative power source from the standpoint of energy resources.

(3) kW and kWh values

When both kW and kWh equivalent factors are calculated from data in Table 4-3-1, they are 1.24 and 1.06, respectively.

Table 4-3-1. Equivalent Factors

Used in Computing kW & kWh Values

1. kW equivalent factor (k_{kw})

$$k_{kw} = \frac{(1 - k_{1H})(k - k_{2H})(1 - k_{3H})(1 - k_{4H})}{(1 - k_{1T})(1 - k_{2T})(1 - k_{3T})(1 - k_{4T})}$$

where, k_{kw} ; kW equivalent factor

k_{1H} ; transmission loss rate from hydro power station to the receiving end (3%)

k_{1T} ; transmission loss rate from the alternative thermal plant to the receiving end (2%)

k_{2H} ; forced outage rate of hydro (1%)

k_{2T} ; forced outage rate of the alternative thermal plant (4%)

k_{3H} ; scheduled outage rate of hydro (3.8%)

k_{3T} ; scheduled outage rate of the alternative thermal plant (12.5%)

k_{4H} ; station use rate of hydro (0.3%)

k_{4T} ; station use rate of the alternative thermal plant (9.0%)

2. kWh equivalent factor (k_{kwh})

$$k_{kwh} = \frac{(1 - \ell_{1H})(1 - \ell_{2H})}{(1 - \ell_{1T})(1 - \ell_{2T})}$$

where, ℓ_{1H} ; transmission energy loss rate from hydro to the receiving end (3%)

ℓ_{1T} ; transmission energy loss rate from the alternative thermal plant to the receiving end (2%)

ℓ_{2H} ; station use energy rate of hydro (0.3%)

ℓ_{2T} ; station use energy rate of the alternative thermal plant (7%)

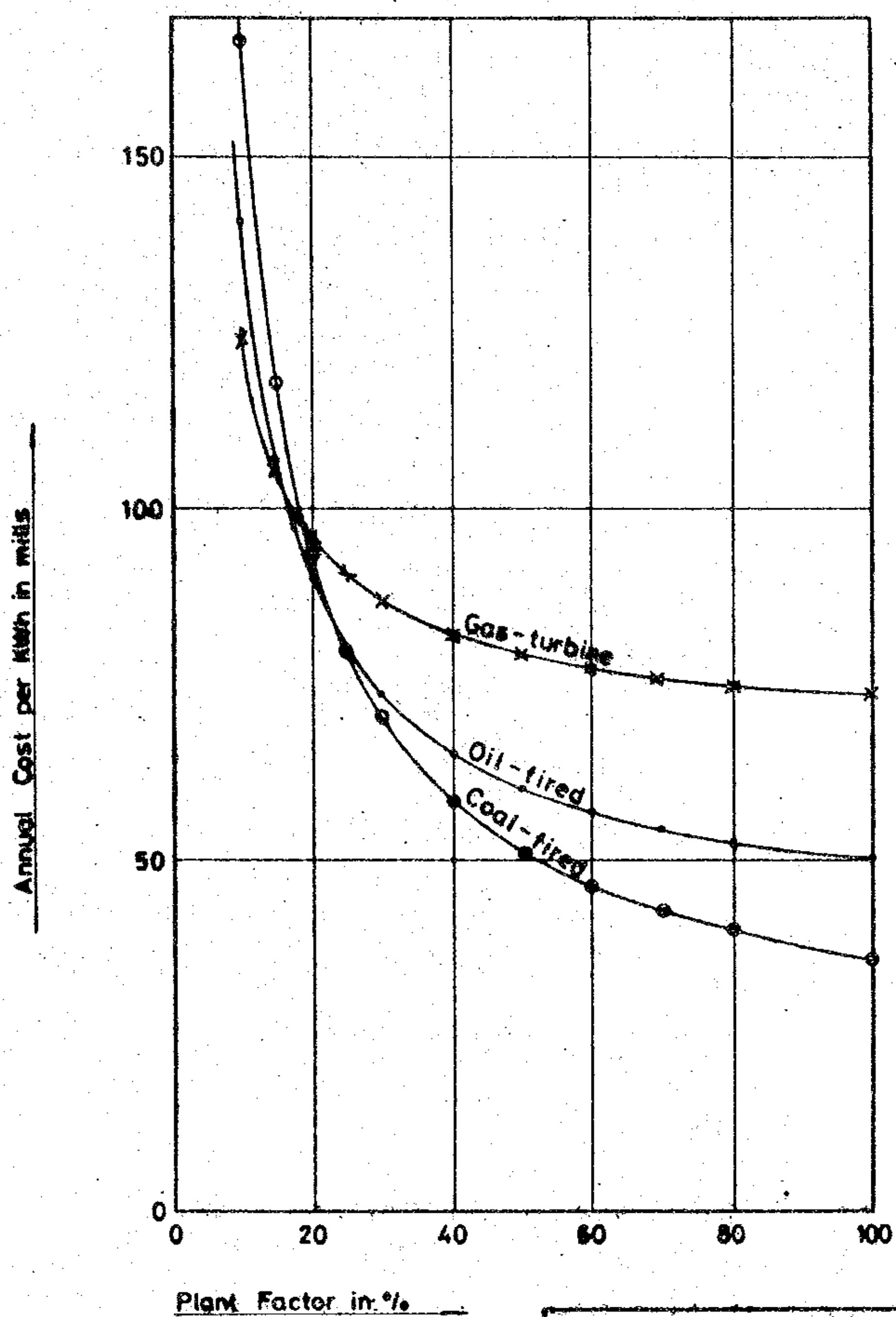
3. Put the numericals shown in the brackets above into the given equation, and the equivalent factors will be :

k_{kw} = 1.24

k_{kwh} = 1.06

Annual Cost per KWh of Thermal Plant

at Interest rate: 8%



Diduyen Hydroelectric Project Upper Cagayan River Republic of the Philippines		
Japan International Cooperation Agency		
Annual Cost per KWh of Thermal Plant		
October	1980	Fig. 4-3-1

Consequently, values per kW and kWh will be:

$$\text{kW value} = 790 \text{ \$/kW} \times 1.24 \fallingdotseq \$979.6$$

$$\text{kWh value} = 22.15 \text{ mill/kWh} \times 1.06 = 23.48 \text{ mill}$$

(4) Benefit

(a) Investment in alternative coal-fired thermal power plant

$$\begin{aligned}\text{Total investment} &= (\text{kW value}) \times (\text{firm output}) \\ &= 979.6 \text{ \$/kW} \times 308.5 \times 10^3 \text{ kW} \\ &\fallingdotseq \$302,200 \times 10^3\end{aligned}$$

Estimated outlay for each year is assumed to be as follows:

	1	2	3	4	Total
Annual ratio	10	15	30	15	100
Investment ($\$10^6$)	30.22	45.33	90.66	45.33	302.2

(b) Fuel cost

$$\begin{aligned}\text{Fuel cost} &= (\text{kWh value}) \times (\text{available power}) \\ &= 23.48 \times 10^{-3} \left(\frac{1}{\text{kWh}}\right) \times 956.8 \times 10^6 \text{ (kWh)} \\ &= \$22,466 \times 10^3\end{aligned}$$

(c) Running cost

$$\begin{aligned}\text{Running cost} &= 0.05 \times \$302.2 \times 10^6 \\ &= \$15,110 \times 10^3\end{aligned}$$

(5) Present worth

If the discount rate for the cost and benefit in each year is assumed to be 6 % to 30 %, the present worth can be calculated as shown in Table 4-3-2. This can be illustrated in Fig. 4-3-2.

(6) Equivalent annual worth

It is easier to understand the cost and benefit if they are expressed in annual value. When the total present worth above is converted into equivalent annual worth, results as shown below can be obtained:

(Unit: 10^6 US$)

	Investment	Running cost	Fuel cost	Total
Total present worth (8%)				
Cost Powerhouse	480.6	27.8	-	508.4
Transmission	10.9	2.9	-	13.8
Total	491.5	30.7	-	522.2
Benefit	412.3	199.6	296.8	908.7
Conversion factor (8%)	$1 + [R \rightarrow P]^{49}_{0.08} = 1 + 12.212 = 13.212$			
Equivalent annual worth (8%)				
Cost	37.2	2.3	-	39.5
Benefit	31.2	15.1	22.5	68.8

(7) Economic Evaluation

If the economic evaluation of this project is expressed using indexes of the present worth conversion process as described above, the following results can be obtained:

COST : BASE , INC, T/L
BENEFIT : BASE , COAL

TABLE 4-3-2 ECONOMIC INTERNAL RATE OF RETURN

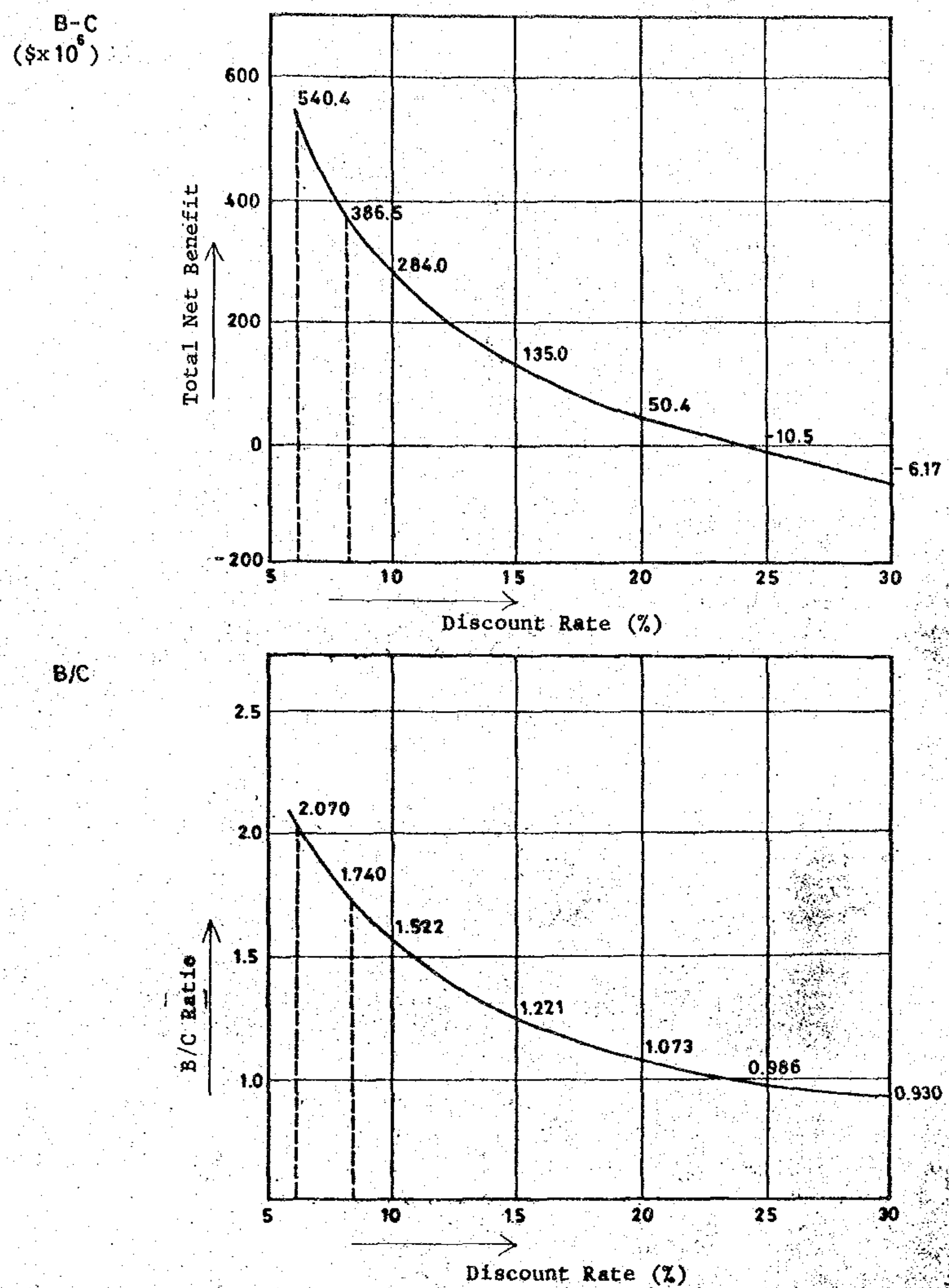
(US$ 1000)

NO	YEAR	COST INVESTMENT P/S	COST INVESTMENT T/L	COST O & M P/S	COST O & M T/L	COST TOTAL	BENEFIT INVESTMENT	BENEFIT FUEL	BENEFIT O & M	BENEFIT TOTAL	PRESENT WORTH COST	PRESENT WORTH BENEFIT	E.R.R 24.05 % FACTOR
1	1985	48040	0	0	0	48040	30220	0	0	30220	141128	88778	2,9377
2	1986	57640	0	0	0	57640	45330	0	0	45330	136500	107348	2,3681
3	1987	115290	1740	0	0	117030	90660	0	0	90660	223411	173070	1,9090
4	1988	115290	3450	0	0	118740	90660	0	0	90660	182726	139515	1,5389
5	1989	48040	3450	0	0	51490	45330	0	0	45330	63874	56233	1,2405
6	1990	0	0	2100	220	2320	0	22466	15110	37576	2320	37576	1,0000
7	1991	0	0	2100	220	2320	0	22466	15110	37576	1870	30291	0,8061
8	1992	0	0	2100	220	2320	0	22466	15110	37576	1508	24418	0,6498
9	1993	0	0	2100	220	2320	0	22466	15110	37576	1215	19684	0,5238
10	1994	0	0	2100	220	2320	0	22466	15110	37576	980	15867	0,4223
11	1995	0	0	2100	220	2320	0	22466	15110	37576	790	12791	0,3404
12	1996	0	0	2100	220	2320	0	22466	15110	37576	637	10311	0,2744
13	1997	0	0	2100	220	2320	0	22466	15110	37576	513	8312	0,2212
14	1998	0	0	2100	220	2320	0	22466	15110	37576	414	6700	0,1783
15	1999	0	0	2100	220	2320	0	22466	15110	37576	333	5401	0,1437
16	2000	0	0	2100	220	2320	0	22466	15110	37576	269	4354	0,1159
17	2001	0	0	2100	220	2320	0	22466	15110	37576	217	3510	0,0934
18	2002	0	0	2100	220	2320	0	22466	15110	37576	175	2829	0,0753
19	2003	0	0	2100	220	2320	0	22466	15110	37576	141	2281	0,0607
20	2004	0	0	2100	220	2320	0	22466	15110	37576	114	1839	0,0489
21	2005	0	0	2100	220	2320	0	22466	15110	37576	92	1482	0,0394
22	2006	0	0	2100	220	2320	0	22466	15110	37576	74	1195	0,0318
23	2007	0	0	2100	220	2320	0	22466	15110	37576	59	963	0,0256
24	2008	0	0	2100	220	2320	0	22466	15110	37576	48	776	0,0207
25	2009	0	0	2100	220	2320	0	22466	15110	37576	39	626	0,0167
1985 - 2009		384300	8640	42000	4400	439340	302200	449320	302200	1053720	759445	756149	
2010 - 2039		0	8640	63000	6600	78240	302200	673980	453300	1429480	180	3477	
1985 - 2039		384300	17280	105000	11000	517580	604400	1123300	755500	2483200	759625	759625	

PRESENT WORTH

	DISCOUNT RATE (%)	(6,0)	(8,0)	(10,0)	(15,0)	(20,0)	(25,0)	(30,0)
COST	INVESTMENT P/S	454832	480595	507555	580497	661948	752695	853579
	INVESTMENT T/L	11278	10930	10875	11345	12166	13118	14144
	O & M P/S	35086	27746	22903	16085	12599	10500	9100
	O & M T/L	3676	2907	2399	1685	1320	1100	953
	TOTAL	504872	522177	543733	609612	688032	777413	877776
BENEFIT	INVESTMENT	417469	412246	417919	456771	512952	578998	653245
	FUEL	375352	296824	245021	172080	134781	112328	97352
	O & M	252451	199636	164794	115736	90650	75549	65477
	TOTAL	1045273	908707	827734	744588	738383	766875	816074
	B/C	2,070	1,740	1,522	1,221	1,073	0,986	0,930
	B-C	540401	386530	284002	134976	50351	-10538	-61701

Present Worth with Varied Discount Rates



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. 4-3-2

(a) Equivalent annual net benefit at a discount rate of 8 %

$$B - C = (68.8 - 39.5) \times 10^6 = \$29.3 \times 10^6$$

(b) Benefit/cost ratio at a discount rate of 8%

$$B/C = 68.8/39.5 = 1.74$$

(c) **Economic internal rate of return**

E.I.R.R. = 24 %

4.3.4. Financial study

(1) Required funds

The escalated fund requirement on annual basis are as outlined in the table below. The disbursement schedule of bare cost is given on Table 4-3-3 and details of financial charges on Table 4-3-4.

Required Funds

($US\$10^6$)

	1985	1986	1987	1988	1989	Total
Construction cost						
Local currency	35.6	47.0	105.3	118.1	57.0	363.0
Foreign exchange	45.7	61.4	139.2	157.6	75.8	479.7
Interest during construction for foreign exchange portion	3.0	7.0	16.0	26.0	30.9	82.9
Total	84.3	115.4	260.5	301.7	163.7	925.6

Table 4-3-3 Disbursement Schedule

(US$1,000)

N	Year	Investment - Original		
		Foreigh (1)	Local (2)	Total (3)
1	1985	22,097	25,940	48,037
2	1986	26,516	31,128	57,644
3	1987	54,041	62,975	117,016
4	1988	55,078	63,665	118,743
5	1989	24,170	27,322	51,492
	Total	181,902	211,030	392,932

Table 4-3-4 **Financial Costs for Foreign Loan During Construction**

(Unit: US10^3)

N	Year	Draw Down (1)	Year End Balance (2)	Outstanding Loan (3)	Commitment Fee (4)	I D C (5)	Total (5)
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			0	82,866	82,866

(2) Required power revenue

If the revenue at the receiving end that will be required to maintain an financial internal rate of return (F.I.R.R.) of 8 % is calculated from Table 4-3-5, this will be approximately $87.4 million per year. Consequently, in terms of 1990 cost, the required unit revenue will become 94.16 mills per kWh (70.62 centavos per kWh). This unit revenue is about twice as high as NPC's anticipated 1980 average unit revenue (35.32 centavos per kWh), or a rise at an annual rate of 7.2 %. This required revenue is reasonable, considering that the annual rise of the local currency portion has been assumed to be 12 % and that the annual load ratio at Luzon Grid is about 70 % as against a plant factor of about 30 % at the Diduyon Hydroelectric Power Plant.

(3) Projected Cash Flow Statement and Debt Service Ratio

Projected Cash Flow Statement for this project (1985 through 1995) are shown in Table 4-3-6. The relevant projected income statements (1990 to 1995) and balance sheets (1985 to 1995) are also shown in Tables 4-3-7 and 4-3-8, respectively.

When the debt service ratio (internal funds ÷ (accrued interest + repayment funds)), a yardstick of the repayment ability, is calculated, it is 1.7 even from the very beginning of operation (as shown in Table 4-3-6 and 4-3-7), exceeding the guideline ratio of 1.3.

The rate of return on the rate base remains 7% in the initial stages of operation as shown in Table 4-3-7 but will grow to about 8% in several years.

COST : ESC, , FI 8,5
REVENUE : ESC, 94,16

TABLE 4-3-5 FINANCIAL RATE OF RETURN

(Unit: $ × 10^3)

		COST						REVENUE			PRESENT WORTH		F.R.R.
NO	YEAR	IDC &	PRINCIPAL REPAYMENT	INTEREST PAYMENT	LOCAL COST	O & M	TOTAL	AVE,RATE MILL/KWH	ENERGY GWH	REVENUE	COST	REVENUE	8,00 % FACTOR
1	1985	3025	0	0	45715	0	48740	0,00	0,00	0,00	71613,97	0,00	1,4693
2	1986	7018	0	0	61441	0	68459	0,00	0,00	0,00	93136,60	0,00	1,3605
3	1987	15969	0	0	139218	0	155187	0,00	0,00	0,00	195489,18	0,00	1,2597
4	1988	26005	0	0	157632	0	183637	0,00	0,00	0,00	214192,96	0,00	1,1664
5	1989	30849	0	0	75766	0	106615	0,00	0,00	0,00	115143,89	0,00	1,0800
6	1990	0	18147	30849	0	4579	53575	94,16	928,00	87380,44	53575,00	87380,44	1,0000
7	1991	0	18147	29307	0	4579	52033	94,16	928,00	87380,44	48178,83	80908,03	0,9259
8	1992	0	18147	27764	0	4579	50490	94,16	928,00	87380,44	43287,29	74915,07	0,8573
9	1993	0	18147	26222	0	4579	48948	94,16	928,00	87380,44	38856,84	69366,02	0,7938
10	1994	0	18147	24679	0	4579	47405	94,16	928,00	87380,44	34844,51	64228,00	0,7350
11	1995	0	18147	23137	0	4579	45863	94,16	928,00	87380,44	31214,05	59470,55	0,6806
12	1996	0	18147	21594	0	4579	44320	94,16	928,00	87380,44	27929,63	55065,50	0,6302
13	1997	0	18147	20052	0	4579	42778	94,16	928,00	87380,44	24961,08	50986,72	0,5835
14	1998	0	18147	18509	0	4579	41235	94,16	928,00	87380,44	22278,53	47210,07	0,5403
15	1999	0	18147	16967	0	4579	39693	94,16	928,00	87380,44	19856,92	43713,17	0,5003
16	2000	0	18147	15424	0	4579	38150	94,16	928,00	87380,44	17671,37	40475,28	0,4632
17	2001	0	18147	13882	0	4579	36608	94,16	928,00	87380,44	15701,07	37477,22	0,4289
18	2002	0	18147	12339	0	4579	35065	94,16	928,00	87380,44	13925,30	34701,24	0,3971
19	2003	0	18147	10797	0	4579	33523	94,16	928,00	87380,44	12326,83	32130,88	0,3677
20	2004	0	18147	9254	0	4579	31980	94,16	928,00	87380,44	10888,40	29750,89	0,3405
21	2005	0	18147	7712	0	4579	30438	94,16	928,00	87380,44	9595,76	27547,20	0,3153
22	2006	0	18147	6169	0	4579	28895	94,16	928,00	87380,44	8434,58	25506,75	0,2919
23	2007	0	18147	4627	0	4579	27353	94,16	928,00	87380,44	7393,05	23617,43	0,2703
24	2008	0	18147	3084	0	4579	25810	94,16	928,00	87380,44	6459,28	21868,06	0,2503
25	2009	0	18137	1542	0	4579	24258	94,16	928,00	87380,44	5621,19	20248,27	0,2317
1985 - 2009		82866	362930	323910	479772	91580	1341058	1883,20	18560,00	1747608,75	1142576,12	926566,79	
2010 - 2039		0	0	0	0	137370	137370	2824,80	27840,00	2621413,13	11945,47	227957,52	
1985 - 2039		82866	362930	323910	479772	228950	1478428	4708,00	46400,00	4369021,88	1154521,58	1154524,31	

PRESENT WORTH

	DISCOUNT RATE (%)	(2,0)	(4,0)	(6,0)	(8,0)	(10,0)	(12,0)	(15,0)
COST	IDC &	86404,33	90063,33	93846,63	97758,10	101801,48	105980,85	112513,64
	PRINCIPALREPAYMENT	302657,19	256483,86	220630,04	192421,21	169943,58	151812,60	130625,61
	INTEREST PAYMENT	287011,07	257049,30	232442,55	212016,31	194888,98	180391,86	162489,34
	LOCAL COST	505999,49	533389,04	561982,60	591823,78	622956,38	655426,51	706741,91
	O & M	146766,47	102301,61	76503,98	60498,50	49939,93	42589,46	35073,27
	TOTAL	1328838,54	1239287,13	1185405,81	1154517,89	1139530,36	1136201,27	1147443,77
REVENUE	REVENUE	2800724,70	1952207,74	1459915,09	1154484,72	952997,01	812728,87	669298,56
	B/C	2,108	1,575	1,232	1,000	0,836	0,715	0,583
	B-C	1471886,16	712920,60	274509,28	-33,17	-186533,35	-323472,40	-478145,21

TABLE 4-3-6 PROJECTED CASH FLOW STATEMENT (1985 - 1995) (In Thousand Dollars)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
I. SOURCE OF FUNDS											
A. Internal Cash Gen.											
Net Income Before Int.						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 Const.	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

Table 4-3-7 Projected Income Statement (1990 - 1995)

(Unit : US$1,000)

	1990	1991	1992	1993	1994	1995
ENERGY SALES						
Sales Energy (GWh)	928	928	928	928	928	928
Average Rate (mills/kWh)	94.16	94.16	94.16	94.16	94.16	94.16
Revenue	87,380	87,380	87,380	87,380	87,380	87,380
OPERATING EXPENSES						
O & M	4,579	4,579	4,579	4,579	4,579	4,579
Depreciation	18,511	18,511	18,511	18,511	18,511	18,511
Total Operating Expenses	23,090	23,090	23,090	23,090	23,090	23,090
Operating Income	64,290	64,290	64,290	64,290	64,290	64,290
Income Deduction						
Interest on Long Term Debt	30,849	29,307	27,764	26,222	24,679	23,137
Total Income Deduction	30,849	29,307	27,764	26,222	24,679	23,137
Net Income (Deficit)	33,441	34,983	36,526	38,068	39,611	41,153
		68,424	104,950	143,018	182,629	223,782
Average Ope. Assets	916,314	897,802	879,291	860,780	842,269	823,758
Rate of Return (%)	7.0	7.2	7.3	7.5	7.6	7.8
Debt Service Ratio	1.7	1.7	1.8	1.8	1.9	2.0

TABLE 4-3-8 PROJECTED BALANCE SHEET (1985 - 1995) (In Thousand Dollars)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
ASSETS											
Utility Plant						925568	925568	925568	925568	925568	925568
Less: Res.for Depreciation						18511	37022	55533	74044	92555	111066
Net Utility Plant						907057	888546	870035	851524	833013	814502
Const.Work in Prog.	84327	199761	460259	761961	925568	0	0	0	0	0	0
Total Utility Plant	84327	199761	460259	761961	925568	907057	888546	870035	851524	883013	814502
Current Assets											
Cash	0	0	0	0	0	33805	69152	106042	144474	189449	225966
Total Current Assets	0	0	0	0	0						
TOTAL ASSETS	84327	199761	460259	761961	925568	940862	957698	976077	995998	1017462	1040468
LIABILITIES & NETWORTH											
Capital											
Capital Stock	48740	117199	272386	456023	562638	562638	562638	562638	562638	562638	562638
Earned Surplus	0	0	0	0	0	33441	68424	104950	143018	182629	223782
Total Capital	48740	117199	272386	456023	562638	596079	631062	667588	705656	745267	786420
Long Term Debt	35587	82562	187873	305938	362930	344788	326636	308489	290342	272195	254048
TOTAL LIABILITIES & NETWORTH	84327	199761	460259	761961	925568	940862	957698	976077	995998	1017462	1040468
Average Operating Assets	0	0	0	0	0	961314	897802	879291	860780	842269	823758

Chapter 5 FOLLOWING ENGINEERING WORK FOR IMPLEMENTATION OF THE PROJECT

Chapter 5. FOLLOWING ENGINEERING WORK FOR IMPLEMENTATION OF THE PROJECT

5.1. Requirements for the Work

As stated previously, in order to complete the Diduyon Project, various engineering works must be carried out prior to launching the main construction project, such as field investigation, preparation of definite design and tender documents, each of which must be completed within a specified period to assure that the project can be completed according to the established construction schedule. (Refer to Table 5-1-1.)

For this purpose, it will be necessary to clearly establish a chain of command, a division of responsibility and procedures for directing the work within NAPOCOR, as the executing agency, by securing and assigning the necessary personnel to each functional division. It will be also necessary to employ a reliable international consultant well versed in investigations for definite design and cost estimation to implement the project in cooperation with the sub-consultants.

By the same token, it is crucial that all of the work, except that may be directly carried out by the executing agency due to unavoidable circumstances, be carried out with certainty and promptness under contracts with reliable contractors. The proposed work schedule prepared in consideration of the time required for each investigation, study, design, tendering, preparatory work and construction work is as shown in the overall work schedule presented in Table 5-1-2.

As indicated in the Table, commissioning and operation start-up of the Diduyon Hydroelectric Power Station is scheduled for the end of 1989, but as a prerequisite, it is necessary first of all that among all preparatory works the investigation and designing work of the construction rords be commenced from the beginning of 1981 and completed by around the end of 1982. The consturction work shall be started from the beginning of 1984, with the major portion of the access road and connecting road being compelted within a year by early 1985 when the main construction work is scheduled to commence. As for other work items, various investigation and study work shall be started by early 1981 in parallel with the field investigation and study of the construction roads to be compelted at latest by the end of 1982.

In this Chapter, the contents of future field investigations and studies to be executed are discussed on the assumption that the work schedule will be carried out under the above-mentioned conditions. The road construction work which shall be launched before the others is outlined separately from the other major works.

5.2. Access Road (Construction Road)

As the road for construction work, an access road and a connection road with a combined total length of about 105 km must be built. For this purpose, investigation and study must be carried out according to the following steps.

5.2.1. Investigation and Design

(1) Determination of the center line of road

As a preliminary study, appropriate center lines of road shall be studied on the basis of aerophotogrammetric map and a preliminary comparative design shall be developed. In so doing, two to three plans, including alternatives, shall be studied. The optimal route shall be selected from the two or three routes that have been selected for comparison upon judgement of the following factors.

(i) Technical comparison of the position and structure of bridges, tunnels and other important structures.

(ii) Technical comparison of the geometric structure of the roads

(iii) Evaluation of soil quality and ground foundation along the routes

(iv) Degree of danger due to natural calamity, degree of difficulty in maintenance work, degree of difficulty in executing the construction work, etc.

To obtain data and information necessary for the above, the following field work shall be carried out:

1) Topographical mapping on a scale of 1/5,000 by aerographic survey

Area of the survey shall be as shown on Fig.5-2-1, covering Malashiu, Compote, Bambang and Kasibu, the damsite, Didipio, the site for the powerhouse and Luna, where new roads are planned to be built. A total area of 290 km^2 shall be mapped.

2) Geological ground reconnaissance over the entire area along the possible routes of the construction road

After completing preliminary review of the area by aerial photography and other data, field reconnaissance of the proposed routes shall be carried out with due regard to the following matters.

a) Observation for occurrence of talus, landslide, and existing face of slope

b) Type of rocks and lithology

c) Geologic structure, conditions of fault, fractured zone and weathered zone

d) Conditions of ground water and spring water

(2) Route survey and geological survey

Route survey and geological survey must be carried out based on the center line of the selected road. As for route survey, the center line surveying, longitudinal leveling and lateral-profile leveling shall be carried out on a scale of 1/500, with the average cross section interval being 50m for a total width of about 100m, or an average width of 50m on each side of the center line.

Accordingly, the quantity of surveying work is anticipated to be about 105km for center line surveying, 105 km for longitudinal leveling and a total extension of 210 km for laterial-profile leveling.

In places where the geological condition of the foundation must be clarified, such as bridge sites, long and extended slopes and landslide zones, test drilling and seismic prospecting must be carried out. The quantity involved is estimated to be 300 m in total extension for test drilling and 3 km in total extension for seismic prospecting.

(3) Soil survey

Shearing tests, compaction tests and tests on physical properties such as grain size composition, density and field moisture content shall be conducted as necessary in order to obtain basic data on the gradients for sloped areas, work efficiency during construction, maintenance work after construction, and roadbed design. As for the cost of the required soil tests, it was estimated on the assumption that soil samples will be collected from 50 spots.

(4) Survey for construction materials

Roadbed material, ballast and asphalt, stone masonry material for bridge and retaining walls, aggregate for concrete and other materials are necessary. The sources of these materials shall be sought and the quality of the available materials shall be tested. Also, because the object of the construction work is a road, it is desirable that these materials are not collected from just one place but from many places as close as possible to the construction site, as required. Particularly, since the required quantity of roadbed material and ballast amounts to approximate volume of 600,000 m^3, it would be ideal if the riverbed deposits of tributaries of the Diduyon River or of some other river or valley close to the route of the road were usable as sources of these materials. In the event there should not be enough material, crushing plants would have to be planned at proper locations. Field investigations for acquiring the necessary quantities of these materials from as convenient sources as possible must be carried out over the entire length of the planned route.

(5) Definite design

The definite design shall be divided into two parts, the design of bridges which is the dominant structure of the road, and the design of the road.

i) As for bridges, the appropriate type shall be selected according to the actual topography and geology of the location, although the long-span bridge shall be avoided as much as possible. Mostly concrete bridge which conforms to the regional characteristics shall be selected with due consideration to minimizing the use of imported materials to the extent feasible.

ii) As for the road, coordination of general alignment and grading, design of roadbed and sub-bed, design of retaining wall and drainage ditch and other works shall be carried out. At the same time, the quantity of work shall be estimated.

5.2.2. Construction Programming

Based on the results of the definite design work, an appropriate construction program shall be developed with due consideration of the time required for the construction work. Since the scale of the project is such that the use of construction equipment is indispensable and the construction work must be started simultaneously at widely scattered locations, plans for carrying in of equipment and materials and transporting them must be developed very carefully.

5.2.3. Acquisition of Necessary Right of Way and Compensation

The scope of land to be acquired as the right of way for construction of the road shall be determined according to the results of the definite design, and shall be divided into two parts - one as the lands for permanent and exclusive use and the other as land only temporarily affected for the duration of the project, in order to determine whether the land must be purchased or owners only are compensated for the damage and inconvenience incurred. Most of these procedures must be completed prior to commencement of the construction work.

5.2.4. Preparation of Tender Documents

On the basis of the results of the definite design, documents necessary for consummating contracts for the construction work shall be prepared, and on-the-spot briefing, bidding, tender evaluation and contracting wrok shall be carried out.

The work include followings :

Preparation of desing documents

Preparation of tender specifications of work and determination of applicable engineering standards

Prequalification

Bidding

Evaluation of bids

Negotiation and award of constract(s)

5.2.5. Engineering Work During Construction Work

The construction work shall be executed by the contractor based on the above described contract, but the executing agency would also perform the detailed designs and drawings as necessary, and/or approving same besides arranging for rental of equipment and for the supply of materials. Furthermore, it must have an organization capable of witnessing the work at site, controlling the progress according to the schedule and conducting the testing of material.

The executing agency shall also be responsible for making final inespection or partial inspection of the completed work for acceptance and payment.

5.3. Field Surveys and Tests

As stated previously, the main construction work is expected to start from the beginning of 1985, by which time all of the preparatory work - from the definite design to the construction contracts - must be completed.

Various investigations and studies necessary for the definite design are as itemized below with brief descriptions.

5.3.1. Topographical Surveying

(1) Aerial photographic survey

1) Outline of aerial photography

At the time of the feasibility study, the existing aerial photographs on a scale of 1/15,000 (photographed in 1971) were used due to the limited time available. These photographs, however, are not suitable for the next investigations and studies not only for reasons of photographing such as flight altitude, flight direction, area covered by photograph and overlapping of continuous or adjoining photographs but also because they have not included the logging tracks, trails, forests, buildings, etc.. since 1972 so that it is difficult to secure adequate precision and coverage from them. Accordingly, new photographs in accordance with the necessary dimensions must be taken for subsequent works.

In carrying out the photographic work, the following points must be noted:

(i) Since permit for photographing must be cleared in advance for reasons of national security, adequate time must be allowed for obtaining the permit.

(ii) Since the area to be mapped does not have sufficient reference triangulation points or supplementary control points, layout of the control points and additional points which must be supplemented shall be planned upon adequate preliminary studies so as to secure the required accuracy. In so doing, datum points and marks indicating the position of necessary structures, installed by NPC during the feasibility study, shall be incorporated in the control point network.

(iii) Since the area to be photographed is broad and photographic work is susceptible to changes in meteorological conditions, particularly by the existence of clouds, a photo flight schedule allowing for adequate margin in time shall be established so that the required photographic work can be satisfactorily achieved.

2) Plane topographic map of the water storage area of the reservoir (on a scale of 1/5,000)

A topographic map of the water storage area of the reservoir is necessary to accurately compute the storage capacity of the reservoir. The map is necessary in order to plan measures against erosion of the face of slope along the lake shore caused by the fluctuating water level of the reservoir owing to the operation of the power plant, such as designing retaining walls or vegetation along the shore for slope protection.

This map will be also used to purchase or compensate for the cultivated land and dwellings upstream of the dam which will be submerged under the reservoir area.

The map shall be drawn on a scale of 1/5,000 covering an estimated total area of about 45 km^2. (Refer to Fig. 5-3-1.)

3) Plane topographic maps of the vicinity of principal facilities (on a scale of 1/5,000)

The sites of principal structures such as dam, intake, surge tank, penstock, power generating plants, and of quarries, spoil bank, and areas which may possibly be affected by the construction activities, including proposed areas for resettlement shall be mapped on a scale of 1/5,000.

This map will be used not only as a reference map for detailed designing of principal structures and ancillary facilities, stock yard and for planning temporary construction facilities but also as a cadastral map for purchasing and compensating for the sites of such facilities.

Also, in selecting the route of the headrace tunnel, the position of adits and provision of access road to each adit, earth covering of the tunnel route, selection of sites for temporary facilities and spoil bank shall be reviewed in detail. For this purpose, an aerial photogrammetric map covering the entire area of the proposed route of the headrace is also necessary. The necessary mapping area is estimated to be about 50 km^2 with the exception of aerial photogrammetric areas which will be carried out during the investigation of the construction road and the reservoir (Refer to Fig.5-3-1.).

4) Plane map for the route of the transmission line (on a scale of 1/5,000)

This map will be developed as a topographic map for the entire length of the proposed transmission line route. This map will be used as the base map for determining the position of steel towers and foundation design, and also as a cadastral map for acquisition of tower sites and compensation for same. It will also be used for studying the method of slope protection in the steeply sloped areas of the mountainous section.

The scope of surveying work shall cover the entire route through which the transmission line will be installed. Assuming that an area of a width of 2 km or 1,000 m on each side of the center line of the proposed transmission line route is to be mapped, the coverage for survey and mapping will be about 90 km^2.

(2) Triangulation Survey

Aerial triangulation of third order accuracy shall be carried out in order to establish definite design of the Project structures and also to provide adequately accurate datum points for use during the construction stage. For this purpose, necessary bench marks with coordinates shall be established for permanent use.

The required number of datum points including supplementary control points shall be 40 points or more. After adequate check survey and adjustment, Triangulation points, supplementary controls, auxiliary control points and true coordinates of principal structures shall be prepared.

(3) Ground Topographic Survey

In the detailed design stage and construction stage, there are many places which require new topographical maps, such as the damsite, vicinity of each tunnel adit, powerhouse and switchyard site, and other places related to the principal structures relocation site, farm land, public facilities.

Survey map shall be scaled at 1/500, and the areas included in the scope of survey are anticipated to be 1 km^2 for the dam and intake sites, 2 km^2 for generating plant and surge tank sites, 1 km^2 for the resettlement area and others, totalling 4 km^2.

(4) Profile and Cross-section Survey

Profile and cross-section surveys of the positions for structures are necessary for the purpose of preparing detailed design. The positions (of field investigations such as geophysical prospecting and drilling tests) shall be firmly determined by further conducting profile and cross-section surveys. The necessary quantity of these profile and cross-section surveys is estimated to be about 60 km in relation to dam, tunnel adits, penstock, powerhouse and other principal facilities, resettlement area and field investigation sites, and about 16 km for the steel tower foundations of the transmission line.

5.3.2. Geological Survey

(1) Geological survey for principal structures

Some drilling work and seismic prospecting have already been conducted to obtain general geological characteristics of the bedrock of the dam, tunnel, surge tank, penstock and generating plant. In the detailed design stage, test pit excavation and other works shall be added besides drilling and seismic prospecting to clarify the geological structure of the bedrock in more detail. Also Lugeon tests to obtain necessary data on the permeability of the bedrock, and rock mechanic tests, using test adits to clarify the physical and mechanical properties of the bedrock, shall be carried out. As required, laboratory tests shall also be considered.

The type of geological survey that must be carried out from now and the quantity involved are as follows:

Drilling is necessary for the total extended length of about 2,700 m, assuming 1,500 m for dam foundation, 300 m for tunnel and adits, 300 m for surge tank and penstock, 180 m for generating plant, 150 m for tailrace and outlet, and 270 m for all others. Seismic prospecting is necessary for about 8 km in total, assuming 2 km for the damsite, 2 km for surge tank and penstock, and 4 km for tunnel. Test aditting is planned to be 400 m in total, assuming 300 m for damsite and 100 m for the saddle section on the right bank of the damsite. Lugeon tests will be carried out at intervals of 5 m down to a depth of 50 m during test drilling operation for the dam foundation.

(2) Geological survey of quarries

The candidate site for a quarry is located 2 km upstream from the damsite on the left bank of the Diduyon River for obtaining the aggregate for concrete. During the detailed design stage, the following geological survey is necessary for the purpose of determining the thickness and distribution of the overburden of the quarry and lithology and rock class of the bedrock and also for sampling rock for a crushing test.

Drilling will be carried out for about 1,500 m in total extended length, by drilling 30 holes each 50 m deep. Seismic prospecting will be for an extended length of 4 km, and test aditting for about 300 m in total length, assuming excavation of 6 adits each of 50 m long.

5.3.3. Laboratory and Field Tests

In addition to the hydraulic model tests described in Section 5.4, the following types of test shall be carried out:

(1) Concrete test

(i) Type of equipment and capacity of the aggregate manufacturing facility to be used for dam construction shall be selected in consideration of the following factors:

1) Lithology of the rock
2) Crushing test of the rock

Also, in order to investigate the necessary properties of finished aggregate, the following tests shall be conducted:

3) Specific gravity
4) Amount of harmful substances contained, and aggregate-alkali reaction
5) Durability and abrasion test

Costs for collecting and hauling approximately 5 samples of rocks from the quarry, and conducting crushing test and mechanical test on the samples will be considered

(ii) Aggregate produced by crushing the rock obtained from the quarry shall be subject to mixing tests by varying the content of cement and the water-cement ratio and also to slump tests. Compressive strength tests and bulk density tests shall be conducted for different ages of test specimen on the 7-day, 28-day, and 91-day after mixing (91st day test is only for dam concrete) in order to determine standard mix proportions that will satisfy the strength of concrete mix required for dam concrete, headrace tunnel concrete, etc. About 150 columnar test specimens of ϕ15cm x 30cm are required for these tests.

(2) Geotechnical soil tests

Mechanical tests, compaction tests, permeability tests and triaxial compression tests are required on core material and filling material of the saddle dam. A series of investigations and tests shall be conducted on the foundation ground in order to obtain basic data for designing the saddle dam.

Also, penetration tests and geotechnical soil tests are necessary to determine the type of structural form of the foundation for such structures as revetment and retaining wall around the dam and intake, etc.

A complete set of the above described soil test instruments must be made ready, and the extended length of drilling for these tests is included in other drilling with 270 m length mentioned in Item (1) of Paragraph 5.3.2.

5.3.4. Other Field Investigations

Aside from topographic and geological surveys, the following items are considered necessary for detailed design:

(1) Hydrological observation

A discharge gauging station on the Diduyon River was installed at Kamamasi(immediate upstream of the damsite) in 1978 and observation is currently continued by NPC.

Gauging observation activities must be continued until the generating plant becomes operational, and the NPC personnel engaged in this work are required to consider the following :

(i) As of August of 1980, this gauging station still does not have any high-water discharge observation facility. It is necessary that the station be equipped with a proper high-water discharge observation facility and that endeavors be made to obtain data on high-water discharge which accounts for quite important portion of the river discharge analysis.

(ii) On low-water discharge observation also, measurement of river cross-sections and accuracy of current meter, and other endeavor to secure reliable discharge data must be made. Selecting the right type of current meter is particularly important. Also, particular care should be taken against possible displacement or washing away of the water gauge staff.

(iii) Since the data of the discharge observation station of the downstream Aglipay Riverflow Gauging Station (which belong to the Bureau of Public Works) is important to determine correlation with the discharge at the Kamamasi Riverflow Gauging Station, close coordination and co-operation must be established between NPC and BPW so that the data can be used for comparative review and study.

(2) Meteorological observations

For the purpose of checking the run-off factor used in determining the maximum flood discharge during the feasibility study stage and to obtain necessary information for forecasting flooding at the damsite to assure safety during construction and operation of the spillway gates after completion, it is necessary to further collect the data on rainfall in the areas relevant to the flood run-off within the catchment area of the Diduyon River.

During the feasibility study stage, six meteorological observation stations were installed by NPC upstream of the damsite where observation is being continued by NPC personnel. When a reasonable amount of observation data has been accumulated, the most practical way would be to evaluate the contents of the data and select, from among the six, one or two representative meteorological observation stations. The facilities for observation at these selected stations be improved to continue with observation after completion of the reservoir and the generating plant.

Also, it is necessary to automate these representative observation stations and establish an integrated information center at one place for collecting and analyzing all information.

This information center shall be taken over by the Dam Control Office in the future. It is desirable that these telemetering automatic observation stations be equipped with not only observation apparatus for rainfall records but with apparatus for recording meteorological data such as temperature, wind velocity, wind direction, sunlight time amount of evaporation, etc. It is also desirable to equip the information center with automatic water gauge, discharge observation device and devices for recording data relevant to river water such as water quality and water temperature. Incidentally, while the cost of full-scale permanent facilities may be included in the construction costs as for miscellaneous works, the expenses required for installing telemetering automatic pluviometer and for continuing observation until the construction work should be disbursed in the following design stage

(3) Investigation on concentration of suspended load and riverbed material

As the basic data for determining the sedimentation characteristics of the reservoir, and establishing protective measures to prevent sedimentation and to flush the sediment, as well as a gate operating procedure, more detailed measurement of the concentration of suspended load and riverbed materials must be carried out to determine the amount of sediment load.

As the testing apparatus for these, standard sieves, mechanical analysis equipment, weight measuring device and miscellaneous apparatuses have been considered in the cost estimates. As samples will be collected from about 50 spots, the expenses for collecting, treating and carrying these samples were also considered in the cost estimates.

(4) Survey of the public road utilized as the transportation route

The following survey is needed on National Highway No. 5 which connects the Port of Manila and Bambang the starting point of the construction road.

(i) Traffic survey shall be conducted at approximately five locations along National Highway No. 5.

(ii) The method of reinforcing bridges and culverts shall be studied. Bridges which require reinforcement (estimated to be about 10 but all the bridges will be reinvestigated in detail) will be checked against the trailer load of trailers carrying heavy goods. Loading tests may be conducted as required, and on the basis of the results of these two, appropriate methods of reinforcement will be determined for each bridge.

(5) Refinement of the optimum design of the project based on the results of field investigations

When the foregoing investigations and study work have made reasonable progress, the results of the studies will be closely checked, whereupon the proposed design for each structure for the project in the feasibility study will be thoroughly reviewed again. The following are particularly important items :

(i) Determination of the final route of the consturction road based on evaluation of the design and estimated cost of alternative routes.

(ii) Detailed assessment of the rock quarries near the damsite and reappraisal of the unit cost of aggregate from these quarries.

(iii) Comparative review of natural aggregate (deposited in downstream riverbed) with the artificial aggregate (produced from the rock quarries near the damsite).

(iv) Examination of dam design which reflects the results of investigation on topography and geology at the dam site (e.g. use of arched gravity dam).

(v) Optimum design for flood spillway and apron.

(vi) Check on the effective reservoir capacity according to the results of the supplementary investigation on the amount of silt deposits.

(vii) Further review of the design for the headrace route and the tunnel section.

(viii) Hydraulic compuration for water channel, including surge tank.

(ix) Detailed design of penstock.

(x) Detailed design for the transmission and substation facilities.

(xi) Detailed computation of generating plant output and generated energy.

(xii) Estimation of construction costs.

(xiii) Preparation of construction schedule and program.

All the expenses required for the above are taken into account as a part of engineering services.

(6) Relocation plan and compensation plan

As some of the local inhabitants will be required to be relocated due to the construction of the reservoir and the powerhouse, an investigation of the living environment in the area reserved for resettlement must be made. A detailed survey is necessary particularly with respect to the soil, available water supply, crop field preparation, and suitable crops for farmland which will be their means of livelihood. In regard to the moving of residences, an investigation shall be carried out to determine the necessary and adequate communal facilities such as schools, churches, potable water, drainage systems, roads, etc. which will serve as basic data for formulating an acceptable plan.

For those inhabitants who wish to remain at the project site, a compensation and indemnity plan that aims to stabilize the people's livelihood and improve their welfare by restoring to them the living environment and industrial infrastructure which will have been lost to them by the construction must be mapped out. In formulating the relocation and community rebuilding plan and compensation and indemnification plan, adequate coordination with related government agencies will be required, and the Consultant shall provide the necessary advice and counsel to each of the concerned government agencies.

These services are summarized and included in the manpower expenses of the investigation and design .

5.4. Hydraulic Model Test

5.4.1. Objective of Hydraulic Model Test

In the detailed design of various structures for hydroelectric generation, it is often necessary to clarify the hydraulic characteristics of the water flow involving.

These hydraulic phenomena are being clarified through theoretical studies and experimental research by the dedicated efforts of many researchers but on matters related to form resistance or in case a more than two-dimensional flow is at issue, or when flowing materials other than water such as drifting sand or entrained air are relevant, or when a complex boundary condition is at issue, it is the general practice to locate the source of the problem and devise a method of solution by conducting hydraulic model studies and directly observing the behavior of water generated there.

In the case of the Diduyon Hydroelectric Development Project, there are many problem areas which should be adequately elucidated prior to completing the final design, such as :

(i) Optimal shape of intake

(ii) Overflow coefficient of dam spillway gate, coefficient of discharge when the gate is in a partially open condition, and form of apron

(iii) Sedimentation characteristics in the reservoir

(iv) Hydraulic characteristics during flood at the tailrace outlet and the retaining walls. Also, water stage fluctuations in the surge tank of chamber type, and hydrodynamic study and selection of the form for the tailrace draft outlets, etc.

These experiments may be implemented during the definite design stage, but since adequate facilities and experienced researchers and technical experts are required to carry out these hydraulic model studies, it is recommend that preparations for these experiments be commenced sufficiently early to equip the required facilities and train the technical specialists the Philippines, about which at present there is little information whether they completely satisfy all of these required conditions.

5.4.2. Model Test Facilities and Manning Program

In order to carry out the above stated hydraulic experiments, various measuring instruments and experienced researchers are required.

Basically, where the problems lie should be clearly understood and approaches to problem solving should be thoroughly investigated on the part of the executing agency, which will greatly affect the future operation, and maintenance of the facilities. It is in this context that briefly outlining below are the facilities and manning programs that will be needed in the event such experiments are conducted in the Philippines.

(1) Test facilities (excluding land and buildings)

1) Common facilities

Pump - maximum capacity 100 liter/sec.,	1 unit
Bottom tank (of concrete) - 10 m x 6 m x 2 m	1 unit
Dam model test tank (of concrete or steel) - 5 m x 5 m x 2 m	1 unit

High water tank (of concrete or steel) -

2 m x 2 m x 1 m	1 unit

Feed pipe (rigid vinyl pipe) - ϕ200mm x 200m 1 unit

Drainage canal (small circulating concrete canal) =

1.0m x 1.0m x 200m 1 unit

Weir for measurement of discharge	3 units
Point gauge	10 sets
Sand level measuring instrument	4 sets
Current meter (with stream direction indicator)	4 sets

2) Specific facilities

a) Intake experiments (on a scale of 1/50)

Intake model
Headrace model
Flow rate control valve
Reservoir model
Modification of models

b) Experiments related to dam (on a scale of 1/100)

Models of the overflow section and spillway gate
Riverbed model for upstream and downstream of dam
Modification of models

c) Experiments on reservoir sedimentation (deformed model, 1/100 horizontal scale and 1/50 vertical scale)

Reservoir topographical model (made of concrete)
Sand feeding device
Models of dam, gate and intake

d) Experiments on tailrace retaining wall and outlet (deformed model, 1/100 horizontal scale and 1/50 vertical scale)

Topographic model of the river course
Model of the draft tube and tailrace
Water level regulating gate at the tailrace end
Modification of models

(2) Research personnel

Overall planning & coordination	(Engineer A)
Facilities and preparation for experiment	(Engineer A)
- " -	(Local Engineer)
Experiments on intake	
Planning, experimenting, and analytical evaluation	(Engineer A)
- " -	(Local Engineer)
Experiments related to dam	
Planning, experimenting, analytical evaluation	(Engineer A)
- " -	(Local Engineer)
Experiments on reservoir	
Planning, experimenting, analytical evaluation	(Engineer A)
- " -	(Local Engineer)

Experiments on generating plant including headrace and tailrace

Planning, experimenting, analytical evaluation (Engineer A)

- " - (Local Engineer)

5.5. Engineering Design Works of the Project and Preparation of Tender Documents

The methods for executing the construction will be determined and the necessary and adequate temporary facilities will be planned only after the detailed engineering design works of the construction road, various components of civil and architectural structures, electro-mechanical machinery, transmission line and substation facilities are carried out based on the results of the above described surveys, investigations, laboratory tests and hydraulic model experiments.

Then the quantity of work, materials and supplies will be finally estimated based on the detailed engineering design. At the same time, unit costs of materials and labor, rental of equipment and machinery and other unit construction cost breakdown and design documents will be prepared. Tender and contract documents will be prepared. Also, handouts will be prepared in advance for briefing the Project which will be made prior to tender and also for publicity campaign aimed at the local inhibitants.

5.6. Cost Estimate of Work

Quantities of field investigation and study works, such as surveying, field investigation, detailed engineering design work for the Project are summarized in Table 5-6-1.

Costs for field investigation and testing are shown in Table 5-6-2.

Of the total, the foreign currency portion is estimated to be U.S.$5.2 million (to read fifty-two million U.S. dollars) with the exception of the following described accommodations and technical assistance to be borne by NPC.

<u>Items Excepted from the Cost Estimates</u>

(a) Suitably furnished and air-conditioned offices with adequate floor space at the project site and at or near NPC headquarters.

(b) The use of all local transportation in the Philippines.

(c) Assurance of free access and use of lands for performing the assigned duty at the field and within the territory of the Philippines.

(d) Communications in and from the Philippines.

(e) Back-up support of NPC's or locally available engineers, geologists and draftsmen.

(f) Provision of clerks, typists and messengers

(g) Securing of required number of workers and provision of pertinent maps available for the field reconnaissance and implementation of field tests and laboratory tests for the geological survey.

Table 5-1-1 Procedures of Project Progress

Stage	Work Item
Engineering	Topographic Investigations Geological Investigations Field Test Laboratory Test Hydraulic Model Test Check and Review of Optimization of Project Design of Structures Resettlement and Compensation Plan Estimation of Quantity of Work Examination of Construction Method Planning of Temporary Facilities Estimation of Construction Costs
Preparation of Tender Documents	Preparation of Contract Documents Establishment of Technical Standard and Preparation of Technical Specifications Preparation of Guidance Materials and Explanation to Contractors
Tendering	Selection of Tendering Method Prequalification of Tenderers Tendering Evaluation of Tenders Contract Awarding Formalities
Construction Work	Purchase of Equipment and Material, and Land Acquisition Procurement of Labour Force Implementation of Construction Work
Operation	Training of Operators Test Operation Commercial Operation
Remaining Work	Recovery of jobsites

Table 5-1-2 Tentative Construction Schedule

Item			Year 19 78	79	80	81	82	83	84	85	86	87	88	89
Feasibility study			■	■	■									
Definite design of the Project and access roads						■	■							
Preparation for tender documents and contract		Access roads and temporary facilities					■							
		Main structures					■	■						
Tendering		Access roads and temporary facilities						■						
		Main structures						■	■					
Construction of access roads									■	■				
Preparatory works									■	■				
Construction of Main Structures	Dam	Diversion tunnel								■				
		Excavation								■	■			
		Concreting									■	■	■	
	Tunnel	Excavation								■	■	■		
		Concrete lining									■	■		
	Surge tank	Excavation									■	■		
		Concrete lining									■	■		
	Penstock	Excavation								■	■			
		Concreting and pipe installation								■	■	■	■	
	Powerhouse	Excavation								■	■			
		Concreting									■	■	■	
		Main equipments									■	■	■	■
	Transmission and Substation											■	■	■
Commercial Operation														▼

Table 5-6-1 Survey Works and Engineering Service Proposed for Definite Design Stage

Item of Works	Description	Unit	Work volume
A. Survey & Design of Access Road			
1. Topo-Survey	Aerial topo-map (1/5,000)	km^2	290
2. Ground Survey	a) Field reconnaissance	km	105
	b) Alignment survey	"	105
	c) Longitudinal levelling	"	105
	d) Cross sectional levelling	"	210
3. Geological Survey	a) Drilling	m	300
	b) Seismic prospecting	km	3
	c) Soil test	pts	50
4. Material Survey	Aggregate for pavement	Lump Sum	1
5. Engineering Service	a) Design and cost estimate of access road including bridges	Lump Sum	1
	b) Planning of implementation program	"	1
	c) Preparation of tender documents	"	1
B. Survey & Design of Transmission Line			
1. Topo-Survey	Aerial topo-map (1/5,000)	km^2	90
2. Ground Survey	Cross-sectional survey of the sites of suspension towers	km	16
3. Engineering Service	Design, cost estimate, implementation program, & preparation of tender documents	Lump Sum	1
C. Survey & Design of Main Structures			
1. Aerial Topo-Survey	a) Reservoir area (1/5,000)	km^2	45
	b) Sites for main structueres (1/5,000)	"	50
2. Geodesic Triangulation	Aerial triangulation of 3rd order on 40 control points	Lump Sum	1

(Continuation)

Item of Works	Description	Unit	Work volume
3. Ground Survey	a) Dam & intake (1/500)	km^2	1
	b) Surgetank to powerhouse (1/500)	"	2
	c) Resettlement areas etc. (1/500)	"	1
	d) Cross sectional survey of job sites	km	60
4. Geological Survey	a) Drilling		
	Damsite No.3	m	1,500
	Headrace tunnel adits	"	300
	Surgetank and penstock	"	300
	Powerhouse	"	180
	Tailrace	"	150
	Quarries	"	1,500
	Others	"	270
	b) Seismic prospecting		
	Damsite No.3	km	2
	Surgetank and penstock	"	2
	Headrace tunnel	"	4
	Quarries	"	4
	c) Test aditting		
	Damsite No.3 including saddle dam	m	400
	Quarries	"	300
	d) Permeability (Lugeon) test	Lump Sum	1
	e) Rock (shear) test at damsite	"	1
5. Construction Material Test	a) Crushing test	Lump Sum	1
	b) Concrete aggregate test	"	1
	c) Concrete design of mixes	"	1
	d) Soil test for embankment	"	1
6. Hydraulic Laboratory Test	a) Planning and design of test facilities	Lump Sum	1
	b) Execution of tests	"	1
	c) Analysis & review	"	1

(Continuation)

Item of Works	Description	Unit	Work volume
7. Miscellaneous	a) Sedimentation test	pts	50
	b) Survey of public road with checking of loading capability	Lump Sum	1
	c) Analysis & review of hydrological data	"	1
8. Engineering Services	a) Definite design, cost estimate and other services	Lump Sum	1
	b) Preparation of tender documents	"	1

Table 5-6-2 Estimated Cost of Engineering Services

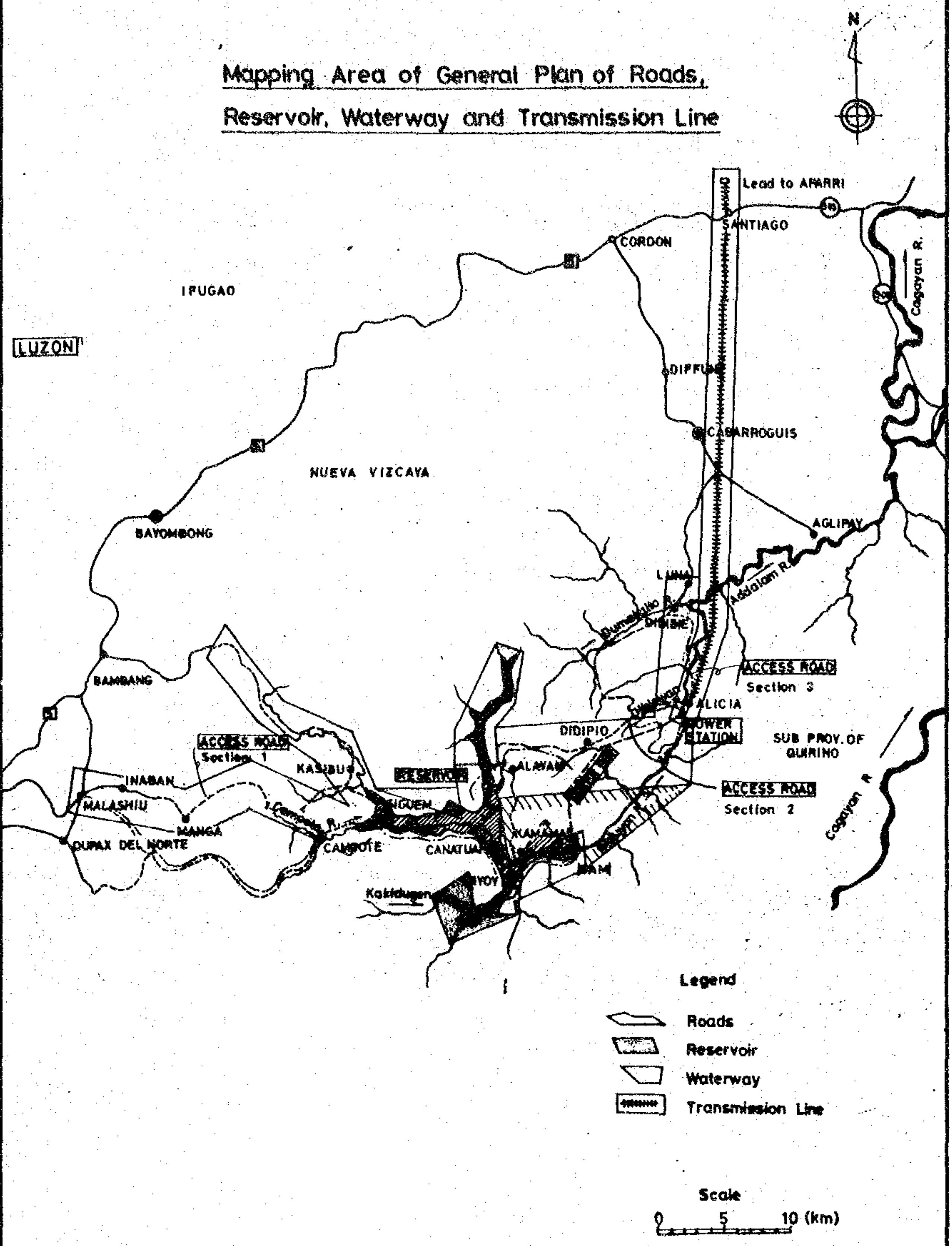
(Unit : ¥10^6 & ₱10^6)

(a)	Foreign Currency Portion	¥1,287 x 10^6 (US\$5.2 x 10^6)
i)	Base salary, 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
iv)	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
Total	¥1,222 x 10^6	₱15.6 x 10^6

Mapping Area of General Plan of Roads, Reservoir, Waterway and Transmission Line



Diduyon Hydroelectric Project Upper Cagayan River Republic of the Philippines
Japan International Cooperation Agency
Mapping Area of General Plan of Roads, Reservoir, Waterway and Transmission Line
October 1980 Fig. 5-3-1

JICA