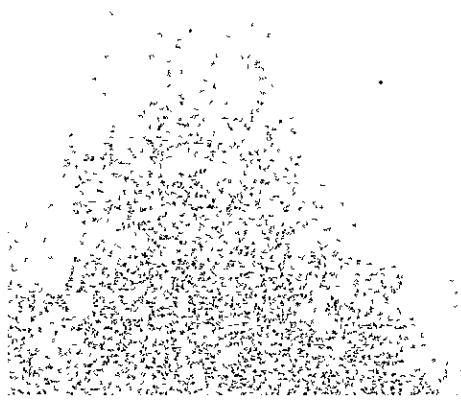
CHAPTER 17

CONSTRUCTION COST



17. Construction Cost

Estimation of the construction cost

The machine costs for the sake of the estimation of the construction costs are obtained by converting the rental rates determined in October of 1979 - "Revised Rental Rates for the Use by All NIA Construction Equipment and Motor Vehicles" - into unit prices prevailing in 1981. The rental rates are applicable only to the type of machinery possessed by the Philippine Government. Accordingly, with regard to the other machines, the depreciation costs and the repair costs are calculated by means of the formula presented below and the obtained values are adopted as costs of machinery.

Annual Depreciation Cost

$$= \frac{90\% \text{ of Equipment Price}}{\text{Useful Life}} + \frac{110\% \text{ of Equipment Price}}{2}$$

$$\times \begin{matrix}\text{Interest} \\ \text{annual} \\ \text{rate}\end{matrix} + \frac{\text{Equipment Price} \times \text{Insurance rate}}{\text{Useful Life}}$$

where Annual rate = 8%

Insurance rate = 5%

Table 17.1 Breakdown of Cost Estimate [Dam (1)]

Work Item	Unit	Quantity	TOTAL Unit Price	TOTAL Amount	F/C Unit Price	F/C Amount	L/C Unit Price	L/C Amount
1. Diversion Works								
Excavation Open	m^3	292,140	22.00	6,427,080	14.57	4,256,480	7.43	2,170,600
Tunnel Half face ex.	m	1,540	2,811.97	4,330,433	1,555.64	2,395,685	1,256.33	1,934,748
Excavation								
Arch timbering	set	1,711	7,643.45	13,077,942	6,086.78	10,414,480	1,556.67	2,663,462
Arch lining	set	147	45,749.04	6,725,108	26,213.94	3,853,449	19,535.10	2,871,659
Third enlargement	m	1,540	1,286.32	1,980,932	769.43	1,184,922	516.89	796,010
Dobera excavation	m	1,540	588.41	906,151	357.55	550,627	230.86	355,524
Side wall concrete (sliding form)	set	147	29,598.78	4,351,020	16,708.95	2,456,215	12,889.83	1,894,805
Side Wall concrete (centre)	set	74	3,217.41	238,088	2,690.00	199,060	527.41	39,028
Invert concrete	m	1,540	1,500.00	2,310,000	788.22	1,213,858	711.78	1,096,142
Reinforced concrete	m^3	3,037	615.00	1,867,755	326.00	990,062	289.00	877,693
Steel bars	ton	1,063	7,950.00	845,085	4,214.00	447,948	3,736.00	397,137
Plug concrete	m^3	6,821	388.47	2,649,753	210.22	1,433,910	178.25	1,215,843
Gate 6.0 x 8.5 x 2				4,004,000		3,640,000		364,000
Grout Curtain	m	1,830	406.50	743,895	299.30	547,719	107.20	196,176
Consolidation	m	1,525	406.50	619,912	299.30	456,432	107.20	163,480
Others 20%				10,215,846		6,808,153		3,407,693
Sub-total				58,739,000		39,147,000		19,592,000

Table 17.1 Breakdown of Cost Estimate [Dam (2)]

Work Item	Unit	Quantity	TOTAL Unit Price	TOTAL Amount	F/C Unit Price	F/C Amount	L/C Unit Price	L/C Amount
2. Dam Foundation Excavation								
Stripping Abutment	m^3	60,190	16.15	972,068	10.69	643,431	5.46	328,637
- do - Riverbed	m^3	63,900	16.15	1,031,985	10.69	683,091	5.46	348,894
Sand & Gravel Abutment	m^3	238,170	22.00	5,239,740	14.57	3,470,137	7.43	1,769.603
- do - Riverbed	m^3	394,800	3.77	1,488,396	2.50	987,000	1.27	501,396
Rock Abutment	m^3	83,950	24.10	2,023,195	14.69	1,233,226	9.41	789,969
- do - Riverbed	m^3	36,900	24.10	889,290	14.69	542,061	9.41	347,229
Grout Curtain	m	21,105	406.50	8,579,182	299.30	6,316,726	107.20	2,262,456
- do - Blanket	m	9,500	406.50	3,861,750	299.30	2,843,350	107.20	1,018,400
Slurry Trench	m^2	9,500	1,300.00	12,350,000	984.36	9,351,420	315.64	2,998,580
Others				5,464,394		3,909,558		1,554,836
Sub-total				41,900,000		29,980,000		11,920,000
3. Embankment								
Core	m^3	585,300	8.08	4,729,224	5.33	3,119,649	2.75	1,609,575
Filter	m^3	479,400	18.70	8,964,780	12.38	5,934,972	6.32	3,029,808
Transition	m^3	1,468,900	15.74	23,120,486	10.50	15,423,450	5.24	7,697,036
Rockfill (from S.P.)	m^3	711,700	17.22	12,255,474	11.57	8,234,369	5.65	4,021,105
- do - (from Q.S.)	m^3	268,410	26.01	6,981,344	16.34	4,385,819	9.67	2,595,525
Others				8,407,692		5,564,741		2,842,951
Sub-total				64,459,000		42,663,000		21,796,000

Table 17.1 Breakdown of Cost Estimate [Dam (3)]

Work Item	Unit	Quantity	TOTAL Unit Price	TOTAL Amount	F/C Unit Price	F/C Amount	L/C Unit Price	L/C Amount
4. Spillway								
Excavation								
Sand	m^3	910,000	22.00	20,020,000	14.57	13,258,700	7.43	6,761,300
Rock	m^3	2,121,000	23,43	49,695,030	14.19	30,096,990	9.24	19,598,040
Reinforced Concrete	m^3	76,680	615.00	47,158,200	326.00	24,997,680	289.00	22,160,520
Steel bars	ton	1,553,600	7,950.00	12,351,120	4,214.00	6,546,870	3,736.00	5,804,250
Gate 9.5^B x 10.5^H X 4				10,125,000		9,205,000		920,000
Grout Curtain	m	4.800	460.50	1,951,200	299.30	1,436,640	107.20	514,560
Consolidation	m	1,200	406.50	487,800	299.30	359,160	107.20	128,640
Others				21,268.252		12,855,156		8,383,096
Sub-total				163,056,000		98,786,000		64,270,000
5. Access Road	m	6,500	1.50	9,750,000	800.00	5,200,000	700.00	4,550,000
6. Land Acquisition	ha	1,700	20,000.00	34,000,000	0	0	20,000.00	34,000,000

Table 17.2 Breakdown of Cost Estimate [Irrigation (1)]

Work Item	Unit	Quantity	TOTAL Unit Price	TOTAL Amount	F/C Unit Price	F/C Amount	L/C Unit Price	L/C Amount
1. Intake								
Reinforced concrete	m^3	1,653	615.00	1,016,595	326.00	538,878	289.00	477.717
Steel bars	ton	57.9	7,950.00	460,305	4,214.00	243,991	3,736.00	216,314
Shaft excavation	m	42	3,785.44	158,988	2,763.58	116,070	1,021.86	42,918
Concrete Shaft	m^3	270	417.92	112,838	227.42	61,403	190.50	51,435
Penstock	m^3	3,117	388.47	1,210,860	210.22	655,255	178.25	555.605
Lining	m^3	4,145	451.12	1,869,892	258.49	1,071,441	192.63	798,451
Penstock Pipe	ton	431	9,160.00	3,947,960	7,330.00	3,159,230	1,830.00	788,730
Welding	time	314	3,331.83	1,046,194	1,907.74	599,030	1,424.09	447,164
Gate $2.5^B \times 4^H \times 1$				650,000		591,000		59,000
Valve Hollow jet ø1800				3,040,000		2,764,000		276,000
Butterfly ø1500 x 2				1,617,000		1,470,000		147,000
Others				2,269,368		1,690,702		578,666
Sub-total				17,400,000		12,961,000		4,439,000
2. Driving Canal & Main Canal Mo								
Excavation	m^3	828,000	12.67	10,490,760	8.74	7,236,720	3.93	3,254,000
Embankment	m^3	164,000	10.30	1,689,200	6.87	1,126,680	3.43	562,520
Lining	m^3	16,360	890.00	14,560,400	427.00	6,985,720	463.00	7,574,680
Pavement	m^3	7,000	134.00	938,000	71.00	497,000	63.00	441,000
Others				4,151,640		2,376,880		1,774,760
Sub-total				31,839,000		18,223,000		13,607,000

Table 17.2 Breakdown of Cost Estimate [Irrigation (2)]

Work Item	Unit	Quantity	TOTAL Unit Price	TOTAL Amount	F/C Unit Price	F/C Amount	L/C Unit Price	L/C Amount
3. Mabini Main Canal								
Excavation	m^3	25,000	12.67	316.750	8.74	218,500	3.93	98,250
Embankment	m^3	28,000	10.30	288,400	6.87	192,360	3.43	96,040
Pavement	m^3	6,000	134.00	804,000	71.00	426,000	63.00	378,000
Others				210,850		125,140		85,710
Sub-total				1,620,000		962,000		658,000
4. East Main Canal								
Excavation	m^3	109,000	12.67	1,381,030	8.74	952,660	3.93	428.370
Embankment	m^3	118,000	10.30	1,215,400	6.87	810,660	3.43	404,740
Pavement	m^3	10,900	134.00	1,460,600	71.00	773,900	63.00	686,700
Others				608,970		380,780		228,190
Sub-total				4,666,000		2,918,000		1,748,000
5. East Lateral Canal								
Excavation	m^3	33,000	12.67	418,110	8.74	288,420	3.93	129,690
Embankment	m^3	356,000	21.43	7,629,680	14.59	5,194,040	6.84	2,435,040
Pavement	m^3	14,000	134.00	1,876,000	71.00	994,000	63.00	882,000
Others				1,488,810		971,540		517,270
Sub-total				11,412,000		7,448,000		3,964,000
6. West Main Canal								
Excavation	m^3	163,000	12.67	2,065,210	8.74	1,424,630	3.93	640,590
Embankment	m^3	179,000	10.30	1,843,700	6.87	1,229,730	3.43	613,970
Pavement	m^3	19,100	134.00	2,559,400	71.00	1,356,100	63.00	1,203,300
Others				969,690		601,550		368,140
Sub-total				7,438,000		4,612,000		2,826,000

Table 17.2 Breakdown of Cost Estimate [Irrigation (3)]

Work Item	Unit	Quantity	TOTAL Unit Price	TOTAL Amount	F/C Unit Price	F/C Amount	L/C Unit Price	L/C Amount
7. West Lateral Canal								
Excavation	m^3	38,000	12.67	481,460	8.74	332,120	3.93	149,340
Embankment	m^3	415,000	21.43	8,893,450	14.59	6,054,850	6.84	2,838,600
Pavement	m^3	16,500	134.00	2,211,000	71.00	1,171,500	63.00	1,039,500
Others				1,738,090		1,133,530		604,560
Sub-total				13,324,000		8,692,000		4,632,000
8. Structure								
Embankment	m^3	8,000	21.43	171,440	14.59	116,720	6.84	54,720
Excavation	m^3	10,000	14.50	145,000	5.50	55,000	9.00	90,000
Hume pipe ø1500	m	1,000	1,120.00	1,120,000	516.00	516,000	604.00	604,000
- do - ø 600	m	1,270	370.00	469,900	167.00	212,090	203.00	257,810
Concrete	m^3	8,148	1,430.00	11,651,640	429.00	3,495,492	1,001.00	8,156,148
Gate	ton	630	30,000.00	18,900,000	16,800.00	10,584,000	13,200.00	8,316,000
Grouted Riprap	m^3	5,133	350.00	1,796,550	158.00	811,014	192.00	985,536
Pile ø300 ℓ=5,000	PC	1,418	1,075.00	1,524,350	525.00	744,450	550.00	779,900
Others				5,366,120		2,480,234		2,885,806
Sub-total				41,145,000		19,015,000		22,130,000
9. On Farm Facility (Irrigation & Drainage)	ha	11,500	3,300.00	37,950,000	300.00	3,450,000	3,000.00	34,500,000
10. Land Acquisition	ha	298.1	20,000.00	5,962,000			20,000.00	5,962,000

CHAPTER 18

ECONOMIC EVALUATION

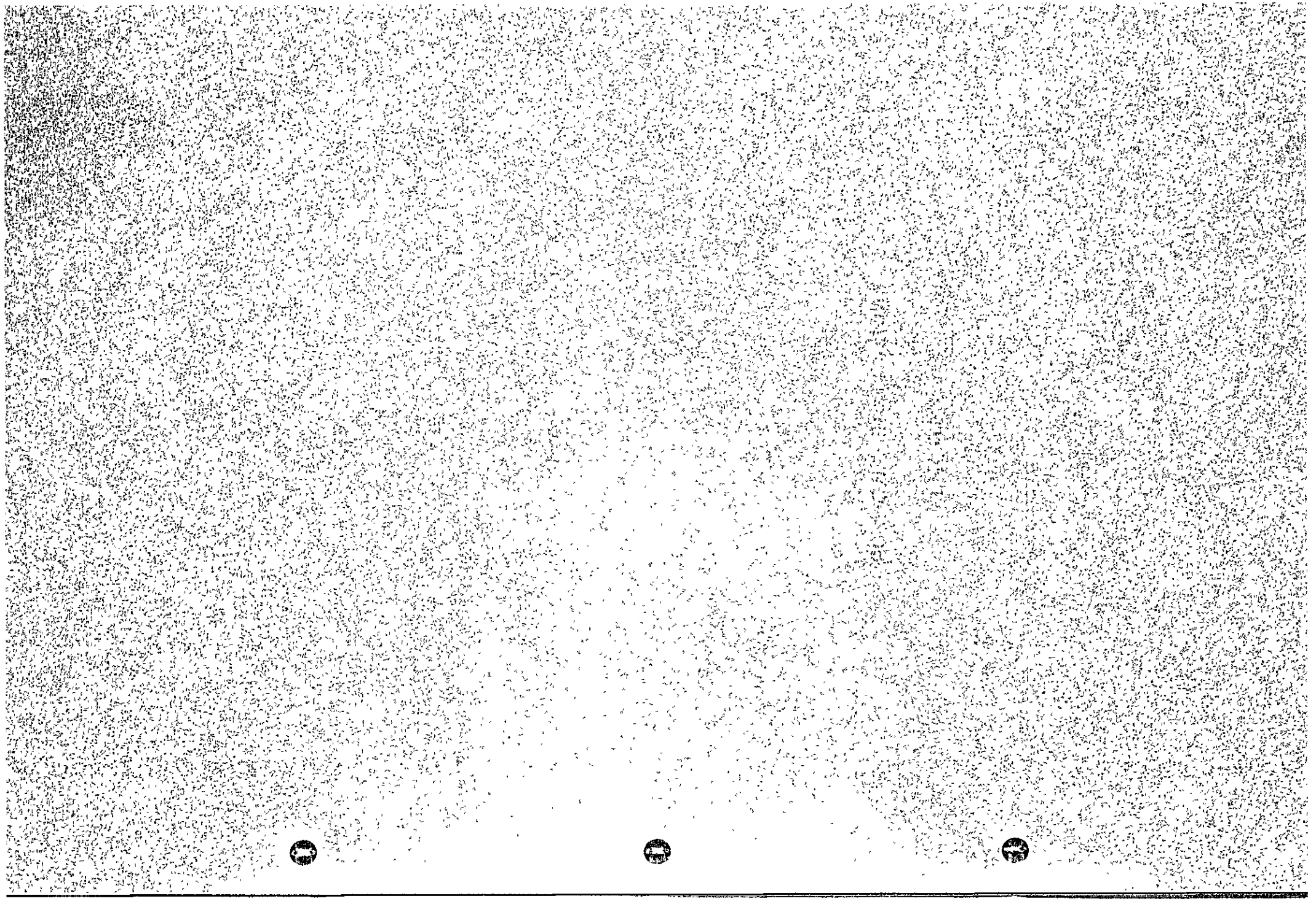


Table 18.1.1 Rice Price Structure

(Unit: ¥/ton)

	1981		1990	
	Financial	Economic	Financial	Economic
Export Price F.O.B. Manila	2,880 ($360)	2,880 ($360)	3,360 ($420)	3,360 ($420)
Exporters Costs	60	50	60	50
Transportation and Handling Cost	160	125	160	125
Milling Fee	200	165	200	165
Sales of By Products	145	120	145	120
Rice Price Ex-Mill Project Area	2,605	2,660	3,085	3,140
Paddy Requirement Price	1,615	1,650	1,975	2,010
Average Cost of Transportation Farm to Mill	20	15	20	15
Farmgate Price	1,595	1,635	1,955	1,995

Table 18.1.2 Price Structure of Fertilizers

	1981						1990					
	Urea		Triple Superphosphate		Mureate of Potash		Urea		Triple Superphosphate		Mureate of Potash	
	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic	Financial	Economic
	(₱/ha)						(₱/ha)					
Export price, F.O.B. Origin	$216	$216	$207	$207	$104	$104	$270	$270	$221	$221	$109	$109
Ocean freight and Insurance	28	28	48	48	48	48	28	28	48	48	48	48
Import price, cost and freight, Manila	244	244	255	255	152	152	298	298	269	269	157	157
Import price, Manila	₱1,950	₱1,950	₱2,040	₱2,040	₱1,215	₱1,215	₱2,385	₱2,385	₱2,150	₱2,150	₱1,255	₱1,255
Port handling, storage and processing charges	130	105	130	105	130	105	130	105	130	105	130	105
Average cost of transportation to and handling at distribution center	100	85	100	85	100	85	100	85	100	85	100	85
Dealers margin	65	55	65	55	65	55	65	55	65	55	65	55
Average transportaton from distribution center to farm	160	125	160	125	160	125	160	125	160	125	160	125
Importers surcharge	310	-	310	-	310	-	310	-	310	-	310	-
Farmgate price (per ton)	2,715	2,320	2,805	2,410	1,980	1,585	3,150	2,755	2,915	2,520	2,020	1,625
Farmgate price (per Nutrient kg)	6.0	5.2	6.1	5.2	3.3	2.6	7.0	6.1	6.3	5.5	3.4	2.7

Table 18.1.3 Rice Crop Production Cost: Input and Unit Price Assumption

Input		Unit	Wet Season		Dry Season	Input	
			Rainfed	Irrigated	Irrigated	Unit	Price
Present:							
Cultivation	- Mechanical	(% Area)	5	55	40	₱/ha	450 (450)
	- Animal	(% Area)	95	45	60	₱/ha	290 (290
Seed	- Transplanted	(kg)	50	50	50	₱/kg	1.9(1.9)
Fertilizer	- N	(Nutrient kg)	22	51	52	₱/kg	5.2(6.0)
	- P	(Nutrient kg)	15	28	28	₱/kg	5.2(6.1)
	- K	(Nutrient kg)	9	27	27	₱/kg	2.6(3.3)
Pesticide	- Liquid	(qt.)	0.65	1.45	1.30	₱/qt.	58.7(70.4)
	- Granule	(kg)	2.0	124	20	₱/kg	6.0(7.3)
Herbicide	- Liquid	(qt.)	0.58	0.20	0.20	₱/qt.	35.3(42.3)
	- Granule	(kg)	8.18	12	14	₱/kg	2.8(3.4)
Harvesting	- Mechanical	(% Area)	100	100	100	6% of Yield Value	
	- Mannual	(% Area)	-	-	-	-	-
Future Without Project:							
Cultivation	- Mechanical	(% Area)	5	55	40	₱/ha	450 (450)
	- Animal	(% Area)	95	45	60	₱/ha	290 (290)
Seed	- Transplanted	(kg)	50	50	50	₱/kg	2.2(2.2)
Fertilizer	- N	(Nutrient kg)	22	51	52	₱/kg	6.1(7.0)
	- P	(Nutrient kg)	15	28	28	₱/kg	5.5(6.3)
	- K	(Nutrient kg)	9	27	27	₱/kg	2.7(3.4)
Pesticide	- Liquid	(qt.)	0.65	1.45	1.30	₱/qt.	58.7(70.4)
	- Granule	(kg)	2.0	24	20	₱/kg	6.0(7.3)
Herbicide	- Liquid	(qt.)	0.58	0.20	0.20	₱/qt.	35.3(42.3)
	- Granule	(kg)	8.18	12	14	₱/kg	2.8(3.4)
Harvesting	- Mechanical	(% Area))	100	100	100	6% of Yield Value	
	- Mannual	(% Area)	-	-	-	-	
Future With Project:							
Cultivation	- Mechanical	(% Area)	-	70	80	₱/ha	450 (450)
	- Animal	(% Area)	-	30	20	₱/ha	290 (290)
Seed	- Transplanted	(kg)	-	65	70	₱/kg	2.2(2.2)
Fertilizer	- N	(Nutrient kg)	-	70	80	₱/kg	6.1(7.0)
	- P	(Nutrient kg)	-	30	30	₱/kg	5.5(6.3)
	- K	(Nutrient kg)	-	0	0	₱/kg	2.7(3.4)
Pesticide	- Liquid	(qt.)	-	2.0	1.95	₱/qt.	58.7(70.4)
	- Granule	(kg)	-	33	30	₱/kg	6.0(7.3)
Herbicide	- Liquid	(qt.)	-	0	0	₱/qt.	35.3(42.3)
	- Granule	(kg)	-	16.5	21	₱/kg	2.8(3.4)
Harvesting	- Mechanical	(% Area)	-	100	100	6% of Yield Value	
	- Mannual	(% Area)	-	-	-		

Table 18.1.4 Lowland Rice Crop Production Cost

	Present			Future Without Project			Future With Project	
	Wet		Dry	Wet		Dry	Wet	Dry
	Rainfed	Irrigated	Irrigated	Rainfed	Irrigated	Irrigated	Irrigated	Irrigated
Cash Input								
Cultivation	300(300)	380(380)	355(355)	300(300)	380(380)	355(355)	400(400)	420(420)
Speed	95 (95)	95 (95)	95 (95)	110(110)	110(110)	110(110)	145(145)	155(155)
Fertilizer	215(255)	480(565)	485(570)	240(280)	540(625)	545(630)	590(680)	655(750)
Agro-Chemicals	95(115)	270(325)	245(295)	95(115)	270(325)	245(295)	430(520)	425(510)
Harvesting	185(180)	315(305)	305(295)	225(225)	375(375)	370(365)	525(515)	550(540)
Others	30 (30)	50 (50)	50 (50)	40 (35)	65 (65)	60 (60)	90 (85)	90 (90)
Interest 1/	(10)	(40)	(40)	(15)	(55)	(55)	(105)	(110)
Land tax	(15)	(20)	(20)	(25)	(30)	(30)	(80)	(80)
Total Cash Input	920(1,000)	1,570(1,780)	1,535(1,720)	1,010(1,105)	1,740(1,965)	1,685(1,900)	2,180(2,530)	2,295(2,655)
Labor Input								
Land Preparation	21	22	21	21	22	21	21	21
Planting	18	20	20	18	20	20	24	24
Crop Management	10	13	14	10	13	14	20	25
Harvesting	21	25	25	21	25	25	35	30
Total Labor Input	70	80	80	70	80	80	100	100

		Present	Future w/o Project	Future With Project
1/	Rainfed -	13%	25%	-
	Irrigated wet -	41%	50%	75%
	dry -	41%	50%	75%

Table 18.1.5 Monthly Labor Requirement

		M O N T H												
		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
		(mandays/ha) 1/												
Lowland Rice														
Wet Season														
Irrigated Rice	P 2/	-	-	-	-	15	28	7	7	17	6	-	-	80
	$\overline{W}$	-	-	-	-	15	28	7	7	17	6	-	-	80
	W	-	-	-	-	6	36	11	6	19	22	-	-	100
Rainfed Rice	P	-	-	-	-	5	28	12	3	3	3	15	1	70
	$\overline{W}$	-	-	-	-	5	28	12	3	3	3	15	1	70
	W	-	-	-	-	-	-	-	-	-	-	-	-	-
Dry Season														
Irrigated Rice	P	11	13	5	-	-	-	-	-	3	17	16	15	80
	$\overline{W}$	11	13	5	-	-	-	-	-	3	17	16	15	80
	W	12	8	18	19	-	-	-	-	-	-	6	37	100

1/ Excluding labor handling farm hachinery

2/ P = Present

$\overline{W}$ = Future Without Project

W = Future With Project

Notes of Table 18.1.5

Economic value of rural labor

The agricultural sector has a high percentage of under employment, including family workers and the shadow wage rate of unskilled workers of rural areas of Philippines is estimated to be of the order of 52% (according to data of the IBRD).

On the other hand, the consumption conversion factor of Philippines is 84% (data of the IBRD) and accordingly the market price of 15₱/day of rural workers is converted into the following economic price.

$$15₱/day \times 0.52 \times 0.84 = 6.55₱/day.$$

CHAPTER 19

ORGANIZATION AND OPERATION

19. Organization and Operation

(1) Operation and Maintenance

The annual cost required for operation and maintenance of the irrigation system is 4 million Peso, and its breakdown is presented in Table 19.1.

Table 19.1 Cost for Operation and Maintenance

I. Salaries and Weges

A. Position Title	No. of Personnel	Rate Per Annum (₱)	Total Salary per Annum (₱)
1. OFFICE OF OPERATION MANAGER			
a. Operation Manager	1		
b. Secretary	1		
c. Clerk	1		
d. Driver	1		
Sub-total	4		90,000
2. ADMINISTRATIVE DIVISION			
a. Administrative Officer	1		
b. Cashier	1		
c. Collection Officer	1		
d. Disbursing Officer	1		
e. Liaison Officer	1		
f. Accounting Clerk	1		
g. Clerk	1		
h. Office Helper	1		
i. Security Guard	1		
Sub-total	9		120,000

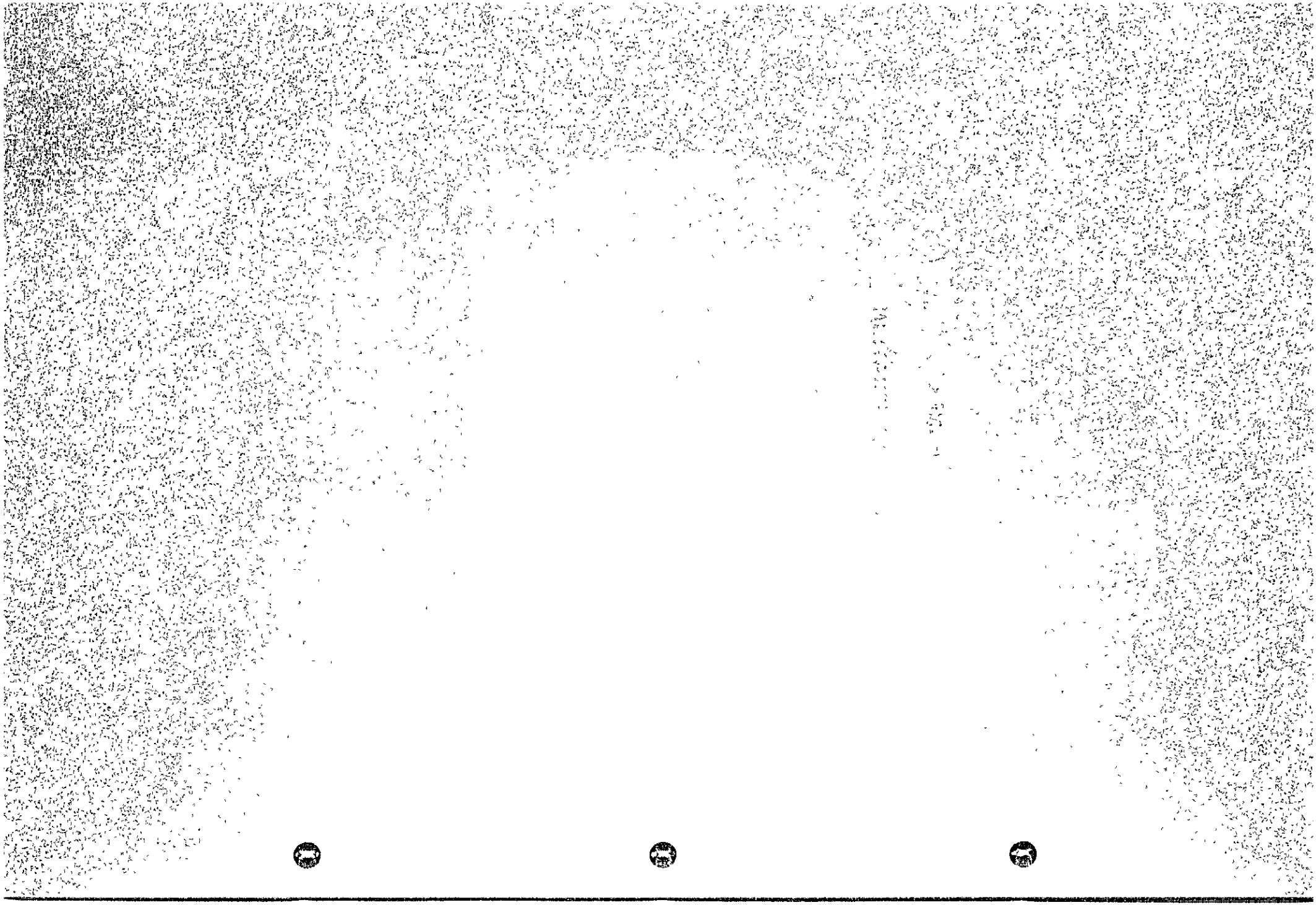
3.	EQUIPMENT DIVISION		
	a. Mechanical Engineer	1	
	b. Asst. Mechanical Engineer	1	
	c. Sr. Mechanic	1	
	d. Heavy Equipment Operator	1	
	e. Mechanic	1	
	f. Electrician	1	
	g. Mechanic Helper	1	
	h. Driver	2	
	i. Clerk	1	
	Sub-total	10	120,000
4.	WATER CONTROL COORDINATING DIVISION		
	a. Principal Engineer B	1	
	b. Sr. Engineer	1	
	c. Asst. Engineer	1	
	d. Engineer Trainee	1	
	e. Instrumentman	1	
	f. Hydrologic Aide	1	
	g. Hydrographic Engineer Aide	1	
	h. Hydromet Observer	1	
	i. Survey Aide	1	
	j. Clerk	1	
	Sub-total	10	170,000
5.	AGRICULTURAL DEVELOPMENT DIVISION		
	a. Agricultural Extension Specialist	1	
	b. Sr. Agricultural Engineer	1	
	c. Sociologist	1	
	d. Training Officer	1	
	e. Biometrician	1	
	f. Economic Researcher	1	
	g. Interviewer	1	

h.	Tracer	1	
i.	Clerk	1	
	Sub-total	9	170,000
6.	OFFICE OF SUPERINTENDENT		
a.	Irrigation Supt. V	1	
b.	Supry. Irrigation Engineer	1	
c.	Sr. Irrigation Engineer	1	
d.	Irrigation Engineer	1	
e.	Engineer Trainee	1	
f.	Draftsman	1	
g.	Water Management Technologist	3	
h.	Water Management Technician	15	
i.	Ditchtender	80	
j.	Cashier	1	
k.	Liaison Officer	1	
l.	Disbursing Officer	1	
m.	Accounting Clerk	1	
n.	Property Custodian	1	
o.	Bill Collector	1	
p.	Billing Clerk	1	
q.	Clerk	1	
r.	Security Guard	1	
s.	Janitor	1	
t.	Driver	2	
	Sub-total	117	1,238,000
	Total A		1,908,000
B.	Cost of Living Allowance		₱ 572,000
C.	Incentive Allowance		₱ 159.000
D.	Personal Insurance		₱ 181,000
	TOTAL = A + B + C + D		₱ 2,820,000

II.	Maintenance Construction	
	Canal	₱ 100,000
	Roadway Maintenance	₱ 425,000
	Others	₱ 105,000
	TOTAL	₱ 630,000
III.	Materials and Supplies	₱ 170,000
IV.	Administrative and General Expenditures	₱ 380,000
	GRAND TOTAL	₱ 4,000,000

ANNEX

POWER GENERATION



A. Power Generation

A.1 Selection of Turbine

(1) Power Station A

The bulb form tubular turbine is adopted in this station, from the chart for turbine type selection. (Refer to Figure A-3 and Figure A-4).

(2) Power Station B

The vertical form Kaplan type turbine is adopted in this station. (Refer to Figure A-3 and Figure A-5).

A.2 Selection of Type of Generator

There are two possible alternatives, i.e., a three-phase synchronous generator or a three-phase induction generator, as basic item to be decided with regard to the type of small capacity turbine generator to be adopted in this case.

Power Stations A & B

Particular attention should be paid to the following points in case of adopting a three-phase induction generator.

Advantages

(a) The Eliminating the exciter device

(b) Speedless governor may be used

(c) Rotator is the cage type and the slip ring may be omitted.

The advantages (a), (b) and (c) above are directly related with the cost reduction of the generator, meaning approximately 15% less weight, compared with the synchronous generator of the same capacity.

Disadvantages

The induction generator can be adopted only in the following system.

(a) Systems without obligation of independent load operation.

(b) Systems without black starting.

(c) Systems without noxious influence on other systems with regard to the rush in case of parallel connection of generator and low power factor operation.

As can be seen from the considerations above, the induction generator is approximately 20% cheaper compared with the synchronous generator and, in addition, the control system is more simple.

However, the sites where the A & B Power Stations will be constructed are in the remote zones, quite distant from urban areas, being tehrefore expected to be unavoidable the execution of both independent load operation and black starting.

In addition, the Power Station A is exclusive for the dry season, while the Power Station B is exclusive for the rainy season. Therefore, if should be recommendable to adopt the three-phase synchronous generator in the present case.

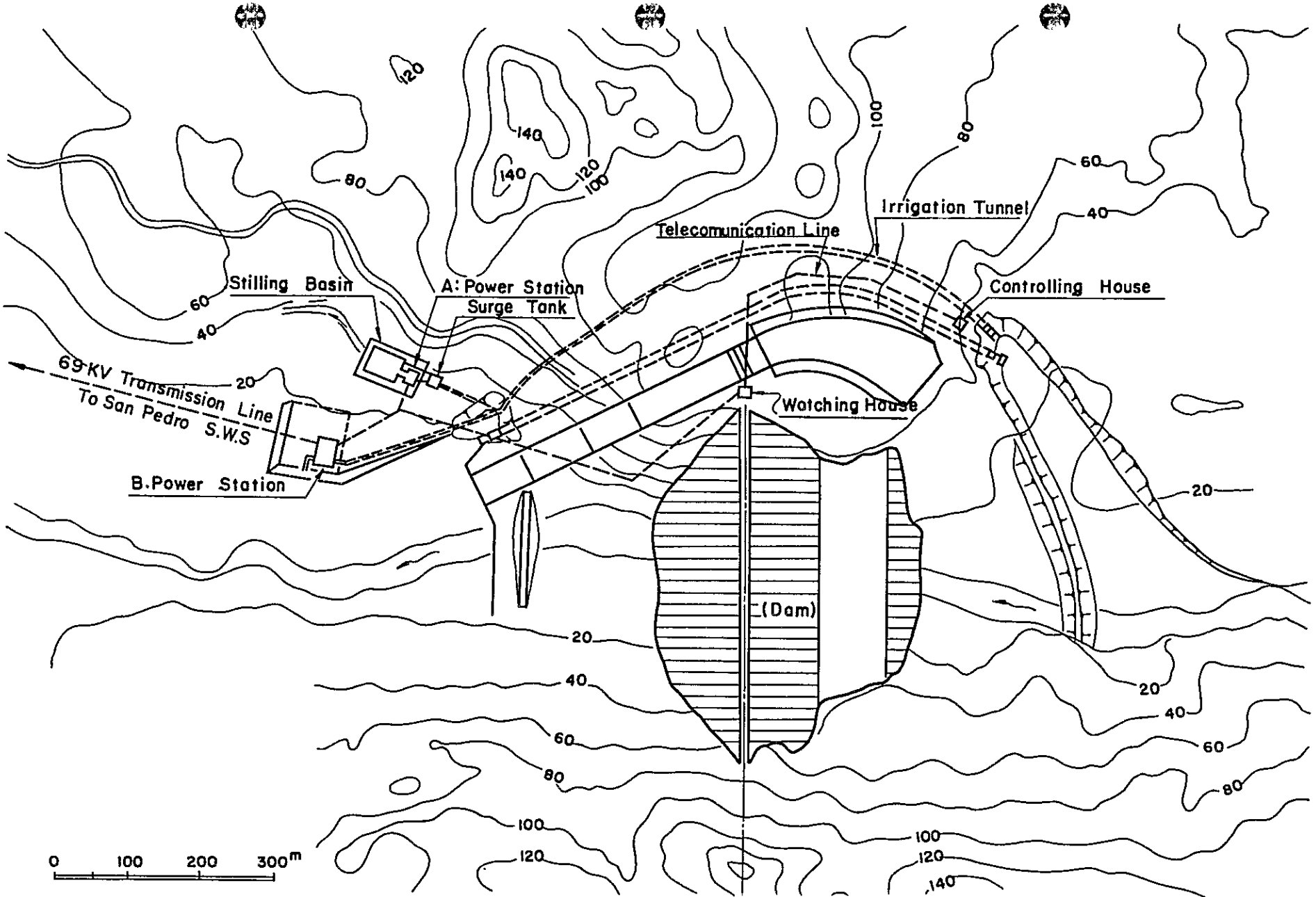
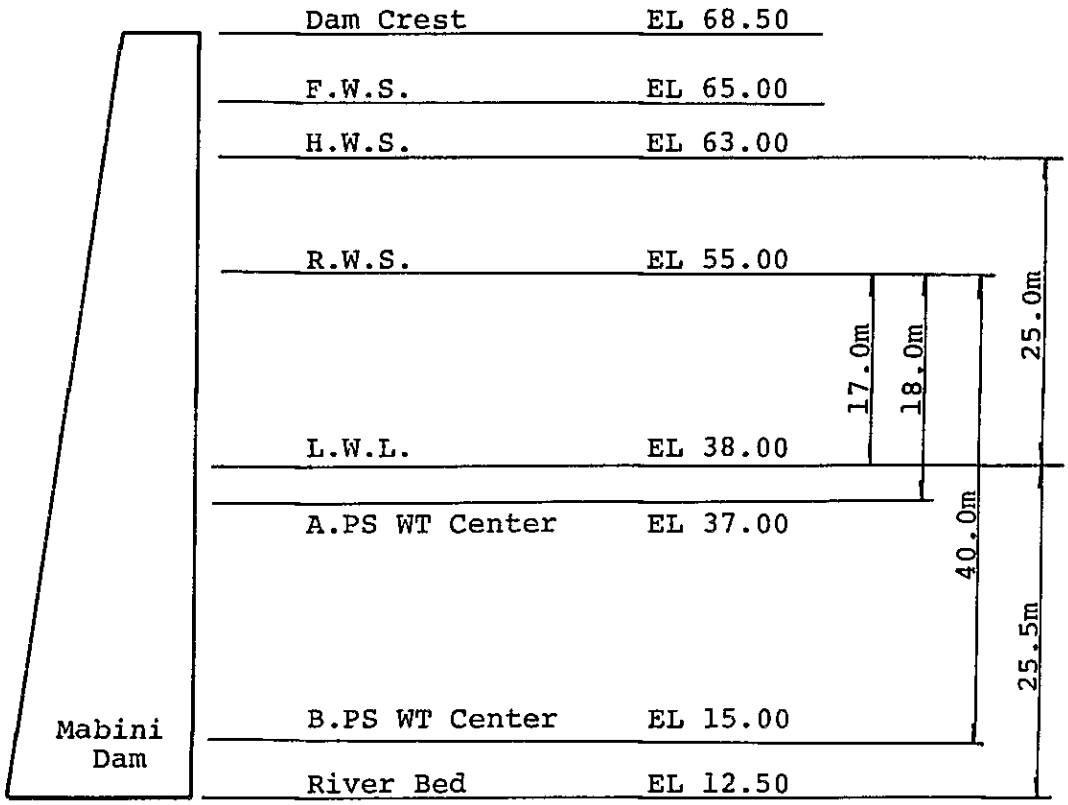


Fig. A-1 General Layout of Power Planning

Fig. A.2 Water Level of Reservoir



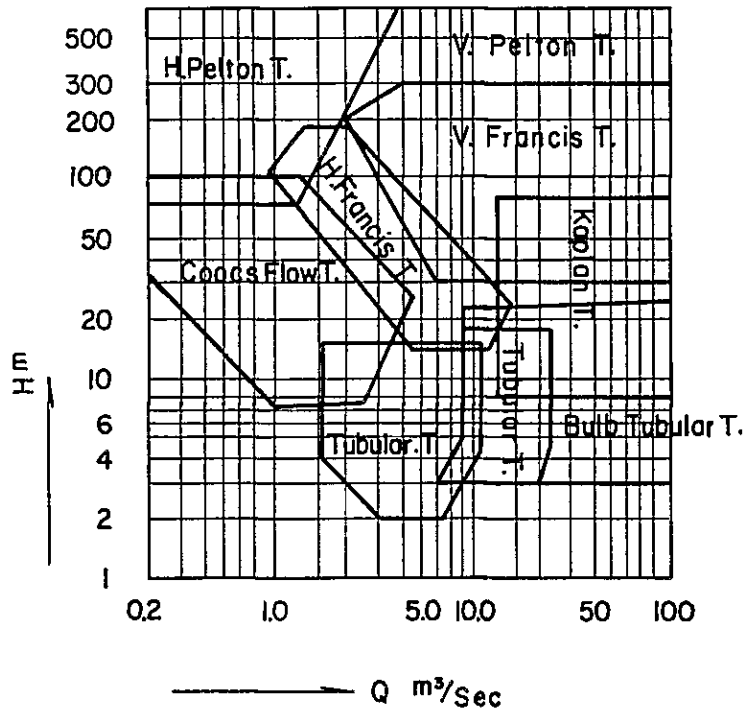


Fig. A.3 Selection Chart for Turbine Type

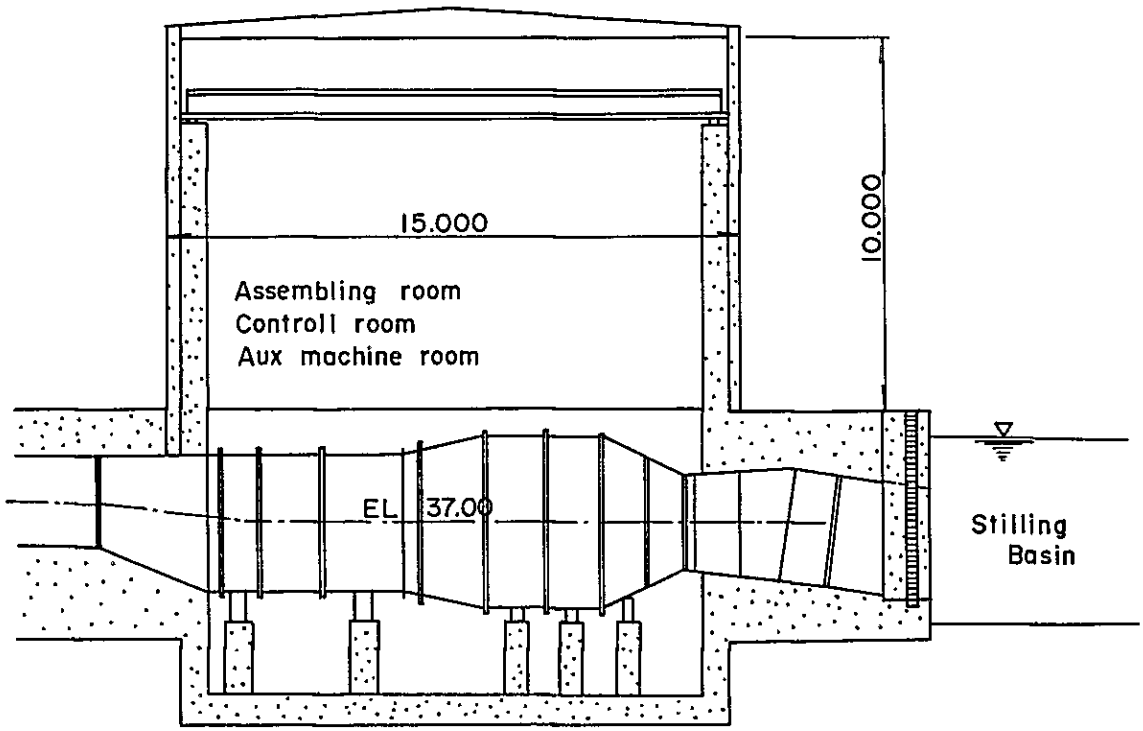


Fig. A.4 A Power Station

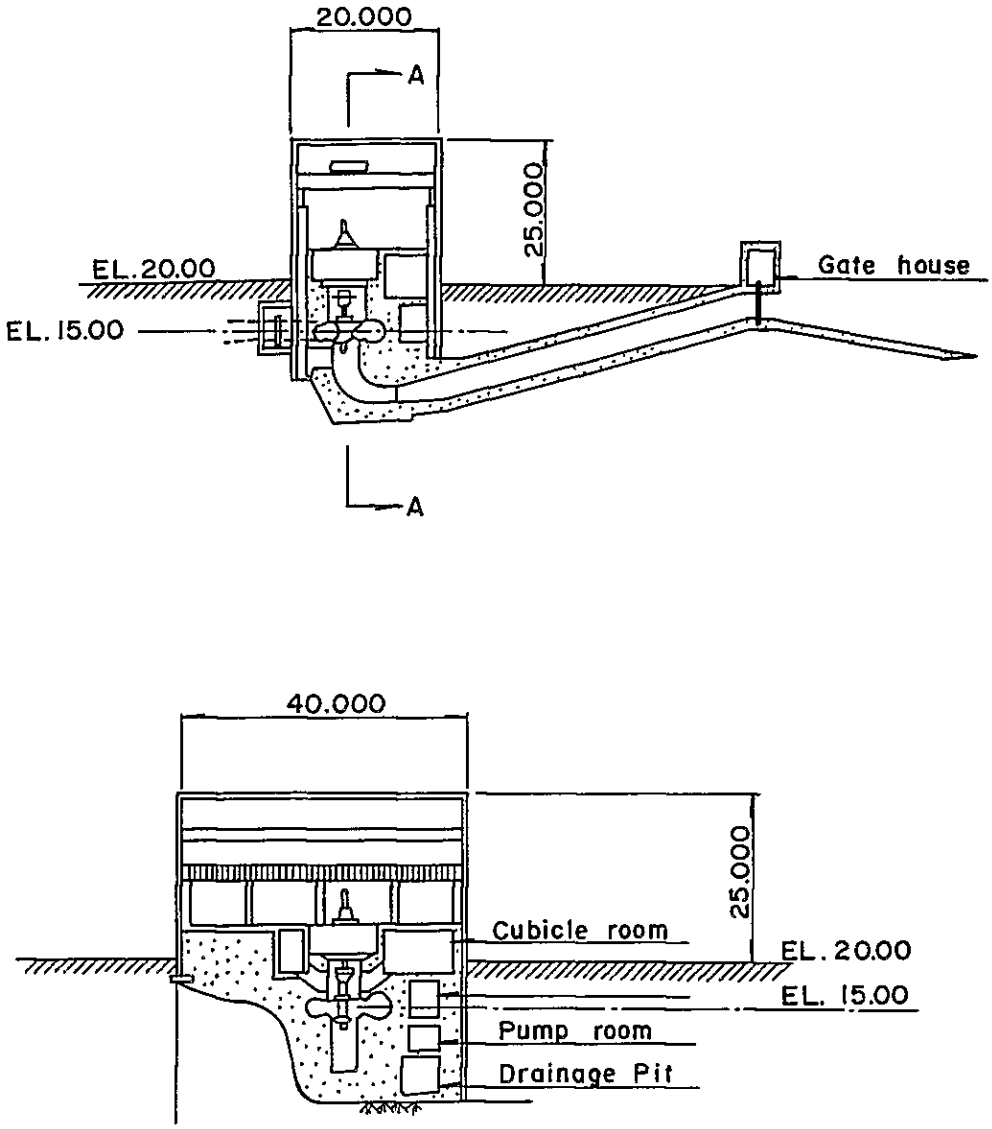


Fig. A-5 B Power Station

Table A-1 Existing Installed Capacity of Hydropower Plant in the Philippines (1980)

Name of System	Installed Capacity	Generated Power
Luzon Power System	3,136 MW.	13,115 GWH.
Visaya Power System	107	321
Mindanao Power System	523	1,650
Total	3,766	15,086

Table A-2. Hydropower Station under Construction

Name of System	Name of Plant	Kind of Plant	Unit & Capacity
Luzon 1,402 MW.	Masiway	Hydro	1 x 12 MW.
	Kalayan	Pumped Storage	2 x 150MW
	Twini	Geothermal	2 x 55MW.
	Magat	Hydro	4 x 90MW.
	Philippine	Nuclear	1 x 620MW.
Visaya 285.5MW.	Cebu	Thermal	1 x 55MW
	"	Diesel	3 x 18MW.
	"	Power Plant Barge	2 x 32MW.
	Tangonan	Geothermal	3 x 37.5MW.
Mindanao 284 MW.	Agus	Hydro	2 x 40MW.
	"	"	2 x 27MW.
	"	"	3 x 50MW.
	Total		1,971.5MW.

Note: Excepting Meralco & Mini Hydro Power.

Table A-3. List of Mini-hydro Power Plant

Name of System	Name of Mini-hydro Power Plant	Location	Capacity KW.
Luzon System	Asin MHE Electric Plant#2	Asin Benquet	1,050
	" " #3	"	1,448
	" " #4	"	724
	Camp John Hay Electric Plant	Banquio City	488
	Amburayan Electric Plant	Suaipen, La Union	200
	Balongbong Electric Plant	Virac Catanduanes	200
	Cauyan Electric Plant	Sorsogon	400
	Lake Buhi-Barit Electric Plant	Bui Camarines Sur	1,800
	Panaranda Chuto Electric Plant	Penaranda, Nueva Eciya	300
	Baliguian Electric Plant	Presentacion Camarines Sur	100
		Sub total	6,710
Bisaya System	Lobac "	Lobac Bohol	1,200
		Sub total	1,200
Mindanao System	Digos Davao "	Digos, Davao	200
	Talomo " #2	Mintal Davao City	600
	" " #2A	"	400
	" " #2B	"	300
	" " #3	"	1,600
		Sub total	3,100
		Total	13,810

A.3 Transmission Line and Switching Station

Presently, the Bani Substation (Tr.5MVA 69/13.8KV) is connected with the San Manuel Substation (Tr.50MVA 230/69 13.8KV) by means of the 69KV transmission line (Conductor 336.4MCM and 4/0 AWG) of the NPC.

The 69KV transmission line to be constructed after the construction of the A and B Power Stations will pass through the San Pedro City. The transmission line should be connected with the 69KV transmission line of the NPC through the San Pedro Switching Station to be constructed anew.

The existing 69KV transmission line of the NPC has sufficient capacity to transmit power generated by the A & B Power Stations.

The Conductor 336.4MCM (160mm^2) has a power transmission capacity of 68MW, while the Conductor AWG 4/0 (100mm^2) has a power transmission capacity of 50MW. (Refer to Figure A-7 and Figure A-8).
to Figure A-4 and Figure A-5).

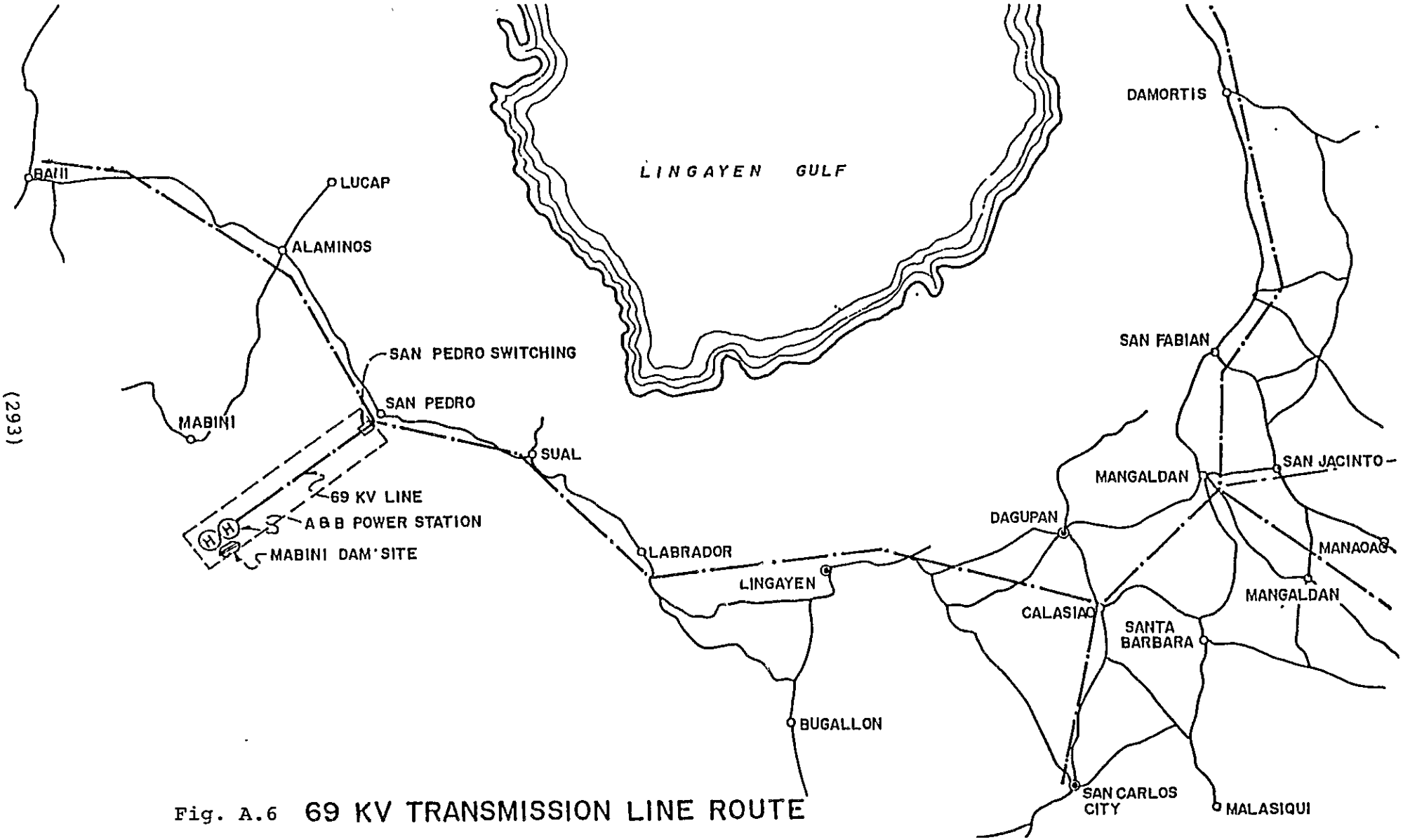


Fig. A.6 69 KV TRANSMISSION LINE ROUTE

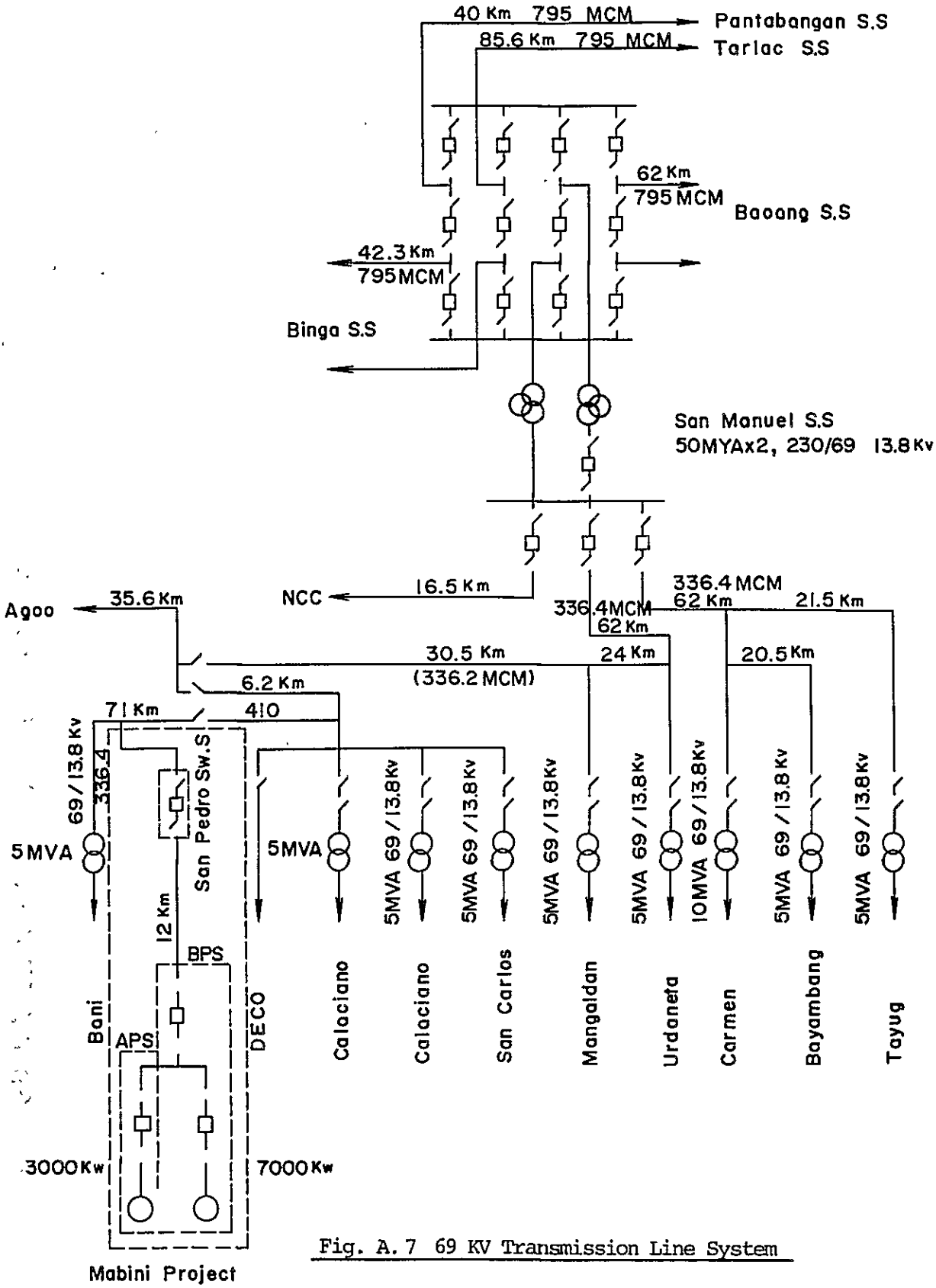


Fig. A.7 69 KV Transmission Line System

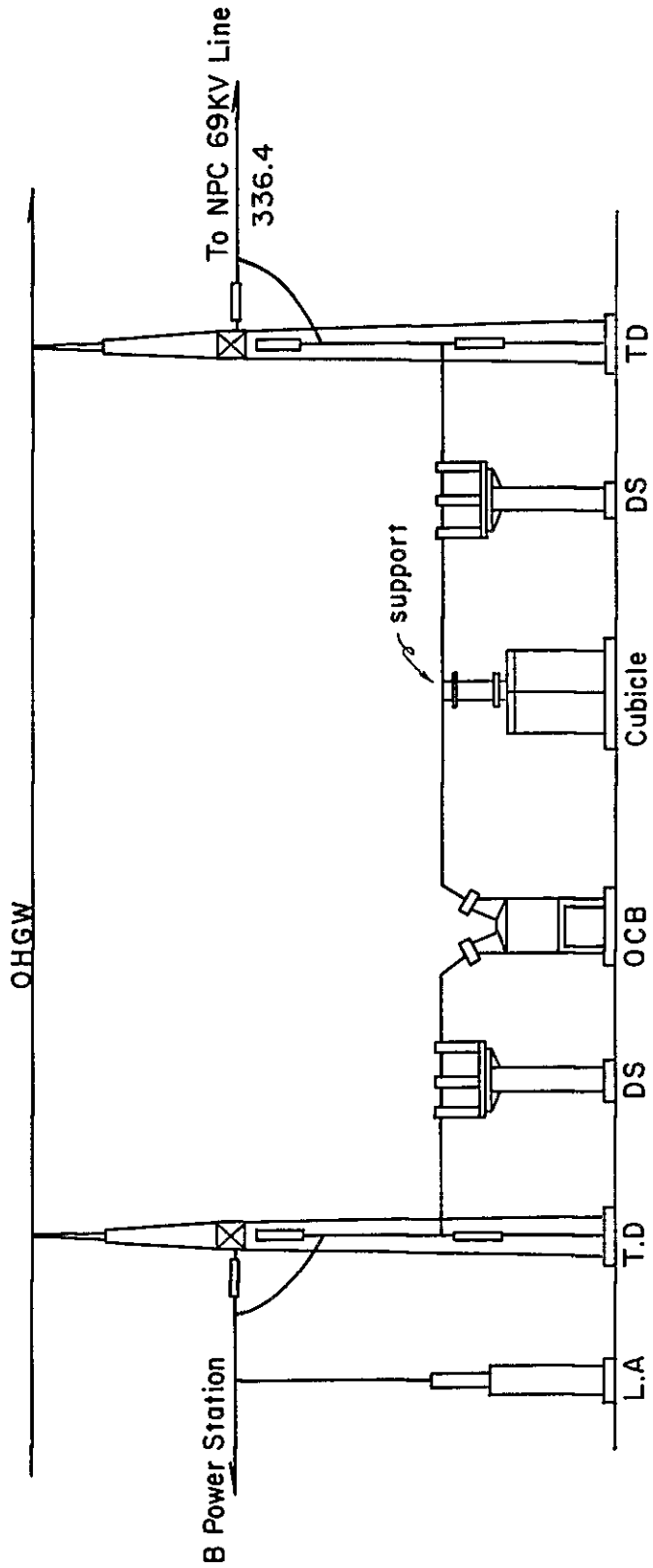


Fig. A.8 San Pedro 69KV Switching Station

A.4 Generated Energy

1) Rainfall and run-off

Rainfall in the Mabini area has been observed since 1956. The monthly average rainfall are observed as follows.

Table A-4

Unit: mm

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
12.9	7.1	24.6	62.1	267.1	514.1	638.1	813.7	499.3	202.9	72.1	20.1

Total: 3,134.7 mm

Assuming the run-off ratio of the catchment area to be 70%, the average quantity of water running off annually is estimated to be 493,708 x 10^6 cubic meters at the proposed dam-site.

2) Generated Energy

The power generated by the A & B Power Stations can be calculated by the volume of water to be released to the River, the required quantity of irrigation water and the irrigation period. The monthly average quantities of irrigation water and river maintenance water are estimated as follows.

Table A-5

Unit: m^3/sec.

Month / Demand	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Irrigation	20.2	20.8	9.5	0.3	1.8	4.0	4.1	0.1	-	-	4.1	17.6
River maintenance	2.3	2.3	2.3	2.3	-	-	-	-	-	-	2.3	2.3

Note: The demands for irrigation are calculated by the rainfall data during 1959 to 1970.

The requirements of water on the monthly basis are calculated as follows from the estimated values presented above.

Table A-6

Unit: x 10^6 m^3

Volume / Month	Inflow (Running off-loss)	Demands for irrigation	Demands for River maintenance	Balance
Jan.	1,878	54.170	6,160	-58.452
Feb.	1,034	50.354	5,564	-54,884
Mar.	3,583	25.460	6,610	-28,037
Apr.	9,047	0.830	5,961	-2,256
May	38,913	4.849	-	34,064
June	74,897	10.243	-	64,654
July	92,963	10.995	-	81,768
Aug.	118,545	0.274	-	118,271
Sept.	72,741	-	-	72,741
Oct.	29,559	-	-	25,559
Nov.	10,591	10.614	5,961	-5,984
Dec.	2,928	47.107	6,160	-50,339
Total	456,679	214.896	35,966	205,817

Note: Losses (Evaporation + Leakage) are assumed to be 7.5% of inflow.

The reservoir should be full water up to EL63.00m by the end of October, according to the irrigation plan.

The Power Station A will be operated during the irrigation season, by using the irrigation water (214.896 x 10^6 cubic meters) and the river maintenance water (35.966 x 10^6 cubic meters). The period of operation of this Power Station is therefore approximately 1/2 year.

The Power Station B can be operated by using surplus water (205.817 x 10^6 cubic meters) during the rainy season. The period of operation of this power station is approximately 1/2 year.

The monthly average quantity of the surplus water which can be used for power generation purposes can be estimated to be as follows.

Table A-7

Unit: $m^3/sec.$

Month	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Volume for generating power	0	0	0	0	0	0	10.8	23.9	20.0	7.36	16.0	0

According to the above condition, the quantity of surplus water used for power generation is as follows.

Table A-8

Unit: x 10^3m^3

Jan.	Feb.	Mar.	Apr.	May	June
0	0	0	0	0	0

Table A-9

July	Aug.	Sept.	Oct.	Nov.	Dec.
28.926	64.013	51.840	19.284	41.472	0

Total 205.535 x 10^6m^3

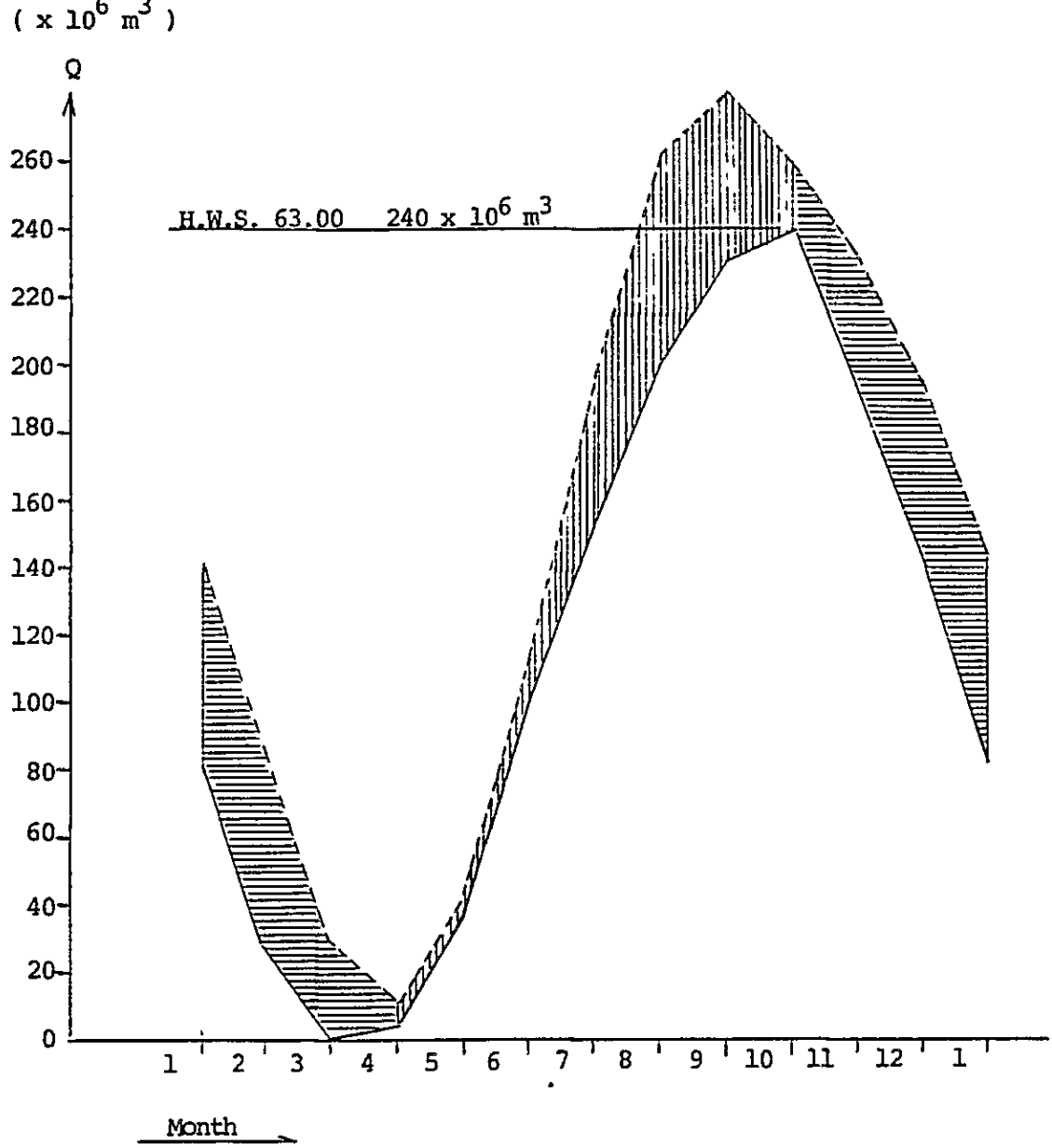
The quantity of balanced water at the Project site between the inflow and the demand for the irrigation plus the river maintenance making use to A Power Station and the excess water making use to B Power Station are shown as in the following table and the drawing of curves. (Fig. A-9)

Table A-10

Unit: 10^6 m^3

Volume / Month	Inflow	Irrigation & River maintenance (A Power Station)		Released water (B Power Station)	Effective water in Reservoir at End of Month
Jan.	1.878	54.170	6.160	-	83.753
Feb.	1.034	50.354	5.564	-	28.869
Mar.	3.583	25.460	6.160	-	0.832
Apr.	9.047	0.830	5.961	-	3.088
May	38.913	4.849		-	37.152
June	74.897	10.243		-	101.806
July	92.963	10.995		28.926	154.848
Aug.	118.545	0.274		53.568	209.541
Sept.	72.741			51.840	230.442 (+0.282)
Oct.	29.559			19.729	240.000
Nov.	10.591	10.614	5.961	41.472	192.544
Dec.	2.928	47.107	6.160	-	142.205
Total	456.679	214.896	35.966	205.535	

Fig. A-9 Storage Capacity



The amount of generating electric power at A & B Power Station may be worked out as in the following table.

Table A-11

Item / Month	At end of Month Effective storage water in reservoir x 10^6 m^3	EL. m	A Power Station		B Power Station	
			Irrigation water + (River maintenance) m^3/sec.	Generated Power Kwh x 10^3	Excess water + (River maintenance) m^3/sec.	Generated Power Kwh x 10^3
Jan.	83.753	52.6	21+(2.3)=23.3	1,858		
Feb.	28.869	44.6	21+(2.3)=23.3	745		
Mar.	0.832	38.5				
Apr.	3.088	39.0				
May	37.152	43.0				
June	101.806	51.0				
July	154.848	58.0			10.8	2,465
Aug.	209.106	60.0			22.0	5,680
Sept.	230.007	63.4			20.0	4,997
Oct.	240.000	63.8			7.36	1,916
Nov.	192.544	63.0	4.1	545	16+(2.3)=18.3	4,533
Dec.	142.205	58.6	17.6+(2.3)=19.9			
				5,529		19,591
			Total		25,120 x 10^3 KWh	

A.5 Alternative

In case of both A and B Power Stations are set Up at one site together, the following merits and demerits can be pointed out.

(i) The purchasing cost of land for B Power Station may be cut down. However, the site area will have to be enlarged to accomodate B Power Station so that saving of cost of land may not be much against expectation.

(ii) The length of penstock for B Power Station may be shortend by 60%.

(iii) The site of B Power Station shall be on EL.38.00m, thereupon, the perpendicular excavation for B Power Station shall be necessary, and the construction cost of B Power Station will be increased by 30%.

(iv) The tailrace tunnel for B Power Station shall be lengthened by 200m up to the river.

(v) The gantry crane (20t) will be necessary because B Power Station is built under ground.

Taking into account these conditions, the following cost will be required in addition;

Item	(i)	Negligible	
"	(ii)	₱6,000,000 x 0.6 = -	₱3,600,000
"	(iii)	20m x 40m x (38-20)m x ₱50/m^3 + ₱7,500,000 x 0.3 = +	₱2,970,000
	(iv)	₱3,500 x 200m = +	₱ 700,000
	(v)	₱30,000/t x 20t = +	₱ 600,000
		Total +	₱ 670,000

Thereupon, it will be rather more expensive when both A and B Power Stations are built at one site. Moreover, it may not be necessary to mention that a power station on the ground is better from the viewpoints of operation and maintenance.

Taking the above into consideration, it is decided to build A and B Power Stations separately at different sites.