REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY REPORT
ON
MABINI AGRICULTURAL DEVELOPMENT PROJECT

(SUPPORTING REPORT)

MARCH 1982

JAPAN INTERNATIONAL COOPERATION AGENCY

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INTRODUCTION

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PROJECT

1. Introduction

No particular comments and graphs.

2. The Project

No particular comments and graphs.

CHAPTER 3

BACKGROUND

Table 3.1.1 Food Balance Sheet (Rice)

Unit: ton

Year	Production	Foreign Trade		Available Supply	Food (Net)
		Gross Exports	Gross Imports		
1960	2,463,307	1,628	-	2,461,679	2,361,275
1961	2,519,741	53	187,864	2,707,552	2,561,848
1962	2,605,513	53	-	2,606,460	2,458,925
1963	2,604,582	90	256,303	2,860,795	2,754,159
1964	2,613,080	91	298,859	2,911,848	2,804,425
1965	2,689,711	26	569,300	3,258,985	3,150,115
1966	2,747,272	20	108,184	2,855,436	2,747,583
1967	3,030,665	108,104	290,452	3,213,013	3,097,909
1968	3,113,960	40,973	8	3,072,995	2,955,171
1969	3,263,927	444	10	3,263,493	3,146,405
1970	3,581,712	1,287	-	3,580,425	3,463,239
1971	3,495,859	5	370,424	3,866,278	3,749,352
1972	3,149,242	4,857	455,891	3,600,276	3,487,236
1973	3,478,893	3,508	336,221	3,811,606	3,680,709
1976	3,594,789	-	33,821	3,575,710	3,571,756
1977	4,066,219	14,920	30,874	3,729,423	3,724,951
1978	4,416,209	-48,264	-	4,105,545	4,100,668

Source: Philippines Food Balance Sheet, NEDA

Table 3.2.1 Total and Household Population, Number of Households (1975)

Municipality	Total Population	(A) Household Population	(B) Number of Households	(A) /(B)
Alaminos	42,496	42,496	7,820	5.43
Bani	27,549	27,547	5,204	5.29
Mabini	15,894	15,890	3,000	5.30
Sual	14,367	14,366	2,588	5.55
Total	100,306	100,299	18,612	5.39
Pangasinan	1,520,085	1,519,363	258,745	5.87

Source: 1975 Integrated Census of the Population and Its Economic Activities
Population, Pangasinan
NEDA, NCSO

Table 3.2.2 Number of Households and Number of Farms

	1970			1971	
Municipality	Total Population	Household Size	(A) Estimated Number of Households	(B) Number of Farms	(B) /(A) (%)
Alaminos	38,773	5.43	7,141	3,744	52.4
Bani	25,176	5.29	4,759	2,929	61.5
Mabini	12,769	5.30	2,409	1,251	51.9
Sual	12,528	5.55	2,298	1,455	63.9
Total	89,245	-	16,587	9,379	56.5

Table 3.2. 3 Farms - Number and area, by land use and municipality, April 1971

Municipality	Total Number of farms	Total area of farms (ha)	Area of all arable land (ha)	Planted to temporary crops (ha)		Planted to permanent crops		Others area (ha)
				(farmer)	(ha)	(farmer)	(ha)	
Alaminos	3,744 (100)	7,760 (100)	7,093 (91)	3,736 (99)	6,671 (86)	2,638 (70)	422 (5)	667 (9)
Bani	2,929 (100)	7,317 (100)	5,453 (75)	2,902 (99)	4,773 (66)	2,008 (69)	660 (9)	1,864 (65)
Mabini	1,251 (100)	3,374 (100)	2,296 (68)	1,247 (99)	2,287 (68)	60 (5)	9 (–)	1,078 (32)
Sual	1,455 (100)	3,307 (100)	2,492 (76)	1,149 (78)	2,176 (66)	510 (35)	316 (10)	815 (24)
Total	9,379 (100)	21,758 (100)	17,334 (80)	9,034 (96)	15,927 (73)	4,841 (22)	1,407 (7)	4,424 (20)

Source: 1971 Census of Agriculture

Note : Other area include lying idle, permanent pasture and meadow, forest temporary crop are crop which growing yield is less than one year.

Table 3.2.4 Hectarage Summary of Land Classes and Land Use

	Land Use	Land Classes (Ha) IR	2R	3R	Total Area (Ha)	ROW	Net Total Area (Ha)	Percent % Total Arable	Total Project
	Pr I	550			550	41	509	4.2	3.0
	Pr Ip	150			150	11	139	1.1	0.8
	Pr	10,010	1,640	780	12,430	932	11,498	94.7	66.7
TOTAL RABLE		10,710	1,640	780	13,130	984	12,146	100.0	70.5
NON ARABLE									
	M	(Residential)					920		5.3
	6	(River/creek)					3,140		18.2
	Fp	(Fish pond)					60		0.3
	ROW	(Right of the way)					984		5.7
TOTAL NON ARABLE							5,104		29.5
GRAND TOTAL							17,250		100.0

Source: NIA

Table 3.2.5 Farms-Number, by Tenure of Operator and by Municipality, April 1971

Province and Municipality	Number of Farms	Full Owner	Part Owner	Tenunt						Manager	Other Form of Tenure
				Total All Type	Cash	Share of Produce	Amount of Produce	Rent Free	Others		
	(100)	(35)	(22)	(38)							(5)
Pangasinan	89,337	31,093	19,932	34,371	220	29,723	2,793	383	1,252	-	3,943
				(100)	(1)	(86)	(8)	(1)	(4)		
	(100)	(47)	(10)	(49)							
Alaminos	3,744	1,541	383	1,820	-	1,110	658	25	26	-	-
				(100)		(62)	(36)	(1)	(1)		
	(100)	(35)	(24)	(40)						(-)	(1)
Sual	1,107	385	267	443	-	291	121	15	16	1	11
				(100)		(66)	(27)	(3)	(4)		
	(100)	(67)	(5)	(28)							(-)
Mabini	1,251	841	56	353	-	343	-	10	-	-	1
				(100)		(97)		(3)			
	(100)	(56)	(15)	(28)							(1)
Bani	2,929	1,627	431	841	-	651	120	5	65	-	30
				(100)		(77)	(14)	(1)	(8)		
	(100)	(49)	(13)	(38)						(-)	(-)
Total	9,031	4,394	1,137	3,457	-	2,395	899	55	107	1	42
				(100)		(69)	(26)	(2)	(3)		
Project Area	(100)	(35)	(13)	(52)							(-)
Total 1979	6,665	2,332	864	3,445		1,497	1,948	-	-	-	24
				(100)		(43)	(57)				

( ): %

Source: 1971 Census of Agriculture
1979 NIA Agro-Economic Survey

Table 3.2.6 Soil Survey Boring Points

Soil Type	Boring Points Finished By NIA	Additional Boring Points By Study Team	Total
AmAsL	1	2	3
AmAsiL	5	1	6
AmBsL	1	1	2
AmBcL	0	1	1
AmccL	1	0	1
AmDcL	0	1	1
BaAc	5	2	7
BaAcL	1	2	3
BaAsiL	1	1	2
BaBcL	1	0	1
TOTAL	16	11	27

Source: Soil Survey by NIA, 1981

Soil Survey by Feasibility Study Team, 1981

Table 3.2.7 Hectarage Summary of Soil Mapping Units and their Extend
(Mabini Reservoir Project)

Soil Mapping Unit	Soil Series/Type	Area (Ha)	Percent %
AmAsL	Alaminos sandy loam, 0.1-1.0 percent slope	2,510	14.55
AmBaL	Alaminos sandy loam, 1.1-2.0 slopes	710	4.12
AmAsiL	Alaminos silt loam, 0.1-1.0 percent slope	2,960	17.16
AmBcL	Alaminos clay loam, 1.1-2.0 percent slope	400	2.32
AmCcL	Alaminos clay loam, 2.1-3.0 percent slope	830	4.81
AmDcL	Alaminos clay loam, 3.1-5.0 percent	2,980	17.28
	SUB-TOTAL	10,390	60.24
BiAsiL	Bani silt loam, 0.1-1.0 percent slope	620	3.59
BiAcL	Bani clay loam, 0.1-1.0 percent slope	1,700	9.85
BiBcL	Bani clay loam, 1.1-2.0 percent slope	530	3.07
BiAc	Bani clay, 0.1-1.0 percent slope	3,700	21.45
	SUB-TOTAL	6,550	37.96
	Fish pond	60	.35
	Rivers/Creeks	250	1.45
	GRAND TOTAL	17,250	100.00

Table 3 .2. 8 Area Harvested By Crops 1975

Unit; ha

Crops	Alaminos	Bani	Mabini	Sual	Total	Pangasinan
Rice	10,758	3,780	2,529	9,233	26,300	264,917
Corn	365	301	328	223	1,217	16,690
Vegetables	112	37	72	62	283	6,238
Mongo	15	40	20	10	85	11,462
Peanuts	5	30	70	3	108	4,186
Tobacco	25	-	5	-	30	9,452
Sugarcane	10	5	5	3	23	5,186
Coconut	235	248	6	130	619	7,322
Mango	138	95	130	150	513	6,955
Fruit Trees	58	50	50	56	214	3,416
Root Crops	40	30	26	70	166	3,068
Total	11,761	4,616	3,241	9,940	29,558	338,892

Source: Socio-Economic Profile Pangasinan

Table 3.2.9 Agricultural Production by Crops, 1975

Unit; ton

Crops	Alaminos	Bani	Mabini	Sual	Total	Pangasinan
Rice	34,673	8,713	6,295	24,077	73,758	766,478
Corn	182	131	164	104	581	16,690
Vegetables	867	337	1,292	166	2,662	60,053
Mongo	8	22	11	5	46	6,440
Peanuts	8	47	110	5	170	6,594
Tobacco	13	-	3	-	16	5,947
Sugarcane	60	30	30	18	138	32,629
Coconut	654	565	7	382	1,608	18,514
Mango	208	143	195	66	612	11,605
Fruit Trees	81	58	58	58	255	3,136
Root Crops	102	74	241	21	438	10,383
Total	11,761	4,616	3,241	9,940	29,558	338,892

Source: Socio-Economic Profile Pangasinan

TABLE 3.2.10 PADDY: AREA PLANTED AND AREA HARVESTED FROM JULY 1980 TO JUNE 1981 in FOUR TOWNS

MUNICIPALITIES	IRRIGATED		RAINFED		UPLAND		2ND CROP		TOTAL	
	Area Planted	Area Harvested	Area Planted	Area Harvested	Area Planted	Area Harvested	Area Planted	Area Harvested	Area Planted	Area Harvested
Alaminos	1182	1176	6036.8	5983	180.3	178	646.2	643	8055.5	7980
Bani	318	317	4438	4403	166.0	163	29.4	29	4951.4	4912
Mabini	225.5	224	2013	1983	91.5	90	40.3	40	2370.3	2337
Sual	844.5	824	2543.2	2513	137.0	134	366.1	364	3890.8	3853
TOTAL	275.0	2559.0	15031.0	14882.0	575.0	565.0	1082.0	1076.0	19258.0	19082

* Preliminary estimates

Difference between planted and harvested area is caused by:

1. Erosion of farm usually flooded during the typohoon season
2. Insufficient water supply during booting stage.
3. Total damage due to pest and diseases.
4. Damage caused by rodents and Animals.

Source: Ministry of Agriculture, Bureau of Agricultural Economics, Alaminos, Pangasinan

Table 3.2.11 Paddy Yield

(ton/ha)

Municipality	Year	Wet Season			Dry Season
		Irrigated	Rainted	Upland	Irrigated
Alaminos	1977	3.29	2.05	1.56	0.33
	1978	3.98	2.06	1.60	3.35
	1979	3.74	2.29	1.75	3.30
	1980	3.80	2.50	1.70	4.88
	1981	3.05	1.90	1.13	2.35
Bani	1977	2.29	1.78	1.39	0.25
	1978	2.19	1.83	1.65	2.75
	1979	2.47	1.89	1.60	2.70
	1980	2.55	1.90	1.55	2.81
	1981	2.15	1.85	1.00	1.80
Mabini	1977	2.26	0.87	1.15	2.75
	1978	2.98	1.45	1.05	2.88
	1979	2.98	1.90	1.20	2.85
	1980	3.05	1.65	1.20	2.85
	1981	3.00	1.35	0.85	-
Sual	1977	3.85	2.20	1.76	3.25
	1978	4.00	2.15	1.80	3.45
	1979	3.85	2.10	1.80	3.50
	1980	3.50	2.25	1.45	3.70
	1981	3.00	1.65	0.95	2.05

Table 3.2.12 Farms - Number, by Size and Municipality, April 1971

Province and Municipality	Total Number of Farms	Under 1 Ha	1 And Under 3 Ha	3 Ha And Under 5 Ha	5 Ha And Under 10 Ha	10 Ha And Under 25 Ha	25 Ha and Over
Pangasinan	89.305	19.237	53.702	12.909	2.662	508	86
	(100)	(22)	(60)	(14)	(3)	(1)	(-)
Alaminos	3.739	324	2.647	678	75	13	2
	(100)	(9)	(71)	(17)	(2)	(1)	(-)
Sual	1.149	120	655	291	58	20	5
	(100)	(10)	(57)	(25)	(5)	(2)	(1)
Mabini	1.244	89	726	327	68	33	1
	(100)	(7)	(58)	(26)	(6)	(3)	(-)
Bani	2.929	350	1.780	557	183	54	5
	(100)	(12)	(61)	(19)	(6)	(2)	(-)
Project Area Total 1971	9.061	883	5.808	1.853	384	120	13
	(100)	(10)	(64)	(20)	(4)	(2)	(-)
Project Area Total 1979	6.665	1.620	4.281			764	
	(100)	(25)	(65)			(10)	

Source: 1971 Census of Agriculture.
1979 NIA Agro-Economic Survey.

Table 3.2.13 Fragmentation of Farmland by Municipality

April, 1971

Province & Municipality	Total No. of Farms		Farm Number by Parsel		
		1	2-3	3-5	6 and more
Pangasinan	89.305 (100)	35.095 (39)	41,485 (46)	94.93 (11)	3232 (4)
Alaminos	3.744 (100)	2.307 (62)	1.256 (34)	93 (3)	28 (1)
Sual	1.155 (100)	689 (60)	632 (37)	28 (2)	6 (1)
Mabini	1.251 (100)	946 (76)	276 (23)	9 (1)	0
Bani	2.929 (100)	1701 (50)	1093 (37)	120 (4)	15 (12)

Source: 1971 Census of Agriculture

Note: Parcel is a piece of land in the holding

Table 3.2.14 EXISTING IRRIGATION SYSTEMS

PROVINCE: Pangasinan

ZONE I Name of System	Municipalities Covered	Potential Service Area (Has)	Irrigated Area (Has)		Type of Diversion	Source of Water Supply	Reliable flow (Liters/sec)	
			Wet	Dry			Wet	Dry
BANI								
Garita	Bani	320	50	-	Reservoir	Reservoir	240	25
Ambabaay	- do -	65	40	0	Reservoir	Ambabaay	-	-
ALAMINOS								
Alos-Con-Coning	Alaminos	435	435	400	Perm. "D"	Conconing	2728	1840
Alos-Pasi	- do -	356	356	300	Perm. "D"	Linsangsangan River	2000	1200
Salapsap-Amandiego	- do -	301	301	190	Perm. "D"	Alaminos	3500	1600
Upper Tawin-Tawin	- do -	75	75	-	Perm. "D"	Inerongan	300	100
Lower Tawin-Tawin	- do -	50	50	-	Perm. "D"	Inerongan	200	100
Cabatuan	- do -	100	100	80	Perm. "D"	Alaminos River	3800	1800
Balangobong	- do -	180	180	100	Perm. "D"	Alaminos River	3800	1000
Bugarin	- do -	202	202	-	Perm. "D"	Bugarin Creek	500	100
Tokoo-Palamis	- do -	200	180	120	Pumps	Alaminos	3500	1000
MABINI								
Calzada	Mabini	125	125	70	Pump	Mabini River	7000	2000
Magalong	- do -	61	61	-	Pump	Mabini River	7000	3000
SUAL								
Camagsese	Sual	552	552	400	Perm. "D"	Siwasiw River	1800	500
Victoria	- do -	155	145	75	Perm. "D"	Yungtog River	1500	200
Paitan	- do -	30	25	22	Pump	Caoayan River	-	-

CHAPTER 4

HYDROLOGY & METEOROLOGY

4. Hydrology & Meteorology

4.1. Available Hydrological and Meteorological Data

4.1.1. Meteorological Data

As shown in Figure 4.1.1, the existing meteorological stations in the project area and at its vicinity are as follows.

- Dagupan City Meteorological Observation Station and Mabini Pluviometric Observation Station, operated and controlled by the PAGASA.
- Evaporation Observation Station of San Roque, San Manuel, which was under the responsibility of the BPW.
- Pluviometric and Evaporation Observation Station of Mabini, which started its operation in December, 1979, under the responsibility of the NIA.

In all observation stations mentioned above, the evaporation is measured by means of the open rim pan.

The recording periods of meteorological data monthly average values of each observation station are summarized in Figure 4.1.2 and Table 4.1.1.
open-rim pan.

The monthly average temperature and the monthly average relative humidity data collected at the meteorological observation station of the Dagupan City are summarized in Table 4.1.2 and Table 4.1.3, respectively, the monthly evaporation of San Manuel in Table 4.1.4, and the monthly rainfall data of Mabini collected by the PAGASA, are summarized in Table 4.1.5

4.1.2. Hydrological Data

As shown in Figure 4.1.1, the observation stations related to the river runoff of the Balincaquin River, where the Mabini reservoir is planned, are as follows.

- Mabini Gauging Station, which was operated and controlled in the past under the responsibility of the BPW.
- Mabini Observation Station, constructed in the Balincaguin River in December, 1979 by the NIA.

The recording period of hydrological data of the stations are indicated in Figure 4.1.2.

The monthly runoff data of the Balincaguin River, measured at the Mabini Observation Station of the BPW are summarized in Table 4.1.6, while the monthly runoff data of the planned dam-site, estimated from the data recorded at the Mabini Observation Station of the BPW, by taking into consieration the basin area ratio, are presented in Table 4.1.7.

4.2. Basic Drought Year

The water balance analysis described later was made based upon the reference drought year. The basic drought year is assumed to be the drought year with non-exceedance probability of 1/5 adopted for the irrigation project. The basic drought year is determined from the frequency analysis regarding the annual rainfall data (Babini Observation Station of the BPW, Period: 1956 through 1980) and the annual runoff data (Balincaguin River Observation Station of the BPW, Period: 1959 through 1974).

According to the rainfall data, the following six years were much drier than other years in the project area.

Year	Rainfall (mm)	Order
1959	1996.9	1
1962	2717.9	6
1968	2668.2	5
1971	2441.6	2
1973	2449.4	3
1977	2658.0	4

The rainfall data presented in the table above are approximately 15% through 40% smaller than the average rainfall, i.e., 3143.7mm.

Regarding the runoff, the annual runoff taking place at the area located upstream of the Mabini Observation Station of the Balincaguin River is as follows.

Year	Runoff (MCM)	Order
1962	493.94	5
1964	491.11	4
1965	420.17	2
1968	359.17	1
1970	429.37	3
1971	495.63	6

The data presented in the table above are approximately 10% through 35% smaller than the annual average runoff of 557.10MCM.

Results of the frequency analysis are as follows.

Probability of Non-exceedance	Rainfall (mm)	Runoff (MCM)
2 - year	3138.9	494.4
3 - year	2881.7	464.0
5 - year	2650.0	433.6
10 - year	2423.9	400.0
20 - year	2259.4	371.8

According to the results of the frequency analysis, the annual rainfall of 2668.2m of 1968 and the annual runoff of 429.3MCM of 1970 correspond to those ones of a drought year, taking place once every approximately 5 years.

Accordingly, the basic drought year is assumed to be 1968.

4.3. Flood Runoff

4.3.1. General

The study of the flood of the Mabini Dam Project was carried out based upon the following manners.

- Design rainfall based upon the concept of Probable Maximum Precipitation (PMP) corresponding to the torrential rain data collected at the Baguio Observation Station of the Luzon Island by the NIA.

- Determination of the unit hydrograph based upon the adimensional graph method applied to the major flood runoff data collected by the BPW at the Mabini Observation Station of the Balincaguin River.

4.3.2. Design Rainfall

The design rainfall is obtained from the maximum rainfall consecutive time curve, and as a matter of fact, data regarding its envelope curve are collected at the Baguio Observation Station of the Luzon Island.

In order to estimate the design rainfall, several kinds of adjustments were carried out in the envelope curve, aiming at attaining the generalization from the local peculiarities of the observed envelope curve. The three types of adjustments listed below are carried out in the first place in the envelope values. Next, an adjustment was made by applying a modification to the average fainfall of the basin.

1) Maximization of the rainfall
2) Shifting of the rainfall
3) Overall adjustment factor

4.3.3. Unit Hydrograph

The unit hydrograph of the dam site is artificially obtained by applying the adimensional graph method to the flood runoff data collected by the BPW at the Mabini Observation Station of the Balincaguin River, because simultaneous data regarding the river discharge and the rainfall are not available.

The obtained unit hydrograph is shown in Figure 4.3.1.

4.3.4. Planned Flood Runoff

Intencity of the effective rainfall is estimated by applying the readjustment described below to the design rainfall estimated in advance as described above, and by subtracting an initial loss and a retention loss from a value obtained as a result of the adjustment.

- In the first place, the design rainfall is increased up to the 3rd day, followed by a gradual reduction up to the end of the rainfall.
- The rainfall consecutive time is assumed to be 108 hours (4.5 days), based upon conclusions obtained from analysis of data observed at the central Luzon and other regions.

Accordingly, the planned flood discharge is estimated by applying the effective rainfall intensity to the unit hydrograph at the damsite. The peak value of the planned flood rainfall calculated as described above is 4,000m^3/s. The planned flood hydrograph obtained by such steps of procedure is shown in Figure 4.3.2.

The frequency analysis of the annual flood peak discharge recorded from 1959 to 1974 at the Mabini Observation Station of the Balincaguin River is carried out, aiming at grasping the frequency of the peak discharge of 4,000m^3/s of the design flood discharge.

The study regarding the frequency analysis is carried out by means of two types of distribution, namelly, the Hazen Distribution and the Log Pearson Type III Distribution.

The frequency curves calculated by means of the two methods are plotted on the same graph for the sake of comparison, as shown in Figure 4.3.3. From the point of view of the state of conformity of the two curves with the measured values, the Hazen method seems to present a better coincidence with the measured value compared with the Log Pearson Type III method.

It is concluded that the frequency of the peak value (4,000m^3/s) of the planned flood discharge corresponds to approximately 1/5,500, from the frequency curve of the peak discharge.

On the other hand, the maximum specific flood discharge actually measured throughout the whole west coast of the Luzon Island and the specific design flood discharges prevailing in other dam projects are plotted in graphs as shown in Figure 4.3.4, aiming at grasping the relative magnitude of the specific design flood discharge. As can be seen from the graph, the specific design flood discharge of 17.8m^3/s/Km^2 estimated in the Mabini dam project can be judged as an appropriate magnitude. The comparison with other dam projects, regarding the total value of the design flood discharge is shown in Table 4.3.1.

4.3.5 Flood Discharge to be Temporarily Drained during the Construction Work

The flood discharge to be provisionally drained during the construction period is assumed to that one equivalent to an exceedance probability of 1/20, according to the results of frequency analysis based upon the maximum annual flood discharge data collected by the BPW at the Mabini Observation Station of the Balincaguin River.

Results of the frequency analysis are presented in the table below. The design flood discharge for the planning of the provisional drainage facilities is estimated at 1,500m^3/s from the data of the table below.

Probability	Peak Discharge (m^3/s)	
	Gauging Station at Mabini	Proposed Dam-site
10 - year flood	1310	1220
20 - year flood	1594	1485
50 - year flood	2000	1860
100 - year flood	2273	2115

NOTE) Drainage area

BPW (Mabini) Gauging Station	242Km^2
Proposed dam-site	225Km^2
Drainage area ratio	0.93 (=225/242)

4.4. Sedimentation

4.4.1. Estimation of the Design Sedimentation

The design sedimentation is estimated to be 29 MCM, as shown below, by making the calculations in terms of sedimentation taking place during a period of 100 years.

Basin area	225Km^2
Catching efficiency of the reservoir	Approximately 100% (Estimated by the Brune's method)
Annual sedimentation Volume	1670 tons/Km^2/year = 1,285 m^3/Km^2/Year (Assuming that 1m^3 = 1.3 tons)

Annual sedimentation

$225Km^2 \times 1,285m^3/Km^2/Year = 0.29$ MCM/year

Sedimentation in 100 years

100 year x 0.29 MCM/year = 29 MCM.

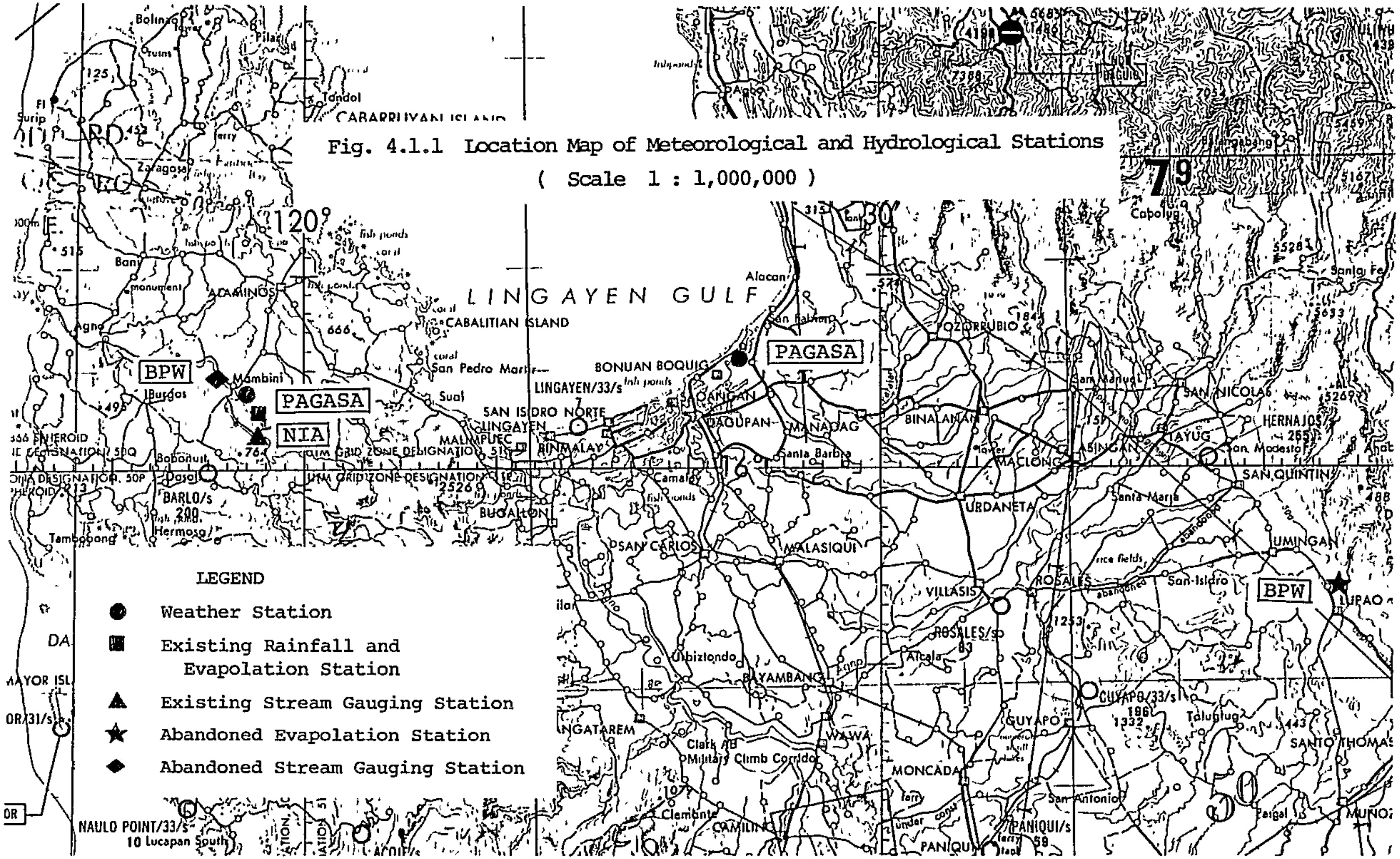


Fig. 4.1.1 Location Map of Meteorological and Hydrological Stations

(Scale 1 : 1,000,000)

Fig. 4-1-2. Meteorological and Hydrological Records

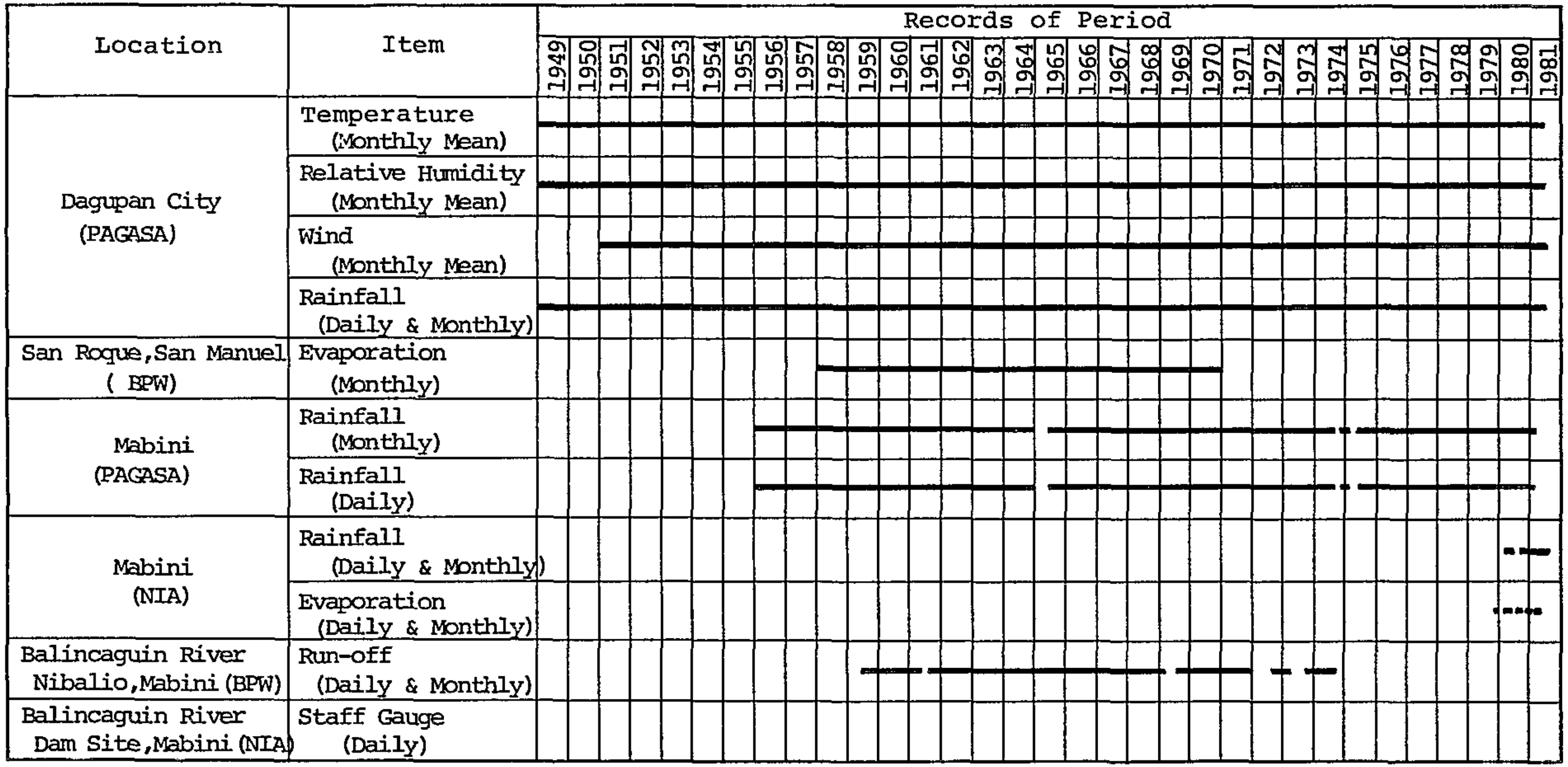


Table 4-1-1 Climatological Data

Item	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
Mean Monthly Rainfall (mm) /1	12.9	7.1	24.6	62.1	267.1	514.1	638.1	813.7	499.3	202.9	72.7	20.1	3134.7
Monthly Mean Relative Humidity (%) /2	73	72	71	70	75	81	83	85	84	79	77	75	-
Monthly Mean Temperature (°C) /2	26.0	26.7	28.2	29.6	29.6	28.8	28.2	27.7	27.9	28.1	27.3	26.6	-
Mean Monthly Evaporation /3	184.5	203.4	250.2	259.0	230.1	146.9	139.0	134.3	118.8	142.2	139.5	159.0	2106.9
Wind Velocity (km/hr) /4	10.0	11.1	11.9	12.0	10.2	9.0	8.3	8.0	8.3	9.2	9.0	9.1	-
Prevailing Wind Direction /4	SSE	SSE	NNW	NNW	SE	SE	SE	SE	SE	SE	SE	SE	-

Notes: /1 Period of observation 1956 - 1980 at Mabini, Pangasinan

/2 Period of observation 1949 - 1980 at Dagupan City

/3 Period of observation 1958 - 1970 at San Manuel, Pangasinan

/4 Period of observation 1951 - 1980 at Dagupan City

Table 4-1-2 Monthly Mean Temperature
Dagupan City

Unit: °C

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL		
													MAX.	MIN.	MEAN
1949	25.3	26.8	28.3	29.8	30.6	28.9	28.2	28.4	28.0	27.9	27.2	26.6	30.6	25.3	28.0
1950	26.7	26.8	27.9	29.5	29.8	28.7	27.9	27.7	28.2	27.8	27.2	25.4	29.8	25.4	27.8
1951	26.1	26.9	28.2	29.8	29.0	28.4	28.6	27.7	28.4	28.6	27.7	26.9	29.8	26.1	28.0
1952	26.9	27.4	28.9	29.6	30.1	28.9	28.6	27.8	28.1	28.7	27.4	27.1	30.1	26.9	28.3
1953	26.0	27.3	29.0	30.0	29.4	28.9	28.3	27.9	28.3	28.8	27.6	27.2	30.0	26.0	28.2
1954	27.0	27.2	28.6	30.1	30.5	29.4	28.9	27.8	27.6	27.8	27.8	26.4	30.5	26.4	28.3
1955	26.0	29.2	28.0	29.3	30.1	28.9	28.1	28.1	28.6	28.3	27.4	25.1	30.1	25.1	28.1
1956	26.1	26.6	28.4	29.1	29.4	29.0	28.4	27.6	27.0	28.3	27.3	26.4	29.4	26.1	27.8
1957	26.4	26.2	28.4	29.4	29.9	28.0	28.4	28.2	28.0	28.2	26.6	27.2	29.9	26.2	27.9
1958	26.7	26.9	29.0	29.8	30.8	30.0	28.2	28.2	27.8	28.5	26.8	26.2	30.8	26.2	28.2
1959	25.4	26.8	28.4	29.7	29.7	30.0	28.8	27.7	28.2	28.0	27.6	27.2	30.0	25.4	28.1
1960	26.8	27.3	28.4	29.1	29.7	28.7	28.8	27.4	28.3	27.7	27.8	26.5	29.7	26.5	28.0
1961	24.9	26.8	28.8	30.1	29.5	28.6	27.4	27.7	27.7	27.6	27.2	26.9	30.1	24.9	27.8
1962	25.4	25.9	28.4	29.5	30.1	29.0	27.7	28.3	28.0	28.5	27.1	26.9	30.1	25.4	27.9
1963	24.9	25.7	27.4	29.3	30.4	27.4	27.9	28.5	28.0	28.7	28.2	26.9	30.4	24.9	27.8
1964	27.1	26.8	28.2	30.0	29.5	28.7	28.3	27.6	28.0	28.0	26.7	25.9	30.0	25.9	27.9
1965	25.1	26.6	27.5	29.0	28.6	28.2	27.5	28.3	28.4	28.7	28.4	27.3	29.0	25.1	27.8

Table 4-1-2 (Continued)

Unit: °C

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL		
													MAX.	MIN.	MEAN
1966	26.8	27.9	29.2	30.1	28.3	29.6	29.0	28.4	27.1	28.7	27.6	27.5	30.1	26.8	28.4
1967	26.2	26.1	27.4	29.1	29.9	27.9	28.2	26.9	27.8	27.3	27.0	25.5	29.9	25.5	27.4
1968	25.8	25.2	27.9	28.6	29.3	29.3	28.4	27.0	27.9	28.2	26.8	26.5	29.3	25.2	27.6
1969	26.8	25.8	28.2	29.8	30.1	29.2	28.0	28.1	27.7	28.3	27.2	27.0	30.1	25.8	28.0
1970	26.5	26.6	28.6	29.9	29.8	28.4	28.1	27.1	27.2	27.8	26.9	28.0	29.9	26.5	27.9
1971	24.6	26.3	26.8	28.6	28.5	28.0	27.6	27.8	27.8	27.4	26.7	26.0	28.6	24.6	27.2
1972	25.8	26.0	26.0	28.9	28.9	28.4	25.8	26.3	28.4	28.3	28.4	26.5	28.9	25.8	27.3
1973	25.8	27.3	27.7	29.8	29.7	28.4	27.7	26.9	27.7	27.0	26.9	25.8	29.8	25.8	27.6
1974	26.0	27.1	28.0	29.9	29.6	28.6	28.7	27.1	28.6	27.7	27.1	27.1	29.9	26.0	28.0
1975	26.9	27.0	28.3	29.6	30.0	28.9	28.3	27.5	28.3	27.8	27.4	26.6	30.0	26.6	28.1
1976	25.8	26.6	28.3	29.9	28.3	28.2	28.5	27.3	27.7	28.7	27.8	26.6	29.9	25.8	27.8
1977	27.2	26.1	27.6	30.1	30.0	29.5	28.6	28.2	27.1	28.9	27.8	26.5	30.1	26.1	28.1
1978	25.8	26.3	28.8	29.5	29.4	28.0	27.6	26.9	27.5	27.0	26.7	26.8	29.5	25.8	27.5
1979	25.3	26.5	28.3	30.1	28.5	29.1	28.5	27.3	28.6	27.4	26.9	25.3	30.1	25.3	27.7
1980	25.0	26.2	28.0	29.5	29.4	29.5	27.9	28.2	28.0	28.2	27.5	25.8	29.5	25.0	27.8
MEAN	26.0	26.7	28.2	29.6	29.6	28.8	28.2	27.7	27.9	28.1	27.3	26.6	29.6	26.0	27.9

Table 4-1-3 Monthly Mean Relative Humidity
Dagupan City

Unit: %

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL		
													MAX.	MIN.	MEAN
1949	73	75	79	77	71	84	89	86	88	85	82	81	89	71	81
1950	79	78	74	74	76	84	86	84	82	80	74	74	86	74	79
1951	76	72	72	71	76	83	82	86	86	82	80	77	86	71	79
1952	73	74	70	70	74	80	81	84	84	79	81	77	84	70	77
1953	72	71	68	70	75	76	82	85	82	78	82	77	85	68	77
1954	73	74	70	70	70	75	80	85	85	82	78	74	85	70	76
1955	74	72	66	70	72	76	82	83	80	78	78	73	83	66	75
1956	77	77	70	72	73	77	82	84	81	79	77	77	84	70	77
1957	75	73	72	70	70	82	81	84	83	78	75	78	84	70	77
1958	73	74	68	66	68	83	84	82	85	80	74	74	85	66	76
1959	73	69	70	68	73	75	81	85	82	77	76	75	85	68	75
1960	74	73	71	75	76	80	82	88	85	80	73	73	88	71	78
1961	71	72	71	68	77	81	85	85	86	82	74	74	86	68	77
1962	72	68	73	71	71	80	85	82	84	75	74	69	85	68	75
1963	69	68	67	67	70	86	84	83	86	76	75	77	86	67	76
1964	74	70	72	64	76	82	83	88	86	83	85	80	88	64	79
1965	74	72	73	71	79	82	85	85	86	76	77	73	86	71	78

Table 4-1-3 (Continued)

Unit: %

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL MAX.	ANNUAL MIN.	ANNUAL MEAN
1966	74	74	70	70	87	79	82	84	86	77	83	78	87	70	79
1967	73	70	72	73	72	85	86	88	84	82	76	76	88	70	78
1968	73	74	72	69	76	78	85	88	84	77	71	74	88	69	77
1969	74	74	73	72	76	82	85	84	88	80	75	74	88	72	78
1970	74	70	71	70	74	82	84	88	84	82	77	77	88	70	78
1971	71	71	68	70	78	82	82	78	83	82	78	76	83	68	77
1972	75	73	69	71	77	80	92	88	81	75	71	76	92	69	77
1973	74	69	66	64	72	80	82	87	80	80	76	72	87	64	75
1974	65	73	69	74	74	82	80	88	81	84	79	75	88	65	77
1975	70	67	71	66	76	79	82	86	82	82	74	73	86	66	76
1976	75	69	71	67	81	81	81	83	84	76	75	75	84	67	77
1977	76	70	74	67	72	77	82	82	89	73	77	70	89	67	76
1978	71	70	72	70	75	82	84	89	86	81	78	77	89	70	78
1979	73	71	71	71	77	86	81	84	75	79	79	72	86	71	77
1980	75	74	70	65	76	77	84	85	88	79	82	61	88	61	76
MEAN	73	72	71	70	75	81	83	85	84	79	77	75	85	70	77

Table 4-1-4 Monthly Evaporation
San Roque, San Manuel, Pangasinan

Unit:mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL	
													TOTAL	MEAN
1958	229.9	203.7	293.1	313.4	282.2	142.8	147.3	164.1	123.2	145.3	179.6	207.3	2431.9	202.7
1959	205.5	235.2	281.9	311.9	256.0	233.1	168.2	140.5	155.4	178.6	176.0	203.7	2546.0	212.2
1960	211.8	222.2	264.6	234.4	226.1	155.4	169.4	122.2	129.3	153.7	193.0	186.7	2268.8	189.1
1961	242.6	221.2	257.1	283.7	192.3	144.0	106.7	121.2	108.5	106.2	133.4	147.1	2064.0	172.0
1962	165.1	203.4	224.8	203.5	201.7	155.2	105.7	121.4	96.0	134.6	146.6	174.5	1932.5	161.0
1963	180.1	198.1	179.8	256.5	254.8	114.8	106.4	124.0	97.0	141.2	140.5	145.8	1939.0	161.6
1964	172.0	228.8	253.0	269.0	191.8	121.7	142.5	111.8	112.8	121.2	84.1	120.7	1929.4	160.8
1965	144.5	153.9	204.0	197.0	197.2	145.5	151.4	149.1	128.8	164.6	136.1	171.1	1943.2	161.9
1966	162.0	195.5	282.2	269.9	215.3	128.5	146.1	166.4	114.6	170.1	113.6	137.5	2101.7	175.1
1967	174.2	225.4	286.6	269.4	290.1	135.3	167.1	118.3	142.6	167.6	148.0	199.0	2323.6	193.6
1968	211.5	218.2	290.5	279.3	251.1	156.0	132.2	115.5	122.9	122.6	136.0	128.2	2164.0	180.3
1969	145.4	180.0	236.7	245.6	260.2	145.6	144.9	170.5	106.8	116.6	120.7	136.8	2009.8	167.5
1970	153.9	158.9	197.9	232.8	172.6	131.3	118.6	120.4	106.3	126.8	106.1	108.1	1733.7	144.5
MEAN	184.5	203.4	250.2	259.0	230.1	146.9	139.0	134.3	118.8	142.2	139.5	159.0	2106.9	175.6

Note: Open rim pan evaporation

Table 4-1-5 Monthly Rainfall
Mabini, Pangasinan

Unit:mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	
													MAY - OCT	ANNUAL
1956	2.5	0.3	11.4	84.7	290.4	459.0	325.6	577.2	967.1	155.2	262.9	14.8	2774.5	3151.1
1957	23.4	T	141.7	50.8	103.1	737.2	983.7	821.8	725.2	134.6	8.4	17.0	3505.6	3746.9
1958	T	4.8	37.8	6.9	197.0	831.0	1010.1	357.2	784.3	194.7	2.5	13.7	3374.3	3440.0
1959	4.9	2.5	105.7	69.9	218.4	194.9	185.3	704.2	332.2	147.9	14.5	16.5	1782.9	1996.9
1960	4.3	85.6	31.0	74.0	201.0	480.6	375.7	1673.3	187.8	205.9	5.9	24.6	3124.3	3349.7
1961	0.0	0.0	72.8	39.1	204.3	986.2	821.9	586.2	415.3	215.5	18.1	T	3229.4	3359.4
1962	T	2.0	8.7	24.4	188.1	326.3	1012.4	421.0	602.8	68.0	43.7	20.5	2618.6	2717.9
1963	7.6	19.5	T	5.1	266.6	1218.0	395.3	755.0	752.1	222.6	73.7	38.6	3609.6	3754.1
1964	0.0	T	37.7	128.4	382.5	580.1	239.3	974.3	295.2	429.0	274.7	7.6	2900.4	3348.8
1965	*	*	*	*	*	657.1	592.9	550.1	327.9	82.0	51.0	25.3	-	-
1966	30.8	T	T	131.6	571.1	275.5	349.2	370.9	1399.5	52.3	281.7	52.2	3018.5	3514.8
1967	0.8	T	T	53.4	152.4	1099.2	580.9	970.0	355.3	373.6	162.8	1.8	3531.4	3750.2
1968	3.3	1.8	0.8	39.7	174.0	237.2	523.0	1013.2	520.2	128.3	24.9	1.8	2595.9	2668.2
1969	15.5	19.8	13.2	52.7	327.4	432.4	1044.7	826.2	656.1	221.6	60.6	0.5	3508.4	3670.7
1970	42.3	T	36.9	66.9	276.9	664.9	693.1	892.3	536.9	181.7	112.1	20.1	3245.8	3524.1
1971	2.5	15.3	0.5	118.5	126.4	390.3	336.5	775.7	282.8	331.3	34.5	27.3	2243.0	2441.6
1972	6.0	3.3	30.6	67.5	227.8	503.0	2038.3	1404.8	282.0	37.3	15.9	35.1	4493.2	4651.6

Note: T (Trace): Amount of rainfall is too small to measure.
* : Records are lost.

Table 4-1-5 (Continued)

Unit:mm

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	
													MAY - OCT	ANNUAL
1973	10.4	0.5	17.8	49.2	190.3	253.5	668.6	554.9	290.1	340.9	25.3	47.9	2298.3	2449.4
1974	4.7	T	0.2	65.9	296.8	516.9	383.8	1802.6	68.1	553.2	*	9.1	3621.4	-
1975	*	1.3	1.2	129.3	238.5	254.0	226.2	718.5	306.8	300.2	17.0	48.7	2044.2	-
1976	39.3	10.9	12.8	63.1	808.5	613.1	483.4	415.5	537.6	65.1	2.0	0.5	2923.2	3051.8
1977	82.0	0.0	3.5	23.4	256.1	106.6	551.9	704.0	791.5	16.8	122.2	T	2426.9	2658.0
1978	0.0	T	0.2	45.1	101.2	463.6	566.7	969.3	337.4	269.0	18.5	4.0	2707.2	2775.0
1979	0.0	0.0	2.0	36.6	464.0	192.2	626.2	789.8	256.1	292.5	27.2	72.4	2620.8	2759.0
1980	16.0	2.0	24.9	63.5	148.3	380.9	938.9	715.5	473.4	53.9	84.7	2.0	2710.9	2904.0
MEAN	12.9	7.1	24.6	62.1	267.1	514.1	638.1	813.7	499.3	202.9	72.7	20.1	2935.2	3134.7

Note: T (Trace): Amount of rainfall is too small to measure.

* : No record

Table 4-1-6 Monthly Runoff Data
Balincaguin River, Nibaleo, Mabini, Pangasinan (Drainage Area=242km^2) Unit:MCM

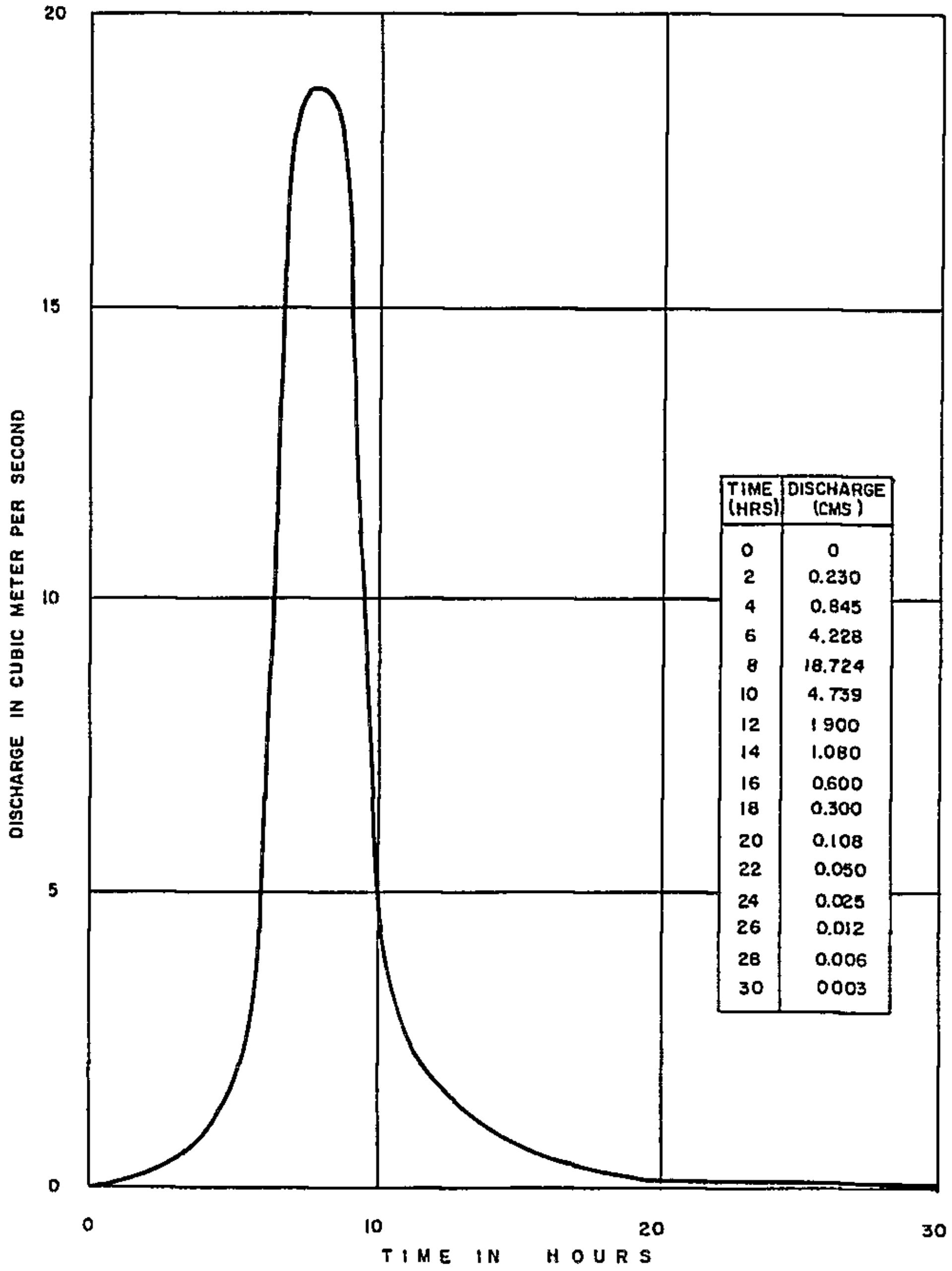
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	
													MAY - OCT	ANNUAL
1959		-	4.10	3.12	8.43	4.82	15.94	90.61	363.51	219.86	131.10	44.88	703.17	-
1960	4.08	3.92	4.17	3.81	8.38	22.53	26.13	341.06	62.43	76.39	31.17	11.43	536.92	595.50
1961	6.75	4.43	4.68	2.33	-	-	-	107.58	130.43	33.49	9.31	7.62	-	-
1962	4.63	2.54	2.47	2.90	3.92	7.41	142.88	102.70	135.56	65.42	14.89	8.62	457.89	493.94
1963	6.20	3.82	3.60	3.39	4.94	112.27	107.45	96.64	146.97	40.75	22.50	10.56	509.02	559.09
1964	7.90	5.96	5.72	4.87	10.25	35.52	24.52	163.07	73.44	88.41	29.24	42.21	395.21	491.11
1965	12.13	4.44	6.10	5.50	24.20	90.57	87.27	84.77	52.95	23.98	18.55	9.71	363.74	420.17
1966	5.86	2.83	2.52	2.50	42.43	57.26	83.04	93.11	176.39	38.73	35.37	15.25	490.96	555.29
1967	8.15	5.93	4.80	4.76	5.12	75.97	79.80	109.05	81.04	72.09	40.25	16.84	423.07	503.80
1968	7.99	5.42	4.66	3.93	4.83	5.87	21.71	99.16	105.84	66.42	23.83	9.51	303.83	359.17
1969	7.93	4.81	3.43	-	-	-	110.59	-	-	65.39	20.03	16.60	-	-
1970	12.03	9.24	8.53	4.79	4.33	3.98	11.90	155.03	73.01	89.84	32.63	24.06	338.09	429.37
1971	31.08	16.74	11.40	4.28	7.69	34.36	61.88	148.64	52.62	89.75	28.84	8.35	394.94	495.63
1972	-	-	-	-	-	-	-	403.51	83.99	33.27	99.37	12.73	-	-
1973	7.43	4.76	-	-	-	-	-	-	48.62	45.37	32.64	19.49	-	-
1974	9.03	3.69	3.59	2.46	4.23	31.59	148.38	346.72	103.58	174.72	-	-	809.22	-
MEAN	9.37	5.61	4.98	3.74	10.73	40.18	70.88	167.26	112.69	76.49	37.98	17.19	478.23	557.10

Table 4-1-7 Monthly Runoff
Balincagin River at Damsite (Drainage Area=225km^2)

Unit:MCM

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL	
													MAY - OCT	ANNUAL
1959		-	3.81	2.90	7.84	4.48	14.82	84.27	338.06	204.47	121.92	41.74	653.94	-
1960	3.79	3.65	3.88	3.54	7.79	20.95	24.30	317.19	58.06	71.04	28.99	10.63	499.33	553.81
1961	6.28	4.12	4.35	2.17	-	-	-	100.05	121.30	31.15	8.66	7.09	-	-
1962	4.31	2.36	2.30	2.70	3.65	6.89	132.88	95.51	126.07	60.84	13.85	8.02	425.84	459.38
1963	5.77	3.55	3.35	3.15	4.59	104.41	99.93	89.88	136.68	37.90	20.93	9.82	473.39	519.96
1964	7.35	5.54	5.32	4.53	9.53	33.03	22.80	151.66	68.30	82.22	27.19	39.26	367.54	456.73
1965	11.28	4.13	5.67	5.12	22.51	84.23	81.16	78.84	49.24	22.30	17.25	9.03	338.28	390.76
1966	5.45	2.63	2.34	2.33	39.46	53.25	77.23	86.59	164.04	36.02	32.89	14.18	456.59	516.41
1967	7.58	5.51	4.46	4.43	4.76	70.65	74.21	101.42	75.37	67.04	37.43	15.66	393.45	468.52
1968	7.43	5.04	4.33	3.65	4.49	5.46	20.19	92.22	98.43	61.77	22.16	8.84	282.56	334.01
1969	7.37	4.47	3.19	-	-	-	102.85	-	-	60.81	18.63	15.44	-	-
1970	11.19	8.59	7.93	4.45	4.03	3.70	11.07	144.18	67.90	83.55	30.35	22.38	314.43	399.32
1971	28.90	15.57	10.60	3.98	7.15	31.95	57.55	138.24	48.94	83.47	26.82	7.77	367.30	460.94
1972	-	-	-	-	-	-	-	375.26	78.11	30.94	92.41	11.84	-	-
1973	6.91	4.43	-	-	-	-	-	-	45.22	42.19	30.36	18.13	-	-
1974	8.40	3.43	3.34	2.29	3.93	29.38	137.99	322.45	96.33	162.49	-	-	752.57	-
MEAN	8.72	5.22	4.63	3.48	9.98	37.37	65.92	155.55	104.80	71.14	35.32	15.99	444.76	518.12

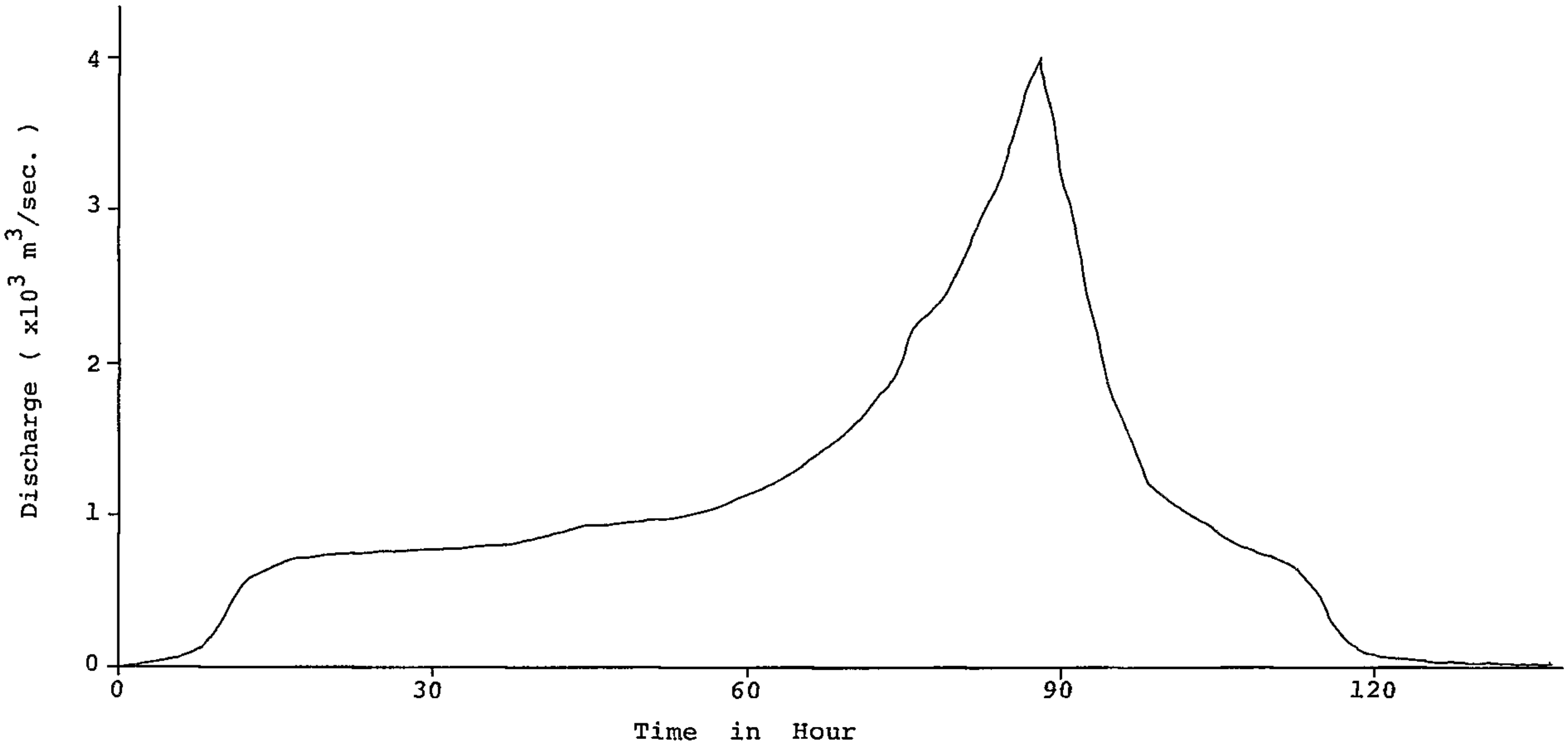
Note: Estimated by drainage area proportion with Balincagin River at Mabini, D.A.= 242km^2



TIME (HRS)	DISCHARGE (CMS)
0	0
2	0.230
4	0.845
6	4.228
8	18.724
10	4.739
12	1 900
14	1.080
16	0.600
18	0.300
20	0.108
22	0.050
24	0.025
26	0.012
28	0.006
30	0003

Fig. 4.3.1 UNIT HYDROGRAPH
MABINI RESERVOIR PROJECT
BALIN BAGUING RIVER
EFFECTIVE DRAINAGE AREA = 209.05 Sq.Kms.
RESERVOIR AREA a MAX.W.S. = 15.95 Sq.Kms.
TOTAL = 225.00 Sq.Kms

Fig. 4-3- 2. Probable Maximum Flood Hydrograph



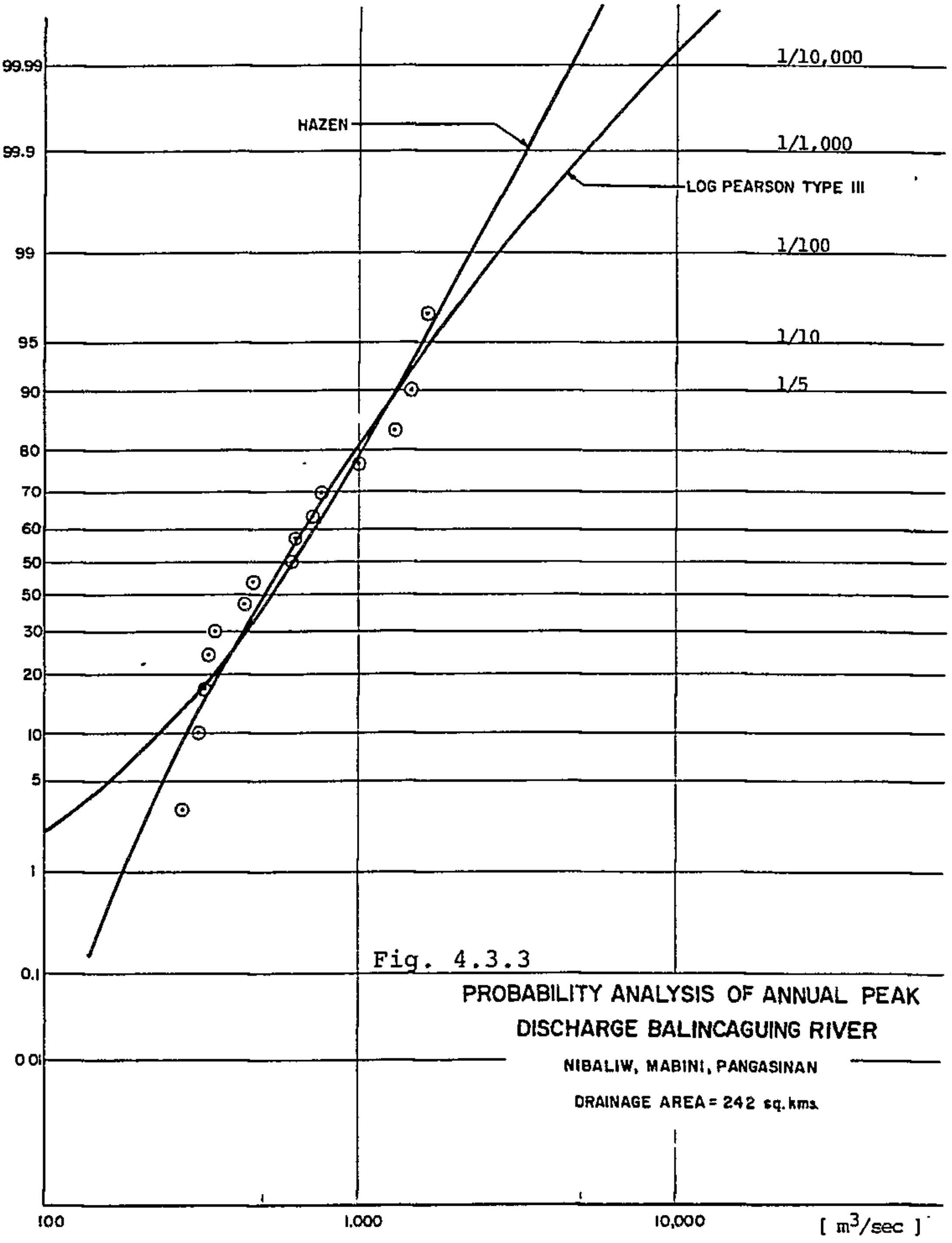


Fig. 4.3.3

PROBABILITY ANALYSIS OF ANNUAL PEAK DISCHARGE BALINCAGUING RIVER

NIBALIW, MABINI, PANGASINAN

DRAINAGE AREA = 242 sq. kms.

Fig. 4.3.4 PEAK DISCHARGE V.S. DRAINAGE AREA

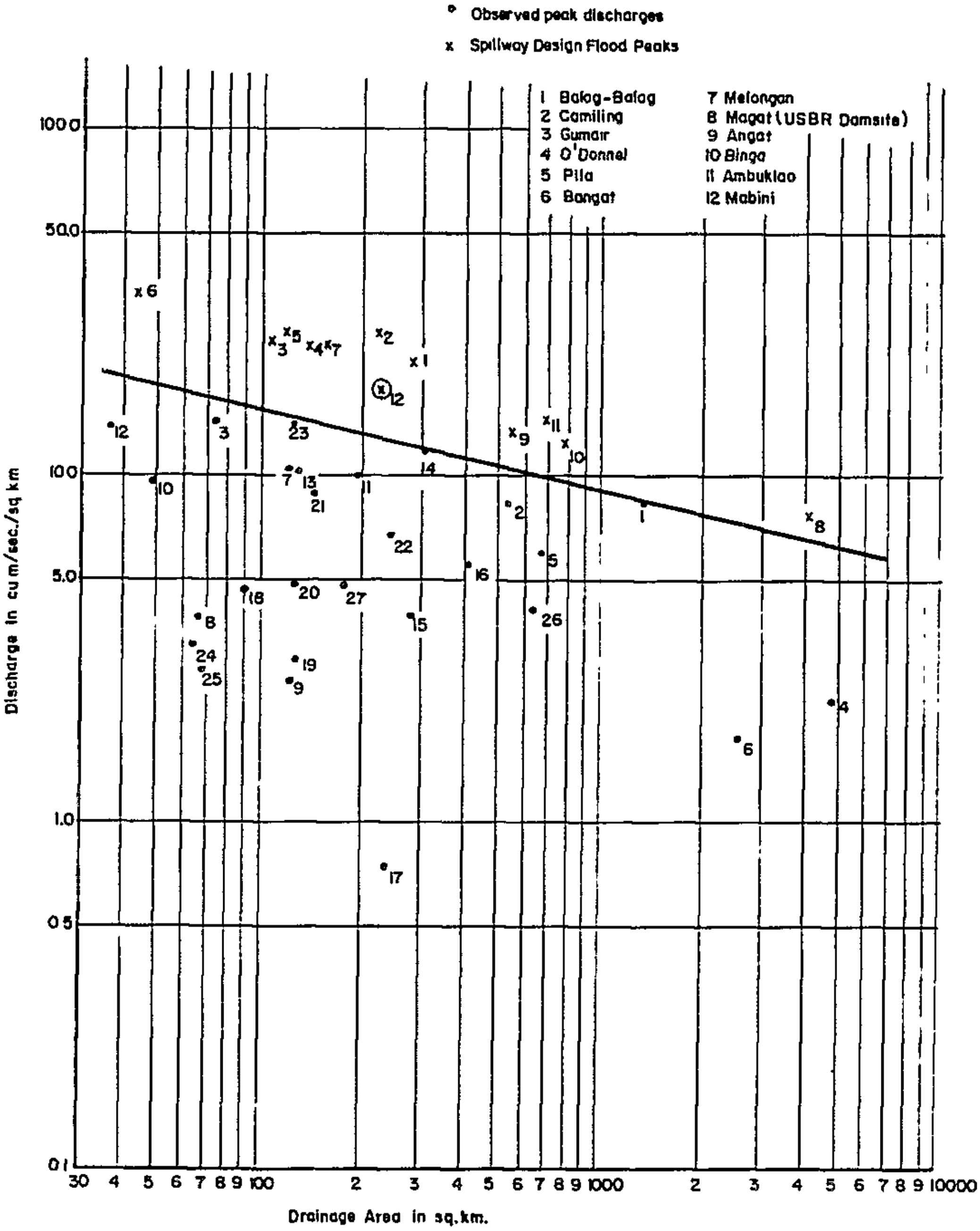


Table 4-3-1 Spillway Design Flood Volumes

Dam Site	Drainage Area(km^2)	Flood Volume	
		Total Volume (MCM)	Volume per km^2 (1000 m^3)
Pantabangan	845.0	1,646.3	1,950
Puncan Mt.	242.0	642.6	2,660
Papaya	124.0	270.3	2,180
Mt.Balintin-gon	223.0	524.5	2,300
Ligaya	477.0	1,071.3	2,250
Kalaanan	89.0	228.2	2,560
Bulu	45.2	105.2	2,330
San Roque	1,221.0	2,877.5	2,360
Tayum	1,159.0	2,746.3	2,370
Lubas	89.0	231.8	2,600
San Nicolas	275.0	681.5	2,480
Sapinit	240.0	595.7	2,480
Balog-Balog	282.0	679.0	2,410
O'Donnoll	139.0	379.0	2,730
Bangat	44.5	131.5	2,960
Camiling	221.0	614.1	2,780
Pila	117.0	332.7	2,840
Mabini	225.0	520.0	2,300

CHAPTER 5

GEOLOGICAL STUDY

5. Geological Study

5.1. Outline of the Geological Studies

A geological survey of the dam site is mainly composed of mechanical drilling carried out by the NIA in 1980. The contents of the field investigation carried out during the feasibility study are as follows.

1) Geological Reconnaissance

Geological mapping of the dam site and reservoir area (Scale: 1/4,000).

2) Drilling Holes

Drilling holes at 11 places were carried out by the NIA from 1980 to 1981. The contents of the drilling are shown in Table 5.1.1.

DH-11, which is one of the cases of drilling listed in the table, carried out at the river deposit of the dam site.

In the studies carried out in 1981 permeability tests are being set forth by using the drilling holes.

At the same time, the standard penetration test is being carried out in layers (of the river deposits of the DH-11 drilling hole) mainly composed of fine particles like fine sand layer, etc., aiming at investigating their density.

Table 5-1-1. List of Contents of the Mechanical Drilling Work

Hole No.	Depth (m)	Elevation (m)	Permiability Test	S.P.T.*	Location	Date Completed	Remarks
DH-1	45.00	36.8	-	-	Left Abutment	Sep. 1980	
2	49.80	22.2	13	-	-do-	May 1980	
3	30.70	-	-	-	Riverbed	1980	
3A	42.55	13.0	3	-	-do-	March 1981	
3B	55.00	21.7	5	-	Right Abutment	May 1981	
5	40.00	29.5	-	-	-do-	Feb. 1980	
7	45.35	14.2	4	-	Riverbed	March 1981	
8	70.00	105.9	11	-	Spillway	July 1981	
9	50.50	91.3	12	-	-do-	Sep. 1981	
10	50.10	112.3	-	-	-do-	Aug. 1981	
11	20.00	26.2	8	4	Riverbed	-	Still Continue
Total	505.00	-	56	4	-	-	

* Standard Penetration Test

3) Seismic Exploration

The seismic exploration is aimed at grasping the underground geological structure underlying at the vicinity of the dam site, through the underground propagation characteristics of elastic waves.

This seismic exploration was carried out by the study team, with the cooperation provided by the NIA.

o Quantitative data regarding the study

Line No.	Length of Line (m)	Location
Line 1	978	Crossing the river
Line 2	982	- do - (Dam axis)
Line 3	955	- do -
Line 4	700	Crossing the dam axis, riverbed
Line 5	600	Spillway
Line 6	400	- do -
Total	4,615	

o Period of study

Field work

- Preparation for measurement
  September 30th to October 5th
- Measurment work
  October 6th to October 20th
- Analysis of the measurement results
  October 21st to November 2nd

o Measurement method

Refraction method using the primary wave (P-wave).
Spacing between measurement points: 5 m and 10m.

o Used measurement instruments

• Recording Oscillograph	Field Graph 32
32 Elements	
Galvanometer	3313: Natural Frequency 370Hz Sensitivity 23.3(m m/mA)
Papper Speed	30cm/sec
• Amplifier	TR-u
24 Channels	
Gain	24dB
Frequency	5-200Hz
Filter	Low Pass Filter 70Hz 12dB/oct.
• Geophones	Natural Frequency 28Hz
• Exploderd	1305 Equipped with Telephones
• Battery	DC12V-6A (Sealed Type)

o Method of analysis

The graphic analysis method based upon the "Hagiwara's Method" was adopted in the present case.

[Method of analysis]

The velocity of an elastic wave propagating in an infinite media is given by the following expression.

$V_p = \sqrt{(\lambda + 2\mu)/\rho}$: Primary Wave (Longitudinal Wave) velocity

$V_s = \sqrt{\mu/\rho}$: Secondary Wave (Transversal Wave) velocity

where

ρ density

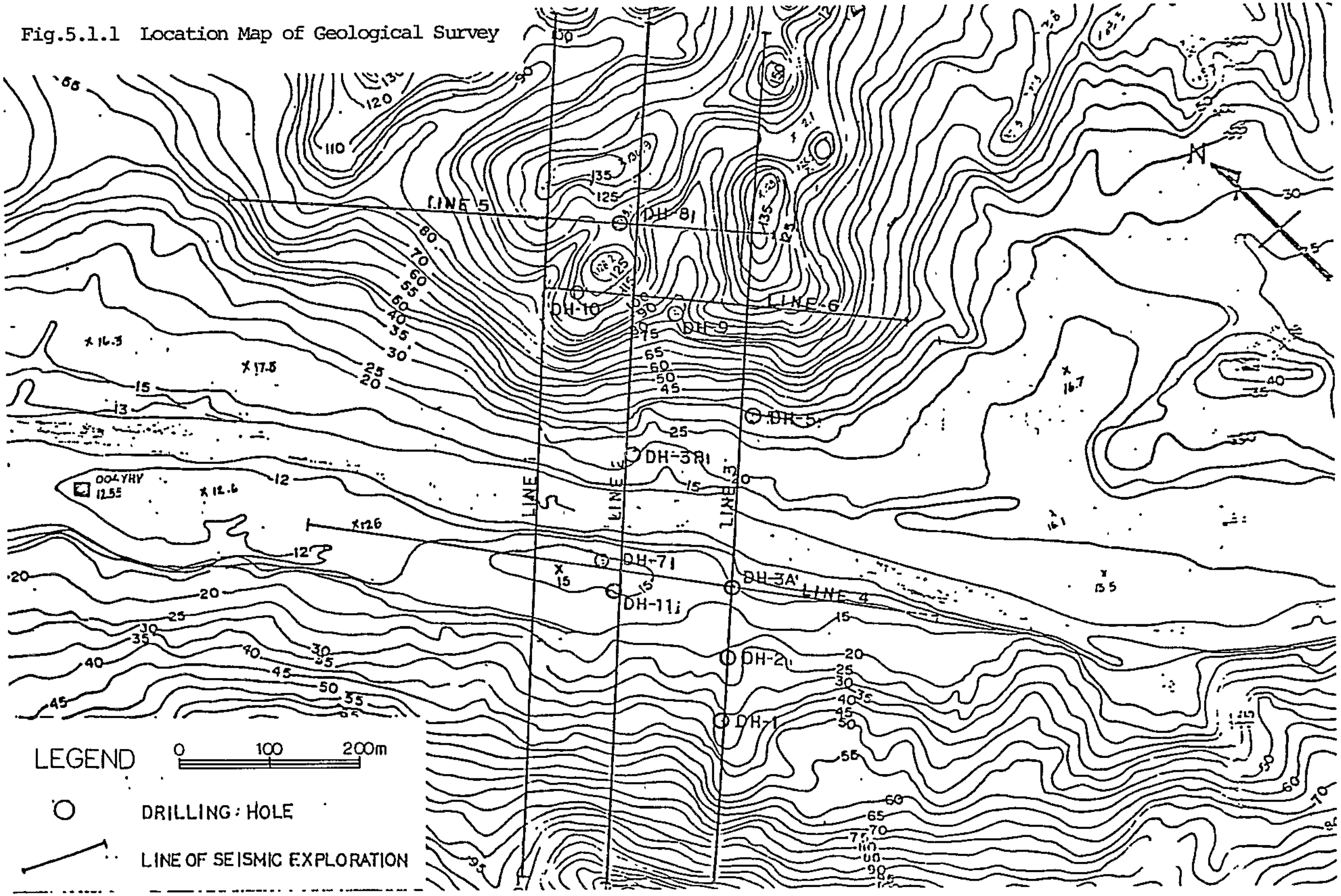
λ Lamé's constant

μ do

In the present case, the analysis is carried out by using the refraction of the P-wave (Primary Wave). As can be seen from the expression above, V_p is related with the rigidity of the media in question, and is a good index to express the physical properties of an elastic body.

The graphic analysis based on the "Hagiwara's Method" was carried out, aiming at classifying the strata (layers) in accordance with the velocity of propagation V_p of the primary wave. The analysis of travel time from each blasting point is carried out by using the stratum cross section drawn out with this method and a comparison is made with the actual travel time. The analysis is concluded by making modifications in the cross section in such a way that the discrepancy between the time of propatation throughout the said cross section and the actually measured value is contained within values of the order of 2 m·sec.

Fig.5.1.1 Location Map of Geological Survey



5.2. Topography and Geology

5.2.1. Topography

The topography of the Luzon Island is influenced by its geological structure, and is characterized by several mountain ranges and plain areas which extend approximately in the N-S direction.

The area where the dam site is planned is located at the northern extremity of the Zambales-Pangasinan Range, which extends throughout the western side of the Luzon Island. The mountain mass in question has the Mt. High Park (Altitude 2,338m) as the principal peak and extends in the NNW-SSE direction, with the South China Sea located at its west side and the Philippine Rift Fault at its east side.

As can be presumed from the description presented above, this mountainous district is dissected by the tributaries of major rivers like the Agno River, Tarlac River, Panpanga River, etc., which flow at the plain region located at the east side of the area in question and by a large number of rivers located at the west side which discharge directly in the South China Sea.

The Mabini dam-site is planned in the Balincaguin River, which originates from the mountain mass of the NNW part of the Zambales-Pangasinan mountain range, approximately 5Km to the SE direction of the center of the town of Mabini. The downstream of the Balincaguin River passes through Agno and discharges into the South China Sea approximately 35Km downstreams from the dam site.

Redgelines with the altitudes of approximately 150m compose the mountain mass at the vicinity of the dam-site.

The altitude increases gradually in the upstream direction (south side) to compose a topograph with pronounced undulations, with the altitudes of the order of several hundred meters. On the other hand, the areas at the downstream side consist of alluvial plains along the river and hilly districts characterized by the low mountains with the altitudes not exceeding 100m, in contrast to the upstream side.

On the other hand, a Karst topography with small undulations develops in the hilly district located at the downstream side of the mountain summits (altitudes exceeding approximately 100m) of the vicinity of the dam-site. A peculiar topography like dolines, etc., can be observed everywhere in the hilly district.

Approximately 4Km to the upstream of the dam-site is located at the confluence of the Balincaguin River with the Balite Basit River, its tributary. The basin of the Balincaguin River, the main stream, is located mostly at the south side of the dam-site, while the basin of the Balite Basit River, the tributary, is located mostly at the mountain mass located at the SE side of the dam-site. The overall area of the basin is approximately 225Km^2.

At the proximity of the dam-site, the river extends over a width of approximately 150m throughout the riverbed, which has an altitude of approximately 15.0m. On the other hand, the slope of the mountainside at both flanks of the dam-site presents a gradient of the order of 15° through 30°.

The topographical conditions prevailing at the vicinity of the dam-site presents the narrowest valley along the river at the downstream side of the confluence of the main stream with the Balite Basit River.

5.2.2. Geology

From the geological point of view, the ground of Western Pangasinan and its vicinities can be broadly classified into strata of 8 different ages, They can be arranged as follows, in order of age.

Age	Lithology
Cretaceous-Paleogene (UV)	Metasedimentary and metavolcanic rocks
Ultramafic Complex (UC)	Peridotite, pyroxenite, dunite, gabbro and serpentinized rocks.
Oligocene (Pg2)	Wacke and shale associated with keratophyre and andesite flows.
Middle to Lower Miocene (N1)	Sandstone, shale, reef limestone and conglomerate intercalated with basic flows, dominantly basalt.
Neogene Intrusive (N1)	Diorite bodies
Upper Miocene (N2)	Clastic sediments (mudstone and sandstone rocks).
Pliocene-Pleistocene (NE3 + Q1)	Mostly limestone interbedded tuffaceous shale with isolated clastic patches.
Quaternary (QV)	Volcanic plugs (basaltic, andesitic and/or dacitic).
(R)	Alluvial deposits

The "backbone" of the Zambales-Pangasinan mountain range consists of the batholiths composed of an ultramorfic complex, popularly known with the name of peridotite gabbro complex. Strata of various ages, including the UV stratum, are distributed at the northern edge and western edge of the aforesaid batholith.

Layers corresponding to the N1 stratum are distributed at the vicinity of the dam-site, and they can be boardly classified into layers of basalt, andesite, quartz-diorite limestone, etc. On the other hand, there are thick sediments of river deposit consisting chiefly of gravel, as new deposits capping the aforesaid base rocks.

Plain zones are formed at the areas located at the downstream side of the dam-site, where are recognized distributions of sandy and clayey alluvia.

Basalt is the stratum composing the base of the dam-site and the distribution of this kind of rock can be observed up to distances of 5Km through 10Km to the upstream side of the dam site. Distributions of the andesite and quartz diorite are observed, by going further to the upstream direction from the basalt distribution area. Limestone is found at the downstream side of the vicinity of the dam site, capping the basalt.

At the dam-site, the horizon of limestone is distributed at altitudes higher than approximately 100m. However, the boundary with the basalt located beneath presents a gentle inclination to the NW direction. Therefore, limestone is generally distributed at the downstream side, and the occurrence of basalt is not observed therein.

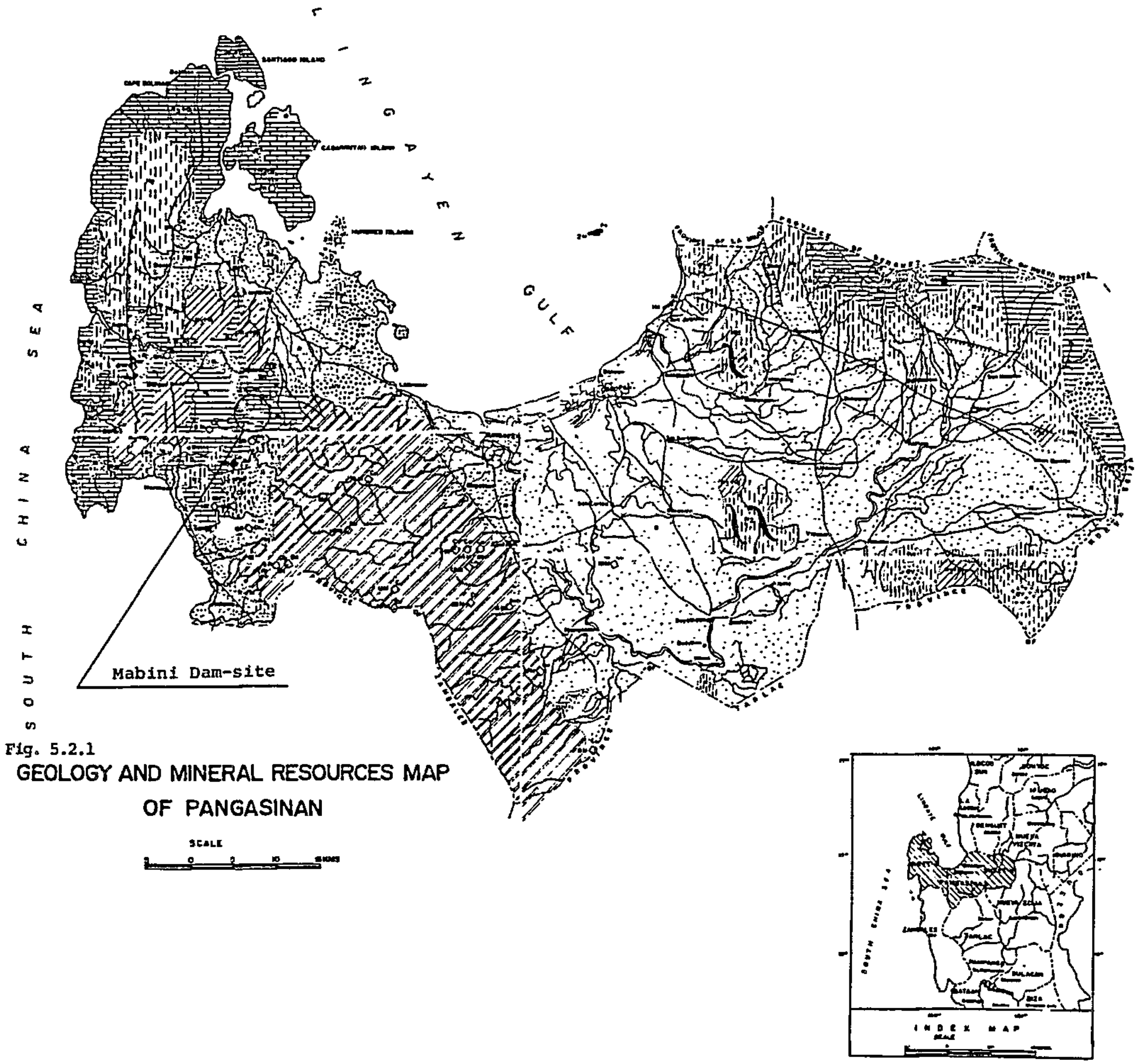


Fig. 5.2.1
GEOLOGY AND MINERAL RESOURCES MAP OF PANGASINAN

SEDIMENTARY AND METAMORPHIC ROCKS

- ▨ Recent
- ▨ Pliocene - Pleistocence
- ▨ Upper Miocene
- ▨ Lower-middle Miocene
- ▨ Oligocene

IGNEOUS ROCKS

INTRUSIVES

- ▨ Neogene
- ▨ Cretaceous - Palaeocene

EXTRUSIVES

- ▨ Quaternary
- ▨ Upper Miocene
- ▨ Cretaceous - palaeocene
- ▨ Pattern denotes limestone bodies on the color assigned to sedimentary rocks of the same age.

GEOLOGIC SYMBOLS

- Geologic contact.
- Close fold.
- High angle fault. Dashed where inferred, allow indicates strike-slip movement.
- Normal fault. Dashed where inferred, hachures on downthrown side.
- Thrust fault. Dashed where inferred saw-teeth on over riding side.
- X Operating and/or producing mines.
- ◆ Explored and/or developed metallic deposit.
- ● Explored and/or developed non-metallic deposit.
- ◇ Metallic prospect/indication.
- ○ Non-metallic prospect/indication
- X Abandoned mines
- Explored and/or developed placer deposit, prospect.

Note: Mineral resources symbols show commodity and reference number

5.3. Geology of the Dam Site

5.3.1. Geology

The geological structure of the dam-site consists of a base of basalt which is capped with horizons of limestone at altitudes exceeding approximately 100m at the mountain masses located at both flanks. On the other hand, on the riverbed is distributed a thick layer of river deposit which has not been consolidated yet.

Flood plains with a relative difference of altitude of 3m through 5m with regard to the riverbed are formed in the basins of part of the rivers. Thin deposits of alluvium are found in the said flood plains.

(1) Basalt

From the lithological point of view, this stratum is composed of pillow lava, lava, volcanic breccia, etc. Generally speaking, it is characterized by the presence of a large quantity of veins of calcite and quartz with configuration of net. At the vicinity of the dam site this stratum presents a pronounced weathering, and its surface layer is argillized in many cases.

The basalt of the dam-site can be classified into the 4 velocity layers listed below, as a result of seismic explorations.

Velocity layer	Elastic Wave Velocity (Km/sec)
1st velocity layer	0.3 through 0.8
2nd velocity layer	0.8 through 1.4
3rd velocity layer	1.4 through 2.2
4th velocity layer	2.8 through 4.0

This classification into velocity layers expresses the conditions of weathering of the basalt with relatively satisfactory fidelity, when this kind of rock is distributed from the surface (including the case of capping with surface soil and fractured rock deposit (talus)). In other words, the comparison of the rock bed classification shown in Table 5.3.1 with the results of the drilling survey evidences that unweathered fresh rock is classified as CH (partially B) and, in terms of velocity of elastic wave, it is classified as 4th velocity layer, with values of the order of V = 2.8 through 4.0Km/sec. On the other hand, weathered strata classified as CL.D are considered as 1st speed layer.

Table 5.3.1 Rock Classification

A	Very fresh. Component minerals and grains have not undergone alternation. Cracks and joints are well closed and no trace of weathering is observed on the cracked or joint faces.
B	Lithologic character is hard and intact. No observable open cracks or joints (of not even 1 mm). Well closed but the component minerals or grains are slightly weathered or altered locally. Hammering sound is clear.
CH	Component minerals and grains have undergone alteration except quartz, but lithologic character is ralatively hard and intact. Generally contaminated by limonite and other substances. The cohesive force of joints and cracks has been reduced slightly and strong hammering may cause separation of rock masses along the joints and cracks. The split faces are sometimes observed to be with a filmy layer of clayey matters. Hammering sound is somewhat soft.
CM	Component minerals and grains except quatz have undergone weathering and the rock is somewhat softened. The cohesion in cracks and joints is somewhat reduced. And ordinary impact of hammering may cause separation of rock masses. The split faces are observed to be with a filmy layer of clayey matters. Hammering sound is soft.
CL	Component minerals and grains have been softened as a result of weathering. Cohesion in cracks and joints is reduced. Light impact of hammering causes separation of rock masses. The split faces are observed to be with residual clayey materials. Hammering sound is soft.
D	Component minerals and grains are much softened as a result of weathering. There is almost no cohesion in cracks and joints, and slight hammering causes crumbling. Split faces are observed to be with clayey residual matters. Hammering causes very soft sound.

From the topographical point of view, the vicinities of the dam-site can be classified into the 5 areas listed below.

1) Ridgelines at the Left Bank Side

At the ridgelines located at the left bank side there are horizons of limestone layers distributed on the basalt. The boundary between the two layers is estimated to be located at the altitudes of the order of 85m through 105m, in view of the conditions of exposure and topographical conditions. In addition, the boundary presents a gentle slope in the NW direction.

2) Left Bank Side Slope ... DH-1 and DH-2

At the left bank side slope, the inclination is relatively gentle compared with the right bank side and the weathered strata corresponding to CL and D are distributed with thicknesses in the order of 5m through 15m. Capping of talus deposits consisting of clay with sand and gravel are observed up to depth of 1.57m at DH-1 and 4.60m at DH-2. The conditions of distribution of the unconsolidated deposits of this surface layer depends upon factors like microscopic topography, etc., and presents therefore considerable variations. Furthermore, it presents practically the same ground conditions of the strongly weathered zone of basalt (D). Consequently, a clear distinction between the zone of strongly weathered basalt and talus is not made in the geological section.

3) River Bed ... DH-3A, DH-7, DH-11

At the river bed, the basalt layer is found at depths of 31.0m through 31.8m, i.e., at the altitudes of -17.6m through -18.0m. In this area the weathered zone of basalt is pronouncedly thin, and the strata corresponding to CL and

and D classification have thicknesses of the order of 1m. A continuous stratum corresponding to CH through B, which presents practically no cracks like joints, etc., is found beneath the CL and D layers.

4) Slope of the Right Bank Side ... DH-3B, DH-5

At the right bank side, the thickness of the weathered layer is relatively larger compared with the left bank side, and the weathered zone is distributed with thicknesses ranging from 10m through 25m.

5) Ridgelines of the Right Bank Side ... DH-8, DH-9, DH-10

Horizons of limestone are found at the upper parts of this area. The distribution of basalt layers is observed from the depths listed below.

DH-8	Depth 18.0m	(Altitude 85.90m)
DH-9	Depth 6.75m	(Altitude 84.55m)
DH-10	Depth 25.50m	(Altitude 76.80m)

Fragile parts, corresponding to the weathered basalt zones, are found beneath the boundary of the upper layer, also in this area. The thickness of this layer, which is classified as D∿CL, is of the order of 3.0m in DH-82, 7.25m in DH-9 and 5.8m in DH-10.

(2) Limestone Layer

The horizon of limestone layer is classified in 2 parts, i.e., the limestone layer located at the upper part and the sandstone horizon located at the lower part.

The presence of sandstone layer was confirmed at the drilling holes DH-8, 9 and 10 of the drilling study carried out at the right bank side, and it is distributed with a layer thickness of the order of 5m through 10m.

Generally speaking, this sandstone layer is chiefly composed of fine sandstone containing shell fossiles with dark bluish gray color, but siltstone (slightly tuffaceous nature) is also observed at the drilling holes DH-9 and 10. This is a soft rock layer with weak resistance against weathering, and, once exposed at the surface layer, it is easily weathered and converted into soil. Accordingly, it is very difficult to observe occurrences of this layer at the surface. Siltstone is particularly soft, and it is collected in argillized state in the boring core. The horizon of sandstone layer has not been sufficiently confirmed at the left bank side yet. But it is entered in the geological section, in view of the stratigraphical correlation, taking place at the vicinity of the place where it is presumed to be located. It is presumed to be distributed with layer thicknesses of the order of 5m through 10m, at the vicinity of altitudes of the order of 85m through 105m.

On the other hand, the limestone layer located at the upper part forms topographical peculiarities like sheer cliffs, etc., being therefore easy to recognize its distribution also from the topographical point of view. Each individual lump of this limestone layer is of hard nature, but the layer as a whole is weathered, with occurrence of open cracks. In view of such conditions, the core recovery at the occasion of drilling is below 30% in many cases. At the same time the Karst topography, scattered with dolines and other formations peculiar to limestone areas, is observed in the areas where this layer is distributed. In addition, water springs are distributed everywhere at the vicinity of the base of the limestone layer, and other peculiarities of this type of layer, like limestone caverns, etc., are observed very frequently.

(3) River Deposit

The presence of river deposit is confirmed up to a depth of 31.0m at the drilling hole DH-3A and 31.8m at the hole DH-7. Drilling work of the hole DH-11 has reached a depth of approximately 26m so far. It has not reached the basalt layer of the foundation yet, but the geological record of boring of the data collected so far is presented in Figure 5.3.1.

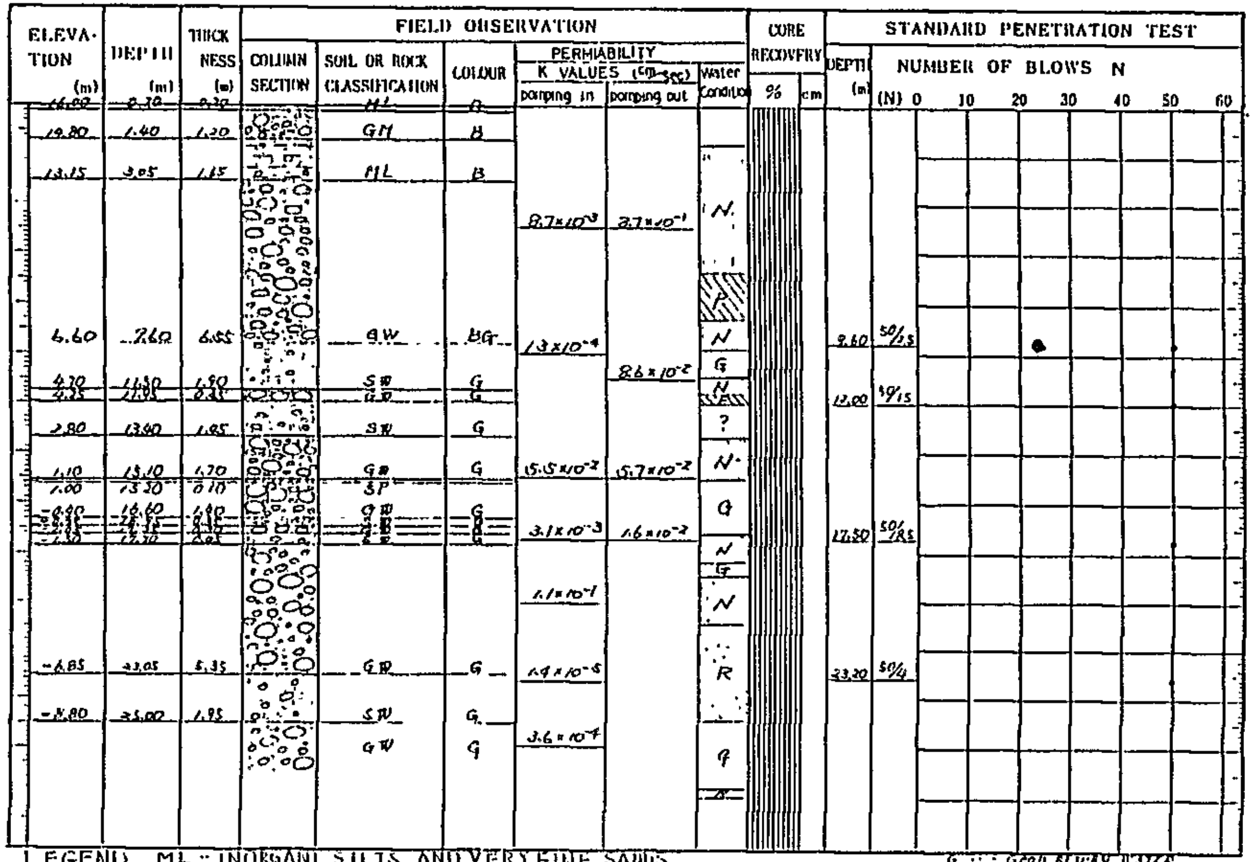
The facies of this river deposit is composed of gravel & sand and sand with gravel containing large quantities of slit at the vicinity of the surface, with depths ranging up to 3.05m. However, at the lower parts it presents alternation of strata of sand and gravel with boulder (GW) and sand with gravel (SW). The contents of the collected drilling core suggests that, in the GW layer, the maximum diameter of the gravel exceeds 30cm and that gravel is composed mostly of quartz-diorite of hard nature. In the collected drilling cores gravel occupies 30% through 50% of the core recovery rate in many cases, suggesting that the absolute majority of the mixed material is composed of gravel. Occurrence of total water loss was observed often during the drilling work, and the wall of the drilling hole was easily collapsible in many cases. In view of the facts, it is presumed that the matrix contains practically no clay and silt.

According to the data collected at the occasion of the standard penetration test, the SW layer contains large quantities of Pebble, and the N-value ranges from 50 strokes/2.5cm through 50 strokes/15cm.

As can be seen from the considerations above, the river deposit is generally composed of coarse material like gravel, sand, etc. No clayey layers are observed, but the detailed stratigraphical relation of the layers in the river deposit is being investigated in detail only in the drilling hole DH-11 which is progressing presently. Therefore, it is very important to make futurely an investigation of the conditions of stratification at the vicinity of the dam axis covering a wide area.

FIG.5.3.1 GEOLOGICAL RECORD OF BORING

HOLE No.	DH-11		
PROJECT	MABINI AGRICULTURAL DEVL. PROJ.	LOCATION	MABINI PANGASHINAN
GROUND ELEVATION	16.2 m	DEPTH OF HOLE	
ANGLE FROM VERTICAL	0°		
DIAMETER OF HOLE	0.00 ~ 19.70 NQ 19.70 ~ BQ	MACHINE	DB 450
DATE OF DRILLING	OCT 14. 1981		
CORE RECOVERY		DEPTH TO GROUND WATER LEVEL IN HOLE	3.58 m
DRILLED BY		LOGGED BY	D A FAJARDO



ELEVATION (m)	DEPTH (m)	THICKNESS (m)	SOIL OR ROCK CLASSIFICATION	COLOUR	PERMIABILITY K VALUES (cm/sec) pumping in	pumping out
16.00	0.30	0.30	ML	B		
14.80	1.40	1.20	GM	B		
13.15	3.05	1.15	ML	B	8.7×10⁻³	3.7×10⁻¹
6.60	9.60	6.55	GW	BG	1.3×10⁻⁴	8.6×10⁻²
4.70	11.50	1.90	SW	G		
4.35	11.85	0.35	GP	G		
2.80	13.40	1.55	SW	G		
1.10	15.10	1.70	GW	G	15.5×10⁻²	5.7×10⁻²
1.00	15.20	0.10	SP			
-0.40	16.60	1.40	GW	G		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.1×10⁻³	1.6×10⁻²
					1.1×10⁻¹	
-6.85	23.05	5.35	GW	G	1.4×10⁻⁵	
-8.80	25.00	1.95	SW	G	3.6×10⁻⁴	
			GW	G		

Water Condition: N, N, G, N, ?, N, G, N, G, N, R, G

STANDARD PENETRATION TEST DEPTH (m)	(N)
9.60	50/2.5
12.00	50/15
17.50	50/18.5
23.20	50/4

LEGEND
ML - INORGANIC SILTS AND VERY FINE SANDS
GM - SILTY GRAVELS GRAVEL SAND SILT MIXTURE
GW - WELL GRADED GRAVELS LITTLE FINES
SW - WELL GRADED SANDS -do-
SP - POORLY GRADED SANDS -do-

B - BROWN
G - GRAY

G - GOOD RETURN WATER
R - RETURN WATER
P - POOR RETURN WATER
N - NO RETURN WATER

5.3.2. Geological Structure

Generally speaking, when a low velocity zone is found as a result of the analysis of the travel time curve of seismic exploration, it is often interpreted as a shear zone. However, there are many causes of occurrence of such low velocity zones, and they do not correspond necessarily to shear zones.

A seismic exploration was carried out during the present study, and the occurrence of low velocity zones at 5 places on the measuring lines was confirmed. The most pronounced low velocity zone passes through the 210∿240m positions of Line-1, 150∿170m of Line-2 and 60∿100m of Line-3. This low velocity zone extends practically in straight line on the slope of the left bank mountainside, and it is presumed that a fault is located in that zone. Besides the results of seismical exploration, the following facts lead us to presume that the aforesaid low velocity zone might be a fault.

1) Generally speaking, the boundary between the limestone layer and basalt layer presents a gentle slope in the NW direction. The comparison of the altitudes of the boundaries of the two layers mentioned above at the two flanks of the dam axis indicates that at the right bank side (east side) the altitude is approximately 80m, while, at the left bank side (west side), the altitude of the boundary is higher, with values of the order of 100m. Therefore, there is a gap in the conditions of distribution of the limestone layer at both banks of the dam site.

2) The results of analysis of air photographs indicate the presence of a vague lineament along the place where the low velocity zone is located.

3) The extension (direction) of this low velocity zone seems to be N10°∿20°W, but joints in the N-S direction are observed relatively often at the vicinity of the dam site.

At the present stage, this possible fault has not been confirmed through evidences like outcrops, etc., being therefore just an "assumed" fault. However, investigations by means of trench cut, test adits, drilling, etc., are being presently set forth by the NIA. It is expected that more concrete conclusions like existence/inexistence of fault, its position, scale, possibility of active fault, etc., will become clear as a result of the said investigations.

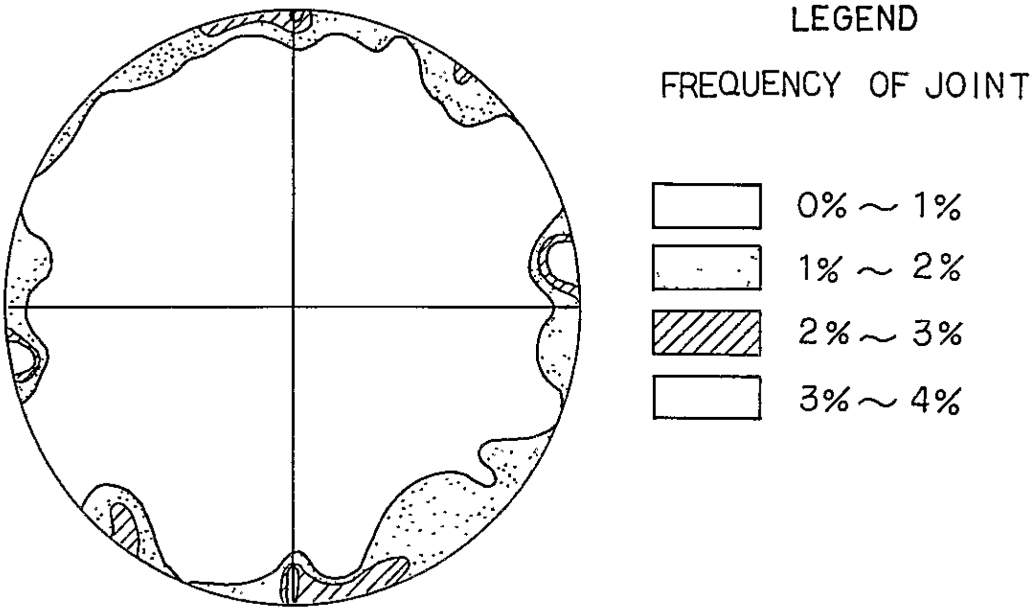
Besides the case described above, low velocity zones are observed also at the 570∿600m position of the Line-1 and 880∿900m position of the Line-3 at the right bank side. However, these low velocity zones do not present any evident relationship with other measuring lines and therefore it is not possible to conclude that it is a continuous shear zone like a fault.

The joints present in the basalt layer at the proximity of the dam site are projected on the Schimidt-Net shown in Figure 5.3.2.

Fig. 5 - 3 - 2

STEREO-NET OF JOINT

(SCHMIDT NET)



The directivity of the joints presents a considerable irregularity and it is not possible to observe a pronounced concentration in any particular direction, but they occur with relatively higher frequency in the following directions.

Strike	Dip
EW-N70W	90° - 80°S
N10°E	90° - 80°N
N55W	80°S

5.3.3. Comparison of the Geological Conditions at the Dam Site with the Results of Seismic Exploration

The geological section determined by seismic wave velocity seems to express with relatively satisfactory fidelity, the conditions of weathering and hardness of the basalt layer, when the said layer is distributed from the surface. However, it presents the following problems at the ridgelines and at the riverbed.

1) When Limestone Layer and Sandstone Layer are Distributed on the Basalt Layer

The limestone layer is quite heterogeneous, because it contains anomalies like open cracks and caves, in addition to hard matter (V = 3 Km/sec) in massive state. Furthermore, sandstone and weathered basalt located at the lower parts are bedrock of soft nature, and the velocities expected to occur therein are of the order of V = 1.5Km/sec at most. On the other hand, the analysis of the seismic prospecting is based upon the premise that the strata become harder (i.e., the elastic wave velocity increases) as the depth increases. Therefore, the facts mentioned above make more complicated the conditions of analysis and, consequently, at the vicinity of the Line-5 and Line-6, the geological structure is not suited for analysis of the underground structure.

2) When River Deposit is Distributed on the Basalt Layer

The river deposit presents elastic wave velocities of the order of V = 2 through 3Km/sec and it tends to form a mirage layer (where the elastic wave velocity increases gradually) as the depth increases. Accordingly, when the basalt bedrock presents an elastic wave velocity of V = 4Km/sec, the results of analysis express the boundary between the two layers with relatively good accuracy. However, it is difficult to determine the boundary between the two layer when the basalt layer presents an elastic wave veloçity of V = 3Km/sec. The area located at the upstream side of Line-3 and Line-4 corresponds to the latter case and the boundary of the layers with V = 2Km/sec and V = 3Km/sec pass through the river deposit.

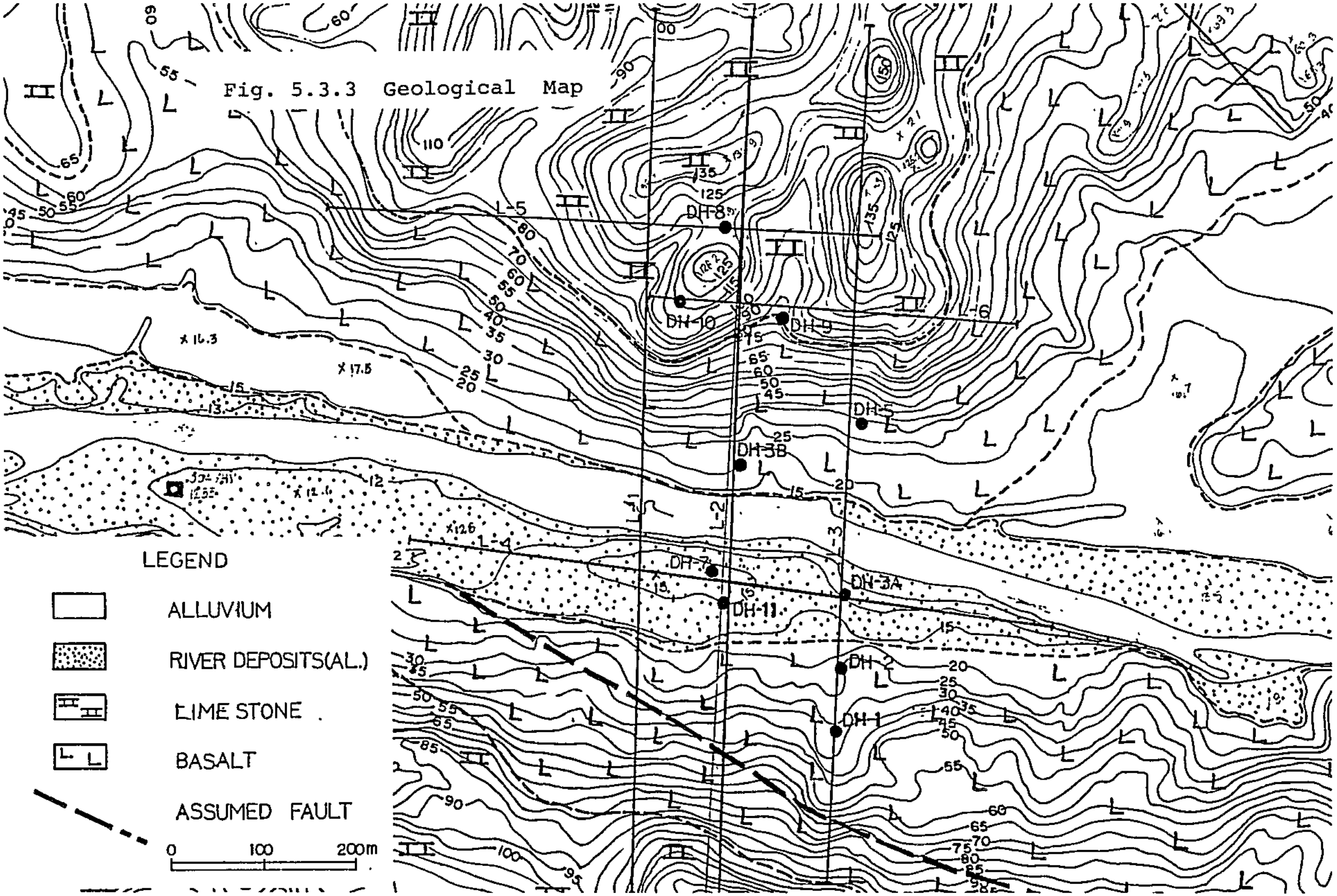


Fig. 5.3.3 Geological Map

Fig. 5-3-4(1) **GEOLOGICAL SECTION**

SCALE V: 1/1,000
H: 1/4000

LEGEND

▨	RIVER DEPOSIT
▤	LIMESTONE
▤	SANDSTONE , SILTSTONE
▨	WEATHERED BASALT
L L L	BASALT

CLASSIFICATION (A, B, C_H, C_M, C_L, D) OF BASALT IS BASED ON TABLE 5-3-2

F //	ASSUMED FAULT AND SHEAR ZONE
/ 1.4	BOUNDARY OF VELOCITY LAYER VELOCITY (Km/s)

(VELOCITY LAYER OF 0.6 (Km/s) AND LESS INCLUDES TALUS DEPOSITS

Fig. 5.3.4(2) **GEOLOGICAL SECTION**

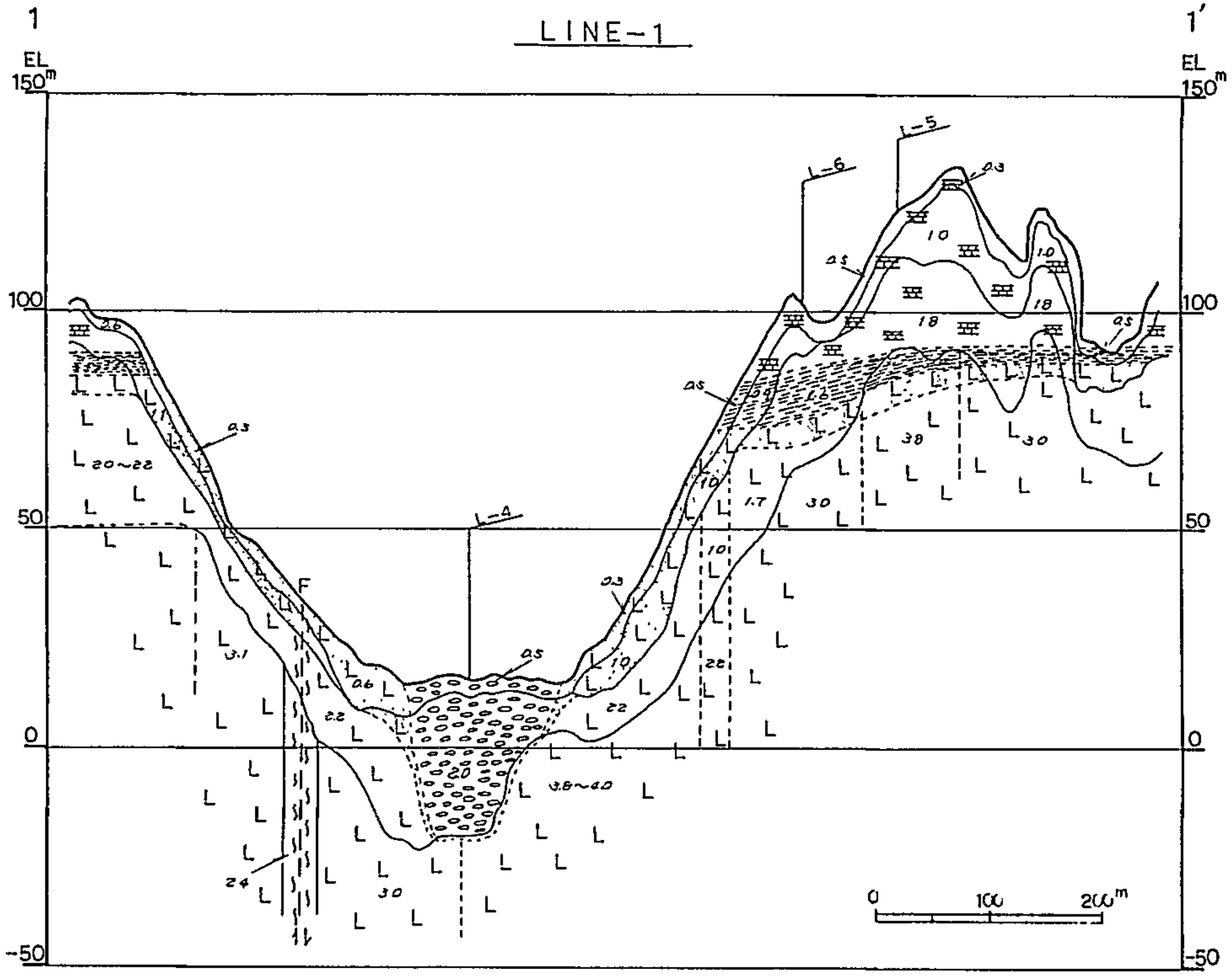


Fig. 5.3.4(3) **GEOLOGICAL SECTION**

LINE-2

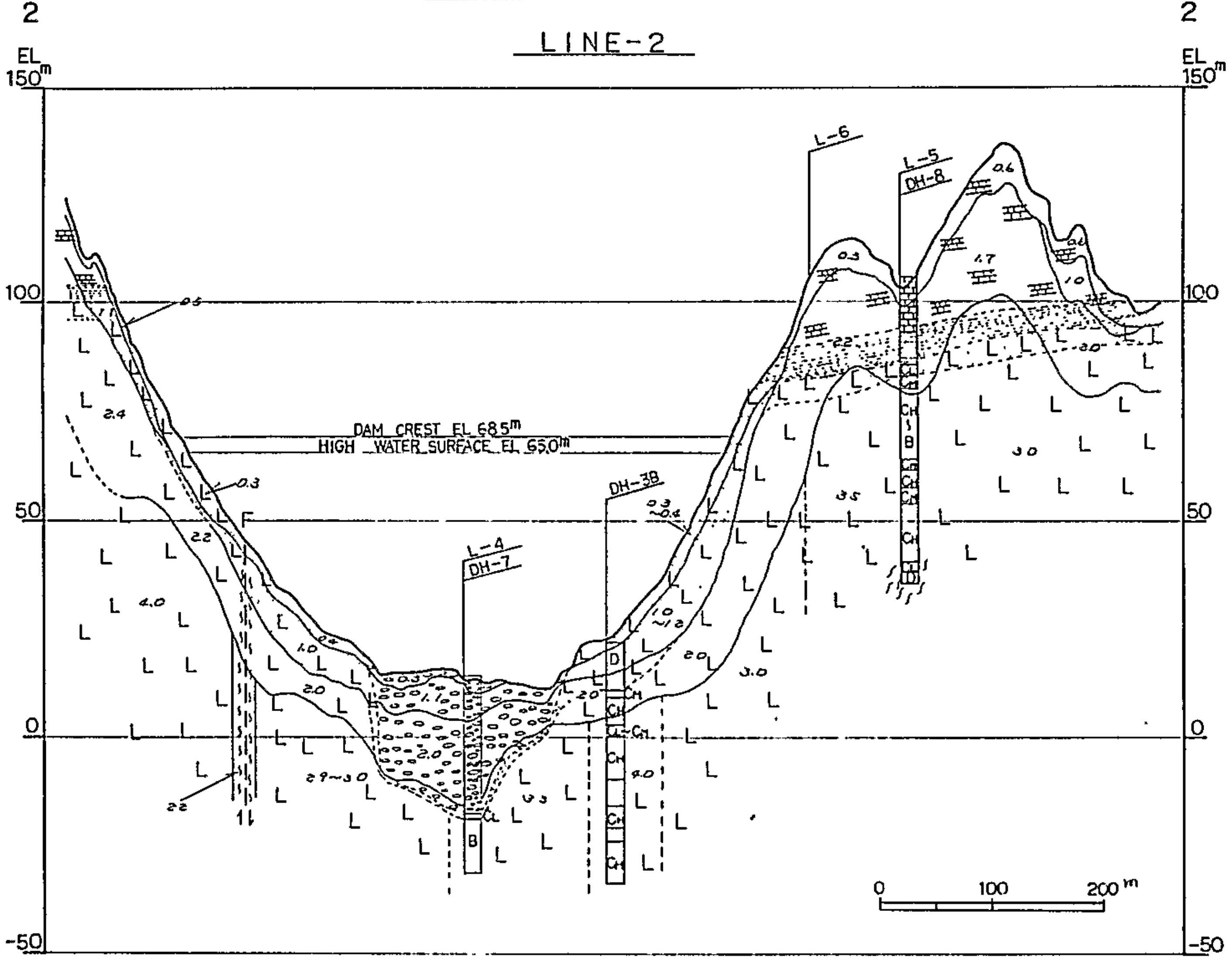


Fig. 5.3.4(4) **GEOLOGICAL SECTION**

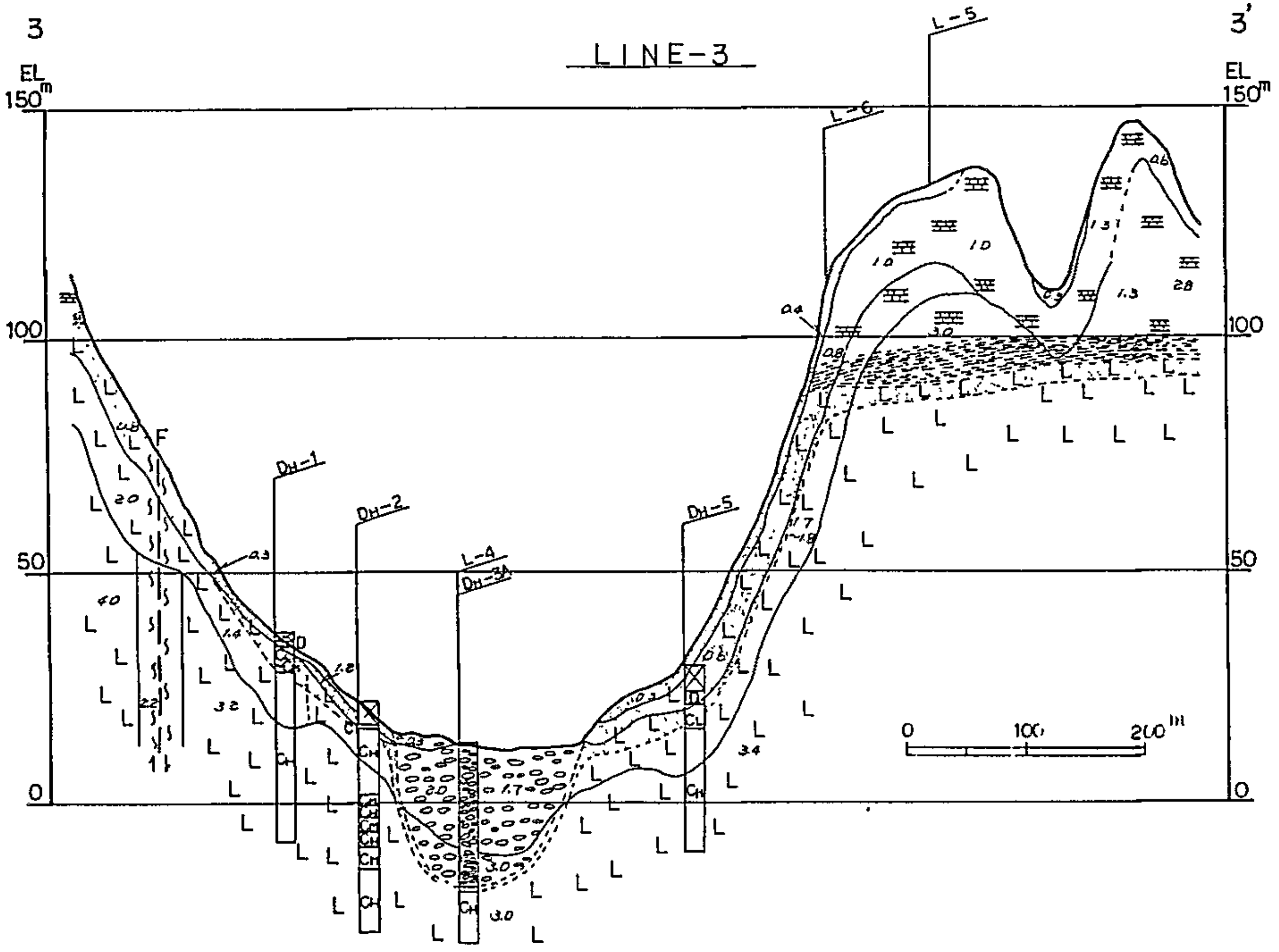


Fig. 5.3.4(5) **GEOLOGICAL SECTION**

LINE-4

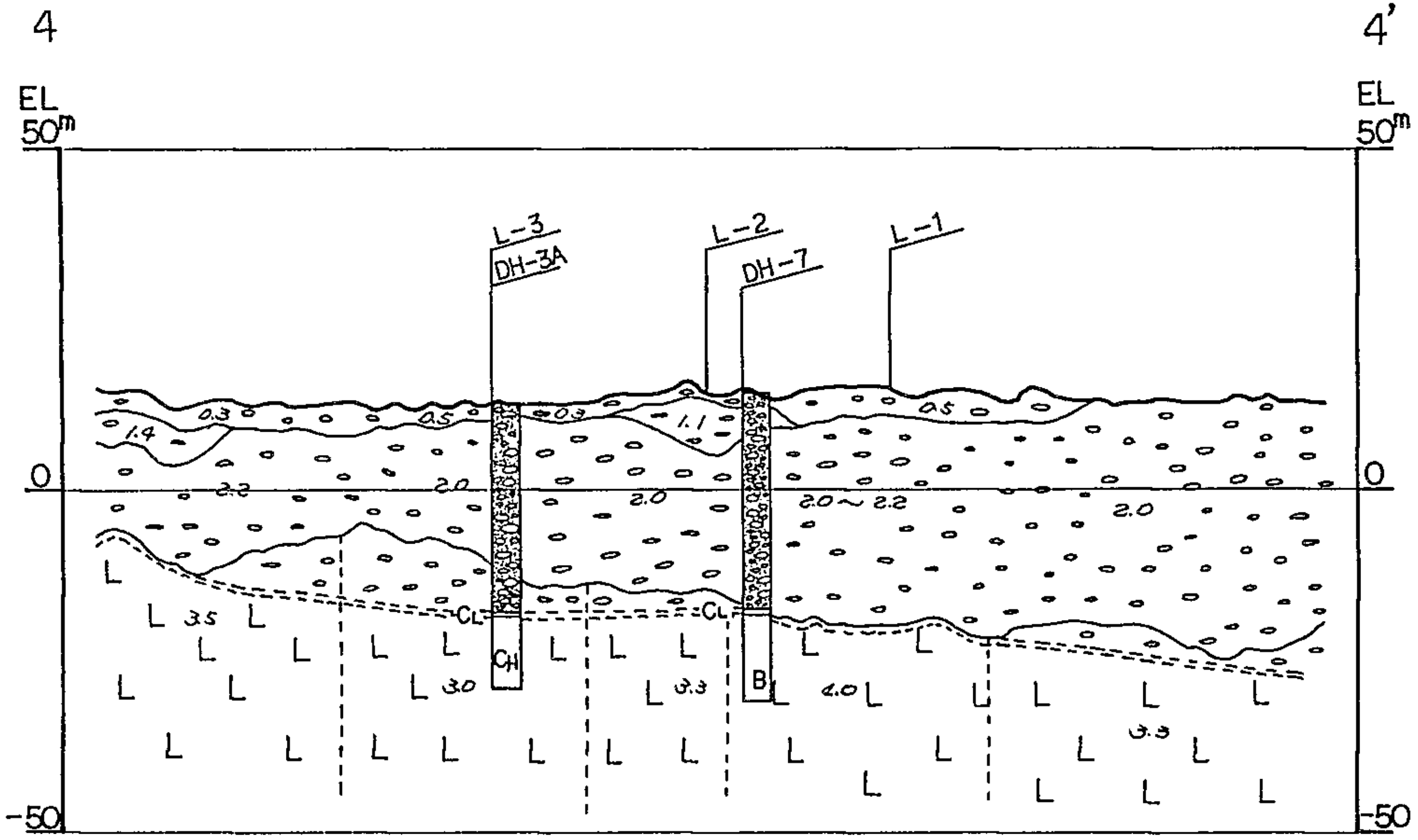
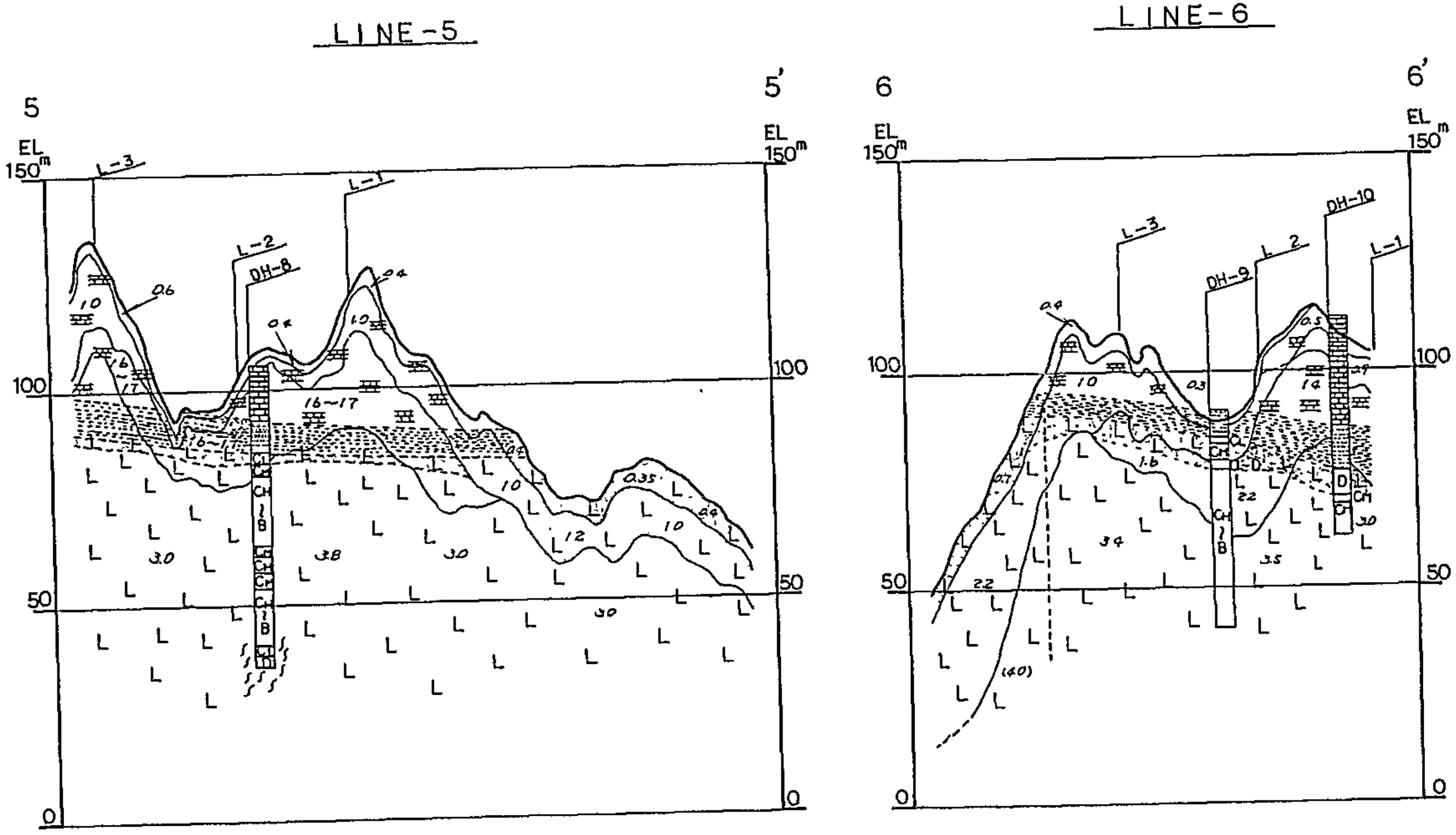


Fig. 5.3.4(6) **GEOLOGICAL SECTION**



5.4. Engineering Geology

5.4.1. Permeability

(1) Basalt

The permeability test regarding basalt layer is being set forth at 6 drilling holes. The results of the permeability test are summarized in the "Data" section. The permeability test is carried out by applying the injection pressure in 3 stages, and the permeability coefficient and Lugeon value of the maximum pressure of each test section are presented in Table 5.4.1.

At the present stage, the number of cases of permeability test is small and they can be used for the sake of Lugeon mapping of the dum body foundation of the dam. The Lugeon values orderly arranged in accordance with the altitudes are presented in Figure 5.4.1.

By taking the actual river bed as boundary, the coefficient of permeability presents generally small values of the order of $K=10^{-5}$ through 10^{-6}cm/sec at parts with low altitudes, and the Luegon value is of the order of $Lu < 1.5$ at the said parts. On the other hand, at positions located at altitudes higher than that one of the actual river bed the permeability tends to increase gradually, with values of the order of $K = 10^{-4}$ through 10^{-5}cm/sec at altitudes of El. 50m through El.60m. The Lugeon value is also large, of the order of $Lu \fallingdotseq 10$ at the said altitudes.

Figure 5.4.1 presents the approximate dotted line curve drawn out within the range of variation of the Lugeon value. However, the figure presents some points with large Lugeon values, discrepant of the general tendency. These points correspond to the shear zone located at depths of the order of 67.5m through 70.0m in the drilling hole DH-8 and horizons at its vicinity containing frequency cracks. The values of the coefficient of permeability and the Lugeon values are quite large, of the order of $K = 10^{-4}$cm/sec and Lu $\fallingdotseq$ 20. The drilling hole DH-8 has the purpose of making the investigation regarding the spillway, and is located far eastward from the place where the dam body is planned.

Table 5.4.1 —a

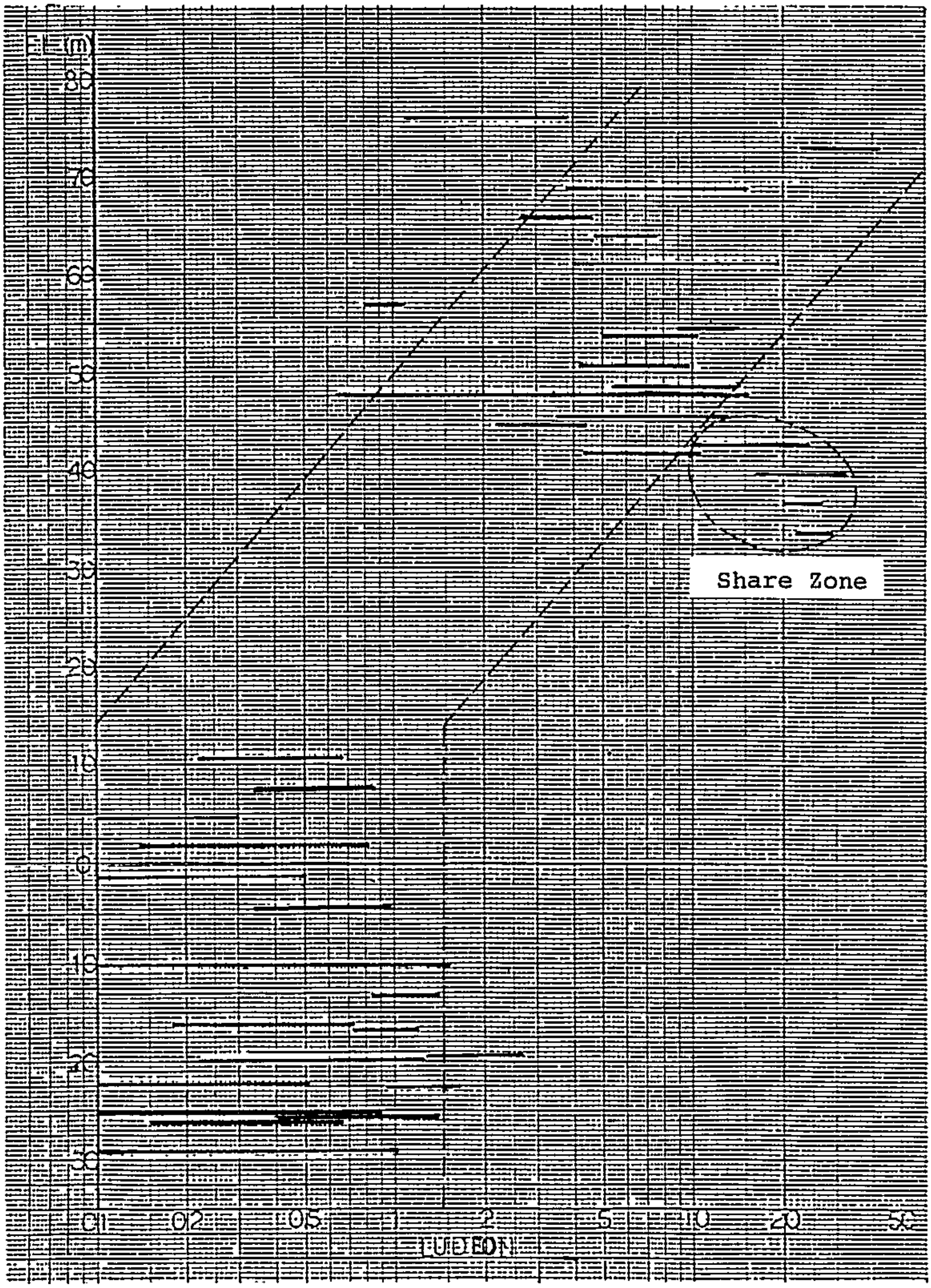
Result of Permeability Test

Hole No.	Depth (m)	Coefficient of Permeability (cm/sec)	Value of Lu
2	10 - 13		0.63
	13 - 16		0.89
	16 - 19		0
	19 - 22		0.58
	22 - 25		0
	25 - 28		0.55
	31 - 34		0.88
	34 - 37		0.76
	37 - 40		0.29
	40 - 43		0.32
	43 - 46		0
	46 - 49		0
3A	31 - 34	1.57×10^{-5}	1.36
	34 - 37	5.38×10^{-6}	0.21
	37 - 40	3.98×10^{-6}	0.34
3B	34 - 37	8.92×10^{-6}	0.83
	37 - 40	7.71×10^{-6}	0.71
	40 - 43	1.39×10^{-5}	1.28
	43 - 46	1.48×10^{-5}	1.36
	46 - 49	4.97×10^{-6}	0.45
7	33 - 36	4.54×10^{-6}	0.41
	36 - 39	8.46×10^{-7}	0.08

Table 5.4.1. -b

Hole No.	Depth (m)	Coefficient of Permeability (cm/sec)	Value of Lu
	39 - 42	1.66×10^{-6}	0.15
	42 - 45	3.84×10^{-6}	0.34
8	36 - 39	1.06×10^{-4}	11.73
	39 - 42	4.39×10^{-5}	4.67
	42 - 45	6.16×10^{-5}	6.78
	45 - 48	1.05×10^{-4}	11.30
	51 - 54	5.12×10^{-5}	5.37
	54 - 57	6.36 x 10-5	3.52
	57 - 60	9.38×10^{-5}	9.94
	60 - 63	1.44×10^{-4}	16.48
	63 - 66	1.67×10^{-4}	19.98
	66 - 69	1.91×10^{-4}	22.83
9	14 - 17	9.13×10^{-6}	1.11
	16 - 19	2.08×10^{-4}	24.33
	19 - 22	1.23×10^{-4}	13.89
	25 - 28	4.40×10^{-5}	4.74
	28 - 31	1.51×10^{-4}	16.02
	32 - 35	7.78×10^{-6}	0.81
	35 - 38	7.22×10^{-5}	7.44
	38 - 41	7.76×10^{-5}	7.93
	41 - 44	3.45×10^{-5}	3.48
	44 - 47	2.19×10^{-5}	2.20
	47 - 50	4.29×10^{-5}	4.27

Fig. 5.4.1 Relation Between Elevation and Ludeon in Basalt



(2) River Deposit

The permeability test of the river deposit is carried out with the following methods.

- Pumping test with test pits
- Pumping test by means of the casing method using the drilling hole DH-11
- Pumping out test.

The drilling work of the DH-11 hole is progressing and, as of December 13th, it has reached a depth of 26m. The following results have been obtained from the said drilling hole so far.

Table 5.4.2 List of Results of the River Deposit Permeability Test

Position and Depth		Geology Symbol **	Coefficient of Permeability K(cm/sec)		Remarks
			Pumping-in	Pumping-out	
Test Pit *		GW	3.9×10^{-1}	-	***
DH-11	5.0	GW	8.7×10^{-3}	2.7×10^{-1}	
"	10.0	SW	1.3×10^{-4}	-	
"	11.0	SW	-	8.6×10^{-2}	
"	15.0	GW	5.5×10^{-2}	5.7×10^{-2}	
"	17.5	SW	3.1×10^{-3}	1.6×10^{-2}	
"	20.0	GW	1.1×10^{-1}	-	
"	23.3	SW	1.4×10^{-5}	-	
"	26.0	GW	3.6×10^{-4}	-	

* The test pit is located on the riverbed, at an intermediate position between DH-7 and DH-11.

** Refer to Figure 5.3.1

*** Corresponding to the horizon at the vicinity of 3.5m depth of the drilling hole DH-11.

A comparison of the results of the pumping-in test and pumping-out test presented in the table above evidences that, generally speaking, the pumping-out tests tend to present larger values of coefficient of permeability. The aforesaid tendency can be attributed to the fact that the percolation of water is restricted due to the sedimentation of fine particle components of materials like slime, etc., at the bottom of test pits and drilling holes. Accordingly, the data obtained by the pumping-out test present a higher reliability.

Data regarding the leakage water occurring during the drilling work are recorded in the geological section of Figure 5.3.1. Comparing the said data with the results of the permeability test, the permeability coefficient has values of the order of $K = 10^{-1}$ through 10^{-2}cm/sec at the leakage sections, evidencing therefore a clear correlation between these two parameters. At sections presenting relatively good return of water, the coefficient of permiability is of the order of $K = 10^{-4}$ through 10^{-5}cm/sec.

At the present stage, the proportion between the pervious zone and return of water from drilling hole is of the order of 6:4 evidencing the predominance of sections with larger coefficients of permeability. However, the layers with small coefficient of permeability tend to predominate as the depth increases.

According to the data collected so far, the depths where layers with coefficient of permeability of the order of $K = 10^{-1}$ through 10^{-2}cm/sec are presumed to be distributed are as follows. Generally speaking, the GW layer is distributed at the said depths.

o Sections where the coefficient of permeability is expected to be of the order of $K = 10^{-1}$ through 10^{-2} cm/sec in the drilling hole DH-11.

Depth (m)	Geology
1.65 ∿ 6.90	ML, GW
6.90 ∿ 8.70 *	GW
8.70 ∿ 10.00	GW, SW
11.00 ∿ 11.70	SW, GW
11.70 ∿ 11.95 *	GW
13.50 ∿ 15.00	GW
17.25 ∿ 18.45	GW, SW
18.95 ∿ 20.95	GW
27.55 ∿ 27.85	GW
Total 144m	

* There is no entire leakage in this section, but the quantity of water leakage is very large.

5.4.2. Dam-Site

(1) Selection of the Positions of the Dam Axis and Other Structures

The Balicaguin River joins with the Balite Basit River at the upstream side of the dam-site. However, at the downstream side of the said confluence, the vicinity of the dam-site presents the narrowest valley topography. Therefore, the vicinity of the planned dam-site presents the most favourable topographical conditions for its location.

The vicinity of the dam-site consists of a geological structure composed chiefly of basalt, but it presents the following problems in terms of geological conditions of a dam-site.

a) On the riverbed there is accumulation of a thick layer of river deposit composed mostly of gravel and sand with boulder exceeding 30cm. The coefficient of permeability of the said layer is of the order of K = 10^{-1} through 10^{-2}cm/sec.

b) A limestone layer is distributed at altitudes higher than approximately 90m in the mountain masses located at both flanks of the dam axis and the said limestone layer presents a large void ratio.

c) At the left bank side of the dam-site there is possible fault of N10°W crossing the dam axis.

With regard to the problems a) and b) mentioned above, the geological conditions prevailing at the dam-site do not present any major change even when the dam axis will be shifted. However, the possible fault crosses the slope as if escaping to the mountain side (west side) when fault line moves from the downstream side to the upstream side. In view of the considerations above, it is desirable to select the dam axis as upstreams as possible, aiming at minimizing the influence on the fault at the occasion of completion of the dam, i.e., aiming at minimizing the hydrostatic pressure applied on the fault.

In addition, it is desirable to locate the facilities like spillway, diversion tunnel and intake tunnel at the right bank side, aiming at keeping them away from the possible fault.

The presence of a fractured zone at the right bank side has been confirmed by the data collected at the drilling hole DH-8, but details like its direction, etc. have not been confirmed yet, being therefore required future studies regarding the matter.

(2) Planned Full Water Level

The determination of the planned full water level of the reservoir suffers a decisive influence of the conditions of distribution of the limestone layer capping the basalt layer.

The limestone layer can be classified into the limestone layer located at the upper part and the sandstone layer located at the lower part. The limestone layer located at the upper part is a stratum with frequent occurrence of caves and open cracks, and the areas where this kind of rock is distributed present a Karst topography peculiar to limestone. On the other hand, the sandstone layer located at the lower part is the so-called soft rock layer, where solidification has not progressed sufficiently yet. This layer is characterized by occurrence of hygroscopic expansion and it is estimated to be in easily weatherable state.

The basalt layer presents a weathered zone with thickness of the order of 5m through 10m at the vicinity of the boundary with the limestone layer. Argillization and frequent and irregular cracks take place in the said zone.

As can be seen from the considerations above, the limestone layer, sandstone layer and weathered zone of basalt are heterogeneous and present furthermore problems regarding permeability and other aspects. Therefore, it is recommendable to design the full water level of the dam at a position lower than the weathered zone of basalt.

From data collected so far, the lower boundary of the weathered zone of basalt is estimated to be located at elevations of the order of El.80m through El.100m at the left bank side and 70m through 85m at the right bank side. In addition, the relation between the basalt layer and the limestone layer is estimated to have an unconformity, with a gap in terms of age. Therefore, it is recommendable to interpret that the boundary between the two aforesaid layers presents rather frequent undulations.

Accordingly, it is recommended to design the full water level of the dam at altitudes not exceeding EL.65m, by taking into consideration the safety for leakage.

(3) Foundation of the Dam

Load-bearing capacity and impermeability are indispensable conditions of the foundation of the dam body, in order to ensure a sufficient stability of the dam and its foundation.

In case of fill-type dams, the load caused by the dam is distributed over a larger foundation area compared with concrete dams. Accordingly, the construction of a dam is possible even when the dam foundation is a permeable ground or a poor subsoil, if cut-off processing to establish impermeable zones and stabilization processing are possible in the foundation in question.

However, when an unconsolidated gravel bed with large coefficient of permeability and thickness exceeding 30m is accumulated on the riverbed, like in the foundation of the present dam site, the foundation processing method becomes the crucial point.

(Basalt)

At first, with regard to the two flanks of the dam axis, where basalt layer is outcropped, its weathered zone is distributed at the right bank side with thicknesses of the order of 10m through 25m, while at the left bank side it is distributed with thicknesses of the 5m through 15m. This weathered zone is a stratum where the elastic wave velocity is smaller than V = 1.4Km/sec. Furthermore, this zone of weathered basalt presents either argillization or a pronouncedly frequent occurrence of irregular cracks, and is estimated to be a very heterogeneous stratum with a large coefficient of permeability. Accordingly, this zone of weathered basalt should be excavated and removed particularly at the foundation of the dam.

A basalt layer with elastic wave velocity of the order of V = 1.4 ∿ 4.0Km/sec is distributed beneath this weathered zone. This basalt layer presents values of uniaxial compressive streangth of the order of V = 50Kg/cm^2 through 200Kg/cm^2, and is expected to have a sufficient load bearing capacity as a dam foundation. However, with regard to the permeability, it frequently presents coefficients of permeability of the order of K = 10^{-4} cm/sec through 10^{-5}cm/sec at the mountainside. In terms of Lugeon value, these coefficients of permeability are of the order of Lu > 1, being therefore required impermeabilization countermeasures by means of curtain grouting. Permeability test data presently available are not sufficient, being therefore required to carry out a detailed survey in order to collect data complete enough to make possible the preparation of the Lugeon map along the dam axis.

On the other hand, a fault is presumed to be located in the interior of the basalt layer at the mountainside slope of the left bank side, according to the data obtained by seismic exploration. Methods like cut-off wall, grouting, etc., can be taken into consideration as foundation treatment measures required to cope with the said fault. Investigations by means of trench work, horizontal test pit, drilling, etc., are being presently set forth in this fault. The foundation treatment measures should be considered after confirming details like existence/inexistence of the fault, its position, scale, bearing capacity of the ground, possibility of active fault, etc.

(River deposit)

Next is discussed the river deposit. A detailed examination of the stratigraphy through the data collected from the drilling hole DH-11 evidences the alternation of gravel-and-sand and sand-with-gravel. Up to depth of the order of 3.05m from the surface, the river deposit is composed of a loose stratum consisting chiefly of silt and sand-with-gravel. However, even the strata located at the lower part and classified as sand-with-gravel contain large quantities of pebble, with quite high compactness, evidenced by penetrations of the order of 2.5cm through 15cm in correspondence to 50 strokes in the standard penetration test. Accordingly, a sufficient load bearing capacity can be expected if a surface layer of approximately 3m in thickness is removed.

Almost 50% of the river deposit is composed of strata with extremely high permeability coefficient, of the order of $K = 10^{-1} \sim 10^{-2}$ cm/sec and large quantities of underflow water are expected to be present therein.

5.4.3. Geology of the Spillway

The spillway is planned at the right bank side of the dam axis, and from the point of view of geological structure, it is composed of limestone, sandstone and basalt layers from the surface to deeper places.

(Foundation)

Generally speaking, unweathered basalt is distributed at the foundation of the spillway, with exception of the apron located at the downstream side. The presence of low velocity zones at some parts of this stratum was confirmed as a result of the seismical exploration. However, it is composed mostly of layers with elastic wave velocity larger than V = 2Km/sec and compressive strength larger than q_u = 50Kg/cm^2 and is therefore expected to have a sufficient bearing capacity to support structures.

(Face of slope of cuttings)

Slope faces of cuttings with a maximum height reaching 80m will be necessary for construction of the spillway.

The limestone layer located at the uppermost position contains frequent caves and open cracks. It is presumed that this layer is divided in individual blocks of various sizes, even when the characteristics evidenced by the outcrops suggest a relatively solid structure. Furthermore, underground water accumulated in this limestone zone is expected to spring out constantly from the vicinity of the bottom of this layer, and this is an unfavourable factor related to the stability of the face of slope of the cuttings.

As can be seen from the consideration above, it is expected that various kinds of strata will be exposed at the slopes of the cuttings. These strata present a plentiful of variations with regard to the stability of the slope, and it is therefore necessary to determine the gradient and the method of protection of the sloped in accordance with the geological conditions prevailing at each site.

5.4.4. Geology of the Diversion Tunnel

Two diversion tunnels, one of which is utilized as headrace tunnel latter, are planned to be constructed in the basalt area of the right bank side.

Weathered basalt with elastic wave velocity of the order of V = 0.3Km/sec through 1.4 Km/sec is distributed with a thickness of the order of 5m through 20m at the vicinity of the entrance of the tunnels, but generally speaking, this area is composed of unweathered basalt with elastic wave velocity of V = 2Km/sec through 3Km/sec.

From the lithological point of view, this basalt is characterized by the fact containing large quantities of pillow lava and volcanic breccia, in addition to the frequent presence of veins of calcite and quartz.

Many joints are irregularly distributed in this layer, but the strikes and dips are predominant in the directions of EW-N70°W/90°∿80°S, N10°E/90∿80°N, N55°/W80°S, etc. and their spacing is of the order of 0.5m through 3m in most of the cases. Besides the aforesaid joints, this layer is prone to crack along the direction of the veins.

There are rare cases of open cracks in this basalt layer, but at the vicinity of the tunnel formation, it is composed mostly of rock with a coefficient of permeability of the order of $K = 10^{-5}$cm/sec through 10^{-6}cm/sec.

The presence of a shear zone was confirmed at depths ranging from El.67.5m through El.70.0 in the drilling hole DH-8. A number of cracks develop at the vicinity of this shear zone, and the coefficient of permeability of the order of $K = 10^{-4}$cm/sec takes place therein. It is expected that confined water with a large head is contained in fissures at the vicinity of this shear zone.

The minimum distance from the diversion tunnel to the shear zone takes place at a distance of approximately 450m from the entrance of the said tunnel. However, details like the direction of the shear zone, head of underground water, etc. are not clearly known and are themes to be studies at the occasion of future surveys.

5.4.5. Geology of the Reservoir Area

The geological structure of the reservoir at the upstream side of the dam-site consists of basalt, andesite and quartz diorite.

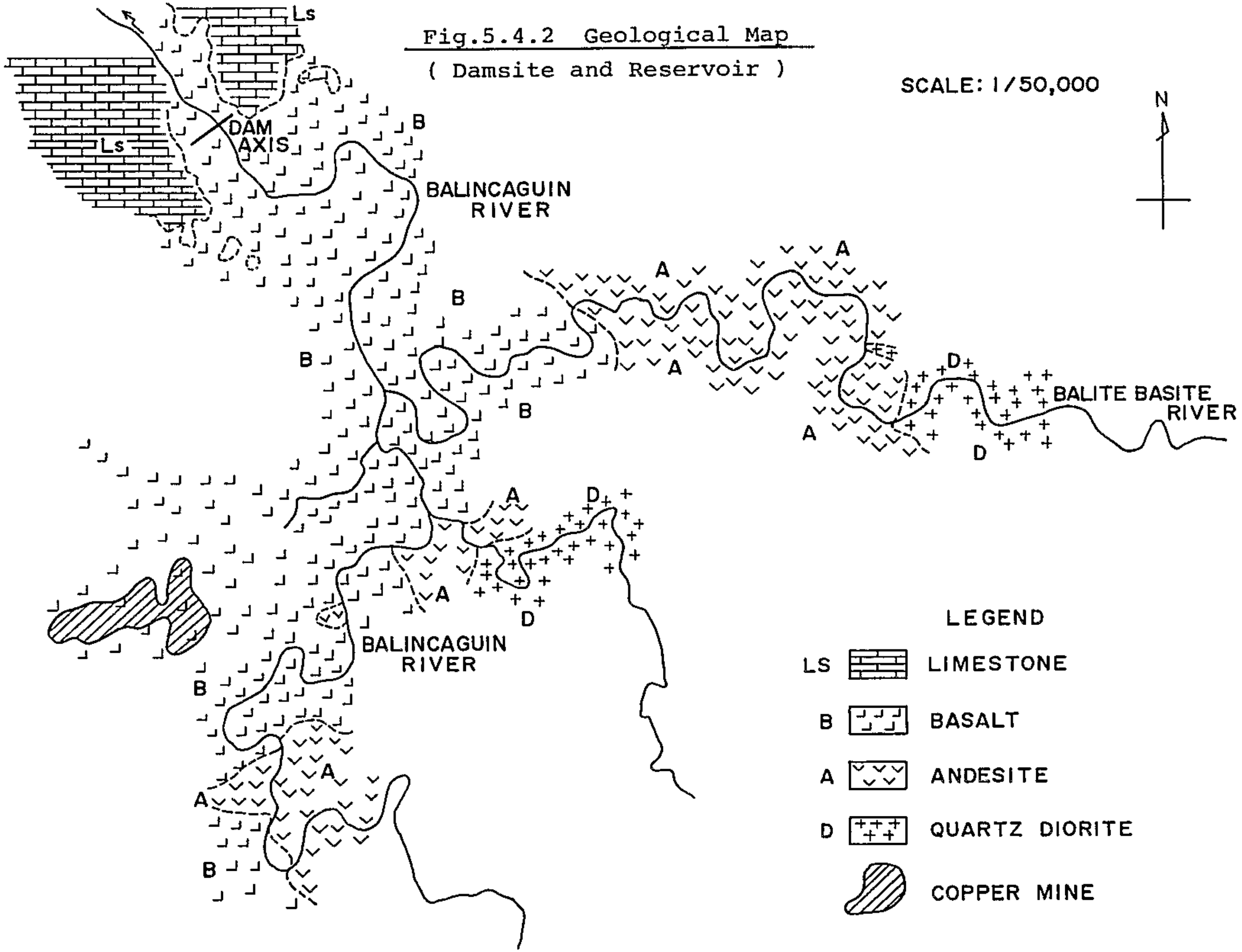
The distribution of basalt can be confirmed at the dam-site and up to a distance of approximately 5Km in the upstream direction to the SW side (Balite Basite River) and a distance of approximately 10Km in the south direction (Balincaguin River). The distribution of andesite and quartz diorite can be observed further upstreams of the aforesaid basalt distribution area. This andesite is a result of the magmatic differentiation of penetrated quartz-diorite and therefore it can be presumed that andesite is in gradation of quartz diorite.

As can be seen from the considerations above, distribution of strata particularly noxious for the sake of ponding is not observed in the geological structure of the storage reservoir area and in addition no case of topography of collapsible type occurs therein.

Approximately 7Km to the SSW of the dam axis there is a copper mine of the MARLO COPPER MINING CO., which is expected to be completely removed by December of 1981.

Fig.5.4.2 Geological Map

(Damsite and Reservoir)



CHAPTER 6

DAMSITE AND RESERVOIR

6. Damsite and Reservoir

6.1. Site Selection

The dam site of the Mabini Dam was decided by selecting initially 2 points, besides the planned site (Site-A) and by carrying out their comparative study through maps with 1:4,000 and 1:50,000 scales.

The Site-B is located in the Namacalan River, approximately 3.3Km upstreams from the point of confluence of the Namacalan River with the Balincaguin River (this point of confluence is located approximately 5Km upstreams from the proposed damsite), while the Site-C is located in the Balincaguin River, approximately 5.2Km upstreams from the point of confluence.

The comparison of the characteristics of each one of the sites mentioned above is presented in Table 6.1.1.

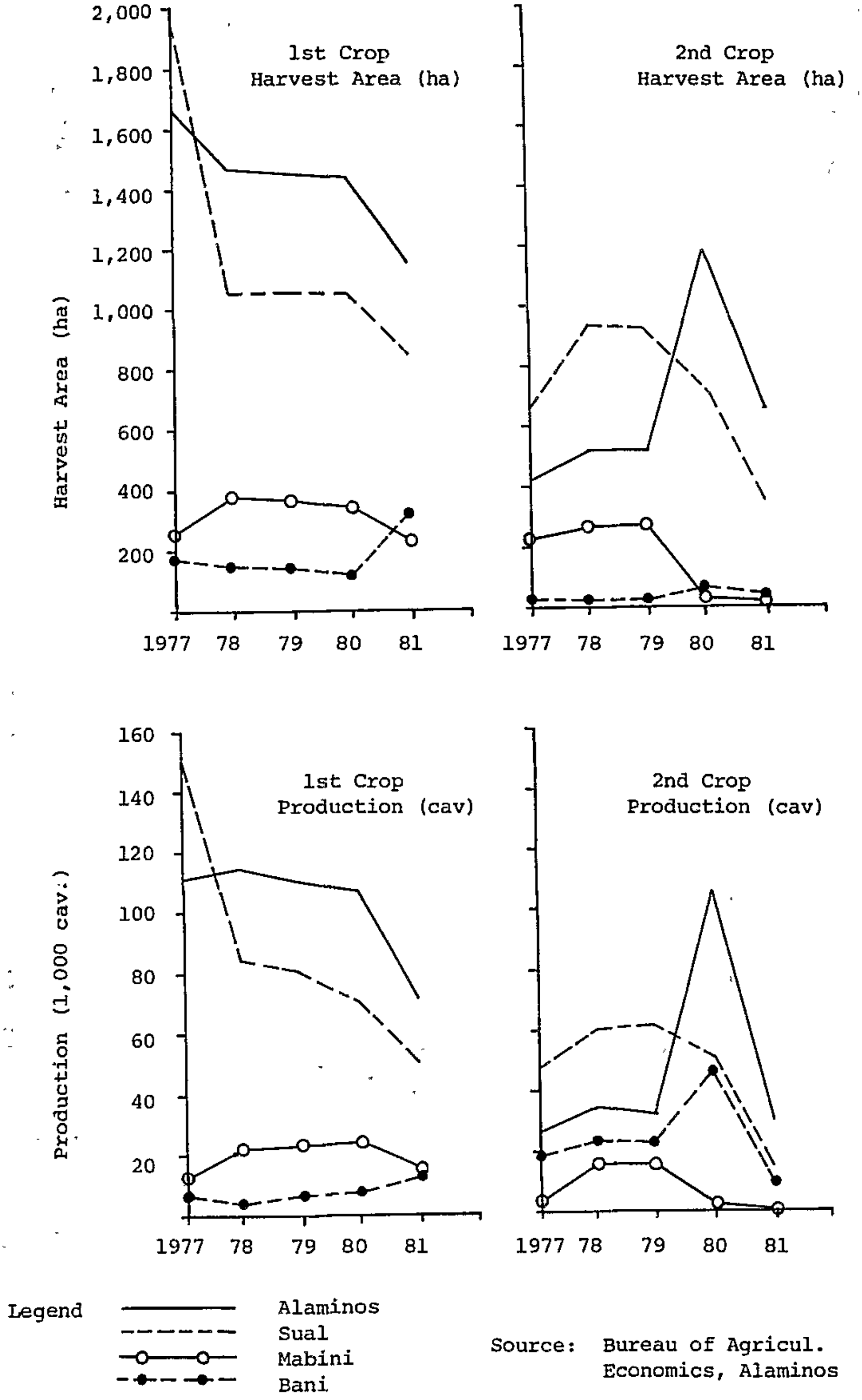
Table 6.1.1 Comparison Table of the Major Items on Each Dam-site

Item	Unit	Damsite-A	Damsite-B	Damsite-C
Catchment Area	km^2	225	62	121
Distance from Damsite-A	km	0	8.3	10.2
Annual River Run-off	m^3/year	486×10^6	134×10^6	261×10^6
Effective Storage Capacity	m^3	240×10^6	67×10^6	131×10^6
Irrigation Service Area	ha	11,500	3,300	6,300
Capacity of L.W.S.	m^3	63×10^6	8×10^6	16×10^6
Capacity of N.W.S.	m^3	303×10^6	75×10^6	147×10^6
N.W.S.	m	63.00	74.00	82.00
Dam Crest Elevation	m	68.50	78.50	87.00
River-bed Elevation	m	13.00	28.00	35.00
Dam Height from River-bed	m	55.50	50.50	52.00
Note		Proposed Dam-site	Namacalan River	Balincaguin River

CHAPTER 7

AGRICULTURAL PRODUCTION IMPROVEMENT

Fig. 7.1 Area and Production of Paddy 1977-1981 Crop Year



Source: Bureau of Agricul. Economics, Alaminos

Table 7.1 Forecast Yield

Unit: Ton/Ha

Municipality	Soil Type	Area	Wet Season					Dry Season		
			Rain fed		Irrigated			Irrigated		
			Future	Present	Future	Present	Increase Percent	Future	Present	Increase Percent
		(%)								
Alaminos	AmASL									
Sual	AmBSL	36.48	2.25	2.25	5.57	3.84	145	5.75	3.83	150
North Part of Mabini	AmASIL									
	BaASIL									
West Part of Mabini	BaBCL									
Scatered on Sloped Land	AmBCL	38.55	1.67	1.67	4.35	3.00	145	4.29	2.86	150
	AmCCL									
	AmDCL									
Bani	BaAC									
West Part of Alaminos	BaACL	24.97	1.87	1.87	3.48	2.40	145	4.16	2.7	150
TOTAL		100.00	1.93	1.93	4.58	3.16	145	4.79	3.19	150

Note:
- ° Future Yield = Present Yield x Increase Percent.
- ° Increase of yield due to fully illigation and agricultural improvement.
- ° In Philippines, rice, yield increase 4.9 percent per annum from 1964 - 65 to 1970 due to high yield variety extension.
- ° Future total yield is average of weighted by area.

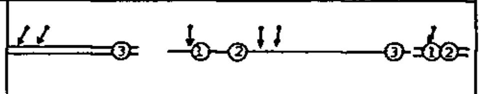
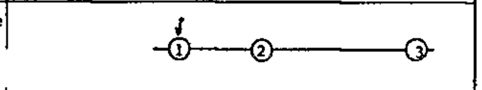
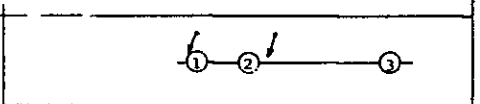
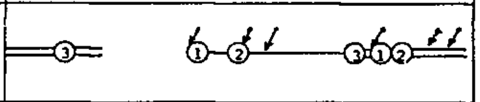
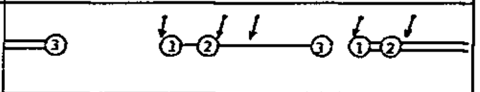
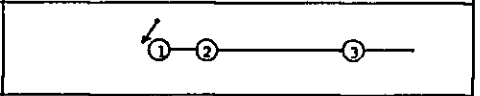
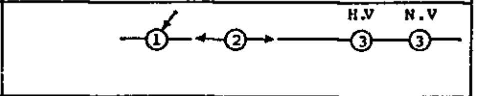
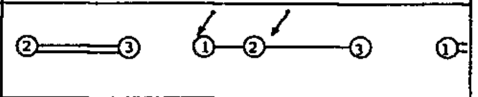
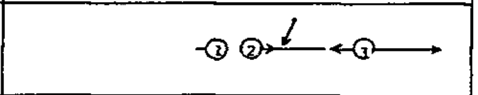
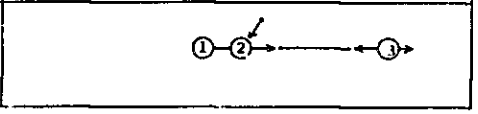
Table 7.2 Agricultural Production, Farm Economy and Living of 10 Farmers (1) Oct. 1981

No. of Far-mer	Adress	Situation		Family(person)			Farm our labor	Hired labor	Land tenure			Land use
	Munici-parity Barangay	(Km) from Bus road post office	(m) Sea level	Male Fe-male	Farm labor Farm labor	school pupil	Kinds mday/year wage/day (₱)	Kinds mday/year wage/day (₱)	Owned (ha)	Lease (ha)	payment for owner	Paddy(%) Upland (%) Parcel (Num.)
1	Alaminos Tucoc	1 4	8.0	1 4	1 1	3	Welder 80 25	non	1.2	1.0		100 0 2
2	Alaminos Polo	7 7	3.0	3 4	1 1	2	farm labor 50 exchange	farm labor 50 exchange	0	3.0	14 cav 13ha/year	100 0 1
3	Alaminos Bued	3 3	4.5	2 4	1 1	4	non	non	0.48	3.0		100 0 2
4	Alaminos Cabatuan	0 5	10.0	5 3	3 0	MANILA MANILA 1 1	non non non	non	0.5	2.0	11cav/2ha/ crop cycle	100 0 1
5	Sual Seselangan	0 10	20.0	2 2	1 1	2 DAGPAN ALAMINOS	non non non	non	0	2	Irrig.1.25ha 22cav/year/2crop partially Irrig. 0.75ha14cav/year	100 0 2
6	Sual Paitan east	0 8	30.0	7 4	2 2	3	Welder 2,400 Plowing 3,000	non	0.25	2.75	owner 25% farmer 75%	100 0 2
7	Mabini Calsada	0 1.5	25.0	6 5	3 0	High school 2 College3	Soldier 1 Merchant 1 total 30₱/day	Plowing 6d.m.w.Ca x30=80₱	1	0.25	8cav/ha/year -1 bag fertilizer	100 0 2
8	Mabini Dacoc	0 8	20.0	2 4	2 0	1	non	transplant 20md=200P Thresher 340cavx0.8=28	0.5	1.75	14cav/2 crop 1 year	100 0 1
9	Bani Ambabaay	0.3 2.5	4.0	3 4	1 1	3	non	Planting 100md 1,000 ₱ Cutting 1,000 Thresher 1,000	6.5	0	non	100 0 2
10	Bani Banog N.	1 4	4.5	9 4	2 1	3	Carpenter 1,000P/year	Planting 60mdx10=600 Plowing 15x30=450 Thresher Hav.x1/12=20cav	1.3	2.0	10.8cav/year	100 0 2

Table 7.2 Agricultural Production, Farm Economy and Living of 10 Farmers (2) Oct. 1981

No. of Far- mer	Adress Munici- parity Barangay	Irrigation Irrigated Rainfed Method	Flooding Month times/10 year Flooding Typhoon damage	Living Water Water Source (m) from house Water Level(m)	Crop Production Crop Curtivated (ha) 1st 2nd Yield/ha (cav) 1st 2nd
1	Alaminos Tucoc	All paddy, not fully 0 Pump up river Irrg. Asso. 80ha	July - Sept. non 2 Slight	Pump house lot 10	rice only 2.2 2.2 80 60
2	Alaminos Polo	0 All rainfed non	July - Aug. 10 1/2 meter	deep well house lot 18	rice only 3.0 one crop 43
3	Alaminos Bued	non All rainfed non	July 10 0.2m deep	Pump house lot 6m	rice only 3.48 one crop 70
4	Alaminos Cabatuan	Irrig. 100% 150 ha, 20 pumps Irrig. Asso.	July - Oct. non 2 slight	Well pump house lot Wet,drys 18	rice 2.5 2.5 85 60
5	Sual Seselangan	Irrigated Pump individually d. Association	June - Aug. sometimes Slightly	Pump house lot 10	rice 2.0 2.0 90 90
6	Sual Paitan east	non Rainfed non	July - Aug. no problem	Pump house lot 12	rice 3.0 45
7	Mabini Calsada	non Rainfed from next year Irrigated	June - Sept. 30 1964 5m	Pump house lot 9	rice 1.5 one crop 57
8	Mabini Dacoc	Irrigated non by FSDC	July - Aug. 4 1m high	Pump house lot 12	rice 2.5 2.0 80 70
9	Bani Ambabaay	non All rainfed non	July - Aug. every year 1m high	Pipe Local Ad. Utility Wat.	rice,calabdo 6.5 4,000P/year 52
10	Bani Banog N.	non Rainfed non	June - Aug. 10 low area	Well 20 2	rice 3.3 50

Table 7.3 Agricultural Condition of 10 Farmers

No. of Far-mer	M99 Loan O	Working facility	Fertilizer (bags)					Insectiside			Herbi side		Seed supply	Variety(%)	Preset Cropping System
		Carabao (heads) Tracter (Nub) (H·P)	crop	45-0-0	14-14-14	16-20-0	12-20-0	numb. of kind	used (bgs) (qt)	Folidole (qt)	2-4-D (bg)	Others (bgs)	BP1(%) Sef(%) exchange Others	H.Y.V IR36 IR42 Others Native V.	① Land preparation ② Trans Planting ③ Harvesting 1st crop —○— 2nd crop ═○═ Fertilizer applicat. ↙ J F M A M J J A S O N D
1	O	1 1 10H·P	1st 2nd	4 4	8 10	0 0	0 0	3			5.5	10		H 60 V 40 0 0	
2	θ	2 non	1st 2nd		2 0	0 0	0 0	0	0	0	0	0	0 50 50	All native WAGWAG others	
3	O	2 0	1st 2nd	4 0	16 0	0 0	0 0	2	5	0	1	1	20 80 0	H 70 V 20 10	
4	O	0 1 10H·P	1st 2nd	 3	20 0	0 0	0 0	2	2 bg 2 qt	0	6.0	0	100 0 0 0	H 50 V 15 (IR50) 35 0	
5	O	1 1 10H·P	1st 2nd	3 4	14 12	0 0	0 0	5	2 3 2 3	0 0	2.5 5 2.5	0 0	100 non	All IR36	
6	θ	0 1 10H·P	1st 2nd	2 0	6 0	0 0	0 0	3	5 bg 3 qt	0	0	3	0 100 0	H 60 non V IR50 40 non	
7	X	1 non	1st 2nd	0 0	0 0	3 0	0 0	1	1 qt	1 qt	3 bgs	0	0 100 0 0	H 20 V 80 0 0	
8	O	2 non	1st 2nd	0 1	0 0	8 5	0 0	2	2 qts	0	0	0	0 100 0 0	H 20 V 80 0 0	
9	X	4 Hand Tracter 10H·P	1st 2nd	11 0	10 0	 0	 0	1	0	1.5 qts	0.5 bg	0	0 100 0 0	H 1.0ha V 0.5ha 0.8 4.2ha	
10	X		1st 2nd	1 0	16 0	0 0	0 0	1	1 qts	0	0	0	0 100 0 0	H 30 V 0 L137.70 0	

Note: ① M99 Loan Utilization O much θ little

Table 7.4 Rough Estimation of farm and Farmer's Economy

No. of Farmer	M99	Rough Estimation of Farm and Farmer's Economy																
	Loan O	Farmer's gross receipts				Farm expenses							Income		Family expenses			Farmer's balance
		Farm Rept.		off Farm Rept.	Total	Land payment	Seeds	Fertilizer chemicals	Hired Labor	Water payment	Others	Total	Farm Income	Farmer's Income	Living exp.	Education exp.	Total	
		Sold Amt.	Value															
1	◎	①	②	③	④-②+③							⑤	⑥-②-⑤	⑦-④-⑤			⑧	⑨-⑦-⑧
2	⊘	62	@65₱ 4,000 (100)	0	4,000 (100)	980	0	204	0	0	237	1,421 (36)	2,609	2,609	2,400	200	2,620	(-) 11
3	O																	
4	O	300	21,000 (100)	0	21,000 (100)	1,416	238	3,814	1,820	1,050	1,769	10,107 (48)	12,800	12,800	10,000	3,000	13,000 (62)	(-) 200
5	O	306	21,420 (100)	0	21,420 (100)	2,520	190	2,631	450	420	1,659	7,870 (37)	13,550	13,550	9,000	4,000	13,000 (61)	(+) 550
6	⊘																	
7	X	40	2,800 (100)	10,000	12,800 (457)	280	105	448	180	0	1,259	2,272 (81)	528	10,528	5,730	5,000	10,730 (382)	(-) 202
8	O																	
9	X	340	25,000 (100)	0	25,000 (100)	0	455	3,260	3,000	2,500 machine	5,878	15,093 (60)	9,907	9,907	9,000	1,800	10,800 (43)	(-) 893
10	X																	

Note: ② palay @70₱, but No. 2 @65₱

Table 7.5 Fragmentation of Farms Land by Municiparity April 1971

Province and Municipality	Total Num. of Farm	Farm number by parcel			
		1	2 - 3	4 - 5	6 and more
Pangasinan	89,305	35,095	41,185	9,493	3,232
	(100)	(39)	(46)	(11)	(4)
Alaminos	3,744	2,307	1,256	93	28
	(100)	(62)	(34)	(3)	(1)
Sual	1,155	689	432	28	6
	(100)	(60)	(37)	(2)	(1)
Mabini	1,251	946	296	9	0
	(100)	(76)	(23)	(1)	
Bani	2,929	1,701	1,093	120	15
	(100)	(58)	(37)	(4)	(1)

Source: 1971 census of agriculture

Note: Parcel is a piece of land in the holding

Table 7.6 Farms - Number by Size and Municipality April 1971

Province and Municipality	Total Num. of Farm	Under 1 ha	1 ha and under 3 ha	3 ha and under 5 ha	5 ha and under 10 ha	10 ha and under 25 ha	25 ha and over
Pangasinan	89,305 (100)	19,237 (22)	53,702 (60)	12,909 (14)	2,662 (3)	508 (1)	86 (-)
Alaminos	3,739 (100)	324 (9)	2,647 (71)	678 (17)	75 (2)	13 (1)	2 (-)
Sual	1,149 (100)	120 (10)	655 (57)	291 (25)	58 (5)	20 (2)	5 (1)
Mabini	1,244 (100)	89 (7)	726 (58)	327 (26)	68 (6)	33 (3)	1 (-)
Bani	2,929 (100)	350 (12)	1,780 (61)	557 (19)	183 (6)	54 (2)	5 (-)
Project area total 1971	9,061 (100)	883 (10)	5,808 (64)	1,853 (20)	384 (4)	120 (2)	13 (-)
Project area total 1979	6,665 (100)	1,620 (25)	4,281 (65)		764 (10)		

Source: 1971 census of agriculture
1979 NIA Agro-Economic Survey

CHAPTER 8

WATER REQUIREMENT

8. Water Requirement

8.1. Reference Crop Evapotranspiration, ETo

The following methods are proposed and recommended by international institutions for the sake of calculation of the reference crop evapotranspiration ETo.

(1) Blaney-Criddle Method

(2) Radiation Method

(3) Penman Method

(4) Pan Evaporation Method

The following meteorological observation data are required in order to calculate the evapotranspiration by means of the aforesaid methods.

Method	Temperature	Humidity	Wind	Sunshine	Radiation	Evaporation	Environ
Blaney-Criddle	*	0	0	0			0
Radiation	*	0	0	*	(*)		0
Penman	*	*	*	*	(*)		0
Pan evaporation		0	0			*	*

*: Measured data;
0: Estimated data;
(*): If available, but not essential

Details regarding the observation stations and observed data of the project area are described in Chapter 4. Hydrology & Meteorology of this report. The following ones among the data are related with the above mentioned calculation methods.

Dagupan City (PAGASA)

Temperature (monthly average) 1949-1981 (33 years)

Relative humidity (monthly average) 1949-1981 (33 years)

Wind velocity & direction (monthly average) 1964-1981 (18 years)

San Roque (BPW)

Evaporation (monthly average) 1958-1970 (13 years)

Mabini (NIA)

Evaporation (monthly average) 1969-1981 (2 years, with many missing data)

After the examination of the methods for calculation of evapotranspiration and the availability of data required by each one of them, it is decided to carry out the calculation with the Penman Method, by using the data collected at the Dagupan City.

The calculation of the evapotranspiration by means of the Penman Method was already calculated by the NIA. Therefore, the said data is used in this report. The results of calculation of the evapotranspiration with the Penman Method are listed in Table 8.1.1.