1. INTRODUCTION

This Supporting Report presents the results of meteorological and hydrological study carried out during the Feasibility Study stage.

Major work items are enumerated below:

(1) Additional data collection,
- Meteohydrological observation by AFCS
- Major flood record by AFFWS (PAGASA)

(2) Compilation of Data Book for meteohydrological observation record by AFCS,

(3) Verification of flood runoff model by use of additional flood record collected,

(4) Reassessment of identified priority flood control area (upstream of Agno river stretch between Bayambang and ARIS dam) due to revised H-V curve at Poponto swamp,

(5) Flood analysis of the design flood discharge distribution for flood control plans,
- Framework plan
- Long Term plan

(6) Flood analysis of the design flood distributions for flood control alternatives,

(7) Flood analysis of the design flood for drainage plan,and
- Relationship between specific runoff and drainage area in the lowland areas
- Design flood hydrographs for inland drainage plan in Dagupan City.

(8) Assessment of seawater intrusion into the Pantal-Sinocalan river due to channel improvement.

2. ADDITIONAL DATA

2.1 Meteohydrological Observation by AFCS

Four automatic rainfall gauges and nine automatic water level gauges were installed by DPWH as shown in Table 2.1. The location map of these gauges is given in Fig. 2.1.

These gauging stations were selected from hydrological viewpoint taking into account the existing meteohydrological observation network in the Agno and Allied river systems. The observed meteohydrological data from said stations together with those from the existing stations were used herein for the hydrological study in the Feasibility Study stage.

Meteohydrological observation records which are newly collected by AFCS is listed in Table 2.2. These records are compiled in the Data Book.

As shown in Table 2.2, discharge measurement was carried out in order to construct discharge rating curves at water level gauging stations. Discharge rating curves prepared for the 6 stations are shown in Fig. 2.2.

2.2 Flood Record in 1990

Major typhoons in 1990 causing heavy rainfall in the Agno and Allied river basins are enumerated below:

Typhoon	Occurrence date
BISING	June 21 - 24
HELING	Aug. 25 - 28
ILIANG	Aug. 30 - Sept. 2
LOLENG	Sept. 5 - 8

The observed 4-day rainfall records by AFCS together with those of PAGASA for the above typhoons are summarized in Table 2.3.

Among the above mentioned typhoons, BISING brought about a very heavy rainfall in the Bued river basin as shown in Fig. 2.3 of the rainfall isohyetal map. Saytan and Camp-4 stations recorded a 1,000 mm and 819 mm. of 4-day rainfall respectively, while other stations located in the Agno river and the Pantal-Sinocalan river basins received rainfall amount less than 400 mm.

The basin mean 4-day rainfall in the Cayanga-Patalan river is estimated at about 740 mm which corresponds to a 25-year probable rainfall. On the other hand, the basin mean rainfall in the Pantal-Sinocalan river is estimated at about 340 mm, which is almost equal to the probable rainfall with a 2-year return period of 308 mm.

The observation records of hourly rainfall and water level during the above major typhoons are illustrated in Figs. 2.4 to 2.7 and Figs. 2.8 to 2.11. In addition, the 3-hour rainfall and water level records are available at 5 telemetered gauging stations of AFFWS. The observed record are summarized in Tables 2.4 to 2.11.

2.3 Water Sampling

Water sampling and electric conductivity test were conducted during the dry season (March, 1990) to assess the sea water intrusion into the Agno, the Pantal-Sinocalan and the Cayanga-Patalan rivers.

The selected sites for water sampling are summarized in Table 2.12. The location map of the sites is shown in Fig. 2.12. The water sampling was made at the following positions of river section.

- at the upper surface	(50 cm below of water surface)
- at the bottom	(channel bottom)
- at the middle	(middle depth)

In case the water depth is less than 2.0 m, water sample was taken at the middle depth of channel section.

The chloride concentration of sampled water was measured in terms of electric conductivity. The results of salinity test are summarized in Tables 2.13 to 2.15. The chloride concentration is about 27,000 to 29,000 ppm in sea water, and fresh water normally contains less than 10 ppm of chloride.

As shown in the test results, the chloride concentration at channel bottom shows higher values than at upper water surface near the river mouth. Thus, sea water intrudes farther at channel bottom than at surface of river channel. Based on the test results, the maximum front point of the sea water intrusion is roughly estimated as follows:

- Agno river	:	About 18 km from the river mouth (near Brgy. Salinap, San Carlos)
- Pantal-Sinocalan river	:	About 12 km the from river mouth (before junction of Ingalera river)
- Cayanga-Patalan river	:	about 10 km from the river mouth (near Brgy. Casibong, San Jacinto)

2.4 Other Related Data and Information

2.4.1 Revised H-V curve at Poponto swamp

The Master Plan on flood control (i.e., Framework Plan and Long Term Plan) in the Agno River was formulated through the period March 25, 1989 - February 15, 1990.

The flood control components formulated in the Master Plan are:

<u>Framework Plan</u> (Agno river)
- River improvement
- Poponto swamp as natural retarding basin
- Moriones-O'Donnel dam

<u>Long Term Plan</u> (Agno river)
- River improvement
- Poponto swamp as natural retarding basin

As shown above, the Poponto swamp is assessed to act as natural retarding basin from the viewpoint of flood control in the Agno river basin. For the assessment of flood control effect of the Poponto swamp, the capacity for natural retarding thereof was estimated based on the existing topo maps with a scale of 1/50,000.

In line with the commencement of Feasibility Study, the topographical mapping of the Poponto swamp area covering about 310 km^2 was executed by JICA with a scale of 1/25,000. Based on the new topo maps, the capacity for natural retarding is re-estimated as shown in Fig. 2.13. As shown in these H-V curves, storage capacity of about 800 x $10^6 m^3$ at an elevation of 16.0 m is reduced to about 500 x $10^6 m^3$, which shows an approximate 40% reduction in storage capacity of the Poponto swamp. This implies that expected flood control effect in the downstream reaches of Wawa in the Agno river is to be decreased due to reduction of natural retarding capacity of the Poponto swamp.

2.4.2 River cross section data in Pantal-Sinocalan river

Sixty river cross sections are available in the Pantal-Sinocalan river after the execution of river survey. Thus the carrying capacity under the present river conditions is to be assessed in the course of the Study.

Along this line, the parameters of storage function in the Pantal-Sinocalan river channel are to be confirmed in the flood runoff model by using these river cross sectional data.

3. FLOOD ANALYSIS

3.1 Verification of Flood Runoff Model

Flood runoff simulation model by means of storage function method was introduced in the Master Plan Study stage for the estimation of probable flood runoff distribution. The simulation model for the Agno river was calibrated on the basis of the flood record of typhoon Maring in 1984.

Since no flood record is available, the flood simulation model in the Allied rivers was developed assuming that the empirical formula calibrated in the Agno river was applicable in the determination of model parameters of basin runoff model.

Flood analysis was herein performed to examine the accuracy of the flood simulation model of the Pantal-Sinocalan river in comparison to the simulation results with the newly observed flood records by AFCS. In this analysis, the same model parameters determined in the Master Plan Study stage were used for basin runoff model, and parameters in river channel model were estimated anew based on the additional river cross section data.

The flood record of typhoon Bising in 1990 was selected for the comparison. The flood hydrographs were simulated well at Tagamusing, Sinocalan and Santa Barbara stations as shown in Fig. 3.1.

In view of the above, the flood simulation model is assessed to be unnecessary for modification. Thus, the probable flood peak discharge distribution of the Agno and Allied rivers under confining dike condition is adopted unchanged compared with the one in the Master Plan Study stage as given in Figs. 3.2 and 3.3.

3.2 Revision of Design Flood Distribution

As mentioned earlier, the peak flood discharge in the downstream reaches of Wawa in the Agno river will increase to some extent due to the reduction of the natural retarding function of the Poponto swamp.

The design flood discharge distributions of formulated flood control plans in the Agno river were revised by using the new storage capacity curve at the swamp. The revised distributions are illustrated in Fig. 3.4 for the Framework Plan, Fig. 3.5 for the Long Term Plan and Fig. 3.6 for the 10-year flood control plan. The previous discharges are indicated inside the parenthesis.

The difference between the revised values and previous ones at the river mouth of the Agno river is compared as follows:

Risk Level	Previous Design Flood (m^3/s)	Revised Design Flood (m^3/s)	Rate of Increase (%)
100-year flood (Framework Plan)	12,300	13,800	12
25-year flood (Long Term Plan)	9,000	10,100	12
10-year flood	6,500	7,400	14

The design flood discharge distribution of the Pantal-Sinocalan river for the 10-year flood control plan is shown in Fig. 3.7.

3.3 Flood Analysis of Dagupan City Area

In order to resolve the technical and socio-economic issues of the urban stretch of the Sinocalan river which was identified through the Feasibility Study stage, the four alternative plans comprising of by-pass and floodway are preliminarily contemplated for comparison. Among these alternative plans, Alternative - 2A (Dagupan by-pass with closure of the urban stretch) will require to formulate a drainage plan of Dagupan City with an area of 6.33 Km^2. Along this line, flood analysis was performed to construct the probable flood discharge hydrographs necessary for the design of drainage structures.

The main procedure and results are briefly discussed below:

(1) Probable basin mean rainfall

Since the objective drainage area in Dagupan City is 6.33 Km^2 and the area reduction of point rainfall is assessed to be negligibly small, the probable basin mean rainfall is estimated based on daily rainfall record at Dagupan station for the period of 1951 to 1988.

The design rainfall duration is assessed to be 4 days from duration record of major storms. Table 3.1 shows the annual maximum point rainfall at Dagupan station with 1-day, 2-day, 3-day and 4-day duration and frequency curve for each duration is given in Fig. 3.8. The probable basin mean rainfall is thus estimated by means of Pearson Type III method as summarized below:

Return Period (Year)	Probable rainfall (mm)			
	1-day	2-day	3-day	4-day
1.05	75	107	131	145
2	158	228	265	291
5	230	351	408	450
10	281	449	522	578
25	346	584	689	768

(2) Rainfall intensity-duration-frequency analysis

The rainfall intensity-duration-frequency analysis (5, 15 and 30 minutes, 1, 6, 12, and 24 hours) on rainfall record at Dagupan station was conducted by PAGASA in 1981. According to the analysis, rainfall extreme values in terms of intensity, duration and frequency at Dagupan City are summarized as shown in Table 3.2.

(3) Probable rainfall intensity-duration curve

The probable rainfall intensity-duration curves were constructed for return period of 5 and 10 years based on the result of rainfall intensity-duration-frequency analysis mentioned before. The applied curve is expressed by the following equation:

$$r = a / (t^{n} + b)$$

where, r : rainfall intensity (mm/hour)
t : duration time (minutes)
a,b,n : constants

This formula is widely used for rainfall intensity-duration curve, and n of constant generally reported to vary from 0.5 to 1.0 . The constants of the formula are determined through the following procedures:

(a) Assuming 6 cases of value of n, i.e., 0.5, 0.6, 0.7, 0.8, 0.9 and 1.0
(b) Determine values of a and b by least square method for each above case, which is expressed as follows:

$$a = ([r]\cdot[r^{2}\cdot t^{n}] - [r^{2}]\cdot[r\cdot t^{n}]) / ([r]^{2} - N\cdot[r^{2}])$$

$$b = (N\cdot[r^{2}\cdot t^{n}] - [r]\cdot[r\cdot t^{n}]) / ([r]^{2} - N\cdot[r^{2}])$$

where, N : number of samples for duration
[] : summation ($\sum_{i}^{N}$)

(c) Calculate standard deviation for each case
(d) Select best combination of constants among above cases which gives the least standard deviation

Table 3.3 shows the calculation results of standard deviations.

Through the adjustment to equalize to estimated probable 1-day rainfall in preceding section (1), the probable rainfall intensity-duration curves are finally examined as follows:

$$r_{5\text{-year}} = 1352 / (t^{0.7} + 5.37)$$

$$r_{10\text{-year}} = 1610 / (t^{0.7} + 6.13)$$

These curves are illustrated in Fig. 3.9 and the probable rainfall intensities are summarized below:

Return Period (Year)	Probable rainfall intensity (mm/hour)						
	Duration Time						
	15 min.	30 min.	60 min.	3 hr.	6 hr.	12 hr.	24 hr.
5	112	84	59	31	20	13	8
10	126	95	68	37	24	15	10

(4) Runoff model and parameters

For the estimation of flood discharge hydrograph in Dagupan City area , the rational formula is herein employed as expressed below:

$$Q = f \cdot r \cdot A / 3.6$$

where, Q : flood peak discharge (m^3/sec)
f : runoff coefficient
r : rainfall intensity for a duration time corresponding to flood concentration time (mm/hour)
A : drainage area (Km^2)

Runoff coefficient in the Dagupan City area is estimated at 0.6 by the weighted average for the following land use:

Land use	Runoff coefficient	Occupation
City area	0.9	25%
Paddy area, fishpond	0.5	75%

Runoff coefficient in city area is assumed to be 0.9 taking into account future urbanization thereof.

Flood concentration time is estimated based on the flood travelling time in main river channel of about 7.8 Km in the drainage area. In this study, the Manning formula is employed to estimate flood flow velocity. The flow velocity is estimated to be about 1.4 m/sec and the flood concentration time is thus estimated at about 1.5 hour.

(5) Probable flood discharge

Design rainfall distribution for 4-day duration is constructed as follows:

1st day : uniform distribution of R4-R3
2nd day : uniform distribution of R2-R1
3rd day : center-concentrated distribution of R1
4th day : uniform distribution of R3-R2

where, R1 : probable 1-day basin mean rainfall
R2 : probable 2-day basin mean rainfall
R3 : probable 3-day basin mean rainfall
R4 : probable 4-day basin mean rainfall

Probable flood discharge hydrograph is estimated by the rational formula based on the design rainfall distribution as illustrated in Fig. 3.10 . The estimated probable flood peak discharge in Dagupan City area with a drainage area of 6.33 Km^2 is given below:

Return period (Year)	Peak discharge (m^3/sec)
5	50
10	58

3.4 Relationship between Specific Runoff and Drainage Area

The relationship between specific probable flood peak discharge and drainage area is examined for drainage sluice/gate design in lowland area along the Pantal-Sinocalan river. The relationship curves for 5-year and 10-year probable floods are shown in Fig. 3.11.

4. SEAWATER INTRUSION ANALYSIS

4.1 General

Seawater intrusion analysis was performed to assess the influence of channel improvement to existing water use along the Pantal-Sinocalan river in comparison with the extent of seawater intrusion under both the existing and proposed by-pass channel conditions.

As mentioned earlier, water sampling and electric conductivity test were conducted during the dry season (on March 6, 1990) along the Pantal-Sinocalan river. The test results shows the chloride concentration at channel bottom gives higher values than at upper water surface near the river mouth. The seawater thus intrudes farther at channel bottom that at surface of river channel. Based on the results, the extent of seawater intrusion is herein analyzed assuming that the boundary face between seawater and river fresh water clearly exists in the shape of a salt wedge. Seawater intrusion analysis was firstly made to calibrate the identified maximum point of front of intruded salt wedge under the condition when water sampling was conducted on March 6, 1990 as shown below:

- Tide level : El. 0.50 m
- River discharge : 6.1 m^3/sec (discharge at Sinocalan station)
- River channel : the existing channel

Simulation results is shown in Fig. 4.1. The estimated maximum point of the front of intruded salt wedge shows about 12 km from the river mouth located before the junction of the Ingalera river, which almost coincides with the location assessed through water sampling and electric conductivity tests.

4.2 Seawater Intrusion of Pantal-Sinocalan River

The rate of seawater intrusion is influenced by the tide levels at the river mouth, river discharge and shape of channel sections. For the present study, the following two cases are taken into consideration in order to estimate the maximum point of front of the salt wedge:

Condition	Case 1	Case 2
(1) Tide level	El. 0.70 m, MSL of average monthly maximum water level	El. 0.70 m, MSL of average monthly maximum water level
(2) River discharge	3.5 m^3/sec, the 95% dependable discharge	3.5 m^3/sec, the 95% dependable discharge
(3) River condition	existing channel	proposed bypass channel

The dependable discharge is estimated on the year 1990 flow duration curve at the Sinocalan water level gauging station as summarized below:

Duration (%)	Discharge (m^3/sec)
20	35.2
40	22.8
60	9.4
80	6.7
90	5.6
95	4.0

The 95% dependable discharge around the front of salt wedge is estimated taking into account the 0.5 m^3/sec of the existing irrigation water use at Sinocalan irrigation dam located downstream of the Sinocalan station. In addition, the annual rainfall amount in 1990 is 1,971 mm at Dagupan station, which shows relatively smaller annual rainfall amount compared with the 2,416 mm annual mean rainfall of 1965-1988.

The simulation results is given in Fig. 4.2. The estimated maximum positions of the front of salt wedge are briefly described below:

Existing channel (Case 1)	:	about 13 km upstream from the river mouth (about 0.5 km upstream of the junction of the Ingalera river)
By-pass channel (Case 2)	:	about 14 km upstream from the river mouth (about 0.5 km upstream of the Calasiao bridge)

In the case of the proposed by-pass channel, the front of salt wedge intrudes about 1 km upstream in addition to the existing condition. Therefore, the Sinocalan irrigation dam of the existing water intake facility which is located about 24 km from the river mouth will not be affected by the seawater intrusion.

TABLES

Table 2.1 ESTABLISHED METEOHYDROLOGICAL OBSERVATION STATION

Station	Date of Installation	Remarks
Rainfall		
(1) Camp 4	Aug. 21, 1989	Near the Aropong-Camp 4 in the upper basin of the Bued River.
(2) Saytan	Aug. 21 1989	At the compound of Saytan Elem. School in the lower basin of the Bued River.
(3) Sto. Domingo	Sept. 3, 1989	Near the Tacnien town in upper basin of the Tuboy River.
(4) Iba	Sept. 3, 1989	Near the Iba town in the lower basin of the Bulsa River.
Water Level		
(1) Camp 1	Dec. 1, 1989	Road bridge crossing Bued River between Baguio City and Brgy. Saytan, Tuba.
(2) Aloragat	Oct. 23, 1989	Road bridge at Aloragat River and connecting towns of Manaoag and Barangay Nalsian.
(3) Angalacan	Oct. 17, 1989	Road bridge of Angalacan River connecting Barangays Aloragat and Cabanbaran.
(4) Tagamusing	Oct. 15, 1989	Road bridge at Tagamusing River connecting the Tocons of Binalonan and San. Manuel.
(5) Sinolacan	Oct. 20, 1989	Road bridge at Sinolacan River connecting the town of Mapandan and Brgy. Pinaludpud,Urdaneta.
(6) Ingalera	Dec. 15, 1989	Road bridge crossing Ingalera River at Brgy. Nansangaan, Malasiqui.
(7) Poponto Left Dike	Sept. 28, 1989	Just upstream of the overflow spillway in the left side earth dike at the poponto floodway, Agno River.
(8) Poponto Right Dike	Oct. 5, 1989	End of the right side earth dike at the poponto floodway, Agno River.
(9) Cojuangco	Nov. 23, 1989	Road bridge connecting the towns of Camiling and Moncado, Tarlac River.

Table 2.2 AVAILABLE METEOHYDOLOGICAL OBSERVATION RECORD BY AFCS

Staion	Available Observation Record
Hourly rainfall record	
(1) Camp 1	Sept., 1989 - July, 1990
(2) Saytan	Sept., 1989 - Dec., 1990
(3) Iba	Sept., 1989 - Nov., 1990
(4) Sto. Domingo	Sept., 1989 - Nov., 1990
Hourly water level record	
(1) Sinolacan	Oct., 1989 - Dec., 1990
(2) Tagamusing	Oct., 1989 - Dec., 1990
(3) Aloragat	Oct., 1989 - Dec., 1990
(4) Angalacan	Oct., 1989 - Nov., 1990
(5) Camp I	Dec., 1989 - Dec., 1990
(6) Cojuangco	Dec., 1989 - July., 1990
(7) Poponto Left Dike	Oct., 1989 - Dec., 1990
(8) Poponto Right Dike	Oct., 1989 - Dec., 1990
(9) Ingalera	Dec., 1989 - Dec., 1990
Discharge measurement record	
(1) Sinolacan	15 times of measurement
(2) Tagamusing	55 times of measurement
(3) Aloragat	15 times of measurement
(4) Angalacan	17 times of measurement
(5) Cojuangco	16 times of measurement
(6) Ingalera	9 times of measurement

Remarks : Camp 1 rainfall station and Cojuangco water level station have not been in operation since July, 1990 due to damage by the earthquake.

Table 2.3 OBSERVED 4-DAY RAINFALL RECORD AT MAJOR TYPHOON IN 1990

(Unit: mm)

Typhoon	Date	Installed by JICA				by AFFWS					by PAGASA		
		Camp-4	Saytan	Iba	Sto. Domingo	San Roque	Carmen	Wawa	Tibag	Sta. Barbara	Baguio	Dagupan	Matalava
Bising	June 21	34.5	303.0	21.5	113.5	86.0	70.0	60.0	23.0	106.0	212.6	-	-
	22	638.0	627.0	51.5	213.5	297.0	105.0	66.0	59.0	188.0	264.0	-	-
	23	123.0	50.0	72.5	35.5	45.0	21.0	29.0	59.0	54.0	45.4	-	-
	24	23.5	20.0	22.5	16.0	18.0	4.0	6.0	15.0	35.0	16.6	-	-
	Total	819.0	1000.0	168.0	378.5	446.0	200.0	161.0	156.0	383.0	538.6		
Heling	Aug. 25	_	1.0	1.0	1.0	11.0	12.0	8.0	0.0	16.0	24.6	-	20.8
	26	_	210.0	33.5	128.5	84.0	79.0	58.0	33.0	104.0	315.6	-	83.8
	27	_	101.5	13.0	51.0	68.0	30.0	35.0	10.0	71.0	30.4	-	53.4
	28		5.0	11.5	34.0	41.0	24.0	12.0	12.0	15.0	22.1	-	13.2
	Total	_	317.5	59.0	214.5	204.0	145.0	113.0	55.0	206.0	392.7	-	171.2
Iliang	Aug. 30	-	6.5	3.0	9.5	17.0	25.0	12.0	3.0	35.0	57.0	-	16.5
	31	-	43.5	9.0	41.5	16.0	6.0	36.0	1.0	19.0	214.0	-	47.0
	Sept. 1	-	91.5	110.5	205.5	213.0	133.0	118.0	119.0	96.0	122.4	-	-
	2	-	9.5	3.5	9.0	12.0	6.0	0.0	17.0	1.0	10.0	-	-
	Total	-	151.0	126.0	265.5	258.0	170.0	166.0	140.0	151.0	403.4	-	63.5
Loleng	Sept. 5	-	2.5	0.0	0.5	0.0	0.0	0.0	1.0	4.0	12.2	0.0	0.0
	6	-	49.5	23.5	19.5	16.0	20.0	22.0	13.0	74.0	122.8	27.6	0.0
	7	-	145.0	101.0	133.5	153.0	85.0	86.0	83.0	148.0	174.1	207.8	182.9
	8	-	29.5	44.0	19.5	33.0	25.0	21.0	16.0	29.0	78.2	62.2	83.8
	Total	-	226.5	168.5	173.0	202.0	130.0	129.0	113.0	255.0	387.3	297.6	266.7

Table 2.4 3-HOUR RAINFALL RECORD BY AFFWS DURING TYPHOON BISING

(Unit: mm)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
June 21, 1990	2:00	0.0	0.0	0.0	0.0	0.0
	5:00	2.0	1.0	0.0	1.0	0.0
	8:00	5.0	5.0	3.0	1.0	4.0
	11:00	0.0	9.0	2.0	0.0	13.0
	14:00	0.0	5.0	1.0	0.0	1.0
	17:00	0.0	8.0	1.0	1.0	1.0
	20:00	23.0	14.0	5.0	7.0	14.0
	23:00	56.0	28.0	48.0	13.0	73.0
June 22	2:00	42.0	5.0	14.0	14.0	37.0
	5:00	69.0	20.0	13.0	12.0	66.0
	8:00	71.0	51.0	20.0	9.0	27.0
	11:00	25.0	9.0	4.0	10.0	16.0
	14:00	37.0	7.0	5.0	7.0	15.0
	17:00	7.0	4.0	4.0	1.0	6.0
	20:00	24.0	3.0	2.0	0.0	9.0
	23:00	22.0	6.0	4.0	6.0	12.0
June 23	2:00	4.0	0.0	1.0	4.0	4.0
	5:00	1.0	1.0	1.0	4.0	1.0
	8:00	1.0	0.0	11.0	4.0	6.0
	11:00	5.0	1.0	0.0	14.0	2.0
	14:00	14.0	4.0	6.0	4.0	23.0
	17:00	12.0	5.0	4.0	14.0	6.0
	20:00	5.0	9.0	4.0	14.0	8.0
	23:00	3.0	1.0	2.0	1.0	4.0
June 24	2:00	0.0	0.0	0.0	1.0	0.0
	5:00	1.0	0.0	0.0	0.0	3.0
	8:00	0.0	0.0	0.0	4.0	0.0
	11:00	11.0	2.0	5.0	8.0	9.0
	14:00	1.0	0.0	1.0	1.0	4.0
	17:00	5.0	2.0	0.0	1.0	19.0
	20:00	0.0	0.0	0.0	0.0	0.0
	23:00	0.0	0.0	0.0	0.0	0.0
	Total	446.0	200.0	161.0	156.0	383.0

Table 2.5 3-HOUR RAINFALL RECORD BY AFFWS DURING TYPHOON HELING

(Unit: mm)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Aug. 25, 1990	2:00	3.0	1.0	0.0	0.0	7.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	0.0	0.0	0.0	0.0
	11:00	0.0	0.0	0.0	0.0	0.0
	14:00	0.0	6.0	1.0	0.0	1.0
	17:00	8.0	5.0	7.0	0.0	8.0
	20:00	0.0	0.0	0.0	0.0	0.0
	23:00	0.0	0.0	0.0	0.0	0.0
Aug. 26	2:00	0.0	4.0	0.0	0.0	4.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	0.0	0.0	0.0	0.0
	11:00	5.0	0.0	2.0	1.0	0.0
	14:00	12.0	7.0	3.0	9.0	4.0
	17:00	10.0	22.0	19.0	9.0	35.0
	20:00	25.0	26.0	17.0	10.0	26.0
	23:00	32.0	20.0	17.0	4.0	35.0
Aug. 27	2:00	32.0	25.0	32.0	5.0	30.0
	5:00	33.0	4.0	1.0	3.0	11.0
	8:00	0.0	0.0	0.0	0.0	2.0
	11:00	0.0	1.0	1.0	1.0	5.0
	14:00	2.0	0.0	0.0	0.0	15.0
	17:00	0.0	0.0	0.0	0.0	8.0
	20:00	0.0	0.0	1.0	1.0	0.0
	23:00	1.0	0.0	0.0	0.0	0.0
Aug. 28	2:00	0.0	0.0	0.0	0.0	1.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	4.0	5.0	5.0	7.0
	11:00	16.0	15.0	0.0	0.0	0.0
	14:00	15.0	2.0	2.0	2.0	0.0
	17:00	1.0	0.0	0.0	0.0	3.0
	20:00	0.0	2.0	5.0	0.0	0.0
	23:00	9.0	1.0	0.0	5.0	4.0
	Total	204.0	145.0	113.0	55.0	206.0

Table 2.6 3-HOUR RAINFALL RECORD BY AFFWS DURING TYPHOON ILIANG

(Unit: mm)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Aug. 30, 1990	2:00	6.0	2.0	2.0	0.0	17.0
	5:00	0.0	0.0	0.0	1.0	1.0
	8:00	2.0	0.0	0.0	0.0	0.0
	11:00	0.0	0.0	0.0	0.0	0.0
	14:00	0.0	0.0	3.0	1.0	1.0
	17:00	9.0	23.0	7.0	0.0	16.0
	20:00	0.0	0.0	0.0	0.0	0.0
	23:00	0.0	0.0	0.0	1.0	0.0
Aug. 31	2:00	3.0	0.0	10.0	0.0	4.0
	5:00	1.0	0.0	2.0	0.0	0.0
	8:00	0.0	2.0	11.0	1.0	8.0
	11:00	0.0	0.0	0.0	0.0	0.0
	14:00	0.0	0.0	0.0	0.0	0.0
	17:00	0.0	2.0	0.0	0.0	2.0
	20:00	0.0	0.0	0.0	0.0	0.0
Sept. 1	23:00	12.0	2.0	13.0	0.0	5.0
	2:00	43.0	8.0	7.0	9.0	7.0
	5:00	24.0	10.0	8.0	1.0	23.0
	8:00	64.0	78.0	41.0	14.0	18.0
	11:00	45.0	6.0	35.0	40.0	16.0
	14:00	37.0	31.0	27.0	53.0	32.0
	17:00	0.0	0.0	0.0	2.0	0.0
	20:00	0.0	0.0	0.0	0.0	0.0
Sept. 2	23:00	0.0	0.0	0.0	0.0	0.0
	2:00	0.0	0.0	0.0	0.0	0.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	0.0	0.0	0.0	0.0
	11:00	0.0	0.0	0.0	0.0	0.0
	14:00	0.0	0.0	0.0	16.0	0.0
	17:00	12.0	0.0	0.0	1.0	1.0
	20:00	0.0	6.0	0.0	0.0	0.0
Sept. 3	23:00	0.0	0.0	0.0	0.0	0.0
	Total	258.0	170.0	166.0	140.0	151.0

Table 2.7 3-HOUR RAINFALL RECORD BY AFFWS DURING TYPHOON LOLENG

(Unit: mm)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Sept. 5 1990	2:00	0.0	0.0	0.0	0.0	0.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	0.0	0.0	0.0	0.0
	11:00	0.0	0.0	0.0	0.0	0.0
	14:00	0.0	0.0	0.0	1.0	4.0
	17:00	0.0	0.0	0.0	0.0	0.0
	20:00	0.0	0.0	0.0	0.0	0.0
	23:00	0.0	0.0	0.0	0.0	0.0
Sept 6	2:00	0.0	0.0	0.0	0.0	0.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	0.0	0.0	0.0	0.0
	11:00	9.0	5.0	0.0	0.0	33.0
	14:00	1.0	6.0	5.0	4.0	11.0
	17:00	1.0	6.0	8.0	5.0	6.0
	20:00	2.0	1.0	4.0	2.0	3.0
	23:00	3.0	2.0	5.0	2.0	21.0
Sept 7	2:00	2.0	0.0	0.0	5.0	0.0
	5:00	3.0	0.0	0.0	7.0	0.0
	8:00	31.0	18.0	8.0	9.0	50.0
	11:00	54.0	25.0	29.0	27.0	28.0
	14:00	31.0	17.0	20.0	10.0	37.0
	17:00	4.0	4.0	6.0	6.0	5.0
	20:00	14.0	4.0	6.0	13.0	19.0
	23:00	14.0	17.0	17.0	6.0	9.0
Sept 8	2:00	14.0	17.0	14.0	5.0	15.0
	5:00	0.0	0.0	0.0	0.0	0.0
	8:00	0.0	0.0	0.0	1.0	0.0
	11:00	5.0	1.0	2.0	4.0	1.0
	14:00	5.0	6.0	5.0	2.0	3.0
	17:00	4.0	0.0	0.0	0.0	3.0
	20:00	0.0	0.0	0.0	0.0	6.0
	23:00	5.0	1.0	0.0	4.0	1.0
	Total	202.0	130.0	129.0	113.0	255.0

TABLE 2.8 3-HOUR WATER LEVEL RECORD BY AFFWS DURING TYPHOON BISING

(Unit: m)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
June 21, 1990	2:00	0.13	0.00	4.48	0.00	2.61
	5:00	0.11	0.00	4.49	0.00	2.61
	8:00	0.33	0.00	4.51	0.00	2.61
	11:00	0.36	0.00	4.57	0.00	2.61
	14:00	0.64	0.00	4.69	0.00	2.61
	17:00	0.25	0.00	4.83	0.00	2.61
	20:00	0.10	0.00	4.88	0.00	2.61
	23:00	0.20	0.00	4.93	0.00	2.61
June 22, 1990	2:00	0.37	0.00	4.98	0.00	2.61
	5:00	1.02	0.00	5.04	0.00	2.61
	8:00	1.70	0.00	5.10	0.00	2.61
	11:00	1.69	0.00	5.60	0.00	2.61
	14:00	1.64	0.00	6.30	0.00	6.90
	17:00	1.59	0.00	6.66	0.00	6.91
	20:00	1.56	0.00	6.97	0.00	6.90
	23:00	1.38	0.00	7.08	0.00	6.90
June 23, 1990	2:00	1.29	0.00	7.13	0.00	6.89
	5:00	1.28	0.00	7.12	0.00	6.92
	8:00	1.13	0.00	7.07	0.00	6.92
	11:00	0.97	0.00	6.97	0.00	6.92
	14:00	1.01	0.00	6.82	0.00	6.94
	17:00	1.14	0.00	6.66	0.00	6.93
	20:00	1.29	0.00	6.57	0.00	6.92
	23:00	1.04	0.00	6.63	0.00	6.89
June 24, 1990	2:00	0.95	0.00	6.73	0.00	6.89
	5:00	0.72	0.00	6.75	0.00	6.86
	8:00	0.80	0.00	6.73	0.02	8.89
	11:00	0.66	0.00	6.71	0.00	6.73
	14:00	1.05	0.00	6.69	0.00	6.66
	17:00	0.86	0.00	6.66	0.00	6.69
	20:00	0.82	0.00	6.64	0.00	6.60
	23:00	0.79	0.00	6.69	0.00	6.54
June 25, 1990	2:00	0.78	-	6.72	0.00	6.35
	5:00	0.74	-	6.66	0.00	6.35
	8:00	0.79	-	6.56	0.00	6.41
	11:00	0.72	-	6.61	0.00	6.09
	14:00	0.88	-	6.52	0.00	5.97
	17:00	0.82	-	6.52	0.00	5.79
	20:00	0.86	-	6.59	0.00	5.70
	23:00	0.89	-	6.61	0.00	5.60
June 26, 1990	2:00	0.84	-	6.61	0.00	5.56
	5:00	0.72	-	6.79	0.00	5.71
	8:00	0.67	-	6.96	0.00	5.78
	11:00	0.66	-	6.94	0.00	5.64
	14:00	0.80	-	6.87	0.00	5.49
	17:00	0.87	-	6.78	0.00	5.49
	20:00	0.88	-	6.74	0.00	5.38
	23:00	0.82	-	6.65	0.00	5.25
June 27, 1990	2:00	0.64	-	6.64	0.00	5.17
	5:00	0.64	-	6.64	0.00	5.11
	8:00	0.62	-	6.60	0.00	5.04
	11:00	0.63	-	6.54	0.00	4.98
	14:00	0.80	-	6.42	0.00	4.93
	17:00	0.76	-	6.36	0.00	4.87
	20:00	1.12	-	6.34	0.00	4.91
	23:00	1.46	-	6.37	0.00	5.49

TABLE 2.9 3-HOUR WATER LEVEL RECORD BY AFFWS DURING TYPHOON HEILING

(Unit: m)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Aug. 25, 1990	2:00	1.03	-	7.12	0.00	4.53
	5:00	1.12	-	7.31	0.00	4.52
	8:00	-	-	7.37	0.00	4.49
	11:00	1.03	-	7.40	0.00	4.46
	14:00	0.98	-	7.38	0.00	4.41
	17:00	1.04	0.00	7.36	0.00	4.38
	20:00	1.02	0.00	7.29	0.00	4.33
	23:00	0.93	0.00	7.25	0.00	4.29
Aug 26, 1990	2:00	0.77	0.00	7.21	0.00	4.22
	5:00	-	0.00	7.19	0.00	-
	8:00	-	0.00	7.16	0.00	-
	11:00	1.03	0.00	7.12	0.00	4.07
	14:00	0.90	0.00	7.06	0.00	4.01
	17:00	0.99	0.00	7.08	0.00	4.06
	20:00	1.53	0.00	7.11	0.00	4.35
	23:00	2.76	0.00	7.30	0.00	4.99
Aug. 27, 1990	2:00	2.64	0.00	7.54	0.00	5.24
	5:00	2.91	0.00	7.56	0.00	5.31
	8:00	2.67	0.00	7.56	0.00	5.31
	11:00	2.42	0.00	7.71	0.00	5.30
	14:00	2.32	0.00	7.91	0.00	5.30
	17:00	2.11	0.00	7.98	0.00	5.31
	20:00	2.11	0.00	8.03	0.00	5.29
	23:00	1.81	0.00	8.04	0.00	5.29
Aug. 28, 1990	2:00	2.01	0.00	8.04	0.00	5.28
	5:00	1.80	0.00	8.03	0.00	5.27
	8:00	1.52	0.00	7.99	0.00	5.27
	11:00	1.65	0.00	7.95	0.00	5.26
	14:00	1.58	0.00	7.91	0.00	5.25
	17:00	1.54	0.00	7.90	0.00	5.23
	20:00	1.36	0.00	7.90	0.00	5.22
	23:00	1.31	0.00	7.89	0.00	5.21
Aug. 29, 1990	2:00	1.40	0.00	7.88	0.00	5.10
	5:00	1.32	0.00	7.83	0.00	5.19
	8:00	1.51	0.00	7.79	0.00	5.18
	11:00	1.20	0.00	7.74	0.00	5.15
	14:00	1.33	0.00	7.71	0.00	5.12
	17:00	1.15	0.00	7.65	0.00	5.08
	20:00	1.18	0.00	7.67	0.00	5.03
	23:00	1.33	0.00	7.60	0.00	5.00
Aug. 30, 1990	2:00	1.24	0.00	7.52	0.00	4.97
	5:00	1.18	0.00	7.50	0.00	4.91
	8:00	1.42	0.00	7.51	0.00	4.88
	11:00	1.39	0.00	7.51	0.00	4.86
	14:00	1.51	0.00	7.55	0.00	4.83
	17:00	1.49	0.00	7.61	0.00	4.84
	20:00	-	0.00	7.61	0.00	-
	23:00	-	0.00	7.61	0.00	-

Table 2.10 3-HOUR WATER LEVEL RECORD BY AFFWS DURING TYPHOON ILIANG

(Unit: m)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Aug. 30, 1990	2:00	1.24	0.00	7.52	0.00	4.97
	5:00	1.18	0.00	7.50	0.00	4.91
	8:00	1.42	0.00	7.51	0.00	4.88
	11:00	1.39	-	7.51	0.00	4.86
	14:00	1.51	0.00	7.55	0.00	4.83
	17:00	1.49	0.00	7.61	0.00	4.84
	20:00	-	-	7.61	0.00	-
	23:00	-	-	7.61	0.00	-
Aug. 31, 1990	2:00	1.32	0.00	7.63	0.00	4.83
	5:00	1.45	0.00	7.57	0.00	4.81
	8:00	1.31	0.00	7.53	0.00	4.76
	11:00	1.23	0.00	7.50	0.00	4.73
	14:00	1.31	0.00	7.46	0.00	4.73
	17:00	1.39	0.00	7.43	0.00	4.69
	20:00	1.30	0.00	7.41	0.00	4.63
	23:00	1.40	0.00	7.41	0.00	4.58
Sept. 1, 1990	2:00	1.65	0.00	7.40	0.00	4.56
	5:00	2.04	0.00	7.39	0.00	4.60
	8:00	3.11	0.00	7.69	0.00	4.96
	11:00	3.91	0.00	7.98	0.00	5.21
	14:00	4.17	6.07	8.21	0.00	5.30
	17:00	3.91	6.44	8.31	0.00	5.31
	20:00	3.45	6.02	8.59	0.00	5.32
	23:00	3.12	0.00	8.83	0.00	5.32
Sept. 2, 1990	2:00	2.61	0.00	9.23	0.00	5.32
	5:00	2.42	0.00	9.41	0.00	5.32
	8:00	-	-	-	-	-
	11:00	-	-	-	-	-
	14:00	-	-	-	-	-
	17:00	-	-	-	-	-
	20:00	-	-	-	-	-
	23:00	-	-	-	-	-
Sept. 3, 1990	2:00	-	-	-	-	-
	5:00	-	-	-	-	-
	8:00	-	-	-	-	-
	11:00	-	-	-	-	-
	14:00	-	-	-	-	-
	17:00	-	-	-	-	-
	20:00	-	-	-	-	-
	23:00	-	-	-	-	-
Sept. 4, 1990	2:00	-	-	-	-	-
	5:00	-	-	-	-	-
	8:00	-	-	-	-	-
	11:00	-	-	-	-	-
	14:00	-	-	-	-	-
	17:00	-	-	-	-	-
	20:00	-	-	-	-	-
	23:00	-	-	-	-	-
Sept. 5, 1990	2:00	-	-	-	-	-
	5:00	-	-	-	-	-
	8:00	1.22	0.00	7.99	0.00	4.53
	11:00	0.84	0.00	7.93	0.00	4.48
	14:00	1.02	0.00	7.85	0.00	4.44
	17:00	0.82	0.00	7.79	0.00	4.39
	20:00	0.66	0.00	7.73	0.00	4.33
	23:00	1.00	0.00	7.61	0.00	4.28

TABLE 2.11 3-HOUR WATER LEVEL RECORD BY AFFWS DURING TYPHOON LOLENG

(Unit: m)

Date	Time	San Roque	Carmen	Wawa	Tibag	Sta. Barbara
Sept. 5, 1990	2:00	-	-	-	-	-
	5:00	-	-	-	-	-
	8:00	1.22	0.00	7.99	0.00	4.53
	11:00	1.84	0.00	7.93	0.00	4.48
	14:00	1.02	0.00	7.85	0.00	4.44
	17:00	0.82	0.00	7.79	0.00	4.39
	20:00	0.66	0.00	7.73	0.00	4.33
	23:00	1.00	0.00	7.61	0.00	4.28
Sept. 6, 1990	2:00	1.14	0.00	7.52	0.00	4.23
	5:00	1.15	0.00	7.45	0.00	4.18
	8:00	1.30	0.00	7.39	0.00	4.13
	11:00	1.06	0.00	7.41	0.00	4.11
	14:00	1.20	0.00	7.43	0.00	4.17
	17:00	1.21	0.00	7.43	0.00	4.16
	20:00	1.10	0.00	7.47	0.00	4.19
	23:00	-	0.00	7.42	0.00	-
Sept. 7, 1990	2:00	1.37	0.00	7.44	0.00	4.27
	5:00	1.18	0.00	7.44	0.00	4.36
	8:00	1.36	0.00	7.42	0.00	4.47
	11:00	2.35	0.00	7.44	0.00	4.62
	14:00	2.78	0.00	7.64	0.00	5.01
	17:00	2.62	0.00	8.17	0.00	5.27
	20:00	-	0.00	8.42	0.00	5.32
	23:00	2.88	0.00	8.56	0.00	5.32
Sept. 8, 1990	2:00	2.38	0.00	8.71	0.00	5.32
	5:00	2.18	0.00	8.82	0.00	5.32
	8:00	2.11	0.00	8.90	0.00	5.32
	11:00	2.02	0.00	8.90	0.00	5.32
	14:00	1.82	0.00	8.84	0.00	5.32
	17:00	2.01	0.00	8.81	0.00	5.31
	20:00	2.11	0.00	8.83	0.00	5.31
	23:00	2.14	0.00	8.91	0.00	5.31
Sept. 9, 1990	2:00	1.80	0.00	8.91	0.00	5.29
	5:00	2.01	0.00	8.91	0.00	5.28
	8:00	1.74	0.00	8.89	0.00	5.26
	11:00	-	0.00	8.87	0.00	5.25
	14:00	1.51	0.00	8.84	0.00	5.24
	17:00	1.64	0.00	8.80	0.00	5.22
	20:00	1.69	0.00	8.79	0.00	5.19
	23:00	1.69	0.00	8.70	0.00	5.17
Sept. 10, 1990	2:00	1.49	0.00	8.63	0.00	5.13
	5:00	1.56	0.00	8.57	0.00	5.09
	8:00	1.66	0.00	8.49	0.00	5.07
	11:00	1.34	0.00	8.42	0.00	5.03
	14:00	-	0.00	8.34	0.00	4.98
	17:00	1.13	0.00	8.26	0.00	4.91
	20:00	1.41	0.00	8.17	0.00	4.82
	23:00	1.40	0.00	8.06	0.00	4.73

Table 2.12 SELECTED SATATIONS FOR WATER SAMPLING

River	Station No.	Distance from Rivermouth(km)	Remarks
Agno			
	A1	3.3	Dumalandan Bridge, Lingaycn
	A2	5.7	Banaga Bridge, Lingayen
	A3	14.7	Brgy. Cabayaoasan, Bugallon
	A4	21.5	Brgy. Salinap, San Carlos
	A5	24.5	Brgy. San Jose, Aguilar
	A6	34.3	Urbiztondo Bridge, Urbiztondo
	A7	41.3	Brgy. Galarin, Urbiztondo
Pantal-Sinocalan			
	P1	4.3	Magsaysay Bridge, Dagupan City
	P2	14.4	Calasiao Bridge, Calasiao
	P3	19.1	Malabago Bridge, Calasiao
	P4	22.2	Maramba Bridge, Sta. Barbara
	P5	26.4	Banaoang Bridge, Sta. Barbara
Cayanga-Patalan			
	C1	2.0	Cayanga Bridge, San Fabian
	C2	8.2	Embarcadero Bridge, Mangaldan
	C3	13.4	Brgy. Casibong, San Jacinto
	C4	16.8	Pias Bridge, Mapandan
	C5	19.9	Mermer Bridge,. Mapandan

Table 2.13 RESULT OF SALINITY TEST OF AGNO RIVER

Date : March 6, 1990

Sampling Location	Time	Upper Temp. (c)	Upper E.C. (ms/cm)	Upper C.C (ppm)	Middle Temp. (c)	Middle E.C. (ms/cm)	Middle C.C (ppm)	Bottom Temp. (c)	Bottom E.C. (ms/cm)	Bottom C.C (ppm)
A1	5:55	27.80	30.40	18,000	28.40	35.90	22,000	24.80	47.00	28,000
	7:01	26.50	32.50	19,000	27.50	35.90	22,000	27.00	44.10	27,000
	8:05	27.60	33.40	19,500	27.60	36.10	22,000	28.10	45.80	28,000
	9:00	27.70	34.40	20,000	27.40	37.40	23,000	27.80	42.60	25,000
	10:00	27.60	37.10	22,500	27.70	42.30	25,000	27.90	48.30	29,000
	11:00	28.20	36.60	22,000	27.80	45.60	27,500	27.70	46.00	28,000
	12:00	28.10	37.50	22,500	27.90	49.50	29,500	27.90	49.70	29,500
	13:00	29.10	37.20	22,500	28.40	50.00	30,000	28.50	50.20	30,000
	14:00	29.10	40.50	24,000	28.50	49.30	29,000	28.40	52.00	31,000
	15:00	28.70	45.20	27,200	28.60	51.90	30,000	28.60	51.80	30,000
	16:00	28.40	52.40	31,000	28.40	52.40	31,000	28.50	52.60	31,000
	17:00	28.40	52.10	30,000	28.60	52.50	31,000	28.60	53.00	32,000
	18:00	28.40	51.80	30,000	28.40	52.80	31,500	28.40	52.90	32,000
A2	6:15	27.90	19.96	11,500	28.40	26.40	15,500	28.40	32.80	19,500
	7:15	27.00	20.12	11,500	28.30	29.80	18,000	28.30	31.60	19,000
	8:15	27.90	20.69	11,500	28.00	32.60	19,500	28.20	36.70	22,000
	9:15	27.00	21.21	12,000	28.00	29.20	17,000	28.10	36.50	21,500
	10:15	28.29	23.90	12,500	28.10	30.90	18,500	28.40	38.70	23,500
	11:15	29.00	23.40	12,500	28.20	38.90	23,500	28.40	41.40	24,500
	12:15	28.00	32.60	19,000	29.00	42.90	26,000	29.10	45.60	27,500
	13:15	29.50	32.30	19,000	28.30	44.50	27,500	28.30	44.70	27,000
	14:15	29.00	37.90	23,000	28.30	44.70	28,000	28.20	47.80	28,500
	15:15	28.50	39.60	24,000	28.40	48.00	29,000	28.60	48.40	29,000
	16:15	28.80	46.90	28,500	28.60	46.10	28,500	28.70	49.20	29,500
	17:15	28.10	45.50	27,500	28.10	46.20	28,500	28.10	50.90	30,000
	18:15	28.10	49.10	29,500	28.10	50.10	30,000	28.10	50.20	30,000
A3	7:10	20.80	3.02	1,550	27.20	3.47	1,900	27.95	4.26	2,250
	8:10	27.80	4.01	2,100	27.85	4.20	2,200	27.96	5.64	3,000
	9:10	28.10	4.93	2,600	27.80	5.56	3,000	27.75	6.43	3,400
	10:10	28.40	6.27	3,250	28.10	7.67	4,200	28.10	10.61	5,800
	11:11	29.40	7.35	4,000	28.80	7.61	4,200	28.50	11.63	6,400
	12:10	29.00	6.53	3,500	28.90	8.91	4,800	28.65	12.92	7,200
	13:11	29.20	8.93	4,800	28.90	10.84	5,800	28.90	17.61	10,000
	14:10	29.00	14.29	8,000	28.90	15.90	8,800	29.10	23.60	14,000
	15:10	28.80	22.10	13,000	29.30	23.90	14,000	29.10	26.30	16,000
	16:10	28.70	27.50	16,500	29.20	28.90	17,000	28.90	29.00	17,500
	17:10	28.50	27.80	16,500	29.00	28.90	17,500	28.80	30.30	18,000
	18:10	28.50	26.70	15,500	29.00	28.80	17,500	28.80	30.20	18,000
	19:10	28.40	27.10	16,000	29.00	28.60	17,500	29.10	30.15	18,000
A4	7:30	28.10	0.50	230	28.10	0.51	240	28.00	0.52	240
	8:30	28.10	0.52	240	28.10	0.52	240	28.10	0.52	240
	9:30	28.25	0.52	240	28.25	0.52	245	28.20	0.52	240
	10:30	28.60	0.52	245	28.50	0.52	240	28.50	0.52	240
	11:30	28.70	0.52	240	28.40	0.52	240	28.40	0.52	240
	12:30	29.10	0.52	245	28.50	0.52	245	28.40	0.52	245
	13:30	29.00	0.52	245	28.90	0.52	245	28.60	0.52	245
	14:30	29.10	0.53	250	29.00	0.53	250	28.80	0.53	250
	15:30	29.00	0.54	250	29.00	0.54	250	29.00	0.55	260
	16:30	29.00	0.56	265	29.00	0.57	270	29.00	0.58	270
	17:30	29.00	0.59	280	29.00	0.59	280	29.00	0.50	230
A5	8:18	28.60	0.48	225	28.60	0.48	225	28.50	0.48	225
	9:07	28.60	0.48	225	28.60	0.49	225	28.60	0.49	225
	10:06	29.40	0.48	225	29.10	0.49	225	28.60	0.49	225
	11:04	30.50	0.50	230	29.30	0.50	230	28.88	0.50	230
	12:05	29.80	0.51	230	29.40	0.51	230	29.00	0.51	230
	13:00	30.30	0.51	230	29.60	0.51	240	29.30	0.52	240
	14:00	29.50	0.52	240	29.60	0.52	240	29.50	0.52	240
	15:06	29.90	0.52	240	29.90	0.52	240	29.80	0.53	245
	16:04	29.50	0.53	250	29.60	0.53	245	29.50	0.52	240
	17:00	29.00	0.53	250	29.30	0.54	250	29.30	0.53	245
	18:00	29.00	0.53	250	29.40	0.53	250	29.40	0.53	250
A6	6:30	-	0.48	225	-	0.49	230	-	0.50	230
	7:15	-	0.49	230	-	0.50	230	-	0.50	230
	8:00	-	0.49	230	-	0.50	230	-	0.51	240
	8:45	-	0.49	230	-	0.50	230	-	0.50	230
	9:30	-	0.50	230	-	0.50	230	-	0.50	230
	11:00	-	0.50	230	-	0.51	230	-	0.50	230
	12:00	-	0.50	230	-	0.50	230	-	0.51	230
	13:00	-	0.50	230	-	0.50	230	-	0.51	230
	14:00	29.50	0.50	230	26.50	0.51	230	26.75	0.51	230
	15:00	29.50	0.50	230	26.70	0.50	230	27.50	0.50	230
	16:00	30.10	0.50	230	27.30	0.50	230	27.00	0.51	230
	17:00	28.40	0.50	230	27.50	0.50	230	26.40	0.51	230
	17:45	27.30	0.51	230	26.20	0.50	230	27.10	0.50	230
A7	6:30	-	-	-	25.75	0.49	220	-	-	-
	7:30	-	-	-	25.80	0.50	230	-	-	-
	8:30	-	-	-	26.20	0.50	230	-	-	-
	9:30	-	-	-	27.00	0.51	230	-	-	-
	10:30	-	-	-	28.10	0.50	230	-	-	-
	11:30	-	-	-	28.75	0.50	230	-	-	-
	12:30	-	-	-	30.25	0.49	230	-	-	-
	1:30	-	-	-	-	0.49	225	-	-	-
	2:30	-	-	-	-	0.48	225	-	-	-
	4:30	-	-	-	-	0.48	225	-	-	-
	5:30	-	-	-	-	0.48	225	-	-	-
	6:00	-	-	-	-	0.48	225	-	-	-

Remarks: E.C. : Electric Conductivity under controlled temperature of 25 c.
C.C. : Chloride Concentration (mg per liter).

Table 2.14 RESULT OF SALINITY TEST IN PANTAL-SINOLACAN RIVER

Date : March 6, 1990

Sampling Location	Time	Sampling Position: Upper Temp. (c)	Upper E.C. (ms/cm)	Upper C.C. (ppm)	Middle Temp. (c)	Middle E.C. (ms/cm)	Middle C.C. (ppm)	Bottom Temp. (c)	Bottom E.C. (ms/cm)	Bottom C.C. (ppm)
P1	7:10	27.70	8.37	4,500	27.80	19.72	11,500	28.90	39.70	24,000
	8:10	27.70	8.76	4,800	27.80	18.90	13,800	28.40	40.40	24,000
	9:09	28.00	8.54	4,700	28.10	23.60	19,000	28.40	40.20	24,500
	10:11	28.40	8.38	4,400	28.25	32.30	19,000	28.40	45.00	27,000
	11:12	28.80	9.56	5,400	28.40	33.20	19,500	28.42	44.90	27,000
	12:12	29.00	17.56	10,100	28.30	36.80	22,000	28.30	45.40	27,500
	13:13	29.10	15.60	8,800	28.20	37.90	23,500	28.40	45.20	27,200
	14:14	29.40	17.26	9,800	28.20	39.50	23,800	28.40	45.70	28,000
	15:06	29.30	26.90	15,000	28.70	40.30	24,000	28.40	46.10	28,000
	16:08	29.30	29.80	17,500	28.90	44.20	26,500	28.80	45.40	27,500
	17:04	29.10	33.70	23,000	28.95	45.20	27,200	29.00	47.90	28,500
	18:04	29.50	27.30	16,000	28.90	48.50	29,000	29.00	50.10	30,000
	19:02	28.70	39.50	23,800	29.00	43.40	26,000	29.00	49.70	29,500
P2	6:30	27.50	0.54	250	27.45	0.55	255	27.50	0.55	260
	7:00	27.40	0.54	250	27.35	0.54	250	27.30	0.54	250
	8:00	27.30	0.05	255	27.30	0.55	260	27.20	0.54	250
	9:00	27.40	0.54	250	27.40	0.55	255	27.20	0.05	260
	10:00	27.60	0.55	260	27.60	0.55	260	27.40	0.55	260
	11:00	28.00	0.55	260	28.00	0.54	250	27.50	0.54	250
	12:00	28.50	0.55	255	28.50	0.55	255	28.00	0.55	255
	13:00	29.00	0.54	250	29.00	0.55	260	28.50	0.55	260
	14:00	29.00	0.55	260	29.00	0.55	260	29.00	0.55	260
	15:00	29.00	0.55	255	29.25	0.55	260	29.25	0.55	260
	16:00	29.20	0.55	255	29.20	0.55	260	-	0.55	260
	17:00	29.10	0.55	260	29.10	0.56	265	29.10	0.55	260
	18:00	29.00	0.55	260	29.00	0.55	260	29.00	0.55	260
P3	6:35	-	-	-	28.20	0.60	280	-	-	-
	7:30	-	-	-	28.00	0.59	275	-	-	-
	8:30	-	-	-	27.90	0.60	275	-	-	-
	9:30	-	-	-	28.40	0.59	275	-	-	-
	10:30	-	-	-	28.40	0.60	285	-	-	-
	11:29	-	-	-	28.70	0.60	285	-	-	-
	12:40	-	-	-	29.50	0.60	285	-	-	-
	13:30	-	-	-	29.90	0.60	285	-	-	-
	14:30	-	-	-	29.40	0.60	285	-	-	-
	15:30	-	-	-	30.10	0.60	285	-	-	-
	16:25	-	-	-	30.05	0.60	285	-	-	-
	17:07	-	-	-	29.50	0.60	285	-	-	-
	17:45	-	-	-	29.20	0.60	285	-	-	-
P4	6:00	-	-	-	26.75	0.67	285	-	-	-
	7:00	-	-	-	26.60	0.56	270	-	-	-
	8:00	-	-	-	26.70	0.55	260	-	-	-
	9:00	-	-	-	27.00	0.55	260	-	-	-
	10:00	-	-	-	27.40	0.55	260	-	-	-
	11:00	-	-	-	28.00	0.55	260	-	-	-
	12:00	-	-	-	28.20	0.55	265	-	-	-
	13:00	-	-	-	28.60	0.56	265	-	-	-
	14:00	-	-	-	28.60	0.56	265	-	-	-
	15:00	-	-	-	28.70	0.56	270	-	-	-
	16:00	-	-	-	28.60	0.56	270	-	-	-
	17:00	-	-	-	28.60	0.56	270	-	-	-
	17:54	-	-	-	28.50	0.56	270	-	-	-
P5	6:00	-	0.55	260	-	0.55	260	-	0.55	260
	7:00	-	0.55	260	-	0.55	260	-	0.55	260
	8:00	-	0.55	260	-	0.55	260	-	0.56	270
	9:00	-	0.56	265	-	0.56	265	-	0.56	265
	10:00	-	0.56	265	-	0.56	265	-	0.56	270
	12:00	-	0.56	270	-	0.56	270	-	0.56	270
	13:00	29.00	0.57	275	29.00	0.57	275	29.30	0.57	270
	14:00	30.40	0.57	270	30.40	0.57	270	29.90	0.56	270
	15:00	30.80	0.56	270	30.80	0.56	270	30.30	0.56	270
	16:00	30.30	0.57	270	30.30	0.57	270	30.20	0.56	270
	17:00	30.00	0.56	270	30.00	0.56	270	30.00	0.56	270
	18:00	29.80	0.56	270	29.80	0.56	270	29.80	0.56	265

Remarks: E.C. : Electric Conductivity under controlled temperature of 25 c.
C.C. : Chloride Concentration (mg per liter).

Table 2.15 RESULT OF SALINITY TEST IN CAYANGA-PATALAN RIVER

Date : March 7, 1990

Sampling Location	Time	Sampling Position: Upper			Middle			Bottom		
		Temp. (c)	E.C (ms/cm)	C.C (ppm)	Temp. (c)	E.C. (ms/cm)	C.C (ppm)	Temp. (c)	E.C. (ms/cm)	C.C. (ppm)
C1	6:35	26.50	11.45	6,400	28.90	45.10	27,000	28.92	48.80	29,500
	7:30	27.00	12.15	6,900	28.50	36.10	21,500	28.90	47.80	28,500
	8:30	27.00	12.59	7,000	28.20	36.40	21,500	28.90	47.90	28,500
	9:25	27.10	12.65	7,100	28.20	40.10	24,000	28.90	49.00	29,500
	10:25	7.00	13.52	7,500	28.70	44.40	27,000	28.90	48.80	29,500
	11:25	28.40	14.79	8,500	28.50	42.20	25,000	28.70	48.70	29,500
	12:25	29.30	19.80	11,500	28.00	40.80	24,500	28.10	46.70	28,500
	13:25	29.40	30.10	18,000	28.40	42.50	25,000	28.30	48.90	29,500
	14:25	30.10	30.60	18,400	28.25	43.50	26,000	28.50	48.60	29,000
	15:26	30.40	35.70	21,000	29.20	44.30	26,500	28.80	49.00	29,500
	16:28	30.00	40.90	24,000	29.30	47.30	28,000	29.10	48.50	29,000
	17:29	29.20	41.20	24,500	29.40	44.50	27,000	29.00	49.30	29,500
	18:30	29.00	43.00	25,500	29.20	48.50	29,000	29.10	49.10	29,500
C2	6:15	-	-	-	24.50	0.91	460	-	-	-
	7:00	-	-	-	24.70	0.66	320	-	-	-
	8:00	-	-	-	25.30	0.65	320	-	-	-
	9:00	-	-	-	27.50	0.65	310	-	-	-
	10:00	-	-	-	28.50	0.65	310	-	-	-
	11:00	-	-	-	30.50	0.65	320	-	-	-
	12:00	-	-	-	31.80	0.65	310	-	-	-
	13:00	-	-	-	33.10	0.66	310	-	-	-
	14:00	-	-	-	32.70	0.65	310	-	-	-
	15:00	-	-	-	32.30	0.65	310	-	-	-
	16:00	-	-	-	32.30	0.64	310	-	-	-
	17:00	-	-	-	31.30	0.64	310	-	-	-
	18:00	-	-	-	29.70	0.65	310	-	-	-
C3	6:20	-	-	-	25.50	0.71	340	-	-	-
	7:16	-	-	-	24.70	0.65	310	-	-	-
	8:05	-	-	-	25.30	0.64	310	-	-	-
	9:07	-	-	-	27.50	0.65	310	-	-	-
	10:15	-	-	-	28.50	0.64	310	-	-	-
	11:10	-	-	-	30.50	0.64	310	-	-	-
	12:00	-	-	-	31.80	0.64	310	-	-	-
	13:05	-	-	-	33.10	0.64	310	-	-	-
	14:05	-	-	-	32.70	0.64	310	-	-	-
	15:05	-	-	-	32.30	0.64	310	-	-	-
	16:03	-	-	-	32.30	0.64	310	-	-	-
	17:00	-	-	-	31.30	0.63	310	-	-	-
	18:00	-	-	-	29.70	0.63	310	-	-	-
C4	6:30	-	-	-	25.60	0.59	280	-	-	-
	7:30	-	-	-	25.50	0.63	300	-	-	-
	8:30	-	-	-	26.00	0.61	300	-	-	-
	9:30	-	-	-	27.00	0.61	290	-	-	-
	10:30	-	-	-	27.50	0.62	300	-	-	-
	11:30	-	-	-	28.00	0.61	300	-	-	-
	12:30	-	-	-	32.00	0.61	300	-	-	-
	13:30	-	-	-	31.50	0.61	300	-	-	-
	14:30	-	-	-	31.90	0.61	300	-	-	-
	15:30	-	-	-	31.70	0.61	290	-	-	-
	16:30	-	-	-	31.00	0.60	290	-	-	-
	17:30	-	-	-	29.00	0.61	290	-	-	-
C5	6:00	-	-	-	24.20	0.57	270	-	-	-
	7:00	-	-	-	24.75	0.57	270	-	-	-
	8:00	-	-	-	24.70	0.57	270	-	-	-
	9:00	-	-	-	25.10	0.57	270	-	-	-
	10:00	-	-	-	26.00	0.57	270	-	-	-
	11:00	-	-	-	-	0.57	270	-	-	-
	12:00	-	-	-	-	0.57	270	-	-	-
	13:00	-	-	-	-	0.57	270	-	-	-
	14:00	-	-	-	-	0.58	280	-	-	-
	15:00	-	-	-	-	0.57	280	-	-	-
	16:00	-	-	-	-	0.57	270	-	-	-
	17:00	-	-	-	-	0.57	270	-	-	-
	18:00	-	-	-	-	0.57	270	-	-	-
C6	6:00	-	-	-	24.60	0.66	320	-	-	-
	7:00	-	-	-	25.00	0.64	310	-	-	-
	8:00	-	-	-	25.80	0.63	310	-	-	-
	9:00	-	-	-	26.90	0.63	310	-	-	-
	10:00	-	-	-	28.40	0.63	310	-	-	-
	11:00	-	-	-	29.60	0.63	310	-	-	-
	12:00	-	-	-	30.40	0.63	310	-	-	-
	13:00	-	-	-	32.40	0.63	300	-	-	-
	14:00	-	-	-	32.50	0.63	300	-	-	-
	15:00	-	-	-	33.30	0.62	300	-	-	-
	16:00	-	-	-	32.90	0.62	300	-	-	-
	17:00	-	-	-	31.60	0.62	300	-	-	-
	18:00	-	-	-	31.30	0.61	300	-	-	-

Remarks: E.C. : Electric Conductivity under r controlled temperature of 25 c.
C.C. : Chloride Concentration (mg per liter).

Table 3.1 ANNUAL MAXIMUM RAINFALL AT DAGUPAN

(Unit : mm)

Year	Duration			
	1-day	2-day	3-day	4-day
1951	148.1	266.0	290.6	320.1
1952	59.2	104.7	143.3	172.5
1953	151.1	256.8	279.7	282.2
1954	171.7	189.5	202.7	209.1
1955	135.4	224.3	228.4	230.7
1956	63.2	125.7	163.8	179.0
1957	203.5	230.2	258.1	273.3
1958	129.5	180.3	227.5	252.9
1959	73.7	147.1	150.9	150.9
1960	197.9	223.5	257.6	430.8
1961	-	-	-	-
1962	319.5	490.2	635.0	749.6
1963	212.1	423.7	429.3	429.3
1964	205.5	363.2	383.7	389.3
1965	115.1	137.2	161.4	179.4
1966	186.3	286.9	320.7	367.9
1967	125.3	212.0	239.2	256.7
1968	280.3	534.4	713.1	845.4
1969	144.6	194.8	258.2	315.9
1970	139.4	167.4	193.3	217.7
1971	144.1	186.1	190.7	207.0
1972	313.0	463.2	599.3	703.4
1973	99.9	137.4	163.6	174.8
1974	260.0	454.5	562.9	602.8
1975	79.0	88.2	104.6	120.6
1976	368.0	653.5	689.5	719.4
1977	158.6	216.0	227.4	255.6
1978	169.7	323.2	343.5	352.2
1979	162.5	303.9	350.9	358.6
1980	167.4	187.2	202.4	223.7
1981	149.4	179.4	239.3	255.2
1982	135.0	185.6	276.6	300.5
1983	97.2	150.0	176.6	247.2
1984	232.2	359.6	438.8	459.2
1985	135.2	220.5	297.0	349.0
1986	376.8	550.6	613.0	638.0
1987	203.2	209.0	218.4	224.2
1988	124.8	153.0	240.2	240.2

Table 3.2 RAINFALL INTENSITY-DURATION-FREQUENCY DATA AT DAGUPAN CITY

(Unit: mm)

Return Period (Year)	Duration									
	5 MINS.	10 MINS.	15 MINS.	30 MINS.	60 MINS.	2 HRS.	3 HRS.	6 HRS.	12 HRS.	24 HRS.
2	13.7	22.6	30.7	44.6	56.3	73.8	82.5	102.1	139.1	192.6
5	17.0	27.4	37.3	53.8	69.1	93.2	105.5	144.1	201.2	292.7
10	19.1	30.5	41.6	59.9	77.6	106.1	120.7	171.8	242.4	359.0
15	20.4	32.3	44.0	63.3	82.4	113.4	129.2	187.5	265.6	396.4
20	21.2	33.5	45.7	65.7	85.7	118.4	135.2	198.5	281.8	422.5
25	21.9	34.5	47.0	67.6	88.3	122.4	139.9	206.9	294.3	442.7
50	23.9	37.4	51.1	73.2	96.2	134.4	154.1	233.0	332.9	504.8
100	25.9	40.3	55.1	78.9	104.1	146.4	168.3	258.8	371.1	566.5

Source: RAINFALL INTENSITY-DURATION-FREQUENCY DATA OF THE PHILIPPINES, Hydrology and Flood Forescast Center of PAGASA in 1981.

Table 3.3 COMPARISON OF STANDARD DEVIATIONS UNDER COMBINATION OF CONSTANTS

(1) 10-year rainfall

Constants			Standard Deviation
n	a	b	(mm)
0.5	568	-0.11	16.2
0.6	1,081	1.87	7.7
0.7	2,038	6.13	4.5
0.8	3,833	14.90	8.2
0.9	7,221	32.54	12.9
1.0	13,662	67.62	17.3

(2) 5-year rainfall

Constants			Standard Deviation
n	a	b	(mm)
0.5	479	-0.31	17.8
0.6	910	1.48	9.0
0.7	1,711	5.37	3.8
0.8	3,209	13.42	5.8
0.9	6,030	29.66	10.0
1.0	11,379	61.96	14.1

Remarks: a and b of constants are determined by least square method.

FIGURES

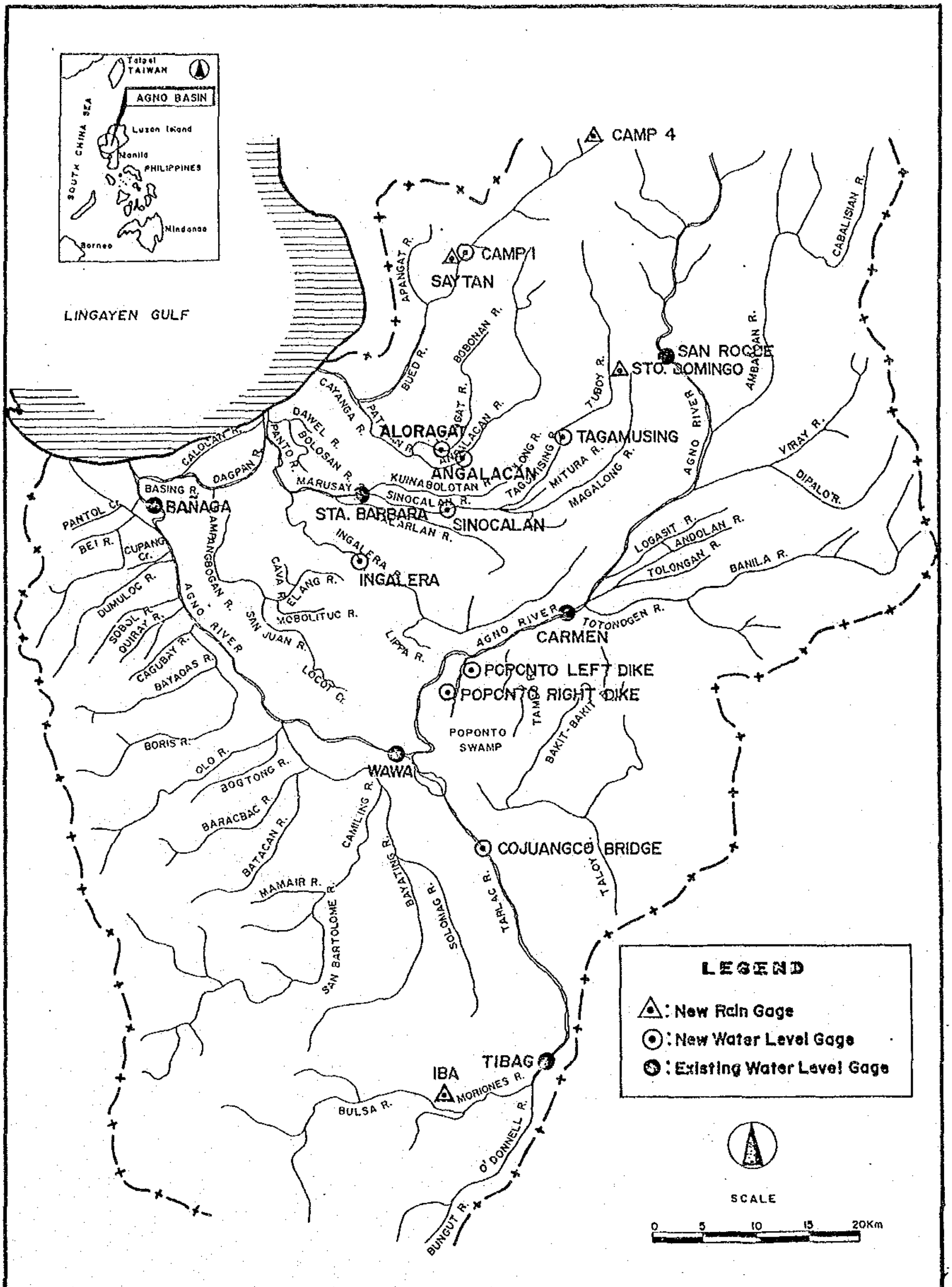
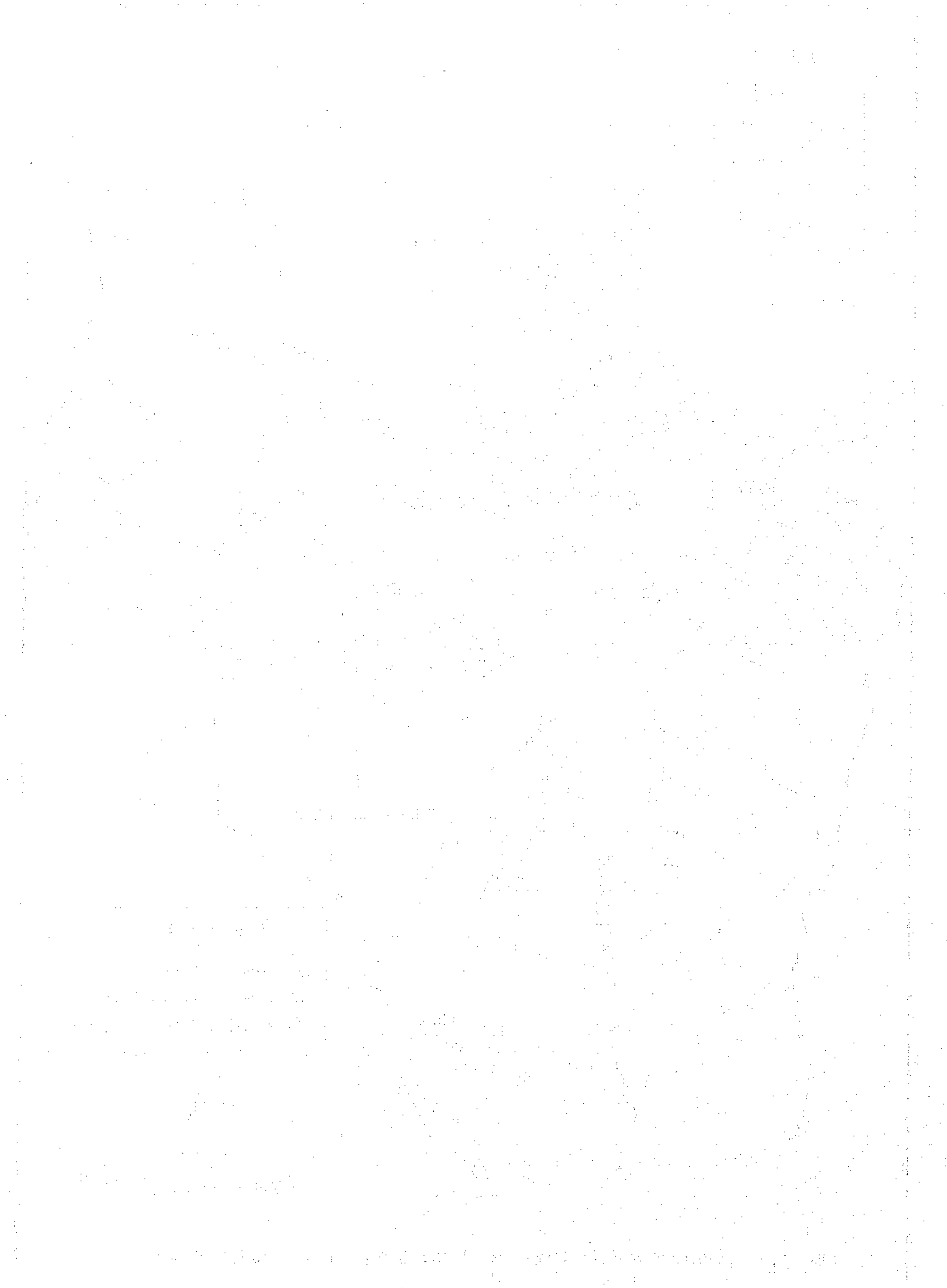


FIG. 2.1 LOCATION MAP OF NEW RAIN GAGES AND WATER LEVEL GAGES



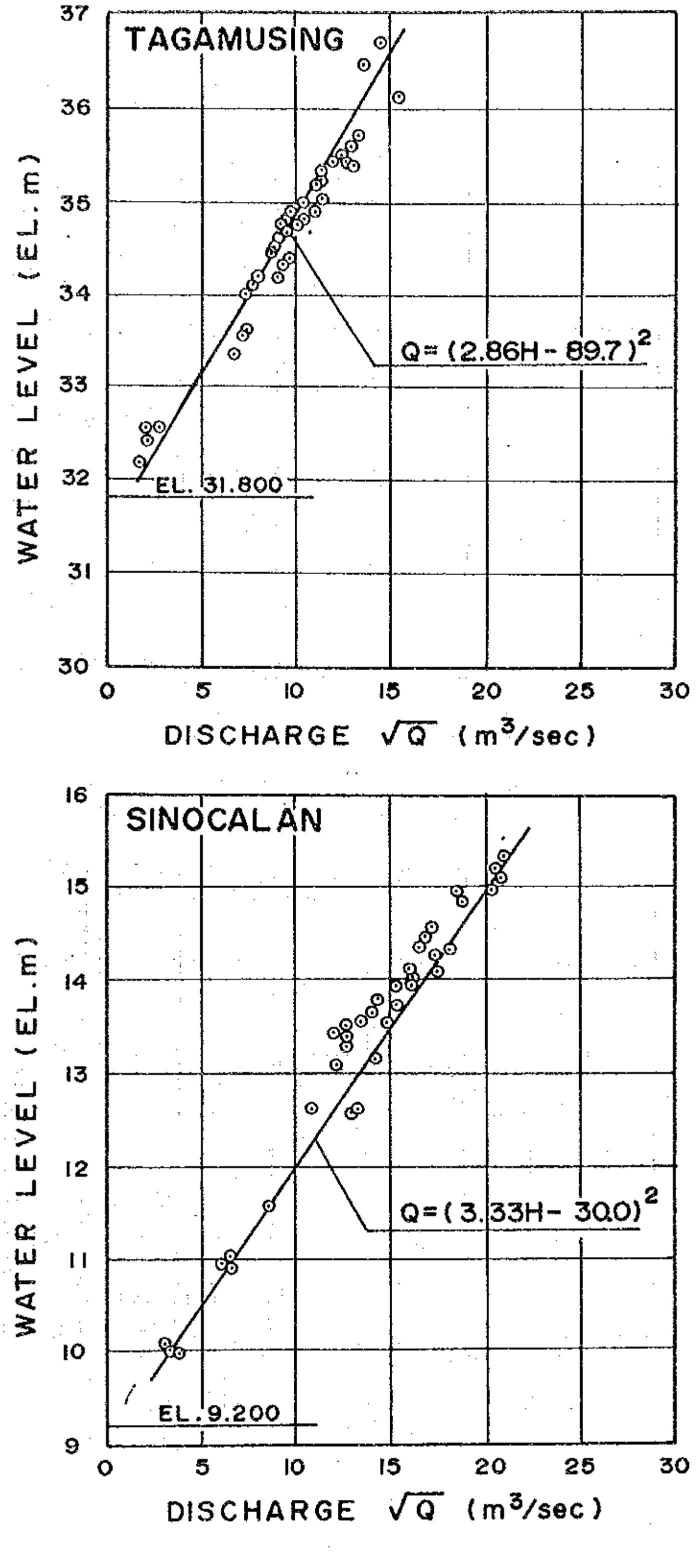
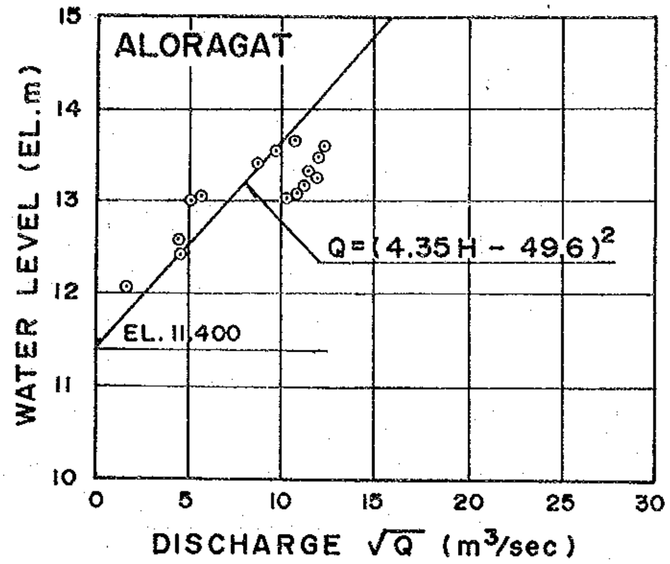


Fig. 2.2 DISCHARGE RATING CURVES AT NEW GAUGING STATION (1/3)



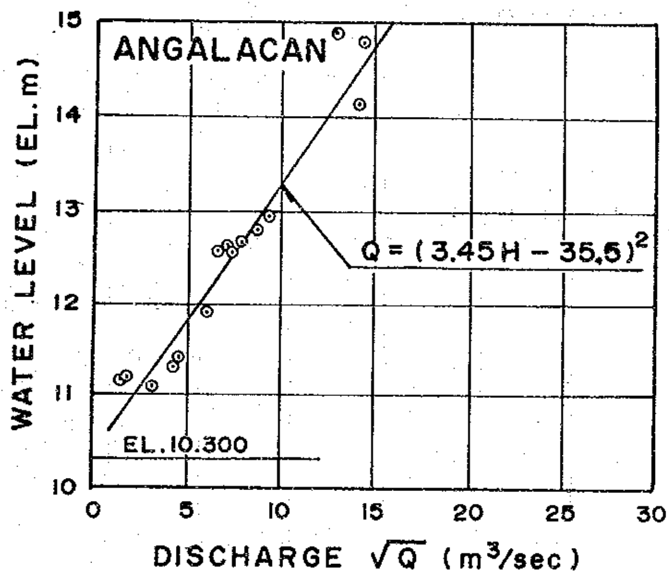


Fig. 2.2 DISCHARGE RATING CURVES AT NEW GAUGING STATION (2/3)

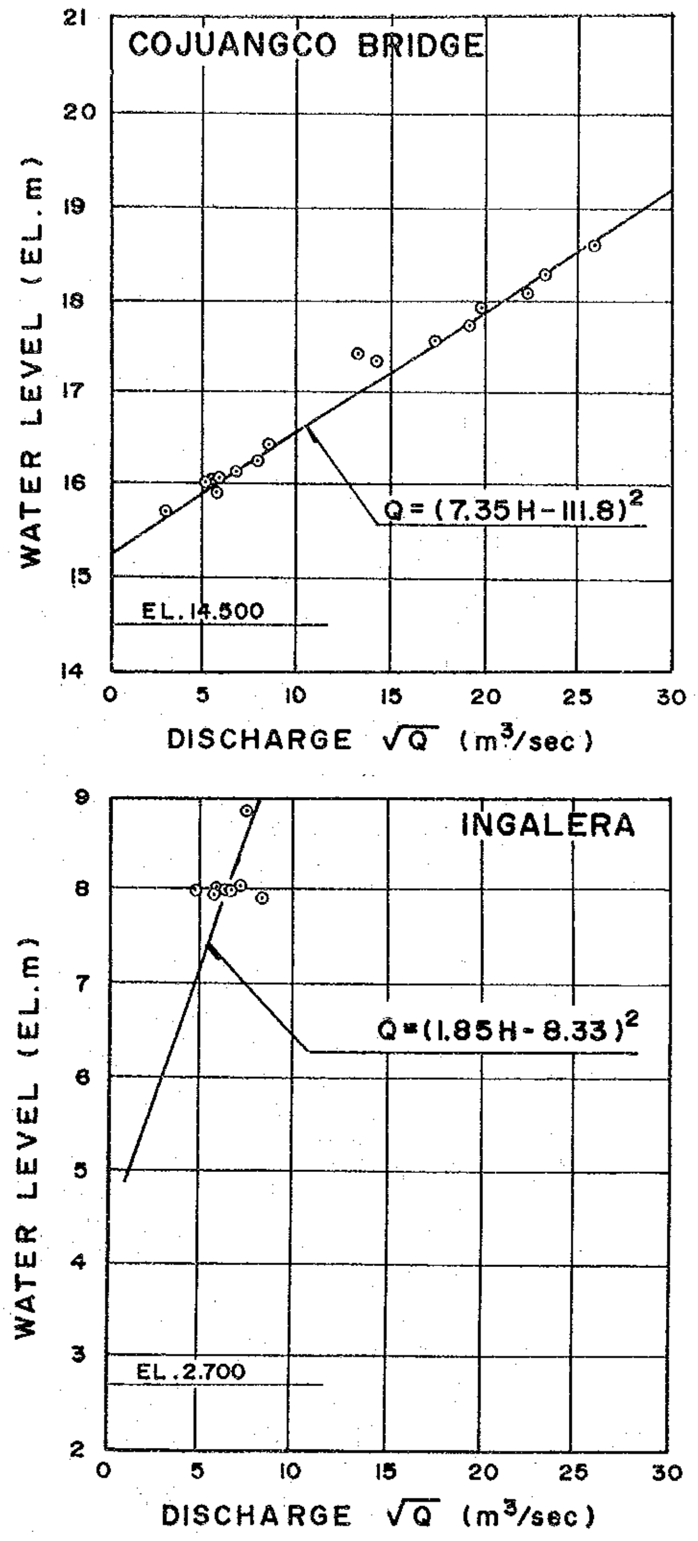


Fig. 2.2 DISCHARGE RATING CURVES AT NEW GAUGING STATION (3/3)

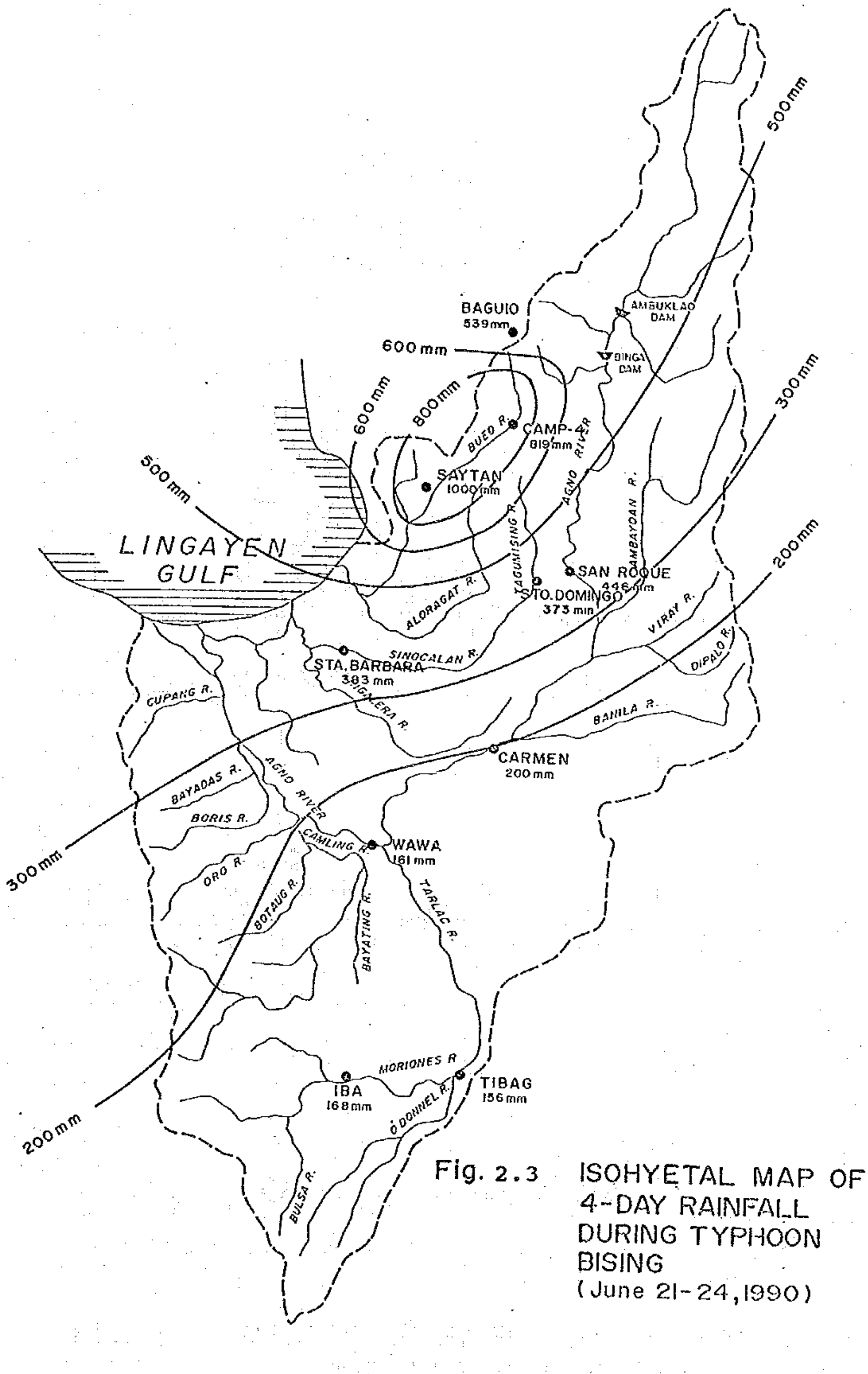


Fig. 2.3 ISOHYETAL MAP OF 4-DAY RAINFALL DURING TYPHOON BISING (June 21-24, 1990)

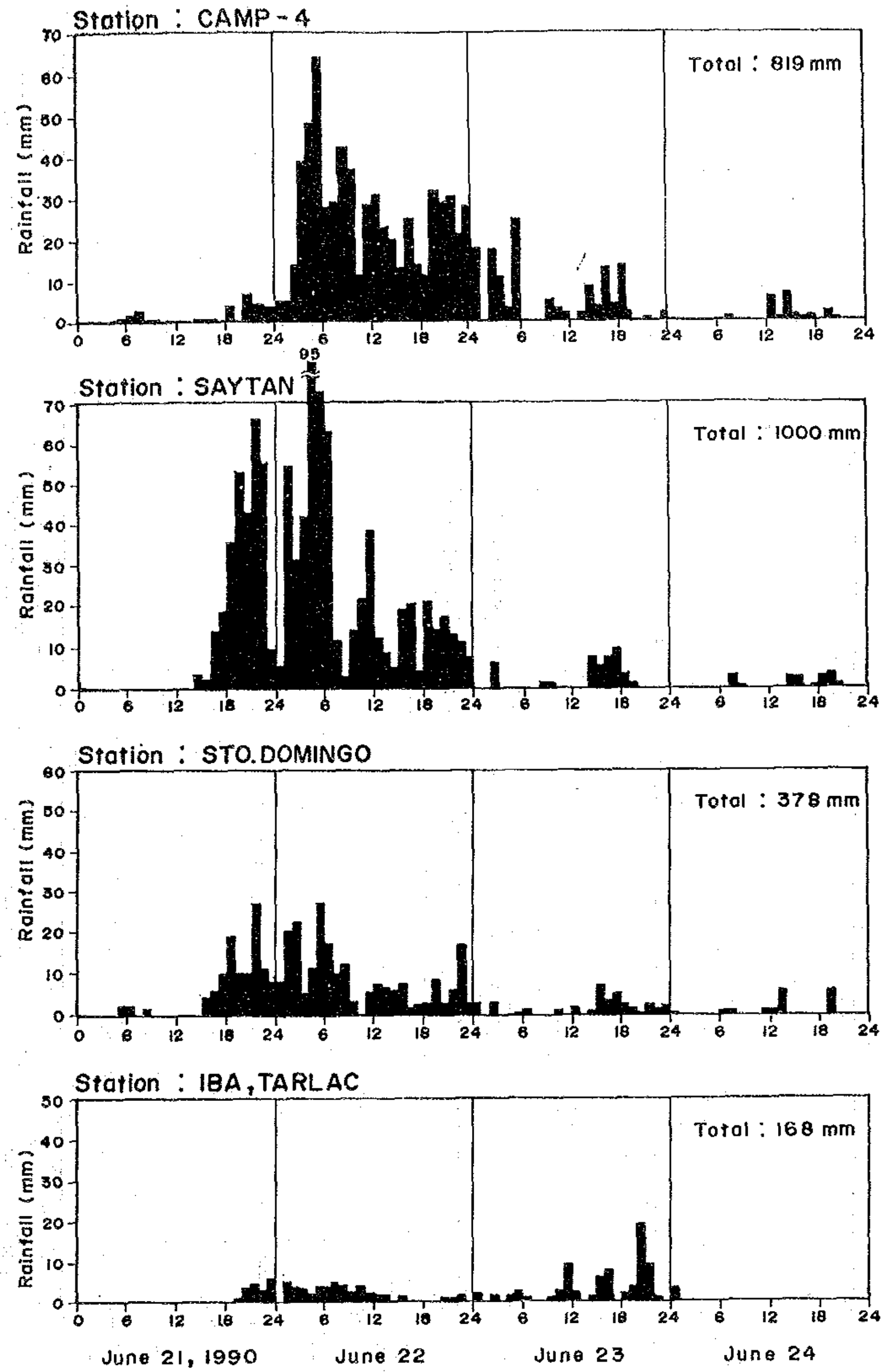


Fig. 2.4 OBSERVED RAINFALL HYETOGRAPH DURING TYPHOON BISING

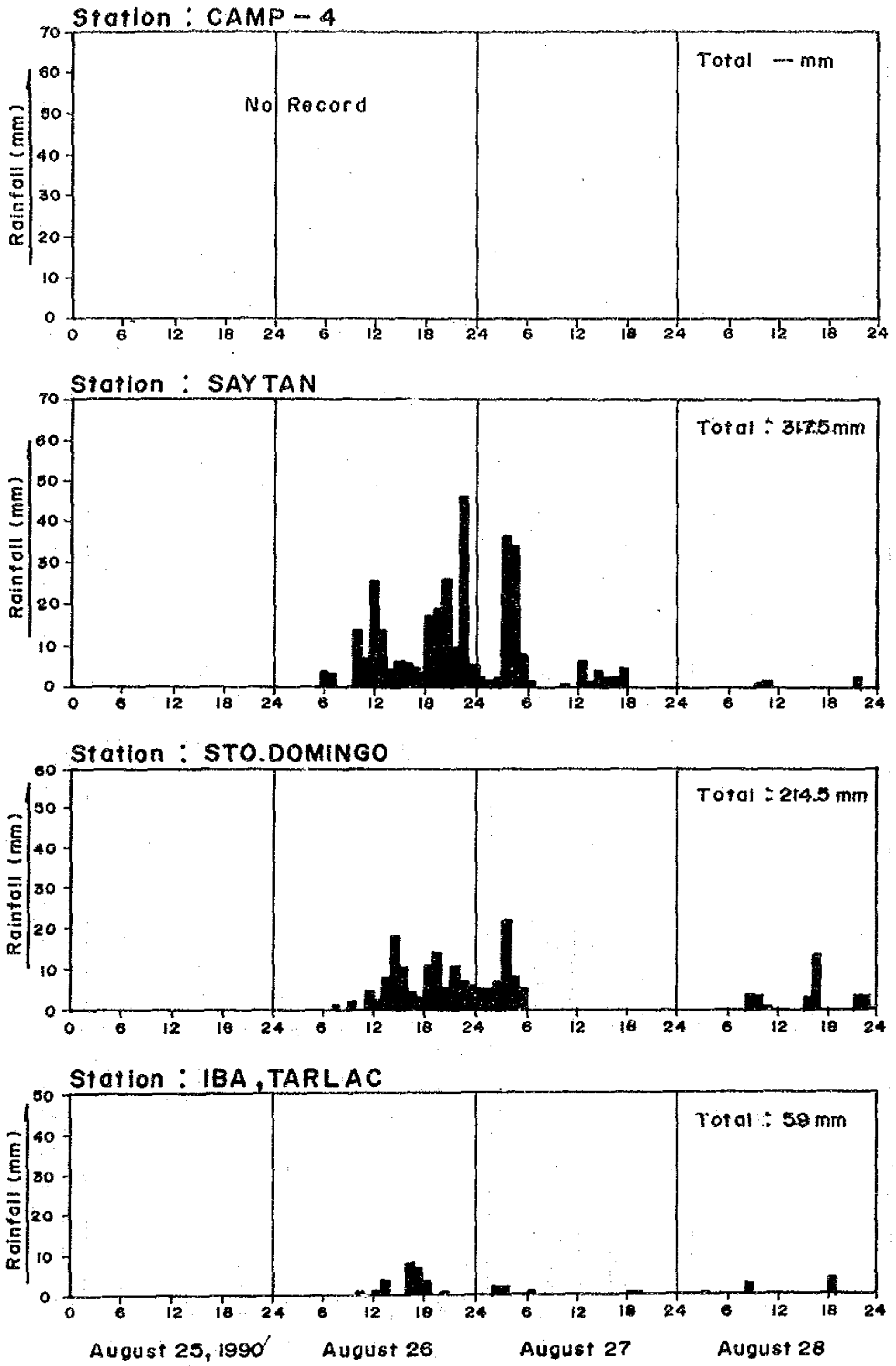


Fig. 2.5 OBSERVED RAINFALL HYETOGRAPHS DURING TYPHOON HELING

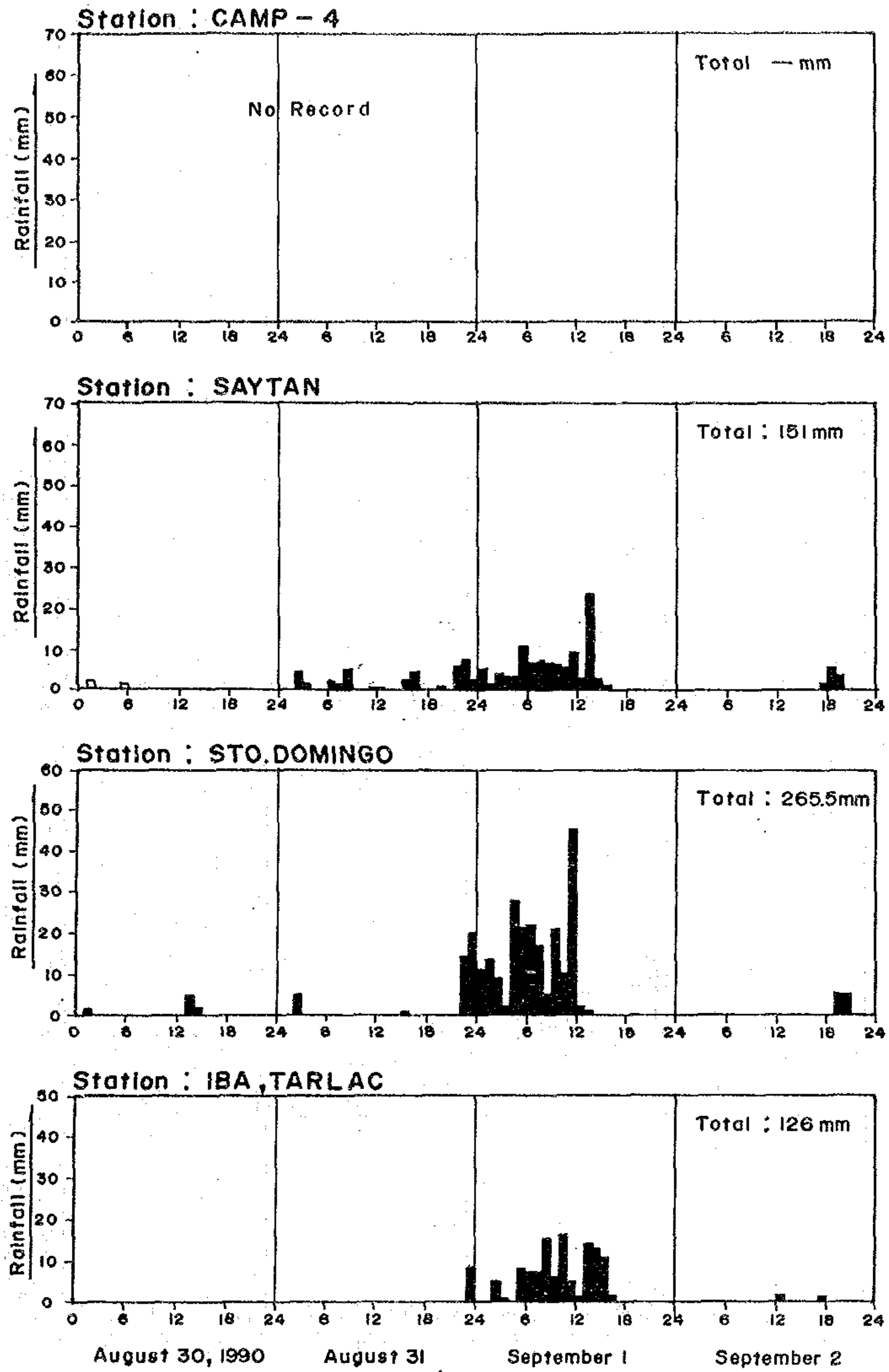


Fig. 2.6 OBSERVED RAINFALL HYETOGRAPHS DURING TYPHOON ILIANG

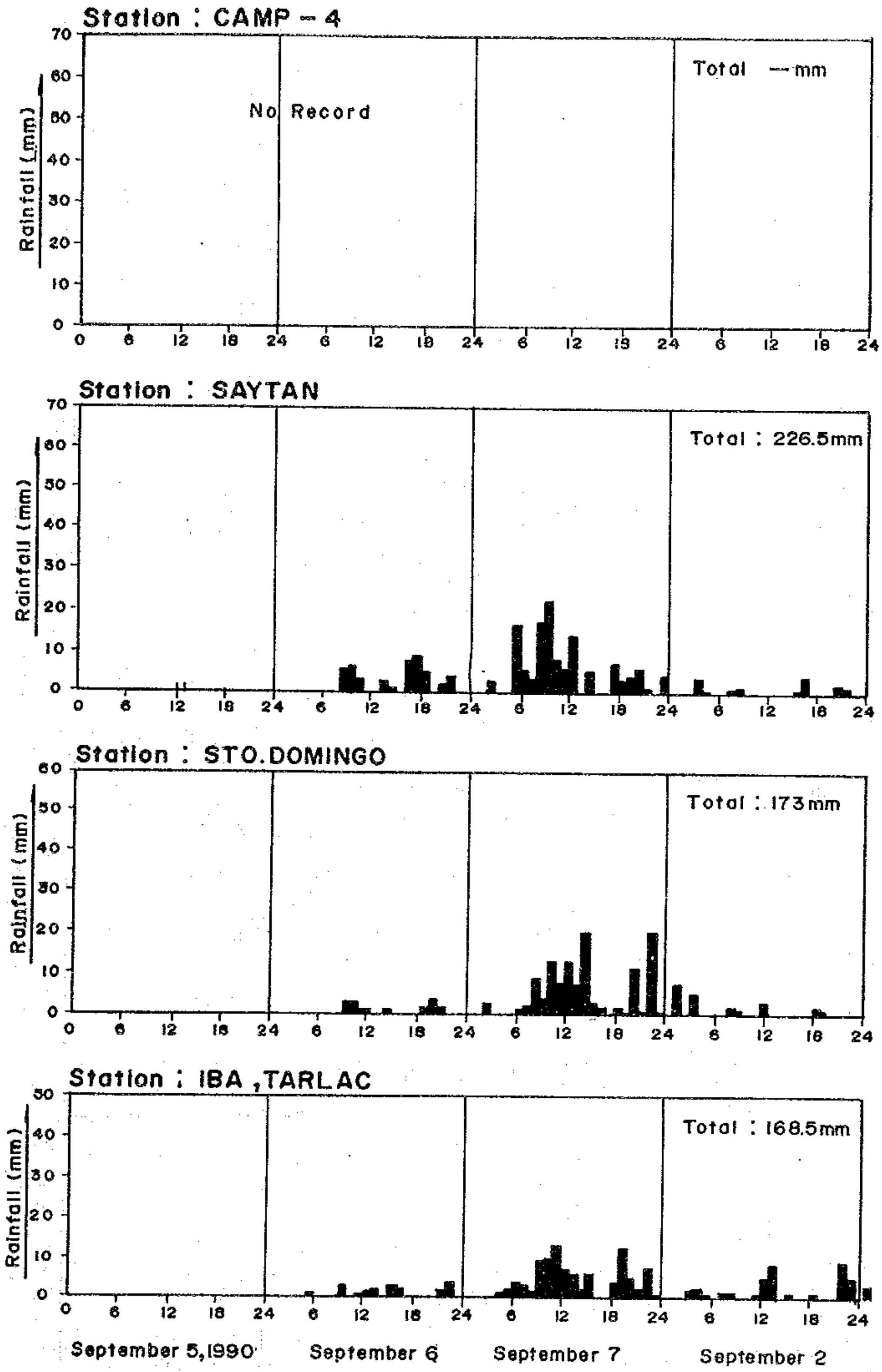


Fig. 2.7 OBSERVED RAINFALL HYETOGRAPHS DURING TYPHOON LOLENG

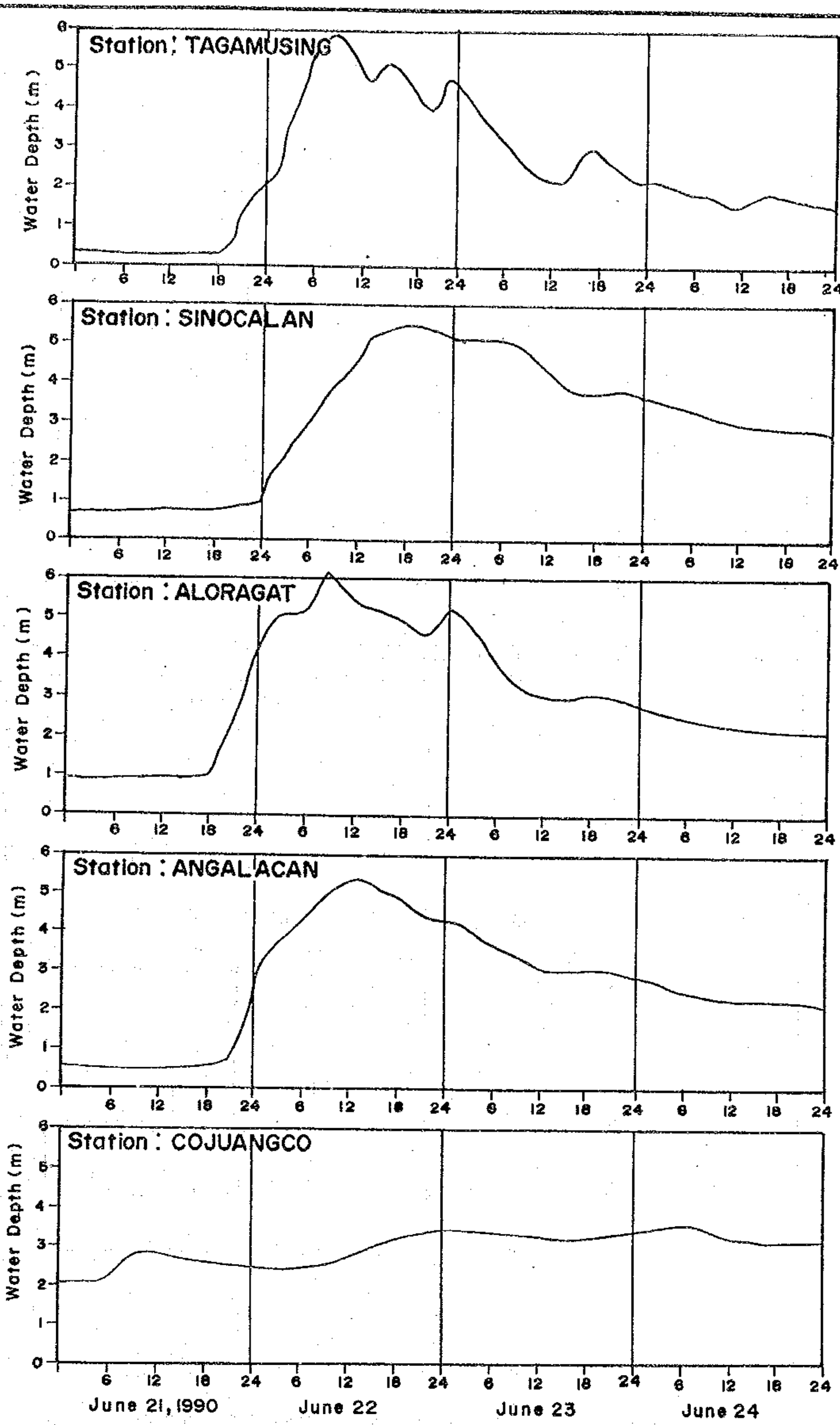


Fig. 2.8 OBSERVED WATER LEVEL HYDROGRAPHS DURING TYPHOON BISING

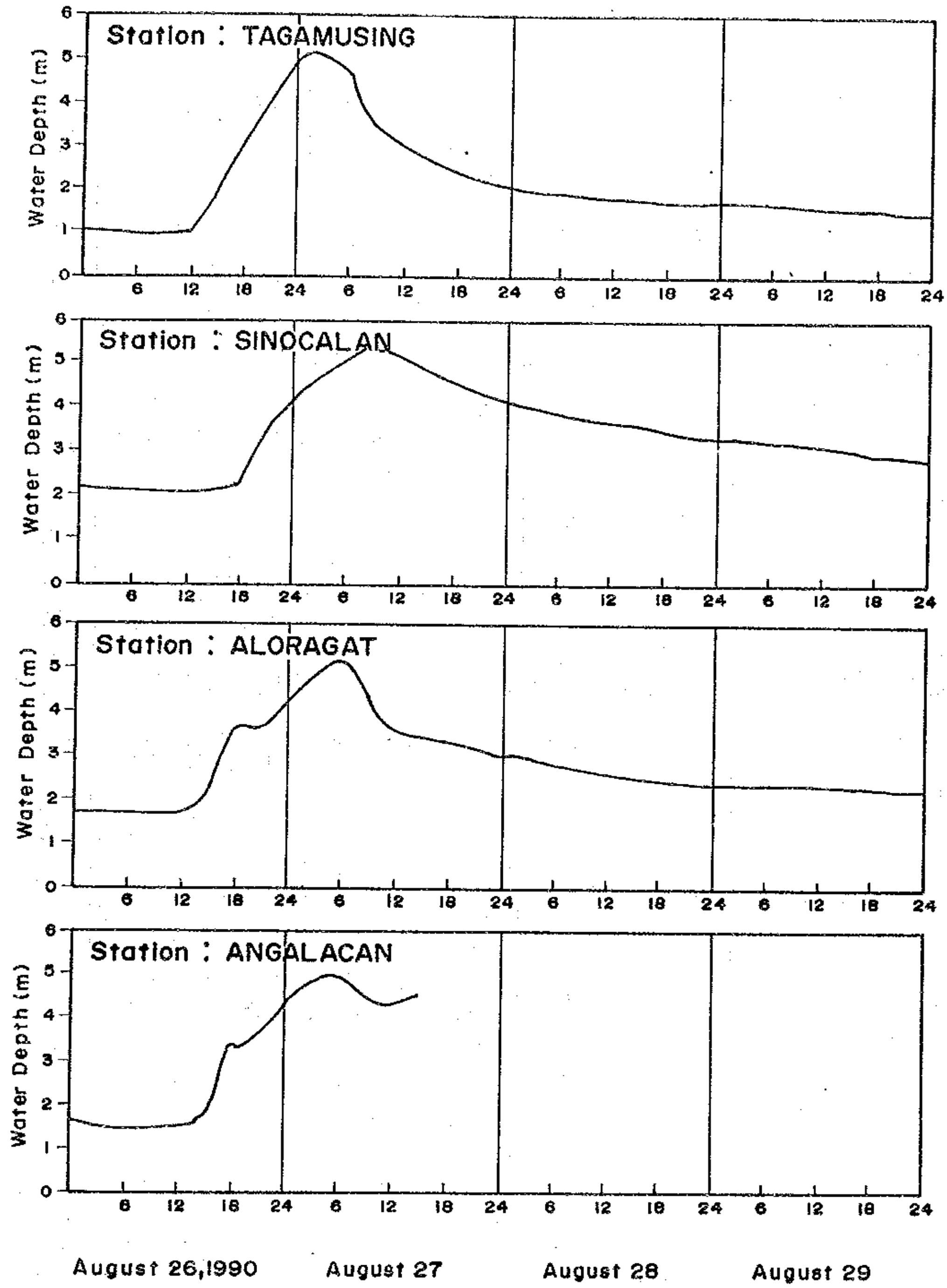


Fig. 2.9 OBSERVED WATER LEVEL HYDROGRAPHS DURING TYPHOON HELING

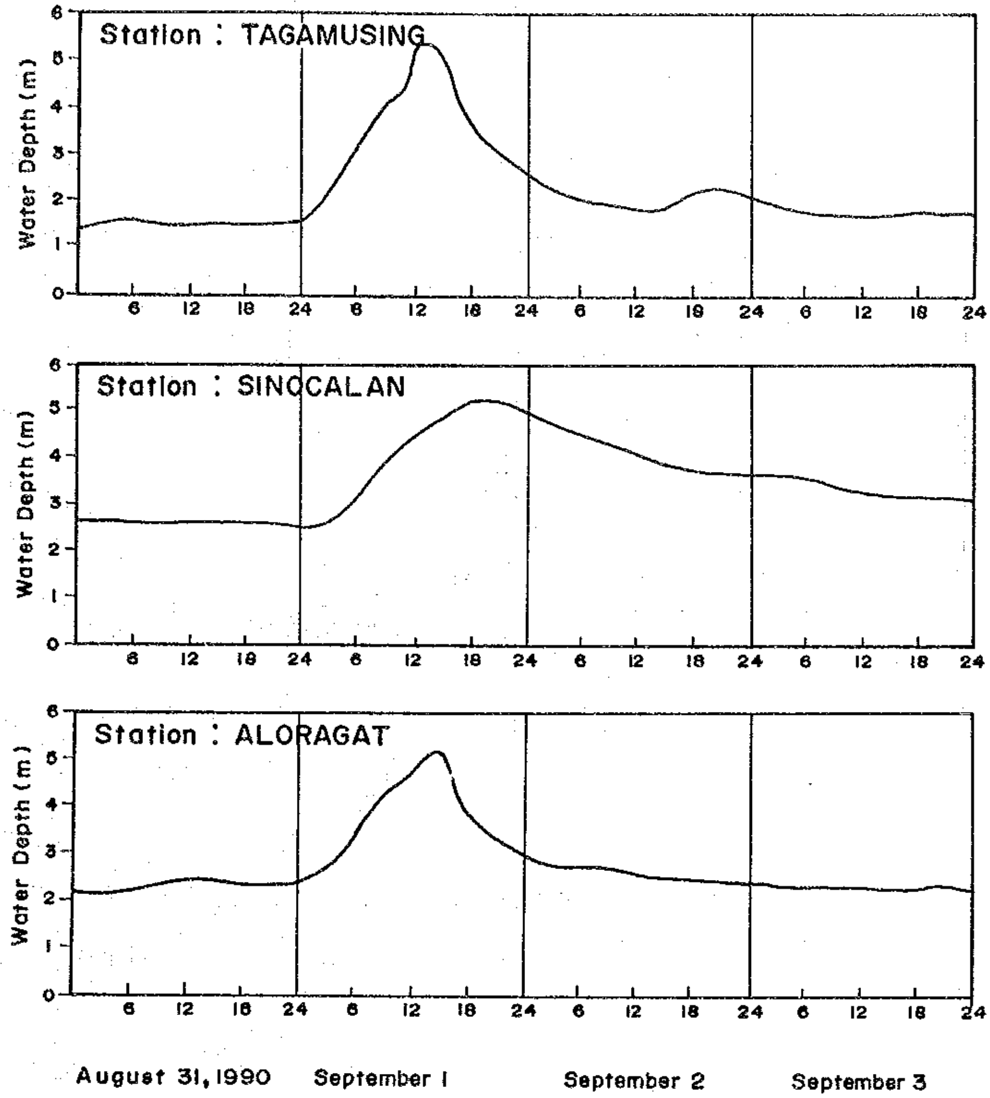


Fig. 2.10 OBSERVED WATER LEVEL HYDROGRAPHS DURING TYPHOON ILIANG

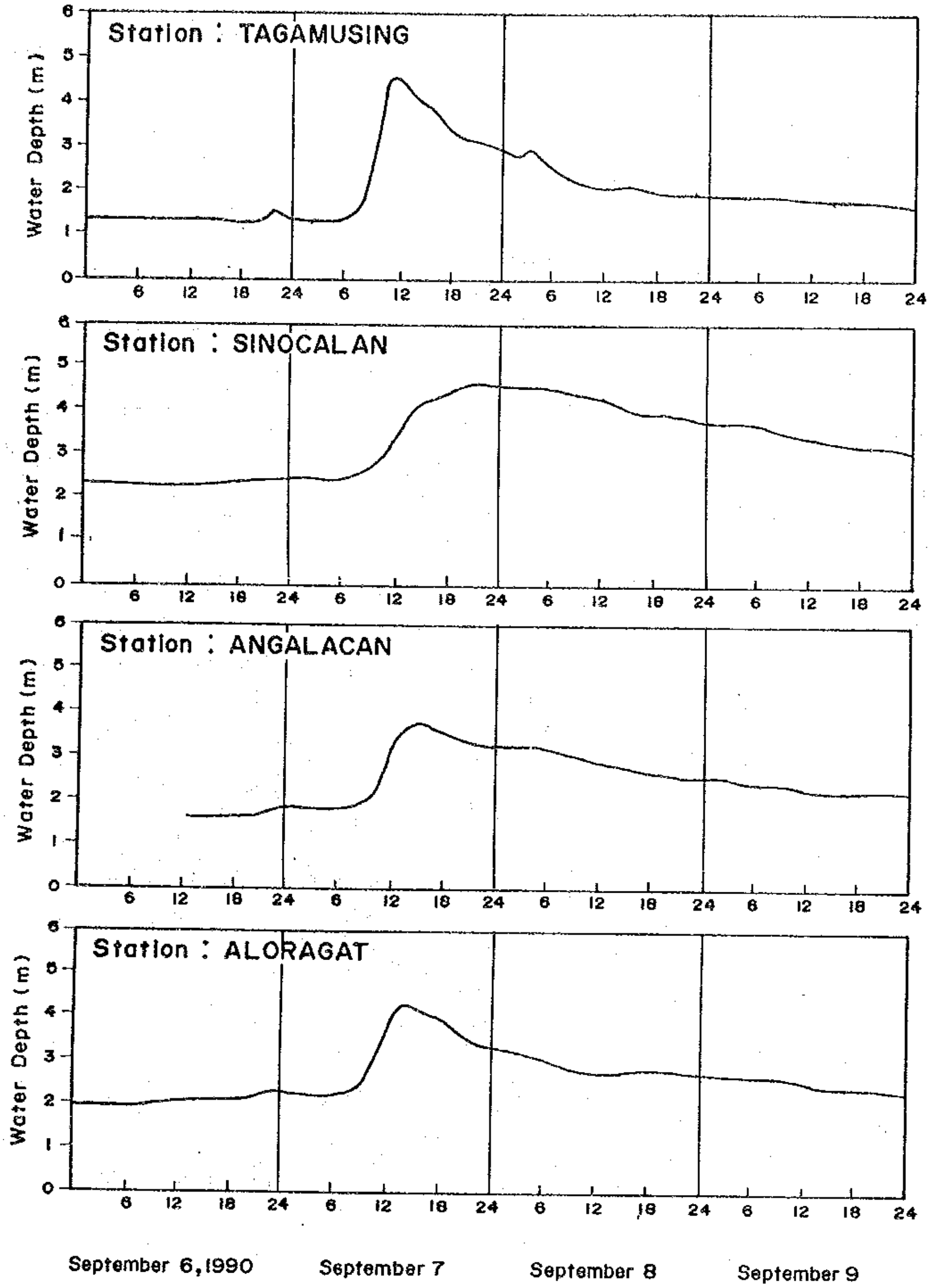


Fig. 2.11 OBSERVED WATER LEVEL HYDROGRAPHS DURING TYPHOON LOLENG

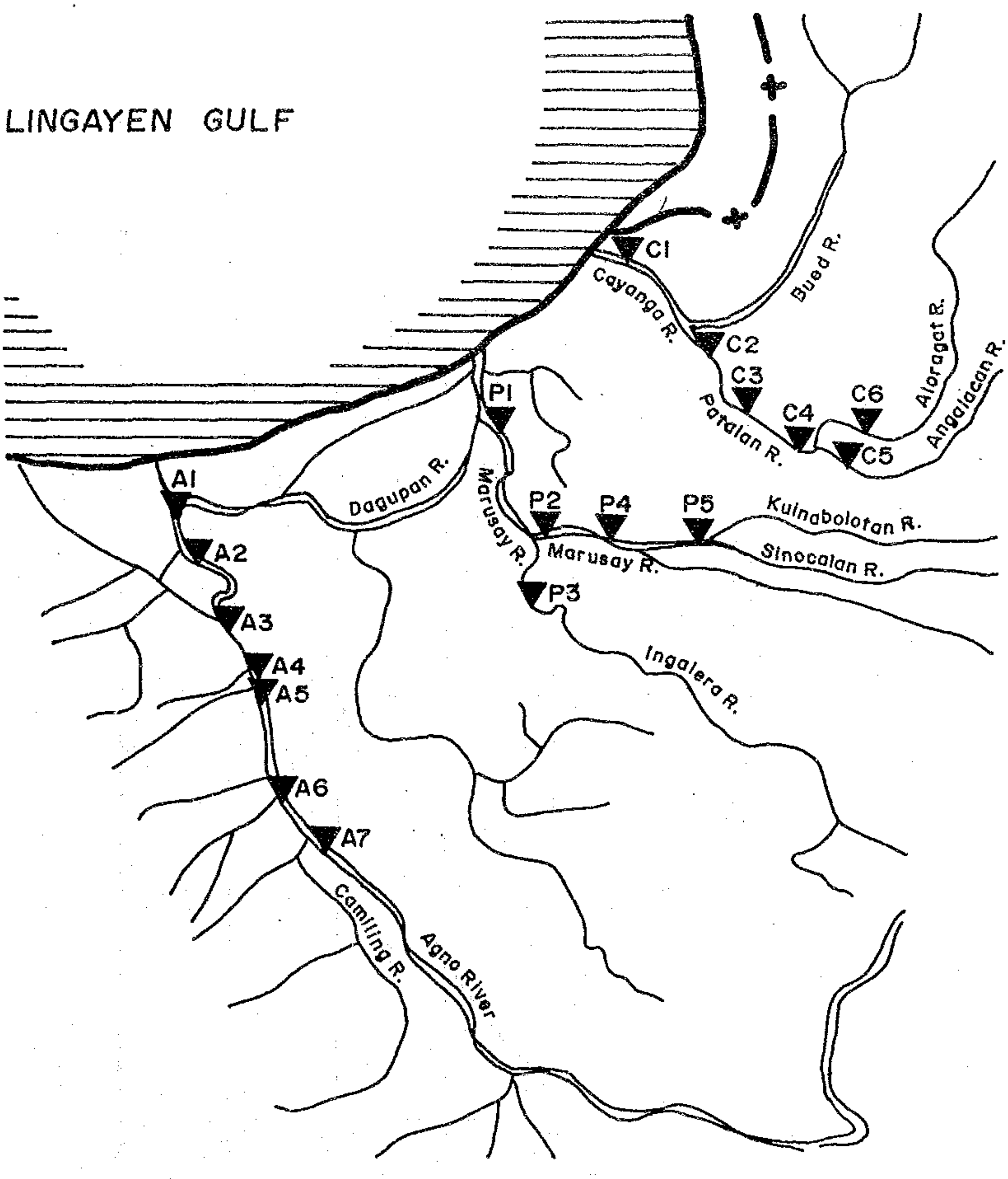


Fig. 2.12 LOCATION MAP OF WATER SAMPLING

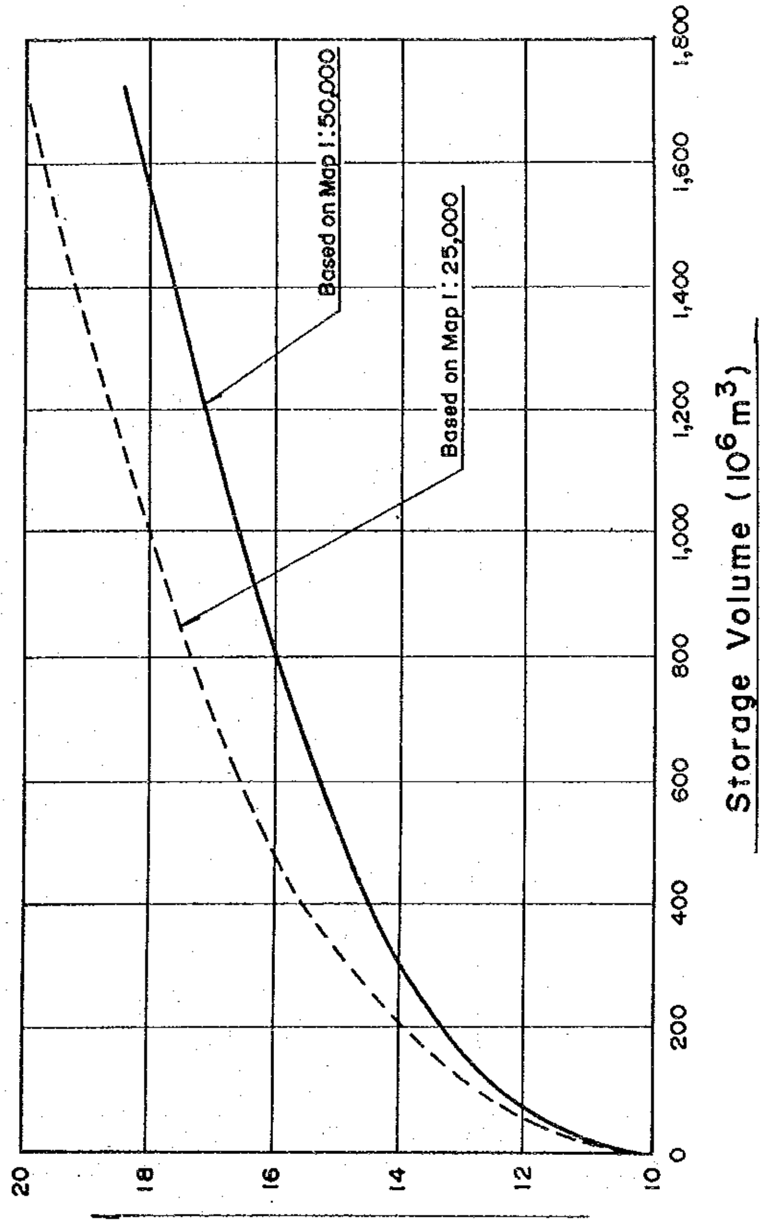


Fig. 2.13 COMPARISON OF H-V CURVES AT POPONTO SWAMP

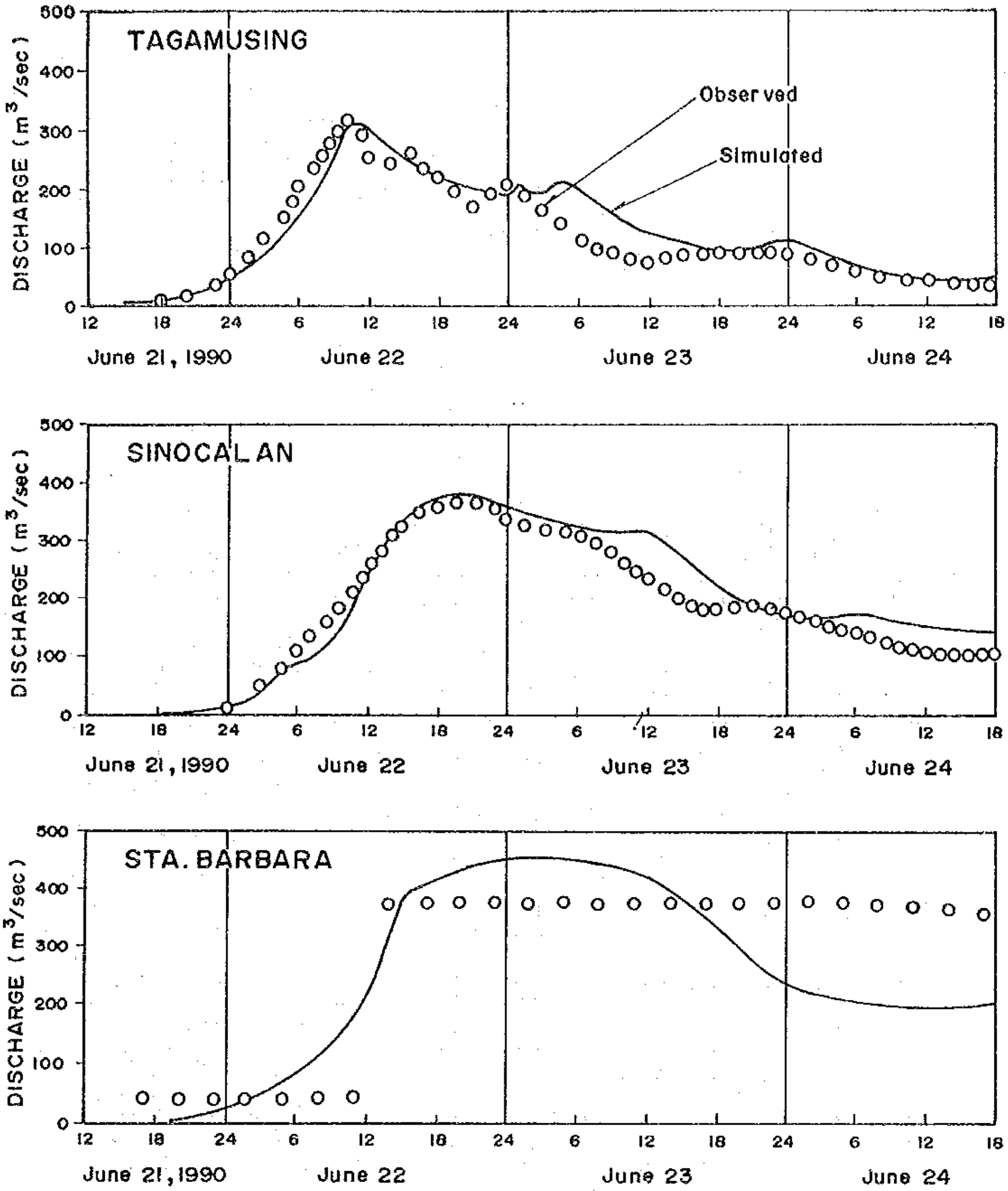
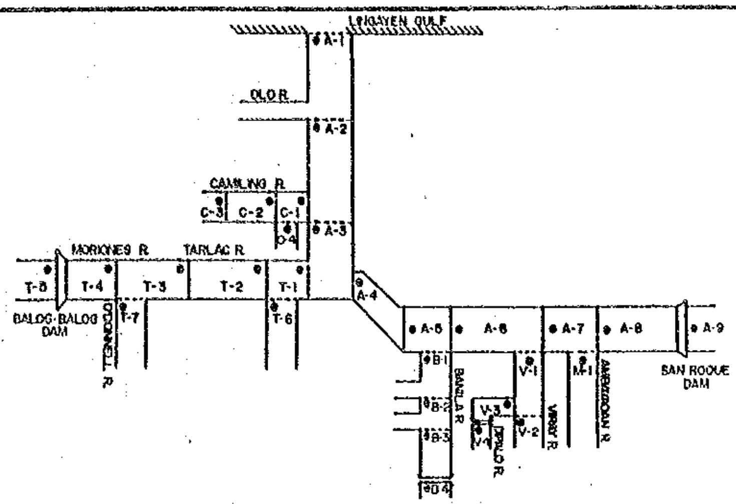
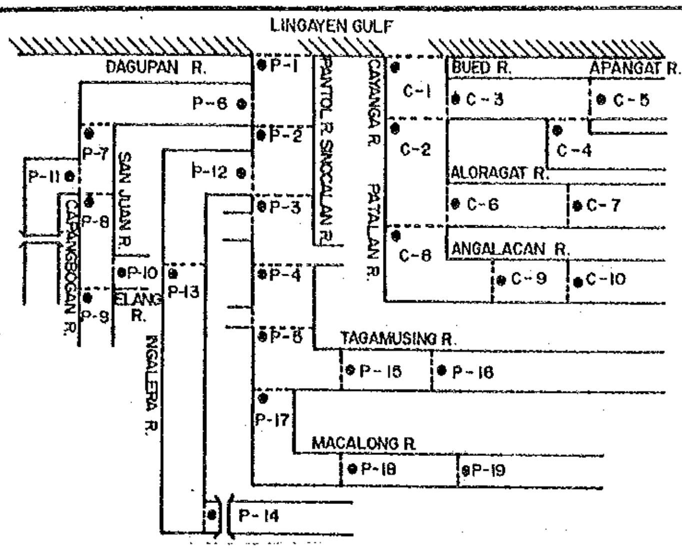


Fig. 3.1 OBSERVED AND SIMULATED FLOOD HYDROGRAPHS DURING TYPHOON BISING



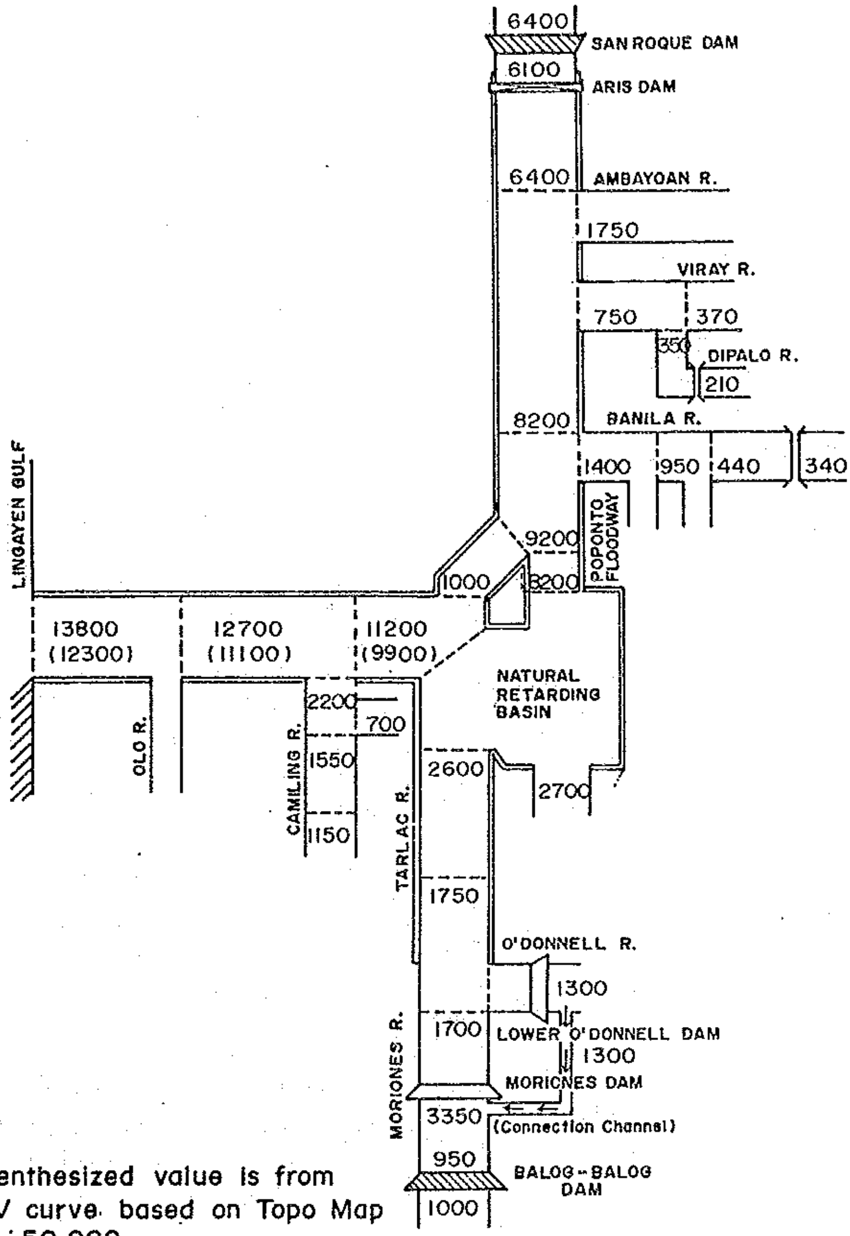
River/Stretch	Location No.	1.05	2	5	10	25	50	100
		Return Period (year)						
1. Main Agno River								
Rivermouth	A-1	1160	2510	5100	7610	11220	14170	17310
Before Junction with Olo R.	A-2	990	2250	4700	6910	10140	12730	15680
Before Junction with Camiling R.	A-3	880	2100	4350	6410	9330	11960	14820
Before Junction with Tarlac R.	A-4	500	1330	2690	3980	5760	7460	9210
Upstream of Poponto Floodway	A-5	490	1320	2680	3960	5730	7430	9190
Before Junction with Banila R.	A-6	410	1140	2330	3470	5020	6570	8140
Before Junction with Viray-Dipalo R.	A-7	360	970	2050	3010	4380	5930	7280
Before Junction with Ambayoan R.	A-8	260	700	1530	2340	3780	5120	6370
San Roque Dam	A-9	320	830	1710	2600	3950	5060	6260
2. Tarlac River								
Junction with Agno R.	T-1	460	960	2000	2930	4350	5510	6720
Before Junction of Baka R.	T-2	240	550	1140	1690	2540	3230	3940
Tarlac	T-3	180	430	870	1340	2020	2580	3180
Baka R. + Sub Basin	T-6	260	530	1000	1490	2150	2640	3150
Moriones R.	T-4	110	280	570	860	1270	1610	1950
O'Donnell R.	T-7	70	170	310	490	760	1000	1230
Balog-Balog	T-5	80	160	300	430	610	760	900
3. Camiling River								
Junction with Agno R.	C-1	200	360	660	1020	1630	2170	2660
Before Junction with Bayating R.	C-2	130	240	450	700	1140	1520	1850
Before Junction with Mamair R.	C-3	90	170	310	480	850	1130	1380
Bayating R.	C-4	70	120	210	320	500	660	800
4. Banila River								
Junction with Agno R.	B-1	110	250	510	740	990	1380	1610
Before Junction with Matablong R.	B-2	60	160	320	470	650	950	1100
Before Junction with Karayoga R.	B-3	30	70	150	220	300	440	510
Bridge	B-4	20	60	110	160	230	330	390
5. Viray-Dipalo River								
Junction with Agno R.	V-1	50	120	240	380	530	730	840
Viray R.	V-2	20	60	130	190	270	370	420
Dipalo R. (Down stream of San Pedro)	V-3	20	60	110	170	250	350	400
(Upstream of San Pedro)	V-4	10	30	70	100	150	210	240
6. Ambayoan River								
Junction with Agno R.	M-1	110	300	590	880	1310	1730	2090

Fig. 3.2 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF AGNO RIVER UNDER CONFINING DIKE CONDITION (WITH SAN ROQUE DAM)



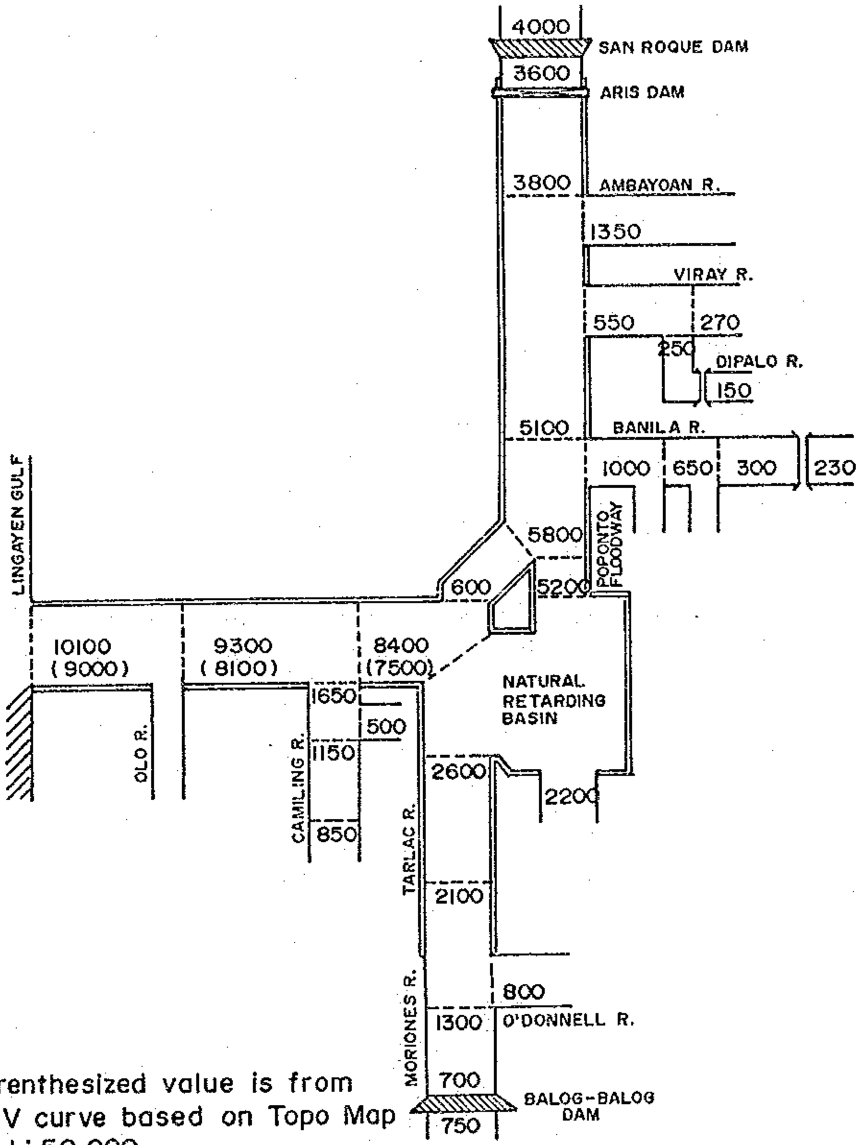
River/Stretch	Location No.	1.05	2	5	10	25	50	100
1.1 Cayanga/Patalan Rivers								
Rivermouth	C-1	270	580	1070	1490	2080	2560	3030
Before Junction with Bued R.	C-2	140	300	550	770	1060	1310	1550
1.2 Bued River								
Junction with Cayanga R.	C-3	130	290	520	730	1040	1290	1550
Before Junction with Apangat R.	C-4	90	200	340	500	750	950	1170
Apangat R.	C-5	30	60	120	160	220	260	300
1.3 Aloragat River								
Junction with Patalan R.	C-6	50	110	210	280	380	470	550
Amagbagan	C-7	30	60	100	140	200	240	290
1.4 Angalacan River								
Junction with Patalan R.	C-8	70	150	280	400	570	710	840
Maraboc	C-9	50	110	190	270	400	510	620
Kililo	C-10	30	80	130	190	290	370	460
2.1 Panto/Sinocalan River								
Rivermouth	P-1	450	850	1390	2000	2820	3510	4130
Before Junction with Dagupan R.	P-2	270	540	850	1220	1740	2220	2670
Before Junction with Ingalera R.	P-3	190	380	600	860	1260	1640	2000
Before Junction with Quinabolotan R.	P-4	140	280	430	620	950	1250	1530
Catablan	P-5	120	250	370	540	850	1120	1380
2.2 Dagupan River								
Junction with Panto R.	P-6	170	300	480	690	950	1110	1260
Before Junction with Basing R.	P-7	130	240	380	540	740	870	990
Lower San Juan R.	P-8	100	170	270	390	540	630	720
Upper San Juan R.	P-9	50	90	150	200	280	330	380
Elang R.	P-10	50	80	120	190	260	310	350
Campangbogan R.	P-11	30	50	80	120	170	190	220
2.3 Ingalera River								
Junction with Sinocalan R.	P-12	80	150	250	360	500	600	700
Talospatang	P-13	60	120	180	260	370	450	540
San Nicolas	P-14	20	40	50	80	120	150	180
2.4 Tagumising/Tuboy River								
Junction with Sinocalan R.	P-15	80	170	250	350	580	790	990
Yatyat	P-16	70	150	230	330	540	730	910
2.5 Macalong River								
Junction with Sinocalan R.	P-17	40	90	130	190	270	330	390
Urdaneta	P-18	30	60	80	120	190	240	280
San Manuel	P-19	10	30	50	70	100	140	160

Fig. 3.3 PROBABLE FLOOD PEAK DISCHARGE DISTRIBUTION OF ALLIED RIVERS UNDER CONFINING DIKE CONDITION



Note: Parenthesized value is from H-V curve based on Topo Map of 1:50,000.

Fig. 3.4 REVISED DESIGN FLOOD DISTRIBUTION OF FRAMEWORK PLAN OF AGNO RIVER



Note: Parenthesized value is from H-V curve based on Topo Map of 1:50,000

Fig. 3.5 REVISED DESIGN FLOOD DISTRIBUTION OF LONG TERM PLAN OF AGNO RIVER (25-YEAR FLOOD)

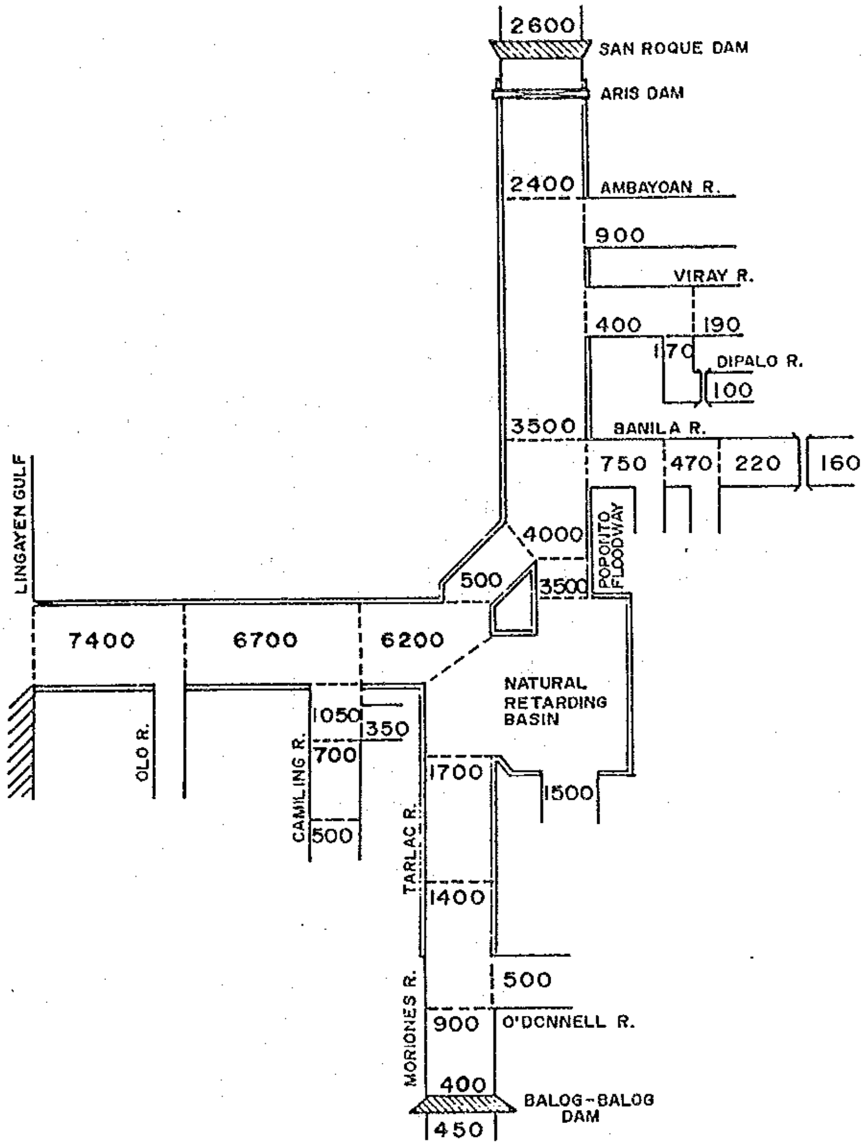


Fig. 3.6 REVISED DESIGN FLOOD DISTRIBUTION OF LONG TERM PLAN OF AGNO RIVER (10-YEAR FLOOD)

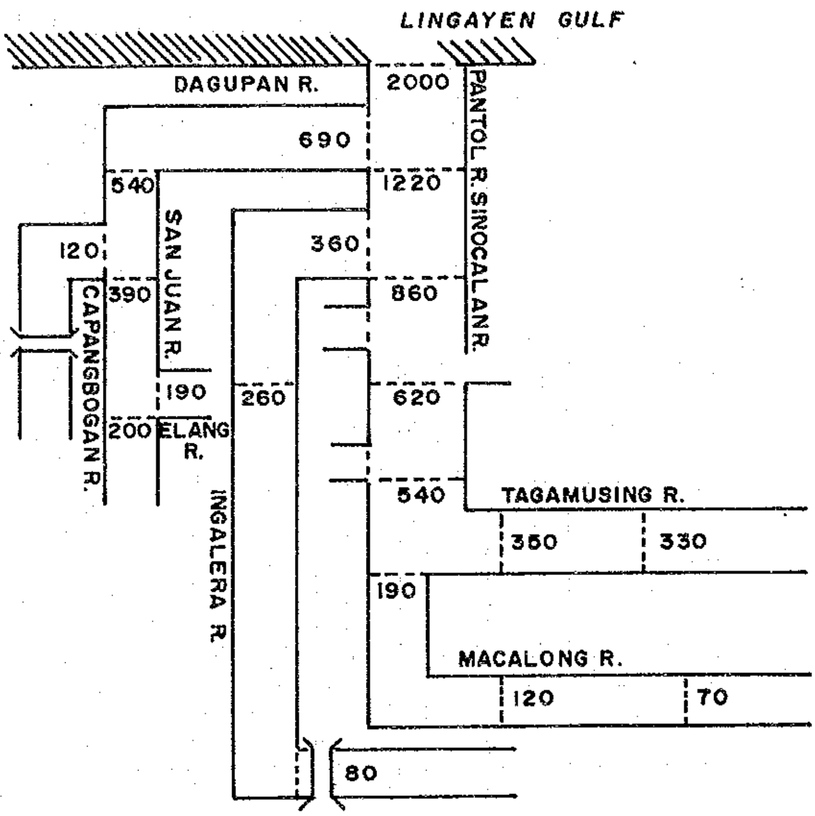


Fig. 3.7 PROBABLE FLOOD DISCHARGE DISTRIBUTION OF PANTAL-SINOCALAN RIVER (10-YEAR FLOOD)

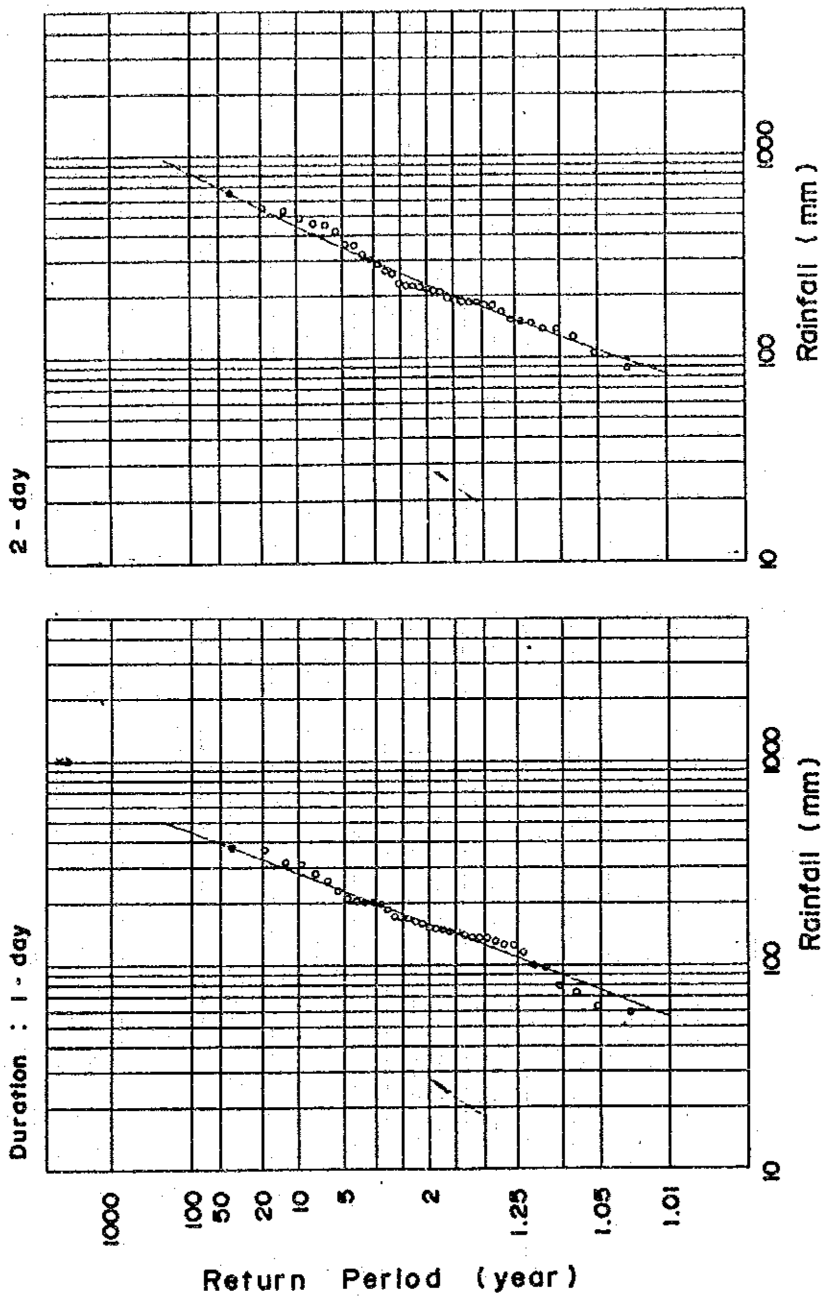


Fig. 3.8 FREQUENCY CURVE OF ANNUAL MAXIMUM RAINFALL AT DAGUPAN (1/2)

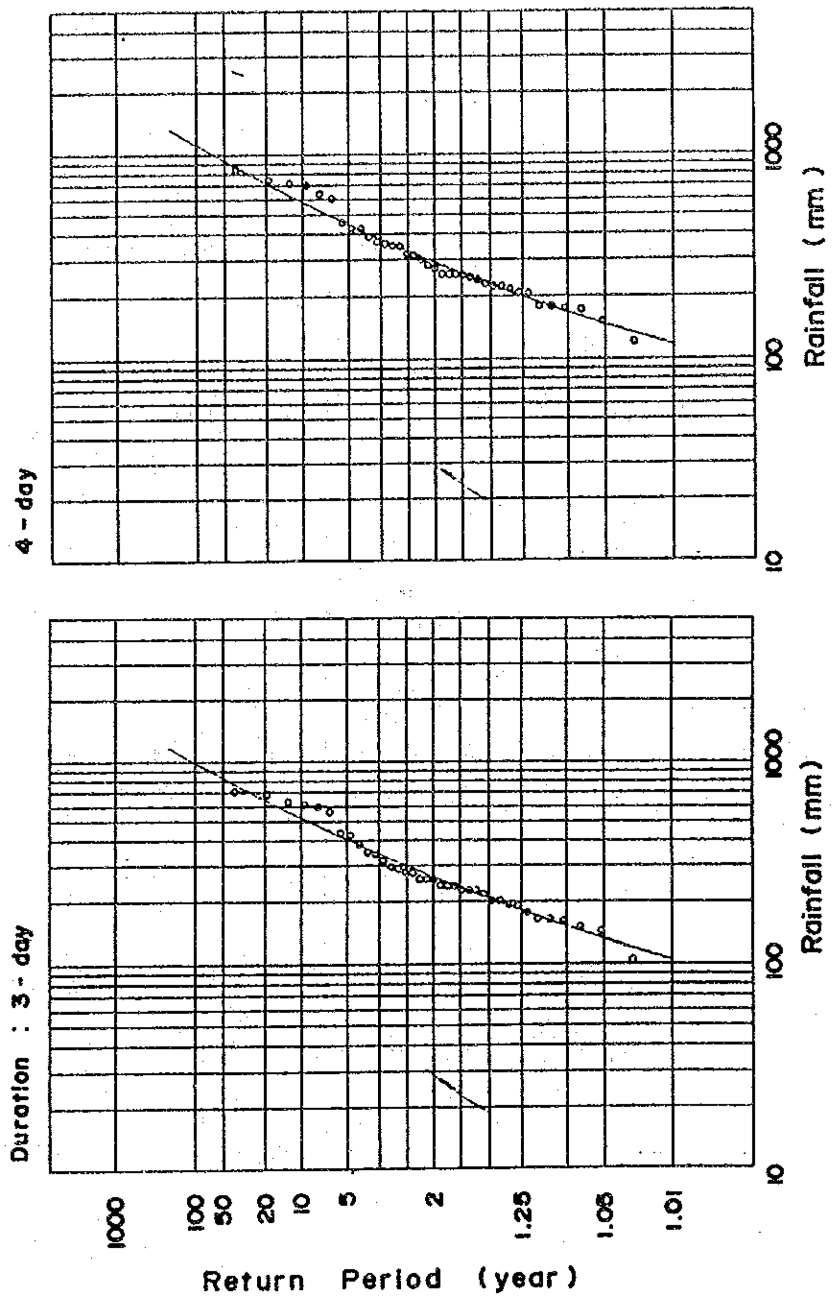


Fig. 3.8 FREQUENCY CURVE OF ANNUAL MAXIMUM RAINFALL AT DAGUPAN (2/2)

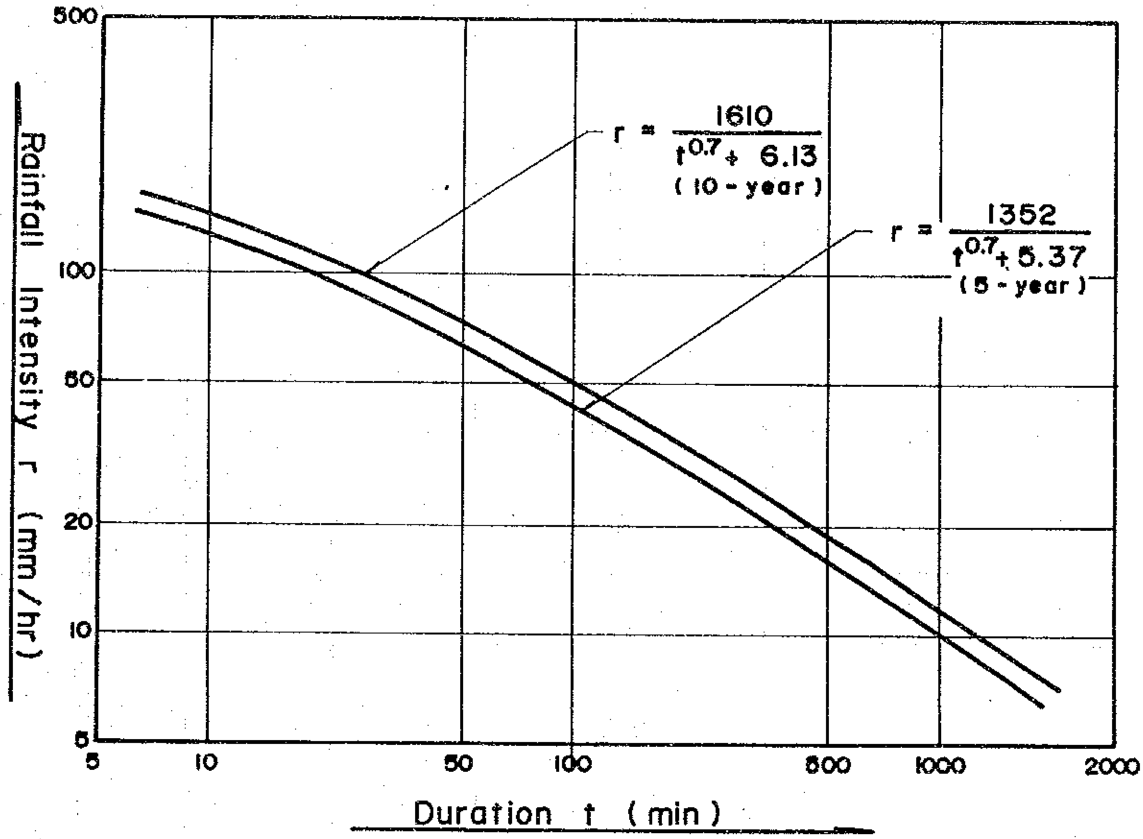


Fig. 3.9 PROBABLE RAINFALL INTENSITY DURATION CURVE AT DAGUPAN

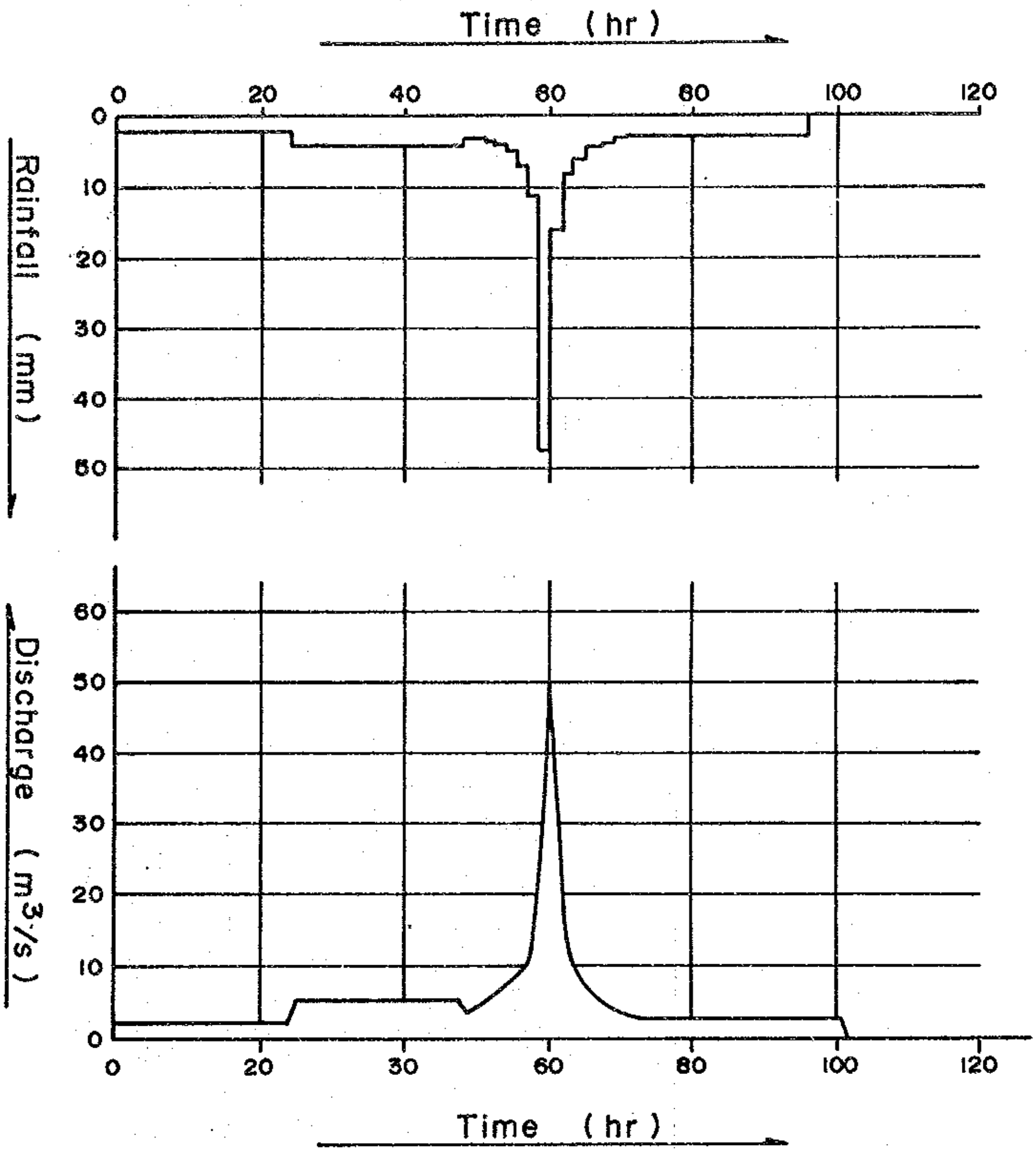
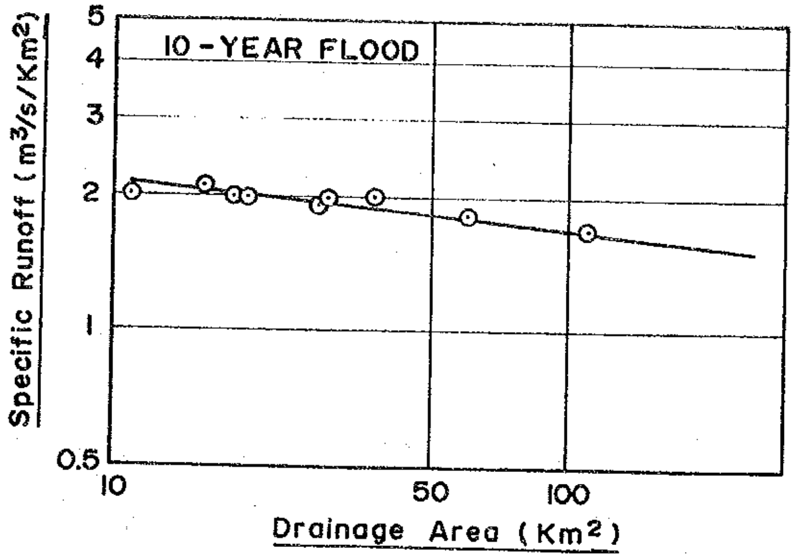


Fig. 3.10 5-YEAR PROBABLE RAINFALL DISTRIBUTION AND FLOOD HYDROGRAPH AT DAGUPAN



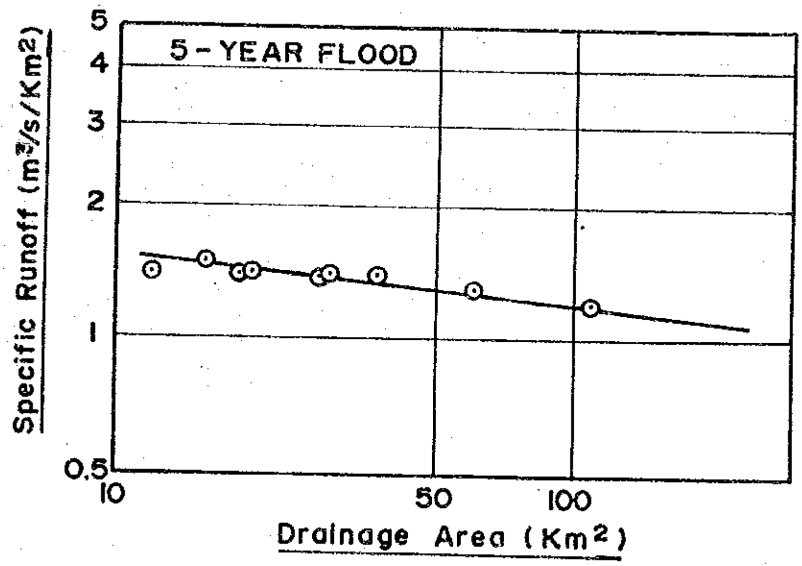


Fig. 3.11 RELATIONSHIP BETWEEN SPECIFIC RUNOFF AND DRAINAGE AREA OF LOWLAND AREA IN PANTOL - SINOCALAN RIVER

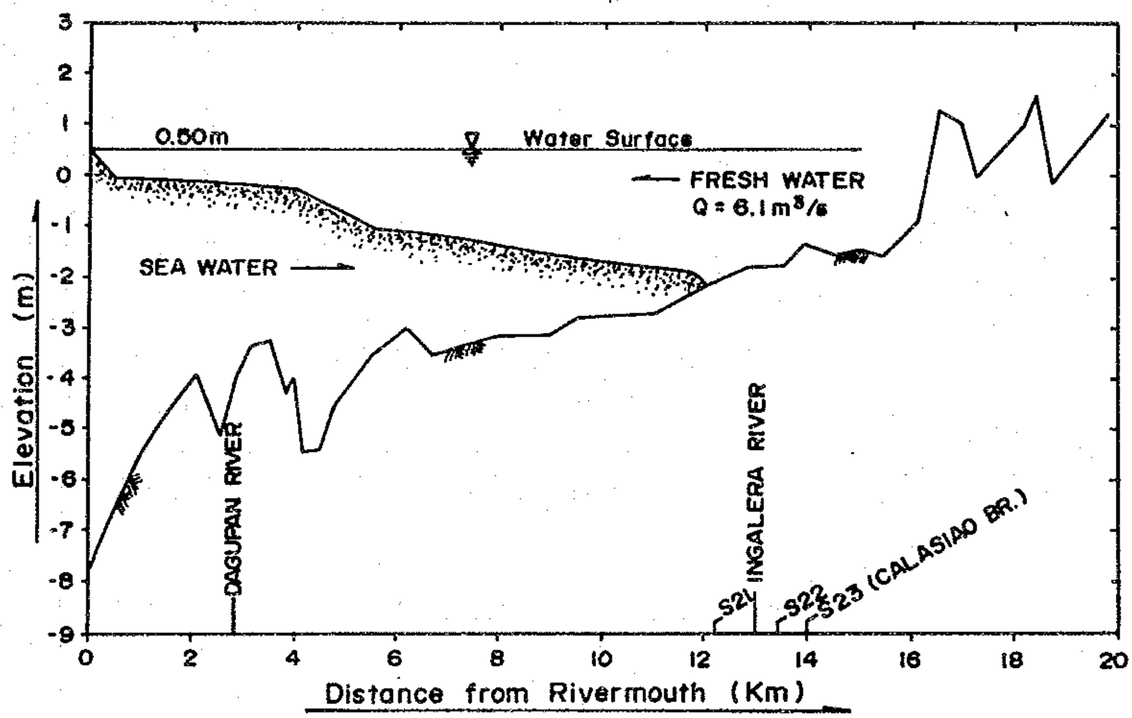


Fig. 4.1 ESTIMATED PROFILE OF SEAWATER INTRUSION IN PANTAL-SINOCALAN RIVER ON MARCH 6, 1990

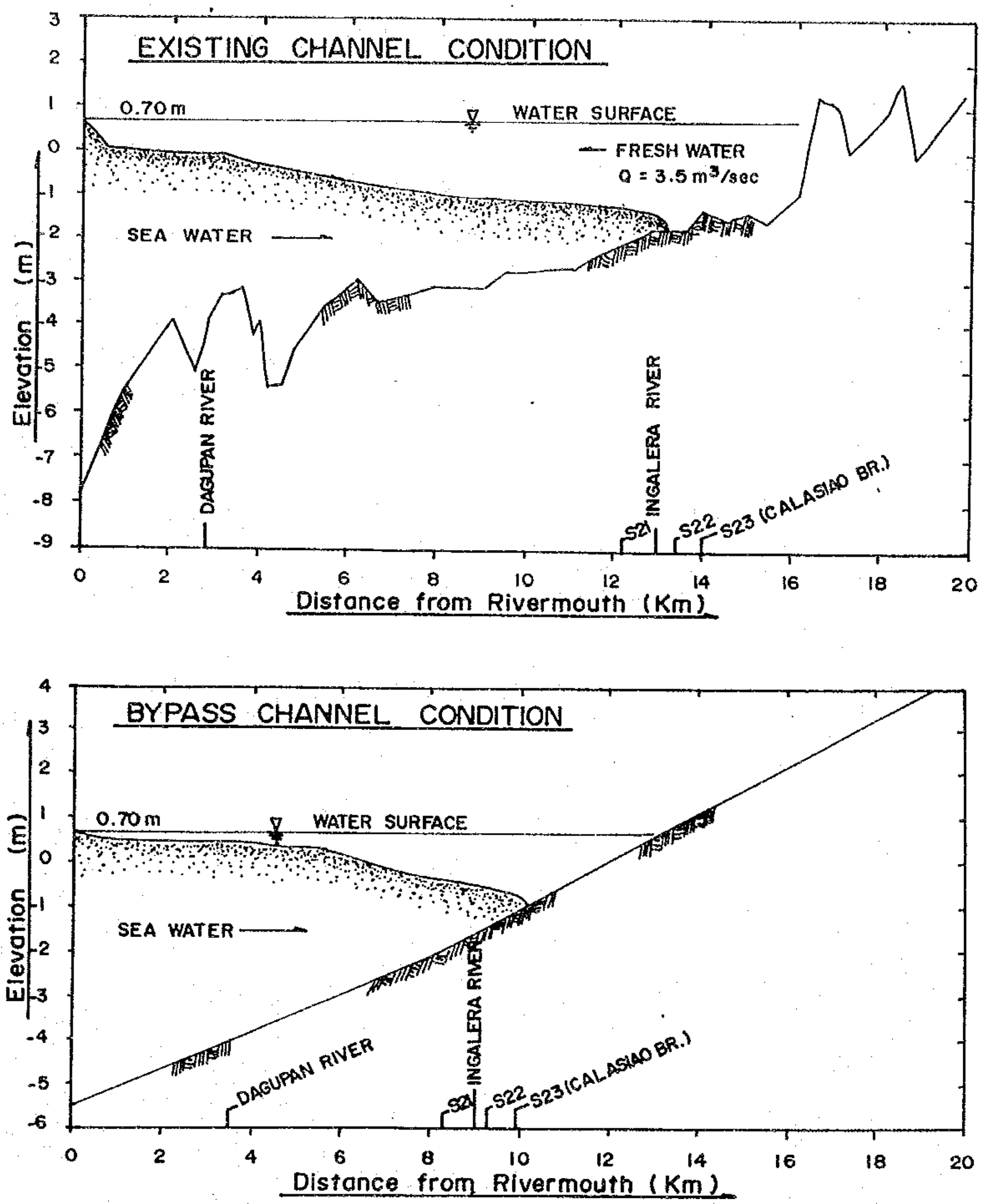


Fig. 4.2 ESTIMATED PROFILE OF SEAWATER INTRUSION IN PANTAL - SINOCALAN RIVER UNDER EXISTING AND BYPASS CHANNEL CONDITIONS

3. GL

3. GL

GEOLOGY

GL: GEOLOGY

SUMMARY

1. Geological investigation composed of core drillings, test pits and material laboratory tests, were performed for the purpose of obtaining geotechnical data on the sub-surface soil and foundation conditions in the feasibility study area. Twenty-nine core drillings were performed in the Agno River Basin, and twenty-six core drillings in the Allied River Basin in May-July, 1990. Additional twenty core drillings were excuted mainly in the middle Agno River and Dagupan City area for the purpose of obtaining data for liquefaction analysis and foundation design in December, 1990 - January, 1991. In May-June, 1991 another six core drillings were excuted consisting five in Dagupan City and one in the Agno River. Refer to the quantities in Tables 1.1 (1/4)-(4/4) and Figures 1.1 (1/13)-(13/13).

2. Geotechnical conditions of soil foundation for dikes and river structures are assessed as follows:

   - Upper Agno River; This area is underlain by mainly gravel and sand mixtures. Permeation problem is expected to occur at the dike resting on the permeable foundation such as old river channel. Sheet piling and slope protection are considered to be one of effective coutermeasures.

   - Middle Agno River; This area is underlain by sand and clayey soil alternately by physiographical conditions. Grain size of soils have a tendency to decrease from the upstream to the downstream. Permeation problem will occur in the area having sand layer, and liquefaction problem in loose sand area. Sheet piling is one of effective countermeasures.

   - Poponto floodway; This area is mainly underlain by clayey soil and partly sandy soil. Due to low bearing capacity at the drill hole No. AG-26 foundation settlement is expected in this area.

   - Proposed weir site; The vicinity of proposed weir site is presumed to be underlain by alluvial deposit and recent river deposit. The recent river deposit of about 20m thick is composed of loose to dense sand. The alluvial deposit assumed to exist under about 20m depth, is composed of dense sand. Pile foundations which reach to the alluvial deposit will be required for the concrete structures. Permeation measures also will be required.

- Downstream of Allied Rivers; This area is underlain by mainly very loose to loose sand. Permeation, liquefaction and settlement problems are expected in this area.

- Proposed By-pass; This area is underlain by clayey soil and fine sand. The upper layer of 0-3m depth is mainly composed of very soft to soft silty clay with some organic materials. The middle layer (3-20m depth) is mainly composed of medium dense fine sand. The lower layer (below 20m depth) is composed of very stiff clayey soil. Replacement or pre-loading are recommended as countermeasures for foundation treatment. Excavation of the By-pass will involves in trafficability problem due to very soft clay with organic materials.

3. It is assessed that the Asingan-San Manuel stretch in the upper Agno River was breached by combined effect of seepage of soil foundation and scour of dike by flood flow. The materials of the existing dikes are composed of silty soils and are considered to be suitable. Sheet piling and slope protection will be required as countermeasures.

4. Residual soil of hilly area and weathered terrus deposits are available for dike construction materials. The potential quantities of these dike materials are estimated to be about $12.4 \times 10^6 m^3$. Refer to the breakdown in Table 4.5.

5. Gravel and sand mixtures of the Agno River, the Bued River and the Aloragat River are available for concrete aggregates. The potential quantities of coarse aggregates are estimated to be about $1.7 \times 10^6 m^3$, and those of fine aggregates are estimated about $1.1 \times 10^6 m^3$. Refer to breakdown in Table 4.6.

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ABBREVIATION

1. GEOLOGICAL TERMS

SPT	Standard Penetration Test
NMC	Natural Moisture Content
OMC	Optimum Moisture Content
MDD	Maximum Dry Density
SG	Specific Gravity
LL	Liquid Limit
PL	Plastic Limit
UU	Unconsolidated and Undrained
ASTM	American Society for Testing and Materials

2. MEASUREMENT UNITS

%	Percent
Kg/cm^2	Kilogramme per square centimeter
cm/sec.	Centimeter per second

1. GENERAL

1.1 Purpose

Geological investigation consisting of core drillings, test pits, and material laboratory tests, were performed for the purpose of obtaining geotechnical data on the sub-surface soil and foundation conditions in the feasibility study areas. Core drillings were performed together with the standard penetration test and partly thin-wall sampling.

The investigation was executed in three stages:

1) Original Work : May - July, 1990
2) Additional Work in FY 1990 : December, 1990 - February, 1991
3) Additional Work in FY 1991 : May - June, 1991

Additional core drillings were performed for the purpose of obtaining geotechnical data after the earthquake occurred in July 16, 1990.

1.2 Location of Geological Survey

The locations of geological survey are shown in Fig. 1.1 (1/13) - (13/13). These maps include location of core drillings, test pits for dike materials and concrete aggregates and additional core drillings.

1.3 Quantity of Geological Survey

1.3.1 Core Drilling

(1) Original Work

Quantities of core drilling are as follows:

Item	Unit	Quantity
1. Drilling: (66 mm diameter)	Nos.	55
(1) for Soil (Sand/Clay)	m.	680.51
(2) for Sand & Gravel	m.	91.08
(3) for Rock (Cobble/Boulder)	m.	53.41
(4) Total Depth	m.	825.00
2. Standard Penetration Test (SPT)	Nos.	412
3. Thin Wall Sampling: (86 mm diameter)	Nos.	2
4. Laboratory Test		
(1) Tri-Axial Compression	Nos.	1
(2) Consolidation	Nos.	2

The total original core drillings are 55 holes including 29 holes for the Agno River and 26 holes for the Allied River. Total depth of core drilling is 825.0 meters, and number of the SPT is 412 times. The breakdown of the core drilling is shown in Table 1.1 (1/4)-(2/4).

(2) Additional Work in FY 1990

Quantities of the additional core drilling in FY 1990 are as follows:

	Item	Unit	Quantity
1.	Type - A Drilling: 66mm diameter	Nos.	14
	(1) for Soil (Sand/Clay)	m.	163.45
	(2) for Sand & Gravel	m.	46.55
	(3) Sub-Total Depth	m.	210.00
2.	Type - B Drilling: 100mm diameter	Nos.	6
	(1) for Soil (Sand/Clay)	m.	106.00
	(2) for Sand & Gravel	m.	14.00
	(3) Sub-Total Depth Type - B	m.	120.00
	Total Depth (Type A - Type B)	m.	330.00
3.	Double tube sampling: 85mm diameter	Nos.	6
4.	Standard Penetration Test (SPT)	Nos.	178

Quantities of total core drilling are 20 holes, 14 holes of 66 mm diameter with 15 meters depth and 6 holes of 100 mm diameter with 20 meters depth. Total depth of core drilling is 330.0 meters, and number of the SPT is 177 times. The breakdown of the core drilling is shown in Table 1.1 (3/4).

(3) Additional Work in FY 1991

Quantities of the additional core drillings in FY 1991 are as follows:

	Item	Unit	Quantity
1.	Type - B Drilling: 100mm diameter	Nos.	6
	(1) for Soil (Sand/Clay)	m.	148.45
	(2) for Sand & Gravel	m.	1.55
	(3) Total Depth	m.	150.00
2.	Double tube sampling : 85mm diameter	Nos.	30
3.	Standard Penetration Test (SPT)	Nos.	126

Total quantities of 100mm core drilling are 6 holes. Total drilling depth is 150.0 meters, and number of the SPT is 126 times. The breakdown of the core drilling is shown in Table 1.1 (4/4).

1.3.2 Test Pit and Laboratory Test

(1) Original Work

Quantities of test pits (sampling) and laboratory tests are shown in Table 1.2 and summarized as follows:

Item	Unit	Quantity
1. Sampling for Soil Tests		
(1) Test Pit	Nos.	20
(2) Disturbed Sample	Nos.	40
2. Laboratory Test for Soils	(see details in Table 1.2)	
3. Sampling for Aggregate Tests		
(1) Test Pit	Nos.	20
(2) Disturbed Sample	Nos.	20
4. Laboratory Test for Aggregates	(see details in Table 1.2)	

Ten soil material sites and ten aggregate sites were chosen respectively, and two test pittings were performed for each site. Forty disturbed samples were obtained for soil materials and twenty samples were obtained for aggregates. Detailed laboratory tests items for soils and aggregates are shown in Table 1.2.

(2) Additional Work in FY 1990

Quantities of additional sampling and laboratory tests in FY 1990 are as follows:

Item	Unit	Quantity
1. Sampling for Soil Tests		
(1) Disturbed Sample	Nos.	24
2. Field Density	Nos.	85
3. Laboratory Test for Soils		
(1) Moisture Content	Nos.	24
(2) Specific Gravity	Nos.	24
(3) Gradation	Nos.	72
(4) Atterberg's Limit	Nos.	39

Laboratory tests for soils were performed on disturbed samples and the SPT samples from the type - B drilling. Field density tests were performed for the SPT samples from the type - B drilling.

(3) Additional Work in FY 1991

Quantities of additional sampling and laboratory tests in FY 1991 are as follows:

Item	Unit	Quantity
1. Sampling for Soil Tests		
(1) Disturbed Sample	Nos.	30
2. Laboratory Test for Soils		
(1) Moisture Content	Nos.	30
(2) Specific Gravity	Nos.	30
(3) Gradation-A (Sieve Analysis)	Nos.	30
(4) Gradation-B (Hydrometer Analysis)	Nos.	4

Laboratory tests for soils were performed on disturbed samples from the type-B drilling.

1.4 Method of Geological Survey

1.4.1 Core Drilling

(1) Core drilling

The core drillings were performed by using four hydraulic driven rotary drilling machines with target core recovery of 100%. Core barrels are double tube and simple tube types, of which diameter is 66 mm for core sampling. Thin-wall samplers, with diameter of 86 mm, were used for undisturbed sampling. The Dames & More type sampler with diameter of 86 mm was used for disturbed sampling of the type - B drilling of the additional work.

Metal bits were used for drilling unconsolidated deposits and diamond bits were used for drilling cobbles and boulders.

The recovered core samples were contained in wooden core boxes and wrapped up with plastic covers. Color photographs of core samples in core boxes were taken by the contractor.

Water level of each hole was measured and recorded every morning before starting daily work.

(2) Standard Penetration Test (SPT)

The standard penetration test (SPT) was performed as specified by the USBR Earth Manual. For the type-B drill holes (100mm) the SPT was performed at each 1m depth. Depth for the SPT was 1m, 2m, 3m, 5m, 7m, 10m, 12m and 15m for 86mm drill holes in principle. The results of the SPT were recorded in number of blows for each 15 cm of penetration of the 30 cm long test drive.

1.4.2 Test Pitting and Sampling

(1) Test pit and Sampling

Test pitting was made by manpower with at least 1.0 m x 1.0 m cross-sectional area through all depth. The depth of test pitting was set at 5m except when encountered with hard rock or ground water. In case of encountering with ground water, test pit was digged up to further 1 m depth from ground water level.

Two packages of each 80 kg. disturbed samples were taken from each test pit for soil materials at the depth of 2 m and 5 m in principle. One mixed sample of 80 kg. was taken from each test pit for aggregates.

All the test pits were logged, colour-photographed, and finally backfilled with excavated materials after inspection.

(2) Field density test

The field density tests were performed for the SPT samples of the type-B drill holes at each 1m depth.

1.4.3 Laboratory Test

(1) Soil Test

Laboratory soil tests were performed for mainly construction dike materials and partly for soil foundations, in accordance with the following American Society for Testing and Materials (ASTM) standard.

<u>Index property tests</u>

. <u>Moisture Content</u> : ASTM D 2216
. <u>Specific Gravity</u> : ASTM D 854
. <u>Atterberg's Limit</u> : ASTM D 423,424
. <u>Gradation analysis</u> : ASTM D 422

Sieving procedure was used for particle sizes larger than 0.074 mm (retained on the No. 200 sieve), while the hydrometer test was used for the particles passing No. 200 sieve.

<u>Mechanical property tests</u>

. <u>Proctor Compaction Test</u> : ASTM D 1557

The materials to be succeedingly compacted was wetted gradually from natural moisture condition.

. Permeability Test : ASTM D 2434 or Earth Manual E-13

The permeability test was performed by the falling-head method on the samples compacted in 95% of the maximum dry density (MDD) within the range of 2% of the optimum moisture content (OMC).

. Unconfined Compression Test : ASTM D 2166

The unconfined compression test was performed on the samples compacted in 95% of the MDD within the range of 2% of the OMC.

. Triaxial Compression Test (UU) : Earth Manual E-17

The triaxial shear test (UU) with pore pressure measurement was performed on the undisturbed sample taken by the thin-wall sampler. UU means unconsolidated and undrained.

. Consolidation Test : ASTM D 2435

The consolidation test was performed on the samples compacted in 95% of the MDD within the range of 2% of the OMC, and on the undisturbed samples taken by thin-wall sampler.

(2) Concrete aggregate tests

Laboratory tests on concrete aggregates were performed in accordance with the following ASTM standard.

Specific Gravity and Absorption of Sand	:	ASTM C 128
Specific Gravity and Absorption of Gravel	:	ASTM C 127
Gradation Analysis	:	ASTM C 136
Organic Impurity	:	ASTM C 40
Soundness of Sand/Gravel	:	ASTM C 88

2. SOIL FOUNDATION ANALYSIS

2.1 Drilling Logs

2.1.1 Drill Logs Done in May - July, 1990

Agno River (AG-1 -- AG-29)

Twenty-nine core drillings were performed in the feasibility study area of the Agno River Basin in the period, May-July, 1990. The results of Core drillings are summarized in the form of geological logs shown in Fig. 2.1 (1/4)-(2/4). Detailed geological logs of each core drilling are attached in Appendix.

Allied River (AL-1 -- AL-26)

Twenty-six core drillings were performed in the feasibility study area of the Allied river basin. The results of core drillings are summarized as geological logs shown in Fig. 2.1 (3/4) - (4/4) Detailed geological logs of each core drilling are attached in Appendix.

2.1.2 Drill Logs Done in December, 1990 - January, 1991

Twenty core drillings were performed in the Agno River basin (UA1-UA4, MA1-MA10) and Dagupan City (DG1-DG6). The results of core drillings are summarized as geological logs shown in Fig. 2.2 (1/2).

2.1.3 Drill Logs Done in May-June, 1991

Six core drillings were performed in Dagupan City (DG7-DG11) and the Middle Agno River Basin (MA11). The results of core drillings are summarized as geological logs shown in Fig. 2.2 (2/2).

2.2 Geological Profile and Cross Section

(1) Dike and Other River Structures

Agno River

The geological profiles along the dike of the Agno River are shown in Fig. 2.3 (1/3)-(3/3). The geological cross sections of Agno River and Poponto Floodway are shown in Fig. 2.4 (1/12)-(12/12). Locations of the cross sections are shown in Fig. 1.1 (1/13)-(7/13) hereinbefore.

Allied River

The geological profiles along the Pantal River and the Sinocalan River are shown in Fig. 2.5 (1/5)-(5/5). The geological cross sections are shown in Fig. 2.6 (1/6) - (6/6). Locations of the cross sections are shown in Fig. 1.1 (8/13) hereinbefore.

(2) Bridge

The geological cross sections of bridges are shown in Fig. 2.7 (1/6)-(6/6). (See Table 1.1 & Fig. 1.1)

2.3 Problem and Design Value of Soil Foundation

2.3.1 Soil Foundation of Dike and River Structures

Geotechnical conditions of soil foundation for dikes are assessed hereunder for each division of river stretch respectively, and summarized as Table 2.1.

The relative density and consistency of the foundation soils are assessed based on the following criteria:

Sand (Peck, Meyerhof)

Classification	N-Value
Very loose	0 - 4
Loose	4 - 10
Medium dense	10 - 30
Dense	30 - 50
Very dense	>50

Clay (Terzaghi)

Classification	N-Value
Very soft	0 - 2
Soft	2 - 4
Medium stiff	4 - 8
Stiff	8 - 15
Very stiff	15 - 30
Hard	>30

(1) Drill Hole Nos. AG 1 - AG 9 (Upper Agno River, Dike of right bank; Station No. AG473-AG408)

The area of the upstream is underlain by mainly gravel and sand mixtures in the lower layer and partly silty soil in the upper layer with 2 to 4 meters thick.

Bearing Capacity, Settlement and Liquefaction

The consistency of silty soil shows medium stiff to stiff (N-value is almost more than 8) and the relative density of gravel shows medium dense to very dense. Therefore, no major bearing capacity, settlement and liquefaction problems will be expected in this area.

Permeation

Permeation problem is expected to occur at the dike resting on the permeable foundation, such as the existing river bed and the old river channel. The dike in this area repeated breaches many times because of seepage through gravel foundation. The sheet piling and slope protection are considered to be one of effective countermeasures for seepage for the area lower than station No. AG460. These countermeasures will be required at following areas:

- River Station No. AG 468 - AG 461
- River Station No. AG 456 - AG 418
- River Station No. AG 415 - AG 413

In the upstream from AG460 sheet piling may not be applicable because of existence of boulders.

(2) Drill Hole Nos. AG9- AG25 (Agno River, Dike of right bank; Station No. AG408-AG281)

This area is underlain by sand and clayey soil (silt to clay) alternately by physiographical conditions. Grain size of soil seems to have a tendency to decrease from the upstream to the downstream.

Bearing Capacity

The relative density of the upper sand layer is partly loose and the N-value of this loose sand is expected to be 5. The consistency of clayey soil is expected to be medium stiff to stiff except AG22 site. AG22 site is underlain by soft clayey soil because of closing area of the river bed, but no soft clayey soil is expected along the dike of right bank.

Settlement

The loose sand layer will not be a major problem of settlement, because sand layer can be settled easily during construction.

Permeation and Liquefaction

Permeation and liquefaction problems may occur in the sand layer area. Sheet piling is considered to be one of effective countermeasures for permeation and liquefaciton. Sheet piling is recommended at following areas:

- . River Station No. AG 406 - AG 368
- . River Station No. AG 353 - AG 350
- . River Station No. AG 347 - AG 341
- . River Station No. AG 321 - AG 309
- . River Station No. AG 306 - AG 303

(3) Drill Hole Nos. MA1 - AG24 (Agno River, Dike of left bank;
Station No. AG407-AG285)

This area is also underlain by sand and clayey soil (silt to clay) alternately by physiographical conditions.

Bearing Capacity

The area of downstream side of Carmen bridge is partly underlain by loose sand in the upper soil layer. The N-value of this loose sand is expected more than 5. The consistency of clayey soil layer is expected to be medium stiff to stiff.

Permeation and Liquefaction

Permeation and liquefaction problem may occur in the following sand layer areas:

- . River Station No. AG 413 - AG 406
- . River Station No. AG 341 - AG 333
- . River Station No. AG 330 - AG 322

Settlement

The loose sand layer will not cause major problem of settlement because of immediate settlement during dike construction.

(4) Drill Hole Nos. AG26 - AG29 (Poponto Floodway;
Station No. AG308-FW310)

This area is mainly underlain by clayey soil and partly sandy soil.

Bearing Capacity

Some area is underlain by very loose sandy soil in the upper layer (AG26 & & AG29). The N-value of this soil is expected only 3. The N-value of clayey soil at upper layer is expected more than 4. There is no any bearing layer at AG26 point.

Permeation and Liquefaction

Chance of permeation and liquefaction problem are expected to be low in this area.

Settlement

Some area is underlain by very soft to soft clayey soil at 3-5m depth and more than 12m depth. The N-value of this layer is expected 2 to 3, therefore some settlement is expected to occur.

(5) Drill Hole Nos. AG 19.20.21, MA11 (Agno River, Proposed weir site; Station No. AG305 & AG306)

The vicinity of the proposed weir site, the western area of Alcala (river station No. AG303 - AG322), is presumed to be underlain by alluvial deposit and recent river deposit. The recent river deposit is composed of fine to coarse sand, the relative density of which varies widely from loose to dense. The N-value of loose sand at the drill hole No. AG20, is expected only 7 or 8 (minimum N-value is 5). Its permeability is also high. On the other hand, the N-value of river deposit at the drill hole No. MA11, shows 20 to 35 approximately. This recent river deposit is assumed to be of about 20m thick.

The alluvial deposit is composed of fine to medium sand, the N-value of which shows more than 30. This alluvial deposit is assumed to exist under about 20m depth.

For the concrete structures pile foundations which reach to the alluvial deposit are required because the recent river deposit has not sufficient bearing capacity. Permeation measures will be required for the foundation of dikes and structures in this area.

(6) Drill Hole Nos. UA1 - UA4 (Upper Agno River, Alternative route for set-back dike; Station No. AG421-AG470)

This area is underlain by mainly gravel and sand mixtures in the lower layer and silty soil in the upper layer with 2 to 3 meters thick. No major problem of bearing capacity, liquefaction and settlement will be expected.

Permeation problem will not be expected to occur in the area covered by silty soil layer, except in the old river channel area near UA4. Sheet piling will be required at this old river channel about 500 m length.

(7) Drill Hole No. AL1 - AL22, DG-11 (Downstream of Sinocalan River)

AL1 is located near the river mouth of the Pantal-Sinocalan River. AL22 is located at about 2 km upstream of Calasiao.

This area is mainly underlain by fine to medium sand with silty soil layer in the upper layer. The lower silty soil layer exists under sand layer in the area from Dagupan City to the river mouth. The very loose sand exist at upper part in the area from AL-2 to AL-21. The N-value of this sand is expected around 2 to 4 (minimum 1 at AL-14 point). Permeation and liquefaction problems will be expected in this area. Sheet piling is considered to be one of effective countermeasures for these problems.

The area of the river mouth (AL-1, DG-11) and east of Calasiao (AL-22), are mainly underlain by medium dense sand. In this area, no major problems will be expected except permeation.

(8) Drill Hole No. AL23 - AL26 (Middle reach of Sinocalan River)

AL23 is located between Calasiao and Santa Barbara. AL26 is located at about 3.5 km upstream of Santa Barbara.

This area is mainly underlain by clayey soil in the upper layer and sand in the lower layer. The N-value of the upper clayey soil layer is expected more than 4. The relative density of the lower sand layer shows partly loose. No major permeation and liquefaction problems will be expected in this area.

(9) Drill Hole Nos. AL3 - AL8 (Dagupan River)

The downstream area (AL3-AL5) of the Dagupan river is underlain by fine to medium sand, and the upstream area (AL6-AL8) is mainly underlain by fine to medium sand with silty sand layer in the upper layer. The relative density of the silty sand show very loose to loose, and the N-value of these layer is expected only 2. Very soft silt layer exist at AL-6 point, therefore, some settlement problem will be expected in this area. Potential permeation and liquefaction problems will be high in the downstream area.

(10) Drill Hole Nos. AL17 - AL20 (Ingalera River)

This area is underlain by clayey soil of very soft to soft consistency, and fine to medium sand of very loose to loose relative density. Some problems of bearing capacity and settlements will be expected in the case of dike construction.

(11) Drill Hole Nos. DG8 - DG9 (Allied River, Proposed By-pass)

DG8 and DG9 are located at about 4 km southwest of Dagupan City, along the proposed By-pass between the Sinocalan river and the Dagupan river.

The vicinity of the proposed By-pass is underlain by alluvial deposit composed of clayey soil and fine sand. The clayey soil is divided into two layers; the upper layer of 0-3 m depth and the lower layer below 20m depth. The upper clay layer is composed of sandy silt and silty clay. The N-value of silt shows 11 to 13, and that of clay shows mainly 0 to 3 (maximum N-value is 11). The lower part (1.7 - 3.0 m) of the upper clay layer includes some organic materials.

The lower clay layer ascertained by the drill hole No. DG9, is composed of silty clay and sandy clay. This lower clay layer is very stiff, N-value of which shows more than 16.

The middle layer is mainly composed of fine sand, depth of which is 3 to 20 m approximately. The N-value of fine sand shows more than 20.

As an embankment foundation some problems of bearing capacity and settlement is expected in this area because the lower part of the upper clay layer is very soft. Replacement with good soil materials or pre-loading are recommended as one of effective countermeasures. Furthermore, excavation of the By-pass involves some difficulty in operation of heavy construction equipment due to very soft to soft clay with some organic materials.

(12) Drill Hole No. DG10 (Dupo River)

DG10 is located at the left bank of the downstream of the Dupo river. This area is underlain by fine sand with a thin clay layer. The relative density of the fine sand is mainly medium dense to dense (N; Over 20), but partly very loose to loose (N;3-8) at the part above the thin clay layer.

The thin clay layer exists at around 7-8.5m depth. This layer is composed of sandy clay and silty clay, the N-value of which shows 3-5.

As an embankment foundation minor problems of bearing capacity and settlement is expected. Permeation problem will be expected due to permeable sand material.

2.3.2 Soil Foundation of Bridge

Geotechnical conditions of soil foundation for bridges are summarized as follows (refer to Fig. 2.7 (1/6) - (6/6):

<u>Bearing soil layer</u>

The bearing layers are found at the elevation of the second column of the table below.

Boring No.	Elevation of Bearing Layer Surface	Soil Type	Expected N-Value of the Bearing Layer	Remarks
AG-13	+ 14.0 m	Sand	30	Carmen Bridge Right Bank
AG-14	+ 10.0 m	Sand	10	Carmen Bridge Left Bank
AL-6	- 2.5 m	Sand	20	Manat Bridge
AL-9	- 3.5 m	Sand	20	
AL-10	- 5.0 m	Sand	30	

Boring No.	Elevation of Bearing Layer Surface	Soil Type	Expected N-Value of the Bearing Layer	Remarks
AL-11	- 6.5 m	Sand	20	Quintos Bridge
AL-12	- 5.0 m	Sand	20	Magsaysay Bridge
AL-15	- 5.5 m	Sand	15	
AL-17	- 3.5 m	Sand	9	
AL-19	- 8.5 m	Sand	20	
AL-20	+ 1.5 m	Clay	4	
	- 11.5 m	Sand	19	
AL-21	- 2.5 m	Sand	20	
	- 4.5 m	Sand	35	
AL-24	- 1.2 m	Sand	40	
DG-7	- 4.5 m	Sand	19	

2.4 Results of Laboratory Tests

(1) Original Work

Result of laboratory tests on thin wall sampling are as follows:

Triaxial Compression Test

Bor. No.	Depth		C
AG - 29	2.45 - 2.95 m	6.5^{o}	0.34 kg/cm^2

Consolidation Test

Bor. No.	Depth	Cc	Pc
AG - 26	2.57 - 2.95 m	0.319	0.67 kg/cm^2
AG - 29	2.45 - 2.95 m	0.368	3.10 kg/cm^2

(2) Additional Work in FY 1990.

Result of laboratory tests on additional work in FY 1990 are shown in Table 2.2 (1/3) - (3/3). These results are used for liquefaction analysis.

(3) Additional Work in FY 1991.

Results of laboratory tests on additional work in FY 1991 are shown in Table 2.3 (1/3) - (3/3). These results are used for seismic resistance analysis.

3. EVALUATION FOR EXISTING DIKE

3.1 Existing dike materials

The core drilling result shows that soil materials of the existing dikes are composed of silty soil, such as sandy silt to clayey silt. The existing dike materials of the dike of the Agno River, in the upstream of Asingan, are assessed to be not insitu materials but surface silty materials of alluvium in the vicinity. The existing dike materials of the middle Agno River, in the downstream from Asingan are assessed to be insitu materials.

The quality of the existing dike materials itself are classified in the range between good and available under the criteria stipulated in Section 4.2.2.

3.2 Cause of Dike Failure

The dike failure in the upper Agno River is considered to be caused by mainly water seepage and piping action of soil foundation, and partly scour of dike slope by flood flow. Therefore, if some countermeasures against water seepage and scour were applied, breach of dikes might be prevented. Sheet piling is considered to be one of effective countermeasures against foundation seepage. Some slope protection measures will be required for the riverside dike slope against scouring by flood flow. The areas which necessitate foundation treatment against seepage are identified in Section 2.3.1.

4. CONSTRUCTION MATERIAL SOURCES

4.1 Test Pitting and Laboratory Tests

4.1.1 Test Pit

Ten dike material sites and ten concrete aggregate sites were identified as shown in Fig.4.1 by site inspection from physiographical and geological viewpoints. Forty test pits (i.e., two test pits for each site) were performed and samples were taken for laboratory tests (see Fig.1.1).

The locations of these sites are listed below.

<u>Identified Dike Material Sources</u>

Dike Material Location No.	Location	Remarks
TS 1	3.5 km north of San Manuel	For Agno, Borrow (Terrus)
TS 2	3.5 Km southeast of Rosales	For Agno, Borrow (Hill)
TS 3	2 km south of Alcala	For Agno, Borrow (Swamp)
TS 4	3.5 km southwest of Alcala	For Agno, Floodway
TS 5	2 km southeast of Manambong	For Agno, Floodway
TS 6	1.5 km northwest of Calasiao	For Allied, Channel
TS 7	2.5 km south of Calasiao	For Allied, Channel
TS 8	3 km south of St. Barbara	For Allied, Borrow (Plain)
TS 9	6 km west of Villasis	For Agno, Borrow (Hill)
TS10	4 km east of San Jacinto	For Allied, Borrow (Hill)

Identified Concrete Aggregate Sources

Aggregates Location No.	Location	Remarks
TA 1	2 km northeast of San Roque	For Agno, River bank
TA 2	5.5 km east-northeast of Asingan	For Agno, River bed
TA 3	5 km southwest of Asingan	For Agno, River bed
TA 4	0.5 km northeast of Carmen	For Agno, River bed
TA 5	5 km west-southwest of Villasis	For Agno, River bed
TA 6	3 km west of Alcala	For Agno, River bed (Weir)
TA 7	1.5 km north of San Jacinto	For Allied, River bed
TA 8	0.5 km northeast of Mapandang	For Allied, River bed
TA 9	1.5 km east of Manaoag	For Allied, River bed
TA 10	6 km east-northeast of Manaoag	For Allied, River bed

The results of test pittings for dike materials and concrete aggregates are summarized in the form of pit logs as shown in Fig. 4.2 and Fig. 4.3 respectively. The detailed test pit logs are attached in Appendix.

4.1.2 Laboratory Tests

(1) Laboratory tests for dike materials

Results of laboratory tests for dike materials are summarized in Table 4.1 (1/3)-(3/3).

(2) Laboratory test for concrete aggregates

Results of laboratory tests for concrete aggregates are summarized in Table 4.2 (1/2)-(2/2). Five samples out of twenty samples were classified as soil samples.

4.2 Selection of Construction Material Sources

4.2.1 Evaluation Criteria for Construction Materials

(1) Dike Materials

The dike materials shall fulfill the following quality requirements:

- Soil materials shall be impervious.
- Grain size distribution shall be fallen within the range shown in Fig. 4.4.
- Coefficient of permeability shall be less than 1×10^{-5} cm/sec.
- Plasticity index should be relatively large value.
- Organic materials shall not be included in principle.
- The natural moisture content shall be around OMC; preferably dry side of OMC

(2) Concrete aggregates

The concrete aggregates shall fulfill the following quality requirements:

- Specific gravity shall be larger than 2.5 for fine aggregate and larger than 2.6 for coarse aggregate.
- Absorption index shall be less than 3.0%.
- Loss value on soundness test shall be less than 10% for fine aggregate and less than 12% for coarse aggregate.
- Any organic materials shall not be included.

4.2.2 Selection of Construction Material Sources

(1) Evaluation of construction materials

Construction materials sources are evaluated by the foregoing criteria using the four kind of evaluation rank. The results of evaluation of dike materials and aggregates are shown in Table 4.3 and Table 4.4 respectively and summarized below.

Dike materials (refer to Table 4.3)

- Excellent soil materials : TS1, TS9, TS10
- Good soil materials : TS2, TS8
- Available soil materials : TS4, TS6, TS7

Aggregate materials (refer to Table 4.4)

- Good aggregates : TA7, TA10
- Available aggregates : TA1, TA2, TA4, TA9

(2) Selected construction materials sites

Selected material sites for dike materials and concrete aggregates are shown in Fig. 4.6 (1/7) - (7/7). Description of the selected sources of dike materials and concrete aggregates are shown in Table 4.5 and Table 4.6, and are summarized below respectively.

Dike Material Sources

Site No	Proposed Area (km^2)	Excavation Depth (m)	Potential Quantity ($x10^6 m^3$)
TS 1	0.55	2.0	1.1
TS 2	1.5	2.0	3.0
TS 4	0.5	2.0	1.0
TS 8	2.5	1.0	2.5
TS 9	1.2	2.5	3.0
TS 10	1.5	1.2	1.8
Total	-	-	12.4

Concrete Aggregates

Site No.	Proposed Area (km^2)	Excavation Depth (m)	Source	Volume ($x10^6$ m^3)
TA 1	0.4	2.0	Fine	0.04
			Coarse	0.5
TA 2	0.5	1.0	Fine	0.02
			Coarse	0.3
TA 4	0.7	2.0	Fine	0.7
TA 7	1.1	1.5	Fine	0.08
			Coarse	0.8
TA 9	0.15	2.0	Fine	0.24
TA 10	0.25	1.0	Fine	0.03
			Coarse	0.1
Total	-	-	Fine	1.11
			Coarse	1.7

TS6 and TS7 sites are not selected because of their limited amount in the cut-off channel. Excavation depth and aggregate volume are possible depth and possible volume from physiographical and geological viewpoint.

4.2.3 Presumed Soil Materials Along The Rivers

Soil materials along the Agno River and the Pantal-Sinocalan River are presumed from geological survey and physiographical viewpoint as shown in Fig 4.7 (1/9) - (9/9) . These maps show presumed soil classification of the river bed materials in the area within about 100 meters width of riverside along the Agno River, and in the area within about 50 meters width along the Allied rivers.

TABLES

TABLE 1.1 (1/4) DETAILED QUANTITY OF CORE DRILLING (AGNO RIVER)

Bor. No.	Thickness (m) Soil (Sand/Clay)	Sand/ Gravel	Rock	Total Depth (m)	SPT (Times)	Remarks
AG - 1	0.26	-	14.74	15.00	0	for Dike
AG - 2	6.85	1.00	7.15	15.00	4	for Dike (DM)(1)
AG - 3	2.00	2.48	10.52	15.00	3	for Dike
AG - 4	4.00	-	11.00	15.00	3	for Dike (DM)
AG - 5	-	5.00	10.00	15.00	4	for Dike
AG - 6	7.00	8.00	-	15.00	8	for Dike (DM)
AG - 7	7.00	8.00	-	15.00	8	for Dike (DM)
AG - 8	5.00	10.00	-	15.00	8	for Dike (DM)
AG - 9	2.15	12.85	-	15.00	8	for Dike
AG - 10	11.80	3.20	-	15.00	8	for Bridge/River Structure
AG - 11	2.00	13.00	-	15.00	8	for Dike
AG - 12	15.00	-	-	15.00	8	for Dike
AG - 13	15.00	-	-	15.00	8	for Bridge (Carmen)/Dike
AG - 14	15.00	-	-	15.00	8	for Bridge (Carmen)/Dike
AG - 15	14.85	0.15	-	15.00	8	for Dike (DM)
AG - 16	15.00	-	-	15.00	8	for Dike (DM)
AG - 17	15.00	-	-	15.00	8	for Dike
AG - 18	15.00	-	-	15.00	8	for Dike
AG - 19	15.00	-	-	15.00	8	for Dike/Weir
AG - 20	9.10	5.90	-	15.00	8	for Weir
AG - 21	15.00	-	-	15.00	8	for Dike/Weir (DM)
AG - 22	15.00	-	-	15.00	8	for Excavation
AG - 23	15.00	-	-	15.00	8	for Excavation
AG - 24	15.00	-	-	15.00	8	for Dike
AG - 25	15.00	-	-	15.00	8	for Dike
AG - 26	15.00	-	-	15.00	7	for Floodway/Pier UDS(2):1 Sample
AG - 27	15.00	-	-	15.00	8	for Dike of Floodway
AG - 28	15.00	-	-	15.00	8	for Dike of Floodway (DM)
AG - 29	15.00	-	-	15.00	7	for Dike of Floodway UDS:1 Sample
Nos. 29	312.01	69.58	53.41	435.00	204	[Sub - Total]

(1) DM: Include Dike Material
(2) UDS: Undisturbed Sampling

TABLE 1.1 (2/4) DETAILED QUANTITY OF CORE DRILLING (ALLIED RIVER)

Bor. No.	Thickness (m) Soil (Sand/Clay)	Sand/ Gravel	Rock	Total Depth (m)	SPT (Times)	Remarks
AL - 1	15.00	-	-	15.00	8	for Dike
AL - 2	15.00	-	-	15.00	8	for Dike
AL - 3	-	15.00	-	15.00	8	for Dike
AL - 4	15.00	-	-	15.00	8	for Dike
AL - 5	15.00	-	-	15.00	8	for Dike/River Structure
AL - 6	15.00	-	-	15.00	8	for Bridge/River Structure
AL - 7	15.00	-	-	15.00	8	for Dike/River Structure
AL - 8	15.00	-	-	15.00	8	for River Structure
AL - 9	15.00	-	-	15.00	8	for Bridge
AL - 10	15.00	-	-	15.00	8	for Bridge
AL - 11	11.50	3.50	-	15.00	8	for Bridge (Quintos)
AL - 12	15.00	-	-	15.00	8	for Bridge (Magsaysay)
AL - 13	15.00	-	-	15.00	8	for Dike/River Structure
AL - 14	14.50	0.5	-	15.00	8	for Dike/Cut-off Channel
AL - 15	15.00	-	-	15.00	8	for Bridge
AL - 16	15.00	-	-	15.00	8	for Cut-off Channel
AL - 17	15.00	-	-	15.00	8	for Bridge
AL - 18	15.00	-	-	15.00	8	for Dike
AL - 19	15.00	-	-	15.00	8	for Bridge
AL - 20	15.00	-	-	15.00	8	for Bridge
AL - 21	15.00	2.5	-	15.00	8	for Bridge
AL - 22	15.00	-	-	15.00	8	for Dike
AL - 23	15.00	-	-	15.00	8	for Dike/River Structure
AL - 24	15.00	-	-	15.00	8	for Bridge
AL - 25	15.00	-	-	15.00	8	for Weir
AG - 26	15.00	-	-	15.00	8	for River Structure
Nos. 26	368.50	21.50	-	390.00	208	[Sub - Total]
Nos. 55	680.51	91.08	53.41	825.00	412	[Total]

Table 1.1 (3/4) QUANTITIES OF ADDITIONAL CORE DRILLING (FY 1990)

Bor. No.	Soil (Sand/Clay)	Sand & Gravel	Sub-Total	S.P.T.	Sampling	LABORATORY TEST MC	SG	GD	AL
UA 1	3.30	11.70	15.00	3	-	-	-	-	-
UA 2	4.25	10.75	15.00	3	-	-	-	-	-
UA 3	7.35	7.65	15.00	5	-	-	-	-	-
UA 4	4.00	11.00	15.00	3	-	-	-	-	-
MA 1	13.00	2.00	15.00	8	-	-	-	-	-
MA 2	10.00	10.00	20.00	7	3	3	3	10	5
MA 3	15.00	-	15.00	8	-	-	-	-	-
MA 4	15.00	-	15.00	8	-	-	-	6	-
MA 5	20.00	-	20.00	15	4	4	4	10	4
MA 6	20.00	-	20.00	16	4	4	4	10	6
MA 7	13.00	2.00	15.00	7	-	-	-	-	-
MA 8	15.00	-	15.00	8	-	-	-	-	-
MA 9	15.00	-	15.00	8	-	-	-	-	-
MA 10	15.00	-	15.00	8	-	-	-	-	-
DG 1	20.00	-	20.00	15	5	5	5	12	7
DG 2	15.00	-	15.00	8	-	-	-	-	-
DG 3	20.00	-	20.00	15	5	5	5	13	8
DG 4	15.00	-	15.00	8	-	-	-	-	-
DG 5	16.00	4.00	20.00	17	3	3	3	11	9
DG 6	13.55	1.45	15.00	8	-	-	-	-	-
Total	269.45	60.55	330.00	178	24	24	24	72	39

Table 1.1 (4/4) QUANTITIES OF ADDITIONAL CORE DRILLING (FY 1991)

Bor. No.	Soil (Sand/Clay)	Sand & Gravel	Sub-Total	S.P.T.	Sampling	LABORATORY TEST MC	SG	GD1	GD2
DG 7	19.45	0.55	20.00	17	4	4	4	4	-
DG 8	20.00	-	20.00	17	4	4	4	4	-
DG 9	30.00	-	30.00	25	6	6	6	6	3
DG 10	19.00	1.00	20.00	17	4	4	4	4	-
DG 11	30.00	-	30.00	25	6	6	6	6	1
MA 11	30.00	-	30.00	25	6	6	6	6	-
Total	148.45	1.55	150.00	126	30	30	30	30	4

TABLE 1.2 QUANTITIES OF SAMPLING AND LABORATORY TESTS DONE IN MAY - JUNE, 1990

ITEM	UNIT	QUANTITY
1. Sampling for Soil Tests		
(1) Test Pit	Nos.	20
(2) Disturbed Sample	Nos.	40
2. Laboratory Test for Soils		
(1) Moisture Content	Nos.	64
(2) Specific Gravity	Nos.	69
(3) Atterberg's Limit	Nos.	49
(4) Gradation	Nos.	64
(5) Proctor Compaction	Nos.	44
(6) Permeability (clay)	Nos.	27
(7) Unconfined Compression	Nos.	21
(8) Consolidation	Nos.	19
3. Sampling for Aggregate Tests		
(1) Test Pit	Nos.	20
(2) Disturbed Sample	Nos.	20
4. Laboratory Test for Aggregates		
(1) Specific Gravity	Nos.	25
(2) Absorption	Nos.	25
(3) Grain Size Analysis for Coarse Aggregates	Nos.	9
(4) Grain Size Analysis for Fine Aggregates	Nos.	16
(5) Organic Content	Nos.	16
(6) Soundness	Nos.	25

Table 2.1 PROBLEMS AND DESIGN VALUE OF SOIL FOUNDATION

Area	Soil Foundation	Problems	Required Countermeasure	Expected Design Value
AG 1 - AG 9 (Agno R. Right bank)	. Gravel and sand mixture mainly dense to very dense . Silty soil in upper layer of 2-4 m thick: medium stiff	. No major problems of bearing capacity, settlement and liquefaction . Permeation problem of gravel	. Sheet piling . Slope protection for dike . Area (River Section No.) AG 468 - AG 461 AG 456 - AG 418 AG 415 - AG 412	. N -value of silty soil: > 8 . N -value of Gravel: > 30 . High coefficient permeability of gravel: 1 x 10 - 10 cm/sec
AG 9 - AG 25 (Agno R. Right bank)	. Sand: partly loose at upper layer . Clayey soil : medium stiff to stiff	. No major problem of bearing capacity, and settlement . Liquefaction and permeation of loose sand	. Sheet piling, Counterweight fill . Area (River Section No.) AG 406 - AG 368 AG 353 - AG 350 AG 347 - AG 341 AG 321 - AG 309 AG 306 - AG 303	. N -value of loose sand: 5 . N-value of silty soil : > 5
MA 1 - AG 24 (Agno R. Left bank)	. Sand: partly loose at upper layer . Clayey soil : medium stiff to stiff	. No major problem of bearing capacity and settlement . Permeation and liquefaction of loose sand	. Sheet piling, Counterweight fill . Area (River Section No.) AG 413 - AG 406 AG 341 - AG 333 AG 330 - AG 322	. N-value of loose sand: 5 . N-value of silty soil: > 5
AG 26 - AG 29 (Poponto Flood Way)	. Clayey soil mainly: partly very soft to soft . Sand soil partly : very loose at AG 26 and AG 29	. No bearing layer at AG 26 . No permeation and liquefaction problem . Settlement problem in very soft to soft clayey soil area.	. Additionel core drilling to identify bearing layer (at AG-26) at D.D. stage	. N-value of loose sand: 3 . N-value of clayey soil: > 4 . N-value of very soft clayey soil: 2
AG 19.20.21, MA 11 (Agno R. Proposed Weir Site)	. River deposits : loose fine to coarse sand partially	. Major problem of bearing capacity partly . Permeation problem	. Weir should be designed carefully . Additional core drillings to identify bearing layer at D.D. stage	. N-value of river deposit: 5 to 25
UA 1 - UA 4 (Upper Agno R. Proposed sec - back dike)	. Gravel and sand mixture mainly : medium dense to very dense . Silty soil in upper layer of 2 - 3 m thick: medium stiff	. No Major problem of bearing capacity, settlement and liquefaction . Minor permeation problem of gravel	. Sheet piling at old river channel near UA 4	. N-value of gravel: > 10 mostly > 30 . N-value of silty soil: > 5
AL 1 - AL 22, DG 11 (Downstream of Sinocalan R.)	. Fine to medium sand mainly: very loose to dense . Minor silty soil in upper layer: medium stiff	. Major problem of bearing capacity, permeation and liquefaction	. Sheet piling, Counterweight fill	. N-value of loose sand: 2 to 4 . N-value of silty soil: > 6
AL 23 - AL 26 (Middlestream of Sinocalan R.)	. Clayey soil mainly in upper layer: soft to medium stiff . Sand in lower layer: loose to dense	. No major problem of bearing capacity, permeation, settlement and liquefaction		. N-value of clayey soil: > 4
AL 3 - AL 8 (Dagupan R.)	. Fine to medium sand mainly: loose to dense . Silty sand partly in upper layer: very loose to loose	. Major problem of bearing capacity, permeation and liquefaction	. Sheet piling, Counterweight fill	. N-value of silty sand: 2
AL 17 - AL 20 (Ingaiera R.)	. Clayey soil: very soft to soft . Fine to medium sand: very loose to dense	. Some problem of bearing capacity and settlement . No permeation problem		. N-value of clayey soil: 2 to 4 . N-value of loose sand : 3 to 4
DG 8 - DG 9 (Allied R. Proposed By-pass)	. Clay in upper layer: very soft to soft . Sand in middle layer: medium dense to dense . Clay in lower layer: stiff to hard	. Some problem of bearing capacity and settlement . Some traficability problem		. N-value of upper clay: 0 to 3 . N-value of sand: > 20
DG 10 (Dupo R.)	. Fine sand mainly: medium dense to dense, loose partially . Thin clay layer: soft to medium stiff	. Some permeation problem		. N-value of sand: > 20, (partially 3 to 8)

TABLE 2.2 (1/3) RESULT OF SOIL TESTS (ADDITIONAL WORK IN FY 1990)

LOCATION NUMBER	SAMPLE NUMBER	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	MOISTURE CONTENT	SPECIFIC GRAVITY	ATTERBERG LIMIT LL	PL	PI	SIEVE ANALYSIS % PASSING 63.5 mm.	52.8 mm.	38.1 mm.	25.4 mm.	19.1 mm.	12.7 mm.	9.52 mm.	4.75 mm.	2.38 mm.	2.00 mm.	1.19 mm.	0.53 mm.	0.42 mm.	0.297 mm.	0.149 mm.	0.074 mm.
DG-1	CS-1	2.0 - 3.0	GRAY, SILTY SAND	SM	28.04	2.646		NP											100	99	99	98	82	46	15
	CS-2	4.0 - 5.0	GRAY, SILTY SAND	SM	37.15	2.636		NP											100	99	98	97	88	46	21
	CS-3	7.0 - 8.0	GRAY, SILTY SAND	SM	24.35	2.684		NP													100	99	90	33	22
	CS-4	12.0 - 13.0	DARK GRAY, POORLY GRADED SAND	SP	20.18	2.690		NP												100	99	97	91	73	11
	CS-5	16.0 - 17.0	DARK GRAY, SILTY SAND	SM	19.60	2.770		NP																	
DG-3	CS-1	2.0 - 3.0	BROWN, SILTY SAND	SM	26.85	2.762		NP											100	99	97	94	76	33	16
	CS-2	4.0 - 5.0	BROWN, SILTY SAND	SM	21.60	2.588		NP											100	99	99	96	76	36	25
	CS-3	6.0 - 7.0	BROWN, SILTY SAND	SM	23.68	2.786		NP														100	96	34	23
	CS-4	11.0 - 12.0	BROWN, SILTY SAND	SP	26.05	2.602		NP												100	99	99	82	15	4
	CS-5	16.0 - 17.0	GRAY, SILTY SAND	SM	25.26	2.783		NP										100	98	95	87	84	82	36	21
DG-5	CS-1	4.0 - 5.0	LIGHT BROWN, SILTY SAND	SM	18.31	2.636		NP								100	99	97	97	96	95	94	82	29	15
	CS-2	9.0 - 10.0	DARK GRAY, SILTY SAND	SM	11.20	2.750		NP											100	98	85	85	83	40	18
	CS-3	12.0 - 13.0	GRAY, CLAYEY SILT	MH	44.20	2.557	52	3	15													100			80
MA-2	CS-1	6.0 - 7.0	BROWN, CLAYEY SAND	SC	29.40	2.692	32	2	10										100	100	100	100	99	72	28
	CS-2	8.0 - 9.0	BROWN, POORLY GRADED SAND W/ SILT	SP-SM	15.80	2.586		NP													100	99	69	61	12
	CS-3	12.0 - 13.0	GRAYISH BROWN, POORLY GRADED SAND	SP	18.55	2.663		NP		98	96	96	89	83	79	70	41		30			23		14	2
MA-5	CS-1	2.0 - 3.0	BROWN, SILTY SAND	SM	8.70	2.769		NP												100	99	96	78	28	18
	CS-2	6.0 - 7.0	GRAY, SILTY SAND	SM	20.90	2.699		NP					100	93	88	88	88	88	88	87	83	77	60	28	16
	CS-3	11.0 - 12.0	GRAY, SILTY SAND	SM	11.40	2.684		NP									100	98	98	90	82	80	66	20	17
	CS-4	16.0 - 17.0	GRAY, POORLY GRADED SAND W/ SILT	SP	21.50	2.706		NP								100	99	98	98	98	97	96	86	72	12
MA-6	CS-1	2.0 - 3.0	BROWN, SILTY SAND	SM	33.60	2.626		NP														100	99	80	24
	CS-2	5.0 - 6.0	GRAY, POORLY GRADED SAND	SP	26.00	2.553		NP									100	99	98	98	92	87	78	16	6
	CS-3	11.0 - 12.0	BROWNISH GRAY, SILTY SAND	SM	17.80	2.667		NP													100	98	84	29	17
	CS-4	16.0 - 17.0	BROWNISH GRAY, POORLY GRADED SILTY SAND	SP	14.20	2.632		NP									100	99	97	91	76	60	46	20	11

TABLE 2.2 (2/3) RESULT OF SOIL TESTS (ADDITIONAL WORK IN FY 1990)

LOCATION STATION	SAMPLE NUMBER	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	MOISTURE CONTENT	SPECIFIC GRAVITY	ATTERBERG LIMIT LL	PL	PI		SIEVE ANALYSIS % PASSING 63.5 mm.	52.8 mm.	38.1 mm.	25.4 mm.	19.1 mm.	12.7 mm.	9.52 mm.	4.75 mm.	SIEVE ANALYSIS % PASSING 2.38 mm.	2.00 mm.	1.19 mm.	0.53 mm.	0.42 mm.	0.297 mm.	0.149 mm.	0.074 mm.
DG-1	SPT- 1	1.15 - 1.45	BROWN, SILTY CLAY	CH			59	27	32											100			96			88
	SPT- 2	3.15 - 3.45	DARK GRAY, SILTY SAND	SM																		100	99	98	55	26
	SPT- 3	5.15 - 5.45	DARK GRAY, SILTY SAND	SM																100	99	99	97	96	46	21
	SPT- 5	8.15 - 8.45	DARK GRAY, SILTY FINE SAND	SP-SM																			100	98	27	12
	SPT- 7	10.15 - 10.45	DARK GRAY, SILTY SAND	SM															100	99	98	96	90	67	24	14
	SPT-10	14.15 - 14.45	DARK GRAY, SILTY SAND	SM													100	98	98	98	97	95	95	93	75	33
	SPT-14	19.15 - 19.45	DARK GRAY, CLAYEY SILT	ML			34	26	8														100			84
DG-3	SPT- 1	1.15 - 1.45	LIGHT BROWN, SILTY SAND	SM			NP	NP	NP								100	93	90	87	82	65	60	52	41	19
	SPT- 2	3.15 - 3.45	BROWN, SILTY SAND	SM																		100	98	92	66	17
	SPT- 3	5.15 - 5.45	BROWN, SILTY SAND	SM																100	99	98	97	95	45	21
	SPT- 4	7.15 - 7.45	BROWN, SILTY SAND	SM															100	99	99	99	97	87	35	24
	SPT- 5	8.15 - 8.45	BROWN, SILTY SAND	SM																100	97	96	91	89	65	15
	SPT- 9	13.15 - 13.45	BROWN, POORLY GRADED SAND	SP															100	98	92	90	74	70	35	6
	SPT-12	17.15 - 17.45	GRAY, SILTY CLAY	CL			37	20	17														100			93
	SPT-14	19.15 - 19.45	GRAY, SILTY CLAY	CL			29	19	10						100	97							93			86
DG-5	SPT- 1	1.15 - 1.45	DARK GRAY, SILTY SAND W/ GRAVEL	SM			NP	NP	NP					100	74	69	62	59	54	51	49	40	36	32	22	15
	SPT- 2	2.15 - 2.45	DARK GRAY, SILTY SAND	SM			31	24	7						100	98	95	89	66	84	82	76	72	63	41	23
	SPT- 4	5.15 - 5.45	DARK GRAY, SILTY SAND	SM			NP	NP	NP											100	95	90	89	87	25	15
	SPT- 6	7.15 - 7.45	DARK GRAY, POORLY GRADED SAND	SP													100	99	98	97	95	89	75	40	14	9
	SPT- 9	11.15 - 11.45	DARK GRAY, SILTY SAND	SM																100	100	100	99	92	52	18
	SPT-11	14.15 - 14.45	DARK GRAY, CLAYEY SILTY	ML			29	23	6	6										100			99			85
	SPT-13	16.15 - 16.45	DARK GRAY, SILTY CLAY	CL			34	16	18	18										100			99			70
	SPT-16	19.15 - 19.45	DARK GRAY, SILTY CLAY	CL			30	19	11	11										100			99			87
MA-2	SPT- 1	1.15 - 1.45	BROWN, SANDY SILT	ML											100		98	95		84			79			68
	SPT- 2	2.15 - 2.45	BROWN, SANDY SILT	ML			30			5								100		95			86			64
	SPT- 3	3.15 - 3.45	BROWN, SANDY SILT	ML														100		97			89			70
	SPT- 4	4.15 - 4.45	BROWN, SANDY SILT	ML																100			91			72
	SPT- 5	5.15 - 5.45	BROWN, SANDY SILT	ML			41			10										100			98			87
	SPT- 6	7.15 - 7.45	BROWN, SILTY SAND	SM														100	98	97	80	70	66	64	55	26
	SPT- 7	9.15 - 9.45	BROWN, SILTY SAND	SM														100	98	98	91	89	87	86	32	13
MA-4	SPT- 1	1.15 - 1.45	BROWN, SILTY SAND	SM																100			90			22
	SPT- 2	3.15 - 3.45	BROWN, SILTY SAND	SM																100			94			16
	SPT- 3	5.15 - 5.45	GRAY, SILTY SAND	SM																100			89			24
	SPT- 4	7.15 - 7.45	GRAY, SILTY SAND	SM														100		92			88			15
	SPT- 5	10.15 - 10.45	GRAY, SILTY SAND	SM													100	98		86			88			18
	SPT- 8	15.15 - 15.45	GRAY, SILTY SAND	SM													100	94		85			76			13

TABLE 2.2 (3/3) RESULT OF SOIL TESTS (ADDITIONAL WORK IN FY 1990)

LOCATION STATION	SAMPLE NUMBER	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	MOISTURE CONTENT	SPECIFIC GRAVITY	ATTERBERG LIMIT LL	PL	PI	SIEVE ANALYSIS % PASSING 63.5 mm.	52.8 mm.	38.1 mm.	25.4 mm.	19.1 mm.	12.7 mm.	9.52 mm.	SIEVE ANALYSIS % PASSING 4.75 mm.	2.38 mm.	2.00 mm.	1.19 mm.	0.53 mm.	0.42 mm.	0.297 mm.	0.149 mm.	0.074 mm.
MA-5	SPT- 2	3.15 - 4.45	BROWN, SILTY SAND	SM																100	99	96	78	24	21
	SPT- 3	4.15 - 4.45	BROWN, SILTY SAND	SM													100		99			94			19
	SPT- 4	5.15 - 5.45	GRAY, SILTY SAND	SM												100	99	96	92	90	84	83	82	30	13
	SPT- 7	10.15 - 10.45	GRAY, SILTY SAND	SM													100	98	98	85	84	82	82	45	31
	SPT- 9	13.15 - 13.45	GRAY, SILTY SAND	SM												100	99	98	98	97	96	94	77	29	22
	SPT-11	15.15 - 15.45	GRAY, POORLY GRADED SAND	SP													100	98	98	93	91	89	88	30	9
MA-6	SPT- 1	1.15 - 1.45	BROWN, SILTY SAND	SM																		100	99	33	15
	SPT- 2	3.15 - 3.45	GRAY, POORLY GRADED SAND	SP												100			100	98	95	92	91	29	11
	SPT- 3	4.15 - 4.45	GRAY, POORLY GRADED SAND	SP													100	94	94	92	81	77	72	23	8
	SPT- 4	6.15 - 6.45	GRAY, SILTY CLAY	CH			54	25	29								100		96			94			91
	SPT- 5	7.15 - 7.45	GRAY, SILTY CLAY	CH			51	25	26										100			98			97
	SPT- 8	10.15 - 10.45	GRAY, SILTY SAND	SM													100	98	97	90	86	85	85	29	18

TABLE 2.3 (1/3) RESULT OF SOIL TESTS (ADDITIONAL WORK IN FY 1991)

LOCATION STATION	SAMPLE NUMBER	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	MOISTURE CONTENT %	SPECIFIC GRAVITY	SIEVE ANALYSIS															
							63.5 mm.	52.8 mm.	38.1 mm.	25.4 mm.	19.1 mm.	12.7 mm.	9.52 mm.	4.75 mm.	2.38 mm.	2.00 mm.	1.19 mm.	0.53 mm.	0.42 mm.	0.297 mm.	0.149 mm.	0.074 mm.
UA-1	SPT-2	2.15 - 2.45	BROWN SANDY SILT	ML									100	100	99	99	98	96	93	90	80	45
UA-2	SPT-2	2.15 - 2.45	GRAY FINE SAND	SP												100	100	93	59	33	11	6
UA-3	SPT-2	2.15 - 2.45	BROWN TO DARK BROWN GRAVELLY SAND	SP									100	84	80	80	78	72	64	45	23	17
	SPT-3	3.15 - 3.45	BROWN TO DARK BROWN GRAVELLY SAND	SP										100	95	93	92	91	85	43	15	9
	SPT-4	5.15 - 5.45	GRAYISH BROWN FINE TO COARSE SAND	SP									100	88	85	84	82	74	65	43	18	13
UA-4	SPT-1	1.15 - 1.45	LIGHT BROWN SANDY SILT	ML												100	95	84	81	78	41	15
	SPT-2	2.15 - 2.45	GRAY TO DARK GRAY FINE TO COARSE SAND	SP													100	100	99	91	34	19
MA-1	SPT-1	1.15 - 1.45	BROWN SANDY CLAY	CL												100	99	97	96	95	84	65
	SPT-3	3.15 - 3.45	DARK GRAY FINE TO COARSE SAND	SP-SW									100	90	77	73	60	34	25	17	7	3
	SPT-4	5.15 - 5.45	DARK GRAY FINE TO COARSE SAND	SP-SW									100	90	82	80	74	54	37	25	11	7
	SPT-7	12.15 - 12.45	DARK GRAY MEDIUM TO COARSE SAND	SP									100	80	74	73	68	44	26	15	6	4
MA-4	SPT-1	1.15 - 1.45	LIGHT BROWN FINE SAND	SP									100	98	98	97	96	95	93	80	28	18
	SPT-2	2.15 - 2.45	LIGHT BROWN FINE SAND	SP															100	88	32	17
	SPT-3	3.15 - 3.45	LIGHT BROWN FINE SAND	SP													100	100	99	86	31	16
	SPT-4	5.15 - 5.45	BROWNISH GRAY FINE TO MEDIUM SAND	SP												100	99	99	91	64	24	16
	SPT-5	7.15 - 7.45	BROWNISH GRAY FINE TO MEDIUM SAND	SP									100	96	94	93	90	84	69	45	22	17
	SPT-7	12.15 - 12.45	BROWNISH GRAY FINE TO MEDIUM SAND	SP													100	96	66	26	3	2
MA-7	SPT-3	3.15 - 3.45	BROWN SANDY SILT	ML												100	98	97	92	90	89	87
	SPT-3	5.15 - 5.45	BROWN SILTY VERY FINE SAND	SM													100	100	99	99	96	40
	SPT-4	7.15 - 7.45	GRAYISH BROWN MEDIUM SAND	SP											100	99	99	98	95	79	70	35
	SPT-5	10.15 - 10.45	BROWNISH GRAY FINE TO MEDIUM SAND	SP												100	99	90	64	47	27	20
	SPT-7	15.15 - 15.45	BROWNISH GRAY FINE TO MEDIUM SAND	SP													100	95	84	55	19	12
MA-8	SPT-2	2.15 - 2.45	BROWN SILTY FINE SAND	SM												100	100	99	96	90	63	51
	SPT-3	3.15 - 3.45	BROWN SILTY FINE SAND	SM													100	99	98	95	77	62
	SPT-4	5.15 - 5.45	BROWN SANDY SILT	ML													100	100	100	99	96	88
	SPT-5	7.15 - 7.45	BROWN SANDY CLAY	CH												100	100	100	100	100	100	99
MA-9	SPT-3	3.15 - 3.45	BROWN CLAYEY SILT	SM											100	100	99	99	98	98	97	91
	SPT-4	5.15 - 5.45	BROWN CLAYEY SAND	SC												100	99	99	99	98	96	47
	SPT-5	7.15 - 7.45	BROWN TO GRAY SILTY FINE SAND	SM-SP													100	96	84	68	47	34
	SPT-6	10.15 - 10.45	GRAY MEDIUM TO COARSE SAND	SP									100	96	94	93	88	59	40	29	17	12
	SPT-7	12.15 - 12.45	GRAY MEDIUM TO COARSE SAND	SP									100	98	98	98	98	92	72	47	20	13
MA-10	SPT-1	1.15 - 1.45	LIGHT BROWN VERY FINE SAND	SM													100	99	98	97	56	42
	SPT-3	3.15 - 3.45	LIGHT BROWN VERY FINE SAND	SM												100	99	99	99	99	84	48
	SPT-4	5.15 - 5.45	LIGHT BROWN VERY FINE SAND	SM											100	100	99	98	97	96	72	48
	SPT-5	7.15 - 7.45	LIGHT BROWN VERY FINE SAND	SM															100	98	74	45
	SPT-6	10.15 - 10.45	BROWN TO GRAY FINE SAND	SP-SM														100	99	96	54	28
	SPT-8	15.15 - 15.45	BROWN TO GRAY FINE SAND	SP-SM													100	98	92	76	29	20

TABLE 2.3 (2/3) RESULT OF SOIL TESTS (ADDITIONAL WORK IN FY 1991)

LOCATION STATION	SAMPLE NUMBER	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	MOISTURE CONTENT %	SPECIFIC GRAVITY	SIEVE ANALYSIS 63.5 mm.	52.8 mm.	38.1 mm.	25.4 mm.	19.1 mm.	12.7 mm.	9.52 mm.	4.75 mm.	2.38 mm.	2.00 mm.	1.19 mm.	0.53 mm.	0.42 mm.	0.297 mm.	0.149 mm.	0.074 mm.
AG-11	SPT-1	1.15 - 1.45	BROWN SANDY SILT	ML													100	99	99	98	84	68
	SPT-2	2.15 - 2.45	BROWN POORLY GRADED SAND	SP									100	96	95	95	94	77	51	34	23	20
	SPT-3	3.15 - 3.45	BROWN POORLY GRADED SAND	SP												100	98	86	53	48	13	10
	SPT-4	5.15 - 5.45	BROWN POORLY GRADED SAND	SP										100	93	90	75	48	31	24	14	10
	SPT-8	12.15 - 12.45	BROWN POORLY GRADED SAND	SP													100	100	100	99	81	33
AG-12	SPT-4	5.15 - 5.45	BROWN SILTY CLAY	CH													100	99	99	99	98	98
	SPT-7	12.15 - 12.45	GRAY FINE TO MEDIUM SAND	SP													100	98	70	37	12	9
AG-13	SPT-3	3.15 - 3.45	DARK GRAY SILTY SAND	SM									100	97	96	94	89	71	56	55	38	26
	SPT-4	5.15 - 5.45	DARK GRAY FINE TO COARSE SAND	SP										100	97	96	91	63	35	20	5	3
	SPT-5	7.15 - 7.45	DARK GRAY FINE TO COARSE SAND	SM									100	75	71	70	67	47	23	11	4	2
	SPT-6	10.15 - 10.45	DARK GRAY SILTY SAND	SP												100	99	97	95	93	86	41
	SPT-7	12.15 - 12.45	DARK GRAY FINE TO COARSE SAND	SP									100	99	97	94	72	64	53	50	49	47
AG-14	SPT-3	3.15 - 3.45	BROWN SILTY SAND	SM									100	91	89	88	87	85	84	83	80	76
	SPT-4	5.15 - 5.45	GRAY POORLY GRADED SAND	SP										100	97	97	96	95	95	94	89	33
	SPT-6	10.15 - 10.45	BROWN SILTY CLAY	CH													100	100	98	91	89	87
	SPT-7	15.15 - 15.45	DARK BROWN SILTY SAND	SM												100	100	99	98	95	66	47
AG-15	SPT-3	3.15 - 3.45	LIGHT BROWN SANDY SILT	ML													100	99	99	99	96	89
	SPT-6	10.15 - 10.45	LIGHT BROWN CLAYEY SILT	CL												100	100	100	100	100	99	98
AG-17	SPT-4	5.15 - 5.45	DARK BROWN SILTY CLAY	CL													100	99	99	98	90	89
	SPT-5	7.15 - 7.45	LIGHT GRAY SILTY CLAY	CH															100	100	99	99
	SPT-6	10.15 - 10.45	LIGHT GRAY SILTY CLAY	CH														100	100	100	97	92
AG-19	SPT-2	2.15 - 2.45	BROWN SILTY SAND	SM											100	99	97	86	58	51	12	10
	SPT-3	3.15 - 3.45	DARK GRAY SILTY SAND	SM													100	96	73	43	18	13
	SPT-4	5.15 - 5.45	DARK GRAY SILTY SAND	SM													99	98	91	66	18	11
	SPT-6	10.15 - 10.45	DARK GRAY SILTY SAND	SM												100	100	82	56	51	15	9
	SPT-7	12.15 - 12.45	DARK GRAY SILTY SAND	SM													100	88	49	26	5	3

TABLE 2.3 (3/3) RESULT OF SOIL TESTS (ADDITIONAL WORK IN FY 1991)

LOCATION STATION	SAMPLE NUMBER	DEPTH M.	SOIL DESCRIPTION	UNIFIED SOIL CLASSIFICATION	SPECIFIC GRAVITY	MOISTURE CONTENT %	SIEVE ANALYSIS														
							25.4 mm.	19.1 mm.	12.7 mm.	9.52 mm.	4.75 mm.	2.38 mm.	2.00 mm.	1.19 mm.	0.53 mm.	0.42 mm.	0.297 mm.	0.149 mm.	0.074 mm.	0.005 mm.	0.001 mm.
DG-7	S-1	4.0 - 5.0	GRAY POORLY GRADED SAND	SP	2.773	25.21								100	98	96	95	38	10		
	S-2	9.0 - 10.0	GRAY TO DARK GRAY FINE TO MEDIUM SAND	SP	2.572	28.54							100	99	99	97	79	69	18		
	S-3	14.0 - 15.0	GRAY TO DARK GRAY FINE SAND	SP	2.583	23.02						100	100	100	89	79	62	40	16		
	S-4	19.0 - 20.0	DARK GRAY VERY FINE SAND	SP	2.538	20.80								100	100	100	98	91	12		
DG-8	S-1	4.0 - 5.0	GRAY FINE TO MEDIUM SAND	SP	2.726	24.34						100	99	99	99	79	72	51	7		
	S-2	9.0 - 10.0	GRAY FINE TO MEDIUM SAND	SP	2.670	20.69									100	95	89	60	6		
	S-3	14.0 - 15.0	GRAY FINE TO MEDIUM SAND	SP	2.573	20.46									100	81	72	35	13		
	S-4	19.0 - 20.0	GRAY FINE TO MEDIUM SAND	SP	2.594	18.55									100	97	95	65	2		
DG-9	S-1	4.0 - 5.0	GRAY POORLY GRADED SAND	SP	2.693	24.00										100	99	81	17		
	S-2	9.0 - 10.0	GRAY POORLY GRADED SAND	SP	2.655	28.95									100	99	95	76	17		
	S-3	14.0 - 15.0	GRAY POORLY GRADED SAND	SP	2.557	28.60									100	99	98	86	26		
	S-4	19.0 - 20.0	GRAY SILTY CLAY	CL	2.673	27.09	W/ HYDROMETER								100	96	91	77	57		
	S-5	24.0 - 25.0	GRAY SANDY CLAY	CL	2.664	36.80	W/ HYDROMETER								100	100	98	93	79		
	S-6	29.0 - 30.0	GRAY SANDY CLAY	CH	2.673	41.32	W/ HYDROMETER								100	99	97	88	81		
DG-10	S-1	4.0 - 5.0	GRAY FINE SAND	SP	2.581	26.93							100	100	99	96	95	81	7		
	S-2	9.0 - 10.0	GRAY FINE SAND	SP	2.721	23.13						100	99	99	93	87	87	74	11		
	S-3	14.0 - 15.0	GRAY FINE SAND	SP	2.571	23.65						100	100	100	100	94	88	64	12		
	S-4	19.0 - 20.0	GRAY FINE SAND	SP	2.558	17.52						100	100	100	100	98	92	75	13		
DG-11	S-1	4.0 - 5.0	GRAY FINE TO MEDIUM SAND	SP	2.700	21.22							100	100	100	98	94	71	9		
	S-2	9.0 - 10.0	GRAY FINE TO MEDIUM SAND	SP	2.682	15.90						100	100	100	96	93	85	50	15		
	S-3	14.0 - 15.0	GRAY FINE TO MEDIUM SAND	SP	2.673	24.77								100	100	98	97	83	35		
	S-4	19.0 - 20.0	GRAY FINE SAND	SP	2.866	23.75							100	99	99	95	93	85	35		
	S-5	24.0 - 25.0	GRAY FINE SAND	SP	2.648	36.28								100	100	91	88	71	21		
	S-6	29.0 - 30.0	DARK GRAY CLAYEY SILT	ML	2.635	30.94	W/ HYDROMETER								100	99	99	97	91		
MA-11	S-1	4.0-5.0	GRAY FINE TO COARSE SAND	SP	2.745	18.54								100	97	68	61	46	2		
	S-2	9.0-10.0	GRAY FINE TO COARSE SAND	SP	2.794	20.00							100	100	94	50	43	30	11		
	S-3	14.0-15.0	GRAY FINE TO COARSE SAND	SP	2.792	9.46						100	99	99	97	51	42	34	10		
	S-4	19.0-20.0	GRAY FINE TO COARSE SAND	SP	2.722	18.21						100	100	100	88	47	39	21	9		
	S-5	24.0-25.0	GRAY FINE SAND	SP	2.730	29.52							100	100	99	98	98	65	15		
	S-6	29.0-30.0	BROWNISH FINE TO MEDIUM SAND	SP	2.738	31.54								100	99	87	78	49	5		