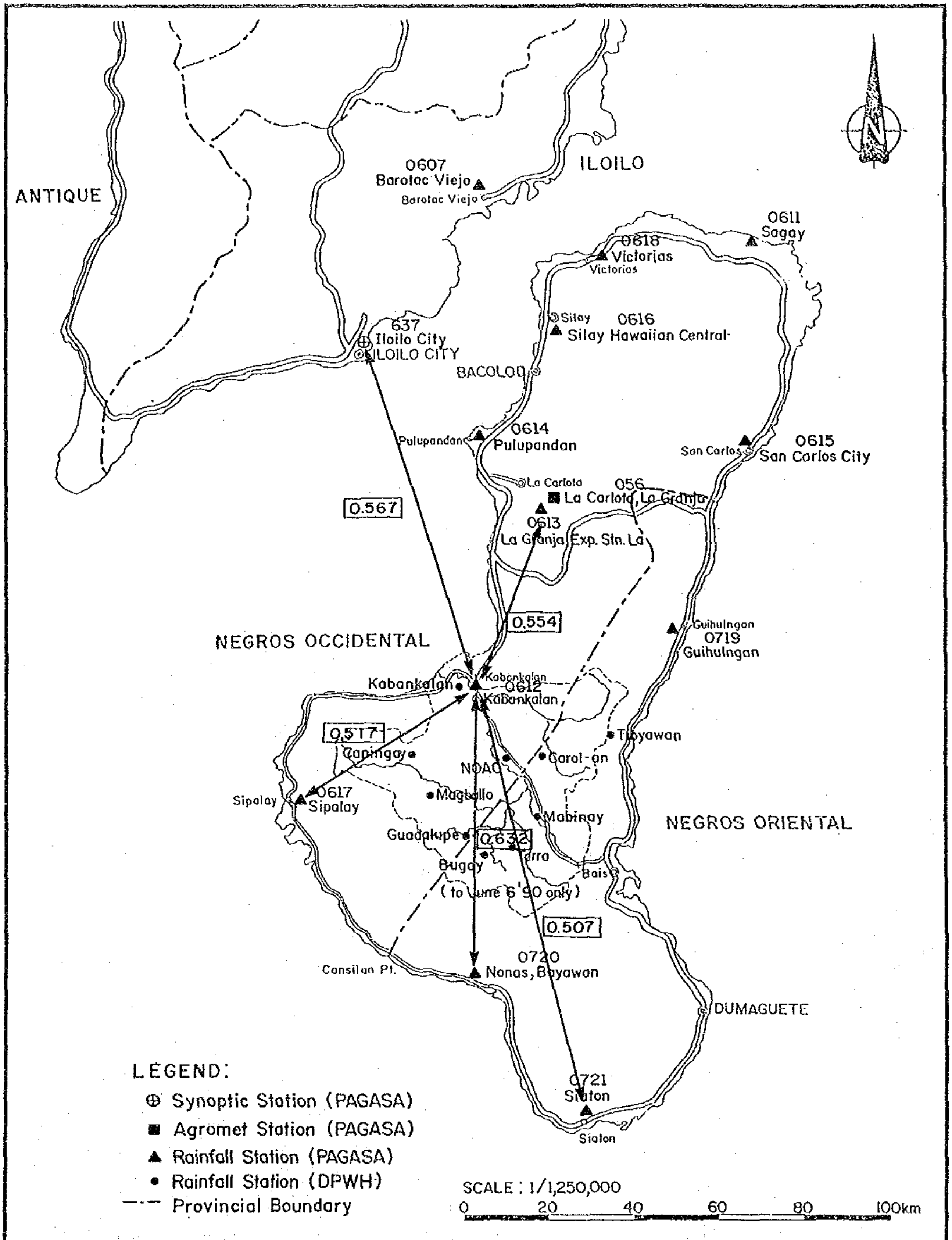
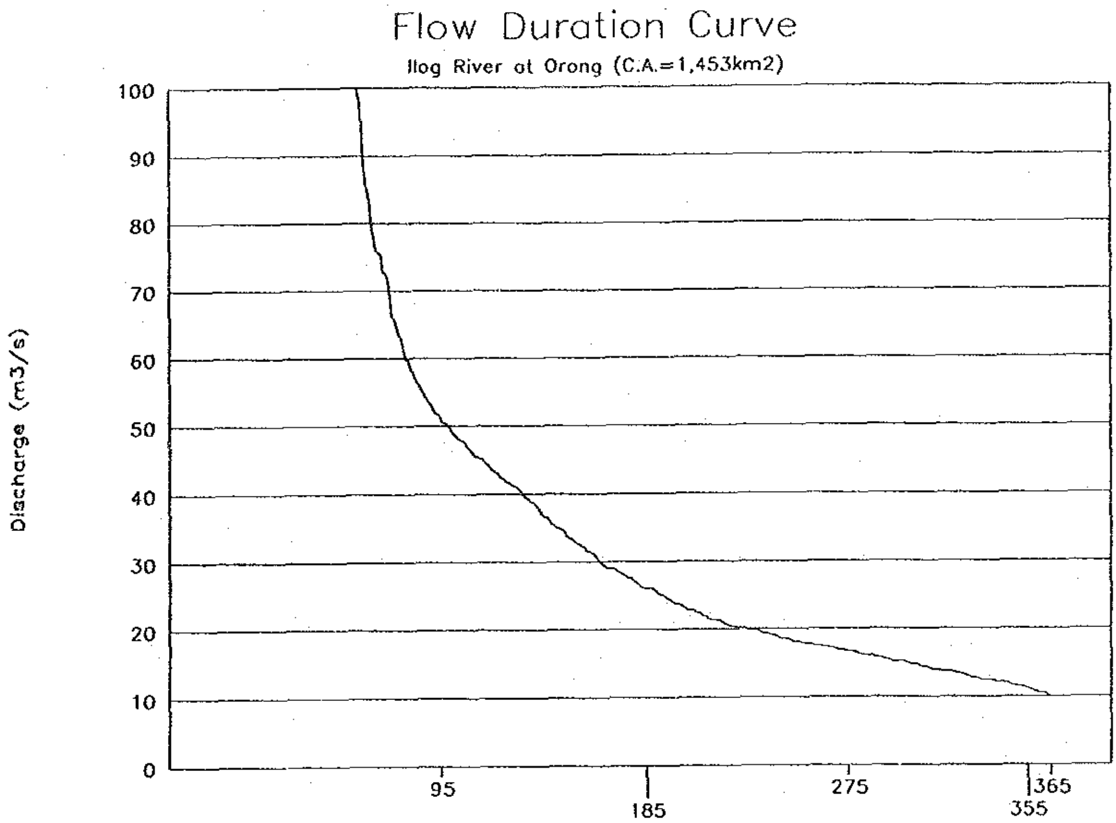
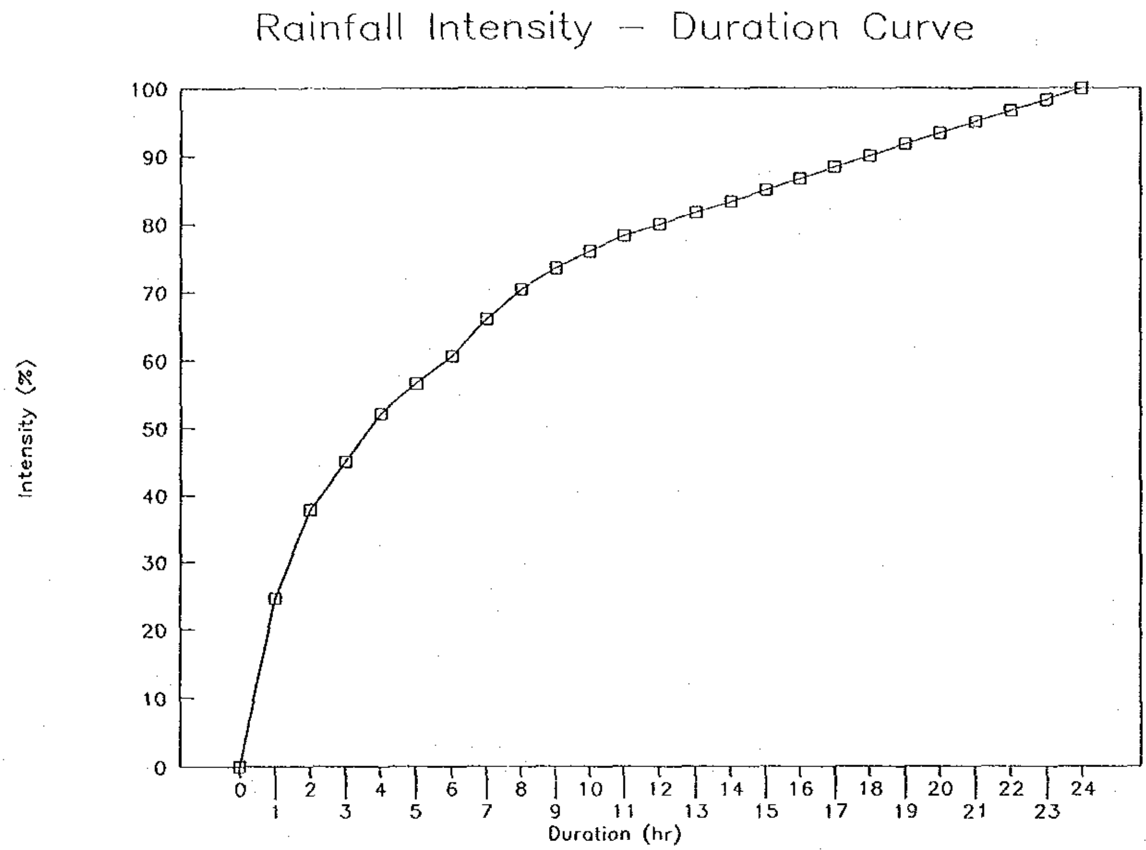


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. II-2-5 MONTHLY RAINFALL CORRELATION COEFFICIENT BETWEEN KABANKALAN AND OTHER STATIONS

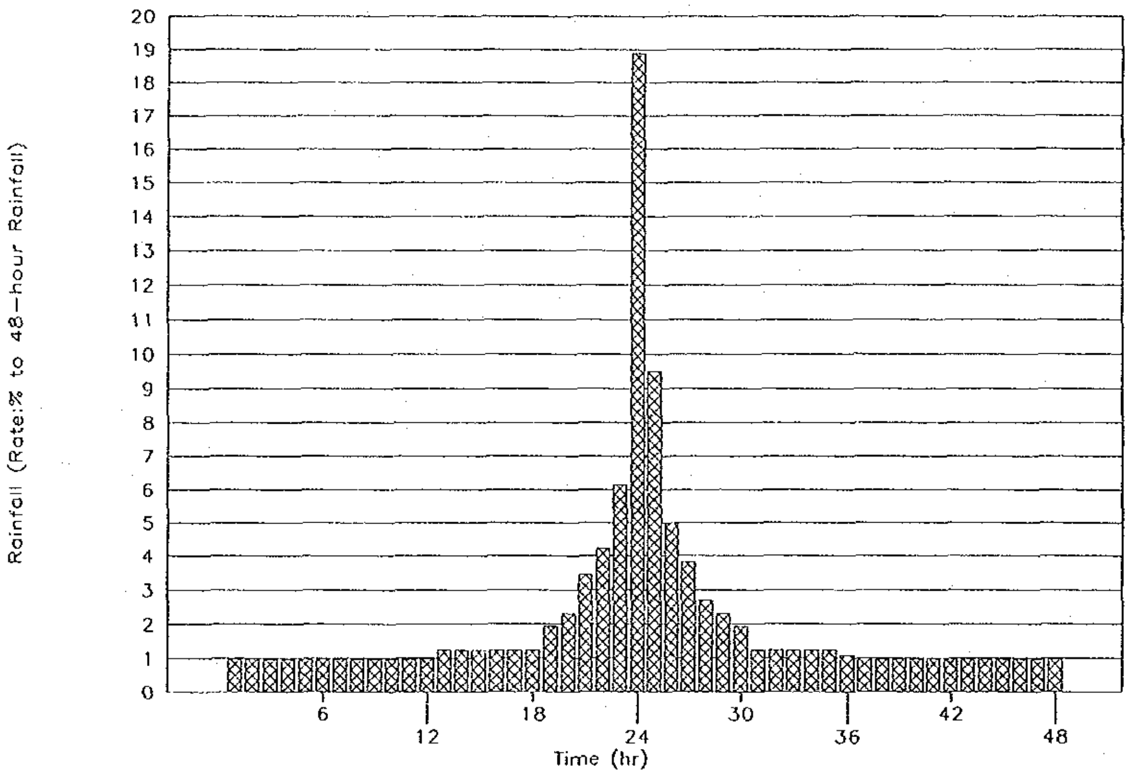


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig.II-2-6 FLOW DURATION OF ILOG RIVER AT PANDAN, ORONG
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-1 RAINFALL INTENSITY-DURATION CURVE
JAPAN INTERNATIONAL COOPERATION AGENCY	

MODEL HYETOGRAPH



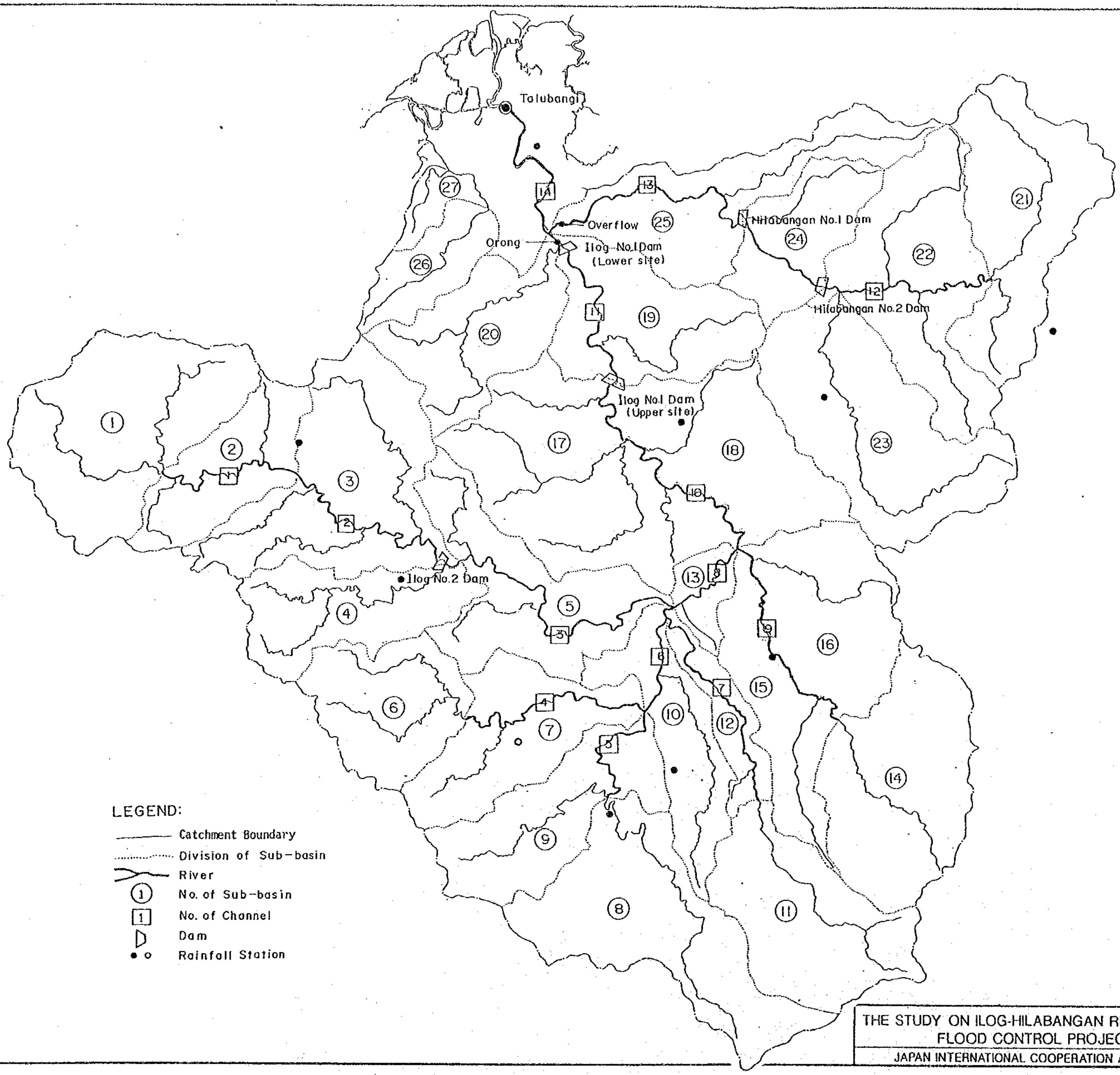
Hourly Rate to 48-hour Rainfall

Time (hr)	Rate (%)	Time (hr)	Rate (%)	Time (hr)	Rate (%)
1	0.97	17	1.23	18	1.23
2	0.97	18	1.23	19	1.23
3	0.97	19	1.92	20	1.23
4	0.97	20	2.30	21	1.07
5	0.97	21	3.45	22	0.98
6	0.97	22	4.22	23	0.97
7	0.97	23	6.14	24	0.97
8	0.97	24	18.87	25	0.97
9	0.97	25	9.51	26	0.97
10	0.97	26	4.99	27	0.97
11	0.97	27	3.84	28	0.97
12	0.98	28	2.68	29	0.97
13	1.23	29	2.30	30	0.97
14	1.23	30	1.92	31	0.97
15	1.23	31	1.23	32	0.97
16	1.23	32	1.23	33	0.97

THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.II-3-2 MODEL HYETOGRAPH



CHARACTERISTIC FEATURES OF SUB-BASIN

Sub-Basin No.	Catchment Area (km2)	Longest Stream (km)	Max. Elevation (El.m)	Min. Elevation (El.m)	Alt. Diff.	Ave. Gradient (1/I)
1	109.7	15.6	520	156	364	42.9
2	53.5	6.6	500	143	357	18.5
3	118.3	19.4	400	112	288	68.1
4	62.2	22.8	558	114	444	51.4
5	83.0	11.6	280	101	179	64.8
6	63.1	16.6	544	150	394	42.1
7	69.8	11.3	400	134	266	42.5
8	112.0	26.9	650	102	548	49.1
9	71.8	16.8	395	102	293	57.3
10	54.2	19.8	333	57	276	71.7
11	88.0	18.5	960	197	763	24.2
12	24.2	3.7	280	160	120	30.8
13	16.2	4.0	140	40	100	40.0
14	99.7	14.5	620	95	525	27.6
15	51.4	10.8	420	67	353	30.6
16	76.7	13.9	378	25	353	18.5
17	125.8	16.1	239	12	227	70.9
18	84.8	11.3	840	15	825	13.7
19	75.1	15.6	700	10	690	22.6
20	66.8	21.2	360	10	350	60.6
21	56.1	16.7	1,260	330	930	18.0
22	100.4	13.6	1,350	240	1,110	12.3
23	118.6	28.4	885	190	695	40.3
24	50.3	11.0	1,120	87	1,033	10.6
25	84.3	16.3	1,350	60	1,290	12.6
Sub-Total	1,959.0					
26	31.1	12.8	340	10	330	38.8
27	11.4	7.6	260	10	150	40.0
Total	2,001.5	-	-	-	-	-

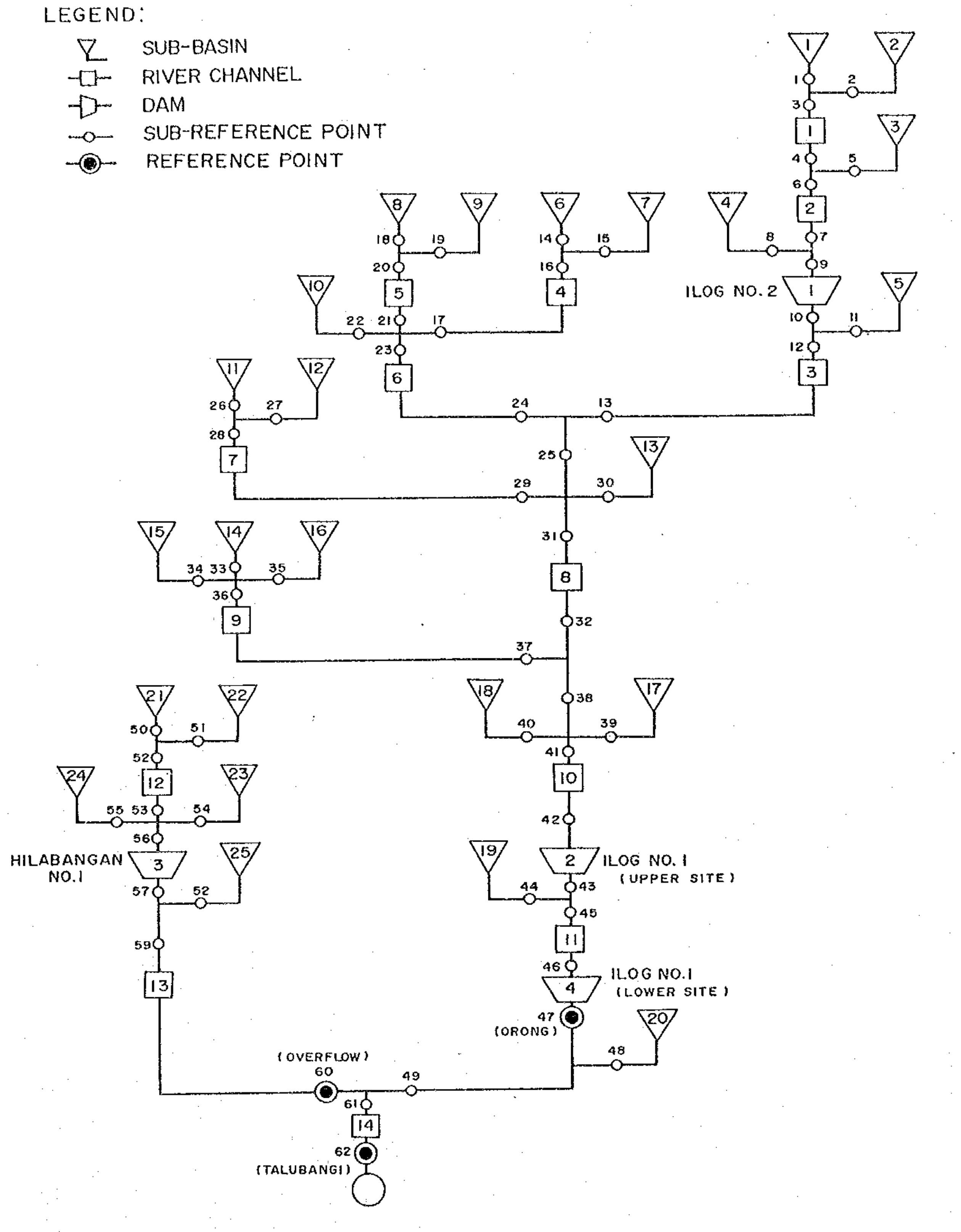
FEATURES OF RIVER CHANNEL

Channel No.	Upstream Elev. (El.m)	Downstream Elev. (El.m)	Channel Length (km)	Average Grad. (1/I)	Average Width (m)
1	155	140	12.6	787.5	50
2	140	110	19.7	656.7	70
3	110	38	21.7	301.4	100
4	150	75	16.8	224.0	70
5	102	75	9.7	359.3	70
6	75	38	7.6	205.4	100
7	197	40	15.2	96.8	70
8	38	25	7.0	538.5	100
9	95	25	16.4	234.3	70
10	25	10	20.7	1380.0	100
11	10	2.5	13.2	1760.0	150
12	330	190	14.2	101.4	100
13	87	2	18.6	216.8	100

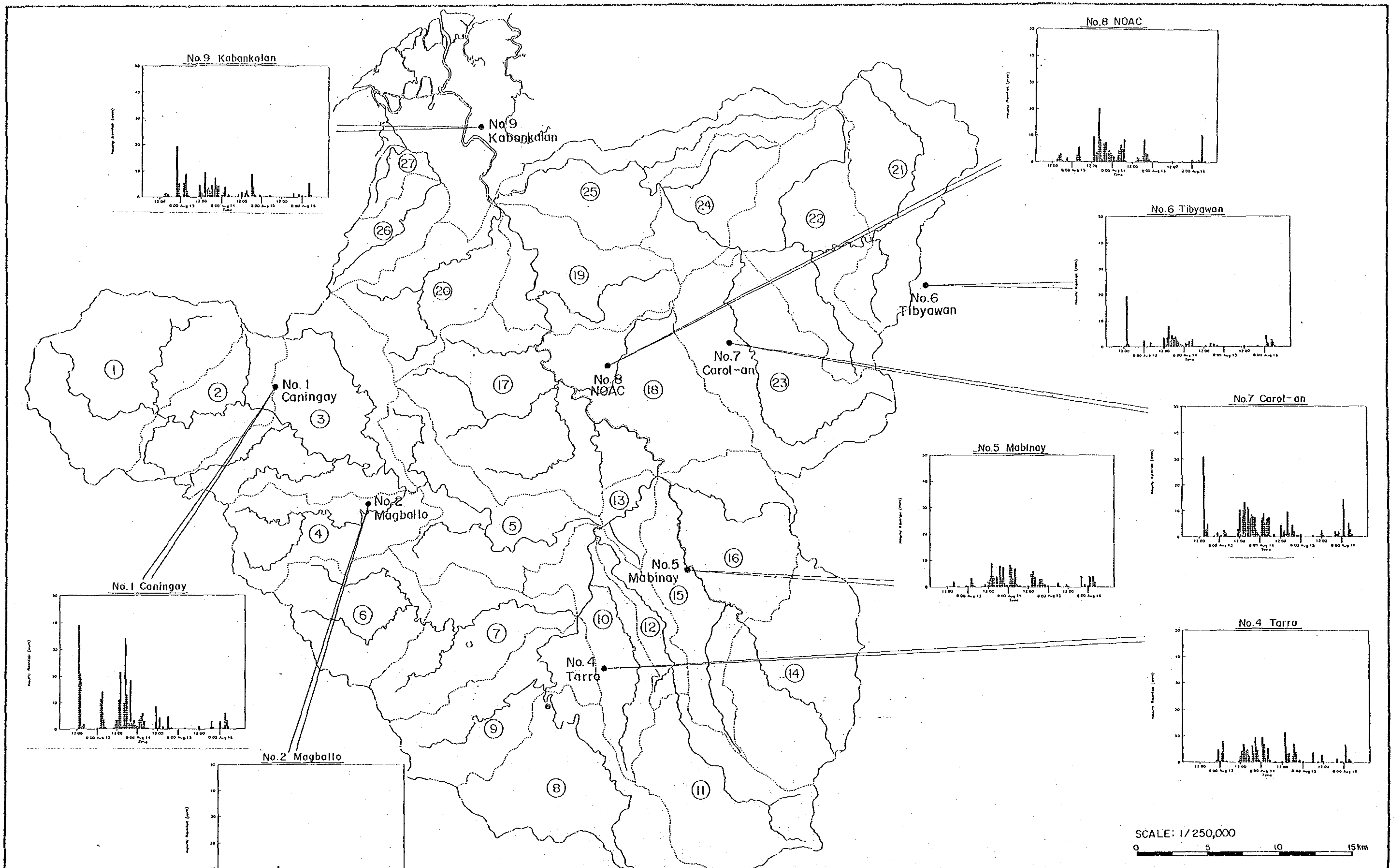
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

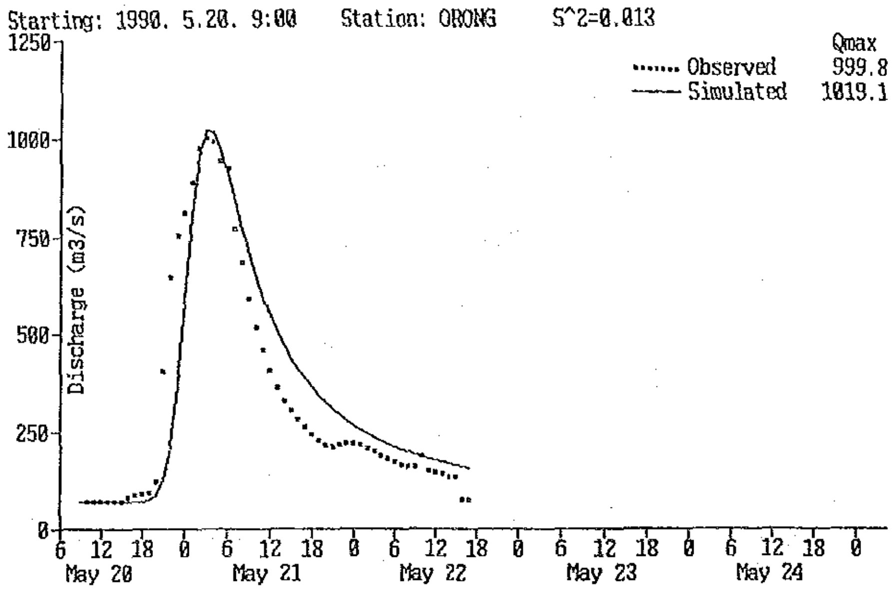
Fig. II-3-3 BASIN DIVISION

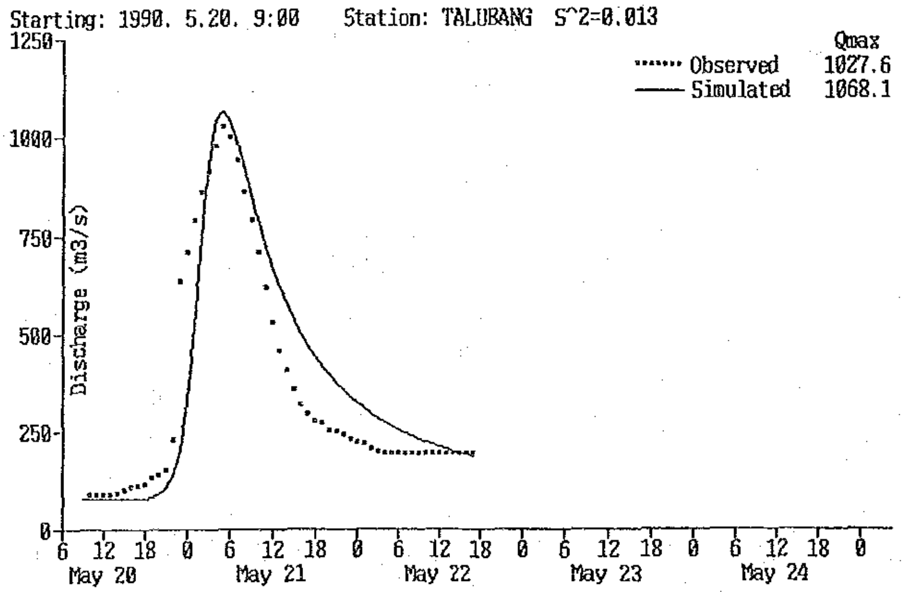


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-4 RIVER SYSTEM DIAGRAM
JAPAN INTERNATIONAL COOPERATION AGENCY	

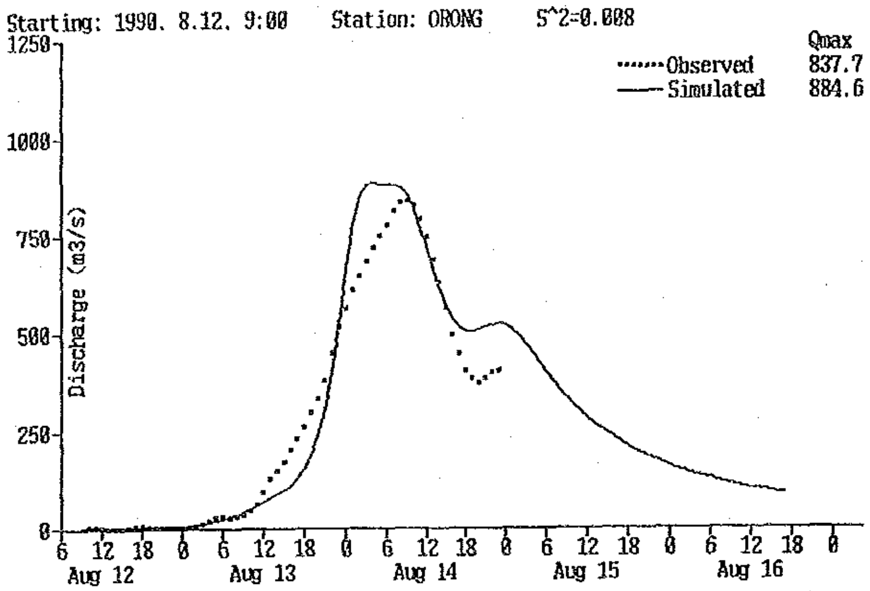


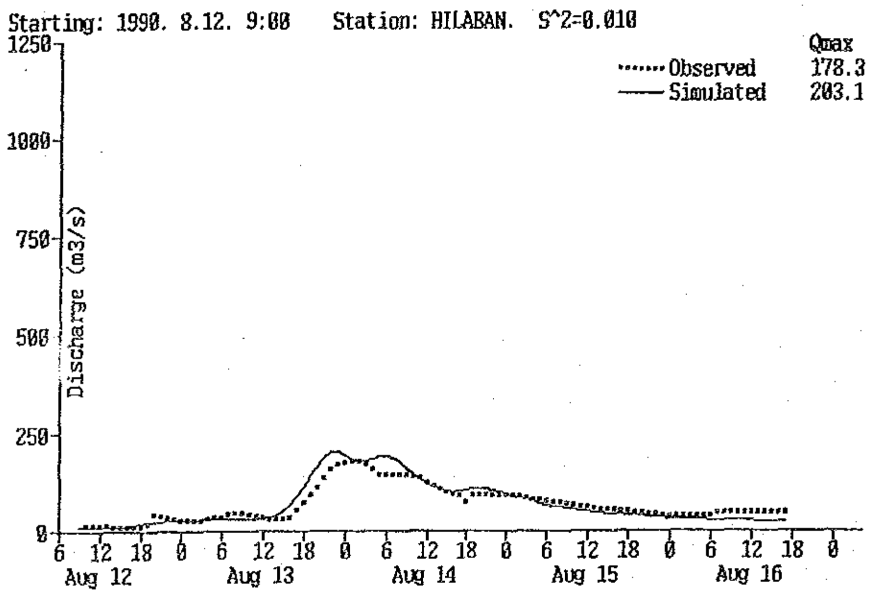
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-5 HOURLY RAINFALL OBSERVED DURING THE FLOOD IN AUGUST 12-16, 1990
JAPAN INTERNATIONAL COOPERATION AGENCY	



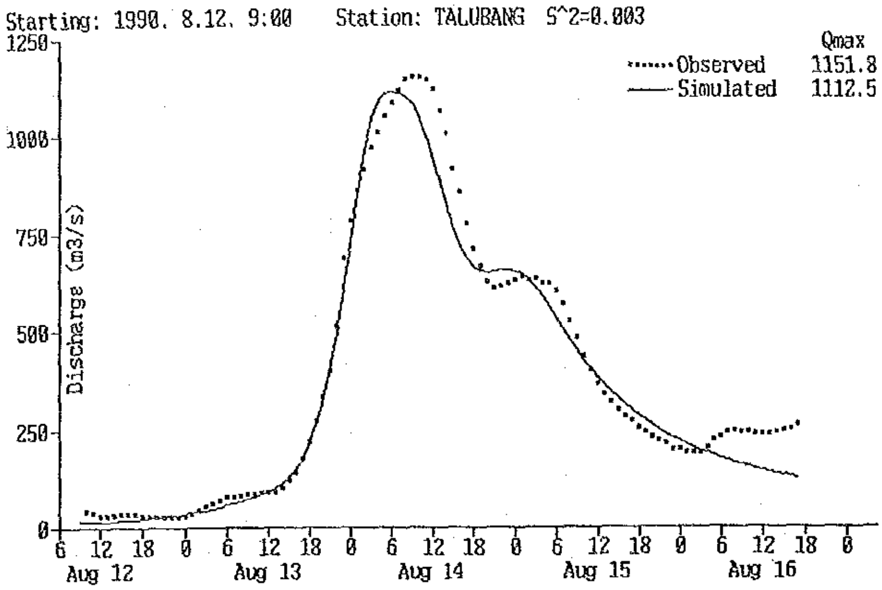


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-6 (1/5) COMPARISON OF SIMULATED AND OBSERVED FLOOD HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	

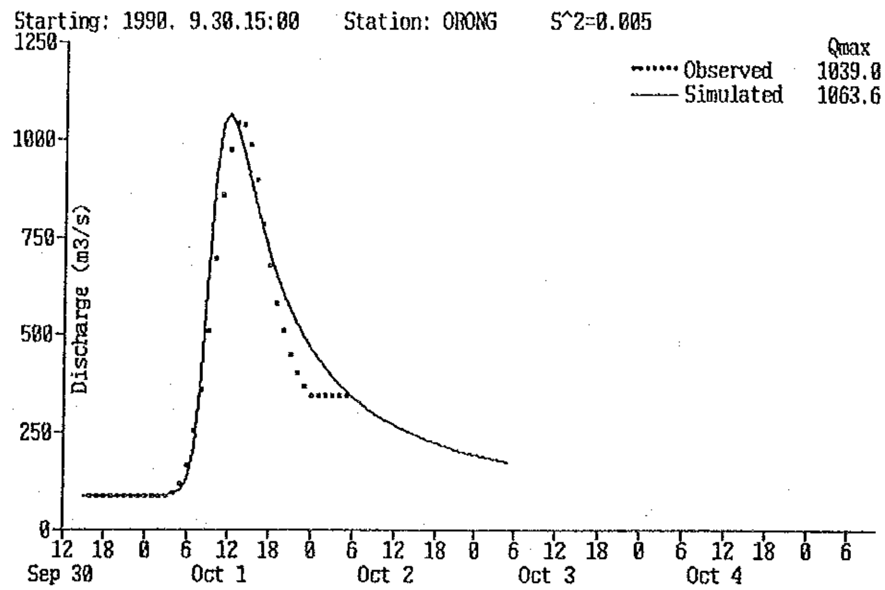


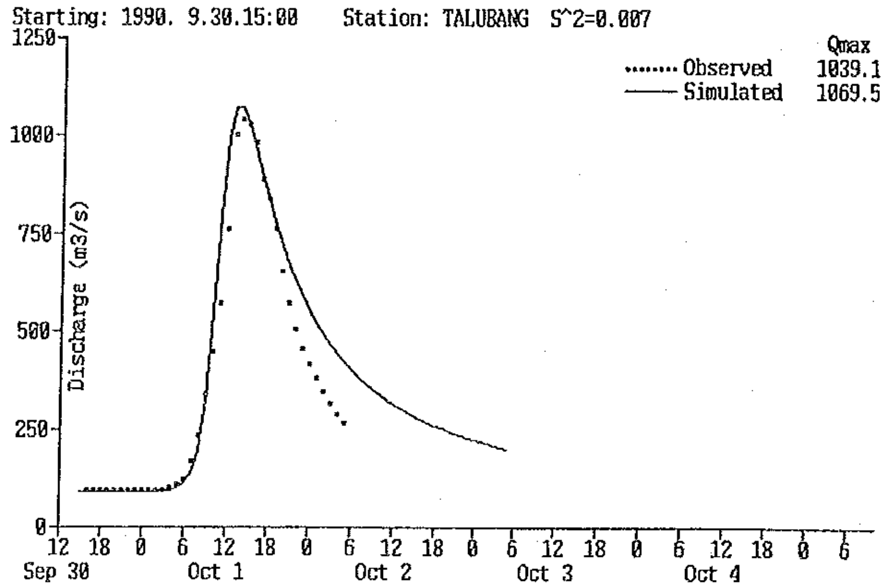


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig.II-3-6 (2/5) COMPARISON OF SIMULATED AND OBSERVED FLOOD HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	

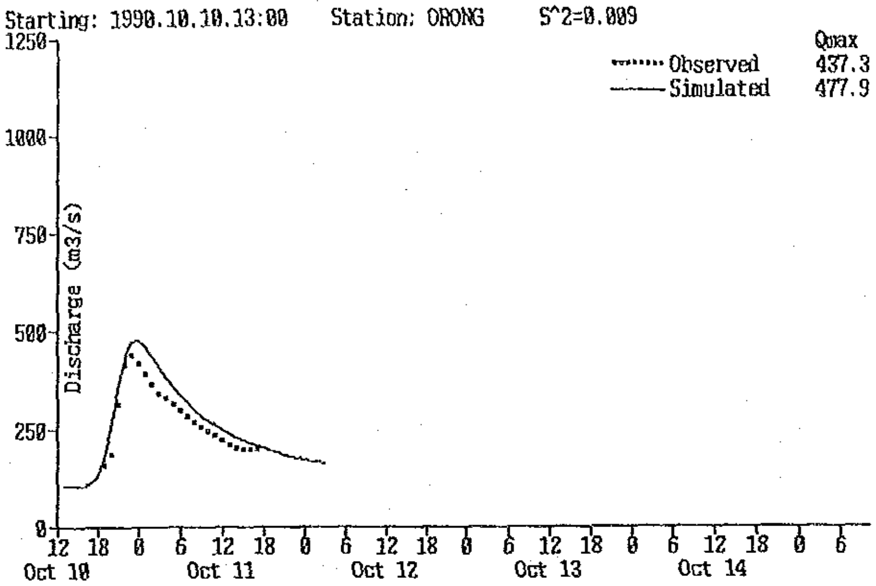


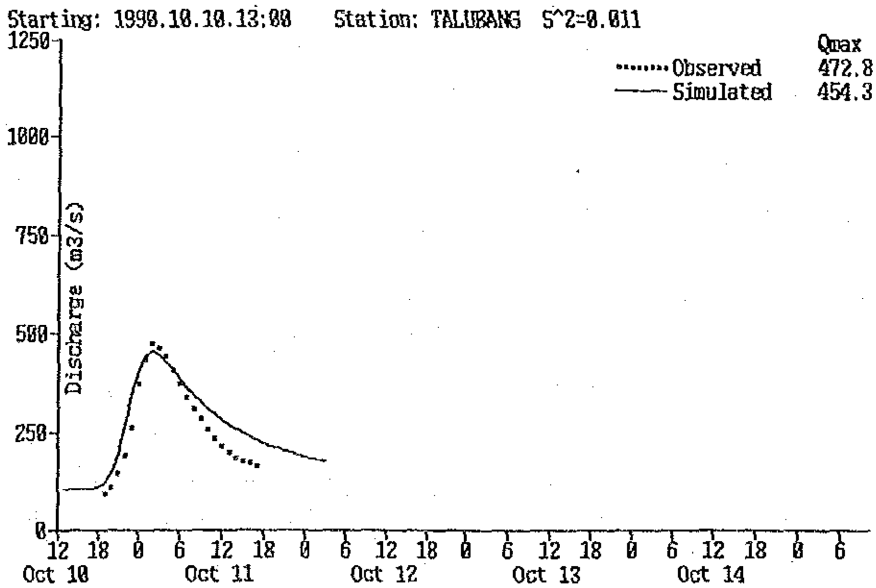
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig.II-3-6 (3/5) COMPARISON OF SIMULATED AND OBSERVED FLOOD HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	



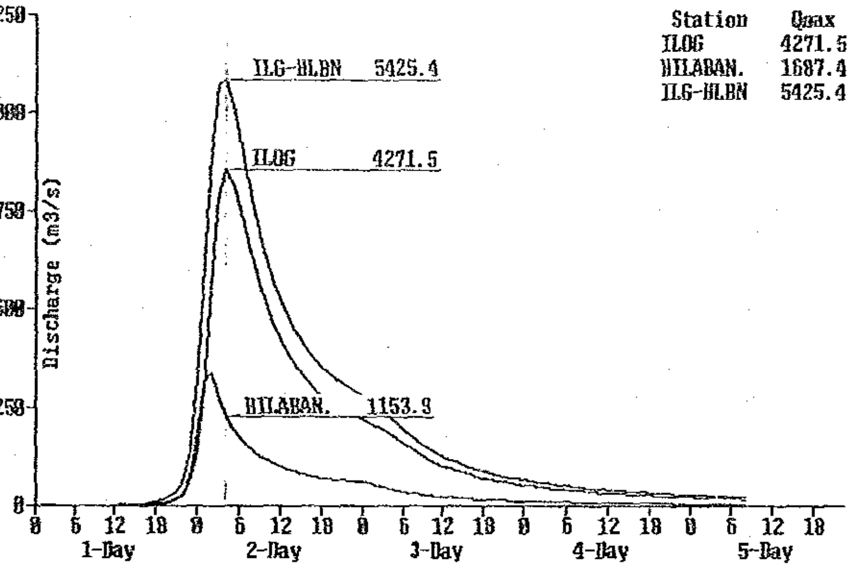


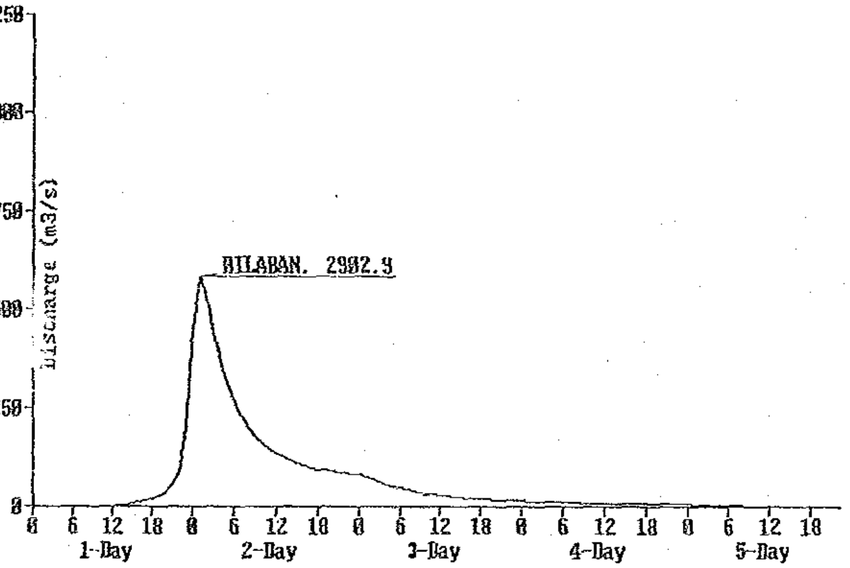
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-6 (4/5) COMPARISON OF SIMULATED AND OBSERVED FLOOD HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	



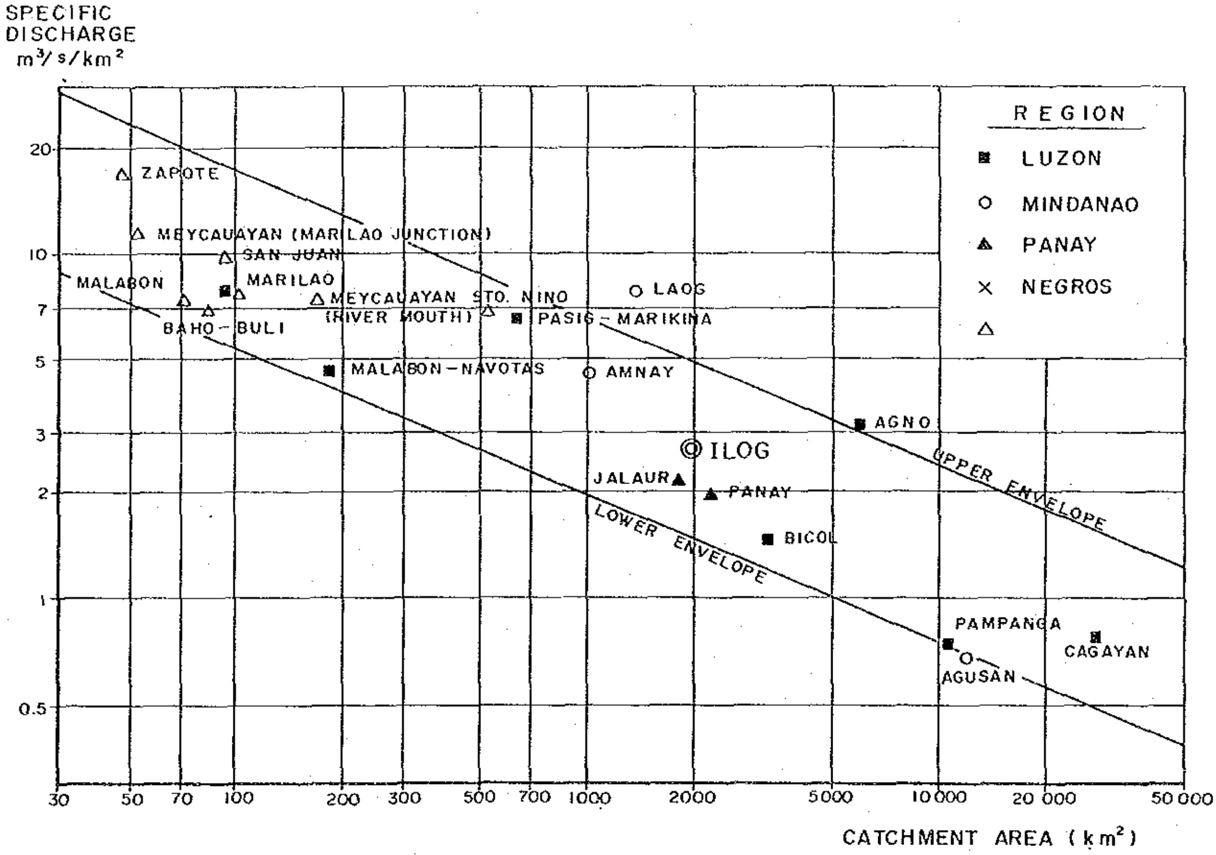


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-6 (5/5) COMPARISON OF SIMULATED AND OBSERVED FLOOD HYDROGRAPH
JAPAN INTERNATIONAL COOPERATION AGENCY	





THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-7 PROBABLE FLOOD HYDROGRAPH FOR THE ILOG AND HILABANGAN RIVERS WITH A 100-YEAR RETURN PERIOD
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. II-3-8 SPECIFIC DISCHARGE PLOT FOR 100-YEAR RETURN PERIOD FLOOD
JAPAN INTERNATIONAL COOPERATION AGENCY	

III. GEOLOGY

STUDY
ON
ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

SUPPORTING REPORT III. GEOLOGY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. GENERAL GEOLOLGY

The Ilog-Hilabangan River Basin, with a catchment area 2,162 km^2, is situated in the central and southern portions of Negros Island. It lies generally between 122° 30' to 123° 10' E longitude, and from 9° 30' to 10° 10' N latitude. The main drainage is the Ilog River whose headwaters originate in the northwestern tip of the basin. The river flows in the southeast direction until it turns to the northwest direction in the middle reaches and discharges into the Panay Gulf. On the other hand, the Hilabangan River originates in the easternmost part of the basin flows generally westward in the upper reaches and then into a northwest direction, and joins the Ilog River at about 3 kilometers from Poblacion Kabankalan. The tributaries which follow a dendritic pattern, drain into the main river channel. The development of the dendritic pattern appears to have been controlled by the lithologic condition and by the geologic structures.

Topography

The Ilog-Hilabangan River Basin is enclosed by three (3) clusters of mountains; namely, Negros Central Mountains to the north, Negros Cordillera to the east, and Southern Negros Mountains to the southwest. It faces Panay Gulf to the northwest. (Refer to Figs. III-1-1 and III-1-2.)

The Negros Central Mountains is a wide, middle degree of dissected mountain region having a dendritic valley with moderate to very steep slopes. The maximum elevation of the area is about 1,000 meters above mean sea level. (Refer to Fig. III-1-3.)

The Negros Cordillera Mountain is of the same degree as the Negros Central Mountains. It is a long, north-trending mountain range, running along the eastern edge of Negros Island with a maximum elevation of around 700 meters above mean sea level.

The Southern Negros Mountains have a highly dissected northwest trending mountain range. The maximum elevation is nearly 700 meters above mean sea level.

The Ilog-Hilabangan Plain is situated in the middle part of the basin. It is characterized by an irregularly shaped depression and a dissected plateau that has an alluvial flat land and gently sloping hills. The highland of this plain has an elevation of less than 300 meters above mean sea level.

In the northwestern part of the plain, the delta along the Ilog-Hilabangan River faces Panay Gulf. From the micro-topographical viewpoint, the delta has a very gentle slope as it comes to the seashore, as shown in Fig. III-1-4.

Geology

(1) Geological History of Negros Island

Negros Island is an uplifted igneous sedimentary basin, named as the Negros-Siquijor basin believed, to have originated during Cretaceous. The basin is considered a back-arc basin generated by an eastward moving subducted plate. The oldest volcanic rocks of the basin with their intercalated pyroclastic and clastic rocks are dated Cretaceous. Intrusion and partial metamorphism took place during the Paleocene.

Intermittent igneous activity and tectonic movement with sedimentation succeeded during the period of earliest Eocene to Recent. Coralline limestone was indicated during Eocene, Late Oligocene, Early to Late Miocene and Pliocene to Pleistocene.

The limestones generally overlie clastic rocks and/or igneous deposits. Diorite and gabbro intrusions took place during the period of Middle to Late Miocene. Sedimentary rocks of Early Miocene and older age are highly cemented.

(2) Distribution of Geology

Old volcanic rocks, partly covered by later sedimentary rocks and young volcanic rocks are exposed in the interior of the Negros Central Mountains and the Negros Cordillera. The front and foothills are generally covered by these sedimentary rocks which include sandstone, siltstone, conglomerate, shale, and limestone.

At the Southern Negros Mountain region, there is a series of old sedimentary rocks with younger sedimentary rocks and volcanic rocks. The region is dominated by old volcanic rocks with the basement complex of metamorphosed igneous and sedimentary rocks.

Ilog-Hilabangan plain is formed of young and old sedimentary rocks, volcanic rocks and limestone. (Refer to Figs. III-1-5 and III-1-6.)

(3) Geologic Structure

Numerous faults and folds are found in the river basin area. The main trend of the faults strikes northwest-southeast and northeast-southwest. Folds generally exist in older sedimentary rocks. The Ilog-Hilabangan plain and the Negros Central Mountains are bordered by faults having NNE-SSW strike and SSE dip.

2. INVESTIGATION FOR THE STUDY

The investigation has comprised field geological surface survey, geological mapping, exploratory drilling with borehole permeability tests and the unconfined compression tests taking four months of time from October to December, 1990.

The surface survey has been conducted by the local consultant Mr. Crispin R. Leyva, geologist, hired by the JICA Study Team. The exploratory core drilling with permeability tests and the unconfined compression tests has been performed by the Construction & Drilling Specialists, Inc., Manila, according to the specificationss prepared by the JICA Study Team. The drilled core samples were inspected by the geologist of the Study Team and counterpart geologists.

2.1 Items and Quantities

Items and quantities of the geological investigation carried out at five (5) dam sites and reservoir areas which were selected as discussed in the sectoral report of Dam Planning are shown in Table III-2-1.

The borehole elevation and length, the number of permeability tests and the sampling number of drilled core for unconfined compression tests are shown in Table III-2-2.

2.2 Geological Surface Survey

Geological surface survey was carried out at five (5) possible dam sites, Ilog No. 1 Lower (I1 Lower), Ilog No.1 Upper (I1 Upper), Ilog No.2 (I2), Hilabangan No.1 (H1) and Hilabangan No.2 (H2) in order to comprehend the outline of the geological conditions of each dam site. (Refer to Fig. III-2-1.) The surface survey was conducted based on the topographical map of 1:50,000. As the result of this survey, Ilog No.2 and Hilabangan No.2 dam sites were eliminated because of wide spreded limestone. (Refer to Figs. III-2-2 to III-2-4.)

Further geological surface survey on three (3) reservoir areas of the Ilog No.1 Lower, Ilog No.1 Upper and Hilabangan No.1 sites was carried out. The Ilog No.1 Lower reservoir is partially overlapped with that of the Ilog No.1 Upper. This surface survey was carried out utilizing the topographical map of 1 : 10,000 and 1 : 50,000 respectively. The geologic maps of the reservoir areas are shown in Figs. III-2-5 and III-2-6.

2.3 Exploratory Drilling and Unconfined Compression Test

In parallel with the surface geological survey, the exploratory core drilling with permeability tests was conducted at the Ilog No.1 Upper and Hilabangan No.1 dam sites where high dams were expected. (Refer to Fig. III-2-7.) The drilling logs of the core samples are shown in Fig. III-2-8, together with the results of permeability tests.

Unconfined compression test was also carried out by using the above-said core samples. These results are summarized in Table III-2-3 and Figs III-2-8 to III-2-10.

3. GEOLOGY

3.1 Regional Geology

Regional geology of the Ilog-Hilabangan River Basin is composed of the following rocks and formation by report of the Map and Mineral Resources Compilation Team.*

Geologic Age		Lithology
Quaternary	Recent	Alluvium Pyroclastic Rocks
	Pleistocene	Carcar Formation
Tertiary	Pliocene	Patonan Formation
	Upper Miocene	Talave Limestone
	Middle Miocene	Macasilao Formation Quartz Diorite
	Lower Miocene	Malabago Group - Panghumayan Shale - Ania Conglomerate - Tigbao Formation - Odeong Formation
Pre-tertiary		Metavolcanics

Metavolcanics cited as the oldest rock of the river basin consists of volcanic flows, agglomerate and tuffs. Exposures are well seen in the southwestern area.

Malabago Group consists of the following sub formations:

(1) Odeong Formation ; interbeddings of volcanic conglomerate and mudstone.

* "Geology and Mineral Resources of Negros Island" R.I.195, Maps and Meneral Resources compilation Team, Bureau of Mines and Geosciences, 1978

(2) Tigbao Formation ; mainly tuffaceous mudstone with interbeds of conglomerate and sandy limestone.

(3) Ania Conglomerate ; conglomerate and conglomeratic sandstone with intercalation of tuffaceous mudstone.

(4) Panghumayan Shale ; consisting of alternate sequence of thinly bedded gray soft clay and dark gray harder shale.

Macasilao Formation consists of a thick alternate beds of sandstone and shale with lenses of conglomerate, coal and limestone.

Talave Limestone consists of crystalline to sandy limestone with thin interbeds of marly limestone. Enormous exposures of this type are found in various places in the region.

Patonan Formation consists of alternate beds of sandstone and shale with thin interbeds of conglomerate and thin lenses of coal.

Carcar Formation is massive to thinly bedded, fairly dense crystalline limestone.

Pyroclastic Rocks are apparently a product of volcanic activities during Quaternary Period. Hence, it overlies the older formation specifically in areas near the inactive volcanoes in Silay, Mandalagan and Canlaon.

Alluvium consists of clay, sand, gravel and boulders derived from long deposition in the lower courses and banks of the rivers, swamps and beaches.

3.2 Topography of Dam Site and Reservoir Area

The lower course of the reservoir area of Ilog No.1 Upper and Lower dam sites is characterized by gently sloping hill while the middle part is moderately dipping. The upper course, specifically the limestone area, is characterized by steeply - dipping cliffs on both walls.

The Ilog No.2 dam site is made up of steep - like cliffs rising to about 80 meters on both abutments.

The lower course of the reservoir is characterized by a karstic topography. The immediate downstream and upstream of the reservoir are made up of steeply - dipping cliffs on both walls. The limestone rock formation lies in this area. The middle portion is generally of moderately dipping hills while the upper part is low - lying to elevated flat lands.

The Hilabangan No.1 dam site and reservoir area are generally characterized by steeply - dipping cliffs on both walls. Conglomerate rocks lie in this area. Two mountain ranges rising to about 100 to 200 meters elevation rim the reservoir area.

The immediate vicinities of the Hilabangan No.2 dam site are characterized by steeply - dipping cliffs on both abutments, made up of limestone formation. The lower course of the reservoir consists of gently dipping hills transforming to low - lying to flat lands at the middle portion. Steep - like cliffs on both valley walls characterize the upper course of the reservoir.

3.3 Geology of Dam Site

The Ilog No.1 Upper and Lower dam sites are underlain by gray volcanic clastic rocks composed of tuff breccia interbeded with sandstone, siltstone and fine grained tuff. It has been named Malabago Group and dated Lower Miocene by the Bureau of Mines and Geo-science (BMG). The clastic rocks are generally hard to moderately hard, massive and scarcely jointed. The structure of bedrocks at damsite is composed of two (2) major anticline that trend northeast along the both river banks and one (1) major syncline along the river bed. Significant faults with sheer zone which may require a special treatment were not found.

The Ilog No.2 dam site is underlain by white to buff stratified fossiliferous limestone. It has been named Dacongcogon Limestone and dated Early to Middle Miocene by BMG. This limestone is hard to vey hard, however, small solution cavities are formed and sinkholes out crop on the river banks up to the higher elevation.

The Hilabangan No.1 dam site is underlain by volcanic clastic rocks, whose lithological components are similar to those of the Ilog No.1 dam site. They seem to be the same geologic age. Structurally, the bedrocks show a general north strike and gentle dip ranging from 5 to 30 degree to the east. Significant faults with sheer zone which may require a special treatment were not found.

The Hilabangan No.2 dam site is underlain mainly by white to buff dense crystalline, stratified limestone and partially by lense-like marly limestone. It has been named Talave Limestone and dated Upper Miocene by BMG. The crystalline limestone deposited during Miocene is generally hard to very hard while marly limestone is friable. Small solution cavities are formed and out crop in the limestone zone.

3.4 Geology of Reservoir Area

The bedrocks of Ilog No.1 reservoir area are composed of volcanic clastic rocks and limestone which has been named Malabago Group and dated lower Miocene by BMG. The lithological components of clastic rocks are similar to the Ilog No.1 dam site. The limestone is white to buff, soft to moderately hard and partially hard, highly porous coralline or marly rock. In the eastern part of the Ilog No.1 reservoir, the limestone body extends from the south (upper reaches) to the north (lower reaches). It is named Talave Limestone and dated Upper Miocene by BMG. The upper course of the Ilog river is flanked by the limestone area. Several sinkholes and caves are commonly observed in the limestone zone of the reservoir area. The limestone area as shown in Fig. III-2-5 is deemed to be distributed higher than about EL.25 m of the riverbed.

The bedrock of Hilabangan No.1 reservoir is mainly composed of volcanic clastic rocks which are similar to those of the Ilog No.1 dam site, but the limestone is found partially. The limestone area as shown in Fig. III-2-6 is deemed to be distributed higher than EL.150 m of the riverbed approximately up to Hilabangan No.2 dam site. It is white to buff, stratified, fossiliferous dense crystalline to sandy bedrock with few lense-like marly limestone. It is generally harder than the limestone spread at the Ilog No.1 reservoir area. Solution cavities, however, may be formed judging from the existence of sinkholes in the area.

4. STUDY RESULTS

4.1 General

Judging from the geological surface survey for possible damsites and their reservoir areas, as well as the exploratory drilling for the sites of high dams, the following geological characteristics were identified.

The following geological conditions were found based on the geological surface survey results. The Ilog No.1 Lower, Ilog No.1 Upper, Hilabangan No.1 dam sites are underlain by volcanic clastic rocks composed of tuff breccia interbeded with sandstone, siltstone and tuff. While, Ilog No.2 and Hilabangan No.2 damsites are underlain by hard, porous limestone. Since dam sites on the limestone zone generally cause leakage problems, the Ilog No.2 and Hilabangan No.2 dam sites were eliminated. (Refer to Figs. III-2-2 to III-2-6.)

Exploratory core drilling was conducted only at the Ilog No.1 Upper and Hilabangan No.1 dam sites, where the high dams were expected. The geological conditions of these two (2) dam sites are as follows:

The bedrocks which are widely distributed around the project areas are largely composed of hard to moderately hard, low permeable volcanic clastic rocks including soft consolidated or extraordinary high permeable portion.

The unconfined compression test results indicate that the strength of volcanic clastic rocks is relatively low, and the bedrocks are classified as "Low" to "Very Low" strength class. Therefore, the dam type suitable for these sites is to be fill type.

The bedrocks of the Ilog No.1 Upper and Ilog No.1 Lower reservoir areas are composed of volcanic clastic rocks and limestone. The limestone is soft to moderately hard, highly porous coralline or marly rock.

The bedrock of Hilabangan No.1 reservoir is mainly composed of volcanic clastic rocks which are similar to those of the Hilabangan No.1 dam site, but the limestone is found partially.

Leakage of the impounded water through the limestone may be expected and cause problems in view of the distribution of limestone.

4.2 Ilog No.1 Upper and Lower Dam Sites

Dam Site

The bedrock of the Ilog No.1 Upper dam site is largely composed of hard tuff breccia and tuff classified mainly as CM class. The unconsolidated tuff breccia classified as D - CL class is found in the deep location of the left bank bedrock. The permeability of the bedrock including unconsolidated portion is relatively low of less than 7 Lugeon. Both the banks are moderately to slightly weathered to a depth of around 7m from the ground surface, while the riverbed elevation is around 5 m.

Samples taken from the drilled core for unconfined compression tests and the results are shown as follows:

Rock Type	Rock Classification	Strength(km/sq.cm)
Tuff Breccia	CM-CL	76.5-125.8
	CM	183.7-238.0
Tuff	CL	194.8
	CM	323.7

The unconfined compressive strength does not necessarily show the strength of the bedrock, but shows the strength of rock prece. The unconfined compressive strength of volcanic sediments of Tertiary age generally ranges from 50 to 500 kg/sq.cm. The result of the tests thus indicates that the strength of the core samples drilled from the Ilog No.1 Upper dam site is relatively small.

The bedrock for dams are usually classified in accordance with the standard of rock classification shown in the following table.

Description	Unconfined Compression Test (kg/sq.cm)	Class
Very high strength	>2,240	A
High strength	1,120-1,120	B
Medium strength	560-1,120	C
Low strength	280-560	D
Very low strength	<280	E

The bedrocks of Ilog No.1 Upper site are classified as "Low to Very Low Strength". As for Ilog No.1 Lower dam site, the lithological condition of basement rocks are similar to that of the Ilog No.1 Upper dam site.

The geology at the Ilog No.1 Upper dam site recognized through the above-said studies is presented in Fig. III-2-9.

Reservoir Area

The bedrocks of Ilog No.1 Upper and Lower reservoir areas are composed of volcanic clastic rocks and limestone. The limestone is highly porous rock.

In the eastern part of the Ilog No.1 reservoir area, the limestone body extends from the south (upper reaches) to the north (lower reaches). The upper course of the Ilog river is flanked by the limestone area. The limestone area as shown in Fig. III-2-5 is deemed to be distributed higher than about EL.25 m of the riverbed.

The leakage of the impounded water through the limestone may be expected and cause problems in view of the distribution of limestone.

Engineering geology

(1) Ilog No.1 Upper Damsite

Approximately 80 meters of dam height is possible judging from the following conditions of the dam site.

(a) There is no particular problem in the dam foundation from the geological point of view.

(b) The topography of dam site and the reservoir area allows the dam up to that height.

However, the leakage may cause many problems because the porous limestone zone is widely distributed in the reservoir area. The limestone zone is deemed to be distributed higher than EL. 25 m of the Ilog riverbed. The proposed dam site is located at about EL. 10 m of the riverbed. Therefore, in case the high water level of the reservoir is higher than 25 meters of elevation, special provision has to be made for leakage and accompanying effects to the surroundings.

(2) Ilog No.1 Lower Damsite

Judging from the topographical condition and geological survey, approximately 35 meters of dam height is possible. However, as in the case of the upper site, the high water level of the reservoir exceeds EL.25 m and leakage countermeasures are required. The lower site has an advantage over the upper site because of its larger storage capacity.

4.3 Hilabangan No.1 Dam Site

Dam Site

The geological feature of the Hilabangan No.1 dam site is almost similar to that of the Ilog No.1 dam site. However, the permeability of unconsolidated to moderately consolidated part of the left bank shows a high value of over 100 Lugeon. The unconsolidated alluvium deposits composed of sand and gravel overlay the bed rock of the riverbed to a thickness of around 14 meters.

Samples taken from the drilled core for unconfined compression tests and the results are shown as follows:

Rock Type	Rock Classification	Strength (km/sq.cm)
Tuff Breccia	CM-CL	85.4-165.9
	CM	110.9-116.8
Tuff	CM-CL	97.4
	CM	103.4

The result of the tests indicates that the strength of the core samples drilled from the Hilabangan No.1 dam site is relatively small. According to the standard of rock classification, the bedrocks of Hilabangan No.1 site are classified as "Low to Very Low Strength".

The geology at the Hilabangan No.1 dam site identified by the above-said study is presented in Fig. III-2-10.

Reservoir Area

The bedrock of Hilabangan No.1 reservoir is mainly composed of volcanic clastic rocks, however, the limestone is found partially. Though the limestone is generally harder than the limestone spread at the Ilog No.1 reservoir area, solution cavities may be formed judging from the existence of sinkholes in the area. The limestone area as shown in Fig. III-2-6 is deemed to be distributed higher than EL.150 m of the riverbed approximately up to Hilabangan No.2 dam site.

Engineering Geology

Leakage is expected through the porous limestone zone widely distributed in the reservoir area. The limestone zone is deemed to be distributed above the elevation of 150 meters, approximately up to the Hilabangan No.2 dam site. Since the riverbed elevation of the Hilabangan No.2 dam site is around 70 meters, the dam higher than 80 meters requires the provision for leakage and its accompanying effect to the surroundings.

TABLES

Table III-2-1 ITEMS AND QUANTITIES OF GEOLOGICAL INVESTIGATION

Location	Geological Exploration		Test Drilling		Laboratory Test
	Dam Site	Reservoir	Core	Permeability	
Ilog No.1 Upper	*	*	* (140 m)	* (28 stages)	* (10 samples)
Ilog No.1 Lower	*	*	-	-	-
Ilog No.2	*	-	-	-	-
Hilabangan No.1	*	*	* (160 m)	* (32 stages)	* (8 samples)
Hilabangan No.2	*	-	-	-	-

Note * : Executed.

Table III-2-2 QUANTITIES OF EXPLORATORY DRILLING

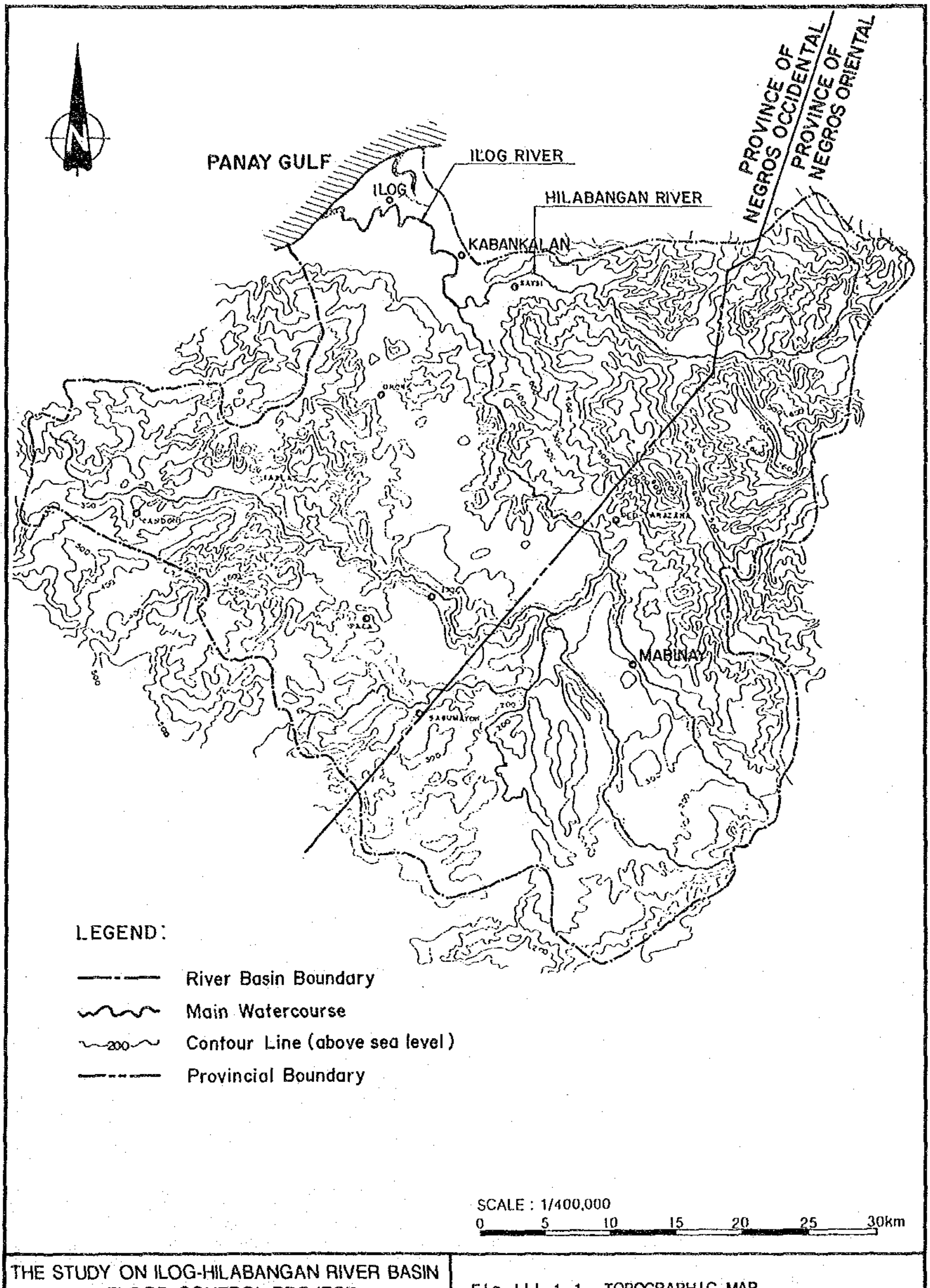
Location	Hole No.	Elevation (m)	Depth (m)	Permeability Test (stages)	Unconfined Compression Test (samples)
Ilog No.1 Upper					
- Left Bank	I1 - 1	42	50	10	2
- Riverbed	I1 - 2	40	50	10	5
- Right Bank	I1 - 3	48	40	8	3
Hilabangan No.1					
- Right Bank	H1 - 1	90	40	8	2
- Riverbed	H1 - 2	80	80	16	3
- Left Bank	H1 - 3	120	40	8	3
Total			300	60	18

Table III-2-3 RESULTS OF UNCONFINED COMPRESSION TEST

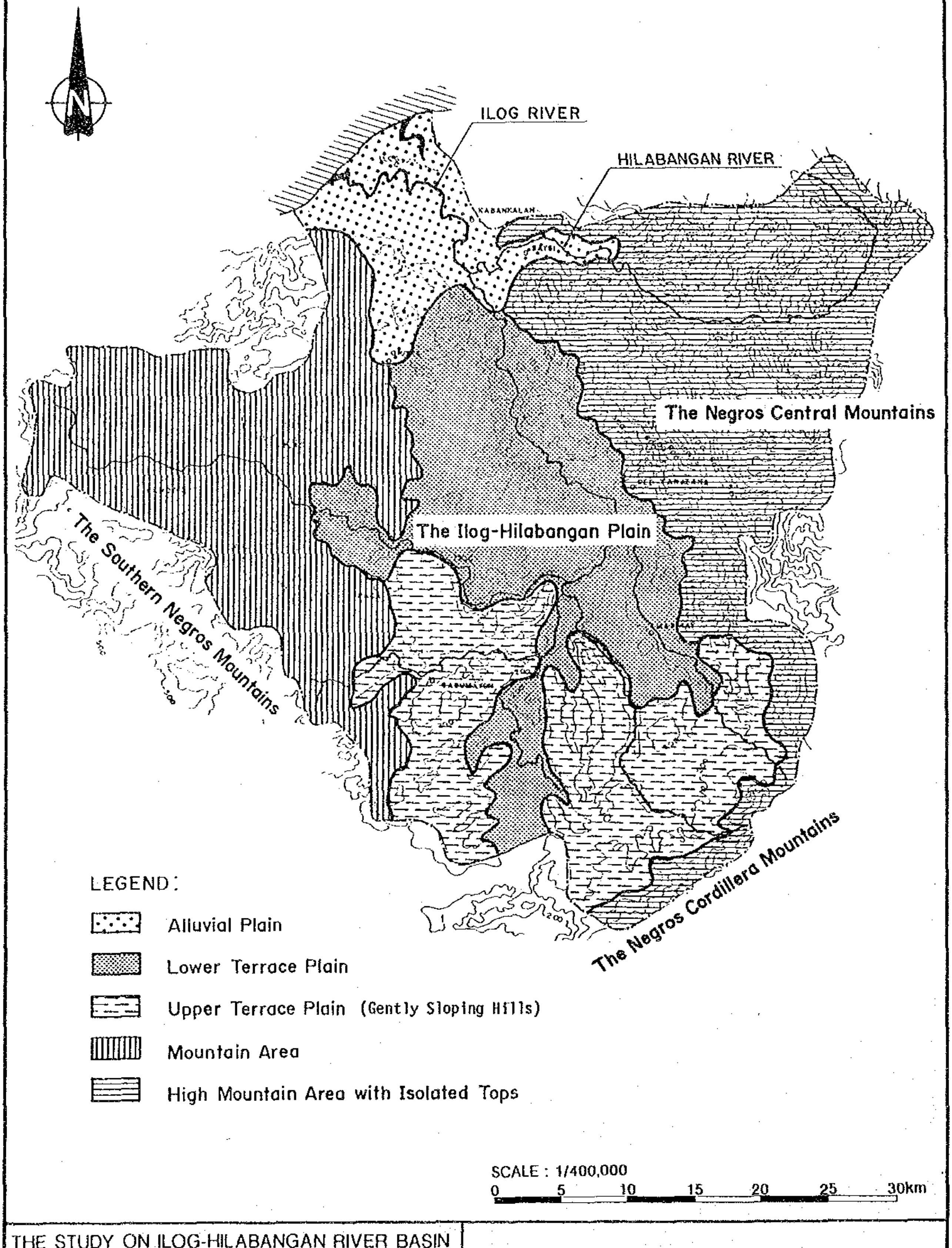
No.	Location: Borehole	Location: Depth (m)	Geology	Rock Classification	Wet Density t(g/cm3)	Unconfined Compressive Strength qu(kg/cm2)
1.	I1 - 1	16.5 - 16.7	Tuff Breccia	CM - CL	1.49	76.5
2.	I1 - 1	16.0 - 16.2	Tuff Breccia	CM - CL	2.30	101.8
3.	I1 - 2	2.0 - 2.2	Tuff Breccia	CM	2.30	194.8
4.	I1 - 2	4.2 - 4.5	Tuff Breccia	CM	2.22	178.1
5.	I1 - 2	19.0 - 19.2	Tuff	CM	2.31	323.7
6.	I1 - 2	31.1 - 31.3	Tuff Breccia	CM	2.18	183.7
7.	I1 - 2	40.3 - 40.5	Tuff Breccia	CM	2.27	227.6
8.	I1 - 3	5.8 - 6.0	Tuff Breccia	CM - CL	2.54	125.8
9.	I1 - 3	15.0 - 15.2	Tuff Breccia	CM	2.14	238.0
10.	I1 - 3	30.0 - 30.2	Tuff Breccia	CM	2.22	205.6
11.	H1 - 1	10.4 - 10.6	Tuff Breccia	CM - CL	1.96	101.4
12.	H1 - 1	37.8 - 38.0	Tuff	CM - CL	1.98	103.4
13.	H1 - 2	21.0 - 21.2	Tuff Breccia	CM - CL	2.06	85.4
14.	H1 - 2	28.0 - 28.2	Tuff Breccia	CM - CL	2.09	165.9
15.	H1 - 2	55.0 - 55.3	Tuff Breccia	CM - CL	2.14	94.7
16.	H1 - 3	10.4 - 10.6	Tuff	CL	1.89	97.4
17.	H1 - 3	12.3 - 12.5	Tuff Breccia	CM	1.99	110.9
18.	H1 - 3	15.3 - 15.5	Tuff Breccia	CM	2.01	116.8

Note : Refer to Fig. III-2-7 for the location of boreholes.

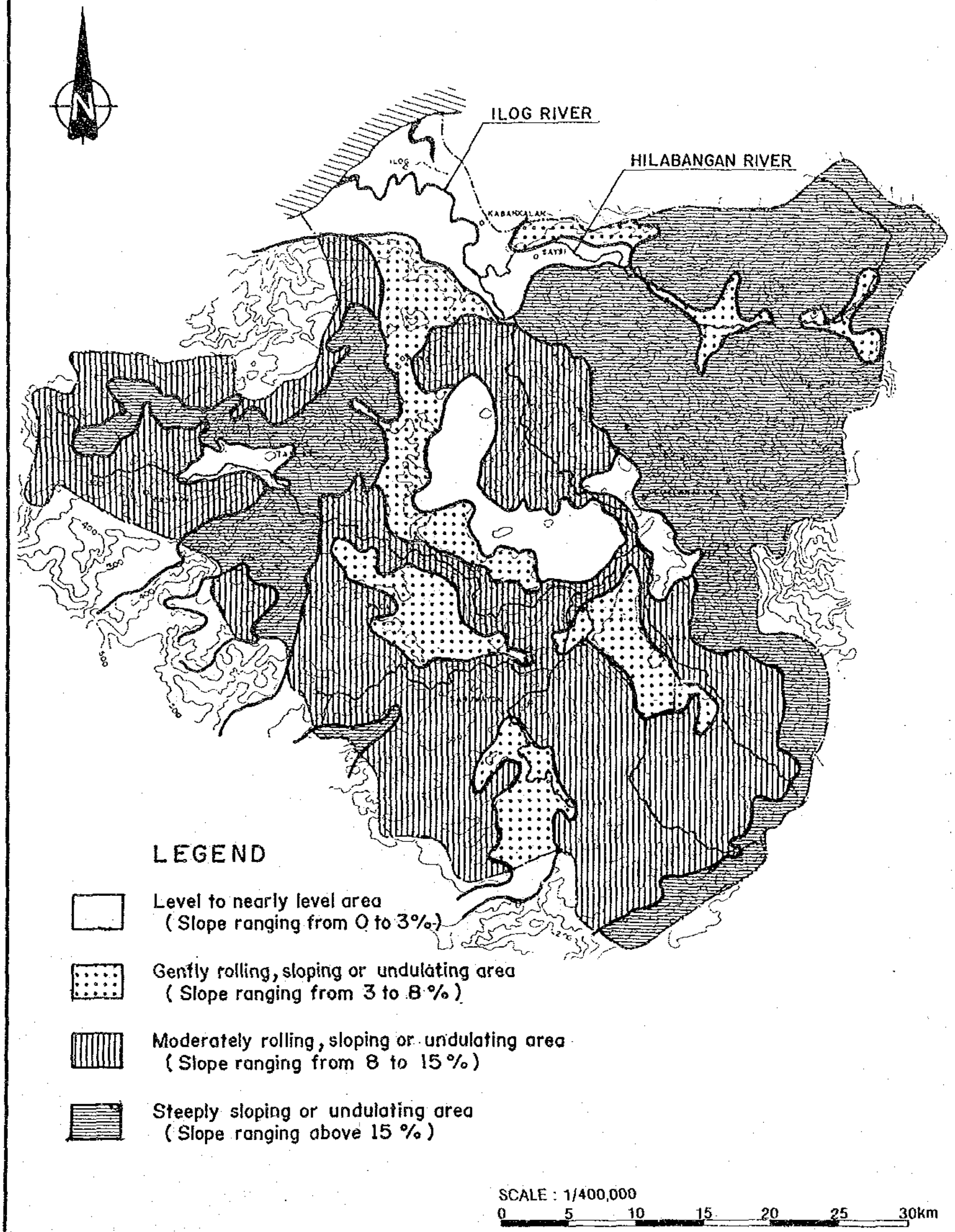
FIGURES



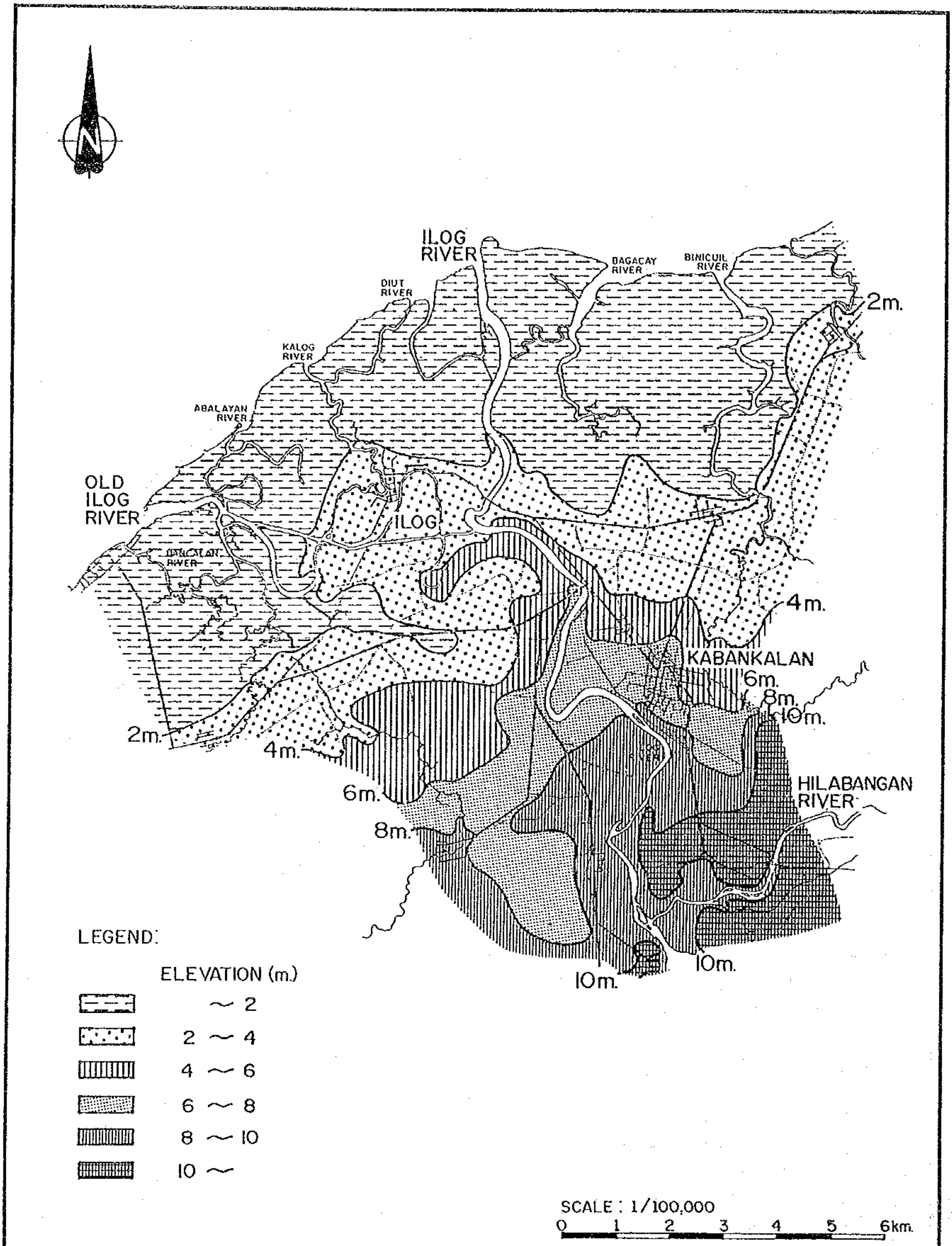
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-1-1 TOPOGRAPHIC MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	



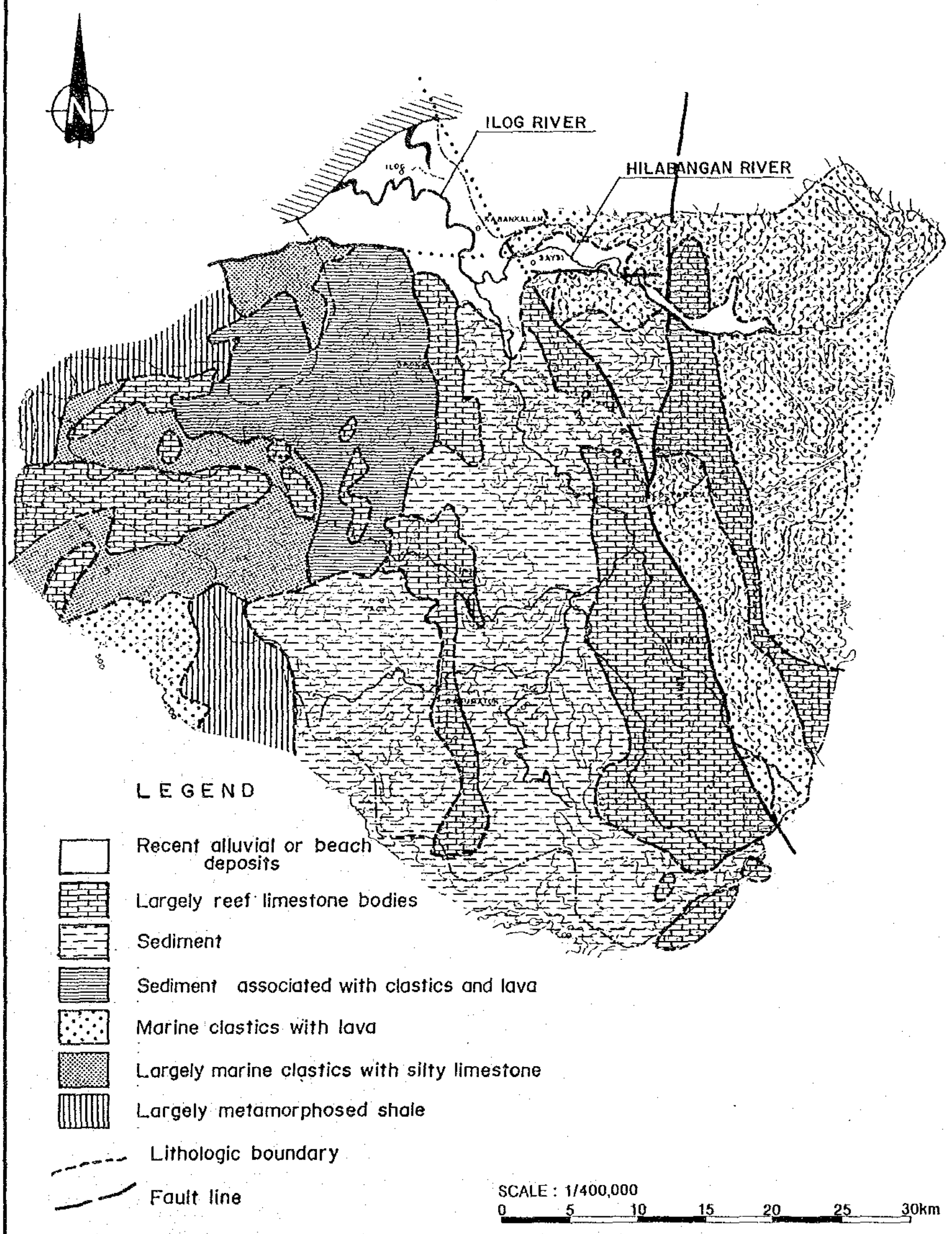
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-1-2 LANDFORM
JAPAN INTERNATIONAL COOPERATION AGENCY	



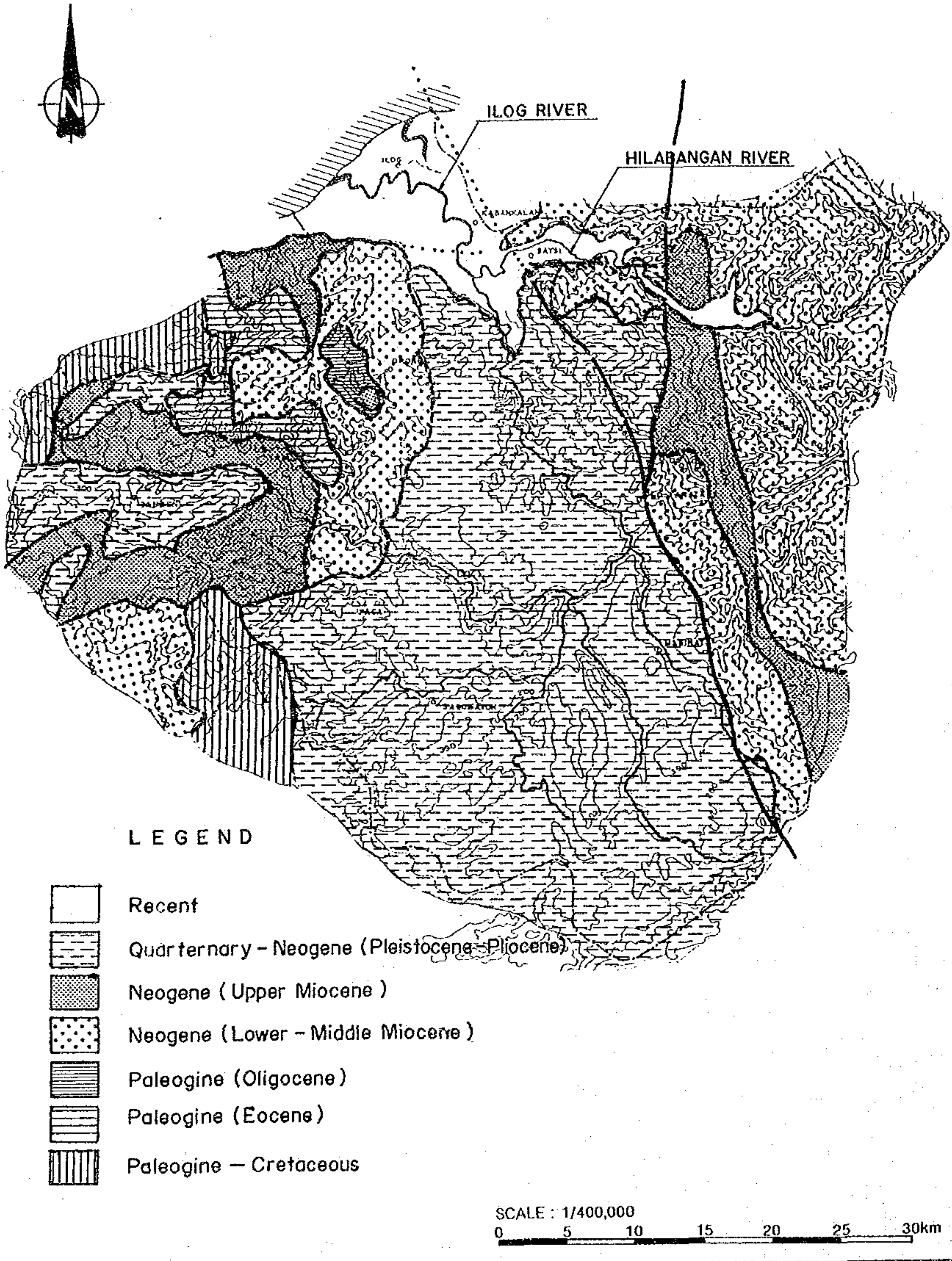
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-1-3 GENERALIZED SLOPE
JAPAN INTERNATIONAL COOPERATION AGENCY	



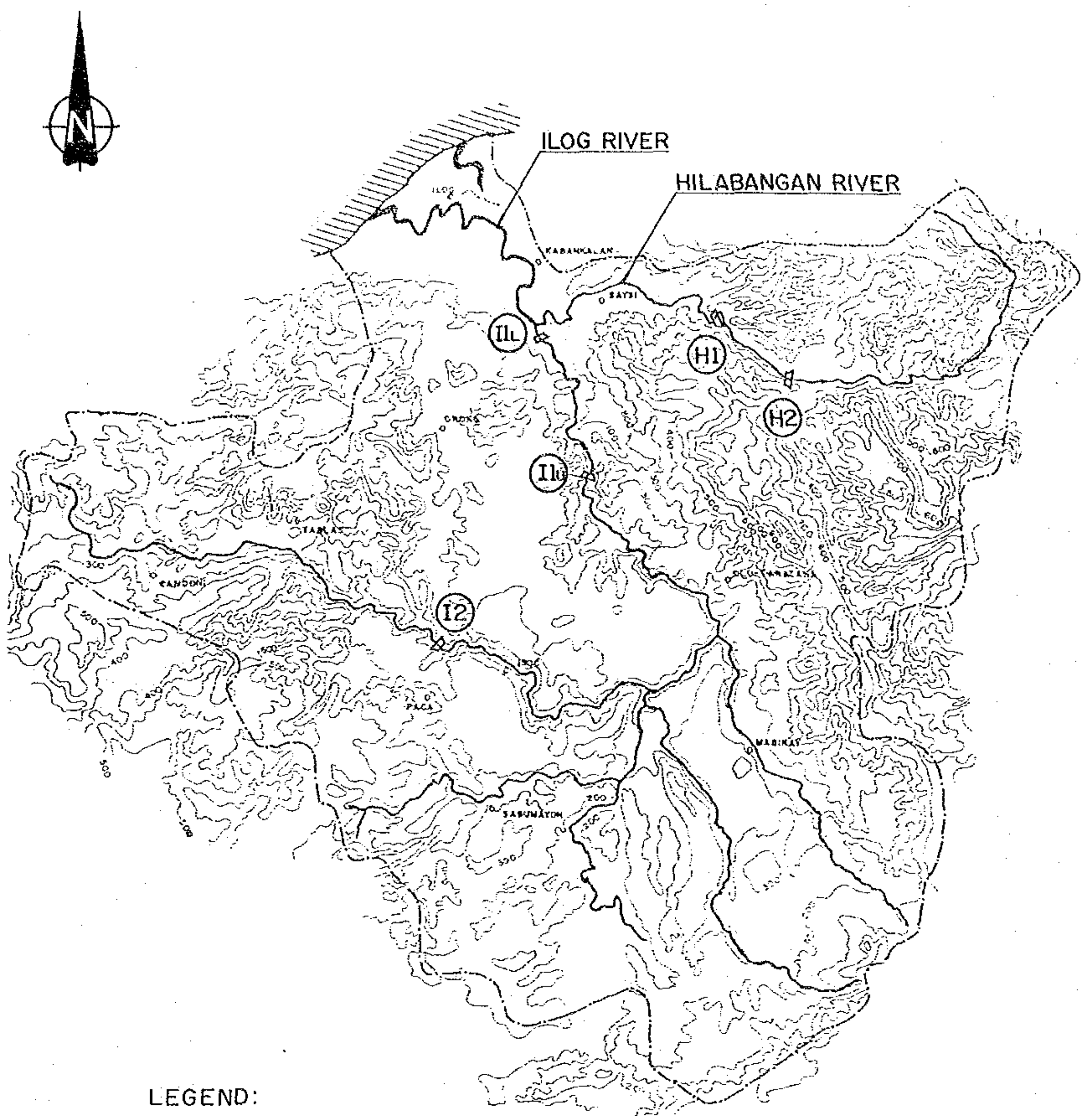
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-1-4 ELEVATION CLASSIFICATION OF THE LOWER REACHES
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-1-5 LITHOLOGICAL MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-1-6 GEOLOGIC MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	



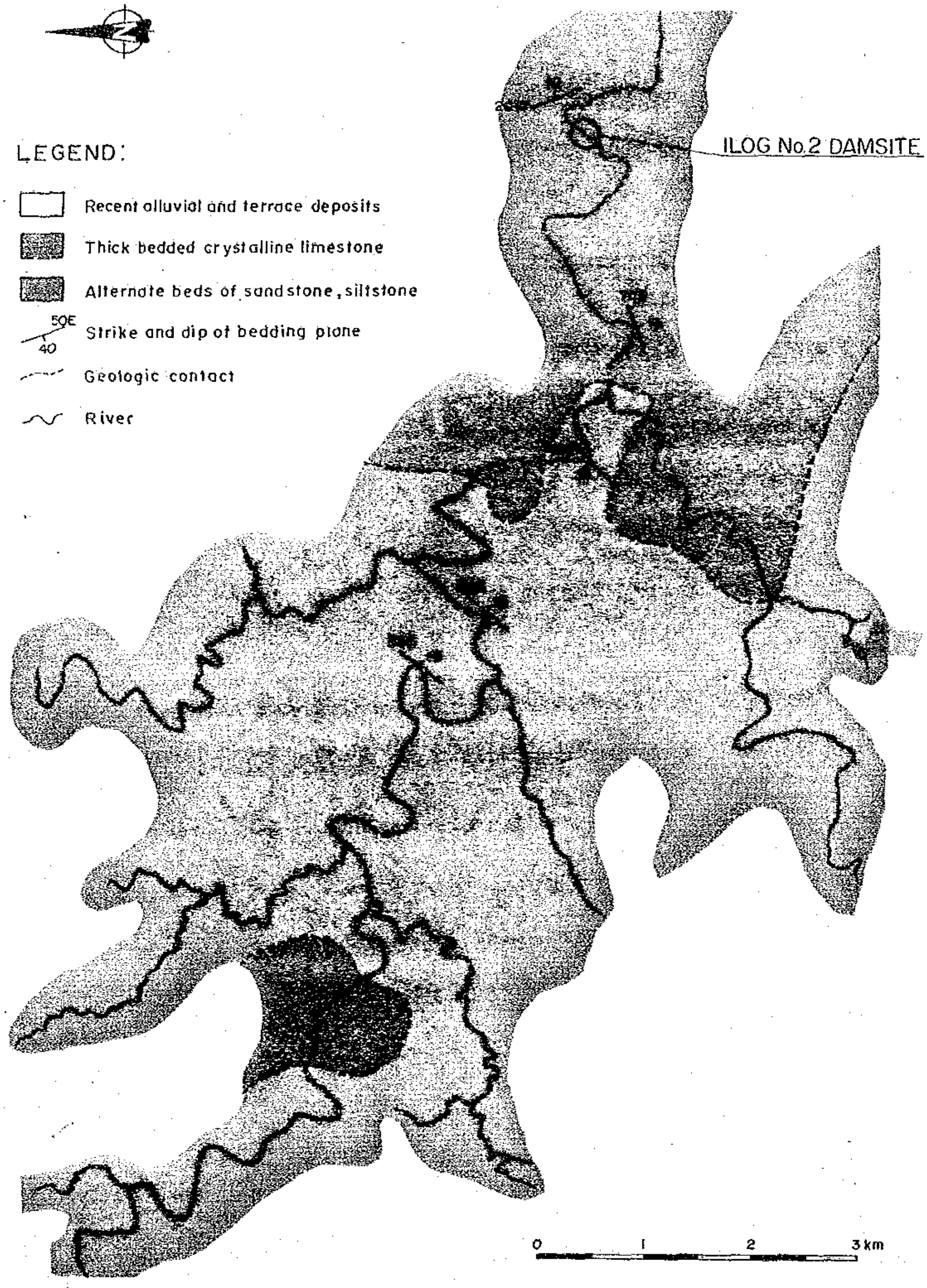
LEGEND:

- (H1) HILABANGAN No. 1 DAM SITE
- (H2) HILABANGAN No.2 DAM SITE
- (Ilu) ILOG No. 1 DAM SITE (UPPER SITE)
- (IlL) ILOG No. 1 DAM SITE (LOWER SITE)
- (I2) ILOG No. 2 DAM SITE

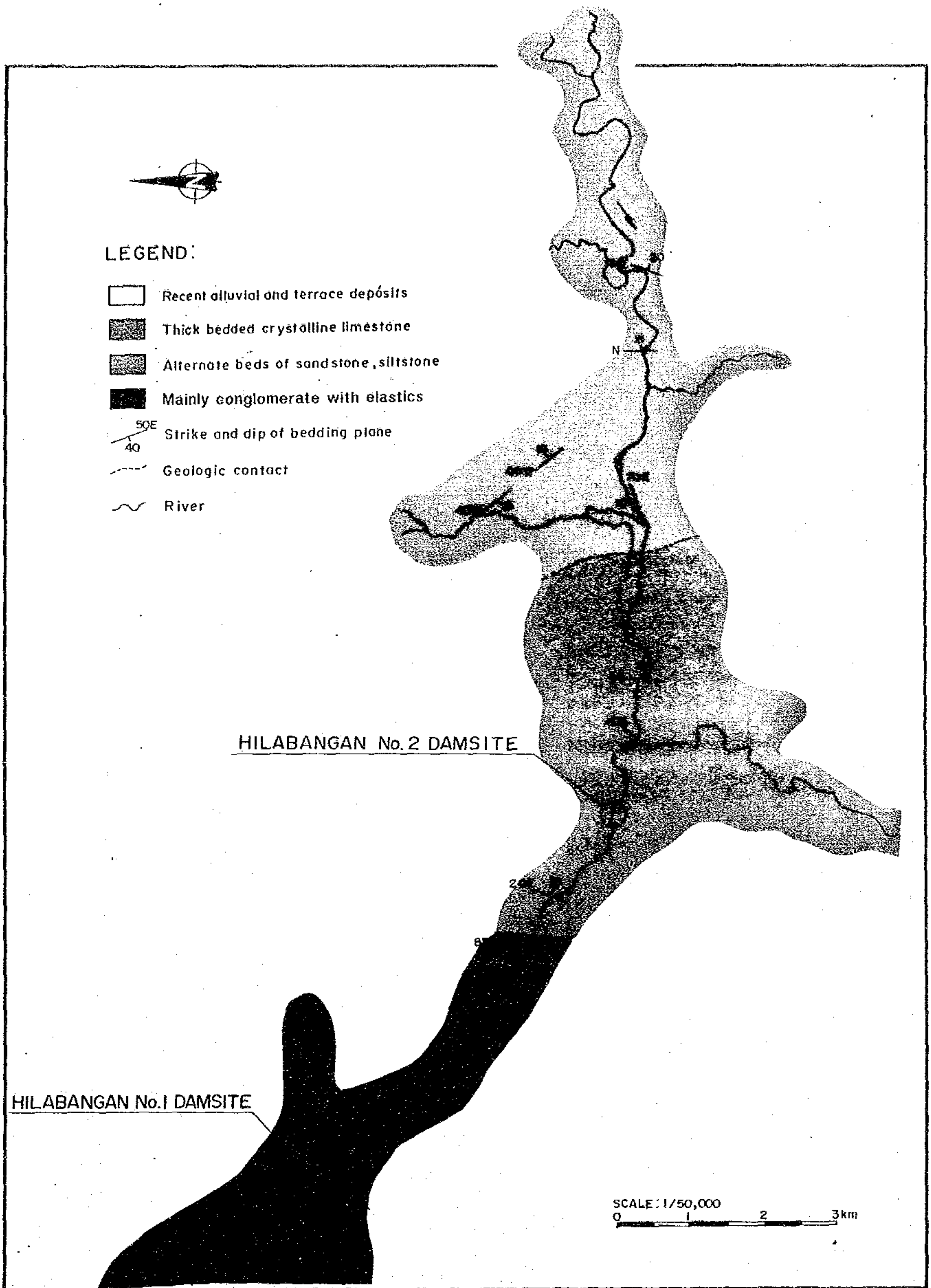
SCALE : 1/400,000

0 5 10 15 20 25 30km

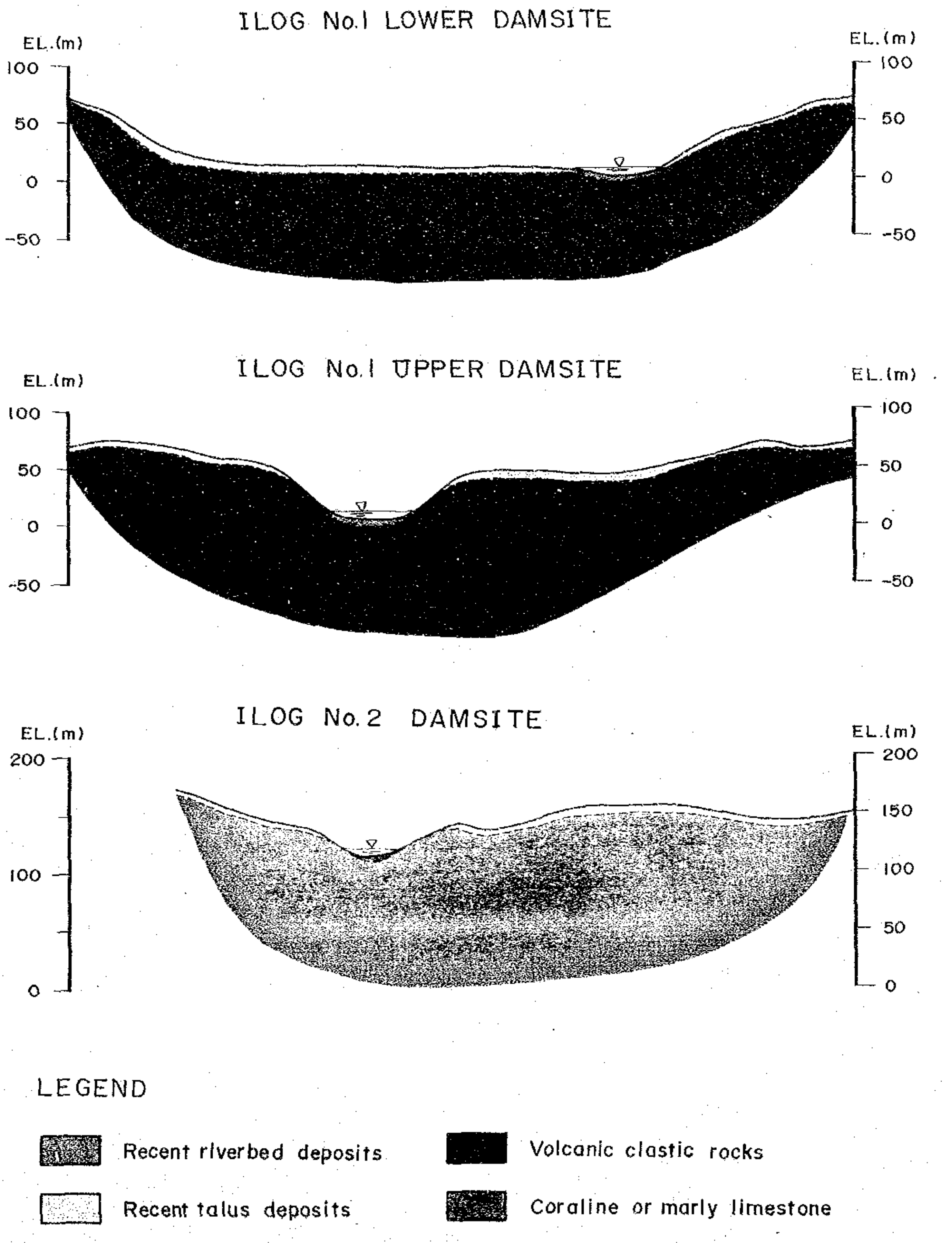
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. III-2-1 LOCATION OF POSSIBLE DAM SITES



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-2 GEOLOGIC MAP OF ILOG NO.2 DAM SITE
JAPAN INTERNATIONAL COOPERATION AGENCY	



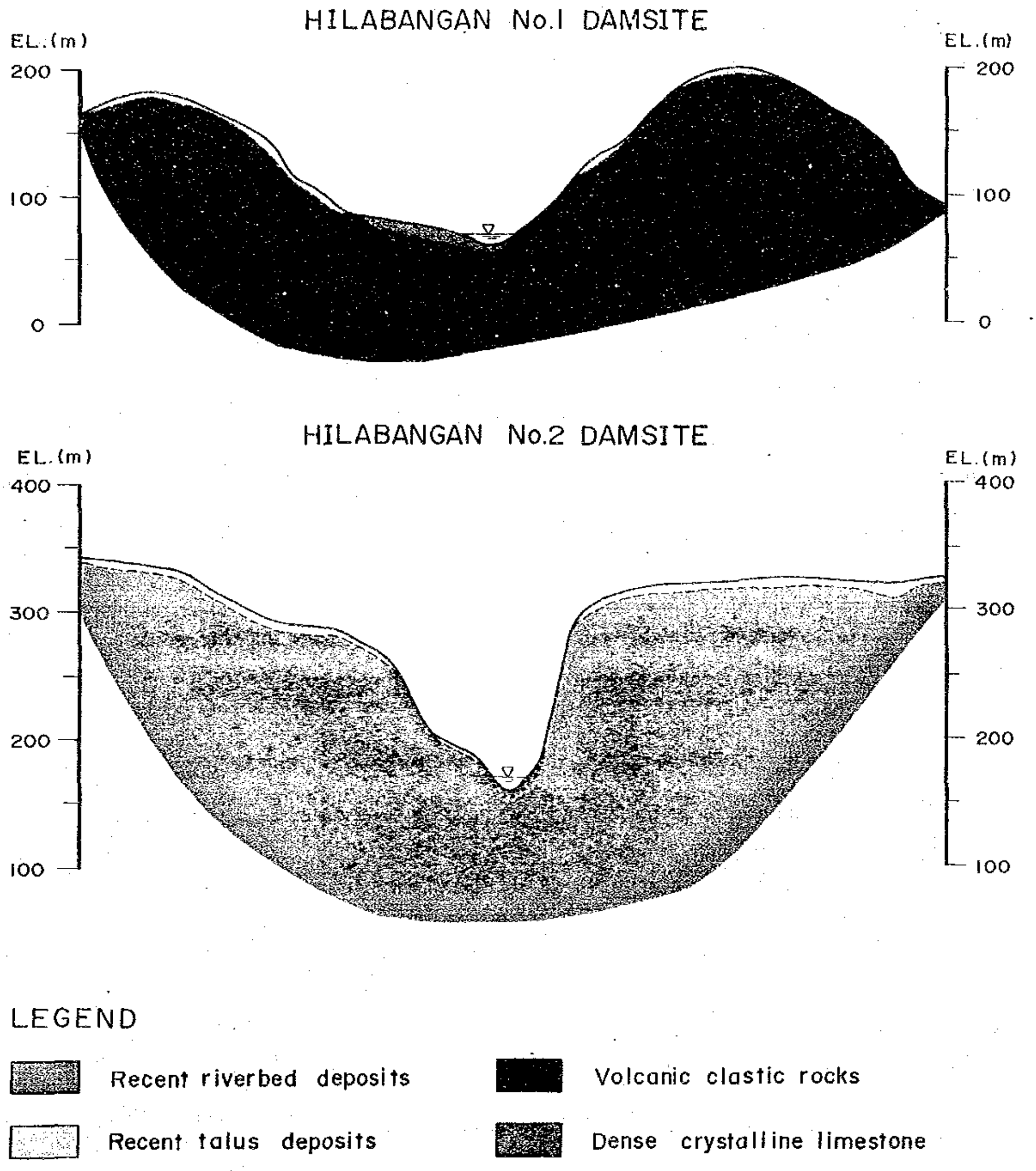
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-3 GEOLOGIC MAP OF HILABANGAN NO. 2 DAM SITE
JAPAN INTERNATIONAL COOPERATION AGENCY	



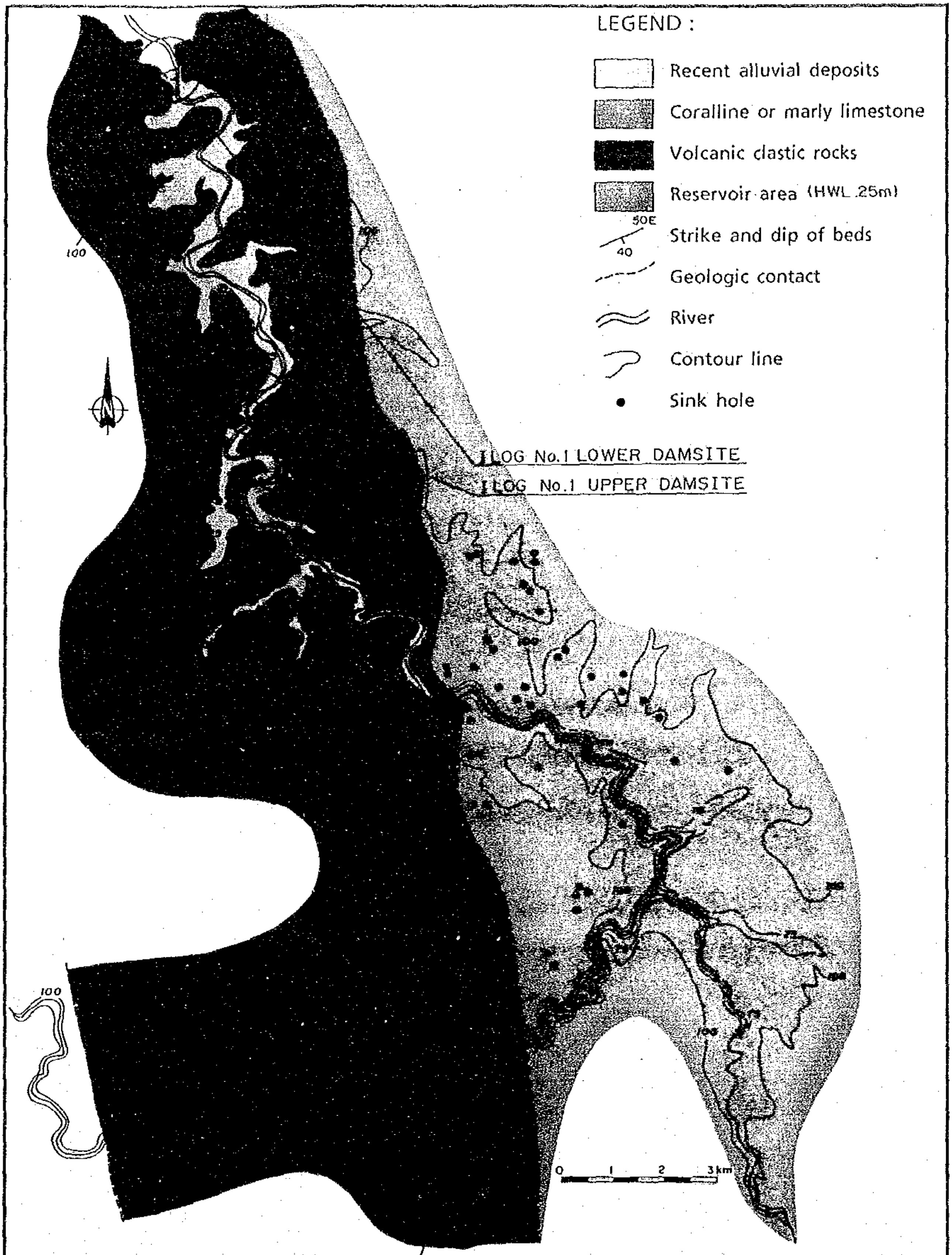
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

Fig.III-2-4 GEOLOGIC SECTION OF DAM SITE (1/2)



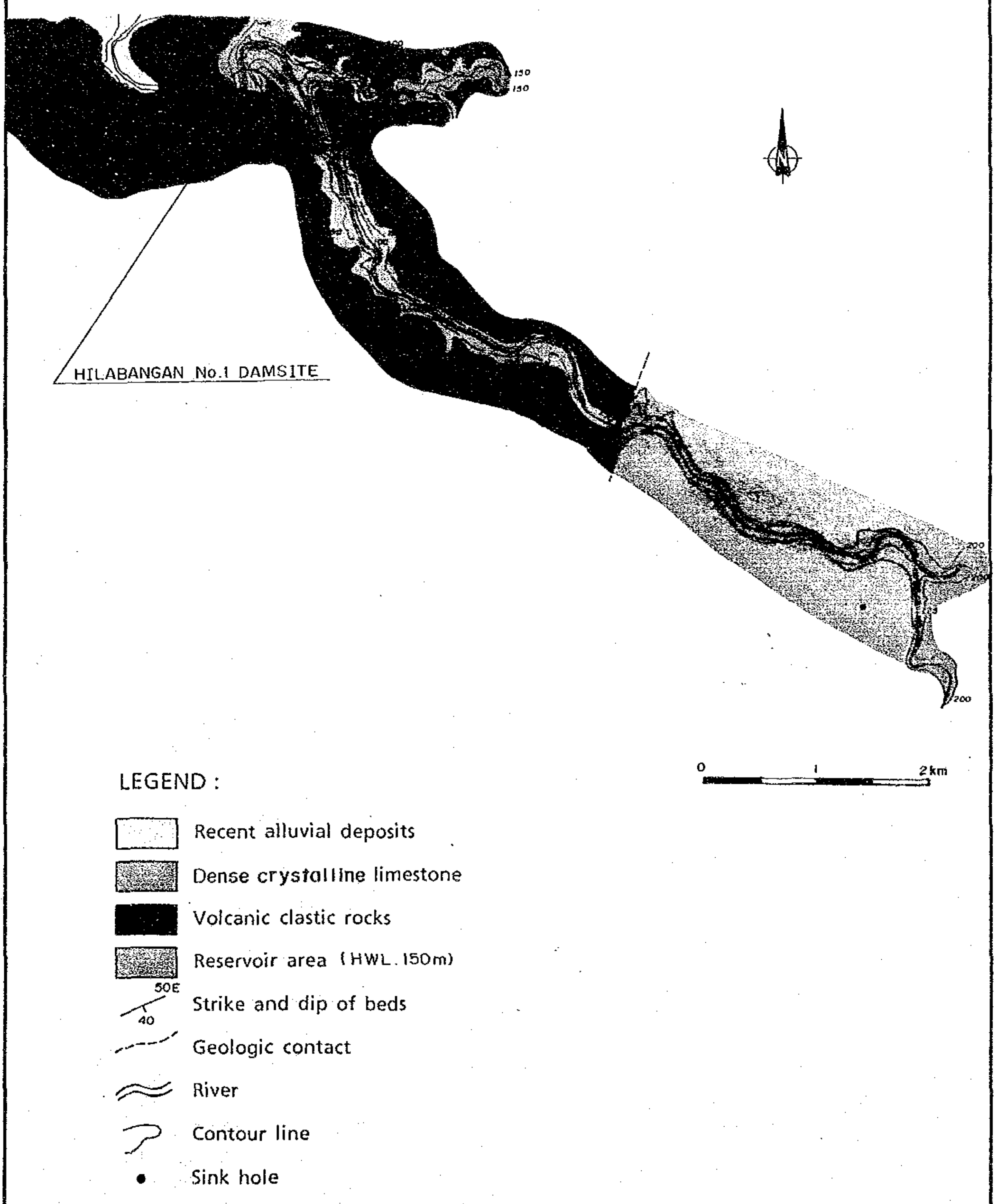
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig.III-2-4 GEOLOGIC SECTION OF DAM SITE (2/2)
JAPAN INTERNATIONAL COOPERATION AGENCY	



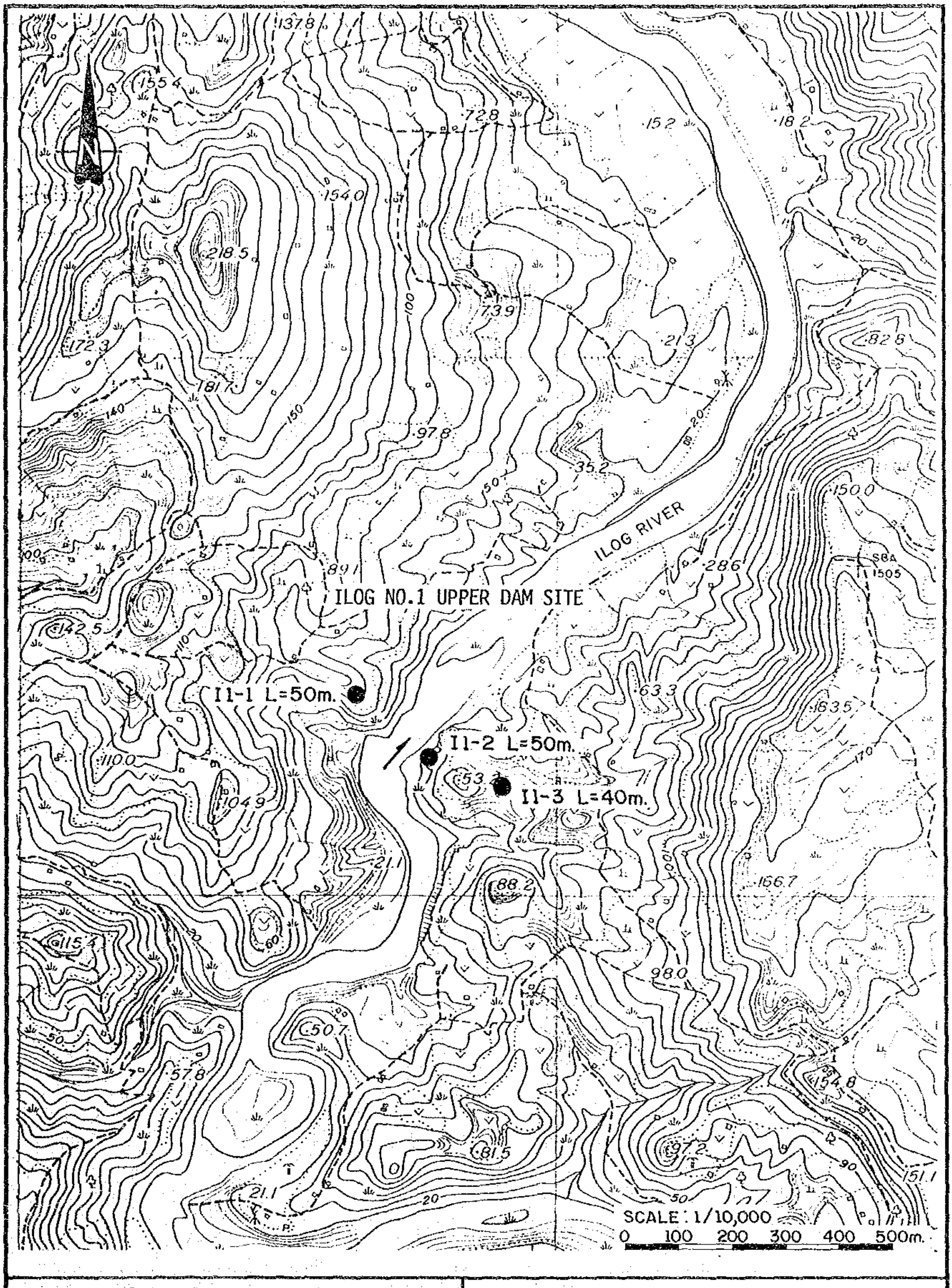
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

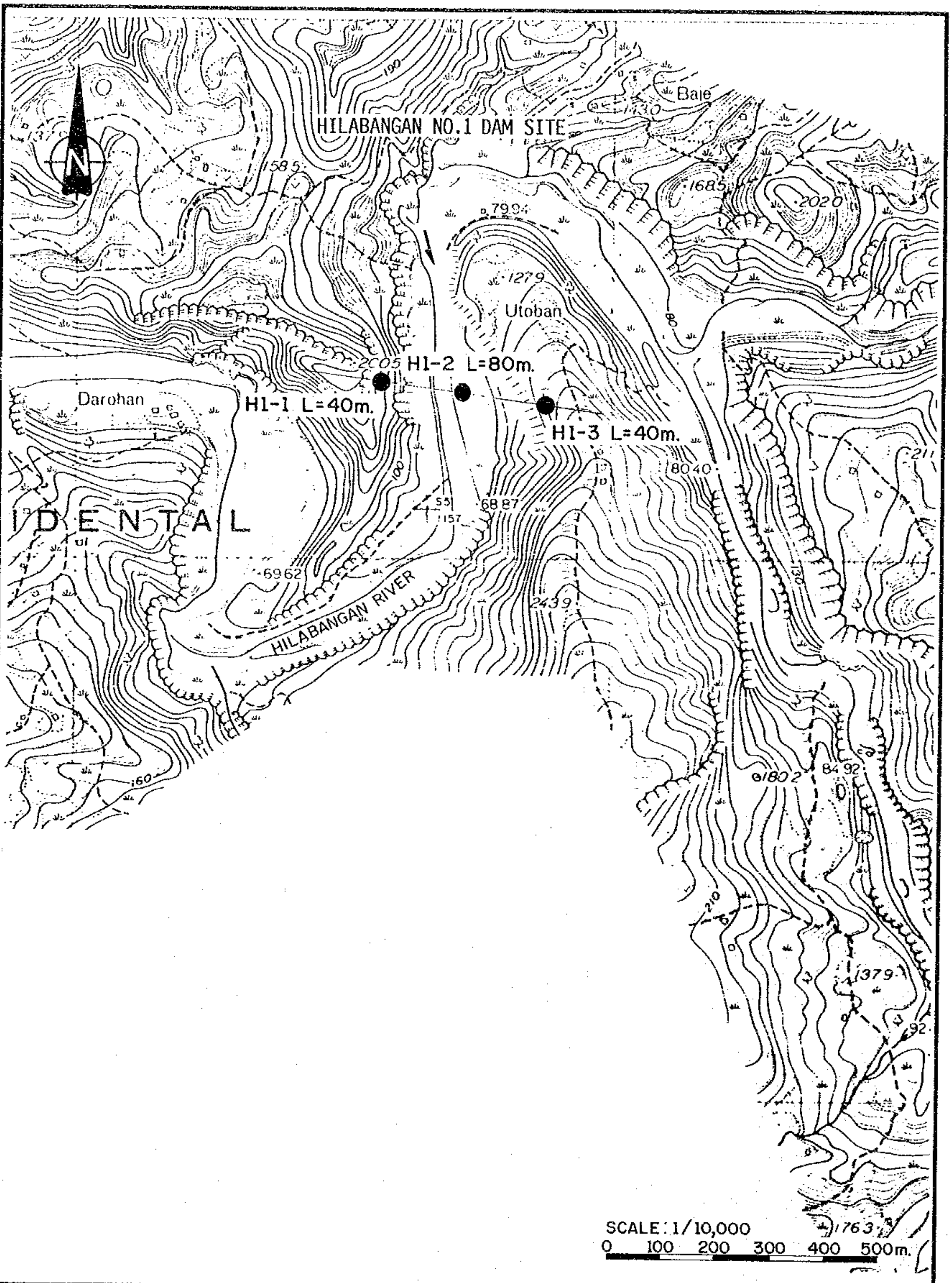
Fig. III-2-5 GEOLOGIC MAP OF ILOG NO.1 UPPER AND LOWER DAM SITES



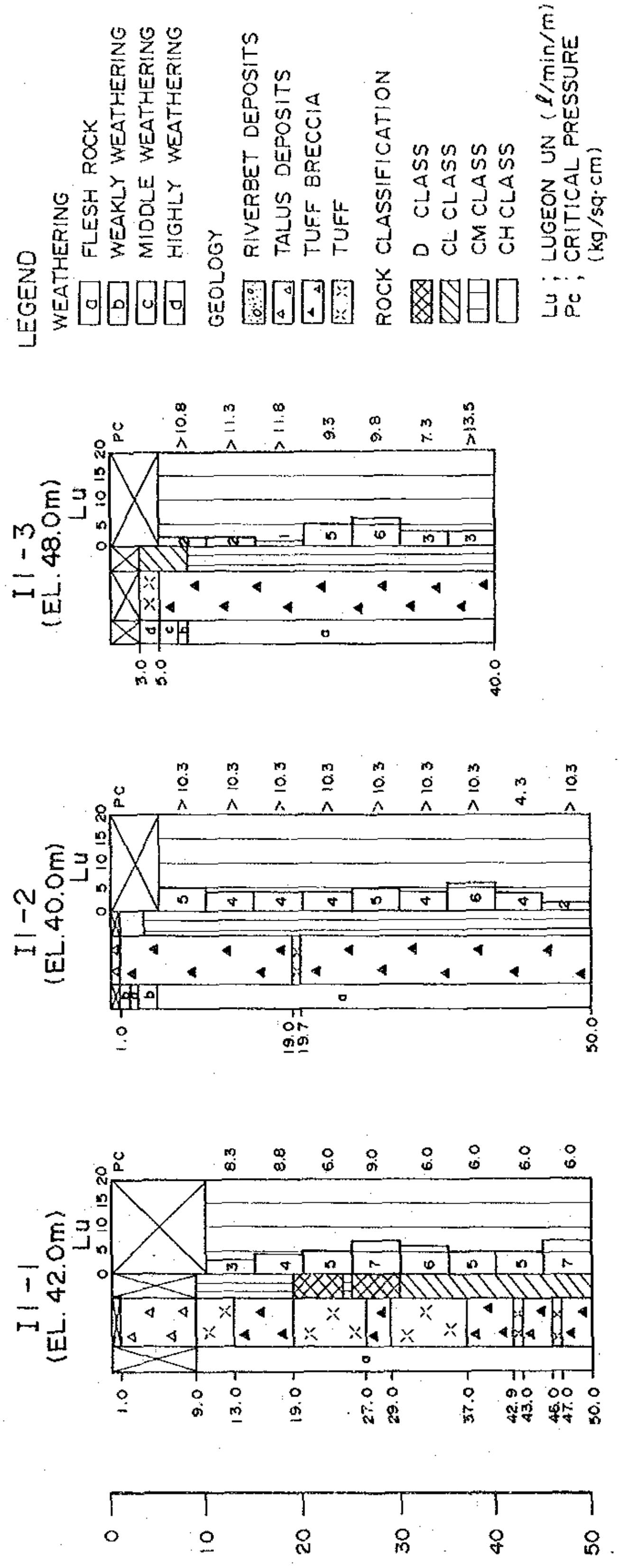
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-6 GEOLOGIC MAP OF HILABANGAN NO. 1 DAM SITE
JAPAN INTERNATIONAL COOPERATION AGENCY	



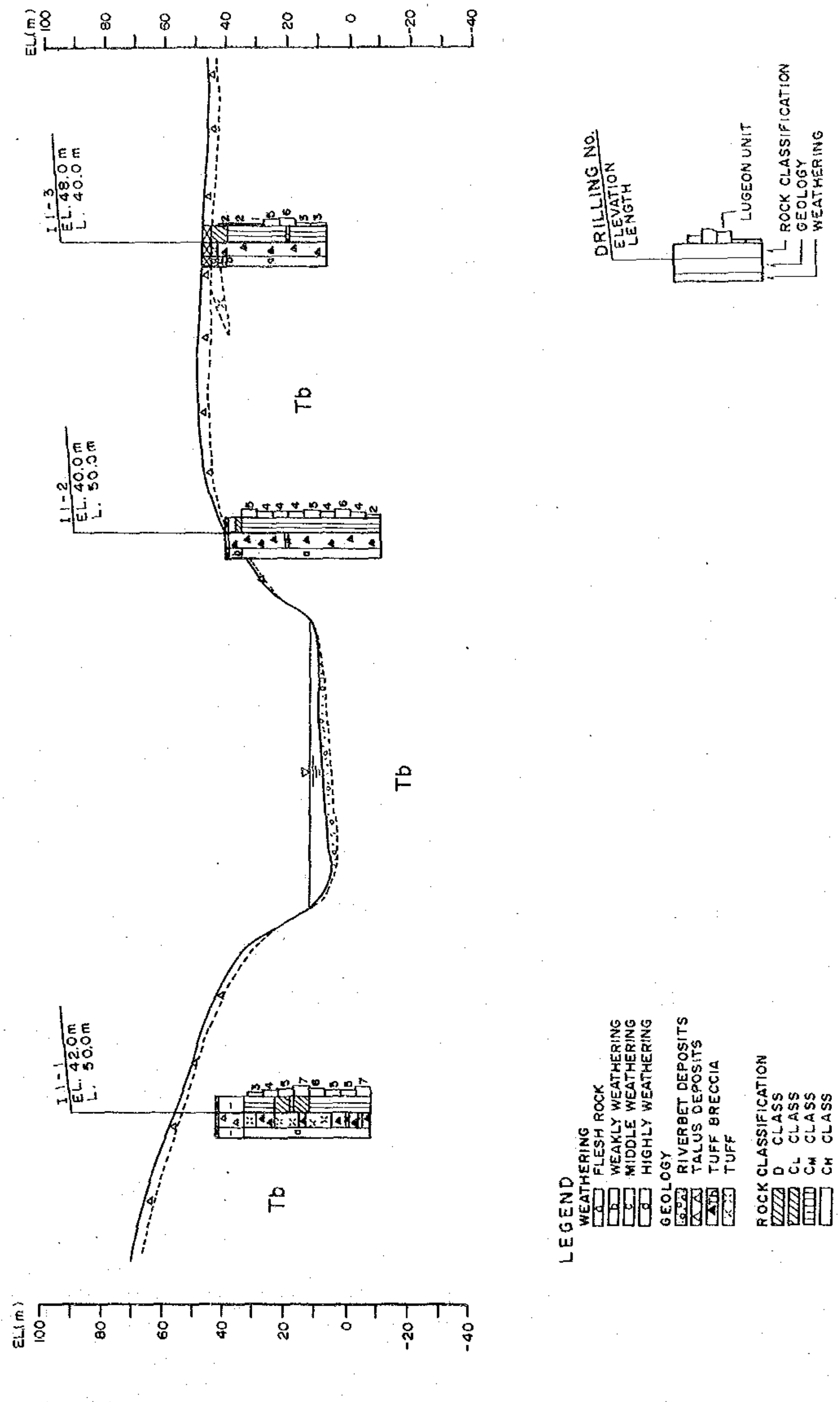
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-7 (1/2) LOCATION MAP OF BORING POINTS
JAPAN INTERNATIONAL COOPERATION AGENCY	



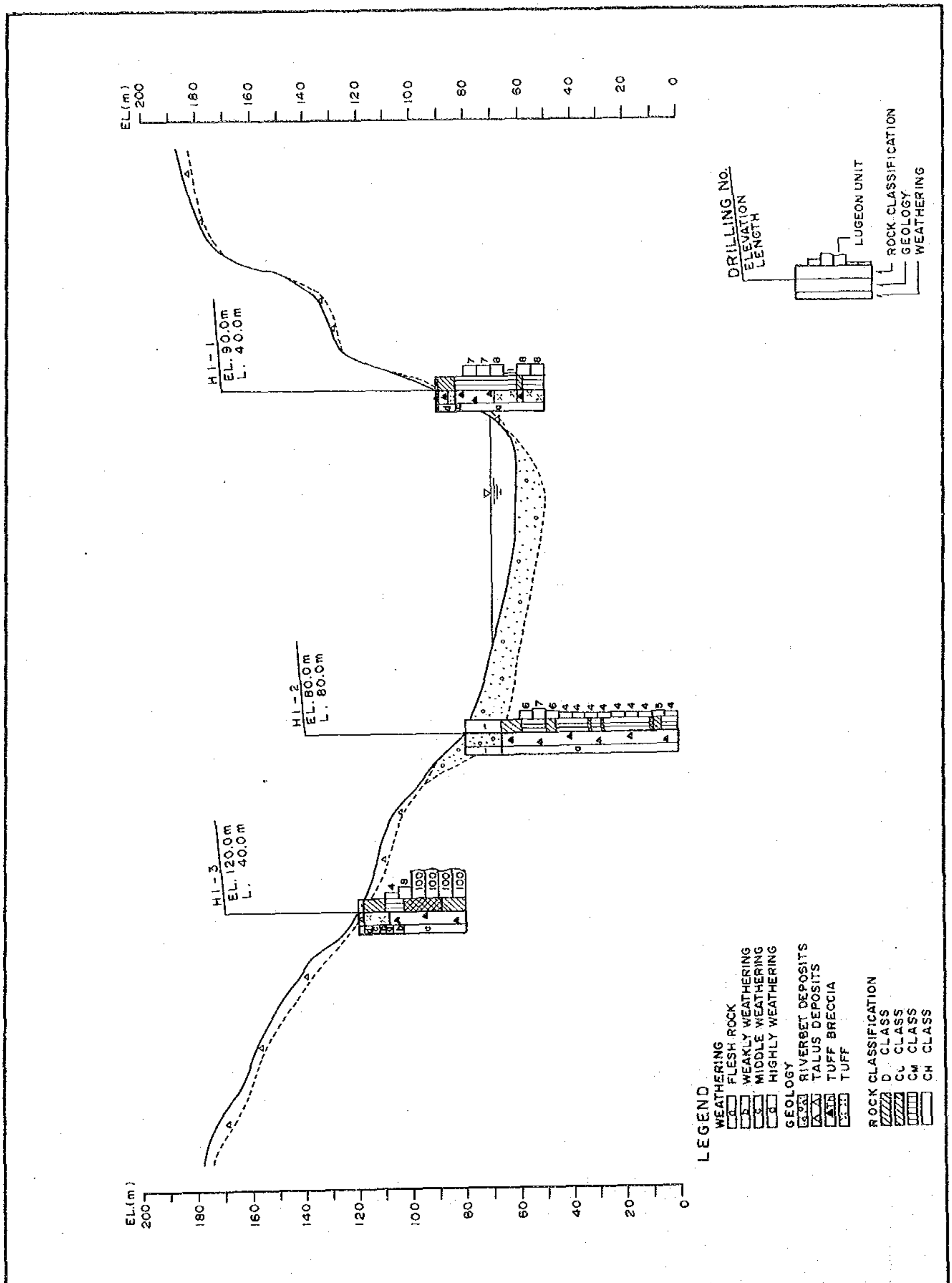
THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-7 (2/2) LOCATION MAP OF BORING POINTS
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-8 (1/2) DRILLING LOGS AND RESULTS OF BOREHOLE PERMEABILITY TEST
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-9 GEOLOGIC SECTION OF ILOG NO. 1 UPPER DAM SITE
JAPAN INTERNATIONAL COOPERATION AGENCY	



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. III-2-10 GEOLOGIC SECTION OF HILABANGAN NO.1 DAM SITE
JAPAN INTERNATIONAL COOPERATION AGENCY	

IV. WATER RESOURCES DEVELOPMENT

STUDY
ON
ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

SUPPORTING REPORT IV. WATER RESOURCES DEVELOPMENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. PRESENT WATER UTILIZATION

1.1 Water Balance

Available Water Resources

The water balance of the Ilog-Hilabangan River Basin which has a drainage area of 2,162 km^2 is assumed as follows based on the hydrological data:

Item	Amount of Water (mm)	(MCM)
Surface Runoff	1,400	3,030
- Flood Runoff	1,140	2,470
- Base Flow	260	560
Evapo-transpiration	1,000	2,160
Percolation	100	210
Total	2,500*	5,400

* Average annual rainfall for 20 years.

Some portions of percolation come out into the river as groundwater. Assuming that 50% of percolation retrieves as groundwater, the total available water including flood runoff of 2,470 MCM, base flow of 560 MCM and percolation of 105 MCM (210 MCM/2) is estimated at approximately 3,100 MCM. (Refer to Fig. IV-1-1.)

Present Water Utilization

There are ten (10) communal irrigation systems for paddy fields in the study area. Irrigation water for paddy and sugarcane cultivation is obtained from many tributaries using intake weirs or portable pumps.

There is no water intake facility in the main stream of the Ilog River. For domestic water supply, many wells are operated in the lower basin which is estimated to be plentiful in groundwater.

There are many brackishwater fishponds in the estuary. The prawn farms have pump stations to draw brackishwater from the tidal river and the others have facilities for natural intake. Additionally, there are two (2) sugar plants in the area that use much water for their cooling system.

The present water utilization is estimated at 52 MCM/year as tabulated in the following table. The water use ratio is only 2% of the total usable water of about 3,100 MCM (i.e., 52 MCM/ 3,100 MCM x 100 = 2%), which means that 98% of the water resources flow out into the sea without being used.

Demand	Annual Volume
Irrigation Sugarcane	10.4 MCM (20%)
Paddy	8.9 MCM (17%)
Aquaculture (Prawn Pond)	8.3 MCM (16%)
Domestic Water	5.0 MCM (9%)
Industrial Water	19.5 MCM (38%)
Total	52.1 MCM (100%)

The water utilization under each category of water use is discussed in the following subsections.

1.2 Agriculture and Irrigation

Production of Sugarcane and Rice

Negros Island is the region leading in sugar production in the Philippines, producing 59% of the total sugar production in the country (cropping year 1988-1989). Sugar price, however, stagnated for a very long period. Furthermore, alternative starch based and low calorie sweeteners had steadily invaded the sugar market. To get over such difficulties of the sugarcane industry, the following countermeasures are to be taken:

(1) To increase the unit yield per hectare with the construction of irrigation systems and improvement of cultivation techniques; and

(2) To lower production cost by rationalization management.

Presently, the study area is extensively cropped with sugarcane, with palay ranking second, followed by corn, coconut and some root crops. The present unit yield of sugarcane in the basin is estimated at 43 tons per ha. This yield is below the country's average of 67 tons in 1989 and only 50% of sugar producing countries like Indonesia and Peru. On the other hand, the unit yield of palay is estimated at 2.5 tons per hectare.

The self-sufficiency rate of rice in this island is at a low level. The total demand of palay is calculated at 523,000 tons based on per capita consumption of 100 kg of rice. Since the production of palay is 274,700 tons based on average production in 1984-1986, the self-sufficiency rate is 53%. Shortage was supplemented by other grains such as corn and importation from other provinces. If this scenario will not change, the self-sufficiency rate is estimated at 38% by 2020 due to the increase of population. (Refer to Tables IV-1-1 and IV-1-2.)

Present Condition of Irrigation

Based on the land use and vegetation map shown in Fig. IV-1-2, present land use in the basin is roughly estimated as shown in Table IV-1-3. The areas of sugarcane and paddy are 36,900 ha and 13,800 ha, respectively.

Most of the farms are under rainfed condition. At present, sugarcane plantations in some areas are served by irrigation systems. The actual irrigated sugarcane is estimated at about 730 ha and most of them are in the Ilog lower basin.

There are ten (10) communal irrigation systems (CIS) for paddy in the entire basin. The total potential paddy area for these CIS is 640 ha, but the actual irrigated area is estimated at 410 ha only. The rate of irrigated area is 2.0% for sugarcane and 3.0% for paddy. (Refer to Fig. IV-1-3.)

Water Quality

The streamflow of the Ilog River has long been used for irrigation purposes in some parts of the lower basin. Results of water quality tests executed in 1974 to 1975 indicate that the water of the Ilog River is suitable for irrigation purposes. (Refer to Table IV-1-4.)

Cropping Pattern and Water Requirement

Sugarcane is planted from October to February and harvested from September to January. Water consumption for sugarcane is estimated according to four (4) different stages of crop management; namely, land preparation, planting or replanting (ratoon), crop management and harvest. In case of paddy, farmers have a double cropping per year. The first cropping is in the month of May to September and the second cropping is in October to February (refer to Fig. IV-1-4). Rice has six (6) stages of development, i.e., land soaking, land preparation, nursery, transplanting, crop maintenance, drainage and harvest. The water requirement for sugarcane is estimated at 14,200 m3 while paddy is about 21,600 m3 per ha per year. (Refer to Table IV-1-5.)

Present Water Utilization

Irrigation water for sugarcane and paddy are obtained from the stream in the foot of a hilly land, from portable pumps in its middle reaches and from water used in cooling system (refer to Sec. 1.5). There are no water utilization facilities to divert water from the main stream of the Ilog River. Based on the actual irrigation area, the present water demand is estimated as follows:

Sugarcane	:	14,200 m^3/ha x 730 ha	= 10.4 MCM/year
Paddy	:	21,600 m^3/ha x 410 ha	= 8.9 MCM/year
Total			= 19.3 MCM/year

1.3 Aquaculture

Present Condition of Brackish Fishery

Since the situation of the sugar industry had worsened in mid-1980's, fishpond operators had rapidly increased in number. At present, the total fishpond area is 15,800 ha and 1,330 operators engage in brackishwater aquaculture in Negros Occidental. The largest concentration of fishpond production and development was in the Ilog lower basin which had about 2,400 ha for fishpond or 15% of the aggregate fishpond area in the province. (Refer to Table IV-1-6.)

As of December 1988, the areas in the basin for bangus (milkfish) fishpond is 2,273 ha, while prawn is 124 ha. A brackishwater fishery, particularly prawn, needs much amount of freshwater to control the water quality of the ponds. Operators are depending on river water withdrawal by the use of pumps. To date, there are nine (9) pump stations in this area. (Refer to Fig. IV-1-5).

Present Water Utilization

To attain optimum growth during the culture period, brackishwater fishponds should be maintained with salinity ranging from 15 ppt to 25 ppt, transparency of pond water at 35 to 45 cm, and pH at 7.0 to 8.5 (neutral to alkaline). To maintain these conditions, old pond water should be changed regularly or diluted with good quality brackishwater, that is, 50% of pond water should be replaced. Change of water in pond is 20 times in one culture for four (4) months (prawn). About 1,670 m3 of freshwater is needed per change per hectare. The present water utilization is estimated as follows:

1,670 m^3/ha x 20 changes x 2 cultures/year x 124 ha = 8.3 MCM/year

1.4 Domestic Water

Present Condition of Water Supply

(1) Water Supply System

There are three (3) categories of potable water supply system in Negros Occidental; namely, Level I (a point source or a well), Level II (a communal water system serving five to six households per faucet), and Level III (individual household connections).

At present about 49% of the provincial population avail themselves of the Level I water system, through assistance of the Local Water Utilities Administration (LWUA), the Department of Public Works and Highways (DPWH), and the former Rural Waterworks Development Corporation (RWDC). Water consumption under the Level I system in rural and urban areas is about 30 and 60 liters per capita, respectively. The ratio of population served by the Level II system is small in the province and in the study area. Level III or individual household connection in the basin serve 14% of the population.

There are two (2) water districts constructed by LWUA, the Kabankalan and Ilog. These water districts have deep wells and springs for water sources with withdrawal capacity of 1,956 liters per second. The annual production volume is 0.7 MCM (refer to Tables IV-1-7 and IV-1-8).

(2) Water Sources

The source of water supply is groundwater extracted through wells, springs and infiltration galleries. To date, there are 44 wells for domestic use in the Ilog lower basin, and the area is estimated to be plentiful of groundwater. Most of them are dug/ artesian wells.

Present Water Utilization

Judging from the present situation, the present amount of domestic water is estimated at about 5 MCM/year in the whole basin as follows:

Area	Population*	Water Utilization (lpcd**)	(MCM/yr)
Lower Basin:	152,400		2.4
1. Urban Area	30,800		1.1
Water District	12,500	-	0.7
Others	18,300	60	0.4
2. Rural Area	121,600	30	1.3
Upper Basin:	194,300		2.6
1. Urban Area	39,200	60	0.9
2. Rural Area	155,100	30	1.7
Total	346,700		5.0

* Projected population of 1990
** Liter per capita per day

1.5 Industrial Water

Present Condition

There are two (2) major industrial establishment in the study area; namely, the Southern Negros Development Corporation (SONEDCO) and the Dacongcogon Rice and Milling Company (DACONGCOGON). SONEDCO and DACONGCOGON are the sugar centrals in the municipality of Kabankalan, with the former located in the lower basin. They need much water for cooling the sugar production plants.

SONEDCO has an intake facility in the Calasa River, a left bank tributary of the Ilog River. The pumping station is located in Sta. Isabel, about 3 kms away from the plant, and equipped with 3 pumps. During the milling season from the middle of October to the middle of April (6 months), these pumps operate simultaneously with the total output of 60 m^3/min. Used water is drained partly to the Ilog River downstream of the pumping station and partly to the Salong Creek which is used for agricultural purposes.

DACONGCOGON has an intake facility installed with two (2) pumps in the Tablas River, a tributary of the Ilog River. During the milling season (middle of October to middle of May) these pumps operate with the capacity of 27 m^3/min.

Additionally, there is another industrial plant near the Ilog lower basin, the Universal Starch Industrial Corporation (UNISTARCH). UNISTARCH produces raw materials for glucose syrup from cassava, and water for its processing plant depends on the Suay River which is outside the Ilog River Basin.

Present Water Utilization

The amount of industrial water utilization depends on the above two sugar centrals. Total water utilization is estimated as follows:

(60 + 27) x 60 min. x 24 hrs. x 155 days = 19.5 MCM

Note: Since the pump is operated 6 days a week, the total operation days are 155 days for 6 months.

1.6 Issue of Water Utilization

Drought Damage

Drought in the last 30 years occurred three (3) times: in 1966, 1979 and 1989. Damages to rice and corn crops in Negros Occidental in 1989-1990 were estimated at 3,318 ha and 791 ha, respectively, of which 57% for rice land and 87% for corn land were in the study area. Southern Negros suffered much due to the lack of irrigation system (refer to Table IV-1-9).

Water Source for Domestic Water

In the Ilog-Hilabangan river basin, shallow and deep well areas cover only about 6% (or 130 km^2) and 74% (or 1,600 km^2); however, the remaining area is difficult for digging wells. As a result of water balance, available groundwater withdrawal is estimated at about 105 MCM. This amount of groundwater is enough for the estimated future demand of domestic water. (Refer to Table IV-1-10 and Fig. IV-1-6.)

On the other hand, utilization of surface river water as the source of water supply would require an intake structure, a treatment plant and transmission pipelines. From the technical and economical aspects, the utilization of surface water may not be justified as potential source of domestic water supply in the future.

River Water for Navigation and Environmental Preservation

The Ilog-Hilabangan River is used for river navigation. In the downstream, rafts made of bamboo and motorized boats are used by the farmers living in the area in transporting rice and other farm products. River transportation will continue in the future.

The extent of saltwater intrusion has been studied under the Nationwide Flood Control Plan. The study shows that intrusion from the estuary reaches up to 11 km of 95% dependable discharge. There are few intake works, wells or pumps, within the stretch affected by saltwater. (Refer to Fig. IV-1-7)

For the past ten (10) years, red tide occurred three (3) times in the Philippines . Negros Occidental suffered from red tide in 1986. The main causes are still unknown up to this time, but the fact that it occurred easily during the dry season/drought years should be considered.

2. WATER RESOURCES DEVELOPMENT

2.1 Projects Related to the Study

To develop much water resources in this basin, the study on the Hilabangan Irrigation Project for the lower basin was carried out in 1975. The Tambolan Communal Irrigation Project for the upper basin is under study by the National Irrigation Administration (NIA).

(1) Hilabangan River Irrigation Project

The development plan of the project envisages irrigation of about 5,900 ha in the dry and wet seasons. The proposed development area along the Ilog River is divided into the left bank area of 3,000 ha and the right bank area of 2,900 ha. The diversion dam site with a drainage area of approximately 430 km^2 is located at Barrio Lupni, 4 km upstream of the confluence with the Ilog River . The proposed diversion dam will be concrete gravity overflow with a height of about 2.5 m above the riverbed and 140 m long. Although the study was once reviewed in 1983, this project has not progressed to the further stage as of 1990.

(2) Tambolan Communal Irrigation Project

In this project, it is proposed that intake facilities be provided at Barangay Casoloning with the catchment area of 30 km^2 upstream of the Hilabangan River. The irrigation area to be covered by this project is approximately 600 ha.

2.2 Future Water Demand

Future water demand in the Ilog River Basin consists of irrigation, aquaculture, domestic water and industrial water. In this study, these demands were assumed using the future land use based on the present land use.

Irrigation

The present area for paddy in the basin is 13,800 ha, of which 410 ha is under irrigation. Irrigation service area of paddy in the future is assumed to be 3,500 ha in consideration of the projects mentioned in Section 2.9 and others.

As for the sugarcane area, it is 36,900 ha at present and 730 ha is the actual irrigated area. Under the same circumstances, the future irrigation area is assumed to increase to 6,000 ha.

Aquaculture

At present, there are 2,400 ha of fishponds in this area. These fishponds do not need freshwater directly and use brackishwater in the estuary. A prawn pond with pump stations to lift up brackishwater from the tidal water is 124 ha and in the future the pond will increase to about 400 ha.

Domestic Water

Demand of domestic water will become larger as population increases. The population in the basin is 346,700 persons in 1990 and this will increase by 1.5 times to 519,100 persons in 2020. Water resources for domestic water in the future will continue to depend on groundwater and springs.

Industrial Water

Presently, industrial water in the basin is used as cooling water for sugar factories. This water will be needed in the future. Since development of small scale industries is expected in the future, an additional amount is needed at about 30% of the present industrial water.

Future Water Demand

Using the above-mentioned water demands, the future water demand of the whole basin in 2020 is estimated as shown in the following table. The annual water demand will be 240.0 MCM and the water utilization rate to the available water resources of 3,000 MCM will increase from 2% at present to 8% in the future, i.e., 240 MCM/3000 MCM x 100 = 8%. (Refer to Table IV-2-1)

Demand	Annual Volume
Irrigation (9,500 ha)	160.8 MCM (68%)
Aquaculture (400 ha)	26.7 MCM (11%)
Domestic Water	24.2 MCM (10%)
Industrial Water	25.4 MCM (11%)
Total	237.1 MCM (100%)

2.3 Water Resources Development Plan

Of the future water demands in the Ilog lower basin, domestic water will be supplied from groundwater and industrial water will depend mainly on the river water from some tributaries of the Ilog River. Further, aquaculture will use the brackishwater in the estuary, and consequently, irrigation will depend only on the river water directly from the main stream of the Ilog River.

Objective Irrigation Area

In the previous irrigation project, the irrigation area of 5,900 ha consisting of 1,200 ha of paddy and 4,700 ha of sugarcane was proposed with the water source from the low water of the Hilabangan River by constructing a diversion dam in the Hilabangan River. In this study, the same irrigation area was adopted as the objective area of water resources development.

Proposed Irrigation Project

According to the water discharge data, the river water can not meet the water requirement in the lower reaches when the river maintenance water is assured. Therefore, it is required that river flow regime is regulated by the dam and reservoir.

It is proposed in this study to apply the Ilog No.1 lower dam site, because this dam site is expected to be the most economical among the three possible dam sites as discussed in the sectoral report of Dam Planning.

Required Storage Volume

The volume to be stored in the proposed reservoir was calculated from the monthly mean discharge data at the Orong Station which has a catchment area of 1,453 km^2. In this calculation, the river maintenance flow of 0.33 $m^3/s/100\ km^2$ was considered as the minimum flow of the Ilog River, i.e., 4.83 m^3/s / 1,453 km^2 x 100 = 0.33 m3/s/100 km^2.

The irrigation areas of paddy and sugarcane are 1,200 ha (about 20% of the total irrigation area) and 4,700 ha (about 80%), respectively. In accordance with the result of water balance analysis for the 24 years from 1956 to 1979, the required storage volume of 48.6 MCM (about 50 MCM) which is the second largest volume, will be applied to the reservoir planning. The volume of about 50 MCM is equivalent to a drought with 10-year return period. (Refer to Tables IV-2-2 and IV-2-3.)

Alternative of Required Storage Volume

The necessary storage volume for irrigation will vary depending on the future land use of paddy and sugarcane. In case of a certain acreage of irrigation area, the necessary volume for irrigation will vary according to the acreage of paddy cultivation.

Considering the socioeconomic conditions in the future, it is rather difficult to fix the future land use. In this study, therefore, the maximum necessary storage volume on the future land use would be calculated based on the paddy area to be developed in the future, since the water requirement of paddy is bigger than that of sugarcane based on the previous table. The maximum paddy acreage is assumed at 80% of the total irrigation area, because 20% of the irrigation area such as sandy soil, hilly area, etc., will be suitable for planting sugarcane. Based on the above assumption of the cultivated areas, the water balance study for the same period of 24 years shows the necessary storage volume of 48.7 MCM. This amount is almost the same as the present one. Consequently, the proposed storage volume of 50 MCM for irrigation would be applied for the reservoir planning. (Refer to Fig. IV-2-1)

Dam Scale (Tentative Plan)

Using Ilog No. 1 lower dam site, the proposed dam dimensions for the above water utilization volume of 50 MCM are roughly estimated at 30 m of dam height and 21.5 m of normal water surface elevation.

TABLES

Table IV-1-1 PRODUCTION AND CONSUMPTION BALANCE OF RICE IN NEGROS ISLAND BY YEAR

Item	Unit	1986	2000	2020
Paddy Area Utilized	x1000 ha	108.1 *	108.1	108.1
Production per One Hectare	ton	2.54	2.60	2.65
Total Production (1)	ton	274,700 *	281,060	286,470
Population	x1000 persons	3,138.3	4,067.0	5,075.0
Per Capita Consumption	kg	100	95	90
Total Consumption of Rice	ton	313,800	386,370	456,759
Total Consumption of Paddy (2)	ton	523,000	643,940	761,260
Balance [(1)-(2)]	ton	- 248,000	- 363,000	- 474,790
Self Sufficiency Rate	%	53	44	38

Note * : Actual Average Amount in 1984 to 1986
(Provincial Profile, March 1988, DA)

Table IV-1-2 PRESENT AND PROJECTED POPULATION IN ILOG-HILABANGAN RIVER BASIN

Unit : 1000 persons

Year	Lower Basin			Upper Basin			Whole Basin		
	Total	Urban	Rural	Total	Urban	Rural	Total	Urban	Rural
1990	152.4	30.8	121.6	194.3	39.2	155.1	346.7	70.0	276.7
2000	183.0	46.7	136.3	233.8	59.7	174.1	416.8	106.4	310.4
2020	227.9	63.6	164.3	291.2	81.4	209.8	519.1	145.0	374.1

Table IV-1-3 PRESENT LAND USE IN ILOG-HIRABANGAN RIVER BASIN

Unit : km2

Land Use	Lower Basin	Upper Basin	Total
Mangrove	2.0	0.0	2.0
Fishpond	24.0	0.0	24.0
Lowland Paddy	17.0	21.0	38.0
Upland Paddy	10.0	90.0	100.0
Sugarcane	70.0	299.0	369.0
Upland Crop	15.0	530.0	545.0
Coconut	1.0	19.0	20.0
Grassland	20.0	517.0	537.0
Forest/Shrubs	33.0	415.0	448.0
Residential	5.0	30.0	35.0
River Reservation	6.0	38.0	44.0
Total	203.0	1,959.0	2,162.0

Source : BSWM, Calculated by JICA Study Team

Table IV-1-4 WATER QUALITY OF ILOG RIVER

Item of Analysis	Station 1	Station 2
Temperature (Centigrade)	29.2	29.4
PH	7.6	7.9
Order, Threshold Odor-Number	1.0	1.0
Color, Color Units	-	-
Turbidity Silica Scale	-	-
Alkalinity, in mg/l	143.0	132.8
Dissolved Oxygen, mg/l	5.8	6.0
B.O.D. (5 days), mg/l	21.9	8.9
Chlorides, mg/l	78.6	9.8
Sulfates, mg/l	12.8	13.7
Total Solids, mg/l	900.0	780.0
Suspended Solids, mg/l	-	-
Phosphates, mg/l	0.50	0.35
Total Hardness, mg/l	168.2	131.3
Coliform, MPN/ 100 ml x 10^5	44.8	34.0

Note : - Smpling Period : 1974 to 1975
- Sampling Sites : Ilog
Station 1 : Ilog Poblacion (9.0 km)
Station 2 : Bgy. Talubangi, Kabankalan (15.5 km)

Table IV-1-5 DIVERSION WATER REQUIREMENT

Unit : mm

Month/ Decade		Rainfall *1	Re *2	Paddy C.W.R. *3	Paddy F.W.R. *4	Paddy D.R. *5	Paddy M.R. *6	Sugarcane C.W.R. *3	Sugarcane F.W.R. *4	Sugarcane D.R. *5	Sugarcane M.R. *6
	1	6	5	80	75	125		25	20	33	
Jan.	2	-	-	80	80	133	405	25	25	42	120
	3	1	-	88	88	147	(4.05)	27	27	45	(1.20)
	1	-	-	80	80	133		45	45	75	
Feb.	2	6	5	80	75	125	365	45	40	67	202
	3	-	-	64	64	107	(3.65)	36	36	60	(2.02)
	1	1	-	16	16	27		64	64	107	
Mar.	2	-	-	-	-	-	27	64	64	107	331
	3	1	-	-	-	-	(0.27)	70	70	117	(3.31)
	1	-	-	-	-	-		68	68	113	
Apr.	2	-	-	-	-	-	-	68	68	113	341
	3	3	-	-	-	-	(-)	69	69	115	(3.41)
	1	6	5	-	-	-		50	45	75	
May	2	16	13	36	23	38	95	50	37	62	185
	3	33	26	60	34	57	(0.95)	55	29	48	(1.85)
	1	29	23	60	37	62		33	10	17	
Jun.	2	40	32	42	10	17	102	33	1	2	19
	3	50	40	54	14	23	(1.02)	33	-	-	(0.19)
	1	57	46	60	14	23		26	-	-	
Jul.	2	29	23	60	37	62	127	26	3	5	5
	3	51	41	66	25	42	(1.27)	29	-	-	(0.05)
	1	44	35	60	25	42		27	-	-	
Aug.	2	30	24	60	36	60	165	27	3	5	7
	3	35	28	66	38	63	(1.65)	29	1	2	(0.07)
	1	37	30	60	30	50		28	-	-	
Sep.	2	8	6	60	54	90	187	28	22	37	37
	3	40	32	60	28	47	(1.87)	28	-	-	(0.37)
	1	33	26	-	-	-		30	4	7	
Oct.	2	39	31	36	5	8	85	30	-	-	39
	3	17	14	60	46	77	(0.85)	33	19	32	(0.39)
	1	29	23	60	37	62		20	-	-	
Nov.	2	18	14	42	28	47	186	20	6	10	30
	3	10	8	54	46	77	(1.86)	20	12	20	(0.30)
	1	-	-	80	80	133		19	19	32	
Dec.	2	4	-	80	80	133	413	19	19	32	99
	3	-	-	88	88	147	(4.13)	21	21	35	(0.99)
Annual				1,792	1,293	2,157	(21.57)	1,320	847	1,415	(14.15)

Note *1 : Assuming an 80% of probability of occurrence (Kabankalan, 1957 - 1982)
*2 : Effective rainfall
*3 : Crop water requirement based on the Hilabangan River Irrigation Project by NIA, Oct. 1975
*4 : Farm water requirement = *3 - *2
*5 : Diversion requirement = *4/0.6 (irrigation efficiency)
*6 : Monthly requirement (1000 cu.m/ha)

Table IV-1-6 BRACKISHWATER AQUACULTURE

	Item	Unit	Negros Occ. (1)	Study Area (2)	Rate (2)/(1)
Bangus	No. of Operators	person	972	140	14.4%
	Area	ha	12,418	2,273	18.3%
	Production	ton	8,044	1,590	19.8%
Prawn	No. of Operators	person	355	24	6.8%
	Area	ha	3,363	124	3.7%
	Production	ton	14,842	639	4.3%
Total	No. of Operators	person	1,327	164	12.4%
	Area	ha	15,781	2,397	15.2%
	Production	ton	22,886	2,229	9.7%

Source : Fisheries Extension Section, BFAR
Note : Study area for this table covers the municipalities of Kabankalan and Ilog.

Table IV-1-7 PERCENTAGE OF POPULATION SERVED BY WATER SUPPLY LEVEL

Area	Level I *1	Level II	Level III	Others *2	Total	W.D. *3
Negros Occidental	48.8%	1.6%	28.7%	20.9%	100.0%	n = 14
Kabankalan & Ilog	56.6%	4.2%	13.8%	25.4%	100.0%	2

Source : Provincial Health Office, 1989
Note *1 : Per capita consumption is estimated at 30 to 60 lpd.
*2 : Droughtful sources.
*3 : Water District (LWUA)

Table IV-1-8 WATER DISTRICT DATA AS OF OCTOBER 1990

Item	Unit	Kabankalan W.D.	Ilog W.D.	Total
Water Resources				
- Deep Well	unit	2	-	2
- Spring	unit	1	2	3
Withdrawal Capacity	lps	1,710	246	1,956
Monthly Production	m3	55,300	2850	58,150
Monthly Distribution	m3	35,400	1700	37,100
Loss	%	36	40	36
No. of Connections	H.H.	1,687	128	1,815
Population Served	person	11,800	700	12,500
Consumption	lpcd	100	80	100
Annual Volume	MCM	0.664	0.035	0.699
Service Per Day	Hr.	24	5	

Table IV-1-9 DROUGHT DAMAGE IN CROPPING YEAR 1989/1990

District	Total Area Affected (ha)	Total Area Damaged (ha)	Estimated Production Loss (ton)	Estimated Value (1000 Peso)
1. Rice				
Negros Occidental (1)	4,934	3,318	10,571	39,801
Study Area (2)	2,893	1,883	5,328	20,236
Rate (2)/(1)	0.59	0.57	0.50	0.51
2. Corn				
Negros Occidental (1)	1,891	791	1,796	9,830
Study Area (2)	1,759	687	1,506	8,335
Rate (2)/(1)	0.93	0.87	0.84	0.85

Source : DA,Region VI, Iloilo City, as of April 18, 1990

Table IV-1-10 EXISTING WELL DATA AND POTENTIAL WELL CAPACITY

Item	Unit	Ilog	Kabankalan	Mabinay	Total
No. of Wells Considered	no.	13	18	10	41
Specific Capacity	lit./sec./m	0.34	0.74	0.68	
Well Depth	m	26	35	42	
Static Water Level	mbgs	3	3	10	
Average Capacity Per Well (SW)	m3/day	55	52	-	
Average Capacity Per Well (DW)	m3/day	323	396	197	
Safe Yield *1 (SW)	1000 m3/day	15	40	-	
Safe Yield *1 (DW)	1000 m3/day	50	160	25	
Potential Max. No. of Wells (SW)	no.	270	770	-	1,040
Potential Max. No. of Wells (DW)	no.	150	400	125	675
Annual Capacity	MCM/year	23.1	72.4	9.0	104.5

Source : Rapid Assessment of Water Supply Sources, May 1982, NWRC
*1 - Estimated by JICA Study Team on the basis of water balance.
Note : mgbs - meter below ground surface
SW - Shallow well
DW - Deep well

Table IV-2-1 ESTIMATED WATER USE IN 2020

	Lower Basin		Upper Basin		Total		
	Area/Pop.	Vol.(MCM)	Area/Pop.	Vol.(MCM)	Area/Pop.	Vol.(MCM)	%
Irrigation							
Paddy	1,500	32.4	2,000	43.2	3,500	75.6	32%
Sugarcane	5,000	71	1,000	14.2	6,000	85.2	36%
Fish Pond	400	26.7			400	26.7	11%
Domestic Water	227.9	10.6	291.2	13.6	519.1	24.2	10%
Urban Area	63.6	4.6	81.4	5.9	145.0	10.5	4%
Rural Area	164.3	6.0	209.8	7.7	374.1	13.7	6%
Industrial Water		17.6		7.8		25.4	11%
Total (round)		160		80		240	100%

Note : Area (ha), Population (x1000 persons)
Unit water requirement, Paddy = 2,160 mm/ha, Sugarcane = 1,420 mm/ha
Fishpond = 6,680 mm/ha
Domestic water = 100 to 200 liter per capita per day
Industrial water = Sugar plant + Small scale industry

Table IV-2-2 REQUIRED STORAGE VOLUME

Order	Year	Volume (MCM)	W
1	1978	52.60	1/10.3
2	1979	48.59	1/8.9
3	1976	42.78	1/7.1
4	1977	39.15	1/6.1
5	1958	37.34	1/5.7
6	1973	28.07	1/3.8
7	1961	18.07	1/2.4
8	1963	16.24	1/2.1
9	1966	14.02	1/1.9
10	1957	7.43	1/1.4

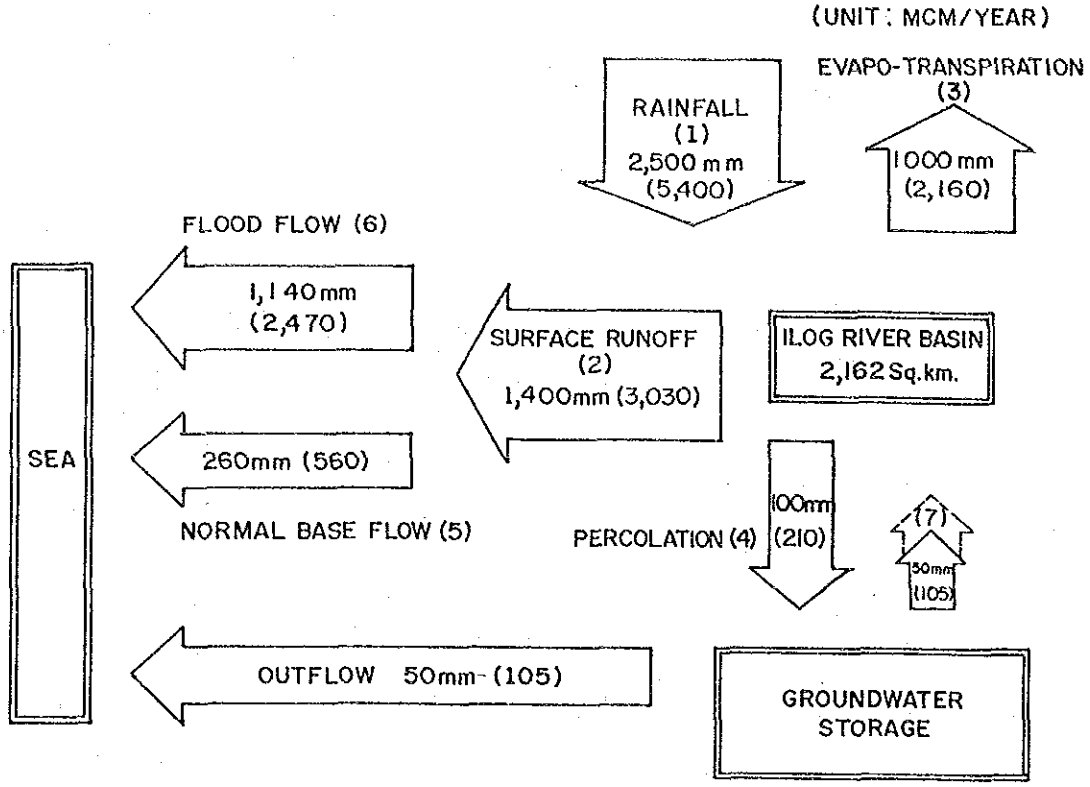
Note : - Irrigation area is 5,900 ha as follows:
1,200 ha (paddy) + 4,700 ha (sugarcane)
- Proposed dam has 1,430 km2 of catchment area.
- River maintenance flow is 0.33 m3/s for 100km2
- W = 1/T (Return period in year)

Table IV-2-3 WATER BALANCE CALCULATION

Unit : MCM

Year	Inflow	Base Flow	Available Flow	Irrigation Demand	Evaporation	Spilled Water	Annual Shortage	Accumulative Shortage
1956	2,857.74	142.44	2,715.30	92.39	6.16	2,616.75	0.00	0.00
1957	1,604.77	142.05	1,462.72	92.39	6.24	1,371.51	7.43	7.43
1958	1,209.47	142.05	1,067.42	92.39	6.91	1,005.46	37.34	37.34
1959	2,254.87	142.05	2,112.82	92.39	6.30	2,019.36	5.24	5.24
1960	2,127.59	142.44	1,985.15	92.39	6.23	1,891.45	4.92	4.92
1961	1,890.89	142.05	1,748.84	92.39	6.48	1,668.05	18.07	18.07
1962	1,980.45	142.05	1,838.40	92.39	6.20	1,742.44	2.63	2.63
1963	1,813.80	142.05	1,671.75	92.39	6.41	1,589.18	16.24	16.24
1964	2,903.22	142.44	2,760.78	92.39	6.16	2,662.22	0.00	0.00
1965	2,708.90	142.05	2,566.85	92.39	6.16	2,468.30	0.00	0.00
1966	2,344.35	142.05	2,202.30	92.39	6.41	2,117.52	14.02	14.02
1967	4,087.41	142.05	3,945.36	92.39	6.16	3,846.80	0.00	0.00
1968	3,477.31	142.44	3,334.87	92.39	6.16	3,236.31	0.00	0.00
1969	1,553.63	142.05	1,411.58	92.39	6.16	1,313.02	0.00	0.00
1970	2,111.75	142.05	1,969.70	92.39	6.16	1,871.14	0.00	0.00
1971	3,210.37	142.05	3,068.32	92.39	6.16	2,969.77	0.00	0.00
1972	2,140.53	142.44	1,998.09	92.39	6.16	1,899.54	0.00	0.00
1973	1,371.43	142.05	1,229.38	92.39	6.70	1,158.36	28.07	28.07
1974	1,220.97	142.05	1,078.92	92.39	6.18	981.73	1.38	1.38
1975	892.59	142.05	750.54	92.39	6.16	656.95	4.96	4.96
1976	1,406.76	142.44	1,264.32	92.39	7.08	1,207.10	42.25	42.78
1977	1,432.55	142.05	1,290.50	92.39	7.26	1,230.53	39.68	39.15
1978	1,130.69	142.05	988.64	92.39	7.54	936.34	47.64	52.60
1979	1,530.43	142.05	1,388.38	92.39	7.19	1,337.38	48.59	48.59
Mean	2,052.60	142.15	1,910.45	92.39	6.45	1,824.88	13.27	

FIGURES



LEGEND:

(1) ANNUAL RAINFALL : BASED ON ISOHYETAL MAP OF ANNUAL RAINFALL

(2) SURFACE RUNOFF : (1)

(3) EVAPO-TRANSPIRATION : 1,720mm (OPEN PAN EVAPORATION IN KABANKALAN) x 60%

(4) PERCOLATION : (1)-(2)-(3)

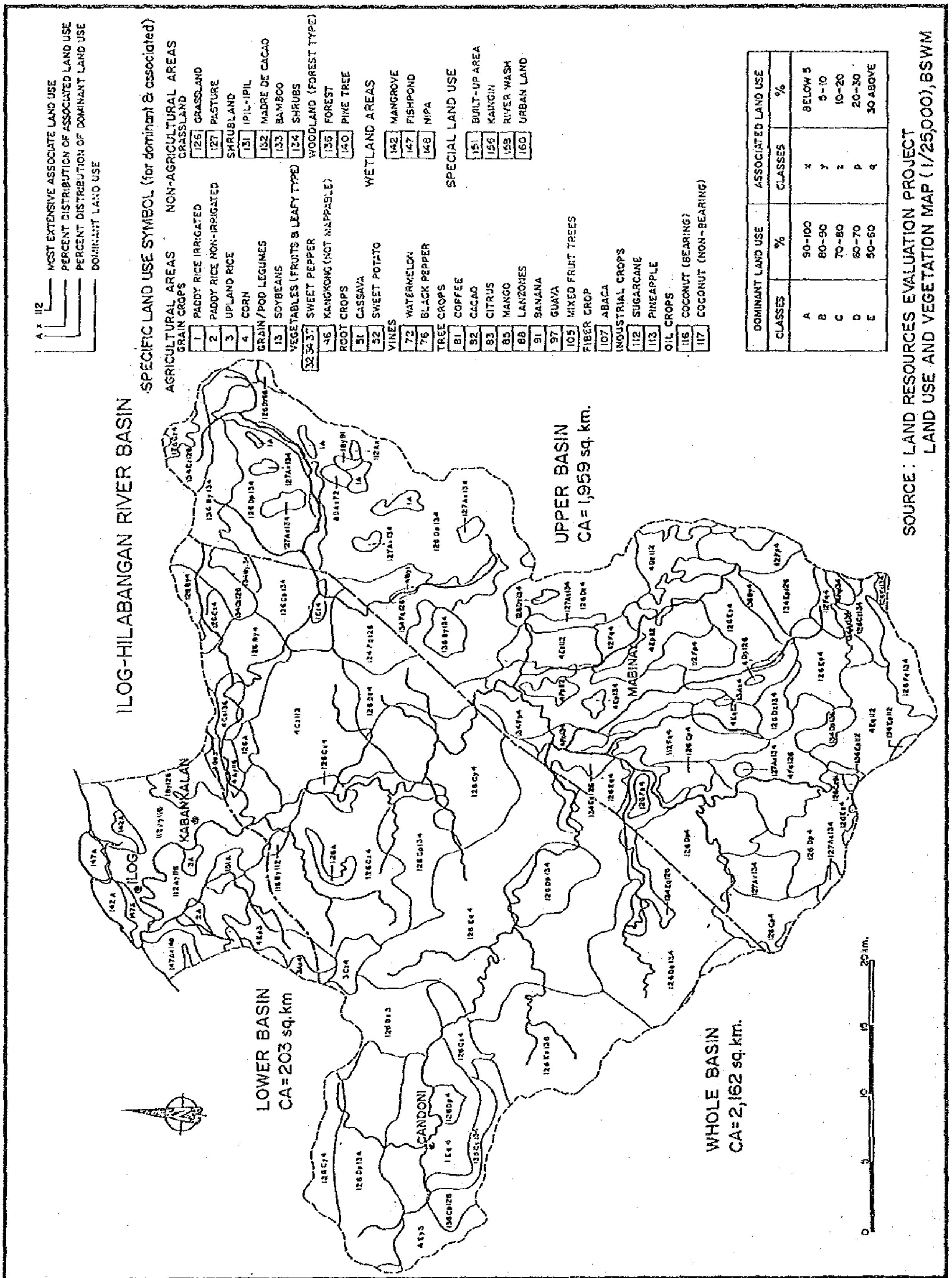
(5) BASE FLOW : ADOPTING DROUGHT WATER DISCHARGE

(6) FLOOD FLOW : (2)-(5)

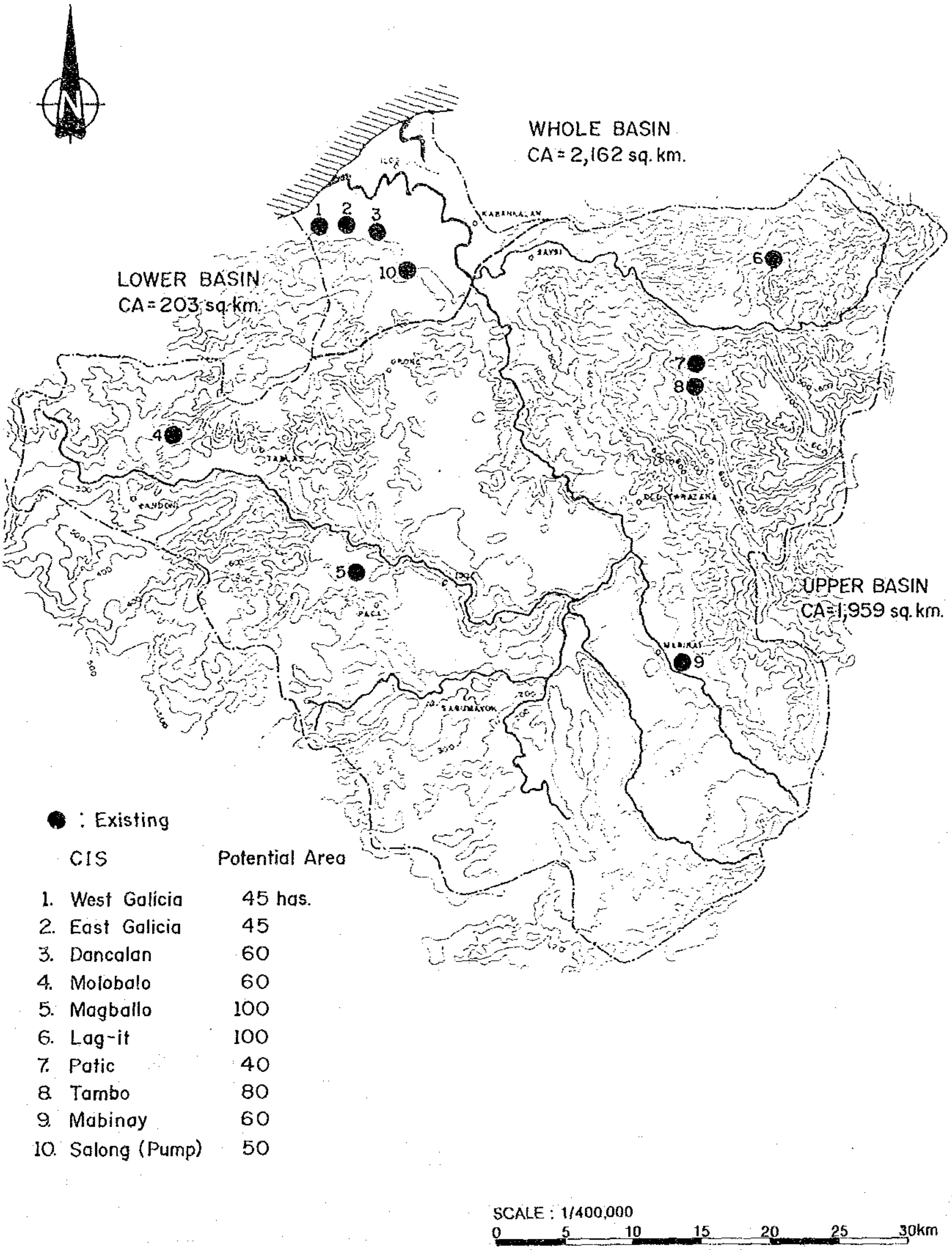
(7) AVAILABLE GROUND WATER : 100mm x 50% (ASSUMED)

(8) TOTAL AVAILABLE WATER : (2)+(7)= 1,450mm (=3,135 MCM/YEAR)

THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT JAPAN INTERNATIONAL COOPERATION AGENCY	Fig. IV-1-1 BASIN WATER BALANCE



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. IV-1-2 LAND USE AND VEGETATION MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	

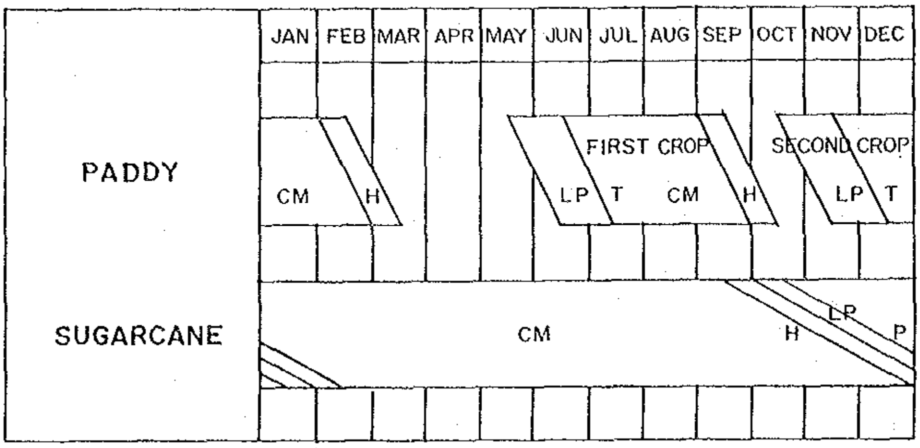


THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT

JAPAN INTERNATIONAL COOPERATION AGENCY

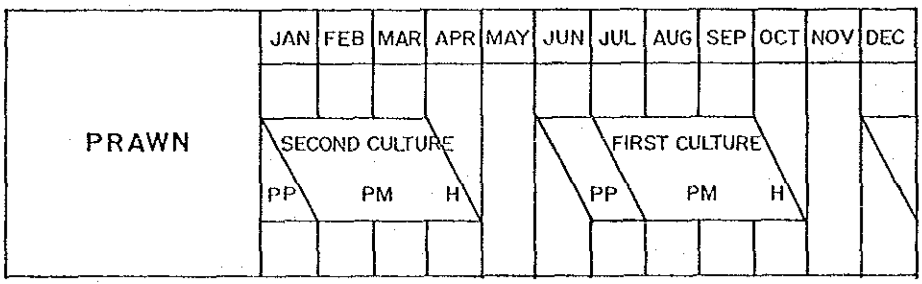
Fig. IV-1-3 EXISTING COMMUNAL IRRIGATION SYSTEM

CROPPING PATTERN



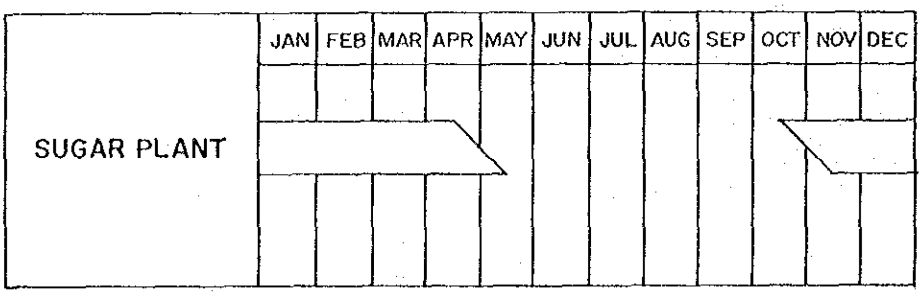
LEGEND: LP - LAND PREPARATION
T - TRANSPLANTING
CM - CROP MANAGEMENT
P - PLANTING
H - HARVESTING

BRACKISHWATER AQUACULTURE



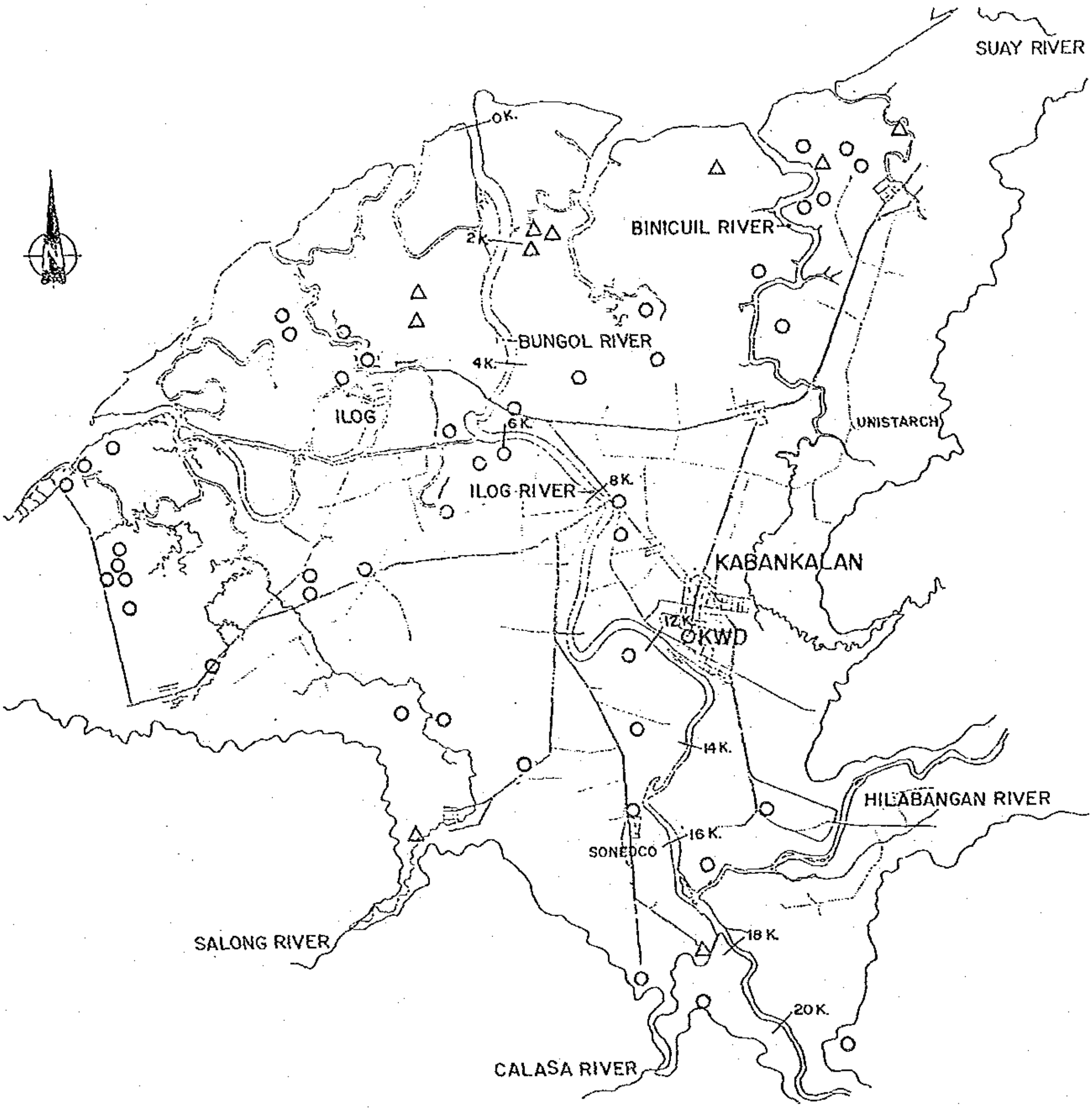
LEGEND: PP - POND PREPARATION
PM - POND MANAGEMENT
H - HARVESTING

INDUSTRIAL WATER



THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT
JAPAN INTERNATIONAL COOPERATION AGENCY

Fig. IV-1-4 WATER USE CALENDAR



LEGEND:

○ WELL

△ PUMP

□ SPRING

SCALE : 1/100,000

0 1 2 3 4 5 6km

THE STUDY ON ILOG-HILABANGAN RIVER BASIN FLOOD CONTROL PROJECT	Fig. IV-1-5 EXISTING WATER UTILIZATION MAP
JAPAN INTERNATIONAL COOPERATION AGENCY	