APPENDIX 9

RIVER AN SABO STUDY

1. STUDY ITEMS

The following 14 bridges were studied under this Appendix.

(1) Affected bridges (Phase III, Group 2)

03.10 Dolores Bridge
03.17 Sula Bridge
03.03 Bacong Bridge
03.07 San Roque Bridge
01.02 Maphilindo Bridge

(2) Alternative Bridges (Group 2)

03.05 Dagat-Dagatan Bridge
03.02 Aeta-Kinarangan Bridge
04.12a Tumalim Bridge
04.15a Kinalapan Bridge
04.03a Paurungan Bridge
03.s Apollo Bridge

(3) Affected Bridges (Phase III, Group 1)

03.08 Pias Bridge
03.11 Pulo Bridge
03.18 Sindol Bridge

Out of the six alternative bridges under Group 2 as listed above, four bridges, namely: 03.02 Aeta-Kinarangan, 04.12a Tumalim, 04.15a Kinalapan and 04.03a Paurungan, were considered to have no effect of Mount Pinatubo eruption and only appear in the description of river conditions by bridge. Studies regarding the river An Sabo were made for the other bridges as described in the following part in accordance with the flow chart illustrated in Figure-1. As shown in the flow chart, the study was made broadly on the following two aspects:

- Whether the bridge site will be affected by lahar or not;
- Whether the bridge site will be affected by ashfall originated sediment discharge

2. RIVER CONDITIONS BY BRIDGE SITE

Conditions of rivers and catchment basins which are prerequisite for the study are summarized in Table-1. Catchment basin maps by bridge in 1/50,000 topographical map are presented in Figure-2, and longitudinal profiles of the rivers, except those in flow lands, e.g., Maphilindo and San Roque, are depicted in Figure-3.

Major characteristics of the rivers and catchment basins are described hereunder.

(1) Dolores Bridge: Gugu Creek

Gugu Creek is a small-scale river located approximately in the center of the alluvial fan formed by the Abacan and Pasig-Potrero rivers both of which originate in higher elevations around Mount Pinatubo proper. Gugu Creek originate in the apex of the alluvial fan. The catchment area of Gugu Creek is 28.9 km^2 at the proposed bridge site, and the river length at the same point is 19 km. The catchment basin forms a long and narrow shape along the river course with widths varying from 1-3 km. The creek flows down in a dissected channel on the alluvial fan with a gradient of about 1/60 in the riverbed and about 1/470 at the bridge site.

(2) Sula Bridge: Sula River

The Sula River is one of the left bank tributaries of the Bulsa River, a northern tributary of the O'Donnell River which originates and flows down in the northern slope of Mount Pinatubo. The Bulsa River does not originate in Mount Pinatubo proper but in Mount Gatas which is located 10 km north of Mount Pinatubo. The Sula River flows down in a mountainous terrain from west to east with a gentle arc curve. The catchment forms a long and narrow shape with river length and width of about 30 km and 3 km, respectively.

Catchment area at the proposed bridge site is 50.8 km^2, and riverbed gradient is 1/10 and steeper in the headwaters and about 1/20 at the proposed bridge site located at 500 m upstream of the confluence to the Bulsa River. The Sula River Basin is located at a distance of about 35 km from

Mount Pinatubo, and ashfall depth is 1 cm and less in accordance with data of PHIVOLCS. Ocular observation during the field investigation revealed, however, more thicker ashfall settling especially in the Bulsa River Basin. The field investigation also revealed a notable sediment deposition along the Bulsa River at the confluence point of the Sula River where the riverbed gradient is partially very gentle.

(3) Bacong Bridge: Pinulot River

The Pinulot River flows in a mountainous terrain in the south of Mount Pinatubo. The catchment basin is divided into two parts by National Road Route 7 which runs east and west in the groin of Bataan Peninsula. The northern part of the basin originates in Bitnug mountains and the southern part originates in Mount Santa Rosa. Both the northern and southern basins consist of numerous long and slender sub-basins, and the Pinulot River has a comparatively large catchment area of 122.8 km^2 in comparison to its river length of about 18 km. Riverbed gradient in headwaters is 1/10 and steeper, and for the stretch from 8 km upstream point of the proposed bridge site, where the river exits the mountainous terrain to the bridge site and at the bridge site, gradiants are about 1/250 and 1/300, respectively. The Pinulot River Basin falls in distances from 25 to 44 km with an average ashfall depth is 10 cm corresponding to about 12 million m^3 in the whole catchment.

(4) San Roque Bridge: Hagonoy River

San Roque Bridge is proposed to cross the Hagonoy River. The Hagonoy River is one of river mouth branches near Manila Bay in the Pampanga River system. It is blanched form the Pampanga River at Santa Lucia and has a catchment area of approximately 20 km^2. It is, however, not clear since rivers and drainage channels are complicatedly joined and blanched in the low-wet land. Almost all water is the one diverted from the Pampanga River at Santa Lucia. The river at the proposed bridge site is a tidal river flowing in the low-wet land near Manila Bay and fish ponds extend in the surrounding areas. No flood has been reportedly observed in the Hagonoy river in accordance with interviews to the local residents, but the area frequently suffers from inundations due to high tide. Ashfall depth in assumed at about 2 cm by PHIVOLCS.

(5) Maphilindo Bridge: Basina River

Maphilindo Bridge is located in low flatland near the river mouth as in the case of San Roque Bridge. The Basina River belongs to the Agno River system and it is a blanch of the Calmay River which flows in the east part of the Agno River. The Basina River flows into the Agno River at 1 km upstream the river mouth. The Calmay river is a downstream part of the Camangbogan River, downstream name of the San Juan River which heavily meanders in the wet and flat land of the former Agno River course. The Basina River blanches from the Calmay River at about 10 km upstream the river mouth; a large portion of the discharge of the Calmay River flows down the main course, and the discharge of the Basina River is usually small. The Basina River at the bridge site is a tidal river. The site is located at about 100 km north of Mount Pinatubo and a slight ashfall was observed during the eruption according to an interview, but no deposit of ash has been presently observed in the area.

(6) Dagat-Dagatan Bridge: Dagat-Dagatan River

The Dagat-Dagatan River is a drainage channel-like small river flowing into a tributary of the Maasin River in the Pampanga River system. Adjoining areas are almost flat hill areas and presently used as paddy fields. Riverbed gradient is gentle and ordinary flow is slow. The site is located at a distance of 60 km north of Mount Pinatubo. Although the PHIVOLCS data show an ashfall depth of less than 1 cm, no deposit of ash was observed in the area during field investigation.

(7) Aeta-Kinarangan Bridge: Duate River

The Duate River is a mountain river in the east slope of Mount Mariveles located in the tip of Bataan Peninsula. It flows in a steep valley with gravel riverbed finally into Manila Bay at Barangay Limay. The catchment area of the river at the proposed bridge site is about 12 km^2, and riverbed gradient is 1/50. Ashfall depth is less than 1 cm according to PHIVOLCS data, but no ash was observed in the area during field investigation.

(8) Tumalim Bridge: Left Bank tributary of the Tumalim River

The Tumalim river has a catchment in the west side of the Taal Lake catchment in Batangas Province and flows westward into South China Sea. The river which Tumalim Bridge crosses is a left bank small tributary of the Tumalim River with a catchment area of 1.5 km^2. The river flows in a 15 m deep dissected valley. No effect of Mount Pinatubo eruption is conceived.

(9) Kinalapan bridge: Pingit River

The Pingit River is a blanch of the San Luis River which flows in Aurora Province to Baler bay in the Pacific Ocean side of Luzon Island. It flows in low and flat land area near the river mouth and it is a tidal river. No effect of Mount Pinatubo eruption is conceived.

(10) Paurungan Bridge: Salawag River

The Salawag River is one of numerous rivers flowing into Manila Bay in the northwestern slope of Taal Lake in Cavite Province. The proposed bridge site is just after the river flows out from gentle hill areas to lowlands. No effect of Mount Pinatubo eruption is anticipated.

(11) Apollo Bridge: Orani River

The Orani River originates in Mount Natib located in the northern part of Bataan Peninsula, and flows northeastward to Pampanga Bay, a northernmost part of Manila Bay. The river is one of numerous rivers which originate in Mount Natib. It dissects a 700 m wide slender valley with a length of about 20 km. Catchment area at the proposed bridge is 18.8 km^2. Riverbed gradient is generally steep throughout its length and it is 1/250 at the bridge site. The average ashfall depth is 6 cm corresponding to 1.1 million m^3 in the entire basin, ashfall deposit is, however, not so much according to field investigation.

(12) Pias Bridge: Tributary of the Callano River

Pias Bridge is planned to cross a tributary of the Callano River. The tributary flows between the Pasig-Potrero and

Porac rivers on the alluvial fan in the southeast of Mount Pinatubo. The site has not yet been affected by lahar as of the present time.

(13) Pulo Bridgé: Tributary of the Gumain River

The river which Pulo Bridge is planned to cross is a left bank tributary of the Gumain River flowing to the latter at just upstream the confluence to the Pasag River. The proposed bridge site is an inundation prone area of the Pasag River. The site has not yet been affected by lahar as of the present time.

(14) Sindol Bridge: Maloma River

The objective river is a branch of the Maloma River which flows in the western slope of Mount Pinatubo. The blanch is located 500 m off the South China Sea coast and runs almost parallel to the coast. It is an old river course and seems to be a 15 m wide narrow pond and there is almost no water flow. Adjoining areas are covered by mud and sand brought by lahar in the Maloma River, but the site has not been affected due to minor topography in the area.

3. STUDY ON EFFECT OF LAHAR

Of the 14 bridge sites included in the study, no site has been directly affected by lahar. The study on whether the site has a possibility of receiving effects of lahar has been conducted in this section.

Definition of "lahar" has been first confirmed hereunder. Lahar is a flowing fluid-sediment (volcanic ash) mixture which occurs in active volcano areas. It has a hydraulic bore at the tip. Lahar velocities range from 10-15 m/s and this is two to several times or the same to debris flow. In some cases, there is no bolder at a tip. Deposition condition shows sometimes stratified and sometimes not stratified. It depends on bulk density, discharge, materials included and slope of the deposition point.

A destructive power is concentrated at the hydraulic bore section and tearing force of the mud flow follows. Flow is relatively easy to divert. It reaches to gentler slopes comparing to debris flow. Run-off rates in the slopes covered by fresh volcanic ash just after the eruption are extremely large and specific discharge in those areas sometimes exceed 100 times those in ordinary mountains. This is because volcanic ash covers the ground surface and water infiltration to the ground is prevented. The cover is mortar-like and consolidated and hardly eroded; it is, however, very easy for side erosion once it eroded. Typical features of lahar and debris flow are compared hereunder.

	Tip Velocity (m/s)	Bulk Density ($kg/^3$)	Particle Size (mm)
Lahar	10 - 15	1,800 - 2,500	0.02 - 10
Debris Flow	3 - 6	1,300 - 1,600	300 and over

As described previously, rivers where lahar has already taken place are those having headwaters in Mount Pinatubo proper. Source of lahar is pyroclastic flow deposit which rest primarily on the steep upper slopes of the volcano within an area of about 15 km diameter, and ash particles settlings with a depth of 30 - 50 cm or over in the same area.

Accordingly, if the volcanic activity is calmed down as it is, there might be no possibility of lahar occurrence in their river proper for rivers which have not experienced lahar. It is obvious referring to examples in the similar volcanoes in the world.

In this case, even the four rivers which are located in relatively closer places to Mount Pinatubo; Gugu Creek (Dolores Bridge), the Sula River (Sula Bridge), the Pinulot River (Bacong Bridge) and the Orani River (Apollo Bridge) have no possibility har occurrence in their own catchment since they have no source of lahar.

Next, a prediction was made on how the present lahar will take place and affect which part of the area. Although estimates of volume of pyroclastic flow deposits and ash particles settlings, source of lahar, have been made in various methods, it is said that the volume already transported by lahar is only 10% or less of the total source amount. It is obvious that the source materials will be carried down as forms of lahar for the coming years.

A study was then made on the possibility of effect by lahar if it continuously occur in the lahar prone rivers. The subject bridge sites are Dolores Bridge and three bridges under Group 1, namely, Pias, Pulo and Sindol. Other bridges will have no effect of lahar.

Topographic map of the area including Dolores and Pias Bridge sites is shown in Figure 4. As shown in the illustration, this area is on the large alluvial fan from the Bamban River in the north to the Porac River in the south. There are another two rivers, namely; the Abacan and Pasig-Potrero rivers. Longitudinal profiles of the four rivers are depicted in Figure 5. Erosion and Deposition conditions of these rivers confirmed through field investigation are as follows:

<u>The Bamban River</u>

- San Francisco Bridge (Bridge for Route 329) : Deposited
- Bamban Bridge (Bridge for Route 3) : Deposited

<u>The Abacan River</u>

- Capaya Bridge (Bridge for North Super Highway) : Deposited
- Pandan Bridge (Bridge for Route 313) : Deposited
- Abacan Bridge (Bridge for Route 3) : Eroded
- Sapangbato Bridge (Back side of Clark Air Base) : Eroded

<u>The Pasig-Potrero River</u>

- Mancatian Bridge (Bridge for Angeles-Porac Road): Eroded

The locations of these bridges are shown in both topographical map and longitudinal profiles. The longitudinal profile with the eroded/deposited condition reveals that stretches with riverbed slopes of steeper than 1/100 are eroded and the ones with gentler slopes or the same are deposited. Heavily eroded Sapangbato spillway site on the Abacan River and Mancatian Bridge site on the Pasig-Potrero River have the riverbed gradient of about 1/50. It is also observed that lahar flowed down even to stretches with riverbed gradient of gentler than 1/500 in all rivers.

These are two modes of possibilities for the four rivers, which have not directly affected as of now, in affecting the bridge sites;

(1) Shifting of river course at the apex of the alluvial fan

Rivers in an alluvial fan generally tend to shift their course at an apex. Shifting of the river course is of discontinuity and not transitional. Causes of shifting are determination of flow condition and direction in the upstream portion of the valley, decrease of capacity to carry sediments at the outlet of the valley and resultant deposition of the sediments, local obstacles as extra-large rocks. Once the river course is shifted at an apex of the alluvial fan, the new river course tends to increase distance from the old river course.

(2) Over-banking, dike break and river shifting at intersection point

An inter-section point is the point where riverbed elevation and ground surface elevation crosses as illustrated in Figure 6. When the lahar passes the inter-section point, sediment deposition occur, and as the flow continues, the elevation of the inter-section point increases. This results in over-banking and dike break and if there is roughness change in the riverbed, the river change its course.

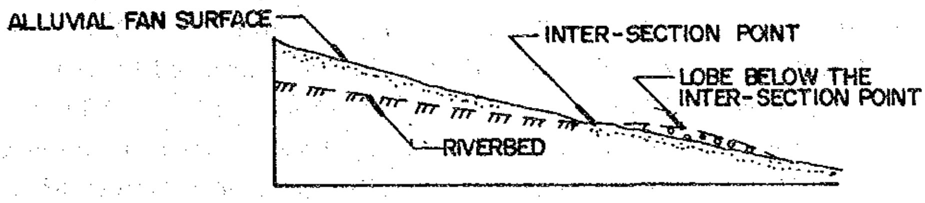

Figure 6 INTER-SECTION POINT

In regard to the sites presently under study, it can be said that the shifting at apex will not occur in the Pasig-Potrero and Porac rivers since the river channel is deeply dissected at the apex. This phenomenon may take place in Sapang Bayo Creek, a tributary of the Abacan River considering the topography of the area. The possible shifting is indicated in Figure 4.

The river ,which has a high possibility of shifting at inter-section point is the Pasig-Potrero River. In accordance with the existing 1/50,000 topo-map, the Pasig-Potrero River assumably has an intersection point at an elevation of about EL 140 m. Filed investigation, however, revealed that this part of the riverbed was deeply eroded by lahar, and in consideration of mudflow inundation, the intersection point is presently around elevation 80 m. Shifting of the river course at this point is consumable (see Figure 4). Although, it requires a detailed analysis on post lahar topo-map to predict more reliably, it is recommended that, as far as the river is concerned, construction of Dolores and Pias (Group 1) bridges is to be avoided.

Pulo Bridge (Group 1) is in the area to be affected by mudflow with possible shifting of the Pasig-Potrero and/or Porac rivers and the degree of influence is smaller than Pias Bridge.

Adjoining areas of Sindol Bridge are covered by mud and sand brought by lahar in the Maloma River, but the site has not been affected due to minor topography in the area. This condition will be maintained in the future.

4. STUDY ON EFFECT OF ASHFALL SETTLING OVER THE RIVER BASIN

In the previous section, four bridges, namely; Dolores, Pias, Pulo and Sindol were concluded to have possibilities of being affected by lahar. Study on effect of ashfall settling over the river basin has been conducted for the remaining 6 bridges; Sula, Bacong, San Roque, maphilindo, Dagat-Dagatan and Apollo.

Discharge mechanism of ashfall settling over the river basin is as follows:

Production

Ashfall settling will be eroded by rainfall and discharged through creeks to the main river channel. Production refers to sediment production in sabo engineering term.

Transportation

Ashfall deposit discharged to the main river course will be transported by river discharge to down stream portion. Transportation refers to sediment transportation in sabo engineering term.

Deposition

Of the transported sediment from upstream portion to the subject site, a part which exceeds possible transportation capacity at the subject site will be deposited.

On the basis of the above discharge mechanism, study was made firstly on whether ashfall settling oriented sediment production will take place or not, or if sediment production will occur, secondly, whether sediment will be deposited at bridge sites in relation to possible transportation capacity or not. It was judged there will be no effect if sediment production will not take place and if sediment deposition will not occur.

(1) Sediment Production

Principal parameters to determine sediment production are:

- Catchment area

- Coverage and vegetation condition of the basin

- Volume of ashfall settling (Catchment area times average Basin's average surface gradient)

Of the six subject bridges, three bridges; namely, San Roque, Maphilindo and Dagat-Dagatan, are considered to have negligibly small sediment production considering the following facts:

- Volume of ashfall settling, source of production, is small.

- River basins are low and flat land and average surface gradi ent
  is extremely small.

Accordingly, sediment production volume is estimated for the remaining three bridges: Sula, bacong and Apollo bridges.

Various methods, are proposed for sediment production volume. There is no established method for volcanic ash areas. For this study, annual specific sediment production is assumed by the following formula referring to specific sediment production volume plot as shown in Figure 7.

$$qs = 60,000 * A^{0.7}$$

where, qs: specific sediment production volume (m^3/year/km^2)

A: catchment area (km^2)

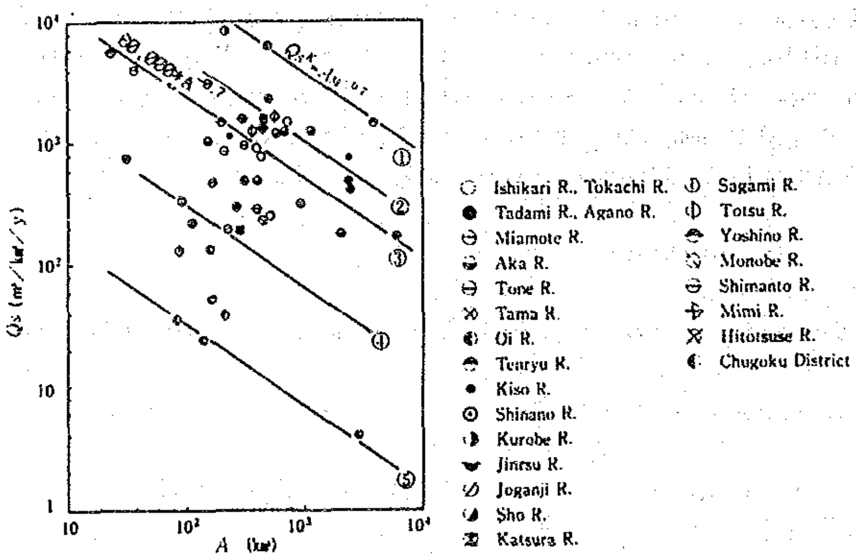

FIGURE 7 SPECIFIC SEDIMENT PRODUCTION VOLUME

Annual sediment production volumes for the subject bridges with their catchment and river channel dimensions are presented in Table 2.

Table 2. ANNUAL SEDIMENT PRODUCTION VOLUME

		Sula	Bacong	Apollo
Catchment Area	km^2	50.8	122.8	18.8
Specific Sediment Production Volume	1000 $m^3/y/km^2$	3,840	2,070	7,700
Annual Sediment Production Volume	km	195.1	254.2	144.8

(2) Sediment Transportation

Sediment transportation volume in the river channel was estimated by Brown's Formula. Assumption was made that discharge with 5% and 10% dependability in annual discharge duration would transport sediment since sediment transportation is mainly controlled by flood water. Actual calculation flow is presented hereunder.

River discharge is firstly estimated from the specific discharge for 5% and 10% dependability of 0.2963 $m^3/s/km^2$ and 0.1481 $m^3/s/km^2$, respectively (source: River Dredging II Project Report, DPWH). This river discharge was then converted to water depth applying Manning's Formula and assuming the channel as wide and shallow.

$$Q = A \times (1/n) R^{2/3} \times I^{1/2}$$

where,
- Q: discharge (m^3/s)
- A: water flow area, B x H (m^2)
- B: water flow width (m)
- h: water flow depth (m)
- R: hydraulic radius, A/P (m)
- P: wetted perimeter (m)
- I: energy gradient

If the channel is a wide and shallow one, P can be considered equals to B and the above formula can be expressed as follows:

$$Q = B \times h \times (1/n) \times h^{2/3} \times I^{1/2}$$

Accordingly, h is expressed as a function of Q as follows:

$$h = \{ (Q \times n) / (B \times I^{1/2}) \}^{0.6}$$

Using the calculated water flow depth (h) and energy gradient (I), shear velocity (u^*) can be calculated by the following formula:

$$u^* = (g \times h \times I)^{1/2}$$

where, u^*: shear velocity (friction velocity)
g : acceleration due to gravity
I : energy gradient

Brown's formula to calculate sediment transportation volume is expressed as follows:

$$qB/(u^* \times d) = 10 \{ u^{*2}/(\delta/P -1)/g/d \}^2$$

where, qB: sediment transportation volume per unit width and unit time
u^*: shear velocity
d : average particle size of riverbed material
S/p: specific weight of riverbed material particle (= 2.5)
g : acceleration due to gravity

Average particle size of riverbed material was assumed to be 0.3 mm. Once sediment transportation volume per unit width and unit time is calculated, possible annual sediment transportation volume can be calculated as follows:

$$Qs = (qB5 \times 0.05 + qB10 \times 0.10) \times 86400 \times 365 \times W$$

where, Qs : possible annual sediment transportation volume
qB5 : sediment transportation volume per unit width and unit time by 10% dependable discharge
pb10: sediment transportation volume per unit width and unit time by 10% dependable discharge
W : river width

Calculation for the three bridges are as shown in the following table:

Table 3 CALCULATION OF POSSIBLE ANNUAL SEDIMENT TRANSPORTATION VOLUME

		Sula	Bacong	Apollo
Catchment area	km^2	50.8	122.8	18.8
Annual sediment production vol.	1000 m^3	195.1	254.2	144.8
Effective river width	m	30.0	40.0	20.0
Energy Gradient	m	1/120	1/300	1/250
Manning's roughness coefficient		0.035	0.035	0.035
Annual 5% dependable discharge	m^3/s	15.2	36.8	5.6
Flow depth	m	0.374	0.704	0.327
Shear velocity		0.175	0.152	0.113
Sediment transp. volume per unit	$m^3/s/m$	0.0253	0.0125	0.00284
Annual 10% dependable discharge	m^3/s	7.6	18.4	2.8
Flow depth	m	0.247	0.465	0.216
Shear velocity		0.142	0.123	0.092
Sediment transp. volume per unit	$m^3/s/m$	0.00891	0.00434	0.00102
Annual possible sediment transp. vol.	1000 m^3	2,040	1,336	154

(3) Conclusion

As discussed under sediment production, San Roque, maphilindo and Dagat-Dagatan bridges are considered not to be affected by ashfall settling in the basin since only negligibly small sediment production is assumed at these bridge sites.

With regard to the three bridges, namely, Sula, Bacong and Apollo, annual possible sediment transportation volume is larger than annual sediment production volume as shown in Table-3, no sediment will be deposited at bridge site. For safety consideration, however, Apollo Bridge which has no sufficient surplus between the transportation capacity of 154,000 m^3 and the production volume of 144,800 m^3, appropriate measures e.g. channelization at bridge site will be preferably considered.

Regarding Sula Bridge, it should be noted that there is a tendency of riverbed elevation raising for the following reason. The Sula River is a tributary of the Bulsa River which originates in Mount Gates, 10 km north o Mount Pinatubo. Field investigation revealed that there are much ashfall oriented sediment deposition on the Bulsa River at the confluence of the Sula River. Since this part has locally very gentle riverbed gradient, this will most probably triggers backsand in the Sula

River and resultant riverbed and water surface elevation raising at the proposed bridge site located 500 m upstream portion of the junction.

Table 1 FEATURES OF RIVERS BY BRIDGE

Name of Bridge	Dolores	Sula	Bacong	San Roque	Maphilindo	Dagat-Dagatan	Apollo
Bridge Number	03.10	03.17	03.03	03.07	01.02	03.05	
Name of River	Gugu Creek	Sula River	Pinulot River	Hagonoy River	Basina River	Dagat-Dagatan	Orani River
Catchment Area (km^2)	28.9	50.8	122.8	- *1	- *1	4.53	18.8
Riverbed Slope at Bridge	1/470	1/120	1/300	>1/1000	>1/1000	1/500	1/250
Effective Riverbed Width	30	30	40	45	160	30	20
Basin's Ave. Ashfall Depth (cm)	13	1	10	2	0	1	6
Basin's Ash Volume (cm)	3.8	0.5	12.3	-	-	-	1.1

Note: *1: own catchment is not clear

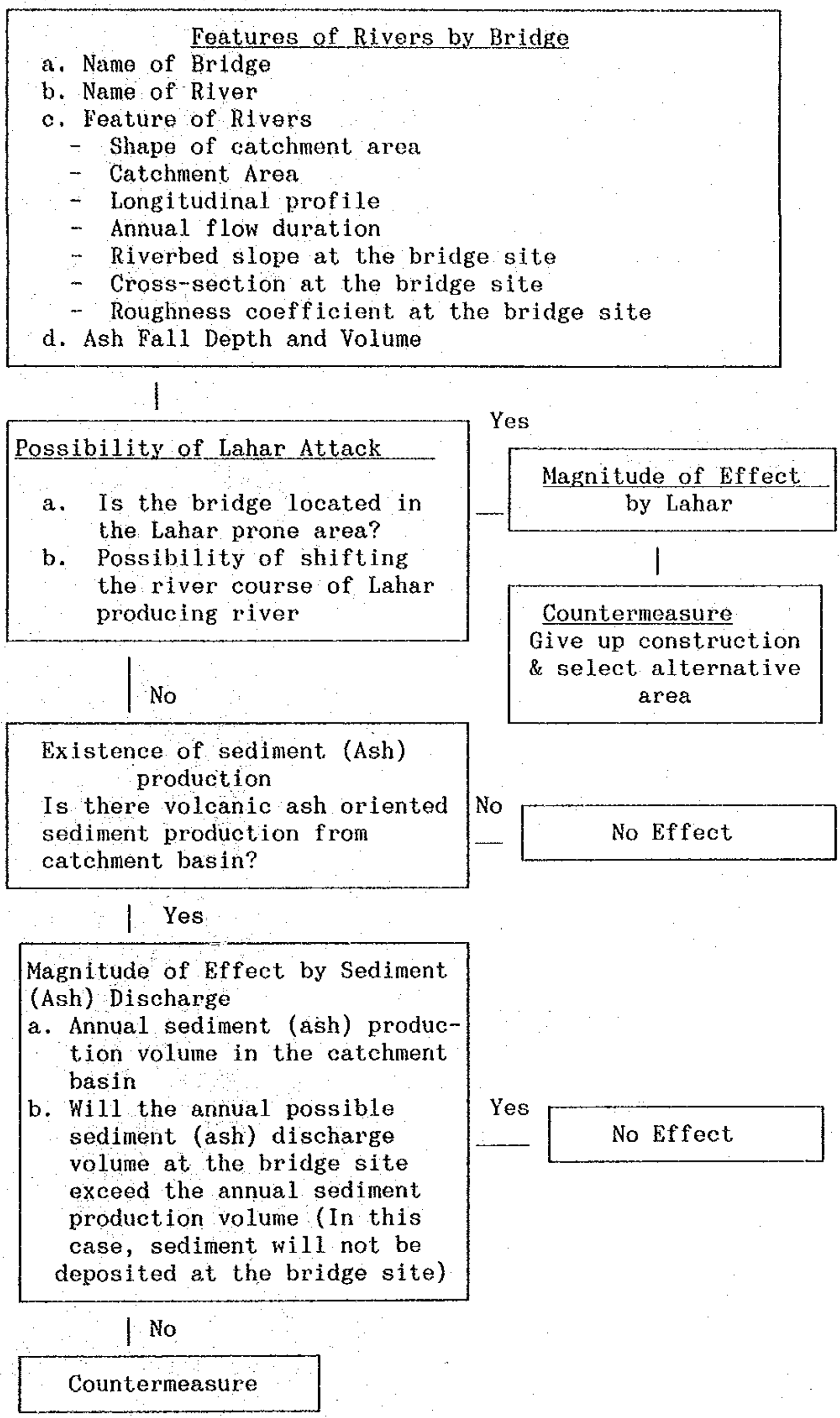

Figure-1 Flow Chart for River and Sabo Study

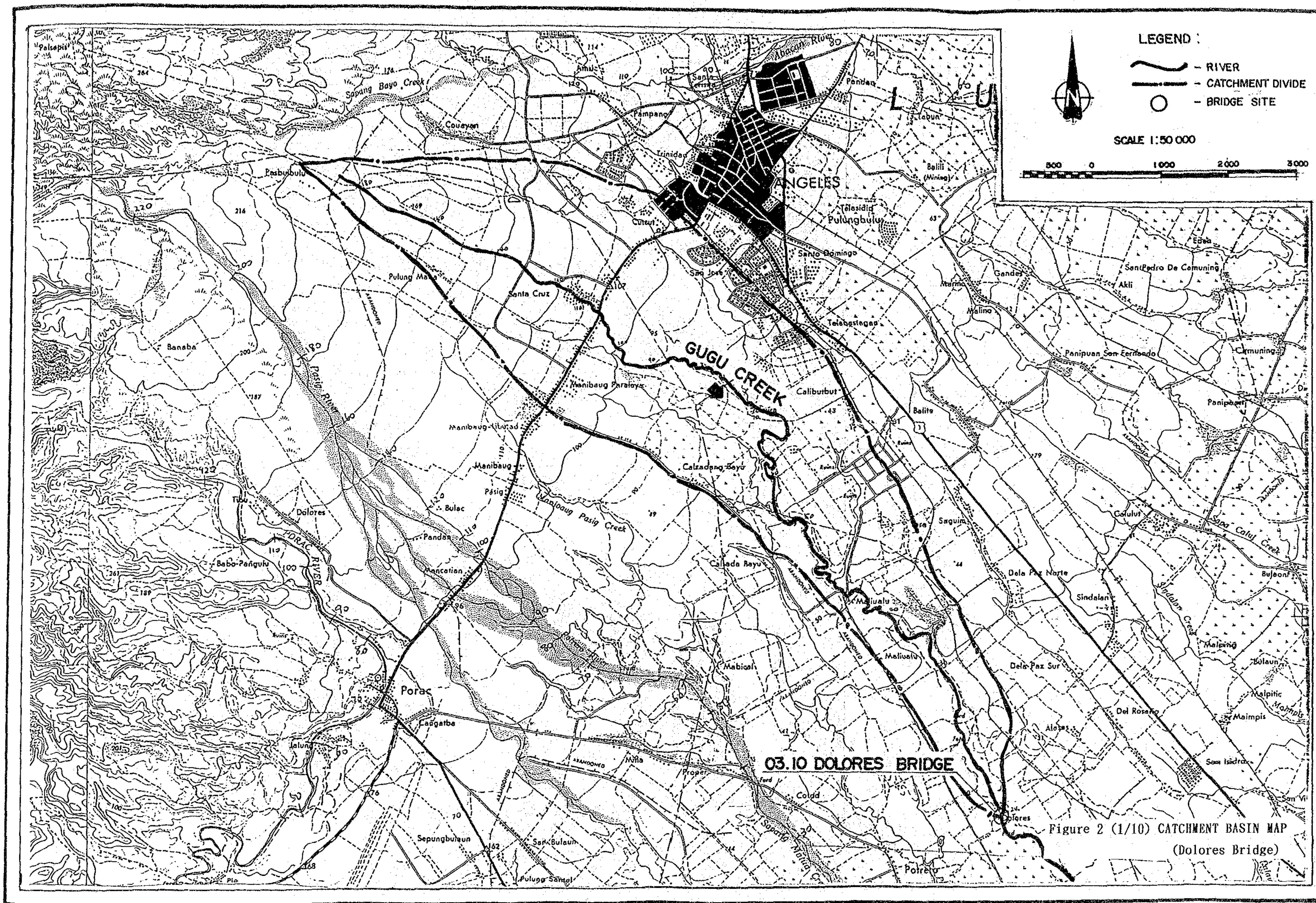

Figure 2 (1/10) CATCHMENT BASIN MAP
(Dolores Bridge)

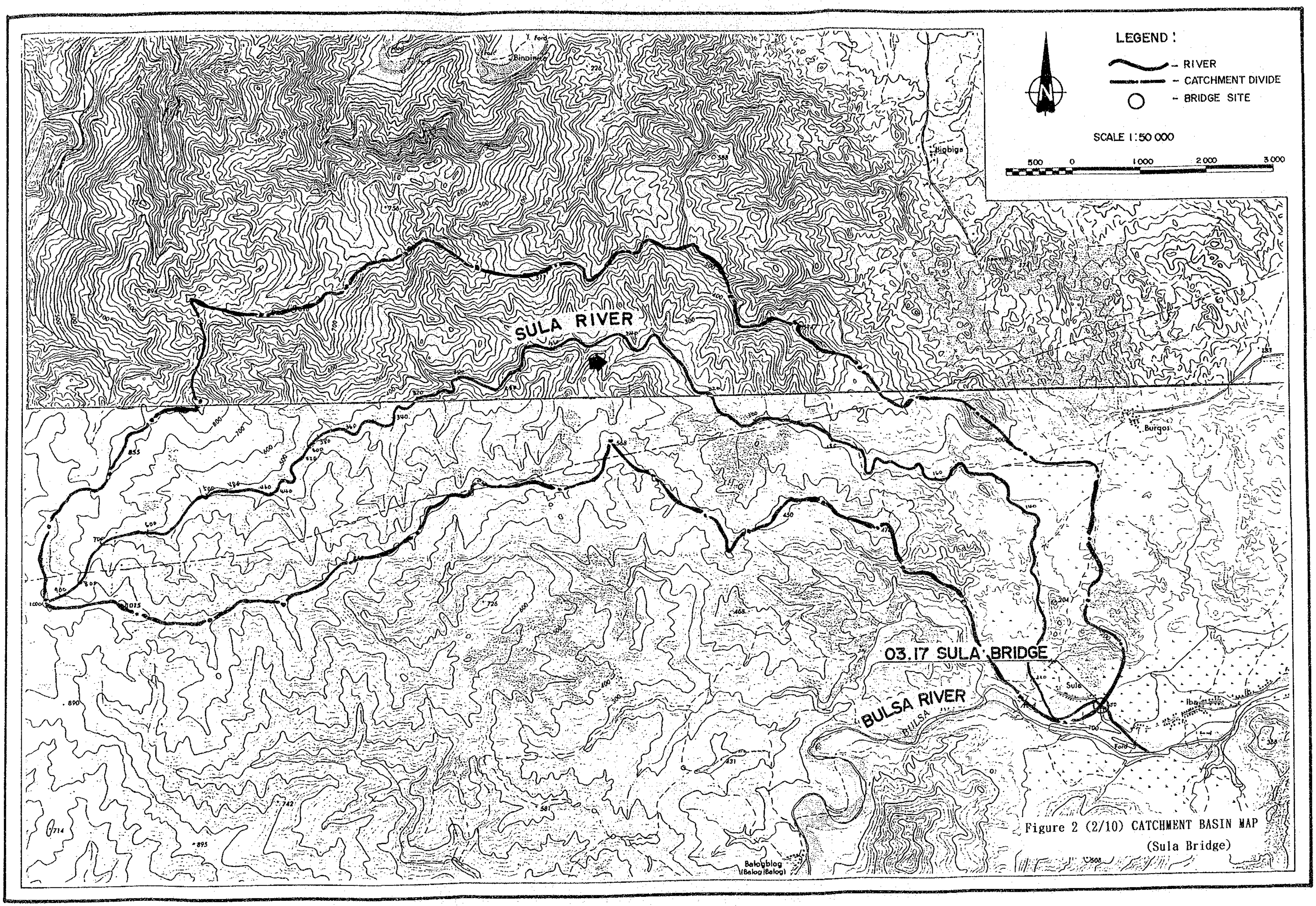

Figure 2 (2/10) CATCHMENT BASIN MAP
(Sula Bridge)

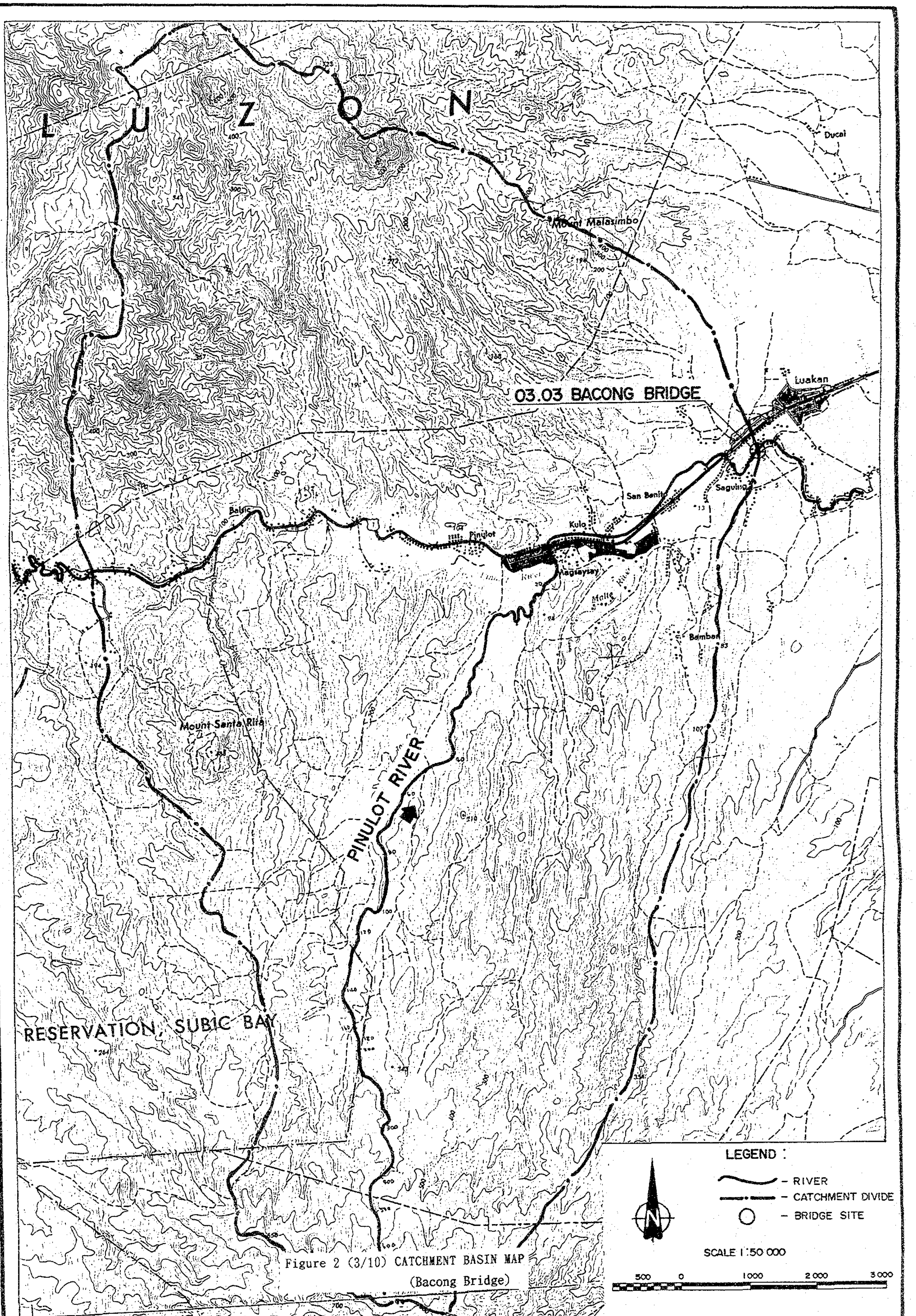

Figure 2 (3/10) CATCHMENT BASIN MAP
(Bacong Bridge)

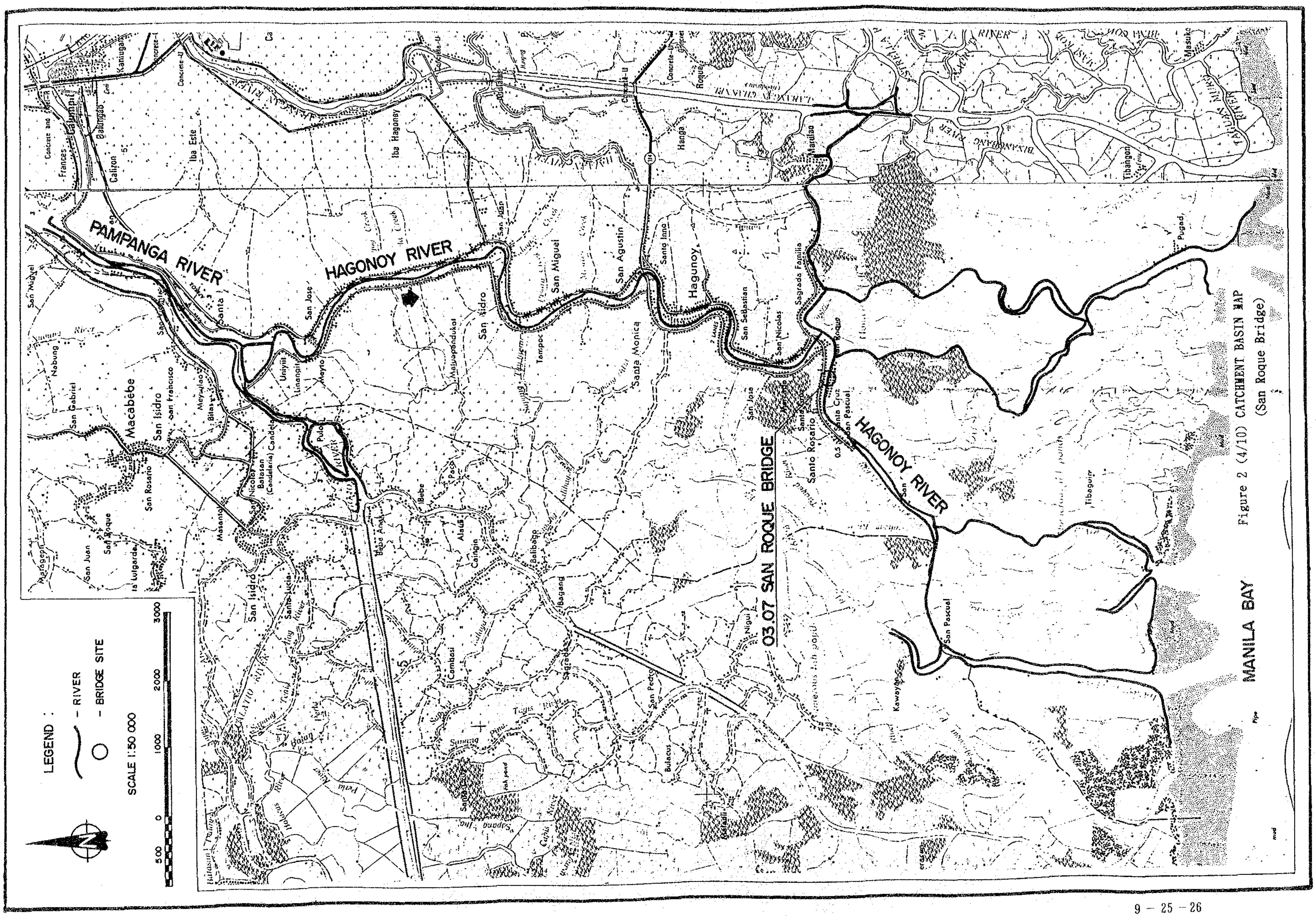

Figure 2 (4/10) CATCHMENT BASIN MAP

(San Roque Bridge)

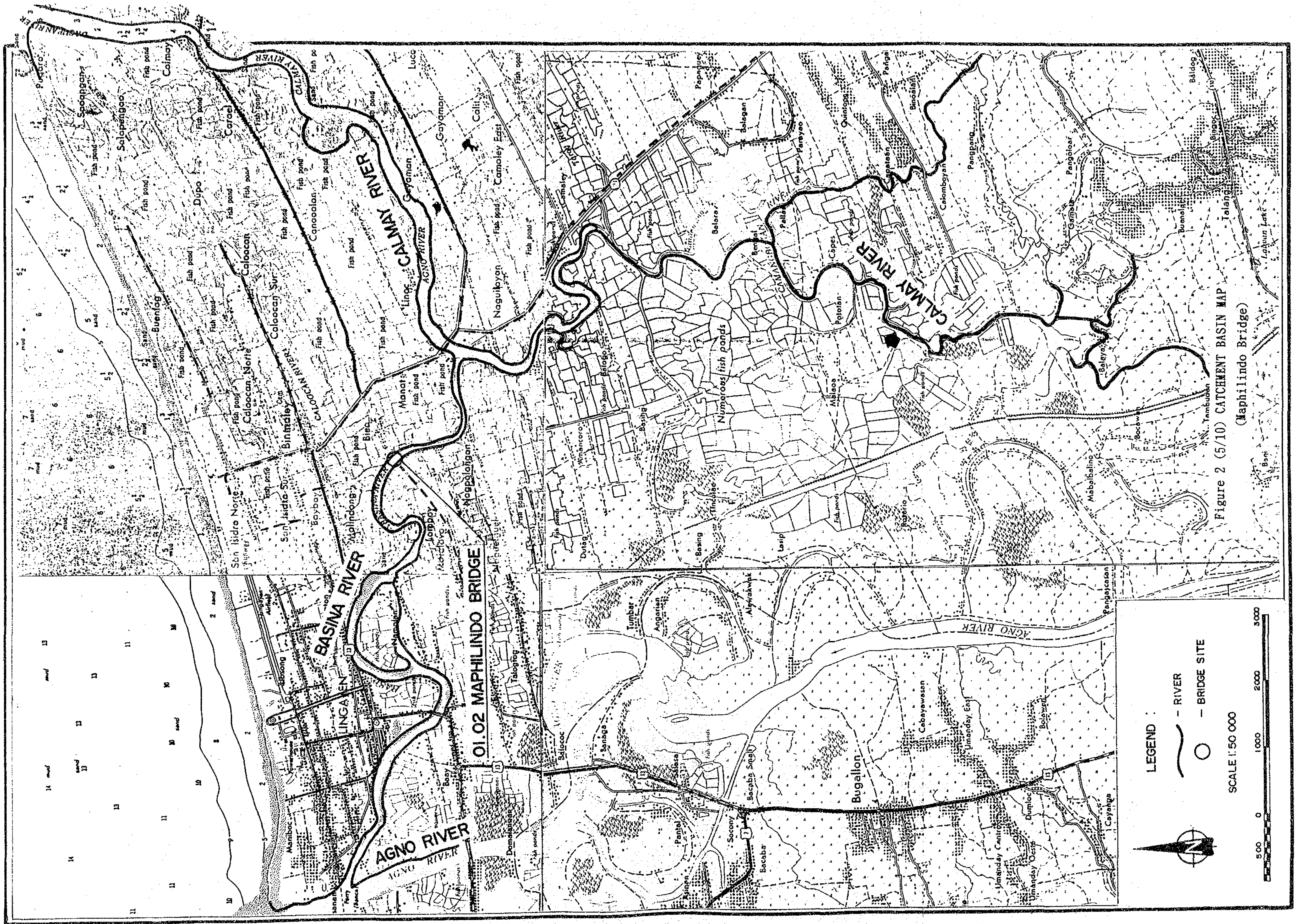

Figure 2 (5/10) CATCHMENT BASIN MAP
(Maphilindo Bridge)

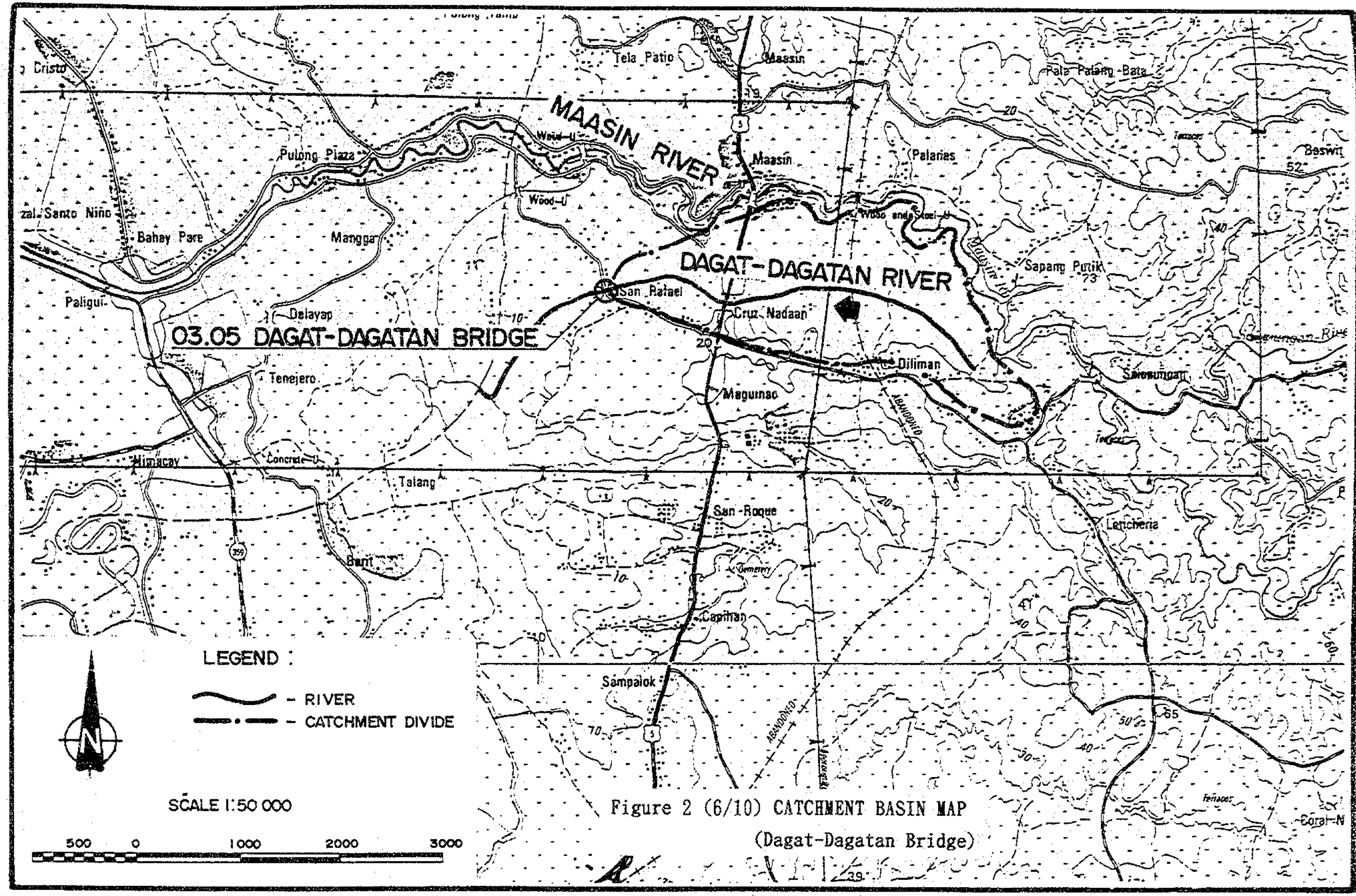

Figure 2 (6/10) CATCHMENT BASIN MAP
(Dagat-Dagatan Bridge)

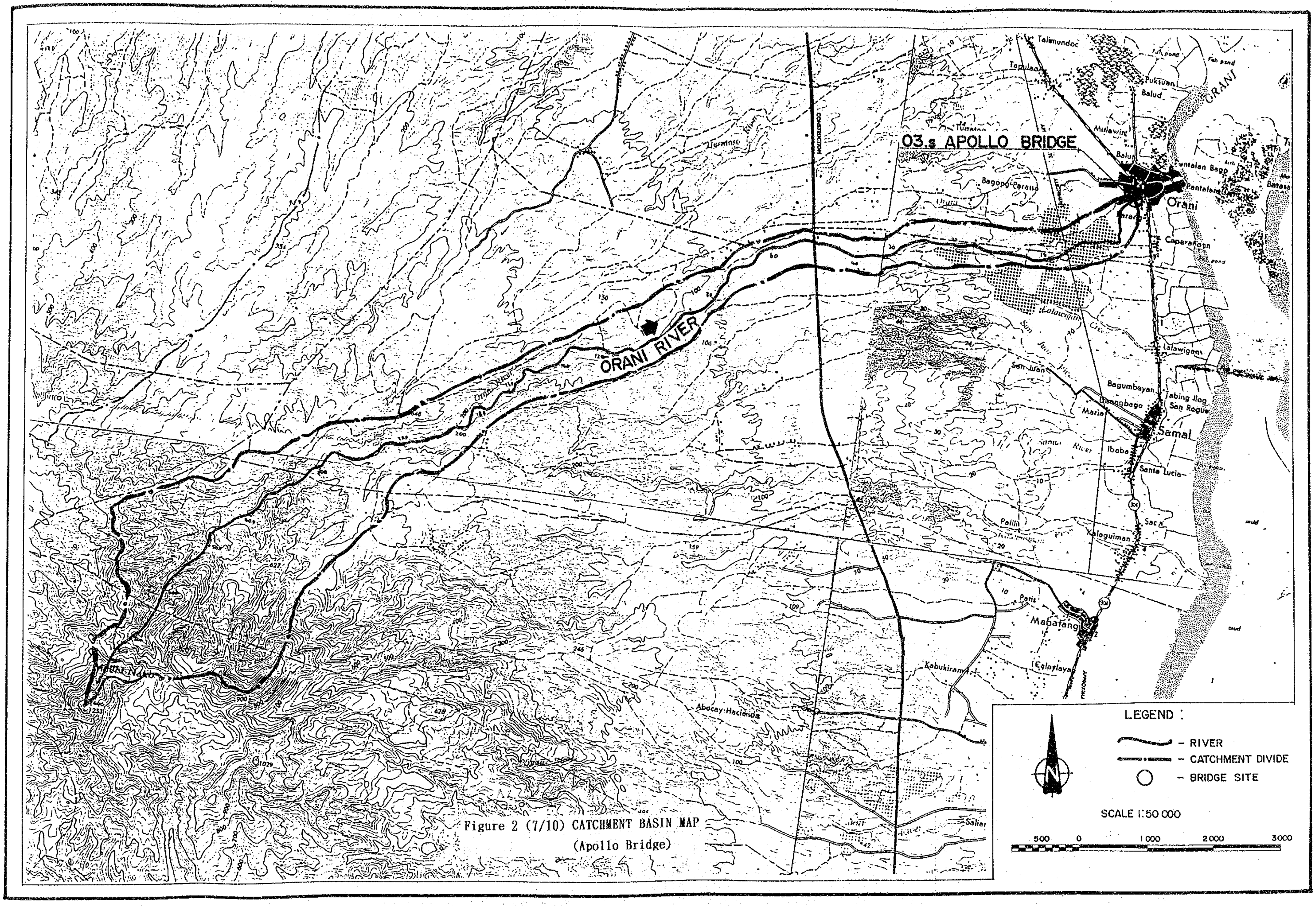

Figure 2 (7/10) CATCHMENT BASIN MAP
(Apollo Bridge)

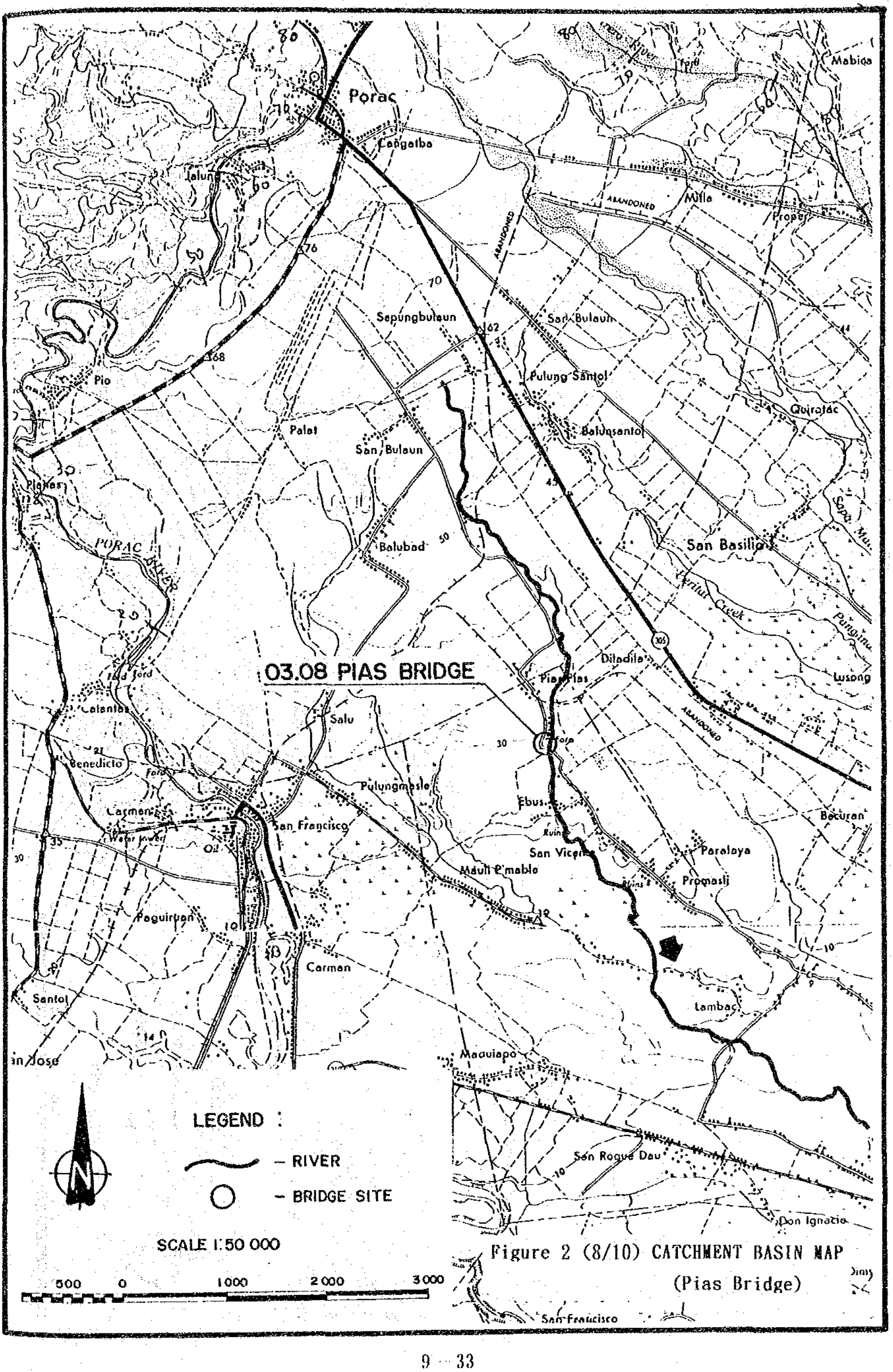

Figure 2 (8/10) CATCHMENT BASIN MAP
(Pias Bridge)

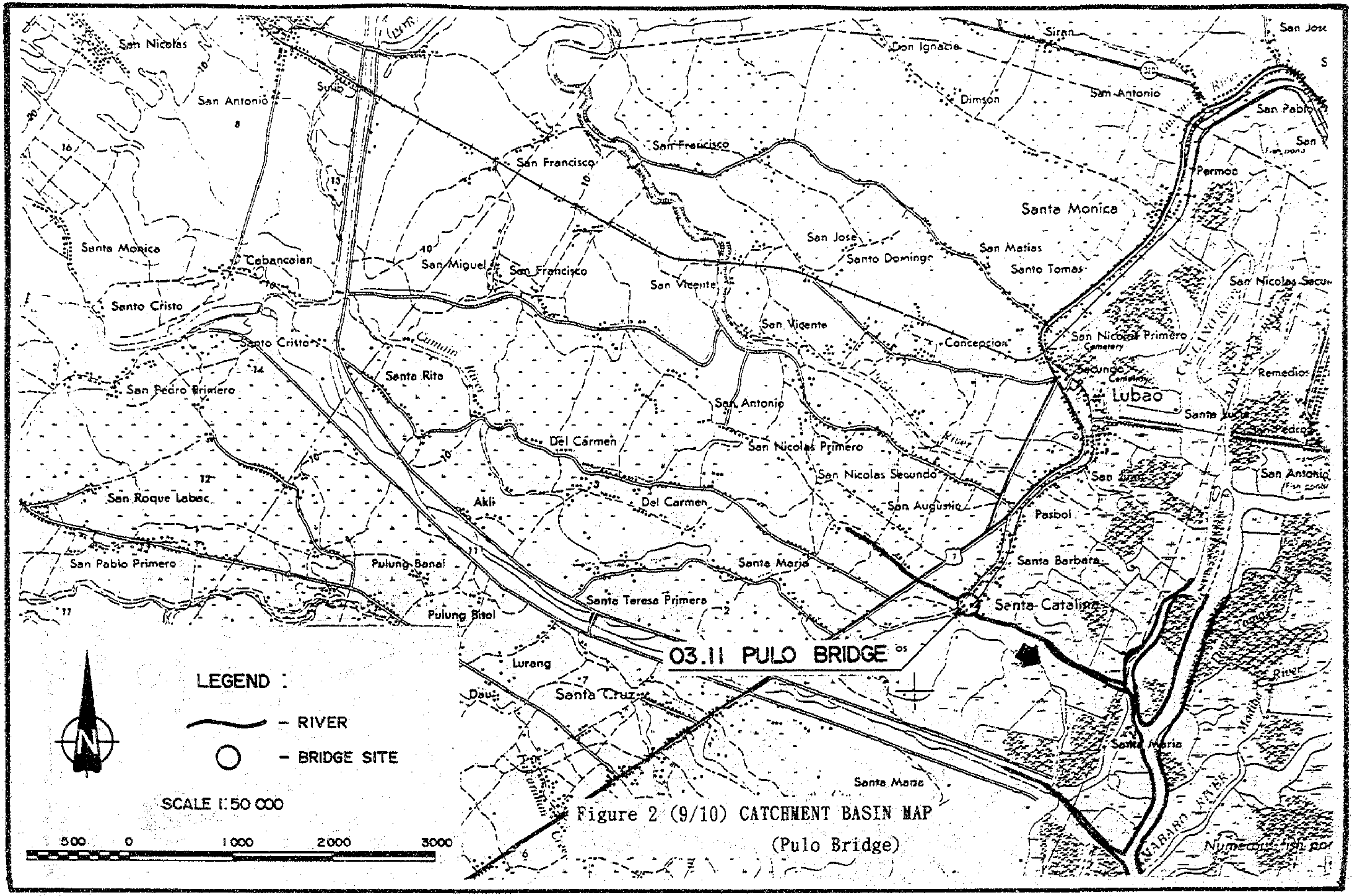

Figure 2 (9/10) CATCHMENT BASIN MAP
(Pulo Bridge)

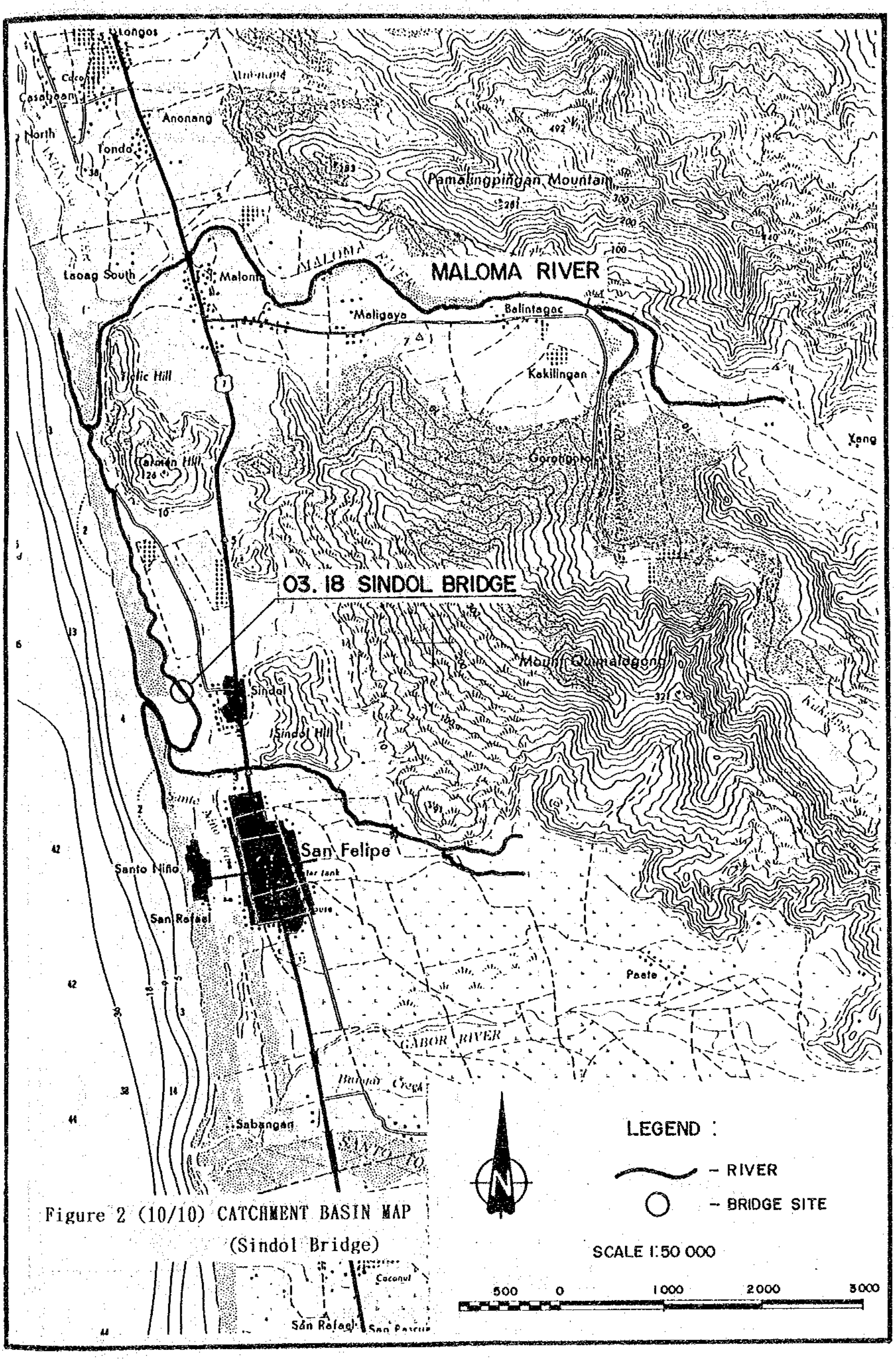

Figure 2 (10/10) CATCHMENT BASIN MAP
(Sindol Bridge)

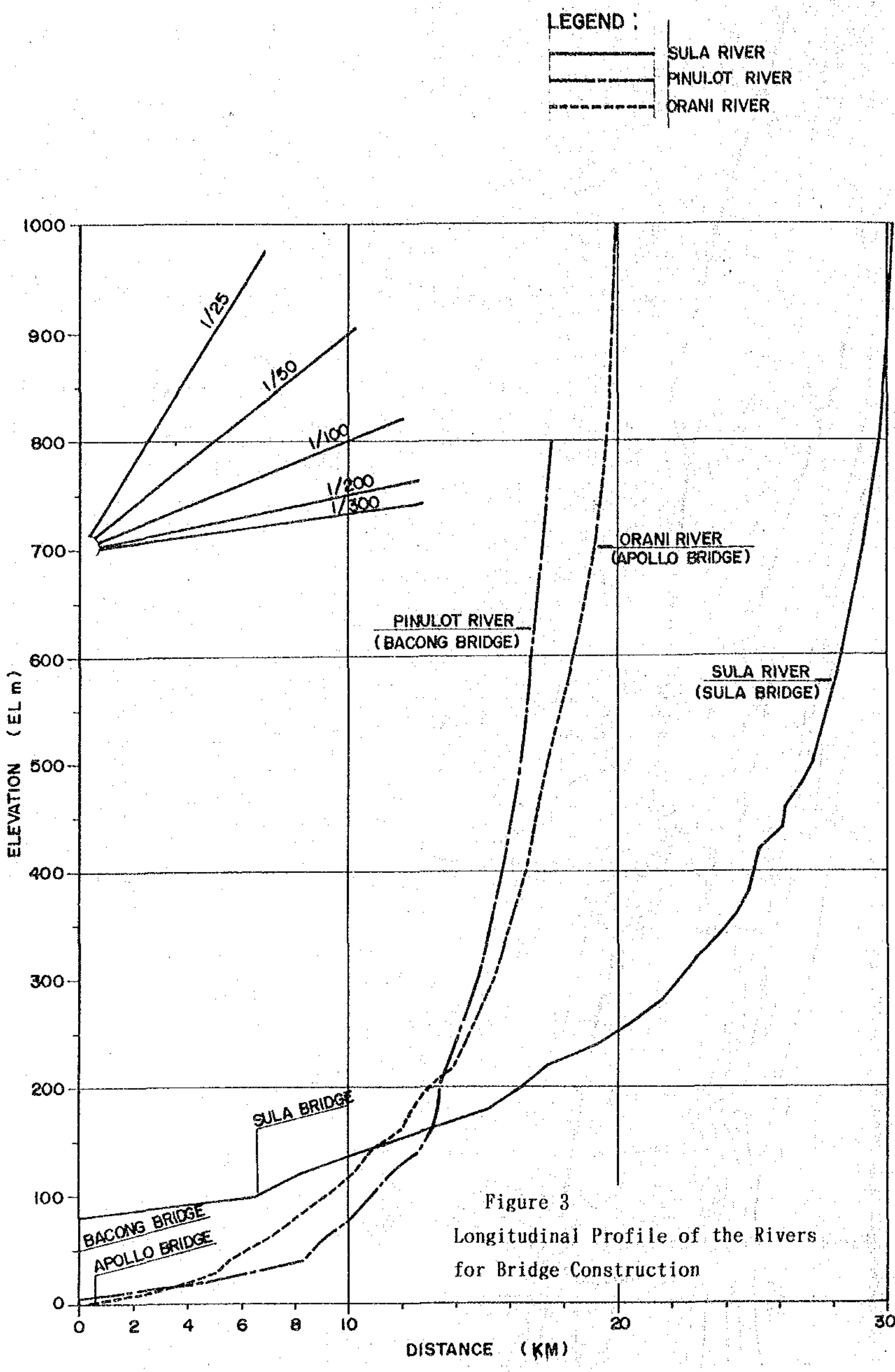

Figure 3
Longitudinal Profile of the Rivers
for Bridge Construction

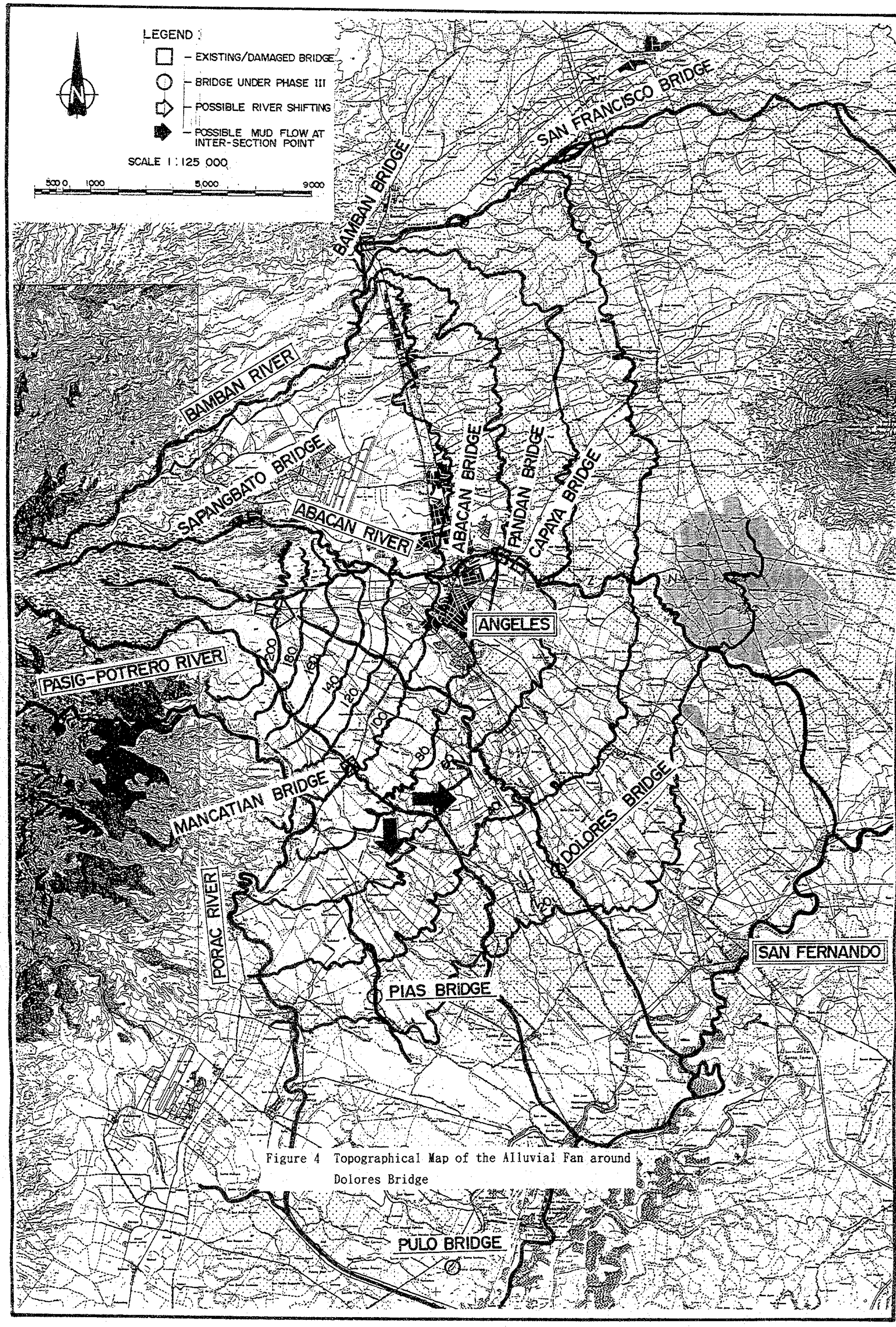

Figure 4 Topographical Map of the Alluvial Fan around Dolores Bridge

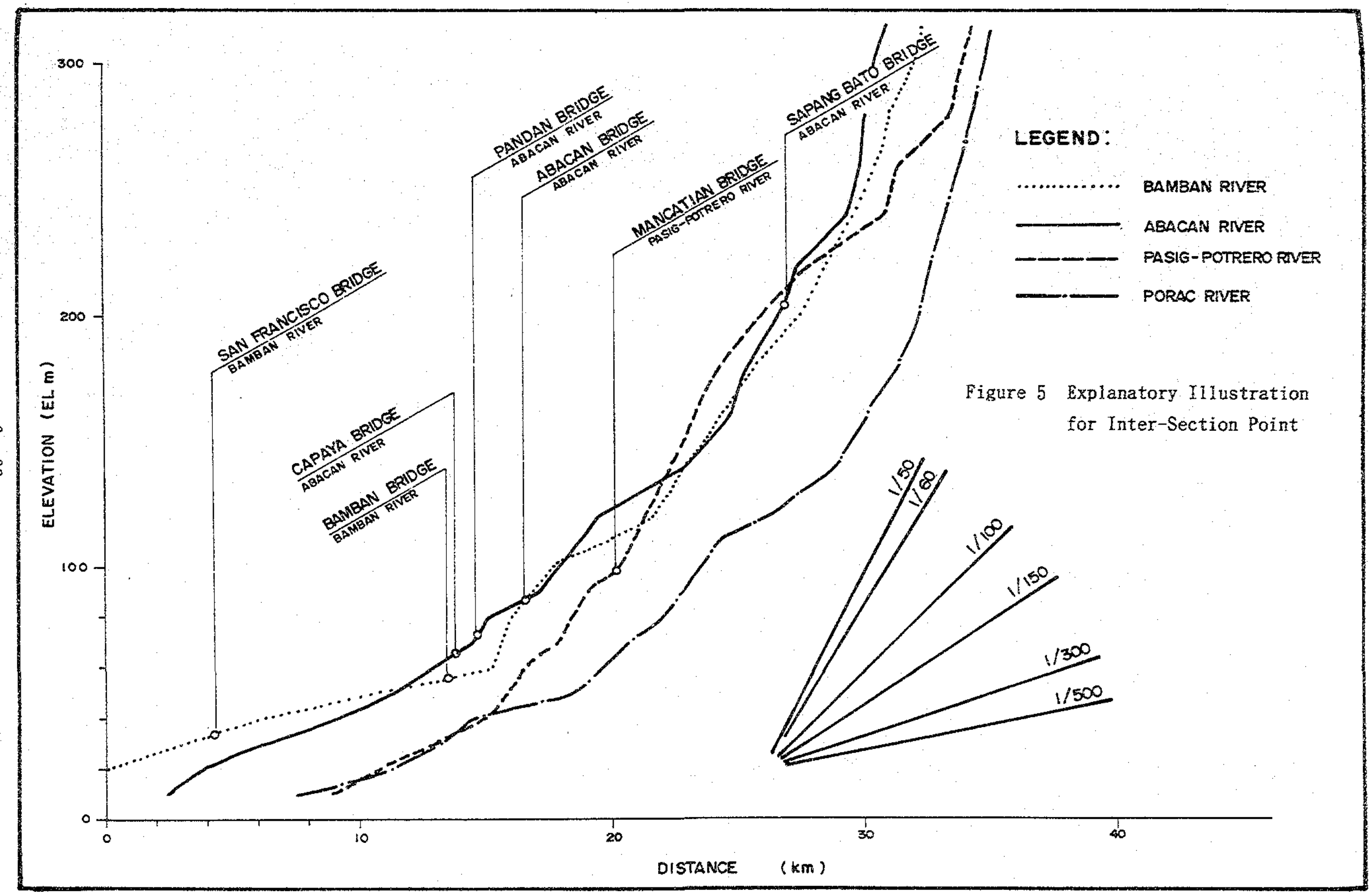

Figure 5 Explanatory Illustration for Inter-Section Point

APPENDIX 10

COST SHOULDERED BY GOVERNMENT OF THE REPUBLIC OF THE PHILIPPINES

APPENDIX 10

COST SHOULDERED BY THE GOVERNMENT OF THE REPUBLIC OF THE PHILIPPINES

(1) 10 subjective bridges for Phase III,Group 2

The scope of undertaking of the Government of the Philippines for the Group 2 Bridge is as follows:

1) Scope of Major Undertakings

a) To ensure the exemption of custom duties, internal taxes and other fiscal levies for the supply of materials under Japan's Grant Aid.

b) To acquire the right-of-way and to provide necessary land area for the construction works.

c) To demolish obstacles including houses within the right-of-way that affect the implementation of the Project.

d) To make passable all roads and bridges leading to the project sites for the transportation of materials and equipment provided under Japan's Grant Aid.

e) To demolish obstacle existing bridges and relocation of incidental facilities.

2) Land Acquisition and Obstacle Demolition

The acquisition of right-of-way, the demolition of obstacles including houses and the temporary provision of necessary land area for construction works are shown in the following table.

Table 10-1 LAND ACQUISITION, HOUSE DEMOLITION AND TEMPORARY LAND FOR CONSTRUCTION WORKS

Bridge No.	Bridge Name	Land Acquisition (m^2)	Obstacle Demolition	The temporary provision of necessary land area for construction work(m^2)
01.02	Maphilindo	4,200	1 (concrete) 2 (wooden)	1,120.5
03.03	Bacong	4,100	2 (concrete) 7 (wooden)	1,120.5
03.07	San roque	2,500	0	1,120.5
03.13	Mangkuyog	2,300	0	1,120.5
03.17	Sula	4,000	0	1,120.5
04.07a	Camagon	3,300	0 (concrete) 1 (wooden)	1,120.5
04.20a	Paragusan	2,100	0 (concrete) 3 (wooden)	1,120.5
04.07b	Tan-Agan	2,400	0 (concrete)	1,120.5
04.10b-2	Ihatuba	2,000	0 (concrete) 1 (wooden)	1,120.5
03.s	Apollo	1,900	1 (concrete) 1 (wooden)	1,120.5
Total		28,800	4 (concrete) 15 (wooden)	11,205

Table 10-2 CONSTRUCTION COST BY THE GOVERNMENT OF THE PHILIPPINES

Item	Quantity	Unit cost (Pesos)	Cost (Pesos)
Rehabilitation of roads Leading to Project Sites	31 Km		3,458,000
Rehabilitation of Bridges Leading to Project Sites	12 bridges		136,000
Road Maintenance	920 Km	600	552,000
Land Acquisition	28,800 m²	60	1,728,000
House Demolition	19 houses	60,000	1,140,000
Necessary Land Rental for Construction Works	11,205 m²	15	168,000
Total			7,182,000

APPENDIX 11

RECOMMENDATION FOR PHASE III, GROUP 1

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RECOMMENDATION FOR PHASE III, GROUP 1

(1) 03.08 Pias Bridge

The tributary between the Pasig-Potrero and Porac river on the alluvial fan does not originate in Mt. Pinatubo, but is located on the foot of Mt. Pinatubo. In the case of shifting the course to the direction of the tributary, there is a possibility to be affected by eruption of Mt. Pinatubo, which will interrupt the progress of the construction.However,this bridge is very important for the remove project of ADB. And DPWH desired to construct this bridge.

For this reason,the study team recommends to construct the bridge in consideration of the following.

Construction of river bank protection of approach roads
Construction of stabile substructure
Maintenance of waterway of the river

(2) 03.11 Pulo Bridge

The clearance between the bottom of girder and riverbed was not enough because of accumulation of mudflow. But construction of the bridge perfectly was completed exept the construction of approach road. So, it is not adequate to remove it to other place. As the result,it was recommended to take some countermeasure as followings.

Removal of the accumulation on the riverbed
Construction of riverbank protection
Reinforcement work for the approach road
Maintenance for the shifting of the water way in the future

(3) 03.18 Sindol Bridge

Now, the influence due to eruption of Mt.Pinatubo was not observed. But in the future,it may be considered that the accumulation from the neighborhood will inflow to the site. But construction of the new bridge was completed all most. It is not adequate to remove the bridge to other place. As the result,the study team recommends the followibngs.

Reinforcement of the approach road

Maintenance for the shifting of the river water way in the future