(v) Ship traffic

Guagua City that, it is said, had been connected by a sea route with Manila in the old days, has developed as a commercial center in this area.

Now, it is nothing but an area near the mouth of the river, with 2 or 3 tons of ship traffic for transportation of people and goods to Fish pond.

(vi) Fishery

There is little water flow in the Pasig-Petrero during dry season with practically no fishery activity. But, in and near the mouth of the river and the Guagua, lobsters, crabs, eneida fishes, comon fishes etc. are caught from the fish ponds and the main river, which supply coastal people with protein.

(vii) The use of the dry riverbed is very limited and paddy field farming is carried out on a small scale.

2-4 Existing riparian structure

1. Levee

A river course plan covering section from the Gua-gua junction of the Pasig-Potrero to 22km upstream has been established by B.P.W. based on a recommendation of ECAFE Report issued in 1964. According to this plan, river repairing work was started at the Santa Barbara upstream in 1974. Up to now the levees on both banks have been completed for an extension of 12km between the Mitla and the Bacolar and now, the work continues. The right bank of upstream of the West Macatian Bridge was embanked in 1965 in order to close the old river course drifting to the Porac side.

Existing extension and history of embankment construction

In 1965	Sta.18 + 400	-	Sta.22 + 100	Right bank 3.7km
1974	Sta. 6 + 200	-	Sta. 9 + 500	Both banks
1975	Sta. 9 + 500	-	Sta.11 + 500	Both banks
1976	Sta.11 + 500	-	Sta.14 + 500	Left bank
	Sta.11 + 500	-	Sta.13 + 50	Right bank
1977	Sta. 6 + 200	-	Sta. 2 + 500	Both banks

These levees use excavated sediment as banking material. The slope of normal surface is 3:1 for both riverside and landside. The height is usually within 4.5m although the by-pass of the National Highway is sometimes as high as 6m. Now, gully erosion by rain is seen occassionally and some of them are as deep as 1.0m extending from crown to bottom.

2. Revetment

The levees have been revetted on both banks of existing levees located upstream of STA4+300 by-pass. This revetment consists of 30cm thick boulder rip-rap laid to HWL section. For foot protection, Boulder 1.0m deep and 1.0m wide is placed. In the concave side of river bent where river course is curved, boulder groyne (1.5m high, crown width 2.0m, normal slope 1:1, length 5.0m) are constructed at a right angle to the embanked normal line for a distance of 300m at intervals of about 5 through 10m around STA9 and STA12. The embankment 2.7km on right bank upstream of the West Mancatian Bridge has also been revetted similarly.

3. Drainage pipe

In the existing levees, drainage pipes have been laid at 4 places on the left bank and at 6 on the right bank in the 7km section between the Mitla and the San Juan villages. These pipes, consist of hume pipes, jointed by concrete collars and concrete has been rubbed into their mounting parts.

Left bank:	Sta. 9 + 183.5	ϕ900mm x 1	Constructed in 1975
	9 + 518	ϕ750mm x 1	"
	12 + 420	ϕ900mm x 1	1976
	12 + 868	ϕ1,000mm x 1	"
Right bank:	Sta. 7 + 470	ϕ1,200mm x 1	1974
	9 + 325	ϕ900mm x 1	1975
	9 + 794	ϕ900mm x 1	"
	10 + 436	ϕ900mm x 1	"
	11 + 496	ϕ900mm x 1	1976
	13 + 50	ϕ900mm x 2	"

Across the national road of Bacolor there are 8 conduits ϕ300 through ϕ600 on the west side and 6 on the east side. As the bypass there are 3 conduits ϕ600 to ϕ1500 on the west side and 5 on the east side. 2 conduits 2.0^mx 2.0^mx 2 are set in ϕ700section between the Pasing Potrero river at the west side and Ruis village. But on the west bank it is somewhere seen that conduits ϕ1,000 are embedded in sediment due to the flood in 1972 and left as they are without functioning.

Some conduits ϕ300 are found on the Anjelas-Porac road at Mancatian and ϕ1,000 are found 100m to the east of East Mancatian.

4. Bridge

There are 2 bridges i.e. East and West bridges over the Mancatian (B=7m, LE=75m, LW=110m) and one (B=11.0m, L=148m) over the bypass. Another bridge (B=7m, L=150m) is under construction over the National Road at Bacolor since 1977. The river section of these bridges is sufficiently large to handle the design flood flow.

5. Damage

The right bank upstream of the West Mancatian bridge constructed on before 1966 was damaged by Typhoon "Irma" in last May, resulting in flooded creeks and subsequent disaster. In 1972, Typhoon "Fdeny" caused unprecedented damage by sand and flood, the right bank of Sta.20+200 being destroyed and a vast amount of sand and earth washed away. On the opposite bank with river bed higher than now, the plateau section was flooded and Maniba suffered damage. As in this downstream area, the river course is scarcely fixed, flooding takes place rather frequently and this combined with flooding of the main Gua-gua river increased intensity of the disaster. In 1974, BPW prepared a river course plan based on the recommendation of ECAFE and started embankment works for the protection of San Juan and St Barbara. Using excavated river bed materials, works were completed upto Sta.6+200 - Sta.9+500, but the back slope on the right bank was flooded by water flowing from upstream. In addition, the right bank upstream of Mancatian was destroyed at the same place as in 1972. In 1975, embankment works proceeded to upstream, completing 2km section. In 1976, works to protect Mitla and Potrero were executed as they are now, but both banks near Sta.8 (Sta.6) completed in 1974 were destroyed. In 1977, when construction of the bypass road con-

necting Gua-Gua and San Fernando was continued from the preceding year, Sta.4+200 crossing over the Pasig-Potrero was constructed and the 3.7Km downstream section remaining uncompleted since 1974 was embanked.

In the same year, flooding with inside water occurred downstream of Mitla weakened the levee. The water, breaking through some 100m length of levee and washing against the land-side revetment, excavated the back slope of the levee near Sta.7+600 Balas, endangering break of embankment.

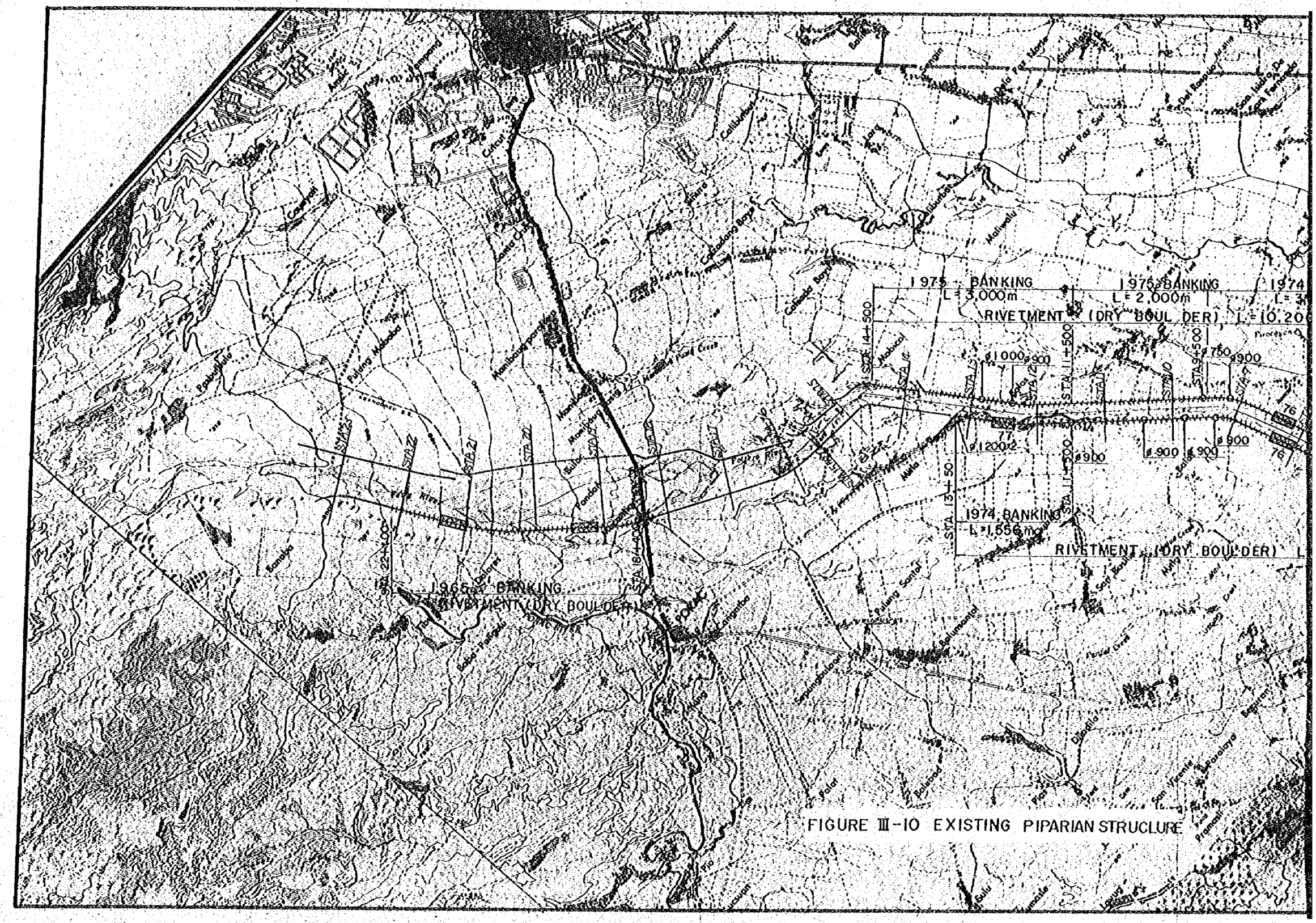


FIGURE III-10 EXISTING PIPARIAN STRUCLURE

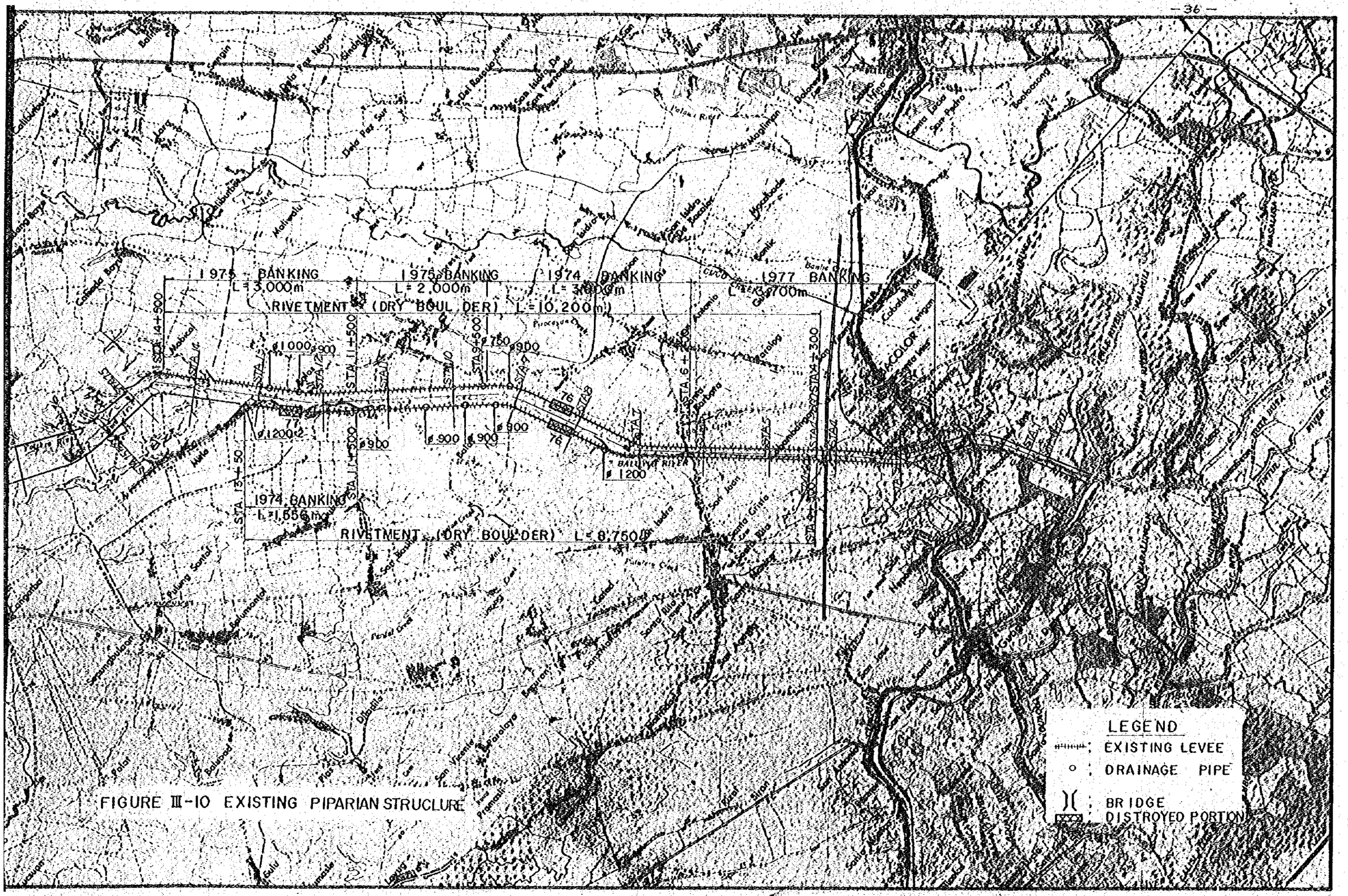


FIGURE III-10 EXISTING PIPARIAN STRUCLURE

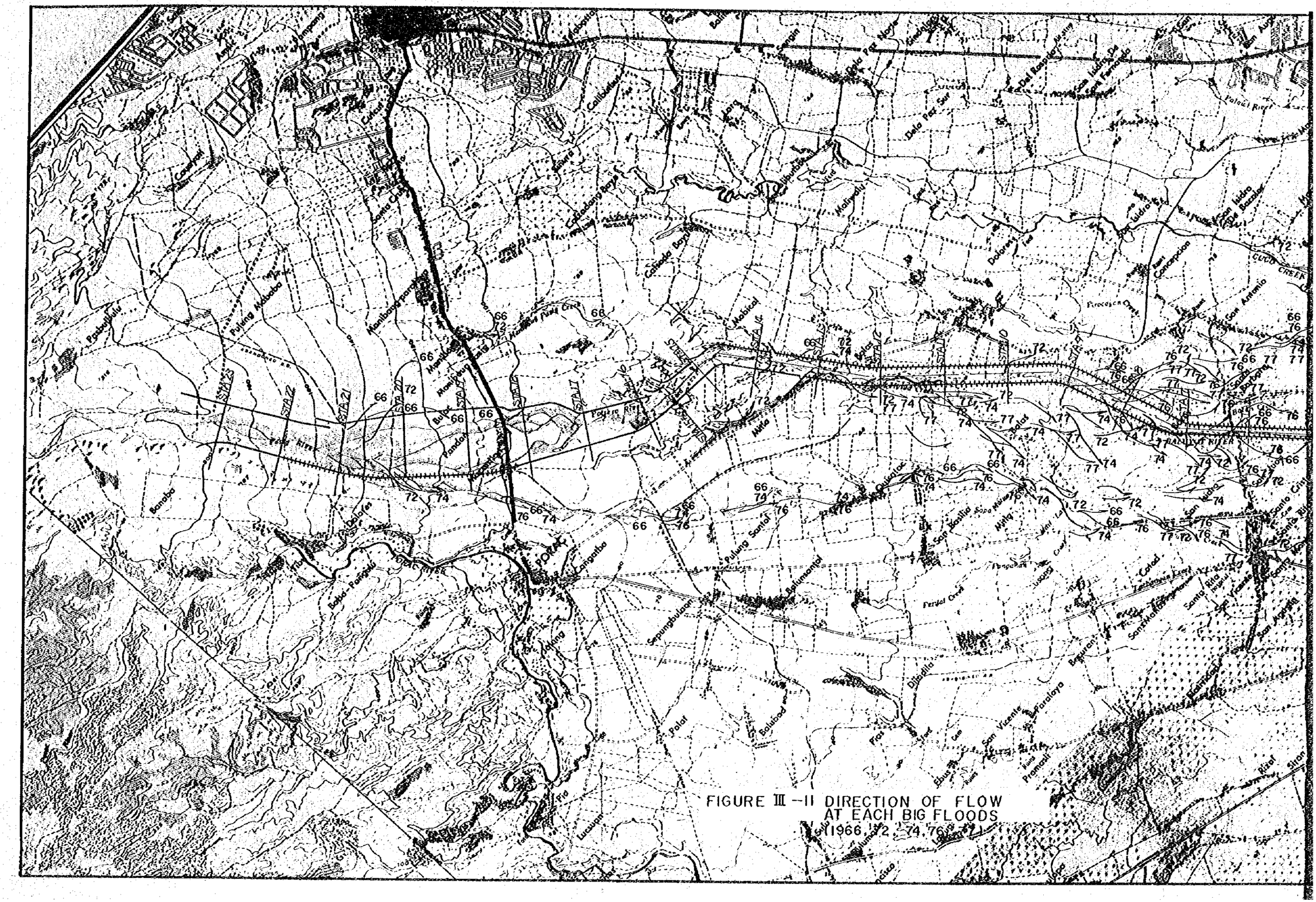


FIGURE III -11 DIRECTION OF FLOW AT EACH BIG FLOODS (1966, 72, 74, 76, 77)

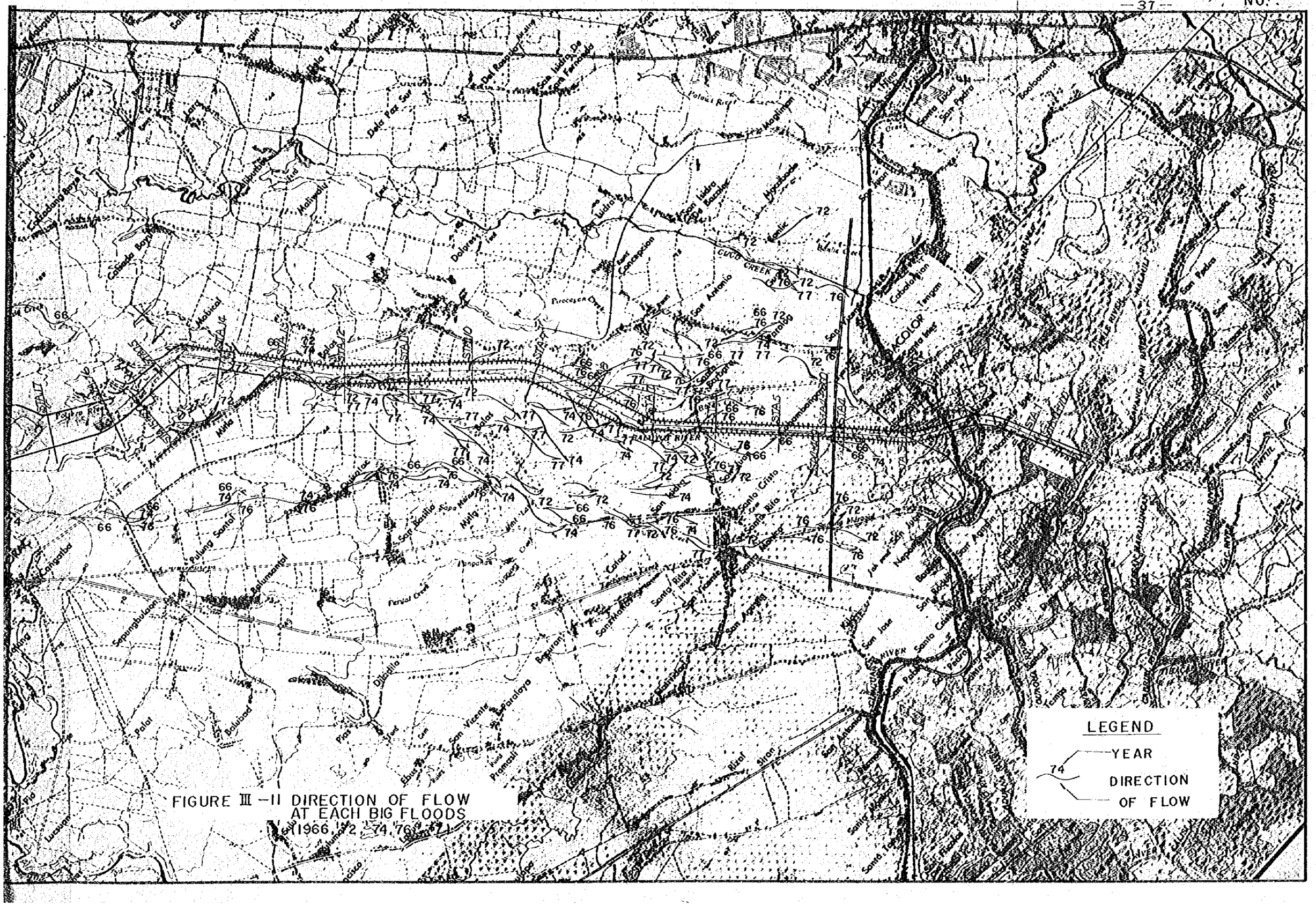


FIGURE Ⅲ-11 DIRECTION OF FLOW AT EACH BIG FLOODS (1966,'72,'74,'76,'77)

III. River Improvement Plan and Sand Reservoir Plan

3.1 General

Prior to preparing these plans, the following two flood prevention plans for an extensive area covering the basins of the Abacan River and the Porac River adjacent to the Psig-Potrero River were stuided.

(1) Plan to guide part of the Abacan River's floodwater from a point upstream of Angeles City to the Pasig-Potrero River.

(2) Plan to guide part of the Pasig-Potrero River's floodwater to the Porac River.

The two plans, (1) and (2), were scrapped because Plan (1) would increase floods downstream of the Pasig-Potrero River and thus merely pass flood damage from the area downstream of the Abacan River over to the Pasig-Potrero basin, and at present, floodwater from the Abacan River would be less likely to cause damage to Angeles City, whereas Plan (2) would increase the danger of flooding Porac Town, which is now relatively safe from floods, and thus raise the potential of flood damage.

The river improvement plan and sand reservoir plan described in this section have been prepared in the background mentioned above. The basic policy is to improve only the Pasig-Petrero River. Specifically, the plans cover flood prevention and discharged sand measures for a section of about 27 km from the top of the fan-shaped part of the Pasig-Potrero River to its confluence with the Guagua River.

The river improvement plan covers the downstream area of the Pasig-Potrero River (from the river mouth to STA15+950), and aims at safely guiding planned flood discharge downstream.

As a result of studying the river plan prepared by the Bureau of Public Works, which is now partially under way, a planned flood discharge rate (Q) of 900 m^3 per second was selected as in the present plan.

As mentioned before, the basis aim of the erosion control plan is to construct a group of check dams in the mountain region upstream of the river, and regulate and control discharged soil. Because of topographical and soil conditions, however, it is impossible to control all the discharged soil with the group of check dams due to limitations on possible dam sites. Accordingly, sand reservoirs and accessory facilities were planned for the section from STA 15+950 and STA 27 for preventing the soil discharged from the mountain region upstream from flowing into the river channel as described in this section.

Soil distribution, which is a basic factor for the sand reservoir plan, must be determined by studying the erosion control plan mentioned in the preceding section. When the group of check dams are built upstream of the river, 835,000 m^3 of soil controlled by the check dams will be discharged to the fan-shaped area, and 144,000 m^3 of it will run further downstream. Annual mean sediment discharges corresponding thereto will be 304,000 m^3 and 30,000 m^3 respectively. Therefore, the sand reservoir plan is prepared based on the difference between the quantity of soil discharged to the fan-shaped area and the quantity of soil which runs further downstream. That is, 691,000 m^3 at flood time, or 274,000 m^3 on the yearly average.

According to the construction plan for the project, the group of check dams upstream of the river will not be constructed in 10 years after the completion of the river improvement and sand reservoir plans. Therefore, there will not be enough soil control by the check dams for the 10 years. Thus a temporary plan providing the sand reservoirs with an extra capacity for a total capacity of 941,000 m^3 for the period will be taken into account.

1. Review of the present plan

The Pasig Potrero River improvement plan prepared by the Bureau of Public Works in 1964 has been in the construction stage since 1974. Of the design data, plane, longitudinal section, and standard section drawings are on hand, but no related reports have been found. The following is a review of the present plan based on the available plane, longitudinal, and cross sectional drawings, and local surveys.

(1) The planned flood discharge of 900 m^3 per second at the Mancantian Bridge (catchment area: 44 km^2) corresponds to an 80-year probability as already mentioned in Section 3.3 Meteorology and Hydrology. Considering the facts that the Pasig-Potrero River discharges much soil despites its relatively small drainage area and that the process of rainfall into run-off discharge is quick, due attention must be paid to not only the safety of the river channel against the conceived floods but also to the safety of the levees against medium- and small-scale floods (400 m^3 per second in 5-year probaility; 520 m^3 per second in 10-year probability), particularly the maintenance of the watercourse and the reinforcement of the levees. (The levees must be safe from breakdown when no floodwater overflows in a medium- or small-scale flood.)

(2) A plane view of the river shows that the river channel runs through a stretch of valleys at low sea level, has groynes at curves and points subject to water hammer action, and an alleviation reach 500 meters long near a point 7 km from the mouth of the river to narrow the river width of 300 m upstream to 150 m downstream to anticipate a soil flash effect at the time of flood. The points that are particularly noticeable from the plane view of the river are as follows:

i) The Pasig-Potrero River joins the Guagua River downstream at right angles. A measure must be taken to ease this confluence at sharp angles.

ii) The curvature of curves is less than 4 times the river width, but because the river is wide for its discharge rate, a measure is necessary for preventing change of flow direction at sharp angles within the river channel.

iii) The river is wide upstream of a point about 7 km from the mouth of the river, where it has levees, and therefore easy turbulence of the flow is anticipated because of the unsteady watercourse.

iv) The left levee of the river upstream of a point 14 km from the mouth of the river runs through the valley. Preferably, the levee should run through the plateau.

(3) A longitudinal sectional view of the river shows that the river has an easy grade downstream and a steel grade upstream without sharp variations. However, the river bed is too low in the 11-km section from the 8-km point to the 18-km point from the mouth of the river, where the river has levees. The low waterway is about 30 m wide, but the rate of discharge through the low waterway is unknown.

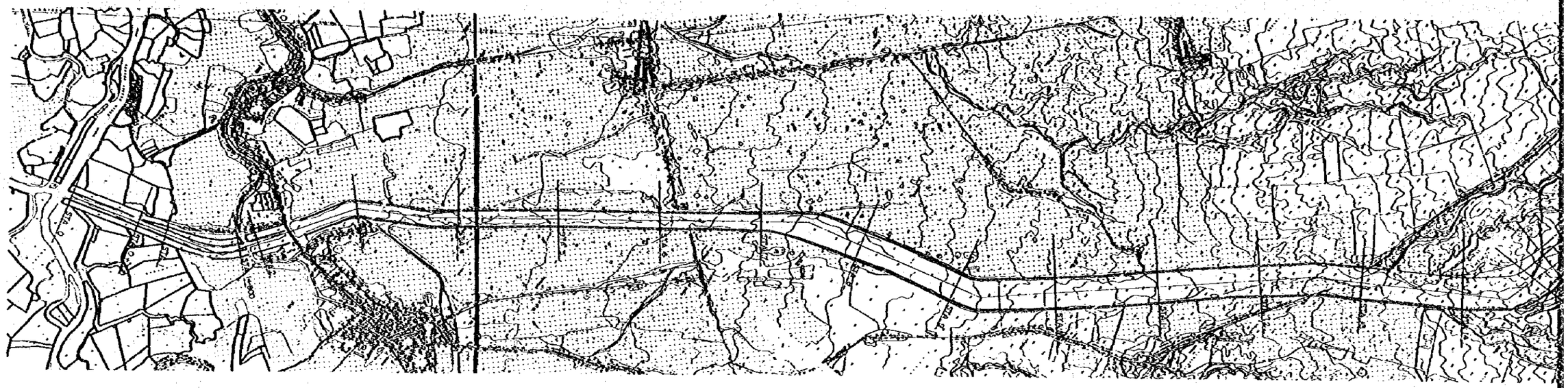
(4) The existent embankment has a simple section, and is build of the river bed material gathered from the nearby area at a slope gradient of 3 to 1. The outer slope (waterside slope) of the embankment is protected by rip lap. Drainage pipes run through the watercourse, avoiding points subject to water hammering action. However, the slopes show erosion by rains at various points; and there is the possibility of a levee break due to floodwater dashing against the slopes along the inner side of the embankment because of poor drainage. Therefore, reinforcement of the inner side of the embankment, the compaction of the levee body, and good management of the river are recommended.

The existent drainage gutters have a drainage capacity of approximately 2 to 3 m^3 per second.

(5) The results of our review of the river improvement plan prepared by the Bureau of Public Works are as outlined above. Considering that the river conditions have changed in the 15-year period since the outset of the plan, and that there was no plan to check soil in the mountain region upstream of the river, a sand producing area, at the time when the plan was prepared, the present plan of erosion control with the group of check

FIGURE III-12-1 COMPARISON OF B.P.W.'S & PROPOSED SCHEMES ON THE RIVER PLAN AND PROFILE (2-1)

PLAN



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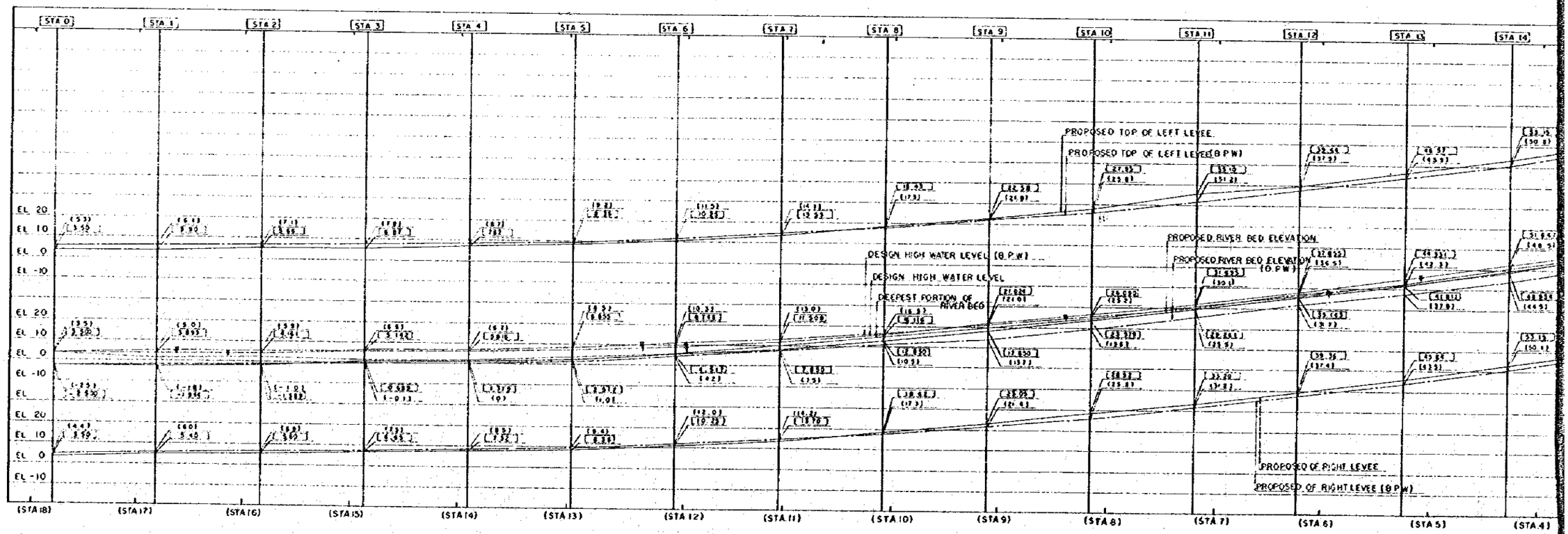
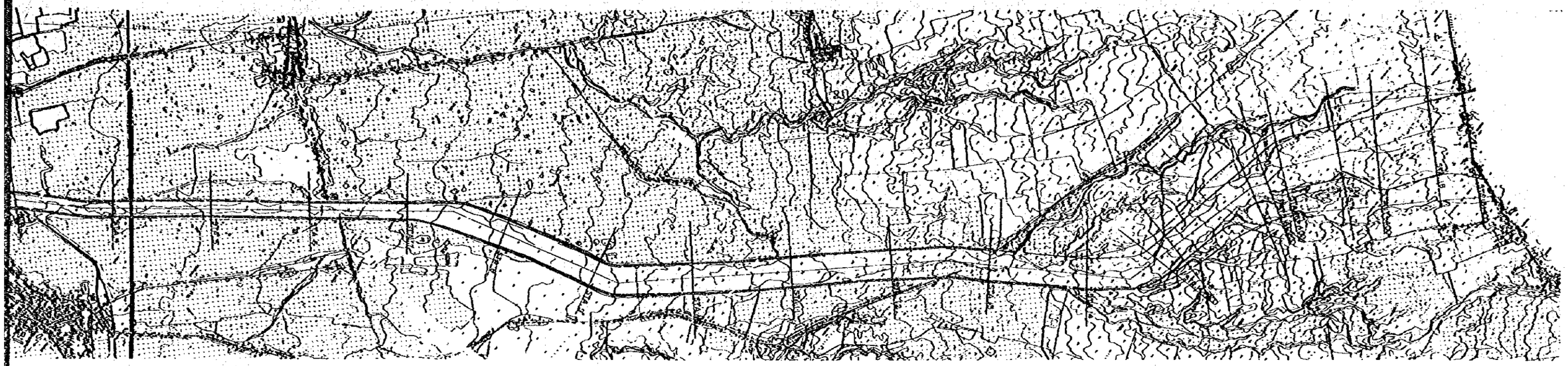


FIGURE III-12-1 COMPARISON OF B.P.W.'s & PROPOSED SCHEMES ON THE RIVER PLAN AND PROFILE (2-1)

PLAN



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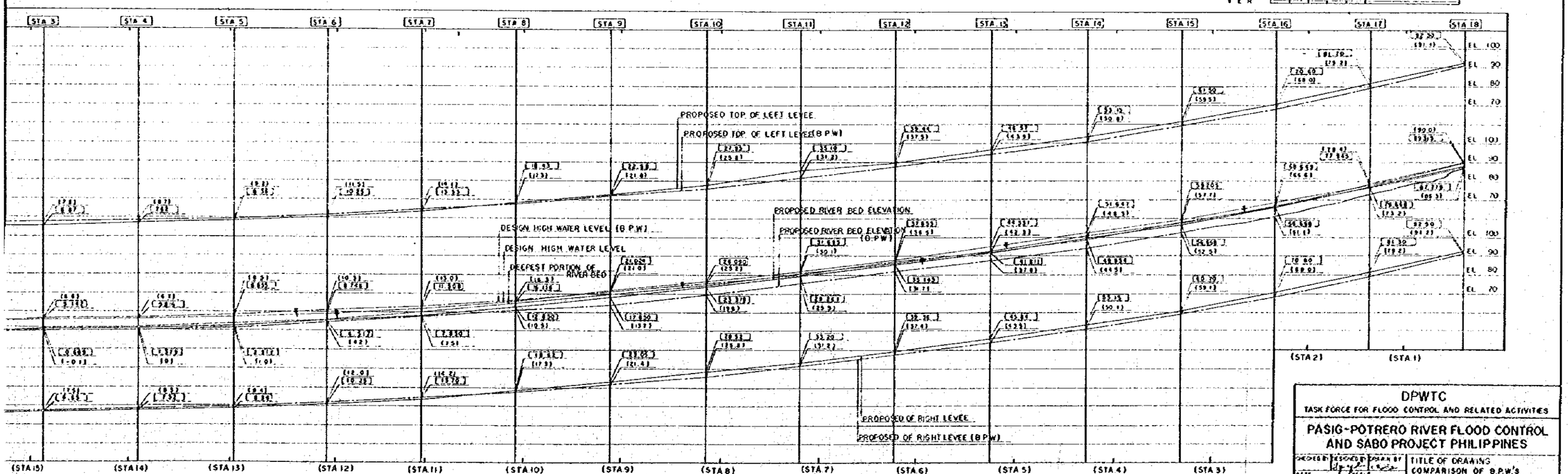


DPWTC

TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITES

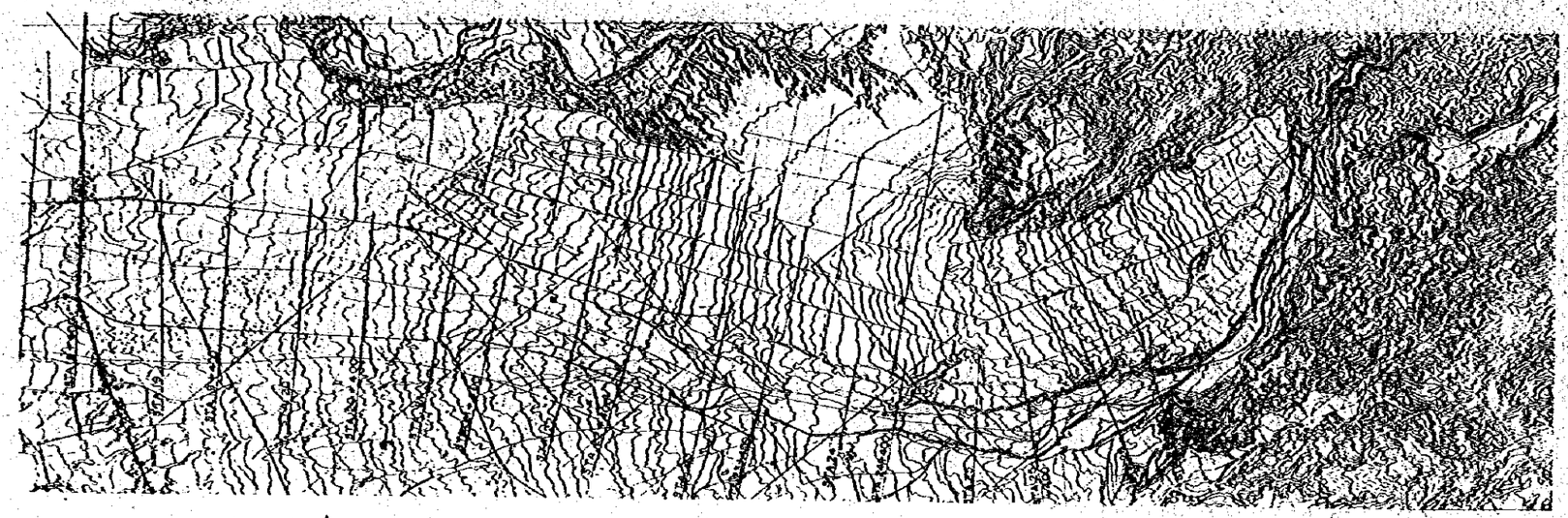
PASIG-POTRERO RIVER FLOOD CONTROL AND SABO PROJECT PHILIPPINES

PROPOSED BY	REVIEWED BY	DRAWN BY	TITLE OF DRAWING
DATE SEP. 30, 1978	SCALE As shown		COMPARISON OF B.P.W'S & PROPOSED SCHEMES ON THE RIVER PLAN AND PROFILE (2-1)
DRAWING NO	PPFS 131		

JAPAN INTERNATIONAL COOPERATION AGENCY

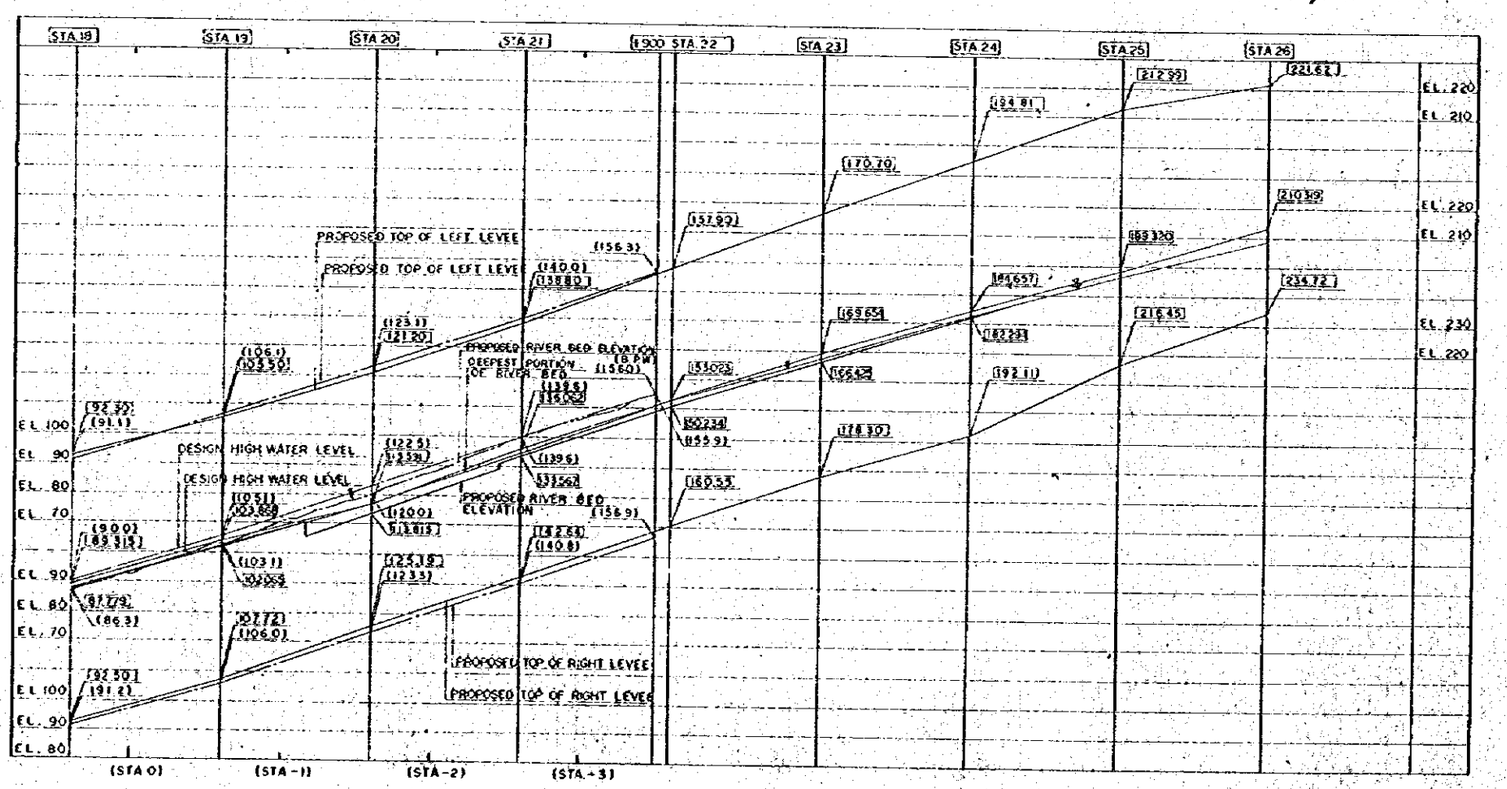
FIGURE II-12-2 COMPARISON OF B.P.W.'s & PROPOSED SCHEMES ON THE RIVER PLAN. AND PROFILE (2-2)

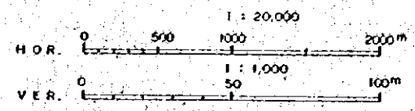
PLAN



PLOFILE

NOTE : ------ (B. P.W) (EL)
——— [PROPOSED] [EL]



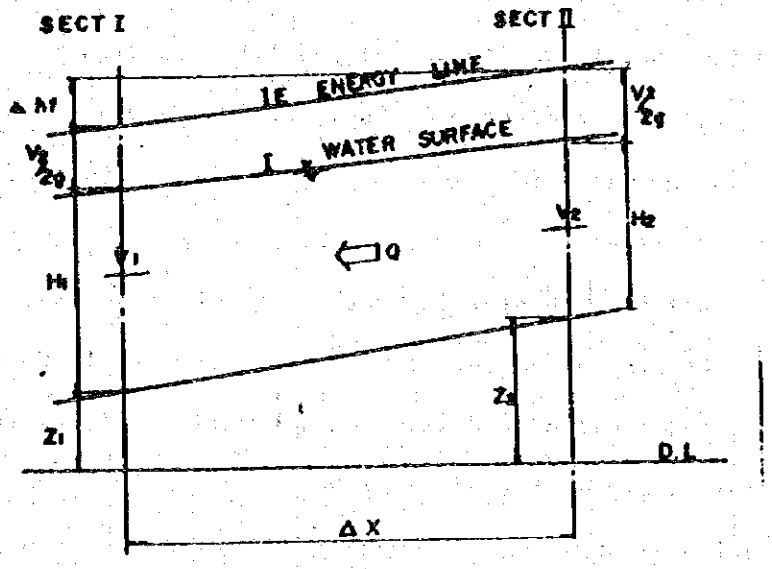


DPWTC TASK FORCE FOR FLOOD CONTROL AND RELATED ACTIVITIES	
PASIG-POTRERO RIVER FLOOD CONTROL AND SABO PROJECT PHILIPPINES	
CHECKED BY / ESTIMATED BY / DRAWN BY DATE SEP. 30, 1978 SCALE AS SHOWN DRAWING NO PPFS 132	TITLE OF DRAWING COMPARISON OF B.P.W'S & PROPOSED SCHEMES ON THE RIVER PLAN AND PROFILE (2-2)
JAPAN INTERNATIONAL COOPERATION AGENCY	

dams must be consistent with the plan for the river channel downstream which is now under way in terms of river system. It is desirable that the river channel be so designed without hitches by paying due attention to the aims of the B.P.W. river plan.

(6) Water flow capacity

In the existing river course, water flow capacity for the design high water discharge Q = 900 m^3/s (80 years probability) is calculated by non-uniform flow calculation. This calculation uses standard sequential calculation.



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where;

H: Water level difference (m)

Hi: Water depth (m)

Z : River bed elevation (m)

α : Correcting factor (=1.1)

Q : Discharge (m^3/S)

g : Acceleration of gravity

A : Cross sectional of flow (m^3)

R : Hydraulic radius (m)

n : Roughness coefficient

Δx: Sectional length

Using this formulas and computer, calculation was made for Q (m^3/s) of 120 (1.1 year probability), 400 (5 years), 520 (10 years) 900 (80 years) and 1,100 (design x 1.2), and roughness coefficient 0.033 downstream and 0.036 upstream of STA.16 and Dx in increment of approx. 1km. Longitudinal and cross-sectional survey map of the present survey was used for computation. The starting water level here is max. recorded value of E.L. 3.50m for flow rates of 900 and 1,100m^3/s. The water level calculated based on the uniform flow water depth at inlet is used for other flow rates. The results of computation as shown on next page indicated that the design high water discharge of 900m^3/s can be handled safely. The brackets in the table indicate leveeless section and the figure shows ground height.

TABLE III-2 VARID FLOW CALCULATION RESULT (PRESENT CHANNEL)

STA	Top of levee (El. m)		Water level (El. m)				
	Left levee	Right levee	Q = 120 m^3/s	400 m^3/s	520 m^3/s	900 m^3/s	1,100 m^3/s
0	(1.890)	(1.300)	-1.000	0.700	1.300	3.200	3.200
1	(1.620)	(1.950)	1.528	2.700	3.012	4.088	4.360
2	(3.470)	(4.200)	2.007	3.681	4.042	5.006	5.347
3	6.970	5.430	6.327	5.804	5.975	6.632	7.011
4	7.620	6.700	6.335	5.937	6.160	6.932	7.342
5	6.840	7.150	6.358	6.279	6.581	7.480	7.914
6	10.250	9.600	7.204	7.843	8.110	8.853	9.207
7	13.530	13.700	10.706	11.445	11.656	12.214	12.469
8	18.430	18.620	15.415	16.082	16.237	16.674	16.883
9	22.580	23.050	20.753	20.880	21.028	21.367	21.519
10	27.950	28.520	25.290	25.872	26.041	26.435	26.618
11	35.100	33.100	30.959	31.426	31.551	31.886	32.058
12	39.440	39.000	37.110	37.561	37.700	38.070	38.210
13	46.570	45.490	43.338	43.941	44.083	44.453	44.633
14	52.720	(51.260)	51.087	51.453	51.599	52.001	52.163
15	(60.340)	(60.350)	58.386	59.045	59.180	59.553	59.727
16	(67.500)	(69.390)	67.330	67.922	68.111	68.603	68.834
17	(80.650)	(80.630)	77.434	77.969	78.096	78.417	78.569
18	(90.520)	(91.920)	89.190	89.504	89.613	89.913	90.044
19	(104.290)	107.720	102.832	103.404	103.567	103.998	104.129
20	(121.060)	125.190	118.076	118.457	118.593	118.972	119.093
21	(138.390)	142.640	135.737	136.236	136.353	136.678	136.798
22	(157.300)	160.550	153.145	153.657	153.841	154.210	154.353
23	(176.840)	177.870	168.525	169.161	169.372	169.952	170.266
24	194.810	192.110	183.639	184.170	184.300	184.657	184.823
25	212.990	216.450	197.275	197.801	197.985	198.320	198.474
26	221.620	234.720	209.308	209.748	209.900	210.319	210.515
27	229.120	251.830	223.038	223.573	223.759	224.270	224.508

Note : ( ) ; Elevation of Natural Bank

(7) Stability of levee

As for the stability of existing levees, calculations were made using circular arc method since the max section occurs near STA.4 bypass (to be discussed later). In this case, if flood and earthquake occur simultaneously, the safety factor goes below 1.2 but it may be disregarded as probability of such an occurrence is very low.

2. Project Area

The Abacan river adjacent to the Pasig Potrero river is very near the main river at the fan-head part, and the Porac river is also very near the main river in Poroles Mancatian, therefore, the rivers might have affected each other for the formation of the fan.

In the case of the Abacan River, there is Angels City at the right bank at the middle stream, while there is Clark Field at the left bank, thus the basin-asset is very great. Also, the Porac river shows its very stable river-course, and it has vast farm land at the middle and down stream.

On the occasion of riparian improving planning of the Pasig Potrero River, there were the following 3 initial plans for the establishment of Project Area with the expectation of the bigger riparian improving effects by including the adjacent 2 rivers into the Project.

(1) Single riparian improving plan for Pasig Potrero River

(2) Protection plan of Angeles City from the flood by establishing a diversion channel at Pasig-Potrero River

(3) Plan to mitigate the flooding damage by Pasig-Potrero River by flowing the flood of Pasig-Potrero River into Polac River

However, it was judged unnecessary to include the above plans (2) and (3) for the Project, and a single riparian improvement is desirable by the following reasons.

(1) The Abacan River

a. Economic aspect

Topographically, Angles City is located at a little higher site than the surrounding area, and the discharge capacity of the river-course is lower than the flowing function around Angeles City. Because there is a strict portion at the river course of the upper stream (there is no inflow of the branch stream in this section). Therefore, the flood will not attack Angeles City directly by the flooding at the upper stream.

b. Technical aspect

Construction costs will be rather great because of the excavating development of the hilllock. Also the Abacan River is not yet stable on its river course, and a great deal of sand is being carried, thus it is very difficult to make the maintenance of the diversion channel.

c. Social aspect

Because of the priority of the economy, there is no problem to mover the damage at the basin of the Abacan River towards the Pasig-Potrero River, namely, the transference of flooding damage will not be a problem.

(2) The Porac River

A present, the Porac River is stable, and the riparian improvement will be judged to induce minus befefit with the needless expansion of the flooding damage, in view of vast farm land around the River.

3. Basic Policy

For planning the river course, the following basic designing policies will be established in view of the specific natures of the river-states and regional characteristics of the river.

(1) Technical concept

a. For the valley of the upper stream, the river course will be fixed with Groyne work by establishing the channel in order to prevent the side erosion.

b. Because of higher volume of sediment produced from the mountain, it is planned to make dispersion of sediment and flowing water by designing an area to keep a function for sand arresting basin at the river course in order to facilitate the maintenance of the river course.

c. For protecting the leveeat the right bank in the upper stream of Mancatian flow-down will be intended always towards the East Mancatian Bridge.

d. Even in the case of the flooding flow over 900 m^3/s, fuse-function will be given at the upper stream in order to secure the safety of the river course.

e. Embankment will be made for protecting the river from bank-erosion, especially, groyne will be established because the bent portion will become a concave side of river bent.

f. In order to maintain the river course at the down stream, a low water channel will be established for a target-object of 120 m^3/s (probability: one year).

g. Design maintenance high water channel will be secured for the maintenance of the river course. Sediment-carrying out road will be constructed at the upper stream, and carrying-in road will be constructed at

the down stream in order to facilitate the inspection and water-protecting activities.

h. At the down-stream from Baclor, some facilities will be constructed for the protection of the pier and for securing the fall, and further one-meter excavation will be done for the low-water way as planing maintenance river bed.

(2) Economical concept

a. The present river course is already under construction, and reversion will be prevented under enough considerations.

b. Facilities for the river course will be planned economically as much as possible, and locally available materials will be used.

c. For the present facilities, short materials will be supplied.

(3) Political and social concept

a. For the policy, it is intended to protect the road connecting the bases between US-forces or with major cities.

b. It is intended to sequre the traffic between villages, which would be cut or broken by the plan for the river course.

(4) Division of the area

The section between the flow-route STA.26+400 and STA.0 will be divided into the following 3 areas.

a. Upper stream portion Sta.26+400 - Sta.23+400

b. Middle stream portion Sta.23+300 - Sta.15+950

c. Lower stream portion Sta.15+950 - Sta.0

Therefore, the river course improvement will be made at the middle and down stream, and the upper stream is planned to be utilized as a sand arresting basin.

3-2 Basic Concept for the Plan

1. Hydraulic Features

(1) Design discharge

Probability	Discharge (m^3/s)	Initial water-level (m)
1/1.1	120*	EL-1.00
1/2	250*	EL-0.70
1/10	520*	EL-1.30
1/20	640	
1/50	820	
1/80	900*	EL-3.50
1/100	950	
1/200	1,100*	EL-3.50

In the above table, calculation was made with the flow of * mark.

(2) Roughness Coefficient

Each 0.033 and 0.036 will be employed up to STA.15+950 of the existing bank of Pasing Potrero River and the upper stream, respectively.

This index will be estimated with the calculation by the following 2 empirical formulas.

(i) Manning-Strikler's formula

$$n = 0.0417\ d\ 1/6\ (m/s)$$

where, d: a representative grain diameter of gravel at river bed (= average grain diameter d50)

STA. 0 - STA. 5: dm = 0.05 n = 0.025

STA. 5 - STA.15: dm = 0.25 n = 0.033

STA.15 - STA.27: dm = 0.45 n = 0.036

(ii) S. Sugio's formula

$$n = \frac{1}{K} R^{0.127} . I^{0.23}$$

where; K: Coefficient (6.49 - Ripples, 9.62 - Dunes, 13.2 - Tansition)

R: Hydraulic mean depth

I: Energy gradient

STA. 0 - STA. 5	R = 3.55,	I = 1/800,	K = 9.62	n = 0.025
STA. 5 - STA.15	R = 1.35,	I = 1/170,	K = 9.62	n = 0.033
STA.15 - STA.27	R = 0.80	I = 1/90,	K = 9.62	n = 0.036

That is, n = 0.033 up to STA 16 and n = 0.036 for the upper stream will be employed for the calculation.

(3) Strating water-level

In the case of flood in 1972, the trace of EL shows 3.16 m around the estuary of Pasig-Potrero River, however, the tidal record shows one-foot higher in 1966. Thus the starting elevation will be 3.50 m with the probability of 200 and 80 years.

For the less flow, the elevation was determined by the calculation of the flow at the estuary, etc.

2. Banking materials

For the banking materials for the embankment, the section will be decided in view of the quality and quantity of the available materials around the construction-site.

Enough strength can be secured by tightening and sodification (compaction) by the sure construction-management for the temporary elevation of SM, SC and ML at the down stream from the part of STA4 and SW, SP at the upper and middle stream.

Uniform construction-section will be taken for the embankment, especially, SM and SC at lower stream will be mixedly used for SW and SP at the upper stream. SM and SC will be used for the soft ground at the lower stream, thus effective diversion will be made each other.

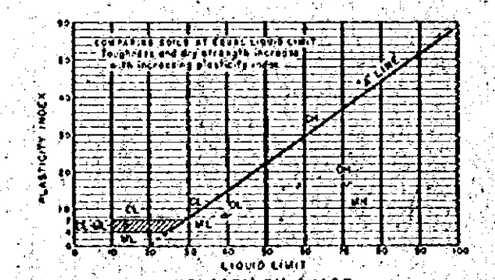
In the case of uniform type, with the diversion of the materials at the river-bed, the coefficient of permeability (k) will be as follows according to Kuappen & Philippine.

By the above result, it is estimated that the materials at the upper and lower stream will not be used in diversion, also, the following numerals for designs will be employed.

Banking materials:	Drying weight of single body	r = 1.75 t/m^3
	Wet weight of " "	r = 2.00 "
	Cohesion	c = 0 "
	Internal friction angle	ϕ = 34°
	Unit body-weight of ground	r = 1.45 t/m^3

UNIFIED SOIL CLASSIFICATION
INCLUDING IDENTIFICATION AND DESCRIPTION

FIELD IDENTIFICATION PROCEDURES (Excluding particles larger than 3 inches and basing fractions on estimated weights)				GROUP SYMBOLS a	TYPICAL NAMES	INFORMATION REQUIRED FOR DESCRIBING SOILS	LABORATORY CLASSIFICATION CRITERIA	
COARSE GRAINED SOILS More than half of material is larger than No. 200 sieve size b (The No. 200 sieve size is about the smallest particle visible to the naked eye)	GRAVELS More than half of coarse fraction is larger than No. 4 sieve size (For visual classifications, the ¼" size may be used as equivalent to the No. 4 sieve size.)	GRAVELS WITH FINES (Appreciable amount of fines)	Wide range in grain size and substantial amounts of all intermediate particle sizes	GW	Well graded gravels, gravel-sand mixtures, little or no fines	Give typical name; indicate approximate percentages of sand and gravel, max size, angularity, surface condition, and hardness of the coarse grains; local or geologic name and other pertinent descriptive information; and symbol in parentheses	Determine percentages of gravel and sand from grain size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size) coarse grained soils are classified as follows:- Less than 5% GW, GP, SW, SP. More than 12% GM, GC, SM, SC. 5% to 12% Borderline cases requiring use of dual symbols.	$C_u = \frac{D_{60}}{D_{10}}$ Greater than 4 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3
		CLEAN GRAVELS (Little or no fines)	Predominantly one size or a range of sizes with some intermediate sizes missing	GP	Poorly graded gravels, gravel-sand mixtures, little or no fines			Not meeting all gradation requirements for GW
			Non-plastic fines (for identification procedures see ML below)	GM	Silty gravels, poorly graded gravel-sand-silt mixtures			Atterberg limits below "A" line, or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
			Plastic fines (for identification procedures see CL below)	GC	Clayey gravels, poorly graded gravel-sand-clay mixtures	For undisturbed soils add information on stratification, degree of compactness, cementation, moisture conditions and drainage characteristics		Atterberg limits above "A" line with PI greater than 7
	SANDS More than half of coarse fraction is smaller than No. 4 sieve size	CLEAN SANDS (Little or no fines)	Wide range in grain sizes and substantial amounts of all intermediate particle sizes	SW	Well graded sands, gravelly sands, little or no fines		$C_u = \frac{D_{60}}{D_{10}}$ Greater than 6 $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}}$ Between one and 3	
			Predominantly one size or a range of sizes with some intermediate sizes missing	SP	Poorly graded sands, gravelly sands, little or no fines			Not meeting all gradation requirements for SW
		SANDS WITH FINES (Appreciable amount of fines)	Non-plastic fines (for identification procedures see ML below)	SM	Silty sands, poorly graded sand-silt mixtures	EXAMPLE:- Silty sand, gravelly; about 20% hard, angular gravel particles ½-in maximum size, rounded and subangular sand grains coarse to fine, about 15% non-plastic fines with low dry strength, well compacted and moist in place, alluvial sand; (SM)		Atterberg limits below "A" line or PI less than 4 — Above "A" line with PI between 4 and 7 are borderline cases requiring use of dual symbols
			Plastic fines (for identification procedures see CL below)	SC	Clayey sands, poorly graded sand-clay mixtures			Atterberg limits above "A" line with PI greater than 7
FINE GRAINED SOILS More than half of material is smaller than No. 200 sieve size. (The No. 200 sieve size is about the smallest particle visible to the naked eye)	IDENTIFICATION PROCEDURES ON FRACTION SMALLER THAN No. 40 SIEVE SIZE							
		DRY STRENGTH (CRUSHING CHARACTERISTICS)	DILATANCY (REACTION TO SHAKING)	TOUGHNESS (CONSISTENCY NEAR PLASTIC LIMIT)				
	SILTS AND CLAYS Liquid limit less than 50	None to slight	Quick to slow	None	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands with slight plasticity	Give typical name; indicate degree and character of plasticity, amount and maximum size of coarse grains; color in wet condition, odor if any, local or geologic name, and other pertinent descriptive information; and symbol in parentheses	Use grain size curve in identifying the fractions as given under field identification.
		Medium to high	None to very slow	Medium	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays		
		Slight to medium	Slow	Slight	OL	Organic silts and organic silt-clays of low plasticity	For undisturbed soils add information on structure, stratification, consistency in undisturbed and remolded states, moisture and drainage conditions	
	SILTS AND CLAYS Liquid limit greater than 50	Slight to medium	Slow to none	Slight to medium	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts		
		High to very high	None	High	CH	Inorganic clays of high plasticity, fat clays	EXAMPLE:- Clayey silt, brown; slightly plastic, small percentage of fine sand; numerous vertical root holes; firm and dry in place; loess; (ML)	
		Medium to high	None to very slow	Slight to medium	OH	Organic clays of medium to high plasticity		
HIGHLY ORGANIC SOILS		Readily identified by color, odor, spongy feel and frequently by fibrous texture			Pt	Peat and other highly organic soils		



PLASTICITY CHART
FOR LABORATORY CLASSIFICATION OF FINE GRAINED SOILS

a Boundary classifications - Soils possessing characteristics of two groups are designated by combinations of group symbols. For example GW-GC, well graded gravel-sand mixture with clay binder.
b All sieve sizes on this chart are U.S. standard.

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FIGURE III-14—Unified soil classification chart. From drawing 103-D-347.