TABLE 2.7 ANNUAL DATA COLLECTION RATE OF THE CONTROL OFFICE

Station Name	Year / Period	1982 Jul-Dec	1983 Jan-Dec	1984 Jan-Dec	1985 Jan-Dec	1986 Jan-Dec	1987 Jan-Dec	1988 Jan-Dec	1989 Jan-May	Total
1.Raingauge Station										
(1) Binga Damsite	Access count	1235	1986	1770	1651	2354	2004	2237	1112	14449
	Data received	358	540	378	2	26	117	1302	536	3459
	Annual rain	1324mm	356mm	2333mm	2mm	1mm	1655mm	2265mm	248mm	
	Collection rate	43.42%	27.19%	21.36%	0.12%	1.10%	5.84%	56.93%	48.20%	23.94%
(2) San Roque	Access count	1235	1986	1770	1651	2354	2004	2236	1112	14448
	Data received	1223	1969	1768	1309	2128	1578	2113	1075	13263
	Annual rain	1437mm	1154mm	2137mm	2087mm	1059mm	1170mm	2003mm	338mm	
	Collection rate	99.07%	99.14%	99.89%	79.29%	90.40%	78.74%	94.52%	96.67%	91.30%
(3) Sta.barbara	Access count	1235	1986	1770	1651	2354	2004	2236	1112	14448
	Data received	1272	1979	1767	1647	2351	1984	2223	1109	14382
	Annual rain	1297mm	1086mm	2203mm	2630mm	2248mm	1202mm	2060mm	445mm	
	Collection rate	98.39%	99.65%	99.83%	99.76%	99.87%	99.00%	99.43%	99.73%	99.54%
(4) Carmen	Access count	1235	1986	1769	1651	2354	2004	2235	1112	14446
	Data received	1273	1979	1751	1646	2352	1994	2226	1110	14333
	Annual rain	381mm	932mm	2072mm	2434mm	2057mm	279mm	1458mm	331mm	
	Collection rate	99.07%	99.65%	98.98%	99.82%	99.92%	99.50%	99.61%	99.82%	99.56%
(5) Wawa	Access count	1235	1986	1769	1651	2354	2004	2285	1112	14446
	Data received	1273	1978	1767	1647	2325	1907	2273	1111	14282
	Annual rain	940mm	964mm	1913mm	2245mm	2344mm	1154mm	1867mm	555mm	
	Collection rate	99.37%	99.60%	99.89%	99.75%	98.81%	95.16%	99.47%	99.91%	98.86%
(6) Tibag	Access count	1235	1986	1766	1650	2353	2004	2283	1112	14433
	Data received	1257	1975	1760	1647	2349	1992	2268	1104	14362
	Annual rain	1133mm	1184mm	2244m	2132mm	2139mm	1145mm	2063mm	448mm	
	Collection rate	98.50%	99.45%	99.66%	99.82%	99.83%	99.40%	99.34%	99.28%	99.47%
2.Water Level Gauging Station										
(1) Binga Damsite	Access count	1230	1968	1729	1611	2326	1980	2254	1102	14250
	Data received	211	0	13	2	0	0	97	0	323
	Collection rate	16.48%	0.00%	0.75%	0.12%	0.00%	0.00%	4.30%	0.00%	2.27%
(2) San Roque	Access count	1230	1968	1729	1611	2322	1980	2254	1102	14246
	Data received	1223	1481	1655	1103	1752	823	1971	574	10597
	Collection rate	99.43%	75.25%	95.72%	68.47%	75.38%	41.57%	87.44%	52.09%	74.39%
(3) Sta.barbara	Access count	1230	1968	1729	1611	2322	1980	2254	1102	14246
	Data received	1271	1962	1728	1610	2321	1970	2244	1100	14206
	Collection rate	99.30%	99.70%	99.94%	99.94%	99.96%	99.49%	99.56%	99.82%	99.72%
(4) Carmen	Access count	1230	1968	1729	1611	2322	1982	2254	1102	14248
	Data received	1126	889	730	0	0	0	0	0	2745
	Collection rate	87.37%	45.17%	42.22%	0.00%	0.00%	0.00%	0.00%	0.00%	19.27%
(5) Wawa	Access count	1230	1968	1729	1611	2322	1980	2254	1102	14246
	Data received	1258	1957	1727	1610	2286	1891	2250	1102	14091
	Collection rate	99.36%	99.44%	99.88%	99.94%	98.45%	95.51%	99.82%	100.00%	98.91%
(6) Banaga	Access count	1230	1968	1729	1611	2322	1980	2254	1102	14246
	Data received	1253	1950	1725	1606	2315	1967	0	1090	11916
	Collection rate	98.67%	99.09%	99.77%	99.69%	99.70%	99.34%	0.00%	98.91%	83.64%
(6) Tibag	Access count	1230	1968	1728	1611	2322	1980	2254	375	14018
	Data received	111	55	175	38	0	0	0	0	379
	Collection rate	3.37%	2.79%	10.13%	2.36%	0.00%	0.00%	0.00%	0.00%	2.70%

TABLE 2.8 FFWS TASK DISTRIBUTION

No	Agency	Tasks to FFWS Activity
1	PAGASA	(a)Flood forecasting in major basins using the existing FFWSs. (b)Issuance and dissemination of flood bulletins through its own channels and OCD's channels. (c)Issuance of warning of weather disturbances by typhoons, storms and depressions, including heavy rainfall given impetus by the monsoon through the same channels as above. (d)Monitoring of operaitonal condition of system equipment. (e)Monitoring of rainfall/water level data transmitted from FFWS Dam office. (f)Request to NIA/NAPOCOR regarding warning operation based on forecasting, as well as appropriate reservoir operation. (g)Assistance in maintenance services of system equipments installed by FFWSDO. (h)Provision of information of weather condition. (i)O/M of FFWS equipment.
2	NIA	(a)Dam reservoir operation mainly for irrigation purpose. (b)Reservoir water release based on the assessment of inflow from upstream areas, telemetered data from gauging stations established by FFWSDO. (c)Issuance of dam discharge warning. (d)Operation of warning stations regarding dam discharge warning, using warning facilities provided by FFWSDO. (e)Warning operations regarding flood warning issued by PAGASA, at its request. (f)O/M of FFWSDO equipments for the dam operated by NIA.
3	NAPOCOR	(a)Dam reservoir operation mainly for power generaiton purpose. (b)Reservoir water release based on the assessment of inflow from upstream areas, telemetered data from gauging stations established by FFWSDO. (c)Issuance of dam discharge warning. (d)Operation of warning stations regarding dam discharge warning, using warning facilities provided by FFWSDO. (e)Warning operations regarding flood warning issued by PAGASA, at its request. (f)O/M of FFWSDO equipments for the dam operated by NAPOCOR.
4	DPWH	(a)O/M of flood control facilities/structures. (b)River management. (c)Monitoring of rainfall/waterlevel data transmitted from Pampanga, Agno, Bicol and Cagayan river basins. (d)O/M of system equipments installed by Pampanga FFWS, ABC system and FFWSDO.
5	NWBR	(a)Coordination in reservoir operation among water use purposed in view of beneficial water use. (b)Coordination in framework change regarding water resources development/management.
6	OCD	(a)Coordination in formulating warning dissemination system in normal time. (b)Relaying warning information received from warning agencies to the tasked agencies and to RDCC/PDCC operation center in case of emergencies. (c)Coordination and monitoring of disaster management activity conducted by national/local governments and private sector through DCC set-up, before, during and after disaster. (d)Assessment of disaster situations during emergency. (e)Organizing DCCs in normal time. (f)O/M of system equipments installed by FFWSDO.

TABLE 3.1 THE AGNO RIVER INTEGRATED FFWS COST ESTIMATIE

Unit : 1000 Yen

Item No.	Description	Equipment Cost	Civil Work	Total
	1. Construction Cost			
1-1	Direct Cost			
1-1.1	Agno River FFWS	698,408	91,400	789,808
1-1.2	San Roque FOS	440,906	37,600	478,506
1-1.3	Moriones FOS	466,218	40,600	506,818
1-1.4	Balog-Balog FOS	466,218	40,600	506,818
1-1.5	Mt.Ampucao Repeater Station	91,014	500	91,514
1-1.6	Mt.Malabobo Repeater Station	76,308	10,200	86,508
1-1.7	St.Ignacia Repeater Station	63,634	4,100	67,734
1-1.8	Binga Dam Office	15,618	200	15,818
1-1.9	Cabanatuan Repeater Station	1,956	100	2,056
1-1.10	NIA FFWS Center	5,000	200	5,200
1-1.11	PAGASA FFWS Center (DIC)	24,326	500	24,826
1-1.12	OCD Monitor Station	6,312	200	6,512
1-1.13	DPWH FFWS Center	23,267	500	23,767
1-1.14	Municipal Warning System	94,524	3,900	98,424
1-1.15	Measuring Equipment	34,726	5,000	39,726
1-1.16	Spare Parts	204,790	5,000	209,790
	Total of Direct Cost	2,713,225	240,600	2,953,825
1-2	Indirect Cost	636,775	160,900	797,675
	Total of Construction Cost	3,350,000	401,500	3,751,500
	2 Engineering Service			750,000
	3 Contingency			675,000
	GROUND TOTAL			5,176,500

TABLE 4.1 THE AGNO RIVER PRIORITY FFWS COST ESTIMATIE

Unit : 1000 Yen

Item No.	Description	Equipment Cost	Civil Work	Total
	1. Construction Cost			
1-1	Direct Cost			
1-1.1	Agno River FFWS	530,886	54,050	584,936
1-1.2	Mt.Ampucao Repeater Station	91,014	500	91,514
1-1.3	Mt.Malabobo Repeater Station	76,308	10,200	86,508
1-1.4	Binga Dam Office	15,618	200	15,818
1-1.5	PAGASA FFWS Center (DIC)	24,326	500	24,826
1-1.6	DPWH FFWS Center	23,267	500	23,767
1-1.7	Municipal Warning System	94,524	3,900	98,424
1-1.8	Measuring Equipment	34,726	5,000	39,726
1-1.9	Spare Parts	85,594	6,985	92,579
	Total of Direct Cost	976,263	81,835	1,058,098
1-2	Indirect Cost	244,066	20,459	264,525
	Total of Construction Cost	1,220,329	102,294	1,322,623
	2 Engineering Service			264,525
	3 Contingency			238,072
	GROUND TOTAL			1,825,220

FIGURES

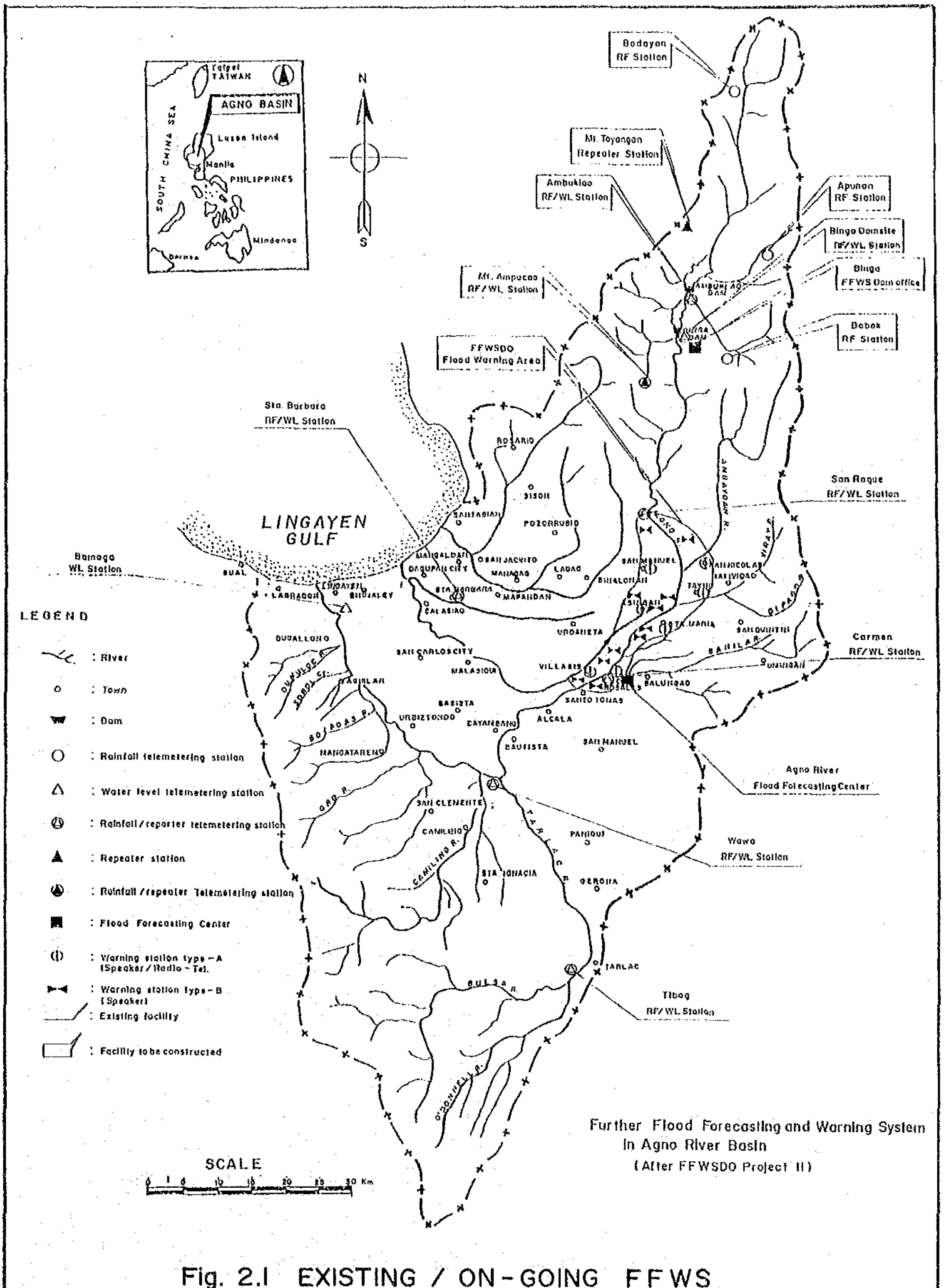


Fig. 2.1 EXISTING / ON-GOING FFWS

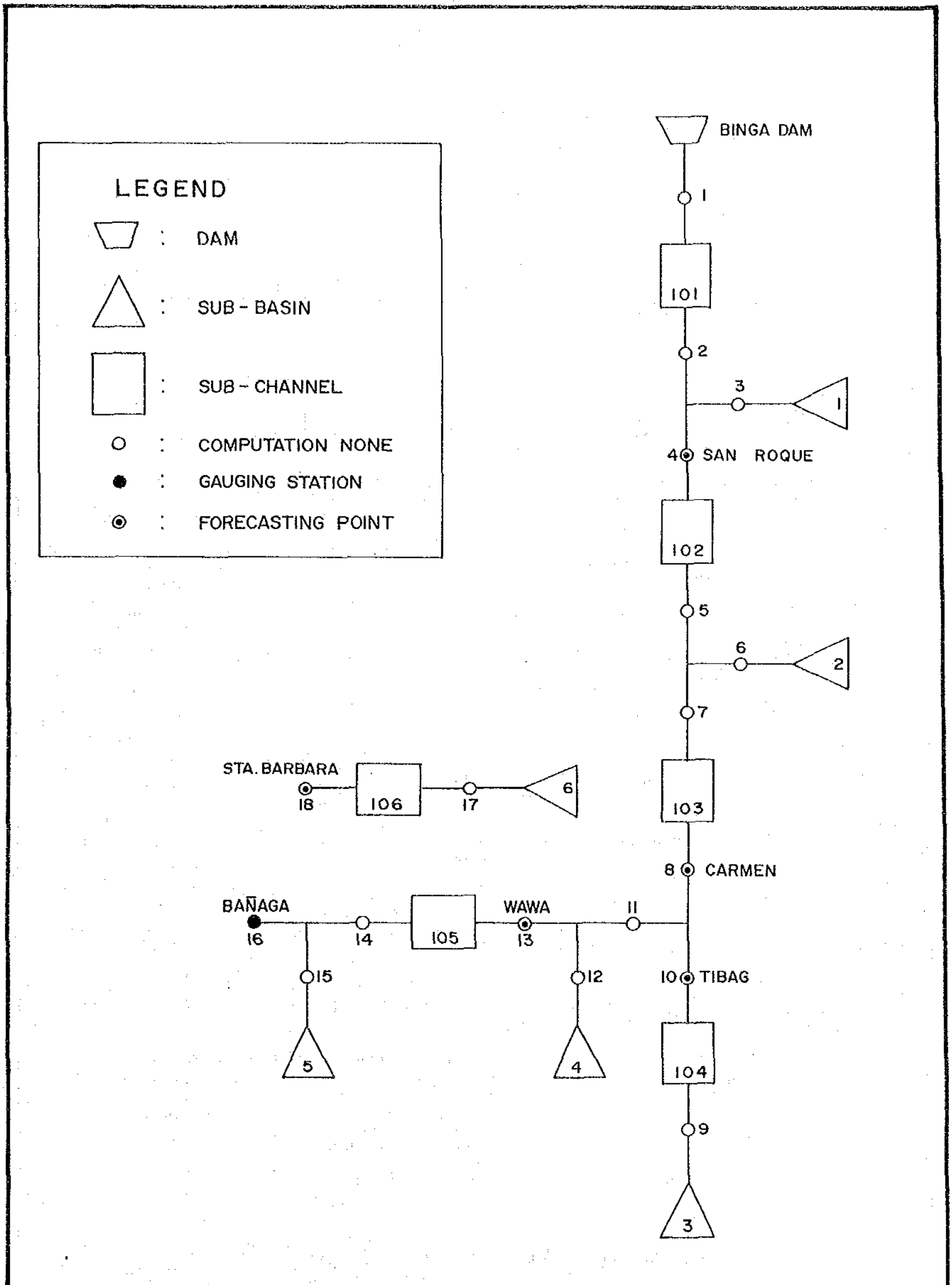


Fig.2.2 SCHEMATIC DIAGRAM FOR THE EXISTING FLOOD RUNOFF MODEL

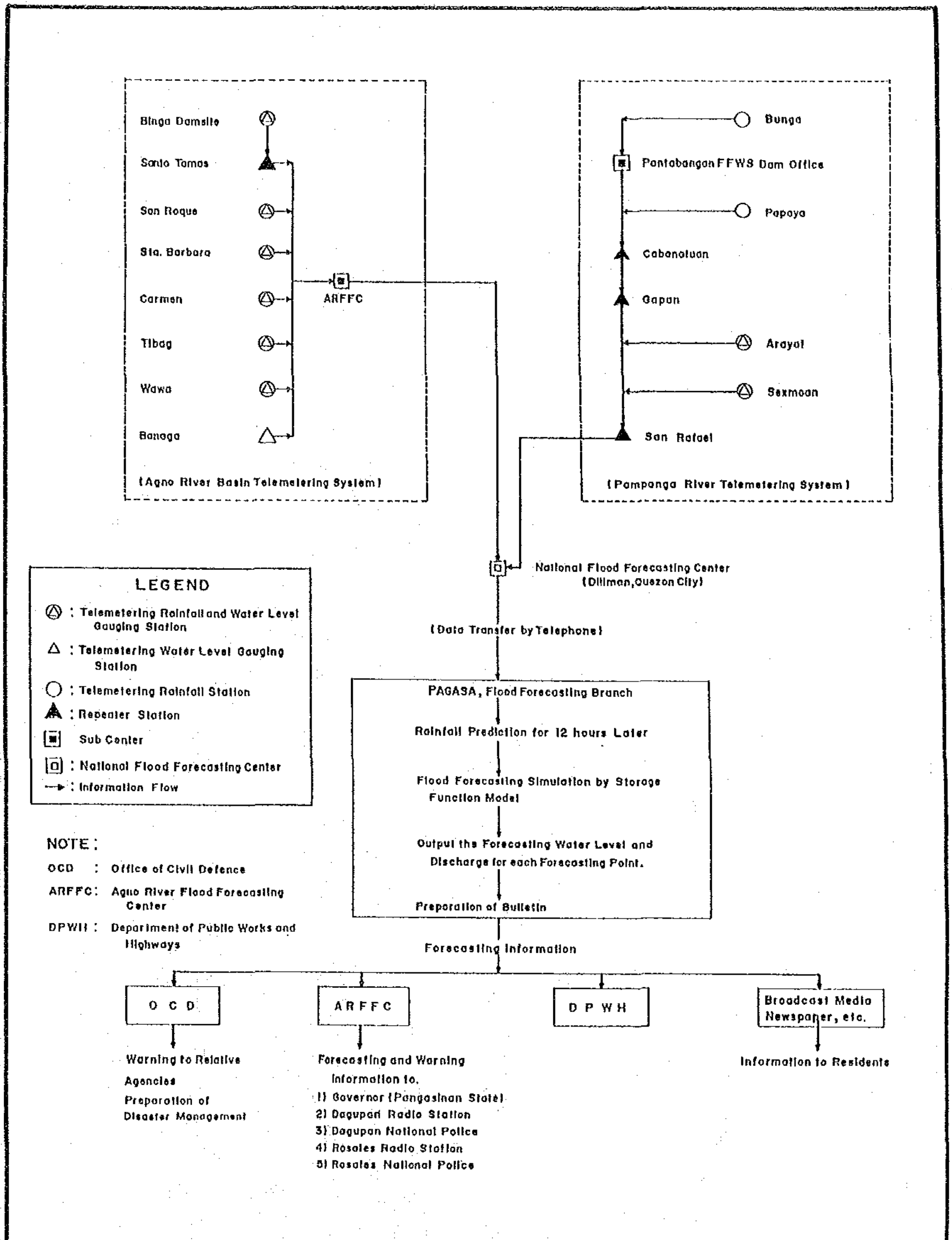


Fig. 2.3 STANDARD PROCEDURES OF FFWS ACTIVITY

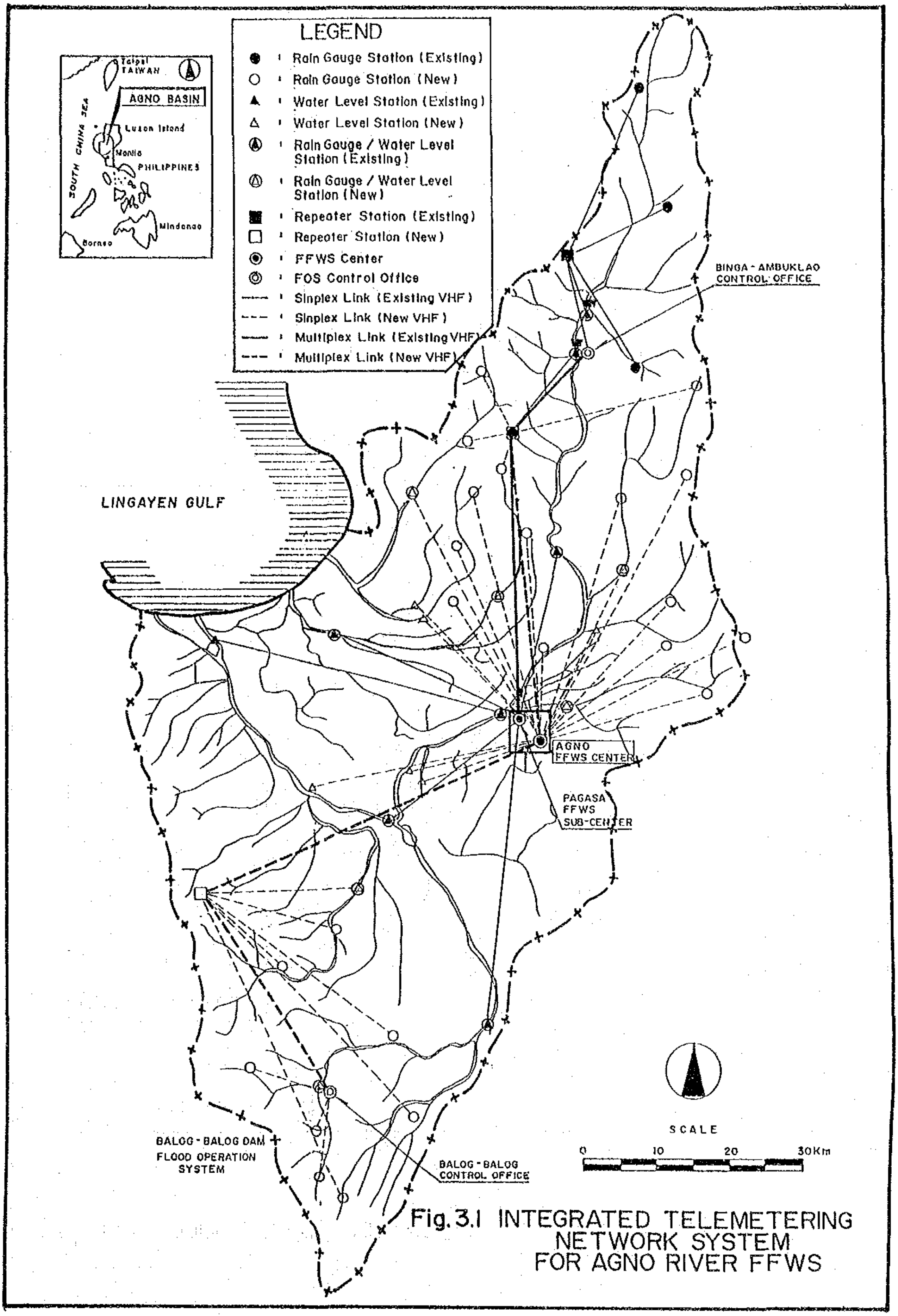


Fig.3.1 INTEGRATED TELEMETERING NETWORK SYSTEM FOR AGNO RIVER FFWS

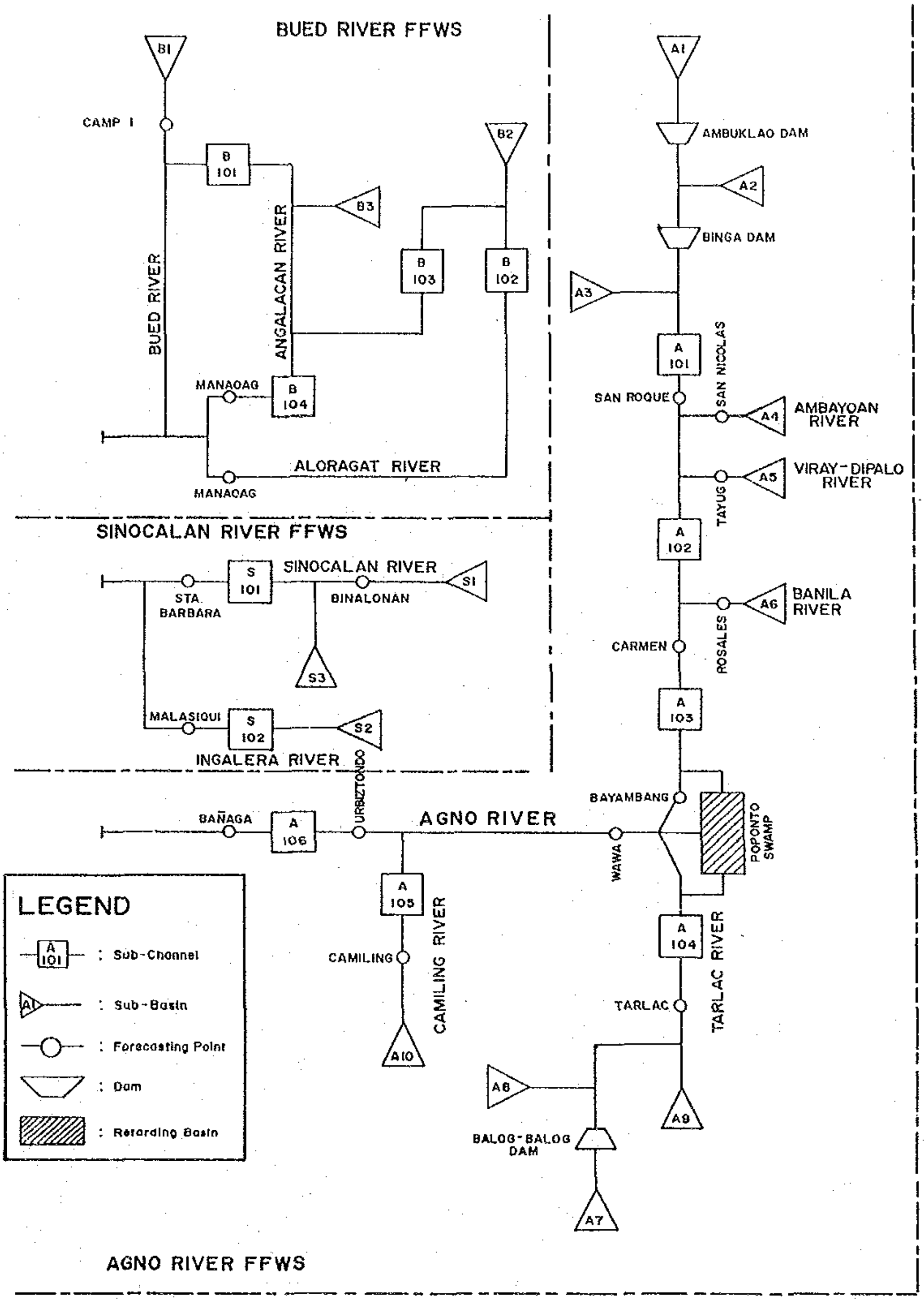


Fig. 3.2 FLOOD FORECASTING MODEL FOR THE INTEGRATED FFWS

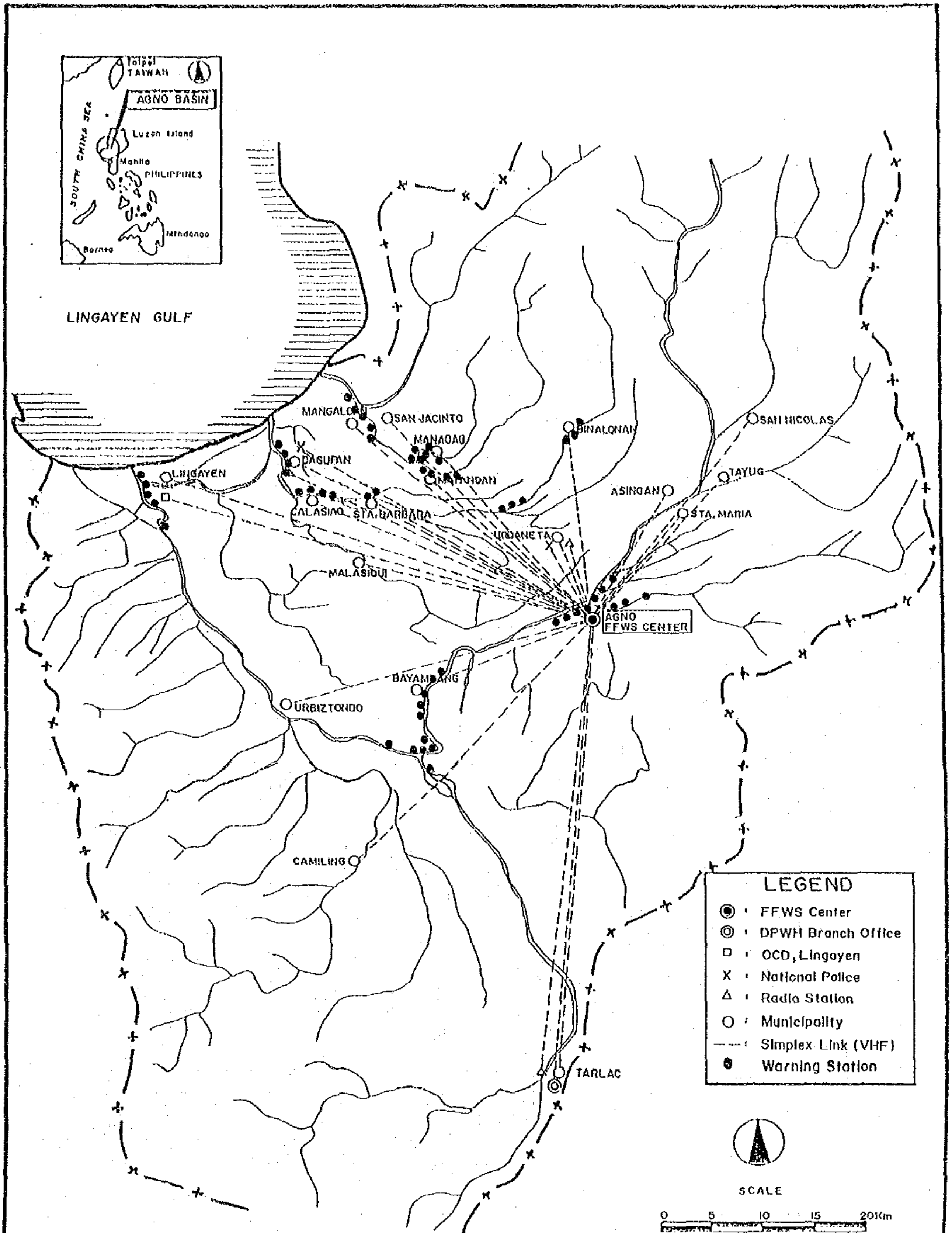


Fig. 3.3 INTEGRATED FLOOD WARNING NETWORK SYSTEM

LEGEND

◎ : Directry Affected

○ : Indirectry Affected

Province	Municipality	Projected Population 1990	Projected Population 2010	1. San Roque	2. Carmen	3. Bayambang	4. Wawa	5. Urbiztondo	6. Banaga	7. San Nicolas	8. Tayug	9. Rosales	10. Tarlac	11. Camiling	12. Sta. Barbara	13. Binalonan	14. Malasiqui	15. Camp 1	16. Manaoag	17. Mapandan
				Agno River Basin											Allied River Basin					
PANGASINAN	1. DAGUPAN	116,000	146,000	○	○										◎	◎	○		○	○
	2. MANGALDAN	60,000	76,000															◎	◎	◎
	3. BINMALEY	55,000	71,000	○	○	○	○	○	○											
	4. LINGAYEN	71,000	98,000	○	○	○	○	○	◎											
	5. CALASIAO	59,000	81,000	○	○										◎	◎	○			
	6. STA. BARBARA	43,000	55,000	○	○										◎	◎	○			
	7. MANAOAG	46,000	66,000	○														○	◎	◎
	8. MAPANDAN	23,000	30,000	○														○	◎	◎
	9. POZORRUBIO	45,000	57,000																	
	10. LAOAC	24,000	33,000	○																
	11. BINALONAN	40,000	48,000	○												◎				
	12. SAN MANUEL	34,000	44,000	◎																
	13. SAN NICOLAS	26,000	32,000	○						◎										
	14. TAYUG	30,000	37,000	◎						○	◎									
	15. STA. MARIA	22,000	28,000	◎							○									
	16. SAN JACINTO	24,000	31,000															○	○	
	17. ASINGAN	41,000	48,000	◎																
	18. BALUNGAO	20,000	26,000									◎								
	19. ROSALES	43,000	55,000		◎					○		◎								
	20. VILLASIS	46,000	61,000		◎															
	21. URDANETA	87,000	116,000	○												○				
	22. BUGALLON	46,000	60,000		○	○	○	○	◎											
	23. AGUILAR	26,000	34,000		○	○	○	○												
	24. SAN CARLOS	117,000	153,000		○	○	○	○									○			
	25. MALASIQUI	83,000	107,000		○												◎			
	26. BASISTA	20,000	26,000		○															
	27. URBIZTONDO	34,000	47,000		○	○	◎	◎												
	28. BAYAMBANG	75,000	96,000		○	◎	○													
	29. BAUTISTA	21,000	27,000		◎	◎														
	30. ALCALA	29,000	37,000		◎															
	31. STO. TOMAS	10,000	12,000		◎															
TARLAC	32. SAN MANUEL	16,000	20,000		◎							○								
	33. SAN CLEMENTE	8,000	10,000											○						
	34. CAMILING	60,000	69,000											◎						
	35. PANIQUI	62,000	73,000										◎							
	36. GERONA	61,000	79,000										◎							
	37. TARLAC	152,000	206,000										◎							

Fig. 3.4 RELATION BETWEEN FLOOD FORECASTING POINT AND AFFECTED MUNICIPALITY

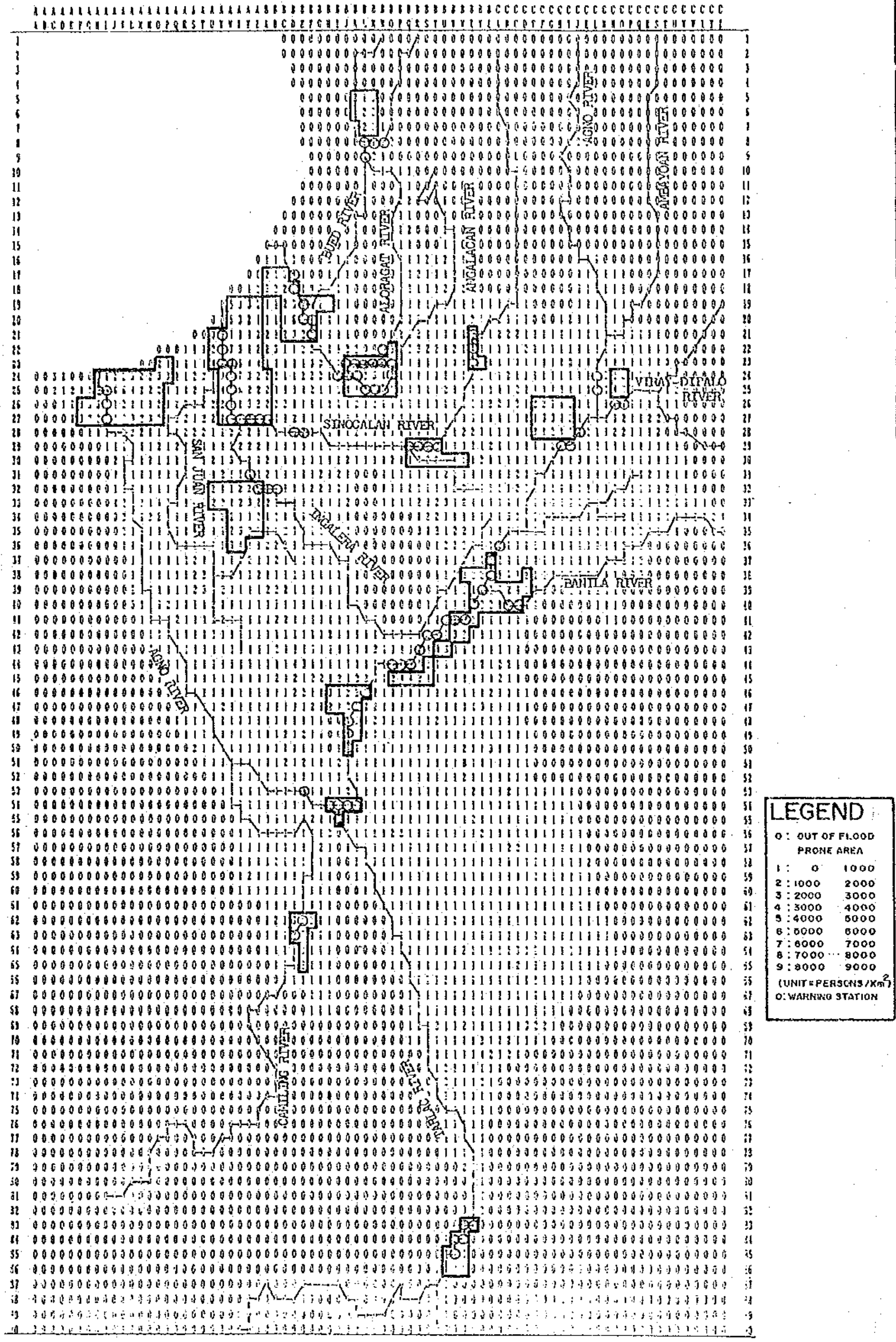


Fig. 3.5 POPULATION DENSITY DISTRIBUTION

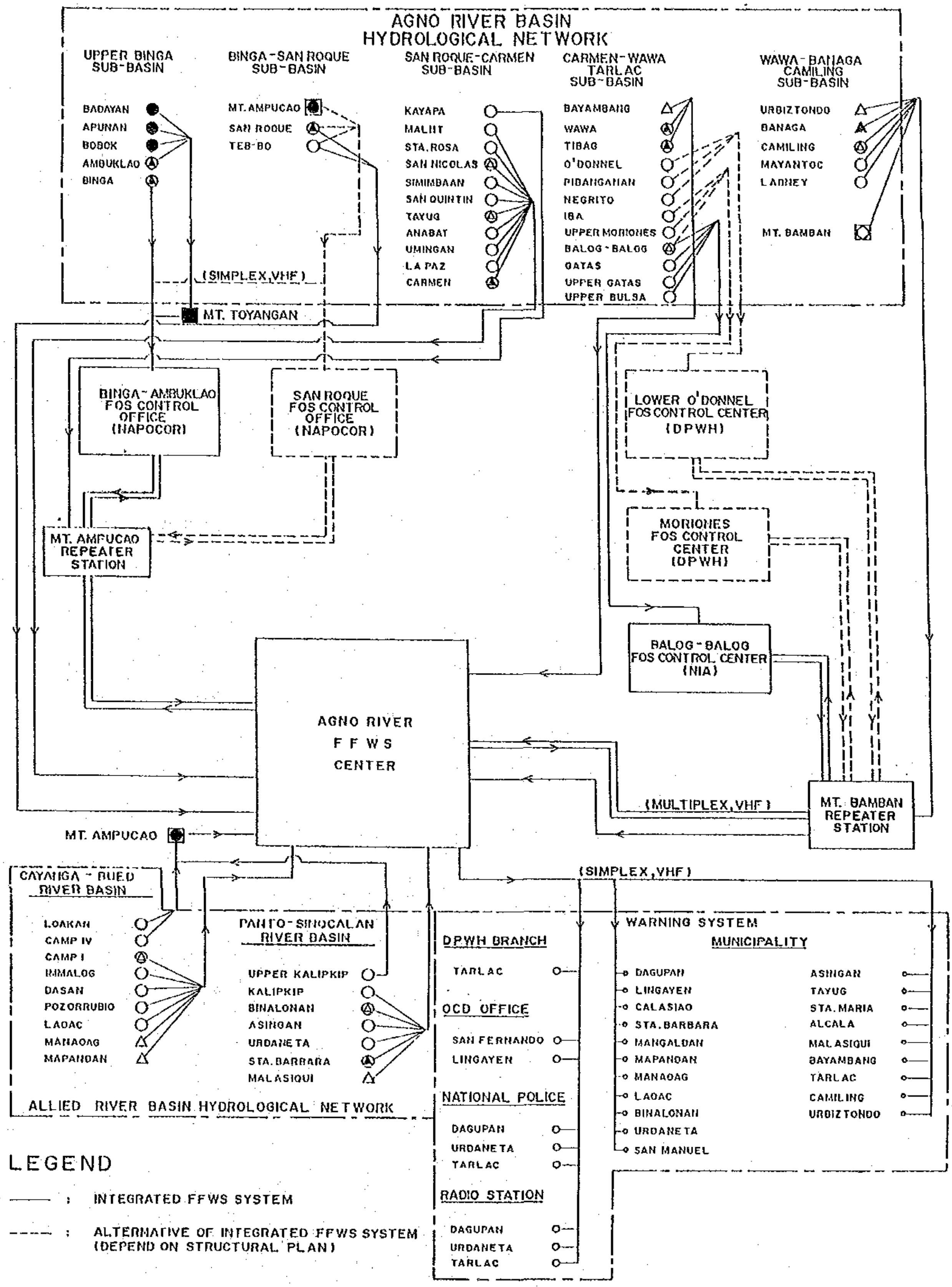


Fig. 3.6 THE INTEGRATED FFWS

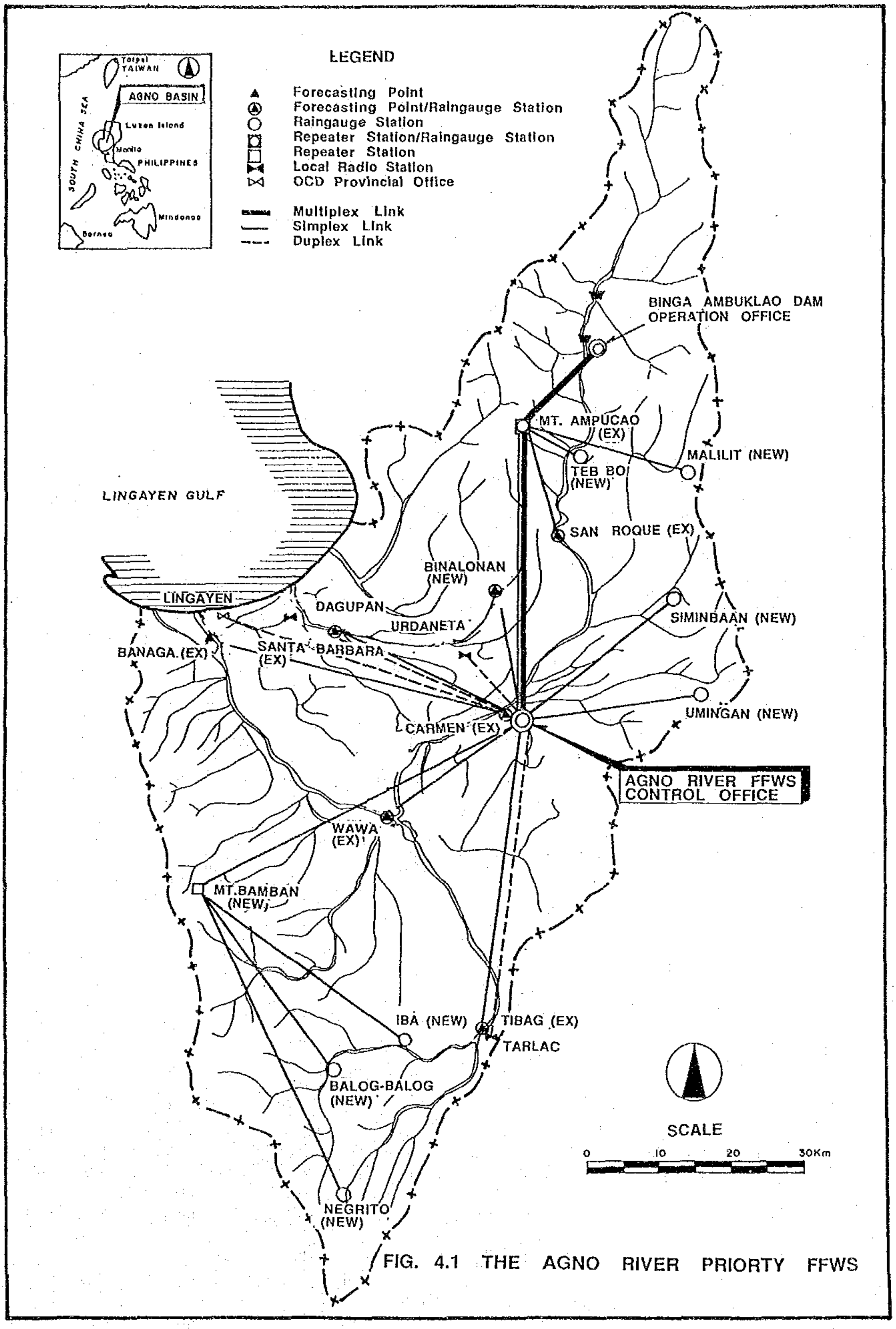
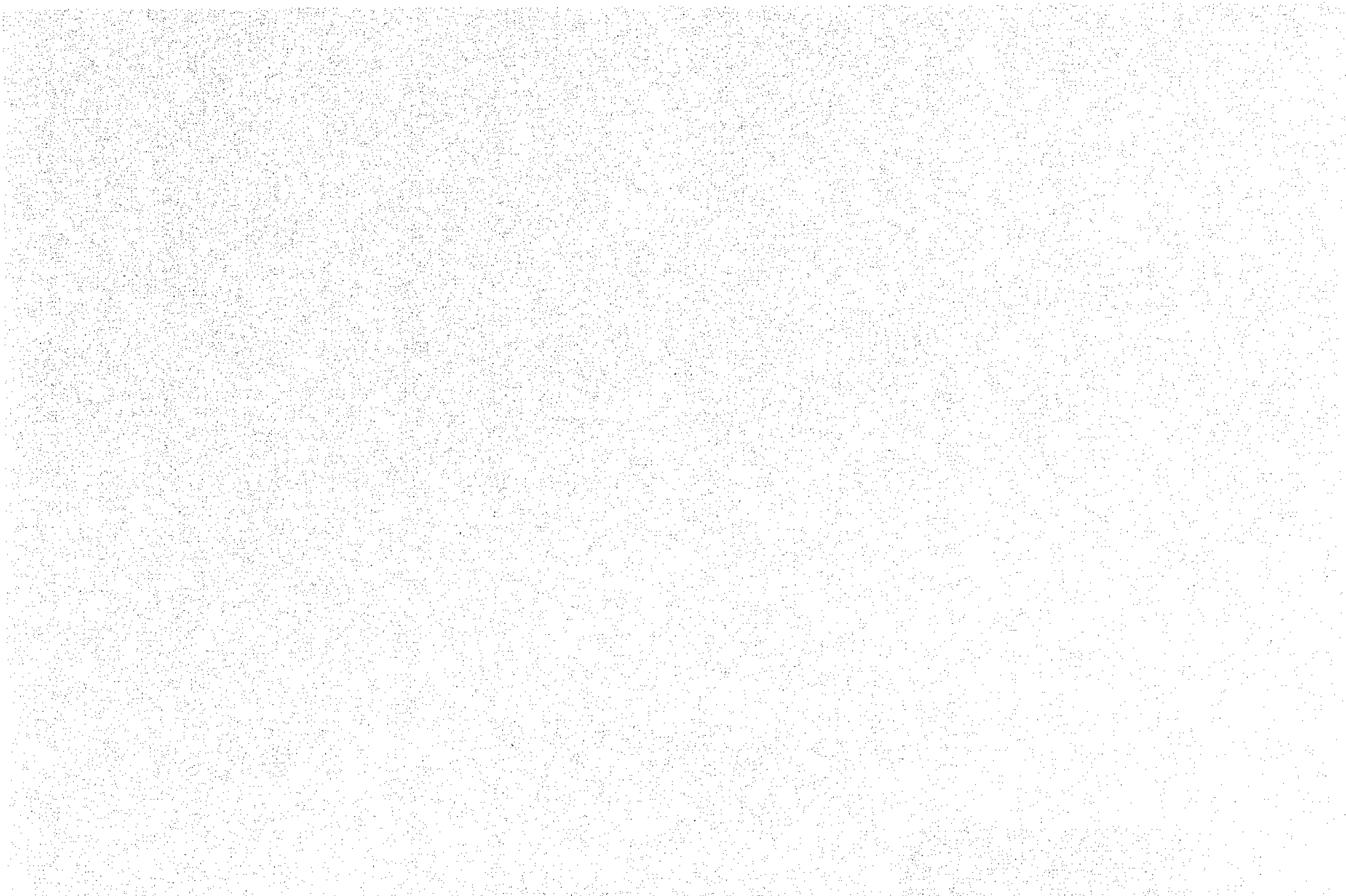


FIG. 4.1 THE AGNO RIVER PRIORTY FFWS



10. DS

10. DS

DESIGN OF STRUCTURES

DS:DESIGN OF RELATED STRUCTURES

SUMMARY

(1) The design of related structures as described in this sectoral report on the Study of Agno River Basin Flood Control was conducted through the following procedure:

(a) Assessment of flood damage on river facilities and structures.

(b) Decision on the basic design concept for related structures.

(c) Structural planning and design of related structures.

(d) Calculation of work quantities.

(2) The analysis on the causes of flood damage to flood control facilities and related structures was made on the basis of the flood damage records shown in Tables 2.1, 2.2 and 2.3 and in Fig. 2.1. The results of the analysis are summarized as follows:

(a) Most of the damage caused by floods are found on dikes, riverbanks and groins. The average cost of restoration works estimated at ₱70 million in this three years correspond to almost three times the annual average cost of flood control projects in five years.

(b) There are some sections with unstable slopes and water colliding fronts without revetment and groin in the typical cross sections of dike shown in Figs. 2.2 and 2.3, which are considered as the causes of bank failure in the past.

(c) It was determined that the upper reaches of the Agno River, the Dipalo River which is a tributary of the Agno River, and the left bank side of the middle reaches of the Agno River have been damaged in almost every year.

(d) The main causes of bank failure consist of scouring of dike materials of silty sand and the strong tractive force to the existing groin of dry masonry during floods. Another cause of dike failure is the

insufficient compaction at the junction between the existing dike and the newly constructed one.

(e) The causes of bridge damage were determined as follows:

- Insufficient clearance.
- Drift current due to decrease of flow area by structure.
- Unsuitable location of abutment.
- No revetment and foot protection around abutment to protect dike from failure due to scouring.

The mechanism of bridge failure is illustrated in Fig. 2.4.

(3) The design work in this study was made based on the following criteria with reference to the river improvement works recently implemented in the Study Area:

(a) Technical Standard for River and Sabo Facilities prepared by the Ministry of Construction of Japan.

(b) Design Guidelines, Criteria and Standards (Vol. I & II) prepared by the DPWH.

The standard design section of the river dike which is one of the most important structure among the flood control facilities in the Study Area is shown in Fig. 4.1.

(4) Structural plan and design were made for the following related structures.

(a) Related Structures for River Improvement Plan
River Dike, Revetment, Groin, Water Gate, Sluiceway, Bridge.

(b) Related Structures for Floodway Plan
Floodway Dike, Revetment.

(c) Related Structures for Flood Control Dam Plan
Dam, Spillway, River Diversion Facilities.

(d) Related Structures for Retarding Basin Plan
Retarding Basin Dike, Overflow Weir, Drainage Gate, Control Gate, Wier.

(c) Related Structures for Other Flood Control Facilities
Fixed Weir on Agno River, Closing Dike in Bued River, Sabo Dam.

DS : DESIGN OF RELATED STRUCTURES

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ABBREVIATIONS

1. NAME OF PHILIPPINE GOVERNMENT AGENCIES

AFCS	Agno Flood Control System
ARIS	Agno River Irrigation System
DENR	Department of Environment and Natural Resources
DOTC	Department of Transportation and Communications
DPWH	Department of Public Works and Highways
GOP	Government of the Philippines
LATRIS	Lower Agno and Totonogen River Irrigation System
NAPOCOR	National Power Corporation
NAMRIA	National Mapping and Resource Information Authority
NIA	National Irrigation Administration
OCD	Office of Civil Defense
PENRO	Provincial Environment and Natural Resources Office
PM	Project Manager
PMO	Project Management Office
PNR	Philippine National Railways
SMORIS	San Miguel - O'Donnell River Irrigation System

2. NAME OF JAPANESE GOVERNMENT AND OTHER OFFICIAL AGENCIES AND ORGANIZATION

GOJ	Government of Japan
JICA	Japan International Cooperation Agency
MOC	Ministry of Construction, Japan
OECF	Overseas Economic Cooperation Fund, Japan
UN	United Nations

3. MEASUREMENT UNITS

(Length)		(Weight)	
mm	millimeter(s)	gr(grs)	gramme(s)
cm	centimeter(s)	kg(kgs)	kilogramme(s)
m	meter(s)	ton(s)	ton(s),eq'vt to 1,000 kg
km	kilometer(s)		

(Area)

mm^2	square millimeter(s)
cm^2	square centimeter(s)
m^2	square meter(s)
km^2	square kilometer(s)
ha(has)	hectare(s)

(Time)

sec	second(s)
min	minute(s)
hr(hrs)	hour(s)
dy(dys)	day(s)
mth(mths)	month(s)
yr(yrs)	year(s)

(Volume)

cm^3	cubic centimeter(s)
m^3	cubic meter(s)
ltr	liter(s)

1. INTRODUCTION

1.1 General

The Agno river basin which is situated at the northwestern portion of Luzon Island, Republic of the Philippines, has been suffering from damage caused by recurrent floods. Under these circumstances, JICA has been undertaking the Study of Agno River Basin Flood Control since March 28, 1989 to formulate the Master Plan to mitigate flood damage.

This sectoral report presents the design of related structures which is one of the components of the study.

1.2 Objectives

The assessment of flood damage on river facilities and structures was conducted to determine the best preventive measure and adopt the most suitable design for structures in the Study Area.

The study on the design of related structures was carried out to obtain the work quantities for flood control facilities such as river improvement, floodway, dam, retarding basin, fixed weir, closing dike and sabo dam. The work quantities served as the basis for the cost estimate and the cost and benefit analysis.

2. ASSESSMENT OF FLOOD DAMAGE ON RIVER FACILITIES AND STRUCTURES

2.1 Record of Flood Damage on River Facilities and Structures

Flood damage records of flood control facilities and related structures caused by major floods in recent years brought by typhoons listed in Table 2.1 are shown in Tables 2.2 and 2.3 and in Fig. 2.1.

2.2 Analysis on Causes of Damage

The construction of flood control facilities in the Study Area had proceeded as shown in Table 2.4. Most of the damage caused by floods are found on dikes, banks and groins. The average cost of restoration works estimated at P70 million in these three years corresponds to almost three times the annual average cost of flood control projects in five years.

The repeated restoration works to prevent damage caused by flood in the Study Area have adopted the typical cross sections of dike shown in Figs. 2.2 and 2.3. However, there are some sections with unstable slopes and water colliding fronts without revetment and groin which are considered as the causes of bank failure in the past.

From the study on bank failure sites caused by recent floods (refer to Fig. 2.1 and Table 2.3), it was determined that the upper reaches of the Agno River, the Dipalo River which is a tributary of the Agno River, and the left bank of the middle reaches of the Agno River have been subject to damage in almost every year.

Since not only dikes but also groins are damaged in these reaches, it is considered that the main causes of bank failure consist of scouring of dike materials of silty sand and the strong tractive force to the existing groin of dry masonry during floods. Another cause of dike failure is the insufficient compaction at the junction between the existing dike and the newly constructed one.

The causes of bridge damage are considered as follows:

- Insufficient of clearance.
- Drift current due to decrease of flow area by structure.
- Unsuitable location of abutment.
- No revetment and foot protection around abutment to prevent dike from failure due to scouring.

The mechanism of bridge failure is explained as follows:

The destruction of a bridge due to insufficient clearance occurs when the flood water level comes up to almost the superstructure and strong dynamic load works directly to it through the debris such as drift timber caught by it, or, when the flood overflows the superstructure and washes it away (refer to No. 1 in Fig. 2.4).

When abutment is placed in the riverside as shown in No. 2 of Fig. 2.4, flood overflow due to the decrease of flow area causes destruction of a bridge, and scouring of dike by drift current ensues due to constriction. Destruction around abutment occurs when scouring of dike by flood flow ensues due to unsuitable location of abutment as shown in No. 3 of Fig. 2.4. Destruction of a dike consisting mainly of silty sand ensues easily when there is no revetment and foot protection around the abutment as shown in No. 4 of Fig. 2.4.

2.3 Requirement of Damage Prevention Measures

The following damage prevention measures are conceived to be effective in the Study Area. They may be employed singly or in suitable combinations with each other.

(1) Dike with Stability for Design Flood Discharge

Dike materials should be carefully investigate and special attention should be given to the compaction of dike. Revetment and groin should be planned around water colliding fronts. The structural type of existing groins is dry masonry; however, it is necessary to plan another structural type that is stable against floods.

(2) Flood control dam and retarding basin to reduce flood peak discharge by temporarily storing floodwaters.

(3) Floodway and diversion facilities to divert parts of flood into another river basin.

(4) Closing dike to prevent floods from spreading due to bank failure.

(5) Pumping facilities, sluice way and water gate for the drainage of inland water.

3. BASIC DESIGN CONCEPT OF RELATED STRUCTURES

3.1 Scope of Basic Design

Basic design shall be carried out for all the structures related to the flood control facilities in the Study Area. The standard design which is stable under general design conditions was applied to the design of related structures, however, the detailed computation for structural analysis is not made in this phase of the study.

Basic design shall be applied to the following related structures:

(1) Related Structures for River Improvement Plan

River Dike, Revetment, Groin, Groundsill, Water gate, Sluice way, Bridge

(2) Related Structures for Floodway Plan

Floodway Dike, Revetment, Diversion facilities

(3) Closing Dike in Allied Rivers

Closing Dike, Revetment, Groin

(4) Related Structures for Flood Control Dam Plan

Dam, Spillway, River diversion facilities

(5) Related Structures for Retarding Basin Plan

Retarding Basin dike, Overflow facilities, Drainage Gate, Pumping stations

(6) Related Structures for Sediment Control Plan

Sabo Dam

3.2 Design Criteria

There are some design criteria for river structures in the Republic of the Philippines. However, actual design works have been conducted on the basis of past experiences and the criteria of foreign countries because of the insufficient data on river structures. Accordingly, the design work in this study was made on the basis of the following criteria with reference to the river improvement works recently implemented in the Study Area.

(1) Technical Standard for River and Sabo Facilities prepared by the Ministry of Construction of Japan.

(2) Design Guidelines, Criteria and Standards (Vol. I & II) prepared by DPWH.

3.3 Typical Design Sections

River dike is the most important structure among the flood control facilities in the Study Area. The relationship among the crown width of the dike, freeboard for design flood discharge and standard design section of the dike are shown in Fig. 4.1. The standard design of retarding basin dike which is of the banking type like the river dike is shown in Fig. 4.18. The standard design section of the river dike shall be basically applied to the floodway dike and the closing dike for allied rivers.

4. STRUCTURAL PLAN AND DESIGN OF RELATED STRUCTURES

4.1 Structural Plan and Design of River Improvement

4.1.1 Dike

Standard design sections of river dike corresponding to the dike height are shown in Fig. 4.1. The dike height is determined by adding the freeboard allowance to the design high water level which is reckoned on the design flood discharge. Freeboard which is the margin of height maintained between the top of the dike and the designed flood level to guard against overtopping and wave wash shall be obtained from the table shown in Fig. 4.1.

The crown width of the dike, which may be required to serve as a road for facilitating the transport of materials during the construction stage and maintenance operations, and its relation to the design flood discharge is also shown in Fig. 4.1.

The side slopes on both landside and riverside of the dike are designed as 2:1, as shown in Fig. 4.1. Berms are provided along the slopes of high dikes as an erosion control measure and also to improve the stability of the side slopes. Berms are designed for the riverside and landside, respectively, as follows:

(i) Riverside

When the crest height from the river bed is more than 5.00 m, berms shall be provided at every 5.00 m. Berms shall be 5.00 m deep from the crest elevation with a width of 3.00 m.

(2) Landside

When the crest height from the existing ground is more than 3.00 m, berms shall be provided at every 3.00 m. It shall be 3.00 m deep from the crest elevation with a width of 3.00 m.

4.1.2 Revetment

Revetments are flood control structures constructed along river banks subjected to direct attack of the river flow and along dike slopes for protection against scouring and wave wash. Standard design sections of low-water channel and high-water channel revetments in relation to the dike height are shown in Figs. 4.2 and 4.3, respectively.

Revetments of low-water channel, which are classified into two types; Type-A and Type-B corresponding to the dike height (See Fig. 4.2), are designed with the use of gabion cylinder of D0.45 m and wooden pile of D0.20 m x 3.00 m in order to suit for variations of the riverbed under the flood flow.

Revetments of high-water channel, which are classified into two types; Type-A and Type-B corresponding to the dike height (see Fig. 4.3), are designed with the use of wet masonry of 0.60 m thick and gabion mattress of 0.50 m x 1.20 m x 3.00 m in order to prevent the dike from scouring under the flood flow.

Slopes of revetments are designed as 2:1 the same as those of the dike.

4.1.3 Groin

Groins are river training structures constructed along the dikes of rivers to deflect or repel the flow for the purpose of training the course of the river channel and to protect the dikes from scouring by inducing siltation in the area. Standard designs of low-water channel and high-water channel groins are shown in Figs. 4.4, 4.5, 4.6, and 4.7.

Groins of both low-water channel and high-water channel are classified into two types: Type-A for general streams and Type-B for the upstream portion of the main Agno River which was repeatedly damaged by flood flow (see Figs. 4.5 and 4.7).

Groins of Type-A 20.00 m long and 2.00 m high are designed with the use of gabion cylinder of D0.45 m for low-water channel or gabion mattress of 0.50 m x 1.20 m x 3.00 m for high water channel and wooden pile of D0.20 m x 3.00 m as a permeable type (see Figs. 4.4 and 4.6). Groins of Type-B 30.00 m long and 2.00 m high are designed with the use of reinforced concrete and gabion cylinder of D0.45 m for low-water channel or gabion mattress of 0.50 m x 1.20 m x 3.00 m for high-water channel as a massive type so as to cope with the flood flow (see Figs. 4.5 and 4.7). The distance between groins of Type-A shall be 30.00 m and that of Type-B shall be 50.00 m.

4.1.4 Sluice Way

Sluice ways are provided for the purpose of drainage or irrigation by use of box culvert with sluice type gate under the dike.

Standard designs of sluice way, which is classified into two types of Type-A and Type-B, are shown in Figs. 4.8 and 4.9, respectively.

Type-A, which has one box culvert of 1.50 m x 1.50 m and Type-B, which has two box culverts of 1.50 m x 1.50 m, shall be determined based on the discharge from its catchment area and inlet capacity. To prevent the differential settlements, wooden piles of D0.20 m x 5.00 m are provided at the foundation. Steel sheet piles 3.00 m long are designed for the purpose of percolation control.

4.1.5 Water Gate

Water gates are provided to protect the branch catchment area from the backwater flood flow of the main river.

Standard designs of water gate, which is classified into two types; Type-A and Type-B, are shown in Figs. 4.10 and 4.11, respectively. Type-A, which has a roller type gate of 10.00 m x 7.00 m and Type-B, which has a roller type gate of 20.00 m x 8.00 m, shall be determined based on the river improvement plan.

To prevent the differential settlements, reinforced concrete piles of 0.40 m x 0.40 m x 8.00 m and wooden piles of D0.20 m x 5.00 m are provided at the foundation. Steel sheet piles 3.00 m long are designed for the purpose of percolation control.

4.1.6 Bridge

A number of bridges are planned to be constructed and/or rehabilitated according to the river improvement plan. The standard design is shown in Fig. 4.12 so as to conceptually understand the type of bridge structure.

4.2 Structural Plan and Design of Floodway

4.2.1 Dike

Binalonan Floodway with a total length of 6.80 km is considered from the Toboy River which is the upstream of the Tagamusing River to the Angalacan River in order to divert the flood flow. The floodway will be divided into two sections. They are the upstream portion which is 3.60 km long to divert 550 m^3/s flood discharge and the downstream portion which is 3.20 km long to divert 650 m^3/s flood discharge.

Standard design sections of floodway dike are shown in Fig. 4.13. The structural type of floodway dike is basically the same as the river dike. The floodway, with dike slope of 2:1 and a crown width of 4.00 m, has low-water channel and high-water channels. The low-water channel width for the upstream portion and the downstream portion are 10.00 m and 15.00 m, respectively. The high-water channel width for both portions are 60.00 m.

4.2.2 Revetment

Since the layout of this floodway is planned in alignment, revetments are proposed only for the low-water channel to protect the dike from scouring caused by the flood flow. The structural type of revetments, provided with gabion cylinder of D0.45 m and wooden pile of D0.20 m x 3.00 m, is basically the same type for the river dike, as shown in Fig. 4.13.

4.3 Structural Plan and Design of Flood Control Dam

4.3.1 Dam

Selection of prospective flood Control dams have been studies for 17 dams. Location of these dams are shown in Fig. 4.14 and typical sections of existing dams and previously studied dams are shown in Fig. 4.15. Consequently, the Moriones Dam and the Lower O'Donnell Dam which reservoirs are to be connected by a open channel are selected for the Framework Plan as an effective flood control measure. Both dams are planned as a concrete gravity dam. The Moriones Dam which is 53.00 m high and has concrete volume of 277,000 m^3, is shown in Fig. 4.16 and the Lower O'Donnell Dam which is 38.00 m high and has concrete volume of 92,000 m^3, is shown in Fig. 4.17.

The design upstream slope of 0.1:1 and the downstream slope of 0.7:1 are the same for both dams.

Curtain grout and consolidation grout are planned for the foundation treatment which shall be made to increase the bearing capacity and homogeneity of the foundation for the purpose of stabilizing the dam.

4.3.2 Spillway

Spillways to divert the design flood discharge for 200-year flood are provided for the purpose of stability of the dam itself.

The Moriones Dam has 15 ordinary flood sluices of orifice type with gates and 180.00 m wide free overflow crest (see Fig. 4.16). Flood water from upstream enter into the reservoir and its outflow is to be controlled by these spillway gates.

The Lower O'Donnell Dam which is connected to the Moriones Dam by a open channel has no spillway since it is expected to work as a saddle dam of the Moriones Dam.

4.3.3 River Diversion Facilities

To divert the river water during the construction of the dam, upstream and downstream cofferdams and a temporary diversion tunnel are planned.

River diversion facilities of the Moriones Dam are planned with two cofferdams of earthfill type and a temporary diversion tunnel of D6.00 m and 200.00 m long as shown in Fig. 4.16.

River diversion facilities of the Lower O'Donnell Dam are planned with two cofferdams of earthfill type and a temporary diversion tunnel of D5.00 m and 240.00 m long as shown in Fig. 4.17.

4.4 Structural Plan and Design of Retarding Basin

4.4.1 Dike

Standard design sections of retarding basin dike in relation to the dike height are shown in Fig. 4.18. The dike height is determined by adding the freeboard of 1.50 m, which is the height maintained between the top of the dike and the designed flood level to guard against overtopping and wave wash, to the design high water level obtained from the result of flood control simulations.

The crown width of the dike, which may be required to serve as a road for facilitating the transport of materials during the construction stage and maintenance operations, is designed as 6.00 m.

The side slopes of the dike should be determined based on the stability calculation by use of soil characteristics. However, in this phase the side slopes on both the retarding basin side and the river landside of the dike are designed as 3:1, while the slope of landside of the dike is designed as 2.5:1 as shown in Fig. 4.18. In case the dike height is higher than 3.00 m, a blanket zone of 10.00 m long and 2.00 m thick is provided at the toe of slope for the purpose of percolation control as a further countermeasure against dike failure.

4.4.2 Overflow Weir

Overflow weir is provided on the retarding basin dike to divert some of the flood discharge to the retarding basin.

The standard design of the overflow weir, with steel sheet piles of 5.00 m long and wooden piles of D0.20 m x 5.00 m are provided for the purpose of percolation control and prevention of differential settlements respectively, is shown in Fig. 4.19. Revetments of 0.60 m thick and gabion mattress of 0.50 m x 1.20 m x 3.00 m are also provided to prevent the dike and the foundation of the toe of slopes from scouring by the diverted flood. Crest length of the overflow weir shall be determined on the basis of the relation between the diverted discharge and the overflow depth.

4.4.3 Drainage Gate

Drainage gate is provided at the downstream of the retarding basin to drain the diverted discharge immediately after the flood. The standard design of the drainage gate, which has five roller type gates of 10.00 m x 7.50 m, in a total span of 50.00 m is shown in Fig. 4.20. Reinforced concrete piles of 0.40 m x 0.40 m x 5.00 m and wooden piles of D0.20 m x 5.00 m are provided to prevent differential settlements at the foundation. Steel sheet piles of 5.00 m long are provided for the purpose of percolation control.

4.4.4 Control Gate Weir

Control gate weir is studied at the downstream of the confluence of the Poponto Floodway and the Tarlac River for the purpose of regulating the flood flow. The control gate weir, which is designed as a concrete structure with ten roller type gates of 15.00 m x 11.30 m in a total span of 150.00 m, has the dike on both sides as shown in Fig.4.21. The dike slope of the retarding basin is 3:1 and it has a blanket zone of 10.0 m long and 2.00 m thick at the toe of upstream slope.

Steel piles of D0.60 m x 20.00 m and reinforced concrete piles of 0.4 m x 0.4 m x 10.00 m are provided to prevent differential settlements at the foundation of the control gate weir. Also, steel sheet piles of 10.00 m long are provided for the purpose of percolation control.

4.5 Structural Plan and Design of Other Flood Control Facilities

4.5.1 Fixed Weir on Agno River

Fixed weir is planned to divert 8,200 m^3/s out of the estimated 9,200 m^3/s of the 100-year flood discharge to the Poponto Floodway. Structural design of the fixed weir is shown in Fig.4.22, and it is designed as overflow type with 2.00 m overflow depth, 250.00 m crest width and 6.50 m height. The weir has the split portion of 5.00 m width in the center for the maintenance flow to the Bayambang stretch of the Agno River.

Reinforced concrete piles of 0.40 m x 0.40 m x 8.00 m and wooden piles of D0.20 m x 5.00 m are provided to increase the bearing capacity of foundation and to prevent differential settlements. Steel sheet piles of 5.00m long are provided for the purpose of percolation control.

4.5.2 Closing Dike in Bued River

Closing dike of 2.00m high and 2.00km long is planned in the upstream left bank of the Bued River to protect the downstream area from the damaging flood flows.

The structural type of this dike, with a slope of 2:1 and a crown width of 4.00 m, is basically the same as the river dike as shown in Fig. 4.23. Revetments of wet masonry type of 0.60 m thick and foot protections by gabion mattress of 0.50 m x 1.20 m x 3.00 m are provided to prevent the dike from scouring. Also, steel sheet piles of 5.00 m long are provided for the purpose of percolation control.

4.5.3 Sabo Dam

Sabo dams are planned to trap and control the sediment produced in the mountain areas. Standard design of sabo dam, with a height of 20.00 m and crest length of 100.00 m, is shown in Fig. 4.24. Although the dam height is designed as 20.00 m in this section, it can be changed according to the dam site and sediment volume. The sabo dam plan is described in detail in the sectoral report on sediment analysis.

5. WORK QUANTITIES

Work quantities of related structures for each flood control plan were calculated through the facilities planning. These work quantities are summarized in CP: CONSTRUCTION PLAN AND COST ESTIMATE.

In addition to these work quantities, more detail work quantities of the Moriones Dam and Lower O'Donnell Dam, fixed weir in the Agno River, closing dike in the Bued River are shown in Tables 5.1 to 5.3.

Major dimensions of proposed sabo dams which are studied in sediment analysis are shown in Table 5.4 and location of these dams are illustrated in Fig. 5.1.

TABLES

Table 2.1 LIST OF DESTRUCTIVE TYPHOON IN THE AGNO RIVER BASIN (1962-1988)

No.	Year	Name of Typhoon	Date	Remarks
1	1962	Kate	July 18-27	
2		Wanda	Aug. 25-Sept.3	
3		Amy	Sept. 3-Sept. 8	
4	1963	Diding	June 24-30	
5	1964	Seniang	Aug. 2-11	
6		Aring	Sept. 3-13	
7	1965	Miling	July 10-18	
8	1966	None		
9	1967	Trining	Oct. 14-20	
10	1968	Didang	July 23-29	
11		Huaning	Aug. 18-25	
12		Lucing	Sept. 2-8	
13		Nitang	Sept. 26-Oct. 2	
14	1969	None		
15	1970	None		
16	1971	Rosing	July 17-24	
17		krising	Oct. 7-14	
18	1972	Kording	June 26-27	
19	1973	Luming	Oct. 2-9	
20	1974	Iling	July 18-21	
21		Susang	Oct. 8-12	
22		Tering	Oct. 14-17	
23		Wening	Oct. 25-29	
24		Aning	Nov. 4-8	
25		Biding	Nov. 24-29	
26	1975	Auring	June 22-26	
27	1976	Huaning	June 22-July 2	
28	1977	Unding	Nov. 10-17	
29	1978	Miding	Aug. 18-26	
30		Kading	Oct. 25-27	
31	1979	Mamang	Aug. 9-15	
32	1980	Gloring	May 22-26	
33		Miting	July 18-22	
34		Aring	Nov. 1-17	
35	1981	Anding	Nov. 21-27	
36	1982	Emang	July 12-16	
37		Norming	Aug. 19-Sept. 4	
38	1983	Bebeng	July 12-16	
39	1984	Maring	Aug. 27-30	*
40	1985	Kuring	June 20-24	*
41		Daling	June 25-29	*
42		Saling	Oct. 15-20	
43	1986	Gading	July 6-10	*
44		Miding	Aug. 24-Sept. 4	*
45	1987	Ising	Aug. 12-19	
46	1988	Unsang	Oct. 21-24	

Source: Office of Civil Defense
PAGASA

Note : * Mark shows the typhoon which brought Huge Damages in the recent years.

Table 2.2 SUMMARY OF FLOOD CONTROL FACILITIES DAMAGED BY FLOODS

River (Reaches)	Damaged Type		1984-Flood Aug. 28-30 ("Maring")		1985-Flood June 22-24 ("Kuring") June 28-30 ("Daling")		1986-Flood July 9-11 ("Gading") Aug. 30- Sept. 5 ("Meding)	
Agno River (Upper)	Earthdike/Revet. Breaches/Gaps	(Site, m)	8	2,760	8	2,290	10	5,340
		(P:1,000)		52,972		17,888		55,402
	Scoured	(Site, m)	0	0	0	0	3	2,900
		(P:1,000)		0		0		2,750
	Damaged Spurdike	(Site, Unit)	2	56	0	0	7	188
		(P:1,000)		1,400		0		3,812
Agno River (Lower)	Earthdike/Revet. Breaches/Gaps	(Site, m)	1	110	0	0	1	500
		(P:1,000)		20,000		0		1,200
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	0	0	1	4
		(P:1,000)		0		0		8,120
Tarlac River	Earthdike/Revet. Breaches/Gaps	(Site, m)	0	0	3	70	5	490
		(P:1,000)		0		660		5,845
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	0	0	3	46
		(P:1,000)		0		0		1,280
Tributaries of Agno River	Earthdike/Revet. Breaches/Gaps	(Site, m)	0	0	3	140	7	1,080
		(P:1,000)		0		1,000		8,300
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	0	0	8	61
		(P:1,000)		0		0		1,744
Allied River	Earthdike/Revet. Breaches/Gaps	(Site, m)	4	976	1	40	9	1,820
		(P:1,000)		8,166		231		8,767
	Scoured	(Site, m)	0	0	0	0	0	0
		(P:1,000)		0		0		0
	Damaged Spurdike	(Site, Unit)	0	0	2	10	3	48
		(P:1,000)		0		576		997
Total Cost of Restoration Works		(P:1,000)		82,538		20,355		109,017

Source: Agno Flood Control System Office, Rosales

Table 2.3 (1/6) SUMMARY OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

	ITEMS	LENGTH (m)	BARANGAY/MUN.	ESTIMATED COST TO RESTORE INCL. PROTECTIVE WORKS (P MILLIONS)	REMARKS
I.	EARTHDIKE AND REV'T. BREACHES/GAPS				
	A. ALONG AGNO RIVER				
1	Sta. 29+800 to Sta. 30+090	290	Narra, Sn. Manuel, Pangasinan	2.047	"MEDING" Aug.30-Sept.5/86
2	Sta. 29+650 to Sta. 29+800	150	-do-	1.039	"MARING" Aug.28-31/84
3	Sta. 29+400 to Sta. 29+650	250	-do-	1.765	"KURING"&"DALING"June 22 to 24;28-30/85
4	Sta. 27+420 to Sta. 29+400	980	Calanutian, Sn. Manuel, Pangasinan	6.918	"MARING" Aug. 28-31/84
5	Sta. 26+900 to Sta. 27+420	520	-do-	3.671	"KURING"&"DALING"June 22 to 24;28-30/85
6	Sta. 26+020 to Sta. 26+900	880	-do-	6.212	"MEDING" Aug.28-31,1986
7	Sta. 25+540 to Sta. 25+600	60	Sn. Vicente, Sn. Manuel, Pangasinan	0.423	"KURING"&"DALING"June 22 to 24;28-30/85
8	Sta. 25+180 to Sta. 25+540	360	-do-	2.541	"MARING" Aug. 28-31/84
9	Sta. 25+050 to Sta. 25+180	130	-do-	0.917	"KURING"&"DALING"June 22 to 24;28-30/85
10	Sta. 24+050 to Sta. 25+050	1,000	-do-	7.060	"GADING" July 9-11, 1986
11	Sta. 22+740 to Sta. 25+110	370	Bato, Sn. Manuel, Pangasinan	2.612	"KURING"&"DALING"June 22 to 24;28-30/85
12	Sta. 22+020 to Sta. 22+740	720	-do-	5.083	"GADING" July 9-11, 1986
13	Sta. 21+500 to Sta. 21+700	200	Guzon, Sn. Manuel, Pangasinan	1.412	-do-
14	Sta. 21+020 to Sta. 21+500	480	-do-	3.388	-do-
15	Sta. 20+860 to Sta. 21+020	160	-do-	1.129	"MARING" Aug. 28-31/84
16	Sta. 20+180 to Sta. 20+860	680	-do-	4.760	"KURING"&"DALING"June 22 to 24;28-30/85
17	Sta. 19+380 to Sta. 19+580	200	-do-	1.400	"MARING" Aug. 28-31/84
18	Sta. 17+700 to Sta. 19+000	1,300	Bantog, Sn. Manuel	9.100	"GADING" Aug. 28-31,1984
19	Sta. 0+000 to Sta. 0+400	400	Caramutan, Villasis, Pangasinan	8.000	-do-

Table 2.3 (2/6) SUMMARY OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

20	Sta. 2+851 to Sta. 3+020	179	Sto. Domingo,Sto. Tomas, Pangasinan	10.645	"MARING" Aug. 28-31/84
21	Sta. 3+032 to Sta.3+106	76	-do-		"KURING"&"DALING"June 22 to 24;28-30/85
22	Sta. 8+420 to Sta. 8+880	460	Sn.Nicolas,Alcala, Pangasinan	9.200	"MARING" Aug. 28-31/84
23	Sta. 8+800 to Sta. 9+000	200	-do-	3.740	"KURING"&"DALING"June 22 to 24;28-30/85
24	Sta. 9+000 to Sta. 9+040	40	-do-	0.800	"MEDING" Aug.30-Sept.5/86
25	Sta. 4+100 to Sta. 4+130	30	Nibalew,Bautista, Pangasinan	0.300	"GADING" & "MEDING" July 9-11, Aug. 30-Sept. 5/86
26	Sta. 18+365 to Sta. 18+800	435	Pob. Bayambang, Pangasinan	0.100	"MARING" Aug. 28-31/84
27	Sta. 0+000 to Sta. 0+110	110	Pob. Urbistondo, Pangasinan	20.000	-do-
28	Sta. 37+700 to Sta. 38+000	300	Quibaol, Lingayen	12.000	"MEDING" Aug.30-Sept.5/86
			T O T A L ---	126.255	

B. ALONG TRIBUTARY RIVER

29	Sta. 4+200 to Sta. 4+450	250	Bantog,Sn Quintin, Pangasinan	2.500	"GADING" July 9-11, 1986
30	Sta. 5+020 to Sta. 5+520	500	Bantog,Sn Quintin, Pangasinan	0.500	"MEDING" Aug.30-Sept.5/8
31	Sta. -0+200 to Sta. -0+250	50	Tulin, Natividad, Pangasinan	0.500	"MEDING" Aug.30-Sept.5/8
32	Sta. - 2+400 to Sta. -2+450	50	-do-	0.500	"MEDING" Aug.30-Sept.5/8
33	Sta. -2+600 to Sta. -2+650	50	-do-	0.500	"MEDING" Aug.30-Sept.5/8
34	Sta. 4+800 to Sta. 4+850	50	Magallanes, Tayug, Pangasinan	0.500	"KURING" & "DALING" June 22-24;28-30/85
35	Sta. 5+450 to Sta. 5+500	50	-do-	0.500	-do-
36	Sta. 2+800 to Sta. 2+990	190	Mancalabasaan, Umingan, Pang.	3.800	"GADING & MEDING" July 9-11 Aug. 30-Sept.5/86
37	Sta. 0+000 to Sta. 0+010	10	Tumana, Rosales, Pangasinan		-do-
			T O T A L ---	14.000	

Table 2.3 (3/6) SUMMARY OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

C. ALONG ALLIED RIVER

38	Sta. -0+270 to Sta. -0+370	100	Esperanza, Sison, Pangasinan	1.203	"MARING" Aug.28-31/84
39	Sta. 1+674 to Sta. 1+729	55	-do-	0.220	-do-
40	Sta. 0+330 to Sta. 1+290	960	-do-	3.852	"GADING" July 9-11/86
41	Sta. 1+290 to Sta. 1+590	300	-do-	1.203	"MEDING" Aug.30-Sept.3/86
42	Sta. 0+540 to Sta. 0+781	241	Binday, Sn. Fabian, Pangasinan	1.511	"MARING" Aug. 28-31/84
43	Sta. 0+503 to Sta. 0+540	37	-do-	0.231	"KURING" & "DALING" June 22-24; 28-30/85
44	Sta. 0+781 to Sta. 1+081	300	-do-	1.881	"GADING" & "MEDING" July 9-11; Aug.30-Sept.5/86
45	Sta. 1+081 to Sta. 1+181	100	-do-	0.627	"MEDING" Aug.30-Sept.5/86
46	Sta. 0+900 to Sta. 0+929	29	Sto.Nino,Binalonan, Pangasinan	0.232	"MARING" Aug. 28-31/84
47	Sta. 0+969 to Sta. 1+003	34	-do-	0.272	"GADING" July 9-11/86
48	Sta. 0+520 to Sta. 0+604	84	Pob. Binalonan, Pangasinan	0.672	"MEDING" Aug.30-Sept.5/86
49	Sta. 0+149 to Sta. 0+159	10	Pinmaludpod, Urdaneta, Pang.	0.080	"MARING" Aug. 28-31/84
50	Sta. 0+270 to Sta. 0+290	20	-do-	0.100	"GADING" July 9-11/86
51	Sta. 0+290 to Sta. 0+300	10	-do-	0.080	"MEDING" Aug.30-Sept.5/86
52	Sta. 0+062 to Sta. 0+413	351	Pias, Mapandan, Pangasinan	5.000	"MARING" Aug. 28-31/84
			T O T A L ---	17.224	

Table 2.3 (4/6) SUMMARY OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

	ITEMS	LENGTH (m)	BARANGAY/MUN.	ESTIMATED COST TO RESTORE INCL. PROTECTIVE WORKS (P MILLIONS)	REMARKS
2.	EARTHDIKE AND REV'T. BREACHES/GAPS				
1	Sta. -2+190 to Sta. -2+200	10	Carangian, Tarlac	0.100	"KURING" June 22-24/85
2	Sta. 2+154 to Sta. 2+190	36	Poblacion, Tarlac	0.360	"DALING" June 28-30/85
3	Sta. 1+180 to Sta. 1+200	20	-do-	0.200	"KURING" June 22-24/85
4	Sta. 2+575 to Sta. 2+615	40	Sipong-Calsada Tarlac, Tarlac	2.000	"MEDING" Aug.30-Sept.5/86
5	Sta. 2+650 to Sta. 3+000	350	Armenia, Tarlac	2.775	"GADING" July 9-11/86
6	Sta. 2+600 to Sta. 2+650	50	-do-	0.425	"MEDING" Aug.30-Sept.5/86
7	Sta. 3+000 to Sta. 3+050	50	-do-	0.425	-do-
			TOTAL ---	6.285	
	B. ALONG TRIBUTARY RIVER				
8	Sta. 0+000 to Sta. 0+022	20	Pitao,Sn. Clemente, Pangasinan	0.200	"GADING" July 9-11, 1986
9	Sta. 0+022 to Sta. 0+044	22	-do-	0.220	"MEDING" Aug.30-Sept.5/86
II	SCOURED				
	A. ALONG AGNO RIVER				
1	Sta. 20+180 to Sta. 20+480	300	Guzon, Asingan, Pangasinan	0.300	"MARING" Aug.28-31, 1984
	B. ALONG TRIBUTARY RIVER				
2	Sta. 2+850 to Sta. 5+220	2,570	Magallanes, Tayug, Pangasinan	2.370	-do-
	C. ALONG ALLIED RIVER				
3	Sta. 0+150 to Sta. 0+190	40	Cabatuan, Alaminos, Pangasinan	0.080	"MEDING" Aug.30-Sept.5/86
			TOTAL ---	3.170	

Table 2.3 (5/6) SUMMARY OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

III DAMAGED SPURDIKES

A. ALONG AGNO RIVER

1	Sta. 21+020 to Sta. 21+500	15 units	Guzon, Asingan, Pangasinan	0.300	"GADING" July 9-11, 1986
2	Sta. 25+180 to Sta. 25+540	8 units	San Vicente, San Manuel, Pangasinan	0.200	"MARING" Aug.28-31, 1984
3	Sta. 27+420 to Sta. 29+000	48 units	Calanutian, San Manuel, Pangasinan	1.200	-do-
4	Sta. 29+000 to Sta. 31+500	40 units	-do-	1.000	"GADING" July 9-11, 1986
5	Sta. 6+470 to Sta. 7+100	19 units	Sta. Maria, Pangasinan	0.437	-do-
6	Sta. 0+100 to Sta. 0+400	29 units	Puelay, Villasis, Pangasinan	0.675	"MEDING" & "GADING" July 5-11, 1986
7	Sta. 2+820 to Sta. 3+200	17 units	Sto. Tomas, Sto. Domingo, Pangasinan	0.680	-do-
8	Sta. 8+320 to Sta. 8+600	10 units	San Nicolas,Alcala, Pangasinan	0.400	-do-
9	Sta. 8+800 to Sta. 9+000	8 units	-do-	0.320	-do-
10	Sta. 38+020 to Sta. 38+200	4 units	Quibaol, Lingayen Pangasinan	0.120	-do-
			T O T A L----	13.392	

B. ALONG TRIBUTARY RIVER

11	Sta. 7+950 to Sta. 8+400	10 units	Casaratan, San Nicolas, Pangasinan	0.260	"MEDING" Aug.30-Sept.5/86
12	Sta. -0+200 to Sta. -0+400	10 units	Tulin, Natividad, Pangasinan	0.260	-do-
13	Sta. -4+200 to Sta. -0+800	3 units	Bantog, San Quintin Pangasinan	0.078	-do-
14	Sta. 2+800 to Sta. 2+990	10 units	Mancabalasaan, Umingan, Pang.	0.260	-do-
15	Sta. 0+000 to Sta. 0+120	-	Tumana, Rosales, Pangasinan	0.200	"GADING" July 9-11, 1986
16	Sta. 0+300 to Sta. 0+500	5 units	-do-	0.200	"MEDING" Aug.30-Sept.5/86
17	Sta. 0+870 to Sta. -1+060	18 units	Bugallon,Pangasinan	0.486	-do-
18	Sta. 0+920 to Sta. 1+065	-	-do-	-	"GADING" July 9-11, 1986
			T O T A L ----	1.744	

Table 2.3 (6/6) SUMMARY OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

C. ALONG ALLIED RIVER					
19	Sta. 0+020 to Sta. 0+200	5 units	San Vicente, San Jacinto, Pang.	0.160	"KURING" June 22-24, 1985
20	Sta. 0+240 to Sta. 0+200	5 units	-do-	0.416	"DALING" June 28-30, 1985
21	Sta. 0+500 to Sta. 0+600	13 units	Poblacion, San Jacinto, Pang.	-	"GADING" July 9-11, 1986
22	Sta. 0+500 to Sta. 0+832	35 units	Tuliao, Sta. Barbara, Pang.	0.997	-do-
23	Sta. 5+260 to Sta. 5+420	-	Talibaew, Sta. Barbara, Pang.	-	-do-
B. ALONG TARLAC RIVER					
24	Sta. 0+000 to Sta. -2+400	40 units	-	1.280	"MEDING" Aug.30-Sept.5/86
25	Sta. 2+000 to Sta. 4+520	-	-	-	-do-
			TOTAL ---	2.853	

Table 2.4 SUMMARY OF ACCOMPLISHMENT OF RIVER CONTROL WORKS (1972-1988)

Year	EARTH DIKE (m)	W/BOULDER FACING/ APRON (m)	REVETMENT GRAVITY WALL (m)	BOULDER SPUR DIKE (UNIT)	BOULDER DIKE (m)	GRAVEL SUR-FACING (m)	CUT-OFF CHANNEL (m)	DRAINAGE GATE (UNIT)	SPILLWAY (m)	TOTAL COST (P)
1972	3,234	0	225	3	0	15,000	0	0	0	305,956
1973	3,322	0	-	155	0	0	0	0	0	12,186,174
1974	28,855	0	3,852	0	0	1,452	7,000	1	0	4,211,700
1975	69,915	0	2,765	1	0	10,248	460	2	0	22,006,479
1976	12,015	2,050	3,100	83	0	12,142	0	1	0	16,043,439
1977	12,607	0	75	26	0	0	3,500	1	1,020	19,157,660
1978	25,295	0	116	0	180	65,816	8,100	1	0	23,651,927
1979	20,631	0	0	29	720	0	0	4	0	9,099,154
1980	6,993	1,160	1,999	30	0	4,250	8,740	0	0	8,610,694
1981	10,805	0	843	0	0	0	992	0	0	8,492,994
1982	5,686	0	1,176	85	0	32,887	12,021	2	0	12,104,140
1983	10,484	0	856	138	0	280	9,599	0	0	15,859,494
1984	2,091	-	441	52	-	18,788	10,000	-	-	10,603,756
1985	1,304	194	2,458	64	-	0	7,426	0	0	11,583,600
1986	3,965	1,524	922	120	759	48,395	600	2	0	22,252,572
1987	7,750	3,633	1,910	182	686	-	1,703	2	0	33,933,000
1988	4,235	9,492	2,347	387	793	0	5,896	0	0	40,763,288
TOTAL	229,187	18,053	23,085	1,355	3,138	209,258	79,037	16	1,020	270,866,027

SOURCE: AGNO FLOOD CONTROL SYSTEM OFFICE, Rosales

Table 5.1 SUMMARY OF WORK QUANTITIES OF MORIONES DAM AND LOWER O'DONNELL DAM COMBINE PLAN

Work Item	Unit	Moriones Dam	Lower O'Donnel Dam	Total	Remarks
I CIVIL WORKS					
1.1 River Diversion Works					
Tunnel excavation	m3	8,810	7,710	16,520	
Lining concrete	m3	3,160	3,000	6,160	
Plug concrete	m3	790	390	1,180	
Steel bar	ton	158	150	308	
Consolidation grout	m	1,510	1,510	3,020	
Cofferdam	m3	108,900	75,300	184,200	
1.2 Dam					
Excavation (common)	m3	40,000	22,000	62,000	
Excavation (rock)	m3	120,000	64,000	184,000	
Concrete	m3	277,000	92,000	369,000	
Curtain grout	m	15,450	10,000	25,450	
Consolidation grout	m	7,300	3,600	10,900	
Saddle dam	m3			650,000	
Excava. for saddle dam	m3			300,000	
1.3 Spillway					
Excavation (common)	m3	104,400	0	104,400	
Excavation (rock)	m3	44,700	0	44,700	
Concrete	m3	30,420	0	30,420	
Steel bar	ton	456	0	456	
1.4 Connection Channel					
Excavation	m3			2,080,000	
II METAL WORKS					
Diversion closure gate	ton	41	20	61	
Spillway gate	ton	188	0	188	
Outlet gate	ton	0	7	7	

Table 5.2 SUMMARY OF WORK QUANTITIES OF THE FIXED WEIR ON AGNO RIVER

Work Item	Unit	Quantity	Remarks
1. Excavation	cu.m	13,700	
2. Concrete (210 kg/sq.cm)	cu.m	21,150	
3. Concrete (140 kg/sq.cm)	cu.m	1,550	
4. Backfilling Gravel	cu.m	1,050	
5. Gabion Mattress (0.5mx1.2mx3.0m)	sq.m	4,800	
6. Re-Bar	kg	49,800	
7. Steel Sheet Pile (L=5.0 m)	sq.m	3,650	
8. RC Pile (4.0mx4.0m,L=8.0m)	m	7,000	
9. Wooden Pile (0.2m diam,L=5.0m)	m	9,400	
10. Revetment Works	sq.m	3,300	

Table 5.3 SUMMARY OF WORK QUANTITIES OF THE CLOSING DIKE IN BUED RIVER

Work Item	Unit	Quantity	Remarks
1. Embankment 1	cu.m	32,000	
2. Revetment Works			
a. Excavation	cu.m	8,500	
b. Stone Masonry	cu.m	1,600	
c. Backfilling Gravel	cu.m	1,300	
d. Concrete (140 kg/sq.m)	cu.m	1,100	
e. Gabion Mattress (0.5mx1.2mx3.0m)	sq.m	12,000	
3. Steel Sheet Pile (L=5.0 m)	sq.m	10,000	
9. Sodding	sq.m	13,400	

Table 5.4 (1/2) SUMMARY OF MAJOR DIMENSION OF PROPOSED SABO DAM

Dam No.	Name of River	Height (m)	Width (m)	River Bed Gradient	Total Dam Volume (m3)	Remarks
D-1	Ambayaoan	20	100	1/ 35	1,190,000	Upper Ambayaoan Dam Site
D-2	-ditto-	20	100	1/ 35	1,191,000	
D-3	-ditto-	20	200	1/ 65	4,810,000	Upper Sapinit Dam Site
D-4	-ditto-	20	100	1/ 70	2,380,000	
D-5	-ditto-	20	300	1/100	11,400,000	
D-6	-ditto-	20	150	1/ 30	1,620,000	
Sub-Total	(Ambayaoan)				22,590,000	
D-7	Dipalo	20	100	1/ 20	680,000	
D-8	Viray	20	100	1/ 5	170,000	
D-9	-ditto-	20	100	1/ 12	425,000	
D-10	-ditto-	20	100	1/ 20	680,000	
D-11	-ditto-	10	100	1/ 15	205,000	
Sub-Total	(Viray)				1,480,000	
D-12	Camiling	20	180	1/ 75	4,950,000	Camiling Dam Site
D-13	-ditto-	15	140	1/ 25	935,000	
D-14	-ditto-	10	140	1/ 75	1,875,000	
Sub-Total	(Camiling)				7,760,000	
D-15	Olo	25	150	1/ 60	4,050,000	Pila Dam Site
D-16	-ditto-	20	100	1/ 35	1,190,000	
D-17	-ditto-	20	100	1/ 35	1,190,000	
D-18	-ditto-	20	100	1/ 35	1,190,000	
Sub-Total	(Olo)				7,620,000	

Table 5.4 (2/2) SUMMARY OF MAJOR DIMENSION OF PROPOSED SABO DAM

Dam No.	Name of River	Height (m)	Width (m)	River Bed Gradient	Total Dam Volume (m3)	Remarks
D-19	Bayaoas	20	180	1/ 75	4,950,000	Bayaoas Dam Site
D-20	Tuboy	20	150	1/ 65	3,510,000	Kalipkip Dam Site
D-21	-ditto-	15	100	1/ 40	1,020,000	
D-22	-ditto-	15	140	1/ 25	935,000	
Sub-Total	(Tuboy)				5,465,000	
D-23	Angalacan	15	80	1/ 25	485,000	
D-24	-ditto-	15	100	1/ 15	380,000	
Sub-Total	(Angalacan)				865,000	
D-25	Bued	20	100	1/ 45	1,530,000	
D-26	-ditto-	20	100	1/ 45	1,530,000	
D-27	-ditto-	20	100	1/ 45	1,530,000	
D-28	-ditto-	20	100	1/ 15	510,000	
D-29	-ditto-	20	100	1/ 25	850,000	
D-30	-ditto-	20	100	1/ 15	510,000	
D-31	-ditto-	20	100	1/ 10	340,000	
D-32	-ditto-	20	100	1/ 10	340,000	
Sub-Total	(Bued)				7,140,000	

FIGURES

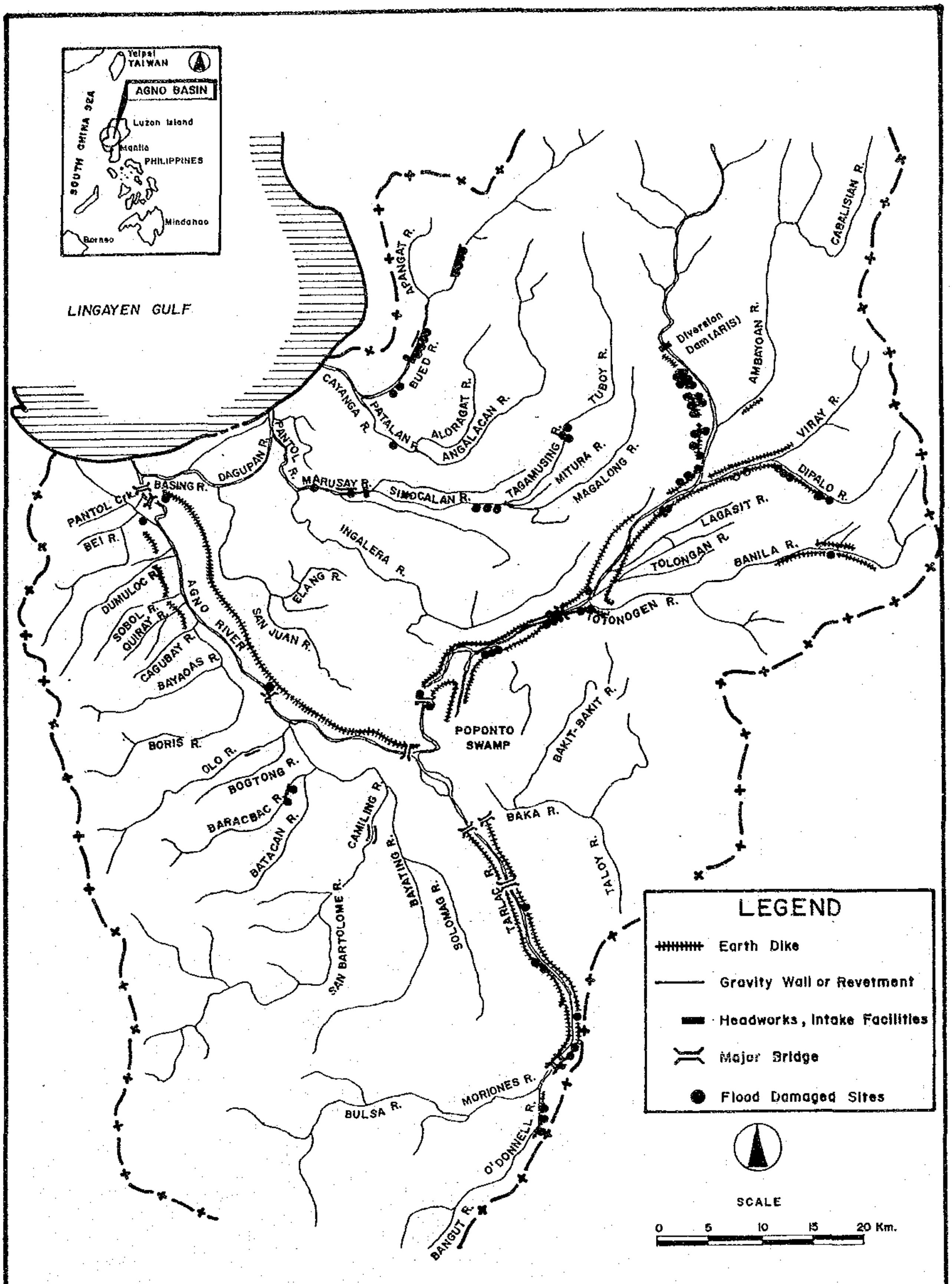


Fig. 2.1 LOCATION OF BREACHES/GAPS AND SCOURS CAUSED BY FLOODS (1984-1988)

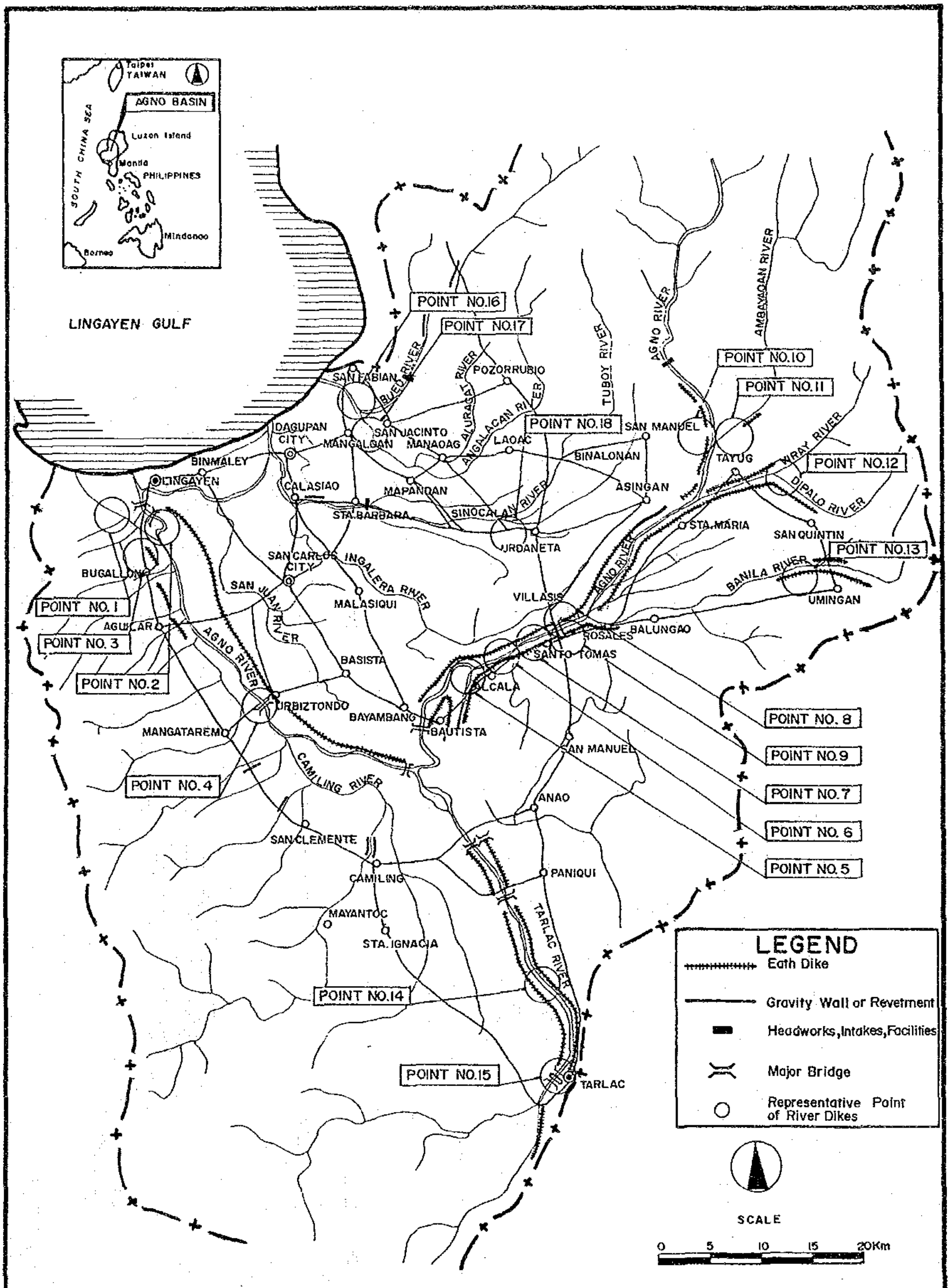


Fig. 2.2 LOCATION MAP OF REPRESENTATIVE POINTS FOR RIVER DIKES

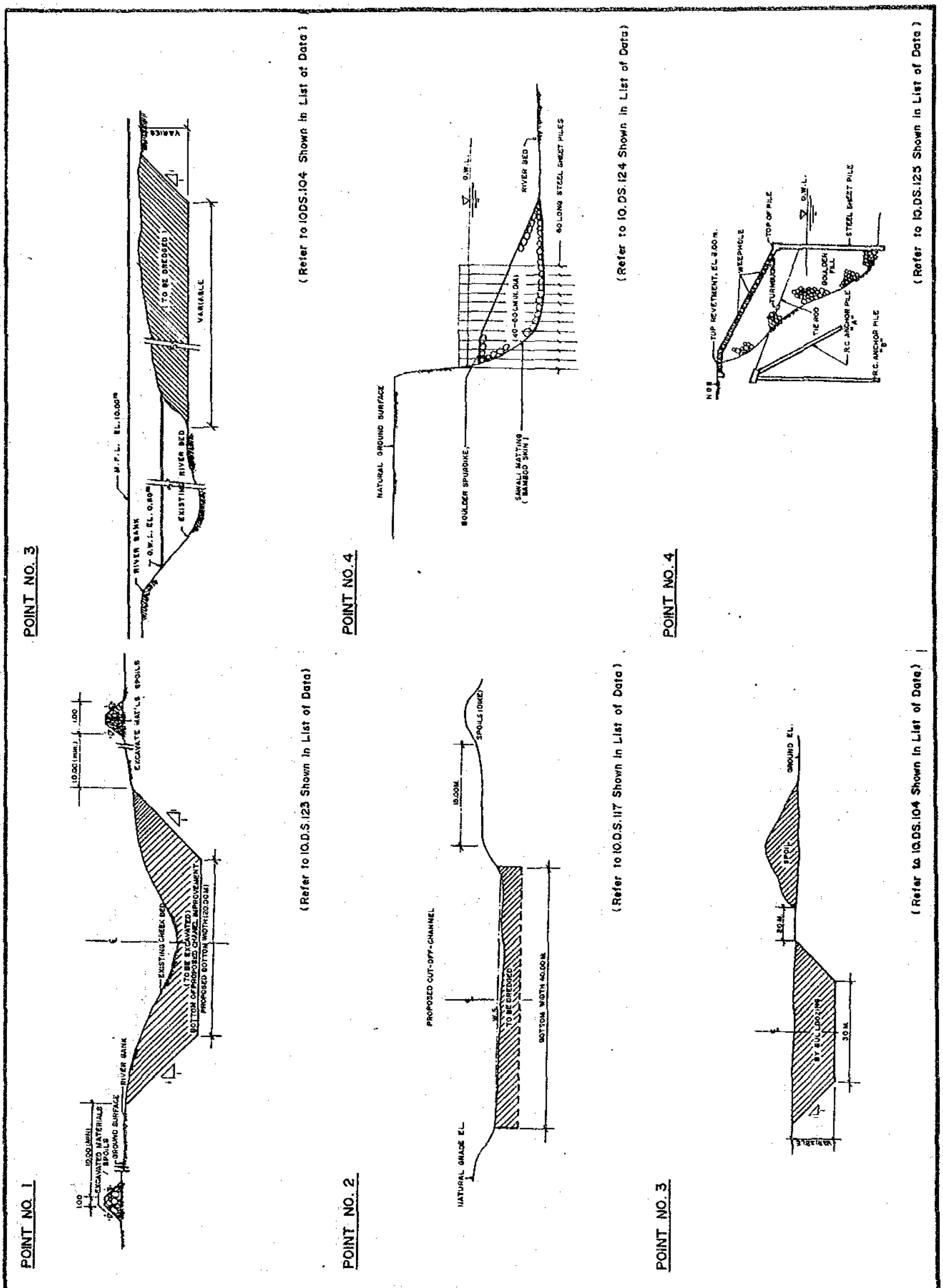


Fig.2.3 (1/4) TYPICAL CROSS SECTIONS OF EXISTING DIKE

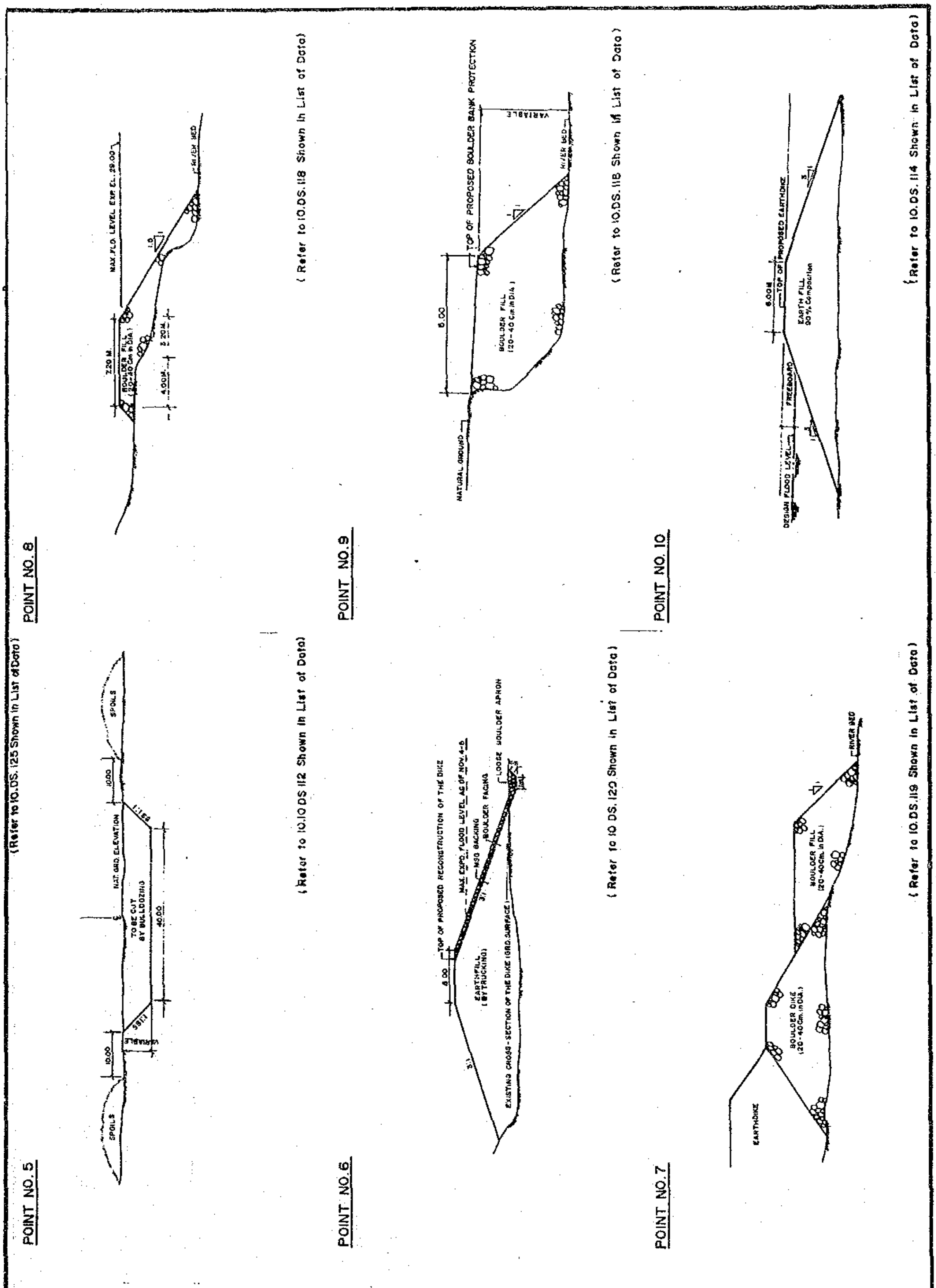


Fig. 2.3 (2/4) TYPICAL CROSS SECTIONS OF EXISTING DIKE

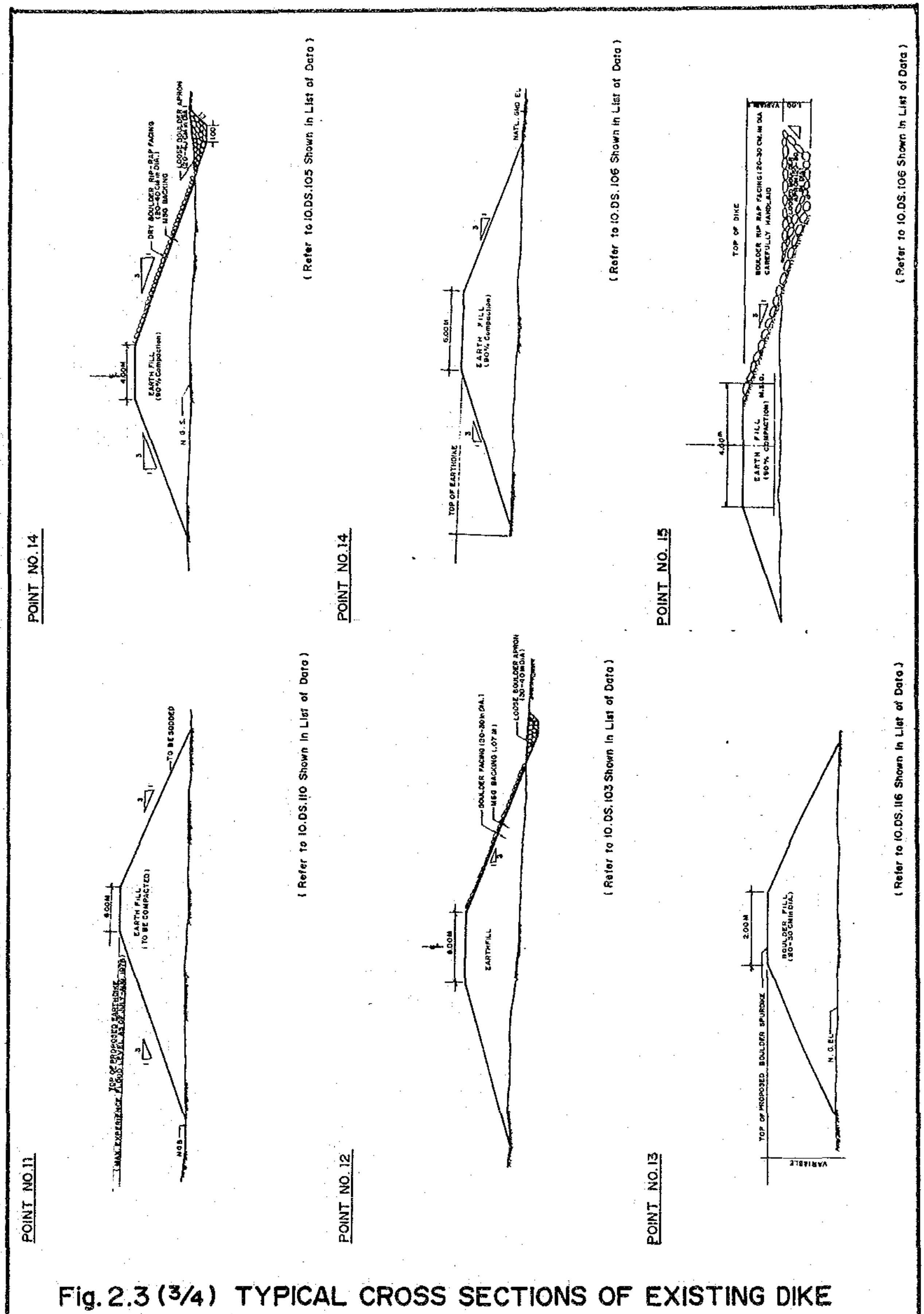


Fig. 2.3 (3/4) TYPICAL CROSS SECTIONS OF EXISTING DIKE

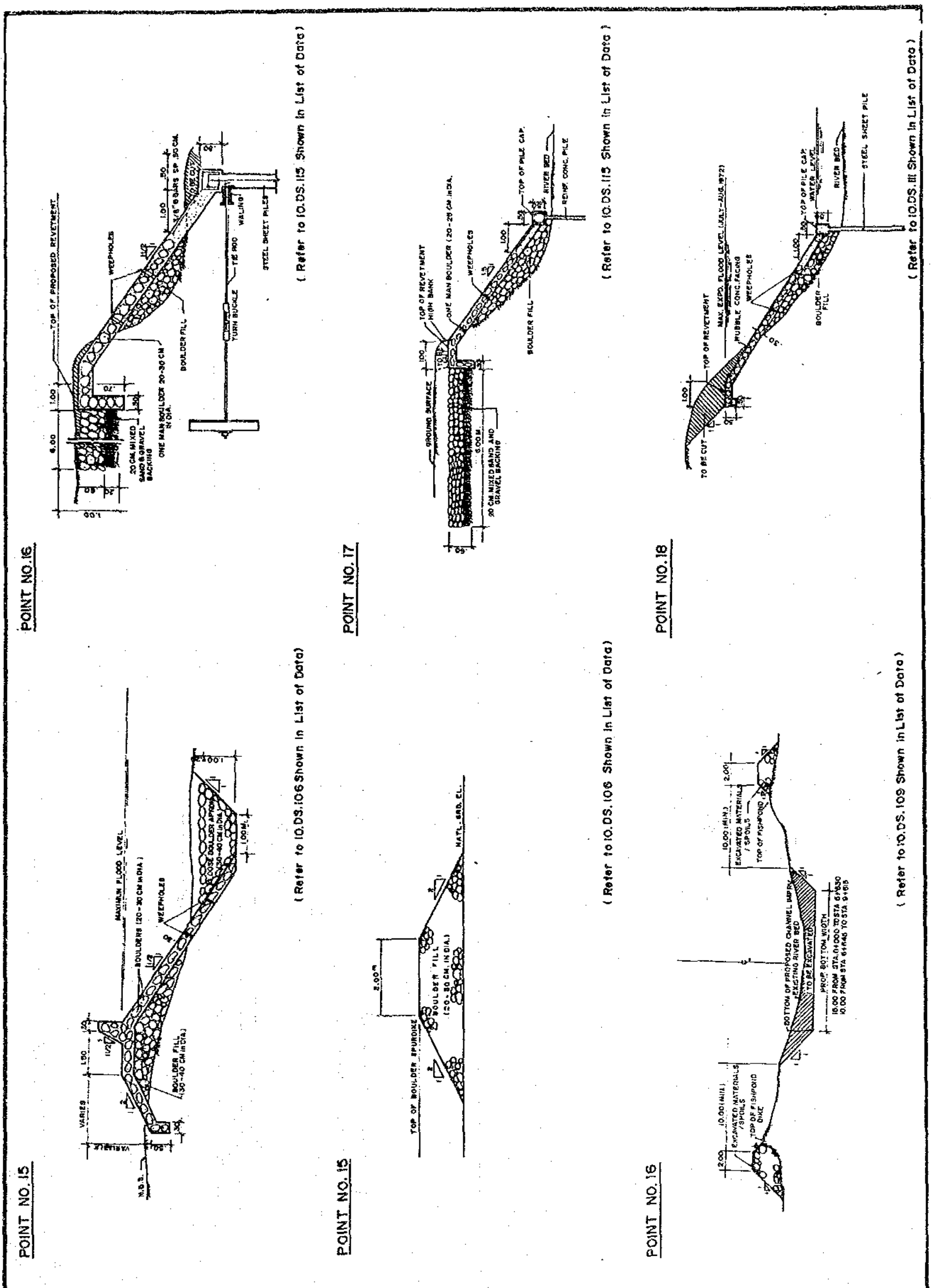


Fig. 2.3 (4/4) TYPICAL CROSS SECTIONS OF EXISTING DIKE

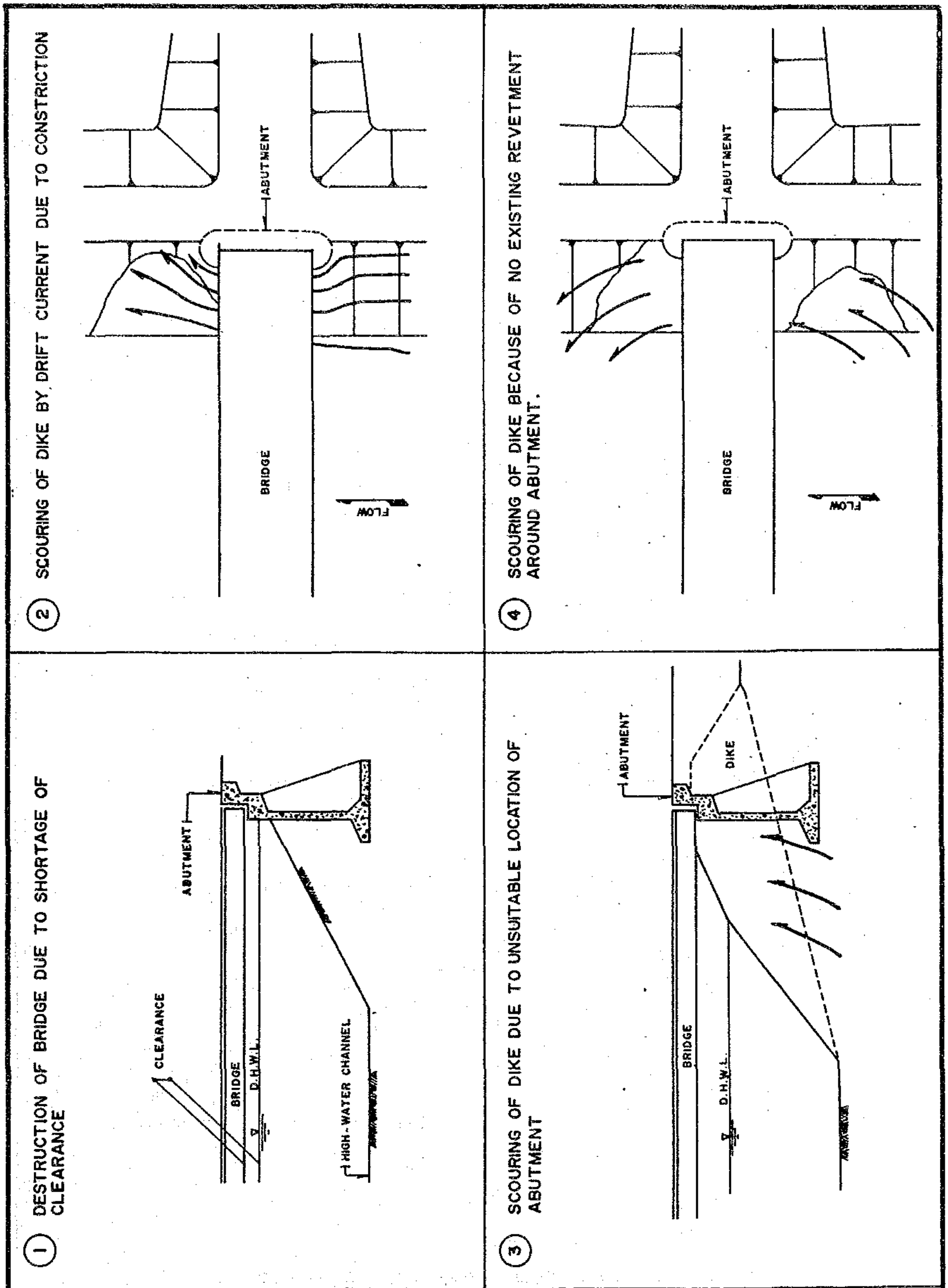


Fig. 2.4 ILLUSTRATION OF CAUSES OF BRIDGE DESTRUCTION

DESIGN DISCHARGE Q(m^3/s)	FREEBOARD FB(m) NOT LESS THAN	CROWN WIDTH CW(m) NOT LESS THAN
< 200	0.60	3.00
200 ∿ 500	0.80	3.00
500 ∿ 2,000	1.00	4.00
2,000 ∿ 5,000	1.20	5.00
5,000 ∿ 10,000	1.50	6.00
10,000 <	2.00	7.00

DIKE HEIGHT : H ≦ 3.00^m

DIKE HEIGHT : 3.00^m < H ≦ 5.00^m

DIKE HEIGHT : 5.00^m < H ≦ 9.00^m

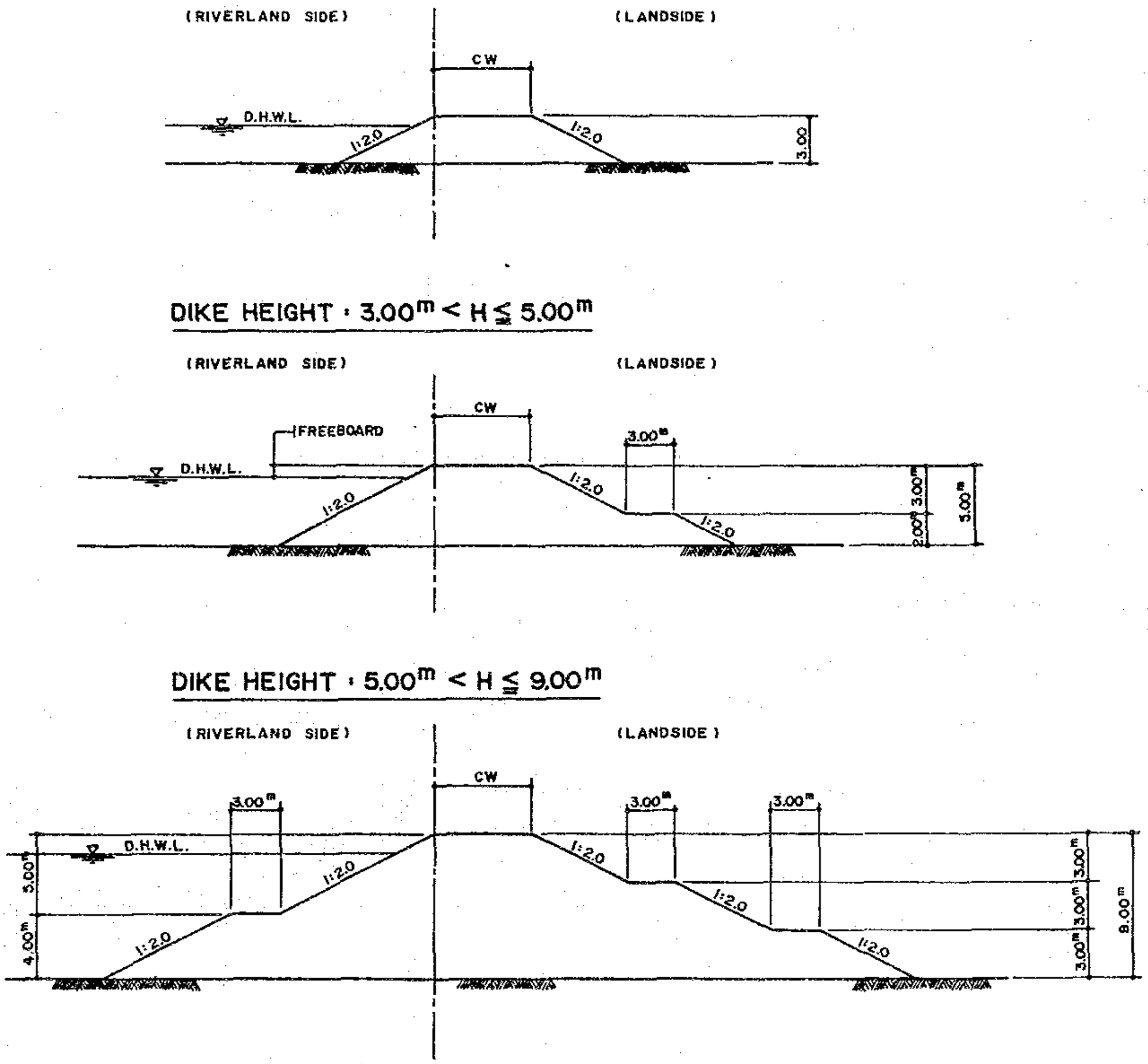
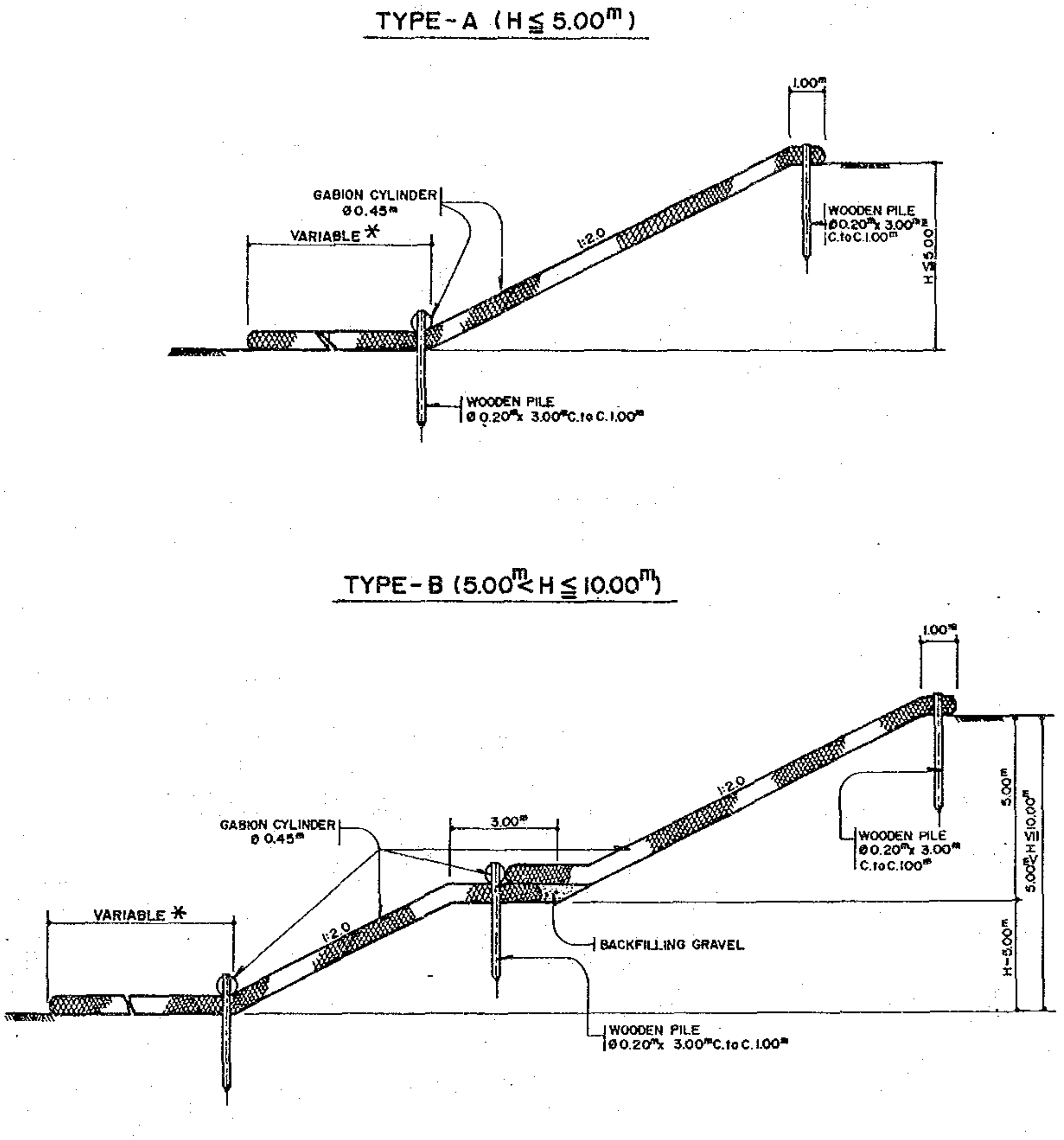


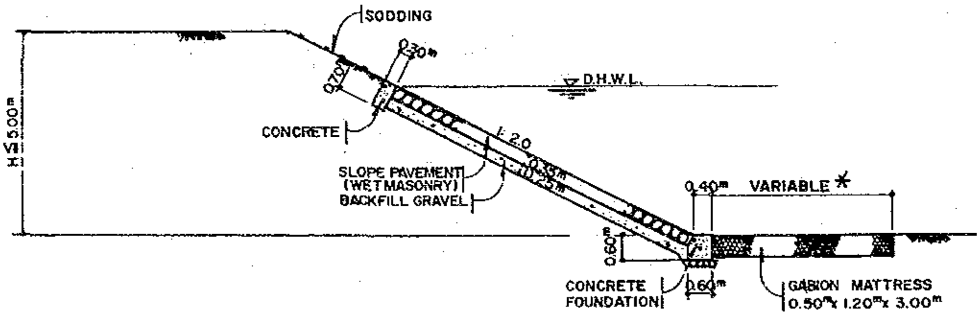
Fig. 4.1 STANDARD DESIGN SECTION OF RIVER DIKE



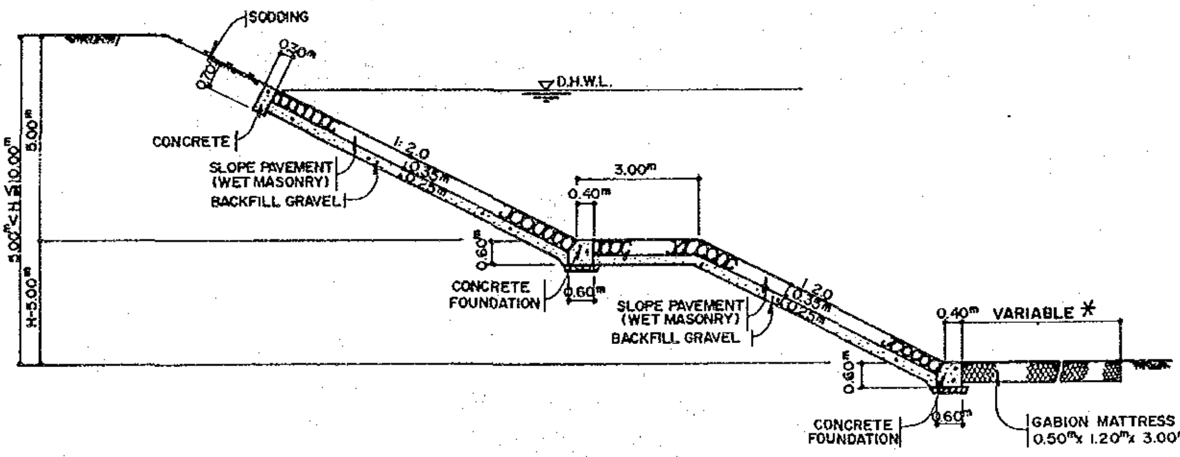
Note : * The length of foot protection shall be changed based on the river bed condition and the river width.

Fig. 4.2 STANDARD DESIGN SECTION OF LOW-WATER CHANNEL

TYPE-A (H ≦ 5.00m)



TYPE-B (5.00m < H ≦ 10.00m)



Note : * The length of foot protection shall be changed based on the river bed condition and the river width.

Fig. 4.3 STANDARD DESIGN SECTION OF HIGH-WATER CHANNEL

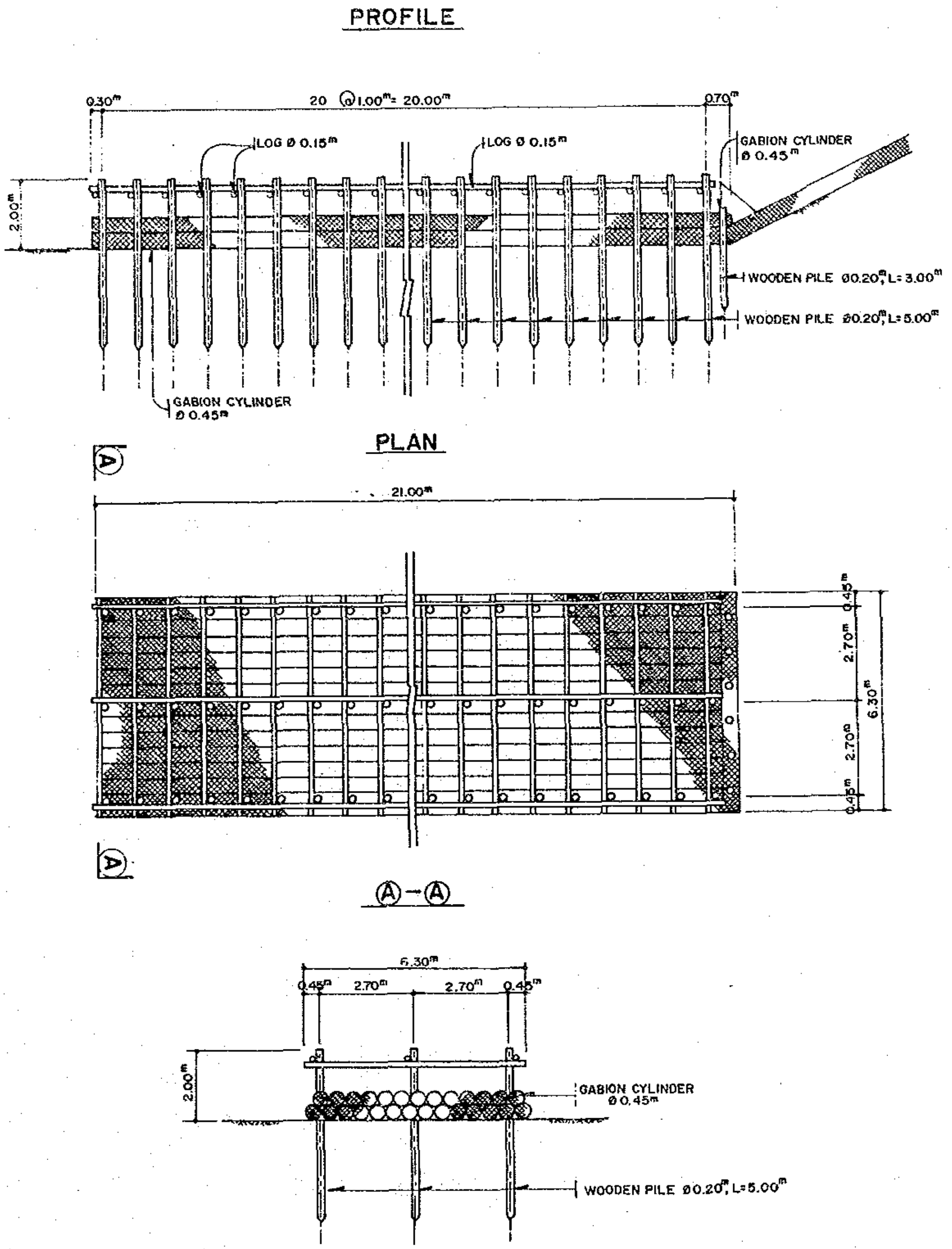


Fig. 4.4 STANDARD DESIGN OF GROIN FOR LOW-WATER CHANNEL (TYPE-A)

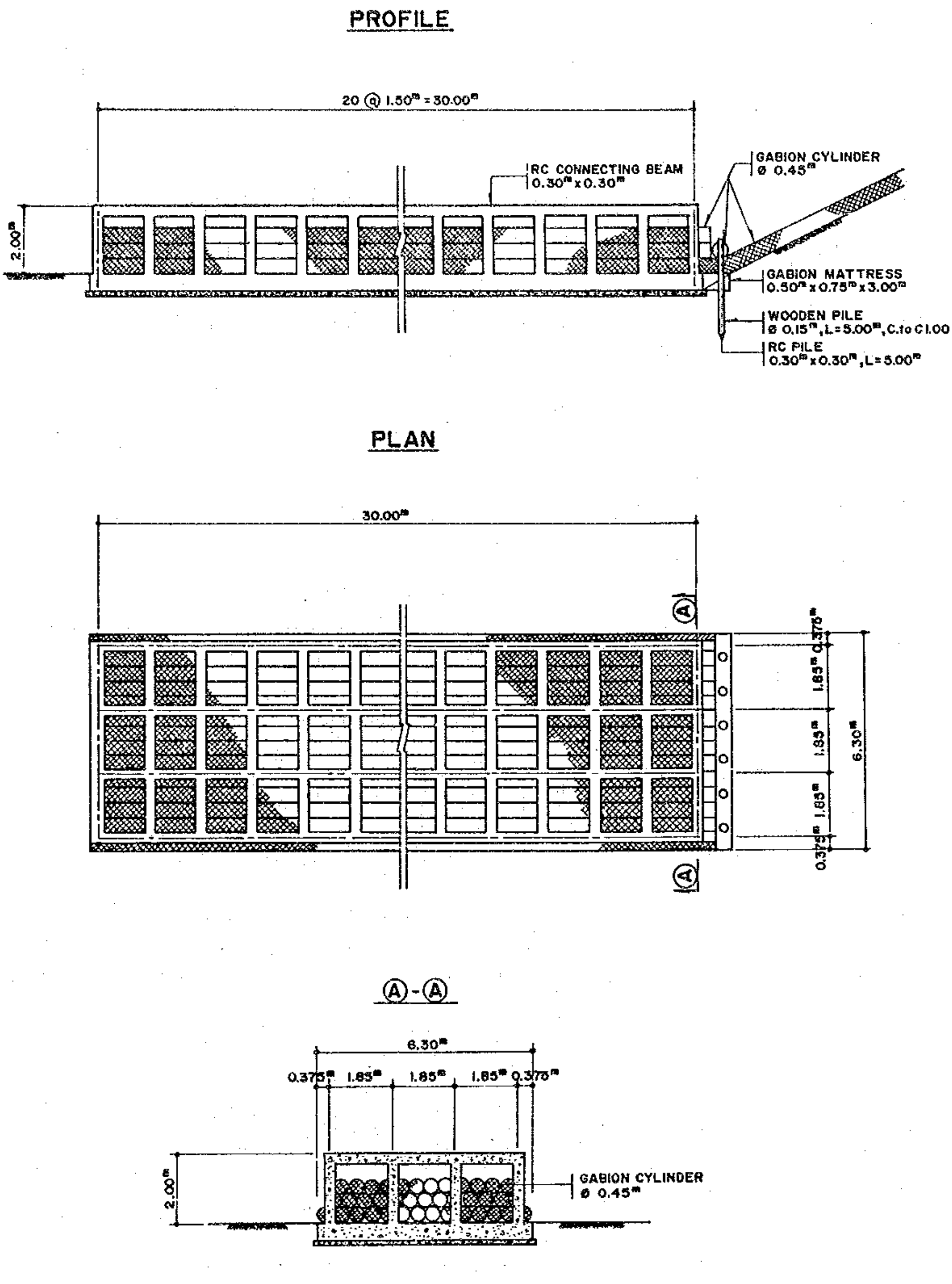


Fig. 4.5 STANDARD DESIGN OF GROIN FOR LOW-WATER CHANNEL (TYPE-B)

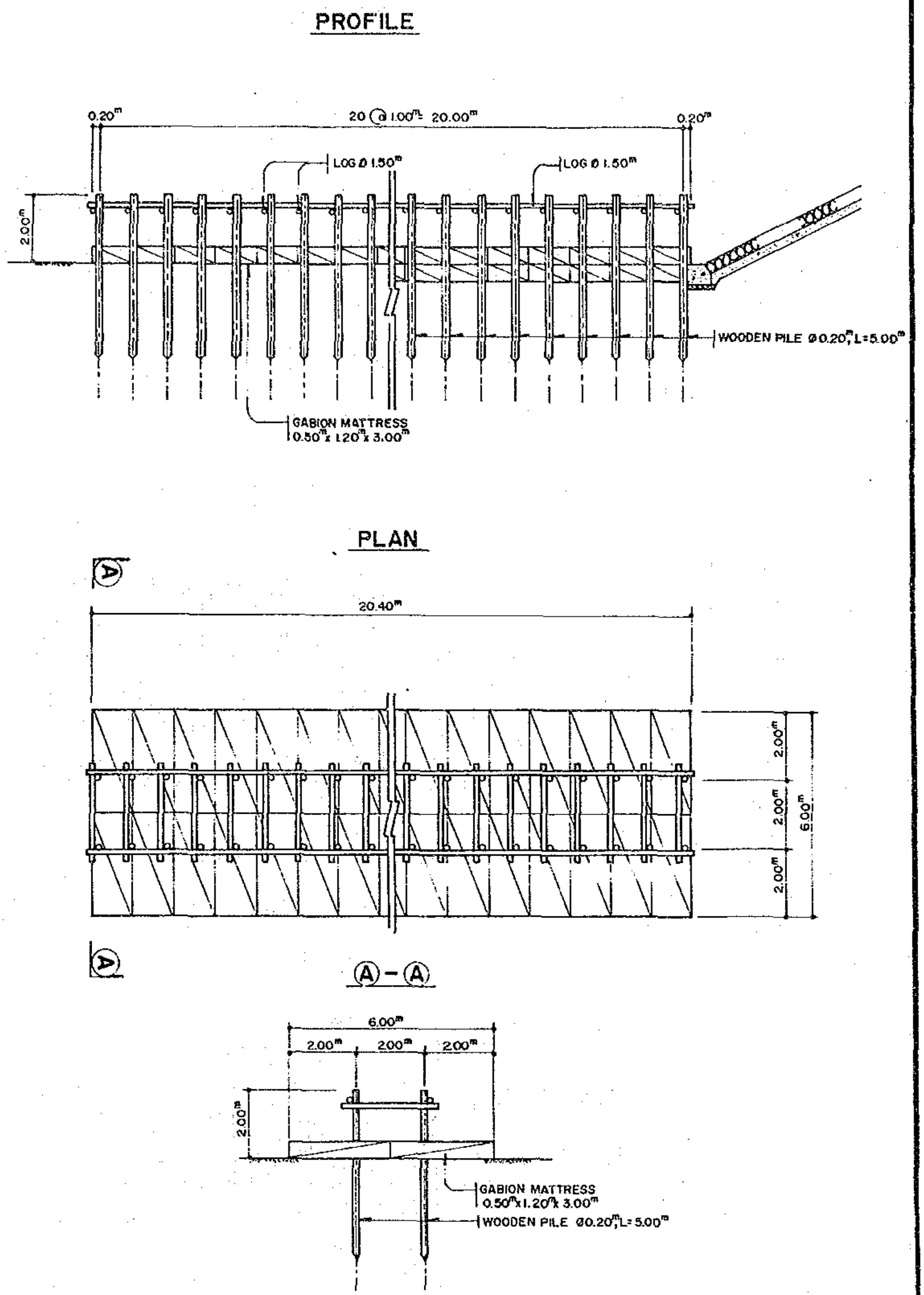


Fig. 4.6 STANDARD DESIGN OF GROIN FOR HIGH-WATER CHANNEL (TYPE-A)

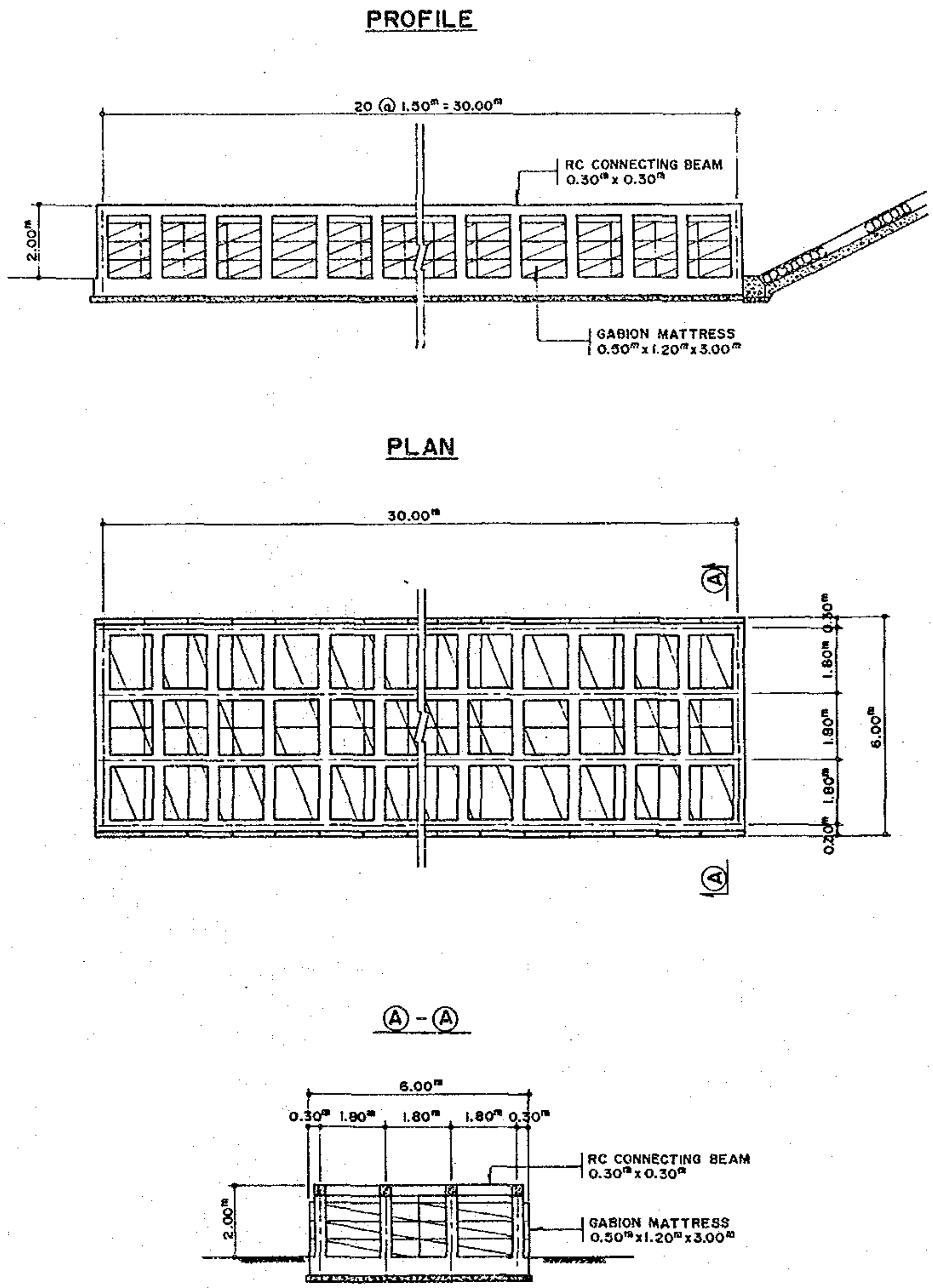


Fig. 4.7 STANDARD DESIGN OF GROIN FOR HIGH-WATER CHANNEL (TYPE-B)

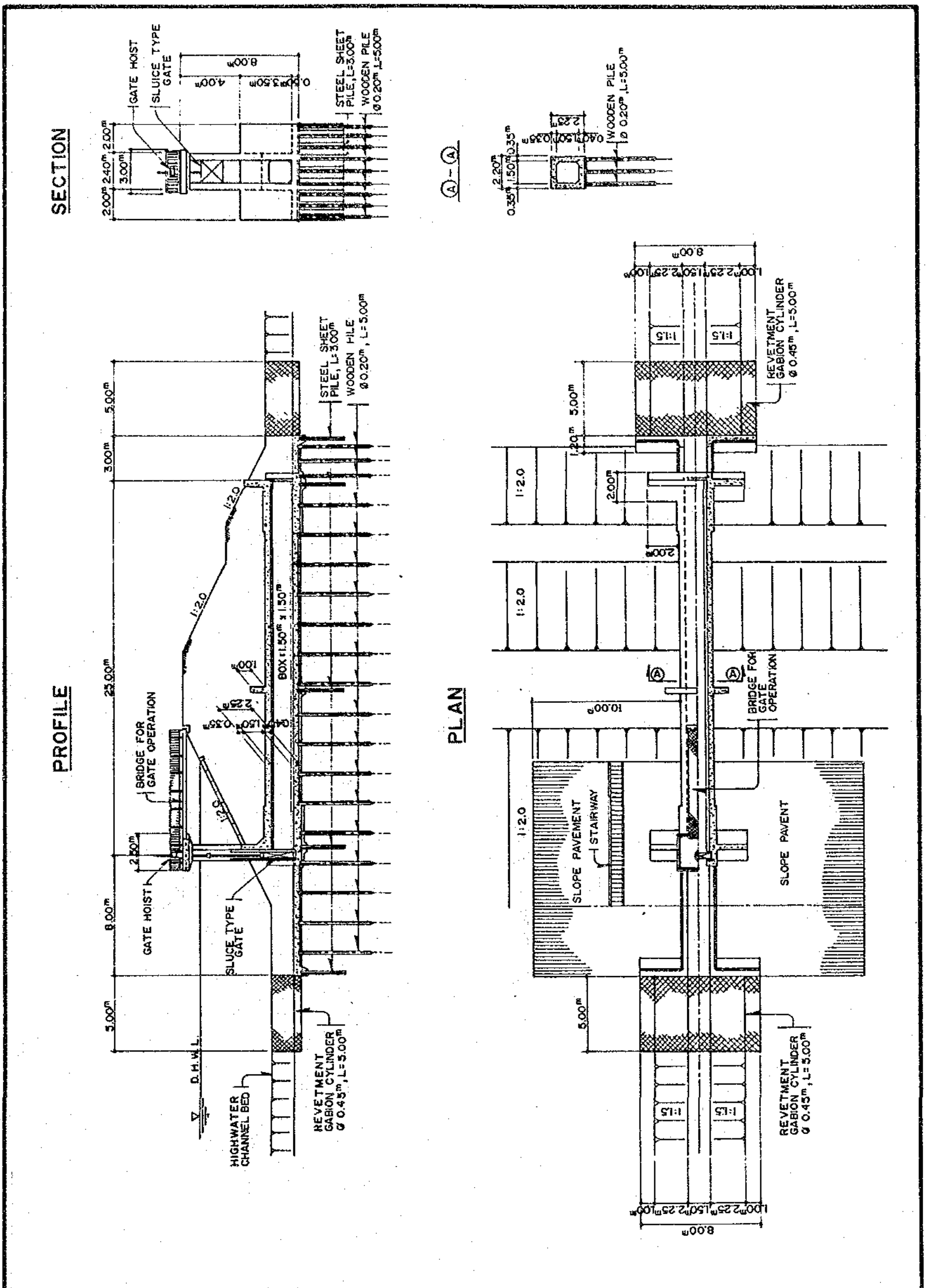


Fig. 4.8 STANDARD DESIGN OF SLUICE WAY (TYPE-A)

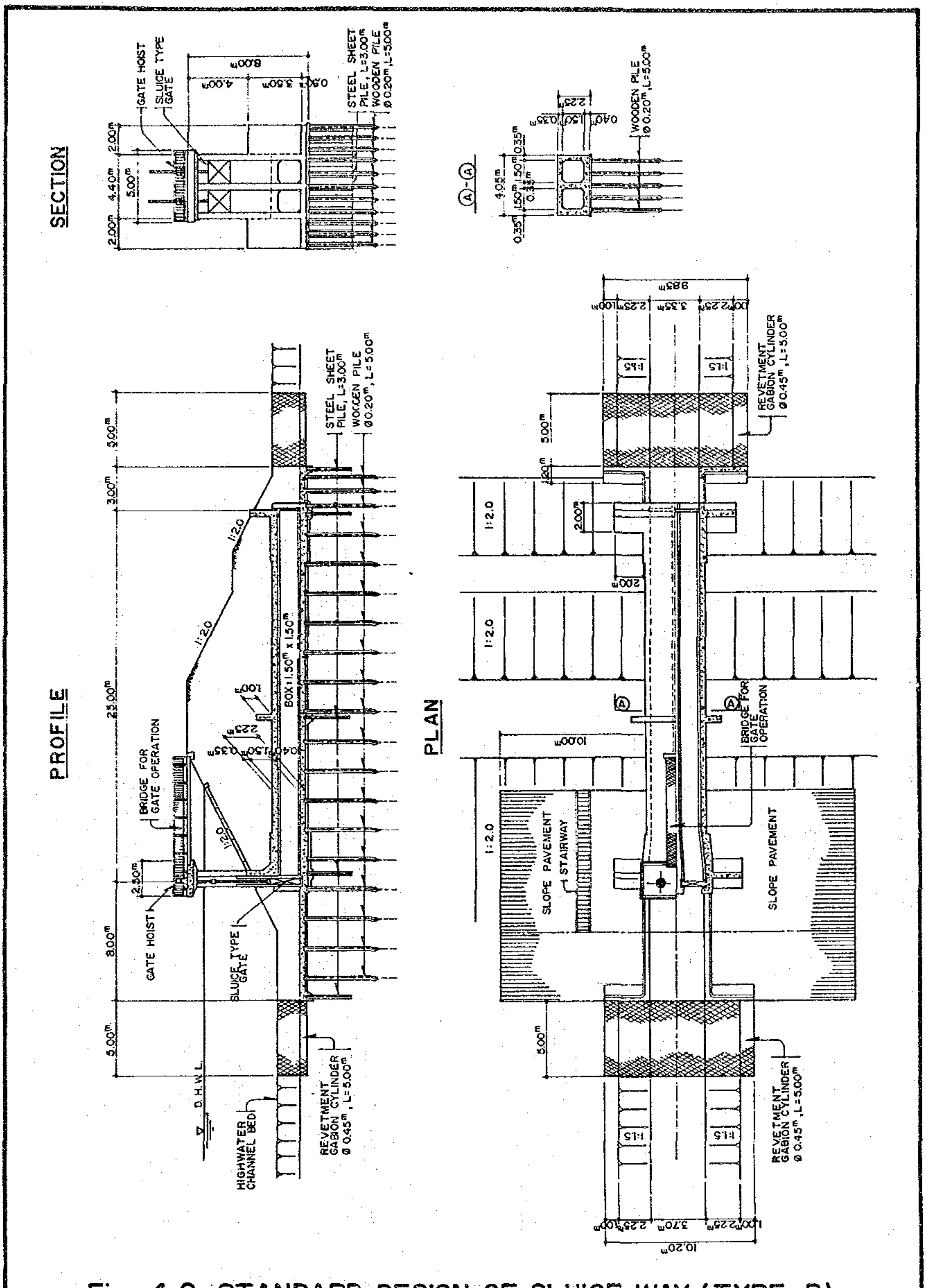


Fig. 4.9 STANDARD DESIGN OF SLUICE WAY (TYPE-B)

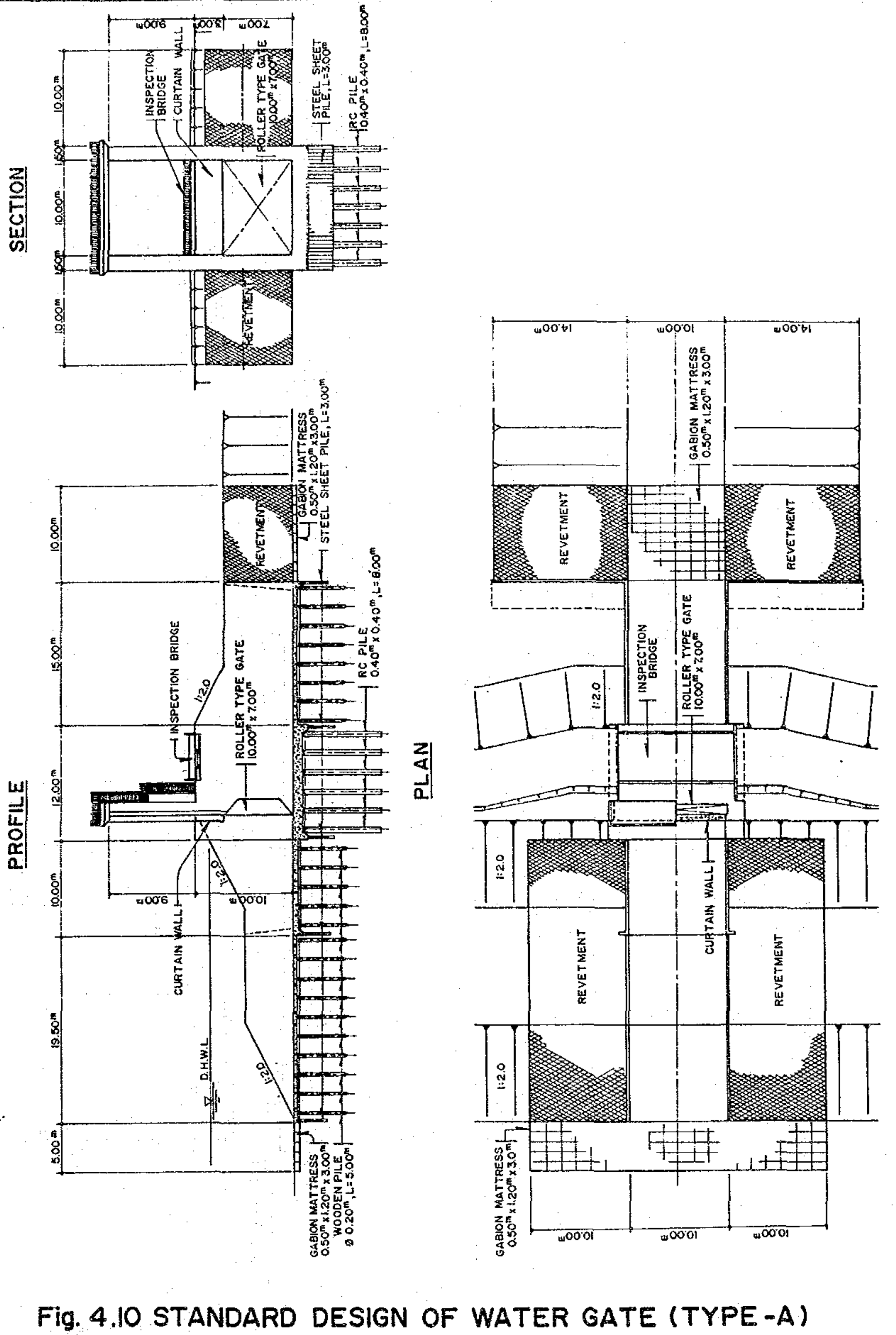


Fig. 4.10 STANDARD DESIGN OF WATER GATE (TYPE-A)

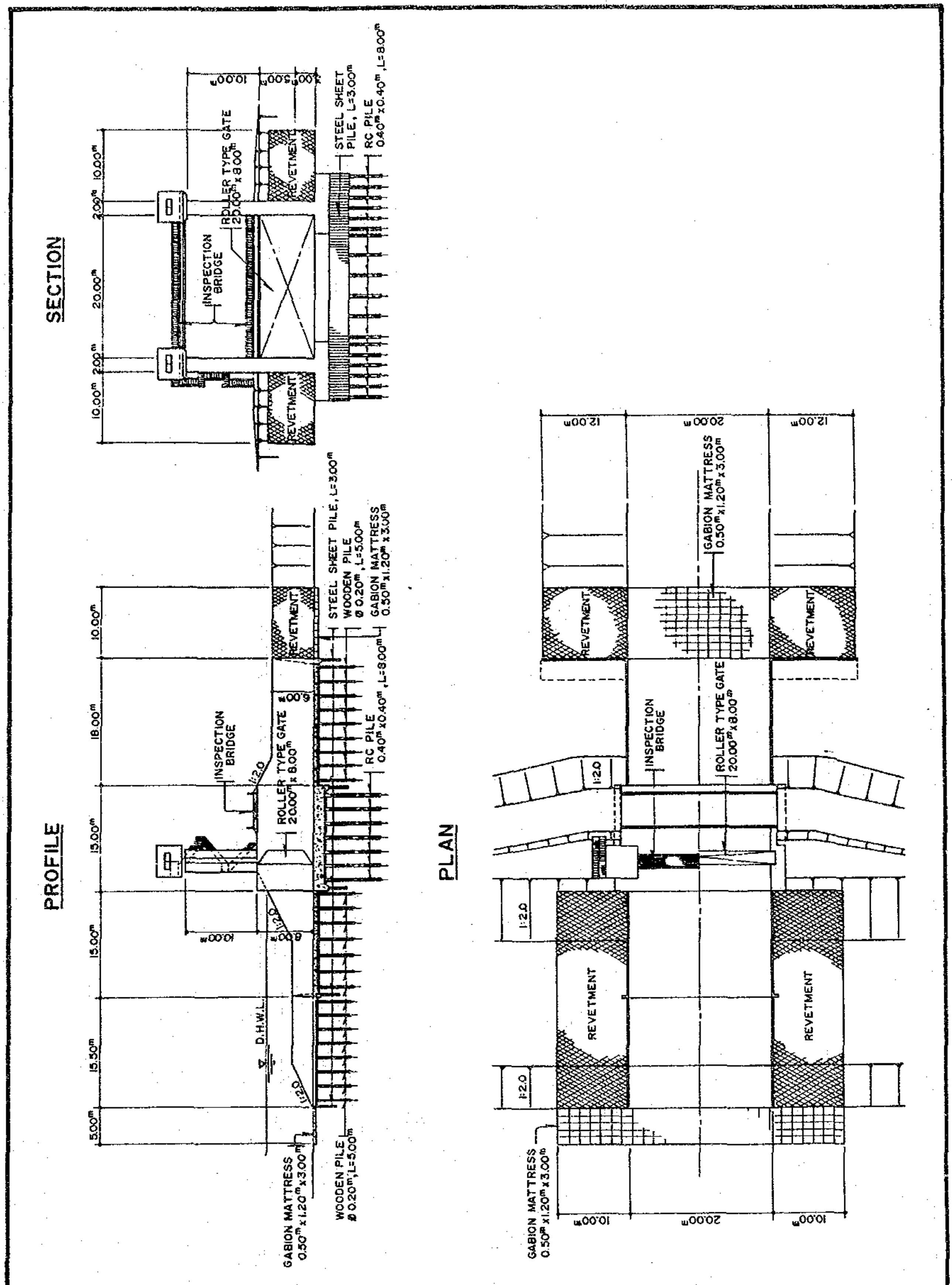


Fig. 4.11 STANDARD DESIGN OF WATER GATE (TYPE-B)

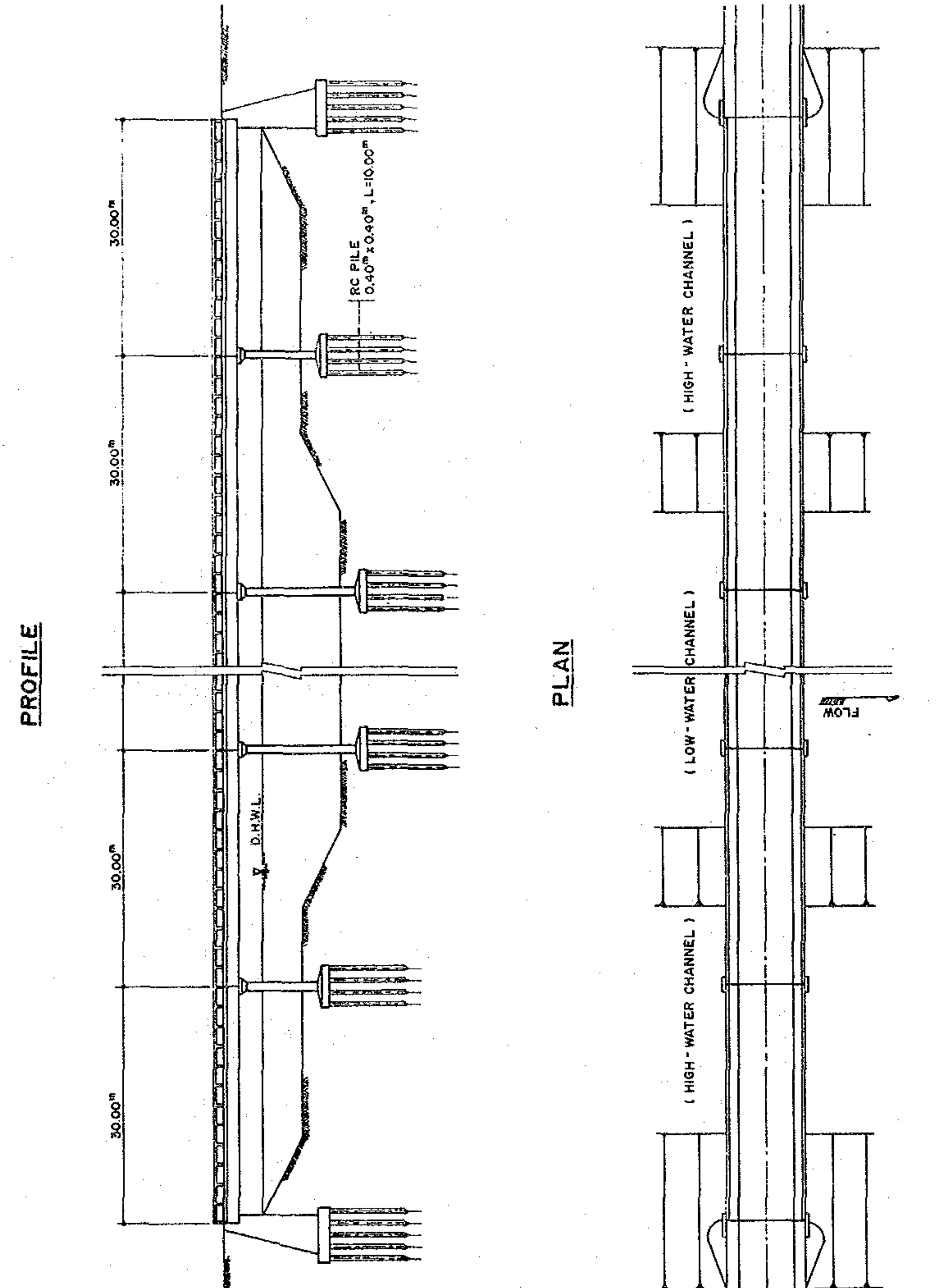
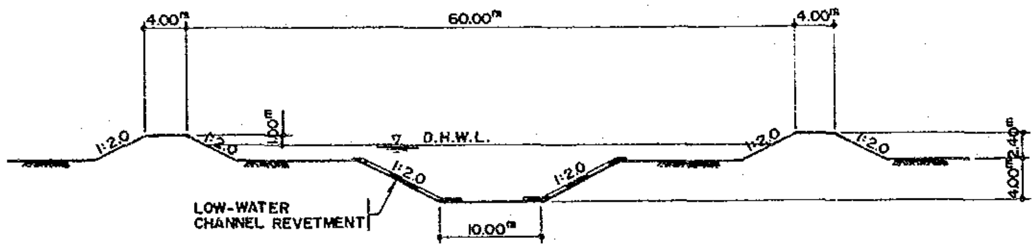


Fig. 4.12 STANDARD DESIGN OF BRIDGE

STANDARD SECTION FOR THE UPSTREAM PORTION (L=3.60Km)



STANDARD SECTION FOR THE DOWNSTREAM PORTION (L=3.20Km)

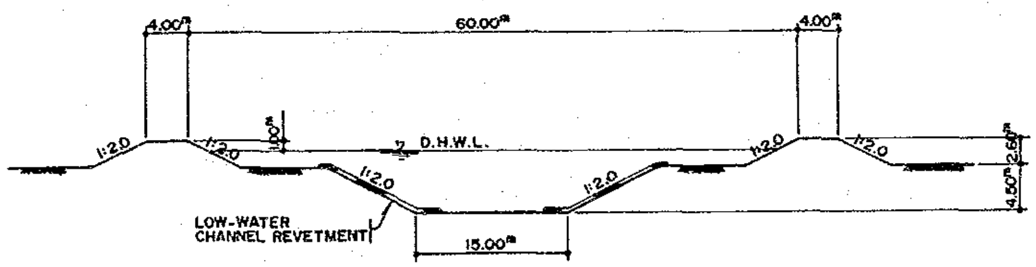


Fig. 4.13 STANDARD SECTIONS OF BINALONAN FLOODWAY

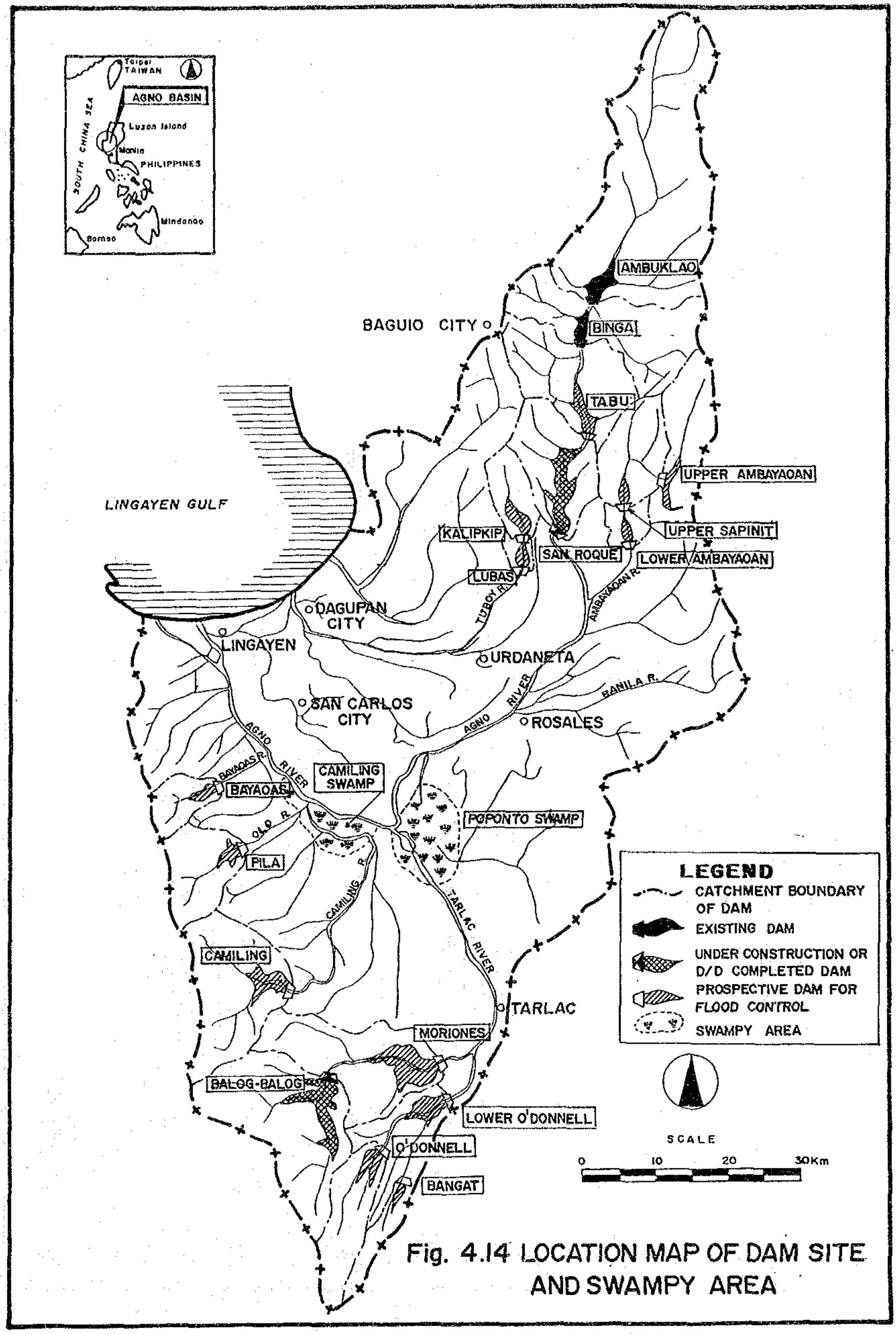


Fig. 4.14 LOCATION MAP OF DAM SITE AND SWAMPY AREA

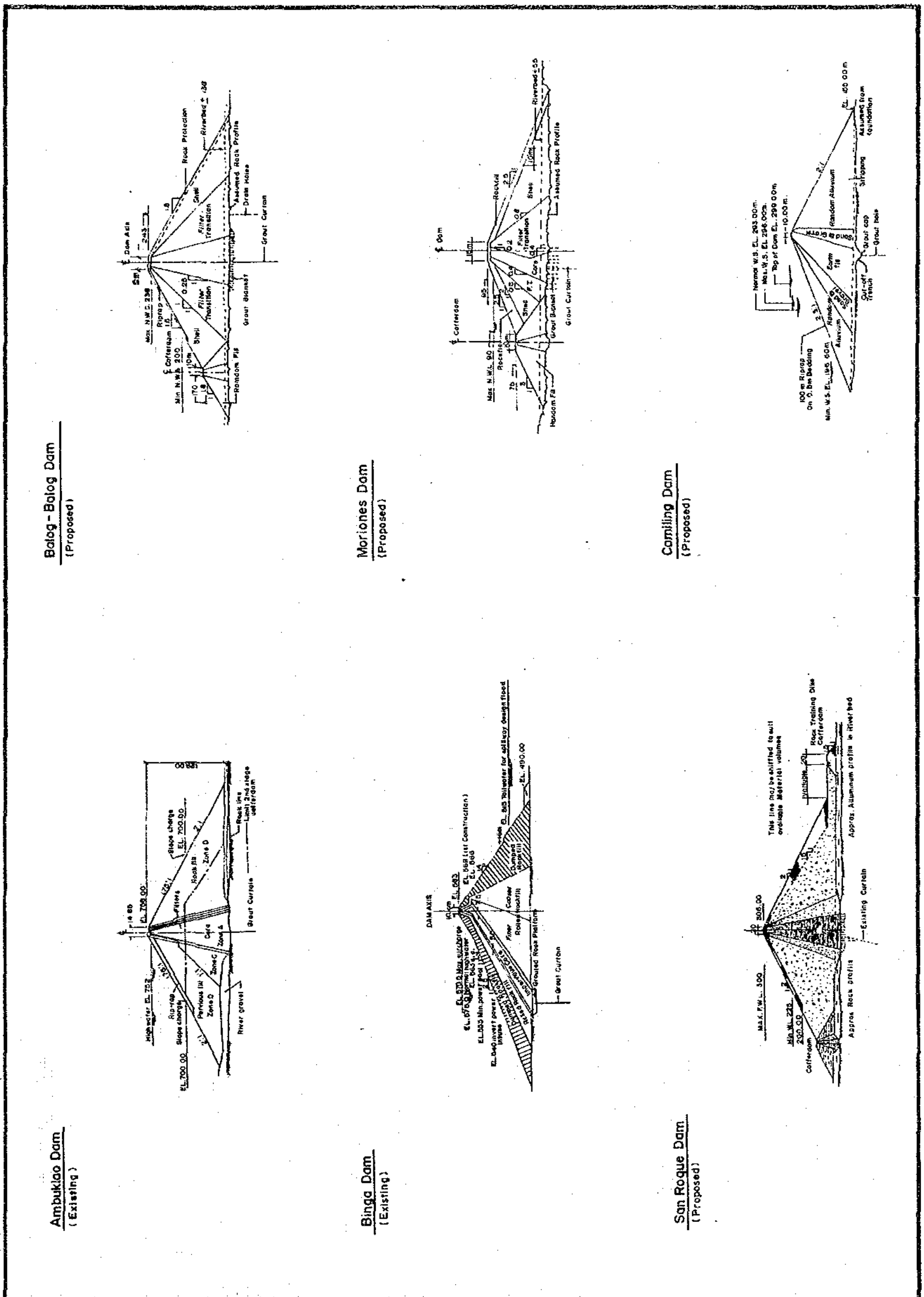


Fig. 4.15 (1/2) TYPICAL SECTIONS OF EXISTING AND PROPOSED DAM

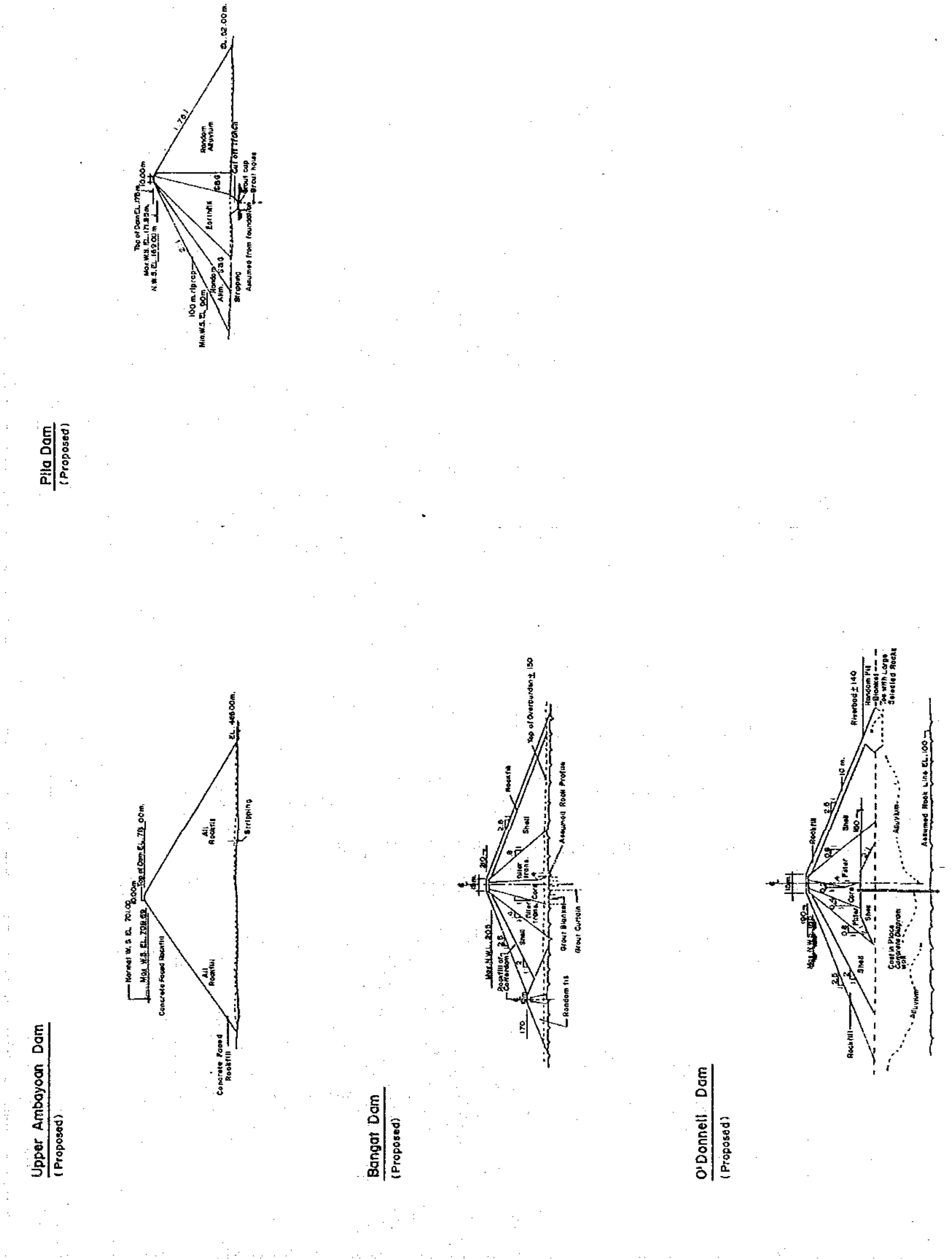


Fig. 4.15 (2/2) TYPICAL SECTIONS OF EXISTING AND PROPOSED DAM

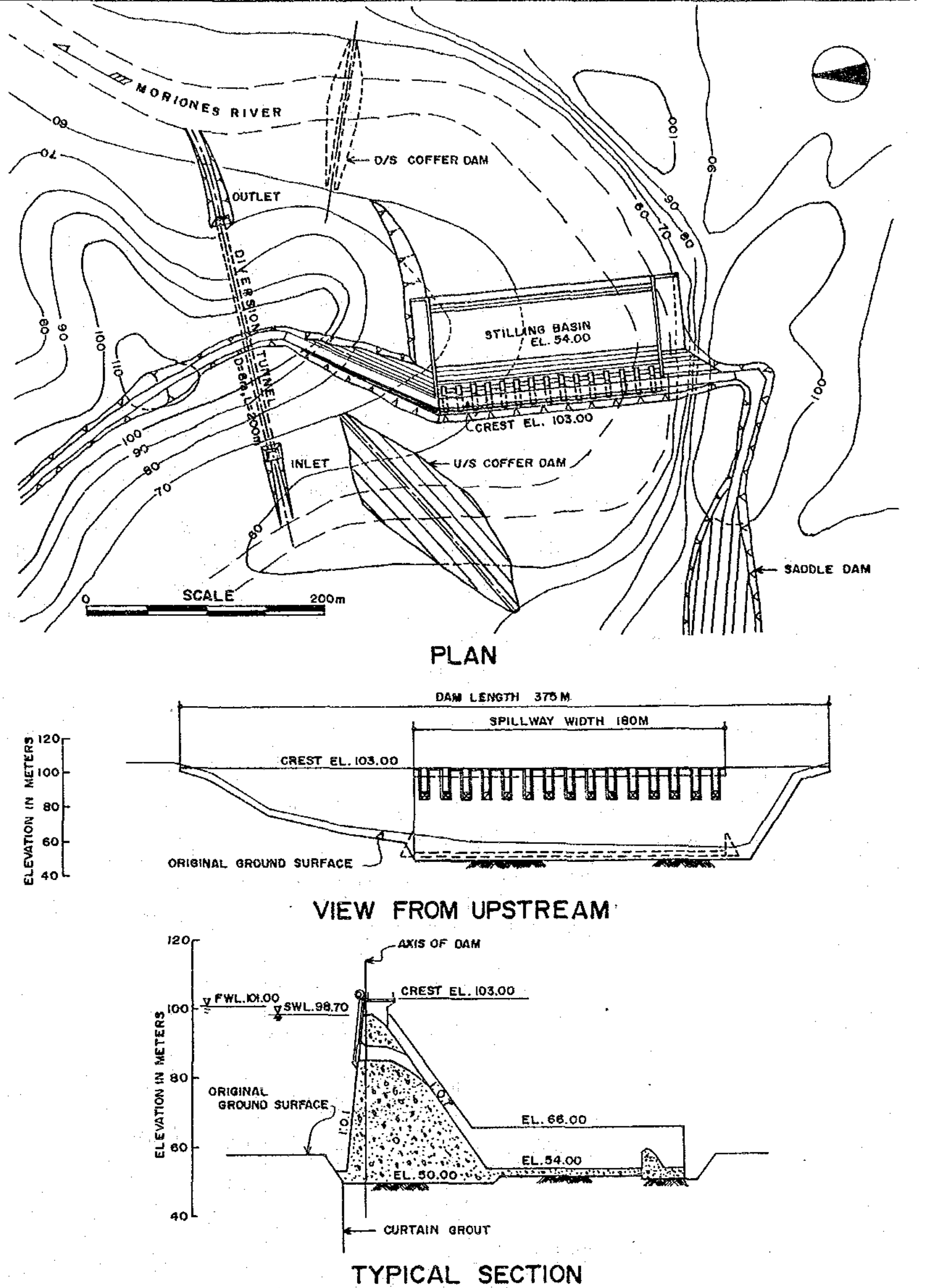


Fig. 4.16 LAYOUT PLAN OF MORIONES AND LOWER O'DONNELL COMBINE DAM PLAN (MORIONES SITE)

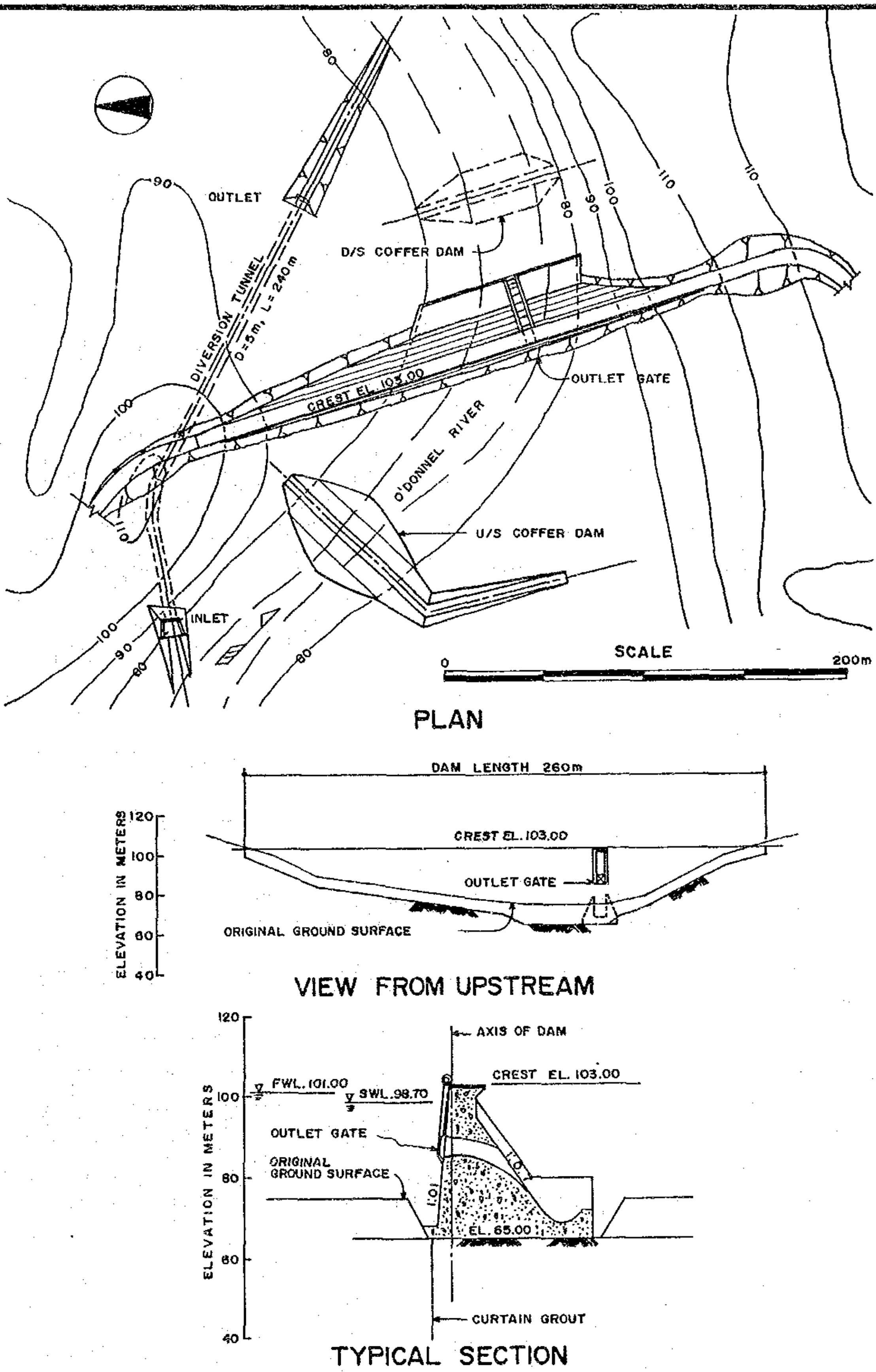


Fig. 4.17 LAYOUT PLAN OF MORIONES AND LOWER O'DONNELL COMBINE DAM PLAN (LOWER O'DONNELL SITE)

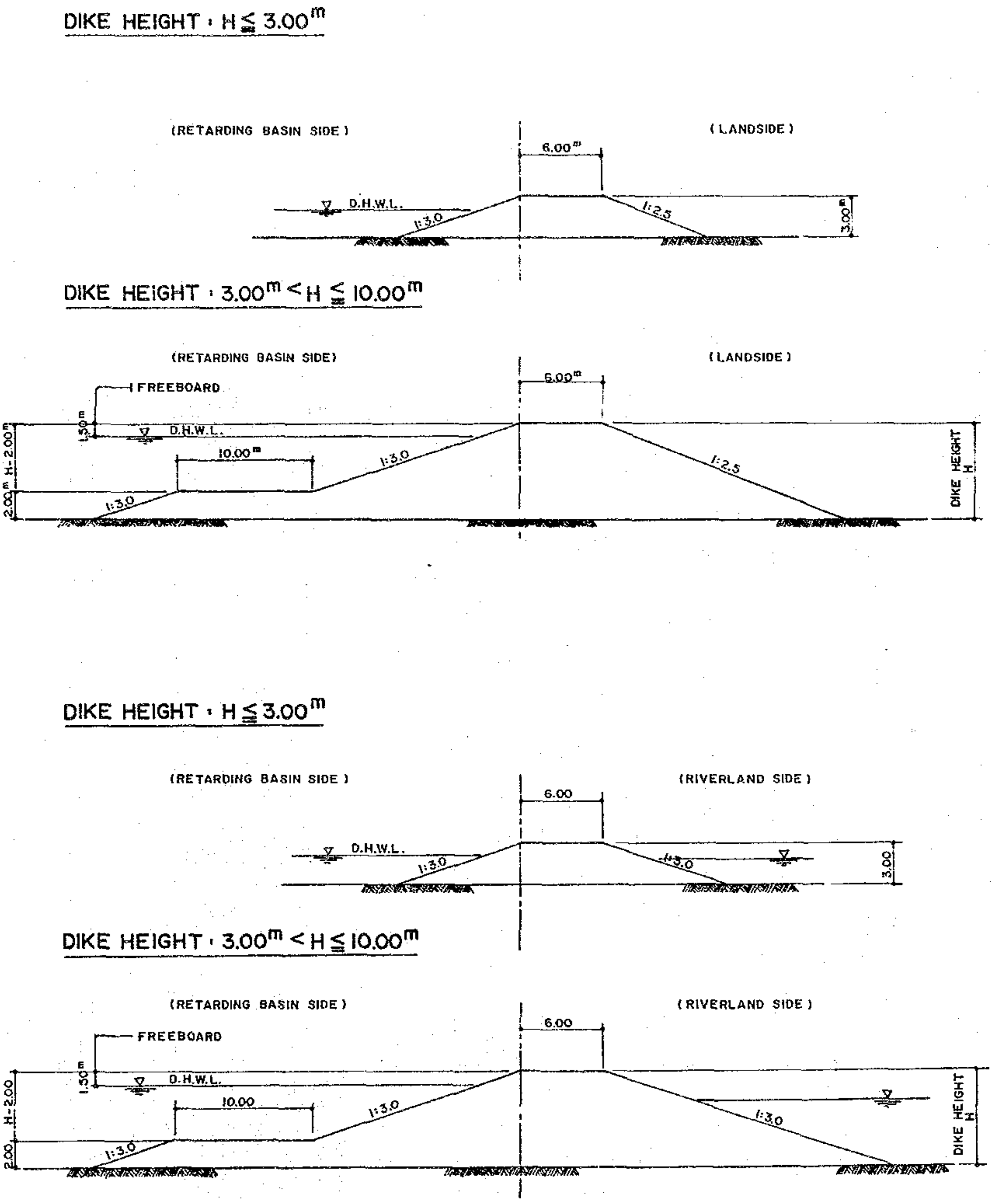


Fig. 4.18 STANDARD DESIGN SECTION OF RETARDING BASIN

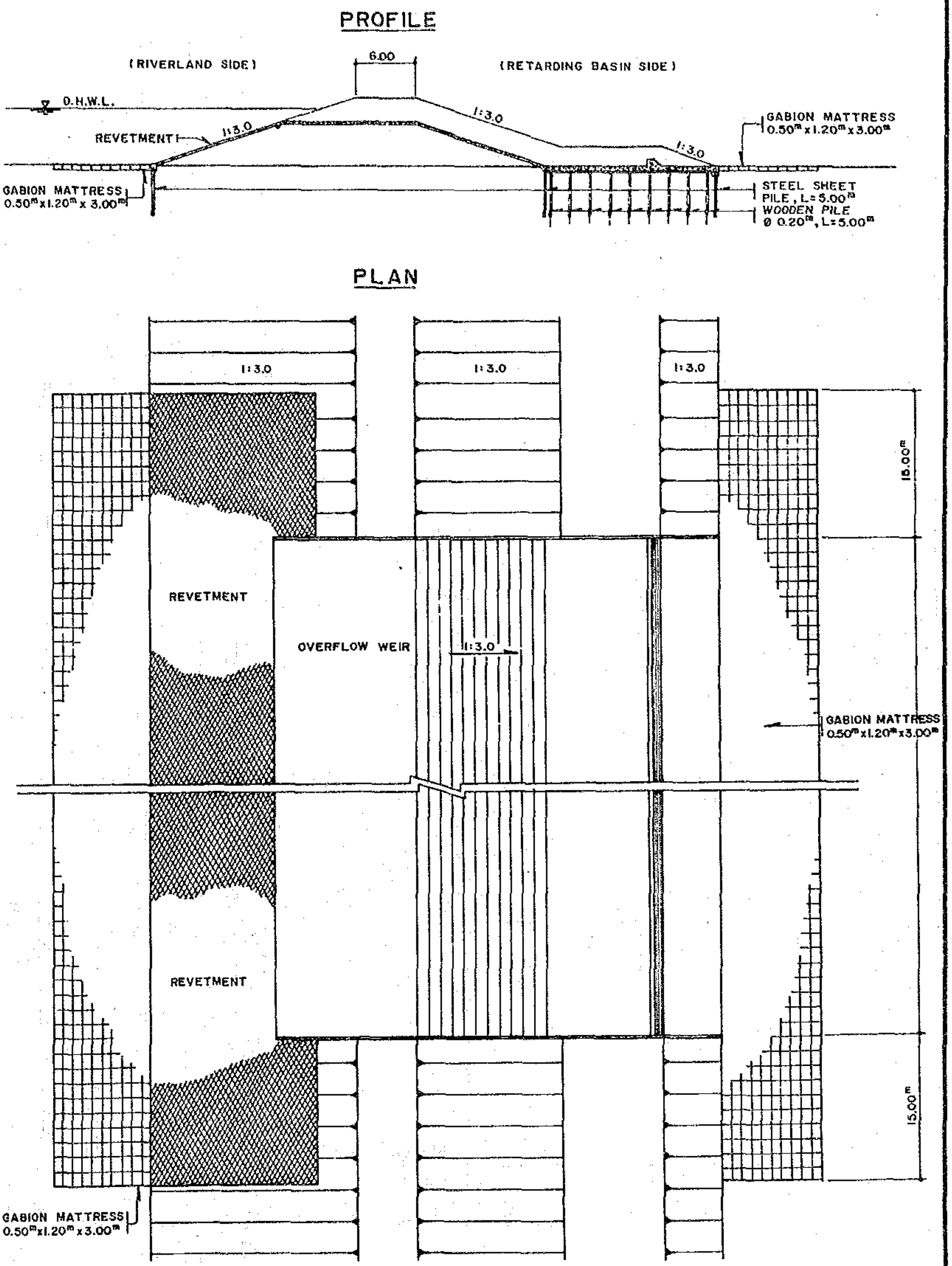


Fig. 4.19 STANDARD DESIGN OF OVERFLOW WEIR FOR RETARDING BASIN

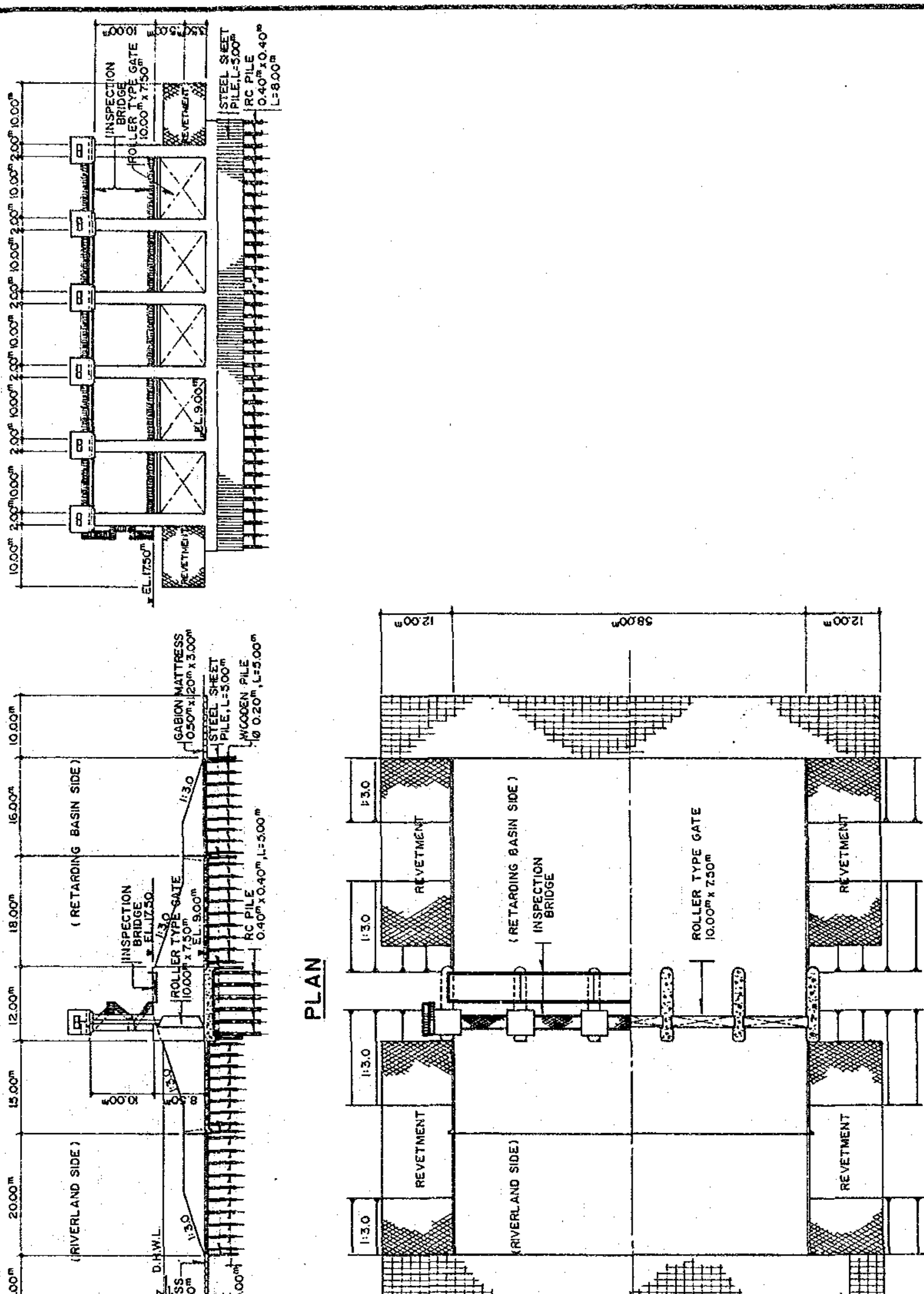


Fig.4.20 DRAINAGE GATE OF RETARDING BASIN

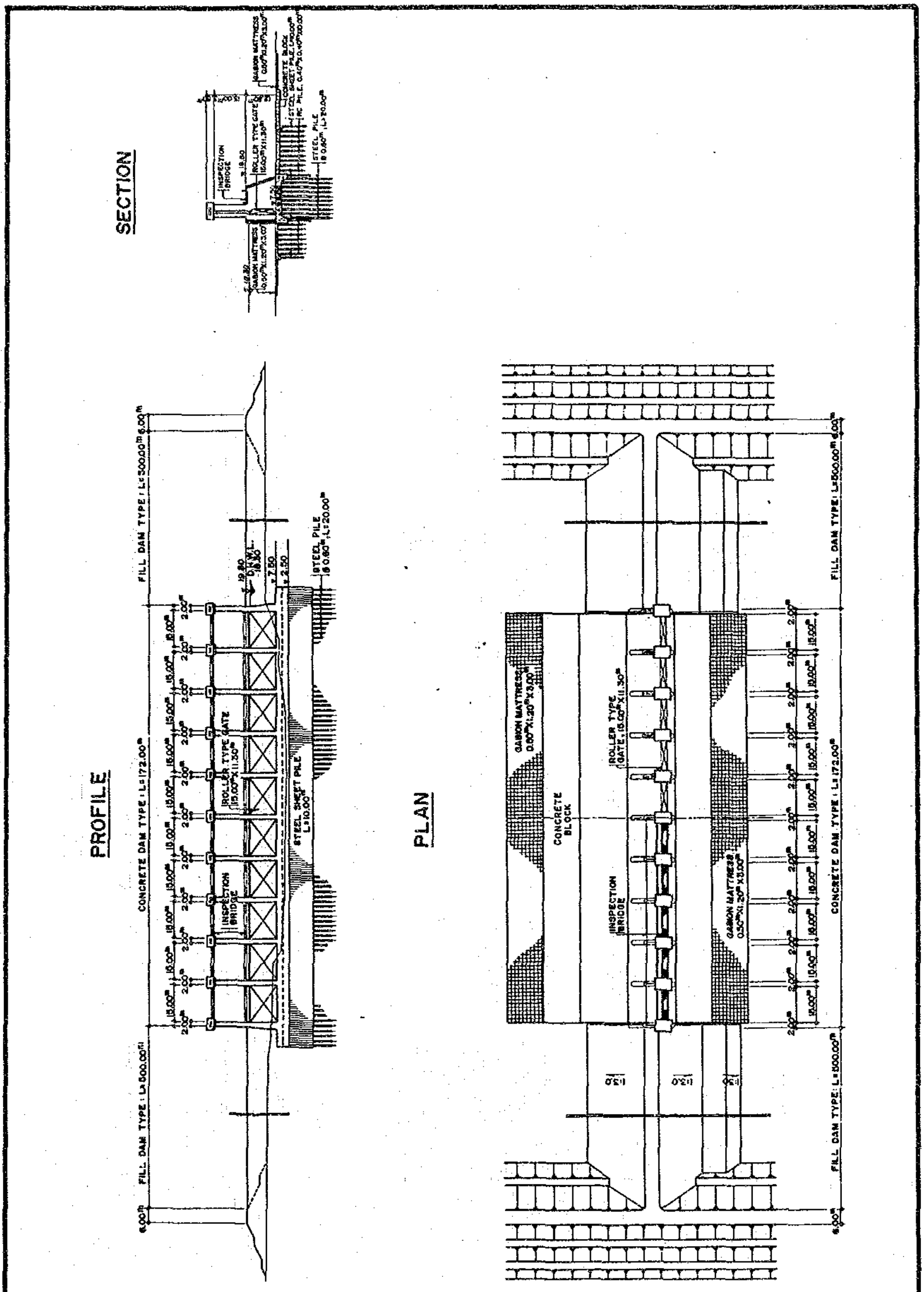


Fig. 4.21 CONTROL GATE WEIR FOR POPONTO RETARDING BASIN

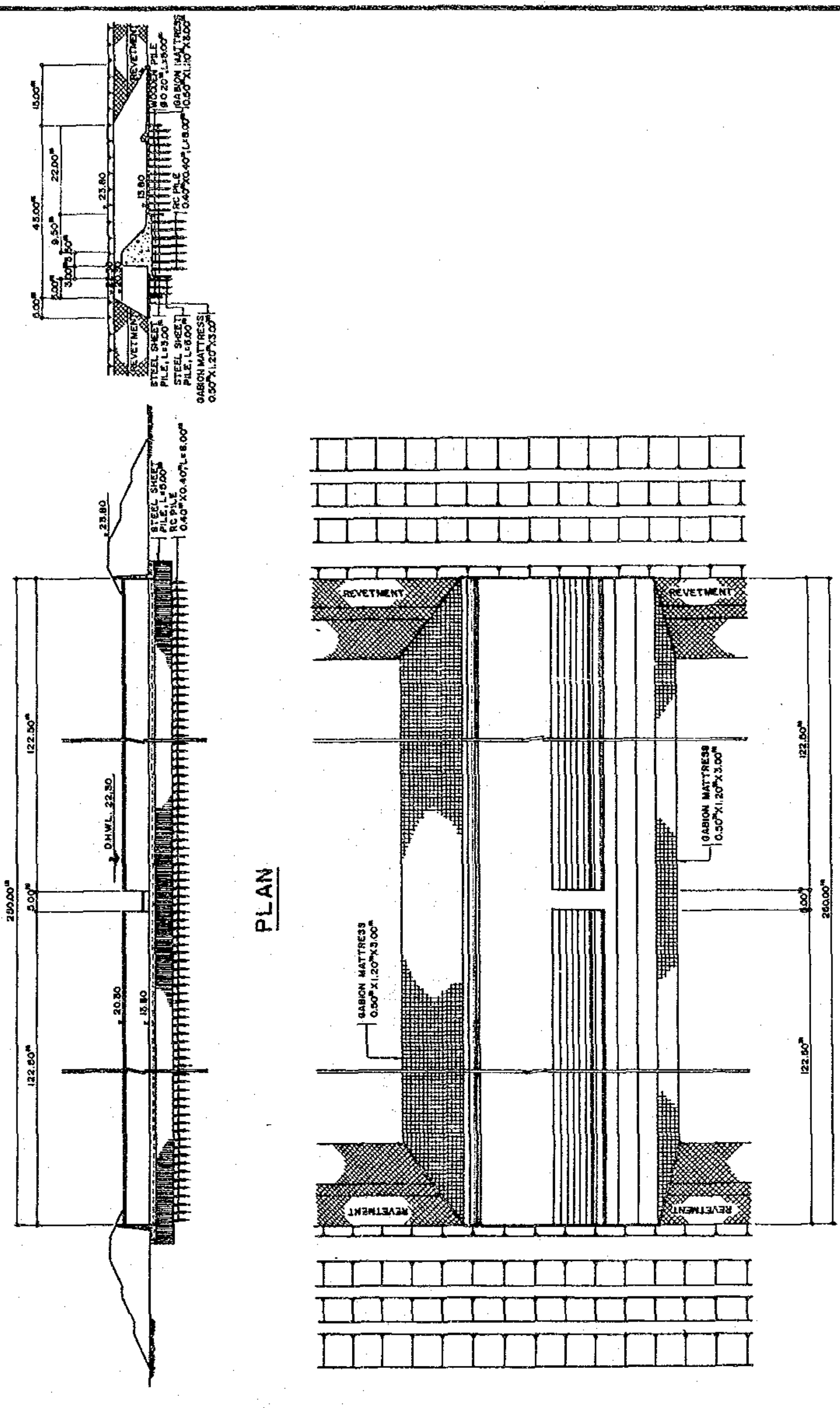


Fig. 4.22 AGNO FIXED WEIR ON DIVERSION POINT

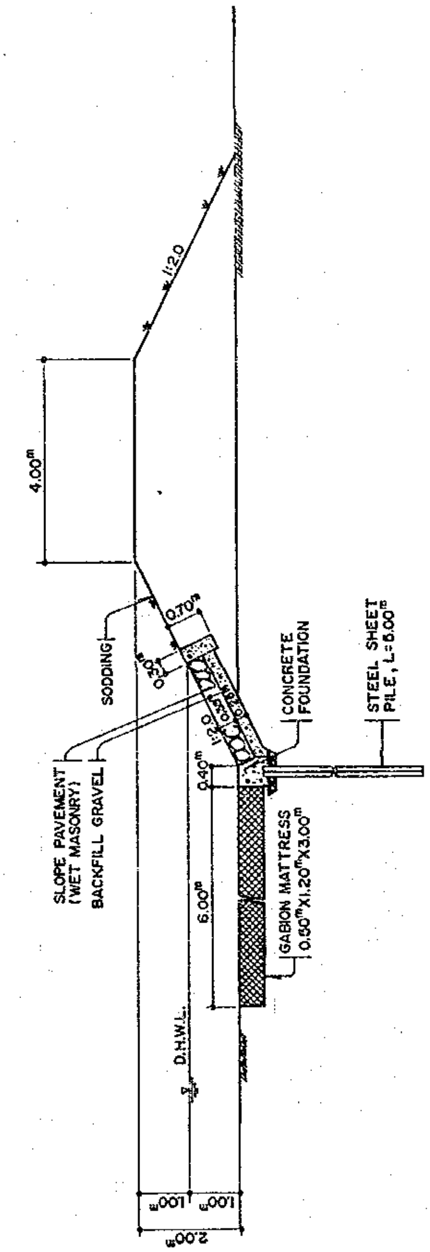


Fig. 4.23 STANDARD DESIGN SECTION OF BUED CLOSING DIKE

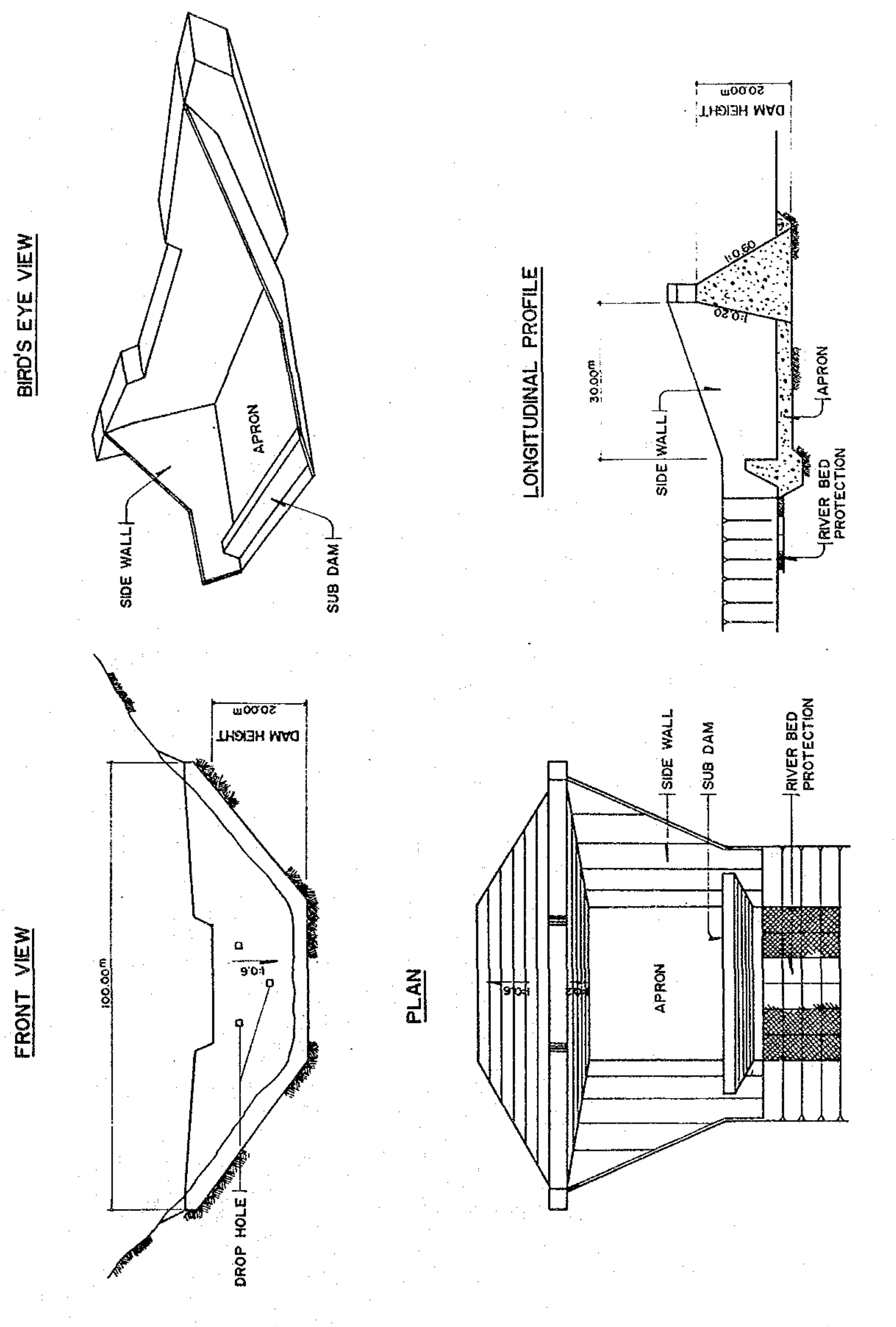


Fig. 4.24 STANDARD DESIGN OF SABO DAM