VENEZUELAN INTERNATIONAL METEOROLOGICAL
AND HYDROLOGICAL EXPERIMENT
(VIMHEX)

HYDROLOGY REPORT

VOLUME III

GEOMETRIC AND HYDRAULIC PROPERTIES OF THE RIVERS

by

D. B. Simons, E. V. Richardson, M. A. Stevens,
J. H. Duke and V. C. Duke

Civil Engineering Department
Colorado State University
Fort Collins, Colorado

October 1971

CER70-71DBS-EVR-MAS-
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The VIMHEX hydrological data and analyses are being presented in a series of VIMHEX hydrology reports. This third volume contains the data pertaining to the geometric and hydraulic properties of the rivers in the Anaco, Venezuela study area. In this report, the relations between discharge, velocity, roughness, slope, bed material size, and cross-sectional geometry of the principal rivers are presented.

Volume I, Precipitation Data and Analysis, contains the precipitation data collected by VIMHEX during the summer of 1969.

Volume II, Streamflow, Groundwater and Ground Response Data, is a presentation of most of the other hydrological information collected by VIMHEX.

Volume IV, Soil Temperatures and Heat Content, contains data collected at the Anaco site, the analyses of those data, and estimates of the amount of heat stored in the soil throughout a 24-hour period.

Further analyses of the hydrological data will be published in other volumes of the VIMHEX hydrology reports.

October 1971

FOREWORD

The project leaders for VIMHEX are Dr. H. Riehl, Atmospheric Science Department, Colorado State University and D. B. Simons, Civil Engineering Department, Colorado State University. VIMHEX is sponsored by the Department of Defense through its THEMIS program. In addition to the financial support provided by the Department of Defense, professional members of the various branches of the Armed Services have contributed significantly to the solution of logistics, management and scientific problems. Mr. James Hughes, Office of Naval Research, who is the Contracting Officer for VIMHEX, has been especially helpful.

ABSTRACT

VIMHEX is an intensive program of tropical meteorological and hydrological observations taken in northeast Venezuela during the summer of 1969 to support a study of tropical atmospheric physics and the resulting effect of rainfall.

The objectives of the program are to express the meso-scale weather structure in terms of the synoptic-scale envelope and to formulate the ground response to the rainfall produced by tropical weather disturbances over relatively flat tropical topography.

The Hydrology Report, Volume III, is a compilation of the data obtained and utilized to develop relations between the discharge and the geometric and hydraulic properties at the primary and secondary river gaging stations. The report includes drawings of the plans, profiles and cross sections of 13 river reaches. The drawings are prepared from the field survey notes. The river basin slopes, obtained from topographic maps, at all gaging stations are listed. A summary of the bed-material size characteristics at 30 locations in the study area is given. The relations between the measured discharge and the corresponding cross-sectional area, average flow velocity, top width, wetted perimeter, hydraulic radius, hydraulic depth, top width to hydraulic depth ratio, and Manning's n are presented for 11 primary gaging stations.

ACKNOWLEDGMENTS

The Venezuelan International Meteorological and Hydrological Experiment (VIMHEX) was conducted by Colorado State University with participation by the National Center for Atmospheric Research, the U. S. National Guard Bureau, the Venezuelan Air Force Meteorological Service, the Venezuelan Minister of Public Works, the Venezuelan National Institute of Sanitation, the Central University of Venezuela, the Eastern University at Jusepin, the Bonn Institute, the Imperial College, Mobile Oil Company of Venezuela and IBIDEM Company of Venezuela.

Special acknowledgment is made to the Ministerio de Obras Publicas (M.O.P.), Division de Hidrologia, under the direction of Dr. Hector Silva. Dr. Silva assigned eleven field technicians to work directly with VIMHEX during the full extent of the study period. These technicians were Abel Santos, Blas Santaella, Bandelio Romero, Eduardo Canache, Cesar Cardot, Eduardo Contreras, Orlando Gomez, Gilberto Rodriquez, Jóse Sabino, Oswaldo Tirado and Antonio Velasquez.

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CHAPTER I

INTRODUCTION

The Venezuelan International Meteorological and Hydrological Experiment (VIMHEX) was an intensive program of tropical meteorological and hydrological observations taken in northeast Venezuela during the summer of 1969 to study tropical atmospheric physics and the resulting effects of rainfall. The general study area is outlined on Figure I-1.

The objectives of the program are: (1) to express the meso-scale (10-50 mile) weather structure in terms of the synoptic-scale (1,000 mile) envelope; (2) to formulate prediction methods from this weather model for runoff from streams, ground trafficability and groundwater variations; (3) to contribute to the understanding of the role of meso-scale weather to large-scale weather, and (4) to observe the extent and severity of equatorial zone thunderstorms relative to that encountered in other areas.

This report is a collection and presentation of the data collected in 1969 on the geometry and hydraulic features of the rivers in the study area.

The slopes of the rivers in the study area are given in Chapter II. The slopes are obtained from topographic maps published by the Ministerio de Obras Públicas.

In Chapter III, the size properties of the river bed-material sediments collected at 30 locations in the study area are summarized.

The relations between the measured discharge and corresponding values for the cross-sectional area, top-width and wetted perimeter at

11 primary gaging stations are presented in Chapter IV. In addition, the velocity-discharge relation, the hydraulic depth-discharge relation, the top width to hydraulic depth ratio-discharge relation, and the Manning's roughness coefficient-discharge relation at each of 11 gaging stations are computed and presented. Exhibits of the plan view of the river reach, the thalweg profile and cross sections of the river channel are included for those gaging-station reaches which were surveyed.

Surveys of the river reach at each of eight crest-stage partial record stations were also made in 1969. That data is presented in Chapter V.

This data report is the third in the series of VIMHEX data reports. The other reports are Hydrology Report, Volume I, "Precipitation Data and Analysis," and Hydrology Report, Volume II, "Streamflow, Groundwater and Ground Response Data." Essentially, all the data which were collected by the Hydrology Section are presented in the three reports.

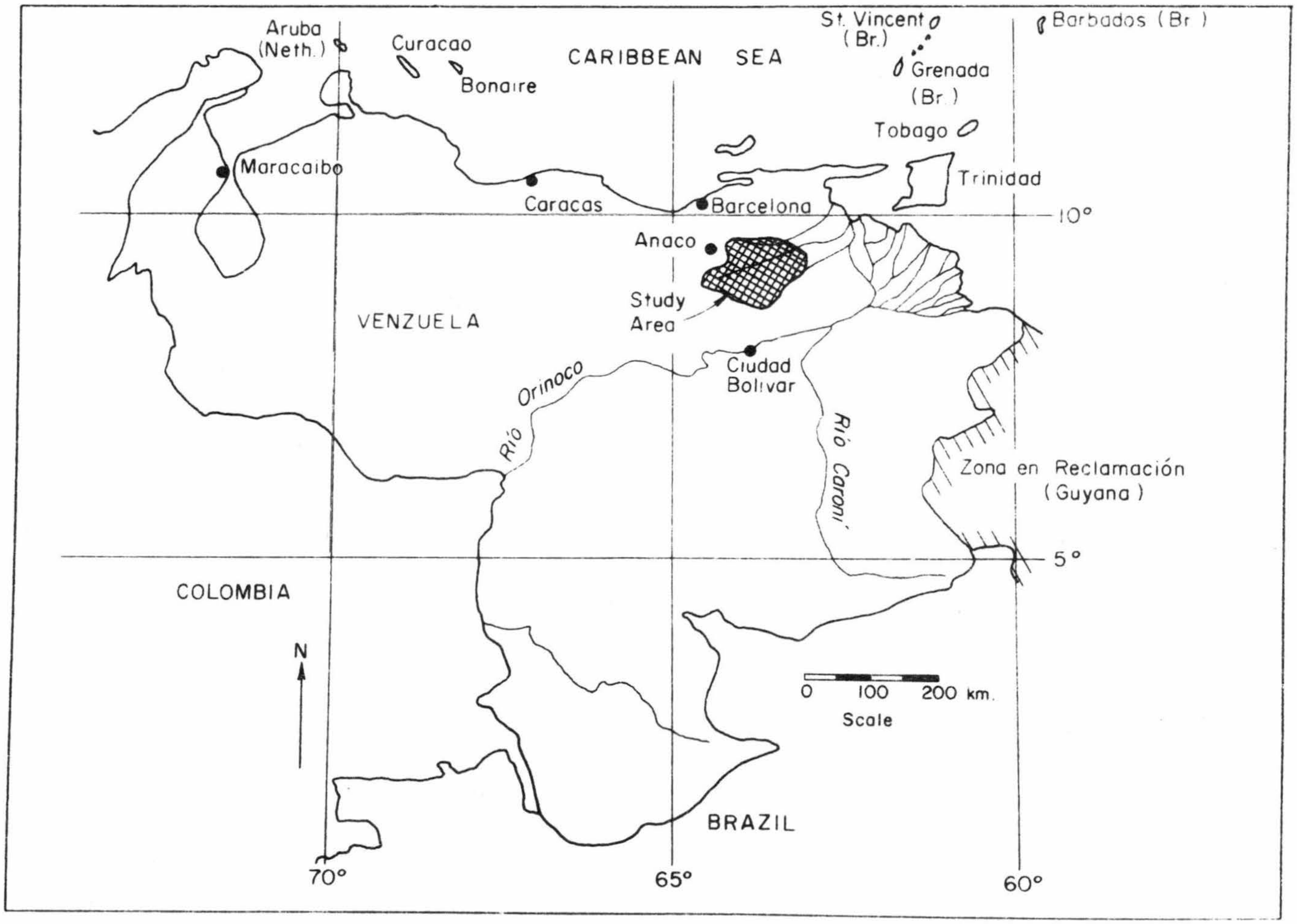


FIGURE I-1 LOCATION OF STUDY AREA

CHAPTER II

RIVER SLOPES

For the rivers shown on Figure II-1, the river profiles were determined from 1:100,000 scale topographic maps produced by the Dirección de Cartografía Nacional. The maps have a 40 meter contour interval with supplemental contours at 20 meter intervals.

The river slopes were obtained by measuring the map distance along the river between contour lines. The distance-elevation information for the rivers in the Río Tigre, the Río Guanipa, the Río Mapirito, and the Río Amana basins are listed in this chapter. The river profiles are plotted on the figures which accompany each table. In the tables under the column titled "Location", contour refers to the location of the contour line on the topographic map. For example, in the Río Tigre basin (Table II-2), the 40-meter contour crosses the Río Tigre at a position 34.5 miles above Sta. No. 17.

The river slopes at the primary and crest-stage gaging stations are given in Table II-1. These slopes are obtained from the topographic maps.

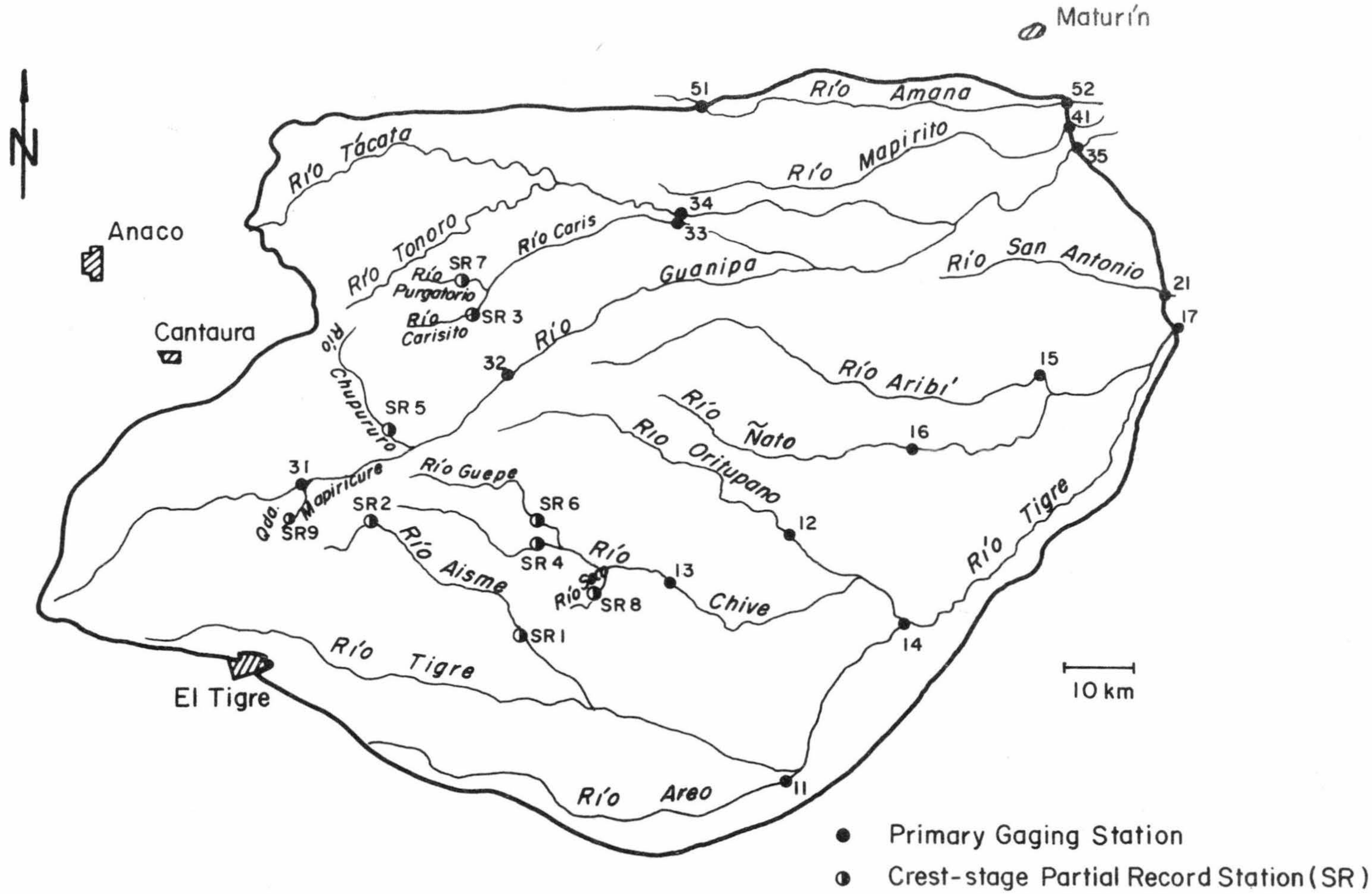


FIGURE II-1 LOCATIONS OF STREAM GAGING STATIONS

TABLE II-1

RIVER SLOPES

Sta. No.	Río	Slope ft/ft	Slope ft/mi
11	Areo	0.00038	2.0
12	Oritupano	0.00053	2.8
13	Chive	0.00083	4.4
14	Tigre	0.00050	2.6
15	Aribí	0.00091	4.8
16	Ñato	0.0011	5.8
17	Tigre	0.00022	1.2
31	Guanipa	0.00080	4.2
32	Guanipa	0.00060	3.2
33	Caris	0.0018	9.5
34	Tonoro	0.0016	8.4
35	Guanipa	0.00097	5.1
41	Mapirito	0.0015	7.9
51	Amana	0.0013	7.0
52	Amana	0.00066	3.5
SR1	Aisme	0.0016	8.7
SR2	Aisme	0.0017	9.2
SR3	Carisito	0.0024	13
SR4	Chive	0.00083	4.4
SR5	Chupururo	0.0021	11
SR6	Guepe	0.00083	4.4
SR7	Purgatorio	0.0025	13
SR8	Seco	0.0023	12

TABLE II-2

RIO TIGRE BASIN PROFILE

Río	Location	Elevation ft AMSL	Distance from Sta. No. 17 ft	Distance from Sta. No. 17 mi
Tigre	Sta. No. 17	70	0	0.0
	Confluence, Aribí	85	50,400	9.5
	Contour, 40 m	131	182,300	34.5
	Contour, 60 m	197	259,600	49.2
	Contour, 80 m	262	385,600	73.0
	Sta. No. 14 and Confluence, Oritupano	295	441,000	83.5
	Confluence, Areo	315	592,200	112.2
	Contour, 120 m	394	661,100	125.2
	Confluence, Aisme	485	739,200	140.0
	Contour, 160 m	525	772,000	146.2
	Contour, 200 m	656	856,800	162.3
	Contour, 240 m	787	923,200	174.8
	Contour, 280 m	919	959,300	181.7
	Contour, 320 m	1050	982,000	186.0
	Headwaters	1065	982,800	186.1
Aribí	Confluence, Tigre	85	50,400	9.5
	Contour, 40 m	131	139,900	26.5
	Confluence, Ñato	138	145,800	27.6
	Sta. No. 15	155	165,100	31.3
	Contour, 80 m	262	280,200	53.1
	Contour, 120 m	394	412,100	78.0
	Contour, 160 m	525	432,200	81.8
	Contour, 200 m	656	482,300	91.3
	Headwaters	787		
Ñato	Confluence, Aribí	138	145,800	27.6
	Sta. No. 16	248	257,600	48.8
	Contour, 80 m	262	268,500	50.8
	Contour, 120 m	394	350,000	66.3
	Contour, 160 m	525	401,200	76.0
	Contour, 200 m	656	414,600	78.5
	Headwaters	700	418,000	79.2
Oritupano	Confluence, Tigre	295	441,000	83.5
	Contour, 100 m	328	503,200	95.3
	Confluence, Chive	330	505,700	95.8
	Sta. No. 12	373	586,300	111.0
	Contour, 120 m	394	625,800	118.5
	Confluence, Guibimba	418	665,500	126.0
	Contour, 160 m	525	770,300	145.9
	Contour, 200 m	656	835,800	158.3
	Headwaters	670	844,200	159.9

TABLE II-2 (continued)

RIO TIGRE BASIN PROFILE

Río	Location	Elevation ft AMSL	Distance from Sta. No. 17 ft	Distance from Sta. No. 17 mi
Chive	Confluence, Oritupano	330	505,700	95.8
	Contour, 120 m	394	535,900	101.5
	Sta. No. 13	507	618,200	117.1
	Contour, 160 m	525	640,900	121.4
	Confluence, Seco	540	660,200	125.0
	Confluence, Guepe	565	689,600	130.6
	SR4	578	703,900	133.3
	Contour, 200 m	656	793,000	150.2
	Contour, 240 m	787	813,100	154.0
	Headwaters	795	814,000	154.2
Guepe	Confluence, Chive	565	689,600	130.6
	SR6	590	719,000	136.2
	Contour, 200 m	656	797,100	151.0
	Contour, 220 m	722	808,900	153.2
	Headwaters	785	818,200	155.0
Seco	Confluence, Chive	540	660,200	125.0
	SR8	580	682,900	129.3
	Headwaters	656	714,000	135.2
Guibimba	Confluence, Oritupano	418	665,500	126.0
	Contour, 160 m	525	752,500	142.5
	Contour, 200 m	656	810,300	153.5
	Headwaters	675	817,600	154.8
Areo	Confluence, Tigre	315	592,200	112.2
	Sta. No. 11	320	603,200	114.2
	Contour, 120 m	394	669,600	126.8
	Contour, 160 m	525	723,000	136.9
	Contour, 200 m	656	786,800	149.0
	Headwaters	761	856,700	162.2
Aisme	Confluence, Tigre	485	739,200	140.0
	Contour, 160 m	525	772,800	146.4
	SR1	581	808,900	152.2
	Contour, 200 m	656	851,800	161.3
	SR2	759	910,600	172.5
	Contour, 240 m	787	926,500	175.5
	Headwaters	919	952,600	180.4

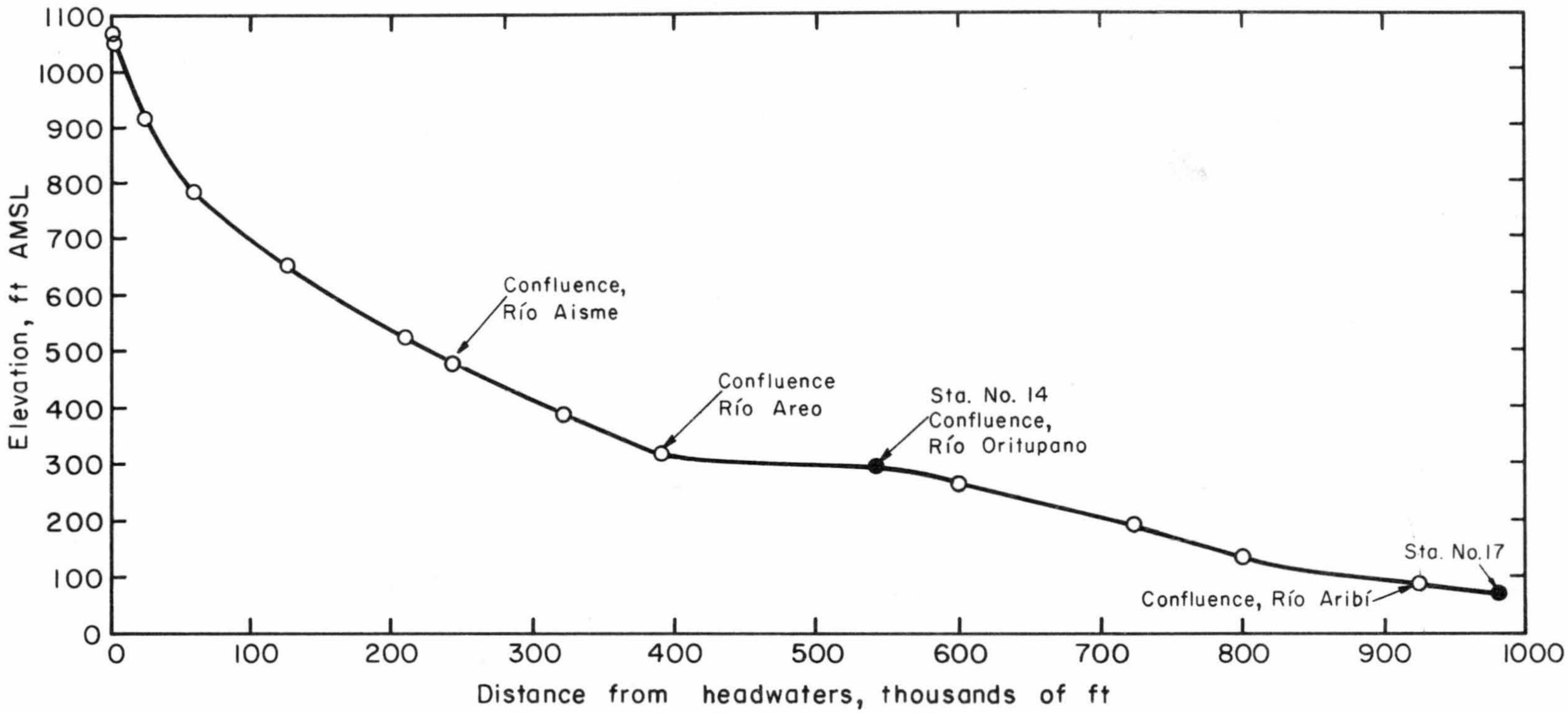


FIGURE II-2 PROFILE OF THE RIO TIGRE

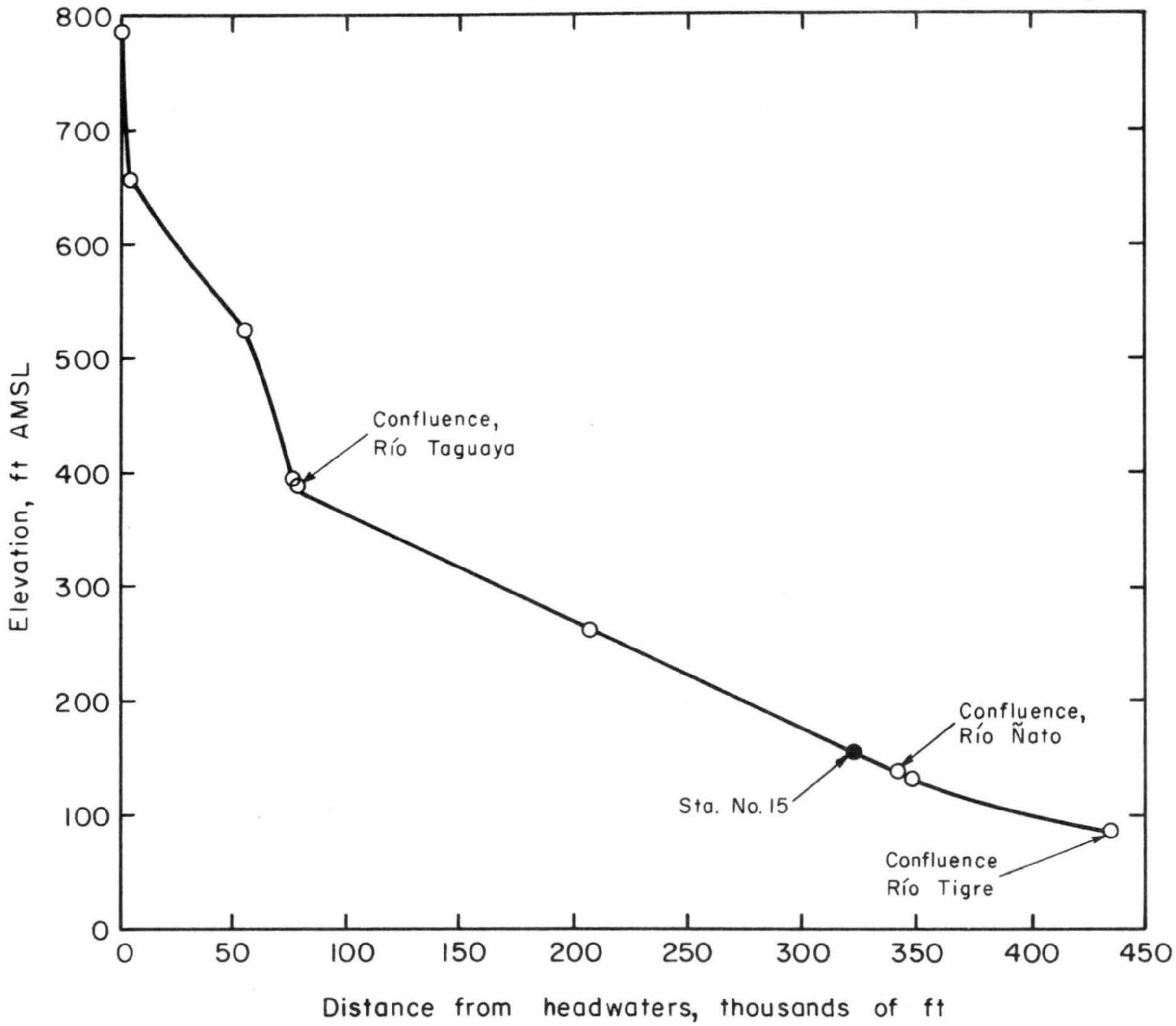


FIGURE II-3 PROFILE OF THE RIO ARIBI

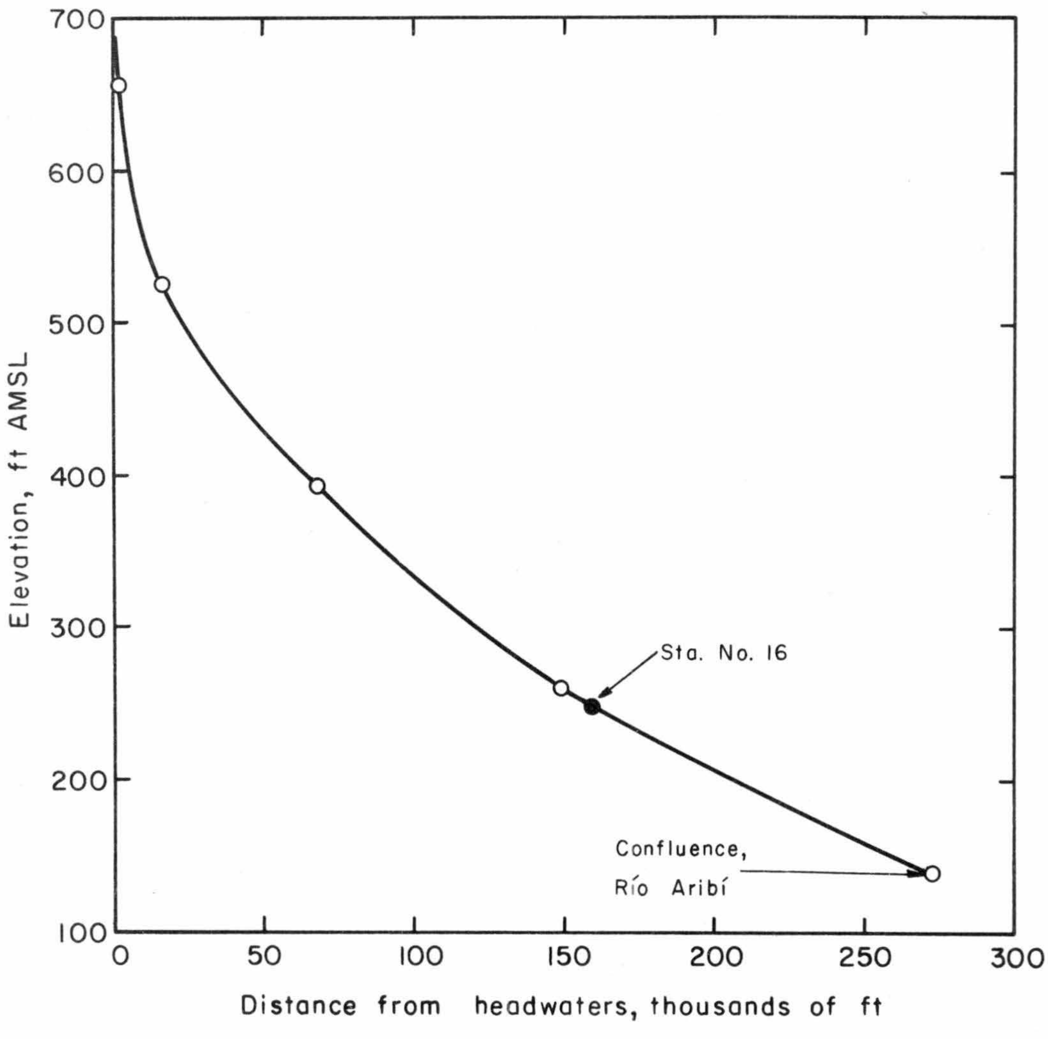


FIGURE II-4 PROFILE OF THE RIO ÑATO

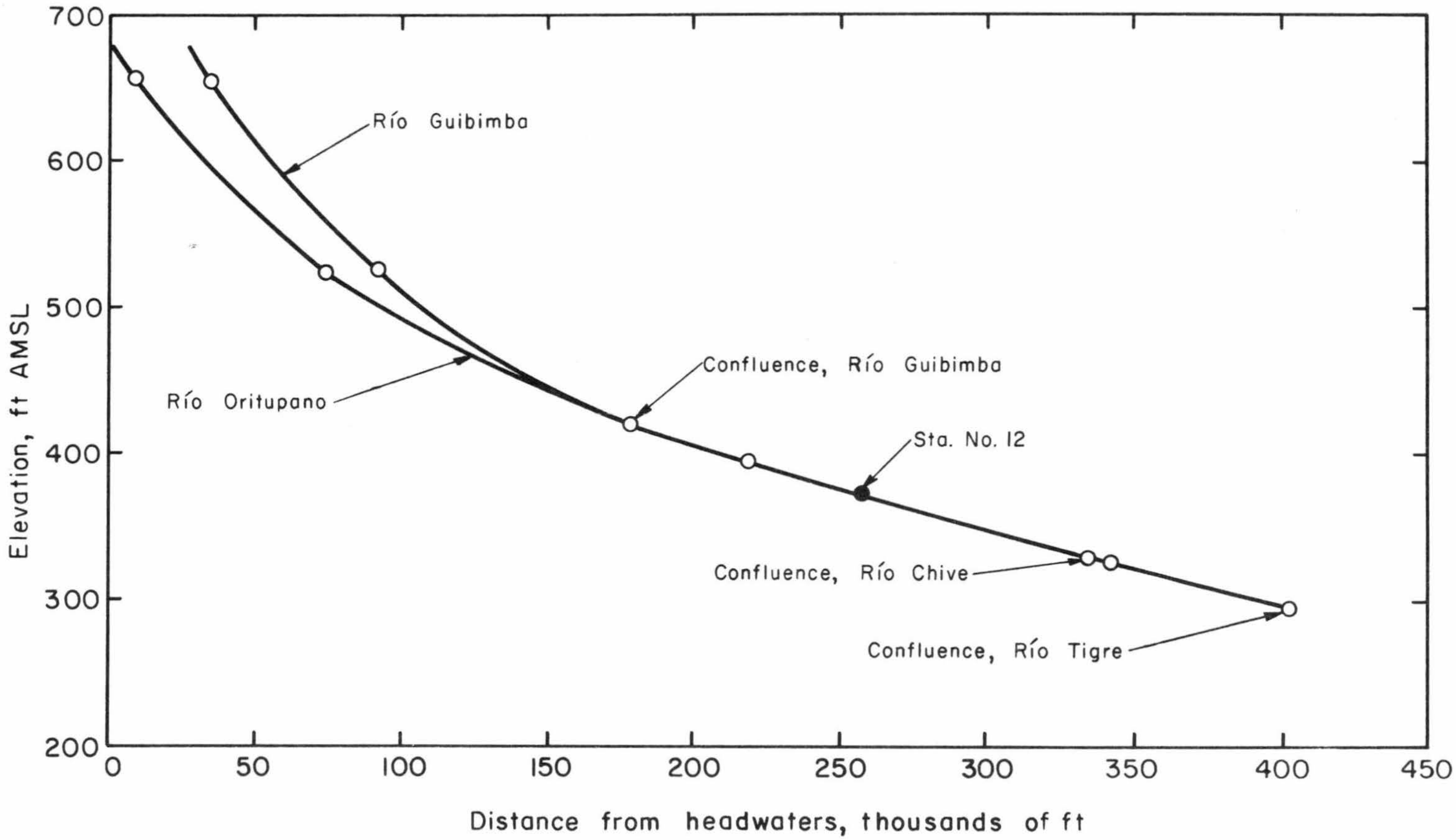


FIGURE II-5 PROFILE OF THE RIO ORITUPANO

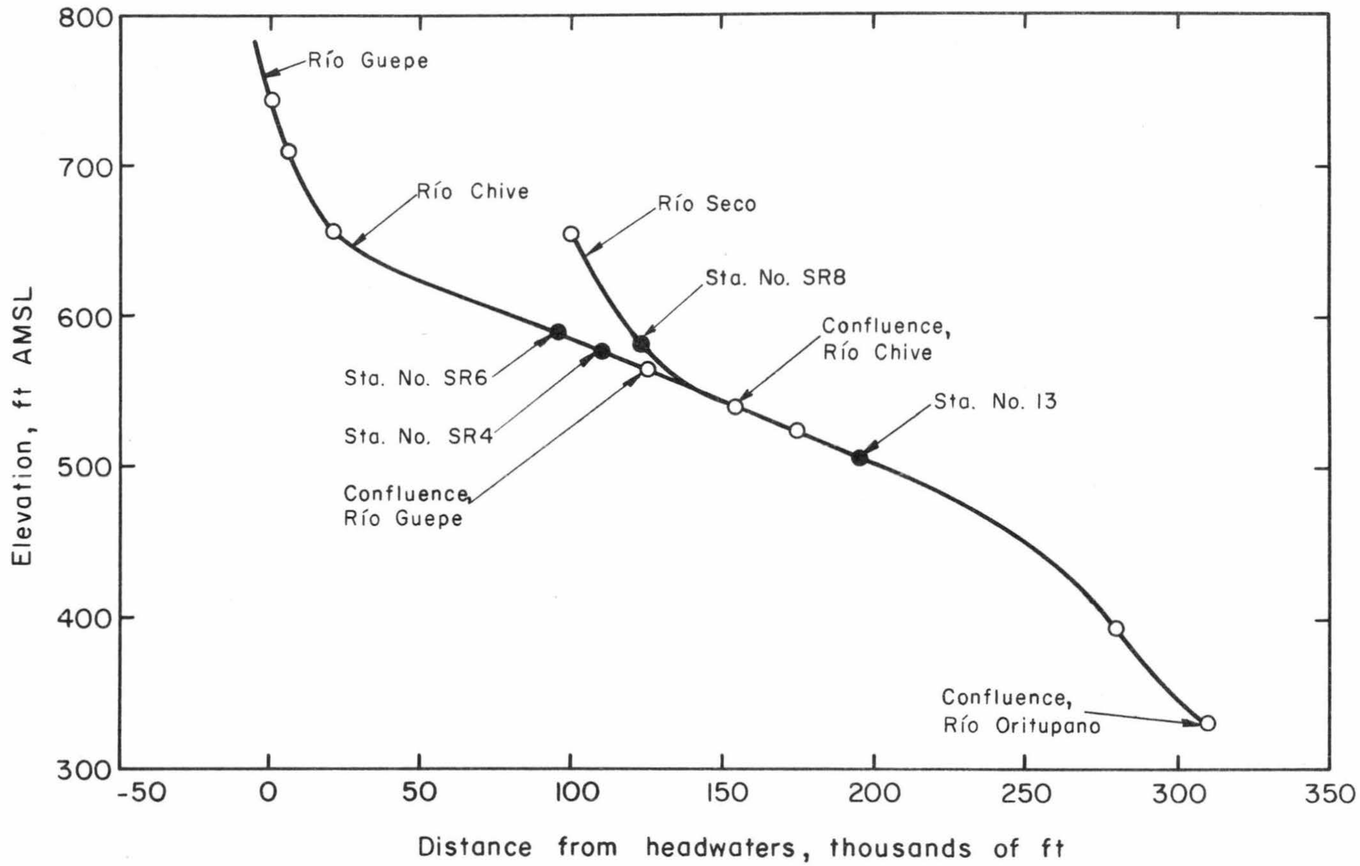


FIGURE II-6 PROFILE OF THE RIO CHIVE

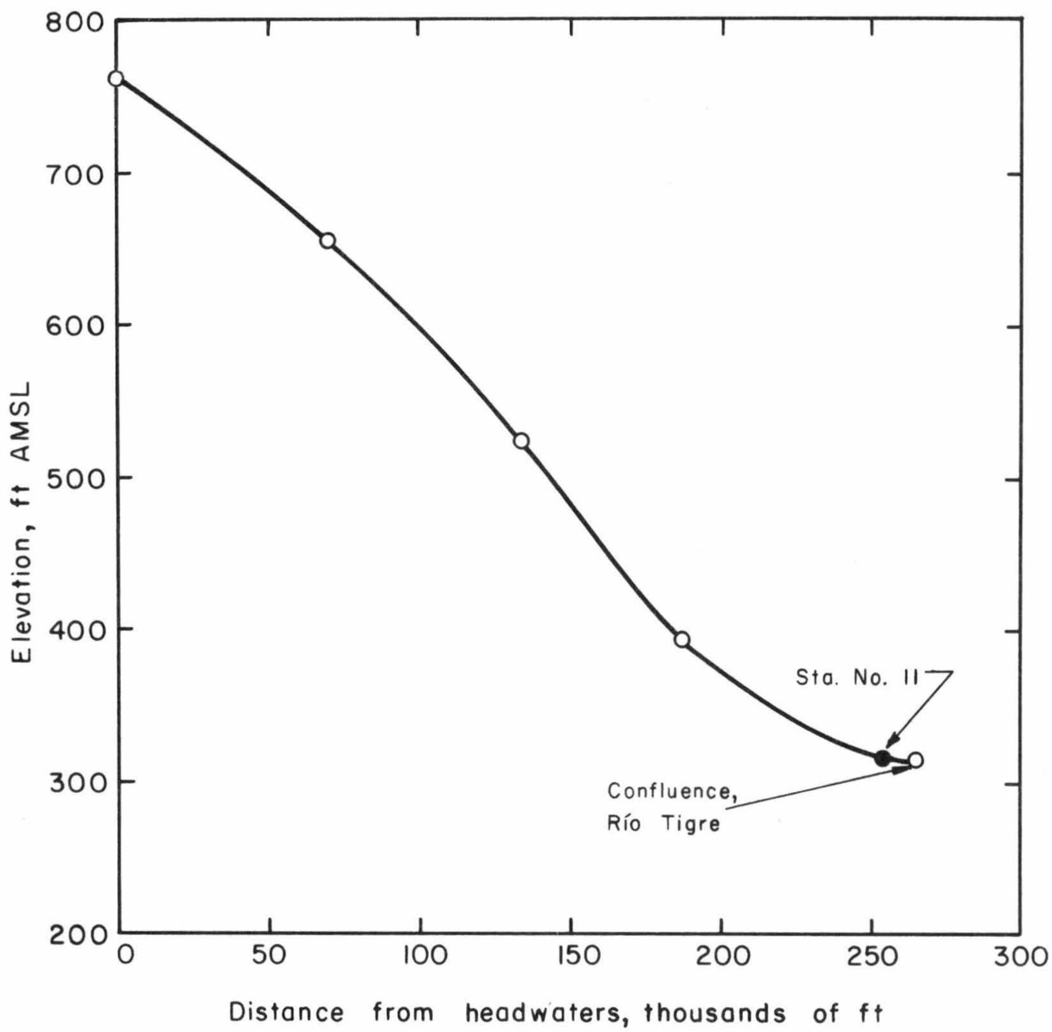


FIGURE II-7 PROFILE OF THE RIO AREO

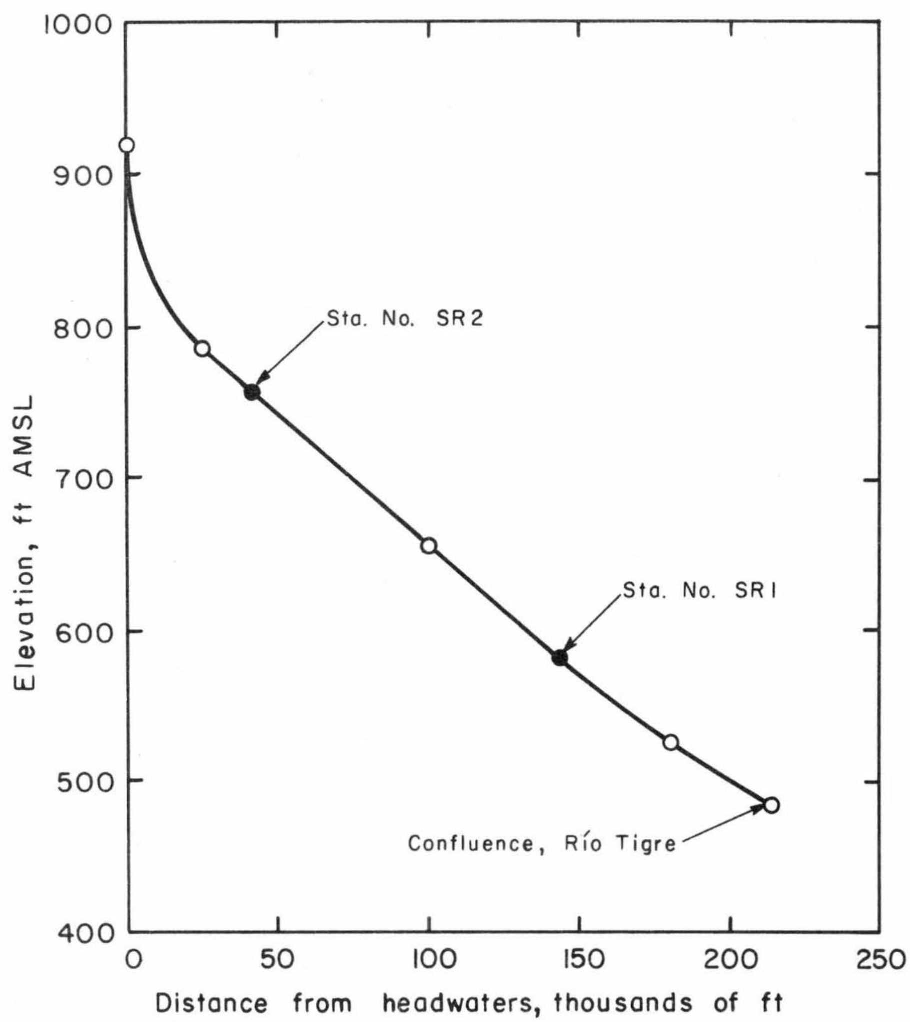


FIGURE II-8 PROFILE OF THE RIO AISME

TABLE II-3

RIO GUANIPA BASIN PROFILE

Río	Location	Elevation ft AMSL	Distance from Sta. No. 35 ft	Distance from Sta. No. 35 mi
Guanipa	Sta. No. 35	161	0	0.0
	Contour, 60 m	197	37,000	7.0
	Confluence, Tonoro	260	120,100	22.7
	Contour, 80 m	262	126,800	24.0
	Contour, 100 m	328	242,800	46.0
	Confluence, Caris	350	284,800	53.9
	Contour, 120 m	394	377,200	71.4
	Contour, 160 m	525	549,400	104.0
	Sta. No. 32	560	609,000	115.3
	Confluence, Chupururo	630	722,400	136.8
	Contour, 200 m	656	758,500	143.6
	Confluence, Mapiricure	685	813,100	154.0
	Sta. No. 31	690	814,000	154.2
	Contour, 240 m	787	923,200	174.8
	Contour, 280 m	919	986,200	186.8
	Headwaters	1100	1,016,000	192.4
Tonoro	Confluence, Guanipa	260	120,100	22.7
	Contour, 80 m	262	128,500	24.3
	Contour, 100 m	328	157,000	29.7
	Contour, 120 m	394	179,700	34.0
	Sta. No. 34	511	275,500	52.2
	Contour, 160 m	525	285,000	54.0
	Contour, 200 m	656	352,300	66.7
	Confluence, Tácata	668	356,500	67.5
	Contour, 240 m	787	428,700	81.2
	Contour, 280 m	919	500,900	94.9
	Contour, 320 m	1050	549,700	104.1
	Contour, 360 m	1181	562,300	106.5
	Headwaters	1191	563,100	106.6
Tácata	Confluence, Tonoro	668	356,500	67.5
	Contour, 240 m	787	411,100	77.8
	Contour, 280 m	919	464,000	87.9
	Contour, 320 m	1050	519,500	98.4
	Contour, 360 m	1181	566,500	107.3
	Contour, 400 m	1312	601,800	114.0
	Contour, 440 m	1444	616,900	116.8
	Headwaters	1456	617,700	117.0

TABLE II-3 (continued)

RIO GUANIPA BASIN PROFILE

Río	Location	Elevation ft AMSL	Distance from Sta. No. 35 ft	mi
Caris	Confluence, Guanipa	350	284,800	53.9
	Contour, 120 m	394	308,300	58.4
	Sta. No. 33	503	366.300	69.4
	Contour, 160 m	525	379,700	71.9
	Contour, 200 m	656	438,500	83.0
	Contour, 240 m	787	481,400	91.2
	Confluence, Purgatorio and Carisito	843	506,600	95.9
Carisito	Confluence, Purgatorio	843	506,600	95.9
	SR3	901	531,400	100.6
	Contour, 280 m	919	537,700	101.8
	Contour, 320 m	1050	567,300	107.4
	Headwaters	1115	574,600	108.8
Purgatorio	Confluence, Carisito	843	506,600	95.9
	SR7	893	528,400	100.1
	Contour, 280 m	919	541,000	102.5
	Headwaters	1050	550,500	104.3
Chupururo	Confluence, Guanipa	630	722,400	136.8
	Contour, 200 m	656	734,600	139.1
	SR5	660	735,900	139.4
	Contour, 240 m	787	792,000	150.0
	Contour, 280 m	919	812,500	153.9
	Contour, 320 m	1050	823,100	155.9
	Headwaters	1148	825,100	156.3
Mapiricure	Confluence, Guanipa	685	813,100	154.0
	Contour, 240 m	787	829,900	157.2
	SR9	795	834,900	158.1
	Headwaters	835	841,200	159.3

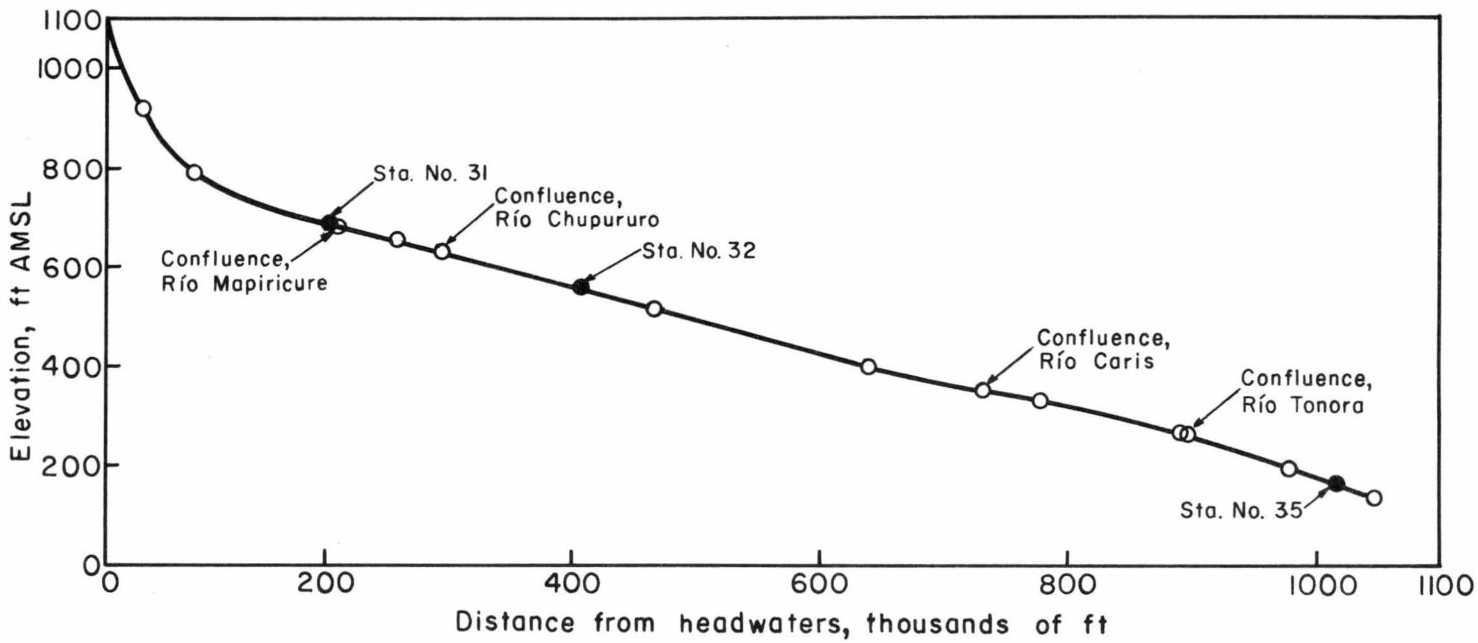


FIGURE II-9 PROFILE OF THE RIO GUANIPA

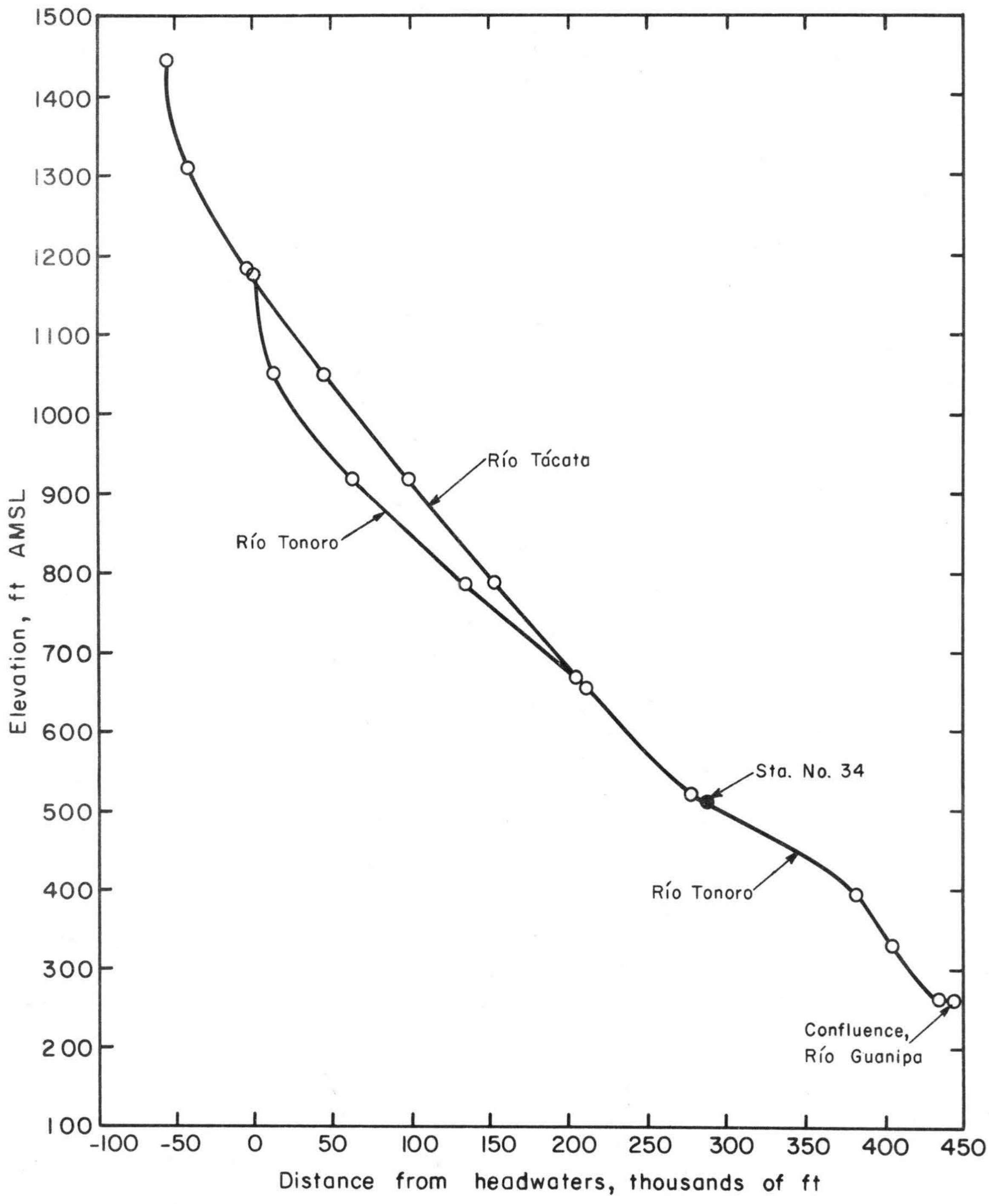


FIGURE II-10 PROFILE OF THE RIO TONORO

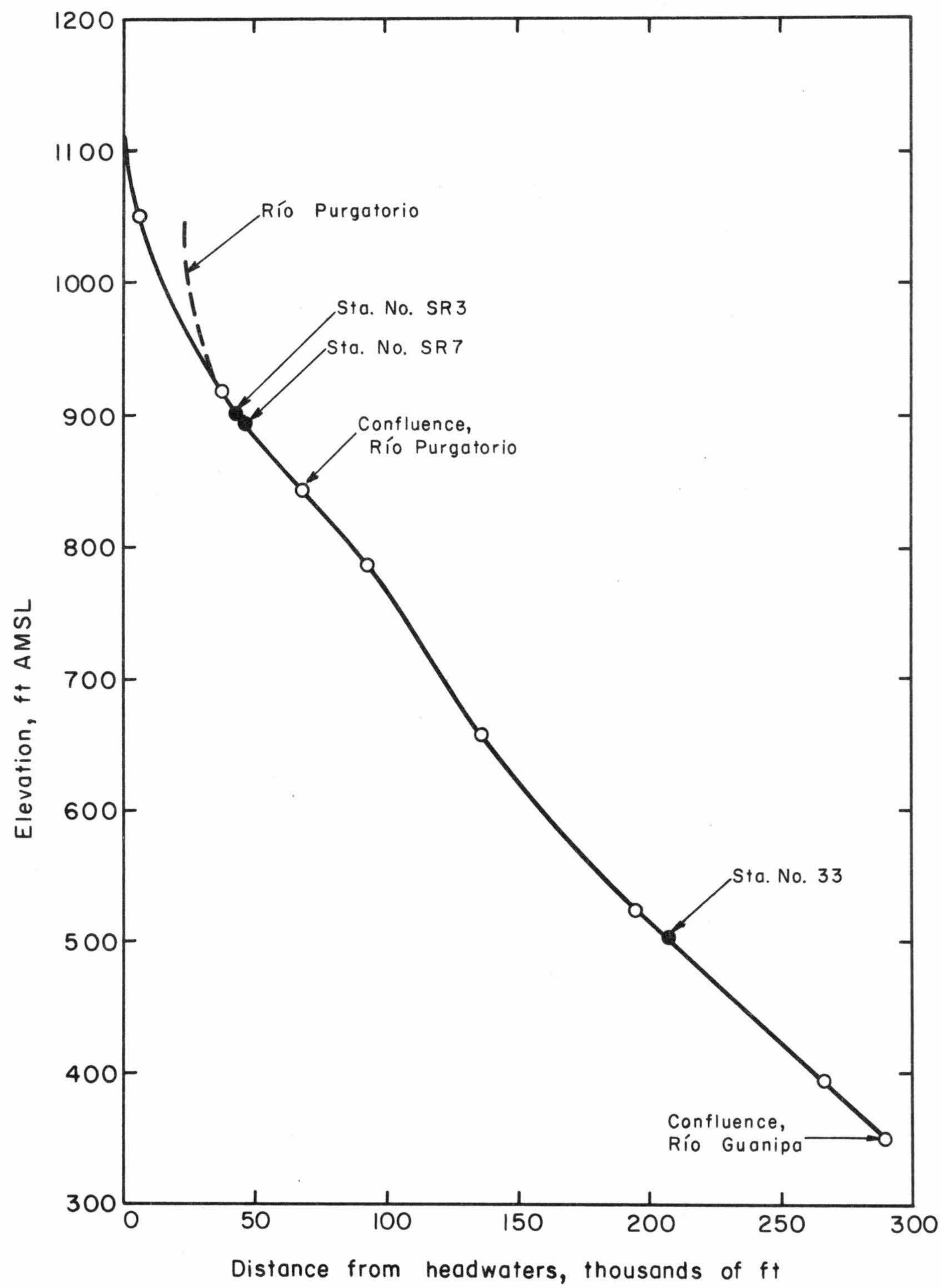


FIGURE II-11 PROFILE OF THE RIO CARIS

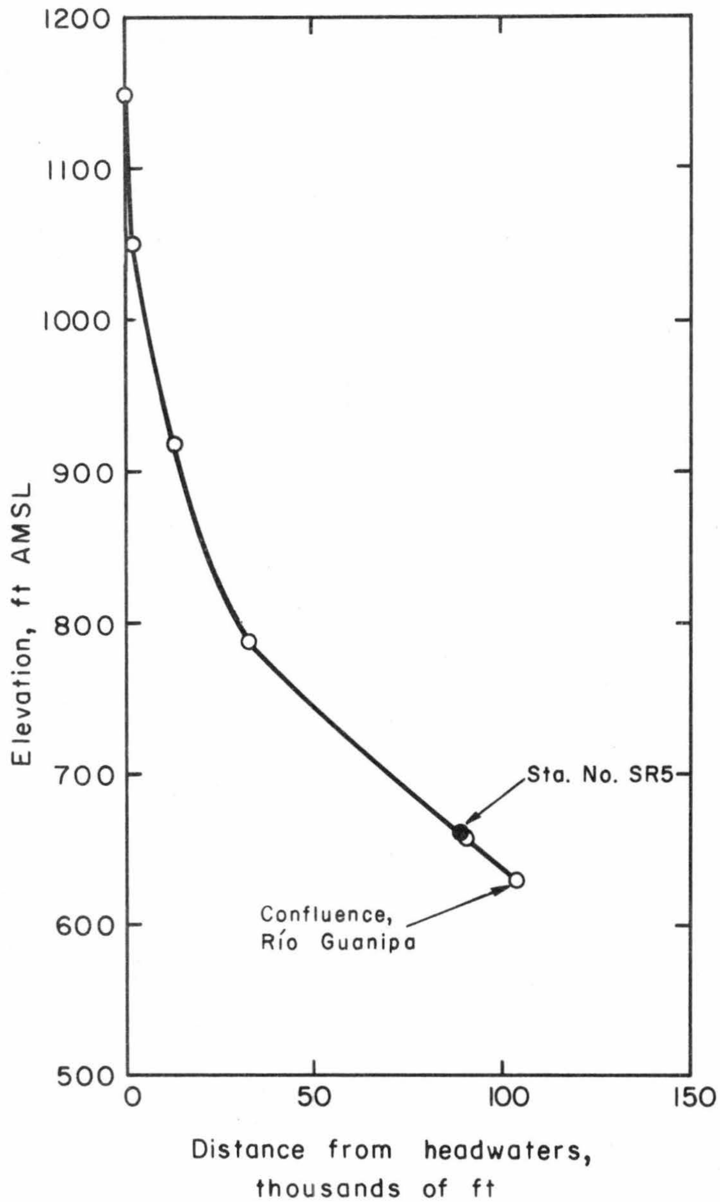


FIGURE II-12 PROFILE OF THE RIO CHUPURURO

TABLE II-4

RIO MAPIRITO BASIN PROFILE

Río	Location	Elevation ft AMSL	Distance from Sta. No. 41 ft	Distance from Sta. No. 41 mi
Mapirito	Sta. No. 41	149	0	0.0
	Contour, 60 m	197	31,100	5.9
	Contour, 80 m	262	70,600	13.4
	Contour, 100 m	328	102,900	19.5
	Contour, 120 m	394	132,700	25.1
	Contour, 140 m	459	166,700	31.6
	Contour, 160 m	525	207,500	39.3
	Contour, 200 m	656	250,700	47.5
	Headwaters	670	252,800	47.9

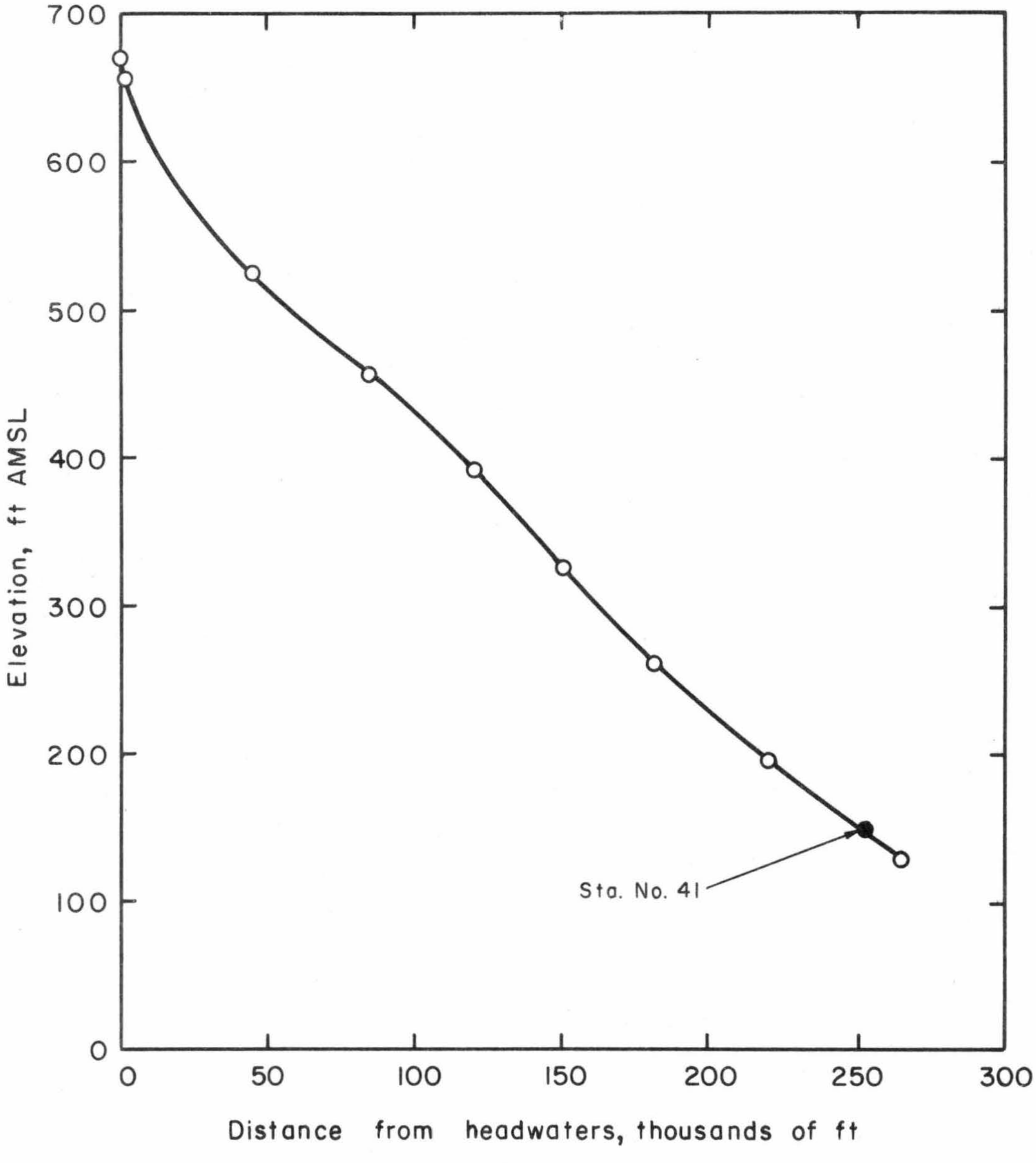


FIGURE II-13 PROFILE OF THE RIO MAPIRITO

TABLE II-5

RIO AMANA BASIN PROFILE

Río	Location	Elevation ft AMSL	Distance from Sta. No. 52 ft	Distance from Sta. No. 52 mi
Amana	Sta. No. 52	131	0	0.0
	Contour, 60 m	197	29,400	5.6
	Contour, 80 m	262	110,000	20.8
	Contour, 100 m	328	139,400	26.4
	Contour, 120 m	394	174,700	33.1
	Sta. No. 51	494	248,600	47.1
	Contour, 160 m	525	272,200	51.6
	Contour, 200 m	656	364,600	69.0
	Contour, 240 m	787	430,900	81.6
	Contour, 280 m	919	509,900	96.6
	Contour, 320 m	1050	535,100	101.3
	Contour, 360 m	1181	551,000	104.4
	Contour, 400 m	1312	560,700	106.2
	Contour, 440 m	1444	572,000	108.3
	Contour, 480 m	1575	587,200	111.2
	Contour, 520 m	1706	597,200	113.1
	Contour, 560 m	1837	604,800	114.5
	Contour, 600 m	1968	625,000	118.4
	Headwaters	2051	630,000	119.3

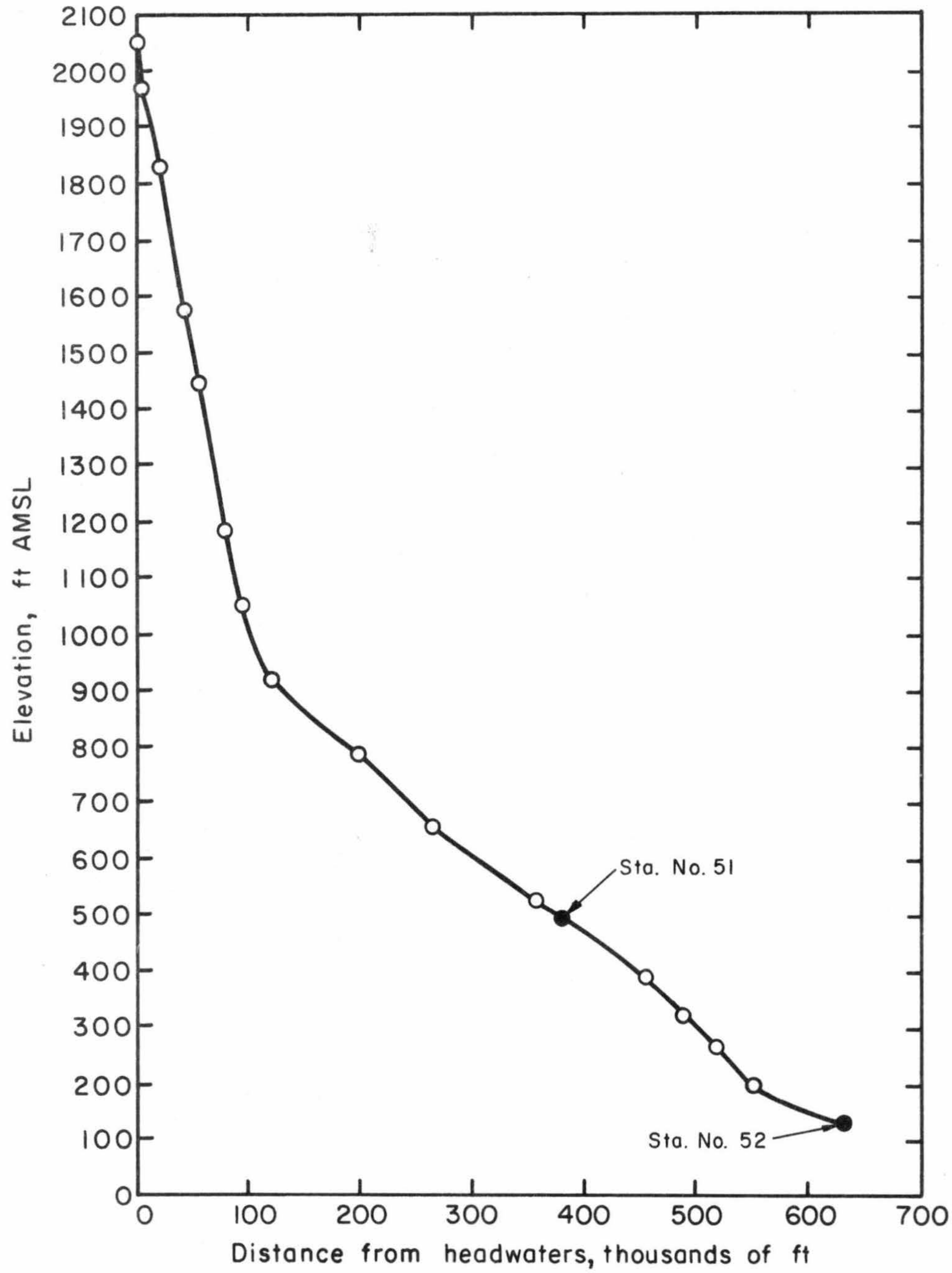


FIGURE II-14 PROFILE OF THE RIO AMANA

CHAPTER III

BED MATERIALS

In VIMHEX Hydrology Report, Volume II, Streamflow, Groundwater and Ground Response Data, the size analyses for the river bed-material samples collected at 10 intervals across the river bed at 30 locations in the drainage area were presented. The size-distributions of all the samples at a river location have been combined to give the composite bed-material size distribution at the location. The composite size distributions are reported in this chapter.

The sieve analyses of the composite bed-material samples for the 30 locations are given in Table III-1. In Table III-2, the median sieve size d_{50} and the size gradation parameter σ of the composite sample are given for each of the 30 locations. The size gradation parameter is defined as

$$\sigma = \frac{1}{2}\left[\frac{d_{84}}{d_{50}} + \frac{d_{50}}{d_{16}}\right]$$

where d_{16} and d_{84} are the sieve sizes for which 16 and 84 percent of the material by weight is finer.

In Tables III-3 and III-4, the elevation and river mileage of each location where bed-material samples were taken in the Río Tigre and Río Guanipa basins are listed along with the corresponding median sieve diameters. The same information is shown on Figure III-2. For the locations sampled in the study area, the bed-material size is apparently independent of the elevation of the location and is also independent of the distance along the river. The median size for most of the sampled locations was between 0.2 and 0.5 mm. At four locations the sampled bed-material sizes were much larger. Those locations are: the Río Oritupano near Pelayo (5.2 mm); the Río Aribí at Sta. No. 15 (2.3 mm); the Río Carisito at SR3 (2.2 mm); and the Río Tigre at El Tigrito (1.7 mm).

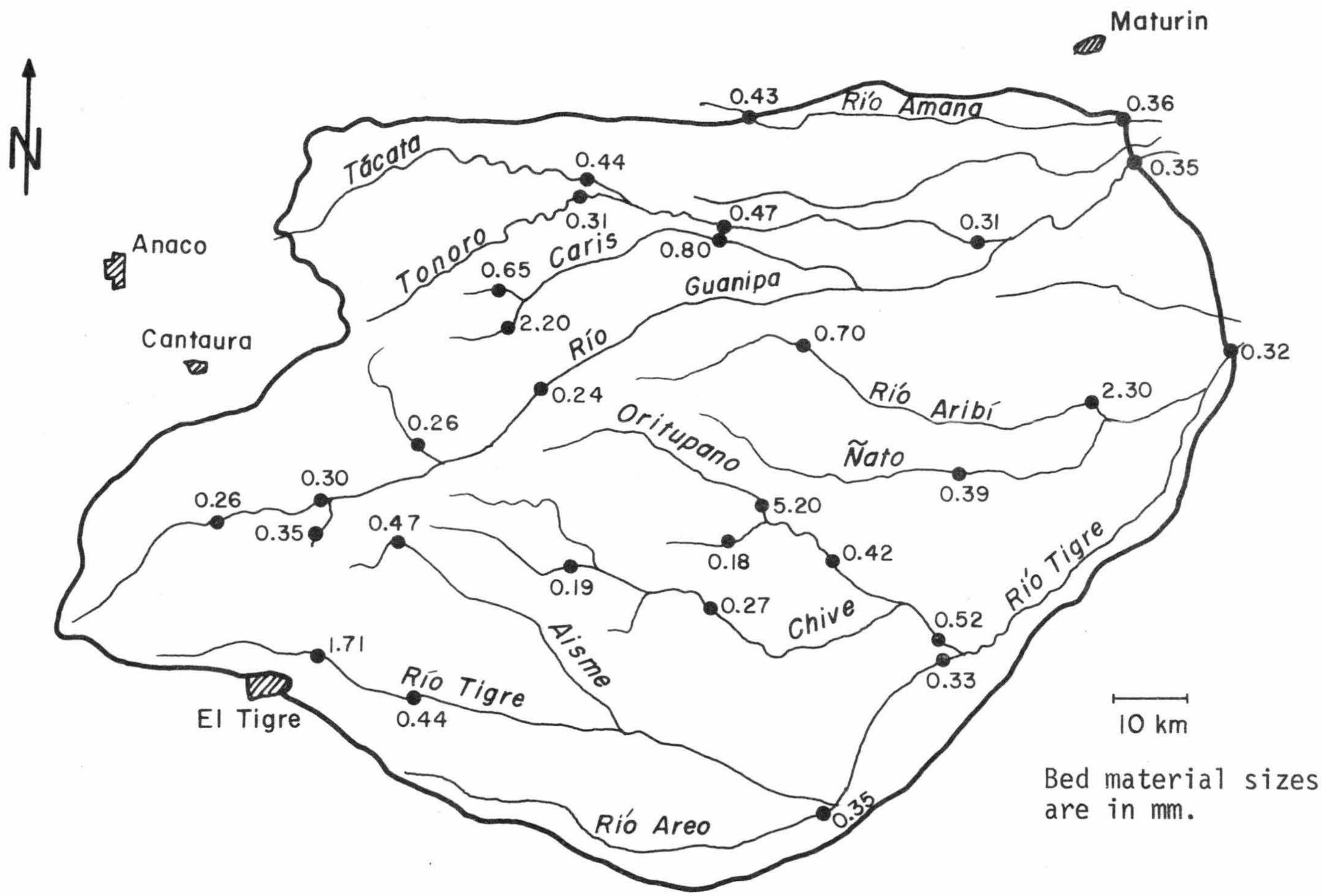


FIGURE III-1 COMPOSITE BED-MATERIAL SIZES

TABLE III-1

SIZE ANALYSES OF COMPOSITE BED-MATERIAL SAMPLES

Río	Sta. No.	Date	Percent, by weight, finer than 32 mm	26.7 mm	16.0 mm	12.5 mm	9.423 mm	8.0 mm	4.0 mm	2.0 mm	1.0 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm	0.053 mm
Oritupano at Los Caracas	12	Aug. 30				100.0	99.6	99.2	95.7	90.8	82.1	61.3	16.2	5.0	0.7	0.4
Chive at La Colmena	13	Aug. 30						100.0	99.8	99.5	98.0	91.2	45.0	8.8	1.6	1.0
Tigre at Las Piedritas	14	Sept. 11		100.0	98.7	98.3	96.5	95.6	92.3	89.8	75.1	71.9	35.1	3.2	0.2	0.1
Aribí at Paso de Aribí	15	Aug. 27	100.0	97.2	84.4	77.3	68.9	65.6	55.1	48.8	44.1	38.0	20.4	8.4	2.8	1.6
Nãto at Las Gaviotas	16	Aug. 30				100.0	99.1	98.1	90.1	83.3	76.9	65.1	20.2	3.2	0.7	0.6
Tigre at the Crossing of the Maturín-Temblador Road	17	Aug. 27						100.0	99.8	98.9	94.7	83.5	29.5	10.5	3.1	2.0
Guanipa at El Aceite	31	Aug. 30				100.0	99.9	99.9	99.4	98.3	95.5	89.1	35.9	3.6	0.1	0.1
Guanipa at Los Palos Blancos	32	Aug. 30				100.0	99.7	99.7	99.4	98.8	97.1	92.4	52.4	9.7	6.7	6.6
Caris at the Crossing of the Santa Bárbara-Aguasay Road	33	Aug. 27		100.0	98.9	97.2	93.6	91.6	80.8	68.6	58.7	32.4	9.6	2.7	0.6	0.4
Toronto at the Crossing of the Santa Bárbara-Aguasay Road	34	Aug. 27		100.0	97.9	97.2	95.3	93.8	84.9	76.4	68.8	53.3	13.0	2.5	0.8	0.6
Guanipa at the Crossing of the Maturín-Temblador Road	35	Aug. 27		100.0	99.5	98.8	97.1	95.3	93.2	90.1	86.5	77.1	22.8	1.2	0.1	0.0
Amana near El Tejero	51	Sept. 3			100.0	99.7	99.4	99.2	97.1	93.4	86.7	61.2	19.6	7.0	2.8	2.2
Amana at the Crossing of the Maturín-Temblador Road	52	Aug. 27						100.0	99.7	97.8	92.0	67.3	30.5	10.7	2.1	1.2
Areo at Hato "Areito"		Sept. 25		100.0	99.5	99.3	99.1	98.7	96.8	92.2	81.1	66.9	34.9	3.3	0.2	0.1
Aisme near El Aisme	SR2	Sept. 8	100.0	99.4	99.0	98.4	97.0	95.7	90.7	83.8	70.5	52.1	29.6	10.4	3.2	2.4
Carisito near Carisito	SR3	Sept. 3		100.0	97.8	95.0	89.1	85.1	65.3	48.0	37.7	29.5	9.3	1.5	0.5	0.3
Chive near Campamento La Leona	SR4	Sept. 8					100.0	99.9	97.1	93.6	90.4	84.8	67.2	21.9	9.5	8.2
Chupururo near Campo Mata	SR5	Sept. 8		100.0	98.2	96.9	95.0	93.9	86.7	77.3	68.9	61.0	48.9	35.1	20.6	17.6
Purgatorio near El Purgatorio	SR7	Sept. 9					100.0	89.9	75.6	63.6	55.4	46.6	19.3	3.1	0.6	0.4
Quebrada Mapiricure o San Miguel near El Aceite	SR9	Sept. 8			100.0	99.8	99.6	99.4	98.8	97.1	86.9	66.3	34.0	3.7	0.4	0.3

TABLE III-1 (continued)

SIZE ANALYSES OF COMPOSITE BED-MATERIAL SAMPLES

Río	Sta. No.	Date	Percent, by weight, finer than 32 mm	26.7 mm	16.0 mm	12.5 mm	9.423 mm	8.0 mm	4.0 mm	2.0 mm	1.0 mm	0.5 mm	0.25 mm	0.125 mm	0.063 mm	0.053 mm
Aribí at Día Perdido		Sept. 6	100.0	98.9	89.3	86.5	80.4	76.7	66.1	56.7	51.8	48.1	30.8	12.1	7.1	6.6
Guanipa at Santa Rosa		Sept. 6		100.0	99.8	99.7	99.5	99.3	98.7	97.3	94.5	88.0	46.9	5.3	0.8	0.3
Guibimba near Boca de Guibimba		Sept. 9						100.0	99.9	99.9	99.6	97.9	78.6	15.4	4.4	0.6
Oritupano near Pelayo		Sept. 6		100.0	86.3	77.6	66.4	61.9	42.9	32.8	28.2	25.0	17.2	9.0	5.5	5.0
Oritupano at Las Piedritas		Sept. 11		100.0	99.2	98.0	95.7	93.8	88.8	82.4	71.6	48.5	5.6	0.6	0.2	0.1
Tácata (1 km upstream from junction with Río Tonoro)		Sept. 3		100.0	99.2	98.4	95.1	93.7	85.9	78.9	72.4	57.5	17.1	5.1	2.7	2.2
Tigre at Cristobero		Sept. 23					100.0	99.7	97.0	93.6	81.7	55.9	29.5	7.8	0.8	0.4
Tigre at El Tigrito		Sept. 6	98.3	95.7	88.6	84.5	76.0	71.8	60.5	52.4	41.9	31.2	16.6	3.7	0.5	0.4
Tonoro at El Zamuro		Sept. 3				100.0	99.9	99.7	97.6	95.6	93.4	86.2	31.2	8.8	4.2	3.2
Tonoro upstream of Tonoro		Sept. 3				100.0	99.7	99.4	98.0	96.3	94.0	86.6	35.4	6.4	1.3	0.8

TABLE III-2

BED-MATERIAL SIZE SUMMARY

Río	Sta. No.	Date	d_{16} mm	d_{84} mm	d_{50} mm	σ
Oritupano at Los Caracas	12	Aug. 30	0.24	1.15	0.42	2.24
Chive at La Colmena	13	Aug. 30	0.14	0.44	0.27	1.78
Tigre at Las Piedritas	14	Sept. 11	0.17	1.52	0.33	3.27
Aribí at Paso de Aribí	15	Aug. 27	0.19	15.70	2.30	9.46
Ñato at Las Gaviotas	16	Aug. 30	0.21	2.15	0.39	3.68
Tigre at the Crossing of the Maturín-Temblador Road	17	Aug. 27	0.15	0.52	0.32	1.88
Guanipa at El Aceite	31	Aug. 30	0.16	0.47	0.30	1.72
Guanipa at Los Palos Blancos	32	Aug. 30	0.14	0.43	0.24	1.75
Caris at the Crossing of the Santa Bárbara-Aguasay Road	33	Aug. 27	0.31	4.85	0.80	4.32
Tonoro at the Crossing of the Santa Bárbara-Aguasay Road	34	Aug. 27	0.26	3.70	0.47	4.84
Guanipa at the Crossing of the Maturín-Temblador Road	35	Aug. 27	0.20	0.80	0.35	2.02
Amana near El Tejero	51	Sept. 3	0.20	0.94	0.43	2.17
Amana at the Crossing of the Maturín-Temblador Road	52	Aug. 27	0.15	0.81	0.36	2.32
Areo at Hato "Areito"		Sept. 25	0.17	1.20	0.35	2.74
Aisme near El Aisme	SR2	Sept. 8	0.15	2.05	0.47	3.75
Carisito near Carisito	SR3	Sept. 3	0.32	7.70	2.20	5.19
Chive near Campamento La Leona	SR4	Sept. 8	0.09	0.48	0.19	2.32
Chupururo near Campo Mata	SR5	Sept. 8	0.05	3.25	0.26	8.85
Purgatorio near El Purgatorio	SR7	Sept. 9	0.22	6.10	0.65	6.17
Quebrada Mapiricure o San Miguel near El Aceite	SR9	Sept. 8	0.17	0.90	0.35	2.32

TABLE III-2 (continued)

BED-MATERIAL SIZE SUMMARY

Río	Sta. No.	Date	d_{16} mm	d_{84} mm	d_{50} mm	σ
Aribí at Día Perdido	—	Sept. 6	0.14	11.00	0.70	10.36
Guanipa at Santa Rosa	—	Sept. 6	0.15	0.47	0.26	1.77
Guibimba near Boca de Guibimba	—	Sept. 9	0.13	0.30	0.18	1.53
Oritupano near Pelayo	—	Sept. 6	0.23	15.00	5.20	12.75
Oritupano at Las Piedritas	—	Sept. 11	0.30	2.35	0.52	3.13
Tácata (1 km upstream from junction with Río Tonoro)	—	Sept. 3	0.23	3.32	0.44	4.73
Tigre at Cristobero	—	Sept. 23	0.16	1.18	0.44	2.72
Tigre at El Tigrito	—	Sept. 6	0.28	12.30	1.71	6.65
Tonoro at El Zamuro	—	Sept. 3	0.16	0.49	0.31	1.76
Tonoro upstream of Tonoro	—	Sept. 3	0.16	0.48	0.31	1.74

TABLE III-3

BED MATERIALS - RIO TIGRE BASIN

Río	Location	d_{50} mm	Elevation ft AMSL	Distance from Sta. No. 17 mi
Tigre	Sta. No. 17	0.32	70	0.0
	Confluence, Oritupano	0.33	295	83.5
	Cristobero	0.44	610	157.9
	El Tigrito	1.71	695	166.6
Aribí	Sta. No. 15	2.30	155	31.3
Ñato	Sta. No. 16	0.39	248	48.8
Oritupano	Confluence, Tigre	0.52	295	83.5
	Sta. No. 12	0.42	373	111.0
	Pelayo	5.20	432	129.1
Guibimba	Boca de Guibimba	0.18	428	128.4
Chive	Sta. No. 13	0.27	507	117.1
	SR4	0.19	578	133.3
Aisme	SR2	0.47	759	172.5
Areo	Sta. No. 11	0.35	320	114.2

TABLE III-4

BED MATERIALS - RIO GUANIPA BASIN

Río	Location	d_{50} mm	Elevation ft AMSL	Distance from Sta. No. 35 mi
Guanipa	Sta. No. 35	0.35	160	0.0
	Sta. No. 32	0.24	560	115.3
	Sta. No. 31	0.30	690	154.2
	Santa Rosa	0.26	770	171.5
Tonoro	Near El Zamuro	0.31	262	24.3
	Sta. No. 34	0.47	511	52.2
	Near Tonoro	0.31	666	67.3
Tácata	Confluence, Tonoro	0.44	668	67.5
Caris	Sta. No. 33	0.80	503	69.4
Carisito	SR3	2.20	901	100.6
Purgatorio	SR7	0.65	893	100.1
Chupururo	SR5	0.26	660	139.4
Mapiricure	SR9	0.35	820	158.1

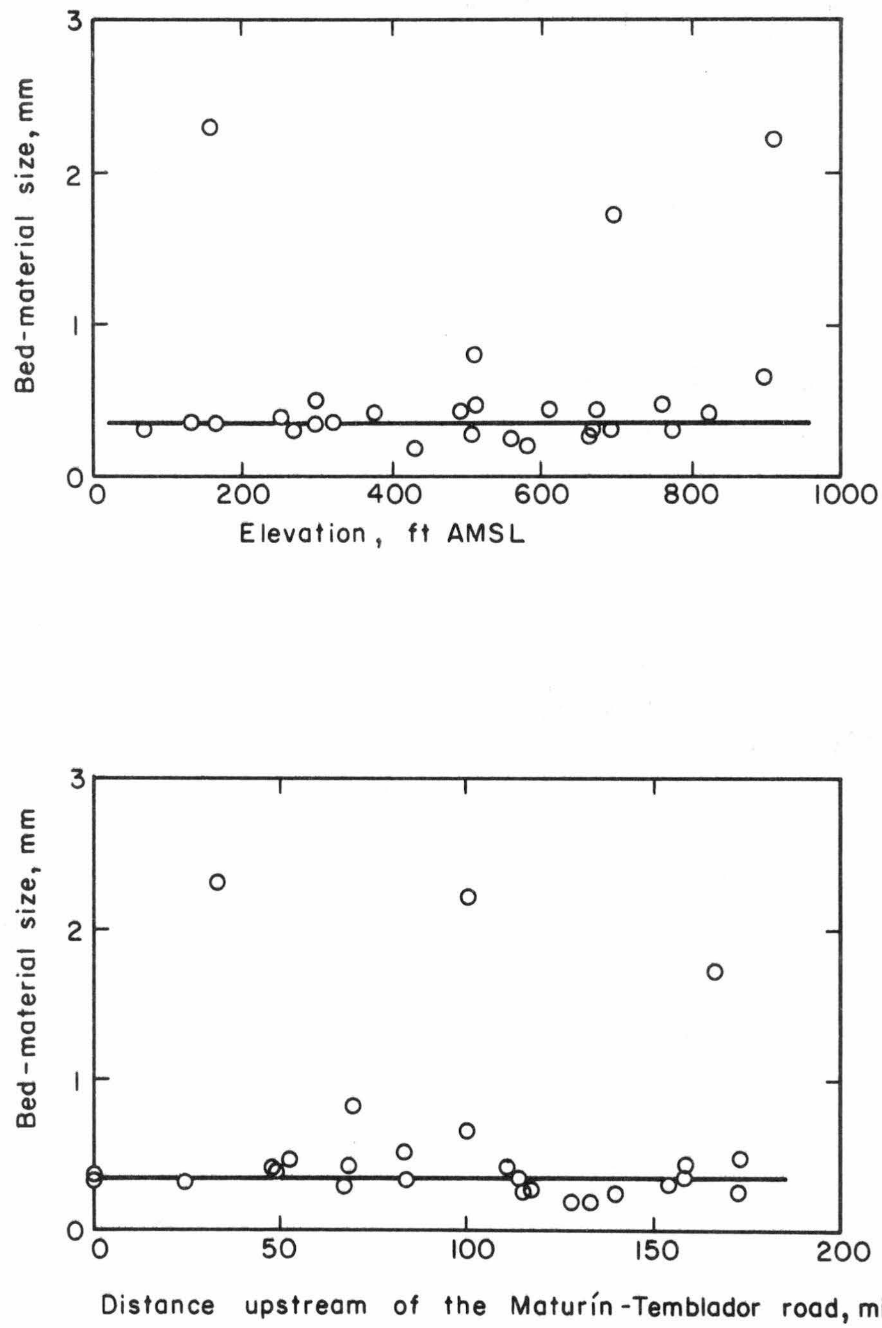


FIGURE III-2 VARIATION OF BED-MATERIAL SIZE
WITH ELEVATION AND DISTANCE

CHAPTER IV

GEOMETRIC AND HYDRAULIC DATA AT PRIMARY RIVER GAGING STATIONS

INTRODUCTION

The 16 primary gaging stations which were established in the study area in 1969 are shown on Figure IV-1. The descriptions of these stations, the discharge measurement summaries, the discharge rating tables and the discharge records for the 16 stations are presented in VIMHEX Hydrology Report, Volume II, Streamflow, Groundwater and Ground Response Data.

Relations between measured river discharge and flow velocity, flow area, top width and wetted perimeter at 11 primary gaging stations have been established and are presented in this chapter. From the discharge-area, discharge-top width and discharge-wetted perimeter relations, the variations of hydraulic depth, hydraulic radius, top width to hydraulic depth ratio, and Manning's n with discharge are computed.

At five primary gaging stations, the data collected were judged not representative of the river reach and have not been included in this report. The Río Areo at Las Bombitas (Sta. No. 11) is affected by backwater from the Río Tigre. Therefore, the variations in hydraulic and geometric properties at Sta. No. 11 are dependent not only on the flow in the Río Areo but also on the flow in the Río Tigre. On the Río Chive at La Colmena (Sta. No. 13), on the Río Guanipa at Los Palos Blancos (Sta. No. 32) and on the Río Amana near El Tejero (Sta. No. 51), each river channel is constricted by a bridge. The only data available at these three sites are measurements taken at the bridge section. The Río San Antonio at the crossing of the Maturín-Temblador road was dry during the study period.

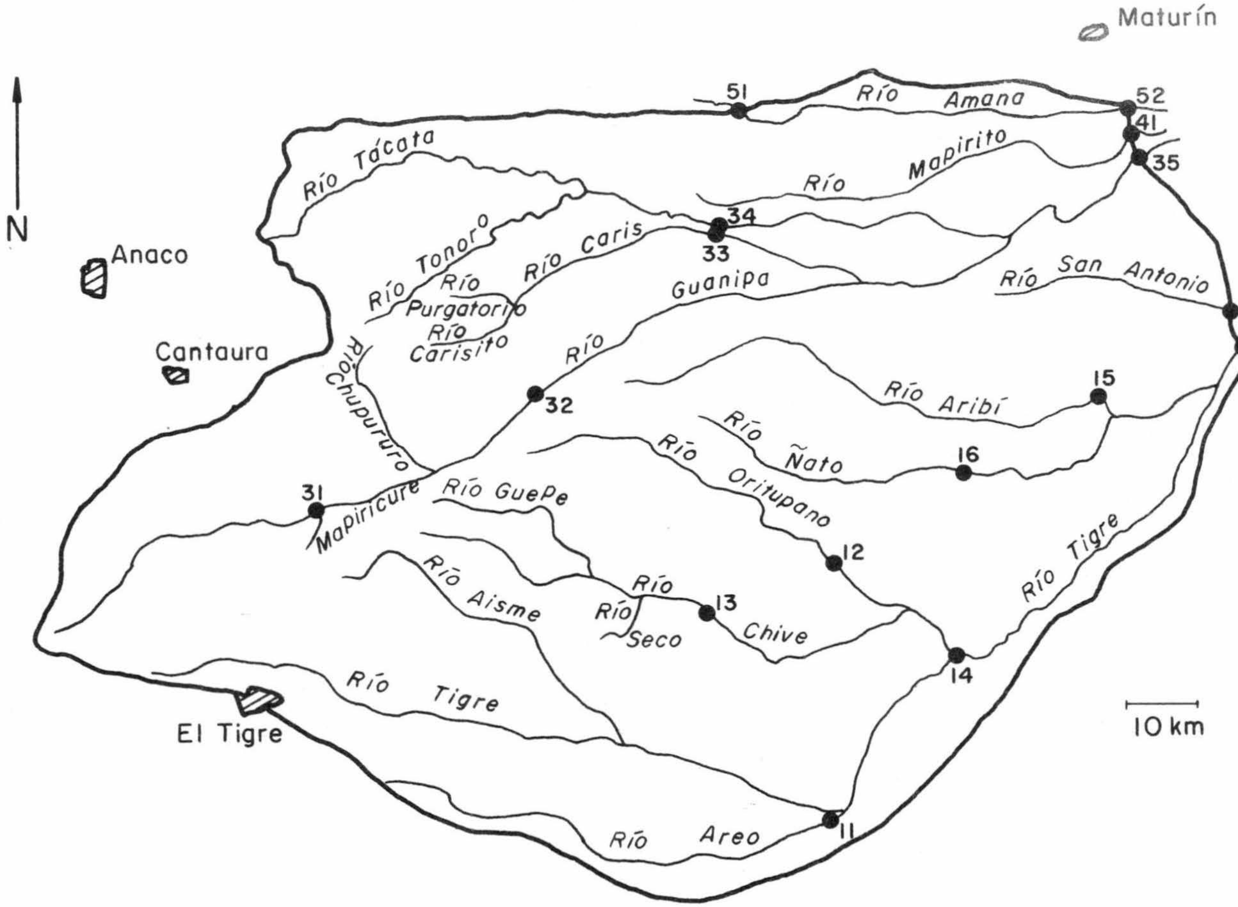


FIGURE IV-1 LOCATIONS OF PRIMARY STREAM GAGING STATIONS

THEORETICAL CONSIDERATIONS

The hydraulic and geometric properties of a river reach can be related in accordance with Manning's equation for open channel flow. The equation is

$$V = \frac{1.486}{n} R^{2/3} S_f^{1/2}$$

where V is the average flow velocity in the reach in fps; n is Manning's roughness coefficient; R is the hydraulic radius of the channel in feet; and S_f is the slope of the energy grade line in feet per foot. In the absence of significant local and convective fluid accelerations in the reach, the energy grade line slope can be replaced by the water surface slope, S_w. Furthermore, if the channel is prismatic, the water surface slope is equal to the bed slope, S_o.

In a river reach where S_w is constant throughout for a given discharge Q, the average velocity V and the hydraulic radius R are obtained in the following manner.

The volume of water within the reach can be approximated as

$$V = \frac{1}{2} \sum_{i=1}^{m-1} (A_i + A_{i+1}) (L_{i+1} - L_i)$$

where A_i is the cross-sectional area of the water passage at a distance L_i downstream along the thalweg from some arbitrary reference point and m is the number of cross sections describing the reach (see Figure IV-2).

The length of the river reach is

$$L = L_m - L_1$$

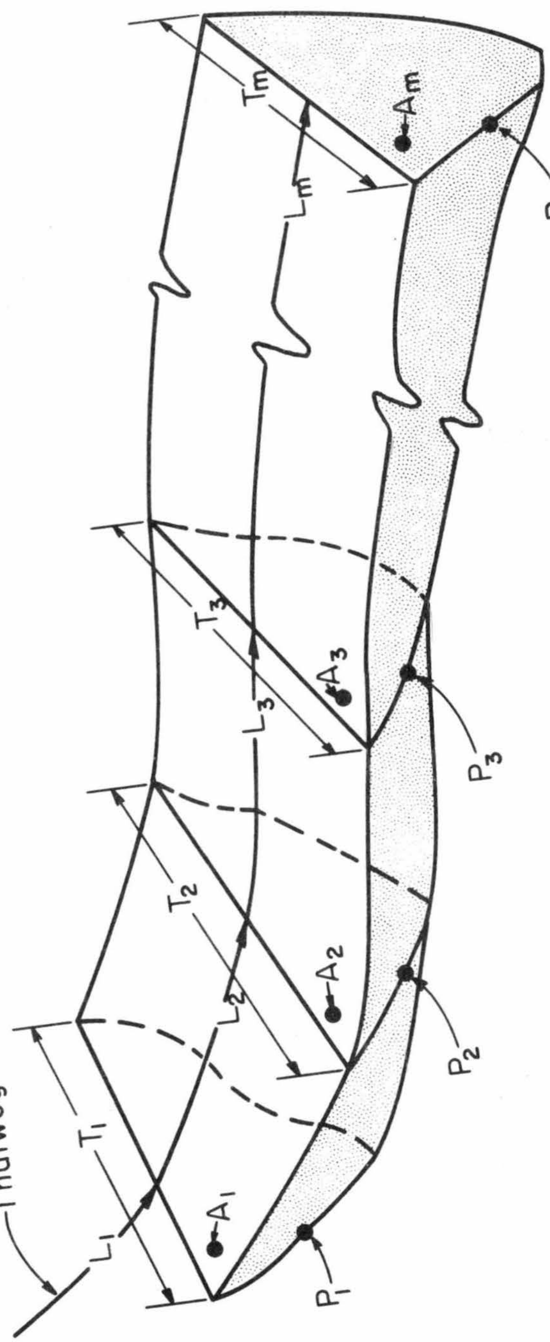


FIGURE IV-2 GEOMETRY OF A RIVER REACH

The average cross-sectional area is the volume divided by the length of the reach or

$$A = \frac{\sum_{i=1}^{m-1} (A_i + A_{i+1}) (L_{i+1} - L_i)}{2 (L_m - L_i)}$$

Similarly, the average wetted perimeter of the reach is

$$P = \frac{\sum_{i=1}^{m-1} (P_i + P_{i+1}) (L_{i+1} - L_i)}{2 (L_m - L_i)}$$

and the average top width is

$$T = \frac{\sum_{i=1}^{m-1} (T_i + T_{i+1}) (L_{i+1} - L_i)}{2 (L_m - L_1)}$$

The hydraulic radius representative of the reach is the average area divided by the average wetted perimeter or

$$R = \frac{A}{P} = \frac{\sum_{i=1}^{m-1} (A_i + A_{i+1}) (L_{i+1} - L_i)}{\sum_{i=1}^{m-1} (P_i + P_{i+1}) (L_{i+1} - L_i)}$$

and the hydraulic depth is

$$D = \frac{A}{T} = \frac{\sum_{i=1}^{m-1} (A_i + A_{i+1}) (L_{i+1} - L_i)}{\sum_{i=1}^{m-1} (T_i + T_{i+1}) (L_{i+1} - L_i)}$$

The average velocity for the reach is

$$V = \frac{Q}{A} = \frac{2\,(L_m - L_1)\,Q}{\sum_{i=1}^{m-1} (A_i + A_{i+1})\,(L_{i+1} - L_i)}$$

In the VIMHEX program, the geometry of a reach was surveyed and related to the gage height at the gaging station. If it is assumed that the geometry-stage relations remain unchanged during succeeding flood hydrographs, then the reach geometry is related to the discharge according to the stage-discharge curve. The above method of relating surveyed reach geometry and hydraulic parameters is called the "survey method" in this report.

For reaches that have not been surveyed, the geometric and hydraulic data are taken from the discharge measurement notes for the gaging station. The information in the discharge measurement notes indicate how the geometry at one cross section changes during hydrograph events. When information from the discharge measurement notes are used to describe the reach, the method is called the "measurement summary" method. For reaches in which the top width to hydraulic depth ratio is greater than 40, it is assumed that the hydraulic depth and hydraulic radius are equivalent.

In the computation for Manning's n, the energy grade line slope is replaced by the bed slope obtained from topographic maps (see Chapter II).

STATION DATA

At each gaging station, a reference bench mark was established to provide vertical control for measurements at the station. Usually, the elevation of the bench mark was assumed to be 100.00 feet. The approximate "above mean sea level" elevations of the gaging stations are obtained from the topographic maps and are given in Chapter II.

When surveys were made on a river reach, the bearing of the horizontal control line was established by compass. Those north point references shown on the plan drawings of river reaches are magnetic north points.

In this report, the discharge is represented as the independent variable and all other hydraulic and geometric properties of a river reach are related to the discharge. The procedure for establishing mean fit curves for the relations is as follows:

1. Plot the measured cross-sectional area, the mean velocity, and the measured top width values versus the corresponding discharge for each measured discharge;

2. Establish a smooth curve through the area-discharge and velocity-discharge data while retaining the relation that $Q = VA$ for the two smoothed curves;

3. Establish a smooth curve through the top width-discharge values;

4. Compute the hydraulic depth-discharge relation from the area-discharge and top width-discharge curves;

5. Establish the top width to hydraulic depth ratio versus discharge curve with values obtained from the top width-discharge and hydraulic depth-discharge curves;

6. If the top width to hydraulic depth ratio is greater than 40, assume that the hydraulic radius is equal to the hydraulic depth. If the ratio is less than 40, compute the wetted perimeter for each measured discharge and establish a wetted perimeter-discharge curve.

7. Compute the hydraulic radius discharge relation with values obtained from the wetted perimeter-discharge and area-discharge curves;

8. Compute Manning's roughness coefficient,

$$n = \frac{1.486}{V} R^{2/3} S^{1/2}$$

Values for velocity and hydraulic radius are obtained from the velocity-discharge and hydraulic radius-discharge curves and the slope is given in Table II-1. Establish the Manning's n-discharge relation:

9. Establish the Manning's n-stream power relation assuming that the stream power is the product of the unit weight of water, the hydraulic depth, the slope and the average velocity.

In this report, the drawings of cross sections are usually distorted 10 to 1. That is, the vertical scale is 10 times larger than the horizontal scale. The scale of the cross section is not shown but can be determined from the information given on the drawing. At the lowest point of the cross section, the lateral position is designated "0" (zero). The elevation of the lowest point is given along with the lateral position in the form $\frac{92.7}{0}$ for example. The elevation and lateral position of a point on each bank are also given. For example, the position $\frac{102.8}{10R}$ indicates that the point is at elevation 102.8 feet and is 10 feet to the right of the thalweg.

Sta. No. 11 Río Areo at Las Bombitas

Longitude 63° 31.5' W, latitude 08° 44.9' N. Approximately 35 km SSW of Oritupano, 1.2 km NW of Las Bombitas.

The 1600-foot reach of river upstream of the gaging station was surveyed on October 16, 1969. The river was at bankfull stage. The gage height at the A-35 recorder was 1.07 feet and at the Type F the gage height was 1.65 feet. The discharge was approximately 150 cfs. A photograph of the gaging station is given in Volume II, page II-5.

The information obtained from the survey is shown on the plan and cross-section drawings. The water surface profile between the Type F and A-35 recorders is shown on Figure IV-5. The average water surface slope on October 16, 1969 was 1.96 feet per mile for a discharge of 150 cfs in the Río Areo. The bed slope obtained from the topographic map is 2.0 feet per mile (Table II-1). The reference bench mark was established on the center-line of the bridge on top of the deck beam over the set of piers next to the south abutment. The elevation of the bench mark is assumed to be 100.00 feet. Relative to this bench mark, the zero gage height corresponds to a stage of 95.20 feet. All surveyed cross sections are referenced to the elevation of the bench mark.

The survey data were used to establish a stage-discharge relation for the gaging station. The method employed to compute the discharges is described in "Computation of Discharge at Gaging Stations Affected by Backwater," by James H. Duke, 1967, Thesis, The University of Texas, Austin, Texas.

The bed-material size at the Areo gaging station is 0.35 mm diameter sand. The bank material is described in Volume II, page III-29.

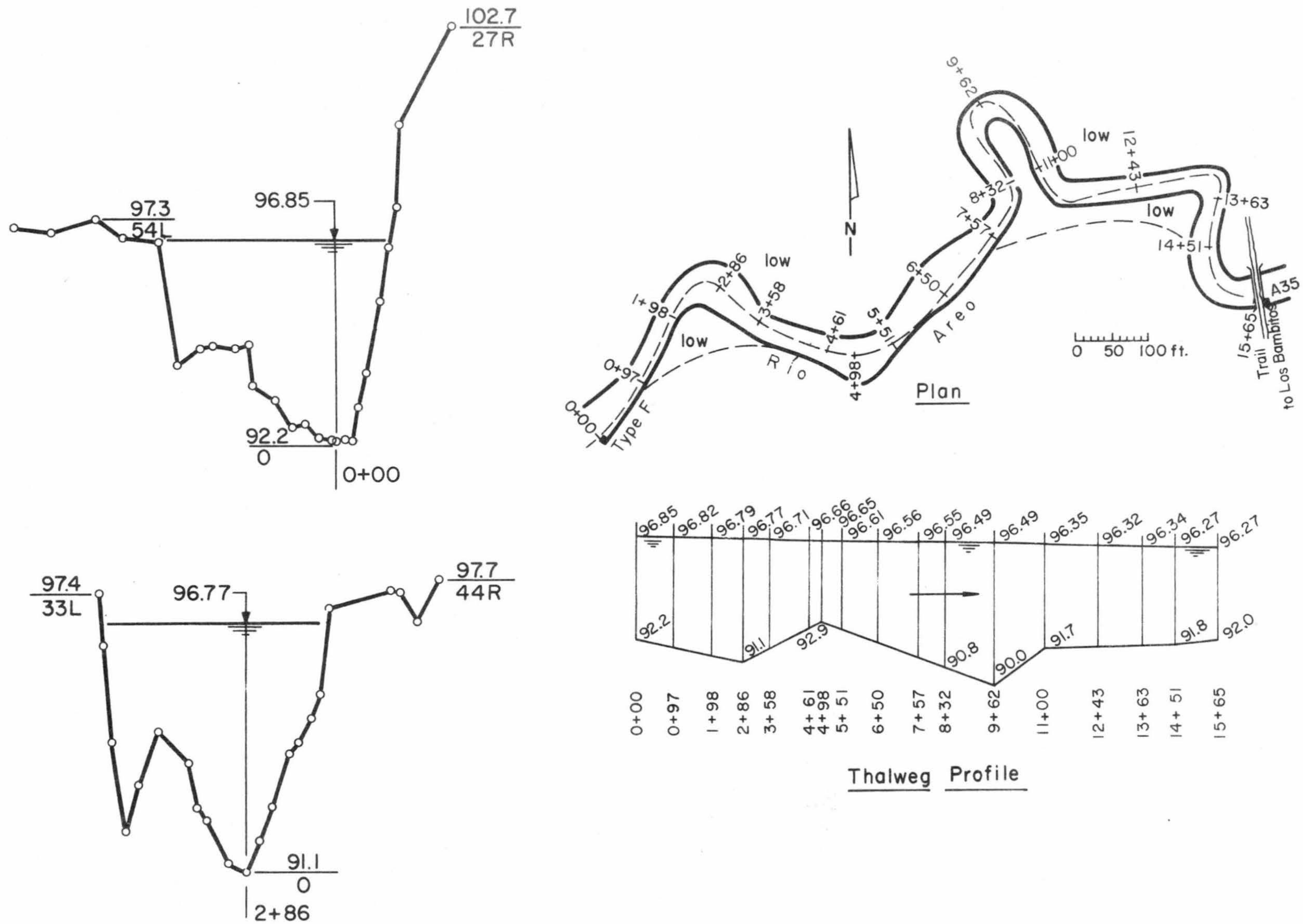


FIGURE IV-3 RIO AREO PLAN AND CROSS SECTIONS

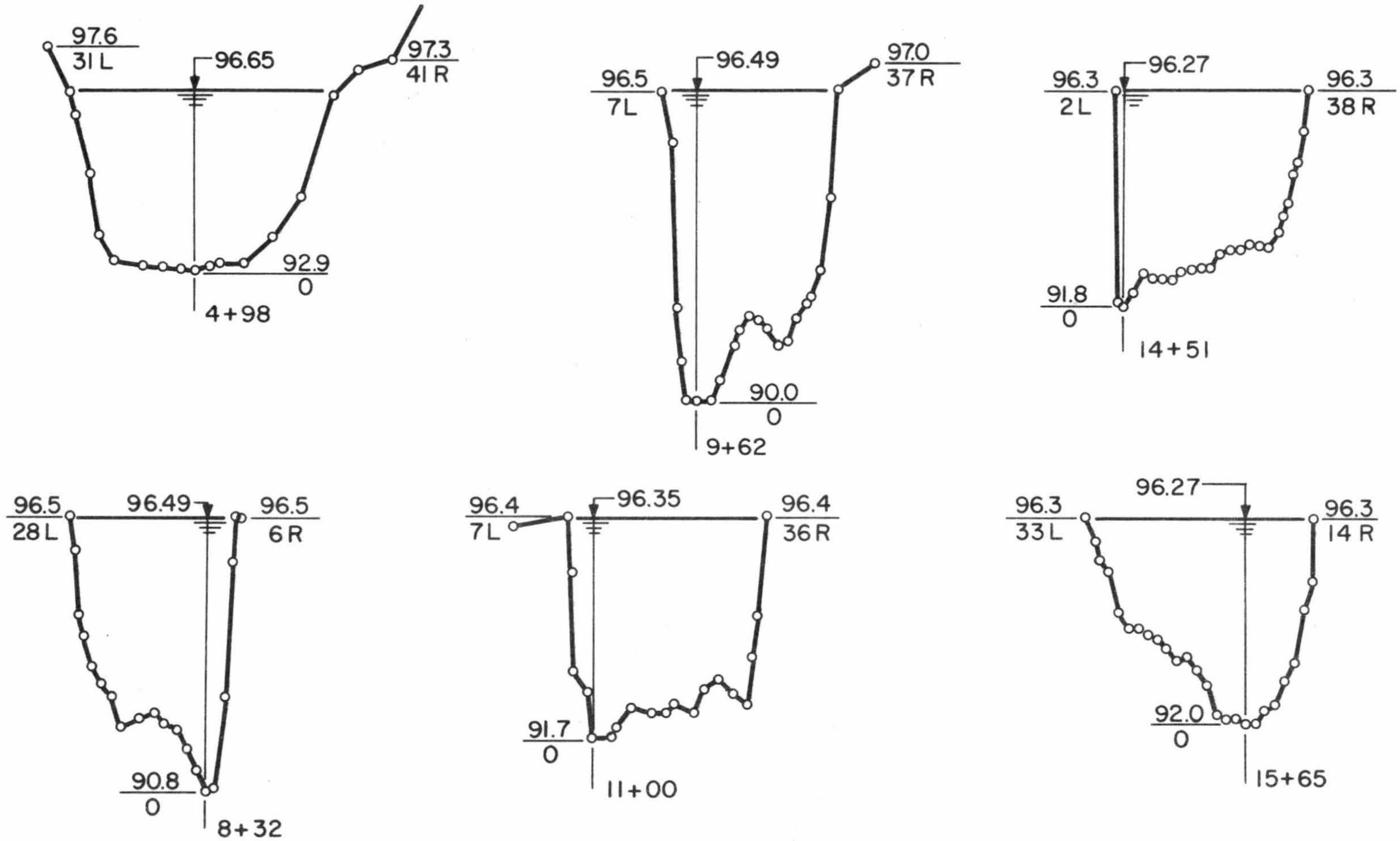


FIGURE IV-4 RIO AREO CROSS SECTIONS

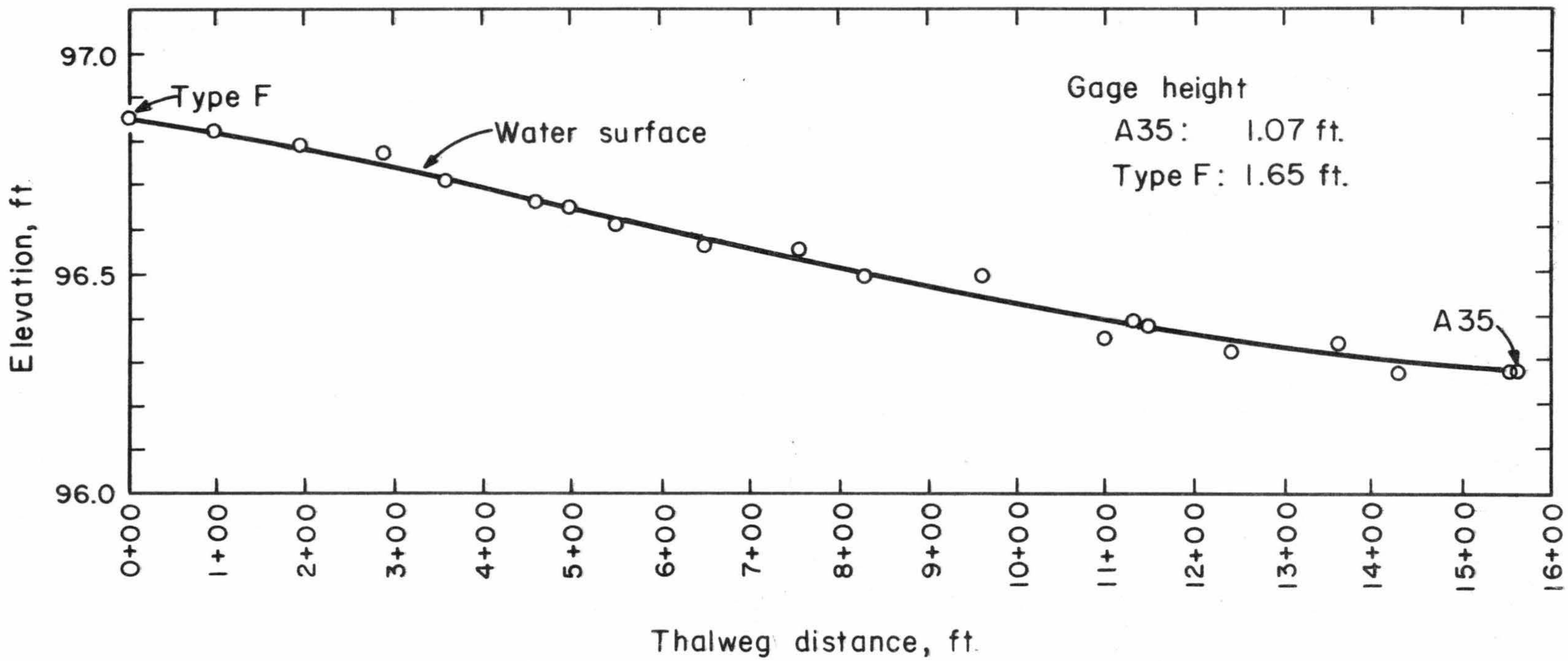


FIGURE IV-5 RIO AREO WATER SURFACE PROFILE

Sta. No. 12 Río Oritupano at Los Caracas

Longitude 63° 30.6' W, latitude 09° 04.2' N. Approximately 7.3 km WNW of Oritupano, at Los Caracas.

The reach of river shown on Figure IV-6 was surveyed on September 25, 1969. The gage height was 1.20 feet and the discharge was 73 cfs. The zero gage height corresponds to elevation 89.94 feet. The reference bench mark (elevation 100.00 feet assumed) is the top of the pipe guard railing on the downstream side of the bridge at the southeast abutment.

The properties of the Río Oritupano at the bridge location are shown on Figures IV-8 and IV-9. These relations are developed from the discharge measurement summary. The same type of relations are also developed from cross section Sta. 0+00 (Figure IV-6). In 1969, cross sections downstream of the bridge were undergoing changes as a cutoff was developing on the point bar at the first bend downstream of the bridge.

The slope of the river is 2.8 feet per mile (Table II-1) and the bed-material size is 0.42 mm (Figure III-1). The bank material is described in Volume II, page III-29 and an aerial photograph of the reach of river is given in Volume II, page II-15.

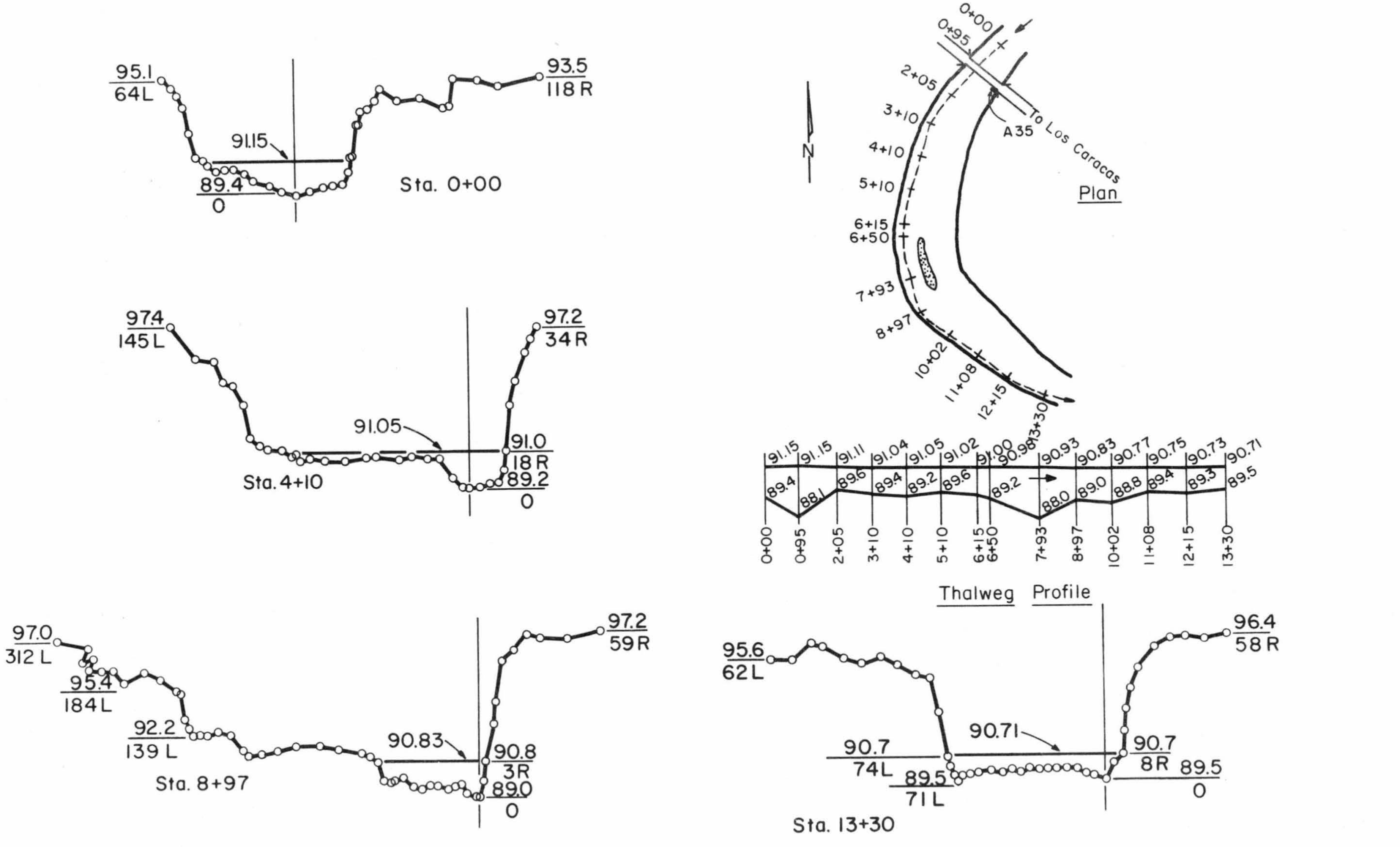


FIGURE IV-6 RIO ORITUPANO PLAN AND CROSS SECTIONS

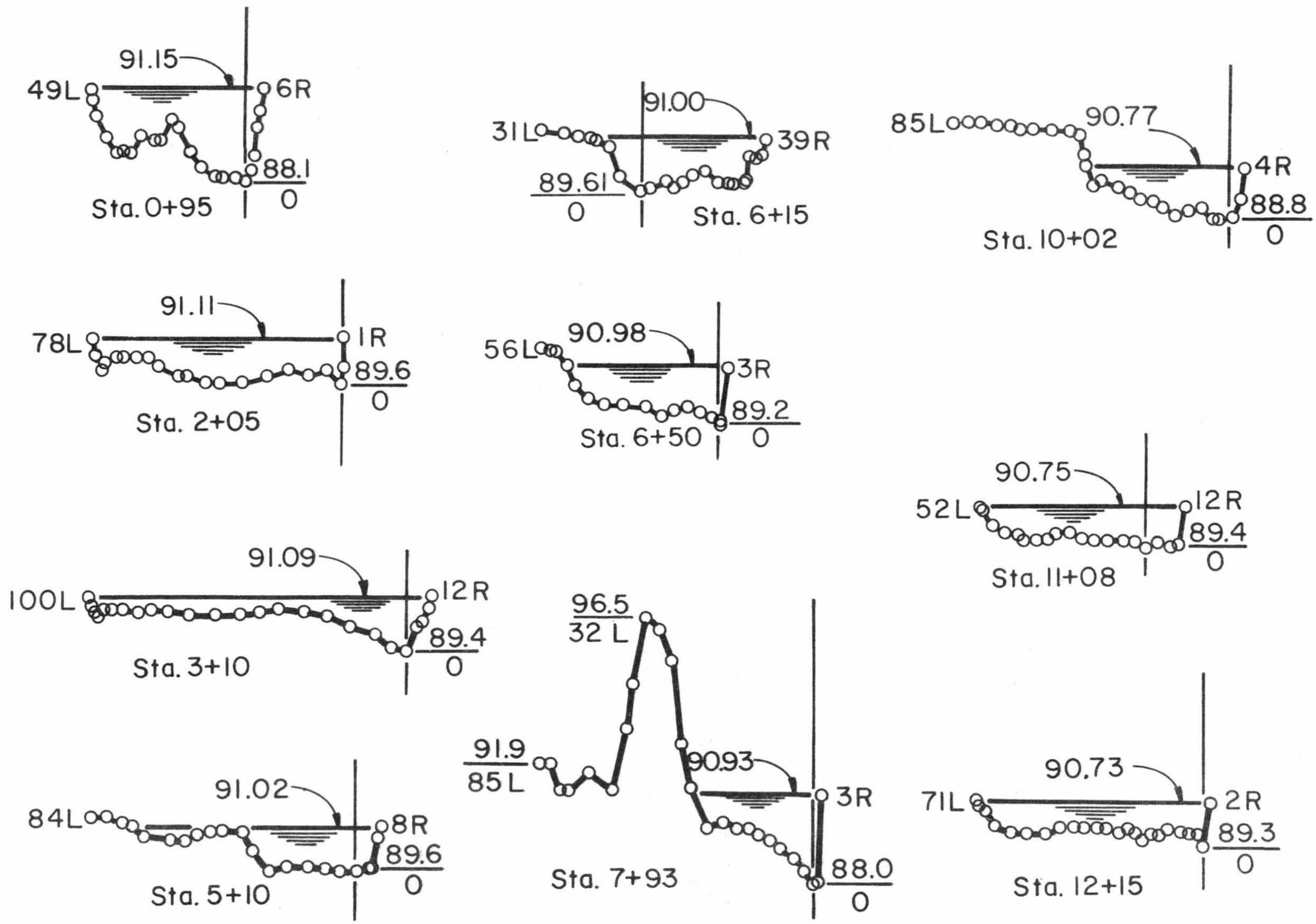


FIGURE IV-7 RIO ORITUPANO CROSS SECTIONS

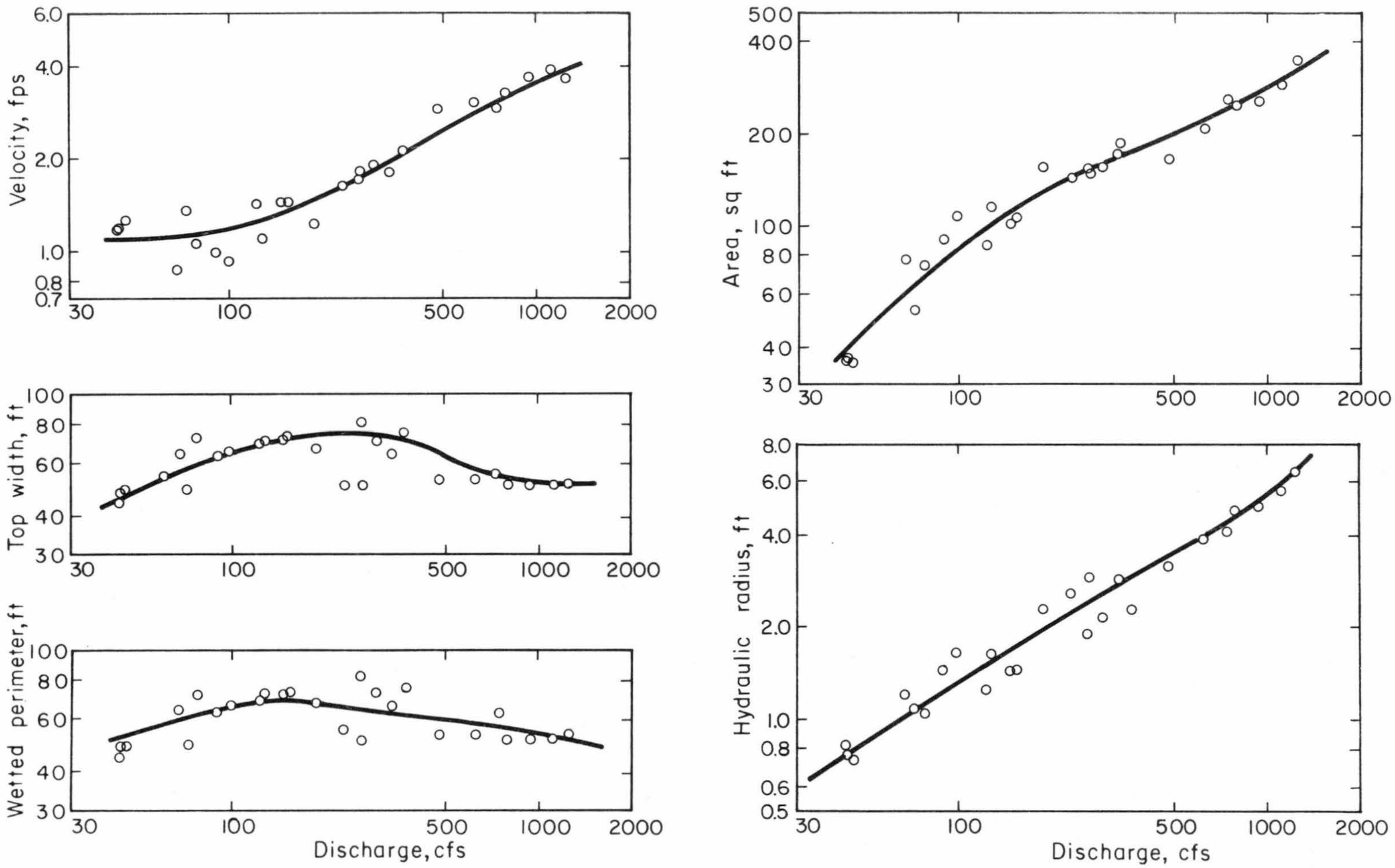


FIGURE IV-8 RIO ORITUPANO RELATIONS DEVELOPED FROM THE DISCHARGE MEASUREMENT SUMMARY

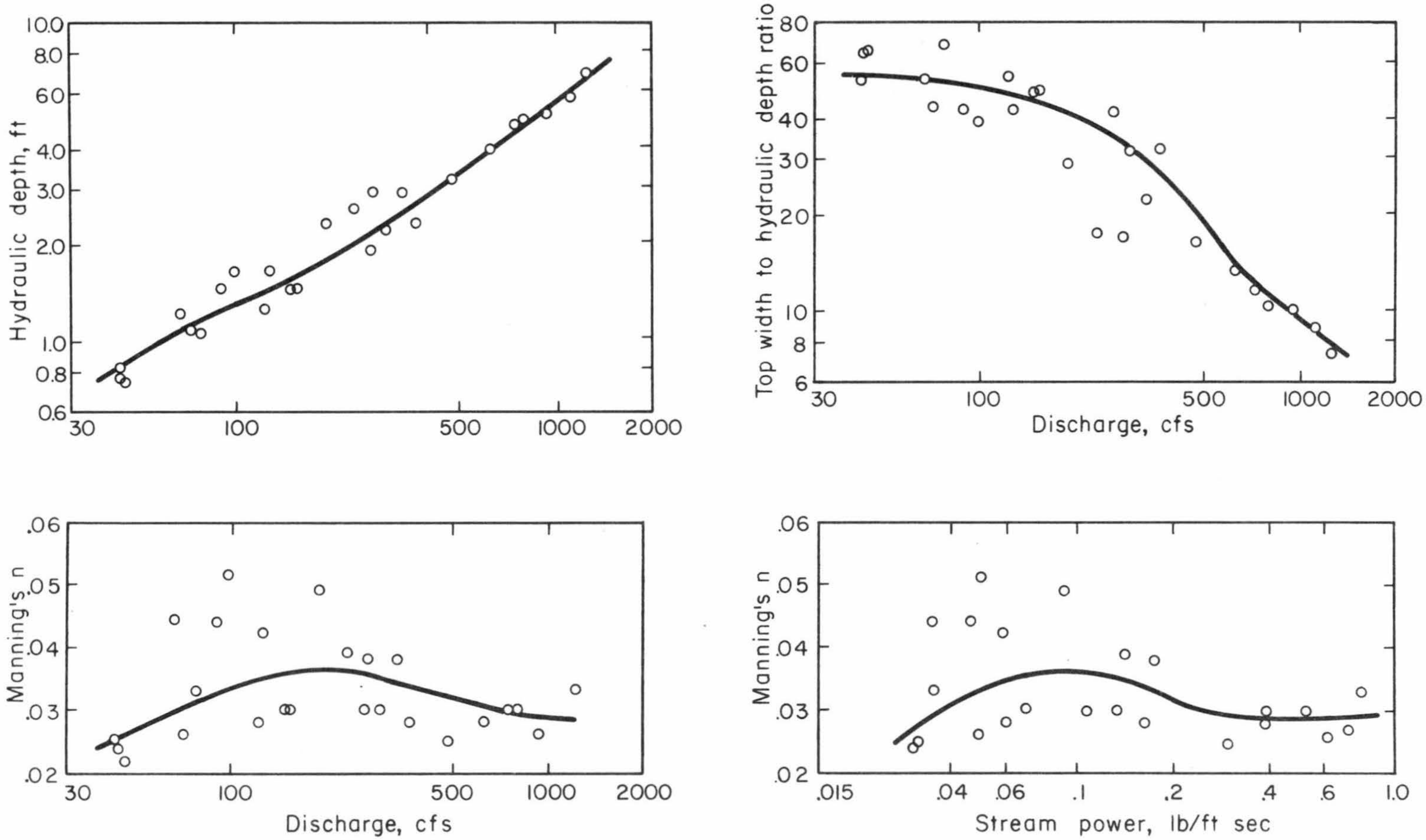


FIGURE IV-9 RIO ORITUPANO RELATIONS DEVELOPED FROM THE DISCHARGE MEASUREMENT SUMMARY

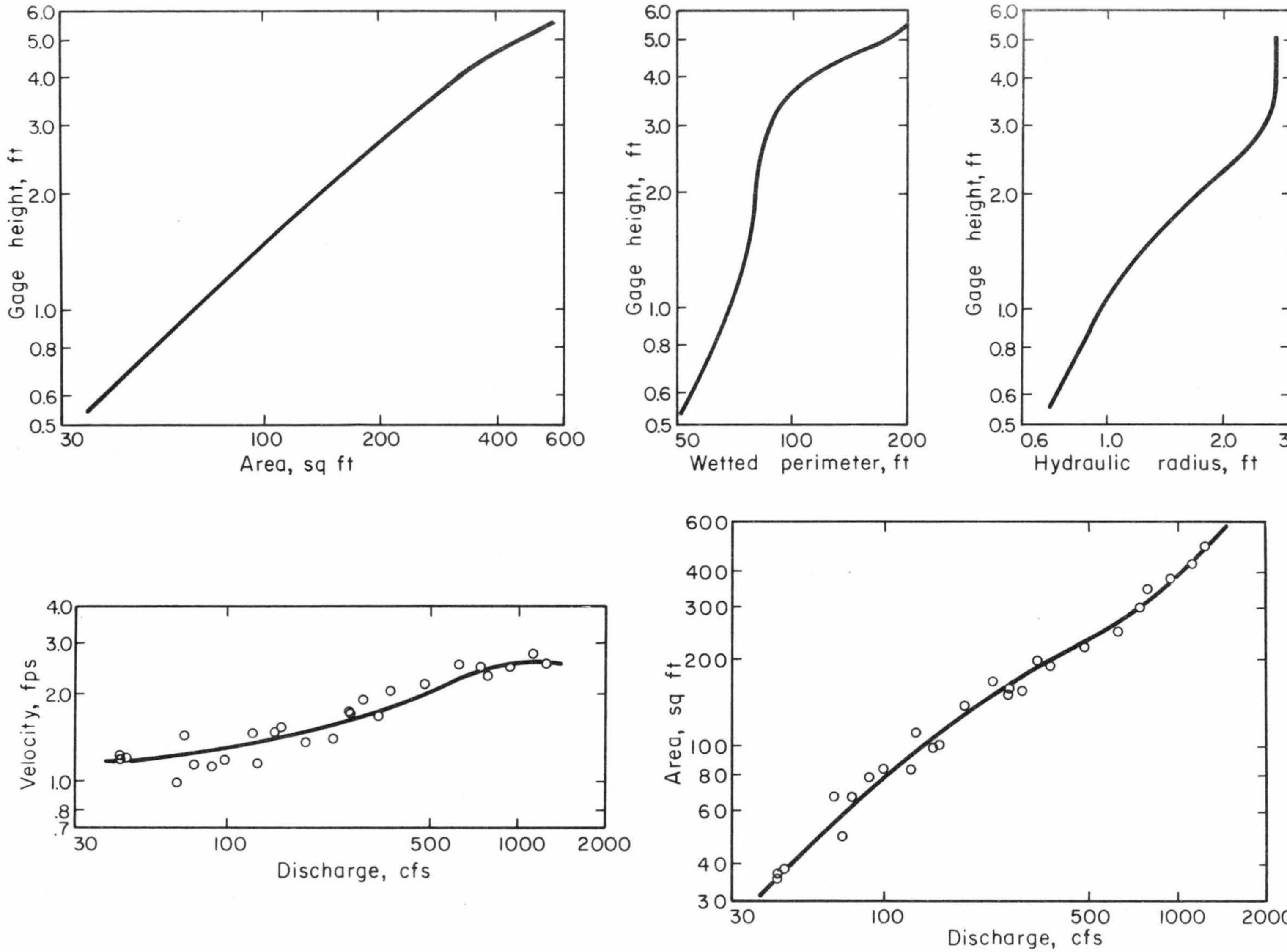
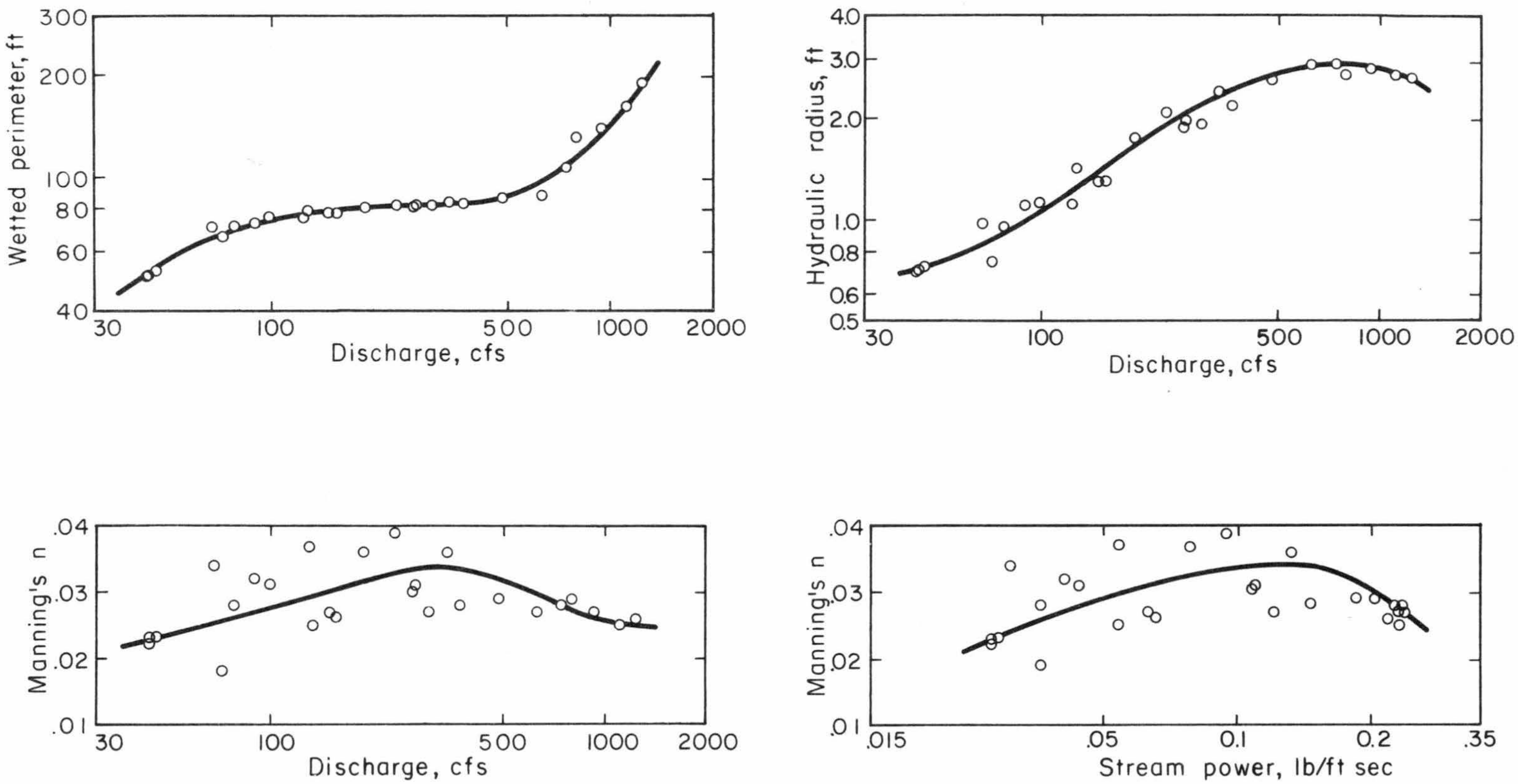


FIGURE IV-10 RIO ORITUPANO RELATIONS DEVELOPED FROM THE SEPT. 25 SURVEY

FIGURE IV-11 RIO ORITUPANO RELATIONS DEVELOPED
FROM THE SEPT. 25 SURVEY



Sta. No. 14 Río Tigre at Las Piedritas

Longitude 63° 21.7' W, latitude 08° 57.2' N. Approximately 14.7 km SE of Oritupano, 1.2 km SSE of Las Piedritas.

The Las Piedritas gaging station is immediately below the confluence of the Río Oritupano and the Río Tigre. An aerial view of the confluence is given in Volume II, page II-35. No survey was made at this site. The relations given on Figures IV-12 and IV-13 are developed from the discharge measurement summary. All discharge measurements were made from a boat at the same river cross section.

The river slope at Las Piedritas is 2.6 feet per mile (Table II-1). The bed-material size upstream of the confluence is 0.52 mm on the Río Oritupano and 0.33 mm on the Río Tigre. The bank material is described in Volume II, page III-30.

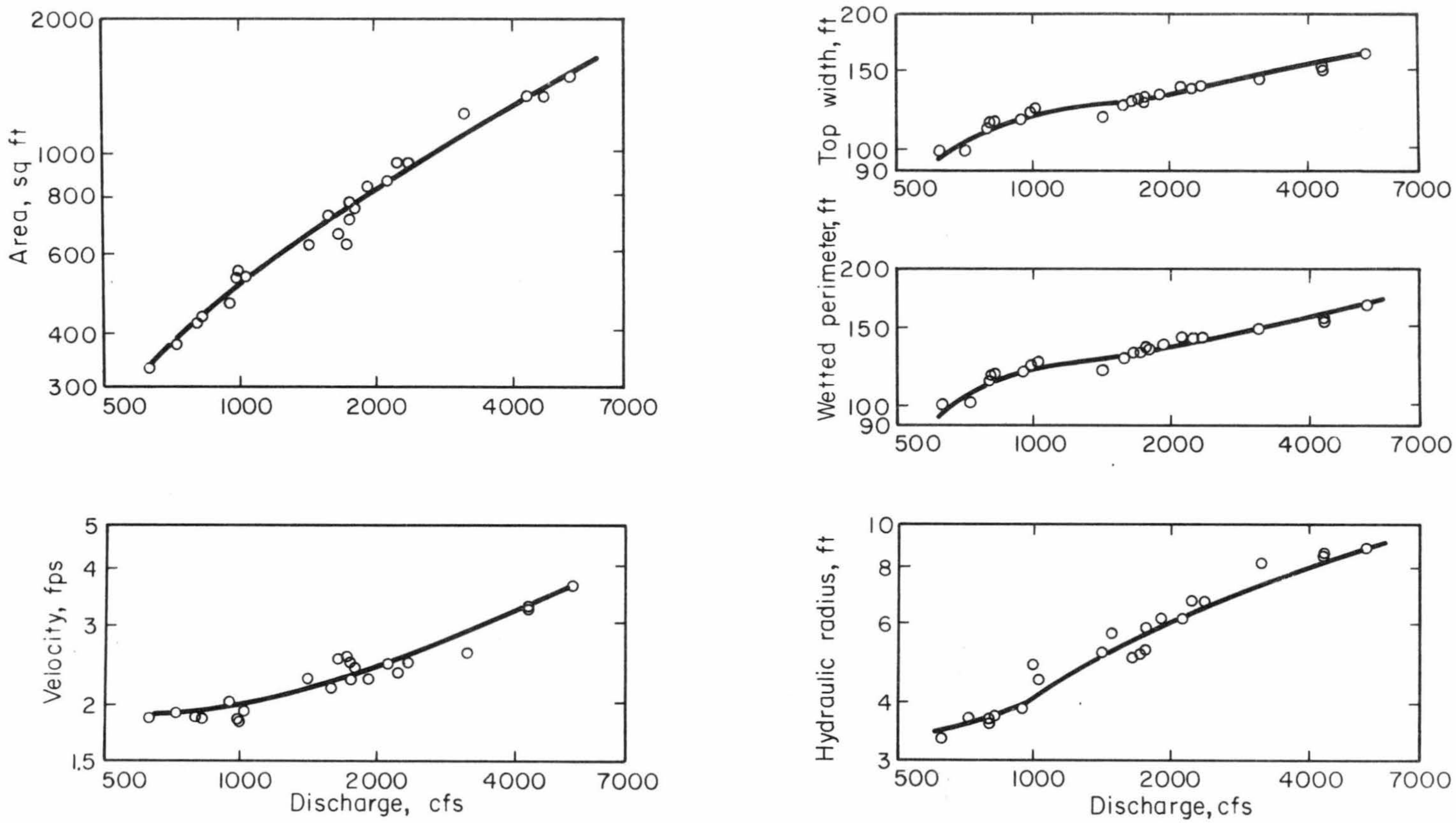


FIGURE IV-12 RELATIONS FOR THE RIO TIGRE AT LAS PIEDRITAS

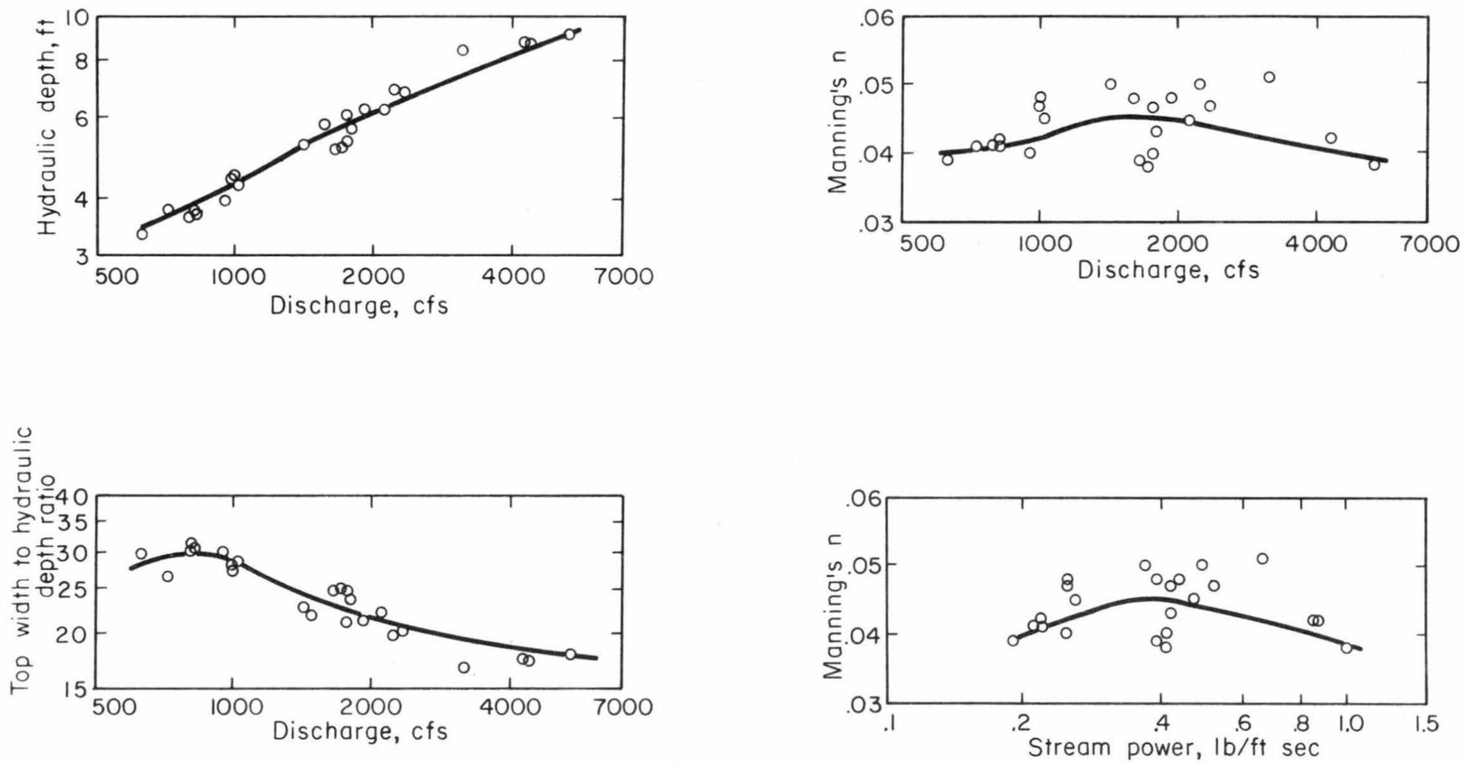


FIGURE IV-13 RELATIONS FOR THE RIO TIGRE AT LAS PIEDRITAS

Sta. No. 15 Río Aribí at Paso de Aribí

Longitude 63° 10.2' W, latitude 09° 16.7' N. Approximately 52.1 km S of Maturín, at El Paso de Aribí.

The reach of river at the Río Aribí gaging station shown on Figure IV-14 was surveyed on September 22, 1969. The gage height was 1.12 feet and the discharge was approximately 75 cfs.

The reference bench mark (elevation 100.00 feet assumed) is top of the piling at the southeast corner of the right abutment. The zero gage height corresponds to an elevation of 87.20 feet.

The relations shown on Figures IV-17 and IV-18 are developed by the survey method utilizing the cross sections at Stations 0+00, 0+97, 2+07, 3+09 and 4+14. The relations on Figure IV-19 are obtained from the discharge measurement summary and are representative of the bridge section (Sta. 1+07). A photograph of the gaging station is given in Volume II, page II-45.

At Sta. No. 15, the median sieve size diameter of the bed material is 2.3 mm (Figure III-1) and the bed slope is 4.8 feet per mile (Table II-1). The bank materials are described in Volume II, page III-31.

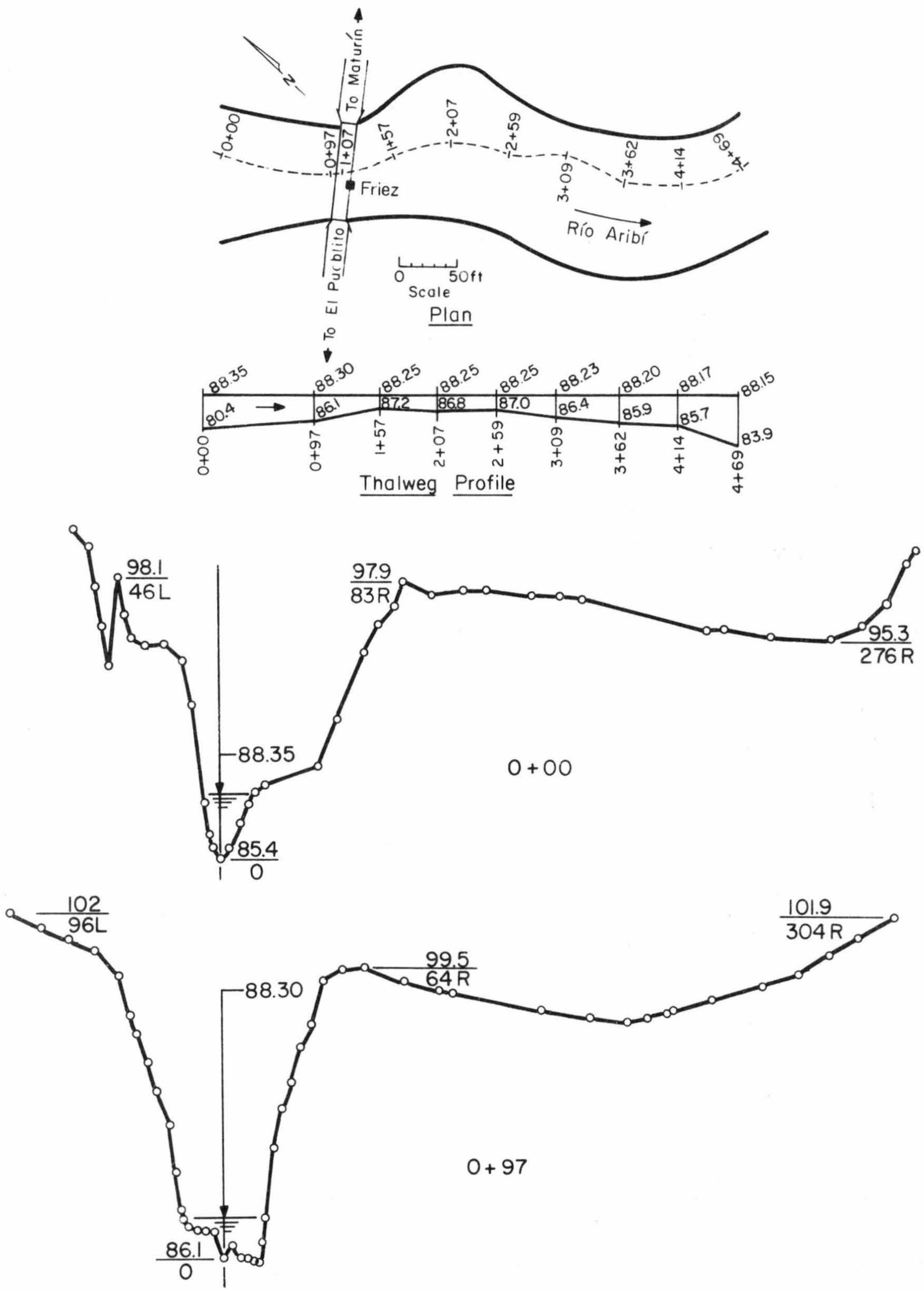


FIGURE IV-14 RIO ARIBI PLAN AND CROSS SECTIONS

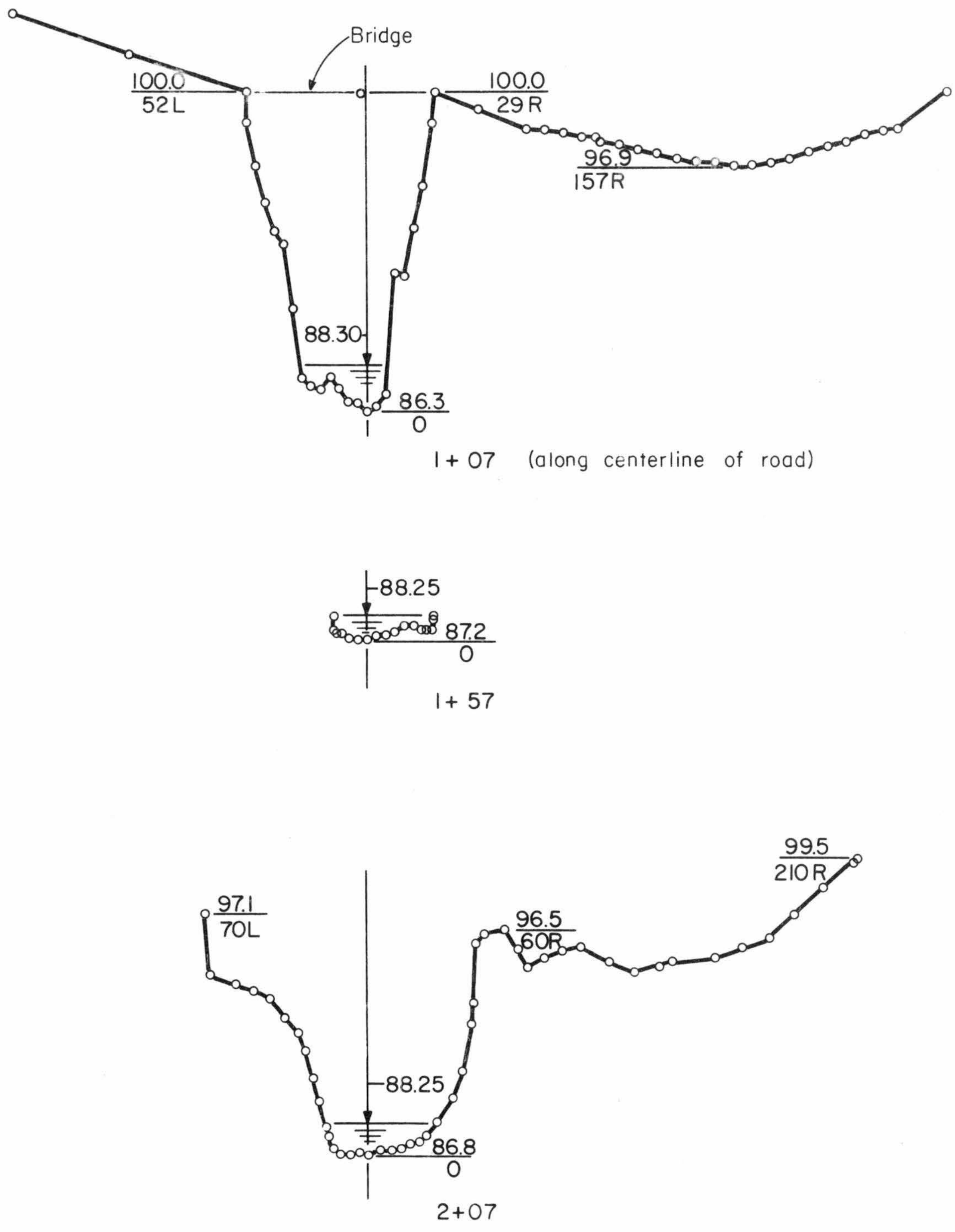


FIGURE IV-15 RIO ARIBI CROSS SECTIONS

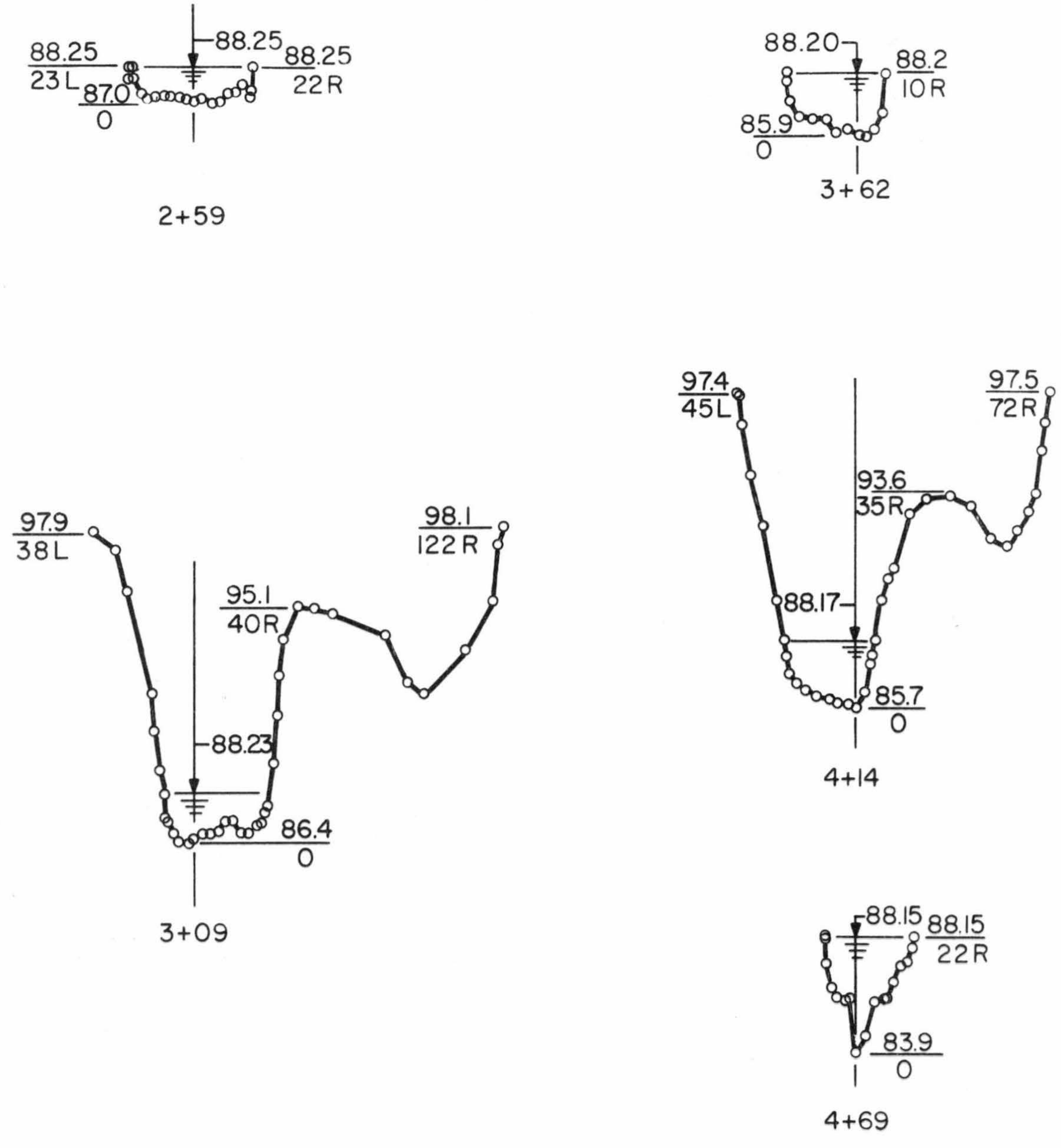


FIGURE IV-16 RIO ARIBI CROSS SECTIONS

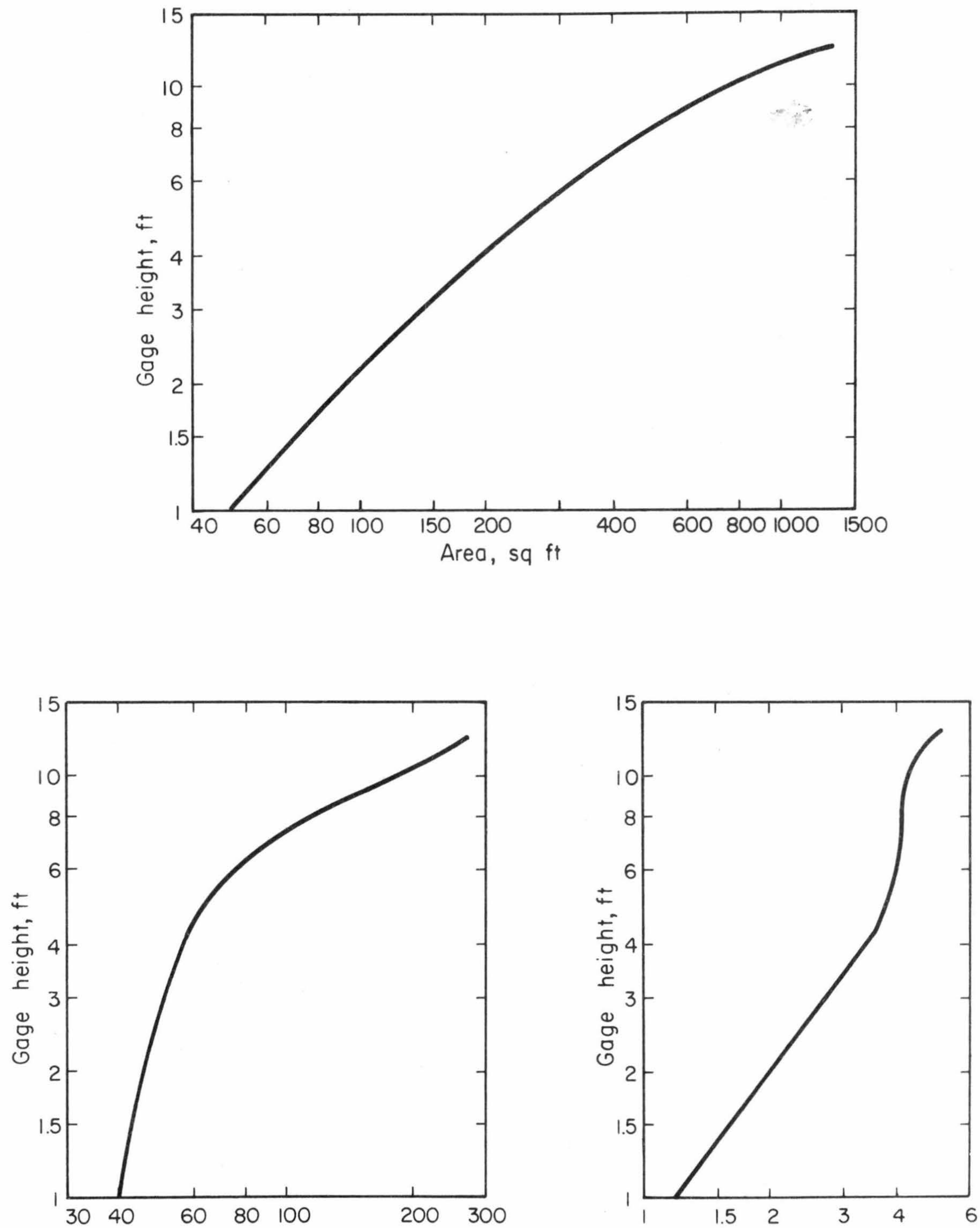


FIGURE IV-17 STAGE RELATIONS FOR THE RIO ARIBI

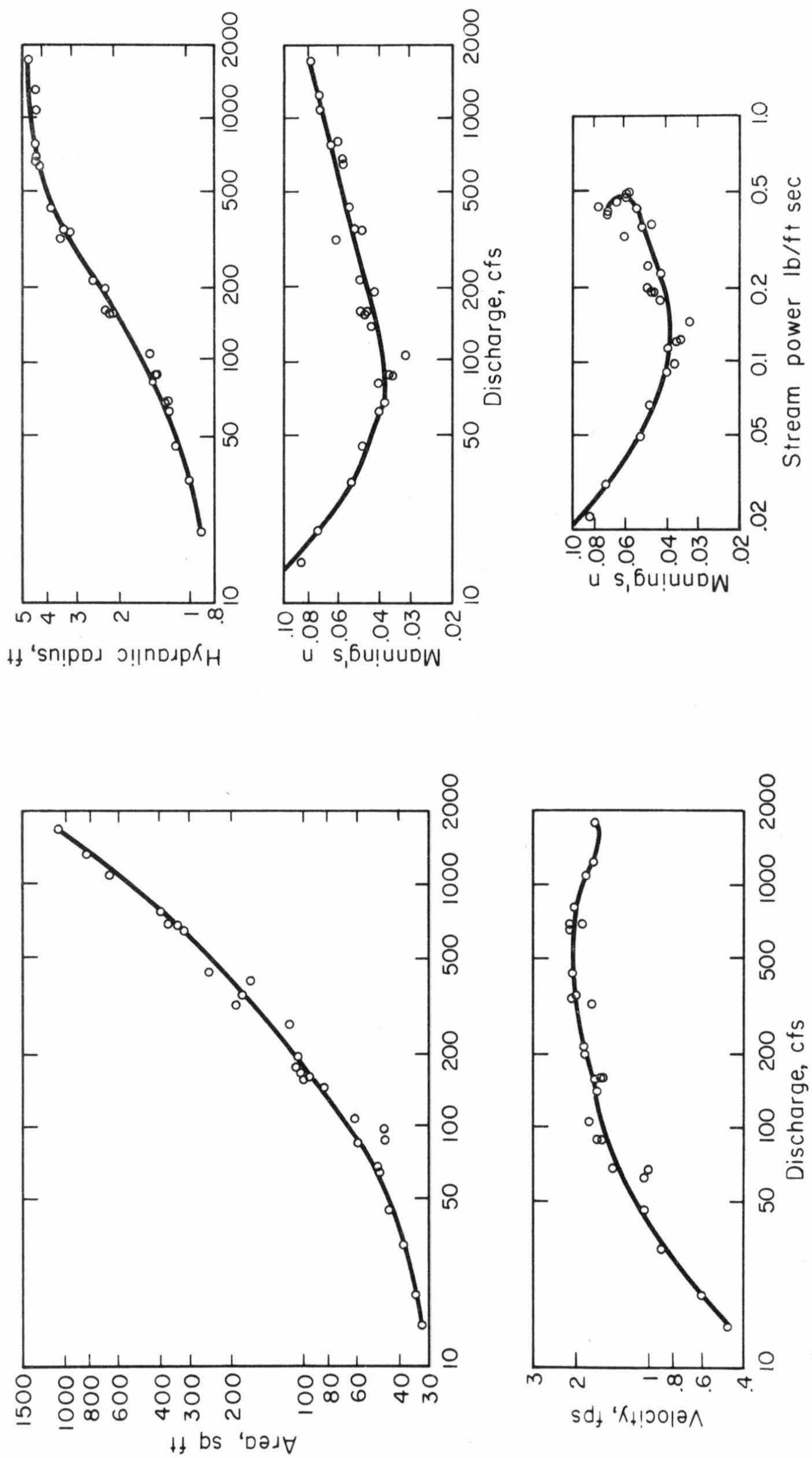


FIGURE IV-18 RELATIONS DEVELOPED FROM THE SURVEY OF THE RIO ARIBI REACH

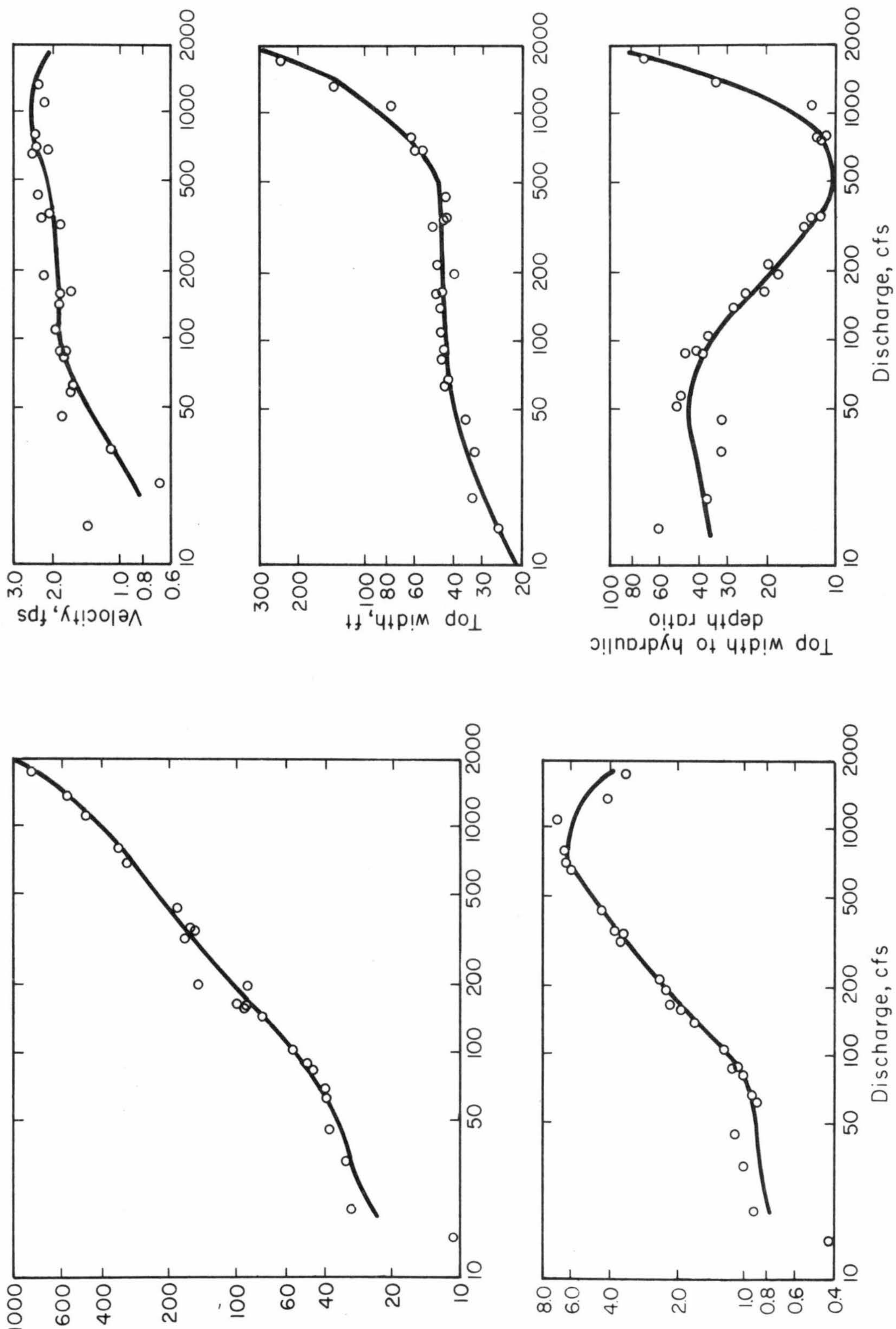


FIGURE IV-19 RELATIONS DEVELOPED FROM THE RIO ARIBI DISCHARGE MEASUREMENT SUMMARY

Sta. No. 16 Río Ñato at Las Gaviotas

Longitude 63° 21.0' W, latitude 09° 10.6' N. Approximately 17.2 km NNE of Oritupano, 3 km NNE of Las Gaviotas.

The river reach shown on Figure IV-20 was surveyed on October 7, 1969, when the gage height was 1.01 feet and the discharge was approximately 13 cfs. A photograph of the reach is given in Volume II, page II-55.

The reference bench mark is the top of the concrete bridge pier on the downstream side near the left abutment. The elevation of the bench mark is assumed to be 100.00 feet. The zero gage height corresponds to an elevation of 87.72 feet.

The relations shown on Figures IV-24 to IV-26 are developed from the discharge measurement summary. The river bed slope is 5.8 feet per mile (Table II-1) and the median bed-material size is 0.39 mm (Figure III-1). The bank materials are described in Volume II, page III-31.

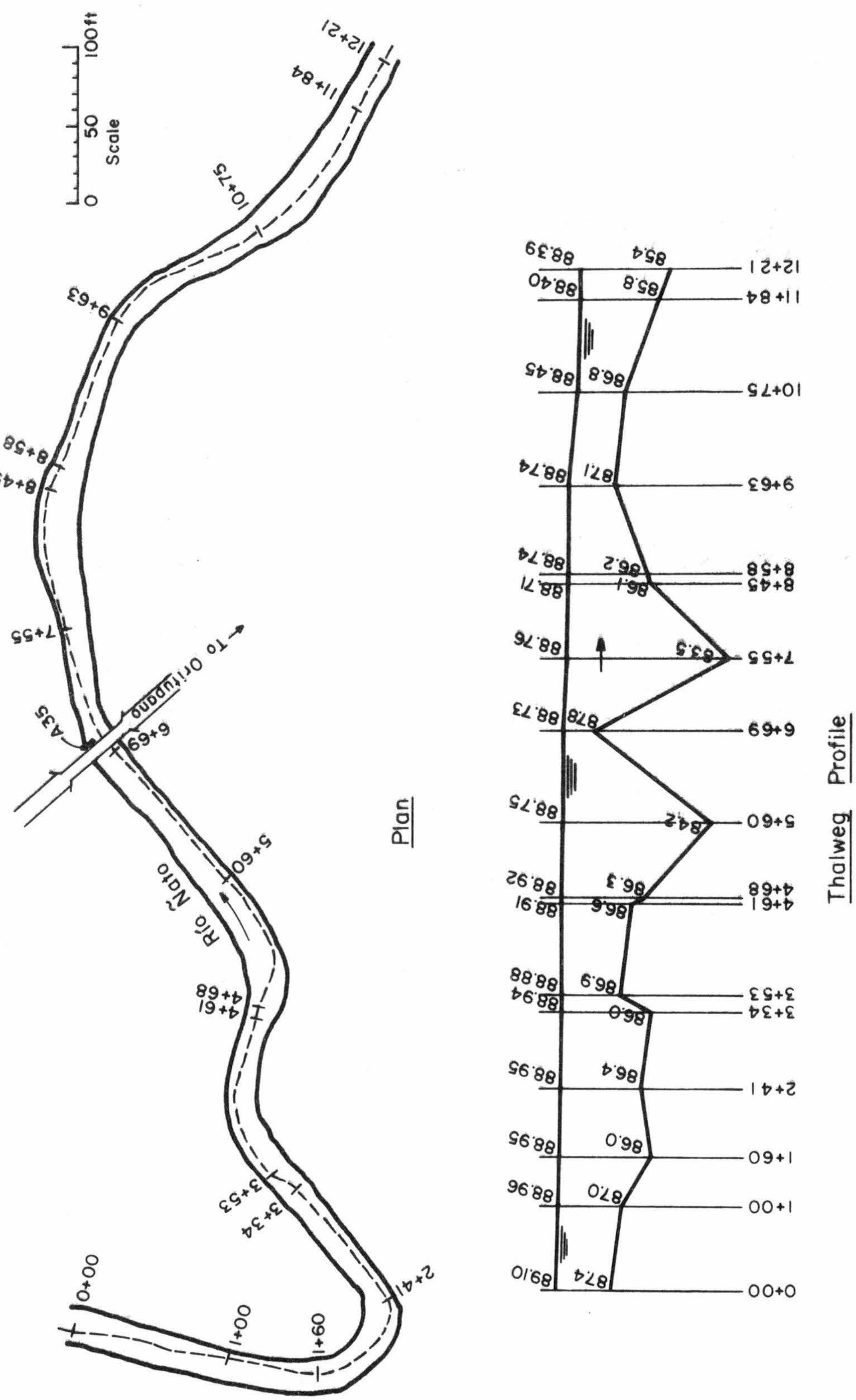


FIGURE IV-20 RIO ÑATO PLAN AND PROFILE

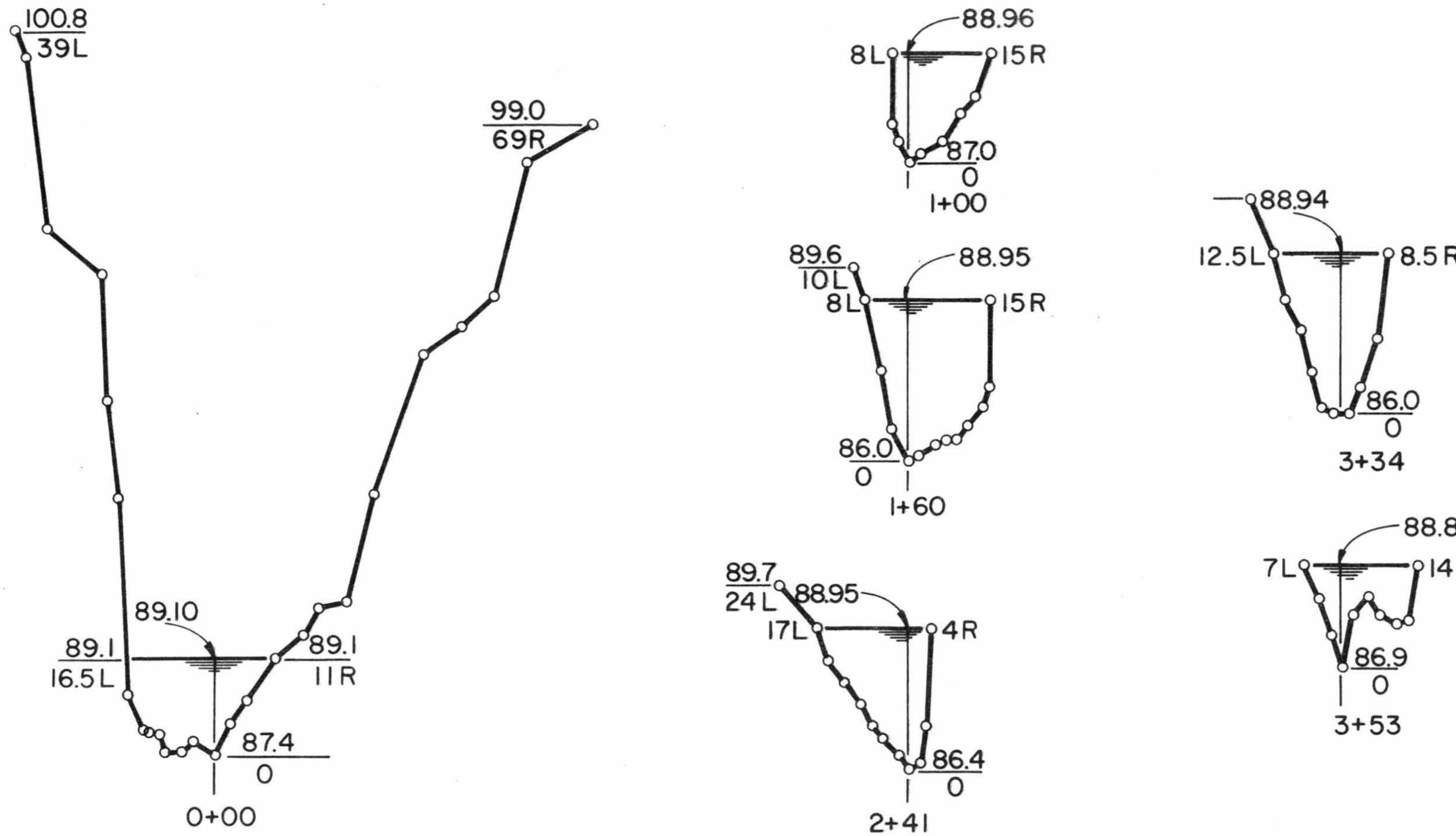


FIGURE IV-21 RIO ÑATO CROSS SECTIONS

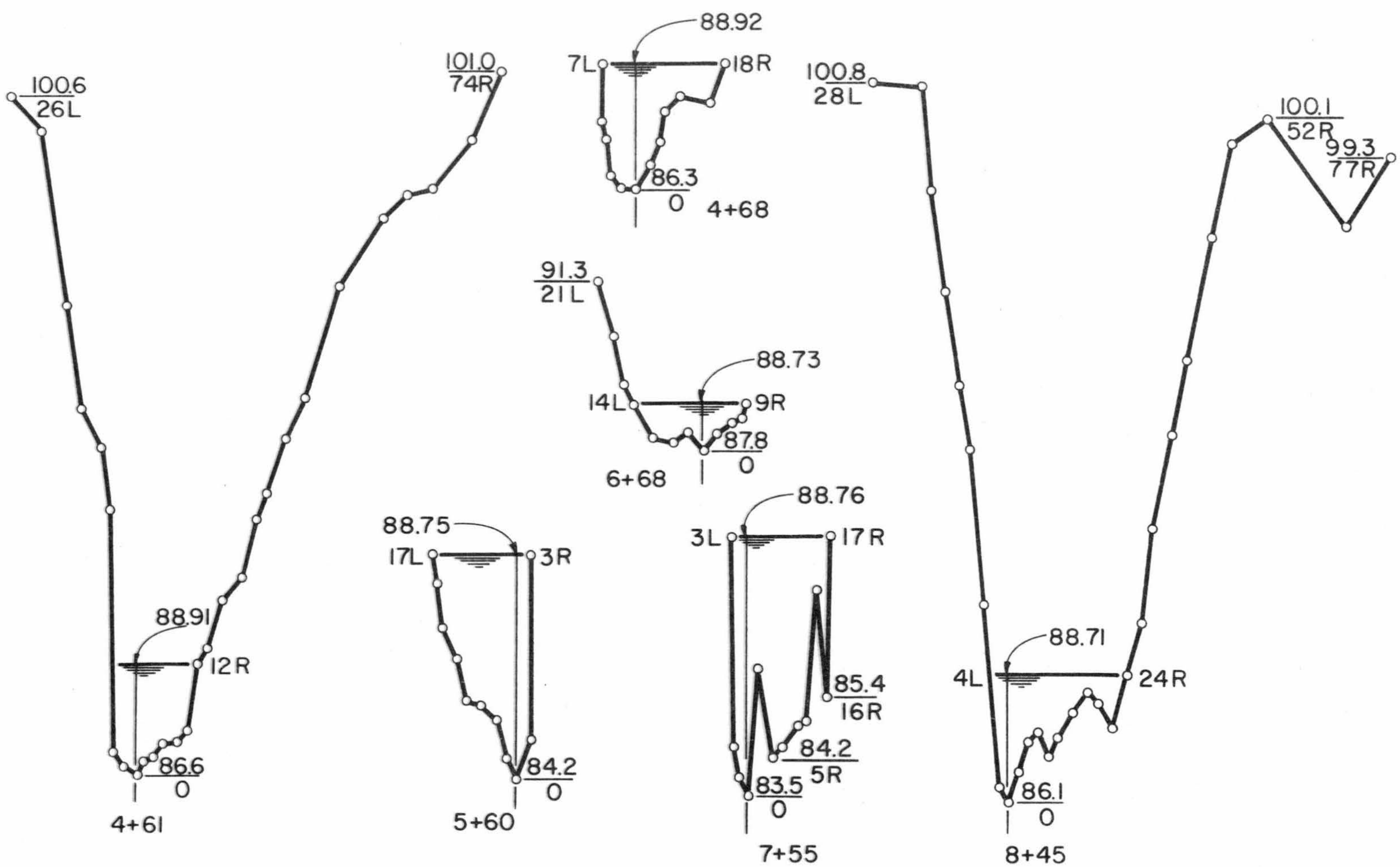


FIGURE IV-22 RIO ÑATO CROSS SECTIONS

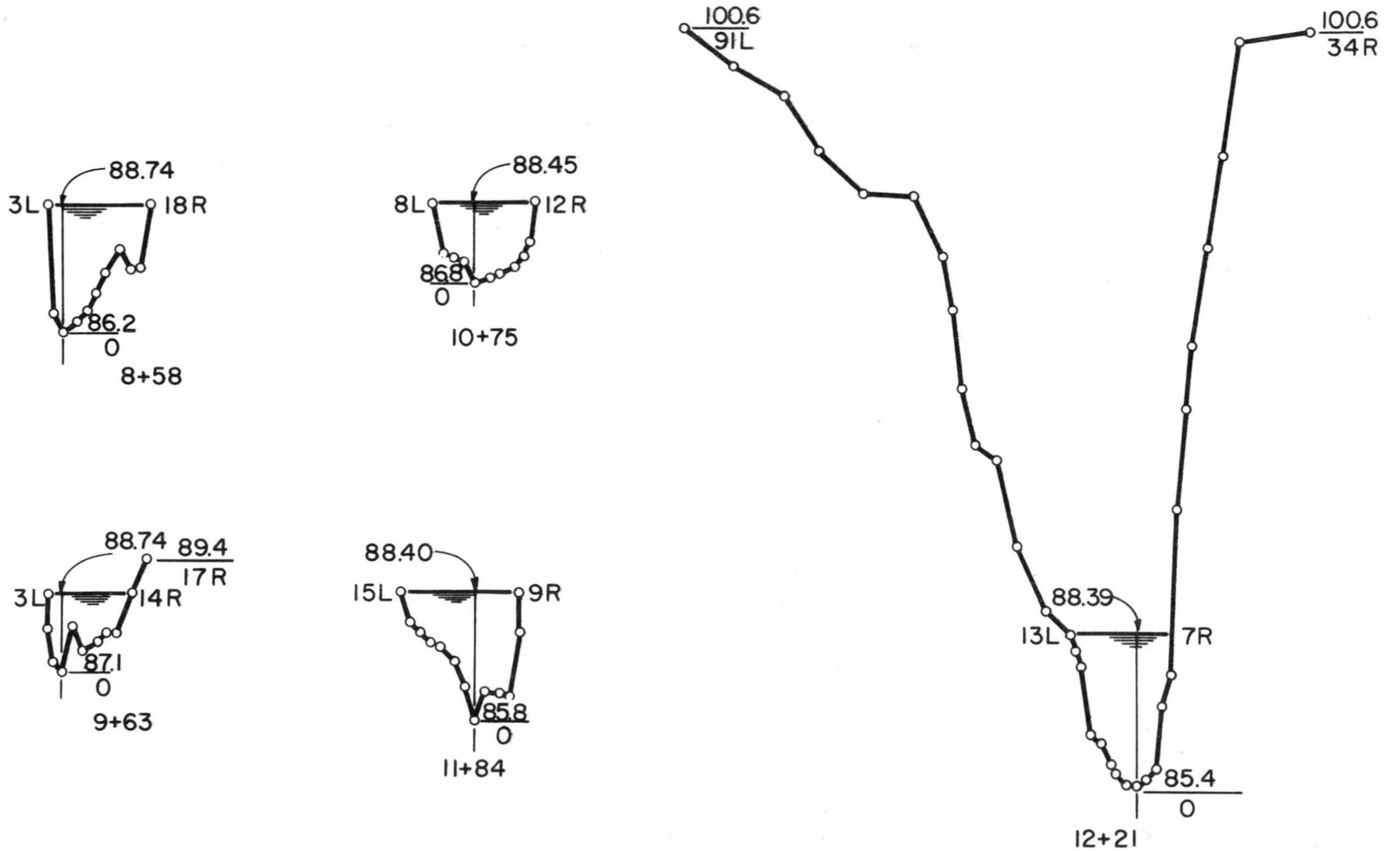


FIGURE IV-23 RIO ÑATO CROSS SECTIONS

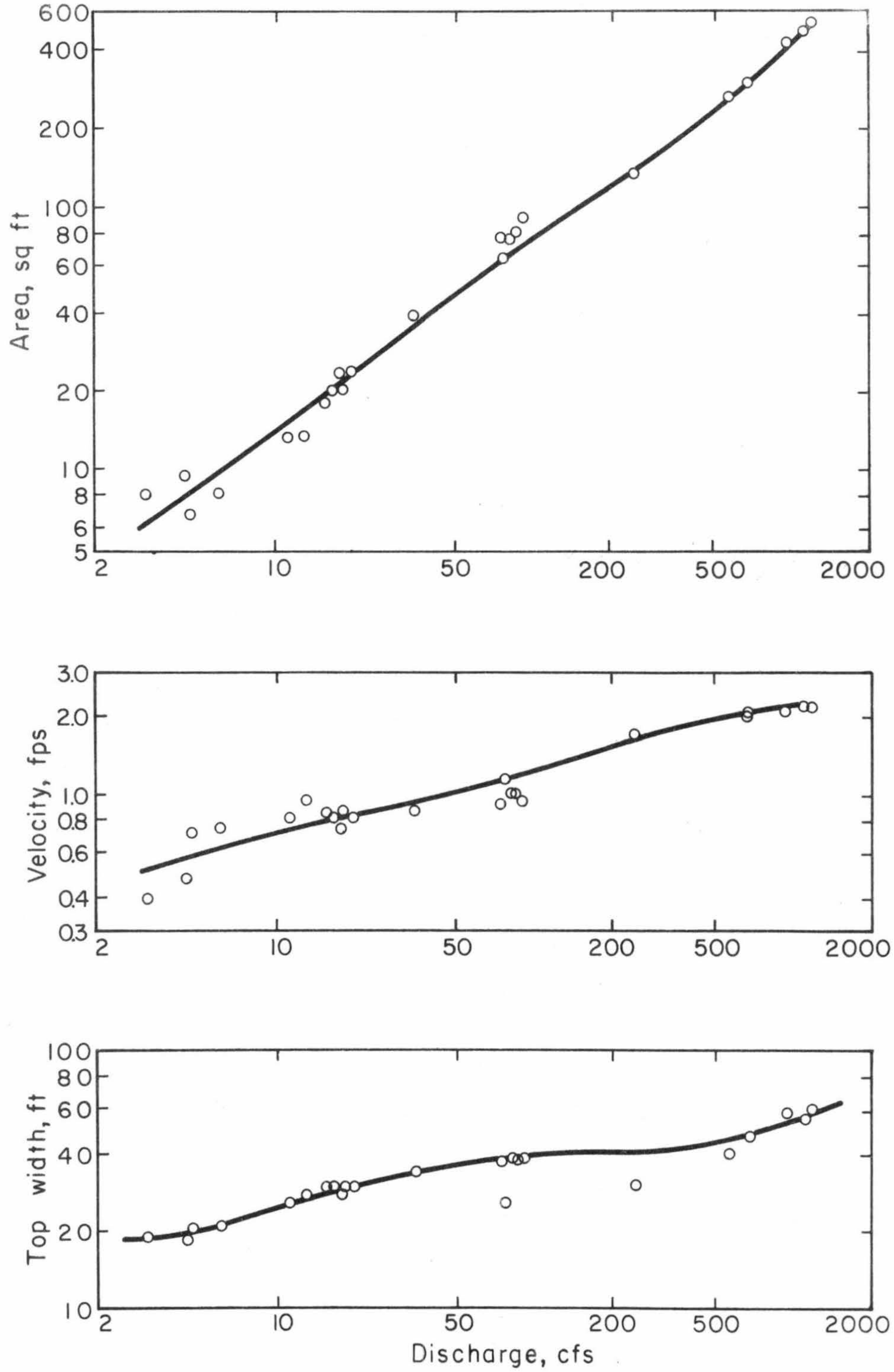


FIGURE IV-24 RELATIONS FOR THE RIO ÑATO GAGING STATION

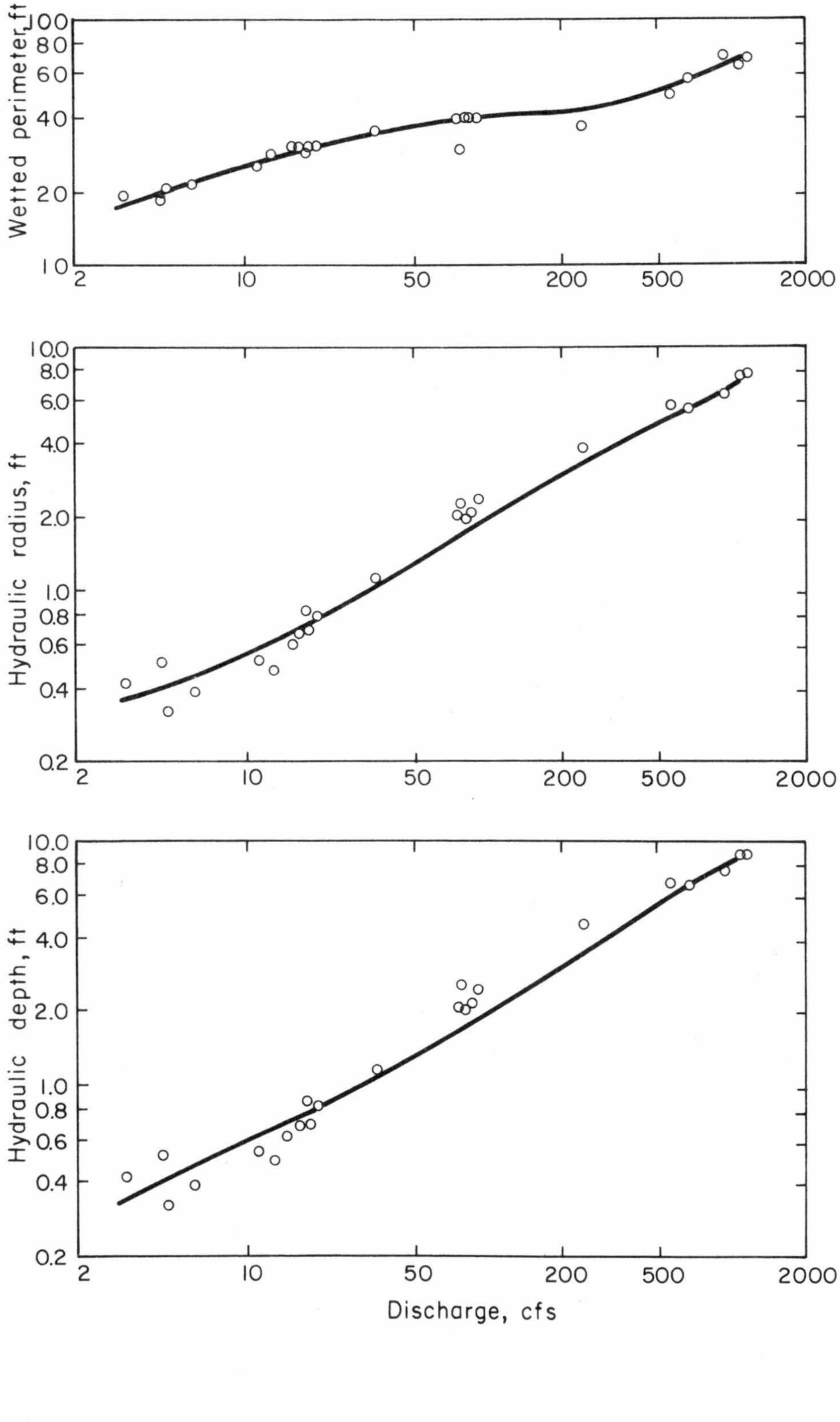


FIGURE IV-25 RELATIONS FOR THE RIO ÑATO GAGING STATION

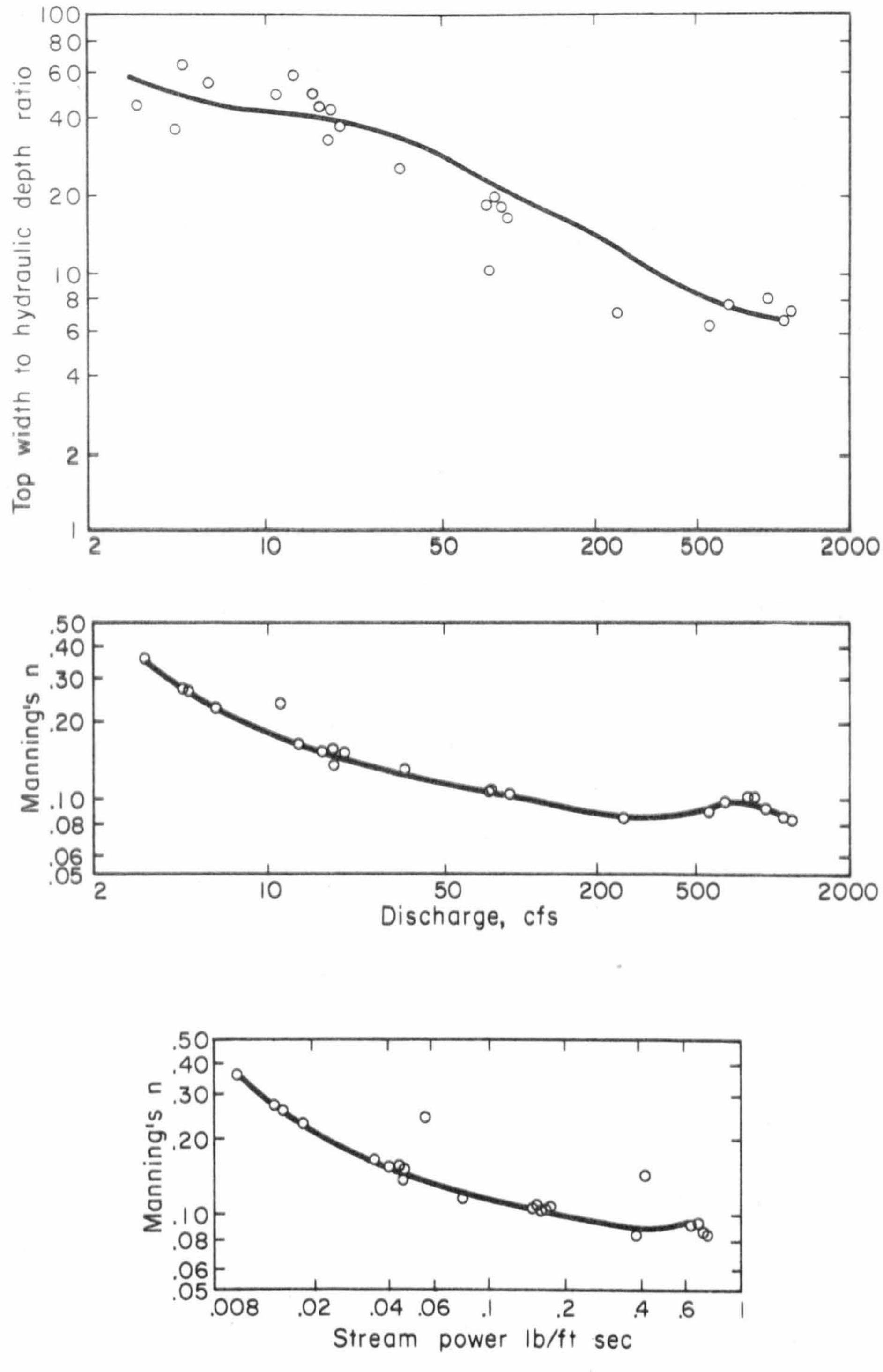


FIGURE IV-26 RELATIONS FOR THE RIO ÑATO GAGING STATION

Sta. No. 17 Río Tigre at the Crossing of the Maturín-Temblador Road

Longitude 62^{o} 59.5' W, latitude 09^{o} 21.0' N. Approximately 48.3 km SSE of Maturín, 4.2 km SSE of El Blanquero.

The relations shown on Figures IV-27 and IV-28 are derived from the discharge measurement summary. All discharge measurements were made from the bridge. No surveys of the reach were made. The river has been aligned with the bridge by excavating a straight channel upstream of the bridge. An aerial view of the river reach is given in Volume II, page II-65.

The zero gage height at the gaging station corresponds to an elevation of 21.995 meters above mean sea level. Cartografía Nacional (1965) bench mark No. SM30 (elevation 27.756 meters) is located on the bridge over the Río Tigre on the Maturín-Temblador road and the gage height is referenced to this bench mark.

At the M.O.P. gaging station and cableway immediately downstream of the bridge the zero gage height on the M.O.P. staff gage corresponds to a stage elevation of 19.853 meters.

The river slope at Sta. No. 17 is 1.2 feet per mile (Table II-1) and the median bed-material size is 0.32 mm (Figure III-1). The bank materials are described in Volume II, page III-32.

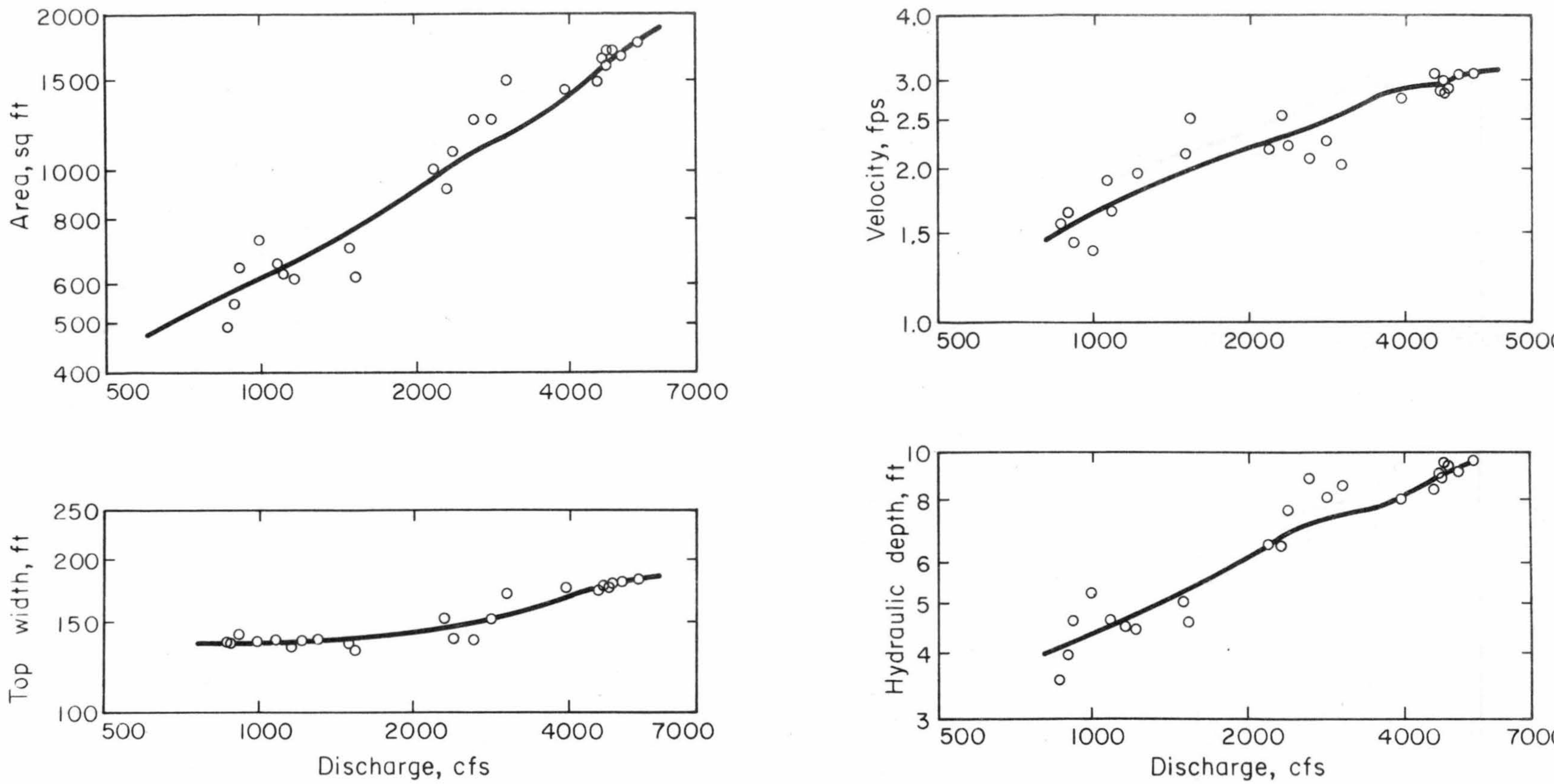


FIGURE IV-27 RELATIONS FOR THE RIO TIGRE AT STA. NO. 17

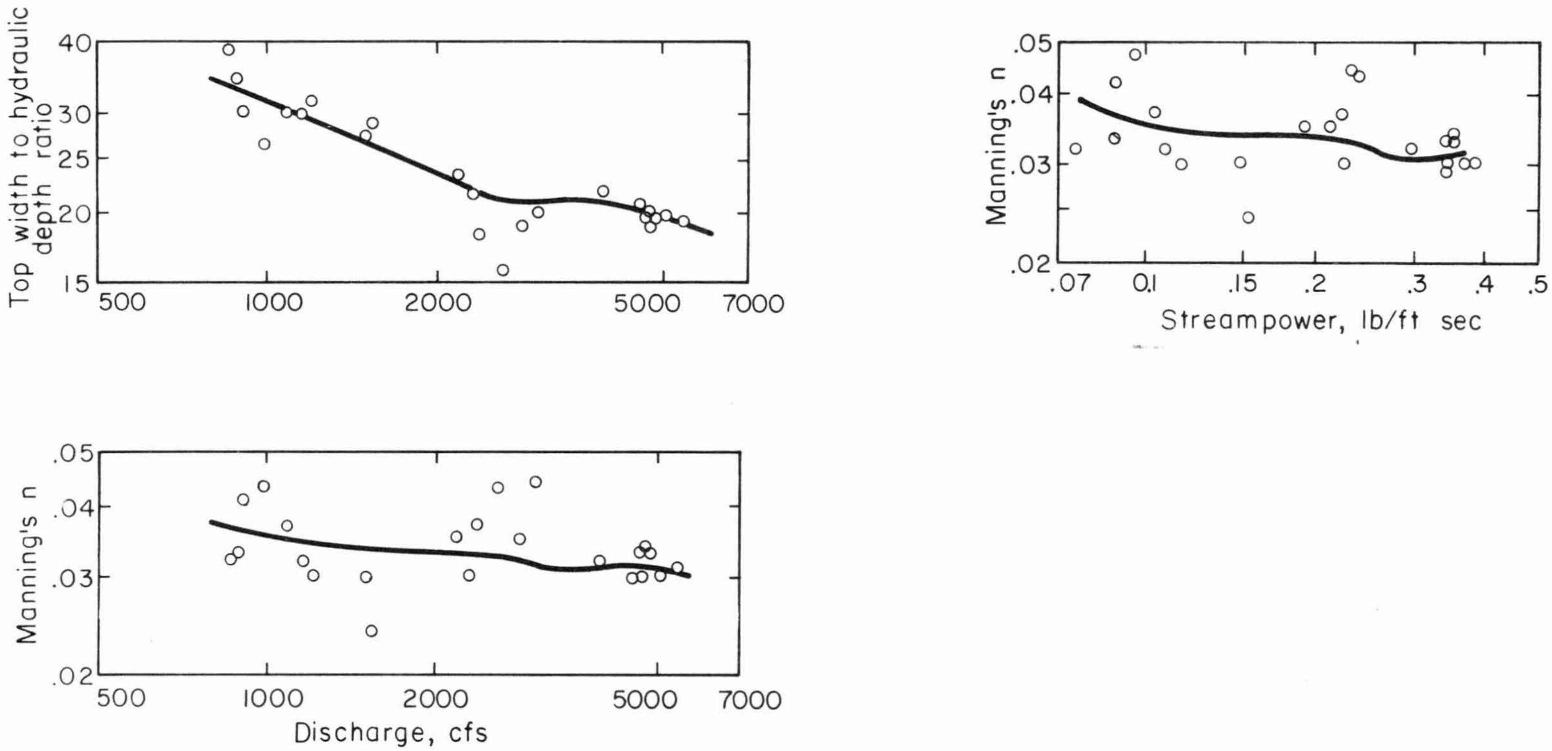


FIGURE IV-28 RELATIONS FOR THE RIO TIGRE AT STA. NO. 17

Sta. No. 31 Río Guanipa at El Aceite

Longitude 64^{o} 11.0' W, latitude 09^{o} 07.9' N. Approximately 28.6 km SE of Cantaura at El Aceite.

The reach of river immediately upstream of gaging station (Figure IV-29) was surveyed on September 17, 1969. The gage height was 1.20 feet and the discharge was approximately 270 cfs. An aerial photograph of the river reach at El Aceite is given in Volume II, page II-75.

The reference bench mark is the top of the sheet piling at the downstream extremity on the left abutment. The elevation is assumed 100.00 feet. The zero gage height corresponds to an elevation of 86.52 feet.

The relations given on Figures IV-31 and IV-32 are developed from the discharge measurement summary. Most of the discharge measurments were made at the bridge.

The median diameter of the bed material at El Aceite is 0.30 mm (Figure III-1) and the river slope is 4.2 feet per mile (Table II-1). The bank materials are described in Volume II, page III-33.

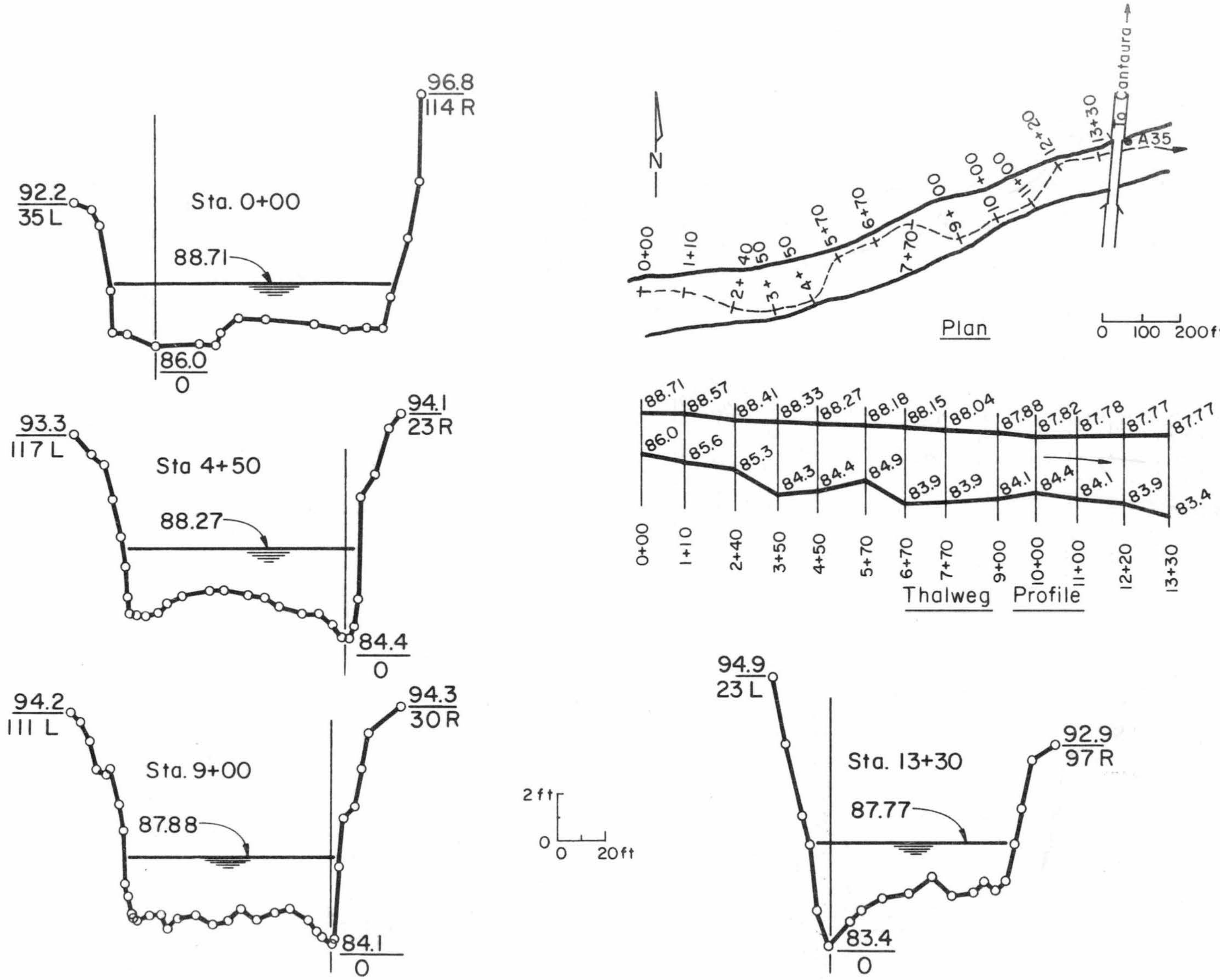


FIGURE IV-29 RIO GUANIPA PLAN AND CROSS SECTIONS AT EL ACEITE

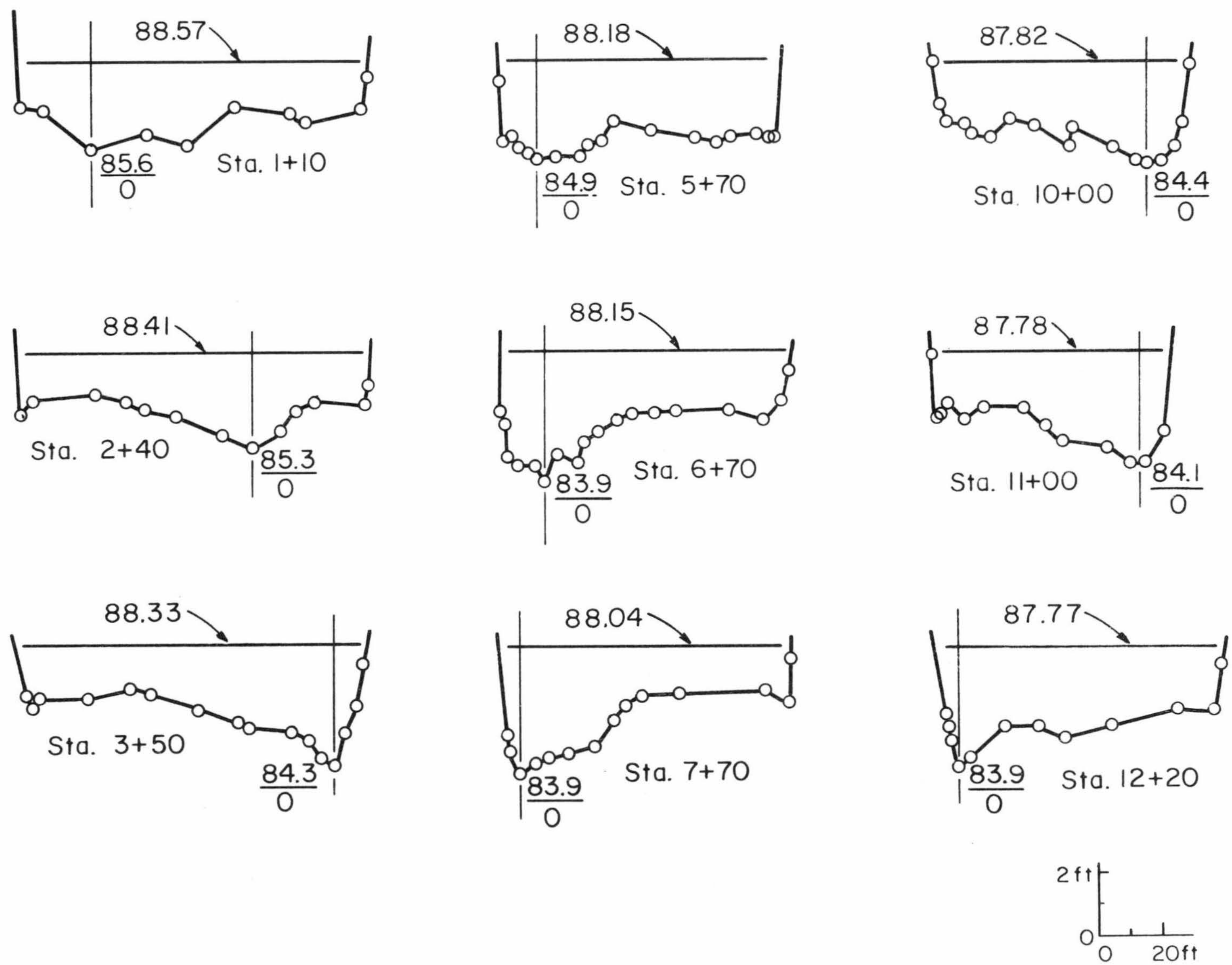


FIGURE IV-30 RIO GUANIPA CROSS SECTIONS AT EL ACEITE

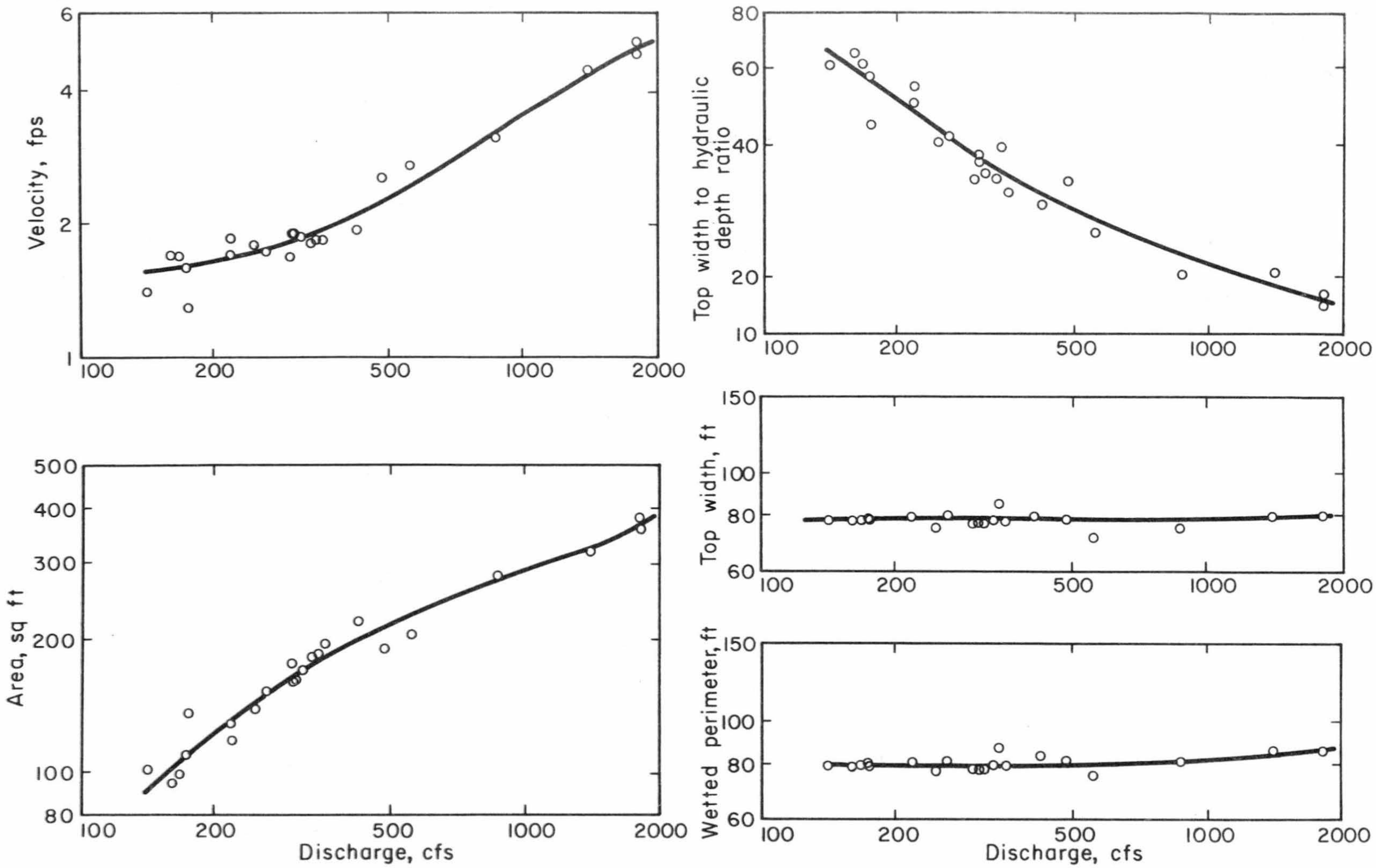


FIGURE IV-31 RELATIONS FOR THE RIO GUANIPA AT EL ACEITE

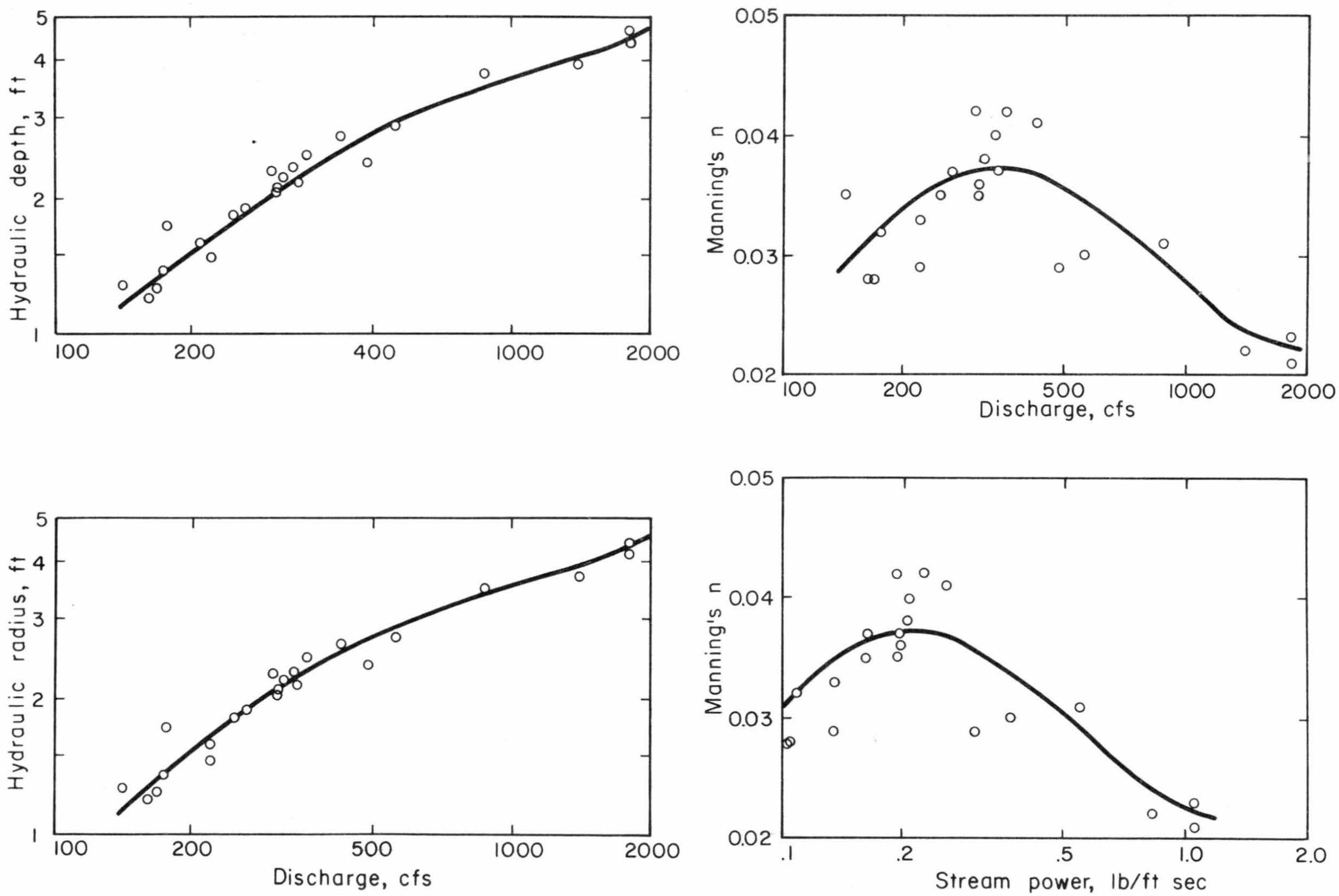


FIGURE IV-32 RELATIONS FOR THE RIO GUANIPA AT EL ACEITE

Sta. No. 33 Río Caris at the Crossing of the Santa Bárbara-Aguasay Road

Longitude 63° 39.6' W, latitude 09° 29.5' N. Approximately 14.6 km SW of Santa Bárbara, 10.2 km NE of Aguasay.

The reach of river shown on Figure IV-33 was surveyed on September 10, 1969. The gage height was 0.55 feet and the discharge was approximately 110 cfs. The reference bench mark is an "X" mark on the bridge railing at the A-35 house. The elevation of the bench mark is assumed 100.00 feet. The zero gage height corresponds to a stage of 82.21 feet.

The relations on Figures IV-35 and IV-36 are derived from the discharge measurement summary. Discharge measurements were made at and immediately downstream of the bridge.

The median diameter of the bed material is 0.80 mm (Figure III-1) and the river slope is 9.5 feet per mile (Table II-1). The bank materials are described in Volume II, page III-35.

A photograph of the surveyed river reach and the Río Caris gaging station is given in Volume II, page II-95.

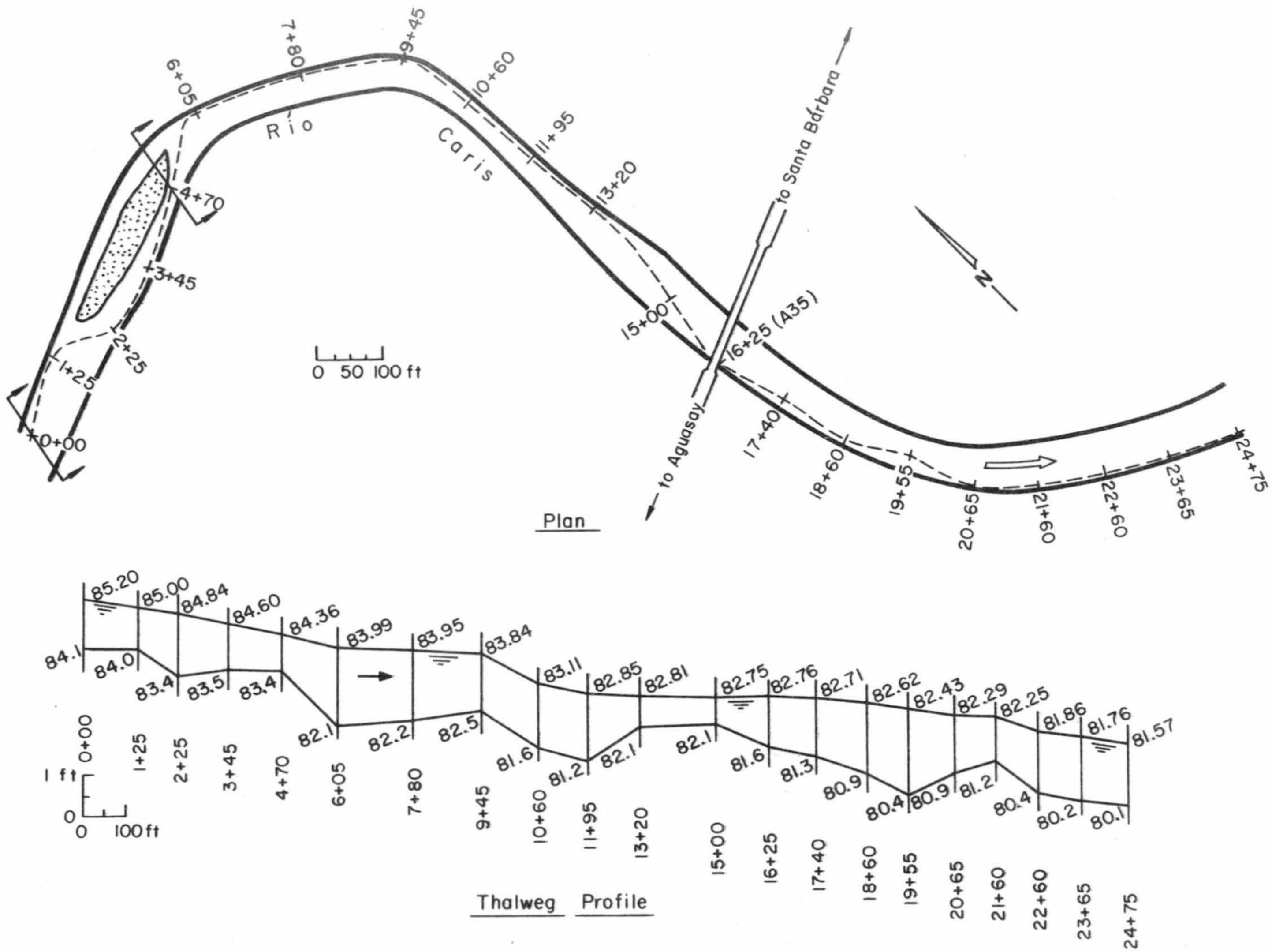


FIGURE IV-33 RIO CARIS PLAN AND PROFILE AT STA. NO. 33

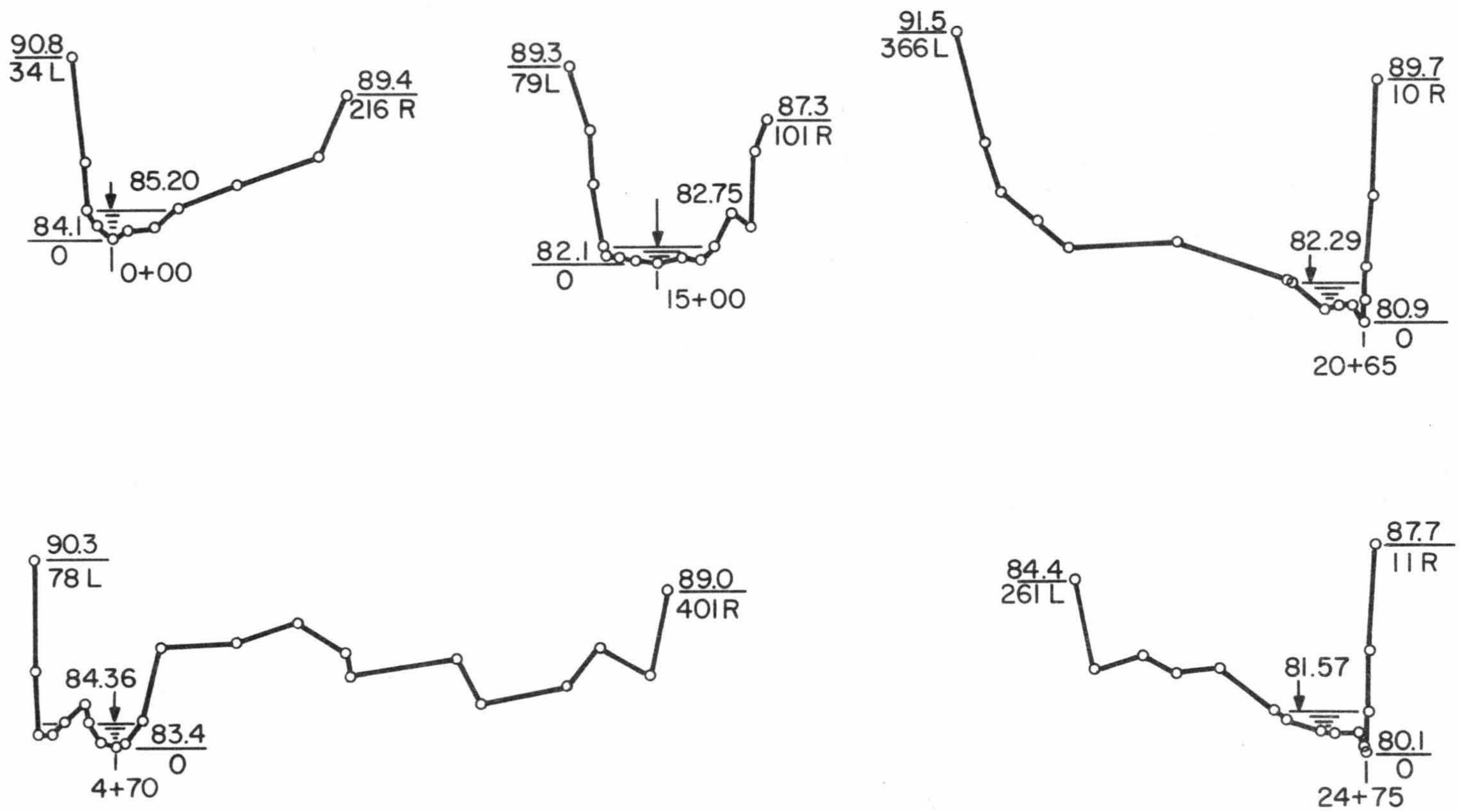


FIGURE IV-34 RIO CARIS CROSS SECTIONS

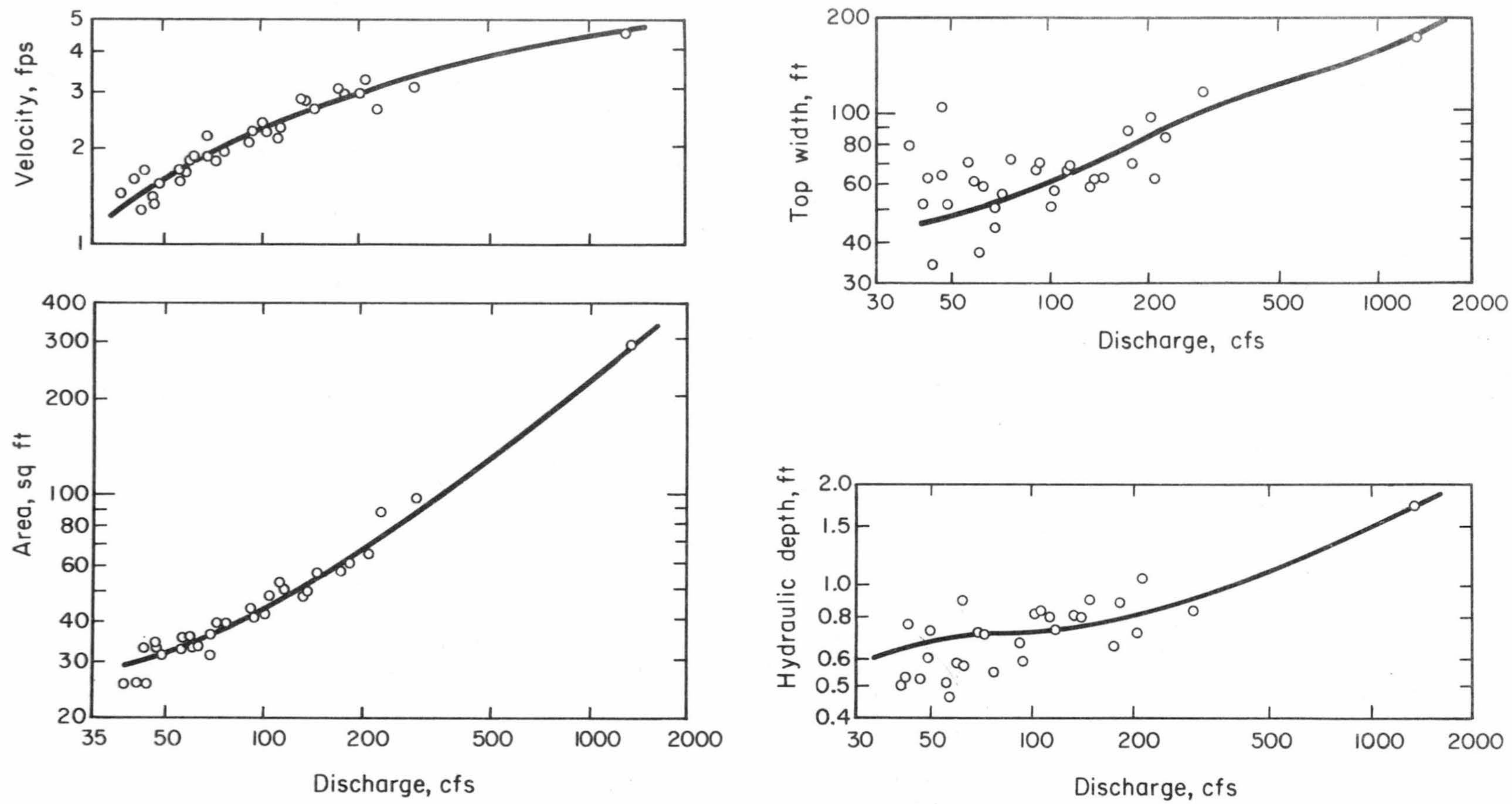


FIGURE IV-35 RELATIONS FOR THE RIO CARIS GAGING STATION

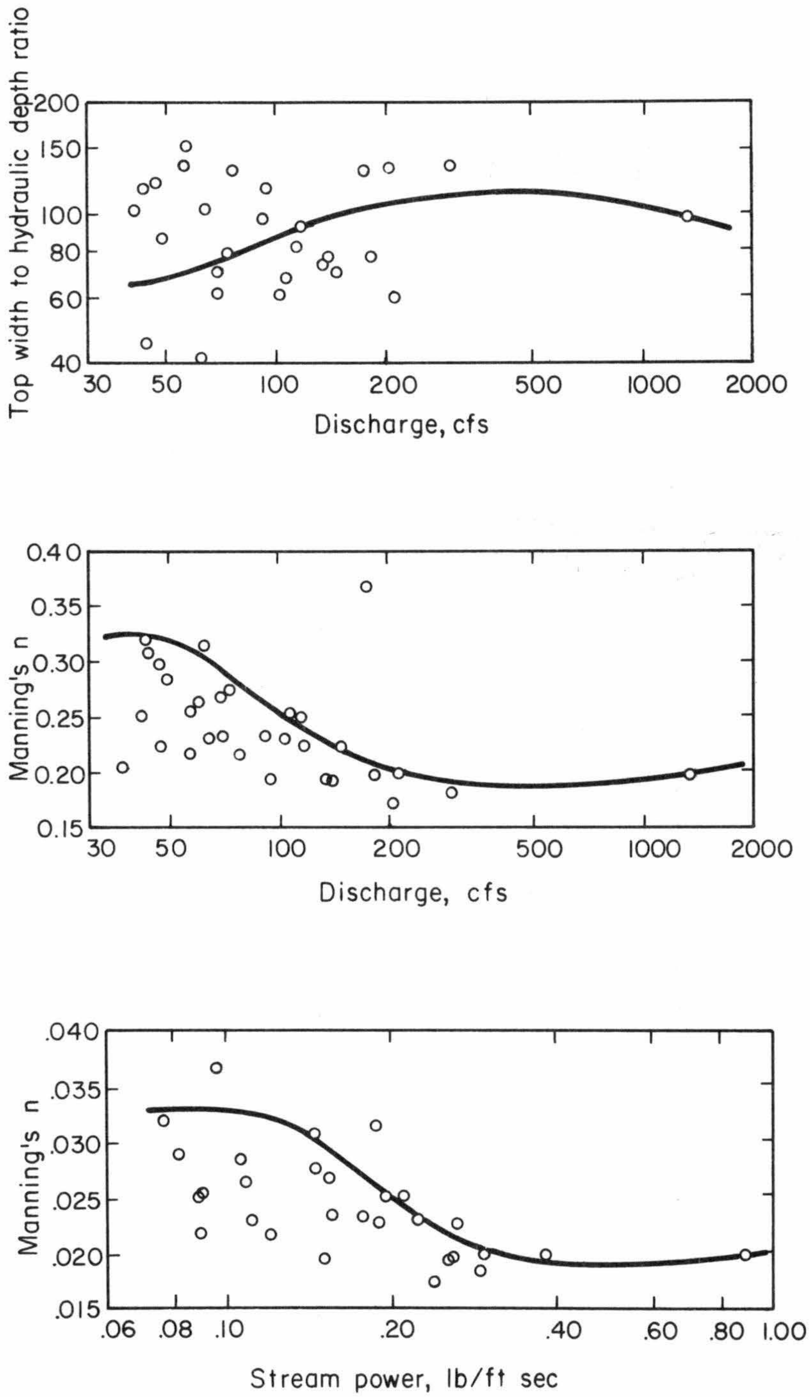


FIGURE IV-36 RELATIONS FOR THE RIO CARIS GAGING STATION

Sta. No. 34 Río Tonoro at the Crossing of the Santa Bárbara-Aguasay Road

Longitude 63^{0} 39.2' W. latitude 09^{0} 30.1' N. Approximately 13.6 km SW of Santa Bárbara, 11.2 km NE of Aguasay.

The reach of river shown on Figure IV-37 has a slope of 8.4 feet per mile according to the topographic maps (Table II-1). The median bed-material size is 0.47 mm (Figure III-1).

The survey of the river reach was conducted on September 5, 1969. The discharge was approximately 140 cfs and the gage height was 0.64 feet. The reference bench mark is an "X" mark on the bridge railing at the A-35 house. The elevation is assumed 100.00 feet. This bench mark is 41.84 feet higher than the reference bench mark at the Río Caris gaging station which is only 1.2 kilometers to the southwest. The divide between the Río Caris and Río Tonoro gaging stations is 60 feet higher than the reference bench mark on the Río Tonoro bridge.

The zero gage height at Sta. No. 34 corresponds to a stage of 79.74 feet.

An aerial view of the Río Tonoro at the gaging station is given in Volume II, page II-105, and the bank materials are described in Volume II, page III-35.

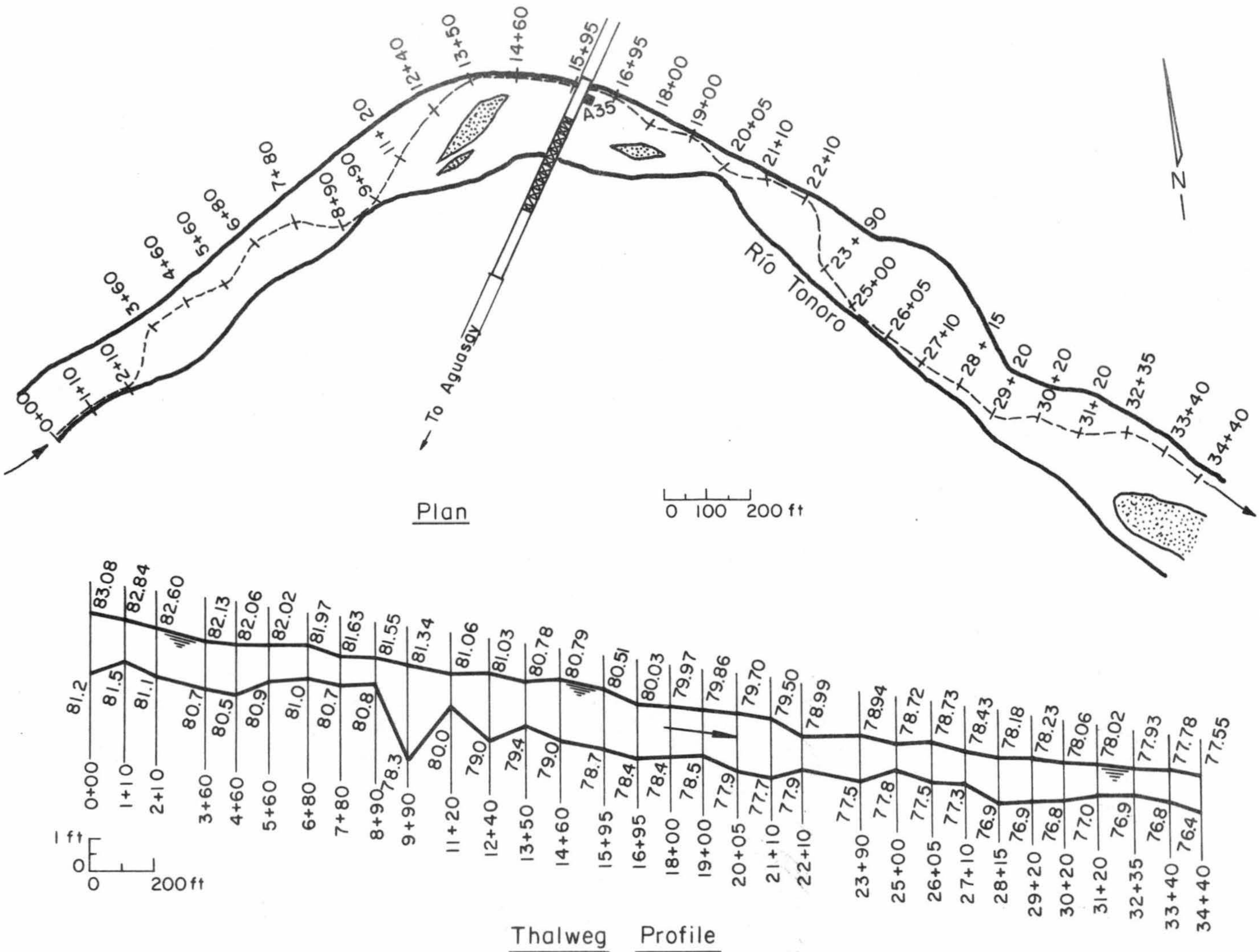


FIGURE IV-37 RIO TONORO PLAN AND PROFILE AT STA. NO. 34

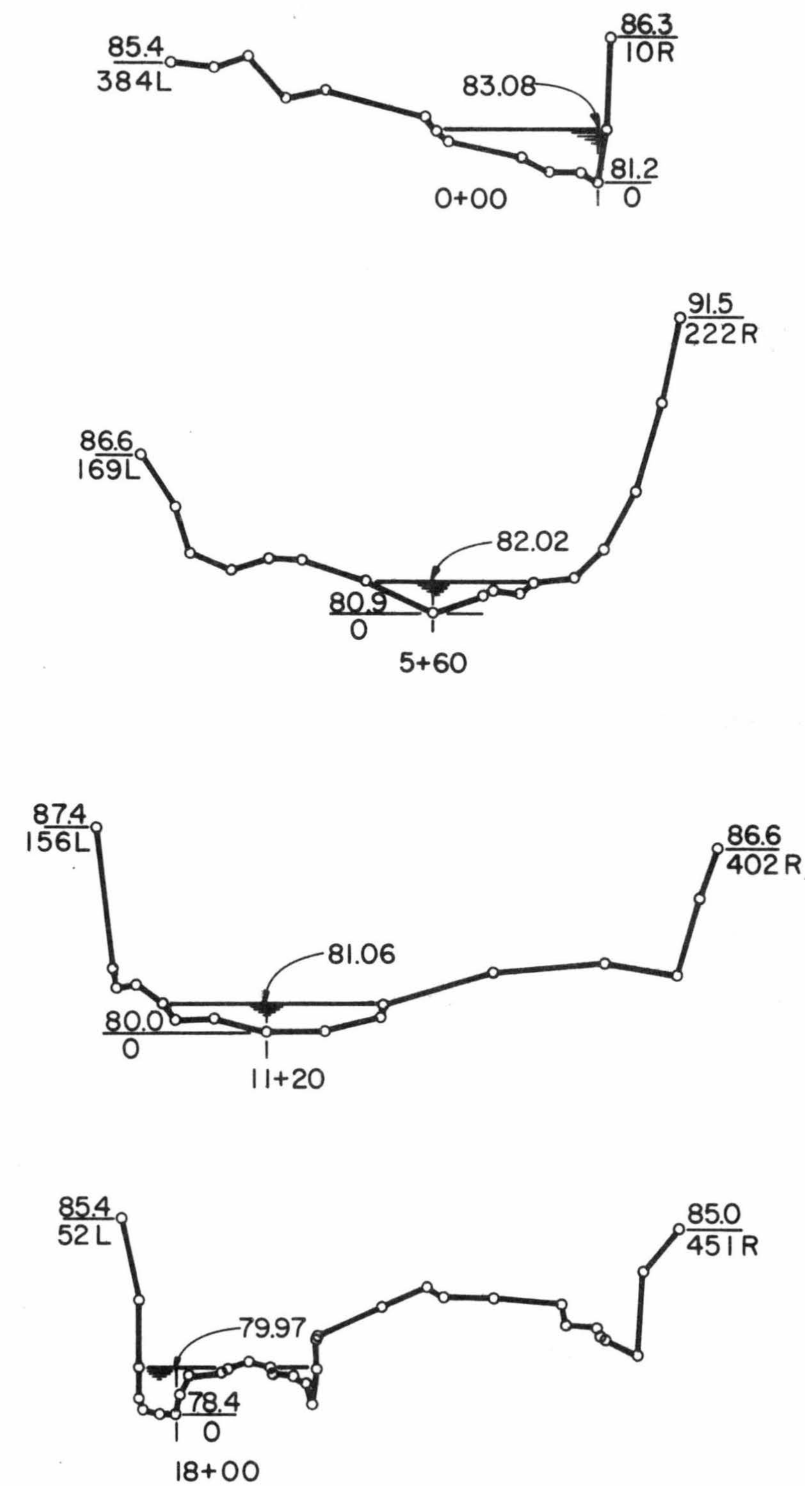


FIGURE IV-38 RIO TONORO CROSS SECTIONS

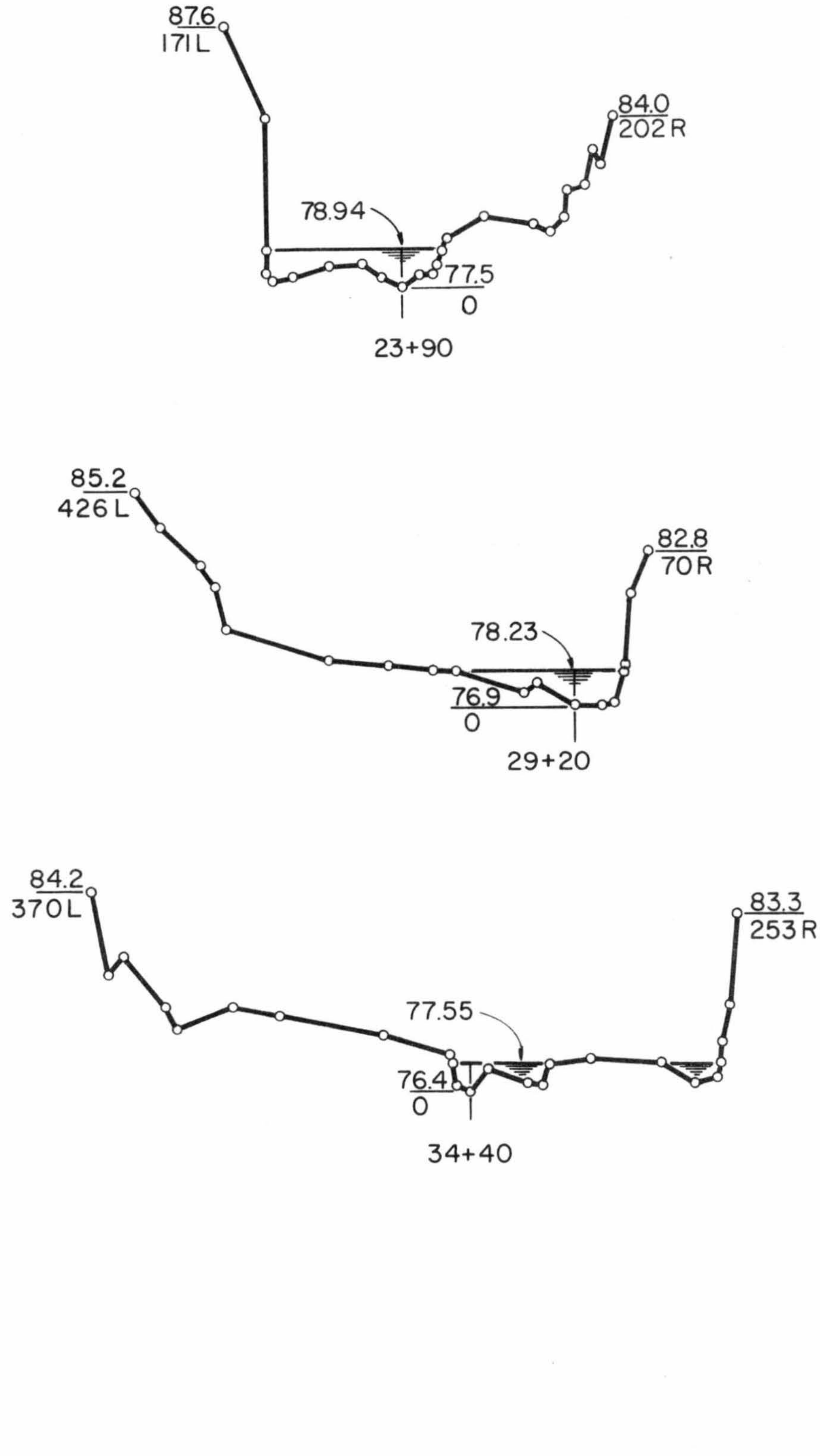


FIGURE IV-39 RIO TONORO CROSS SECTIONS

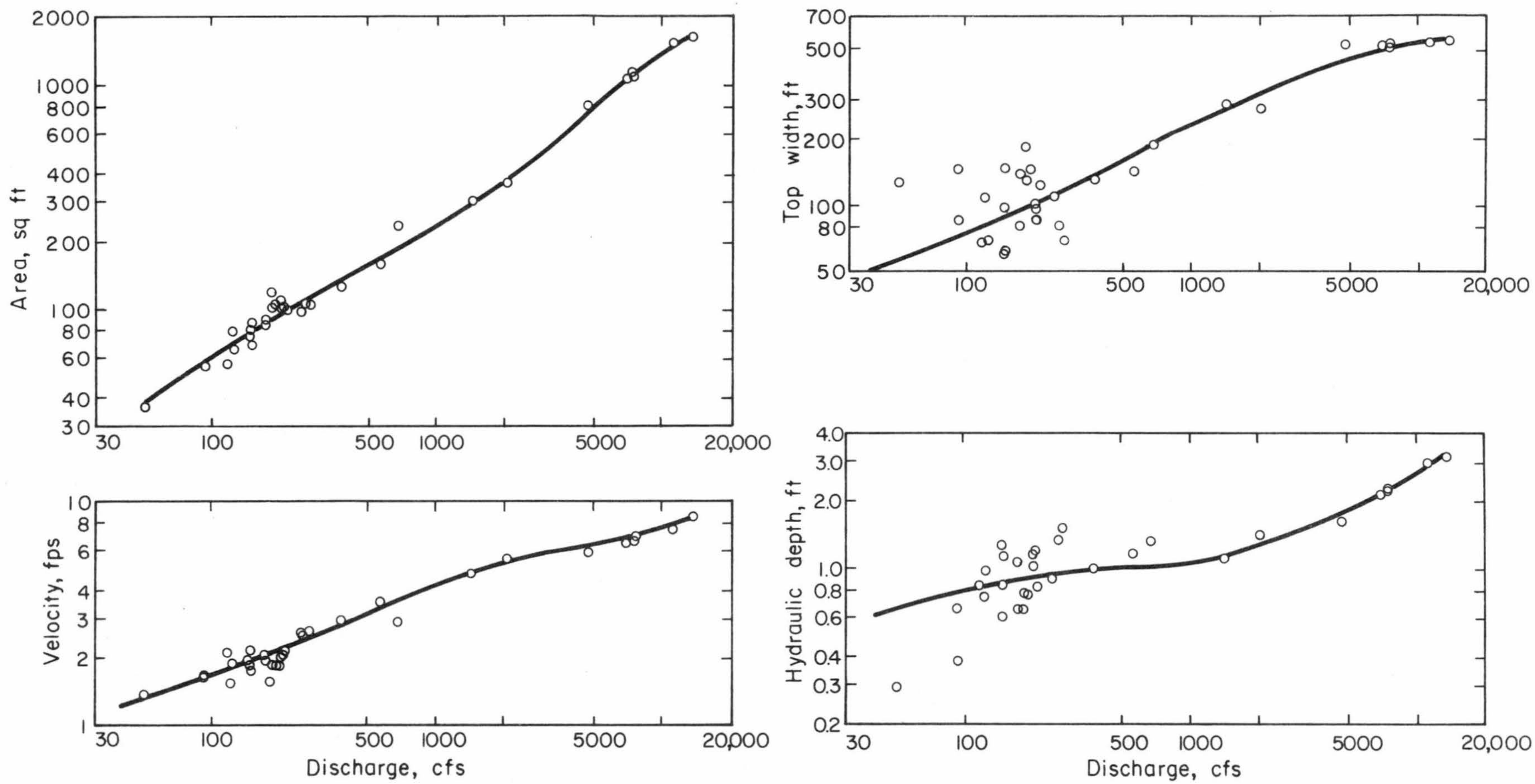


FIGURE IV-40 RELATIONS FOR THE RIO TONORO GAGING STATION

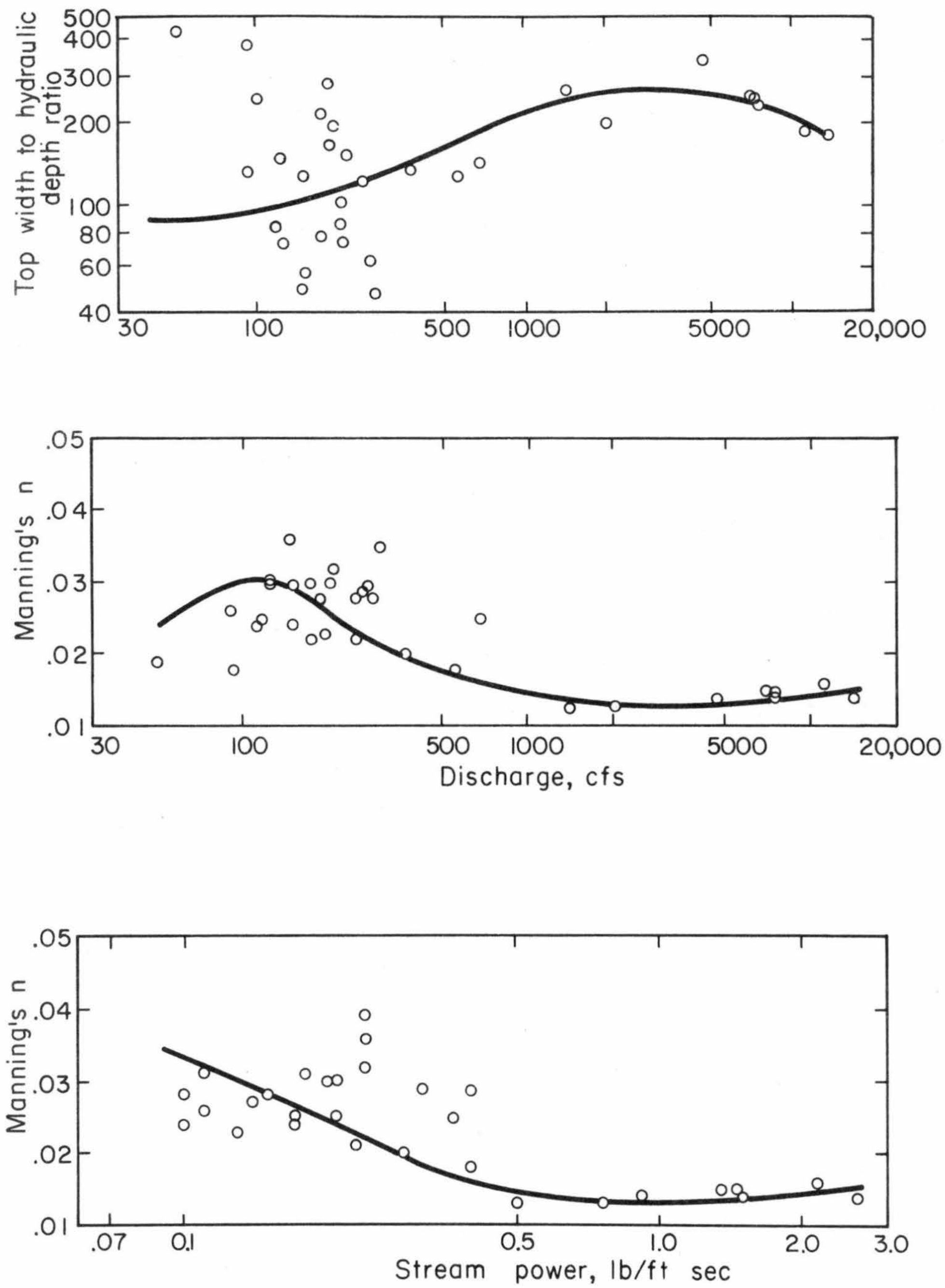


FIGURE IV-41 RELATIONS FOR THE RIO TONORO GAGING STATION

Sta. No. 35 Río Guanipa at the Crossing of the Maturín-Temblador Road

Longitude 63° 07.4' W, latitude 09° 35.0' N. Approximately 18.8 km SSE of Maturín.

The plan and profile shown on Figure IV-42 were obtained on October 14, 1969. The gage height was 2.020 meters and the discharge was approximately 1470 cfs. The zero gage height corresponds to elevation 43.064 meters above mean sea level. The reference bench mark is Cartagrafía Nacional (1965) No. SM38, elevation 49.235 meters AMSL located on the bridge across the Río Guanipa. The elevations given on Figures IV-42 and IV-43 are referenced to bench mark No. SM38 but for an assumed elevation of 100.00 feet.

The relations for the reach of river at the Maturín-Temblador road crossing are developed from the surveyed cross sections 0+00, 2+10, 4+14 and 6+15 and are shown on Figures IV-43 and IV-44. The same relations are derived from the discharge measurement summary and are shown on Figures IV-45 and IV-46.

At Sta. No. 35, the median diameter of the bed material is 0.35 mm (Figure III-1) and the river slope is 5.1 feet per mile (Table II-1). The bank materials are described in Volume II, page III-35.

An aerial view of the river reach in the vicinity of the Maturín-Temblador road is given in Volume II, page II-115.

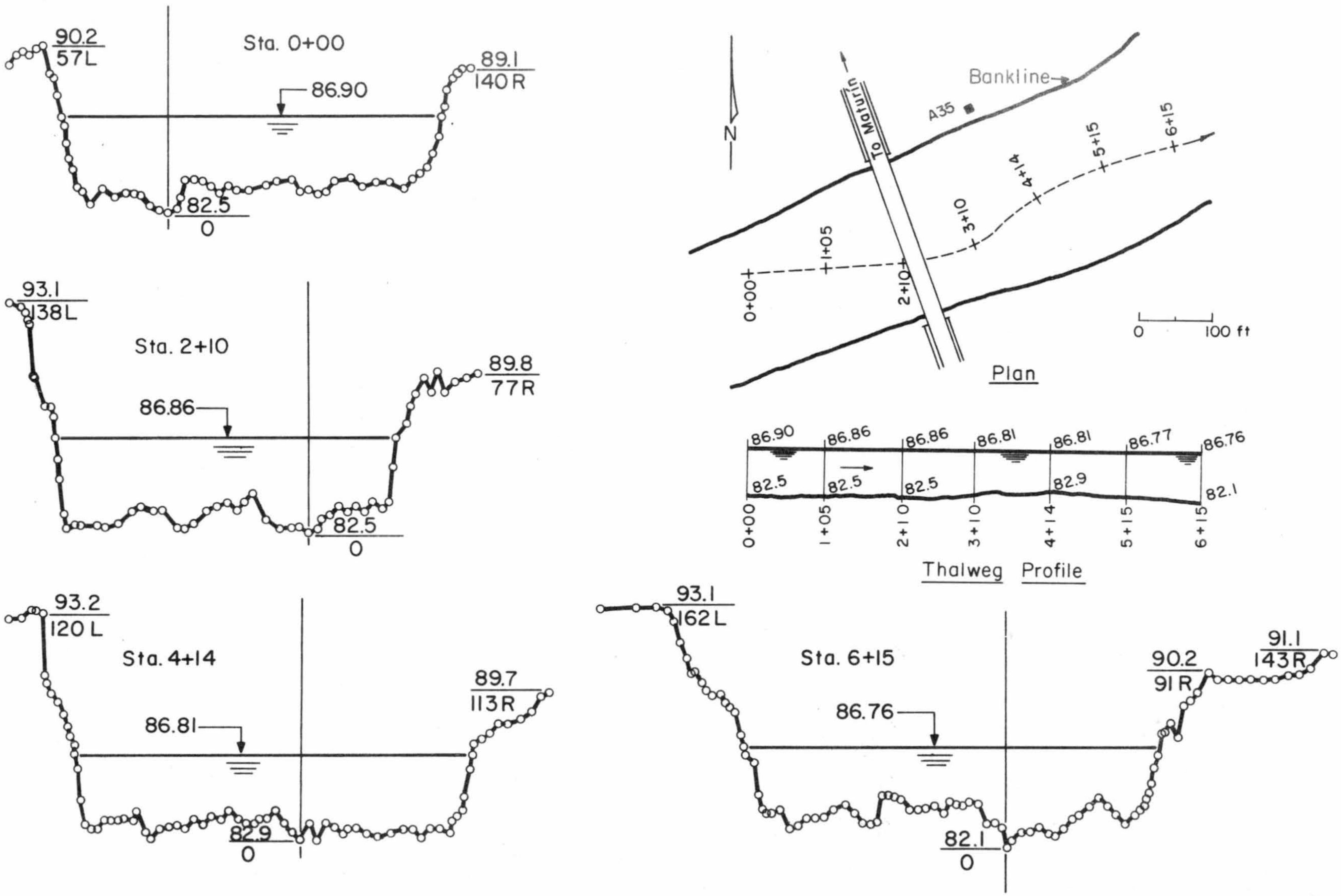


FIGURE IV-42 RIO GUANIPA PLAN AND CROSS SECTIONS AT STA. NO. 35

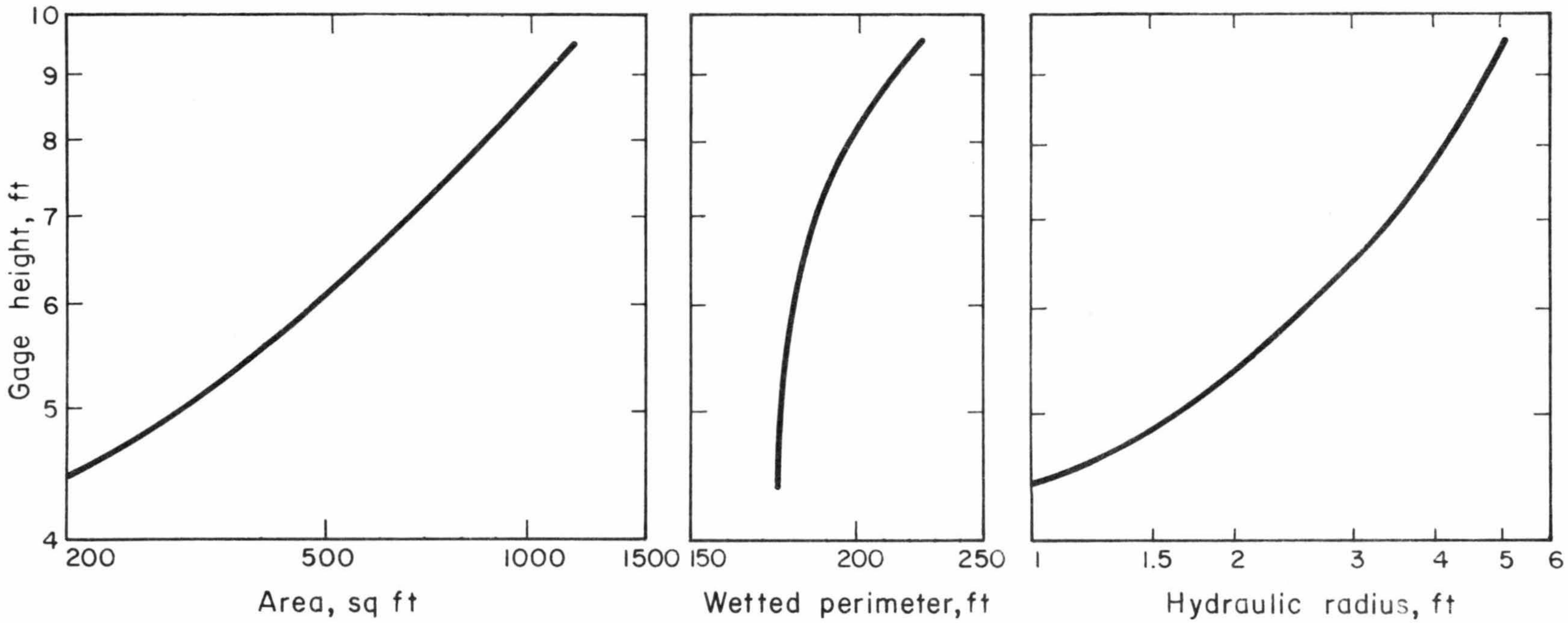


FIGURE IV-43 GEOMETRY-STAGE RELATIONS FOR THE RIO GUANIPA

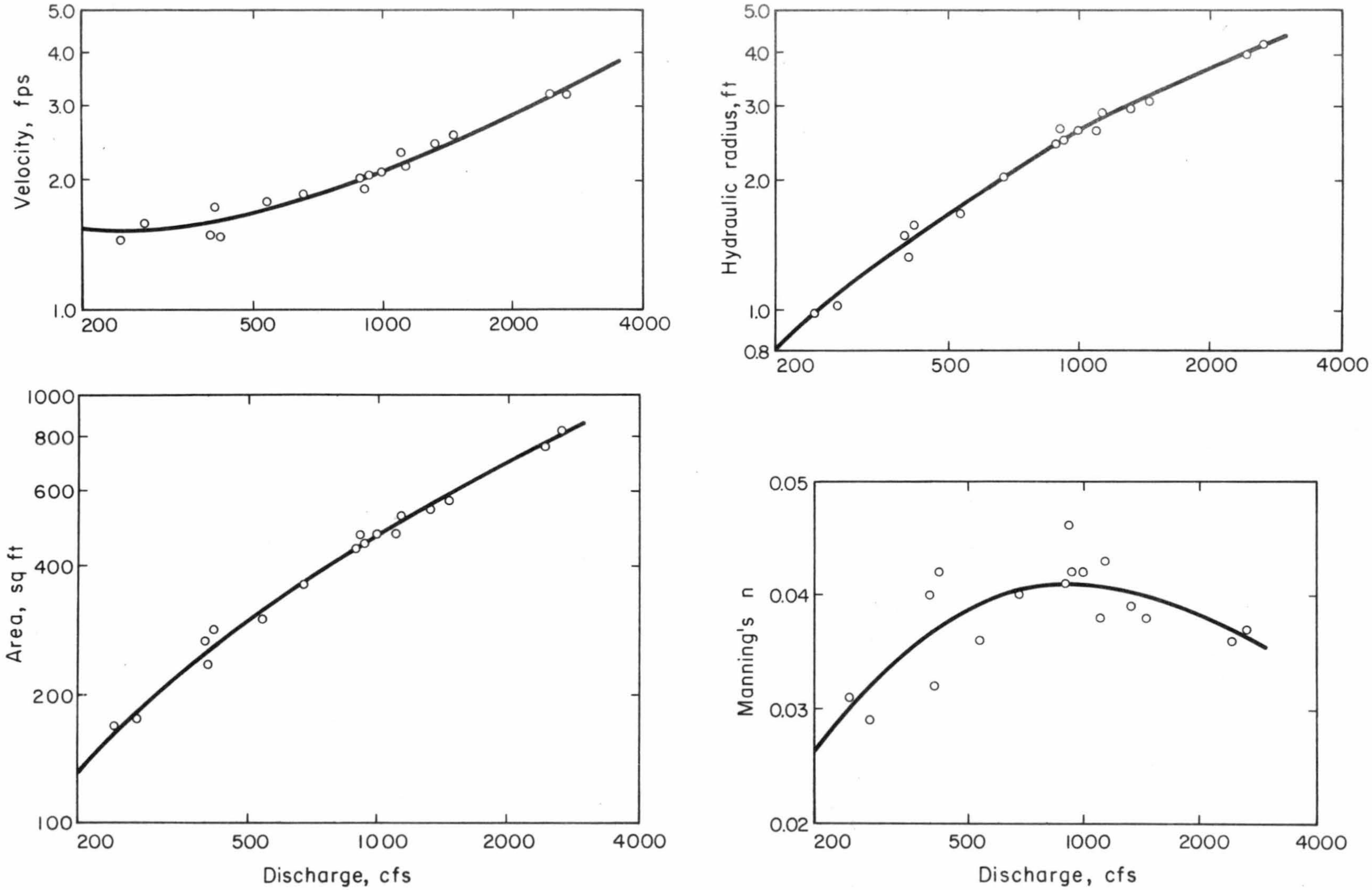


FIGURE IV-44 RELATIONS FOR THE RIO GUANIPA DEVELOPED FROM THE SURVEYED CROSS SECTIONS

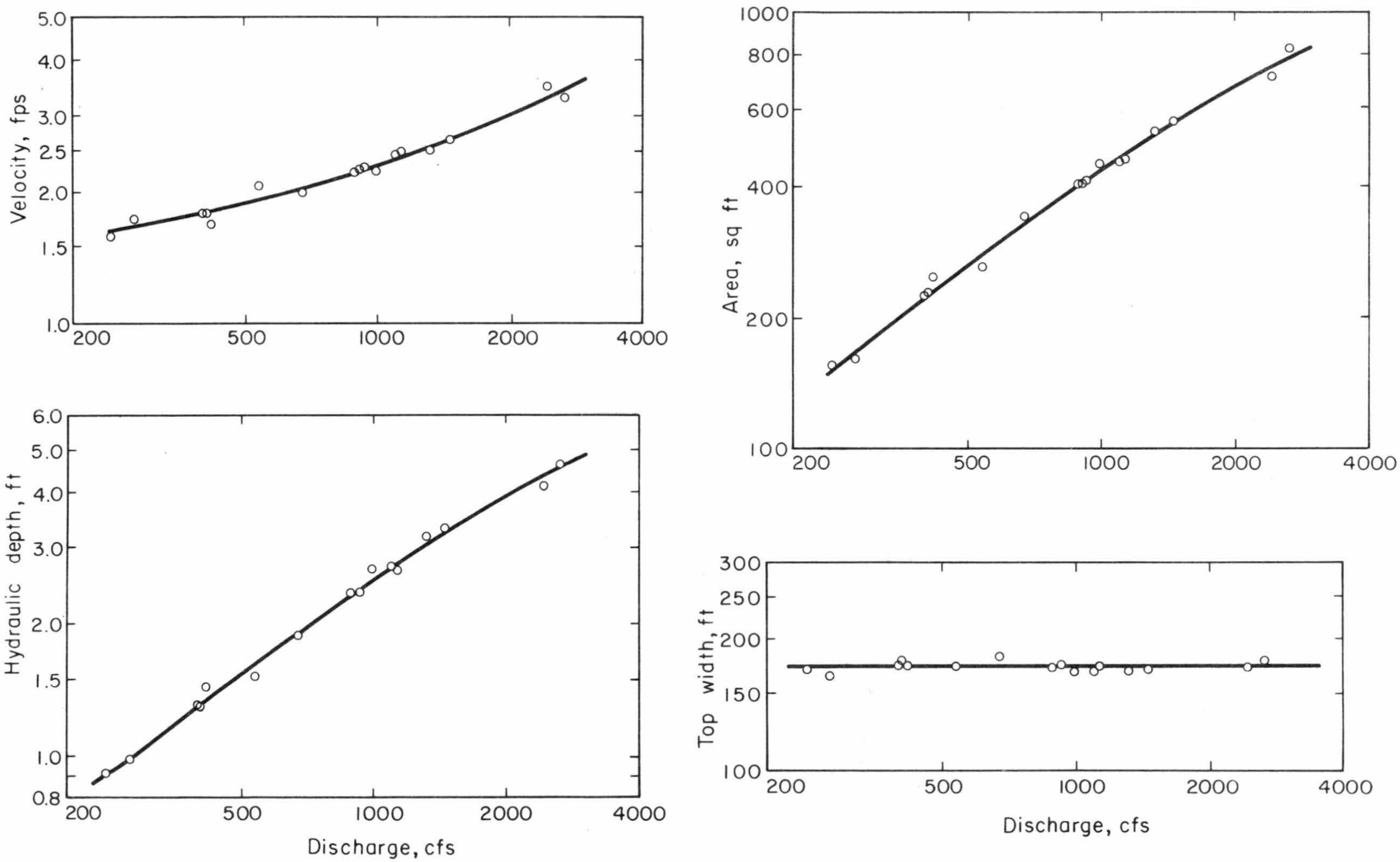


FIGURE IV-45 RELATIONS FOR THE RIO GUANIPA GAGING STATION
DEVELOPED FROM THE DISCHARGE MEASUREMENT SUMMARY

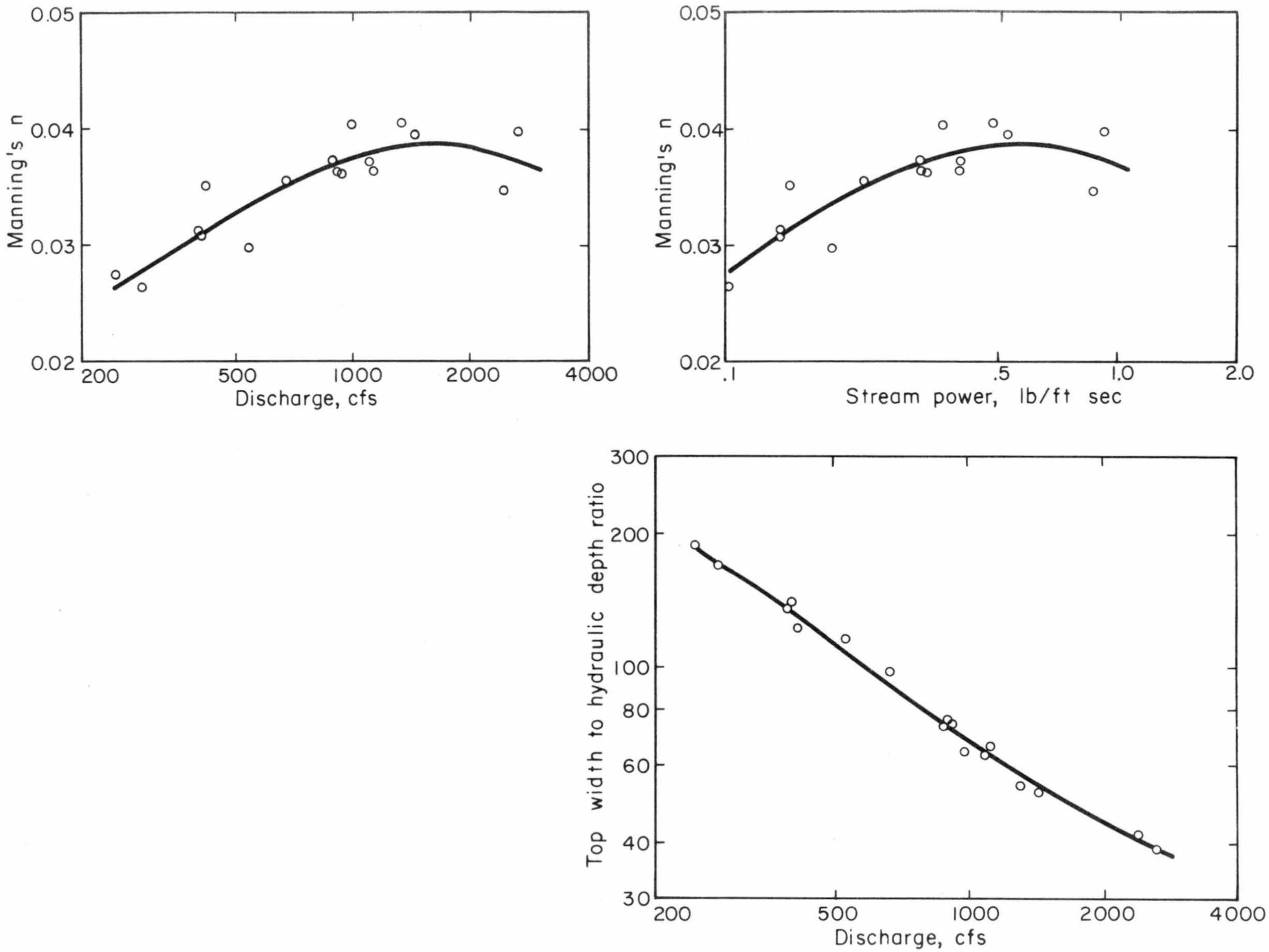


FIGURE IV-46 RELATIONS FOR THE RIO GUANIPA GAGING STATION DEVELOPED FROM THE DISCHARGE MEASUREMENT SUMMARY

Sta. No. 41 Río Mapirito at the Crossing of the Maturín-Temblador Road

Longitude 63° 08.2' W, latitude 09° 36.8' N. Approximately 15.3 km SSE of Maturín, at Balneario Mapirito.

The reach of river at Sta. No. 41 was not surveyed. The relations shown on Figures IV-47 and IV-48 are developed from the discharge measurement summary. In 1969, the reach of river was affected by a growth of grass vegetation in the channel. The vegetation affected the channel flow during the latter part of the summer. A photograph of the view looking downstream from the bridge is given in Volume II, page II-123.

No bed-material samples were collected at Sta. No. 41. The river slope is 7.9 feet per mile (Table II-1). The bank materials are described in Volume II, page III-36.

The zero gage height at Sta. No. 41 corresponds to a stage of 40.425 meters AMSL. The reference bench mark is Cartografía Nacional (1965) No. SM39 for which the elevation is 43.881 meters AMSL. The bench mark is on the Maturín-Temblador road bridge over the Río Mapirito.

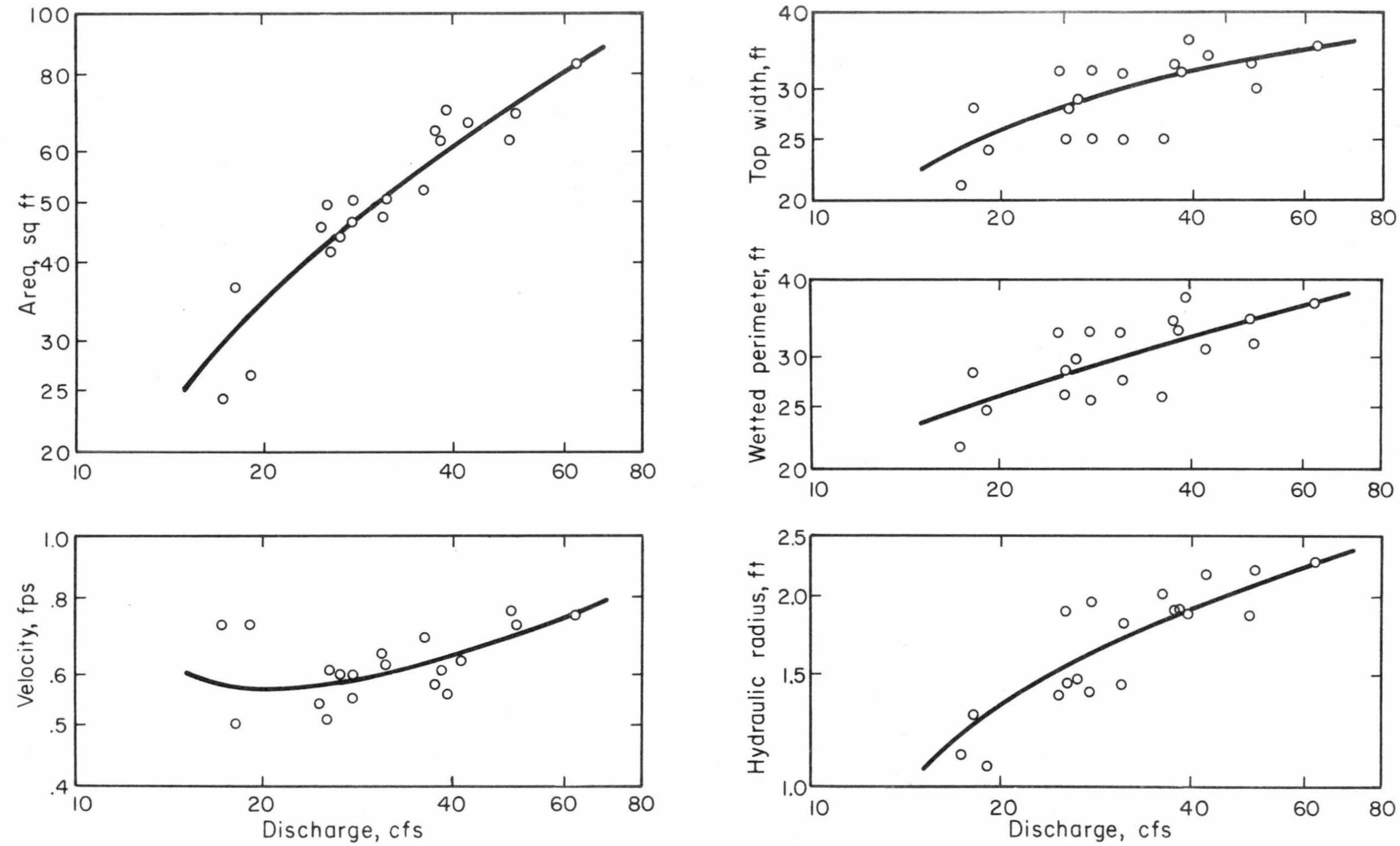


FIGURE IV-47 RELATIONS FOR THE RIO MAPIRITO GAGING STATION

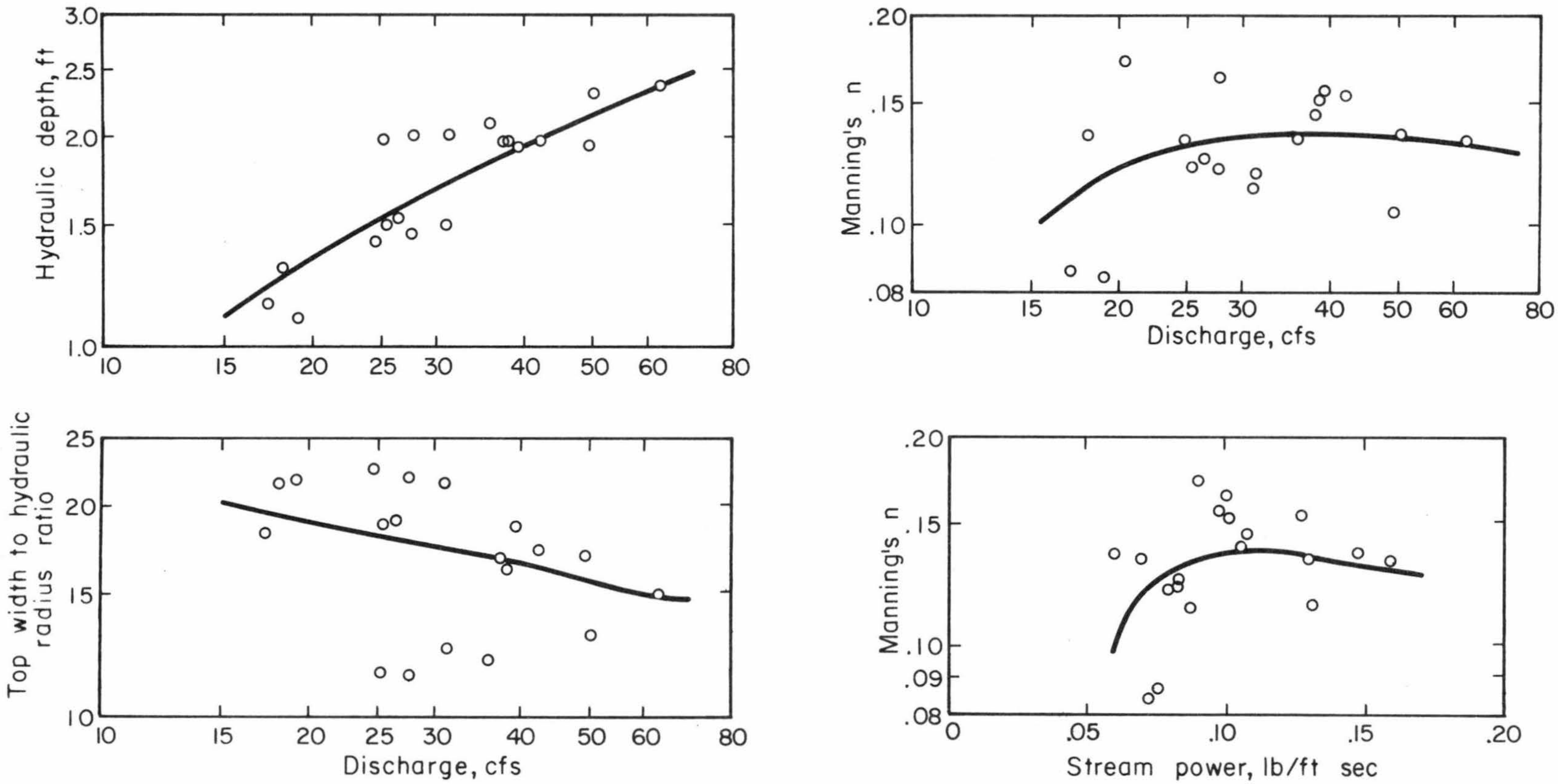


FIGURE IV-48 RELATIONS FOR THE RIO MAPIRITO GAGING STATION

Sta. No. 52 Río Amana at the Crossing of the Maturín-Temblador Road

Longitude 63^{o} 08.2' W, latitude 09^{o} 39.0' N. Approximately 11.5 km SSE of Maturín, at Amana Abajo.

No survey was made of the Río Amana. The relations shown on Figures IV-49 and IV-50 are obtained from the discharge measurement summary.

The zero gage height at Sta. No. 52 is 39.521 meters AMSL. The reference bench mark is Cartografía Nacional (1965) No. SM40 on the bridge over the Río Amana. The elevation of the bench mark is 47.142 meters.

The river slope at Sta. No. 52 is 3.5 feet per mile (Table II-1) and the bed-material size is 0.36 mm (Figure III-1). The bank materials are described in Volume II, page III-37.

An aerial view of the Río Amana at the crossing of the Maturín-Temblador road is given in Volume II, page II-143.

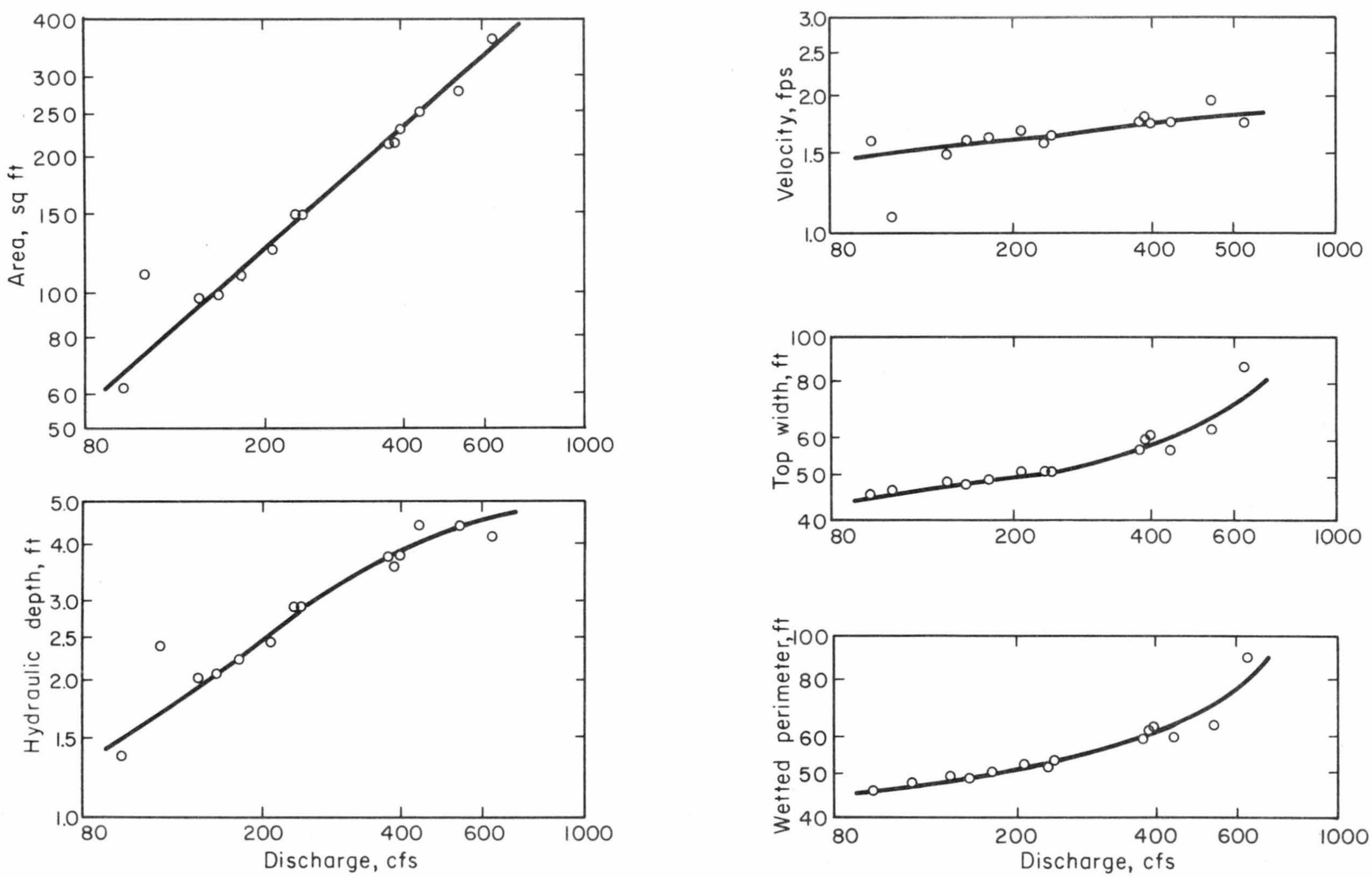


FIGURE IV-49 RELATIONS FOR THE RIO AMANA AT STA. NO. 52

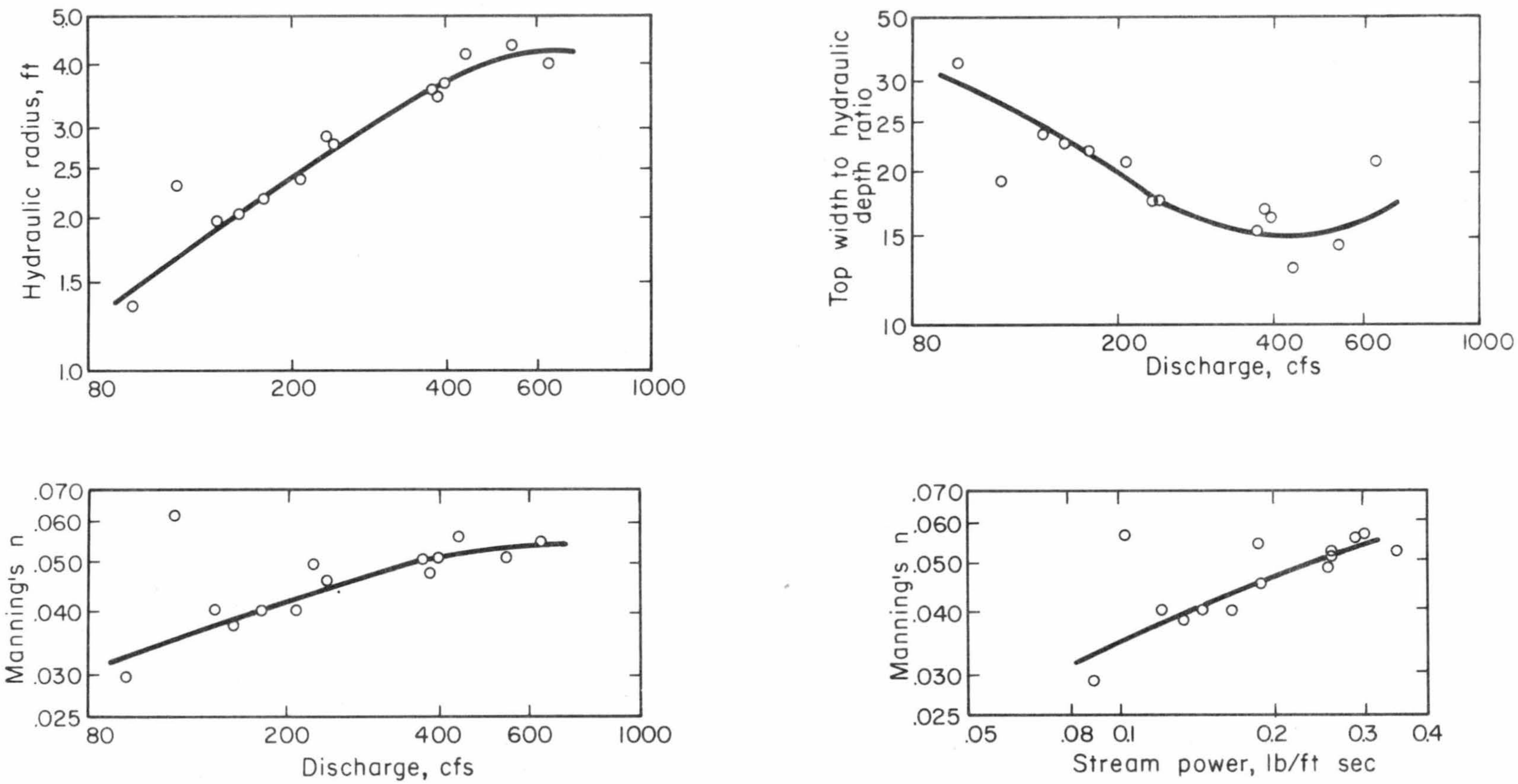


FIGURE IV-50 RELATIONS FOR THE RIO AMANA AT STA. NO. 52

CHAPTER V

SURVEYS OF THE CREST-STAGE GAGING STATIONS

STATION DATA

Surveys were made of cross sections and river reaches at the eight crest-stage gaging stations shown on Figure V-1. The information obtained from those surveys are presented in this chapter. At all stations, the cross section of the river at the SR gage was obtained. At four stations, a reach of river was surveyed. Because only a few discharge measurements were made at each station, the survey information was used to help establish the discharge rating curves for the SR gaging stations. As the stage-discharge rating curves and the relations between geometry and discharge are not developed independently, the geometry-discharge relations are not presented as data.

The river slopes at the SR gaging stations are obtained from topographic maps. The elevation and river distance information is given in Chapter II and the slopes are listed in Table II-1.

Bed material samples were collected and analyzed for size at five of the SR stations shown on Figure V-1. The size properties of the bed material samples are given in Chapter III.

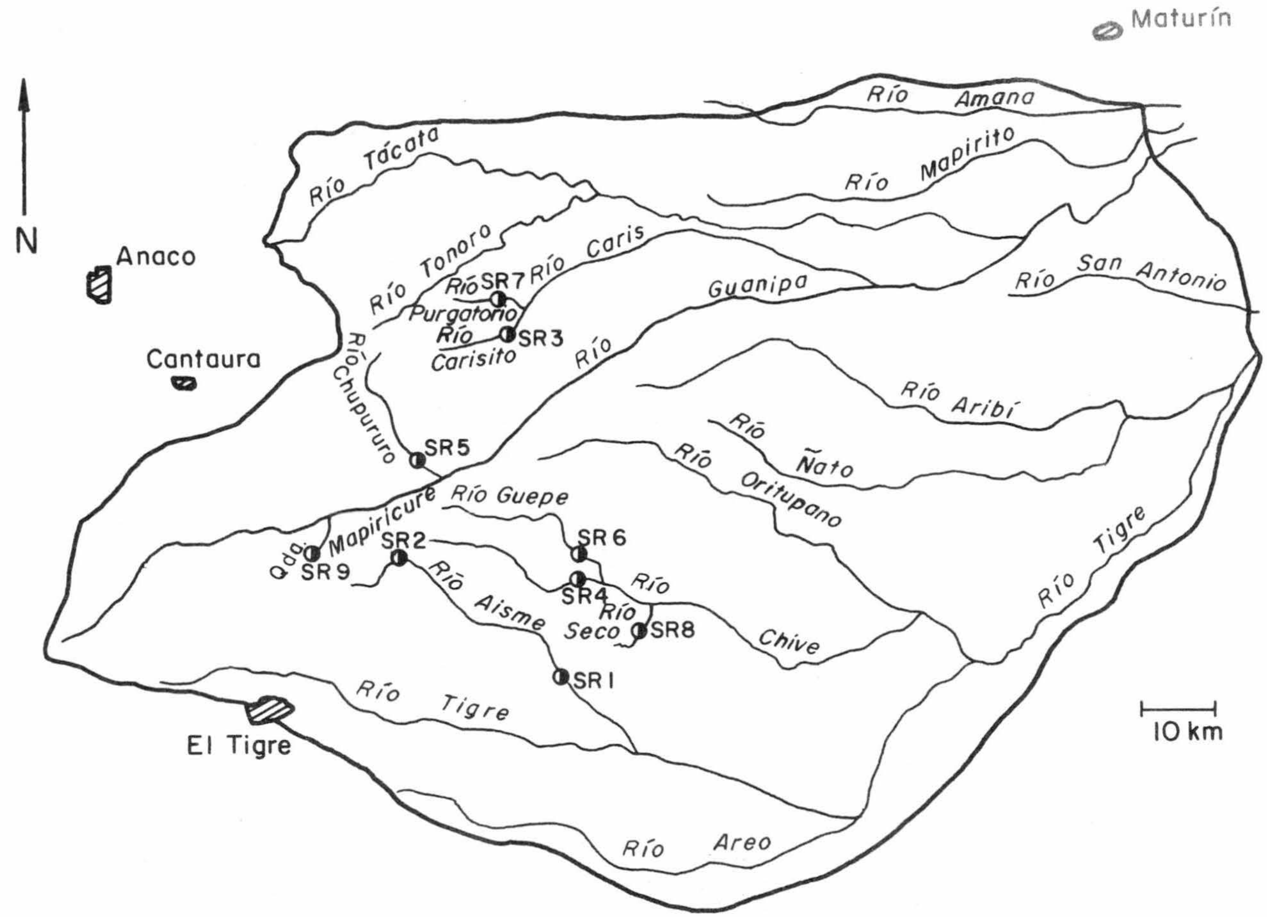


FIGURE V-1 LOCATIONS OF CREST-STAGE PARTIAL RECORD STATIONS

Sta. No. SR1 Río Aisme near Urupia

Longitude 63° 52.7' W, latitude 08° 56.2' N. Approximately 41.3 km ENE of El Tigre, 2.2 km ESE of Urupia.

The Río Aisme at Sta. No. SR1 is relatively narrow and deep with heavy vegetation on the banks and on the flood plain. The cross section at the bridge is shown on Figure IV-2. The section is representative of the reach of river. A photograph of the river channel at the bridge is given in Volume II, page II-157.

The reference bench mark at Sta. No. SR1 is the top of the guard rail on the downstream side of the bridge at the left abutment. The elevation of the bench mark is assumed to be 100.00 feet. The zero gage height corresponds to a water surface stage elevation of 84.5 feet. The maximum gage height recorded during the summer of 1969 was 18.1 feet. The discharge for this gage height was estimated as 5000 cfs.

The bed materials at Sta. No. SR1 were not sampled. The bank materials are described in Volume II, page III-39.

The river slope at Sta. No. SR1 is 8.7 feet per mile (Table II-1) according to the topographic maps.

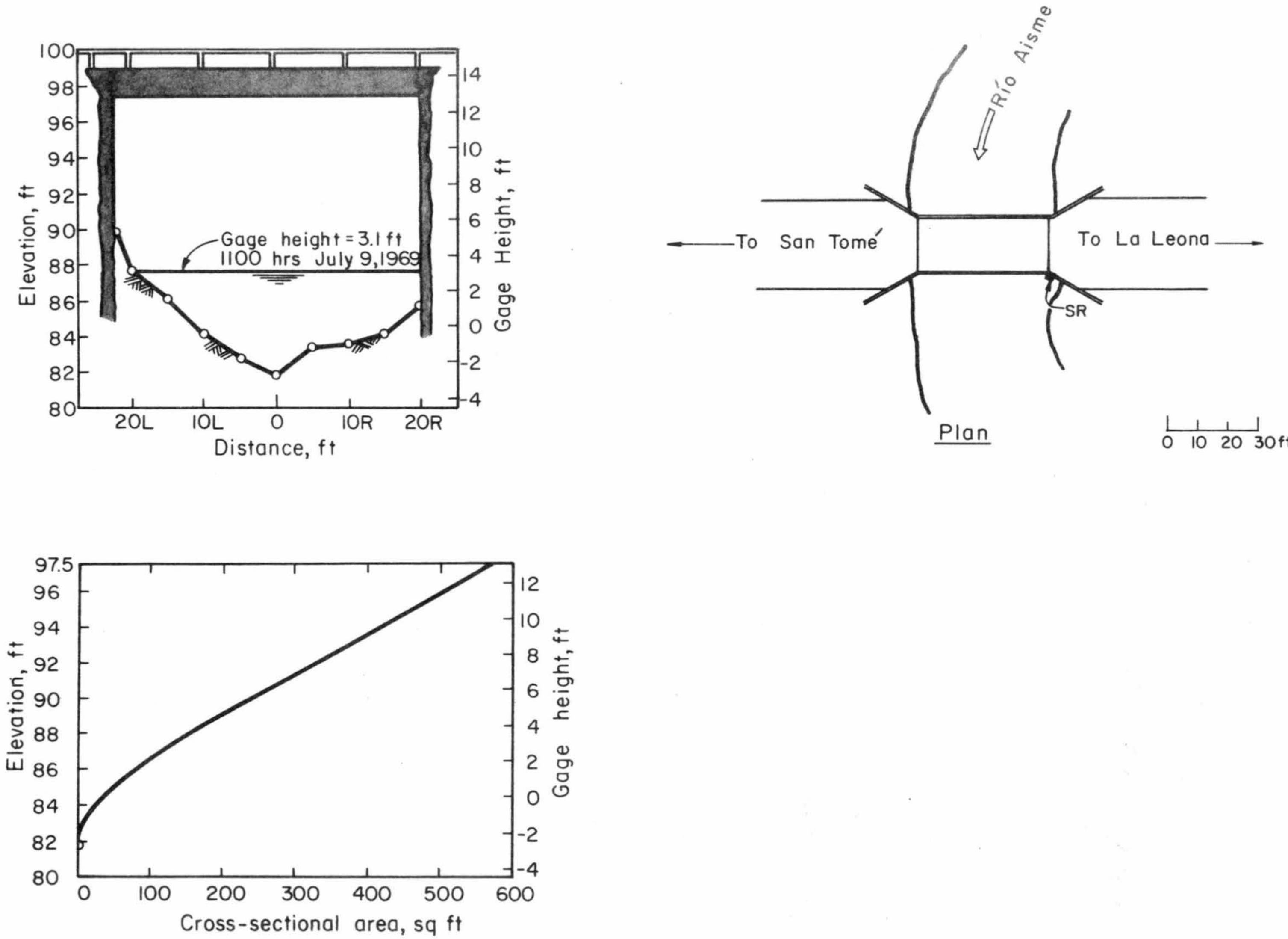


FIGURE V-2 PLAN AND CROSS SECTION OF THE RIO AISME NEAR URUPIA

Sta. No. SR2 Río Aisme near El Aisme

Longitude 64° 04.8' W, latitude 09° 05.0' N. Approximately 40.4 km SE of Cantaura, near El Aisme.

Surveys were made of the river reach at the SR2 gaging station on August 26 and 27, 1969. The discharge was less than 1 cfs and the water surface stage elevation was 79.7 feet. The river reach was surveyed so that the peak flood discharge which occurred between 0200 hours and 1800 hours on August 12, 1969, could be computed. The reference bench mark is the top and extreme end of the guard rail which runs along the sheet piling abutment on the right bank on the upstream side of the bridge. The bench mark elevation is assumed 100.00 feet.

The plan of the river reach is shown on Figure V-3. A photograph of the same reach is given in Volume II, page II-165. The river is incised in this reach and the banklines are well defined. The banklines, the low water channel and the thalweg position are identified on Figure V-3. The Quebrada El Caruto is a tributary to the Río Aisme.

Cross sections of the Río Aisme are presented on Figures V-4, V-5 and V-6. The high water marks (HWM) for the August 12 flood are shown on the cross sections.

The profile of the river reach is shown on Figure V-7. The high water marks define a uniform slope between stations 0+00 and 6+00. Below the Quebrada El Caruto, the high water marks indicate an erratic water surface profile due possibly to the influence of the tributary. The peak flood discharge corresponding to the high water marks is estimated as 9200 cfs.

The river slope at SR2 is 9.2 feet per mile (Table II-1). The median diameter of the bed material is 0.47 mm (Figure III-1). The bank materials are described in Volume II, page III-40.

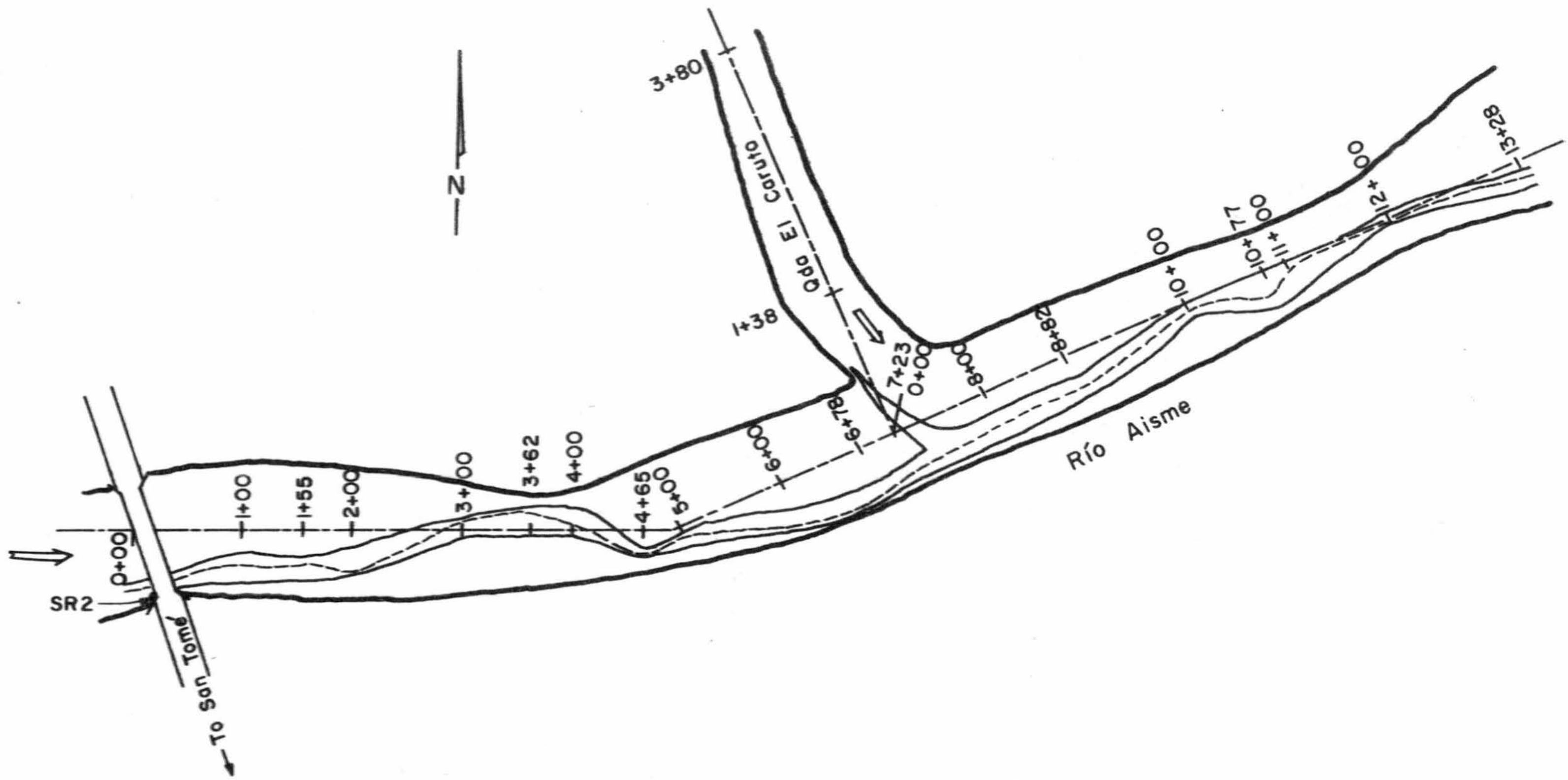


FIGURE V-3 PLAN OF THE RIO AISME NEAR EL AISME

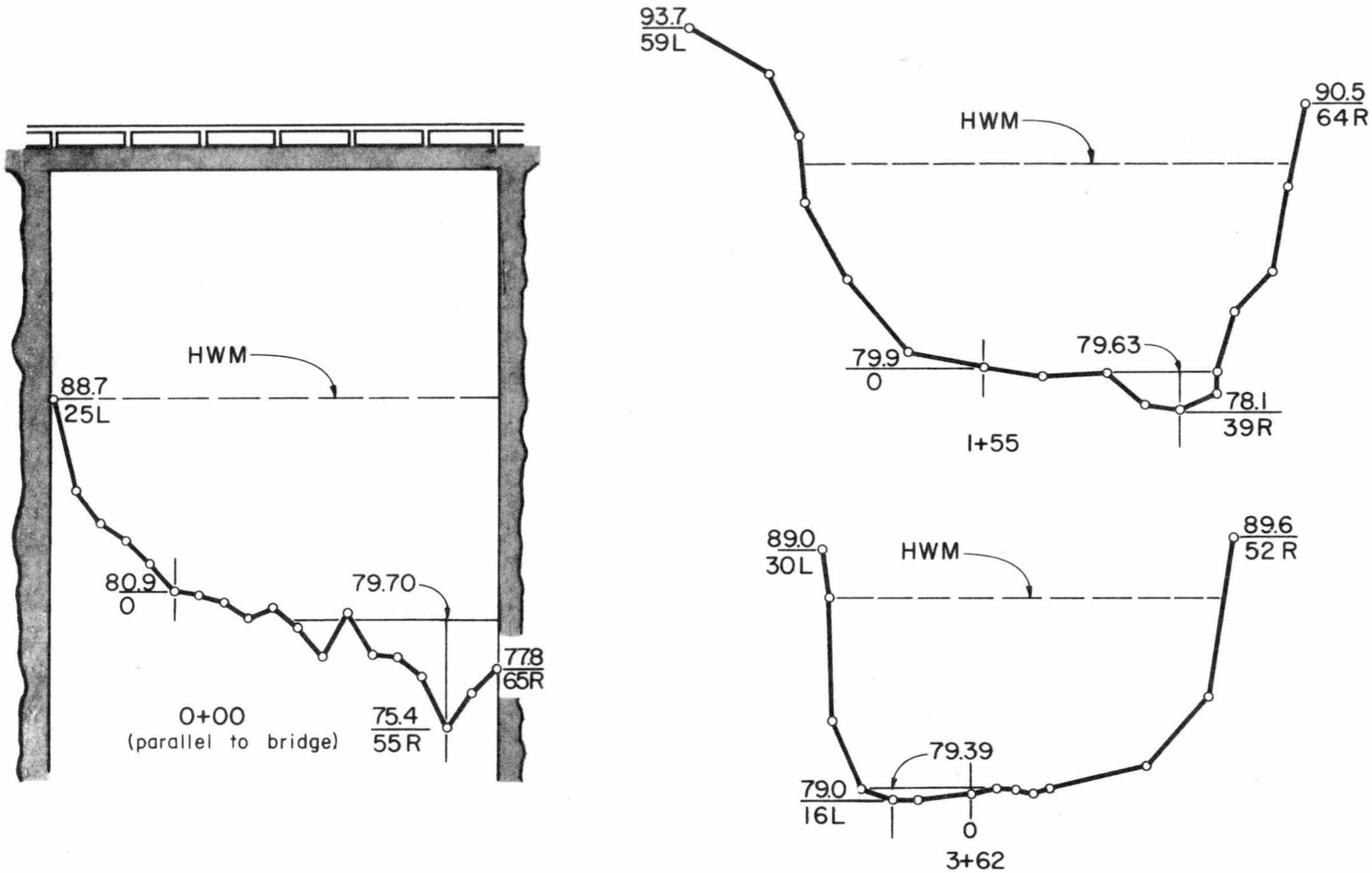


FIGURE V-4 RIO AISME CROSS SECTIONS

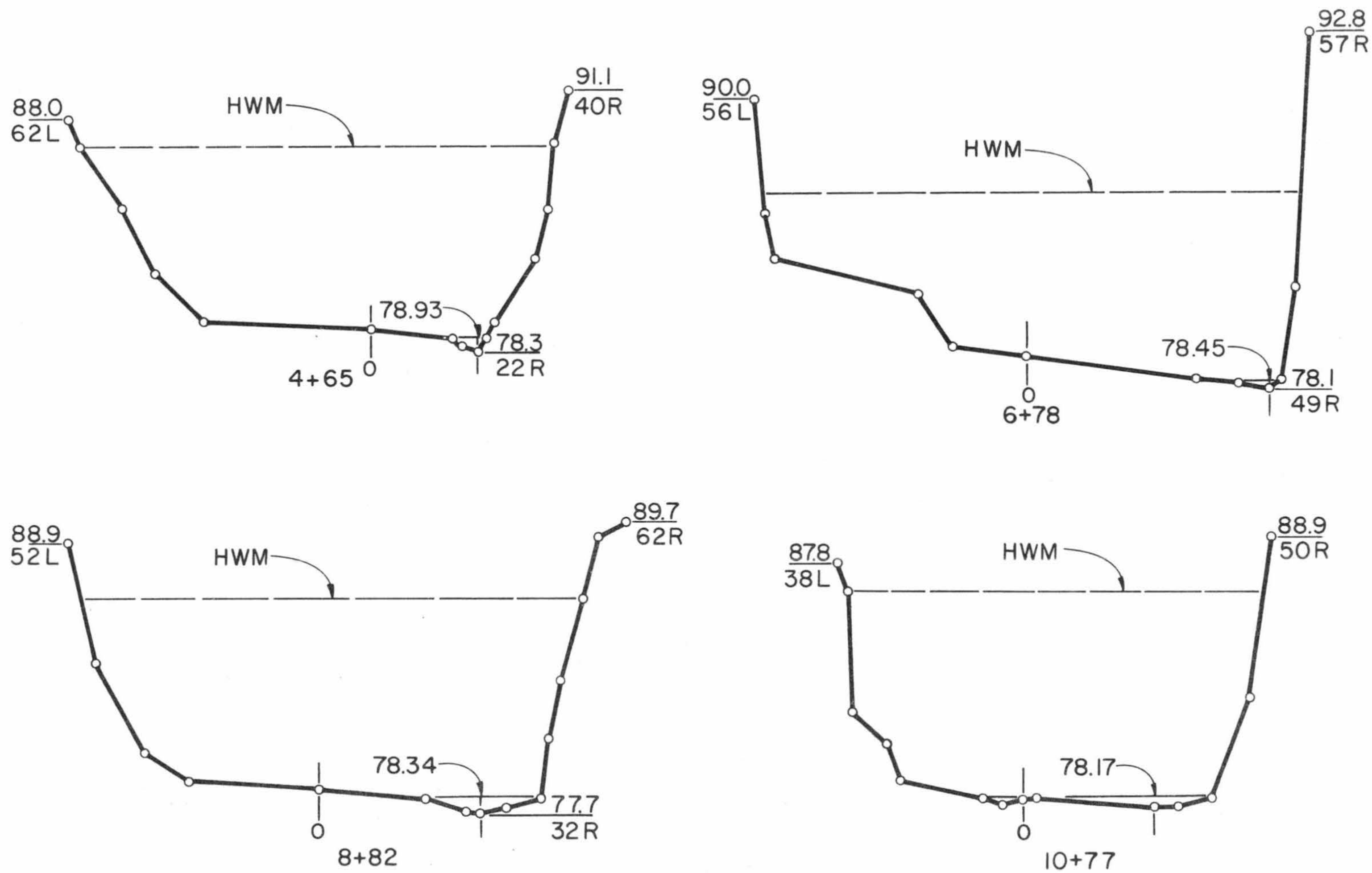
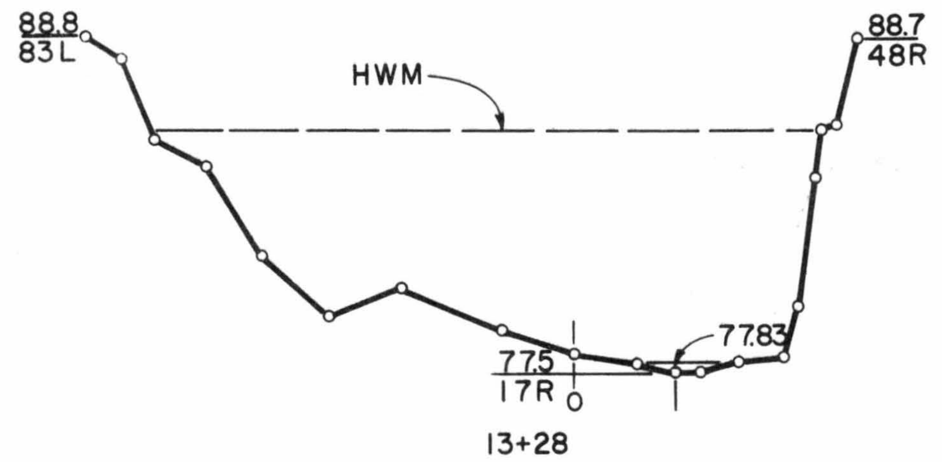
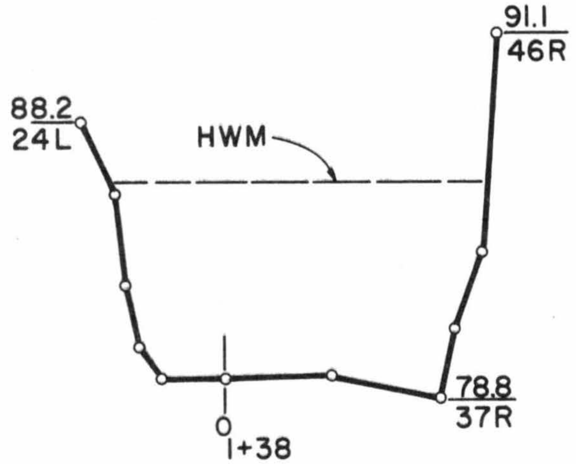


FIGURE V-5 RIO AISME CROSS SECTIONS





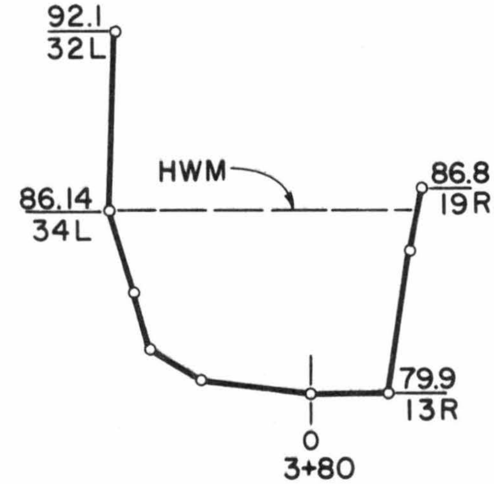


FIGURE V-6 RIO AISME AND QDA EL CARUTO CROSS SECTIONS

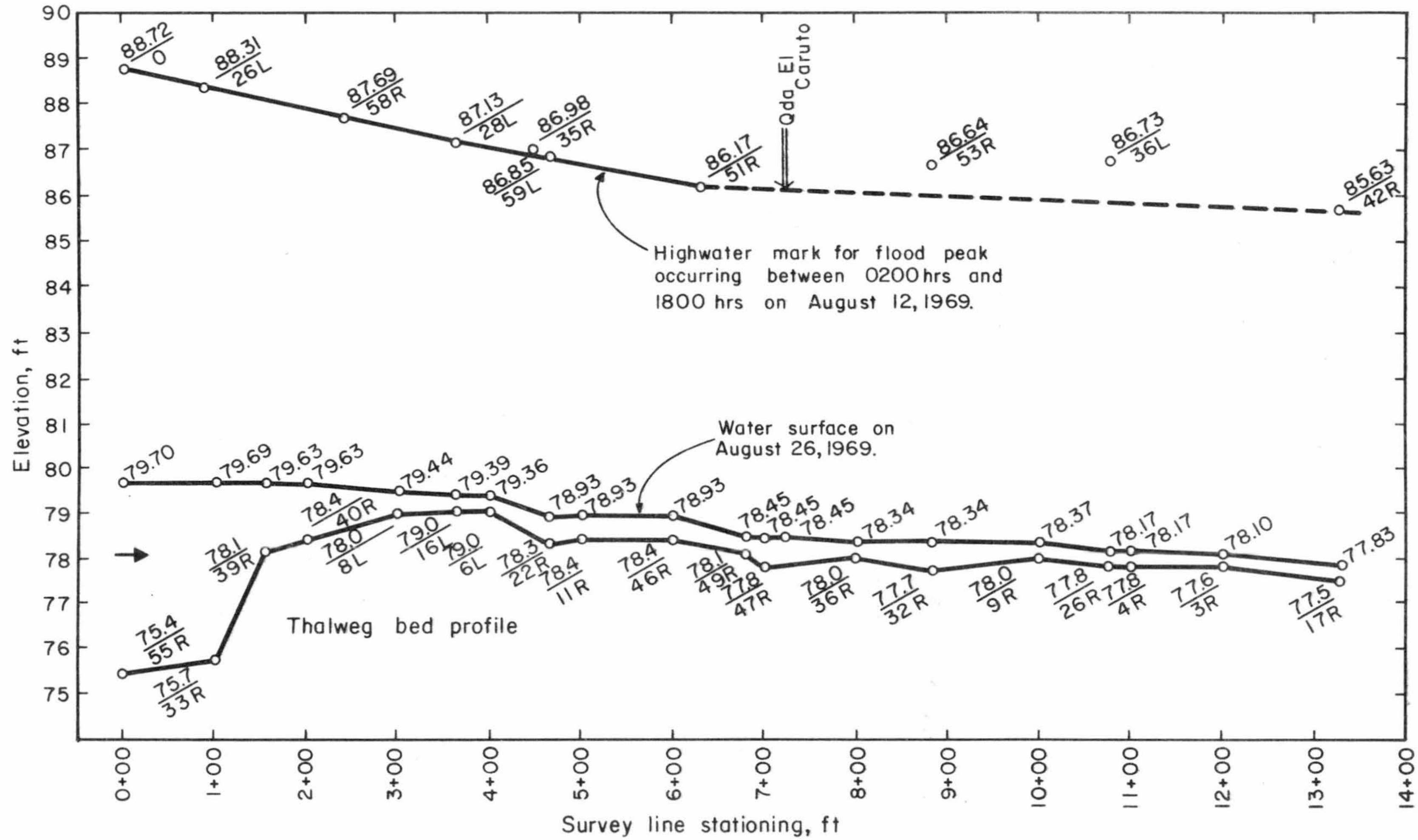


FIGURE V-7 PROFILE OF THE RIO AISME NEAR EL AISME

Sta. No. SR3 Río Carisito near Carisito

Longitude 63° 56.8' W, latitude 09° 21.8' N. Approximately 25.2 km WSW of Aguasay, near Carisito.

The reach of river shown on Figure V-8 was surveyed on October 9, 1969. The gage height was 1.17 feet and the water surface stage was 93.77 feet. A photograph of the view looking upstream from the bridge is given in Volume II, page II-173.

The reference bench mark is the top of the 6-inch diameter steel post which marks the downstream left abutment of the bridge. The bench mark elevation is assumed to be 100.00 feet. The discharge at the time of the survey was approximately 7 cfs.

According to the topographic maps, the river slope is 13 feet per mile.

The median diameter of the bed material at the Carisito gaging station is 2.20 mm. The bank materials are described in Volume II, page III-40.

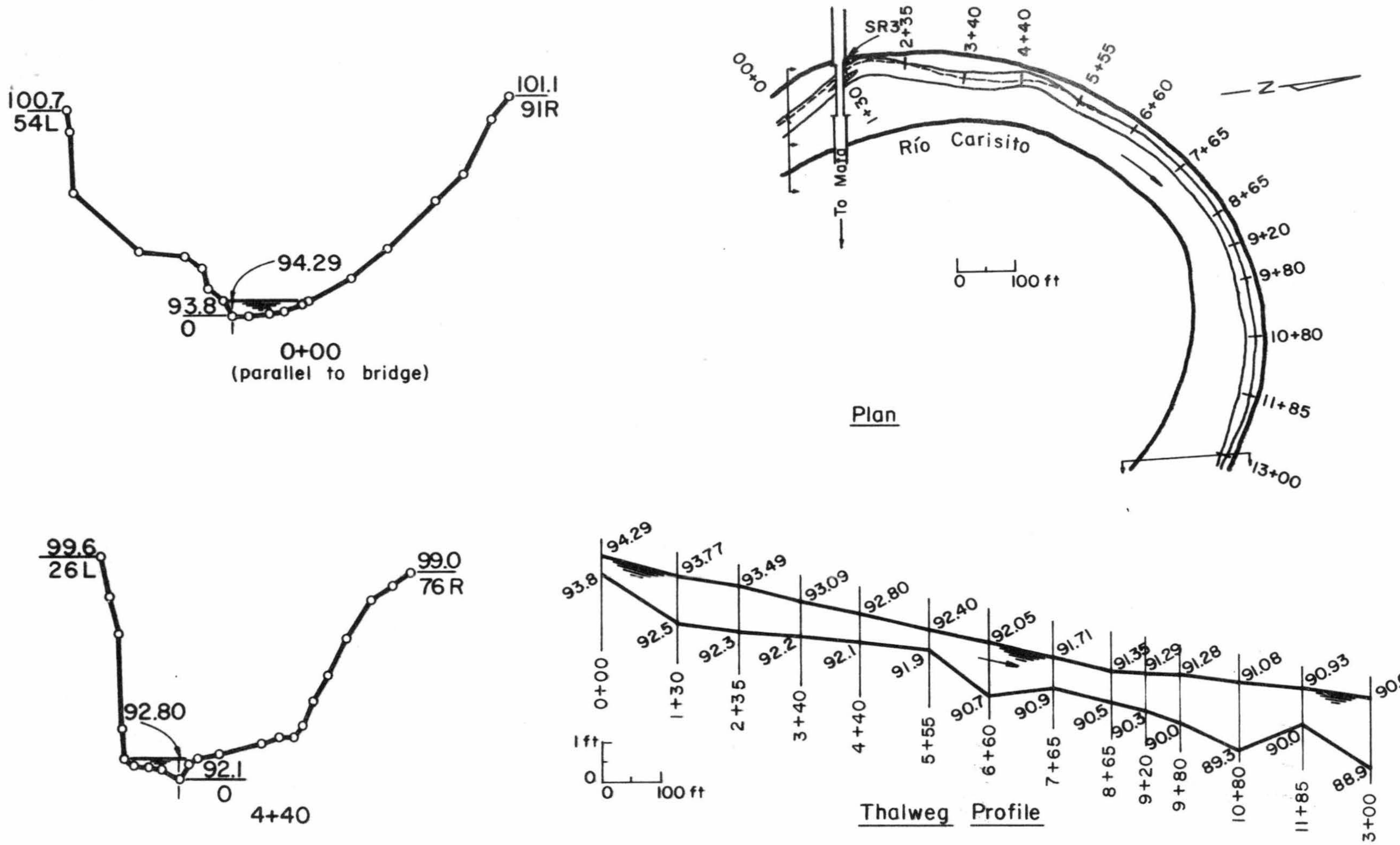


FIGURE V-8 RIO CARISITO PLAN AND CROSS SECTIONS

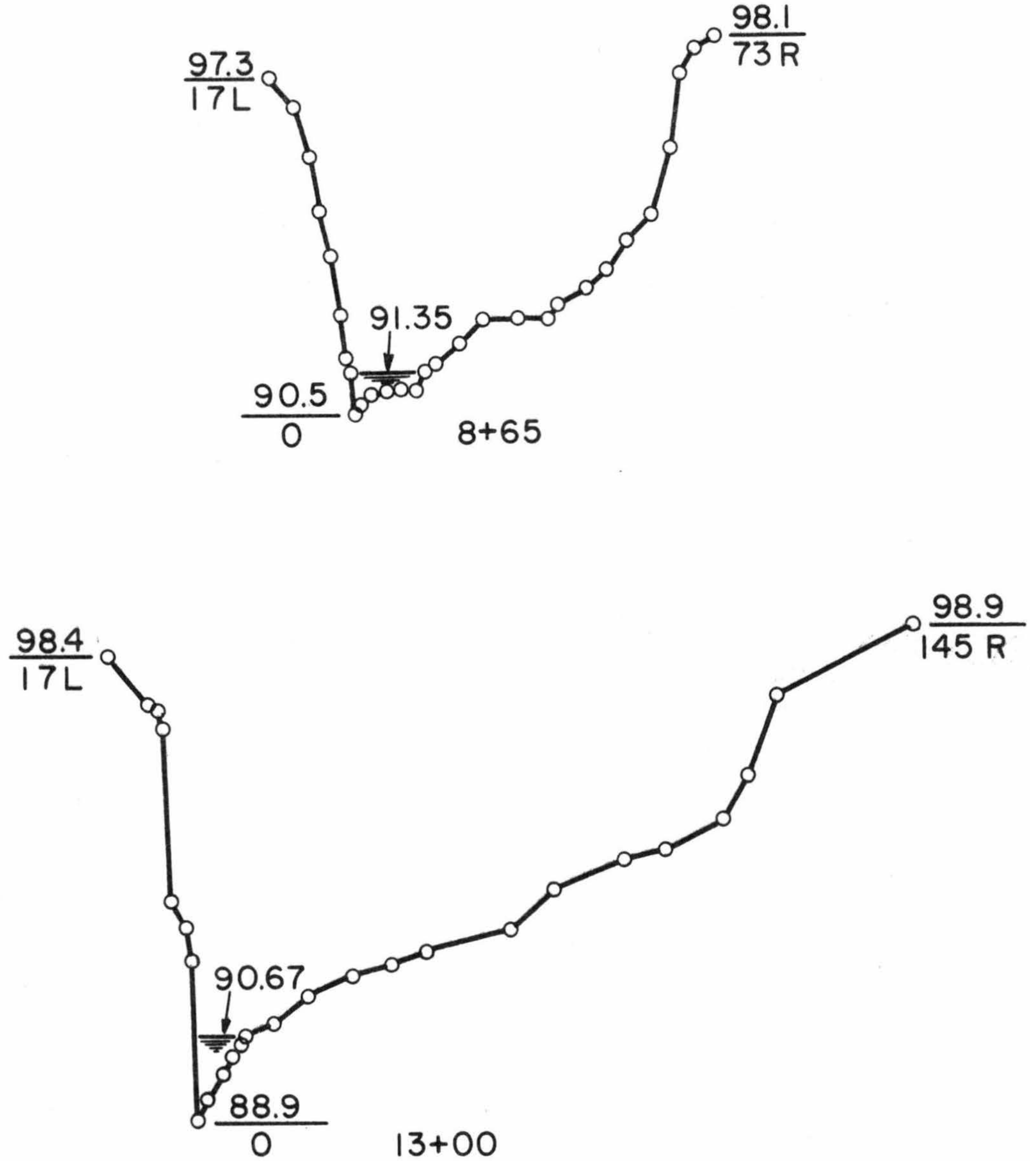


FIGURE V-9 RIO CARISITO CROSS SECTIONS

Sta. No. SR4 Río Chive near Campamento La Leona

Longitude 63° 51.2' W, latitude 09° 03.2' N. Approximately 44.8 km W of Oritupano, 6.1 km NNW of Campamento La Leona.

The cross section at the SR recorder on the bridge over the Río Chive near Campamento La Leona is shown on Figure V-10. The gage height for zero discharge is 0.50 feet and the corresponding stage is 87.0 feet.

The Río Chive has a broad flood plain in this region. Flood flows which submerged the bridge occurred during the summer of 1969. The river slope is 4.4 feet per mile at SR4.

The median sieve diameter of the bed material is 0.19 mm. Sta. No. SR4 had the smallest bed material of the 30 river locations which were sampled. The reach of river at the bridge is a large pool and the river carries a large wash load. A photograph of the river channel and bridge are given in Volume II, page II-181. The bank materials are described in Volume II, page III-40.

The reference bench mark at Sta. No. SR4 is the top of the 10-inch diameter pipe which protects the bridge truss on the left bank at the upstream side of the bridge. The elevation of the bench mark is assumed to be 100.00 ft.

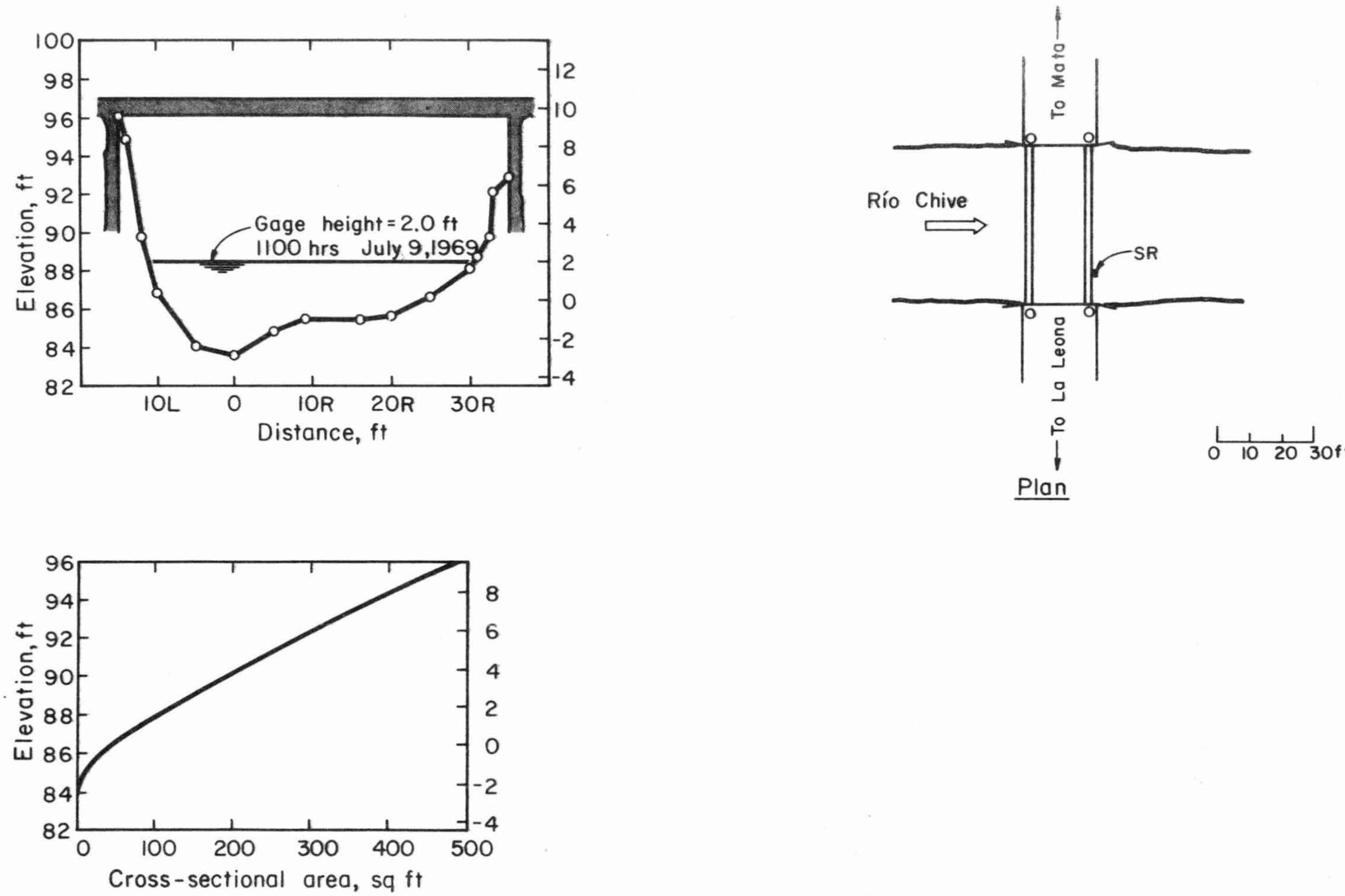


FIGURE V-10 PLAN AND CROSS SECTION OF THE RIO CHIVE AT STA. NO. SR4

Sta. No. SR5 Río Chupururo near Camp Mata

Longitude 64^{o} 03.5' W, latitude 09^{o} 12.6' N. Approximately 34.5 km ESE of Cantaura, 1 km SW of Campo Mata.

The Río Chupururo near Camp Mata is a relatively deep and narrow channel. The river slope is 11 feet per mile; the bed material is 0.26 mm diameter sand. The bank materials are described in Volume II, page III-40.

The river reach upstream of the SR recorder was surveyed on June 25, 1969. The channel was dry. The reach of river is represented on Figure V-11 and a photograph of the lower part of the reach is given in Volume II, page II-189. The reference bench mark (assumed elevation 100.00 feet) is the top of the outer end of the sheet piling on the left bank on the upstream side of the bridge.

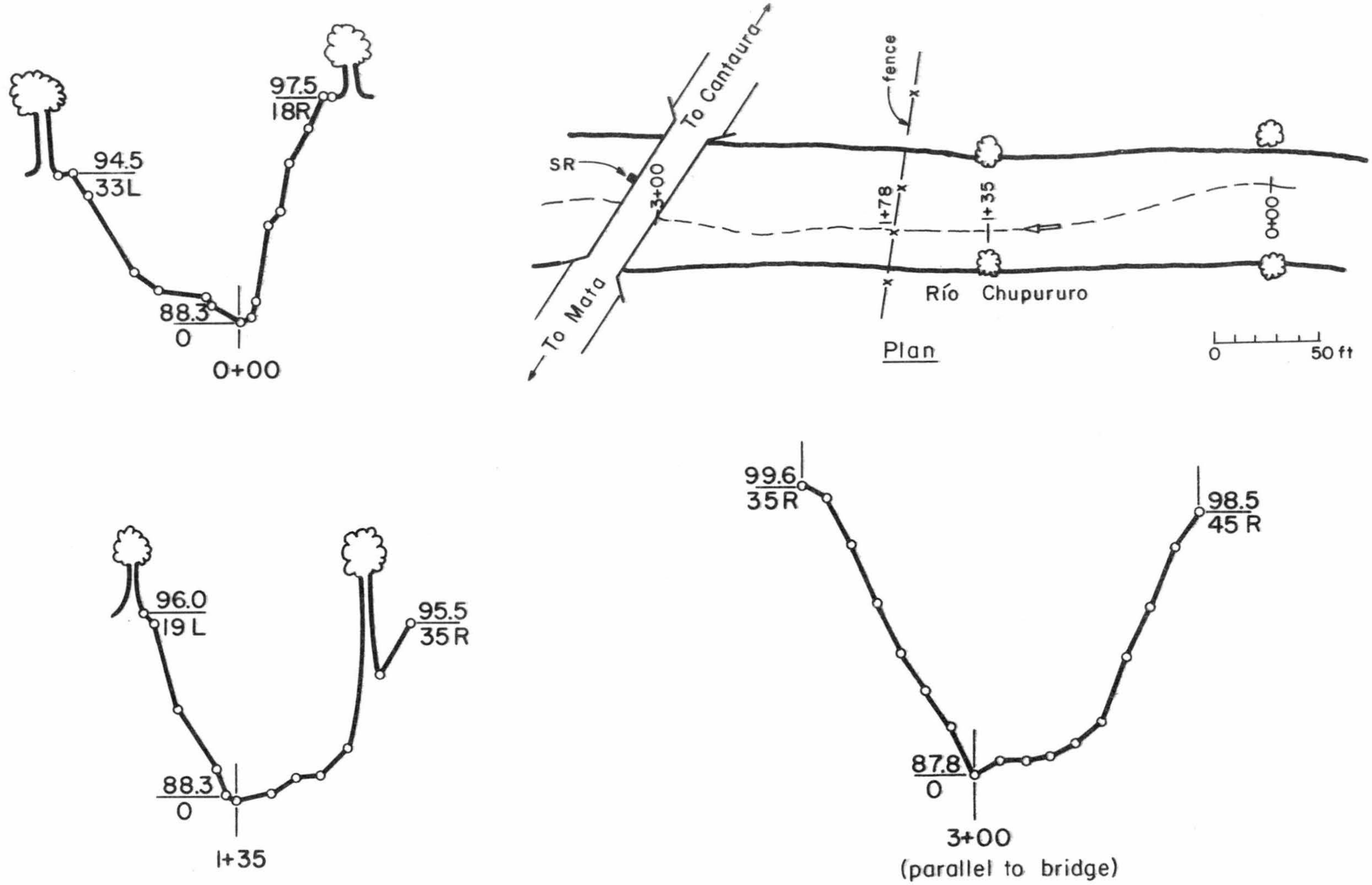


FIGURE V-11 RIO CHUPURURO PLAN AND CROSS SECTIONS

Sta. No. SR6 Río Guepe near El Limón

Longitude 63° 51.2' W, latitude 09° 05.2' N. Approximately 45.3 km WNW of Oritupano, 1.2 km SW of El Limón.

The Río Guepe gaging station is very similar to the Río Chive SR station. The plan view and cross section of the Río Guepe at the bridge are shown on Figure V-12. The river slope is 4.4 feet per mile.

At SR6, the zero gage height corresponds to zero discharge. The reference bench mark (assumed elevation 100.00 feet) is the top of the 10-inch pipe that protects the bridge truss at the right abutment on the upstream side of the bridge. The stage for a zero gage height is 83.9 feet.

The bank materials are described in Volume II, page III-41. The bed materials were not sampled at Sta. No. SR6.

A photograph of the Río Guepe channel at bankfull discharge is given in Volume II, page II-197.

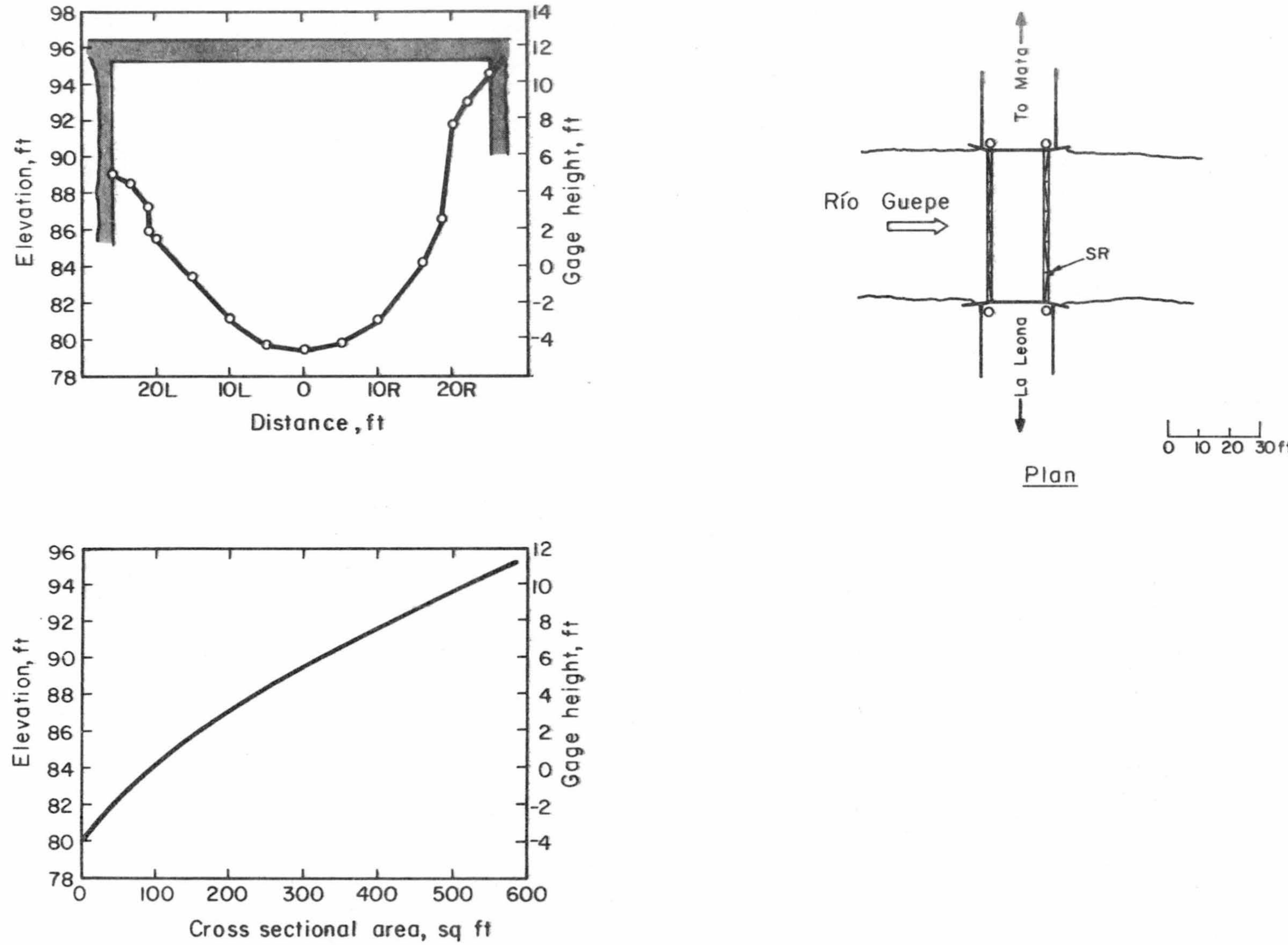


FIGURE V-12 RIO GUEPE PLAN AND CROSS SECTION

Sta. No. SR7 Río Purgatorio near El Purgatorio

Longitude 63° 57.6' W, latutude 09° 24.7' N. Approximately 25.4 km W of Aguasay, 2.2 km NNE of El Purgatorio.

The Río Purgatorio reach shown on Figure V-13 was surveyed on October 10, 1969. The discharge was less than 1 cfs and the water level stage at the SR gage was 96.60 feet. The zero gage height is 96.10 feet.

There is no bridge across the Río Purgatorio. A mat of 2-inch diameter pipe on the river bed provides a suitable vehicle crossing. The mat is marked by a set of 6-inch diameter posts on both banks of the river. The top of the marker post on the downstream side on the right bank is the reference bench mark. The bench mark has an assumed elevation of 100.00 feet. The SR recorder was attached to this post.

The banks of the Río Purgatorio are well defined in the reach. The river slope is 13 feet per mile and the median diameter of the bed material is 0.65 mm. An aerial view of the river downstream from the gaging station is given in Volume II, page II-205 and the bank materials are described in Volume II, page III-41.

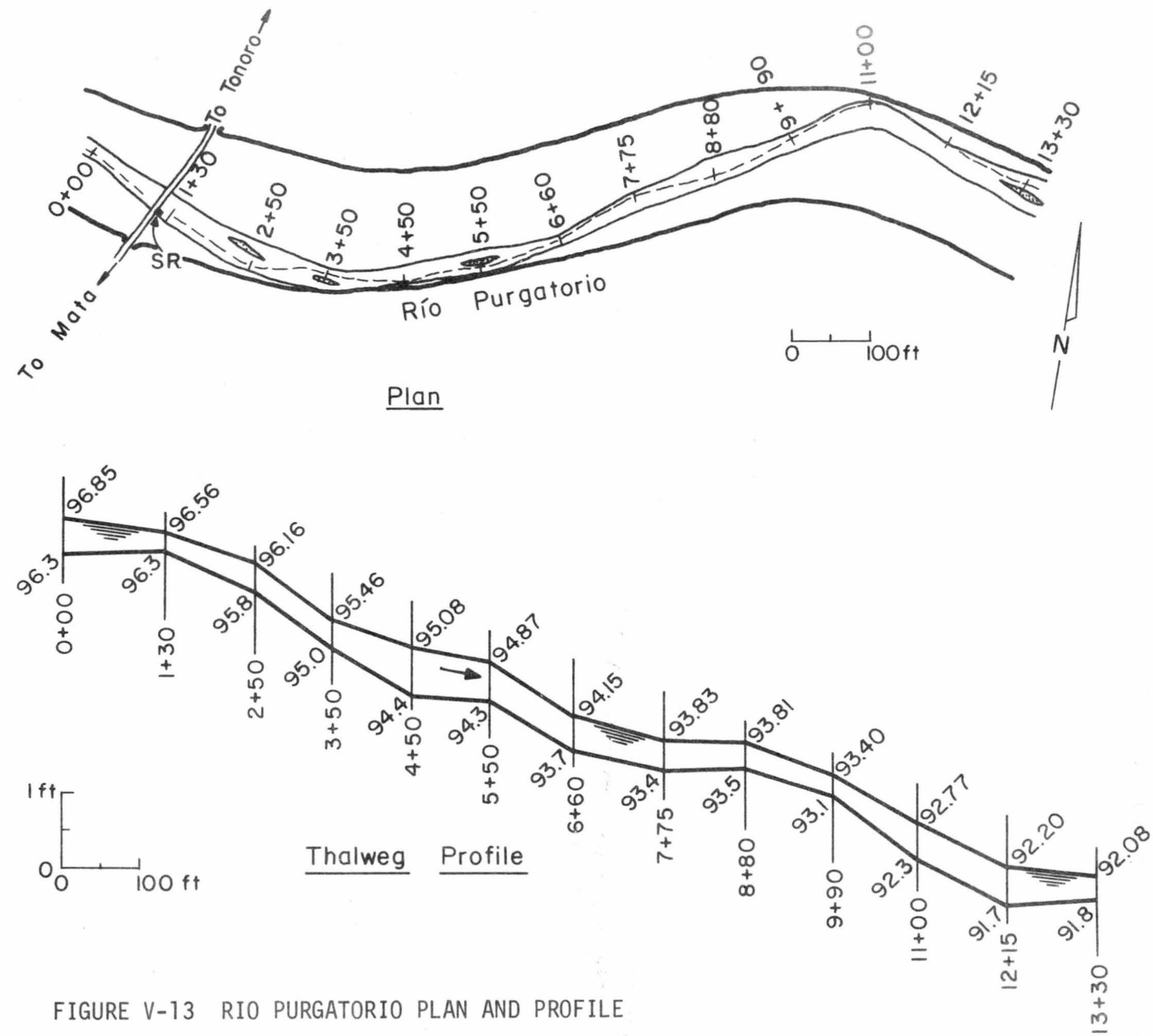


FIGURE V-13 RIO PURGATORIO PLAN AND PROFILE

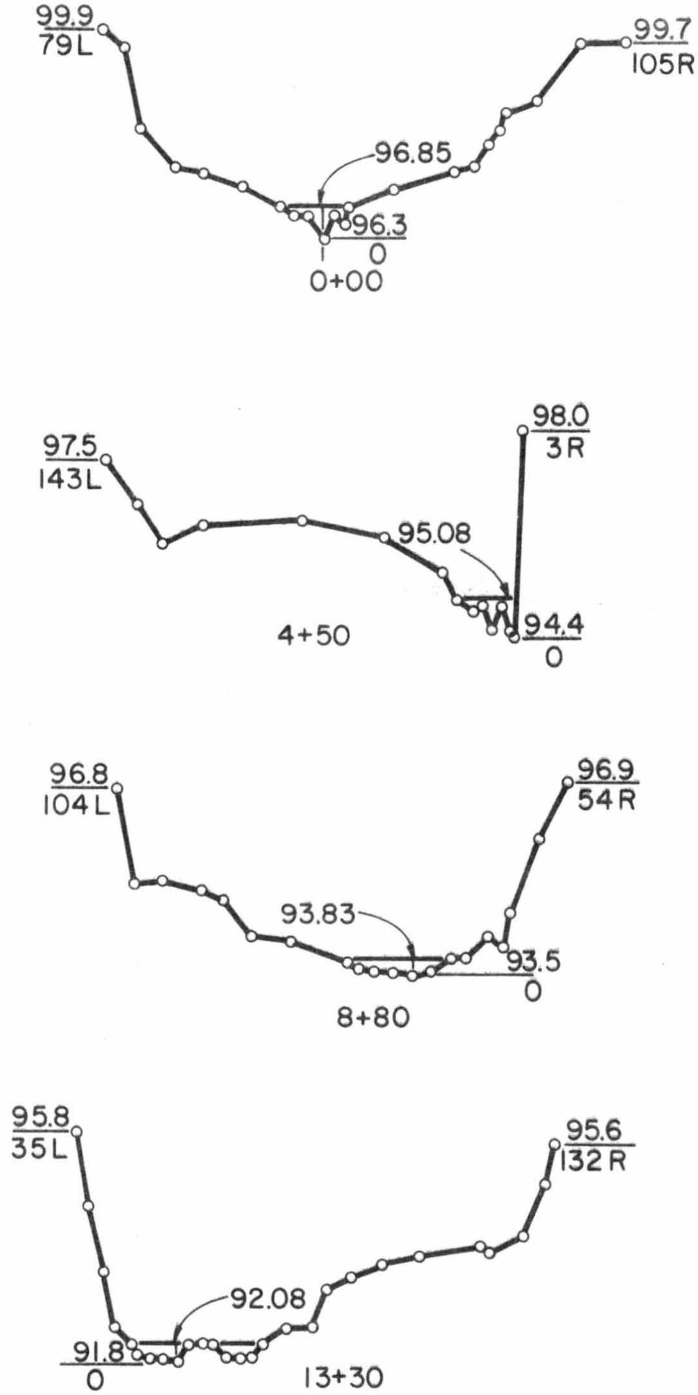


FIGURE V-14 RIO PURGATORIO CROSS SECTIONS

Sta. No. SR8 Río Seco near Campamento La Leona

Longitude 63° 46.6' W, latitude 08° 59.4' N. Approximately 36.9 km WSW of Oritupano, 7.2 km ESE of Campamento La Leona.

The Río Seco is a wide, shallow sand-bed river which is, as the name implies, nearly always dry. The bank materials are described in Volume II, page III-42. The river slope is 12 feet per mile according to the topographic map. The bed materials were not sampled.

The Río Seco was surveyed on October 10, 1969. The river was dry. The plan and profile of the river reach at Sta. No. SR8 are shown on Figure V-15 and the cross sections are on Figure V-16. A photograph of the river channel and bridge is given in Volume II, page II-213. The reference bench mark (elevation 100.00 feet) is the top of the guard rail at the right abutment on the downstream side of the bridge.

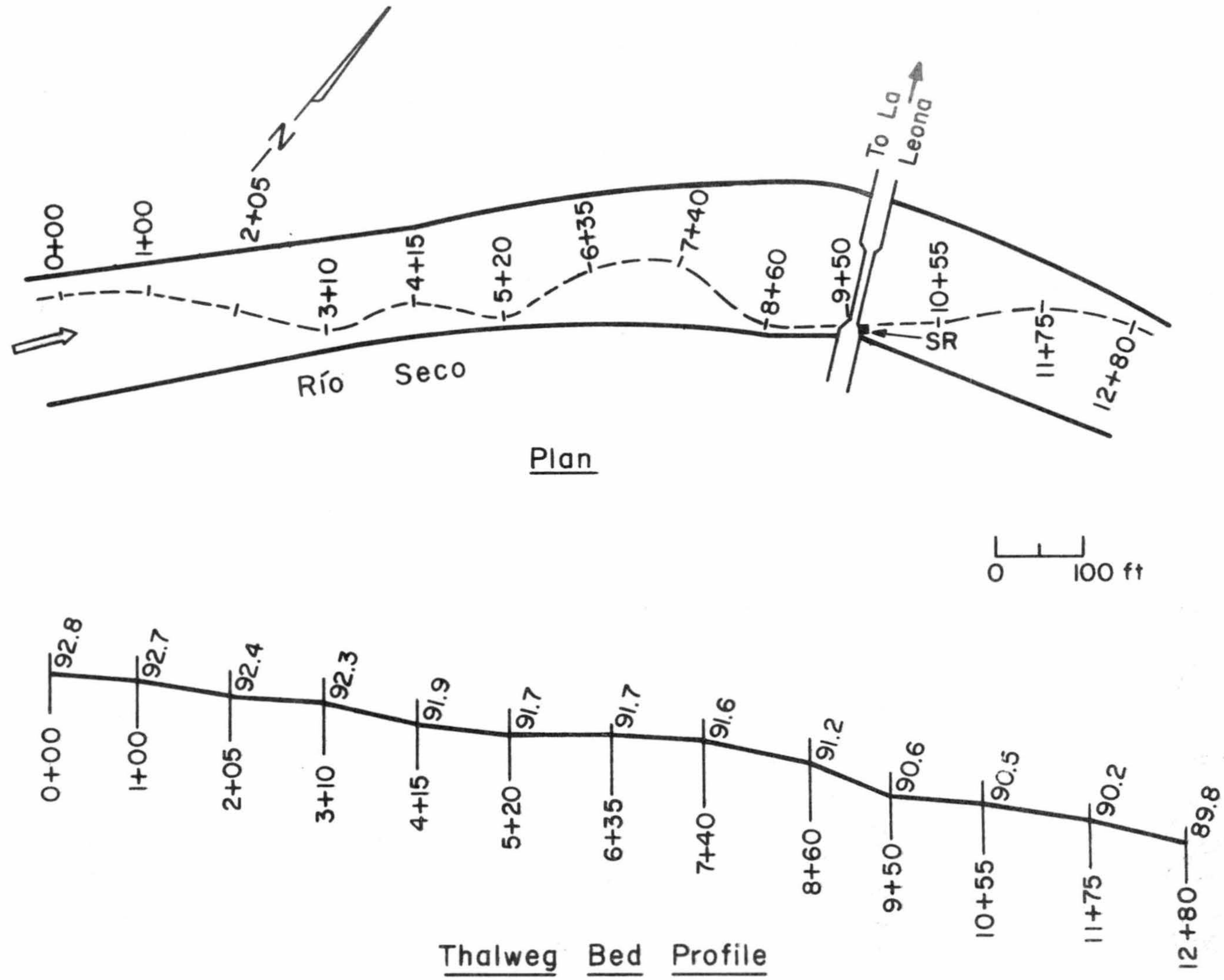


FIGURE V-15 RIO SECO PLAN AND PROFILE

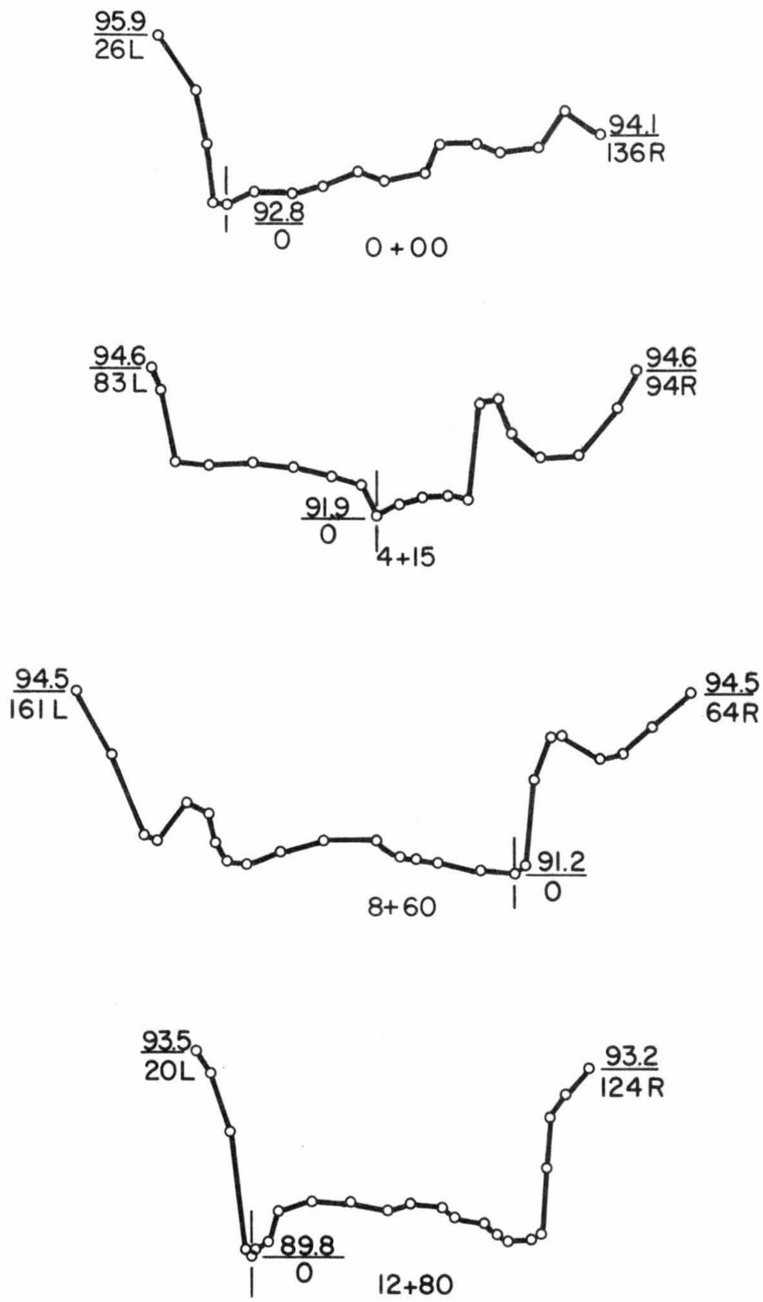


FIGURE V-16 RIO SECO CROSS SECTIONS