A-3. DEVELOPMENT SCHEME

[1] Projection of Interconnectable Energy Production and Power Demand in Central-North System Period 1985-2009

[2] Projection of Daily Load Curve

Appendix A-3[1] Table 1

Sistema Interconectado Centro-Norte
Proyeccion de la Demanda de Potencia (MW)
Periodo 1985 - 2009

Cuadro No. 3.1

CENTRO DE CARGA	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Tumbes	(3.0)	(3.2)	(3.3)	(4.4)	(4.5)	(4.2)	(7.4)	(8.1)	(8.5)	(10.1)	(10.9)	(11.9)	(12.9)	(13.6)	(16.5)	(18.1)
Piura	(15.8)	(14.8)	(15.8)	(19.7)	(20.4)	(21.0)	(22.9)	(24.1)	(25.4)	(28.0)	29.4	41.0	55.4	62.7	67.1	70.6
Talara	(9.6)	(9.4)	(29.8)	(29.9)	(30.0)	(25.1)	(23.6)	(24.7)	(25.9)	(30.6)	(31.6)	(31.9)	(32.1)	(34.5)	(34.9)	(35.1)
Bayovar	(0.4)	(0.4)	(0.4)	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	(0.6)	20.5	20.5	20.5
Chiclayo	(14.1)	(15.8)	(17.7)	(19.4)	(20.8)	(21.2)	(22.3)	(23.5)	(24.9)	(28.5)	32.6	34.8	37.4	40.4	47.9	51.5
Pacasmayo	(19.8)	(19.6)	(23.2)	(20.8)	(19.9)	(19.1)	(20.0)	(20.0)	(20.0)	(20.0)	25.6	26.0	26.3	26.6	26.8	27.2
Cajamarca	(2.4)	(2.5)	(2.9)	(3.3)	(3.5)	(3.7)	(4.1)	(4.3)	(4.6)	(4.8)	(5.1)	(5.4)	(5.8)	(6.2)	(6.6)	(8.0)
Trujillo	(50.6)	(52.9)	51.8	51.6	56.3	51.4	56.2	60.4	68.2	74.5	82.0	84.8	88.1	92.0	96.2	100.3
Chimbote	(68.5)	(83.0)	86.3	87.0	83.4	82.3	89.2	92.5	93.9	98.1	99.1	132.8	134.5	137.0	139.0	141.0
Huallanca	(5.7)	(8.2)	8.4	11.0	12.3	10.1	10.3	11.1	16.0	16.5	16.8	17.9	20.2	20.8	22.5	23.2
Paramonga	(41.0)	(41.0)	46.5	53.7	59.8	57.8	64.6	65.3	67.3	68.9	70.4	72.0	73.7	91.3	92.2	95.1
Lima	615.7	650.5	700.2	785.6	829.7	792.5	801.1	811.1	843.9	882.4	923.1	966.6	1,023.8	1,084.2	1,153.0	1,218.0
Pisco	11.0	13.7	14.9	16.6	37.8	39.2	44.8	46.7	49.7	53.5	55.3	57.4	62.0	65.2	67.9	74.5
Ica	6.2	8.2	9.9	10.0	12.6	13.3	15.3	16.6	19.4	22.7	28.5	33.2	37.9	42.8	47.6	48.6
Marcona	51.0	53.0	50.0	50.0	52.8	50.0	50.0	50.0	50.0	50.0	50.1	50.2	64.6	88.5	88.7	117.3
Pachachaca	(12.3)	(13.0)	(13.8)	(14.5)	(14.3)	(14.8)	(14.3)	28.2	28.6	31.3	31.6	31.9	32.4	32.9	37.0	76.5
La Oroya	(71.6)	(75.6)	(80.4)	(80.0)	(79.0)	(82.1)	(85.7)	87.8	104.6	116.6	132.9	144.0	147.5	163.2	170.8	176.5
Cerro de Pasco	(24.7)	(26.1)	(27.7)	(29.0)	(31.5)	(32.7)	(33.7)	34.3	37.6	50.6	56.8	61.0	62.5	64.6	72.0	76.3
Huancayo	10.7	9.6	10.6	11.6	12.7	12.5	15.9	17.0	20.7	23.7	25.5	27.5	29.3	31.1	32.8	34.7
Huancavelica	(0.6)	(0.7)	(0.8)	(0.8)	(0.8)	(0.9)	(1.1)	1.1	1.1	16.5	20.7	21.5	22.2	23.1	26.8	27.4
Mantaro	(4.7)	(5.0)	(5.3)	(5.7)	14.2	14.9	15.0	15.0	17.6	18.5	18.7	19.4	19.7	20.1	20.5	20.9
Pucallpa	(2.8)	(3.9)	(4.5)	(5.3)	(5.3)	(5.8)	(6.2)	(6.9)	(7.7)	(10.8)	(11.8)	(13.7)	(16.0)	(20.6)	(21.5)	(24.1)
Total Interconectable	1,042.2	1,110.1	1,204.2	1,310.4	1,402.1	1,355.1	1,404.3	1,449.3	1,536.2	1,657.2	1,759.1	1,885.5	2,004.9	2,181.9	2,308.8	2,485.4
Total Interconectado *	680.7	720.3	959.0	1,055.6	1,055.6	1,101.5	1,139.2	1,310.4	1,390.2	1,493.3	1,665.1	1,785.6	1,899.3	2,064.9	2,184.7	2,352.1

CENTRO DE CARGA	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tumbes	(18.5)	(19.1)	(19.9)	20.6	21.3	21.9	23.2	24.5	25.7	27.0	28.6	30.1	31.7	33.6	35.7	37.8
Piura	74.3	78.5	82.8	87.5	92.1	97.3	105.2	114.3	122.5	131.8	143.0	155.3	168.0	182.9	199.2	216.2
Talara	(35.5)	(35.9)	(36.2)	59.2	59.6	60.0	62.1	64.3	66.0	67.9	70.6	73.3	76.0	79.2	82.4	85.8
Bayovar	20.5	20.5	20.5	20.5	20.5	48.4	49.6	51.0	51.8	52.8	54.4	56.0	57.4	59.2	60.9	62.7
Chiclayo	51.5	77.7	81.9	86.3	90.7	95.6	104.2	114.0	122.6	132.5	144.9	158.3	172.3	188.8	206.8	226.9
Pacasmayo	27.7	28.0	28.5	28.8	29.3	29.8	30.9	32.3	33.6	34.9	36.5	38.3	39.9	41.9	44.1	46.3
Cajamarca	(9.0)	(9.5)	(10.1)	(10.9)	(11.5)	(12.1)	(13.2)	(14.4)	(15.5)	58.2	60.9	63.6	94.3	98.1	101.9	105.6
Trujillo	104.8	109.5	114.7	119.9	125.2	130.6	141.2	153.6	163.9	176.0	190.8	206.7	222.7	241.9	262.3	284.3
Chimbote	143.1	145.4	148.0	150.4	185.4	188.2	195.8	204.8	211.5	219.9	230.3	241.4	252.3	265.4	279.2	294.0
Huallanca	24.5	25.3	48.3	49.1	50.0	51.0	53.2	55.8	57.7	60.1	63.2	66.4	69.5	73.0	76.5	79.9
Paramonga	112.1	113.1	146.8	147.9	149.1	175.2	181.0	187.5	192.0	197.7	205.2	213.0	220.5	229.6	238.9	248.7
Lima	1,287.1	1,361.3	1,439.3	1,521.9	1,606.8	1,695.6	1,813.4	1,946.6	2,063.7	2,185.2	2,342.6	2,509.4	2,660.3	2,837.3	3,023.8	3,221.6
Pisco	77.6	80.2	82.8	85.7	110.6	114.0	120.6	127.5	133.6	140.7	149.2	158.2	167.3	178.1	189.3	201.3
Ica	49.9	51.0	52.3	53.4	54.8	56.1	58.9	62.2	64.9	68.0	72.0	76.0	80.1	84.8	90.2	95.8
Marcona	117.5	117.7	117.8	118.0	118.2	132.7	136.2	140.3	142.8	146.0	150.7	155.5	160.0	165.2	170.8	176.4
Pachachaca	77.0	80.3	80.8	93.5	93.9	94.3	97.2	100.4	138.4	141.7	146.4	151.3	155.7	161.2	166.6	172.3
La Oroya	189.0	194.6	199.2	213.1	214.7	216.6	224.5	233.3	239.0	246.1	255.7	265.7	274.9	286.0	297.4	309.3
Cerro de Pasco	78.0	79.6	81.4	83.5	85.4	87.5	91.9	96.8	100.9	105.9	111.6	118.2	124.5	132.1	139.8	148.2
Huancayo	36.6	39.3	43.1	45.5	47.5	50.9	55.1	60.1	65.2	70.5	76.7	82.6	89.3	97.0	105.4	114.5
Huancavelica	27.8	28.3	28.7	29.3	29.8	30.4	31.8	33.3	34.5	35.9	37.7	39.7	41.7	43.9	46.3	48.8
Mantaro	21.4	21.9	22.4	22.9	23.5	24.1	25.4	26.9	28.1	29.5	31.4	33.4	35.4	37.8	40.5	43.5
Pucallpa	(25.3)	(26.4)	(27.8)	(29.5)	31.8	33.6	35.6	37.8	40.1	43.0	46.0	49.4	53.3	57.6	62.6	68.5
Total Interconectable	2,608.7	2,743.1	2,912.9	3,077.3	3,251.5	3,445.9	3,650.2	3,881.7	4,113.8	4,371.5	4,648.3	4,941.6	5,247.0	5,574.5	5,920.4	6,288.2
Total Interconectado *	2,470.0	2,599.2	2,762.5	2,976.2	3,175.4	3,365.1	3,564.2	3,789.9	4,016.4	4,284.0	4,555.4	4,842.8	5,142.0	5,463.0	5,802.0	6,162.5

* Factor de Simultaneidad del Sistema = 0.98

Table 2

Sistema Interconectado Centro-Norte
Proyeccion de la Demanda de Energia (GWh)
Periodo 1985 - 2009

Cuadro No. 3.2

CENTRO DE CARGA	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Tumbes	(12.8)	(14.3)	(15.3)	(18.6)	(22.2)	(16.1)	(24.1)	(27.5)	(29.3)	(33.8)	(36.6)	(39.6)	(43.2)	(45.6)	(57.2)	(61.8)
Piura	(73.1)	(76.0)	(72.2)	(83.8)	(93.8)	(78.2)	(89.0)	(101.6)	(107.4)	(119.2)	126.4	181.2	247.1	267.1	284.4	298.8
Talara	(65.0)	(60.2)	(201.5)	(207.9)	(195.4)	(87.5)	(167.3)	(180.6)	(187.8)	(223.4)	(228.7)	(230.1)	(231.5)	(241.8)	(243.5)	(245.4)
Bayovar	(1.7)	(1.7)	(1.7)	(1.1)	(1.3)	(1.7)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	(2.0)	133.8)	133.8	133.8
Chiclayo	(58.6)	(62.7)	(69.5)	(77.6)	(87.4)	(88.6)	(95.2)	(100.4)	(106.4)	(119.9)	132.5	141.6	153.2	165.9	179.5	195.4
Pacasmayo	(73.9)	(99.8)	(113.8)	(88.6)	(93.2)	(69.0)	(102.1)	(102.3)	(102.4)	(102.5)	119.5	120.4	121.4	122.6	123.6	124.6
Cajamarca	(7.8)	(8.2)	(9.3)	(9.8)	(11.0)	(12.6)	(14.1)	(14.8)	(15.7)	(16.6)	(17.6)	(18.8)	(20.1)	(21.5)	(23.1)	(28.2)
Trujillo	(196.4)	(229.5)	228.5	241.4	252.1	234.8	251.6	282.9	323.7	347.4	384.2	396.9	413.0	432.0	452.2	471.3
Chimbote	(295.5)	(353.2)	364.6	340.7	292.1	285.4	276.6	302.1	332.1	361.5	395.4	579.8	586.4	596.5	605.1	613.7
Huallanca	(14.7)	(23.8)	32.2	31.4	47.0	31.3	45.0	48.4	80.6	81.6	82.9	85.4	96.9	98.7	103.7	105.4
Paramonga	(288.8)	(331.3)	332.0	326.9	314.4	302.4	315.3	331.2	345.5	356.2	366.9	377.6	389.1	528.3	532.8	552.9
Lima	3,408.8	3,554.3	3,846.6	4,289.3	4,571.7	4,451.6	4,582.2	4,679.5	4,800.9	5,023.2	5,260.5	5,512.8	5,843.1	6,192.0	6,582.9	6,956.3
Pisco	44.3	51.9	59.8	70.7	85.5	140.5	158.1	167.9	191.5	219.5	246.2	277.1	307.9	320.0	330.2	372.1
Ica	27.1	36.6	43.8	51.3	57.8	67.2	69.1	74.7	83.7	93.8	114.8	128.8	143.5	158.6	173.8	178.6
Marcona	306.3	318.2	299.5	290.9	294.2	226.5	270.0	285.7	302.4	320.0	328.6	329.0	419.5	570.1	570.8	751.4
Pachachaca	(89.6)	(97.8)	(101.0)	(104.0)	(106.0)	(105.4)	(102.7)	160.0	213.0	244.9	247.9	251.0	254.1	257.3	289.4	599.3
La Oroya	(519.6)	(567.1)	(585.6)	(592.6)	(603.3)	(600.8)	(638.0)	653.4	767.3	836.5	915.6	996.9	1,020.9	1,122.3	1,175.3	1,213.1
Cerro de Pasco	(179.2)	(195.6)	(202.0)	(228.7)	(232.9)	(231.9)	(251.2)	255.6	277.5	363.7	383.2	413.2	421.8	434.1	487.3	518.0
Huancayo	34.7	37.0	40.1	44.9	50.2	54.7	48.4	52.2	64.5	77.8	89.3	91.1	96.9	102.1	107.7	113.6
Huancavelica	(4.3)	(4.5)	(4.2)	(3.2)	(3.4)	(3.5)	(3.5)	3.6	3.7	102.8	114.1	118.3	123.0	127.4	147.5	149.6
Mantaro	(28.9)	(33.4)	(34.9)	(35.0)	52.6	84.0	90.0	93.0	109.3	115.9	116.7	117.8	119.0	120.3	121.8	123.3
Pucallpa	(11.3)	(14.3)	(18.6)	(21.8)	(25.4)	(25.5)	(29.1)	(32.7)	(36.1)	(47.6)	(52.4)	(61.2)	(71.4)	(82.2)	(86.6)	(95.9)
Total Interconectable	5,742.4	6,171.4	6,676.7	7,160.2	7,492.9	7,199.2	7,624.6	7,952.1	8,482.8	9,209.8	9,762.0	10,470.6	11,125.0	12,140.2	12,812.2	13,902.5
Total Interconectado *	3,821.2	3,998.0	5,247.1	5,687.5	6,017.6	5,878.4	6,106.3	7,390.2	7,895.7	8,544.8	9,424.7	10,118.9	10,756.8	11,749.1	12,401.8	13,471.2

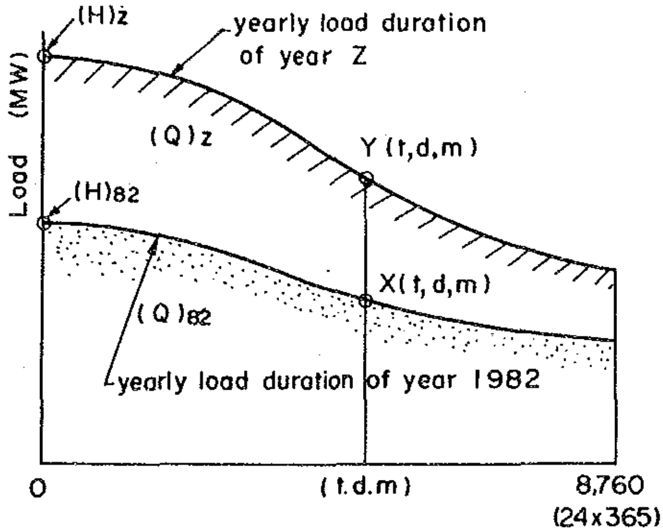
CENTRO DE CARGA	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Tumbes	(64.0)	(66.4)	(69.4)	72.2	75.1	78.1	83.1	88.4	93.4	98.6	105.0	111.9	118.9	126.9	135.4	144.5
Piura	314.5	331.6	350.0	369.6	389.2	410.8	445.3	483.8	519.6	559.2	608.1	662.7	718.5	785.1	857.7	933.7
Talara	(247.2)	(249.3)	(251.4)	404.7	407.2	409.8	422.9	437.9	448.0	460.8	478.2	496.5	513.8	534.4	556.1	578.6
Bayovar	133.8	133.8	133.8	133.8	133.8	328.8	337.1	346.5	351.8	359.1	369.6	380.4	390.1	402.0	414.1	426.5
Chiclayo	210.9	382.2	400.0	419.2	433.3	458.8	498.6	543.9	584.0	629.3	687.2	750.3	816.5	895.4	982.0	1,077.8
Pacasmayo	126.0	127.2	128.7	130.0	131.7	133.3	138.3	144.1	148.5	153.9	160.9	168.2	175.2	183.6	192.7	202.1
Cajamarca	(31.3)	(33.5)	(36.0)	(38.8)	(41.4)	(44.2)	(48.5)	(53.3)	(57.9)	303.1	316.1	329.9	497.5	518.4	540.2	563.2
Trujillo	492.1	513.9	537.7	560.5	583.6	608.4	658.5	715.9	764.7	821.0	892.9	969.5	1,047.8	1,140.5	1,241.2	1,350.4
Chimbote	112.5	114.8	262.2	264.7	267.5	270.5	280.6	291.9	300.2	310.6	323.8	337.7	350.9	366.9	383.5	400.9
Huallanca	623.6	636.0	646.9	658.3	816.1	828.6	862.0	902.7	932.9	969.4	1,016.7	1,066.6	1,115.8	1,174.6	1,237.0	1,303.7
Paramonga	686.2	691.4	957.2	963.0	969.1	1,174.6	1,210.7	1,251.6	1,278.5	1,313.1	1,359.8	1,408.4	1,453.7	1,508.8	1,565.2	1,624.6
Lima	7,354.2	7,767.5	8,203.4	8,674.5	9,146.3	9,640.6	10,314.2	11,061.2	11,718.4	12,417.9	13,295.2	14,228.5	15,111.3	16,125.7	17,197.9	18,335.7
Pisco	384.1	394.9	405.7	417.9	606.1	620.1	651.5	684.6	712.5	745.7	786.5	830.5	873.9	926.5	983.3	1,039.5
Ica	184.1	189.7	195.7	202.1	208.3	215.0	227.7	241.9	254.1	268.2	285.9	304.6	323.6	345.8	369.9	395.7
Marcona	752.2	752.9	753.7	754.6	755.4	846.4	868.6	893.9	908.9	928.9	957.6	986.8	1,013.3	1,046.0	1,079.4	1,113.5
Pachachaca	606.6	628.6	632.0	731.8	735.3	738.8	761.1	786.2	1,083.5	1,109.9	1,146.8	1,184.8	1,219.4	1,261.7	1,304.7	1,349.0
La Oroya	1,302.3	1,339.6	1,368.9	1,471.2	1,481.6	1,492.3	1,541.0	1,605.2	1,642.0	1,688.5	1,751.7	1,816.8	1,877.8	1,950.9	2,026.1	2,103.9
Cerro de Pasco	527.4	536.8	546.7	556.9	567.5	578.7	605.0	635.0	657.9	685.9	721.4	759.0	796.2	840.0	886.3	935.7
Huancayo	119.9	129.3	143.5	151.2	159.3	167.9	181.7	197.2	211.4	227.7	247.4	268.8	290.8	316.4	344.3	375.0
Huancavelica	150.7	151.8	153.1	154.6	156.5	158.3	163.8	170.2	174.7	180.4	188.1	196.0	203.8	212.2	222.8	233.1
Mantaro	124.9	126.7	128.5	130.4	132.5	134.7	140.6	147.2	152.4	158.8	167.2	176.1	185.3	196.1	208.1	221.3
Pucallpa	(101.3)	(106.6)	(112.8)	(120.4)	129.1	137.1	146.1	155.4	166.0	178.8	191.9	206.7	223.9	242.9	264.8	290.4
Total Interconectable	14,649.8	15,404.5	16,417.3	17,380.5	18,330.9	19,475.8	20,586.8	21,838.0	23,161.3	24,568.6	26,057.9	27,640.7	29,317.9	31,100.9	32,992.6	34,998.7
Total Interconectado *	14,206.0	14,948.7	15,947.7	17,221.3	18,289.5	19,431.6	20,538.3	21,784.7	23,103.4	24,568.6	26,057.9	27,640.7	29,317.9	31,100.9	32,992.6	34,998.7

Appendix A-3[2] Projection of Daily Load Curve

The actual daily load data for 1982 obtained from ELECTROPERU are expanded here to cover the object period of calculation (1999 and thereafter in this Report).

The expanded daily load data are arranged to conform to the annual peak power demand (Table 3-13 of the Report) and annual energy consumption (Table 3-14 of the Report) projection by ELECTROPERU.

In effect, if it were to be hypothesized that the daily load in the future has a linear relationship with the daily load in 1982, the following equation will hold true:



$$y(t,d,m) = a \cdot x(t,d,m) + b \qquad \cdots\cdots (1)$$

where,

$y(t,d,m)$: load at time t on day d in month m of year z

$x(t,d,m)$: load at time t on day d in month m of 1982

a, b: constants determined according to year

Further, if the annual energy consumption of the year z is $(Q)z$ and that in 1982 is $(Q)82$:

$$(Q)z = \sum_{t \cdot d \cdot m} y(t,d,m)$$

$$(Q)82 = \sum_{t \cdot d \cdot m} x(t,d,m)$$

From Eq. ①

$$\sum_{t,d,m} y(t,d,m) = a \sum_{t,d,m} x(t,d,m) + \sum_{t,d,m} b$$

$$(Q)z = a(Q)82 + 8{,}760\ b \qquad \cdots\cdots ②$$

Meanwhile, since the relationship of Eq. ① is valid between the z-th year and 1982 regarding annual peak power demand H also,

$$(H)z = a(H)82 + b \qquad \cdots\cdots ③$$

From Eqs. ② and ③ a and b will respectively be determined as follows:

$$a = \frac{8{,}760\ (H)z - (Q)z}{8{,}760\ (H)82 - (Q)82}$$

$$b = \frac{(H)82 \cdot (Q)z - (H)z \cdot (Q)82}{8{,}760 \cdot (H)82 - (Q)82}$$

Consequently, substituting these in Eq. ①, the daily load of day d in month m in year z will be obtained by the following equation from the correlative daily load of 1982.

$$y(t,d,m) = \frac{8{,}760 \cdot (H)z - (Q)z}{8{,}760 \cdot (H)82 - (Q)82} \cdot x(t,d,m) + \frac{(H)82 \cdot (Q)z - (H)z \cdot (Q)82}{8{,}760 \cdot (H)82 - (Q)82}$$

As examples, the actual daily load data for July 1982 are shown in Table 3, and the projected daily load data for July 1999 obtained from the above equation in Table 4.

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SUB-GERENCIA DE PLANEAMIENTO
UNIDAD DE ESTUDIOS DE MERCADO
SERVICIO DE DEMANDA DE CARGAS ESPECIALES

FECHA 13/ 7/84

Table 3 SISTEMA INTERCON CENTRO-NORTE GEN.

CARGAS HORARIAS PROMEDIO (MW) DEL MES DE JUL.1982

1	625	587	564	557	553	592	657	755	802	819	831	834	812	830	797	816	787	868	1055	1028	1003	933	904	714
2	637	611	581	583	574	609	651	732	814	825	843	842	795	787	793	770	767	854	1036	1017	1038	902	760	736
3	646	606	588	571	575	577	560	723	747	767	783	738	729	628	698	689	725	843	1007	1054	949	863	774	706
4	616	591	549	530	497	497	540	539	534	550	605	598	562	550	537	513	550	580	572	746	746	637	654	669
5	567	552	541	527	553	602	534	761	791	780	811	808	776	795	765	755	753	801	1036	998	976	921	787	715
6	637	594	584	578	571	600	573	677	784	856	876	900	828	743	813	777	782	859	1048	1049	1009	927	759	729
7	671	673	627	611	536	624	649	750	832	843	848	829	804	772	778	767	762	804	1067	1057	1014	966	846	731
8	720	628	625	609	605	645	695	771	824	850	870	867	838	814	783	701	812	923	1059	1079	993	946	822	728
9	623	629	603	596	613	647	762	818	837	869	875	876	847	870	824	803	816	926	1071	1077	1030	977	835	736
10	678	613	635	619	611	627	572	708	855	870	895	878	762	735	721	694	683	801	1033	1029	972	917	821	770
11	695	631	592	587	535	595	559	576	600	617	629	622	507	563	567	562	537	686	882	878	861	797	710	650
12	594	554	550	555	554	607	654	695	850	817	844	842	820	823	845	821	812	939	1085	1080	1066	1002	900	758
13	591	647	645	643	651	595	637	859	857	900	899	887	854	854	885	853	915	901	1107	1119	1055	1033	873	765
14	713	688	651	670	664	698	741	881	891	897	917	971	859	859	865	854	822	908	1145	1117	1046	995	881	805
15	714	671	652	669	647	635	714	891	895	886	897	884	845	841	853	826	827	911	1122	1119	1102	1031	898	798
16	712	686	663	669	669	699	751	913	893	912	909	911	875	870	847	858	867	967	1107	1078	1051	976	852	798
17	701	663	664	647	651	670	567	699	770	831	839	827	798	778	772	740	741	783	1035	1024	976	912	824	730
18	606	623	592	584	591	572	542	490	546	534	534	535	607	569	540	543	573	655	883	861	915	824	728	649
19	537	556	563	569	572	597	650	795	826	853	890	882	849	852	823	845	857	930	1093	1099	1059	935	885	757
20	657	620	649	646	637	674	710	813	863	891	908	876	855	857	825	832	842	910	1070	1087	1053	979	825	742
21	639	617	624	625	655	603	729	810	870	856	859	705	782	793	813	808	732	971	1050	1045	1011	952	877	744
22	711	673	673	658	655	691	698	839	841	889	895	874	861	859	873	843	856	912	1097	1064	954	932	838	714
23	634	670	652	636	632	554	722	859	842	853	854	861	831	832	845	859	965	943	1076	1070	982	901	864	829
24	703	685	663	659	646	692	691	689	788	840	832	843	820	772	770	745	731	824	1052	1034	1015	922	839	755
25	546	636	590	588	570	585	537	533	587	619	643	650	627	617	632	630	646	632	860	881	851	800	715	654
26	593	562	553	541	547	573	608	752	771	809	825	807	800	721	774	788	791	821	1053	1032	971	927	855	717
27	550	614	588	600	598	623	626	770	821	834	877	795	754	709	698	700	689	749	951	933	898	819	723	645
28	580	539	531	505	507	507	476	501	525	550	549	554	531	527	493	495	479	409	785	793	742	729	695	607
29	559	532	405	477	484	469	437	458	518	554	550	552	523	510	452	479	523	558	783	783	766	755	655	573
30	559	534	512	505	528	557	538	679	741	794	791	802	776	771	761	739	753	836	1003	995	947	902	791	720
31	671	637	597	610	613	617	593	678	726	777	737	759	684	704	648	652	695	760	943	938	917	873	785	711

Table 4 Hourly Mean Load (MW) JUL. 1999

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	2030.	2064.	2092.	2000.	1850.	2064.	2168.	2318.	2021.	2190.	2214.	1963.	2229.	2297.	2300.	2294.
2	1911.	1985.	1969.	1923.	1804.	1933.	2174.	2037.	2040.	1991.	2046.	1810.	2095.	2220.	2168.	2214.
3	1841.	1893.	1914.	1795.	1770.	1902.	2034.	2027.	1960.	2058.	1926.	1798.	2089.	2138.	2141.	2144.
4	1819.	1899.	1862.	1737.	1728.	1884.	1985.	1978.	1939.	2009.	1911.	1816.	2082.	2165.	2162.	2162.
5	1807.	1871.	1874.	1636.	1807.	1862.	1908.	1966.	1991.	1985.	1905.	1810.	2107.	2147.	2095.	2159.
6	1926.	1978.	1881.	1636.	1957.	1951.	2024.	2089.	2095.	2034.	1905.	1972.	2211.	2220.	2061.	2223.
7	2125.	2107.	2134.	1767.	1749.	1868.	2101.	2242.	2446.	1865.	1822.	2116.	2064.	2382.	2300.	2413.
8	2425.	2355.	2327.	1764.	2443.	2186.	2410.	2474.	2618.	2281.	1878.	2242.	2743.	2810.	2841.	2924.
9	2569.	2606.	2401.	1749.	2535.	2514.	2661.	2636.	2676.	2734.	1951.	2716.	2774.	2841.	2853.	2862.
10	2593.	2639.	2462.	1798.	2502.	2734.	2694.	2716.	2774.	2777.	2003.	2615.	2869.	2859.	2826.	2905.
11	2658.	2694.	2511.	1969.	2596.	2795.	2710.	2804.	2795.	2853.	2040.	2697.	2866.	2921.	2859.	2896.
12	2667.	2691.	2373.	1945.	2587.	2869.	2651.	2768.	2795.	2801.	2018.	2661.	2829.	3086.	2820.	2902.
13	2599.	2547.	2346.	1835.	2489.	2648.	2575.	2679.	2703.	2446.	1972.	2624.	2728.	2740.	2700.	2792.
14	2590.	2523.	2037.	1829.	2547.	2388.	2538.	2667.	2716.	2425.	1853.	2633.	2758.	2743.	2688.	2804.
15	2554.	2541.	2251.	1758.	2456.	2618.	2495.	2526.	2636.	2321.	1850.	2700.	2823.	2762.	2725.	2706.
16	2612.	2471.	2223.	1685.	2425.	2492.	2462.	2535.	2572.	2238.	1835.	2627.	2755.	2728.	2642.	2740.
17	2523.	2462.	2333.	1798.	2419.	2508.	2446.	2599.	2612.	2205.	1911.	2599.	2914.	2630.	2645.	2768.
18	2771.	2728.	2694.	1890.	2566.	2740.	2575.	2954.	2948.	2566.	2214.	2986.	2872.	2893.	2902.	3074.
19	3343.	3285.	3196.	1865.	3285.	3321.	3379.	3355.	3392.	3275.	2814.	3438.	3502.	3618.	3548.	3502.
20	3260.	3226.	3340.	2398.	3168.	3324.	3349.	3291.	3410.	3263.	2801.	3419.	3538.	3532.	3538.	3413.
21	3184.	3291.	3018.	2398.	3101.	3202.	3217.	3168.	3266.	3089.	2749.	3376.	3343.	3315.	3486.	3330.
22	3046.	2875.	2755.	2223.	2933.	2951.	3070.	3009.	3104.	2921.	2554.	3181.	3282.	3159.	3269.	3101.
23	2575.	2440.	2483.	2116.	2523.	2468.	2703.	2630.	2673.	2627.	2287.	2838.	2786.	2810.	2862.	2722.
24	2300.	2367.	2275.	2162.	2303.	2346.	2352.	2342.	2367.	2471.	2104.	2434.	2456.	2578.	2557.	2557.

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1	2260.	1969.	1911.	2156.	2070.	2290.	2238.	2266.	2214.	1930.	2104.	1890.	1826.	1826.	2168.
2	2144.	2021.	1816.	2040.	2003.	2174.	2165.	2211.	2061.	1835.	1994.	1761.	1743.	1749.	2064.
3	2147.	1926.	1838.	2073.	2037.	2174.	2110.	2144.	1939.	1807.	1914.	1740.	1354.	1682.	1942.
4	2095.	1902.	1856.	2092.	2027.	2128.	2061.	2131.	1914.	1770.	1951.	1660.	1575.	1660.	1982.
5	2113.	1923.	1865.	2064.	2119.	2119.	2049.	2092.	1887.	1789.	1945.	1666.	1596.	1731.	1991.
6	2165.	1865.	1911.	2177.	1960.	2229.	2116.	2232.	1905.	1884.	2021.	1666.	1547.	1819.	2003.
7	2156.	1774.	2104.	2349.	2346.	2251.	2324.	2229.	1758.	1975.	2030.	1572.	1452.	1761.	1899.
8	2254.	1614.	2547.	2602.	2593.	2682.	2716.	2223.	1746.	2416.	2471.	1648.	1517.	2193.	2190.
9	2560.	1786.	2642.	2755.	2777.	2688.	2691.	2526.	1911.	2480.	2627.	1722.	1700.	2382.	2336.
10	2658.	1902.	2725.	2810.	2734.	2807.	2725.	2685.	2009.	2590.	2667.	1829.	1810.	2544.	2492.
11	2682.	1902.	2838.	2893.	2743.	2853.	2758.	2661.	2082.	2639.	2798.	1795.	1798.	2535.	2523.
12	2645.	1905.	2814.	2795.	2272.	2789.	2749.	2710.	2104.	2584.	2547.	1810.	1804.	2569.	2437.
13	2557.	1972.	2713.	2731.	2508.	2749.	2658.	2624.	2034.	2563.	2422.	1740.	1731.	2489.	2208.
14	2495.	1856.	2722.	2737.	2529.	2743.	2682.	2477.	1972.	2535.	2284.	1728.	1676.	2474.	2269.
15	2477.	1767.	2633.	2639.	2602.	2804.	2700.	2471.	2049.	2483.	2251.	1624.	1517.	2443.	2098.
16	2379.	1777.	2700.	2661.	2587.	2710.	2740.	2394.	2043.	2526.	2257.	1630.	1581.	2376.	2110.
17	2382.	1868.	2737.	2691.	2508.	2734.	2762.	2352.	2092.	2535.	2223.	1581.	1715.	2419.	2150.
18	2511.	2119.	2960.	2899.	2780.	2905.	3000.	2636.	2049.	2627.	2407.	1364.	1822.	2673.	2440.
19	3343.	2817.	3474.	3389.	3327.	3471.	3407.	3334.	2746.	3337.	3025.	2517.	2511.	3199.	3000.
20	3248.	2749.	3477.	3441.	3315.	3370.	3389.	3278.	2810.	3272.	2970.	2541.	2511.	3159.	2985.
21	3101.	2914.	3355.	3337.	3208.	3034.	3119.	3220.	2719.	3086.	2862.	2385.	2459.	3012.	2921.
22	2905.	2636.	3132.	3110.	3058.	2844.	2872.	2936.	2563.	2951.	2621.	2346.	2428.	2875.	2786.
23	2636.	2342.	2823.	2639.	2798.	2679.	2758.	2654.	2303.	2734.	2327.	2242.	2119.	2535.	2517.
24	2349.	2101.	2431.	2365.	2391.	2300.	2651.	2425.	2116.	2309.	2089.	1972.	1858.	2318.	2290.

A-4. PRELIMINARY LAYOUT

[1] Layout of Tambo Puerto Prado Project
(HWL 445 m)

[2] Construction Program

[3] Diversion and Care of River during Construction

[1] Layout of Tambo-Puerto Prado Project (HWL 445 m)

(1) Dam

This site is located at slightly narrow valley at immediately downstream of the confluence of the Ene and Perene Rivers. The width is approximately 350 m and wide compared with the Ene-Paquitzapango site. The thickness of the river-bed deposit is estimated to be a maximum of approximately 60 m, and in case of high water level elevation of 445 m the dam height would be 220 m.

It is judged to be optimum from the standpoint of overall layout for a rockfill dam that power waterways and powerhouses be constructed at the right bank, and a spillway at the left bank. The dam would have an upstream slope of 1:2.5 and a downstream slope of 1:2.0, while the dam volume would be as much as 37 x 10^6 m^3. Insofar as practicable, spillway excavation muck is to be used as dam embankment material.

Foundation treatment is to be carried out providing a gallery at the boundary between dam body and foundation rock, from where conventional cement grouting is to be done. Besides curtain grouting, there will be a necessity for blanket grouting of adequate width to be performed. It will be important to appropriately decided the extent of foundation treatment based on the results of geological investigations to be carried out in the future. Further, foundation treatment tunnels are to be provided in the left and right abutments as necessary.

(2) Diversion and Care of River

In view of the fact that the main dam and the upstream and downstream second cofferdams are to be rockfill, the design flood discharge for care of river during construction is taken to be 18,500 m^3/s, roughly corresponding to a 25-year return period flood. The six diversion tunnels are to have horseshoe-shaped cross sections 14 m in width and 17 m in height, and they are to be arranged at the right bank.

The upstream second cofferdam crest is to be at a height approximately 45 m above the river bed. Regarding the thick deposits at the foundation, water is to be cut off through foundation treatment by grouting or by constructing a continuous underground wall. The upstream second cofferdam would have an embankment volume of 2.2×10^6 m^3, and it is to be involved eventually into the main dam.

For construction of the powerhouse to be provided near the outlets of diversion tunnels, cofferdam therefor is to be built after start of water impoundment and commissioning of the No. 1 and No. 2 units.

(3) Spillway

Due to the rockfill dam to be constructed the design flood discharge is to be 37,200 m^3/s corresponding to a 10,000 return period flood, is to be adopted. The rise in surcharge water level is to be approximately 2.7 m, and the maximum discharge from the spillway after peak cutting will be approximately 23,900 m^3/s. The spillway is to be a conventional chute type with five two-deck roller gates, each 20 m in width and 21 m height be provided. When it is necessary to discharge certain amount of water for downstream river maintenance at the initial stage of water impoundment, it will be possible to provide outlet facilities in one of the diversion tunnels.

(4) Power Waterways

As it is planned to start operation at the powerhouses in succession from Unit No. 1, the diversion tunnels are designed to be converted to waterways for power generation after completion of the dam. However, the No. 1 and No. 2 units are to have separately their own power waterways and are to start operation at the beginning simultaneously with completion of the dam. The six diversion tunnels are to be closed with gates at their upstream inlets simultaneously with completion of the dam, and are to be connected to intakes and headrace tunnels (inclined shafts) constructed in advance, each to be converted into a power waterway for two units.

The surge tank is to be designed to cope with breaking and abrupt increase of load.

Penstocks are to be bifurcated immediately upstream of the powerhouse and be connected to turbines. From surge tank to 100 m on the upstream side is to be steel liner pipe, and upstream of this section is to be reinforced concrete lining.

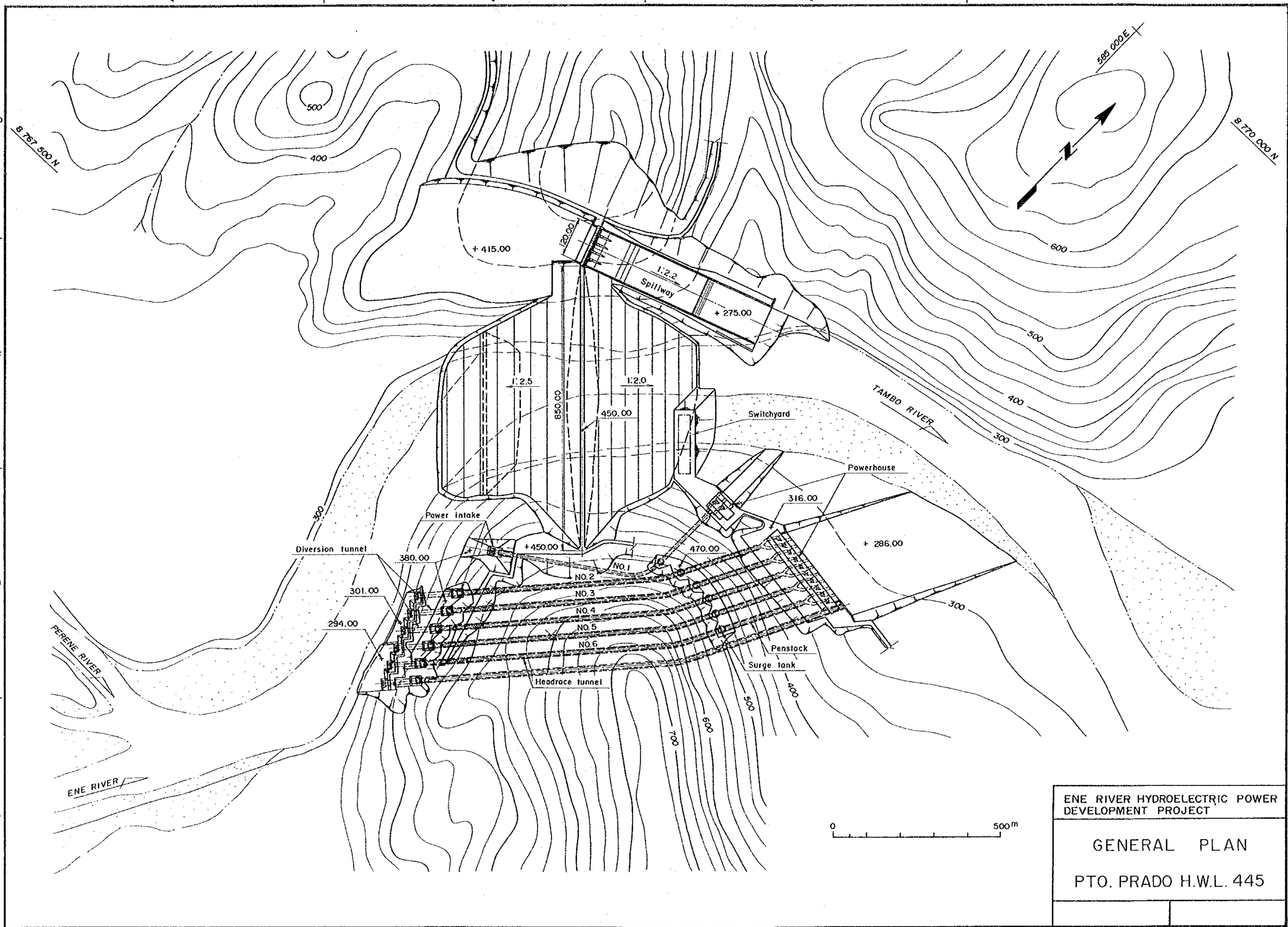
(5) Powerhouse

The powerhouse in which the No. 1 and No. 2 units are installed (Powerhouse No. 1) is to be located adjacent to the dam on the downstream right-bank side. Another powerhouse is planned to be provided to accommodate the No. 3 to No. 12 units (Powerhouse No. 2) at the outlets of the diversion tunnels.

Twelve Francis turbines, each of standard output 208 MW, are to be installed in the powerhouses. As for generators, twelve 227 MVA units are to be installed coupled with the turbines.

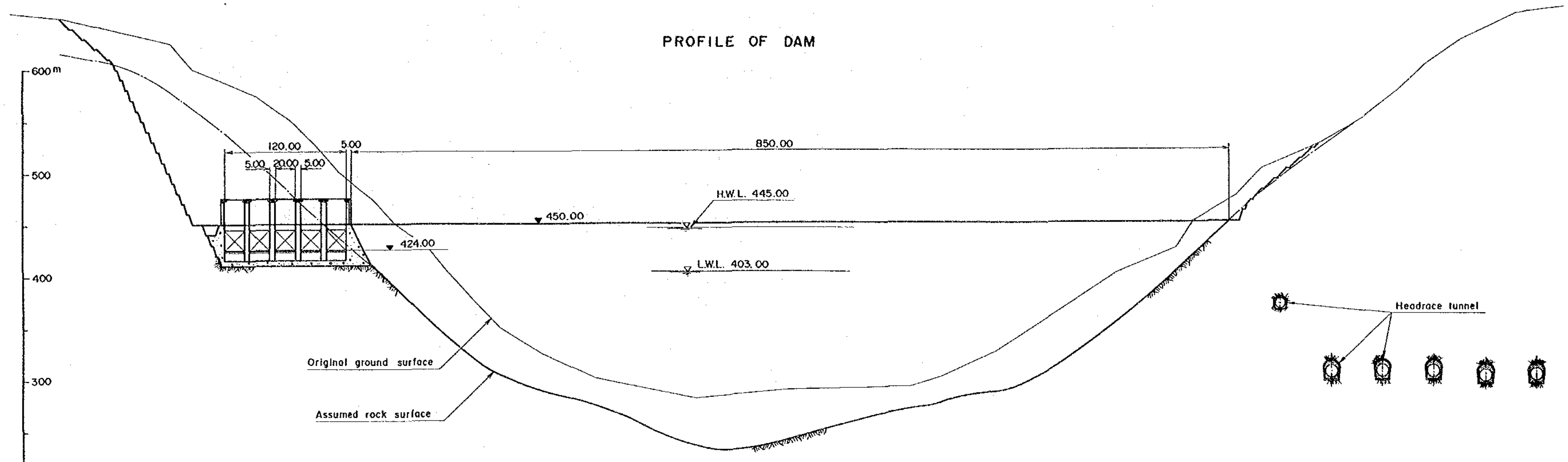
The unit capacities of the turbines and generators were decided taking transportation limitations into consideration.

The switchyard is to be located at an open space built up immediately downstream of the dam.

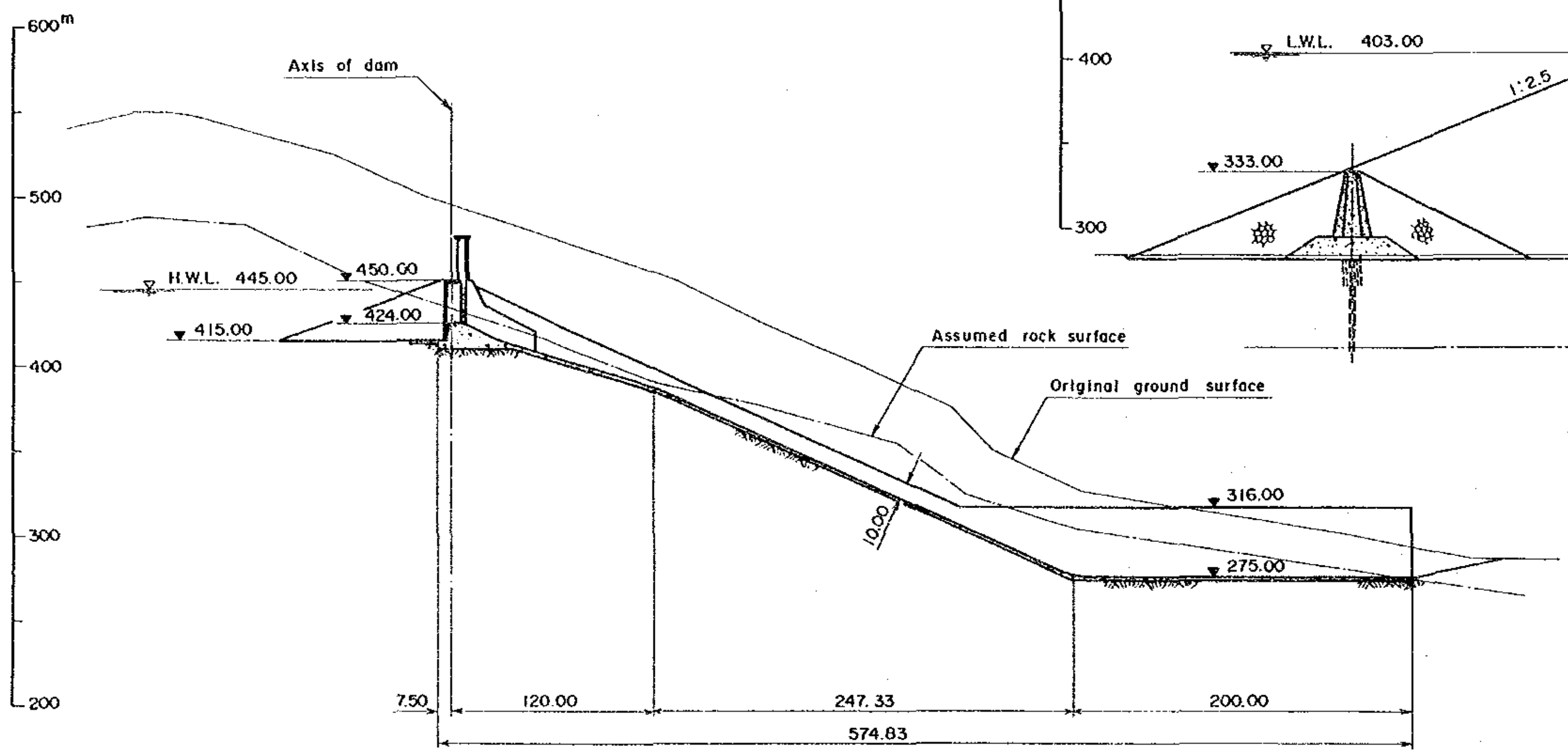


585 000 E
8 767 500 N
8 770 000 N
N
500
400
600
300
+ 415.00
120.00
1:2.2
Spillway
+ 275.00
1:2.5
1:2.0
850.00
450.00
TAMBO RIVER
Switchyard
Powerhouse
316.00
+ 286.00
Power intake
+ 450.00
470.00
Diversion tunnel
380.00
301.00
294.00
NO.1
NO.2
NO.3
NO.4
NO.5
NO.6
Penstock
Surge tank
Headrace tunnel
700
PERENE RIVER
ENE RIVER
0
500m
ENE RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT
GENERAL PLAN
PTO. PRADO H.W.L. 445

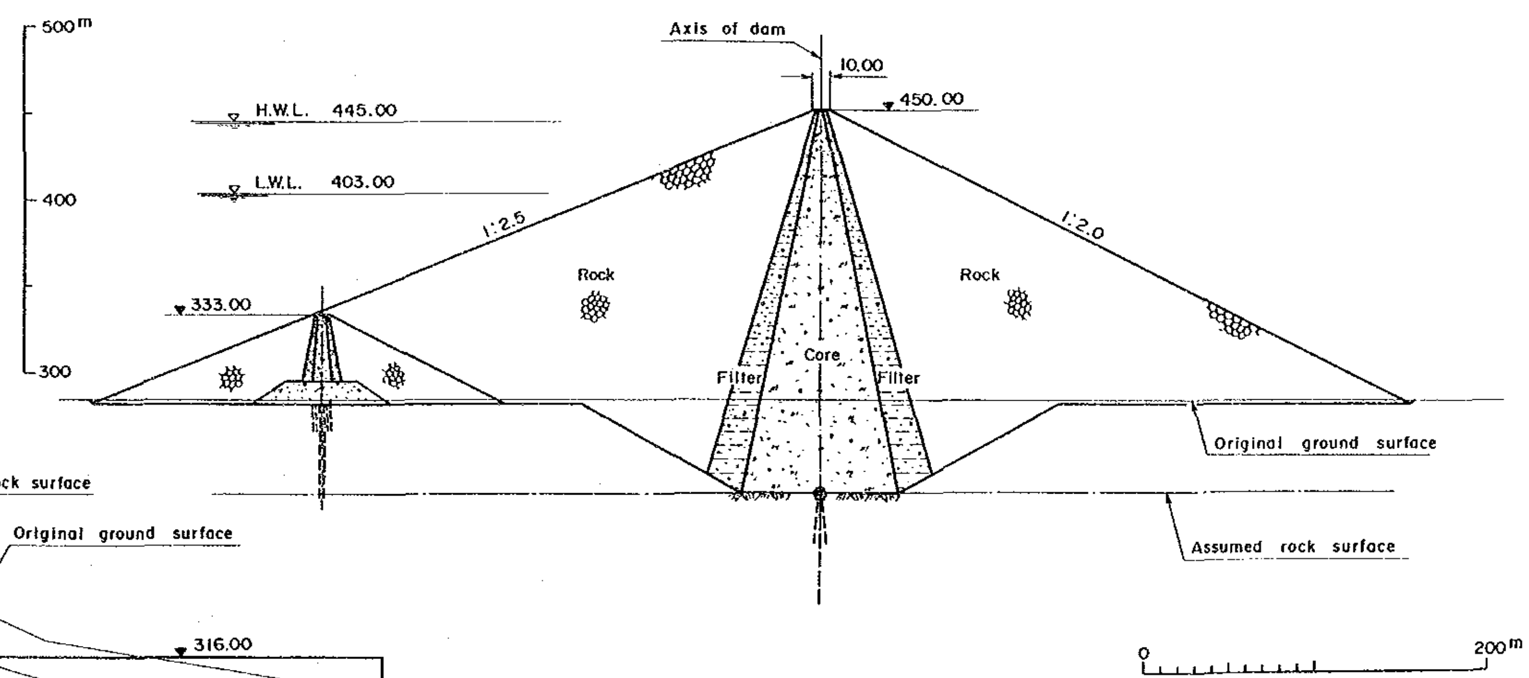
PROFILE OF DAM



PROFILE OF SPILLWAY



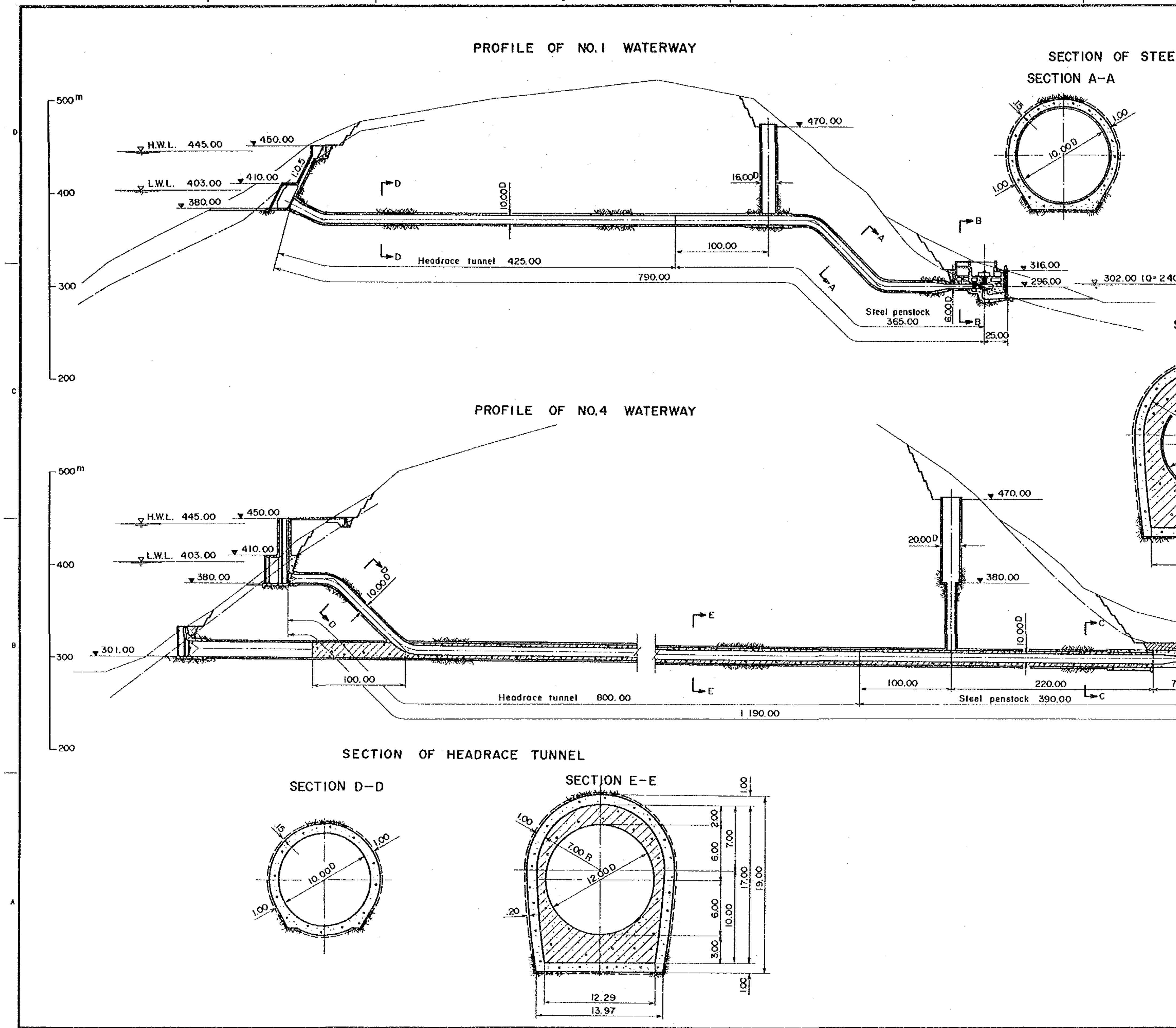
TYPICAL SECTION OF DAM



ENE RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

PROFILES & SECTION

PTO. PRADO H.W.L. 445

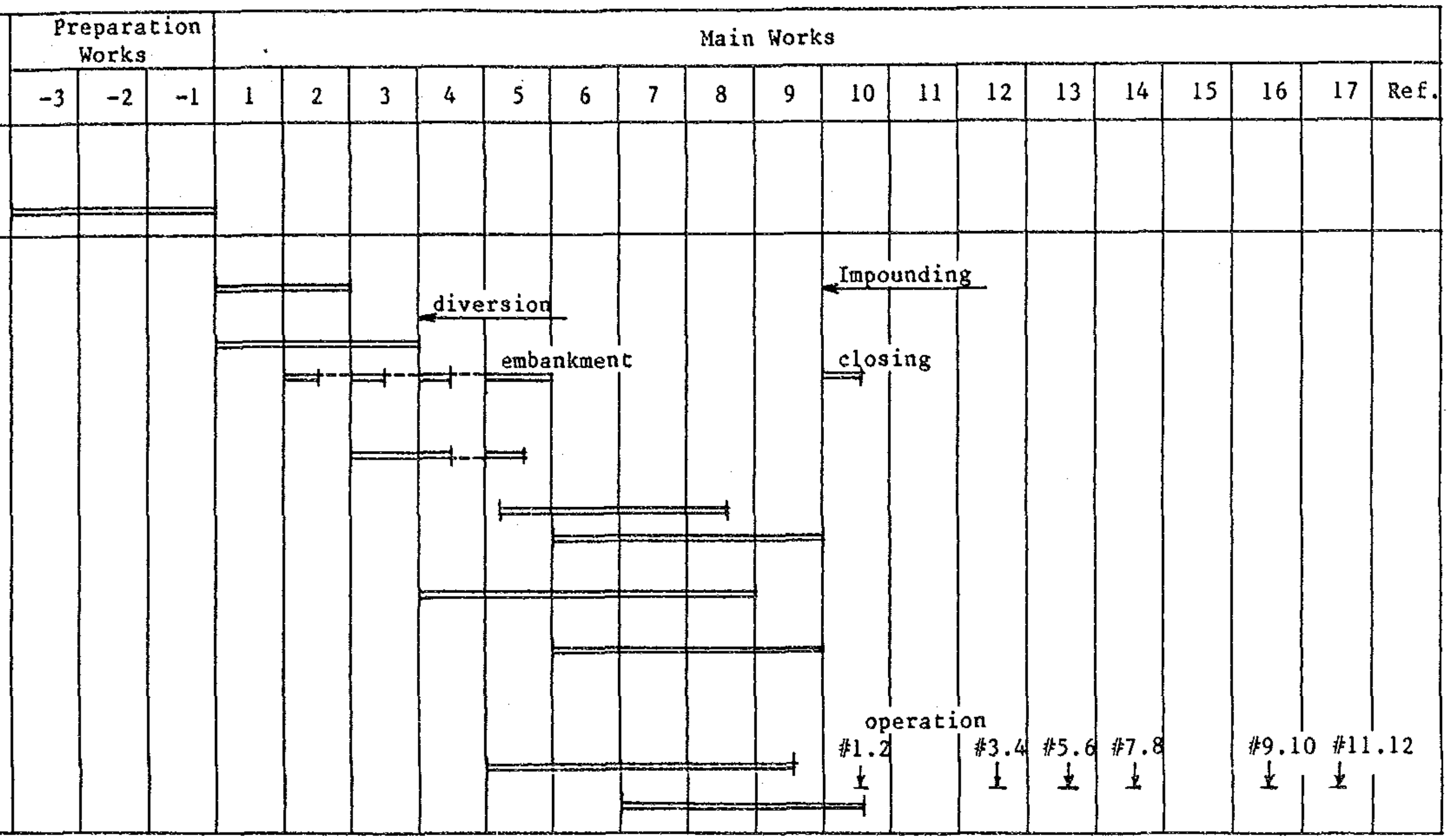


ENE RIVER HYDROELECTRIC POWER DEVELOPMENT PROJECT

PROFILES & SECTIONS OF WATERWAYS PTO. PRADO H.W.L. 445

[2] Construction Program

Description	Unit	Quantity
[TAMBO PUERTO PRADO - 445]		
Preparation Works		
Construction Facilities		
Care of River Diversion Coffer Dam		
Dam Excavation	10^6m^3	5.7
Foundation Treatment		
Embankment	10^6m^3	35.0
Spillway Excavation	10^6m^3	27.0
Concrete Gates	Unit	(gate) 5
Power House		
Power House		
Equipment	Unit	12.0



[3] Diversion and Care of River during Construction

(1) General

In case of constructing a dam on a large river of large-volume runoff such as the Ene River or the Tambo River, diversion and care of river during construction will be the most important problem, both technically and economically.

In general, at the stage of a master plan, it is seldom to discuss into such a detail as construction methods for the dam and powerhouse, but in case of this Project, how diversion and care of river are to be done is the most important factor for selecting the main damsite, and moreover, has great weight on the construction cost. Therefore, outlines of diversion and care of river for the two sites of Ene-Paquitzapango and Tambo-Puerto Prado will be described hereafter. (The site of Sumabeni may be considered to have roughly the same conditions as the Tambo-Puerto Prado site.)

When constructing a dam on a large river of broad width and large-volume runoff, the runoff considered for diversion during construction will be large, and as seen at Itaipu (Brasil), Tukurui (Brasil), and Gezhoubo (China), employing an open channel system is often generally advantageous. However, in the cases of the damsites on the Ene River, it is not possible to adopt open channel systems.

The Tambo-Puerto Prado site was initially thought favorable since it could adopt a diversion method combining tunnel and open channel if the deposit of river-bed sand-gravel were not thick, and it would be economically also advantageous. But as a result of the geological investigations lately made, the thickness of the sand-gravel layer was found to be thicker than expected, and so it will not be possible to provide an open channel. Consequently, it is judged appropriate for diversion and care of river at the Tambo-Puerto Prado site to be done by a diversion tunnel system.

In case of the Ene-Paquitzapango site, it is not possible from the standpoint of topography to adopt an open channel system, thus a tunnel system would be used.

The outlines of the diversion and care of river for the two sites examined in the study of the Master Plan are described below.

With regard to diversion and care of river it will be necessary to make detailed studies at the next prefeasibility study or feasibility study.

(2) Ene-Paquitzapango Site

In order to prevent tunnels from being choked due to driftwood, and also to keep the number of tunnels less, the diversion tunnel cross section adopted is to be height of 17 m width of 14 m, the largest possible within limits that rapid construction can be done, and two each at the left- and right-bank sides, a total of four tunnels are planned to be provided.

The two diversion tunnels at the left-bank side are to be provided at elevations as low as practicable to hold down water level rise during the first cofferdam construction to switch the river flow to the diversion tunnels and during the second cofferdam construction in the dry season.

At the upstream side, a concrete gravity type second cofferdam of height approximately 72 m is to be provided to discharge 12,400 m^3/sec; a 10-year return period flood by the diversion tunnels.

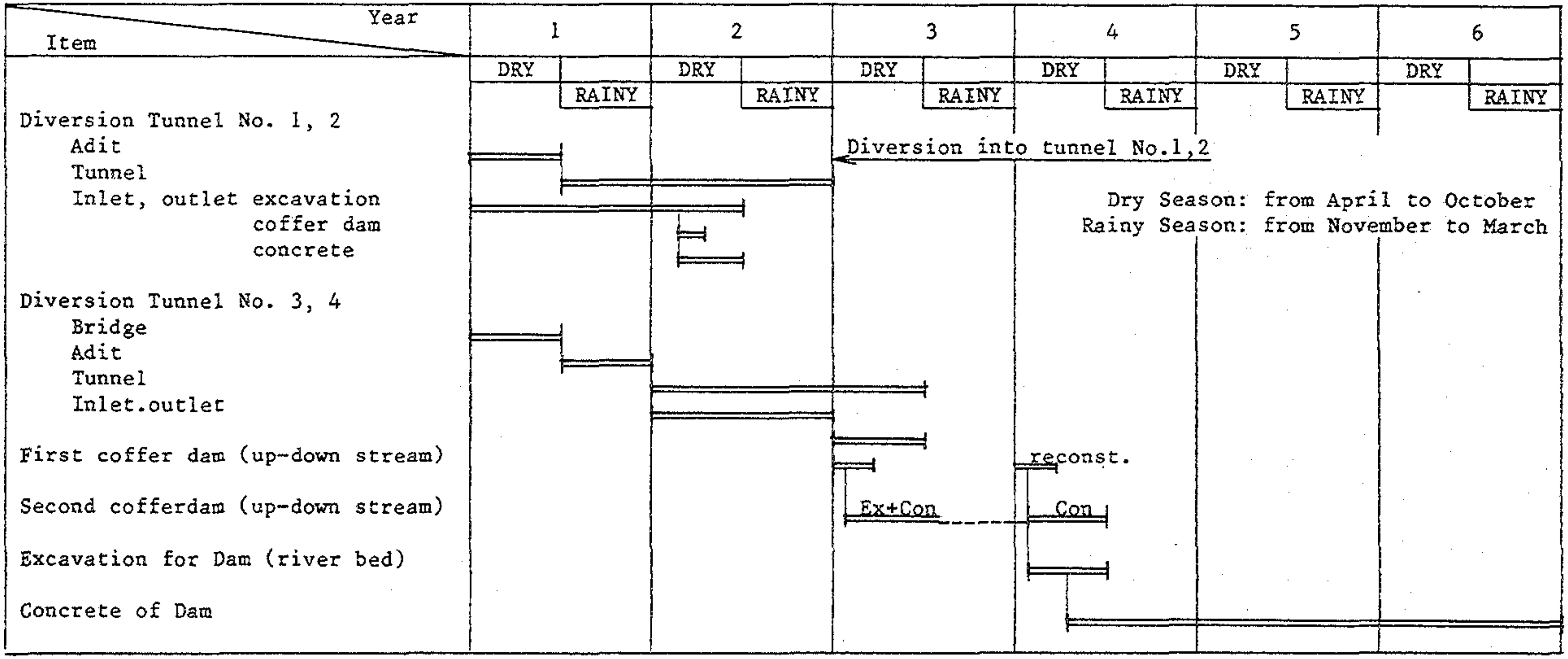
Since it will be necessary for driving the four diversion tunnels to work continuously even in the rainy season, it will be needed to provided access adits on both upstream and downstream sides at elevations that will be safe against flood water levels in the rainy season.

When diversion tunnel concrete linings have been completed, the upstream and downstream first cofferdams are to be immediately constructed by embankment of earth and rock, and to switch the river flow to the diversion tunnels (the two on the left-bank side). When the upstream and downstream first cofferdams have been completed, the area enclosed by the cofferdams is to be dewatered and foundation excavation and concrete placement for the second cofferdams are to be carried out. The upstream second cofferdam is to be constructed in a period of 2 years, where excavation and concrete placement at the foundation will be done in the first year, while in the following year the first cofferdams are to be reconstructed for river diversion, and placement of concrete for the second cofferdam above the foundation concrete is to be performed. Since the period during which concrete can be placed is very short (4 months), a special construction technique is to be used, in which steel structure forms are assembled beforehand and setting at the site, concrete is continuously poured in between these forms.

The runoff to be considered for the diversion tunnels is a 10-year return period flood (12,400 m^3/s), so that there is a possibility for the cofferdam to be overtopped by a greater flood during construction of the main dam. But even if inundated, the bedrock line of the foundation is not very deep, so that if placement of concrete for the foundation of dam will have been completed by then, there should not be very great effects on the works.

As described above, there are problems such that 2 years are required for construction of the second cofferdams, that a special method must be used for concrete placement, etc., but diversion and care of river are well possible with the abovementioned construction method.

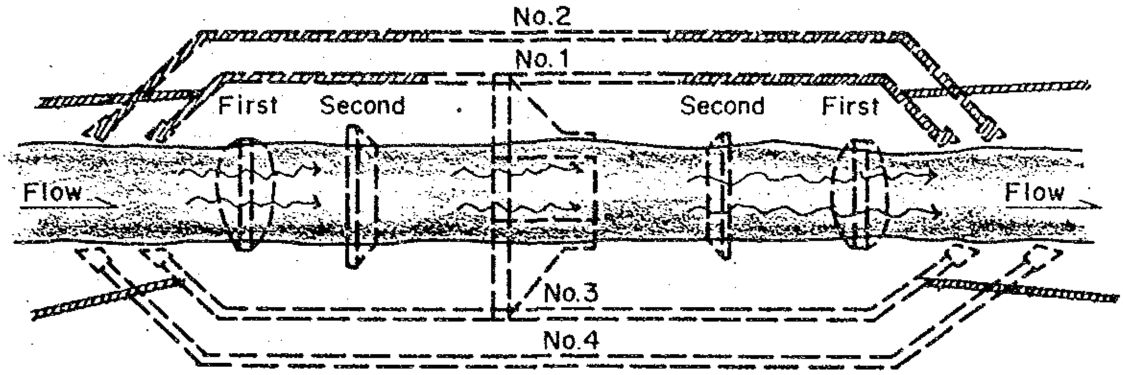
Diversion and Care of River during Construction
(Ene Paquitzapango - 455 m)



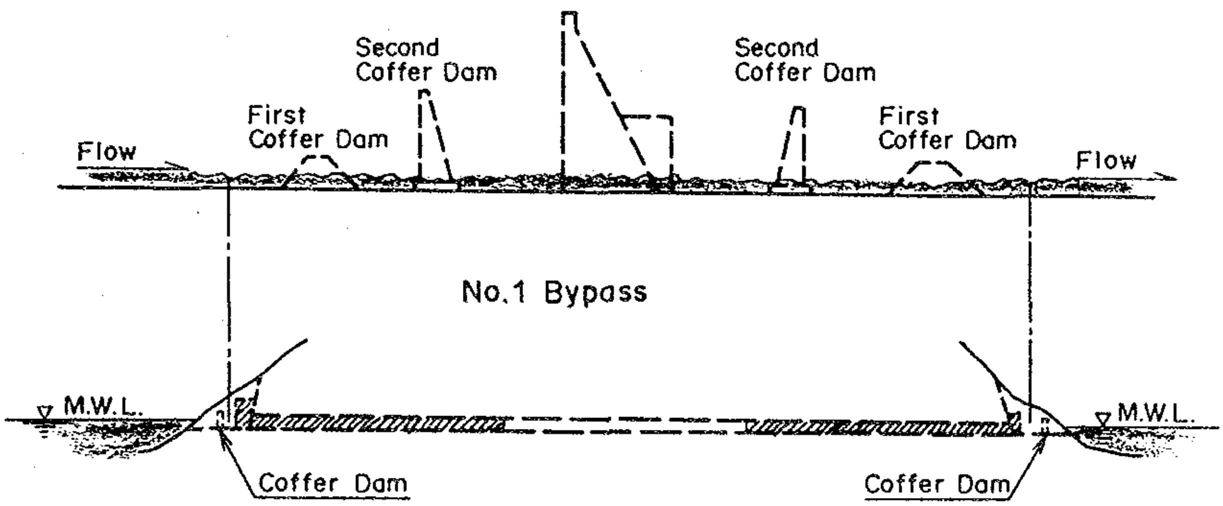
Care of River (Ene Paquitzapango)

YEAR	SEASON
2nd	DRY

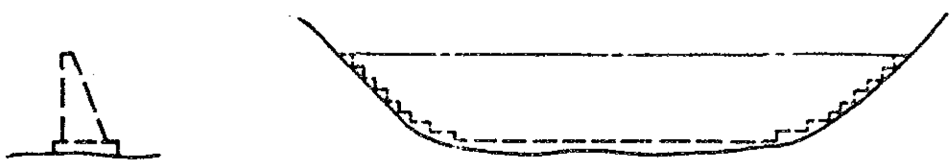
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season							"				
							RAINY S.				



Profile of River



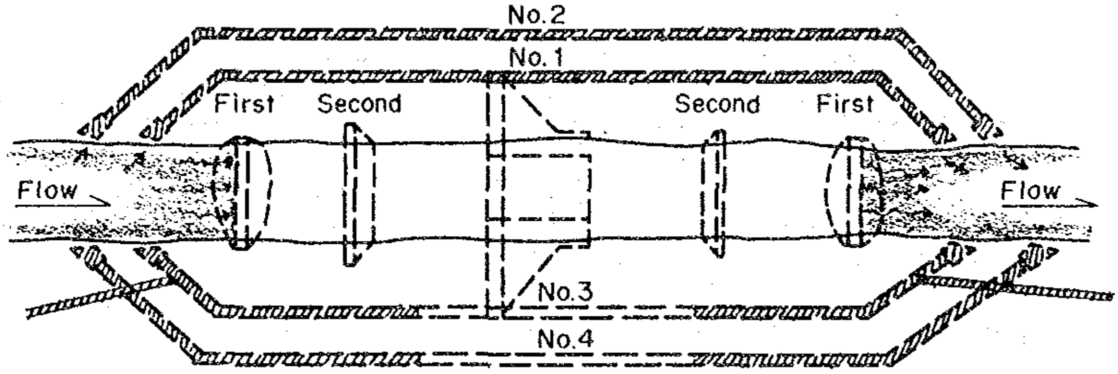
Second Coffer Dam



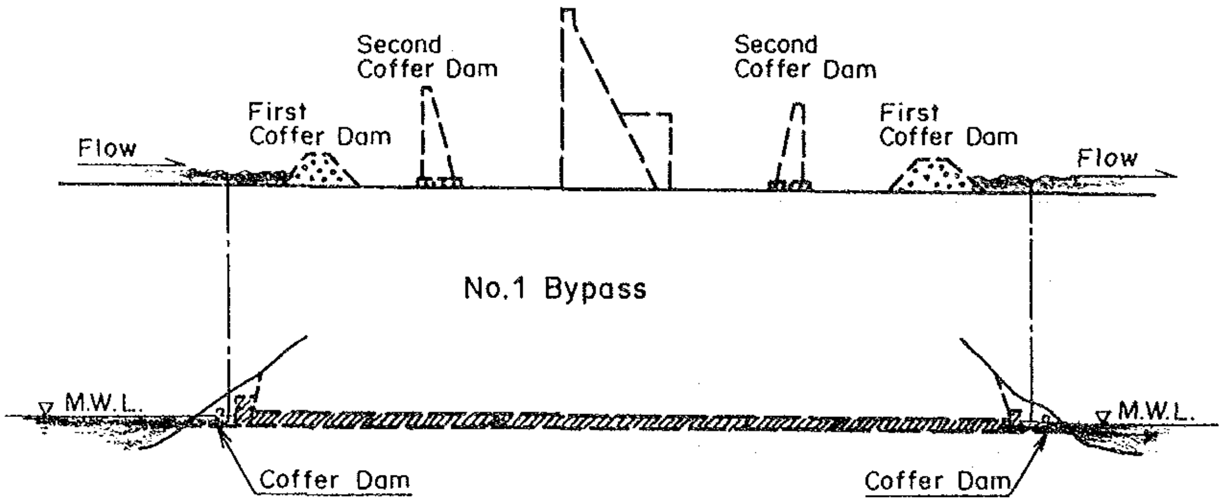
Care of River (Ene Paquitzapango)

YEAR	SEASON
3rd	DRY

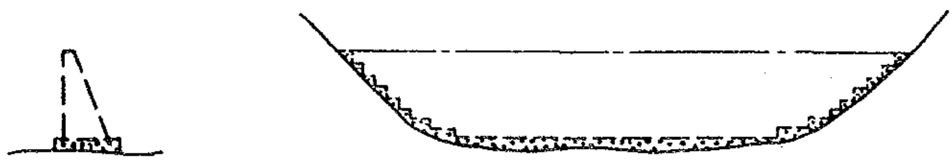
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Profileof River



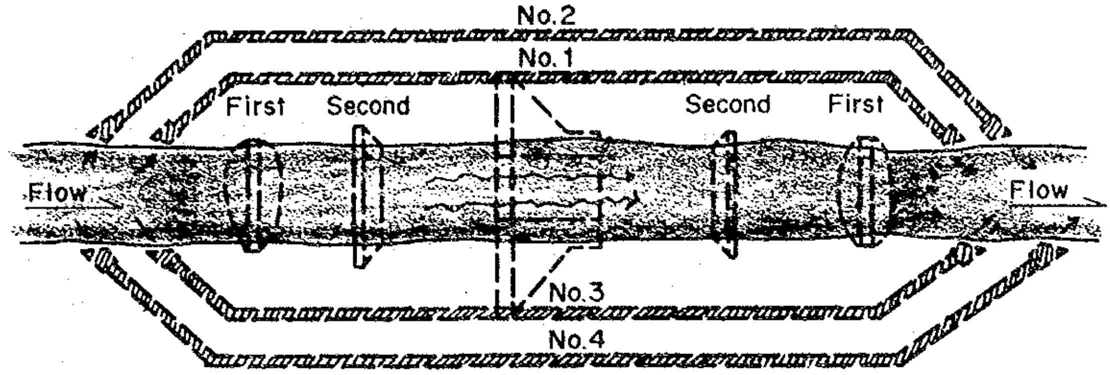
Second Coffer Dam



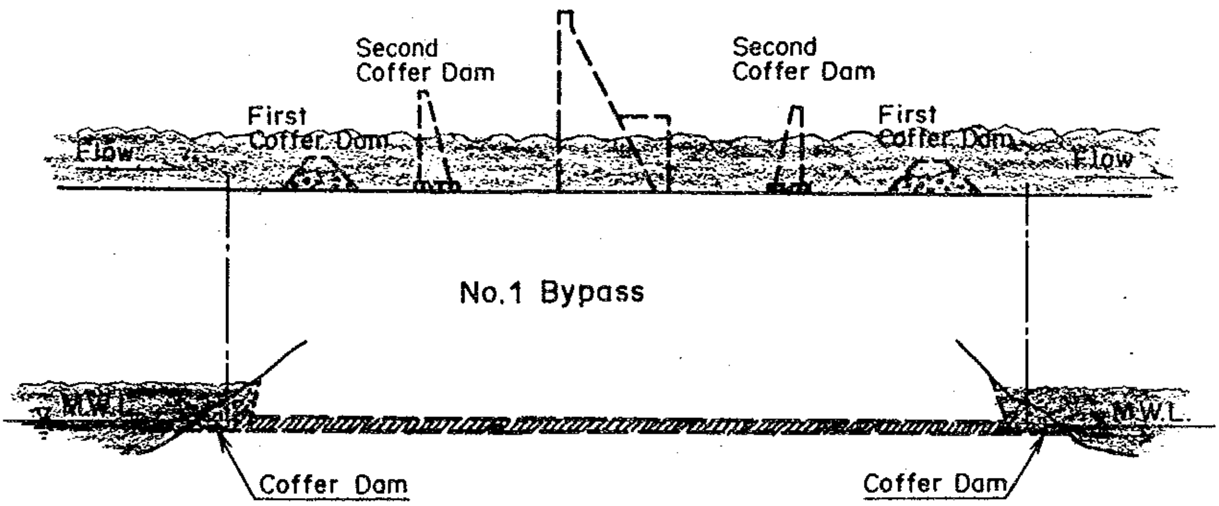
Care of River (Ene Paquitzapango)

YEAR	SEASON
3rd	RAINY

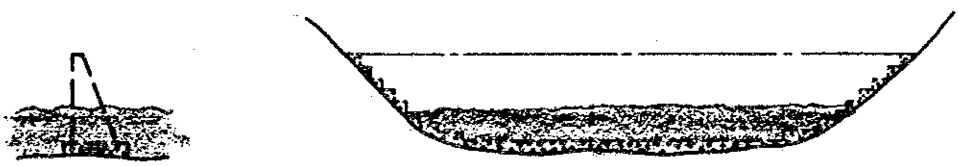
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Profileof River



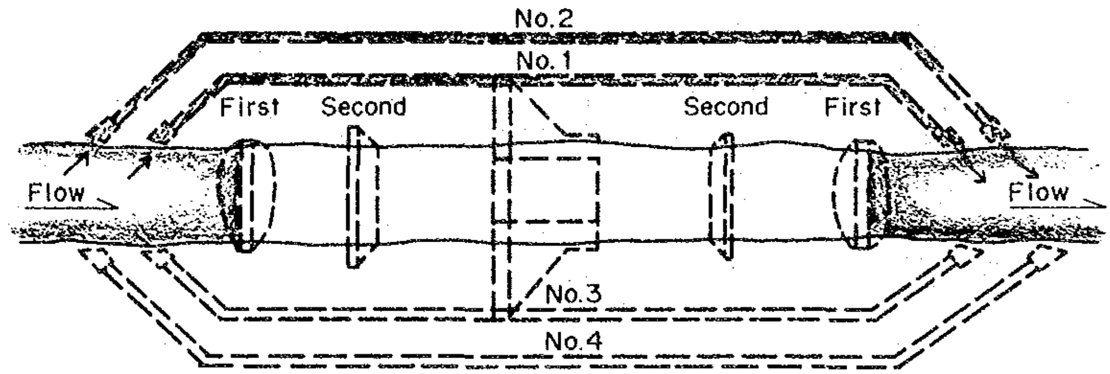
Second Coffer Dam



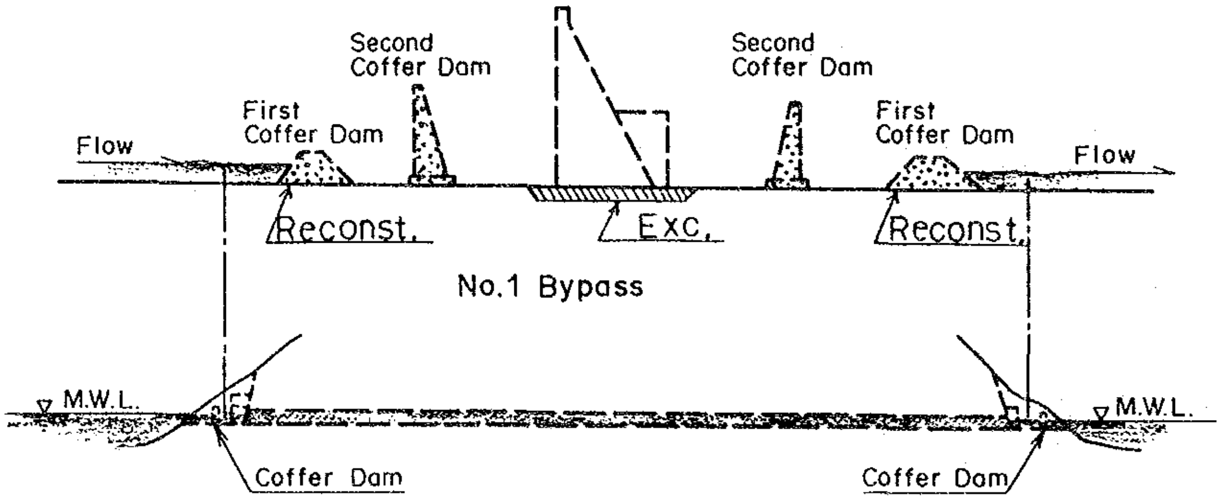
Care of River (Ene Paquitzapango)

YEAR	SEASON
4th	DRY

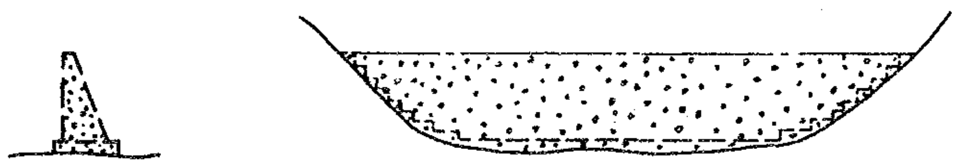
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Profileof River



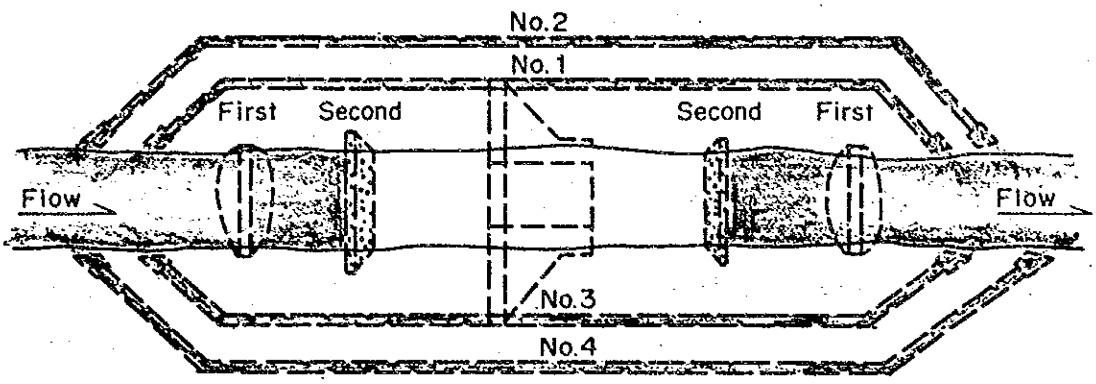
Second Coffer Dam



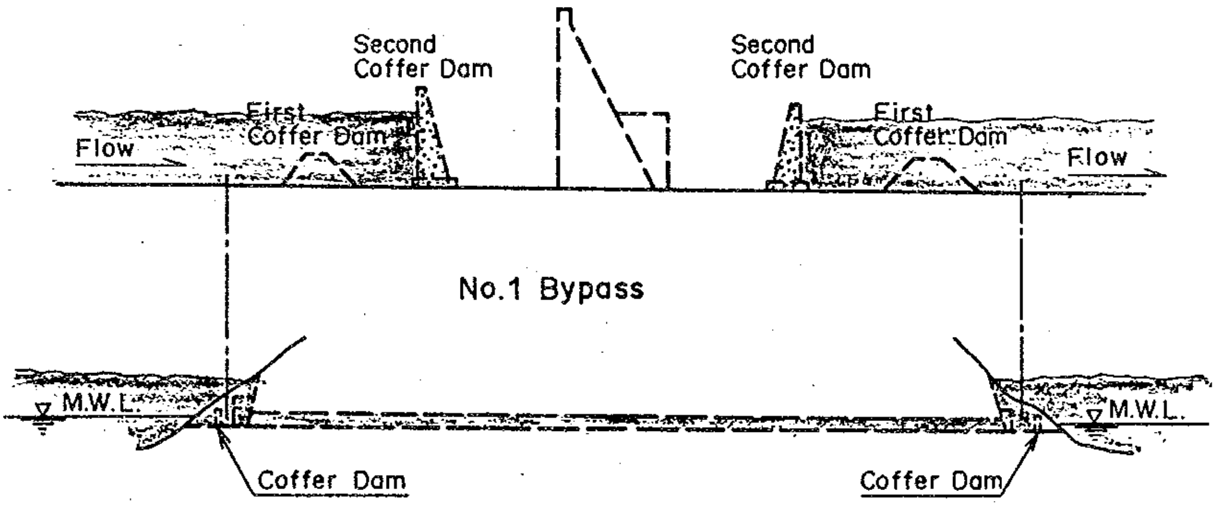
Care of River (Ene Paquitzapango)

YEAR	SEASON
4 th	RAINY

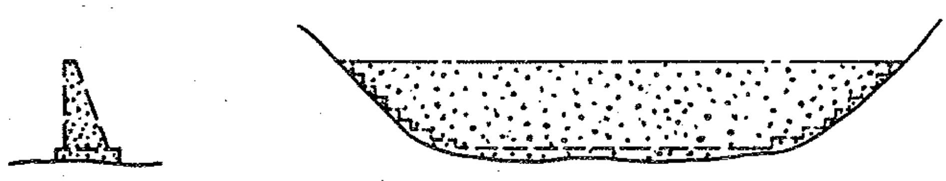
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Profil of River



Second Coffer Dam



(3) Tambo-Puerto Prado Site

As mentioned before, in the case of this site, the thickness of the deposited sand-gravel layer is estimated to be thick at a minimum of aobut 60 m, and as stated previously, it is difficult to adopt a concrete gravity type to second cofferdam. Therefore, this sand-gravel layer is not to be removed but left in place, and an impervious layer is to be formed by a special grouting method (clay, cement grout, etc.), or by the continuous under-ground wall method, on which a fill type dam is to be constructed as the second cofferdam.

The work for an impervious layer is to be carried out in the following procedure. That is, the impervious layer work is first to be performed in the dry seasons during the two years when the diversion tunnels are being excavated, at the right bank side where no flowing water during the dry seasons. After diverting the flow to the diversion tunnels, the impervious layer work at the left-bank side where flow center is located is to be carried out during the next dry season, and in the following year, the first cofferdams are to be reconstructed, and the embankment of the second cofferdam is started. The crest of the second cofferdam would be at elevation 334 m, and the volume would be 2.2 x 10^6 m^3. It is necessary for embankment of this dam to be completed in approximately 7 months, but because of the great length of the dam, this will be possible only if a sufficient number of heavy equipment is deployed.

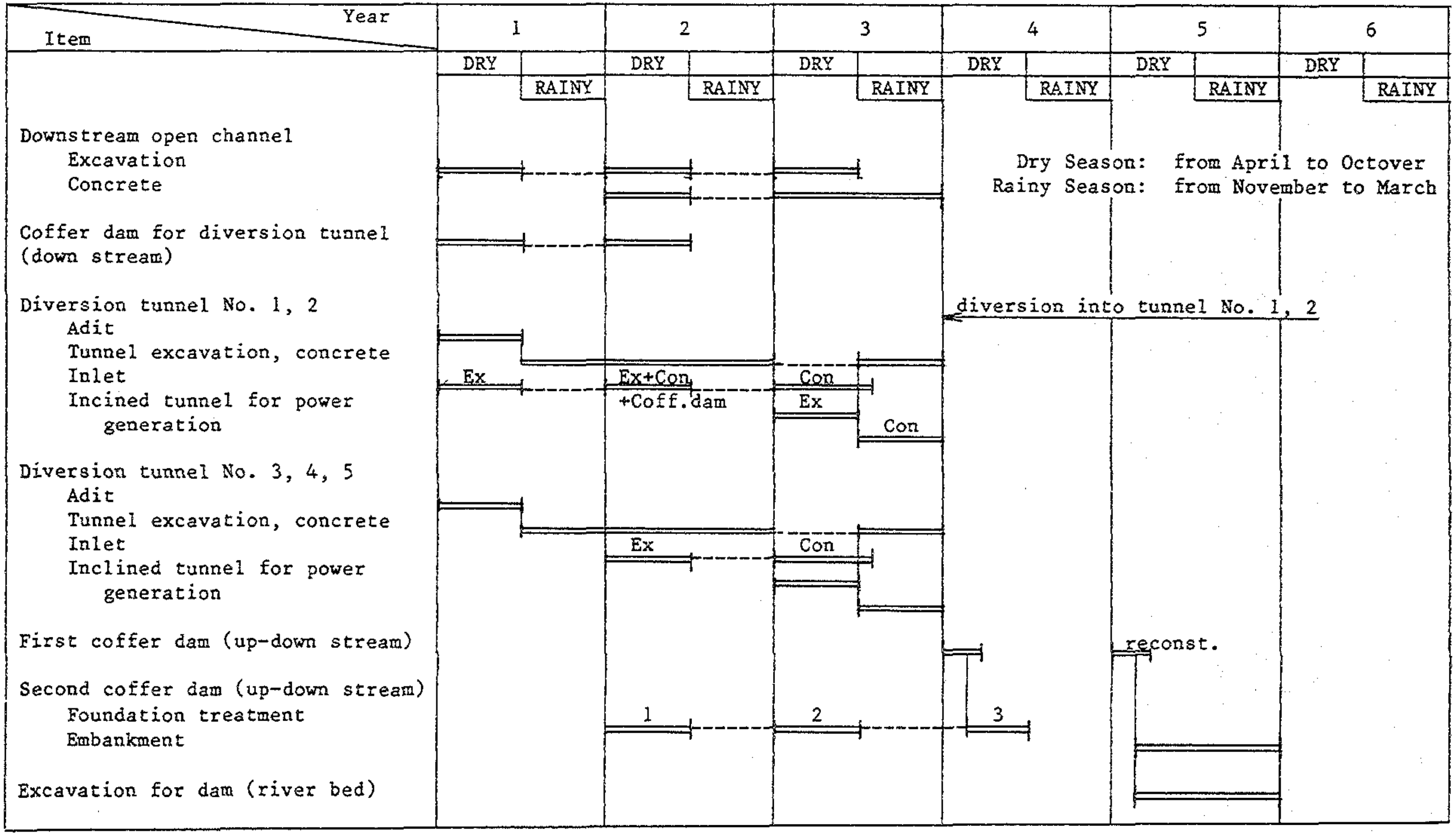
Since the second cofferdam is a fill type, diversion tunnels to be provided should have capacity to discharge a 10-year return period flood of 16,100 m^3/s.

The diversion tunnel size is to be 17 m heigh and 14 m wide, and five tunnels are to be provided. The elevations of inlet of two of these tunnels are provided as low as possible to prevent water level rise during construction of the first and second cofferdams.

These six tunnels will be converted into headraces in the future so that the elevation of outlets at the downstream side are to be decided taking into consideration the design elevations of the turbines. Because of this, closure dykes are necessary during construction at the outlet portals of the diversion tunnels also.

In the case of this site, there are such problems as providing an impervious layer in a sand-gravel deposit, or as overtopping of the cofferdam, but such problems could be coped with by adopting the abovementioned construction method.

Diversion and Care of River during Construction
(Tambo Puerto Prado - 445 m)



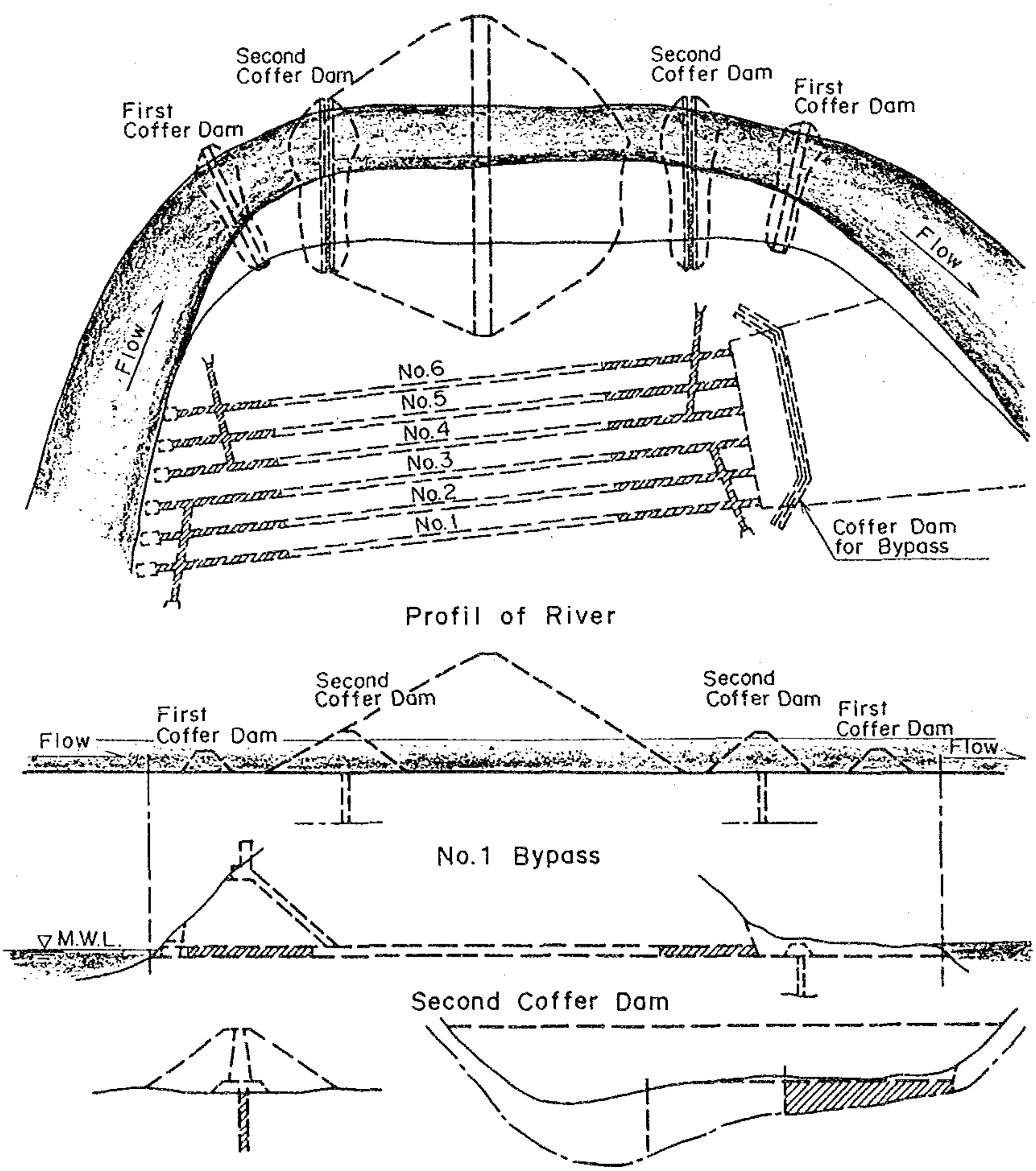
(4) Sumabeni Site

The site has topographical and geological conditions resembling those of the Tambo-Puerto Prado site. Accordingly, in diversion and care of river, it will be possible to carry out basically the same method as for Tambo-Puerto Prado.

Care of River (Tambo Puerto Prado)

YEAR	SEASON
2nd	DRY

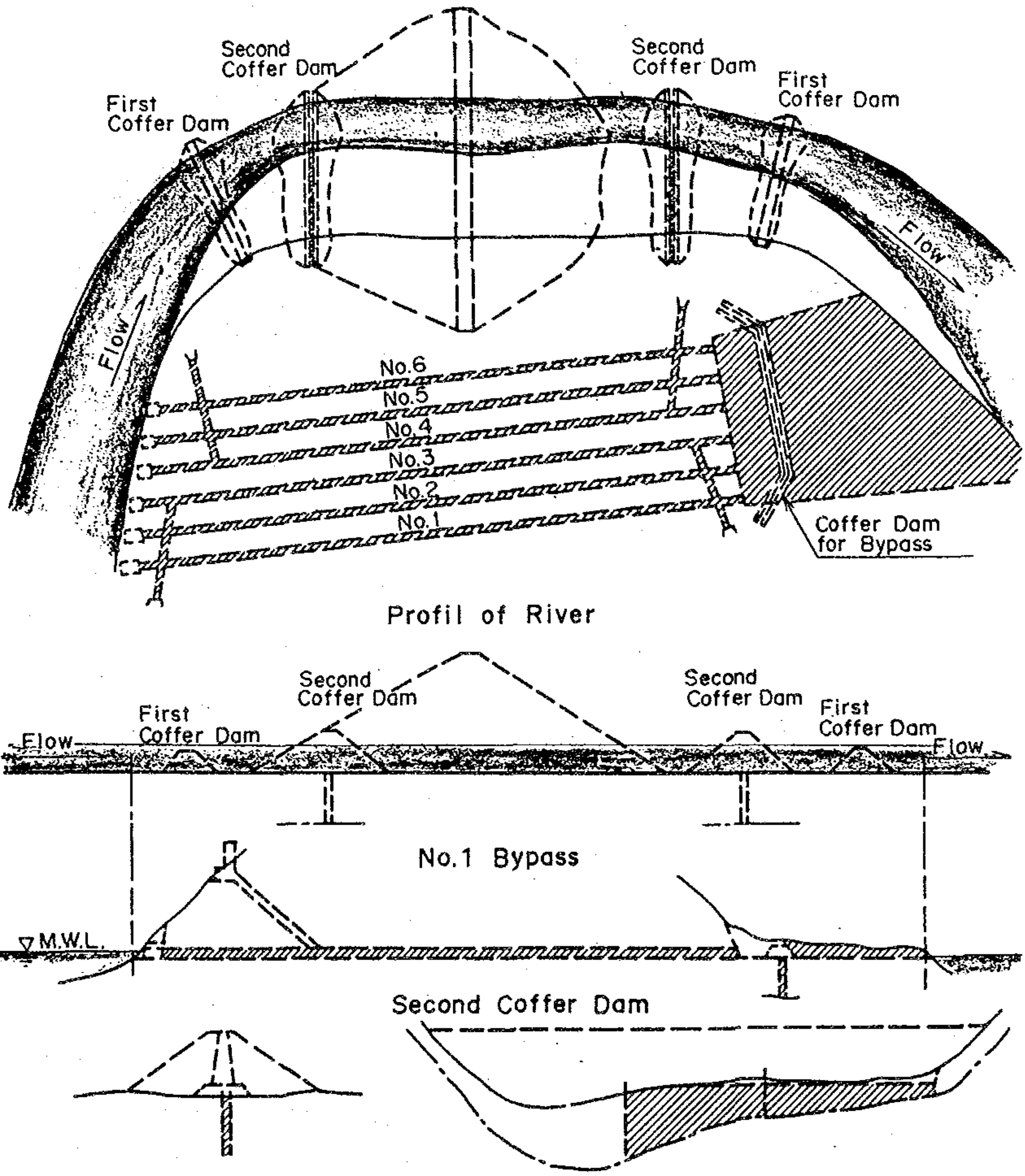
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Care of River (Tambo Puerto Prado)

YEAR	SEASON
3 rd	DRY

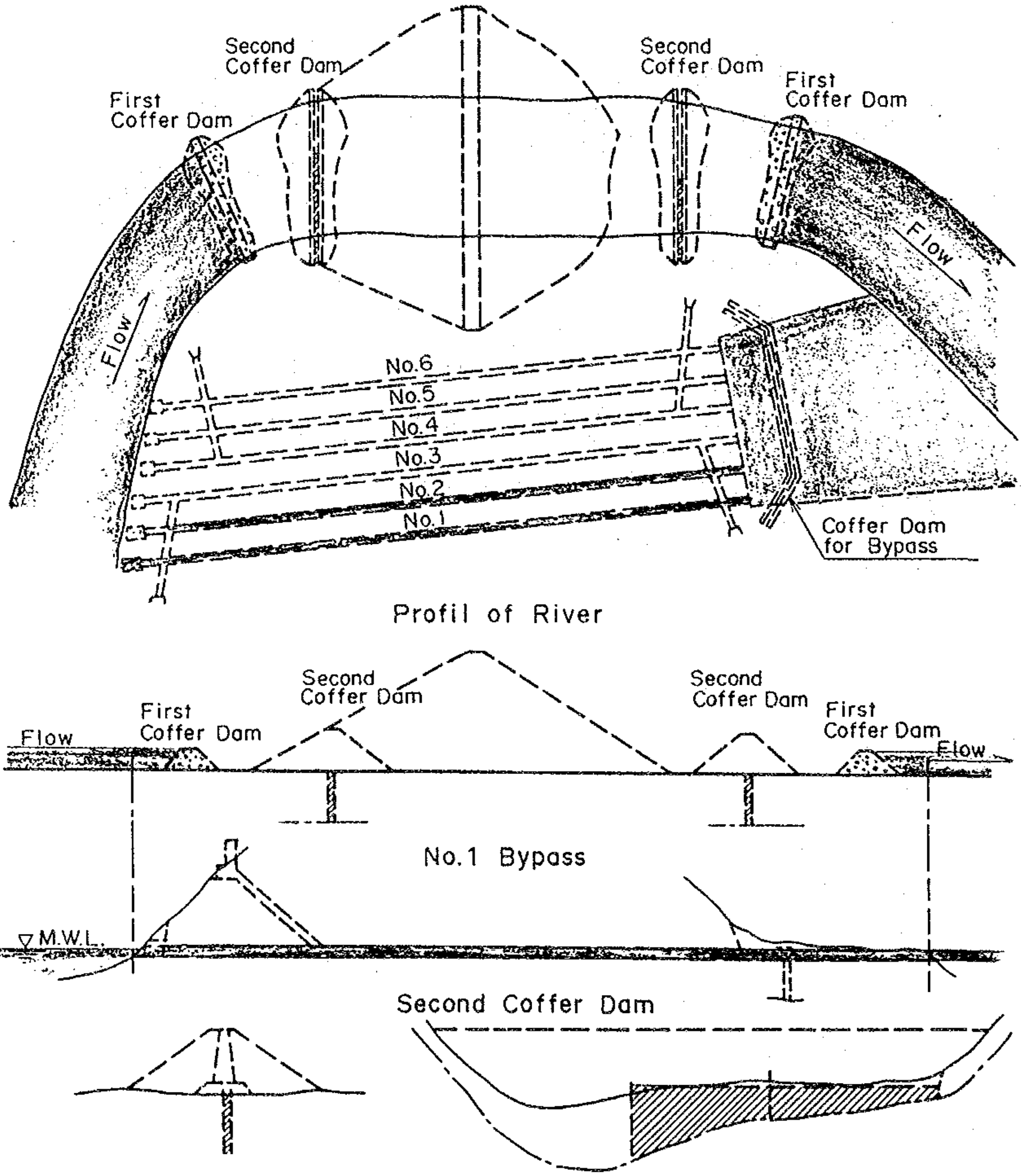
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Care of River (Tambo Puerto Prado)

YEAR	SEASON
4 th	D R Y

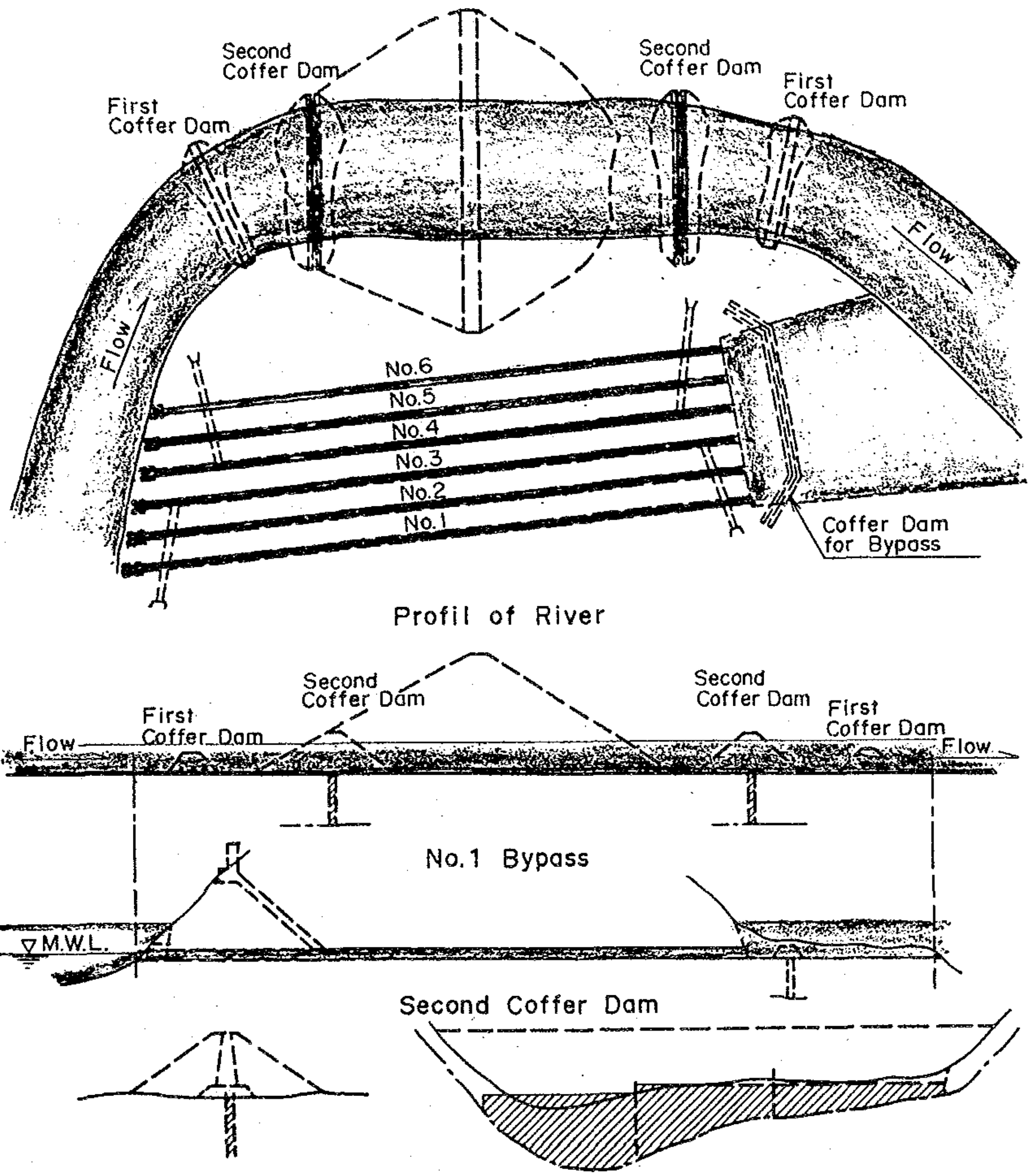
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Care of River (Tambo Puerto Prado)

YEAR	SEASON
4 th	RAINY

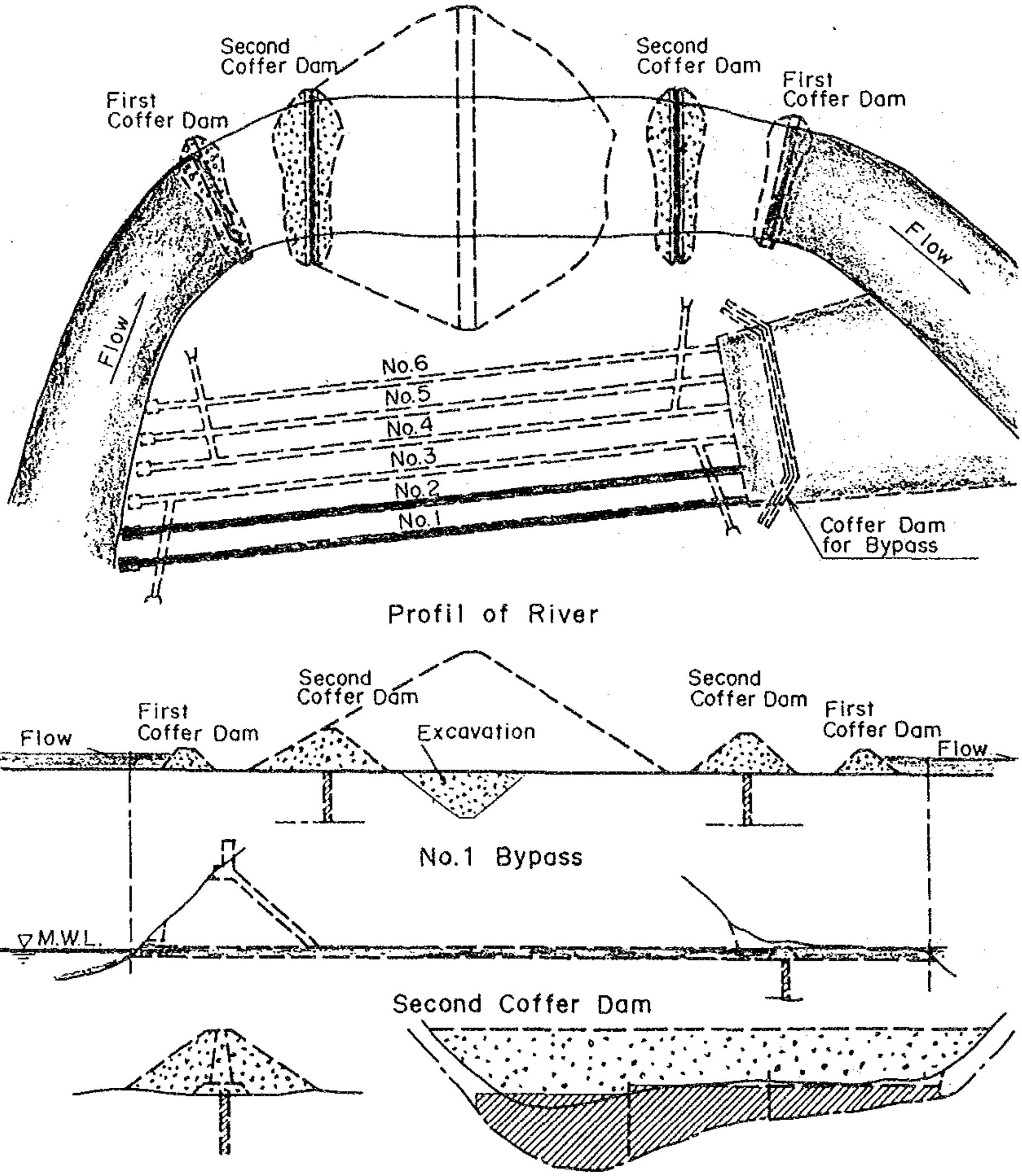
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



Care of River (Tambo Puerto Prado)

YEAR	SEASON
5 th	D R Y

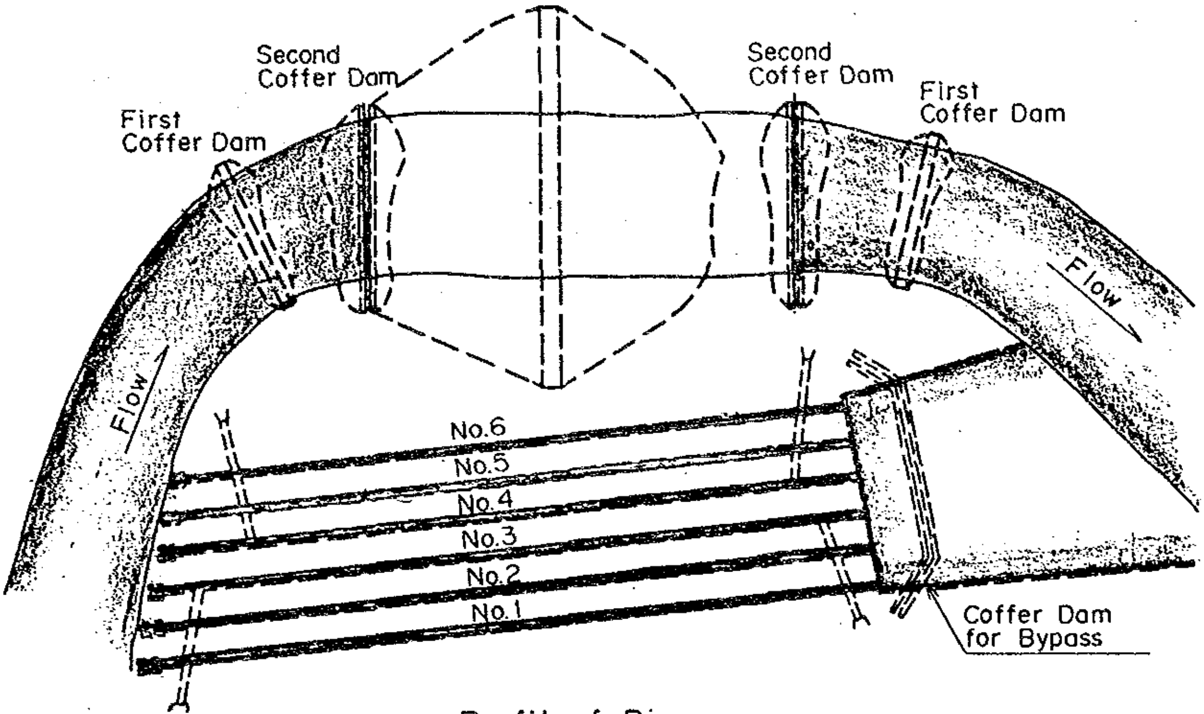
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



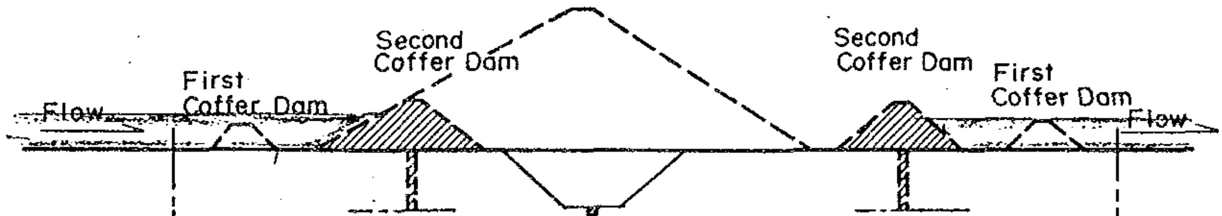
Care of River (Tambo Puerto Prado)

YEAR	SEASON
5 th	RAINY

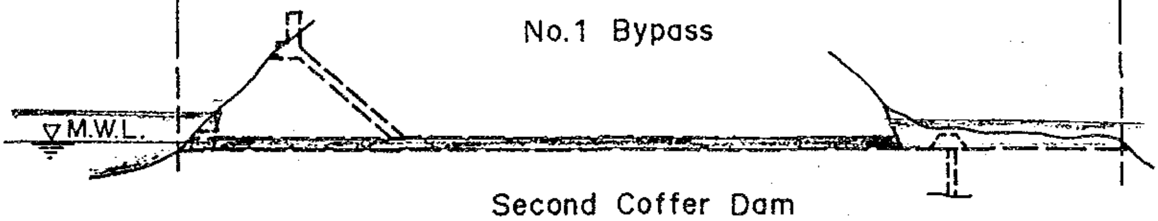
YEAR											
A	M	J	J	A	S	O	N	D	J	F	M
DRY Season											
							RAINY S.				



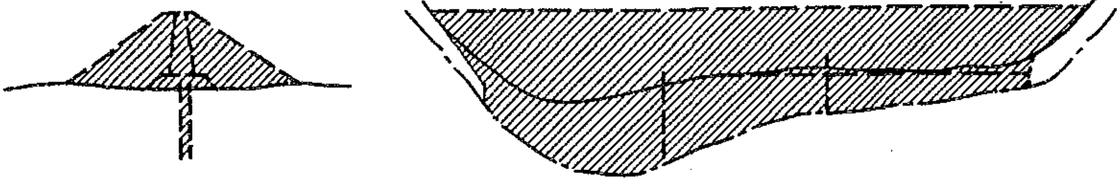
Profil of River



No.1 Bypass



Second Coffer Dam



A-5. SEISMIC ANALYSIS

[1] Probability Analysis on Seismic Intensity at Hydro-electric Project Sites in Peru

1. Seismicity Data

Seimicity data used in this study are those compiled by NOAA (National Oceanic and Atmospheric Administration Environmental Data Service). A magnetic tape offered by ELP contains the data for a wide region covering from 30°W to 85°W and from 60°S to 15°N during the period from 1868 to 1981. Before 1925, however, the data are not available for this study mainly due to lack of earthquake magnitude. Meanwhile, the concerned project sites are located around 11°-12°S and 74°W, as shown in Table 1. General aspects on seismicity around the project sites can be seen from Figs. 1 - 9, in which locations of the sites and epicenters of the seismic data from 1925 to 1981 are plotted in accordance with their magnitude and focal-depth ranks.

For the sake of simplicity, three project sites; that is, Tambo Puerto Prado, Ene Paquitzapango and Ene Sumabeni, are refered to as site A, B and C respectively, and symbols A, B and C will be used to indicate each site in this report. Tables A-1, B-1 and C-1 show distribution of magnitude and epicentral distance of the earthquakes available for this study. As for the earthquakes listed in these tables, numbers of the earthquakes occured in a year during the period 1925 to 1981 are shown in Tables A-2, B-2 and C-2, together with accumulative numbers from 1925.

2. Attenuation Models

Of previously proposed attenuation models which express peak acceleration, A (gal), in terms of earthquake magnitude, M, and hypocentral distance, R (km), or epicentral distance, D (km), five models shown below are used in this study.

$$\log A = 3.090 + 0.347M - 2 \log (R+25) \tag{1}$$

proposed by C. Oliveira[1].

$$\log A = 2.674 + 0.278M - 1.301 \log (R+25) \tag{2}$$

proposed by R. K. McGuire[2].

$$\log A = 2.041 + 0.347M - 1.6 \log D \tag{3}$$

proposed by L. Esteva and E. Rosenblueth[3].

$$\log A = 2.308 + 0.411M - 1.637 \log (R+30) \tag{4}$$

proposed by T. Katayama[4].

References:

1) Oliveira, C.;Seismic Risk Analysis, EERC 74-1, Earthquake Engineering Research Center, University of California, Berkeley (1974), 1-102.
2) McGuire, R. K.;Seismic Structural Response Risk Analysis incorporating Peak Response Regressions on Earthquake Magnitude and Distance. Mass. Inst. Technol. Dep. Civ. Eng., R74-51 (1974).
3) Esteva, L. and Rosenblueth, E.;Espectros de Temblores A Distancias Moderadas y Grandes, Proc. Chilean Conference on Seismology and Earthquake Engineering, Vol. 1, University of Chile (1963) .
4) Katayama, T.;Fundamentals of Probabilistic Evaluation of Seismic Activity and Seismic Risk (in Japanese), SEISAN-KENKYU (Monthly Journal of Institute of Industrial Science, University of Tokyo), 27-5 (1975), 1-11.

3. Statistical Analysis of Maximum Accelerations

The seismicity data are available for successive 56 years from 1925 to 1981 for each site. Thus, a probalistic model based on the "Theory of Extreme Values" can be established by taking an equal time interval to be one year.

Although a probability function of the maximum acceleration expected at a dam site is not known, it is reasonable to suppose that the function should be associated with the third type asymptotic distribution defined by

$$P(x) = \exp[-[(w-k)/(w-u)]^{k}]$$

where w is an upper limit of a variable, k is a shape parameter, u is a characteristic value, and x is a random variable taken as logarithm of the maximum acceleration during a year-long interval, expressed as

$$x = \log A_{max}$$

In Tables A-3, B-3 and C-3, maximum accelerations during a year from 1925 to 1981 are shown for every attenuation model described previously. The maximum values are plotted in Figs. A-1 -4, B-1 - 4, and C-1 -4. Plotting position of each maximum value was calculated by

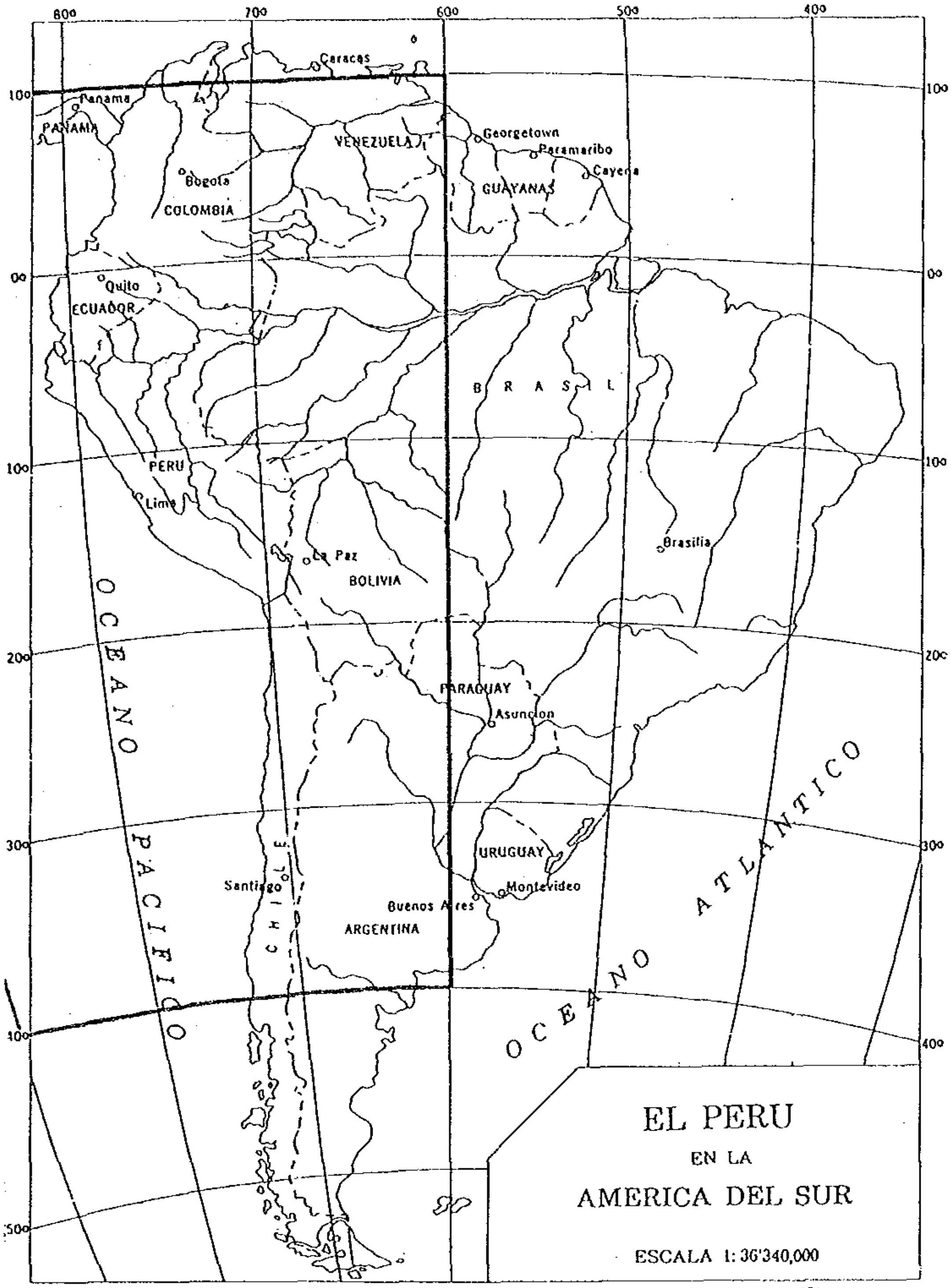
$$p(m) = (N-m+1)/(N+1)$$

where N (=56) is the total number of the time interval and m is the order of the value from the largest one. In these figures, regression curves estimated for the third asymptotic distribution function are also shown by solid lines, from which the maximum acceleration for any return period can be evaluated. Table A-4, B-4 and C-4 show the maximum acclerations expected at each site for different three return periods of 50, 100 and 200 years.

Table 1

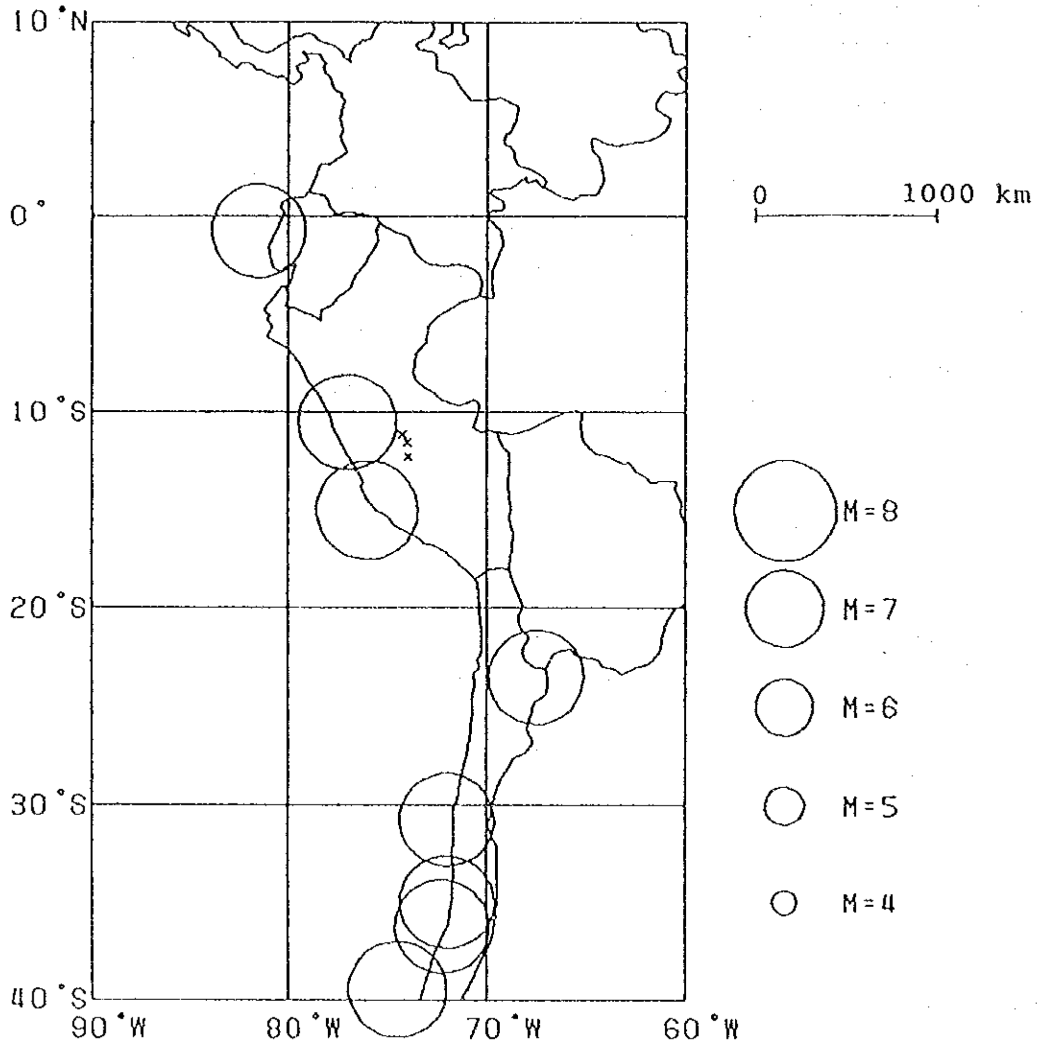
Location of Project Sites.

	S	W
A : Tambo Puerto Prado (Tambo-10)	11°09'10"	74°14'21"
B : Ene Paquitzapango (Ene -40)	11°31'04"	74°04'30"
C : Ene Sumabeni (Ene -10)	12°09'50"	74°04'13"



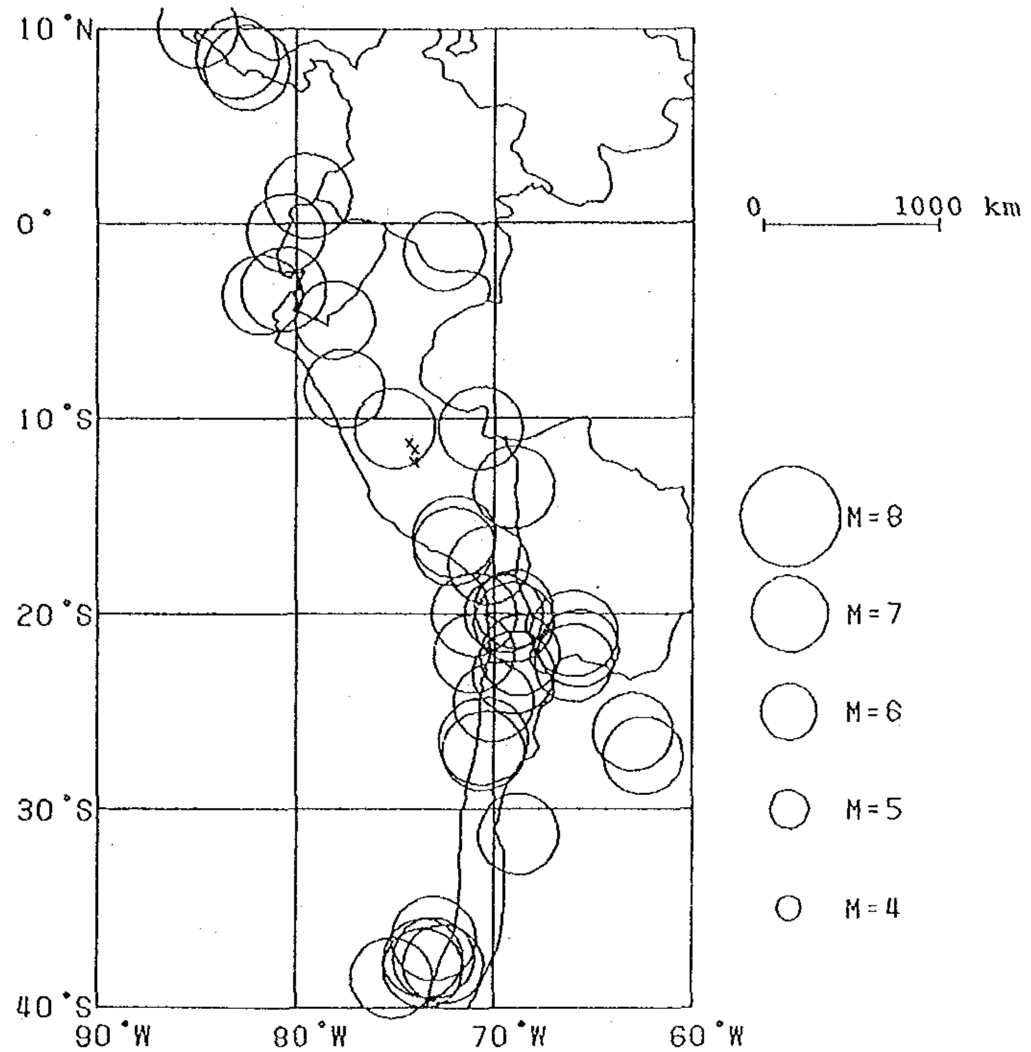
EL PERU
EN LA
AMERICA DEL SUR
ESCALA 1: 36'340,000
OCEANO PACIFICO
OCEANO ATLANTICO
Caracas
Panama
PANAMA
VENEZUELA
Georgetown
Paramaribo
Cayena
GUAYANAS
Bogota
COLOMBIA
Quito
ECUADOR
BRASIL
PERU
Lima
Brasilia
La Paz
BOLIVIA
PARAGUAY
Asuncion
URUGUAY
Montevideo
Santiago
CHILE
Buenos Aires
ARGENTINA

Fig.1



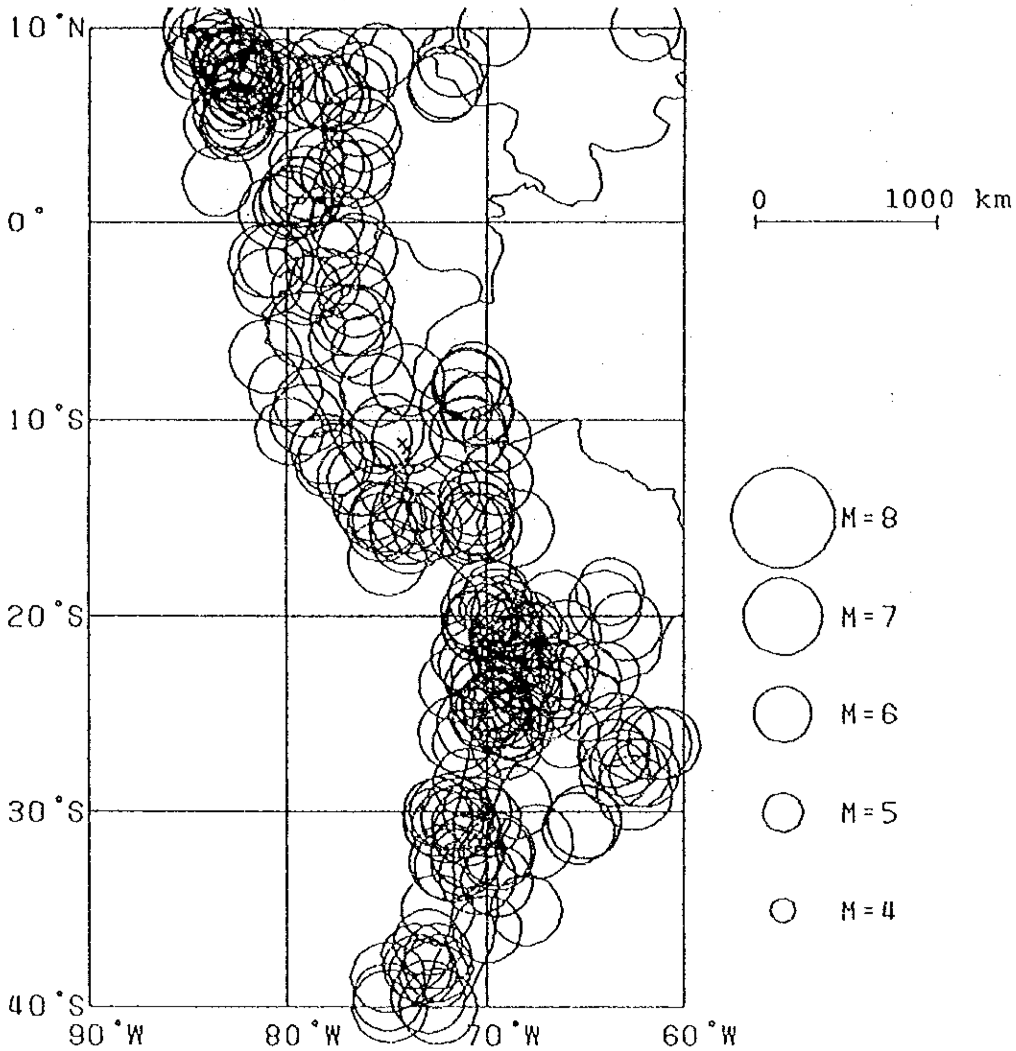
Seismicity of Magnitude M≧7.5 in 1925-1981,
Total Number of Plots are 8.

Fig.2



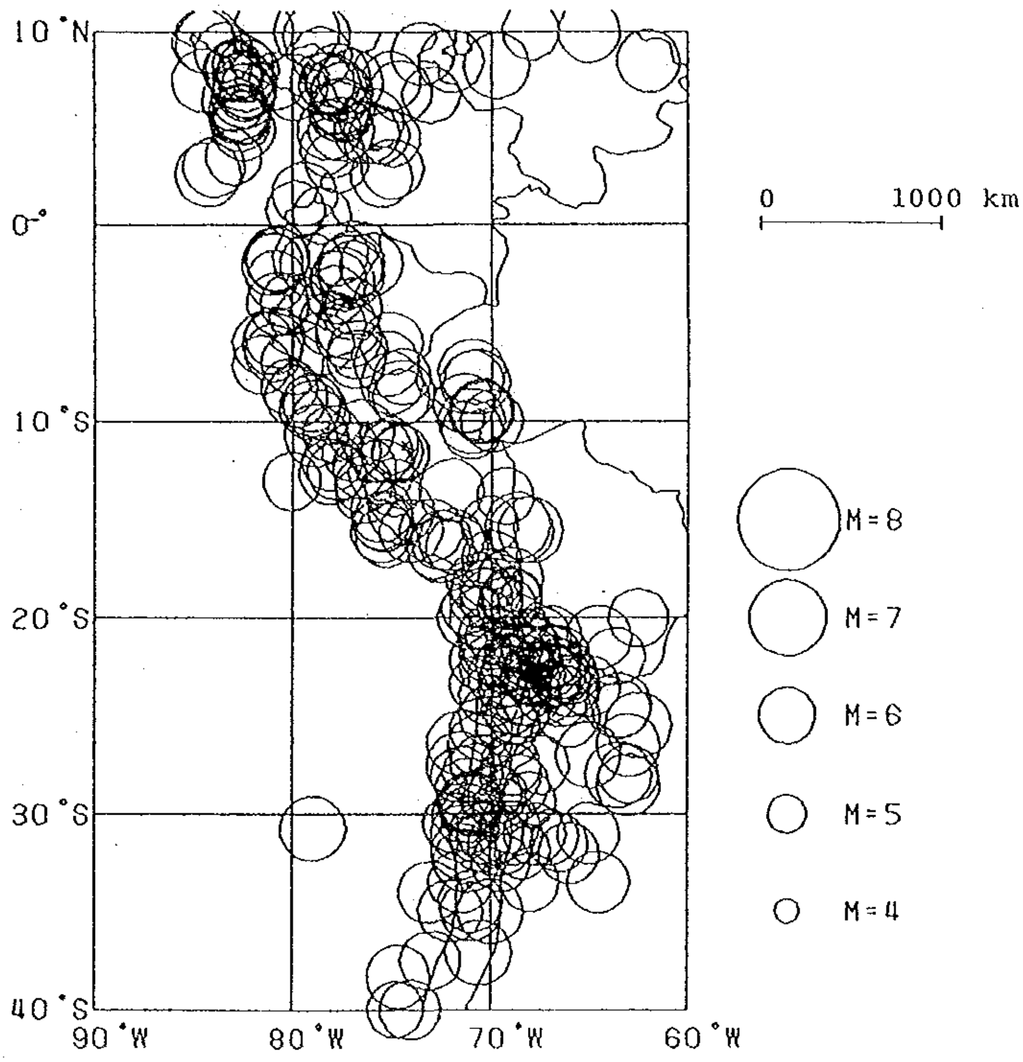
Seismicity of Magnitude 7≤M<7.5 in 1925-1981,
Total Number of Plots are 40.

Fig.3



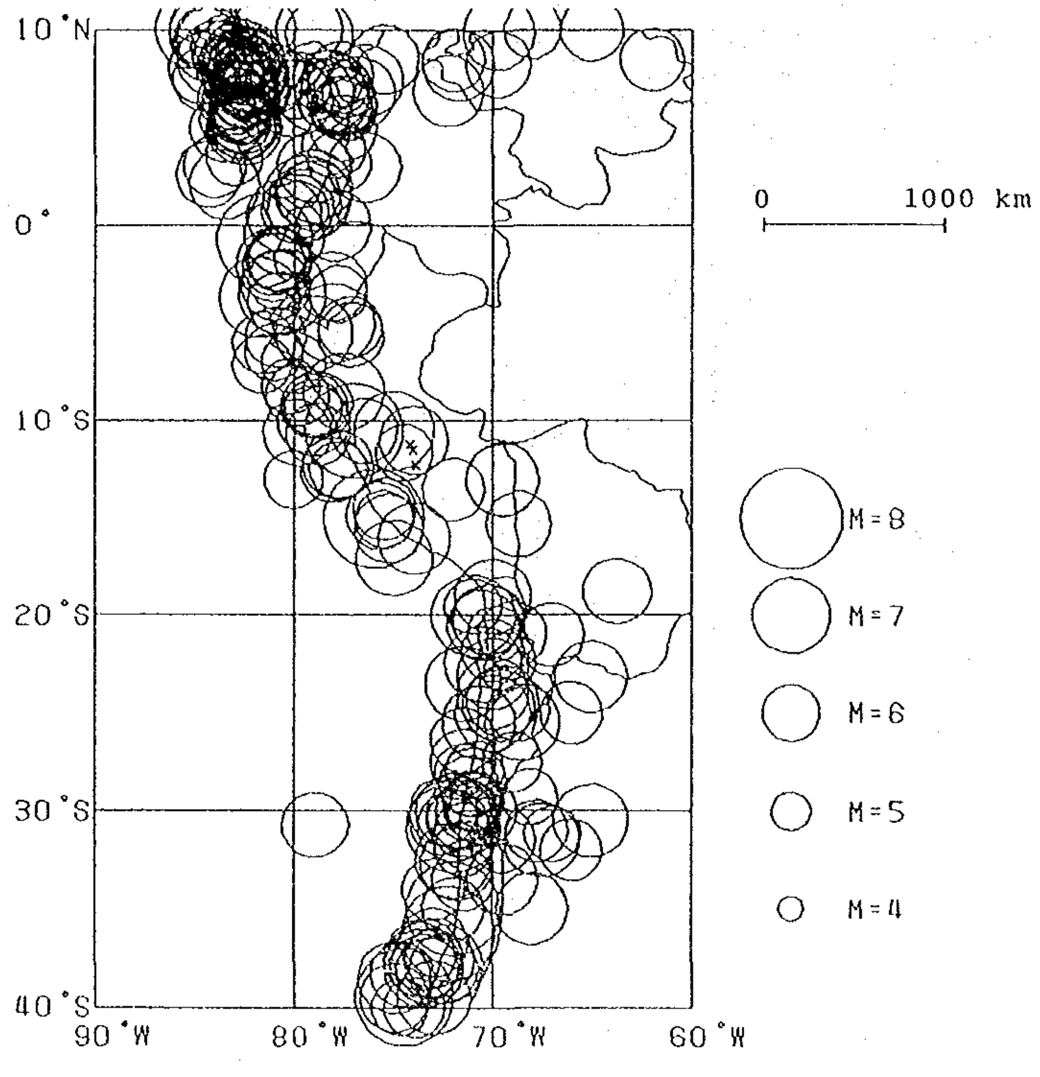
Seismicity of Magnitude 6.5≦M<7 in 1925-1981,
Total Number of Plots are 251.

Fig.4



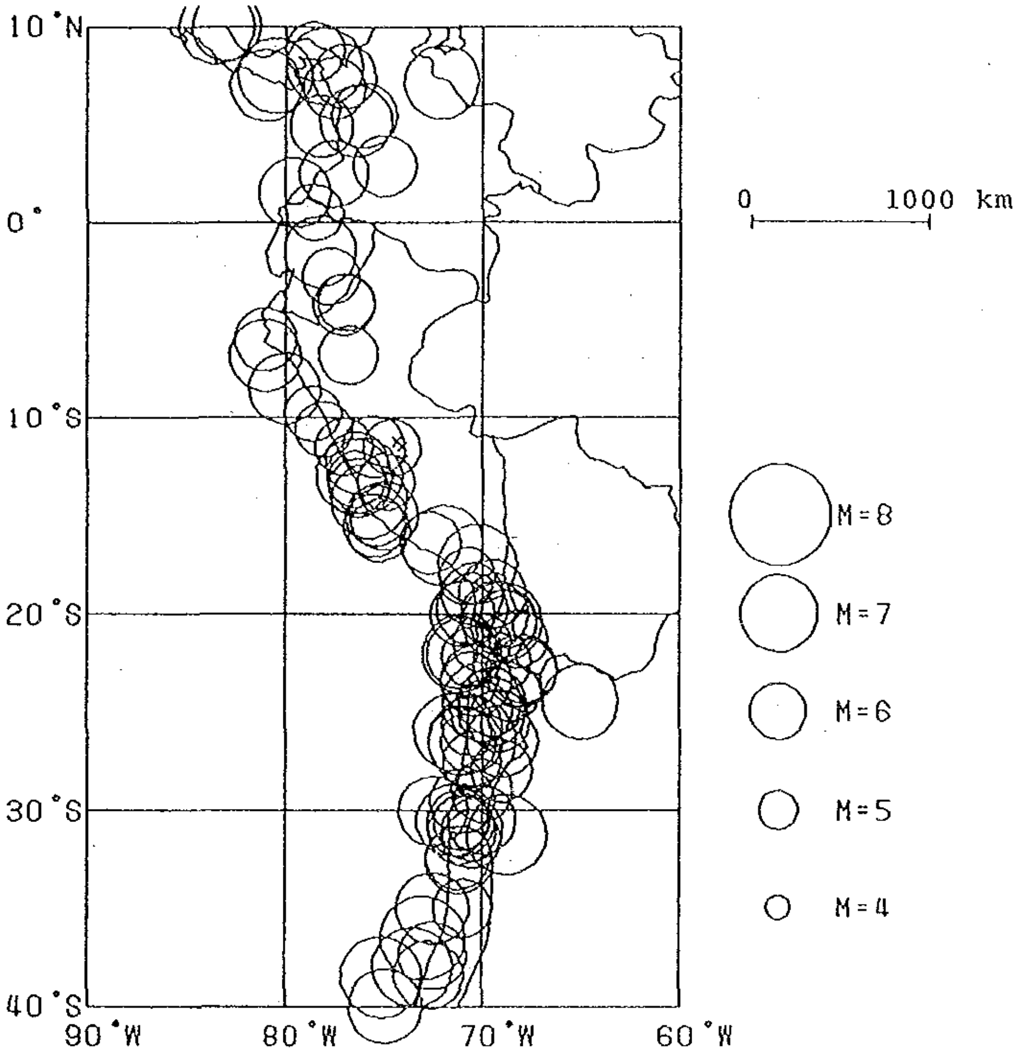
Seismicity of Magnitude 6≦M<6.5 in 1925-1981,
Total Number of Plots are 290.

Fig.5



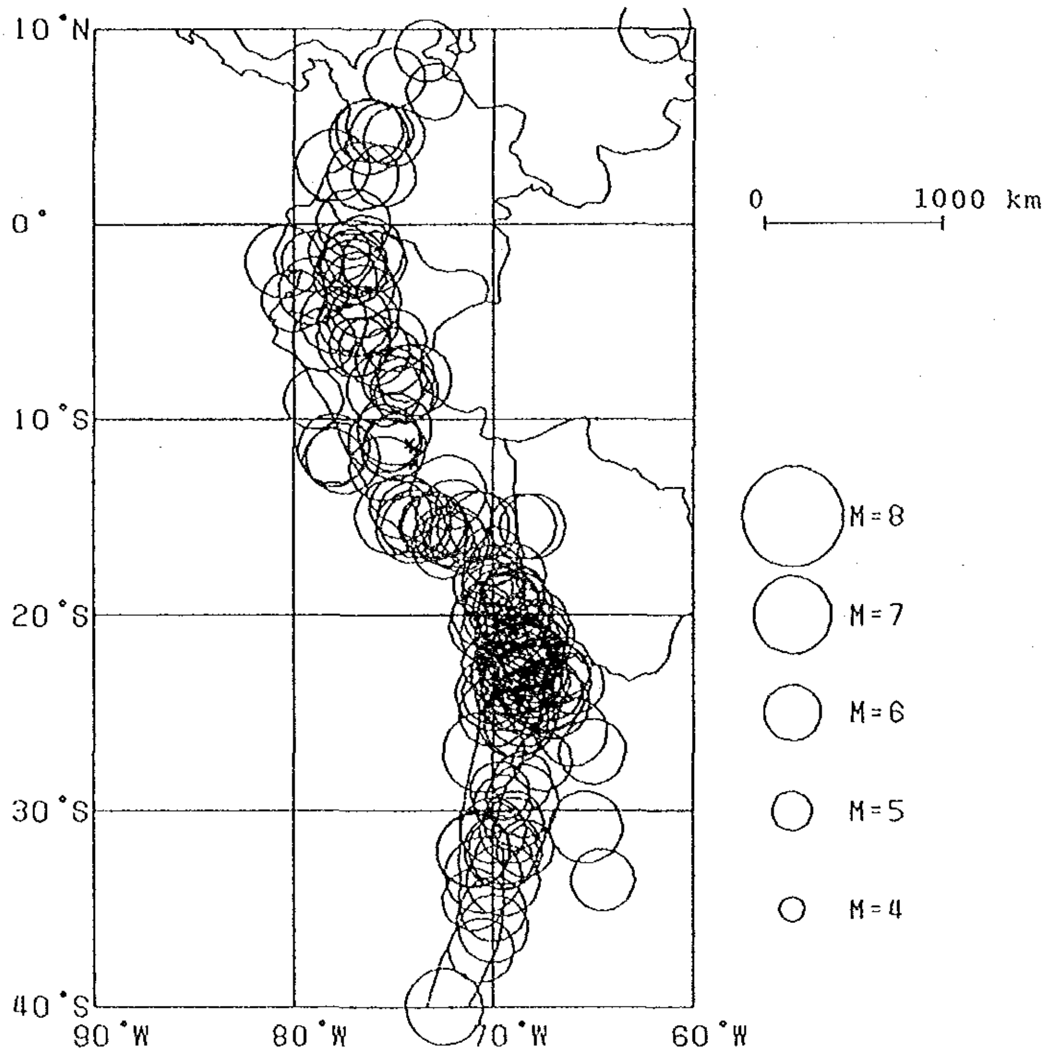
Distribution of Focal Depth 0≦D<50 km(M≧6), in 1925-1981,Total Number of Plots are 242.

Fig.6



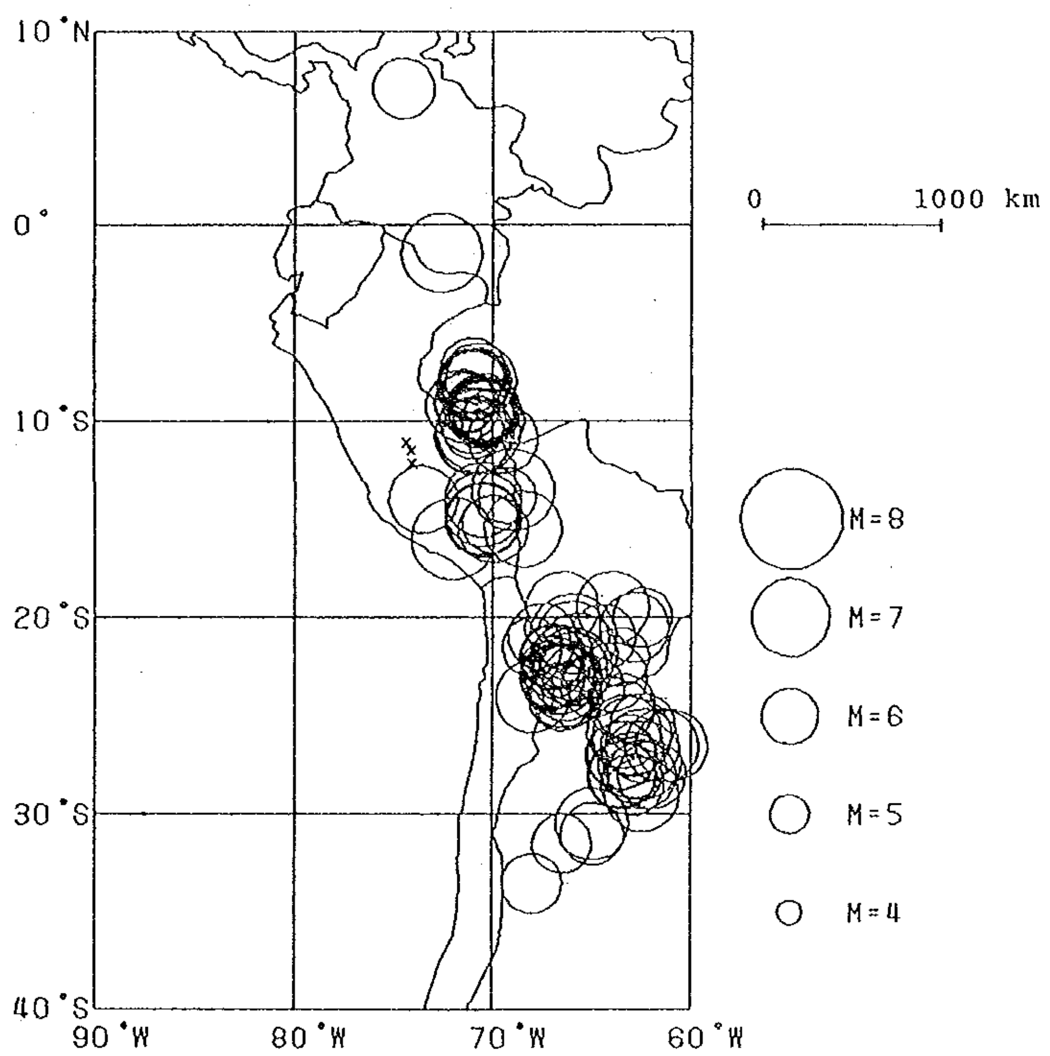
Distribution of Focal Depth 50≦D<100 km(M≧6), in 1925-1981, Total Number of Plots are 99.

Fig.7



Distribution of Focal Depth 100≦D<200 km(M≧6), in 1925-1981, Total Number of Plots are 154.

Fig. 8



Distribution of Focal Depth D≧200 km(M≧6),
in 1925-1981, Total Number of Plots are 94.

Fig.9

Table A-1

Distribution of Magnitude and Epicentral Distance of the Seismicity Data

	$0 \leq \Delta < 50$	< 100	< 200	< 300	< 400	< 500	< 600	< 700	< 800	≦ 1000	TOTAL
$3.0 \leq M < 3.5$	0	0	0	0	1	0	1	0	0	1	3
< 4.0	1	1	2	1	8	11	12	17	24	55	132
< 4.5	3	11	34	31	69	64	84	85	72	147	600
< 5.0	5	19	39	46	98	116	162	92	51	115	743
< 5.5	1	3	19	29	41	67	90	41	32	74	397
< 6.0	0	2	12	5	16	26	12	9	6	16	104
< 6.5	0	4	1	6	12	15	12	10	8	20	88
< 7.0	1	0	2	1	10	15	13	6	3	7	58
< 7.5	0	0	1	0	1	1	1	2	1	1	8
< 8.0	0	0	0	0	1	1	0	0	0	0	2
TOTAL	11	40	110	119	257	316	387	262	197	436	2135

Δ : Epicentral Distance (Km)
M : Magnitude

Table A-2

Number of Earthquakes in a year during the period from 1925 to 1981

Year	N	Sum of N	Year	N	Sum of N
1925	1	1	1954	1	102
1926	1	2	1955	2	104
1927	2	4	1956	4	108
1928	5	9	1957	2	110
1929	1	10	1958	5	115
1930	1	11	1959	2	117
1931	3	14	1960	6	123
1932	4	18	1961	9	132
1933	9	27	1962	2	134
1934	2	29	1963	104	238
1935	6	35	1964	111	349
1936	3	38	1965	128	477
1937	8	46	1966	179	656
1938	1	47	1967	142	798
1939	9	56	1968	168	966
1940	9	65	1969	143	1109
1941	4	69	1970	136	1245
1942	3	72	1971	85	1330
1943	4	76	1972	82	1412
1944	2	78	1973	92	1504
1945	1	79	1974	135	1639
1946	2	81	1975	74	1713
1947	2	83	1976	69	1782
1948	3	86	1977	72	1854
1949	1	87	1978	76	1930
1950	10	97	1979	87	2017
1951	1	98	1980	81	2098
1952	1	99	1981	37	2135
1953	2	101			

Table A-3

Maximum Accelerations during a year from 1925 to 1981

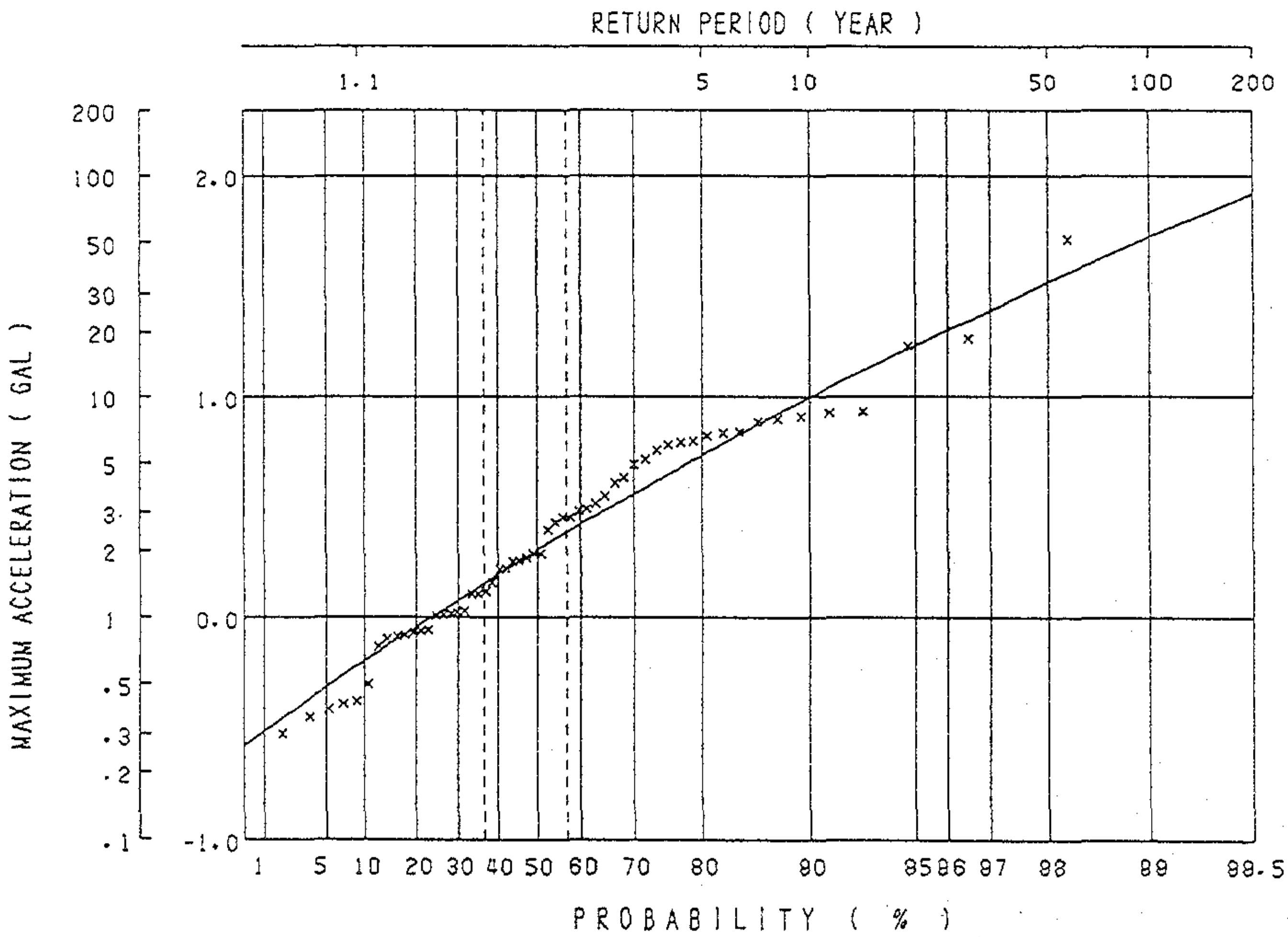
year	Oliveira,C Eq.(1)	McGuire,R.K. Eq.(2)	Esteva,L.& Rosenblueth,E. Eq.(3)	Katayama,T. Eq.(4)
1925	1.4	13.0	1.6	5.5
1926	0.4	5.7	0.5	2.0
1927	0.3	4.4	0.4	1.4
1928	0.9	9.6	1.1	3.9
1929	1.9	15.6	2.0	7.0
1930	0.4	5.3	0.5	1.8
1931	1.8	14.6	1.9	6.2
1932	1.6	14.4	1.8	6.4
1933	6.2	33.5	5.7	17.7
1934	0.3	4.6	0.4	1.5
1935	0.7	7.9	0.8	2.8
1936	1.1	10.2	1.2	3.9
1937	3.1	19.5	2.9	8.4
1938	0.5	6.3	0.6	2.1
1939	5.8	30.6	5.2	15.0
1940	6.6	35.8	6.0	23.1
1941	1.9	16.3	2.1	7.6
1942	2.9	23.6	3.3	14.1
1943	1.0	10.7	1.2	4.5
1944	0.8	9.4	1.0	3.8
1945	7.7	39.2	7.1	22.0
1946	3.1	22.3	3.2	11.2
1947	18.6	72.4	16.5	49.2
1948	2.5	19.3	2.6	9.4
1949	0.8	8.8	1.0	3.4
1950	1.8	15.5	2.0	7.2
1951	1.0	10.7	1.2	4.4
1952	0.8	9.5	1.1	3.9
1953	0.4	5.6	0.5	1.9
1954	0.4	5.9	0.6	2.1
1955	1.3	12.1	1.4	5.2
1956	0.9	9.4	1.0	3.7
1957	1.3	12.0	1.4	5.0
1958	51.8	132.7	52.1	92.7
1959	1.0	10.4	1.2	4.1
1960	1.3	12.7	1.5	5.6
1961	3.6	21.0	3.3	8.5
1962	0.8	9.1	1.0	3.6
1963	1.1	8.4	1.0	2.8
1964	6.9	28.1	6.4	10.2
1965	4.1	22.4	3.6	9.0
1966	6.3	27.2	5.7	10.1
1967	3.3	17.3	2.9	5.6
1968	8.1	31.2	7.7	12.3
1969	6.8	32.1	6.0	14.7
1970	6.1	25.0	5.7	8.3
1971	1.9	12.8	1.7	4.7
1972	1.7	11.6	1.5	3.6
1973	4.9	22.1	4.5	7.3
1974	5.2	27.8	4.7	12.8
1975	7.9	36.2	6.9	17.6
1976	17.1	60.1	15.4	32.4
1977	8.5	33.0	7.9	14.4
1978	2.8	16.2	2.5	5.4
1979	8.6	33.7	7.9	13.3
1980	4.3	21.8	3.8	8.0
1981	2.7	16.5	2.4	5.9

unit:gal

Table A-4

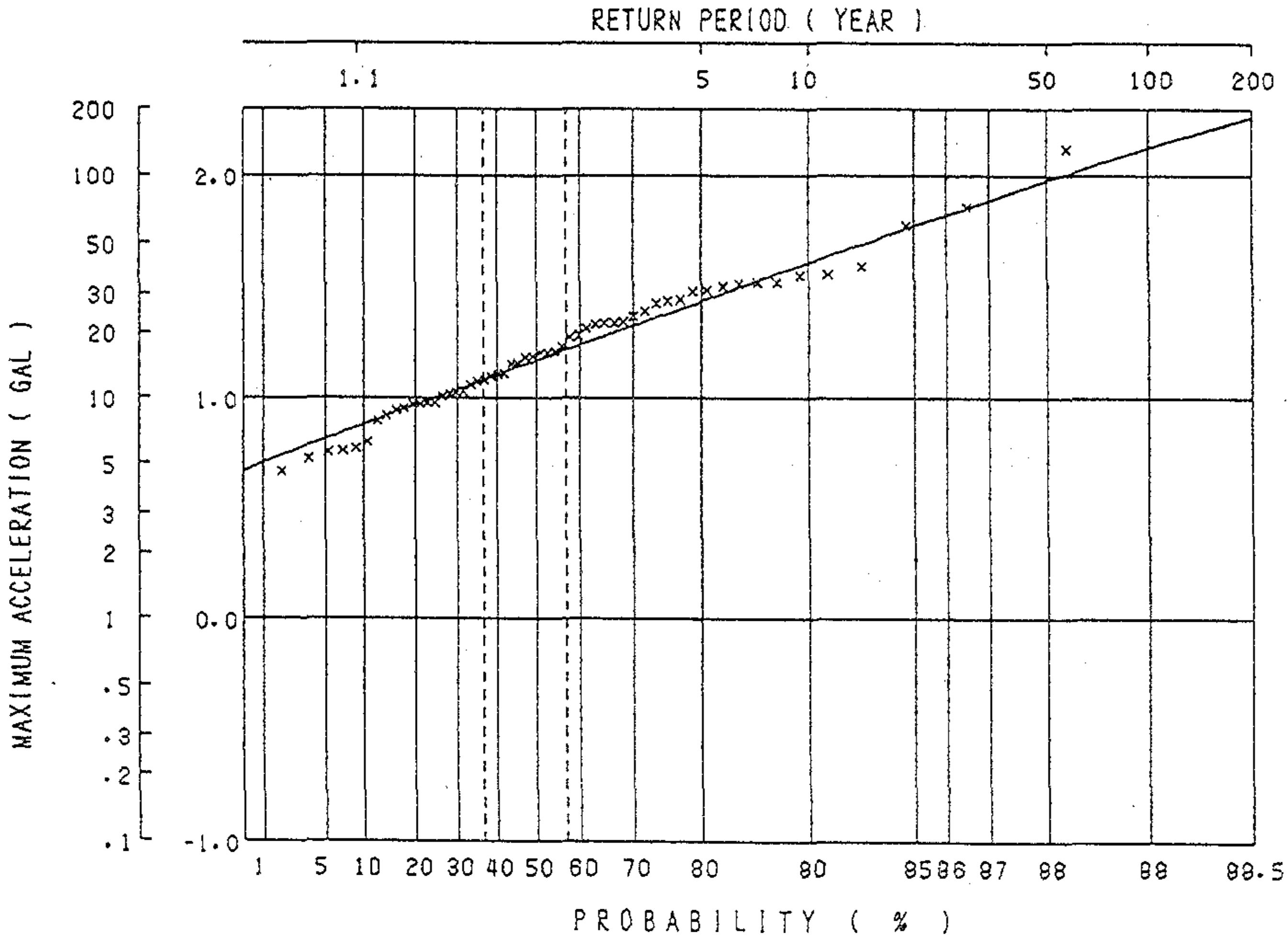
Maximum Accelerations for Three Return Periods (gal)

Model (Eq.No.)	Proposer(s)	Return Period, Tr (year)		
		50	100	200
(1)	C.Oliveira	33.5	53.4	82.7
(2)	R.K.McGuire	94.9	133.3	185.4
(3)	L.Esteva & E.Rosenbiueth	30.8	51.8	86.4
(4)	T.Katayama	59.6	92.4	142.6



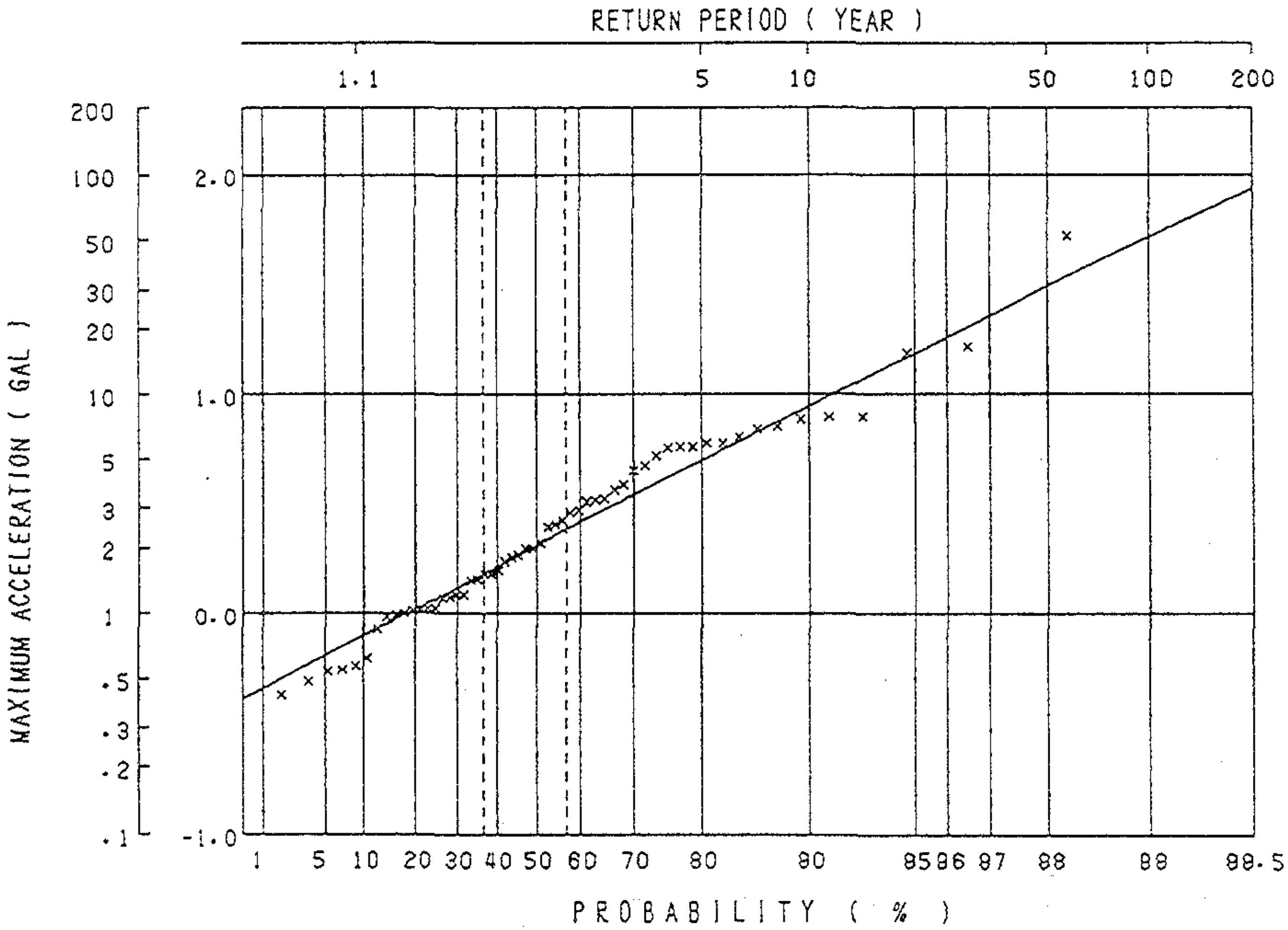
Distribution of the Maximum Accelerations derived from Eq.(1) by C.Oliveira.

Fig.A-1



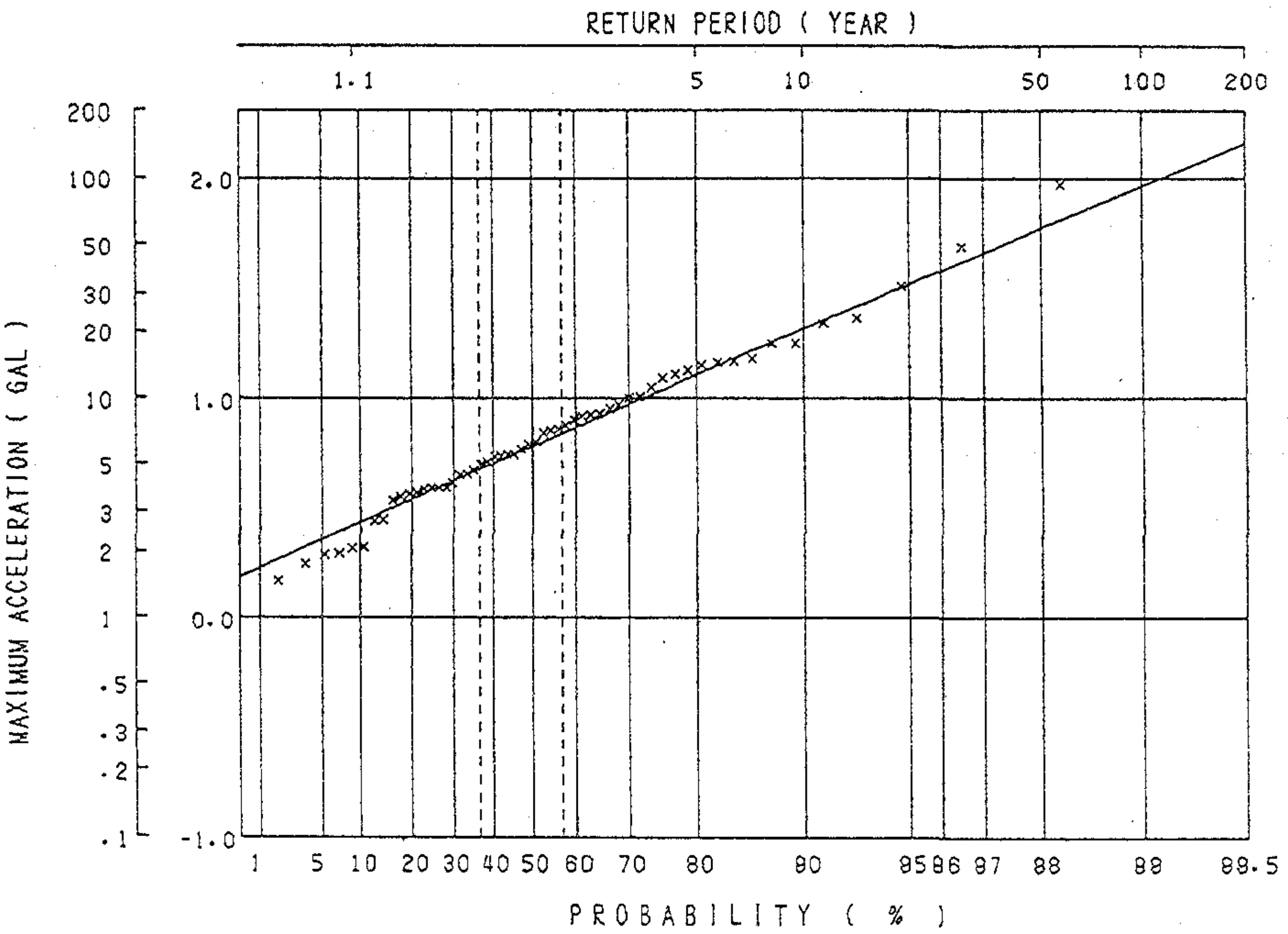
Distribution of the Maximum Acceleration derived from Eq.(2) by R.K.McGuire.

Fig.A-2



Distribution of the Maximum Acceleration derived from Eq.(3) by L.Esteva & E.Rosenblueth.

Fig.A-3



Distribution of the Maximum Accelerations derived from Eq.(4) by T.Katayama.

Fig.A-4

Table B-1

Distribution of Magnitude and Epicentral Distance of the Seismicity Data

	0 ≦ Δ < 50	< 100	< 200	< 300	< 400	< 500	< 600	< 700	< 800	≦ 1000	TOTAL
3.0 ≦ M < 3.5	0	0	0	0	1	0	1	0	0	1	3
< 4.0	0	2	2	3	5	16	14	15	28	56	132
< 4.5	0	10	34	32	76	79	80	53	90	159	600
< 5.0	9	12	33	44	110	117	159	67	77	123	743
< 5.5	1	3	19	19	52	70	90	33	43	78	397
< 6.0	0	3	8	8	10	20	10	5	8	16	104
< 6.5	1	1	4	3	11	17	15	6	9	22	88
< 7.0	0	1	2	2	12	14	12	4	4	7	58
< 7.5	0	0	1	0	1	0	4	0	1	1	8
< 8.0	0	0	0	0	1	1	0	0	0	0	2
TOTAL	11	32	103	111	287	334	393	183	260	464	2178

Δ : Epicentral Distance (Km)
M : Magnitude

Table B-2

Number of Earthquakes in a year during the period from 1925 to 1981

Year	N	Sum of N	Year	N	Sum of N
1925	1	1	1954	1	106
1926	1	2	1955	2	108
1927	1	3	1956	4	112
1928	5	8	1957	2	114
1929	1	9	1958	4	118
1930	1	10	1959	2	120
1931	3	13	1960	6	126
1932	6	19	1961	9	135
1933	10	29	1962	2	137
1934	2	31	1963	101	238
1935	6	37	1964	112	350
1936	3	40	1965	129	479
1937	8	48	1966	195	674
1938	2	50	1967	148	822
1939	9	59	1968	170	992
1940	9	68	1969	143	1135
1941	4	72	1970	140	1275
1942	3	75	1971	86	1361
1943	4	79	1972	84	1445
1944	2	81	1973	96	1541
1945	1	82	1974	136	1677
1946	3	85	1975	73	1750
1947	2	87	1976	70	1820
1948	3	90	1977	74	1894
1949	1	91	1978	75	1969
1950	10	101	1979	86	2055
1951	1	102	1980	85	2140
1952	1	103	1981	38	2178
1953	2	105			

Table B-3

Maximum Accelerations during a year from 1925 to 1981

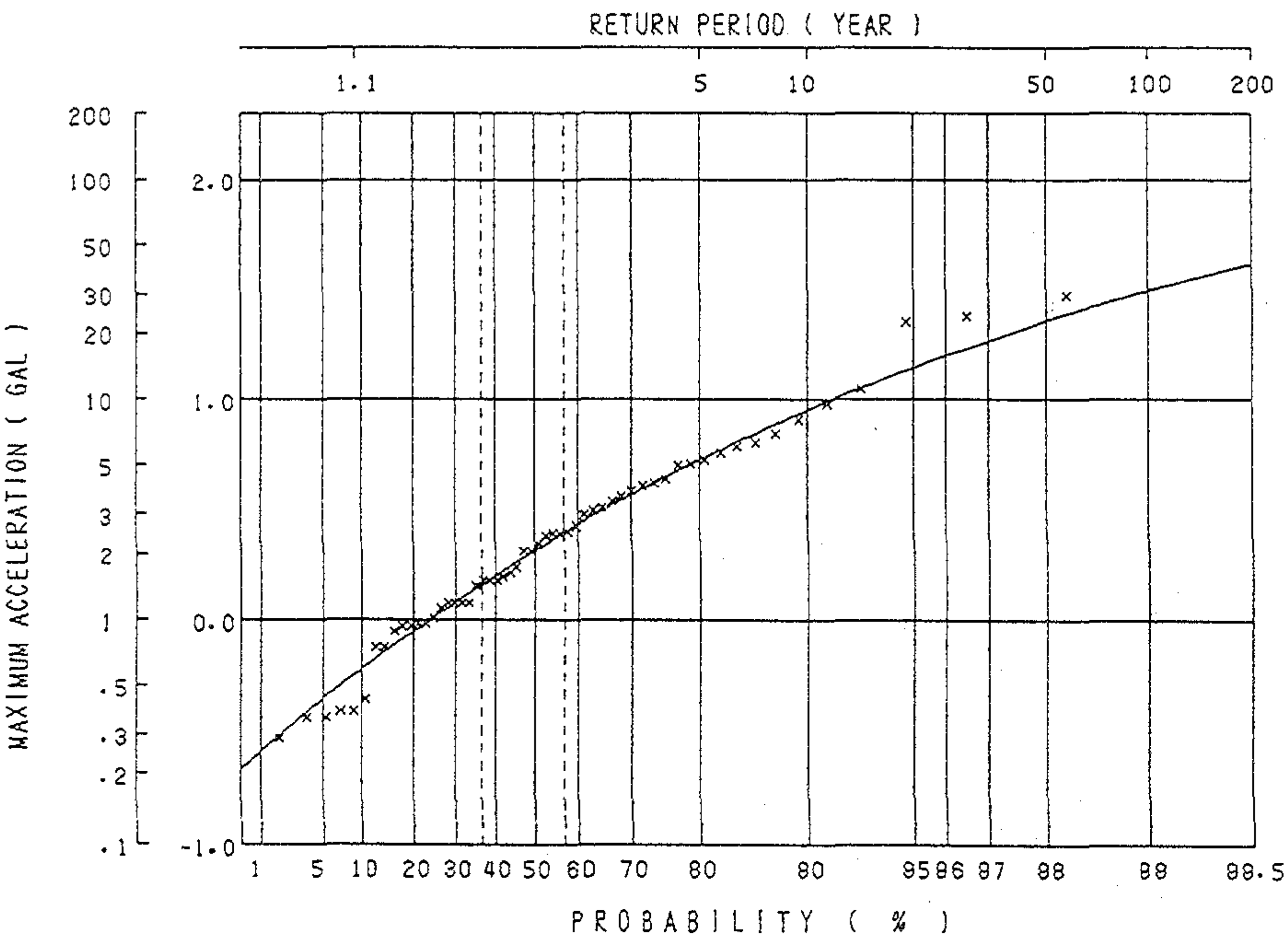
year	Oliveira,C Eq.(1)	McGuire,R.K. Eq.(2)	Esteva,L.& Rosenblueth,E. Eq.(3)	Katayama,T. Eq.(4)
1925	1.8	14.6	1.9	6.4
1926	0.4	5.3	0.5	1.8
1927	0.3	4.5	0.4	1.4
1928	1.0	10.3	1.2	4.3
1929	1.5	13.7	1.7	6.0
1930	0.4	5.3	0.5	1.8
1931	1.4	12.7	1.5	5.2
1932	1.6	14.0	1.7	6.1
1933	5,0	29.1	4.7	14.8
1934	0.3	4.3	0.4	1.4
1935	0.8	8.2	0.9	2.9
1936	0.9	9.1	1.0	3.3
1937	2.5	17.2	2.4	7.1
1938	0.4	5.7	0.5	1.9
1939	5.1	28.3	4.7	13.7
1940	6.1	32.2	5.5	20.3
1941	2.4	18.8	2.5	9.1
1942	3.2	25.5	3.7	15.5
1943	1.2	11.8	1.4	5.1
1944	0.9	10.2	1.1	4.3
1945	5.7	32.3	5.4	17.3
1946	3.4	23.6	3.5	12.0
1947	11.2	52.2	10.2	33.0
1948	2.7	20.0	2.8	9.8
1949	0.9	9.8	1.1	3.8
1950	2.1	16.9	2.2	8.0
1951	1.2	11.8	1.4	5.0
1952	1.0	10.3	1.2	4.3
1953	0.4	5.5	0.5	1.9
1954	0.4	5.5	0.5	1.9
1955	1.5	13.6	1.7	6.0
1956	1.0	10.3	1.2	4.1
1957	1.2	11.5	1.4	4.8
1958	29,5	92.0	26.8	60.1
1959	1.2	11.4	1.3	4.6
1960	1.5	13.9	1.7	6.3
1961	3.0	21.7	3.4	8.9
1962	0.8	8.5	0.9	3.3
1963	1.6	10.9	1.5	3.2
1964	9.6	34.8	9.4	13.1
1965	4.1	22.5	3.7	9.1
1966	3.6	19.1	3.2	6.6
1967	2.5	14.4	2.2	4.4
1968	6.4	26.8	5.8	9.6
1969	7.0	32.8	6.2	15.1
1970	3.1	16.3	2.8	5.4
1971	2.2	13.9	2.0	4.5
1972	1.1	9.1	1.1	2.8
1973	3.0	16.1	2.7	5.0
1974	4.3	24.6	3.9	11.0
1975	8.1	36.9	7.1	18.0
1976	22.4	71.7	20.9	40.0
1977	23.6	64.2	31.2	27.7
1978	2.5	15.1	2.3	5.0
1979	4.0	20.6	3.6	7.4
1980	5.3	24.7	4.7	9.1
1981	2.1	13.9	1.9	4.8

unit:gal

Table B-4

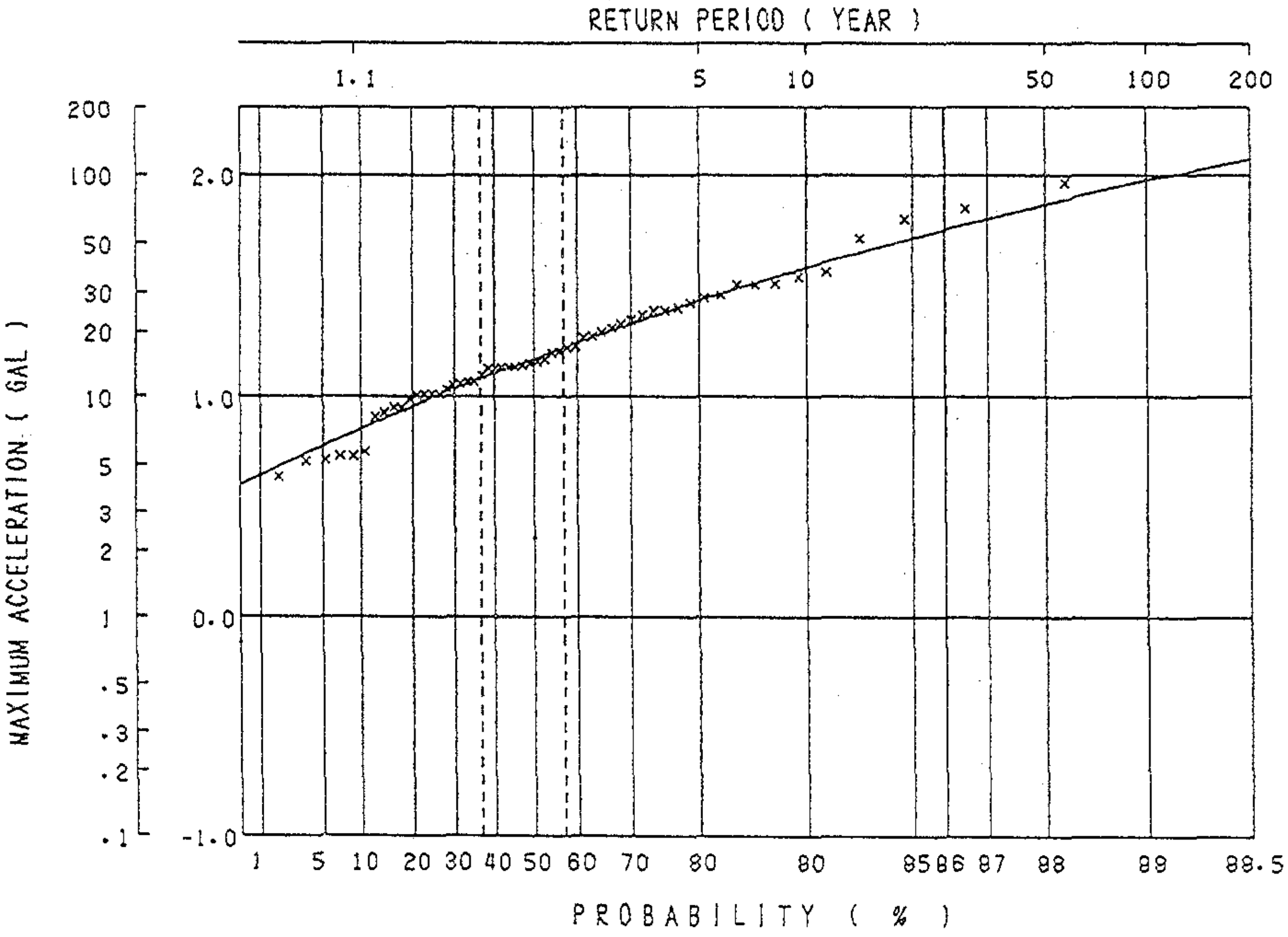
Maximum Accelerations for Three Return Periods (gal)

Model (Eq.No.)	Proposer(s)	Return Period, Tr (year)		
		50	100	200
(1)	C.Oliveira	22.7	31.0	40.9
(2)	R.K.McGuire	74.5	94.4	117.2
(3)	L.Esteva & E.Rosenbiueth	22.3	32.3	45.4
(4)	T.Katayama	44.9	61.7	82.8



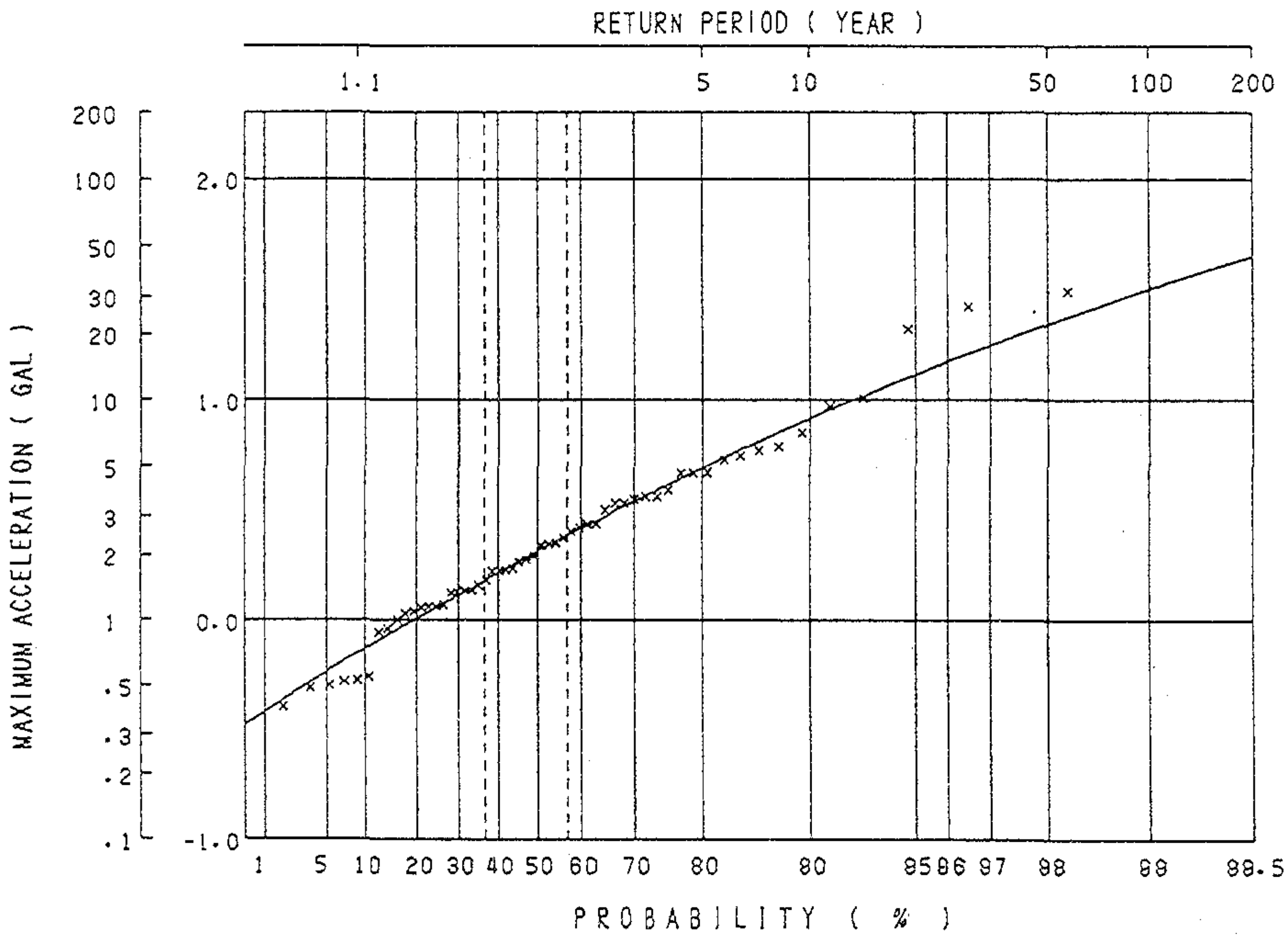
Distribution of the Maximum Accelerations derived from Eq.(1) by C.Oliveira.

Fig.B-1



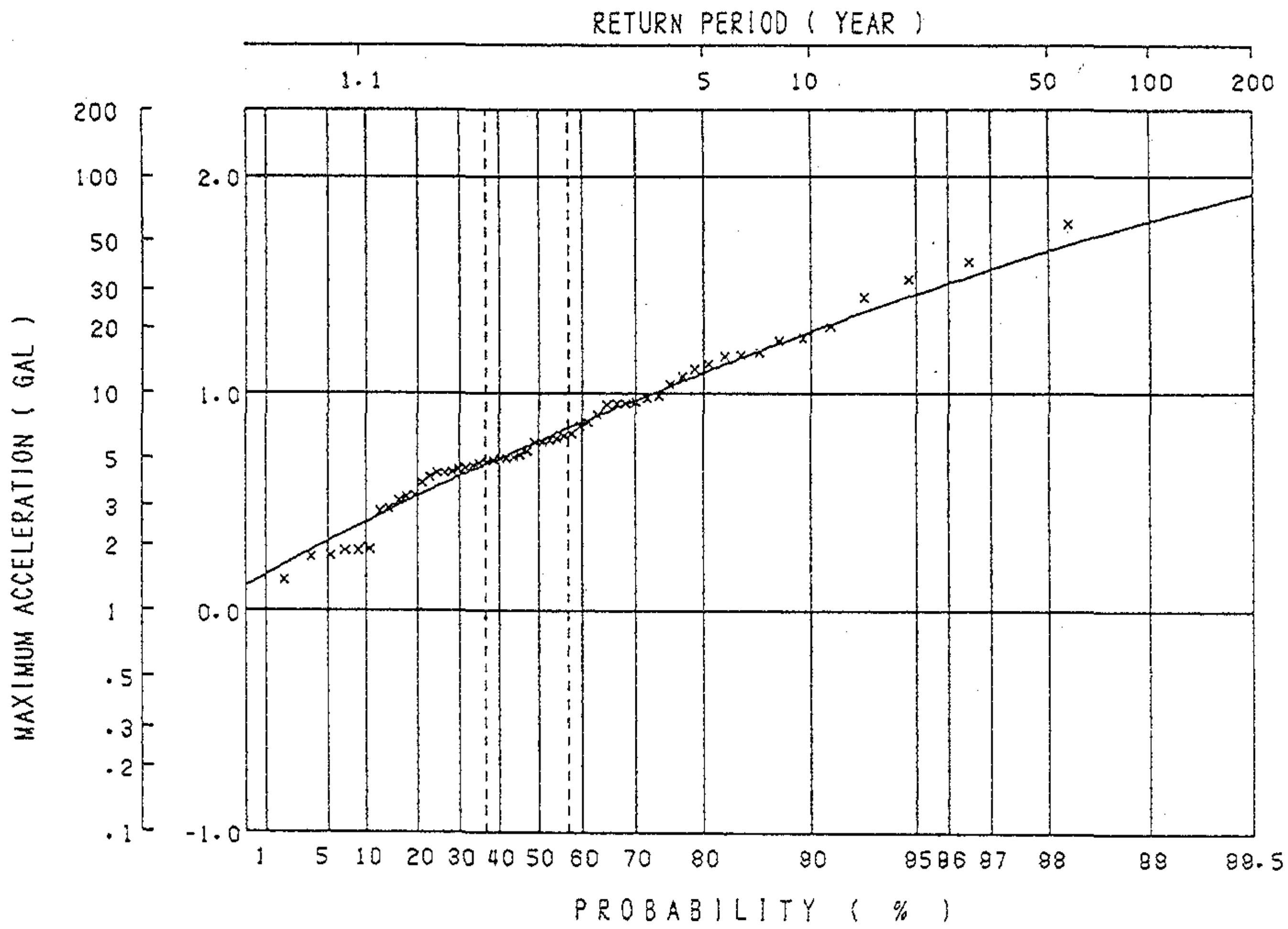
Distribution of the Maximum Accelerations derived from Eq.(2) by R.k.McGuire.

Fig.B-2



Distribution of the Maximum Accelerations derived from Eq.(3) by L.Esteva & E.Rosenblueth.

Fig.B-3



Distribution of the Maximum Accelerations derived from Eq.(4) by T.Katayama.

Fig.B-4

Table C-1

Distribution of Magnitude and Epicentral Distance of the Seismicity Data

	0 ≦ Δ < 50	< 100	< 200	< 300	< 400	< 500	< 600	< 700	< 800	≦ 1000	TOTAL
3.0 ≦ M < 3.5	0	0	0	1	0	0	1	0	1	0	3
< 4.0	0	1	4	3	8	15	17	21	32	50	151
< 4.5	1	6	35	45	74	86	80	61	67	177	632
< 5.0	4	11	36	52	116	136	124	67	78	134	758
< 5.5	3	1	21	25	56	71	76	43	30	90	416
< 6.0	2	0	8	11	21	13	19	6	8	19	107
< 6.5	0	2	5	5	9	18	9	10	8	21	87
< 7.0	0	0	1	7	11	13	12	3	3	12	62
< 7.5	0	0	0	1	0	2	3	0	1	5	12
< 8.0	0	0	0	0	2	0	0	0	0	0	2
TOTAL	10	21	110	150	297	354	341	211	228	508	2230

Δ : Epicentral Distance (Km)
M : Magnitude

Table C-2

Number of Earthquakes in a year during the period from 1925 to 1981

Year	N	Sum of N	Year	N	Sum of N
1925	1	1	1954	1	110
1926	1	2	1955	3	113
1927	1	3	1956	4	117
1928	5	8	1957	2	119
1929	1	9	1958	4	123
1930	1	10	1959	2	125
1931	4	14	1960	6	131
1932	5	19	1961	8	139
1933	10	29	1962	4	143
1934	3	32	1963	97	240
1935	6	38	1964	114	354
1936	4	42	1965	124	478
1937	8	50	1966	190	676
1938	2	52	1967	156	832
1939	9	61	1968	174	1006
1940	9	70	1969	145	1151
1941	3	73	1970	143	1294
1942	3	76	1971	95	1389
1943	5	81	1972	89	1478
1944	2	83	1973	98	1576
1945	1	84	1974	136	1712
1946	3	87	1975	78	1790
1947	2	89	1976	72	1862
1948	3	92	1977	76	1938
1949	2	94	1978	73	2011
1950	10	104	1979	91	2102
1951	1	105	1980	87	2189
1952	2	107	1981	41	2230
1953	2	109			

Table C-3

Maximum Accelerations during a year from 1925 to 1981

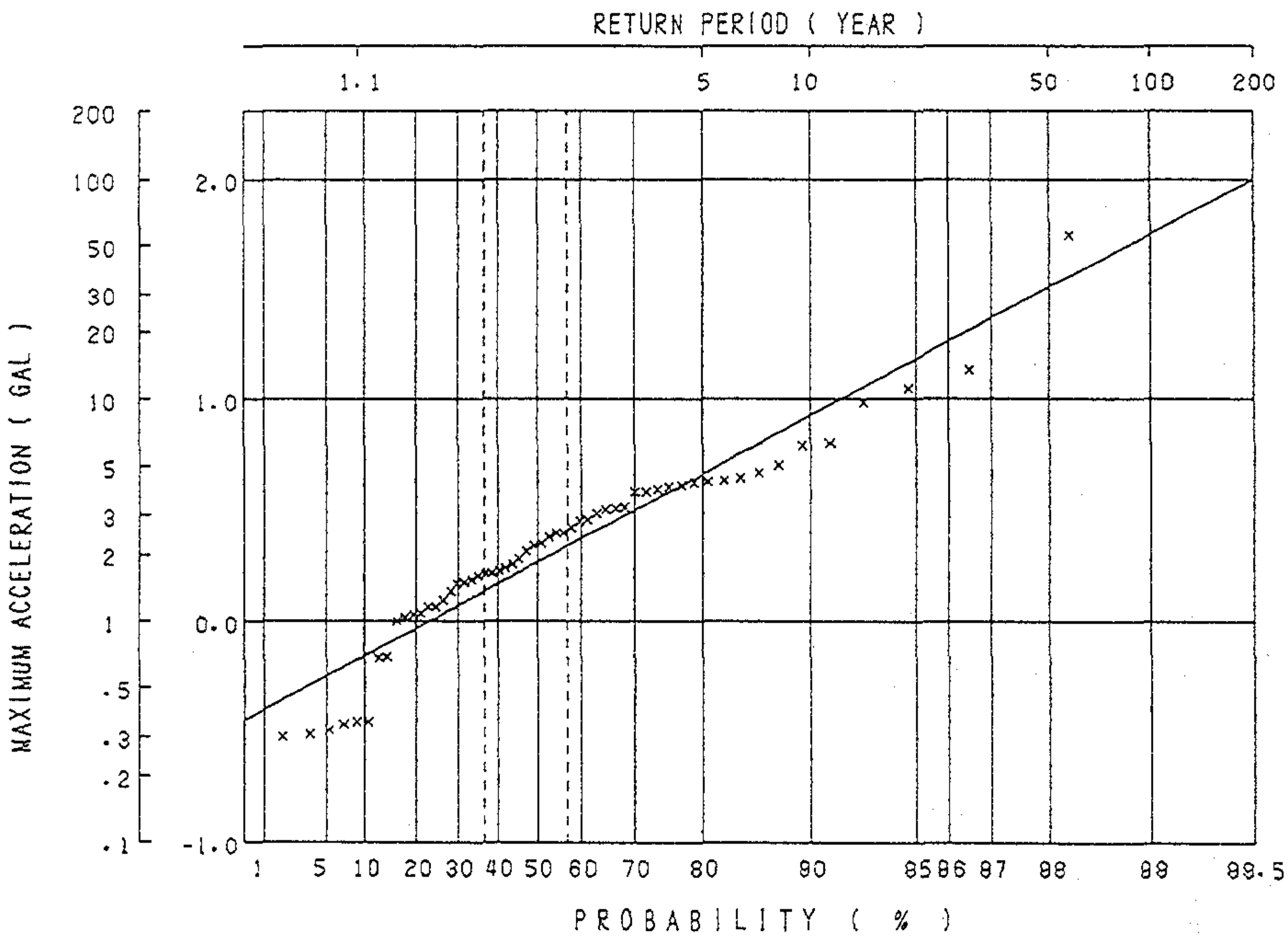
year	Oliveira,C Eq.(1)	McGuire,R.K. Eq.(2)	Esteva,L.& Rosenblueth,E. Eq.(3)	Katayama,T. Eq.(4)
1925	2.4	18.0	2.4	8.2
1926	0.3	4.8	0.4	1.6
1927	0.3	4.3	0.4	1.3
1928	1.0	10.8	1.2	4.5
1929	1.2	11.4	1.3	4.8
1930	0.3	5.1	0.5	1.7
1931	1.7	14.1	1.8	5.8
1932	1.8	15.0	1.9	6.6
1933	3.8	24.4	3.7	12.0
1934	0.3	4.8	0.4	1.7
1935	1.0	9.9	1.1	3.7
1936	0.7	7.6	0.8	2.7
1937	2.5	17.2	2.4	7.0
1938	0.3	5.0	0.5	1.6
1939	4.3	25.5	4.0	12.0
1940	5.1	29.0	4.7	17.8
1941	3.3	22.9	3.3	11.6
1942	4.3	30.6	4.6	19.4
1943	1.5	13.7	1.7	6.1
1944	1.1	11.2	1.3	4.8
1945	3.8	24.8	3.7	12.5
1946	4.4	27.8	4.3	14.8
1947	6.4	36.2	6.1	21.0
1948	3.2	22.5	3.2	11.3
1949	1.2	11.7	1.4	4.8
1950	2.8	20.9	2.9	10.3
1951	1.6	14.3	1.8	6.4
1952	1.1	11.1	1.3	4.8
1953	0.3	5.2	0.5	1.8
1954	0.3	5.0	0.5	1.7
1955	2.2	17.2	2.3	7.9
1956	1.4	12.5	1.5	5.2
1957	1.2	11.3	1.3	4.7
1958	9.7	44.6	8.6	25.1
1959	1.6	13.9	1.8	5.9
1960	2.1	16.9	2.2	8.0
1961	4.2	23.3	3.8	9.7
1962	0.7	8.1	0.9	3.1
1963	3.1	16.4	2.7	5.2
1964	4.7	21.8	4.1	7.5
1965	2.6	16.8	2.4	6.4
1966	1.9	12.0	1.7	3.8
1967	1.6	11.2	1.5	3.7
1968	3.9	19.6	3.5	6.6
1969	11.2	40.4	10.6	16.8
1970	2.5	15.1	2.2	5.0
1971	2.8	16.0	2.5	5.3
1972	1.7	12.4	1.6	4.3
1973	1.5	10.4	1.4	2.9
1974	3.2	20.3	3.0	8.6
1975	6.2	31.2	5.6	14.7
1976	13.5	51.6	12.0	27.0
1977	55.8	123.6	86.5	69.4
1978	1.5	10.7	1.4	3.3
1979	2.2	13.8	2.0	4.5
1980	4.0	21.1	3.6	7.9
1981	4.1	21.8	3.6	8.5

unit:gal

Table C-4

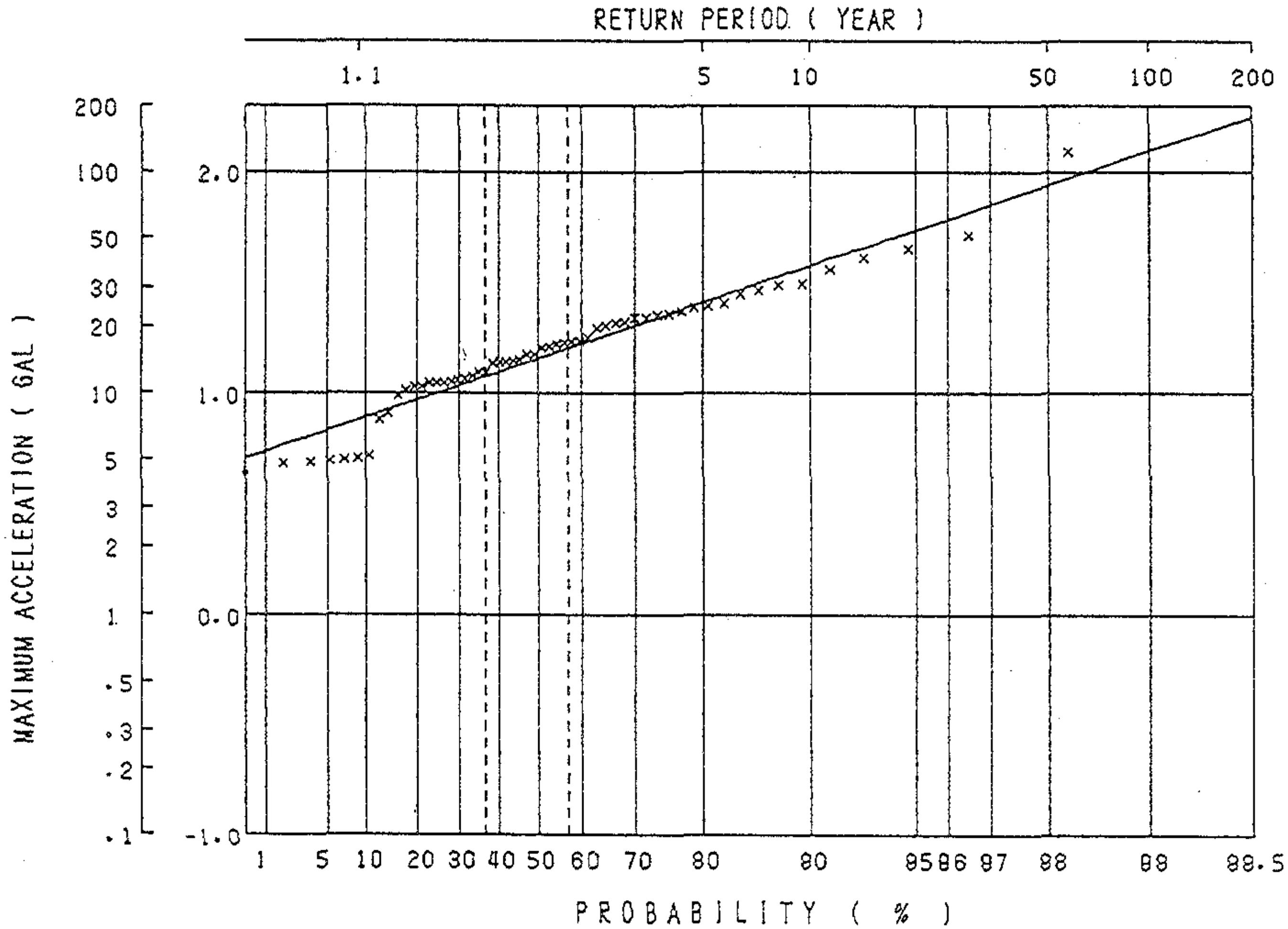
Maximum Accelerations for Three Return Periods (gal)

Model (Eq.No.)	Proposer(s)	Return Period, Tr (year)		
		50	100	200
(1)	C.Oliveira	32.1	56.4	98.8
(2)	R.K.McGuire	87.2	124.4	177.1
(3)	L.Esteva & E.Rosenbiueth	46.6	87.6	164.4
(4)	T.Katayama	47.2	69.6	101.7



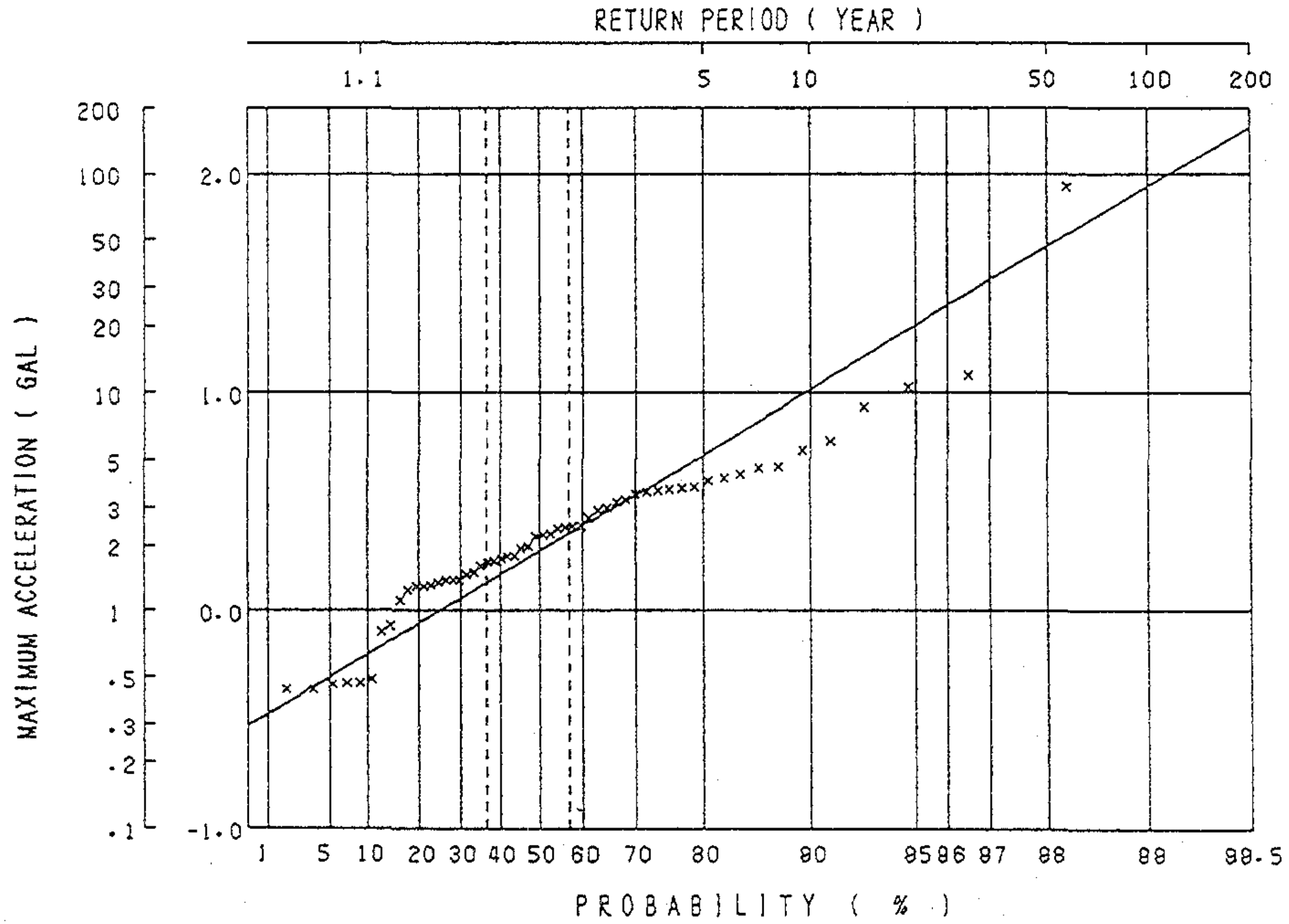
Distribution of the Maximum Accelerations derived from Eq.(1) by C.Oliveira.

Fig.C-1



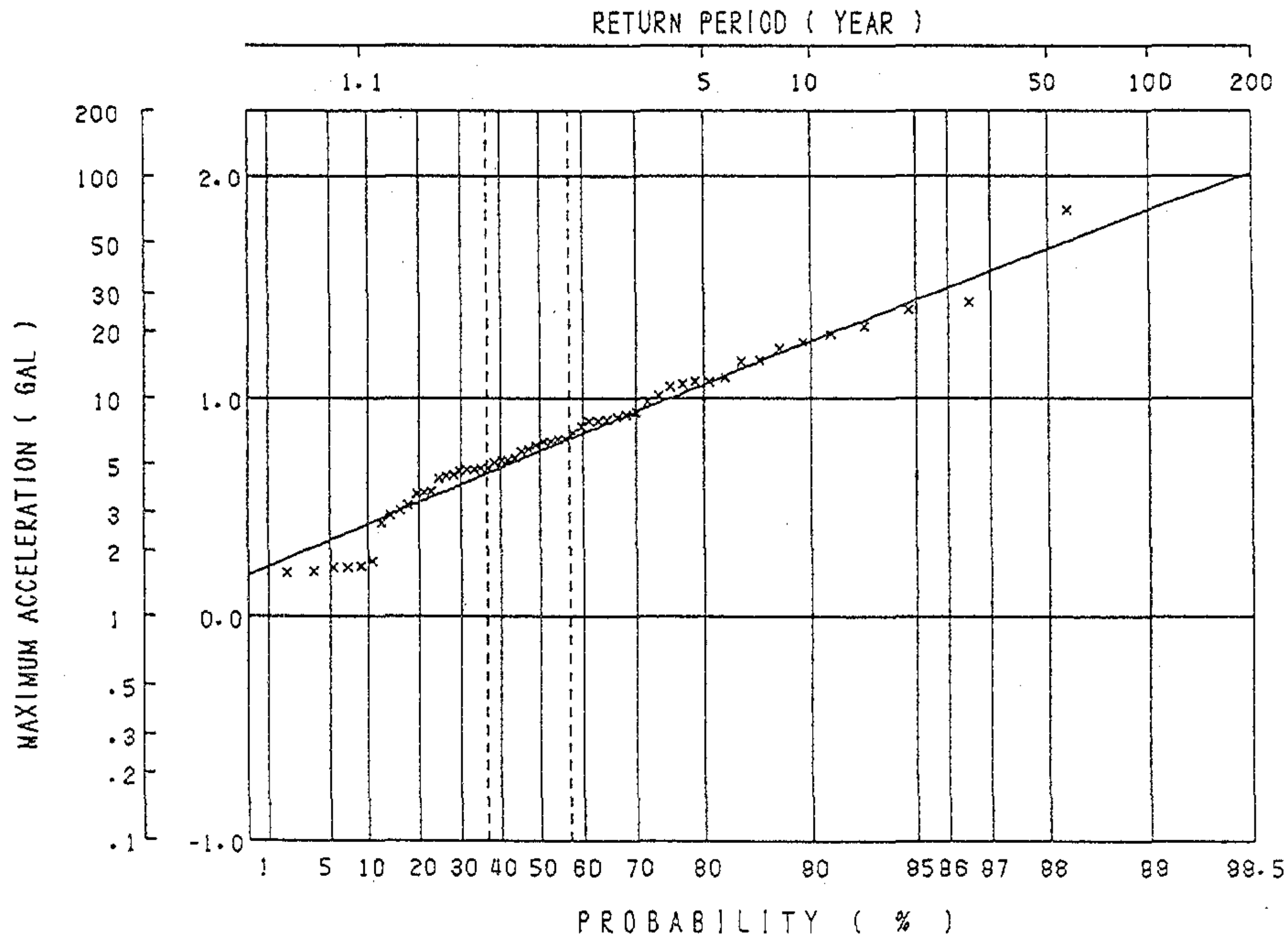
Disribution of the Maximum Accelerations derived from Eq.(2) by R.K.McGuire.

Fig.C-2



Distribution of the Maximum Accelerations derived from Eq.(3) by L.Esteva & E.Rosenblueth.

Fig.C-3



Distribution of the Maximum Accelerations derived from Eq.(4) by T.Katayama.

Fig.C-4

A-6. INVESTIGATION ON ENVIRONMENT

[1] Tables

[2] List of Collected Data

[1] Tables

[1] Tables

Table 1. Tree Species to be Protected for Ceasing to Exist

Name	Species Distributing in This Planned Area
1. palo de rosa	○
2. oje	○
3. leche caspi	○
4. quenoa	
5. quishvar	
6. ccasi	
7. las orquideas delas lomas	
8. paya o santon	
9. los fosiles vivientes	
10. los cactus del genero Oroya	

Table 2. The Reptiles Inhabiting in Planned Road Area of Central Selva Zone

Nº	Zoological Name (NOMBRE CIENTIFICO)	Popular Name (NOMBRE VULGAR)	Abundance (ABUNDANCIA)
	Orden Testudinata		
1	Geochelone denticulata (L.)	motelo	comun
2	Kinosternon scorpioides scorpioidea (L.)	mata mata	comun
3	Prodocnemis unifilis Troschel	taricaya	rara
	Orden Squamata		
	Fam. Boidae		
4	Eunectes murinus murinus (L.)	yacu mama	muy rara
5	Epicrates cenchria Stull	mantona	comun
6	Boa constrictor costrictor L.	boa	raro
	Fam. Crotalidae		
7	Bothrops atrox L.	jergon	comun
8	Bothrops bilineatus smaradinus Hoge	loro machaco	comun
9	Bothrops chloroelas Boul.	lamon	comun
10	Bothrops m. microphthalmus Cope	jergon pudridor	raro
11	Lachesis m. muta (L.)	shushupe	raro
	Fam. Elapidae		
12	Micrurus a. anellatus (Peters)	naka naka	raro
13	Micrurus lemniscatus helleri Schmidt y Schmidt	naka naka	raro
	Orden Crocodilia		
14	Caiman sclerops Schneider	lagarto blanco	raro
15	Melanosuchus niger (Spix)	lagarto negro	raro
	Fam. Iguanidea		
16	Iguana iguana (L.)	iguana	comun

FUENTE: Meneses (1974).

Table 3. Major Fishes Recorded in Tarma, Chanchamayo and Perene Rivers

N°	Zoological Nama (NOMBRE CIENTIFICO)	Popular Name (FAMILIA)	(NOMBRE VULGAR) Name of Family
1	Rhamdia quelen	Pimelodidae	"Bagre"
2	Rhamdia pentlandi	Pimelodidae	"Bagre"
3	Pseudodoras niger	Doradidae	"Dorado"
4	Pygidium oroyae	Pygididae	"Bagre"
5	Astroblepus sabalo	Astroblepidea	"Bagre"
6	Astroblepus praeliorum	Astroblepidae	"Bagre"
7	Ancistrus bufonius	Loricaridae	"Carachama"
8	Hemibrycon jolskii	Characidae	"Caracha"
9	Astyanax bimaculatus	Characidae	"Simiracu"
10	Astyanax maximus	Characidae	"Simiracu"
11	Ceratobranchia obtusirostris	Characidae	-
12	Bryconacidnus ellisis	Characidae	"Carachita"
13	Creagrutus peruanus	Characidae	"Ancho"
14	Salminus affinis	Characidae	"Salmon"
15	Prochilodus caudofasciotus	Prochilodontidae	Chupadora"
16	Prochilodus hemuralis	Prochilodontidae	"Chupadora"

FUENTE: Eigenmann y Allen (1942)
Fowler (1954)

NOTA: Confeccionado por el Dr. A. Tovar
(UNA)

Table 4. Wild Animals which Allowed for the Inhabitants to Hunt or Capture for Food

1	Venado rojo (Mazama americana)
2	Sajino (Tayassu tajacu)
3	Huangana (Tayassu albirostris)
4	Sachavaca (Tapirus terrestris)
5	Majaz opicuru (Caniclus paca)
6	Anuje O cutpes (Dasyprocta spp)
7	Machetero O pacarana (Dinomys branickii)
8	Ronsoco (Hudroschoeris hydrochaeris)
9	Corachupa O armadillo (Dasypus novmcinctus)
10	Paujiles (Mitu spp.)
11	Pacacunga (Nothocrax sp.)
12	Pavas de monte (Denelope spp. Ortalis spp.)
13	Perdices de Selva (Crypturelìu spp.)
14	Palomas de Selva (Columba spp.)
15	Motelos (Geochelones spp.)

Table 5. Valuable Animals etc. Forecasted to Inhabit in the Surroundings of Planned Area

N°		NOMBRE CIENTIFICO	NOMBRE VULGAR
	A.	Especies en vias de extincion	
1		Pteronura brasiliensis	lobo de rio
	B.	Especies en situacion vulnerable	
2		Ateles paniscus	maquisapa
3		Saimiri sciureus	fraila
4		Saguinus mystax	pichico
5		Cebus apella	machin negro
6		Cebus albifrons	machin blanco
7		Aotus trivirgatus	musmuqui
8		Pithecia monachus	huapo negro
9		Alouatta seniculus	coto
10		Cyclops didactylus	serafin
11		Tamandua tetradactyla	shihul
12		Myrmecophaga tridactyla	oso bandera
13		Priodontes giganteus	yaunguntu ro
14		Tremarctos ornatus	oso de anteojo
15		Felis pardalis	tigrillo
16		Leo onca	jaguar
17		Rupicola peruviana	gallito de roca
18		Melanosuchus niger	lagarto negro
19		Caiman sclerops	lagarto blanco
20		Podocnemis expansa	charapa
21		Podocnemis unifilis	taricaya
22		Eunectes murinus	yacu moma
23		Boa constrictor	boa
	C.	Especies en situacion rara	
24		Dinomys branickii	pacarana
	D.	Especies en situacion indeterminada	
25		Potos flavus	shosna
26		Felis wiedii	huaburusho
27		Felis yagouaroundi	anuje puma
28		Pudu mephistophiles	sacha cabra

FUENTE: Direccion General Forestal y de Fauna (1977)
Cuadros 10, 11 y 12.

NOTE:
- 1 - 16 the Mammalia
- 17 the Birds
- 18 - 23 the Reptiles
- 24 - 28 the Mammalia

Table 6. Production Volume of Lumber in Satipo Forest Area

(unit: m3)

Especie	1977	1978	1979	1980	1981	Total	%
Corriente			2,387	2,649	1,569	6,605	3
Abogue	56	19	108	111	48	342	ø
Cedro	387	382	653	1,860	2,529	5,811	2
Congona	941	675	1,231	2,110	2,418	7,375	3
Moena	9,015	8,946	11,725	12,455	11,167	53,308	20
Roble	15,695	18,169	25,314	30,202	24,623	114,003	43
Tornillo	8,892	10,955	11,649	13,172	12,431	57,099	22
Otros	4,237	4,413	1,621	905	7,558	18,734	7
Total	39,223	43,559	54,688	63,464	62,343	263,277	100

Source: Directorate General of Animals and Plants

Table 7. Appendix. Land Utilization of Rio Ene Indigene

(unit: ha)

Community	Land Area Registered as Grazing Land	Cultivated Land
Tres Unidos de Matereni	1,838.00	360.00
Shinpenchariato	153.13	32.00
Centro Tsomaveni	8,814.95	570.00
Saniveni	3,475.00	160.00
Unión Puerto Ashaninka	1,086.00	163.00
Quimaropitari	530.00	116.00
Camantavishi	4,547.97	683.00
Quempiri	9,408.00	1,412.00
Cutivireni	8,914.16	1,337.24
Potsoteni	5,026.00	268.00
Meteni	2,641.00	288.00
Quiteni	1,058.75	108.00
Total	47,492.96	5,497.24

FUENTE: Ministerio de Agricultura

[2] List of Collected Data

The collected data at this investigation on environment are as follows.

(1) Ley Forestal y de Fauna silvestre

(2) Reglamento de conservación de Flora y Fauna Silvestre

(3) Decreto Supremo No. 934-73-AG

(4) Resolución Ministerial No. 01710-77-AG

(5) Resolución Ministerial No. 5056-70-AG

(6) Reglamento de Ordenación Forestal

(7) Reglamento de Aprovechamiento Forestal en Bosques Nacionales

(8) Reglamento de Extracción y Transformación Forestal

(9) Reglamento de Unidades de Conservación

(10) Estudio de Factibilidad Técnico Económico de Extracción Forestal cuenca Hidrográfica RíoPerené

(11) Data related to the populations of Native and Immigrant

(12) Informe sobre la Carta de Petición Adicional del Estudio de Impacto Ambiental

(13) Mapa Forestal del Perú (Memoria Explicativa)

(14) Mapa Ecológico del Perú: 1976

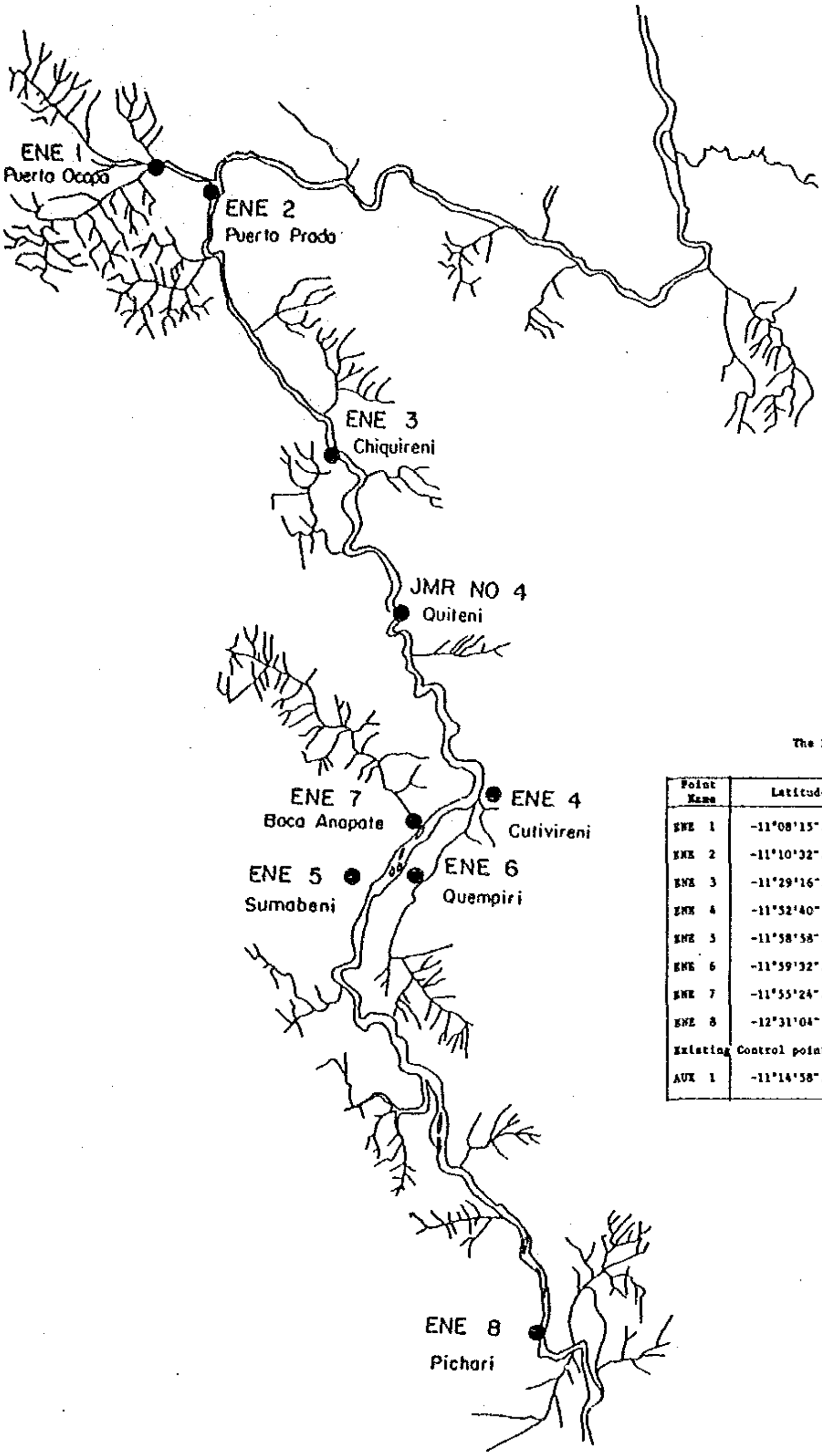
(15) Mapa Ecológico del Perú: 1976 (Escala; 1:1,000,000)

A-7. TOPOGRAPHICAL SURVEY

[1] Location of Control Points

[2] Index of Topographical Map

〔1〕 Location of Control Points

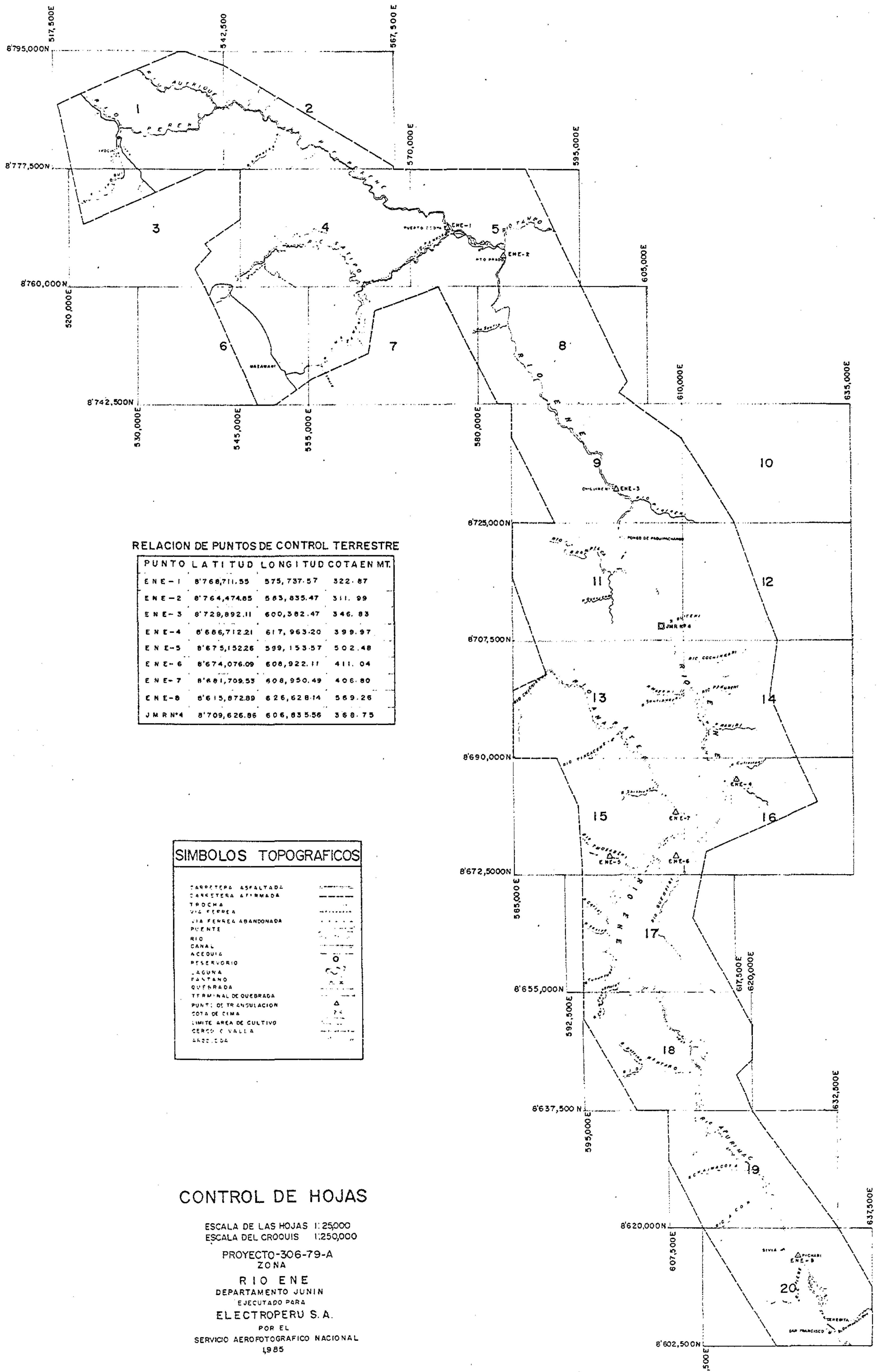


The Results of Control Point Surveying

Point Name	Latitude	Longitude	Altitude
ENE 1	-11°08'15".012	-74°18'23".156	322.87 m
ENE 2	-11°10'32".287	-74°13'55".847	311.99 m
ENE 3	-11°29'16".322	-74°04'46".718	346.83 m
ENE 4	-11°52'40".196	-73°55'02".041	399.97 m
ENE 5	-11°58'58".551	-74°05'21".435	502.48 m
ENE 6	-11°59'32".480	-73°59'58".337	411.04 m
ENE 7	-11°55'24".002	-73°59'58".312	406.80 m
ENE 8	-12°31'04".637	-73°50'04".632	369.26 m
Existing Control point used is as follows.			
AUX 1	-11°14'58".0552	-74°38'05".8367	637.25 m

Location of Control Points

〔2〕 Index of Topographical Map



RELACION DE PUNTOS DE CONTROL TERRESTRE

PUNTO	LATITUD	LONGITUD	COTA EN MT.
ENE-1	8'768,711.55	575,737.57	322.87
ENE-2	8'764,474.65	563,835.47	311.99
ENE-3	8'729,892.11	600,382.47	346.83
ENE-4	8'686,712.21	617,963.20	399.97
ENE-5	8'675,152.26	599,153.57	502.48
ENE-6	8'674,076.09	608,922.11	411.04
ENE-7	8'681,709.53	608,950.49	406.80
ENE-8	8'615,872.89	626,628.14	569.26
JMR Nº4	8'709,626.86	606,835.56	368.75

SIMBOLOS TOPOGRAFICOS

- CARRETERA ASFALTADA
- CARRETERA AFIRMADA
- TROCHA
- VIA FERREA
- VIA FERREA ABANDONADA
- PUENTE
- RIO
- CANAL
- ACEQUIA
- RESERVORIO
- LAGUNA
- PANTANO
- QUEBRADA
- TERMINAL DE QUEBRADA
- PUNTO DE TRIANGULACION
- COTA DE CIMA
- LIMITE AREA DE CULTIVO
- CERCO O VALLA
- ARBOLEDA

CONTROL DE HOJAS

ESCALA DE LAS HOJAS 1:25,000
ESCALA DEL CROQUIS 1:250,000

PROYECTO-306-79-A
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EJECUTADO PARA
ELECTROPERU S.A.
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1985