Fig. II.3.1 Drill Logs (Present Investigation) 8/12

DRILL LOG

HOLE NO. 93-6 SHEET NO. 2 OF 2 (30~40m)

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)			DEPTH	40 m	ELEVATION	193.78 m
SITE	Penstock Line (alternative)	COORDINATE	: :	INCLINATION	-90°	DRILL RIG	
AVERAGE CORE RECOVERY	100%	DATE	FROM 11. Jun TO 30. Jun '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	BIT & DIAMETER	Rock Class	CORE RECOVERY RQD %	Lugeon Value (Lu) 0 10 20 30 40 50	DEPTH
	30		CAMPO ALEGRE FORMATION (ITAJAI GROUP)		Continue from sheet 1		CH H2A2 F2S2			30
	31		Calcite Vein		20° ~ 40°		CM			1
	32				Fresh Rhyolite interbedded dark grey rhyolite (diabase)		CH-B			2
	33						H2A1 F2HV S2			3
	34		Rhyolite interbedded		Hard enough.					4
	35				Joint interval 30 to 50 cm		CM H2A2 F3S3			5
	36		With Diabase		Open cracks a few.		CH-B			6
	37		SAMPLE No Tunl 6		Calcite veins in some places.		H2A1 F2HV S2			7
	38				350~360					8
	39				Horizontal joint 5cm interval.		CH H2A2 F2S2			9
	40 40.0	153.78	Hole Bottom			No GWL				40

HOLE NO.

LOG FORM-8

*R.Q.D is Rock Quality Designation. R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) × 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 9/12

DRILL LOG

HOLE NO. 93-7 SHEET NO. 1 OF 1

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)			DEPTH	20m	ELEVATION	119.69m
SITE	Power House (Downstream)	COORDINATE	: :	INCLINATION	-90m	DRILL RIG	
AVERAGE CORE RECOVERY	100%	DATE	FROM 30. May TO 12. May '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION		COLUMN SECTION	DESCRIPTION	BIT & DIAMETER	Rock Class	CORE RECOVERY RQD %	Lugeon Value (Lu) 0 10 20 30 40 50	DEPTH
				Alluvial Soil		0.0 ~ 12.0 Alluvial Soil. Mainly Clay in grain size. Soft and loose. 1.1 ~ 2.6 Granite block Rolling Stone.	GWL -11.5				
	12.0	107.69	CAMPO ALEGRE FORMATION	Diabase		12.0 ~ 20.0 Diabase or Rhyodacite Part of Rhyolite. Hard enough.	CL	CL H3A2 F4S4			
	13.0	106.69				Joints develop at interval of 5-10cm. Cracky.	CH	CH H2A2 F3SV S3			
						12.0 - 13.0 Cracky.	CM	CM			
						13.7, 13.9 Joint 60° dip 15.0 Vertical joint open	CH	CH H2A2 F3SV S3			
	20.0	99.69				17.5, 18.4, 19.7 Slanting joint 50-60° dip.	CM	CM H2A2 F3SV S4			

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation. R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 10/12

DRILL LOG

HOLE NO. 93-8-1 SHEET NO. 1 OF 1

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)			DEPTH	25 m	ELEVATION	360.0 m
SITE	Quarry Site (Upstream)	COORDINATE	: :	INCLINATION	-90°	DRILL RIG	
AVERAGE CORE RECOVERY	100%	DATE	FROM 15. Jul TO 27. Jul '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	BIT DIAMETER	Rock Class	CORE RECOVERY / RQD %	Lugeon Value (Lu) 0 10 20 30 40 50
	0.4	359.6			0.0 ~ 0.4 Top Soil				
	25.0	335.0	SUBIDA FORMATION Granite	+ +	0.4 ~ 25.0 Granite Kalifelsper rich. Pink and rosy colour is shown. Medium in grain size. Massive, joint interval 3 to 5m. Closed and tight in joint condition. Open cracks are litle. Very hard. Rarely cracked.	GWL -1.8	A (H1 A1 F1 S1)		

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation. R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Rock Class ( ) Brasil Standard

Fig. II.3.1 Drill Logs (Present Investigation) 10/12

DRILL LOG

HOLE NO. 93-8-2 SHEET NO. 1 OF 1

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)				DEPTH	20 m	ELEVATION	384.0 m
SITE	Quarry (Downstream)	COORDINATE	: :		INCLINATION	-90°	DRILL RIG	
AVERAGE CORE RECOVERY	100%	DATE	FROM 24 Jun TO 15 Jul '93		DRILLED	J. Arvez	LOGGED	S. Ikeda

DATE	DEPTH	ELEVATION	ROCK TYPE OR FORMATION	COLUMN SECTION	DESCRIPTION	BIT & DIAMETER	Rock Class	CORE RECOVERY / RQD % / cm	Lugeon Value (Lu) 0 10 20 30 40 50	DEPTH
	0–20		Clayey Soil		0° ~ 20° Clayey Soil. Granite origin. Heavily weathered completely decomposed and altered into soil. Below 15m. Rock texture can be seen, but very loose as a result soil.		Soil			
	20.20°	364°				No GWL				20

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation, R.Q.D=(Total length of cylindric cores longer than 10 cm)/(Total core length) x 100%
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

Fig. II.3.1 Drill Logs (Present Investigation) 12/12

DRILL LOG

HOLE NO. 93-8-3 SHEET NO. 1 OF 1

PROJECT	Salto Pilão Hydroelectric Power Development Project (Brazil)	DEPTH	25m	ELEVATION	306.0 m
SITE	Quarry (Downstream) COORDINATE : :	INCLINATION	-90°	DRILL RIG	
AVERAGE CORE RECOVERY	100% DATE FROM 17. Jul TO 26. Jul '93	DRILLED	J. Arvez	LOGGED	S. Ikeda

DEPTH	ELEVATION	ROCK TYPE OR FORMATION	DESCRIPTION	BIT & DIAMETER	Rock Class
5.8	300.2	Clay	$0^{0} \sim 5^{8}$ Clay. Weathered and altered soil. Granite origin.		
8.9	297.1	Granite Block	$5^{8} \sim 8^{9}$ Granite block.		B (H1A1 F1S1)
16.7	289.3	Clayey Soil	$8^{9} \sim 16^{7}$ Clayey Soil. Decomposed granite. Rock texture can be seen. Very loose and soft.		
25.0	281.0	Granite	$16^{7} \sim 25^{0}$ Granite. Massive rock. Hard. Joint space 3 to 5m.	No GWL	B (H1A1 F1S1)

FORMATION: SUBIDA FORMATION

CORE RECOVERY: RQD % / cr

Lugeon Value (Lu): 0 10 20 30 40 50

HOLE NO.

LOG FORM-B

*R.Q.D is Rock Quality Designation, R.Q.D = (Total length of cylindric cores longer than 10 cm)/(Total core length) × 100% Rock class ( ) Brasil Standard
*LUGEON VALUE is l/min/m under injection water pressure of 10kg/cm²
*DEPTH and ELEVATION are in meter
*DIAMETER is in millimeter

PLATE XII E-4

DRILL HOLE Nº 1

LENGTH: 20.30 COORDINATES: ______
ANGLE: Vertical GROUND ELEVATION: 334.8

Elevation / depth of hole: 331.8 / 2.80; 323.3 / 11.30; 319.3 / 15.00; 314.3 / 20.30

Depth	Classification and physical condition	% core recovery	Pressure Kg/Cm²	Water loss L/Min/M
0 - 2.80	Soil (sandy, silty clay)			
2.80 - 11.30	Decomposed granite. Hard and soft decomposed portions with hard, loose boulders.	35%, 0%, 6%		
11.30 - 20.30	Granite (massive medium grained, hard). Small localised decomposed stretches at 12.00, 13.22-13.37, 13.50-13.83 and 18.45. Rock is fairly intact after 15.00. Total loss of water reported at 18.53.	63%, 70%, 100%, 85%, 88%	0 / 2 / 5 / 2 / 0	8.0 / 13.8 / 20.8 / 9.0 / 7.5
			0 / 2 / 5 / 2 / 0	6.3 / 10.0 / 15.0 / 10.0 / 6.2

DRILL HOLE Nº 2

LENGTH: 78.00 COORDINATES: ______
ANGLE: 30° (from vertical) GROUND ELEVATION: 338.7

Elevation / depth of hole: 318.3 / 20.25; 373.0 / 23.30; 310.8 / 26.45; 385.4 / 32.86; 303.0 / 35.49; 300.3 / 37.80; 358.1 / 38.84; 335.9 / 43.02; 48.00

Depth	Classification and physical condition	% core recovery	Pressure Kg/Cm²	Water loss L/Min/M
0.0 - 20.25	Overburden (soil and soft and hard decomposed basalt)			
20.25 - 74.50	Granite (massive, medium grained type). Shows slight decomposition and alteration. Both regular and irregular fracturing with generally little or no infilling material. Many slip plane surfaces.	80%	0 / 5 / 10 / 5 / 0	0 / 3.0 / 1.1 / 0.8 / 0
		70%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 1.1 / 0 / 0
20.25 - 23.30	11 regular joints at 75-80° to core axis. Open, slightly stained with light coating of decomposed material. 2 joints parallel to core axis with smooth slip (slickensided) surfaces	88%	0 / 5 / 10 / 5 / 0	0.06 / 0.8 / 1.1 / 0.7 / 0
23.30 - 26.45	18 joints at 75-85° to axis, all slightly stained. 1 slip joint at 30° to core axis. Rock is hard but shows slight alteration and decomposition. Low recovery.		0 / 5 / 10 / 5 / 0	0 / 3.5 / 1.0 / 0.3 / 0
26.45 - 32.84	26 joints at 50-85° to core axis. Open or loosely sealed and with stained surfaces. 2 slip joints and smooth surfaces at 27.00 and 29.50. Several irregular sealed fractures. Lower limit of most of stained joints.	6%, 80%	0 / 5 / 10 / 5 / 0	0 / 0.8 / 0.8 / 1.1 / 0
			0 / 5 / 10 / 5 / 0	0 / 0.3 / 1.3 / 0.3 / 0
32.84 - 35.49	Only core fragments recovered. Grinding of core accounts for a portion of core loss; remainder, uncertain.	30%	0 / 5 / 10 / 5 / 0	0 / 0.5 / 1.0 / 0.3 / 0
35.49 - 37.90	At 38.00 a slip joint at 30° to core axis with rock gouge hardened on the surface. One slip perpendicular to axis.	100%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 1.0 / 0.3 / 0
37.90 - 39.84	Low recovery. Core size reduced at 37.90. 8 joints at 75°, open and very slightly stained. Much grinding of core.	100%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 1.4 / 0.7 / 0

DRILL HOLE Nº 2 (continued)

LENGTH: 75.95 COORDINATES: ______
ANGLE: 30° (from vertical) GROUND ELEVATION: 338.7

Elevation / depth of hole: 49.00; 348.3 / 51.50; 341.0 / 53.88; 341.3 / 60.17; 337.9 / 64.72; 334.3 / 88.42; 328.0 / 74.50; 75.95

Depth	Classification and physical condition	% core recovery	Pressure Kg/Cm²	Water loss L/Min/M
39.84 - 43.82	13 joints at varying angles. Rock is less fractured.	30%, 65%	0 / 5 / 10 / 5 / 0	0 / 0.8 / 0.3 / 0.3 / 0
43.82 - 51.50	18 joints at angles varying from 45-80° to core axis (7 show slip surfaces). Loosely sealed. 6 irregular hairline fractures, sealed	48%	0 / 5 / 10 / 5 / 0	0 / 1.1 / 3.0 / 0.8 / 0
51.50 - 53.88	Only core fragments recovered; some show slip surfaces and pervasive rock decomposition. Shear or fracture zone?	33%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 1.1 / 0.3 / 0
53.88 - 60.17	Decomposed, broken core. 9 joints at varying angles, some slip surfaces	41%	0 / 5 / 10 / 5 / 0	0 / 0.4 / 1.2 / 0.3 / 0
60.17 - 64.72	Rock improving, less fractured but still altered and decomposed. 2 stained open joints at 35° to core axis. 3 open or loosely sealed, not stained at 25°-40°.	87%, 38%, 93%, 23%	0 / 5 / 10 / 5 / 0	0 / 0.5 / 1.2 / 0.5 / 0
64.72 - 65.42	Small solution pits with local decomposition of rock. 3 open, loosely bonded joints.	88%	0 / 5 / 10 / 5 / 0	0 / 0.1 / 0.3 / 0 / 0
65.42 - 88.42	Improved core; less fractured and less altered. 1 open, stained joint at 20° to core at 88.42. 1 at 30° to core open and unstained.	88%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 1.0 / 0.3 / 0
88.42 - 69.20	Only core fragments recovered (probably due to small core diameter).	30%	0 / 5 / 10 / 5 / 0	0 / 0.8 / 1.2 / 0.3 / 0
69.20 - 74.50	5 joints at 70-75°. 2 are open and stained. Grinding of core	16%	0 / 5 / 10 / 5 / 0	0 / 0.4 / 1.0 / 0.3 / 0
74.50 -	DRILL HEAD LOST			

DRILL HOLE Nº 3

LENGTH: 60.00 COORDINATES: ______
ANGLE: Vertical GROUND ELEVATION: 138.0

Elevation / depth of hole: 135.6 / 1.35; 134.0 / 2.00; 148.0 / 10.00; 143.1 / 13.00; 120.9 / 27.00; 128.0 / 28.90; 125.1 / 31.77; 123.5 / 33.18; 123.0 / 33.85; 115.9 / 41.00; 115.1 / 42.80; 48.00

Depth	Classification and physical condition	% core recovery	Pressure Kg/Cm²	Water loss L/Min/M
0.0 - 1.35	Soil.			
1.35 - 2.00	Boulder.			
2.00 - 10.00	Soil grading into soft decomposed rock.	1.5%		
10 - 13.00	Boulder fragments.	20%		
13.00 - 27.00	'Chipped' core? Only coarse, angular sand-like rock fragments recovered. Probably well fractured rock mechanically broken by sidia bit. Bedrock surface may be at 13.00.	0%		
27.00 - 28.90	Stained core fragments of hard decomposed rock. Absolutely certain bedrock surface at 28.90.	11%		
28.90 - 31.77	Diorite dike? Hard, massive, fine to medium grained rock. Contains disseminated pyrite. 7 stained joints open, at 15-45° to core axis.	59%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.9 / 0.3 / 0
31.77 - 58.35	Granodiorite. Massive fine to medium grained with many dark inclusions in a pinkish groundmass. Hard to slightly brittle.	0%, 100%, 46%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.8 / 0.3 / 0
31.77 - 33.48	Core is well fractured. Many irregular sealed joints parallel to core axis. 7 joints, open and stained at angles varying from 15-75° to axis.	31%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.8 / 0.3 / 0
33.48 - 33.85	Core reported destroyed by driller.	18%	0 / 5 / 10 / 5 / 0	0 / 0.5 / 0.9 / 0.4 / 0
33.85 - 41.00	3 open or loosely sealed stained joints parallel to core (probably reason for low recovery). 10 joints at varying angles, most are open or loosely bonded.	99%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.6 / 0.7 / 0
41.00 - 42.80	Core fragments with much associated calcite			

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DRILL HOLE Nº 3 (cont.)

LENGTH: 60.00 COORDINATES: ______
ANGLE: Vertical GROUND ELEVATION: 150.0

Elevation / depth of hole: 49.00; 90.8 / 57.05; 98.8 / 58.35; 95.8 / 60.00

Depth	Classification and physical condition	% core recovery	Pressure Kg/Cm²	Water loss L/Min/M
42.80 - 57.05	Good hard, massive granodiorite, well spaced joints. 8 open, clean surface joints except at 49.80 which is stained.	59%, 100%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.8 / 0.3 / 0
57.05 - 58.35	Calcite infilled, sealed sheared (slickensided), fractures. Pyrite.	95%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.4 / 0.2 / 0
58.35 - 60.00	Dikelets of pink granodiorite (?), in black grey, sedimentary looking rock. Possible contact zone.	40%, 100%	0 / 5 / 10 / 5 / 0	0 / 0.3 / 0.7 / 0.2 / 0

REFERENCE:

For Drill Holes location see Plate XII E-2

NOTES:

1 - Elevation Datum SSE (=CNG)
2 - All figures indicating depth of Holes are in meters.

REPUBLIC OF BRAZIL
UNITED NATIONS DEVELOPMENT PROGRAMME

POWER STUDY OF SOUTH BRAZIL

URUGUAI BASIN — CANOAS DIVERSION

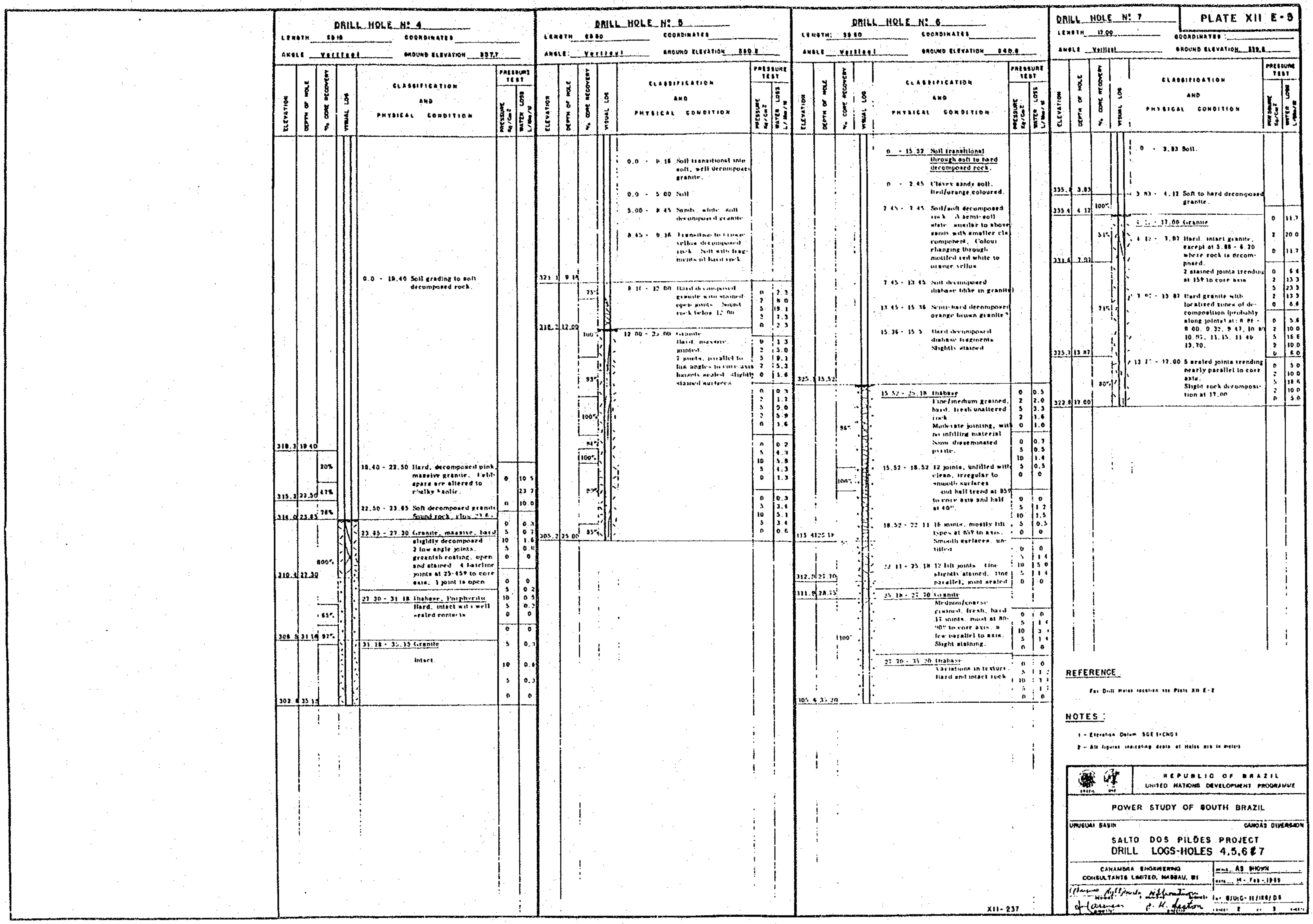
SALTO DOS PILÕES PROJECT
DRILL LOGS - HOLES 1, 2 & 3

CANAMBRA ENGINEERING CONSULTANTS LIMITED, NASSAU, BI

Scale: AS SHOWN
Date: 14 - Feb - 1969
No.: UHC-R 028/04
Sheet 1 of 3

JAPAN INTERNATIONAL COOPERATION AGENCY
CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL
SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

Fig. II.3.2
Drill Logs (by Canambra E.C.) 1/3



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. II.3.2 Drill Logs (by Canambra E.C.) 2/3

PLATE XII E - 6

DRILL HOLE Nº 8

LENGTH: 75.01 COORDINATES: ______

ANGLE: 30° (from vertical) GROUND ELEVATION: 210.0

Elevation	Depth of hole	% Core recovery	Classification and physical condition
		83%	0.0 - 75.00 Granodiorite or rhyodacite. Fine grained, massive, hard varying to brittle. Highly jointed, with stained surfaces. Contains many inclusions sealed within the rock mass, otherwise fairly homogeneous.
		100%	0 - 4.73 88 joints, most trend at 40° and remainder at 35 - 60° to core axis (interpreted as horizontal joints). About 1/2 are open, stained. No introduced material only decomposition products on joint planes.
205.8	4.73		4.73 - 5.84 10 joints, stained. Sound rock after 5.84.
205.2	5.84	92%	5.84 - 11.18 33 joints, all stained, 2/3 are open, no infilling material. Trend averages 40 - 60°
201.6	11.18		11.18 - 14.13 15 joints mostly at 55° to core axis. Faces are smoother than before.
199.2	14.13	100%	14.13 - 22.00 22 joints, smooth faces clean and unstained
192.8	22.00	97% / 100%	22.00 - 35.20 11 joints, smooth faced 4 are slightly stained.
181.1	35.20	94%	35.20 - 38.25 Diorite dike.
181.0	36.25	100%	36.25 - 50.00 21 joints at 80 - 70°. Most are open.
178.6	38.00	73% / 100%	
173.1	48.00		

Pressure test (Pressure kg/cm² – Water loss L/min/m), in order down the hole:
0 – 0.3; 2 – 0.8; 0 – 0.3; 0 – 0; 2 – 0; 0 – 0 |
0 – 0, 2 – 0, 5 – 0.2, 2 – 0, 0 – 0 |
0 – 0, 2 – 0.2, 5 – 0.8, 2 – 0.3, 0 – 0 |
0 – 0, 5 – 0.3, 10 – 0.3, 5 – 0.3, 0 – 0 |
0 – 0, 5 – 0, 10 – 0.3, 5 – 0, 0 – 0 |
0 – 0, 5 – 0.1, 10 – 0.3, 5 – 0.2, 0 – 0 |
0 – 0, 5 – 0, 10 – 0.2, 5 – 0, 0 – 0 |
0 – 0, 5 – 0.1, 10 – 0.3, 5 – 0.1, 0 – 0 |
0 – 0, 5 – 0.1, 10 – 0.3, 5 – 0.1, 0 – 0 |
0 – 0, 5 – 0.1, 10 – 0.3, 5 – 0.1, 0 – 0 |
0 – 0, 5 – 0.3, 10 – 0.4, 5 – 0.3, 0 – 0 |
0 – 0, 5 – 0.2, 10 – 0.3, 5 – 0.1, 0 – 0 |
0 – 0, 5 – 0.3, 10 – 0.4, 5 – 0.3, 0 – 0

DRILL HOLE Nº 8 (continued)

LENGTH: 75.01 meters COORDINATES: ______

ANGLE: 30° (from vertical) GROUND ELEVATION: 210.0

Elevation	Depth of hole	% Core recovery	Classification and physical condition
173.1	48.00	100% / 93%	50.00 - 60.00 22 joints. Some with slight staining. Stains and massive pyrite 57.10.
		100% / 85% / 95%	60.00 - 75.01 Rock in good condition, only slightly jointed.
159.7	75.00		

Pressure test (Pressure kg/cm² – Water loss L/min/m):
0 – 0, 5 – 0.2, 10 – 0.4, 5 – 0.3, 0 – 0 |
0 – 0, 5 – 0, 10 – 0.3, 5 – 0, 0 – 0 |
0 – 0, 5 – 0.3, 10 – 0.3, 5 – 0.3, 0 – 0 |
0 – 0, 5 – 0.3, 10 – 0.6, 5 – 0.3, 0 – 0 |
0 – 0, 5 – 0.2, 10 – 0.5, 5 – 0.3, 0 – 0 |
0 – 0, 5 – 0, 10 – 0.3, 5 – 0.08, 0 – 0 |
0 – 0, 5 – 0.1, 10 – 0.3, 5 – 0.08, 0 – 0 |
0 – 0, 5 – 0, 10 – 0.1, 5 – 0, 0 – 0 |
0 – 0, 5 – 0, 10 – 0.3, 5 – 0.1, 0 – 0

DRILL HOLE Nº 9

LENGTH: 60.00 meters COORDINATES: ______

ANGLE: 30° (from vertical) GROUND ELEVATION: 348.2

Elevation	Depth of hole	% Core recovery	Classification and physical condition
		0%	0 - 13.10 Overburden.
			0 - 11.00 Mostly boulders of diabase and granite.
339.8	10.50		11.00 - 12.00 Residual soil
339.2	11.07	83.3%	12.00 - 13.10 Hard, decomposed to well fractured granite. Stained core fragments. Bedrock surface approx at 13.10.
338.3	12.00	0%	
337.3	13.10	34.5%	13.10 - 13.70 Granite. Stained joints
336.8	13.70	100%	13.70 - 16.00 Diabase. Hard, fresh. 12 joints at 75° to core axis; 5 are open, stained.
334.8	16.00	91% / 99%	16.00 - 31.80 Porphyritic Granite. Hard-brittle; fresh, very compact, crystalline rock. Moderately jointed. 27 joints at varying angles, with slight greenish coating.
318.5	34.80	98.5%	34.80 - 36.55 Diabase. Relatively intact.
317.7	36.55	98.5%	36.55 - 37.80 Porphyritic Granite.
315.9	37.80	100%	37.80 - 40.60 Diabase.
313.6	40.60	79%	40.60 - 43.80 Granite. As above, moderate jointing
310.6	43.80	98%	43.80 - 48.85 Diabase.

Pressure test (Pressure kg/cm² – Water loss L/min/m):
0 – 2.3, 2 – 5.0, 5 – 10.0, 2 – 5.0, 0 – 2.3 |
0 – 1.8, 2 – 2.6, 5 – 4.0, 2 – 2.5, 0 – 1.3 |
0 – 1.6, 5 – 3.0, 10 – 5.0, 5 – 3.0, 0 – 1.3 |
0 – -, 5 – -, 10 – -, 5 – -, 0 – - |
0 – 0.07, 5 – 0.7, 10 – 0.8, 5 – 0.3, 0 – 0.01 |
0 – 0.01, 5 – 0.1, 10 – 0.5, 5 – 0.1, 0 – 0

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DRILL HOLE Nº 9

LENGTH: 60.00 meters COORDINATES: ______

ANGLE: 30° (from vertical) GROUND ELEVATION: ______

Elevation	Depth of hole	% Core recovery	Classification and physical condition
305.4	48.85	90%	48.85 - 55.23 Granite. Slightly blocky core. Joints are clean with no introduced material. Some grinding of core.
300.6	55.23		55.23 - 60.00 Diabase.
298.5	60.00		

Pressure test (Pressure kg/cm² – Water loss L/min/m):
0 – -, 5 – -, 10 – 0.05, 5 – -, 0 – - |
0 – 0.01, 5 – -, 10 – 0.02, 5 – -, 0 – -

REFERENCE:

For Drill Holes location see Plate XII E-2

NOTES:

1 - Elevation Datum SGE (+CNE)

2 - All figures indicating depth of Holes are in meters

REPUBLIC OF BRAZIL
UNITED NATIONS DEVELOPMENT PROGRAMME

POWER STUDY OF SOUTH BRAZIL

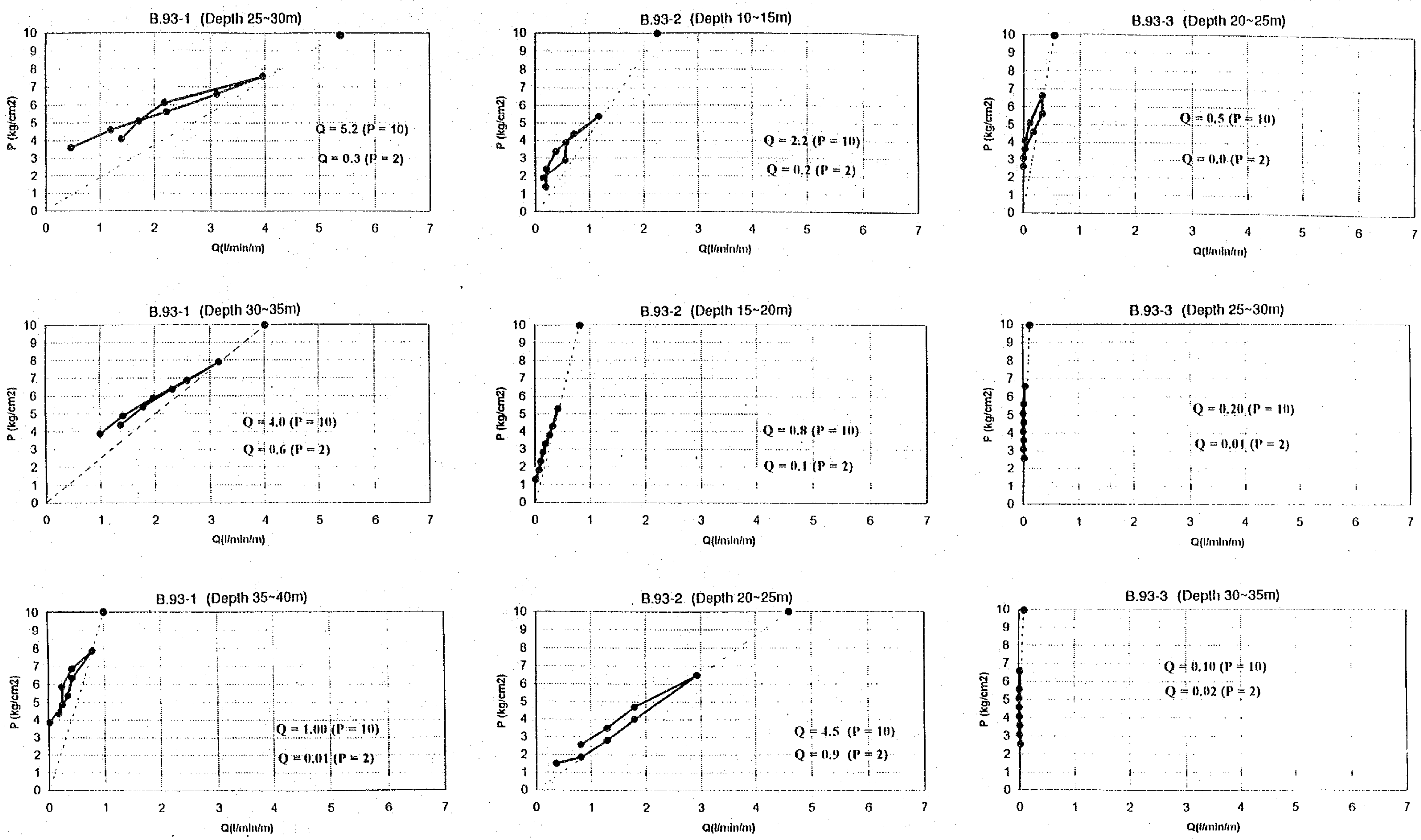
URUGUAI BASIN — CANOAS DIVERSION

SALTO DOS PILÕES PROJECT
DRILL LOGS - HOLES 8 & 9

CANAMBRA ENGINEERING CONSULTANTS LIMITED, NASSAU, BI

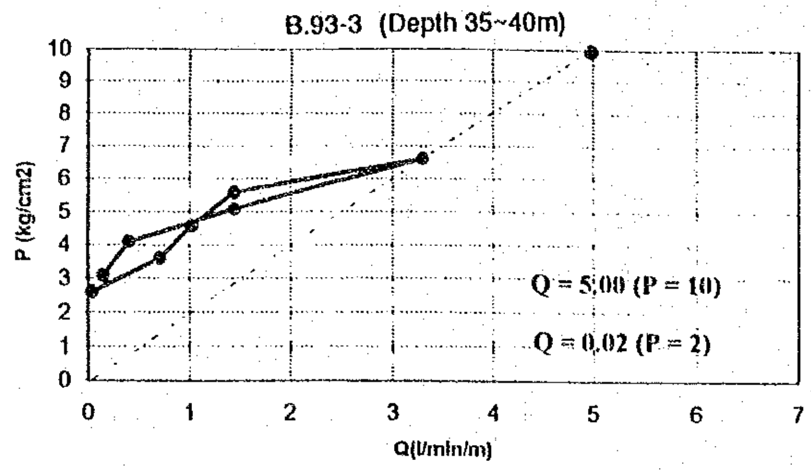
Scale: AS SHOWN
Date: 14 - FAB - 1968
No. 8/WG-II/184/D9
Sheet 2 of 3

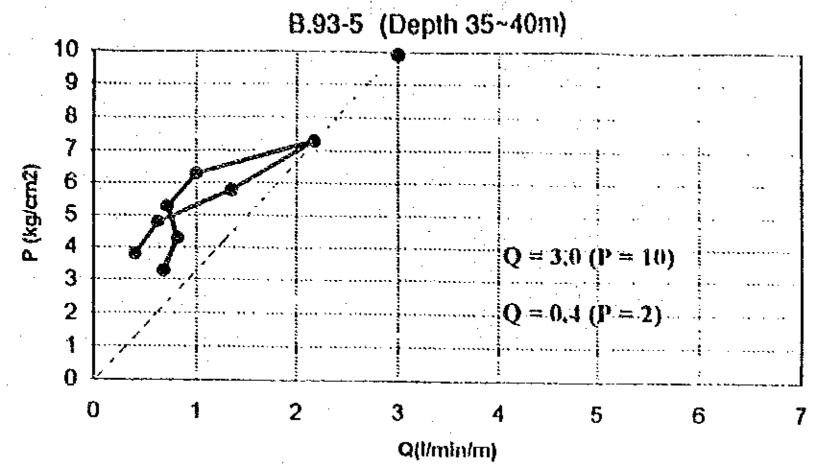
JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. II.3.2 Drill Logs (by Canambra E.C.) 3/3

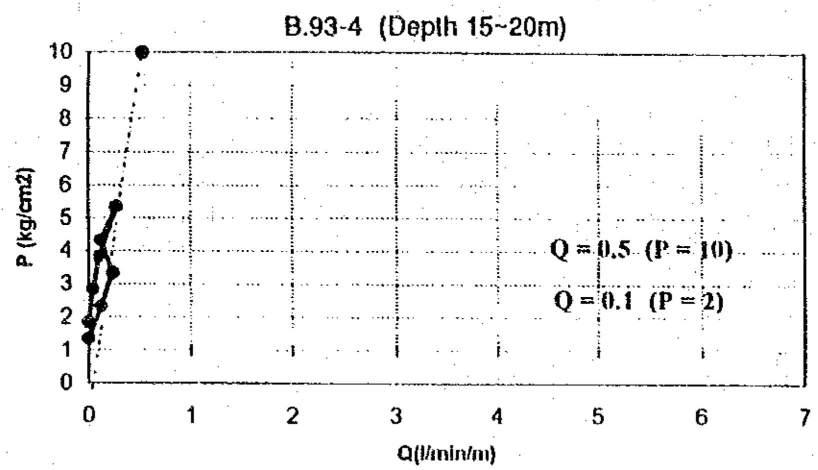


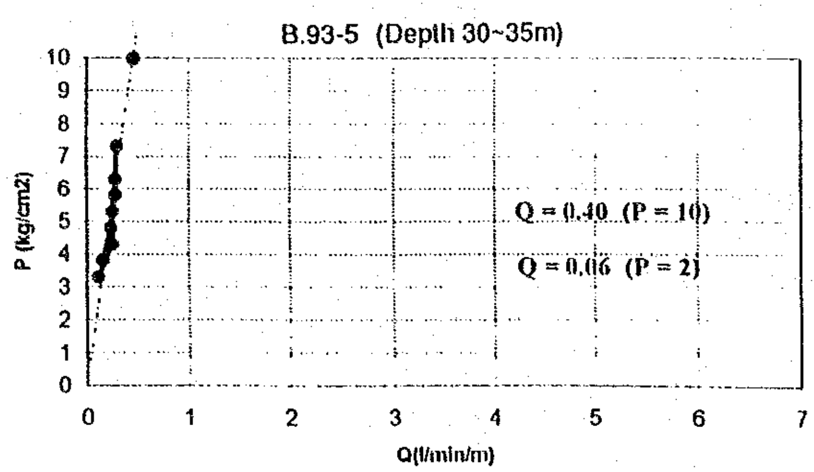
JAPAN INTERNATIONAL COOPERATION AGENCY
CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL
SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

Fig. II.3.3
Results of Permeability Test (1/2)







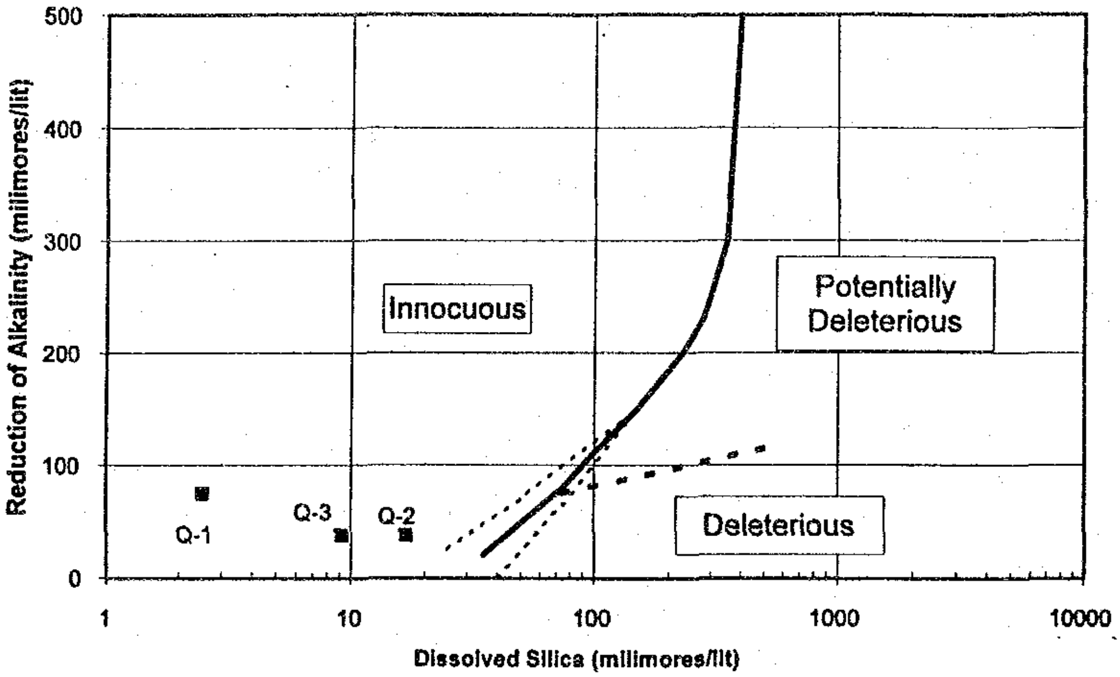


B.93-3 (Depth 1~5m)

ACCUMULATED TIME (min)	DROPMENT (cm)	OUTLET (cm^3/s)	PERMEABILITY COEFFICIENT ($x10^{-4}$ cm/s)
0	0.0	-	-
5	1.2	5.025	4.104
10	1.0	4.188	3.420
15	1.0	4.188	3.420
20	1.0	4.188	3.420
25	0.8	3.350	2.736
30	1.0	4.188	3.420
35	0.8	3.350	2.736
40	0.8	3.350	2.736
45	0.8	3.350	2.736
50	0.6	2.513	2.052
61	0.8	1.523	1.244

AVERAGE	2.911×10^{-4}

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. II.3.3 Results of Permeability Test (2/2)



Result of Alkali Reactivity Test

Sample No.	Test No.	Dissolved Silica (milimoles of SiO2/L)	Reduction of Alkalinity (milimoles of NaOH/L)
	1	3.33	76.16
Quarry-1	2	2.91	78.88
	3	1.25	70.72
	Average	2.50	75.25
	1	14.57	35.14
Quarry-2	2	21.23	40.16
	3	14.57	37.65
	Average	16.79	37.65
	1	12.49	32.63
Quarry-3	2	7.91	40.16
	3	7.08	40.16
	Average	9.16	37.65

Fig. II.4.1
Result of Alkali Reactivity Test

ANNEX III

HYDROLOGICAL STUDY

ANNEX III HYDROLOGICAL STUDY

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ATTACHMENT

1. INTRODUCTION

This hydrological study was made aiming at; 1) clarifying the meteorological and hydrological conditions for the proposed Salto Pilão hydropower scheme; 2) deciding daily discharge and probable peak flood discharges; and 3) estimating sediment yield at the proposed damsite. To achieve these objectives, the following data collection and analysis were made:

a) Hydrological data collection and compilation of climatic records, rainfall data, water level and discharge data including discharge measurement and hydrograph records, sediment data, and results of water quality tests,

b) Establishment of flow discharge duration curve at the proposed damsite to compute the electric power output,

c) Derivation of probable flood hydrographs with several return periods required for design of dam and related structures,

d) Estimation of annual sediment yield and clarifying the grain size distribution of sediment flowing into the reservoir, and

e) Derivation of stage-discharge rating curves at dam and powerhouse sites for planning project facilities.

2. AVAILABLE DATA

Among the available data in the Itajaí river basin, the following data were collected for the hydrological study in this stage. The collected data are listed in Table III.2.1 and the location of the observation stations is given in Fig. III.2.1.

(1) Climate

Climatic observations of temperature, relative humidity, evaporation and wind velocity have been carried out at 2 observatories in Blumenau and Ituporanga by EPAGRI near the project site since 1985 at Ituporanga and 1911 at Blumenau, respectively. Of these, the observations at Blumenau were stopped at the end of the 1960's.

(2) Rainfall

There are 77 rainfall gauging stations in and around the Itajaí river basin at which the daily rainfall amount has been observed at 7 o'clock every morning by DNOS, DNAEE, INMET, CELESC, EMPASC and SOUZA CRUZ. Out of them 19 stations are located around the basin and another 58 stations are densely distributed along the Itajaí river and its tributaries in the basin. Among the mentioned 77 stations, 6 stations were installed in the 1930's, and 14 stations in the 1940's, and most of others in the 1970's. Since then, the observations at 12 gauging stations have been discontinued.

Of the above stations, daily rainfall records at 12 stations which are Rio do Campo, Vidal Ramos, Santa Clara, Trombudo Central, Rio do Sul, Taio, Anitapolis, Ituporanga, Witmarsum, Lomba Alta, Ibirama and Rio Bonito, were collected taking into account their location and duration of the observation period for estimation of the basin mean rainfall in the upstream area of the proposed damsite.

(3) Discharge

There are 4 water level and discharge gauging stations with long-term observation period more than 40 years near the damsite, namely, Rio do Sul, (Rio do Sul Novo after 1978) and Apiúna in the main stream of the Itajaí river, Ituporanga in the Sul river, Taio in the Oeste river, and these stations have been operated by DNAEE and ELETROSUL since 1930's.

Discharge measurement has been carried out about 10 times a year by the above mentioned organizations. Discharge rating curves for converting water levels to discharges have been corrected periodically by using the discharge measurement records.

(4) Sediment

Sediment concentration and grain size distribution of wash and suspended loads at the damsite were surveyed by the JICA study team for about 2 months from June to July in 1993 entrusting it to the Blumenau university .

3. CLIMATIC AND HYDROLOGICAL CONDITIONS

3.1 Climate

The mean monthly climatic records from 1985 to 1991 at Ituporanga with an altitude of EL. 475 m, which is located at about 50 km upstream from the damsite with an altitude of about EL. 300 m, are listed in Table III.3.1 and summarized as follows:

Items	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
Max. temperature (°C)	30.9	30.6	29.7	26.6	23.9	20.8	20.5	22.1	22.8	25.3	28.1	30.5	25.4
Mean temperature (°C)	22.6	22.3	21.8	19.5	14.6	12.3	11.9	14.1	15.5	18.0	20.4	22.1	17.9
Min. temperature (°C)	17.7	17.3	16.2	13.4	9.2	5.5	6.0	8.6	10.4	12.6	14.2	16.9	13.2
Relative humidity (%)	82.8	80.5	81.2	85.0	86.5	87.5	85.1	83.4	82.6	79.4	76.2	76.8	81.9
Evaporation (mm)	171	164	149	106	77	56	61	83	97	141	165	188	1,458
Wind velocity (km/hr)	4.56	4.26	5.40	5.16	5.16	4.02	4.08	5.76	8.34	7.52	7.21	7.13	5.72

The annual mean temperature is 17.9°C and the recorded maximum and minimum temperatures are 30.9 °C and 5.5 °C respectively. The annual mean relative humidity is 81.9 % and the monthly mean relative humidity from June to September is slightly higher than that in other months. The basin mean annual evaporation amount was around 1,500 mm which corresponds to an evaporation rate of 4.1 mm/day. The annual mean wind velocity is 5.7 km/hour or 1.6 m/sec.

3.2 Rainfall

Fig. III.3.1 shows the isohyetal map of the annual mean rainfall in the upstream basin of the damsite established by using the rainfall data observed at the aforesaid 12 rainfall gauging stations. The annual rainfall ranges from 1,400 mm to 1,500 mm in the center of the basin and from 1,500 mm to 1,800 mm in the mountainous area of the northern and southern parts of the basin. The basin mean annual rainfall was estimated to be about 1,500 mm.

The mean monthly rainfall at 3 gauging stations, which are Rio do Campo in the Oeste river basin, Lomba Alta in the Sul river basin and Rio do Sul at about 26km upstream of the damsite, is given in the above Fig.III.3.1. This figure shows that the monthly rainfall amount ranges from 80 mm in March to 150 to 200 mm in January and 3 stations have the similar rainfall patterns through a year.

The rainy days at Rio do Sul near the damsite is 145 days per year on an average for the latest decade from 1982 to 1991 as follows:

Daily	Nos. of Rainy Days												
Rain fall(mm)	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
0 - 5	7	6	6	6	4	5	5	6	6	5	5	6	67
5 - 10	3	3	2	1	1	2	1	1	2	3	3	2	23
10 - 15	3	2	1	1	2	1	1	1	2	1	1	2	16
15 - 20	1	1	1	1	1	1	1	1	1	1	1	1	11
20 - 30	1	1	1	1	1	1	1	1	0	1	1	1	12
> 30	1	2	1	1	1	1	2	1	1	2	1	1	15
Total	16	14	12	12	10	9	11	10	12	12	13	13	145

Number of rainy days with heavy rainfall more than 30 mm is 15 days (4 %) in the normal year and its frequency of occurrence of heavy rainfall is rather low.

3.3 Runoff

Monthly mean discharges at Rio do Sul and Apiúna water level gauging stations are given in Tables III.3.2 and III.3.3. Long term average monthly discharges at these stations for 50 years from 1941 to 1990 are summarized as follows:

(Unit : cms)

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Mean
Rio do Sul	93.3	117.8	95.8	64.2	78.5	84.5	101.3	123.5	137.8	136.8	101.3	83.2	101.4
Apiúna	155.4	192.8	165.3	111.8	136.9	152.7	179.6	205.6	231.0	233.2	168.3	149.5	173.4

The average runoff coefficients for the basin mean annual rainfall based on the above and the preceding isohyetal map of annual rainfall were estimated at 41 % for Rio do Sul and 39 % for Apiúna. The annual loss was estimated at 890 mm and 922 mm respectively.

According to the result of the Hydro Inventory Study - 1991, water consumption in the upstream basin of Rio do Sul water level gauging station has been studied as follows:

River Basin	Annual Mean Intake Water (cms)				Water Volume ($mil.m^3$)
	Irrigation	Municipal Water	Industrial Water	Total	
Itajaí do Sul	0.29	0.08	0.02	0.39	12.3
Itajaí do Oeste	4.05	0.02	0.09	4.16	131.2
Total	4.34	0.10	0.11	4.55	143.5

Water consumption of 143.5 million m^3 corresponds to 1.8 % of annual rainfall or 4.5 % of annual runoff at Rio do Sul gauging station.

3.4 Flood Flows and Rain Storms

(1) Flood Flows

According to annual maximum discharge records at Rio do Sul/Rio do Sul Novo and Apiúna gauging stations, which were obtained by gauge reading twice a day, as given in Table III.3.4, four large scale floods have occurred after completion of Sul and Oeste dams which are exclusively for flood control purpose. The recorded peak flood discharges at these stations were as follows:

Name of Station	Peak Flood Discharge (cms)			
	Dec.1978	Dec.1980	Jul.1983	Aug.1984
Rio do Sul Novo	750	1,290	2,560	2,370
Apiúna	2,160	3,090	4,330	4,320

Hydrographs of those floods recorded at Rio do Sul are shown in Fig. III.3.2, which have a rising phase of 1 to 2 days and a falling phase of 3 to 4 days. The flood in 1983 is characterized by the long rising phase of 6 days.

(2) Rain Storms

Rain storms which caused the above floods are characterized by regional and hourly rainfall distribution. According to the isohyetal maps of the rain storms causing the above mentioned large scale floods as shown in Figs. III.3.3 to III.3.5, heavy rainfall occurred throughout whole Itajaí river basin and was intensive in the mountainous area of the main tributaries, the Benedito river, the Itajaí do Norte river, the Itajaí do Oeste river, the Itajaí do Sul river and the Itajaí Mirim river. In 1984 heavy rainfall occurred in the Itajaí Mirim river basin and the daily amount of the rainfall was around 150 mm a day.

In the upstream basin of the Salto Pilão damsite, the basin mean 1-day and total rainfalls in a rain storm were 107 mm and 125 mm in 1978, 70 mm and 160 mm in 1980, 66 mm and 360 mm in 1983 , and 98 mm and 230 mm in 1984 respectively. The rain storm in 1983 was noteworthy for its great quantity of rainfall (360 mm) as compared to the other storms.

Based on the hourly rainfall distribution recorded in July 1983 and August 1984 as shown in Figs. III.3.6 to III.3.8, a maximum hourly rainfall of 10 to 25 mm/hour was estimated for the basin area in 1983 and 1984 but these were not regarded as intensive. The recorded maximum rainfall intensity in the Itajaí river basin was 94 mm/hour at Blumenau in March 1965.

3.5 Water Quality

The results of chemical analysis made for water samples taken at Rio do Sul by DNAEE are given in Table III.3.5.

Of the test items for water quality, acidity is of importance for estimating the corrosion of such metal structures for hydropower schemes as steel intake gates, penstocks and generation equipment. According to the aforesaid table, the measured pH value, which is the indicator of acidity, was in the range of 5.5 to 7.6 in the Itajaí river. This range is classified as neutral and it is judged that there will be no adverse effect on corrosion of metal structures.

Also, from the view point of utilization of river water for concrete works, oil and grease with a range from 3 ppm to 13 ppm were detected in the river water at Rio do Sul.

Although these contents are still on harmless level, re-confirmation of adaptability of the river water for concrete construction before construction stage is recommendable.

4. LOW FLOW ANALYSIS

4.1 General Procedure

Since there are no runoff data at the dam site, it is necessary for low flow analysis to work out the long-term daily runoff for the Salto Pilão project based on the data available in the basin. Establishment of flow duration curve based on estimated runoff is also necessary to formulate hydroelectric power development.

To meet these requirements, the following studies were carried out:

a) Interpolation of missing daily mean discharge records at Rio do Sul and Rio do Sul Novo, which were applied for estimating long-term daily runoff at the damsite,

b) Confirmation of reliability of runoff data at the aforesaid gauging stations,

c) Estimation of the daily mean discharge and derivation of monthly mean discharges at the project site based on the hydrological relationship between the key gauge and the project site, and

d) Preparation of flow duration curve based on the estimated daily mean discharges at the damsite.

4.2 Runoff at Rio do Sul

4.2.1 Rio do Sul Gauging Station

Rio do Sul water level gauge, which has a catchment area of 5,230 km^2 and is located at about 27 km upstream of the damsite, was installed at 800 m downstream of the confluence of the Itajaí do Oeste and Sul rivers at the end of 1940. In 1978, this gauge was shifted to the bridge site near the original gauge site and renamed as Rio do Sul Novo. In this report, both old and new gauges are called Rio do Sul.

Rio do Sul gauge was selected as the key gauge for estimating the daily mean discharges at the damsite since this gauge has the long-term runoff records of more than 50 years since 1941 and the catchment area of the gauge covers 93 % of that at the damsite.

4.2.2 Correlation between Runoffs at Rio do Sul and Apiúna

Correlation analysis aims at confirming reliability of the data at the Rio do Sul gauging station and at interpolating the missing data of the records from the runoff data at the Apiúna gauging station. Using the daily discharge records from 1941 to 1990 at both gauging stations, correlation coefficient was worked out at 0.96, which indicates that these stations have significantly high correlation to interpolate the missing data at Rio do Sul gauging station from Apiúna.

Based on the correlation analysis mentioned, the relationship between daily discharges at Rio do Sul and Apiúna is expressed by the following regression equations:

[Daily discharge at Rio do Sul] = 0.572 x [Daily discharge at Apiúna]

[Daily discharge at Apiúna] = 1.653 x [Daily discharge at Rio do Sul]

The monthly mean discharges interpolated by using the above equations and daily discharges at Rio do Sul and Apiúna are given in Tables III.3.2 and III.3.3.

4.2.3 Double Mass Curve Analysis

In order to further confirm the reliability of the runoff data at Rio do Sul, the double mass curve analysis was applied by using the basin mean rainfall at Rio do Sul and the runoff data at Apiúna.

The basin mean rainfall at Rio do Sul was estimated by Thiesen's method, using daily rainfall data at the existing rainfall gauging stations upstream of the damsite. Name of the existing stations and estimated Thiesen's coefficients are given as follows and location of the stations and Thiesen polygons are illustrated in Fig. III.4.1;

No.	Name of Station	Thiesen's Coefficient
02749003	Taio	0.388
02749013	Trombudo Central	0.183
02749002	Ituporanga	0.203
02749007	Lomba Alta	0.189
02749008	Rio do Sul	0.037

The monthly rainfall derived from the above method is given in Table III.4.1.

Using the annual runoff data at Rio do Sul and Apiúna and the basin mean annual rainfall, the double mass curve between these data are worked out as shown in Fig. III.4.2. It is judged that the runoff records are reliable since the double mass curves indicate linear relationship between runoff at Rio do Sul and Apiúna, and between the runoff and the basin mean rainfall at Rio do Sul.

4.2.4 Estimation of Flow Discharge at Proposed Damsite

Flow discharges at the damsite was estimated based on daily mean discharge at the Rio do Sul. In this estimation, the daily mean discharges at Rio do Sul were converted into those at the damsite by the following equation using the basin mean annual rainfall ratio and catchment area ratio of Rio do Sul and the damsite;

$$Q_{site} = Q_{Rio\ do\ Sul} \cdot (R_{site} / R_{Rio\ do\ Sul}) \cdot (A_{site} / A_{Rio\ do\ Sul})$$

where;

Q_{site} : daily mean discharge at the proposed damsite

$Q_{Rio\ do\ Sul}$: daily mean discharge at Rio do Sul

R_{site} : average of the basin mean annual rainfall at damsite (1,508 mm) as estimated in Table III.4.2, to which the following Thiesen's coefficients were applied.

No.	Name of Station	Thiesen's Coefficient
02749003	Taio	0.357
02749013	Trombudo Central	0.168
02749002	Ituporanga	0.187
02749007	lomba Alta	0.174
02749008	Rio do Sul	0.034
02749001	Ibirama	0.080

$R_{Rio\ do\ Sul}$: average of the basin mean rainfall at Rio do Sul (1,515 mm) as estimated in Table III.4.1.

A_{site} : catchment area at the proposed damsite (= 5,597 km^2 at dam axis B)

$A_{Rio\ do\ Sul}$: catchment area at Rio do Sul (= 5,230 km^2)

The estimated daily mean discharges at the proposed damsite by means of the above equation are illustrated in Fig. III.4.3 and the monthly discharges are listed in Table III.4.3. Table for daily mean discharge at the proposed damsite is attached to the end of this Annex III. The discharges shown in these tables are at the dam axis B which has the catchment are of 5,597 km^2. The same discharges are applied for the other dam axes C and D (c.a. = 5,601 km^2 and 5,603 km^2, respectively) since increment of the catchment area is only 0.07% and 0.11%, respectively.

4.3 Flow Duration Curve

Flow duration curve to show characteristics of river flow at the damsite was established by arranging the daily mean discharge records. In order to apply the curve for energy generation simulation study of the project, the following two hydrological periods were considered:

- Critical Period : From Apirl 1949 to November 1956.
  This period was designated by ELETROBRAS to be the hydrologically critical or driest period for power generation in the area covered by the interconnected power system of the south and southeast regions.

- Long Term Period : From January 1941 to December 1990.
  This period covers entire length of discharge record available at present.

Fig. III.4.4 presents the flow duration curves for both periods and the following table shows discharges corresponding to typical excess percentages:

(Unit : cms)

Period	Max.	Percentage against 365 days						Mean
		10%	25%	50%	75%	97%	100%	
1. Critical period (Apr.1949 to Nov.1956)	1958.5	189.2	96.7	50.4	29.4	12.6	4.1	86.3
2. Long term period (1941 to 1990)	2498.6	235.0	121.4	63.5	35.5	14.2	4.1	108.2

5. FLOOD RUNOFF ANALYSIS

5.1 General Procedures

Estimation of design flood for Salto Pilão dam in the Hydro Inventory Study - 1991 was based on the statistical analysis using the annual maximum discharges among the records observed twice a day at Rio do Sul. There is possibility that the design flood was under-estimated since the used data were not always peak flood discharge considering frequency of the observation.

Flood runoff analysis was made to review the previous study results and to estimate the probable peak flood discharges and their hydrograph with several return periods by applying a mathematical simulation model and using rainfall data in order to obtain the basis for design of project facilities. The return periods are designated at 2, 5, 10, 20, 50, 100, 200, 500, 1000 and 10000-year to cover design scale of permanent and temporary facilities for the project.

In estimating probable floods, the following assumptions were applied:

(a) No retardation effect of reservoir created by the proposed dam is taken into account since no flood storage space is provided in the reservoir.

(b) Flood control effect of the existing upstream dams; Sul, Oeste and Norte dams, is not considered assuming that a rain storm with a long duration as long as in 1983 would fill the storage volume up to flood water levels of these dams before a big probable flood occurs.

Probable floods were derived through simulation study based on rainfall data. In the simulation study, the following analyses were carried out:

a) Estimation of basin mean probable rainfall with each return period in the project catchment area,

b) Preparation of hyetograph for probable rainfall, and

c) Simulation of probable flood hydrograph using the storage function model established in the Itajaı river basin flood control study-1988 by JICA, and inputting the hyetograph of the probable rainfall into the model.

5.2 Flood Runoff Analysis

5.2.1 Simulation Model

In the Itajaı river basin flood control study - 1988, JICA established the simulation model by means of the storage function method developed in Japan. The model has been calibrated using actual rainfall and flood records during the major floods in 1978, 1980, 1983 and 1984 after the construction of Sul and Oeste dams.

The established simulation model mainly consists of:

a) Basin model which converts rainfall into flood discharge from a basin,
b) River channel model which enables to express retardation effect in a river channel and flooding in a inland area, and
c) Model for the existing flood control dams/reservoirs.

The basin division including river channel and sub-basin is shown in Fig. III.5.1 and river system model and storage functions of basins are given in Fig. III.5.2. As described in the Section 5.1, retardation effect of the existing 3 flood control dams, was excluded in the simulation model for this study. Basic equations of the storage function of the basin and river channel model are described as follows:

(1) Basin model

The basin model is expressed by the following equation:

$$S = K \cdot Q^P$$

$$dS/dt = (1/3.6) \cdot f \cdot r \cdot A - Q$$

Where,

	S	:	basin storage (m^3)
	Q	:	runoff from basin except base flow (cms)
	K and P	:	constants
	t	:	time (sec)
	f	:	runoff coefficient
	r	:	basin mean rainfall (mm/hr)
	A	:	catchment area (km2)

Constants K and P in the equation were estimated by the following formula which were determined by an average riverbed slope in a basin and through calibration of the model:

$K = 1.3 \cdot 118.84 \cdot i^{0.3}$
$P = 0.175 \cdot i^{-0.235}$
Where, i : average river bed slope

(2) River channel model

The river channel model is expressed by the following equation:

$S = K \cdot Q^{P}$

Where,	S	:	storage in a channel (m^3)
	Q	:	flood discharge into a channel (cms)
	K and P	:	constants

Constants K and P in the equation were estimated by means of non-uniform flow calculation using river cross sections.

5.2.2 Inputs to Simulation Model

(1) Runoff coefficient

The runoff coefficients during floods have been studied by using rainfall and runoff data during large scale floods in 1978, 1980, 1983 and 1984 in the Itajaí river basin flood control study - 1988. Since there were no large scale floods corresponding to the preceding floods after the flood in 1984, the results of the study in 1988 were applied to this study.

Fig. III.5.3 shows the relationship between flood runoff depth and rainfall amount during the preceding four floods. From this figure, a preliminary runoff coefficient was set at 0.5, and the saturated rainfall, which is the turning point from preliminary runoff coefficient, is set at 200 mm.

(2) Base flow

The average of annual mean discharge of 108.2 cms at the proposed damsite as given in Table III.4.3 was adopted as the base flow.

(3) Basin mean probable rainfall

(a) Duration of probable rainfall

Fig. III.5.4 shows the relationship between duration and accumulated basin mean daily rainfall at the damsite during the major rain storms as listed below, which caused peak flood discharge more than 1,000 cms.

Date of Major Rain Storms		Duration (days)	Rainfall Amount (mm)
May	1948	4	150
Aug.	1957	4	140
Aug.	1972	7	177
Jul.	1973	6	103
Oct.	1975	5	107
Dec.	1980	7	169
Jul.	1983	9	360
Aug.	1984	8	235

This Fig.III.5.4 indicates that more than 80 % of the rainfall amount tend to occur within 4 days and these rainfalls tend to induce floods. On the basis of the result of these observations, a period of 4 days was adopted as the duration of probable rainfall.

(b) Probable basin mean rainfall

The probable basin mean rainfalls with duration of 1 to 4 days at the damsite were estimated by means of Gumbel method using the aforesaid basin mean daily rainfall given in Table III.5.1. The derived basin mean probable rainfalls are shown in Table III.5.2 and their frequency curves are illustrated in Fig. III.5.5.

(c) Hyetograph of probable rainfall

The Hydro Inventory Study - 1991 by JICA established the following rainfall intensity-duration curve by enveloping the relationship between rainfall intensities and durations recorded at Saltinho, Rio do Sul, Timbó Grande and Doutor Pedrinho gauging stations during rain storms in 1983 and 1984 and Blumenau in 1965:

$$I_t = R_{4\text{-day}} \cdot \{ 10.57 / (t^{0.8} + 4.16) \}$$

where,
- I_t : rainfall intensity (mm/hr)
- $R_{4\text{-day}}$: rainfall amount for 4 days
- t : time (hour)

The following procedure was applied to establish hyetographs of the probable rainfalls with the designated return period, using the mentioned equation;

i) Estimation of intesities of probable 4 -day rainfall for durations from 1 hour to 96 hours (4 days).

ii) Conversion of the estimated rainfall intensity to rainfall amount for each duration from 1 hour to 96 hours (4 days).

iii) Establishment of hyetograph of the probable 4-day rainfall by allocating the estimated rainfall amounts in item (ii) to hourly rainfall assuming centralized type of hyetograph, and

iv) Adjustment of the established hyetograph in order to meet severity of the probable rainfalls for durations from 1 day to 4 days estimated by using the annual maximun series.

The established design hyetograph with a return period of 10,000-year, which is a usual design scale of spillway for large reservoir project in Brazil, was illustrated in Fig. III.5.6.

5.2.3 Probable Flood Hydrograph at Damsite

Based on the mentioned inputs and the simulation model, flood hydrographs with the designated return periods were worked out as shown in Fig. III.5.7. The obtained flood peak discharges are as follows:

Return Period (year)	Peak Flood Discharge at Damsite (cms)	
2	1,600	(1,100)
5	2,300	(2,000)
10	2,600	(2,500)
20	2,900	
50	3,300	
100	3,600	
200	3,900	
500	4,700	
1,000	5,300	
10,000	7,400	

Figures in brackets in the above table show flood peak discharge estimated taking into account the retardation effect by the existing Sul and Oeste reservoirs, referring the analysis by the Itajaí river basin flood control study is 1988.

5.2.4 Probable Flood Discharge at Powerhouse Site

Probable peak flood discharge at the proposed powerhouse site was estimated from the floods at the damsite applying their catchment area ratio (1.61 = 9041 km^2 /5597 km^2). Result of the estimation is as follows;

Return Period (year)	Peak Flood Discharge at Powerhouse (cms)
2	2,600
5	3,700
10	4,200
20	4,700
50	5,400
100	5,800
200	6,300
500	7,600
1000	8,600
10000	12,000

5.3 Comparison of Design Peak Flood Discharge

In order to check the derived peak discharge of the flood with 10,000-year return period, specific discharges of design floods applied to several other dam projects in and around the Itajaí river basin were compared applying Creager's coefficient (C), which indicates the relationship between catchment area and peak flood discharge, as shown in Fig. III.5.8. This figure indicates that the specific discharge of 1.32 (7,400 cms / 5,597 km^2) of the Salto Pilão project correspods to flood discharge with C of about 50. On the other hand, the C of the Norte, Sul and Campos Novos dams, of which the catchment areas are in the similar order, are also about 50. Considering the scale of the design floods of the mentioned projects, it was judged that the discharge of 7,400 cm is reasonable for the flood with 10,000-year return period at the Salto Pilão damsite.

After the Hydro Inventory Study - 1991, ELETROSUL undertook review study on probable flood discharges by means of frequency analysis using the annual maximum daily mean discharges in 52 years from 1940 to 1991 at Rio do Sul and by multiplying its result by the catchment area ratio of the damsite and Rio do Sul. As the result, the probable peak flood discharge of 5,700 cm was worked out for the flood with 10,000-year return period. This figure corresponds to C of about 35 and it was judged to be too small value compared with figures in other projects. Difference of peak discharge estimated by the present study and ELETROSUL is appearently caused by the difference of data, namely daily mean discharge and instantaneous flood peak discharge taking into account the comparatively small catchment area of the Salto Pilão project.

In order to carry out flood analysis with high accuracy in the future detailed design stage, accumulation of records on hourly water levels and discharges during floods at the damsite or at Rio do Sul is recommended. For this purpose, it is recommendable to install at the damsite a new gauge equipped with automatic recorder.

6. SEDIMENT ANALYSIS

6.1 Sediment Rating Curve

The sediment study to establish wash and suspended loads rating formula was made in Itajai river basin flood control study stage in 1998 and Hydro Inventory Study in 1991 by using the sediment concentration and flow discharge records at 5 stations on the main stream of the Itajaí river and its tributaries, and the following formula was derived:

$Qs = 0.096\ Q^{1.759}$

where, Qs : Suspended load (tons / day)

Q : Flow discharge (cms)

Fig. III.6.1 shows relationship between flow discharge rate and corresponding sediment yield per day.

To check the applicability of the above rating formula for estimation of the sediment inflow into the reservoir, sediment survey on wash and suspended loads was undertaken at Lontras suspension bridge located at 4.5 km upstream of the damsite in June to August 1993. River water was sampled at 3 places; left and right bank sides and center of the river channel, in each time of total 25 observations. Solid content in the sampled water was measured by using a decanting method (Imhoff cone method). It was revealed during the survey that this method indicates relatively high content of sediment since solid particles settles in bottom of the measurement cone in colloidal state due to unexpectedly very fine particles. In the later observations, the solid content was measured again by filtering method using glass fiber filter. Solid contents measured by both methods are shown in Table III.6.1. Average value given by the filter method is 23 mg/lit.

Daily sediment yield at Lontras culculated from these new observation results are plotted on Fig. III.6.1. This figure shows that the amounts of surveyed sediment yield widely scatter around the line of the rating formula shown above. However, it is considered that the formula still indicates general tendency of sediment yield. The formula was therefore applied for estimating the sediment yield at the dam site.

6.2 Sediment Discharge into Reservoir

Based on the sediment rating formula and the long-term daily mean discharges for 50 years from 1941 to 1990 at Rio do Sul, monthly wash and suspended loads were estimated as shown in Table III.6.2. The average annual load at Rio do Sul is 231 thousand tons/year. Assuming the wet density of sediment to be 1.2 tons/m^3, the annual sediment volume was calculated to be about 193 thousand m^3 corresponding to a specific sediment yield of 37 m^3/km^2/year.

Assuming that other riverbed load corresponds to 20 % of the wash and suspended loads, the annual amount of the riverbed load was roughly estimated to be 37 thousand m^3. Consequently, the total sediment load at Rio do Sul was estimated at 230 thousand m^3 or 44 m^3/km^2/year.

Applying this specific sediment yield of 44 m^3/km^2/year, total sediment inflow into the reservoir was estimated at 247 thousand m^3/year.

6.3 Grain Size Distribution

In parallel with the survey of river water sediment load in the present study, grain size distribution, specific gravity and density at wash and suspended loads were tried to investigated. However, grain size of solids in river water sampled at the Lontras suspension bridge was very small and its classification was impossible. In order to estimate grain size distribution of total sediment load including wash, suspended and bed loads, river bed material was sampled and tested. As river bed material could not be sampled at the Lontras bridge because of rocky river bed, the sampling was made in the vicinity of the Lontras highway bridge and another Rio do Sul supervision bridge.

Grain size of the sampled river bed material was measured by 2 methods; sieve analysis for grains larger than 0.075 mm and densimeter analysis for smaller grains. The results of the analysis are shown in Table III.6.3 and graphed on Fig. III.6.2.

As shown in this figure, grain size of sediment load at the dam site are as follows:

- At least 50% of sediment load is smaller than 0.075 mm in size.
- Content of grains larger than 0.3 mm is less than 13%.
- Content of grains larger than 1.0 mm is very scarce and probably less than 1%.

7. RATING CURVES AT DAM AND POWERHOUSE SITES

In order to estimate stage-discharge relationship of the river at the damsite and powerhouse sites, water level observation was carried out once a day for about 3 months from June to August, 1993 at the left bank of the dam axis C and at the bridge pier of the powerhouse site.

Corresponding flow discharge at both observation sites was estimated from the discharge records at Rio do Sul for the dam site, and at Apiúna for the powerhouse site, using catchment area ratio between the gange site and the observation site. The observed water levels and corresponding discharges estimated are presented in Table III.7.1 and those are plotted on Fig.III.7.1 for powerhouse site and on Fig. III.7.2 for the damsite.

As large floods could not be observed in the period of the present investigation, water levels at high flow were estimated by non-uniform flow analysis assuming 0.03 of Manning's roughness coefficient. The result of the estimation is as follows;

Powerhouse site		Dam site (Axis B)	
Disch. (cms)	Water Level (m)	Disch. (cms)	Water Level (m)
1,000	113.8	500	309.1
2,600	115.9	1,100	309.6
4,200	117.7	2,500	310.6
5,800	119.4	3,600	311.3
8,600	122.2	5,300	312.2
12,000	125.0	7,400	313.1

Stage-discharge rating curves thus obtained for the damsite (axis B) and the powerhouse site are shown in Figs.III.7.1 and III.7.2.

Table

Table III.2.1 Hydrologic Data Collected

Name of station	No.	Institute	Type of data
(A) Climate			
(1) Ituporanga	-	EPAGRI	Monthly temperature
			Monthly relative
			Monthly evaporation
			Monthly wind velocity
(2) Blumenau	-	EPAGRI	Monthly temperature
			Monthly relative
			Monthly evaporation
(B) Rainfall			
(1) Rio do	02650014	DNAEE	Daily
(2) Vidal Ramos	02749033	DNAEE	Daily
(3) Santa Clara	02749032	DNAEE	Daily
(4) Trombudo	02749013	DNAEE	Daily
(5) Rio do Sul	02749008	DNAEE	Daily
(6) Taio	02749003	DNAEE	Daily
(7) Anitapolis	02749027	DNAEE	Daily
(8) Ituporanga	02749002	DNAEE	Daily
(9) Witmarsum	02649053	DNAEE	Daily
(10) Lomba Alta	02749007	DNAEE	Daily
(11) Ibirama	02749001	DNAEE	Daily
(12) Rio Bonito	02749009	DNAEE	Daily
(C) Discharge Records			
(1) Taio	83050000	DNAEE	Daily
(2) Ituporanga	83250000	DNAEE	Daily
(3) Rio do Sul	83300002	DNAEE/ ELETROSUL	Daily
(4) Rio do Sul N	83300200	DNAEE/ ELETROSUL	Daily
(5) Apiuna	83050002	DNAEE/ ELETROSUL	Daily
(D) Discharge Rating Table and Measurement Records			
(1) Taio	83050000	DNAEE	
(2) Ituporanga	83250000	DNAEE	
(3) Rio do Sul	83300002	DNAEE	
(4) Rio do Sul N	83300200	DNAEE	
(5) Apiuna	83050002	DNAEE	
(E) Houry Rainfall during Flood			
(1) Taio		DNAEE	

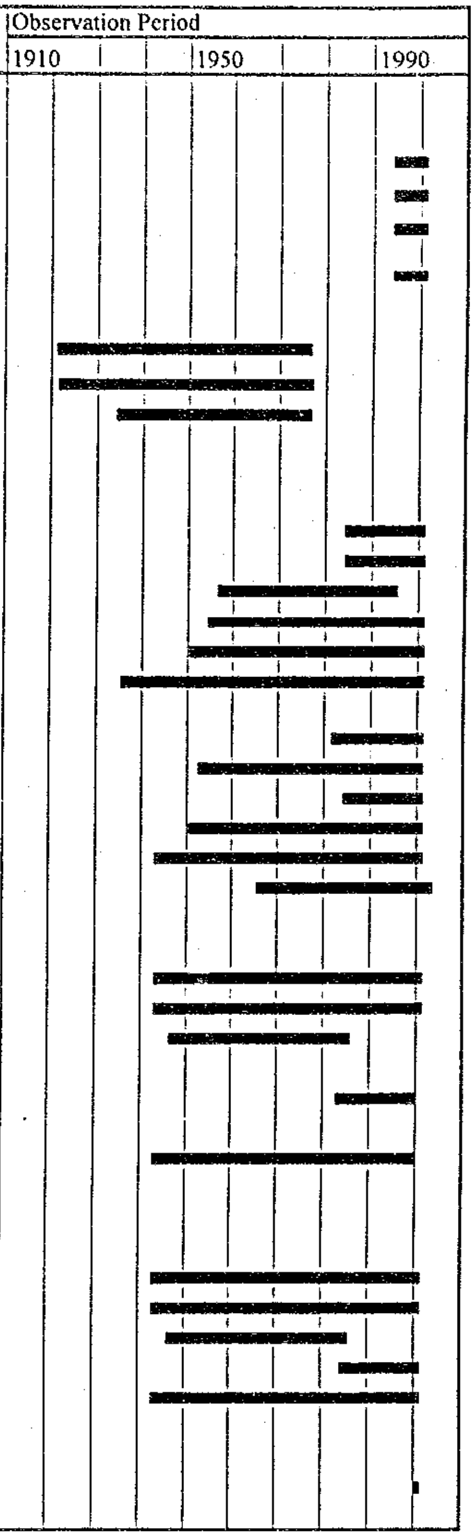


Table III.3.1 Climatic Features at Ituporanga

(1) Maximum Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct	Nov	Dec	Mean
1985	-	-	-	-	-	-	-	21.2	21.2	24.9	28.1	29.7	25.0
1986	30.9	29.7	28.2	25.8	22.4	20.8	19.4	22.1	21.9	25.3	26.7	27.8	25.1
1987	30.6	28.6	29.3	25.9	19.0	18.4	20.5	18.9	19.5	23.4	26.8	28.6	24.1
1988	30.8	27.3	29.7	23.7	18.6	17.3	18.6	20.5	21.8	23.3	26.7	28.5	23.9
1989	27.6	29.6	28.3	25.7	21.5	19.7	18.4	20.7	20.2	23.2	26.5	-	23.8
1990	27.4	29.4	28.0	26.4	20.7	18.1	16.7	20.2	20.6	24.7	27.2	28.6	24.0
1991	29.2	30.6	28.9	26.6	23.9	20.1	19.3	20.4	22.8	24.9	27.1	30.5	25.4
Max.	30.9	30.6	29.7	26.6	23.9	20.8	20.5	22.1	22.8	25.3	28.1	30.5	25.4

(2) Mean Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	-	-	-	-	14.8	15.8	18.7	20.9	22.2	18.5
1986	23.1	22.8	21.6	19.5	16.0	13.7	12.9	15.3	15.8	18.0	20.4	21.5	18.4
1987	23.1	22.3	21.8	21.1	13.2	10.4	14.9	13.2	14.7	17.7	20.6	21.9	17.9
1988	23.7	21.5	22.3	17.7	13.6	11.3	10.8	14.2	16.1	17.4	19.4	22.2	17.5
1989	22.0	22.8	21.3	19.4	14.6	13.2	10.6	13.4	15.0	16.8	19.8	-	17.2
1990	22.0	21.9	22.2	20.4	13.6	11.9	10.9	13.5	14.6	19.2	21.2	21.7	17.8
1991	21.8	22.3	21.5	19.1	16.4	13.1	11.4	14.3	16.4	18.5	20.3	23.2	18.2
Mean	22.6	22.3	21.8	19.5	14.6	12.3	11.9	14.1	15.5	18.0	20.4	22.1	17.9

(3) Minimum Temperature (°C)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	-	-	-	-	10.3	12.3	14.4	16.4	16.9	14.1
1986	18.6	19.0	16.2	15.8	12.4	9.5	8.5	11.0	11.9	13.2	16.2	17.3	14.1
1987	18.8	18.4	16.6	16.2	9.2	5.5	11.5	8.8	11.0	13.4	15.9	17.2	13.5
1988	19.4	17.8	17.7	13.4	10.6	7.6	6.0	10.2	12.4	13.3	14.2	17.9	13.4
1989	18.6	18.5	17.5	15.9	10.9	9.8	6.3	8.6	11.8	12.6	15.0	-	13.2
1990	19.0	17.6	18.7	17.3	9.4	8.3	7.1	9.0	10.4	15.6	17.4	17.4	13.9
1991	17.7	17.3	17.3	14.9	12.2	9.4	6.5	10.3	12.7	14.3	16.1	18.1	13.9
Min.	17.7	17.3	16.2	13.4	9.2	5.5	6.0	8.6	10.4	12.6	14.2	16.9	13.2

(4) Relative Humidity (%)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean
1985	-	-	-	-	-	-	-	84.5	84.1	78.7	74.5	74.5	79.3
1986	89.0	85.4	80.2	87.0	88.0	89.6	88.7	85.0	82.3	77.2	79.7	82.8	84.6
1987	82.7	84.3	78.8	88.8	90.1	88.2	88.7	84.0	84.4	83.1	77.7	76.8	84.0
1988	79.8	82.8	82.0	85.0	88.7	88.6	81.4	82.7	83.9	79.6	73.5	77.0	82.1
1989	83.5	80.6	83.1	83.8	85.9	87.1	82.3	82.1	83.1	75.0	72.7	-	81.7
1990	84.9	77.9	83.1	85.1	82.5	85.3	85.9	82.0	81.1	82.5	81.5	74.7	82.2
1991	76.7	72.1	80.2	80.5	83.6	86.3	83.8	83.2	79.3	79.4	74.1	74.7	79.5
Mean	82.8	80.5	81.2	85.0	86.5	87.5	85.1	83.4	82.6	79.4	76.2	76.8	81.9

(5) Evaporation (mm) by Pan A

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1985	-	-	-	-	-	-	-	-	-	-	179	206	-
1986	205	168	149	108	70	52	68	92	98	164	138	139	1,451
1987	103	154	179	99	75	52	58	75	85	124	151	197	1,351
1988	214	148	155	95	61	55	69	81	90	138	183	174	1,461
1989	160	151	137	98	73	45	29	82	107	143	176	-	-
1990	161	188	137	128	86	74	64	87	103	123	162	193	1,505
1991	185	178	140	107	99	60	76	80	99	154	167	219	1,564
Mean	171	164	149	106	77	56	61	83	97	141	165	188	1,458

(6) Wind Velocity (km/hour)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1985	-	-	-	-	-	-	-	-	-	5.18	4.79	5.00	4.99
1986	3.24	2.52	2.52	1.44	1.44	1.08	1.44	2.16	1.44	1.80	2.16	2.16	1.95
1987	3.24	2.16	7.92	3.24	6.48	3.96	3.24	7.56	8.64	10.44	11.80	13.68	6.86
1988	2.52	2.16	-	1.44	1.44	1.44	2.16	2.16	4.32	3.24	3.96	2.52	2.49
1989	2.52	1.80	1.08	3.60	4.68	5.40	7.20	7.56	15.12	12.60	11.16	-	6.61
1990	6.84	9.00	8.64	8.64	10.08	5.76	4.68	9.00	10.44	11.88	9.36	10.80	8.76
1991	9.00	7.92	6.84	12.60	6.84	6.48	5.76	6.12	10.08	-	-	8.64	8.03
Mean	4.56	4.26	5.40	5.16	5.16	4.02	4.08	5.76	8.34	7.52	7.21	7.13	5.72

Table III.3.2 Monthly Mean Discharges at Rio do Sul

Year	Monthly Mean Discharges (cms)													Annual Runoff
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	(mm)
1941	78.0	131.1	120.6	40.8	76.1	108.5	47.1	153.5	85.1	89.3	129.2	72.4	94.0	569
1942	35.9	117.7	80.9	86.0	68.1	67.9	59.9	65.9	63.4	55.1	24.9	32.3	62.7	379
1943	28.4	48.2	21.3	16.8	51.6	173.7	108.3	273.4	129.3	83.4	61.0	34.3	86.0	520
1944	102.5	38.7	94.2	29.8	17.4	20.1	20.6	15.8	24.7	26.0	46.5	15.3	37.7	228
1945	8.5	58.1	26.9	21.6	9.8	15.5	28.7	20.3	51.9	59.0	*17.8	26.8	28.5	172
1946	75.1	199.0	150.1	54.7	53.5	128.6	171.5	108.1	63.5	97.5	49.0	58.6	100.3	606
1947	54.7	123.6	74.6	25.0	29.5	48.9	57.6	89.4	228.8	200.6	88.7	77.2	91.2	552
1948	62.5	115.3	107.6	88.6	220.0	53.9	107.1	276.3	53.1	49.4	63.4	21.6	101.9	616
1949	31.2	15.7	35.7	62.9	28.2	82.0	34.2	76.3	94.4	57.8	26.3	26.2	47.6	288
1950	87.7	74.5	103.1	30.8	38.9	32.0	28.9	100.1	67.1	195.8	40.3	57.7	71.7	434
1951	115.2	216.5	125.7	37.5	20.8	*19.2	32.6	14.0	14.7	176.3	78.4	45.8	74.0	447
1952	60.2	45.0	20.7	16.7	11.1	54.1	80.0	30.6	137.0	178.0	136.8	47.2	68.0	411
1953	64.7	95.5	51.8	25.2	21.4	17.1	22.1	21.5	63.4	127.7	166.2	71.9	62.0	375
1954	65.4	58.9	105.3	68.4	161.1	144.8	215.7	60.7	*166.2	373.2	54.5	24.3	125.6	759
1955	*27.9	45.3	*49.4	63.8	116.8	96.1	240.8	102.7	128.5	47.2	39.4	68.3	85.9	519
1956	124.7	133.8	50.8	102.1	116.0	52.3	47.9	82.3	214.0	123.4	59.1	50.1	96.1	581
1957	53.8	51.6	66.9	71.1	65.9	47.8	200.6	555.1	418.7	168.3	80.0	43.9	152.8	924
1958	39.2	61.5	198.9	48.1	30.1	80.9	46.0	109.7	200.9	151.7	132.4	110.3	101.0	610
1959	57.0	99.8	45.5	78.9	69.2	36.5	26.0	53.0	162.3	54.2	24.2	27.8	60.7	367
1960	26.9	72.8	71.7	59.7	28.7	24.8	14.0	142.0	90.9	127.0	153.4	79.5	74.2	449
1961	64.2	112.8	146.4	71.5	36.8	43.4	46.4	20.6	343.6	310.5	351.3	148.3	140.9	852
1962	65.9	62.3	79.2	34.9	85.7	51.1	70.8	38.4	139.4	97.2	78.3	45.7	70.8	428
1963	*129.1	*230.8	*209.5	*71.4	33.3	*19.2	*23.0	*27.6	157.5	*273.6	*197.8	69.2	119.4	722
1964	34.7	55.3	36.5	*53.3	*75.9	*41.5	*46.6	*71.6	*106.3	*84.9	*38.5	*38.5	56.9	344
1965	*32.1	*22.1	*48.3	*46.2	*134.2	*49.7	*123.2	161.2	192.1	*131.6	*113.6	170.5	102.7	621
1966	142.8	516.2	*165.4	80.5	61.5	111.5	66.8	64.1	175.9	135.8	84.8	126.4	141.6	856
1967	91.5	183.8	117.6	51.7	37.8	63.6	*60.5	68.9	188.8	109.5	*99.2	101.9	97.2	587
1968	*40.2	19.8	22.2	19.6	10.3	14.9	23.4	10.2	59.0	49.9	82.5	74.4	35.5	215
1969	148.2	206.3	116.3	229.7	44.4	131.3	94.6	44.7	55.1	41.8	85.7	33.5	101.5	614
1970	69.3	61.8	63.3	39.6	48.5	121.8	115.2	79.2	95.3	74.2	*34.1	*105.2	75.8	458
1971	229.3	*149.5	226.2	170.8	*150.5	*194.5	164.1	77.7	94.1	88.7	25.7	16.7	132.3	800
1972	42.3	216.8	88.5	61.1	25.0	89.0	73.7	315.9	249.0	173.2	121.2	105.2	129.6	784
1973	113.3	121.5	65.9	*57.3	100.4	156.9	186.9	317.6	254.1	92.5	72.0	55.7	132.9	804
1974	120.3	132.4	143.6	41.6	*32.4	48.9	76.7	38.5	111.5	*49.0	61.3	27.0	73.2	443
1975	60.3	45.6	123.9	*41.9	46.1	59.9	40.2	130.6	335.6	281.1	89.5	276.1	128.2	775
1976	172.0	63.5	125.4	44.3	121.9	177.3	79.0	205.9	111.2	79.5	63.9	*181.7	119.3	721
1977	272.6	245.9	121.5	85.0	44.3	28.6	35.8	256.3	88.0	278.4	205.5	76.0	144.5	873
1978	78.7	59.3	80.0	23.9	16.4	20.5	49.1	38.8	105.2	65.2	81.7	111.0	60.9	368
1979	50.2	28.9	38.9	47.4	160.9	61.5	61.0	67.5	82.0	352.4	172.8	159.2	107.7	651
1980	102.4	51.7	185.3	60.0	62.8	55.0	160.8	314.5	253.3	150.7	125.7	313.6	153.9	930
1981	174.9	109.9	45.9	40.4	31.3	31.0	43.1	33.7	69.8	68.3	60.2	95.9	66.9	404
1982	42.9	189.9	98.7	53.7	40.6	87.8	123.4	97.9	57.5	166.7	355.5	139.6	120.4	728
1983	190.5	184.8	234.7	131.8	339.3	338.3	*991.3	*360.7	216.3	133.2	124.6	179.0	287.1	1,736
1984	110.3	75.6	105.7	86.8	110.1	205.7	177.6	508.9	159.1	180.1	179.4	99.3	167.1	1,011
1985	58.0	223.5	97.3	111.2	58.4	33.8	59.4	27.9	48.1	51.0	90.3	15.3	71.6	433
1986	22.1	83.3	49.3	41.8	30.7	47.7	28.1	40.7	69.7	125.6	193.8	196.6	77.3	467
1987	232.9	194.6	57.1	55.6	233.7	126.8	112.1	137.9	83.3	257.1	67.8	47.8	133.9	810
1988	57.8	77.0	68.4	73.5	224.1	126.8	58.3	31.3	79.0	80.6	38.8	27.3	78.6	475
1989	170.3	167.4	96.2	108.4	199.1	41.7	56.8	63.7	252.5	84.2	48.9	46.2	110.8	670
1990	344.1	194.7	133.4	145.0	94.7	340.0	228.0	170.3	200.6	331.2	246.8	86.5	209.5	1,267
Mean	93.3	117.8	95.8	64.2	78.5	84.5	101.3	123.5	137.8	136.8	101.3	83.2	101.4	613
Min.	8.5	15.7	20.7	16.7	9.8	14.9	14.0	10.2	14.7	26.0	17.8	15.3	28.5	172
Max.	344.1	516.2	234.7	229.7	339.3	340.0	991.3	555.1	418.7	373.2	355.5	313.6	287.1	1,736

* : Interpolated from runoff data of Apiúna

Table III.3.3 Monthly Mean Discharges at Apiúna

Year	Monthly Mean Discharges (cms)													Annual Runoff
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	(mm)
1941	129.6	185.5	165.3	*67.4	115.9	174.9	*77.8	235.4	131.1	157.7	218.8	129.7	148.8	496
1942	67.6	247.6	147.7	165.0	126.4	151.0	119.3	124.5	105.4	91.4	46.6	59.7	120.0	400
1943	51.3	75.4	*35.1	*27.8	70.1	265.6	172.4	435.1	212.4	132.5	*100.8	58.0	136.7	456
1944	153.6	66.4	138.9	45.3	26.0	28.8	28.7	28.4	45.7	39.0	80.5	30.4	59.4	198
1945	15.0	117.5	49.0	34.5	19.0	25.3	63.9	29.5	70.5	85.4	31.0	39.0	47.8	159
1946	114.0	374.1	285.1	112.3	87.7	243.7	299.3	174.5	108.3	174.9	83.3	112.3	179.7	599
1947	90.0	200.8	120.9	42.7	50.9	87.0	96.6	160.0	399.2	334.9	149.1	138.8	155.4	518
1948	131.6	211.4	204.7	170.1	369.8	102.0	165.1	429.0	94.9	88.7	113.0	37.2	176.9	590
1949	54.5	25.7	61.1	127.7	52.0	145.1	53.6	122.2	140.0	82.6	44.8	42.3	79.4	265
1950	153.4	133.2	198.8	59.3	65.3	57.4	47.0	133.4	101.6	319.8	72.1	90.9	119.7	399
1951	163.7	333.8	213.8	65.7	37.7	33.6	54.7	24.2	24.7	312.3	134.5	*75.8	121.8	406
1952	*99.5	69.3	*34.1	25.8	20.3	83.0	111.3	46.0	220.1	301.1	208.5	81.4	108.3	361
1953	130.5	156.4	86.4	46.2	43.1	36.7	40.2	40.4	110.0	240.9	284.1	110.4	110.0	367
1954	116.9	117.7	213.4	107.9	308.1	245.8	347.3	107.3	290.6	567.7	97.6	57.4	215.9	720
1955	48.8	74.3	86.4	102.7	216.5	188.5	392.8	173.8	235.5	79.8	65.9	115.7	149.0	497
1956	191.9	196.8	83.8	149.5	219.3	95.9	90.4	145.5	340.4	185.3	94.1	72.4	155.1	517
1957	92.4	98.4	118.7	122.6	113.9	120.3	406.6	883.9	739.1	273.1	151.6	84.4	268.3	894
1958	73.9	139.9	374.3	99.4	64.5	182.9	86.3	185.1	315.8	238.8	191.9	219.0	181.1	604
1959	116.3	157.3	77.0	122.7	120.4	66.9	50.3	109.2	295.5	100.7	51.1	50.2	109.1	364
1960	49.9	130.7	117.6	93.1	56.7	52.6	31.2	265.6	142.6	232.1	290.1	131.4	132.7	442
1961	107.5	175.8	245.8	109.6	70.5	92.0	80.8	38.4	562.9	516.6	537.6	257.8	232.4	775
1962	103.1	107.7	151.9	60.6	117.0	78.3	108.3	60.0	237.3	184.4	135.8	71.6	118.0	393
1963	225.7	403.4	366.2	124.8	50.9	33.6	40.2	48.2	216.9	478.4	345.8	179.9	208.2	694
1964	*57.3	112.5	71.7	93.2	132.7	72.6	81.5	125.2	185.8	148.5	67.4	67.4	101.2	337
1965	56.1	38.6	84.4	80.8	234.6	86.9	215.5	294.0	297.1	230.0	198.6	370.4	183.6	612
1966	256.4	810.1	289.1	155.3	110.2	230.4	138.5	115.6	339.8	287.9	183.6	225.7	257.8	859
1967	165.6	329.6	244.6	105.4	65.5	119.8	105.7	104.5	302.2	186.3	173.4	216.9	175.4	585
1968	70.2	48.9	*36.7	51.6	26.7	31.9	44.5	24.7	92.7	86.6	131.4	116.6	63.5	212
1969	236.3	310.1	184.9	368.7	101.7	297.1	205.1	104.0	124.8	94.0	136.7	71.3	184.7	616
1970	130.1	103.8	108.3	73.7	83.2	239.2	219.6	142.8	169.2	151.7	59.5	183.9	139.1	464
1971	442.1	261.3	350.3	301.1	263.2	339.9	292.4	*128.4	144.5	168.0	53.8	41.8	232.2	774
1972	73.0	332.3	168.1	126.5	43.5	145.2	143.8	502.4	464.0	341.6	200.0	189.8	226.9	756
1973	202.3	201.3	116.6	100.1	178.9	319.1	293.7	563.7	463.5	192.7	133.5	118.8	240.5	802
1974	248.2	248.9	298.8	97.5	56.7	98.0	186.4	80.9	219.1	85.7	*101.3	48.1	146.8	489
1975	103.2	80.7	180.7	73.2	82.6	111.1	81.5	232.8	503.9	508.1	180.7	474.3	218.9	730
1976	274.5	121.4	219.9	96.9	229.2	350.1	158.0	345.9	199.0	145.2	139.3	317.7	217.2	724
1977	378.4	293.3	198.6	177.6	67.6	50.1	70.8	349.0	137.0	454.3	286.5	135.1	216.5	722
1978	112.2	94.9	147.9	42.3	31.1	41.1	94.8	76.9	178.9	109.0	139.0	212.5	106.9	356
1979	83.3	49.7	56.3	80.4	317.0	101.8	109.0	104.3	154.2	593.4	302.5	258.9	185.6	619
1980	175.0	98.3	286.7	108.0	100.7	94.2	334.2	502.6	412.5	245.8	213.8	575.4	263.8	879
1981	278.2	194.8	79.9	67.2	54.3	48.7	56.8	56.8	101.7	114.4	117.1	193.4	113.3	378
1982	78.5	272.6	153.9	88.0	70.9	183.1	249.4	171.1	102.1	291.7	595.9	262.7	209.1	697
1983	303.4	318.2	445.7	204.0	597.8	544.5	1764.1	624.4	409.3	233.0	184.0	293.8	496.7	1,656
1984	164.4	119.9	171.0	132.6	161.6	326.9	260.2	852.5	245.7	271.1	278.3	141.8	261.4	871
1985	88.3	298.7	141.5	200.7	95.3	52.8	94.2	42.5	78.4	72.9	119.1	25.3	107.5	358
1986	35.9	120.1	90.8	90.7	49.5	74.6	46.4	67.9	118.0	189.7	278.1	343.4	125.3	418
1987	351.2	294.1	91.5	84.4	374.5	237.6	172.3	208.1	129.3	372.1	100.9	74.8	207.6	692
1988	92.5	113.9	87.4	90.6	389.5	213.3	92.6	51.1	121.9	160.6	68.5	45.2	127.4	425
1989	267.5	295.4	178.4	201.4	321.7	75.2	111.9	118.9	411.9	146.0	77.9	70.3	188.8	629
1990	567.1	276.9	205.1	217.0	184.7	556.9	391.1	291.7	302.4	562.8	367.9	153.2	340.0	1,133
Mean	155.4	192.8	165.3	111.8	136.9	152.7	179.6	205.6	231.0	233.2	168.3	149.5	173.4	578
Min.	15.0	25.7	34.1	25.8	19.0	25.3	28.7	24.2	24.7	39.0	31.0	25.3	47.8	159
Max.	567.1	810.1	445.7	368.7	597.8	556.9	1764.1	883.9	739.1	593.4	595.9	575.4	496.7	1,656

* : Interpolated from runoff data of Rio do Sul

Table III.3.4 Annual Maximum Peak Flood Discharges At Rio do Sul and Apiuna

	Rio do Sul			Apiuna		
Year	Date		Discharge (cu.m/sec)	Date		Discharge (cu.m/sec)
1934	-		-	Feb.	25	1,111
1935	-		-	Sep.	24	1,914
1936	-		-	Aug	6	1,507
1937	-		-	Oct.	16	950
1938	-		-	Jun.	27	1,111
1939	-		-	Nov	26	1,742
1940	-		-	Aug	26	1,033
1941	-		-	Nov	17	918
1942	Mar	31	465	Feb.	8	881
1943	Aug	2	1,090	Aug	3	1,960
1944	Mar	14	324	Mar	14	495
1945	Feb.	19	270	Feb.	20	566
1946	Aug	29	801	Aug	29	1,280
1947	Oct.	26	645	Sep.	2	1,100
1948	Aug	2	1,080	May	17	2,250
1949	Jun.	12	338	Apr.	3	702
1950	Oct.	17	992	Oct.	17	1,680
1951	Oct.	19	675	Oct.	19	1,260
1952	Sep.	7	518	Sep.	7	909
1953	Oct.	31	780	Nov	1	1,620
1954	Oct.	22	1,470	Oct.	22	2,630
1955	Jul.	7	846	May	19	1,890
1956	Jan.	31	730	Sep.	20	881
1957	Aug	19	1,190	Aug	18	3,090
1958	Mar	19	666	Mar	19	1,220
1959	Sep.	5	535	Sep.	2	936
1960	Aug	18	682	Aug	18	1,240
1961	Nov	3	1,020	Nov	2	2,160
1962	Sep.	20	801	Sep.	20	1,550
1963	-		-	Sep.	29	1,750
1964	-		-	May	2	648
1965	-		-	Aug	21	1,460
1966	Feb.	16	1,180	Feb.	17	1,830
1967	Sep.	22	441	Feb.	26	859
1968	Dec	25	532	Dec	25	562
1969	Feb.	19	750	Apr.	5	1,730
1970	Jul.	2	637	Jul.	2	1,020
1971	Jun.	9	1,000	Jun.	9	2,030
1972	Aug	28	1,210	Aug	28	2,210
1973	Jul.	22	1,120	Aug	29	2,310
1974	Feb.	25	458	Sep.	1	951
1975	Oct.	3	1,050	Oct.	3	2,760
1976	Aug	10	638	May	29	1,575
1977	Aug	18	969	Aug	17	1,764
1978	Dec	26	750	Dec	26	2,156
1979	Oct.	9	668	May	9	1,847
1980	Dec	21	1,290	Dec	21	3,086
1981	Jan.	1	432	Dec	23	927
1982	Nov	15	677	Nov	15	1,539
1983	Jul.	12	2,560	Jul.	12	4,327
1984	Aug	7	2,370	Aug	7	4,314
1985	-		-	Feb.	15	836
1986	Nov	6	823	Nov	6	1,307
1987	May	15	703	May	21	1,297
1988	-		499	-		1,297
1989	-		720	-		1,450

Note : Figures are based on the observed values twice a day at the gauge sites

Table III.3.5 Quality of River Water at Rio do Sul

	Items	Unit	1986		1987				1988	1989	
			Apr. 7	Jun. 17	Jan.19	Apr.22	Jul.15	Oct.19	Jan.18	Jan.12	Apr.18
(1)	Alcalinity	mg/l	22.1	23	9	17	15	10	13	42	27
(2)	Aldrin	Ug/l	ND	ND	ND	ND	ND	ND	ND	-	-
(3)	Detergent	mg/l	0.05	0.01	0.05	0.03	0.1	0.02	0.02	-	-
(4)	Cadmium	mg/l	0.005	ND	-	0.001	-	ND	ND	ND	ND
(5)	Carbonate	mg/l	-	-	-	-	-	-	-	-	-
(6)	Lead	mg/l	0.02	0.01	-	0.02	0.01	ND	10	ND	ND
(7)	Fecal Coliform	NMP/100 ml	35	93	2400	1100	-	460	15	540000	160000
(8)	Total Coliform	NMP/100	-	-	-	-	-	460	-	540000	160000
(9)	Conductivit	UMHO/cm	-	78	35.3	59.1	49.1	39.2	48.4	-	0.047
(10)	Colour	mgPt/l	312	90	250	45	130	175	175	23.3	25
(11)	BOD	mg/l	-	-	0.7	0.8	2.6	1.8	2	78.7	30
(12)	COD	mg/l	18	18.8	6.1	9.3	14.1	15.7	10.4	-	-
(13)	Hardness	mg/l	15.3	18	11	18	25	16	14	-	-
(14)	Phenol	mg/l	ND	0.009	0.011	0.001	0.004	0.003	0.004	ND	0.002
(15)	Phosphate	mg/l	-	0.06	0.05	0.21	0.04	0.12	0.25	0.0023	0.002
(16)	Phosphoric ion	mg/l	0.05	0.35	-	-	-	-	-	-	-
(17)	Mercury	mg/l	0.001	ND	0.031	-	-	0.3	6E-04	ND	ND
(18)	Nitrogen Nitrate	mg/l	0.8	0.9	2.7	2.1	2.7	5	2.1	3.76	0.007
(19)	Nitrogen Nitrite	mg/l	0.02	0.074	0.013	0.052	0.036	0.026	0.047	0.035	ND
(20)	Nitrogen Ammonium	mg/l	0.4	0.1	-	0.4	0.1	0.1	0.2	0.56	ND
(21)	Oil and	mg/l	6	11.3	10	12.7	10	11.7	10	3	7
(22)	DO	mg/l	6	1.4	7.8	5.7	6.6	9.3	6.3	3.7	7.9
(23)	pH		7.6	6.4	6.3	6.6	5.5	7.3	5.9	6	6.9
(24)	Suspended Solid	mg/l	-	9.6	83	110	68.8	21.6	210.8	60	32
(25)	Total Solid	mg/l	55	-	-	-	-	-	-	-	-
(26)	Water Temperature	°C	-	17.5	24	21	19	17	26.5	21	22
(27)	Air Temperature	°C	-	16.5	27	25	25	19	28	24	25
(28)	Turbidity	UFT	67	24	154	20	88	111	150	50	12

Note : ND ; not detected

Table III.4.1 Basin Mean Monthly Rainfall at Rio do Sul

Year	Month												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1946	198	266	227	44	137	167	117	128	24	157	69	143	1,676
1947	143	194	91	43	81	111	71	148	240	181	54	161	1,517
1948	123	165	136	111	239	4	170	160	43	120	76	33	1,381
1949	104	54	133	129	39	111	48	132	119	72	37	188	1,165
1950	153	119	195	57	88	49	43	160	108	181	56	177	1,386
1951	196	226	98	67	41	55	59	4	69	296	153	96	1,359
1952	188	93	62	16	85	143	116	22	162	209	106	141	1,341
1953	162	124	97	62	69	15	72	62	108	241	76	113	1,200
1954	132	173	100	98	155	130	174	27	196	206	7	84	1,480
1955	125	133	91	120	120	100	223	67	79	75	78	114	1,324
1956	265	147	123	116	112	85	88	90	185	121	32	146	1,510
1957	172	95	122	140	53	117	240	340	268	114	52	89	1,800
1958	111	228	192	60	86	130	71	150	168	193	164	160	1,711
1959	115	173	90	173	78	58	35	127	159	72	76	103	1,259
1960	92	140	127	79	72	65	42	219	78	144	169	100	1,327
1961	136	200	169	97	47	79	52	32	406	251	255	158	1,881
1962	97	144	156	99	145	76	122	54	179	126	93	74	1,363
1963	326	200	203	32	31	26	55	73	252	174	151	72	1,595
1964	80	136	97	140	55	74	72	108	136	125	47	104	1,172
1965	67	73	109	153	105	56	133	156	178	98	120	239	1,487
1966	229	363	138	67	68	173	38	115	135	168	67	144	1,705
1967	189	191	125	78	59	101	64	92	234	128	134	115	1,509
1968	133	49	133	69	20	63	60	40	141	118	83	179	1,088
1969	212	240	175	156	61	150	72	94	94	83	125	41	1,502
1970	159	146	131	44	110	183	72	113	85	89	36	206	1,371
1971	243	191	194	160	118	134	110	98	117	86	54	58	1,563
1972	164	286	146	52	27	189	117	291	175	138	98	118	1,801
1973	210	129	112	93	118	172	121	285	153	70	98	162	1,722
1974	224	182	107	41	41	128	97	59	111	94	82	109	1,275
1975	106	128	149	22	89	85	51	154	260	167	144	226	1,579
1976	215	73	171	41	205	99	143	142	82	140	108	233	1,653
1977	312	159	150	75	43	44	70	253	73	206	197	75	1,656
1978	172	93	141	1	34	84	122	52	120	116	107	214	1,255
1979	43	129	55	129	200	43	78	69	128	299	142	186	1,499
1980	157	85	218	61	89	82	190	200	155	180	92	311	1,821
1981	165	72	86	103	27	57	91	63	111	95	78	152	1,099
1982	56	325	131	24	85	152	87	129	37	221	260	130	1,636
1983	231	237	113	159	279	160	614	126	173	92	168	262	2,615
1984	173	135	121	95	106	158	133	325	131	125	170	104	1,776
1985	92	265	124	120	58	22	97	43	88	100	104	27	1,140
1986	156	167	67	104	118	28	53	80	114	159	217	205	1,468
1987	236	201	45	114	233	104	117	112	60	241	53	95	1,610
1988	168	134	56	163	180	90	10	9	107	117	66	95	1,193
1989	256	132	118	129	152	29	113	72	223	78	126	88	1,515
1990	333	225	178	140	143	181	207	135	163	231	169	103	2,207
Mean	169	165	129	91	100	97	109	120	143	149	108	136	1,515
Max.	333	363	227	173	279	189	614	340	406	299	260	311	2,615
Min.	43	49	45	1	20	4	10	4	24	70	7	27	1,088

Table III.4.2 Basin Mean Monthly Rainfall at Damsite

Year	Month												Total
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	
1946	200	263	228	44	132	168	119	129	26	159	67	140	1,674
1947	142	198	93	43	82	109	74	142	236	180	54	160	1,514
1948	131	164	138	108	240	4	170	158	44	119	77	35	1,388
1949	103	56	137	130	38	111	47	132	117	71	40	182	1,163
1950	158	120	195	60	89	49	42	159	109	184	56	172	1,391
1951	195	221	96	65	40	54	60	4	68	299	149	95	1,347
1952	184	88	64	17	81	146	112	22	164	208	107	140	1,333
1953	167	127	101	61	71	15	72	62	107	237	74	110	1,204
1954	137	176	101	99	158	129	174	28	193	206	7	88	1,496
1955	124	143	89	119	122	102	218	67	81	74	78	120	1,336
1956	262	144	125	116	113	83	87	89	189	119	33	141	1,501
1957	177	97	122	140	55	118	237	335	270	114	53	94	1,811
1958	104	228	193	60	85	130	69	145	165	188	159	161	1,686
1959	112	172	88	169	77	56	35	127	157	70	76	102	1,240
1960	93	141	126	78	74	64	40	217	77	145	168	98	1,319
1961	130	191	165	93	47	79	50	32	401	243	250	163	1,844
1962	97	147	153	95	143	73	120	53	174	127	91	76	1,348
1963	322	194	201	31	30	26	55	72	247	178	152	73	1,579
1964	78	132	95	138	53	74	72	104	131	125	49	101	1,152
1965	78	74	105	150	107	56	130	151	174	97	120	238	1,479
1966	231	357	133	68	69	172	36	113	136	167	69	149	1,699
1967	183	190	124	74	57	103	68	88	228	123	138	113	1,487
1968	133	48	128	69	20	61	58	40	136	119	80	177	1,070
1969	214	232	176	153	62	156	71	93	95	83	124	44	1,504
1970	158	142	135	42	109	185	74	113	86	90	38	213	1,382
1971	237	188	192	161	116	134	108	99	118	86	56	60	1,553
1972	159	280	150	50	25	182	116	288	176	133	97	119	1,774
1973	212	124	109	95	116	171	121	283	153	70	96	156	1,706
1974	227	176	113	41	39	126	99	57	108	95	82	107	1,268
1975	106	132	146	22	87	85	52	153	256	167	145	224	1,576
1976	206	71	174	42	205	101	144	139	82	137	105	225	1,631
1977	300	152	153	77	42	45	70	248	71	209	194	74	1,633
1978	172	93	142	1	34	82	122	51	119	116	113	213	1,256
1979	40	128	54	131	202	43	77	69	128	297	142	185	1,495
1980	157	91	214	64	88	82	193	196	154	180	95	308	1,820
1981	165	75	84	101	27	55	91	61	107	99	79	160	1,102
1982	55	318	129	25	84	152	86	127	36	219	258	128	1,617
1983	229	234	112	156	277	159	599	124	175	97	162	256	2,578
1984	179	141	123	97	103	158	131	323	129	124	168	104	1,780
1985	91	261	118	122	58	22	97	41	90	98	101	30	1,128
1986	153	169	68	104	115	28	53	80	114	157	216	203	1,460
1987	236	199	45	114	233	106	115	111	60	242	51	97	1,609
1988	167	133	57	161	182	90	9	9	112	118	64	93	1,194
1989	257	132	116	130	149	29	114	72	220	77	123	92	1,512
1990	342	219	176	137	142	183	204	136	161	231	174	103	2,207
Mean	169	164	129	90	99	97	109	119	142	148	107	136	1,508
Max.	342	357	228	169	277	185	599	335	401	299	258	308	2,578
Min.	40	48	45	1	20	4	9	4	26	70	7	30	1,070

Table III.4.3 Monthly Discharges at Damsite

Year	Monthly Mean Discharges (cms)													Annual Runoff
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Mean	(mm)
1941	83.2	139.9	128.7	43.5	81.3	115.8	50.3	163.9	90.9	95.3	137.9	77.3	100.4	566
1942	38.4	125.7	86.4	91.8	72.7	72.4	64.0	70.3	67.7	58.8	26.5	34.5	67.0	378
1943	30.3	51.4	22.7	17.9	55.0	185.4	115.6	291.9	138.0	89.0	65.1	36.6	91.8	518
1944	109.4	41.2	100.5	31.8	18.6	21.4	22.0	16.8	26.4	27.8	49.6	16.3	40.2	227
1945	9.0	62.1	28.7	23.1	10.5	16.5	30.6	21.7	55.4	62.9	18.9	28.6	30.4	172
1946	80.2	212.4	160.2	58.3	57.1	137.2	183.0	115.4	67.7	104.0	52.3	62.5	107.0	603
1947	58.3	131.9	79.6	26.7	31.5	52.2	61.5	95.4	244.2	214.1	94.7	82.4	97.4	549
1948	66.7	122.6	114.9	94.5	234.8	57.5	114.3	294.9	56.7	52.7	67.7	23.0	108.7	613
1949	33.3	16.8	38.1	67.2	30.1	87.5	36.5	81.4	100.8	61.7	28.1	27.9	50.8	287
1950	93.7	79.5	110.0	32.9	41.5	34.2	30.8	106.8	71.6	208.9	43.0	61.6	76.5	431
1951	122.9	231.1	134.1	40.0	22.2	20.5	34.8	14.9	15.7	188.1	83.7	48.9	78.9	445
1952	64.2	48.0	22.0	17.8	11.8	57.7	85.4	32.6	146.2	190.0	146.0	50.4	72.6	409
1953	69.1	102.0	55.3	26.9	22.9	18.3	23.6	22.9	67.7	136.3	177.4	76.8	66.2	374
1954	69.8	62.9	112.4	73.0	171.9	154.5	230.2	64.7	177.4	398.3	58.2	25.9	134.0	756
1955	29.8	48.3	52.8	68.1	124.6	102.6	257.0	109.6	137.1	50.3	42.1	72.9	91.7	517
1956	133.1	142.6	54.3	109.0	123.8	55.8	51.2	87.8	228.4	131.7	63.0	53.4	102.5	578
1957	57.4	55.1	71.4	75.9	70.4	51.1	214.1	592.4	446.8	179.6	85.3	46.9	163.1	919
1958	41.8	65.6	212.3	51.3	32.1	86.4	49.0	117.1	214.4	161.9	141.3	117.8	107.8	608
1959	60.9	106.5	48.5	84.2	73.8	38.9	27.7	56.6	173.2	57.8	25.8	29.7	64.8	365
1960	28.8	77.6	76.5	63.7	30.7	26.4	15.0	151.6	97.0	135.5	163.7	84.8	79.2	447
1961	68.5	120.4	156.2	76.3	39.2	46.4	49.5	22.0	366.8	331.4	375.0	158.3	150.4	848
1962	70.4	66.4	84.5	37.3	91.5	54.5	75.6	40.9	148.8	103.7	83.5	48.7	75.5	426
1963	137.8	246.3	223.6	76.2	35.5	20.5	24.5	29.4	168.1	292.1	211.1	73.8	127.4	718
1964	37.0	58.9	38.9	56.9	81.0	44.3	49.8	76.5	113.4	90.6	41.1	41.1	60.8	343
1965	34.2	23.6	51.5	49.3	143.2	53.0	131.5	172.0	205.1	140.4	121.2	182.0	109.6	618
1966	152.4	550.9	176.5	85.9	65.6	119.0	71.3	68.4	187.7	144.9	90.5	134.9	151.1	852
1967	97.6	196.1	125.5	55.2	40.3	67.9	64.5	73.6	201.5	116.8	105.9	108.8	103.7	585
1968	42.9	21.1	23.7	20.9	11.0	15.9	25.0	10.9	63.0	53.2	88.1	79.4	37.9	214
1969	158.2	220.2	124.1	245.2	47.4	140.2	100.9	47.7	58.8	44.6	91.5	35.7	108.4	611
1970	74.0	65.9	67.6	42.2	51.8	130.0	122.9	84.5	101.7	79.2	36.3	112.3	80.9	456
1971	244.7	159.5	241.4	182.3	160.7	207.5	175.1	82.9	100.4	94.6	27.5	17.8	141.2	796
1972	45.1	231.0	94.4	65.2	26.7	95.0	78.6	337.2	265.8	184.8	129.3	112.2	138.3	780
1973	121.0	129.6	70.4	61.1	107.2	167.4	199.5	339.0	271.2	98.7	76.8	59.4	141.8	800
1974	128.4	141.3	153.3	44.4	34.6	52.2	81.8	41.1	119.0	52.3	65.4	28.8	78.1	441
1975	64.4	48.7	132.3	44.7	49.2	63.9	42.9	139.3	358.2	300.0	95.5	294.7	136.8	772
1976	183.6	67.6	133.9	47.3	130.1	189.3	84.3	219.8	118.7	84.8	68.2	193.9	127.3	718
1977	291.0	262.4	129.6	90.8	47.3	30.5	38.3	273.5	93.9	297.1	219.3	81.1	154.2	869
1978	84.0	63.3	85.4	25.5	17.5	21.9	52.4	41.4	112.3	69.6	87.2	118.5	65.0	366
1979	53.6	30.8	41.5	50.6	171.7	65.6	65.1	72.0	87.5	376.2	184.4	169.9	114.9	648
1980	109.3	54.9	197.8	64.0	67.0	58.7	171.6	335.6	270.4	160.9	134.1	334.7	164.2	926
1981	186.6	117.3	49.0	43.1	33.4	33.1	46.0	35.9	74.4	72.9	64.3	102.3	71.3	402
1982	45.8	202.7	105.3	57.3	43.4	93.8	131.7	104.5	61.3	177.9	379.4	149.0	128.5	725
1983	203.4	197.3	250.5	140.7	362.1	361.0	1058.0	384.9	230.9	142.2	133.0	191.0	306.4	1,728
1984	117.8	80.4	112.8	92.7	117.5	219.6	189.5	543.2	169.8	192.2	191.5	106.0	178.4	1,006
1985	61.9	238.5	103.8	118.7	62.4	36.0	63.4	29.8	51.3	54.4	96.4	16.3	76.4	431
1986	23.6	88.9	52.7	44.6	32.8	50.9	30.0	43.4	74.4	134.0	206.9	209.9	82.5	465
1987	248.6	207.7	60.9	59.3	249.4	135.4	119.6	147.2	89.0	274.4	72.4	51.0	143.0	806
1988	61.7	82.0	73.0	78.5	239.2	135.3	62.2	33.4	84.3	86.0	41.5	29.1	83.8	473
1989	181.7	178.7	102.7	115.7	212.5	44.5	60.6	68.0	269.4	89.9	52.2	49.3	118.3	667
1990	367.3	207.8	142.4	154.8	101.1	362.9	243.4	181.8	214.1	353.4	263.4	92.3	223.6	1,261
Mean	99.5	125.7	102.3	68.5	83.8	90.2	108.1	131.8	147.1	146.0	108.1	88.8	108.2	610
Min.	9.0	16.8	22.0	17.8	10.5	15.9	15.0	10.9	15.7	27.8	18.9	16.3	30.4	172
Max.	367.3	550.9	250.5	245.2	362.1	362.9	1058.0	592.4	446.8	398.3	379.4	334.7	306.4	1,728

Table III.5.1 Annual Maximum Basin Mean Rainfall at the Damsite

Year	1 day Date	1 day Rainfall Amount (mm)	2 days Date	2 days Rainfall Amount (mm)	3 days Date	3 days Rainfall Amount (mm)	4 days Date	4 days Rainfall Amount (mm)
1946	Dec. 11	58	Aug. 28 - 29	72	Aug. 27 - 29	90	Aug. 26 - 29	93
1947	Oct. 25	46	Oct. 24 - 25	69	Oct. 23 - 25	72	Oct. 23 - 26	74
1948	May 17	98	May 16 - 17	126	May 16 - 18	130	May 16 - 19	150
1949	Dec. 28	47	Dec. 28 - 29	83	Dec. 27 - 29	90	Dec. 27 - 30	95
1950	Aug. 13	48	Mar. 2 - 3	79	Mar. 1 - 3	110	Mar. 1 - 4	122
1951	Oct. 18	61	Oct. 18 - 19	77	Oct. 17 - 19	94	Oct. 15 - 18	109
1952	Jan. 23	49	Jan. 23 - 24	81	Jan. 23 - 25	99	Jan. 23 - 26	103
1953	Oct. 31	51	Oct. 30 - 31	56	Oct. 29 - 31	90	Oct. 28 - 31	104
1954	Oct. 21	87	Oct. 21 - 22	108	Oct. 19 - 21	111	Oct. 18 - 21	111
1955	May 18	47	May 18 - 19	88	May 17 - 19	100	May 16 - 19	105
1956	Dec. 6	47	Dec. 5 - 6	49	Jan. 17 - 19	55	Jan. 17 - 20	66
1957	Aug. 18	58	Aug. 17 - 18	113	Aug. 17 - 19	132	Aug. 16 - 19	140
1958	Mar. 14	57	Mar. 14 - 15	77	Mar. 14 - 16	113	Mar. 14 - 17	124
1959	Apr. 26	53	Apr. 25 - 26	54	Aug.31-Sep.2	62	Aug.30-Sep.2	81
1960	Aug. 18	46	Aug. 17 - 18	61	Jul.31-Aug.2	72	Jul.31-Aug.3	86
1961	Sep. 11	64	Sep. 11 - 12	98	Sep. 10 - 12	122	Sep. 9 - 12	156
1962	May 21	42	May 20 - 21	66	May 20 - 22	82	May 19 - 22	83
1963	Nov. 10	51	Sep. 26 - 27	96	Sep. 26 - 28	133	Sep. 25 - 28	158
1964	Oct. 26	35	Feb. 1 - 2	43	Jan.31-Feb.2	49	Jan.31-Feb.3	51
1965	Aug. 20	40	Aug. 19 - 20	68	Aug. 18 - 20	88	Aug. 17 - 20	96
1966	Feb. 9	62	Feb. 9 - 10	71	Feb. 15 - 17	83	Feb. 9 - 12	126
1967	Dec. 3	28	Sep. 20 - 21	44	Sep. 19 - 21	59	Sep. 18 - 21	79
1968	Dec. 24	48	Dec. 23 - 24	80	Dec. 23 - 25	107	Dec. 22 - 25	131
1969	Mar. 20	44	Feb. 18 - 19	75	Feb. 17 - 19	98	Feb. 16 - 19	130
1970	Aug. 23	38	Jun. 6 - 7	54	Jun. 5 - 7	58	Jun. 4 - 7	59
1971	Jul. 4	49	Jul. 3 - 4	64	Jul. 2 - 4	78	Jul. 2 - 5	87
1972	Aug. 26	69	Aug. 25 - 26	118	Aug. 25 - 27	135	Aug. 25 - 28	166
1973	Jul. 22	59	Jul. 21 - 22	87	Jun. 23 - 25	105	Jun. 22 - 25	107
1974	Jan. 9	44	Jan. 8 - 9	70	Jan. 8 - 10	82	Jan. 8 - 11	85
1975	Oct. 2	58	Sep. 11 - 12	79	Sep. 10 - 12	84	Sep. 9 - 12	91
1976	Jan. 13	49	Jan. 12 - 13	70	Jan. 11 - 13	93	Jan. 10 - 13	105
1977	Aug. 17	73	Aug. 16 - 17	131	Aug. 16 - 18	161	Aug. 15 - 18	164
1978	Dec. 26	107	Dec. 25 - 26	124	Dec. 25 - 27	125	Dec. 25 - 28	125
1979	May 9	93	May 8 - 9	101	May 7 - 9	110	May 7 - 10	112
1980	Jul. 30	83	Dec. 20 - 21	140	Dec. 19 - 21	151	Dec. 19 - 22	160
1981	Dec. 22	58	Dec. 21 - 22	79	Dec. 21 - 23	98	Dec. 21 - 24	99
1982	Nov. 5	50	Nov. 5 - 6	79	Nov. 4 - 6	94	Nov. 3 - 6	108
1983	Sep. 23	80	Jul. 7 - 8	121	Jul. 6 - 8	173	Jul. 7 - 10	216
1984	Aug. 6	98	Aug. 6 - 7	175	Aug. 5 - 7	216	Aug. 5 - 8	226
1985	Feb. 12	42	Feb. 12 - 13	67	Feb. 12 - 14	108	Feb. 12 - 15	121
1986	Nov. 6	59	Nov. 5 - 6	69	Nov. 4 - 6	106	Nov. 3 - 6	121
1987	Jan. 14	56	Jan. 13 - 14	80	Jan. 12 - 14	89	Jan. 11 - 14	115
1988	Apr. 13	40	Sep. 21 - 22	53	Sep. 20 - 22	54	Sep. 20 - 23	56
1989	Sep. 12	52	May 4 - 5	82	May 4 - 6	99	May 3 - 6	108
1990	Feb. 13	47	Feb. 12 - 13	78	Jul. 18 - 20	108	Jul. 18 - 21	130

Tabe III.5.2 Probable Basin Mean Rainfall at the Damsit

(unit : mm)

Return Period	Duration			
(year)	1 days	2 days	3 days	4 days
2	55	80	100	110
5	75	105	130	145
10	85	125	150	170
20	95	140	170	190
50	110	165	195	220
100	120	180	215	245
200	130	195	235	265
500	145	220	260	295
1000	155	235	280	315
10000	190	290	345	390

Table III.6.1 River Water Sediment Concentration Survey Record

Sampling Location : Suspension Bridge at Lontras

No.	Sampling Date (1993)	Sediment Concentration (mg/lit) Left		Center		Right		Average		Flow Disch. at Bridge (cms)	Daily Sediment Yield, Estimated (ton/day)	
1	June 15	<120		<120		<120		<120		84	-	
2	June 16	"		"		"		<120		83	-	
3	June 17	"		"		"		<120		82	-	
4	June 18	120		"		"		<120		90	-	
5	June 21	<120		"		"		<120		84	-	
6	June 22	"		"		"		<120		83	-	
7	June 23	"		"		"		<120		79	-	
8	June 24	"		"		"		<120		76	-	
9	June 25	"		"		"		<120		76	-	
10	June 28	"		"		"		<120		72	-	
11	July 14	120		600		120		280		192	5568	
12	July 15	360		120		120		200		164	3396	
13	July 16	<120		<120		240		<160		140	-	
14	July 19	720		600		480		600		271	16884	
15	July 20	120		480		120		320		217	7188	
16	July 21	120		240		120		160		181	3000	
17	July 22	120		240		120		160		148	2460	
18	July 23	<120		240		<120		<160		119	-	
19	July 26	<120	(2.5)	120	(10.5)	<120	(100.0)	<120	(37.7)	99	-	(388)
20	July 27	<120	(51.0)	120	(6.5)	<120	(2.5)	<120	(20.0)	92	-	(192)
21	July 28	<120	(19.0)	240	(21.5)	<120	(4.0)	<160	(14.8)	91	-	(141)
22	July 29	<120	(24.5)	120	(36.5)	<120	(38.0)	<120	(33.0)	110	-	(378)
23	July 30	360	(52.5)	360	(50.0)	720	(49.5)	480	(50.7)	208	10344	(1091)
24	Aug. 02	<120	(11.0)	120	(2.5)	<120	(3.5)	<120	(5.7)	116	-	(68)
25	Aug. 03	<120	(1.0)	<120	(2.0)	<120	(1.0)	<120	(1.3)	109	-	(15)
						Average (Nos. 19 - 25)			(23.3)	118		(325)

Remarks:

1) Residual Solid Measurement Method: Imhoff Cone Method (NBR 10561)
   ( ) : Filter Method (NBR 10664)
2) Imhoff cone measures volume of sediment. The volume was converted to weight as shown in this table applying the assumed unit weight of 1.2 kg/lit.

Table III.6.2 Monthly Sediment Discharge at Rio do Sul

(unit : thousand ton)

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1941	7.2	15.6	16.7	2.2	6.9	12.5	2.8	31.7	9.8	9.8	21.7	5.9	142.8
1942	1.8	16.5	10.3	8.9	5.6	6.5	4.5	5.3	4.7	3.9	0.8	1.6	70.4
1943	1.4	2.9	0.7	0.4	7.7	29.7	20.9	101.8	16.0	7.6	5.1	1.7	195.9
1944	13.2	1.8	13.3	1.4	0.5	0.7	0.7	0.6	1.0	1.1	3.3	0.4	38.0
1945	0.2	5.5	1.1	1.0	0.2	0.4	1.6	0.6	3.2	5.1	0.5	1.3	20.7
1946	7.7	34.6	23.8	4.0	4.0	23.9	28.2	27.6	5.1	13.3	2.9	5.0	180.1
1947	3.9	15.9	6.6	0.9	1.2	3.5	5.1	9.7	50.2	42.2	9.6	7.2	156.0
1948	5.1	13.5	12.8	10.4	78.4	3.4	18.4	95.8	3.2	3.4	4.8	0.7	249.9
1949	1.7	0.4	2.0	7.0	1.2	9.8	1.6	7.5	10.2	3.9	1.0	1.2	47.5
1950	9.8	5.8	16.6	1.3	2.9	1.4	1.4	17.3	5.8	62.1	2.0	4.4	130.8
1951	13.8	41.7	17.8	1.8	0.6	0.6	1.8	0.3	0.4	43.9	6.7	2.6	132.0
1952	6.1	2.6	0.7	0.5	0.4	5.0	9.5	1.3	24.9	38.3	21.7	2.9	113.9
1953	4.9	11.1	3.5	0.9	0.8	0.5	1.0	1.2	5.7	25.1	38.4	6.6	99.7
1954	6.1	5.9	14.3	6.8	35.1	23.7	42.9	4.3	28.2	174.2	3.8	0.9	346.2
1955	1.1	2.4	3.9	5.0	31.3	12.3	66.4	11.4	23.4	2.9	2.2	7.6	169.9
1956	24.6	18.2	3.4	11.6	16.4	3.4	2.9	7.8	54.2	15.5	4.5	3.8	166.3
1957	3.8	3.3	6.2	8.8	5.4	3.6	49.7	270.7	135.8	37.5	6.7	2.4	533.9
1958	2.2	5.8	54.1	2.9	1.4	9.6	3.0	18.0	40.8	26.7	20.7	12.4	197.6
1959	4.0	10.6	2.7	11.1	6.5	1.8	0.9	4.1	27.5	3.6	0.8	1.2	74.8
1960	1.4	6.5	7.4	6.7	1.4	1.2	0.3	26.6	11.9	23.3	24.4	7.3	118.4
1961	5.2	12.6	31.4	6.3	1.8	2.7	3.0	0.6	123.3	88.5	152.0	24.1	451.5
1962	5.1	4.5	7.9	1.6	16.7	3.2	6.5	2.0	36.9	9.7	7.3	3.0	104.4
1963	29.7	61.8	49.8	6.2	1.5	0.5	1.0	1.2	76.3	64.6	44.1	5.5	342.2
1964	1.6	3.6	1.8	3.8	9.1	2.3	3.0	6.5	11.7	8.2	2.0	2.0	55.6
1965	1.5	0.8	3.2	3.0	22.6	3.0	17.8	47.5	37.2	20.1	15.9	28.8	201.4
1966	19.6	223.2	28.4	6.9	4.5	17.4	5.7	7.4	35.2	18.8	8.4	17.6	393.1
1967	9.4	29.6	16.1	3.4	1.9	4.9	4.5	9.6	33.6	13.1	12.2	13.2	151.5
1968	2.1	0.6	0.8	0.6	0.2	0.5	1.2	0.2	7.4	4.3	9.3	14.4	41.6
1969	28.5	50.6	15.6	68.7	2.5	21.9	10.9	3.3	3.5	2.2	8.7	1.5	217.9
1970	6.5	4.4	5.7	2.2	3.6	16.6	20.1	9.1	10.6	6.9	1.6	16.6	103.9
1971	55.0	19.9	47.4	31.7	27.9	54.3	40.8	6.9	10.2	9.4	0.9	0.4	304.8
1972	3.0	59.9	8.8	4.5	0.9	14.0	6.9	139.9	50.9	32.4	14.2	13.7	349.1
1973	15.0	13.8	5.2	4.4	14.4	36.9	52.9	107.9	52.0	9.1	5.9	3.8	321.3
1974	16.0	19.5	19.6	2.1	1.4	3.1	10.9	2.2	16.8	3.9	5.1	1.1	101.7
1975	4.8	3.0	15.9	2.3	3.5	4.2	2.1	23.1	93.9	86.9	9.4	64.3	313.4
1976	31.4	4.6	16.8	2.4	26.8	31.9	8.5	44.4	14.6	7.8	4.8	36.8	230.8
1977	70.7	54.3	14.9	8.5	2.5	1.1	2.1	89.6	8.0	70.0	41.2	7.0	369.9
1978	7.5	4.0	8.2	0.8	0.4	0.7	4.9	2.2	13.9	7.2	7.7	24.5	82.0
1979	4.4	1.2	2.4	3.2	33.8	4.7	4.6	6.9	8.0	96.5	28.0	25.1	218.8
1980	11.3	3.1	36.1	4.8	4.7	4.5	33.2	90.7	57.7	23.0	17.8	94.3	381.2
1981	33.4	11.4	2.7	2.6	1.3	1.4	3.2	1.7	6.3	5.7	4.6	13.6	87.9
1982	2.7	33.0	11.2	4.3	3.0	10.5	17.4	10.9	4.0	30.4	99.3	19.9	246.6
1983	38.2	30.1	59.9	18.6	97.9	88.3	713.8	142.5	56.2	18.2	15.8	31.3	1310.8
1984	12.2	6.6	12.8	8.0	14.0	53.2	30.0	265.8	29.1	37.3	31.3	11.0	511.3
1985	4.3	48.2	10.8	14.6	4.2	1.4	5.2	1.1	3.0	3.5	13.6	0.4	110.3
1986	0.9	8.2	3.3	2.5	2.6	4.0	1.2	3.2	7.5	22.8	47.5	36.1	139.8
1987	59.0	30.3	3.9	4.1	61.5	18.3	12.6	18.8	7.1	64.9	5.0	3.2	288.7
1988	4.4	6.4	6.7	7.7	45.8	16.4	4.0	1.3	12.4	8.5	1.9	1.1	116.6
1989	34.7	27.0	10.1	14.1	51.6	2.1	5.2	5.3	64.9	7.8	2.9	2.9	228.6
1990	93.9	37.2	17.1	20.8	16.6	104.3	58.5	31.8	36.2	103.0	51.9	8.3	579.6
Mean	14.6	20.7	13.8	7.2	13.7	13.6	27.1	34.5	27.8	28.6	17.0	12.1	230.8

Table III.6.3 Grain Size Distribution of Riverbed Material

Sample No.		1		2		3		4		5		6	
Location		RS-L		RS-R		LO-R		LO-L		RS-L		RS-R	
Sampling Date		Jul. 7		Jul. 7		Jul. 20		Jul. 20		Jul. 23		Jul. 23	
Specific Gravity		2.554		2.520		2.395		2.493		2.518		2.531	
Density (g/cm3)		1.741		1.759		1.987		2.104		1.828		1.628	
		% of Weight Passed		% of Weight Passed		% of Weight Passed		% of Weight Passed		% of Weight Passed		% of Weight Passed	
Sieve (mm)	2.0	100		100		100		100		100		100	
	1.2	-		-		99.75		99.58		99.57		-	
	0.6	99.75		99.47		98.49		97.86		97.56		99.61	
	0.42	99.75		99.04		97.86		92.34		96.09		98.97	
	0.3	96.85		98.70		97.42		87.20		93.88		97.71	
	0.15	82.48		92.89		96.27		78.00		78.40		86.95	
	0.075	67.03		71.12		91.54		71.33		64.26		70.75	
		Grain Size (mm)	% of Smaller Size	Grain Size (mm)	% of Smaller Size	Grain Size (mm)	% of Smaller Size	Grain Size (mm)	% of Smaller Size	Grain Size (mm)	% of Smaller Size	Grain Size (mm)	% of Smaller Size
Densimeter Analysis		0.075	61.1	0.075	65.2	0.077	79.7	0.079	63.3	0.080	51.5	0.076	49.2
		0.055	52.4	0.056	52.9	0.057	65.6	0.058	52.8	0.057	46.1	0.054	45.9
		0.040	48.9	0.040	45.9	0.041	61.8	0.041	48.6	0.042	36.9	0.039	41.0
		0.027	45.4	0.028	38.9	0.029	55.8	0.028	46.5	0.029	33.3	0.027	37.8
		0.020	42.0	0.020	33.6	0.021	49.9	0.020	40.2	0.021	27.8	0.019	34.5
		0.014	40.2	0.015	30.1	0.015	47.9	0.015	36.0	0.015	26.0	0.014	31.5
		0.010	35.0	0.011	26.6	0.011	41.9	0.011	29.7	0.011	20.5	0.010	28.0
		0.007	31.5	0.008	23.0	0.008	36.0	0.008	25.7	0.008	18.6	0.070	24.7
		0.005	28.2	0.006	19.7	0.006	26.2	0.006	21.5	0.006	15.0	0.005	21.2
		0.004	21.8	0.004	15.8	0.004	18.9	0.004	15.8	0.004	11.0	0.004	16.1
		0.003	16.5	0.003	9.7	0.003	14.9	0.003	13.7	0.003	6.8	0.003	12.7
		0.001	14.1	0.002	9.0	0.002	10.1	0.002	8.6	0.002	4.9	0.002	9.3

Remarks: Location RS = Suspension Bridge in Rio do Sul (Sao Cristovao)
LO = Highway Bridge in Lontras

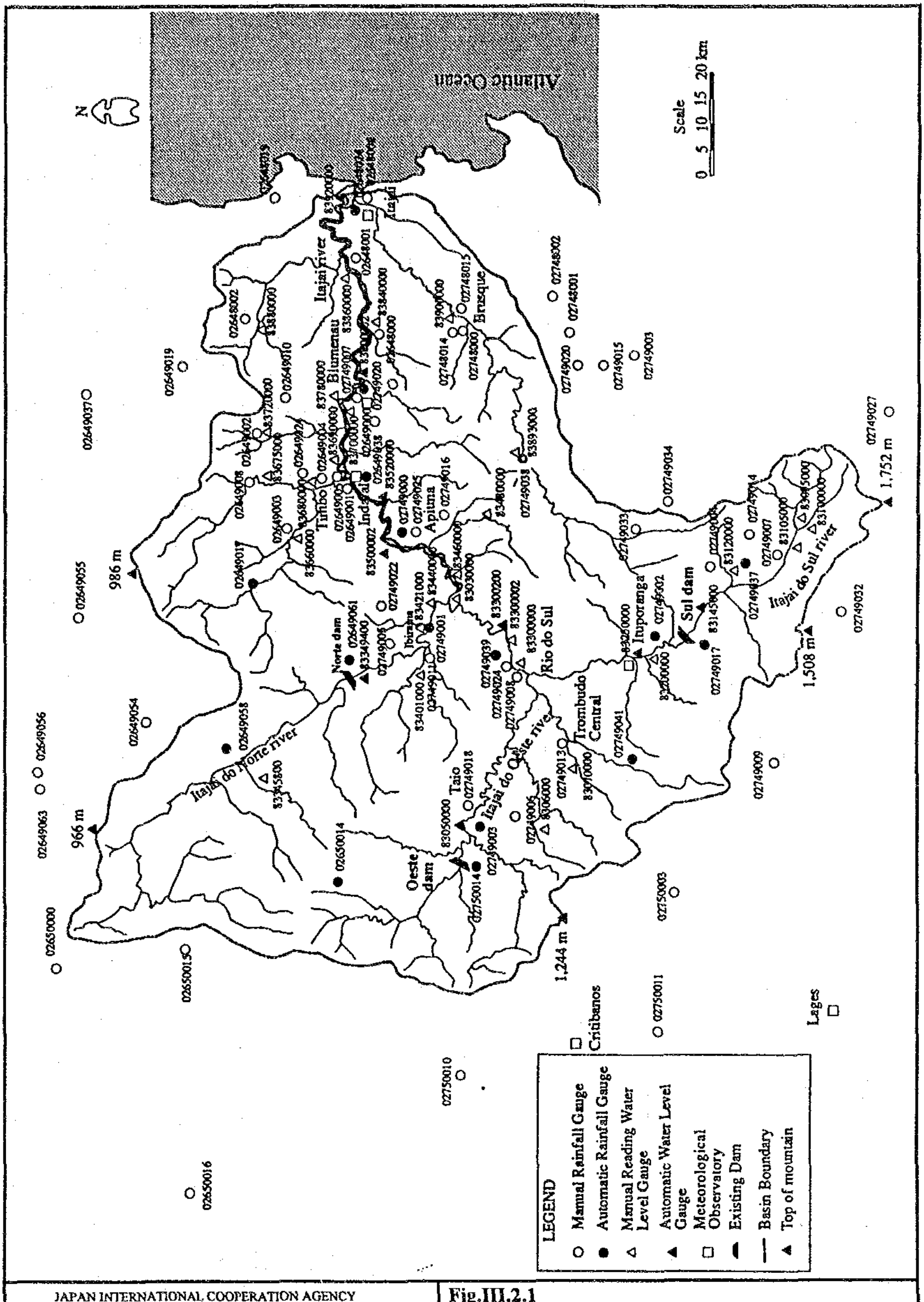
-L = Left Bank Side
-R = Right Bank Side

Table III.7.1 Water Level and Discharge at Damsite and Powerhouse Site

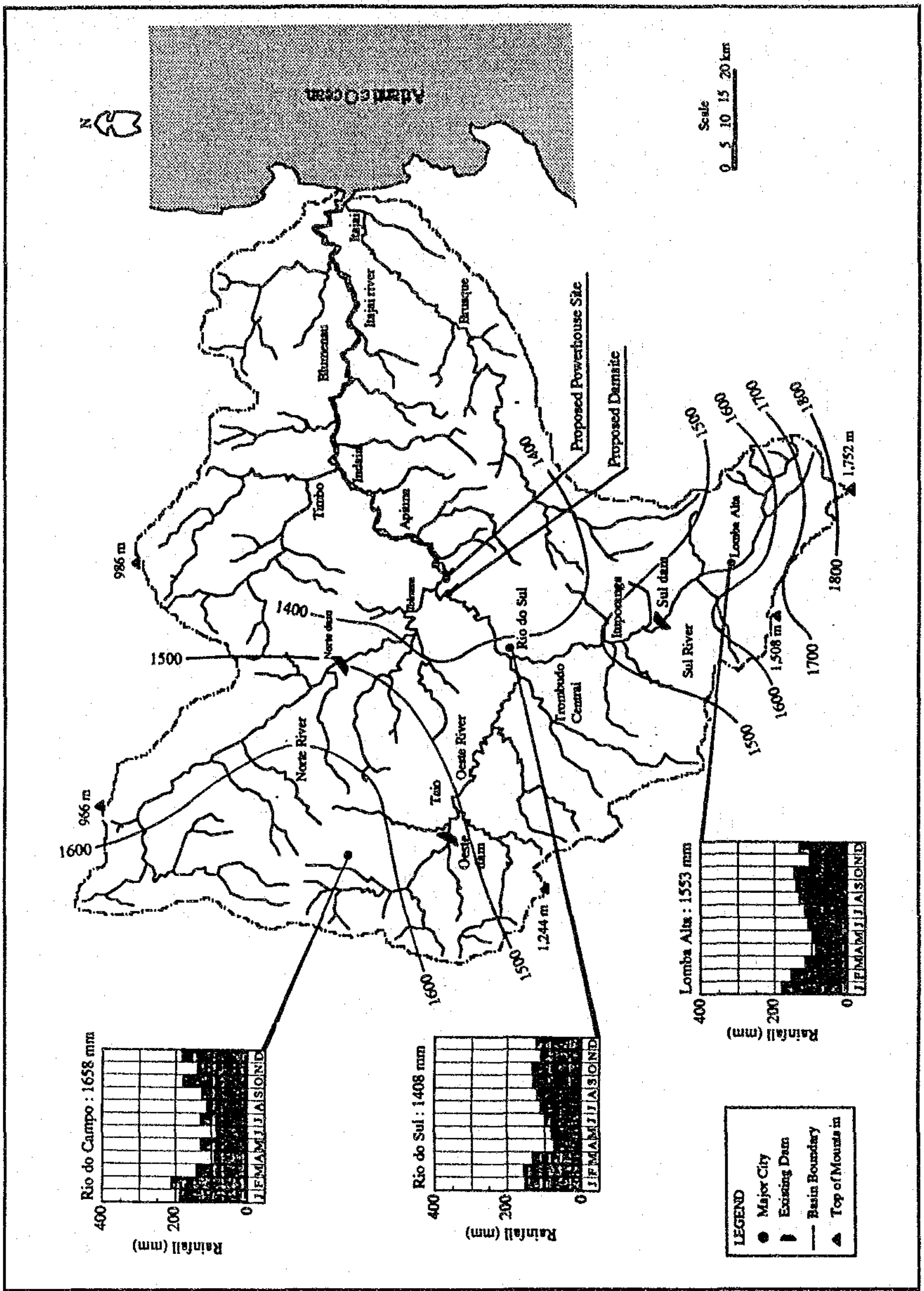
Date	June				July				August			
	Damsite		P/H site		Damsite		P/H site		Damsite		P/H site	
	W.L. at Axis C (m)	Disch. (cms)	W.L. (m)	Disch. (cms)	W.L. at Axis C (m)	Disch. (cms)	W.L. (m)	Disch. (cms)	W.L. at Axis C (m)	Disch. (cms)	W.L. (m)	Disch. (cms)
1			112.08	248	302.82	70	111.06	89	303.53	132	111.88	196
2			112.02	248	302.91	69	111.12	98	303.32	117	111.70	166
3			111.56	153	303.90	302	112.10	242	303.23	110	111.50	148
4			111.40	126	304.01	339	112.22	278	303.17	102	111.40	138
5			112.12	297	304.10	358	112.40	316	303.13	97	111.44	128
6			112.38	338	303.99	327	112.38	287	303.10	96	111.38	124
7			111.97	248	303.93	297	112.20	272	303.09	95	111.40	121
8			111.80	193	303.84	276	112.10	251	303.08	95	111.38	121
9	303.17	139	111.70	169	303.78	247	112.00	233	302.96	94	111.30	107
10	303.12	118	111.54	148	303.74	247	111.98	219	303.02	93	111.28	112
11	303.05	100	111.42	131	303.70	230	111.90	213	303.01	86	111.26	107
12	303.01	86	111.36	121	303.82	252	112.18	254	302.97	80	111.27	100
13	302.99	86	111.34	119	303.80	239	112.30	300	302.92	79	111.24	96
14	302.99	97	111.32	119	303.65	197	112.16	272	302.89	72	111.16	91
15	303.01	90	111.30	116	303.53	194	112.10	230	302.86	75	111.12	87
16	302.97	83	111.24	109	303.40	150	111.80	188	302.84	75	111.10	85
17	302.93	82	111.20	102	303.32	131	111.68	166	302.83	73	111.08	85
18	302.96	85	111.22	105	303.75	197	112.38	325	302.84	73	111.06	89
19	303.22	94	111.60	159	303.79	206	112.68	395	302.81	72	111.04	107
20	303.21	90	111.70	159	303.74	245	112.50	362	302.94	72	111.10	98
21	303.07	86	111.44	131	303.55	189	112.20	287	302.85	70	111.08	87
22	303.00	83	111.34	116	303.40	173	112.02	219	302.79	66	111.04	81
23	302.96	83	111.28	107	303.32	131	111.80	185	302.75	61	111.02	76
24	302.92	76	111.22	102	303.25	110	111.68	166	302.75	61	111.00	76
25	302.94	76	111.24	107	303.19	105	111.58	151	302.78	60	111.02	76
26	303.00	75	111.28	109	303.13	101	111.50	136	302.76	60	110.96	76
27	302.93	75	111.24	102	303.09	96	111.42	128	302.74	58	110.94	74
28	302.86	73	111.22	94	303.07	92	111.40	121	302.72	58	110.92	72
29	302.84	71	111.20	91	303.09	92	111.38	119	302.69	58	110.86	68
30	302.82	70	111.08	87	303.50	171	111.98	210	302.66	57	110.84	68
31					303.73	202	112.06	269	302.62	56	110.82	64
Ave.		87		149		195		225		79		101

Remarks: Discharges shown were estimated from those of Rio do Sul and Apiuna applying catchment area ratio.
Damsite = 1.070 x (Rio do Sul), Powerhouse = 0.953 x (Apiuna)

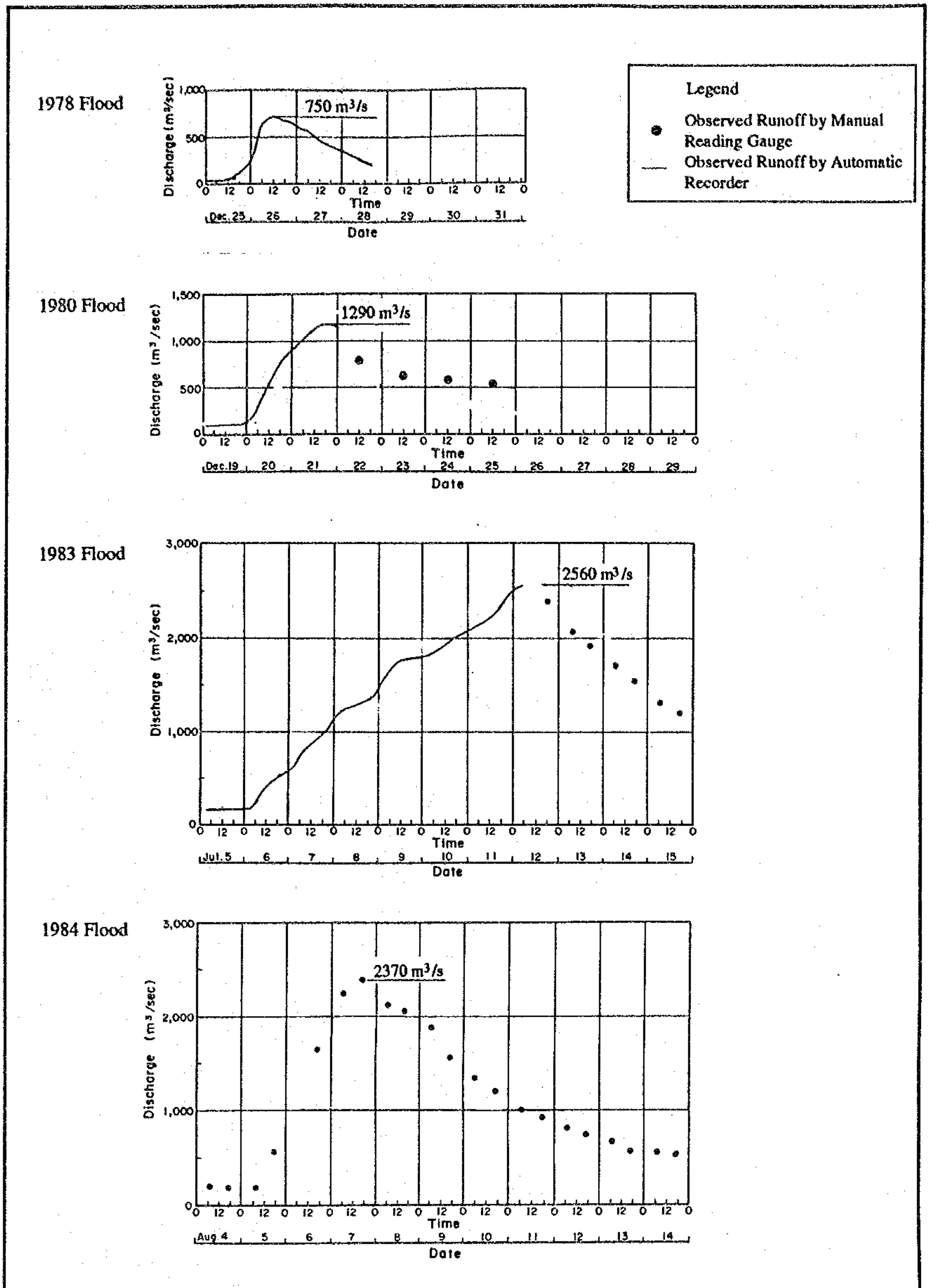
Figure



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig.III.2.1** **Location Map of Meteo-Hydrological Gauging Stations in and around Itajaí River Basin**



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. III.3.1** **Isohyetal Map of Annual Rainfall in Project Area**



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. III.3.2** **Recorded Flood Hydrographs at Rio do Sul in Dec. 1978, Dec. 1980, July 1983 and Aug. 1984.**

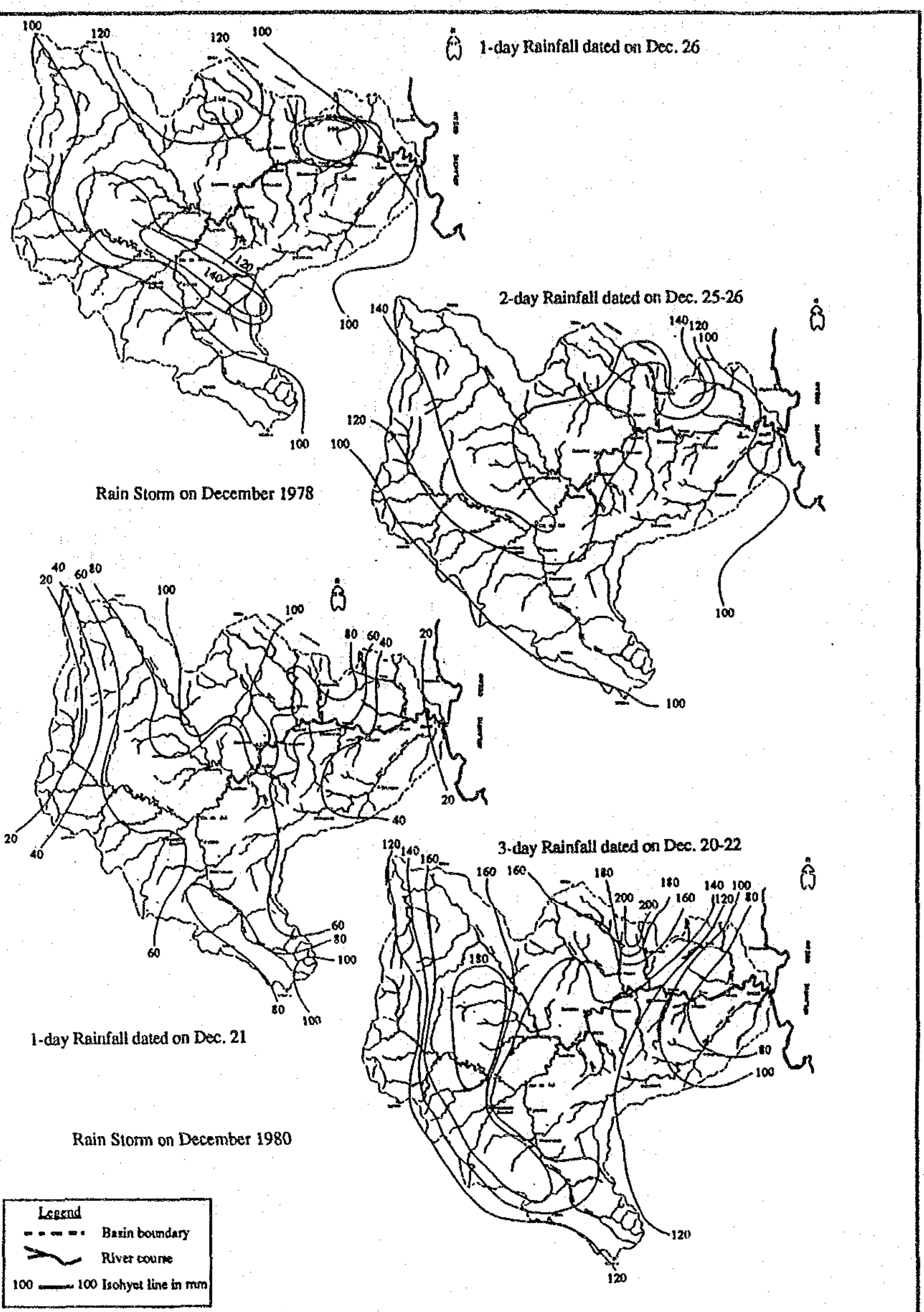


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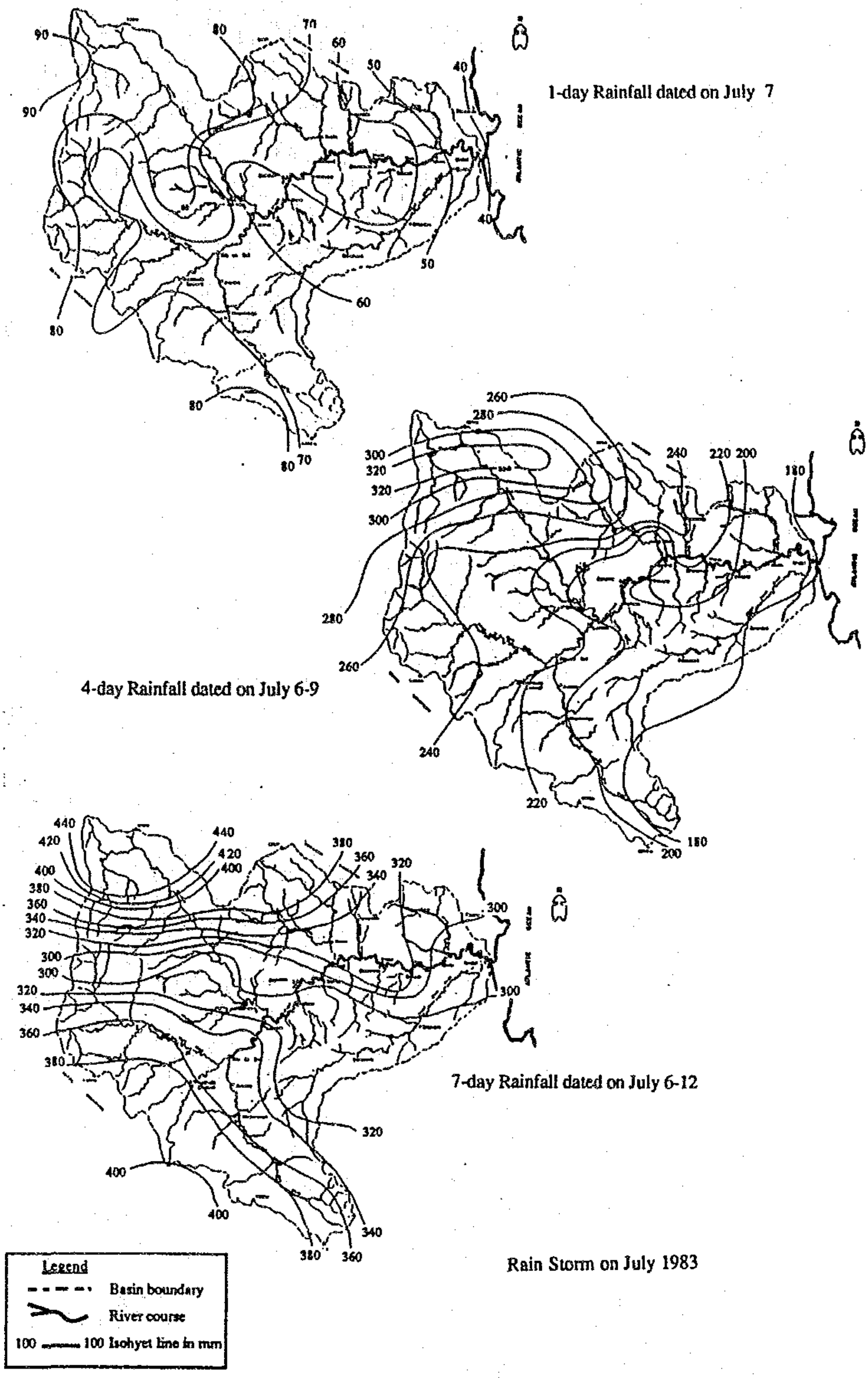
Fig. III.3.3
Isohyetal Map of Rain Storm during Flood in 1978 and 1980



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. III.3.4** **Isohyetal Map of Rain Storm during Flood in 1983**

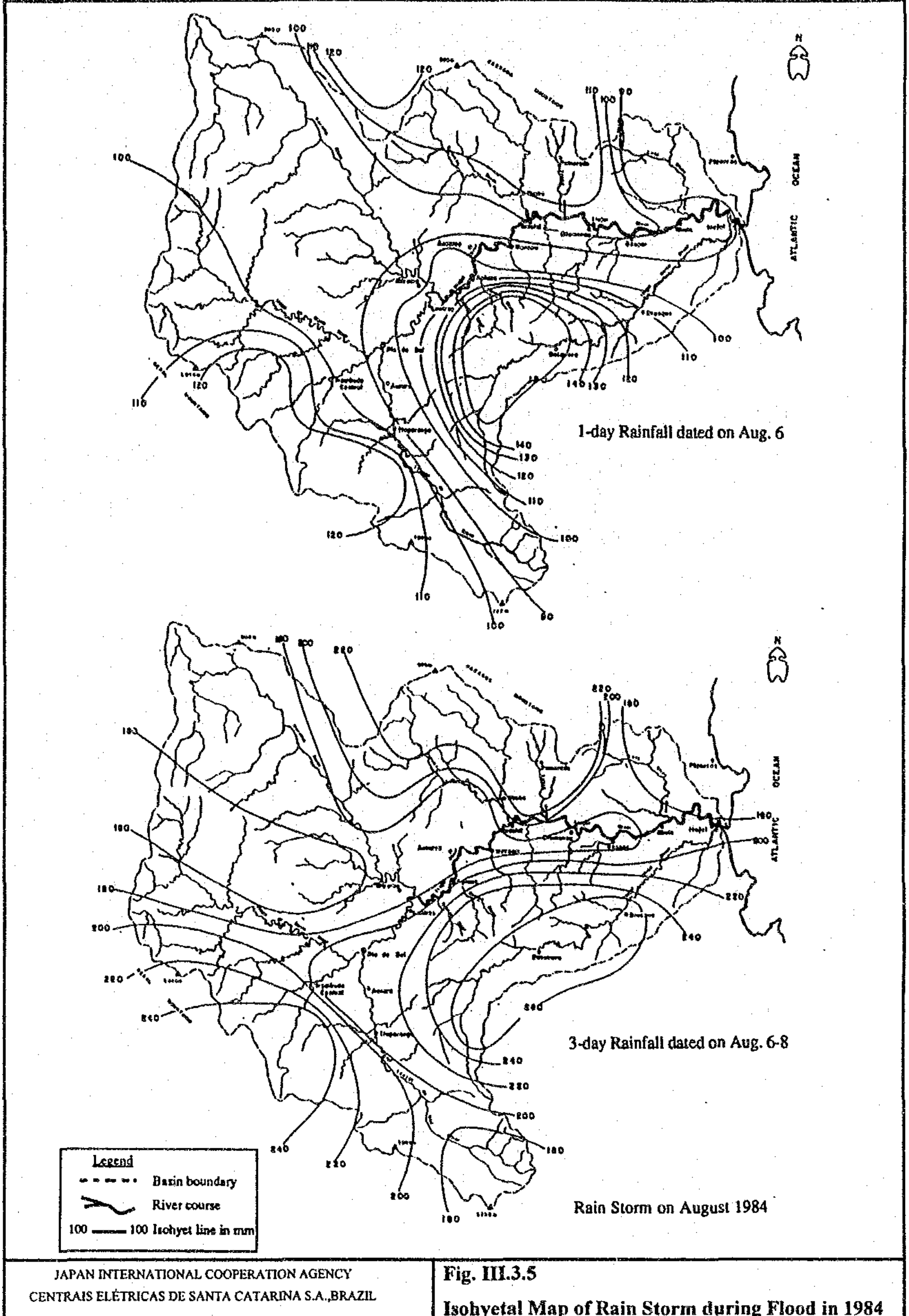


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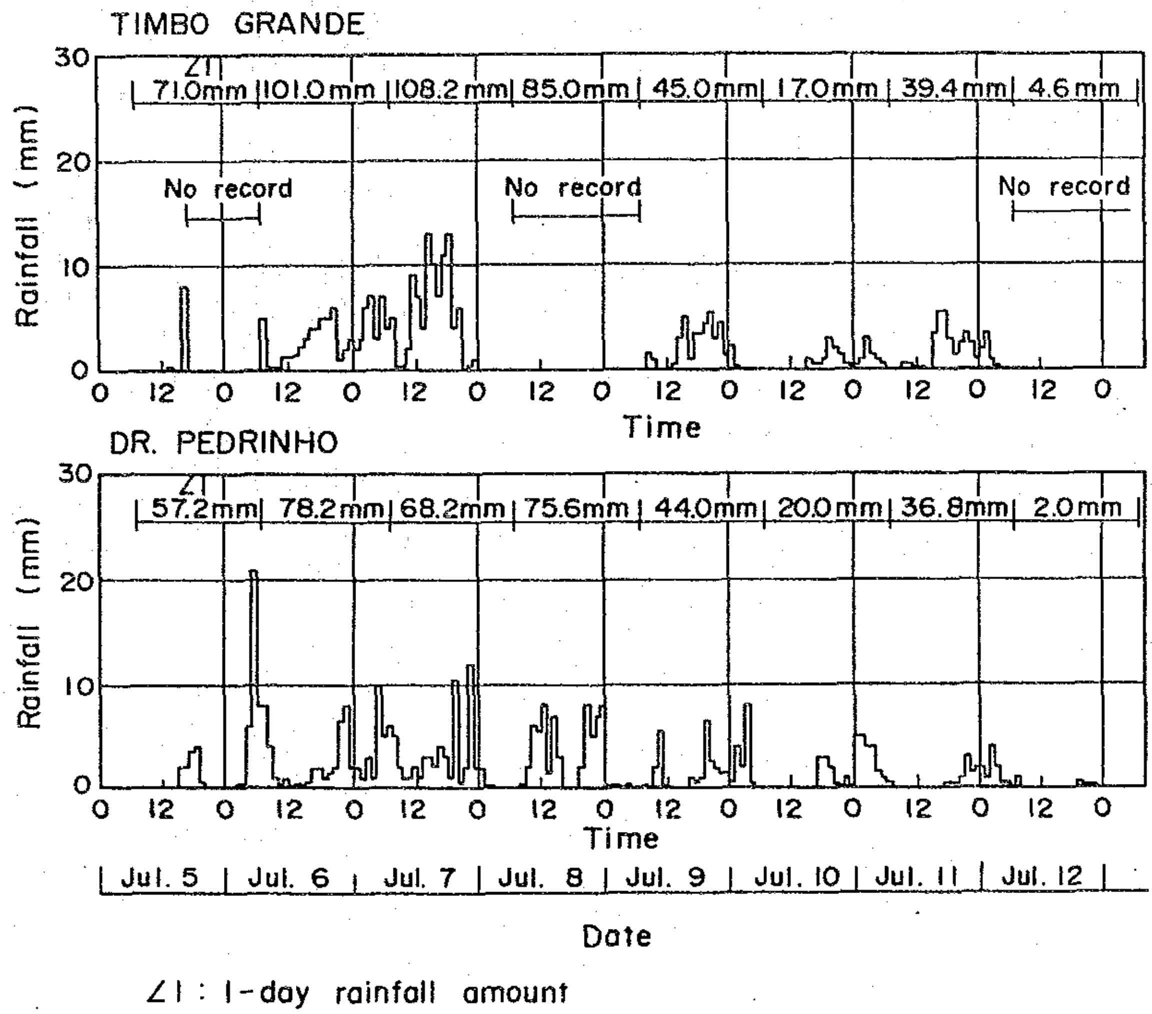
Fig. III.3.5

Isohyetal Map of Rain Storm during Flood in 1984



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. III.3.6** **Recorded Hourly Rainfall Distribution of Rain Storm in 1983**

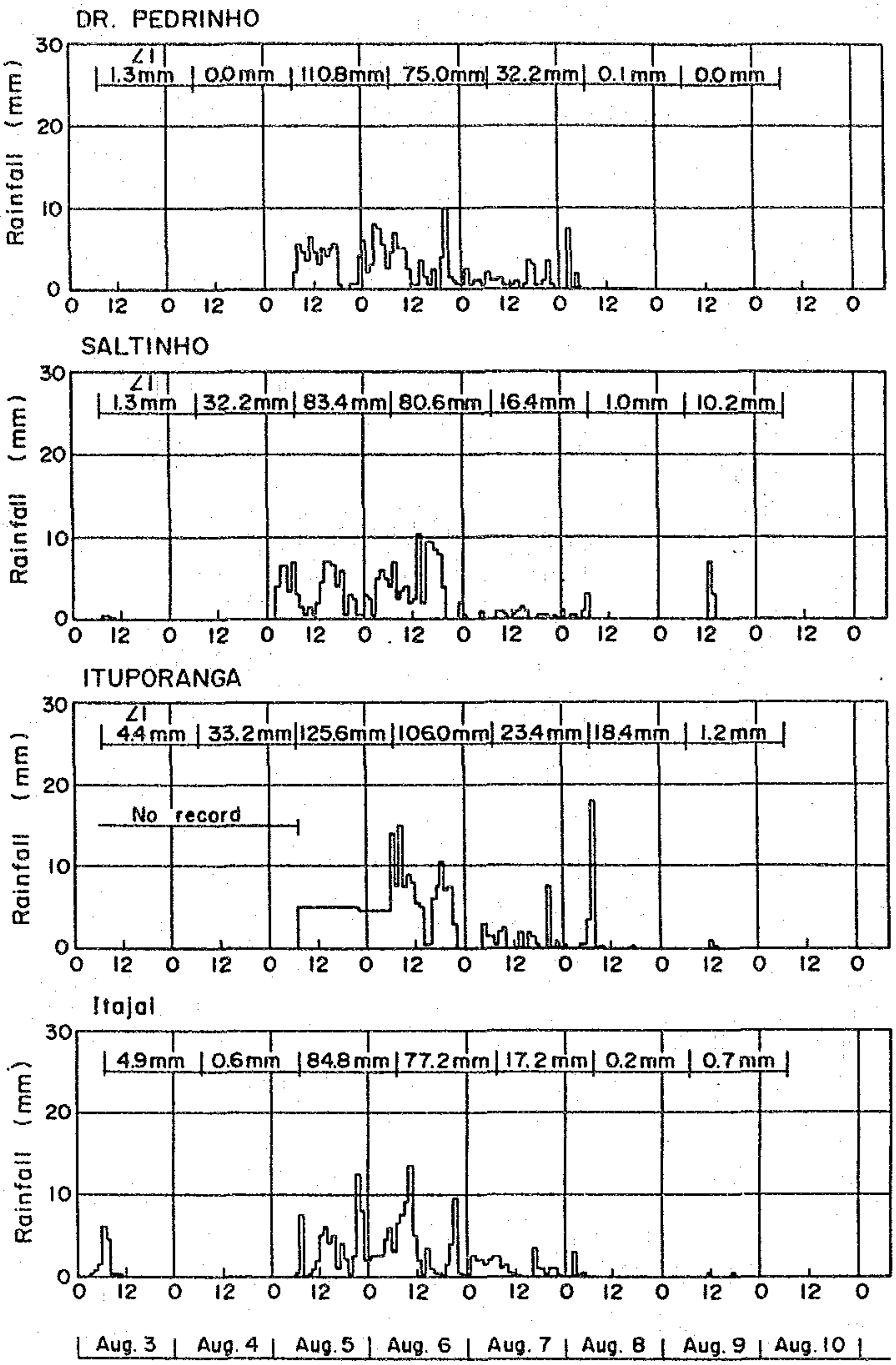


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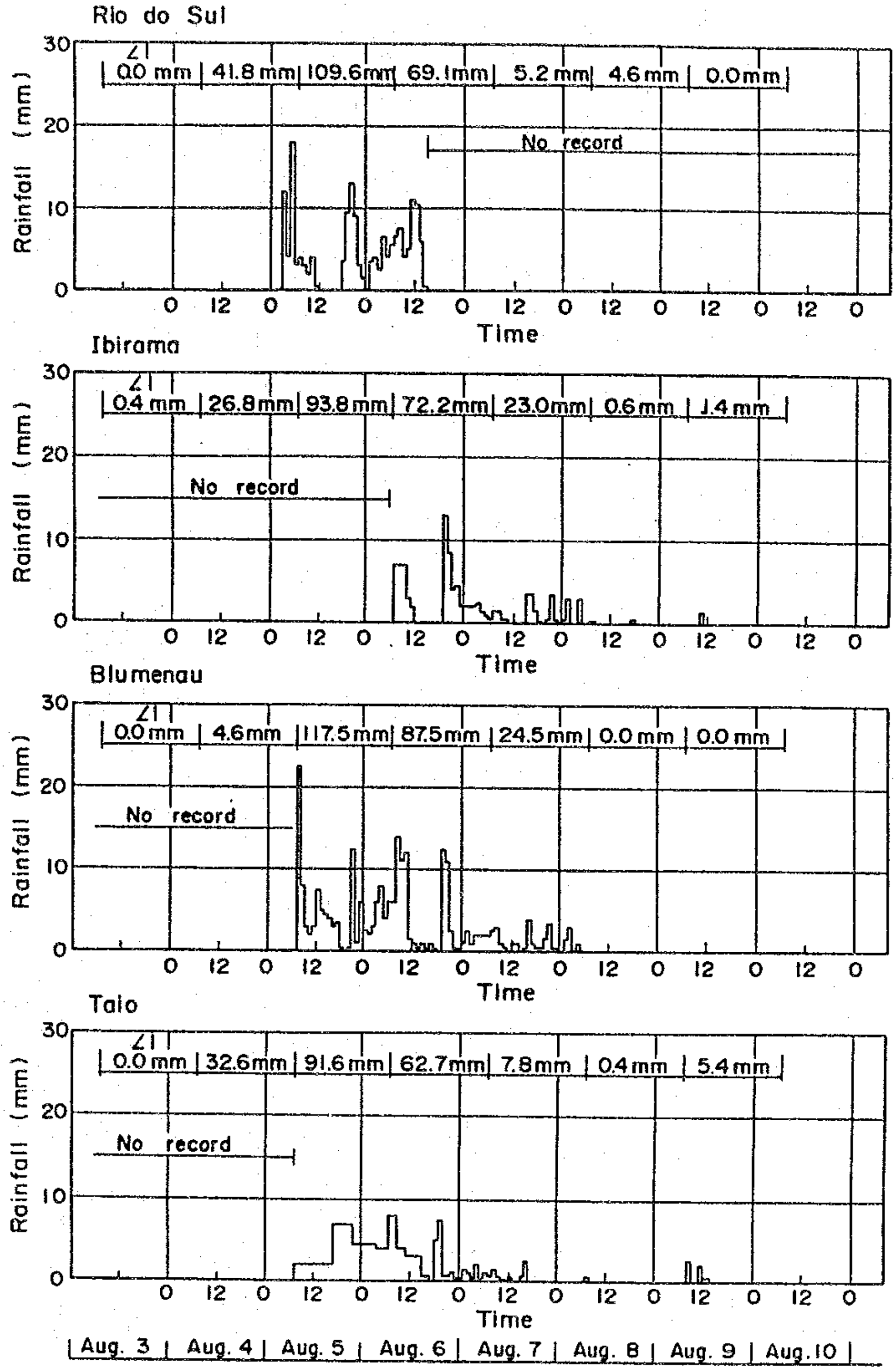
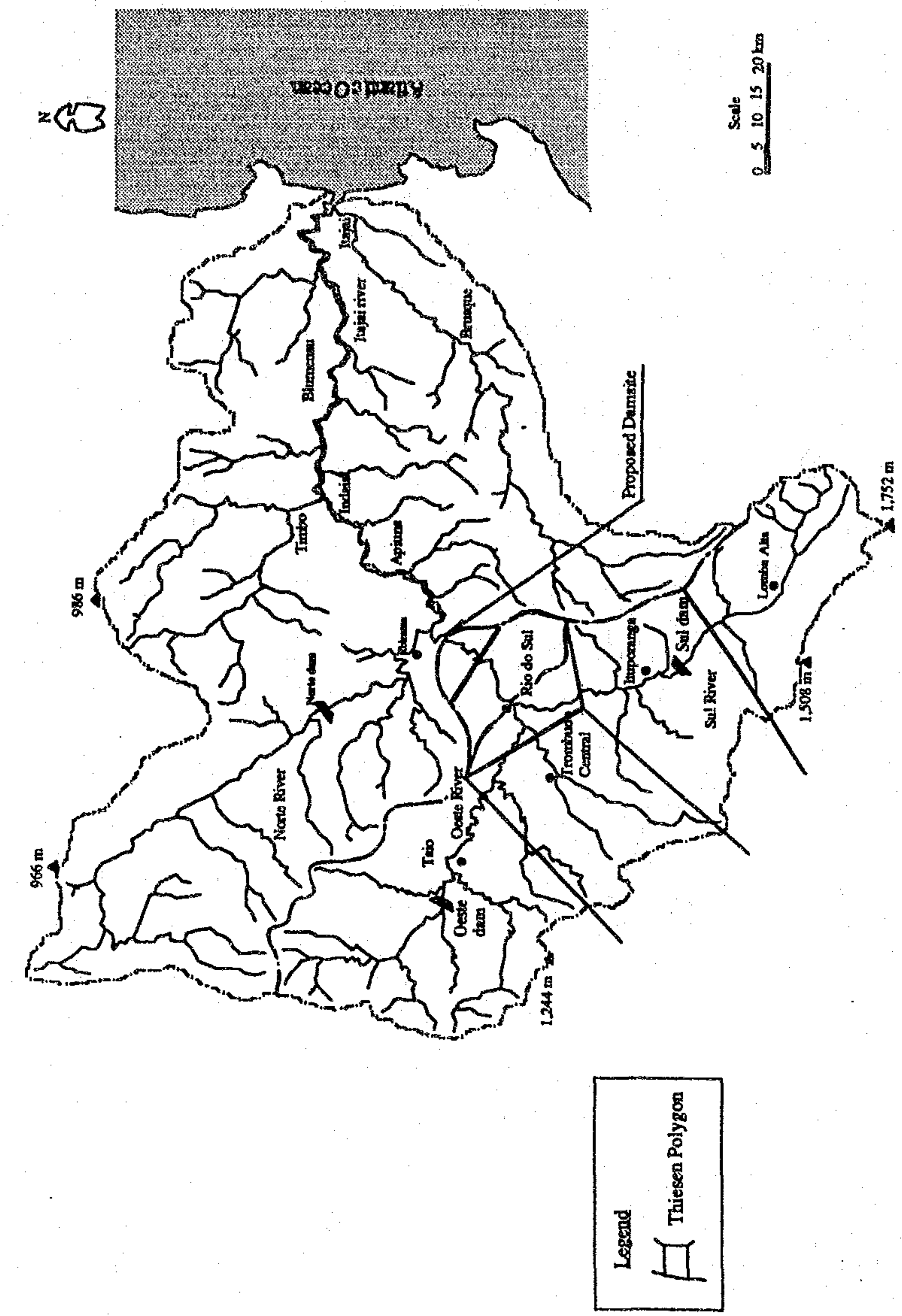
Fig. III.3.7
Recorded Hourly Rainfall Distribution of Rain Storm in 1984 (1/2)



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. III.3.8** **Recorded Hourly Rainfall Distribution of Rain Storm in 1984 (2/2)**



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. III.4.1** **Thiesen Polygon for Estimating Basin Mean Rainfall at Rio do Sul**