3.4 Raking Equipment and Disposal System

In order to prevent clogging trash racks meshes due to concentrations of debris and to dispose it, the raking equipment and disposal system were designed under the following concepts;

(i) Raking equipment is operated from the deck at EL. 324.8 m. It should cover whole the area of trash racks.

(ii) Two (2) sets of raking machine which will travel on rails are provided, considering the area of trash rack and malfunction of one unit.

(iii) A rake width in one time raking operation is around 2.0 m, considering 5.7 m trash rack width.

(iv) Each raking machine will have a operator cab on its body and will be operated at there manually or automatically by electric sequences such as no-man control by means of periodic operation or detector to monitor head loss at the trash racks.

(v) Trashes and garages, etc. raked up by the raking machines will be dumped onto the horizontal stationary conveyors which will be separately provided beneath the main bodies, and then conveyed to trash bins which will be located at the right bank side. When the bins become full, these will be transported by trucks to designated place for incineration.

The feature of the raking equipment thus design is as follows;

- Two (2) sets of traveling type mechanical raking equipment with one set of stationary conveyer system, four numbers of bin and one lot of hydraulic type container truck, having each capacity of 0.5 ton / 2.0 m rake width by 0.5 m rake mouth opening.

3.5 Inlet Gates and Stoplog

In order to close and open the inlet of the desanding basin for dewatering of the desanding chamber and headrace waterway for regular inspection or cleaning, the inlet gate and stoplog were designed under the following concepts:

(i) An inlet gates is provided at the inlet of approach channel of each desanding chamber, and usually kept full opened.

(ii) Each gate should be of the fixed-wheel type, sealing at its downstream face edges. It shall have enough self-weight to shut-off full water flow, and also capable of partial-opening without any vibration to feed cleaning water.

(iii) Each guide frame is extended up to the hoist deck for maintenance of the gate from the deck at EL. 324.8 m.

(iv) Each gate is operated by a each hoist to be located on the hoist deck which will be of one-electric motor and two drums type, moving with a speed of around 1.0 m/min. to attain the objectives mentioned above.

(v) Stoplog is provided in front of each gate for inspection and maintenance and/or for substitutional services of each gate. Each stoplog piece will be handled by the monorail crane which will be also used for the sandflush stoplog as explained in Section 3.1.

The features of the inlet gate and stoplog thus designed are as follows;

- Three (3) sets of fixed-wheel gate with guide frame and electrically driven hoist, having net opening of 3.7 m wide by 4.4 m high.

- One (1) set of three pieces - divided stoplog with three (3) sets of guide frame, one (1) set of lifting beam and all other necessary steel structures, having net opening of 3.7 m wide by 4.5 m (3 @ 1.5 m) high.

3.6 Sand Drain Gates

To flush out sediments trapped in the desanding chambers by periodic gate operation the sand drain gates were designed under the following concepts;

(i) Three (3) sand drain gates are installed in each desanding chamber, which will be usually kept closed.

(ii) Each gate should be of the fixed-wheel type, sealing at its upstream face edges to ensure water tightness. Sharply-edged gate at the bottom is recommended to reduce vibration during partial opening operation.

(iii) Each hoist should be of spindle type which will be located on the hoist deck at EL. 324.8 m.

(iv) Inspection and maintenance of the gates will be made after dewatering the basin by use of the both inlet and intake gates.

The sand drain gates thus designed comprise nine (9) sets of fixed-wheel gate with guide frame and electrically driven spindle hoist, having net opening of 2.5 m wide by 1.0 m high.

3.7 Intake Gates

The intake gates were designed under the same concepts as for the inlet gates except for the following items;

(i) Sealing is made at its upstream face edges.

(ii) The stoplog is not provided because gate inspection and maintenance will be made from the deck at El. 324.8, and

(iii) Use of stainless clad steel for guide frames is proposed to minimize inspection and maintenance frequencies and also to minimize stoppage of generating operation.

The intake gate thus designed comprise one (1) set of fixed-wheel gate with guide frame and electrically driven hoist, having net opening of 3.8 m wide by 4.8 m high.

3.8 Draft Tube Gates

In order to clear the draft tube for periodic regular inspection, maintenance or repair the draft tube gates were designed under the following concepts;

(i) One gate is provided for closing either one of two draft tube openings.

(ii) Gate should be a slide type, sealing at its upstream face edges.

(iii) Draft tube will usually be kept full. Open gate will be stored in the dogging devices located at the upper part of gate slots.

(iv) A movable gantry crane is provided, which travels the required length to regulate two draft tube with one gate.

The draft tube gates thus designed comprise one (1) set of slide gate with four (4) - guide frames, one - lifting beam and one electrically driven gantry crane, having net opening of 3.4 m wide by 3.1 m high.

3.9 Steel Conduits

The steel conduits were designed under the following concepts;

(i) Diameter of No.1 culvert is 4.8 m and that of No.2 culvert 5.8 m. Length of steel is 394 m and 70 m, respectively.

(ii) Steel material and its allowable stress shall be of those usually employed for similar works in Brazil. Full penetration - butt welding joint with joint efficiency more than 90% shall be applied

(iii) A minimum wall thickness shall be equal or more than 8.0 mm. Each segment of steel conduit pipe shall have a number of inner spiders for fabrication, handling and concrete placing purposes. Corrosion and wear allowance of 1.5 mm is recommended.

(iv) Full internal pressure on about 13.0 m in water head at maximum should be applied to steel conduit design without expecting strength of concrete.

(v) Since free drain material will be used to fill the culverts, water pressure equal to its height of pipe, namely diameter, is recommended for design external pressure. A factor of safety against buckling due to external pressure will be 1.5.

The steel conduits thus designed consists of two thinner steel lined conduit pipes, one is 4.8 m diameter 394 m in length and 8 mm in thickness and another 5.8 m in diameter 70 m in length and the same thickness.

3.10 Steel Liner

In order to discharge 90 m3/sec of river water in peak time for power generation and to cope with the maximum internal and external design pressures, the steel liner was designed under the following concepts;

(i) Maximum internal and external design pressures are as follows.

(a) Max. internal design pressure at center of turbine.

- Static head (FSL - Center EL. 107.2 m) = 211.8 m
- Water hammer (28 % of (FSL - TWL)) = 58.7 m *
- Max. internal design pressure = 270.5 m

Note: This assumes to be zero (0) at the center of surge tank, decreasing gradually along centerline of waterway.

(b) Max. internal design pressure at the center of surge tank.

- Static head (FSL - Tunnel center) = 32.7 m

- Surging head (HSWL - FSL) = 13.1 m
- Max. internal design pressure = 45.8 m

(c) Max. external design pressure equivalent to water head between original ground surface and penstock centerline.

- Beginning point (Point A) = 164.0 m
- Point B = 70.0 m
- Bifurcation = 36.0 m
- End point of penstock = 26.0 m

(d) Other temporary external pressure such as due to contact grouting, concrete-placement and so forth.

(ii) Steel materials to be used for steel penstocks shall be ASTM, A36 (sigma-ultimate 40.8 - 56.2 kgf/sq.mm) and A576 (sigma-ultimate min. 49 kgf/sq.mm). Allowable stresses is around 120 MPa and safety against buckling due to external pressure is 1.5.

(iii) A minimum shell thickness of steel liner required for fabrication and handling purposes shall be more than that calculated from a equation of (Di + 800/400). A corrosion and wear allowance of 1.5 mm shall be added to the calculated values,.

(iv) Full penetration and welding joint with back-ganging and its joint efficiency more than 90% is recommended for all girth and longitudinal weld lines.

(v) According to the criteria used in ELETROSUL, high pressure tunnel unlined with steel liner is allowed if rock cover measured in vertical is larger than 70 % of the internal design pressure. In addition, the rule-of-thumb criteria introduced by Bergh-Christese and Dannevig in 1971 which is widely used in the world was also applied to this design. Based on these criteria limitation of unlined section shall be determined.

(vi) The section where part of internal design pressure can be shared by bedrock shall be limited to the area where a minimum rock cover (in m) is more than 10 times of tunnel excavation diameter (in m), according to the ASCE/EPRI Guides 1989. Steel liner downstream of this area shall be designed for 100% of the internal design pressure.

(vii) A shearing ratio of internal design pressure to bedrock shall be calculated by the equations as developed by "Higashi, Vaughan and Patterson, with use of the following figures.

(a) Temperature change (= 0~20°C)
(b) Coefficient of plastic deformation of concrete (= 0.0)
(c) Tunnel excavation diameter (= 370 + 2 x 60 = 490 cm)
(d) Coefficient of plastic deformation of bedrock (÷ 0.5)
(e) Poisson's number of bedrock (= 5)
(f) Elastic modulus of bedrock (150,000 kgf/sq.cm with factor of safety of 4.0 against laboratory rock test value of minimum 600,000 kgf/sq.cm. More detail survey will be required)

It was assumed in this study that the steel materials to be used is ASTM A36 grade, and sharing load by rock is 30 %. In the next design stage it should be confirmed that stress by the internal design pressure will not exceed the sigma-yield without only shearing the load to rock.

(viii) Design of bifurcation shall be made for the following conditions;

(a) Spherical type bifurcation is employed based on the past-installed records (for Di = 4.3 m and Hd = 266.2 m).
(b) Its sphere diameter is 6.4 m which is within a range of 1.3 Di to 1.6 Di.
(c) Bifurcation angle is 60.0 degrees, which will allow head loss coefficient down to around 0.05 by installing flow regulating plates inside as designed for Y-branch type.

(vix) Penstock diameter at the end points shall be 2.5 m to connect the inlet of turbine scroll casings.

The steel liner thus designed is one (1) lane of steel liner, ranging its diameter from 4.3 m to 2.5 m via a spherical type bifurcation in 6.4 m diameter, and having total length of approximately 365.0 m.

4. GENERATING EQUIPMENT

4.1 General

Two units of the generating equipment consisting of a hydraulic turbine, a generator and a main transformer will be installed in the powerhouse to generate a power outlet of 142 MW and to produce a firm annual energy of 82.59 MWy by utilizing the maximum plant discharge of 90 m^3/s and the gross water head of 210.0 m. An overhead traveling crane will be provided in the powerhouse for assembly, erection and maintenance of the equipment.

Single line diagram for major circuits is shown on Figure VIII.4.9.

4.2 Unit Speed

The turbine speeds of 300 rpm, 327.3 rpm and 360 rpm are selective from the turbine output of 72,600 kW, the rated head of 179.3 m and the system frequency of 60 Hz.

Comparison among 300 rpm, 327.3 rpm and 360 rpm was made as tabulated below:

		300 rpm	327.3 rpm	360 rpm
(a)	Number of generator poles	24	22	20
(b)	Specific speed (m-kW)	123.2	134.4	147.8
(c)	Required suction head (m)	-2.4	-3.7	-5.7
(d)	Turbine center elevation	EL.108.5	EL.107.2	EL.105.2
(e)	Max. peripheral speed (rpm)	143.9	152.3	162.2
(f)	Machine cost (US$)	+368,200	0	-387,400
				(+368,200)
(g)	Civil work cost (US$)	-195,000	0	+300,000
(h)	Total cost difference (US$)	+173,200	0	-87,400
				(+668,200)

Although 327.3 rpm (22-pole generator) is not a speed preferred by various national and international standards of generator, many generator manufacturers have much experience to make generators of 22-poles. That is why 327.3 rpm is also selective to the generator of this scale.

The machine cost consists of costs for two turbines, two generators and a powerhouse crane. The generator cost was estimated assuming that all generators are of semi-umbrella type with standard inertia. In case of 360 rpm, generator may often be designed with suspended type instead of semi-umbrella type due to higher speed.

Suspended type generator will be more expensive than semi-umbrella type and the machine cost for the generator of suspended type is shown in parenthesis in the above.

As the machine speed is higher, in general, the machine cost becomes cheaper but the turbine setting level gets lower. Obviously a lower setting will introduce higher civil works cost due to increase in excavation and concrete volume.

The suction head of the turbine was also considered from the technical point of view. If the suction head is in the range between -5 to -10 m, the Francis turbine at part-load operation may often incur unacceptable pressure fluctuation in the draft tube. In case of such suction head, a forced aeration system using a large air compressor system may be required besides an ordinary natural aeration system to dampen pressure fluctuations at part load. So, such suction head should preferably be avoided from the operational problem.

The unit speed was therefore selected at 327.3 rpm.

4.3 Hydraulic Turbines

Each hydraulic turbine will be the vertical shaft, single runner, single flow, Francis type and has a rated output of 72,600 kW when operating at a rated speed of 327.3 rpm under a net head of 179.3 m. Francis turbine was selected from the calculated specific speed of 134.4 m-kW.

The center line of the turbine distributor will be placed at EL. 107.2 below the lowest tailrace water level of EL. 109.0 to provide the suction head required.

The hydraulic turbines will be operated under the following conditions:

(a)	Reservoir water level		
	- Full supply water level	:	EL. 319.0
	- Minimum operational water level	:	EL. 318.0
(b)	Tailrace water level		
	- Rated water level	:	EL. 111.5
	- Low water level	:	EL. 109.0
(c)	Heads		
	- Maximum gross head	:	210.0 m
	- Rated head	:	179.3 m
(d)	Maximum unit discharge	:	45 m^3/s

The turbines will usually be operated under the water level governing control that will automatically regulate the turbine output in proportion to the water level; namely, the turbine will be operated with full load at full supply water level, will be operated with part load between full supply water level and minimum operational water level, and will automatically stop when the water level goes down below the minimum operational water level. For this water level governing control, at least two water level detectors will be installed at the intake and the water level will be signaled to the turbine governors by way of control cable lines to be installed between the intake and the powerhouse.

Each hydraulic turbine will be provided with an inlet valve having an inside diameter of 2.5 m. Ordinary type and throughflow type butterfly valves were considered as the inlet valve, because both of them are applicable from the maximum gross head of 210.0 m and the inside diameter of 2.5 m. The throughflow type butterfly valve was selected because of low hydraulic loss.

Cooling water supply system for the generator air coolers and bearing coolers will be provided with a cooling water head tank for removal of trash suspended in the water. Cooling water will be taken from the draft tube and pumped up to the cooling water head tank. From the water head tank, cooling water will be piped to and supplied to each cooler by gravity.

4.4 Generators

Each generator will be the three-phase, vertical shaft, semi-umbrella type synchronous alternator and will be rated at 78,900 kVA, 60 Hz, 0.9 power factor (lagging), 13.8 kV and 327.3 rpm.

In selection of type of the generator, semi-umbrella type and suspended type generators were considered from the rated output of 78,900 kVA and the rated speed of 327.3 rpm. Comparison between semi-umbrella type and suspended type generator was made as follows:

		Semi-umbrella	Suspended
(a)	Estimated weight of rotor (with standard inertia)	152.3 ton	186.3 ton
(b)	Required hoisting height of crane for generator erection	5.5 m	9.3 m
(c)	Estimated cost of a generator (with standard inertia)	US$ 5,305,800	US$ 5,629,800

Judging from the past supply records of the generator manufacturers, semi-umbrella type is fully applicable to the generator of 78,900 kVA and 327.3 rpm. Suspended type generator is heavier and more expensive than semi-umbrella type one and will introduce higher civil works cost for powerhouse superstructure because the higher hoisting height of the crane will be required for the generator erection. That is why semi-umbrella type generator was selected for this Project.

The rated power factor was selected at 0.9 lagging, referring to the ELETROSUL's generators of the recent development. The rated voltage was selected at 13.8 kV from the standard voltage of the generators for this scale and to limit three-phase short-circuit current on the station-service transformer circuit within 50 kA.

The stator winding of the generator will be star-connected and the neutral will be grounded through a neutral grounding transformer or a neutral grounding resistor to limit the ground fault current on the generator circuit.

The generator will be provided with a static, thyrister rectifier, potential-source type excitation system.

4.5 Powerhouse Crane

The powerhouse crane will be of electric motor driven, cab control type bridge crane and will be equipped with a main hoist, an auxiliary hoist and a monorail hoist.

The heaviest package to be handled by the powerhouse crane will be the generator rotor assembly. The weight of the rotor with standard inertia was estimated at 153.9 ton.

Standard inertia of the generator rotor was estimated at 1,527 ton-m^2. The penstock tunnel optimization study in Clause 8.3 of Chapter 8 describes that the optimized water way will cause to increase the penstock pressure up to 127.8 % and to increase the unit speed up to 145 % during sudden full load rejection of two units on condition that the equivalent closing time of the turbine guide vane is 10 seconds. To limit the pressure rise and speed rise within the above mentioned values, inertia of the rotor will be required to be 2,412 ton-m^2. On the other hand, the inertia required to provide good stability on speed regulation was estimated at 2,437 ton-m^2. Additional inertia (difference between the standard and the required inertia) can increase the weight of the rotor by increase in inertia. The weight of the rotor with inertia of 2,437 ton-m^2 was calculated to be 187 ton.

The lifting capacity of the powerhouse crane was therefore determined at 200 ton.

4.6 Main Transformers

The main transformers to step up the generator voltage to the trans-mission line voltage of 138 kV will be installed in the transformer yard. Each main transformer will be the three-phase, two-windings, oil-immersed, OFAF (forced oil circulation and forced air cooled) cooling, outdoor use type with an off-circuit tap changer. The rated power of the main transformer will be 78,900 kVA that is equal to the generator rated output. Nominal voltage ratio of the main transformer will be 13.8/138 kV.

The transformer tank may be of three-subdivided three-phase constructions, which is so designed that the lower tank is separated to each phase and the upper tank is common to all three phases for internal three-phase winding connection, from physical size and weight limitations imposed by shipping and transportation restrictions.

The main transformers will be connected to the 138 kV switchgear in the outdoor switchyard by cross-linked polyethylene (XLPE) insulated power cables, which will be laid in the cable culvert to be provided between the transformer yard and the outdoor switchyard.

4.7 Generator Voltage Switchgear

The generator will be connected with the main transformer through a disconnector that is a part of the indoor station-type switchgear assembly enclosed in metal-clad cubicle. The generator switchgear cubicle for each unit will be provided with a disconnector, voltage transformers, current transformers, a set of surge absorber and a circuit breaker for station-service transformer circuit. No synchronizing circuit breaker will be provided in this cubicle because synchronizing of the generator will be made by the 138 kV circuit breaker on the main transformer circuit.

The generator and the main transformer will be connected by the generator main bus through the generator voltage switchgear. Segregated phase bus (SPB) and isolated phase bus (IPB) were considered as the generator main bus. SPB will be constructed that all three-phase conductors are in a common enclosure but are segregated by non-magnetic metal barriers between phases. SPB is generally applicable to the circuits of normal current up to 5,000 A. SPB is superior to IPB in respect of economy and compact installation space.

The rated current of the generator will be 3,301 A and therefore the generator main bus will be rated at 4,000 A. In this case, the required installation space for SPB will be

1.9 m x 0.8 m, while that for IPB will be 2.9 m x 1.2 m. That is why SPB was selected as the generator main bus.

4.8 138 kV Switchgear and Outdoor Switchyard

The switchyard will be conventional outdoor open-type bus-and-switch arrangements for the 138 kV switchgear. The 138 kV bus will employ the main- and transfer-bus scheme that adds a transfer bus (an auxiliary bus) to the single-bus scheme. An extra bus-tie circuit breaker will be provided to tie the main and transfer buses together. The transfer bus will be used to keep the circuit energized when a circuit breaker is removed from service for maintenance. This bus scheme is the standard of the CELESC's 138 kV substations.

The layout of the above equipment is as shown in Figures VIII.5.11 and VIII.5.12.

3.9 Supervisory Control System

The supervisory control system will be arranged in a hierarchical structure with three levels of lower level (machine bay), higher level (control room) and highest level (central remote control station).

The control functions at the lower level will be decentralized into a number of local control blocks that are arranged for individual control of each turbine-generator unit, station common equipment and outdoor switchyard equipment. A local control board will be provided at each control block for manual control, local and remote automation and protection and alarm management with the aid of the programmable controllers. Each local control board will consist of manual control panel with all control and measuring instruments, programmable controller, electrical protective relays, measuring transducers, etc.

The main supervisory computer system with man-machine interface equipment will be provided as the higher level hierarchy in the control room to perform supervisory control of the power station and data processing to accomplish a complete database for operational management.

The main supervisory computer system and the decentralized programmable controllers will be linked by the dataway for high-speed data transfer to permit data exchange among them.

The central remote control station as the highest level may be added in the future. Only provisions for data transfer to the central remote control station will be included in the supervisory control system.

4.10 138 kV Transmission Line

Two circuits of the 138 kV transmission lines will be introduced to this power station by means of T-branch of the double circuit transmission line between Blumenau and Rio do Sul Substations. A part of the existing Blumenau - Rio do Sul line is still single circuit line as of 1993 but is scheduled by CELESC to be revised to double circuit line by end of 1994.

A new 138 kV double transmission line will be constructed between the branching point of the existing line and this power station. The construction work of this transmission line is out of the scope of work of the project..

Extension of the 138 kV double circuit transmission line from the Rio do Sul Substation to the Vidal Ramos Jr. Substation as shown in Figure VIII.5.9 is suggested by CELESC and this power station will be put into commercial operation through this extended transmission line.

5 FEASIBILITY DESIGN DRAWING

Feasibility deign is shown in Figure VIII.5.10 to VIII.5.12.

Table

Table VIII. 2.1 Construction Cost of Alternative Diversion Methods

	Unit	Unit Price (US$)	Tunnel Diversion Quantitie	Tunnel Diversion Amount (1000US$)	Multi Stage Diversion Quantities	Multi Stage Diversion Amount (1000US$)
Coffer dam						
Embankment						
Rock material	m3	18.0	8,300	149	21,000	378
Impervious soil	m3	5.2	20,000	104	50,000	260
Removal of cofferdam	m3	5.2	28,300	147	71,000	369
Diversion Tunnel & Channel						
Excavation						
Open excavation, common	m3	5.8	430,000	2,494	215,200	1,248
Open excavation, rock	m3	12.8	66,000	845	2,400	31
Tunnel Excavation	m3	75.0	35,000	2,625	-	-
Concrete						
Open structure	m3	136.2	1,200	163	-	-
Underground	m3	165.0	4,300	710	-	-
Plug	m3	165.0	1,200	198	-	-
Cement	ton	190.0	1,800	342	-	-
Reinforcement bars	ton	1,400.0	55	77	-	-
Others				785		21
Contingency				1,296		346
Total Direct Cost				8,640		2,653

Table VIII. 2.2 Construction Cost of Alternative Dam and Spillway Type

	Concrete Dam		Rockfill Dam
	Non-gated spillway	Gated spillway	Gated spillway
Basic Feature			
Full supply water level (masl)	319	319	319
Spillway design flood (m3/sec)	5,400	5,400	5,400
Design flood water level (masl)	324.6	331.0	331.0
Spillway crest elevation (masl)	319.0	317.0	317.0
Dam crest elevation (masl)	324.6	331.0	332.0
Dam foundation elevation (masl)	308 to 314	308 to 314	309 to 315
Spillway gate size (nos. x w x h in meter)	-	6 x 14.6 x 3.0	6 x 14.6 x 3.0
Intake discharge (m3/sec)	90.0	90.0	90.0
Construction Cost (1000 US$)			
River diversion	2,300	1,800	2,600
Dam	8,200	11,000	4,000
Spillway		1,300	6,700
Civil works	include in dam	include in dam	5,400
Hydromechanical	-	1,300	1,300
Intake & Desanding basin	19,400	20,300	20,500
Civil works	18,500	19,400	19,600
Hydro-mechanical	900	900	900
Contingency	4,440	5,050	4,690
Total Direct Cost	34,340	39,450	38,490

Note: Contingency - 10% for civil and 5% for hydro-mechanical equipment

Table VIII.2.3 Economic Comparison of Headrace Waterway Alternative Alignment

Item	Uni	nit pric (US$)	uantitie	Amount (1,000US$
(1) Incremental construction cost of Route II compared to Route I				**-278**
a) Direct cost				-186
Open common excavation for no.2 culvert	m3	5	-60,000	-300
Open rock excavation for no.2 culvert	m3	13	-5,000	-65
Concrete for no.2 culvert	m3	184	-1,277	-235
Steel pipe for no.2 culvert	ton	3,322	-90	-299
Tunnel excavation in concrete section	m3	75	-1,415	-106
Tunnel excavation in shotcrete section	m3	75	9,621	722
Concrete for tunnel lining	m3	212	-358	-76
Shotcrete for tunnel lining	m3	280	488	137
Invert concrete	m3	146	332	48
Contingence (15% for civil works & 10% for steel pipe)				-11
b) Indirect cost (29% 0f direct cost)				-54
c) a) + b)				-239
d) Interest during construction				-39
(2) Incremental loss of energy benefit due to head loss of Route II compared to Route I				**415**
(3) Total of (1) & (2)				**137**

Note: Minus indicates saved cost in compare with that of route I.

Table VIII.2.4 Basic Features of Alterative Penstock Types

	Unit	TYPE I	TYPE II	TYPE III
(1) Type		Open air	Underground vertical shaft	Underground inclined shaft
(2) FSL	masl	319	319	319
(3) Max. plant discharge	m3/sec	90	90	90
(4) Length of headrace tunnel & culvert	m	6,105	6,105	6,005
(5) Total length of penstock line	m	493	624	605
(5-1) Length of steel liner	m	493	335	335
- Length before bifurcation	m	450	292	292
- Length after bifurcation	m	43	43	43
(5-2) Diameter of steel pipe				
- Diameter before bifurcation	m	4.3	4.3	4.3
- Diameter after bifurcation	m	2.5	2.5	2.5
(5-3) Length of concrete lining tunnel	m	0	289	270
(5-4) Diameter of concrete tunnel	m	-	4.8	4.8
(6) Max. head loss in penstock	m	3.7	4.4	3.8

Note ; Decreased head loss of headrace waterway by 100 m is counted in Type III.

Table VIII.2.5 Economic Comparison of Alternative Penstock Type

Unit : 1000US$

ITEMS	TYPE I	TYPE II	TYPE II
(1) Construction Cost	21,110	17,833	19,274
Direct cost	14,528	12,274	13,265
- Headrace tunnel			
Increased cost for type III in comparison with type I & II			-124
- Surge tank			
Increased cost for type III in comparison with type I & II			600
- Penstock			
Civil works	5,055	7,289	7,736
Hydro-mechanical works			
- Penstock steel liner	7,541	4,053	4,053
- Penstock valve	1,000	-	-
- Contingency	933	932	1,000
Indirect Cost	4,213	3,559	3,847
Interest	2,368	2,001	2,162
(2) Loss of Energy Benefit due to Head Loss in Penstock	1,544	1,809	1,577
(3) Total of (1) +(2)	22,653	19,643	20,850

Table VIII.2.6 Optimum Diameter of Steel Liner and Closing Time

Case	Headrace Tunnel		Penstock Tunnel						Hr	Pt	Pg	N	Tc	dP	dN	GD2r	GD2s	GD2n	Wr	Construction Cost (C)				Loss of Benefit (B)	(C+B)
			Concrete lining		Steel lining															Civil works	Metal works	Turbine	Generator		
	Length m	Dia. m	Length m	Dia. m	Length m	Dia. m	Length m	Dia. m	m	kW	kVA	rpm	sec			ton-m	ton-m	ton-m	ton	ill.US	ill.US	Mill.US$	Mill.US$	Mill.US$	Mill.US$
A-1	6,090	5.8	264	4.8	292	3.9	43	2.5	179.6	72,700	79,000	327	7	0.47	0.45	1,941	2,959	1,530	206	6.2	7.7	14.0	23.2	1.6	52.6
A-2	6,090	5.8	264	4.8	292	3.9	43	2.5	179.6	72,700	79,000	327	8	0.40	0.45	2,111	2,959	1,530	206	6.3	7.5	13.8	23.2	1.6	52.3
A-3	6,090	5.8	264	4.8	292	3.9	43	2.5	179.6	72,700	79,000	327	9	0.35	0.45	2,286	2,959	1,530	206	6.3	7.3	13.7	23.2	1.6	52.1
A-4	6,090	5.8	264	4.8	292	3.9	43	2.5	179.6	72,700	79,000	327	10	0.31	0.45	2,464	2,959	1,530	206	6.4	7.2	13.6	23.2	1.6	51.9
A-5	6,090	5.8	264	4.8	292	3.9	43	2.5	179.6	72,700	79,000	327	11	0.28	0.45	2,644	2,959	1,530	206	6.4	7.1	13.5	23.2	1.6	51.8
A-6	6,090	5.8	264	4.8	292	3.9	43	2.5	179.6	72,700	79,000	327	12	0.25	0.45	2,826	2,959	1,530	206	6.4	7.0	13.4	23.2	1.6	51.6
B-1	6,090	5.8	264	4.8	292	4.1	43	2.5	180.1	72,900	79,200	327	7	0.44	0.45	1,912	2,671	1,535	196	6.4	8.2	13.9	21.8	1.4	51.8
B-2	6,090	5.8	264	4.8	292	4.1	43	2.5	180.1	72,900	79,200	327	8	0.38	0.45	2,084	2,671	1,535	196	6.5	8.0	13.8	21.8	1.4	51.5
B-3	6,090	5.8	264	4.8	292	4.1	43	2.5	180.1	72,900	79,200	327	9	0.33	0.45	2,261	2,671	1,535	196	6.6	7.9	13.6	21.8	1.4	51.2
B-4	6,090	5.8	264	4.8	292	4.1	43	2.5	180.1	72,900	79,200	327	10	0.29	0.45	2,440	2,671	1,535	196	6.6	7.7	13.5	21.8	1.4	51.1
B-5	6,090	5.8	264	4.8	292	4.1	43	2.5	180.1	72,900	79,200	327	11	0.26	0.45	2,621	2,671	1,535	196	6.6	7.6	13.5	21.8	1.4	50.9
B-6	6,090	5.8	264	4.8	292	4.1	43	2.5	180.1	72,900	79,200	327	12	0.24	0.45	2,804	2,671	1,535	200	6.6	7.6	13.4	22.5	1.4	51.4
C-1	6,090	5.8	264	4.8	292	4.3	43	2.5	180.4	73,100	79,400	327	7	0.41	0.45	1,888	2,437	1,539	187	6.7	8.8	13.9	20.9	1.2	51.5
C-2	6,090	5.8	264	4.8	292	4.3	43	2.5	180.4	73,100	79,400	327	8	0.36	0.45	2,063	2,437	1,539	187	6.7	8.6	13.7	20.9	1.2	51.2
C-3	6,090	5.8	264	4.8	292	4.3	43	2.5	180.4	73,100	79,400	327	9	0.31	0.45	2,241	2,437	1,539	187	6.8	8.5	13.6	20.9	1.2	50.9
C-4	6,090	5.8	264	4.8	292	4.3	43	2.5	180.4	73,100	79,400	327	10	0.28	0.45	2,421	2,437	1,539	187	6.8	8.3	13.5	20.9	1.2	50.7
C-5	6,090	5.8	264	4.8	292	4.3	43	2.5	180.4	73,100	79,400	327	11	0.25	0.45	2,604	2,437	1,539	193	6.8	8.2	13.4	21.5	1.2	51.3
C-6	6,090	5.8	264	4.8	292	4.3	43	2.5	180.4	73,100	79,400	327	12	0.23	0.45	2,787	2,437	1,539	200	6.9	8.2	13.4	22.4	1.2	52.0
D-1	6,090	5.8	264	4.8	292	4.5	43	2.5	180.7	73,200	79,500	327	7	0.39	0.45	1,867	2,242	1,542	180	6.9	9.5	13.8	20.1	1.1	51.5
D-2	6,090	5.8	264	4.8	292	4.5	43	2.5	180.7	73,200	79,500	327	8	0.34	0.45	2,042	2,242	1,542	180	7.0	9.3	13.7	20.1	1.1	51.2
D-3	6,090	5.8	264	4.8	292	4.5	43	2.5	180.7	73,200	79,500	327	9	0.30	0.45	2,221	2,242	1,542	180	7.0	9.1	13.6	20.1	1.1	50.9
D-4	6,090	5.8	264	4.8	292	4.5	43	2.5	180.7	73,200	79,500	327	10	0.26	0.45	2,403	2,242	1,542	186	7.0	9.0	13.5	20.7	1.1	51.3
D-5	6,090	5.8	264	4.8	292	4.5	43	2.5	180.7	73,200	79,500	327	11	0.24	0.45	2,586	2,242	1,542	193	7.1	8.9	13.4	21.5	1.1	51.9
D-6	6,090	5.8	264	4.8	292	4.5	43	2.5	180.7	73,200	79,500	327	12	0.22	0.45	2,770	2,242	1,542	199	7.1	8.8	13.4	22.3	1.1	52.6
E-1	6,090	5.8	264	4.8	292	4.7	43	2.5	180.9	73,300	79,600	327	7	0.38	0.45	1,849	2,078	1,544	174	7.1	10.2	13.8	19.6	1.0	51.7
E-2	6,090	5.8	264	4.8	292	4.7	43	2.5	180.9	73,300	79,600	327	8	0.32	0.45	2,025	2,078	1,544	174	7.2	9.9	13.7	19.6	1.0	51.4
E-3	6,090	5.8	264	4.8	292	4.7	43	2.5	180.9	73,300	79,600	327	9	0.28	0.45	2,205	2,078	1,544	179	7.2	9.8	13.5	20.0	1.0	51.6
E-4	6,090	5.8	264	4.8	292	4.7	43	2.5	180.9	73,300	79,600	327	10	0.25	0.45	2,388	2,078	1,544	185	7.3	9.6	13.5	20.7	1.0	52.1
E-5	6,090	5.8	264	4.8	292	4.7	43	2.5	180.9	73,300	79,600	327	11	0.23	0.45	2,571	2,078	1,544	192	7.3	9.5	13.4	21.4	1.0	52.7
E-6	6,090	5.8	264	4.8	292	4.7	43	2.5	180.9	73,300	79,600	327	12	0.21	0.45	2,756	2,078	1,544	199	7.3	9.5	13.3	22.2	1.0	53.3

Abbribation : Hr = Rated head, Pt = Turbine outpot, Pg = Generator output, N = Unit speed, Tc = Closing time, dP = Pressure rise, dN = Speed rise, GDr2 = Inertia required by dP and dN
GDs2 = Inertia required for stability on speed regulation, GDn2 = Natural inertia of generator, Wr = Weight of rotor

Note : Cost of generator includes overhead crane cost.

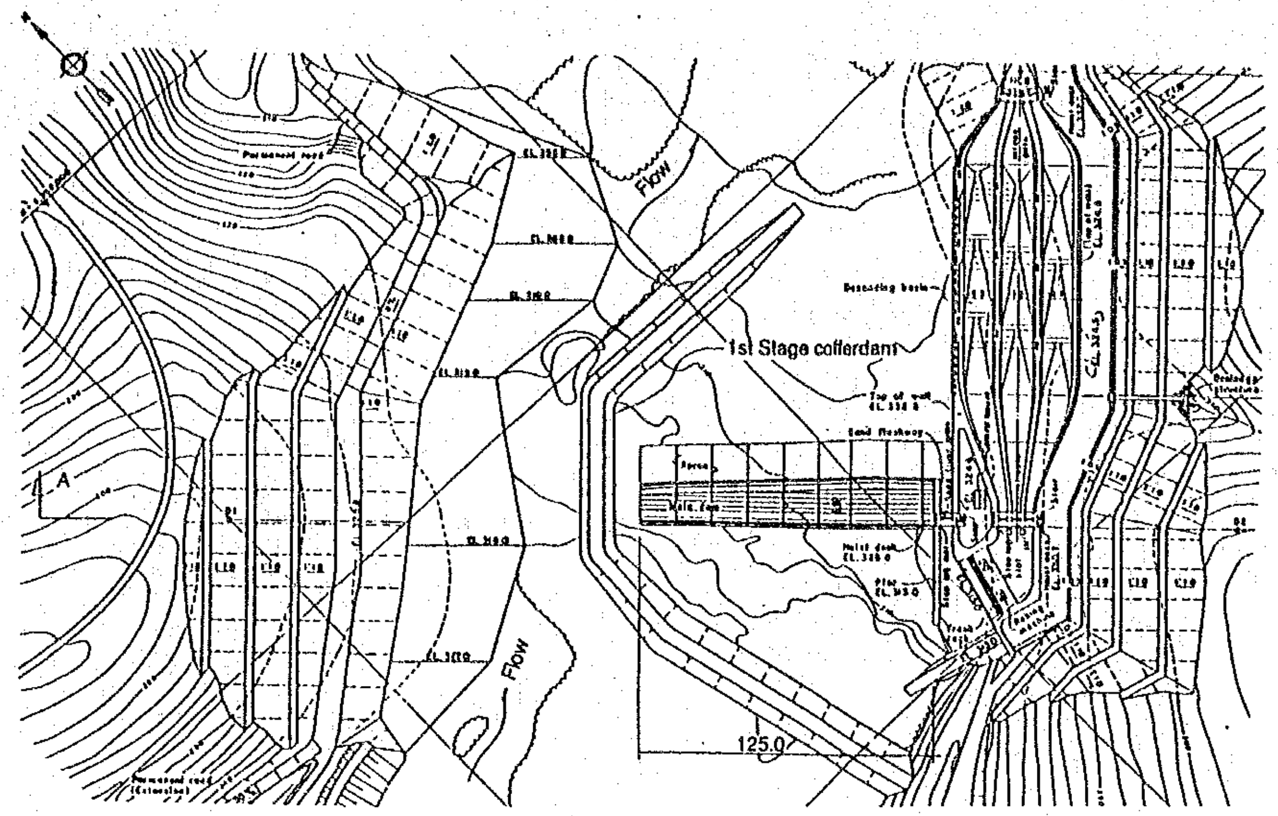
Table VIII.2.7 Optimum Number of Units

	Two units	Three units	Four units
Basic Features			
Maximum plant discharge (m3/sec)	90	90	90
Max. unit discharge (m3/sec)	45	30	22.5
Min. unit discharge (m3/sec)	18	12	9
Unit output (MW)	70.0	46.6	34.8
Size of powerhouse (l x w x h in meter)	59x32x43	64x30x41	82x27x39
Construction Cost (1,000 US$)	73,079	81,812	85,024
Direct cost	48,711	54,531	56,673
Civil			
- Direct cost including continence	11,270	12,948	14,752
Electrical mechanical equipment			
- Direct cost including continence	36,345	40,291	40,790
Hydro-mechanical			
(Bifurcation. Penstock after bifurcation & Draft tube gate)			
- Direct cost including continence	1,096	1,292	1,130
Indirect cost	14,126	15,814	16,435
Interest during construction	10,242	11,466	11,917
Benefit in 50 year operation			
Annual energy output (MWy)	74.30	76.15	76.49
Energy output in planned maintenance year (MWy)	65.00	61.38	55.76
Total energy output in 50 years MWy)	3,678	3,748	3,742
Capitalized energy benefit (1,000US$)	327,192	334,256	334,529
Net Benefit (1,000US$)	254,113	252,444	249,505

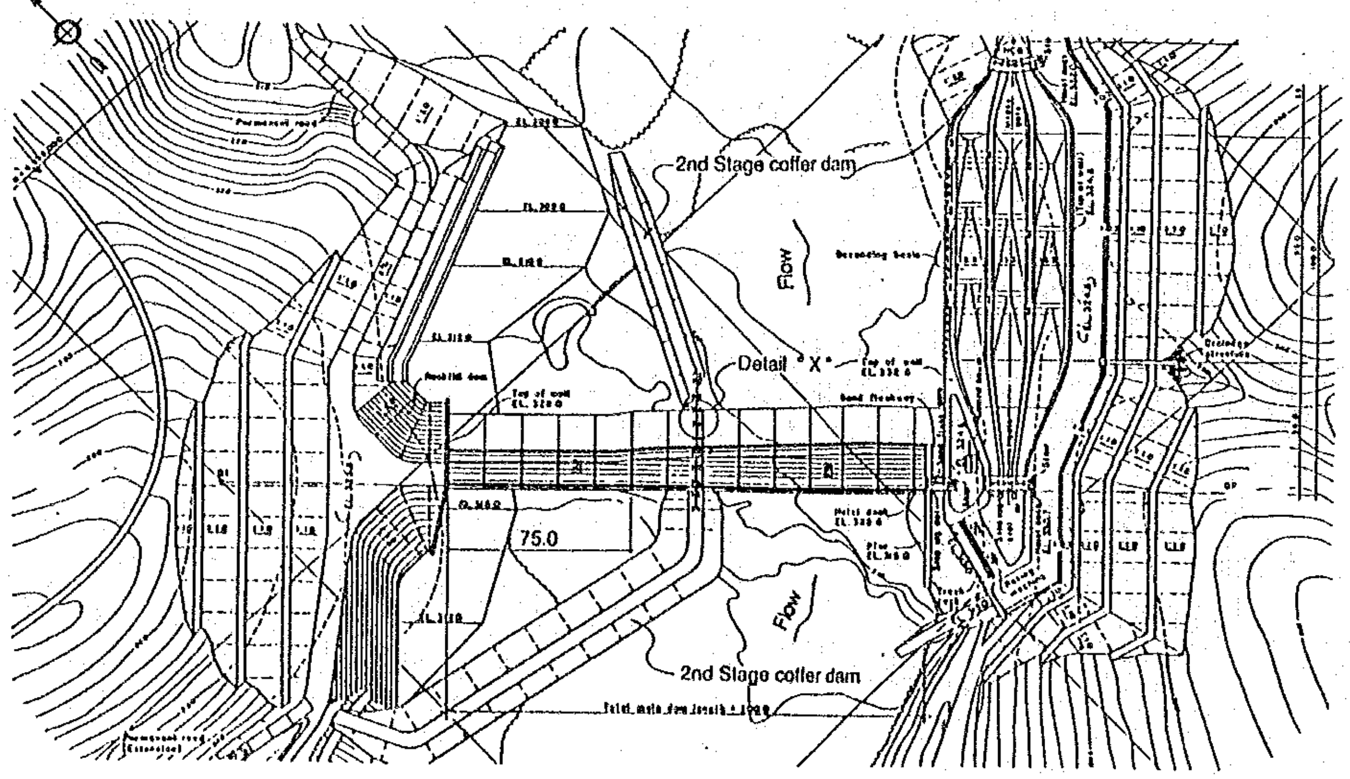
Table VIII.2.8 Construction Cost of Underground Powerhouse

Item No.	Work Items	Unit	Unit price	Quantity	Amount (1000US$)
1.	Earth Works				
1.1	Open excavation				
1.1.1	Excavation common	m3	5.8	36,000	209
1.1.2	Excavation rock	m3	12.8	12,000	154
1.2	Underground excavation				
1.2.1	Powerhouse cavern	m3	50	39,000	1,950
1.2.2	Tunneling	m3	75	39,000	2,925
1.3	Embankment for switch yard		3.5	70,000	245
2.	Rock Supporting Works for Cave				
2.1	Rock bolt l=5,000m for arch	m	44	1,800	79
2.2	Prestress rock anchor	m	900	4,000	3,600
2.3	Consolidation grouting	m	73	2,000	146
2.4	Drain hole	m	50	6,000	300
3.	Concrete Works				
3.1	Structural concrete	m3	185	11,000	2,035
3.2	Tunnel concrete	m3	194	2,000	388
3.3	Shotcrete t=180mm	m2	50	9,000	450
3.4	Reinforcement bars	ton	1,400	660	924
4	Others	10 % of the above total			1,340
5	Contingency	15%			2,011
	Total				16,756

Figure



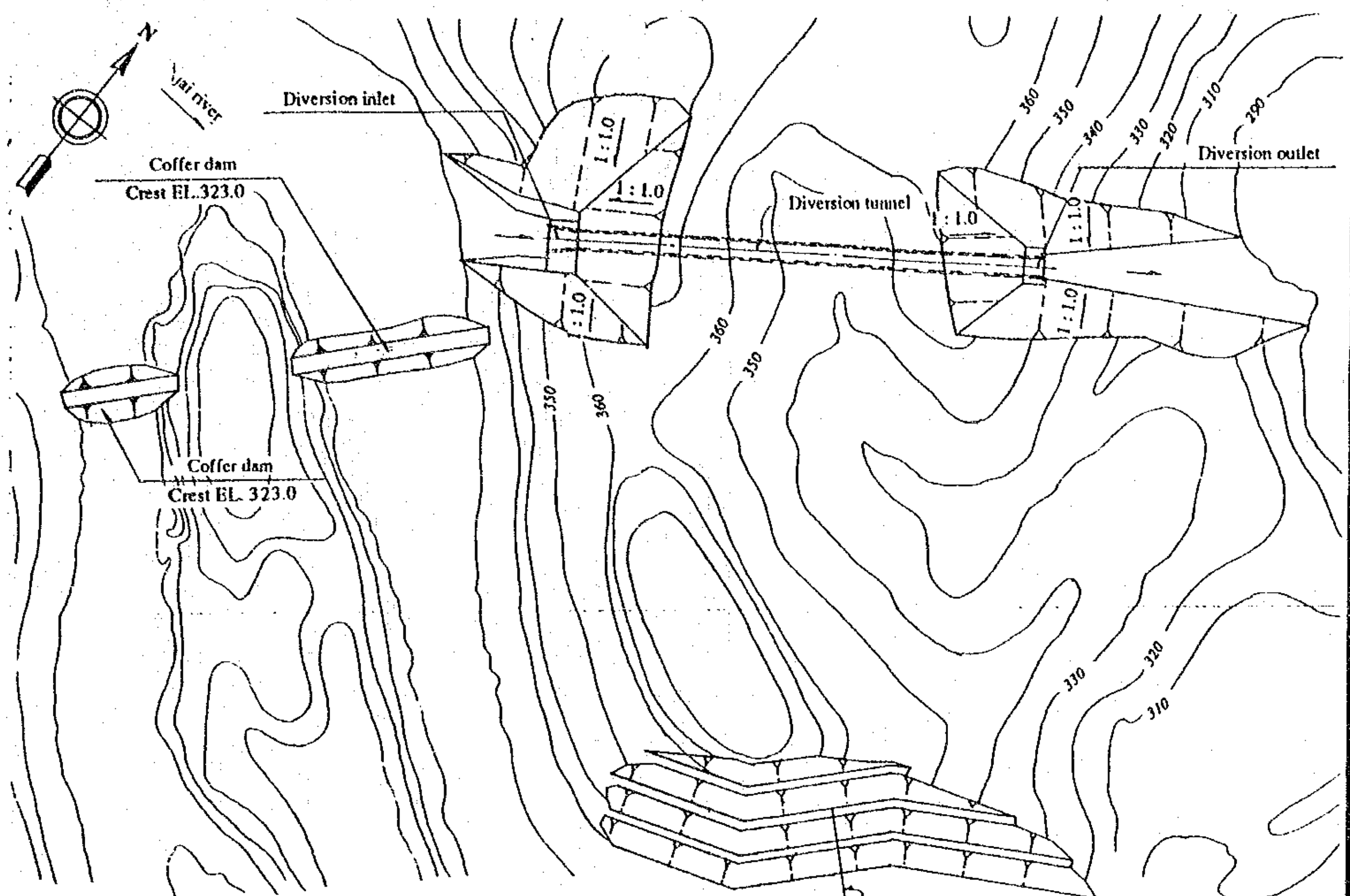
1st Stage Diversion no scale



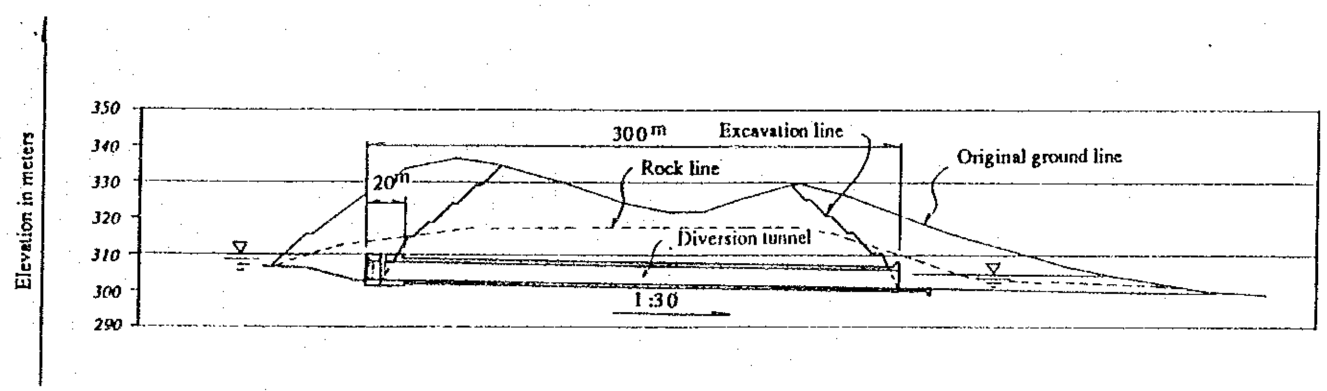
2nd Stage Diversion no scale

Multi-stage Diversion Method

Scale 0 20 m



Plan



Profile

Tunnel Diversion Method

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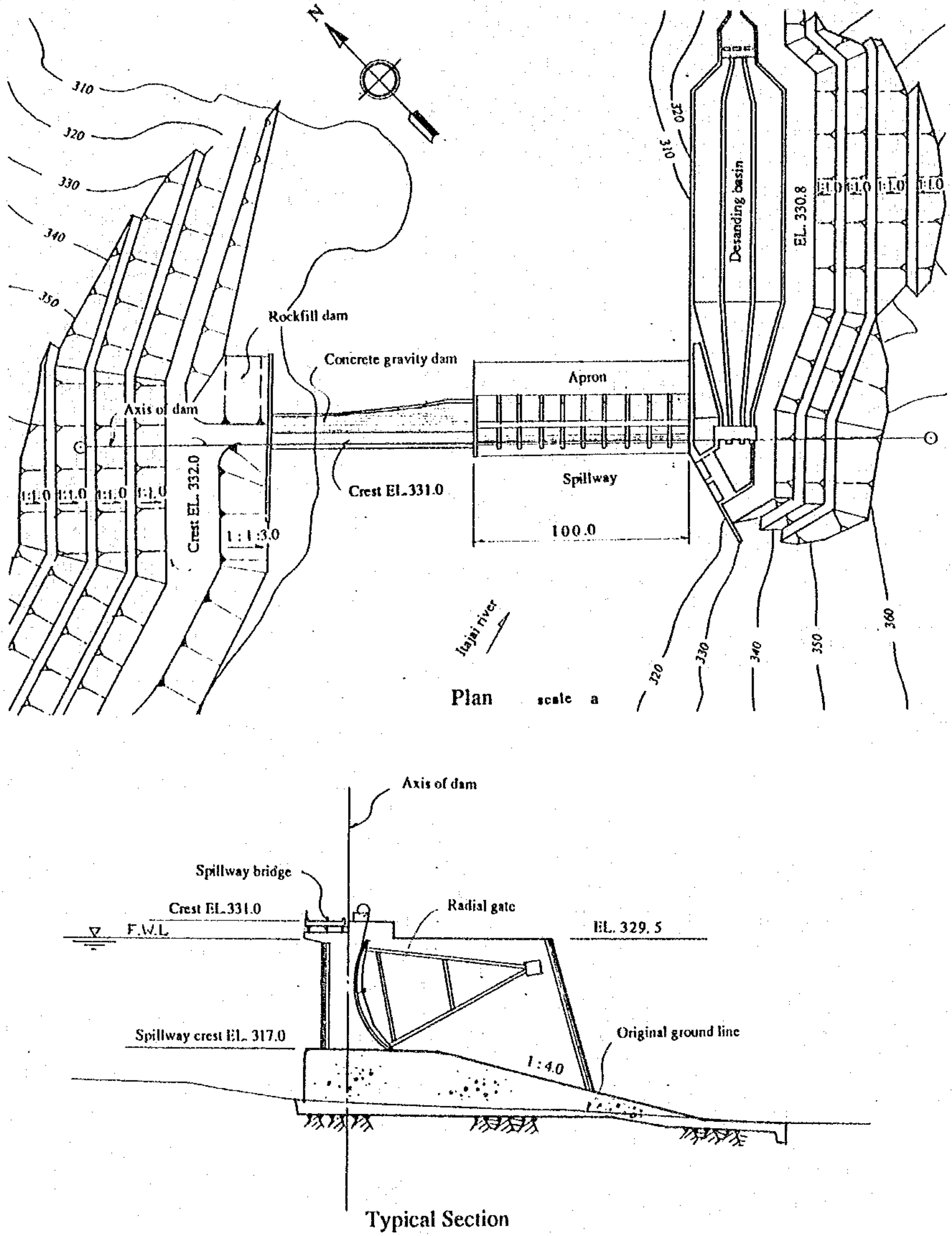
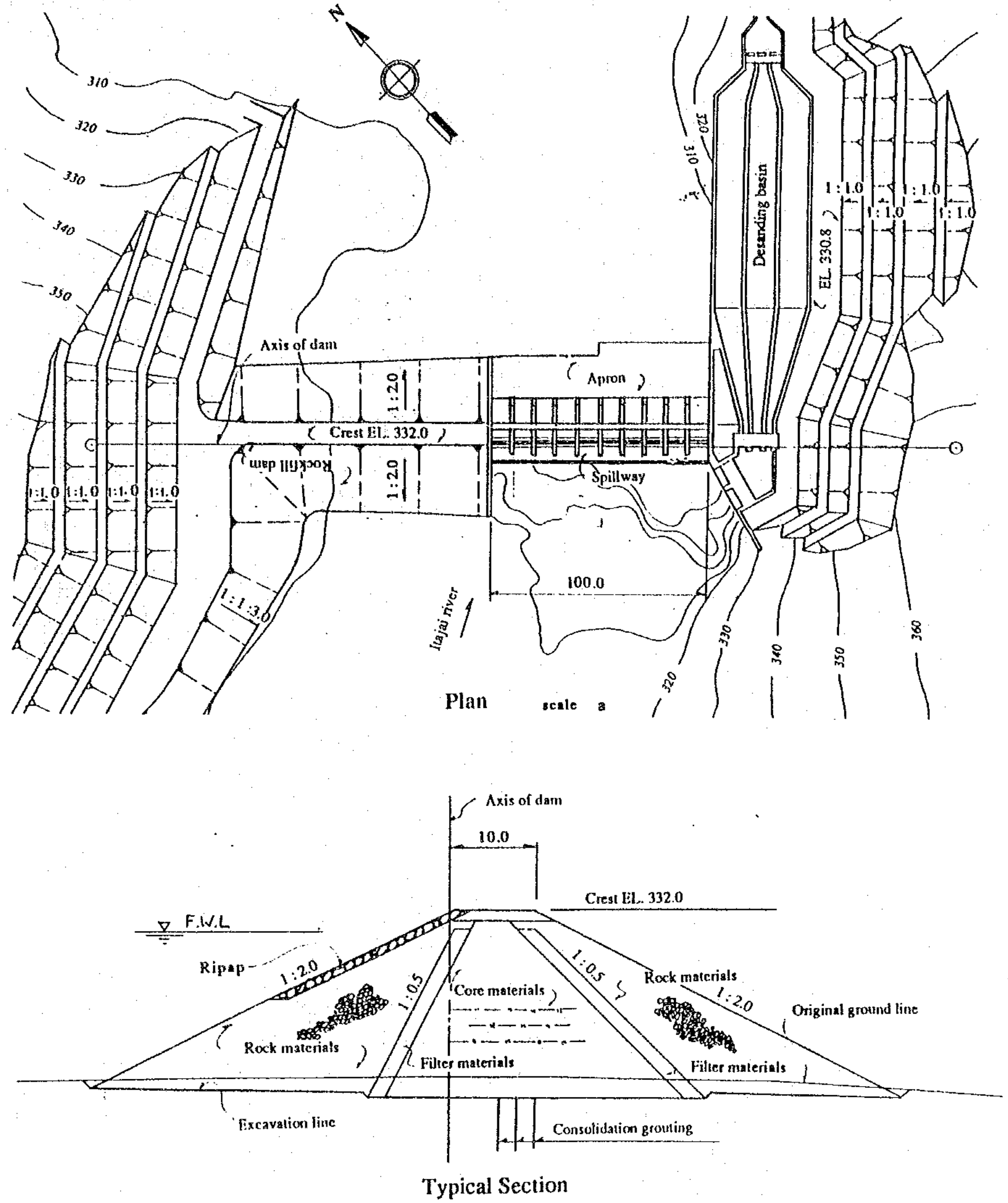


Concrete gravity and gated spillway scale b



Rockfill dam and gated spillway scale b

Scale a 0 125 m

Scale b 0 30 m

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Figure VIII.2.2
Dam - Alternative Dam and Spillway Types

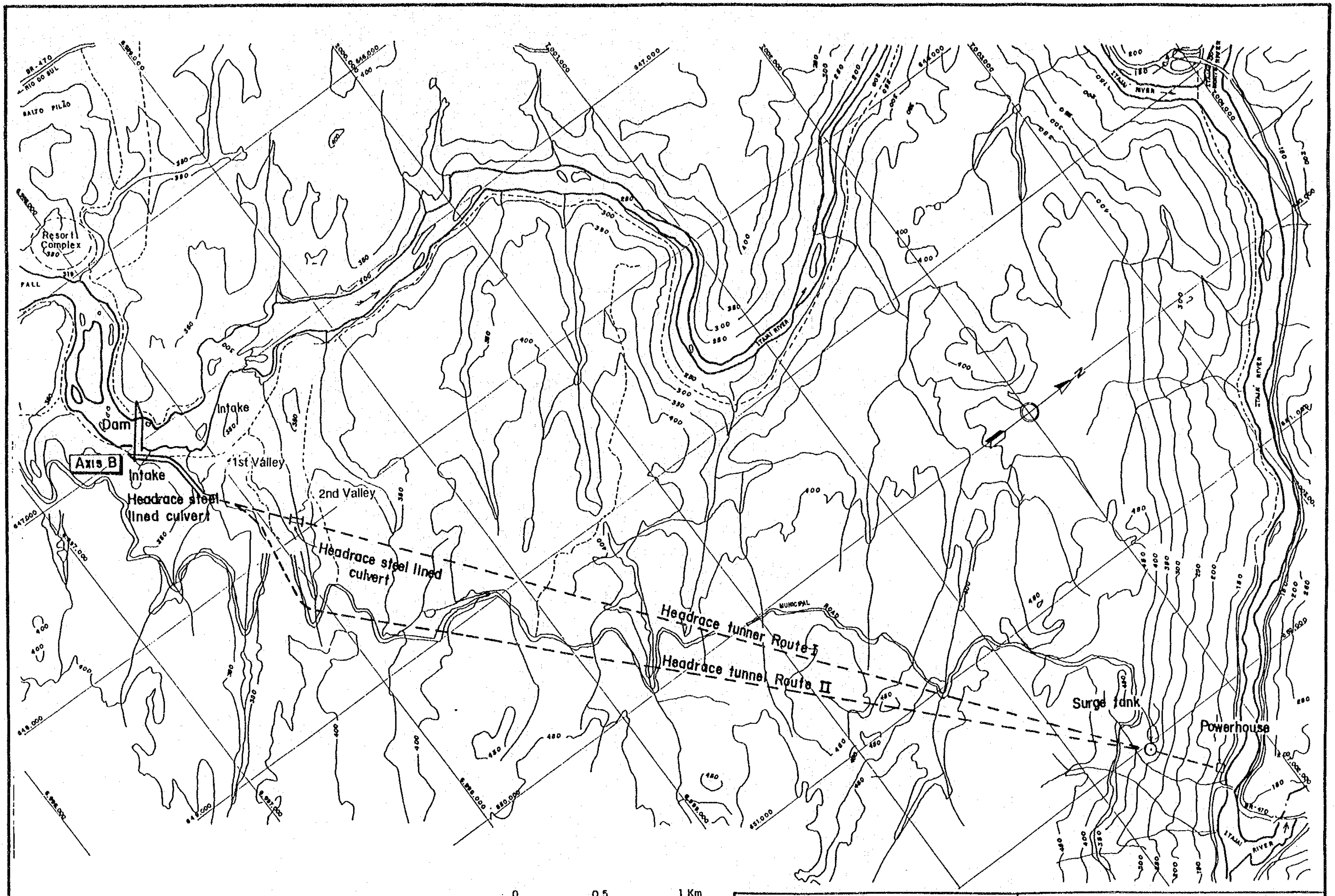

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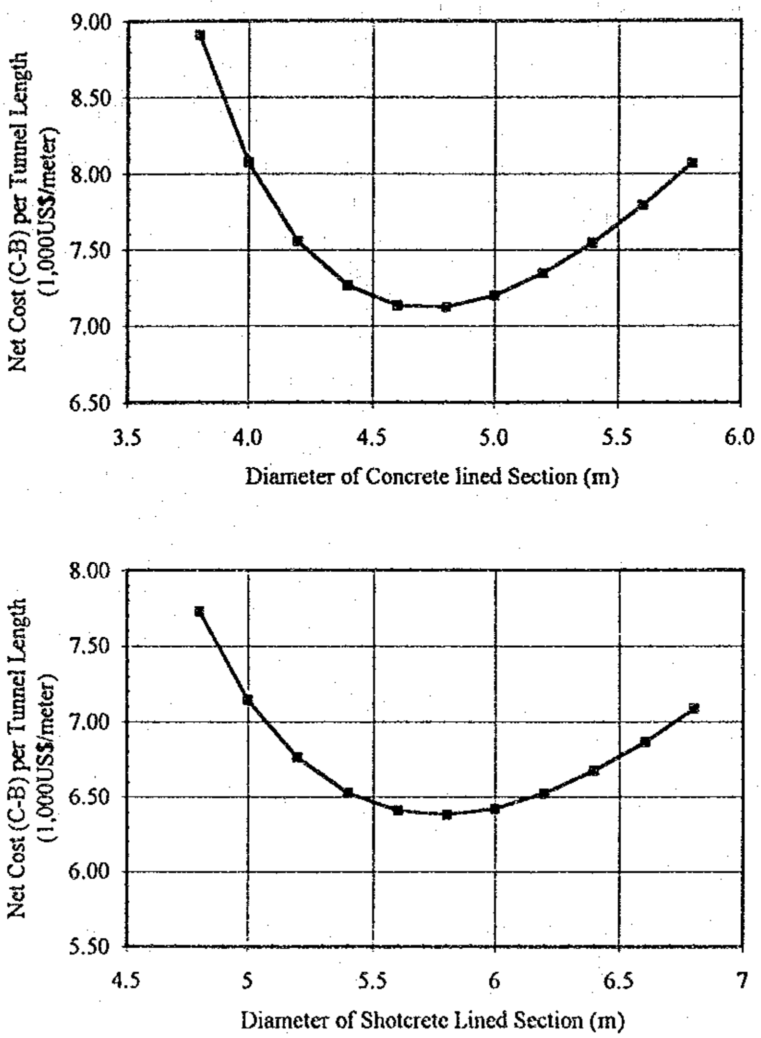
Figure VIII. 2.3
Headrace Waterway - Alternative alignments



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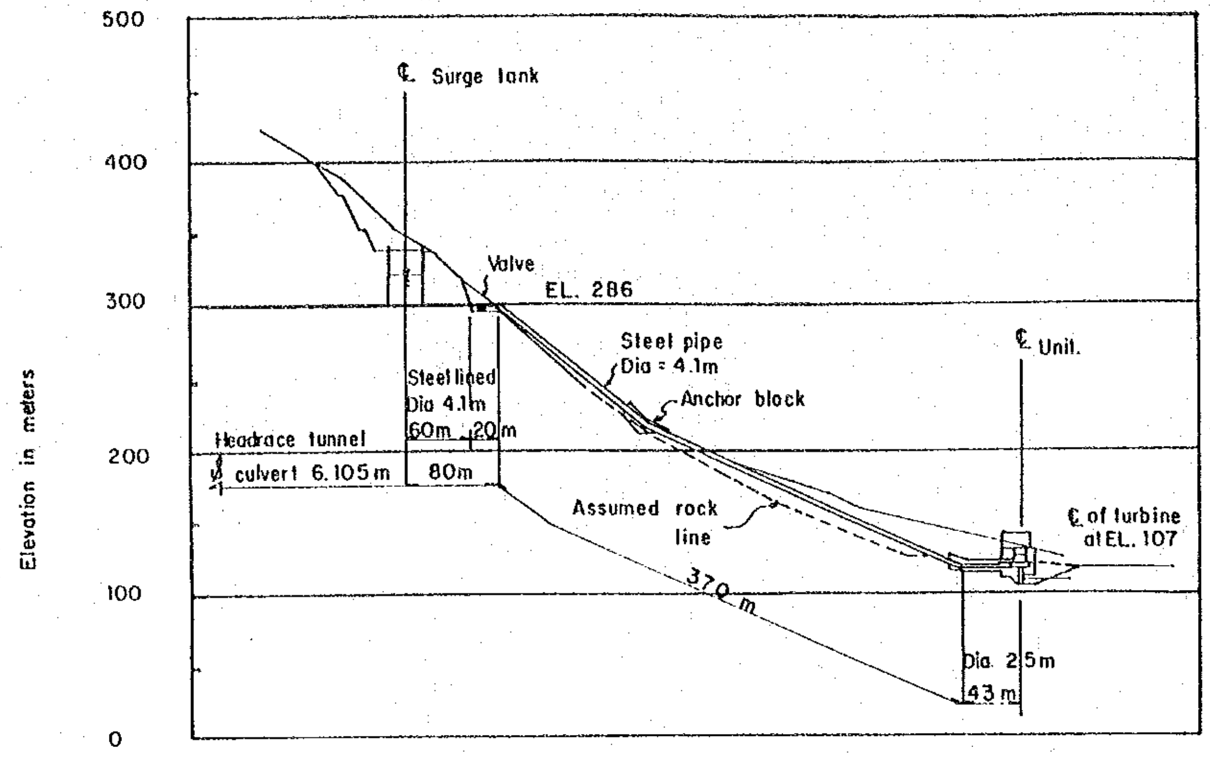
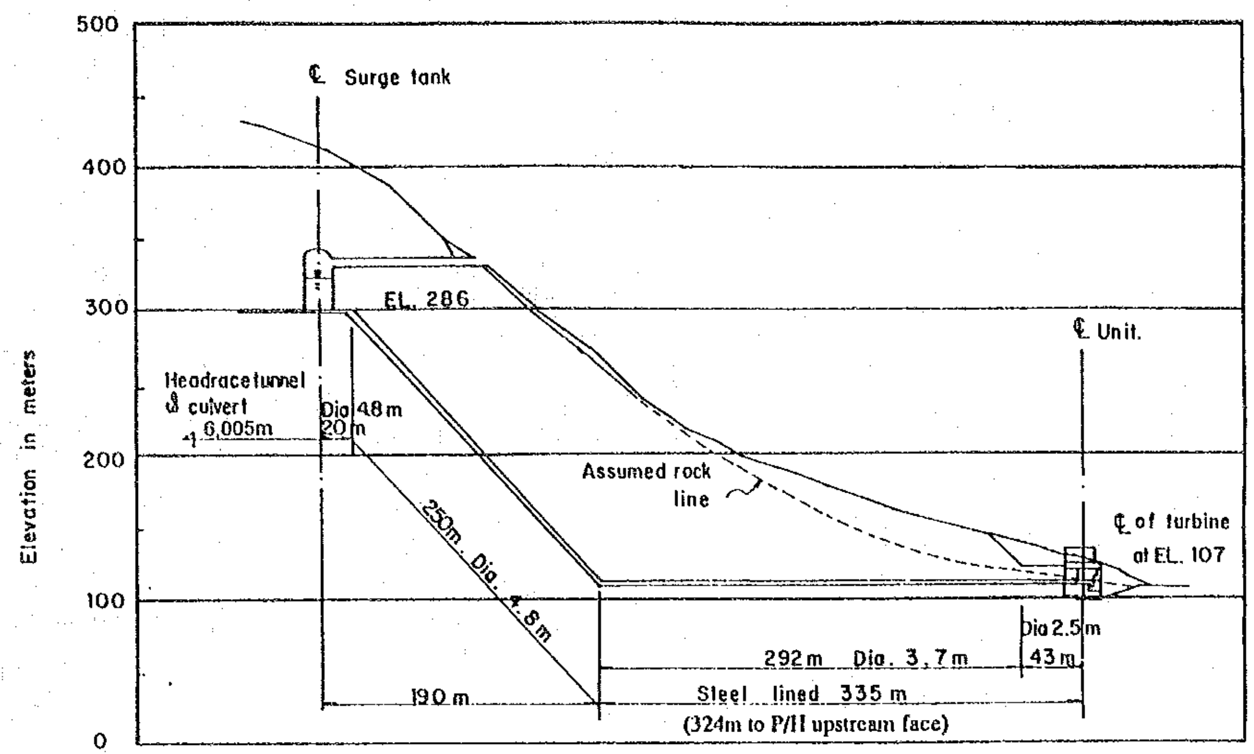
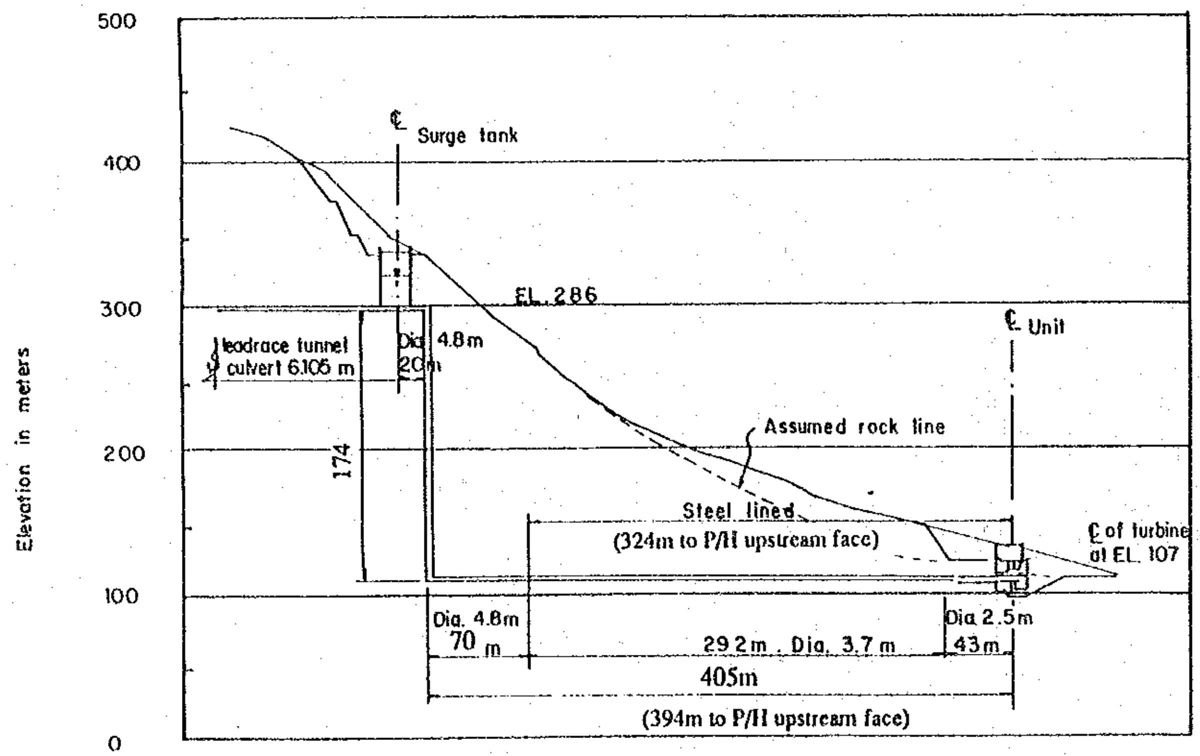


Type I



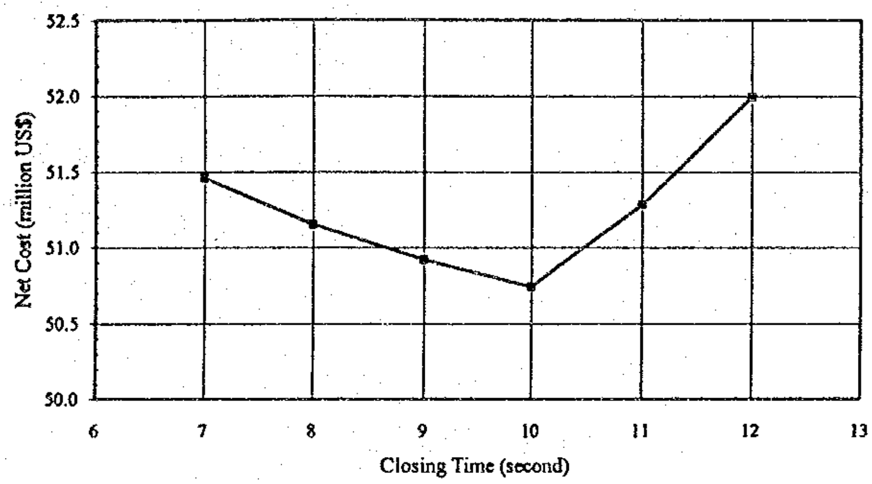
Type III



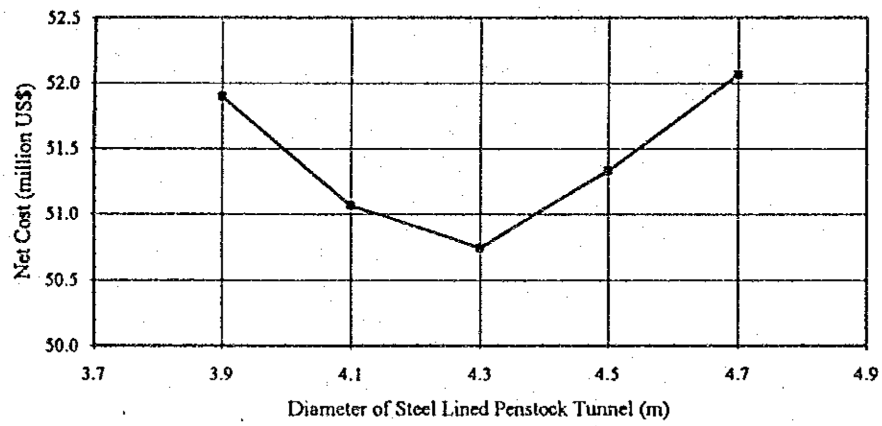
Type II

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. VIII.2.5 Penstock - Alternative Types

Net Cost (Construction Cost & Loss of Benefit due to Head Loss) vs. Closing Time in Case of Diameter 4.3 m of Steel Lined Penstock Tunnel



Net Cost (Construction Cost & Loss of Benefit due to Head Loss) vs. Diameter of Steel Lined Penstock Tunnel at Closing Time 10 Second



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig.VIII.2.6** **Penstock - Optimum Diameter of Steel Liner and Closing Time**

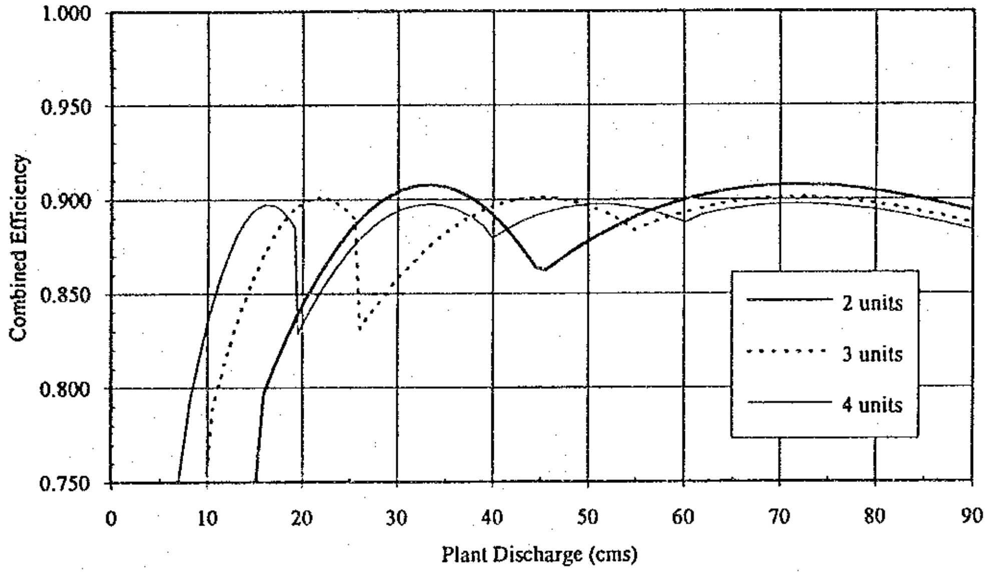


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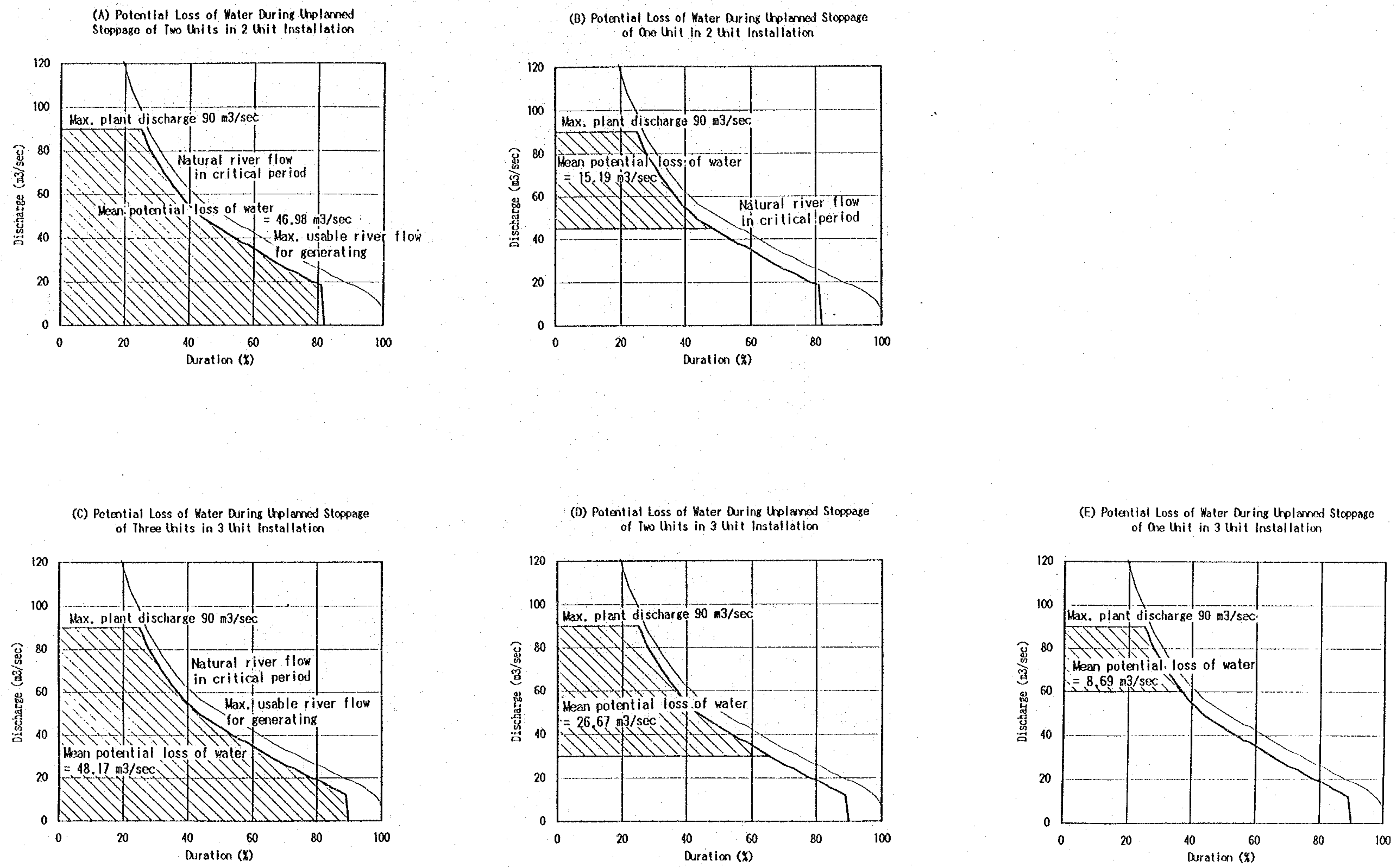
Fig.VIII.2.7
Optimum Unit Nunber
- Combined Efficiency



Scale
Scale
Scale

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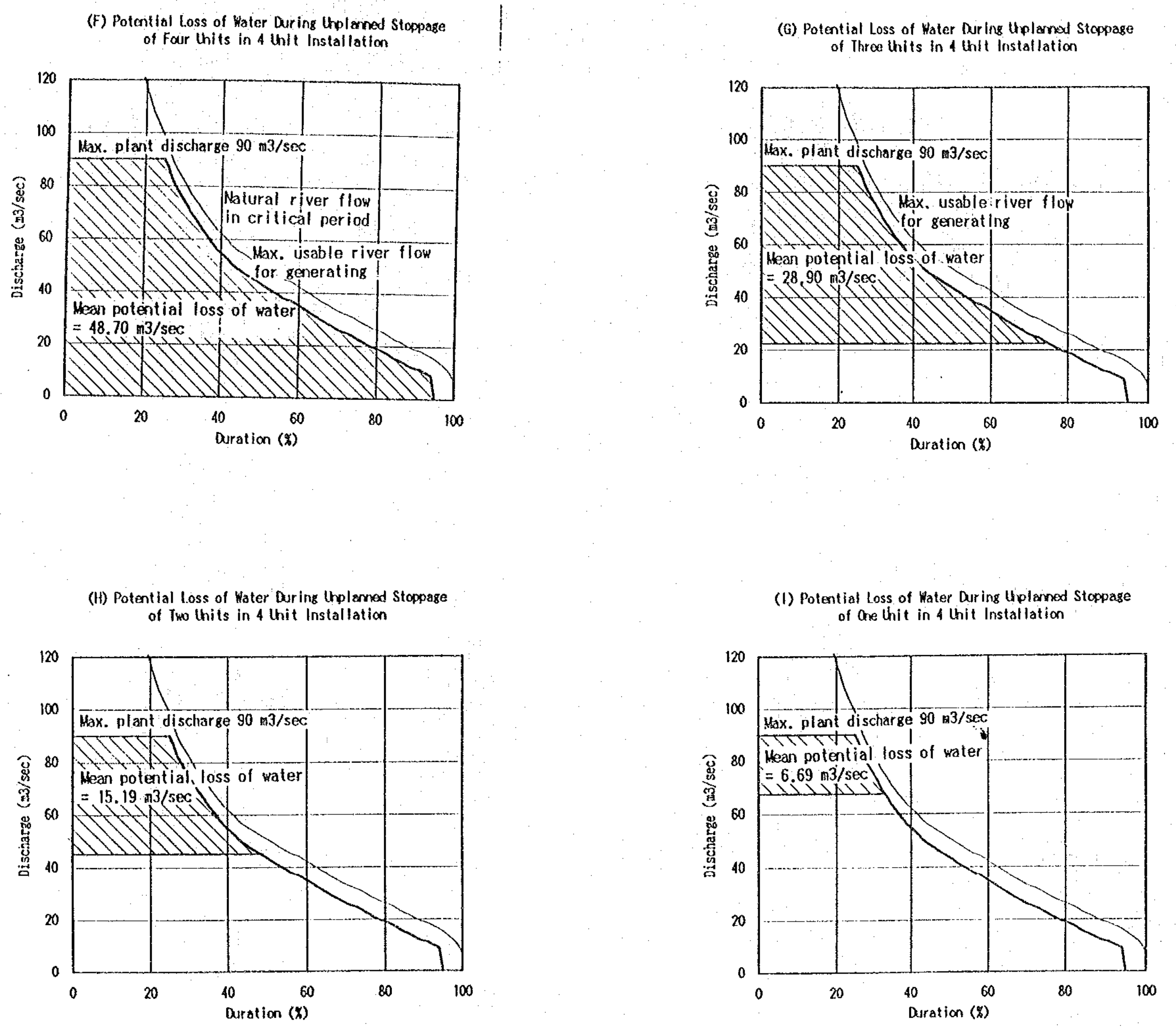
Fig. VIII.2.8.
Number - Potential Loss of Water during Unplanned Stoppage (1/2)



Scale
Scale
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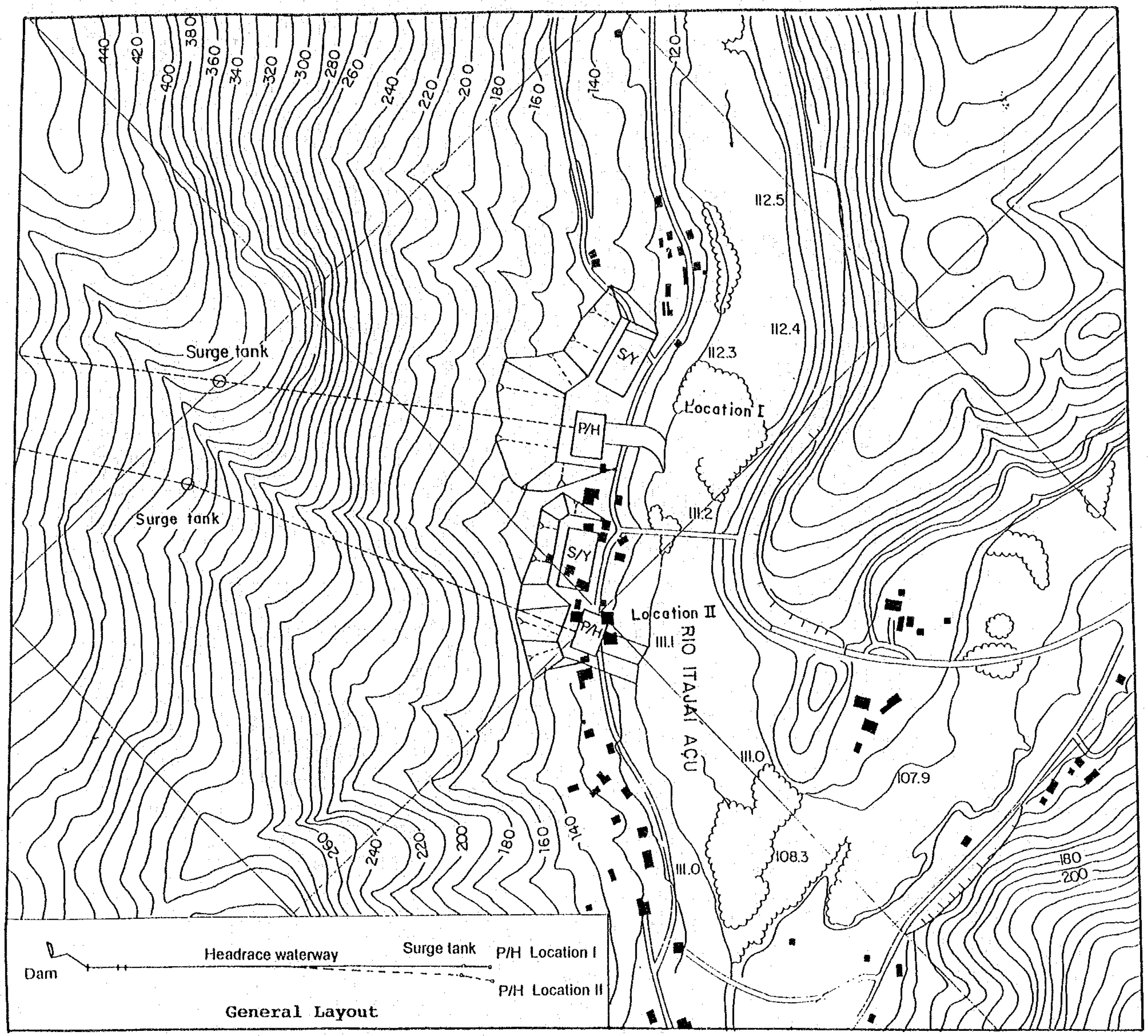
JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Fig. VIII.2.8. Number - Potential Loss of Water during Unplanned Stoppage (2/2)



Scale
Scale
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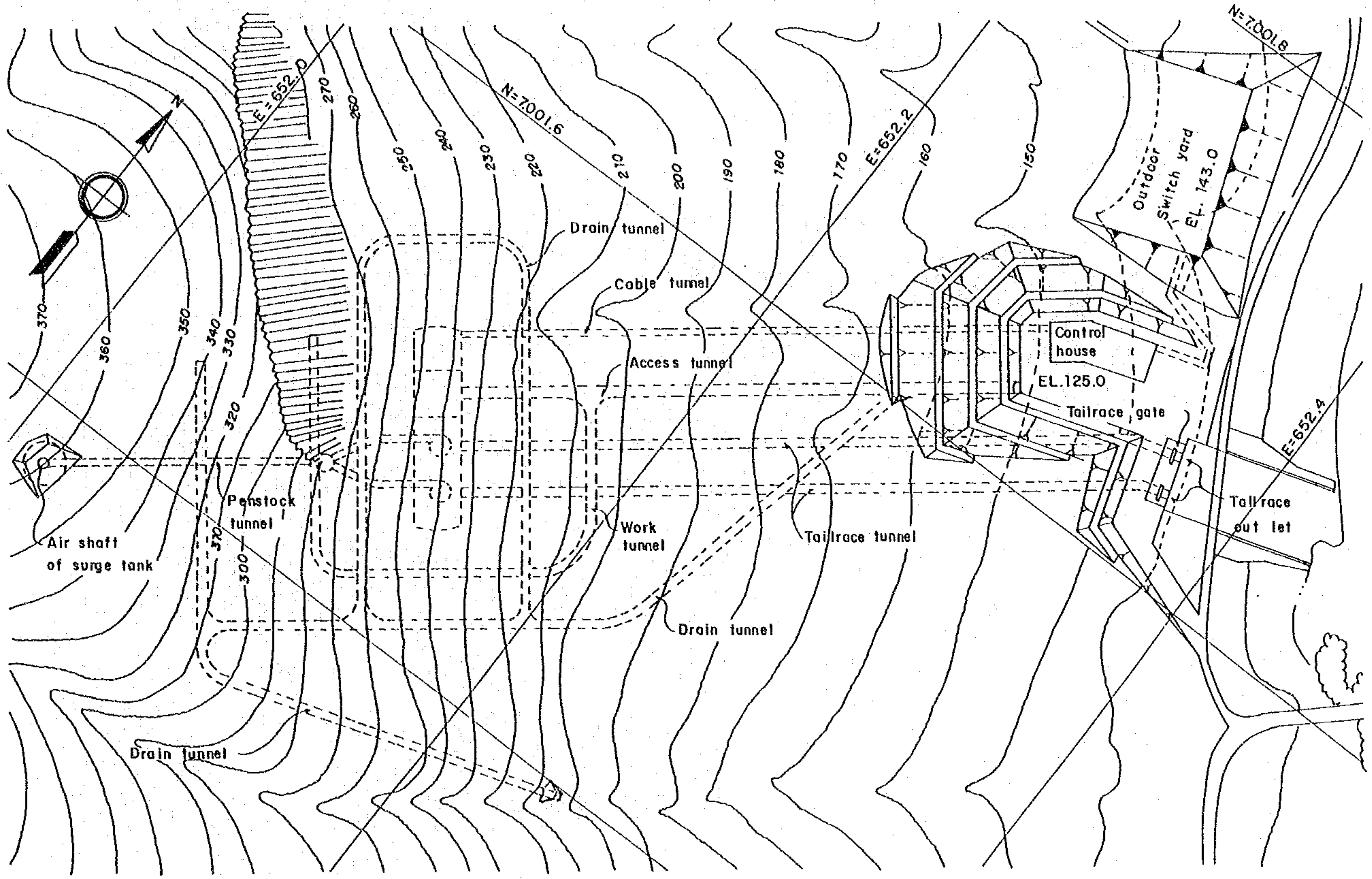
Fig. VIII.2.9
Powerhouse - Alternative Location of Site



General Plan for Underground Powerhouse Scheme SCALE A

Scale

Scale

Scale

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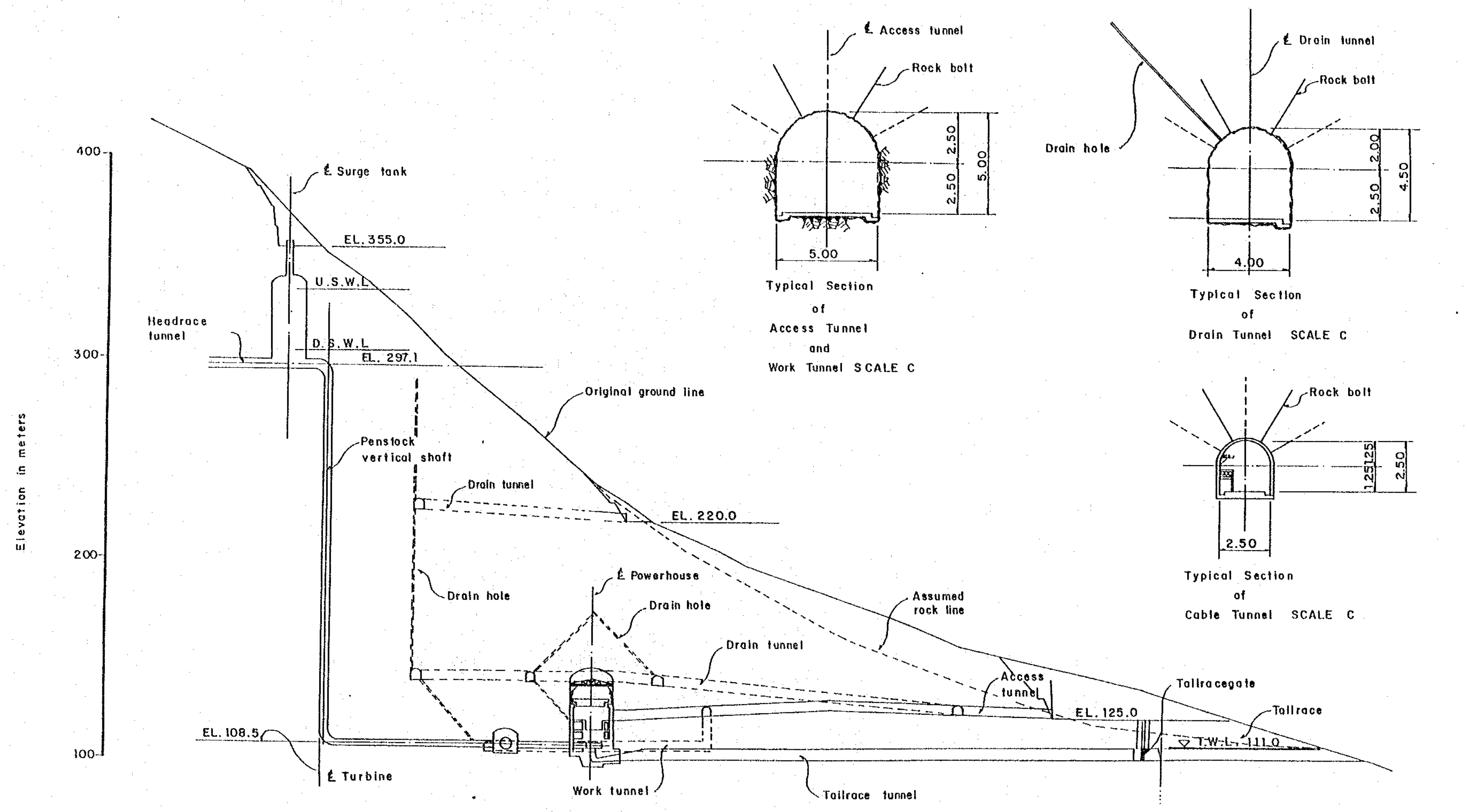
SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

Fig. VIII.2.10
Underground Powerhouse - General Plan



Profile of Underground Powerhouse Scheme SCALE A

Scale
Scale
Scale

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Fig. VIII.2.11
Underground Powerhouse - Profile

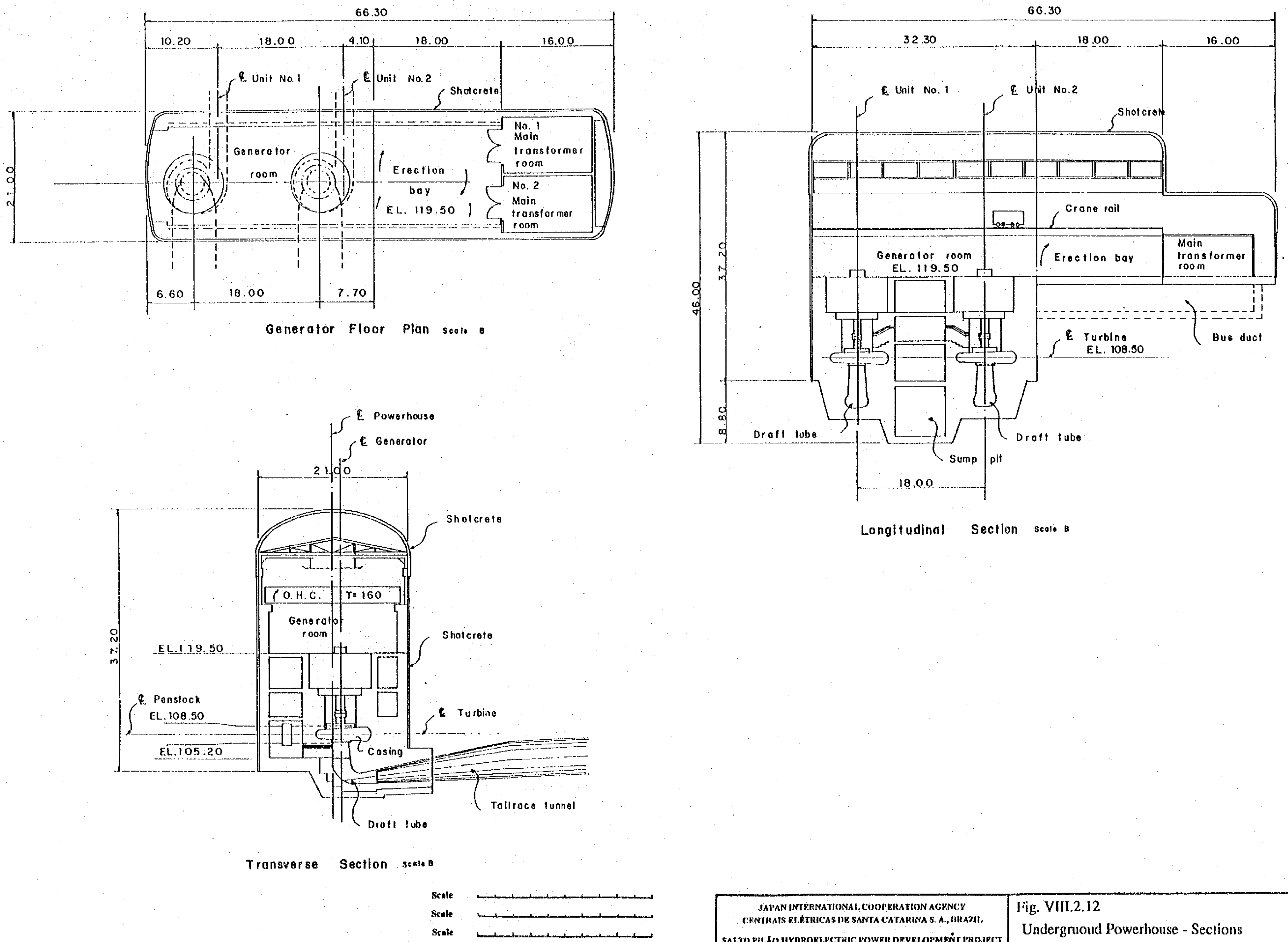

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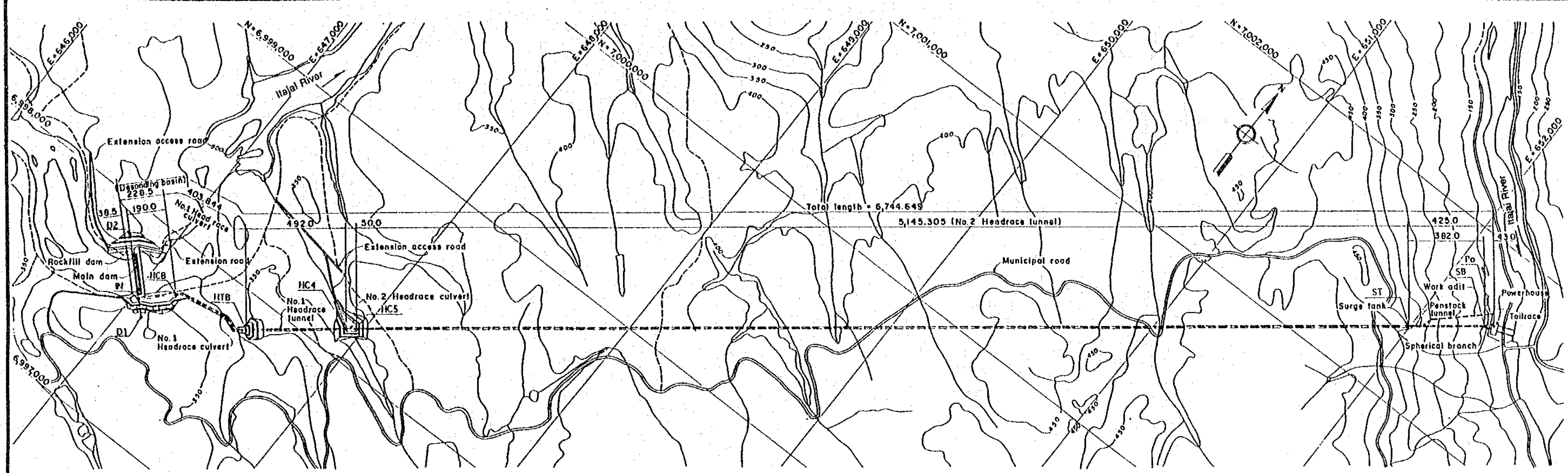
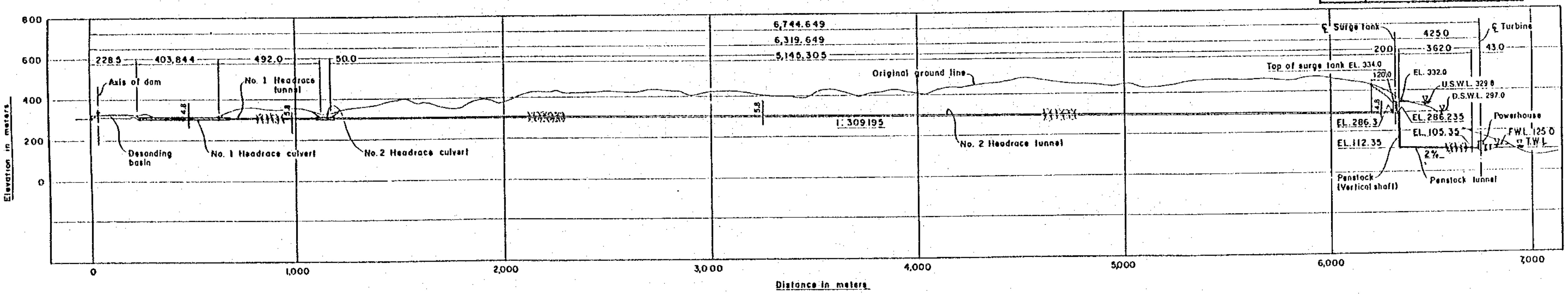
Fig. VIII.2.12
Undergruoud Powerhouse - Sections



General Plan

COORDINATES (Unit : m)

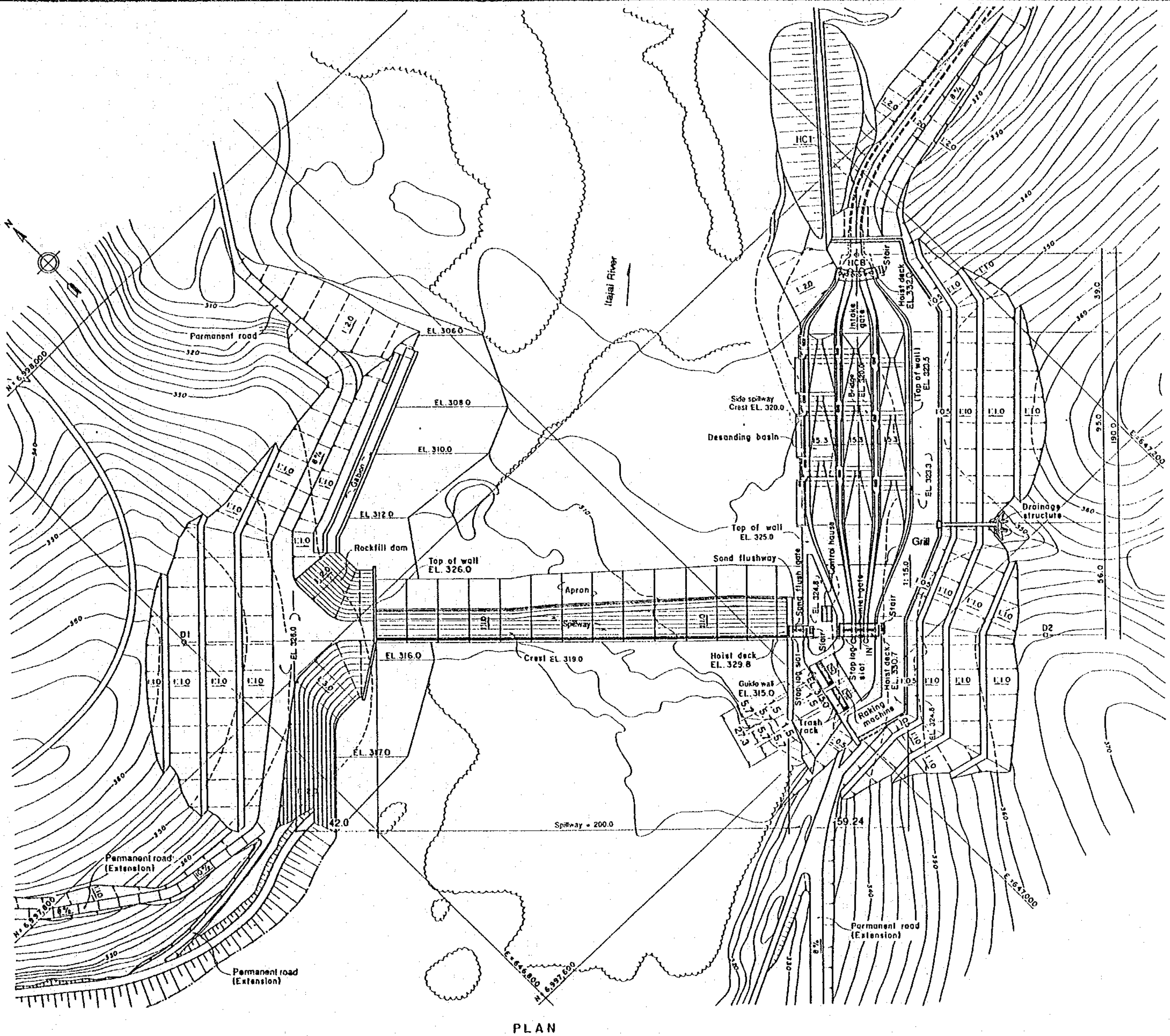
Points	N	E
D1	6,997,560.000	647,100.000
D2	6,997,850.000	646,800.000
IN	6,997,622.552	647,035.291
HCB	6,997,759.160	647,167.345
HTB	6,997,830.000	647,540.000
HC4	6,998,135.656	647,925.536
HC5	6,998,166.719	647,964.717
ST	7,001,363.255	651,996.630
SB	7,001,600.573	652,295.969
Po	7,001,627.287	652,329.665



Profile

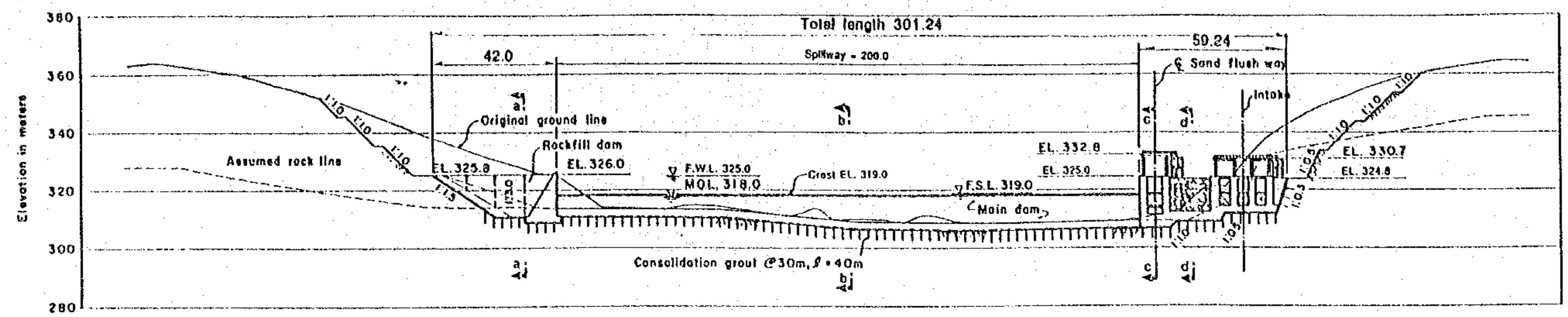
Scale 0 — 1,000 m

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Figure VIII. 5.1 General Plan and Profile

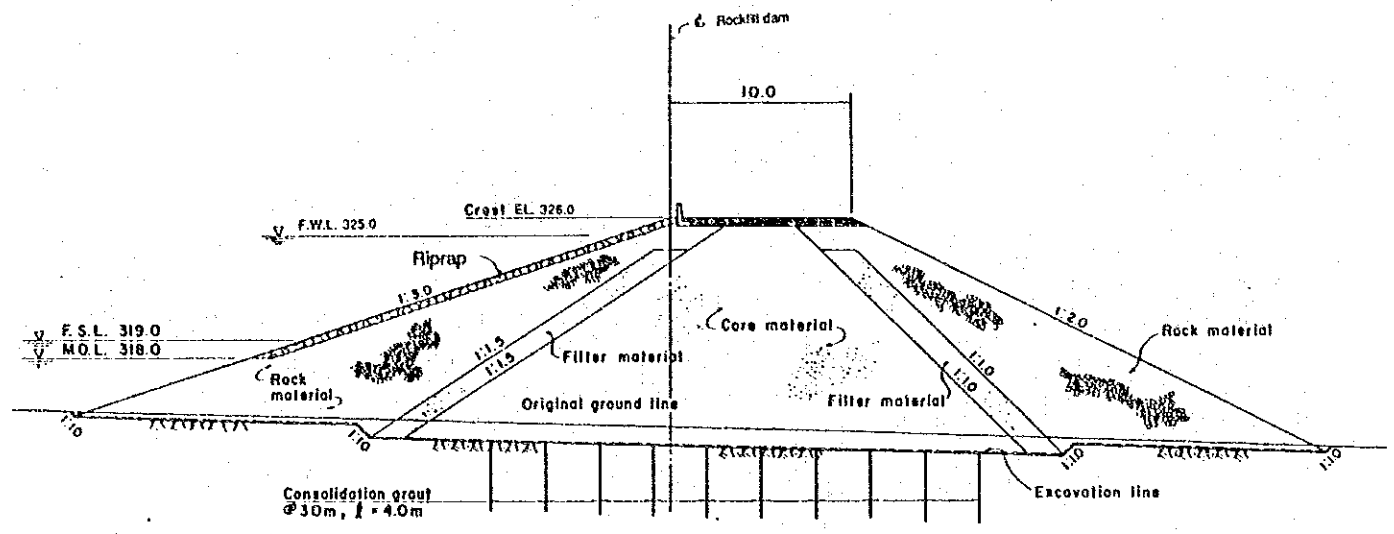


Scale 0 — 100m

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Figure VIII. 5.2 Dam and Intake Facilities - General Plan

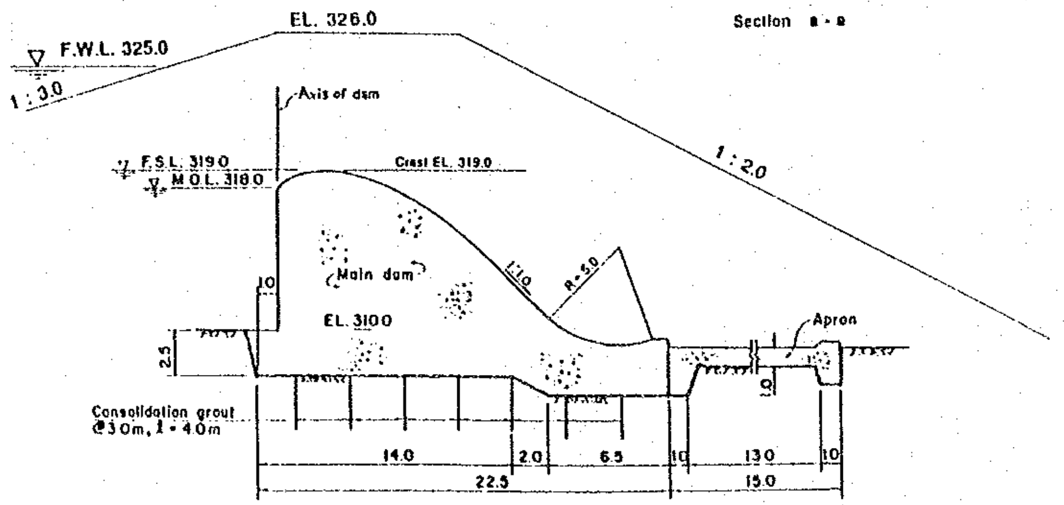


Profile of Dam scale a



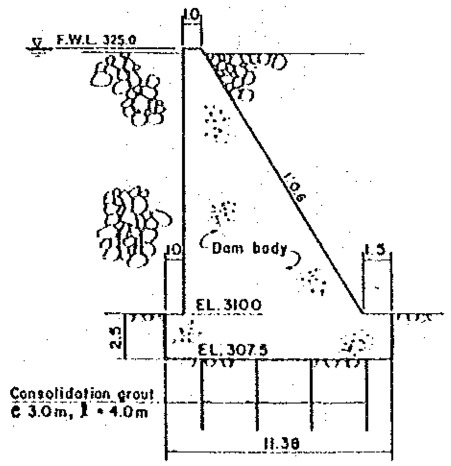
Typical Section of Rockfill Dam scale b

Section a - a



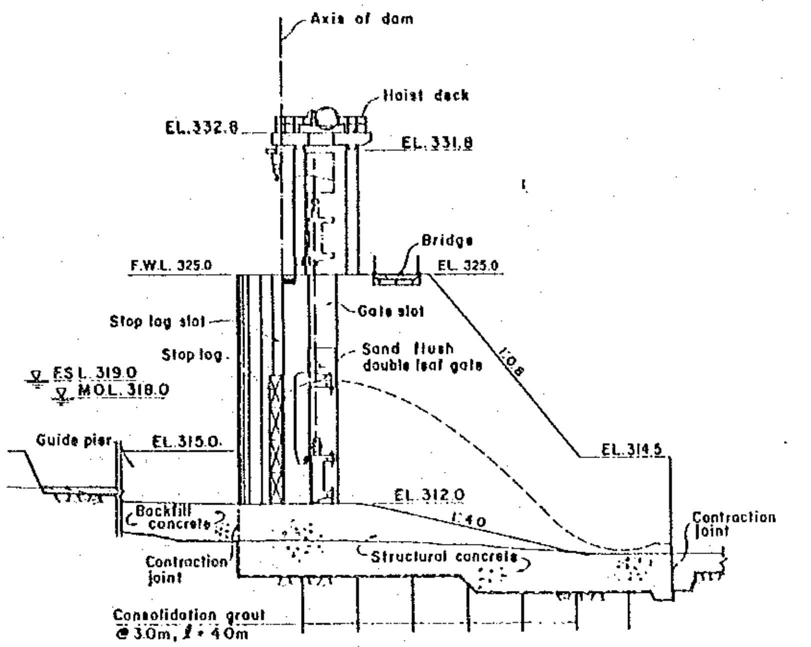
Typical Section of Main Dam Spillway Portion scale b

Section b - b



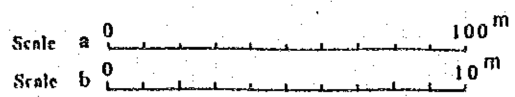
Typical Section of Non Overflow Portion scale b

Section d - d



Typical Section of Sandflush Way scale b

Section c - c



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SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

Figure VIII. 5.3

Dam - Profile and Typical Sections

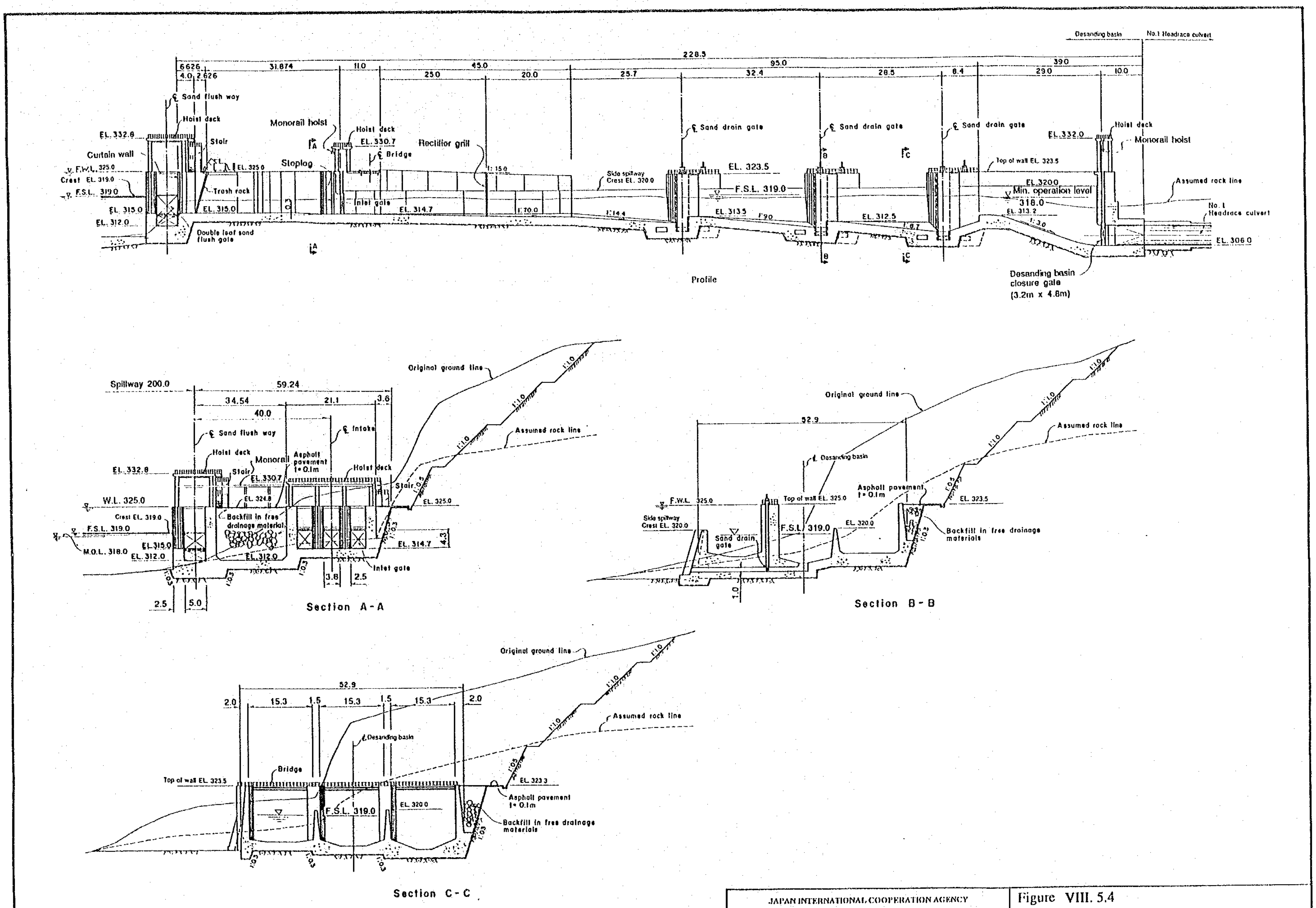

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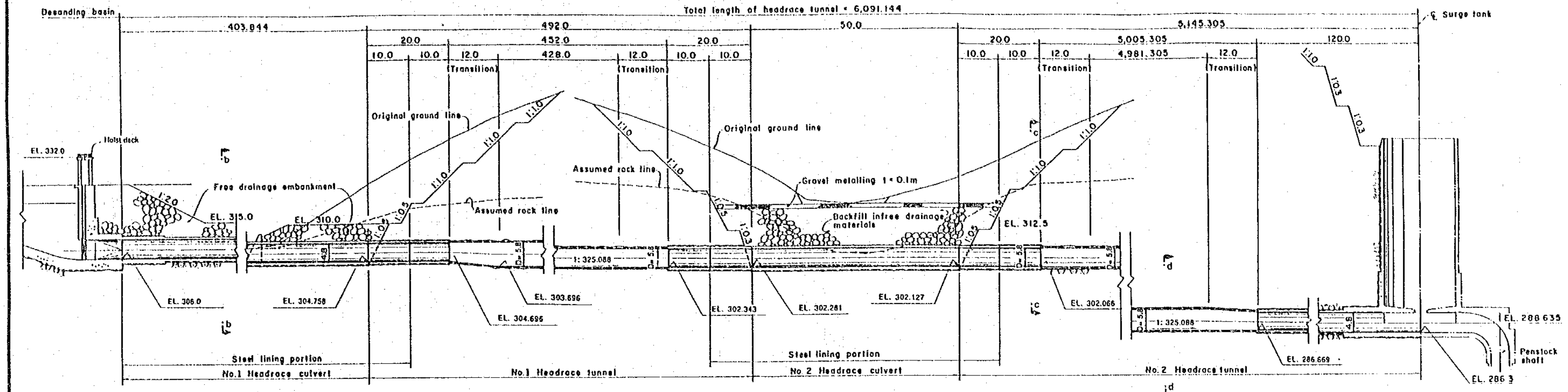
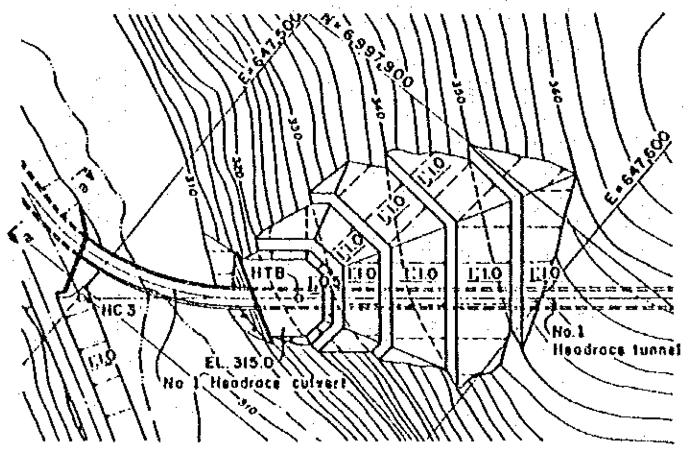
Figure VIII. 5.4

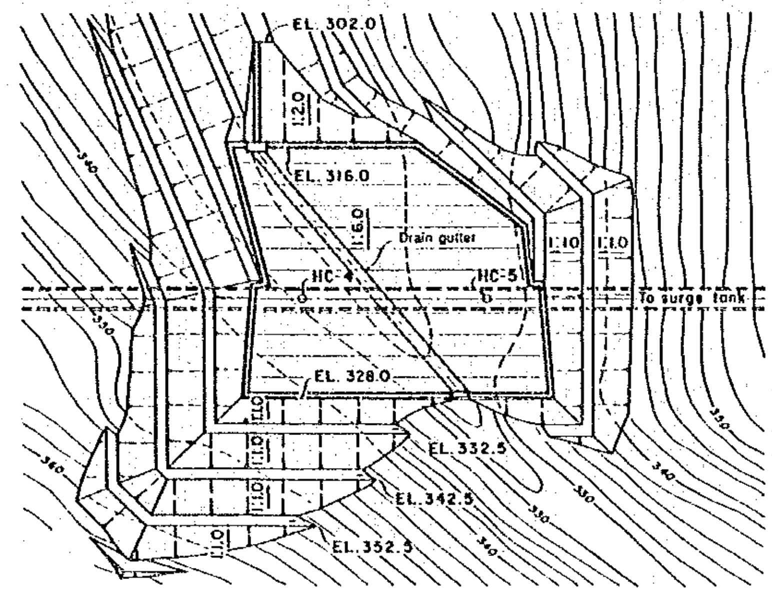
Intake and Desanding Basin - Typical Sections



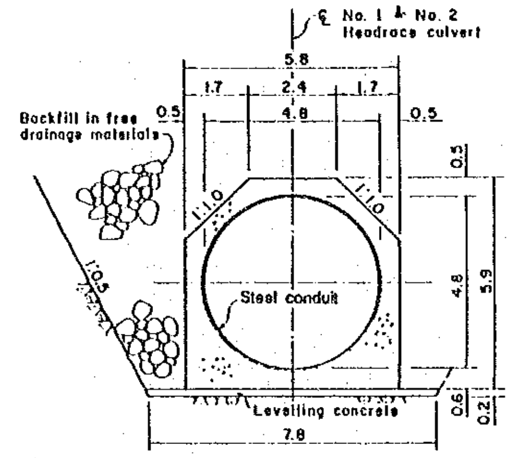
Profile of Headrace Tunnel scale b



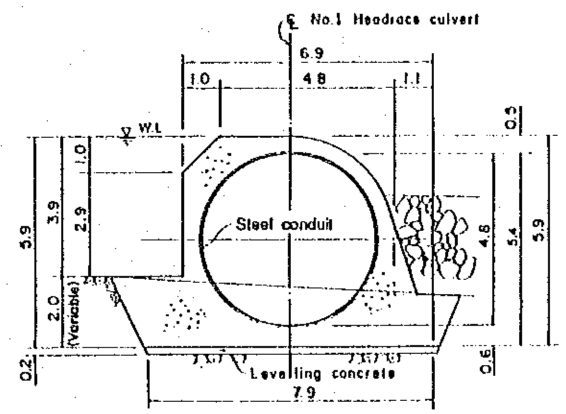
Plan scale a
(Portal of headrace tunnel)



Plan scale a
(No.2 Headrace culvert portion)



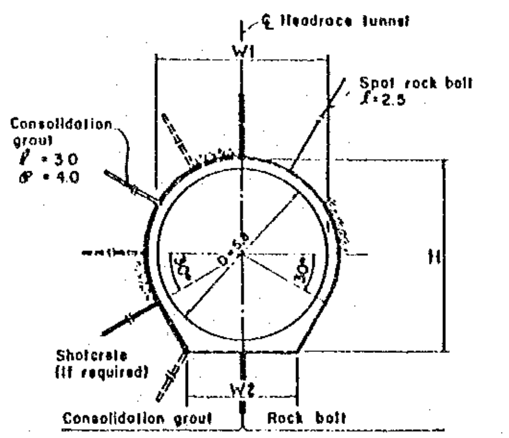
Section a - a scale c



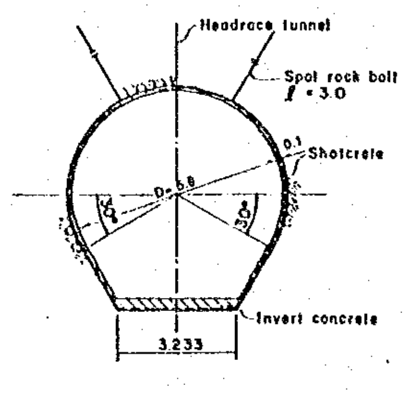
Section (Swamp cross portion) scale c
Section b - b

COORDINATES (Unit : m)

Points	N	E
HTB	6,997,830.000	647,540.000
HC4	6,998,135.656	647,925.536
HC5	6,998,166.719	647,964.717



Typical Section
for Fair condition & Good condition scale c
Section c - c



Section (Shotcrete portion) scale c
Section d - d

Dimension Table

	D=4.8		D=5.8	
	t=40mm	t=25mm	t=40mm	t=25mm
W1	5.88	5.85	4.88	4.85
W2	3.395	3.377	2.817	2.8
H	5.88	5.85	4.88	4.85

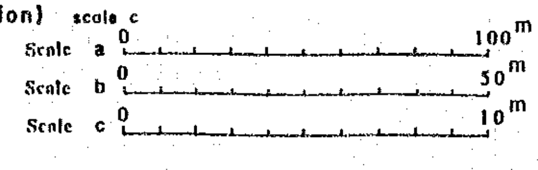


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Figure VIII. 5.5
Waterway - Headrace Culvert and Headrace Tunnel
Plans and Sections

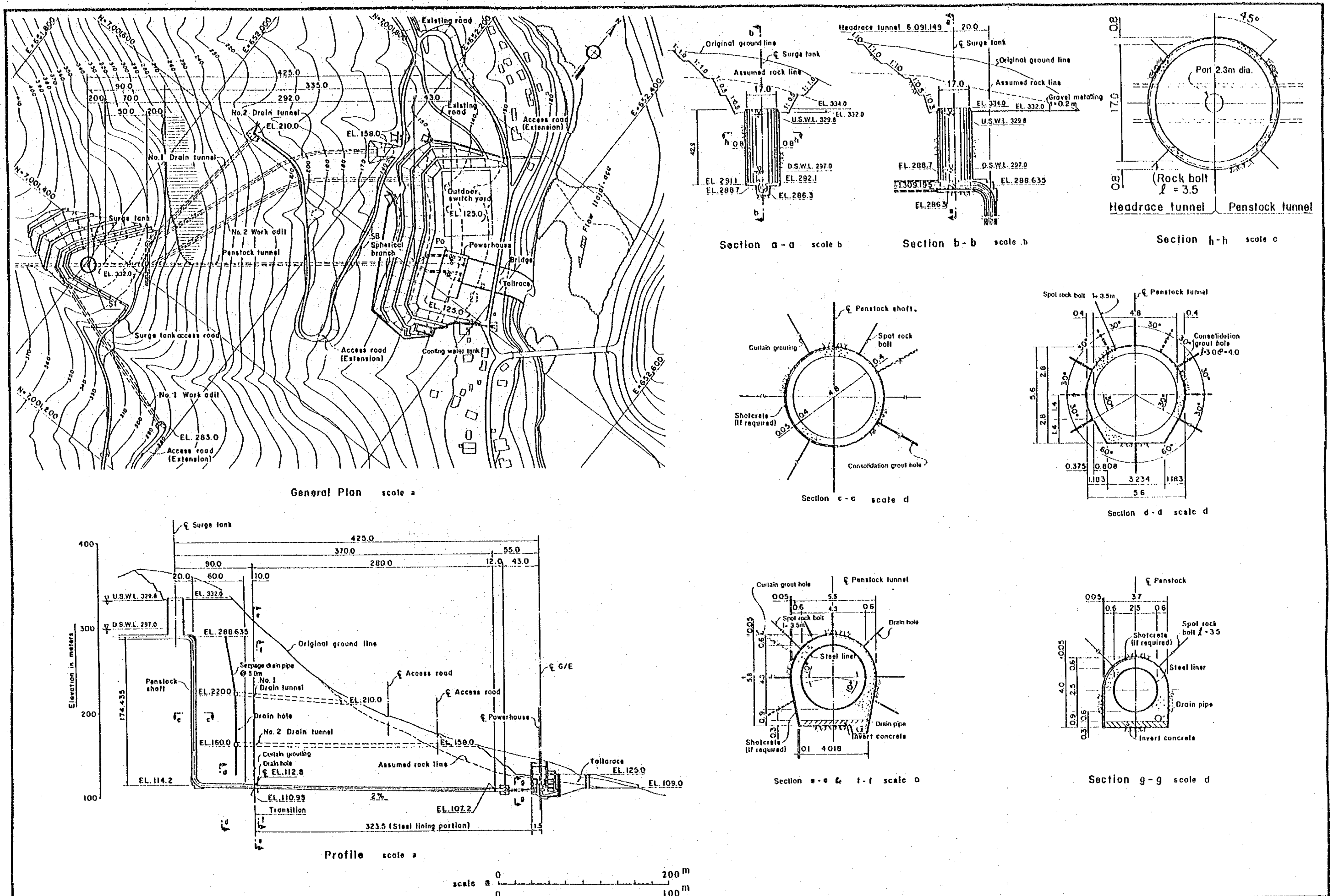

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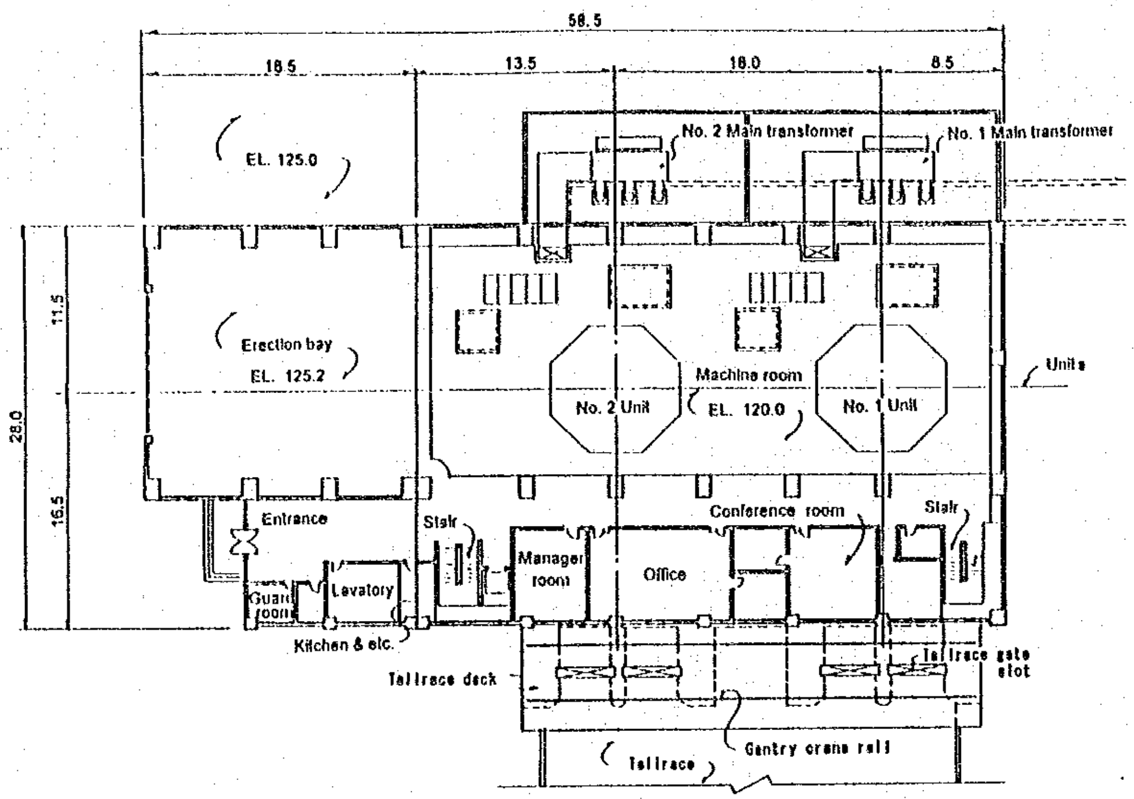
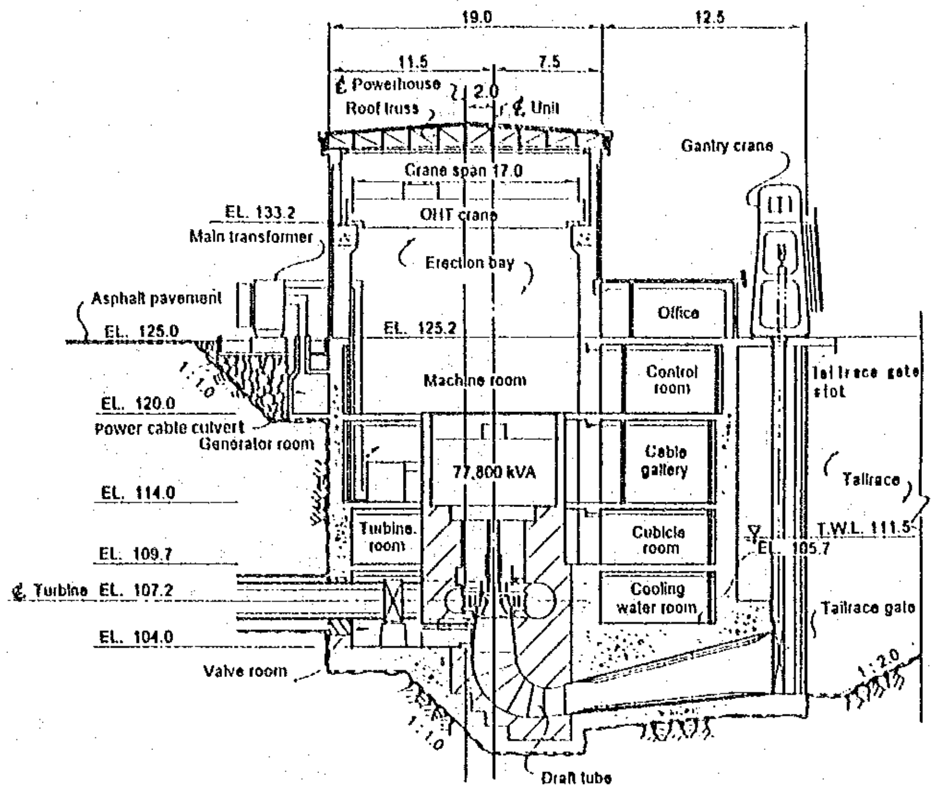
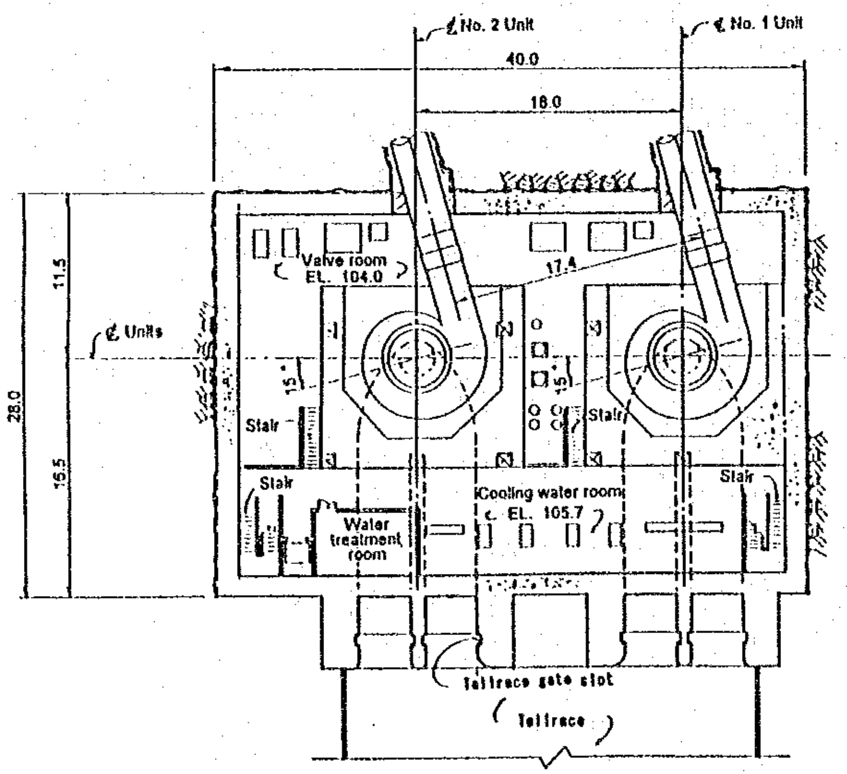
Figure VIII. 5.6
Waterway - Surge Tank and Penstock Tunnel
General Plan, Profile and Sections



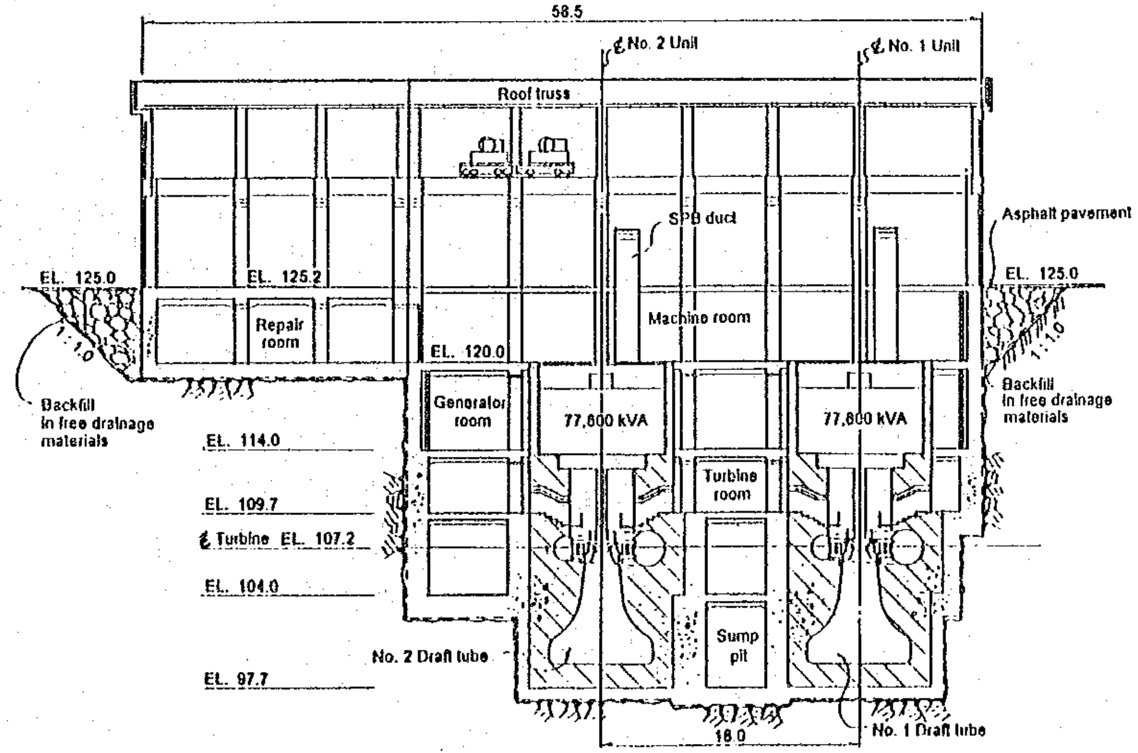
FLOOR PLAN 120.0 AND 125.2



TRANSVERSE SECTION



FLOOR PLAN EL. 104.0 AND 105.7



LONGITUDINAL SECTION

Scale 0 25 m

JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	Figure VIII. 5.7 Powerhouse - Floor Plans Transverse Section and Longitudinal Section

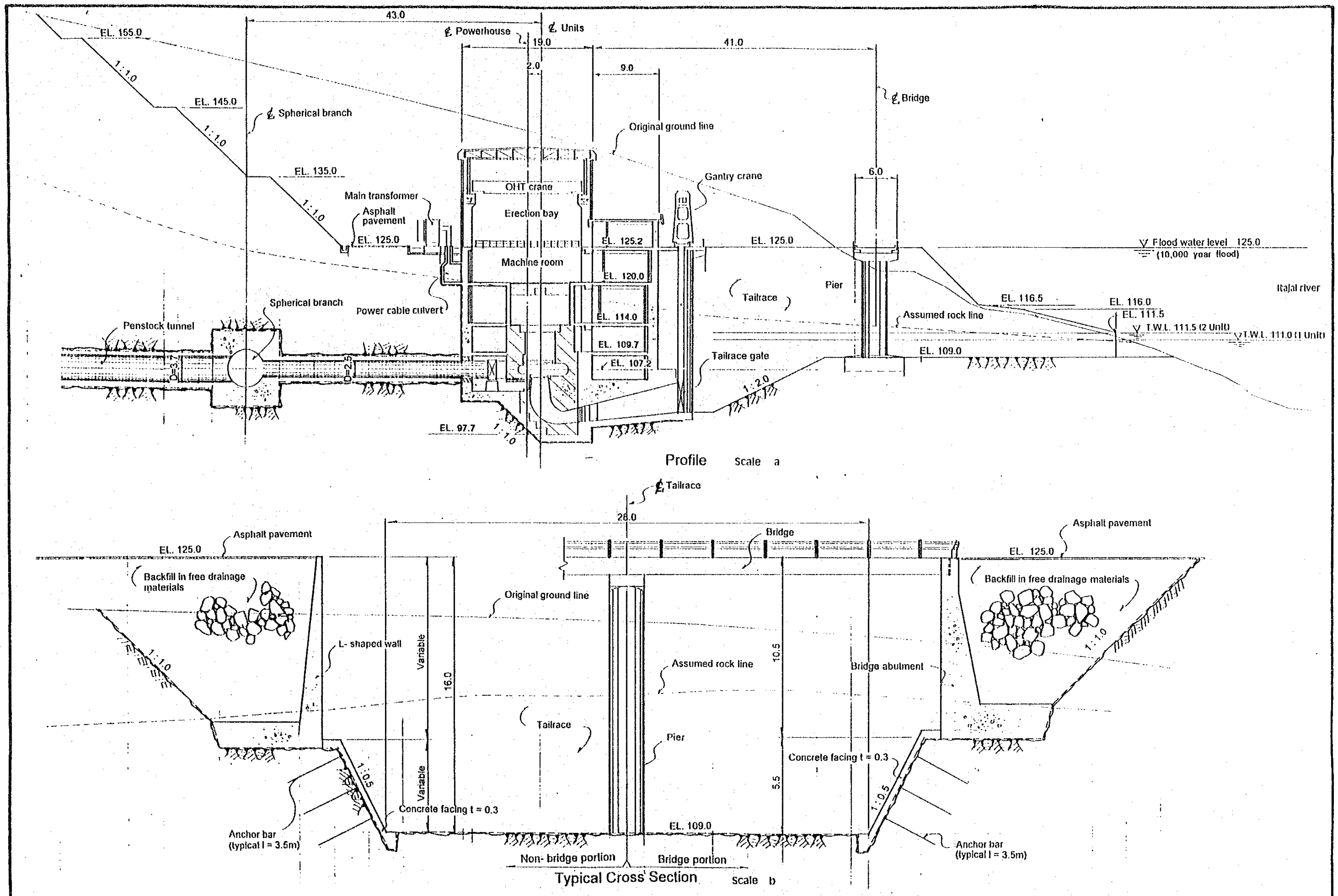


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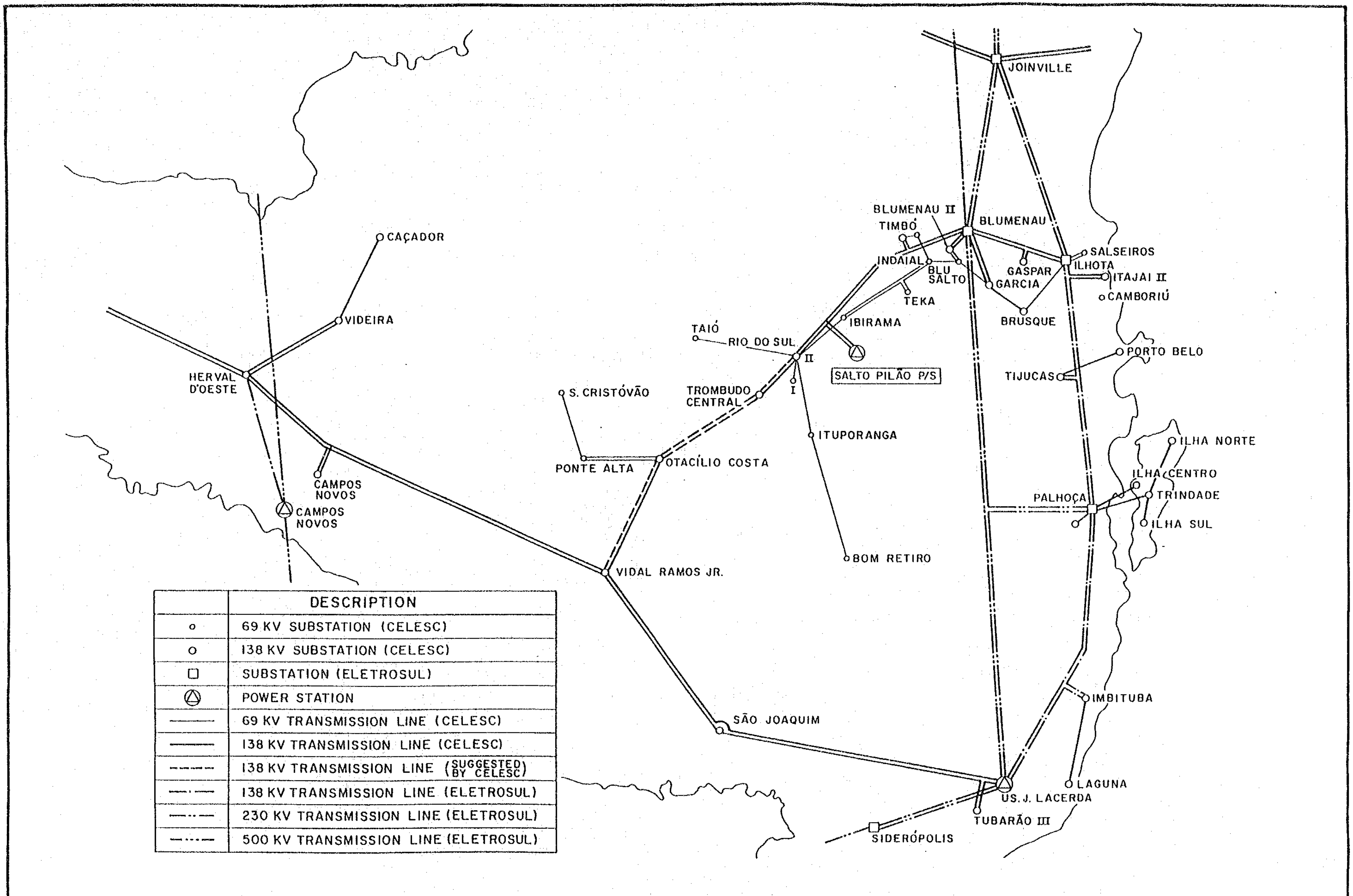
Figure VIII. 5.8
Tailrace - Profile and Typical Cross Section



Scale
Scale
Scale

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Figure VIII. 5.9

Transmission Line System (As of 1998)

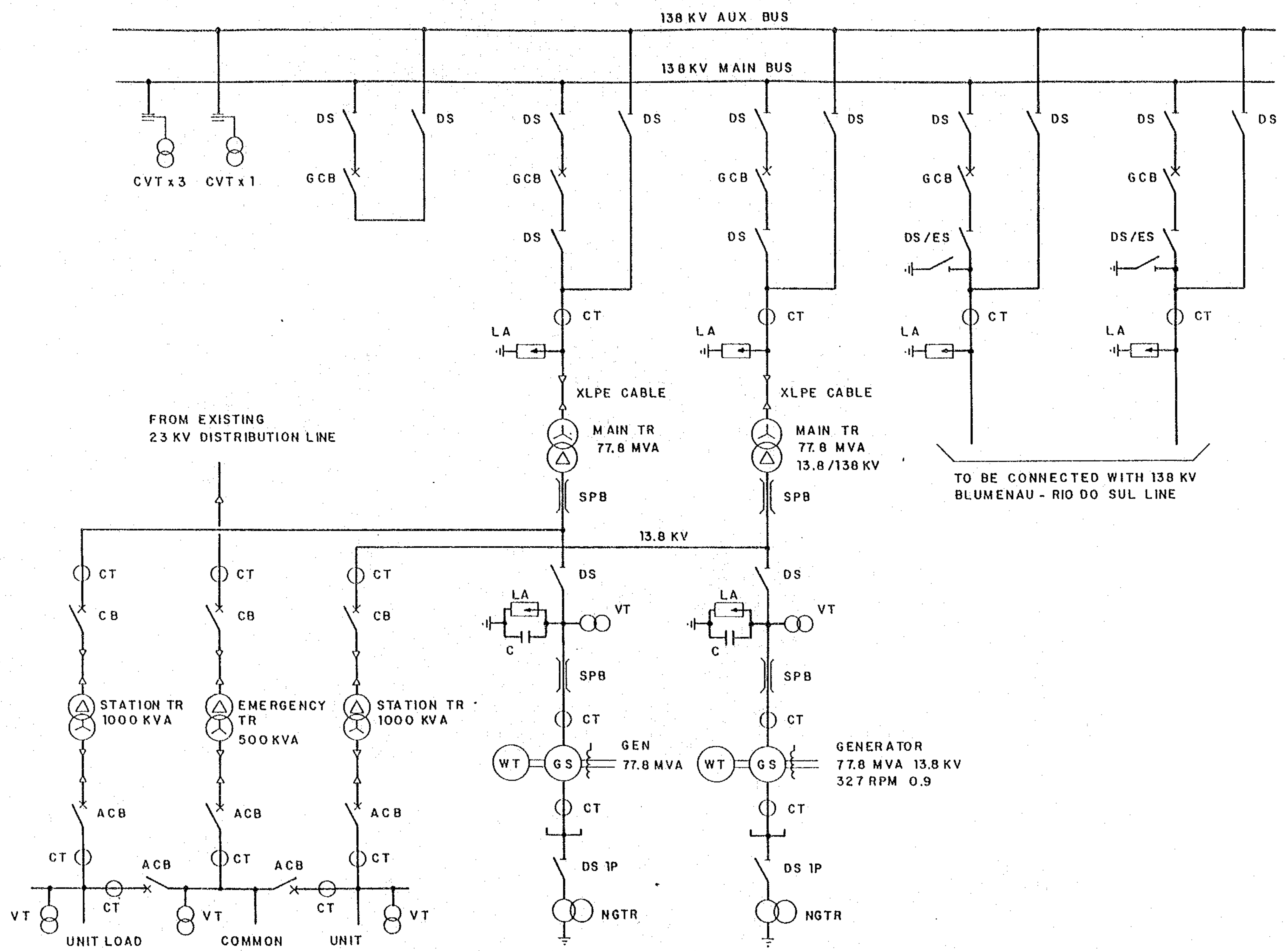

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Figure VIII. 5.10

Single Line Diagram

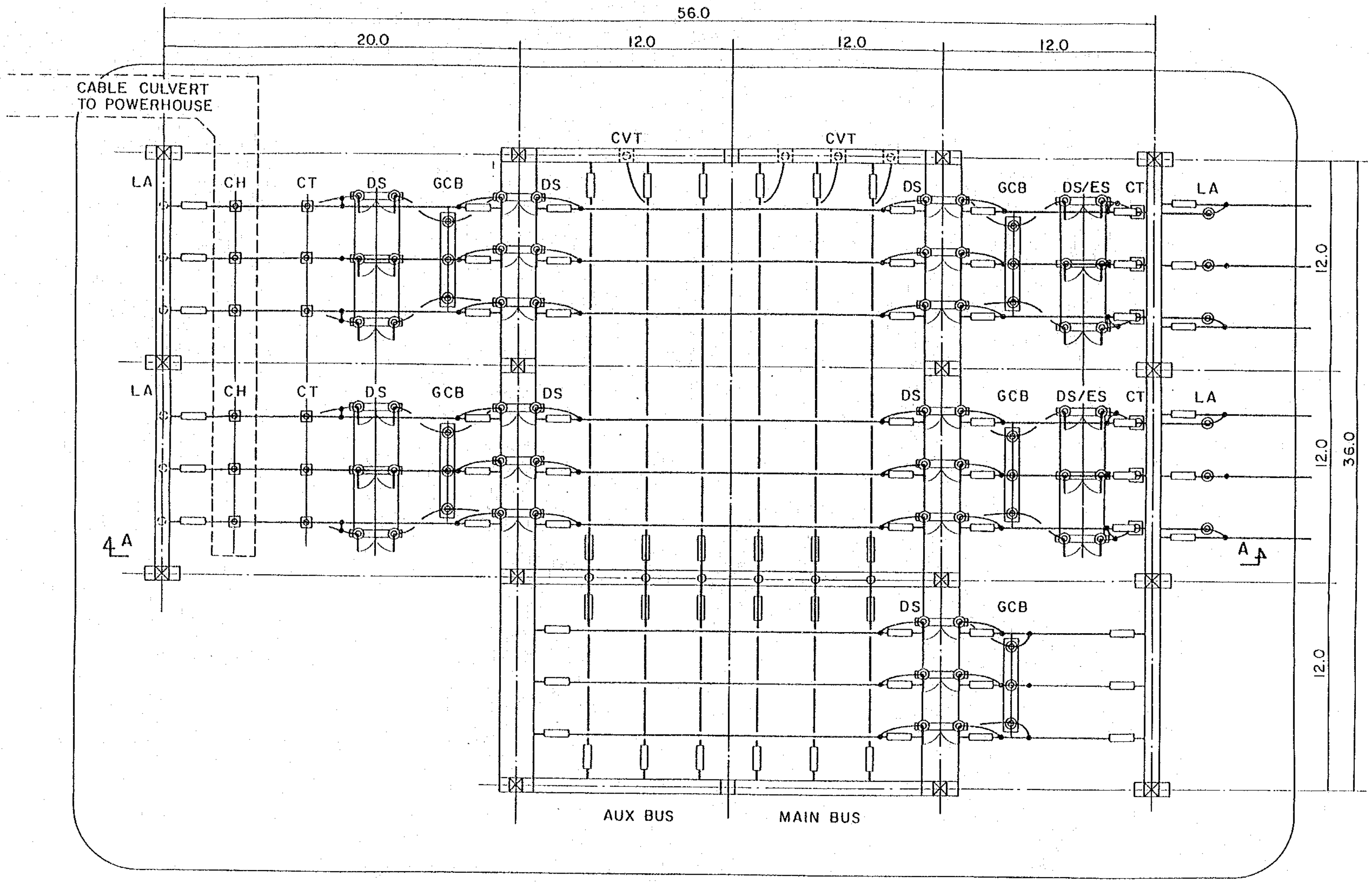

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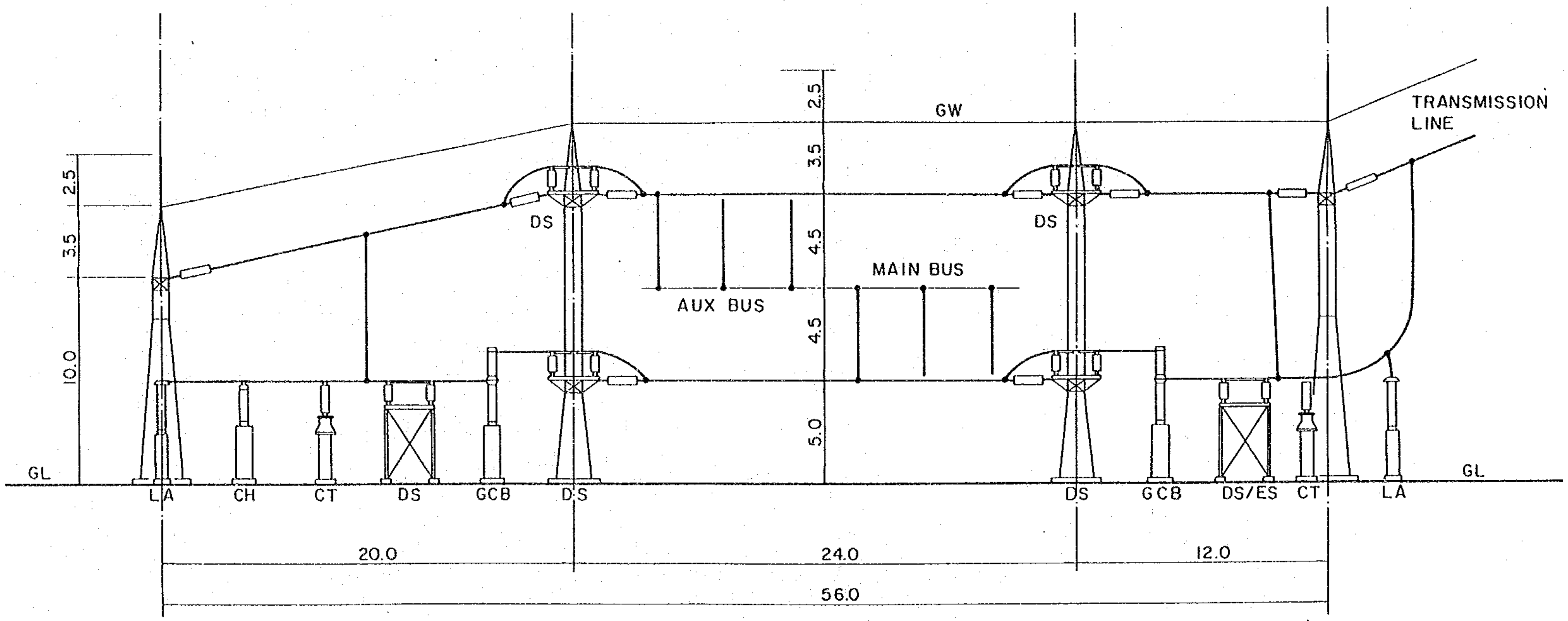
Figure VIII. 5.11

Outdoor Switchyard - Plan



SECTION A-A

Scale
Scale
Scale

JAPAN INTERNATIONAL COOPERATION AGENCY
CENTRAIS ELÉTRICAS DE SANTA CATARINA S. A., BRAZIL

SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT

Figure VIII. 5.12

Outdoor Switchyard - Profile

ANNEX IX

POWER GENERATION SIMULATION

ANNEX IX POWER GENERATION SIMULATION

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LIST OF FIGURES

ATTACHMENT

1. INTRODUCTION

Daily power output of the proposed scheme was simulated on the daily basis using the daily discharge series at damsite and powerhouse site. The salient features of the proposed scheme are as follows:

. Dam axis	:	B
. Reservoir full supply level	:	319.0 m
. Design tailwater level	:	111.5 m
. Design static head	:	207.5 m
. Max. loss of head	:	28.2 m
. Headrace, length	:	6,091.1 m
. Penstock, length	:	599.4 m
. Generating equipment		
Number of units	:	2
Installed capacity	:	2 x 71.0 MW = 142.0 MW
. Max. plant discharge	:	90 cms
. Rated head	:	179.3 m

2. SIMULATION RESULT

Daily energy outputs obtained by the simulation are shown in Attachment to this ANNEX. From those daily outputs, the monthly outputs were computed as shown in Table IX.2.1 and Fig. IX.2.1. Yearly average energy outputs and the yearly maximum and minimum outputs, are shown in Fig. IX.2.2.

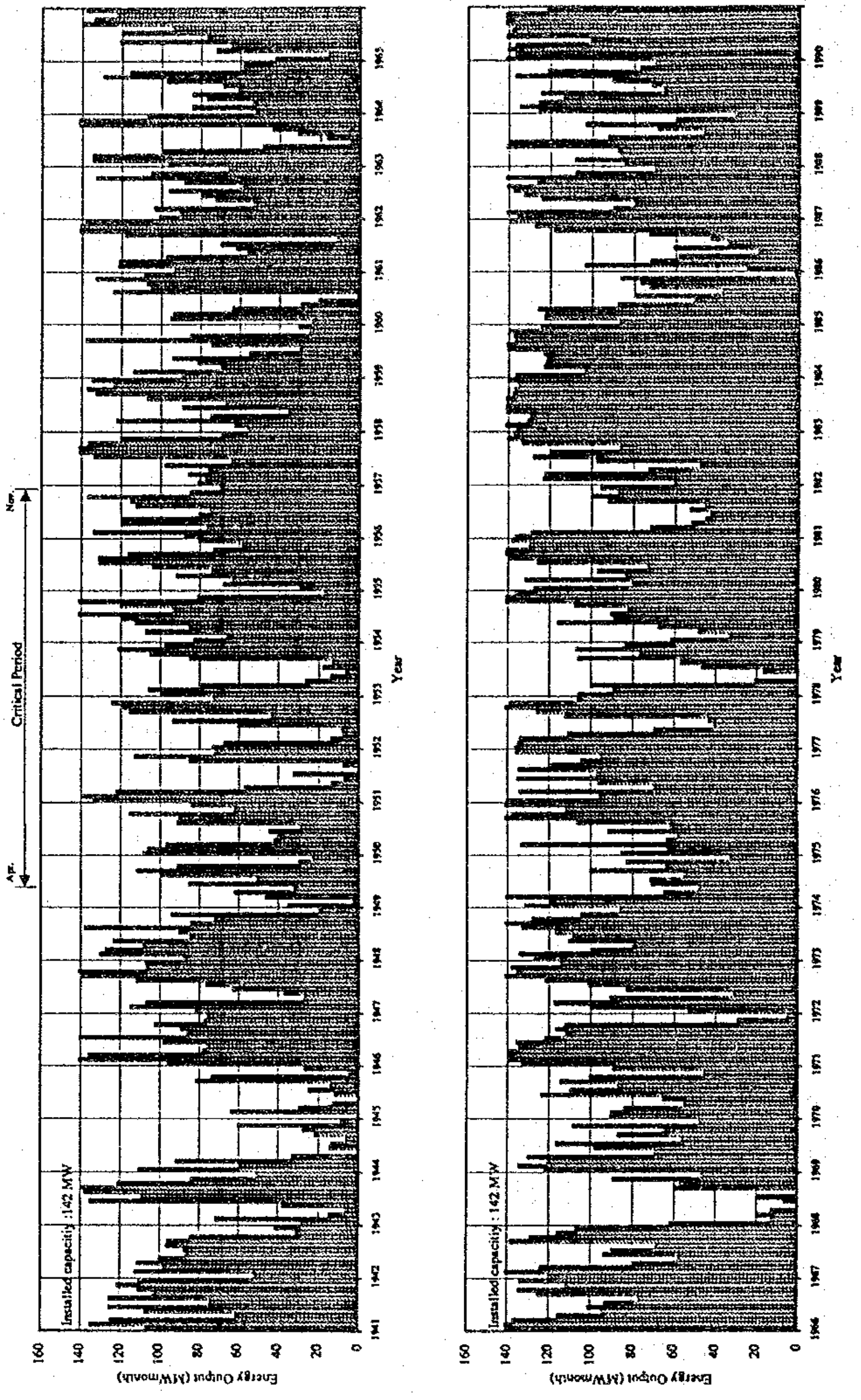
Table

Table IX.2.1 Average Monthly Energy Output

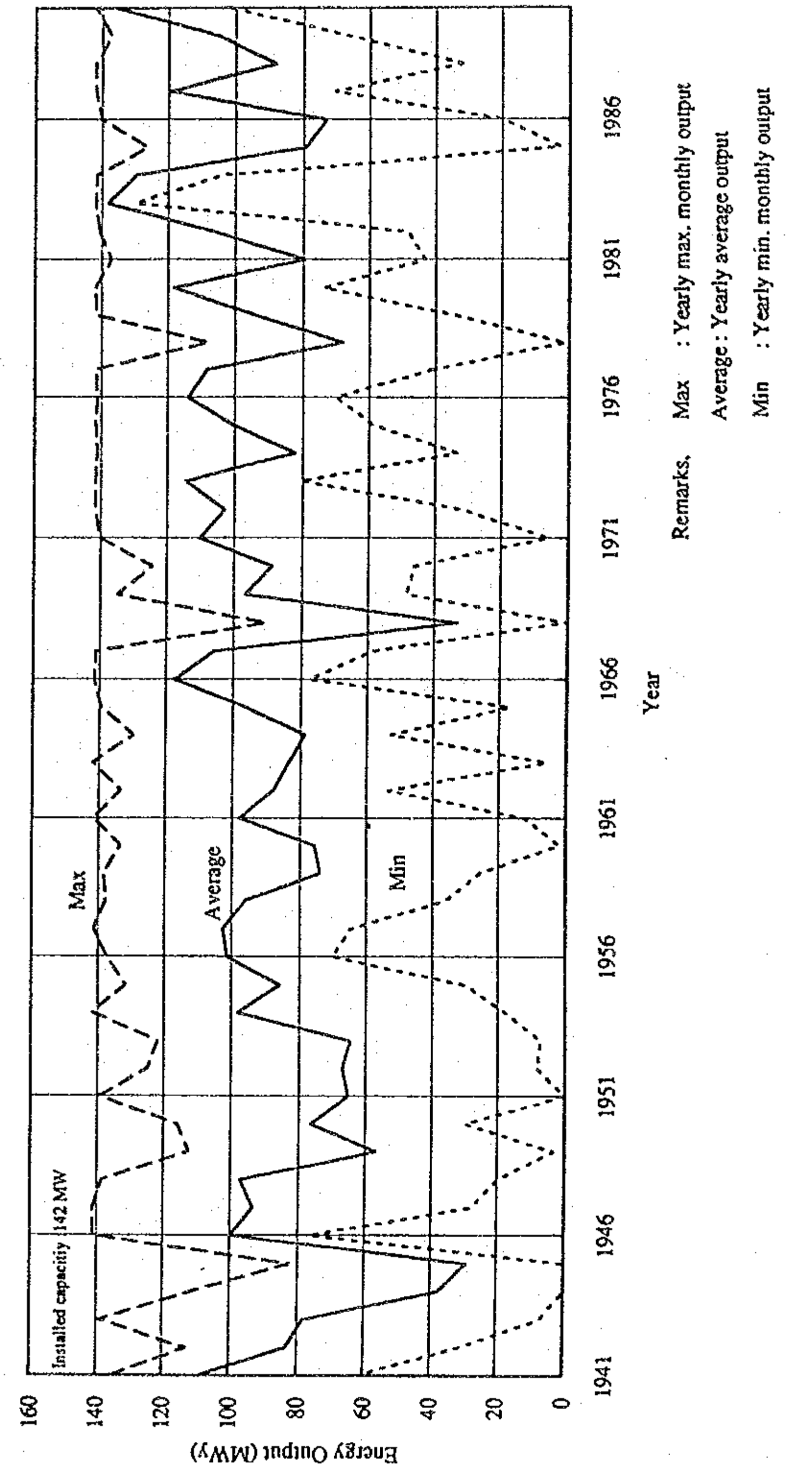
Year	Monthly Energy Output (MWmonth)												Annual Output
	Jan.	Feb.	Mar.	Apr.	May	Jun	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	(MWy)
1941	107.42	135.42	125.37	61.92	107.85	125.80	75.06	125.84	103.71	111.47	121.94	110.80	109.24
1942	52.41	112.94	98.55	111.69	100.55	87.22	88.40	97.00	96.58	85.22	31.37	42.02	83.44
1943	28.72	72.06	15.33	6.99	38.29	135.70	109.96	138.58	139.05	121.70	84.65	51.25	78.43
1944	111.20	59.79	92.41	33.58	0.00	14.91	14.15	6.85	22.51	28.23	60.65	9.24	37.73
1945	1.32	64.32	30.00	13.36	0.00	12.41	25.51	14.62	82.24	74.28	5.46	27.51	28.97
1946	96.45	141.12	136.41	78.76	76.60	98.73	140.96	86.53	90.02	102.99	77.98	76.39	100.06
1947	82.16	115.50	107.35	27.67	37.27	63.58	77.03	112.14	139.91	141.35	107.24	107.94	93.17
1948	88.41	130.72	127.76	108.99	124.05	85.34	90.75	138.60	84.81	72.76	94.66	19.82	97.08
1949	35.43	3.21	46.90	62.58	32.47	85.95	51.05	99.89	112.35	91.76	30.18	23.62	56.54
1950	109.13	106.62	97.29	42.60	40.61	44.91	29.66	91.87	91.01	115.87	62.81	84.65	76.35
1951	134.09	139.16	122.63	57.60	14.23	7.81	32.91	0.00	8.36	85.75	113.44	72.69	65.33
1952	73.70	67.93	14.43	8.18	9.18	60.95	94.07	44.06	116.18	119.29	124.91	73.54	67.09
1953	99.85	106.48	80.78	26.88	14.58	7.09	18.15	13.92	85.59	105.87	121.82	98.08	64.63
1954	83.44	66.79	107.83	85.53	113.20	119.83	141.77	94.16	120.85	141.72	81.46	17.66	98.06
1955	29.77	68.36	63.74	92.27	74.38	104.23	131.40	131.65	116.76	73.60	58.87	81.04	85.56
1956	88.32	134.38	76.83	120.17	119.45	81.11	75.40	112.80	115.69	137.36	85.31	70.05	101.23
1957	81.54	78.00	86.39	76.04	98.15	64.67	134.17	141.54	141.49	136.89	120.81	69.33	102.64
1958	56.33	62.99	122.66	75.22	35.79	89.50	67.44	107.43	133.39	137.72	124.40	135.30	95.84
1959	90.10	114.26	70.02	82.04	94.60	55.49	30.34	74.98	138.42	85.67	25.63	30.82	74.03
1960	24.38	95.52	93.97	64.38	29.85	21.15	1.75	124.44	105.67	107.69	133.36	108.78	75.75
1961	93.91	121.96	121.44	97.72	56.51	62.43	69.99	12.06	118.75	141.65	141.03	138.41	97.71
1962	101.57	91.12	103.77	53.37	72.97	79.43	96.61	59.31	88.91	133.37	105.39	66.38	87.72
1963	96.76	135.04	135.01	99.55	48.85	5.35	17.10	31.21	44.04	141.62	141.73	107.32	83.33
1964	52.65	84.87	53.93	77.28	84.75	61.32	69.10	97.48	129.60	116.37	58.91	58.55	78.67
1965	42.66	16.39	72.48	64.98	121.37	77.49	120.49	95.16	139.56	134.32	122.86	138.30	96.09
1966	140.07	141.58	137.56	116.02	95.16	101.65	93.93	77.39	125.72	134.87	112.01	134.26	117.36
1967	120.42	141.11	124.63	79.64	58.55	94.33	90.56	69.18	139.01	129.47	116.42	107.51	105.60
1968	62.58	13.23	20.31	13.18	0.00	7.16	19.89	0.88	60.06	57.42	89.93	47.18	32.65
1969	122.15	134.88	121.02	130.38	69.90	98.72	116.89	56.96	87.73	65.73	108.99	48.36	96.39
1970	91.24	90.85	84.50	56.02	65.85	124.19	110.23	87.71	114.79	101.03	46.00	90.06	88.56
1971	133.34	140.27	139.68	139.62	134.98	136.19	122.27	112.49	116.87	112.70	30.00	5.61	110.14
1972	53.53	100.48	117.99	91.21	31.65	83.41	101.67	122.17	141.62	135.92	138.71	115.15	102.68
1973	127.47	134.80	99.67	80.62	110.66	108.99	117.18	133.39	141.61	128.41	105.35	86.69	114.46
1974	132.01	120.04	141.12	65.56	48.77	71.45	72.13	55.52	100.72	64.64	83.44	33.27	82.10
1975	85.94	63.56	133.97	64.10	58.71	92.32	62.18	106.93	141.67	138.55	112.41	141.65	100.44
1976	141.06	96.32	134.49	69.97	97.15	135.74	97.63	134.93	119.07	105.05	95.87	136.25	113.81
1977	137.06	135.42	134.40	111.46	69.99	40.88	43.86	112.86	126.15	141.61	139.51	106.80	108.15
1978	106.63	89.92	99.58	21.42	0.83	16.96	47.16	57.29	106.86	77.33	107.66	84.19	67.86
1979	62.19	33.99	48.95	68.22	116.19	89.73	91.16	83.06	108.39	141.59	141.37	136.52	93.84
1980	127.86	81.05	131.87	84.48	97.54	73.64	126.17	140.09	141.74	141.29	130.08	138.86	118.20
1981	137.03	129.19	72.47	52.56	45.93	43.15	53.20	46.16	92.74	100.49	87.96	96.10	79.46
1982	60.80	123.58	122.77	73.31	48.60	97.93	128.36	119.30	87.06	133.46	140.72	137.75	106.06
1983	136.31	141.73	131.02	129.66	141.62	141.61	141.17	141.61	138.06	137.61	135.38	140.84	138.04
1984	137.06	103.84	123.25	122.28	121.98	123.33	140.90	141.44	137.29	137.92	140.37	124.73	129.66
1985	87.38	123.14	122.89	126.09	88.20	51.59	79.72	38.09	73.06	77.41	87.00	2.57	79.35
1986	25.73	103.84	72.66	58.89	19.77	61.25	35.27	43.40	73.14	118.49	127.67	139.94	73.01
1987	136.15	141.37	90.48	80.18	124.48	132.83	138.10	141.20	126.54	141.72	108.52	70.48	119.24
1988	84.86	108.73	87.01	88.37	141.71	140.42	92.85	47.02	69.06	103.59	60.36	31.82	87.85
1989	125.85	134.85	125.99	114.27	124.90	65.92	71.90	90.90	137.34	121.54	77.37	70.12	104.90
1990	141.61	137.19	141.09	137.28	101.16	141.67	139.20	138.57	141.83	141.66	141.77	122.35	135.38
Average	91.56	101.79	99.25	76.08	71.20	78.55	82.74	87.01	108.27	112.68	98.03	83.37	90.80
Longterm Average (Jan.1941 ~ Dec.1990)													90.80
Critical period average (Apr.1949 ~ Nov.1956)													78.46

Firm energy	78.46
Secondary energy	12.34

Figure



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. IX.2.1** **Monthly Power Output**



JAPAN INTERNATIONAL COOPERATION AGENCY CENTRAIS ELÉTRICAS DE SANTA CATARINA S.A.,BRAZIL SALTO PILÃO HYDROELECTRIC POWER DEVELOPMENT PROJECT	**Fig. IX.2.2** **Yearly Maximum, Average and Minimum Output**

Attachment

Result of Daily Generation Simulation

POWER GENERATION SIMULATION

Year : 1941 Dam Axis B F.S.L = 319.00 m Rated Head : 179.30 m Max. Plant Discharge : 90.00 cms Installed Capacity : 143.0 MW

Date		Discharge Dam (cms)	Discharge F&I (cms)	RMF or Spillage (cms)	Tail water level m	Plant Q (cms)	Loss	Resv level	Effect. Head h	Unit	Efficiency	Output MW	Monthly Ave. MW
Jan.	1	66.4	93.8	7.2	111.14	59.3	13.21	319.00	195.45	2	0.902	102.34	
	2	53.3	73.9	7.2	111.00	44.0	7.37	319.00	200.63	2	0.867	78.40	
	3	43.8	61.9	7.2	110.93	36.6	4.67	319.00	203.41	1	0.908	65.37	
	4	40.0	56.2	7.2	110.89	32.8	3.75	319.00	204.37	1	0.911	59.87	
	5	37.3	48.6	7.2	110.85	30.0	3.19	319.00	205.03	1	0.907	54.69	
	6	34.7	44.8	7.2	110.81	27.5	2.63	319.00	205.56	1	0.899	49.79	
	7	69.2	83.9	7.3	111.07	62.0	13.39	319.00	194.54	2	0.906	107.05	
	8	123.3	240.5	33.3	112.10	90.0	28.21	319.12	178.81	2	0.899	141.71	
	9	186.0	206.5	95.0	112.22	90.0	28.21	319.33	178.90	2	0.898	141.77	
	10	143.2	228.1	53.2	111.94	90.0	28.21	319.20	179.05	2	0.898	141.87	
	11	116.7	179.6	26.7	111.67	90.0	28.21	319.10	179.22	2	0.898	141.97	
	12	98.6	147.7	8.6	111.48	90.0	28.21	319.01	179.31	2	0.898	142.00	
	13	100.4	144.9	10.4	111.47	90.0	28.21	319.02	179.34	2	0.898	142.00	
	14	91.9	164.9	7.2	111.59	84.7	24.89	319.00	182.43	2	0.905	136.98	
	15	88.1	158.1	7.2	111.55	81.9	23.36	319.00	184.09	2	0.907	134.05	
	16	156.7	194.4	66.7	111.75	90.0	28.21	319.25	179.38	2	0.898	142.00	
	17	132.8	194.4	42.8	111.76	90.0	28.21	319.17	179.30	2	0.898	141.96	
	18	119.4	182.6	29.4	111.69	90.0	28.21	319.11	179.21	2	0.898	141.97	
	19	103.3	153.4	13.3	111.52	90.0	28.21	319.04	179.31	2	0.898	142.00	
	20	70.1	103.7	7.2	111.21	62.9	13.78	319.00	194.02	2	0.907	108.43	
	21	57.8	84.8	7.2	111.11	50.6	8.92	319.00	198.98	2	0.882	87.08	
	22	52.2	83.9	7.2	111.07	45.0	7.05	319.00	200.87	2	0.863	76.64	
	23	121.3	119.7	31.3	111.31	90.0	28.21	319.12	179.40	2	0.898	142.00	
	24	98.6	133.3	8.4	111.40	90.0	28.21	319.01	179.60	2	0.898	142.00	
	25	79.6	108.6	7.2	111.24	72.4	18.26	319.00	189.51	2	0.912	122.53	
	26	64.5	91.3	7.2	111.12	57.5	11.43	319.00	196.44	2	0.898	99.09	
	27	55.1	83.9	7.2	111.07	47.9	7.99	319.00	199.94	2	0.873	81.98	
	28	49.4	68.5	7.2	110.97	42.2	6.30	319.00	201.83	2	0.851	71.06	
	29	44.7	64.1	7.2	110.94	37.5	4.90	319.00	203.16	1	0.906	67.46	
	30	41.9	60.0	7.2	110.91	34.7	4.19	319.00	203.89	1	0.911	63.15	
	31	40.0	64.1	7.2	110.94	32.8	3.75	319.00	204.31	1	0.911	59.86	107.42
Feb.	1	84.3	105.7	7.2	111.21	77.1	20.70	319.00	187.08	2	0.910	128.70	
	2	90.9	125.2	7.2	111.34	83.7	24.40	319.00	183.26	2	0.905	136.11	
	3	60.7	108.6	7.2	111.24	53.5	9.97	319.00	197.79	2	0.880	92.28	
	4	72.0	114.2	7.2	111.27	64.8	14.40	319.00	193.10	2	0.909	111.41	
	5	176.5	142.0	86.6	111.45	90.0	28.21	319.31	179.45	2	0.898	142.00	
	6	340.3	263.8	150.2	112.12	90.0	28.21	319.50	179.17	2	0.898	141.94	
	7	180.7	224.9	90.7	111.92	90.0	28.21	319.32	179.19	2	0.898	141.95	
	8	151.9	173.7	61.9	111.64	90.0	28.21	319.23	179.38	2	0.898	142.00	
	9	195.7	206.6	105.7	111.83	90.0	28.21	319.36	179.33	2	0.898	142.00	
	10	209.5	257.3	119.5	112.09	90.0	28.21	319.40	179.10	2	0.898	141.90	
	11	166.5	241.3	76.5	112.01	90.0	28.21	319.28	179.06	2	0.898	141.87	
	12	126.2	194.4	36.2	111.76	90.0	28.21	319.14	179.17	2	0.898	141.94	
	13	130.9	185.5	40.9	111.71	90.0	28.21	319.23	179.31	2	0.898	142.00	
	14	204.8	244.3	114.8	112.02	90.0	28.21	319.39	179.15	2	0.898	141.93	
	15	199.2	276.7	109.2	112.18	90.0	28.21	319.37	178.98	2	0.898	141.82	
	16	157.8	244.3	67.8	112.02	90.0	28.21	319.25	179.02	2	0.898	141.85	
	17	121.3	206.6	31.3	111.83	90.0	28.21	319.12	179.09	2	0.898	141.89	
	18	153.8	176.7	63.8	111.66	90.0	28.21	319.24	179.37	2	0.898	142.00	
	19	217.7	224.9	127.7	111.92	90.0	28.21	319.42	179.29	2	0.898	142.00	
	20	174.6	200.5	84.6	111.79	90.0	28.21	319.30	179.30	2	0.898	142.00	
	21	135.6	176.7	45.6	111.66	90.0	28.21	319.18	179.31	2	0.898	142.00	
	22	118.5	144.9	28.5	111.47	90.0	28.21	319.11	179.43	2	0.898	142.00	
	23	106.2	136.3	16.2	111.41	90.0	28.21	319.05	179.43	2	0.898	142.00	
	24	97.7	132.5	7.7	111.40	90.0	28.21	319.00	179.40	2	0.898	142.00	
	25	86.2	125.2	7.2	111.34	78.0	21.74	319.00	185.92	2	0.909	130.90	
	26	74.0	108.6	7.2	111.24	66.8	15.54	319.00	192.22	2	0.910	114.31	
	27	68.3	103.7	7.2	111.21	61.1	13.00	319.00	194.79	2	0.904	105.49	
	28	88.2	106.3	7.2	111.22	81.0	22.85	319.00	184.93	2	0.908	133.27	135.42
Mar.	1	113.8	136.3	23.8	111.41	90.0	28.21	319.09	179.46	2	0.898	142.00	
	2	106.2	162.0	16.2	111.57	90.0	28.21	319.05	179.27	2	0.898	142.00	
	3	87.2	142.0	7.2	111.45	80.0	22.29	319.00	183.26	2	0.909	131.99	
	4	100.4	136.3	10.4	111.41	90.0	28.21	319.02	179.40	2	0.898	142.00	
	5	90.0	130.7	7.2	111.38	82.8	23.86	319.00	183.74	2	0.906	135.14	
	6	82.4	108.6	7.2	111.24	75.2	19.69	319.00	188.07	2	0.911	126.29	
	7	74.0	96.3	7.2	111.16	66.8	15.54	319.00	192.30	2	0.910	114.56	
	8	65.4	83.9	7.2	111.07	58.2	11.80	319.00	196.13	2	0.900	100.67	
	9	57.8	73.9	7.2	111.00	50.6	8.92	319.00	199.08	2	0.882	87.09	
	10	54.1	70.7	7.2	110.99	46.9	7.66	319.00	200.35	2	0.870	80.12	
	11	50.4	61.9	7.2	110.93	43.2	6.50	319.00	201.58	2	0.856	73.03	
	12	45.7	61.9	7.2	110.93	38.5	5.16	319.00	202.91	1	0.905	69.15	
	13	41.9	60.0	7.2	110.91	34.7	4.19	319.00	203.89	1	0.911	63.18	
	14	124.2	108.6	34.2	111.24	90.0	28.21	319.13	179.69	2	0.898	142.00	
	15	328.0	286.5	238.0	112.22	90.0	28.21	319.67	179.24	2	0.898	141.99	
	16	326.6	372.8	236.6	112.56	90.0	28.21	319.67	178.90	2	0.898	141.77	
	17	200.2	276.7	110.2	112.18	90.0	28.21	319.37	178.99	2	0.898	141.82	
	18	112.8	164.9	22.8	111.59	90.0	28.21	319.08	179.29	2	0.898	142.00	
	19	80.6	130.7	7.2	111.38	73.4	18.76	319.00	188.86	2	0.912	123.84	
	20	77.7	108.6	7.2	111.24	70.5	17.31	319.00	190.45	2	0.911	119.94	
	21	166.5	153.4	76.5	111.52	90.0	28.21	319.28	179.55	2	0.898	142.00	
	22	213.0	257.3	123.0	112.09	90.0	28.21	319.41	179.11	2	0.898	141.90	
	23	183.9	231.4	93.9	111.96	90.0	28.21	319.33	179.16	2	0.898	141.94	
	24	201.4	224.9	111.4	111.92	90.0	28.21	319.38	179.24	2	0.898	141.99	
	25	223.5	244.3	133.5	112.02	90.0	28.21	319.45	179.21	2	0.898	141.97	
	26	220.1	263.8	130.1	112.12	90.0	28.21	319.43	179.10	2	0.898	141.90	
	27	168.5	200.5	78.5	111.79	90.0	28.21	319.28	179.28	2	0.898	142.00	
	28	126.2	170.6	36.2	111.62	90.0	28.21	319.14	179.31	2	0.898	142.00	
	29	100.4	136.3	10.4	111.41	90.0	28.21	319.02	179.40	2	0.898	142.00	
	30	86.2	119.7	7.2	111.31	78.0	21.74	319.00	185.96	2	0.909	130.93	
	31	75.8	108.6	7.2	111.24	68.6	16.39	319.00	191.37	2	0.911	117.20	125.37

Date		Discharge Dam (cms)	Discharge F&I (cms)	RMF or Spillage (cms)	Tail water level m	Plant Q (cms)	Loss	Resv level	Effect. Head h	Unit	Efficiency	Output MW	Monthly Ave. MW
Apr.	1	68.3	100.8	7.2	111.19	61.10	13.00	319.00	194.81	2	0.904	105.90	
	2	60.7	88.6	7.2	111.11	53.50	9.97	319.00	197.93	2	0.880	92.35	
	3	54.0	82.7	7.2	111.07	46.80	8.39	319.00	199.64	2	0.877	83.68	
	4	52.2	77.0	7.2	111.03	45.00	7.05	319.00	200.92	2	0.863	74.46	
	5	47.5	70.1	7.2	110.98	40.30	5.66	319.00	202.36	2	0.843	67.34	
	6	43.8	64.6	7.2	110.94	36.60	4.57	319.00	203.39	1	0.908	66.27	
	7	39.1	57.7	7.2	110.90	31.90	3.54	319.00	204.54	1	0.911	58.34	
	8	38.1	56.2	7.2	110.89	30.80	3.33	319.00	204.79	1	0.909	56.38	
	9	37.2	55.0	7.2	110.88	30.00	3.15	319.00	204.99	1	0.907	54.68	
	10	36.4	53.7	7.2	110.87	29.20	2.97	319.00	205.14	1	0.905	53.13	
	11	34.7	51.2	7.2	110.85	27.50	2.63	319.00	205.51	1	0.899	49.78	
	12	33.7	49.8	7.2	110.84	26.50	2.45	319.00	205.71	1	0.894	47.77	
	13	32.0	47.3	7.2	110.82	24.80	2.14	319.00	206.03	1	0.884	44.39	
	14	31.2	46.0	7.2	110.82	24.00	2.01	319.00	206.18	1	0.879	42.63	
	15	29.4	43.3	7.2	110.80	22.30	1.72	319.00	206.49	1	0.866	38.68	
	16	28.6	42.3	7.2	110.79	21.40	1.59	319.00	206.62	1	0.859	37.21	
	17	48.5	71.5	7.2	110.99	41.30	5.94	319.00	202.07	2	0.847	69.30	
	18	134.2	189.4	34.2	111.70	90.00	28.21	319.13	179.23	2	0.898	141.96	
	19	69.2	102.1	7.2	111.19	62.00	13.39	319.00	194.42	2	0.906	106.98	
	20	51.5	75.8	7.2	111.02	44.30	6.77	319.00	201.21	2	0.839	74.73	
	21	41.9	61.9	7.2	110.93	34.70	4.19	319.00	203.88	1	0.911	63.17	
	22	38.1	56.2	7.2	110.89	30.90	3.33	319.00	204.79	1	0.909	56.38	
	23	37.2	55.0	7.2	110.88	30.00	3.15	319.00	204.99	1	0.907	54.68	
	24	34.7	51.2	7.2	110.85	27.50	2.63	319.00	205.51	1	0.899	49.78	
	25	33.7	49.8	7.2	110.84	26.50	2.45	319.00	205.71	1	0.894	47.77	
	26	32.9	48.5	7.2	110.83	25.70	2.30	319.00	205.87	1	0.890	46.11	
	27	32.0	47.3	7.2	110.82	24.80	2.14	319.00	206.03	1	0.884	44.39	
	28	31.2	46.0	7.2	110.82	24.00	2.01	319.00	206.18	1	0.879	42.63	
	29	30.3	44.7	7.2	110.81	23.10	1.86	319.00	206.34	1	0.873	40.76	
	30	32.0	47.3	7.2	110.82	24.80	2.14	319.00	206.03	1	0.884	44.39	61.92
May	1	112.8	81.7	22.8	111.06	90.00	28.21	319.08	179.81	2	0.898	142.00	
	2	79.6	133.3	7.2	111.40	72.40	18.26	319.00	189.35	2	0.912	122.47	
	3	60.7	88.8	7.2	111.11	53.50	9.97	319.00	197.92	2	0.880	92.35	
	4	87.2	114.3	7.2	111.27	80.00	22.30	319.00	185.44	2	0.909	132.10	
	5	123.3	147.7	33.3	111.48	90.00	28.21	319.13	179.43	2	0.898	142.00	
	6	121.3	167.8	31.3	111.61	90.00	28.21	319.12	179.31	2	0.898	142.00	
	7	109.9	153.4	19.9	111.52	90.00	28.21	319.07	179.54	2	0.898	142.00	
	8	98.6	136.3	8.6	111.41	90.00	28.21	319.01	179.39	2	0.898	142.00	
	9	81.5	105.7	7.2	111.21	74.30	18.23	319.00	188.57	2	0.911	125.14	
	10	67.3	91.3	7.2	111.12	60.10	12.58	319.00	195.30	2	0.903	103.87	
	11	57.8	81.7	7.2	111.06	50.60	8.92	319.00	199.02	2	0.882	87.06	
	12	53.2	72.9	7.2	111.00	44.00	7.37	319.00	200.63	2	0.867	78.40	
	13	50.4	70.7	7.2	110.99	43.20	6.50	319.00	201.52	2	0.856	73.02	
	14	51.3	78.5	7.2	111.04	44.10	6.77	319.00	201.18	2	0.859	74.72	
	15	233.0	114.2	143.0	111.27	90.00	28.21	319.46	179.97	2	0.897	142.00	
	16	124.2	188.5	34.2	111.73	90.00	28.21	319.13	179.20	2	0.898	141.96	
	17	86.2	136.3	7.2	111.41	79.00	21.74	319.00	185.83	2	0.909	130.85	
	18	67.3	103.7	7.2	111.21	60.10	12.58	319.00	195.31	2	0.903	103.82	
	19	56.0	81.7	7.2	111.06	48.80	8.29	319.00	199.65	2	0.877	83.68	
	20	52.2	79.5	7.2	111.04	45.00	7.05	319.00	200.90	2	0.863	74.65	
	21	51.3	70.7	7.2	110.99	44.10	6.77	319.00	201.24	2	0.859	74.74	
	22	50.4	64.1	7.2	110.94	43.20	6.50	319.00	201.56	2	0.856	73.02	
	23	54.1	68.5	7.2	110.97	44.90	7.66	319.00	200.37	2	0.870	80.13	
	24	49.4	61.9	7.2	110.93	42.20	6.20	319.00	201.87	2	0.851	71.08	
	25	46.6	61.9	7.2	110.93	39.40	5.41	319.00	202.67	1	0.900	70.42	
	26	45.7	68.5	7.2	110.97	38.50	5.16	319.00	202.87	1	0.900	69.13	
	27	46.6	84.8	7.2	111.11	39.40	5.41	319.00	202.49	1	0.900	70.37	
	28	99.5	185.5	9.5	111.71	90.00	28.21	319.02	179.10	2	0.898	141.90	
	29	112.8	221.9	22.8	111.91	90.00	28.21	319.08	178.97	2	0.898	141.81	
	30	86.2	159.1	7.2	111.55	79.00	21.74	319.00	185.71	2	0.909	130.76	
	31	102.3	144.9	12.3	111.47	90.00	28.21	319.03	179.35	2	0.898	142.00	107.85
Jun.	1	120.4	167.8	30.4	111.61	90.00	28.21	319.12	179.30	2	0.898	142.00	
	2	93.8	142.0	7.2	111.45	86.60	26.12	319.00	181.43	2	0.902	138.95	
	3	79.6	116.9	7.2	111.29	72.40	18.26	319.00	189.45	2	0.912	122.54	
	4	71.1	106.2	7.2	111.22	63.90	14.22	319.00	193.56	2	0.908	110.02	
	5	62.5	91.8	7.2	111.14	55.30	10.65	319.00	197.21	2	0.894	95.56	
	6	56.0	83.9	7.2	111.07	48.80	8.29	319.00	199.63	2	0.876	83.68	
	7	52.2	73.1	7.2	111.01	45.00	7.05	319.00	200.93	2	0.863	74.67	
	8	50.4	70.7	7.2	110.99	43.20	6.50	319.00	201.52	2	0.856	73.00	
	9	48.5	66.3	7.2	110.96	41.30	5.94	319.00	202.10	2	0.847	69.31	
	10	46.6	61.9	7.2	110.93	39.40	5.41	319.00	202.67	1	0.900	70.42	
	11	68.3	73.1	7.2	111.01	61.10	13.00	319.00	194.98	2	0.905	105.60	
	12	244.7	188.5	154.7	111.73	90.00	28.21	319.49	179.55	2	0.898	142.00	
	13	244.7	499.4	154.7	112.93	90.00	28.21	319.49	178.35	2	0.889	141.43	
	14	200.2	341.2	110.2	112.45	90.00	28.21	319.37	178.72	2	0.899	141.65	
	15	143.2	218.8	53.2	111.89	90.00	28.21	319.20	179.10	2	0.898	141.90	
	16	118.5	179.6	28.5	111.67	90.00	28.21	319.11	179.22	2	0.898	141.98	
	17	109.0	153.4	19.0	111.52	90.00	28.21	319.07	179.34	2	0.898	142.00	
	18	102.3	153.4	12.3	111.52	90.00	28.21	319.03	179.30	2	0.898	142.00	
	19	105.2	188.5	15.2	111.73	90.00	28.21	319.05	179.11	2	0.898	141.91	
	20	119.4	212.7	29.4	111.86	90.00	28.21	319.11	179.04	2	0.899	141.86	
	21	110.9	194.4	20.9	111.76	90.00	28.21	319.08	179.11	2	0.898	141.90	
	22	129.9	162.6	39.9	111.69	90.00	28.21	319.15	179.25	2	0.898	141.99	
	23	172.6	191.5	82.6	111.74	90.00	28.21	319.30	179.34	2	0.898	142.00	
	24	167.6	215.8	77.6	111.88	90.00	28.21	319.28	179.20	2	0.898	141.96	
	25	174.6	218.8	84.6	111.89	90.00	28.21	319.30	179.20	2	0.898	141.96	
	26	153.8	200.5	63.8	111.79	90.00	28.21	319.24	179.24	2	0.898	141.98	
	27	123.2	179.6	33.2	111.67	90.00	28.21	319.14	179.25	2	0.898	141.99	
	28	115.7	150.6	25.7	111.50	90.00	28.21	319.10	179.38	2	0.898	142.00	
	29	100.4	139.1	10.4	111.43	90.00	28.21	319.02	179.38	2	0.898	142.00	
	30	87.2	130.7	7.2	111.38	80.00	22.29	319.00	185.33	2	0.909	132.04	125.90

POWER GENERATION SIMULATION

Year : 1941

Dam Axis B
F.S.L.= 319.00 m

Rated Head : 179.50 m
Max. Plant Discharge : 90.00 cms

Installed Capacity : 142.0 MW

Date		Discharge Dam (cms)	Discharge P/R (cms)	RMF or Spillage (cms)	Tail water level m	Plant Q (cms)	Loss	Resv level	Effect. Head h	Unit	Efficiency	Output MW	Monthly Ave. MW
Jul.	1	78.7	114.1	7.2	111.29	71.5	17.80	319.00	180.91	2	0.912	121.31	
	2	72.0	107.0	7.2	111.23	63.6	15.08	319.00	182.49	2	0.909	112.99	
	3	69.2	102.1	7.2	111.19	62.0	13.39	319.00	194.42	2	0.906	106.98	
	4	65.4	96.6	7.2	111.14	58.2	11.80	319.00	196.06	2	0.900	100.42	
	5	62.5	92.3	7.2	111.13	55.3	10.65	319.00	197.22	2	0.894	95.57	
	6	58.0	88.2	7.2	111.10	52.6	9.64	319.00	198.56	2	0.888	90.72	
	7	56.0	83.7	7.2	111.07	48.8	8.29	319.00	199.64	2	0.877	83.46	
	8	53.2	78.4	7.2	111.04	46.0	7.37	319.00	200.59	2	0.867	78.58	
	9	50.4	74.4	7.2	111.01	43.2	6.50	319.00	201.49	2	0.856	72.99	
	10	48.5	71.5	7.2	110.99	41.3	5.94	319.00	202.07	2	0.847	69.50	
	11	46.6	68.8	7.2	110.97	39.4	5.41	319.00	202.62	1	0.900	70.40	
	12	44.7	66.0	7.2	110.95	37.5	4.90	319.00	203.13	1	0.906	67.66	
	13	41.9	61.9	7.2	110.93	34.7	4.19	319.00	203.88	1	0.911	63.17	
	14	41.0	60.5	7.2	110.92	33.8	3.98	319.00	204.11	1	0.912	61.63	
	15	38.1	57.7	7.2	110.90	31.9	3.54	319.00	204.56	1	0.911	58.24	
	16	36.4	53.7	7.2	110.87	29.2	2.97	319.00	205.16	1	0.905	53.13	
	17	37.2	55.0	7.2	110.88	30.0	3.13	319.00	204.99	1	0.907	54.68	
	18	41.0	60.5	7.2	110.92	33.8	3.98	319.00	204.11	1	0.912	61.63	
	19	40.0	59.1	7.2	110.91	32.8	3.75	319.00	204.35	1	0.911	59.87	
	20	37.2	55.0	7.2	110.88	30.0	3.13	319.00	204.99	1	0.907	54.68	
	21	36.4	53.7	7.2	110.87	29.2	2.97	319.00	205.16	1	0.905	53.13	
	22	35.5	52.5	7.2	110.86	28.3	2.79	319.00	205.35	1	0.902	51.37	
	23	34.7	51.2	7.2	110.85	27.5	2.63	319.00	205.51	1	0.899	49.78	
	24	34.7	51.2	7.2	110.85	27.5	2.63	319.00	205.51	1	0.899	49.78	
	25	34.7	51.2	7.2	110.85	27.5	2.63	319.00	205.51	1	0.899	49.78	
	26	33.7	49.8	7.2	110.84	26.5	2.43	319.00	205.71	1	0.896	47.77	
	27	78.7	116.1	7.2	111.29	71.5	17.80	319.00	180.91	2	0.912	121.31	
	28	96.7	142.7	7.2	111.45	89.5	27.90	319.00	179.63	2	0.899	141.61	
	29	60.7	89.6	7.2	111.11	53.5	9.97	319.00	197.83	2	0.880	92.35	
	30	48.5	71.5	7.2	110.99	41.3	5.94	319.00	202.07	2	0.847	69.50	
	31	41.9	61.9	7.2	110.93	34.7	4.19	319.00	203.88	1	0.911	63.17	75.06
Aug.	1	93.8	108.6	7.2	111.34	86.6	26.13	319.00	181.64	2	0.902	139.08	
	2	541.6	472.9	471.6	112.86	90.0	28.31	320.10	179.03	2	0.898	141.85	
	3	628.9	733.3	539.9	113.37	90.0	28.31	320.31	178.64	2	0.900	141.40	
	4	502.7	565.4	412.7	113.11	90.0	28.31	320.00	178.69	2	0.899	141.63	
	5	381.7	573.1	281.7	113.06	90.0	28.31	319.78	178.49	2	0.899	141.51	
	6	312.7	480.5	222.7	112.88	90.0	28.31	319.64	178.55	2	0.899	141.55	
	7	222.4	348.0	132.4	112.47	90.0	28.31	319.43	178.75	2	0.899	141.67	
	8	170.6	240.8	80.6	112.12	90.0	28.31	319.29	178.96	2	0.898	141.81	
	9	139.4	209.7	49.4	111.84	90.0	28.31	319.19	179.14	2	0.898	141.92	
	10	128.9	179.6	38.9	111.67	90.0	28.31	319.15	179.27	2	0.898	142.00	
	11	118.4	168.0	28.4	111.57	90.0	28.31	319.11	179.33	2	0.898	142.00	
	12	103.3	133.5	13.3	111.40	90.0	28.31	319.04	179.43	2	0.898	142.00	
	13	89.1	123.5	7.2	111.37	81.9	23.36	319.00	184.31	2	0.977	134.20	
	14	82.4	122.3	7.2	111.33	73.2	19.69	319.00	187.98	2	0.911	126.23	
	15	86.2	128.0	7.2	111.36	79.0	21.74	319.00	185.90	2	0.909	130.88	
	16	100.3	150.6	13.3	111.50	90.0	28.31	319.04	179.33	2	0.898	142.00	
	17	128.0	188.5	38.0	111.73	90.0	28.31	319.15	179.21	2	0.898	141.97	
	18	201.4	320.6	111.4	112.37	90.0	28.31	319.38	178.80	2	0.899	141.71	
	19	152.8	317.3	62.8	112.35	90.0	28.31	319.23	178.67	2	0.899	141.62	
	20	134.2	200.5	54.2	111.79	90.0	28.31	319.15	179.13	2	0.898	141.92	
	21	106.2	170.8	16.2	111.62	90.0	28.31	319.05	179.22	2	0.898	141.97	
	22	90.9	136.3	7.2	111.41	83.7	24.40	319.00	183.19	2	0.904	138.07	
	23	84.3	130.7	7.2	111.38	77.1	20.70	319.00	186.92	2	0.910	128.59	
	24	74.6	119.7	7.2	111.31	66.8	15.54	319.00	192.15	2	0.910	114.47	
	25	63.4	100.7	7.2	111.21	58.2	11.50	319.00	196.00	2	0.900	100.60	
	26	60.7	96.3	7.2	111.16	53.5	9.97	319.00	197.87	2	0.880	92.32	
	27	56.9	86.3	7.2	111.09	49.7	8.60	319.00	199.31	2	0.879	85.36	
	28	55.1	83.9	7.2	111.07	47.9	7.99	319.00	198.94	2	0.873	81.98	
	29	53.2	79.5	7.2	111.04	46.0	7.37	319.00	200.59	2	0.867	78.37	
	30	50.4	75.1	7.2	111.01	43.2	6.50	319.00	201.49	2	0.856	72.99	
	31	48.5	70.7	7.2	110.99	41.3	5.94	319.00	202.07	2	0.847	69.50	125.84
Sep.	1	47.5	70.7	7.2	110.99	40.3	5.66	319.00	202.36	2	0.843	67.34	
	2	44.6	66.3	7.2	110.96	38.4	5.41	319.00	202.63	1	0.900	70.41	
	3	79.6	103.7	7.2	111.21	72.4	18.36	319.00	188.54	2	0.912	122.40	
	4	110.9	173.7	20.9	111.64	90.0	28.21	319.08	179.33	2	0.898	141.96	
	5	79.6	144.9	7.2	111.47	72.4	18.36	319.00	188.28	2	0.912	122.43	
	6	63.5	98.7	7.2	111.17	56.3	11.06	319.00	196.79	2	0.896	97.31	
	7	57.8	86.3	7.2	111.09	50.6	8.93	319.00	198.99	2	0.882	87.04	
	8	54.1	83.9	7.2	111.07	46.9	7.66	319.00	200.27	2	0.870	80.06	
	9	49.4	77.3	7.2	111.03	42.2	6.20	319.00	201.77	2	0.851	71.09	
	10	47.5	70.7	7.2	110.99	40.3	5.66	319.00	202.36	2	0.843	67.34	
	11	44.6	66.3	7.2	110.96	38.4	5.41	319.00	202.64	1	0.900	70.41	
	12	45.7	61.9	7.2	110.93	38.5	5.16	319.00	202.91	1	0.903	69.15	
	13	51.3	66.3	7.2	110.96	44.1	6.77	319.00	201.37	2	0.859	74.76	
	14	65.4	73.1	7.2	111.01	58.2	13.31	319.00	195.78	2	0.902	100.42	
	15	60.7	101.2	7.2	111.19	53.5	9.97	319.00	197.84	2	0.880	92.31	
	16	49.6	77.3	7.2	111.03	42.2	6.20	319.00	201.77	2	0.851	71.03	
	17	44.7	66.1	7.2	110.94	37.5	4.90	319.00	203.16	1	0.906	67.66	
	18	42.0	63.0	7.2	110.91	35.8	4.41	319.00	203.67	1	0.910	64.67	
	19	40.0	58.1	7.2	110.90	32.8	3.75	319.00	204.35	1	0.911	59.87	
	20	91.9	68.8	7.2	111.11	84.7	24.89	319.00	182.91	2	0.904	137.29	
	21	381.7	554.9	291.7	112.90	90.0	28.31	319.78	178.07	2	0.898	141.88	
	22	244.7	348.0	154.7	112.47	90.0	28.21	319.49	178.80	2	0.899	141.71	
	23	174.6	247.6	84.6	112.04	90.0	28.21	319.30	179.05	2	0.898	141.87	
	24	148.0	212.7	58.0	111.86	90.0	28.21	319.22	179.15	2	0.898	141.91	
	25	136.6	194.4	46.6	111.76	90.0	28.31	319.18	179.21	2	0.898	141.97	
	26	111.8	170.8	21.8	111.62	90.0	28.31	319.08	179.23	2	0.898	141.99	
	27	101.4	153.4	11.4	111.52	90.0	28.31	319.03	179.30	2	0.898	142.00	
	28	91.8	136.3	7.2	111.41	84.6	26.12	319.00	181.47	2	0.902	138.97	
	29	83.4	119.7	7.2	111.31	76.2	20.33	319.00	187.47	2	0.911	127.51	
	30	74.0	114.2	7.2	111.27	66.8	15.54	319.00	192.19	2	0.910	114.49	103.71
Oct.	1	64.4	108.6	7.2	111.34	59.30	12.31	319.00	193.36	2	0.902	100.39	
	2	64.5	98.7	7.2	111.17	57.30	11.43	319.00	196.39	2	0.898	99.06	
	3	63.5	88.8	7.2	111.11	56.30	11.06	319.00	196.83	2	0.896	97.35	
	4	72.0	93.8	7.2	111.14	64.80	14.62	319.00	193.24	2	0.909	111.49	
	5	82.4	132.7	7.2	111.38	75.20	19.80	319.00	187.93	2	0.911	126.19	
	6	77.7	140.0	7.2	111.45	70.50	17.31	319.00	190.24	2	0.911	119.80	
	7	123.3	144.8	33.3	111.47	90.00	28.21	319.13	179.45	2	0.898	142.00	
	8	227.1	237.0	137.1	111.99	90.00	28.21	319.44	179.24	2	0.898	141.99	
	9	265.9	418.9	175.9	112.72	90.00	28.21	319.56	178.61	2	0.899	141.59	
	10	209.5	474.5	119.5	112.87	90.00	28.21	319.40	178.32	2	0.899	141.40	
	11	193.3	330.9	103.3	112.41	90.00	28.21	319.33	178.71	2	0.899	141.66	
	12	148.0	260.3	58.0	112.12	90.00	28.21	319.22	178.89	2	0.898	141.76	
	13	121.3	208.6	31.3	111.83	90.00	28.21	319.12	179.08	2	0.898	141.89	
	14	107.2	173.7	17.2	111.64	90.00	28.21	319.06	179.21	2	0.898	141.97	
	15	94.8	123.4	7.2	111.32	87.60	26.79	319.00	180.76	2	0.901	139.85	
	16	91.9	142.8	7.2	111.45	84.70	24.89	319.00	182.57	2	0.905	137.07	
	17	106.2	138.1	16.2	111.53	90.00	28.21	319.05	179.39	2	0.898	142.00	
	18	103.3	160.0	13.3	111.57	90.00	28.21	319.05	179.33	2	0.898	141.99	
	19	81.5	133.3	7.2	111.40	74.30	19.35	319.00	188.38	2	0.911	125.01	
	20	74.0	116.0	7.2	111.30	66.80	15.54	319.00	192.17	2	0.910	114.48	
	21	65.4	106.3	7.2	111.22	58.20	11.80	319.00	195.98	2	0.900	100.59	
	22	61.7	94.3	7.2	111.16	54.50	10.34	319.00	197.50	2	0.892	94.15	
	23	57.8	88.8	7.2	111.11	50.60	8.93	319.00	198.98	2	0.882	87.03	
	24	54.1	83.9	7.2	111.07	46.90	7.66	319.00	200.27	2	0.870	80.08	
	25	53.2	78.5	7.2	111.04	46.00	7.37	319.00	200.59	2	0.867	78.37	
	26	51.3	75.1	7.2	111.01	44.10	6.77	319.00	201.21	2	0.859	74.73	
	27	50.4	75.1	7.2	111.01	43.20	6.50	319.00	201.49	2	0.856	72.99	
	28	49.4	70.7	7.2	110.99	42.20	6.20	319.00	201.81	2	0.851	71.05	
	29	48.5	70.7	7.2	110.99	41.30	5.94	319.00	202.07	2	0.847	69.30	
	30	47.5	66.3	7.2	110.96	40.30	5.66	319.00	202.39	2	0.843	67.36	
	31	45.7	61.9	7.2	110.93	38.50	5.16	319.00	202.91	1	0.903	69.15	111.47
Nov.	1	42.8	58.1	7.2	110.90	35.60	4.41	319.00	203.69	1	0.910	64.68	
	2	41.0	56.5	7.2	110.87	33.80	3.98	319.00	204.15	1	0.912	61.64	
	3	39.1	52.4	7.2	110.86	31.90	3.54	319.00	204.60	1	0.911	58.25	
	4	42.8	63.9	7.2	110.92	35.60	4.41	319.00	203.51	1	0.910	64.62	
	5	64.4	125.2	7.2	111.34	59.30	12.31	319.00	193.43	2	0.901	102.22	
	6	97.7	144.8	7.7	111.47	90.00	28.21	319.00	179.33	2	0.898	142.00	
	7	78.7	136.3	7.2	111.41	71.50	17.80	319.00	180.78	2	0.912	121.22	
	8	70.1	116.9	7.2	111.29	62.90	13.78	319.00	193.93	2	0.907	108.38	
	9	74.9	108.6	7.2	111.24	67.70	15.96	319.00	191.80	2	0.911	115.86	
	10	63.5	105.7	7.2	111.21	56.30	11.06	319.00	194.76	2	0.896	97.28	
	11	56.0	81.7	7.2	111.06	48.80	8.28	319.00	199.65	2	0.877	83.40	
	12	86.2	125.2	7.2	111.34	79.00	21.74	319.00	185.83	2	0.909	130.80	
	13	285.7	418.9	208.7	112.72	90.00	28.21	319.40	178.67	2	0.899	141.43	
	14	206.0	380.1	116.0	112.59	90.00	28.21	319.39	178.59	2	0.899	141.37	
	15	138.4	241.1	48.4	112.01	90.00	28.21	319.19	178.97	2	0.898	141.81	
	16	118.4	182.6	28.4	111.69	90.00	28.21	319.11	179.21	2	0.898	141.87	
	17	390.9	664.1	300.9	113.25	90.00	28.21	320.15	178.69	2	0.899	141.64	
	18	435.5	631.1	345.5	113.19	90.00	28.21	319.98	178.63	2	0.899	141.50	
	19	271.7	495.4	181.7	112.57	90.00	28.21	319.55	178.67	2	0.899	141.62	
	20	172.6	370.3	82.6	112.15	90.00	28.21	319.30	178.94	2	0.898	141.79	
	21	128.9	200.5	38.9	111.79	90.00	28.21	319.15	179.15	2	0.898	141.93	
	22	138.4	208.7	48.4	111.84	90.00	28.21	319.19	179.13	2	0.898	141.92	
	23	188.2	296.8	98.2	112.27	90.00	28.21	319.34	178.86	2	0.898	141.73	
	24	141.3	247.8	51.3	112.04	90.00	28.21	319.20	178.95	2	0.898	141.80	
	25	111.8	197.5	21.8	111.78	90.00	28.21	319.08	179.09	2	0.898	141.89	
	26	95.7	164.9	7.2	111.59	88.50	27.28	319.00	180.11	2	0.900	140.53	
	27	85.3	130.4	7.2	111.52	78.10	21.24	319.00	186.34	2	0.910	129.71	
	28	90.0	136.3	7.2	111.41	82.80	23.90	319.00	183.71	2	0.906	135.12	
	29	81.5	136.3	7.2	111.41	74.30	19.33	319.00	188.36	2	0.911	125.00	
	30	88.1	128.0	7.2	111.34	81.90	23.36	319.00	184.28	2	0.907	134.13	121.94
Dec.	1	180.4	284.4	90.4	111.76	90.00	28.21	319.40	179.05	2	0.898	141.87	
	2	130.9	215.8	40.9	111.88	90.00	28.21	319.16	179.07	2	0.898	141.88	
	3	111.8	188.5	21.8	111.73	90.00	28.21	319.08	179.14	2	0.898	141.93	
	4	96.7	160.0	7.2	111.57	89.50	27.90	319.00	179.33	2	0.899	141.54	
	5	83.4	140.0	7.2	111.45	76.20	20.22	319.00	187.33	2	0.911	127.42	
	6	74.0	123.5	7.2	111.33	64.80	15.54	319.00	192.13	2	0.910	114.46	
	7	65.4	106.2	7.2	111.22	58.20	11.80	319.00	195.98	2	0.900	100.59	
	8	61.7	98.7	7.2	111.17	54.50	10.34	319.00	197.46	2	0.892	94.12	
	9	82.4	111.4	7.2	111.24	75.20	19.40	319.00	188.05	2	0.911	126.27	
	10	80.6	133.5	7.2	111.40	73.60	18.76	319.00	188.84	2	0.912	123.82	
	11	70.1	116.9	7.2	111.29	62.90	13.78	319.00	193.93	2	0.907	108.38	
	12	57.8	94.3	7.2	111.16	50.60	8.93	319.00	198.93	2	0.882	87.04	
	13	90.9	122.5	7.2	111.33	83.70	24.40	319.00	183.27	2	0.905	136.12	
	14	120.4	159.1	30.4	111.33	90.00	28.21	319.12	179.53	2	0.898	142.00	
	15	109.9	188.5	19.9	111.73	90.00	28.21	319.07	179.14	2	0.898	141.92	
	16	91.9	159.1	7.2	111.55	84.70	24.89	319.00	182.46	2	0.905	137.00	
	17	74.9	125.2	7.2	111.34	67.70	15.96	319.00	191.09	2	0.910	115.80	
	18	68.3	108.6	7.2	111.24	61.10	13.00	319.00	194.75	2	0.904	105.47	
	19	64.5	100.7	7.2	111.31	57.30	11.43	319.00	196.34	2	0.898	99.04	
	20	77.7	108.6	7.2	111.24	70.50	17.31	319.00	190.41	2	0.911	119.94	
	21	130.9	153.4	28.9	111.52	90.00	28.21	319.08	179.35	2	0.898	142.00	
	22	89.1	150.6	7.2	111.50	81.90	23.36	319.00	184.14	2	0.907	134.09	
	23	70.1	116.9	7.2	111.29	62.90	13.78	319.00	193.93	2	0.907	108.38	
	24	60.7	101.2	7.2	111.19	53.50	9.97	319.00	197.84	2	0.880	92.31	
	25	55.1	86.3	7.2	111.09	47.90	7.99	319.00	198.92	2	0.873	81.97	
	26	51.3	83.9	7.2	111.07	44.10	6.77	319.00	201.15	2	0.859	74.70	
	27	50.4	79.7	7.2	110.99	43.20	6.50	319.00	201.52	2	0.856	73.00	
	28	47.5	66.3	7.2	110.96	40.30	5.66	319.00	202.39	2	0.843	67.36	
	29	44.6	73.9	7.2	111.00	38.40	5.41	319.00	202.59	1	0.900	70.40	
	30	48.5	79.5	7.2	111.04	41.30	5.94	319.00	202.01	2	0.847	69.27	
	31	51.3	86.3	7.2	111.09	44.10	6.77	319.00	201.14	2	0.859	74.70	110.80