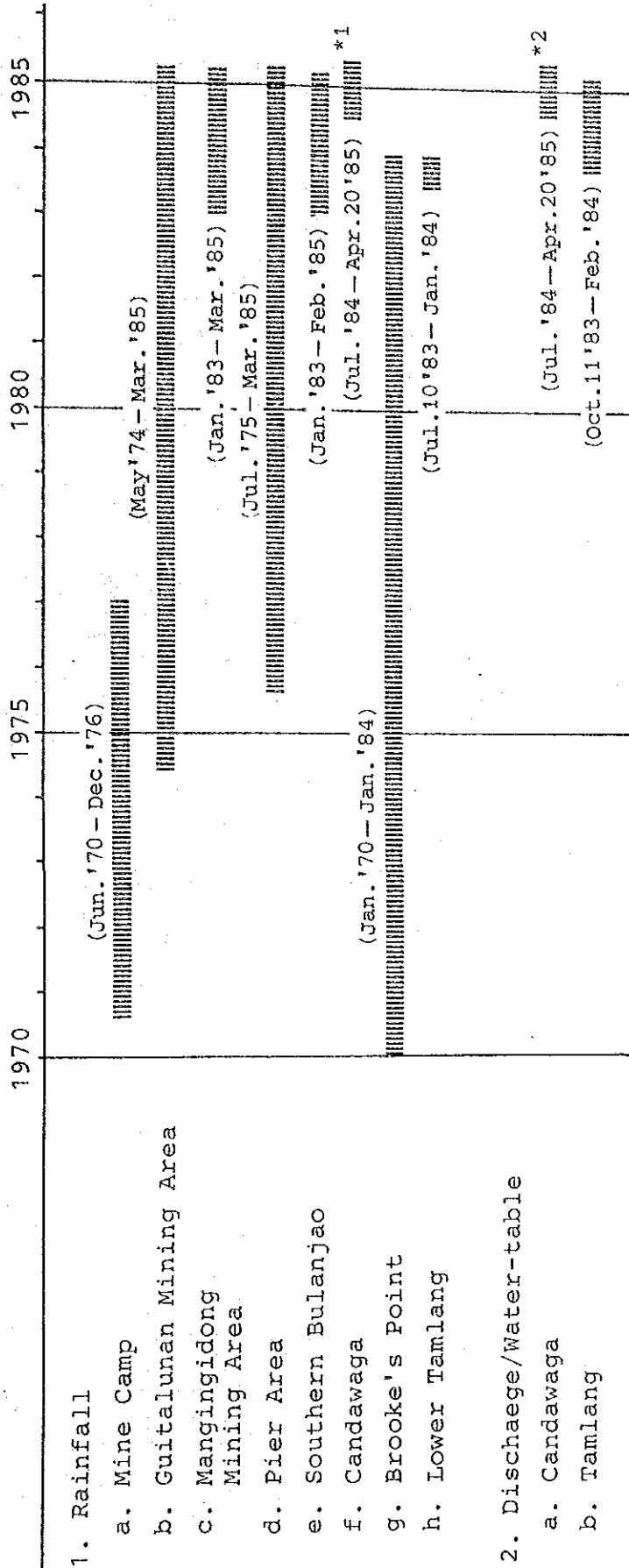
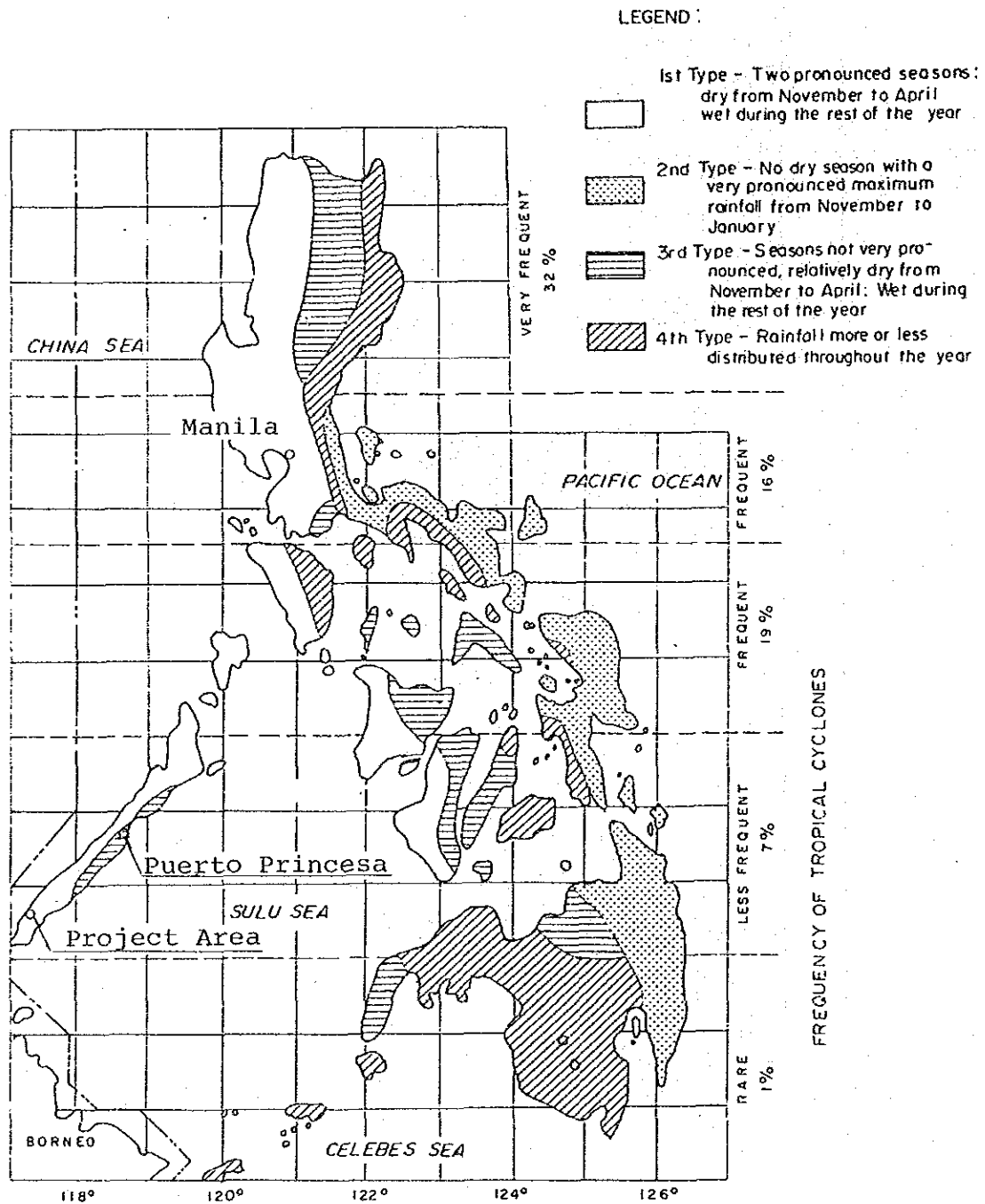


水文觀測期間

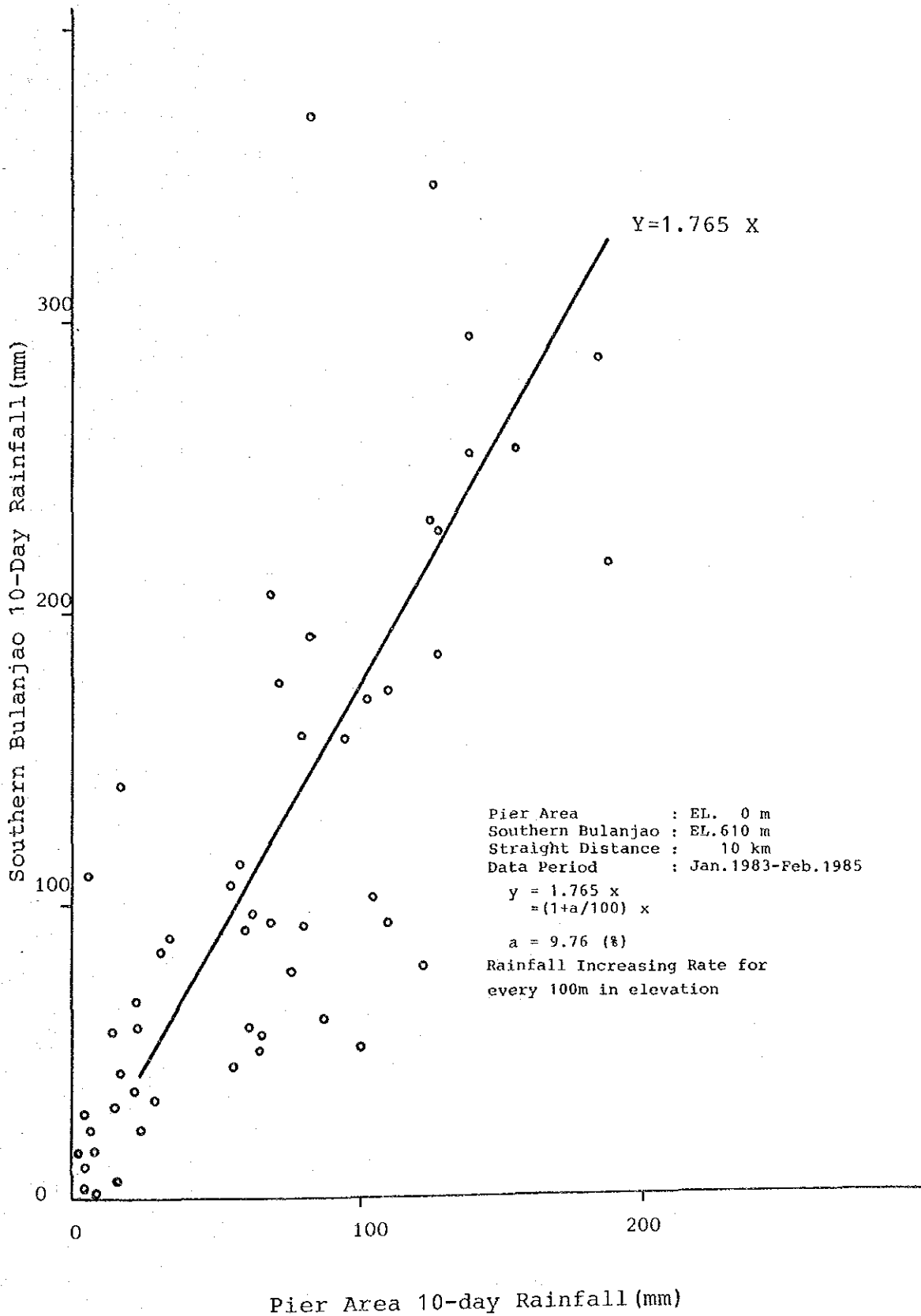


*1. Sep. '84 lacking
*2. Sep. '84 lacking

フィリピン気象区分 (コロナス方式)

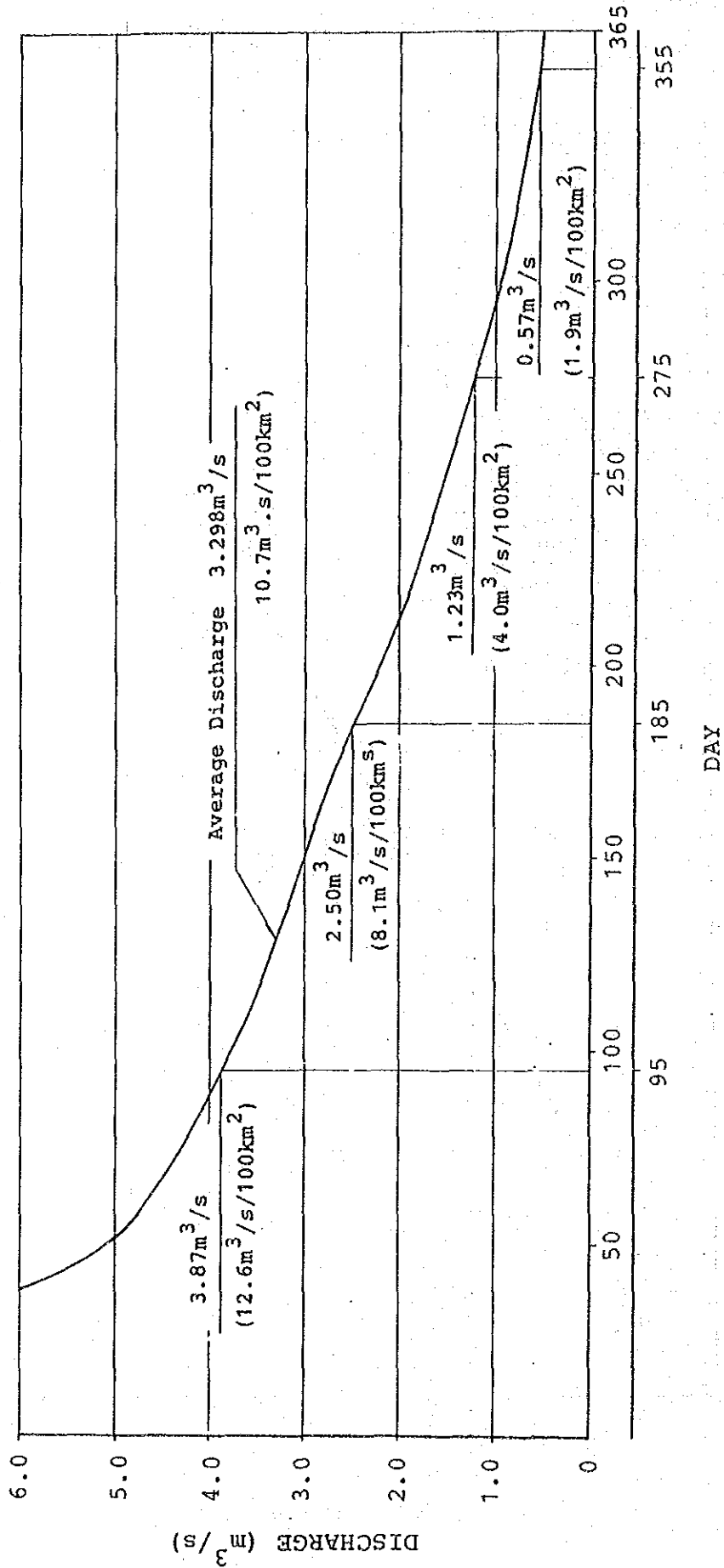


Pier Area-S.Bulanjao 旬降雨量相關



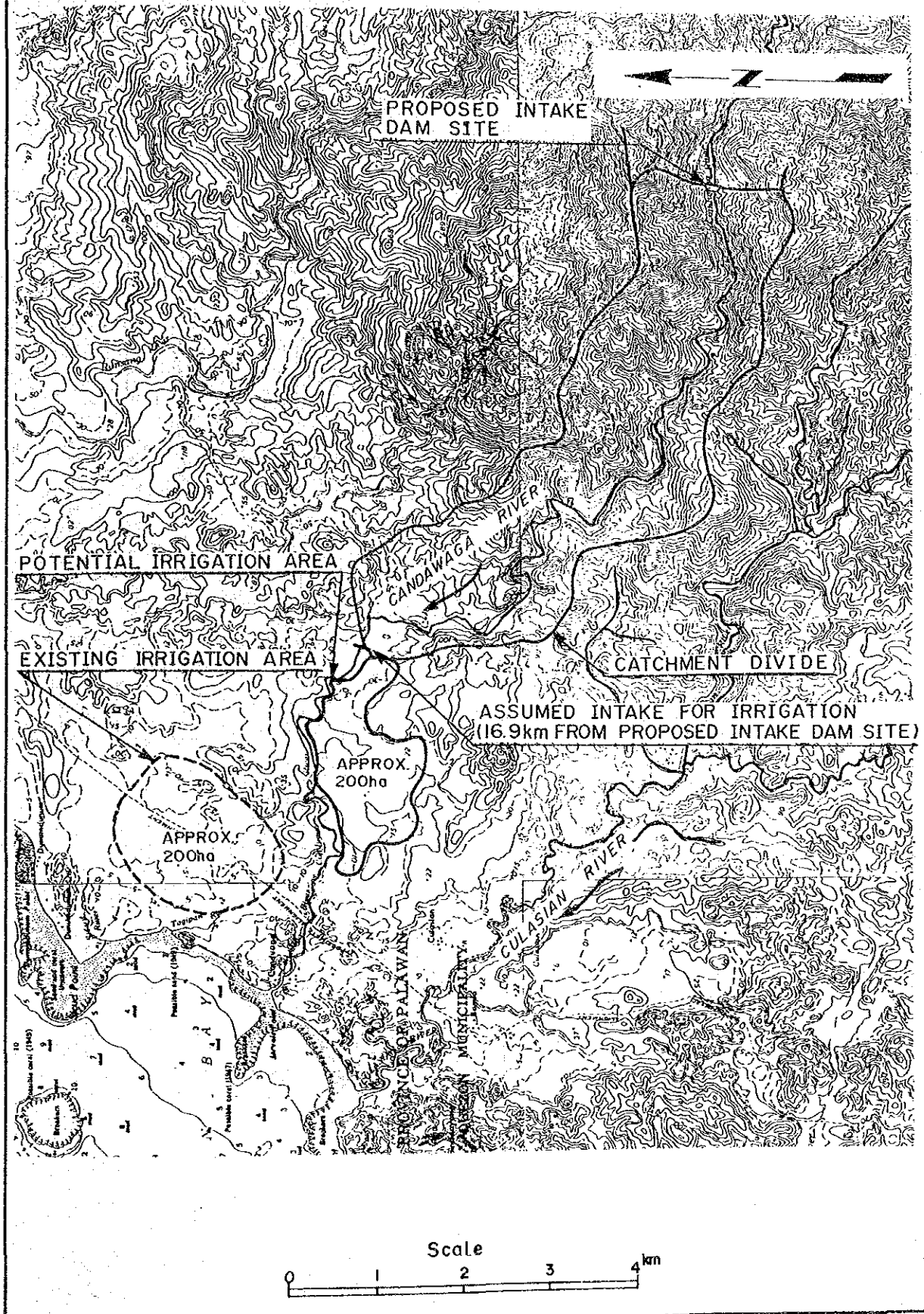
CANDAWAGA 川 1975-85 想定平均流況曲線

STATION : INTAKE DAM SITE (RIVER BED EL.255.0m)
 CATCHMENT AREA : 30.8km²

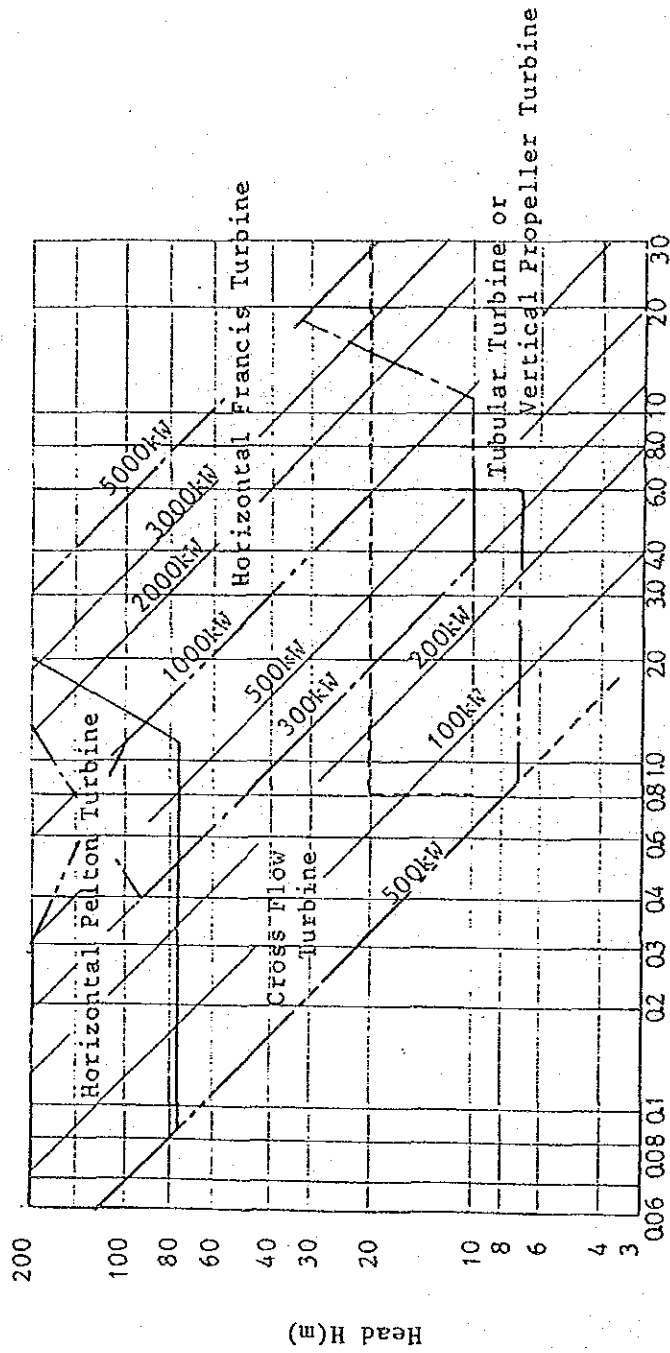


CANDAWAGA 川下流かんがい可能地域

図 2-6



水車 種別選定図



Discharge Q (m³/s)





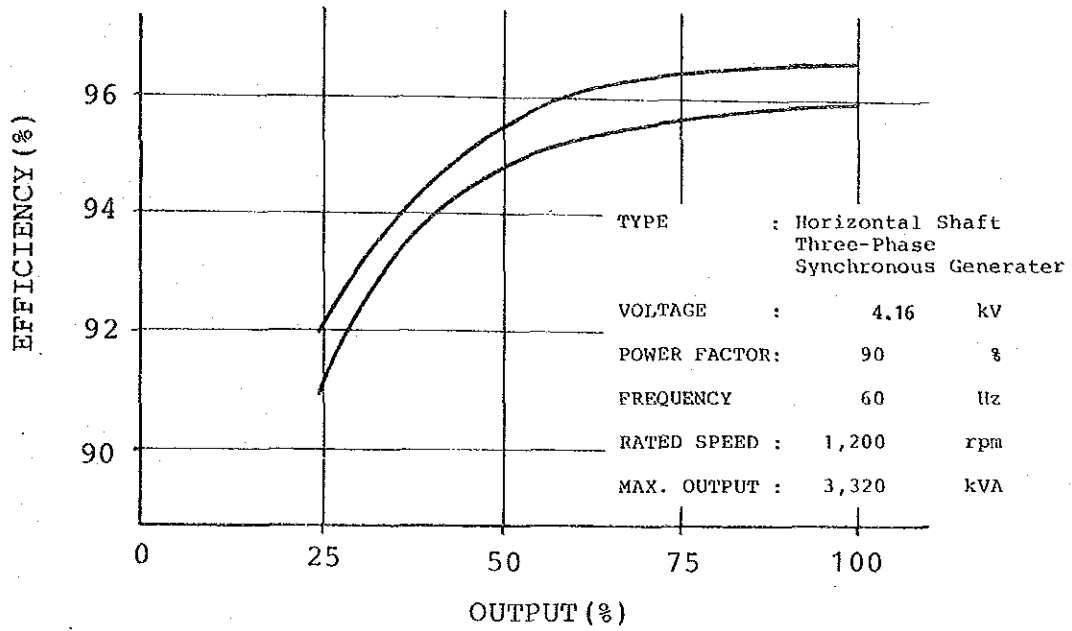
-  Horizontal Shaft Pelton Turbine
-  Horizontal Shaft Francis Turbine
-  Cross Flow Turbine
-  Tubular Turbine or Vertical Shaft Propeller Turbine

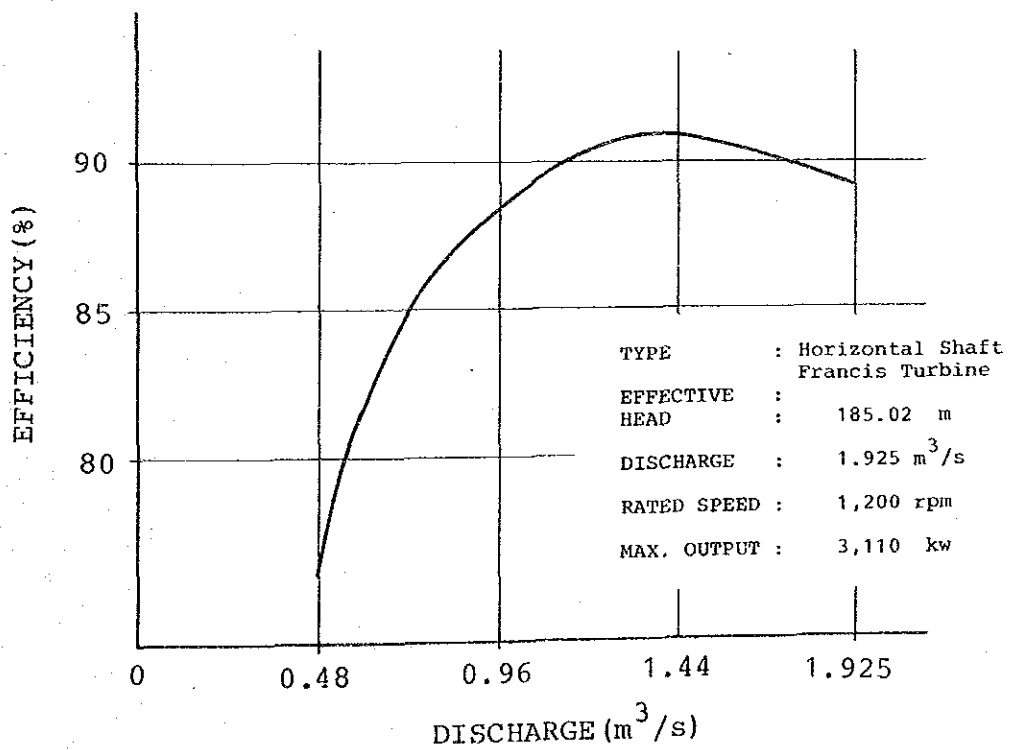
圖 3-2

圖 3-3

發電機效率曲線圖



水車 效率曲線圖



添付資料 I 設計図面表

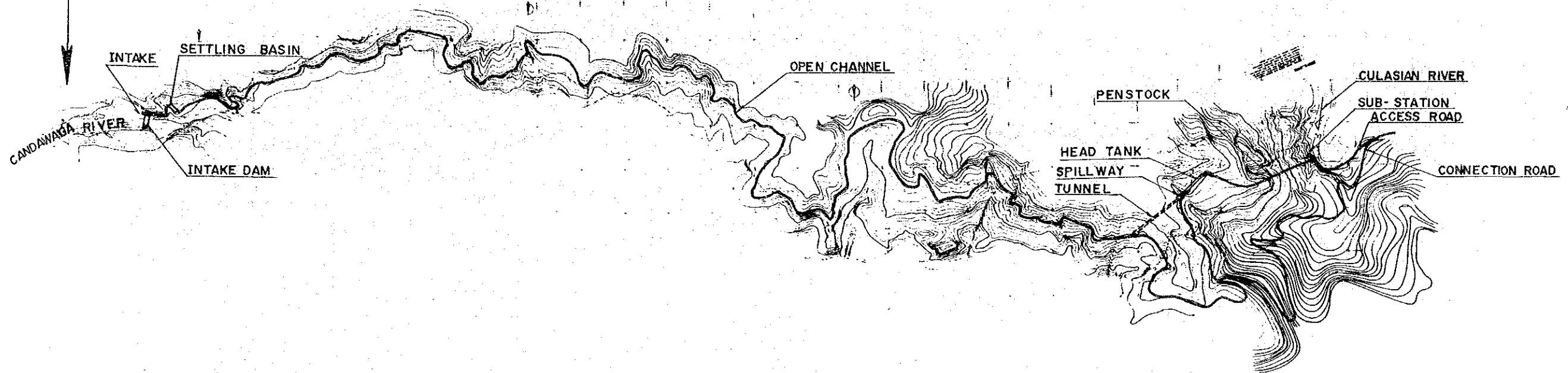
土木施設

DRWG.No.	タイトル
101	WATRWAY PLAN PLOFILE & SECTION
102	INTAKE DAM & SETTLING BASIN PLAN PROFILE & SECTIONS
103	HEAD TANK PLAN, SECTIONS & DETAIL
104	PENSTOCK PLAN, PROFILE & SECTION
105	POWERHOUSE PLAN & SECTIONS
106	INTAKE DAM DIVERSION WORKS
107	GENERAL PLAN FOR ALTERNASTIVE CANDAWAGA TALIRACE SCHEME

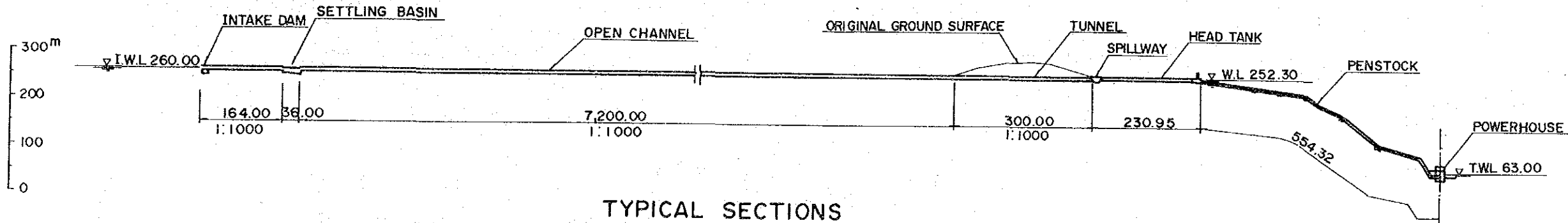
電気施設

DRWG.No.	タイトル
201	POWER SYSTEM DIAGRAM(IN 1989)
202	SINGLE LINE DIAGRAM
203	SUBSTATION
204	STANDARD WOODEN POLE FOR 69kV TRANSMISSION LINE

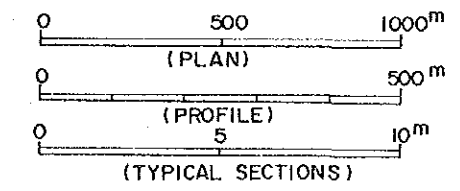
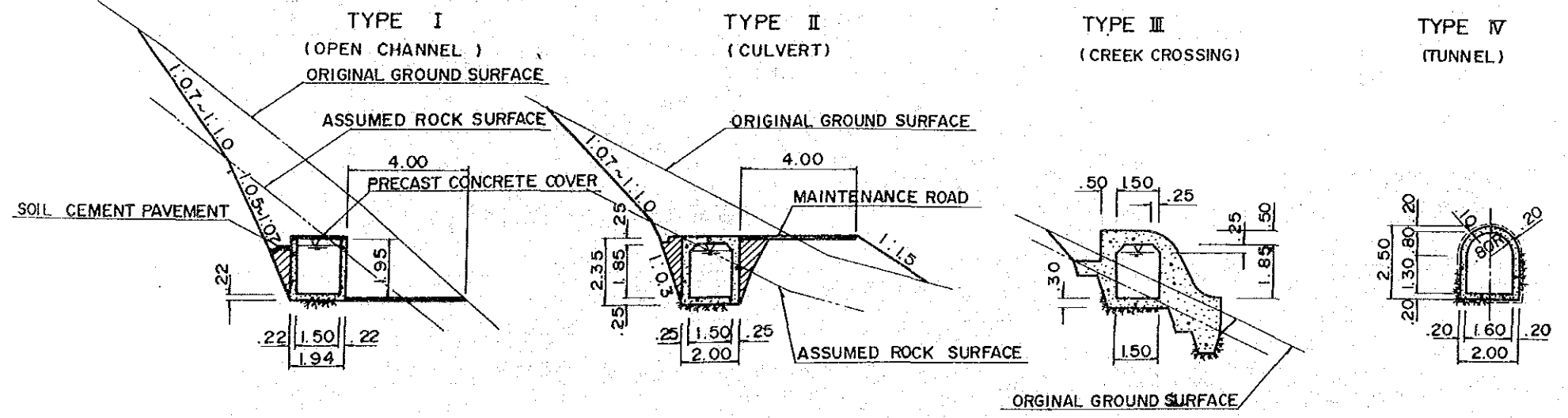
PLAN



PROFILE



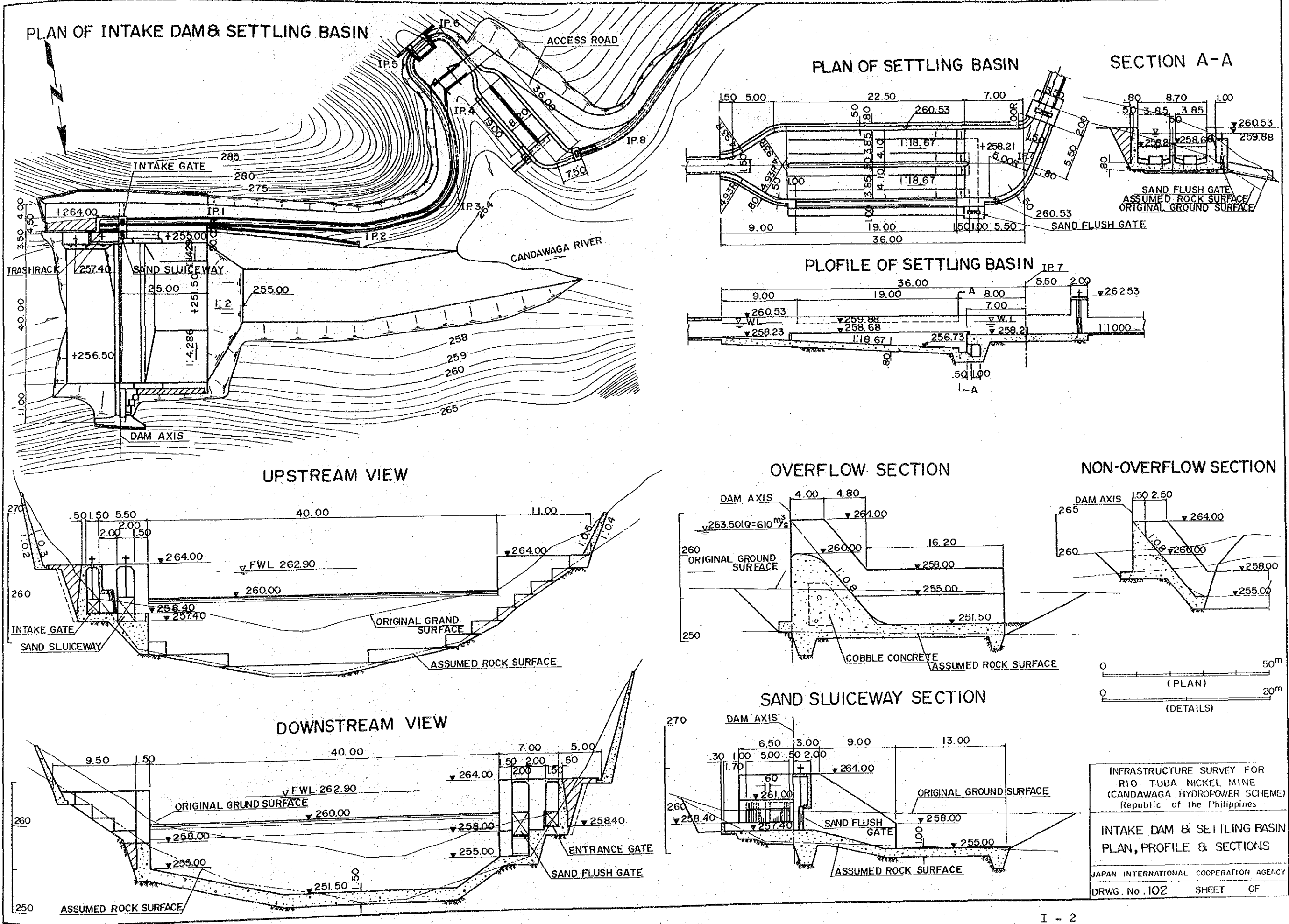
TYPICAL SECTIONS



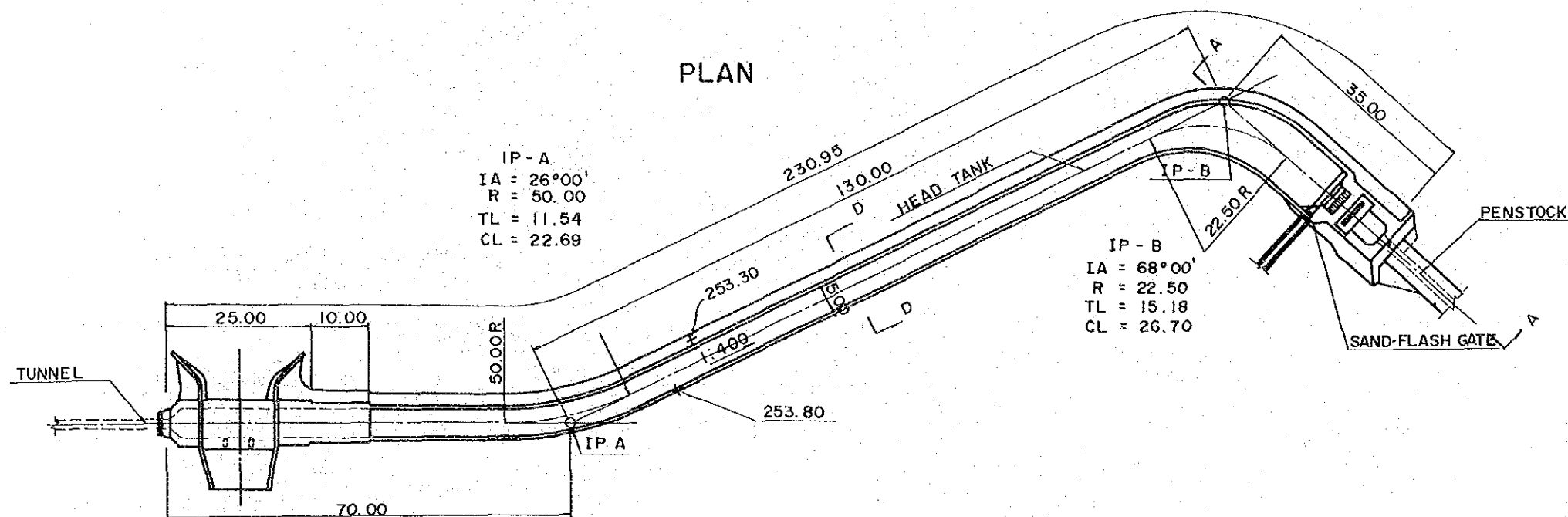
INFRASTRUCTURE SURVEY FOR
 RIO TUBA NICKEL MINE
 (CANDAWAGA HYDROPOWER SCHEME)
 Republic of the Philippines

WATERWAY PLAN
PROFILE & SECTIONS

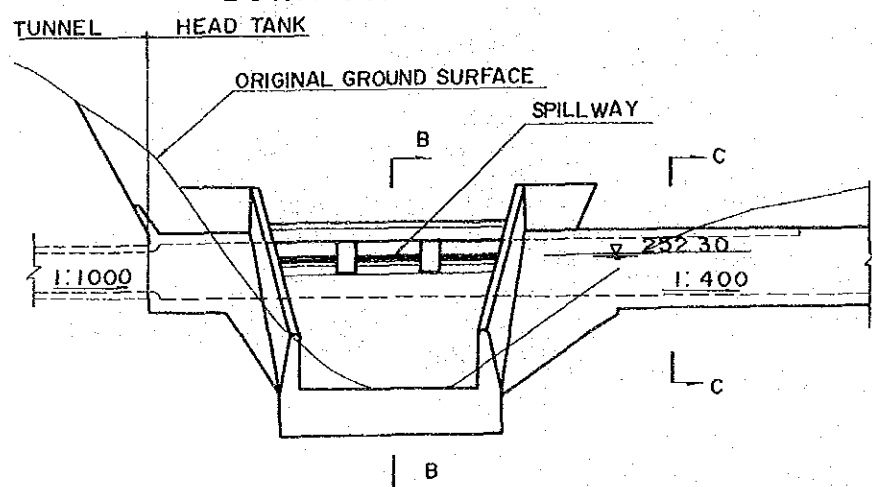
JAPAN INTERNATIONAL COOPERATION AGENCY
 DRWG. No. 101 SHEET OF



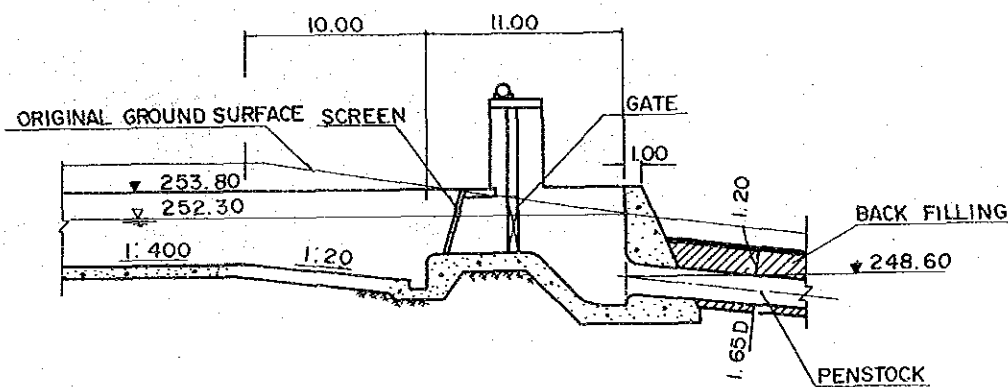
PLAN



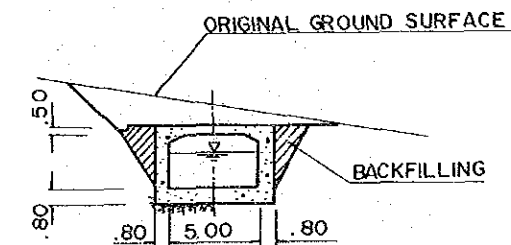
DOWN STREAM VIEW OF SPILLWAY



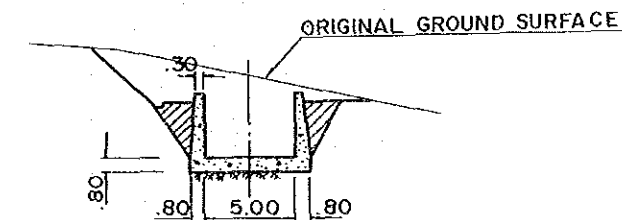
SECTION A-A



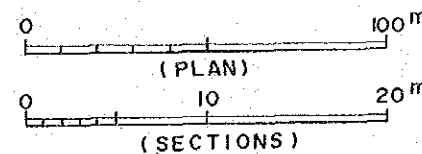
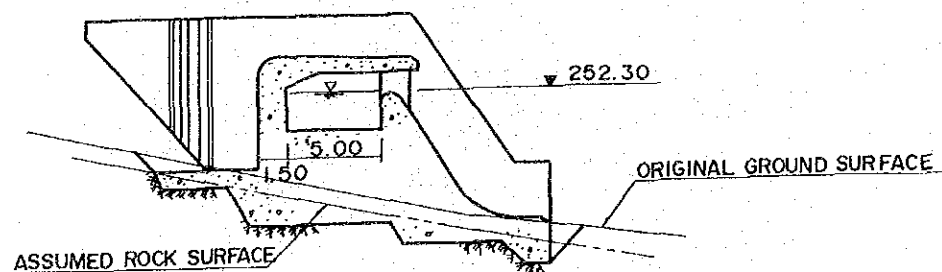
SECTION C-C



SECTION D-D

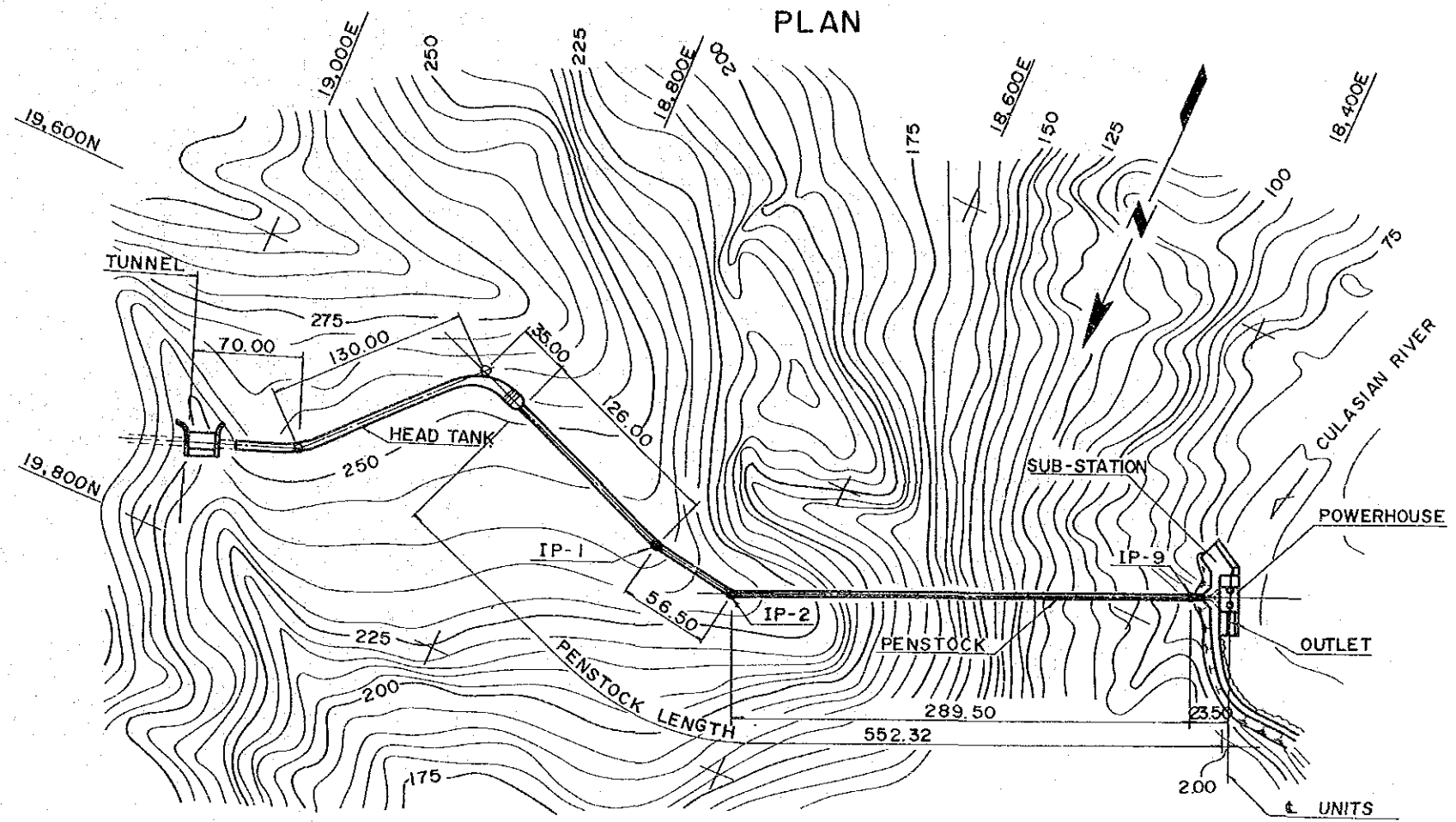
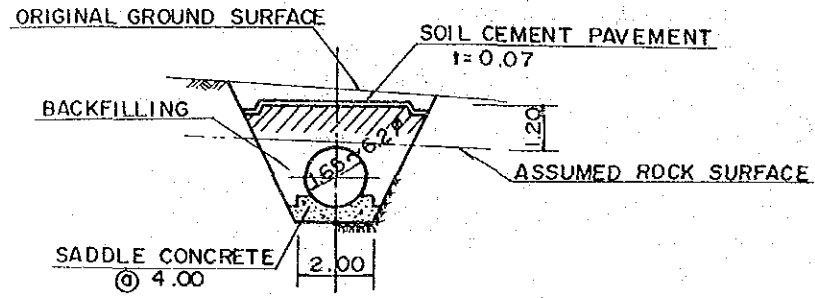


SECTION B-B

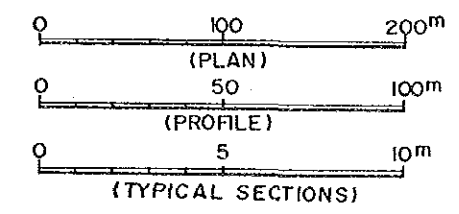
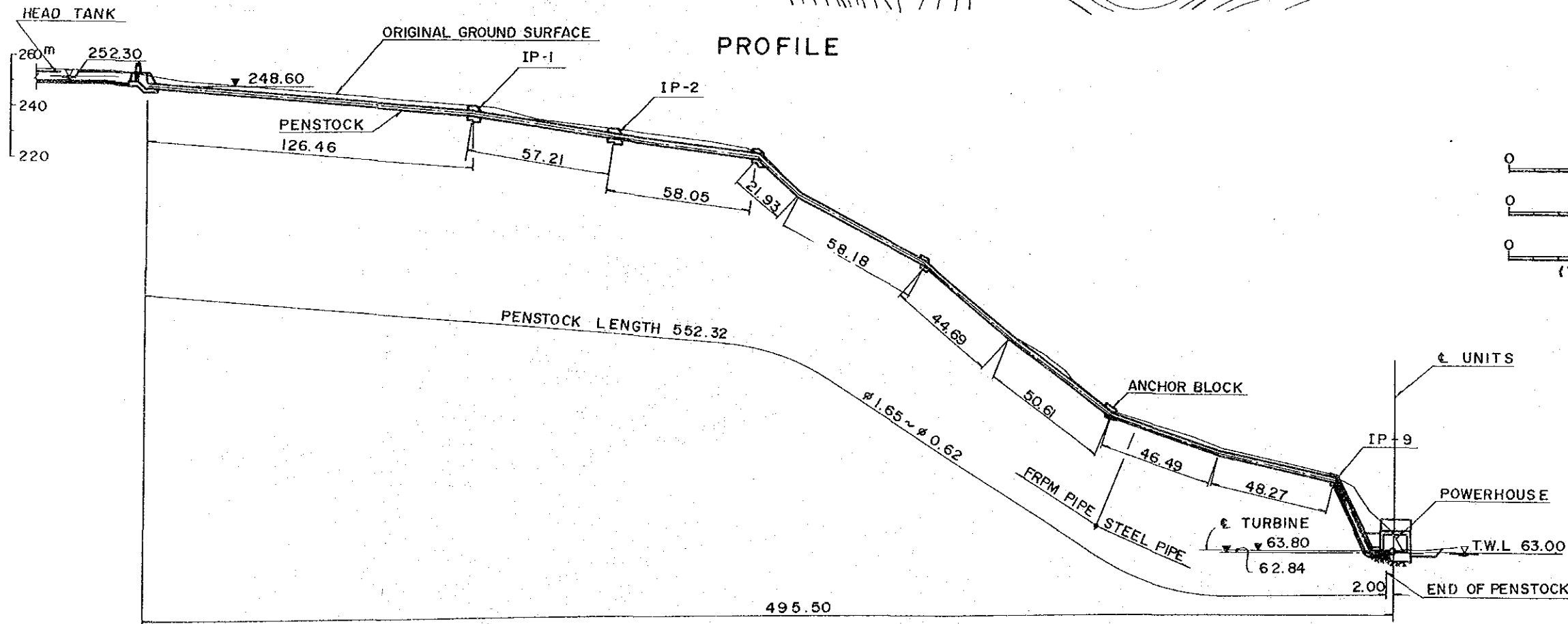


INFRASTRUCTURE SURVEY FOR RIO TUBA NICKEL MINE (CANDAWAGA HYDROPOWER SCHEME) Republic of the Philippines	
HEAD TANK PLAN, SECTIONS & DETAIL	
JAPAN INTERNATIONAL COOPERATION AGENCY	
DRWG. No. 103	SHEET OF

TYPICAL CROSS SECTION



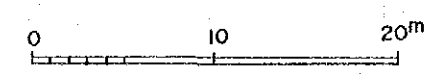
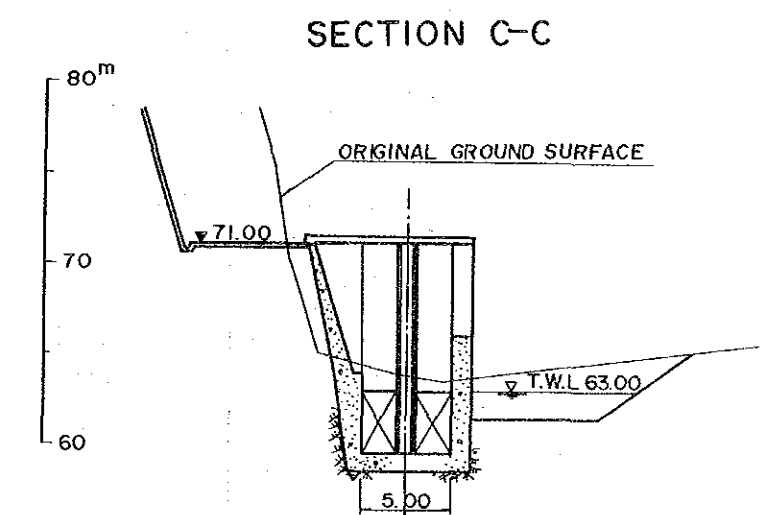
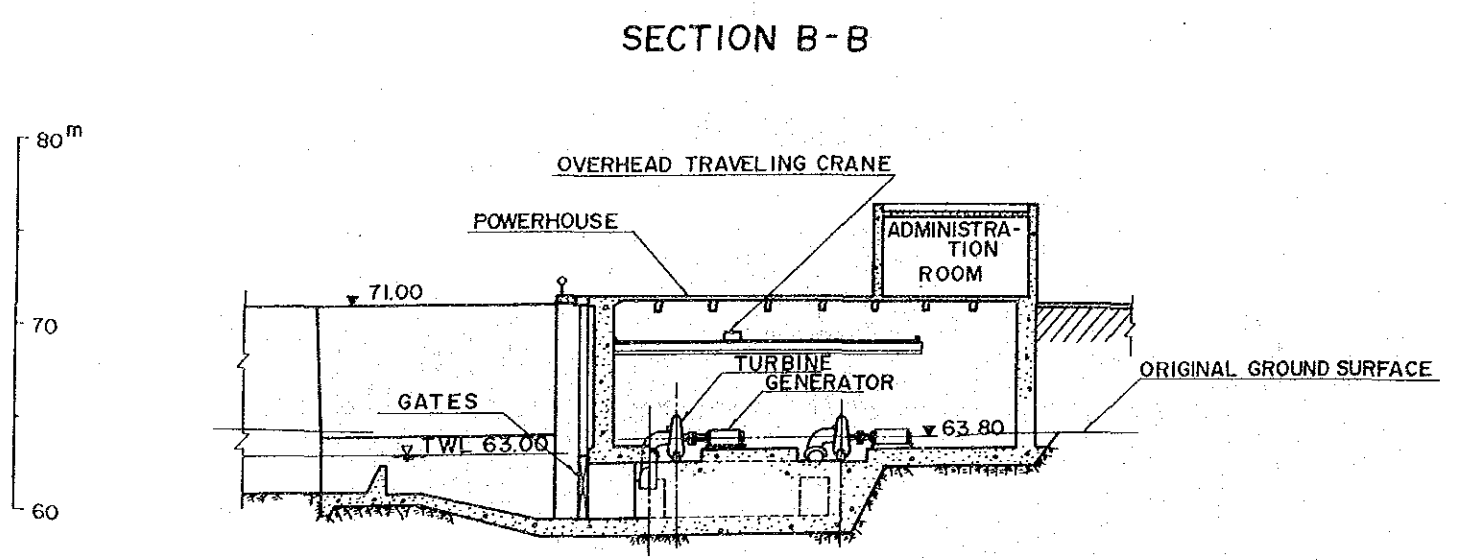
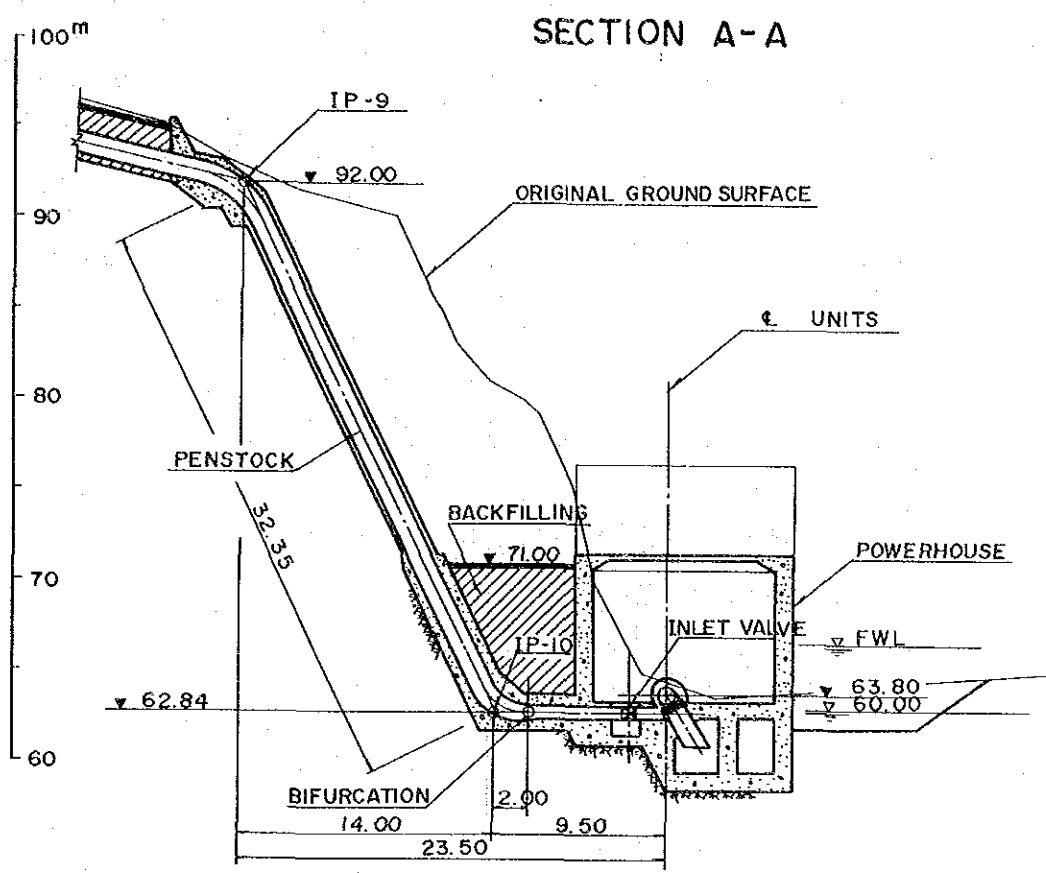
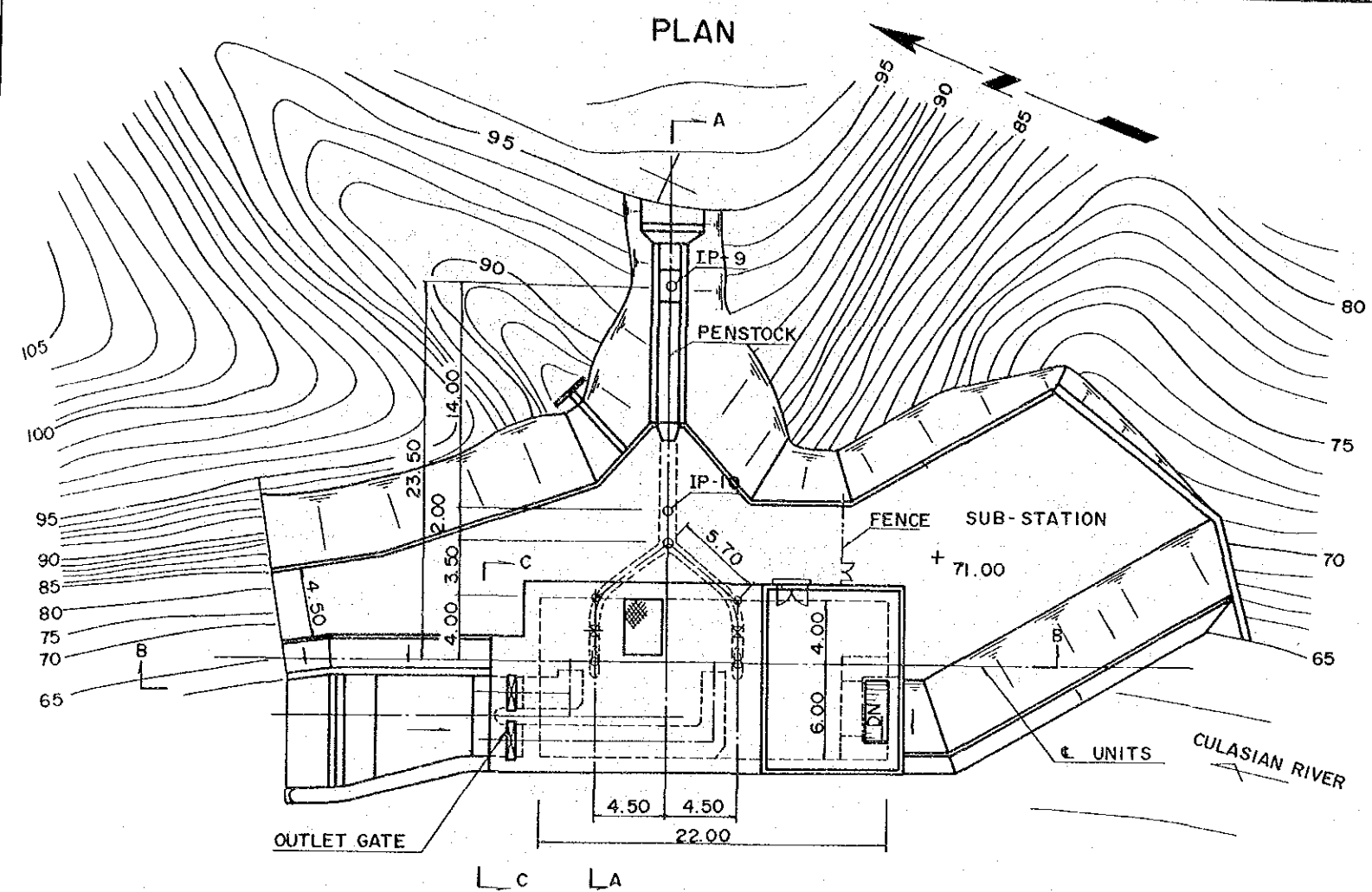
PROFILE



INFRASTRUCTURE SURVEY FOR
RIO TUBA NICKEL MINE
(CANDAWAGA HYDROPOWER SCHEME)
Republic of the Philippines

**PENSTOCK PLAN,
PROFILE & SECTION**

JAPAN INTERNATIONAL COOPERATION AGENCY
DRWG. No. 104 SHEET OF

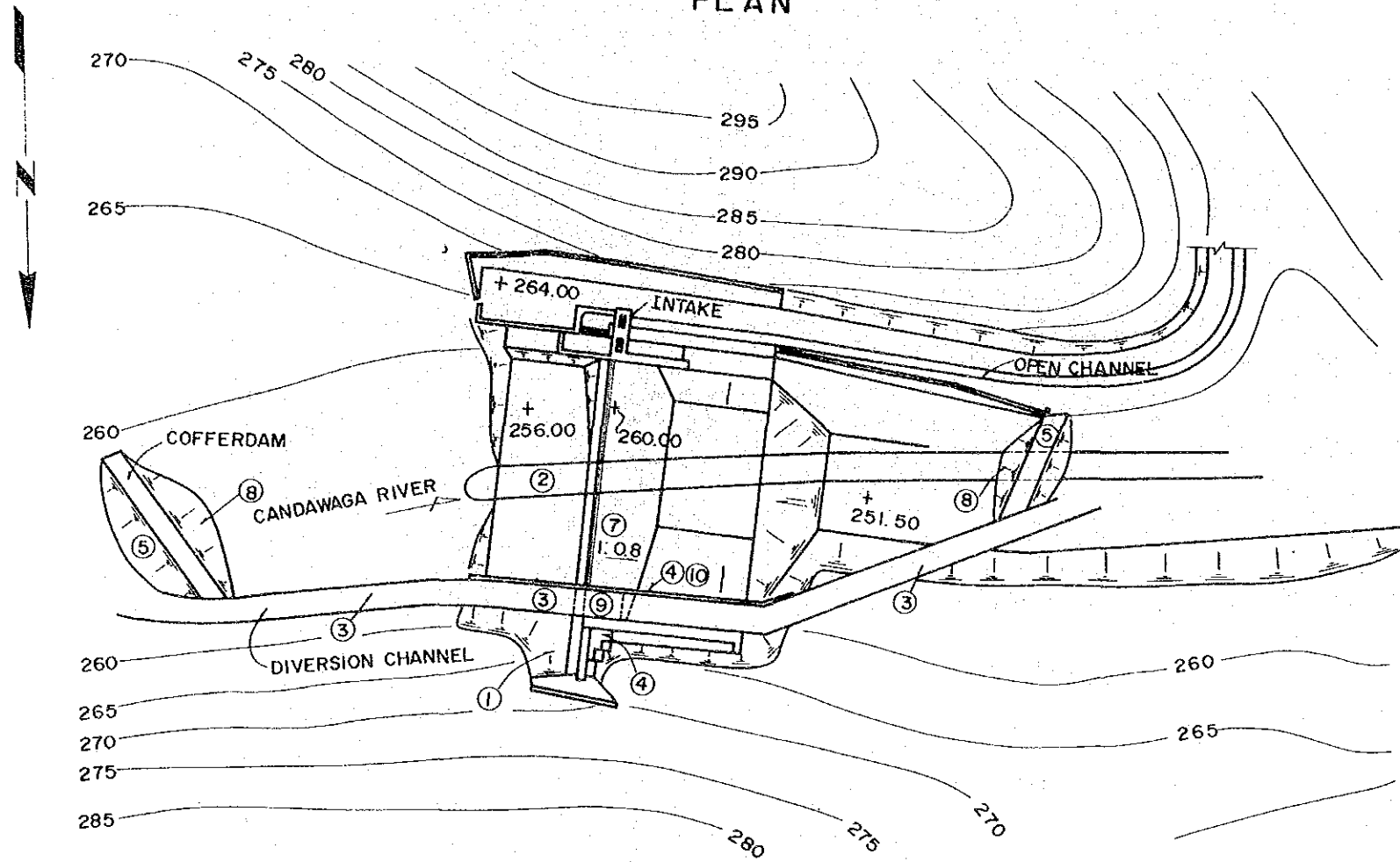


INFRASTRUCTURE SURVEY FOR
 RIO TUBA NICKEL MINE
 (CANDAWAGA HYDROPOWER SCHEME)
 Republic of the Philippines

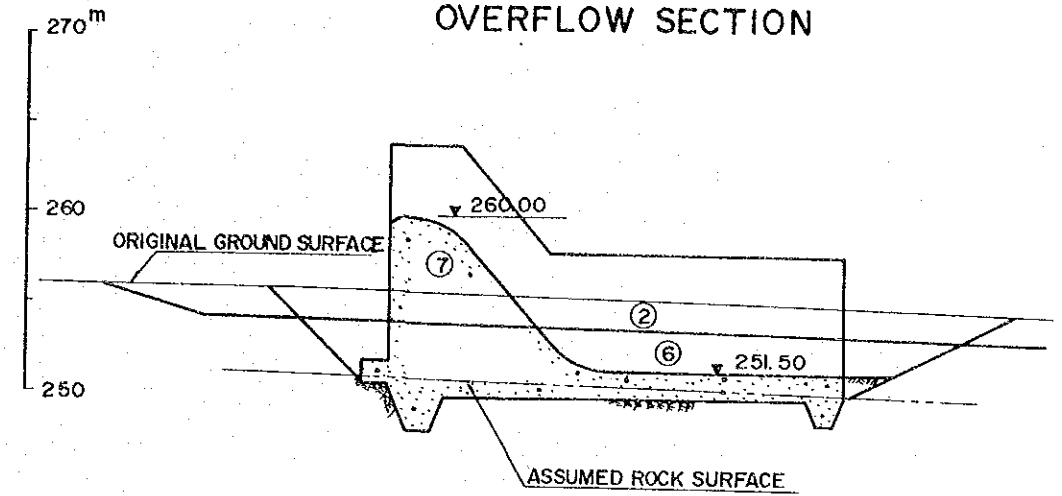
POWERHOUSE PLAN & SECTIONS

JAPAN INTERNATIONAL COOPERATION AGENCY
 DRWG. No. 105 SHEET OF

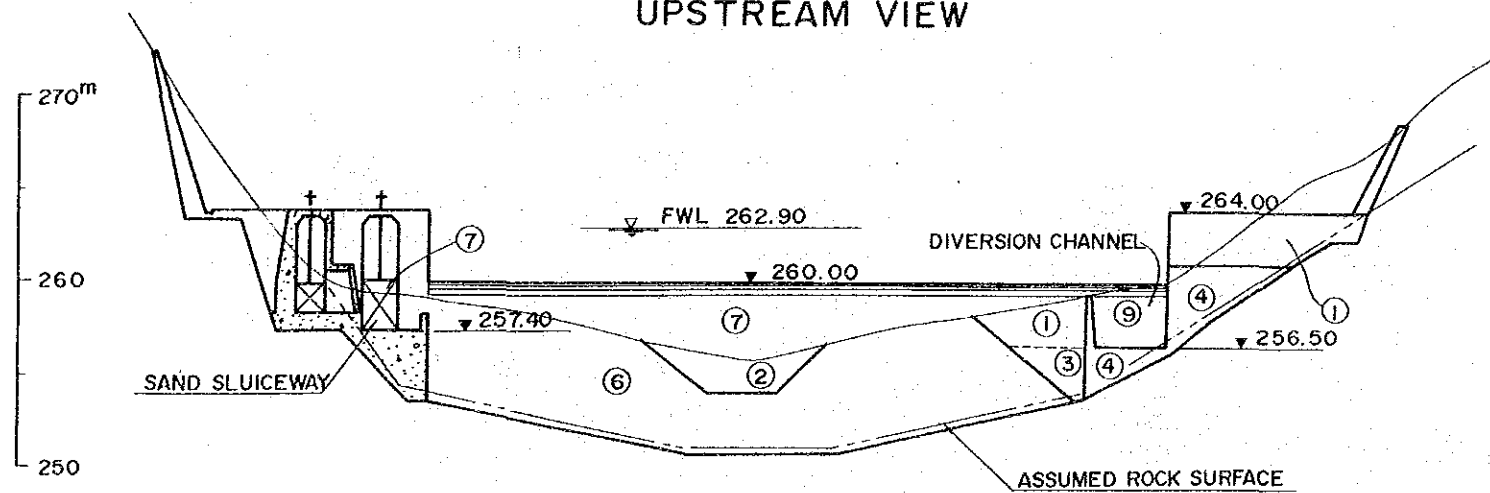
PLAN



OVERFLOW SECTION

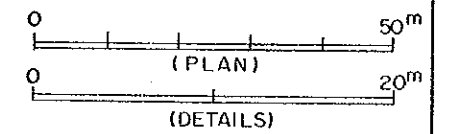


UPSTREAM VIEW



WORK PROCEDURE

- ① EXCAVATION OF DAM FOUNDATION (RIGHT BANK, ABOVE EL.256.50)
- ② EXCAVATION OF RIVER BED
- ③ EXCAVATION FOR DIVERSION CHANNEL AND DAM FOUNDATION
- ④ PLACING OF CONCRETE FOR DAM AND DIVERSION CHANNEL
- ⑤ COFFERDAM CONSTRUCTION AND DIVERSION OF THE RIVER
- ⑥ EXCAVATION OF DAM FOUNDATION.
- ⑦ PLACING OF DAM CONCRETE ETC. AND INSTALLATION OF SAND FLUSH GATE
- ⑧ REMOVAL OF COFFERDAM, DEWATERING THROUGH SAND FLUSHING CHANNEL
- ⑨ PLACING OF DAM CONCRETE ON THE DIVERSION CHANNEL
- ⑩ DEMOLISHING OF DIVERSION CHANNEL CONCRETE



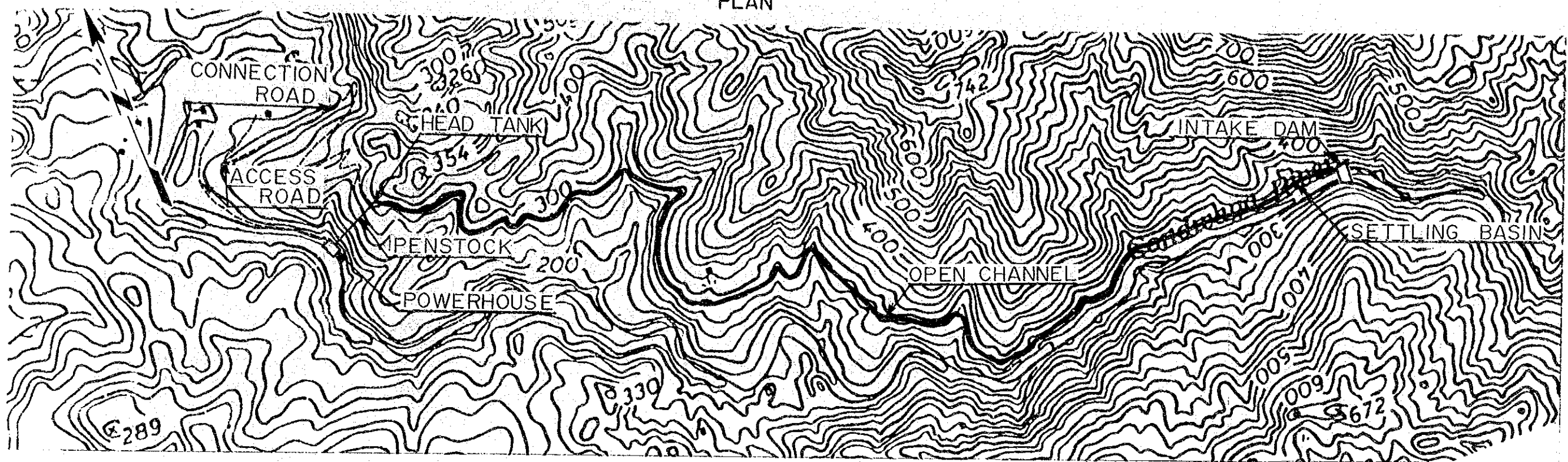
INFRASTRUCTURE SURVEY FOR
RIO TUBA NICKEL MINE
(CANDAWAGA HYDROPOWER SCHEME)
Republic of the Philippines

INTAKE DAM DIVERSION WORKS

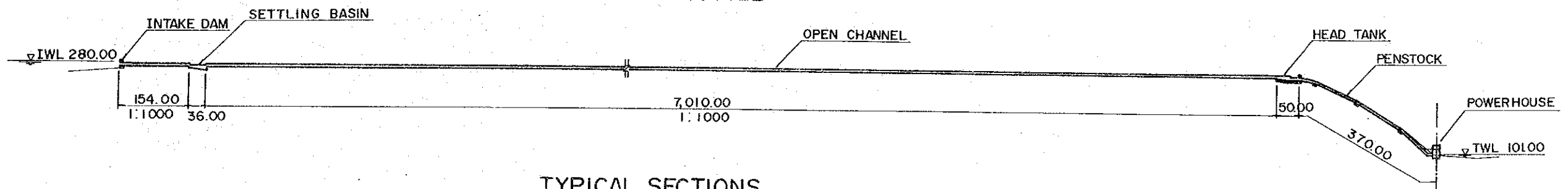
JAPAN INTERNATIONAL COOPERATION AGENCY

DRWG. No. 106 SHEET OF

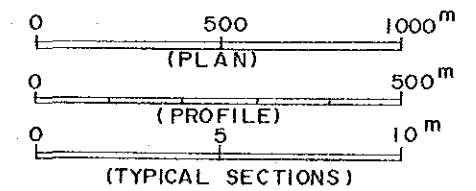
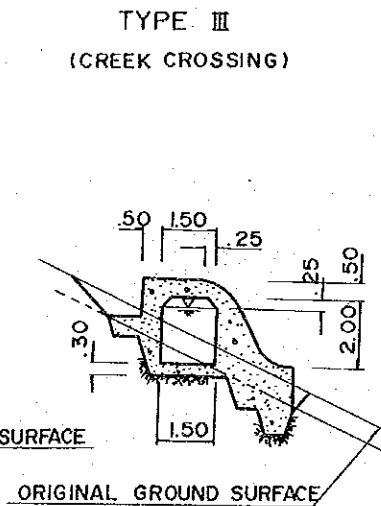
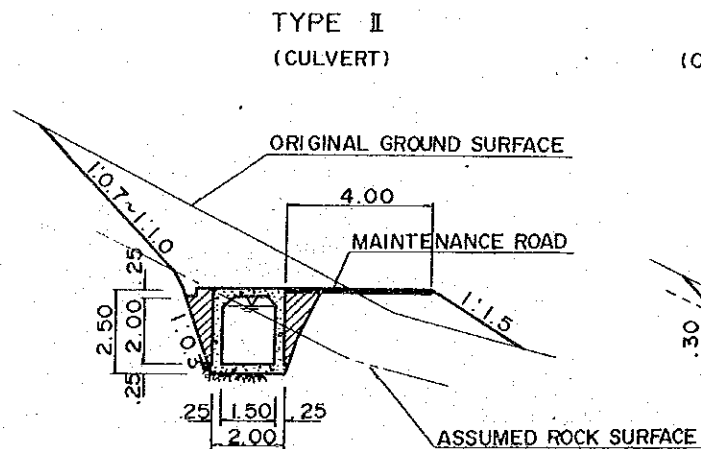
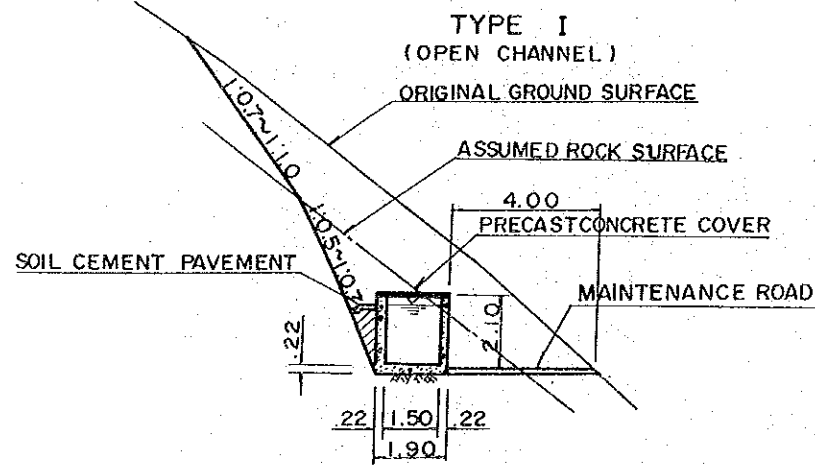
PLAN



PROFILE



TYPICAL SECTIONS

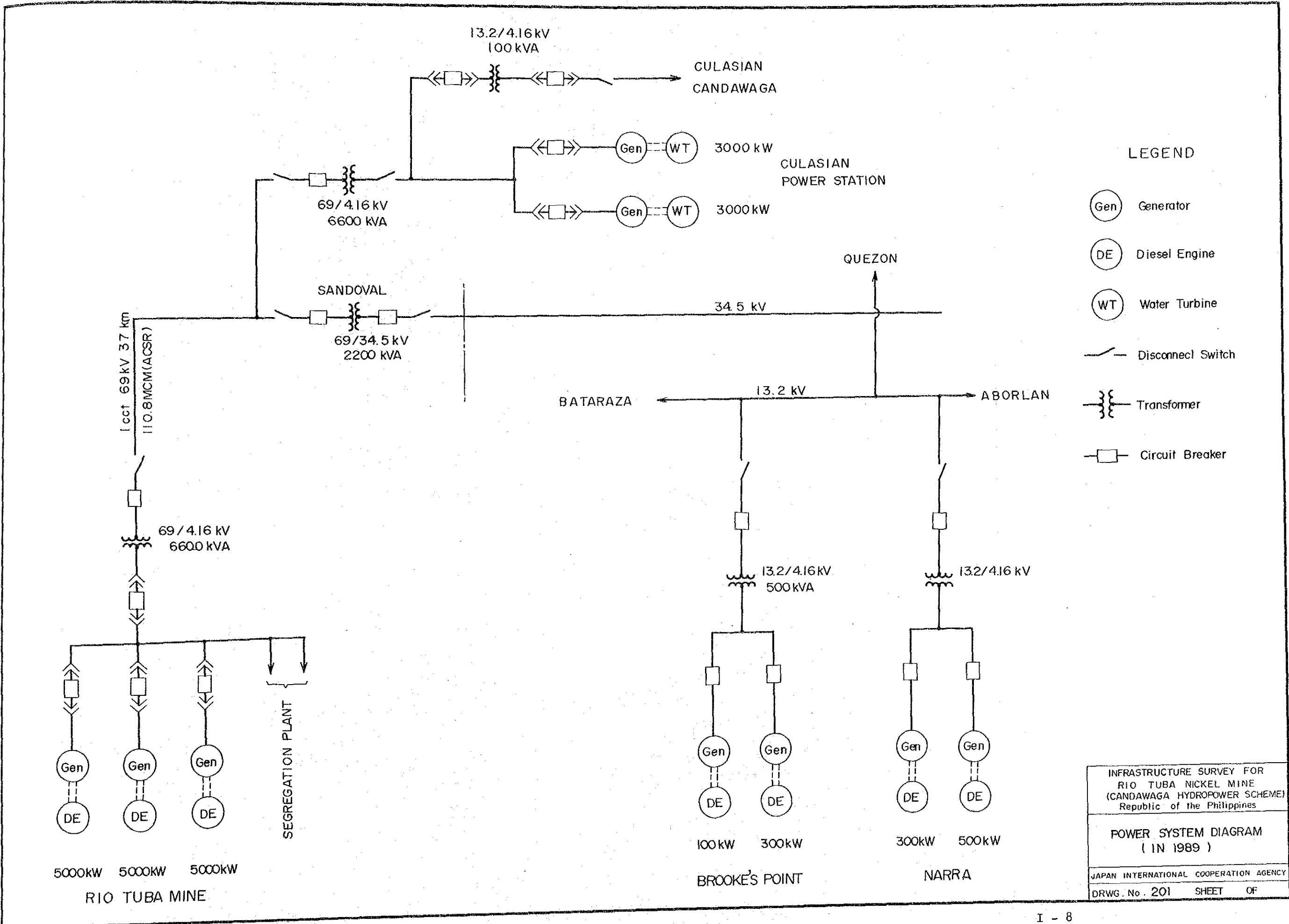


INFRASTRUCTURE SURVEY FOR
RIO TUBA NICKEL MINE
(CANDAWAGA HYDROPOWER SCHEME)
Republic of the Philippines







GENERAL PLAN FOR ALTERNATIVE
CANDAWAGA P/S SCHEME

JAPAN INTERNATIONAL COOPERATION AGENCY

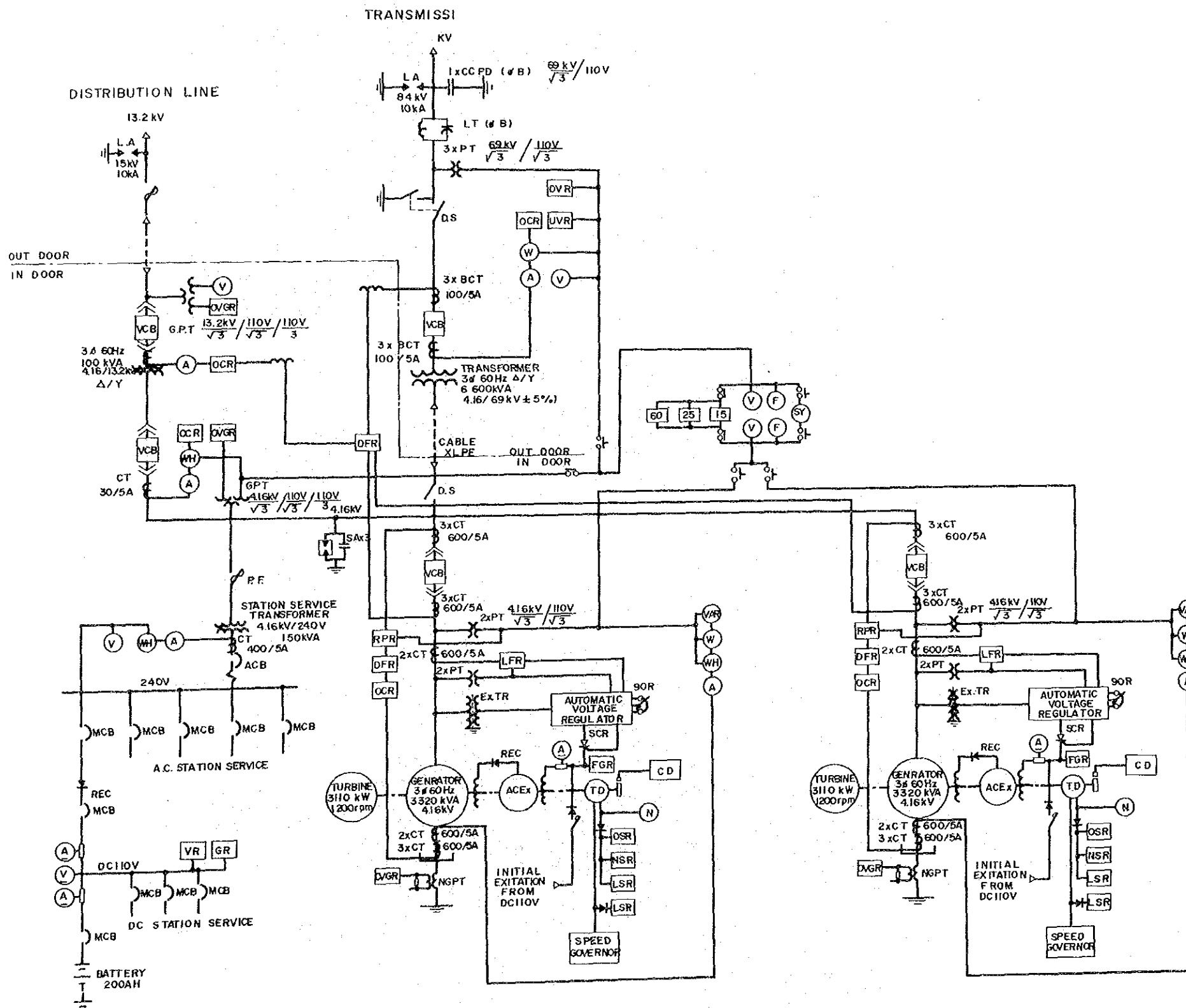
DRWG. No. 107 SHEET OF



LEGEND

-  Generator
-  Diesel Engine
-  Water Turbine
-  Disconnect Switch
-  Transformer
-  Circuit Breaker

INFRASTRUCTURE SURVEY FOR RIO TUBA NICKEL MINE (CANDAWAGA HYDROPOWER SCHEME) Republic of the Philippines	
POWER SYSTEM DIAGRAM (IN 1989)	
JAPAN INTERNATIONAL COOPERATION AGENCY	
DRWG. No. 201	SHEET OF



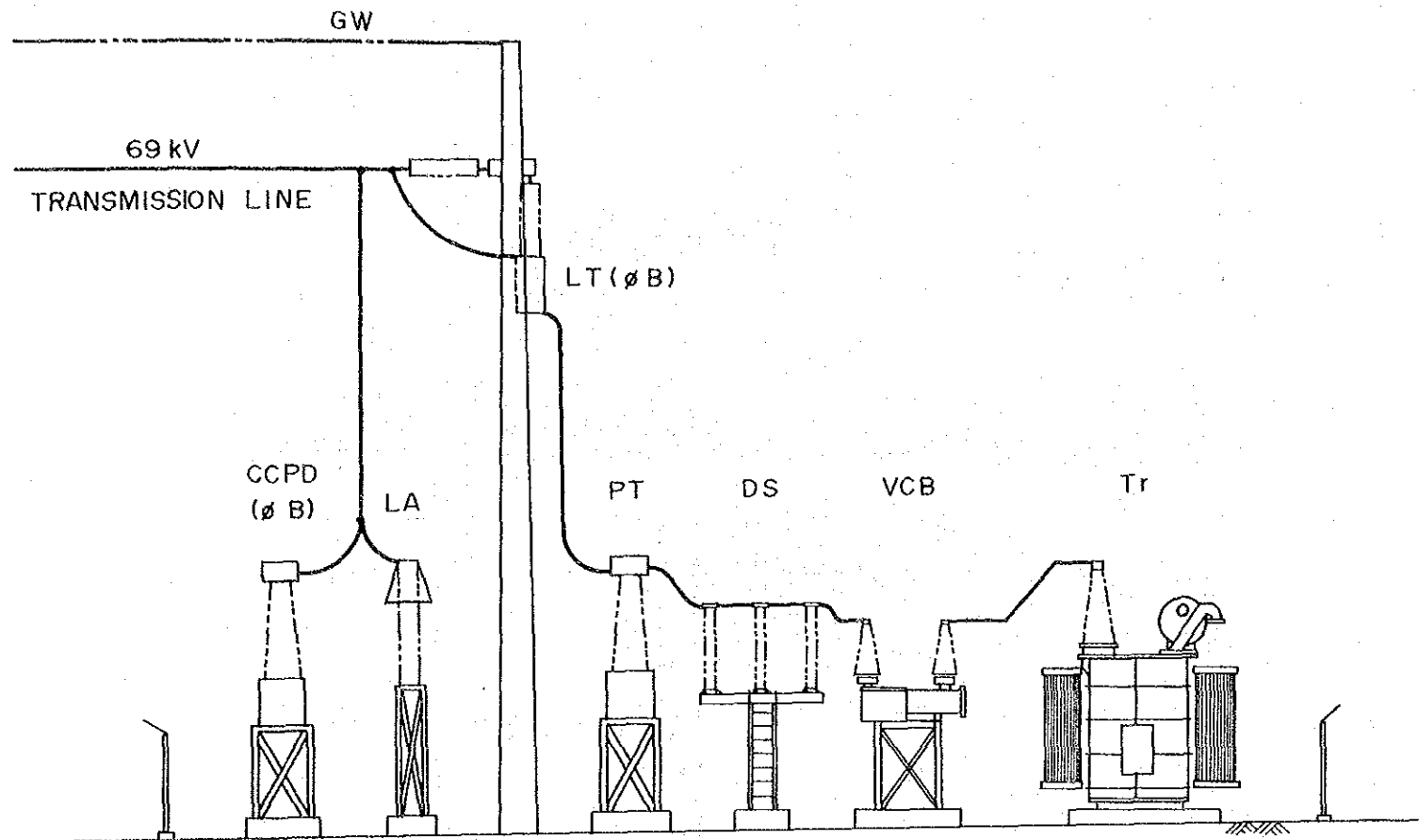
LEGEND

- | | | | | | |
|-----|---------------------------|-----|------------------------|-------|---|
| OCR | Over Current Relay | 60 | Voltage Matcher | SA | Surge Absorber |
| OVR | Overvoltage Relay | 15 | Speed Matcher | Ex.TR | Existing Transformer |
| UVR | Undervoltage Relay | 25 | Synchronizer | TD | Tachometer Dynamo |
| DGR | Directional Ground Relay | CD | Crawling Detector | NGPT | Neutral Grounding Potential Transformer |
| DFR | Differential Relay | W | Wattmeter | AC.Ex | AC Exciter |
| LFR | Loss-of-field Relay | WH | Watt-hourmeter | | |
| RFR | Reverse Power Relay | VM | Var-meter | | |
| FGR | Field Ground Relay | N | Speed Meter | | |
| DGR | Over Voltage Ground Relay | + | Rectifier | | |
| VR | Voltage Relay | ~ | Styristor | | |
| GR | Ground Relay | CT | Current Transformer | | |
| OSR | Over Speed Relay | PT | Potential Transformer | | |
| NSR | Nominal Speed Relay | VCB | Vacuum Circuit Breaker | | |
| LSR | Low Speed Relay | CB | Circuit Breaker | | |
| V | Voltmeter | MCB | Molded Circuit Breaker | | |
| V0 | Grounding Voltmeter | DS | Disconnecting Switch | | |
| A | Ammeter | PF | Power Fuse | | |
| A | D.C. Ammeter | LA | Lightning Arrestor | | |
| V | D.C. Voltmeter | PT | Potential Transformer | | |
| F | Frequency meter | CT | Current Transformer | | |
| SY | Synchroscope | BCT | Bushing Type C.T. | | |

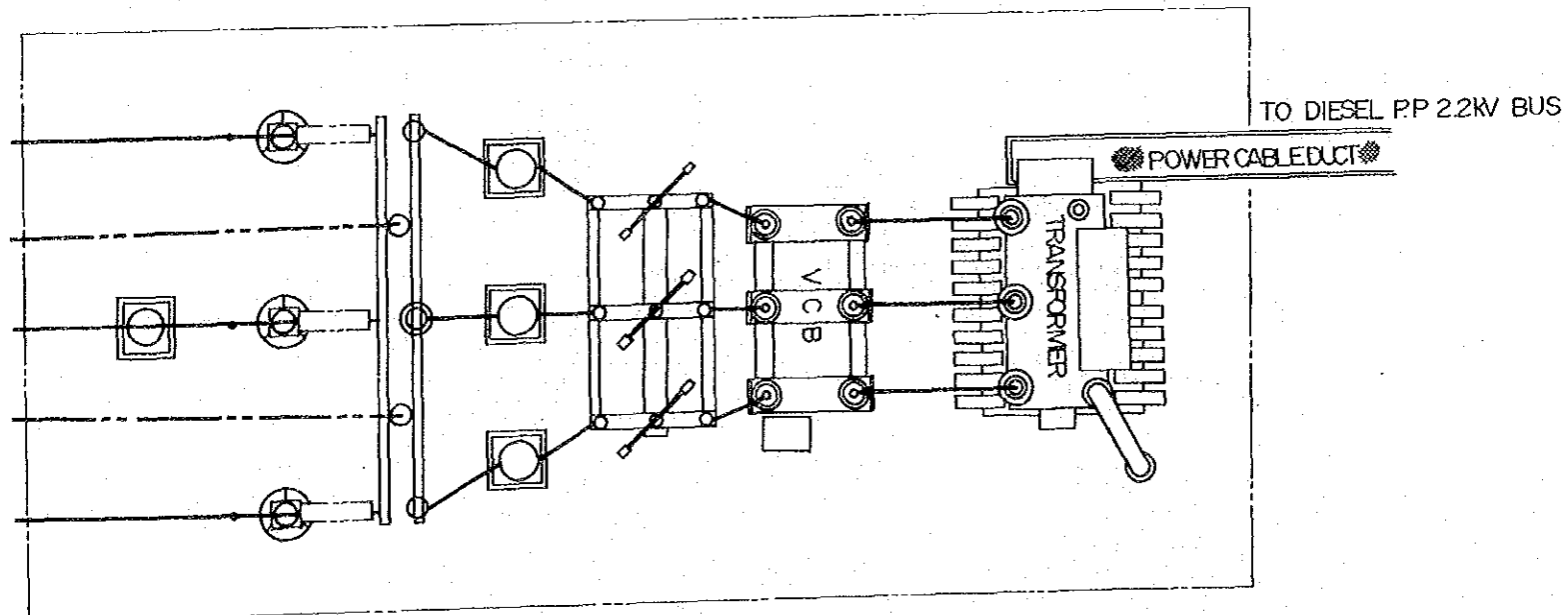
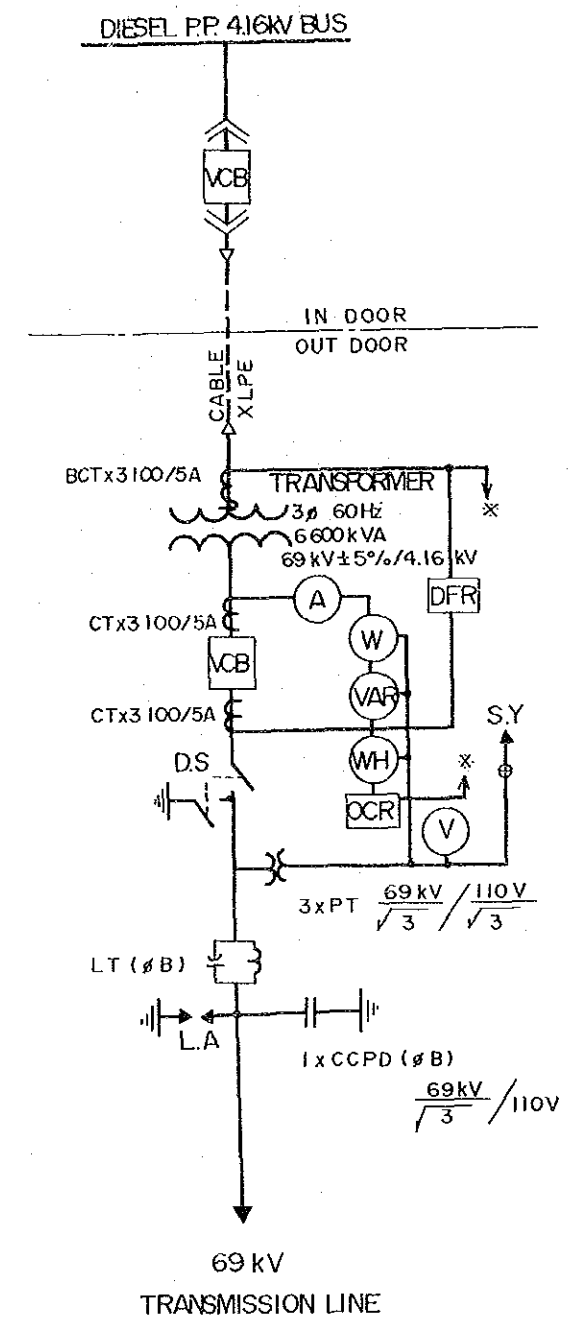
INFRASTRUCTURE SURVEY FOR
 RIO TUBA NICKEL MINE
 (CANDAWAGA HYDROPOWER SCHEME)
 Republic of the Philippines

SINGLE LINE DIAGRAM

JAPAN INTERNATIONAL COOPERATION AGENCY
 DRWG. No. 202 SHEET OF



SINGLE LINE DIAGRAM
(RIO TUB MINE SIDE)

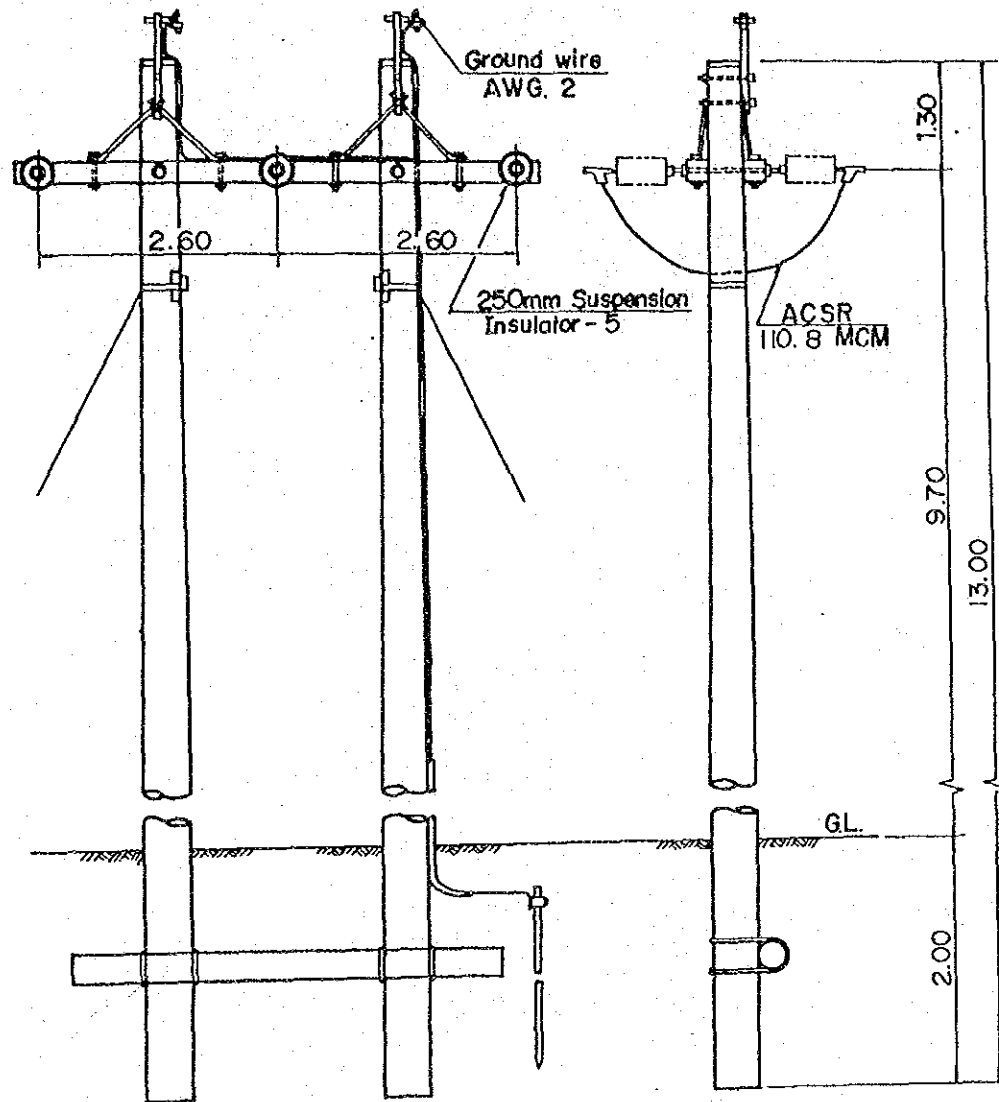


INFRASTRUCTURE SURVEY FOR
RIO TUBA NICKEL MINE
(CANDAWAGA HYDROPOWER SCHEME)
Republic of the Philippines

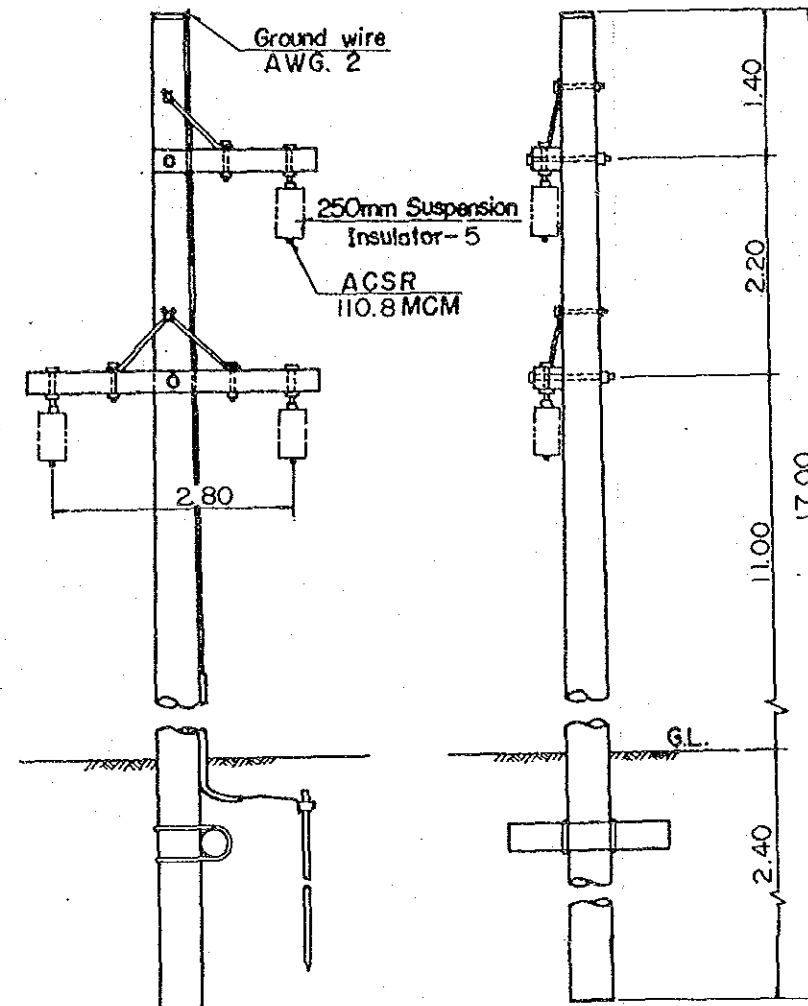
SUBSTATION

JAPAN INTERNATIONAL COOPERATION AGENCY
DRWG. No. 203 SHEET OF

TENSION



SUSPENSION



INFRASTRUCTURE SURVEY FOR
 RIO TUBA NICKEL MINE
 (CANDAWAGA HYDROPOWER SCHEME)
 Republic of the Philippines

STANDARD WOODEN POLE
 FOR 69KV TRANSMISSION LINE

JAPAN INTERNATIONAL COOPERATION AGENCY
 DRWG. No. 204 SHEET OF

添付資料Ⅱ 基本設計計算書

- Ⅱ-1 有効落差の計算
- Ⅱ-2 洪水吐越流量
- Ⅱ-3 取水ダムの安定計算
- Ⅱ-4 水路タイプ別流量曲線
- Ⅱ-5 沈砂池
- Ⅱ-6 水圧管の強度計算

II-1 有効落差の計算

1. 計算記号

V : 流速 (m/sec)

Q : 流量 (m³/sec)

A : 流積 (m³)

f : 損失水頭係数

g : 重力の加速度 = 9.8m/s²

n : 粗度係数 (コンクリート n = 0.013、鋼管 n = 0.012、FRPM管 n = 0.011)

L : 水路長 (m)

θ : 管路の曲がりの角度 (度)

D : 管内径 (m)

ρ : 管路の曲がりの半径 (m)

h : 損失水頭 (m)

2. 損失水頭の計算

2.1 水槽における損失水頭: h_1

(1) スクリーンによる損失水頭

$$h_{1-(1)} = f_r \cdot \frac{v^2}{2g} = \beta \cdot \sin \theta \cdot \left(\frac{t}{b}\right)^{4/3} \cdot \frac{Q^2}{2 \cdot g \cdot A^2}$$

ここに β : スクリーンバーの形状による係数 = 2.34

θ : スクリーンバーの傾斜角 = 73.3° (1:0.3)

t : スクリーンバーの厚 = 1cm

b : スクリーンバーの純間隔 = 5cm

A : スクリーンの前面流積 = $3.4 \times 5.0 = 17.0 \text{ m}^2$

$$\begin{aligned} h_{1-(1)} &= 2.34 \times \sin 73.3^\circ \times \left(\frac{1}{5}\right)^{4/3} \times \frac{1}{2 \times 9.8 \times 17.0^2} Q^2 \\ &= 0.463 \times 10^{-4} Q^2 \end{aligned}$$

(2) 水槽における損失水頭の合計

$$\begin{aligned} h_1 &= h_{1-(1)} \\ &= 0.463 \times 10^{-4} Q^2 \end{aligned}$$

2.2 水圧管路における損失水頭: h_2

(1) 流入による損失水頭

$$h_{2-(1)} = f_e \cdot \frac{v^2}{2g} = f_e \cdot \frac{Q^2}{2gA^2}$$

ここに f_e : 流入損失係数 = 0.2

A : 流入後の流積

$$= \frac{\pi D^2}{4} = \frac{\pi \times (1.65)^2}{4} = 2.138 \text{ (m}^2\text{)}$$

$$h_{z-(1)} = 0.2 \times \frac{1}{2 \times 9.8 \times 2.138} Q^2$$

$$= 22.323 \times 10^{-4} Q^2$$

(2) 摩擦による損失水頭

$$h_{z-(2)} = f \cdot \frac{L}{D} \cdot \frac{V^2}{2g} = 124.5n^2 \cdot \frac{L}{D^{4/3}} \cdot \frac{Q^2}{2g \left(\frac{\pi D^2}{4} \right)^2}$$

ここに f : 管の直径を用いる場合の損失係数

D : 管内径 (m)

L : 管路延長 (m)

上式を変形すると

$$h_{z-(2)} = 124.5 \times n^2 \times \frac{4^2}{2 \times 9.8 \times \pi^2} \times \frac{L \cdot Q^2}{D^{16/3}}$$

$$= 102.975 \times 10^{-4} \times \frac{n^2 \cdot L \cdot Q^2}{D^{16/3}}$$

ただし、漸縮部の管内径は平均径をもちいるものとする。

また分岐後の流量は $Q' = \frac{Q}{2}$ として算出する。

D (m)	L (m)	$h_{2-(2)}$ (m)	摘 要
1.650	272.025	$193.832 \times 10^{-4} Q^2$	FRPM管につき $n = 0.010$
1.575	2.000	1.826 "	"
1.500	152.244	180.351 "	"
1.425	2.000	3.115 "	"
1.350	42.065	87.406 "	"
1.275	2.000	5.637 "	"
1.200	48.152	270.028 "	鋼管 $n = 0.012$
1.100	1.500	13.379 "	"
1.000	22.697	336.560 "	"
0.900	4.276	111.217 "	"
0.800	2.829	137.905 "	" 分岐後
0.710	0.533	49.103 "	" "
0.620	0	—	" "
計	552.321	$1,390.359 \times 10^{-4} Q^2$	

(3) 曲がりによる損失水頭

$$h_{2-(3)} = f_{b1} \cdot f_{b2} \cdot \frac{v^2}{2g} = f_{b1} \cdot f_{b2} \cdot \frac{Q^2}{2g \left(\frac{\pi D^2}{4} \right)^2}$$

$$= 0.08271 \times f_{b1} \times f_{b2} \times \frac{1}{D^4} Q^2$$

ここに f_{b1} : 曲り中心角 90° に対する損失係数

f_{b2} : 任意の曲り角度に対する補正値

ただし、分岐後の流量は $Q' = \frac{Q}{2}$ として算出する。

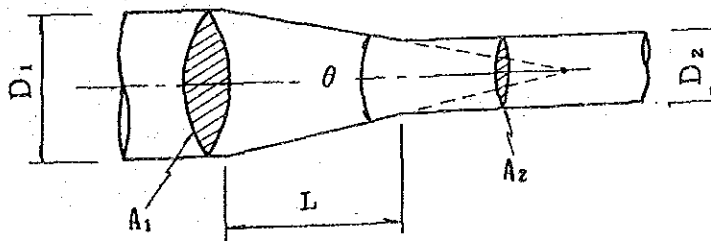
管径 D (m)	中心角 θ °	曲率半径 ρ (m)	ρ/D	f_{b1}	f_{b2}	$h_{z-(3)}$ (m) (3)
1.650	18.395505 °	10.000	6.061	0.08	0.34	$3.035 \times 10^{-4} Q^2$
1.650	36.66208	5.000	3.030	0.10	0.59	6.584 "
1.650	35.23165	5.000	3.030	0.10	0.56	6.249 "
1.650	14.38474	15.000	9.091	0.08	0.28	2.500 "
1.500	11.69458	15.000	10.000	0.08	0.22	2.875 "
1.500	2.68654	20.000	13.333	0.08	0.02	2.614 "
1.500	18.95097	10.000	6.667	0.08	0.35	4.575 "
1.350	5.65216	20.000	14.815	0.08	0.11	2.191 "
1.200	51.18133	5.000	4.167	0.09	0.75	26.924 "
1.000	64.35388	2.000	2.000	0.14	0.85	98.425 "
0.800	52.12502	3.000	3.750	0.09	0.75	136.302 "
計						$292.274 \times 10^{-4} Q^2$

(4) 漸縮による損失水頭

$$\begin{aligned}
 h_{z-(4)} &= f_{ec} \cdot \frac{v^2}{2g} = f_{ec} \cdot \frac{Q^2}{2g \left(\frac{\pi D_2^2}{4} \right)^2} \\
 &= 0.08271 \times f_{ec} \times \frac{Q^2}{D_2^4}
 \end{aligned}$$

ここに f_{ec} : 漸縮損失係数

v : 漸縮後の流速 (m/s)



D_1 (m)	D_2 (m)	L (m)	$\theta = 2 \tan^{-1} \left(\frac{D_1 - D_2}{2L} \right)$	$\frac{A_2}{A_1}$	f_{gc}	$h_{z-(4)}$ (m)
1.650	1.500	2.000	4.29517	0.826	0.0001	$0.016 \times 10^{-4} Q^2$
1.500	1.350	2.000	4.29517	0.810	0.0001	0.025 "
1.350	1.200	2.000	4.29517	0.790	0.0001	0.040 "
1.200	1.000	1.500	7.62815	0.694	0.0015	1.241 "
1.000	0.800	分岐管		—	—	—
0.800	0.620	0.533	19.16860	0.601	0.0075	41.981 "
計						$43.303 \times 10^{-4} Q^2$

(5) 分岐による損失水頭

$$h_{z-(5)} = f_B \cdot \frac{v^2}{2g} = f_B \cdot \frac{Q^2}{2g \left(\frac{\pi D_1^2}{4} \right)^2}$$

$$= 0.08271 \times f_B \times \frac{Q^2}{D_1^4}$$

ここに f_B : 分岐による損失係数 = 0.5
(分岐管の始部を円錐状にした対称 Y分岐)

D_1 : 分岐前の管径 = 1.000m

$$h_{z-(5)} = 0.08271 \times 0.5 \times \frac{1}{1.000^4} \times Q^2$$

$$= 413.550 \times 10^{-4} Q^2$$

(6) 入口弁における損失水頭

$$h_{z-(6)} = f_r \cdot \frac{v^2}{2g} = f_r \cdot \frac{\left(\frac{1}{2} Q \right)^2}{2gA^2}$$

ここに f_r : 弁による損失係数 = 0.3

$$A : \text{断面積} = \frac{1}{4} \pi D^2 = \frac{1}{4} \times \pi \times 0.62^2 = 0.302 \text{ m}^2$$

$$h_{z-(6)} = 0.3 \times \frac{1}{2 \times 9.8 \times 0.302^2 \times 4} \times Q^2$$

$$= 419.557 \times 10^{-4} Q^2$$

(7) 水圧管路損失水頭合計

流入による損失水頭	$h_{z-(1)} = 22.323 \times 10^{-4} Q^2$
摩擦	$h_{z-(2)} = 1,390.359 \quad "$
曲り	$h_{z-(3)} = 292.274 \quad "$
漸縮	$h_{z-(4)} = 43.303 \quad "$
分岐	$h_{z-(5)} = 413.505 \quad "$
入口弁	$h_{z-(6)} = 419.557 \quad "$
計	$h_z = 2,581.321 \times 10^{-4} Q^2$

2.3

ドラフト出口における損失水頭 h_3

$$h_3 = f \cdot \frac{v^2}{2g} = f \cdot \frac{Q^2}{2gA^2}$$

ここに f : 損失係数 = 1.0 (フランシス水車)

A : ドラフト断面積 = $2.00 \times 1.50 = 3.00 \text{ m}^2$

$$h_3 = 1.0 \times \frac{\left(\frac{1}{2} Q\right)^2}{2 \times 9.8 \times 3.00}$$

$$= 14.172 \times 10^{-4} Q^2$$

2.4

損失水頭総括

水槽における損失水頭	$h_1 = 0.463 \times 10^{-4} Q^2$
水圧管路	$h_2 = 2,581.321$ "
ドラフト出口	$h_3 = 14.172$ "
その他および余裕	$h_4 = 204.044$ "
合 計	$h = 2,800 \times 10^{-4} Q^2$

従って最大使用水量 $Q = 3.85 \text{ m}^3/\text{sec}$ の時の水圧管路部による損失水頭は $h = 4.1 \text{ m}$ である。

3. 有効落差の計算

3.1 諸元

(1) 取水位	260.00 m
(2) 水槽水位	252.30 m ($260.00 - 7,700 \times 1/1000 = 252.30 \text{ m}$)
(3) 放水位	63.00 m
(4) 総落差	197.00 m
(5) 有効落差	185.10 m
(6) 最大使用水量	3.85 m^3/sec

3.2 有効落差の計算

最大出力時の有効落差 H_e は次のとおり

$$H_e = (2) - (3) - h$$

$$= 252.30 - 63.0 - 2.800 \times 10^{-4} \times (3.85)^2$$

$$\approx 185.10\text{m}$$

常時出力時は

$$H_e = 252.30 - 62.67 - 2.800 \times 10^{-4} \times (0.57)^2$$

$$\approx 189.5\text{m}$$

3.3 出力の計算

最大出力時

$$P = 9.8Q \cdot H_e \cdot \eta_T \cdot \eta_G$$

ここに Q : 使用水量 (m^3/sec)

H_e : 有効落差 (m)

η_T : 水車効率 = 0.891

η_G : 発電効率 = 0.962

$$P = 9.8 \times 1.925 \times 185.1 \times 0.891 \times 0.962$$

$$= 3,000\text{kW}$$

$$P_{\text{max}} = P \times 2 = 3,000 \times 2 = 6,000\text{kW}$$

ここに P_{max} : 発電所最大出力

II-2 洪水吐越流量

1. 条件

洪水吐流下量の計算は次式によるものとする。

$$Q = Q_1 + Q_2$$

ここに

Q : 洪水吐流下量 (m³/sec)

Q₁ : 越流堰からの越流量 (m³/sec)

Q₂ : 排砂ゲートからの流下量 (m³/sec)

2. 基本式

Q₁と Q₂ は次の式によって計算する。

(1) 越流堰からの越流量

$$Q_1 = CBH^{3/2} \quad \dots\dots\dots (1)$$

$$C_a = 2.20 - 0.0416(H_a / W)^{0.990}$$

$$C = 1.6 \times \frac{1 + 2a(H/H_a)}{1 + a(H/H_a)}$$

ここに

Q₁ : 越流量 (m³/sec)

B : 越流堰幅 (m) = 40.0m

H : 越流頂を基準とした越流水頭 (m)

W : 堰高 (m) = 3.5m

H_a : 設計水頭 (m) = 3.0m

C : 越流量係数

C_a : H = H_a における越流量係数

a : 定数 = 0.546

a は H = H_a における C の値すなわち C_a を計算し C_a 式に代入して求める

(2) 排砂ゲートからの流下量

$$Q_2 = C_c \cdot a \cdot B \frac{2g(h_0 - C_c \cdot a)}{1 - (C_c \cdot a/h_0)}$$

ここに

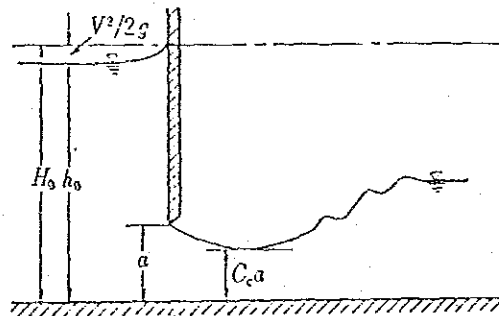
Q_2 : 流下量 (m³/sec)

C_c : 収縮係数

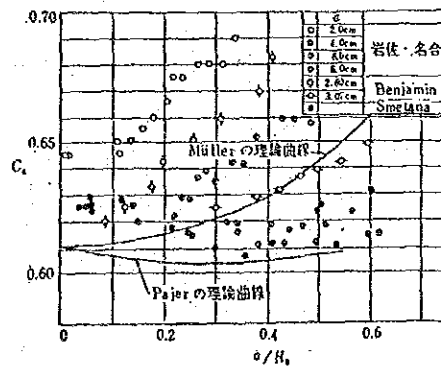
a : ゲートの開度 (m) = 2.5

h_0 : 上流水深 (m)

B : 排砂ゲート幅 (m) = 2.0



収 縮 係 数



越流量堰からの越流量

水位 (m)	水深 H (m)	越流量係数 C	越流量 Q (m ³ /sec)
260.0	0	0	0
260.5	0.5	1.733	24.515
261.0	1.0	1.846	73.854
261.5	1.5	1.943	142.790
262.0	2.0	2.027	229.326
262.5	2.5	2.100	332.093
263.0	3.0	2.165	450.001
263.5	3.5	2.223	582.135

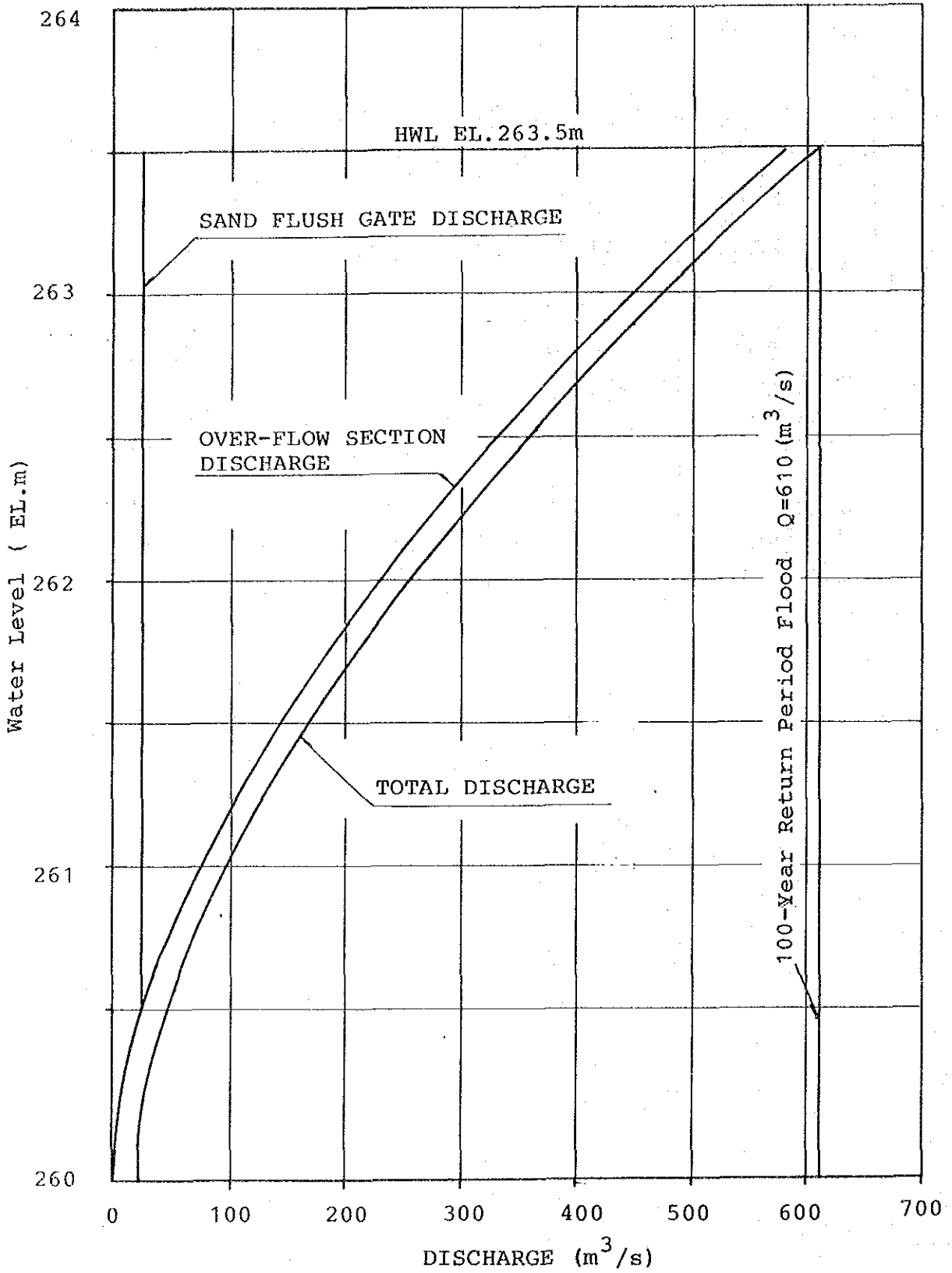
排砂ゲートからの流下量

水位 (m)	上流水深 H ₀ (m)	a/H ₀	収縮係数 C _c	流下量 Q (m ³ /sec)
260.0	2.6	0.962	0.719	20.831
260.5	3.1	0.806	0.673	21.762
261.0	3.6	0.694	0.648	22.840
261.5	4.1	0.610	0.635	24.028
262.0	4.6	0.543	0.628	25.249
262.5	5.1	0.490	0.624	26.465
263.0	5.6	0.446	0.621	27.633
263.5	6.1	0.410	0.619	28.774

洪水吐からの流下容量

水位 (m)	流下容量 (m ³ /sec)		合計流下量 (m ³ /sec)
	越流堰	排砂ゲート	
260.0	0	20.831	20.831
260.5	24.515	21.762	46.277
261.0	73.854	22.840	96.694
261.5	142.790	24.028	166.818
262.0	229.326	25.249	254.575
262.5	332.093	26.465	358.558
263.0	450.001	27.633	477.634
263.5	582.135	28.774	610.909

洪水吐流下容量曲線



II-3 取水ダムの安定計算

取水ダムの安定の検討を平常時と地震時について行う。

1. 検討条件

- (1) 堤体上流面には引張応力は起らないものとする。
- (2) 滑動に対する検討は次式で行なうものとし、安全率が 4 を下廻らないものとする。

$$F_s = \frac{I \cdot A + \mu \Sigma V}{\Sigma H} > 4$$

ここに F_s : 滑動に対する安全率

I : 基礎岩盤の剪断許容応力 = 150 t/m^2

A : 基礎面積 (m)

μ : コンクリートと岩盤との摩擦係数 = 0.75

ΣV : 合計鉛直力 (t)

ΣH : 合計水平力 (t)

- (3) 基礎岩盤の圧縮力は以下の数値を上廻らないものとする。

基礎岩盤 = 200 t/m^2

2. 設計応力

- (1) 死荷重

コンクリートの単位重量 $\gamma_c = 2.3 \text{ t/m}^3$

水の単位重量 $\gamma_w = 1.0 \text{ t/m}^3$

- (2) 地震荷重

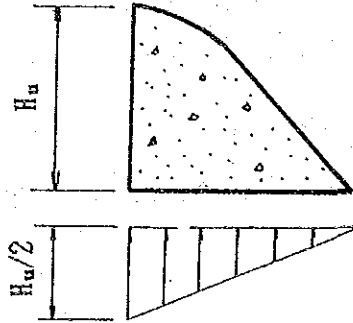
地震力の水平震度 $K = 0.12$

- (3) 水圧及び堆泥圧

ダムに働く水圧および堆泥圧は以下のとおりとする。

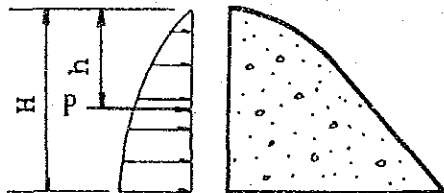
- a) 揚圧力

揚圧力は次の如く働くものとする。



b) 動水圧

動水圧は次の如く働くものとする。



$$P = 7/8 \gamma_w \cdot K \cdot H \cdot h \quad (\text{t/m}^2)$$

c) 泥圧

設計堆泥面はE1,258.4m とし、堆泥圧は次式による。

$$P_e = C_e \cdot \gamma_s \cdot d \quad (\text{t/m}^2)$$

ここに C_e : 堆泥圧係数 = 0.5

γ_s : 堆泥の単位重量 = 1.1t/m³

d : 堆泥深さ = 8.4m

3. 安定計算結果

(I) 平常時

作用力	V (t)	H (t)	x (m)	y (m)	M ₊ (t·m)	M ₋ (t·m)
自重	170.775	—	4.267	—	728.697	—
静水圧	—	50.000	—	3.333	166.650	—
揚水圧	-31.250	—	4.167	—	—	130.219
堆泥圧	—	19.404	—	2.800	54.331	—
計	139.525	69.404			949.678	130.219

モーメント M₊ : 時計廻り

$$\frac{\Sigma M_+}{\Sigma H} = 7.29$$

$$x = \frac{\Sigma M}{\Sigma V} = 5.873$$

$$e = 5.873 - \frac{12.5}{2} = -0.377 < \frac{B}{6} = 2.083$$

地耐力

$$P = \frac{\Sigma V}{B} \left(1 \pm \frac{6e}{B}\right) = \frac{139.525}{9.14} \left(1 \pm \frac{6 \times (-0.377)}{9.14}\right) = 13.18 \text{ t/m}^2 < 200 \text{ t/m}^2 \dots\dots\dots \text{OK}$$

$$\text{安全率} = \frac{I \cdot A + \mu \Sigma V}{\Sigma H}$$

$$= \frac{150 \times 12.5 + 0.75 \times 139.525}{69.404} = 28.52 > 4 \dots\dots\dots \text{OK}$$

(2) 地震時

作用力	V (t)	H (t)	x (m)	y (m)	M ₊ (t-m)	M ₋ (t-m)
自重	170.775	—	4.267	—	728.697	—
地震力	—	-20.493	—	3.904	—	80.005
静水圧	—	50.000	—	3.333	166.650	—
揚水圧	31.250	—	4.167	—	—	130.219
動水圧	—	-5.670	—	3.600	—	20.412
堆泥圧	—	19.404	—	2.800	54.331	—
計	139.525	43.241			949.678	230.636

$$\frac{\Sigma M_+}{\Sigma M_-} = 4.12$$

$$x = \frac{\Sigma M}{\Sigma V} = 5.154$$

$$e = 5.154 - \frac{12.5}{2} = -1.096 < \frac{B}{6} = 2.083$$

地耐力

$$P = \frac{\Sigma V}{B} \left(1 \pm \frac{6e}{B} \right) = \frac{17.03}{5.29} \text{ t/m}^2 < 200 \text{ t/m}^2 \dots\dots\dots \text{OK}$$

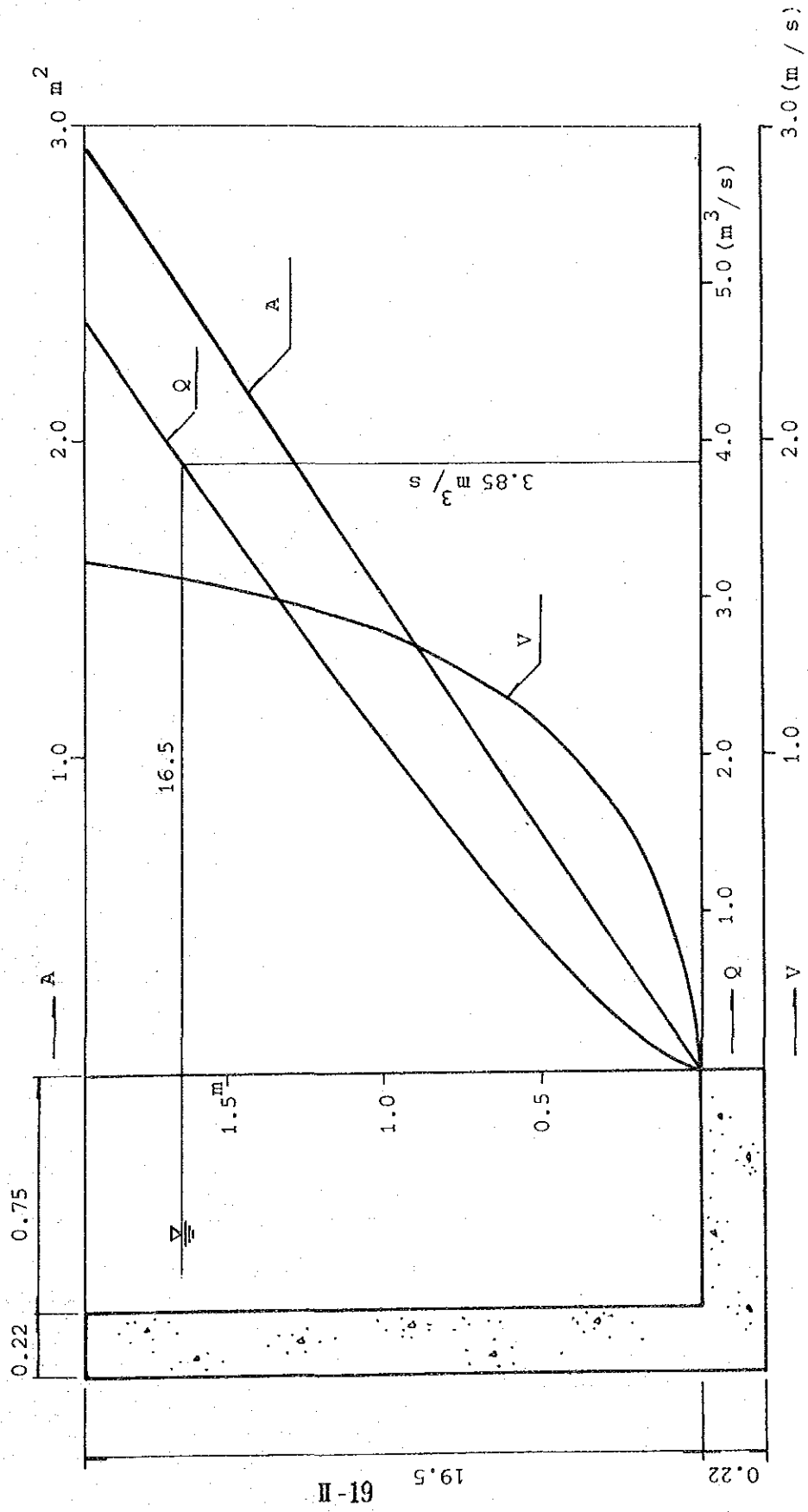
$$\text{安全率} = \frac{I \cdot A + \mu \Sigma V}{\Sigma H}$$

$$= \frac{150 \times 12.5 + 0.75 \times 139.525}{43.241} = 45.78 > 4 \dots\dots\dots \text{OK}$$

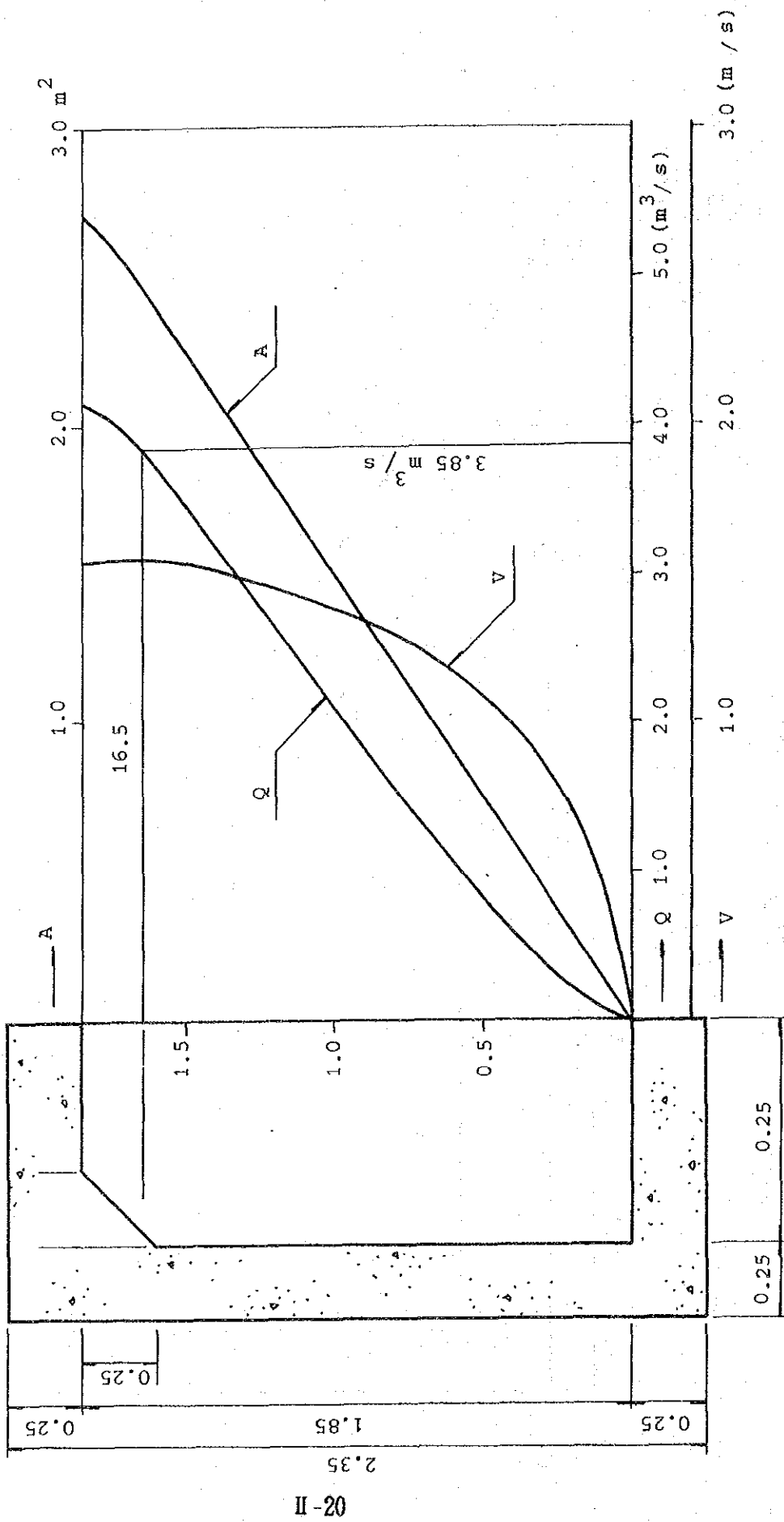
以上の結果、平常時、地震時共に取水ダムの安定性は十分安全である。

II-4 水路タイプ別流量曲線

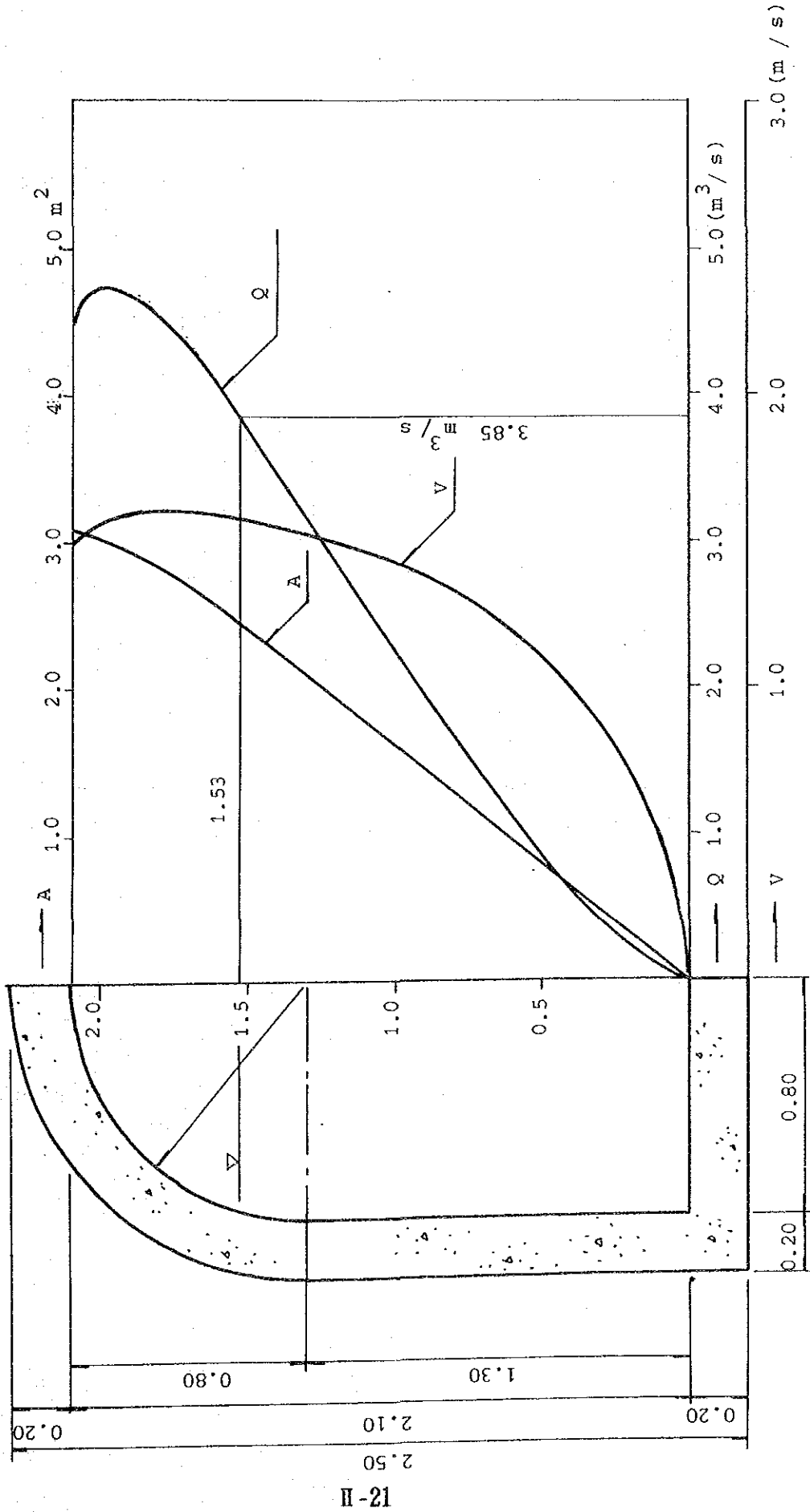
OPEN CANAL TYPE I



OEPN CANAL TYPE II



TUNNEL TYPE



II-5 沈砂池

沈砂池は設計流量 $3.85 \text{ m}^3/\text{sec}$ に対して池内平均流速を $0.3 \text{ m}/\text{sec}$ とし、沈澱最少粒子径を 0.3 mm として断面を決定する。

沈砂池長の決定にあたり、池の有効水深 h 、は下流水路水深 1.65 m と同値とする。 0.3 mm の砂の沈降速度は $155 \text{ m}/\text{hr} = 0.043 \text{ m}/\text{sec}$ (石英)

以上から池の有効長さは

$$L > \frac{v}{v_g} \cdot h = \frac{0.3}{0.043} \times 1.65 = 11.5 \text{ m}$$

$$B > \frac{Q}{v_g \cdot L} = \frac{3.85}{0.043 \times 11.5} = 7.8 \text{ m}$$

ここに

Q : 沈砂池流入量 (m^3/S)

v : 沈砂池内平均流速 (m/S)

v_g : 砂粒子の沈降速度 (m/S)

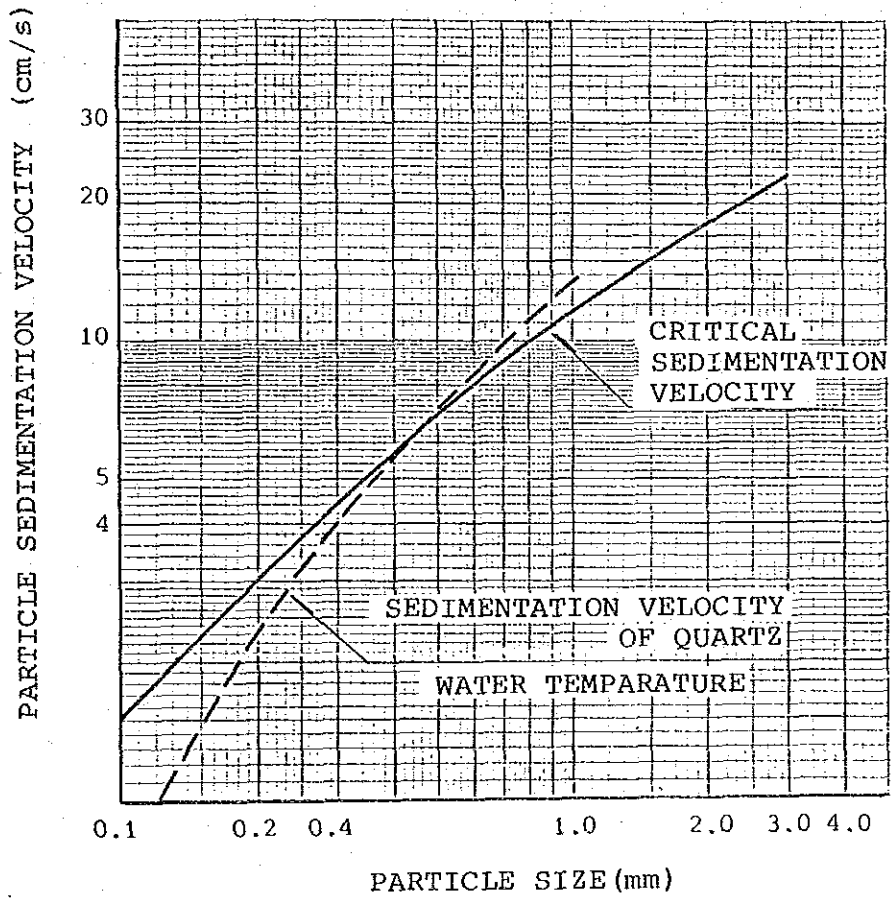
L : 沈砂池の最少所要長 (m)

B : 沈砂池の有効巾 (m)

h : 沈砂池の有効水深 (m)

以上の計算では最少所要長は $L = 11.5 \text{ m}$ であるが、実際には池に副流などの影響を考慮して沈砂池長さを計算値の約 2倍の $L = 22.5 \text{ m}$ とする。また、導水路への漸変部を急変させると接近流速が速くなるため沈澱槽の微粒砂を下流に引きこむ。これを防ぐため沈澱槽と導水路の間に流速の緩和区間約 12 m を設ける。

砂粒子の平均径と沈降速度



II-6 水圧管の強度計算

1. 水撃圧の計算

水撃圧はアリエビの式を用いて計算する。

(1) 基本数値

水槽水位	E1.	252.3m
水車中心標高	E1.	63.8m
最大使用水量	$Q_{max.}$	$= 3.7 \text{ m}^3/\text{sec.}$
水圧管路の長さ	L	$= 552.32\text{m}$
弁の閉塞時間	T	$= 6\text{sec.}$

(2) 計算式

$$\frac{h_o}{H_o} = \frac{n}{2} + \frac{1}{2} n^2 + 4n$$

$$n = \left(\frac{v_o \cdot L}{g \cdot T \cdot H_o} \right)^2$$

ここに h_o : 水撃作用による水車中心の上昇水圧 (m)

H_o : 水車中心の静水圧 = 188.5 (m)

L : 管路の長さ = 552.32 (m)

g : 重力の加速度 = 9.8 (m/sec²)

T : 弁の閉塞時間 = 6 (sec)

(3) 管路の平均流速 v_o

$$v_o = \frac{Q}{A_o}$$

$$A_o = \frac{L}{\sum (\ell_i / A_i)}$$

ここに v_o : 管路の平均流速 (m/sec)

ℓ_i, A_i : i 番目の管路区間に対する区間長 (m) および断面積

D (m)	A _i (m ²)	ℓ _i (m)	ℓ _i / A _i
1.650	2.138	272.025	127.233
1.650 ~ 1.500	1.948	2.000	1.027
1.500	1.767	152.244	86.160
1.500 ~ 1.350	1.595	2.000	1.254
1.350	1.431	42.065	29.396
1.350 ~ 1.200	1.277	2.000	1.566
1.200	1.131	48.152	42.575
1.200 ~ 1.000	0.950	1.500	1.579
1.000	0.785	22.697	28.913
1.000 ~ 800	0.636	4.276	6.723
0.800	0.503	2.829	5.624
0.800 ~ 0.620	0.396	0.533	1.346
計		552.321	333.396

故に $A_0 = \frac{552.321}{333.396} = 1.657 \text{ (m}^2\text{)}$

$v_0 = \frac{3.850}{1.657} = 2.323 \text{ (m/sec)}$

(4) 水撃圧の計算

$n = \left(\frac{2.323 \times 552.321}{9.8 \times 6 \times 188.5} \right)^2 = 0.0134$

$\frac{h_0}{H_0} = \frac{0.0134}{2} + \frac{1}{2} \cdot 0.0134^2 + 4 \times 0.0134 = 0.1227$

以上に対し15%の余裕を見込むと水位上昇率は 14.1 %となる。従って水車中心での水撃圧 h_0 は $h_0 = 188.5 \times 0.141 \approx 26.6 \text{ (m)}$

2. 水圧管の強度計算

(1) 主要点における設計水圧

水撃作用による最大上昇水圧は水車中心において26.6m となった。水圧管路呑口(水槽)における上昇水圧を0m とし、中間は直線変化するものとして計算した主要点における設計水圧を下表に示す。

測 点	累 加 距 離 (m)	管路中心標高 (m)	静 水 圧 (m)	水撃圧 (m)	設 計 水 圧 (m)
管路始点	0	248.600	3.700	0	3.700
BC ₁	124.826	238.138	14.162	5.990	20.152
BC ₂	181.973	229.261	23.039	8.732	31.771
BC ₃	239.981	221.219	31.081	11.516	42.597
BC ₄	261.507	207.295	45.005	12.549	57.554
BC ₅	320.025	178.739	73.561	15.357	88.918
BC ₆	365.770	149.304	102.996	17.552	120.548
BC ₇	415.176	120.689	131.611	19.923	151.534
BC ₈	462.315	103.318	148.982	22.185	171.167
BC ₉	509.177	92.324	159.976	24.434	184.410
BC ₁₀	542.337	62.840	189.460	26.025	215.485
分岐点	544.825	62.840	189.460	26.144	215.604
BC ₁₂	549.059	62.840	189.460	26.347	215.807
管路終点	552.321	62.840	189.460	26.504	215.964
水車中心	554.321	63.800	188.500	26.600	215.100

(2) 許容水頭の計算

許容水頭の計算は次式による。なお、FRPM管使用箇所も仮に鋼管を使用するものとして計算する。

$$P = 2(t - \varepsilon) \cdot \delta_a \cdot \frac{\eta}{D}$$

ここに P : 許容水頭 (kg/cm²)

t : 使用板厚 (cm)

ε : 余裕厚 = 0.20 (cm)

δ_a : 鋼材の許容引張応力 SM41 …………… δ_a = 1,300 kg/cm²

D : 鉄管内径 (cm)

η : 縦継手効率 = 0.95

最小板厚については次の値以上とする。

$$t' = \frac{D' + 800}{400} \geq 6\text{mm}$$

ここに t' : 余裕厚を含んだ使用板厚 (mm)

D' : 管の内径 (mm)

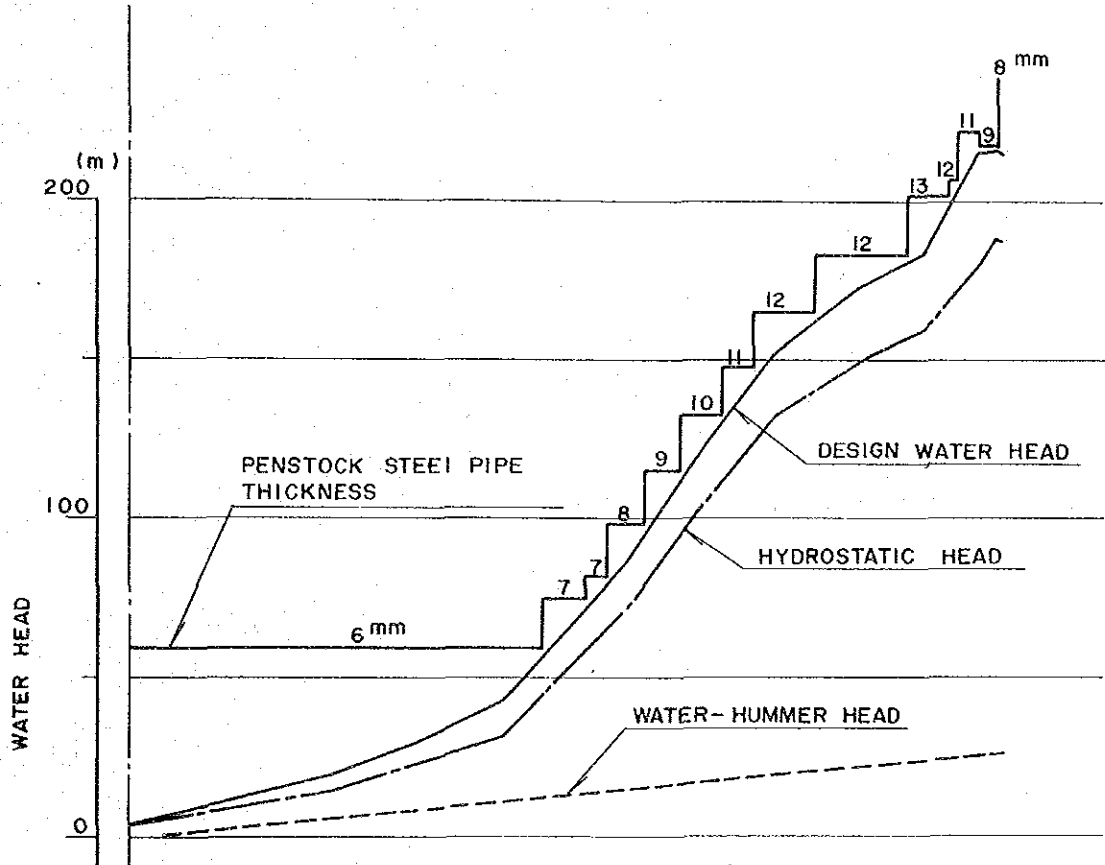
最小板厚

管径 D' (mm)	最小板厚 t' (mm)
1,650	7
1,500	6
1,350	6
1,200	6
1,000	6
800	6
620	6

下表に許容水頭の計算結果を示す。

管 径 D (m)	鋼管許容応力 δ_a (kg/cm ²)	使用板厚 t (mm)	計算鉄厚 $t - \epsilon$ (mm)	許容水頭 (m)
1.650	1.300	6	4	59.879
"	"	7	5	74.848
1.500	"	7	5	82.333
"	"	8	6	98.800
"	"	9	7	115.267
"	"	10	8	131.733
"	"	11	9	148.200
"	"	12	10	164.667
1.350	"	12	10	182.963
"	"	13	11	201.259
1.200	"	12	10	205.833
1.000	"	11	9	222.300
0.800	"	9	7	216.125
0.620	"	8	6	239.032

設計水頭と管厚



STATION	ACCUMULATED DISTANCE (m)	DESIGNED WATER HEAD (m)
START	0	3.700
BC. 1	124.826	20.152
BC. 2	181.973	31.771
BC. 3	239.981	42.597
BC. 4	261.507	57.554
BC. 5	320.025	88.918
BC. 6	365.770	120.548
BC. 7	415.176	151.534
BC. 8	462.315	171.167
BC. 9	509.177	184.410
BC. 10	542.337	215.485
BC. 11	544.825	215.604
BC. 12	549.059	215.807
BC. 13	552.321	215.964
END	554.321	215.100

添付資料Ⅲ ボーリング柱状図

DRILLING CORE LOG

Name of Project: Celasian P/s No. of Hole: BH-1

Location: Celasian P/s Depth of Hole: 15.0 m

Elevation: 150 m Bore Hole Dia.: 76.0 mm

Direction: Vertical Type of Drill: Rotary Drill

Inclination: Vertical Core Recovery: 92 % Drill Machine: Longyear 24

Underground Water Table: 5.75 m Capacity of Pump: 1 /min

Operator: NUKAZUKA Supervisor: Asst. Antonio S. Santos

Depth (m)	Geological Symbol	Geology	Rock Quality Classifications	Color	Weathering	Hardness	Rock Quality Designation	Permeability Test		Drilling Status		Remarks	Date Drilled
								p (kg/cm ²)	q (l/m ² -min)	Infiltrate Water Vol.	Loss Water Vol. (l/min)		
1	(1.0)	Talus Deposit	D	Light Brown			20 40 60 80%						
2													
3	(5.3)	Shale	CL	Light Gray	Mod. slight rate	Soft						Angular gravel with sand.	
4													
5													
6													
7													
8													
9													
10	(8.7)	Sandstone	CM		Mod. rate	Hard							
11			CL										
12			B										
13			CL										
14			CH										
15			CL	Light Gray									
16													
17													
18													
19													
20													
21													
22													
23													
24													
25													
26													
27													
28													
29													
30													

DRILLING CORE LOG

Name of Project: Culusion Penstock Line No. of Hole: BH-2 Depth of Hole: 20.0 m

Location: Culusion Penstock Line Bore Hole Dia.: 76.0 mm

Elevation: _____ m Core Recovery (ave): 98 % Type of Drill: Rotary Drill

Direction: Vertical Underground Drill Machine: Longyear 24

Inclination: Vertical Water Table: 12.60 m Capacity of Pump: 1 l/min Operator: _____ Supervisor: _____

Depth (m)	(Thickness) (m)	Geological Symbol	Geology	Rock Quality Classifications	Color	Weathering	Hardness	Core Characteristics		Permeability Test		Drilling Status		Remarks	Date Drilled
								Rock Quality Designation	Rock Quality (%)	p - q curve	Lugeon Value	Infiltrate Water Vol.	Loss Water Vol. (l/min)		
1	(2.0)	○	Talus Deposit	D	Reddish Brown										
2		○													
3		○													
3	(3.4)	▨	Shale	CL	Yellowish Brown	Mod. rate	Soft							gravelly SAND	
4		▨													
5		▨													
6		▨													
7		▨													
8		▨													
9		▨		CM											
10		▨													
11		▨													
11	(14.6)	▨	Shale	CL	Light Gray	Fresh									
12		▨		CM											
13		▨		CL			Mod. rate								
14		▨					Hard								
15		▨													
16		▨		CM											
17		▨													
18		▨													
19		▨													
20		▨													
21		▨													
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28		▨													
29		▨													
30		▨													

Remarks: Fine-grained, moderately indurated, with thin interbeds of shale. Cores samples obtained in angular fragments of different sizes and short columnar shape.

Remarks: Dry Drilling

Remarks: Light Gray

Remarks: MQ in some portions; Core usually breaks along bedding contacts. Rock core is generally hard except for the shale interbeds.

NOTE: RE-DRILL TO 20.0m

DRILLING CORE LOG

Name of Project: Culiclan Penstock Line No. of Hole: BH-3

Location: Culiclan Penstock Line Bore Hole Dia.: 76.0 mm Depth of Hole: 20.0 m

Elevation: _____ Type of Drill: Rotary Drill Operator: _____

Direction: Vertical Core Recovery (Cve.): 99 % Drill Machine: Longyear 24 Supervisor: _____

Inclination: Vertical Underground Water Table: 10.10 m Capacity of Pump: 1 /min

Depth (m)	(Thickness) Elevation (m)	Geological Symbol	Geology	Rock Quality Classifications	Color	Weathering	Hardness	Rock Quality Designation	Permeability Test		Drilling Status		Remarks	Date Drilled
									p (kg/cm ²)	q (l/m ² ·min)	Infiltrate Water Vol. (l/min)	Loss Water Vol. (l/min)		
1	(0.9)		Talus Deposit	D	Light Brown			20 40 60 80%			Dry Drilling	NW Coe	sandy CLAY; low-medium plasticity.	
2	(4.1)		Shale	CL	Brownish Gray	Weak	Soft				Light Brown-Yellowish	Bit with Tungsten Carbide	Fragmental and soft.	
3				CL										
4				CL										
5				CL										
6				CL										
7				CL										
8				CL										
9				CL										
10				CL	Light Gray									
11	(15.0)			CL	Dark Gray		Slightly Soft							
12			Shale	CL										
13				CL										
14				CL										
15				CL										
16				CL										
17				CL										
18				CL										
19				CL										
20				CL										
21														
22														
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30														

Rock is generally fresh, although in some portions (5.0-11.1 m), fracture planes are, coated with iron stains; alternating laminae of light and dark gray shale very prominent; core easily breaks along laminations by light hammering; bedding planes, about 40-50° from core axis; pyrite and chalcopyrite specks noted at 19.30-19.50 m.

DRILLING CORE LOG

Name of Project: Location Candawaga P/S No. of Hole: BH-4 Depth of Hole: 20.0 m

Depth of Bedrock: 76.0 mm Bore Hole Dia.: 76.0 mm

Core Recovery (ave.): 90 % Type of Drill: Rotary Drill

Elevation: _____ m Drill Machine: Longyear 24 Operator: _____

Direction: Vertical Capacity of Pump: _____ l/min Supervisor: _____

Inclination: _____ m

Depth (m)	(Thickness) (m)	Geological Symbol	Geology	Rock Quality Classifications	Color	Weathering	Hardness	Rock Quality Designation	Permeability Test		Drilling Status		Remarks	Date Drilled
									P (kg/cm ²)	q (l/m ² ·min)	Infiltrate Water Vol. (l/min)	Loss Water Vol. (l/min)		
1-10	(10.0)		Talus Deposit	D	Light Brown			20 40 60 80%						
10-11	(1.2)		Shale		Gray to Light Gray	Moist (red)	Slightly Hard							
11-15	(3.8)		Shale	CL	Gray to Light Gray	Fresh	Slightly Hard							
15-16				CM										
16-17				CL										
17-18				CM										
18-20				CL										
20-30														

Light gray, slightly weathered sandstone boulder at 0.6-5.3 m; others, consist of angular, gravel-size fragments of sandstone and shale; with appreciable amount of clay.

Fragments difficult to break with fingers.

Moderately indurated; thin interbeds of fine sandstone noted at various depths; Bedding planes about 50° from core axis; Generally, individual beds are difficult to break with fingers, but very easy to split along bedding contacts; highly broken cores at different sections.

DRILLING CORE LOG

Name of Project: Location Candavanga Barback Line No. of Hole: BH-5 Depth of Hole: 25.0 m

Bore Hole Dia. 76.0 mm Operator: DOROTEO BAYON

Type of Drill: Rotary Drill Operator: PRIMITIVO APOSTOL

Drill Machine: Longyear 2A Supervisor: _____

Core Recovery (ave): 97 % Capacity of Pump: 25 GPM

Underground Water Table: 3.0 m

Direction: vertical

Depth (m)	(Thickness) (Elevation)	Geological Symbol	Geology	Rock Quality Classifications	Core Characteristics			Permeability Test		Drilling Status		Remarks	Date Drilled	
					Color	Weathering	Hardness	Rock Quality Designation	p - q curve	Lugeon Value	Infiltrate Water Vol.			Loss Water Vol. (l/min)
1-2	(3.0)		Talus deposit	D	Light Brown to gray Brown			20						
3-6	(6.0)		Shale	CL, S, CM	Gray Fresh	Slightly Hard								SILT - clayey; low plasticity; with sandstone boulder at 0 - 0.25 m.
7-12	(7.4)		Sandstone	CH	Light Gray Fresh	Mod. Fresh Hard								Thin interbeds of fine sandstone noted in some sections; bedding about 50° from core axis; broken cores at different depths; easy to break along bedding contacts.
13-19	(7.4)		Shale	CL, S, CM	Dark Gray Fresh	Slightly Hard								Fine grained; massive; with occasional calcite veinlets.
20-24	(1.2)		Sandstone	CH	Light Gray	Mod. Fresh Hard								Laminated; easy to split along bedding planes.
25-30														Fine grained.

JICA