REPUBLIC OF INDONESIA
MINISTRY OF PUBLIC WORKS AND ELECTRIC POWER
DIRECTORATE GENERAL OF WATER RESOURCES DEVELOPMENT

FEASIBILITY REPORT ON THE WONOGIRI MULTIPURPOSE DAM PROJCET

—ANNEX I STUDY REPORT (1)—

OCTOBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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ANNEX I

I. WONOGIRI DAM

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1. GENERAL

1.1. Plan of Development

The principal purpose of the Wonogiri multipurpose dam is the supply of irrigation water, generation of electric power and mitigation of flood damages in the downstream areas.

Water released from the reservoir will first pass through the powerplant (10,200 kW in installed capacity) and generate electric power. Water will then be taken at Colo intake weir, located at 13 km downstream from the Wonogiri dam, and diverted to an irrigation area of 23,600 ha. During the dry months from June to November, the Colo weir will release 2 m^3/s of water to maintain the minimum discharge in the downstream river channel.

Flood control effect is achieved by the flood storage functions of the reservoir provided with a storage capacity of 220 x 10^6 m^3 specifically for this purpose.

1.2. Wonogiri Dam and Reservoir

<u>Reservoir</u>

The reservoir formed by Wonogiri dam will have a gross storage capacity of 730 million m^3 at the water level during the inflow of the project design flood (S.H.F.D.). It inundates over 87 km^2 of land and about 23,000 houses. Relocation of submerged roads of about 55 km long will be required owing to the creation of the reservoir.

Normal high water level (N.H.W.L.)	EL. 136.0 m
Low water level	EL. 127.0 m
S.H.F.D. Surcharge water level (H.W.L.)	EL. 138.2 m
Design flood level	EL. 138.4 m
Extraordinary flood level	EL. 138.9 m
Controlled water level during flood season	EL. 135.3 m
Gross storage capacity at H.W.L.	730 x 10^6 m^3
" " " at N.H.W.L.	560 x 10^6 m^3

Fig. I -1 Location Map

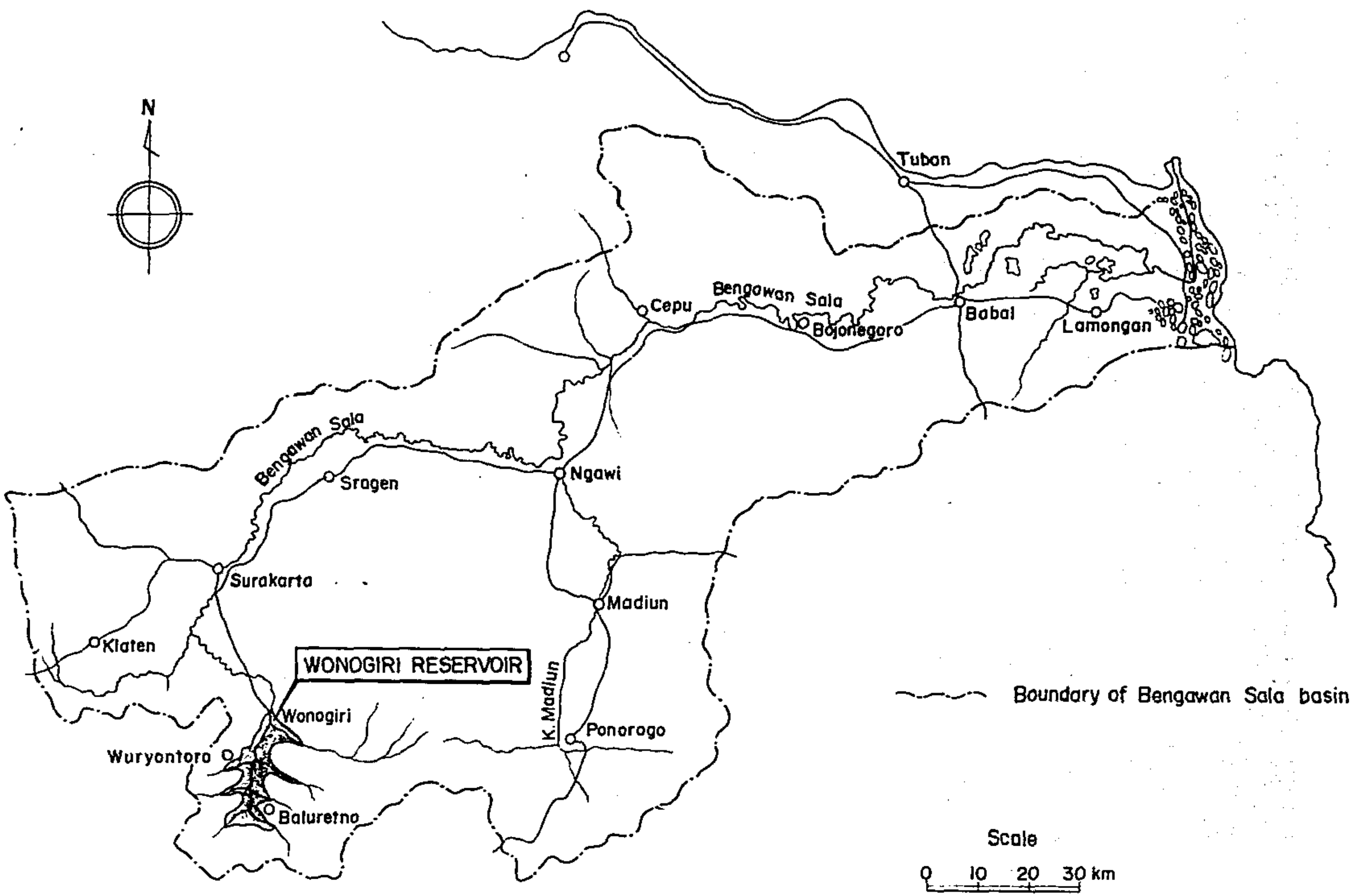
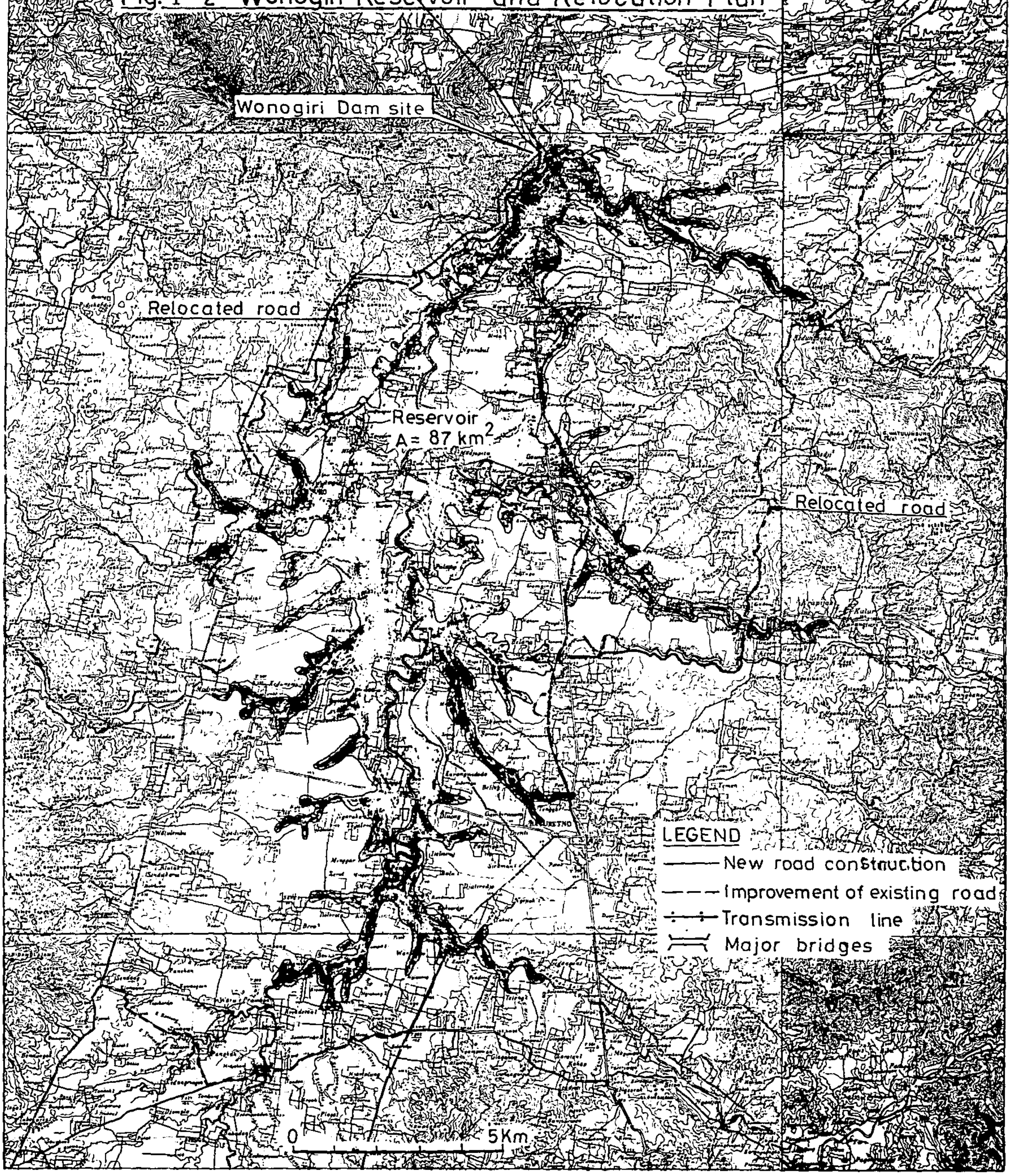


Fig. I -2 Wonogiri Reservoir and Relocation Plan



Effective storage	
irrigation and power	440×10^6 m^3
flood control	220×10^6 m^3
Dead storage for sediment	120×10^6 m^3
Water surface area at H.W.L.	87 km^2
" " " at N.H.W.L.	73 km^2

Fig. I-3 shows the area-storage capacity curve of reservoir.

Wonogiri dam

Wonogiri dam is located on the main stem of Bengawan Sala just downstream of the confluence with Kali Keduwan. Principal features of the dam and appurtenant facilities are;

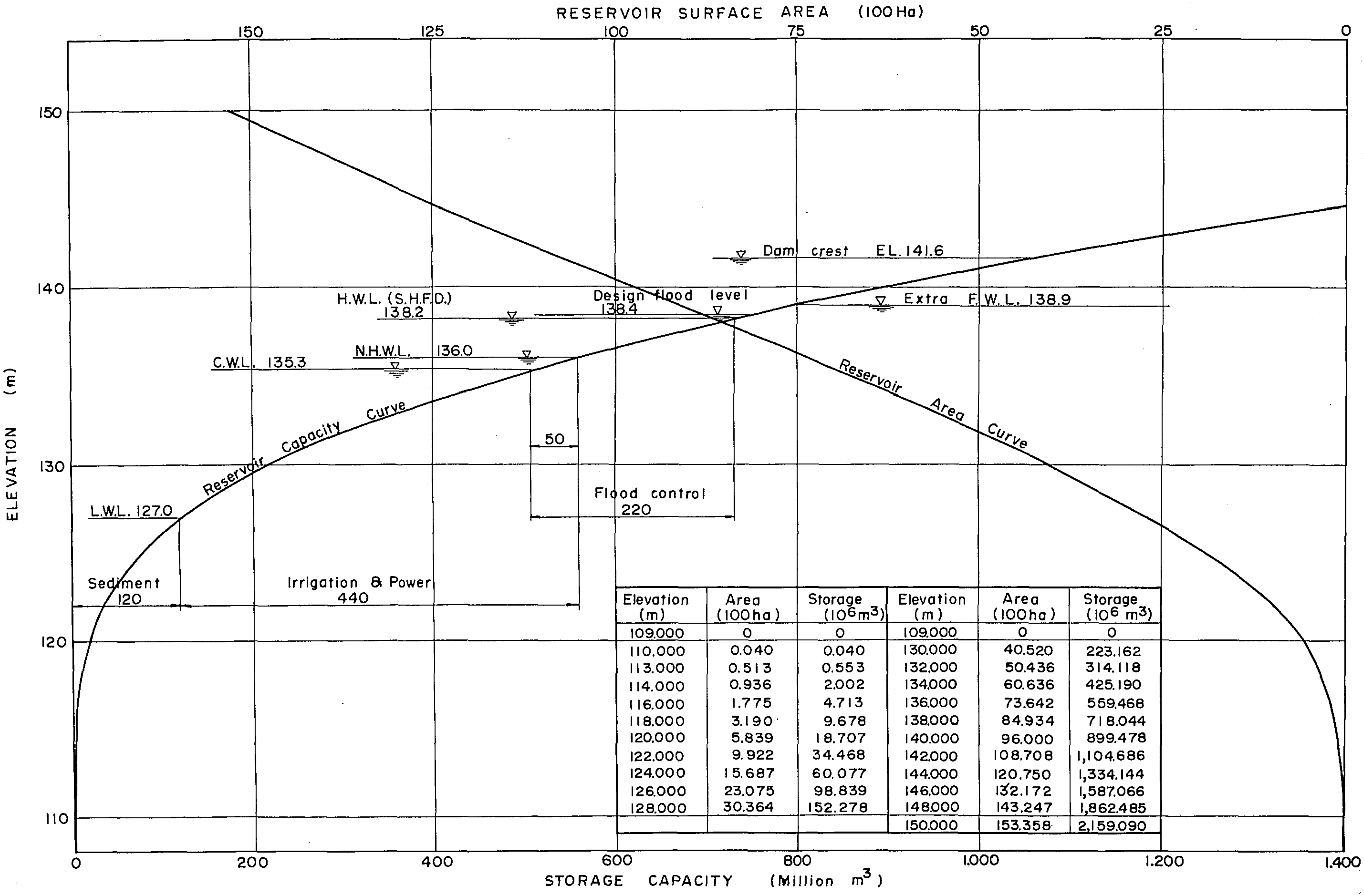
- Dam
  - Type: Rockfill with central core
  - Crest length: 1,440 m
  - Crest elevation: EL. 141.6 m
  - Height above foundation: 37.5 m
  - Embankment volume: 1,800,000 m^3 (including blanket fill)

- Spillway
  - Location: Left bank
  - Type : Overflow weir with control gates and concrete lined chuteway
  - Capacity: 1,550 m^3/s at Extra F.W.L.
  - Gate : Roller gate, 8 m wide x 7.7 m high 4 nos.

- Diversion conduit
  - Location: Right bank
  - Size : Semi-circular section of 7 m wide x 7 m high, lined with concrete.

- Intake
  - Type : Vertical tower
  - Height above foundation: 22.6 m.

Fig. I - 3 Area - Capacity Curve of Wonogiri Reservoir



Elevation (m)	Area (100ha)	Storage ($10^6 m^3$)	Elevation (m)	Area (100ha)	Storage ($10^6 m^3$)
109.000	0	0	109.000	0	0
110.000	0.040	0.040	130.000	40.520	223.162
113.000	0.513	0.553	132.000	50.436	314.118
114.000	0.936	2.002	134.000	60.636	425.190
116.000	1.775	4.713	136.000	73.642	559.468
118.000	3.190	9.678	138.000	84.934	718.044
120.000	5.839	18.707	140.000	96.000	899.478
122.000	9.922	34.468	142.000	108.708	1,104.686
124.000	15.687	60.077	144.000	120.750	1,334.144
126.000	23.075	98.839	146.000	132.172	1,587.066
128.000	30.364	152.278	148.000	143.247	1,862.485
			150.000	153.358	2,159.090

- Pressure tunnel and penstock

  Type : Combined construction of concrete lined and steel penstock tunnel

  Diameter: 6 m - 4.2 m

  Length : 250 m maximum

<u>Powerplant and outlet</u>

Powerplant is located just downstream of the dam. It will be capable of meeting a 6-hour daily peak power demand.

- Powerplant

  Installed capacity: 10,200 KW
  (Q_{max} = 60 m^3/s)

  Average annual energy output: 28,200 MWH

  Powerplant building: 20 m wide by 32 m long,
  Reinforced concrete structure

- Outlet for irrigation water

  Regulating valve: Hollow - jet valve, 1 no.

  Diameter : 1.80 m

  Discharge capacity: 35m^3/s (at L.W.L. of reservoir)

  Valve house : 15.5 m wide by 9 m long,
  Reinforced concrete structure

2. HYDROLOGICAL DATA

2.1. Run-off Records

Monthly mean run-off data utilized in the reservoir development study cover 20 years period from 1953/54 to 1972/73. Although the data for 1973/74 year was available, it was excluded from the study since corresponding rainfall records in the irrigation area (which is required to estimate irrigation water requirement in the year) had not been available by the time.

Of the total records, those for the period from 1953/54 to 1968/69 were estimated based on the run-off record at Karangnongko with using a technique of run-off correlation.[/1]

Measurement of daily river stage at Juranggempal has been conducted since 1965. Review on the measurement records found that the 1965-1968 records often lacked in data, supposedly no measurements, involved unreasonable change of the datum of gauge staff and no adjustment for the influence of the aggradation of river bed caused by the 1966 flood. Therefore, they were eliminated and only the 1969/70 - 1972/73 data were adopted in the study.

Table I-1 shows monthly mean run-off data for the 20 year period. The results of frequency study made on the run-off records are shown in Fig. I-4.

2.2. Flood Data

Flood data adopted in the design of dam are those estimated in Annex III, Hydrology. They are shown in the table below.

/1 Ref. Annex III, Hydrology

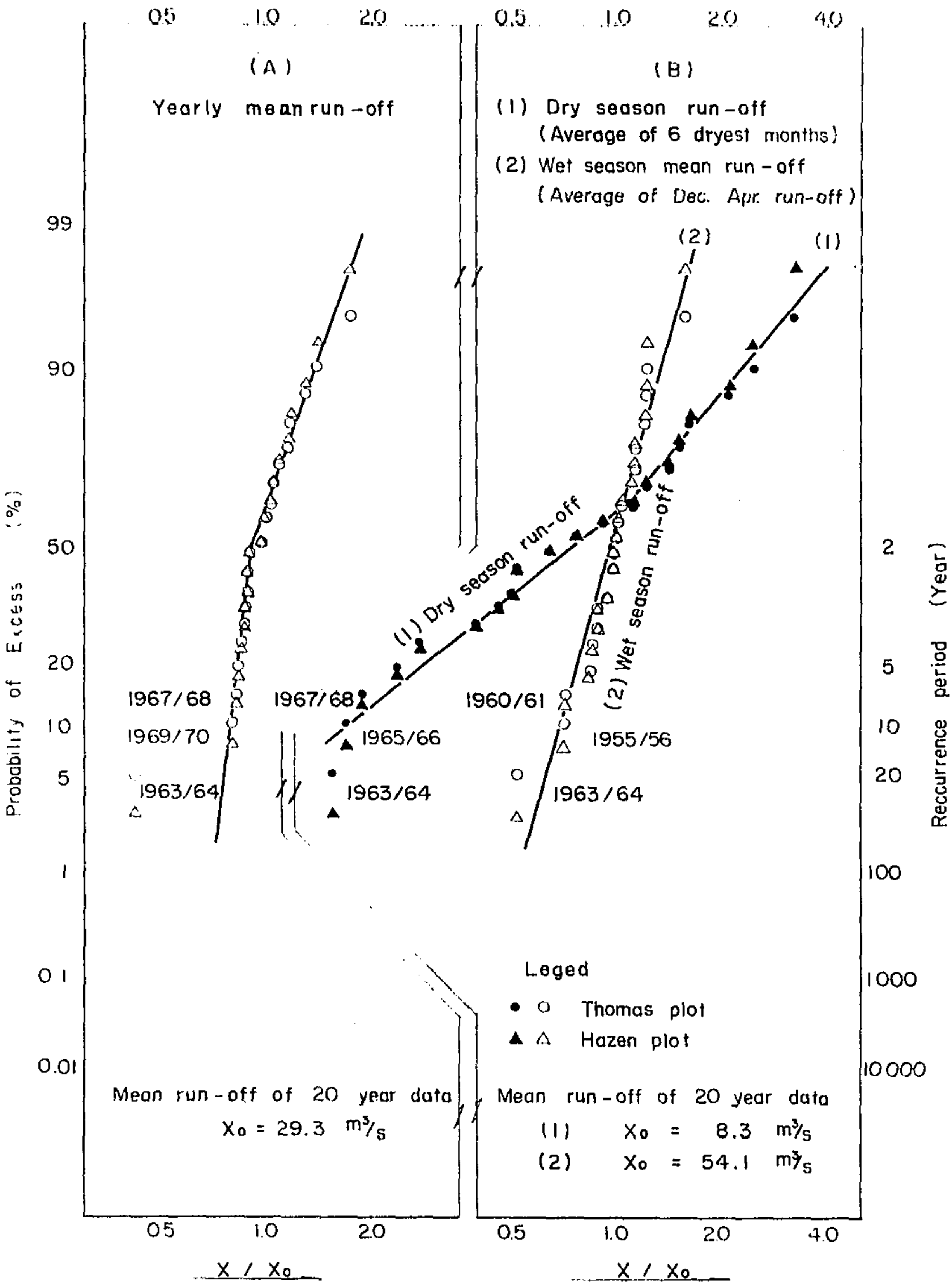
Table I-1 Monthly Mean Run - off Record (Unit: m^3/sec)

Year	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Yearly mean	6 dry months mean	Des. - Apr. mean	Yearly mean run-off after U/S dams completed /2
1953/54	72.8	2.1	2.5	0.6	0.6	0.5	7.2	28.9	62.8	77.4	45.7	44.4	28.8	2.3	51.8	24.7
1954/55	45.8	12.8	7.0	4.3	1.2	3.2	53.8	41.3	56.7	41.0	43.5	56.9	30.6	12.4	47.9	26.4
1955/56	21.8	15.6	23.9	8.4	3.8	5.6	37.8	26.6	62.5	60.1	31.0	11.9	25.8	13.2	38.4	21.7
1956/57	13.6	29.2	17.8	7.4	3.1	4.8	7.7	35.5	29.6	38.2	91.8	35.6	26.2	11.7	46.1	23.0
1957/58	8.9	1.3	13.3	5.3	0.8	0.7	3.5	49.9	17.0	78.9	62.3	61.1	25.3	4.2	53.8	22.0
1958/59	32.2	2.7	14.0	3.9	1.8	11.8	11.9	57.9	81.2	86.3	69.7	35.7	34.1	7.5	66.2	29.1
1959/60	27.1	15.2	5.9	1.0	1.4	0.8	8.0	53.0	46.1	90.6	60.0	55.1	30.4	5.4	61.1	26.3
1960/61	54.0	4.2	3.3	0.9	0.8	0.8	28.3	20.6	37.5	52.1	53.4	31.1	23.9	6.4	38.9	19.1
1961/62	23.0	2.7	1.2	1.0	0.8	0.8	5.3	14.6	73.1	51.3	45.5	80.7	25.0	2.0	53.0	22.3
1962/63	19.3	5.3	3.8	1.8	0.7	1.4	10.1	39.3	69.4	71.9	80.2	37.4	28.4	3.9	59.6	24.8
1963/64	4.3	3.1	1.0	0.9	0.8	0.8	1.4	8.6	16.3	21.3	50.0	43.8	12.7	1.3	28.0	11.6
1964/65	22.0	13.8	1.9	1.3	1.0	23.8	18.7	17.7	47.8	69.7	54.7	35.4	25.7	10.1	45.1	22.3
1965/66	4.7	1.9	1.5	0.9	0.7	0.6	2.8	30.2	41.2	67.1	95.5	43.6	24.2	1.4	55.5	21.3
1966/67	31.8	26.5	5.3	3.0	0.8	4.1	18.9	51.6	105.3	71.1	45.8	47.7	34.3	9.8	64.3	29.5
1967/68	13.1	3.9	2.1	1.1	0.7	0.6	1.3	26.2	45.5	53.8	91.5	65.9	25.5	1.6	56.6	22.9
1968/69	62.0	40.7	39.1	24.8	12.7	10.3	31.5	58.3	31.3	96.9	49.9	36.9	41.2	26.5	54.7	34.7
1969/70	10.6	5.4	2.4	1.8	1.3	4.0	10.9	14.6	33.9	84.2	60.2	47.6	23.1	4.3	48.1	20.3
1970/71	67.2	28.9	7.0	4.2	11.4	23.3	47.2	81.3	64.1	115.4	125.6	39.6	51.3	20.3	85.2	43.9
1971/72	34.0	21.0	10.2	8.0	5.7	25.0	46.5	52.2	85.4	39.5	98.4	35.2	38.4	17.5	62.1	33.0
1972/73	30.8	4.8	3.3	3.8	1.6	1.6	5.4	14.0	62.1	66.9	122.3	65.5	31.8	3.3	66.2	28.3
Mean	30.0	12.1	8.3	4.2	2.6	6.2	17.9	36.2	53.4	66.7	68.8	45.6	29.3	8.3	54.1	25.4
Basic mean year /1	23.0	5.3	3.8	1.8	1.0	1.6	10.1	30.2	47.8	67.1	60.0	43.6	24.6			

Note: /1 Basic mean year: A typical average water year assumed for power generation study. Records at 10th from the lowest are taken.

/2 Total drainage area of U/S dams assumed: 247 km^2.

Fig I - 4 Probability Analysis of Run-off Record



Flood	Peak Discharge (m^3/s)	Remarks
Standard highest flood discharge (S.H.F.D.)	4,000	Project design flood (for flood control)
Spillway design flood	5,200	1.2 times100-year flood.*
Extraordinary flood	6,200	1.2 timesof spillway design flood.*
Diversion flood	3,100	20-year flood.

* Ref. Design criteria for dams, Japanese National Comittee on Large Dams.

Even in the dry season (May to November) the flood occurs sometimes but its peak discharge is markedly small. Estimated dry season flood of 10-year return period is 300 m^3/s in peak discharge.

Hydrograph of the above assumed floods is shown in Fig I-15.

2.3. Reservoir Sediment

2.3.1. Sediment rate

Estimate of sediment volume for the Wonogiri reservoir is based on suspended sediment load samples taken at 3 gauging stations along the river. The measurement data were plotted on log-log paper against stream run-off data to estimate the yearly yield of suspended sediment load.

Taking 1,020 m^3/km^2/year for suspended load and assuming a 15% increase for bed load, annual average sediment yield at the Wonogiri damsite was determined at 1,170 m^3/km^2. (Refer to Annex III, Hydrology, 2.8 sediment estimate).

2.3.2. Trap efficiency of reservoir

The trap efficiency of reservoir is defined as the ratio of sediment trapped in the reservoir to the total sediment inflow at the damsite. It is known that the trapping rate is related to the annual water inflow to the reservoir and also to the storage capacity of the reservoir.

In this study, the trap efficiency of the reservoir was estimated by using Brune's graph and Brown's empirical formula. The results show a comparatively high trap efficiency.

Method	Trap efficiency
By Brune's graph	92 %
By Brown's formula	99%

It was recommended to adopt a conservative trap rate of 100% for the purpose of determining distribution of sediment in the reservoir.

2.3.3. Sediment Distribution

Based on the above estimated sediment yield and trap efficiency of the reservoir, total sediment volume in the reservoir was determined at 120×10^6 m^3.

- Sediment yield rate — 1,170 m^3/km^2/year
- Assumed life of reservoir — 100 years
- Sediment yield area — 1,020 km^2
- Total sediment volume after 100 years — 1,170 m^3/km^2/year x 100 years x 1,020 km^2 = 120×10^6 m^3.

The dead storage of the reservoir was determined for this volume, by which the low water level of the reservoir was fixed at EL. 127.0 m. The distribution of sediment in the reservoir was estimated by an "empirical area-reduction" method of U.S.B.R. Table below shows the sediment distribution after 100 years, together with that for 50 years.

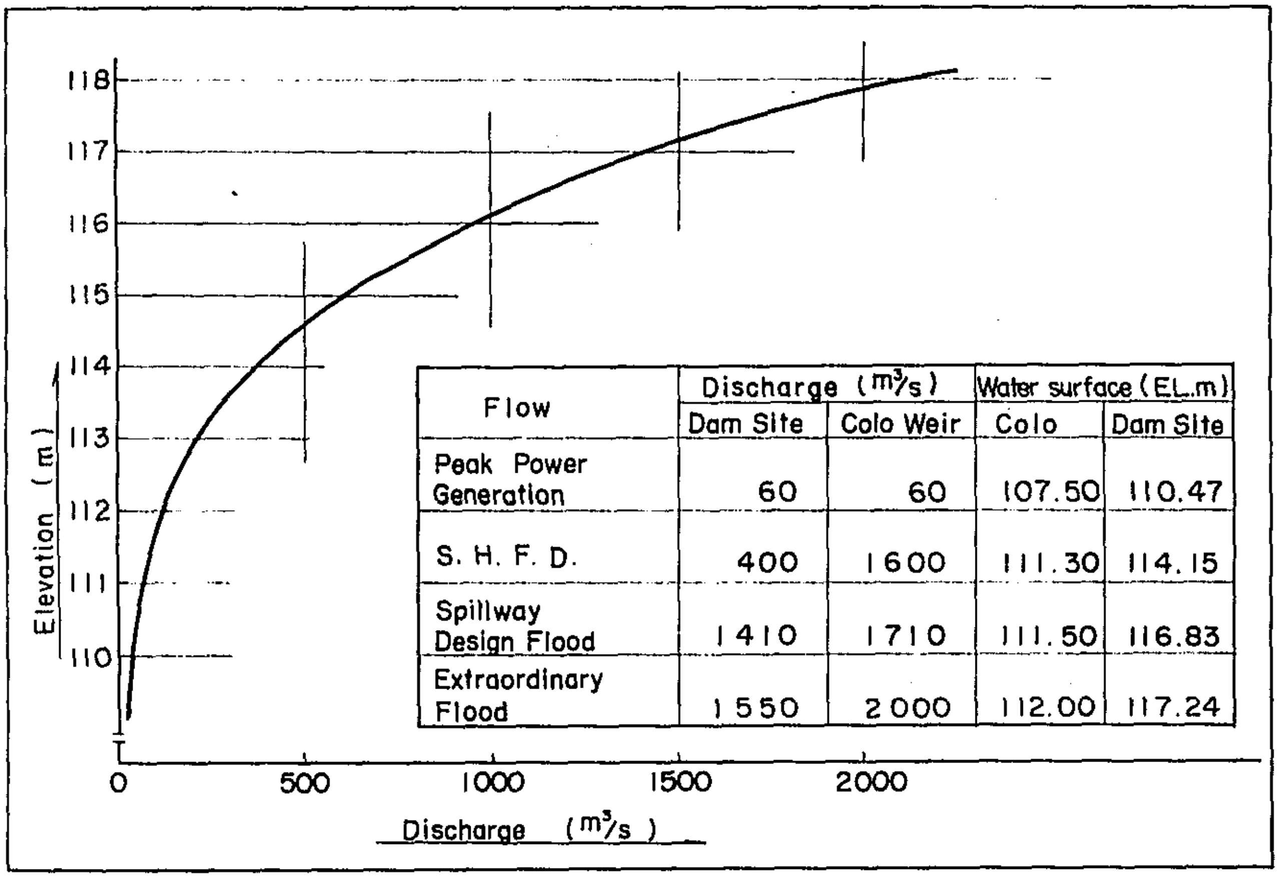
Reservoir level (m)	Accumulated volume of sediment (10^6 m^3)	
	After 100 years	After 50 years
109	0	0
121	25.4	18.8
127 (L.W.L.)	72.0	38.2
130	93.0	47.7
136 (N.H.W.L.)	120.0	60.0

The distribution shows that some part of sediment will be deposited in the active storage area. However, the extent appears to be within allowable limit in the case of 50 years sediment (Life of overall project facilities). The depth of sediment at the dam is calculated to reach EL. 121.0 m and EL. 117.5 m after 100 and 50 years respectively.

2.4. Tailwater Rating Curve

The rating curve at the damsite was obtained from back water calculation between the Colo weir and damsite. The control level assumed in the back water calculation is water surface elevation at the Colo weir site, which is determined by the rating curve of the Colo weir. River sections are assumed from the topographic maps of 1/2,000 scale. The result is shown in Fig. I-5.

Fig. I -5 Rating Curve at Damsite



Flow	Discharge (m³/s)		Water surface (EL.m)	
	Dam Site	Colo Weir	Colo	Dam Site
Peak Power Generation	60	60	107.50	110.47
S. H. F. D.	400	1600	111.30	114.15
Spillway Design Flood	1410	1710	111.50	116.83
Extraordinary Flood	1550	2000	112.00	117.24

3. WATER RESOURCES

3.1. Reservoir Inflow

Master Plan/1 recommended the future development of several irrigation dams in the upstream area of the basin. Actually, the government has made a plan of building 9 dams in the basin, of which one has already been constructed and the two others are under construction or design.

In this study, it was assumed that those development schemes would ultimately cover a total drainage area as large as 247 km^2. Reservoir operation study was therefore carried out on the assumption that about 18 % (247 km^2/1,350 km^2) of the dry season run-off would be consumed in the upstream irrigation projects and the remaining 82 % available for the Wonogiri reservoir.

Table I-3 shows the run-off data utilized in the study. Evaporation loss from the reservoir surface was assumed at 3 mm/day.

3.2. Available water resource

A primary assumption made in the study is that no single space of reservoir storage will be allocated for power generation purpose. Therefore, storage requirement of the reservoir depends solely on irrigation consumption. As the requirement of irrigation water differs each year due to the difference in the effective depth of rainfall, the study was carried out for a total period of 20 years varying the irrigation water requirement.

/1: Master Plan of Sala River basin development,
Supporting Report.
Part - IV. Water resource development.

In estimating the maximum water resources of the Wonogiri basin, it was assumed that the maximum water resources exploitable should be 90 % of the total river run-off during a typical droughty period as actually recorded in 5 years from 1960/61 to 1964/65. This is to ensure the reliable supply of irrigation water even during such a droughty period. This basic principle was assumed in the Master Plan study /1 and also adopted in this study.

Diversion requirement for three tentative irrigation development plans are worked out to compare it with the river run-off data.

Alternative plan	Irrigation area	River run-off (A)	Diversion requirement (B)	Rate of water resource exploitation(B/A)
Case I	26,000 ha	17.9m^3/sec	17.4 m^3/sec	97 %
Case II	23,600 ha	"	15.9 "	89 ≑ 90 %
Case III	20,000 ha	"	13.5 "	75 %

Note: (1) River run-off and diversion requirement represent the average of 1960/61 - 1964/65 data.

(2) Diversion requirement includes irrigation requirement, loss of irrigation water in Colo pondage and release of minimum river discharge during dry season.

The above table indicates that the development plan of Case II can be implemented within the assumed limit of available water resources (90 % of the total river inflow during a typical droughty period).

Through the above considerations, it is assumed that the maximum potential of water resources would be to meet the supply of irrigation water for an area of about 23,600 ha.

/1: Master Plan, Supporting Report, Part IV-Water Resource Development. Page 61.

Fig. I-6 illustrates mass curves for the above alternative plans. Mass curve of Case-II shows that the failure of the reservoir stage recovery will rarely occurs, except 3 years (not more than 2 successive years) out of 20-year period. It ensures the reliable supply of irrigation water.

3.3. Water balance calculation

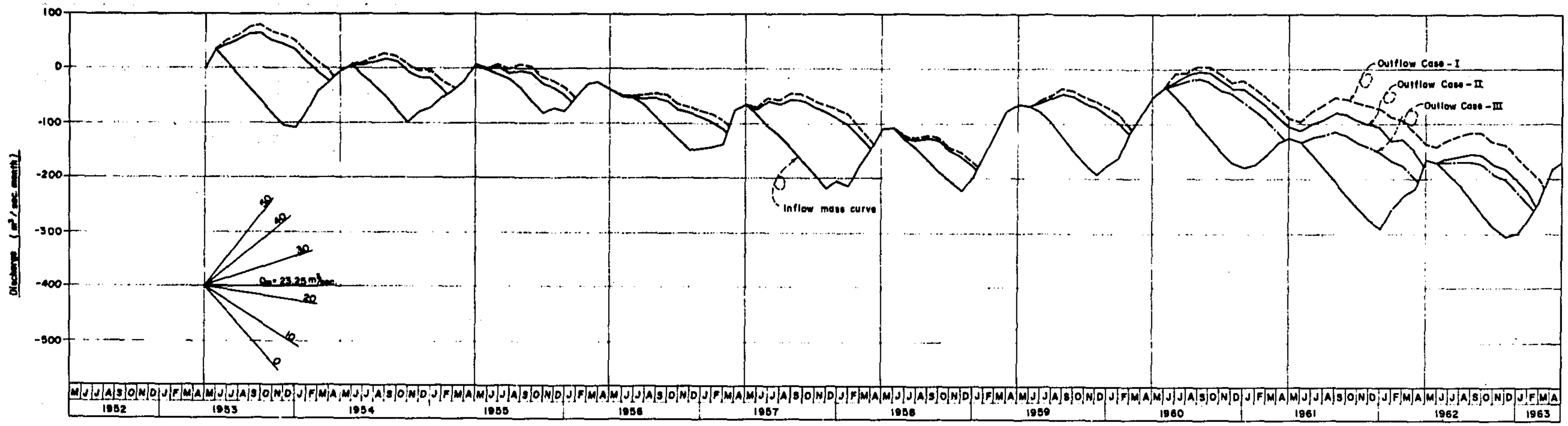
Table I-2 shows irrigation requirement for an area of 23,600 ha covering 20 years period. Based on these data, water balance calculation was carried out to determine the required storage capacity of the reservoir. The results of the calculation are shown in Table I-3 and Fig. I-7. /1

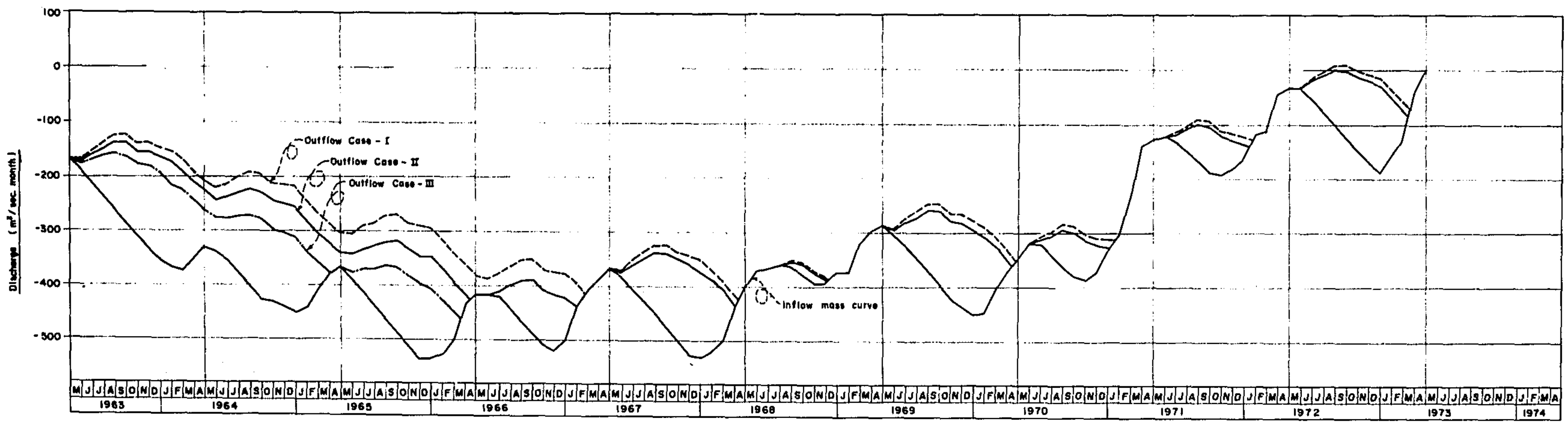
Selected active reservoir storage capacity, 440 x 10^6 m^3, will be capable of supplying the required irrigation water at a dependability of 90 % throughout the total period. The reservoir storage consists of:

- Storage for net irrigation requirement 400 x 10^6 m^3
- Loss of irrigation water in Colo pondage abt. 10 x 10^6 m^3
- Storage for release of minimum discharge to downstream reaches (2 m^3/s during the dry season) abt. 30 x 10^6 m^3.

/1: Water balance calculation is also made in Annex (II), irrigation, based on net diversion requirement excluding loss in Colo weir and release of minimum discharge in downstream reaches.

Fig I - 6 Mass Curve of Wonogiri Reservoir





Note : (1) Alternative development plans

Case	Irrigation area (ha)	Outflow from dam (m^3/sec-mo) Dry season (June – Nov.)	Wet season (Dec. – May)	Remarks
I	26,000	145.37	50.73	
II	23,600	130.83	45.66	Proposed plan
III	20,000	112.06	38.81	

(Above alternatives assumed for water resource assessment only)

(2) Inflow mass curve is based on net inflow data. (evaporation loss deducted)

(3) Outflow includes irrigation requirement and release of minimum discharge to downstream reaches.

Table I-2 Diversion Requirement (Monthly Mean)

(Unit : m^3/sec)

Year	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Mean	Max
1953/54	2.14	10.46	36.02	31.41	33.33	22.61	10.39	14.96	15.00	0	4.60	7.96	15.74	36.02
1954/55	1.21	8.62	30.95	25.58	26.25	18.65	5.65	11.93	22.41	4.89	8.61	3.21	14.00	30.95
1955/56	1.63	17.54	24.25	15.12	25.56	20.42	5.37	13.51	11.67	0	4.89	8.89	12.40	25.56
1956/57	2.01	11.70	20.18	23.76	23.54	17.33	6.88	18.37	16.29	12.44	10.70	2.91	13.84	23.76
1957/58	2.24	17.12	34.66	20.21	30.30	22.40	9.63	16.63	13.21	9.47	0	0	14.66	34.66
1958/59	1.53	9.87	6.50	19.13	25.56	16.67	5.37	15.84	5.03	4.59	1.44	1.07	9.38	25.56
1959/60	1.71	11.48	29.92	27.41	32.66	20.64	8.65	16.00	10.40	9.17	0	7.79	14.65	32.66
1960/61	1.96	10.10	34.60	32.40	32.60	21.50	7.80	9.40	23.00	7.90	6.90	5.50	16.14	34.60
1961/62	3.10	15.10	35.60	33.50	33.40	22.40	9.40	17.70	21.10	6.40	10.40	7.00	17.93	35.60
1962/63	0.70	14.70	30.90	26.00	28.90	22.00	6.90	15.40	3.60	6.10	2.60	3.50	13.44	30.90
1963/64	3.00	18.70	33.70	34.30	34.40	22.60	9.50	19.60	15.50	15.00	5.70	4.10	18.01	34.40
1964/65	1.70	9.90	29.00	31.40	30.00	19.30	5.10	19.30	16.80	1.80	3.20	0.80	13.61	31.40
1965/66	3.10	16.68	34.32	30.30	33.33	22.40	9.75	13.85	17.91	3.36	0	0.16	15.43	34.32
1966/67	1.99	16.27	29.27	34.30	32.66	21.28	4.66	16.15	17.91	7.34	5.46	7.79	16.26	34.30
1967/68	3.39	18.64	36.35	34.30	33.33	22.40	9.75	17.11	17.91	2.13	2.59	0	16.49	36.35
1968/69	1.56	9.97	20.87	17.94	26.25	18.88	6.78	11.59	14.76	6.11	2.59	4.59	11.82	26.25
1969/70	1.43	17.33	35.66	34.30	33.00	22.61	6.42	17.42	12.44	8.86	3.44	2.14	16.25	35.66
1970/71	2.41	9.59	32.64	31.02	33.33	18.88	8.42	14.62	18.80	9.17	4.87	0	15.31	33.33
1971/72	3.90	11.13	29.58	31.41	32.66	20.64	4.57	17.26	16.03	10.09	15.69	2.14	16.26	32.66
1972/73	2.06	11.03	36.02	34.30	31.99	22.61	10.39	16.79	18.50	0	0	2.30	15.50	36.02
Mean	2.14	13.30	30.05	28.40	30.65	20.81	7.57	15.67	15.41	6.24	4.68	3.59	14.86	

Note: Diversion requirement in this table includes net diversion requirement, loss in Colo weir and release of minimum dry season discharge.

Table I-3 ** Water Balance Calculation (1)

(Unit m^3/sec)

Year: 1953/54

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	57.4	10.46	0	0
J	-0.4	36.02	--36.02	-36.06
J	-0.1	31.41	-67.48	-67.48
A	-1.6	33.33	-102.41	-102.41
S	-1.6	22.61	-126.62	-126.62
O	-1.7	10.39	-138.71	-138.71
N	3.8	14.96	-149.87	-149.87
D	21.5	15.00	-143.37	-143.37
J	49.2	0	-94.17	-94.17
F	61.1	4.60	-37.67	-37.67
M	41.4	7.96	-4.23	-4.23
A	42.3	1.21	0	0

Year: 1957/58

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	5.2	17.12	-11.92	-11.92
J	-1.0	34.66	-47.58	-47.58
J	8.1	20.21	-59.69	-59.69
A	2.2	30.30	-87.79	-87.79
S	-1.4	22.40	-111.59	-111.59
O	-1.5	9.63	-122.72	-122.72
N	-1.8	16.63	-141.15	-141.15
D	38.1	13.21	-116.26	-116.26
J	11.8	9.47	-113.93	-113.93
F	62.4	0	-51.53	-51.53
M	56.6	0	0	0
A	59.0	1.53	0	0

Year: 1954/55

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	35.3	8.62	0	0
J	8.4	30.95	-22.55	-22.55
J	3.6	25.58	-44.53	-44.53
A	1.4	26.25	-69.38	-69.38
S	-1.1	18.65	-89.13	-89.13
O	0.5	5.65	-94.28	-94.28
N	41.9	11.93	-64.31	-64.31
D	31.7	22.41	-55.02	-55.02
J	44.3	4.89	-15.61	-15.61
F	31.4	8.61	0	0
M	39.6	3.21	0	0
A	54.8	1.63	0	0

Year: 1958/59

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	24.2	9.87	0	0
J	0.1	6.50	-6.40	-6.40
J	9.3	19.13	-16.16	-16.16
A	1.1	25.56	-40.62	-40.62
S	-0.6	16.67	-57.89	-57.89
O	7.5	5.37	-55.76	-55.76
N	7.6	15.84	-64.00	-64.00
D	45.2	5.03	-23.83	-23.83
J	64.2	4.59	0	0
F	68.4	1.44	0	0
M	63.1	1.07	0	0
A	33.6	1.71	0	0

Year: 1955/56

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	15.9	17.54	-1.64	-1.64
J	10.8	24.25	-15.09	-15.09
J	17.6	15.12	-12.61	-12.61
A	4.8	25.56	-33.37	-33.37
S	1.0	20.42	-52.79	-52.79
O	2.5	5.37	-55.66	-55.66
N	29.0	13.51	-40.17	-40.17
D	19.8	11.67	-32.04	-32.04
J	49.4	0	0	0
F	47.3	4.89	0	0
M	27.5	8.89	0	0
A	9.8	2.01	0	0

Year: 1959/60

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	20.1	11.48	0	0
J	10.3	29.92	-19.62	-19.62
J	2.7	27.41	-44.33	-44.33
A	-1.3	32.66	-78.29	-78.29
S	-1.0	20.64	-99.93	-99.93
O	-1.4	8.65	-109.98	-109.98
N	4.4	16.00	-121.58	-121.58
D	41.9	10.40	-90.08	-90.08
J	35.6	9.17	-63.65	-63.65
F	71.9	0	0	0
M	54.4	7.79	0	0
A	53.0	1.96	0	0

Year: 1956/57

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	9.0	11.70	-2.70	-2.70
J	21.8	20.18	-1.08	-1.08
J	12.4	23.76	-12.44	-12.44
A	4.0	23.54	-31.98	-31.98
S	0.4	17.33	-48.91	-48.91
O	1.8	6.88	-53.99	-53.99
N	4.2	18.37	-68.16	-68.16
D	26.9	16.29	-57.55	-57.55
J	22.1	12.44	-47.89	-47.89
F	29.1	10.70	-29.49	-29.49
M	85.8	2.91	0	0
A	33.5	2.24	0	0

Year: 1960/61

Month	Net Inflow	Div. Requirement	Balance	Balance accum.
M	42.3	10.1	0	0
J	1.4	34.6	-33.2	-33.2
J	0.6	32.4	-65.0	-65.0
A	-1.3	32.6	-98.9	-98.9
S	-1.4	21.5	-121.8	-121.8
O	-1.4	7.8	-131.0	-131.0
N	2.3	9.4	-138.1	-138.1
D	14.9	23.0	-146.2	-146.2
J	28.8	7.9	-125.3	-125.3
F	40.9	6.9	-91.3	-91.3
M	47.9	5.5	-48.9	-48.9
A	29.0	3.1	-23.0	-23.0
		194.8		

Table I-3 Water Balance Calculation (2)

(Unit: m^3/sec)

Year: 1961/62

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	16.9	15.1	0	-21.2
J	0.1	35.6	-35.5	-56.7
J	-1.1	33.5	-70.1	-91.3
A	-1.3	33.4	-104.8	-126.0
S	-1.4	22.4	-128.6	-149.8
O	-1.4	9.4	-139.4	-160.6
N	2.3	17.7	-154.8	-176.0
D	9.9	21.1	-166.0	-187.2
J	58.1	6.4	-114.3	-135.5
F	40.1	10.4	-84.6	-105.8
M	41.3	7.0	-50.3	-71.5
A	78.6	0.7	0	0

Year: 1965/66

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	1.6	16.68	-15.08	-43.28
J	-0.5	34.32	-49.90	-78.10
J	-0.9	30.30	-81.10	-109.30
A	-1.4	33.33	-115.83	-144.03
S	-1.5	22.40	-139.73	-167.93
O	-1.6	9.75	-151.08	-179.28
N	0.2	13.85	-164.73	-192.93
D	22.5	17.91	-160.14	-188.34
J	31.5	3.36	-132.00	-160.20
F	52.7	0	-79.30	-107.50
M	86.4	0.16	0	-21.26
A	41.5	1.99	0	0

Year: 1962/63

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	13.8	14.7	-0.9	-0.9
J	2.3	30.9	-29.5	-29.5
J	1.0	26.0	-54.5	-54.5
A	-0.6	28.9	-84.0	-84.0
S	-1.5	22.0	-107.5	-107.5
O	-0.9	6.9	-115.3	-115.3
N	6.2	15.4	-124.5	-124.5
D	30.3	3.6	-97.8	-97.8
J	55.0	6.1	-48.9	-48.9
F	57.1	2.6	0	0
M	74.5	3.5	0	0
A	35.3	3.0	0	0

Year: 1966/67

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	24.1	16.27	0	0
J	19.7	29.27	-9.57	-9.57
J	2.3	34.30	-41.57	-41.57
A	0.4	32.66	-73.83	-73.83
S	-1.4	21.28	-96.51	-96.51
O	1.3	4.66	-99.87	-99.87
N	13.5	16.15	-102.52	-102.52
D	40.4	17.91	-80.03	-80.03
J	84.9	7.34	-2.47	-2.47
F	56.4	5.46	0	0
M	41.6	7.79	0	0
A	45.6	3.39	0	0

Year: 1963/64

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	1.4	18.7	-17.3	-17.3
J	0.4	33.7	-50.6	-50.6
J	-1.3	34.3	-86.2	-86.2
A	-1.3	34.4	-121.9	-121.9
S	-1.4	22.6	-145.9	-145.9
O	-1.4	9.5	-156.8	-156.8
N	-0.9	19.6	-177.3	-177.3
D	4.9	15.5	-187.9	-187.9
J	11.2	15.0	-191.7	-191.7
F	15.3	5.7	-182.1	-182.1
M	45.6	4.1	-140.6	-140.6
A	41.7	1.7	-100.6	-100.6

Year: 1967/68

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	8.6	18.64	-10.04	-10.04
J	1.1	36.35	-45.29	-45.29
J	-0.4	34.30	-79.99	-79.99
A	-1.2	33.33	-114.52	-114.52
S	-1.5	22.40	-138.42	-138.42
O	-1.6	9.75	-149.77	-149.77
N	-1.0	17.11	-167.88	-167.88
D	19.4	17.91	-165.59	-165.59
J	35.2	2.13	-132.52	-132.52
F	42.0	2.59	-93.11	-93.11
M	85.2	0	-7.91	-7.91
A	63.8	1.56	0	0

Year: 1964/65

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	16.1	9.9	0	-94.4
J	9.3	29.0	-19.7	-114.1
J	-0.5	31.4	-51.6	-146.0
A	-1.0	30.0	-82.6	-177.0
S	-1.3	19.3	-103.2	-197.6
O	17.5	5.1	-90.8	-185.2
N	13.3	19.3	-96.8	-191.2
D	12.5	16.8	-101.1	-195.5
J	37.3	1.8	-65.6	-160.0
F	55.4	3.2	-13.4	-107.8
M	50.2	0.8	0	-58.4
A	33.3	3.1	0	-28.2

Year: 1968/69

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	48.5	9.97	0	0
J	31.2	20.87	0	0
J	29.9	17.94	0	0
A	18.1	26.25	-8.15	-8.15
S	8.3	18.88	-18.73	-18.73
O	6.3	6.78	-19.21	-19.21
N	23.6	11.59	-7.20	-7.20
D	45.6	14.76	0	0
J	23.5	6.11	0	0
F	76.0	2.59	0	0
M	45.5	4.59	0	0
A	34.8	1.43	0	0

Table I-3 Water Balance Calculation (3)

(Unit m^3/sec)

Year: 1969/70

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	6.6	17.33	-10.73	-10.73
J	2.3	35.66	-44.09	-44.09
J	-0.1	34.30	-78.49	-78.49
A	-0.6	33.00	-112.09	-112.09
S	-1.0	22.61	-135.70	-135.70
O	-1.2	6.42	-143.32	-143.32
N	6.8	17.42	-153.94	-153.94
D	9.8	12.44	-156.58	-156.58
J	25.6	8.86	-139.84	-139.84
F	66.6	3.44	-76.68	-76.68
M	55.3	2.14	-23.52	-23.52
A	45.5	2.41	0	0

Year: 1970/71

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	52.8	9.59	0	0
J	21.5	32.64	-11.14	-11.14
J	3.6	31.02	-38.56	-38.56
A	1.3	33.33	-70.59	-70.59
S	7.2	18.88	-82.27	-82.27
O	17.0	8.42	-73.69	-73.69
N	36.5	14.62	-51.81	-51.81
D	64.3	18.80	-6.31	-6.31
J	50.3	9.17	0	0
F	92.2	4.87	0	0
M	117.7	0	0	0
A	37.5	3.90	0	0

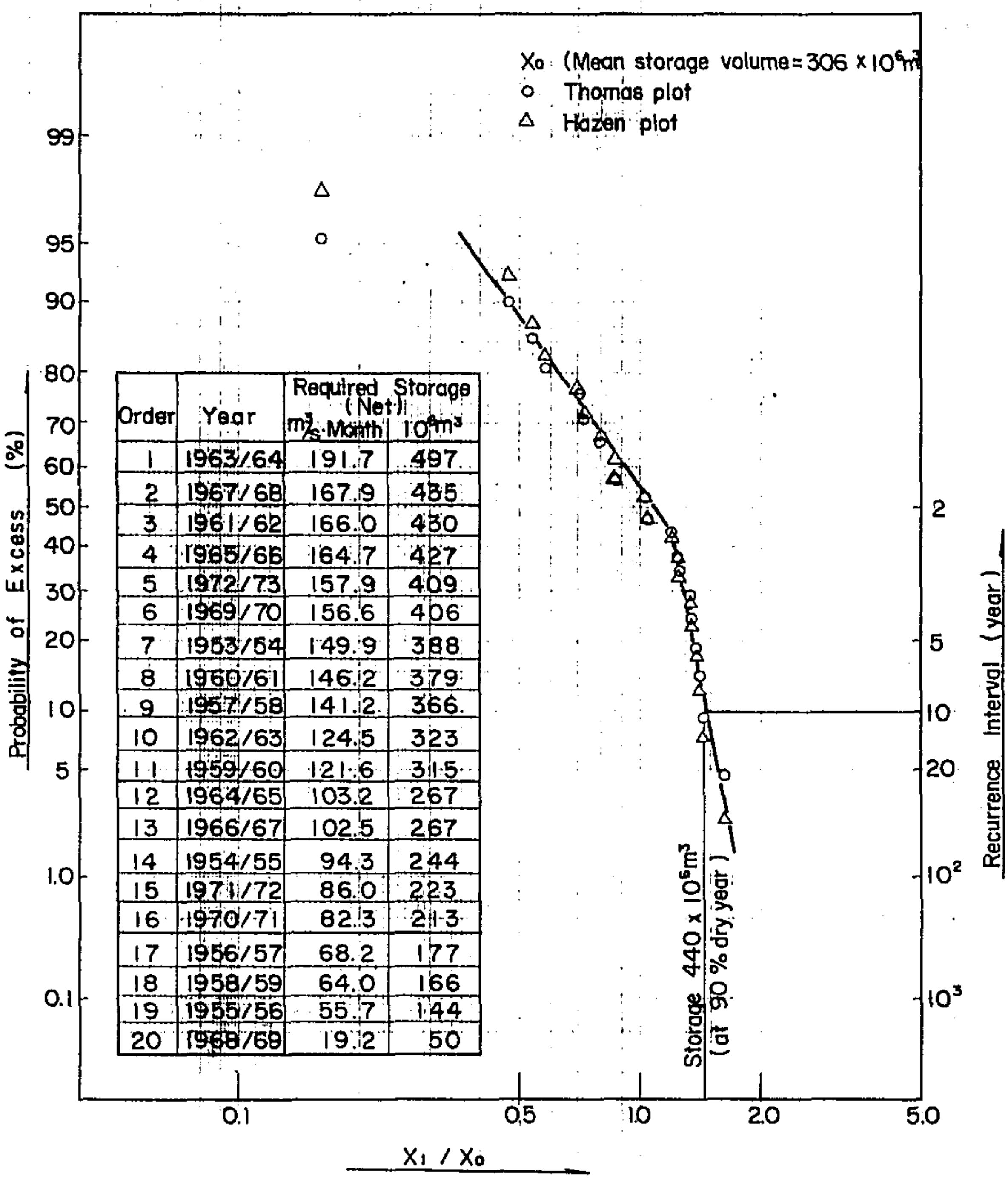
Year: 1971/72

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	25.7	11.13	0	0
J	15.1	29.58	-14.48	-14.48
J	6.2	31.41	-39.69	-39.69
A	4.4	32.66	-67.95	-67.95
S	2.6	20.64	-85.99	-85.99
O	18.3	4.57	-72.26	-72.26
N	35.9	17.26	-53.62	-53.62
D	40.5	16.03	-29.15	-29.15
J	67.6	10.09	0	0
F	29.2	15.69	0	0
M	91.8	2.14	0	0
A	33.1	2.06	0	0

Year: 1972/73

Month	Net Inflow	Div. Requirement	Balance	Balance Accum.
M	23.1	11.03	0	0
J	1.8	36.02	-34.22	-34.22
J	0.6	34.30	-67.92	-67.92
A	0.2	31.99	-99.71	-99.71
S	-0.8	22.61	-123.12	-123.12
O	-0.8	10.39	-134.31	-134.31
N	2.3	16.79	-148.80	-148.80
D	9.4	18.50	-157.90	-157.90
J	48.6	0	-109.30	-109.30
F	52.5	0	-56.80	-56.80
M	114.6	2.30	0	0
A	63.4	13.61	0	0

Fig I -7 Probability Analysis for Reservoir Storage Requirement



Order	Year	Required (Net) m^3/s·Month	Storage 10^6m^3
1	1963/64	191.7	497
2	1967/68	167.9	485
3	1961/62	166.0	450
4	1965/66	164.7	427
5	1972/73	157.9	409
6	1969/70	156.6	406
7	1953/54	149.9	388
8	1960/61	146.2	379
9	1957/58	141.2	366
10	1962/63	124.5	323
11	1959/60	121.6	315
12	1964/65	103.2	267
13	1966/67	102.5	267
14	1954/55	94.3	244
15	1971/72	86.0	223
16	1970/71	82.3	213
17	1956/57	68.2	177
18	1958/59	64.0	166
19	1955/56	55.7	144
20	1968/69	19.2	50

4. PLAN FORMULATION

4.1. Irrigation Development Plans

Within the limit of available water resources, alternative development plans are formulated to select the most appropriate scale of irrigation development scheme. In order to evaluate the project works as completed in a multipurpose scheme, flood control and power generation schemes were also take into account in the comparative study. Recommended scale of power installation in each alternative plan was determined through preliminary reservoir operation study. Flood control capacity of the reservoir is tentatively assumed to be 220 million m^3 in this comparative study.

As described in Section 3, it was presumed that the maximum development scale would be around 440 million m^3 in terms of the reservoir storage capacity, which could meet the irrigation requirement over an area of about 23,600 ha. This development plan is included in the comparative study as one of the alternative plans. Two other alternatives assumed are smaller development scales with reduced irrigation areas of 15,600 ha and 8,500 ha respectively.

For each of those alternatives, the total construction cost of the dam, power and irrigation facilities was estimated and benefits from flood control, power production and irrigation were worked out for economical comparison of the plans. Table I-4 shows the results of the comparative study.

As is apparent in the table, Plan A receives the highest economical assessment among the plans. Accordingly, the Plan A is selected as the most economic scale of the irrigation development. Required active storage capacity of the reservoir for irrigation water supply will be 440 million m^3.

Table I-4 Alternative Development Plans

ITEM	PLAN-A	PLAN-B	PLAN-C
Plan of development			
Irrigation area (ha)	23,600	15,600	8,500
Power installation (kW)	10,200	11,400	7,700
Annual power energy (MWh)	28,200	28,400	23,200
Flood control (m^3/s)			
- outflow from reservoir	400	400	400
Principal features of work			
Reservoir storage (10^6 m^3)			
- Sediment	120	120	120
- Irrigation & power	440	310	190
- Flood control	220	220	220
Reservoir stage (m)			
- L.W.L.	127.0	127.0	127.0
- N.H.W.L.	136.0	134.1	132.0
- S.H.L.D. Surcharge W.L.	138.2	136.6	134.9
- H.W.L.	138.4	136.8	135.2
- Extra F.W.L.	138.9	137.5	135.9
Dam			
- Crest EL (m)	141.6	140.2	138.6
- Max. dam height (m)	37.5	36.1	34.5
- Embankment volume (10^3m^3)	1,800	1,600	1,420
Spillway			
- Controlled outflow during S.H.L.D. (m^3/s)	400	400	400
- Max. discharge capacity (m^3/s)	1,550	1,550	1,550
Construction cost (10^3 US$)			
- Dam and reservoir	43,400	42,300	38,100
- Power and transmission lines	11,700	13,400	10,700
- Irrigation	33,100	22,620	13,180
- River improvement	18,270	18,270	18,270
Total	106,470	96,590	80,250

- to be continued -

Annual net benefit (10^3 US$)			
- Irrigation	13,620	9,000	4,900
- Power generation	1,350	1,500	1,100
- Flood control	5,810	5,810	5,810
- Negative benefit	-820	-740	-660
Total	19,960	15,570	11,150
Economic Evaluation			
- Net present worth (Discount rate at 10 %) (10^3 US$)	30,155	18,361	10.551

4.2. Flood Control Plans

4.2.1. Design flood for flood control plan

A design flood assumed in the flood control study is SHFD (Standard highest flood discharge) having a peak discharge of 4,000 m^3/s at the damsite, which is the recorded maximum flood in the recent decade corresponding to a flood event of 60-year recurrence probability.

4.2.2. Alternative flood control plans

The purpose of flood control works is the mitigation of flood damages in the reaches downstream from the damsite. According to the results of the previous Master Plan survey, the most favourable flood control work for the Sala river can be realized by the combination of levee construction and flow regulation by dam. In this respect, the major objective of the flood control study is to select the most economic combination of levee and dam constructions.

To select the flood control capacity of the reservoir which will minimizes the required cost for flood control measures, a comparative study was made for 3 cases of the outflow discharge rating at 400, 700 and 1,000 m^3/s respectively.

In the study, the total cost of the reservoir and river improvement works was estimated for assessing the alternative plans. The result indicates that the flood control capacity of the reservoir of 220 x $10^6 m^3$ is most preferable. See Table I-5 for the results of the comparative study.

4.2.3. Flood control of reservoir

Recommended flood control method is to control the outflow by operation of spillway gates. An alternative method was natural flow control through an ungated spillway. However, it was finally abondoned owing to the increase of storage requirement for flood control and eventually the necessity of higher dam construction; 2.7 m higher than that of the recommended plan, if the same extent of flood control effect is insisted.

Table I-5 Alternative Flood Control Plans

Item	Plan - I	Plan - II	Plan - III
Wonogiri reservoir			
- Inflow discharge (m^3/s)	4,000	4,000	4,000
- Outflow discharge (m^3/s)	400	700	1,000
- Storage capacity: ($10^6 m^3$)			
Gross at S.W.L (SHFD)	730	660	630
Flood control	220	150	120
Irrigation and power	440	440	440
Sediment	120	120	120
- Dam crest EL (m)	141.6	141.3	140.7
- Dam height (m)	37.5	37.2	36.6
- Max. spillway capacity (m^3/s)	1,550	1,630	1,920
- Total construction cost (A) (include land acquisition costs) (10^3 US$)	43,400	43,200	43,000
River improvement			
- Projected highest flood discharge at Surakarta (m^3/s)	5,300	5,300	5,300
- Discharge after dam regulation at Surakarta (m^3/s)	2,000	2,300	2,600
- Length of improvement (km)	32.2	32.2	32.2
- Volume of earth moving (10^6 m^3)	11,170	11,860	13,100
- Construction cost (B) (10^3 US$)	18,300	20,000	22,400
Total construction cost (A) + (B) (10^3 US$)	61,700	63,500	65,900

Type	Peak inflow (m^3/s)	Outflow (m^3/s)	Required storage/1 (10^6m^3)	Dam crest (EL)	Remarks
Gate control	4,000	400	220	141.6	(Selected)
Natural control (Ungated)	4,000	400	340	144.3	(Alternative)

4.3. Power Development Scale

4.3.1. Power development alternatives

As has been revealed in the preliminary study under this investigation and also suggested in the Master Plan, power generation scheme appears to be costly as compared with the irrigation scheme. With this in view, power generation is planned within the scope of the irrigation development, that is, the whole of the reservoir storage is allocated principally for irrigation use and no specific storage for power water will be provided in the reservoir. Power generation will be made by using water stored for the irrigation requirement and further the surplus water available during the flood season. A study on power development is therefore to select the most appropriate scale of power facilities under the reservoir operation rule established for irrigation water supply.

As was determined in the comparative study on irrigation development scheme, the reservoir has an active storage capacity of 440 million m^3 above the low water level. Normal high water level of the reservoir is set at EL. 136.0 m. With average tailwater level being EL. 110.5 m (in case of the discharge of 60 m^3/sec) and the estimated loss of head 1.0 m, the maximum effective head available is 24.5 m, while the minimum head is 15.5 m at the low water level of EL. 127.0 m. Thus, a large fluctuation of effective head is unavoidable in power generation.

Table I-6 shows the seasonal fluctuation of the reservoir water level and effected head as calculated by the reservoir operation study for a period of 20 years.

Note: /1 Including about 20% allowance over net surcharge requirement

As no specific storage for power generation is provided in the Wonogiri reservoir, the available discharge for power generation has to be subordinate to the outflow for irrigation use. In the dry season, the discharge for power generation will be within the release of irrigation water. In the rainy season, most of the inflow run-off has to be stored to recover the reservoir to its full content by the end of the rainy season, for ensuring the successful supply of irrigation water in the next year. Power discharge available during this period, will only be surplus water in excess of the requirement for storage recovery. According to the reservoir operation study, power discharge during the rainy season varies widely from 7.2 m^3/s to 47.1 m^3/s year to year. Yearly variation of the power discharge is shown in Table I-7.

Owing to the variation of power discharge and the large fluctuation of effective head as described above; the seasonal and yearly fluctuation of power output is unavoidable, which will result in the drop of dependable power capacity.

Under the above conditions of water utilization, four alternatives of the power development plan were formulated to select the most appropriate scale of the power installation. In accordance with the results of power demand and system surveys, the Wonogiri powerplant will be exploited as a peaking power plant to be operated for 6 hours day. During the period when the surplus water is available, the plant will generate additional off-peak power.

For each alternative, power output calculation was conducted to calculate the dependable peak power capacity and annual energy output, and construction cost estimated estimated for economical comparison. For convenience sake, the comparison was made on the basis of construction cost requirement per kW of 85% dependable peak capacity. (Annual energy output is nearly the same for all the alternative plans).

Table I-8 shows the alternative plans studied and the result of the comparison, which indicates that the Plan (C) is the most economical plan to be selected by the project.

Operation study of power generation for a period of 20 years (1953/54 - 1972/73) is shown in Fig. I-8.

Table I-6 Reservoir Water Level and Effective Head
(Average of 20-year records 1953/54 - 1972/73)

Month	Reservoir water level (EL. m)	Effective head /1 (m)	Outflow from reservoir 24-hour average (m^3/sec)
May	135.7	24.2	25.3
June	135.2	23.7	31.4
July	134.2	22.7	28.7
Aug.	133.0	21.5	30.0
Sept.	131.7	20.2	20.4
Oct.	130.6	19.1	19.8
Nov.	129.8	18.3	22.5
Dec.	129.5	18.0	23.0
Jan.	130.3	18.8	20.6
Feb.	131.8	20.3	20.2
Mar.	133.6	22.1	19.9
Apr.	135.2	23.7	14.5

Nore: /1 Effective head is calculated under conditions;

Tailwater level EL. 110.5 ($Q = 60\ m^3/s$)
Loss of head 1.0 m

Table I-7 Discharge available for power generation

Year	Discharge available for 6-hour peak power generation (m^3/s)		
	Dry season (May - Sept.)	Rainy season (Oct. - Apr.)	Yearly mean
1953/54	36.1	12.4	22.3
1954/55	27.4	21.9	24.2
1955/56	20.6	20.3	20.4
1956/57	19.3	20.3	19.9
1957/58	24.9	15.6	19.5
1958/59	23.5	29.2	26.8
1959/60	26.1	22.2	23.8
1960/61	32.7	9.1	18.9
1961/62	24.5	13.1	17.9
1962/63	24.5	21.1	22.5
1963/64	26.3	8.0	15.6
1964/65	22.0	7.2	13.4
1965/66	27.4	12.9	19.0
1966/67	28.3	26.5	27.2
1967/68	29.0	14.7	20.7
1968/69	31.0	33.2	32.3
1969/70	28.6	9.7	17.6
1970/71	33.7	47.1	41.5
1971/72	28.0	33.0	30.9
1972/73	29.6	23.6	26.1
Mean	27.2	20.1	23.0

Table I-8 Comparison of Power Development Plans

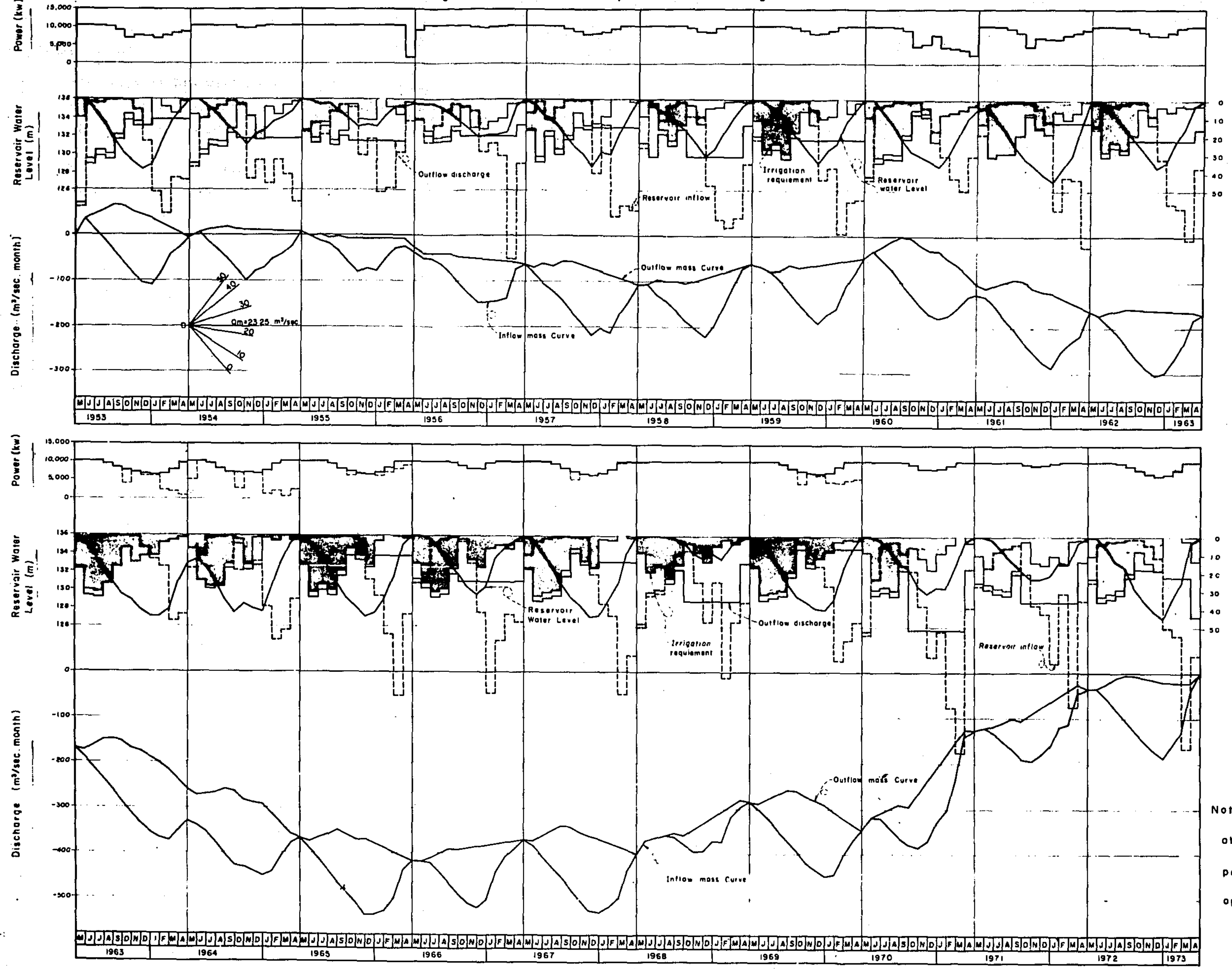
Item	Alternative Development Plans			
	Plan (A)	Plan (B)	Plan (C)	Plan (D)
Development plan				
Peak plant discharge (m^3/s)	44	52	60	68
Installed capacity (kW)	7,600	8,900	10,200	11,600
85% dependable peak power (kW)/1	5,400	6,200	6,900	7,500
Annual energy output (MWh)/2				
Peak power	11,800	13,800	15,600	17,200
Off peak power	16,600	14,500	12,600	10,800
Total	28,400	28,300	28,200	28,000
Construction cost (10^3US$)/3				
Intake	520	540	560	590
Pressure tunnel	710	810	880	980
Power house	1,153	1,230	1,280	1,380
Generating equipment	6,322	6,829	7,262	8,288
Transmission facilities	2,577	2,577	2,577	2,577
Gates and Penstocks	883	942	989	1,057
Total	12,165	12,928	13,548	14,872
Comparison				
Construction cost per kW of dependable peak Power (10^3US$)	2,253	2,085	1,961	1,983

Note: /1 Peaking capacity that would be available during 85% of time throughout total period

/2 Plant factor is assumed at 80%

/3 Cost of civil works (only specific items related to the power scheme) does not include depreciation cost of construction machineries. Gates and penstocks include intake gate, tailrace gate, trashracks and penstocks.

Fig. I-8 Reservoir Operation of Wonogiri Reservoir



Note : Power (kw) indicated above shows average peak power for 6-hour operation a day.

4.3.2. Power output

Power output available will depend on the level of reservoir which will fluctuate seasonally according to the released volume of irrigation water. It will vary from 10,200 kW to 6,400 kW in average water year.

Table I-9 shows the results of power and energy output calculations for a period of 20 years.

4.4. Reservoir Operation

In most years, the reservoir will reach the maximum storage capacity in April. After May, run-off volume into the reservoir gradually decreases and the stored water will be released to meet the requirement for irrigation in the downstream area. Water released from the reservoir will be used first for the generation of electric power before being delivered to the irrigation area.

During the dry season (June to September), average release of irrigation water reaches 27 m^3/s, which is more than the requirement of peak power generation (15 m^3/s in 24 hour average discharge, corresponding to 60 m^3/s for 6-hour plant operation). This excess release will enable the plant to work as an base-load plant during off-peak hours.

From October to May, the powerplant will be mostly operated as a peaking plant by discharging 60 m^3/s for 6 hours a day. In some droughty years when the reservoir water level lowers near to the low water level, power generation may have to be controlled to recover the reservoir level to full level by the end of rainy season. In wet years, additional release of water will be made for power generation during off-peak hours.

The reservoir operation study for a period of the past 20 years shows that minor shortage of irrigation water will occur in 2 years of the period (1961/62 and 1963/64). In those years, power generation will also be restricted. Other years encounter no water shortage and successful supply of irrigation water will be maintained.

Table I-9 Power Generation of Wonogiri Power Station

Year	Max. Power Output (kW)/1			6-hour Peak Power Output (kW)/2			Energy Output (MWH)/3		
	Max.	Min.	Mean	Max.	Min.	Mean	Peak (6 hrs)	Off peak	Total
1953/54	10,200	7,430	9,350	10,200	6,750	8,600	15,090	12,530	27,620
1954/55	"	9,530	10,150	10,200	9,530	10,150	17,790	13,150	30,940
1955/56	"	10,200	10,200	10,200	1,560	9,570	16,780	9,980	26,750
1956/57	"	9,800	10,180	10,200	9,130	10,080	17,660	7,520	25,180
1957/58	"	7,960	9,500	10,200	7,950	9,500	16,650	6,790	23,430
1958/59	"	8,570	9,910	10,200	8,570	9,910	17,370	15,680	33,050
1959/60	"	8,170	9,690	10,200	8,170	9,690	16,970	12,280	29,250
1960/61	"	7,720	9,360	10,200	2,320	6,940	12,210	11,100	23,300
1961/62	"	6,740	9,030	10,200	4,700	8,360	14,650	5,920	20,570
1962/63	"	7,730	9,550	10,200	7,730	9,550	16,720	10,390	27,110
1963/64	"	6,500	8,490	10,200	930	6,510	11,420	6,570	17,990
1964/65	"	6,970	8,740	10,200	580	5,330	9,370	5,000	14,380
1965/66	"	6,610	8,850	10,200	6,400	8,300	14,570	7,320	21,890
1966/67	"	8,370	9,830	10,200	8,370	9,830	17,220	16,800	34,020
1967/68	"	6,520	8,810	10,200	6,520	8,620	15,110	8,750	23,860
1968/69	"	10,200	10,200	10,200	10,200	10,200	18,040	25,140	43,180
1969/70	"	7,030	9,020	10,200	4,170	7,300	12,810	7,910	20,720
1970/71	"	8,450	9,720	10,200	8,450	9,720	17,030	33,050	50,080
1971/72	"	9,390	10,100	10,200	9,390	10,100	17,680	20,880	38,560
1972/73	"	6,730	9,050	10,200	6,730	9,050	15,860	15,240	31,100
Mean	10,200	8,030	9,500	10,200	6,400	8,870	15,550	12,600	28,150

Remarks:
- Installed capacity 5,100 kW x 2 units = 10,200 kW
- Maximum operating level EL. 136.0 m (H.W.L.)
  Minimum operating level EL. 127.0 m (L.W.L.)
- 85 % dependable peak power: 6,900 kW

Note:
/1 Max. power output under given hydraulic conditions
/2 Average peak power output for 6-hour operation
/3 Plant factor assumed at 85 %

Average annual supply to the irrigation area is $438 \times 10^6 m^3$ and the output of the power generation 28,200 MWh. Table I-4 summarizes the results of reservoir operation studies. Storage and discharge hydrograph of the reservoir are shown in Fig. I-8.

Table I-10 Summary of Reservoir Operation Study (for a period of 20 years from 1953 to 1973)

Wonogiri reservoir:	
- Normal high water level	EL. 136.0
- Low water level	EL. 127.0
- Effective storage capacity	$440 \times 10^6 m^3$
Water requirement: (average year)	
- Irrigation	$438 \times 10^6 m^3$ /1
- Release for minimum discharge in downstream reaches	$30 \times 10^6 m^3$
- Power	$582 \times 10^6 m^3$ /2
Water supply:	
- Average annual inflow	$801 \times 10^6 m^3$ /3
- Spillage and evaporation loss	$219 \times 10^6 m^3$
- Supply for irrigation and other uses	$582 \times 10^6 m^3$
Power generation:	
- Installed power capacity	10,200 kW
- Average annual energy output	28,200 MWh

/1 Including loss in Colo pondage

/2 Assumed plant factor: 80%

/3 Inflow after U/S dams completed

4.5. Plan Formulation of Proposed Plan

The proposed plan of the Wonogiri dam and reservoir scheme has been defined through comparative studies of various structures.

4.5.1. Site selection

An alternative site of the Wonogiri dam is the Candi site, about 3 km upstream from the proposed site. As to the comparison between the both sites, a review of the Master Plan study had concluded that the proposed site was superior taking both the geological aspect and water resources available at the site in view. (The proposed site is blessed with about 1.6 times of water resources as compared with the alternative site).

Therefore, investigation and study conducted this time were concentrated on the proposed site, located just downstream of the confluence with Kali Keduwan.

4.5.2. Type of dam

Concrete gravity type and homogeneous embankment type were eliminated at an early stage of the study, because of the unsuitable geological condition for the former and the limited availability of embankment material for the latter.

It appeared that the rockfill type would be recommendable because rock materials (tuff breccia) of relatively good quality would be available from the mountain-foot areas on the left bank near the damsite (Kedungareng-Pancil area). Although the area has not been investigated by subsurface explorations yet, the result of geological reconnaissance indicates that the area will yield suitable rock materials both in quality and quantity.

A prospective borrow area of impervious core material is Candi area, located about 3 km upstream from the damsite. The material available from this area consists mostly of finer grains, classified as CH under Unified Soil Classification System.

A series of laboratory tests indicated that the material would require quality improvement by mixing sandy materials before being placed in the embankment. As the mixture operation causes a relatively high cost of core material, it will be desirable to select such a type of rockfill as requiring the minimum embankment of impervious core material.

Two types of the dam embankment, central core type and inclined core type, are examined for cost comparison. The result shown in Fig. 1-9 indicates that the central core type is superior to the inclined core type.

Besides the advantage of construction cost requirement, technical review also recommends the adoption of central core type embankment. They are,

Central core type

- Central core construction minimizes the possibility of future damages of dam structure due to settlement of core embankment.
- It is easy to carry out re-grouting works even if excessive leakage through the foundation rocks is observed after the completion.
- The government has much experience in constructing this type of dam, e.g. Karangkates, Lahor, etc.

Inclined core type

- Geological condition in the inclined core foundation area seems slightly inferior to that in the central core foundation area.
- A diversion cofferdam must be constructed in an area between the foot of inclined core embankment and the confluence of Kali Keduwan. The area appears to be insufficient for placing the cofferdam of required height.

4.5.3. Right bank fill (Sub-dam):

Geological explorations revealed that the right bank area of the proposed damsite is covered with a thick layer of overburden earths and heavily weathered tuff, reaching 17 m at the deepest. In this respect, the selection of the type of embankment along the right bank ridges was a matter of consideration.

To select the economic type of embankment, a comparative study was conducted for the following 2 alternatives:

Plan (a) : Same embankment as the main part of dam. Core will rest on groutable rock layer which occurs at about 15 to 17 m depth.

Plan (b) : Randum fill with laying impervious blanket on the upstream side of the ridge. Excavation required for the blanket fill will be limited only to surface soft clay layer.

Cost comparison study indicated the advantages of Plan (b), although the difference is minor in the order of U.S.$.500,000. The Plan (b) was selected to be included in the proposed plan.

4.5.4. Spillway

(1) Capacity of spillway

Size and capacity of spillway relates to the height of dam. If a spillway of larger discharge capacity is provided, it will require less flood routing capacity of the reservoir and consequently a lower dam. Conversely, a small spillway will require a higher dam.

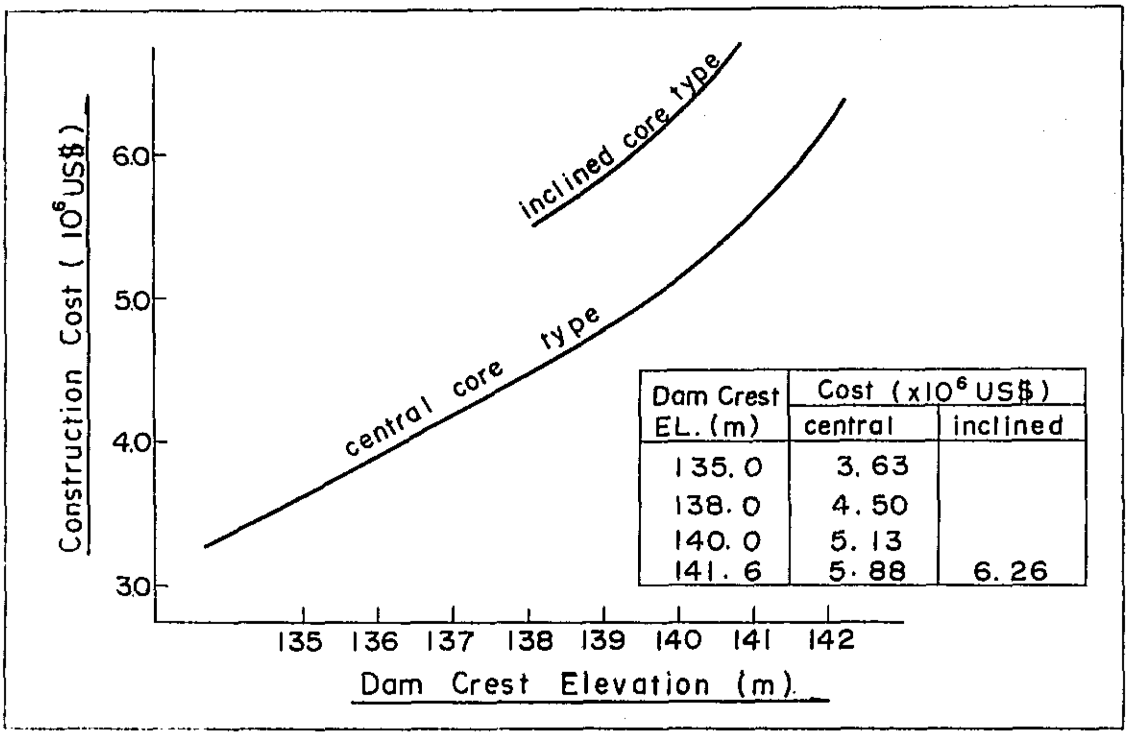
The optimum scale of spillway would be obtained from minimization of combined costs of the dam, spillway and land acquisition in reservoir area.

Required costs are estimated for alternative cases of different spillway capacities and associated dam crest heights. The result shown in Fig. I-10 and I-11 indicate that the most economical combination of the spillway capacity and dam crest elevation would be 1,410 m^3/sec (at spillway design flood) and EL 141.6 m respectively.

(2) Location and type of spillway

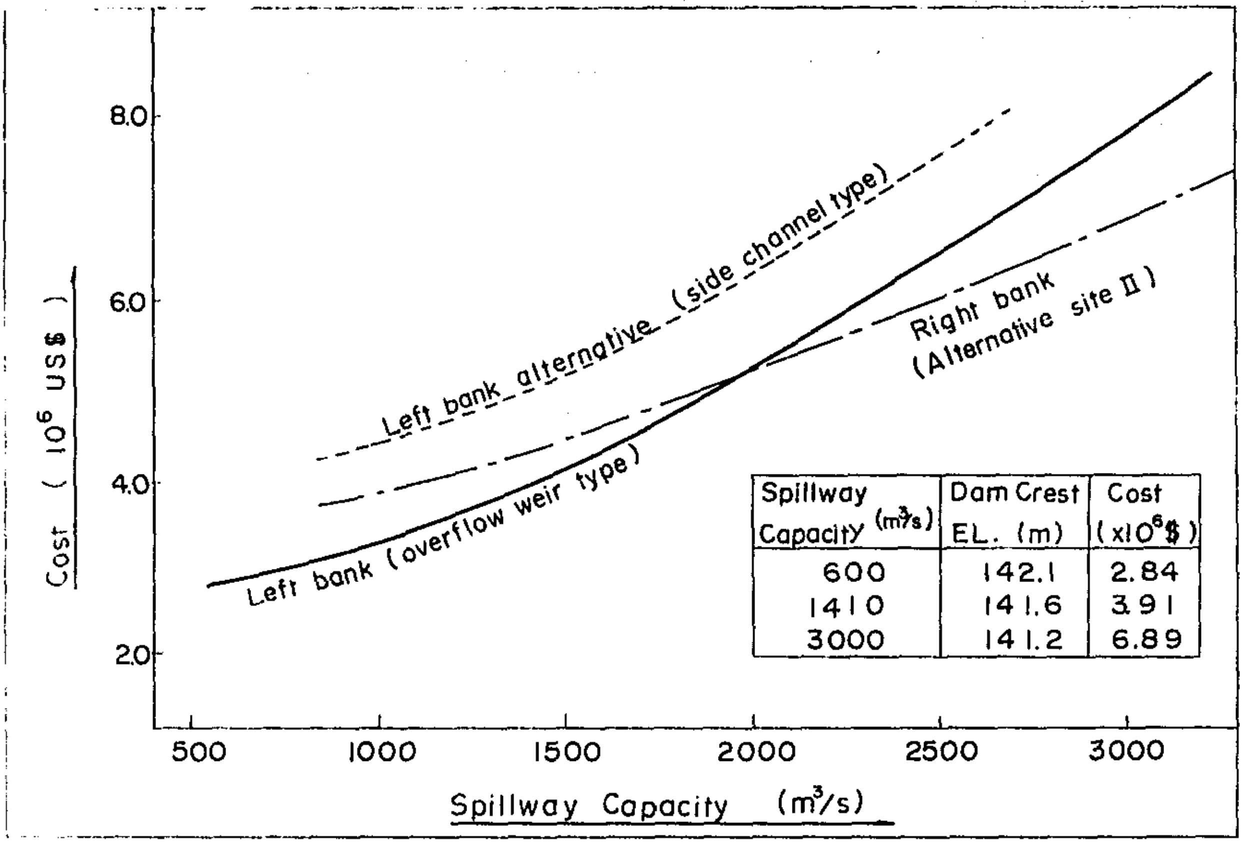
Proposed spillway, located on the left bank, is the overflow weir type with a chuteway, 20 m wide.

Fig I-9 Construction Cost of Rockfill Dams



Dam Crest EL. (m)	Cost (x10^6 US$)	
	central	inclined
135.0	3.63	
138.0	4.50	
140.0	5.13	
141.6	5.88	6.26

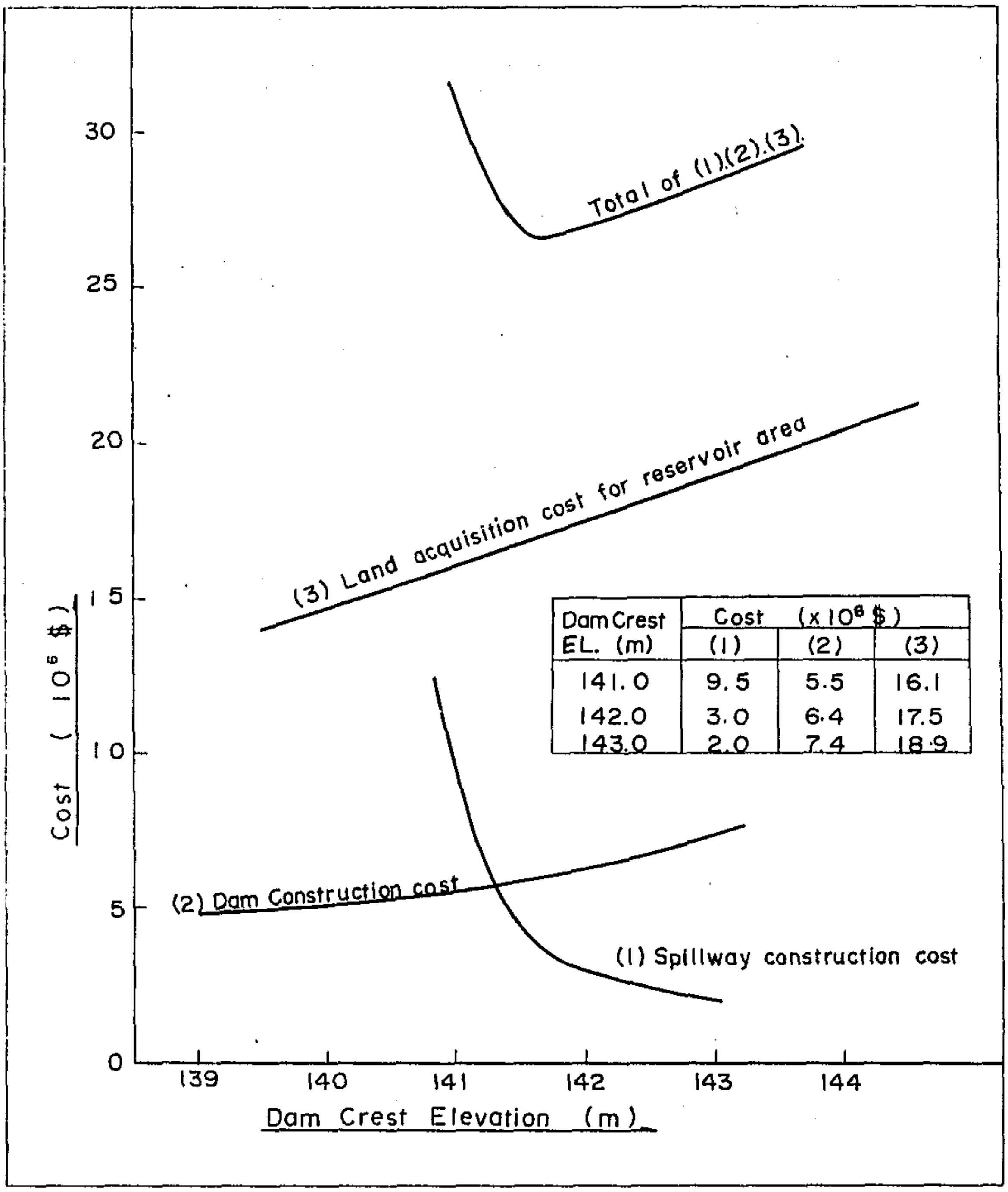
Fig I-10 Construction Cost of Spillway



Spillway Capacity (m^3/s)	Dam Crest EL. (m)	Cost ($\times 10^6$ $)
600	142.1	2.84
1410	141.6	3.91
3000	141.2	6.89

Note: The above cost includes cost for spillway gate

Fig. I—II Optimum Combination of Spillway Capacity and Dam Height



Dam Crest EL. (m)	Cost (x 10^6 \$)		
	(1)	(2)	(3)
141.0	9.5	5.5	16.1
142.0	3.0	6.4	17.5
143.0	2.0	7.4	18.9

In selecting the type and location of spillway, the following alternatives were studied for cost comparison.

Table I-11 Spillway Alternatives

Item	Location	Type	Construction cost/1 (10^3 U.S.$)
(1) Proposed plan	Left bank	Overflow weir Chuteway width 20 m (Ref. DWG. WD-003)	3,910
(2) Alternative I	"	Same type as the proposed spillway Chuteway width 15 m	4,100
(3) Alternative II	"	Side channel type Chuteway width 20 m	4,970
(4) Alternative III	Right bank	Overflow weir type Straight chuteway, 20 m wide	4,400

Note: Spillway capacity 1,550 m^3/sec (at W.L. 138.9 m)
/1 including cost for spillway gate

So far as the result of cost comparison study indicates, the proposed plan is recommended and therefore adopted in the design. Seismic exploration data show that the proposed weir site is in the area of comparatively sound rock zone of 3 km/sec in seismic velocity.

Another alternative was an overflow weir type spillway at the saddle of the right bank ridge. (Alternative IV in Fig. I-12). However, this plan was abandoned because of unfavourable geological condition at the weir site and the large work requirement involved in a long chuteway of about 1,200 m.

4.5.5. Diversion conduit

A preliminary plan of the river diversion work was the excavation of a diversion tunnel underneath the left abutment of the dam. The tunnel planned is 7 m in diameter and about 500 m long (See Fig. I-12 for proposed layout).

Geological investigation data revealed, however, that the tunnelling work would involve some technical difficulties and require a relatively high construction cost in the order of U.S.$ 1,900,000. Therefore, this plan was abandoned.

An alternative plan was the construction of a diversion conduit along the river side on the right bank. This plan gives the lower cost requirement of about U.S.$ 810,000 excluding plant and equipment depreciation cost which is nearly 50% of the tunnel plan.

A comparative study was conducted to find an appropriate scheme of the river diversion works. Alternatives assumed were 3 different sizes of diversion conduit, being varied from 6 to 8 m in diameter. For each of the alternatives, the required height of main cofferdam was worked out. (See Table I-12 for the details of alternative plans.)

Total construction cost for diversion conduit and the incremental volume of cofferdam shows the advantage of adopting the plan of 6 m. diameter conduit. However, in view of the minor cost difference between the plans and expected critical time schedule of the cofferdam construction during 1978 dry season, the plan of 7 m diameter conduit was finally selected.

Another reason for the selection of the 7 m dia. conduit was to reduce the risk of submergence of existing railway bridge located upstream of the damsite. The bridge will be utilized for hauling core materials during the construction period.

Another alternative plan of the diversion work is to utilize the pressure tunnel as a diversion tunnel. However, the plan seemed difficult in view of the limited time allowed for the powerplant construction after the closure of the tunnel. If this plan is adopted, the completion of the powerplant will be delayed by about one year. Further details will be studied at the time of detailed design.

Fig. I —12 Alternative Layout of Spillway & Diversion Tunnel

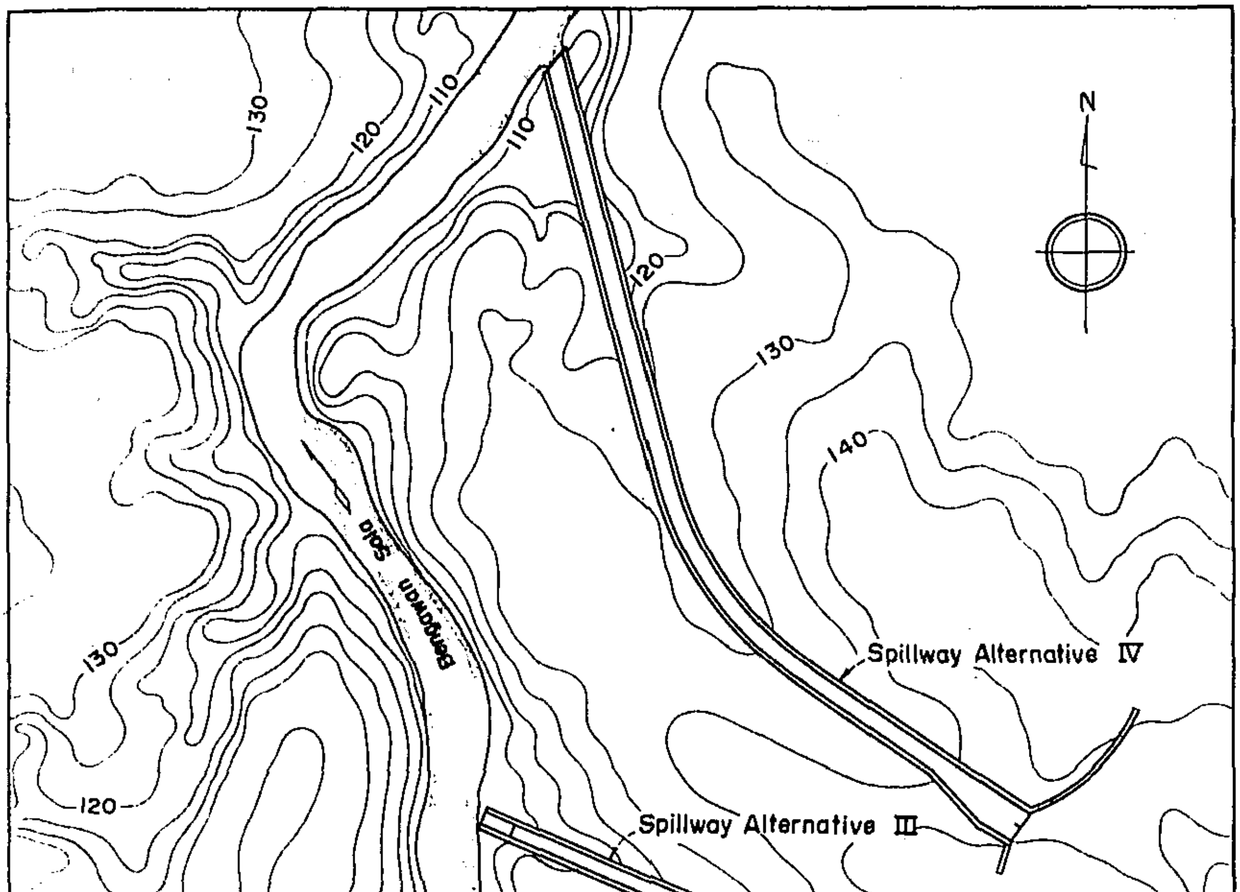


Table I-12 Alternative Plans of River Diversion Work

Item	Plan I	Plan II	Plan III
Diversion conduit	6 m dia.	7 m dia.	8 m dia.
Main cofferdam crest EL (m)	128.5	127.7	127.0
Increased volume of main cofferdam embankment (m^3)	+50,000	+25,000	±0
Construction cost (10^3US.$)			
- Diversion conduit	670	810	1,120
- Increment of cofferdam embankment.	140	70	0
- Total	810	880	1,120

Note: Depreciation cost of plant and equipment not included in the above estimate.

5. DESCRIPTION OF PROJECT

5.1. Damsite Geology

In the right bank area, ridges develop at a relatively low elevation. This particular topography requires a dam to be constructed over a long distance of about 1,440 m. Overburden (including heavily decomposed tuff) in the right bank area is generally thick with acceptable foundation rock occurred at about 15 m depth.

The left bank ridge at the damsite forms a massive abutment at more than 100 m above the river bed. Overburden above the proposed foundation rock is 5 to 10 m thick in the left bank area.

The damsite is mostly in the province of tuff breccia. The rock is not so fairly consolidated and hard, but seems acceptable for the foundation of a rockfill dam of the proposed height. It is generally water-tight, allowing little chance for excessive leakage.

No major geological defects were detected by subsurface explorations conducted this time, except for minor faults observed at abutment on the left bank.

5.2. Dam and Reservoir

The proposed damsite is located on the main stem of Bengawan Sala just downstream of the confluence with Kali Keduwan.

The reservoir created by the dam will have a surface area of 87 km^2 at high water level during the inflow of S.H.F.D. (EL. 138.2 m) and a gross storage capacity of 730 x $10^6 m^3$.

The normal high water level of the reservoir is at EL. 136 m and the low water level at EL. 127 m. The storage between them will be 440 x $10^6 m^3$, which is an active storage for the supply of irrigation and power water.

For flood control purpose, a storage of 220 x $10^6 m^3$ will be provided above controlled water level of EL. 135.3 m, which is 0.7 m below the normal high water level. Fig. I-13 shows the space allocation of the reservoir.

The dam consists of the central core embankment with outer shells of rockfill. The maximum height of the dam is 37.5 m above the foundation rock and the crest length is about 1,440 m. The dam crest level of EL. 141.6 m provides a freeboard of 2.7 m above the extraordinary flood level (EL. 138.9 m) and 3.2 m above the spillway design flood level.

The free board of 2.7 m provided above the extraordinary flood level consists of:[/1]

(i)	Wind wave:	1.2 m
	- Wind velocity	20 m/s
	- Max. distance of waving in reservoir	11 km
	- Height of wave due to earthquake is estimated at 0.4 m, which is smaller than the wind wave	
(ii)	Allowance for misoperation of gates:	0.5 m
(iii)	Free board specifically provided for fill-type dam:	1.0 m
	Total	2.7 m

Random fill proposed for the ridge on the right bank intends to make an effective use of materials excavated from spillway, intake, powerplant and tunnels. Selected rocks from excavation will also be utilized for embankment in inner zones of the main dam.

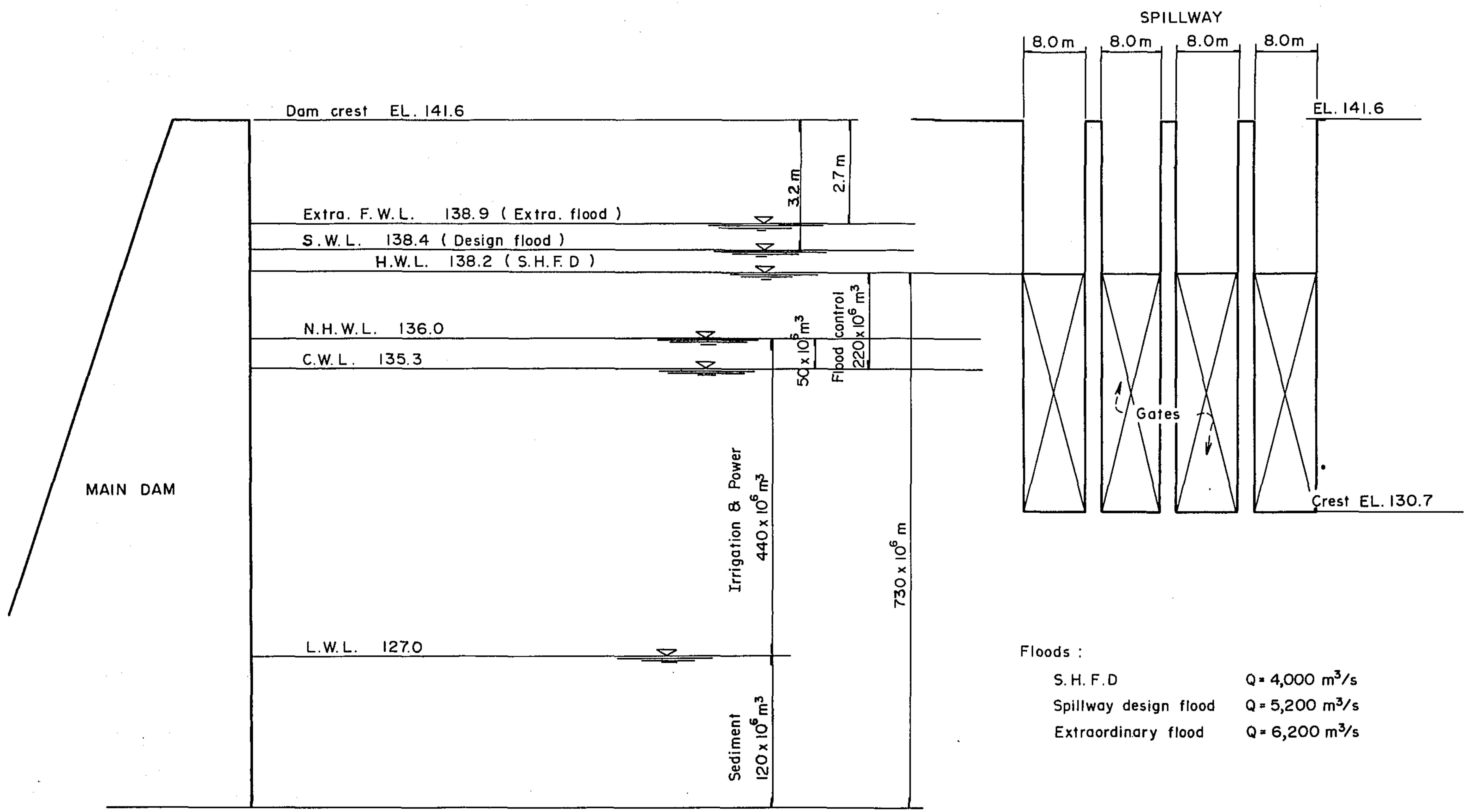
The thickness of vertical core is kept to a minimum in view of the relatively high cost of core material.

Embankment volumes required in the dam are shown in Table I-13 together with the source of materials.

In the foundation area of core embankment, a row of curtain grouting and grids of blanket grouting will be required.

/1 Japanese Committee on Large Dams: Design Criteria for Dam

Fig I - 13 ALLOCATION OF RESERVOIR STORAGE



The stability analysis of dam was carried out for the preliminary design of embankment section. Stability calculation was made for the following cases:

1) normal high water level without horizontal earthquake acceleration,
2) normal high water level with horizontal earthquake acceleration,
3) empty reservoir without horizontal earthquake acceleration,
4) empty reservoir with horizontal earthquake acceleration.

Assumptions and constants used in the analysis are given below:

1) unit weight of water: Pw = 1.0 ton/m^3
2) density of embankment materials

core material	wet	: γ_t = 1.79
	saturated:	γ_{sat} = 1.80
filter material		: γ_t = 1.94
		: γ_{sat} = 2.15
rock material		: γ_t = 1.85
		: γ_{sat} = 2.12

3) seismic coefficient K = 0.12
4) angle of internal friction of materials

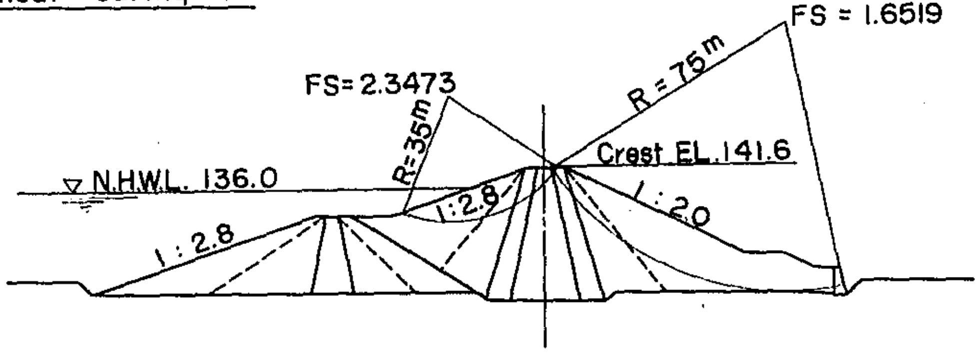
core material	ϕcu = 18.5°
filter material	34°
transition material	36°
rock material	37°

5) cohesion of core material C = 3 ton/m^2
6) normal high water level EL. 136.0 m
7) crest elevation of coffer dam EL. 127.7 m
   crest elevation of main dam EL. 141.6 m

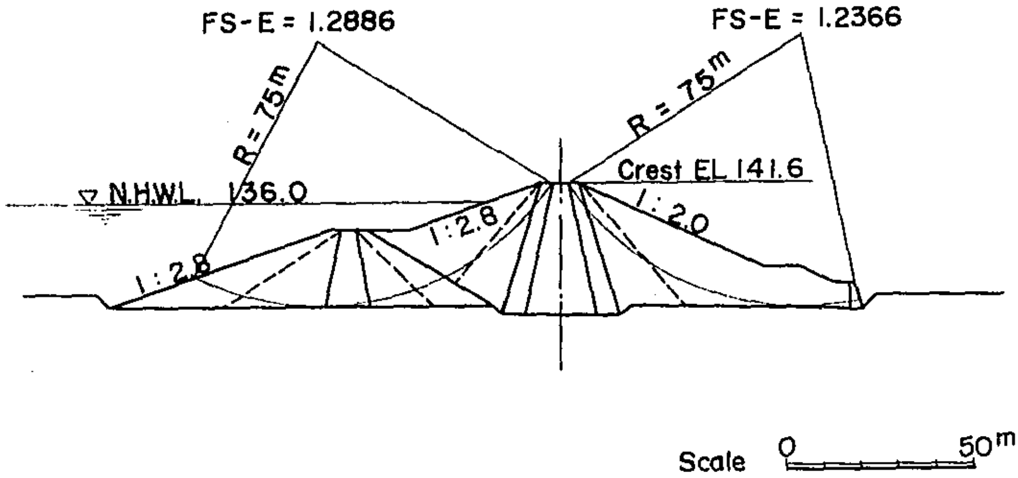
The calculation was made for several different embankment sections varying the slope of embankment. As the result, the slope gradient was determined as 1:2.8 for the upstream and 1:2.0 for the downstream faces respectively. The result of stability analysis is shown in Fig. I-14.

Fig. I - 14 Stability Analysis of Dam

Without earthquake



With earthquake



SLOPE GRADIENT	UPSTREAM SIDE 1 : 2.8 DOWNSTREAM SIDE 1 : 2.0		
RESERVOIR	FULL		EMPTY
SIDE	UPSTREAM	DOWNSTREAM	UPSTREAM
K = 0	2.3473	1.6519	2.3874
K = 0.12	1.2886	1.2366	1.8557

Table I-13 Volumes of Materials Required and Wasted

Material	Volume (10^3 m^3 emganlonent measure)						
	Core	Filter	Transi-tion	Rock	Randum fill	Earth blanket	Waste
Required in dam	241	166	283	736	287	86	-
Available from							
Diversion conduit	-	-	20	-	-	-	60
Dam foundation	-	-	-	-	70	86	390
Spillway	-	-	100	80	190	-	140
Intake	-	-	20	10	20	-	40
Pressure tunnel	-	-	-	-	-	-	15
Powerplant	-	-	20	10	10	-	20
Deficiency supplied from							
Candi area	241	-	-	-	-	-	-
Rack quarry		166	123	636	-	-	-

Note: Of the total waste volume (665,000 m^3, in embankment measure), about 130,000 m^3 will be utilized for embankment of temporary cofferdams, backfill around powerplant, etc.

5.3. Spillway

The proposed spillway, on the left bank, consists of an overflow weir 39.5 m wide, concrete-lined chuteway 20 m wide and 340 m long, and hydraulic-jump stilling basin 45 m long. On the overflow weir crest are provided 4 nos. of roller gates, 8 m wide by 7.7 high. Dwg. WD-003 illustrates the design features of spillway.

The spillway is capable of passing the estimated extraordinary flood at a water level of EL. 138.9 m, which is 2.7 m lower than the crest of the dam. This ensures that the dam will not be endangered by the occurrence of any flood events. Table I-14 summarizes outflow discharge and corresponding reservoir water level at the passage of several assumed floods. Flood hydrographs are shown in Fig. I-15.

Table I-14 Flood Inflow and Spillway Discharge

Flood event	Peak inflow discharge (m^3/s)	Total volume of flood ($10^6 m^3$)	Peak outflow discharge (m^3/s)	Max. reservoir (EL.)
S.H.F.D.	4,000	280	400	138.2
Spillway design flood	5,200	370	1,410	138.4
Extraordinary flood	6,200	448	1,550	138.9

Besides the above floods, another abnormal flood event was assumed to ascertain further the safety of dam. The assumed flood event is the occurrence of a double peak flood of the magnitude of spillway design flood (5,200 m^3/s), the peaks occurring at 4-day interval. Even in this case, the maximum reservoir water level rises only to EL. 138.5 m and the dam is still safe against such an abnormal flood event.

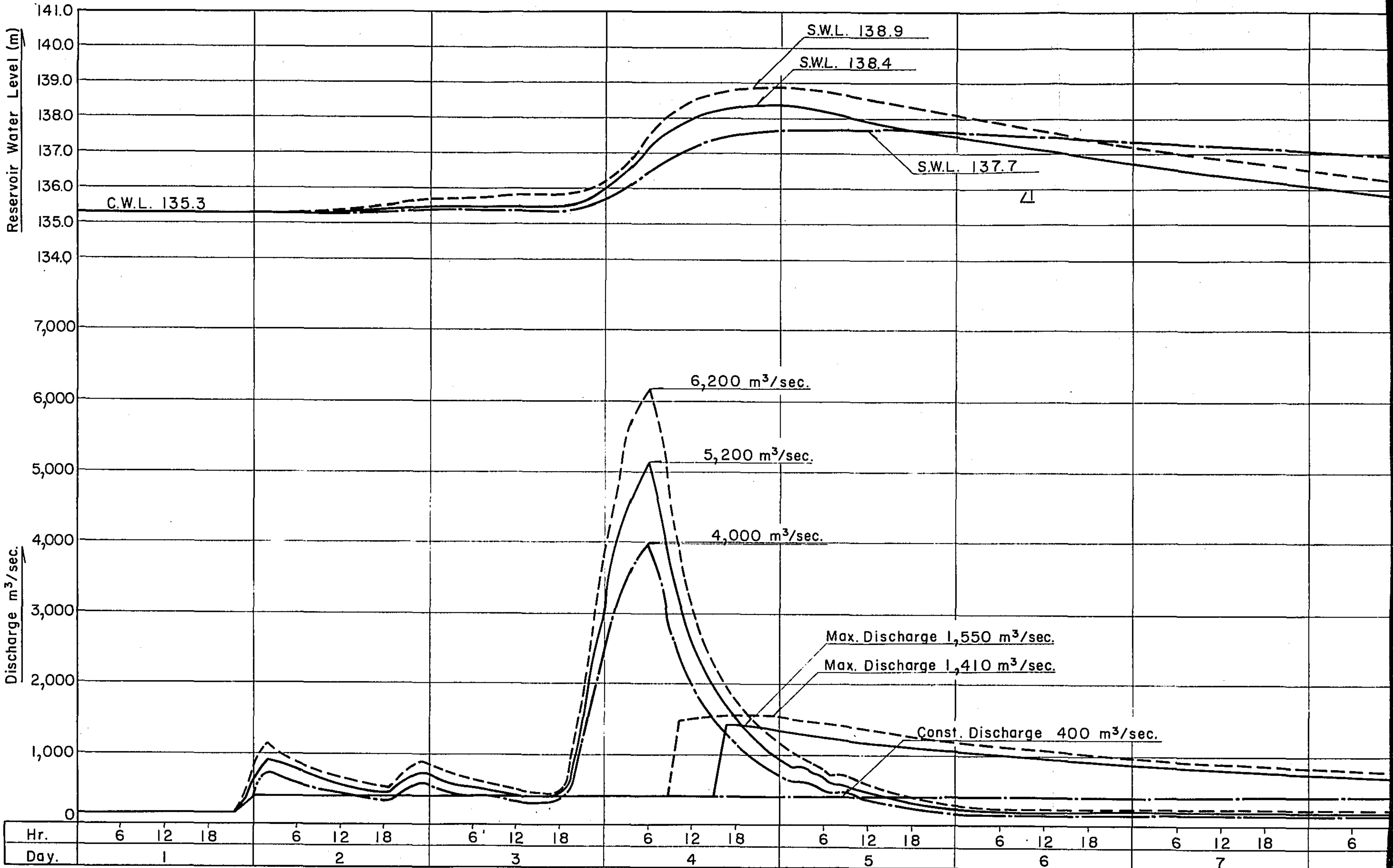
The proposed gate operation rule is that the gates will be partially opened to control outflow discharge at 400 m^3/sec unless the reservoir water level exceeds EL. 138.2 m. With this operation rule, the spillway will control most of usual floods less than S.H.F.D. (equivalent to 60-year flood) at the designated outflow discharge.

In case of occurrence of unusual large floods such as spillway design flood (peak discharge 5,200 m^3/s) and extraordinary flood (peak discharge 6,200 m^3/s), reservoir water level will rise above EL. 138.2 m. In such cases, the spillway gate will be fully opened.

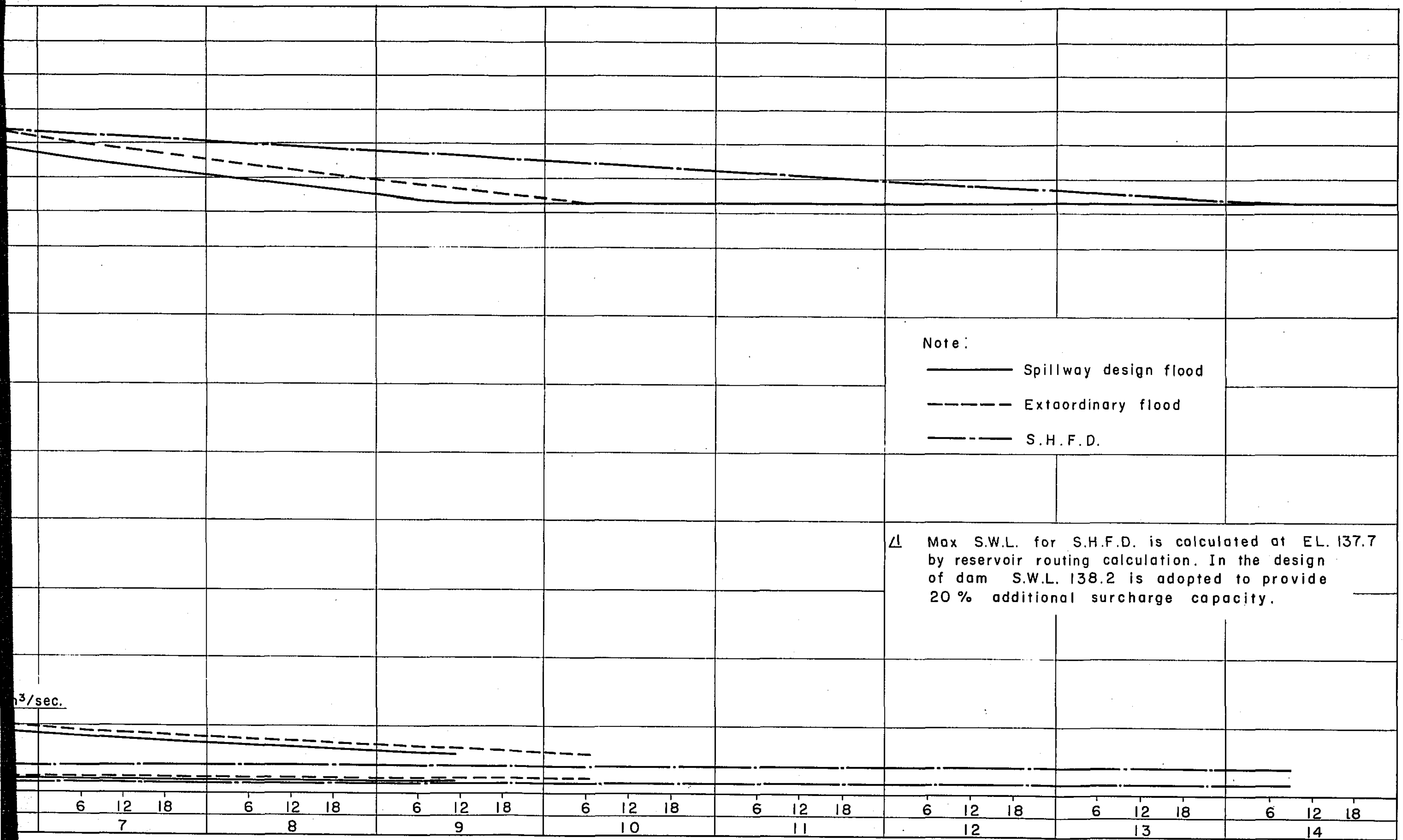
Even if extraordinary floods occur, outflow discharge through the fully opened spillway gates will be one fourth of the inflow discharge.

During the flood period ending March each year, the reservoir stage will be maintained below the control water level of EL. 135.3 m. It will be recovered to normal high water level (EL. 136.0 m) by the end of April.

Fig. I-15 Inflow and Outfl



Inflow and Outflow Hydrographs of Flood



5.4. River Diversion Work

During the construction period of dam, flow of the river will be diverted through a diversion conduit of 7.0 m dia. The conduit will be 290 m long located on the right bank.

Emergency outlet work will be provided in the plug concrete of diversion conduit. The work consists of a steel conduit of 1.4 m dia. equipped with oil-pressure gate and steel bulkhead. It will be operated to lower the reservoir water level in an emergency case occurring after the completion of the dam.

River diversion work includes the construction of two cofferdams upstream of the main dam embankment, primary cofferdam and main cofferdam. The primary cofferdam will be required during the construction of main cofferdam. It is planned to be safe against the probable dry season flood as large as 300 m^3/s in peak discharge.

The main cofferdam comprises a part of main dam embankment. It will have a crest elevation of 127.7 m, capable of handling a 20-year flood with peak inflow of 3,100 m^3/s. Embankment of about 265,000 m^3 will have to be completed during 4 months in the dry season of 1978.

Downstream cofferdam will have a crest elevation of 115.5 m, which is 0.8 m higher than the water level during the outflow of the 20-year flood discharge through the diversion conduit.

Table I-15 River Diversion Floods

Flood	Peak discharge (m^3/sec)		Water level	
	Inflow	Outflow (through diversion conduit)	Upstream	Downstream
20-year flood	3,100	540	127.2	114.7
Dry season flood	300	260	118.0	113.4

Note: (1) U/S primary cofferdam Crest EL. 118.5
U/S main cofferdam Crest EL. 127.7
D/S cofferdam Crest EL. 115.5

5.5. Intake and Pressure Tunnel

5.5.1. Intake

Proposed intake structure is of vertical tower type. It enables the maximum utilization of reservoir water for power generation down to the low water level (EL. 127.0 m).

The sill of intake is set at EL. 121.0 m, for enabling to utilize the water stored below the low water level, if the situation requires in such very droughty years.

The intake tower is of reinforced concrete construction, 17 m dia. and 23.6 m high above the foundation level. The structure incorporates a roller gate, 6 m wide by 6 m high, operated by hoisting equipment on the top of the structure. Steel trash racks are installed on each face of 6 openings of inlet.

5.5.2. Pressure tunnel and steel penstock

Pressure tunnel will deliver water to the powerplant and outlet work. It is a concrete-lined circular-shaped tunnel of 6 m in diameter.

To provide the maximum ground coverture above tunnel roof in the area below the dam foundation, the tunnel takes a curved route into deep abutment at the lowest elevation, EL. 107.3 m, which is the elevation of water turbines in the powerplant.

In view of the economy and low water pressure inside the tunnel, steel penstock will only be installed in a limited length of 60 m at the downstream end of the tunnel. The diameter of penstock varies from 6 m to 4.2 m.

5.6. Powerplant

Powerplant will be located close to the outlet of pressure tunnel on the left bank. The powerplant building is of reinforced concrete construction, 20 m wide by 32 m long. It will house two units of generating equipment of 5,100 kW capacity.

The plant is operated with reservoir water level varying from EL. 136.0 m (N.H.W.L.) to EL. 127.0 m (L.W.L.). Each turbine will have the hydraulic capacity of 30 m^3/s at a rated head of 21.1 m. Head loss of waterway is calculated to be 1.0 m including some allowance.

Further details of electrical and mechanical installations of the powerplant are included in Annex (I), Wonogiri Power Station.

5.7. Outlet Valve House

Outlet valve is provided to bypass irrigation water. Normally, the whole of any required release will be discharged through water turbines of the powerplant. Notwithstanding, outlet work is required, to be operated chiefly at an unusual condition such as the shutdown of the powerplant operation, etc.

A valve house, annexed to the powerplant building, will accommodate a unit of Hollow-jet valve of 1.80 m diameter. It is capable of discharging 35 m^3/s at the low water level of the reservoir.

5.8. Afterbay Weir (Colo Irrigation Intake)

An irrigation intake dam at Colo will act as an afterbay weir of the dam. Excess release of water from the powerplant over the irrigation requirement will be stored thereat for subsequent diversion to the irrigation areas. The required storage capacity of Colo weir is enough to store all the excess of released water, i.e. 1.2×10^6 m^3.

- Release from powerplant 60 m^3/s max.
- Diversion from Colo:
  - (1) Minimum of dry season months 4.6 m^3/s (Oct. 1971)
  - (2) Average of 20-year dry season months 21.8 m^3/s
- Storage requirement of afterbay:
  - (1) (60 m^3/s - 4.6 m^3/s) x 6 hrs. ≑ 1.2×10^6 m^3
  - (2) (60 m^3/s - 21.8 m^3/s) x 6 hrs. ≑ 0.83×10^6 m^3

Further details of the Colo weir are described in Annex (II), Irrigation.

5.9. Land Acquisition and Road Relocation

Right-of-land for the reservoir is estimated to be approximately 9,700 ha. Land will be acquired and people relocated in accordance with appropriate legal procedures. The submerged area will have to be cleared before the impoundment of reservoir.

The maximum water level of the reservoir will rise to EL. 138.9 m at the occurrence of extraordinary flood. Acquisition of land will be made for the area below EL. 140.0 m, about 1 m above the maximum water level. Number of houses and inhabitants to be removed account for 23,000 houses and 9,600 families respectively.

The length of required road relocation work reaches about 55 km, of which 34 km will be the improvement of existing road and 21 km the construction of new road. It includes the construction of about 25 bridges.

Table I-16 Land Acquisition and Road Relocation

Reservoir			
Land	Cultivated land, Sawah	4,438	ha
	" , Tegal	2,851	ha
	Yard	2,239	ha
	Cemetery & forestry	206	ha
Houses		22,918	nos.
Inhabitant	Family	9,573	families
	Population	47,627	
Relocation of road			
New road construction		21	km
Improvement of existing road		34	km
Total		55	km
Bridges		25	nos.
Clearing of reservoir area (of a total area of 8,700 ha below EL. 138 m)		about 2,500	ha
Project construction site			
Land		24	ha
House		335	nos.
Population		1,350	

5.10. Recommendation on Sediment Control

In the basin area upstream of Wonorigi, most of the area has been opened for cultivation and only steep and rock-outcropped areas are left unused. The area is supposedly subject to surface erosion and is yielding sediment materials into the river. According to the previous survey at the time of the Master Plan study, however, erosion in the area is of moderate extent and most part of the sediment materials is yielded from the scouring of the river banks, especially along the courses of K. Wuryantoro, K. Gares, K. Ngrowo and K. Alang. To minimize the sediment materials being transported into the Wonogiri reservoir, it is recommended to provide ground sills, bank protection works and Sabo dams for those tributaries.

Erosion control in the high land area is also desirable. Reforestation is to be much exercised where is applicable. In the farmlands, the protection of cut and excavated slop surfaces, with providing such measures as sod facing, stone masonry, bamboo hardling will be required.

It will be recommended to carry out a further detailed survey on the erosion control and sediment prevention works in the subsequent stages.

6. CONSTRUCTION PLAN AND ESTIMATE

6.1. Construction Materials

(a) Embankment materials

The project construction includes approximately 1,900,000 m^3 of embankment work, of which 1,800,000 m^3 will be required for the main dam including impervious blanket fill.

Investigations have shown that impervious core, filter and rock materials for the dam embankment are all available from areas within 3 km from the damsite. The estimated yield of core materials from the proposed borrow areas is sufficient for the requirement.

For final assessment of the borrow areas, however, further detailed investigation will be required in the subsequent design stage.

Selected rock materials from the project excavation works will also be utilized for the embankment of dam, temporary cofferdams, powerplant backfill, etc.

Table I-17 Expected Material Sources

Location	Requirement	Total yield capacity	Remarks
Rock quarry B	510×10^3 m^3	$1,200 \times 10^3$ m^3	Rock Filter, Transition
Candi borrow area	240×10^3 m^3	500×10^3 m^3	Core
River deposit:			
Dam foundation area	140×10^3 ton	140×10^3 ton	Aggregate
K. Keduwan	60×10^3 ton	Sufficient	Aggregate (Filter-Alternative source)

(b) Concrete Materials

Estimated total quantity of concrete work is about 73,000 m^3 including temporary facilities works.

Aggregate will be supplied from the river deposit excavation in the dam foundation area. It is presumed that the deposit will yield about 140,000 tons of aggregate, which is slightly deficient for the total requirement. The shortage will be supplemented from sand and gravel bars existing along the course of Kali Keduwan.

Construction cost estimate in this report assumes that cement will be imported from abroad. Required quantity of cement will be about 24,000 tons including the requirement for grouting works.

Reinforcing steel bars of about 1,200 tons will also be imported from abroad.

(c) Mechanical and electrical equipment

Most of the hardware and equipment required for the work, such as structural steels, penstocks, gates, major electrical equipment, will have to be imported.

Other supplies such as steel sheets, wires, lighting equipment and fixtures are available in local market.

(d) Local materials

Local materials will be utilized to the maximum extent. The major items are wooden materials, bricks, stone-blocks, oil products, etc.

6.2 Construction Facilities

(a) General layout

Construction facilities include residential quarters, offices, warehouses, work shops, motor pool and repair shop, concrete and aggregate production plants, raw aggregate stockpiles and various construction roads. A tentative layout of the facilities is shown in DWG. No.WD-006.

The facilities will occupy a total area of about 24 ha, which will be acquired before the start of construction works.

(b) Office and quarters

The government office and quarters will be built on the left bank area, about 800 m apart from the future powerplant site.

The quarters will be provided with adequate residences, mess halls, a guest house and other necessary facilities to accommodate about 80 supervisory staff from the government and consultant. A part of the quarters will be of permanent construction for accommodation of future operation personnel after the completion of the works.

(c) Access road and bridges

Most of the construction materials, equipment and supplies will be transported by road from Surakarta to the damsite.

On the route of the existing road, there are 16 bridges including 2 large bridges spanning over the Bengawan Sala. Some of them appear not to have sufficient capacity for the passing of the project goods (40 tons maximum). Reinforcement of the existing bridges will be a primary work item to be performed before the commencement of main works.

(d) Road relocation near damsite

The existing road on the left bank of the damsite is to be relocated at an early period of the construction. The proposed route is shown on Dwg. WD-006.

6.3 Construction Plant and Equipment

The dam construction work requires about 45 items of construction plant and equipment.

Concrete production facilities will be one aggregate screening plant and one concrete batching plant, 50 ton/hour and 24 m^3/hour capacities respectively. Major items of heavy equipment will be 1.2 - 2.7 m^3 class shovels, 20 - 30 ton bulldozers and 8 - 15 ton dump trucks. Table I-18 shows the items and required number of plant and equipment.

Construction power will be supplied from a diesel generating plant of 1,000 kW capacity. Two pumping stations will supply construction water to various work sites including offices and residential quarters. The peak requirement of water supply is estimated to be about 8.4 m^3/min. Compressed air plant will be installed one each at the damsite and rock quarry.

This report assumes that equipment for the road relocation work could be procured locally.

Further details of the construction plants are as follows;

(1) Aggregate screening plant

The plant is of the simple type equipped with primary crusher, several stages vibrating screens, classifier and other accessories.

Daily concrete placement volume		200 m^3
Daily aggregate requirement	$200^{m^3} \times 2.1^{ton}$	= 420 tons
Daily operation hour		14 hrs
Working efficiency		0.6
Required plant capacity	$\dfrac{420^{tons}}{14^{hrs} \times 0.6}$	≑ 50 ton/hr

(2) Concrete batching and mixing plant

Daily concrete production requirement		200 m^3
Daily operation hour		14 hrs
Working efficiency		0.85
Required plant capacity	$\dfrac{200\ m^3}{14^{hrs} \times 0.85}$	= 17 m^3/hr

A semi-automatic concrete plant equipped with 2 units of 21 cft mixers will be installed.

(3) Water supply system

Construction water requirement is estimated as follows;

Location	Requirement
- Aggregate plant 50 ton/hr	1.5 m^3/min
- Concrete plant 21 cft x 2	0.2
- Repair shop	0.8
- Motor pool & storage yard	1.0
- Warehouses and shops	0.2
- Office	0.1
- Government living quarters	0.2
- Contractor's living camp	0.1
- Labour's camp	0.3
- Damsite work area	2.0
- Diesel generating plant	1.0
- Others	1.0
Total	8.4 m^3/min

Water is taken from the river, pumped up to head tanks through 300 mm dia. pipe line, and distributed to each delivery points. For the main supply system on the left bank, three units of 200 mm dia. centrifugal pump equipped with 75 kW motor will be installed at the pump station.

(4) Power supply system

Electric power generated by 2 units of 500 kW diesel generator is distributed to each site by 20 kV distribution line.

The peak requirement of power is totaled to 630 kW assuming the power demand factor of 0.45. In usual case, one generator can supply enough power to the work sites.

Location	Power requirement
- Aggregate plant 50 ton/hr	200 kW
- Concrete plant 21 cft x 2	50
- Water supply	225
- Lighting, damsite and road	50
- Repair shop	100
- Motor pool & work shops	35
- Office & quarters	150
- Dewatering pump	100
- Welding equipment	300
- Others	200
Total	1,410 kW

(5) Fuel supply system

Daily fuel consumption of equipment and mobiles is estimated to be 30,000 liters of light oil and 5,000 liters of gasoline at the peak construction time.

Three fuel storage and supply facilities will be provided. Required storage volume of the facility is estimated to be three times of daily consumption.

(i) Fuel tank on ground (light oil) .... 20,000 ℓ x 4 tanks

(ii) Fuel tank, underground (light oil) ..... 10,000 ℓ x 1 tank

(iii) Fuel tank, underground (gasoline) ...... 15,000 ℓ x 1 tank

Fuel tank (i) will be installed at diesel generator plant. It is erected on ground for convenience of gravity supply to the plant.

Table I-18 Construction Plant and Equipment for Dam and Road Relocation Works

Nos.	Equipment	Capacity	Required Nos. of Equipment		
			Total	Dam	Road relocation
1	Diesel generator	500 kW	2	2	-
2	Screening plant	50 ton/hr	1	1	-
3	Concrete plant	21 cft x 2	1	1	-
4	Bulldozer	30 ton	9	5	4
5	- do -	20 ton	10	5	5
6	Wheel loader	2.7 m^3	6	3	3
7	Crawler loader	2.0 m^3	5	2	3
8	Power shovel	1.2 m^3	3	3	-
9	Back hoe	0.6 m^3	1	1	-
10	Heavy dump truck	15 ton	15	15	-
11	Dump truck	8 ton	55	40	15
12	Agitator truck	3.2 m^3	6	6	-
13	Truck crane	50 ton	1	1	-
14	- do -	30 ton	1	1	-
15	Cargo truck	6 ton	15	10	5
16	Vibration roller	15 ton	1	1	-
17	Sheep foot roller	20 ton	1	1	-
18	Road roller	8 ton	4	1	3
19	Trailer truck	30 ton	1	1	-
20	Motor grader	3.7 m	3	1	2
21	Crease car	6 ton	2	1	1
22	Maintenance car	6 ton	1	1	-
23	Fuel tanker	8 ton	3	2	1
24	Water tanker	8 ton	4	2	2
25	Fork lift	3 ton	1	1	-
26	Boring machine	max 150 m	6	6	-
27	Grout mixer & pump	150 ℓ/min.	4	4	-
28	Crawler drill	3 inch bit	3	3	-
29	Leg drill and sinker	2.7 m^3/min.	25	15	10
30	Pick hammer	1.2 m^3/min.	25	15	10

Nos.	Equipment	Capacity	Required Nos. of Equipment		
			Total	Dam	Road relocation
31	Portable air compressor	17 m^3/min.	10	8	2
32	Concrete pump truck	8 inch	1	1	-
33	Concrete sprayer	2 inch	1	1	-
34	Centrifugal pump	8 inch	4	4	-
35	Submergible	6 inch	6	6	-
36	- do -	4 inch	6	6	-
37	Air tamper	hand type	15	15	-
38	Fuel supply system		1	1	-
39	Saw mill		1	1	-
40	Repair shop		1	1	-
41	Ripper attachment	Bull 30 ton	5	3	2
42	Crane attachment	Shovel 1.2 m^3	2	2	-
43	Dragline attachment	- do -	1	1	-
44	Back hoe attachment	- do -	1	1	-
45	Miscellaneous		L.S.	L.S.	L.S.

Note: Equipment for road relocation work will be procured locally.

6.4 Construction Method

Construction work will generally be done by conventional method.

Excavation will be mostly by blading and ripping with bulldozers, loading by shovels and hauling by dump trucks. Concrete is produced by a central mixing plant of 21 cft x 2 units and delivered to each placing site by agitator trucks.

Monthly average embankment of the dam will be about 140,000 m^3. In the placement of fill materials, impervious core zone will be placed in 25 cm layer and compacted by sheepsfoot roller. Pervious rock zones are placed in 0.5 m to 1.0 m layer with compaction effected by vibrating roller. Core embankment will be almost suspended during the wet season, mid November to mid May.

Excavation and concrete works for the spillway will be divided in 3 areas, i.e. overflow weir, chuteway and stilling basin areas. Excavation in the overflow weir and upstream part of chuteway will precede to supply rock materials to the cofferdam embankment. Concerning will progress intermittently in parallel with the intake, pressure tunnel and powerplant pour works.

In view of the expected geological condition along the route of pressure tunnel, the tunnel excavation will require adequate timbering works with using steel-rib supports. After providing the lining for its entire length, the tunnel may be deemed as an emergency diversion tunnel, to be utilized only at the occurrence of an abnormal flood event.

During the intake excavation and concrete works in the area of EL. 119.0 m; a part of the ground must be left unexcavated to form a cofferdam at a height of EL. 127.7 m.

The powerplant site will be excavated initially in a partial area for approaching to the portal of pressure tunnel. Subsequently, the area will be enlarged to the designated full width.

The project site is commanded by 2 distinct seasons, dry and flood seasons. River diversion work proposed for the dam construction works consists of 5 stages of operation:

(i) Construction of a diversion conduit (May 1967 to Apr. 1968)

(ii) Diversion of the 1968 dry season run-off through the diversion conduit. Dam foundation area is dewatered by upstream primary cofferdam and downstream cofferdam.(May to Oct. 1968)

(iii) River diversion throughout the year after the completion of main cofferdam.(Nov. 1968 to Sept. 1980)

(iv) Closure of the diversion conduit and commencement of the impounding of the reservoir.. (Oct. 1980 to Feb. 1981)

(v) Spillout of river flow from spillway. (Mar. 1981 expected)

The downstream cofferdam will be removed before the spillout of flow from the spillway.

6.5 Construction Schedule

Construction period of the dam and reservoir works will extend over a period of about 5 years starting in mid 1977 and completing in Mar. 1981. Construction works will proceed throughout the year, with maintaining 2 working shifts except during the peak wet period.

A proposed construction time schedule is shown on Fig . I-16 in the form of bar chart.

6.6 Construction Cost Estimate

The estimated construction cost of the Wonogiri dam project will be US$43,400,000, excluding generating equipment and transmission lines. It is composed of US$25,400,000 equivalent of local currency and US$18,000,000 of foreign currency portions respectively.

The estimate includes a contingency and reserve of about 15% and expenses for engineering service.

Table I-19 shows the estimated construction cost by work items and Table I-20 yearly disbursement schedule.

Construction cost estimated on financial cost basis is shown in Table I-21, together with yearly disbursement schedule.

Fig. I – 16 PROPOSED CONSTRUCTION SCHEDULE

WORK ITEM		Q'TY
DETAILED DESIGN	Main Works	
	Gov. Camp & Relocated road	
RESERVOIR	Land acquisition	9,750 ha
	Reservoir clearing	8,500 ha
ROAD RELOCATION	Submerged road	55 km
PREPARATORY WORKS	Reinforcement of bridges	16 nos
	Access road to camp & R.bank	3.5 km
	Government camp	
	Contractor's camp & shops	
	Construction roads	
	Construction plant	
	Procure. of const. equipment	
RIVER DIVERSION	Diversion cunduit	L = 290 m
	U / S Primary cofferdam	36,000 m³
	D / S Cofferdam	20,000 m³
	Plug Concrete	1,000 m³
MAIN COFFERDAM	Excavation	175,000 m³
	Embankment	265,000 m³
MAIN DAM	Excavation	450,000 m³
	Foundation grouting	19,000 m³
	Embankment	1,540,000 m³
SPILLWAY	Exavation	450,000 m³
	Concrete structure	37,000 m³
	Bridges	L = 40 m
	Gate installation	200 t
INTAKE & PENSTOCK	Excavation in intake	85,000 m
	Vertical shaft Exca. & Conc.	H = 12 m
	Intake tower concrete	H = 30 m
	Access bridge	L = 60 m
	Gates & screens	240 t
	Pressure tunnel	L = 225 m
	Steel penstock	170 t
POWERPLANT & OUTLET WORK	Excavation	50,000 m
	Backfill	12,000 m
	Powerplant building	
	Tailrace	
	Equipment installation	
TRANSMISSION SYSTEM	Switchyard	
	Transmission lines	

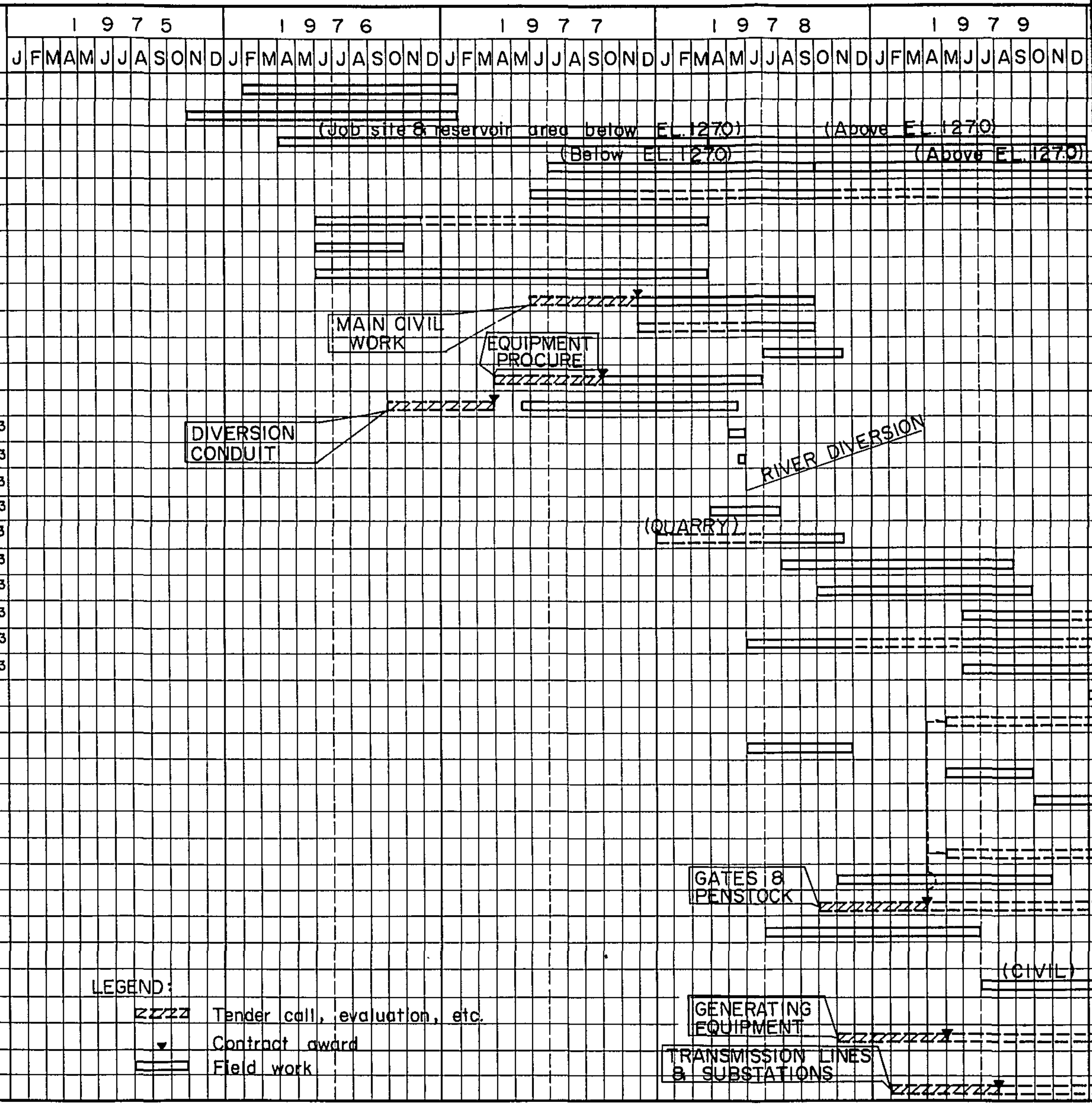


Fig. I-16 PROPOSED CONSTRUCTION SCHEDULE

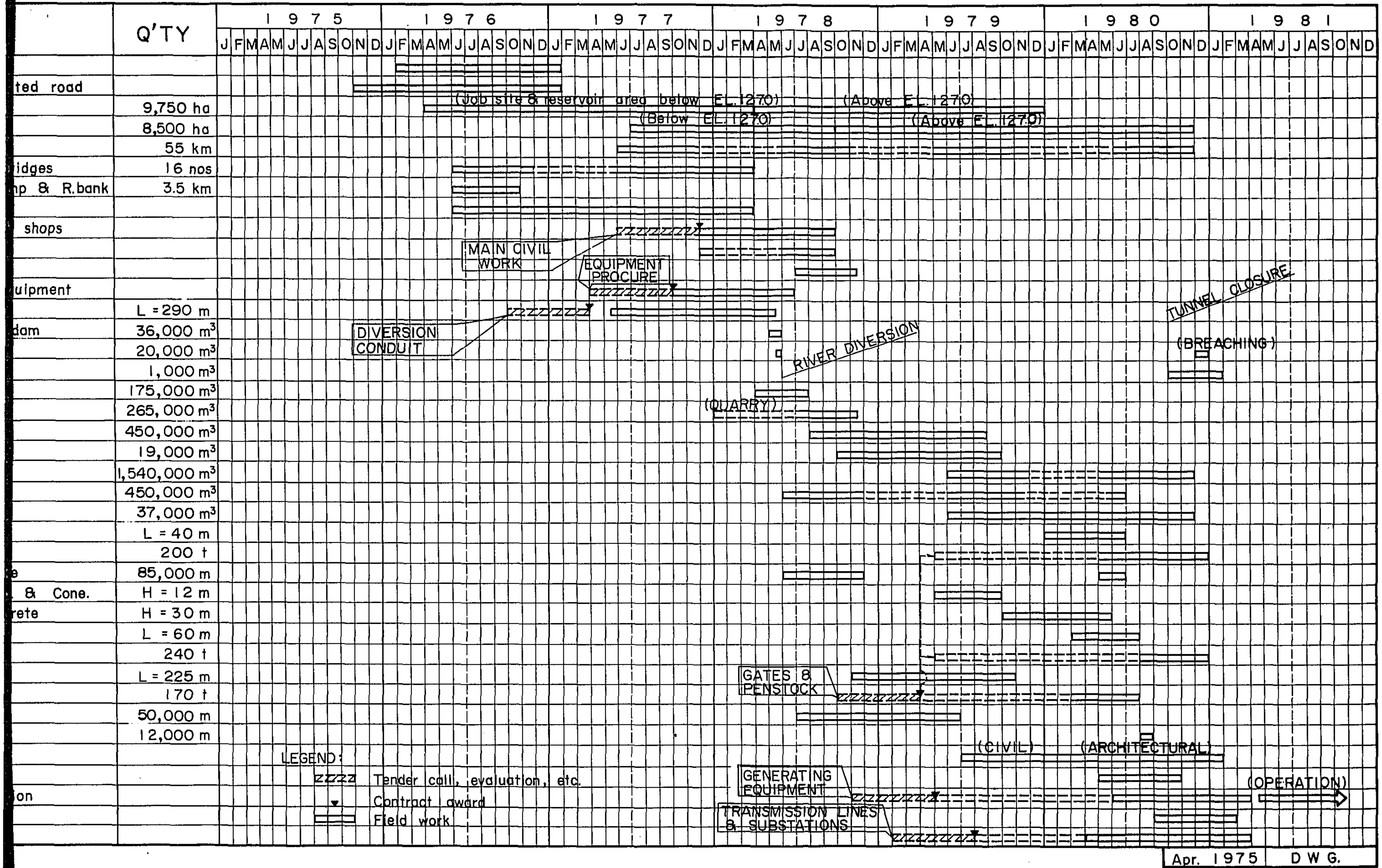


Table I-19 Estimated Construction Cost of Wonogiri Dam Project

	Work item	Total amount (10^3 US$)	Local currency (10^3 US$)	Foreign currency (10^3 US$)
I.	Main civil work	17,800	6,500	11,300
	(1) Dam and cofferdam	(5,880)	(2,380)	(3,500)
	(2) Spillway	(3,140)	(850)	(2,290)
	(3) Intake	(560)	(160)	(400)
	(4) Pressure Tunnel	(880)	(230)	(650)
	(5) Power house	(1,280)	(320)	(960)
	(6) River diversion	(1,020)	(810)	(210)
	(7) Construction facilities	(2,040)	(1,500)	(540)
	(8) Plant and equipment	(3,000)	(250)	(2,750)
II.	Gates and penstocks	2,100	300	1,800
III.	Land acquisition	11,600	11,600	0
	(1) Land acquisition	(11,300)	(11,300)	(0)
	(2) Reservoir clearing	(300)	(300)	(0)
IV.	Road relocation	4,000	3,200	800
	Total of I to IV	35,500	21,600	13,900
V.	Contingency & Reserve (15 %)	5,400	3,300	2,100
VI.	Engineering service & administrative expenses	2,500	500	2,000
	T O T A L	43,400	25,400	18,000

Table I-20 Yearly Budgetary Schedule

(Unit : 10^3US$)

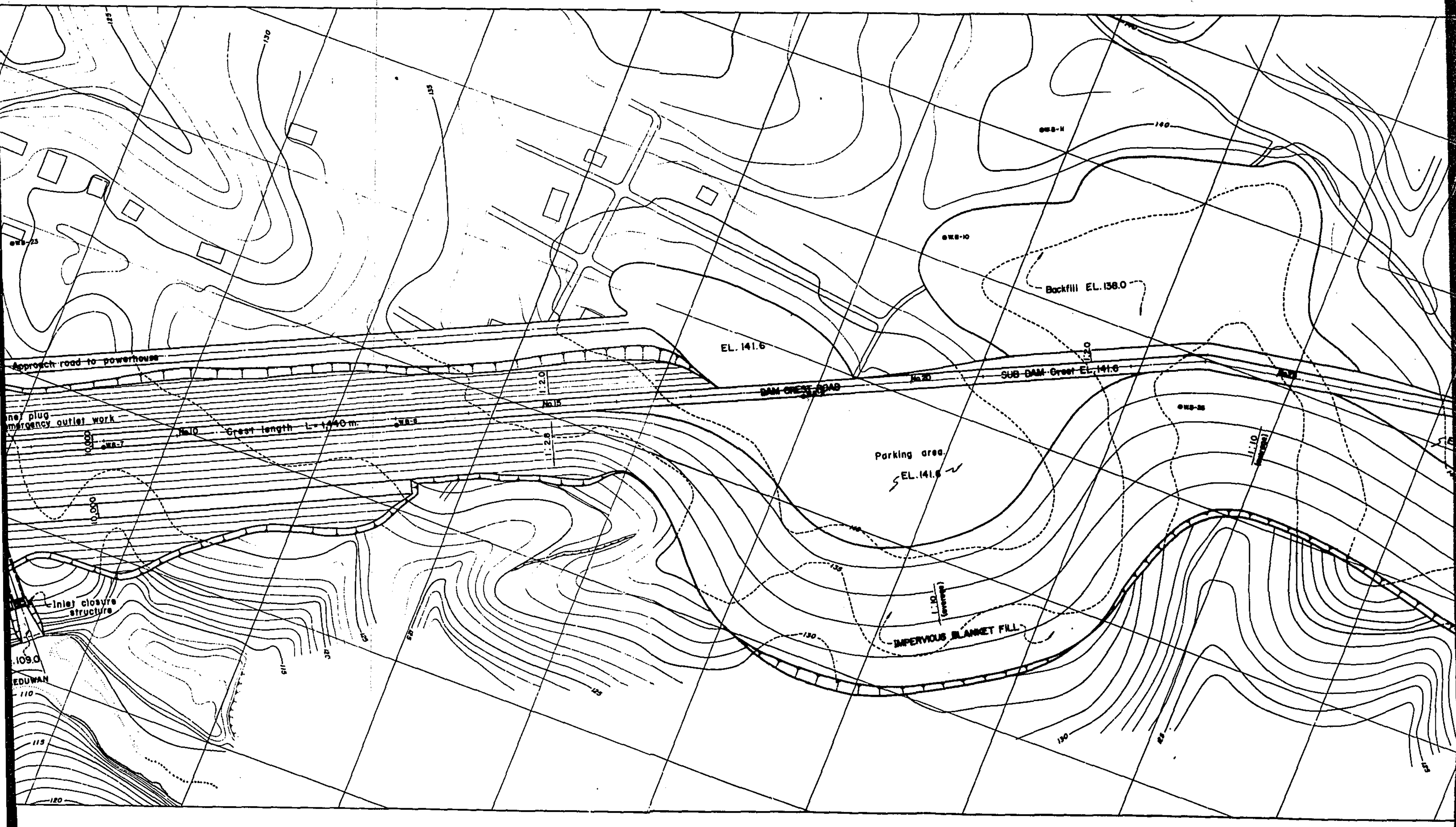
Work item	1976 L.C.	1976 F.C.	1977 L.C.	1977 F.C.	1978 L.C.	1978 F.C.	1979 L.C.	1979 F.C.	1980 L.C.	1980 F.C.	Remarks
I. Main Civil Works	420	-	1,510	580	1,300	2,370	1,780	4,820	1,490	3,530	
(1) Dam			(30)		(580)	(960)	(1,000)	(1,480)	(770)	(1,060)	
(2) Spillway					(140)	(190)	(460)	(1,300)	(250)	(800)	
(3) Intake					(40)	(70)	(70)	(210)	(50)	(120)	
(4) Pressure tunnel							(80)	(210)	(150)	(440)	
(5) Power house					(30)	(30)	(120)	(500)	(170)	(430)	
(6) River diversion			(570)	(70)	(180)	(90)	(30)	(20)	(30)	(30)	
(7) Construction facilities	(420)	-	(800)	(310)	(280)	(230)					
(8) Plant & equipment			(110)	(200)	(50)	(800)	(20)	(1,100)	(70)	(650)	
II. Gates & Penstocks					60	550	150	1,140	90	110	
III. Land Acquisition & Clearing	200		2,420		4,300		4,320		360		
(1) Land acquisition	(200)	-	(2,400)		(4,200)		(4,200)		(300)		
(2) Reservoir clearing			(20)		(100)		(120)		(60)		
IV. Road relocation			300	100	900	200	1,100	300	900	200	
Sub-total of I to IV	620		4,230	680	6,560	3,120	7,350	6,260	2,840	3,840	
V. Contingency & Reserve	80		670	120	990	480	1,100	940	460	560	
VI. Engineering Service & Administrative expenses			100	400	150	500	150	600	100	500	
TOTAL	700	-	5,000	1,200	7,700	4,100	8,600	7,800	3,400	4,900	

Table I-21 Construction Cost and Yearly Disbursement Schedule
(Financial Cost Basis)

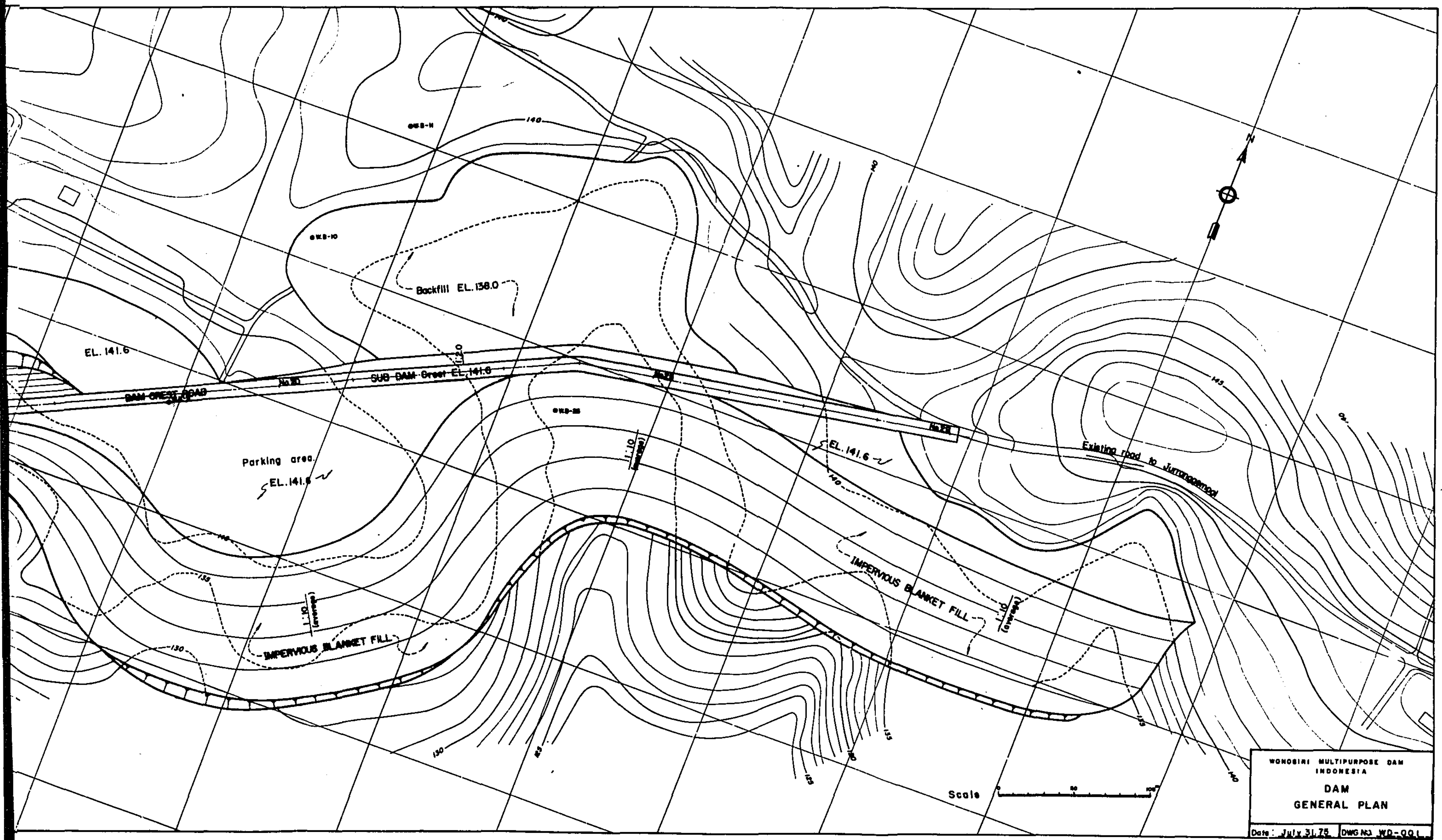
(Unit : 10^3US$)

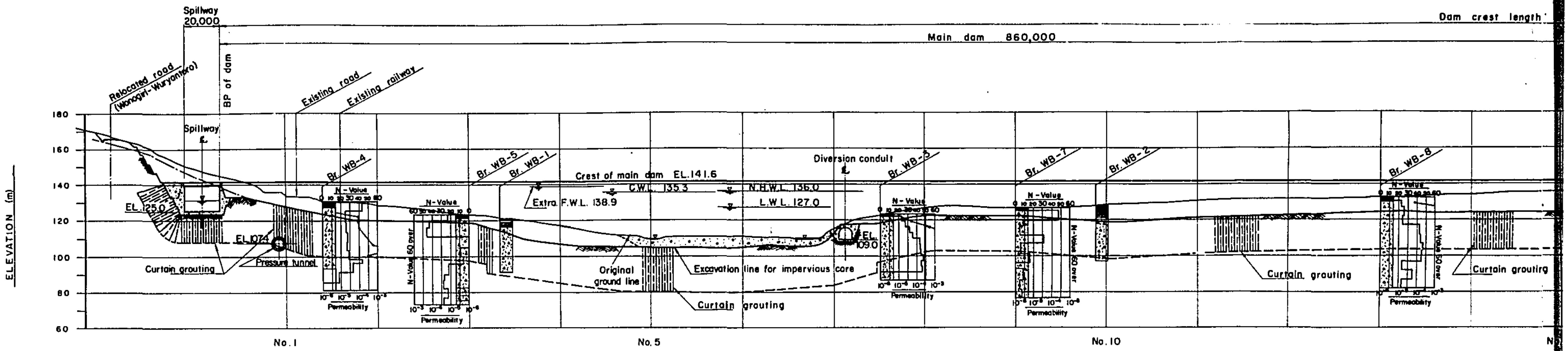
Work item	Estimated Construction Cost			Yearly Disbursement Schedule										Remarks
				1976		1977		1978		1979		1980		
	Total	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	
I. Main Civil Works	17,800	6,500	11,300	420	-	1,510	4,380	1,300	2,870	1,780	3,920	1,490	130	
(1) Dam	(5,880)	(2,380)	(3,500)			(30)		(580)	(960)	(1,000)	(1,480)	(770)	(1,060)	
(2) Spillway	(3,140)	(850)	(2,290)					(140)	(190)	(460)	(1,300)	(250)	(800)	
(3) Intake	(560)	(160)	(400)					(40)	(70)	(70)	(210)	(50)	(120)	
(4) Pressure tunnel	(880)	(230)	(650)							(80)	(210)	(150)	(440)	
(5) Power house	(1,280)	(320)	(960)					(30)	(30)	(120)	(500)	(170)	(430)	
(6) River diversion	(1,020)	(810)	(210)			(570)	(70)	(180)	(90)	(30)	(20)	(30)	(30)	
(7) Construction facilities	(2,040)	(1,500)	(540)	(420)		(800)	(310)	(280)	(230)					
(8) Plant & equipment	(3,000)	(250)	(2,750)			(110)	(4,000)	(50)	(1,300)	(20)	(200)	(70)	(-2,750)	
II. Gates of Penstocks	2,100	300	1,800					60	550	150	1,140	90	110	
III. Land Acquisition & Clearing	28,430	28,430	-	500		6,020		10,100		11,120		690		
(1) Land acquisition	(28,130)	(28,130)	-	(500)	-	(6,000)		(10,000)		(11,000)		(630)		
(2) Reservoir clearing	(300)	(300)	-			(20)		(100)		(120)		(60)		
IV. Road relocation	4,100	3,300	800			300	100	1,000	200	1,100	300	900	200	
Sub-total of I to IV	52,430	38,530	13,900	920		7,830	4,480	12,460	3,620	14,150	5,360	3,170	440	
V. Contingency & Reserve	7,900	5,800	2,100	80		1,170	620	1,890	580	2,100	840	560	60	
VI. Engineering Service & Administrative expenses	2,500	500	2,000			100	400	150	500	150	600	100	500	
TOTAL	62,830	44,830	18,000	1,000	-	9,100	5,500	14,500	4,700	16,400	6,800	3,830	1,000	


To Wonogiri
To Wonogiri
OUTLET VALVE HOUSE
OUTDOOR SWITCHYARD
Tailrace
POWER HOUSE
EL. 108.0
D/S COFFERDAM EL. 116.5
D/S Toe wall
EL. 113.7
EL. 117.5
EL. 117.5
Approach road to powerhouse
PRESSURE TUNNEL
Chuteway
Tunnel plug & emergency outlet work
Crest length L=1,440 m.
MAIN DAM Crest EL. 141.6
MAIN COFFER DAM Crest EL. 127.7
Crest road bridge
RELOCATED ROAD
Intake bridge
INTAKE
EL. 141.6
EL. 141.6
EL. 119.0
SPILLWAY
EL. 127.0
U/S PRIMARY COFFERDAM
EL. 118.5
EL. 109.0
Inlet closure structure
K. KEDUWAN
B. SOLO
Wuryantoro



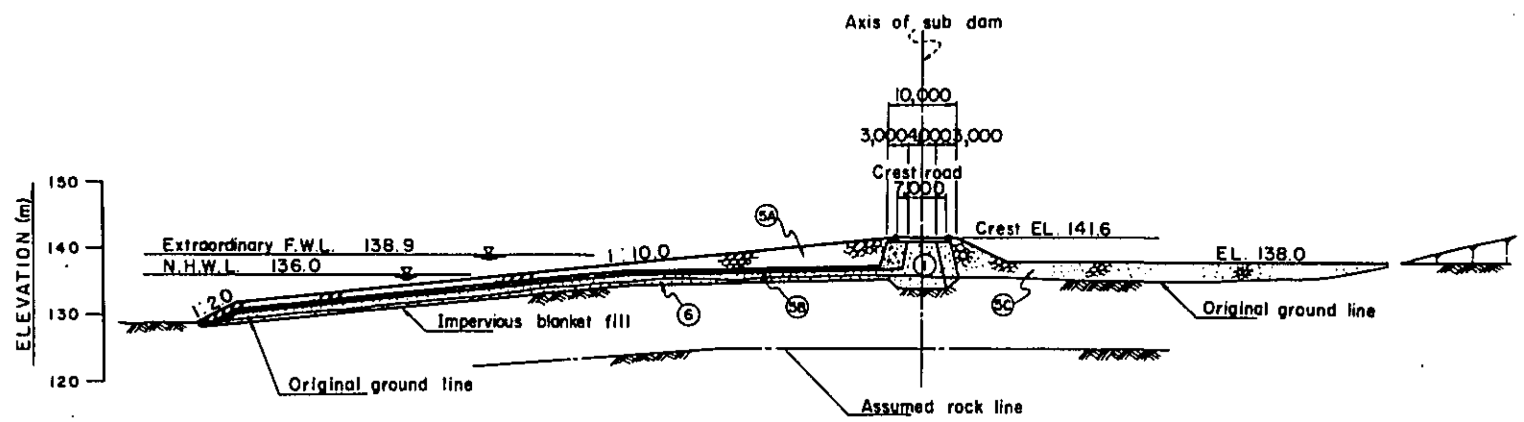
Approach road to powerhouse
EL. 141.6
DAM CREST ROAD
SUB DAM Crest EL. 141.6
Backfill EL. 138.0
Parking area
EL. 141.6
Crest length L = 1,440 m.
emergency outlet work
Inlet closure structure
IMPERVIOUS BLANKET FILL


Backfill EL. 138.0
EL. 141.6
DAM CREST ROAD
SUB DAM Crest EL. 141.6
Parking area
EL. 141.6
IMPERVIOUS BLANKET FILL
IMPERVIOUS BLANKET FILL
Existing road to Jurangmanao
EL. 141.6
Scale
WONOGIRI MULTIPURPOSE DAM
INDONESIA
DAM
GENERAL PLAN
Date : July 31, 75
DWG No. WD-001



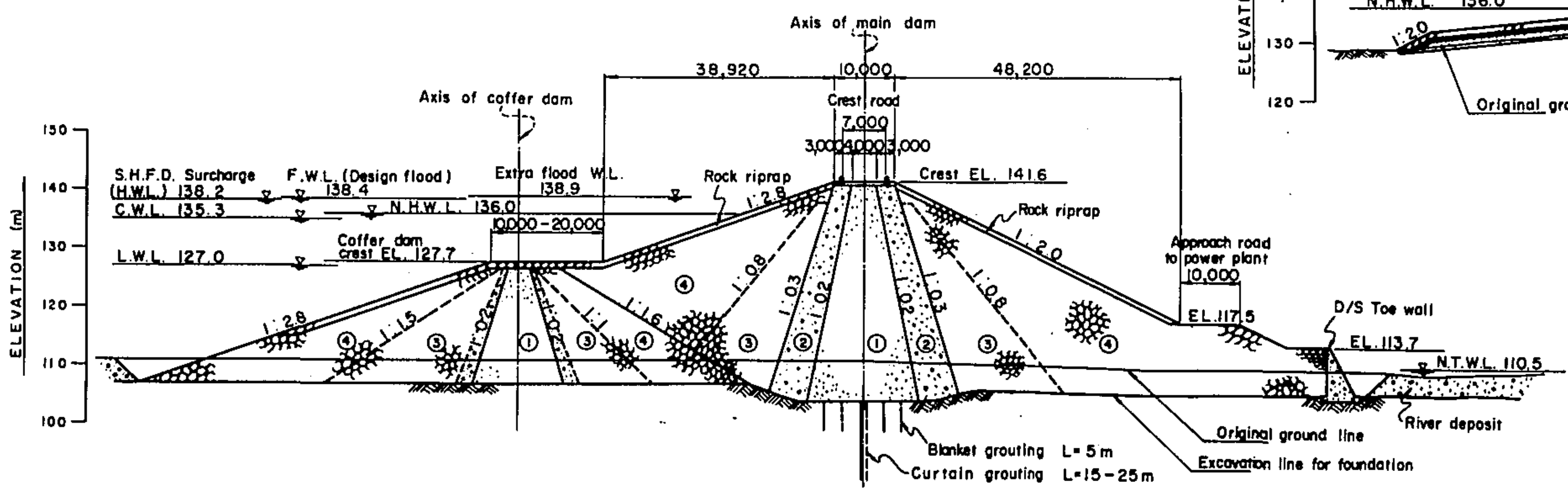
PROFILE ALONG

(Scale A



TYPICAL CROSS SECTION OF SUB DAM

(Scale B)

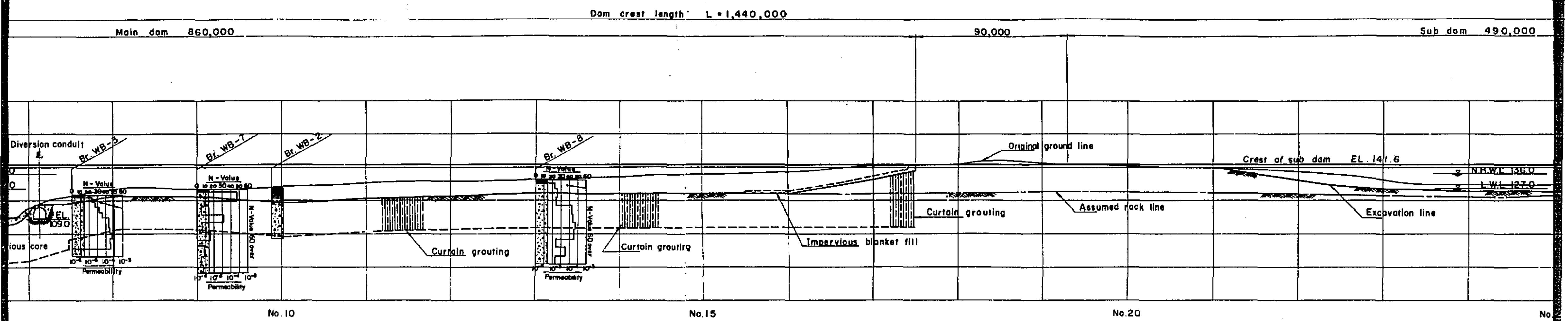


TYPICAL CROSS SECTION OF MAIN DAM

(Scale B)

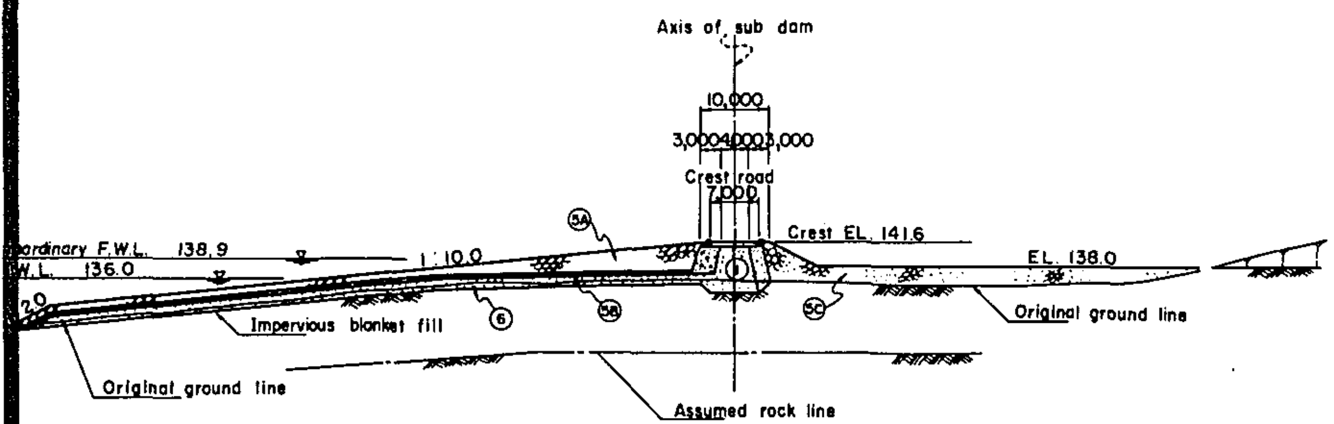
EMBANKMENT ZONES

Zone No.	Zone	Embankment material
①	Impervious core	Mixture of volcanic clay and crushed sandy tuff from Candi borrow area
②	Filter	Crushed breccia tuff (or alternatively river sand and gravel)
③	Transition	Finer grains of quarry-run rock (or selected rocks from excavation in spillway, etc.)
④	Rockfill	Coarser grains of quarry-run rocks
5A	Random fill (I)	Selected rock from excavations in spillway, intake, etc.
5B	〃 (II)	Finer part of zone 5A material
5C	〃 (III) Backfill	Excavated materials
⑥	Impervious blanket	Impervious materials from excavations

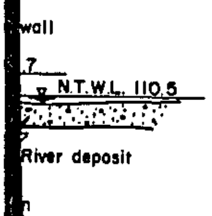


PROFILE ALONG AXIS OF DAM

(Scale A)

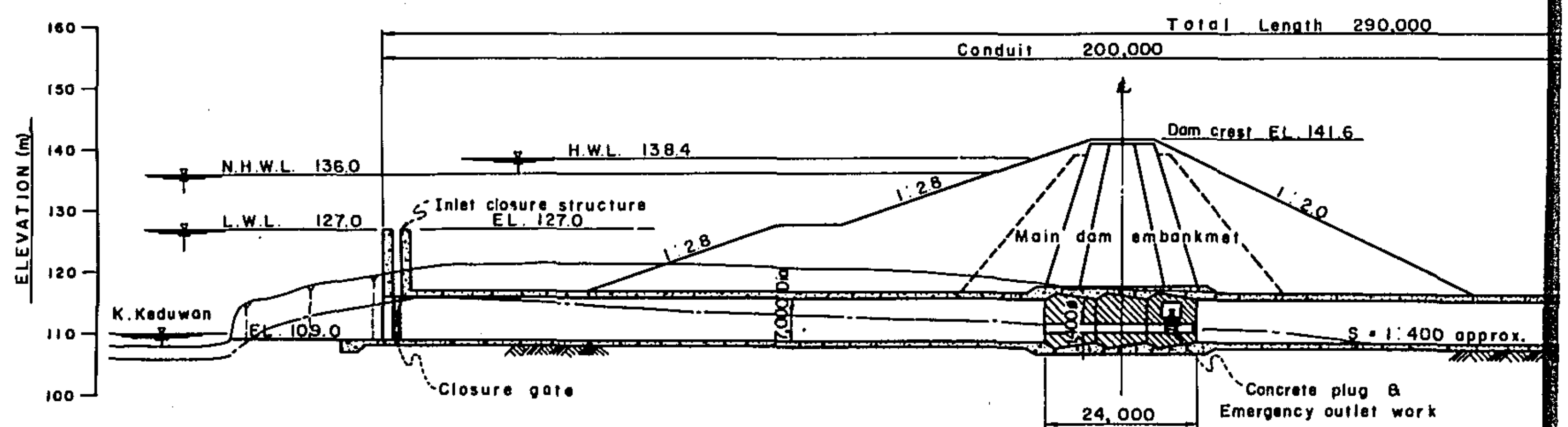


TYPICAL CROSS SECTION OF SUB DAM
(Scale B)

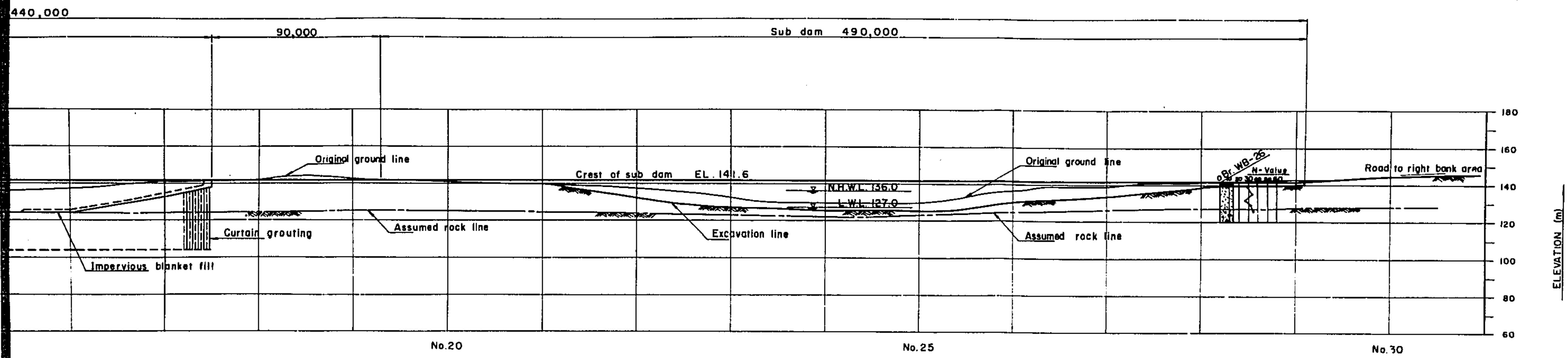


EMBANKMENT ZONES

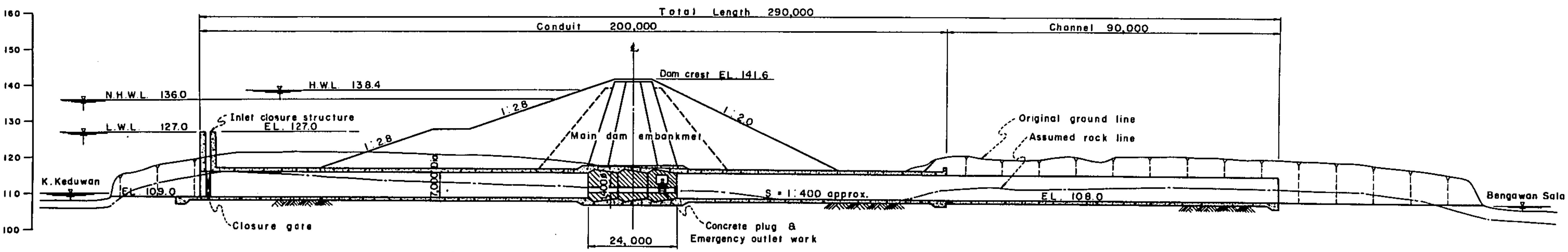
Zone No.	Zone	Embankment material
①	Impervious core	Mixture of volcanic clay and crushed sandy tuff from Candi borrow area
②	Filter	Crushed breccia tuff (or alternatively river sand and gravel)
③	Transition	Finer grains of quarry-run rock (or selected rocks from excavation in spillway, etc.)
④	Rockfill	Coarser grains of quarry-run rocks
⑤A	Random fill (I)	Selected rock from excavations in spillway, intake, etc.
⑤B	〃 (II)	Finer part of zone ⑤A material
⑤C	〃 (III) Backfill	Excavated materials
⑥	Impervious blanket	Impervious materials from excavations



PROFILE OF DIVERSION CONDUIT
(Scale B)



OF DAM



PROFILE OF DIVERSION CONDUIT
(Scale B)

Scale A 0 100 (m)

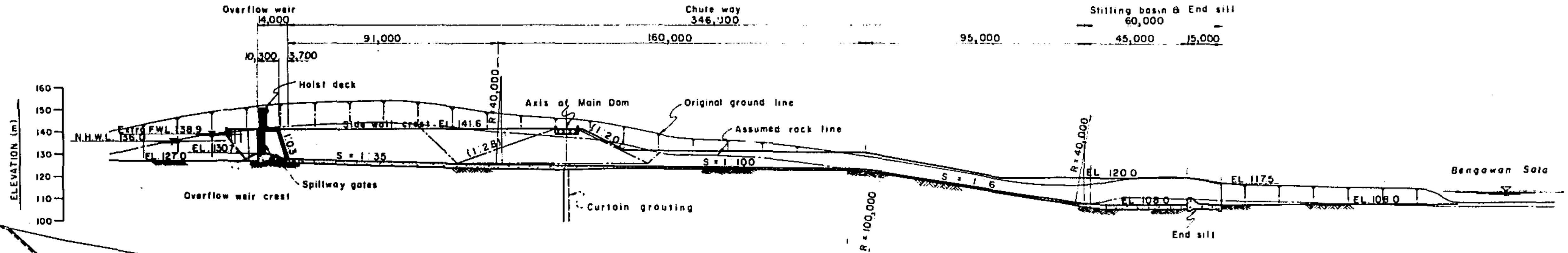
Scale B 0 50 (m)

WONOGIRI MULTIPURPOSE DAM
INDONESIA

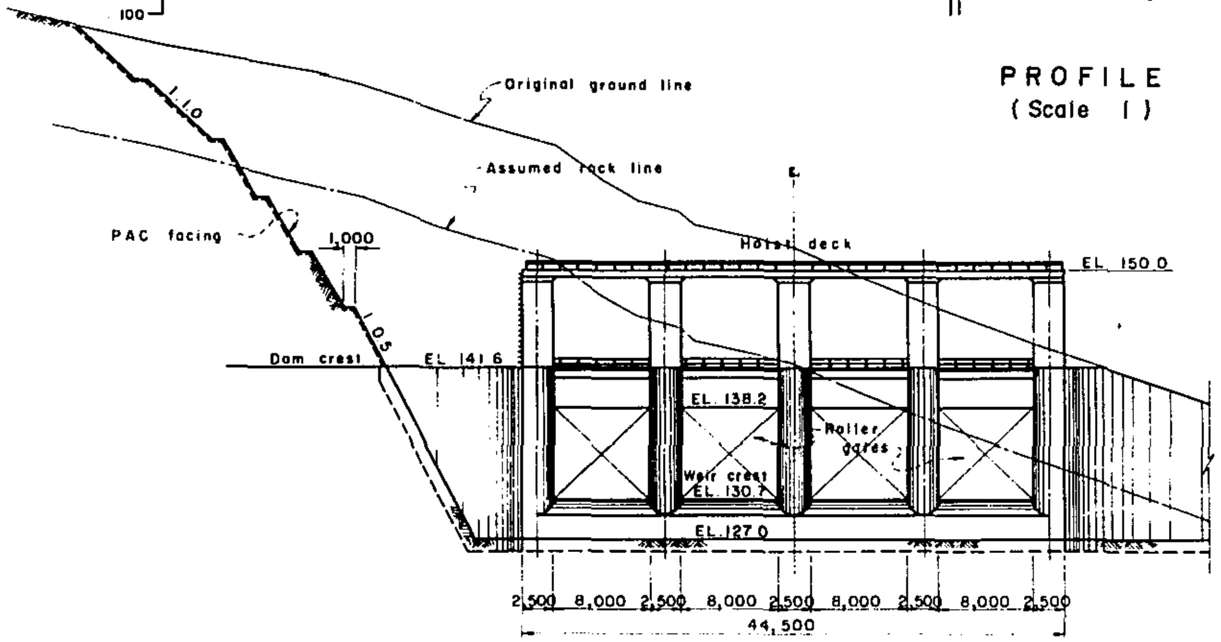
DAM

PROFILE & CROSS SECTIONS

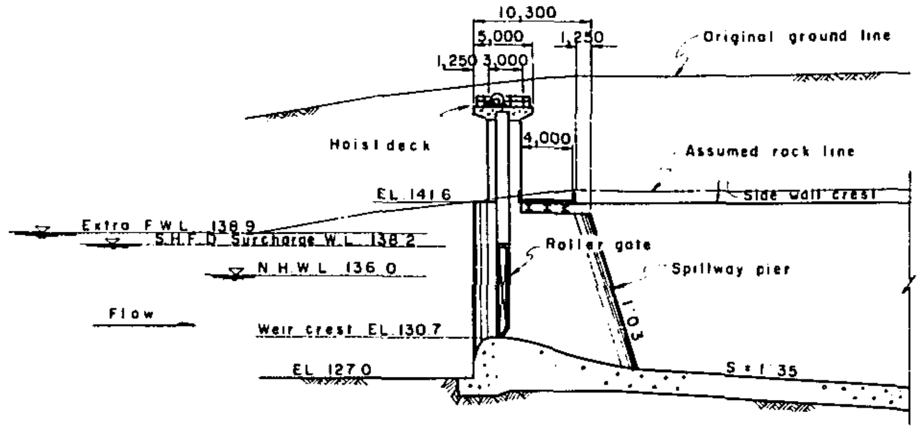
Date: July 31, 75	DWG NO. WD-002



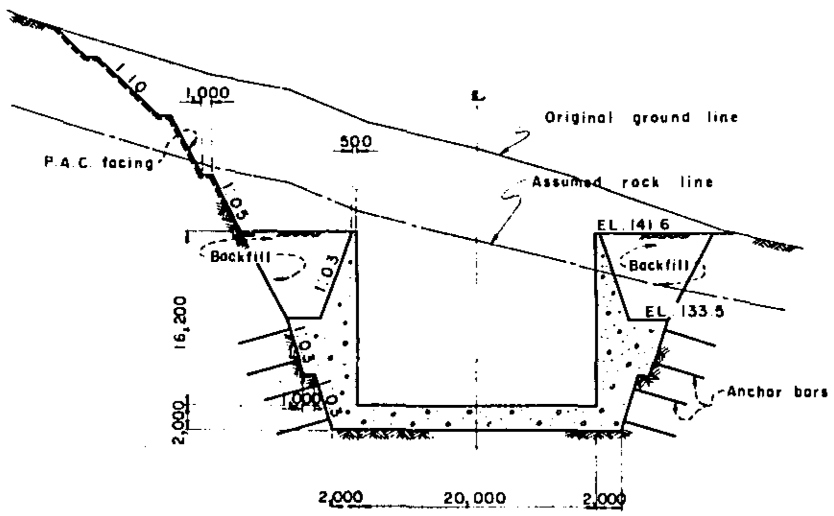
PROFILE
(Scale 1)



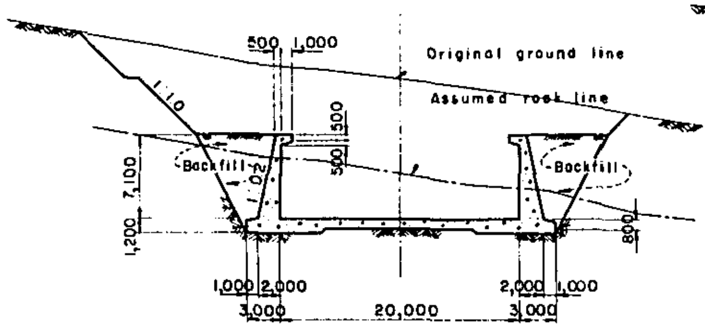
OVERFLOW WEIR - FRONT VIEW
(Scale 2)



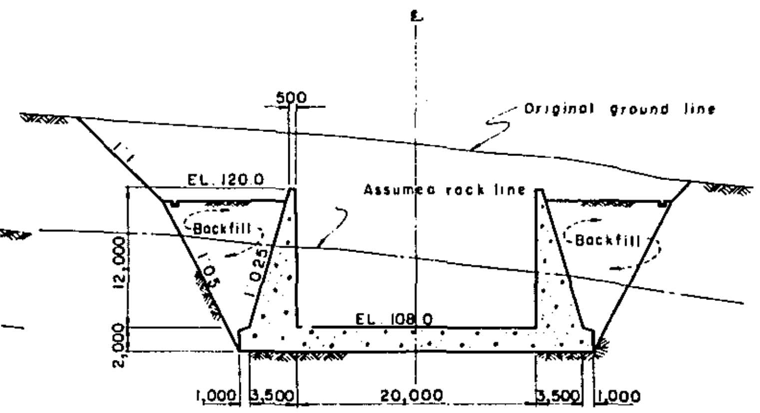
OVERFLOW WEIR - PROFILE
(Scale 2)



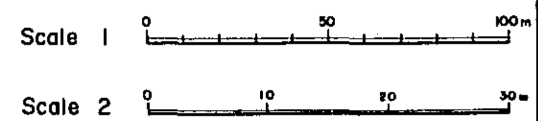
CHUTEWAY U/S PART-CROSS SECTION
(Scale 2)



CHUTEWAY - CROSS SECTION
(Scale 2)



STILLING BASIN - CROSS SECTION
(Scale 2)

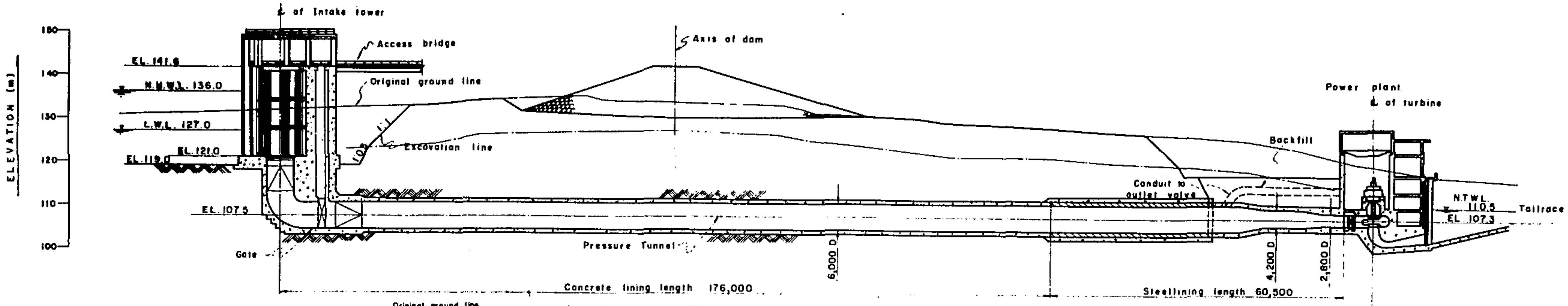


WONOGIRI MULTIPURPOSE DAM
INDONESIA

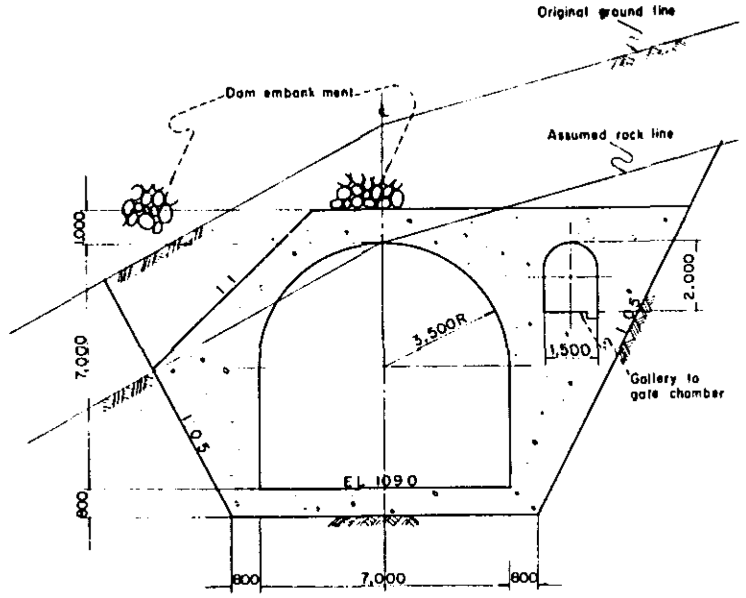
SPILLWAY

PROFILE & SECTIONS

Date: July 31, 75 | DWG.NO. WD-003

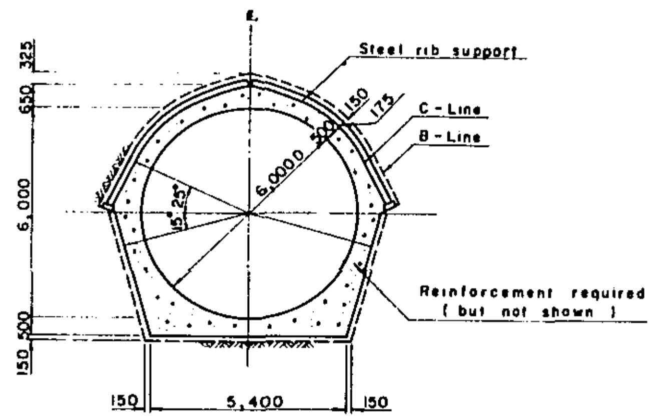


PROFILE OF WATER WAY (Scale 2)

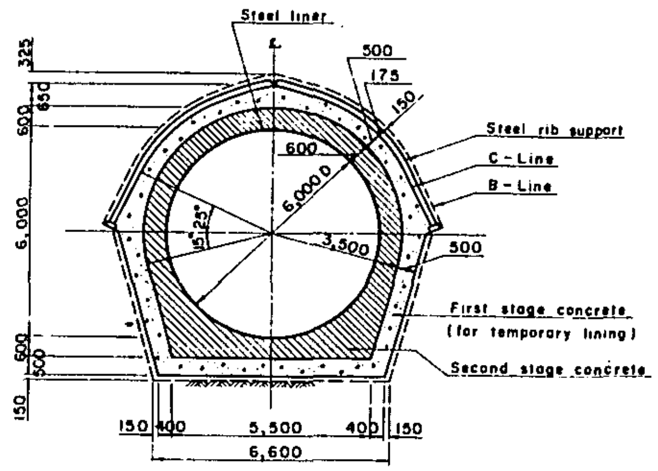


TYPICAL SECTION OF DIVERSION CONDUIT

(Scale 1)

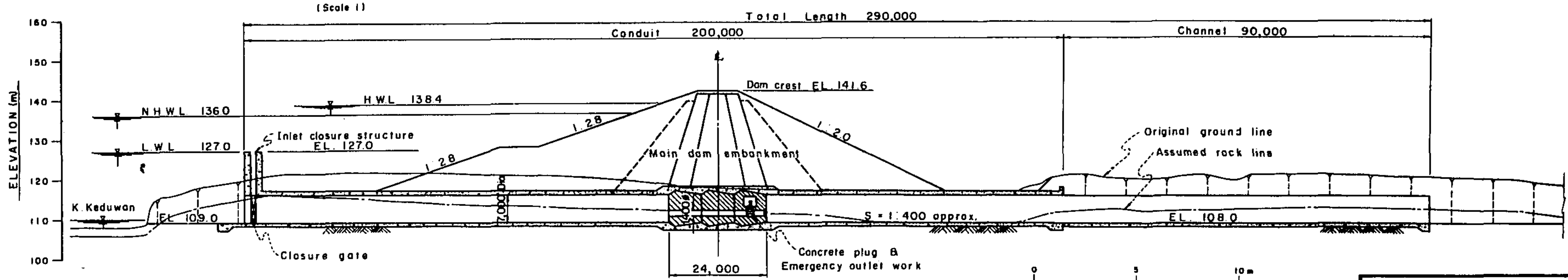


TYPE I
(Scale 1)

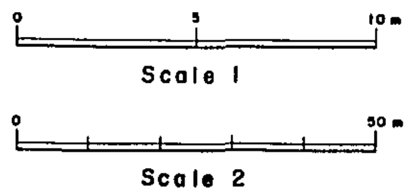


TYPE II
(Scale 1)

TYPICAL SECTION OF PRESSURE TUNNEL



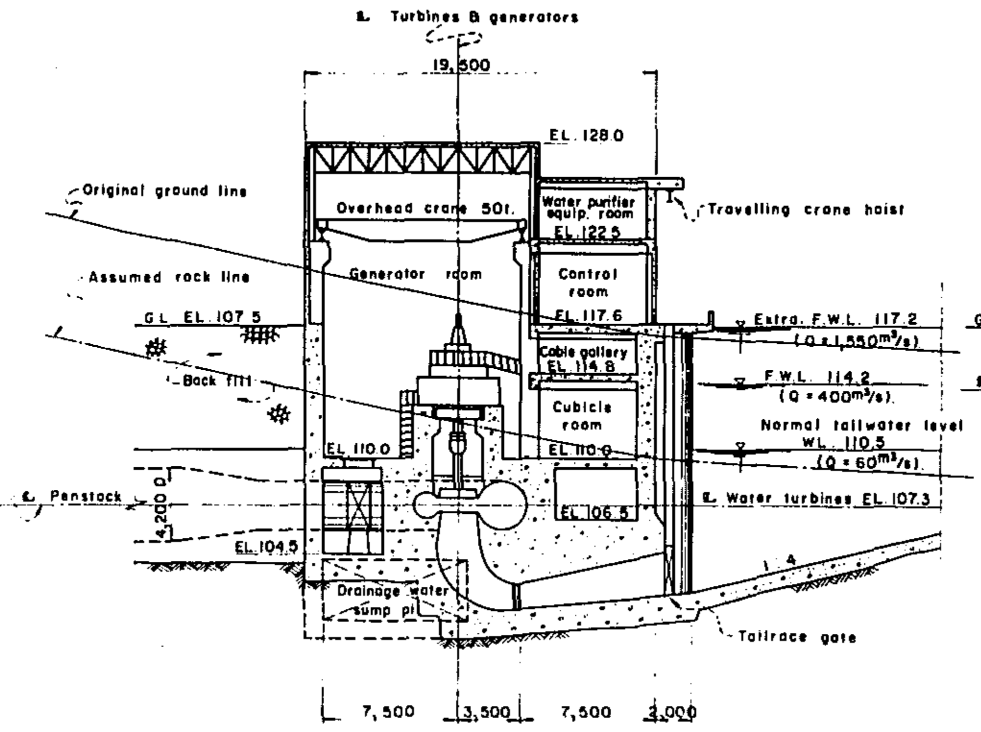
PROFILE OF DIVERSION CONDUIT
(Scale 2)



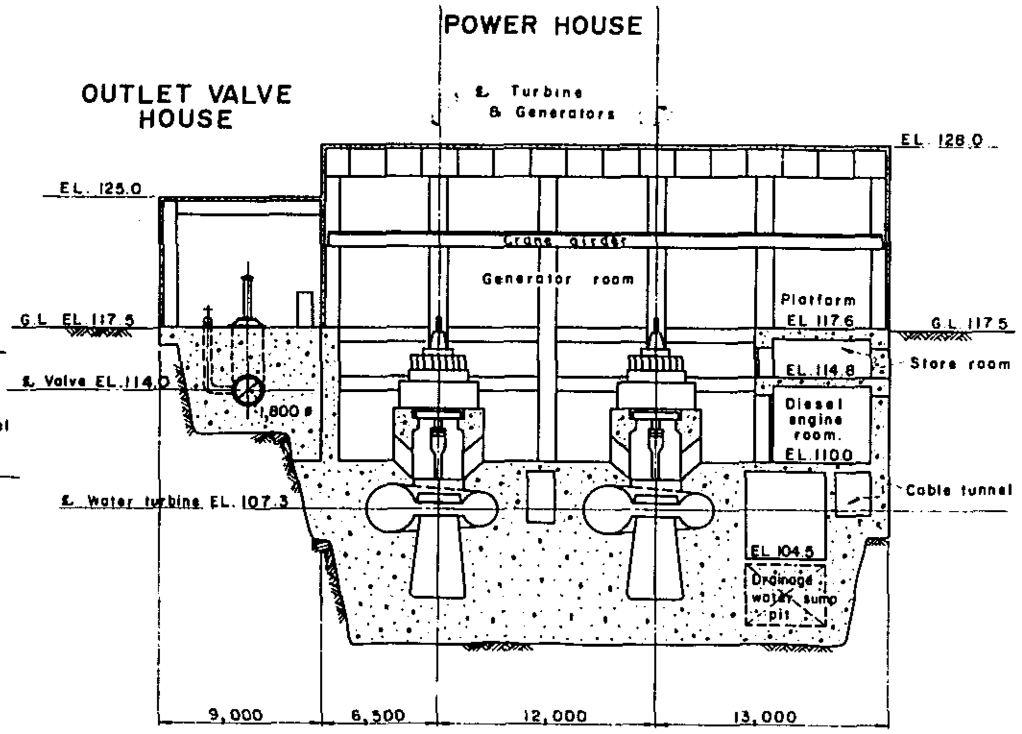
WONOGIRI MULTIPURPOSE DAM
INDONESIA

WATERWAY & DIVERSION CONDUIT PROFILE & SECTIONS

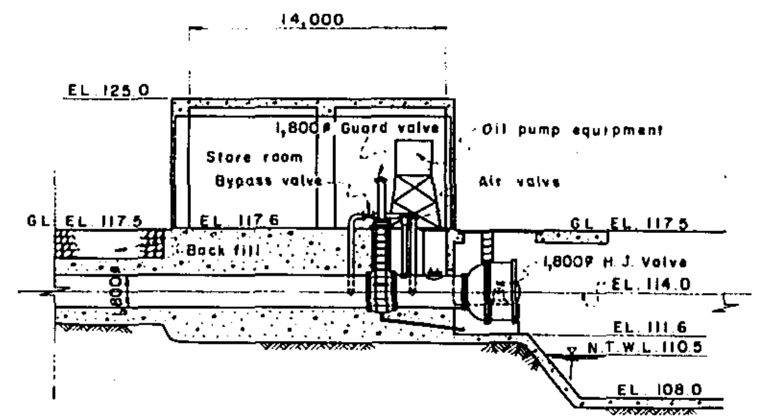
Date : July.31.75.	DWG.NO. WD-004



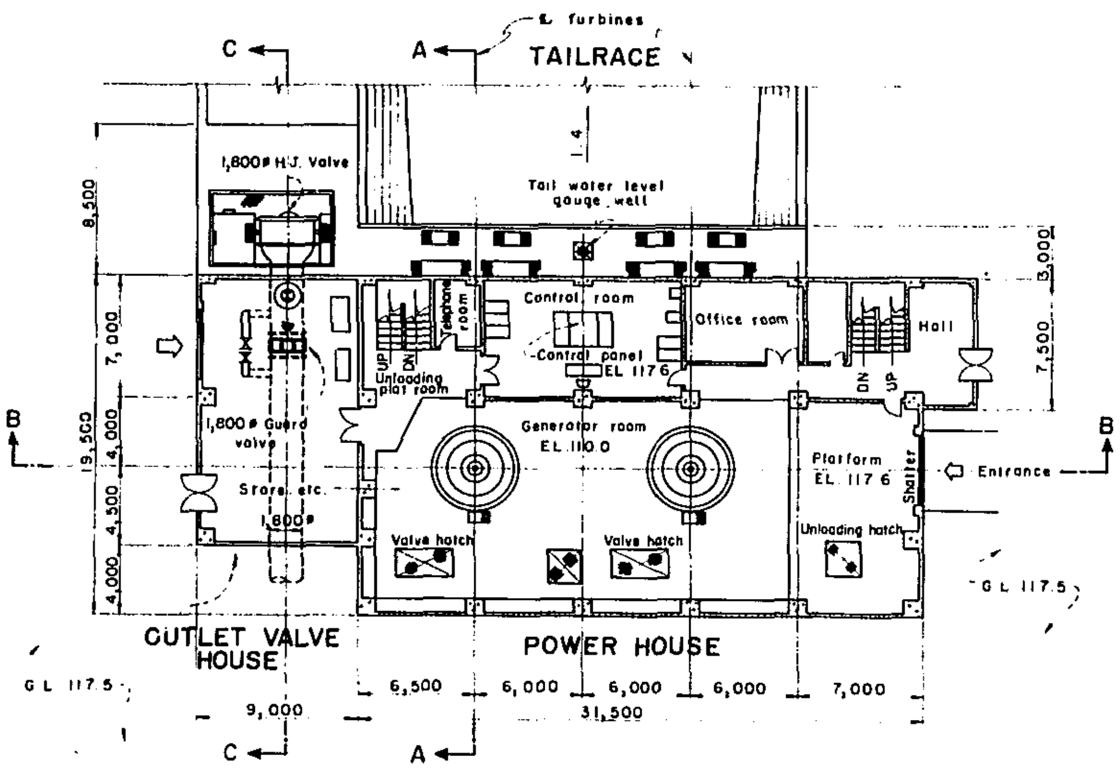
Section A – A



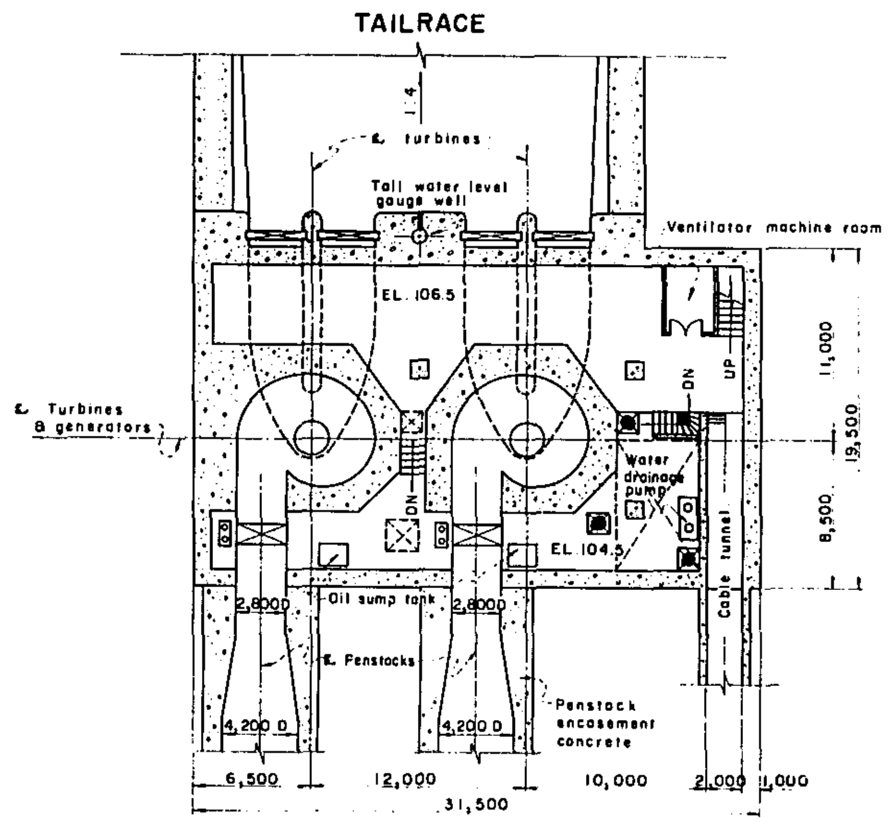
Section B – B



Section C – C



PLAN EL. 117.6



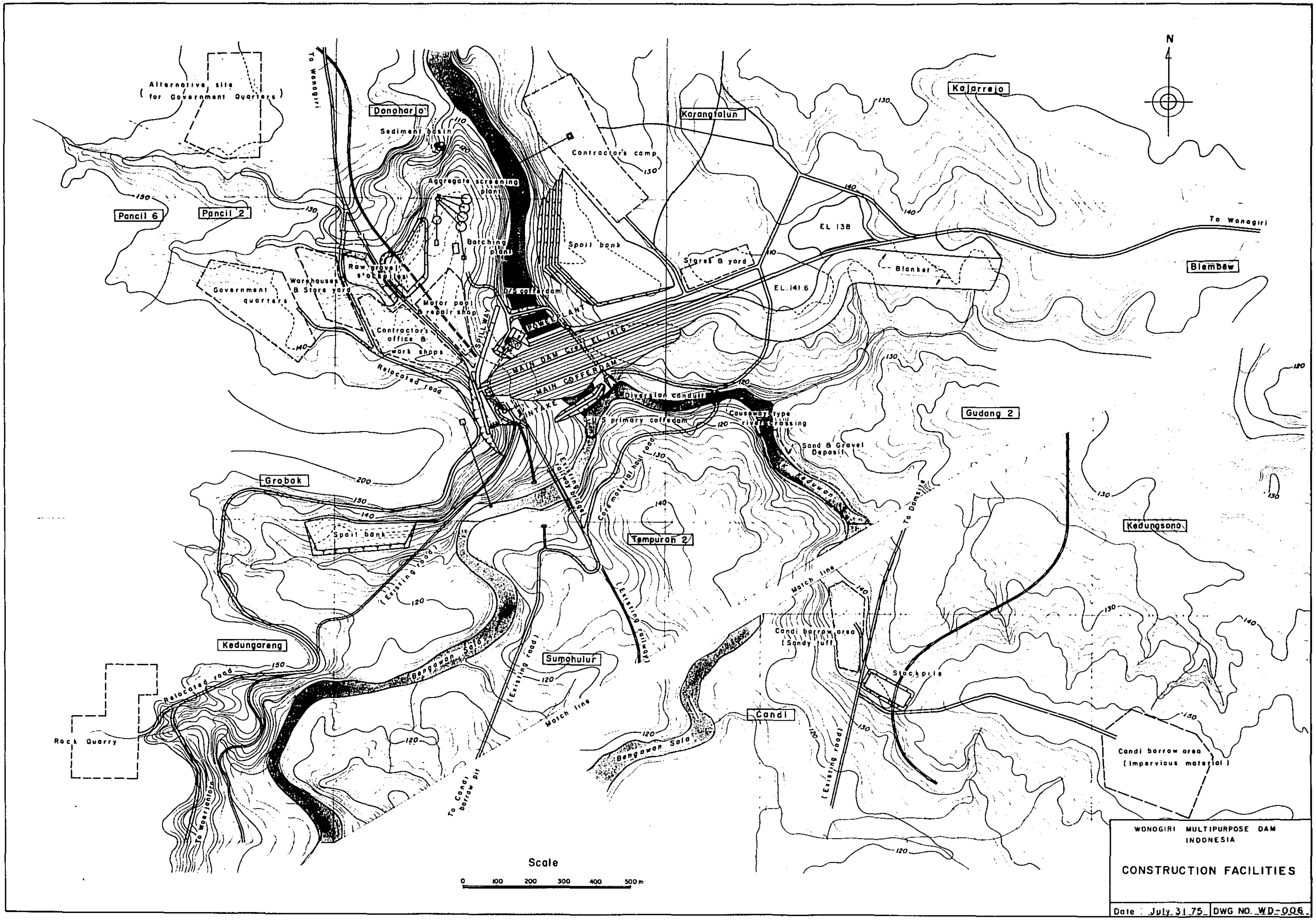
PLAN EL. 107.3

Scale 0 10 20m

WONOGIRI MULTIPURPOSE DAM
INDONESIA

POWER PLANT AND OUTLET VALVE HOUSE PLAN & SECTIONS

Date July 31, 75	DWG NO. WD-005


N
Alternative site
(for Government Quarters)
To Wonogiri
Donoharjo
Sediment basin
Aggregate screening plant
Batching plant
Contractor's camp
Karangtalun
Kajarrejo
Pancil 6
Pancil 2
Spoil bank
EL 138
To Wonagiri
Stores & yard
Blanket
Blembaw
EL.141.6
Raw gravel stockpiles
Warehouses & Store yard
Government quarters
Motor pool & repair shop
D/S cofferdam
POWER PLANT
Contractor's office & work shops
SPILLWAY
MAIN DAM Crest EL.141.6
MAIN COFFERDAM
Relocated road
INTAKE
Diversion conduit
U/S primary cofferdam
Causeway type river crossing
Gudang 2
Sand & Gravel Deposit
Grobak
Spoil bank
Kedungsono
Tempuran 2
To Domsile
Match line
Kedungareng
Sumohulur
Candi borrow area (Sandy tuff)
Stockpile
Bengawan Sola
Candi
Relocated road
Rock Quarry
Candi borrow area (Impervious material)
To Candi borrow pit
To Woerjantoro
(Existing road)
(Existing railway)
Scale
0 100 200 300 400 500 m
WONOGIRI MULTIPURPOSE DAM
INDONESIA
CONSTRUCTION FACILITIES
Date : July 31 75
DWG NO. WD-006

ANNEX I

II. WONOGIRI POWER STATION

P O W E R

CONTENTS

LIST OF TABLES

LIST OF FIGURES

APPENDIXES

LIST OF DRAWINGS

1. PRESENT SITUATION

1.1 Existing Power Supply System

1.1.1 Power generating facilities

At present, the power supply system in Central Java consists of two main grids, the Tuntang and Ketenger grids with 30 kV transmission lines.

The installed capacity of the PLN's Central Java power system is 79,880 kW in Tuntang system and 19,412 kW in Ketenger system, and 10,726.2 kW in isolated stations, the total being 110,018.2 kW in Central Java (refer to the attached Appendix-1). In addition to the PLN's, installed capacity totalling 102,132.559 kW is owned by private enterprises (refer to the attached Appendix-2).

The existing generating facilities owned by PLN and private in Central Java as of March 1975 are given as below:-

Existing generating facilities owned by PLN

	Hydro (kW)	Gas (kW)	Diesel (kW)
(a) Tuntang Grid			
(i) Jelog	20,480	-	-
(ii) Timo	12,000	-	-
(iii) Semarang	-	34,000	-
(iv) Kalisari	-	-	6,020
(v) Wirobrajan	-	-	4,060
(vi) Kudus	-	-	1,120
(vii) Purwosari	-	-	2,200
Sub-total	32,480	34,000	13,400
(b) Ketenger Grid			
(i) Ketenger	7,040	-	-
(ii) Pekalongan	-	-	1,380
(iii) Tegal	-	-	6,296
(iv) Cilacap	-	-	4,696
Sub-total	7,040	-	12,372

	Hydro (kW)	Steam (kW)	Diesel (kW)
(c) Isolated Stations			
(i) 2-Hydro Stations	380	-	-
(ii) 14-Diesel Stations	-	-	10,346.2
Sub-total	380	-	10,346.2
Total	39,900	34,000	36,118.2
Grand Total		110,018.2	

Private generating facilities

	Hydro (kW)	Steam (kW)	Diesel (kW)
(i) Semarang Area (26,364.117 kW)	47.84	2,082.512	24,233.765
(ii) Sala Area (2,334.32 kW)	-	-	2,334.32
(iii) Yogyakarta Area (23,486.6 kW)	3,840	400	19,246.6
(iv) Tegal Area (28,312.172 kW)	-	-	28,312.172
(v) Purwokerto Area (11,675.1 kW)	38	350	11,287.1
(vi) Magelang Area (6,431.6 kW)	-	-	6,431.6
(vii) Cepu Area (3,528.65 kW)	-	-	3,528.65
Total	3,925.84	2,832.512	95,374.207
Grand Total		102,132.559	

1.1.2 Transmission and distribution facilities

PLN's existing transmission facilities in Central Java are listed in Table II-1. (30 kV transmission line system will be cancelled in the future).

New 150 kV transmission lines are being constructed by PLN to provide the main trunk of each grid and to interconnect these two grids in the near future.

Moreover, the interconnection of Central and East Java system is also under planning by PLN.

The standard voltage and frequency of the PLN's power system are as follows:

Transmission line	150 kV
Distribution line	22 kV, 6 kV
Low tension line	220-127 V (this voltage will be changed to 380-220 V in the future), 3-Phase, 4-Wire System
Frequency	50 Hz

1.2 Power Consumption

Records of installed capacity, peak demand, generated energy, sold energy, etc. in Central Java from January 1972 to December 1974 are shown on Table II-2.

The maximum peak demand in the past three years was recorded at 63,300 kW in September 1974 for the Tuntang system, and 10,700 kW in July 1974 for Ketenger system.

The total sold energy in 1974 was recorded at 239,708,330 kWh which was 27.2 % less than the generated energy of 328,031,051 kWh rendering approximately 2 % to the station use and 25.2 % to the transmission and distribution loss.

Electric power consumption in Central Java is mainly limited to the urban areas and rarely in the rural areas. Per capita consumption in 1974 was 287 kWh in power energy and 70 kW in the peak power against the estimated urban population of 832,000.

With respect to the present power consumption in several isolated load centers related to the project, records of installed capacity, peak demand, generated energy in the town of Wonogiri and Sukoharjo from January 1972 to December 1974 are shown on Table II-3.

1.3 Power Rate

Tariff structure of PLN is very complicated depending on the kinds of consumers. The power rate now being applied in Central Java in summarized in Table II-4.

1.4 Waiting Consumer

As shown in Table II-5, the total contracted capacity of waiting consumers accepted by PLN during 8 years for 1967 - 1974 was 242,459,470 VA in Central Java, while total capacity installed during the same period was only 31,278,120 VA, equivalent to 13 % of the total contracted capacity.

Accepted waiting consumers have been selected by PLN, and there are many applicants who are still waiting the PLN's acceptance.

2. POWER DEMAND AND DEVELOPMENT PLAN IN THE FUTURE

2.1 Demand Forecast

As seen in the figures of the waiting consumer, even at present, there exists substantial demand for power.

Moreover, after the completion of the extension and improvement of transmission and distribution systems which are now under way in Central Java it is anticipated that a remarkable growth of power demand will arise.

Load forecast and power development program in Central Java are shown on the attached Fig. II-1 and II-2. These figures show the projected future power and energy requirements by yearup to 2000 in relation to the power development plan, based on the tentative estimates.

In calculating the peak power demand for each year, the yearly growth rate is estimated based upon an arithmetical progression after the year 1975 as follows:

1975 - 1977 ..... 15 %
1978 - 1979 ..... 20 %
1980 - 1982 ..... 15 %
1983 - 2000 ..... 7 %

And annual load factor to be applied for the estimate of energy requirements are the following percentages:

1975 - 1978 ..... 65 %
1979 - 2000 ..... 60 %

For several isolated load centers related to the project such as Wonogiri, Sukoharjo and Wuryantro town, the future load forecasts are as shown in Fig. II-4 and II-5.

2.2 New Power Supply Facility under Construction and Planning

Construction of large scale power plants, improvement and extension of power supply system as well as the incorporation of isolated power generating facilities into the expanded power grids have been contemplated, because the present shortage of electric power supply is much impeding the economic development in the Central Java.

The power stations under construction and planning in Central Java by PLN are listed below:

Name of Power Station	Unit	Combustion	Completion Date
Yogyakarta	2,150 kW x 3	Diesel	1975
Tegal	2,500 kW x 2	Diesel	1976
Purwosari	250 kW x 2	Diesel	1976
Cilacap	18 MW x 2	Steam (Oil-fired)	1977
Semarang	50 MW x 2	Steam (Oil-fired)	1977
	20 MW x 2	Gas (Oil-fired)	1977

The new transmission line facilities now under construction and planning in Central Java are listed in Appendix-3.

Based on the construction schedule mentioned above, the available power output in each year up to 1977 is estimated below (except private facilities):

1975	116,468.2 kW
1976	121,968.2 kW
1977	297,968.2 kW

3. HYDROPOWER POTENTIAL IN BENGAWAN SALA BASIN

Due to the topography of the basin having less difference of elevation, there are not many suitable potential sites for hydropower development. Potential head created by the construction of the dam for hydropower generation is found only in the Bengawan Sala River.

Potentiality of the prospective power developments and their brief descriptions in this basin are summarized hereunder (refer to the attached DWG. No. WP-001 titled "LOCATION MAP OF THE PROJECTS IN THE SALA BASIN"

(i) Wonogiri Project

This project site is located at about 2 km upstream from the town of Wonogiri. Near this site, a right side tributary, the Keduwan River joins to Bengawan Sala River, and the selected dam site is just downstream of the confluence of the Keduwan River.

The dam will be of rockfill type with a height of 38.5 m and the total embankment volume of $1,800,000^3$, and effective water storage capacity is estimated to be 440 million m^3.

Exclusive water storage for the hydropower generation is not provided but designed to use the stored water also for hydropower generation.

By constructing the hydropower station just downstream of the dam, the maximum gross head of 24.5 m becomes available. At the maximum discharge of 60 m^3/sec maximum output 10,200 kW is expected when operated for peak power supply. Annual energy production will account for 35,068 MWh. The proposed Colo irrigation intake weir is designed to work as an afterbay.

(ii) Badegan Project

This project site is located on the Semorobangun River, a left side tributary of Madiun River at about 17 km westward from Ponorogo. The dam will be of rockfill type with a height of 60.5 m and the total embankment volume of 7,750,000 m^3.

By utilizing the maximum effective head 57.0 m obtained by the construction of the dam, the hydropower station at just downstream of the dam will generate the maximum output of 6,000 kW at the maximum discharge of 12.2 m^3/sec. The total annual energy production is estimated at 18,800 MWh.

(iii) Bendo Project

This project site is located on the Ngindeng River, a right side tributary of Madiun River about 15 km south east of Ponorogo. The dam will be of rockfill type with a height of 80.5 m and total embankment volume of 2,110,000 m^3.

By construction of the hydropower station just downstream of the dam, the maximum effective head of 56.0 m becomes available and the maximum output of 3,500 kW is expected to be generated at the maximum discharge of 7.3 m^3/s. Total annual energy of 10,000 MWh can be produced.

(iv) Jipang Project

This project site is located at about 6 km upstream of Cepu. The dam will be of earthfill type with a height of 27.5 m and the total embankment volume of 4,200,000 m^3.

Maximum effective head of 15.5 m becomes available by constructing the hydropower station at just downstream of the dam and with the maximum discharge of 135.0 m^3/sec, maximum output of 18,000 kW is expected to be generated. Total annual energy of 70,800 MWh can be produced at this power station.

4. DEVELOPMENT PLAN OF WONOGIRI POWER STATION

The hydro power in general can take a valuable part of the total power generation in meeting short duration peak load. In reviewing the long - range power development in Central Java, the study was made putting stress on the operation of the Wonogiri power plant during the peak load time.

From the present pattern of daily load curve, a peaking period of around six (6) hours seems to be appropriate.

On the basis of the above condition, the study of installed capacity and unit output to be installed is carried out.

4.1 Alternative Plans

Wonogiri Power Plant is required to be furnished with the plant capacity for peak power generation taking into consideration of water use for irrigation purpose, because no specific water is allocated to the power use.

On the basis of the reservoir operation established from the water supply for irrigation use during the past 20-year period, the monthly power output in terms of both peak power and power energy of the plant were estimated for four plans with different maximum discharge as shown in Table II-6.

The features of the four alternative plans for power development are as follows:

	Max. Discharge (m^3/sec)	Design Head (m)	Installed Capacity (kW)	Monthly Mean Energy Output (MWh)
Case A	44	21.3	7,600	2,959.7
Case B	52	21.2	8,900	2,946.0
Case C	60	21.1	10,200	2,932.3
Case D	68	21.0	11,600	2,918.7

4.2 Economic Comparison of the Alternative Plans

In order to determine the most optimum scale of the power development, economic comparison is made on four alternative plans in terms of the unit construction cost per kW.

Firstly, construction cost including civil works, power generating equipment and transmission facilities is estimated for each case as presented in the following table.

(10^3 US$)

	Case A	Case B	Case C	Case D
Intake	520	540	560	590
Pressure Tunnel	710	810	880	980
Power House	1,153	1,230	1,280	1,380
Generating Equipment	6,322	6,829	7,262	8,288
Power Transmission & Communication	2,577	2,577	2,577	2,577
Gate & Penstock	883	942	989	1,057
Total	12,165	12,928	13,548	14,872

In succession, unit construction cost per kW of the devendable peak is calculated assuming that the dependability is 85% of the total period.

	(1) Total Construction Cost (US$1,000)	(2) Dependable Peak power (kW)	(3) Unit Construction Cost per kW(US$) (1)/(2)
Case A	12,165	5,400	2,253
Case B	12,928	6,200	2,085
Case C	13,548	6,910	1,961
Case D	14,872	7,500	1,983

The result of the above comparison shows that the plan C is selected as the most appropriate power plant scale.

4.3 Value of the Generated Power

The value of the hydro power is measured based on the cost required to produce the equivalent capacity and energy by the least cost alternative means. In the present case, the alternative is a oil-fired steam power plant with the capacity of 50,000 kW.

Capacity value

Capacity value is estimated on the basis of the alternative cost as follows:

(i) Investment cost for alternative steam power plant

Foreign currency	US$30,800,000
Local currency	US$ 7,700,000
Total	US$38,500,000
Per kW installed	US$ 770/kW

(ii) Annual fixed cost

Interest and Depreciation (Capital Recovery)	
12 % for foreign currency	US$3,824,000
12 % for local currency	US$ 956,000
Fixed O & M 2 %	US$ 770,000
Total	US$5,550,000

Capital recovery factor (30 years)
12 % : 0.124144

Annual fixed cost per kW installation US$111/kW

The following adjustments are made for the difference between hydro and steam power plant.

	Hydro (%)	Steam (%)
Loss up to primary substation	4.0	2.0
Forced outage	-	2.0
Auxiliary power use	0.3	6.0
Overhaul	2.0	8.0

$$\text{Factor} = \frac{\text{Hydro}}{\text{Steam}} = \frac{(1-0.04)(1-0.003)(1-0.02)}{(1-0.02)(1-0.02)(1-0.06)(1-0.08)}$$

$$= 1.13$$

Capacity value = 111 x 1.13 = US$125.4/kW

Energy value

Energy value is estimated as follows:

(iii) *Energy costs*

Fuel cost : 0.06 $/ℓ

Bunker C : 10,000 k cal/ℓ

1 k cal = 3.968 BTU (British Thermal Unit)

1 kWh = 860 k cal = 3,412 BTU

Thermal efficiency : 30 %

$$\frac{3412}{39680} \times \frac{100}{30} = 0.287 \ \ell/\text{kWh}$$

$$0.287 \times 0.06 = 0.0172 \ \$/\text{kWh}$$

Adjustment in difference between hydro and steam power plant is also applied to fuel consumption:

	Hydro (%)	Steam (%)
Loss upto primary substation	4.0	2.0
Auxiliary power use	0.3	6.0

$$\text{Factor} = \frac{\text{Hydro}}{\text{Steam}} = \frac{(1 - 0.04)(1 - 0.003)}{(1 - 0.02)(1 - 0.06)} = 1.04$$

Energy value = 0.0172 x 1.04

US$0.0179/kWh

Annual benefit

On the basis of the capacity value and energy value calculated above, annual benefit from the Wonogiri power station is estimated at US$1.35 million as shown below:

Capacity benefit

6,910 kW/1 x US$125.4 = US$867,000

Energy benefit

28,200 MWh x 0.96/2 x US$0.0179 = US$485,000

Total annual benefit US$1,352,000

(≒ US$1,350,000)

/1 85 % dependable peaking capacity

/2 4 % transmission loss excluded

5. DESIGN AND COST OF POWER STATION

5.1 Power House

The power house will be constructed on the left bank at just downstream of the dam, and the building will be 30 m long, 19 m wide, 18 m deep and 8 m high. Sub-structure of the power house will be constructed on the base rock of tuff-breccia.

The generating units, each of 5,100 kW capacity, will be placed at 12 m interval from the center to center. The elevation of principal floors and centerline of the turbine are set out as follows.

Turbine room floor	EL. 104.50
Cable gallery floor	EL. 106.50
Casing center	EL. 107.30
Generator, cubicle, engine generator room repair-shop floor	EL. 110.00
Air conditioner, battery, cable gallery room and aux. room floor	EL. 114.80
Control, telephone and aux. room floor	EL. 117.60
Conference room, terrace and aux. room floor	EL. 122.50

One set of trailrace gate will be provided at the outlet of draft tubes, to be handled by travelling monorial crane.

5.2 Power Generating Equipment

5.2.1 Hydraulic turbine

The hydraulic turbine to be installed at Wonogiri Power Station will be vertical shaft, Kaplan type with an elbow type draft tube.

Owing to the fluctuation of the reservoir water level, the effective head of the turbine will vary from a maximum head of 24.5 m to a minimum head of 15.5 m. As the result of the examination of the design head, annual average effective head is obtained at 21.1 m, therefore, this head is selected as the design head.

The turbine will have 333 rpm rated speed in full gate opening and at 21.1 m design head it will generate 5,100 kW rated output per unit. At 15.5 m of the minimum head in full gate opening, the output of the turbine will be calculated as 3,341 kW per unit.

The following are the items which were taken into consideration on selection of the hydraulic turbine to be installed in Wonogiri Power Station.

(i) Basic Data

Elevation of dam crest	EL. 141.60
Normal max. reservoir water level	EL. 136.00
Min. reservoir water level	EL. 127.00
Normal max. tailwater level	EL. 110.50

(ii) Type

Considering the effective head ranging from 15.5 m to 24.5 m, Kaplan type hydraulic turbine is adopted.

(iii) Head

The head for the best efficiency (design head) is determined at 21.1 m which is the average head for 2 unit operation obtained from the reservoir operation.

(iv) Speed

JEC (Japanese Electrotechnical Committee) formula based on the experience of hydraulic turbine installation was used to determine the speed.

$$Ns = \frac{20{,}000}{Hd + 20} + 50 = \frac{20{,}000}{21.1 + 20} + 50 = 537 \text{ (m - kW)}$$

$$N = \frac{Ns \cdot Hd^{5/4}}{HP^{\frac{1}{2}}} = \frac{537 \times 21.1^{5/4}}{5{,}100^{\frac{1}{2}}} = 340$$

From the above calculation, 333 rpm of the turbine speed is chosen. The number of poles of synchronous generator is therefore 18 poles for 50 Hz in the system frequency.

(v) Turbine Installation

Draft head was determined as follows:

Atmospheric pressure Ha = 10 m

$$Ns = \frac{N \cdot P^{\frac{1}{2}}}{Hd^{5/4}} = \frac{333 \times 5{,}100^{\frac{1}{2}}}{21.1^{5/4}} = 526 \text{ (m - kW)}$$

Cavitation factor:

$$2.33 \times 10^{-6} \times Ns^2 - 2.47 \times 10^{-4} \times Ns + 0.181$$

$$= 2.33 \times 10^{-6} \times 526^2 - 2.47 \times 10^{-4} \times 526 + 0.181$$

$$= 0.645 - 0.13 + 0.181 = 0.696$$

Centerline of runner blade below the spiral case center is obtained at about 0.85 m.

Total draft head Hs is:

$$Hs = 10 - 0.696 \times 21.1 + 0.85 = -3.8$$

From the result of above calculation, theoretical center line of turbine blade shall be set at about 4 m below normal maximum tailwater level of EL. 110.50.

5.2.2 Alternating current generator

The generator to be installed at Wonogiri Power Station will be vertical shaft, revolving field, or ordinary type to be coupled directly with the Kaplan turbine. It will therefore have 333 rpm of the speed and rated at 6.375 kVA, 6.6 kV, 3-Phase, 50 Hz and 0.8 power factor.

The generator will be assembled and disassembled using the overhead travelling crane.

The power factor selected for the Wonogiri generator is 0.8 considering the reactive power supply from the generator to the load center. The terminal voltage of generator is selected at 6.6 kV as the most economical voltage for the capacity planned.

5.2.3 Main transformer

The main transformer to be installed at Wonogiri Power Station will be rated at 12,000 kVA, 50 Hz, 3-Phase two windings, 6.6 kV delta to 150 kV star connected outdoor, self-cooled type. The neutral point of 150 kV windings will be grounded directly.

5.2.4 Station service equipment

Station service power will be supplied from one 300 kVA transformer, which is to be connected to generator main circuit. For emergency use, a diesel engine driven generator set will be installed. Power for intake gate and spillway gate will be supplied from one 200 kVA step-up transformer, which is connected to the low tension circuit.

Station service transformer and step-up transformer for the diesel engine driven generator set and for gates will be of outdoor and self cooled type.

5.2.5 Switchyard equipment

The switchyard with 27 m by 30 m space will be provided adjacent to the power station building on the ground level of 117.50 (refer to the attached DWG. No. WP-006 titled "ARRANGEMENT OF OUTDOOR EQUIPMENT).

A single circuit transmission line will be connected to the 150 kV bus. The circuit breaker will be rated at 168 kV, 800 A, 5,800 MVA interrupturing capacity, and shall be suitable for synchronizing between Wonogiri Power Station and Tuntang system.

The circuit breaker on 6.6 kV side of generator will be used for parallel operation of the generators at Wonogiri Power Station and for synchronizing of the generators at Wonogiri Power Station with Tuntang system (refer to the attached DWG. No. WP-004 titled "WONOGIRI POWER STATION SINGLE LINE CONNECTION DIAGRAM).

5.3 Transmission Line and Substation

The necessary power transmission capacity for the single-circuit 150 kV transmission line from Wonogiri Power Station to East Sala Substation is around 10,000 kW based on 5 per cent regulation and 80 per cent power factor.

The conductor is selected as 200 mm^2 ACSR considering corona discharge voltage (refer to the attached DWG. No. WP-007 titled "TRANSMISSION LINE AND DISTRIBUTION LINE ROUTE" and DWG. No. WP-008 titled "SINGLE LINE DIAGRAM OF TRANSMISSION AND DISTRIBUTION LINE").

The above 150 kV transmission line of 40 km is constructed along the highway between Wonogiri Power Station and East Sala Substation via Sukoharjo town and will be connected to 150 kV bus of East Sala Substation (refer to the attached DWG. No. WP-011 titled "EAST SALA SUBSTATION, SINGLE LINE CONNECTION DIAGRAM" and DWG. No. WP-012 titled "ARRANGEMENT OF OUTDOOR EQUIPMENT").

Power for the Sukoharjo twon will be supplied from East Sala Substation by a 20 kV distribution line including a step down transformer (22 kV to 6 kV) and will be connected to the existing 6 kV system.

A single circuit 20 kV distribution line is also constructed between Wonogiri Power Station and Wuryantoro town via Wonogiri permanent camp area and from where a line to Wonogiri town is branched off. Step-down transformers will be installed at the load centers.

The power demand to be connected to the above line is estimated as follows (refer to the attached Fig. II-4);

Wonogiri Permanent Camp Area .... 500 kW
Wonogiri Town .... 1,000 kW
Wuryantoro Town .... 500 kW

Typical towers and insulator strings for 150 kV transmission line and typical assemblies for 20 kV distribution line are shown on the attached drawings (refer to the DWG. No. WP-009 and WP-010).

5.4 Power Line Carrier Telephone System

Power line carrier telephone system will be composed of load dispatching channel (System A) and administrative channel (System B) to be transmitted on the 150 kV transmission line, as referred to the attached DWG. No. WP-013 titled "POWER LINE CARRIER TELEPHONE SYSTEM".

5.5 Construction Cost

The total construction cost of the generating equipment and power transmitting facilities with communication equipment is estimated at US$11,700,000 comprising of the foreign currency portion of US$10,190,000 and the local currency portion of US$1,510,000 equivalent. The summary of the estimate is given in Table II-7.

The prices for the generating equipment, transmission line, distribution line, substation and communication equipment are estimated referring to the current prices in the Japanese market. It was assumed that the custom duties on the imported plant and materials would be exempted.

Table II - 7 Summary of Cost Estimate

Item	Foreign Currency (10^3 US$)	Local Currency (10^3 US$)	Total (10^3 US$)
I. Electric Power Generation			
Generating Equipment	6,851	411	7,262
II. Electric Power Transmission & Communication			
150 kV T/L (1c.c.t., 40km)	740	400	1,140
20 kV D/L (1c.c.t., 38km w/Tr. 1250 kVA)	639	380	1,019
Low Tension Line (5km)	85	50	135
East Sala S.S.	155	12	167
Power Line Carrier Telephone	111	5	116
Sub Total	1,730	847	2,577
III. Land Acquisition	---	21	21
IV. Contingency	1,269	171	1,440
V. Engineering & Administrative Expenses	340	60	400
Grand Total	10,190	1,510	11,700

The cost disbursement schedule for the power project is estimated as follows:

Item		1979 (10^3 US$)	1980 (10^3 US$)
Generating Equipment	F.C.	4,624	2,227
	(L.C.)	(123)	(288)
150 kV T/L	F.C.	740	-
	(L.C.)	-	(400)
20 kV D/L	F.C.	639	-
	(L.C.)	-	(380)
Low Tension Line	F.C.	85	-
	(L.C.)	-	(50)
East Sala S.S.	F.C.	47	108
	(L.C.)	-	(12)
PLC Telephone	F.C.	34	77
	(L.C.)	-	(5)
Total	F.C.	6,169	2,412
	(L.C.)	(123)	(1,135)

5.6 Construction Plan

Almost of all construction works will be affected by dry and wet seasons, especially, outdoor construction works will be often interrupted by heavy rain during the wet season and with a scorching sun during the dry season. Therefore, planning of construction works should be carried out in due consideration of the climatic conditions in this area.

5.6.1 Power generating equipment

Working time is estimated at about two years including manufacturing, transportation and erection at site, and the commencement of commercial operation is scheduled for April, 1981.

As the commencement of the installation works is scheduled for December 1979, the construction of power house shall be started earlier and the construction of roofs, walls and windows shall be finished by June 1980.

The wet test of the generating equipment will be scheduled in March and April 1981, waiting the reservoir water level to reach EL. 132.6 m.

5.6.2 Transmission line

The construction work of the transmission line during the rainy season will be disturbed by heavy rain. Therefore, commencement of the construction work is expected in April 1980 and the completion in January 1981.

To keep the above schedule, all foundation works must be finished during the dry season and the erection of towers will follow.

5.6.3 20 kV distribution line

Since the route of the distribution line from East Sala substation to Sukoharjo town will run through the paddy field, the construction work shall be carried out during the dry season.

While, the distribution line from Wonogiri power station to Wuryantoro will be constructed along the highway which will be newly constructed for the submerged highway between Wonogiri town and Wurayantoro town. The construction work will be possible even in the rainy season.

5.6.4 Low tension line

Low tension distribution lines excluding service wires for the consumers will be constructed in Wuryantoro town in parallel with the construction of the 20 kV distribution line to Wuryantoro.

5.6.5 East Sala substation

The generated power at the Wonogiri Power Station will be sent to East Sala Substation to be constructed under another project. Therefore, no main transformer is provided under this project. However, to connect the 150 kV disconnecting switches, all the necessary switchgear and miscellaneous materials are included in this project.

The switching equipment to be installed at East Sala Substation will be located at 150 kV switch-yard, and dead end tower of 150 kV transmission line will be constructed between dead end tower for South Yogyakarta and Surabaya line (proposed by PLN Semarang). Installation works will be completed by March 1981.

5.6.6 Power line carrier telephone

Construction time of PLC telephone equipment will be selected just before commencing the commercial operation of the project, after the 150 kV transmission line is completed.

5.6.7 Transportation

All equipment and materials will be unloaded at Surabaya port, the main port for East Java and Central Java, which has sufficient unloading capacity for the plants to be used for the project. The equipment and materials unloaded at Surabaya port will be transported to the site by railway or road.

All routes of the access to the site are shown in the attached sheet, and drawing of loading clearance of railway is also attached to this report (refer to the attached Appendix-5).

5.7 Construction Time Schedule

Since the completion of the Wonogiri dam is scheduled for the end of 1980 and the impounding of the reservoir in the beginning of the rainy season of the same year, all works of the power sector will have to be completed before the scheduled date of the wet test operation of the power facilities, namely, by the beginning of March 1981.

Overall time schedule including design, manufacturing, transportation, field construction and erection, etc, will be made as shown in Fig, II-7.

Table II-1 Existing Transmission Facility in Central Java

(Mar. 1975)

(DC: Double Circuits)
(SC: Single Circuit)

Section	Voltage (kV)	Length (kM)	Type (DC or SC)	No.of Circu-it	Conductor		
					Kind	Size (mm^2)	Approx AWG
I. Tuntang System							
Jelog - Jatingaleh	30	28	DC	2	Cu.HD	50	1/0 Cu
Jatingaleh-Semarang North	30	13	DC	1	do	do	do
Jatingaleh - Kudus	30	56	DC	1	do	25	#3 Cu
Kudus - Pati	30	23	SC	1	ACSR	99/66	2/0ACSR
Jelog - Timo	30	5	DC	2	ACSR	-	4/0ACSR
Jelog - Magelang	30	40	DC	1	Cu	50	1/0 Cu
Magelang-Jogyakarta	30	40	DC	1	do	do	do
Jogyakarta-Surakarta	30	52.5	DC	1	do	do	do
Surakarta - Jelog	30	57	DC	1	do	do	do
Magelang-Purworejo	30	41.5	SC	1	do	25	#5 Cu
Purworejo-Kutoharjo	30	11	SC	1	do	25	#5 Cu
Pedan - Ceper	30	3	SC	1	do	do	do
II. Ketenger System							
Pemalang-Tegal	30	26	DC	1	Cu	50	1/0
Pemalang-Pekalongan	30	31.5	DC	1	Cu	50	1/0
Pemalang-Ketanger	30	35	SC	1	ACSR	-	1/0
	30	3.7	SC	1	Cu	35	2
	30	21	SC	1	Cu	50	1/0
Ketenger-Purwokerto	30	12	DC	2	Cu	25	3
Purwokerto-Gambarsari	30	1.3	DC	2	Cu	25	3
	30	2.6	DC	2	Cu	16	5
					Cu	25	3
	30	10	DC	2	Cu	25	3
Purwokerto-Purbolinggo	30	11.5	SC	1	Cu	25	3
Gambarsari-Karanganyar	30	41	SC	1	Cu	25	3
Gambarsari-Pesanggrahan	30	4	DC	2	Cu	25	3
	30	9	SC	1	Cu	24	3
Pesanggrahan-Cilacap	30	0.8	SC	1	Cu	25	3
	30	2.6	SC	1	Cu	16	5
	30	17.3	SC	1	Cu	25	3

Table II-2 Power Consumption (obtained from PLN Pembangkitan II Semarang)

Year & Month	Installed Capacity (kW)				Peak Load (kW)				Generated Output (kWh)			
	Tuntang	Ketenger	Isolated	Total	Tuntang	Ketenger	Isolated	Total	Tuntang	Ketenger	Isolated	Total
1	2	3	4	5	6	7	8	9	10	11	12	13
1972 Jan.	57,680	15,108	5,411	78,199	39,500	8,800	3,089	51,389	18,698,159	4,713,539	1,538,288.4	24,949,986.4
Feb.	57,680	15,108	6,411	79,199	38,500	8,150	3,030	49,680	17,846,709	4,505,826	1,421,386.2	23,773,921.2
Mar.	57,680	16,108	6,411	80,199	38,300	8,000	3,172	49,472	18,844,327	4,553,571	1,566,572.8	24,964,470.8
Apr.	57,680	16,108	6,411	80,199	36,400	8,400	3,169	47,969	18,256,182	4,646,277	1,536,273.8	24,438,732.8
May	57,680	16,108	6,411	80,199	37,800	8,650	3,150	49,600	18,944,600	4,842,690	1,383,636.4	25,170,926.4
June	57,680	16,108	6,511	80,299	41,000	8,200	3,150	52,350	17,780,711	4,461,027	1,507,948	23,749,686
July	57,680	16,108	6,511	80,299	39,800	8,650	3,101	51,551	18,032,997	4,589,884	1,540,038.8	24,162,919.8
Aug.	57,680	16,108	6,511	80,299	40,300	8,235	3,237	51,772	18,362,167	4,412,824	1,592,914.2	24,367,905.2
Sep.	57,680	17,108	6,511	81,299	40,600	8,050	3,195	51,845	17,368,922	4,110,053	1,497,087.4	22,976,062.4
Oct.	57,680	17,108	6,611	81,399	33,800	8,050	3,299	45,149	17,236,979	4,189,531	1,569,834.2	22,996,344.2
Nov.	57,680	17,108	6,883	81,671	35,600	8,600	3,354	47,554	16,898,866	4,258,247	1,545,558.4	22,702,671.4
Dec.	57,680	17,108	7,133	81,921	38,600	8,900	3,374	50,874	18,109,182	4,875,792	1,626,960.8	24,611,934.8
Total	-	-	-	-	-	-	-	-	(216,379,801)	(54,159,261)	(18,326,499.4)	(288,865,561.4)
1973 Jan.	57,680	17,108	7,383	82,171	43,300	8,825	3,613	55,738	19,350,027	4,822,729	1,642,420.1	25,815,176.1
Feb.	57,680	17,108	10,231	85,091	41,300	8,875	3,733	53,908	17,237,812	4,286,195	1,590,032.86	23,114,039.86
Mar.	59,880	17,108	10,331	87,319	43,200	8,960	3,725	55,885	20,481,816	5,056,582	1,838,628.5	27,377,026.5
Apr.	59,880	19,412	10,331	89,623	42,400	10,425	3,801	56,626	19,886,060	5,219,004	1,810,275.78	26,915,339.78
May	59,880	19,412	10,331	89,623	32,900	9,925	3,827	46,652	19,777,291	5,327,262	1,903,040.9	27,007,593.9
June	59,880	19,412	10,331	89,623	32,900	10,350	3,824	47,074	19,380,410	5,212,083	1,762,032.38	26,354,525.38
July	59,880	19,412	10,331	89,623	44,450	11,060	3,757	59,267	20,680,693	5,247,070	1,789,894.63	27,717,657.63
Aug.	59,880	19,412	10,426.2	89,718.2	45,250	8,900	3,721	57,871	20,392,589	4,966,935	1,757,504.17	27,117,028.17
Sep.	59,880	19,412	10,726.2	90,018.2	43,800	9,000	3,731	56,531	19,799,783	4,820,078	1,676,395.7	26,296,256.7
Oct.	59,880	19,412	10,726.2	90,018.2	42,300	9,480	3,634	55,414	20,593,417	4,992,601	1,787,943,44	27,373,961.44
Nov.	59,880	19,412	10,726.2	90,018.2	43,100	10,300	3,818	57,218	20,259,306	5,038,540	1,719,597.63	27,017,443.63
Dec.	59,880	19,412	10,726.2	90,018.2	42,800	9,450	3,799	56,049	20,458,711	4,959,026	1,758,144.03	27,175,881.03
Total	-	-	-	-	-	-	-	-	(238,297,915)	(59,948,105)	(21,035,910.12)	(319,281,930.12)
1974 Jan.	59,880	19,412	10,726.2	90,018.2	41,450	9,800	3,785	55,035	20,362,146	4,963,479	1,775,252.44	27,100,877.44
Feb.	59,880	19,412	10,726.2	90,018.2	41,350	9,850	3,778	54,978	18,811,059	4,444,879	1,636,899.54	24,892,837.54
Mar.	59,880	19,412	10,726.2	90,018.2	42,250	10,300	3,814	56,364	20,866,603	4,838,844	1,809,371,45	27,514,818.45
Apr.	59,880	19,412	10,726.2	90,018.2	43,700	9,650	3,752	57,102	20,121,661	4,747,882	1,715,597.95	26,585,140.95
May	59,880	19,412	10,726.2	90,018.2	42,900	10,000	3,903	56,803	20,516,547	4,891,539	1,782,724	27,190,810
June	59,880	19,412	10,726.2	90,018.2	40,300	9,875	3,896	54,071	20,258,551	4,797,938	1,561,799	26,800,288
July	59,880	19,412	10,726.2	90,018.2	45,100	10,700	3,906	59,706	21,214,207	4,934,220	1,809,556	27,957,983
Aug.	59,880	19,412	10,726.2	90,018.2	43,000	10,300	3,879	57,179	21,355,479	5,016,874	1,628,622	28,000,975
Sep.	79,880	19,412	10,726.2	110,018.2	63,300	10,050	4,129	77,479	20,975,992	4,922,277	1,628,375	27,526,644
Oct.	79,880	19,412	10,726.2	110,018.2	43,200	10,000	3,685	56,885	21,734,485	5,018,661	1,669,843	28,422,989
Nov.	79,880	19,412	10,726.2	110,018.2	41,200	9,825	3,663	54,688	20,952,763	4,916,018	1,621,522	27,490,303
Dec.	79,880	19,412	10,726.2	110,018.2	43,400	9,900	3,597	56,897	21,842,100	5,034,789	1,670,496	28,547,385
Total	-	-	-	-	-	-	-	-	(249,011,593)	(58,527,400)	(20,310,058.38)	(328,031,051.38)

Load Factor (%)									
Tuntang	Ketenger	Isolated	Total	Aux. Power Use at P.S. (kWh)	Sending Power (kWh)	Receiving Power (kWh)	Transmission Line Loss (kWh)	Aux. Power Use at S.S. (kWh)	Sold Energy (kWh)
14	15	16	17	18	19	20	21	22	23
63.6	72.0	66.9	65.3	254,576.1	24,695,410.3	21,720,592.3	2,974,818	53,103	18,381,381
66.6	79.4	67.4	68.8	241,039.5	23,532,881.7	20,753,076,7	2,779,805	83,396	18,095,268
66.1	76.5	66.4	67.8	253,052.3	24,711,418.5	21,666,755.5	3,044,663	44,233	17,720,920
69.7	76.8	67.3	70.6	237,297	24,201,435.6	21,113,721.8	3,087,714	53,297	18,000,423
67.4	75.2	59.0	68.2	233,765.7	25,137,160.7	21,889,383.7	3,247,777	55,498	17,857,011
60.2	75.6	66.5	63.0	237,968.8	23,511,717.2	20,376,455.2	3,135,262	54,449	18,107,898
60.9	71.3	66.8	63.0	249,215.1	23,913,704.7	21,170,755.7	2,742,949	52,093	18,033,477
61.2	72.0	66.1	63.3	263,805.1	24,104,100.1	21,350,337.1	2,753,763	51,999	18,321,758
59.4	70.9	65.1	61.6	303,444.3	22,672,618.1	20,216,426.1	2,456,192	57,257	18,436,258
68.5	70.0	64.0	68.5	260,162	22,736,182.2	20,406,675.2	2,329,507	47,467	17,689,685
65.9	68.8	64.0	66.3	310,836.4	22,391,835	19,957,349	2,434,486	47,078	17,996,105
63.1	73.6	64.8	65.0	268,900.7	24,343,034.1	21,918,025.1	2,425,009	51,387	17,669,187
(60.1)	(69.2)	(61.8)	(62.8)	(5,845,063.0)	(285,951,498.2)	(252,539,553,4)	(33,411,945)	(651,257)	(216,309,371)
60.1	73.5	61.1	62.3	302,655.2	25,512,520.9	22,637,822.9	2,854,698	55,240	19,076,786
62.1	71.9	63.4	63.8	315,487.56	22,798,552.3	20,150,997.3	2,647,555	56,528	19,013,622
63.7	75.9	66.3	65.8	390,123.3	26,986,903.2	24,186,865.2	2,800.038	55,938	18,557,467
65.1	69.5	66.1	66.0	547,905.73	26,367,434.05	23,676,176.05	2,691,258	75,745	19,450,151
80.8	72.1	66.8	77.8	547,640.22	26,459,953.68	23,749,214.68	2,710,739	74,084	19,153,944
81.8	69.9	64.0	77.6	507,935.46	25,846,589.92	23,055,592.92	2,790,997	63,142	19,775.496
62.5	63.8	64.0	62.9	499,533.15	27,218,124.48	24,432,437.48	2,785.687	59,195	19,477,024
60.6	75.0	63.5	63.0	431,640.09	26,685,388.08	24,079,878.08	2,605,510	65,728	19,862,517
62.8	74.4	62.4	64.6	406,050,52	25,890,206.18	23,170,867.18	2,719,339	64,536	19,640,226
65.4	70.8	66.1	66.4	429,614.74	26,944,346.7	24,033,587.7	2,910,759	59,437	19,339,202
65.3	67.9	62.6	65.6	482,387.37	26,535,056.26	23,655,713.26	2,879,343	64,041	19,555,316
64.2	70.5	62.2	65.2	556,244.91	26,619,636.12	24,329,391.12	2,290,245	63,231	19,448,614
(60.1)	(61.9)	(62.7)	(61.5)	(5,417,218.25)	(361,740,177.07)	(281,158,543.87)	(32,686,168)	(756,845)	(232,350,365)
66.0	68.1	63.0	66.2	506,837	26,594,040.44	23,823,224.44	2,770,816	63,715	19,920,391
67.7	67.2	64.5	67.4	466,638.54	24,426,199	21,824,955	2,601,244	56,123	18,951,736
66.4	63.1	63.8	65.6	546,593.73	26,968,224.72	24,250,640.72	2,717,584	61,114	18,694,929
64.0	68.3	63.5	64.7	518,874.83	26,066,266.12	23,642,540.12	2,423,726	49,172	19,736,208
64.3	65.7	61.4	64.3	529,869	26,660,941	24,205,824	2,455,117	48,016	19,483,490
69.8	67.5	55.7	68.8	499,429	26,300,859	23,856,491	2,444,368	51,189	20,011,455
63.2	62.0	62.3	62.9	495,836	27,462,147	24,992,923	2,469,224	53,574	19,612,269
66.8	65.5	56.4	65.8	465,787	27,555,188	24,657,072	2,898,116	57,889	20,437,738
46.0	68.0	54.8	49.3	443,281	27,083,363	25,002,578	2,080,785	58,717	20,505,146
69.9	67.5	60.9	67.2	467,406	27,955,583	25,640,985	2,314,598	55,576	20,218,750
70.6	69.5	61.5	69.8	461,302	27,029,001	24,590,607	2,438,394	59,099	20,640,525
67.6	68.4	62.4	67.4	470,089	28,077,296	25,519,262	2,558,034	54,926	20,495,693
(44.9)	(62.4)	(56.2)	(48.3)	(5,871,943.1)	(322,179,108.28)	(292,007,102.28)	(30,172,006)	(669,110)	(239,708,330)

Distribution Line Loss (kWh)	T/L and D/L Loss (%)	
	T/L Loss	D/L Loss
24	25	26
3,286,108.3	11.92	13.17
2,574,412.7	11.69	10.83
3,901,602.5	12.20	15.63
3,060,001.8	12.63	12.52
3,976,874.7	12.80	15.67
2,214,108.2	13.20	9.32
3,137,278.7	11.35	12.90
2,976,580.1	11.30	12.22
1,722,911.1	10.89	7.49
2,669,523.2	10.12	11.60
1,914,166	10.72	8.43
4,197,451.1	9.85	17.05
(35,631,018.4)	11.57	12.33
3,525,796.9	11.05	13.65
1,080,847.3	11.45	4.67
5,573,460.2	10.22	20.35
4,150,280.05	9.99	15.41
4,521,186.68	10.03	16.74
3,216,954.92	10.59	12.20
4,896,218.48	10.05	17.66
4,151,633.08	9.61	15.31
3,466,105.18	10.34	13.18
4,634,948.7	10.62	16.93
4,036,356.26	10.66	14.94
4,817,546.12	8.42	17.72
(48,071,333.87)	10.24	15.06
3,839,118.44	10.22	14.16
2,817,096	10.44	11.31
5,494,597.72	9.87	19.96
3,857,160.12	9.12	14.51
4,674,318	9.03	17.19
3,793,847	9.12	14.15
5,327,080	8.83	19.05
4,161,445	10.34	14.85
4,438,715	7.33	16.12
5,366,659	8.14	18.88
3,890,983	8.87	14.15
4,968,643	8.96	17.40
(52,629,662.28)	9.20	16.04

Table II-3 Power Consumption in The Town of Sukoharjo & Wonogiri (obtained from PLN Pembangkitan II Semarang)

Year & Month	Installed Capacity (kW)			Peak Load (kW)			Generated Output (kWh)		
	Sukoharjo	Wonogiri	Total	Sukoharjo	Wonogiri	Total	Sukoharjo	Wonogiri	Total
1972 Jan.	120	120	240	51	58	109	18,907.6	21,182.4	40,090
Feb.	"	"	"	52	"	110	17,868	20,091.6	37,959.6
Mar.	"	"	"	51	"	109	19,777.2	21,609.6	41,386.8
Apr.	"	"	"	52	"	110	19,043.6	21,326.4	40.370
May	"	"	"	51	58	109	19,507.6	21,790.8	41,298.4
June	"	"	"	53	59	112	19,132	21,378.8	40,510.8
July	"	"	"	52	"	111	20,006.8	21,992	41,998.8
Aug.	"	"	"	"	"	"	20,208	22,832.8	43,040.8
Sep.	"	"	"	"	"	"	19,346.4	23,338	42,684.4
Oct.	"	"	"	"	"	"	19,799.2	22,485.6	42,284.8
Nov.	"	"	"	52	59	111	19,185.6	21,337.2	40,522.8
Dec.	120	120	240	49	54	103	16,578.4	20,002.4	36,580.8
Total	-	-	-	-	-	-	229,360.4	259,367.6	488,728
1973 Jan.	120	120	240	50	55	105	20,177.2	22,114	42,291.2
Feb.	"	"	"	53	59	112	17,854.8	20,036.8	37,891.6
Mar.	"	"	"	"	"	"	20,137.6	22,410	42,547.6
Apr.	"	"	"	53	"	112	19,431.6	21,526.8	40,958.4
May	"	"	"	52	"	111	20,100.4	22,616.4	42,716.8
June	"	"	"	53	59	112	19,432	21,432.4	40,864.4
July	"	"	"	52	69	121	19,911.6	23,624.8	43,536.4
Aug.	"	"	"	56	75	132	20,889.2	26,090	46,979.2
Sep.	"	"	"	54	75	129	19,800.8	24,664.8	44,465.6
Oct.	"	"	"	"	77	131	19,956.4	22,838.8	42,795.2
Nov.	"	"	"	54	80	134	19,545.6	25,089.2	44,634.8
Dec.	120	120	240	56	79	135	19,641.6	25,117.2	44,758.8
Total	-	-	-	-	-	-	236,878.8	277,561.2	514,440
1974 Jan.	120	120	240	56	86	142	20,912.4	26,326.4	47,238.8
Feb.	"	"	"	56	"	142	18,593.6	24,438.8	43,032.4
Mar.	"	"	"	54	"	140	20,317.6	27,096.4	47,414
Apr.	"	"	"	54	"	140	19,786.4	25,457.2	45,243.6
May	"	"	"	56	"	142	20,507	26,719	47,226
June	"	"	"	55	86	141	20,133	25,388	45,521
July	"	"	"	56	82	138	21,042	25,902	46,944
Aug.	"	"	"	56	"	138	21,031	26,492	47,523
Sep.	"	"	"	66	82	148	20,726	25,181	45,907
Oct.	"	"	"	68	81	149	22,713	26,130	48,843
Nov.	"	"	"	"	84	152	22,961	25,742	48,703
Dec.	120	120	240	68	84	152	24,021	26,693	50,714
Total	-	-	-	-	-	-	252,744	311,565.8	564,309.8

Table II-4 Tariff Base

A 1. Small Consumer

Burden	Charge	Exploitation Charge	Total
60 VA	Rp.220	Rp.150/Mon	Rp.350
75	250	200	450
100	300	250	550
125	400	300	700
150	450	350	800
175	500	400	900
200	600	450	1,050

A 2. Social Agencies

(Minimum 250 VA)

(a) Burden Charge: Rp.6/25 VA
(b) Consumption Charge: Rp.6/kWh
(c) Exploitation Charge: Rp.4.50/kWh

B 1. Household

(Minimum 250 VA)

(a) Burden Charge: Rp.12/25 VA
(b) Consumption Charge:
Up to 200 h Rp.13/kWh
Over 200 h .... Rp. 6/kWh
(c) Exploitation Charge: Rp.4.50/kWh

B 2. Commercial, including Bank

(Minimum 250 VA)

(a) Burden Charge: Rp.27.50/25 VA
(b) Consumption Charge:
Up to 200 h Rp.20/kWh
Over 200 h .... Rp. 8/kWh
(c) Exploitation Charge: Rp.4.50/kWh

C 1. Industry

(Minimum 99 kVA)

(a) Burden Charge: Rp.160/0.5 kVA
(b) Consumption Charge:
(1) Off peak load hour
Up to 150 h Rp.10/kWh
Over 150 h .... Rp. 6/kWh
(2) Peak load hour Rp.20/kWh
(3) Reactive Power (kVArh)
According to PLN provisions
(c) Exploitation Charge: Rp.4.50/kWh

C 2. Government: State Enterprises, Foreign Office etc.,

(Minimum 250 VA)

(a) Burden Charge: Rp.8/25 VA
(b) Consumption Charge:
Up to 200 h Rp.13/kWh
Over 200 h .... Rp. 6/kWh
(c) Exploitation Charge: Rp.4.50/kWh

D. Public Street Lighting

Rp.10/kWh

(Price compensation for bulb lamps, releasing box etc., to be added).

Exploitation Charge: Rp.4.50/kWh

E. Big Consumers

(Minimum 100 kVA)

(a) Burden Charge
(1) for first 400 kVA Rp.460/kVA
(2) 401 - 1000 kVA Rp.420/kVA
(3) 1001 - 2000 kVA Rp.375/kVA
(4) Over 2000 kVA Rp.275/kVA
(b) Consumption Charge
(1) Off peak load hour Rp. 5/kWh
(2) Peak load hour Rp.20/kWh
(3) Reactive power (kVArh)
According to PLN provisions.
(c) Exploitation Charge: Rp.4.50/kWh

F. Special Purpose: Short term supply

(Minimum 500 VA)

(a) Consumption Charge only.. Rp.30/kWh
(b) Exploitation Charge Rp.4.50/kWh

Note: The exploitation charge is particularly fixed by PLN according to the special generating conditions of each Exploitasi.

Table II-5 Waiting Consumer List

(obtained from PLN Pembangkitan II Semarang)

Year	Contract	Tuntang System (VA)	Ketenger System (VA)	Isolated Station (VA)	Total (VA)
1967	Accepted	4,504,615	17,106,189	1,981,279	23,592,083
	Installed	2,660,030	192,045	118,345	2,970,420
1968	Accepted	–	13,375,075	2,226,544	15,601,619
	Installed	349,100	246,770	52,485	648,355
1969	Accepted	19,342,471	11,298,145	2,047,745	32,688,361
	Installed	1,750,805	14,440	27,345	1,792,590
1970	Accepted	25,830,926	19,484,325	2,783,423	48,098,674
	Installed	2,130,810	314,325	44,600	2,400,535
1971	Accepted	–	–	–	–
	Installed	2,688,400	15,215	33,255	2,736,870
1972	Accepted	–	–	–	–
	Installed	3,156,530	673,945	168,065	3,998,540
1973	Accepted	54,391,612	–	2,692,440	57,084,052
	Installed	5,762,010	852,335	738,805	7,353,950
1974	Accepted	62,037,261	2,692,180	665,241	65,394,681
	Installed	6,954,930	1,799,655	622,275	9,376,860

Table II-6 Total Energy Output (Monthly Mean)

(unit: MWH)

Q(MAX) / Year	Case A 44 m³/s	Case B 52 m³/s	Case C 60 m³/s	Case D 68 m³/s
1953	2,904.4	2,891.1	2,877.8	2,864.5
54	3,252.4	3,238.0	3,023.6	3,209.2
55	2,811.2	2,799.1	2,787.0	2,774.8
56	2,646.2	2,634.4	2,622.6	2,610.8
57	2,463.9	2,452.3	2,440.8	2,429.2
58	3,474.1	3,458.2	3,442.2	3,426.3
59	3,075.4	3,061.2	3,047.1	3,032.9
60	2,450.6	2,439.3	2,427.9	2,416.6
61	2,164.1	2,153.5	2,142.9	2,132.3
62	2,851.2	2,837.8	2,824.4	2,811.0
63	1,892.7	1,883.4	1,874.1	1,864.7
64	1,513.3	1,505.3	1,497.3	1,489.4
65	2,302.8	2,291.5	2,280.2	2,268.9
66	3,575.5	3,559.3	3,543.1	3,527.0
67	2,510.3	2,498.0	2,485.7	2,473.4
68	4,536.7	4,517.5	4,498.3	4,479.1
69	2,179.6	2,169.1	2,158.7	2,148.2
70	5,266.1	5,241.4	5,216.7	5,192.1
71	4,053.8	4,035.4	4,017.1	3,998.7
72	3,270.3	3,254.8	3,239.3	3,223.8
Mean	2,959.7	2,946.0	2,932.3	2,918.7

The above-mentioned energy is calculated with design head of 21.3 m for Case A, 21.2 m for Case B, 21.1 m for Case C and 21.0 m for Case D, and detailed data are attached to Table V-14.

Fig. II - 1 Peak Load Forecast and Power Development Program in Central Java

(x10^{3}kW)

Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Peak	49.9	52.1	52.3	60.1	81.1	121.7	135.1	162.1	186.4	214.3
Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Peak	235.8	252.3	269.9	288.8	309.0	330.7	353.8	378.6	405.1	433.4
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	
Peak	463.8	496.2	531.0	568.2	607.9	650.5	696.0	744.7	796.9	

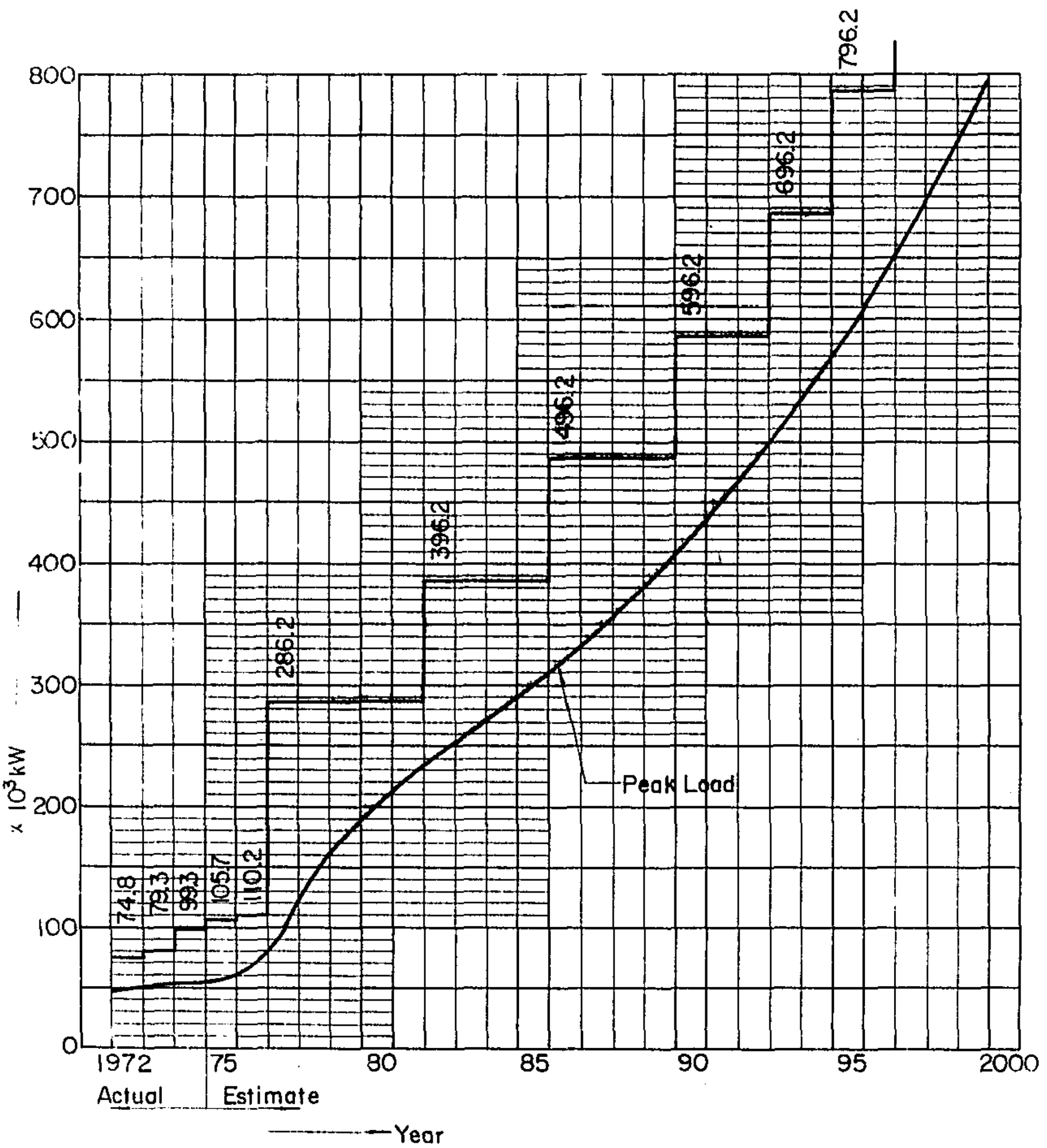


Fig. II-2 Annual Energy Forecast in Central Java

(x10⁶)

Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
Energy	271	298	308	342	462	693	769	852	980	1,126
Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Energy	1,239	1,326	1,419	1,518	1,624	1,738	1,860	1,990	2,129	2,278
Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	
Energy	2,438	2,608	2,791	2,986	3,195	3,419	3,658	4,072	4,357	

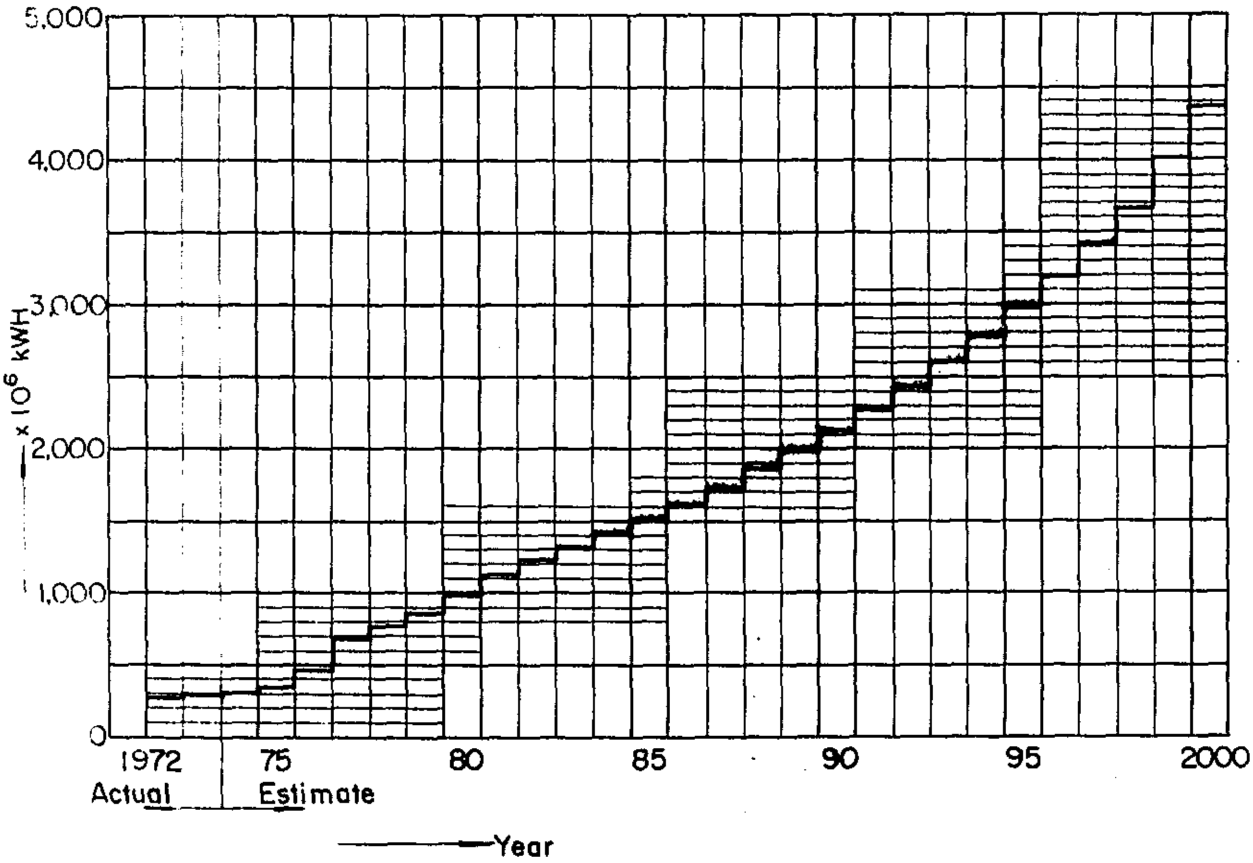


Fig.II-3 Population Forecast in Central Java
(obtained from supporting report, part-six)

(x10³)

Y	1971	1972	1973	1974	1975	1980	1985	1990	1995	2000
U	770	789	809	831	852	974	1,104	1,378	1,489	1,729
R	3,958	4,031	4,107	4,184	4,264	4,685	5,158	5,681	6,267	6,905
T	4,728	4,820	4,916	5,015	5,116	5,659	6,262	7,059	7,756	8,634

Y : Year
U : Urban
R : Rural
T : Total

Note : abovementioned forecast will be considered with family plan

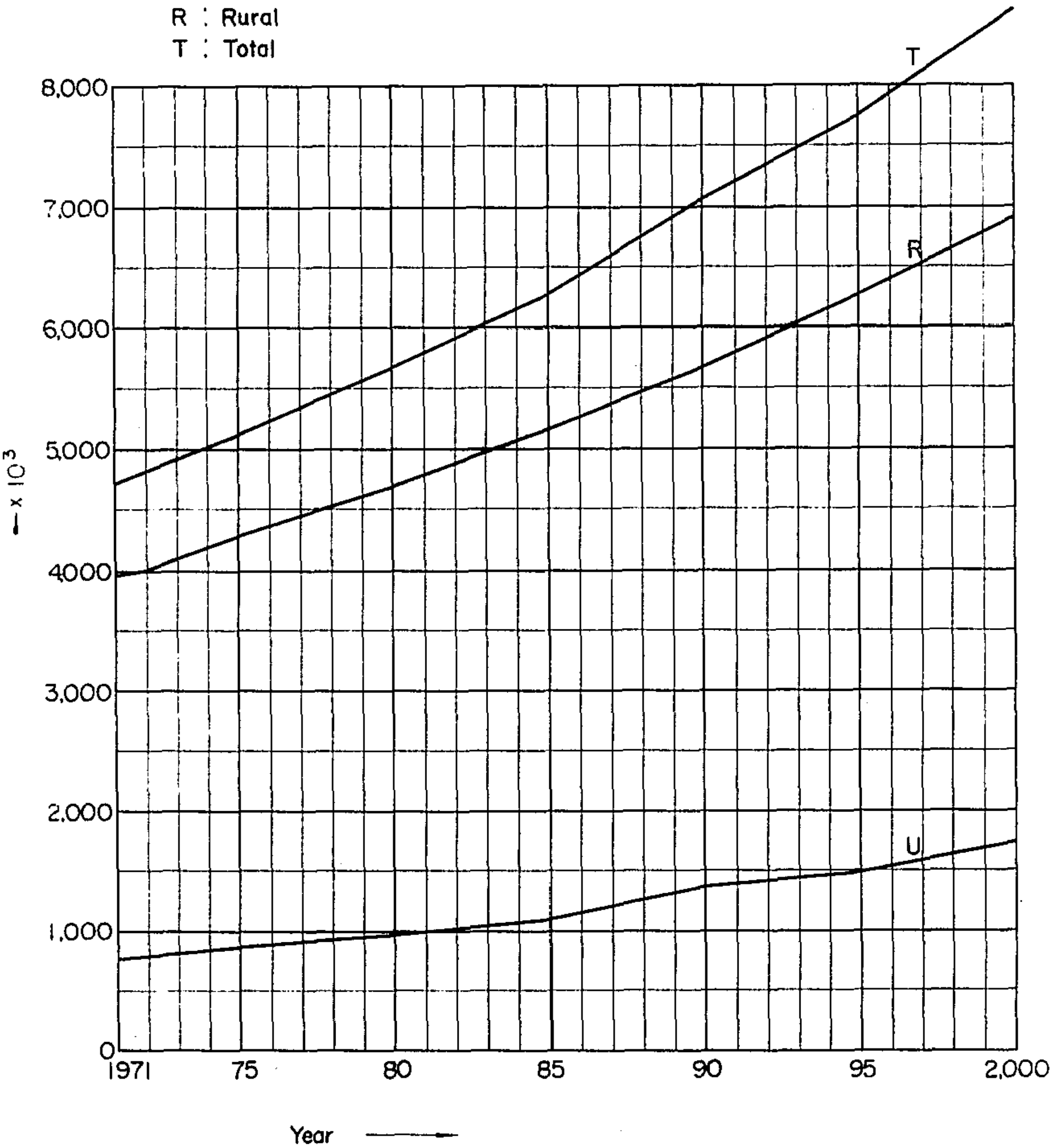


Fig.II-4 Peak Load Forecast In The Town of Wonogiri, Sukoharjo Wuryantoro

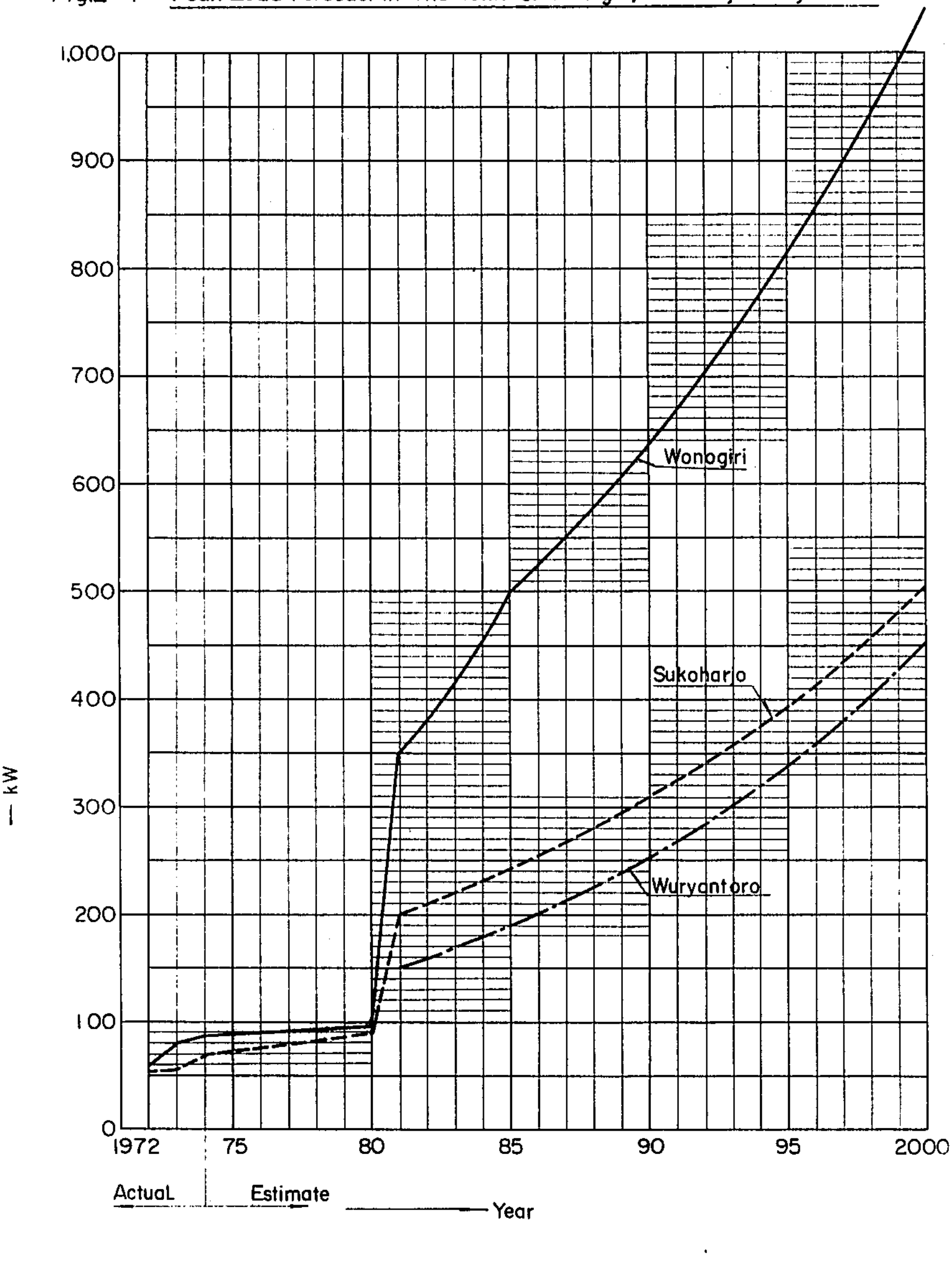


Fig.II-5 Annual Energy Forecast in The Town of Wonogiri, Sukoharjo & Wuryantoro

(x 10³)

Year	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
W	259	278	312	324	331	335	340	348	353	1,840
S	229	237	253	271	283	298	309	324	335	1,051
U	—	—	—	—	—	—	—	—	—	788

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
W	2,008	2,186	2,381	2,628	2,759	2,896	3,043	3,196	3,353	3,522
S	1,104	1,162	1,219	1,277	1,340	1,409	1,477	1,551	1,629	1,713
U	836	888	941	993	1,056	1,120	1,188	1,256	1,330	1,414

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000
W	3,700	3,884	4,079	4,278	4,494	4,720	4,956	5,203	5,461
S	1,798	1,887	1,982	2,081	2,186	2,297	2,407	2,528	2,654
U	1,498	1,587	1,682	1,782	1,887	2,003	2,123	2,250	2,386

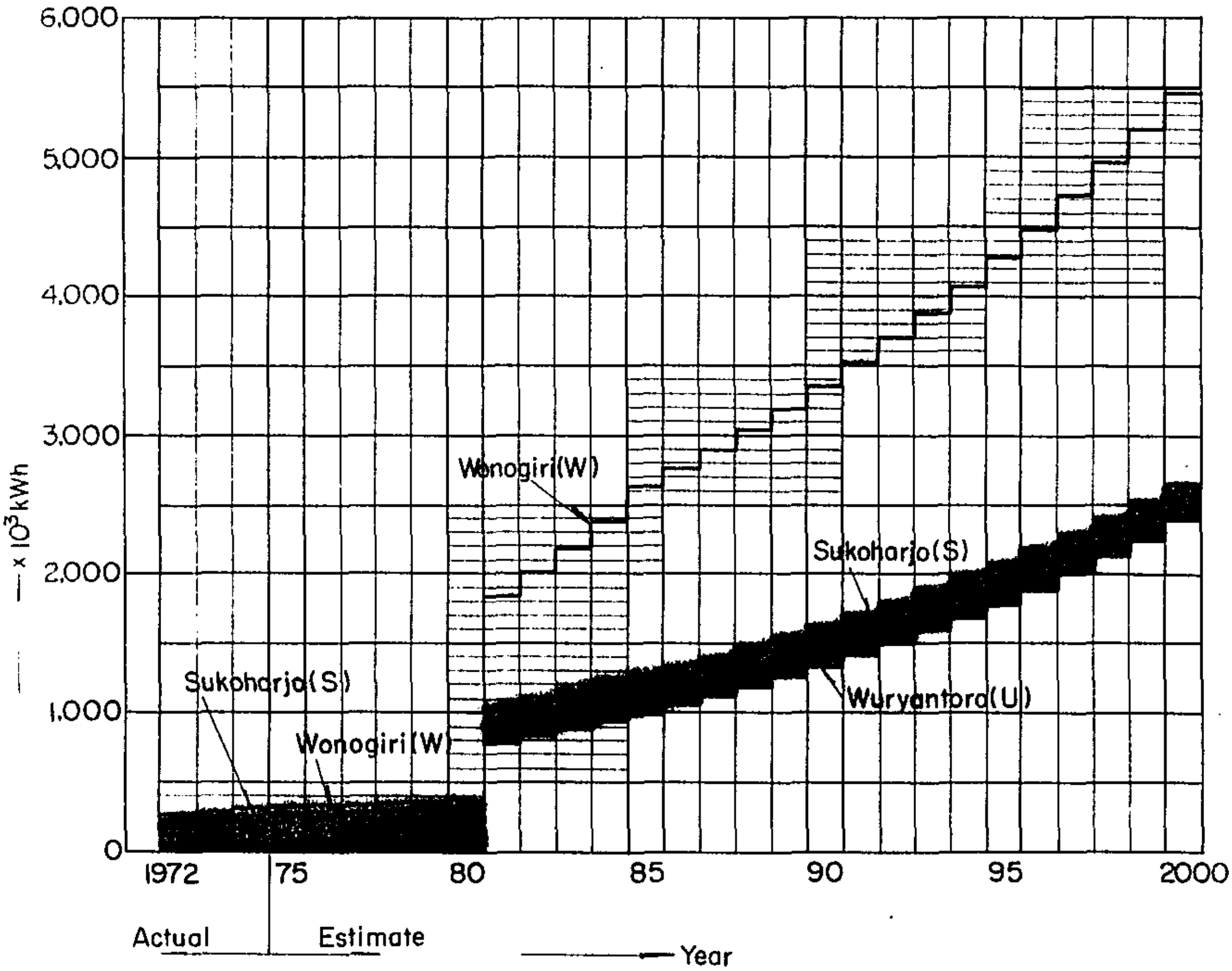


Fig.II-6 Population Forecast in The Town of Wonogiri, Sukoharjo & Wuryantoro (Not including outskirt)

(x10³)

Y	1971	1972	1973	1974	1975	1980	1985	1990	1995	2000
W	18.5	19.0	19.5	20.0	20.5	23.1	25.8	31.0	33.3	37.9
S	17.9	18.3	18.8	19.3	19.8	22.2	24.9	29.8	32.1	36.5
U	3.7	3.8	3.9	4.0	4.1	4.6	5.1	6.2	6.6	7.6

Y : Year
W : Wonogiri
S : Sukoharjo
U : Wuryantoro

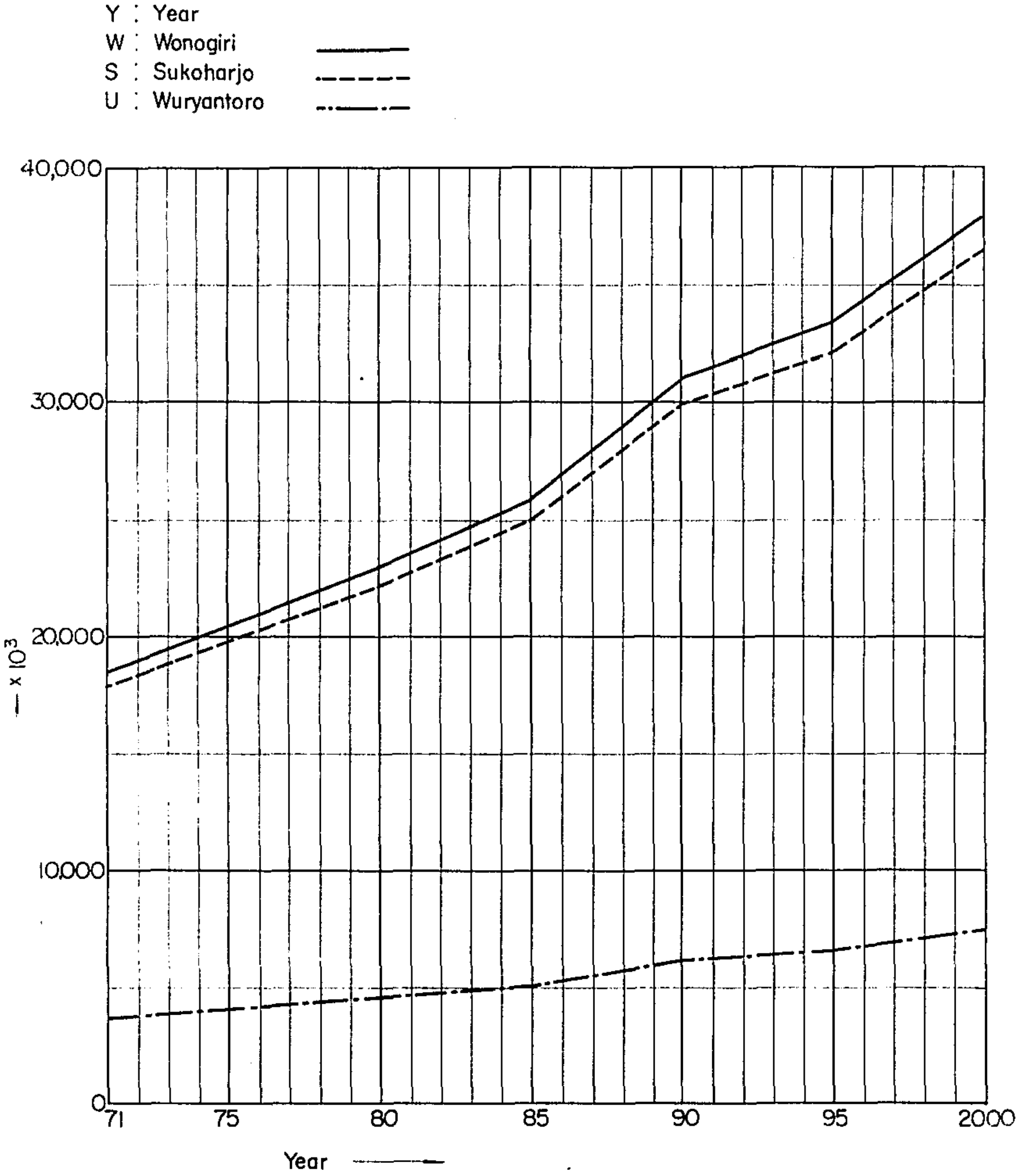
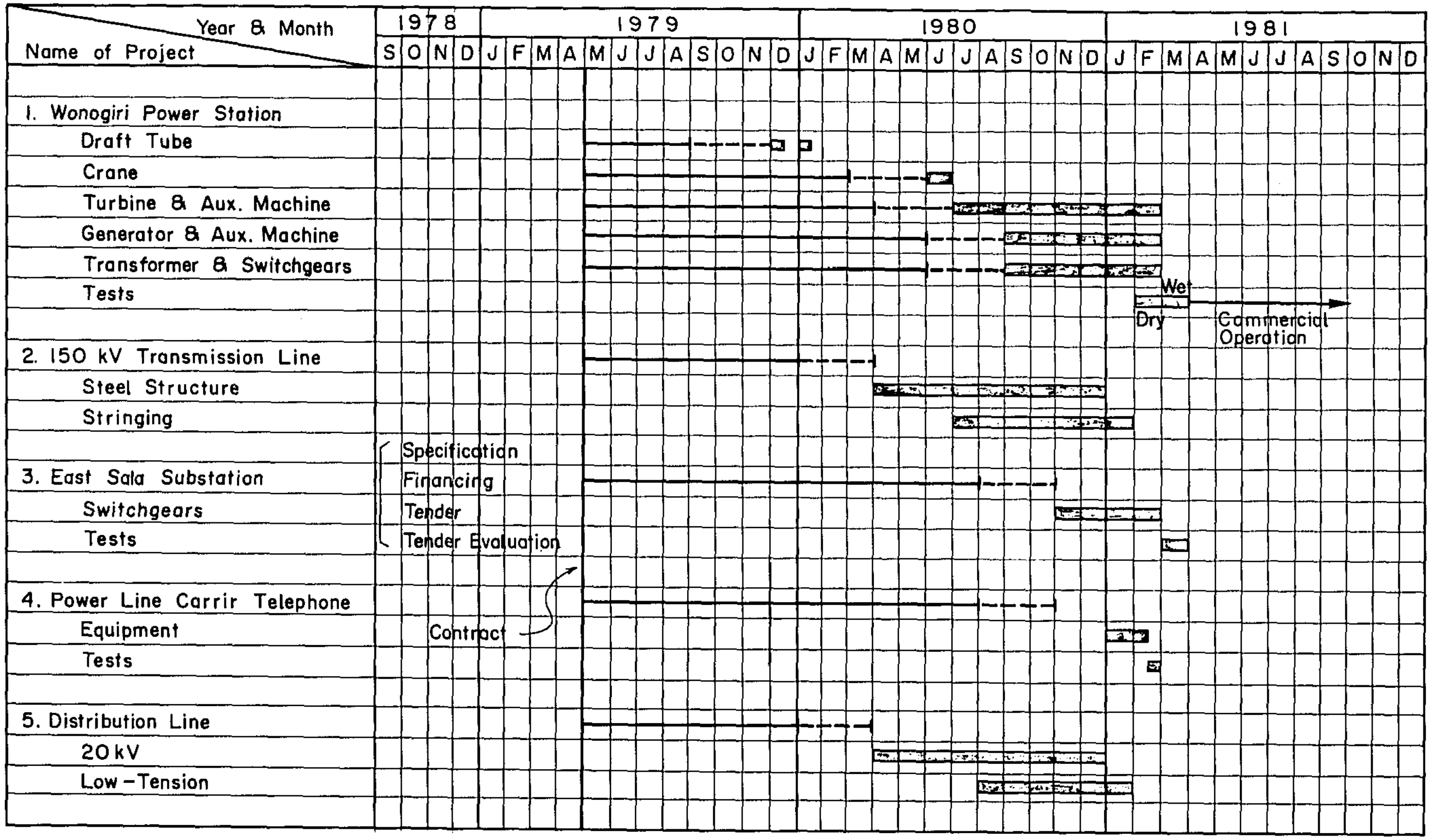


Fig. II-7 Construction Time Schedule (Power Project)



——— Design and Manufacturing

------- Transportation by Sea, Custom Clearance and Inland Transportation

Appendix-1 Existing Generating Facilities in Central Java

(obtained from the data of PLN Jakarta and PLN Pumbangkitan II Semarang) (Mar. 1975)

Name of Power Station	Date in Service	Classification of Turbine	Combustion	kVA	Power Factor	kW	Total kW
1	2	3	4	5	6	7	8
I. Tuntang System							79,880
(1) Jelok	1938	Hydro	Hydro	6,400 x 3	0.8	5,120 x 3	
	1962	Hydro	Hydro	6,400 x 1	0.8	5,120 x 1	
							20,480
(2) Timo	1963	Hydro	Hydro	5,000 x 3	0.8	4,000 x 3	
							12,000
(3) Kalisari	1930	Diesel	Diesel	1,275 x 1	0.8	1,020 x 1	
	1950	Diesel	Diesel	1,250 x 2	0.8	1,000 x 2	
	1951	Diesel	Diesel	1,250 x 1	0.8	1,000 x 1	
	1953	Diesel	Diesel	1,250 x 2	0.8	1,000 x 2	
							6,020
(4) Pandean Lamper	1968	Gas	Oil-Fired	16,000 x 1	0.875	14,000 x 1	
	1974	Gas	Oil-Fired			20,000 x 1	
							34,000
(5) Wirobrajan	1954	Diesel	Diesel	1,250 x 1	0.8	1,000 x 1	
	1958	Diesel	Diesel	1,275 x 1	0.8	1,020 x 1	
	1959	Diesel	Diesel	1,275 x 2	0.8	1,020 x 2	
							4,060
(6) Kudus	1962	Diesel	Diesel	700 x 2	0.8	560 x 2	
							1,120
(7) Purwosari	1973	Diesel	Diesel	1,375 x 2	0.8	1,100 x 2	
							2,200
II. Ketenger System							19,412
(1) Ketenger	1939	Hydro	Hydro	4,400 x 2	0.8	3,520 x 2	
							7,040

1	2	3	4	5	6	7	8
(2) Pekalongan	1928	Diesel	Diesel	860 x 1	0.8	688	
	1969	Diesel	Diesel	400 x 1	0.8	320	
	1971	Diesel	Diesel	465 x 1	0.8	372	
							1,380
(3) Tegal - I	1927	Diesel	Diesel	380 x 1	0.8	304 x 1	
	1930	Diesel	Diesel	860 x 1	0.8	688 x 1	
	1955	Diesel	Diesel	1,250 x 1	0.8	1,000 x 1	
	1972	Diesel	Diesel	1,250 x 2	0.8	1,000 x 2	
							3,992
(4) Tegal - II	1973	Diesel	Diesel	1,440 x 2	0.8	1,152 x 2	
							2,304
(5) Cilacap	1927	Diesel	Diesel	160 x 1	0.8	128 x 1	
	1925	Diesel	Diesel	500 x 1	0.8	400 x 1	
	1965	Diesel	Diesel	730 x 2	0.8	584 x 2	
	1970	Diesel	Diesel	1,250 x 2	0.8	1,000 x 2	
	1971	Diesel	Diesel	1,250 x 1	0.8	1,000 x 1	
							4,696
III. Isolated Stations							10,726.2
(1) Wonosobo	1943	Hydro	Hydro	155 x 1	0.8	124 x 1	
	1950	Diesel	Diesel	60 x 2	0.8	48 x 2	
	1972	Diesel	Diesel	125 x 1	0.8	100 x 1	
							320
(2) Banjarnegara	1949	Hydro	Hydro	320 x 1	0.8	256 x 1	
							256
(3) Jepara	1950	Diesel	Diesel	60 x 3	0.8	48 x 3	
	1970	Diesel	Diesel	75 x 1	0.8	60 x 1	
	1973	Diesel	Diesel	125 x 1	0.8	100 x 1	
							304

1	2	3	4	5	6	7	8
(4) Purwodadi	1955	Diesel	Diesel	63 x 3	0.8	50.4 x 3	
	1951	Diesel	Diesel	100 x 1	0.8	80 x 1	
	1971	Diesel	Diesel	135 x 1	0.8	108 x 1	
	1973	Diesel	Diesel	119 x 1	0.8	95.2 x 1	
	1970	Diesel	Diesel	100 x 1	0.8	80 x 1	
							514.4
(5) Weleri	1969	Diesel	Diesel	250 x 1	0.8	200 x 1	
	1969	Diesel	Diesel	93.7 x 1	0.8	75 x 1	
							275
(6) Cepu	1924	Diesel	Diesel	400 x 1	0.8	320 x 1	
	1914	Diesel	Diesel	380 x 1	0.8	304 x 1	
	1963	Diesel	Diesel	375 x 1	0.8	300 x 2	
	1972	Diesel	Diesel	1,250 x 1	0.8	1,000 x 1	
	1971	Diesel	Diesel	1,250 x 1	0.8	1,000 x 1	
	1973	Diesel	Diesel	1,440 x 2	0.8	1,152 x 2	
							5,528
(7) Lasem	1928	Diesel	Diesel	220 x 1	0.8	176 x 1	
	1954	Diesel	Diesel	288 x 1	0.8	230.4 x 1	
	1972	Diesel	Diesel	125 x 1	0.8	100 x 1	
	1972	Diesel	Diesel	375 x 1	0.8	300 x 1	
							806.4
(8) Tuban	1927	Diesel	Diesel	175 x 2	0.8	140 x 2	
	1955	Diesel	Diesel	288 x 1	0.8	230.4 x 1	
	1973	Diesel	Diesel	340 x 2	0.8	272 x 2	
							1,054.4
(9) Sragen	1955	Diesel	Diesel	117 x 1	0.8	93.6 x 1	
	1972 & 1973	Diesel	Diesel	312.5 x 2	0.8	250 x 2	
							593.6
(10) Sukoharjo	1962	Diesel	Diesel	75 x 2	0.8	60 x 2	
							120

1	2	3	4	5	6	7	8
(11) **Karanganyar**	1962	Diesel	Diesel	75 x 1	0.8	60 x 1	
	1969	Diesel	Diesel	75 x 1	0.8	60 x 1	
							120
(12) **Wonogiri**	1964	Diesel	Diesel	75 x 2	0.8	60 x 2	
							120
(13) **Wates**	1968	Diesel	Diesel	30 x 1	0.8	24 x 1	
	1959	Diesel	Diesel	30 x 1	0.8	24 x 1	
	1960	Diesel	Diesel	30 x 1	0.8	24 x 1	
	1972	Diesel	Diesel	75 x 1	0.8	60 x 1	
							132
(14) **Wonosari**	1962	Diesel	Diesel	75 x 2	0.8	60 x 2	
							120
(15) **Majenang**	1960	Diesel	Diesel	119 x 1	0.8	95.2 x 1	
	1972	Diesel	Diesel	340 x 1	0.8	272 x 1	
							367.2
(16) **Bumiayu**	1959	Diesel	Diesel	119 x 1	0.8	95.2 x 1	
							95.2

Appendix-2 Private Generating Facilities
(Obtained from PLN Pembangkitan II Semarang)

Item	Area	Installed Capacity (kW)			
		Hydro	Steam	Diesel	Total
1.	Semarang	47.84	2,082.512	24,233.765	26,364.117
2.	Sala	-	-	2,334.32	2,334.32
3.	Yogyakarta	3,840	400	19,246.6	23,486.6
4.	Tegal	-	-	28,312.172	28,312.172
5.	Purwokerto	38	350	11,287.1	11,675.1
6.	Magelang	-	-	6,431.6	6,431.6
7.	Cepu	-	-	3,528.65	3,528.65
8.	T o t a l	3,925.84	2,832.512	95,374.207	102,132.559

Appendix-3 New Transmission Line Facilities Under Construction and Planning in Central Java (Mar. 1975)

(obtained from PLN Pembangunan VII Semarang)

Section	Voltage (kV)	Length (kM)	No. of Circuit	Date in Service
Under construction				
Semarang East-Jatingaleh	150	8.0	1	1975
Jatingaleh-Semarang West	150	8.0	1	1975
Semarang East - H. Jelog	150	28.0	1	1975
Jelog - Surakarta	150	57.0	1	1975
Cilacap - Purwokerto	150	47.0	2	1976
Purwokerto - Tegal	150	120.0	2	1976
Tegal - Pekalongan	150	57.0	2	1976
Tegal - Cirebon	150	-	2	1976
Planning				
Semarang East-Jatingaleh	150	8.0	1	1977
Jatingaleh-Semarang West	150	8.0	1	1977
Semarang East - Jelog	150	28.0	1	1977
Jelog - Magelang	150	40.0	1	1977
Magelang - Jogyakarta	150	40.0	1	1977
Jogyakarta - Surakarta	150	63.0	1	1977
Semarang West-Pekalongan	150	75.0	1	1977

Appendix-4 Data of Meteorology

(obtained from Supporting Report, Part-One)

Observation Records at Panasan Air!Port in Surakarta

Month	Average Monthly (1964 - 1972)		
	Temp. (°C)	Humidity (%)	Wind (km/hr)
Jan.	27.3	75.8	5.2
Feb.	27.4	76.9	4.7
Mar.	27.8	76.4	5.8
Apr.	28.3	72.0	5.0
May	28.5	69.4	5.7
June	28.0	66.6	6.8
July	27.5	62.7	6.6
Aug.	28.0	59.4	8.4
Sept.	29.1	59.5	10.3
Oct.	29.6	60.8	8.5
Nov.	28.8	70.5	8.1
Dec.	28.1	74.0	6.4
Mean	28.2	68.7	6.8

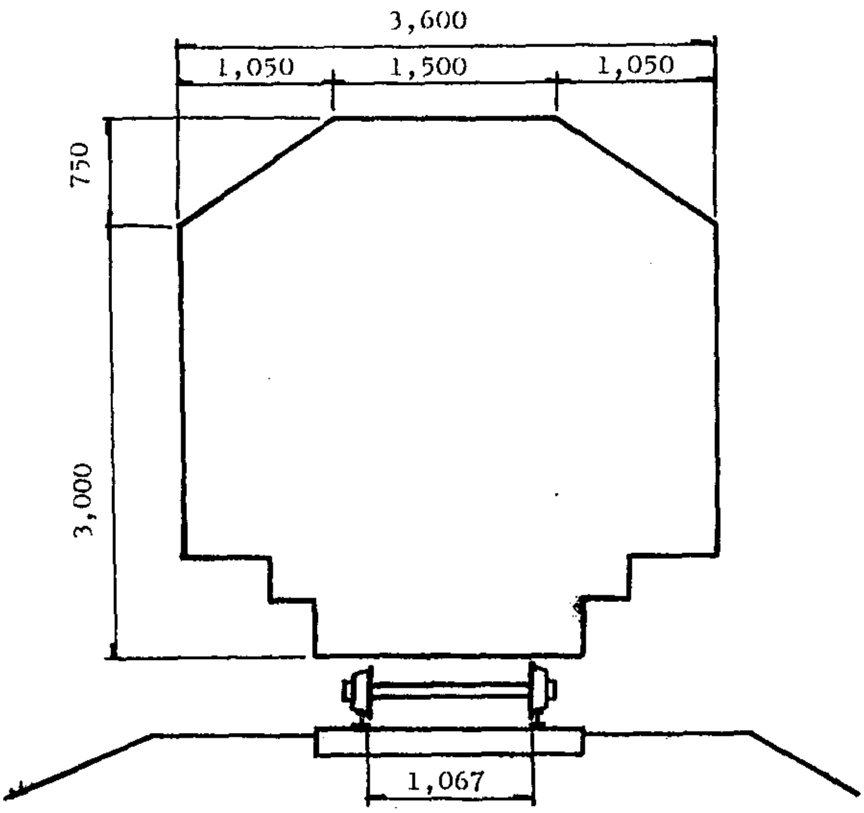
Observation Records at Bengawan Sala Project Office in Surakarta

Year	Month	Temperature (°C)			Humidity (%)	
		Mean	Max.	Min.	Max.	Min.
1972	Sept.	27.9	37.0	14.5	98.5	19.5
	Oct.	29.7	37.8	16.5	97.5	24.0
	Nov.	30.1	37.0	22.0	95.5	35.0
	Dec.	28.0	34.0	21.0	99.0	46.0
1973	Jan.	27.0	32.6	22.4	96.0	54.0
	Feb.	28.0	33.5	21.5	96.0	57.0
	Mar.	28.0	33.0	22.0	96.0	55.0
	Apr.	28.0	33.5	23.0	96.0	51.0
	May	27.0	32.0	22.6	96.0	54.0
	June	27.0	33.0	21.0	96.0	50.0
	July	27.0	33.0	20.0	96.0	50.0
	Aug.	28.0	33.5	20.5	96.0	43.0
	Sept.	27.0	34.5	20.2	96.0	38.0

The maximum wind velocity was observed at 4.62 m/sec on 1974.

Appendix-5 **Access to the Site and Loading Clearance of Railway**

Route	From	To	Hours	By	Remarks
1	Jakarta	Jogyakarta	1	Plane	Flight 3 times /day
	Jogyakarta	Surakarta	1	Road	
	Surakarta	Wonogiri	2/3	Road	
2	Jakarta	Surakarta	1	Plane	Flight 1 times /day
	Surakarta	Wonogiri	1	Road	
3	Jakarta	Surakarta	14	Rail	BIMA Express Train
	Surakarta	Wonogiri	2/3	Road	
4	Jakarta	Wonogiri	14-16	Road	
5	Surabaya	Surakarta	6.5-8.5	Rail	BIMA Express
	Surakarta	Wonogiri	2/3	Road	
6	Jakarta	Surakarta	13	Rail	
	Surakarta	Wonogiri	2/3	Road	
7	Cilacap	Jogyakarta	5½	[illegible]	
	Jogyakarta	Surakarta	1	Road	
	Surakarta	Wonogiri	2/3	Road	



Appendix-6 <u>Construction Cost For Generating Equipment</u>

(10^3 US$)

		Case A	Case B	Case C	Case D
1.	Water Turbines	2,320	2,460	2,620	2,940
2.	Generators	1,320	1,520	1,660	2,000
3.	Transformers	189	217	231	259
4.	Switchgears	491	491	491	491
5.	Ancillary Equipment	261	261	261	316
6.	Miscellaneous Materials	687	742	789	901
7.	Total	5,268	5,691	6,052	6,907
8.	Erection Fee	1,054	1,138	1,210	1,381
	(F.C.)	(696)	(751)	(799)	(911)
	(D.C.)	(358)	(387)	(411)	(470)
9.	Total	6,322	6,829	7,262	8,288
	(F.C.)	(5,964)	(6,442)	(6,851)	(7,818)
	(D.C.)	(358)	(387)	(411)	(470)

Case A

Q(MAX)=44.0 m^3/sec
RATED HEAD=21.3m
TAILWATER EL.=110.3m

44-1 Monthly Inflow (Unit $10^6 m^3$)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	30.3	27.3	30.3	29.3	153.7	93.4	84.1	89.3	58.6	31.2	38.8	40.2
54	58.8	53.1	58.8	56.9	94.5	80.2	68.5	70.3	48.3	58.8	56.9	58.8
55	62.7	56.6	62.7	5.2	47.0	62.9	40.5	68.5	52.9	62.7	60.7	62.7
56	57.0	51.5	57.0	36.8	31.3	52.3	63.6	63.0	44.9	57.0	55.2	57.0
57	41.2	37.3	41.2	39.9	45.9	89.8	54.1	81.2	58.1	41.2	43.0	41.2
58	84.9	76.7	84.9	37.1	64.8	82.2	51.2	68.5	43.2	84.9	82.2	84.9
59	59.5	53.7	59.5	57.5	53.8	77.6	73.4	87.5	53.5	59.5	57.5	59.5
60	21.2	16.7	14.7	8.0	113.3	89.7	86.8	87.3	55.7	20.9	24.4	61.6
61	33.2	30.0	33.2	32.1	35.4	80.9	78.5	78.2	50.8	22.0	40.2	49.6
62	58.9	53.2	58.9	41.5	39.4	80.1	69.6	77.4	57.0	58.9	57.0	58.9
63	31.6	10.9	8.8	3.6	50.1	87.4	91.9	72.3	45.9	19.8	39.7	32.4
64	4.8	7.7	2.1	8.0	20.9	66.4	79.8	76.3	47.7	13.7	50.0	45.0
65	31.6	28.5	31.6	30.6	44.7	88.9	81.2	89.2	58.1	30.8	36.0	47.9
66	70.8	64.0	70.8	68.2	64.5	75.9	91.9	87.5	55.2	70.8	68.6	70.8
67	39.6	35.8	39.6	38.4	49.8	94.1	91.9	89.2	58.1	26.2	41.5	47.9
68	97.0	87.6	97.0	40.2	129.9	80.9	80.1	70.3	48.9	97.0	93.8	97.0
69	23.8	17.7	19.6	18.9	46.3	92.5	91.9	88.4	58.6	19.6	45.1	33.2
70	139.0	125.6	139.0	47.2	141.4	84.6	83.1	89.3	48.9	139.0	134.5	139.0
71	97.0	87.6	97.0	35.8	68.8	76.7	84.1	87.5	53.5	97.0	93.8	97.0
72	59.7	53.9	59.7	114.3	61.9	93.4	91.9	85.7	58.6	47.9	46.4	49.6

44-2 Power Release (Unit m^3/s)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	41.2	43.8	41.0	38.9	37.9	39.1	41.5	43.7	42.0	40.7	39.7	39.5
54	43.0	41.6	40.6	38.9	37.9	38.6	40.1	41.9	43.9	42.9	42.9	43.7
55	42.0	40.1	39.3	38.9	38.0	38.4	38.8	39.4	40.7	42.4	43.1	43.0
56	43.5	43.7	41.5	38.5	38.7	38.8	39.1	40.1	41.5	43.1	43.6	43.3
57	41.4	42.6	42.4	39.3	38.3	39.8	41.5	43.3	43.0	41.7	40.4	40.6
58	42.9	42.8	40.2	38.5	37.9	38.9	40.2	41.6	43.4	43.2	41.7	41.4
59	42.0	43.7	41.0	38.9	37.9	38.5	40.0	42.3	43.5	42.4	40.8	40.9
60	40.5	42.4	43.2	40.4	37.9	39.0	41.2	43.9	42.3	41.3	40.7	40.0
61	39.8	42.5	43.9	40.1	39.4	40.3	42.8	43.0	41.4	40.2	39.3	38.3
62	41.6	43.6	41.0	38.5	38.0	38.9	40.7	42.9	43.2	41.7	40.3	40.0
63	37.8	38.3	40.5	43.2	38.5	40.1	42.8	42.9	41.4	40.3	39.3	38.2
64	40.0	42.9	41.4	38.7	43.0	43.3	43.1	41.1	39.1	38.8	39.2	38.7
65	39.1	41.4	43.0	38.8	38.4	40.0	42.6	43.0	41.1	39.6	38.4	38.0
66	43.3	41.1	39.6	38.5	37.9	38.2	39.6	42.0	43.7	42.4	41.1	41.1
67	38.9	40.8	43.7	39.4	38.3	39.7	42.3	43.0	41.2	39.8	38.6	37.9
68	41.9	41.1	39.4	38.5	37.9	37.9	37.9	38.2	38.8	40.1	41.7	41.8
69	39.4	42.0	42.3	39.1	38.3	39.7	42.2	43.1	41.4	40.2	39.4	38.8
70	41.6	42.7	41.6	38.5	37.9	38.3	39.5	41.7	43.7	42.9	41.3	41.2
71	43.8	43.1	41.2	38.5	37.9	38.4	39.6	41.6	43.7	43.2	42.7	42.8
72	39.0	41.2	43.0	38.5	37.9	39.0	41.4	43.8	42.2	40.8	39.4	38.2

44-3 Reservoir Water Level (Unit m)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	130.2	132.6	134.4	135.6	136.2	135.5	134.1	132.5	130.9	129.7	128.8	128.7
54	133.3	134.0	134.6	135.6	136.2	135.8	134.9	133.9	132.9	131.8	131.7	132.5
55	133.8	134.8	135.4	135.6	136.2	135.9	135.7	135.3	134.5	133.6	133.3	133.3
56	132.3	132.5	134.1	135.8	135.7	135.7	135.5	134.9	134.1	133.3	132.4	132.1
57	130.3	131.4	133.6	135.4	136.0	135.0	134.1	133.1	131.8	130.6	129.5	129.6
58	131.7	133.4	134.8	135.8	136.2	135.6	134.8	134.0	133.1	132.0	130.7	130.4
59	131.0	132.5	134.4	135.6	136.2	135.8	135.0	133.7	132.3	131.1	129.8	129.9
60	129.6	131.3	133.2	134.7	136.2	135.6	134.2	132.7	131.2	130.2	129.7	129.1
61	129.0	131.4	132.8	134.9	135.3	134.7	133.4	131.8	130.3	129.3	128.5	127.6
62	130.5	132.4	134.3	135.8	136.2	135.6	134.6	133.3	132.0	130.7	129.4	129.1
63	127.2	127.6	129.5	132.1	135.9	134.9	133.4	131.7	130.3	129.4	128.5	127.6
64	129.1	131.7	134.1	135.7	133.3	133.1	131.9	130.1	128.3	128.1	128.4	128.0
65	128.4	130.3	133.3	135.6	135.9	134.9	133.5	131.8	130.1	128.8	127.8	127.4
66	132.1	134.3	135.2	135.8	136.2	136.0	135.2	133.8	132.5	131.2	130.1	130.1
67	128.1	129.8	132.5	135.3	136.0	135.1	133.6	131.9	130.2	129.0	127.9	127.3
68	133.9	134.3	135.3	135.8	136.2	136.2	136.2	136.0	135.7	134.9	134.0	133.9
69	128.6	130.9	133.6	135.5	136.0	135.1	133.7	132.0	130.3	129.3	128.6	128.1
70	136.0	131.5	134.0	135.8	136.2	136.0	135.2	134.0	133.0	131.7	130.3	130.2
71	132.6	133.2	134.3	135.8	136.2	135.9	135.1	134.0	133.0	132.0	131.5	131.7
72	128.2	130.2	133.3	135.8	136.2	135.5	134.1	132.6	131.1	129.8	128.5	127.6

44-4 Maximum Power (Unit MW)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	6.26	7.51	7.62	7.62	7.62	7.62	7.62	7.47	6.64	6.04	5.60	5.52
54	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.08	7.06	7.48
55	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62
56	7.35	7.45	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.39	7.25
57	6.34	6.90	7.62	7.62	7.62	7.62	7.62	7.62	7.09	6.50	5.91	5.98
58	7.04	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.22	6.50	6.86
59	6.65	7.47	7.62	7.62	7.62	7.62	7.62	7.62	7.38	6.73	6.07	6.10
60	5.96	6.81	7.62	7.62	7.62	7.62	7.62	7.57	6.78	6.29	6.01	5.73
61	5.65	6.88	7.62	7.62	7.62	7.62	7.62	7.11	6.34	5.83	5.41	5.01
62	6.42	7.40	7.62	7.62	7.62	7.62	7.62	7.62	7.20	6.51	5.87	5.74
63	4.84	5.02	5.93	7.22	7.62	7.62	7.62	7.05	6.34	5.87	5.42	4.99
64	5.73	7.06	7.62	7.62	7.62	7.62	7.15	6.21	5.36	5.24	5.37	5.18
65	5.37	6.34	7.62	7.62	7.62	7.62	7.62	7.10	6.21	5.58	5.08	4.92
66	7.27	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.48	6.80	6.21	6.23
67	5.27	6.08	7.46	7.62	7.62	7.62	7.62	7.14	6.25	5.66	5.14	4.85
68	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62
69	5.48	6.62	7.62	7.62	7.62	7.62	7.62	7.19	6.34	5.81	5.46	5.23
70	6.45	6.96	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.05	6.30	6.27
71	7.51	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.62	7.22	6.96	7.02
72	5.32	6.27	7.62	7.62	7.62	7.62	7.62	7.52	6.75	6.07	5.46	5.00

44-5 Monthly Energy Output (Unit 10^2 MWh)

1) Peak

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	11.6	12.6	14.2	13.7	14.2	13.7	14.2	13.9	12.0	11.2	10.1	10.3
54	14.2	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.7	13.2	12.7	13.9
55	14.2	12.8	14.2	2.8	14.2	13.7	14.2	14.2	13.7	14.2	13.7	14.2
56	13.7	12.5	14.2	13.7	14.2	13.7	14.2	14.2	13.7	14.2	13.3	13.5
57	11.8	11.6	14.2	13.7	14.2	13.7	14.2	14.2	12.8	12.1	10.6	11.1
58	13.1	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.7	13.4	11.7	11.8
59	12.4	12.5	14.2	13.7	14.2	13.7	14.2	14.2	13.3	12.5	10.9	11.3
60	8.6	7.4	7.2	4.2	14.2	13.7	14.2	14.1	12.2	8.8	10.0	10.7
61	10.5	11.6	14.2	13.7	14.2	13.7	14.2	13.2	11.4	8.8	9.7	9.3
62	11.9	12.4	14.2	13.7	14.2	13.7	14.2	14.2	13.0	12.1	10.6	10.7
63	9.0	4.0	3.6	1.7	14.2	13.7	14.2	13.1	11.4	8.0	9.8	9.3
64	1.9	3.5	1.1	4.4	10.3	13.7	13.3	11.6	9.7	5.1	9.7	9.6
65	10.0	10.7	14.2	13.7	14.2	13.7	14.2	13.2	11.2	10.4	9.1	9.1
66	13.5	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.5	12.7	11.2	11.6
67	9.8	10.2	13.9	13.7	14.2	13.7	14.2	13.3	11.3	10.4	9.2	9.0
68	14.2	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.7	14.2	13.7	14.2
69	9.2	7.7	9.8	10.2	14.2	13.7	14.2	13.4	11.4	7.8	9.8	9.7
70	12.0	11.7	14.2	13.7	14.2	13.7	14.2	14.2	13.7	13.1	11.3	11.7
71	14.0	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.7	13.4	12.5	13.1
72	9.9	10.5	14.2	13.7	14.2	13.7	14.2	14.0	12.1	11.3	9.8	9.3

44-5 Monthly Energy Output

2) Off Peak (Unit 10^2 MWh)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	1.1	0.4	1.5	2.2	71.6	36.9	28.8	28.5	13.8	1.6	5.1	5.3
54	14.8	14.2	16.5	17.2	38.6	30.3	22.0	21.4	9.6	13.8	13.3	14.0
55	17.4	17.1	19.6	0	12.0	20.9	7.9	22.6	13.8	17.2	16.1	16.7
56	13.1	11.9	14.9	6.5	2.9	14.8	20.3	19.1	9.2	13.9	12.7	13.1
57	5.8	5.2	6.4	7.8	11.2	34.1	13.4	25.5	13.9	5.8	6.8	5.8
58	25.7	25.2	30.6	6.7	22.0	31.0	12.8	20.7	7.4	26.0	23.9	24.4
59	13.8	12.9	16.5	17.6	15.9	28.9	24.7	29.6	11.9	13.8	12.9	13.3
60	0	0	0	0	49.1	35.0	30.4	27.7	12.6	0	0	13.9
61	2.6	1.9	1.8	3.2	4.8	28.8	24.7	22.7	10.2	0	5.6	8.7
62	13.4	12.7	16.2	9.1	7.8	29.9	22.1	24.0	13.5	13.4	12.5	12.8
63	2.2	0	0	0	13.4	32.4	31.2	19.9	8.1	0	5.4	2.5
64	0	0	0	0	0	18.7	23.5	20.5	8.5	0	9.4	7.1
65	2.1	1.5	1.4	3.0	10.5	33.3	26.2	27.7	13.2	1.7	4.1	8.1
66	13.5	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.5	12.7	11.2	11.6
67	9.8	10.2	13.9	13.7	14.2	13.7	14.2	13.3	11.3	10.4	9.2	9.0
68	14.2	12.8	14.2	13.7	14.2	13.7	14.2	14.2	13.7	14.2	13.7	14.2
69	0	0	0	0	11.5	35.7	31.9	27.5	13.5	0	7.5	2.7
70	47.9	45.2	56.6	12.2	64.7	33.1	30.4	31.1	10.0	50.4	45.7	47.0
71	32.2	30.2	35.7	5.9	24.2	28.6	30.8	30.3	12.2	31.6	30.0	31.1
72	12.7	12.3	15.2	49.1	20.4	37.0	32.8	26.9	13.9	8.5	8.0	8.7

44-5 Monthly Energy Output

3) Total

(Unit 10^2 MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.8	13.0	15.6	16.0	85.8	50.6	43.0	42.4	25.7	12.9	15.2	15.6
54	28.9	27.0	30.7	30.9	52.8	44.0	36.0	35.6	23.3	26.9	26.0	27.9
55	31.6	29.9	33.8	2.8	26.2	34.6	22.1	36.8	27.5	31.3	29.8	30.9
56	26.8	24.4	29.1	20.2	17.1	28.6	34.5	33.3	22.9	28.1	26.0	26.6
57	17.6	16.8	20.6	21.5	25.3	47.8	27.6	39.7	26.6	17.8	17.5	16.9
58	38.8	38.0	44.8	20.4	36.2	44.7	27.0	34.9	21.1	39.4	35.6	36.2
59	26.1	25.5	30.7	31.4	30.0	42.6	38.9	43.8	25.2	26.3	23.8	24.7
60	8.6	7.4	7.2	4.2	63.2	48.8	44.6	41.8	24.8	8.8	10.0	24.5
61	13.1	13.5	16.0	17.0	19.0	42.5	38.9	35.9	21.6	8.8	15.4	18.0
62	25.3	25.1	30.4	22.8	22.0	43.6	36.3	38.2	26.4	25.5	23.1	23.5
63	11.2	4.0	3.6	1.7	27.6	46.1	45.4	33.0	19.5	8.0	15.2	11.8
64	1.9	3.5	1.1	4.4	10.3	32.4	36.8	32.1	18.2	5.1	19.1	16.7
65	12.0	12.2	15.6	16.7	24.7	47.1	40.4	40.9	24.4	12.0	13.2	17.2
66	33.0	32.9	37.9	37.5	36.0	42.0	49.2	44.1	26.2	31.6	28.8	29.8
67	14.9	14.8	18.8	20.6	27.6	50.2	46.0	41.1	24.5	10.4	15.3	17.1
68	49.0	45.2	52.1	22.1	72.5	45.1	44.7	39.0	26.7	51.2	47.7	49.2
69	9.2	7.7	9.8	10.2	25.6	49.4	46.1	40.9	24.9	7.8	17.4	12.4
70	59.8	56.8	70.7	25.9	78.9	46.8	44.5	45.3	23.7	63.5	57.0	58.7
71	46.2	43.0	49.9	19.7	38.4	42.3	44.9	44.5	25.9	45.0	42.5	44.2
72	22.6	22.8	29.4	62.9	34.5	50.7	47.0	40.9	26.0	19.8	17.9	18.0

Case B

Q(MAX)=52.0 m^3/sec
RATED HEAD=21.2 m
TAIL WATER EL=110.3 m

52-1. Monthly Inflow (Unit: 10^6 m^3)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	30.3	27.3	30.3	29.3	153.7	93.4	84.2	89.3	58.6	31.2	38.8	40.2
54	58.8	53.1	58.7	56.9	94.5	80.2	68.5	70.3	48.3	58.8	56.9	58.8
55	62.7	56.6	62.7	51.8	47.0	62.9	40.5	68.5	52.9	62.7	60.7	62.7
56	57.0	51.5	57.0	36.8	31.3	52.3	63.6	63.0	44.9	57.0	55.2	57.0
57	41.2	37.3	41.2	39.9	45.9	59.8	54.1	81.2	58.1	41.2	43.0	41.2
58	84.9	76.7	84.9	37.1	64.8	82.7	51.2	68.5	43.2	84.9	82.2	84.9
59	59.5	53.7	59.5	57.5	53.8	77.6	73.4	87.5	53.5	59.5	57.5	59.5
60	21.2	16.7	14.7	80.4	113.3	89.7	86.8	87.3	55.7	20.9	24.4	61.6
61	33.2	30.0	33.2	32.1	35.4	80.9	78.5	78.2	50.8	22.0	40.2	49.6
62	58.9	53.2	58.9	41.5	39.4	80.1	69.6	77.4	57.0	58.9	57.0	58.9
63	31.6	10.9	8.8	3.6	50.1	87.4	91.9	72.3	49.9	19.8	39.7	32.4
64	4.8	7.7	2.1	8.0	20.9	66.4	79.8	76.3	47.7	13.7	50.0	45.0
65	31.6	28.5	31.6	30.6	44.7	88.9	81.2	89.2	58.1	30.8	36.0	47.9
66	70.8	64.0	70.8	68.2	64.5	75.9	91.9	87.5	55.2	70.8	68.6	70.8
67	39.6	35.8	39.6	38.4	49.8	94.1	91.9	89.2	58.1	26.2	41.5	47.9
68	97.0	87.6	97.0	40.2	129.9	80.9	80.1	70.3	48.9	97.0	93.8	97.0
69	23.8	17.7	19.6	18.9	46.3	92.5	91.9	88.4	58.6	19.6	45.1	33.2
70	139.0	125.6	139.0	47.2	141.4	84.6	83.1	89.3	48.9	139.0	134.5	139.0
71	97.0	87.6	97.0	35.8	68.8	76.7	84.1	87.5	53.5	97.0	93.8	97.0
72	59.7	53.9	59.7	114.3	61.9	93.4	91.9	85.7	58.6	47.9	46.4	49.6

52-2 Power Release (Unit: m^3/s)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	48.7	51.7	48.4	45.9	44.8	46.1	49.0	51.6	49.7	48.1	46.9	46.7
54	50.8	49.1	47.9	46.0	44.8	45.6	47.3	49.5	51.9	50.7	50.7	51.7
55	49.6	47.4	46.4	46.0	44.9	45.4	45.8	46.5	48.1	50.0	50.9	50.8
56	51.4	51.6	49.1	45.5	45.8	45.8	46.2	47.4	49.0	50.9	51.5	51.1
57	48.9	50.3	50.1	46.4	45.2	47.0	49.0	51.2	50.8	49.3	47.7	47.9
58	50.6	50.5	47.4	45.5	44.8	45.9	47.5	49.1	51.3	51.1	49.3	48.9
59	49.7	51.6	48.5	45.9	44.8	45.5	47.2	49.9	51.4	49.9	48.2	48.3
60	47.9	50.1	51.1	47.7	44.8	46.0	48.7	51.9	50.0	48.8	48.0	47.3
61	47.0	50.2	51.9	47.4	46.6	47.6	50.5	50.8	48.9	47.5	46.4	45.2
62	49.1	51.5	48.5	45.5	44.8	45.9	48.0	50.7	51.0	49.3	47.6	47.3
63	44.7	45.2	47.8	51.1	45.4	47.4	50.6	50.7	48.9	47.7	46.4	45.1
64	47.3	50.7	49.0	45.5	50.8	51.2	50.9	48.6	46.2	45.9	46.2	45.7
65	46.2	48.9	50.8	45.9	45.4	47.3	50.3	50.8	48.5	46.8	45.4	44.9
66	51.2	48.6	46.8	45.5	44.8	45.2	46.7	49.6	51.7	50.1	48.5	48.6
67	45.9	48.2	51.6	46.6	45.2	46.9	50.0	50.9	48.7	47.1	45.6	44.7
68	49.5	48.5	46.6	45.5	44.8	44.8	44.8	45.1	45.8	47.4	49.2	49.4
69	46.6	49.6	50.0	46.2	45.2	46.8	49.9	51.0	48.9	47.5	46.5	45.8
70	49.2	50.4	49.2	45.4	44.8	45.2	46.7	49.3	51.6	50.7	48.8	48.7
71	51.7	51.0	48.6	45.5	44.8	45.3	46.8	49.2	51.6	51.1	50.4	50.6
72	46.1	48.7	50.8	45.5	44.8	46.0	48.9	51.8	49.9	48.2	46.5	45.2

52-3. Reservoir Water Level (Unit: m)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	130.1	132.5	134.3	135.5	136.1	135.4	134.0	132.4	130.8	129.6	128.7	128.6
54	133.2	133.9	134.5	135.5	136.1	135.7	134.8	133.8	132.8	131.7	131.6	132.4
55	133.7	134.7	135.3	135.5	130.1	135.8	135.6	135.6	134.4	133.5	133.2	133.2
56	132.2	132.4	134.0	135.7	135.6	135.6	135.4	134.8	134.0	133.2	132.3	132.0
57	130.2	131.3	133.5	135.3	135.9	134.9	134.0	133.0	131.7	130.5	129.4	129.5
58	131.6	133.3	134.7	135.7	136.1	135.5	134.7	133.9	133.0	131.9	130.6	130.3
59	130.9	132.4	134.3	135.5	136.1	135.7	134.9	133.6	132.2	131.0	129.7	129.8
60	129.5	131.2	133.1	134.6	136.1	135.5	134.1	132.6	131.1	130.1	129.6	129.0
61	128.9	131.3	132.7	134.8	135.2	134.6	133.3	131.7	130.2	129.2	128.4	127.5
62	130.4	132.3	134.2	135.7	136.1	135.5	134.5	133.2	131.9	130.6	129.3	129.0
63	127.1	127.5	129.4	132.0	135.8	134.8	133.3	131.6	130.2	129.3	128.4	127.5
64	129.0	131.6	134.0	135.6	133.2	133.0	131.8	130.0	128.2	128.0	128.3	127.9
65	128.3	130.2	133.2	135.5	135.8	134.8	133.4	131.7	130.0	128.7	127.7	127.3
66	132.0	134.2	135.1	135.7	136.1	135.9	135.1	133.7	132.4	131.1	130.0	130.0
67	128.0	129.7	132.4	135.2	135.9	135.0	133.5	131.8	130.1	128.9	127.8	127.2
68	133.8	134.2	135.2	135.7	136.1	136.1	136.1	135.9	135.6	134.8	133.9	133.8
69	128.5	130.8	133.5	135.4	135.9	135.0	133.6	131.9	130.2	129.2	129.5	128.0
70	130.5	131.4	133.9	135.7	136.1	135.9	135.1	133.9	132.9	131.6	130.2	130.1
71	133.1	134.2	135.7	133.7	136.1	135.8	135.0	133.9	132.9	131.4	131.6	132.5
72	128.1	130.1	133.2	135.7	136.1	135.4	134.0	132.5	131.0	129.7	128.4	127.5

52-4. Maximum Power (Unit: MW)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	7.35	8.83	8.97	8.97	8.97	8.97	8.97	8.79	7.81	7.10	6.57	6.48
54	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.33	8.30	8.79
55	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97
56	8.64	8.76	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.53
57	7.45	8.11	8.97	8.97	8.97	8.97	8.97	8.97	8.34	7.63	6.94	7.03
58	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.49	7.65	8.28
59	7.82	8.78	8.97	8.97	8.97	8.97	8.97	8.97	8.68	7.91	7.13	7.17
60	7.00	8.00	8.97	8.97	8.97	8.97	8.97	8.90	7.97	7.39	7.06	6.73
61	6.64	8.09	8.97	8.97	8.97	8.97	8.97	8.36	7.44	6.85	6.36	5.88
62	7.55	8.70	8.97	8.97	8.97	8.97	8.97	8.97	8.46	7.65	6.90	6.75
63	5.68	5.89	6.97	8.50	8.97	8.97	8.97	8.29	7.45	6.90	6.36	5.86
64	6.73	8.30	8.97	8.97	8.97	8.97	8.41	7.30	6.30	6.15	6.31	6.08
65	6.30	7.45	8.97	8.97	8.97	8.97	8.97	8.35	7.29	6.55	5.96	5.77
66	8.55	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.80	8.00	7.29	7.32
67	6.18	7.15	8.78	8.97	8.97	8.97	8.97	8.39	7.35	6.65	6.03	5.70
68	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97
69	6.44	7.78	8.97	8.97	8.97	8.97	8.97	8.45	7.45	6.82	6.41	6.13
70	7.58	8.18	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.29	7.41	7.36
71	8.83	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.97	8.49	8.18	8.25
72	6.24	7.36	8.97	8.97	8.97	8.97	8.97	8.84	7.93	7.13	6.41	5.87

52-5. Monthly Energy Output

1) Peak

(Unit: 10^2 MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.7	13.0	15.6	15.9	16.7	16.1	16.7	16.3	14.1	12.8	11.8	12.1
54	16.7	15.1	16.7	16.1	16.7	16.1	16.7	16.7	16.1	15.5	14.9	16.4
55	16.7	15.1	16.7	2.8	16.7	16.1	16.7	16.7	16.1	16.7	16.1	16.7
56	16.1	14.7	16.7	16.1	16.7	16.1	16.7	16.7	16.1	16.7	15.7	15.9
57	13.6	16.7	16.1	15.1	16.7	16.1	16.7	15.0	14.2	12.5	13.1	13.9
58	15.4	15.1	16.7	16.1	16.7	16.1	16.7	16.7	16.1	15.8	13.8	13.9
59	14.5	14.8	16.7	16.1	16.7	16.1	16.7	16.7	15.6	14.7	12.8	13.3
60	8.6	7.4	7.2	4.2	16.7	16.1	16.7	16.6	14.3	8.8	10.0	12.5
61	12.4	13.4	15.9	16.1	16.7	16.1	16.7	15.6	13.4	8.8	11.4	11.0
62	14.0	14.6	16.7	16.1	16.7	16.1	16.7	16.7	15.2	14.2	12.4	12.5
63	10.6	3.9	3.6	1.7	16.7	16.1	16.7	15.4	13.4	8.0	11.5	10.9
64	1.9	3.5	1.1	4.3	10.2	16.1	15.6	13.6	11.3	5.1	11.4	11.3
65	11.7	12.1	15.5	16.1	16.7	16.1	16.7	15.5	13.1	12.0	10.7	10.7
66	15.9	15.1	16.7	16.1	16.7	16.1	16.7	16.7	15.8	14.9	13.1	13.6
67	11.5	12.0	16.3	16.1	16.7	16.1	16.7	15.6	13.2	10.3	10.9	10.6
68	16.7	15.1	16.7	16.1	16.7	16.1	16.7	16.7	16.1	16.7	16.1	16.7
69	9.2	7.7	9.7	10.2	16.7	16.1	16.7	15.7	13.4	7.8	11.5	11.4
70	14.1	13.7	16.7	16.1	16.7	16.1	16.7	16.7	16.1	15.4	13.3	13.7
71	16.4	15.1	16.7	16.1	16.7	16.1	16.7	16.7	16.1	15.8	14.7	15.4
72	11.6	12.4	16.7	16.1	16.7	16.1	16.7	16.4	14.3	13.3	11.5	10.9

52-5. Monthly Energy Output

2) Off Peak

(Unit: 10^2 MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	0	0	0	0	68.7	34.3	26.1	25.8	11.5	0	3.3	3.4
54	12.1	11.9	13.9	14.7	35.9	27.7	19.4	18.7	7.1	11.3	10.9	11.4
55	14.8	14.7	17.0	0	9.4	18.3	5.3	20.0	11.3	14.5	13.5	14.1
56	10.6	9.6	12.3	4.0	0.4	12.3	17.6	16.5	6.7	11.2	10.3	10.6
57	3.6	3.1	3.8	5.3	8.6	31.4	10.8	22.8	11.5	3.5	4.9	3.7
58	23.2	22.7	27.9	4.2	19.3	28.4	10.2	18.0	4.8	23.4	21.6	22.1
59	11.5	10.6	13.9	15.1	13.2	26.3	22.1	26.9	9.5	11.5	10.8	11.2
60	0	0	0	0	46.3	32.4	27.6	25.1	10.3	0	0	11.9
61	0.7	0	0	0.8	2.2	26.2	22.0	20.2	8.1	0	3.9	7.0
62	11.1	10.4	13.6	6.6	5.2	27.3	19.4	21.3	11.0	11.2	10.5	10.8
63	0.6	0	0	0	10.8	29.8	28.5	17.5	6.0	0	3.7	0.8
64	0	0	0	0	0	16.1	21.0	18.3	6.7	0	7.6	5.3
65	0.2	0	0	0.5	7.9	30.7	23.5	25.2	11.1	0	2.4	6.4
66	17.0	17.7	21.0	21.2	19.2	25.7	32.3	27.2	10.3	16.6	15.5	16.0
67	3.3	2.7	2.4	4.4	10.8	33.9	29.1	25.3	11.1	0	4.4	6.4
68	32.1	29.9	35.2	5.9	55.5	28.8	27.8	22.1	10.5	34.3	31.3	32.5
69	0	0	0	0	8.9	33.1	29.2	25.0	11.4	0	5.7	0.9
70	45.4	42.8	53.7	9.7	61.9	30.5	27.7	28.4	7.5	47.8	43.4	44.7
71	29.5	27.7	33.0	3.5	21.6	26.0	28.1	27.6	9.7	29.0	27.6	28.6
72	10.9	10.3	12.6	46.5	17.7	34.4	30.1	24.2	11.6	6.4	6.2	7.0

52-5. Monthly Energy Output

3) Total (Unit: 10^2 MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.7	13.0	15.6	15.9	85.5	50.4	42.8	42.2	25.6	12.8	15.1	15.5
54	28.8	26.9	30.5	30.8	52.6	43.8	36.1	35.4	23.2	26.8	25.9	27.8
55	31.5	29.7	33.6	2.8	26.1	34.5	22.0	36.7	27.4	31.2	29.7	30.7
56	26.7	24.3	29.0	20.2	17.1	28.4	34.3	33.1	22.8	27.9	25.9	26.4
57	17.5	16.7	20.5	21.4	25.2	47.6	27.5	29.5	26.5	17.7	17.4	16.8
58	38.6	37.8	44.6	20.3	36.0	44.5	26.8	34.7	21.0	39.2	35.4	36.0
59	26.0	25.4	30.6	31.2	29.9	42.4	38.7	43.6	25.1	26.2	23.6	24.5
60	8.6	7.4	7.2	4.2	63.0	48.6	44.4	41.6	24.7	8.8	10.0	24.4
61	13.0	13.4	15.9	16.9	18.9	42.3	38.7	35.8	21.5	8.8	15.3	17.9
62	25.2	25.0	30.3	22.7	21.9	43.5	36.1	38.0	26.3	25.4	22.9	23.3
63	11.2	3.9	3.6	1.7	27.5	45.9	45.2	32.9	19.4	8.0	15.1	11.7
64	1.9	3.5	1.1	4.4	10.2	32.3	36.6	31.9	18.0	5.1	19.0	16.6
65	12.0	12.1	15.5	16.6	24.6	46.9	40.2	40.7	24.2	12.0	13.6	17.1
66	32.9	32.8	37.7	37.3	35.9	41.9	49.0	43.9	26.1	31.4	28.6	29.6
67	14.8	14.7	18.7	20.5	27.5	50.0	45.7	40.9	24.4	10.3	15.2	17.0
68	48.8	45.0	51.9	22.0	72.2	45.0	44.5	38.8	26.6	51.0	47.5	48.9
69	9.2	7.7	9.7	10.2	25.5	49.2	45.9	40.7	24.8	7.8	17.3	12.4
70	59.5	56.6	70.4	25.8	78.6	46.6	44.4	45.1	23.6	63.2	56.7	58.4
71	46.0	42.8	49.7	19.6	38.3	42.1	44.8	44.3	25.8	44.8	42.3	43.9
72	22.5	22.7	29.3	62.6	34.4	50.5	46.8	40.7	25.9	19.7	17.7	17.9

Case C

Q(MAX) = 60.0 m^3/sec
RATED HEAD = 21.1 m
TAIL WATER EL. = 110.5 m

60-1. Monthly Inflow (Unit $10^6 m^3$/sec)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	30.3	27.3	30.3	29.3	153.7	93.4	84.1	89.3	58.6	31.2	38.8	40.2
54	58.8	53.1	58.8	56.9	94.5	80.2	68.5	70.3	48.3	58.8	56.9	58.8
55	62.7	56.6	62.7	5.2	47.0	62.9	40.5	68.5	52.9	62.7	60.7	62.7
56	57.0	51.5	57.0	36.8	31.3	52.3	63.6	63.0	44.9	57.0	55.2	57.0
57	41.2	37.3	41.2	39.9	45.9	89.8	54.1	81.2	58.1	41.2	43.0	41.2
58	84.9	77.7	84.9	37.0	64.8	82.2	51.2	68.5	43.2	84.9	82.2	84.9
59	59.5	53.7	59.5	57.5	53.8	77.6	73.4	87.5	53.5	59.5	57.5	59.5
60	21.2	16.7	14.7	8.0	113.3	89.7	86.8	87.3	55.7	20.9	24.4	61.6
61	33.2	30.0	33.2	32.1	35.4	80.9	78.5	78.2	50.8	22.0	40.2	49.6
62	58.9	53.2	58.9	41.5	39.4	80.1	69.6	77.4	57.0	58.9	57.0	58.9
63	31.6	10.9	8.8	3.6	50.1	87.4	91.9	72.3	45.9	19.8	39.7	32.4
64	4.8	7.7	2.1	8.0	20.9	66.4	79.8	76.3	47.7	13.7	50.0	45.0
65	31.6	28.5	31.6	30.6	44.7	88.9	81.2	89.2	58.1	30.8	36.0	47.9
66	70.8	64.0	70.8	68.2	64.5	75.9	91.9	87.5	55.2	70.8	68.6	70.8
67	39.6	35.8	39.6	38.4	49.8	94.1	91.9	89.2	58.1	26.2	41.5	47.9
68	97.0	87.6	97.0	40.2	129.9	80.9	80.1	70.3	48.9	97.0	93.8	97.0
69	23.8	17.7	19.6	18.9	46.3	92.5	91.9	88.4	58.6	19.6	45.1	33.2
70	139.0	125.6	139.0	47.2	141.4	84.6	83.1	89.3	48.9	139.0	134.5	139.0
71	97.0	87.6	97.0	35.8	68.8	76.7	84.1	87.5	53.5	97.0	93.8	97.0
72	59.7	53.9	59.7	114.3	61.9	93.4	91.9	85.7	58.6	47.9	46.4	49.6

60-2 Power Release (Unit m^3/sec)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	56.1	59.7	55.8	53.0	51.7	53.2	56.5	59.6	57.3	55.5	54.1	53.8
54	58.6	56.7	55.3	53.0	51.7	52.6	54.6	57.1	59.8	58.5	58.5	59.6
55	57.2	54.7	53.5	53.0	51.7	52.4	52.8	53.6	55.5	57.7	58.7	58.6
56	59.3	59.5	56.6	52.4	52.8	52.8	53.3	54.7	56.5	58.7	59.4	59.0
57	56.4	58.0	57.8	53.5	52.2	54.2	56.6	59.1	58.6	56.9	55.1	55.3
58	58.4	58.3	54.7	52.5	51.7	53.0	54.8	56.7	59.2	58.9	56.9	56.4
59	57.3	59.6	55.9	52.9	51.7	52.5	54.4	57.6	59.3	57.5	55.6	55.7
60	55.2	57.8	58.9	55.0	51.7	53.1	56.2	59.9	57.7	56.2	55.4	54.5
61	54.3	58.0	59.9	54.6	53.7	54.9	58.3	58.6	56.4	54.8	53.5	52.1
62	56.6	59.4	55.9	52.5	51.7	52.9	55.4	58.5	58.8	56.9	55.0	54.5
63	51.5	52.1	55.1	58.9	52.4	54.6	58.4	58.5	56.4	55.0	53.5	52.0
64	54.5	58.5	56.5	52.7	58.6	59.1	58.7	56.0	53.3	52.9	53.3	52.7
65	53.3	56.4	58.6	52.9	52.3	54.5	58.0	58.6	56.0	54.0	52.3	51.8
66	59.1	56.1	54.0	52.5	51.7	52.1	53.9	57.2	59.6	57.7	56.0	56.1
67	53.0	55.6	59.6	53.7	52.1	54.0	57.7	58.7	56.1	54.3	52.5	51.5
68	57.1	56.0	53.7	52.5	51.7	51.7	51.7	52.0	52.8	54.6	56.8	56.9
69	53.7	57.2	57.7	53.3	52.1	54.0	57.6	58.8	56.4	54.7	53.6	52.8
70	56.7	58.2	56.7	52.5	51.7	52.1	53.8	56.9	59.5	58.4	56.3	56.2
71	59.7	58.8	56.1	52.4	51.7	52.3	54.0	56.8	59.6	58.9	58.2	58.4
72	53.1	56.2	58.7	52.5	51.7	53.1	56.4	59.7	57.6	55.6	53.6	52.1

60-3 Reservoir Water Level (Unit m)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	130.0	132.4	134.2	135.4	136.0	135.3	133.9	132.3	130.7	129.5	128.6	128.5
54	133.1	133.8	134.4	135.4	136.0	135.6	134.7	133.7	132.7	131.6	131.5	132.3
55	133.6	134.6	135.2	135.4	136.0	135.7	135.5	135.1	134.3	133.4	133.1	133.1
56	132.1	132.3	133.9	135.6	135.5	135.5	135.3	134.7	133.9	133.1	132.1	131.9
57	130.1	131.2	133.4	135.2	135.8	134.8	133.9	132.9	131.6	130.4	129.3	129.4
58	131.5	133.2	134.6	135.6	136.0	135.4	133.6	133.8	132.9	131.8	130.5	130.2
59	130.8	132.3	134.2	135.4	136.0	135.6	134.8	133.5	132.1	130.9	129.6	129.7
60	129.4	131.1	133.0	134.5	136.0	135.4	134.0	132.5	131.0	130.0	129.5	128.9
61	128.8	131.2	132.6	134.7	135.1	134.5	133.2	131.6	130.1	129.1	128.3	127.4
62	130.3	132.2	134.1	135.6	136.0	135.4	134.4	133.1	131.8	130.5	129.2	128.9
63	127.0	127.4	129.3	131.9	135.7	134.7	133.2	131.5	130.1	129.2	128.3	127.4
64	128.9	131.5	133.9	135.9	133.1	132.9	131.7	129.9	128.1	127.9	128.2	127.8
65	128.2	130.1	133.1	135.4	135.7	134.7	133.3	131.6	129.9	128.6	127.6	127.2
66	131.9	134.1	135.0	135.6	136.0	135.8	135.0	133.6	132.3	131.0	129.9	129.9
67	127.9	129.6	132.3	135.1	135.8	134.9	133.4	131.7	130.0	128.8	127.7	127.1
68	133.7	134.1	135.1	135.6	136.0	136.0	136.0	135.8	135.5	134.7	133.8	133.7
69	128.4	130.7	133.4	135.3	135.8	134.9	133.5	131.5	130.1	129.1	128.4	127.9
70	130.4	131.3	133.8	135.6	136.0	135.8	135.0	133.8	132.8	131.5	130.1	130.0
71	132.4	133.0	134.1	135.6	136.0	135.7	134.9	133.8	132.8	131.8	131.3	131.5
72	128.0	130.0	133.1	135.6	136.0	135.3	133.9	132.4	130.9	129.6	128.3	127.4

60-4 Maximum Power (Unit MW)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	8.4	10.1	10.3	10.3	10.3	10.3	10.3	10.1	9.0	8.1	7.5	7.4
54	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	9.6	9.5	10.1
55	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
56	9.9	10.1	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.0	9.8
57	8.5	9.3	10.3	10.3	10.3	10.3	10.3	10.3	9.6	8.8	8.0	8.1
58	9.5	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	9.7	8.8	8.6
59	9.0	10.1	10.3	10.3	10.3	10.3	10.3	10.3	10.0	9.1	8.2	8.2
60	8.0	9.2	10.3	10.3	10.3	10.3	10.3	10.2	9.1	8.5	8.1	7.7
61	7.6	9.3	10.3	10.3	10.3	10.3	10.3	9.6	8.5	7.9	7.3	6.7
62	8.7	10.0	10.3	10.3	10.3	10.3	10.3	10.3	9.7	8.8	7.9	7.7
63	6.5	6.7	8.0	9.8	10.3	10.3	10.3	9.5	8.5	7.9	7.3	6.7
64	7.7	9.5	10.3	10.3	10.3	10.3	9.7	8.4	7.2	7.1	7.2	7.0
65	7.2	8.6	10.3	10.3	10.3	10.3	10.3	9.6	8.4	7.5	6.8	6.6
66	9.8	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.1	9.2	8.4	8.4
67	7.1	8.2	10.1	10.3	10.3	10.3	10.3	9.6	8.4	7.6	6.9	6.5
68	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3
69	7.4	8.9	10.3	10.3	10.3	10.3	10.3	9.7	8.5	7.8	7.4	7.0
70	8.7	9.4	10.3	10.3	10.3	10.3	10.3	10.3	10.3	9.5	8.5	8.4
71	10.1	10.3	10.3	10.3	10.3	10.3	10.3	10.3	10.3	9.7	9.4	9.5
72	7.2	8.4	10.3	10.3	10.3	10.3	10.3	10.2	9.1	8.2	7.3	6.7

60-5 Monthly Energy Output

1) Peak (Unit 10^2MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.6	12.9	15.5	15.8	19.2	18.5	19.2	18.8	16.1	12.7	13.6	13.8
54	19.2	17.3	19.2	18.5	19.2	18.5	19.2	19.2	18.5	17.8	17.1	18.8
55	19.2	17.3	19.2	2.8	19.2	18.5	19.2	19.2	18.5	19.2	18.5	19.2
56	18.5	16.9	19.2	18.5	17.0	18.5	19.2	19.2	18.5	19.2	18.0	18.2
57	15.9	15.6	19.2	18.5	19.2	18.5	19.2	19.2	17.2	16.3	14.3	15.0
58	17.7	17.3	19.2	18.5	19.2	18.5	19.2	19.2	18.5	18.1	15.8	15.9
59	16.7	16.9	19.2	18.5	19.2	18.5	19.2	19.2	17.9	16.9	14.7	15.3
60	8.5	7.4	7.2	4.2	19.2	18.5	19.2	19.0	16.5	8.8	9.9	14.4
61	12.9	13.3	15.9	16.8	18.8	18.5	19.2	17.9	15.4	8.7	13.1	12.5
62	16.1	16.8	19.2	18.5	19.2	18.5	19.2	19.2	17.5	16.3	14.2	14.4
63	11.1	3.9	3.6	1.7	19.2	18.5	19.2	17.7	15.4	7.9	13.1	11.6
64	1.9	3.5	1.1	4.4	10.2	18.5	18.0	15.6	13.0	5.1	13.0	13.0
65	11.9	12.0	15.4	16.5	19.2	18.5	19.2	17.8	15.1	11.9	12.3	12.3
66	18.3	17.3	19.2	18.5	19.2	18.5	19.2	19.2	18.2	17.1	15.1	15.6
67	13.2	13.8	18.6	18.5	19.2	18.5	19.2	17.9	15.2	10.2	12.4	12.1
68	19.2	17.3	19.2	18.5	19.2	18.5	19.2	19.2	18.5	19.2	18.5	19.2
69	9.1	7.7	9.7	10.2	19.2	18.5	19.2	18.0	15.4	7.8	13.2	12.3
70	16.2	15.8	19.2	18.5	19.2	18.5	19.2	19.2	18.5	17.7	15.3	15.7
71	18.9	17.3	19.2	18.5	19.2	18.5	19.2	19.2	18.5	18.1	16.9	17.6
72	13.3	14.2	19.2	18.5	19.2	18.5	19.2	18.9	16.4	15.2	13.2	12.5

60-5 Monthly Energy Output

2) Off Peak (Unit 10^2MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	0	0	0	0	66.0	31.7	23.4	23.2	9.3	0	1.4	1.6
54	9.5	9.5	11.2	12.1	33.2	25.1	16.8	16.1	4.6	8.9	8.6	8.9
55	12.2	12.3	14.3	0	6.8	15.8	2.8	17.4	8.7	11.9	11.0	11.4
56	8.1	7.3	9.7	1.5	0	9.8	15.0	13.8	4.2	8.6	7.8	8.1
57	1.5	1.0	1.2	2.8	6.0	28.8	8.2	20.1	9.1	1.4	3.0	1.7
58	20.7	20.3	25.2	1.7	16.7	25.8	7.6	15.4	2.4	20.9	19.4	19.9
59	9.2	8.3	11.3	12.6	10.6	23.7	19.4	24.3	7.0	9.2	8.8	9.1
60	0	0	0	0	43.6	29.8	25.0	22.4	8.1	0	0	9.9
61	0	0	0	0	0	23.6	19.3	17.7	6.0	0	2.1	5.3
62	8.9	8.1	11.0	4.1	2.6	24.7	16.8	18.7	8.7	8.9	8.6	8.8
63	0	0	0	0	8.2	27.2	25.8	15.0	3.9	0	1.9	0
64	0	0	0	0	0	13.6	18.5	16.1	4.9	0	5.8	3.6
65	0	0	0	0	5.3	28.1	20.9	22.7	9.0	0	0.8	4.7
66	14.5	15.3	18.4	18.6	16.6	23.1	29.6	24.6	7.8	14.2	13.4	13.9
67	1.6	0.9	0	1.9	8.2	31.3	26.4	22.8	9.0	0	2.7	4.7
68	29.4	27.5	32.5	3.4	52.8	26.2	25.2	19.5	8.0	31.6	28.7	29.6
69	0	0	0	0	6.3	30.5	26.5	22.5	9.3	0	3.9	0
70	43.0	40.5	51.0	7.2	59.1	27.9	25.0	25.7	5.0	45.2	41.1	42.4
71	26.9	25.3	30.3	1.0	19.0	23.4	25.4	24.9	7.2	26.4	25.2	26.1
72	9.0	8.3	10.0	43.9	15.1	13.8	27.4	21.6	9.3	4.4	4.4	5.3

60-5 Monthly Energy Output

3) Total (Unit 10^2 MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.6	12.9	15.5	15.8	85.1	50.2	42.6	42.0	25.5	12.7	15.0	15.4
54	28.7	26.8	30.4	30.7	52.3	43.6	35.9	35.2	23.1	26.7	25.7	27.7
55	31.3	29.6	33.5	2.8	26.0	34.3	21.9	36.5	27.3	31.1	29.5	30.6
56	26.5	24.2	28.8	20.1	17.0	28.3	34.2	33.0	22.7	27.8	25.8	26.3
57	17.4	16.6	20.4	21.4	25.1	47.4	27.4	39.3	26.4	17.7	17.3	16.7
58	38.4	37.6	44.4	20.2	35.9	44.4	26.7	34.6	20.9	39.0	35.2	35.8
59	25.9	25.2	30.4	31.1	29.8	42.3	38.6	43.4	25.0	26.1	23.5	24.4
60	8.5	7.4	7.2	4.2	62.7	48.4	44.2	41.4	24.5	8.8	9.9	24.2
61	12.9	13.3	15.9	16.8	18.8	42.1	38.5	35.6	21.4	8.7	15.2	17.8
62	25.0	24.9	30.1	22.6	21.8	43.3	36.0	37.8	26.2	25.3	22.8	23.2
63	11.1	3.9	3.6	1.7	27.3	45.7	45.0	32.7	19.3	7.9	15.0	11.6
64	1.9	3.5	1.1	4.4	10.2	32.1	36.4	31.7	17.9	5.1	18.8	16.5
65	11.9	12.0	15.4	16.5	24.5	46.7	40.0	40.5	24.1	11.9	13.1	17.0
66	32.7	32.6	37.6	37.2	35.7	41.7	48.8	43.7	26.0	31.3	28.5	29.5
67	14.7	14.7	18.6	20.4	27.4	49.8	45.5	40.7	24.2	10.2	15.2	16.9
68	48.5	44.8	51.7	21.9	71.9	44.8	44.3	38.7	26.5	50.8	47.3	48.7
69	9.1	7.7	9.7	10.2	25.4	49.0	45.6	40.5	24.7	7.8	17.2	12.3
70	59.2	56.3	70.1	25.7	78.3	46.4	44.2	44.9	23.5	62.9	56.4	58.1
71	45.7	42.6	49.5	19.5	38.1	42.0	44.6	44.1	25.7	44.6	42.1	43.7
72	22.3	22.5	29.1	62.3	34.3	50.3	46.6	40.5	25.7	19.6	17.7	17.8

Case D

Q(MAX) 68.0 m^3/sec
RATED HEAD 21.0 m
TOTAL WATER EL. 110.6 m

68-1 Monthly Inflow (Unit $10^6 m^3$)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	30.3	27.3	30.3	29.3	153.7	93.4	84.1	89.3	58.6	31.2	38.8	40.2
54	58.8	53.1	58.8	56.9	94.5	80.2	68.5	70.3	48.3	58.8	56.9	58.8
55	62.7	56.6	62.7	5.2	47.0	62.9	40.5	68.5	52.9	62.7	60.7	62.7
56	57.0	51.5	57.0	36.8	31.3	52.3	63.6	63.0	44.9	57.0	55.2	57.0
57	41.2	37.3	41.2	39.9	45.9	89.8	54.1	81.2	58.1	41.2	43.0	41.2
58	84.9	76.7	84.9	37.1	64.8	82.2	51.2	68.5	43.2	84.9	82.2	84.9
59	59.5	53.7	59.5	57.5	53.8	77.6	73.4	87.5	53.5	59.5	57.5	59.5
60	21.2	16.7	14.7	8.3	113.3	89.7	86.8	87.3	55.7	20.9	24.4	61.6
61	33.2	30.0	33.2	32.1	35.4	80.9	78.5	78.2	50.8	22.0	40.2	49.6
62	58.9	53.2	58.9	41.5	39.4	80.1	69.6	77.4	57.0	58.9	57.0	58.9
63	31.6	10.9	8.8	3.6	50.1	87.4	91.9	72.3	45.9	19.8	39.7	32.4
64	4.8	7.7	2.1	8.3	20.9	66.4	79.8	76.3	47.7	13.7	50.0	45.0
65	31.6	28.5	31.6	30.6	44.7	88.9	81.2	89.2	58.1	30.8	36.0	47.9
66	70.8	64.0	70.8	68.2	64.5	75.9	91.9	87.5	55.2	70.8	68.6	70.8
67	39.6	35.8	39.6	38.4	49.8	94.1	91.9	89.2	58.1	26.2	41.5	47.9
68	97.0	87.6	97.0	40.2	129.9	80.9	80.1	70.3	48.9	97.0	93.8	97.0
69	23.8	17.7	19.6	18.9	46.3	92.5	91.9	88.4	58.6	19.6	45.1	33.2
70	139.0	125.6	139.0	47.2	141.4	84.6	83.1	89.3	48.9	139.0	134.5	139.0
71	97.0	87.6	97.0	35.8	68.8	76.7	84.1	87.5	53.5	97.0	93.8	97.0
72	59.7	53.9	59.7	114.3	61.9	93.4	91.9	85.7	58.6	47.9	46.4	49.6

68-2 Power Release (Unit m^3/s)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	63.6	67.7	63.2	60.0	58.5	60.3	64.0	67.5	64.9	62.8	61.2	60.9
54	66.4	64.2	62.6	60.1	58.5	59.6	61.8	64.7	67.8	66.3	66.3	67.6
55	64.9	62.0	60.6	60.0	58.6	59.3	59.8	60.8	62.9	65.4	66.6	66.4
56	67.2	67.5	64.1	59.4	59.8	59.8	60.3	61.9	64.0	66.5	67.3	66.9
57	63.9	65.7	65.5	60.6	59.1	61.4	64.1	67.0	66.4	64.4	62.4	62.6
58	66.2	66.1	62.0	59.4	58.5	60.0	62.1	64.2	67.1	66.7	64.4	63.9
59	64.9	67.5	63.3	60.0	58.5	59.4	61.7	65.3	67.3	65.2	62.9	63.1
60	62.6	65.4	66.8	62.3	58.5	60.1	63.7	67.8	65.3	63.7	62.7	61.7
61	61.5	65.7	67.9	61.9	60.8	62.2	66.1	66.4	63.9	62.1	60.6	59.0
62	64.2	67.3	63.4	59.4	58.6	60.0	62.8	66.3	66.7	64.5	62.3	61.8
63	58.3	59.0	62.4	66.8	59.4	61.9	66.2	66.2	63.9	62.3	60.6	58.9
64	61.7	66.3	64.0	59.7	66.4	67.0	66.5	63.5	60.4	59.9	60.4	59.7
65	60.4	63.9	66.4	59.9	59.3	61.7	65.8	66.4	63.4	61.2	59.3	58.6
66	66.9	63.5	61.1	59.4	58.5	59.0	61.0	64.8	67.6	65.4	63.4	63.5
67	60.0	63.0	67.5	60.9	59.0	61.2	65.4	66.5	63.6	61.5	59.5	58.4
68	64.7	63.4	60.8	59.4	58.5	58.5	58.5	58.9	59.8	61.9	64.3	64.5
69	60.8	64.8	65.4	60.3	59.0	61.2	65.2	66.7	63.9	62.0	60.7	59.8
70	64.3	65.9	64.3	59.4	58.5	59.0	61.0	64.4	67.5	66.2	63.8	63.6
71	67.6	66.7	63.5	59.4	58.5	59.2	61.2	64.3	67.5	66.8	65.9	66.1
72	60.2	63.6	66.5	59.4	58.5	60.1	63.9	67.7	65.2	62.9	60.7	59.0

68-3 Reservoir Water Level (Unit m)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	129.9	132.3	134.1	135.3	135.9	135.2	133.8	132.2	130.6	129.4	128.5	128.4
54	133.0	133.7	134.3	135.3	135.9	135.5	134.6	133.6	132.6	131.5	131.4	132.2
55	133.5	134.5	135.1	135.3	135.9	135.6	135.4	135.0	134.2	133.3	133.0	133.0
56	132.0	132.2	133.8	135.5	135.4	135.4	135.2	134.6	133.8	133.0	132.1	131.8
57	130.0	131.1	133.3	135.1	135.7	134.7	133.8	132.8	131.5	130.3	129.2	129.3
58	131.4	133.1	134.5	135.5	135.9	135.3	134.5	133.7	132.8	131.7	130.4	130.1
59	130.7	132.2	134.1	135.3	135.7	135.5	134.7	133.4	132.0	130.8	129.5	129.6
60	129.3	131.0	132.9	134.4	135.9	135.3	133.9	132.4	130.9	129.9	129.4	128.8
61	128.7	131.1	132.5	134.6	135.0	134.4	133.1	131.5	130.0	129.0	128.2	127.3
62	130.2	132.1	134.0	135.5	135.9	135.3	134.3	133.0	131.7	130.4	129.1	128.8
63	126.9	127.3	129.2	131.8	135.6	134.6	133.1	131.4	130.0	129.1	128.2	127.3
64	128.7	131.4	133.8	135.4	133.0	132.8	131.6	129.8	128.0	127.8	128.1	127.7
65	128.1	130.0	133.0	135.3	135.6	134.6	133.2	131.5	129.8	128.5	127.5	127.1
66	131.8	134.0	134.9	135.5	135.9	135.7	134.9	133.5	132.2	130.9	129.8	129.8
67	127.8	129.5	132.2	135.0	135.7	134.8	133.3	131.6	129.9	128.7	127.6	127.0
68	133.6	134.0	135.0	135.5	135.3	135.3	135.3	135.1	135.4	134.6	133.7	133.6
69	128.3	130.6	133.3	135.2	135.7	134.8	133.4	131.7	130.0	129.0	128.3	127.8
70	130.3	131.2	133.7	135.5	135.9	135.7	134.9	133.7	132.7	131.4	130.0	129.9
71	132.3	132.9	134.0	135.5	135.9	135.6	134.8	133.7	132.7	131.7	131.2	131.4
72	127.9	129.9	133.0	135.5	135.9	135.2	133.8	132.3	130.8	129.5	128.2	127.3

68-4 Maximum Power (Unit MW)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	9.5	11.4	11.6	11.6	11.6	11.6	11.6	11.3	10.1	9.2	8.5	8.4
54	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	10.8	10.7	11.4
55	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
56	11.2	11.3	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.3	11.0
57	9.6	10.5	11.6	11.6	11.6	11.6	11.6	11.6	10.8	9.9	9.0	9.1
58	10.7	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.0	9.9	9.7
59	10.1	11.4	11.6	11.6	11.6	11.6	11.6	11.6	11.2	10.2	9.2	9.3
60	9.0	10.4	11.6	11.6	11.6	11.6	11.6	11.5	10.3	9.6	9.1	8.7
61	8.6	10.5	11.6	11.6	11.6	11.6	11.6	10.8	9.6	8.8	8.2	7.6
62	9.8	11.3	11.6	11.6	11.6	11.6	11.6	11.6	11.0	9.9	8.9	8.7
63	7.3	7.6	9.0	11.0	11.6	11.6	11.6	10.7	9.6	8.9	8.2	7.5
64	8.7	10.7	11.6	11.6	11.6	11.6	10.9	9.4	8.1	7.9	8.1	7.8
65	8.1	9.6	11.6	11.6	11.6	11.6	11.6	10.8	9.4	8.5	7.7	7.4
66	11.1	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.4	10.3	9.4	9.5
67	8.0	9.2	11.4	11.6	11.6	11.6	11.6	10.9	9.5	8.6	7.8	7.3
68	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6
69	8.3	10.1	11.6	11.6	11.6	11.6	11.6	10.9	9.6	8.8	8.3	7.9
70	9.8	10.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	10.7	9.6	9.5
71	11.4	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.6	11.0	10.6	10.7
72	8.1	9.5	11.6	11.6	11.6	11.6	11.6	11.5	10.3	9.2	8.3	7.6

68-5 Monthly Energy Output

1) Peak (Unit 10^2MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.6	12.8	15.4	15.8	21.6	20.9	21.6	21.2	18.2	12.6	14.9	15.3
54	21.6	19.5	21.6	20.9	21.6	20.9	21.6	21.6	20.9	20.1	19.3	21.2
55	21.6	19.5	21.6	2.8	21.6	20.9	21.6	21.6	20.9	21.6	20.9	21.6
56	20.8	19.1	21.6	20.0	16.9	20.9	21.6	21.6	20.9	21.6	20.3	20.5
57	17.3	16.5	20.3	20.9	21.6	20.9	21.6	21.6	19.4	17.6	16.1	16.6
58	19.9	19.5	21.6	20.1	21.6	20.9	21.6	21.6	20.8	20.4	17.8	18.0
59	18.8	19.1	21.6	20.9	21.6	20.9	21.6	21.6	20.2	19.0	16.6	17.2
60	8.5	7.3	7.1	4.2	21.6	20.9	21.6	21.4	18.6	8.7	9.8	16.2
61	12.9	13.3	15.8	16.8	18.8	20.9	21.6	20.1	17.3	8.7	14.8	14.1
62	18.2	18.9	21.6	20.9	21.6	20.9	21.6	21.6	19.7	18.4	16.0	16.2
63	11.0	3.9	3.5	1.7	21.6	20.9	21.6	20.0	17.3	7.9	14.8	11.5
64	1.9	3.5	1.1	4.3	10.1	20.9	20.2	17.6	14.6	5.0	14.7	14.6
65	11.8	12.0	15.4	16.5	21.6	20.9	21.6	20.1	17.0	11.8	13.0	13.8
66	20.6	19.5	21.6	20.9	21.6	20.9	21.6	21.6	20.5	19.2	17.0	17.6
67	14.6	14.6	18.5	20.3	21.6	20.9	21.6	20.2	17.1	10.2	14.0	13.7
68	21.6	19.5	21.6	20.9	21.6	20.9	21.6	21.6	20.9	21.6	20.9	21.6
69	9.0	7.6	9.6	10.1	21.6	20.9	21.6	20.4	17.3	7.7	14.9	12.2
70	18.2	17.8	21.6	20.9	21.6	20.9	21.6	21.6	20.9	20.0	17.2	17.7
71	21.3	19.5	21.6	19.4	21.6	20.9	21.6	21.6	20.9	20.4	19.1	19.9
72	15.0	16.0	21.6	20.9	21.6	20.9	21.6	21.3	18.5	17.1	14.9	14.1

68-5 Monthly Energy Output

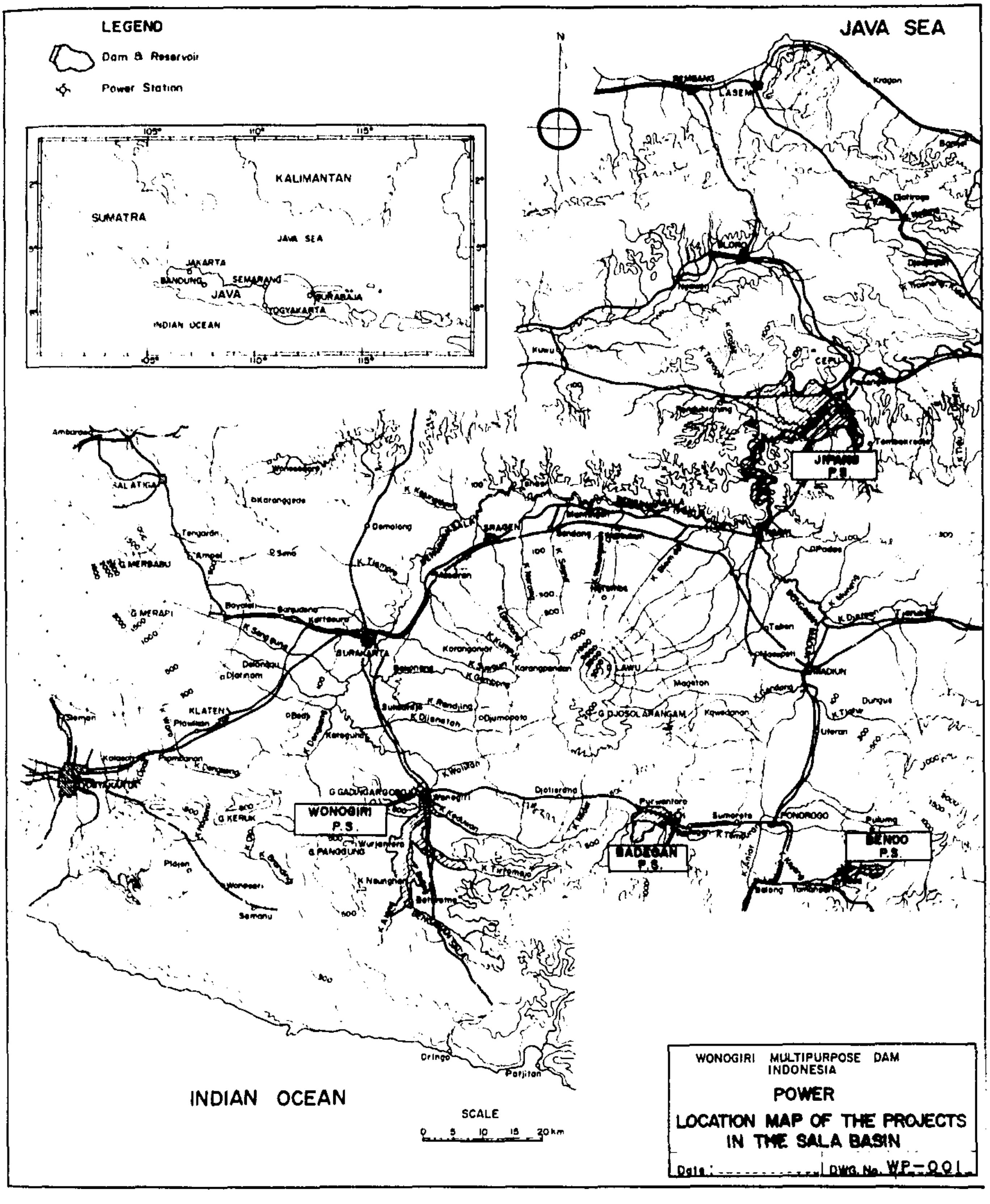
2) Off Peak (Unit 10^2MWH)

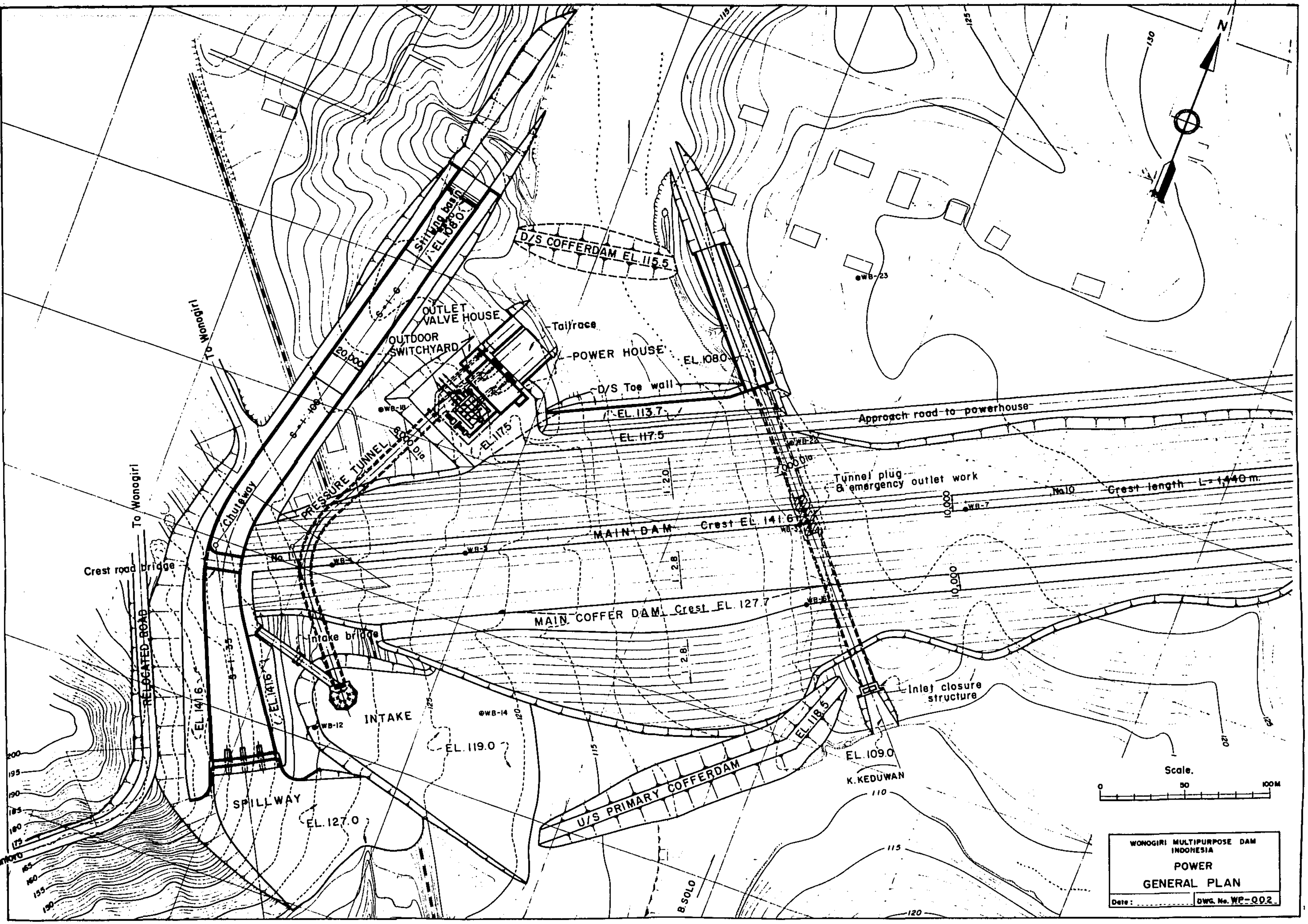
Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	0	0	0	0	63.2	29.1	20.8	20.6	7.2	0	0	0
54	6.9	7.2	8.7	9.6	30.5	22.5	14.1	13.5	2.1	6.5	6.3	6.3
55	9.6	10.0	11.8	0	4.3	13.3	0.2	14.8	6.3	9.3	8.5	8.8
56	5.6	5.0	7.1	0	0	7.3	12.4	11.2	1.7	6.1	5.4	5.6
57	0	0	0	3.5	3.4	26.3	5.6	17.5	6.8	0	1.0	0
58	18.3	17.9	22.6	0	14.1	23.3	5.0	12.8	0	18.4	17.2	17.7
59	6.9	6.0	8.7	10.1	8.1	21.2	16.8	21.6	4.6	6.9	6.8	7.0
60	0	0	0	0	40.9	27.2	22.4	19.8	5.9	0	0	7.9
61	0	0	0	0	0	21.0	16.7	15.3	3.9	0	0.4	3.6
62	6.7	5.8	8.4	1.6	0.1	22.2	14.2	16.1	6.3	6.7	6.6	6.9
63	0	0	0	0	5.6	24.6	23.2	12.6	1.9	0	0.2	0
64	0	0	0	0	0	11.1	16.0	14.0	3.2	0	4.1	1.8
65	0	0	0	0	2.8	25.6	18.2	20.2	7.0	0	0	3.1
66	12.0	13.0	15.8	16.1	14.0	20.6	27.0	21.9	5.3	11.9	11.3	11.7
67	0	0	0	0	5.6	28.7	23.7	20.3	7.0	0	1.1	3.1
68	26.7	25.1	29.8	1.0	50.0	23.7	22.5	16.9	5.5	28.9	26.1	26.9
69	0	0	0	0	3.7	27.9	23.8	19.9	7.2	0	2.2	0
70	40.7	38.2	48.2	4.7	56.4	25.3	22.4	23.1	2.5	42.6	38.9	40.1
71	24.3	22.9	27.6	0	16.3	20.9	22.8	22.3	4.7	23.9	22.8	23.6
72	7.2	6.4	7.4	41.2	12.5	29.2	24.8	19.0	7.1	2.4	2.6	3.6

68-5 Monthly Energy Output

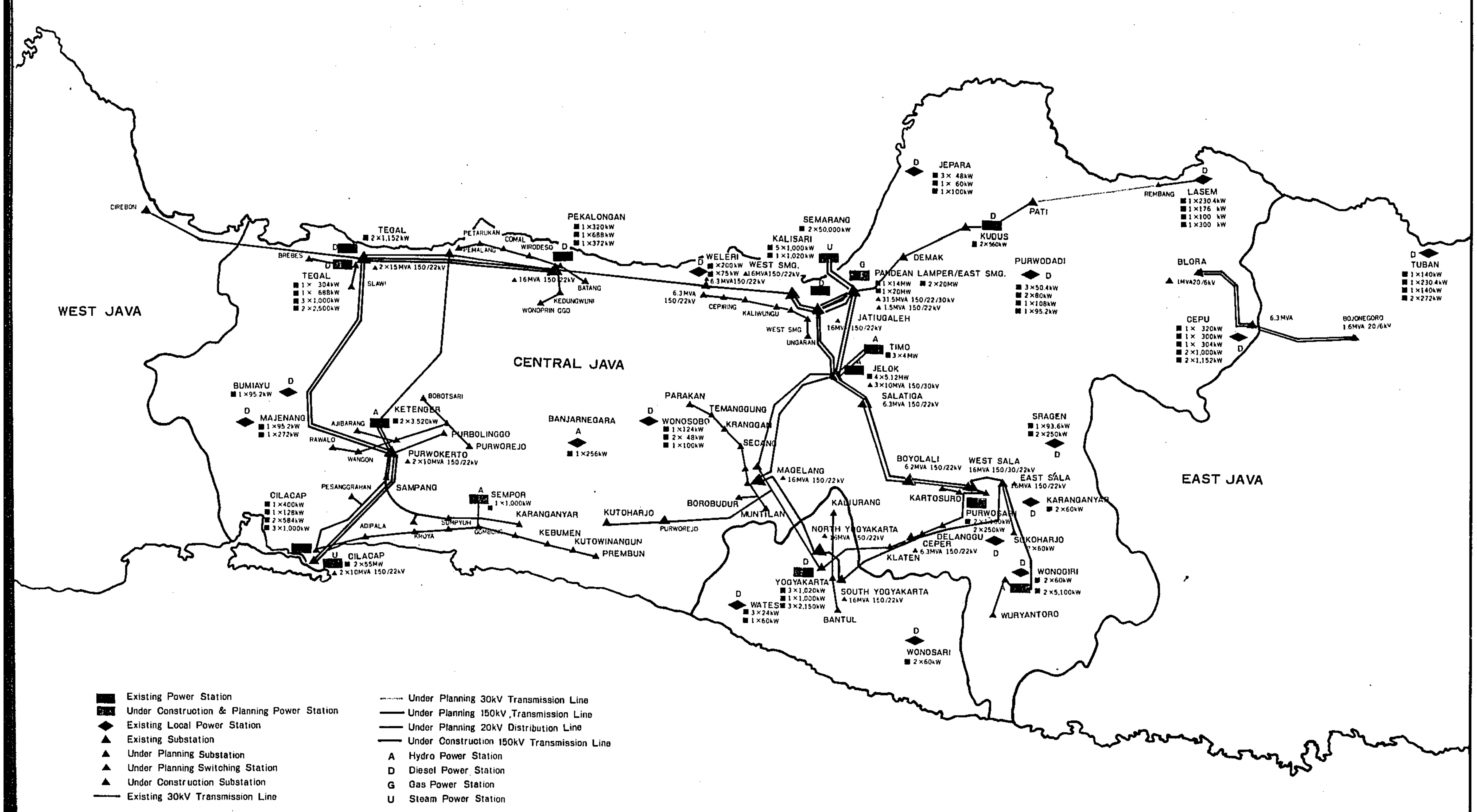
3) Total (Unit 10^2MWH)

Month / Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
1953	12.6	12.8	15.4	15.8	84.8	50.0	42.4	41.8	25.3	12.6	14.9	15.3
54	28.5	26.7	30.3	30.5	52.1	43.4	35.8	35.1	23.0	26.5	25.6	27.5
55	31.2	29.5	33.4	2.8	25.9	34.2	21.8	36.4	27.2	30.9	29.4	30.4
56	26.4	24.1	28.7	20.0	16.9	28.2	34.0	32.8	22.6	27.7	25.7	26.2
57	17.3	16.5	20.3	21.3	25.0	47.2	27.2	39.1	26.2	17.6	17.2	16.6
58	38.2	37.5	44.2	20.1	35.7	44.2	26.6	34.4	20.8	38.8	35.0	35.6
59	25.7	25.1	30.3	31.0	29.7	42.1	38.4	43.2	24.8	25.9	23.4	24.3
60	8.5	7.3	7.1	4.2	62.5	48.1	44.0	41.0	24.4	8.7	9.8	24.1
61	12.9	13.3	15.8	16.8	18.8	41.9	38.3	35.4	21.3	8.7	15.1	17.7
62	24.9	24.7	30.0	22.5	21.7	43.1	35.8	37.7	26.0	25.1	22.7	23.1
63	11.0	3.9	3.5	1.7	27.2	45.5	44.8	32.6	19.2	7.9	14.9	11.5
64	1.9	3.5	1.1	4.3	10.1	32.0	36.3	31.5	17.8	5.0	18.7	16.4
65	11.8	12.0	15.4	16.5	24.4	46.5	39.8	40.3	24.0	11.8	13.0	16.9
66	32.6	32.5	37.4	37.0	35.6	41.5	48.6	43.5	25.8	31.1	28.3	29.3
67	14.6	14.6	18.5	20.3	27.2	49.6	45.3	40.5	24.1	10.2	15.1	16.8
68	48.3	44.6	51.4	21.8	71.6	44.6	44.2	38.5	26.4	50.6	47.1	48.5
69	9.0	7.6	9.6	10.1	25.3	48.8	45.4	40.3	24.5	7.7	17.1	12.2
70	58.9	56.0	69.8	25.6	78.0	46.2	44.0	44.7	23.4	62.6	56.1	57.8
71	45.5	42.4	49.2	19.4	37.9	41.8	44.4	43.9	25.6	44.3	41.9	43.5
72	22.2	22.4	29.0	62.1	34.1	50.1	46.4	40.3	25.6	19.5	17.6	17.7


LEGEND
Dam & Reservoir
Power Station
JAVA SEA
N
KALIMANTAN
SUMATRA
JAVA SEA
JAKARTA
BANDUNG
SEMARANG
JAVA
SURABAJA
YOGYAKARTA
INDIAN OCEAN
JIPANG P.S.
CEPU
SRAGEN
SURAKARTA
KLATEN
SALATIGA
G. MERBABU
G. MERAPI
LAWU
G. DJOSOL ARANGAN
MADIUN
PONOROGO
WONOGIRI P.S.
BADEGAN P.S.
BENDO P.S.
INDIAN OCEAN
SCALE
0 5 10 15 20km
WONOGIRI MULTIPURPOSE DAM
INDONESIA
POWER
LOCATION MAP OF THE PROJECTS
IN THE SALA BASIN
Date: DWG. No. WP-001



N
D/S COFFERDAM EL.115.5
Stilling basin
EL.108.0
OUTLET VALVE HOUSE
OUTDOOR SWITCHYARD
Tailrace
POWER HOUSE
EL.108.0
D/S Toe wall
EL.113.7
EL.117.5
Approach road to powerhouse
PRESSURE TUNNEL
EL.117.5
Tunnel plug & emergency outlet work
Crest length L=1,440 m.
MAIN DAM Crest EL.141.6
MAIN COFFER DAM Crest EL.127.7
Chuteway
Crest road bridge
RELOCATED ROAD
To Wonogiri
To Wuryantoro
Intake bridge
Inlet closure structure
INTAKE
EL.119.0
EL.141.6
SPILLWAY
EL.127.0
U/S PRIMARY COFFERDAM
EL.118.5
EL.109.0
K. KEDUWAN
B. SOLO
Scale.
0 50 100M
WONOGIRI MULTIPURPOSE DAM INDONESIA
POWER
GENERAL PLAN
Date :
DWG. No. WP-002

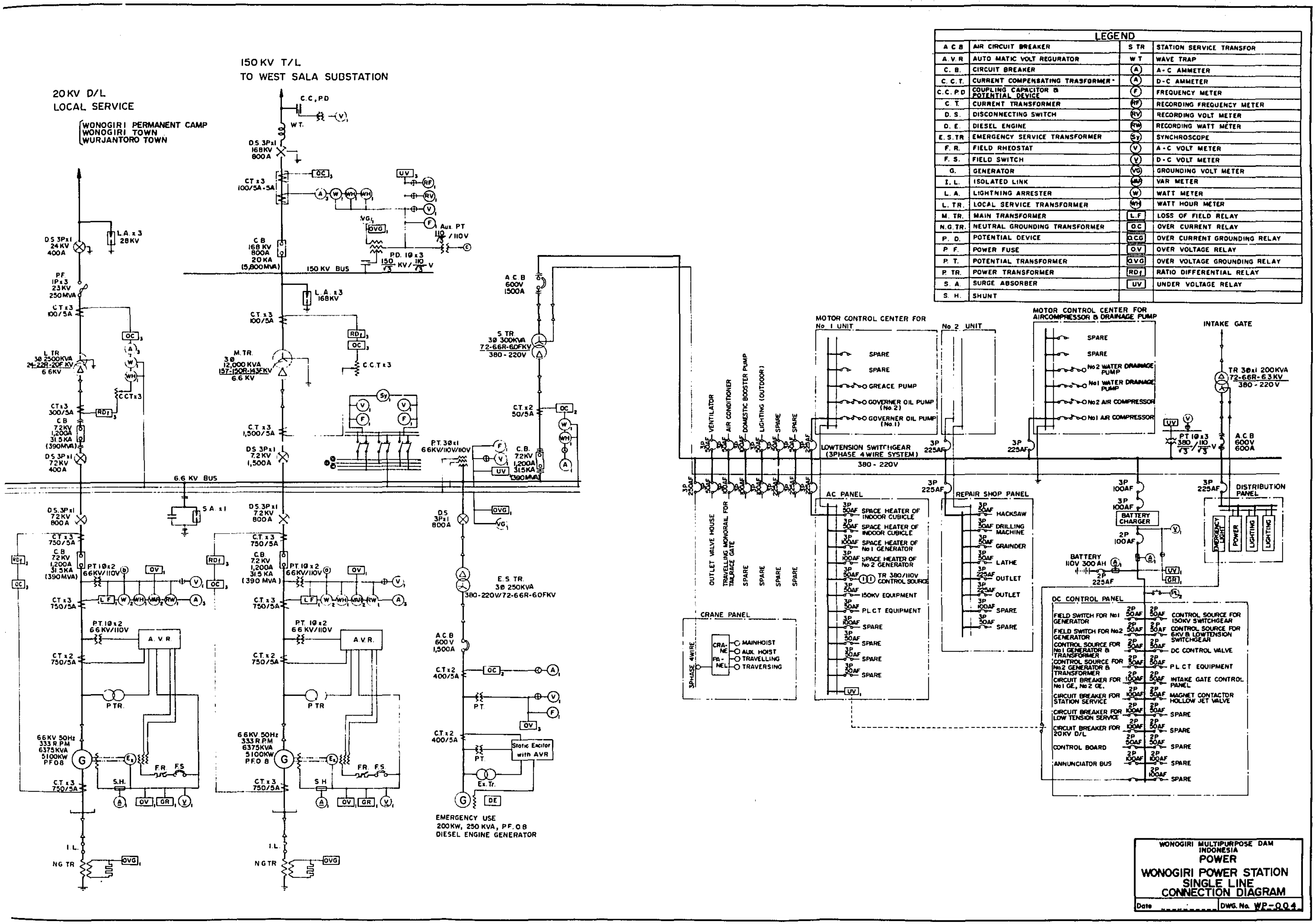


WONOGIRI MULTIPURPOSE DAM
INDONESIA

POWER

ELECTRIFICATION SKELETON DIAGRAM

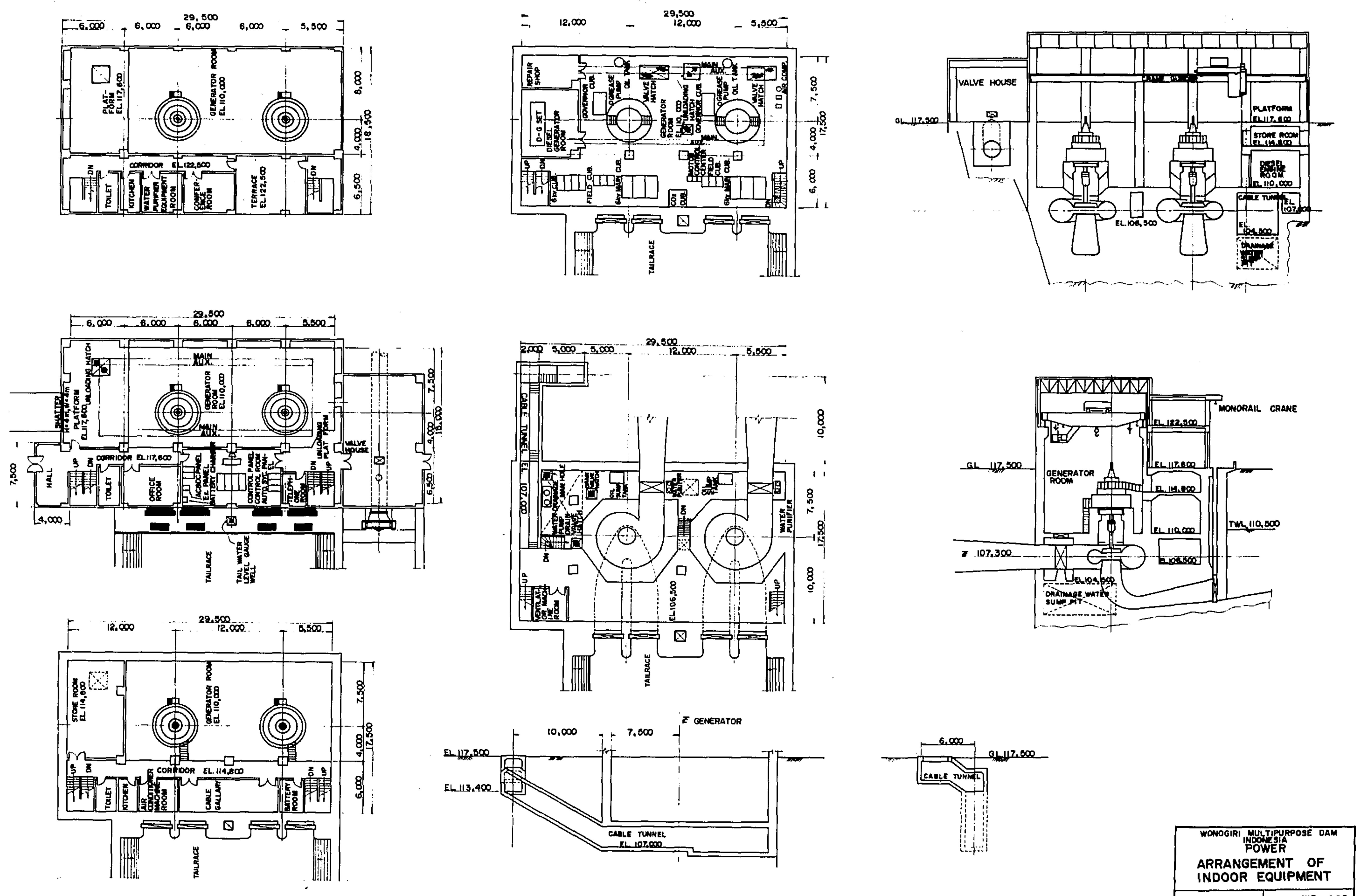
Date:............................	DWG. No. WP-003



LEGEND			
A C B	AIR CIRCUIT BREAKER	S TR	STATION SERVICE TRANSFOR
A. V. R	AUTO MATIC VOLT REGURATOR	W T	WAVE TRAP
C. B.	CIRCUIT BREAKER	(A)	A-C AMMETER
C. C. T.	CURRENT COMPENSATING TRASFORMER	(A)	D-C AMMETER
C. C. P D	COUPLING CAPACITOR & POTENTIAL DEVICE	(F)	FREQUENCY METER
C. T.	CURRENT TRANSFORMER	(RF)	RECORDING FREQUENCY METER
D. S.	DISCONNECTING SWITCH	(RV)	RECORDING VOLT METER
D. E.	DIESEL ENGINE	(RW)	RECORDING WATT METER
E. S. TR	EMERGENCY SERVICE TRANSFORMER	(Sy)	SYNCHROSCOPE
F. R.	FIELD RHEOSTAT	(V)	A-C VOLT METER
F. S.	FIELD SWITCH	(V)	D-C VOLT METER
G.	GENERATOR	(VG)	GROUNDING VOLT METER
I. L.	ISOLATED LINK	(VAR)	VAR METER
L. A.	LIGHTNING ARRESTER	(W)	WATT METER
L. TR.	LOCAL SERVICE TRANSFORMER	(WH)	WATT HOUR METER
M. TR.	MAIN TRANSFORMER	L.F	LOSS OF FIELD RELAY
N. G. TR.	NEUTRAL GROUNDING TRANSFORMER	OC	OVER CURRENT RELAY
P. D.	POTENTIAL DEVICE	OCG	OVER CURRENT GROUNDING RELAY
P. F.	POWER FUSE	OV	OVER VOLTAGE RELAY
P. T.	POTENTIAL TRANSFORMER	OVG	OVER VOLTAGE GROUNDING RELAY
P. TR.	POWER TRANSFORMER	RDf	RATIO DIFFERENTIAL RELAY
S. A.	SURGE ABSORBER	UV	UNDER VOLTAGE RELAY
S. H.	SHUNT		

WONOGIRI MULTIPURPOSE DAM
INDONESIA
POWER
WONOGIRI POWER STATION
SINGLE LINE
CONNECTION DIAGRAM

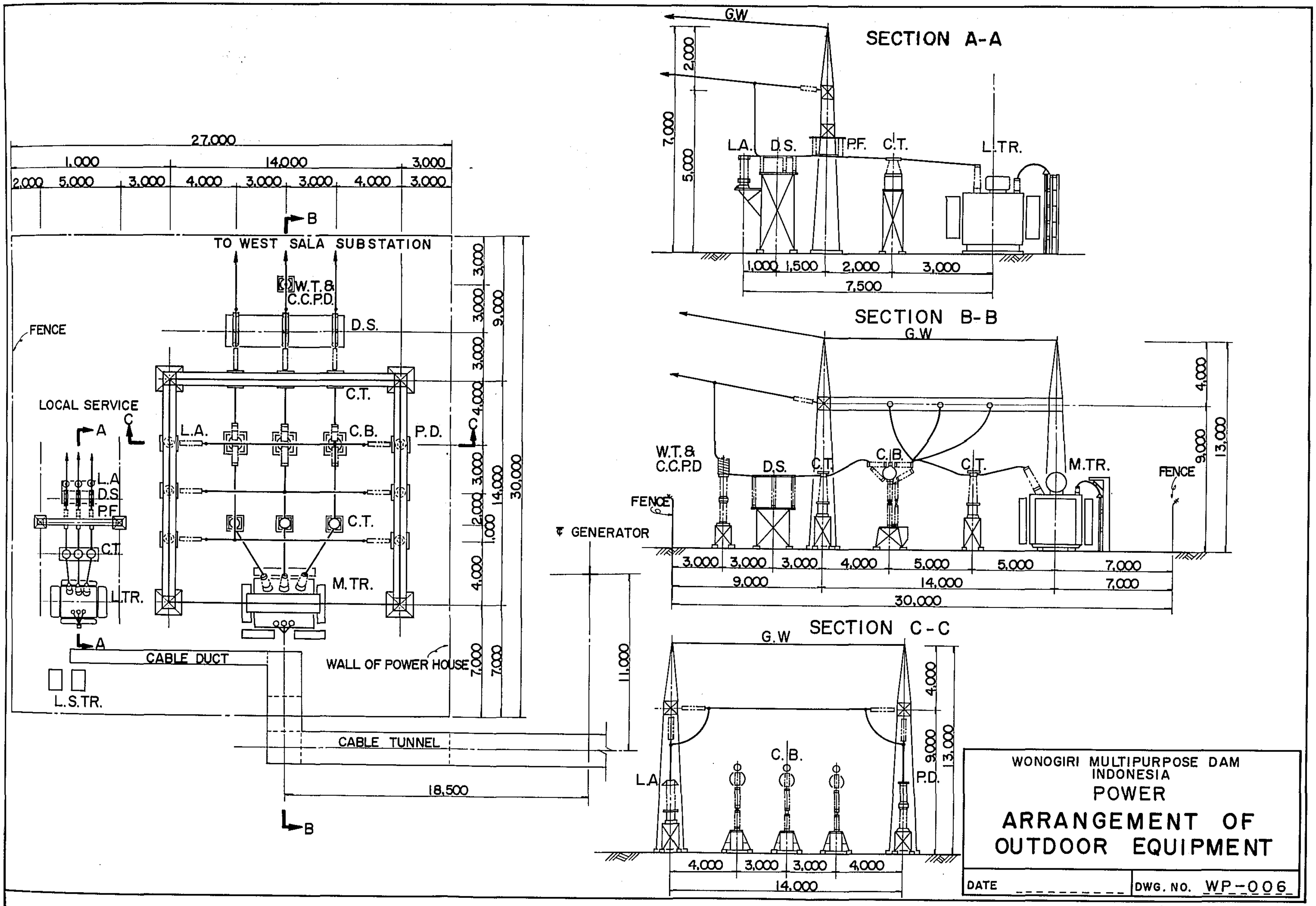
Date .... DWG. No. WP-004



WONOGIRI MULTIPURPOSE DAM INDONESIA
POWER

ARRANGEMENT OF INDOOR EQUIPMENT

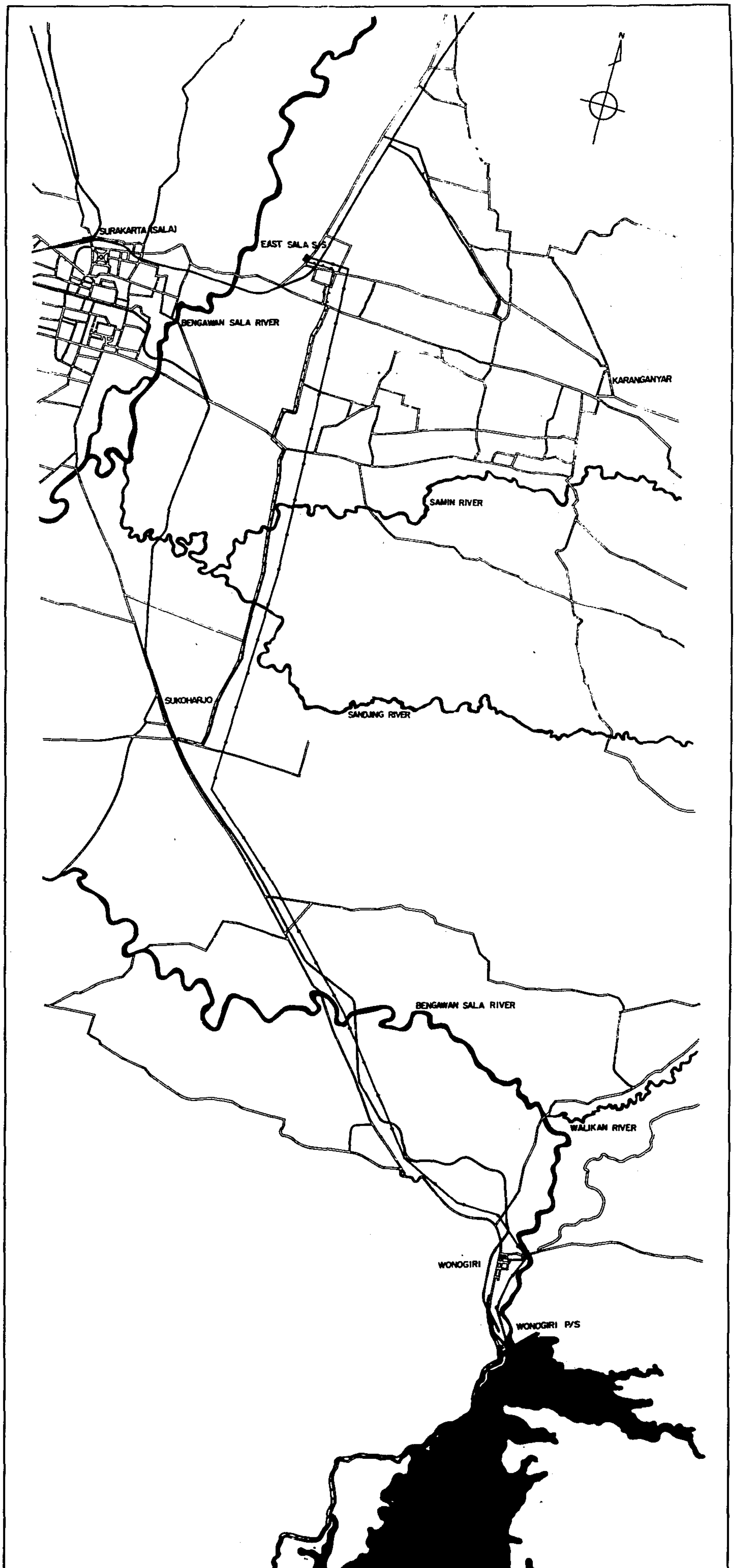
DATE	DWG. NO. WP-005

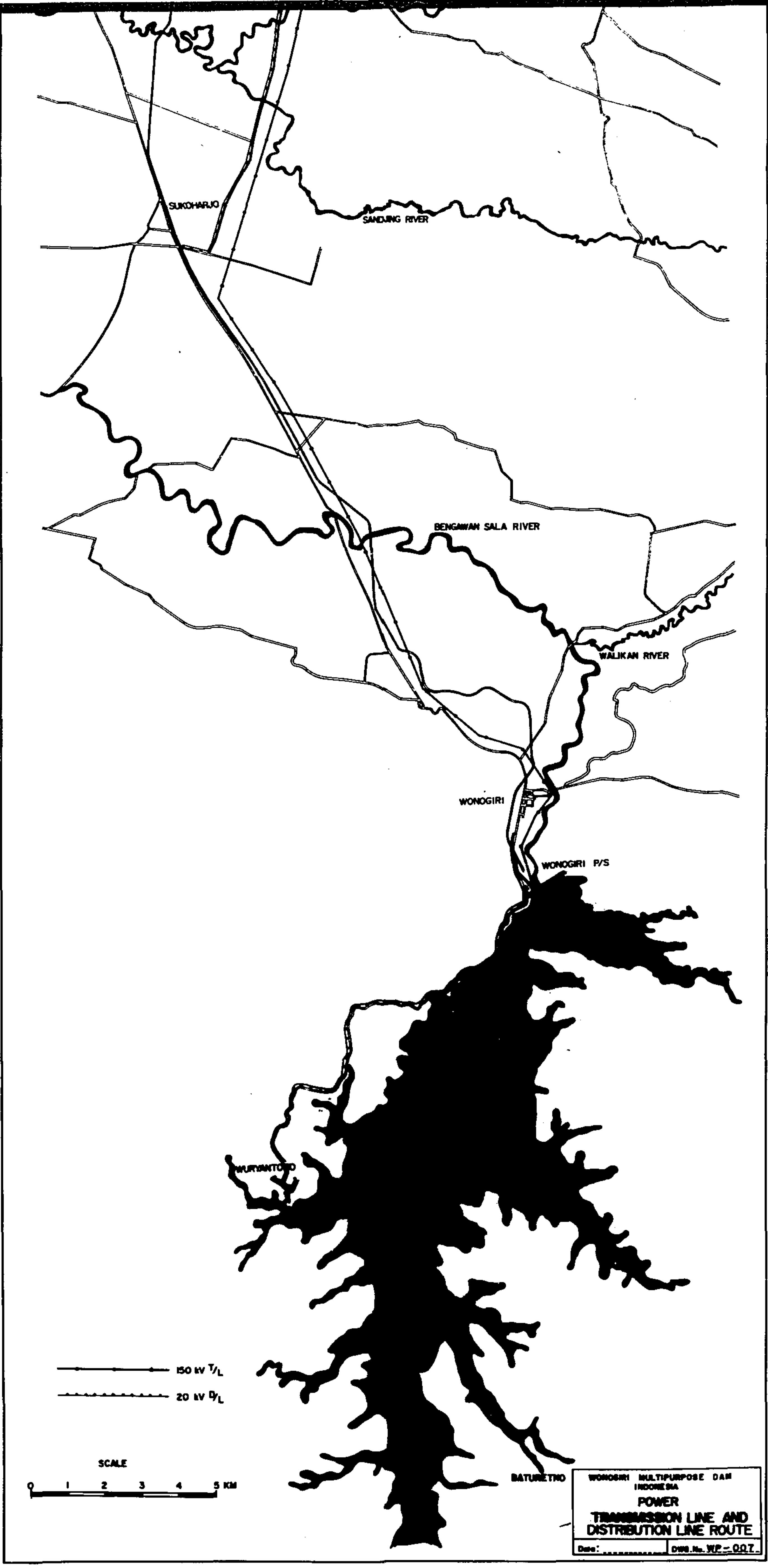


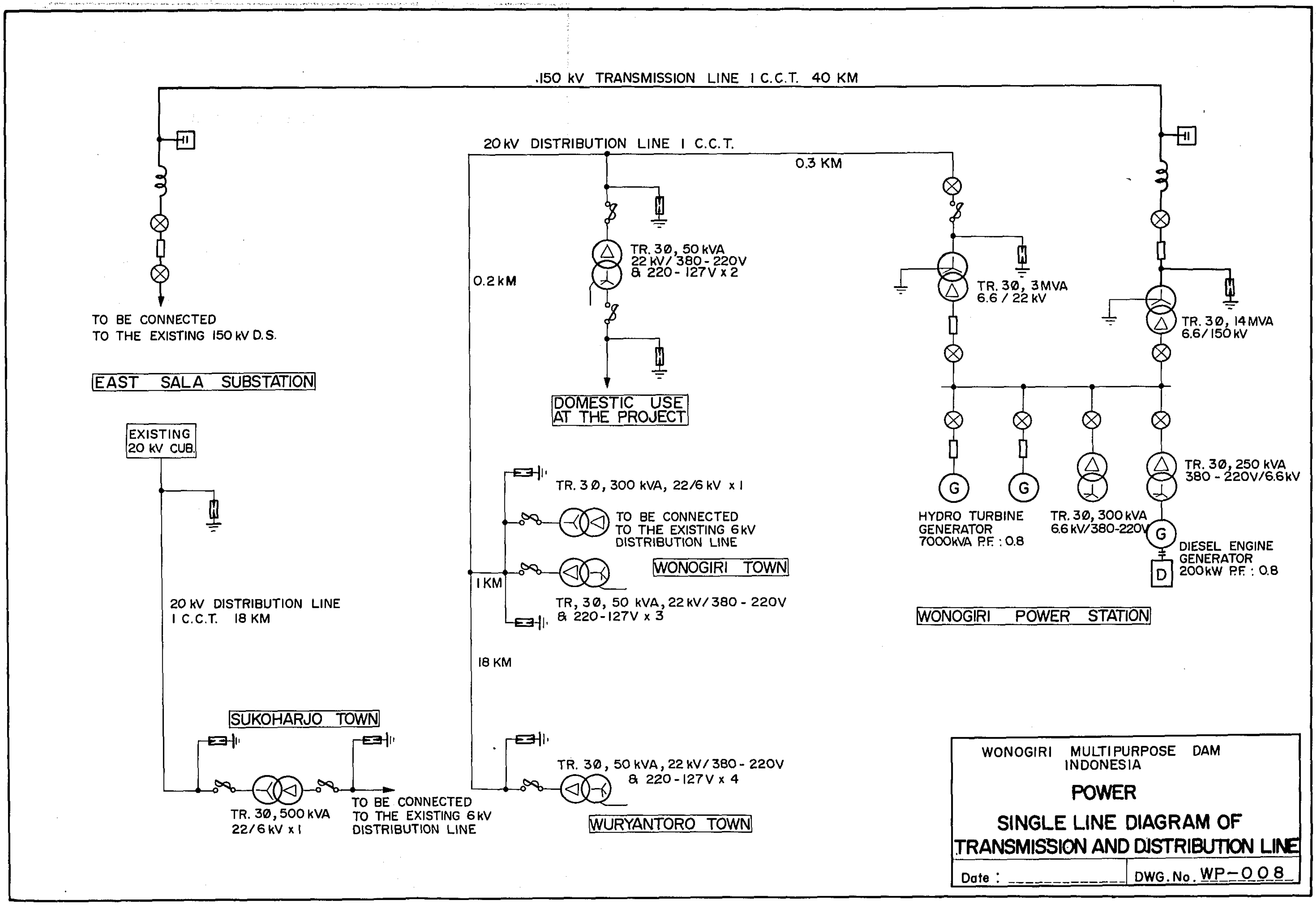
WONOGIRI MULTIPURPOSE DAM
INDONESIA
POWER

ARRANGEMENT OF OUTDOOR EQUIPMENT

DATE ---------- DWG. NO. WP-006


N
SURAKARTA (SALA)
EAST SALA S/S
BENGAWAN SALA RIVER
KARANGANYAR
SAMIN RIVER
SUKOHARJO
SANDJING RIVER
BENGAWAN SALA RIVER
WALIKAN RIVER
WONOGIRI
WONOGIRI P/S


SUKOHARJO
SANDJING RIVER
BENGAWAN SALA RIVER
WALIKAN RIVER
WONOGIRI
WONOGIRI P/S
WURYANTORO
BATURETNO
150 kV T/L
20 kV D/L
SCALE
0 1 2 3 4 5 KM
WONOGIRI MULTIPURPOSE DAM
INDONESIA
POWER
TRANSMISSION LINE AND
DISTRIBUTION LINE ROUTE
Date:
DWG. No. WP-007

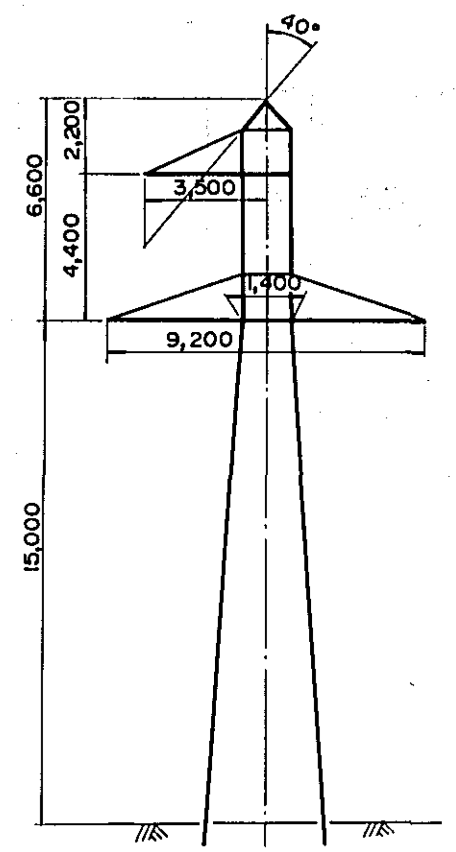


WONOGIRI MULTIPURPOSE DAM
INDONESIA

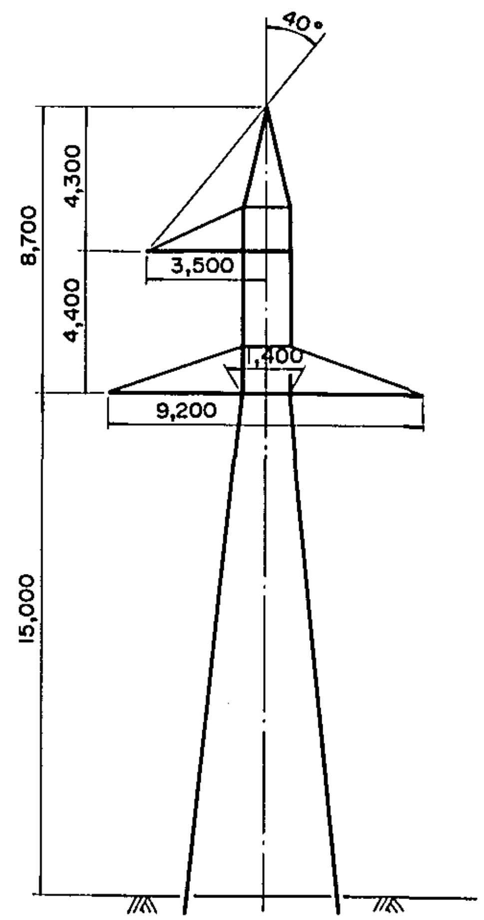
POWER

SINGLE LINE DIAGRAM OF TRANSMISSION AND DISTRIBUTION LINE

Date : ____________ DWG. No. WP-008

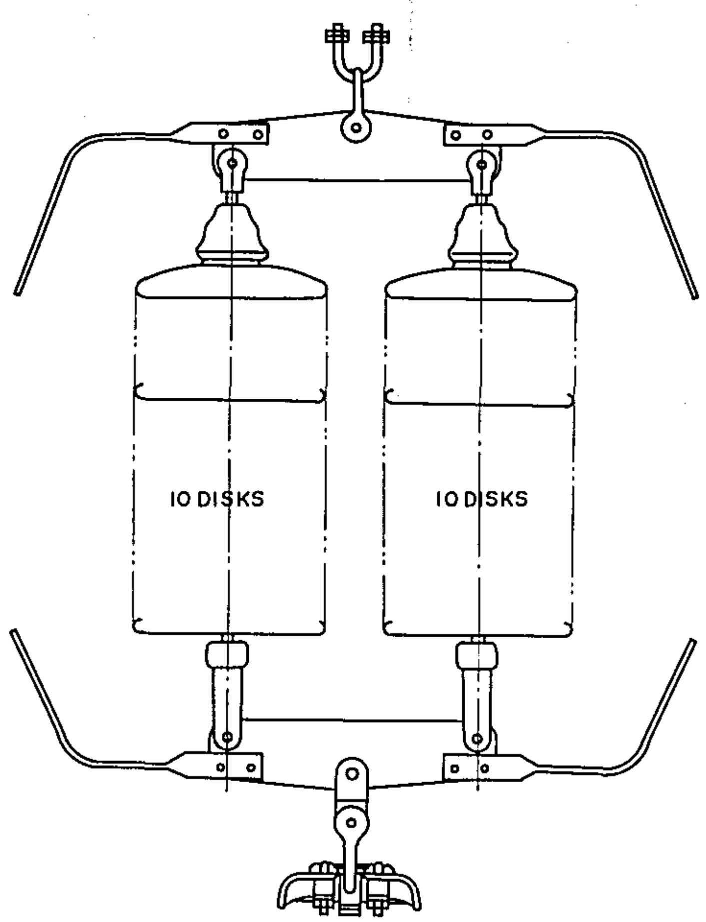


SUSPENSION TOWER

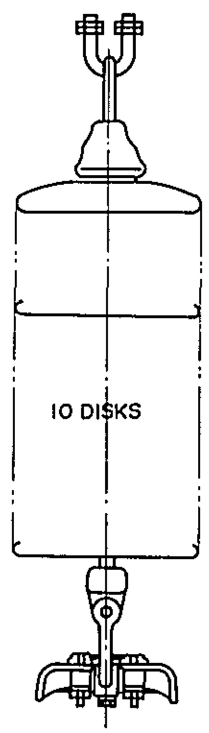


TENSION TOWER

SUSPENSION INSULATOR STRING

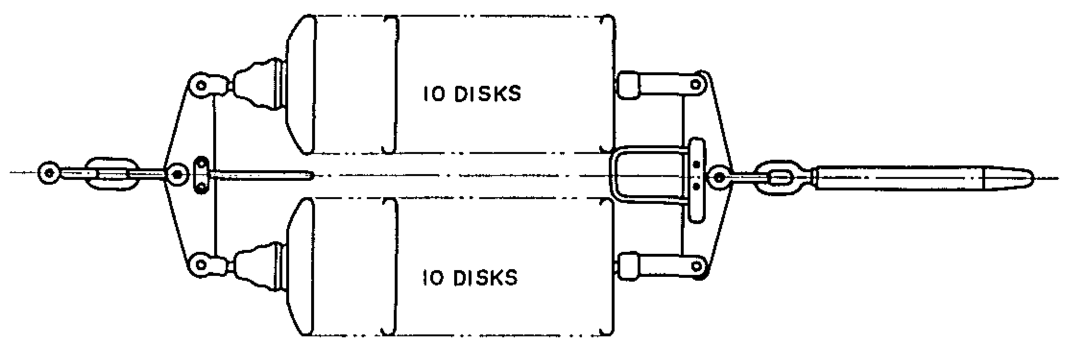


HEAVY SUSPENSION SET

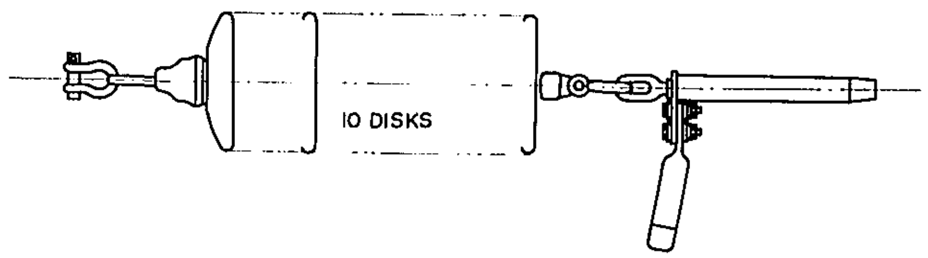


STANDARD SUSPENSION SET

TENSION INSULATOR STRING



HEAVY TENSION SET



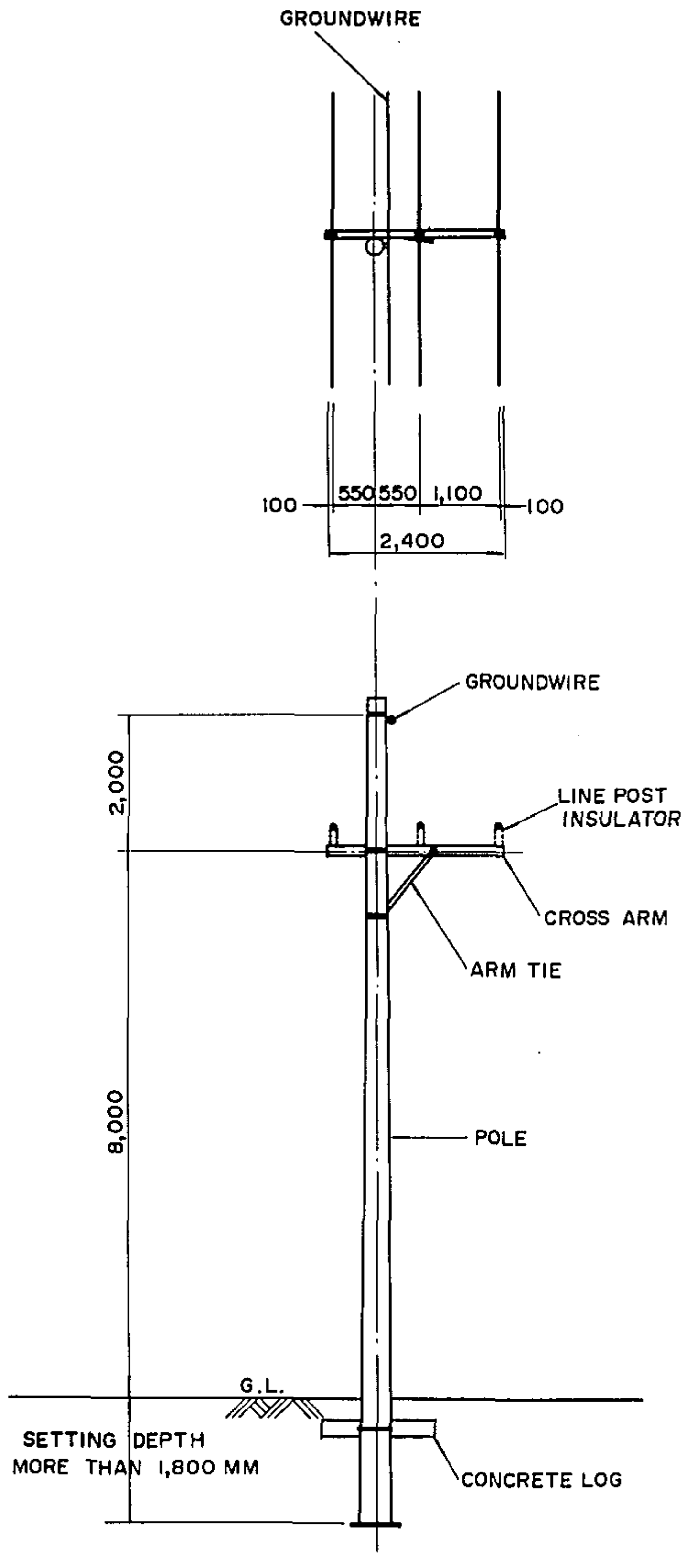
STANDARD TENSION SET

WONOGIRI MULTIPURPOSE DAM
INDONESIA

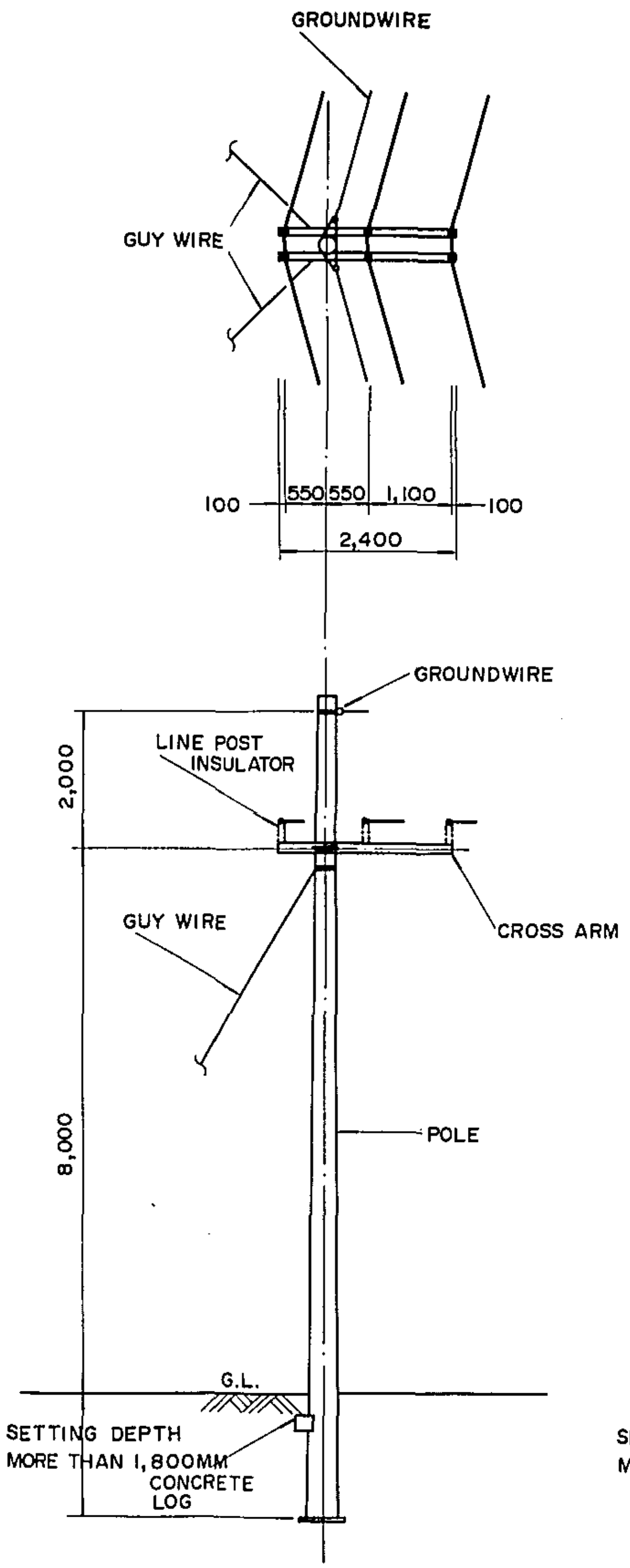
POWER

150KV TRANSMISSION LINE TYPICAL
. TOWERS & INSULATOR STRINGS

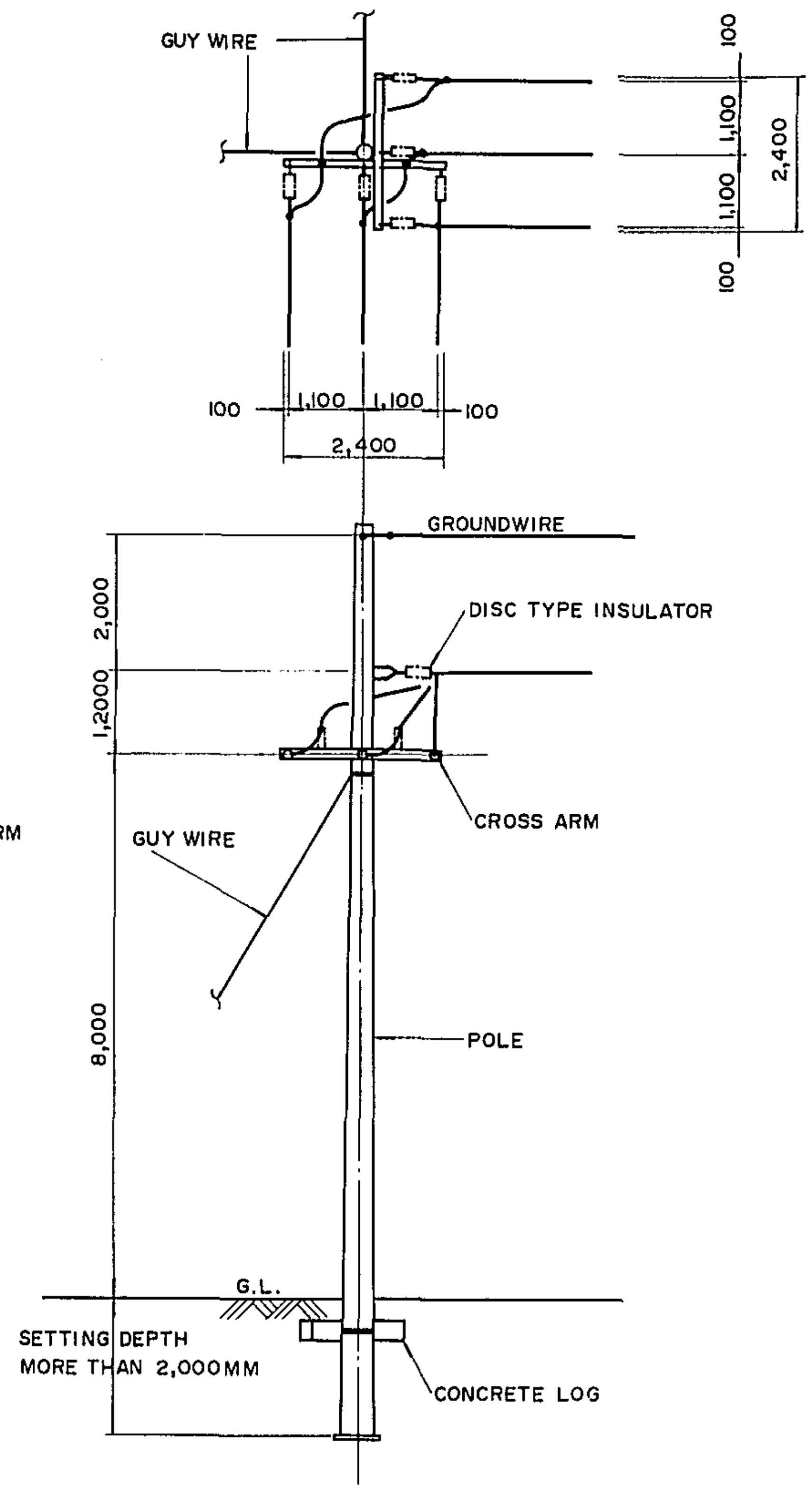
Date : ____________ DWG. No. WP-009



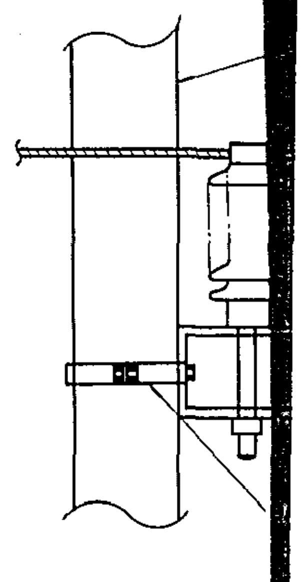
TYPE-A



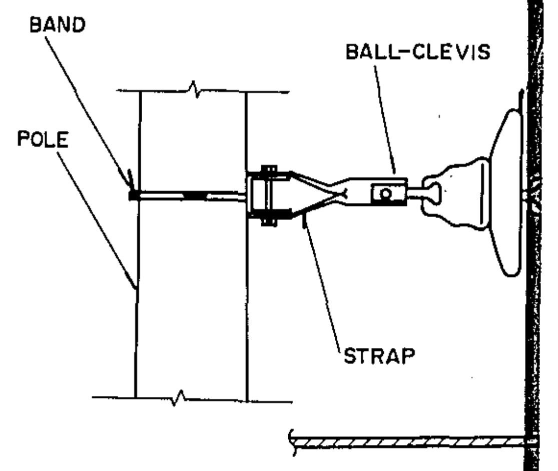
TYPE-B



TYPE-C

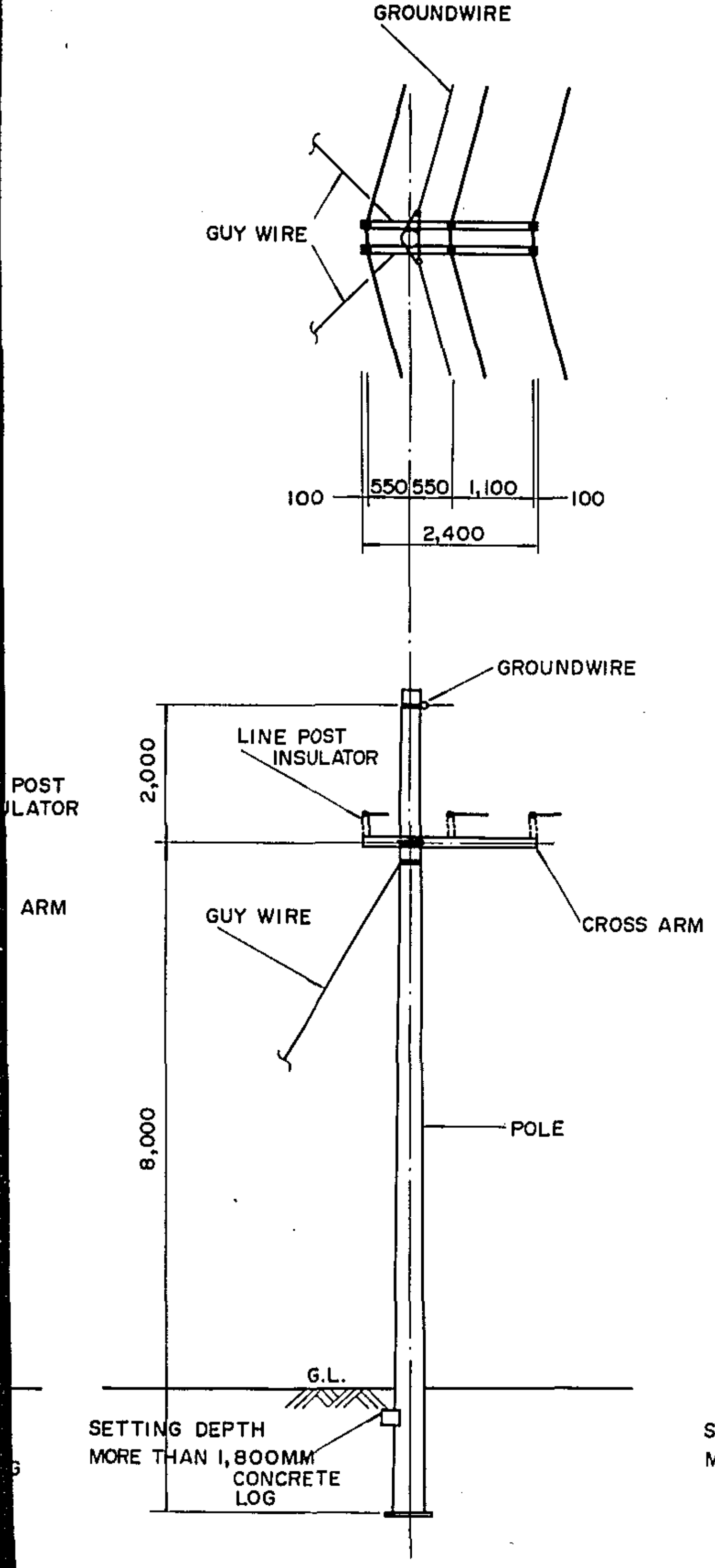


SUS



TENSION TYPE AS

Do



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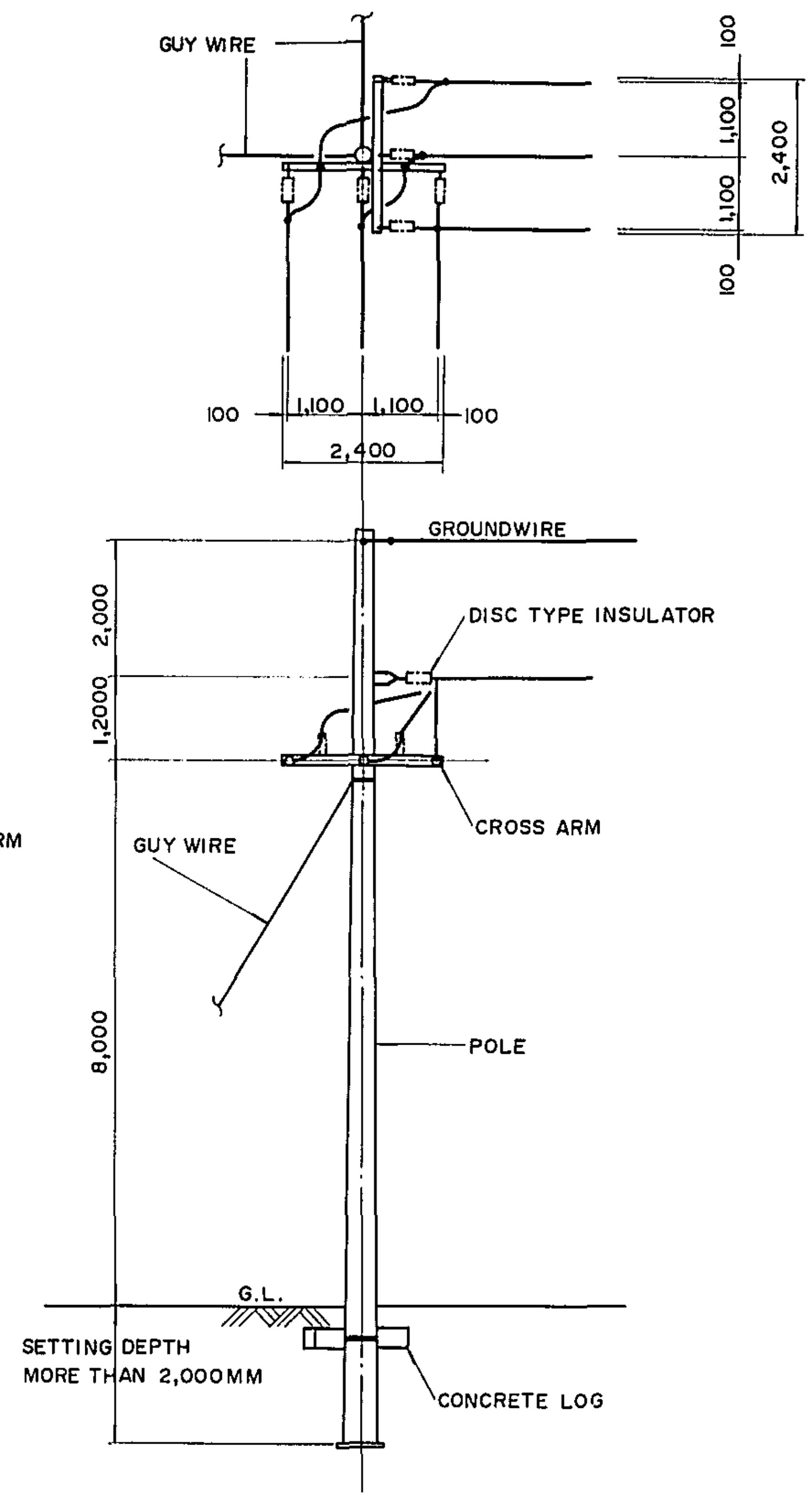

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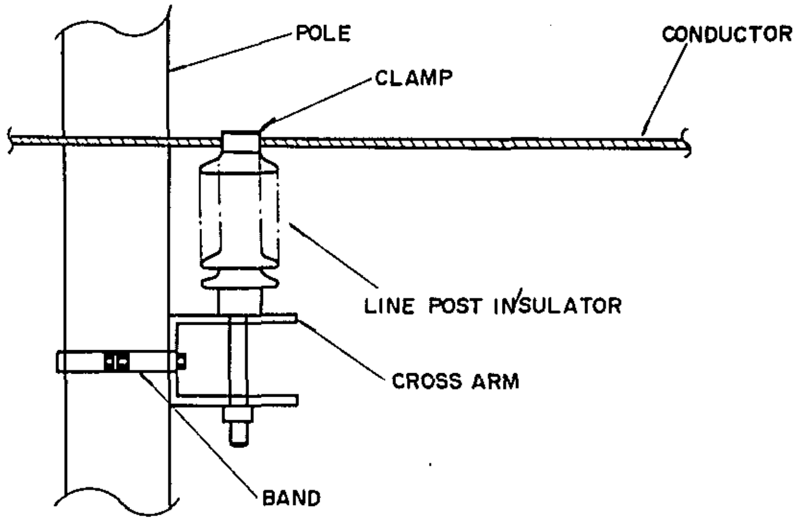
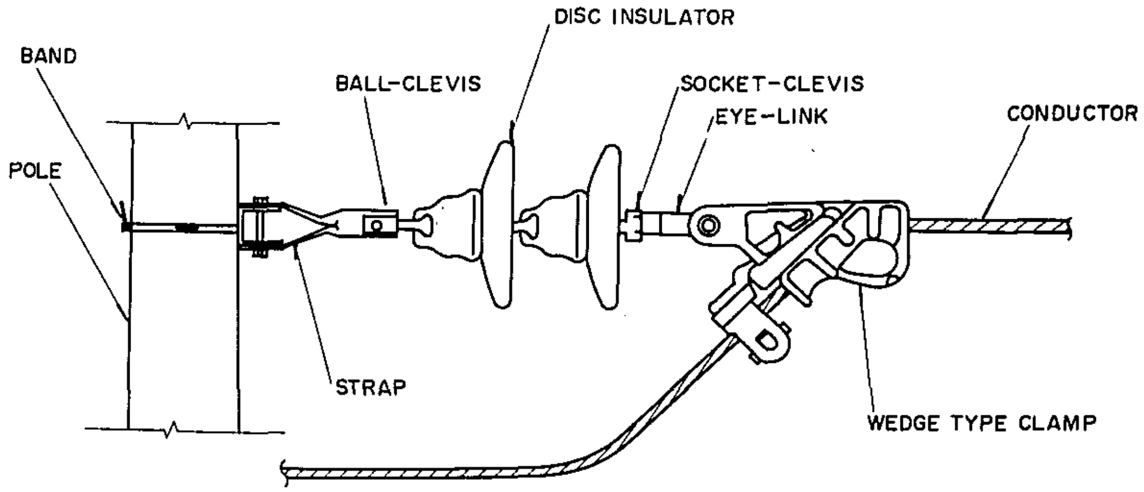


SUSPENSION TYPE ASSEMBLY



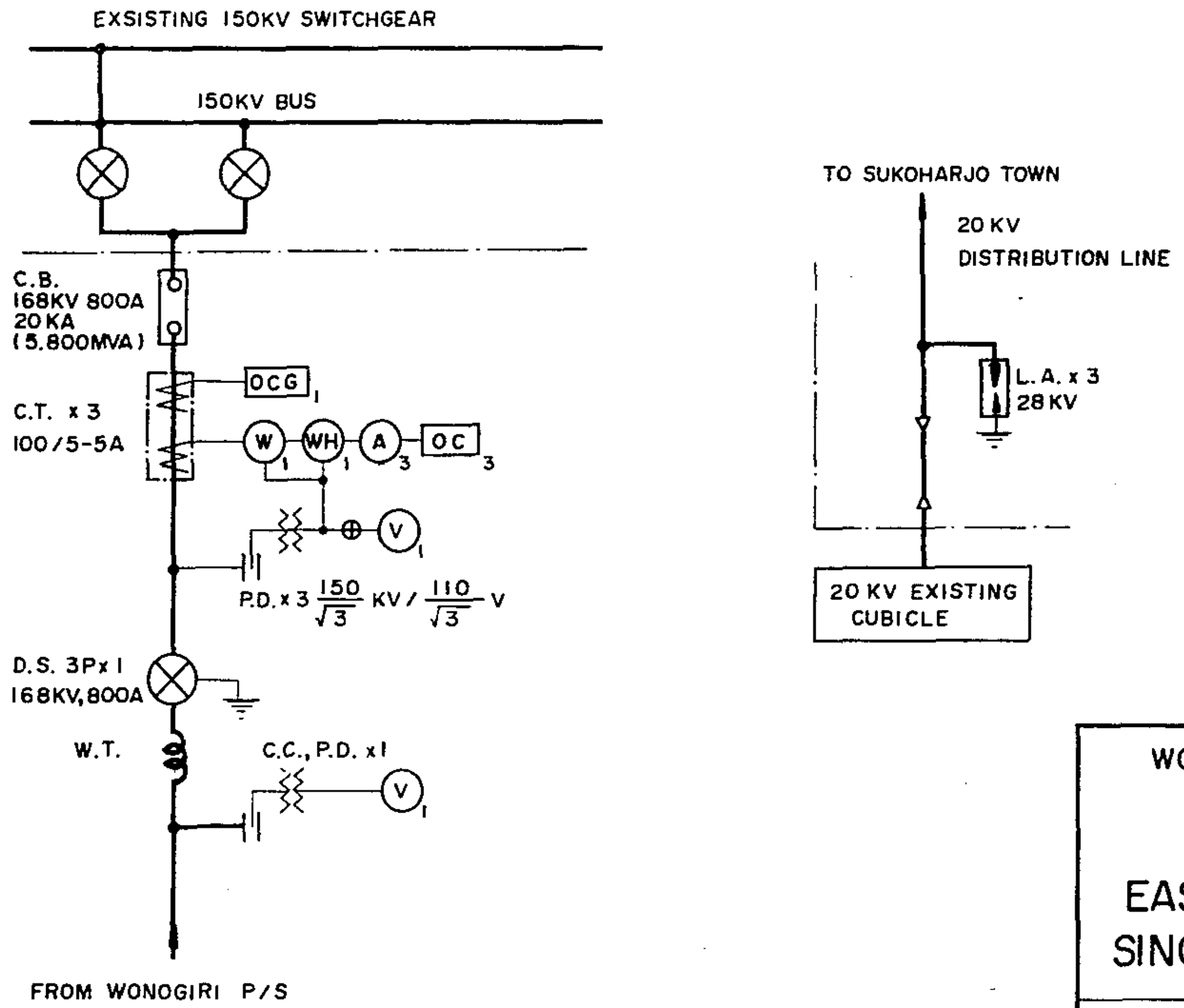
TENSION TYPE ASSEMBLY

WONOGIRI MULTIPURPOSE DAM
INDONESIA

POWER

**20KV DISTRIBUTION LINE
TYPICAL ASSEMBLIES**

Date : ________	DWG.No. WP-010



LEGEND

MARK	DESCRIPTION
C. B.	CIRCUIT BREAKER
C. C.	COUPLING CAPACITOR
C. T.	CURRENT TRANSFORMER
D. S.	DISCONNECTING SWITCH
L. A.	LIGHTNING ARRESTER
P. D.	POTENTIAL DEVICE
W. T.	WAVE TRAP
(A)	A.C. AMMETER
(V)	A.C. VOLTMETER
(W)	WATT METER
(WH)	WATT HOUR METER
OC	OVER CURRENT RELAY
OCG	OVER CURRENT GROUNDING RELAY

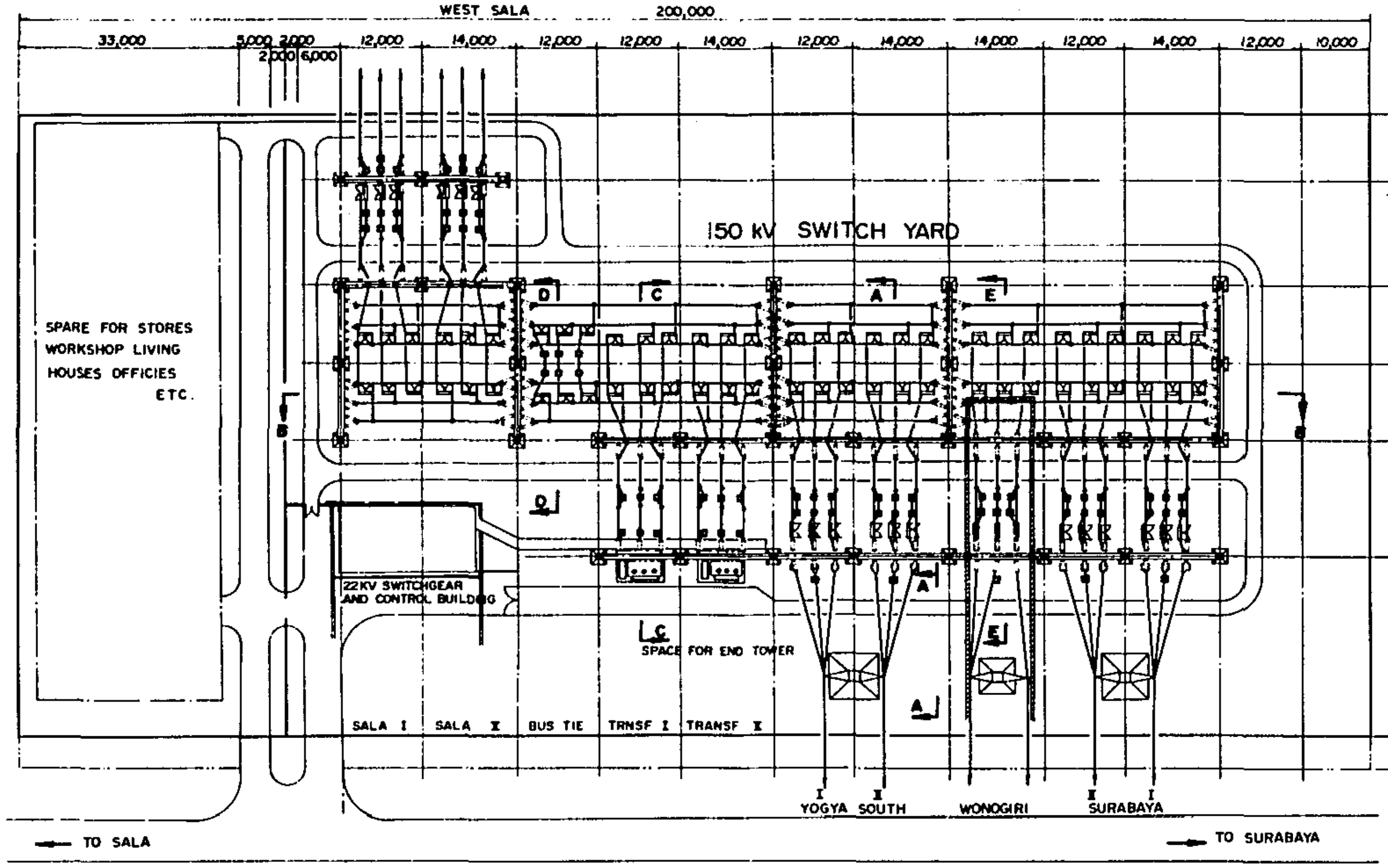
WONOGIRI MULTIPURPOSE DAM
INDONESIA

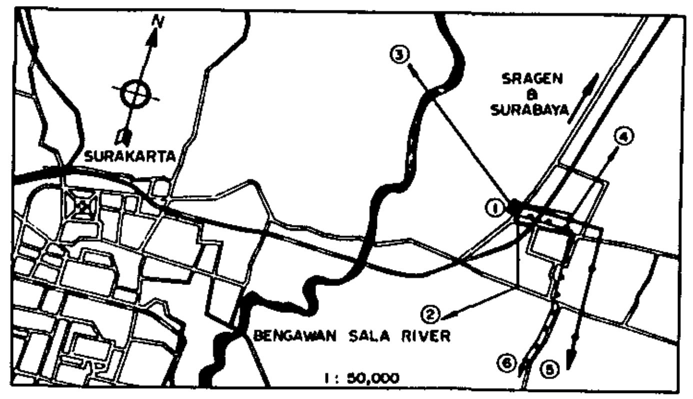
POWER

EAST SALA SUBSTATION

SINGLE LINE CONNECTION DIAGRAM

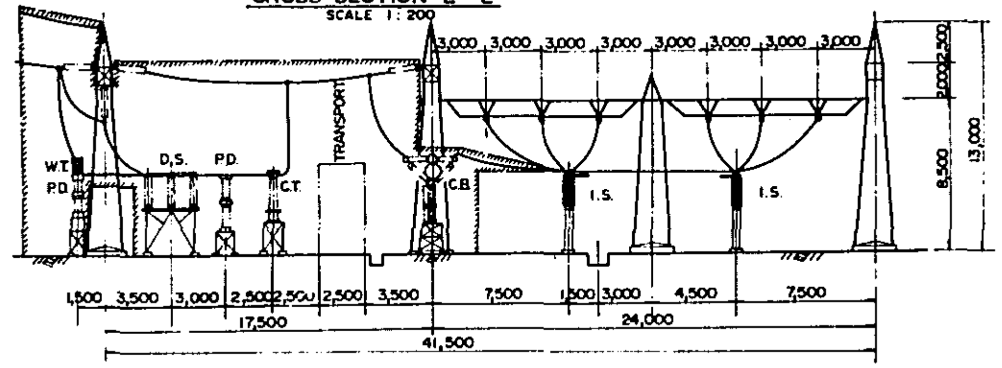
Date: ____________ DRG. No.: WP-011



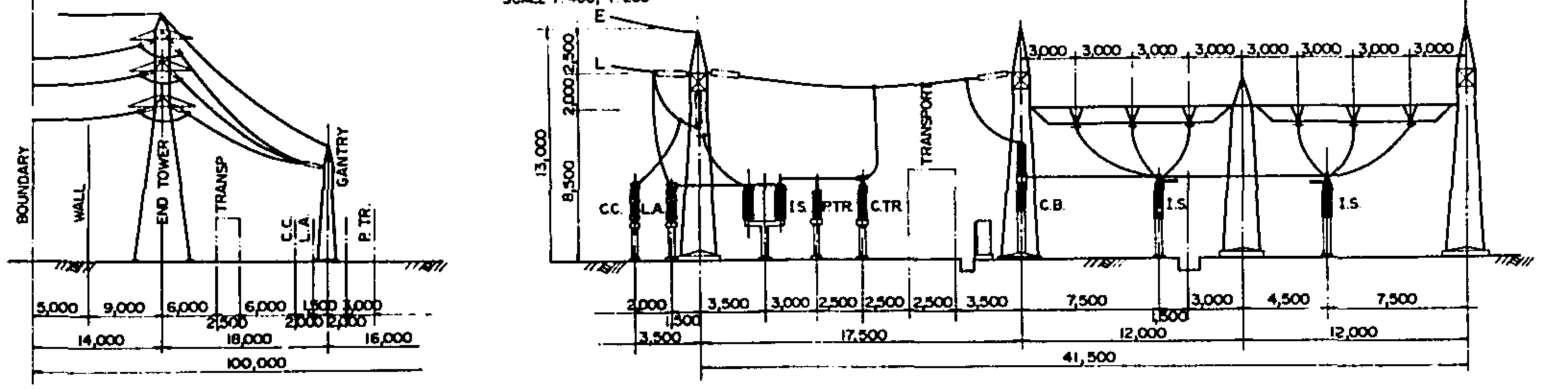


① WEST SALA SUBSTATION
② 150 kV TRANSMISSION LINE(SOUTH YOGYAKARTA SUBSTATION)
③ 150 kV TRANSMISSION LINE(WEST SALA SUBSTATION)
④ 150 kV TRANSMISSION LINE(SURABAYA)
⑤ 150 kV TRANSMISSION LINE(WONOGIRI POWER STATION)
⑥ 20 kV DISTRIBUTION LINE

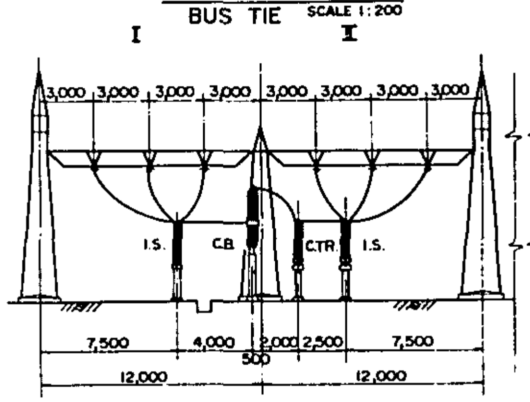
CROSS SECTION E - E
SCALE 1 : 200



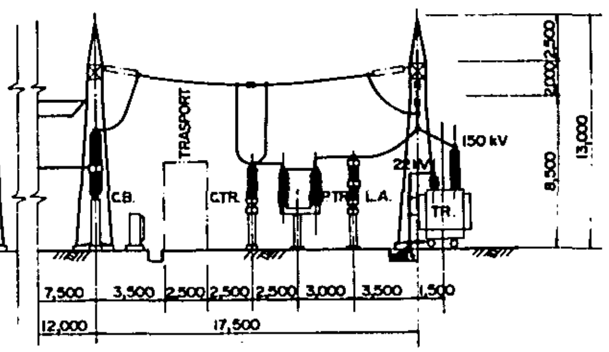
CROSS SECTION A - A
SCALE 1 : 400, 1 : 200



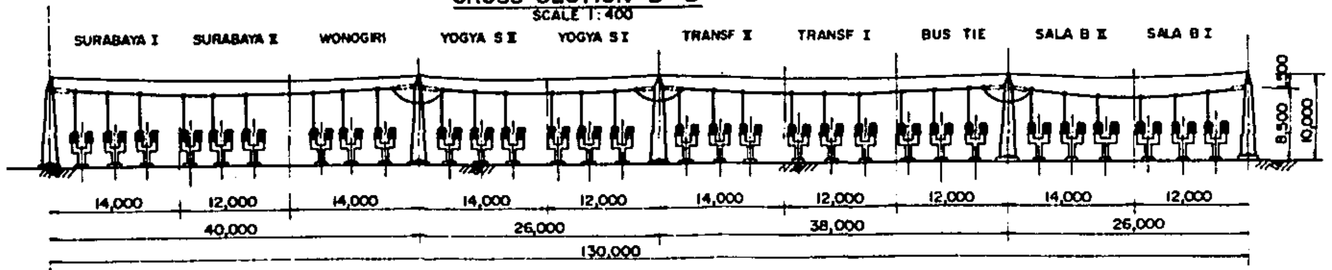
CROSS SECTION D-D
BUS TIE SCALE 1 : 200



CROSS SECTION C - C
TRANSFORMER SCALE 1 : 200



CROSS SECTION B - B
SCALE 1 : 400

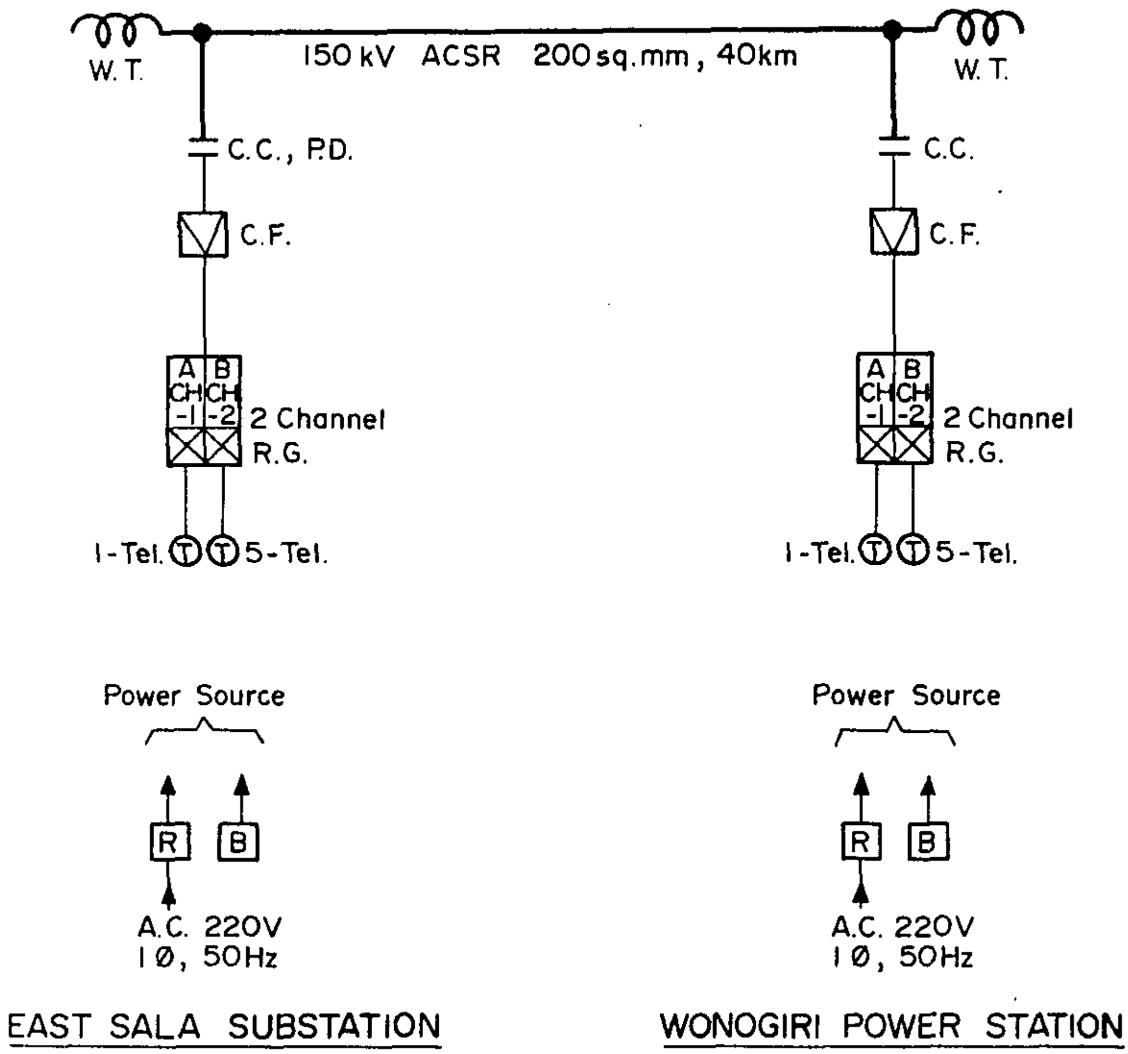


NOTE

▨ TO BE PROVIDED BY THE WONOGIRI POWER PROJECT

WONOGIRI MULTIPURPOSE DAM
INDONESIA
POWER
EAST SALA SUBSTATION
ARRANGEMENT OF
OUTDOOR EQUIPMENT

Date : .... DWG. No. WP -- 012



MARK	LEGEND
B	BATTERY
C.C.	COUPLING CAPACITOR
P.D.	POTENTIAL DEVICE
C.F	COUPLING FILTER
R	RECTIFIER
R.G.	RELAY GROUP
W. T.	WAVE TRAP

WONOGIRI MULTIPURPOSE DAM
INDONESIA

POWER

POWER LINE CARRIER TELEPHONE SYSTEM

Date : ___________ DWG. No. WP-013

ANNEX I

III. FLOOD CONTROL

CONTENTS

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LIST OF DRAWINGS

1. PRESENT RIVER CONDITION

1.1 General Features of Upper Sala Basin

Bengawan Sala Basin lies extendingly in both Central and East Java covering the drainage area of 16,100 km^2. Out of this drainage area, Upper Sala Basin (upstream from Ngawi), takes 6,100 km^2. The Upper Sala rises in the southern boundary hills and runs northward along the valley between G. Merapi and G. Lawu and turns the course to eastward after bounded by northern Kendeng Ridge. Within this reaches, the river travels through the alluvial land formed by soils of volcanic origin in most part, and the river channel shows eroded banks in general formed by its heavily meandering course. The average river gradient is so mild as to be 1/3,000 in Upper Sala River, because the elevation of the river bed does not rise higher than 100 m above the sea level even at the spots far distant inland about 500 km from the estuary.

River width varies from 50 m - 100 m in the Upper Sala River, and the mean depth of the river is generally 1/10 - 1/30 of the average river width.

The river bed is generally of sandy soil except in the mountain slope reaches. As silty soil in the river bank is generally vulnerable to easy erosion, the river bank at water front has collpsed by lateral erosion of the flowing water and this is accelerating meandering of the river channel. To cope with such condition, bank protection works with pillar like permeable spurs are provided to fix the river channel. Moreover, short cut of the channel at some places of the heaviest meandered parts has been executed.

1.2 Tributaries

Upper Sala Basin (upstream from Ngawi) is divided into 20 subbasins at the spots of the confluence of principal tributaries. Table III-1 shows the catchment area of each sub-basin of the tributaries with distance from the estuary.

1.3 Plane Profile

The existing river courses are heavily meandering throughout the river courses. To express the meandering conditions quantitatively, the rate β was calculated.

β = d/D

d = Distance of meandering

D = Distance of non-meandering

The mean values of β in Upper Sala Basin is about 1.52; the maximum value of β is given in sections No. 482-484.

$$\beta = \frac{2000}{196} = 10.2$$

1.4 Longitudinal Profile

Present river profile shows the following gradient in respective sections;

	Cross section No.	Gradient
Upper Sala	No. 313-335	1/7,600
	No. 337-375	1/2,200
	No. 377-420	1/3,500
	No. 422-466	1/2,400
	No. 468-507	1/3,200

1.5 Cross Section

The present cross sections have been formed mostly of natural eroded valley of which banks rise 3 to 8 m high above the river bed. Most sections are of single channel section, and of unsymmetrical shape owing to the meandering of the river channel.

The channel width distribution, the distribution of river side depth on the Upper Sala and the ratio of channel width to depth on the Upper Sala are presented in Fig. III-1, III-2 and III-3 respectively.

1.6 Flow Capacity of the River

Flow capacity of the present river channel is examined by using Manning's formula at the sections every 2 km distance along the river course.

Manning's formula is given below:

$$Q = V.A = \frac{1}{n} I^{1/2}.R^{2/3}.A$$

where ; Q = discharge (m^3/s)
V = mean flow velocity (m/s)
A = flow area (m^2)
n = roughness coefficient
I = surface gradient
R = perimeter depth (m)

The result is given in Fig. III-4.

Table III-1 Distribution of Catchment Area on the Upper Sala

Number	Name of Tributary	Distance from section No. 0 (km)	Catchment Area (km^2)	Total catchment area upstream from number (km^2)
1.	K. Madium	313.00	57	6,107
2.	K. Andong	324.73	151	6,050
3.	K. Soko	333.23	102	5,899
4.	K. Papungan	337.53	194	5,797
5.	K. Kuncen	362.38	81	5,603
6.	K. Bibis	367.22	125	5,522
7.	K. Banger	370.96	174	5,397
8.	K. Sawur	383.87	244	5,223
9.	K. Kenatan	393.71	246	4,979
10.	K. Munakung	416.28	488	4,733
11.	K. Grompol	433.59	283	4,245
12.	K. Cemoro	442.63	435	3,962
13.	K. Anyar	452.66	251	3,527
14.	K. Pepe	458.45	63	3,276
15.	K. Samin	462.10	328	3,213
16.	K. Brambang	469.55	318	2,885
17.	K. Dengkeng	480.41	800	2,567
18.	K. J lantah	494.92	212	1,767
19.	K. Blatukan	503.88	195	1,555
20.	Wonogiri	521.84	1,360	1,360

Fig.Ⅲ-1 Channel Width Distribution on The Upper Sala

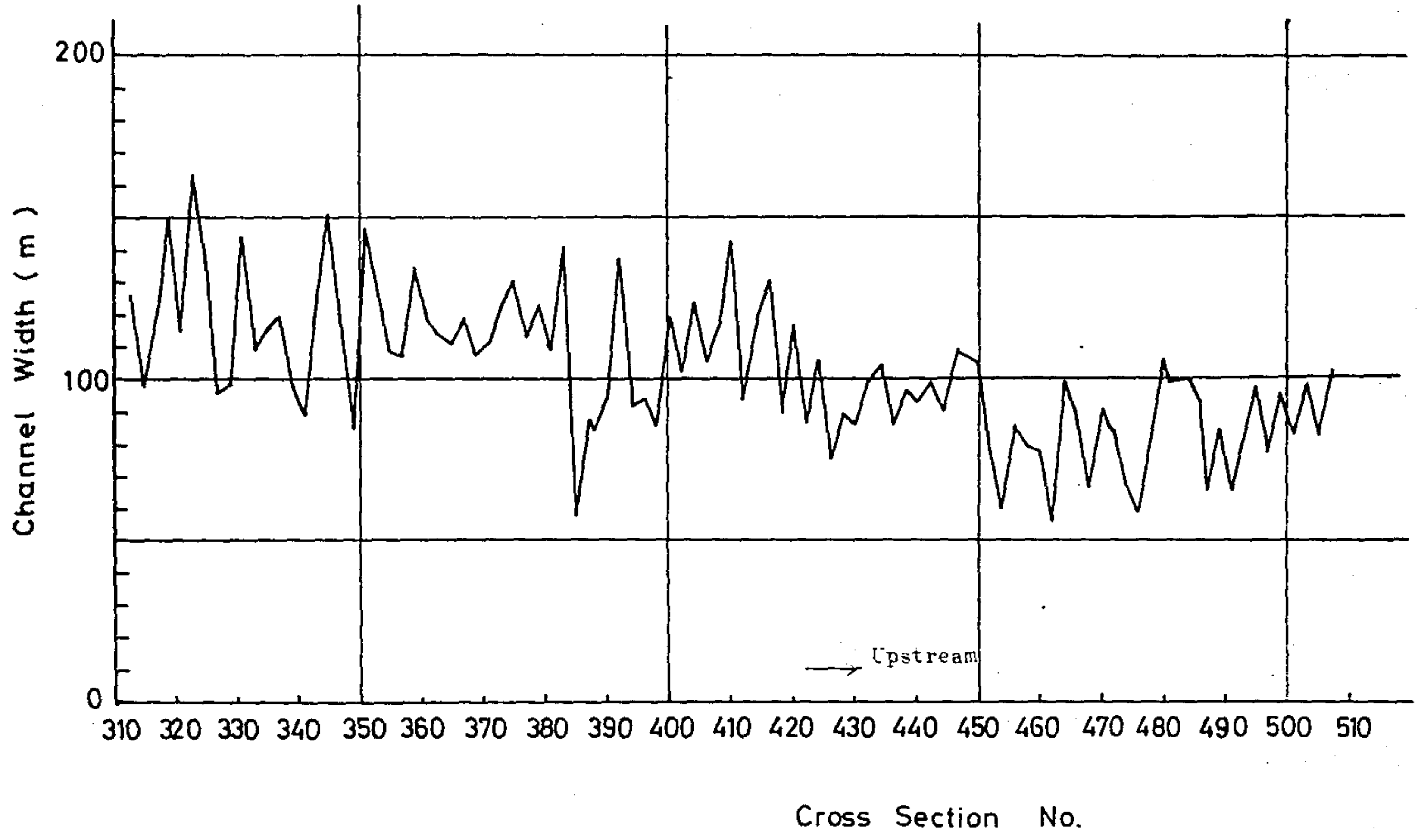


Fig III -2 Distribution of River Side Depth on The Upper Sala

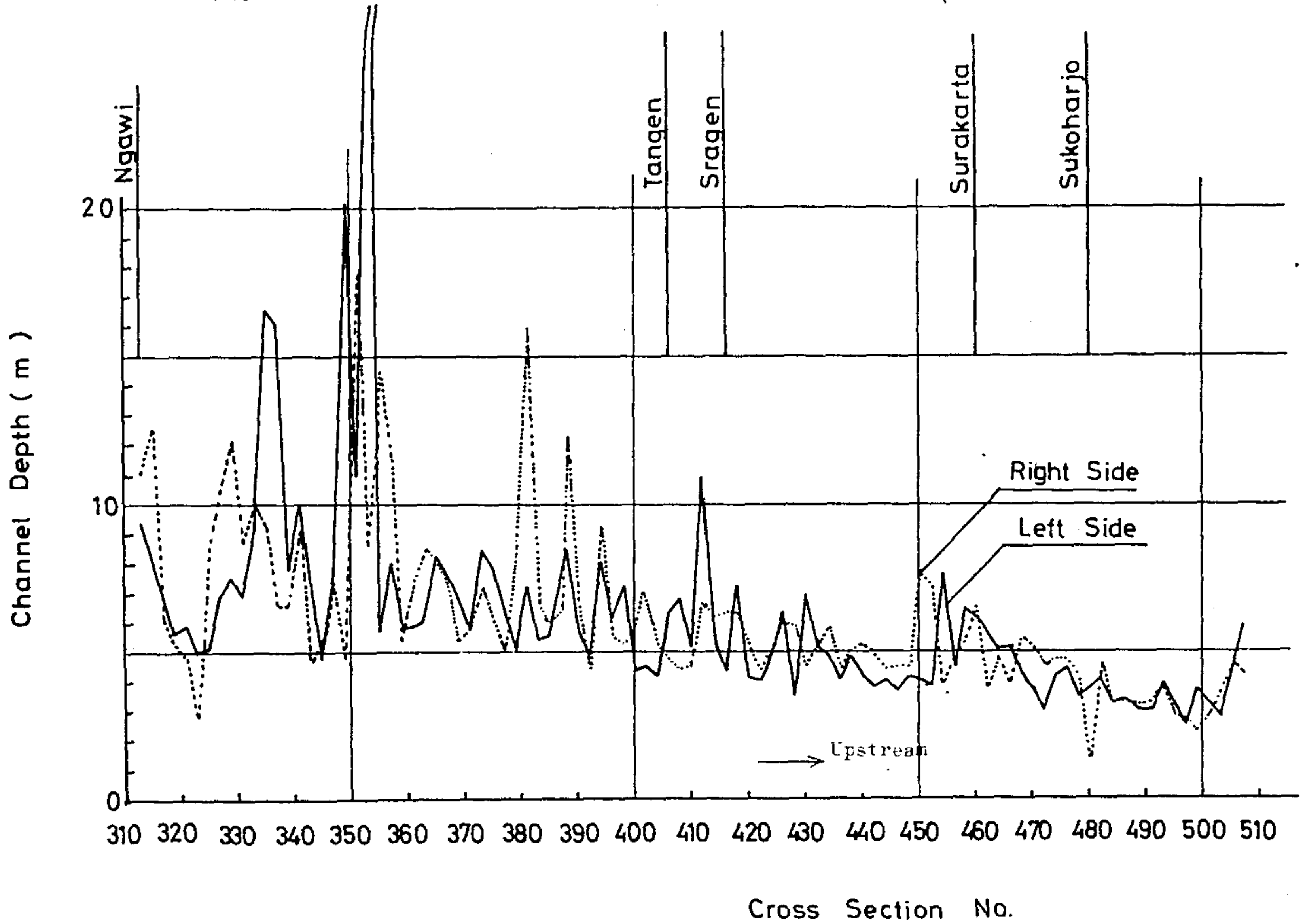


Fig III-3 Ratio of Channel Width to Depth on the Upper Sala

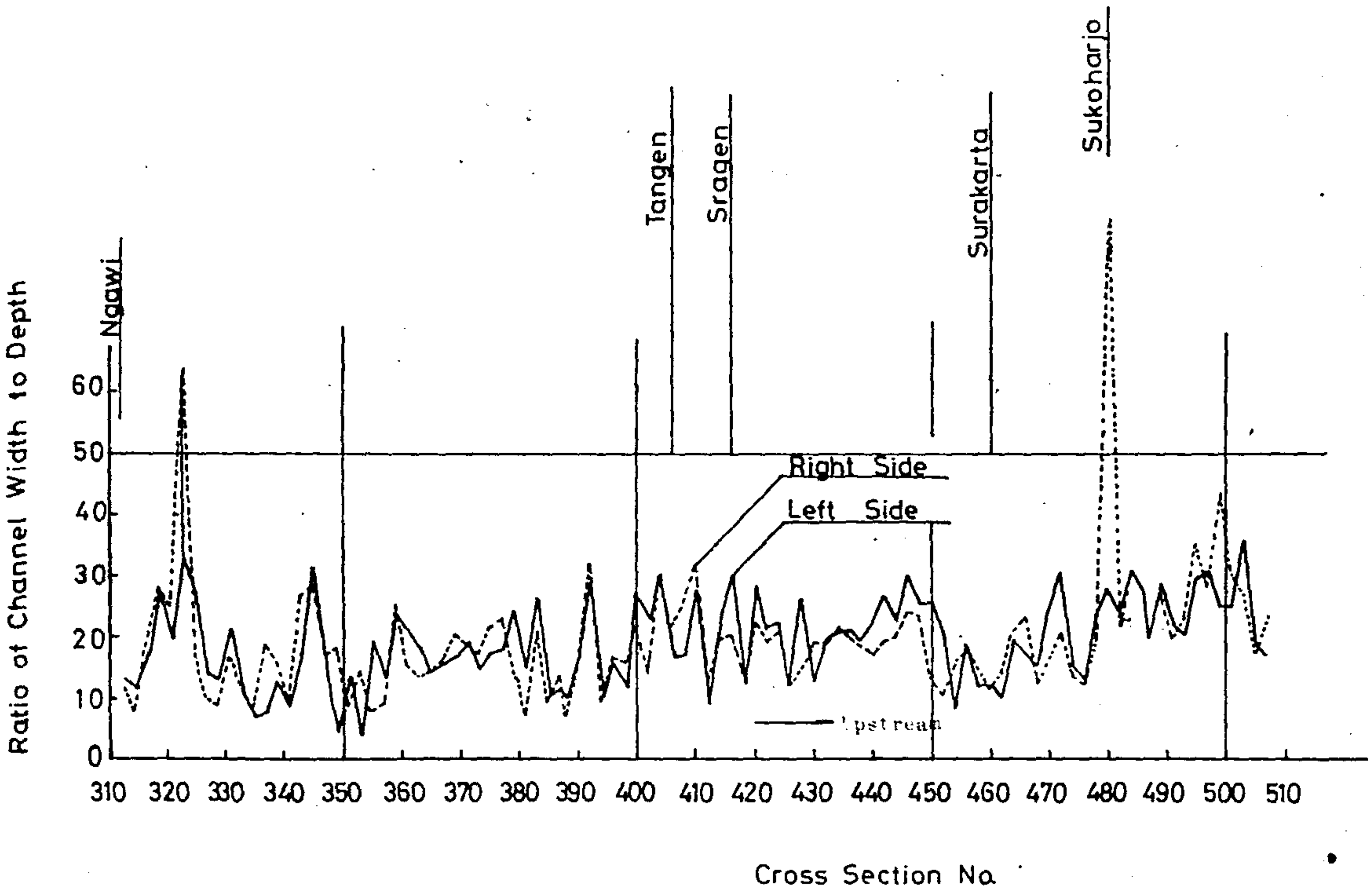
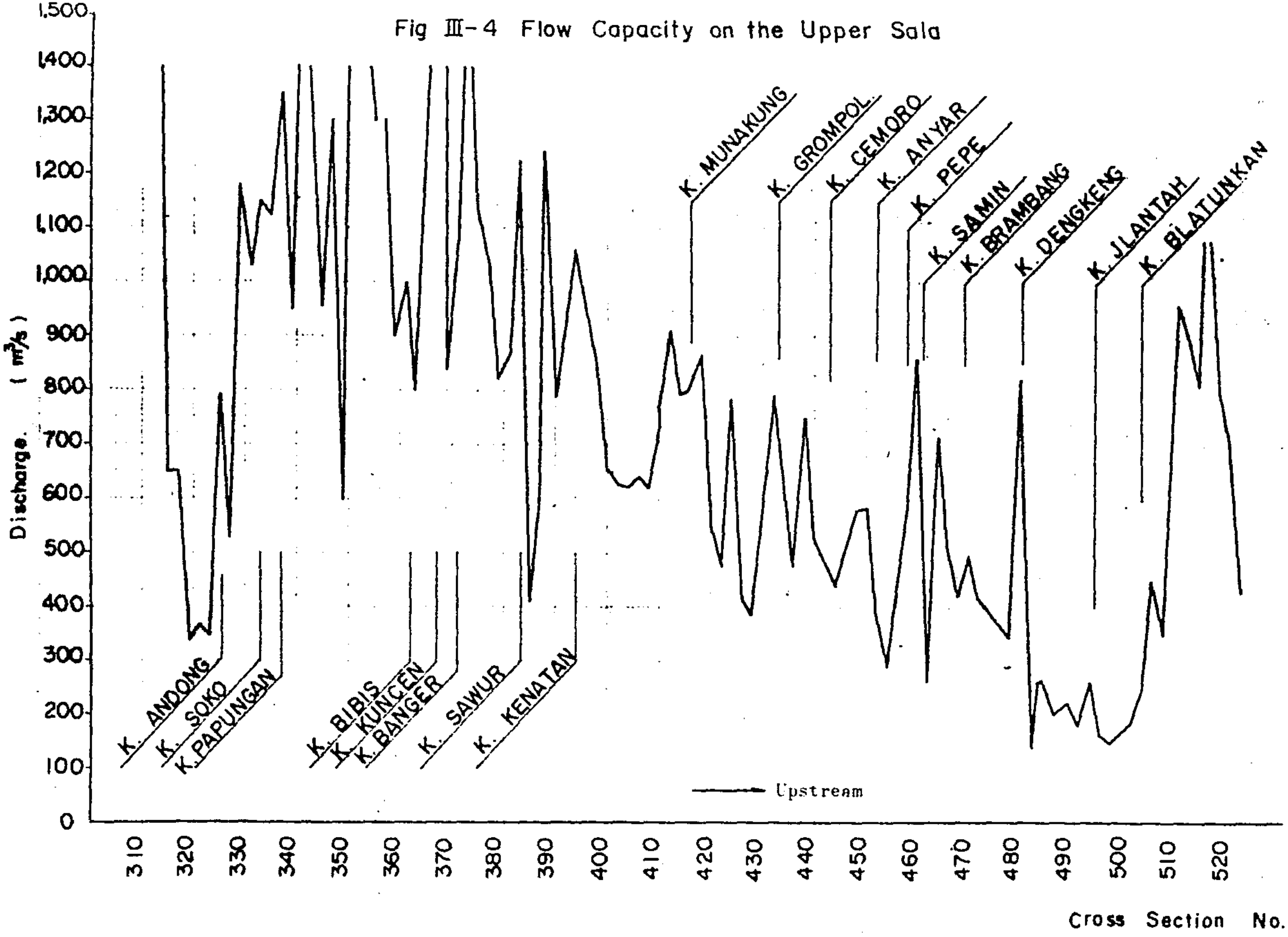


Fig III-4 Flow Capacity on the Upper Sala



2. FLOOD

2.1 Maximum Flood Record

The maximum flood discharge recorded in the past years is the discharge occurred in March 1966. The peak discharge at the representative stations along the river is as follows:

	Wonogiri	Surakarta	Ngawi
Peak discharge of 1966 flood	3,950m^3/s	2,160m^3/s	1,890m^3/s

2.2 Flood Frequency

According to the past flood records, the inundation will occur when the river water stage exceeds 4.0 m at Demangan gauging staff located in Surakarta city. Table III-2 shows the flood record at Surakarta during the period of Jan. 1962 to Dec. 1971.

Table III-2 Flood Record at Surakarta

(Jan. 1962 - Dec. 1971)

Water stage 1) (m)	4.0 -4.5	4.5 -5.0	5.0 -5.5	5.5 -6.0	6.0 -6.5	6.5 -8.0	8.0 -8.5	Total
Discharge 2) (m^3/s)	500 -650	650 -800	800 -1,000	1,000 -1,200	1,200 -1,400	1,400 -2,100	2,100 -2,400	
Nov.								0
Dec.	1							1
Jan.	4	1	1	1				7
Feb.	2	2		1				5
Mar.	5	3	1	1			1	11
Apr.			1					1
May								0
Total	12	6	3	3			1	25

Note: 1) Gauging staff at Demangan

2) Discharge was estimated from the correlation of water stage at Demangan and Jurug

Data source: Kota Madya Surakarta

Ref. Master Plan Study, Supporting Report, Part II "Flood control and river improvement," January 1974

From the above table, it can be said that the flooding has occurred as frequently as 2.5 times per annum during the past 10 years.

2.3 Flooding Duration

From the hydrographs of the past 25 floods, the duration time of water stage exceeding 4.0 m at Demangan gauging staff can be estimated as tabulated in Table III-3. This table shows that the duration time is usually proportionate to the magnitude of flood. The total flooding duration time in the event of the past maximum flood occurred in 1966 was about 7 days.

Considering the difference of the flooding duration time place by place, the mean flooding duration time over the whole inundated area can be estimated to be nearly equal to one half of the total flooding duration.

2.4 Flood Discharge at Surakarta and Return Period

The correlation between discharges at Surakarta (under the present river condition) and their return period is estimated as follows:

(Ref. to Data, Hydrology, Annex III)

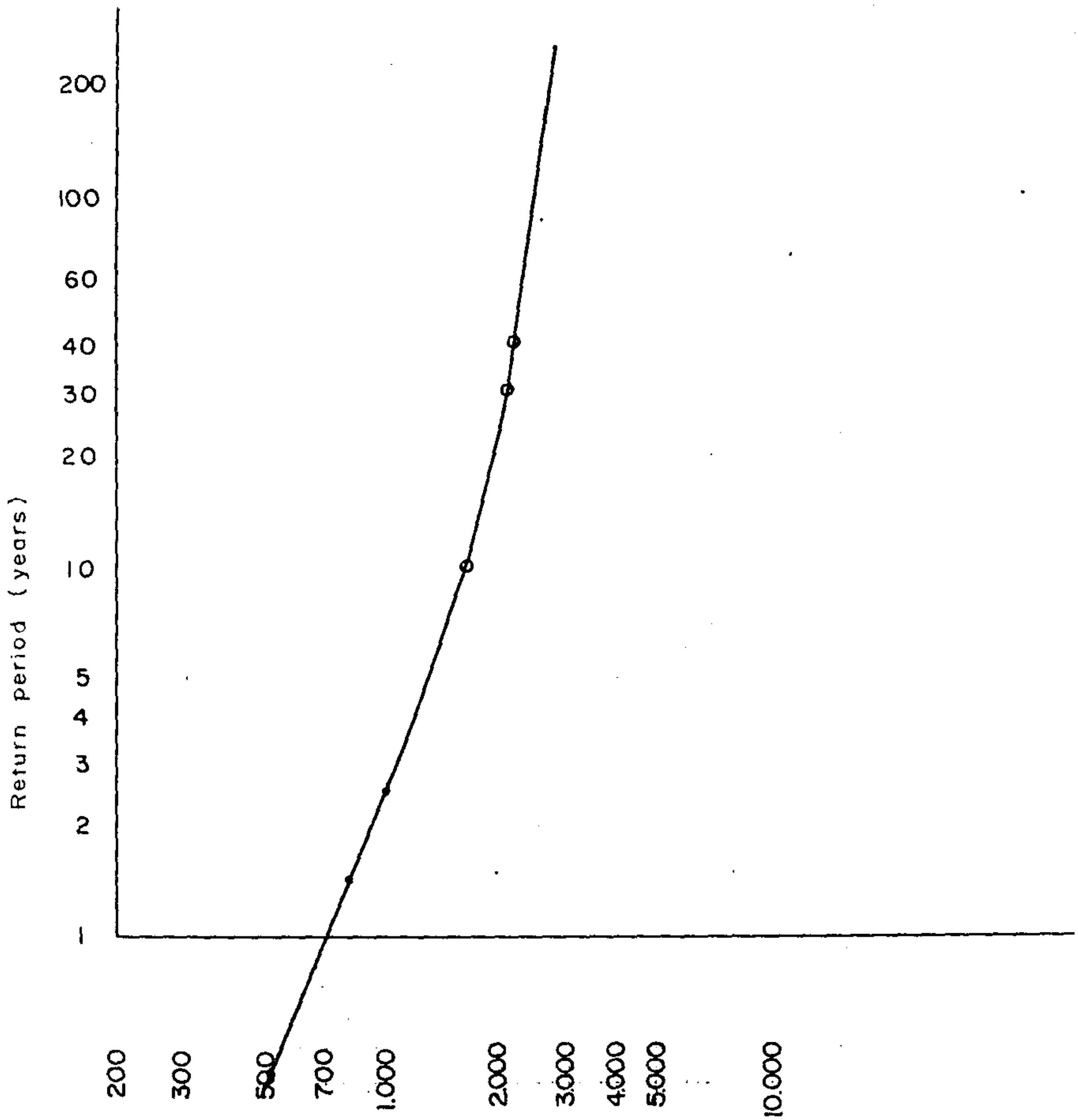
Return period (years)	Discharge at Surakarta (m^3/s)
200	2,650
100	2,450
60	2,250
40	2,160
30	2,050
20	1,900
10	1,600
5	1,300
2	920

Table III-3 Flooding Duration

Water stage at Surakarta (m)	4.0-4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-8.0	8.0-8.5	Total
Discharge at Surakarta (m^3/s)	500-650	650-800	800-1,000	1,000-1,200	1,200-1,400	1,400-2,100	2,100-2,400	
Flood frequency per year	1.2	0.6	0.3	0.3			0.1	2.5
Total flooding duration (day)	1.2	2.4	3.0	4.2	5.2		7.2	
Mean flooding duration (day)	1	1	2	2	3		4	

Ref.: Bibliography (1)

Fig III-5 Return Period – Discharge Curve at Surakarta
(under the present river condition without dam)



3. INUNDATION AND FLOOD DAMAGE

3.1 Inundation

3.1.1 Maximum inundation record

The past maximum inundation is estimated from the records of the major flood events as shown in Fig. III-6. A large part of the area is habitually inundated.

The inundation area in the Upper Sala Basin consists of the following three areas.

Wonogiri area: upstream area of Wonogiri
Surakarta area: from Wonogiri to Surakarta
Sragen area: from Surakarta to Ngawi

The maximum inundation area totals 33,000 ha, equivalent to about 5.4% of the Upper Sala Basin, among which 3,700 ha are in Wonogiri area, 19,500 ha in Surakarta area and 9,700 ha in Sragen area.

Table III-4 shows the inundation depth in the maximum flood event. At the maximum flood, the mean flooding depths of Surakarta and Sragen areas are estimated to reach 2.4 m and 2.5 m respectively.

The population of the whole inundation area is 462,000, and this inundation area is so densely inhabited and highly developed into farm production areas that damages on houses and properties as well as farm crops are considerably heavy.

Table III-5 shows the population, number of houses and land area afflicted by inundation at the maximum flood event.

3.1.2 Inundation area by flood scale

The inundation areas relative to floods of various scales were estimated on the topographic maps on a scale of 1/5,000, referring to the maps prepared for the respective floods of the past. Inundation areas affected by floods of various scales are shown in Fig. III-7 and Table III-6. Fig. III-8 shows the area in Surakarta city inundated by the 1966 flood.

3.1.3 Population, houses and land use in the inundation area

The existing population, number of houses, farm land, yard and other areas are shown in Table III-7 for each inundation area, relating to the flood discharge at Surakarta.

3.1.4 Damageable houses and inundation area

The houses in these inundation areas are not wholly submerged by flood water. Generally, the ratio of the number of damageable houses to the total number of existing houses becomes larger in proportion to the flood scale.

The damageable houses and inundation areas are estimated for respective flooding depths, relating to the flood discharge at Surakarta. The results are shown in Table III-8 and Table III-9.

Note: Bibliography (1)

Survey and study for the development of Sala river basin. Supporting report part-two "FLOOD CONTROL AND RIVER IMPROVEMENT" January, 1974.

Table III-4 Inundation Depth in the Maximum Flood Event

	Total inundation area (ha)	Mean depth (m)	Inundation Area in every flooding depth 0-1.0 (m)	1.0-2.0 (m)	2.0-3.0 (m)	3.0-4.0 (m)	4.0-5.0 (m)
			(ha)	(ha)	(ha)	(ha)	(ha)
Surakarta area	19,500	2.4	3,500	3,800	4,000	4,800	3,400
Sragen area	9,700	2.5	1,300	1,900	2,400	4,100	-

Ref.: Bibliography (1)

Table III-5 Population, Houses and Land Use in the Maximum Inundation Area (by 1966 flood).

	Wonogiri Area.	Surakarta Area.	Sragen Area	Total of upper Sara Basin.
Nos. of Kecamatan & Kodya.	9	15	14	38
Inundation area (ha).	3,700	19,500	9,700	33,000
Farm land.	2,300	14,800	7,600	25,000
Yard.	1,400	4,700	2,100	8,000
Others.	-	-	-	-
Population.	20,000	360,000	82,000	462,000
Density of population.	5.4	18.5	8.5	14.0
Nos. of houses.	3,900	72,000	1,900	95,000
Density of houses.	1.1	3.7	2.0	2.9

Ref. : Bibliography (1).

Table III-6 Innundation Area under Various Flooding Conditions

(Surakarta area)

Discharge at Surakarta (m^3/s)	Flooding duration (day)	Total inundation area (ha)	Innundation area at every flooding depth (ha)									
			0 -0.5	0.5 -1.0	1.0 -1.5	1.5 -2.0	2.0 -2.5	2.5 -3.0	3.0 -3.5	3.5 -4.0	4.0 -4.5	4.5 -5.0
500	1	2,900	2,900									
1,000	2	10,000	1,800	2,200	2,600	3,400						
1,500	3	15,500	1,500	1,800	1,800	2,200	2,200	2,600	3,400			
2,000	3	20,200	1,600	2,600	2,000	1,800	1,800	2,200	2,200	2,600	3,400	
2,500	4	23,200	2,000	2,600	2,600	2,000	1,800	1,800	2,200	2,200	2,600	3,400

(Sragen area)

Discharge at Surakarta (m^3/s)	Flooding duration (day)	Total inundation area (ha)	Inundation area at every flooding depth (ha)									
			0 (m) -0.5	0.5 -1.0	1.0 -1.5	1.5 -2.0	2.0 -2.5	2.5 -3.0	3.0 -3.5	3.5 4.0	4.0 4.5	4.5 5.0
500	1	3,800	1,600	2,200								
1,000	2	6,900	400	1,000	1,400	1,900	2,200					
1,500	3	8,400	900	1,000	1,000	1,400	1,900	2,200				
2,000	3	9,700	500	800	900	1,000	1,000	1,400	1,900	2,200		
2,500	4	10,900	100	800	800	800	900	1,000	1,000	1,400	1,900	2,200

Table III-7 Population, Houses and Land Use in the Inundation Area at Each Flood Scale.

(Surakarta Area)

Discharge at Surakarta.	500	1,000	1,500	2,000	2,500	Remarks.
Inundation area	2,900	10,000	15,500	20,200	23,200	
Farm land	2,400	8,100	12,400	15,600	18,100	
Yard	500	1,900	3,100	4,600	5,100	
Others	-	-	-	-	-	
Population.	38,500	133,000	218,000	375,000	412,000	
Number of houses	7,800	26,800	44,900	75,800	84,200	

(Sragen Area).

Inundation area	3,800	6,900	8,400	9,700	10,900	Remarks.
Farm land	3,000	5,400	6,600	7,600	8,500	
Yard	800	1,500	1,800	2,100	2,400	
Others	-	-	-	-	-	
Population	31,800	57,700	70,200	81,600	91,800	
Number of houses	6,900	13,100	16,400	19,300	21,800	

Table III-8 Damageable Houses under Various Flooding Conditions (1)

(Surakarta Area).

Discharge at Surakarta	Flooding duration	Total Number of damageable houses	Damangeable house at every flooding depth (Nos.)									
			0 (m) - 0.5	0.5 - 1.0	1.0 - 1.5	1.5 -2.0	2.0 -2.5	2.5 -3.0	3.0 -3.5	3.5 -4.0	4.0 -4.5	4.5 -5.0
500	1	0										
1,000	2	10,400	2,800	3,300	4,300							
1,500	3	22,500	3,000	3,000	3,500	3,500	4,100	5,400				
2,000	3	32,300	4,500	3,500	3,100	3,100	3,800	3,800	4,500	6,000		
2,500	4	44,700	5,400	5,400	4,200	3,800	3,800	4,700	4,700	5,500	7,200	

(Sragen Area).

Discharge at Surakarta	Flooding duration	Total Number of damageable houses	Damageable house at every flooding depth (Nos.)									
			0 (m) - 0.5	0.5 - 1.0	1.0 -1.5	1.5 -2.0	2.0 -2.5	2.5 -3.0	3.0 -3.5	3.5 -4.0	4.0 -4.5	4.5 -5.0
500	1	0										
1,000	2	5,500	800	1,200	1,600	1,900						
1,500	3	8,900	1,200	1,200	1,700	2,200	2,600					
2,000	3	12,700	1,100	1,200	1,400	1,400	2,000	2,600	3,000			
2,500	4	17,000	1,200	1,300	1,300	1,400	1,400	1,600	2,200	3,000	3,400	

Ref. : Biliography (1).

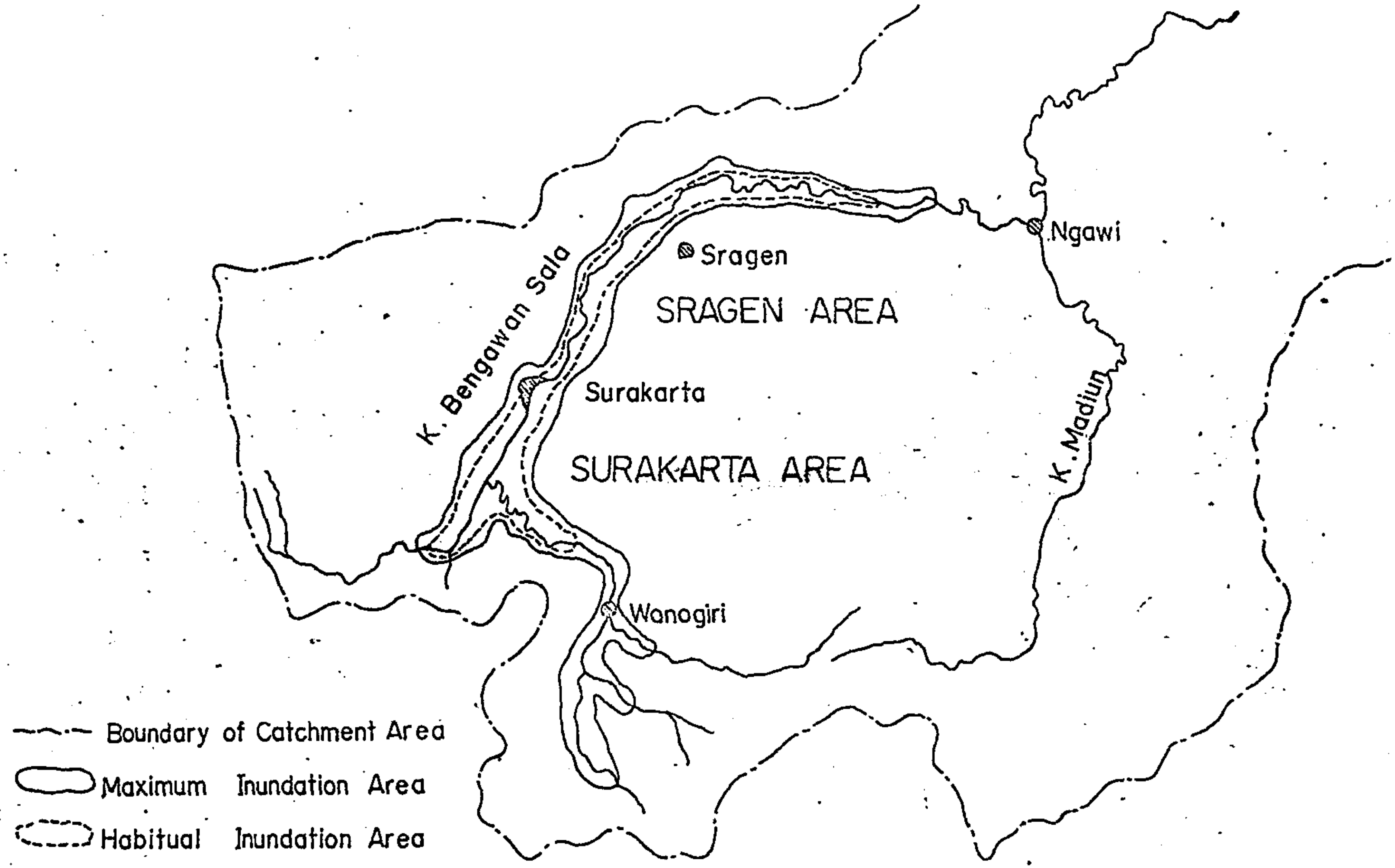
Table III-9 Damageable Houses under Various Flooding Conditions (2)

(Surakarta City).

Discharge at Surakarta (m^3/s)	Flooding duration (day)	Mean. flooding depth (m)	Total Number of damageable houses
500	1	-	-
1,000	2	-	-
1,500	3	-	-
2,000	3	1.0	26,900
2,500	4	1.0	26,900

Ref. : Bibliography (1).

Fig III - 6 Inundation Area in Upper Sala Basin



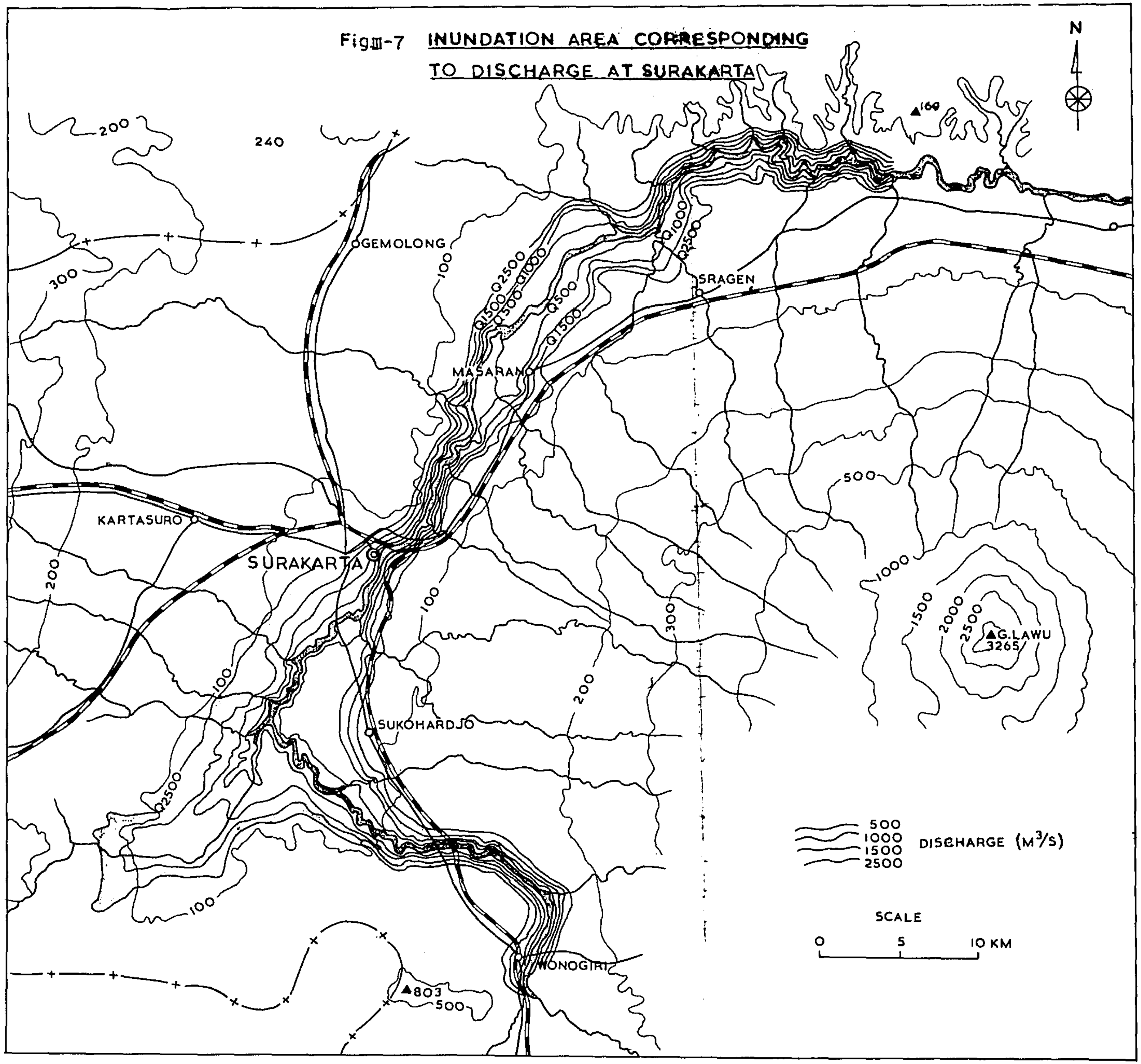
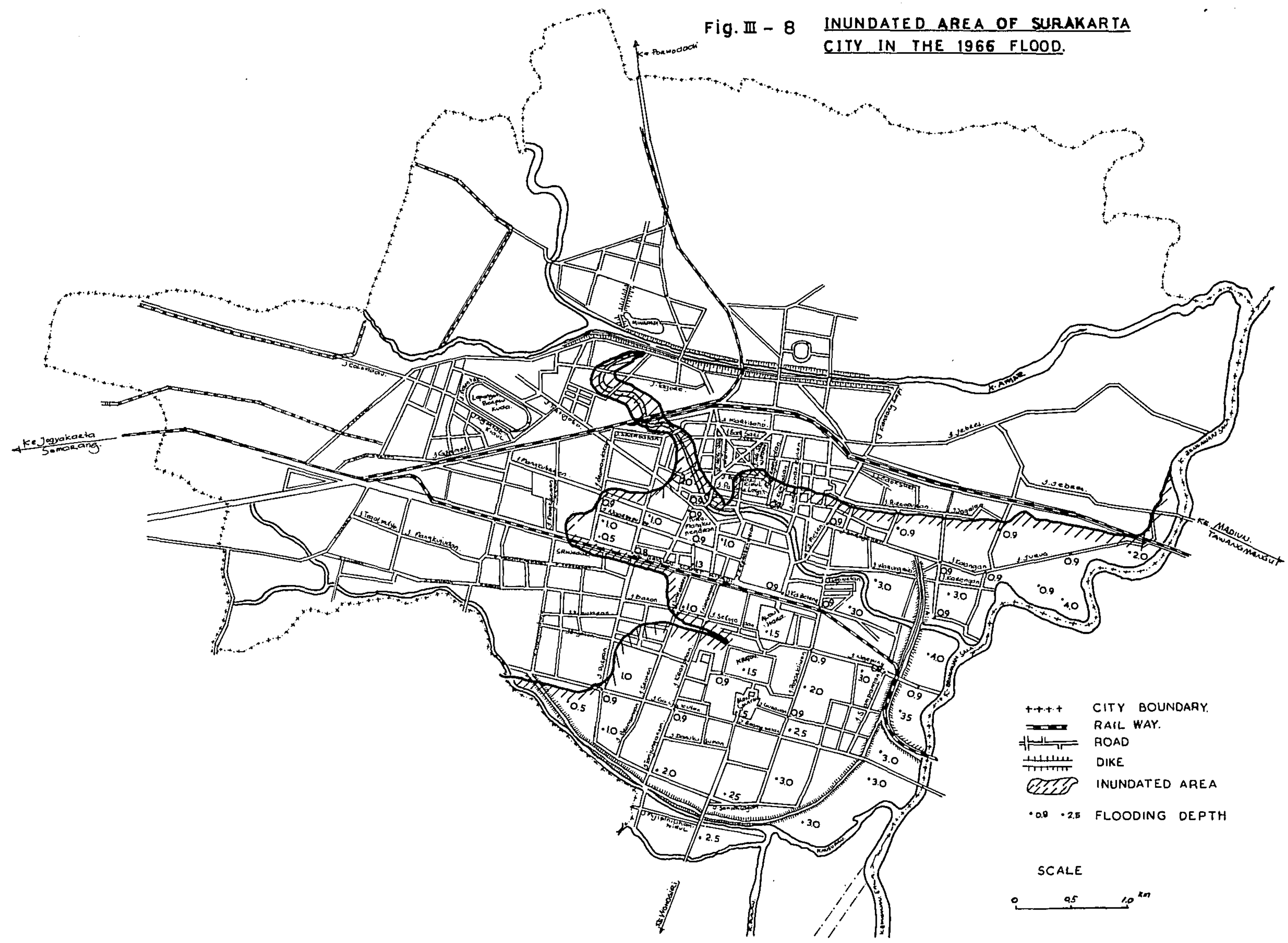


Fig III-7 INUNDATION AREA CORRESPONDING TO DISCHARGE AT SURAKARTA
N
GEMOLONG
SRAGEN
MASARAN
KARTASURO
SURAKARTA
SUKOHARDJO
WONOGIRI
G.LAWU 3265
803
169
Q1000
Q2500
Q1500
Q500
500
1000
1500
2500
DISCHARGE (M3/S)
SCALE
0 5 10 KM

Fig. III - 8 INUNDATED AREA OF SURAKARTA CITY IN THE 1966 FLOOD.



3.2 Flood Damage

Flood damage under the present condition of the basin is estimated as follows.

3.2.1 House damage

(1) Value of building and household effects

Average value of building and household effects per house is shown in Table III-10.

The value of building per household is estimated by multiplying the value used in the previous study/1 by 1.25, taking into account an increase in the value in the past two years. Besides, the value of household effects is obtained by multiplying the value estimated in the same study by 1.5, considering the average price rise in the past two years.

Table III-10 Value of Building and Household Effects

	Surakarta city			Other inundation area		
	Building (US$)	Household effects (US$)	Total (US$)	Building (US$)	Household effects (US$)	Total (US$)
Farmer's house	360	180	620	360	180	620
General residence	3,610	1,620	5,960	750	440	1,340
Shop	3,760	12,720	17,240	810	2,000	2,980
Office	11,190	9,440	22,870	2,230	410	3,080

The numbers of farmer's houses, general residences, shops and others such as offices, schools and factories are estimated from the proportion of such houses and buildings to the total numbers of building based on the data of Surakarta city and some Kabupaten concerned within the inundation area.

/1 . Ref. Bibliography (1)

	Surakarta city	Other inundation area
Farmer's house	2%	81%
General residence	88%	17%
Shop	6%	1%
Others	4%	1%

Ref.: Bibliography (1)

By applying the above sharing ratio to the figures in Table III-10, the average value of building and household effects per household in the inundation area can be estimated as follows.

(US$)

	Building	Household effects	Total
Surakarta city	3,857	2,570	6,427
Other inundation area	450	250	700

(2) Flood damage rate of building and household effects

Table III-11 shows the flood damage rate of building and household effects, relating to flood depth above floor level. In this table, the damage rate of building is quoted from the rate applied to the case in which the ground gradient of inundation area is fairly gentle, and the damage rate of household effects is the rate adopted in the "Feasibility Study on Surabaya River Improvement" prepared by the Japanese Survey Team in 1973.

Flood damage rates used in this study is shown in Table III-12, which are estimated collectively by applying the sharing ratio mentioned in the above sub-section.

(3) Calculation of house damage potential

The amount of damage per household at every flooding depth above floor lefel is estimated as shown in Table III-13, by multiplying the flood damage rate by the value of building and household effects per household obtained before.

Table III-11 Flood Damage Rate of Building and Household Effects

Height above floor level (m)	Building	Household effects				
		Farmer's house	Residence	Shop	Office	School & Factory
0 - 0.5	0.05	0.09	0.11	0.08	0.09	0.08
0.5 - 1.0	0.07	0.24	0.29	0.22	0.28	0.24
1.0 - 1.5	0.11	0.33	0.41	0.35	0.42	0.35
1.5 - 2.0	0.11	0.37	0.47	0.44	0.47	0.39
2.0 - 2.5	0.15	0.39	0.49	0.51	0.49	0.40
2.5 - 3.0	0.15	0.39	0.51	0.57	0.49	0.41
Over 3.0	0.22					

Table III-12 Flood Damage Rate of Building and Household Effects

Height above floor level (m)	Surakarta City		Other indundation area	
	Building	Household Effects	Building	Household Effects
0. - 0.5	0.05	0.11	0.05	0.09
0.5 - 1.0	0.07	0.28	0.07	0.25
1.0 - 1.5	0.10	0.40	0.10	0.34
1.5 - 2.0	0.12	0.46	0.12	0.39
2.0 - 2.5	0.14	0.49	0.14	0.41
2.5 - 3.0	0.18	0.51	0.18	0.41
3.0 -	0.22	0.52	0.22	0.41

Table III-13 Amount of House Damage per Household

Flooding depth(m)	0 -0.5	0.5 -1.0	1.0 -1.5	1.5 -2.0	2.0 -2.5	2.5 -3.0	over 3.0
Surakarta city	476	990	1,413	1,645	1,799	2,005	2,185
Other inundation area	45	94	130	152	166	184	202

the flood damage rate by the value of building and household effects per household obtained before.

The total amount of house damage of each inundation area at every flood discharge is estimated by multiplying the figures in Table III-13 by the number of damageable houses in Table III-8. The results are shown in Table III-14.

Table III-14 House Damage at Every Flood Discharge

Discharge at Surakarta	Surakarta area		Sragen area	
	Damageable house	Damage ($x10^3$US$)	Damageable house	Damage ($x10^3$US$)
500	0	-	0	-
1,000	10,400	995	5,500	646
1,500	22,500	3,078	8,900	1,154
2,000	59,200	37,191	12,700	1,974
2,500	71,600	39,219	17,000	2,855

3.2.2 Crop damage

(1) Value of crop

The present prices of crops per hectare of haddy field and yard are estimated from the data collected this time as shown in Talbe III-15.

Table III-15 Prices of Crop per hectare

Item	Price	
Paddy field	216,000 Rp/ha	520 US$/ha
Yard	30,000 Rp/ha	72 US$/ha

While, each inundation area has such share in the area as shown in Table III-16.

Table III-16 Sharing Ratio of Each Field

Item	Farm land (%)	Yard (%)	Others (%)
Surakarta area	76	24	-
Sragen area	78	22	-

The average value of crops per hectare of each inundation area can be estimated as shown in Table III-17 from these data by assuming that all the farmland in the inundation area are paddy fields.

Table III-17 Average Value of Crops per hectare

Item	Surakarta area	Sragen area
Paddy	395 US$/ha	406 US$/ha
Yard	17 "	16 "
Total	412 "	422 "

(2) Flood damage rate of crops

Flood damage rate of crops correlates to flooding depth, flooding duration and growing stage of crops in the flood season. Table III-18 shows the flood damage rate of paddy adopted in "Feasibility Study on Surabaya River Imprvement." Based on this, Table III-19 was prepared for this project area.

The average damage rate was estimated by assuming that the rate for the respective periods of tillering stage, booting stage, heading time and ripening stage was 31%, 28%, 8% and 33% respectively.

Table III-18 Flood Damage Rate of Paddy in Surabaya River Basin

Growing stage		Tillering stage	Booting stage	Heading stage	Ripening stage
Relative growth (%)		0 - 59	60 - 76	77 - 79	80 - 100
Relative growth (cm)		0 - 74	75 - 95	96 - 99	100 - 125
over head flooding	1 - 2 day	10 %	70 %	30 %	5 %
	3 - 4	20	80	80	20
	5 - 6	30	85	90	30
	over 7	35	95	100	30
Flooding up to 75 % plant height	1 - 2 day	6	40	10	4
	3 - 4	9	46	23	15
	5 - 6	14	49	26	23
	over 7	16	55	30	23
Flooding up to 50 % plant height	1 - 2 day	4	37	8	2
	3 - 4	9	42	22	4
	5 - 6	13	45	25	6
	over 7	15	50	28	6

Table III-19 Flood Damage Rate of Paddy

Flooding depth (m)	Flooding duration (day)	Tillering stage	Booting stage	Heading stage	Ripening stage	Average
0 - 0.5	1 - 2	6 %	37 %	8 %	2 %	14 %
	3 - 4	9	42	22	4	18
	5 - 6	14	45	25	6	21
	over 7	16	50	28	6	23
0.5 - 1.0	1 - 2	10	40	10	4	16
	3 - 4	20	46	23	15	26
	5 - 6	30	49	26	23	33
	over 7	35	55	30	23	36
Over 1.0	1 - 2	10	70	30	5	27
	3 - 4	20	80	80	20	42
	5 - 6	30	85	90	30	50
	over 7	35	95	100	30	55

As to yard crops such as cassava, peanuts and soybeans, damages are considered to be larger when compared with paddy under the same condition of inundation because their roots are weak against inundation.

In this study, the flood damage rate usually used in Japan is considered applicable. The flood damage rate of such crops is summarized in Table III-20.

Table III-20 Flood Damage Rate of Crops

Flooding depth (m)	Flooding duration (day)	Paddy (%)	Yard crops (%)
0-0.5	1-2	14	27
	3-4	18	42
	5-6	21	54
	over 7	23	67
0.5-1.0	1-2	16	35
	3-4	26	48
	5-6	33	67
	over 7	36	74
Over 1.0	1-2	27	51
	3-4	42	67
	5-6	50	81
	over 7	55	91

(3) Calculation of crop damage potential

Crop damage consists of two kinds of damages. One is the loss that some part of the inundation area can not be planted in the flood season because of frequent inundation. Another is the usual damage on the planted crops by flooding in the farmland.

Unplantable area in the flood season is roughly estimated as shown below from the data of crop planting, field survey and analysis of the flooding conditions in each inundation area.

Unplantable area

	Surakarta area	Sragen area
Unplantable area	2,000 ha	1,000 ha

While, the amount of crop damage of each inundation area at every flood discharge at Surakarta is estimated by multiplying the figures in Table III-21 by the average of the inundation area shown in Table III-6. The estimate includes losses in the unplantable area at a damage rate of 100%. The results are shown in Table III-22.

Table III-21 Amount of Crop Damage per hectare

	Flooding depth (m) \ Flooding duration (day)	1 - 2	3 - 4	5 - 6	Over 7
Surakarta area	0 - 0.5	60	78	92	102
	0.5 - 1.0	69	111	142	155
	Over 1.0	115	177	211	233
Sragen area	0 - 0.5	61	80	94	104
	0.5 - 1.0	71	113	145	158
	Over 1.0	118	181	216	238

Table III-22 Amount of Crop Damage of Every Flood Scale

Discharge at Surakarta (m^3/s)	Surakarta area		Sragen area	
	Damageable Area (ha)	Damage (10^3US$)	Damageable Area (ha)	Damage (10^3US$)
500	2,900	878	3,800	605
1,000	10,000	1,544	6,900	1,048
1,500	15,500	2,946	8,400	1,603
2,000	20,200	3,715	9,700	1,892
2,500	23,200	4,207	10,900	2,149

3.2.3 Total damage

(1) Direct flood damage

As direct flood damages, house damage including household effects damage, crop damage, public facilities damage, livestock damage and fishery damage should be taken into account. But, in this study, only house and crop damages are taken into account because other direct damages are supposed to be small as compared with these two damages.

(2) Indirect flood damage

Indirect flood damages are looses from interruption of utility services, looses of normal profit and earnings to capital, management and labour in the area afflicted by flood, net cost incremental for the flood warning, evacuation, flood fighting, and temporary living. They are estimated at about 10% of the direct flood damage.

(3) Total damage

Total flood damages are summarized, relating to the discharge at Surakarta, as shown in Table III-23 and Fig. III-9.

3.2.4 Average annual flood damage

(1) Calculation method for estimating the average annual flood damage

Average annual flood damage will be estimated in the following manner.

Table III-23 Total Flood Damage

Surakarta area

Discharge at Surakarta m^3/s	Direct damage (US $)			Indirect damage (US $)	Total (US $)
	House	Crop	Total		
500	0	$878x10^3$	$878x10^3$	$88x10^3$	$966x10^3$
1,000	$995x10^3$	1,544x "	2,539x "	254x "	2,793x "
1,500	3,078x "	2,946x "	6,024x "	602x "	6,626x "
2,000	37,191x "	3,715x "	40,906x "	4,091x "	44,997x "
2,500	39,219x "	4,207x "	43,426x "	4,343x "	47,769x "

Sragen area

Discharge at Surakarta m^3/s	Direct damage (US $)			Indirect damage (US $)	Total (US $)
	House	Crop	Total		
500	0	$605x10^3$	$605x10^3$	$61x10^3$	$666x10^3$
1,000	$646x10^3$	1,048x "	1,694x "	169x "	1,863x "
1,500	1,154x "	1,603x "	2,757x "	276x "	3,033x "
2,000	1,974x "	1,892x "	3,866x "	387x "	4,253x "
2,500	2,855x "	2,149x "	5,004x "	500x "	5,504x "

Fig III - 9 Correlation between Discharge at Surakarta and Amount of Total Flood Damage.

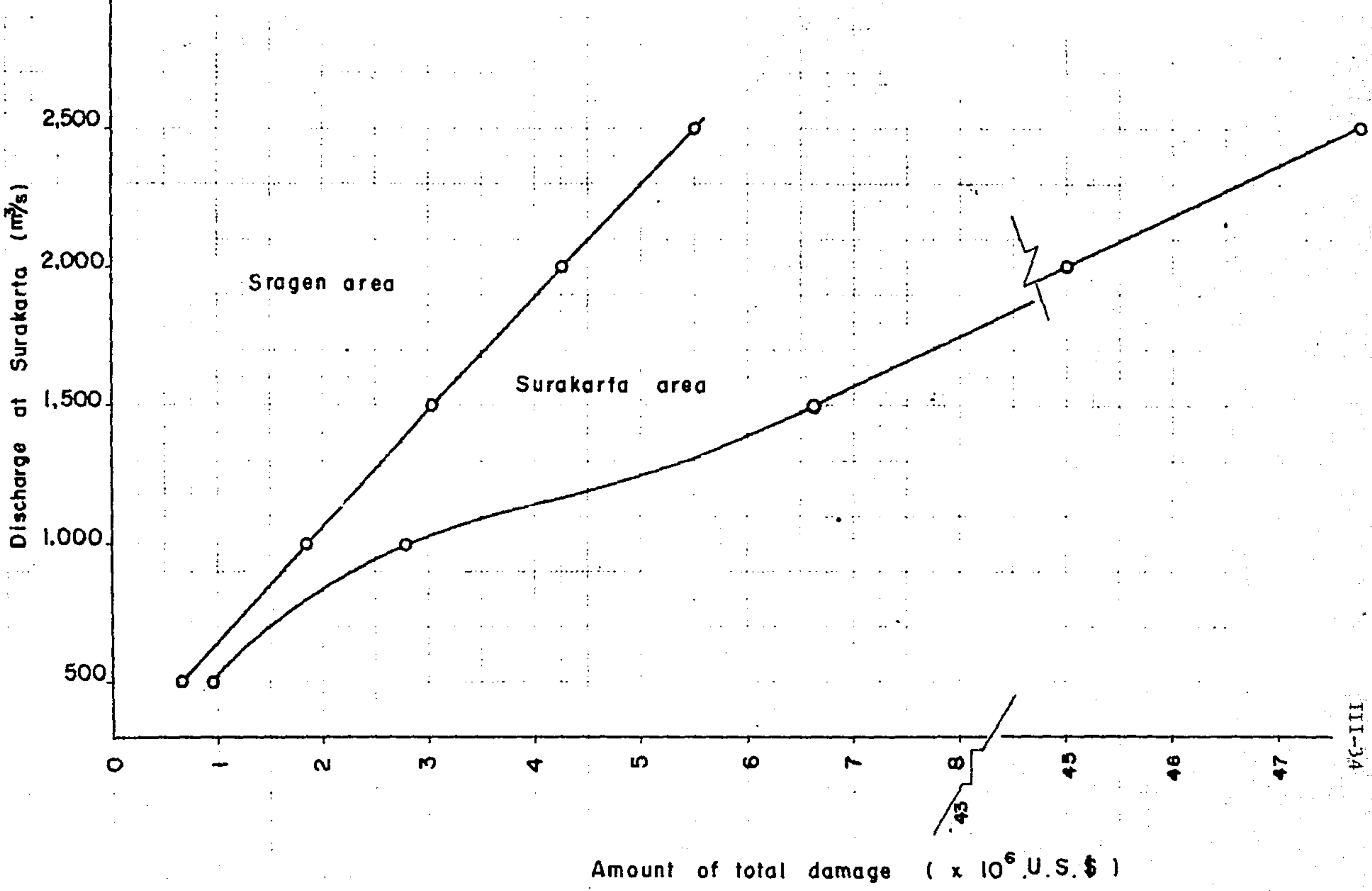


Table III-24 Calculation Method of Average Annual Flood Damage

Discharge	Average annual probability of excess	Probability of occurrence	Amount of flood damage	Amount flood damage	Average Annual flood damage	Accumulated average annual flood damage
Q_1	N_1	$N_1 - N_2$	L_1	$\frac{L_1 + L_2}{2}$	$(N_1-N_2) x \frac{L_1+L_2}{2}$	$(N_1-N_2) x \frac{L_1+L_2}{2}$
Q_2	N_2	$N_1 - N_3$	L_2	$\frac{L_2 + L_3}{2}$	$(N_2-N_3) x \frac{L_2+L_3}{2}$	$(N_1-N_2) x \frac{L_1+L_2}{2} + (N_2-N_3) x \frac{L_2 + L_3}{2}$
⋮	⋮	⋮	⋮	⋮	⋮	⋮
Q_m	N_m=0.00	$N_{m-1}-N_m$	L_m	$\frac{L_{m-1}+L_m}{2}$	$(N_{m-1}-N_m)$ x $\frac{L_{m-1}-L_m}{2}$	⋮

$$\text{Average annual flood damage} = \sum_{i=1}^{N} (N_i - N_{i+1}) \frac{L_1 + L_{i+1}}{2}$$

(2) Average annual flood damage

By using the methods mentioned above, average annual flood damage is estimated as shown in Tables III-25 and III-26.

The results are summarized below.

Average flood damage under the present condition:

Surakarta area US$6.74 x 10^6

Sragen area US$3.49 x 10^6

Table III-25 Average Annual Flood Damage under the Present Condition

(Surakarta area)

Probability	Probability of occurence	Discharge (m^3/s)	Amount of Flood damage $x10^6$(US $)	Average flood damage $x10^6$(US $)	Average annual flood damage $x10^6$ (US $)	Accumulated average annual flood damage $x10^6$ (US $)
	1,500	600	1.20	1.20	1.80	1.80
1/1		700	1.50			
	0.500			1.95	0.98	2.78
1/2		920	2.40			
	0.300			3.90	1.17	3.95
1/5		1,300	5.40			
	0.100			6.30	0.63	4.58
1/10		1,600	7.20			
	0.050			7.95	0.40	4.98
1/20		1,900	8.70			
	0.0167			26.85	0.45	5.43
1/30		2,050	45.00			
	0.0083			45.45	0.38	5.81
1/40		2,160	45.90			
	0.0083			46.10	0.38	6.19
1/60		2,250	46.30			
	0.0067			46.85	0.31	6.50
1/100		2,450	47.40			
	0.0050			47.95	0.24	6.74
1/200		2,650	48.50			

Table III-26 Average Annual Flood Damage under the Present Condition

(Sragen area)

Probability	Probability of occurence	Discharge (m^3/s)	Amount of Flood damage $x10^6$ (US $)	Average flood damage $x10^6$ (US $)	Average annual flood damage $x10^6$ (US $)	Accumulated average annual flood danage $x10^6$ (US $)
	1.500	600	0.95	0.95	1.43	1.43
1/1		700	1.15			
	0.500			1.43	0.72	2.15
1/2		920	1.70			
	0.300			2.15	0.65	2.80
1/5		1,300	2.60			
	0.100			2.95	0.30	3.10
1/10		1,600	3.30			
	0.050			3.65	0.18	3.28
1/20		1,900	4.00			
	0.0167			4.18	0.07	3.35
1/30		2,050	4.35			
	0.0083			4.48	0.04	3.39
1/40		2,160	4.60			
	0.0083			4.73	0.04	3.43
1/60		2,250	4.85			
	0.0067			5.10	0.03	3.46
1/100		2,450	5.35			
	0.0050			5.63	0.03	3.49
1/200		2,650	5.90			

4. FLOOD CONTROL PLAN

The flood control measures conceivable for the Upper Sala Basin is the flood regulation by the Wonogiri reservoir and the flood protection by the river improvement work.

4.1 Wonogiri Reservoir

To select the most appropriate scale of flood control capacity of the reservoir in combination of the river improvement work, the comparison of the following three alternative plans are worked out by varying the outflow discharge after the regulation by the Wonogiri reservoir:

Regulated outflow by the reservoir	
Case A	400 m^3/sec
Case B	700 m^3/sec
Case C	1,000 m^3/sec

The features and construction cost of each case are as tabulated below.

	Case A	Case B	Case C
Wonogiri reservoir			
- Inflow discharge (m^3/s)	4,000	4,000	4,000
- Outflow discharge (m^3/s)	400	700	1,000
- Storage capacity: ($10^6 m^3$)			
Gross at S.W.L (SHFD)	730	660	630
Flood control	220	150	120
Irrigation and power	440	440	440
Sediment	120	120	120
- Dam crest EL (m)	141.6	141.3	140.7
- Dam height (m)	37.5	37.2	36.6
- Max. spillway capacity (m^3/s)	1,550	1,630	1,920
- Total construction cost (A) (include land acquisition costs) (10^3 US$)	43,400	43,200	43,000

4.2 River Improvement

4.2.1 Design Flood Discharge

Standard Highest Flood Discharge (S.H.F.D.) for the flood control plan is termed as the project flood discharge in the case no regulation measures against the flood discharge are taken for determining the scale of the flood control plan. The S.H.F.D. is determined based on the 1966 flood for the condition of no flooding all along the river stretches.

	Wonogiri	Surakarta	Ngawi
Discharge of 1966 Flood (Flow without routing actions)	3,950 m3/s	5,250 m3/s	4,850 m3/s

Ref. Hydrology, Annex (III), Data.

Design discharge of the proposed S.H.F.D. is assumed as follows;

Wonogiri	Surakarta	Ngawi
4,000 m3/s	5,300 m3/s	4,900 m3/s

The design flood discharge at Surakarta and Ngawi after the flood regulating effect of the Wonogiri reservoir is as follows:

	Wonogiri	Surakarta	Ngawi
Case A	400 m3/s	2,000 m3/s	2,830 m3/s
Case B	700	2,300	3,130
Case C	1,000	2,600	3,430

Between the reaches from Wonogiri to Surakarta, the sectional design discharge is determined as shown in Fig. III-10 for each case.

4.2.2 Selection of improvement method

(a) Basic consideration of the river channel design

(i) Design high water level

The design high water level of channel is desirable to be fixed at as low as possible. But if the high water level is fixed too low, a large volume of excavation work and expenses will be needed. Therefore, the river channel should be improved by adequately combining channel excavation and levee construction.

In this study, the design high water level is fixed at the level close to the highest water level along the river course in the past.

(ii) Design discharge of low water channel

The cross sectional area required to flow the design flood discharge becomes the smallest when it is of a single section. However, in a river the discharge of which differs greatly between normal and flood times, the discharge of normal time can not flow uniformly in the channel of a single section, and flow concentration will often occur in the channel, which makes it difficult to maintain the river course.

Sala river has large difference in its seasonal change of discharge. If such existing conditions are taken into consideration, it is desirable to design a river course of adequate retarding capacity by adopting the composite section, enlarging the total width of channel.

In adopting the composite section, the study of the design discharge is made to determine the dimension of low water channel. As the cross section must be easily maintained after improvement, the dimension of low water channel is preferably determined not to disturb the natural equilibirium condition, referring to the current discharge capacity along the river channel and flood frequency. Based on the above consideration, the design discharge for low water channel is determined to be the present discharge capacity on an average.

(iii) Cross section

On the basis of river channel designs mentioned above, the cross section in each stretches is decided as shown in Table III-27, by using Manning's Formula.

4.3 Selection of Most Desirable Case of Flood Control

According to each cross section decided above, and plane profile and longitudinal profile mentioned in Section 5, the investment cost river improvement is estimated in each case as shown in Table III-28.

Total cost of the dam and river improvement works is summarized below.

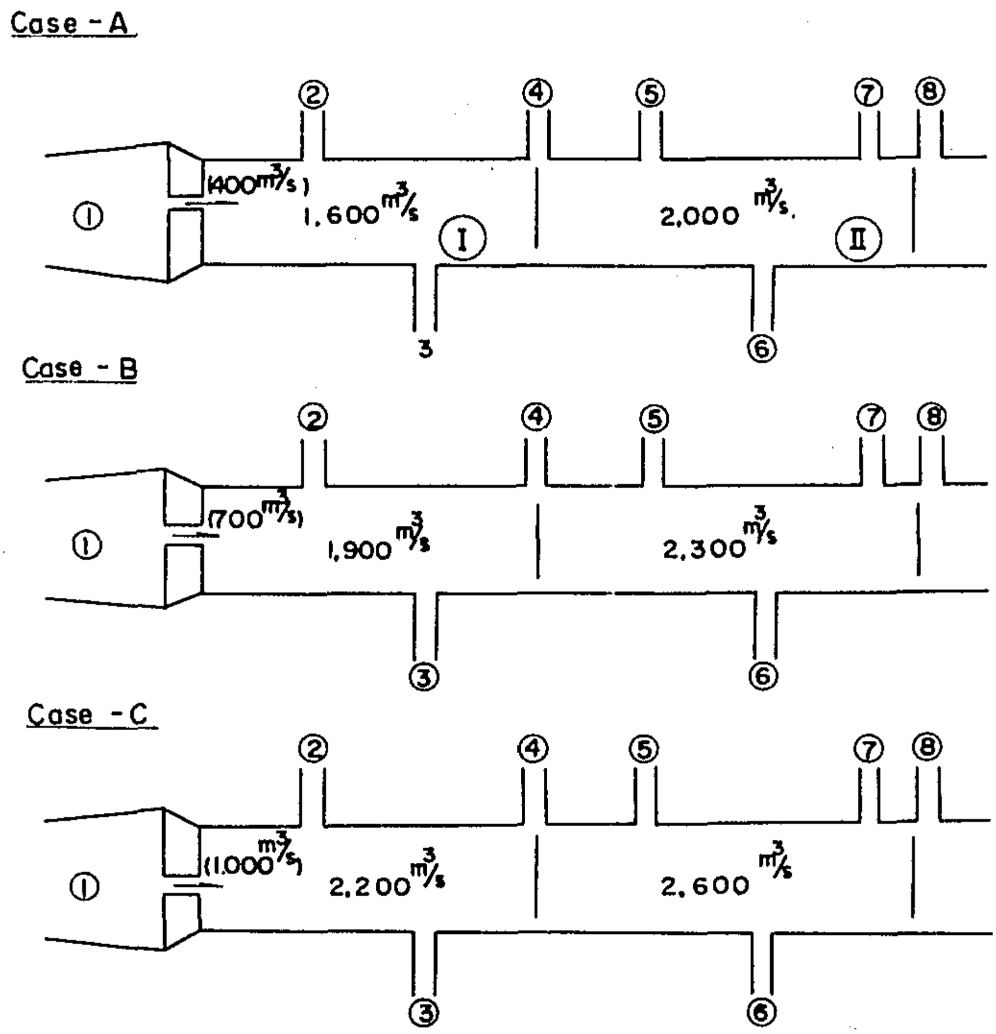
	Case A	Case B	Case C
River improvement	18.3	20.0	22.4
Wonogiri reservoir	43.4	43.5	43.5
Total	61.7	63.5	65.9

The most preferable case should be decided so as to minimize the combined cost of Wonogiri dam and river improvement work, and not to increase the flood damage in the downstream basin.

The combined cost is the smallest in the case A as shown above. While, the more the outflow discharge from Wonogiri reservoir increases, the peak discharge on the downstream from Surakarta becomes larger than the discharge under the present condition.

Considering such a situation, the case in which the outflow discharge is 400 m^3/s from the dam is decided as the most preferable case.

Fig III-10 Distribution of Design Flood Discharge



note : ( ) regulated outflow discharge from wonogiri reservoir

① wonogiri reservoir
② k. Blatunkan
③ k. Jlantah
④ k. Deng keng
⑤ k. Bram bang
⑥ k. Samin
⑦ k. Pepe
⑧ k. Anyar

Table III- 27 Design of River Channel

Case	Block number	Q (m^3/s)	Q1 (m^3/s)	Bo (m)	B1 (m)	HL (m)	HH (m)
CASE-A	I	1,600	200	45	175	3.5	3.5
	II	2,000	500	45	175	5.0	3.5
CASE-B	I	1,900	200	45	228	3.5	3.5
	II	2,300	500	45	228	5.0	3.5
CASE-C	I	2,500	200	45	280	3.5	3.5
	II	2,600	500	45	280	5.0	3.5

where Q : total discharge

Q1 : discharge for low water channel

Bo, B1, HL, HH } as shown below

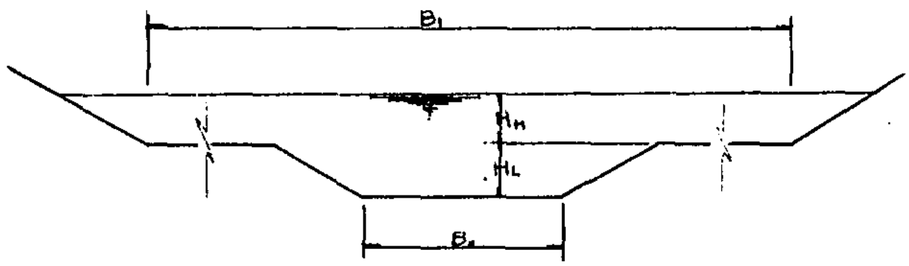


Table III-28 Comparison of Investment Cost

	unit cost	CASE-A		CASE-B		CASE-C	
		q.t.y	amount	q.t.y	amount	q.t.y	amount
	(US $)		(US $)		(US $)		(US $)
I Civil works			13,501,000		14,675,000		16,393,000
Excavation	0.5	$6,380x10^3$	3,190,000	$7,656x10^3$	3,828,000	$9,570x10^3$	4,785,000
Banking	0.45	$5,161x10^3$	2,322,000	$5,161x10^3$	2,322,000	$5,161x10^3$	2,322,000
Bank Protection	-	-	2,729,000		2,729,000		2,729,000
Bridge			85,000		106,000		128,000
Sluice way			920,000		970,000		1,012,000
Intercepting drain			240,000		240,000		240,000
Construction Machinery			4,015,000		4,480,000		5,177,000
II Land Acquisition		(ha) 702	1,514,000	871	1,878,000	1,038	2,239,000
III Contingency			2,253,000		2,483,000		2,795,000
IV Engineering			1,000,000		1,000,000		1,000,000
Total			18,268,000		20,036,000		22,427,000

4.4 Flood Control Effect

4.4.1 Correlation between the discharge at Surakarta and return period.

The correlation between discharge at Surakarta and their return period after the completion of the Wonogiri dam is estimated as follows:

Return period (year)	Discharge at Surakarta (m3/s)
200	1,620
100	1,500
60	1,400
40	1,340
30	1,290
20	1,200
10	1,090
5	960
2	760

Note: Outflow discharge from dam = 400 m3/s

The above data is graphically shown on Fig. III-11.

4.4.2 Decrease in average annual flood damage

(1) By Wonogiri reservoir

The average annual flood damage still remained after the completion of the Wonogiri reservoir is estimated as shown in Table III-29 and Table III-30. The results are summarized below.

Surakarta area	3.34×10^6 US$
Sragen area	2.42×10^6 US$

Therefore, the flood control effect by the Wonogiri reservoir is estimated as follows:

Surakarta area	$6.74 \times 10^6 - 3.34 \times 10^6 = 3.40 \times 10^6$ US$
Sragen area	$3.49 \times 10^6 - 2.42 \times 10^6 = 1.07 \times 10^6$ US$

(2) By river improvement (with the Wonogiri reservoir)

The river improvement work down to the Sarakarta City is designed to protect the inland against the flood discharge of 40-year return period under the future condition after the completion of the Wonogiri reservoir.

Should flood control be aimed to protect the area extending from Nguter to Surakarta completely by the flood regulation of the Wonogiri reservoir and the river improvement work, the decrease in annual flood damage in the Surakarta area is estimated at US$3.22 million from Table III-29.

While, in the Sragen Area, no river improvement work is contemplated in this study in consideration of the adverse effect to the downstream area. The flood discharge in the Sragen area before and after the river improvement work is 2,160 m^3/sec and 2,000 m^3/sec respectively which shows that no significant flood control effect of the Wonogiri reservoir is expected in the Sragen area, offsetting its effect by increasing discharge due to the river improvement work.

(3) By Wonogiri reservoir and river improvement

The combined flood control effect of the Wonogiri reservoir and the river improvement in the Surakarta area is estimated as follows:

	By Wonagiri reservoir	By river improvement	Total
Surakarta area	3.40×10^6	3.22×10^6	6.62×10^6 US$
Sragen area	1.07×10^6	-1.07×10^6	-
Total	4.47×10^6	2.15×10^6	6.62×10^6 US$

Note /1 Offsetting of the flood control effect due to the river improvement in the Surakarta area.

However, the flood control effect of US$6.62 million per annum is considered to be too optimistic figure, because the control capacity of the Wonogiri reservoir is actually limited to control the flood discharge less than 4,000 m^3/sec. Therefore, a conservative estimate control effect, US$5.81 million per annum as presented in Table III-25, will be adopted in the subsequent economic analysis.

Fig III-11 Return period – Discharge Curve at Surakarta

(under the present river condition with dam)

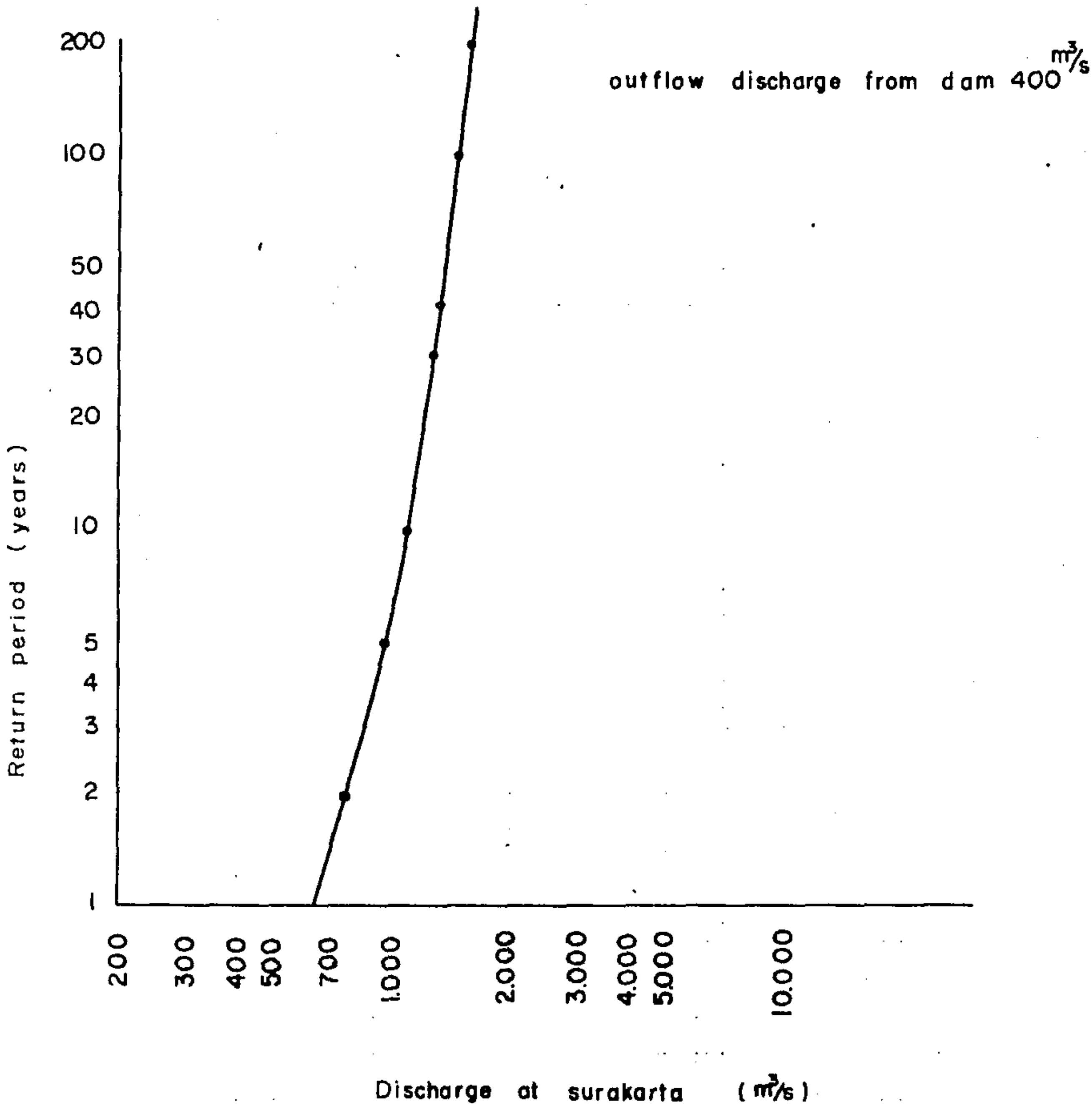


Table III- 29 Average Annual Flood Damage after Regulation by Wonogiri Reservoir

(Surakarta area)

Probability	Probability of occurance	Discharge (m^3/s)	Amount of Flood damage $x10^6$ (US $)	Average flood damage $x10^6$ (US $)	Average annual flood damage $x10^6$ (US $)	Accumulated average annual flood damage $x10^6$ (US $)
1/1	1.000	600	1.20	1.20	1.20	1.20
	0.500			1.45	0.73	1.93
1/2		760	1.70			
	0.300			2.15	0.65	2.58
1/5		960	2.60			
	0.100			3.05	0.31	2.89
1/10		1,090	3.50			
	0.050			4.05	0.20	3.09
1/20		1,200	4.60			
	0.0167			5.00	0.08	3.17
1/30		1,290	5.40			
	0.0083			5.55	0.05	3.22
1/40		1,340	5.70			
	0.0083			5.85	0.05	3.27
1/60		1,400	6.00			
	0.0067			6.30	0.04	3.31
1/100		1,500	6.60			
	0.0050			6.90	0.03	3.34
1/200		1,600	7.20			

Table III-30 Average Annual Flood Damage after Regulation by Wonogiri Reservoir

(Sragen area)

Probability	Probability of occurence	Discharge (m^3/s)	Amount of flood damage $x10^6$ (US $)	Average flood damage $x10^6$ (US $)	Average annual flood damage $x10^6$ (US$)	Accumulated average annual flood damage $x10^6$ (US $)
1/1	1.000	600	0.95	0.95	0.95	0.95
	0.500			1.13	0.57	1.52
1/2		760	1.30			
	0.300			1.55	0.47	1.99
1/5		960	1.80			
	0.100			1.95	0.20	2.19
1/10		1,090	2.10			
	0.050			2.23	0.11	2.30
1/20		1,200	2.35			
	0.0167			2.45	0.04	2.34
1/30		1,290	2.55			
	0.0083			2.63	0.02	2.36
1/40		1,340	2.70			
	0.0063			2.75	0.02	2.38
1/60		1,400	2.80			
	0.0067			2.90	0.02	2.40
1/100		1,500	3.00			
	0.0050			3.15	0.02	2.42
1/200		1,600	3.30			

4.5 Flood Damage Effect on the Irrigation Area in Sragen

As explained in the preceding section, flood damage in Sragen area will remain almost unchanged even if the river improvement work is undertaken in Surakarta area together with the construction of the dam.

The area in Sragen consists mainly of paddy field and a part of which is included in the project area.

Since the estimated future agricultural productions/1 both for without-project and with-project conditions are made on the condition without flood damages, expected crop damage in the Sragen area should be taken into consideration for getting proper irrigation benefit.

Basic condition or assumption used when estimating the expected flood damage are as follows:

1) The future flood discharge in Sragen area will not change or remain at the present level even after the construction of the flood control facilities, and the extent of the flood affected area also will be same.

2) The damage related to the project area is confined to only the right bank side of the Sala River, the area of which is about 55% of the total area of Sragen.

Based on the above conditions, expected crop damages of the project area in Sragen are estimated both for without-irrigation project and with irrigation project conditions.

Crop damage of the project area in Sragen (without-irrigation project)

Average annual crop damage of the project area is estimated for each flood discharge as shown in Table III-31. From this, the expected crop damage is estimated at US$1.16 million under without-project condition.

Note /1 Ref. Study Report (2), Annex II.

Crop damage of the project area in Sragen (with-irrigation project)

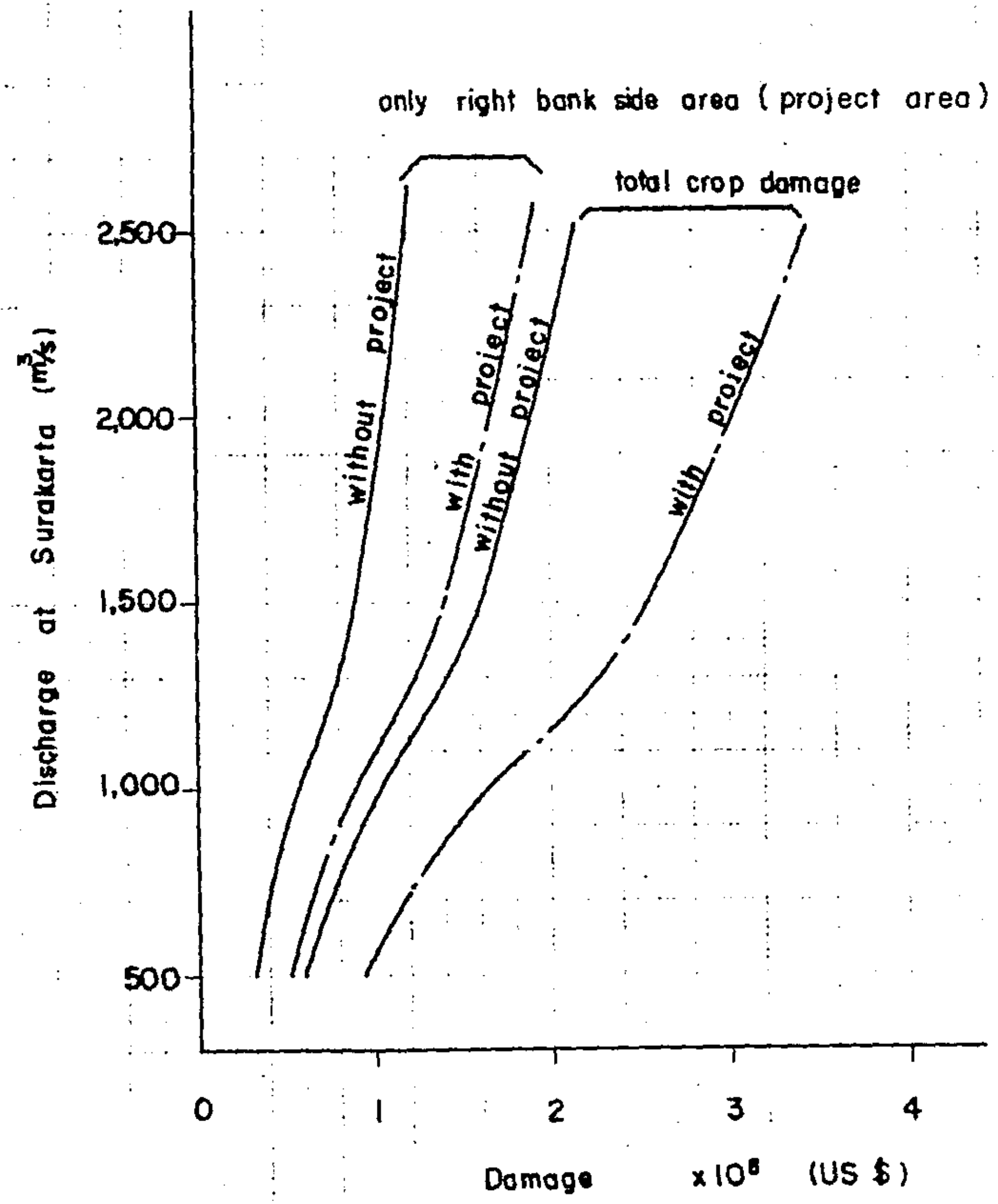
Although flood discharge in Sragen will not change after the river improvement work is carried out, the amount of crop damage will rise due to productivity increase per ha with the introduction of the irrigation project. The flood damages on crops are estimated at 330,000 Rp/ha for paddy and 80,000 Rp/ha for yard crop.

On these conditions, average annual crop damage in the project area is estimated for each flood discharge as shown in Table III-32. The expected crop damage is estimated at US$1.84 million under with-irrigation project condition.

Incremental flood damage

Incremental flood damage is calculated at US$0.68 million (US$1.84 million - US$1.16 million), which is the amount to be deducted from the net incremental value for estimating the net irrigation benefit from the Wonogiri Multipurpose Dam Project.

Fig III-12 Crop Damage in Sragen area Classified by Flood Scale



Without Irrigation project

discharge	total damage	right bank side damage
500	605×10^3	333×10^3
1,000	1,048x 〃	576 x 〃
1,500	1,603x 〃	882 x 〃
2,000	1,892x 〃	1,041 x 〃
2,500	2,149x 〃	1,182x 〃

With irrigation project

discharge	total damage	right bank side damage
500	956×10^3	526×10^3
1,000	1,666 x 〃	916x 〃
1,500	2,549 x 〃	1,402x 〃
2,000	3,010 x 〃	1,656x 〃
2,500	3,421 x 〃	1,882x 〃

Table III-31 Average Annual Crop Damage in the Project Area Without Irrigation Project

(Sragen area)

Probability	Probability of occurrance	Discharge (m^3/s)	Amount of flood damage $x10^6$ (US $)	Average flood damage $x10^6$ (US $)	Average annual flood damage $x10^6$ (US $)	Accumulated average annual flood damage $x10^6$ (US $)
	1.500	600	0.35	0.35	0.53	0.53
1/1		700	0.40			
	0.500			0.45	0.23	0.76
1/2		920	0.50			
	0.300			0.65	0.20	0.96
1/5		1,300	0.80			
	0.100			0.86	0.09	1.05
1/10		1,600	0.92			
	0.050			0.97	0.05	1.10
1/20		1,900	1.02			
	0.0167			1.05	0.02	1.12
1/30		2,050	1.08			
	0.0083			1.09	0.01	1.13
1/40		2,160	1.10			
	0.0083			1.11	0.01	1.14
1/60		2,250	1.12			
	0.0067			1.15	0.01	1.15
1/100		2,450	1.18			
	0.0050			1.20	0.01	1.16
1/200		2,650	1.22			

Table III-32 Average Annual Crop Damage in the Project Area without Irrigation Project

(Sragen area)

Probability	Probability of occurrance	Discharge (m^3/s)	Amount of flood damage $x10^6$ (US $)	Average flood damage $x10^6$ (US $)	Average annual flood damage $x10^6$ (US $)	Accumulated average annual flood damage $x10^6$ (US $)
	1,500	600	0.57	0.57	0.86	0.86
1/1		700	0.63			
	0.500			0.73	0.37	1.23
1/2		920	0.83			
	0.300			1.05	0.32	1.55
1/5		1,300	1.27			
	0.100			1.37	0.14	1.69
1/10		1,600	1.46			
	0.050			1.53	0.08	1.77
1/20		1,900	1.60			
	0.0167			1.64	0.03	1.80
1/30		2,050	1.68			
	0.0083			1.71	0.01	1.81
1/40		2,160	1.74			
	0.0083			1.76	0.01	1.82
1/60		2,250	1.78			
	0.0067			1.83	0.01	1.83
1/100		2,450	1.87			
	0.0050			1.91	0.01	1.84
1/200		2,650	1.95			

4.6 Consideration for the River Improvement Plan

Flood control should be planned, needless to say, so as to get larger benefit in the Upper Sala basin with smaller cost and without causing increased flood discharge in the Lower Sala river.

The benefits of flood control works in such cases as (1) by Wonogiri reservoir and river improvement up to Ngawi, (2) by Wonogiri reservoir and river improvement up to Surakarta and (3) by Wonogiri reservoir only, were studied in the previous chapter.

The total benefit in each of the above cases has been 9.20×10^6 (US\$), 5.81×10^6 (US\$), and 3.40×10^6 (US\$) respectively.

On the other hand, the discharge in each case has been as follows: (Ref. Hydrology, Annex (III), Data)

(i) Present condition without flood control

Wonogiri	4,000	m3/s
Surakarta	2,160	m3/s
Ngawi	1,890	m3/s

(ii) Wonogiri reservoir and river improvement up to Ngawi

Wonogiri	400	m3/s
Surakarta	2,000	m3/s
Ngawi	2,800	m3/s

(iii) Wonogiri reservoir and river improvement up to Surakarta

Wonogiri	400	m3/s
Surakarta	2,000	m3/s
Ngawi	(1,890)	m2/s

As shown above, even if the flood is regulated by the Wonogiri dam, the river improvement up to Ngawi will result in an increase of discharge of about 1,000 m3/s at Ngawi and may cause more damages in the downstream of Ngawi. While, if the river improvement is limited only up to Surakarta, the discharge will not increase at Surakarta and Ngawi, that is, the flooding in the downstream will remain at the present extent. Therefore, the river improvement is proposed for the section between Wonogiri and Surakarta together with the construction of Wonogiri reservoir.

5. RIVER IMPROVEMENT

5.1 Design Flood Discharge

Design flood discharge is as follows:

Wonogiri	Confluence of K. Dengkeng	Surakarta
.	1,600 m^3/s	2,000 m^3/s

5.2 Cross Section Number

The corss section numbers used in the previous Master Plan Study have been modified. The correlation between the previous cross section numbers and the modified numbers is as follows:

Previous cross section No.		Modified corss section No.
No. 456	....	No. 1
No. 460	....	No. 6
No. 493	....	No. 37
No. 505	....	No. 51

5.3 Alignment of Improvement Work

The plane profile of low water channel is determined with a principal view to minimize the volume of excavation work. But the present river channel is so meandering that the plane profile is to be improved in the distance covering 37% of the total length of the river by adopting short cut method.

The length of short cut work is about 12 km and the total length of the channel to be improved is 32.2 km.

The designed plan is shown in DWG. WF-001 and DWG. WF-002.

5.4 Longitudinal Profile

The longitudinal profile of the river course is examined in line with the plane profile of the low water channel. The design slope of the improved river channel is determined to take the averaged slope of the existing river bed profile. The proposed longitudinal profile is shown in DWG. WF-003.

5.5 Channel Cross Section

The cross section of the low water channel is designed so as to have enough capacity to carry the design discharge for the low water channel and the overall width of river channel is determined to carry the design flood through the whole section. The results are as shown in Table III-27 (Case A) and DWG. WF-004.

5.6 Bank Protection Works

In the present river course, the bank is eroded at many places because the geology along the Sala River is principally of alluvial soil. No bank protection works are provided except at a few places by pile groynes.

If no bank protection works is taken into account, the erosion will be intensified even after the improvement, and the extension of this erosion will bring about the destruction of the levee. Therefore, stone pitching and sodding are planned as bank protection.

Stone pitching is provided for only the parts of heavily meandering and the foot protection work is planned to protect the foot of the stone pitching of low water channel by using mattress of stone basket. Other parts are protected by sodding.

5.7 Drainage of Inner Basin

The run off from the both banks must be drained into the main river through major tributaries. This water is gathered into the tributaries through drainage channels to be constructed at the end of the back water from Sala River. The tributaries are protected from inundation by extending the levee of Sala River.

There are many small channels draining the inland water to the Sala River and its major tributaries. The drainage function of these channels may be affected if the levees are constructed. In order to maintain their function, sluice ways will be needed at appropriate places. And these sluice must be provided with devices to stop reverse flow from the main river to inland area.

5.8 Construction

5.8.1 Quantities of major work items

Quantities of major work items under the river improvement project are as follows:

Excavation	6,380,000 m^3
Banking	5,160,000 m^3
Bank protection	3,150,000 m^3

5.8.2 Construction period

Construction period is planned to be 6 years in total from 1978 to 1983 excluding preparator works. It is assumed that the workable months are limited to 6 months in the dry season from may to October.

5.8.3 Work section

Work section is divided into 6 sections corresponding to the construction year as shown below together with the volume of embankment work.

Work Section	Cross Sec. No.	Right Left Bank	Embankment (m^3) Volume
I	No. 1 - No. 11 (including K. Samin)	left bank right bank	888,000
II	No. 12 - No. 34	right bank	882,000
III	No. 12 - No. 29 (including K. Brambang,	left bank K. Sevenan)	853,000
IV	No. 30 - No. 33 (including K. Dengkeng	Left bank K. Kupan)	837,000
V	No. 34 - No. 53	left bank	807,000
VI	No. 35 - No. 53 (including Jlantah)	right bank	894,000
	Total		5,160,000

5.8.4 Priority of the improvement program

The priority order of the improvement program should be planned considering the significance of the protect area, such as urban area and high productive area. The inundation area under the present condition is the largest in work section II, about 34% of the total inundation area when the discharge at Surakarta is 1,000 m3/s. As for Surakarta city, the most important city in the Upper Sala basin, is protected and safe against the flood less than 2,000 m3/s in peak discharge, because of the existence of levee around this city. Further, the discharge at Surakarta will be decreased to 1,350 m3/s (at time of the design flood) after the regulation by the cofferdam of Wonogiri dam. In this view, the probability of flooding over the existing levee around Surakarta city seems to be very small. The other work sections have the following rate of their own inundation area to the total inundation area, as 16%, 10%, 16%, 13% and 11% in work section I, III, IV, V and VI respectively. Considering that mentioned above, the priority order of the improvement program is planned as shown in Fig. III-14.

5.8.5 Excavation and embankment

The total volumes of excavation and embankment are 6.38 x 10^6 m^3 and 5.16 x 10^6 m^3 respectively. The short cut work involves a large volume of excavation work, corresponding to about 80% of the total excavation work. The best way is to use excavated materials for banking to minimize the investment cost, so the construction schedule should be planned carefully by combining excavation and embankment. The materials, excavated by bulldozer, and loaded by wheel loader or crawler loader, will be transported to the nearest embankment place by dump truck. It is compacted by bulldozer or other equipment.

5.8.6 Bank protection and sluice way

Bank protection consists of stone pitching on the levee slope where channel is sharply meandering and sodding on other slopes. These will be done according to the progress of embankment and excavation work.

Sluice ways will be constructed before the embankment begins at each place.

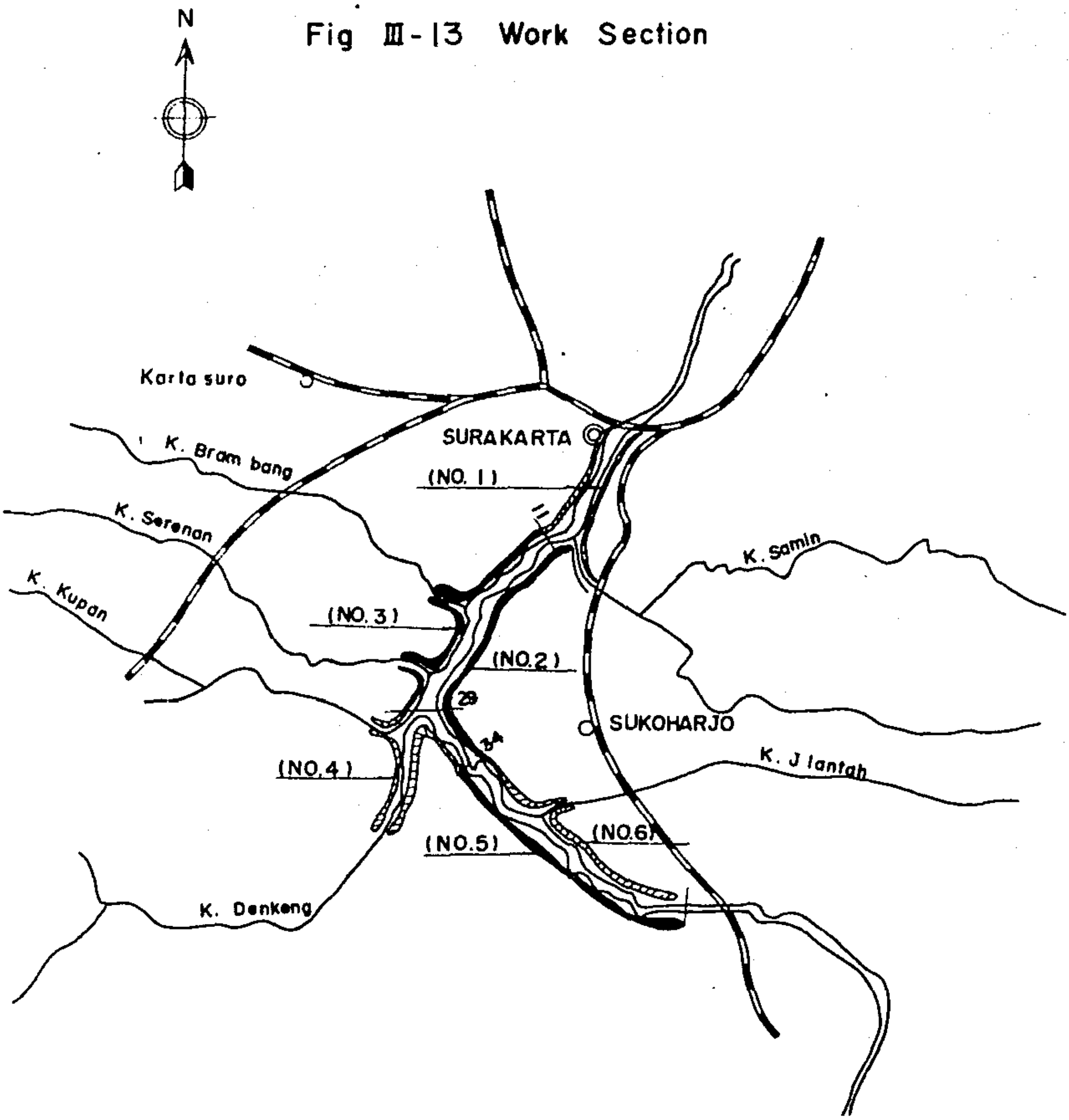
5.8.7 Equipment for river improvement

Equipment for river improvement are as follows:

No.	Equipment	Capacity	Q'ty
1	Bulldozer	20 ton	16
2	Wheel loader	2.7 m3	3
3	Crawler loader	2.0 m3	4
4	Back Hoe	1.2 m3	5
5	Dump truck	8 ton	50

No.	Equipment	Capacity	Q'ty
6	Motor grader	3.7 m	2
7	Vibration roller	5 ton	3
8	Fuel tanker	8 ton	3
9	Water tanker	8 ton	3
10	Trailer truck	30 ton	1
11	Cargo truck	6 ton	9
12	Grease car	6 ton	3
13	Truck crane	30 ton	1
14	Submergible	6 inch	6
15	Submergible	4 inch	6
16	Diesel generator	50 KW	3
17	Ripper attachment bull	20 ton	2
18	Dragline attachment shovel	1.2 m3	4
19	Repair shop		L.S.
20	Miscellaneous		L.S.

Fig III-13 Work Section



(NO.) : work section

Fig Ⅲ - 14 Construction Schedule

WORK SECTION	ITEM	UNIT	Q.T.Y	1978	1979	1980	1981	1982	1983
				JF MA MJ JA SO ND	JF MA MJ JA SO ND	JF MA MJ JA SO ND	JF MA MJ JA SO ND	JF MA MJ JA SO ND	JF MA MJ JA SO ND
	Excavation	M^3	718×10^3		━━━				
	Banking	〃	888×10^3		━━━				
Ⅰ	Bank protection	M^2	530		━━━				
	Sluice way	place	8		━━━				
	Excavation	M^3	713×10^3	━━━					
Ⅱ	Banking	〃	882×10^3	━━━					
	Bank protection	M^2	530	━━━					
	Sluice way	plca	8	━━━					
	Excavation	M^3	690×10^3			━━━			
Ⅲ	Banking	〃	853×10^3			━━━			
	Bank protection	M^2	530			━━━			
	Sluice way	place	8			━━━			
	Excavation	M^3	677×10^3				━━━		
Ⅳ	Banking	〃	837×10^3				━━━		
	Bank protection	M^2	530				━━━		
	Sluice way	place	7				━━━		
	Excavation	M^3	653×10^3					━━━	
Ⅴ	Banking	〃	807×10^3					━━━	
	Bank protection	M^2	510					━━━	
	Sluice way	place	7					━━━	
	Excavation	M^3	723×10^3						━━━
Ⅵ	Banking	〃	894×10^3						━━━
	Bank protection	M^2	520						━━━
	Sluice way	place	8						━━━

5.9 Construction Cost Estimate

Investment cost for the river improvement is as shown in Tables III-33 and III-34.

5.10 Yearly Decrease of Flood Damage

The decrease of flood damage will appear to some extent mostly stage-wise, even during the construction period as shown in Table III-35. The flood damage will be decreased firstly by the cofferdam of Wonogiri dam from 4.94 million (US$) to 2.67 million (US$) and then it will decrease according to the progress of the river improvement. The decrease of flood damage by river improvement is estimated assuming that it is proportionate to the inundation area corresponding to each levee construction.

Table III-33 Investment Cost (Economic price)

Item	Quantity	Unit	Unit cost (US $)	Amount (US $)		
				Total	Foreign	Local
I Civil Works						
Excavation	6,380x10^3	m^3	0.50	3,190,000	-	3,190,000
Banking	5,161x "	"	0.45	2,322,000	-	2,322,000
Bank Protection						
Stone pitching	148x "	m^2	13.8	2,042,000	-	2,042,000
mattress basket	9x "	m	23.0	207,000	-	207,000
Sodding	3,000x "	m^2	0.16	480,000	-	480,000
Bridge	-		-	85,000	51,000	34,000
Sluice Way	46	place	20,000	920,000	644,000	276,000
Intercepting Drain	80,000	m	3.0	240,000	-	240,000
Construction Machinery		-	-	4,015,000	4,015,000	-
II Land Acquisition				1,514,000	-	1,514,000
III Contingency (15%)				2,255,000	707,000	1,548,000
IV Engineering & Administrative Expenses				1,000,000	800,000	200,000
Total				18,270,000	6,217,000	12,053,000

Table III-34 Land Acquisition (Economic Price)

Item		Quantity	Unit	Unit cost (US $)	Amount (US $)
House					875,000
	bamboo	2,770	house	169	468,000
	wooden	230	"	361	83,000
	brick	290	"	1,084	314,000
	factory	10	"	602	6,000
	others	30	"	120	4,000
Field					639,000
	farm land	315	ha	1,036	326,000
	yard	379	"	819	310,000
	others	8	"	361	3,000
Miscellaneous					
Total					1,514,000

Table III-35 Decrease of Flood Damage in Fiscal Year

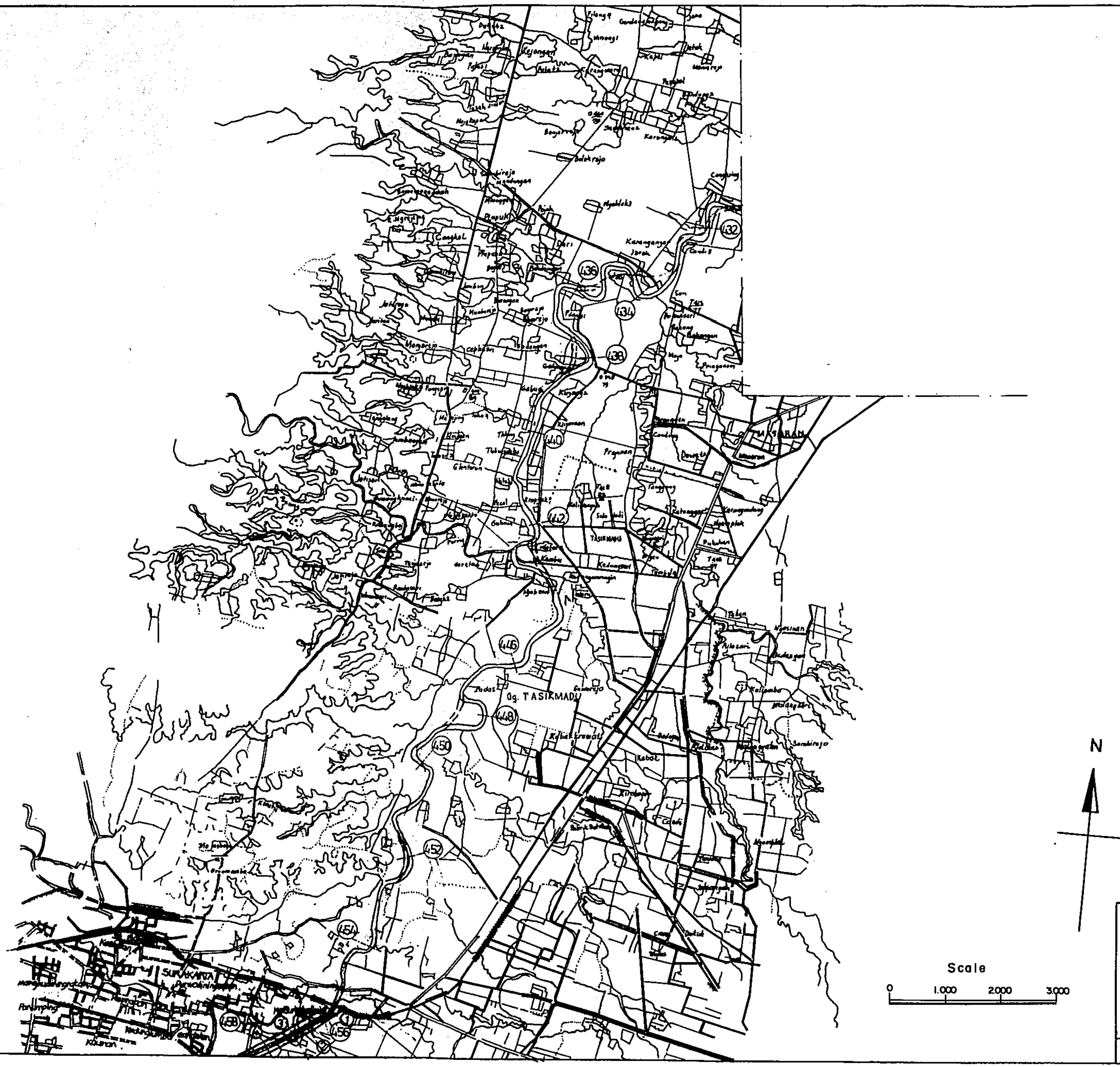
Work Section	fiscal year / (1)	1978 D	1978 R	1979 D	1979 R	1980 D	1980 R	1981 D	1981 R	1982 D	1982 R	1983 D	1983 R	1984 D	1984 R
II	1.10	☒	1.10		1.10		1.10		1.10		1.10		1.10		1.10
I	0.52			☒	0.52		0.52		0.52		0.52		0.52		0.52
III	0.32					☒	0.32		0.32		0.32		0.32		0.32
IV	0.52							☒	0.52		0.52		0.52		0.52
V	0.42									☒	0.42		0.42		0.42
VI	0.34											☒	0.34		0.34
benefit by river improvement		1.10		1.62		1.94		2.46		2.88		3.22		3.22	
benefit by coffer dam		2.59		2.59		2.59		2.59		2.59		2.59		2.59	
total benefit		3.69		4.21		4.53		5.05		5.47		5.81		5.81	

note (1) total benefit by river improvement

unit : ($\times 10^6$) US $

☒ : construction period of each work section

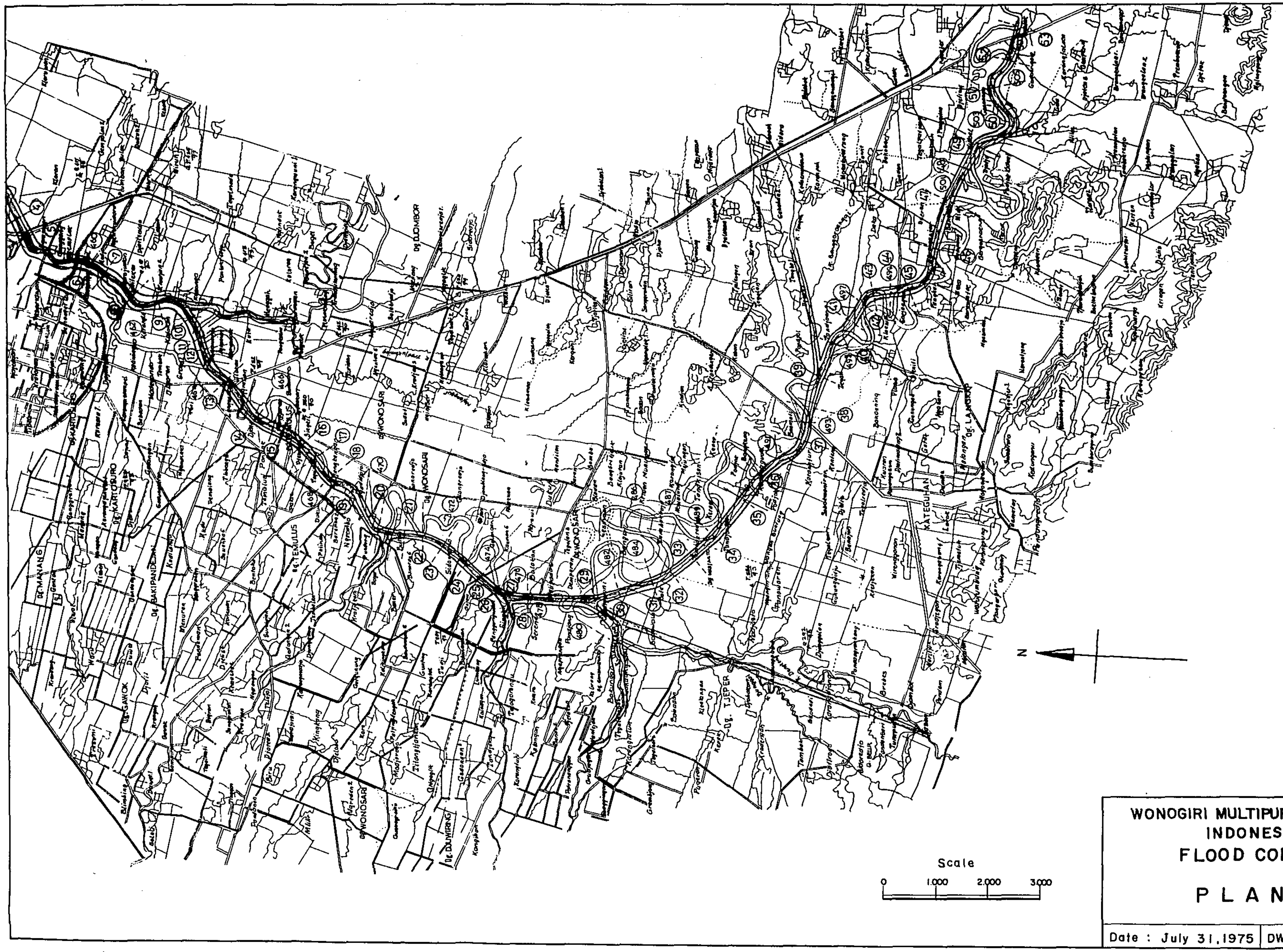
DRAWINGS



WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

P L A N (1)

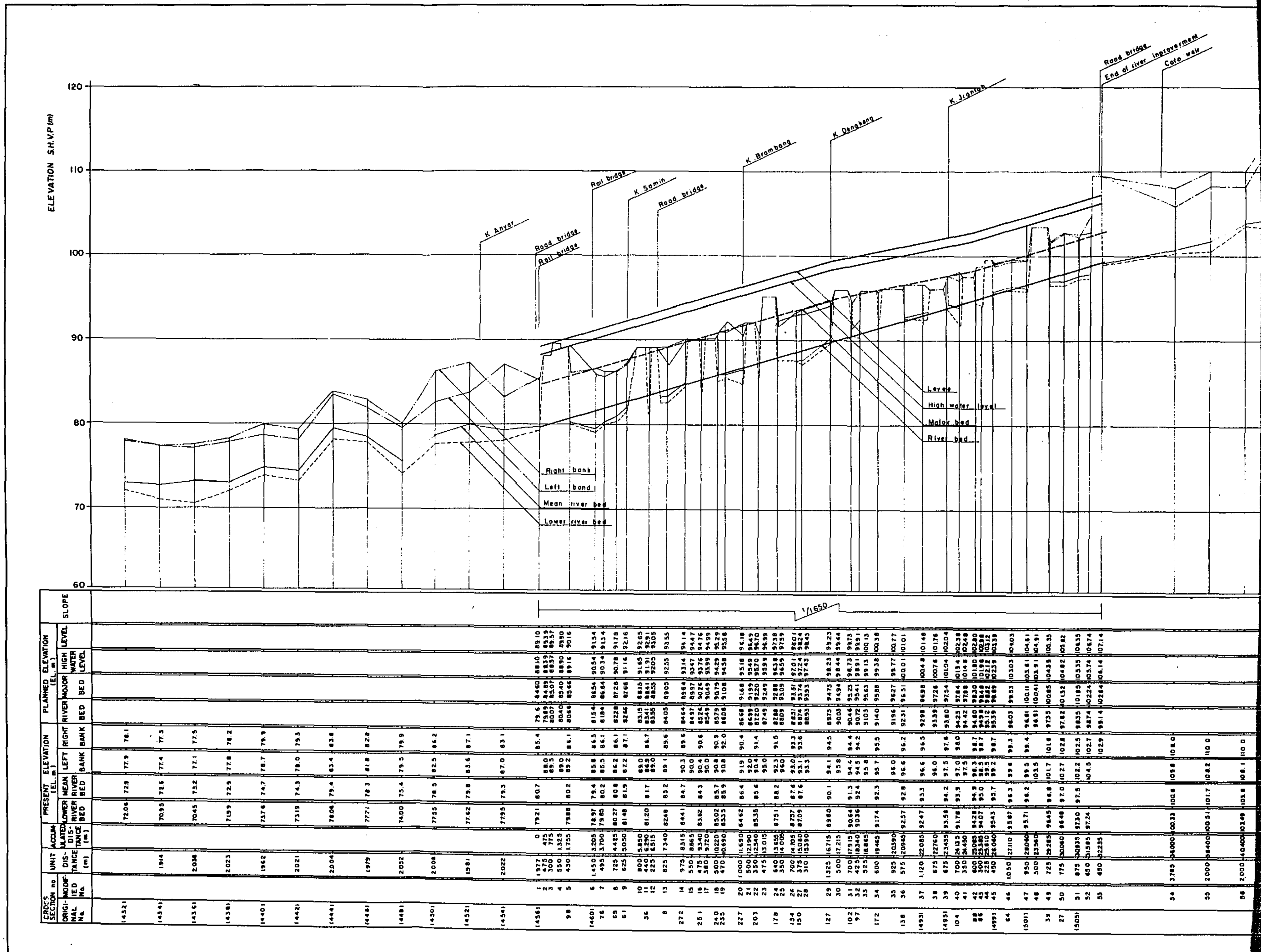
Date : July 31, 1975	DWG NO. WF 001.



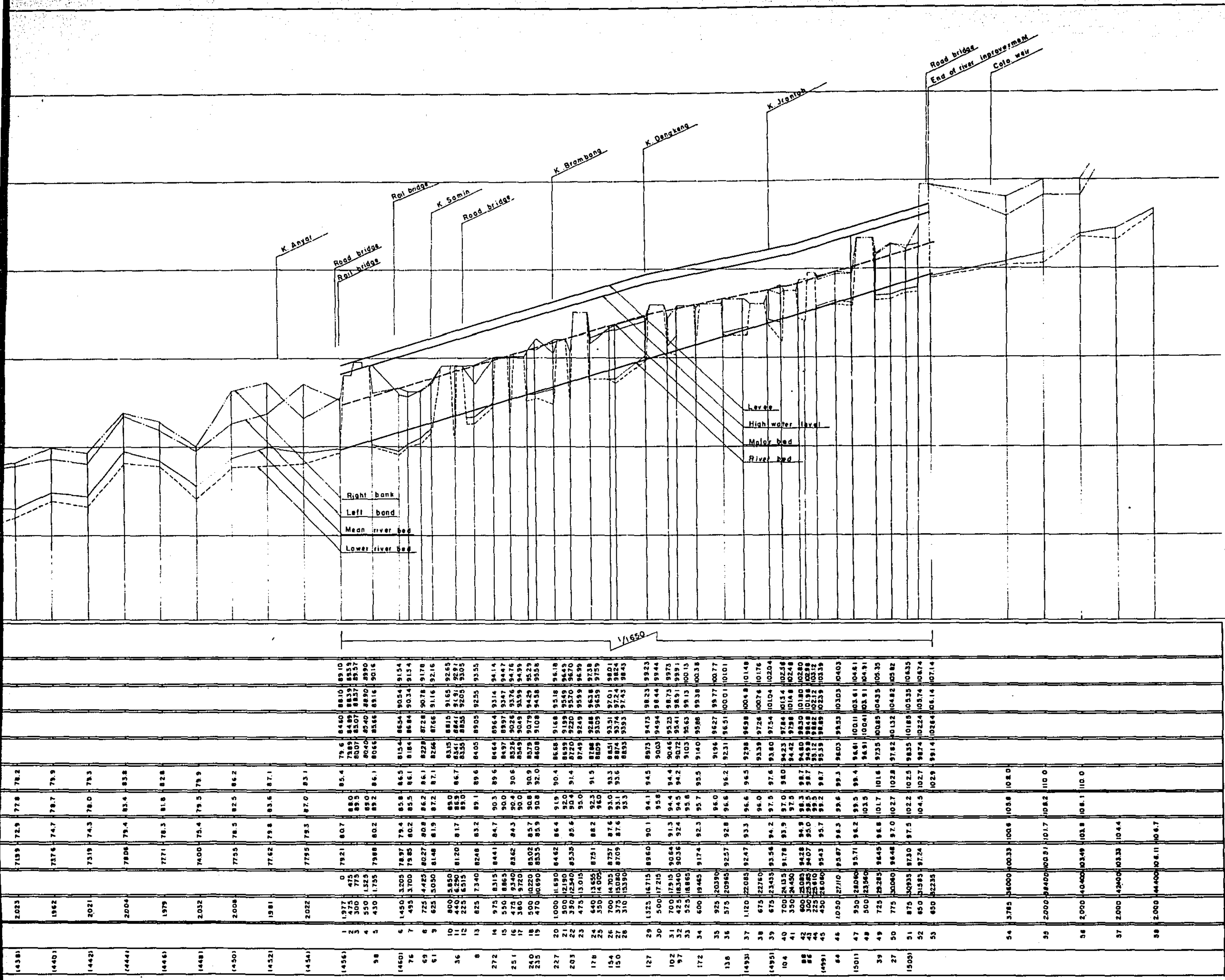
WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

PLAN (2)

Date : July 31, 1975 | DWG NO. WF 002 .



ELEVATION S.H.V.P (m)
120
110
100
90
80
70
60
K. Anyar
Road bridge
Rail bridge
Rail bridge
K. Samin
Road bridge
K. Brambang
K. Dengkeng
K. Jenggot
Road bridge
End of river improvement
Colo weir
Levee
High water level
Major bed
River bed
Right bank
Left band
Mean river bed
Lower river bed
SLOPE
1/1650
PLANNED ELEVATION (EL. m)
LEVEL
HIGH WATER LEVEL
MAJOR BED
RIVER BED
PRESENT ELEVATION (EL. m)
RIGHT BANK
LEFT BANK
MEAN RIVER BED
LOWER RIVER BED
ACCUMULATED DISTANCE (m)
UNIT DISTANCE (m)
CROSS SECTION No.
MODIFIED No.
ORIGINAL No.



Scale

V 0 2 4 6 8 10 12m

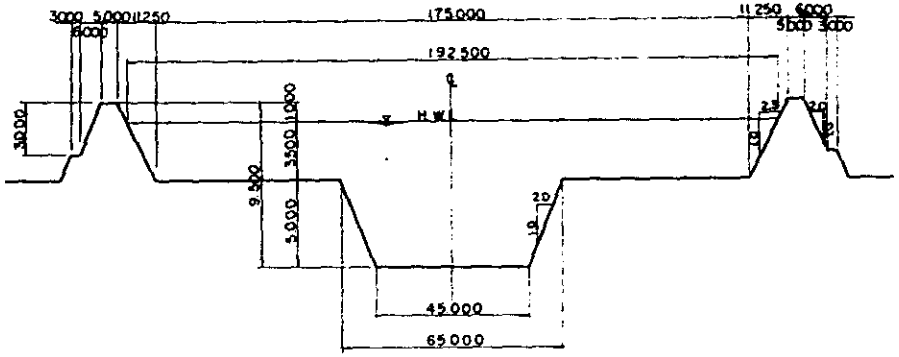
H 0 1 2 3 4 5 6 (x10³)m

WONOGIRI MULTIPURPOSE DAM INDONESIA

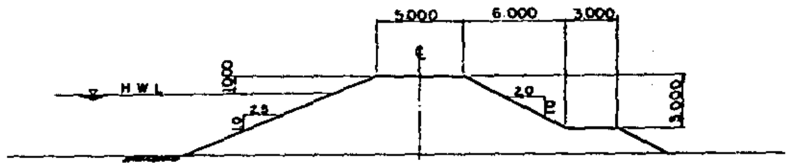
FLOOD CONTROL

LONGITUDINAL SECTION

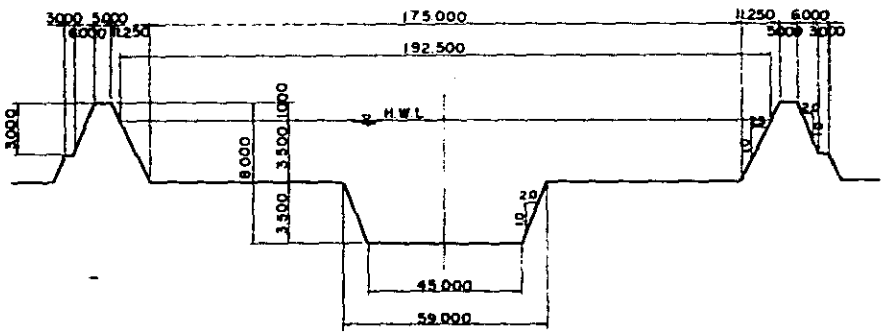
Date : July 31, 1975 | DWG NO. WF 003



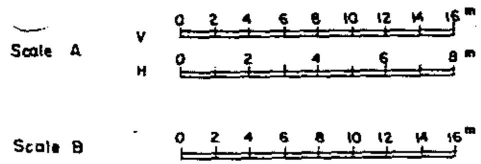
NO. 1 ~ NO. 29 (Scale A)



LEVEE (Scale B)



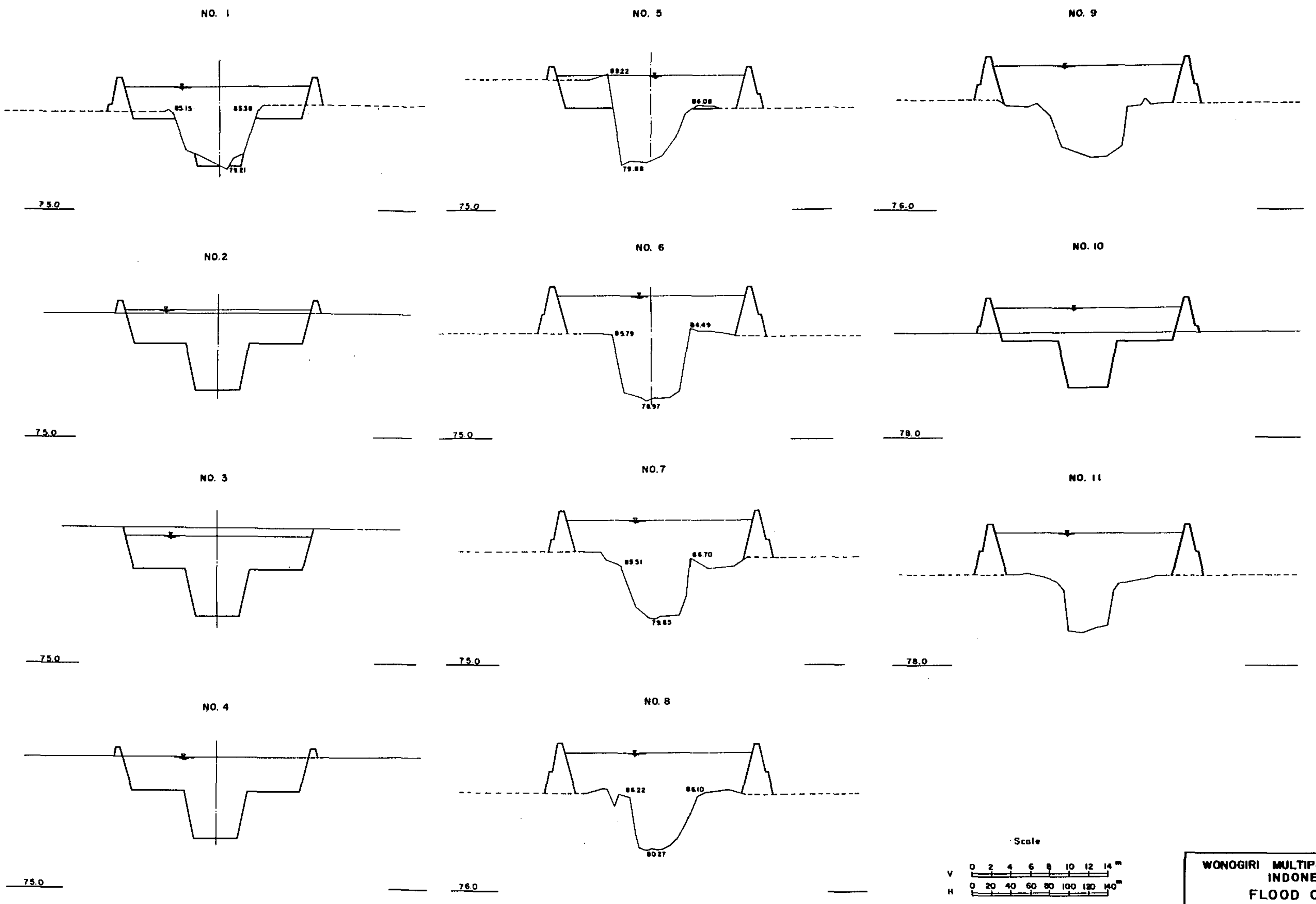
NO. 29 ~ NO. 52 (Scale A)



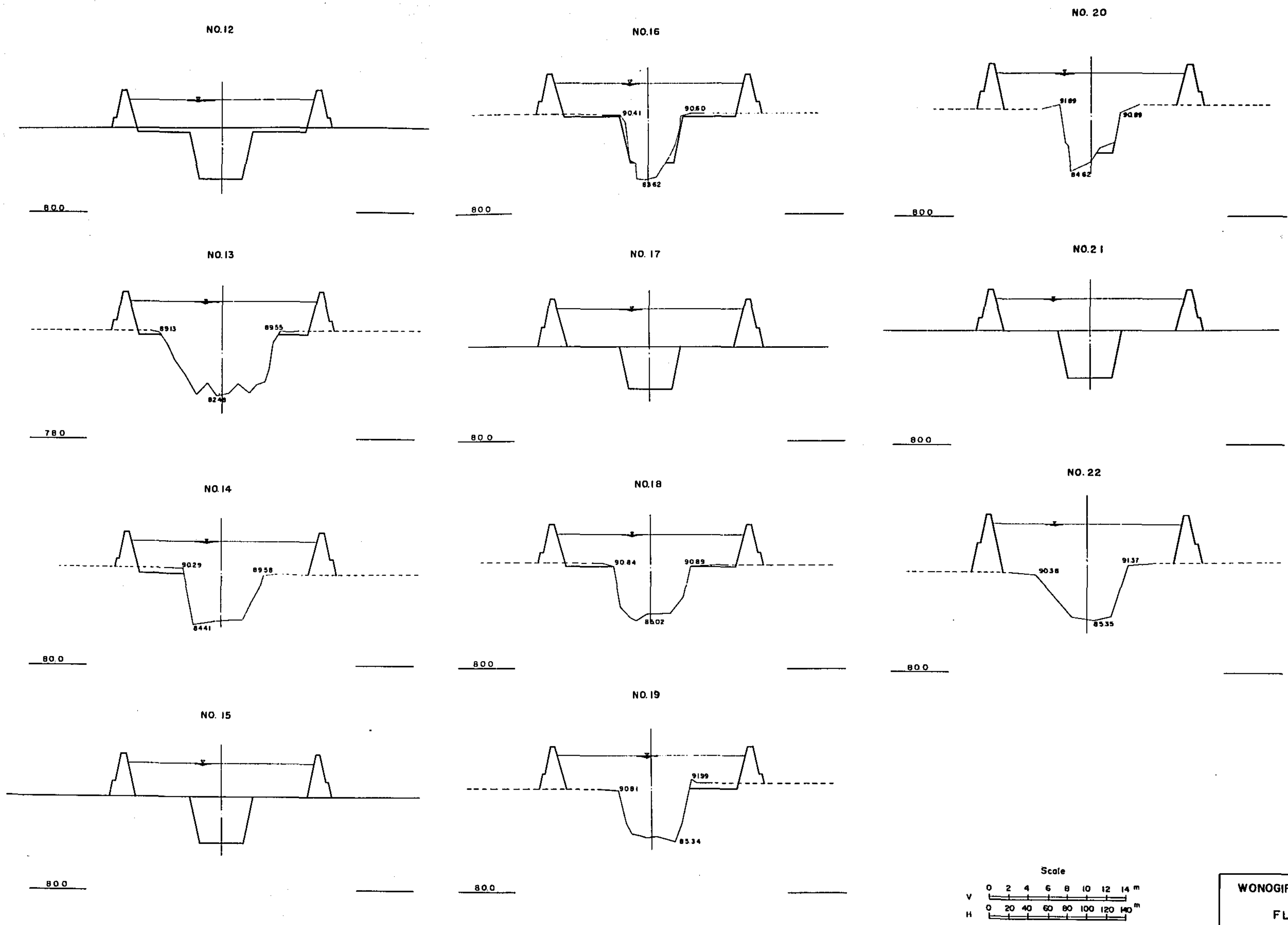
WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

STANDARD CROSS SECTION

Date : July 31, 1975	DWG NO. WF 004



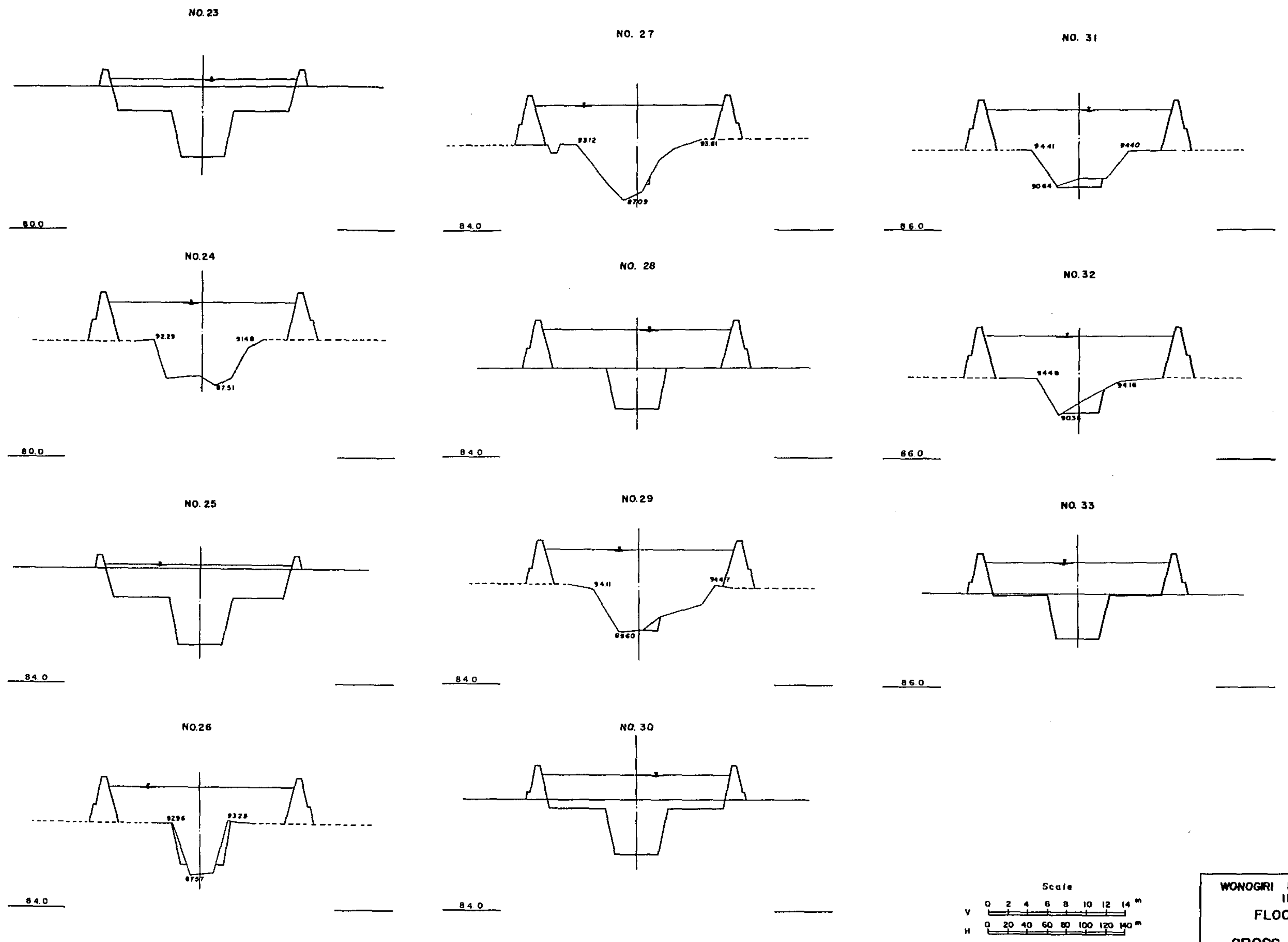
WONOGIRI MULTIPURPOSE DAM INDONESIA FLOOD CONTROL CROSS SECTIONS (I)	
Date : July 31, 1975	DWG NO. WF 005



WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

CROSS SECTIONS (2)

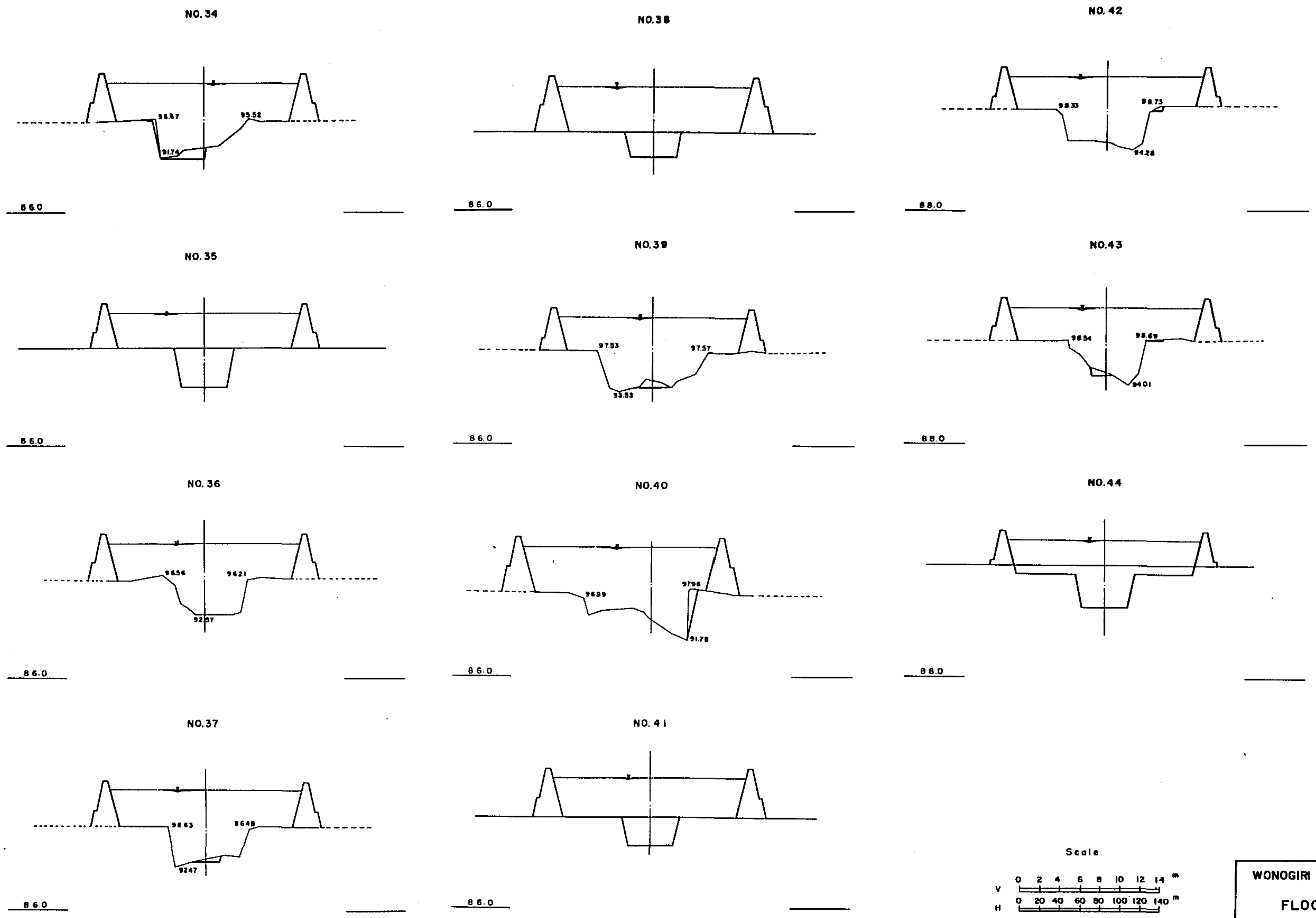
Date : July 31, 1975 | DWG NO. WF 006



WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

CROSS SECTIONS (3)

Date : July 31, 1975	DWG NO. WF 007

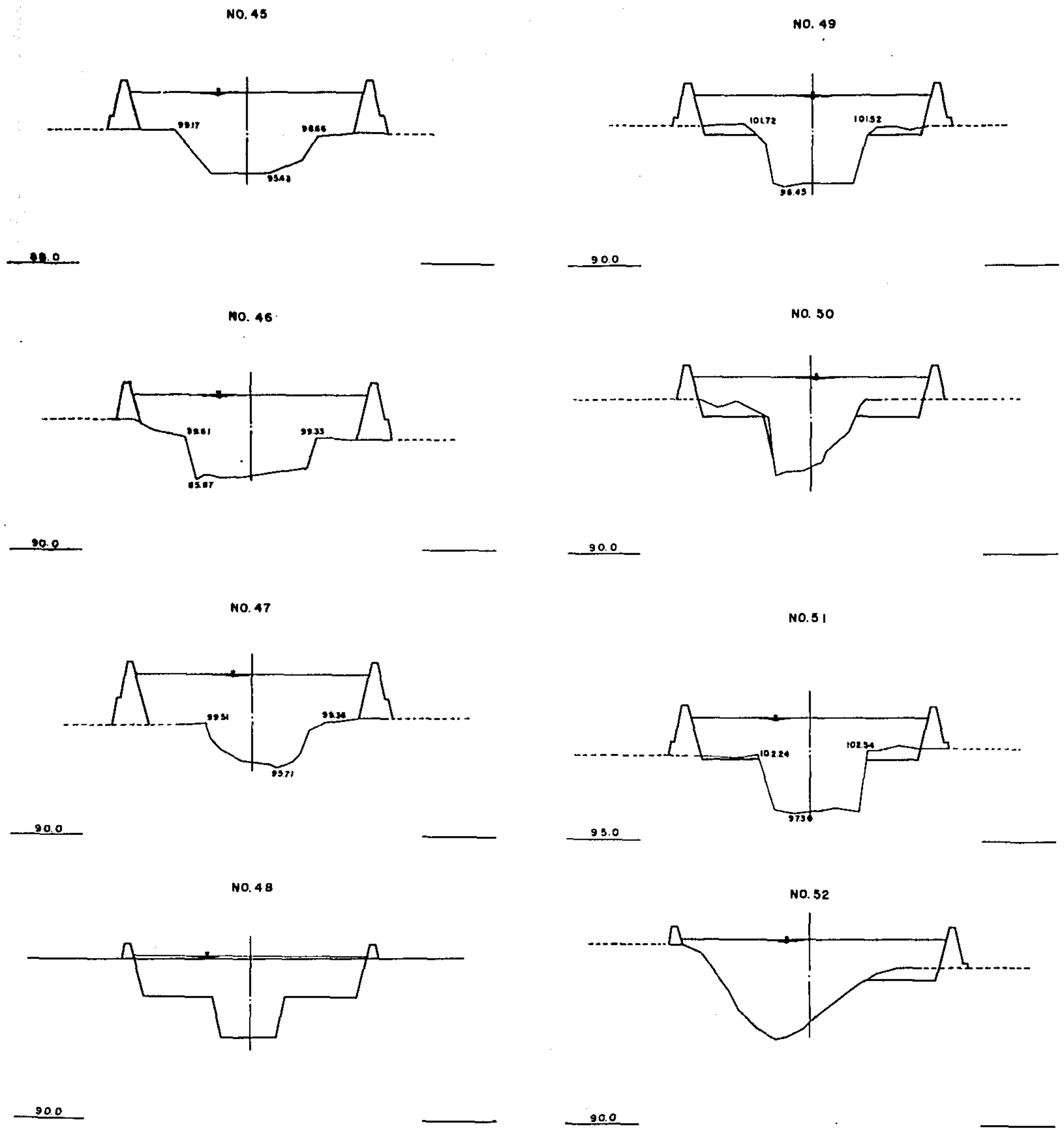


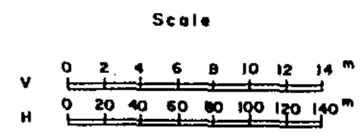
WONOGIRI MULTIPURPOSE DAM
INDONESIA

FLOOD CONTROL

CROSS SECTIONS (4)

Date : July 31, 1975	DNG NO. WF 008





WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

CROSS SECTIONS (5)

Date : July 31, 1975 | DWG NO. WF 009

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