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

FEASIBILITY REPORT ON THE WONOGIRI MULTIPURPOSE DAM PROJECT

—MAIN REPORT—

OCTOBER, 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request of the Government of the Republic of Indonesia, the Government of Japan has decided to undertake a feasibility study on the Wonogiri Multipurpose Dam Project and the Japan International Cooperation Agency executed the study.

The Agency dispatched a survey team consisting of 20 experts headed by Mr. N. AIHARA, Director, Planning Department, Water Resources Development Corperation, to Indonesia for five months from November 1974 to April 1975. The survey team conducted the field investigation and engineering studies in close cooperation with the Indonesian staffs. The results of the study was summarized into an interim report at the project site in April 1975.

After returning to Japan, the team refined the study and finalized the report incorporating the comments given during several discussions in Indonesia.

I sincerely hope that the feasibility report will contribute to the future implementation of the project and promote further economic cooperation between Japan and Indonesia.

Finally, I wish to express my appreciation to all the staffs who participated in executing this study and also express my heartful gratitude to the authorities concerned of the Republic of Indonesia for their kind cooperation.

Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo, Japan

LETTER OF TRANSMITTAL

October, 1975

Mr. Shinsaku Hogen
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Sir,

We have the pleasure of submitting herewith the feasibility report on the Wonogiri Multipurpose Dam Project in compliance with the terms of reference agreed between the Government of Japan and the Government of Indonesia.

Through the field investigation and socio-economic studies, the need for the primary objectives of the project such as irrigation water supply, electric power and flood control are identified. To meet the regional demand, the most optimum scale of the Wonigiri Multipurpose Dam Project is formulated in the report. In the project formulation, irrigation plan is designed to exploit the available water resources in the basin to its maximum extent, while the power development is planned as a secondary function and subordinate to the irrigation scheme. River improvement plan is worked out in combination with the flow regulation by the dam.

The results of the engineering study including feasibility design and construction planning and economic analysis confirm that the project is technically sound and economically feasible.

In the course of the preparation of the feasibility report, we held several meetings for discussion with the staffs of the Government of Indonesia. All the findings and comments raised during the meetings are restudied and fully incorporated in this report.

It was really a great pleasure that we have had the opportunity of performing this study and we hope that this project will be implemented in the near future.

In submitting this report, we wish to express our heartiest thanks to your staffs, Embassy of Japan and the authorities concerned of the Government of Indonesia for the courtesies and cooperations afforded during our field survey and home office work.

Very truly yours,

Nobuo Aihara

N. Aihara
Team Leader
JICA Survey Team

SUMMARY AND CONCLUSION

On the basis of the data and informations collected in the current field investigation and the previous studies as well, this feasibility study was worked out to determine the most appropriate scheme of the development and to define the technical and economic feasibility of the Wonogiri Multipurpose Dam Project. The study also includes the preliminary design of the major facilities, cost estimate, construction planning and the financial analysis of the project. All the studies are described in the respective chapters of this main report and further details are explained in the study reports.

(Plan of Development)

1. The Wonogiri Dam Project is a multipurpose scheme aiming at irrigation water supply, power generation and flood control. The scheme includes the construction of the Wonogiri Dam on the upper reaches of the Sala river, at about 2 km upstream of the town of Wonogiri. It has a catchment area of 1,350 km^2 at the damsite.

The proposed irrigation area is 23,600 ha. The project will provide all weather irrigation system in the area. The power plant, located just downstream of the dam, will generate peaking power and supply it to the existing Tuntang grid which covers the project area. The installed capacity of the power plant will be 10,200 kW. The purpose of the flood control work is to reduce flood damages in the downstream areas, from Nguter to Surakarta. Flood flow is regulated by the reservoir to smaller discharges, and in the downstretches, it will be confined in the river channel to eliminate further inundation of the present flood-affected area.

(Dam and Reservoir)

2. As the result of the economic comparison of several alternative schemes, the economically optimum size of the dam and reservoir is to have the normal high water level of 136.0 m and the flood high water level of 138.2 m. The reservoir will have a surface area of 87 km^2 at the high water level of 138.2 m and a gross storage capacity of 730 million m^3, of which 120 million m^3 is sediment storage, 440 million m^3 the active storage for irrigation water supply and power generation and 220 million m^3 (including 50 million m^3 of the active storage) the storage for flood control.

3. The proposed dam is a rockfill-type dam of 37.5 m in height. The embankment volume is about 1.8 million m^3 and the length of the dam 1,440 m at the crest elevation of 141.6 m. The spillway will accommodate extraordinary flood discharge of 6,200 m^3/sec with extra surcharge storage volume associated with a depth of 0.7 m above the high water level of 138.2 m.

4. In the reservoir area, land totaling about 9,700 ha will be submerged, and the population of about 48,000 (composed of about 9,600 families) will have to be removed. Resettlement is considered to be the most important problem for the implementation of the project. The resettlement program is now being prepared by the survey team appointed by the central and local governments in collaboration with the central office of the Bengawan Sala Project.

(Irrigation)

5. Through the Pelita-I and Pelita-II, the main objective of the Government's policy for economic development has been placed on the growth of agricultural sector. In particular, the Government emphasizes to increase agricultural products for attaining self sufficiency of foodstuffs since the present situation indicates that the agricultural production is still short of the increasing demand in the country. Along with the above economic policy and requirement, this project aims to increase crop production, especially paddy rice production, by providing all weather irrigation facilities in the area.

6. Irrigation area commanded by the project work is 23,600 ha in total, of which 2,800 ha is situated in K. Denkeng area on the left bank of the Sala River and the remaining 20,800 ha is on the right bank, extending over a long area of about 60 km in length from Colo to Sragen. Water required for irrigation will be supplied from the Wonogiri reservoir throughout the year.

Irrigation facilities to be provided by the project include a headwork at Colo site, 89-km long main canal, 105-km long secondary canal, 311 crossing structures, 69 turnouts, 3 regulating reservoirs, wasteways, supply ditches, drains and road networks on farms.

7. With the irrigation system completed, the present cropping pattern will be changed to the one for year-round farming and the intensive use of farm land will be practiced. The productivity of agricultural production is expected to increase substantially, in particular, the yield of paddy rice will rise to about 189,000 tons, approximately 2.5 times of the present yield of 73,000 tons.

The expected incremental net income from the agricultural production will be US$ 13.62 million per annum at the full development stage.

(Power Generation)

8. The power demand in the system is rapidly increasing along with recent economic growth of the area. The present situation is that the growing demand is suppressed by the limit of present supply capacity. It is expected that the annual growth rate of peak power demand will be 15 to 20 % for the coming several years. To cope with the increasing power demand, the Government contemplates to install an additional power capacity of 187,950 kW in Central Java in the coming three years (1975 - 1977), where the present capacity is 110,018 kW.

9. The Wonogiri power plant will accommodate two units of generating equipment having a capacity of 5,100 kW each. A single circuit, 150-kV transmission line, about 40 km long, will deliver the generated power to Surakarta substation. The power to local townships such as Wonogiri, Wuryantoro and Sukoharjo will be sent by a separate 20-kV line.

10. Being incorporated in the system, the Wonogiri power plant will be operated principally as a peak-load plant. During the months of peak irrigation period and the flood season in wet years, the reservoir will discharge the excess water over the requirement for peak power generation. For those periods, the power plant will generate additional power energy using the excess discharge, being operated as a base-load plant during off-peak hours. The plant could supply 28,200 MWh of power energy annually.

The project benefit derived from power generation is estimated to be US$ 1.35 million annually.

(Flood Control)

11. During the flood season, the Sala River rages often and causes much damages on agricultural products and various properties in the inundation area. According to the flood records of the past years, the inundation by flood has taken place at a frequency of 2.5 times a year. In particular, in case of the flood in March 1966 which is the maximum recorded flood in the past decade, the depth of flooding reached 2.5 m in Surakarta and Sragen areas and the inundation continued for a week. Under such circumstances, the implementation of flood control measures has been long desired.

12. Flood control work of the project is planned for the design flood having the magnitude of the 1966 flood. It has a peak flood discharge of 4,000 m^3/sec at the damsite and 5,300 m^3/sec (under the flow condition as confined in levees) at Surakarta, which corresponds to a flood event of 60-year recurrence probability at the damsite and 40-year at Surakarta respectively.

The proposed flood control plan is composed of the flood regulation by the reservoir and the flood protection work in the downstream reaches. The Wonogiri reservoir will regulate most part of flood inflow and will discharge at the constant outflow of 400 m^3/sec. By this regulation, the flood discharge at Surakarta will be reduced to 2,000 m^3/sec. The proposed river improvement work in the downstream reaches is to protect the area from inundation by accommodating the above design discharge of 2,000 m^3/sec in the river channel, while the present river channel is merely capable of passing the discharge as large as 500 m^3/sec. The work includes the training of the river channel, the construction of levees along the course of the river and other related structures such as bank protection, sluiceways, bridges, etc. The improvement work will be carried out for the section of 32.2 km in length between Nguter and Surakarta along the main stream of the Sala River. The work is also proposed for 6 tributaries in the total lengths of 17.5 km where the back water of the Sala River reaches.

13. With the implementation of the above flood control works, the present inundation area will be relieved from flood damages in future so far as the flood magnitude is less than the flood of 40-year reccurrence

probability at Surakarta. The amount of the reduced flood damages is estimated at US$ 5.81 million per annum.

(Construction Time Schedule)

14. Total construction period required for the execution of the project works is 7 years excluding a part of preparatory works. According to the time schedule proposed in this report, the construction work will be started in 1977 and terminated in 1983. The dam and power facilities will be completed in 1981, the irrigation work in 1982 and the river improvement in 1983 respectively.

(Construction Cost)

15. The total construction cost estimated on economic cost basis is US$ 106.47 million equivalent, comprising US$ 51.18 million of foreign currency portion and US$ 55.29 million of domestic currency portion. The economic evaluation of the project is based on this estimated cost.

16. Fund requirement of the project work is estimated at US$ 211.33 million, which includes the cost for land acquisition and resettlement estimated on financial cost basis, interest cost during the construction period and the contingencies for price escalation in future. It comprises US$ 91.32 of foreign currency portion and US$ 120.01 equivalent of domestic currency portion.

(Economic Analysis)

17. Benefit of the project comprises irrigation benefit, flood control benefit and power benefit. Negative benefit, which is the expected loss of future agricultural net income on the farmlands to be submerged by the reservoir, is also taken into account. The total project benefit is estimated at US$ 19.96 million per annum.

Economic analysis of the project is made by means of internal rate of return method assuming that the project life is 50 years. The internal rate of return is calculated at 13.9 %, which presents the economic feasibility of the project.

(Financial Analysis)

18. Farm budget is firstly analyzed for the typical farm size of 0.72 ha to evaluate the project from farmers' viewpoint. With the irrigation project completed, the expected net reserve per farmer will be quadrupled and will attain US$300 per annum, which shows not only the financial soundness of the project but also sufficient capacity to pay for some charges on the irrigation water.

For financial analysis of the project, the expected water charge and power rate for the repayment of the construction cost and O & M cost are calculated on the basis of the financial cost, which includes interest cost during construction and the financial cost for land acquisition and resettlement.

Assuming that the loan repayment period is 30 years after the completion of the project and the interest is imposed only on the foreign currency portion at a rate of 5 % per annum, the expected water charge and power rate are calculated at Rp.34,740/farm and Rp.20/kWh respectively. Both rates are considered to be in the reasonable range compared with the expected net reserve of farmer and the present power rate. With respect to flood control works, the investment cost shall be subsidized by the Government in view of the nature of the project.

(Conclusion)

19. The Wonogiri Multipurpose Dam Project is needed for economic development and public welfare of the region. As described above, the proposed project is technically sound and economically feasible. It is recommended that the plan for the Wonogiri Multipurpose Dam Project is adopted substantially as set forth in this report and steps taken soonest possible for the implementation of the project.

Principal Features of the Project

(Wonogiri Dam & Power Station)

Dam and reservoir	
Catchment area	1,350 km^2
Type of dam	Rockfill, Central core type
Crest elevation	141.60 m SHVP
Max. height of dam	37.5 m
Crest length	1,440 m
Embankment volume	1.8 million m^3
Low water level (L.W.L.)	EL. 127.00 m
Normal high water level (N.H.W.L.)	EL. 136.00 m
Surcharge W.L. (H.W.L.)	EL. 138.20 m
Controlled W.L.	EL. 135.30 m (Flood season)
Sediment storage capacity	120 million m^3 (below L.W.L.)
Effective storage capacity	440 million m^3 (L.W.L. - N.H.W.L.)
Flood control capacity	220 million m^3 (C.W.L. - S.W.L.)
Spillway	
Type of spillway	Overflow weir-chuteway type, spillway with gates
Gate	4 Nos., 8.0 x 7.7 m
Max. discharge capacity	1,550 m^3/sec
Intake and waterway	
Max. discharge	60 m^3/sec
Type of intake	Vertical intake tower
Elevation of bottom sill	121.00 m
Intake tunnel	6.0 m dia., concrete lined
Penstock	4.2 m dia., 2 lines
Outlet valve	1.8 m dia., Hollow-jet valve; Q max. = 35 m^3/sec
Power station	
Turbine	2 units of 5,100 kW vertical shaft Kaplan type
Generator	2 units of 6,375 kVA, alternate current generator
Design head	21.2 m
Max. discharge	60 m^3/sec

Max. output	10,200 kW
Dependable peak power	6,900 kW
Annual energy output	28,200 MWh

<u>Transmission line</u> — Single circuit, 150 kV
Distance; 40 km

(Irrigation Facilities)

<u>Diversion weir</u>

Type of weir	Concrete weir
Min. intake W.L.	EL. 106.50 m
Height of weir	10 m
Length of weir	108 m
Gate	3 Nos. 5 x 4.6 m (Sand flush)
Intake left	1 No. 4 x 3.4 m Qmax. = 4.0 m^3/sec
right	3 Nos. 5 x 3.6 m Qmax. = 29.6 m^3/sec
Crest elevation of overflow weir	107.6 m

<u>Irrigation canal</u>	<u>Right bank</u>	<u>Left bank</u>
Irrigation area (ha)	20,800	2,800
Length of main canal (km)	63.9	25.6
Max. discharge (m^3/sec)		
at beginning section	29.6	4.0
at end section	1.0	0.4
Gradient of canal	1/2,500	1/6,000
Length of secondary canal (km)	131.8	13.1
Max. discharge (m^3/sec)		
at beginning section	3.1	0.8
at end section	0.2	0.2
Gradient of canal	1/3,000	1/2,500

<u>Crossing</u>	<u>Right bank</u>	<u>Left bank</u>
Siphon	15	2
Aqueduct	12	4
Culvert	73	22
Bridge	145	38

	Right bank	Left bank
Turnout	39	10
Checkgate	3	3
Regulating reservoir	3	-

(River Improvement)

Improved section: Nguter - Surakarta

Length of the section: 32.2 km along the main river
17.5 km along the tributaries

Design discharge (after dam regulation)
at beginning section (Nguter) 1,600 m^3/sec
at end section (Surakarta) 2,000 m^3/sec

(Construction Cost)

Economic Cost

(US$1,000)

	Foregin Currency	Local Currency	Total
Dam & Reservoir	18,000	25,400	43,400
Hydropower	10,190	1,510	11,700
Irrigation	16,770	16,330	33,100
River Improvement	6,217	12,053	18,270
Total	51,177	55,293	106,470

Fund requirement

(US$1,000)

	Foreign Currency	Local Currency	Total
Dam & Reservoir	26,970	64,350	91,320
Hydropower	14,010	2,520	16,530
Irrigation	23,770	29,030	52,800
River Improvement	10,030	24,110	34,140
Interest Cost	16,540	-	16,540
Total	91,320	120,010	211,330

Note: (1) Interest rate: 5 % per annum for foreign currency portion.

(2) Price escalation:

(i) Foreign currency portion

10% per annum for the first year and 7% compound rate per annum thereafter.

(ii) Local currency portion

15% per annum for the first year and 10% compound rate per annum thereafter.

(Benefit)

	(US$1,000)
Irrigation Benefit	13,620
Negative Benefit	-820
Flood Control Benefit	5,810
Electric Power Benefit	1,350
Total	19,960

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GROSSARY OF TERMS AND ABBREVIATION

1) Local Terms of Administrative Areas

Prop = Propinsi = Province

Kares = Karesidenan = Residency

Kab = Kabupaten = Regency

Kec = Kecamatan = Township

Desa = Village

Kota Madya = Municipality

Wilayah = Governance unit by Irrigation Office, corresponding to Residency level

Seksi = Governance unit by Irrigation Office, corresponding to Regency level

2) Natural Features

G = Gunung = Mountain

K = Kali = River

Sawah = Rice field, Paddy field

Tegal = Upland field

3) Other Local Terms

Pelita = Five year plan

Gotong Royong system = Mutual cooperation

Polowijo = Upland crop

4) Administrative Organization

PUTL = Ministry of Public Work and Electric Power

DGWRD = Directorate General of Water Resources Development

PLN = Public Corporation of Electicity

DITSUN = Directorate of River

DIRGASI = Directorate of Irrigation

PBS PUSAT = Central Office of Bengawan Sala Project

PNP = State Estate Corporation

BULOG, DOLOG = Central and Provincial Rice Purchasing Agencies

BUUD, KUD = Agricultural Cooperative Organization

BUPATI = Local Governer

OTCA = Overseas Technical Cooperation Agency of Japan

OECF = The Overseas Economic Cooperation Fund

5) Length

mm = millimeter
cm = centimeter
m = meter
km = kilometer

6) Area

m^2 = square meter
ha = hectare = $10^4 m^2$
km^2 = square kilometer = $10^6 m^2$

7) Volume

ℓ = liter = 1,000 cm^3
m^3 = cubic meters

8) Weight

mg = milligramme
g = gramme
kg = kilogramme
t = ton = 1,000 kg
qwt = quintal = 100 kg

9) Time

s (sec) = second
h (hr) = hour
d = day
yr = year

10) Currency

US$ = United States Dollar
Rp = Rupiah
US$ = 415 Rp

11) Electric Measures

kV = kilovolt
kW = kilowatt
MW = megawatt = 1,000 kW
kWh = kilowatt-hour
MWh = megawatt-hour = 1,000 kWh
kVA = kilovolt-ampere
Hz = hertz

12) Other Measures

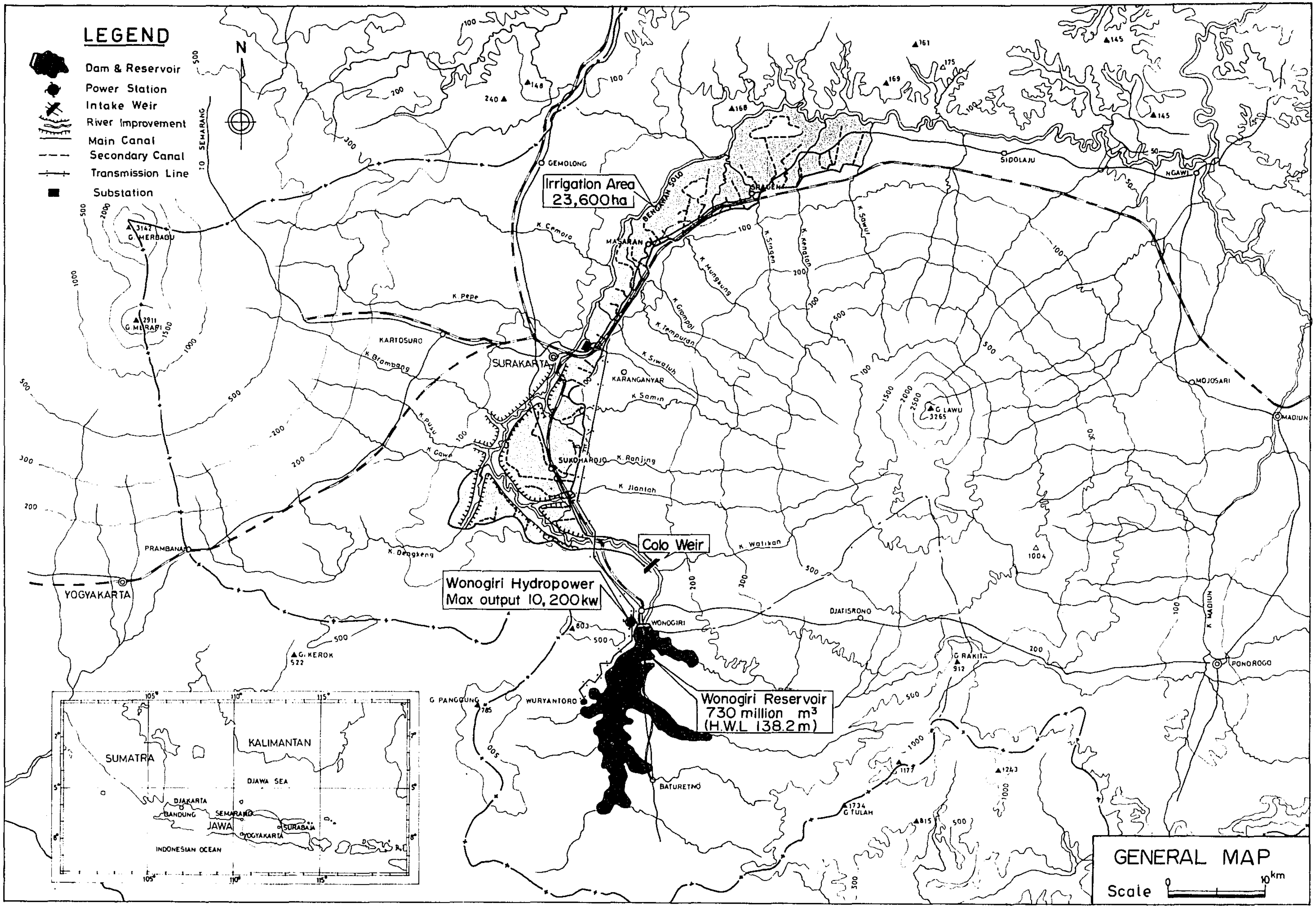
% = per cent
ppm = parts per million
rpm = revolution per minute
HP = horse power
°C = degree centigrade
10^3 = thousand
10^6 = million
10^9 = billion

13) Derived Measures based on the Same Symbols

m^3/s, m^3/sec = cubic meter per second
t/ha, ton/ha = ton per hectare
m^3/km^2 = cubic meter per square kilometer
mm/day = millimeter per day
l/day = liter per day
m^3/yr = cubic meters per year
m^3/hr = cubic meters per hour
m^3/min = cubic meters per minute
l/sec = liter per second
l/sec/m = liter per second per meter
m/yr = meter per year
US$/ha = US dollar per hectare
Rp/ton = Rupiah per ton
Kg/m^3 = kilogramme per cubic meters
$m^3/km^2/year$ = cubic meters per square kilometers per year
$m^3/s/km^2$ or $m^3/s/ha$ = cubic meters per second per square kilometers or hectare

14) Other Abbreviations

EL = Elevation
WL = Water level
LWL = Law Water level
NHWL = Normal high water level
SHFD = Standard highest flood discharge
FWL = Flood water level
MSL = Mean sea level
P.S = power station
S.S = substation
T/L = transmission line
D/L = distribution line
NNW = north-northwest
SSE = south-southeast
GDP = Gross domestic product


LEGEND
Dam & Reservoir
Power Station
Intake Weir
River Improvement
Main Canal
Secondary Canal
Transmission Line
Substation
N
Irrigation Area
23,600ha
Colo Weir
Wonogiri Hydropower
Max output 10,200kw
Wonogiri Reservoir
730 million m³
(H.W.L 138.2m)
SURAKARTA
YOGYAKARTA
PRAMBANAN
KARTOSURO
GEMOLONG
MASARAN
SRAGEN
SIDOLAJU
NGAWI
KARANGANYAR
SUKOHARDJO
WONOGIRI
WURYANTORO
BATURETNO
DJATISRONO
PONOROGO
MADIUN
MOJOSARI
G. MERBABU
G. MERAPI
G. LAWU
G. RAKITA
G. KEROK
G. PANGGUNG
G. TULAH
BENGAWAN SOLO
SUMATRA
KALIMANTAN
DJAWA SEA
DJAKARTA
BANDUNG
SEMARANG
JAWA
YOGYAKARTA
SURABAJA
INDONESIAN OCEAN
GENERAL MAP
Scale 0 10km

CHAPTER I

INTRODUCTION

I. INTRODUCTION

1.1 Project History

The Wonogiri Multipurpose Dam Project of the Bengawan Sala was firstly formulated through the field investigation and engineering studies carried out during the period of 1963 to 1965, and identified as one of the important development projects of the country.

After this pioneer study, the Bengawan Sala raged often and caused serious damages over the Sala River basin, especially in Surakarta city in 1966 and in the lower Sala basin in 1968. These events impressed strong necessity of flood control work by constructing multipurpose dams on the Sala for the stabilization and further development of the basin.

However, in those days, Indonesia suffered from political instability and eventually economic deterioration continued for several years. Such social and economic situation gave negative impact on further promotion for the realization of the project.

In 1969, the First Five-Year Plan (Pelita-I) was launched by the new Government for reconstructing the deteriorated economy by rehabilitation and improvement of the infrastructure of the country, putting emphasis on the rehabilitation of agricultural sector. Along with the Plan, the Government has made a great effort to attain the target and made a considerable investment in various economic and social sectors, particularly in the agricultural sector.

In parallel with such direct effort, the identification and formulation of the prospective development projects have been geared up for providing materials for future development program. In this program, the study on development of water resources, especially multipurpose development scheme, has been facilitated with a considerable emphasis.

Under the above background, the Sala River basin was restudied and a Master Plan for the basin development was formulated under the technical assistance of the Japanese Government during the period of 1972 to 1974.

The Master Plan proposed various schemes for irrigation, flood control, power generation, sediment control and drainage, and concluded that high economic return was expected especially in irrigation sector followed by power sector and flood control. Among the proposed schemes, the Wonogiri Multipurpose Dam Project in the upper Sala River basin is selected as the most viable project with high economic return and recommended to be implemented firstly for the basin development.

Based on the recommendation of the Master Plan, the Government of Indonesia decided to undertake the feasibility study of the project as the first priority scheme of the basin development program, taking into account the importance of increasing food production, lessening flood damage and supplying hydro-electric power in the region.

1.2 Feasibility Study

In response to the request from the Government of Indoneisa, the Japanese Government despatched a survey team for the feasibility study of the Wonogiri Multipurpose Dam Project during the period from November 1974 to April 1975.

The survey team headed by Mr. N. Aihara consists of 20 experts from the Japanese Government, OECF, Nippon Koei Co., Ltd., Japan Engineering Consultants Co., Ltd. and CTI Engineering Co., Ltd. The names of the members are listed in Appendix I together with the names of the Indonesian counterparts.

The feasibility study aims to ascertain the viability of the project both in technical and economic aspects through the field investigations and in-depth studies.

According to the memorandum agreed between the both governments, the scope of services to be rendered by the survey team is summarized hereunder:

i) Collection of additional data and recent informations
ii) Estimation of hydrological and hydraulic quantities
iii) Topographic survey of the dam site, Colo weir site quarry site and borrow area and other relevant areas

iv) Geological survey of the dam site, Colo weir, quarry site and borrow area and analysis of the results

v) Soil mechanic survey of the embankment material and estimate of the borrow quantity

vi) Planning and preliminary design of the dam and reservoir, and cost estimate

vii) Power study including preliminary design and estimate of construction cost and benefit

viii) Agricultural study including agronomic analysis, preparation of the basic layout and design of the irrigation systems and estimate of the construction cost and benefit

ix) Study on the flood control and river improvement including an estimate of construction cost and benefit

x) Economic evaluation of the project and advice for the resettlement and compensation

The results of the study are compiled in four separate volumes of the Main Report together with three Annex Reports as listed below.

- Feasibility Report on the Wonogiri Multipurpose Dam Project (Main Report)
- Annex I Study Report (1)
  - I Wonogiri Dam
  - II Wonogiri Power Station
  - III Flood Control
- Annex II Study Report (2)
  - IV Agriculture
  - V Irrigation
- Annex III Data
  - I Hydrology
  - II Geology
  - III Soil Mechanics

CHAPTER II

SOCIO-ECONOMIC BACKGROUND

II. SOCIO-ECONOMIC BACKGROUND

2.1 Present National Economy

Indonesia maintains about 126 million people on her land of 1.9 million km^2. The population has increased at a high annual rate of 2.2% during the past decade.

As in most of the countries of South East Asia, the economy of Indonesia depends on the primary sector particularly agriculture, while industrial activities remain at a lower level due to lack of sufficient infrastructures and the shortage of technical and managerial manpower. According to the recent statistics, agriculture sector produced about 44% of the Gross Domestic Product (GDP) and mining, manufacturing and public utilities shared 16% in total while services sector shared 37% in 1972.

With respect to the economic growth, the country has achieved significant progress. The GDP is estimated to have increased at an annual average rate of 7.8% during 1968 - 1972 which shows a substantial increase compared with that of 2.1% during 1965 - 1967.

The balance of payments in recent years had changed from deficits to increasing surplus and the resulting gross official reserves climbed from US$160 million at the end of 1970 to US$807 million at the close of 1973. But the situation again changes for the worse due to the recent recession of the world economy.

In the agricultural sector, production attained rather satisfactory growth of 4% per annum during 1969 - 1973. The production of rice as a main crop rose by an annual average of 3.2% during 1970 - 1973 and attained 14.5 million tons in 1973. The growth of rice production originated from the increase of unit yield and the expansion of total cultivated area. Total harvested area increased from 8.1 million ha in 1970 to 8.4 million ha in 1973 and the average unit yield rose to 1.7 tons per ha in 1973 at a compound rate of 2.0% annually. Higher unit yield is attributable to the BIMAS and INMAS programs of the Ministry of Agriculture which provide a package of improved seeds, fertilizers, credits and technical assistance, and to the improvement of irrigation facilities.

However, in spite of the recent considerable gains in domestic output, agricultural production, particularly food grain production is not sufficient to meet the demand. The volume of imported rice rose from 0.8 million ton in 1969 to 1.2 million tons in 1973, while the import of wheat, which is another food crop to be imported doubled in volume from 1971 through 1973.

Estate crops produced for the home market also performed well in the past five years. The output of sugar cane rose by more than 20% but is still short of the national demand. In 1973, imports of sugar amounted to 0.25 million ton.

In the industrial sector, activities are far from the expected level owing partly to the recent price escalation of imported capital goods. Insufficient conditions of the infrastructure such as power supply and transportation system are the bottleneck for the development as well as the shortage of technical and managerial manpower.

Electric power supply of the country increased its capacity to 1,055 MW at the end of the Pelita-I. But supply capacity per capita is still at quite a low level; 9.2 watts in Java and 8.1 watts in the whole country. Transmission and distribution systems are still in poor condition although great effort for extension was made during the Pelita-I.

Road transportation network has been improved considerably during the Pelita-I. However, other transportation systems, especially interinsular marine transport and railway have not yet been improved.

Aside from the economic aspects, there arise social problems from the fact that the pace of social development has lagged very much behind the growth of GDP. The rate of unemployment in urban areas was estimated at 4.8% in 1971 while that of rural areas 1.7%. But these figures seemed not to represent the actual situation since the statistics were taken for only the registered number of those seeking jobs. Furthermore, underemployment is considered to be prevalent.

The above-stated social and economic problems as well as inequitable distribution of income and regional imbalance in development have become the most important problems which are now taken up as the objectives of the Second Five-Year Plan (Pelita-II) from 1974 to 1978.

2.2 Basic Policy for Economic Development

Facing these social and economic problems, Pelita-II was prepared for the years of 1974 - 1978. The Plan places primary emphasis on the following basic policies:

i) to provide sufficient food and clothing of low price and better quality

ii) to provide housing facilities together with necessary fittings

iii) to continue the construction of the infrastructure

iv) to improve national welfare and promote its equitable distribution

v) to expand employment opportunity

In quantitative terms, the target of the plan is set at the average annual growth rate of real GDP by 7.5 % which is slightly higher than that of the previous plan (Pelita-I). Real GDP is expected to increase by 44 % at the end of the Plan.

Under the national policy mentioned above, detailed programs of development are set forth by each economic sector. Main focus of economic development is laid out on the sectors of industry, mining, power and transportation besides agriculture.

The target and the expected growth rate of the development in each sector are set out in the following table.

Table II-1 Target Composition of National Production by Economic Sector (%)

	Fiscal Year 1973/1974	Annual Growth Rate	Fiscal Year 1978/1979
Agriculture	40.2	(4.6)	35.6
Mining	9.2	(9.0)	9.9
Manufacturing	9.8	(13.0)	12.5
Construction	3.7	(9.2)	4.0
Transport	4.1	(10.0)	4.7
Others	33.0	(7.6)	33.3
Gross National	100.0		

Although the share of the agricultural sector in GDP indicates declining tendency, the sector still is the most important sector for the country to attain self sufficiency in food and is expected to increase its output at an annual rate of 4.6%.

For the development of the agricultural sector, principal policies are mapped out as follows:

i) to increase the productivity in agricultural sector

ii) to achieve self-sufficiency in food by emphasizing rice production

iii) to increase exports of agricultural products by the production increase

iv) to reduce unemployment and underemployment now prevailed in the villages

v) to achieve balanced growth between agricultural sector and industrial sector

vi) to utilize natural resources with necessary measures for conservation

In order to attain the above targets, introduction of the irrigation farming is indispensable in this country where surface water is quite limited during the critical stage of growing period of dry season crops.

At the beginning of the Pelita-I, it was contemplated that more than 60% of the existing irrigation systems would require rehabilitation and improvement works. During Pelita-I, they were partly improved and are scheduled to be completed by the end of the Pelita-II. In addition, the Government of Indonesia goes on further strategic development plans for agricultural development in Pelita-II. The strategic plans are reclamation of swampy land, prevention of flood over farm land, exploitation of new water resources and its effective utilization and construction of multipurpose dams.

Under these principles, detailed policies are worked out particularly for rice production. In the Plan, it is projected that the rice production will increase from 14.5 million tons in 1973 to 18.2 million tons in 1978, in which the growth is equivalent to a compound rate of 4.6% a year.

In the industrial sector, the Government intends to facilitate the progress attained during Pelita-I by emphasizing labor-intensive industries. The Government also promotes private investment with providing such necessary infrastructure as transportation, telecommunication and electric power for the industrial development. To cope with the increasing demand for electricity in industries and home consumption, the Government plans to develop the power supply capacity by 1,105 MW and extend transmission line by about 3,700 km during the Plan.

Regarding social development, employment opportunity will be increased to a extent of absorbing about 96% of the incremental labour force during the Plan. About 1.2 million, or approximately a fifth of the above additional employment of 5.5 million, are expected to be absorbed in the agricultural sector.

CHAPTER III

PRESENT CONDITION OF THE PROJECT AREA

III PRESENT CONDITION OF THE PROJECT AREA

3.1 Geographical Condition

3.1.1 Location and topography

Bengawan Sala basin having about 600 km river length and 16,100 km^2 drainage area is situated in the central part of Java island. The basin is bounded by high mountain complexes with above 2,000 m peak in the west and east and low mountain ranges in the north and south running in parallel to the coastal line.

The Sala River originates from the southern mountain range (Gunung Seribu), south of Surakarta (Sala), and debouches to Java Sea near Surabaya. At Ngawi town located at the center of the basin, the Sala River receives the largest tributary, Kali Madiun which also originates from southern mountains and has a drainage area of 3,755 km^2.

The project area is situated in the upper Sala basin of which drainage area is 6,072 km^2 at Ngawi. Administratively, it is in the ex-Karesidenan (Residency) Surakarta including a part of Kabupaten (Regency) Klaten in the west, Sukoharjo and Wonogiri in the south, and Karanganyar and Sragen in the east. Kota Madya (Municipality) Surakarta occupies at the center of the area.

The headwater of the Wonogiri basin is the southern low mountains (Gunung Kidul) and the southern slope of G. Lawu 3,265 m above MSL. Near Wonogiri town, regency capital of Kabupaten Wonogiri about 30 km south of Surakarta, the Sala valley is narrowed by low ridges and this presents a favorable damsite. In the area downstream of the Wonogiri damsite, the upper Sala plain extends along the Sala River between the altitude of 80 m to 150 m. Many small tributaries join to the Sala River from the slope of G. Merapi, a famous volcano in the west boundary and G. Lawu in the east.

3.1.2 Climate

Located between 7^{o} and 8^{o} of south latitude, the project area has tropical monsoon climate, commanded by two distinct seasons, the wet and dry seasons. From December to May, eastward wind of wet monsoon brings a considerable amount of rain, while from June to November, the westward wind brings dry climate.

Average wind velocity ranges from 3.6 km/hr to 10.5 km/hr, relatively stronger in the dry season. Duration of sunshine is 68.7% and 38.6% on an average in the dry and wet seasons respectively. (Refer to Appendix 2).

Average temperature is usually ranging between 33°C at the maximum and 23°C at the minimum. Seasonal fluctuation is only about 2°C but daily fluctuation shows a wide range of about 8° - 10° C. Relative humidity drops below 50% in the mid dry season (August and September) and reaches to the maximum, nearly 100% in the mid rainy season (February and March). Monthly average is, however, ranging from 60% to 80%. (Refer to Appendix 2).

There exist 199 rain gauges including 10 automatic rain recorders in the upper Sala basin. The location is presented in Appendix 3. Average annual rainfall in the project area amounts to about 2,190 mm during the past 24 years; about 1,600 mm in the driest year and about 2,870 mm in the wettest year. Nearly 80% of the annual amount falls in 6 months of the wet season, usually from mid November to mid May. Average monthly rainfall in the project area is shown in Appendix 4.

Distribution of rain is generally erratic with heavy storm occurring only in the limited narrow area. The duration is also usually short, not lasting more than 15 hours.

No long-term records concerning evaporation are available in the project area, except the record at Pabelan (Surakarta) observed since 1972. Based on the data at Pabelan and the records of other observation points in and outside the Sala River basin, average evaporation is presumed to be about 1,100 mm annually or 3.0 mm daily.

3.1.3 Geology

The Sala River rises in Tertiary mountainous ranges which extend along the southern coast of Java and runs northward receiving Kali Alang, Kali Gares and Kali Keduwan before it crosses low ridge of Tertiary formation formed by G. Gadjah Mungkur and G. Dongok near the proposed dam site.

The area surrounded by these ridges is of alluvial formation. The base rock in the basin consists of mainly shale, sandstone, bedded limestone etc., which are supposedly originated by marine sedimentation and hold unbedded coarse volcanic agglomerate between them.

The ridge near the damsite is also formed by marine sedimentation of volcanic rock consisting of marly tuff, sandy-tuff, tuff breccia and lapili-tuff which belong to upper Miocene.

Quarternary pyroclastic deposits which are seemingly originated from G. Lawu covers the Tertiary on the right bank area of the damsite. Left bank of the damsite mainly consists of tuff-breccia gradually changing into tuff dominant formation in the part near the surface. Several joints and faults run with strike of NW-SE in this area.

3.1.4 Run-off, sediment and flood

River gauging has been carried out since 1965 at Juranggempal (Wonogiri) and Jurug (Surakarta) on the main Sala River.

Before 1965, only gauge records at Karangnongko station located just downstream of the confluence with K. Madiun are available. Correlation of river run-off between Juranggempal and Korangnongko was studied in the previous study/1. Run-off estimated by this correlation study and observed monthly discharge at Juranggempal are shown in Appendix 5.

Average annual run-off at the Wonigiri damsite is estimated at about 924 million m^3 or 29.3 m^3/sec in yearly mean; 12.7 m^3/sec in the driest year and 51.3 m^3/sec in the wettest year.

/1 Master Plan of the Sala River Basin Development, Supporting Report, PART - 1, OTCA Survey Team, 1972, pp 30

In the project area, no consistent observation of the sediment load has been conducted yet. Available data are limited to those collected during the previous study/1. The previous study gives the annual mean suspended load as shown below.

	Juranggempal (Wonogiri)	Winongo (Madiun)	Karangnongko (Lower Sala)
Annual volume of suspended load ($10^6 m^3$)	0.50	2.58	15.82
Catchment area (km^2)	1,350	2,345	10,007
Specific volume of suspended load (m^3/km^2)	370	1,100	1,582

In the project area, there are several irrigation reservoirs constructed about 30 to 60 years ago for which the reservoir sediment data are available. According to the data from these aged reservoirs, annual sediment rate is estimated at about 800 m^3/km^2 on an average. (See Appendix 6).

Based on the above data, the suspended sediment load for the Wonogiri basin is estimated at about 1,020 $m^3/km^2/year$. Assuming a 15 % increase for bed load, annual average sediment load at the Wonogiri damsite is determined at 1,170 m^3/km^2.

With respect to flood, the project area has been suffered from flood innundation at a frequency of 2.5 times a year. At the flood occurred in March 1966, the maximum recorded flood in recent decade, average flooding depth in the inundation area marked 2.5 m in Surakarta and Sragen districts and the inundation lasted for about one week.

/1 Ibid, pp 65 - 76.

Fig. III-1 shows innundation area recorded during major flood events in the past. The maximum inundation area totals to 33,000 ha, equivalent to about 5.4 % of the total area of the upper Sala basin of 610,700 ha, of which 3,700 ha is in Wonogiri area, 19,500 ha in Surakarta and 9,700 ha in Sragen area respectively. As far as Surakarta city is concerned, the inundation occurs when the river discharge exceeds 2,000 m^3/sec. For small floods, the area is protected by the existing flood dyke.

Since the flood-affected area is so densely-populated and highly developed productive farmland, the population in the inundation area ammount to about 462,000 and the damages on houses and properties as well as farm crops are considerably heavy. The number of population and houses and the area of the land in the flood-affected area are summarized for each flood scale in Table III-1.

Fig Ⅲ - 1 Inundation Area in Upper Sala Basin

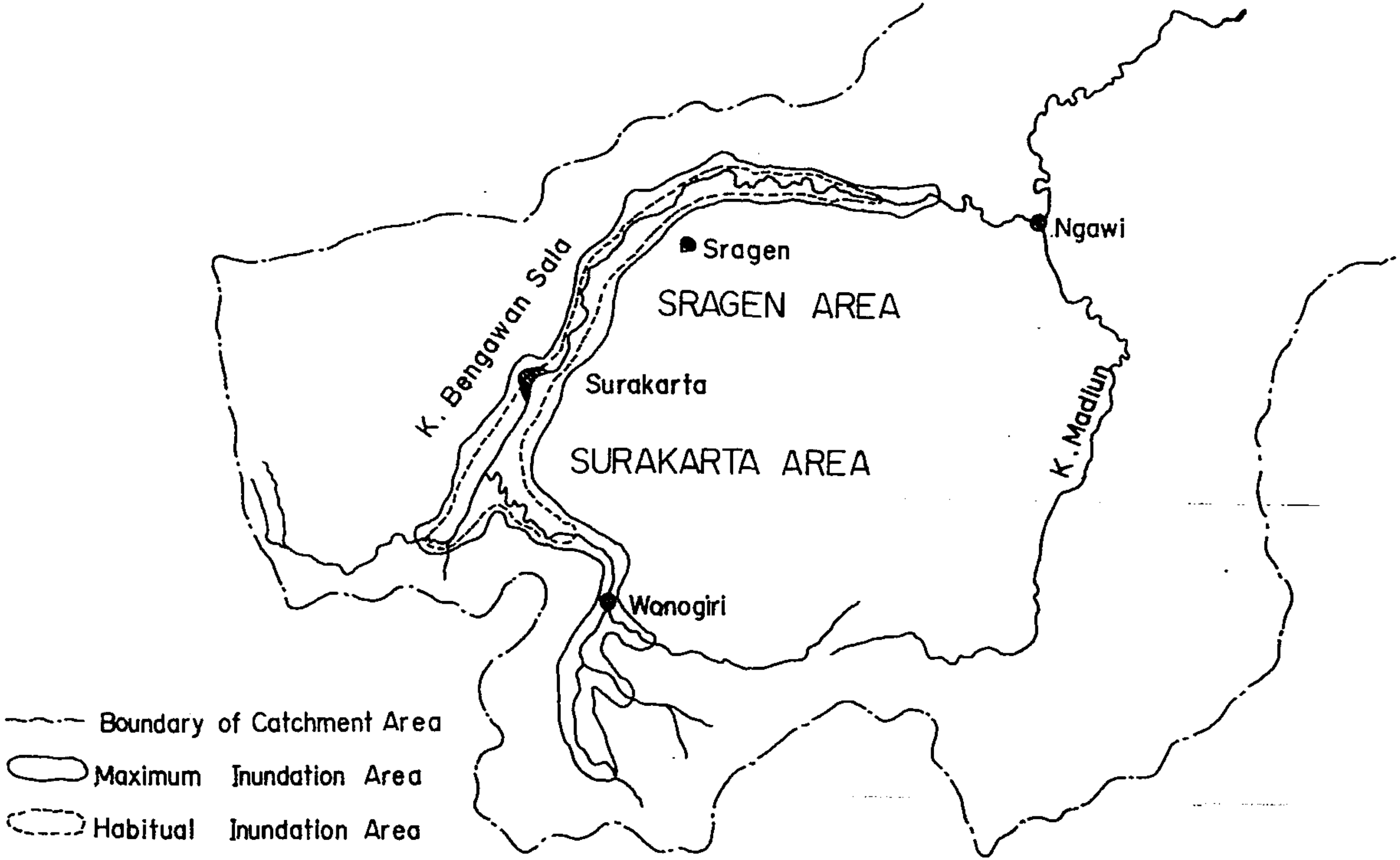


Table III-1 Population, House and Land in the Inundation Area of Every Flood Scale

(Surakarta Area) (Unit: ha)

Discharge at Surakarta (m^3/sec)	500	1,000	1,500	2,000	2,500
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
Nos of house	7,800	26,800	44,900	75,800	84,200

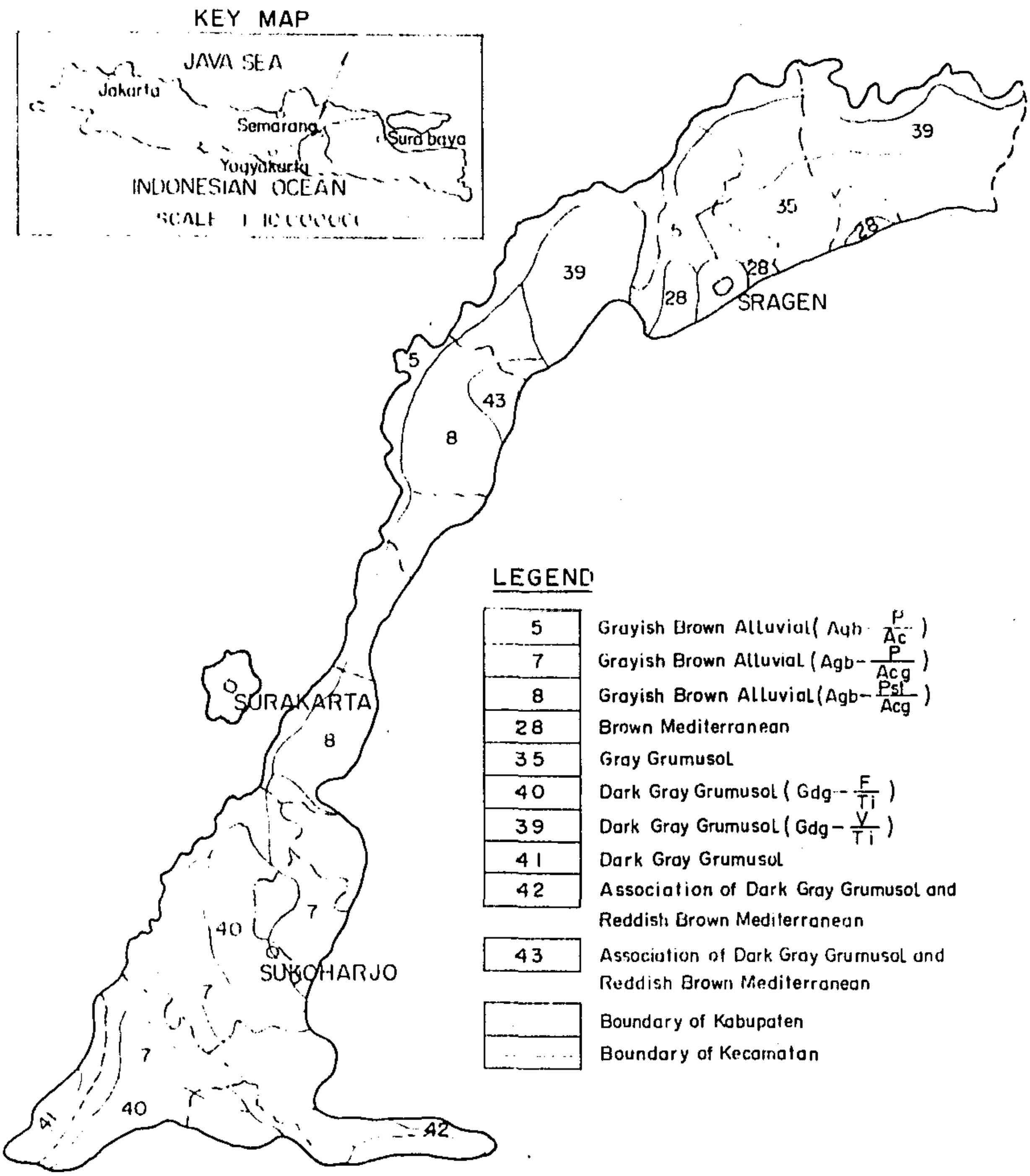
(Sragen Area)

Inundation area	3,800	6,900	8,400	9,700	10,900
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
Nos. of house	6,900	13,100	16,400	19,300	21,800

3.1.5 Soil and land capability

Most popular soil groups found in the project area are alluvial grumsol and mediteranean soil. Alluvial is predominant in the low land extending along the main Sala River. Grumsol occupies near the foot of the mountains. Mediteranean soil covers the area at higher altitude above grumsol area and the upper reach of the project area is partly covered by regosol. Most lands covered with these soils appear to be suitable for paddy cultivation. The soil map of the project area is presented in Fig.III-2.

Fig. III-2 SOIL MAP OF THE IRRIGABLE AREA



SCALE 1 : 250.000

Prepared by Soil Research Institute, 1973

3.2 Socio-Economic Setting

3.2.1 Demography

The total population of Kabupatens related to the project is about 3.5 million within the area of 4,420 km^2 excluding the population of Surakarta city, 414,000, which is an administrative, economic and cultural center of the project area.

Annual growth rate of population in the past decade, 1961 to 1971, indicates 2.5 % in Kabupaten Sragen, 3.5 % in Kabupaten Sukoharjo and 0.87 % in Kabupaten Wonogiri. Population increase in the former two regencies is mainly due to the expansion of urban area of Surakarta city toward the adjacent regions, while less increase in the latter regency is owing to the increase of emigrant to other regions because of limited land resources available in this region.

Urbanization in the outskirt of Surakarta city greatly affects on the population increase in Kabupaten Sukoharjo, where urban population increase marked a higher rate of 7.3 % annually in the past decade compared with 2.0 % in Surakarta and 2.5 % in Kabupaten Sragen.

Although urbanization is progressing, more than 60 % of the population in the project area still depend their livings upon crop farming, and the residuals are involved in rather minor sectors such as cottage industry, transportation and services. As shown in the population structure, the economy of the project area mostly depends on agricultural production and economic activity in other sectors is quite limited.

Family size in the project area is 4.8 persons in 1971 which showed a slight increase from 4.6 persons in 1961.

3.2.2 Agricultural economy

Land use

Most lowland (Sawah) extending along the Sala River is utilized for crop farming, especially for rice and sugar cane. Even in hilly area situated at the altitude above 200 m up to 1,000 m, the land has been extensively opened for crop cultivation. Irrigated farming by using water available from the tributaries has been practised since long past.

Present land use in the regencies related to the project area is given in Table III-2.

Table III-2 Present Land Use

Item		Wonogiri	Sukoharjo	Sragen	K. Anyar	Klaten
Paddy field	(ha)	39,181	23,070	41,653	25,552	35,644
(Sawah)	(%)	23.1	50.5	46.0	35.8	54.8
Upland	(ha)	57,406	8,288	22,139	18,502	7,514
(Tegal)	(%)	33.9	18.1	24.5	25.9	11.6
Yard	(ha)	47,274	8,042	20,175	14,451	16,956
	(%)	27.9	17.6	22.3	20.2	26.1
Estate	(ha)	-	470	-	-	-
	(%)	-	1.0	-	-	-
Forest	(ha)	18,399	394	-	9,008	1,175
	(%)	10.9	0.9	-	12.6	1.8
Others	(ha)	7,094	5,456	6,489	3,944	3,742
	(%)	4.2	11.9	7.2	5.5	5.7
Total	(ha)	169,354	45,720	90,456	71,457	65,031
	(%)	100	100	100	100	100

Farm size and land tenure

Average farm size in the area is estimated at 0.72 ha which is average holding in the entire Java but is smaller compared with 1.10 ha in Madium basin and 1,49 ha in the lower Sala basin.

The average holding per farmer is comprised of sawah of 0.46 ha, yard of 0.15 ha, tegal of 0.06 ha and others of 0.05 ha.

According to the data collected during the survey, about 90 % of the land is classified as farmer's land and the remaining 10 % as the land of village offices. Among the farmer's land, about 60 % is owned fully by farmers and the remaining 40 % partly owned by farmers and landlords.

Cropping pattern

Present crop farming in the project area is rather intensive and the cropping calender is established on the basis of the rainfall pattern.

At present, most of the sawah area is being utilized for paddy cultivation, and rotative cultivation of paddy, sugar cane and polowijo is practiced in partial areas. The tegal area is utilized mainly for polowijo cultivation. Mixed culture of paddy and polowijo is still prevailing on sawah not only in the dry season but also in the wet season due to water shortage and scarcity of tegal.

Typical cropping pattern at present in the project area is estimated on the basis of agronomic study and presented in Fig.III-3.

Irrigation facilities

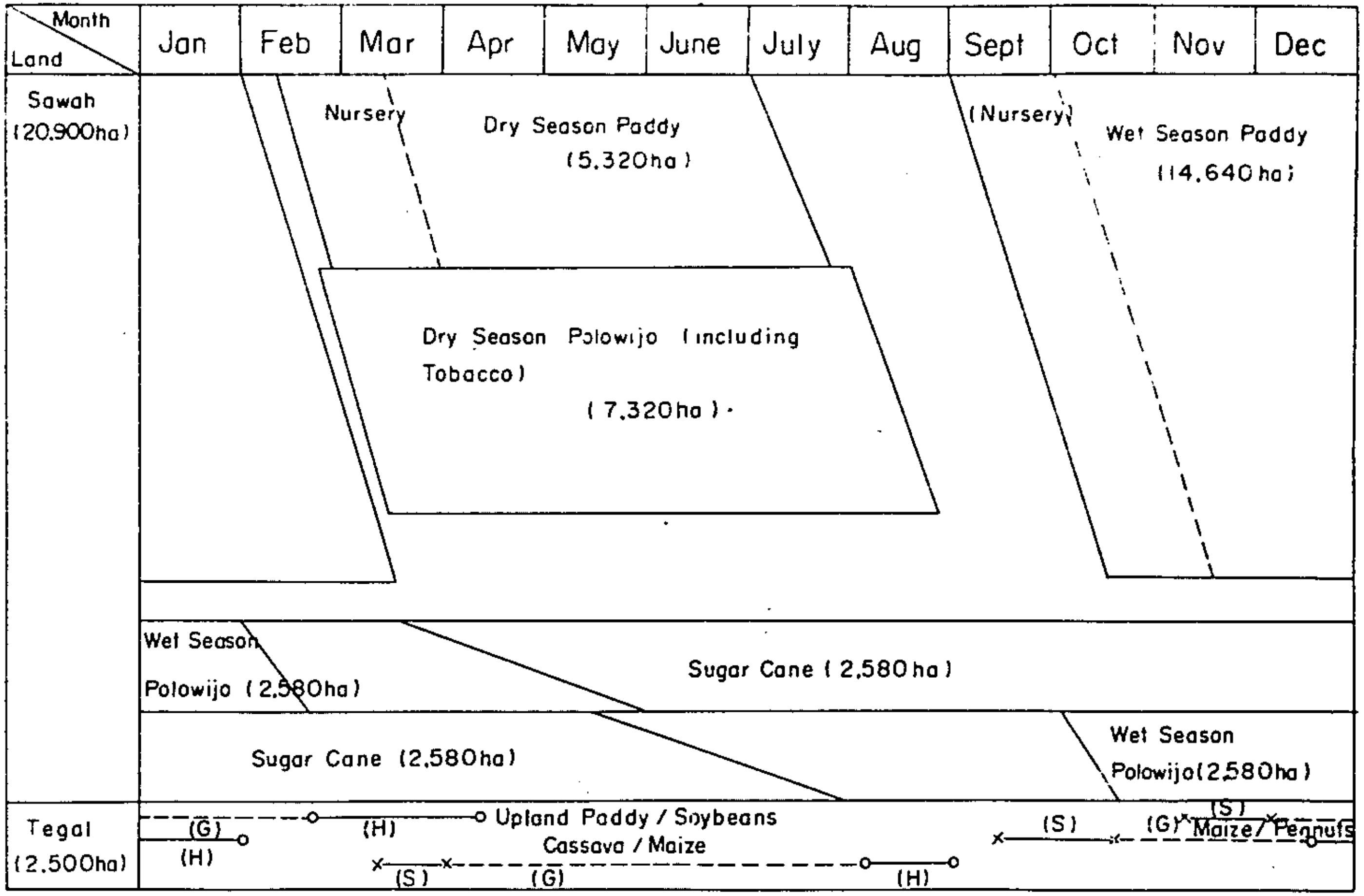
Irrigation system had been well developed in the project area. But the system is deteriorated due to the lack of maintenance, which causes the drop of irrigation efficiency. During the Pelita-I, rehabilitation of those irrigation systems were carried out and still continued in the Pelita-II.

Out of the total area in the upper Sala, more than 70 % is being irrigated technically or non-technically while about 20 % is left as rainfed area. The irrigated areas are supplied with water by 6 irrigation reservoirs, 42 diversion weirs on tributaries, 28 pumps and 2 springs./1 Water available in the dry season, however, can barely irrigate the area of 40 % of the existing irrigation area.

Water distribution of the existing irrigation system is managed mainly by local irrigation office and very small parts by villages. Daily operation is usually entrusted to the operators selected from villagers. Recently the water management has been improved along with the extension of "Dharma Tirta". Most of the maintenance work is carried out by the Gotong Royong system (mutual cooperation) among the villagers with financial support from the local government.

/1 Details of the present irrigation system are studied in the Annex II, Study Report (2).

Fig III- 3 .Present Cropping Pattern



Note : (S) ····· Sowing (G) ······ Growing (H) ······ Harvesting

With respect to the drainage facilities, existing tributaries and channels in the area act as drainage facilities when the river water level is low. But in the high flow season, the area is often suffered from inundation due to the backwater of the river. On farms, a certain number of drains exist, of which density is about 10 m/ha.

Existing farm roads have a width of about 2 m on an average. The network density of the road is estimated to be about 20 m/ha. The roads are in very poor condition, especially during the rainy season.

Crop yield

Unit crop yield of major agricultural commodities at present is shown in the following table. The yield is estimated on the basis of the data collected at agricultural offices of Kecamatan in the project area and year book of Central Java.

Table III-3 Unit Crop Yield at Present

Kind of crops	Unit yield (t/ha)
Paddy/1	
Dry season	3.3
Wet season	3.4
Upland	1.8
Maize	0.5
Cassava	3.3
Peanuts	0.5
Soybean	0.4
Tobacco/2	0.4
Sugar cane	85.0

Note /1 Dry stalk paddy
/2 Dry leaf

Livestock production

Livestock breeding itself is not a main line in the agricultural activity in the project area, but plays an important role in view of supplying animal power and protein food. Average holding of large size livestock such as cattle and buffalo is less than one head per family, while six small fowls are held by a farm at present.

The total number of livestock in the project area is presented by each kind in Table III-4.

Table III-4 Number of Livestock held in the Project Area

Kind of Livestock	Total Nos. (head)
Cattle	16,700
Buffalo	12,100
Sheep	9,900
Goat	18,900
Pig	3,300
Fowl	269,400
Total	330,300

Data Source: Agricultural Offices in Kecamatan.

There are two problems concerning livestock breeding in the area. One is the shortage of fodder, because this area is the most densely populated area and the fodder cultivation area is so limited. The other is the requirement of animal power for farm works which is a contradictory condition to the increased demand for livestock products.

Marketing

In general, dry stalk paddy is collected at BUUD (Badan Usaha Unit Desa), milled into rice and sold to the market. Rice for the government stock is purchased by BULOG. Some part of rice is sold to middleman and then sold to consumers through wholesaler and retailer./1 The price of rice purchased by the government is controlled at a stable price, while various prices are prevailing in the local market depending on location and season.

/1 The market flow of rice is illustrated in Fig.IV-5 of the Annex II Study Report (2).

For crops other than rice, no price control exists and the prices are determined in the market. However, cash crops such as tobacco, sugar cane, are cultivated under the contract with PNP and their prices are relatively stable./1

Agricultural institution

Since the beginning of 1973, new organization called BUUD has been formed with the government supports. Main objectives are providing services for agricultural extension, credit supply, distribution of the agricultural necessities and processing and marketing.

At present, BUUD can not provide sufficient services for farmers because the organization is now fully occupied in the quality control, milling and transporting of rice.

In future, BUDD's activities will be taken over by KUD (Koperasi Unit Desa). KUD will become a multipurpose cooperative nation wide organization, and all the agricultural activities will be operated by KUD.

Extension service is provided through a systematic structure from the Ministry of Agriculture to desa./2 Extension service is conducted for some specified crops under close cooperation of the extension workers and technical workers. Present capacity of the extension service is about 700 to 800 ha per extension worker. Seed multiplication system of paddy rice is also established, under the control of the Central Agricultural Institute of Bogor. The improved seed is distributed to villagers through the established channel.

/1 The market flow of other crops than rice is illustrated in Fig. IV-6 in the Annex (II), Study Report (2).

/2 Refer to Figs. IV-7 to IV-9 in the Annex II, Study Report (2).

3.2.3 Social infrastructure

Electric power supply

Present power supply system in Central Java is comprised of two main grids, the Tuntang grid and Ketenger grid. Overall interconnection between those grids is not yet realized.

At present, power is supplied mainly by PLN partly supplemented by privately-owned plants. The installed capacity of PLN's power supply system is shown in the following table.

Table III-5 Installed Capacity in Central Java (kW).

	Power station	Hydro	Gas turbine	Diesel	Total
(1) Tuntang grid	Jelog	20,480			
	Timo	12,000			
	Semarang		34,000		
	Kalisari			6,020	
	Kudus			1,120	
	Purwosari			2,200	
	Wirobrajan			4,060	
	Sub-total	32,480	34,000	13,400	79,880
(2) Ketenger grid	Ketenger	7,040			
	Pekalongan			1,380	
	Tegal			6,296	
	Cilacap			4,696	
	Sub-total	7,040	0	12,372	19,412
(3) Isolated station	2 - Hydro	380			
	14 - Diesel			10,346.2	
	Sub-total	380	0	10,346.2	10,726.2
	Total	39,900	34,000	36,118.2	110,018.2

As shown in the table, the total installed capacity of 110,018.2 kW is now provided by PLN in Central Java. In addition, privately owned capacity is estimated at 102,133 kW.

The maximum peak demand during the past three years (1972 to 1974) was 63,300 kW for the Tuntang system and 10,700 kW for Ketenger system. Sold energy was 239,708,330 kWh in 1974, which was about 73 % of the generated energy of 328,031,051 kWh.

Electric power consumption in Central Java is now limited to the urban area. Per-capita consumption in 1974 is estimated at 287 kWh against the urban population of 832,000. However, potential demand for electricity in the area is considered to be substantial from the waiting consumer list.

The project area is partly covered by the Tuntang grid, in which installed capacity was only 79,880 kW and its peak load was barely 63,300 kW in 1974 far less to meet the peak demand of the present service area.

Surakarta area is covered by Tuntang grid but other principal urban centers in the project area such as Wonogiri, Sukoharjo and Sragen are electrified by isolated small diesel plants. Most of the industrial firms in the project area are equipped with private power supply sources because of unstable supply from the grid..

Transportation and communication

Transportation service in the project area is provided by means of road, railway, and airplane. At present, roads play the most important role for both passenger transport and goods transport. Paved national roads have well been developed and connect major cities and important rural areas. Provincial and Kabupaten roads, mostly paved, compose sub-networks to connect production areas with the market.

With respect to other modes of transport in the area, south trunk line of national railway connecting Jakarta and Surabaya passes through the project area, while a local line goes to Wonogiri from Surakarta.

National carrier, Garuda Indonesia Airway, operates daily services between Jakarta and Surakarta.

Telecommunication service is provided by the public corporation of telecommunication, which connects major towns by wire cable system. In addition to this, microwave network is in service.

Water supply

Municipal and industrial water in Surakarta city is now supplied from Cokroturung spring which is located on the skirt of Mount Merapi. The quality of the water is quite good. But the present service area is very limited and the supply is often interrupted because of the deterioration of the system.

Under this situation, the extension plan for water supply to the city area was prepared as an emergency plan in addition to the improvement work for them. According to the plan, available groundwater will meet the demand up to 1980 - 1985 and thereafter, water supply from the Sala River will have to be considered.

CHAPTER Ⅳ

PROJECT FORMULATION

IV. PROJECT FORMULATION

4.1 General

This chapter aims to formulate the most optimum scale of the Wonogiri Multipurpose Dam Project and to estimate anticipated benefits in future with the project.

Firstly, the development scale of the project is defined through several comparative studies. The study includes economic comparison of alternative schemes of irrigation and power development and comparative study on flood control plans. Based on the results of these studies, the major features of the project work are determined.

Further to the above studies, another comparative studies are conducted to find the optimum plan of the project work in each sector. In irrigation sector, several alternative plans are studied to find the most appropriate system of irrigation facilities, while a comparative study for the determination of power development scale is made in the power sector.

Finally, the benefits from the project for each sector such as irrigation, power generation and flood control with the proposed scale of the project are estimated.

4.2 Development Scale of Wonogiri Dam and Reservoir

4.2.1 Preliminary considerations

In view of the present situation of the project area and the needs for the development as stated in the preceding chapters, the Wonogiri multipurpose dam project has been formulated for the purposes of irrigation water supply, power generation and flood control.

The Wonogiri project commands a large irrigable area of approximately 32,000 ha. Both the Master Plan and the preliminary study under the present investigation have revealed that irrigation development would bring forth the largest benefit among other development schemes. In this regard, the irrigation scheme is deemed to be the principal development program in formulating this project.

As has been revealed in this study and also suggested in the Master Plan, power generation scheme appears to be costly as compared with the benefit therefrom. With this in view, power generation is planned within the scope of the irrigation development, that is, the scale of reservoir will be determined on the basis of irrigation requirement and no specific storage for power generation will be provided in the reservoir. Power generation will be made by using water stored for irrigation requirement as well as 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 proposed reservoir operation rule established for irrigation water supply.

The purpose of flood control works is to reduce flood damages in the reaches downstream from the damsite. Since it appears that the most favourable flood control work on the Sala river can be realized by the combination of levee construction and flow regulation by dam, the main objective of the flood control study is to select the scale of levee and dam construction works.

4.2.2 Irrigation development plan

Available water resources

It is recommended in the Master Plan to exploit the Wonogiri reservoir to its maximum extent within the limit of the available water resources. In this regard, estimation of the maximum availability of water resources is firstly conducted before formulating any alternative development scale of the project.

In the previous study, development of several irrigation dams was recommended in the upstream area of the basin. Actually, the government has made a plan of building nine dams in the basin, of which one has already been constructed and two others are under construction or design. It is presumed that the development plan will ultimately cover a total drainage area as large as 247 km^2. Water resource study was therefore carried out on the assumption that 18% (247 km^2/1,350 km^2, total drainage area of the Wonogiri basin) of the dry season run-off would be consumed in the upstream irrigation projects and the remaining 82% available for the Wonogiri reservoir.

Based on the above run-off data, a study was conducted to find the maximum scale of irrigation development scheme within the limit of available water resources.

The Master Plan contemplates that the maximum water resources exploitable should be less than 90%, at the most, of the total run-off during such a droughty period as actually recorded in successive 5 years from 1960/61 to 1964/65. This assumption was made to ensure the reliable supply of irrigation water even during such a long droughty period. The above principle is also adopted in this study.

Average diversion requirement for a period of 5 years from 1960/61 to 1964/65 is worked out for three tentative development plans. They are compared with the river run-off data as presented below.

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

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

(2) Diversion requirement includes net irrigation requirement, loss of irrigation water in Colo intake 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 total river run-off during a typical droughty period). It is assumed that the maximum irrigation development of this project will be around 23,600 ha in irrigation area.

Alternative development plans

Within the limit of available water resources, alternative development plans were formulated to select the most appropriate scale of irrigation development scheme. In order to evaluate the project works in the framework of a multipurpose scheme, flood control and power generation schemes were also taken 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 as 220 million m^3 in this comparative study.

Three alternative plans were formulated for comparative study as shown in Table IV-1. Plan A is the maximum irrigation development plan and two other plans are smaller development schemes with reduced irrigation area.

Construction cost together with operation and maintenance cost are estimated as well as the expected benefit. On the basis of the cost and benefit, economic comparison of three alternatives is made by means of the present worth method.

Table IV-1 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
- 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
- SHFD Surcharge W.L.	138.2	136.6	134.9
- 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 SHFD (m^3/sec)	400	400	400
- Max. discharge capacity (m3/sec)	1,550	1,550	1,550
Construction cost (10^3US$)			
- Dam and reservoir	43,400	42,300	38,100
- Power and transmission line	11,700	13,400	10,700
- Irrigation	33,100	22,620	13,180
- River improvement	18,270	18,270	18,270
T O T A L	106,470	96,590	80,250
Annual benefit (10^3US$)			
- 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
T O T A L	19,960	15,570	11,150
Economic Evaluation			
- Net present worth (Discount rate at 10%) (10^3 US$)	30,155	18,361	10,551

As indicated in the above table, Plan A is the most favourable development scale among the plans. Accordingly, it is recommended that the project will be formulated with the development scale as proposed in Plan A. Active storage capacity of the reservoir for irrigation water supply will be 440 million m^3.

Further details of the economic comparison is described in Appendix 7.

4.2.3 Flood control capacity of reservoir

In the present condition, flooding of the Sala River occurs at the frequency of 2.5 times a year on an average. Very flat topography in the riparian area and small flow capacity of the existing river channel result in inundation of large areas. Very gentle gradient of the river makes it difficult to prevent flooding of the Sala River by means of river improvement alone within appropriate economic limit. In this regard, flood regulation by the reservoir is required for formulating the flood control plan.

Design flood assumed in the flood control study is SHFD (Standard Highest Flood Discharge) having a peak discharge of 4,000 m^3/sec at the damsite, which is the recorded maximum flood in the recent decade corresponding to a flood event of 60-year recurrence probability at the damsite and 40-year at Surakarta respectively.

To select the most appropriate system of flood control works, the flood control capacity of the Wonogiri reservoir is examined by the economic comparison of the following alternative plans.

Plan I	Wonogiri dam controls the flood outflow to 400 m^3/sec.
Plan II	Wonogiri dam controls the flood outflow to 700 m^3/sec.
Plan III	Wonogiri dam controls the flood outflow to 1,000 m^3/sec.

For determining the scale of the river improvement work in the downstream reaches, design flood discharge at Surakarta and Ngawi after the completion of the Wonogiri dam is estimated for respective cases as follows;

(Unit: m^3/sec.)

Item	Damsite (Wonogiri)	Surakarta	Ngawi
Before regulation by reservoir:	4,000	5,300	4,900
After regulation by reservoir:			
Plan I	400	2,000	2,830
Plan II	700	2,300	3,130
Plan III	1,000	2,600	3,430

Based on the above design discharges, preliminary design of river improvement work is worked out and required construction cost are estimated for three alternative plans. Construction cost of the Wonogiri dam is also estimated for three alternatives as presented in Table IV-2.

Through the cost comparison of the alternatives, Plan I is selected as the most preferable plan and the required reservoir storage for flood control is determined to be 220 million m^3.

Table IV-2 Cost Comparison of Alternative Flood Control Plans (Unit: US$)

	Plan I	Plan II	Plan III
River improvement	18.3×10^6	20.0×10^6	22.4×10^6
Wonogiri dam	43.4×10^6	43.2×10^6	43.0×10^6
Total cost	61.7×10^6	63.2×10^6	65.4×10^6

Further details of the above comparison are described in Appendix 8.

4.2.4 Proposed scale of Wonogiri reservoir

Reservoir capacity

The scale of the project development has been defined through the studies made in the preceding sections. According to the result of the studies, the recommended scale of the irrigation development is to irrigate an area of about 23,600 ha. For supplying sufficient irrigation water to the area, the Wonogiri reservoir will have an active storage capacity of 440 million m^3.

The above active storage capacity was determined by water budget calculation and probability analysis of the storage requirement. The selected capacity, 400 million m^3, will consist 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 river discharge to downstream reaches (2 m^3/sec during the dry season): Abt. 30 x 10^6 m^3

The above storage capacity will be sufficient for supplying the required irrigation water to an area of 23,600 ha at a dependability of 90%. The details of water balance calculation are included in Annex 1, Study Report (I).

With providing an additional storage capacity of 220 million m^3 for the reservoir, most of floods less than 4,000 m^3/sec in peak discharge will be regulated in the reservoir and the outflow from the reservoir controlled to 400 m^3/sec. At Surakarta, peak flood flow of 5,300 m^3/sec will be decreased to 2,000 m^3/sec.

Power development

Although the proposed reservoir has no storage space for specific use of power generation as described hereinbefore, the reservoir water stored for irrigation use will be utilized for power generation by harnessing water head created by the dam. Installed capacity of the proposed power facilities will be 10,200 kW, which is determined from the reservoir operation study. Details of the power development study are included in Section 4.3 of this chapter.

Topographic and regional conditions

Topography of the proposed damsite necessitates to provide long sub-dam embankment on the right bank besides the main dam, if the reservoir water level is raised to an elevation around 140 m.

In the proposed reservoir area, there are several densely-populated towns, which form local economic centers in the area: the important are Baturetno, Wurjantoro and Nguntoronadi. They are located at an elevation of between 140 m and 150 m. Moreover, relatively well consolidated farm land is found at these elevations.

If the reservoir submerges these local economic centers, farm land, and the regional community in the upstream basin will be devastated. To save the local community to be sacrificed by the realization of project, it is desirable to set the submerged level below an elevation of 140 m at the highest.

The maximum water level of the proposed reservoir is an elevation of 138.9 m at the occurrence of extra ordinary flood, for which land will be acquired for areas below an elevation of 140 m. These water level and land acquisition conditions will meet the requirement of the topographic and regional conditions stated above. In this respect, proposed scale of the reservoir appears to be appropriate.

4.2.5 Negative benefit in reservoir area

Upon completion of the dam and reservoir, approximately 9,700 ha of land will be submerged. Out of the total submerged area, about 7,200 ha is the cultivated land where paddy and polowijo are planted.

Once the dam is constructed and the area submerged, no agricultural production is expected in the area. Therefore, the value of the products thus lost is accounted as negative benefit of the project.

In order to estimate the negative benefit, cropping areas for each crop and their unit yield are estimated by applying the same method used in the estimate of irrigation benefit.

The annual negative benefit is evaluated at Rp. 340 million (about US$820,000) as presented in Table IV-3.

Table IV-3 Negative Benefit in the Submerged Area

Item	Cropping Area(ha)	Unit Benefit (Rp/ha)	Total Benefit (Rp.)
Paddy/1			
Dry Season	430	65,200	28,036,000
Wet Season	3,890	70,100	262,689,000
Upland	570	6,000	3,420,000
(Sub-total)	(4,890)		(304,145,000)
Maize	1,780	100	178,000
Cassava	2,840	10,800	30,672,000
Peanuts	360	12,000	4,320,000
Soybean	1,070	1,500	1,605,000
Total	10,940		340,920,000
			(≑US$820,000.00)

Note: /1 Dry stalk paddy

4.3 Hydro-Electric Power

4.3.1 Demand forecast and future development plan

Peak load in the existing Tuntang system was recorded at 63,300 kW in 1974. Low electrification rate at present in the area, especially in rural areas as well as the isolated urban areas, suggests that the demand potential for electric power is large and will grow as the regional economic development progresses. Since growing demand is suppressed by the limit of present supply capacity, extension of the capacity will surely bring forth a leaping increase in demand further even within the existing system.

To cope with the expected growth of power demand, development program of the power supply in Central Java, both generating capacity and transmission system, is now envisaged by PLN, the summary of which is presented in Table IV-4 and IV-5.

Table IV-4 Development Program of Generating Capacity in Central Java

	Station	Capacity	Combustion	Total supply capacity
Present installation				110,018 KW
1975	Yogyakarta	2.15 MW x 3	Diesel	116,468 KW
1976	Purwosari	0.25 MW x 2	Diesel	
	Tegal	2.50 MW x 2	Diesel	121,968 KW
1977	Semarang	50 MW x 2	Steam	
		20 MW x 2	Gasturbine	
	Cilacap	18 MW x 2	Gasturbine	297,968 KW

Table IV-5 Development Program of Transmission Line Facilities in Central Java

Section	Voltage (kV)	Length (km)	No. of Circuit	Year 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

4.3.2 Power potential in the region

In Central Java, large potential of hydro electric power is not expected. Potential of more than 100 MW is only reserved in K. Serayu basin. The Sala River and other major rivers in the Central Java flow generally in very flat plain area. Sites suitable for hydropower generation are therefore very scarce along the river and only small capacity of several megawatts is expected.

According to the Master Plan of Sala River Development, there are four potential sites for hydropower generation in the basin, exploitable by the multipurpose dam schemes. The expected output and annual energy of these schemes are shown in the table below.

Table IV-6 Power Potential of the Sala River

Scheme	Power Output (kW)	Annual energy (MWh)
Wonogiri dam	10,200	28,200
Badegan dam	6,000	18,800
Bendo dam	3,500	10,000
Jipang dam	18,000	70,800
Total	37,700	127,800

Note: Figures other than for Wonogiri are extracted from the Master Plan Report.

4.3.3 Proposed development plan

Since hydropower is the most economical means to meet peaking load for relatively short duration, it is desirable to design the hydropower station to bear peak power supply as much as possible in such area having small hydropower potential as Central Java. In this connection, the proposed Wonogiri power station is assumed to take a part of peaking power supply and further to provide some off peak power if available.

An alternative plan of the power development scheme is to exploit the Wonogiri power station as a base-load plant supplying power to an isolated area around Wonogiri district. However, it was abondoned in view of less economy of the plan and low dependability of power supply due to the particular condition of water utilization as explained below.

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. Owing to this operation rule, discharge for power generation varies seasonally in wide range and effective head also fluctuates due to the large fluctuation of reservoir water level. Accordingly, the seasonal fluctuation of power output is unavoidable, which will result in the drop of dependable power capacity.

Under the above conditions of water utilization, four alternative plans for power installation were formulated to select the most appropriate scale of power development of the project. Table IV-7 shows the alternative plans studied.

Table IV-7 Alternative Power Development Plans

Item	Plant design discharge (m^3/sec)			
	44 Plan-a	52 Plan-b	60 Plan-c	68 Plan-d
Installed capacity (kW)	7,600	8,900	10,200	11,600
85% dependable peak power (kW) /1	5,400	6,200	6,910	7,500
Annual energy output (MWh) /2	28,400	28,300	28,200	28,000
Construction cost /3 (10^3 US$)	12,165	12,928	13,548	14,872
Const. cost per kW of dependable peak power (US$/kW)	2,253	2,085	1,961	1,983

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

/2 Plant factor is assumed at 80%.

/3 Cost includes generating equipment, transmitting facilities, and specific items of civil works such as waterway, power house.

Taking into consideration that the total annual energy output is almost the same for all the alternative plans, the comparison was made on the basis of the construction cost per kW of 85% dependable peak capacity. The result of the comparison shows that the construction cost is minimized in Plan-c.

The power development scale of the project is therefore selected at 10,200 kW in installed capacity with yearly energy production of 28,200 MWh.

4.3.4 Power benefit

Benefit from hydropower is estimated based on the cost of the competitive alternative thermal or diesel system. In this case, the least costly alternative is assumed to be oil-fired thermal plant having 50 MW in installed capacity. On the basis of this assumption, the capacity value and the energy value of the power output are estimated as follows:

<u>Capacity value (kW value)</u>

From the recent cost data of the thermal power project, it is estimated that the unit construction cost per kW of the installed capacity is US$770. Using this figure and assuming an interest rate of 12%, the capacity value of the alternative thermal power is calculated at US$111/kW.

The capacity value of the Wonogiri hydropower is evaluated at US$125.4/kW by applying a capacity adjustment factor of 1.13[/1] for the adjustment of difference between hydro and steam plants.

/1 The capacity adjustment factor is calculated on the basis of the following assumptions:

	Hydro (%)	Thermal (%)
Loss at substation	4.0	2.0
Forced outage	-	2.0
Auxiliary power use	0.3	6.0
Overhaul	2.0	8.0

$$\text{Adjustment factor} = \frac{(1-0.04)\ (1-0.003)\ (1-0.02)}{(1-0.02)\ (1-0.02)\ (1-0.06)\ (1-0.08)} = 1.13$$

Energy value (kWh value)

Energy value is estimated on the basis of the operation cost for generating one kWh of power energy by the alternative thermal plant. For the claculation of the energy value, international market price instead of local market price is applied to the fuel cost.

Price of Fuel	US$0.06/ℓ
Fuel consumption	0.287 ℓ/kWh
Energy cost	US$0.0172/kWh

Energy value of the Wonogiri hydropower is evaluated at US$0.0179/kWh by applying the energy adjustment factor of 1.04 /1.

Annual benefit

Annual benefit from the Wonogiri power station is estimated at US$1.35 million as shown below:

Capacity benefit	
6.910 kW /2 x US$125.4	= US$867,000
Energy benefit	
28,200 MWh x 0.96 /3 x US$0.0179/kWh	= US$485,000
Total annual benefit	US$1,352,000
	(÷ US$1,350,000)

/1 The energy adjustment factor is calculated based on the following assumptions;

	Hydro (%)	Thermal (%)
Loss of primary substation	4.0	2.0
Auxiliary power use	0.3	6.0

Energy adjustment factor $= \frac{(1-0.04)\ (1-0.003)}{(1-0.02)\ \ (1-0.06)} = 1.04$

/2 85% dependable peaking capacity

/3 4% transmission loss excluded

4.4 Agriculture and Irrigation

4.4.1 Land use and cropping pattern

Project land

Land commanded by the irrigation scheme of this project covers about 32,000 ha in area. Topographically, the area is divided into two areas; namely, the left bank area of 4,000 ha till K. Gawo and the right bank area of 28,000 ha till K. Kedungbateng. The area extends northward for about 60 km along the Sala River with relatively narrow width of 4 to 5 km between the altitude of 80 m to 100 m. Soils in the project area consists of alluvial (60 % of the total area) and grumsol (40 %).

Land use

Out of 32,000 ha, cultivated area is about 23,400 ha at present; 20,900 ha of sawah and 2,500 ha of tegal. The ratio of sawah to tegal is around 8.4:1 in the project area. Compared with the ratio in the whole upper Sala basin of 1.3:1, this area seems to be in much more favorable condition for crop production.

As shown in Table IV-8, paddy is a main crop in the project area which covers 67 % of the total cultivated area in the wet season but only 22 % in the dry season. The remaining land is used for sugar cane, tobacco and polowijo such as maize, cassava, peanuts, soybean, beans, sweet potato and vegetable. In the area as a whole, utilization of farm land is rather intensive and overall crop intensity already attains to 1.76 at the present stage.

After the irrigation facilities are provided for the area, the land is expected to be used more intensively particularly in the dry season. Additional 200 ha of land will be changed into cultivated land through introduction of irrigation system and the total acreage of cultivated land will come to 23,600 ha comprising 21,200 ha of sawah and 2,400 ha of tegal.

Paddy will continue to be the predominant crop in sawah area. The ratio of paddy planting area to the total area will reach about 70 % in the dry season and the cropping intensity will be increased to 1.92.

Present and future land use in the project area is presented by crops in Table IV-8.

Table IV-8 Land Use in the Project Area

(Unit: ha)

Kind of crops	Present (w/o project)			Future
	Wet Season	Dry Season	Yearly	(w/project)
Paddy	15,780/1	5,320	21,100	34,300
Sugar cane	(2,580)	(2,580)	2,580	2,700
Tobacco	-	90	90	800
Polowijo			17,430	7,600
Total crop area			41,200	45,400
Cultivated area			23,400	23,600
Crop intensity			1.76	1.92

Note: /1 including upland paddy of 1,140 ha.

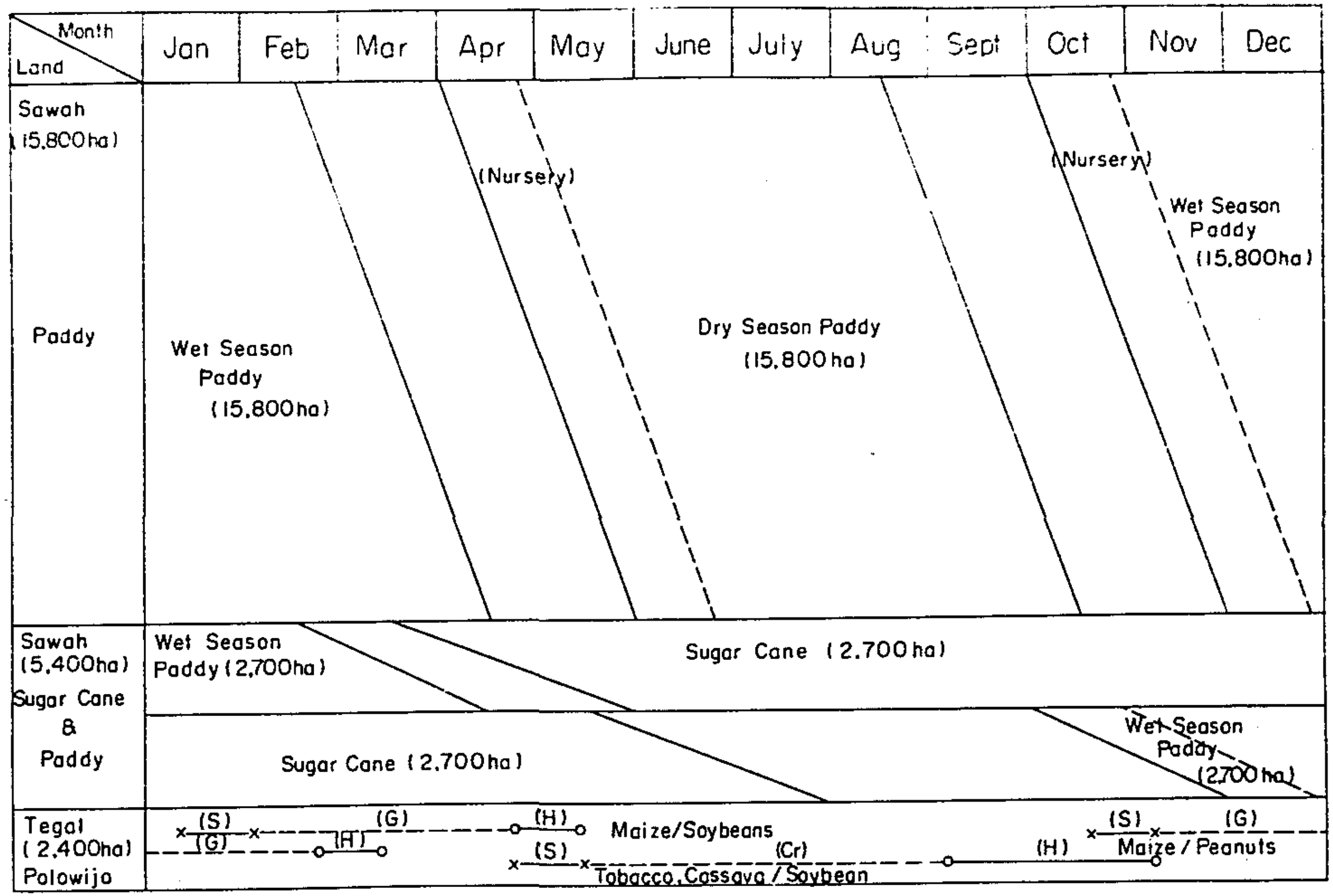
Cropping pattern

If no irrigation facilities are provided, the present cropping pattern will not change appreciably even in the future. Paddy will continue to be a main crop in sawah area. It is only anticipated that the cropping area of some crops such as beans, sugar cane, tobacco, will increase slightly to gain cash income.

After the project is implemented, cropping pattern will be remarkably changed. Anticipated future cropping pattern is illustrated in Fig. IV-1.

According to this cropping pattern, paddy will be cropped in the area about 70 % of the irrigated area of 23,600 ha. Double cropping of paddy will be intensively exercised to increase the production of paddy,

Fig.IV- I. Future Cropping Pattern (with Project)



Note : (S) ······ Sowing (G) ······ Growing (H) ······ Harvesting which will be attainable by the adoption of year-round irrigation on farms. Polowijo such as maize, cassava, will be cropped in reduced area, while cash crops particularly tobacco will gain larger area for increased cropping.

4.4.2 Crop yields

Unit yield

Present unit yield of the agricultural products in the project area is already described in the preceding chapter.

Under the present farming conditions, no increase of the unit yield will be expected in future except slight increase in the unit yield of paddy which is attributable to the extensive use of improved crop varieties and inputs of fertilizers and chemicals.

With the irrigation facilities provided in the area, unit yield is predicted to increase considerably because sufficient water supply will enable the use of fertilizer-response crop varieties and furthermore the implementation of the all weather irrigation will stimulate the improvement of farm management and cultural practice.

Expected future unit yield is estimated after reviewing crop yield data obtained from the field survey in the project area, the results of unit yield investigation by the Central Research Institute for Agriculture of Bogor and actual yield attained during the period of Pelita I.

Particularly in estimating the unit yield of paddy, the following data are referred:

i) Unit yield of paddy attained 4.4 - 5.8 t/ha (dry stalk paddy) under BIMAS program during Pelita-I.

ii) Some high yield varieties marked the yield of about 4.7 - 5.4 t/ha in paddy grain (about 7 t/ha in dry stalk paddy) at the experimental station of the Central Agriculture Institute of Bogor.

iii) Unit yield of new varieties such as B-9-C, B-57-C, which were bred from traditional varieties, is 4.6 - 5.0 t/ha (paddy grain).

iv) Several experimental famrs in the project area actually yield 5.0 - 6.0 t/ha (dry stalk paddy).

The future unit yield of various crops is estimated for both the without-and with-project conditions in the following table:

Table IV-9 Future Unit Yield of Crops

(Unit: ton/ha)

Kind of Crops	Without-Project	With-Project
Paddy /1		
Dry season	3.5	5.5
Wet Season	3.6	5.5
Upland	1.9	-
Maize	0.5	2.0
Cassava	3.3	5.0
Peanuts	0.5	1.5
Soybean	0.4	1.4
Tobacco /2	0.4	0.8
Sugar cane	85.0	120.0

Note: /1 Dry stalk paddy

/2 Dry leaf

Crop production

Future production of farm crops in the project area is estimated on the basis of the land use plan and unit yield data defined in the preceding studies. In the estimate, irrigation area is assumed at 23,600 ha in total area.

Table IV-10 shows the future crop production for both the without- and with-project conditions.

Table IV-10 Future Crop Production

(Unit: tons)

Kind of crops	Without-project (A)	With-Project (B)	Increment (B) - (A)
Paddy /1			
Dry season	18,620	86,900	68,280
Wet season	52,704	101,750	49,046
Upland	2,166	-	- 2,166
(Total paddy)	(73,490)	(188,650)	(115,160)
Maize	2,820	3,000	180
Cassava	21,351	7,500	- 13,851
Peanuts	510	2,250	1,740
Soybean	980	3,220	2,240
Tobacco /2	36	640	604
Sugar cane	219,300	324,000	104,700

Note: /1 Dry stalk paddy
/2 Dry leaf

As mentioned above, expected increase in paddy production will be about 115,000 tons at the full development of the irrigation project.

In view of the present shortage and the future demand increase for rice corresponding to the population growth, the above increased production of 115,000 tons will find outlets in the market in and outside the project area.

Sugar cane and other polowijo crops also have sufficient domestic demand, which are now partly exported.

4.4.3 Irrigation benefit

For the estimate of irrigation benefit, expected incremental net income from the agricultural products is firstly estimated by using the enterprise method.

In succession, an adjustment is made by reducing the expected decrease of benefit owing to flood damage on farm crops in Sragen area where the flood protection work will not be provided.

Price of agricultural product

For evaluating economic values of the products, the projected international market price/1 is used. The farm gate prices are then estimated based on the above prices taking into account the transportation cost and other expenses.

Table IV-11 Farm Gate Price of Agricultural Products

Kind of Crops	Price (Rp./ton)
Paddy/1	60,000
Maize	30,000
Cassava	13,000
Peanuts	95,000
Soybean	69,000
Tobacco/2	360,000
Sugar cane	5,000

Note: /1 Dry stalk paddy
/2 Dry leaf

/1 The international price applied in this report is based on IBRD estimate. See Appendix 9 for details.

Production cost

The quantities of inputs required for the production of each crop are estimated on the basis of the data collected from the local agricultural offices and the Central Statistics Bureau.

With respect to the price of inputs, the projected international market price is applied. Labour cost and other related costs are estimated based on the data collected from the local agricultural offices.

Estimated production cost is presented by crop items in Table IV-12.

Table IV-12 Production Cost per Hectare

(Unit: Rp.)

Kind of Crops	Without-Project	With-Project
Paddy		
Dry Season	55,900	79,000
Wet Season	54,800	79,000
Upland	36,000	-
Maize	8,900	17,800
Cassava	15,200	21,300
Peanuts	20,600	42,400
Soybean	15,400	37,600
Tobacco	107,200	141,400
Sugar cane	172,800	234,400

Incremental income from agricultural production/1

Net income of each crop per ha for without-and with-project conditions is calculated on the basis of the price of products and production cost and the result is presented in Table IV-13.

The expected increase in annual net income will be Rp.5,934.8 million (US$14.3 million), as detailed in Table IV-14.

/1 Further details of crop enterprise study are included in the Annex II, Study Report (2).

Table IV-13 Net Income from Crop Production

Kind of crops		Without Project			With Project		
		Gross returns (Rp/ha)	Product. expenses (Rp/ha)	Net income (Rp/ha)	Gross returns (Rp/ha)	Product. expenses (Rp/ha)	Net income (Rp/ha)
Paddy/1	Dry Season	210,000	55,900	154,100	330,000	79,000	251,000
	Wet Season	216,000	54,800	161,200	330,000	79,000	251,000
	Upland	114,000	36,000	78,000	-	-	-
Maize		15,000	8,900	6,100	60,000	17,800	42,200
Cassava		42,900	15,200	27,700	65,000	21,300	43,700
Peanuts		47,500	20,600	26,900	142,500	42,400	100,100
Soybean		27,600	15,400	12,200	96,600	37,600	59,000
Tobacco/2		144,000	107,200	36,800	288,000	141,400	146,600
Sugar cane		425,000	172,800	252,200	600,000	234,400	365,600

Note: /1 Dry stalk paddy, /2 Dry leaf

Table IV-14 Net Incremental Income

Kind of Crops	Without Project			With Project			Difference
	Cult. land (ha)	Average return (Rp/ha)	Total return (Rp.)	Cult. land (ha)	Average return (Rp/ha)	Total return (Rp.)	(6) - (3) (Rp.)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Paddy/1							
Dry Season	5,320	154,100	819,812,000	15,800	251,000	3,965,800,000	3,145,988,000
Wet Season	14,640	161,200	2,359,968,000	18,500	251,000	4,643,500,000	2,283,532,000
Upland	1,140	78,000	88,920,000	-	-	-	-88,920,000
Maize	5,640	6,100	34,404,000	1,500	42,200	63,300,000	28,896,000
Cassava	6,470	27,700	179,219,000	1,500	43,700	65,550,000	-113,669,000
Peanuts	1,020	26,900	27,438,000	1,500	100,100	150,150,000	122,712,000
Soybean	2,450	12,200	29,890,000	2,300	59,000	135,700,000	105,810,000
Tobacco/2	90	36,800	3,312,000	800	146,600	117,280,000	113,968,000
Sugar Cane	2,580	252,200	650,676,000	2,700	365,600	987,120,000	336,444,000
Total	39,350		4,193,639,000	44,600		10,128,400,000	5,934,761,000

(≑ U.S.$14,300,000)

Note: /1 Dry stalk paddy, /2 Dry leaf

Derivation of irrigation benefit

Even after the construction of the Wonogiri dam and the river improvement work, flood condition in Sragen area will be left unimproved. Since the net incremental income estimated in Table IV-14 is calculated on the condition that the whole of the project irrigation area will be completely protected from flooding by the river improvement work, the expected flood damage in Sragen area should be deducted for assessing the net irrigation benefit.

Anticipated flood damage in Sragen area is estimated at US$680 thousand using the same method exercised in the estimate of flood control benefit. (Details are explained in Annex II, Study Report (2).) With the above flood damage included, the amount of annual benefit from the irrigation project is estimated at US$13,620 thousand.

Besides the above benefit, it is expected that an additional benefit will accrue from the production increase in some areas outside the project area where the additional water saved by the project can be utilized. The benefit is estimated at about US$200 thousand annually,/1 but excluded from the calculation of the economic analysis for the conservative estimate of benefit.

4.4.4 Water requirement

Since no field data on the consumptive use of water of the crops are available, the consumptive use is calculated by using Blaney-Criddle method based on the climatic data available in the project area.

Consumptive use calculated by the above method is shown below, together with percolation, puddling water requirement, effective rainfall data.

/1 Refer to Annex II, Study Report (2).

	Dry Season	Wet Season	Yearly
Consumptive use (mm/day)			
Paddy	7.9	7.8	7.5
Sugar cane			4.9
Percolation (mm/day)	3	2	
Puddling water (mm)	150	200	
Effective rainfall (mm/day)	0.8-3.0	5.6-8.4	

Based on the above data, irrigation requirement of crops is estimated as follows;

	Paddy rice	Sugar cane	Polowijo (tegal)
Annual (mm)	1,686	496	423
Dry Season (mm)	1,233	442	423
Wet Season (mm)	453	53	0
Daily max. (mm)	11.3	5.8	4.0

Overall irrigation efficiency in the project area is assumed to be about 70% from experimental data in the paddy land of Java. Applying this 70% irrigation efficiency, diversion requirement for the irrigation of 23,600 ha is estimated at 429 million m^3 (excluding loss in Colo pondage). Maximum monthly requirement occurs in June at the rate of 33.5 m^3/sec.

4.4.5 Irrigation system

Four alternative plans are formulated to select the most appropriate system of irrigation facilities. Outlines of these alternatives are briefly explained below and the proposed layout is illustrated in Appendix 10.

Alternative plan - A: Water is taken from the intake pondage at Colo, located at 13 km downstream from the damsite and delivered by gravity flow to the irrigation area of 23,600 ha extending downstream on both banks.

Alternative plan - B: Irrigation water is directly released from the Wonogiri reservoir into main canals and conveyed by gravity flow. Two sub-alternative plans are conceived in this case. One is to divert water to both banks and the other is to divert it to the left bank only.

Alternative plan - C: Main system is the same as plan-A. A pumping station will be provided to irrigate a part of the left bank area.

Alternative plan - D: Irrigation area is divided into two areas; the upstream part and downstream part. As to the upstream area, the scheme is basically the same as plan-A, while for downstream area, two sub-alternative plans are considered. One is to obtain irrigation water from the Sala River by pump and then to convey water to the area, and the other is to build a diversion weir at Surakarta for distributing water to the area by gravity flow.

Comparison of the above alternative plans was made on the basis of required construction cost per ha including operation and maintenance cost. Through the evaluation, the plan-A is selected as the most beneficial plan. Further details of the comparative study are included in Appendix 10 of this report and Annex (II), Study Report (2).

4.5 Flood Control

4.5.1 Flood control plan

Flood control work will consist of flood regulation by the Wonogiri dam and flood protection by the river improvement in the downstream reaches.

As stated in the preceding section, the Wonogiri dam will regulate most of the inflow floods and release the reduced discharge of 400 m^3/sec, in case that flood magnitude does not exceed 4,000 m^3/sec in peak discharge at the damsite. By this control, the flood discharge in the downstream reaches will be decreased to as small as 2,000 m^3/sec at Surakarta.

The present river channel of the Bengawan Sala barely passes the discharge of 500 m^3/sec. Consequently, for eliminating inundation in the downstream reaches, the river flow capacity must be increased to such an extent as 2,000 m^3/sec at Surakarta by appropriate river improvement.

Design flood assumed in the flood control study is S.H.F.D. (Standard Highest Flood Discharge). It corresponds to a flood event having the recurrence probability of 60 years at the damsite and 40 years at Surakarta. Discharge data of the design flood are as shown below.

(Unit : m^3/sec)

Condition	Damsite	Surakarta	Ngawi
Present river condition	4,000	2,160	1,890
After confined in levees (Before regulation by dam)	4,000	5,300	4,900
After regulation by dam	400	2,000	2,830

In this study, river improvement work is proposed for the main stream of the Sala river in the section between Nguter (located at about 16 km from the damsite) and Surakarta, about 32.2 km long along the river course. An alternative plan is to extend the improvement work further downstream to Sragen area. However, it was finally abondoned in view of less economy of the work and the unfavourable effect of flow concentration in the further downstream areas. The improvement work also includes levee construction of 17.5 km in length along the course of six tributaries.

4.5.2 Flood control benefit

Flood control benefit is the expected reduction of flood damages resulting from the flood control work.

In order to estimate the flood control benefit, the present flood damage potential in the project area is firstly estimated based on data of damage rate, occupancy ratio and the value of various properties in the flood affected area.

In succession, flood frequency at Surakarta is estimated to obtain the discharge-frequency relation of the flood events. On the basis of those estimates, annual flood damage is worked out to estimate the benefit of flood control work.

Inundation area

Inundation area at each flood scale is estimated from the past flood records and the results are presented in Table IV-15.

Damage rate

Extent of flood damages on the existing utilities, properties, land and crops depends on the depth and duration of inundation. Damage rates on various properties and crops are estimated as shown in Table IV-16.

Occupancy ratio of the damageable properties

There are various kinds of buildings, utilities and crops in the flood-affected area. The rate of occupancy of buildings, farmland and other facilities was estimated from the data of Surakarta city and several Kabupatens in the project area. Table IV-17 shows the present occupancy ratio of various facilities in the area.

Table IV-15 Flood Inundation Area

(Surakarta area)

Discharge at Surakarta (m^3/s)	Flooding Duration (day)	Total inundation area (ha)	Inundation area by 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	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

Table IV-16 <u>Flood Damage Rate</u>

(1) Building & Household Effects

Flooding depth(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						

(2) Crops

Flooding depth (m)		Flooding duration (days)			
		1 - 2	3 - 4	5 - 6	over 7
0 - 0.5	Paddy	0.14	0.18	0.21	0.23
	Yard crops	0.27	0.42	0.54	0.67
0.5 - 1.0	Paddy	0.16	0.26	0.33	0.36
	Yard crops	0.35	0.48	0.67	0.74
over 1.0	Paddy	0.27	0.42	0.50	0.55
	Yard crops	0.51	0.67	0.81	0.91

Table IV-17 Occupancy Ratio

(%)

	Surakarta city	Other area
Farmer's house	2	81
General residence	88	17
Shop	6	1
Others	4	1
Paddy land	-	77
Yard	-	23

Value of properties and crops

The average values of properties and crops are estimated in Table IV-18.

Table IV-18 Average Value of Properties and Crops

(Unit: US$)

	Surakarta city			Other area		
	Building	House hold effects	Total	Building	House hold effects	Total
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
Others	11,190	9,440	22,870	2,230	410	3,080
(per ha of crop)						
Paddy						520
Yard crops						72

Amount of flood damage per house and farm area is firstly calculated by using the data of damage rate, occupancy ratio and the value of house and crops. The results are summarized in Table IV-19.

Table IV-19 Amount of Flood Damage per House and Crop per Hectare

(a) Per house (Unit: US$)

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	1,418	1,645	1,799	2,005	2,185
Others	45	94	130	152	166	184	202

(b) Crop per ha

Flooding depth (m)	Flooding duration			
	1 - 2	3 - 4	5 - 6	over 7
0 - 0.5	45	59	69	76
0.5 - 1.0	52	84	107	117
over 1.0	87	135	160	176

The total amount of flood damage of the project area is then estimated based on the amount of damages per house and crop per ha multiplied by the total number of houses and crop areas.

Besides the direct damage estimated above, indirect flood damage is also considered. It includes losses from interruption of utility services, losses of normal profit and earnings from daily economic activity, costs incurred by flood warning, evacuation, flood fighting and temporary living of the refugees, etc. The indirect damage is estimated conservatively at 10% of the direct damage.

Table IV-20 summarizes the estimated amount of probable flood damages at different discharges at Surakarta.

Table IV-20 Flood Damage Potential

(Unit: US$1,000)

Discharge at Surakarta (m^3/sec)	House damage	Crop damage	Indirect damage	Total damage
500	-	878	88	966
1,000	995	1,544	254	2,793
1,500	3,078	2,946	602	6,626
2,000	37,191	3,715	4,091	44,997
2,500	39,219	4,207	4,343	47,769

Flood frequency at Surakarta

The peak discharge of the design flood (SHFD) at Surakarta is 2,160 m^3/sec under the present channel condition. It corresponds to the flood having a return period of 40 years at Surakarta. Including this flood data, the frequency of flood events at Surakarta is analysed on the basis of the data recorded in the past 10 years as shown in Fig. IV-2.

Flood control benefit

Annual flood damage in the project area is estimated on the basis of the flood frequency data and the estimated flood damage for each scale of the flood discharge. The estimated annual damage is shown in Table IV-21.

After the Wonogiri dam and river improvement work are implemented, the project area will not be afflicted with inundation and will be relieved of flood damages as far as the flood magnitude is less than SHFD (2,160 m^3/sec at Surakarta under the present channel condition) which will occurs at a recurrence probability of once every 40 years. The relieved flood damage is the benefit attributable to the flood control work. Annual benefit from the flood control plan is, therefore, estimated at US$5.81 million from Table IV-21.

Fig. IV - 2 Return Period - Discharge Curve at Surakarta
(under the present condition)

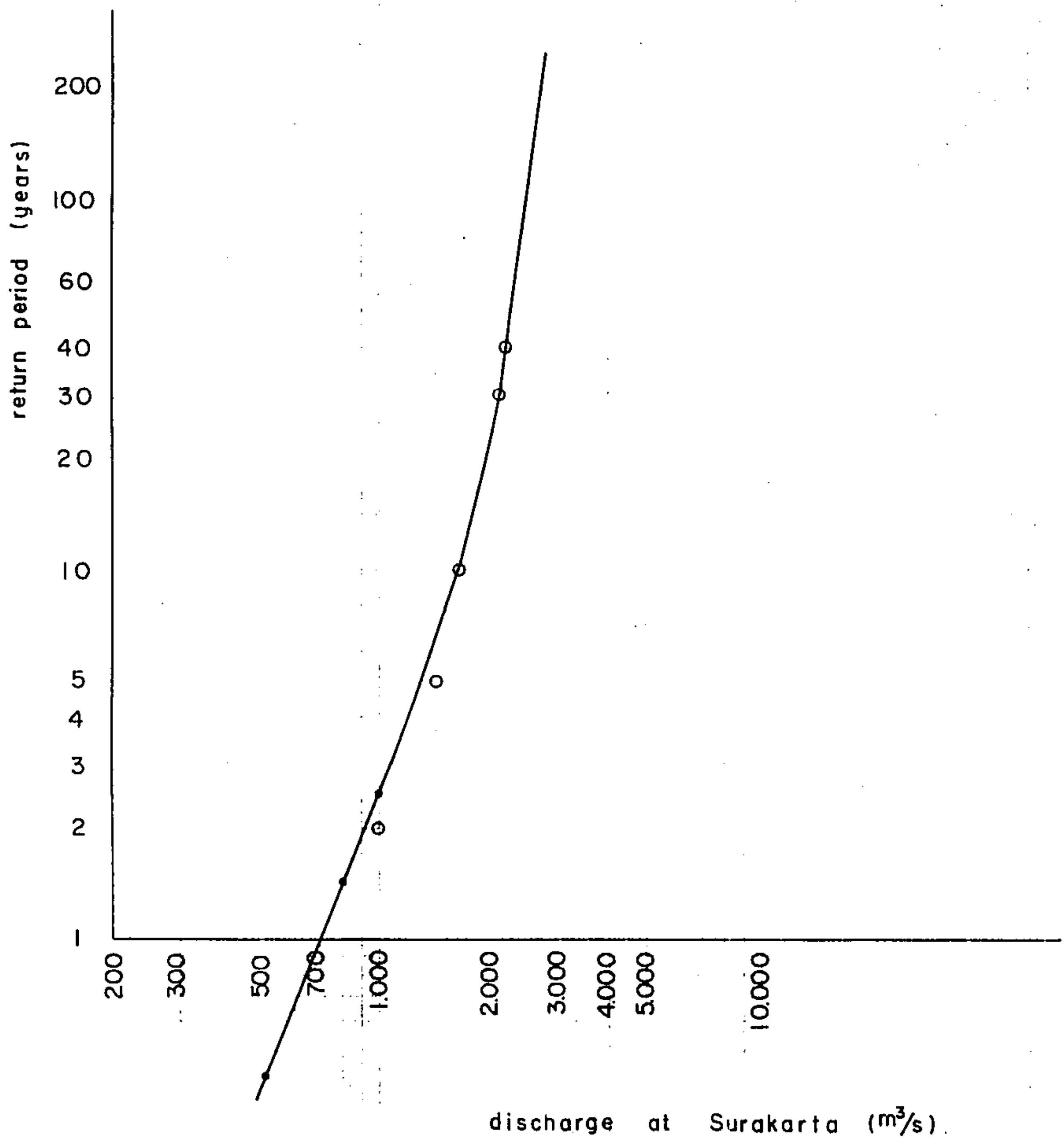


Table IV-21 **Average Annual Flood Damage**

(Surakarta area)

Probability of occurrence	Probability	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			

CHAPTER V

DESIGN AND ESTIMATE

V. DESIGN AND ESTIMATE

5.1 Wonogiri Dam and Reservoir

5.1.1 Dam and reservoir

<u>Damsite geology</u>

In the right bank area, ridges develop at a relatively low elevation. This requires a dam to be constructed over a long distance of about 1,440 m. Overburden (including heavily decomposed tuff) is generally thick with acceptable foundation rock occurred at 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 this 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 minor faults observed at the abutment on the left bank.

<u>Wonogiri Reservoir</u>

The reservoir created by the dam will have a surface area of 87 km^2 at high water level (EL. 138.2 m) during the inflow of S.H.F.D. (Standard Highest Flood Discharge) and a gross storage volume of 730 million m^3.

The normal high water level of the reservoir is EL. 136 m and the low water level is EL. 127 m. The storage between these water levels will be 410 million m^3, which is an active storage for the water supply of irrigation and power generation.

Flood routing capacity of the reservoir is 220 million m^3 above the controlled water level of EL. 135.3 m. Flood inflow will be stored in this space and the outflow of the reservoir will be controlled by gate operation of the spillway in such manner as to maintain the outflow below a rate of 400 m^3/sec.

Sediment volume presumed for the reservoir is 120 million m^3. It is 100-year sediment, the volume being associated with the reservoir water level at EL. 127.0 m.

Fig. V-1 shows the space allocation of Wonogiri reservoir.

Reservoir operation

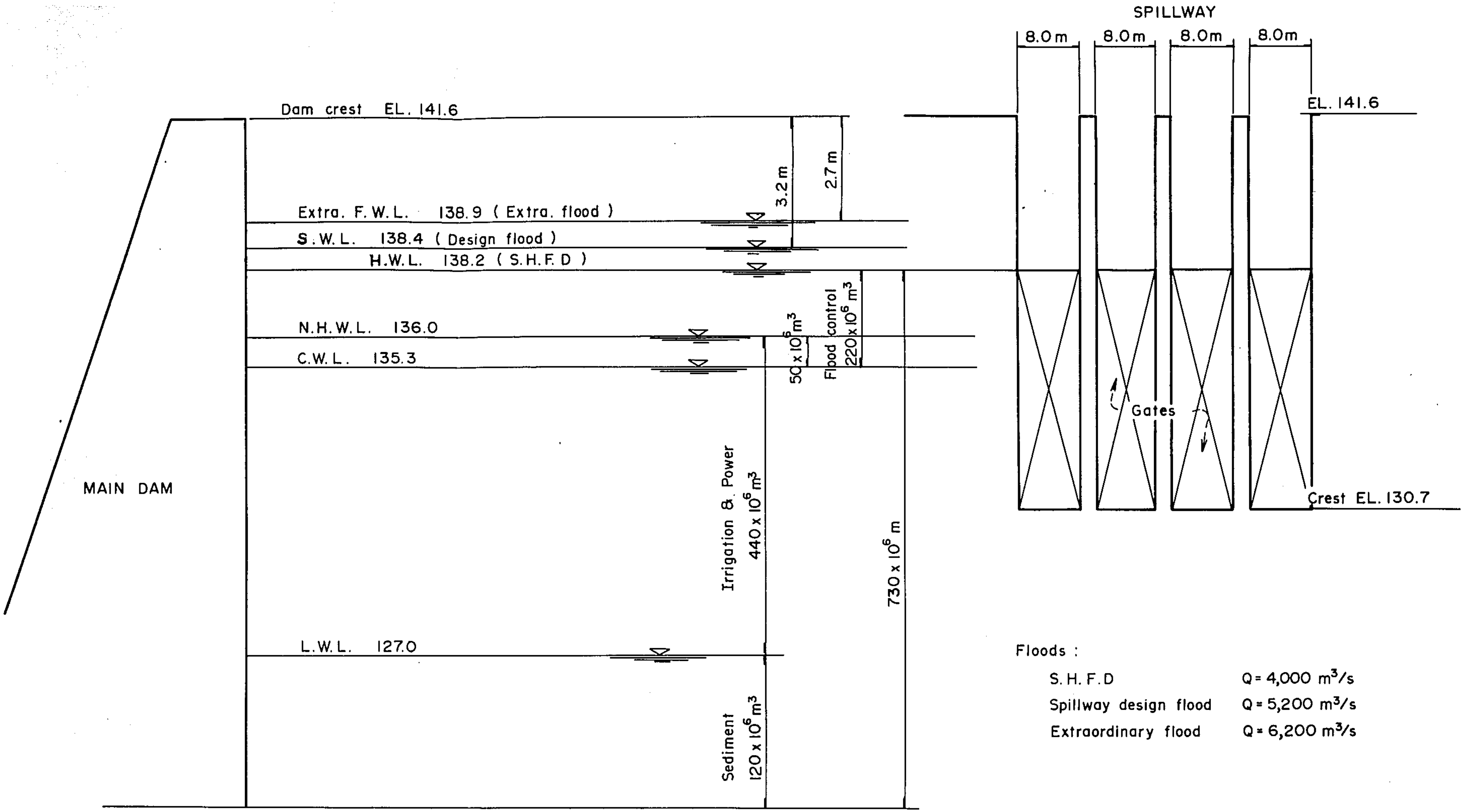
In most years, the reservoir has the maximum storage content at the beginning of the dry season. In the dry season after May, the runoff gradually decreases and stored water will be released to meet the requirement for irrigation use. Water released from the reservoir will firstly pass through the power plant and generate electric power. It will then be stored at the Colo weir, located at 13 km downstream from the damsite, for delivery to the irrigation area. To guarantee the reliable water supply for irrigation use, the reservoir is to be recovered to full stage by the end of every rainy season.

Water released for power generation is principally limited to the quantity required for irrigation, since no additional storage for power generation is provided in the reservoir. In the rainy season of wet years, however, excess water available over the requirement for recovery of the reservoir will be utilized for power generation.

During the dry season (peak irrigation period from June to September), the reservoir will release the water at 27.5 m^3/sec on an average for irrigation use, while in the rainy season (October to May) the release from the reservoir will be about 20.7 m^3/sec including additional discharge for power generation.

Fig. V-2 shows the reservoir operation of the proposed scheme.

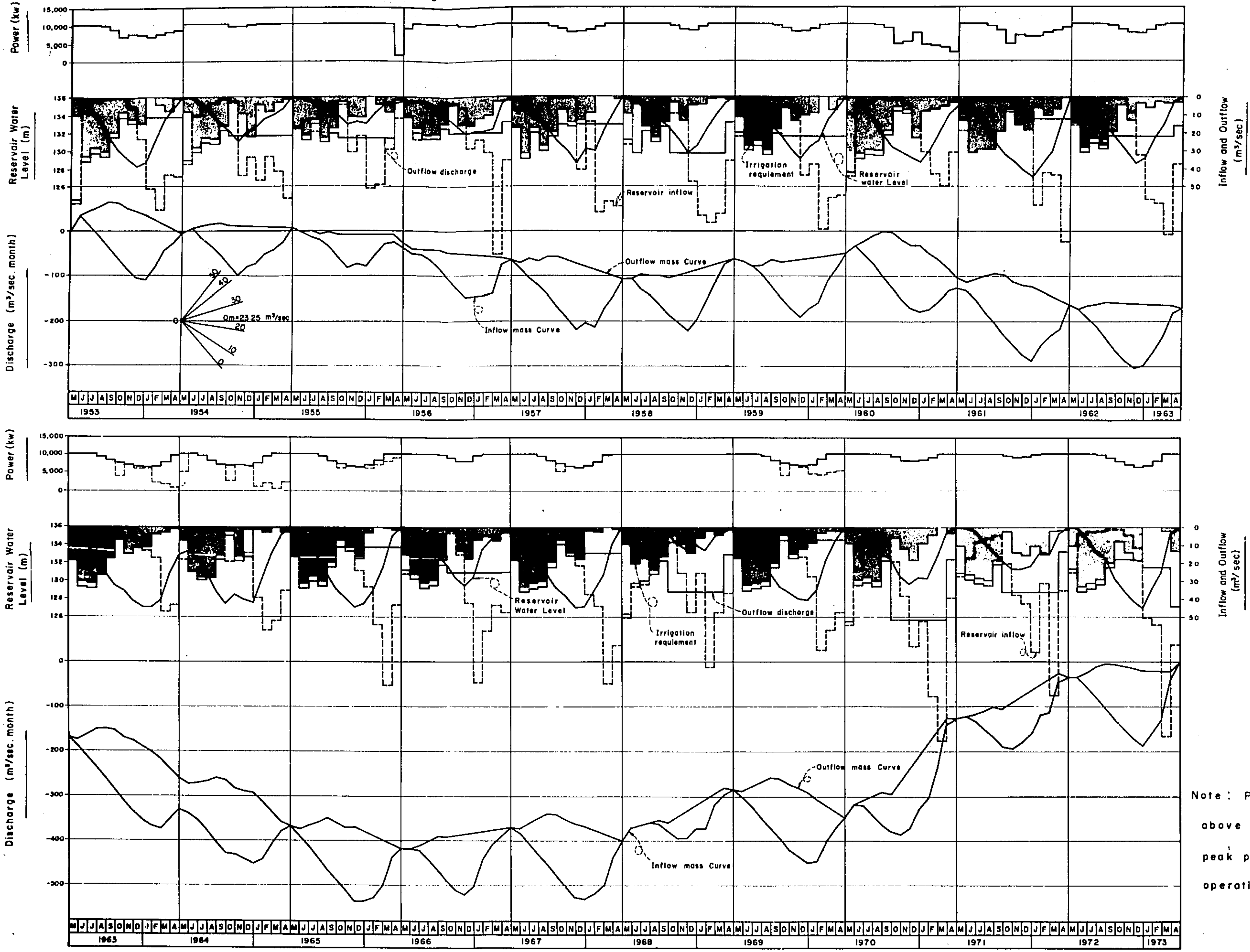
Fig.V-1 ALLOCATION OF RESERVOIR STORAGE



Floods :

S. H. F. D	Q = 4,000 m³/s
Spillway design flood	Q = 5,200 m³/s
Extraordinary flood	Q = 6,200 m³/s

Fig.V - 2 Reservoir Operation of Wonogiri Reservoir



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

Dam

Damsite is selected at the place immediate downstream of the confluence with K. Keduwan because of the advantages in its geological condition and controlling basin 1.6 times larger than the alternative Candi site, located about 3 km upstream from the proposed site.

The type of the dam is determined to be rockfill with central core from the various alternatives such as homogeneous fill type, rockfill with inclined core, etc. The advantages of this type are;

(i) least construction cost requirement,

(ii) least possibility of embankment failure due to the settlement of core,

(iii) easy execution of re-grouting for the foundation of the dam, even if unexpected leakage is found, and

(iv) much experience in the construction of the same type in Indonesia.

Auxiliary embankment (sub-dam) is required in the low ridge area on the right bank. In view of unfavorable geological condition in the area covered with thick overburden earth and heavily weathered tuff, random fill by laying impervious blanket is selected on the upstream side rather than the same embankment as the main dam.

The dam consists of the central core embankment with outer shells of rockfill. The maximum height of the dam will be 37.5 m above the foundation rock and crest length about 1,440 m. The dam crest level is set at EL. 141.6 providing a free board of 2.7 m above the extraordinary flood level (EL. 138.9) and 5.6 m above normal high water level (EL. 136.0 m). Dwgs. WD-001 and WD-002 show the design features of the dam.

For the random fill of sub-dam on the right bank, materials excavated from spillway, intake, powerplant and tunnel will be utilized to the maximum extent. Selected rocks from the excavation will also be utilized for embankment of the inner zones of the main dam. The thickness of vertical core is kept at minimum in view of the relatively high cost of core material which has to be treated by mixing at the stockpile before placing. Embankment volumes required for the dam are shown in Table V-1 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.

Table V-1 Embankment Volume of Dam

Material	Volume ($10^3 m^3$ - Embankment measure)						
	Core	Filter	Transition	Rock	Random fill	Earth blanket	Waste & other use
Required volume	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	-	-	-	-	-	-
Quarry	-	166	123	636	-	-	-

5.1.2 Spillway

A comparative study was conducted to select the most optimum size and capacity of the spillway. Through this study, a relatively small spillway having the maximum discharge capacity of 1,550 m^3/sec was selected, being associated with the dam crest elevation of 141.6 m, which would minimize the combined cost of dam and spillway.

For determining the location and type of the spillway, four alternatives were studied.

(i) Overflow weir type on the left bank with a chuteway, 20 m wide.
(ii) Same type as (i), but with a chuteway, 15 m wide.
(iii) Side channel type on the left bank.
(iv) Overflow weir type on the right bank.

Cost comparison study of the above alternatives revealed that plan (i) would be the most appropriate type, although the difference of the costs are comparatively small in the order of US$200,000 to US$1,000,000 as compared with other plans.

The selected spillway, located on the left bank, consists of an overflow weir 39.5 m wide, concrete-lined chuteway 20 m wide and 360 m long, and hydraulic jump stilling basin 60 m long. On the overflow weir crest are provided 4 roller gates, 8 m wide by 7.7 m high. Dwg. WD-003 illustrates the design features of the spillway.

The spillway is capable of passing 1,550 m^3/sec, outflow of the estimated extraordinary flood, with the water level of EL. 138.9 m, which is 2.7 m lower than the crest of the dam.

Table V-2 summarizes the outflow discharge and the corresponding reservoir water level at the passage of several assumed floods. Flood hydrographs are shown in Fig. V-3.

Fig. Ⅴ - 3 Inflow and

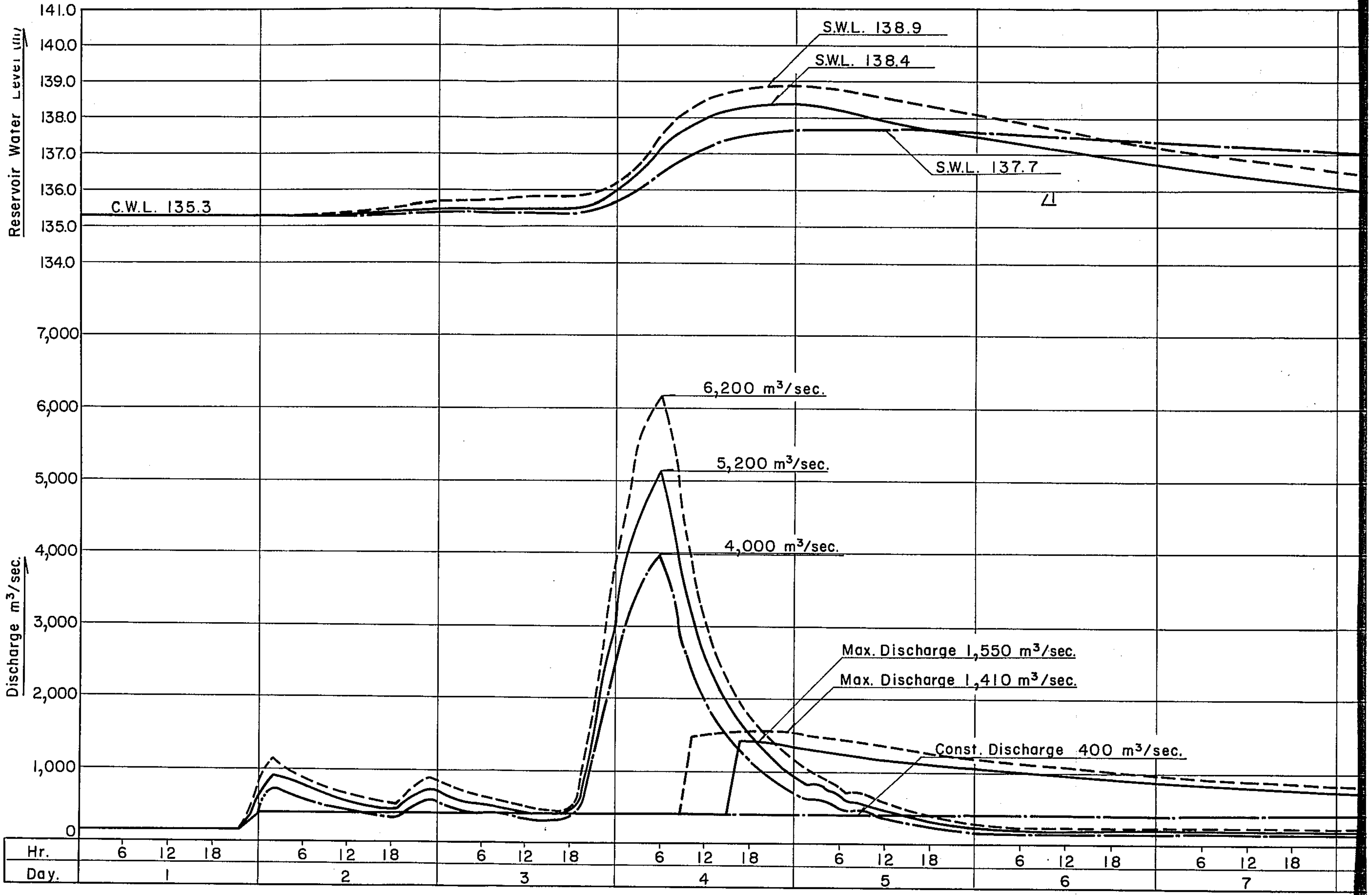
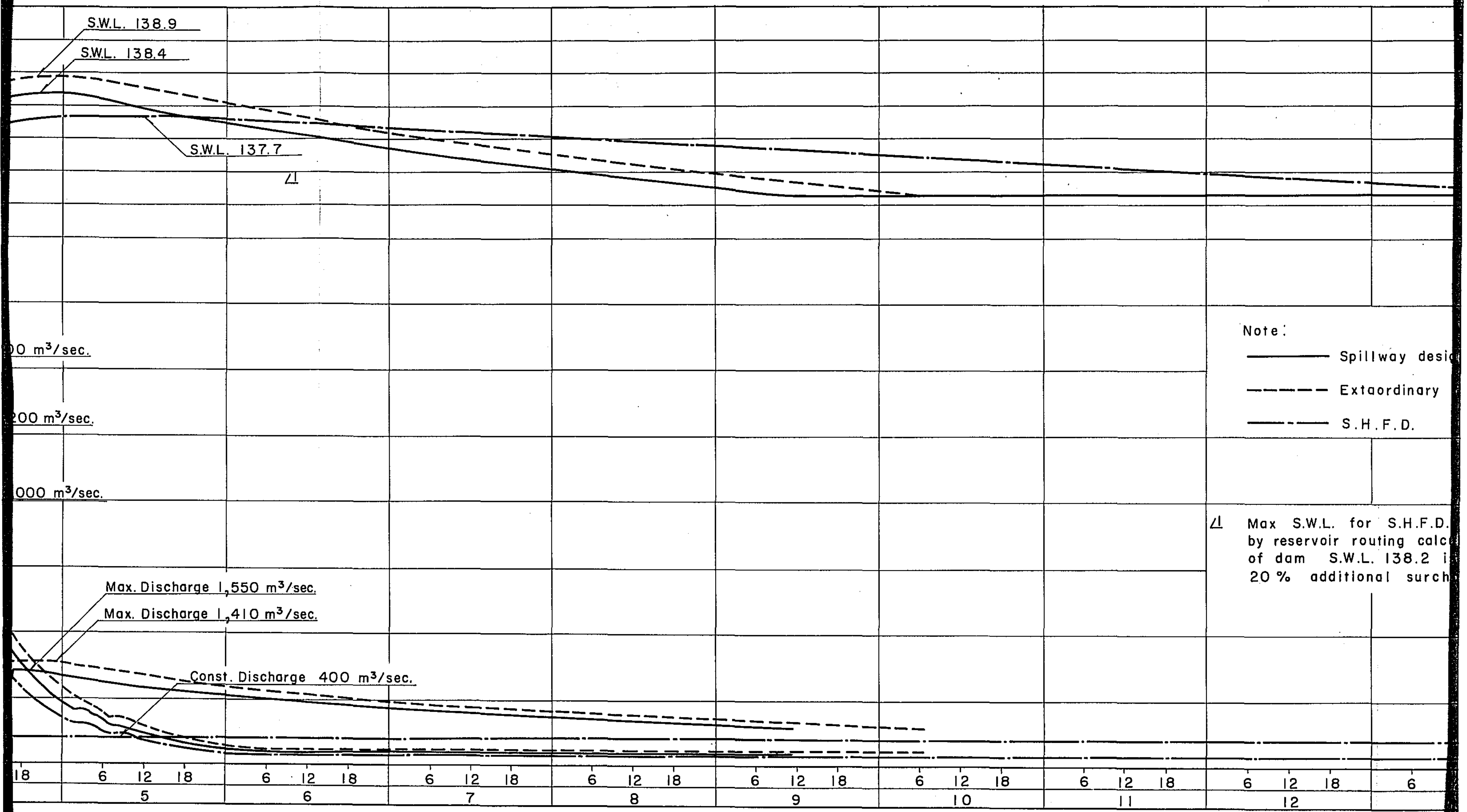


Fig. V - 3 Inflow and Outflow Hydrographs of Flood



nd Outflow Hydrographs of Flood

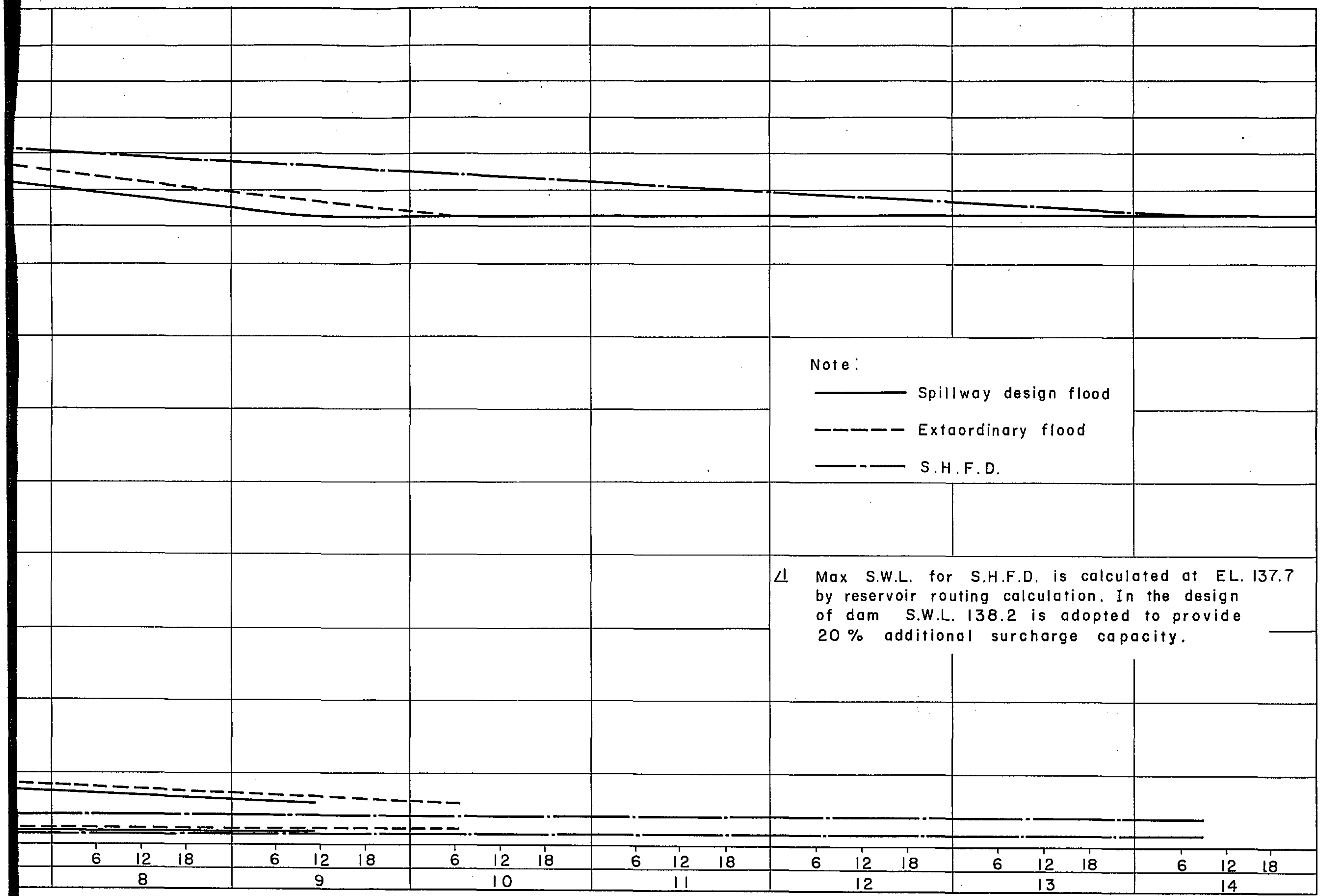


Table V-2 Flood Inflow and Spillway Discharge

Flood event	Max. inflow discharge (m^3/sec)	Total volume of flood (10^6 m^3)	Max. outflow discharge (m^3/sec)	Max. reservoir water level (EL)
S.H.F.D.	4,500	280	400	138.2
Spillway design flood	5,200	370	1,410	138.4
Extraordinary flood	6,200	448	1,550	138.9

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 the usual floods less than S.H.F.D. (equivalent to 60-year flood) at the designated outflow discharge.

In case of the 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.

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

5.1.3 River diversion work

For diverting the river flow during the construction period, diversion conduit is selected instead of the diversion tunnel, because the geological condition underneath the left abutment of the dam suggests that tunnelling through this part may involve some technical difficulties and more cost. The cost of the diversion tunnel is about US$1.0 million higher than that of the diversion conduit.

The diversion conduit will be of semi-circular shape 7.0 m in dia. and 290 m long located on the right bank. River diversion work includes two cofferdams upstream of the main dam embankment; primary cofferdam and main cofferdam. The upstream primary cofferdam will be required during the construction of the main cofferdam. It is planned to be safe against the probable dry season flood having the peak discharge of 300 m^3/sec.

The main cofferdam will become a part of the main dam embankment. It will have the embankment of about 260,000 m^3 at a crest elevation of 127.7 m, capable of handling a 20-year flood with a peak inflow of 3,100 m^3/sec.

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

Emergency coutlet work, a gated conduit of 1.4 m dia. embedded in the diversion conduit plug, is to lower the reservoir water level in an emergency case to be occurred after the completion of the dam.

5.1.4 Intake and pressure tunnel

Intake structure is designed to be vertical tower type. The sill of the intake will be set at EL. 121.0 m for enabling to utilize the additional water stored below the low water level (EL. 127.0 m) for irrigation, if the situation requires in very droughty years.

The intake tower will be of reinforced concrete construction, 17 m in dia. and 23.6 m high above the foundation level. The structure will incorporate a roller gate 6 m wide and 6 m high, operated by the hoisting equipment on the top of the structure. Steel trashracks will be installed on each face of the six openings of the intake.

Pressure tunnel will be circular shaped tunnel with concrete lined of 6 m in diameter. To provide the maximum ground coverture above the tunnel roof in the area below the dam foundation, the tunnel takes a curved route into deep abutment at the lowest elevation of EL. 107.3 m, which is the elevation of water turbines in the power plant.

From economic consideration and low water pressure in the tunnel, steel penstock will only be embedded in a limited length of about 60 m at the downstream end of the waterway.

5.1.5 Outlet valve house

Outlet valve will be provided to by-pass irrigation water. Normally, the required release will be discharged through water turbines of the powerplant. An outlet valve is required to be operated chiefly under an unusual condition such as the shutdown of the powerplant operation, etc.

A valve house, annexed to the power plant building, will accommodate a unit of Hollow-jet valve of 1.8 m dia. It is capable of discharging 35 m^3/sec at the low water level of the reservoir.

5.1.6 Land acquisition and road relocation

The land which will be submerged by the construction of the reservoir will be acquired in advance of the respective construction works and the area be cleared before the impoundment of the reservoir.

The maximum water level of the reservoir is estimated at EL. 138.9 m at the occurrence of an extraordinary flood. Assuming that the land to be acquired is the areas below EL. 140.0 m, the right of land for the reservoir is estimated at about 9,700 ha. About 9,600 families will have to be resettled under appropriate legal procedures.

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

The land area to be acquired and the number of houses and inhabitants to be removed for the project construction are summarized as shown in Table V-3.

Fig. V-4 Wonogiri Reservoir and Relocation Plan

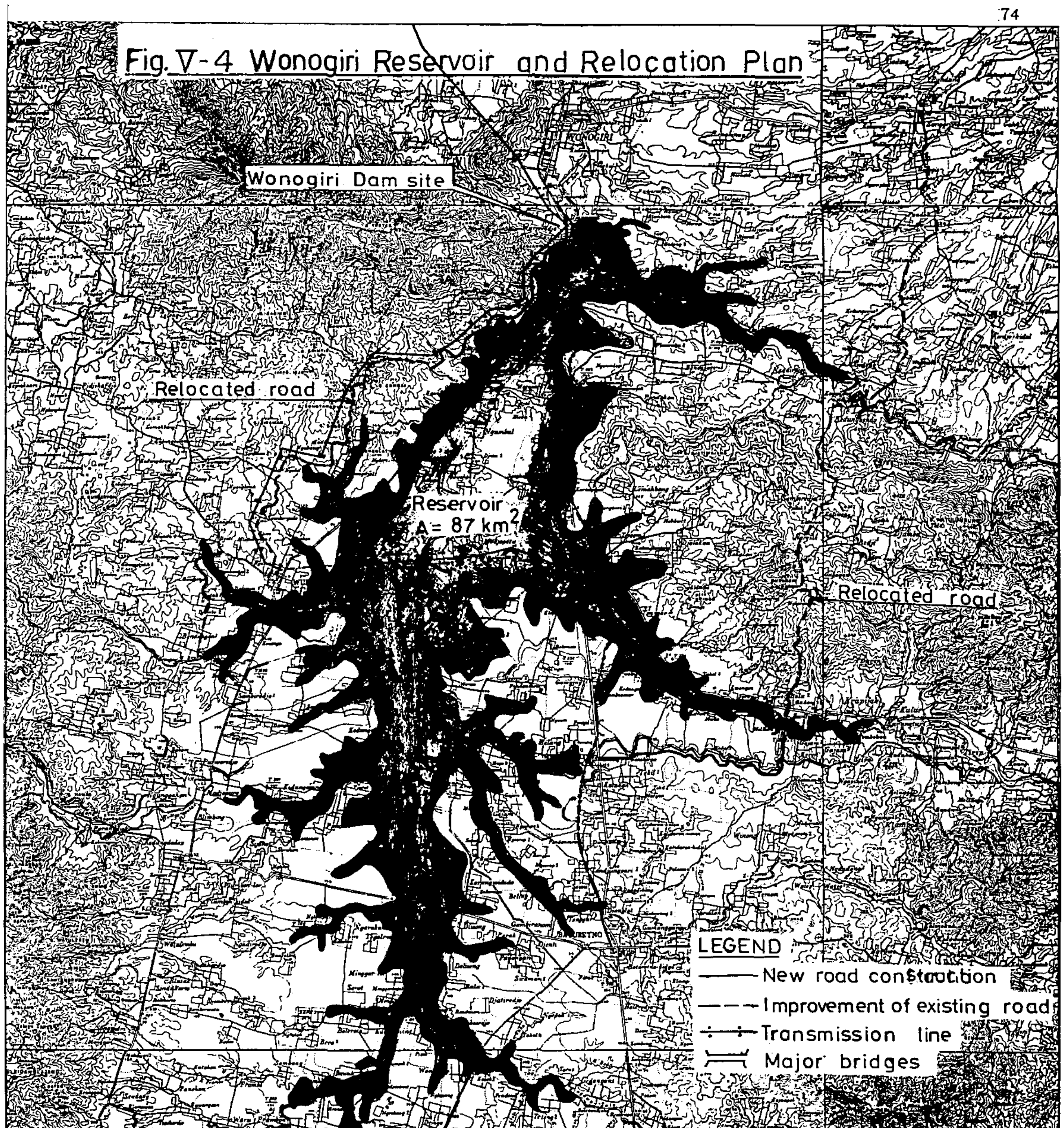


Table V-3. Land Acquisition and Road Relocation

Land Acquisition			
(Reservoir)			
Land	Cultivated land: Sawah		4,438 ha
	: Tegal		2,851 ha
	Yard		2,239 ha
	Cemetery & forestry		206 ha
	(Total)		(9,734 ha)
House			22,918 nos.
Inhabitant	Family		9,573 families
	Population		47,627
(Project construction site)			
Land			24 ha
House			335 nos.
Population (Family)			1,350 (261)
Relocation of road			
New road construction			21 km
Improvement of existing road			34 km
(Total)			(55 km)
Bridges			25 nos.
Clearing of reservoir Area		about	2,500 ha
	(of a total area of 8,700 ha below El. 138.2 m)		

5.1.7 Construction cost estimate

The estimated construction cost of the Wonogiri dam is US$43.4 million which is composed of US$25.4 million equivalent of local currency portion and US$18.0 million of foreign currency portion. It includes the costs for civil works, gate and penstock, land acquisition, road relocation and engineering service.

The contingency of about 15 % of the total cost excluding the engineering and administrative expenses is also included.

Table V-4 shows the summary of the estimated construction cost by work items.

V-4 Cost Estimate for Wonogiri Dam

(10^3 US$)

	Item	Foreign Currency	Local Currency	Total
I.	Civil Works			
	Dam	(3,500)	(2,380)	(5,880)
	Spillway	(2,290)	(850)	(3,140)
	Intake	(400)	(160)	(560)
	Pressure Tunnel	(650)	(230)	(880)
	Power House	(960)	(320)	(1,280)
	River Diversion	(210)	(810)	(1,020)
	Construction Facilities	(540)	(1,500)	(2,040)
	Construction Machinery (Plant & Equipment)	(2,750)	(250)	(3,000)
	Sub-total	11,300	6,500	17,800
II.	Gates & Penstocks	1,800	300	2,100
III.	Land Acquisition & Clearing			
	Land Acquisition	-	(11,300)	(11,300)
	Reservoir Clearing	-	(300)	(300)
	Sub-total	-	11,600	11,600
IV.	Road Relocation	800	3,200	4,000
V.	Contingency	2,100	3,300	5,400
VI.	Engineering & Administrative Expenses	2,000	500	2,500
	Total	18,000	25,400	43,400

5.2 Wonogiri Power Station

5.2.1 Power house

The power house will be located on the left bank just downstream of the dam. The building will be of reinforced concrete construction, 31.5 m long, 19.5 m wide, 18 m deep and 10.5 m high above the ground level. Substructure of the power house will be constructed on the base rock of tuff-breccia.

The power house will accommodate 2 units of generating equipment of 5,100 kW capacity. The units will be installed at 12 m interval from center to center. The elevations of principal floors and center line of turbine are set as follows;

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

One set of tailrace gate will be provided at the outlet of draft tubes which will be handled by travelling monorail crane.

5.2.2 Power equipment

Hydraulic turbine

Hydraulic turbine to be installed at Wonogiri power station will be the vertical shaft, Kaplan type with elbow type draft tube.

The followings are the hydraulic conditions which are taken into consideration in the selection of the hydraulic turbine to be installed at the Wonogiri power station.

Elevation of dam crest	EL. 141.60 m
Normal maximum reservoir water level	EL. 136.00 m
Minimum reservoir water level	EL. 127.00 m
Normal tailwater level	EL. 110.50 m

Due 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. The turbine is designed to have a hydraulic capacity of 30 m^3/sec at the rated head of 21.1 m.

The turbine will have 333 rpm rated speed at the design head and develop 5,100 kW rated output per unit.

Alternating current generator

Generator to be installed at the Wonogiri power station will be an ordinary type of vertical shaft revolving field type coupled directly with the Kaplan turbine. It will have 333 rpm speed and is rated at 6,375 kVA, 6.6 kV, 3-phase, and 50 Hz.

Power factor is assumed at 0.8 considering the reactive power supply from the generator to load center. The terminal voltage of generator is 6.6 kV which would be the most economic voltage for the capacity planned.

Main transformer

Main transformer to be installed at the 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 winding will be grounded directly.

Station service equipment

A.C. station service power will be provided by one 300 kVA transformer which will be connected to the main circuit of the generator. For emergency use, a diesel engine driven generator will be installed in the power house. Electric power for the operation of intake gate and spillway gate will be supplied from one 200 kVA step-up transformer, which will be connected to the low tension circuit.

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

Switchyard equipment

Switchyard, 27 m by 30 m in area, is located adjacent to the power house at the ground level of EL. 117.5 m.

A single circuit transmission line will depart from 150 kV bus. The interrupting capacity of the circuit breakers will be rated at 168 kV, 800 A, 5,800 MVA. The circuit breaker on 6.6 kV side of the generator will be used for parallel operation of the generators at the Wonogiri power station and for synchronizing between the Wonogiri power station and the Tuntang system.

5.2.3 Transmission lines and substation

The power transmission capacity of the single circuit 150 kV system from the Wonogiri power station to East Sala substation is around 10,000 kW based on 5 % regulation and 80 % power factor.

The 150 kV transmission line 40 km long will be constructed along the highway from the Wonogiri power station and East Sala substation via Sukoharjo town and connected to 150 kV bus at the substation. Power for the Sukoharjo town is supplied from East Sala substation by 20 kV distribution line including a step-down transformer (22 kV to 6 kV) which will be connected to the existing 6 kV system.

Another single circuit 20 kV distribution line will be constructed between the Wonogiri power station and Wuryantoro town via permanent construction camp area, from where an additional line is branched off to the Wonogiri town. Step-down transformers will be installed on the distribution lines for delivering power to each distribution area. The power transmission capacity of the lines to each area will be as follows.

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 of Annex I, Study Report (1).

Power line carrier telephone system will be installed on the 150 kV transmission line. It will comprise load dispatching channel and administrative channel.

5.2.4 Construction cost estimate

Total construction cost for the generating equipment and transmission facilities is estimated at US$11.7 million including US$1.51 million equivalent of local currency portion and US$10.19 million of foreign currency portion. The summary of the estimate is given below.

Table V-5 Cost Estimate for Power Equipment

(10^3US$)

Item	Foreign Currency	Local Currency	Total
I. Electric Power Generating			
Generating Equipment	6,851	411	7,262
II. Electric Power Transmission & Communication			
150 kV T/L (1c.c.t., 40 km)	(740)	(400)	(1,140)
20 kV D/L (1c.c.t., 38 km w/Tr. 1250 kVA)	(639)	(380)	(1,019)
Low Tension Line (5km)	(85)	(50)	(135)
East Sala Substation	(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
Total	10,190	1,510	11,700

5.3 Irrigation Facilities

5.3.1 Colo headwork

A diversion weir will be constructed at Colo site, about 13 km downstream from the Wonogiri damsite.

The site is selected at the terrace on the left bank of the Sala River for facilitating the construction of the weir under dry condition. The river terrace consists of fine deposits of sand and clay of 20 to 25 m thick above the bed rock.

A concrete diversion weir having two irrigation intakes for the left and right ends will be constructed on the proposed site. Intake water level of the Colo weir is set at EL.106.5 to provide sufficient head for diverting the water to irrigation areas.

The Colo weir will have a role of afterbay weir to control the peak discharge released from the power station. The power station is designed to discharge the water at the rate of 60 m^3/sec for six-hour peak operation, for which the required regulating storage capacity of the Colo weir will be about 1.2 million m^3. To meet this storage capacity, the normal high water level of the Colo weir is set at EL.107.6 m.

Taking into account the geological conditions at the site, the weir is planned to be a floating foundation type built on the river bed deposit.

A comparative study was conducted to select the type of the weir. Two types of the weir, fixed weir type (Plan A) and movable weir type (Plan B), were compared from the viewpoints of the influence of back water at the time of floods, construction cost requirement and the convenience of operation and maintenance. In the plans, the overflow section of the weir is designed to be capable of passing the flood discharge of 2,000 m^3/sec, an extraordinary flood at the site. Main features of the plans are presented below.

Item	Fixed weir (Plan A)	Movable weir (Plan B)
Total span of weir	108.0 m	108.1 m
Crest EL. of weir	EL.107.6	EL.104.0
Opening for flood	4.4 m x 83.5 m	5.3 m x 75.6 m
Max. back water level	EL.112.0	EL.109.3
Scouring sluice	5.0 m wide x 4.6 m high, 3 nos.	Same as Plan A.
Flood sluice	None	10.8 m wide x 3.6 m high 7 nos.
Construction cost	US$2,500,000.	US$3,200,000.

Although the back water level in the upstream area is kept low in the case of Plan B, the construction cost of Plan B will be more costly than Plan A. Besides, Plan A is superior to Plan B in operation and maintenance aspects.

Finally, Plan A (fixed weir type) was selected as the proposed plan. The main features of the Colo weir are shown in Dwg. WI-003 and WI-004.

5.3.2 Canals

In order to supply the required water to the irrigation area, two main canals, one 25 km long with the design discharge of 4.0 m^3/sec and the other 64 km long with the design discharge of 29.6 m^3/sec, will be constructed in the left bank area and the right bank area respectively. The route of the main canal is aligned on the basis of the available maps of 1/50,000, 1/25,000 and 1/5,000 scale.

Secondary canals will be laid out to supply water to the irrigation blocks of 150 ha in area. Existing irrigation canals will be improved and rehabilitated to utilize them as secondary canals. For areas not irrigated at present or the areas in which the existing canals do not have sufficient capacity, new secondary canals will be constructed.

For the design of the canals, network diagram and design discharge of the main and secondary canals are worked out as presented in Appendix 11.

Preliminary design of the canals is based on the following design conditions;

(i) Type of canal - unlined excavated or earth-embanked canal with trapezoidal section.

(ii) Maximum velocity - less than 0.8 m/sec to protect the unlined section from scouring.

(iii) Longitudinal gradient - to provide enough diverting head at turnouts and to give sufficient head at siphons to wash down sediment and drifts.

Under these principles, preliminary design and layout are prepared and the major features are presented below.

	Left bank area	Right bank area
i) Main canal		
Irrigation area (ha)	2,800	20,800
Design discharge (m^3/sec)		
Initial	4.0	29.6
Tail	0.4	1.0
Total length (km)	25.6	63.9
Gradient of canal	$\frac{1}{2,500} - \frac{1}{3,000}$	$\frac{1}{2,500} - \frac{1}{6,000}$
Canal density (m/ha)	9.2	3.1
ii) Secondary canal		
Number	5	33
Total length (km) (of which rehabilitation)	13.1 (1.0)	131.8 (31.7)
Max. discharge (m^3/sec)	0.8	3.1
Min. discharge (m^3/sec)	0.2	0.2
Gradient of canal	$\frac{1}{2,500}$	$\frac{1}{3,000}$
Canal density (m/ha)	4.7	6.3

Discharge of the main canal varies at the location from 29.6 m^3/s to 0.4 m^3/s, for which 17 types of standard cross sections are designed; 12 types for the right and 5 types for the left main canals respectively. For the secondary canals, 10 types are designed in total.

The standard cross section and longitudinal profile of the canals are shown in Dwgs. WI-005 to WI-008. Details of the types and lengths of the canals are shown in Appendix 12.

5.3.3 Crossing and turnout

Since the proposed canals cross many tributaries, channels, roads, and railway tracks, crossing structures such as culvert, aqueduct, siphon, etc. are required. Major crossing structures along the main canals include 33 on tributaries, 147 on canals, 261 on roads and 16 on railway tracks.

Considerations made for the preliminary design of these crossings are as follows:

(i) Aqueduct is adopted at places where enough clearance above the maximum flood water level is available.

(ii) Siphon is adopted at places where aqueduct can not be adopted.

(iii) Culvert is adopted at places where the existing road or railway is situated at higher elevation than the main canal.

(iv) Road bridge is adopted at places where culvert is not applicable.

(v) Flow velocity in siphon and aqueduct is specified as follows:

Discharge (m^3/sec)	Design velocity (m^3/sec)	
	Siphon	Aqueduct
30 - 10	1.80 - 2.20	2.20 - 2.50
10 - 5	1.50 - 1.80	1.70 - 2.00
2 - 5	1.30 - 1.50	1.50 - 1.80
2	1.00 - 1.30	1.30 - 1.50

Standard designs of crossing structures are shown in Dwgs. WI-009 to WI-012. Types and the number of crossing structures are detailed in Appendix 13.

The proposed irrigation area of 23,600 ha will be divided into 49 blocks, 10 blocks in the left bank area and 39 blocks in the right bank area. Turnouts will be provided at each irrigation block on the main and secondary canals. They are provided at locations where the major existing canals join the main canal, and where the secondary canal branches off to divert the water to newly irrigated area.

Three standard types (Type A, B and C) of turnouts are proposed for enabling the standardized operation of turnout gate and for the convenience of maintenance. Romiyn gate is provided for the type B and type C turnouts and sluice gate is for the type A. Standard design of the structure is shown in Dwgs. WI-013 and WI-014.

5.3.4 Regulating structures and reservoir

For smooth distribution of water from the main canal, diversion of water, protection and maintenance of the canal, emergency treatment, etc., some regulating structures or devices will have to be provided along the canal.

Waste way and spillway

Since many aqueducts or siphons are built on this canal, waste way and spillways will be provided immediate upstream of the crossing structures for the maintenance of canals, clearance of drifts, and evacuation of excess flood water. Typical design of the structure is shown in Dwgs. WI-009.

Check gate

Check gate will be installed just downstream of the major turnouts to maintain water level, to lessen rapid change of water level and to prevent high velocity of flow. Proposed type of the check gate is a combination of the fixed overflow and manual operating gate. Typical design of the check gate is illustrated in Dwg. WI-013.

Regulating reservoir

It would be desirable to provide some regulating reservoirs on the route of the main canal for enabling uniform water distribution over the area. However, if the reservoirs are provided on the main canal in this project area, it requires an additional water head for canal network or makes the irrigable area narrower. Therefore, regulating reservoirs will be provided on the secondary canal which serves the area of more than 1,800 ha.

Three regulating reservoirs are proposed in the system which are capable of storing one day requirement of irrigation water. Homogeneous earthfill dyke is designed for the reservoir.

Major features of the proposed regulation reservoirs are as follows:

		TURNOUT NO.	
	No. 6	No. 30	No. 35
Service area (ha)	1,800	1,820	2,290
Max. discharge (m^3/sec)	2.4	2.5	3.0
WL. of reservoir (m)	EL.97.5	EL.85.0	EL.84.0
Storage capacity (m^3)	210,000	210,000	260,000
Reservoir area (ha)	14.4	11.0	14.2
Reservoir depth (m)	1.5	2.0	2.0
Height of dyke (m)	2.5	3.0	3.0
Length of dyke (m)	1,800	1,100	1,200

Typical design of the structure is shown in Dwg. WI-015.

5.3.5 Irrigation network on farm

The existing small irrigation canals will be utilized as tertiary canals. Since the present density is only 10 m/ha, new tertiary canals or farm ditches will be constructed in the farm to the extent of 30 m/ha, laying out 400 m in distance on an average.

With respect to drainage on farm, the present drains have the density of only 10 m/ha. Additional drains will be provided to prevent inundation due to heavy rains. The density of farm drains will be increased to 30 m/ha.

No additional main drainage will be necessary since the tributaries in the area will work as the trunk drainage.

Farm roads will also be increased to a density of 40 m/ha from the present 20 m/ha.

5.3.6 Operation and maintenance of the irrigation system

Operation and maintenance services for the Colo weir, main and secondary canals and their appurtenant facilities will be managed by the project, while other facilities are managed by the local organization of "Dharma Tirta."

For the over-all management of the irrigation system including water control, inspection and maintenance of the facilities, an irrigation management office will be organized. The office, stationing about 15 staffs, will keep records concerning meteorological conditions, operation and maintenance works.

Management of turnouts, check gates and regulating reservoirs will be made by the operational staffs to be assigned for each facility under the direction of the irrigation management office.

In addition, Colo headwork management office will be necessary. The office, stationing two staffs, will make close contact with the Wonogiri dam office and conduct water control at the headwork. Operation of the scouring sluice gate and periodical inspection on the weir facilities are also the responsibility of the office.

5.3.7 Construction cost estimate

The estimated construction cost of the irrigation facilities is US$33.1 million, consisting of the foreign exchange component of US$16.77 million and the local currency of US$16.33 million as shown in Table V-6.

Table V-6 Cost Estimate for Irrigation Facilities

Item		Foreign Currency	Local Currency	Total
I.	Civil Works			
	Preparatory Works	(-)	(187)	(187)
	Colo Diversion Weir	(2,086)	(881)	(2,967)
	Main Canal	(6,245)	(4,570)	(10,815)
	Secondary Canal (incl. regulating reservoir)	(972)	(1,224)	(2,196)
	Farm Ditch	(-)	(1,115)	(1,115)
	Drainage	(-)	(1,299)	(1,299)
	Farm Road	(-)	(3,718)	(3,718)
	Construction Machinery	(4,237)	(148)	(4,385)
	Sub-total	13,540	13,142	26,682
II.	Land Acquisition	-	800	800
III.	Contingency	2,030	2,088	4,118
IV.	Engineering & Administrative Expense	1,200	300	1,500
	Total	16,770	16,330	33,100

5.4 River Improvement

River improvement work is proposed for the section 32.2 km long between Nguter (located at about 16 km downstream from the damsite) and Jurug, Surakarta (48 km from the damsite) along the main stream of the Sala river. Besides, levee will be also constructed on 6 tributaries in the section where the back water of the main stream reaches, the length of which is about 17.5 km in total. The improvement work consists of levee construction, river bed dredging, bank protection, construction of bridges, and sluice ways, and drainage works.

5.4.1 Design flood

Design flood assumed for the river improvement work is S.H.F.D. (Standard Highest Flood Discharge) having a peak discharge of 4,000 m^3/sec at the Wonogiri damsite. It is regulated by the Wonogiri reservoir and the regulated out flow at the damsite is 400 m^3/sec.

The flood flow increases to 1,600 m^3/sec at Colo site and 2,000 m^3/sec at Surakarta.

Details of the design flood are described in Annex III, Data.

5.4.2 River training and improvement

<u>Alignment of improvement</u>

It was intended that the improvement work would be made along the existing channel to the maximum extent. But the present river channel is so heavily meandering that short cut work is required for a distance of about 12 km out of the total length of 32 km along the main channel.

The proposed plan of improvement work is shown in Dwgs. WF-001 and WF-002.

<u>Longitudinal profile</u>

Longitudinal profile of the river improvement work was studied on the basis of the proposed alignment plan. It was worked out in due consideration of the profile of the present river channel. The proposed longitudinal profile is shown in Dwg. WF-003.

Design high water level

If the design water level of the river channel is set at a relatively low elevation, the improvement work would require much excavation work which will be costly. The channel improvement will therefore be planned in an adequate combination of channel excavation and levee construction. The design water level in the proposed plan is assumed at the highest flood level recorded in the past (1966 flood).

Cross section of river channel

Single cross section usually requires the least flow area. However, in case of the Sala River in which seasonal fluctuation of the river flow is extremely large, composite type cross section is recommendable to stabilize the dry season flow and to avoid the concentration of high flood flow.

Since the present river channel has been formed by natural force and shows relatively stable flow condition in the low water season, the design discharge for the low water channel is determined to accord with the present flow capacity.

Standard cross section is shown in Dwg. WF-004.

Bank protection

At present, the river bank is eroded at many places along the river course, especially at sharply meandering sections. No bank protection works are provided presently except pile groines at quite few places.

The proposed improvement work involves the construction of long levees along the both banks of the river. Sodding and stone pitching are planned for the protection of banks. The stone pitching with foot protection work is proposed for the parts of sharp meandering, while sodding is applied for the other sections.

Drainage of inner basin

Run-off from the inner basin will be gathered and drained through adequate systems of collecting ditches and channels. Most of them are connected to the tributaries for draining therefrom.

There are many small channels and ditches flowing into the river, which are presently functioning to drain the inland water. After the levee is constructed, inland draining will be made through sluiceways to be constructed at necessary places. The sluiceways will be provided with gates to shut-off the reverse flow from the river to inland area.

5.4.3 Construction cost estimate

Total construction cost of the river improvement works is estimated at US$18.27 million, consisting of the foreign exchange component of US$6.217 million and local currency of US$12.053 million as shown in Table V-7.

V-7 Cost Estimate for River Improvement

(10^3US$)

Item	Foreign Currency	Local Currency	Total
I. Civil Works			
Excavation	(-)	(3,190)	(3,190)
Banking	(-)	(2,322)	(2,322)
Bank Protection	(-)	(2,729)	(2,729)
Bridge	(51)	(34)	(85)
Sluice way	(644)	(276)	(920)
Interception Drain	(-)	(240)	(240)
Construction Machinery	(4,015)	(-)	(4,015)
Sub-total	4,710	8,791	13,501
II. Land Acquisition	-	1,514	1,514
III. Contingency	707	1,548	2,255
IV. Engineering & Administrative Expenses	800	200	1,000
Total	6,217	12,053	18,270

CHAPTER VI

CONSTRUCTION PLAN

VI. CONSTRUCTION PLAN

6.1 Basic Considerations

The construction plan for the Wonogiri Multipurpose Dam Project is formulated in this chapter taking into account the local availability of the construction materials, requirement for machineries and equipment, climate condition, accessibility of the project site and other related factors.

In this construction plan, the construction period to be required is minimized as practical as possible for the efficient execution and acquiring the expected benefit soon.

6.1.1 Construction materials

Embankment materials

The Construction work will require approximately 10 million m^3 of embankment work, of which 1.9 million m^3 will be for the dam and its appurtenant facilities, 2.9 million m^3 for the irrigation facilities and 5.2 million m^3 for the river improvement works.

Investigation has shown that impervious core, filter and rock materials for the dam embankment are all available in the area within 3 km from the damsite. Selected rock materials from the excavation will also be utilized for the embankment works such as the dam, temporary cofferdams, powerplant backfill, etc.

Embankment materials for irrigation facilities and river improvement area mostly obtained from the excavation works.

Concrete materials

Estimated total quantity of concrete work will amount to 146,000 m^3 for the dam, power station, irrigation facilities and river improvement.

As to concrete work in the dam and related structures, aggregate will be supplied from the river deposit in the foundation area of the dam. It is presumed that the deposit will yield about 140,000 tons of aggregate, which is slightly short of the total requirement. The deficient will be supplemented by the sand and gravel bars along the course of Kali Keduwan. For irrigation and river improvement works, aggregate will be available from river deposits near the work site.

Required total quantity of cement, which is assumed to be imported, will be about 49,000 tons including the requirement for the dam grouting works.

Reinforcing steel bars of about 4,800 tons will be required, presumably to be imported.

Mechanical and electrical equipment

Most of the hardware and equipment required for the works such as structural steels, penstocks, gates, major electrical equipment, will have to be imported. For other materials, local products will be utilized to the maximum extent. The major items available are wooden goods, bricks, stone blocks, oil products, etc.

6.1.2 Construction plant and equipment

Various kinds of construction plant and equipment are required for the Wonogiri Multipurpose Dam Project with different capacities.

There exist no domestic manufacturers and assemblers of heavy duty machinery at present. Many kinds and number of construction plant and equipment have been imported for the various similar projects and some of them are suitable for the execution of this project. But most of them are fully engaged and not transferable to this project. Most of plant and equipment for this project are therefore to be imported.

6.1.3 Construction facilities

Construction facilities including residential quarters, offices, warehouses, motor pool and repair shop, concrete and aggregate production plant, raw aggregate stockpiles and various construction roads will be provided for the exclusive use of the project construction.

A tentative layout of the dam construction facilities is shown in Dwg. WD-006.

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

The quarter will be provided with adequate residences, mess halls, a guest house and other necessary facilities to accommodate about 80 supervisory staffs from the Government. A part of them will be used for the accommodation of future operational personnel after the completion of the work.

6.1.4 Access road and bridges

Most of the construction materials, equipment and machines will be transported by road from Surakarta to the site. On the route of the existing road, there are 16 bridges including 2 large bridges spanning over the Bengawan Sala. Those bridges appears not to have sufficient capacity for transporting the project goods (40 tons maximum). Reinforcement of the existing bridges will be a primary work to be performed before the commencement of the main works.

6.1.5 Road relocation near damsite

The existing road on the left bank of the damsite has to be relocated at an early period of the construction. Other existing roads to be submerged under the reservoir will be relocated in parallel with the construction of dam. The proposed route is shown on Fig. V-4 and Dwg. WD-006.

6.2 Wonogiri Dam and Power Station

6.2.1 Construction plan

Implementation method

In view of economic aspect and special work operations required for the construction works, it is recommended to execute the work on contract basis. Competitive contractors should be selected through perqualification and tender procedures.

The main part of the dam and the powerplant construction works may be divided into 4 or 5 separate contracts, that is main civil works, gates and penstocks, generating equipment and transmission system. Other preparatory construction works also be divided into the contracts for the government camp, road relocation and diversion conduit works respectively.

Work plan

Construction work will generally be performed by conventional methods. Excavation will be mostly by the blading and ripping with bulldozers, loading by shovels and hauling by dump trucks. Concrete is produced by a central mixing plant of 24 m^3/hr capacity.

Monthly average embankment of the dam will be about 140,000 m^3. In the placement of fill materials, impervious core material will be placed in 25 cm layer and compacted by sheepsfoot roller. Other zones are compacted in 0.5 m to 1.0 m layer by vibration roller. No core embankment work will be provided during the wet season, November to April.

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 the upstream part of chuteway will be initiated to supply rock materials to the cofferdam embankment. Concreting of the chuteway will progress intermittently in parallel with the intake, the pressure tunnel and the powerplant pour works.

In view of the geological condition along the route of pressure tunnel, the tunnel excavation will require adequate timbering work with using steel-rib supports. After providing the lining for its entire length, the tunnel may act as an emergency diversion tunnel which will 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 part of the cofferdam at an height of El. 127.7 m.

Powerplant area will be excavated initially in a partial area to provide an approach road to the portal of pressure tunnel for enabling the early start of the tunnel excavation. Subsequently, the area will be enlarged to the designated full width for the construction of power house.

Construction plant and equipment

The dam construction work requires about 45 items of construction plant and heavy equipment. Concrete production facilities will be one aggregate screening plant and one concrete batching plant with 50 ton/hr and 24 m^3/hr 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.

Power for construction works will be supplied from a diesel generating plant of 1,000 kW capacity. Two pumping stations will supply water to various construction sites including the officices and the residential quarters. The peak requirement of water supply is estimated to be about 8 m^3/min. Compressed air plant will be installed both at the damsite and the rock quarry.

The required number of construction plant and equipment for the dam construction is summarized in Appendix 14.

6.2.2 Construction schedule

The project site is commanded by 2 distinct seasons, dry and flood seasons. Taking into account this seasonal fluctuation, the dam construction will be carried out according to the following stages of operation:

(i) Construction of the diversion conduit (up to Apr. 1978).

(ii) Construction of the primary cofferdams and diversion of riverflow at the beginning of 1978 dry season.

(iii) Construction of the main cofferdam (1978 season).

(iv) Construction of the main dam, spillway, intake, pressure tunnel and power house.

(v) Commencement of the impoundment of the reservoir (from Nov. 1980).

The construction works will be performed throughout the year with maintaining 2 working shifts except during the peak wet period. The construction period of the dam and reservoir work will extend over a period of 5 years starting in mid. 1977 and completing in March 1981.

Work period for the power equipment will be about 2 years including manufacturing, transportation and erection works. The installation work at the site will be started from December 1979 and the most parts be completed in early 1981 while commencement of the commercial operation is scheduled in April 1981.

Construction work of the transmission line will be executed from April 1980 to January 1981, most part of which will be carried out mainly during the dry season. Electrical works for the Sala substation will be carried out during 5 months from November 1980 to March 1981.

6.3 Irrigation Facilities

6.3.1 Construction plan

<u>Work plan</u>

The construction of the Colo diversion weir is divided into two stages. In the first stage, the construction of the weir, riprap and bank rivetment around the weir will be carried out by dry work method without any river diversion work.

In the second stage, the excavation of the approach channel and outlet channel will be executed and the river flow be diverted into the channels. Succeedingly, the present river channel will be backfilled with excavated materials and the main canal on the right bank will be connected to the intake structure.

The construction of the main canal will be divided into five work sections, four on the right main canal and one on the left main canal. Work division for the main canal is presented in Table VI-1, together with the number of related structures.

Table VI-1 Work Division and Sequence for Construction of Main Canal

Section	Type of Main Canal		Length (m)	Const. Year	Related Structure (No.)				
					Siphon	Aqueduct	Culvert	Turn-out	Bridge
1	Right	I	10,450	1982	4	-	2	6	17
2	"	II-III	15,000	1980	3	2	-	11	28
3	"	IV-VII	19,400	1979	5	3	2	14	52
4	"	VIII-XII	19,000	1978	2	7	1	8	48
5	Left	I-V	25,550	1981	2	4	2	10	58

The construction of the secondary canal will also be divided into five work sections as shown below.

Table VI-2 Work Division of Secondary Canal

Section	Const. Year	Length of Secondary Canal (m)		
		New Construction	Rehabilitation	Total
1	1982	23,900	-	23,900
2	1980	12,700	5,100	17,800
3	1979	30,900	8,700	39,600
4	1978	32,600	17,900	50,500
5	1981	12,100	1,000	13,100

Construction of the canals will be started at any place where easy access is obtainable. All the excavated earth will be used for the embankment of roads and canals. A part of the embankment materials will be hauled from the borrow areas nearby the construction site, if required.

The construction work of the main canal will be executed mainly by using machineries while that of the secondary canal, farm ditch and drain carried out mainly by manpower.

Construction plant and equipment

Concrete plant and other required plant for the construction of Colo weir will be transferred from the dam site.

As to water, power and fuel supply facilities, stationary-type facilities will be set at the Colo weir work site. For the canal construction, portable equipment such as portable pumps, generator and tank rolly, etc. will be utilized.

During the construction of Colo weir, large power will be required to drive the plant transferred from the dam. It is planned that a 20 kV transmission line will be constructed before the commencement of construction of Colo weir for supplying electricity to the site.

Items and required number of construction equipment for the irrigation work are shown in Appendix 14.

6.3.2 Construction schedule

Construction of the Colo weir is scheduled to start from 1981 taking into account the availability of construction plant and equipment from the Wonogiri dam which will be completed in early 1981. After the completion of the Wonogiri dam, the river flood will be decreased considerably, which makes the construction work to carry out in less risky condition. Before starting the main work, preparatory works such as access road, construction quarters, power and water supply systems, etc. will be completed.

Most of the other construction works will be completed in 1982 corresponding to the work schedule for the Colo weir. Total period required for the construction of the irrigation facilities is five years excluding one year for the preparatory works. The construction works will be principally carried out during the dry season, in view of inefficient working conditions during the wet season.

6.4 River Improvement

6.4.1 Construction plan

Work plan

River improvement work will be divided into 6 work sections as presented below.

Work section	Cross section No.	Right or left bank	Embankment work, (m^3)
I	No. 1 - No. 11 (Includ. K. Samin)	Left bank Right bank	888,000
II	No. 12 - No. 34	Right bank	882,000
III	No. 12 - No. 29 (Includ. K. Brambang, K. Serenan)	Left bank	853,000
IV	No. 30 - No. 33 (Includ. K. Dengkeng, K. Kupan)	Left bank	837,000
V	No. 34 - No. 53	Left bank	807,000
VI	No. 35 - No. 53 (Includ. K. Jlantah)	Right bank	894,000
	Total:		5,160,000

The priority of the improvement section should be determined considering the significance of the flood protection area. Urban areas or high productivity areas will receive high priority.

With the above in consideration, it is planned that the improvement work will be commenced in the work Section-II, followed by Section-I, Section-III, Section-IV, Section-V and Section-VI in the order.

The total volume of excavation and embankment works is 6.4×10^6 m^3 and 5.2×10^6 m^3 respectively. Of the total excavation volume, about 80% is yielded from the excavation of channel short cut work. In view of the volume of proposed earth works, the work will be carried out under an appropriate earth moving schedule, in which the maximum utilization of excavated earth for embankment is planned; excavated earth be delivered directly to the embankment place. The material excavated by bulldozer and shovel will be transported to the nearest embankment place by dump truck. In the embankment, it is usually compacted by bulldozer or other equipment.

Bank protection work, consisting of stone pitching and sodding will be done in accordance with the progress of embankment and excavation works. Sluiceways will be constructed before the embankment work begins at each place.

Construction plant and equipment

No particular stationary plant is deemed necessary in view of nature of the work which consists mainly of earth moving work.

Water, power and fuel supply systems for the work execution are planned in the same manner as the canal construction of the irrigation work.

Since the major part of the construction work consists of excavation or dredging in the river bed and embankment of the levee for the distance of about 50 km, the type and required number of equipment are determined in due consideration of the wide availability of equipment for various works. Appendix 14 shows the equipment list for the river improvement work.

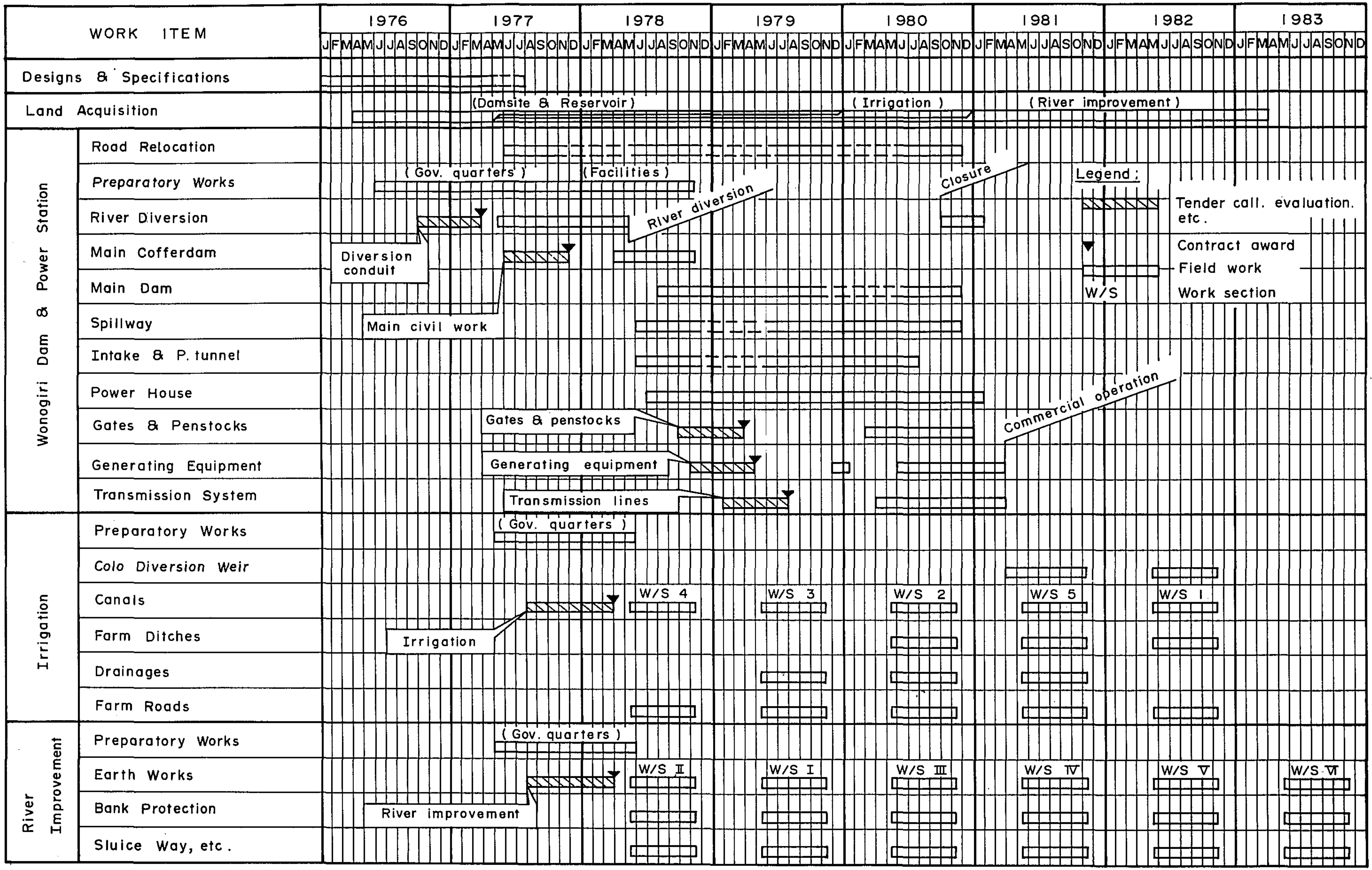
6.4.2 Construction schedule

Construction period is scheduled to extend about 6 years in total from 1978 to 1983, assuming that yearly workable days is limited to 180 days during the dry season.

6.5 Overall Construction Schedule of the Project

Overall time schedule for the construction works of the Wonogiri Multipurpose Dam Project is presented in the form of bar chart as shown in Fig. VI-1.

Fig. VI - 1 Proposed Construction Schedule for Wonogiri Multipurpose Dam Project



6.6 Project Administration

Project sponsor for the construction works

The Directorate General of Water Resources Development (DGWRD) of the Ministry of Public Works and Electric Power (PUTL) will have the overall responsibility for the implementation of the Wonogiri Multipurpose Dam Project as experienced in many other similar projects in Indonesia. The DGWRD will also be entrusted for the execution of the power house construction by the Public Corporation of Electricity (PLN). Meanwhile, the design and construction of the power equipment and power transmission facilities will be executed by the PLN themselves in cooperation with the DGWRD.

With respect to the resettlrment in the reservoir area which is the most important problem for the implementation of the project, the local governor (BUPATI) will take necessary procedures and actions under the instruction of the Provincial Governor of Central Java.

Executive agency at the project site

For the execution of construction works in the project area, the existing Central Office of Bengawan Sala Project (PBS PUSAT) will have the responsibility for the field operation of the project under the control of the DGWRD.

The Directorate of River (DITSUN) and the Directorate of Irrigation (DIRGASI) will provide necessary officers for the PBS PUSAT to assist the General Manager in the field operations.

One field office tentatively named the Project Office of Wonogiri Dam (PRO WONOGIRI) will be required to be established at the work site under the control of the PBS PUSAT. This field office will operate daily field works, such as design and supervision of field works, procurement of the necessary materials for construction, maintenance of the plant and equipment, operation of field and laboratory test, and other administrative works.

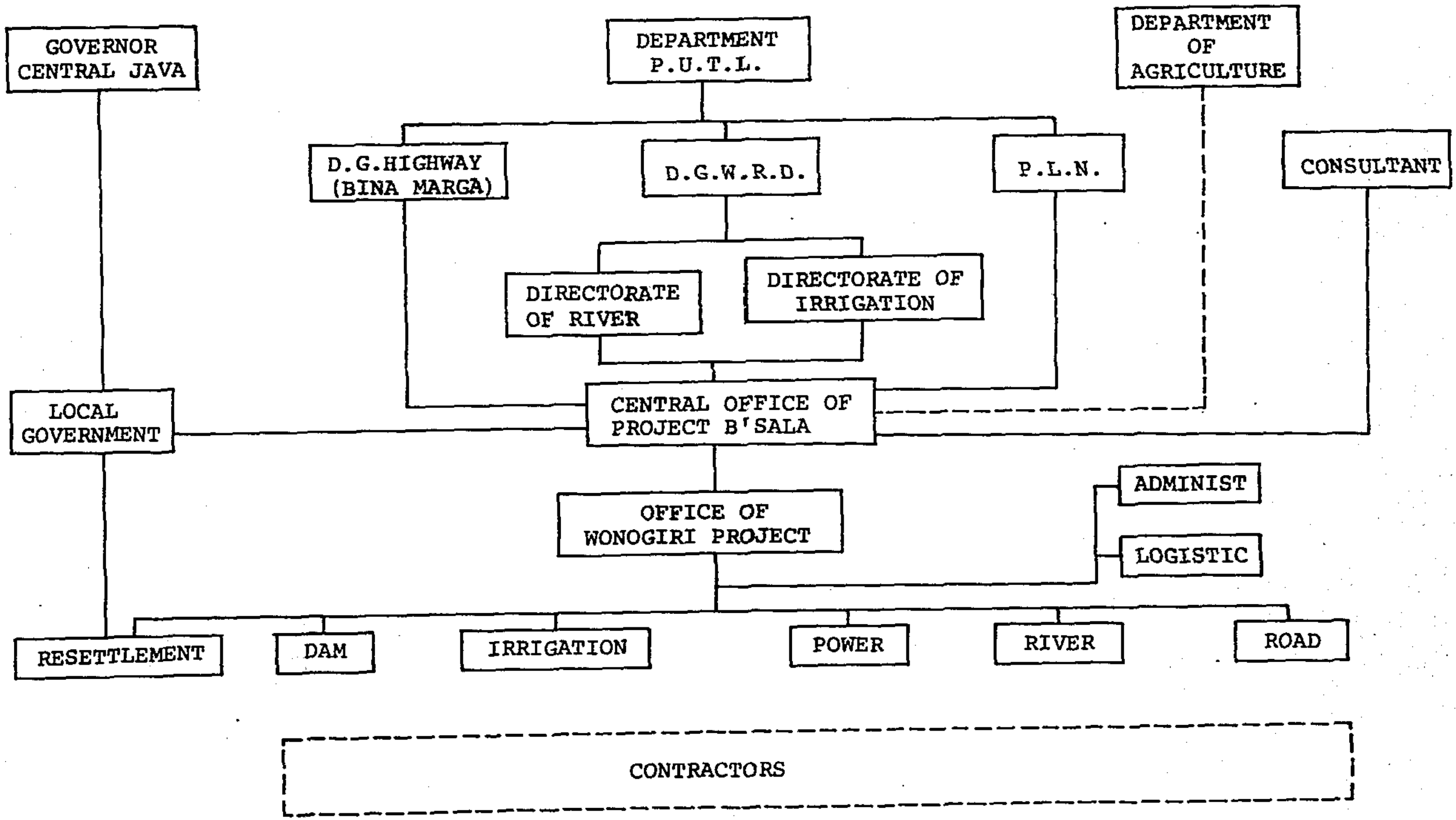
Necessary staffs will be appointed to the respective sections of the PRO WONOGIRI and the daily field operation will be carried out in close cooperation with local offices of the PUTL and the local government offices.

The construction works of the main part of the project such as dam, intake weir, main canal, etc., should be carried out or the contract basis with local contractors, or if they are not available, with foreign contractors under the supervision of the PRO WONOGIRI.

Besides, a technical assistance by consulting engineers from foreign and/or local will be provided at the PBS PUSAT for the successful performance of the construction work.

The overall construction organization chart is presented in Fig. VI-2.

Fig. VI-2 Organization Chart for Project Implementation



CHAPTER VII

ECONOMIC AND FINANCIAL EVALUATION

VII ECONOMIC AND FINANCIAL EVALUATION

7.1 General

The project evaluation in this chapter aims to ascertain the feasibility of the project in view of economic, financial and social aspects.

Firstly, economic feasibility of the project is evaluated by using the internal rate of return method. Project costs and price of outputs are estimated for the analysis, which reasonably reflect social opportunity costs excluding the effects of import duties and subsidies as practical as possible. The benefits are assesed using the "future with project" and "future without project" principle. In the economic evaluation, sensitivity analysis is also made with respect to the implementation timing of the irrigation facilities, the agricultural productivity and the price of the agricultural product.

Secondly, financial evaluation is conducted by means of farm budget analysis and repayability analysis of the financial cost. Farm budget analysis is designed to confirm the soundness of the project from farmers' point of view, while the repayability analysis is made for checking the financial viability of the project in terms of water charge and power charge.

Finally, socio-economic impacts of the project are briefly assessed in due consideration of the effect of the project to the regional development.

Costs and benefits to be used in the economic analysis are estimated basically at early 1975. All conversions from Rupiah to Dollar value are made at an exchange rate of Rp.415 = US$1 and the project life for the evaluation is assumed at 50-year period of 1976 - 2025.

7.2 Economic Evaluation

7.2.1 Summary of benefits

Project benefits are comprised of two kinds of benefits, namely primary benefits and secondary benefits. For the calculation of the internal rate of return, only the primary benefits are included.

Primary benefits

Primary benefits are comprised of irrigation benefit, flood control benefit and hydropower benefit of which details are explained in the previous chapters. Negative benefit on the submerged area by the reservoir is also included in the analysis.

The summary of the annual primary benefits are presented in the following table.

Table VII-1 Summary of Benefits

(US$1,000)

Benefit	Annual
Irrigation Benefit	13,620
Flood Control Benefit	5,810
Hydropower Benefit	1,350
Negative Benefit	-820
Total	19,960

For the economic evaluation, the development period of the irrigation benefit is assumed at 5-year after the completion of irrigation facilities during which the irrigation benefit will increase linearly.

Flood control benefit is expected to accrue, to some extent, after the coffer dam is completed and continue to increase stepwise corresponding to the river improvement works until 1983.

After completion of the construction of the power station in early 1981, electric power benefit is expected to attain its maximum extent.

Negative benefit will arise from the rainy season of 1978 when the cultivated land is partly submerged by the completion of the coffer dam and increase to its full amount in 1981, when the reservoir will be filled.

Secondary Benefit

In addition to the primary benefits quantified above, another economic benefits are expected to accrue from fishery, recreation and tourism and improvement of local transportation upon completion of the project. Municipal water supply will also be possible for Surakarta city.

The Wonogiri reservoir will have a water surface area of approximately 9,000 ha, which will provide enough potential for fishery. Surakarta city has a population of about 414,000, thus the fish would have a ready sale in the market as fresh fish.

With a surface area of 9,000 ha and a coastline length of more than 80 km, the Wonogiri reservoir will provide opportunity for recreation and tourism. Since opportunities for recreation in Indonesia at present are rather limited, there is expected proportional increase in the demand for recreation facilities, as the standard of living be improved. The reservoir area is located near Surakarta city, easily accessible by road and could provide convenient recreation opportunity.

Another benefits are expected from the improved farm road network in the irrigation area. This expanded road system will improve the inadequate transporation condition at present and facilitate agricultural activities.

Since the existing water sources for municipal water supply in Surakarta city will not be sufficient to meet the demand in the future which will increase with population growth and income increase, it will be necessary to cope with the short of the requirement by utilizing the water from the reservoir. It is therefore expected that considerable benefit will accrue from the municipal water supply in the future.

7.2.2 Summary of costs

Construction cost

The total construction cost will be US$106.47 million comprising the foreign currency portion of US$51.177 million and local currency portion of US$55.293 million, which covers the cost for the construction of dam including land acquisition of reservoir area, power plant and transmission lines, irrigation facilities, and river improvement works.

These costs are summarized into Table VII-2 by each item. Annual disbursement schedule is also summarized in Table VII-3 for the economic analysis of the project.

Table VII-2 Summary of Costs

(US$1,000)

Item	Foreign Portion	Local Portion	Total
Dam & Reservoir	18,000	25,400	43,400
Hydropower	10,190	1,510	11,700
Irrigation	16,770	16,330	33,100
River Improvement	6,217	12,053	18,270
Total	51,177	55,293	106,470

The land acquisition cost for the Wonogiri dam and reservoir includes the costs of yard, housing quarters and resettlement expenses for the families to be displaced. The cost for the acquisition of sawah and tegal is excluded in the estimated cost but is incorporated in the negative benefit.

Land acquisition cost is based on the survey of the reservoir area made by DPUT in 1975 and unit costs estimated from the same data. The resettlement expenditure for the displacement are calculated referring to the unit price estimated by Gadjah Mada University in the first survey report.

The summary of the land acquisition cost is presented in Table VII-4.

Table VII-3 Annual Disbursement Schedule of the Construction Cost

(US$1,000)

	1976	1977	1978	1979	1980	1981	1982	1983	Total
I. Dam & Reservoir	700	6,200	11,800	16,400	8,300	-	-	-	43,400
	(700)	(5,000)	(7,700)	(8,600)	(3,400)	(-)	(-)	(-)	(25,400)
II. Hydropower	-	-	-	7,480	4,220	-	-	-	11,700
	(-)	(-)	(-)	(200)	(1,310)	(-)	(-)	(-)	(1,510)
III. Irrigation	-	880	4,780	5,100	6,130	8,370	7,840	-	33,100
	(-)	(620)	(2,030)	(2,340)	(3,360)	(4,280)	(3,700)	(-)	(16,330)
IV. River Improvement	-	-	3,550	2,950	2,950	2,960	3,130	2,730	18,270
	(-)	(-)	(2,011)	(2,008)	(2,008)	(2,008)	(2,008)	(2,010)	(12,053)
Total	700	7,080	20,130	31,930	21,600	11,330	10,970	2,730	106,470
	(700)	(5,620)	(11,741)	(13,148)	(10,078)	(6,288)	(5,708)	(2,010)	(55,293)

Note: The figures in the parenthesis indicate the local currency portion.

Table VII-4 Land Acquisition Cost for Wonogiri Dam & Reservoir

	Quantity (ha or Nos.)	Amount (Rp.1,000)
Housing and Quarters		
Bamboo	10,697	748,790
Wooden	11,519	1,727,850
Brick	216	97,200
Factory	24	6,000
Others	797	39,850
Yard	2,242	762,280
Cemetry and Forest	206	30,900
Expenditure for Resettlement	9,834	1,278,420
Total		4,691,290
		(equiv. to US$11,300,000)

Operation, maintenance and replacement costs

The total annual cost for operation, maintenance and replacement of the project is estimated at US$0.47 million. The summary of the costs by purposes is presented in the following table.

Table VII-5 Annual Operation, Maintenance and Replacement Cost

Item	Amount (US$1,000)
Dam and Reservoir	40
Power Plant	280
Irrigation	130
River Improvement	20
Total	470

The cost to be incurred by providing more intensive institutional services such as credit, research, training, extension, etc. are not included in these costs but these are regularly budgeted by the government through its various agencies.

7.2.3 Evaluation

The economic evaluation of the project is carried out by means of internal rate of return method. On the basis of the benefits and costs estimated above, the rate of reutrn is calculated at 13.9 % for the project life of 50-year as shown in the attached table in Appendix 15. The rate of return is considered to indicate the economic viability of the project.

In succession, sensitivity analysis is made with respect to the construction timing of the irrigation facilities, productivity of paddy and price of paddy to evaluate their effects on the project feasibility.

Effect of the construction timing of the irrigation facilities

Internal rate of return is calculated for the following three cases in addition to the proposed plan to analyze the effect of the construction timing of the irrigation system on the project feasibility.

Case I — The irrigation system will be completed after 5-year of the dam construction.

Case II — The irrigation system will be completed after 8-year of the dam construction.

Case III — The irrigation system will be completed after 11-year of the dam construction.

The results of the sensitivity study are presented in the following table.

	Case I	Case II	Case III
Internal Rate of Return	12.8 %	12.0 %	11.6 %

<u>The effect of the productivity of paddy</u>

The effect of the productivity of paddy on the project feasibility is analyzed in the following two cases.

Case I — The productivity of paddy will decrease to 5.0 t/ha at its full operation stage.

Case II — The productivity of paddy will decrease further to 4.5 t/ha at its full operation stage.

The results of the sensitivity analysis are shown in the following table.

	Case I	Case II
Internal Rate of Return	12.6 %	11.5 %

<u>Effect of the price of rice</u>

Internal rate of return is calculated for the following three cases with respect to the price of rice.

Case I — Economic price of rice is US$240 per ton.

Case II — Economic price of rice is US$300 per ton.

Case III — Economic price of rice is US$330 per ton.

The results of the sensitivity analysis are shown in the following table.

	Case I	Case II	Case III
Internal Rate of Return	12.2 %	15.3 %	16.5 %

In addition to the above analysis, the effect of the power sector to the whole project is briefly studied in Appendix 16.

7.3 Financial Analysis

Financial analysis of the project includes farm budget analysis and repayability evaluation for each function of the project.

Farm budget analysis is made to assess whether the project will have sufficient incentive to the farmers in the project area and will bring enough cash income increase in the farmer's economy.

In succession, financial cost is estimated on the basis of actual cost requirement and the cost is allocated for each purpose of the project to share the justifiable financial charge equitably. Based on the allocated cost, financial evaluation of the project is examined to ascertain the repayability to the cost of each purpose.

Finally, the financial cost is inflated by the assumed price escalation rate to estimate the actual fund requirement to finance the implementation of the project.

7.3.1 Farm budget analysis

In order to evaluate the feasibility of the project from farmers economy, farm budget is investigated for future without the project and future with the project conditions.

After checking the data collected in the "Master Plan of the Bengawan Sala Basin Development", sample farm survey was carried out for re-estimating the typical farm budget in the project area, which includes the investigation of outputs and inputs for typical farmers both for agricultural and non-agricultural production.

The average farm size at present is estimated at 0.72 ha comprising 0.46 ha of sawah and 0.06 ha of tegal and 0.20 ha of others. It is assumed that the farm holding size will not change considerably in the future even if the project is completed due to the difficulty in land extension.

Based on the data checked by the farm survey and the average farm holding, typical farm budget is estimated, for which financial price or actual price is applied to the agricultural outputs and inputs. The results of the calculation are presented in Table VII-6 and Table VII-7.

Upon completion of the project, crop income is expected to increase substantially from Rp.122,710(or US$296) to Rp.290,740 (or US$701), while other incomes such as gains from livestock and wage labor will remain at lower level. Although the production costs will also rise for sustaining intensive farming with the project, the resulting net income, which is defined as the difference between farm income and production costs, will reach to the level of Rp.232,400 (or US$560).

Since the family size is estimated at 4.9 in the project area, percapita income will be over US$114, indicating substantial increase compared with that of some US$50 without the project.

Annual net reserve or capacity to pay will also grow from Rp.28,650 or US$69 to Rp.124,360 or US$300 in spite of the expected increase in living expenses. The increased net reserve indicates sufficient capacity to pay for some charge imposed on the irrigation water such as water charge in the future.

Table VII-6 Typical Farm Budget Without Project

I t e m	Amount (Rp)
I. Farm Income	
Crop Income /1	122,710
Other Income /2	28,740
Total Gross Income	151,450
II. Farm Expenses	
Production Costs	
Crop Production Costs /3	41,530
Other Expenses /4	7,220
(Sub-total)	(48,750)

Note: /1, /3 Estimated on the basis of the average farm holding per family of 0.72 ha.

/2, /4 Includes the incomes or expenses from livestock breeding and off-farm labor which are evaluated using the "Master Plan of Sala River Basin Development".

I t e m	Amount (Rp)
Living Expenses	
Food Consumption	44,720
Other Living Expenses	27,930
Taxes	1,400
(Sub-total)	(74,050)
Total Farm Expenses	122,800
III. Net Reserve (or Capacity to pay)	28,650

Table VII-7 Typical Farm Budget With - Project

I t e m	Amount (Rp)
I. Farm Income	
Crop Income /1	290,740
Other Income /2	35,900
Total Gross Income	326.640
II. Farm Expenses	
Production Costs	
Crop Production Costs /3	82,450
Other expenses /4	11,790
(Sub-total)	(94,240)
Living Expenses	
Food Consumption	58,580
Other Living Expenses	46,600
Taxes	2,740
(Sub-total)	(107,920)
Total Farm Expenses	202,160
III. Net Reserve (or Capacity to pay)	124,360

Note: /1, /3 Estimated on the basis of the average holding per family of 0.72 ha.

/2, /4 Includes the incomes or expenses from livestock breeding and off-farm labor which are estimated using the "Master Plan of Sala River Basin Development".

7.3.2 Financial evaluation

Financial Cost

Financial cost of the project is estimated at US$141.28 million, which includes interest cost during construction and actual cost for land acquisition and resettlement. Interest cost takes into account only for the foreign currency portion assuming that the local portion is provided by the government with interest free. The summary of the financial cost is presented in the following table.

Table VII-8 Financial Cost of the Project

(US$1,000)

Item	Foreign Portion	Local Portion	Total
Dam & Reservoir	18,000	44,830	62,830
(Land Acquisition /1 and Resettlement Cost)	(-)	(28,130)	(28,130)
Hydropower	10,190	1,510	11,700
Irrigation	16,770	16,820	33,590
River Improvement	6,220	13,470	19,690
Interest during Construction /2	13,470	0	13,470
Total	64,650	76,630	141,280

Note /1: Estimated taking into account the first survey report of Gadjah Mada University but will be reevaluated referring to the results of the final survey.

/2: Includes interest cost for only foreign currency portion with 5 % per annum.

Cost allocation

Based on the estimated financial cost, cost allocation of the multipurpose project is carried out by using "Separable Cost - Remaining Benefit Method".

The result of the cost allocation is shown in Table VII-9 and the details of the calculation are presented in Appendix 17.

Table VII-9 Allocated Cost of the Project

(US$1,000)

Purpose	Foreign Portion	Local Portion	Total
Irrigation	34,490	42,340	76,830
Flood Control	16,540	30,340	46,880
Hydropower	13,620	3,950	17,570
Total	64,650	76,630	141,280

Assessment of the repayability

For the assessment of the repayability of the project, the required annual payment including capital repayment with interest, and operation, maintenance and replacement costs is estimated on the basis of the financial cost for each function. Then, expected charge on the irrigation water and the generated power to be collected from the respective beneficiaries are calculated.

Financial evaluation of the project viability is made by comparing the estimated charge for each function with the existing power rate or the expected net farm income (or capacity to pay).

Repayability in the flood control section is evaluated in terms of expected increase in the government revenue.

i) Repayment amount with interest cost is estimated on the following financial conditions assumed.

For the foreign currency portion of the project:

annual interest rate	5 %
repayment period	30 years after project construction

For the local currency portion:

annual interest rate	free
repayment period	30 years after project construction

ii) Annual operation, maintenance and replacement costs are assumed to be the same amount as the economic costs and the operation and maintenance cost of dam is allocated to three purposes in proportion to the additional allocated construction cost.

	(US$1,000)
Irrigation	150
Flood Control	40
Hydropower	280

Based on the above conditions, the required annual repayment to the cost is estimated for each purpose as follows.

(US$1,000)

	Repayment			Total
	Foreign	Local	OM & R	Annual Payment
Irrigation	2,240	1,410	150	3,800
Flood Control	1,080	1,010	40	2,130
Hydropower	890	130	280	1,300

Assuming that the salable power energy is 27,072 Mwh/1, the power rate from the Wonogiri power plant will be US$0.048/kWh (or equivalent to Rp.20/kWh). Comparing with the prevailing power rate which is ranging from Rp.14.5/kWh to Rp.24.5/kWh for private use in Central Java, the expected power rate of Rp.20 is acceptable.

Since the area of 23,600 ha will get the benefit from the irrigation, expected charge on the irrigation water is calculated at US$161/ha per year, which is equivalent to US$83.7/farm or Rp.34,740/farm/2.

Traditionally, farmers in Indonesia have not paid directly for capital costs of irrigation systems but have contributed indirectly through the land tax.

/1 expected energy output of 28,200 MWh x 0.96

/2 out of average farm size of 0.72 ha, 0.46 ha of sawah and 0.06 ha of tegal is covered by the irrigation system.

The land tax forms a major source of revenue at the provincial and district levels, and any charge in this tax must be considered in the broader context of overall taxation policy.

Although the Government may not intend to impose new charges in the irrigation area at present, the increase in incomes as a result of the project will increase the tax base in the project area. If total annual payment is to be repaid by the beneficialies, the required charge amounts to about 28 % of the net reserve of the typical farm budget with the project, which shows some repayability to the investment cost for the irrigation function.

With respect to flood control, it is expected that substantial decrease in damage of agricultural products and properties will be brought with the flood control. These effects will stimulate further general economic activity and increase income in the region. Consequently, it will increase the government revenues through direct or indirect taxes, which will cover some part of necessary repayment to the cost invested to the flood control function.

However, the repayment of the flood control function should be considered to be financed by some government subsidies in view of the nature of the project.

7.3.3 Fund requirement

For predicting the financial requirement of the project construction at the implementation time, the project cost including the contingency of price escalation is estimated. Since the construction cost is expected to be affected by recent inflationary trend both in the world and in Indonesia, tentatively following presumption is made for the estimate of the financial requirement.

i) Foreign currency portion: 10 % per annum for the first year disbursement (1976) and 7 % compound rate per annum from the second year disbursement (1977-1983)

ii) Local currency portion: 15 % per annum for the first year disbursement (1976) and 10 % compound rate per annum from the second year disbursement (1977-1983)

With the above condition, total fund requirement is estimated at US$211.3 million including interest cost during construction of US$16.5 million, as shown in Table VII-10. The disbursement schedule is also presented by each function in Table VII-11.

Table VII-10 Fund Requirement (with Price Contingency)

(US$1,000)

Item	Foreign Currency	Local Currency	Total
Dam & Reservoir	26,970	64,350	91,320
Hydropower	14,010	2,520	16,530
Irrigation	23,770	29,030	52,800
River Improvement	10,030	24,110	34,140
Interest Cost /1	16,540	-	16,540
Total	91,320	120,010	211,330

Note: /1 includes interest only for foreign portion with interest rate of 5 % per annum

Table VII-11 Annual Disbursement of Fund Requirement

	1976	1977	1978	1979	1980	1981	1982	1983	Total
Dam & Reservoir	1,150	17,940	26,090	34,280	11,860	-	-	-	91,320
	(1,150)	(11,470)	(20,170)	(25,110)	(6,450)	(-)	(-)	(-)	(64,350)
Hydropower	-	-	-	10,120	6,410	-	-	-	16,530
	(-)	(-)	(-)	(310)	(2,210)	(-)	(-)	(-)	(2,520)
Irrigation	-	7,630	5,280	6,240	8,530	12,640	12,480	-	52,800
	(-)	(970)	(2,980)	(3,750)	(5,860)	(7,930)	(7,540)	(-)	(29,030)
River Improvement	-	-	9,130	3,800	4,160	4,580	7,260	5,210	34,140
	(-)	(-)	(3,130)	(3,440)	(3,780)	(4,160)	(4,570)	(5,030)	(24,110)
Interest Cost	-	330	1,010	1,920	2,780	3,220	3,540	3,740	16,540
Total	1,150	25,900	41,510	56,360	33,740	20,440	23,280	8,950	211,330
	(1,150)	(12,440)	(26,280)	(32,610)	(18,300)	(12,090)	(12,110)	(5,030)	(120,010)

Note: (1) The figures in the parenthesis indicate the local currency portion.

(2) Interest cost during construction accounts only for foreign currency portion with the rate of 5% per annum.

7.4 Socio-Economic Aspects of the Project

The project will give socio-economic impact, both of positive and negative, on a great many people and institutions in the project area.

For the fruitful operation of the project, careful consideration should be given, from the stage of the designing to operation of the project, to maximize those positive impacts and minimize the anticipated negative impacts.

<u>Positive socio-economic impact</u>

First of all, creation of the employment opportunity and transfer of technological knowledge are expected through the execution of the project construction.

The large scale construction work can offer numerous employment opportunity to the project area. Since the area is over-populated with scarce job opportunity, job opportunity to be increased by the project will no doubt provide benefit to solve the unemployment and under employment.

Besides the project will offer considerable job opportunities to Indonesia, this will effect on gaining experience in various work fields and training their skill on the jobs. Through these, Indonesia will accumulate sufficient knowledge and skill for the future development.

Secondly, substantially improved living conditions will result from the development of the Wonogiri Multipurpose Dam Project.

Agricultural production is expected to increase considerably with the irrigation project. Consequently, more farm income will be available for acquiring the necessities or luxuries such as television, motor cycle etc. Housings will be improved with the additional income.

Health and sanitation conditions will be improved upon completion of the flood control measures with dam and river improvement. Electrification will give benefit on the region and will also contribute to the improvement of living condition considerably.

Furthermore, socio-economic stability will be promoted through all of the above mentioned effects. Much of the social security and stability can result from the shift from near-subsistence farming to more intensive agriculture producing more crops for sale and thereby increasing cash income and national benefits. Further social stability will result from increased consumption of commercial goods and service, which will stimulate the activity in the other sectors of the economy.

Negative (or minus) impact

Besides the positive impact mentioned above, minus impact is anticipated to accrue from the project construction.

One of the minus impact would be inflation caused by massive employment of laborers and purchasing materials for construction and consumptive goods during the construction period. This impact will break the balance of the present equilibrium of the local market and suppress economic situation of the residents in the project area.

Major negative impact might come from the construction of the reservoir. Upon completion of the Wonogiri reservoir, approximately 7,000 ha of cultivation land will have to be abandoned and over 48,000 persons will be displaced. Although the people affected will be fully compensated for their lands and quarters, they will not be able to continue their livelihoods as they are. Further, the community life in the adjacent areas will be seriously affected by the structural change of the community such as decrease in the number of village people, relatives, and village public facilities.

It is therefore contemplated that preparation of the reconstruction program of the local community is also an important problem as well as the resettlement of the displaced people and securing alternative employment opportunity for them for the successful execution of the project.

At present, a special committee headed by chief of Kabupaten is established to tackle with this problem in colaboration with Gadjah Mada University. Under this committee four sub-committees are organized which will be engaged in compensation survey, migration survey, man power survey and public information respectively.

The problem of resettlement and the reconstruction plan having many administrative aspects, it is suggested that the project executing organization (or DPUT) will make necessary coordination between the related governmental organization and take initiative step based on the recommendation of the committee for the early implementation of the project.

APPENDICES

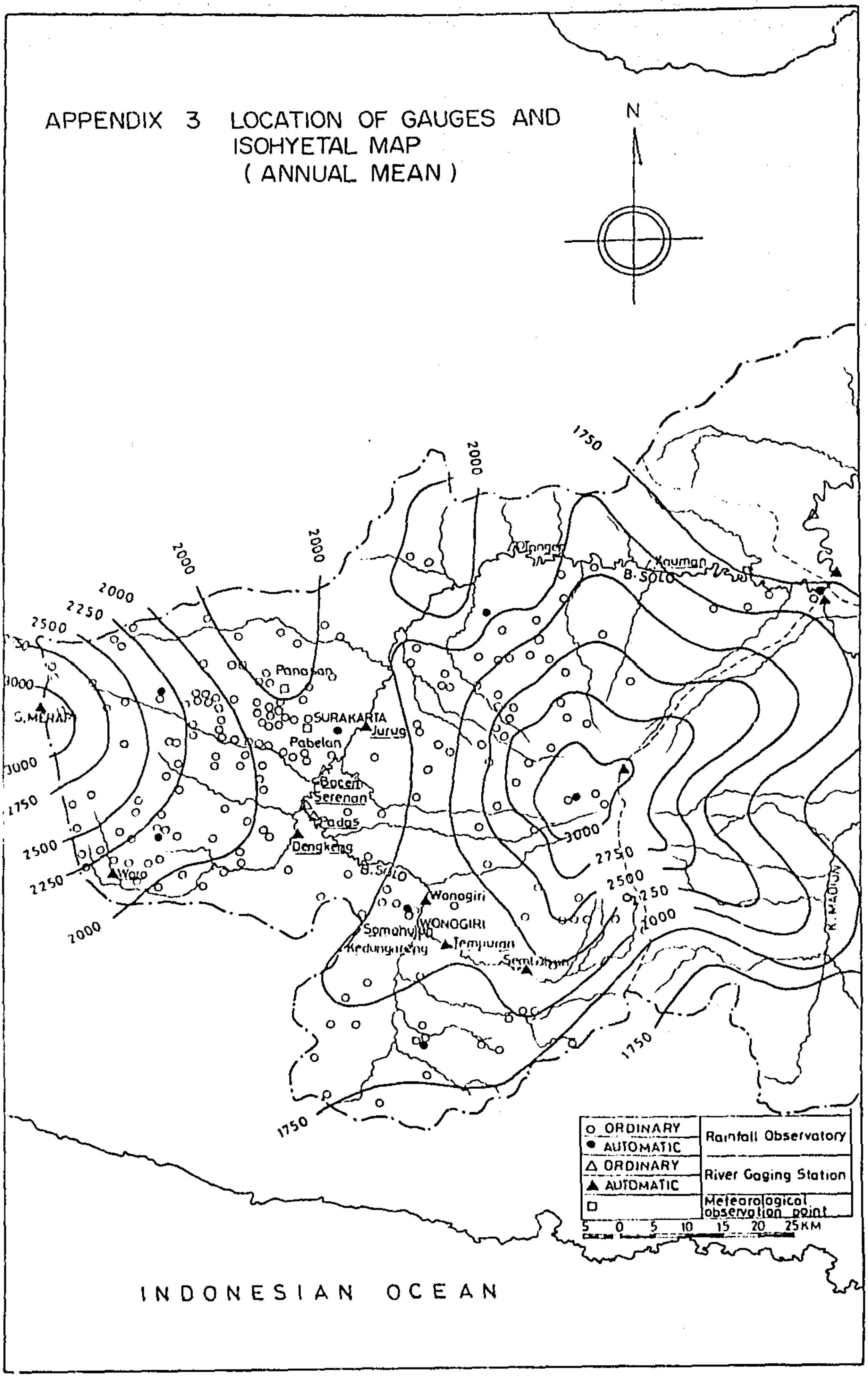
APPENDIX 1. LIST OF THE FILED SURVEY TEAM AND COUNTERPARTS

Speciality	Experts in charge	Principals & Counterparts
Team Leader	Mr. N. Aihara	Mr. Soeminto
Deputy Leader	Mr. E. Yoshitake	Mr. Sudarto
	Mr. K. Kimura	Mr. Soeradji
	Dr. K. Takase	
Deputy Leader	Mr. K. Sawaya	Mr. Sidharto
Hydrology & Hydraulic	Mr. S. Asada	Mr. Suprapto
		Mr. Wuryanto
		Mr. Supeno
Dam	Mr. M. Kato	Mr. Triemurat Sunaryo
		Mr. Kusnaeni
Structure	Mr. T. Takenaka	Mr. Prayoga
		Mr. Sulamto
Soil Mechanics	Mr. C. Moriya	Mr. NY. Suyono
		Mr. Heru Marsudi
Geology	Mr. H. Sasaki	Mr. Sukamto
		Mr. Mulyono
River Engineering	Mr. T. Fukumoto	Mr. Haryanto
		Mr. Bambang DWI Susetyo
Mechanical Engineering	Mr. A. Sezaki	Mr. Adhi Sarwoko
		Mr. Aris
Project Economy	Mr. T. Tai	Mr. Kusdibyo
		Mr. Sunarko
Irrigation	Mr. H. Yonehara	Mr. Muchsin Zaini
	Mr. T. Amano	Mr. Wukir Rahardjo
Agronomy	Mr. I. Koshino	Mr. Hendromoyo
		Mr. Subanu
		Mr. Nurardin
		Mr. Murtadi
Power	Mr. K. Ando	Mr. Haryadi
Accounting	Mr. S. Nishikata	Mr. Liliek Suwardi
Coordinator	Mr. K. Kumagishi	
	Mr. K. Miyajima	

Meteorological Record in the Project Area

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Wind velocity (m/sec) Panasan	1.4	1.3	1.6	1.4	1.6	1.9	1.8	2.3	2.9	2.4	2.2	1.8	1.9
Duration of Sunshine (%) Panasan	30.0	31.1	36.6	45.6	51.1	63.3	70.0	72.5	75.0	52.5	48.8	33.8	49.7
Average Temperature (°C) Pabelan	27.3	27.9	28.2	29.4	28.6	28.5	28.1	27.8	27.4	28.5	28.6	28.1	28.2
Average Maximum Temp. (°C) Pabelan	30.4	31.2	31.4	32.8	32.2	32.4	31.6	32.6	31.9	32.3	30.9	30.5	31.7
Average Minimum Temp. (°C) Pabelan	23.5	23.7	23.7	24.8	24.7	23.1	23.6	23.2	22.8	23.5	23.9	23.0	23.6
Average Relative Humidity (%) Panasan	75.8	76.9	76.4	72.0	69.4	66.6	62.7	59.4	59.5	60.8	70.5	74.0	68.7
Average Rainfall (mm) Project area	330.7	322.7	337.1	220.9	156.2	67.4	60.3	75.5	34.2	108.6	226.5	286.1	2.190
Daily Evaporation (mm) Pabelan	1.5	1.4	1.5	1.7	1.5	2.3	3.2	3.4	4.8	2.9	2.4	2.0	876

APPENDIX 3 LOCATION OF GAUGES AND ISOHYETAL MAP (ANNUAL MEAN)



APPENDIX 4

Average Monthly Rainfall in Upper Sala Basin

(Unit: mm)

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1952	273.3	242.5	306.9	114.8	98.6	11.4	6.8	93.1	56.2	193.3	340.1	254.5	2,191.5
1953	203.1	333.9	326.8	274.4	203.0	14.9	29.2	0.4	5.7	3.8	190.8	282.1	1,868.1
1954	395.5	363.6	214.6	275.0	223.3	90.5	68.3	67.1	42.5	166.1	427.5	212.6	2,546.6
1955	405.7	248.5	342.4	229.0	177.2	144.7	142.7	93.3	57.0	203.8	316.6	255.5	2,816.0
1956	355.4	312.5	164.2	182.8	177.6	193.6	127.5	127.1	55.6	95.2	167.2	244.5	2,183.2
1957	258.6	294.8	418.2	205.6	80.4	26.7	155.5	61.7	2.7	35.6	192.8	339.5	2,071.7
1958	271.7	387.6	448.5	283.0	191.2	71.5	157.9	71.4	121.4	187.4	189.3	491.7	2,872.6
1959	340.3	339.5	387.4	181.2	164.6	74.6	72.7	7.0	39.6	42.5	218.2	323.1	2,190.7
1960	335.3	433.6	226.7	255.3	254.2	31.1	32.7	6.7	10.1	55.7	371.6	200.9	2,243.9
1961	331.2	257.3	263.2	157.8	137.1	1.6	16.5	0.3	0.4	40.8	165.7	254.0	1,635.9
1962	389.0	265.4	339.4	397.1	59.1	110.5	52.3	54.7	4.1	83.8	189.6	406.2	2,341.2
1963	354.5	370.7	386.9	185.2	19.3	26.0	0	0	0	26.7	91.1	257.4	1,717.8
1964	234.9	223.5	309.5	276.2	195.2	90.1	16.9	20.8	28.1	297.1	138.2	223.1	2,053.4
1965	340.3	311.7	283.6	138.4	49.9	17.3	16.7	0	0.9	17.9	160.3	270.2	1,601.2
1966	317.7	323.8	425.6	217.0	80.1	76.3	0.6	1.2	18.2	164.4	308.9	226.2	2,060.0
1967	501.4	320.4	220.6	173.3	30.1	0	0	0	1.5	37.8	160.4	245.3	1,690.6
1968	299.1	345.0	440.2	220.6	296.3	185.9	210.3	77.8	36.7	118.9	278.8	362.3	2,871.9
1969	333.0	289.7	267.2	302.6	40.3	11.1	1.9	0.1	1.3	90.8	142.9	259.1	1,740.0
1970	306.9	314.9	335.3	213.5	263.4	54.5	32.8	1.3	93.9	85.4	341.7	323.3	2,365.9
1971	325.7	286.3	399.8	104.0	186.6	113.4	30.3	5.9	24.1	198.8	262.8	310.0	2,447.7
1972	181	238	453	217	161	0	0	19	0	20	193	355	1,937
1973	413	399	417	265	348	139	55	61	153	125	235	230	2,839
Mean	330.7	322.7	337.1	220.9	156.2	67.4	60.3	35.5	34.2	108.6	226.5	286.1	2,190

Monthly Mean Run - Off at Wonogiri (Unit : m^3/sec).

Year	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	Yearly mean	6 dry months mean	Dec-Apr. mean	Yearly mean with upstream dams
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	36.6	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	53.9	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	45.4	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	13.1	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	31.0	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	2.8	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	63.4	66.7	68.8	45.6	29.3	8.3	54.1	25.4
Basic mean	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			

APPENDIX 6

Sedimentation of the Existing Irrigation Reservoir in the Project Area

	Reservoir	Age (Year)	Catchment Area (km^2)	Original Storage (10^3 m^3)	Present Strage (10^3 m^3)	Lost Storage (10^3 m^3)	Sedimentation Ratio ($m^3/km^2/yr.$)
1.	Krisak	32	7.5	2,923	2,623	300	1.176
2.	Kedungguling	59	3.1	471	221	250	1,367
3.	Plumbon	47	5.1	1,200	600	600	2,503
4.	Ngancar	31	7.1	1,619	1,419	1,200	909
5.	Delingan	55	30.0	3,967	3,167	800	485
6.	Mulur	54	50.0	4,935	3,435	1,500	556
7.	Tewel	64	6.1	80	5	75	192
8.	Kebangan	36	7.3	500	350	150	571
9.	Gebyar	33	15.0	701	601	100	202
10.	Brambang	64	6.6	104	94	10	24

Mean = 800 $m^3/km^2/year$

APPENDIX 7. COMPARATIVE STUDY FOR SELECTION OF THE MOST OPTIMUM SCALE OF THE PROJECT

1. General

For the selection of the most optimum scale of the project, comparative study is conducted for the following three alternative development plans.

Item	Plan A	Plan B	Plan C
Dam & Reservoir			
Dam Height (m)	37.5	36.1	34.5
Dam Volume (10^3m^3)	1,800	1,600	1,420
Reservoir Storage (10^6m^3)	660	530	410
Irrigation Area (ha)	23,600	15,600	8,500
Power			
Installed Capacity (kW)	10,200	11,400	7,700
Yearly Energy (kWh)	28,200	28,400	23,200

Selection is made by means of the net present worth method where discount rate is assumed at 10 %.

2. Project Benefit

The expected benefits are estimated for three alternatives and summarized in the following table

(US$1,000)

Item	Plan A	Plan B	Plan C
Irrig. Benefit	13,620	9,000	4,900
Flood-Control Benefit	5,810	5,810	5,810
Power Benefit	1,350	1,500	1,100
Negative Benefit	- 820	- 740	- 660
Total	19,960	15,570	11,150

3. Project Costs

Construction cost, operation, maintenance and replacement costs for three alternative plans are summarized in the following tables.

Summary of Construction Cost

(US$1,000)

	Plan A	Plan B	Plan C
Dam & Reservoir	43,400	42,300	38,100
Power	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

Summary of O M & R Cost

(US$1,000)

	Plan A	Plan B	Plan C
Dam & Reservoir	40	40	40
Power	280	330	260
Irrigation	130	90	50
River Improvement	20	20	20
Total	470	480	370

4. Evaluation

Based on the benefits and costs estimated above, net present worth is calculated assuming 10% of discount rate. The result of the calculation is summarized as follows.

(US$1,000)

	Plan A	Plan B	Plan C
Net Present Worth	30,155	18,361	10,551

From the above figures, the plan A is preferably selected as the most beneficial plan.

APPENDIX 8 COMPARISON OF THE ALTERNATIVE FLOOD CONTROL PLANS

Item	Plan - I	Plan - II	Plan - III
Wonogiri eservoir			
- 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) (10^3 US$) (include land acquisition costs)	43,400	43,200	43,000
River improvement			
- Projected highest flood discharge at Surakarta (m^3/s)	5,300	5,300	5,300
- Discharge after dam regulation at Surakarta (m^3/s)	2,000	2,300	2,600
- Length of improvement (km)	32.2	32.2	32.2
- Volume of earth moving (10^6 m^3)	11,170	11,860	13,100
- Construction cost (B) (10^3 US$)	18,300	20,000	22,400
Total construction cost (A) + (B) (10^3 US$)	61,700	63,200	65,400

APPENDIX 9. LIST OF THE PRICES OF AGRICULTURAL PRODUCTS AND INPUTS

The prices of the agricultural products and inputs used in the economic analysis is derived from IBRD estimate and presented as follows:

(US$)

Item	Estimated Price (at 1980)
Crops	
Rice	270/ton
Maize	93/ton
Peanuts	267/ton
Soybean	203/ton
Tobacco	1,110/ton
Sugar cane	200/ton
Fertilizer	
Urea	91/ton
Muriate of potash	39/ton
DAP	129/ton

Source: IBRD "Price Forecast for Major Primary Commodities" June 19, 1974

APPENDIX 10. COMPARATIVE STUDY OF IRRIGATION

The features of the alternative development plans for the irrigation system are presented in the following table and the location is illustrated in the attached figure, the most optimum scale of the project is determined by the least cost method.

Firstly, the construction costs for each plan are estimated together with the operation and maintenance costs. Secondly, the operation and maintenance costs are capitalized by discount rate of 10 % with 30 year period.

Then, unit costs per ha including the construction costs and the capitalized operation and maintenance costs are calculated. The least unit cost of Plan-A is finally selected as the most optimum one as shown in the following table.

Summary of Comparison of the Alternatives

Item	Plan A	Plan B 1	Plan B 2	Plan C	Plan D 1	Plan D 2
Irrigation area (ha)	23,600	29,600 /1	24,600 /2	24,200 /3	23,600	18,500
Main canal (km)	89.5	89.5	89.5	89.5	89.5	89.5
Tunnel	-	17.0	5.0	-	-	-
Max. discharge (m^3/sec)	33.6	42.0	34.9	34.4	33.5	26.3
Colo weir	o	-	o	o	o	o
Surakarta weir	-	-	-	-	o	o
Pumping station	-	-	-	o	o	-
Power generation at Wonogiri	o	-	o	o	o	o

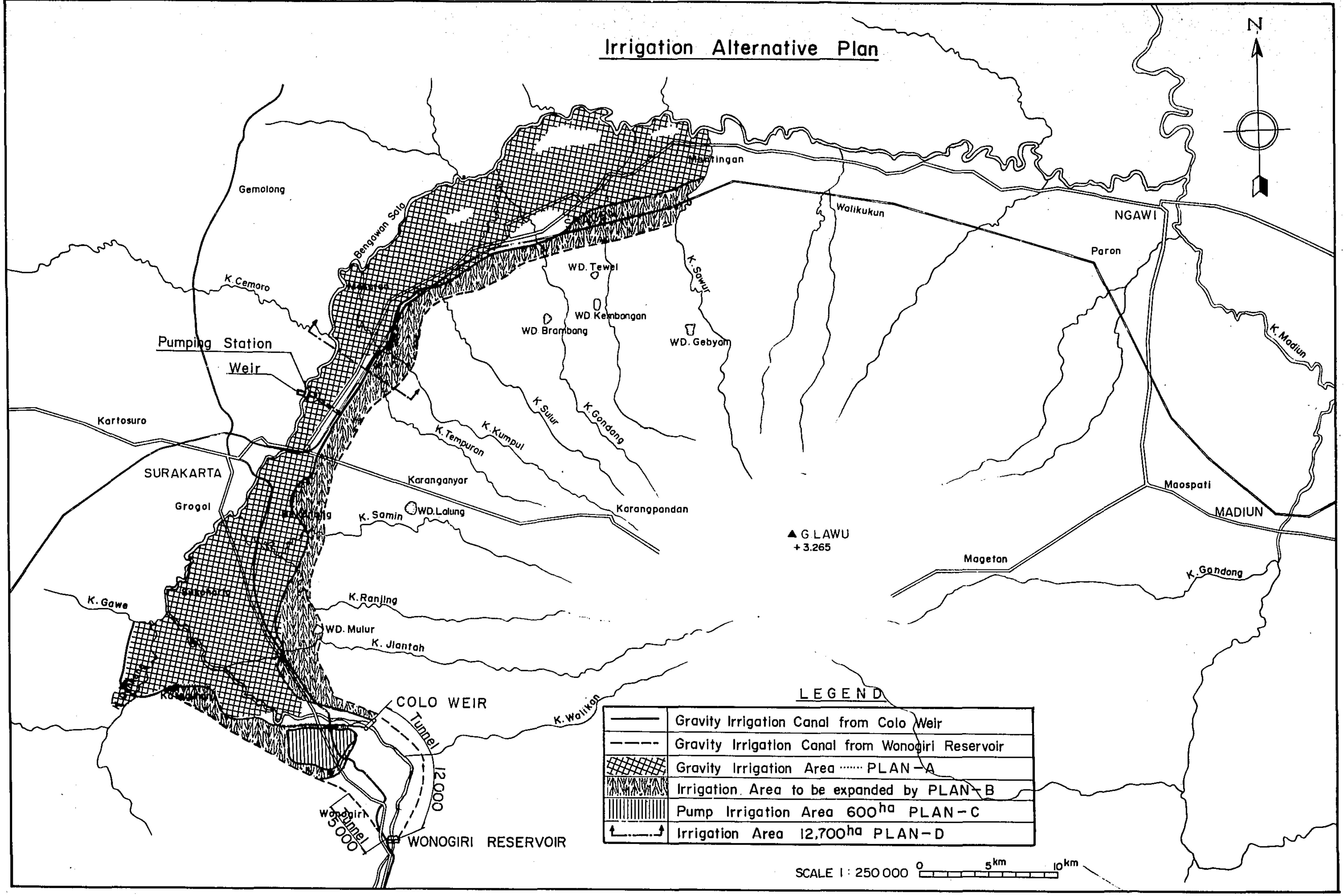
Note: /1, /2, /3 In addition to 440 million m^3 of the available water from the reservoir, water from tributaries will be utilized to its maximum extent.

Remarks: Work item marked with o is required or to be installed for the plan.

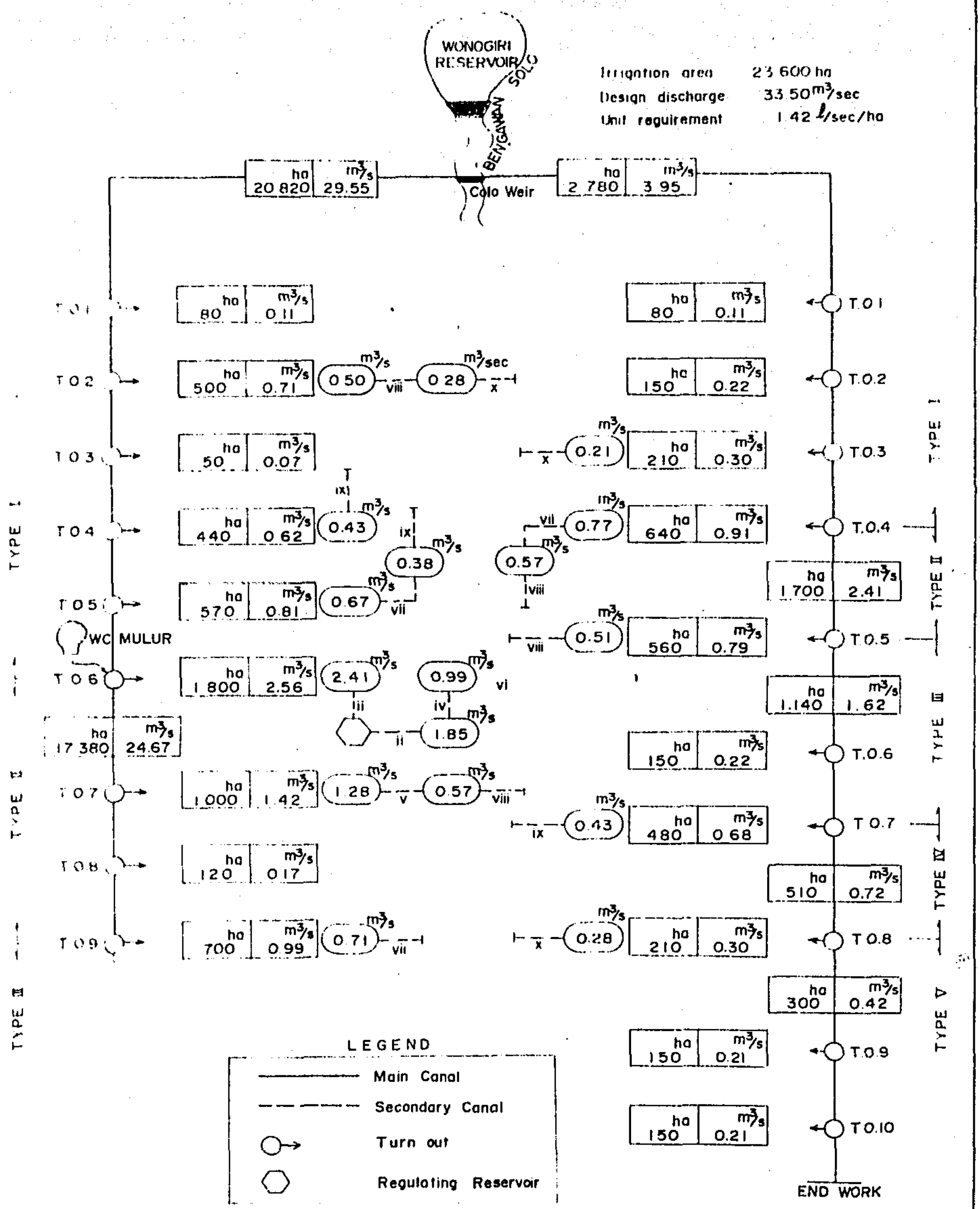
Summary of Cost Comparison

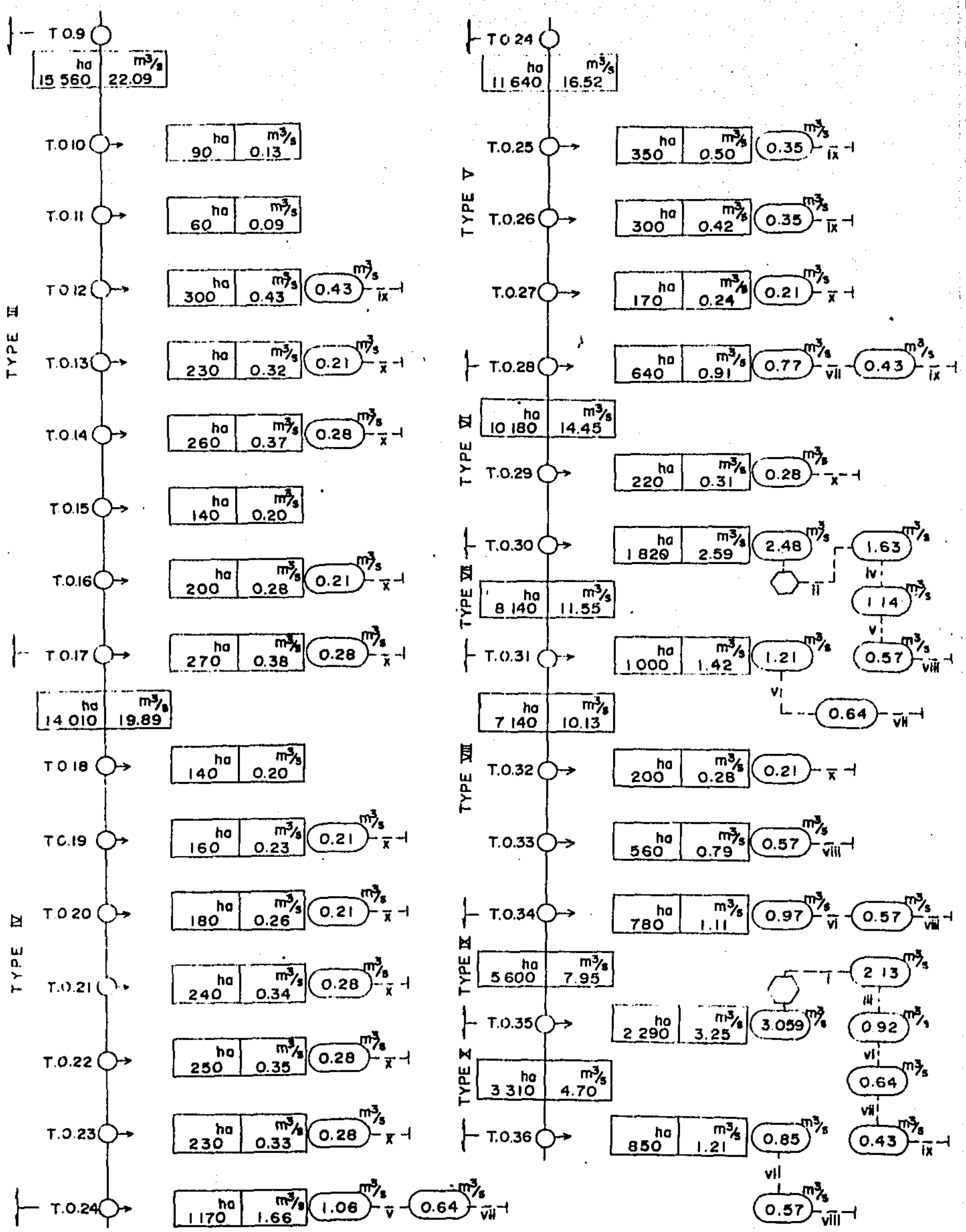
(US$1,000)

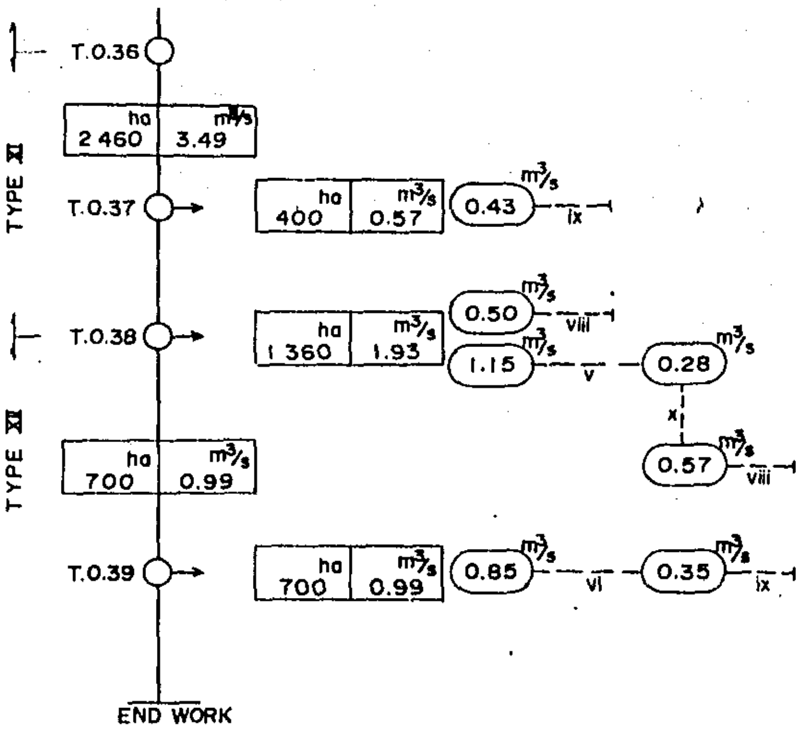
Item	Plan A	Plan B 1	Plan B 2	Plan C	Plan D 1	Plan D 2
1) Construction cost	33,100	74,150	42,770	34,200	37,000	31,270
2) Annual OM cost	130	130	130	195	382	130
3) Capitalized OM cost	1,230	1,230	1,230	1,840	3,600	1,230
4) Total cost (1)+(3)	34,330	75,380	44,000	36,040	40,600	32,500
5) Unit cost per ha	1.45	2.55	1.79	1.49	1.72	1.76


Irrigation Alternative Plan
N
Gemolong
Bengawan Solo
K. Cemoro
Pumping Station
Weir
Kartosuro
SURAKARTA
Grogol
K. Gawe
K. Samin
WD. Lalung
Karanganyar
K. Tempuran
K. Kumpul
K. Sulur
K. Gondang
K. Sawur
WD. Tewel
WD Kembangan
WD Brambang
WD. Gebyon
Walikukun
NGAWI
Paron
K. Madiun
Maospati
MADIUN
Magetan
K. Gondang
Karangpandan
▲ G LAWU
+ 3.265
K. Ranjing
WD. Mulur
K. Jlantah
K. Walikan
COLO WEIR
Tunnel
12,000
Wonogiri
Tunnel
5000
WONOGIRI RESERVOIR
LEGEND
Gravity Irrigation Canal from Colo Weir
Gravity Irrigation Canal from Wonogiri Reservoir
Gravity Irrigation Area ······ PLAN-A
Irrigation Area to be expanded by PLAN-B
Pump Irrigation Area 600ha PLAN-C
Irrigation Area 12,700ha PLAN-D
SCALE 1 : 250 000
0
5km
10km

APPENDIX 11 NETWORK DIAGRAM OF PROPOSED IRRIGATION SYSTEM




T.O.9
ha 15 560 m3/s 22.09
T.O.10 ha 90 m3/s 0.13
T.O.11 ha 60 m3/s 0.09
T.O.12 ha 300 m3/s 0.43 0.43 m3/s IX
TYPE III
T.O.13 ha 230 m3/s 0.32 0.21 m3/s X
T.O.14 ha 260 m3/s 0.37 0.28 m3/s X
T.O.15 ha 140 m3/s 0.20
T.O.16 ha 200 m3/s 0.28 0.21 m3/s X
T.O.17 ha 270 m3/s 0.38 0.28 m3/s X
ha 14 010 m3/s 19.89
T.O.18 ha 140 m3/s 0.20
T.O.19 ha 160 m3/s 0.23 0.21 m3/s X
T.O.20 ha 180 m3/s 0.26 0.21 m3/s X
TYPE IV
T.O.21 ha 240 m3/s 0.34 0.28 m3/s X
T.O.22 ha 250 m3/s 0.35 0.28 m3/s X
T.O.23 ha 230 m3/s 0.33 0.28 m3/s X
T.O.24 ha 1170 m3/s 1.66 1.06 m3/s V 0.64 m3/s VII
T.O.24
ha 11 640 m3/s 16.52
T.O.25 ha 350 m3/s 0.50 0.35 m3/s IX
TYPE V
T.O.26 ha 300 m3/s 0.42 0.35 m3/s IX
T.O.27 ha 170 m3/s 0.24 0.21 m3/s X
T.O.28 ha 640 m3/s 0.91 0.77 m3/s VII 0.43 m3/s IX
ha 10 180 m3/s 14.45
TYPE VI
T.O.29 ha 220 m3/s 0.31 0.28 m3/s X
T.O.30 ha 1 829 m3/s 2.59 2.48 m3/s II 1.63 m3/s IV 1.14 m3/s V 0.57 m3/s VIII
TYPE VII
ha 8 140 m3/s 11.55
T.O.31 ha 1 000 m3/s 1.42 1.21 m3/s VI 0.64 VII
ha 7 140 m3/s 10.13
TYPE VIII
T.O.32 ha 200 m3/s 0.28 0.21 X
T.O.33 ha 560 m3/s 0.79 0.57 m3/s VIII
T.O.34 ha 780 m3/s 1.11 0.97 m3/s VI 0.57 m3/s VIII
TYPE IX
ha 5 600 m3/s 7.95
T.O.35 ha 2 290 m3/s 3.25 3.059 m3/s I 2.13 m3/s III 0.92 m3/s VI 0.64 m3/s VII 0.43 m3/s IX
TYPE X
ha 3 310 m3/s 4.70
T.O.36 ha 850 m3/s 1.21 0.85 m3/s VII 0.57 m3/s VIII


T.0.36
ha
m³/s
2 460
3.49
TYPE XI
T.0.37
ha
m³/s
400
0.57
0.43
m³/s
ix
0.50
m³/s
viii
T.0.38
ha
m³/s
1 360
1.93
1.15
m³/s
v
0.28
m³/s
x
TYPE XII
ha
m³/s
700
0.99
0.57
m³/s
viii
T.0.39
ha
m³/s
700
0.99
0.85
m³/s
vi
0.35
m³/s
ix
END WORK

APPENDIX 12 TYPE AND LENGTH OF MAIN CANAL AND SECONDARY CANAL

(1) Main Canal

Turnout No.	Main Canal				Turnout	
	Irrig. area	Discharge	Canal Type	Length	Irrigation Area	Discharge
Right Main Canal						
Intake	20,820 ha	29.55 m^3/s		m	- ha	- m^3/sec
1	20,740	29.44			80	0.11
2	20,240	28.73			500	0.71
3	20,190	28.66	I	10,450	50	0.07
4	19,750	28.04			440	0.62
5	19,180	27.23			570	0.81
6	17,380	24.67			1,800	2.56
7	16,380	23.25			1,000	1.42
8	16,260	23.08	II	4,100	120	0.17
9	15,560	22.09			700	0.99
10	15,470	21.96			90	0.13
11	15,410	21.87			60	0.09
12	15,110	21.44			300	0.43
13	14,880	21.12	III	10,900	230	0.32
14	14,620	20.75			260	0.37
15	14,480	20.55			140	0.20
16	14,280	20.27			200	0.28
17	14,010	19.89			270	0.38
18	13,870	19.69			140	0.20
19	13,710	19.46			160	0.23
20	13,530	19.20	IV	8,900	180	0.26
21	13,290	18.86			240	0.34
22	13,040	18.51			250	0.35
23	12,810	18.18			230	0.33
24	11,640	16.52			1,170	1.66
25	11,290	16.02			350	0.50
26	10,990	15.60	V	6,950	300	0.42
27	10,820	15.36			170	0.24
28	10,180	14.45			640	0.91
29	9,960	14.14	VI	1,900	220	0.31
30	8,140	11.55			1,820	2.59

Turnout No.	Main Canal		Tuanout			
	Irrig. Area	Discharge	Canal Type	Length	Irrigation Area	Discharge
			VII	1,700		
31	7,140	10.13			1,000	1.42
32	6,940	9.85			200	0.28
33	6,380	9.06	VIII	8,300	560	0.79
34	5,600	7.95			780	1.11
35	3,310	4.70	IX	1,400	2,290	3.25
36	2,460	3.49	X	1,800	850	1.21
37	2,060	2.92	XI	4,500	400	0.57
38	700	0.99			1,360	1.93
39	0	0	XII	3,000	700	0.99
Left Main Canal						
Intake	2,780	3.95				
1	2,700	3.84			80	0.11
2	2,550	3.62	I	13,900	150	0.22
3	2,340	3.32			210	0.30
4	1,700	2.41	II	2,150	640	0.91
5	1,140	1.62			560	0.79
6	990	1.40	III	4,300	150	0.22
7	510	0.72			480	0.68
8	300	0.42	IV	2,850	210	0.30
9	150	0.21			150	0.21
10	0	0	V	2,350	150	0.21

Total Length (Right) 63,900 m
(Left) 25,550 m

(2) Secondary Canal

Right bank	Irrig. Area	Dischar ge	Length	Canal Type		Irrig. Area	Dischar ge	Length	Canal Type
	(Ha)	(m^3/sec)	(m)		To.30-b	1,150	1.63	1,600	iv
T.O 2-a	350	0.50	1,500	viii	c	800	1.14	1,800	v
b	200	0.28	1,200	x	d	400	0.57	1,500	viii
4-a	300	0.43	2,800	ix	31-a	850	1.27	2,800	v
5-a	470	0.67	2,500	vii	b	450	0.64	4,300	vii
b	270	0.38	3,000	ix	32-a	150	0.21	*700	x
6-a	1,700	2.41	4,000	ii	33-a	400	0.57	*3,600	viii
b	1,300	1.85	3,400	iv	34-a	680	0.97	2,500	vi
c	700	0.99	5,500	vii	b	400	0.57	*2,700	viii
7-a	900	1.28	4,700	v	35-a	2,190	3.11	2,700	i
b	400	0.57	3,900	viii	b	1,500	2.13	3,200	iii
9-a	500	0.71	2,700	vii	c	650	0.92	4,000	vi
12-a	300	0.43	*2,500	ix	d	450	0.64	5,000	vii
13-a	150	0.21	500	x	e	300	0.43	4,000	ix
14-a	200	0.28	*1,500	x	36-a	600	0.85	*2,300	vi
16-a	150	0.21	*1,100	x	b	400	0.57	*2,800	viii
17-a	200	0.28	900	x	37-a	300	0.43	*1,000	ix
19-a	150	0.21	700	x	38-a	350	0.50	*2,500	viii
20-a	150	0.21	1,100	x	a	810	1.15	3,000	v
21-a	200	0.28	600	x	b	200	0.28	2,600	x
22-a	200	0.28	*2,000	x	c	400	0.57	*2,300	viii
23-a	200	0.28	*1,500	x	39-a	600	0.85	1,800	vi
24-a	750	1.04	2,800	v	39-b	250	0.35	3,800	ix
b	450	0.64	5,400	vii	Left bank				
25-a	250	0.35	*1,500	ix	TO 3-a	150	0.21	1,200	x
26-a	250	0.35	*3,000	ix	4-a	540	0.77	2,800	vii
27-a	150	0.21	*700	x	b	400	0.57	3,600	viii
28-a	540	0.77	2,800	vii	5-a	360	0.51	2,400	viii
b	300	0.43	1,000	ix	7-a	300	0.43	2,100	ix
29-a	200	0.28	900	x	8-a	200		*1,000	x
30-a	1.750	2.48	3,600	ii					

* Rehabilitation Canal.

Total length	Right:	Left :
	100,100	12,100
	* 31,700	* 1,000
	131,800 m	13,100

Number of Proposed Turnout and Crossing

Canal Type	Turnout			Check Gate	Siphon			Aqueduct			Culvert		Bridge	
	A	B	C		A	B	C	A	B	C	A	B	A	B
Right Main Canal														
Type I	1	3	2	1	1	3	1				2	4	2	15
II	1	1	1				1					9		6
III			8		1	1		1	1			10		22
IV	1		6		1		3			1		9	1	33
V		1	3				1	1		1	1	7		10
VI	1		1	1							1	2		3
VII	1											1		5
VIII	1	1	1				1	1	1	1	1	5		20
IX	1											4		5
X	1			1						1		3		5
XI	1	1				1			1	1		6		10
XII			1							1		8		8
T o t a l	9	7	23	3	3	5	7	3	3	6	5	68	3	142
Left Main Canal														
Type I		1	3	1		1				1	2	5		22
II		1		1								3		1
III		1	1	1	1					1		3		8
IV*			1							2		2		3
V			2									7		4
T o t a l		3	7	3	1	1				4	2	20		38
Grand Total	9	11	29	6	4	6	7	3	3	10	7	88	3	180

APPENDIX 14. LIST OF CONSTRUCTION PLANT AND EQUIPMENT

(1) Construction Plant & Equipment for Dam

No.	Equipment	Capacity	Q'ty Total	Q'ty Dam	Road replacement
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.	Wheal 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.	Grease 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 shinker	2.7 m^3/min.	25	15	10
30.	Pick hammer	1.2 m^3/min.	25	15	10
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	-

No.	Equipment	Capacity	Q'ty Total	Q'ty Dam	Road replacement
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.

(2) Construction Plant & Equipment for Irrigation

No.	Equipment	Capacity	Total	Q'ty Purchased	Transferred from the dam
1.	Bulldozer	20 ton	16	15	-
2.	Crawler loader	2.0 m^3	5	5	-
3.	Back hoe	1.2 m^3	6	6	-
4.	Dump truck	8 ton	95	95	-
5.	Motor grader	3.7 m	3	3	-
6.	Vibration roller	5 ton	3	3	-
7.	Fuel tanker	8 ton	2	2	-
8.	Water tanker	8 ton	2	2	-
9.	Trailer truck	30 ton	1	1	-
10.	Cargo truck	6 ton	10	10	-
11.	Grease car	6 ton	5	5	-
12.	Truck crane	30 ton	1	1	-
13.	Portable concrete mixer	0.1 m^3	4	4	-
14.	Concrete plant	21 cft x 2	1	-	1
15.	Agitator truck	3.2 m^3	3	-	3
16.	Pump w/engine	4 inch	8	8	-
17.	Road roller	8 ton	2	2	-
18.	Screening plant	50 ton/hr	1	-	1
19.	Repair shop		L.S.	L.S.	-
20.	Saw mill		L.S.	L.S.	-
21.	Ripper attachment for Bulldozer	20 ton	2	2	-
22.	Dragline attachment shovel	1.2 m^3	3	3	-
23.	Power shovel attachment shovel	1.2 m^3	3	3	-
24.	Diesel pile hammer attachment	1.2 m^3	2	2	
25.	Miscellaneous		L.S.	L.S.	

(3) Construction Plant & Equipment for River Improvement

No.	Equipment	Capacity	Q'ty
1.	Bulldozer	20 ton	16
2.	Wheel loader	2.7 m^3	3
3.	Crawler loader	2.0 m^3	4
4.	Back hoe	1.2 m^3	5
5.	Dump truck	8 ton	50
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.	- do -	4 inch	6
16.	Diesel generator	50 kW	3
17.	Ripper attachment bull	20 ton	2
18.	Dragline attachment shovel	1.2 m^3	3
19.	Repair shop		L.S.
20.	Miscellaneous		L.S.

CALCULATION SHEET OF IRR

I. Proposed Plan

(Unit: 1,000US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFE-RENCE	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRIGA-TION	NEGATIVE BENEFIT	POWER	TOTAL		12%	15%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total						(B-A)		
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-625	-609
1977	6,200	-	880		-		-		7,080	-	7,080	-	-	-	-	-	-7,080	-5,644	-5,353
1978	11,800	-	4,780		3,550		-		20,130	-	20,130	3,690	-	-200	-	3,490	-16,640	-11,844	-10,941
1979	16,400	-	5,100		2,950	10	7,480		31,930	10	31,940	4,210	-	-250	-	3,960	-27,980	-17,781	-15,999
1980	8,300	-	6,130		2,950	10	4,220		21,600	10	21,610	4,530	-	-740	-	3,790	-17,820	-10,111	-8,860
1981	(43,400)	40	8,370		2,960	10	(11,700)	280	11,330	330	11,660	5,050	-	-820	1,350	5,580	-6,080	-3,080	-2,628
1982		40	7,840		3,130	10		280	10,970	330	11,300	5,470	-	-820	1,350	6,000	-5,300	-2,397	-1,992
1983		40	(33,100)	130	2,730	20		280	2,730	470	3,200	5,810	2,720	-820	1,350	9,060	5,860	2,367	1,916
1984		40		130	(18,270)	20		280	(106,470)	470	470	5,810	5,450	-820	1,350	11,790	11,320	4,082	3,218
1985		40		130		20		280		470	470	5,810	8,170	-820	1,350	14,570	14,040	4,521	3,471
1986		40		130		20		280		470	470	5,810	10,900	-820	1,350	17,240	16,770	4,821	3,604
1987		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490	5,003	2,643
1988		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
⋮		⋮		⋮		⋮		⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	41,130	24,166
2025		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
Total																		10,442	-6,364

$$IRR = 12\% + \frac{10,442}{10,442 + 6,364} (15-12)\%$$

$$= 13.9\%$$

II-1. Irrigation Facilities will be Constructed after 5-year of Dam Construction (Unit: 1,000 US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFERENCE (B-A)	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRIGATION	NEGATIVE BENEFIT	POWER	TOTAL		10%	13%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-636	-620
1977	6,200	-	-		-		-		6,200	-	6,200	-	-	-	-	-	-6,200	-5,124	-4,855
1978	11,800	-	-		3,550		-		15,350	-	15,350	3,690	-	-200	-	3,490	-11,860	-8,910	-8,220
1979	16,400	-	-		2,950	10	7,480		26,830	10	26,840	4,210	-	-250	-	3,960	-22,880	-15,627	-14,032
1980	8,300	-	880		2,950	10	4,220		16,350	10	16,360	4,530	-	-740	-	3,790	-12,570	-7,805	-6,823
1981	(43,400)	40	4,780		2,960	10	(11,700)	280	7,740	330	8,070	5,050	-	-820	1,350	5,580	-2,490	-1,406	-1,196
1982		40	5,100		3,130	10		280	8,230	330	8,560	5,470	-	-820	1,350	6,000	-2,560	-1,468	-1,088
1983		40	(6,130)	-	2,730	20		280	8,860	340	9,200	5,810	-	-820	1,350	6,340	-2,860	-1,334	-1,076
1984		40	8,370	-	(18,270)	20		280	(8,370)	340	8,710	5,810	-	-820	1,350	6,340	-2,370	-1,005	-789
1985		40	7,840	-		20		280	7,840	340	8,180	5,810	-	-820	1,350	6,340	-1,840	-709	-542
1986		40	(33,100)	130		20		280	(106,470)	470	470	5,810	2,720	-820	1,350	9,060	8,590	3,010	2,239
1987		40		130		20		280		470	470	5,810	5,450	-820	1,350	11,790	11,320	3,607	2,612
1988		40		130		20		280		470	470	5,810	8,170	-820	1,350	14,510	14,040	4,067	2,867
1989		40		130		20		280		470	470	5,810	10,900	-820	1,350	17,240	16,770	4,416	3,030
1990		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490	4,666	3,116
1991		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
.		.		.		.		.		.	.	.	.	.	.	.	.		
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.		.		.		.		.		.	.	.	.	.	.	.	.		
2025		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
Total																		20,740	-1,737

$$IRR = 10\% + \frac{20,740}{20,740 + 1,737} (13-10)\%$$

$$= 12.8\%$$

II-2. Irrigation Facilities will be Constructed after 8-year of Dam Construction

(Unit: 1,000 US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFE-RENCE (B-A)	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRI-GATION	NEGATIVE BENEFIT	POWER	TOTAL		10%	13%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-636	-620
1977	6,200	-	-		-		-		6,200	-	6,200	-	-	-	-	-	-6,200	-5,124	-4,855
1978	11,800	-	-		3,550		-		15,350	-	15,350	3,690	-	-200	-	3,490	-11,860	-8,910	-8,220
1979	16,400	-	-		2,950	10	7,480		26,830	10	26,840	4,210	-	-250	-	3,960	-22,880	-15,627	-14,032
1980	8,300	-	-		2,950	10	4,220		15,470	10	15,480	4,530	-	-740	-	3,790	-11,690	-7,258	-6,345
1981	(43,400)	40	-		2,960	10	(11,700)	280	2,960	330	3,290	5,050	-	-820	1,350	5,580	2,290	1,293	1,100
1982		40	-		3,130	10		280	3,130	330	3,460	5,470	-	-820	1,350	6,000	2,540	1,304	1,080
1983		40	(880)	-	2,730	20		280	3,610	340	3,950	5,810	-	-820	1,350	6,340	2,390	1,115	899
1984		40	4,780	-	(18,270)	20		280	(4,780)	340	5,120	5,810	-	-820	1,350	6,340	1,220	517	406
1985		40	5,100	-		20		280	5,100	340	5,440	5,810	-	-820	1,350	6,340	900	347	265
1986		40	6,130	-		20		280	6,130	340	6,470	5,810	-	-820	1,350	6,340	-130	-46	-34
1987		40	8,370	-		20		280	8,370	340	8,710	5,810	-	-820	1,350	6,340	-2,370	-755	-547
1988		40	7,840	-		20		280	7,840	340	8,180	5,810	-	-820	1,350	6,340	-1,840	-533	-376
1989		40	(33,100)	130		20		280	(106,470)	470	470	5,810	2,720	-820	1,350	9,060	8,590	2,262	1,552
1990		40		130		20		280		470	470	5,810	5,450	-820	1,350	11,790	11,320	2,710	1,810
1991		40		130		20		280		470	470	5,810	8,170	-820	1,350	14,510	14,040	3,055	1,987
1992		40		130		20		280		470	470	5,810	10,900	-820	1,350	17,240	16,770	3,317	2,100
1993		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490	3,506	2,159
1994		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
'		'		'		'		'		'	'	'	'	'	'	'	'	30,356	16,279
'		'		'		'		'		'	'	'	'	'	'	'	'		
2025		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
Total																		10,893	-5,392

$$IRR = 10\% + \frac{10,893}{10,893 + 5,392}(13-10)\%$$

$$= 12.0\%$$

II-3. Irrigation Facilities will be Constructed after 11-year of Dam Construction (Unit: 1,000 US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFE-RENCE (B-A)	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRI-GATION	NEGATIVE BENERIT	POWER	TOTAL		10%	13%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total								
1976	700	-	-	-	-		-		700	-	700	-	-	-	-	-	-700	-636	-620
1977	6,200	-	-	-	-		-		6,200	-	6,200	-	-	-	-	-	-6,200	-5,124	-4,855
1978	11,800	-	-	-	3,550		-		15,350	-	15,350	3,690	-	-200	-	3,490	-11,860	-8,910	-8,220
1979	16,400	-	-	-	2,950	10	7,480		26,830	10	26,840	4,210	-	-250	-	3,960	-22,880	-15,627	-14,032
1980	8,300	-	-	-	2,950	10	4,220		15,470	10	15,480	4,530	-	-740	-	3,790	-11,690	-7,258	-6,345
1981	(43,400)	40	-	-	2,960	10	(11,700)	280	2,960	330	3,290	5,050	-	-820	1,350	5,580	2,290	1,293	1,100
1982		40	-	-	3,130	10		280	3,130	330	3,460	5,470	-	-820	1,350	6,000	2,540	1,304	1,080
1983		40	-	-	2,730	20		280	2,730	340	3,070	5,810	-	-820	1,350	6,340	3,270	1,525	1,230
1984		40	-	-	(18,270)	20		280	-	340	340	5,810	-	-820	1,350	6,340	6,000	2,545	1,997
1985		40	-	-		20		280	-	340	340	5,810	-	-820	1,350	6,340	6,000	2,313	1,768
1986		40	880	-		20		280	880	340	1,220	5,810	-	-820	1,350	6,340	5,120	1,795	1,335
1987		40	4,780	-		20		280	4,780	340	5,120	5,810	-	-820	1,350	6,340	1,220	389	281
1988		40	5,100	-		20		280	5,100	340	5,440	5,810	-	-820	1,350	6,340	900	261	184
1989		40	6,130	-		20		280	6,130	340	6,470	5,810	-	-820	1,350	6,340	-130	-34	-23
1990		40	8,370	-		20		280	8,370	340	8,710	5,810	-	-820	1,350	6,340	-2,370	-567	-379
1991		40	7,840	-		20		280	7,840	340	8,180	5,810	-	-820	1,350	6,340	-1,840	-400	-260
1992		40	(33,100)	130		20		280	(106,470)	470	470	5,810	2,720	-820	1,350	9,060	8,590	1,699	1,075
1993		40		130		20		280		470	470	5,810	5,450	-820	1,350	11,790	11,320	2,036	1,254
1994		40		130		20		280		470	470	5,810	8,170	-820	1,350	14,510	14,040	2,296	1,377
1995		40		130		20		280		470	470	5,810	10,900	-820	1,350	17,240	16,770	2,492	1,456
1996		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490	2,633	1,497
1997		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
·		·		·		·		·		·	·	·	·	·	·	·	·	24,670	11,181
·		·		·		·		·		·	·	·	·	·	·	·	·		
2025		40		130		20		280		470	470	5,810	13,620	-820	1,350	19,960	19,490		
Total																		8,695	-7,919

$$IRR = 10\% + \frac{8,695}{8,695 + 7,919} (13-10)\%$$

$$= 11.6\%$$

III-1. Productivity of Paddy (5.0 t/ha)

(Unit: 1,000 US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFERENCE	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRIGATION	NEGATIVE BENEFIT	POWER	TOTAL	(B-A)	10%	13%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-636	-620
1977	6,200	-	880		-		-		7,080	-	7,080	-	-	-	-	-	-7,080	-5,851	-5,545
1978	11,800	-	4,780		3,550		-		20,130	-	20,130	3,690	-	-200	-	3,490	-16,640	-12,502	-11,533
1979	16,400	-	5,100		2,950	10	7,480		31,930	10	31,940	4,210	-	-250	-	3,960	-27,980	-19,110	-17,160
1980	8,300	-	6,130		2,950	10	4,220		21,600	10	21,610	4,530	-	-740	-	3,790	-17,820	-11,064	-9,673
1981	(43,400)	40	8,370		2,960	10	(11,700)	280	11,330	330	11,660	5,050	-	-820	1,350	5,580	-6,080	-3,432	-2,920
1982		40	7,840		3,130	10		280	10,970	330	11,300	5,470	-	-820	1,350	6,000	-5,300	-2,720	-2,253
1983		40	(33,100)	130	2,730	20		280	2,730	470	3,200	5,810	2,230	-820	1,350	8,570	5,370	2,505	2,020
1984		40		130	(18,270)	20		280	(106,470)	470	470	5,810	4,460	-820	1,350	10,800	10,330	4,381	3,439
1985		40		130		20		280		470	470	5,810	6,680	-820	1,350	13,020	12,550	4,838	3,697
1986		40		130		20		280		470	470	5,810	8,910	-820	1,350	15,250	14,780	5,180	3,853
1987		40		130		20		280		470	470	5,810	11,140	-820	1,350	17,480	17,010	5,419	3,924
1988		40		130		20		280		470	470	5,810	11,140	-820	1,350	17,480	17,010		
·		·		·		·		·		·	·	·	·	·	·	·	·		
·		·		·		·		·		·	·	·	·	·	·	·	·	52,745	29,895
·		·		·		·		·		·	·	·	·	·	·	·	·		
2025		40		130		20		280		470	470	5,810	11,140	-820	1,350	17,480	17,010		
Total																		19,753	-2,876

$$IRR = 10\% + \frac{19,753}{19,753 + 2,876}(13-10)\%$$

$$= 12.6\%$$

III-2. Productivity of Paddy (4.5 t/ha) (Unit: 1,000 US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFE-RENCE	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRI-GATION	NEGATIVE BENEFIT	POWER	TOTAL	(B-A)	10%	13%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-636	-620
1977	6,200	-	880		-		-		7,080	-	7,080	-	-	-	-	-	-7,080	-5,851	-5,545
1978	11,800	-	4,780		3,550		-		20,130	-	20,130	3,690	-	-200	-	3,490	-16,640	-12,502	-11,533
1979	16,400	-	5,100		2,950	10	7,480		31,930	10	31,940	4,210	-	-250	-	3,960	-27,980	-19,110	-17,160
1980	8,300	-	6,130		2,950	10	4,220		21,600	10	21,610	4,530	-	-740	-	3,790	-17,820	-11,064	-9,673
1981	(43,400)	40	8,370		2,960	10	(11,700)	280	11,330	330	11,660	5,050	-	-820	1,350	5,580	-6,080	-3,432	-2,920
1982		40	7,840		3,130	10		280	10,970	330	11,300	5,470	-	-820	1,350	6,000	-5,300	-2,720	-2,253
1983		40	(33,100)	130	2,730	20		280	2,730	470	3,200	5,810	1,730	-820	1,350	8,070	4,870	2,272	1,832
1984		40		130	(18,270)	20		280	(106,470)	470	470	5,810	3,460	-820	1,350	9,800	9,330	3,957	3,106
1985		40		130		20		280		470	470	5,810	5,200	-820	1,350	11,540	11,070	4,267	3,261
1986		40		130		20		280		470	470	5,810	6,930	-820	1,350	13,270	12,800	4,486	3,337
1987		40		130		20		280		470	470	5,810	8,660	-820	1,350	15,000	14,530	4,629	3,352
1988		40		130		20		280		470	470	5,810	8,660	-820	1,350	15,000	14,530		
⋮		⋮		⋮		⋮		⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
⋮		⋮		⋮		⋮		⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	45,055	25,537
⋮		⋮		⋮		⋮		⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
2025		40		130		20		280		470	470	5,810	8,660	-820	1,350	15,000	14,530		
Total																		9,351	-9,279

$$IRR = 10\% + \frac{9,351}{9,351 + 9,279}(13-10)\%$$

$$= 11.5\%$$

IV-1 Price of Rice (US$240/ton)

(Unit: 1,000US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFERENCE	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRIGATION	NEGATIVE BENEFIT	POWER	TOTAL	(B-A)	10%	13%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-636	-620
1977	6,200	-	880		-		-		7,080	-	7,080	-	-	-	-	-	-7,080	-5,851	-5,545
1978	11,800	-	4,780		3,550		-		20,130	-	20,130	3,690	-	-200	-	3,490	-16,640	-12,502	-11,533
1979	16,400	-	5,100		2,950	10	7,480		31,930	10	31,940	4,210	-	-250	-	3,960	-27,980	-19,110	-17,160
1980	8,300	-	6,130		2,950	10	4,220		21,600	10	21,610	4,530	-	-740	-	3,790	-17,820	-11,064	-9,673
1981	(43,400)	40	8,370		2,960	10	(11,700)	280	11,330	330	11,660	5,050	-	-820	1,350	5,580	-6,080	-3,432	-2,920
1982		40	7,840		3,130	10		280	10,970	330	11,300	5,470	-	-820	1,350	6,000	-5,300	-2,720	-2,253
1983		40	(33,100)	130	2,730	20		280	2,730	470	3,200	5,810	2,030	-820	1,350	8,370	5,170	2,412	1,945
1984		40		130	(18,270)	20		280	(106,470)	470	470	5,810	4,070	-820	1,350	10,410	9,940	4,216	3,309
1985		40		130		20		280		470	470	5,810	6,100	-820	1,350	12,440	11,970	4,614	3,526
1986		40		130		20		280		470	470	5,810	8,140	-820	1,350	14,480	14,010	4,911	3,652
1987		40		130		20		280		470	470	5,810	10,170	-820	1,350	16,510	16,040	5,110	3,700
1988		40		130		20		280		470	470	5,810	10,170	-820	1,350	16,510	16,040	49,737 (1988–2025)	28,191 (1988–2025)
⋮		⋮		⋮		⋮		⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮		
2025		40		130		20		280		470	470	5,810	10,170	-820	1,350	16,510	16,040		
Total																		15,685	-5,381

$$IRR = 10\% + \frac{15,685}{15,685 + 5,381}(13-10)\%$$
$$= 12.2\%$$

IV-2 Price of Rice (US$300/ton)

(Unit: 1,000US$)

ITEM	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFE-RENCE	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER:		TOTAL COSTS			FLOOD CONT.	IRRIGA-TION	NEGATIVE BENEFIT	POWER	TOTAL	(B-A)	14%	17%
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-614	-598
1977	6,200	-	880		-		-		7,080	-	7,080	-	-	-	-	-	-7,080	-5,448	-5,172
1978	11,800	-	4,780		3,550		-		20,130	-	20,130	3,690	-	-200	-	3,490	-16,640	-11,232	-10,390
1979	16,400	-	5,100		2,950	10	7,480		31,930	10	31,940	4,210	-	-250	-	3,960	-27,980	-16,567	-14,933
1980	8,300	-	6,130		2,950	10	4,220		21,600	10	21,610	4,530	-	-740	-	3,790	-17,820	-9,256	-8,128
1981	(43,400)	40	8,370		2,960	10	(11,700)	280	11,330	330	11,660	5,050	-	-820	1,350	5,580	-6,080	-2,770	-2,370
1982		40	7,840		3,130	10		280	10,970	330	11,300	5,470	-	-820	1,350	6,000	-5,300	-2,118	-1,766
1983		40	(33,100)	130	2,730	20		280	2,730	470	3,200	5,810	3,410	-820	1,350	9,750	6,550	2,296	1,865
1984		40		130	(18,270)	20		280	(106,470)	470	470	5,810	6,830	-820	1,350	13,170	12,700	3,905	3,091
1985		40		130		20		280		470	470	5,810	10,240	-820	1,350	16,580	16,110	4,345	3,351
1986		40		130		20		280		470	470	5,810	13,660	-820	1,350	20,000	19,530	4,621	3,472
1987		40		130		20		280		470	470	5,810	17,070	-820	1,350	23,410	22,940	4,762	3,487
1988		40		130		20		280		470	470	5,810	17,070	-820	1,350	23,410	22,940		
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:		:		:		:		:		:	:	:	:	:	:	:	:		
2025		40		130		20		280		470	470	5,810	17,070	-820	1,350	23,410	22,940		
Total																		5,707	-7,632

$$IRR = 14\% + \frac{5,707}{5,707 + 7,632}(17-14)\%$$

$$= 15.3\%$$

IV-3 Price of Rice (US$330/t)

(Unit: 1,000US$)

ITEM / YEAR	A. PROJECT COSTS											B. PROJECT BENEFITS					DIFFERENCE (B-A)	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		POWER		TOTAL COSTS			FLOOD CONT.	IRRIGATION	NEGATIVE BENEFIT	POWER	TOTAL		17%	14%
	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total								
1976	700	-	-		-		-		700	-	700	-	-	-	-	-	-700	-598	-614
1977	6,200	-	880		-		-		7,080	-	7,080	-	-	-	-	-	-7,080	-5,172	-5,448
1978	11,800	-	4,780		3,550		-		20,130	-	20,130	2,690	-	-200	-	3,490	-16,640	-10,390	-11,232
1979	16,400	-	5,100		2,950	10	7,480		31,930	10	31,940	4,210	-	-250	-	3,960	-27,980	-14,933	-16,567
1980	8,300	-	6,130		2,950	10	4,220		21,600	10	21,610	4,530	-	-740	-	3,790	-17,820	-8,128	-9,256
1981	(43,400)	40	8,370		2,960	10	(11,700)	280	11,330	330	11,660	5,050	-	-820	1,350	5,580	-6,080	-2,370	-2,770
1982		40	7,840		3,130	10		280	10,970	330	11,300	5,470	-	-820	1,350	6,000	-5,300	-1,766	-2,118
1983		40	(33,100)	130	2,730	20		280	2,730	470	3,200	5,810	4,100	-820	1,350	10,440	7,240	2,062	2,538
1984		40		130	(18,270)	20		280	(106,470)	470	470	5,810	8,210	-820	1,350	14,550	14,080	3,427	4,330
1985		40		130		20		280		470	470	5,810	12,310	-820	1,350	18,650	18,180	3,781	4,903
1986		40		130		20		280		470	470	5,810	16,420	-820	1,350	22,760	22,290	3,963	5,274
1987		40		130		20		280		470	470	5,810	20,520	-820	1,350	26,860	26,390	4,011	5,479
1988		40		130		20		280		470	470	5,810	20,520	-820	1,350	26,860	26,390		
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2025		40		130		20		280		470	470	5,810	20,520	-820	1,350	26,860	26,390		
Total																		-2,578	13,382

$$IRR = 14\% + \frac{13,382}{13,382 + 2,578}(17-14)\%$$

$$= 16.5\%$$

APPENDIX 16 EFFECTS OF THE POWER SECTOR ON THE FEASIBILITY OF THE PROJECT

Since the power development is subordinate to the irrigation, the power sector has been considered to be less economy compared with other sectors.

In order to evaluate the effects of the sector on the project feasibility, internal rate of return is calculated for the case that the power development is excluded from the project.

The separable cost for the power sector is firstly estimated, which includes the total cost of power plant and transmission line and equitable cost for dam construction. Then, the estimated separable cost is deducted from the total project cost to get the appropriate cost for the two purposes of irrigation and flood control as follows.

	(US$1,000)
Total construction cost for the project	US$106,470
Separable cost for power	
Wonogiri power station	11,700
equitable cost of dam	3,600
Residual cost	91,170

Internal rate of return is calculated on the basis of the disbursement schedule of the residual cost as shown in the following table.

The internal rate of return slightly increases to 14.7 % from the proposed plan, which reveals that the power sector is less economy compared with other sectors.

ITEM	A. PROJECT COSTS									B. PROJECT BENEFITS				DIFFERENCE	DISCOUNTED VALUE	
	DAM		IRRIGATION		RIV. IMPR.		TOTAL COSTS			FLOOD CONT.	IRRIGATION	NEGATIVE BENEFIT	TOTAL	(B-A)		
YEAR	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Cap.	OM&R	Total						12%	15%
1976	640	-	-		-		640	-	640	-	-	-	-	-640	-571	-557
1977	5,910	-	880		-		6,790	-	6,790	-	-	-	-	-6,790	-5,413	-5,133
1978	11,210	-	4,780		3,550		19,540	-	19,540	3,690	-	-200	3,490	-16,050	-11,424	-10,552
1979	14,890	-	5,100		2,950	10	22,940	10	22,950	4,210	-	-250	3,960	-18,990	-12,068	-10,858
1980	7,150	-	6,130		2,950	10	16,230	10	16,240	4,530	-	-740	3,790	-12,450	-7,064	-6,190
1981	(39,800)	40	8,370		2,960	10	11,330	50	11,380	5,050	-	-820	4,230	-7,150	-3,622	-3,091
1982		40	7,840		3,130	10	10,970	50	11,020	5,470	-	-820	4,650	-6,370	-2,881	-2,394
1983		40	(33,100)	130	2,730	20	2,730	190	2,920	5,810	2,720	-820	7,710	4,790	1,935	1,566
1984		40		130	(18,270)	20	(91,170)	190	190	5,810	5,450	-820	10,440	10,250	3,696	2,914
1985		40		130		20		190	190	5,810	8,170	-820	13,220	12,970	4,176	3,206
1986		40		130		20		190	190	5,810	10,900	-820	15,890	15,700	4,514	3,374
1987		40		130		20		190	190	5,810	13,620	-820	18,610	18,420	4,728	3,443
1988		40		130		20		190	190	5,810	13,620	-820	18,610	18,420		
⋮		⋮		⋮		⋮		⋮	⋮	⋮	⋮	⋮	⋮	⋮	38,872	22,839
2025		40		130		20		190	190	5,810	13,620	-820	18,610	18,420		
Total															14,878	-1,433

$$IRR = 12\% + \frac{14,878}{14,878 + 1,433}(15 - 12)\%$$

$$= 14.7\%$$

APPENDIX 17. COST ALLOCATION

The Wonogiri Multipurpose Dam Project comprises three primary purposes of irrigation, flood control and hydropower.

In order to find the equitable cost for each purpose, allocation of the financial cost (without interest cost) is carried out by means of "Separable Cost - Remaining Benefit Method".

This method of cost allocation provides that each purpose will be assigned costs no greater than that purposes benefits or the alternate single purpose costs whichever is the least in proportion to the percentage of remaining justifiable expenditure.

The alternative costs for each purpose is firstly obtained for the comparison with the expected benefit, which is the cost of the most economic single purpose project that can provide the same benefit as the multipurpose project.

Then, separable cost, those expenditures which could be avoided if one purpose were excluded from the project, is estimated and assigned to that purpose. Remaining justifiable expenditure is given by deducting the separable cost from the justifiable expenditure, which is the least cost of the expected benefit and the alternative cost.

The remaining joint costs of the project are then divided into each purpose in proportion to the remaining justifiable expenditure. The summary of the calculation of the cost allocation is presented in the attached Table (1).

Finally, allocated cost for each purpose is determined by adding the interest cost during construction to the cost estimated above as follows.

Purpose	Total Allocated Cost Without Interest	Interest	Total
Irrigation	69,835	6,995	76,830
Flood Control	42,488	4,392	46,880
Power	15,487	2,083	17,570
Total	127,810	13,470	141,280

Table (1) COST ALLOCATION (Without Interest Cost)

(US$1,000)

ITEM	IRRIGATION	FLOOD CONTROL	HYDROPOWER	TOTAL
1. Cost to be Allocated				134,300
a. Construction costs (financial cost without interest)				127,810
b. OM & R costs (Capitalized)/1				6,490
2. Benefits (Capitalized)/2	122,450	79,500	18,630	220,580
3. Alternative Costs	92,190	62,090	18,630	172,910
4. Justifiable Expenditure	92,190	62,090	18,630	172,910
5. Separable Costs	49,720	22,080	17,850	89,650
a. Construction costs	(47,920)	(21,820)	(15,100)	(84,840)
b. OM & R costs (Capitalized)	(1,800)	(260)	(2,750)	(4,810)
6. Remaining Justifiable Expenditure (4-5)	42,470	40,010	780	83,260
7. Percent Distribution of 6	51.0	48.1	0.9	100
8. Remaining Joint Costs	22,772	21,476	402	44,650
a. Construction costs	(21,915)	(20,668)	(387)	(42,970)
b. OM & R costs	(857)	(808)	(15)	(1,680)
9. Total Allocated Cost (5 + 8)	72,492	43,556	18,252	134,300
a. Construction cost	(69,835)	(42,488)	(15,487)	(127,810)
b. OM & R cost	(2,657)	(1,068)	(2,765)	(6,490)

Note: Discount rate of 7 % is used for capitalizing benefits and costs.
/1 OM & R cost for each purpose is assumed to be same as that of economic cost.
/2 Economic benefits are applied.

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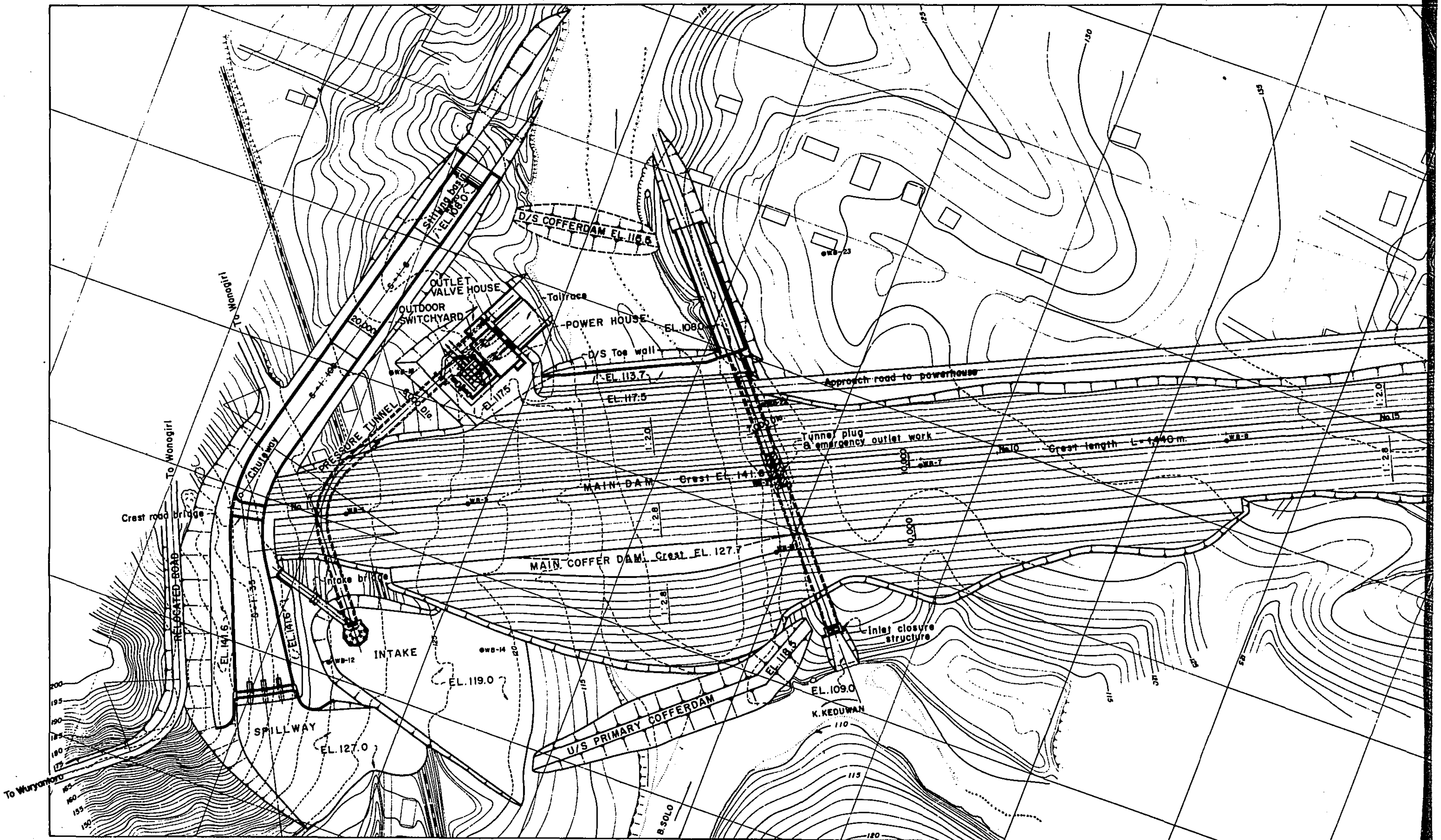
DRAWINGS


D/S COFFERDAM EL.116.5
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
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.141.0
MAIN COFFER DAM Crest EL.127.7
Crest road bridge
To Wonogiri
To Wonogiri
RELOCATED ROAD
EL.141.6
EL.141.6
Intake bridge
INTAKE
EL.119.0
SPILLWAY
EL.127.0
U/S PRIMARY COFFERDAM
EL.118.5
Inlet closure structure
EL.109.0
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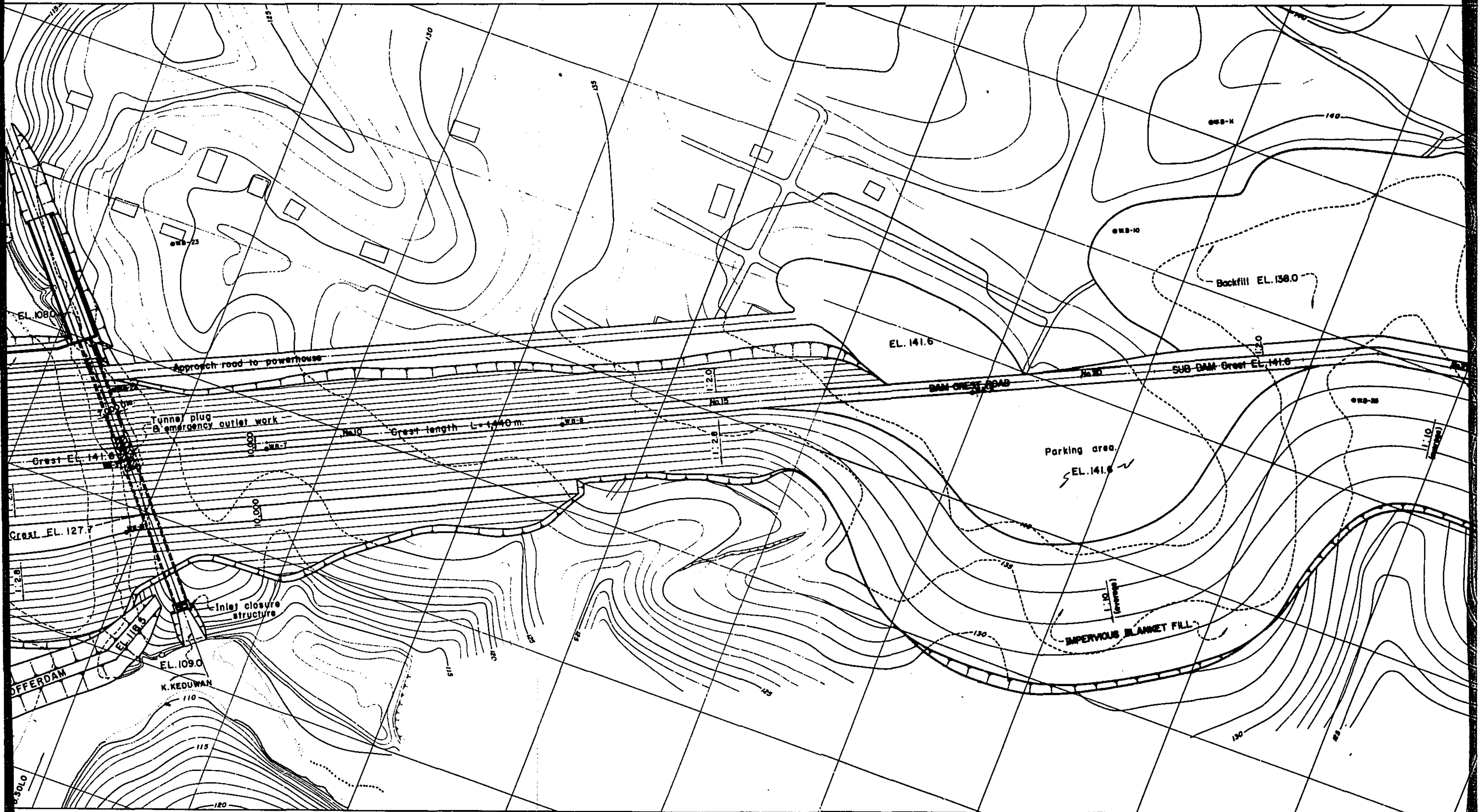
Approach road to powerhouse
Tunnel plug
& emergency outlet work
Crest length L=1,440 m.
Crest EL. 141.6
Crest EL. 127.7
EL. 108.0
EL. 118.5
EL. 109.0
Inlet closure
structure
K. KEDUWAN
COFFERDAM
DAM CREST ROAD
SUB DAM Crest EL. 141.6
EL. 141.6
Parking area.
EL. 141.6
Backfill EL. 138.0
IMPERVIOUS BLANKET FILL
No.10
No.15
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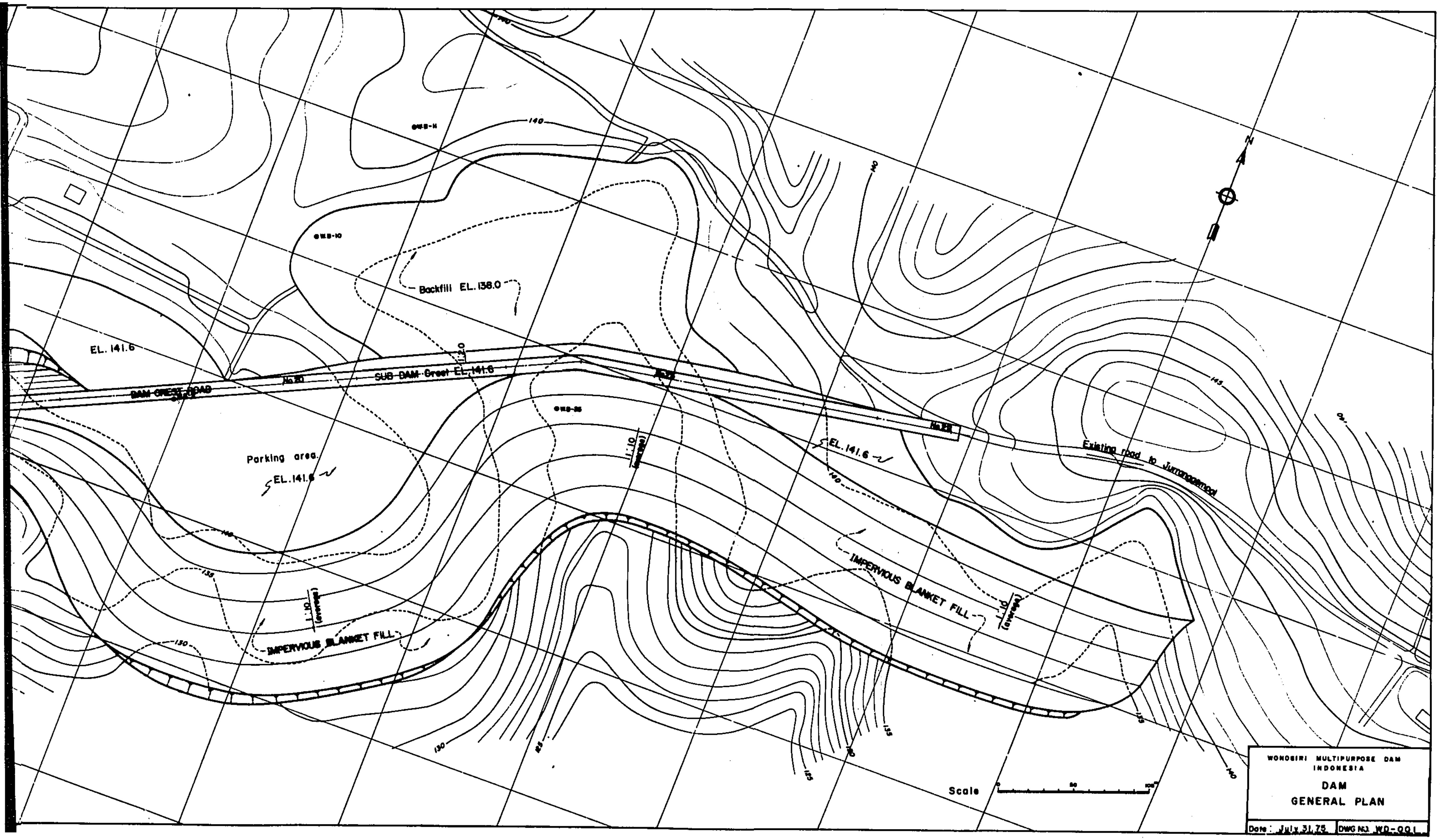

Backfill EL. 138.0
EL. 141.6
DAM CREST ROAD
SUB DAM Crest EL. 141.6
Parking area
EL. 141.6
EL. 141.6
IMPERVIOUS BLANKET FILL
IMPERVIOUS BLANKET FILL
Existing road to Jurangempol
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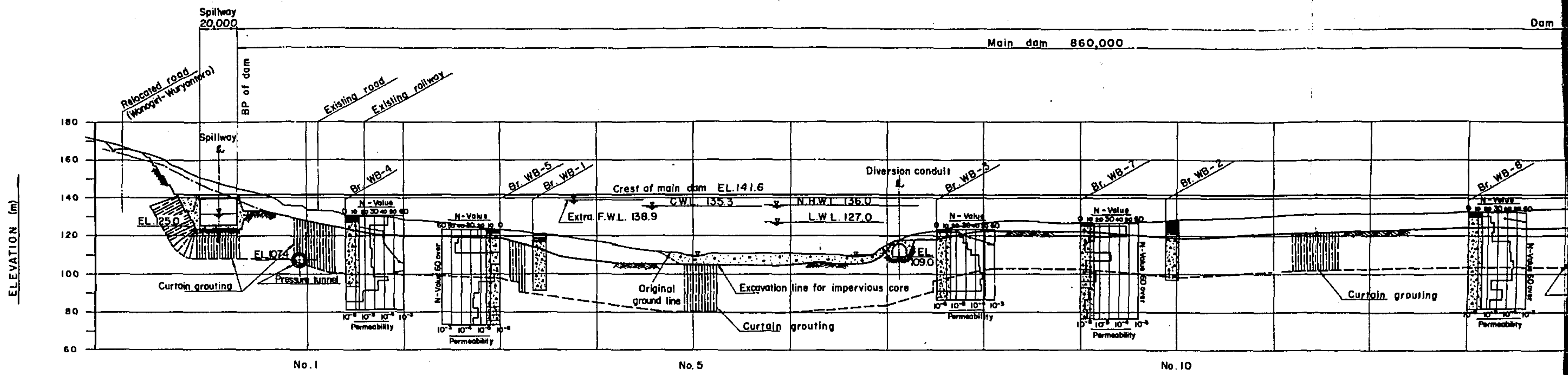
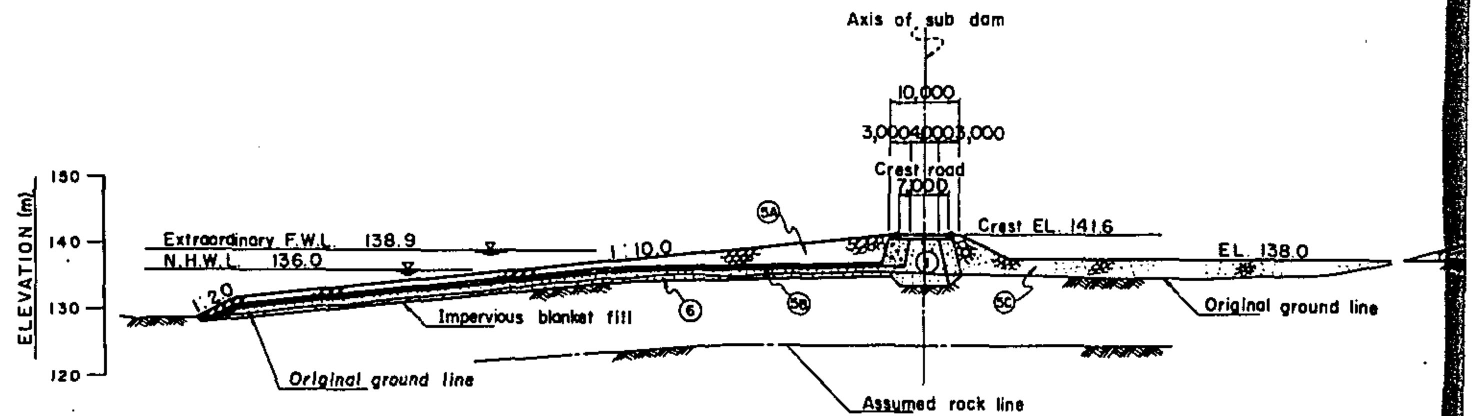
Scale
WONOGIRI MULTIPURPOSE DAM
INDONESIA
DAM
GENERAL PLAN
Date : July 31,75
DWG NO. WD-001

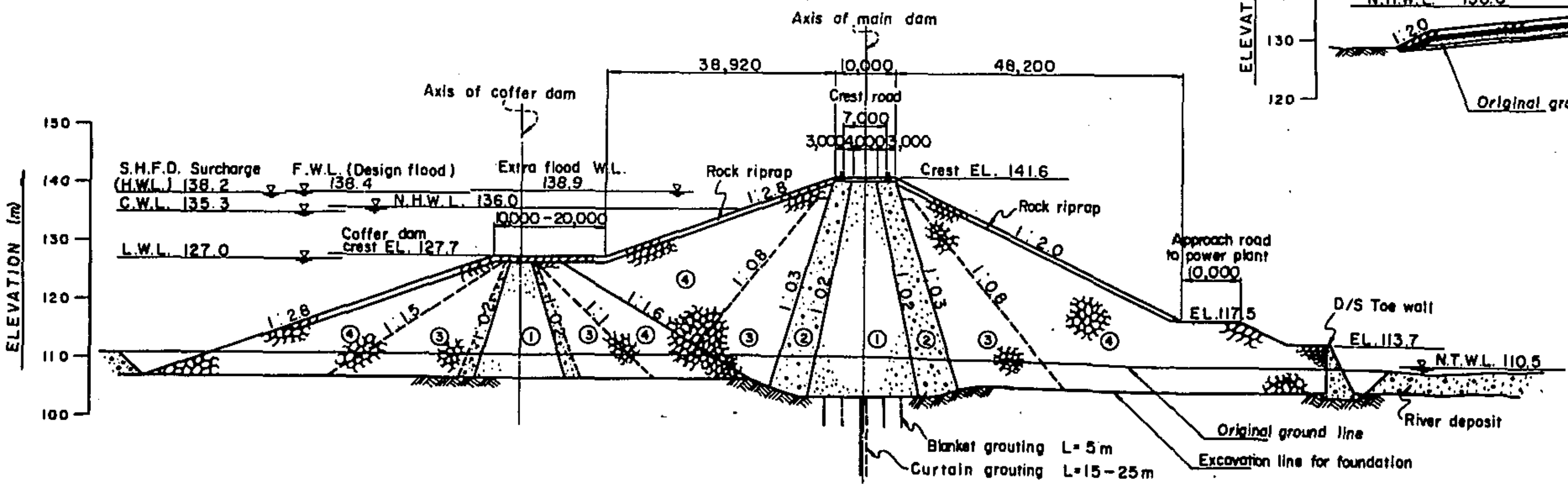


PROFILE



TYPICAL CROSS SECTION OF SUB DAM

(Scale B)

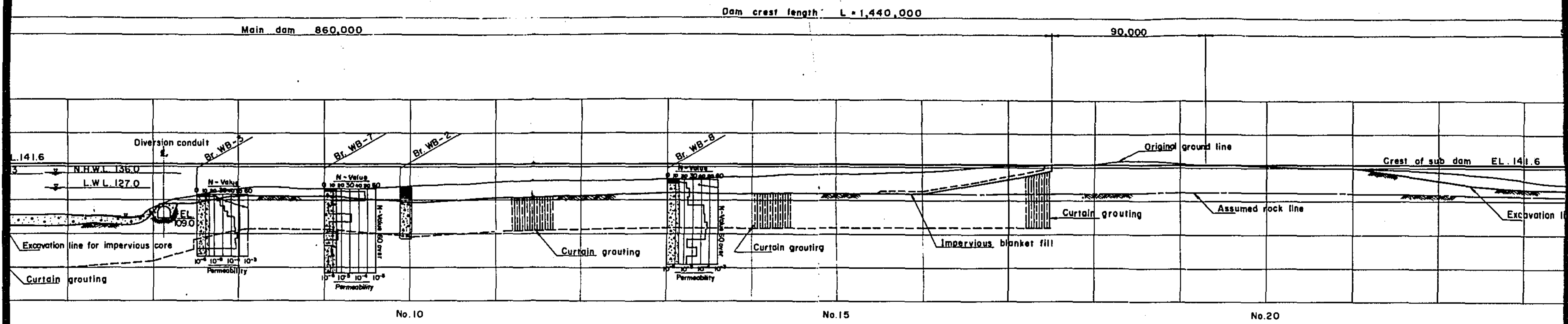


TYPICAL CROSS SECTION OF MAIN DAM

(Scale B)

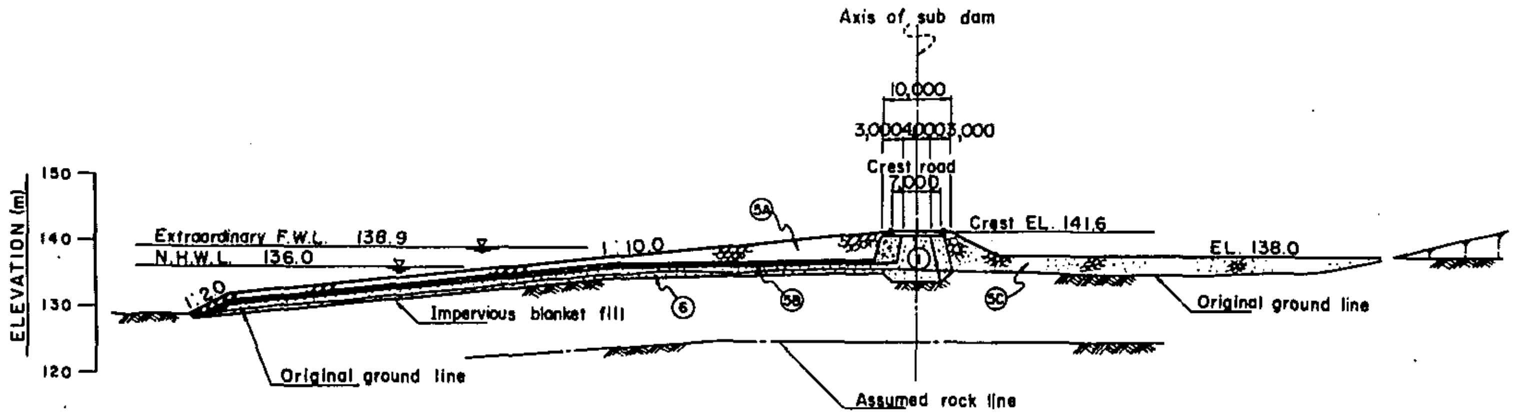
EMBANKMENT ZONES

Zone No.	Zone	Embankment material
①	Impervious core	Mixture of volcanic clay and crushed sandy tuff from Condi 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, e
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



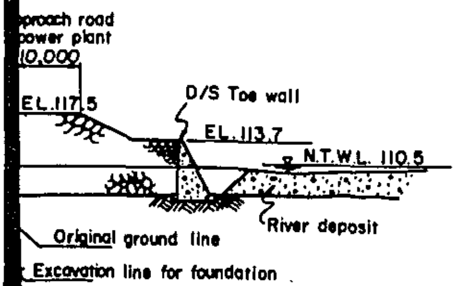
PROFILE ALONG AXIS OF DAM

(Scale A)



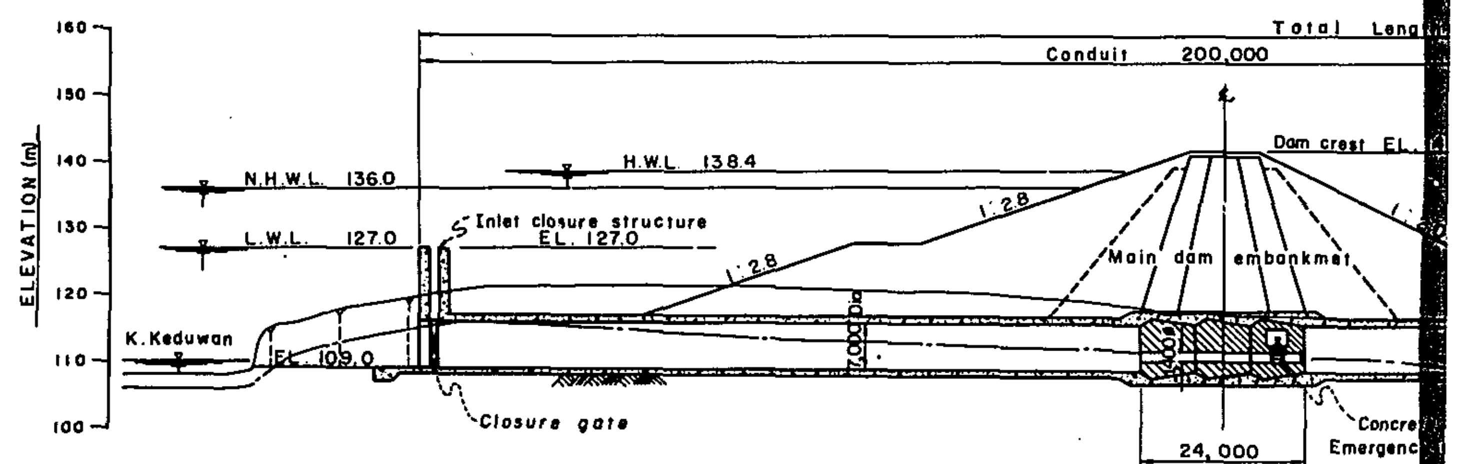
TYPICAL CROSS SECTION OF SUB DAM

(Scale B)



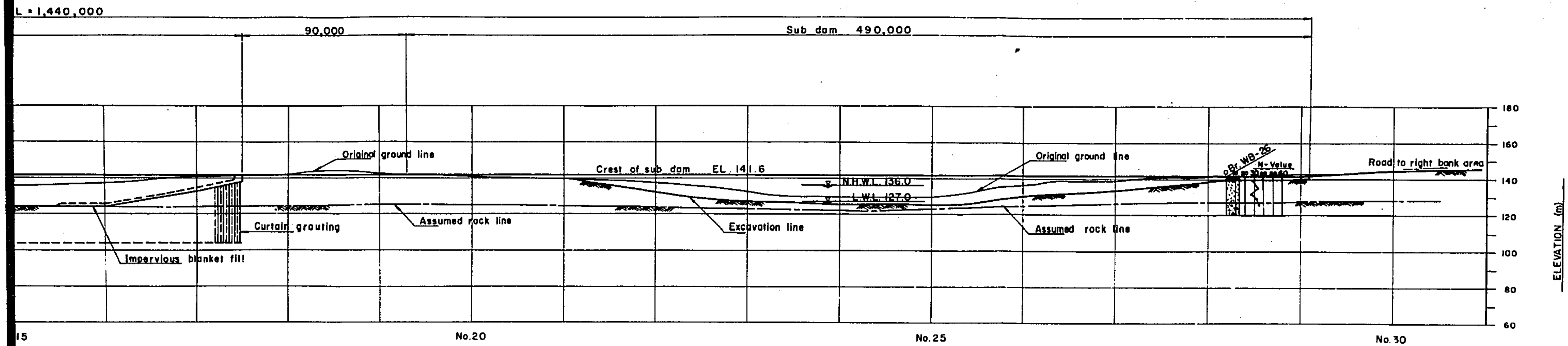
EMBANKMENT ZONES

Zone No.	Zone	Embankment material
①	Impervious core	Mixture of volcanic clay and crushed sandy tuff from Condi 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

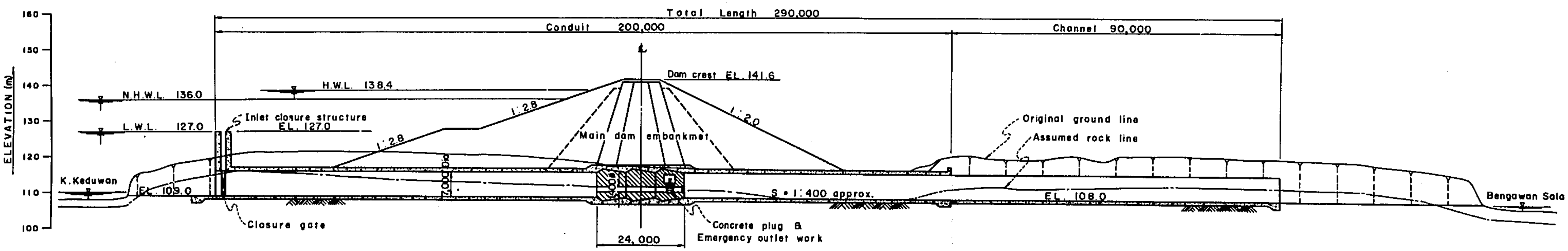


PROFILE OF DIVERSION CONDU

(Scale B)



XIS OF DAM

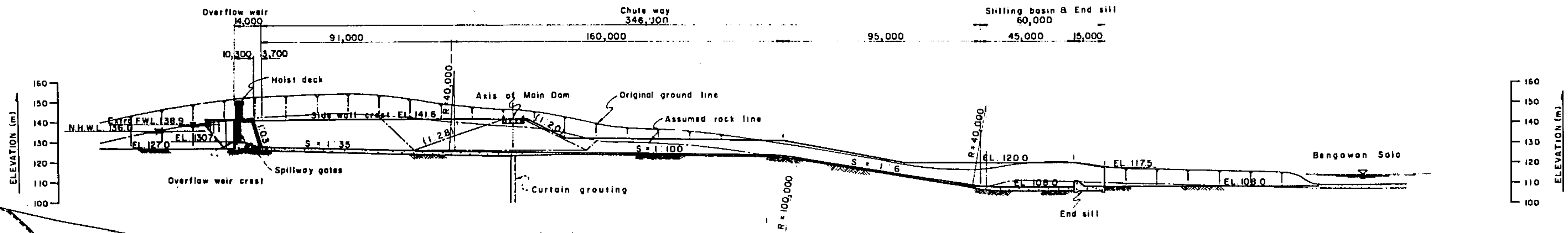


PROFILE OF DIVERSION CONDUIT
(Scale B)

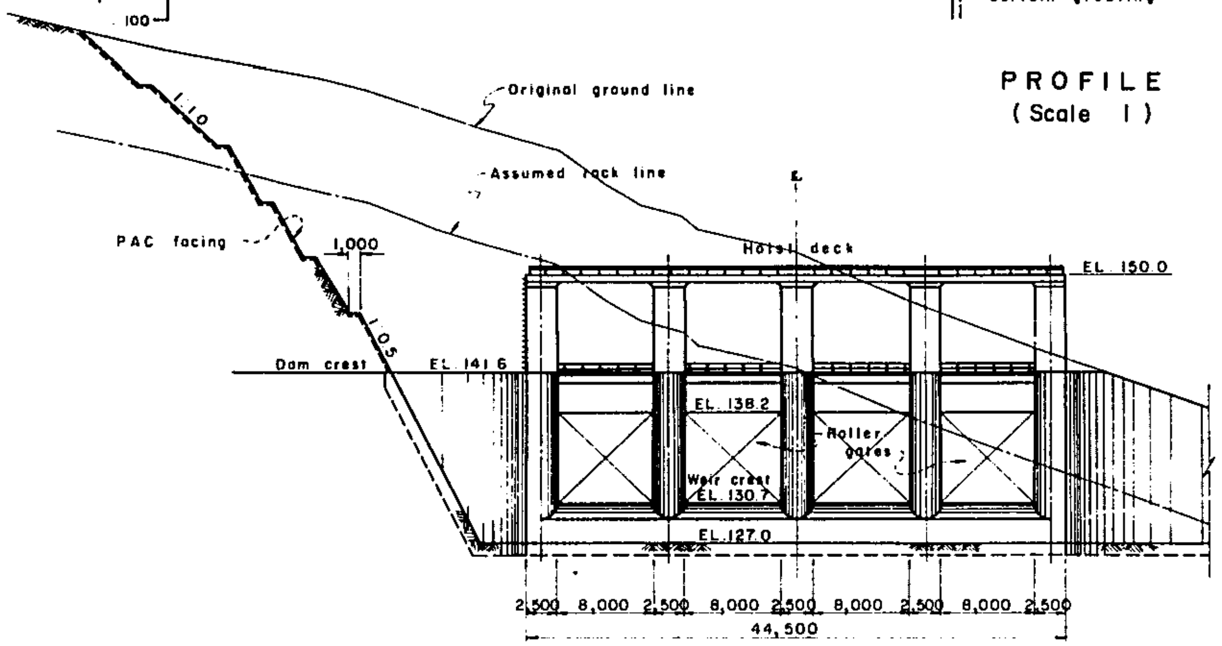
Scale A 0 — 100 (m)

Scale B 0 — 50 (m)

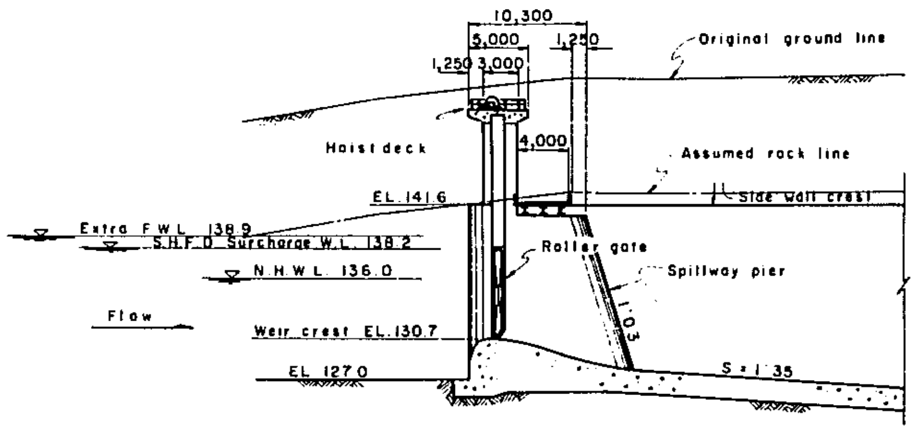
WONOGIRI MULTIPURPOSE DAM INDONESIA
DAM
PROFILE & CROSS SECTIONS
Date: July 31, 75   DWG NO. WD-002



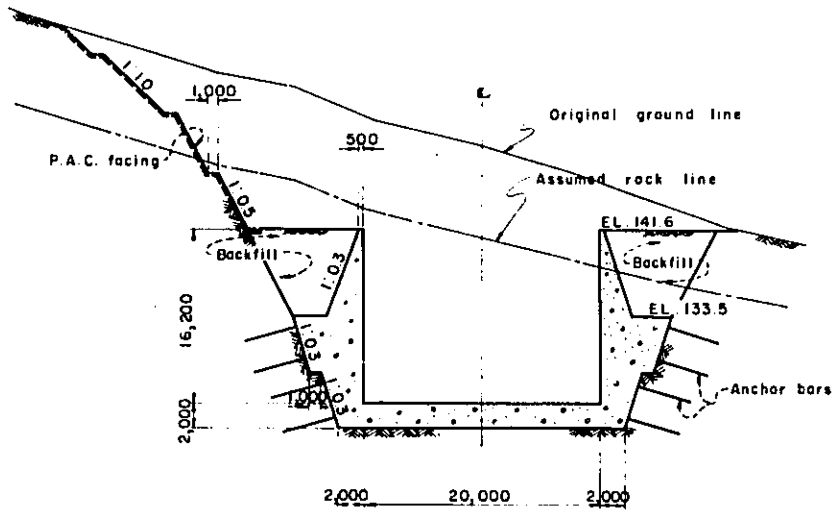
PROFILE
(Scale 1)



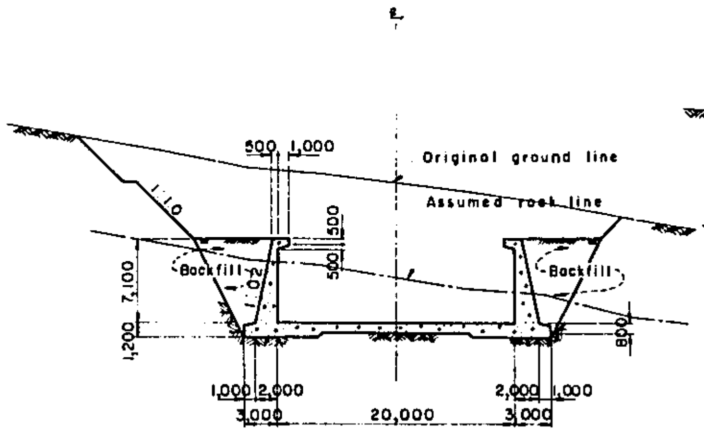
OVERFLOW WEIR - FRONT VIEW
(Scale 2)



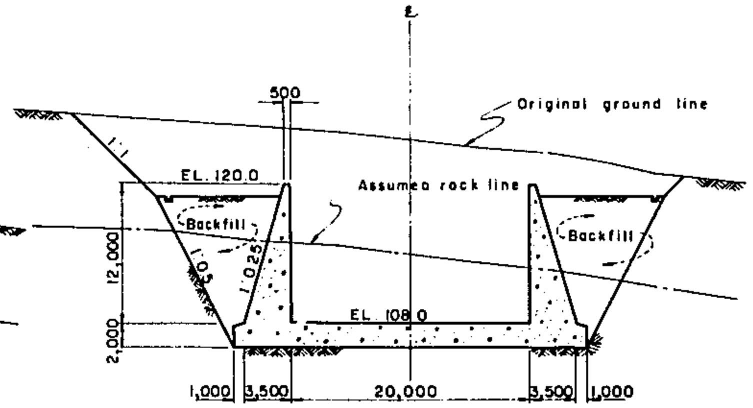
OVERFLOW WEIR - PROFILE
(Scale 2)



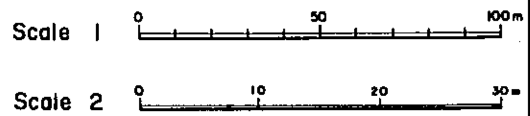
CHUTEWAY U/S PART - CROSS SECTION
(Scale 2)



CHUTEWAY - CROSS SECTION
(Scale 2)



STILLING BASIN - CROSS SECTION
(Scale 2)

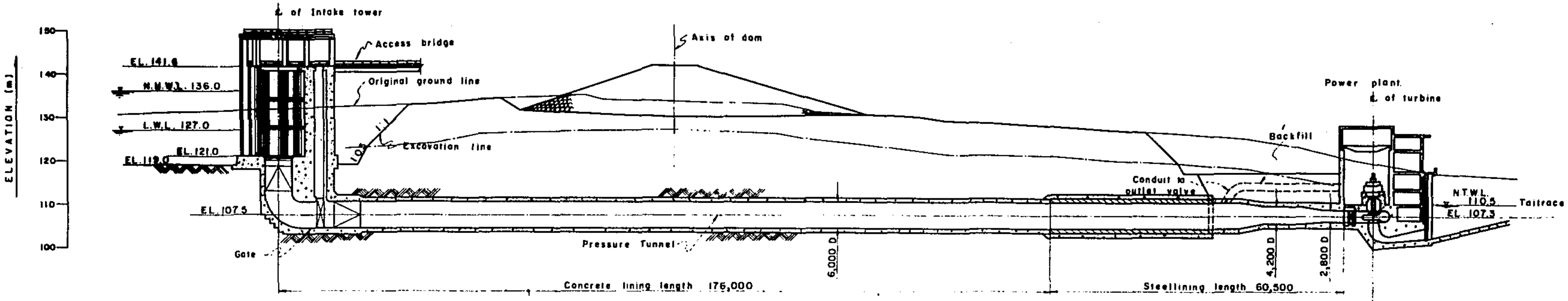


WONOGIRI MULTIPURPOSE DAM
INDONESIA

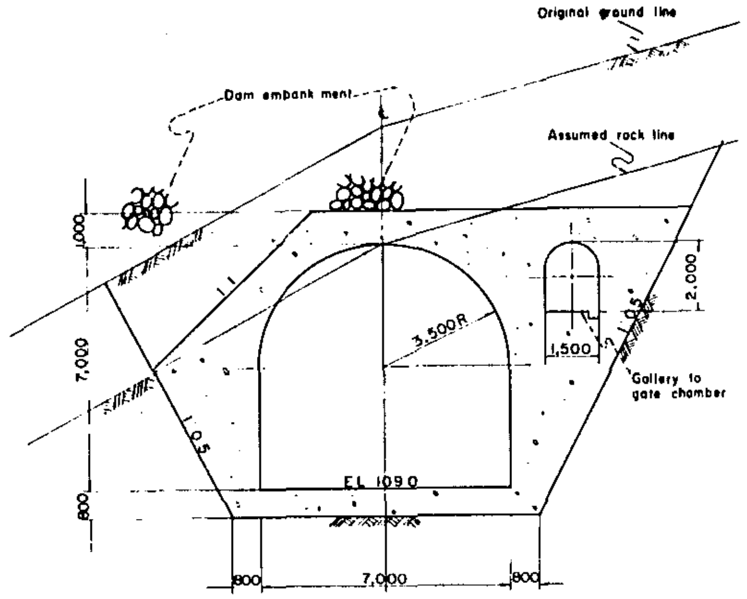
SPILLWAY

PROFILE & SECTIONS

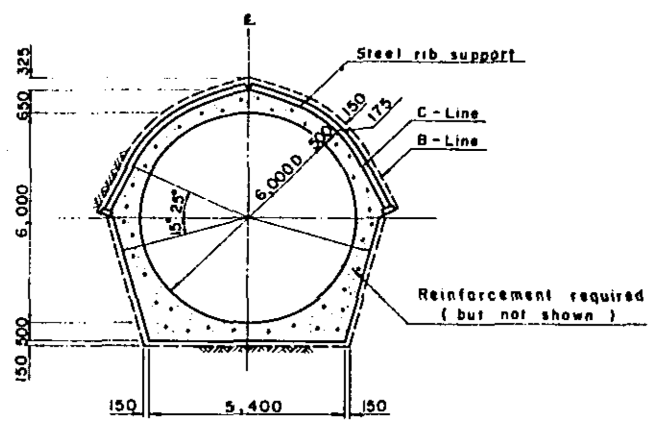
Date : July 31, 75	DWG.NO. WD-003



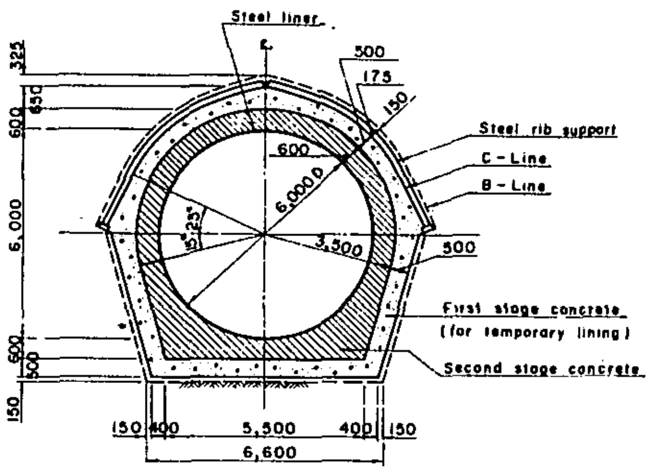
PROFILE OF WATER WAY (Scale 2)



TYPICAL SECTION OF DIVERSION CONDUIT (Scale 1)

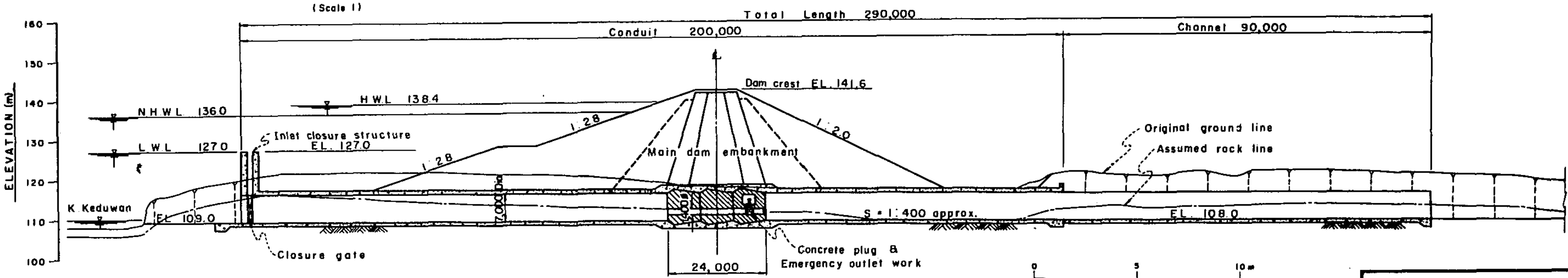


TYPE I (Scale 1)



TYPE II (Scale 1)

TYPICAL SECTION OF PRESSURE TUNNEL



PROFILE OF DIVERSION CONDUIT (Scale 2)

0 5 10 m

Scale 1

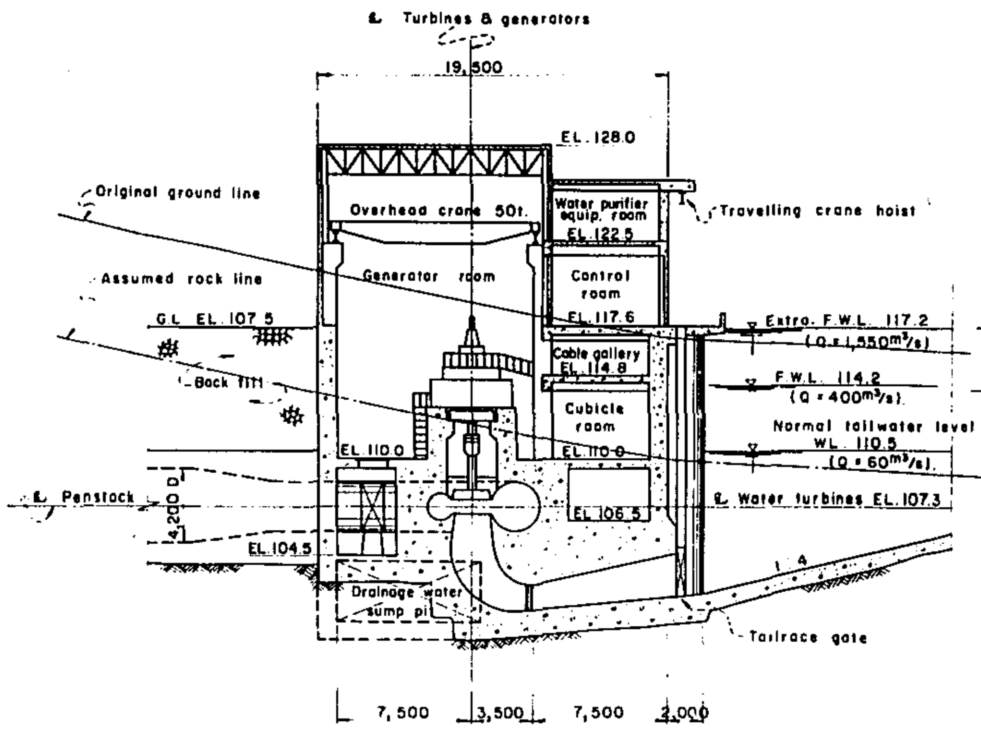
0 50 m

Scale 2

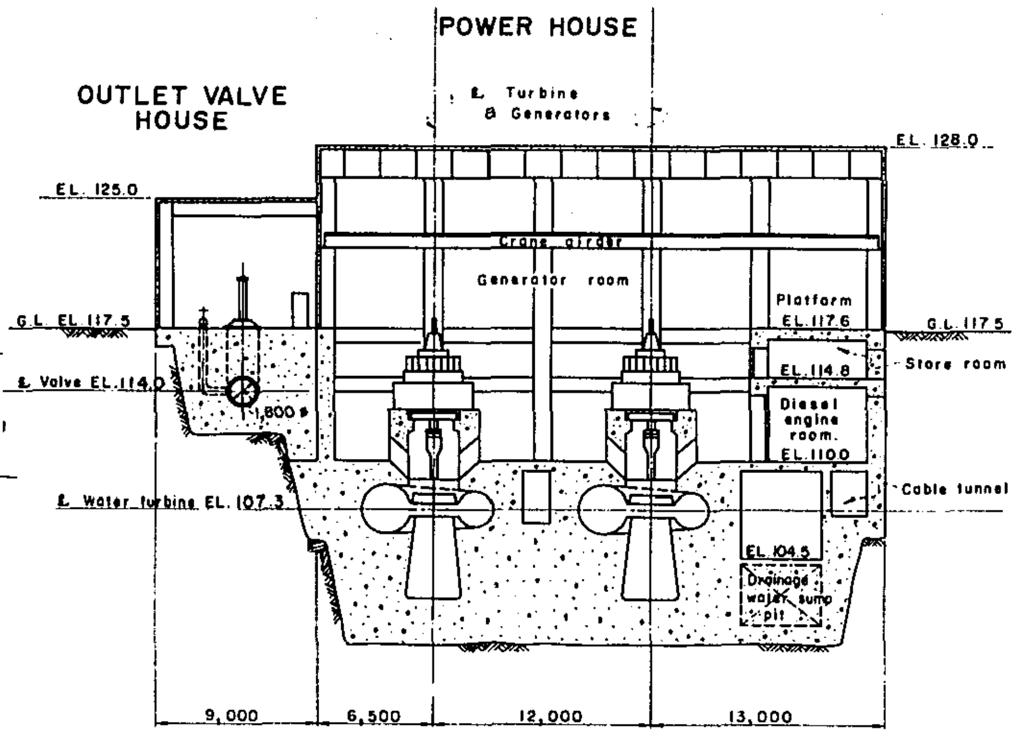
WONOGIRI MULTIPURPOSE DAM
INDONESIA

WATERWAY & DIVERSION CONDUIT PROFILE & SECTIONS

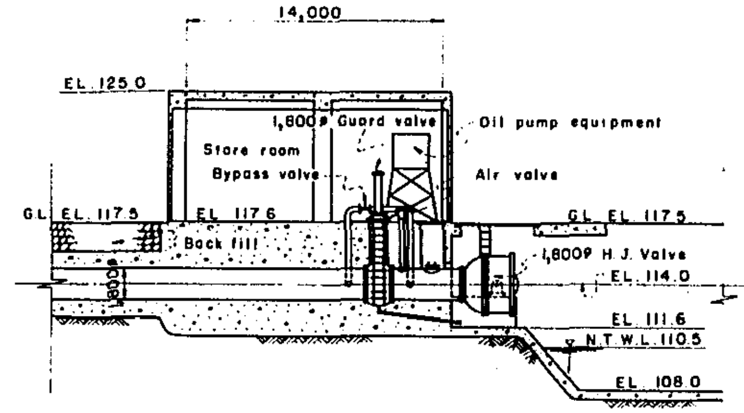
Date : July. 31. 75. | DWG. NO. WD-004



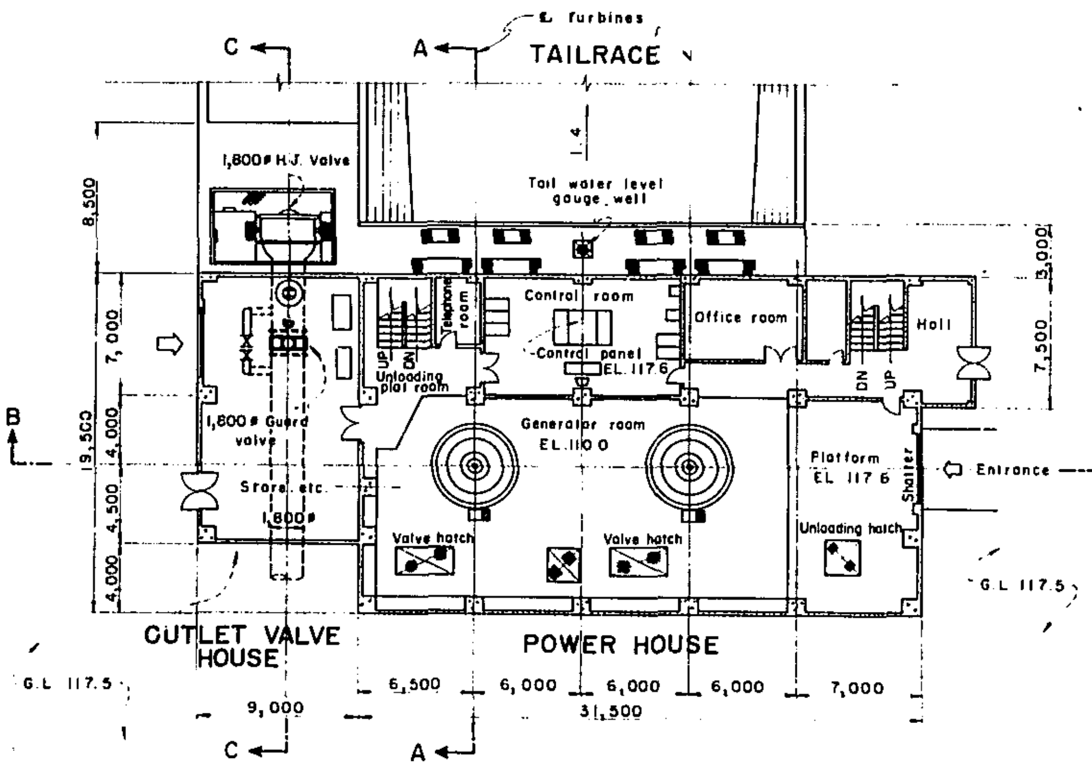
Section A – A



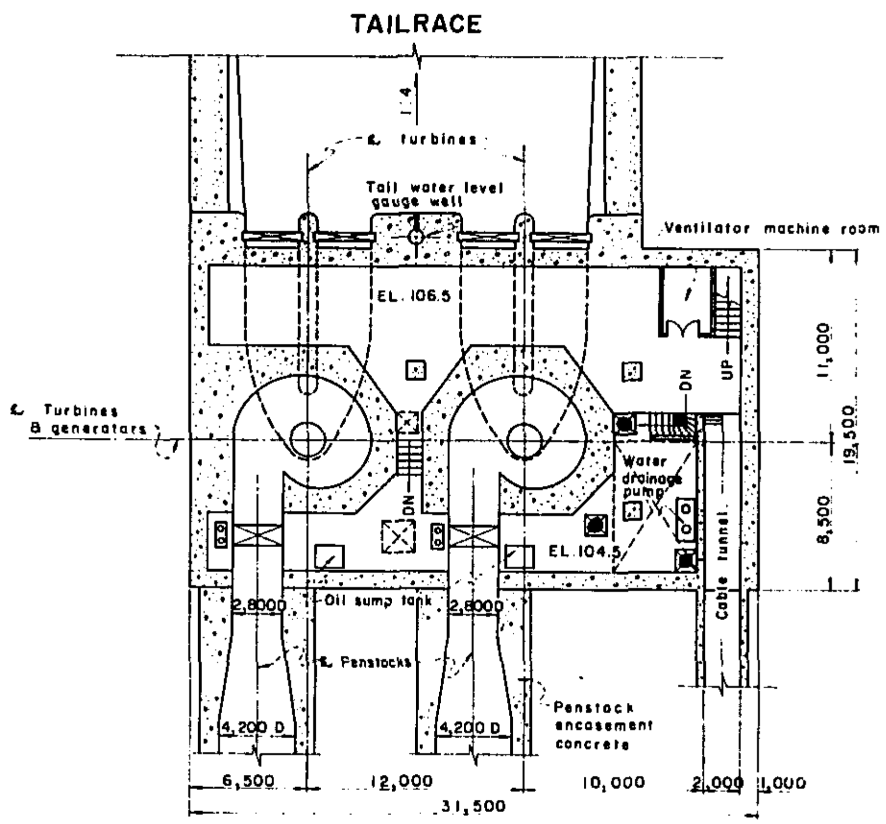
Section B – B



Section C – C



PLAN EL. 117.6



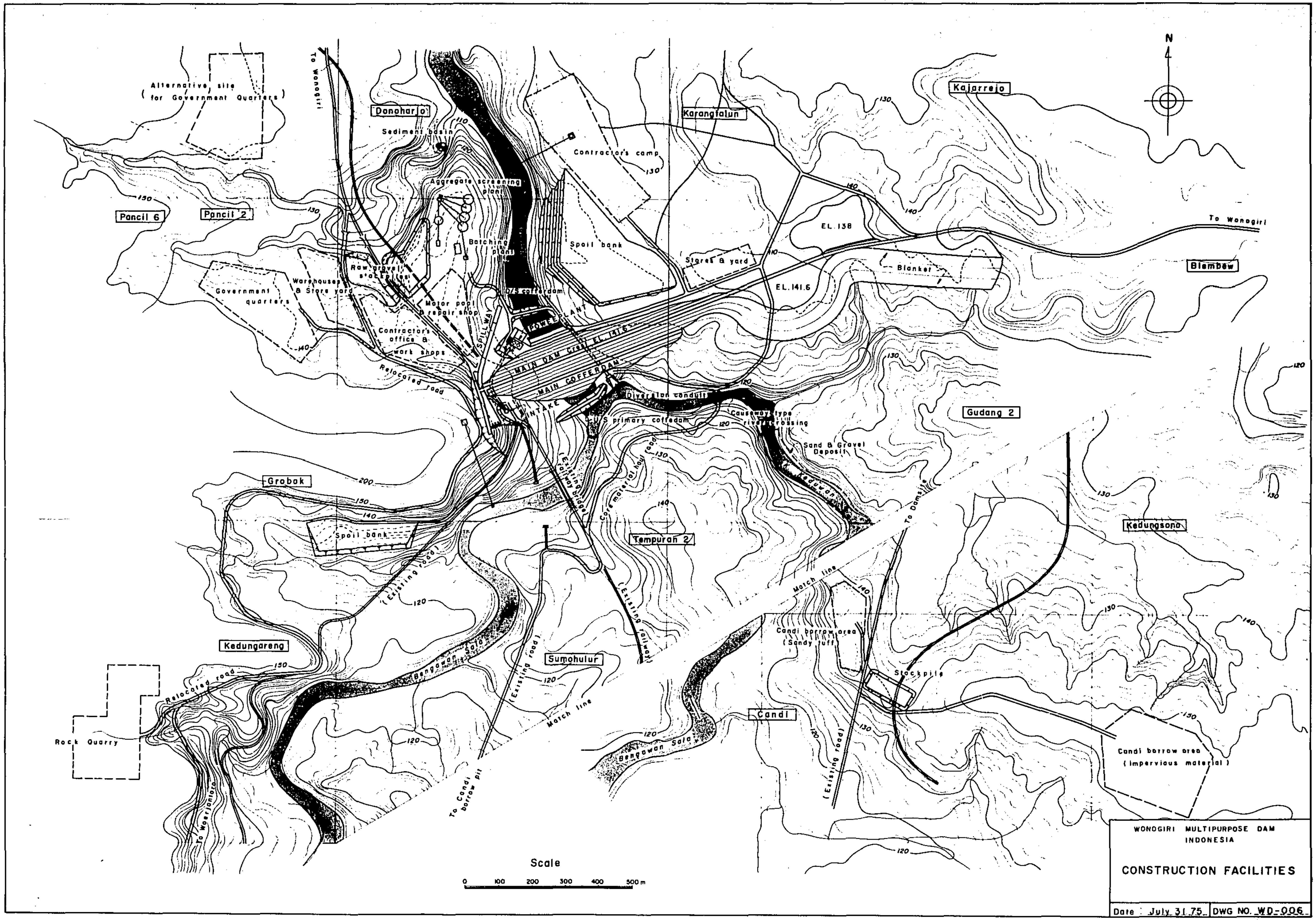
PLAN EL. 107.3

Scale 0 10 20m

WONOGIRI MULTIPURPOSE DAM
INDONESIA

POWER PLANT AND
OUTLET VALVE HOUSE
PLAN & SECTIONS

Date : July 31, 75	DWG NO. WD-005

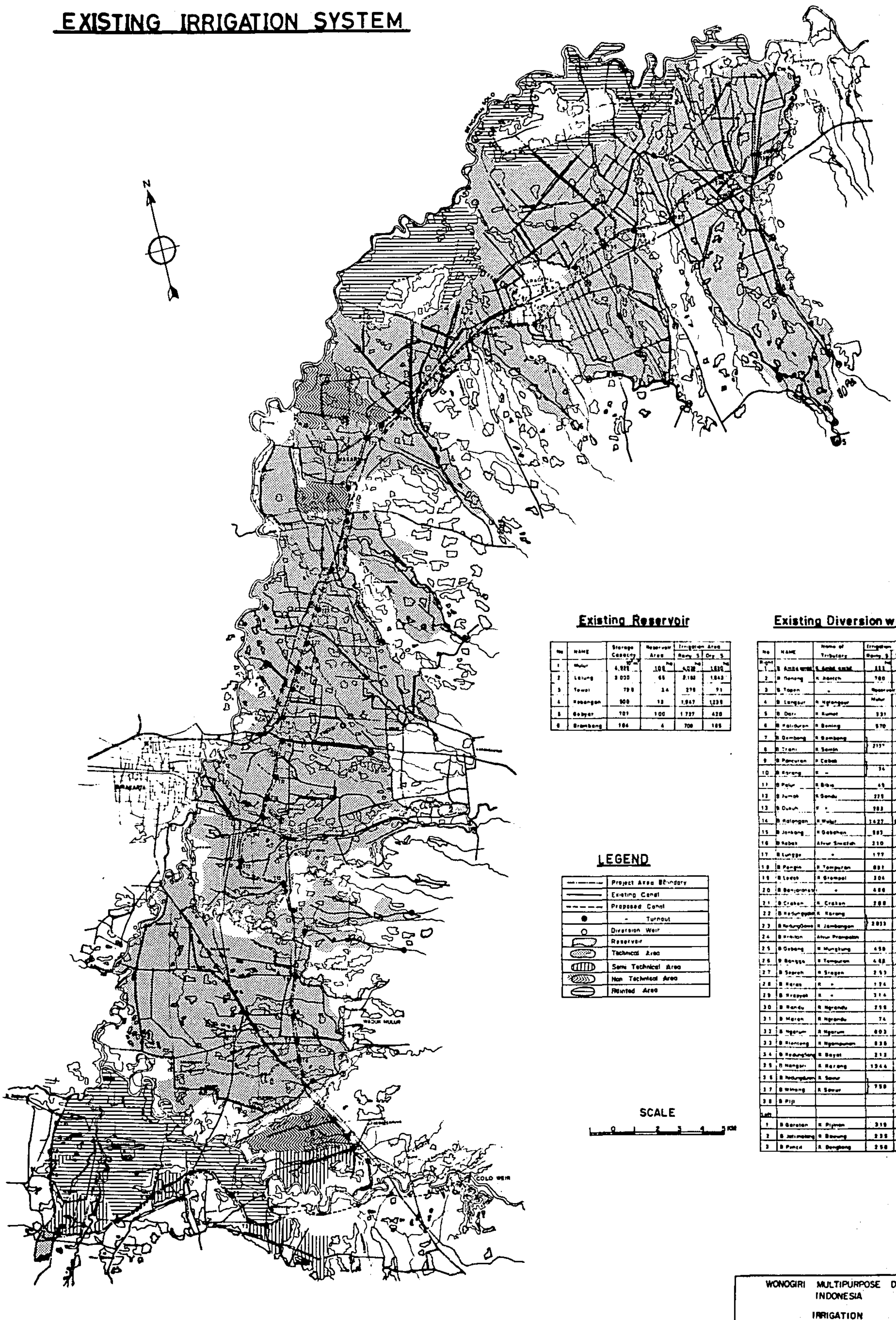


WONOGIRI MULTIPURPOSE DAM
INDONESIA

CONSTRUCTION FACILITIES

Date : July. 31. 75. DWG NO. WD-006

EXISTING IRRIGATION SYSTEM



Existing Reservoir

No	NAME	Storage Capacity ($10^3 m^3$)	Reservoir Area (ha)	Irrigation Area Rainy S (ha)	Irrigation Area Dry S (ha)
1	Mulur	4,928	100	4,028	1,630
2	Lalung	8 030	65	2,183	1,843
3	Towai	798	24	279	71
4	Kesangan	900	13	1,947	1,239
5	Gebyar	701	100	1 727	420
6	Brambang	184	4	709	185

LEGEND

‒ · ‒ · ‒	Project Area Boundary
———	Existing Canal
- - - -	Proposed Canal
●	Turnout
○	Diversion Weir
	Reservoir
	Technical Area
	Semi Technical Area
	Non Technical Area
	Rainfed Area

SCALE 0 1 2 3 4 5 KM

Existing Diversion weir

No	NAME	Name of Tributary	Irrigation Area Rainy S (ha)	Irrigation Area Dry S (ha)
Right				
1	B Ambawang	R Ambawang	333	8
2	B Nonong	R Jonteh	780	218
3	B Tapen	"	Reservoir Mulur	
4	B Langsur	R Ngiongsur		
5	B Dari	R Kumot	331	30
6	B Kaliduren	R Boning	570	170
7	B Gembong	R Gembong		
8	B Trani	R Samin	2137	850
9	B Pancuran	R Cabak		
10	B Karang	R –	34	0
11	B Palur	R Bibis	45	45
12	B Jumok	R Gondu	275	144
13	B Dubuh	R "	183	184
14	B Kalongan	R Walur	1427	1216
15	B Jonbang	R Gebehan	983	290
16	B Rebet	Afvur Sinatah	210	129
17	B Lungge	"	177	143
18	B Pengin	R Tempuran	881	483
19	B Ledok	R Grompol	306	64
20	B Banjarancar	"	480	107
21	B Croken	R Croken	288	87
22	B Kedungpalo	R Karang		
23	B Kedungdowo	R Jambangan	2833	589
24	B Krelon	Afvur Prampalan		
25	B Gebang	R Mungkung	450	187
26	B Bangga	R Tempuran	488	113
27	B Soprah	R Sragen	253	80
28	B Karas	R "	174	31
29	B Krapyak	R "	314	107
30	B Randu	R Ngrandu	238	121
31	B Maron	R Ngrandu	74	27
32	B Ngarum	R Ngarum	603	218
33	B Klontong	R Ngampunan	838	311
34	B Kedungfang	R Bayat	313	53
35	B Nangsri	R Karang	1344	381
36	B Kedungpluon	R Sawur		
37	B Wilang	R Sawur	750	145
38	B Piji			
Left				
1	B Garotan	R Pijinan	319	0
2	B Jatimalang	R Bawang	235	0
3	B Pancd	R Dengkeng	250	0

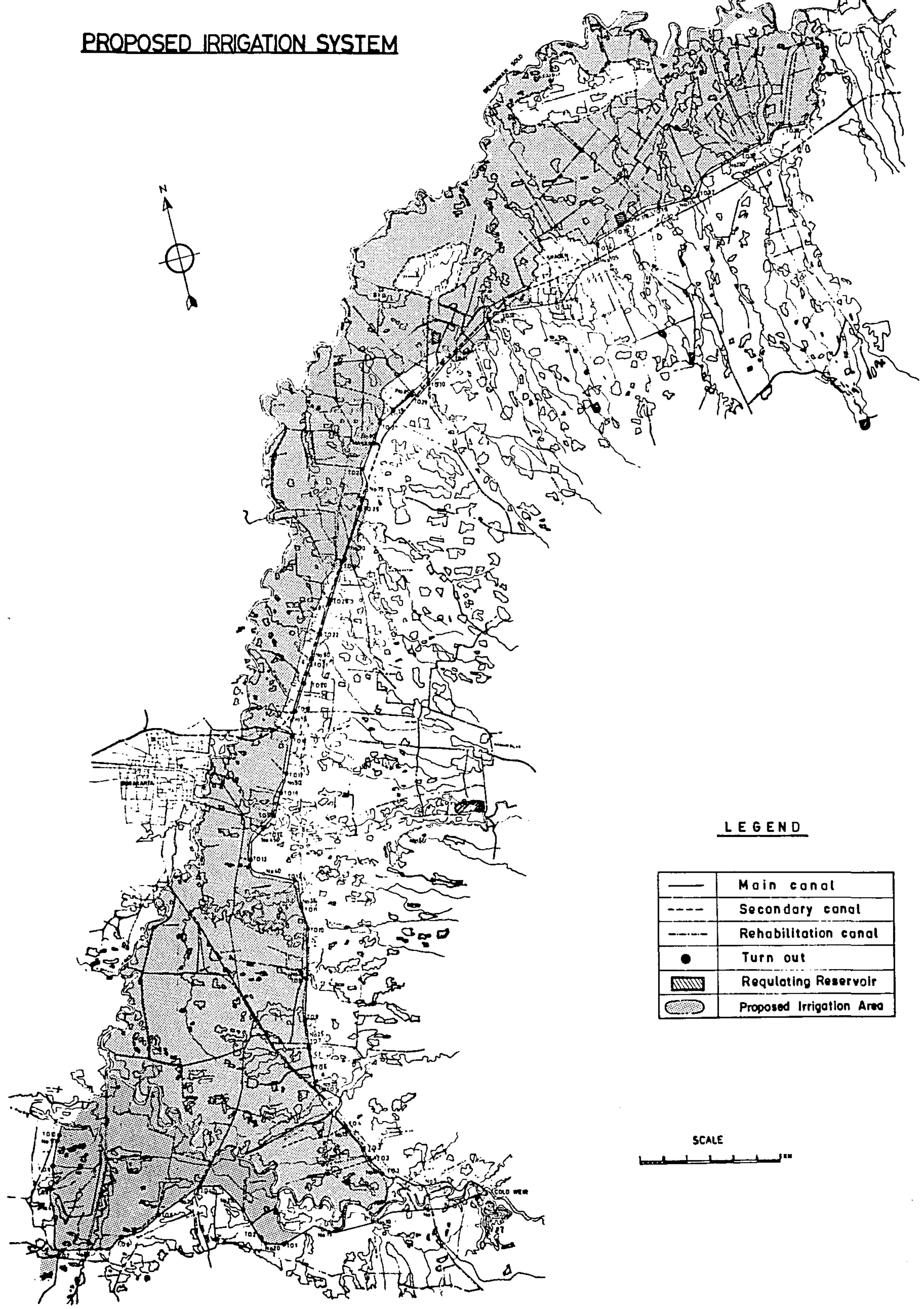
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

EXISTING IRRIGATION SYSTEM

Date : July 31, 1975 | DWG NO WI-001

PROPOSED IRRIGATION SYSTEM



LEGEND

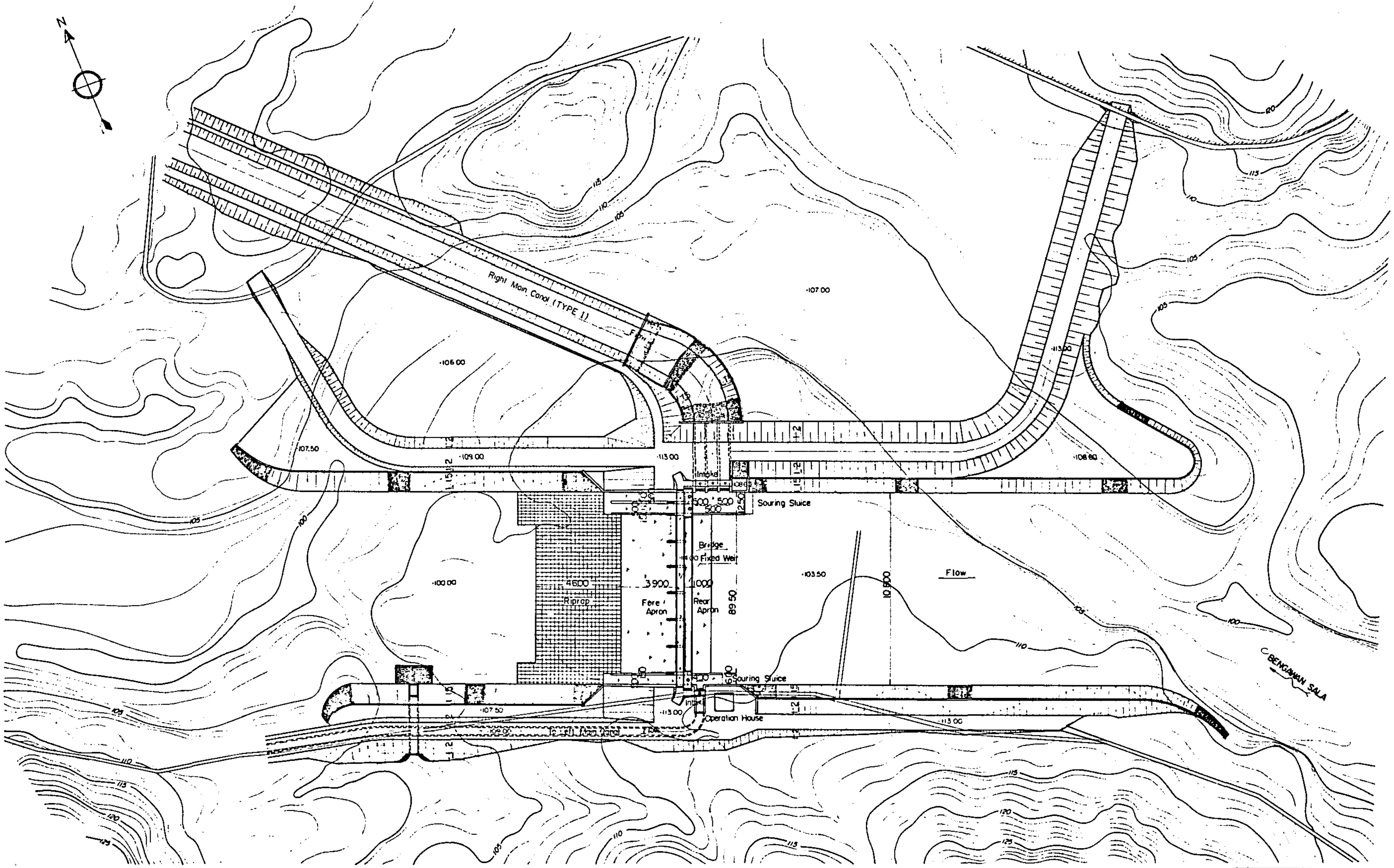
——	Main canal
- - - -	Secondary canal
—·—·—	Rehabilitation canal
●	Turn out
(hatched box)	Regulating Reservoir
(shaded oval)	Proposed Irrigation Area

WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION

PROPOSED IRRIGATION SYSTEM

Date : July 31, 1975 | DWG NO WI-002

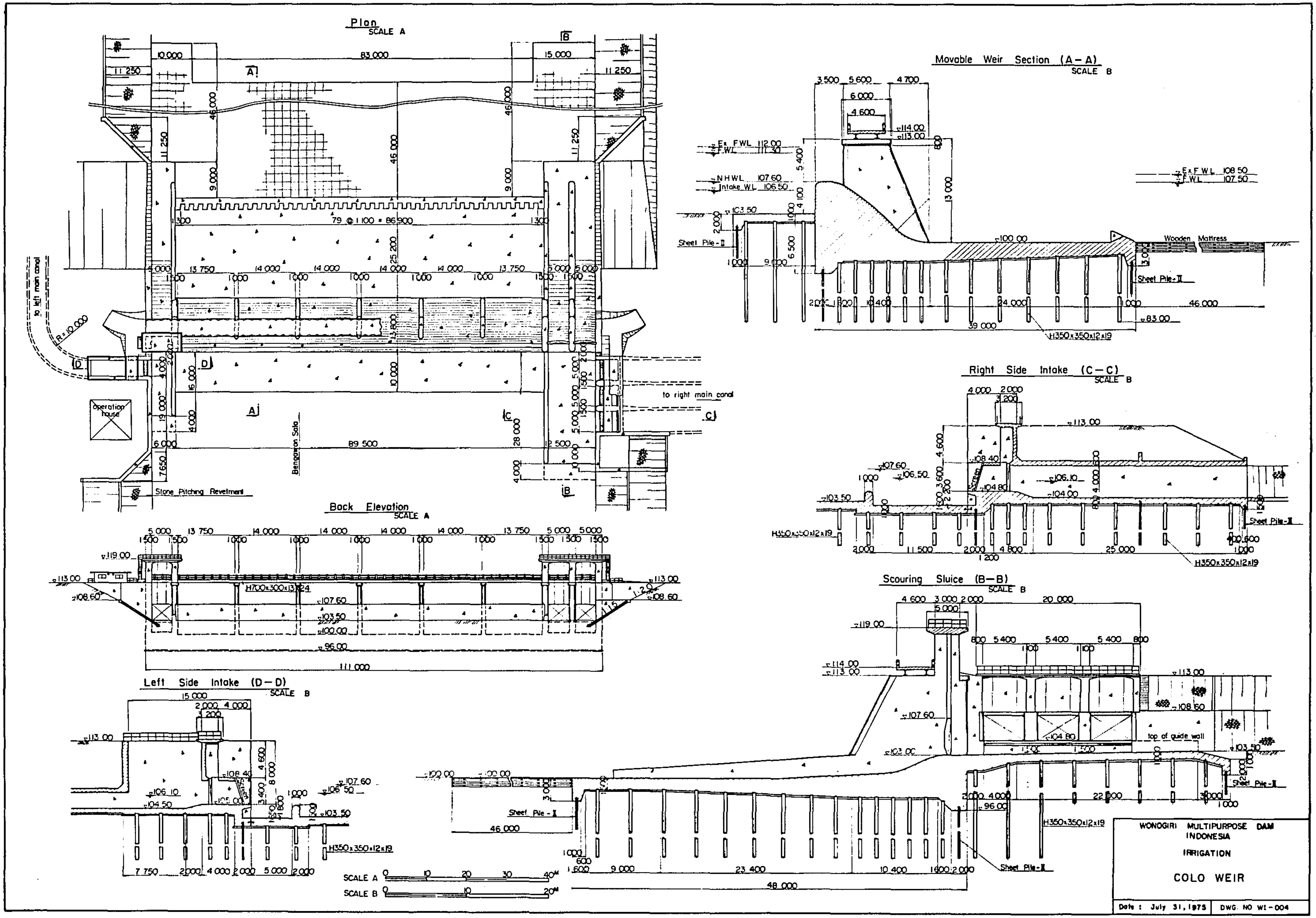
GENERAL LAYOUT OF COLO WEIR

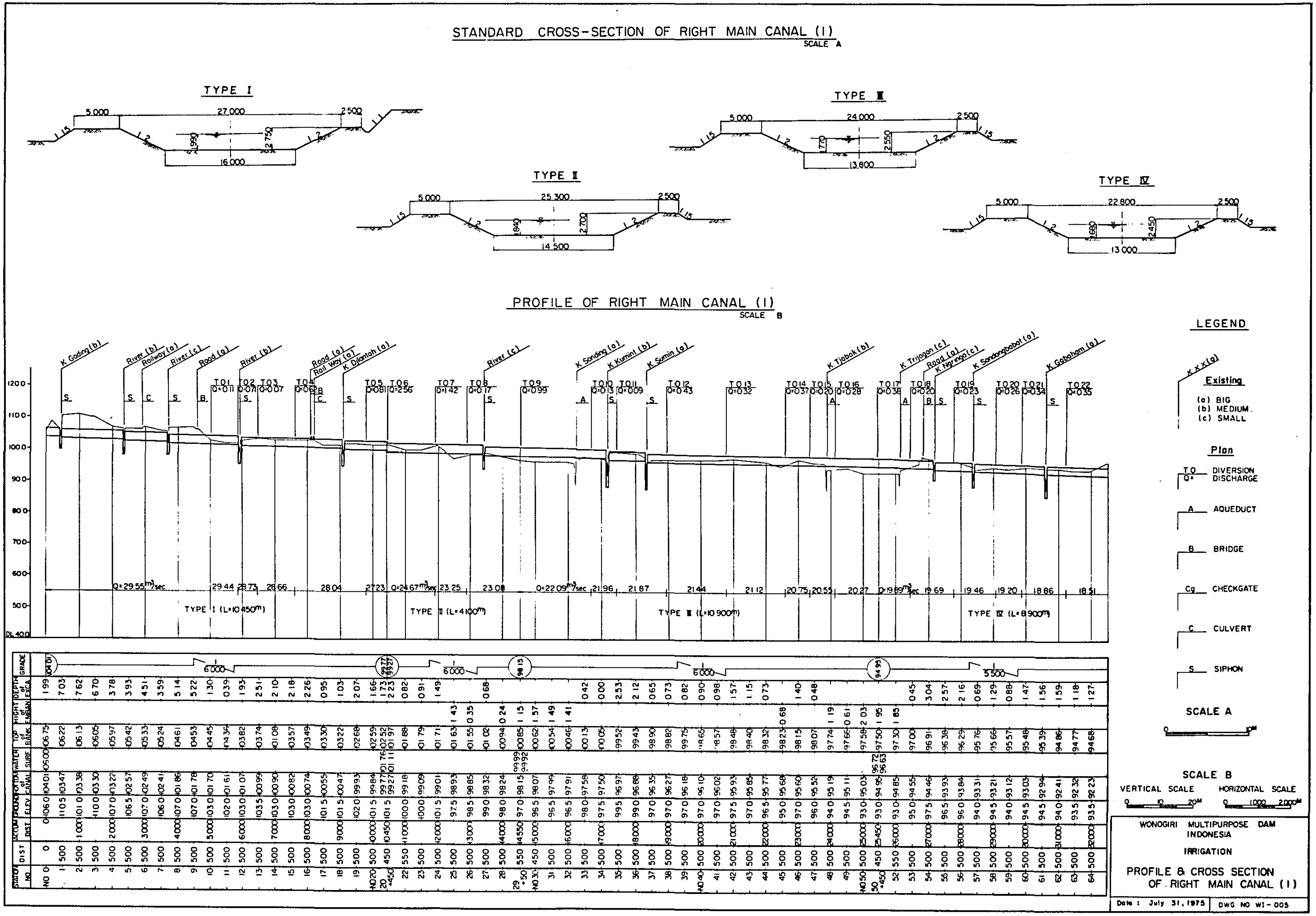


WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION

GENERAL LAYOUT OF COLO WEIR

Date : July 31, 1975	DWG NO WI-003

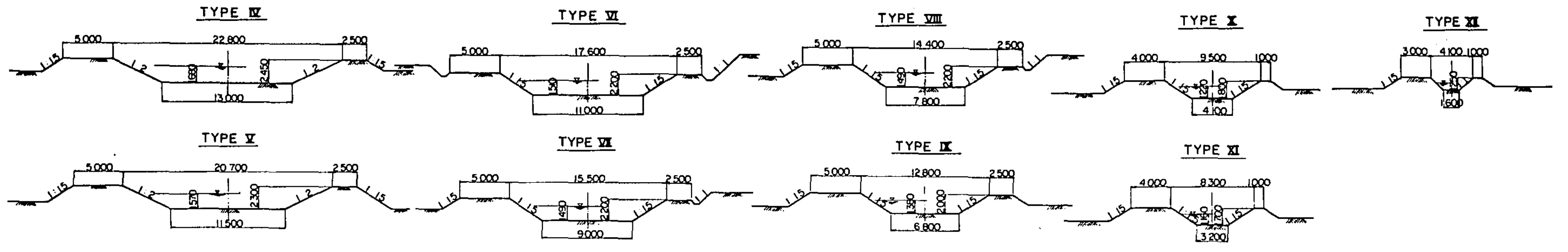

Plan
SCALE A
Movable Weir Section (A – A)
SCALE B
Right Side Intake (C – C)
SCALE B
Back Elevation
SCALE A
Scouring Sluice (B – B)
SCALE B
Left Side Intake (D – D)
SCALE B
to left main canal
to right main canal
operation house
Bengawan Solo
Stone Pitching Revetment
Sheet Pile - II
Sheet Pile - I
Wooden Mattress
H350 x 350 x 12 x 19
H700 x 300 x 13 x 24
top of guide wall
Ex. F.W.L. 112.00
F.W.L. 111.30
N.H.W.L. 107.60
Intake W.L. 106.50
Ex. F.W.L. 108.50
F.W.L. 107.50
83.000
89.500
111.000
79 @ 1.100 = 86.900
48.000
SCALE A 0 10 20 30 40M
SCALE B 0 10 20M
WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION
COLO WEIR
Date : July 31, 1975
DWG. NO WI-004



STANDARD CROSS-SECTION OF RIGHT MAIN CANAL (I)
SCALE A
TYPE I
TYPE II
TYPE III
TYPE IV
PROFILE OF RIGHT MAIN CANAL (I)
SCALE B
TYPE I (L=10450m)
TYPE II (L=4100m)
TYPE III (L=10900m)
TYPE IV (L=8900m)
LEGEND
Existing
(a) BIG
(b) MEDIUM.
(c) SMALL
Plan
T.O DIVERSION
Q= DISCHARGE
A AQUEDUCT
B BRIDGE
Cg CHECKGATE
C CULVERT
S SIPHON
SCALE A
SCALE B
VERTICAL SCALE
HORIZONTAL SCALE
WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION
PROFILE & CROSS SECTION
OF RIGHT MAIN CANAL (I)
Date : July 31, 1975
DWG NO WI-005

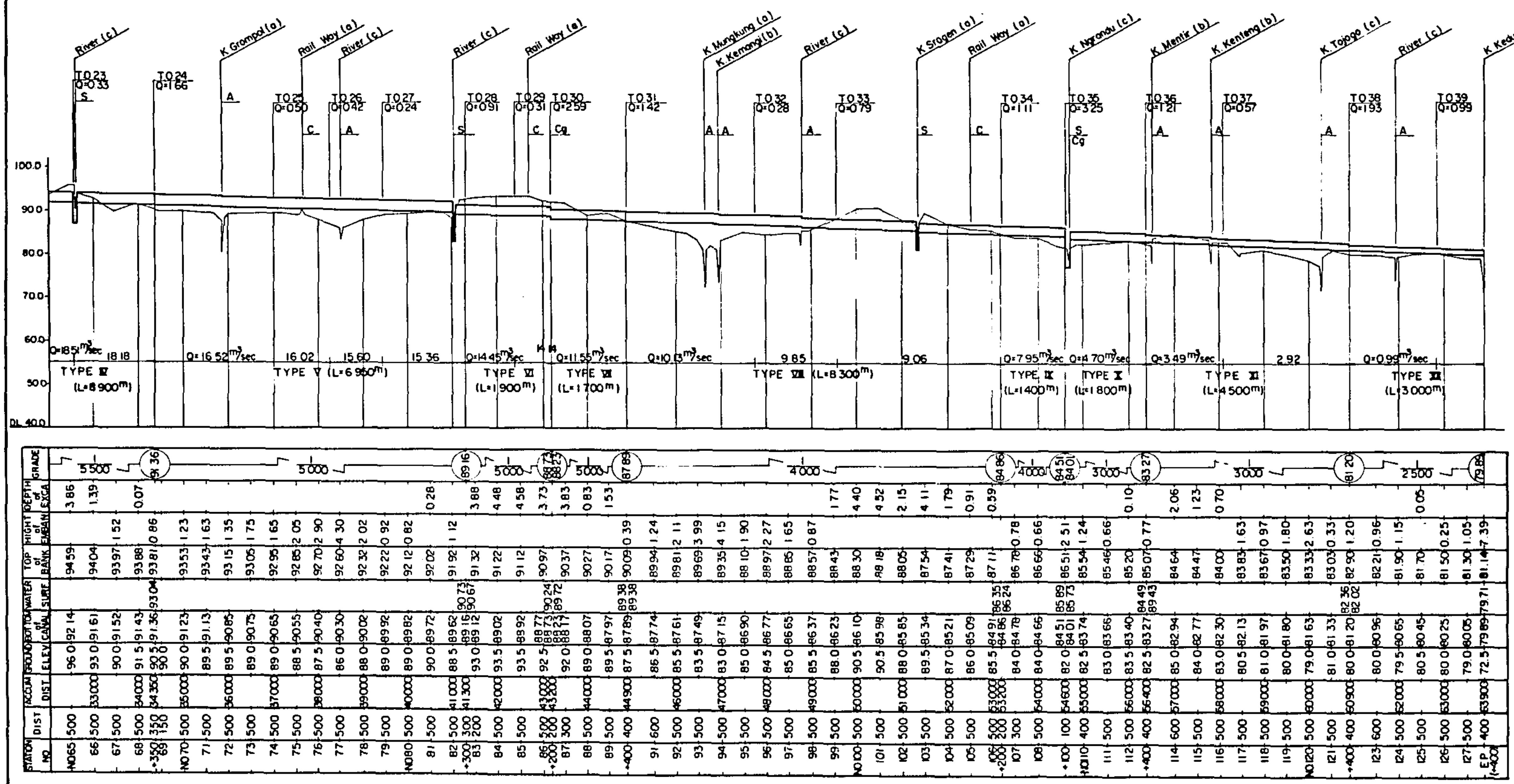
STANDARD CROSS-SECTION OF RIGHT MAIN CANAL (2)

SCALE A

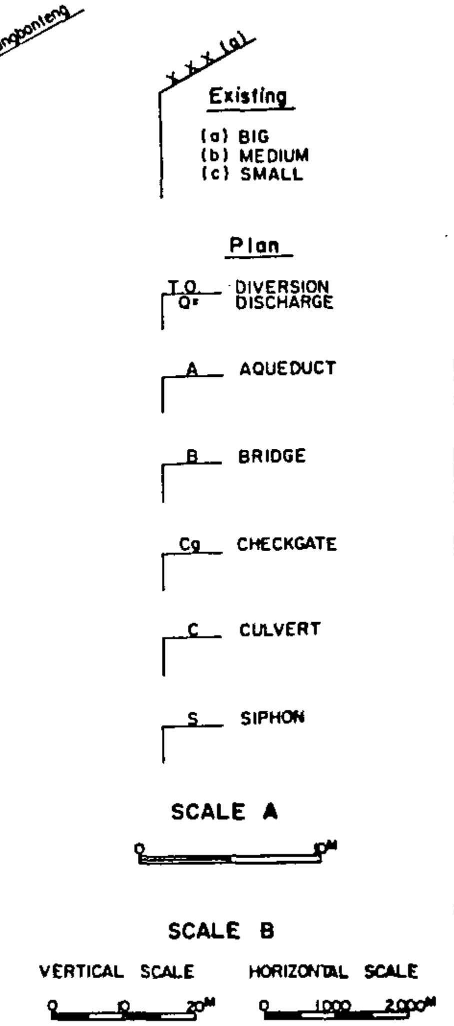


PROFILE OF RIGHT MAIN CANAL (2)

SCALE B



LEGEND



WONOGIRI MULTIPURPOSE DAM
INDONESIA

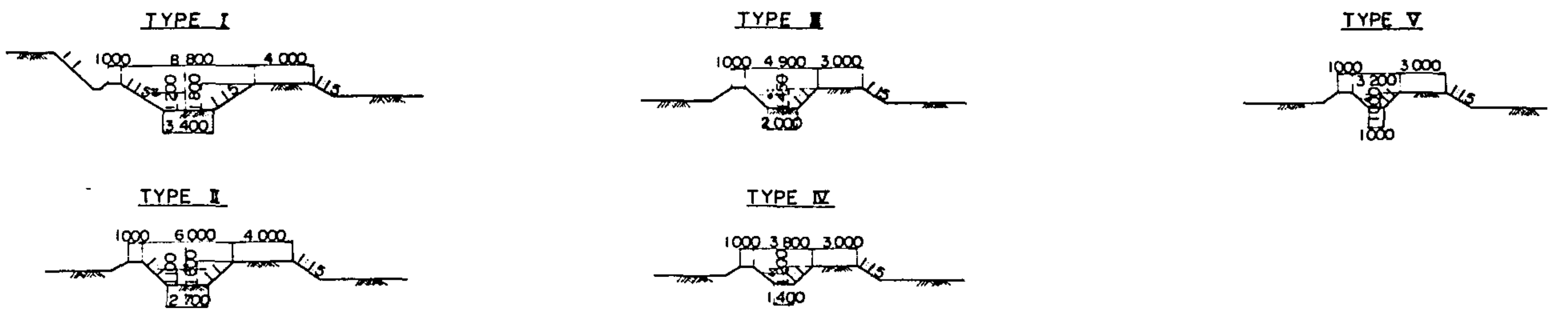
IRRIGATION

PROFILE & CROSS SECTION
OF RIGHT MAIN CANAL (2)

Date: July 31, 1975 | DWG NO WI-006

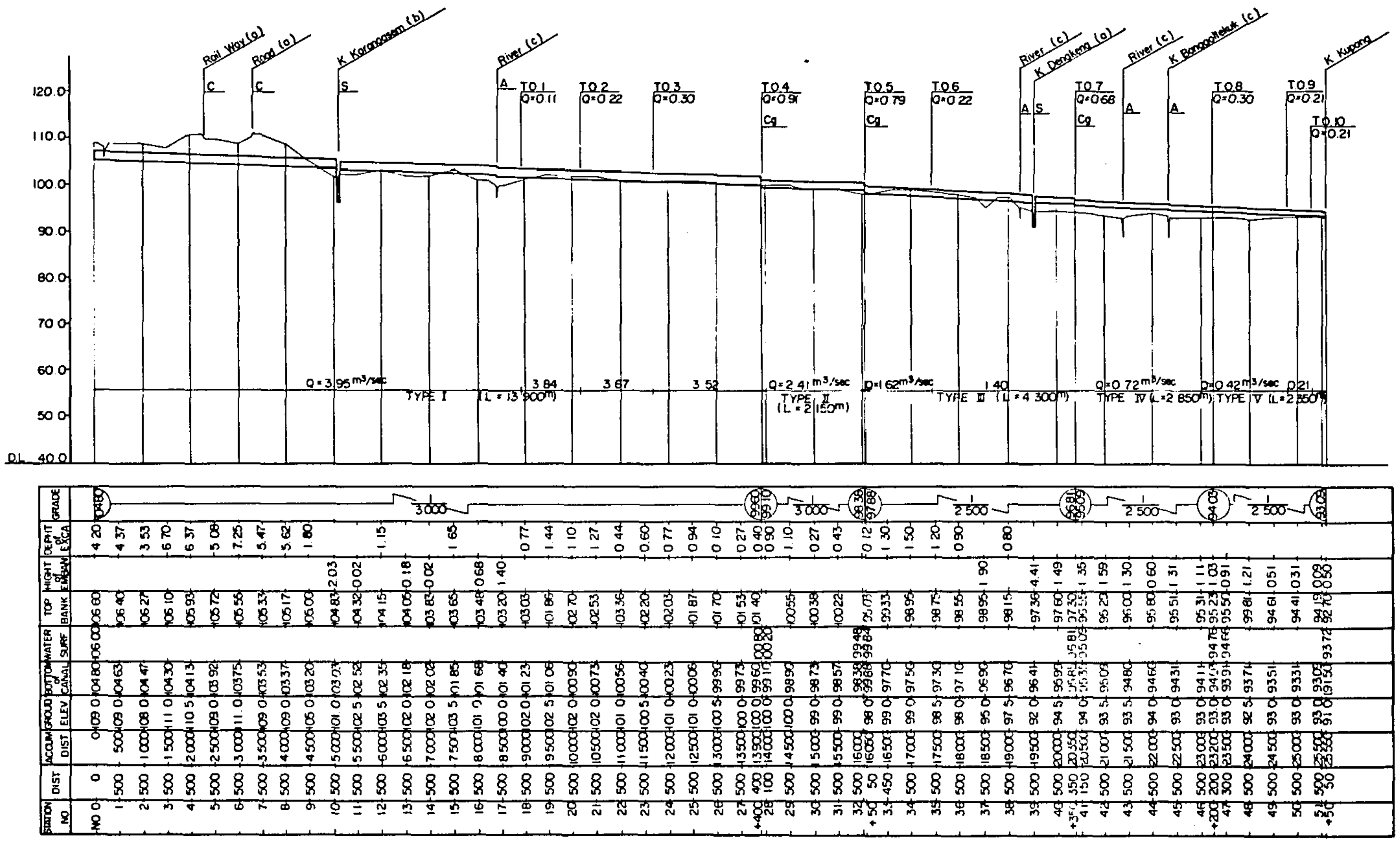
STANDARD CROSS-SECTION OF LEFT MAIN CANAL

SCALE A



PROFILE OF LEFT MAIN CANAL

SCALE B



LEGEND

- Existing
  - (a) BIG
  - (b) MEDIUM
  - (c) SMALL
- Plan
- T.O / Q — DEVERSION / DISCHARGE
- A — AQUEDUCT
- B — BRIDGE
- Cg — CHECK GATE
- C — CULVERT
- S — SIPH ON

SCALE A 0 — 10M

SCALE B VERTICAL SCALE 0 10 20M; HORIZONTAL SCALE 0 1000 2000M

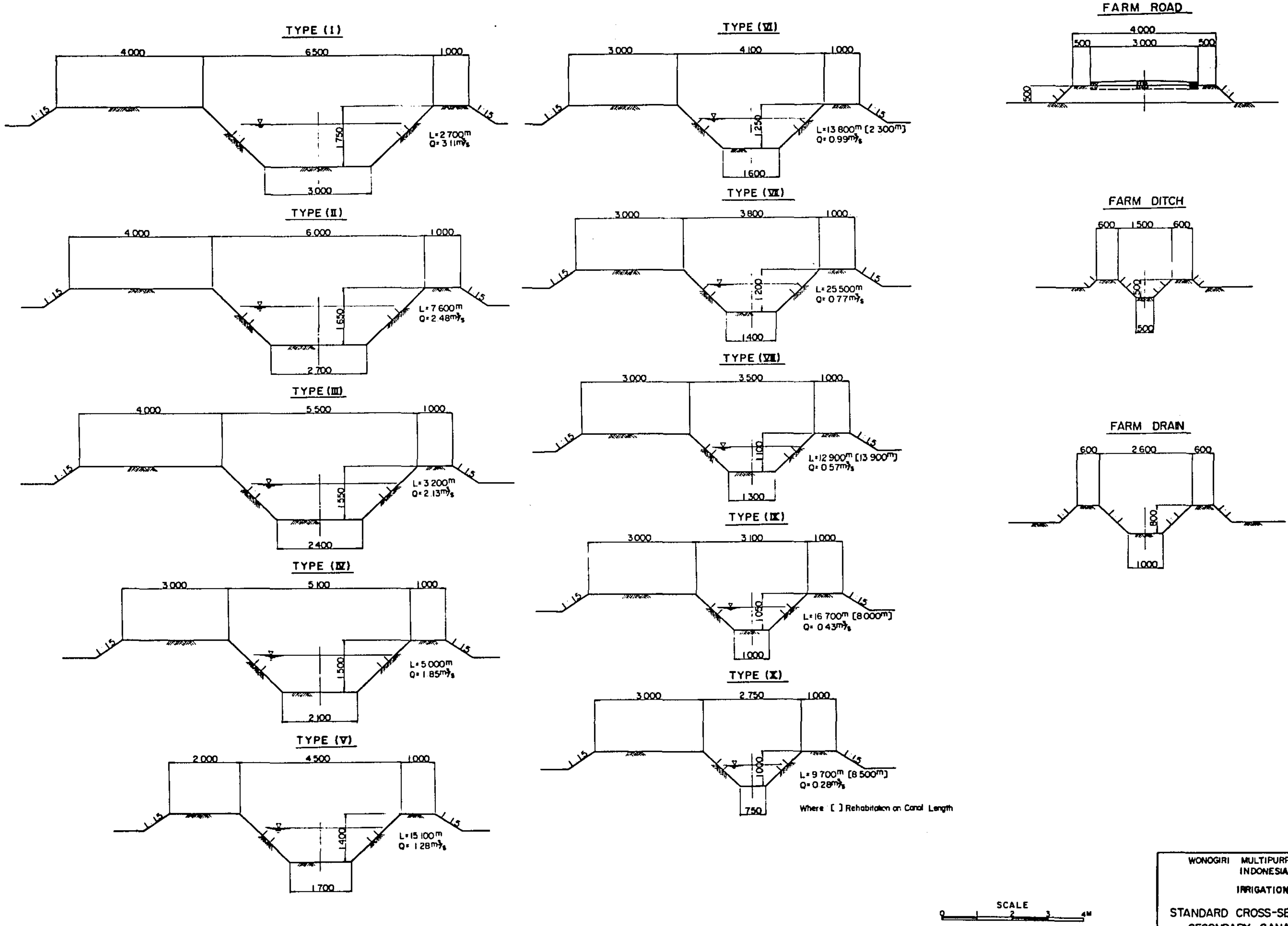
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

PROFILE & CROSS SECTION OF LEFT MAIN CANAL

Date: July 31, 1975 | DWG NO WI-007

STANDARD CROSS-SECTION OF SECONDARY CANAL

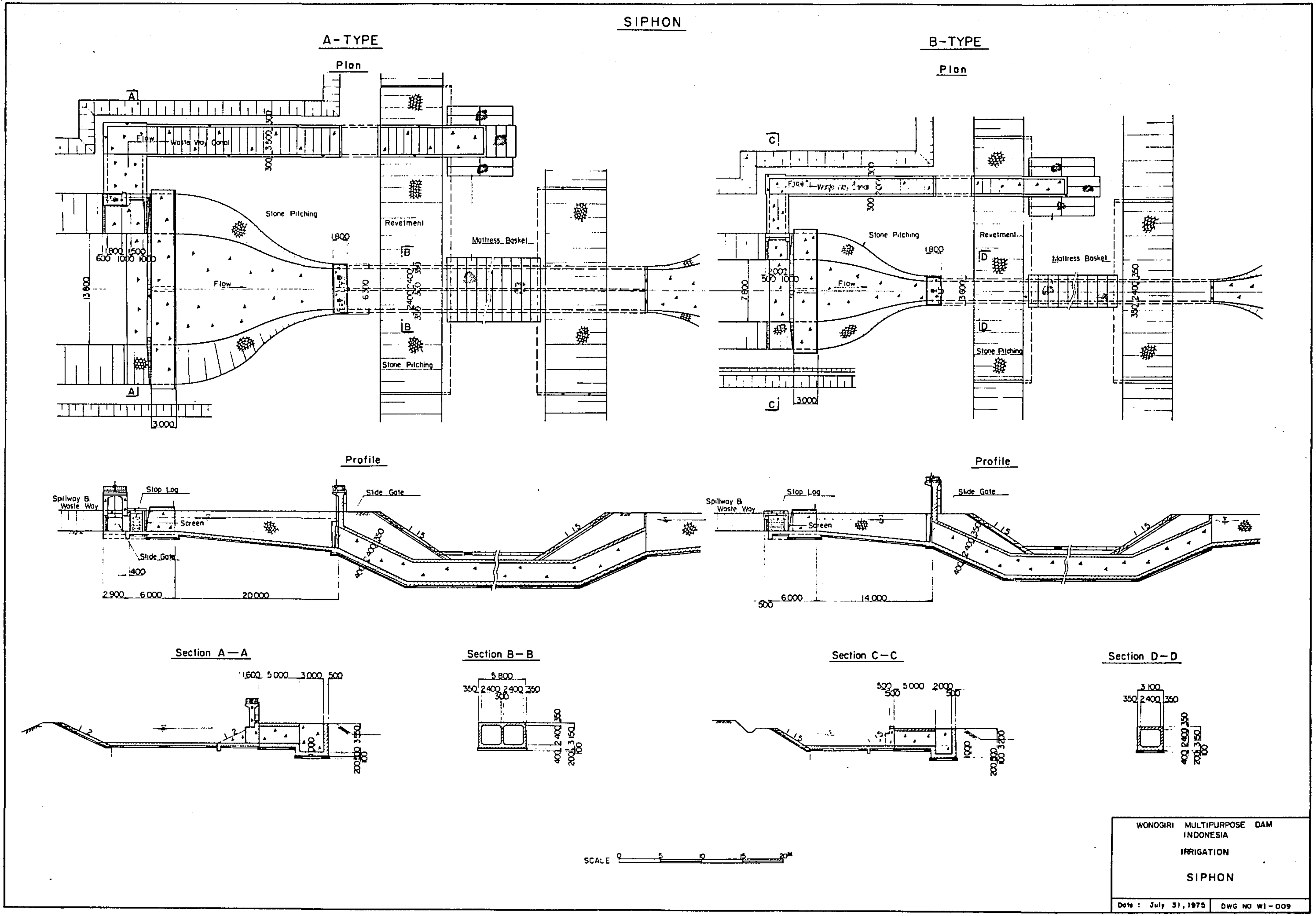


WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

STANDARD CROSS-SECTION OF SECONDARY CANAL & OTHERS

Date : July 31, 1975	DWG NO WI-008

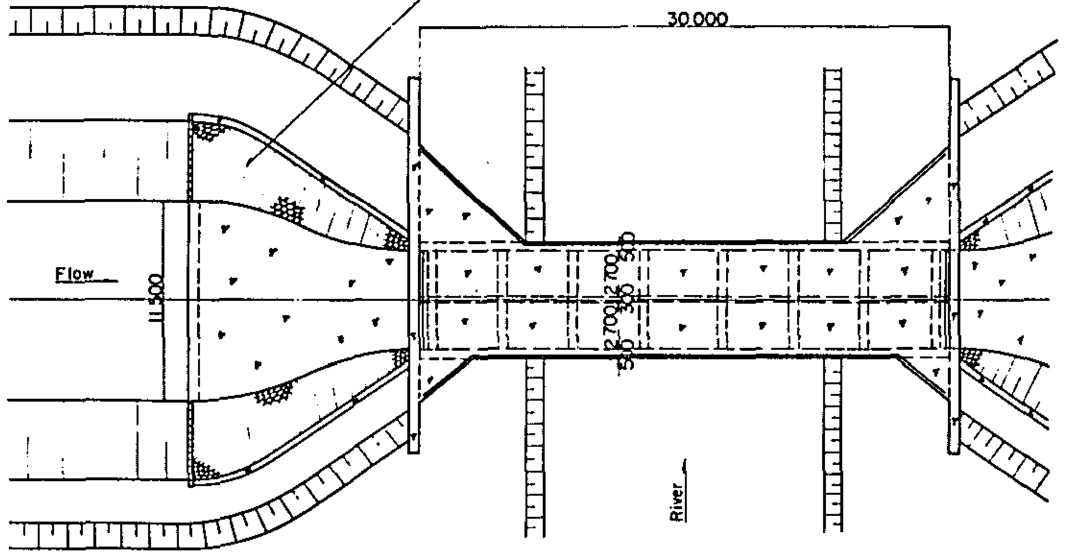


SIPHON
A-TYPE
Plan
Flow
Waste Way Canal
Stone Pitching
Revetment
Mattress Basket
Flow
Stone Pitching
B-TYPE
Plan
Flow
Waste Way Canal
Stone Pitching
Revetment
Mattress Basket
Flow
Stone Pitching
Profile
Spillway & Waste Way
Stop Log
Screen
Slide Gate
Slide Gate
Profile
Spillway & Waste Way
Stop Log
Screen
Slide Gate
Section A—A
Section B—B
Section C—C
Section D—D
SCALE 0 5 10 15 20M
WONOGIRI MULTIPURPOSE DAM
INDONESIA
IRRIGATION
SIPHON
Date : July 31, 1975
DWG NO WI-009

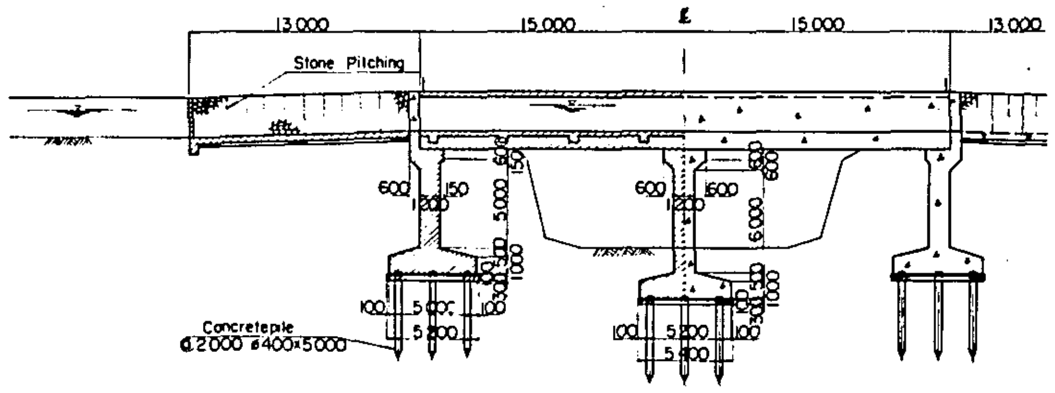
AQUEDUCT

A TYPE

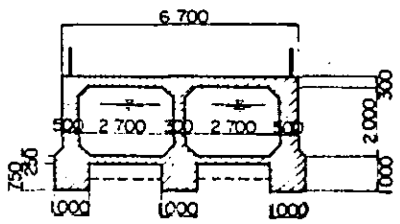
Plan
SCALE A



Profile
SCALE A

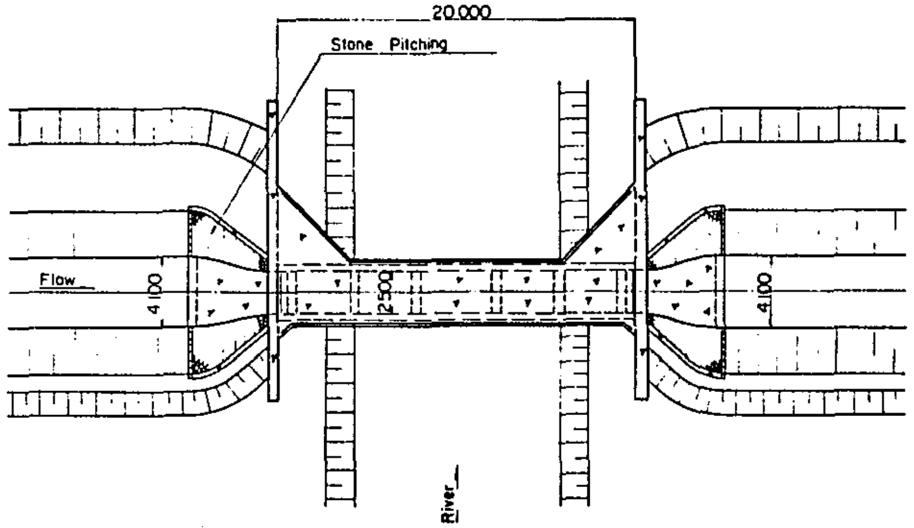


Aqueduct Section
SCALE B

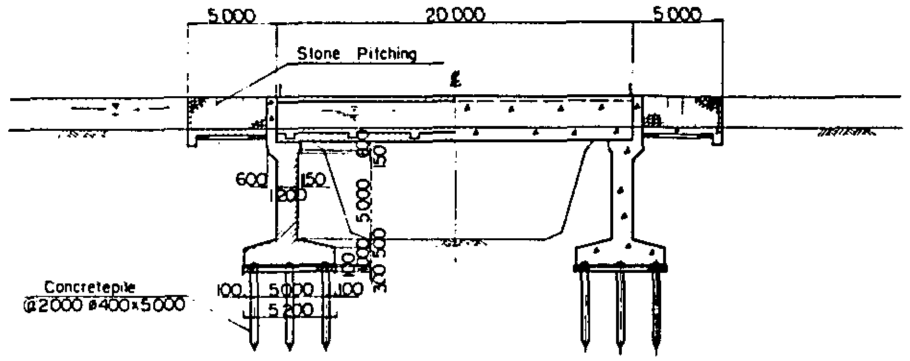


B TYPE

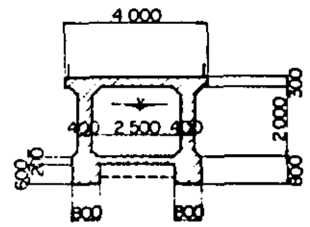
Plan
SCALE A

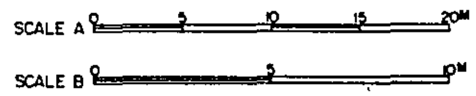


Profile
SCALE A



Aqueduct Section
SCALE B

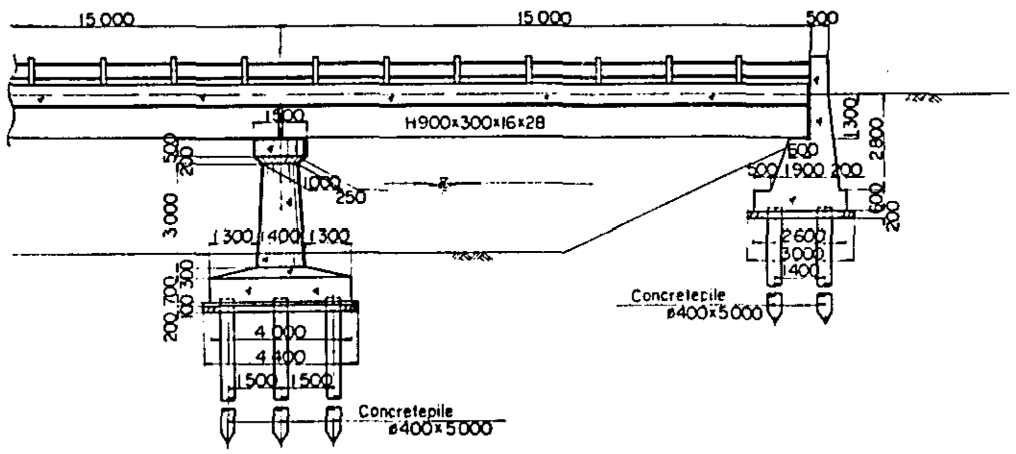




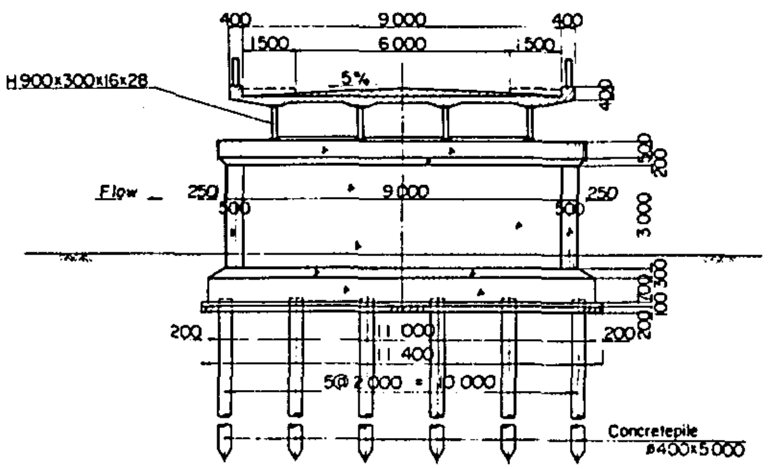
WONOGIRI MULTIPURPOSE DAM INDONESIA IRRIGATION AQUEDUCT	
Date : July 31, 1975	DWG NO WI-010

GENERAL ROAD BRIDGE (BRIDGE A TYPE)

Profile

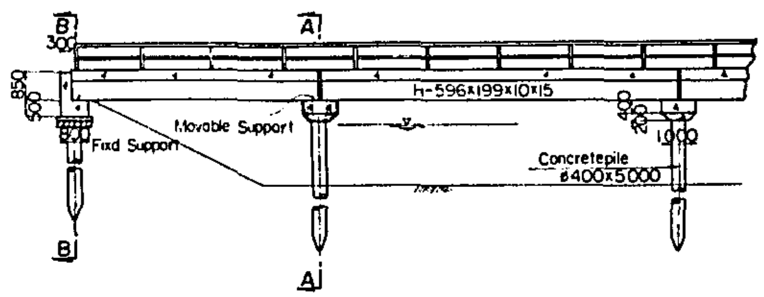


Bridge Pier

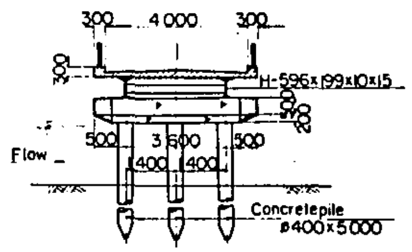


FARM-ROAD BRIDGE (BRIDGE B TYPE)

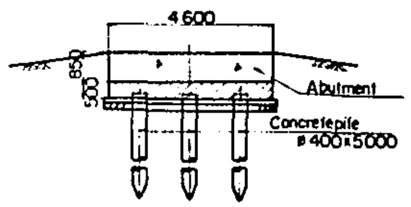
Profile



Section A-A



Section B-B



Dimension Table

Type	Span	Canal Type No	No
B-a		Main (R) Type I-IV	34
B-b		Main (R) Type V-IX	20
B-c		Main (R) X-XII " (L) I-V Secondary	126

SCALE 0 5 10M

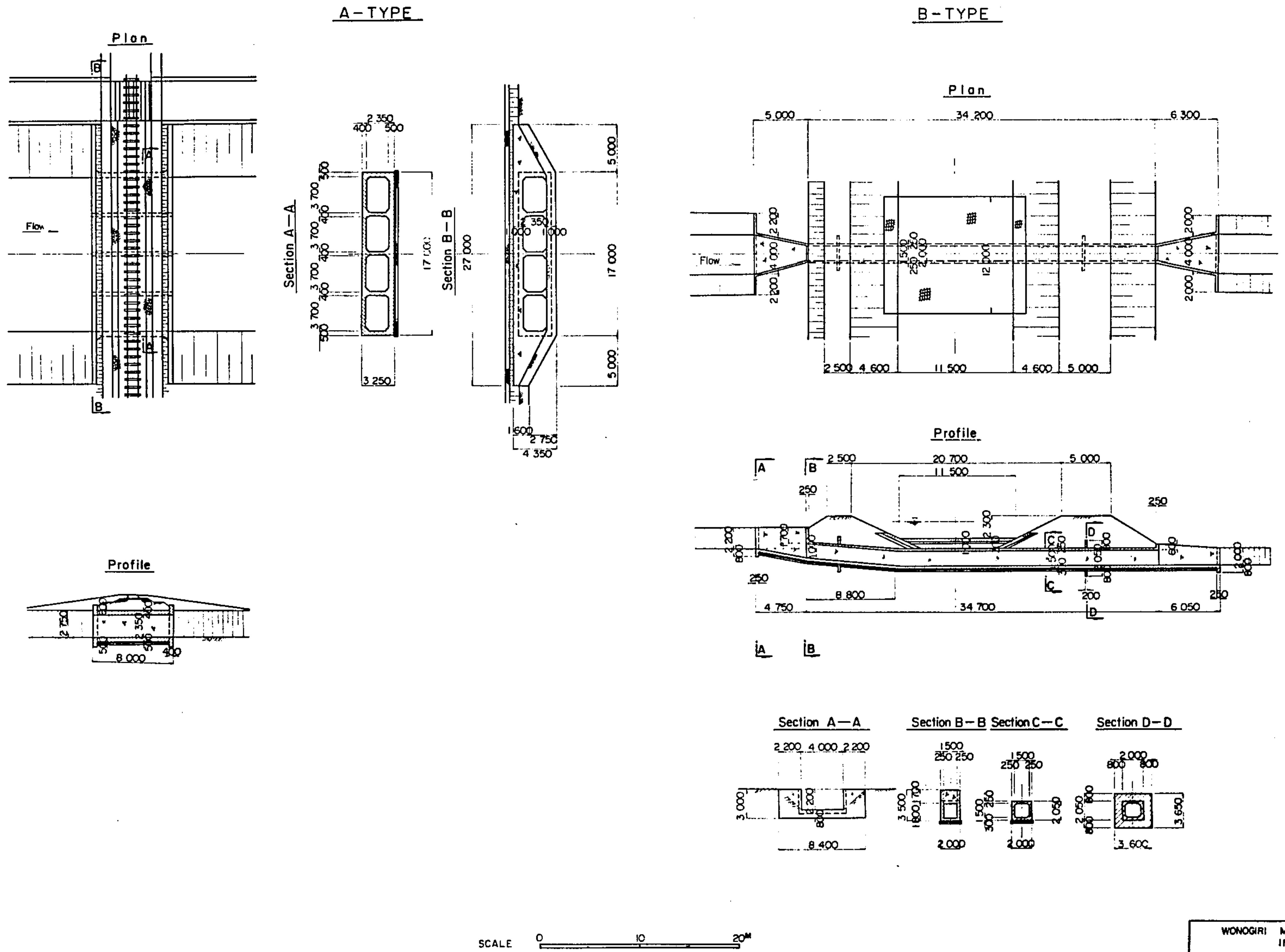
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

BRIDGE

Date : July 31, 1975 DWG NO WI-011

CULVERT



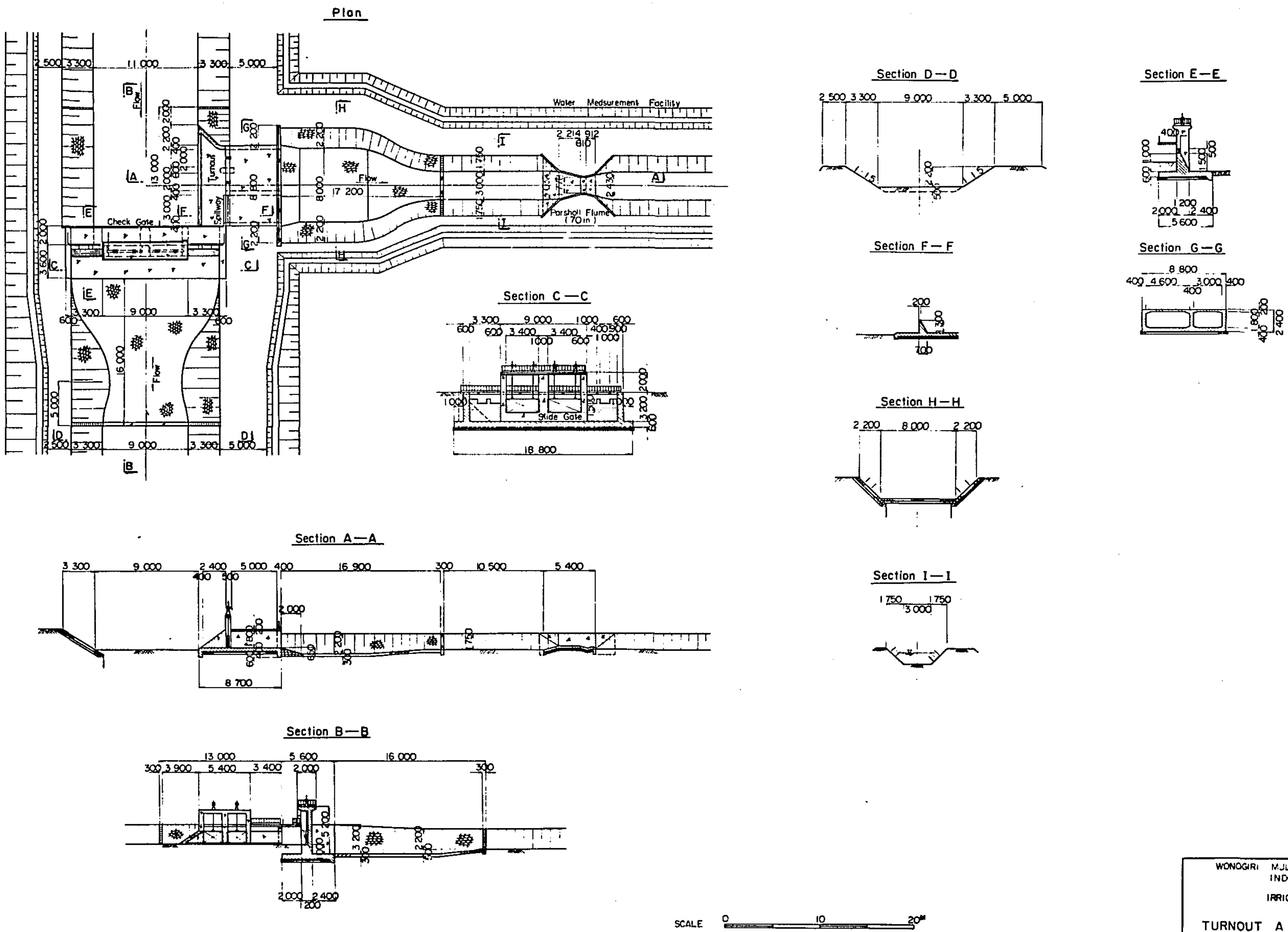
WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

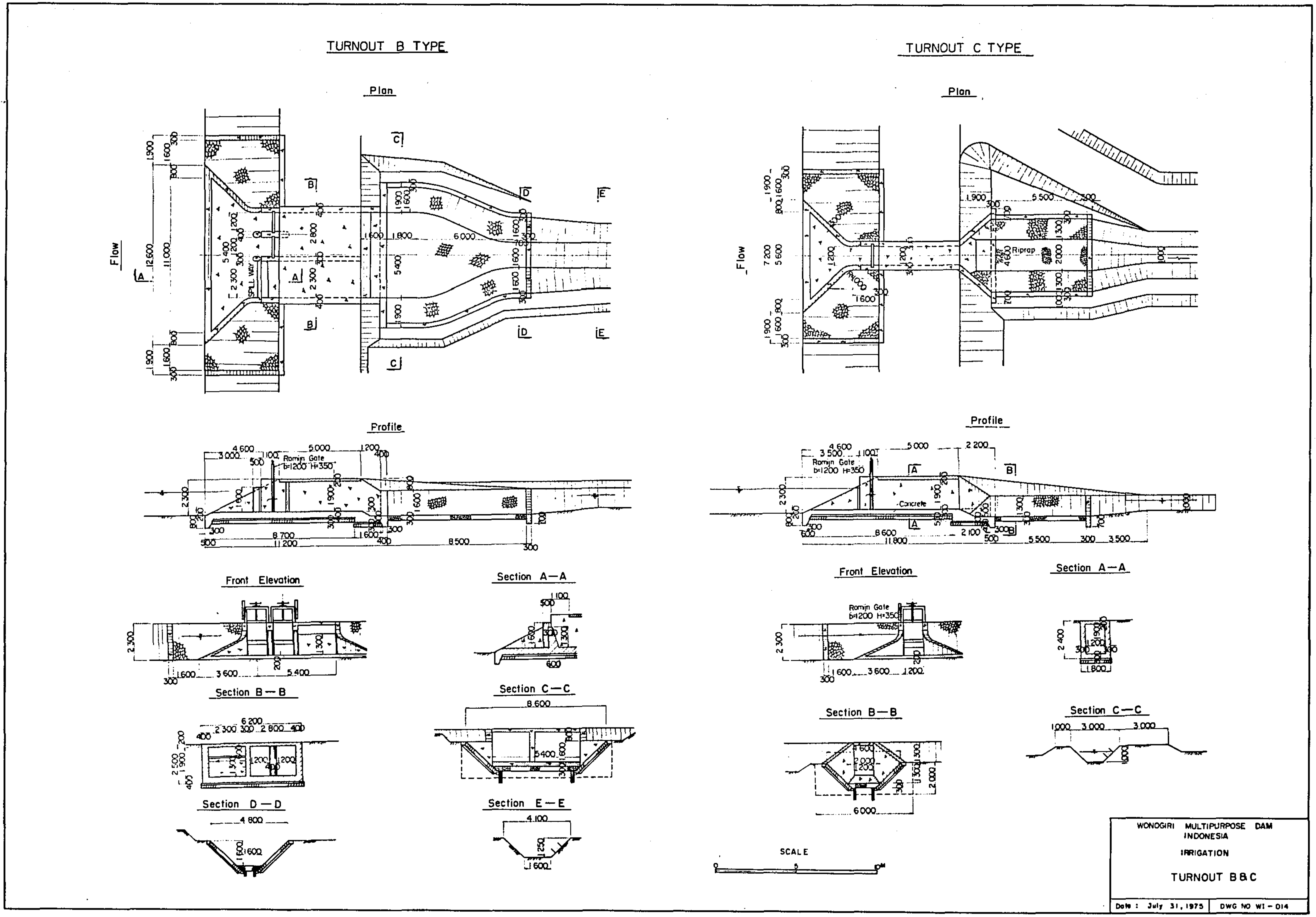
CULVERT

Date : July 31, 1975 | DWG NO WI — 012

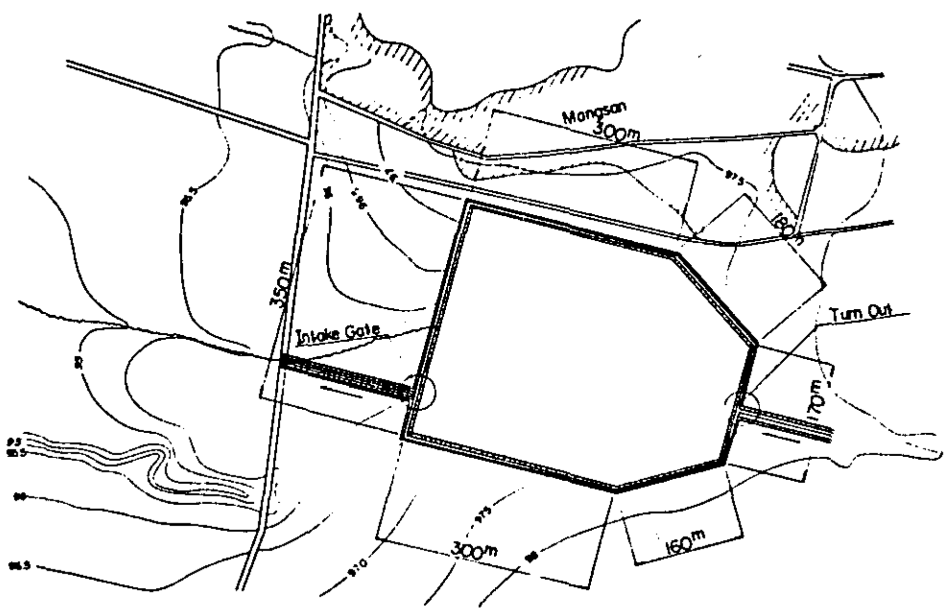
TURNOUT A TYPE & CHECK GATE



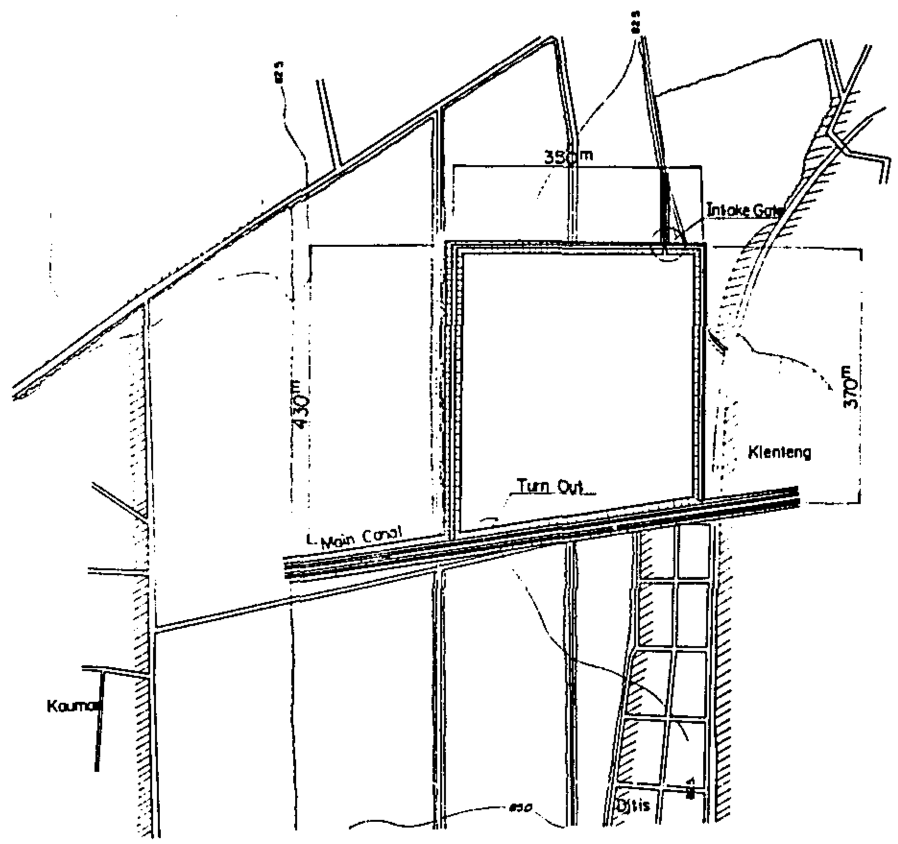
WONOGIRI MULTIPURPOSE DAM INDONESIA
IRRIGATION
TURNOUT A & CHECK GATE
Date : July 31, 1975 — DWG NO WI-013


TURNOUT B TYPE
Plan
Flow
SPILL WAY
Profile
Romijn Gate b=1200 H=350
Front Elevation
Section A—A
Section B—B
Section C—C
Section D—D
Section E—E
TURNOUT C TYPE
Plan
Flow
Riprap
Profile
Romijn Gate b=1200 H=350
Concrete
Front Elevation
Romijn Gate b=1200 H=350
Section A—A
Section B—B
Section C—C
SCALE
WONOGIRI MULTIPURPOSE DAM INDONESIA
IRRIGATION
TURNOUT B&C
Date : July 31, 1975
DWG NO WI - 014

REGULATING RESERVOIR (NO. 1)
SCALE A



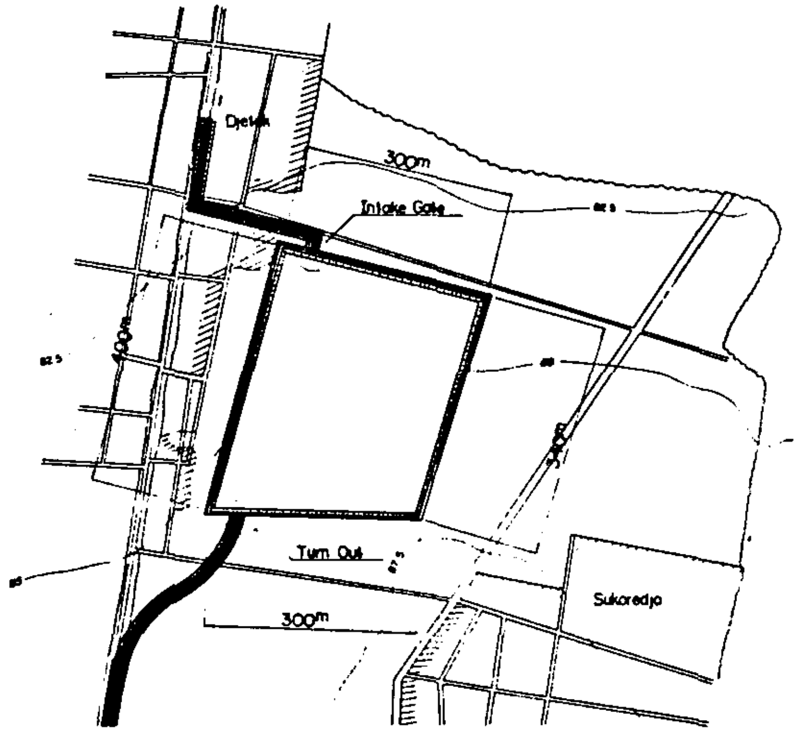
REGULATING RESERVOIR (NO. 3)
SCALE A



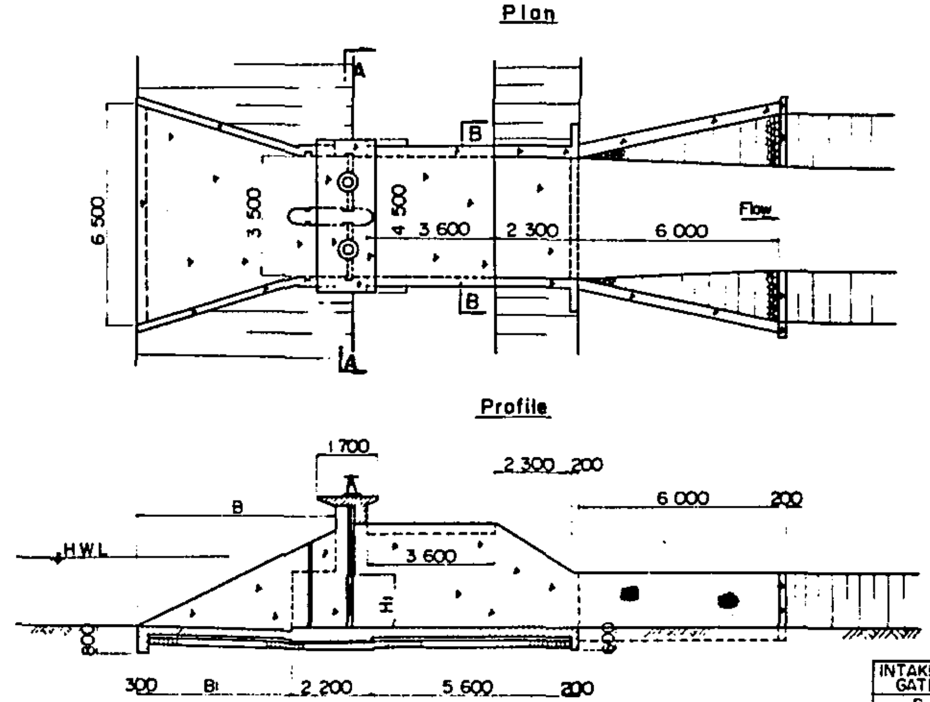
Main Features of The Proposed Regulating Reservoirs

REGULATING RESERVOIR NO. (Turnout NO)		NO 1 (NO 6)	NO 2 (NO 30)	NO 3 (NO 35)
Governing area	(ha)	1,800	1,820	2,290
Max discharge	(m/sec)	2 4	2 5	3 0
Crest of reservoir	(m)	EL98 5	EL 96 0	EL85 0
W.L of reservoir	(m)	EL97 5	EL 85 0	EL84 0
Storage capacity	(m³)	210,000	210,000	260,000
Reservoir area	(ha)	14 4	11 0	14 2
Reservoir depth	(m)	1 5	2 0	2 0
Height of dyke	(m)	2 5	3 0	3 0
Length of dyke	(m)	1,800	1,100	1,200
EL of reservoir basin	(m)	EL96 0	EL 83 0	EL82 0

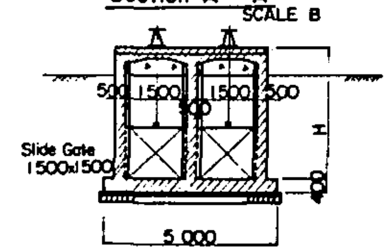
REGULATING RESERVOIR (NO. 2)
SCALE A



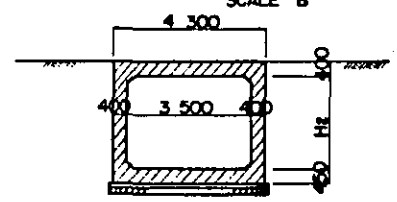
INTAKE GATE
SCALE B



Section A — A
SCALE B



Section B — B
SCALE B



SCALE A 0 — 500M

SCALE B 0 — 5 — 10M

INTAKE GATE NO	NO 1	NO 2	NO 3
B	5 500	6 500	6 500
B1	4 000	5 000	5 000
H	3 800	4 800	4 800
H1	1 500	2 000	2 000
H2	2 700	3 200	3 200

WONOGIRI MULTIPURPOSE DAM
INDONESIA

IRRIGATION

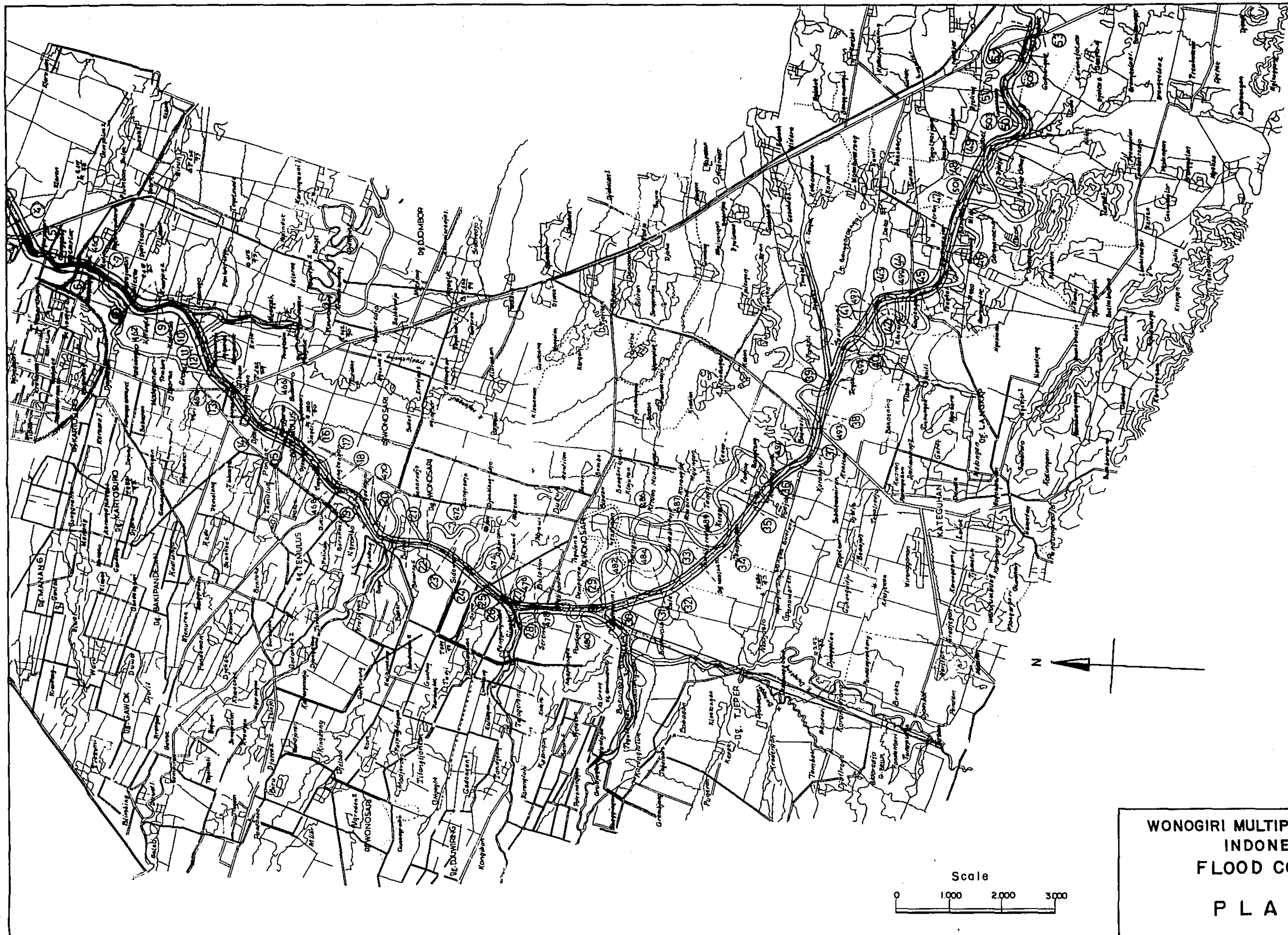
REGULATING RESERVOIR

Date : July 31, 1975 | DWG NO WI – 015

WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

PLAN (1)

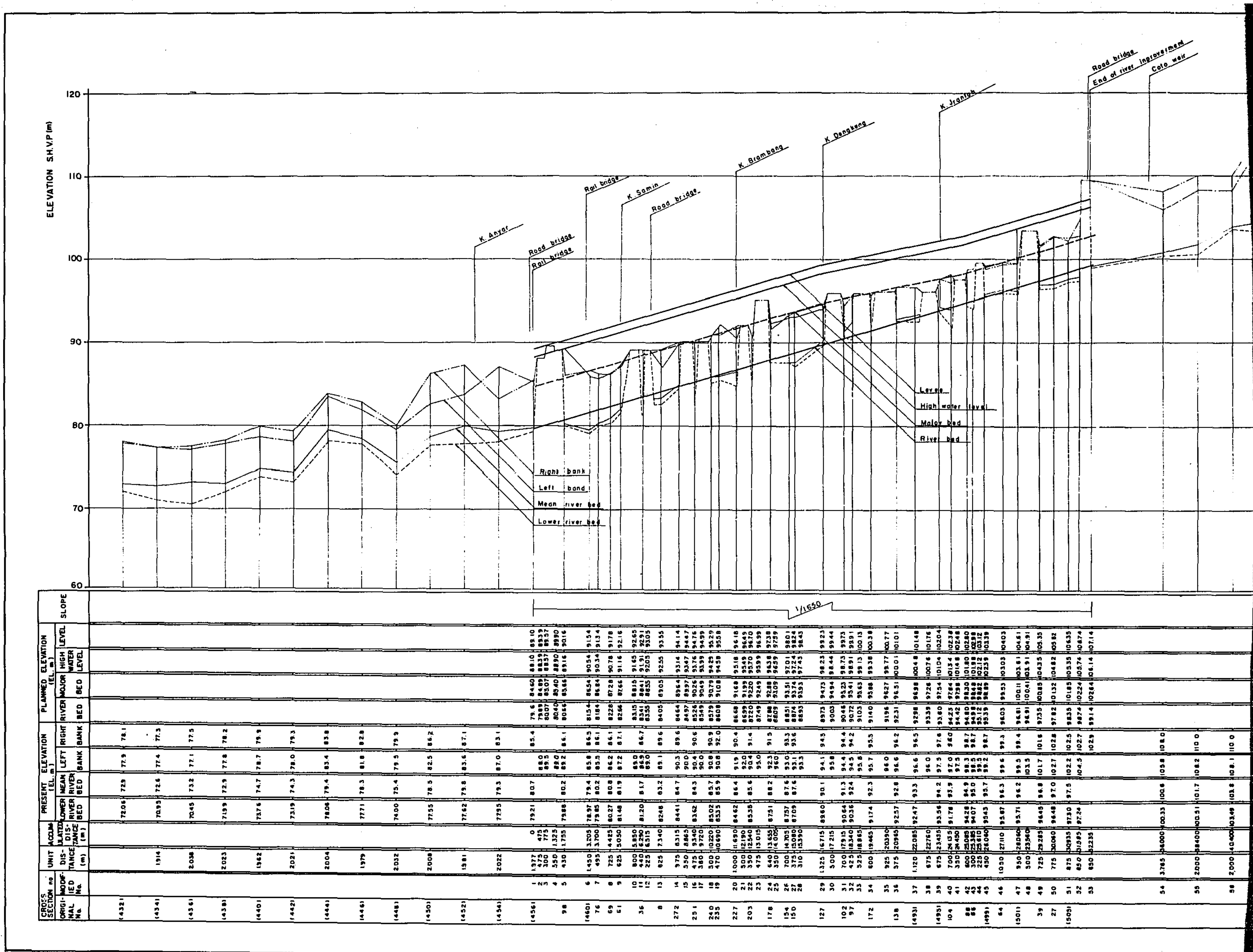
Date : July 31, 1975	DWG NO. WF 001.



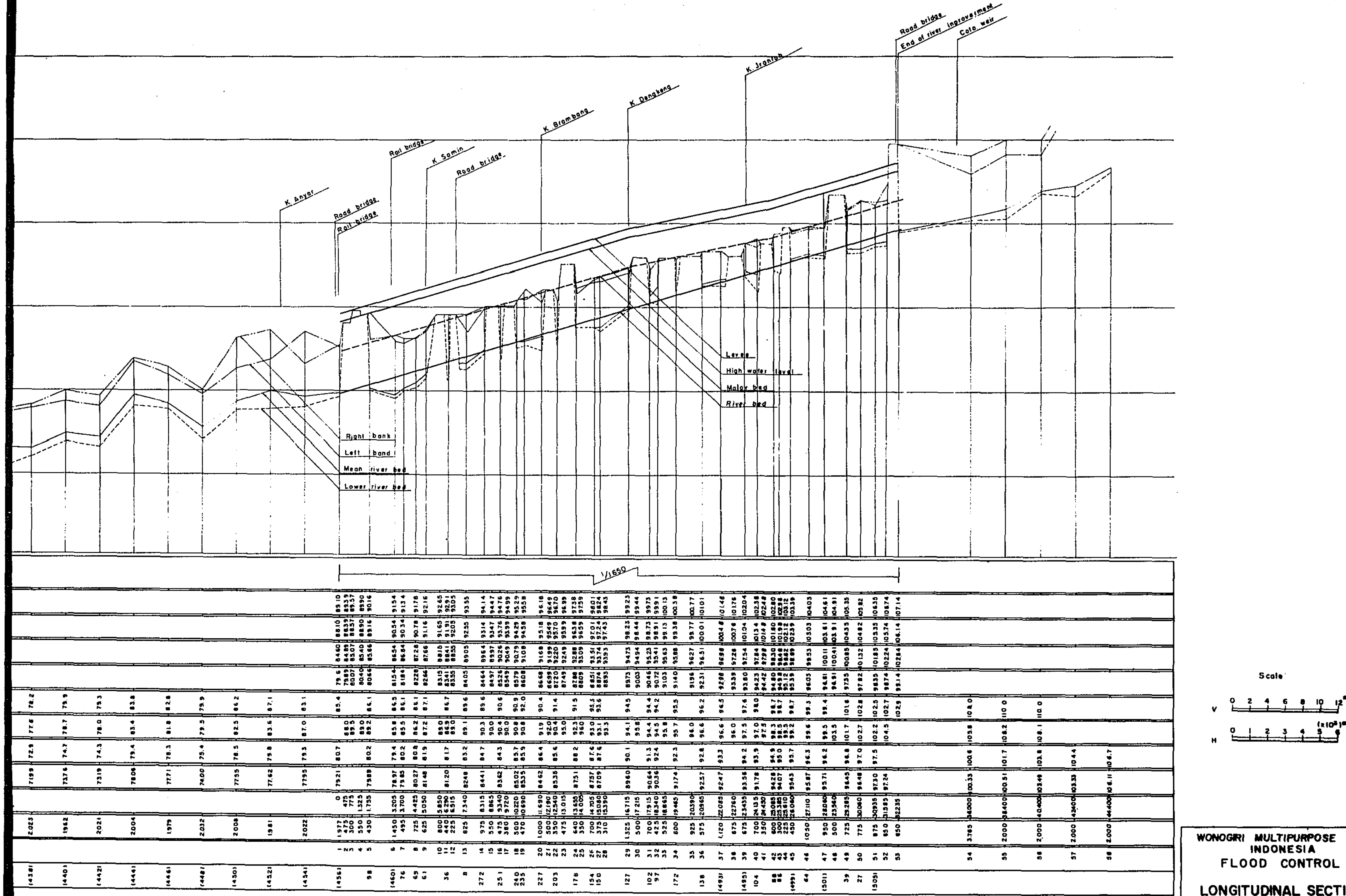
WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

PLAN (2)

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



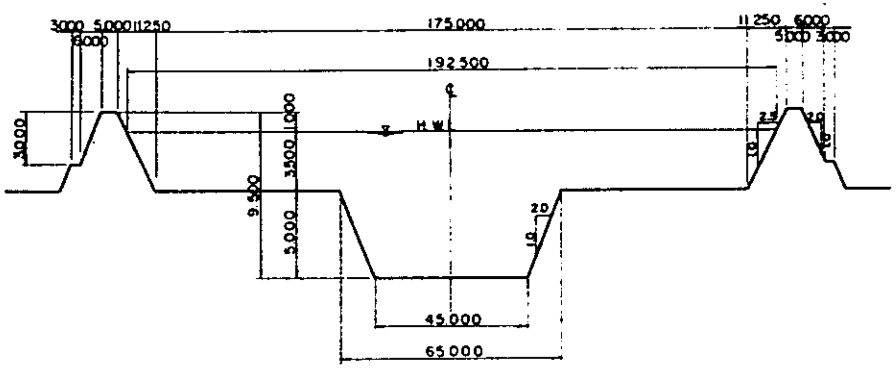
ELEVATION S.H.V.P (m)
120
110
100
90
80
70
60
K. Anyar
Road bridge
Rail bridge
Rail bridge
K. Samin
Road bridge
K. Brambang
K. Dengkeng
K. Jrangah
Road bridge
End of river improvement
Colo weir
Levee
High water level
Major bed
River bed
Right bank
Left band
Mean river bed
Lower river bed
SLOPE
1/1650
PLANNED ELEVATION (EL. m)
LEVEL
HIGH WATER LEVEL
MOJOR 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
ORIGINAL No.
MODIFIED No.



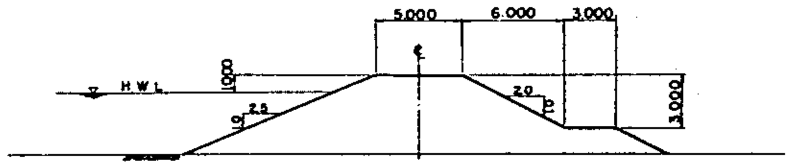
WONOGIRI MULTIPURPOSE DAM
INDONESIA
FLOOD CONTROL

LONGITUDINAL SECTION

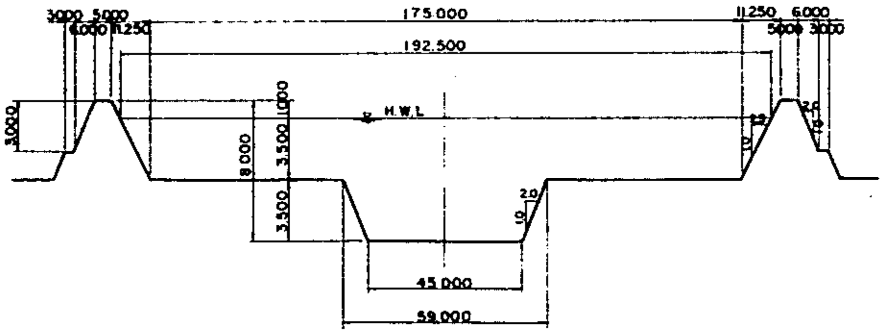
Date : July 31, 1975	DWG NO. WF 003



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

社会開発協力部報告書