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

FOR DEVELOPMENT OF THE SALA RIVER BASIN

INTERIM REPORT
FEASIBILITY STUDY OF WONOGIRI MULTIPURPOSE DAM

APRIL 1975

JAPAN INTERNATIONAL COOPERATION AGENCY

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Apr. 22, 1975

Letter of Transmittal

Ir. Suyono Sastrodarsono

Director General of
Water Resources Development

Ministry of Public Works and
Electric Power,
Republic of Indonesia

Dear Sir,

The survey team of the Japan International Cooperation Agency for the feasibility study of Wonogiri multipurpose dam, has the pleasure of submitting this Interim Report to the Government of Indonesia in accordance with the Memorandum agreed on November 1974.

This report includes all the findings and results of field survey, investigations and study, and prefeasibility of the Wonogiri multipurpose project involving Wonogiri dam and power station, irrigation, river improvement on the basis of the materials so far provided. Contexts of the report will be refined after the team goes back Japan and compiled in a form of feasibility report by the end of July.

The team wishes to express profound gratitude for the cooperation and support provided by the officials of the Government of Indonesia, the counterpart personnels to the team, the officials of the Government of Japan and the Japanease Colombo Plan experts to Indonesia.

Sincerely Yours,

Nobuo Aihara

Nobuo Aihara
The leader of the survey
team for feasibility study
of Wonogiri multipurpose dam

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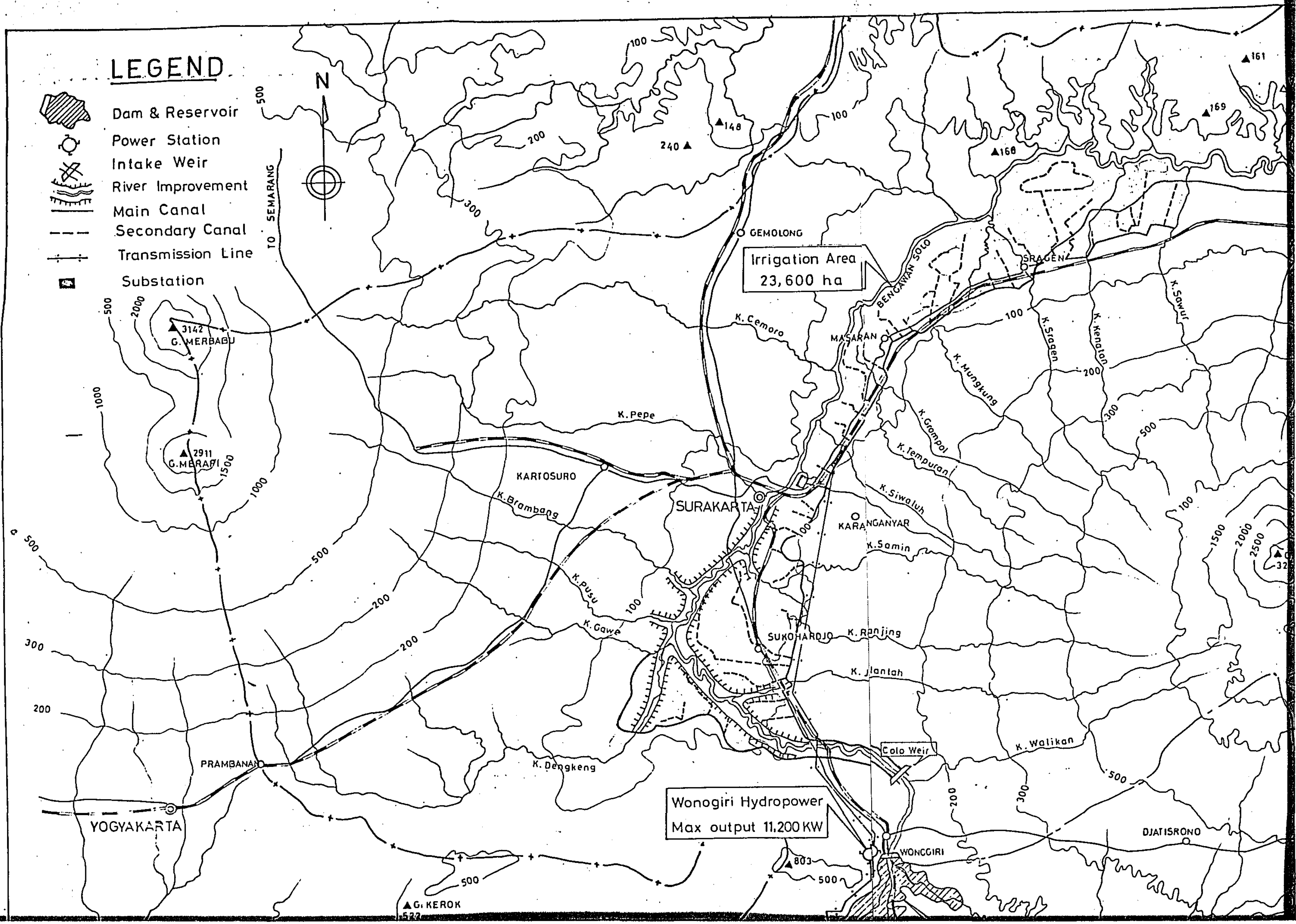
LEGEND
Dam & Reservoir
Power Station
Intake Weir
River Improvement
Main Canal
Secondary Canal
Transmission Line
Substation
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TO SEMARANG
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3142
G. MERAPI
2911
GEMOLONG
Irrigation Area
23,600 ha
BENGAWAN SOLO
SRAGEN
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PRAMBANAN
YOGYAKARTA
Wonogiri Hydropower
Max output 11,200 KW
WONOGIRI
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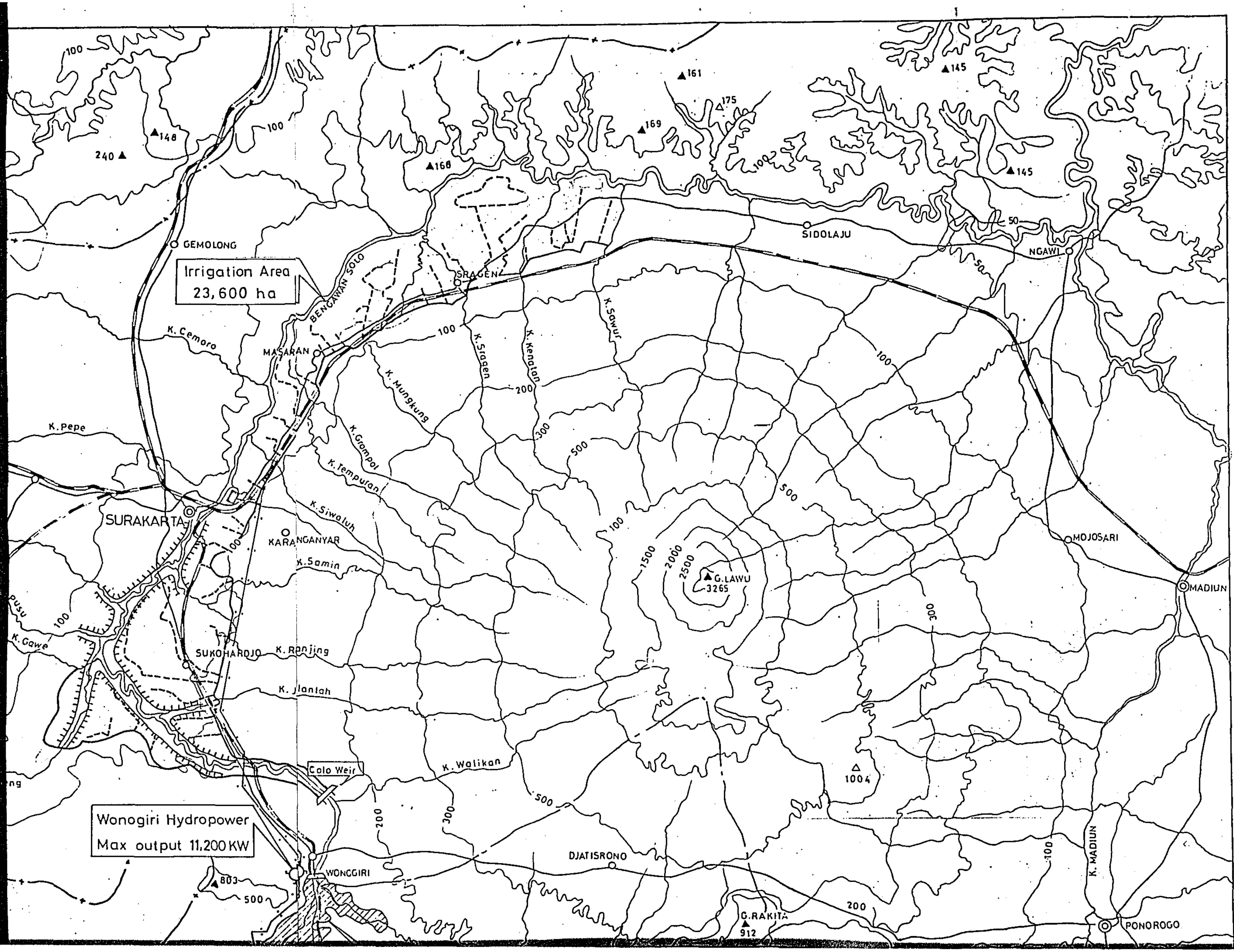
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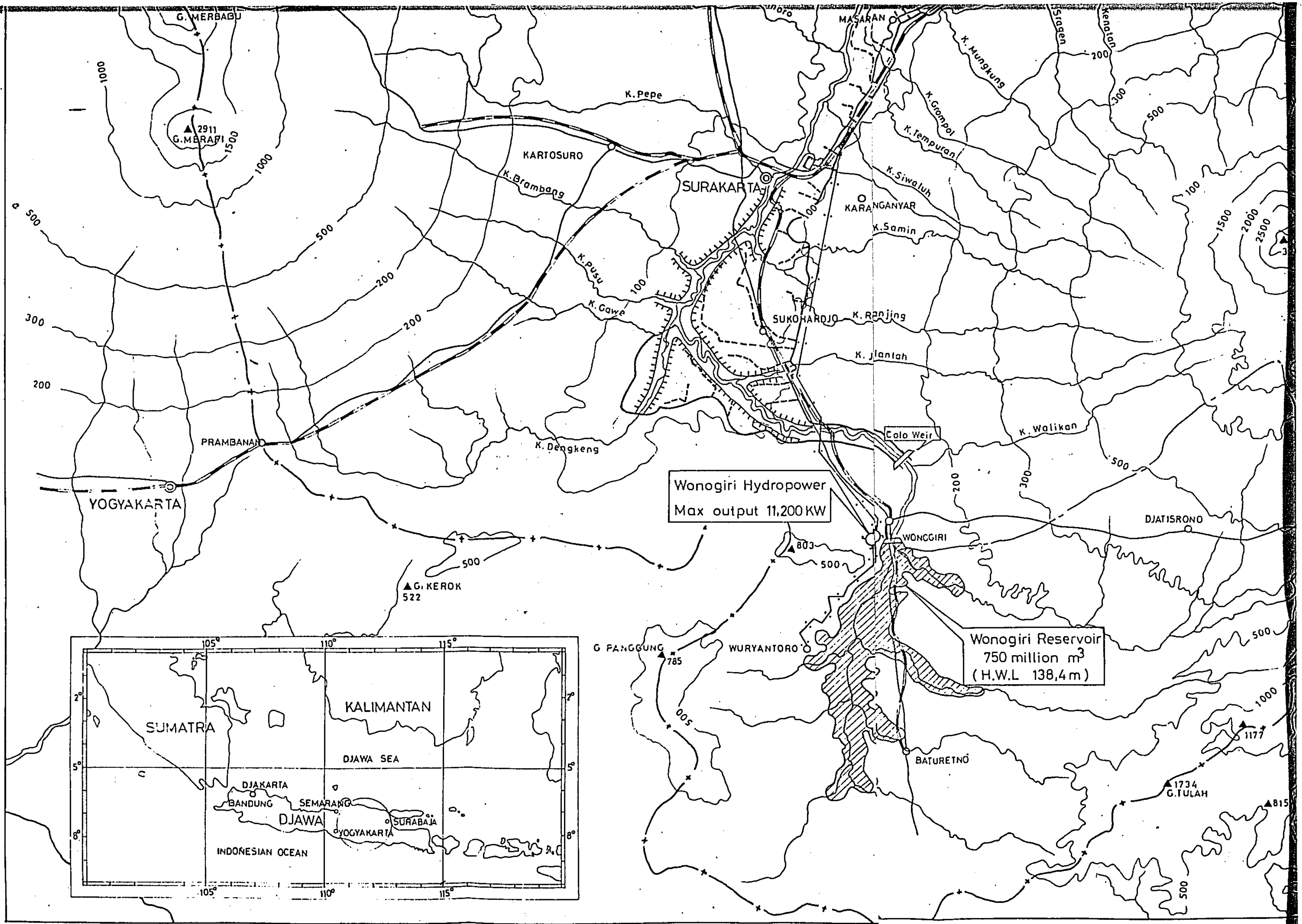

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Wonogiri Hydropower
Max output 11,200 KW
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G PANGGUNG
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WURYANTORO
Wonogiri Reservoir
750 million m³
(H.W.L 138,4 m)
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KALIMANTAN
SUMATRA
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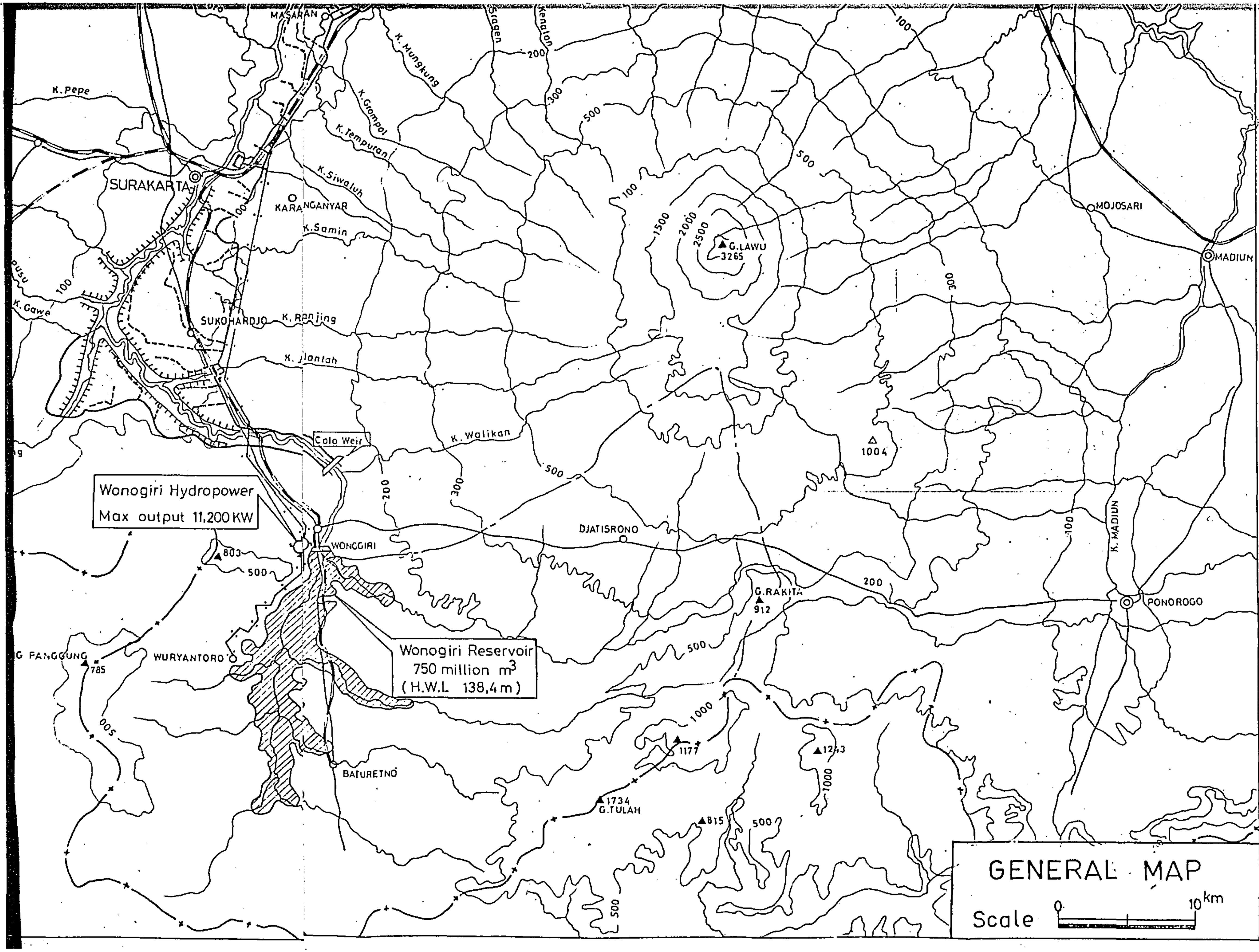
SURABAJA
INDONESIAN OCEAN



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GENERAL MAP
Scale
0
10 km

I. INTRODUCTION

Scope of Study

In accordance with decision of the Government of Indonesia to carry out feasibility study of the Wonogiri multipurpose dam project in the upper river basin of the Bengawan Sola under the technical assistance from the Government of Japan, the survey team consisting of 18 experts were dispatched to the project site since 25 November 1974.

The scope rendered to the Survey team is to

(1) carry out necessary field investigations,

(2) analyze the results of investigations and formulate optimum scale of the project,

(3) examine feasibility of the project,

(4) prepare an interim report by the end of field study,

(5) prepare feasibility report,

(6) transfer knowledge or technical know-how to counterparts of the Government of Indonesia on job training.

This interim report deals with techinical study accomplished at the job site and preliminary feasibility of the Project for reference of preparing financial application for the detailed engineering, and necessary terms of works to be accomplished by the project office before detailed design will be commenced.

Draft of final report shall be prepared within three months after submission of the interim report and be submitted to the Government for commenting. Upon receiving the comments, if any, the Team will finalize the feasibility report within the succeeding two months.

Background of the Project

Bengawan Sala, the largest river in Java, has been unused for as economic resources, except some tributaries for

irrigation.
Recent economic situation, especially after First Five Year Development Plan (Pelita-I) implemented, it gradually puts the light on the possibility of multiple utilization of natural water resources.

Since the Government has placed great emphasis on rehabilitation of agricultural sector, the main support of national economy, rehabilitation of the deteriorated irrigation facilities has being progressed with a great deal of investment and this has so much contributed to increase of food production. To follow this, the Government turns her policy to develop other economic and social sectors with continuation of development of agricultural sector.

To support this national policy, study on development of natural water resources has been instituted with a considerable emphasis though multipurpose water resources development schemes have been envisaged step by step since a decade ago. In this framework, the Sala River basin development has been restudied to formulate a master plan during the period from 1972 to 1974 under the technical assistance of the Government of Japan.

Based on the recommendation in the master plan, the Government of Indonesia has decided to carry out feasibility study of the Wonogiri multipurpose project as first priority project to be implemented in the basin development program. And to increase food production and to lessen menace of the dreadful flood in lowstream area is convinced indispensable for regional development now the Government stressed.
During the Pelita-II, 1974 - 1978, preparation of implementation has to be completed in order to realize the project in the succeeding Pelita-III.

II. PROBLEMS AND NEEDS

1. Present Economic Situation and Main Problems

By the economic construction through First Five Years Development Plan (PELITA-I), Indonesia has steadly consolidated her economic base for future jump. Her main effort has put on increase of food production aiming at self sufficiency, expansion of industries and promotion of export of crude oil, traditional agricultural product including forest and fishery products. Since embargo of Middle East oil export and oil price rising thereby, the balance of payment marks some surplus never experienced.
However, her economic stability and economic growth are still imbalance.

Agricultural production, particularly farm food production, is not to support self-sufficiency. Industrialization as well as reconstruction of the existing industries is to be braked by inflated price of the imported capital goods. Power supply, essential for industrial development is still far from satisfactory condition. Transportation system, especially interinsular marine transport and railway, is so much deteriorated as yet. Shortage of trained bureaucratic and technocratic personnel are much hampering to heighten efficiency of economic development.

Firstly to be achieved is self-support in foodstuff.
Even though export of oil earns enough money to import food, it is exhaustible resources. From the nationwide point of view, rice, most important food, production increases at the annual rate of 4.4% in the period of Pelita-I.

Table II-1 Production Increase of Rice

Year	Harvested area	Production	Unit yield
1968	8,020 (x 1,000 ha)	11,666 (x 1,000 t)	1.27 (t/ha)
1969	8,014	12,249	1.32
1970	8,135	13,140	1.47
1971	8,317	13,724	1.66
1972 /1	7,984	13,305	1.67
1973 /2	8,388	14,455	1.72

/1 Preliminary
/2 Estimate

Production increase has achieved by mainly Bimas and Inmas programs together with rehabilitation and extension of irrigation system. However, upland crop has decreased harvest of maize and root crop due to decrease of cropped area and less merited. Introduction of Bimas and Inmas programs created a considerable opportunity for employment in rural area in forms of labour for intensive farming, transporting input, (fertilizer, chemical etc.), rehabilitating and constructing irrigation facilities and roads. by being guaranteed the minimum price of food crops, income level of the farmers has been raised substantially. Nevertheless, the production of rice and other food crops could not reach to the level of self-sufficiency for high dependency of cultivation on rain water.

Sugar production is also far from to meet the national requirement. It was imported by about 162,000 ton in 1973.

Indonesia now has total wet paddy field of 5.6 million ha, out of which about 62.5%, 3.5 million ha has some irrigation facilities. But about 13.5%, 0.8 million ha, of this wet paddy field annually suffer from flood inundation.

Electric power supply of the country increase its supply capacity to 1,055 MW at the end of Pelita-I. But supply capacity per capita is still in quite low level, 9.2 watts in Java, 8.1 watts in Indonesia. Transmission and distribution system is as yet poor although great effort for extention has been made during Pelita-I.

2. <u>Basic Policy of Economic Development</u>

In Pelita-II started from April 1974, the following basic policy is launched up,

(1) to supply sufficient food and clothing in better quality and cheap price,

(2) to supply credit for housing, aiming at equi-distribution of wealth,

(3) to continue construction of infrastructure,

(4) to upgrade and equalize people's welfare, and

(5) to expand employment opportunity.

Under the above national policy, detailed programs of development are set forth by each economic sector. Main focus of economic development is still set on the sector of industry, mining, power, transportation besides agriculture. As short term target, Pelita-II sets out the following economic growth by 1978/1979.

Table II-2 Target Composition of National Production by Economic Sector (%)

	1973/1974	Annual growth rate	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		100.0

With the above prospect, annual growth of national income is projected to increase at 7.5%.

In agricultural sector, following programs are set out :

(1) increase the production of rice, polowijo crops and vegetables,
(2) increase of production of estate crops,
(3) increase of production of fishery, livestock and forestry,
(4) improvement and conservation of forest, land and river,
(5) agricultural education,
(6) agricultural survey.

Besides these, construction of infrastructure, improvement of efficiency of agro-administration and organization are taken up parallelly.

For increase of farm crop production,

(i) expansion of intensive farming through Bimas and Inmas program.
(ii) introduction and distribution of improved [illegible] varieties,

(iii) development of extension services,
(iv) improvement of farming practice ; fertilizer, productivity, mechanical farming etc.,
(v) improvement of marketing of product and inputs,
(vi) production increase of polowijo, and
(vii) development of rice cultivation in swampy area and dry land,

are instituted in detail.

To support the production increase, the irrigation farming is indispensable in this country where surface water almost diminishes during critical stages of growing period of dry season crops, without irrigation.

At the beginning of Pelita-I, more than 60% of the existing irrigation systems is need of some rehabilitation. They are programed to be rehabilitated or improved by the end of Pelita-II. For expansion of year round irrigation, the Government establishes such development policy besides rehabilitation program as

(i) exploitation of new water resources,
(ii) prevention of flooding over farm land,
(iii) construction of multipurpose dam,
(iv) reclamation of swampy land to farm land,
(v) research of effective water utilization.

From the long range viewpoint, development of potential river basin may be essential in this context. Especially, the rivers in Java of which potential water resources can easily benefit to the already developed farm land now suffering from lack of irrigation water in dry season.
Water demand in future is expected to quickly increase not only for irrigation use but also for industrial and municipal

water as industrialization and urbanization are progess. Large rivers which have potential water resources often have adverse characteristic to give damages on farm land and trunk transportation lines by flooding. Construction of multipurpose dam and river improvement, or a combination of them are ultimate measure not only to consolidate firmly infrastructure of agricultural production but to support economic development by hydropower generation, water supply for industrial and municipal uses.

3. Necessity and Potential of Development

On the ground of national policy for economic development, regional development is envisaget at provincial level.

Central Java in where the project area involved, stands mainly on agriculture base economy. More than 58% of total population depends upon agricultural sector followed by 13% on industry, 14% on commercial trade and 10% on services. Notwithstanding high dependency on agriculture, some areas in this province suffer sometimes from starving ; Wonogiri, Karanganyar and Sragen in the project area. Even at present, farm crop productivity in this project area is high compared with the average in Central Java. But water supply limits dry season cropping to a considerable extent due to lack of water sources. In Surakarta region, many small and home industries, most of them are batik industry, are operated with their out of date facilities. Poor power supply and municipal water supply set back the development in the urban area.

Limited scale of the regional economy increase unemployment of labour population both in urban and rural area.

Since no labour attractive industries are anticipated, development or improvement of agriculture and the existing industries will be only relief to this area. Year round irrigation to be realized by new water sources, mitigating menace of habitual flooding, supply of sufficient power and water are indispensable for this region together with modernization of production practice.

The arable land in this project area has been developed to the maximum extent : farm land ratio to the total land reaches to about 57% to 71%, exclusive yard area, and out of the farm land area, about 67% is occupied by paddy field, the remainder by upland. However, lack of water in dry season drops the utilization ratio of the paddy and upland field to about 31% and 30% respectively. New water resources, if they are available, could survive uncultivable firm land due to lack of water, to considerable extent.
Besides the water shortage, farmland about 15,000 ha including yard area is inflicted by flooding from the Sala River and lost a considerable harvest in rainy season.

Since most of tributaries in this area have been utilized for irrigation, but no flood control facilities is provided yet with them. No room for increasing water supply source and less possibility for controlling flood by the development of tributaries eventually set a focus to the main Sala River whose potential is as yet not developed at all.

4. Master Plan of Sala River Basin Development

For developing potential of the Sala River basin, the Government of Indonesia formulated a master plan of water resources development in 1974 under technical assistance of the Government of Japan.

The master plan drew various schemes for irrigation, flood control, power generation, sediment control and drainage. The envisaged schemes are summarized in Table II-3.

Master Plan mentioned that high economic return would be expected to irrigation sector followed by power generation and flood control. Among the proposed schemes multipurpose dam and irrigation project of Wonogiri in the Upper Sala basin and Jipang in the Lower Sala basin will bear high economic return compared with the remaining schemes.

Table II-4 Internal rate of Return (%)

	Upper Sala	K. Madiun	Lower Sala
Multipurpose dam & irrigation	16.2	5.9	10.8
Multipurpose dam & irrigation and river improvement	13.3	7.6	9.2
All projects inclusive	12.3	7.4	8.9

And the Master Plan recommended that Wonogiri multipurpose project shall be implemented as first project of the Sala River Basin Development, together with river improvement of the upstream part of Surakarta.

5. Wonogiri Multipurpose Project

The Wonogiri dam is planned to control the drainage area of 1,350 km^2 upstream of Wonogiri town. The scheme proposed to maximize regulated river water and to minimize the flood outflow by providing storage capacity of reservoir as large as possible.

With effective storage of 440 million m^3, the dam can supply water to irrigate an area of 22,000 ha throughout year, and with another storage space of 220 million m^3, the flood of peak discharge, 4,000 m^3/s can be regulated to 400 m^3/s from the dam.

By utilizing of the effective storage for water supply, hydropower plant with 13,300 kw installed capacity can produce power energy of 34,100 MWH annually.

Main features of this project set out in the Master Plan are summarized as follows :

Location : 2 km upstream of Wonogiri town

Catchment area : 1,350 km^2

Dam;	Type	Height	Crest length	Volume
	Rockfill	31.5 m	740 m	850,000 m^3

Reservoir ;	High	Normal High	Controlled	Low
Water level	EL.137.5 m	EL.135.5 m	EL.134.5 m	EL.124.0 m

Reservoir	Gross	Flood control	Irrigation	Sediment
Storage capacity (mill. m^3)	660	220	440	70

Reservoir surface area : 8,800 ha at H.W.L.

Effect :		
	Flood control	Inflow = 4,000 m^3/sec.
		Regulated outflow = 400 m^3/sec
	Irrigation	22,000 ha year round
	Hydropower	Installed capacity = 13,300 kW
		Energy production = 3,100 MWH

Construction cost ;

Dam & Reservoir	19.2 million US$
Power plant	5.3 "
Irrigation	15.3 "
	39.8 million US$

Table II-3

Master Plan of the Sala River Basin

		Purpose	Dam height(m)	Dam Volume (10^3 m^3)	Storage Capacity ($10^6 m^3$)	Irrig. area (ha)	Power Installation (kW)	Cost (HP 10^3)
I.	Multipurpose schemes							
	Wonogiri dam and	I.F.P	31.5	850	Gross 660	22,000	13,300	39,800
	Irrigation (Upper Sala)				Net 440			
	Jipang dam and irrigation (Lower Sala)	I.F.P.	27.5	4,200	Gross 920	54,000	18,000	111,750
					Net 740			
	Badegan dam and Irrigation (Madiun)	I.F.P.	60.5	7,750	Gross 138	4,800	6,000	40,500
					Net 109			
	Bendo dam and irrigation (Madiun)	I.F.P.	80.5	2,110	Gross 86	3,000	10,000	15,040
					Net 68			
II.	River Improvement	F.	Length (km)	Retarding Basin				
	Upper Sala		80					33,100
	K. Madium		54					21,400
	Lower Sala		114	Jabung Basin V = 216 x 10^6 m^3				60,100
III.	Tributary Irrigation schemes	I	Nos of dam	Storage capacity		Irrig.Area (ha)		
	Tributary dam		25	361 x $10^6 m^3$		28,500		110,100
	Improvement					198,700		50,000
IV.	Sand Prevention	S	13 tributaries, 32-checkdam, 88-Grandsill					5,150
V.	Drainage of Jero Swamp	F	15,000 ha					5,900
						Total		492,860

I = Irrigation P = Hydropower

F = Flood Control S = Sand Prevention.

III. THE PROJECT AREA

1. Geographical Condition

1.1. Location and topography

(Bengawan Sala) having about 600 km river length and 16,100 km^2 basin area is situated at near center part of Java island. The basin bounded by high mountain complexes peaking above 2,000 m in the west and east and low mountain ranges in the north and the south running parallel to the coastal lines.

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 recieves the largest tributary, Kali Madiun which also originates from southern mountains and has a drainage basin of 3,755 km^2.

land is situated in the Upper Sala basin of which drainage area is 6,072 km^2, upstream basin from Ngawi and extending on both banks of the main Sala River. Administratively, it is in the ex-Karesidenan (Residency) Surakarta included 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.

of the Sala River 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. Downstream of this 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.

1.2. Climate

Between 7° and 8° parallels in south latitude, the project area is thoroughly governed by tropical monsoon climate. From December to May, eastward wind, wet mosoon, brings a considerable amount of rain, while from June to November, the westward wind, dry monsoon brings drier climate.

Only two meteorological stations are located at near Surakarta in the project area.

1.2.1. Wind and sunshine

Wind prevailed in the project area usually tends its direction to eastward in mid rainy season and then to northward in mid dry season. Average wind velocity ranges from 3.6 km/hr to 10.5 km/hr, relatively stronger in dry season. Duration of sunshine averagely accounts for 68.7% and 38.6 % in dry and wet season respectively (See Table III.1).

1.2.2. Temperature and relative humidity

Average temperature is usually ranging between 33°C at maximum and 23° C at minimum. Seasonal fluctuation is only about 2°C but daily one appears about 8° - 10° C.

Relative humidity drops less than 50 % in the mid dry season, say August and September, and reaches to the maximum in the mid rainy season, February and March. Monthly average is, however, ranging from 60% to 80%. (See Table III.1).

1.2.3. Rainfall

There exist 199 - rain gauges including 10 - automatic rain recorders in the project area. Those location are given in Fig.III.1, togheter with meteorological points.

Average annual rainfall in this 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 into 6 months of the wet season, usually from mid November to mid May.

Table III-2 gives average monthly rainfall in the project area.

Distribution of rain is generally so erratic and high intensity range is relatively limitted in the norrow area, and its duration is also usually short, not lasting more than 15 hours.

1.2.4. Evaporation

No long term records are available in the project area, except the observed record at Pabelan (Surakarta) since 1972. From the records of other observation points in the Sala River basin and nearest points outside the basin, the average evaporation is deemed about 1,100 mm annually and 3.0 mm daily.

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 tertiary ridge formed by G. Gadjah Mungkur and G. Dongok, near the proposed dam site.

The area surrounded by those ridges is of alluvial formation. The base rocks 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 tertiary ridges near the damsite is also formed by marine sedimentation of volcanic rock consisting of marly tuff, sandy-tuff, tuff breccia and lapilli-tuff belonging to upper Miocene.

Quarternary pyroclastic deposit 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 changes into tuff dominant formation in the part nearer to the surface. Several joints and faults run with strike of NW-SEE in this area.

Table III-1 Meteorological Record in the Project Area.

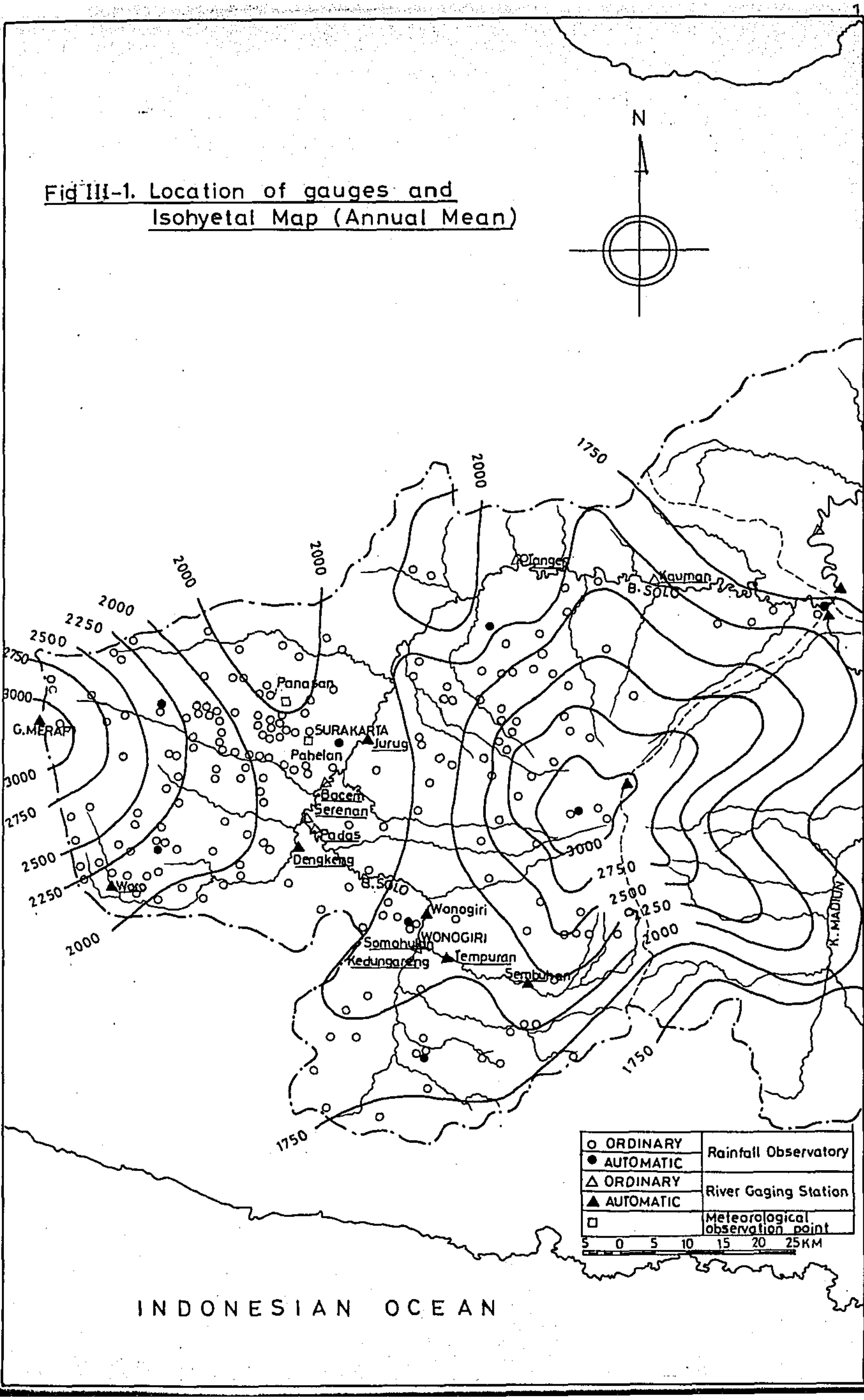
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Year
Wind velocity (m/sec) Panasan	1.4	1.3	1.6	1.4	1.6	1.9	1.8	2.3	2.9	2.4	2.2	1.8	1.9
Duration of Sunshine (%) Panasan	30.0	31.1	36.6	45.6	51.1	63.3	70.0	72.5	75.0	52.5	48.8	33.8	49.7
Average Temperature (°C) Pabelan	27.3	27.9	28.2	29.4	28.6	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

Table III-2 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	266.7	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

Fig III-1. Location of gauges and Isohyetal Map (Annual Mean)



1.4. Hydrology

1.4.1. River Discharge

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

Before 1965, only gauge records at Karangnongko station located at the lower Sala River are available. Corelation of river run-off between those gauges were established in the previous study[1]. Estimated by this corelation and observed monthly discharge at Juranggempal are shown in Table III-3.

Average annual run-off at the Wonogiri damsite 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.

1.4.2. River Sediment

In the project area, no consistent observation of the sediment loads are operated yet. Only available is the data collected in the previous study [1]. The previous study led the following relation between river discharge and suspended load from the available data.

Juranggempal (Wonogiri)	$Qs = 9.0 \times 10^{-6} Q^{1.88}$
Winongo (Madiun)	$Qs = 1.2 \times 10^{-5} Q^{1.88}$
Karangnongko (Lower Sala)	$Qs = 3.4 \times 10^{-5} Q^{1.88}$

Where, Qs = suspended load discharge (m^3/s).
Q = river water discharge (m^3/s).

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

[1] Ibid, pp 65 - 76.

These equations give the annual mean suspended load volume as shown below.

	Jurang gempal	Winongo	Karangnongko
Annual volume of suspended load Vs, ($10^6 m^3$)	0.50	2.58	15.82
Catchment area A, (km^2)	1,350	2,345	10,007
Specific volume of suspended load US, (m^3/km^2)	370	1,100	1,582

On the other hand, several small irrigation reservoir was constructed in the project area. Those have lost their storage spaces by sedimentation for long time. Data from the aged reservoirs indicate the annual sedimentation ratio of about 800 m^3/km^2 on an average. (See Tabel III - 4).

From the above both data, the suspended loads in the Sala River is supposedly determined about 950 m^3/km^2/year. Bed load is estimated at about 15 percent of the total volume of suspended load from the various data of the similar projects. Total sediment outflow in the project area is; therefore about 1,090 m^3/km^2/year.

1.4.3. Flood

The biggest flood ever recorded in the project area is the Mar. 16 flood in 1966. This flood caused severe damages for Sala city by breaking the flood bank arround the city. High water of the Sala River usually occurs in the mid to the end of rainy season, say in February and March. Since no bank was constructed along the main river, and river gradient and bank slope are so gentle, high water of the Sala River habitually inundates a considerable area of lowland, mostly consisting of fertile paddy land and densely settled area.

Yearly maximum flood recorded at Demangan east end of Surakarta city, is given in the table below.

Year	W.L.(m)	Discharge (m3/sec)	Year	W.L.(m)	Discharge (m3/sec)
1962	5.12	850	1968	5.79	1,100
1963	4.28	600	1969	4.38	600
1964	3.42	400	1970	4.10	550
1965	5.50	1,000	1971	4.70	700
1966	8.32	2,300	1972		
1967	5.59	1,000	1973		

Peak discharge of the 1966 flood at Juranggempal site is recorded 4,000 m^3/sec.

1.5. Soil and land capability

Great 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. Mediteranian soil covers the area at higher altitude above grumsol area. In the Upper reaches of the Project Area is partly covered by regosol.

Land capability is classified most area into moderate and and slightly good in the part of Kabupaten Sukoharjo and Karanganyar and slightly poor in the east at part of Kab. Sragen. The waterhead area in Kabupaten Wonogiri is mostly classified into very poor.

1.6. Land Use

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

Present land use in the regencies related to the Project Area appears in Table III-5.

Table III-3 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 run-off after U/S dams complex
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	43.6	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			

Table III-4 Sedimentation of the Existing Irrigation Reservoir in the Project Area

Reservoir	Age (Year)	Catchment Area (km^2)	Original Storage (10^3 m^3)	Present Storage (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

Table III-5 Present Land Use.

		Wonogiri	Sukoharjo	Sragen	K.Anyar	Klaten
Paddy field	(ha)	39,181	23,070	41,653	25,552	35,644
	(%)	23.1	50.5	46.0	35.8	54.8
Upland	(ha)	57,406	8,288	22,139	18,502	7,514
	(%)	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

1.7. Electric power, transportation and communication network

1.7.1. Power supply

The project land is partly covered by the Tuntang system which interconnected Semarang, Yogyakarta and Surakarta. The nominal supply capacity of this system is only 79.000 kW and its dependable peaking capacity is barely 67.300 kW far less to meet the peak demand of the present service area. The power grid consists of 30 kV and 150 kV (Sema - rang - Surakarta) trunk transmission lines.

Only Surakarta area is covered by this grid and other principal urban centers in the Project Area, such as Wono-giri, Sukoharjo and Sragen are electrified by using isolated small diesel plant.

Most industrial firms in the project area are equipped with private power supply sources because of unstable supply from the grid.

1.7.2. Transportation

South trunk line of national railway connecting between Jakarta and Surabaya, passes through the project area. Local lines between Surakarta and Semarang, to Wonogiri branch of at Surakarta. Of particular importance is only the truck line.

Paved national roads have well been developed in Java and connect between major cities and important urban centers Provincial and Kabupaten roads, mostly paved, compose sub-networks to connect crop production areas with markets.

Recently, roads becomes principal transport channels in the project area as well as the country. National carrier, Garuda Indonesia Airway, operates daily services between Jakarta and Surakarta.

1.7.3. Telecommunication

Public coorporation of telecommunication networks major townships by wire cable system. Recently microwave network puts into service.

2. Socio-Economic Condition

2.1. Population

Total population of Indonesia is estimated about 129.3 million by the end of 1974 increasing at the annual rate of about 2.5 % since 1971, the latest census year.

By 1971, population of Kabupaten related to the project accounts for about 3.5 million within the area of 4,420 km^2 exclusive population of Surakarta city, 414,000, administrative, economic and cultural center of the project area.

In 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 are as mainly results from expansion of urban area of Surakarta city toward the adjacent regions, while less increase in the latter regency results from increase of emigrant to other regions because of limitted resources available in this region.

Urbanization of outskirt of Surakarta city greatly affects on the population increase in Kabupaten Sukoharjo, where urban population increase marked high rate of 7.3 % annually in the past decade, comparing 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. In Kabupaten Wonogiri, this rate reaches to about 90 %. As a general tendency, farm engaged population becomes gradually to decrease in the Central Java.

2.2. Project land

Objective area of irrigated agricultural development linked with the Wonogiri multipurpose dam project extends to about 32,000 ha.

Topographycally the area is divided into the left bank area of 4,000 ha till K. Gawo and the right bank area of 28,000 ha till K. Kedungbanteng by the Bengawan Sala which runs down northward. The project area is extending about 70 km along the main Solo with relatively narrow width of 4 or 5 km between the altitude of 80 m to 100 m. Soils in the project area mainly consists of alluvial (60%) and grumsol (40%). Many tributaries, large and small, join to the Sala across this area.

National highway and provincial roads run through the area and the junction of those roads near the center of the project area, regional capital city, Surakarta is situated. This project land has been relatively consolidated for farm crop production with irrigation facilities in one form or another at present.

Areal distribution of the present irrigation in the project area is presented in Fig. III-2.

Irrigation Area in the Project area

	(ha)	(%)
Total area	32,000	(100)
Total farmland	23,400	100 (73)
Technical	12,700	54.3
Semi-technical	400	1.7
Non-technical	1,300	5.6
Rainfed area	9,000	38.4

However, . the existing irrigation facilities as well as other infrastructure for crop production are still need to be rehabilited or extended.

Crucial need at present is water shortage in dry season cropping, although the area is now being supplied the water from 42-tributary weirs, 6-reservoir on the tributaries, 28-pumps and 2-spring. In rainy season, the area could recieve water for cropping in most years except some droughts, but in dry season , about less than half of the area could be irrigated.

Besides : the water shortage in dry season, the lowland suffered from inundation by flood water of the main Sala every year, though the magnitude of flooding varies year by year. Since such lowland area is well developed paddy field, the annual loss of paddy production by flood inundation is not to be disregarded.

Water. distribution of the existing irrigation system is mostly managed by local irrigation office and very small parts by villagers. Recently, the water management on the farm level has been improved along with the extension of " Dharma.Tirta ". Comparing with the main and secondary water supply system, the network on farm including drainage and farm road is less developed as yet.

Present farm Network Density

Tertiary or farm ditch	10 m/ha
Farm drainage	10 m/ha
Farm road	20 m/ha

2.3. Agricultural setting

2.3.1. Farm family and land holding

In the project area of 32,000 ha, population of 335,000 lives in, and about 70% of the total active population including farm labour about 10% is estimated to be engaged in agricultural works. Economic activities other than the agricultural production is quite limited.

Farm families in the project area is accounted for about 70,000 families, and average family size attained 4.8 persons in 1971.

The average size of a farm is estimated at 0.72 ha, which is almost same to average farm size on the entire Java but less than the average of whole Sala Basin of 1.15 ha. The average holding per farmer is comprised of sawah of 0.46 ha, tegal of 0.06 ha, yard of 0.15 ha and others of 0.05 ha.

Judging from the data collected, about 90% of the land is classified as farmers land and the remaining 10% as the land belonging the village offices. Among the farmer's land, about 60% of it are owned fully by farmers and another 40 % is partly owned by farmers and landlords.

There exist two types of borrowing land by farmers , namely fixed rental system and crop sharing system. In the fixed rental system, the contract period is comparatively long for about 18.8 seasons, while in crop sharing system, it is only 2.7 seasons in sharing crop by 50%.

2.3.2. Market

In general, dry stalk paddy is collected at BUUD (Badan Usaha Unit Desa), then milled into rice and sold to the market. Rice for government stock is purchased by BULOG (Badan Urusan Logistik). Some part of rice is sold directly to middleman and to consumers through wholesaler and retailer. Various prices for the rice are now prevailing and the price varies widely depending on the location and season. The market flow of rice is illustrated in Fig. III-3.

For other crops than rice, there exist no price control and the prices are determindd in the market every occasion. However, cash crops such as tobacco and sugar cane are cultivated under contract base with PNP and their prices are, therefore, relatively stable. The market flow of other crops except cash crops than rice is illustrated in Fig. III-4.

2.3.3. Agricultural institution

Since the beginning of 1973, BUUD has been introduced as new agricultural cooperative organization with the government support. Main objectives are agricultural extension services, 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 not fully occupied in quality control of product milling and transporting of rice.

In future , BUUD's activities will be developed to KUD (Koperasi Unit Desa). All the activities now dealt with BUUD will be opareted by KUD which will come a multipurpose cooperative organization.

Extension services have been managed through a systematic structure from The Ministry of Agriculture to desa and conducted under close cooperation of the extension workers and technical workers for specified crops. Present capability of extension services is about 700 to 800 ha per worker.

Seed multiplication is also managed through a systematic structure from Central Agricultural Institute of Bogor down to farmers and the improved seed is distributed through this channel.

Table-III-6 Population Summary.

	Surakarta	Sukoharjo	Sragen	Klaten	Karanganyar	Wonogiri	
Total population(1,000)	414.1	453.7	642.0	957.5	502.0	893.0	(1971)
Area (km^2)	59.5	452.7	929.4	644.4	721.6	1,781.7	
Density per km^2	6,961	1,088	690	1,481	695	501	
Urban population(1,000)	414.1	28.7	32.7	39.0	4.5	19.5	
Rural population(1,000)	-	465.0	609.3	918.5	497.5	873.5	
Annual growth rate (%)							(1961-1971)
Total population	1.33	3.45	2.49	1.37	1.87	0.87	
Urban population	1.33	7.29	2.45	5.97	2.18	1.37	
Nos of family (1,000)	399.7	486.9	621.8	954.5	490.8	883.1	
Farm family (%)	0.7	59.7	78.3	47.0	67.0	90.1	
Non farm family (%)	99.3	40.3	21.7	53.0	33.0	9.9	
Economic active (1,000)	258.7	279.1	353.1	555.8	278.8	504.1	(Over 15 yrs)
Population (%)	62.5	56.6	55.1	58.0	55.7	56.3	(to total pop)
Farm active popul. (%)	0.4	33.7	43.1	27.3	37.3	50.7	(")

Fig. III-2 Present Irrigation Area

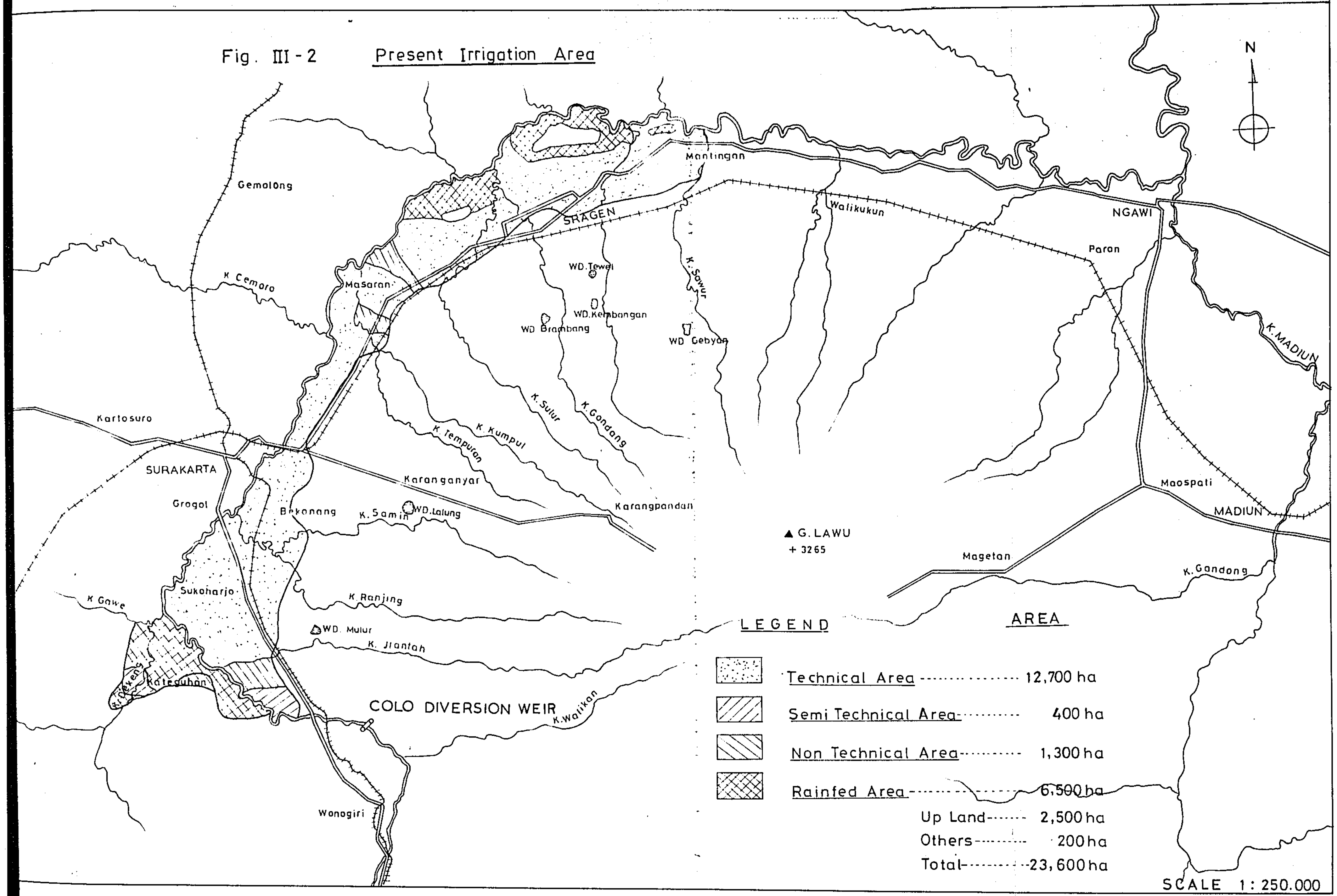


Fig. III-3 MARKET FLOW OF RICE

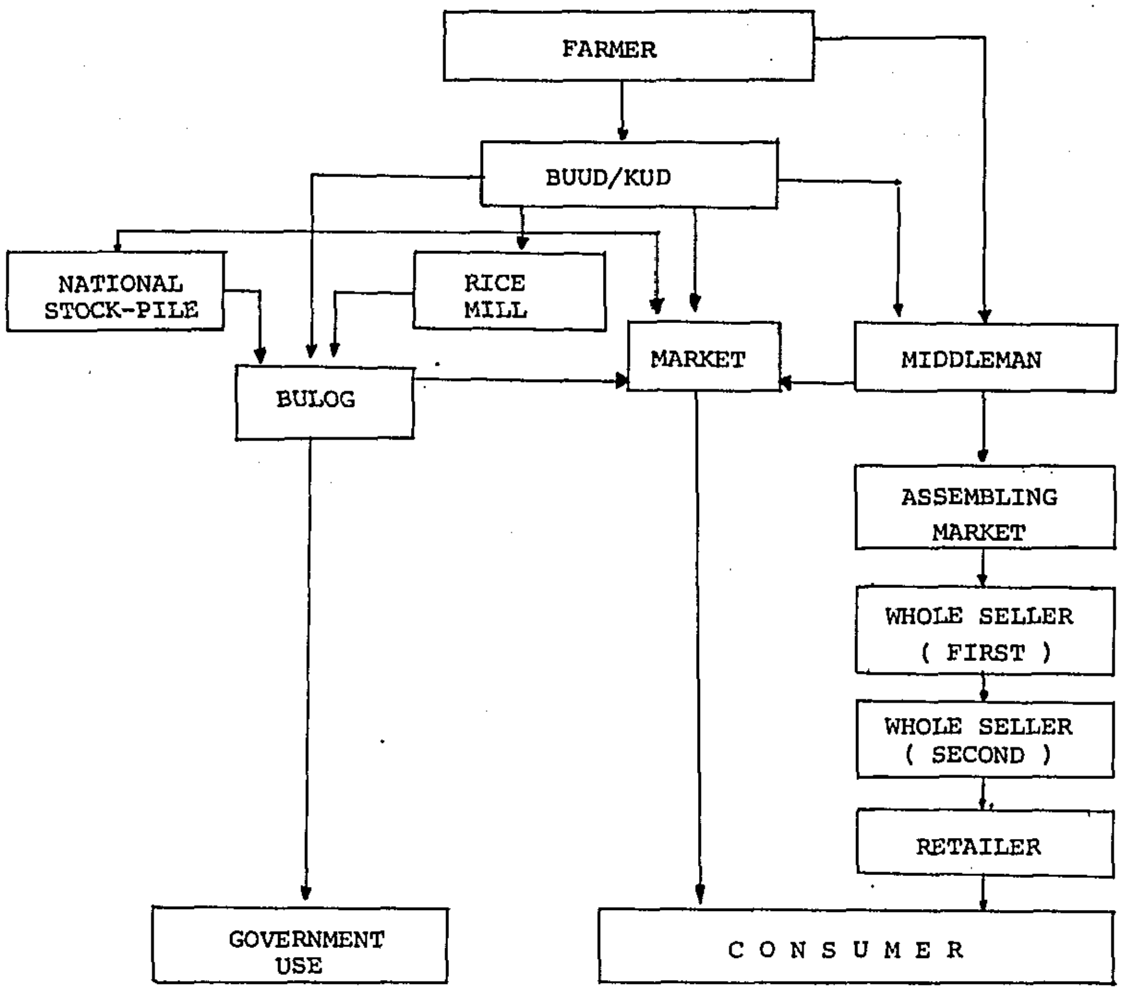
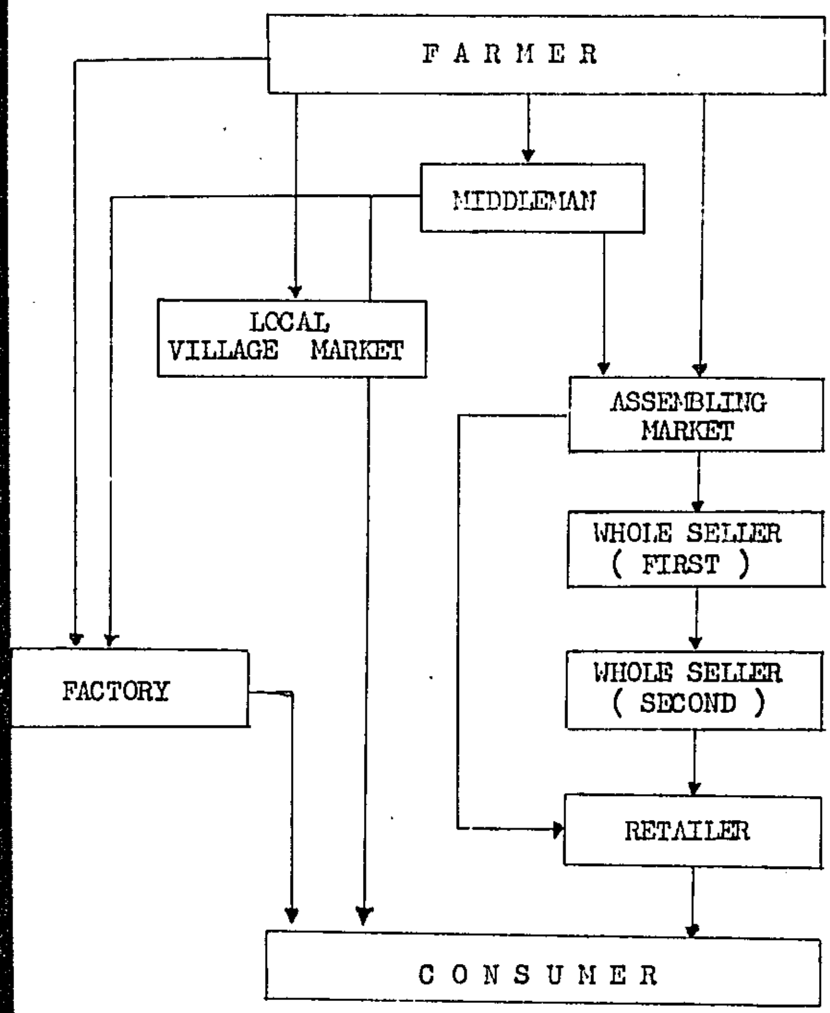


Fig III-4 MARKET FLOW OF OTHER CROPS



IV. PROJECT FORMULATION

1. Wonogiri Dam and Reservoir

1.1. Available water resources

Since the master plan recommends to exploit the Wonogiri reservoir in the maximum scale within the limit of available water resources. Estimate of the maximum availability of water resources is first conducted before preceeding to select any alternative development scale.

Review of the available hydrlogical data and future development plan of irrigation dams in the upstream basin 9 irrigation dams would cut the drainage area totaling 247 km^2 ultimately in future, it reveals that the maximum availability of water in the Wonogiri basin would be about 440 million m^3 in term of reservoir storage capacity.

1.2. Alternative development plan

In the premise that the available water resources limits the maximum reservoir storage capacity to about 440 million m^3, the alternative scales of the reservoir development plan are studied on the selected three cases as shown in Table IV-1.

Economic comparison of those alternatives are worked out and, as presented in Table IV-1, Plan A (maximum development scale) is assessed as the most optimum scale of the development plan from economical print of view.

1.3. Plan formulation of Wonogiri dam

On the basis of the above scale of the development, location, type and preliminary dimensions of the dam and its related structures are determined through comparative studies of several alternatives from engineering and economical aspects.

(1) Damsite is selected at immediate downstream of the confluence with K.Keduwan with respect to the advantages in its geological condition and controlling 1.6 times larger upstream basin that the laternative Candi sites located about 3 km upstream on the main stem.

(2) Type of dam is selected to rockfill with central core among the various alternative types such as concrete gravity, homogeneous fill type, rockfill with inclined core and rockfill with central core. Advantages are ;

   (i) minimum embankment volume resulted from the particular topography of the site, eventually the least costly,

   (ii) minimizing possibility of embankment failure by the settlement of core,

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

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

(3) Right bank fill (sub-dam) is required on the low ridge area on the right bank. Unfavorable geological condition in the area covered with thick overburden earth and heavily weathered tuff makes to select randum fill by lying impervious blanket in the upstream side rather than same embankment of the main dam.

(4) Spillway is of a side-channel type and selected its location on the left bank.
The three alternative locations are studied in colaborated with suitable types for them; namely overflow weir type on the ridge and on the central part of the

main dam, and side channel type on the left bank.

The first one is rejected by geological unfovorability for constructing large concrete weir and necessity to provide long chuteway of 1,200 m, and the second one is also rejected owing to the geological uncertaity and to avoid heterogeneous construction which, sometimes causes troubles at the joint sections.

(5) Diversion conduit is selected instead of the diversion tunnel of 7 m diameter and 500 m long. Geological condition underneath the left abutment of the dam suggests that tunnelling through this part may involve some technical difficulties and costs of the order of US$ 2.5 million.

It is more costly by about US$ 1.2 million than the selected one.

Economic comparison in demension of conduit is also conducted in coordinating with the required height of coffer dam.

Although the economic comparison recommends the plan of the diameter of conduit of 6 m, the plan of the diameter of 7 m is finally selected by the following reason.

(i) Cost difference between the both plans is comparatively minor US$ 80,000. The plan of 7 m dia. conduit requires light work load of the coffer dam embankment operation during the limited period in one dry season. It will ensure the successful achievement of the river diversion work.

(ii) The lower height of coffer dam could minimize the risk of submergence of the existing railway bridge located in the reservoir area which will have to be utilized not only for daily traffic but also for hauling route of construction materials until access and relocation of roads are completed.

1.4. Reservoir

1.4.1. Irrigation

Water resources in the upstream basin will be regulated seasonaly with the selected storage capacity of 440 million m^3 and capable to supply the irrigation water over the area of 23,600 ha at a dependability of 90% dry year.

1.4.2. Power generation

No single space of reservoir storage is allocated for the specific use of power generation. The power generation is, therefore, operated within the limit of water release for irrigation.

However, in respect to operation of the power plant, the average discharge of 60 m^3/sec would be available for the peak generation of 6 hours a day, since the Colo weir located at about 13 km downstream of the dam can re-regulate the released water from the power plant for diverting the required water to the irrigation area at any instance.

During dry season (June to September), the reservoir has to release the water averaged at 25 m^3/sec for irrigation use, which is more than the requirement of peak power generation (60 m^3/sec for 6-hour operation is equivalent to 15 m^3/sec for 24-hour). Therefore in this season, the excess release still enable the plant to generate off-peak power to some extent.

From October to May, the reservoir will avaragely release 60 m^3/sec for 6 hours a day, and any excess will be stored in for recovering storage capacity to normal level. In rich flow years, additional release will be made for off-peak power generation. In some drought years when the reservoir water level lowers near to the low water level, power generation may have to be controlled in order to recover the reservoir level to normal high water level by the end of April.

Study on the available records in the past 20 years, incates such controlled power generation obliged in three years. In those years, the water supply for irrigation also becomes a little short to meet the required demand.

1.4.3. Flood control

A storage capacity of 220 million m^3 will be provided for flood control space. Flood inflow will be stored into this space and the outflow of the reservoir will be controlled by gate operation to be installed at the spillway.

Since the magnitude of the controlled outflow by reservoir has close relation with the scale of river improvement in the downstream reaches, comparative study on the basis of variation of the magnitude of the outflow such as, 400, 700 and 1,000 m^3/sec are carried out to find the most economical case. The result shown in Table IV-2 recommends to case of 400 m^3/sec of outflow.

Control operation by the spillway will be designeted to maintain the outflow to a constant rate of 400 m^3/sec by partial openning of the gates.

2. Hydroelectric Power

2.1. Present condition

Two main grids, the Tuntang and Ketenger grid, consist of the present power supply system with 30 kv transmission line networks in Central Java.

Present power sources operated by PLN are as follows ;

Table IV-3 Installed Capability (kW)

	Power station	Hydro	Gas turbine	Diesel	Total
(1) Tuntang grid	Jelog	20,480			
	Timo	12,000			
	Semarang		14,000		
			20,000		
	Kalisari			6,020	
	Kudus			1,120	
	Purwosari			2,200	
	Yogyakarta			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		12,372	19,412
(3) Isolated	3 - Hydro	616			
	15 - Diesel			10,046	
	Sub-total	616		10,046	10,662
	Total	40,136	34,000	35,818	109,954

Besides the above, privately owned capacity is totaled 10,133 kw.

At present, overall interconnection between those grids is not yet realized to the Wonogiri power station.

2.2. Power market and demand

Peak load in the existing Tuntang system was recorded at 67,300 kw in 1974.

Low electrification rate in the area, especially in rural area as well as the isolated urban areas, suggests the wider marketability of electric power and it has to be grown as the regional economic development progress. Since growing demand is supressed by the limit of supply capacity, extention of the capacity will surely bring forth leaping increase of demand.

2.3. Present development plan

To improve the existing transmission grids, the new main trucks of 150 kv line are under construction for each grid and will be interconnected in near future. Moreover, interconnection of the main supply grids between Central and East Java is also being studied.

Development program now envisaged by PLN for future supply service in Central Java is presented in Table IV-4.

Table IV-4 Development Program by P.L.N.

	Station	Capacity	Type	Total supply capacity of PLN
Present installation				109,954 kW
1975	Yogyakarta	2.15 MW x 3	Diesel	116,404 kW
1976	Purwosari	0.25 MW x 2	Diesel	
	Tegal	2.50 MW x 2	Diesel	121,904 kW
1977	Semarang	50 MW x 2	Steam	
		20 MW x 2	Gas turbine	
	Cilacap	18 MW x 2	Steam	297,904 kW

2.4. Wonogiri hydro power station

In Central Java, less potentials of hydro electric power are expected. Potential to be harnessed more than 100 MW is only reserved on K.Serayu basin, at present stage, The Sala river as well as other major rivers in the Central

Java, has particular topography that the most river course runs down so flat plain area. Sites suitable for hydropower generation are, therefore, very scarce along the river, even only small capacity of several megawatts is expected.

In the Sala River basin, the following four hydropower potentials are exploitable by the multipurpose dam schemes.

Table IV-5 Possible Capacity

Scheme	Output (kW)	Annual energy (MWH)
Wonogiri dam	11,200	28,200
Badegan dam	6,000	18,800
Bendo dam	3,500	10,000
Jipang dam	18,000	70,800
Total	38,700	127,800

Rem. : figures other than Wonogiri are extracted from Master Plan.

Since hydropower is the most economical mean 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 the area of less expecting hydropower potentials such as Central Java. In connection with future power development undertaken by PLN, the proposed Wonogiri power station is assumed to take a part of peaking power supply and to supply some off peak power, if possible.

2.5. Power generation and transmission

As no specific storage for power generation is provided with the Wonogiri reservoir, the available discharge useable for power generation has to subordinate to the outflow for irrigation use. By putting the Colo intake in the downstream to work as an afterbay, the power station could be operated to generate peak power for 6-hour duration as principal. Besides this, the water from the reservoir is still available for additional power generation during off-peak hours due to necessity of continoues outflow for irrigation use. Such principal and additional peak power to be generated are shown in Table IV-6, maximum possible output and annual energy production are 11,200 kw and 28,200 MHW respectively. The power from Wonogiri is transmitted by 150 kv transmission line to Surakarta substation which is situated at far about 40 km. Another single circuit of 20 kv line is built to Wuryantoro via Wonogiri permanent camp and Wonogiri town.

2.6. Power benefit

Benefit of hydropower is measured by the cost required to produce the equivalent power and energy by the alternative means ; in this case, it would be oil-fired steam plant of 50 MW capacity.

(a) Capacity value

The recent cost of steam plant is estimated as follows.

(i) Investment cost for 50 MW	(US$	1,000)
Foreign currency		30,000
Local currency		20,000
Total		50,000
per kw installed	US$	1,000

(ii) Annual fixed cost (US$ 1,000)	
Interest Depreciation (30 years)	
12% for foreign currency	3,724
10% for local currency	2,122
Fixed O & M cost, 2%	1,000
Total fixed cost	6,846

Therefore, the annual fixed cost per kw of installed capacity becomes 137 US$/kw.

Benefit from the capacity value is evaluated at US$ 154.8/kw by adjusting the above fixed cost with capacity adjustment factor of 1.13 derived below.

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

Adjustment factor = $\frac{\text{Hydro}}{\text{Steam}}$

$$= \frac{(1 - 0.04)\ (1 - 0.003)\ (1 - 0.02)}{(1 - 0.02)\ (1 - 0.02)\ (1 - 0.06)\ (1 - 0.08)}$$

= 1.13

(b) Energy value

Energy value is evaluated based on the operation cost to generate one KWH of power energy by the thermal.

Fuel cost 0.06 US$/1 (Banker C)

Banker C ; 10,000 k cal/1

1 k cal = 3.968 BTU (British Thermal Unit).

1 KWH = 860 k cal = 3,412 BTU

Thermal efficiency = 30%

Fuel consumption 0.287 1/KWH

Energy cost per KWH is, therefore, estimated at US$ 0.017. Benefit from power energy is evaluated at US$ 0.0171/KWH by adjusting the energy cost with the energy adjustment factor of 1.004 calculated below.

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

Energy adjustment factor = $\frac{\text{Hydro}}{\text{Steam}}$

$$= \frac{(1 - 0.04)\ (1 - 0.003)}{(1 - 0.02)\ (1 - 0.06)} = 1.004$$

Annual benefit of the hydropower is, consequently, evaluated by the above calculated values as follows.

Maximum peak output	11,200	MW
Energy production	28,200	MWH
Salable energy production	27,100	MWH ∠1

Capacity benefit	= 11,200 kW x 154.8 \$/kW	= \$	1,734,000
Energy benefit	= 27,100 MWHx0.0171 \$/kWH	= \$	463,000
Total benefit US \$		=	2,197,000
			(≈ \$ 2,200,000)

∠1 : Loss 4 % transmission loss.

Table IV-1 Alternative Development Plan

Item	Plan A	Plan B	Plan C
Plan of development			
Irrigation area (ha)	23,600	15,600	8,500
Power installation(kW)	11,200	13,600	8,400
Annual power energy (MWH)	28,200	25,300	22,700
Flood control (m^3/sec)			
- 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
- SHLD Surcharge W.L.	138.2	136.6	134.9
- H.W.L.	138.4	136.8	135.2
- Extra F.W.L.	138.9	137.5	135.9
Dam.			
- Crest EL (m)	141.6	140.2	138.6
- Max. dam height (m)	37.5	36.1	34.5
- Embankment volume(10^3m^3)	1,750	1,550	1,330
Spillway			
- Controlled outflow during SHFD (m^3/sec)	400	400	400
- Max. discharge capacity (m^3/sec)	1,550	1,550	1,550

Construction cost (10^3 US $)			
- Dam of power facilities	59,300	58,000	51,400
- Irrigation	32,330	21,840	12,750
- River improvement	18,370	18,370	18,370
T o t a l	110,000	98,210	82,520
Annual net benefit (10^3 US $)			
- Irrigation	13,290	8,780	4,790
- Power generation	2,200	2,500	1,700
- Flood control	4,980	4,980	4,980
- Negative benefit	- 820	- 760	- 660
T o t a l	19,650	15,520	10,810
Economic Evaluation			
- Net present worth	20,356	11,765	2,012
(Discount rate at 10 %)			
(10^3 U.S. $)			

Table IV-2 Comparison of Flood Control Alternatives

Item	Plan - I	Plan - II	Plan - III
Wonogiri reservoir			
- Inflow discharge (m^3/s)	4.000	4.000	4.000
- Outflow discharge (m^3/s)	400	700	1.000
- Storage capacity : ($10^6 m^3$)			
Gross at S.W.L (SHFD)	730	660	630
Flood control	220	150	120
Irrigation and power	440	440	440
Sediment	120	120	120
- Dam crest EL (m)	141 6	141.3	140.7
- Dam height (m)	37.5	37.2	36.6
- Max. spillway capacity (m^3/s)	1 550	1 630	1.920
- Total construction cost (A) (includ. power facilities and compensation costs) (10^3 U.S $)	59.300	59.000	58.200
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 U.S. $)	18.400	20.100	22.300
Total construction cost (A) + (B) (10^3 U.S. $)	77 700	79 100	80 500

Table IV- 6. Power Generation of Wonogiri Power Station

Y e a r	Power output (kW) Max.	Min.	Mean	Yearly energy output (M.W.H.) Peak (6 hrs)	Off peak	Total	Control of power generation (Month)
1953/54	11.200	7.440	9.730	16.168	12.114	28.282	0
1954/55	"	9.480	10.610	18.582	10.509	29.091	0
1955/56	"	10.430	11.010	19.341	13.038	32.379	0
1956/57	"	9.400	10.530	18.456	9.162	27.618	0
1957/58	"	8.150	9.850	17.260	6.823	24.083	0
1958/59	"	8.590	10.390	18.209	15.174	33.383	0
1959/60	"	8.180	10.090	17.722	12.350	30.072	0
1960/61	"	9.360	10.090	11.623	8.556	20.169	0
1961/62	"	7.340	9.640	15.895	8.582	24.477	0
1962/63	"	7.510	9.850	17.255	10.334	27.589	0
1963/64	"		6.140	8.337	8.104	16.441	4
1964/65	"		6.110	3.715	6.440	10.155	4
1965/66	"		7.900	12.768	6.746	19.514	2
1966/67	"	8.330	10.010	17.534	16.185	33.719	0
1967/68	"	6.360	8.980	15.739	8.138	23.877	0
1968/69	"	10.750	11.110	19.458	22.491	41.949	0
1969/70	"	6.520	9.690	15.742	8.294	24.036	0
1970/71	"	8.660	10.280	18.019	31.003	49.022	0
1971/72	"	9.260	10.490	18.348	19.141	37.489	0
1972/73	"	6.670	9.240	16.190	15.164	31.354	0
Total	-	-	-	-	-	-	10 (4 %)
Mean	11.200	7.100	9.580	15.818	12.417	28.235	-

Note : (1) Installed capacity 5.600 kW x 2 units = 11.200 kW

(2) Maximum operating level EL. 136.0 (HWL)
Minimum operating level EL. 127.0 (LWL)

(3) Power generation suspended if reservoir water level lowers below EL. 127.0.

(4) Assumed plant factor : 80 %.

3. Agricultural and Irrigation

3.1. Alternative plans

Four alternatives of the irrigation plan are formulated to propose the optimum one. Outlines of these plans are presented below.

Alternative plan-A; Construction of Colo diversion weir from where irrigation water is taken into the main canals laid out both banks. Water is conveyed by gravity canal to the area of 23,600 ha.

Alternative plan-B; Water is directly diverted into the main canals from the reservoir and conveyed by the gravity canal to the area of 29,600 ha.

Alternative plan-C; Main system is same as the plan-A but pumping irrigation to the area of 600 ha from the loft main canal is added.

Alternative plan-D; Irrigation area of the plan-A is divided into the upstream and downstream areas of 10,900 ha and 12,700 ha respectively. Irrigation system to the upstream area is basically same as the plan-A, while to the downstream area, water is taken from the Sala River at downstream of Surakarta by pumping up or providing a diversion weir and is conveyed to the area by gravity cannal.

Summary of the comparison of those alternative plans are presented in Table IV-7. And the plan-A is proposed from technical and economic point of views.

3.2. Irrigation area

Required head for distributing the irrigation water to the downstream end of the area determines the intake water level at the headwork. Minimum water level of the intake located at Colo is need to be set at EL. 106.5 m above SHVP. Within the limit not afflicting the tail water level of the power station in the upstream, the intake water level could be raised up to EL. 108 m or so.

Table IV-7 Summary of Comparison of the Alternatives

	Alternative Plan	Scale of Construction	Irrigation Area (ha)	Construction Cost /1 Total	Construction Cost /1 Unit	Advantage	Disadvantage
A	Gravity irrigation from Colo weir	1 Colo weir 2 Main canal Right: 64km Left : 25km	23,600	($ 1,000) 16,000	($) 680	1).easy operation. 2).power generation 3).easy construction.	1).long canal 2).complicated water - management
B	Gravity irrigation from Wonogiri reservoir	1 Main canal 89 km 2 Tunnel R : 12 km L : 5 km	29,600	(13,500) (38,500) 52,000	1,760	1).no diversion weir 2).wide irrigation area	1).high cost 2).no power generation 3).difficult construction
C	Gravity irrigation from Colo weir and pump-up irrigation	1 ALT.-A 2 Pump	(23,600) + (600) 24,200	(16,000) (800)/2 16,800	690	1).widening irrigation area besides of ALT.-A	1).irrigation & main te - nance of pump besides of ALT.-A.
D-1	Gravity irrigation from Colo weir and pump-up irrigation	1 Colo weir and main canals 2 Diversion weir and pump	(10,900) (12,700) 23,600	(12,000) (5,200)/2 17,200	730	1).shot canal length 2).easier operation and maintenance than ALT.-A	1).operation and maintenance of pump
D-2	Gravity irrig. from Colo weir and gravity irrig. from downstream weir	1 Colo weir and main canals 2 Sala diversion weir	(10,900) (7,600) 18,500	(12,000) (2,500) 14,500	780	same as the ALT.-D-1	1).narrowing irrig.area 2).easy flooding.

/1 : excluding cost of turnout, secondary canal and field network

/2 : excluding the operation and maintenance cost of pump.

At the initial water level of EL. 106.5 m, the main canals are laid out on the both banks as shown in DWG. VIII-002. The inner side area bounded by these canals and the Sala-River difines the irrigation area totaling 23,600 ha out of the project area of 32,000 ha.

3.3 Land use and cropping pattern

In almost all sawah and part of tegal area, paddy is planted as a most important crop followed by polowijo and some part of the irrigated sawah area, sugar cane and tobacco are cultivated.

The presently cultivated area in the project area is about 23,400 ha; 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. Comparing with the ratio in the whole Upper Sala Basin of 1.3 : 1, this area is in much favorable condition for crop production among others.

Paddy planting area covers the area about 67 % of the total cultivated area in wet season, but only about 22 % in dry season. The remaining area is used for sugar cane, tobacco and polowijo such as maize, cassava, peanuts, soybean, sweet potatoes and vegetables.

Present crop intensity attains such a considerably high as 1.76 resulting from rather intensive utilization of the farm land even at present.

Under the condition with the project, the crop intensity is expected to rise more particularly by increase of cultivatiable area in dry season. By introducing year round irrigation, total cultivated land throughout year will become 23,600 ha comparising of sawah area of 21,200 ha upland area of 2,400 ha.

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

Table IV-8 Land Use (ha)

Kind of crops	Present (w/o project)			Future
	Wet Season	Dry Season	Yearly	(w/project)
Paddy	15,780 /1	5,320	21,100	31,600
Sugar	(2,580)	(2,580)	2,580	3,000
Tobacco	-	- 90	90	800
Polowijo			17,430	11,900
Total crop area			41,200	47,300
Cultivated area			23,400	23,600
Crop intensity			1.76	2.01

/1 including upland paddy of 1,140 ha.

The generalized cropping pattern prevailing in the project area is established on the basis of agronomic study and illustrated in Fig. IV-1.

As shown in the figure, mixed culture is commonly practised on sawah not only in dry season but also in wet season, because of the water shortage and scarcity of tegal area. It is also recognized that present cropping calender is established on the basis of the rainfall pattern.

Future cropping pattern without the project is not expected to change appreciably. Paddy will continue to place the principal crop in sawah area, and beans and cash crop such as sugar cane and tobacco might increase slightly for gaining cash income.

However, under the condition with the project, it is anticipated that the cropping calender will change due to adoption of complete year round irrigation on farms.

Basic consideration for determing future cropping pattern with the project are as follows ;

(i) soil and land capability of the area,
(ii) effective water utilization throughout the year,
(iii) national policy to attain self-sufficiency in food crops, and
(iv) increase in cash income for farmers.

Based on these considerations, future cropping pattern with the project is established and illustrated in Fig. IV-2.

According to this cropping pattern, paddy will be cropped throughout year over the area about 70 % of the irrigated area of 23,600 ha, and cash crops such as sugar cane and tobacco will increase their cropped area considerably. However, cropping of polowijo on sawah area will be still continued in the future because of the existing local demand for them.

Cropping intensity with the project is expected to reach to 2.01 in future.

3.4. Water requirement

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

Consumptive use calculated by the above method, percolation, puddling water requirement, effective rainfall over the irrigation area are presented below.

Consumptive use (mm/day)	Dry Season	Wet Season	Yearly
Paddy	7.2	6.8	7.0
Sugar cane			5.1
Polowijo (lowland)			3.6
Polowijo (upland)			3.9
Percolation (mm/day)	3	2	
puddling water (mm)	150	200	
Effective rainfall (mm/day)	0.8 - 3.0	5.6 - 8.4	

Unit irrigation requirement by crops to be adopted for the proposed cropping pattern presented in Fig. IV-2 in the project area are estimated as follows.

	Paddy rice	Sugar cane	Polowijo (sawah)	Polowijo (tegal)
Annual (mm)	1,592	723	368	407
Dry Season (mm)	1,159	628	323	359
Wet Season (mm)	433	95	45	48
Daily max. (mm)	10.7	5.7	3.6	3.9

Overall irrigation efficiency in the project area is considered to be about 70 % by experiences in Java.
By applying this 70 % irrigation efficiency, gross diversion requirement for irrigation water supply calls for 312.8 million m^3 per year on an average.

Maximum annual diversion requirement is about 504.8 million m^3 in the driest year of the past 20 years. Maximum monthly requirement occurs in July at the rate of 33.5 m^3/sec, say 90 million m^3 per month.

Water balance between diversion requirement and river run-off in the past 20 years gives the net supply requirement from the Wonogiri reservoir every year as shown below.

Year	Net Supply Storage ($10^6 m3$)	Year	Net Supply Storage ($10^6 m3$)
1953 / 54	356.4	1963 / 64	454.0
1954 / 55	239.2	1964 / 65	241.8
1955 / 56	112.5	1965 / 66	392.0
1956 / 57	137.6	1966 / 67	147.3
1957 / 58	321.9	1967 / 68	382.8
1958 / 59	180.4	1968 / 69	37.8
1959 / 60	277.1	1969 / 70	360.0
1960 / 61	341.0	1970 / 71	187.6
1961 / 62	375.8	1971 / 72	198.0
1962 / 63	286.7	1972 / 73	356.0

Frequency analysis based on the above data gives the required net storage capacity of Wonogiri reservoir as follows.

90 % dry year	400 million m^3
80 % dry year	370 million m^3
50 % dry year	270 million m^3

As the intake site of irrigation water is planned at Colo diversion weir situated at about 13 km downstream of the Wonogiri dam, allowance of about 2.5 % for loss of water in the river section between them is taken into account. Total net storage requirement, therefore, amounts to 410 million m^3. In addition to this net storage, another 30 million m^3 will have to be relied on the reservoir to release the water of 2 m^3/sec at least to downstream of the river for maintaining the minimum dry season flow.

3.5. Crop yield

Unit yields of main crops at present condition are estimated on the basis of the data collected at the local agricultural offices related to the project area. Since the yields vary from one year to another depending on the natural conditions such as weather and flooding, the average yield are estimated from those data.

For the future without project, only slight increase is expected in paddy yield, attributing to use of the improved varieties and perhaps some increase in fertilizer and chemical use.

For future with the project condition, assuming realization of all weather irrigation culture, improvement in farm management and cultural practices, sufficient use of fertilizer and chemicals and wide use of fertilizer-response crop varieties, the unit yields of crops are predicted to get them reasonably expected after receiving crop yield data obtained by field survey in the project area and from the Central Research Institute for Agriculture of Bogor, and referring to the results attained during the period of Pelita I.

The average unit yields of crops at present and those estimated both without and with the project in future are shown in Table IV-9.

Judging from the yields attained in the project area and farmer's understanding for necessity of extensive irrigation agriculture with fertilizer and chemical use at present, the projected crop yields in future with project will be considered not so high target as to be achieved, but supposedly in rather conservative estimate.

Table IV-9 Unit Yield by Crops at Present, Future Without and With Project

(Unit : ton / ha)

Kind of crop	Present	Future	
		w/o Project	w/Project
Paddy ∠1			
Dry season paddy	3.3	3.5	5.5
Wet season paddy	3.4	3.6	5.5
Upland paddy	1.8	1.9	-
Maize	0.5	0.5	2.0
Cassava	3.3	3.3	5.0
Peanuts	0.5	0.5	1.5
Soybean	0.4	0.4	1.4
Tobacco ∠2	0.4	0.4	1.0
Sugar cane	85.0	85.0	120.0

Note ∠1 : Dry stalk paddy
∠2 : Dry leaf.

3.6. Crop production

Total production of the farm crops in the project area is calculated for future without the project and with the project on the basis of the land use of cropping and unit yield.

Although some local crops such as cassava and maize will decrease their outputs, paddy output will increase subtantially from present output of 73,000 tons to 174,000 tons.

Summary of the output by crops for the respective conditions is presented in Table IV-10.

Table IV-10 Total Production in Future Without Project and With Project

(Unit : tons)

Kind of crop	Future without project (A)	Future with project (B)	Increment (B) - (A)
Paddy			
Dry season	18,620	86,900	68,280
Wet season	52,704	86,900	34,196
Upland	2,166	-	-2,166
Total paddy	(73,490)	(173,800)	(100,310)
Maize	2,820	2,000	-820
Cassava	21,351	11,500	-9,851
Peanuts	510	4,800	4,290
Soybean	980	4,900	3,920
Tobacco	36	800	764
Sugar cane	219,300	360,000	140,700

3.7. Benefit of irrigated agriculture

By introducing all weather irrigation in the project area, efficient agricultural management and improved cultural practices, the farmlands in the project area can raise a considerable increase of the agricultural products. Such production increase are evaluated in term of monetary value, in general, by measuring the balance of net reciept on the farms between under the condition of without the project and with the project in future.

To measure the receipt from sale of the products, the prices of the products and the cost need to produce the crops on the farm are estimated.

3.7.1. Price of the product

For evaluating economic values of the products, the prices estimated through the projected international market prices are tentatively used.

The farm gate prices are estimated by making necessary adjustments and shown as follows.

Table IV-11 Price of Agricultural Products

Kind of crop	Price (Rp./ton)
Paddy (dry stalk)	60,000
Maize	30,000
Cassava	13,000
Peanuts	70,000
Soybean	69,000
Tobacco (dry leaf)	360,000
Sugar cane	5,000

3.7.2. Production cost

The quantities of input required for the production of each crop are estimated on the basis of the data collected in the local agricultural office and from the Central Statistics Bureau, with respect to the price of such inputs, the same estimation of the forecast prices of the inputs are applied. Labour cost, land tax and other miscellaneous costs are estimated by using the data collected in the local agricultural offoce and average rate is calculated over the project area.

The summary of production costs for each crop is presented in Table IV-12.

Table IV-12 Summary of Production Costs per Ha

(Rp.)

Kind of Crops	Prod.Costs w/o Project	Prod.Costs w.Project
Dry Season Paddy	55,900	79,000
Wet Season Paddy	54,800	79,000
Upland Paddy	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

3.7.2. Benefit from the project area

On the basis of the cropped area, unit yield, and price of the crops and their input costs mentioned in the preceding paragraphes, the balance (net income on the farm), between the future without project and the future with the project condition are estimated for the unit area per ha, as shown in Table IV-13.

The increase in net income resulting from development of all weather irrigation for the project area of 23,600 ha amounts to about Rp. 5,514 millions (US $ 13,290 millions equivalent) or Rp. 233,660 (US $ 563) per irrigated ha.

Besides this direct benefit, it is expected that an addi - tional benefit will accrue from the production increase on the area outside the project.

Upon completion of the irrigation system, the water so far used through existing channel is not required in the project area and become available for the other area which will in-crease for agricultural activities in the area outside the project.

Table IV-13 Benefit from the Project

Kind of Crop	Without Project			With Project			Difference
	Cultivation land (ha)	Average return (Rp/ha)	Total return (Rp.)	Cultivation land(ha)	Average return (Rp.)	Total return (Rp.)	(6) - (3)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Paddy /1							
Dry Season Paddy	5,320	154,100	819,812,000	15,800	251,000	3,965,800,000	3,145,988,000
Wet Season Paddy	14,640	161,200	2,359,968,000	15,800	251,000	3,965,800,000	1,605,832,000
Uplan Paddy	1,140	78,000	88,920,000	-	-	-	- 88,920,000
Maize	5,640	6,100	34,404,000	1,000	42,200	42,200,000	7,796,000
Cassava	6,470	27,700	179,219,000	2,300	43,700	100,510,000	- 78,709,000
Peanuts	1,020	14,400	14,688,000	3,200	62,600	200,320,000	185,632,000
Soybean	2,450	12,200	29,890,000	3,500	59,000	206,500,000	176,610,000
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	3,000	365,600	1,096,800,000	446,124,000
T o t a l	39,350		4,180,889,000	45,400		9,695,210,000	5,514,321,000

Note /1 Dry stalk paddy

/2 Dry leaf.

The amount of water additionally available is estimated at 1.0 m^3/sec in the dry season which will be able to irrigate sufficiently 1,050 ha of cultivated land outside the project area.

Since soil and land capability is considered to be almost same as that of project area, the ancillary benefit expected is roughly estimated at US $ 242 thousands [1]

3.8. Main irrigation system

(a) Headwork

In the downstream reaches between the Wonogiri dam and Colo at where the Sala River enters in the flat plain, Colo site at the most downstream end of the gorge is proposed for the headwork site by comparative study.

A concrete diversion weir having two irrigation intakes to the left and right areas is contructed.
At this site the river bed elevation is EL. 100 m, then the water level has to be raised at least to EL. 106.5 m to divert the water. Furthermore, this Colo weir has to have a role of afterbay weir to control the peak discharge outflowed from the power station.

Since the power station is planned to use the water at the rate of 60 m^3/sec for six hours peak operation, the necessary re-regulating capacity providing with Colo weir becomes about 1.2 million m^3. To meet this storage capacity, the proposed water level of the Colo weir is fixed at EL. 107.5m.

Principal features of Colo diversion weir are given below.

Crest elevation	EL. 107.5 m SHVP
Min. intake W.L.	EL. 106.5 m SHVP
Height of weir	7.5 m
Length of weir	100 m
Max. intake discharge, left	3.95 m^3/sec
" right	29.55 m^3/sec
Design flood discharge	550 m^3/sec
Extraordinary flood discharge	2,000 m^3/sec.

1: 1,050 ha x US$ 230 (for dry season paddy)
Rp251,000 - Rp154,100 = Rp96,900 (≑$230)

(b) Main canal

Proposed features of the main canals are presented below

	Left	Right
Irrigation area (ha)	2,800	20,800
Design discharge (m^3/sec)		
Initial	3.95	29.55
Tail	0.42	0.99
Total length (km)	25	64
Slope of canal	$\frac{1}{2,500}$ $\frac{1}{3,000}$	$\frac{1}{2,500}$ $\frac{1}{6,000}$
Slope of canal	9.2	3.1

(c) Secondary canal

Secondary canal is laid out to supply the water for the minimum block of 150 ha.

Most of the existing irrigation canals in the area are improved and rehabilitated to utilize as secondary canals. For non-irrigated area at present or the area for which the existing canals have insufficient capacity, new secondary canals are planned.

	Left	Right
Number	5	33
Total length (m)	13,100	131,800
of which, rehabilitation	(1,000)	(31,700)
Max. discharge (m^3/sec)	0.77	3.11
Min. discharge (m^3/sec)	0.21	0.21
Slope	$\frac{1}{2,500}$	$\frac{1}{3,000}$

(d) Crossing and turnout

From the topographic view point, it is inevitable the canals cross many tributaries, roads channels and rail trucks.

Major crossings along the total travelling length of the main canals account for 33-tributary, 147-canal, 261-road and 16-railtruck as broken down below.

	Left canal	Right canal	Total
Total river	6	27	33
L>20 m	1	6	7
20 m>L>10 m	1	8	9
10 m>L	4	13	17
Total canal	31	116	147
L>5 m	11	25	36
5 m>L	20	91	111
Total road	62	119	261
Main road	1	3	4
L > 8 m	-	10	10
8 m > L > 4 m	13	74	87
4 m > L	48	112	160
Total railtruck	1	15	16
Main	1	5	6
Decauville	-	10	10

For those crossings, basically culverts are adopted, and aqueduct and siphon are planned at the places where the topographic condition does not allow to pass the canal by culvert. Total nembers of aqueduct and siphon are accounted for 16 and 17, respectively.
Along the main canals, turnouts are provided at 39 places on the right and at 10 places on the left canals.

(e) Regulating structures

Check gate, diversion and spillway are provided on the main canal for maintenance and emergency use. Check gate is situated at the downstream of the major turnouts, and diversion and spillway are at the upstream of each aqueduct and siphon.
Besides the above, three regulating reservoirs are proposed on the secondary canal governing the area more than 1,800 ha.

3.9. Irrigation network on farm

(a) Tertiary canal and farm ditch

Present density of farm ditch of 10 m/ha is increased to 40 m/ha. Layouts of the firm ditch is basically planned to place at every 400 m distance.

(b) Drainage

Since the tributaries in the area play a role of trunk drainage, no additional main drainages are necessary. Drainage on farm at present, however, is insufficient, only 10 m/ha density. The ultimate farm drainage is planned to be of 30 m/ha density.

(c) Farm road

Few roads are vehicle passable at present. This hampered farm management.
Net work density of 20 m/ha at present is increased to 40 m/ha with the road providing the canal side.

4. Flood Control and River Improvement

4.1. Fllod of the Bengawan Sala

1.1. Present condition of the river

The upper Sala in the downstream reaches of the Wonogiri dam runs through the flat alluvial plain heavily meandering. The average riverbed slope along the channel is about 1/3,000 and the channel width varies between 50 - 100 m with depth of 1/10 - 1/30 to the average channel width.
The river bank at meandering parts has been eroded laterrally but protection works has never been provided.

There are no levees provided along the main river except the flood dyke around Surakarta. As the present natural river bank barely rises about 3 to 8 m above the channel bed, the flow capacity of the existing channel is so small just to pass the discharge of about 500 m^3/sec. If the river discharge exceeds to this magnitude, river water is flooding over the lowland on both banks.

4.1.2. Flood frequency

Estimate of the annual frequency of the flooding over the bank based on the records in the past 10 years reveals that it might have occurred 2.5 times every year.

Inundation usually occurs along the main river when the river stage exceeds to 4.0 m at Demangan gauge at Surakarta.

4.1.3. Flood duration and depth

Generally, the hydrograph of flood in the Upper Sala reaches shows steep peak lasting short duration, and the duration is usually proportionate to the magnitude of the flood stage. The average flooding duration is estimated as shown in Table IV-14.

At the maximum flood event (the 1966 flood), the mean flooding depth in the inundation area marks about 2.4 m and 2.5 m in Surakarta and Sragen district respectively.

4.1.4. Inundation area

The inundation area estimated from the past records at major flood events are drawn in Fig. IV-3.

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 accurs in Wonogiri area, 19,500 ha in Surakarta and 9,700 ha in Sragen area respectively.

The inundation areas in Surakarta and Sragen were correlated to the flood discharge at Surakarta gauge. As far as Surakarta city concerned, the inundation occurs when the river discharge exceeds to 2,000 m^3/sec even the flood dyke exists. Inundation area at each flood scale are presented in Table IV-15.

4.1.5. Population, house and land in the flood afflicted area

Since the flood-afflicted area is so densely populated and highly developed into the productive farmland, the population in the inundation area accounts for 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 by use to be afflicted are summarized correlating to at each flood scale in Table IV-16.

4.2. Flood damage

Although the area is attacked by frequent inundation of various scales of flood, the existing utilities, properties, lands and crops submerged by the flood are not wholly damaged. Damage rates of those objects are naturally varying in accordance with the flood magnitude and flooding duration.

4.2.1. Damage rate

Damage rates are, therefore, estimated referring to the various data as shown in Table IV-17.

4.2.2. Occupancy ratio of the damageable objects

There are various kinds of buildings, utilities and crops grown in the flood-afflicted area.

The present occupancy by such buildings and the farmland used for crop growing is estimated from the data of Surakarta city and the Kabupaten concerned in the project area. Table IV-18 gives the present occupancy ratio by the objects.

Table IV-18 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

4.2.3. Value of the flood-afflicted objects

The average values of floof-afflicted objects are estimated as shown in Table IV-19.

Table IV-14 Average Flooding Duration

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

Table IV-15 Inundation Area in Every Flooding Condition

(Surakarta area)

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

(Sragen area)

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

Table IV-16 Population, House and Land Use in the Inundation Area of Every Flodd Scale.

(Surakarta Area).

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

(Sragen Area).

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

Table IV-17 Damage Rate by Flood Inundation

(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	0.22					

(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	0.81
	Yard crops	0.51	0.67	0.81	0.91

Table IV-19 Average Value of the Objects

(Unit : US $)

	Surakarta city			Other area		
	Building	House hold	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						314
Yard crops						8
Total crop						322

4.2.4. Flood damage potential

The number and area of flood-afflicted objects vary according to the magnitude of the flood.

Damage potential of the house and farm crops according to every inundation depth are calculated by using the estimated data compiled in the preceeding tables in this section.

The results are summarized in Table IV-20.

Table IV-20 Amount of Damage per House and Crop per Ha

(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
Other area	45	94	130	152	166	184	202

(b) Crop per ha

Flooding depth (m)	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

And the total damage potential in the project area is also calculated to every magnitude of the flood, expressed in the discharge at Surakarta.

Table IV-21 Damage Potential

(Unit : US $1,000)

Discharge at Surakarta	House damage		Crop damage		Total
	Nos of house	Damage	Area (ha)	Damage	
500	0	-	2,900	670	670
1,000	10,400	995	10,000	1,173	2,168
1,500	22,500	3,078	15,500	2,247	5,325
2,000	59,200	37,191	20,200	2,833	40,024
2,500	71,600	39,219	23,200	3,207	42,426

4.3. Flood control benefit

4.3.1. Flood frequency at Surakarta

At SHFD at Wonogiri damsite; $Q_p = 4,000\ m^3/sec$, the peak discharge at Surakarta was estimated at 2,160 m^3/sec.
It corresponds to the probable return period of 40-years.
While the probable flood discharge at Wonogiri, Surakarta and Ngawi sites were studied in non-flooding condition in the previous study ∠1.
And flood frequency analysis in the past 10 years results in such discharge frequency relation.

Discharge	Frequency per year	Return period
800 m^3/sec	0.7	1.43
1,000 m^3/sec	0.4	2.50

From the above data, the discharge-frequency relation at Surakarta in the present condition is established as shown in Fig IV-4.

∠1 Master Plan of the Sala River Basin Development, Supporting Report, PART - ONE, Hydrology.

4.3.2. Average annual damage

In estimating the annual flood damage, besides the above-stated direct damages, the indirect damages is also taken into account, Indirect damages include losses from interruption in utility services induced by flood, loss of profits and earnings to daily economic activity in the flood afflicted area, and net costs incremental for flood warning, evacuating and reoccupying flooded areas, flood fighting and temporary living of the refugess. In this study, the indirect damage is estimated at 10 % of the direct damage.

Annual flood damage in the project area is estimated by means of probable treatment method. On the basis of the flood frequency the estimated flood damage at every scale of the flood discharge, the annual damage is calculated as shown in Table IV-22.

4.3.3. Annual benefit

By constructing Wonogiri dam and the river improvement for its downstream reaches in the project area, the present flooding of the Sala River could be considerably eliminated.

At the controled discharge of 400 m^3/sec from the Wonogiri dam in the case of the SHFD, the discharge at Surakarta becomes about 2,000 m^3/sec /1. This discharge is equivalent to the discharge of probable return period of 40 - year in persent condition. The river improvement in the project area is also planned adopting this discharge as the design discharge.

With Wonogiri dam and river improvement, the present flood damage incurred from the discharge less then 2,000 m^3/sec will be completely saved in future.
Therefore, the annual benefit on this flood control plan is assessed to US $ 4.98 million from Table IV-22.

/1 Stury Report, Chapter I Hydrology.

(Surakarta area) Table IV-22 Annual Flood Damage

Probality	Probality of occurrence	Discharge (m^3/s)	Amount of flood damage control(US$)	Average flood damage control(US$)	Average annual flood flood damage (US$)	Accumulated Average annual flood damage (US$)
	1.500	600	0.95 x 10^6	0.95 x 10^6	1.43 x 10^6	1.43 x 10^6
1/1		700	1.2 x 10^6			
	0.500			1.60 x "	0.80 x "	2.23 x "
1/2		920	2.0 x "			
	0.300			3.3 x "	0.99 x "	3.22 x "
1/5		1,300	4.6 x "			
	0.100			5.75 x	0.58 x "	3.80 x "
1/10		1,700	6.9 x "			
	0.050			7.43 x "	0.37 x "	4.17 x "
1/20		1,900	7.95 x "			
	0.0167			26.13 x "	0.44 x "	4.61 x "
1/30		2,050	44.3 x "			
	0.0083			44.55 x "	0.37 x "	4.98 x "
1/40		2,150	44.8 x "			
	0.0083			45.08 x "	0.37 x "	5.35 x "
1/60		2,250	45.35 x "			
	0.0067			45.73 x "	0.31 x "	5.66 x "
1/100		2,400	46.1 x "			
	0.0033			46.4 x "	0.15 x "	5.81 x "
1/150		2,500	46.7 x "			

4.4. Scale of the river improvement

The flood protection measure envisaged in the project area is combination plan of the Wonogiri dam and downstream river improvement.

Case study of this combination plan is examined for the following three cases that the Wonogiri dam controlls the flood outflow two i) 400 m^3/sec (Case-A), ii) 700 m^3/sec (Case-B) and iii) 1,000 m^3/sec (Case-C). The selection of the most recommendable case is made in least cost base of the combined cost of the total dam and total river improvement.

4.4.1. Design flood discharge

The design flood discharge at Surakarta and Ngawi after completion of the Wonogiri dam are estimated for each case as follows,

	Wonogiri	Surakarta	Ngawi
Case-A	(4,000) 400	2,000	2,830
Case-B	(4,000) 700	2,300	3,130
Case-C	(4,000) 1,000	2,600	3,430

Rem : ( ) shows the peaks inflow discharge
: Unit in m^3/sec

The distribution of the design flood along the river in each case are illustrated in Fig. IV-5

4.4.2. Channel improvement

(a) High water level

Fixing too low the design water level in the river channel usually requires extremely large earth work in the project stretch. The channel improvement will be, therefore, planned adequately combining channel excavation and levee construction. The design water level is fixed at the highest water level of channel in the past along the project stretch.

(b) Discharge of low water channel

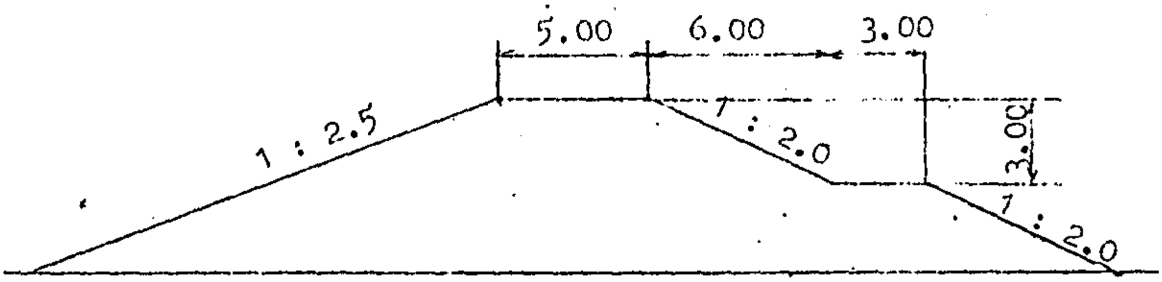
Single section of the channel usually requires the least flow area. However, in such a case of the Sala River of which seasonal fluctuation of channel flow is extremely large, a composite cross section is recommendable to stabilize the low flow and to avoid of concentration of high flood flow which makes maintenance of the channel difficult.

In the premise of adopting the composite section for channel improvement, the determination of the scale of low water channel is worked out.

Since the present river channel has been formed by natural force and has relatively stable flow condition in low water season, the design discharge for the low water channel de - termined to existing flow capacity at each design section.

(c) Proposed section of levee

The typical cross section of the levee to be provided along the river at the edge of the high water channel on both banks is proposed as shown below.



4.4.3. Scale of the channel improvement

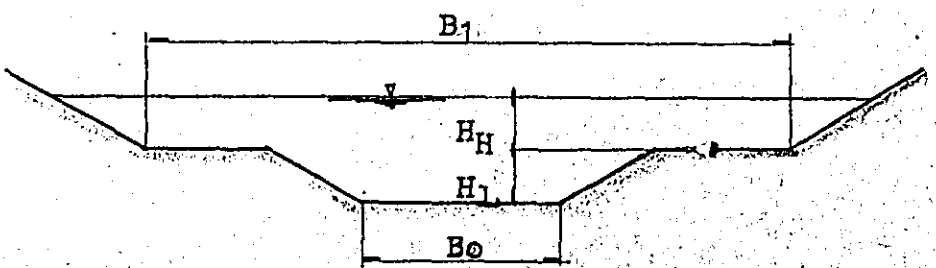
On the basis of the conditions stated in the preceeding sub-section, the channel sections in the project reach will be improved to have the dimensions as shown in Table IV-23.

Table IV -23 Scale of the Channel Improvement

CASE	Block number	Q (m^3/s)	Q_1 (m^3/s)	B_o (m)	B_1 (m)	H_1 (m)	H_H (m)
	1	2,000	500	45	175	5.0	3.5
	2	1,750	440	40	150	5.0	3.5
CASE - A	3	1,500	380	40	145	5.0	3.0
	4	850	200	40	125		
	5	650	200	40	115	3.5	2.0
	6	550					
	1	2,300	500	45	227	5.0	3.5
	2	2,050	440	40	200	5.0	3.5
CASE - B	3	1,800	380	40	188	5.0	3.2
	4	1,150	200	40	176		
	5	950	200	40	144	3.5	2.5
	6	850					
	1	2,600	500	45	280	5.0	3.5
	2	2,350	440	40	253	5.0	3.5
CASE - C	3	2,100	380	40	235	5.0	3.3
	4	1,450	200	40	214		
	5	1,250	200	40	189	3.5	2.8
	6	1,150					

Q : discharge

Q_1 : discharge for low water channel



4.5. Proposed improvement plan

Based on the proposed channel improvement, the required construction cost of the river improvement proper is estimated. The combined cost of the flood control is, then, also estimated by adding the cost of Wonogiri dam.

Economic comparison of the conceived three cases concludes that the Case-A is the most preferable scale of the flood control for this project as shown below.

Cost (US $)	Case-A	Case-B	Case-C
River improvement	18.4×10^6	20.1×10^6	22.3×10^6
Wonogiri dam	59.1×10^6	58.8×10^6	57.9×10^6
Total combined	77.5×10^6	78.9×10^6	80.2×10^6

5. Proposed Development Plan

To impound the active storage for irrigation water of 440 million m^3, the high of dam has to be raised about 38.5 m above the river bed and the crest of the dam extends to about 1,500 m.

Rockfill with central core type dam will require total embankment volume of 1.53 million m^3.

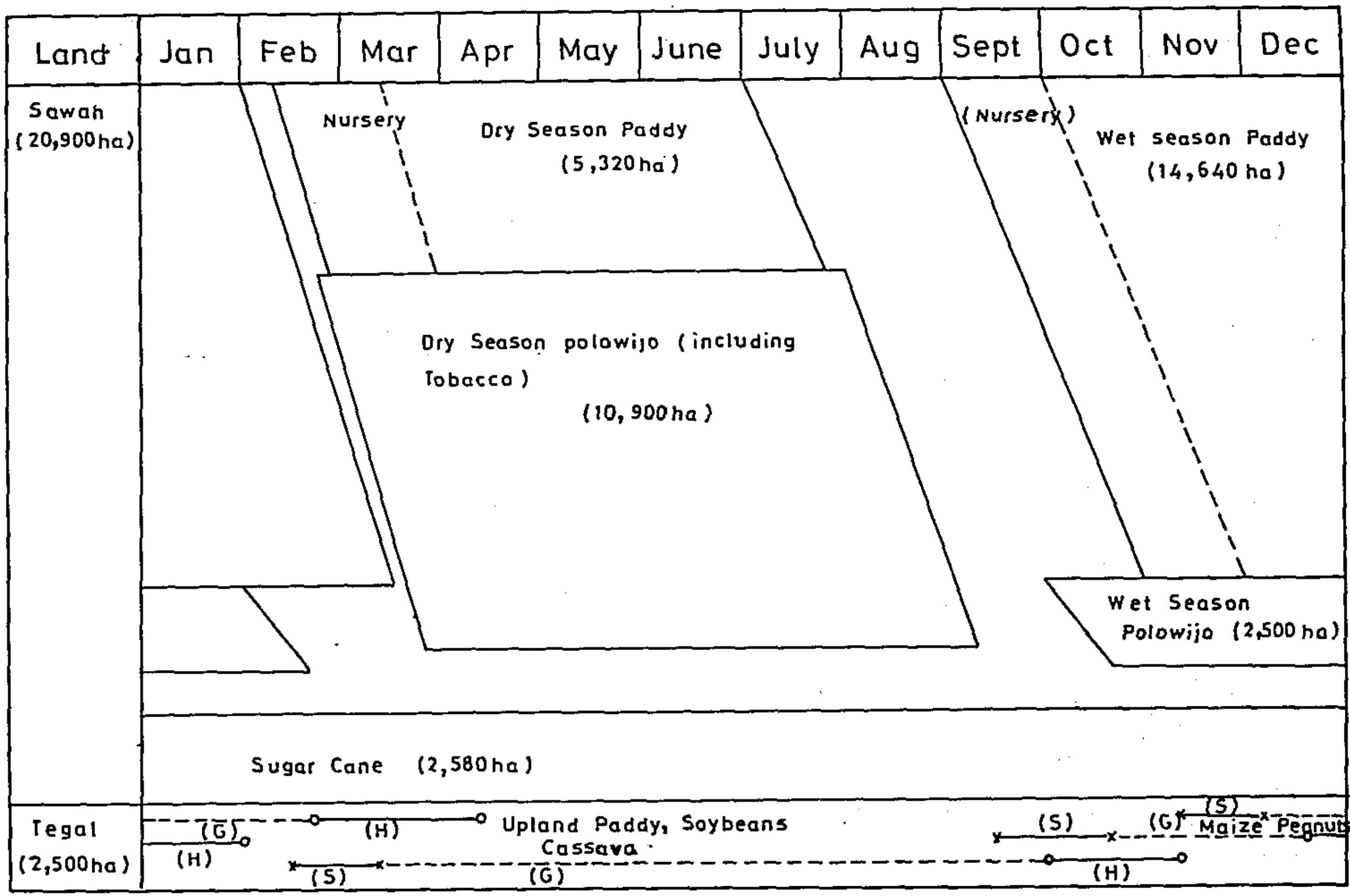
Spillway can evacuate the maximum outflow discharge of 1,550 m^3/sec abnormal flood event (the maximum inflow discharge of 6,200 m^3/sec). By providing the controlled water level limiting the high water level during the flood season below the normal high water level, the usual floods of which peak inflow discharges are less than 4,000 m^3/sec (SHFD) could be controlled to release a constant outflow of 400 m^3/sec.

With active storage capacity of 440 million m^3, the water from the Wonogiri dam is basically release at the rate of 60 m^3/sec for 6 hour a day, the deficit water of irrigation use occuring in most dry season will have to be released continueously during off-peak hours through the power plant which could generate off-peak power.

Water discharged from the power plant will be taken at the Colo weir and diverted to the irrigation area of 23,600 ha, extending 20,800 ha on the right bank and 2,800 ha on the left bank by re-regulating the water to meet the required discharge.

Even after the Wonogiri dam is completed, and it requalites the flood outflow to the extend of about 400 m^3/sec, the downstream reaches of the Sala River could not be complitely free from the flooding. To relieve the flood-afflicted area in the project area of 32,000 ha as well as Surakarta city, the river section along the mainstream for a distance of about 32 km will be improved so as to confine the flood discharge after Wonogiri within the channel.

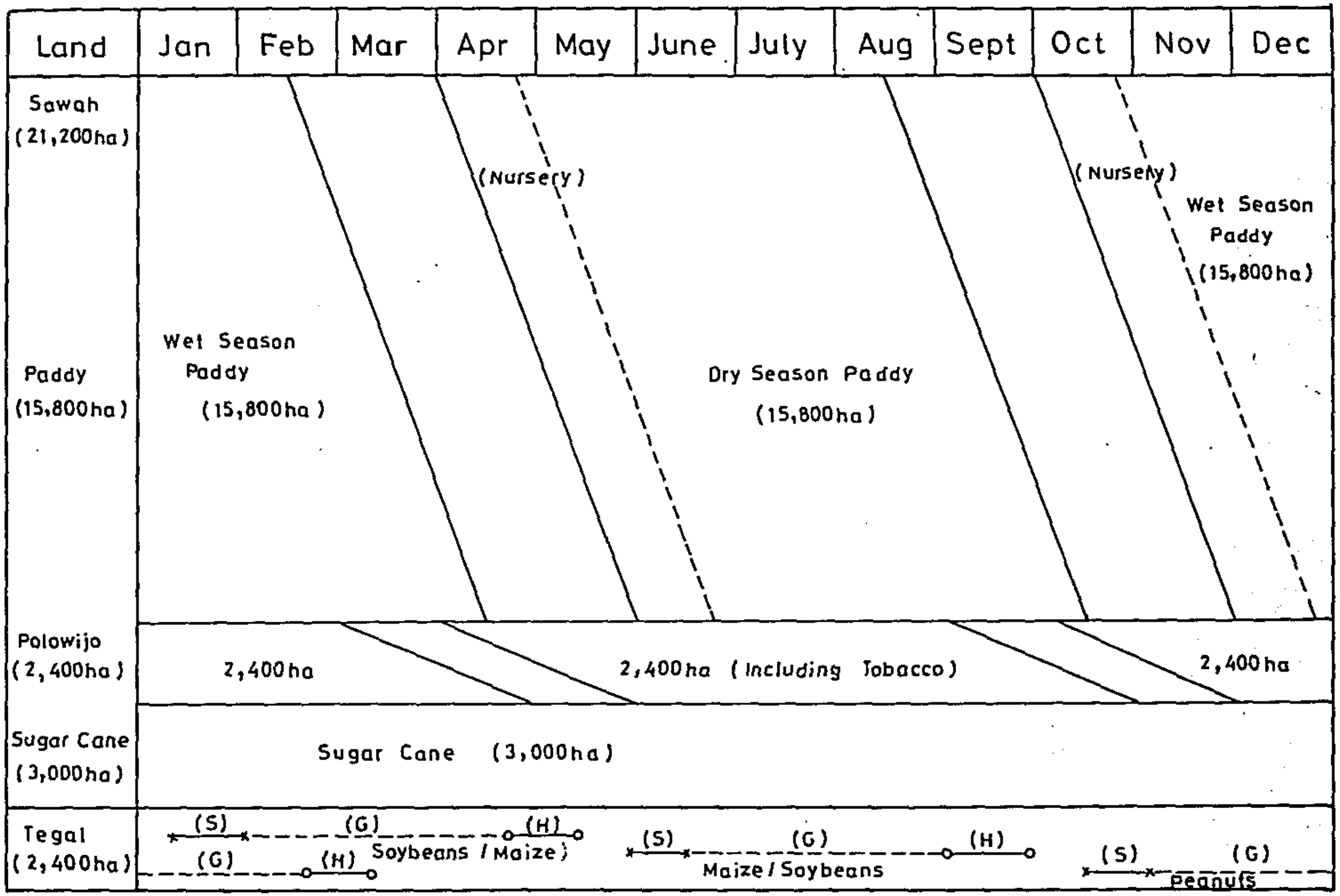
Fig. IV-1 Present Cropping Pattern



Note: Cultivation area rotating for polowijo and sugar cane is allocated at 30% of total sawah area

(S)......Sowing (G)......Growing (H)......Harvesting

Fig. IV-2. Future Cropping Pattern (With Project)



Note: 1) Cultivation area rotating for polowijo and sugar cane is allocated at 30% of total sawah area

(S)......Sowing (G)........Growing (H)........Harvesting

Fig IV-3 Inundation Area in Upper Sala Basin

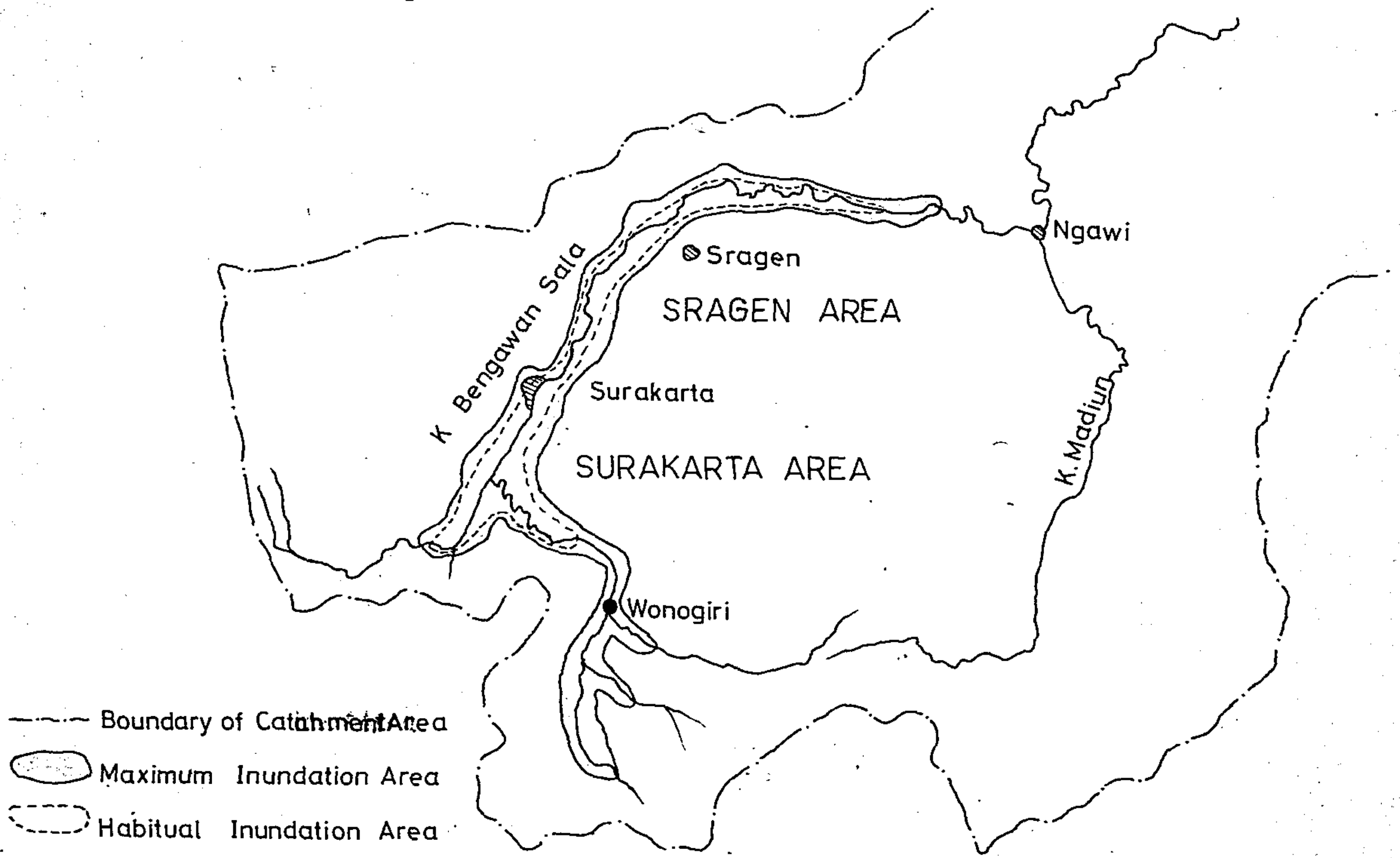


Fig. IV-1. Flood Discharge Frequency at Surakarta in the Present Condition.

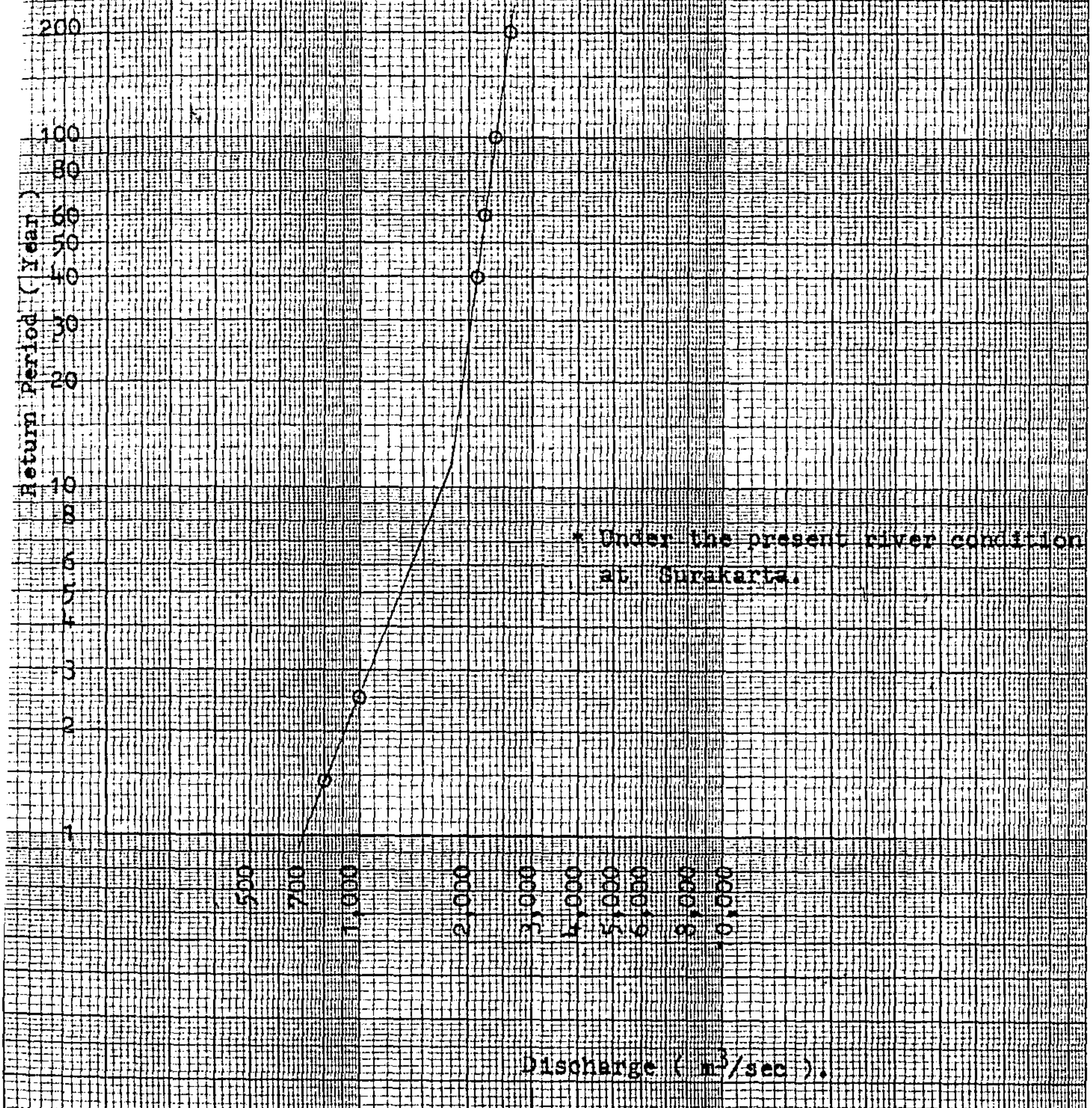
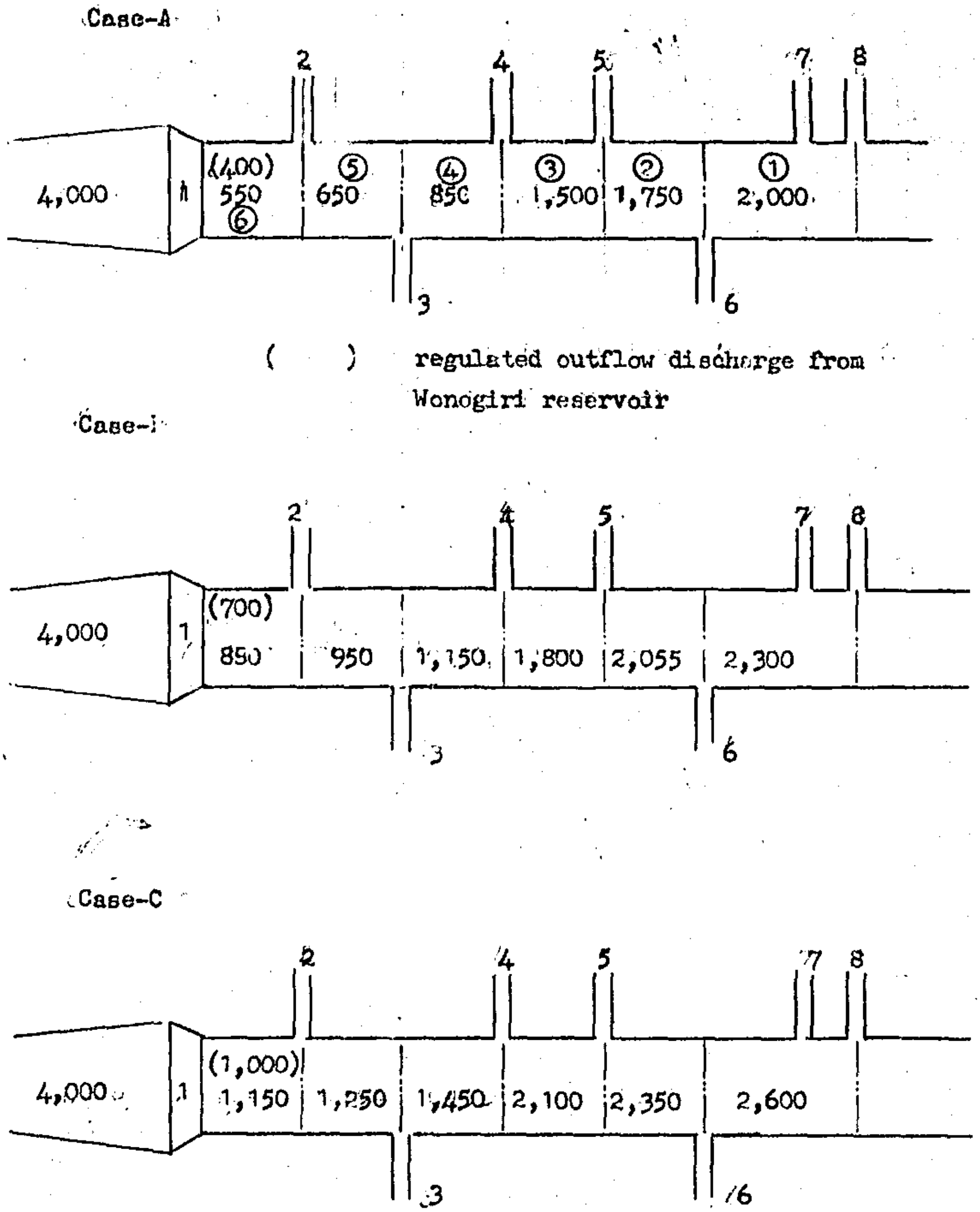


Fig. IV-5 Distribution of Design Flood Discharge



1. Wonogiri Reservoir
2. K. Blatunkan
3. K. Jlantah
4. K. Dengkeng
5. K. Brambang
6. K. Samin
7. K. Pepe
8. K. Anyar

V. THE PROJECT

1. Design and Cost Estimate

1.1. Wonogiri Dam

1.1.1. Damsite geology

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 1.420 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 10[illegible] m above the river bed. Overburden above the proposed foundation rock is 5 to 10 m thick.

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

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

1.1.2. Dam

The dam consists of a central core embankment with outer shells of rockfill. The maximum height of the dam is 37.5 m above the foundation rock and crest length about 1,420 m. The dam crest level of EL.141.6 provides 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). See Dwg IV-2 for the design features of the dam.

Randum fill proposed for sub-dam on the right bank intends to make effective use of materials excavated from spillway intake, powerplant and tunnel.

Excavated rocks will also be utilized for embankment in inner zones of the main dam. The thickness of vertical core was kept to a minimum in view of the relatively high cost of core material.

Embankment volumes required in 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.

1.1.3. Spillway

The proposed spillway, on the left bank, consists of a side-overflow weir of 47.5 m long, concrete-lined chuteway of 329 m long and hydraulic jump stilling basin of 74 m long. On the overflow weir crest are provided 4 nos of roller gates, 8 m wide by 7.7 m high. Dwg. IV-2 illustrates the design features of spillway.

The spillway is capable of passing the estimated extraordinary flodd at a water level of EL. 138.9, which is 2.7 m lower than the crest of the dam.

Table V-2 summarizes outflow discharge and corresponding reservoir water level at the passage of several assumed floods. Flood hydrographs are shown in Fig. V-1

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	4,000	280	400	138.2
Spillway design flood	5,200	370	1.400	138.4
Extraordinary flood	6,200	448	1.550	138.9

During the flood period ending March of each year, the reservoir stage will be maintained below a control water level of

Table V-1. Embankment Volume of Dam

Material	Volume ($10^3 m^3$ - Embankment measure)						
	Core	Filter	Transition	Rock	Randum fill	Earth blanket	Waste & other use
Required in dam	257	182	265	642	299	108	-
Available from							
Diversion conduit	-	-	20	-	20	-	45
Dam foundation	-	-	-	-	70	108	440
Spillway	-	40	90	20	169	-	90
Intake	-	-	20	10	20	-	46
Pressure Tunnel	-	-	-	-	10	-	3
Powerplant	-	-	20	10	10	-	43
Defficiency supplied from							
Candi area	257	-	-	-	-	-	-
Rock quarry	-	142	115	602	-	-	-

EL. 135.3. It will be recovered to normal high water level (EL. 136.0) by the end of April.

1.1.4. River diversion work

During the construction period of dam, flow of the river will be diverted through a diversion conduit of 7.0 m dia. The conduit will be of 290 m long located on the right bank. River diversion work includes the construction of two cofferdams which be required during the construction of main cover dam. It is planned to be safe against the probable dry season flood as large as 550 m^3/sec in peak discharge.

The main cofferdam comprises a part of the main dam embankment. It will have a crest elevation of 127.5 m, capable of handling a 20-years flood with a peak inflow of 3,100 m^3/sec. Embankment of about 250,000 m^3 will have to be completed during 4 months in the dry season of 1978.

Downstream cofferdam will have a crest elevation of 114 m, which is 0.5 m higher than the water level during the outflow of the 20-year flood discharged through the diversion conduit.

1.1.5. Intake and pressure tunnel

(a) Intake

Proposed intake structure is of vertical tower type. The sill of intake being set at EL. 121.0, further consumption of storaged water below the low water level (EL. 127.0) will be attainable through a irrigation outlet valve, if the situation requires.

The intake tower is of reinforced concrete construction, 16 m dia and 23.6 m high above the foundation level. The structure incorporate a fixed-wheel gate of 6 m wide by 6m high, operated by hoisting equipment on the top of the structure. Steel trashracks are installed each face of 6 openings of the inlet.

(b) Pressure tunnel and steel penstock

Pressure tunnel is a concrete lined circular shaped tunnel of 6 m in diameter.

To provide the maximum ground coverture above the tunnel roof in the area below the dam foundations, the tunnel takes a curved route into deep abutment at the lowest elevation, EL. 105, which is the elevation of water turbines in the power plant.

From view of economy and low water head in the tunnel, steel penstock will only be installed in a limited length of 60 m at the downstream end of the tunnel.

1.1.6. Powerhouse

Powerplant will be located close to the outlet of pressure tunnel on the left bank. The powerplant building is of a reinforced concrete construction, 21 m wide by 32 m long and will house two units of generating equipment of 5,600 kw capacity.

1.1.7. Outlet valve house

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

A valve house, annaxed to the powerplant building, will accomodate a unit of Hollow-jet valve of 1.8 m diameter. It is capable of discharging 35 m^3/sec at the low water level of the reservoir.

1.1.8. Land acquisition and road relocation

Right of land for the reservoir is estimated to be approximately 9,730 ha. Land will be acquired and people relocated in accordance with appropriate legal procedures.

The submerged area will be cleared before the impoundment of reservoir.

The maximum water level of the reservoir is EL. 138.9 at the occurrance of extraordinary flood and the crest elevation of the dam EL. 141.6. Acquisition of land will be limited to the area below EL. 140.0.

The length of required road relocation work reaches about 55 km including the improvement of existing road 34 km long. It includes the construction of about 25 bridges.

Table V-3. Land Acquisition and Road Relocation

Reservoir		
Land	Cultivated land, Sawah	4,438 ha
	" " , Tegal	2,851 ha
	Yards	2,239 ha
	Cemetry & forestry	206 ha
	Total	9,734
Houses		23,253 nos.
Inhabitant	Family	9,573 families
	Population	47,627
Relocation of road		
New road construction		21 km.
Improvement of existing road		34 km
	Total	55 km
Bridges		25 nos.
Clearing of reservoir Area	abt.	2,500 ha
		(of a total area of 8,700 ha)
Project construction facilities		
Land		24 ha
House		335 nos
Population		1,350

1.1.9. Construction cost estimate

The estimated construction cost of the Wonogiri dam project is US$ 59.300.000 including generating equipment and power transmission facilities. It is composed of US$ 31.700.000 equivalent of local currency portion and US$ 27.600.000 of foreign currency portion. The estimate includes an administration expenses. and engineering service and contingency of about 15 %.

Table V-4 shows the estimated construction cost by work items and Table V-5 yearly budget schedule.

1.2. Power station

1.2.1. Powerhouse

The powerhouse will be constructed to the left side of just down stream of the dam , and the building will be 32 m long, 21 m wide, 20 m depth and 11 m height.

Sub-structure of the powerhouse will be constructed on the base rock of tuff-breccia.

The generating units, each of 5,600 KW capacity, will be spaced at 12 m interval center to center.

The elevation of principal floors and centerline of turbine are set out as follows.

Turbine room floor	EL. 102.00
Cable gallery floor	EL. 104.00
Turbine center	EL. 104.80
Generator, cubicle, engine generator room, repair-shop floor	EL. 108.00
Air conditioner, battery, cable gallery room and aux. room floor	EL. 113.00
Control, telephone and aux. room floor	EL. 117.00
Conference room, terrace and aux. room floor	EL. 121.50

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

Table V-4. Estimate of Construction Cost of Dam
(including power facilities)

Work item	Total amount (10^3 US$)	Local currency (10^3 US$)	Foregn currency (10^3 US$)
I. Main civil work	16.600	6.330	10.270
(1) Dam and cofferdam	(4.600)	(2.000)	(2.600)
(2) Spillway	(1.880)	(520)	(1.360)
(3) Intake	(340)	(120)	(220)
(4) Pressure Tunnel	(580)	(160)	(420)
(5) Power house	(870)	(230)	(640)
(6) River diversion	(780)	(630)	(150)
(7) Electrical & mechanical	(170)	(40)	(130)
Sub Total	(9.220)	(3.700)	(5.520)
(8) Construction facilities	(1.560)	(1.180)	(380)
(9) Plant and equipment	(2.670)	(220)	(2.450)
(10) General expenses	(3.150)	(1.230)	(1.920)
II. Gates and penstocks	2.000	200	1.800
III. Genevating equipment & Transmission system	10.880	1.510	9.370
IV. Land acquisition & clearing	15.600	15.600	0
(1) Land acquisition	(15.300)	(15.300)	(0)
(2) Reservoir clearing	(300)	(300)	(0)
V. Road relocation	4.000	3.200	800
Total for I to V	49.080	26.840	22.240
VI. Engineering service & administrative expenses	2.500	600	1.900
VII. Contingency & reserve	(15%)7.720	4.260	3.460
T O T A L	59.300	31.700	27.600

Fig. V-1. Inflow and Outflow Hydrographs of Flood

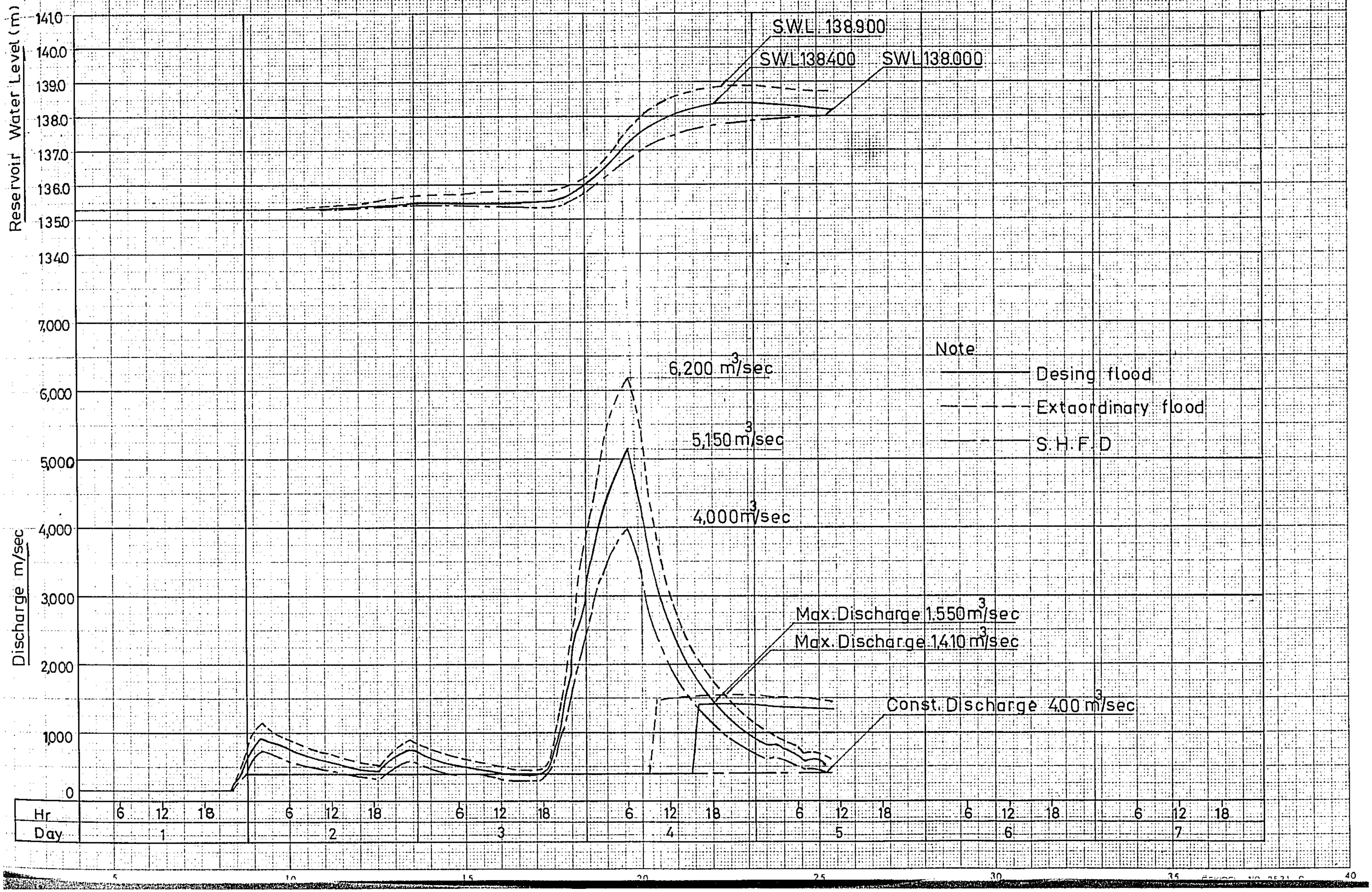


Table V-5. Yeary Budgetary Schedule (Unit : 10^3 US $)

Work Item	Construction Cost Total amout	Construction Cost Local currency	Construction Cost Foreign currency	1976 L.C.	1976 F.C.	1977 L.C.	1977 F.C.	1978 L.C.	1978 F.C.	1999 L.C.	1999 F.C.	1980 L.C.	1980 F.C.	Remarks
I. Main Civil Works	16.600	6.330	10.270	330		1.410	4,190	1.380	2,880	1.780	3,200	1.430	0	
(1) Dam and coferdam	(4.600)	(2.000)	(2.600)			(20)	(0)	(440)	(650)	(850)	(1.000)	(680)	(950)	
(2) Spillway	(1.880)	(520)	(1.360)					(80)	(90)	(280)	(760)	(160)	(510)	
(3) Intake	(340)	(120)	(220)					(30)	(40)	(60)	(110)	(30)	(70)	
(4) Pressure Tunnel	(580)	(160)	(420)					(60)	(140)	(100)	(280)			
(5) Powerhouse	(870)	(230)	(640)					(30)	(40)	(110)	(370)	(90)	(230)	
(6) River diversion	(780)	(630)	(150)			(460)	(40)	(140)	(60)	(10)	(30)	(20)	(20)	
(7) Electrical & mechanical	(170)	(40)	(130)									(40)	(130)	
(8) Construction fasilities	(1.560)	(1.180)	(380)	(330)		(640)	(210)	(210)	(170)					
(9) Plant and equipment	(2.670)	(220)	(2.450)			(110)	(3.670)	(40)	(1.100)	(10)	(100)	(60)	(-2.510)	
(10) General expenses	(3.150)	(1.230)	(1.920)			(180)	(290)	(350)	(590)	(350)	(550)	(350)	(690)	
II. Gates and Penstocks	2.000	200	1.800					60	550	130	1.140	10	110	
III. Generating Equipment	10.880	1.510	9.370							450	2.820	1.060	6.550	
IV. Compensation & Clearing	15.600	15.600	0	500		2.530	0	6.100	0	6.420	0	50	0	
(1) Light of way	(15.300)	(15.300)	(0)	(500)		(2.500)		(6.000)		(6.300)				
(2) Reservoir clearing	(300)	(300)	(0)			(30)	(0)	(100)	(0)	(120)	(0)	(50)	(0)	
V. Road relation	4.000	3.200	800			300	100	900	200	1.100	300	900	200	
Total for I to V.	49.080	26.840	22.240	830		4.240	4.290	8.440	3.630	9.880	7.460	3.450	6.860	
VI. Engineering service, etc.	2.500	600	1.900	50	0	100	300	150	500	150	550	150	550	
VII. Contingency & reserve	7.720	4.260	3.460	70	500	560	610	1.110	570	1.670	1.290	850	990	
TOTAL	59.300	31.700	27.600	950	0	4.900	5.200	9.700	4.700	11.700	9.300	4.450	8.400	

1.2.2. Power generating equipment

(a) Hydraulic turbine

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

Owing to the fluctuation in the reservoir water level which varies from EL. 136.0 (NHWL) to EL. 127.0 (LWL), the effective head of the turbine will vary from a maximum head of 24.8 m to a minimum head of 15.8 m. However, as the result of the examination of the design head , annual total output will be maximized at 23.2 m head, therefore this head is adopted as the design head.

The turbine with 333 rpm rated speed under full gate opening and 23.2 m design head will develop 5,600 kw as a rated output per unit. Under 15.8 m minimum head at full gate opening, the output of the turbine will be 3,180 kw per unit.

The followings are the items taking into consideration of the selection of hydraulic turbine to be installed at Wonogiri power station.

Elevation of dam crest	EL.	141.60
Normal maximum reservoir water level	EL.	136.00
Minimum reservoir water level	EL.	127.00
Normal maximum tailwater level	EL.	110.00
Normal minimum tailwater level	EL.	109.00

(b) Alternating current generator

Generator to be installed at Wonogiri power station will be vertical shaft revolving field type to be coupled directly to the Kaplan turbine. It will therefore be 333 rpm and rated at 7,000 kVA, 6.6 kv, 3 phase, 50 Hz and 0.8 power factor. And an ordinary type generator is adopted.

The generator will be assembled and disassembled by means of the overhead travelling crane.

The 0.8 power factor is selected for the Wonogiri power plant considering the reactive power supply from the generator to load center.

The terminal voltage of generator is chosen to be 6.6 kv : it would be the most economical voltage for the capacity planned.

(c) Main transformer

Main transformer to be installed at Wonogiri power station will be rated at 14,000 KVA, 50 Hz, 3-Phase, two windings, 6.6 kv delta to 150 kv star connected, outdoor, self cooled type. The neutral point 150 kv winding will be grounded directly.

(d) Station service equipment

A.C. station service power will be supplied from one 300 kva transformer, of which is connected to generator main circuit.

For an emergency use, engine driven generating set is used.

Station service transformer and step-up transformer for engine driven generating set will be of outdoor and self - cooled type.

(e) Switchyard equipment

Switchyard occupying a 24 m by 40 m area is adjusted to the ground level of 117.00.

A single circuit transmission line will depart from 150 kv bus. The circuit breakers will be rated at 168 kv, 800 A, 2,500 MVA interrupting capacity.

The circuit breaker on 6.6 kv side of generator will be used for parallel operation of the generators at Wonogiri power station and for synchronizing, between Wonogiri power and Tuntang system.

1.2.3. Transmission line and substation

The power transmission capacity of the single circuit 150 kv system from the Wonogiri power station to Surakarta substation is around 11,000 kw based on 5 percent regula tion and 80 percent power factor.

The above 150 kV transmission line of 40 km is constructed along the highway from the Wonogiri power station and Surakarta substation, and step-down transformer at each receiving end is included.

A single circuit 20 kV transmission line is also constructed between Wonogiri power station and Wuryantoro town via Wonogiri permanent camp area and Wonogiri town. And step-down transformer on the 22 kV distribution line and materials for low tension line are also included.

1.2.4. Construction cost estimate.

The total construction cost of the generating equipment and power transmitting facility is estimated at US$. 10,880,000 , including US$. 1,510,000 equivalent of local currency portion and US$.9,370,000 of foreign currency portion, as given in Table V-6.

Table V-6 Estimate of Construction Cost of Power Equipment and Facilities

	Foregn currency (10^3 US$)	Local Currency (10^3 US $)	Total (10^3 US $)
1. Electric Power Generating	7,450	450	7,900
Generating Equipment			
2. Electric Power Transmission			
150 kV T/L(1c.c.t) 40 km	650	400	1,050
20 kV D/L(1c.c.t) 42 km W/Tr 1250kVA	670	420	1,090
Low tension Line20km	340	200	540
Surakarta S.S.	140	20	160
Sub Total	1,800	1,040	2,840
3. Communication			
PowerLine Carrier			
Telephone	120	20	140
4. Congtingency	(Included in Table V-5)		
5. Engineering and Administration Cost	(Included in Table V-5)		
6. Total	10,880	1,510	9,370

1.3. Irrigation facilities

1.3.1. Colo diversion weir

(1). Intake water level

Intake water level at Colo weir is determined by the following conditions :

(a) Field elevation (EL. in SHVP)
    Upstream end 104 m
    Downstream end 80 m

(b) Required water level at the end turnout ; EL. 80.5 m

(c) Mean loss of head at every crossing structure along the canal ; 0.3 m

(d) Canal length : 64 km
    Crossing : 27 places
    Mean longitudinal grade : 1/4,500

From the above conditions, gross head to be secured at Colo intake is calculated 22.3 m. By taking about 15% allowence for head losses for various other devices provid ed in the canal, the water level at the beginning point of main canal is necessary to be set at EL. 106.0 m SHVP, at lowest.

Intake water level of Colo diversion weir is, therefore, decided at EL. 106.5 m SHVP taking into account of loss head in the intake structure.

Besides this, the Colo weir has to have afterbay function of the Wonogiri power plant. As the power plant is designed for peaking operation within 6 hours a day, discharge from the reservoir through turbines is rated at 60 m^3/sec maximum. This peak discharge has to be re-regulated to meet the diversion requirement for irrigation day by day.

For this purpose, the regulation capacity of about 1.2 million m^3 is need to be provided with Colo afterbay. Raising up the water level by one meter would be enough to provide the required capacity. Therefore, the crest elevation of the fixed weir portion is set at EL. 107.5 m.

(2). Type of weir

The weir site is selected on the river terrace at the left bank of the Sala River. The river terrace consists of compacted fine silty sand deposit with 20 - 25 m thickness on tuff-breccia base which outcrops on the right bank. The diversion weir is designed by floating type on the river bed.

Selection of the type between fixed weir and movable weir as shown in Fig. V-2 , mainly depends on the restriction of back water at flood time. Overflow section of this weir has to be designed to pass the flood discharge of 2,000 m^3/sec, abnormal flood discharge at the site.

In the case of fixed weir with overflow section of 97 m wide, the maximum water level in upstream of the weir becomes at EL. 115.0 m ; (107.5 + 7.5).

In the case of movable weir provided with 3.5 m high gates above the elevation of 104.0 m the required length of overflow section comes to 85 m and the maximum water level in this case reaches to EL. 110.0 m ; (104.0 + 6.0).

Economic comparison of these types of the weir reveals that the movable type is more expensive, US$ 2.9 million, than the fixed type. However, the influence of back water to upstream will be lessened by provision of movable section. Therefore the movable type is selected as the proposed plan. The main features of the Colo weir are shown in Dwg. VIII-003 and Dwg. VIII-004.

1.3.2. Canal

(1). Design discharge

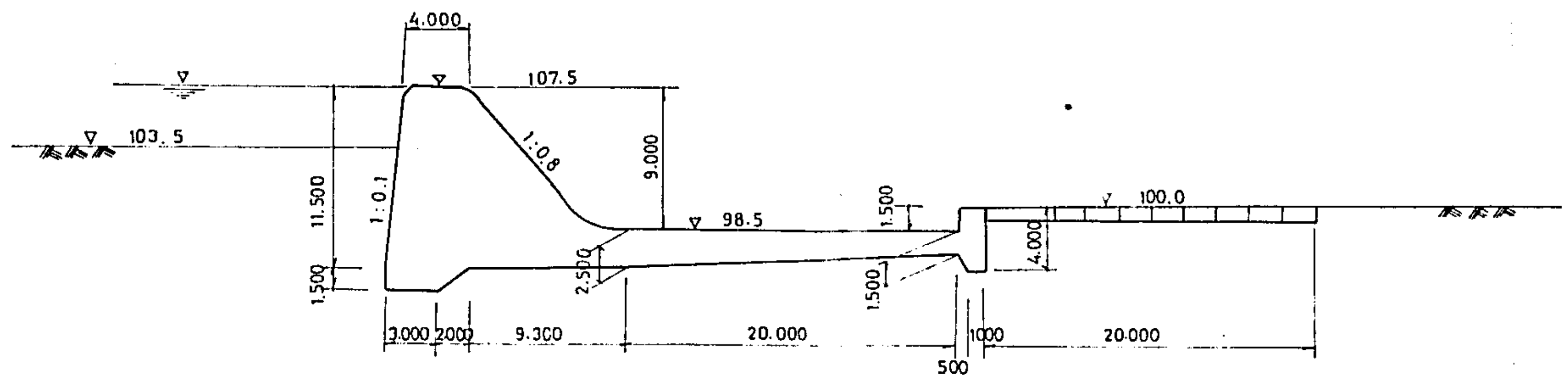
Network diagram and design discharge of the main and secondary canals are presented in Fig. V-3.

Locations of turnout are selected at crossing of the major existing canal to connect it to the main canal, and at

Fig. V- 2 **Selected Type of Weir**

Scale 1: 400

Fixed weir



Monable weir

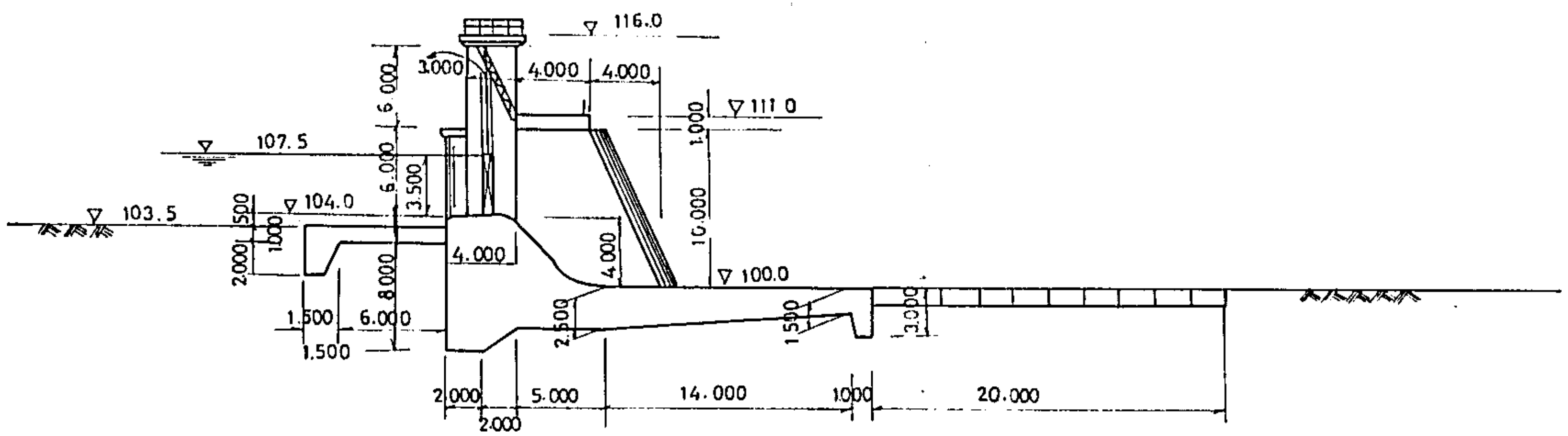
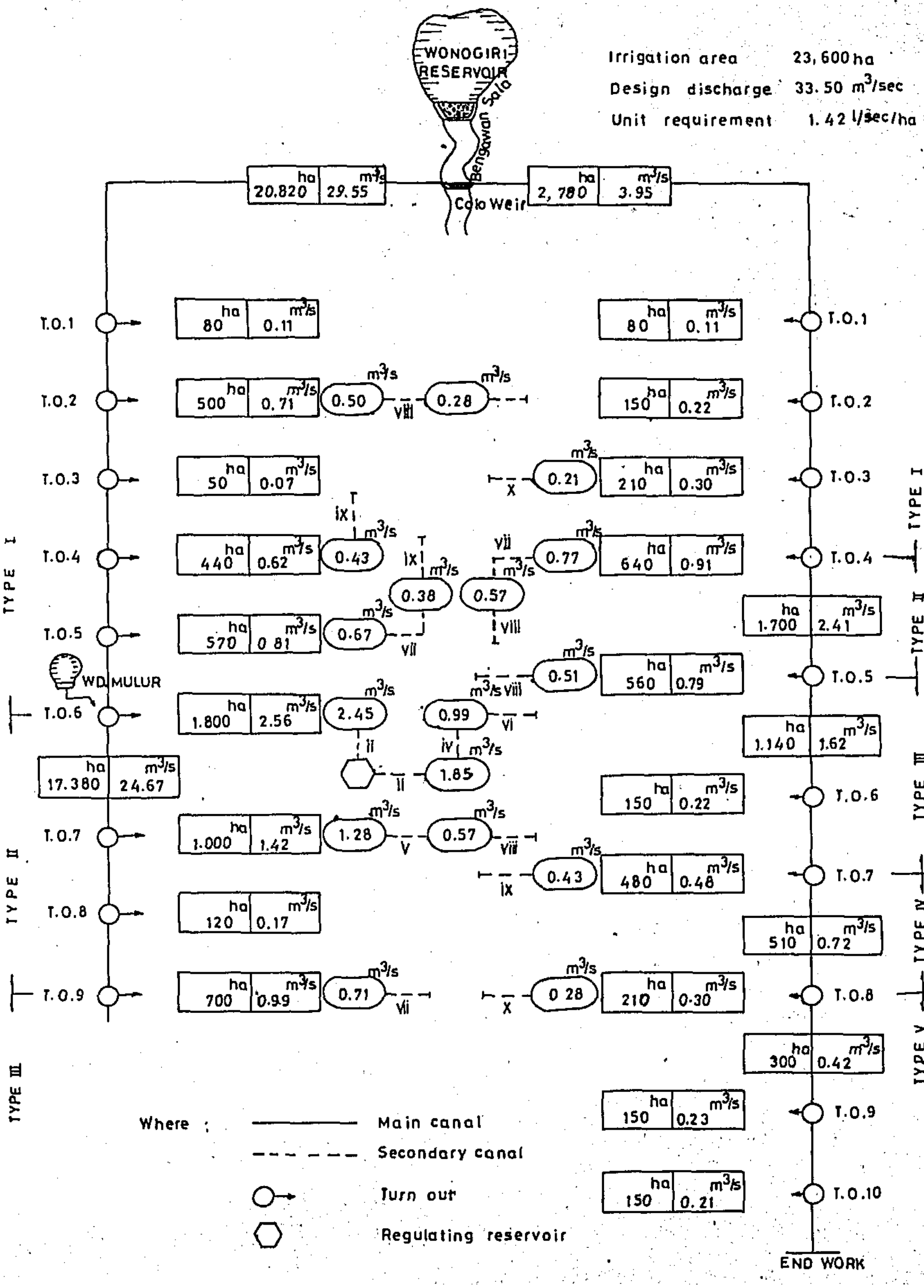
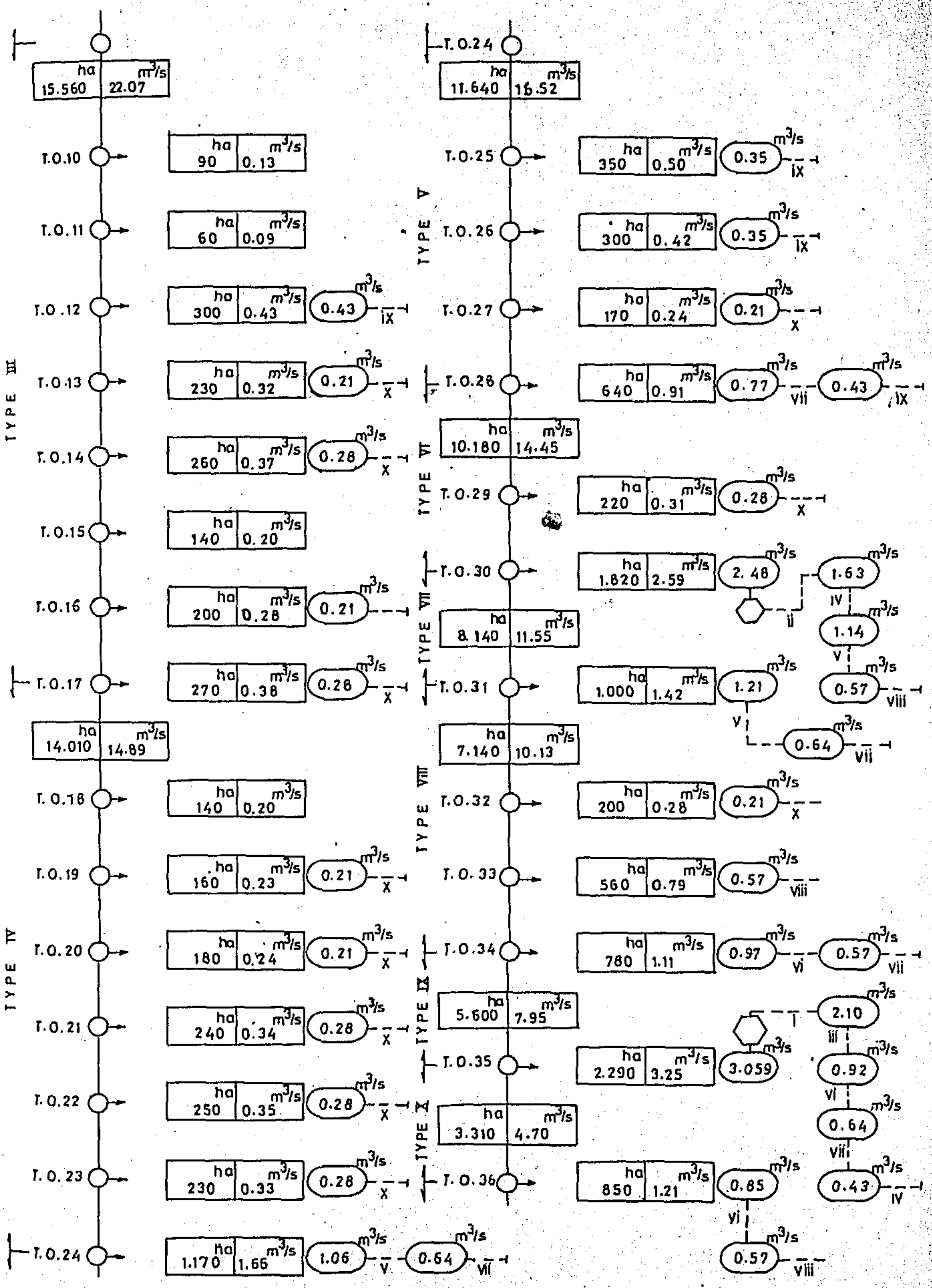
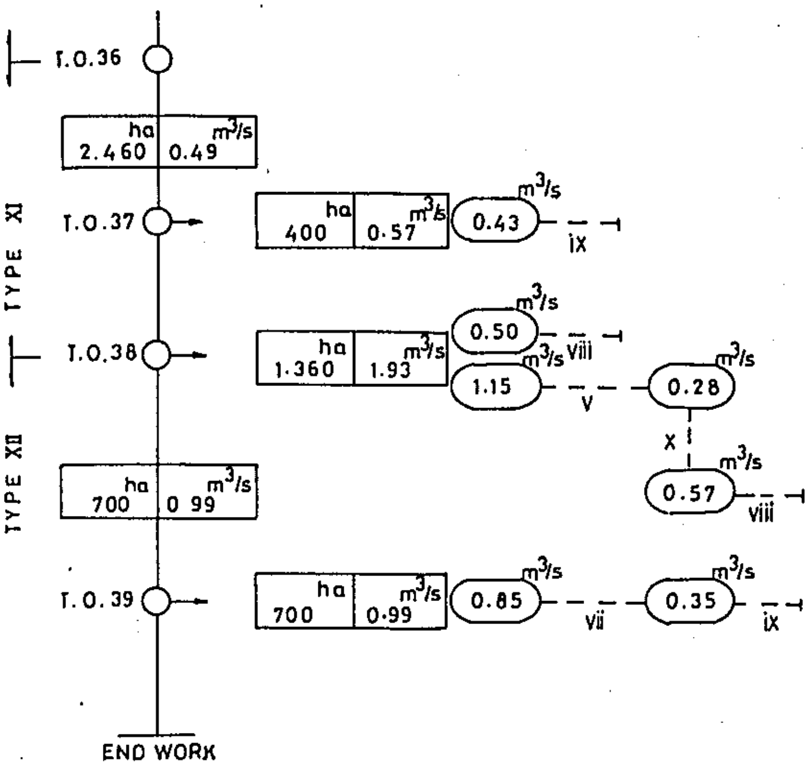


Fig. V-31 Network Diagram of Irrigation System





TYPE III
TYPE IV
TYPE V
TYPE VI
TYPE VII
TYPE VIII
TYPE IX
TYPE X
ha 15.560 m3/s 22.07
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
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
T.O.17 ha 270 m3/s 0.38 0.28 m3/s X
ha 14.010 m3/s 14.89
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 0.24 0.21 m3/s X
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 1.170 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
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
T.O.29 ha 220 m3/s 0.31 0.28 m3/s X
T.O.30 ha 1.820 m3/s 2.59 2.48 m3/s II 1.63 m3/s IV 1.14 m3/s V 0.57 m3/s VIII
ha 8.140 m3/s 11.55
T.O.31 ha 1.000 m3/s 1.42 1.21 m3/s V 0.64 m3/s VII
ha 7.140 m3/s 10.13
T.O.32 ha 200 m3/s 0.28 0.21 m3/s 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 VII
ha 5.600 m3/s 7.95
T.O.35 ha 2.290 m3/s 3.25 3.059 m3/s I 2.10 m3/s III 0.92 m3/s VI 0.64 m3/s VII 0.43 m3/s IV
ha 3.310 m3/s 4.70
T.O.36 ha 850 m3/s 1.21 0.85 m3/s VI 0.57 m3/s VIII


T.O.36
ha
2.460
m3/s
0.49
TYPE XI
T.O.37
ha
400
m3/s
0.57
m3/s
0.43
ix
m3/s
0.50
viii
T.O.38
ha
1.360
m3/s
1.93
m3/s
1.15
v
m3/s
0.28
x
m3/s
0.57
viii
TYPE XII
ha
700
m3/s
0 99
T.O.39
ha
700
m3/s
0.99
m3/s
0.85
vii
m3/s
0.35
ix
END WORK

necessary point to branch the water for newly irrigated area. Total numbers of turnout is accumulated 49, 39 on the right main and 10 on the left main canal.

(2). Design condition

(a) Type of canal - unlined earth excavated or embankment canal with trapezoidal section.

(b) Maximum velocity - less than 0.8 m/sec should be kept for the safty of unlined section.

(c) Major crossing - siphon and aqueduct for tributary, and bridge and culvert for road and railway.

(d) Longitudinal gradient - to arrange the sectional gradient so as to keep the enough diverting head at every turnout and to give sufficient head for every syphone to wash down sediments or drifts. It is shown in Dwg.VIII-005 to Dwg.VIII-007.

(3). Cross section

According to the sectional discharge between the turnouts, 17 types of cross section are designed for the main canal; 12 types for the right main and 5 types for the left main. For the secondary canals, total 10 types are designed.

Standard section of those are shown in Dwg.VIII-008 to Dwg.VIII-10. And the sections and their length of each type of the canal are presented in Table V-7.

(4). Crossing

The main and secondary canals cross at many places over or under the tributaries, roads and railway. Bridge, culvert aqueduct and siphon are designed for those crossing.

Design consideration for these crossings are as follows ;

(i) Aqueduct is adopted at the places where the clearance under it has enough height above the maximum flood water level.

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

Table V-7 Type and Length of the Canal

Turnout No.	Main Canal Irrigation area	Main Canal Discharge	Canal Type	Length	Turnout Irrigation area	Turnout Discharge
Right Main Canal						
	ha	m3/sec		m	ha	m3/sec
Intake	20,820	29.55			-	-
1.	20,740	29.44	I	10,450	80	0.11
2.	20,240	28.73			500	0.71
3.	20,190	28.66			50	0.07
4.	19,750	28.04			440	0.62
5.	19,180	27.23			570	0.81
6.	17,380	24.67	II	4,100	1,800	2.56
7.	16,380	23.25			1,000	1.42
8.	16,260	23.08			120	0.17
9.	15,560	22.09	III	10,900	700	0.99
10.	15,470	21.96			90	0.13
11.	15,410	21.87			60	0.09
12.	15,110	21.24			300	0.43
13.	14,880	21.12			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	IV	8,900	270	0.38
18.	13,870	19.69			140	0.20
19.	13,710	19.46			160	0.23
20.	13,530	19.20			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	V	6,950	1,170	1.66
25.	11,290	16.02			350	0.50
26.	10,990	15.60			300	0.42
27.	10,820	15.36			170	0.24
28.	10,180	14.45	VI	1,900	640	0.91
29.	9,960	14.14			220	0.31
30.	8,140	11.55			1,820	2.59

Turnout No.	Main Canal Irrigation area	Main Canal Discharge	Canal Type	Length	Turnout Irrigation area	Turnout Discharge
31.	7,140	10.13	VII	1,700	1,000	1.42
32.	6,940	9.85	VIII	8,300	200	0.28
33.	6,380	9.06			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	XII	3,000	1,360	1.93
39.	0	0			700	0.99
Left.						
Intake	2,780	3.95	I	13,900		
1.	2,700	3.84			80	0.11
2.	2,550	3.62			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	IV	2,850	480	0.68
8.	300	0.42			210	0.30
9.	150	0.21	V	2,350	150	0.21
10.	0	0			150	0.21

Total Length (Right) 63,900 m

(Left) 25,550 m.

Secondary Canal

Right bank	Irrig. Area (Ha)	Discharge (m^3/sec)	Length (m)	Canal Type
T.O.2-a	350	0.50	1,500	viii
-b	200	0.28	1,200	x
4 -a	300	0.43	2,800	ix
5 -a	470	0.67	2,500	vii
-b	270	0.38	3,000	ix
6 -a	1,700	2.41	4,000	ii
-b	1,300	1.85	3,400	iv
-c	700	0.99	5,500	vi
7 -a	900	1.28	4,700	v
-b	400	0.57	3,900	viii
9 -a	500	0.71	2,700	vii
12 -a	300	0.43	*2,500	ix
13 -a	150	0.21	500	x
14 -a	200	0.28	*1,500	"
16 -a	150	0.21	*1,100	"
17 -a	200	0.28	900	"
19 -a	150	0.21	700	"
20 -a	150	0.21	1,100	"
21 -a	200	0.28	600	"
22 -a	200	0.28	*2,000	"
23 -a	200	0.28	*1,500	"
24 -a	750	1,06	2,800	vii
-b	450	0.64	5,400	vii
25 -a	250	0.35	*1,500	ix
26 -a	250	0.35	*3,000	ix
27 -a	150	0.21	* 700	x
28 -a	540	0.77	2,800	vii
-b	300	0.43	1,000	ix
29 -a	200	0.28	900	x
30 -a	1,750	2.48	3,600	ii
T.O.30-b	1,150	1.63	1,600	iv
-c	800	1.14	1,800	v
-d	400	0.57	1,500	viii
31 -a	850	1.27	2,800	v
-b	450	0.64	4,300	vii
32 -a	150	0.21	* 700	x
33 -a	400	0.57	*3,600	viii
34 -a	680	0.97	2,500	vi
-b	400	0.57	*2,700	viii
35 -a	2,190	3.11	2,700	i
-b	1,500	2.13	3,200	iii
-c	650	0.92	4,000	vi
-d	450	0.64	5,000	vii
-e	300	0.43	4,000	ix
36 -a	600	0.85	*2,300	vi
-b	400	0.57	*2,800	viii
37 -a	300	0.43	*1,000	ix
38- a'	350	0.50	*2,500	viii
-a	810	1.15	3,000	v
-b	200	0.28	2,600	x
-c	400	0.57	*2,300	viii
39 -a	600	0.85	1,800	vi
39 -b	250	0.35	3,800	ix

Left Bank	Irrig. Area (Ha)	Discharge (m^3/sec)	Length (m)	Canal Type
T.O.3-a	150	0.21	1,200	x
4-a	540	0.77	2,800	vii
-b	400	0.47	3,600	viii
5-a	360	0.51	2,400	viii
7-a	300	0.43	2,100	ix
8-a	200		1,000	x

* : rehabilitation canal.

(iii) Culvett will be adopted in such a case as the tributary canal, road or railway is situated at higher formation than that of the main canal.

(iv) Over bridge will be adopted for road crossing where culvert is not applicable.

(v) Design velocity for siphon and aqueduct

Q (m^3/sec)	Design velocity (m^3/sec)	
	Siphon	Aqueduct
30 - 10	1.80 - 2.20	2.00 - 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

The types and the numbers of the crossings to be adopted are listed in Table V-8 and standard design of each crossing structures are shown in Dwg VIII-02[illegible] to Dwg VIII-017.

(5). Turnout

Design of turnout is standardized to provide 3 types of gate diversion works for the secondary canal for convinience of controlling discharge and maintenance.

Romijn gate is standardized for type B and type C and sluice gate is adopted to type A.

Standard design of the structure is shewn in Dwg.VIII-018 to Dwg.VIII-020.

(6). Regulating structure

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

(a) Waste way and spillway

Waste way has to have capacity to drain out water in certain section of the canal for emergency case.

Table V-8 Numbers ofCrossing by Type

Canal Type	Turnout			Check	Siphon			Aqueduct			Culvert		Bridge	
	A	B	C	Gate	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
Total	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
Total		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

Since many aqueducts or siphons are built on this canal waste way structure is provided at immediate upstream side of those crossing structures for maintenance and clearing the drifts.

Spillway to evacuate the exsess flood water is also provided with this diversion structure.

Typical design of the structure is shown in Dwg. VIII-014, Dwg.VIII-013, Dwg.VIII-019 and Dwg.VIII-020.

(b) Check gate

Check gates are provided at the downstream of the major turnouts to maintain a certain water level, to lessen rapid change of water level and to prevent high velocity of flow. Type designed for the check gate is a combination of the fixed overflow and manual operating gate.

Typical design of the check gate is illustrated in Dwg. VIII-020.

(7). Regulating reservoir

Regulating reservoir is designed at three sites on the way of the secondary canal by which large area is governed, in order to store one day requirement of the respective irrigation block.

Homogeneous earthfill dyke is designed for this by using excavated earth as much as possible.

Main features of the proposed regulation reservoirs are as follow :

Turnout No.	No.6	No.30	No.35
Governing 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.VIII-021.

(8). Construction cost estimate

The estimated construction cost of the irrigation project is US$ 26,600,000, comprising of the foreign exchange. component equivalent to US$ 12,920,000 and the local currency of Rp. 5.677.000.000 (equivalent to US$ 13,680,000)

The breakdown of the estimate is referred to Table V-9 and yearly budgetary schedule is given in Table V-10.

1.4. River improvement

1.4.1. River section to be improved

The segment to be improved by this project is the reaches extending from the section No.1 (No.456 of the master plan) to the section No. 53 (No.508), between the highway bridge at Nguter and the highway bridge at Jurug Surakarta.

(a) Plane profile

The plan profile of low water channel is determined so as to correct the existing channel with the minimum excavation. But the present river channel is so heavily meandering that the plane profile has to be modified about 37% of the total stretches of the project segment by means of short cut method. The total length of short cut channel reaches to about 12 km out of total length of 32.2 km along the main channel.

The designed plane profile is shown in Dwg.VI-001 and 002

(b) Longitudinal plan

Longitudinal profile of the river course is examined in line with the plane profil plan of the low water channel. The profile is designed so as to smoothen the existing river bed as uniformly as possible. The designed longitudinal profil is shown in Dwg. VI-003.

(c) Cross section of the river channel

Cross section to carry safely the design discharge for

Table V-9 Estimates of Construction Cost of Irrigation

(US $)

Item	Total	Domestic currency	Foreign currency
1. Preparation works	156,000	156,000	-
2. Colo diversion weir	1,737,000	448,000	1,289,000
3. Canals	11,331,000	5,507,000	5,824,000
3.1. Main	8,460,000	3,626,000	4,834,000
3.2. Secondary	1,829,000	993,000	836,000
3.3. " (Rehabilitation)	36,000	36,000	-
3.4. Farm ditch	1,008,000	1,008,000	-
4. Drainage	1,169,000	1,169,000	-
5. Farm road	3,168,000	3,168,000	-
6. Construction Machinary cost	3,934,000	124,000	3,810,000
Sub total	21,497,000	10,728,000	10,769,000
7. General expenses (20 % above)	4,303,000	2,152,000	2,151,000
8. Land acquisition	800,000	800,000	-
Total	26,600,000	13,680,000	12,920,000

Table V - 10 Yearly Budgetary Schedule

Work Item	Construction Cost			1977		1978		1979		1980		1981		1982	
	Total	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.
I. Irrigation Facilities	25,800	12,800	12,920	210	5,200	2,110	1,380	2,440	1,600	2,490	1,620	2,620	1,710	3,010	1,410
II. Land Acquisition	800	800	-	200	-	200	-	200	-	200	-	-	-	-	-
III. Engineering Services	1,500	300	1,200	60	260	40	170	50	190	50	190	50	190	50	200
IV. Contingency	4,230	2,100	2,130	440	450	290	300	340	340	340	340	340	350	350	350
T o t a l	32,330	16,080	16,250	910	5,910	2,640	1,850	3,030	2,130	3,080	2,150	3,010	2,250	3,410	1,960
	32,330			6,820		4,490		5,160		5,230		5,260		5,370	

the channel is designed to have a comosite section as presented in Dwg.VI-004.

1.4.2. Bank protection

At present, the river bank is eroded at many places along the river course. Notwithstanding, no bank protection works except pile groynes at quite few places are provided.

The proposed river improvement involves constructing long levee along both banks of the river, If no bank protection is considered, the bank erosion will develop at many places especially at sharply meandering section and extend to destruct the levees itself.

Sodding and stone pitching are, therefore, planned for those parts. The stone pitching is designed for the parts of sharp meandering with foot protection work. While, for the other parts, the slope of the levee is protected by sodding.

1.4.3. Drainage of inner basin

The run-off from the inner basin must not be ponded in the inland. The inland water is, therefore, gathered and drained through collecting ditches or channels which are connected with the tributaries near the back water end of the high water from the main Sala.

The tributaries are protected their floodings by the levee which is extended from the levee of the main river up to the back water end of high water.

1.4.4. Construction cost estimate

The total construction cost of the river improvement project is estimated at US$ 18.370.000, consisting of the foreign exchange component equivalent to US$ 6,350,000 and local currency of Rp. 4.988.3 x 10^6 (equivalent to US$ 12,020,000), as broken down in Table V-11. Yearly budgetary requirement is estimated as presented in Table V-12.

Table V-11 Estimate of Construction Cost of River Improvement

Item	Quantity	Unit	Unit Cost	Amount (US$)		
				Total	Domistic currency	Foreign currency
Construction						-
Excavation	$6,351 \times 10^3$	m^3	0.45	2,858,000	2,858,000	-
Banking	$4,823 \times 10^3$	"	0.4	1,929,200	1,929,200	-
Bank protection						-
Stone pitching	148×10^3	m^2	12	1,776,000	1,776,000	-
mattress basket	9 x "	m	20	180,000	180,000	-
Sodding	2,340 x "	m^2	0.14	327,600	327,600	-
Bridge (pier)	800	m^3	90	72,000	28,800	43,200
Sluice way	46	place	15,000	690,000	276,000	414,000
Interception drain	80,000	m	2.5	200,000	200,000	-
Equipment				3,650,000	-	3,650,000
Sub total				11,682,800	7,575,600	4,107,200
General expenses				1,747,200	1,134,400	612,800
Compensation				1,540,000	1,540,000	-
Engineering				1,000,000	200,000	800,000
Contingencies				2,400,000	1,570,000	830,000
Total				18,370,000	12,020,000	6,350,000

Table V-12 Yearly Budgetary Schedule

(x 10^3 US$)

	1978	1979	1980	1981	1982	1983	Total
Construction							
Equipment	3,630	-	-	5	1,100	-1,085	3,650
Others	1,630	1,630	1,630	1,630	1,630	1,630	9,780
Compensation	265	255	255	255	255	255	1,540
Engineering	170	166	166	166	166	166	1,000
Contingency	860	307	307	307	472	147	2,400
Total	6,555	2,358	2,358	2,363	3,623	1,113	18,370
Domestic currency	2,015	2,000	2,000	2,005	2,165	1,835	12,020
Foreign currency	4,540	358	358	358	1,458	- 722	6,350

2. Construction Plan and Schedule

2.1. Wonogiri Dam

2.1.1. Construction materials

(a) Embankment materials

The project construction includes approximately 1,850,000 m^3 of embankment work of which 1,750,000 m^3 will be required for dam including impervious blanket fill.

Investigation have shown that impervious core, filter and rock materials for the dam embankment are all available from areas within 3 km from the dam site.

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

(b) Concrete materials

Estimated total quantity of concrete works reach to about 65,000 m^3 including temporary facilities works. Aggregate will be supplied from the river deposit excavation in the foundation area of dam. It is presumed that the deposit will yield about 140,000 tons total requirement. The shortage will be supplemented from sand and gravel bars existing along the course of Kali Keduwan.

Construction cost estimate in this report assumes that cement will be imported from abroad. Required total quantity of cement will be about 4,500 tons including the requirement for grouting works.

Reinforcing steel bars of about 1,100 tons will also be imported from abroad.

(c) 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.

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

(d) Other materials

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

2.1.2. Construction facilities

(a) General layout

Construction facilities include residential quarters, offices, warehouses and shops, motor pool and repair shop, concrete and aggregate production plant, raw aggreagate stockpiles and various construction roads within total area of about 10 ha. A téntative layout of the facilities is shown in Dwg. IV - I

(b) Office and quarters

The government office and quarters will be built at a slope on the left bank area, about 600 m apart from the future powerplant site.

The quarter will provide adequate residences, mess halls, a guest house and other necessary facilities to accomodate about 80 supervisory staff from the government and construction for the accomodation of future operational personels after the completion of the works.

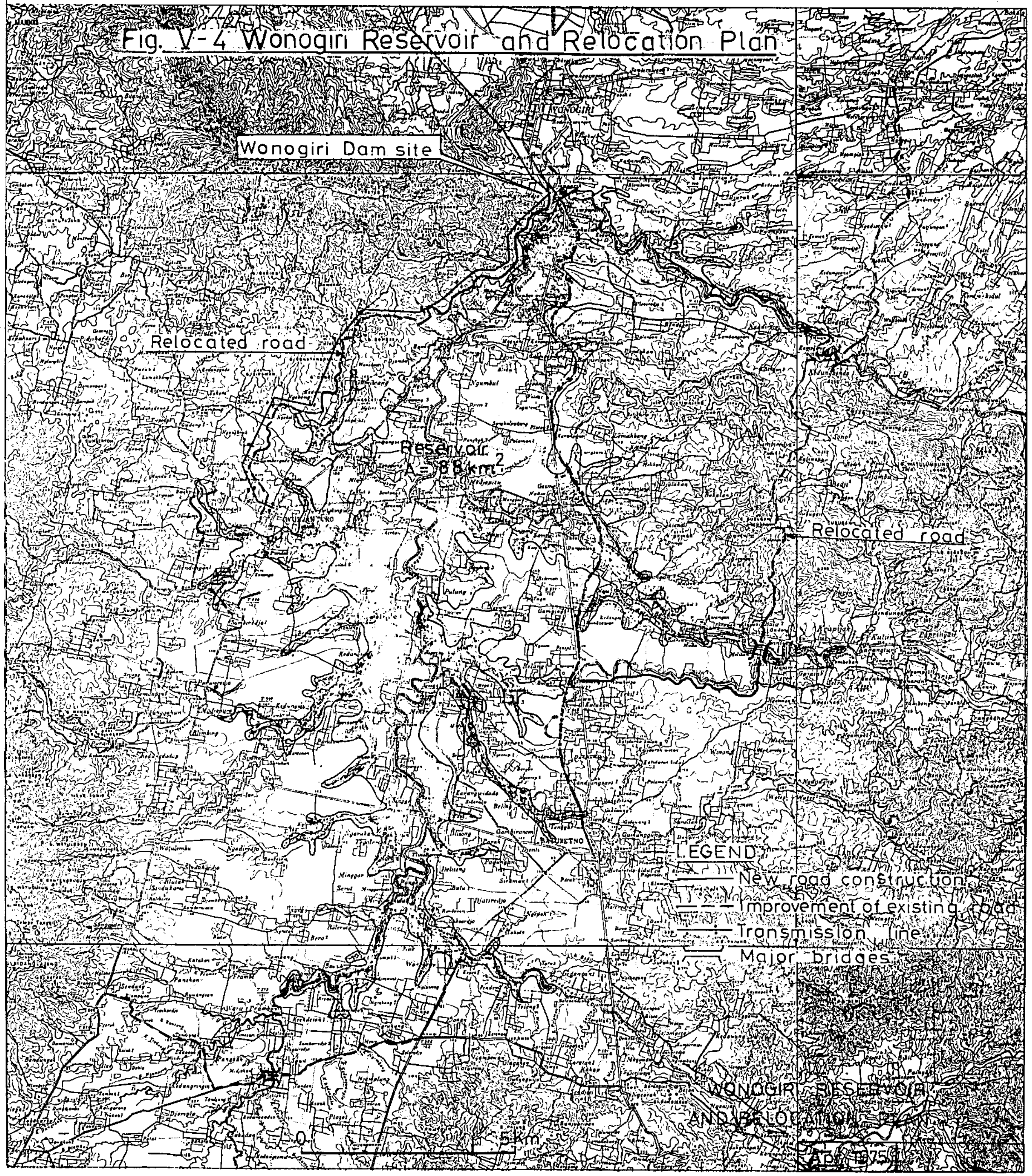
(c) Access road and bridges

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

(d) Road relocation near damsite

The existing road on the left bank of the damsite is to be relocated at an early period of the construction. The proposed route is shown on Fig.V - 4.

Fig. V-4 Wonogiri Reservoir and Relocation Plan



2.1.3. Construction plant and equipment

The dam construction works require about 45 items of construstion plant and heavy equipment.

Concrete production facilities will be one each of aggregate screening and concrete batching plant, 50 ton/hr and 24 m3/hr capabilities respectively. Major items of heavy equipment will be 1.2-2.7 m3 class shovels, 20-30 ton bulldozers and 8-15 ton dump trucks.

Construction power will be supplied from a diesel generating plant of 1,000 kw capacity. Two pumping station will supply construction water to varius sites including office and residesial quarters. The peak requirement of water supply is estimated to be about 8 m^3/min. Compressed air plant will be installed one each at the damsite and rock quarry.

2.1.4. Construction plant

(a) Implementation method

Chiefly from view of economy and the specialized operations involved in the construction works, it is recommended to execute the works on contract basis.

Competitive constructors should be selected through prequalification and tender procedures.

The main part of the dam and powerplant constructions may be divided into 3 or 4 separate contracts, that is main civil works, gates and penstocks, generating equipment and transmission system. Other preparatory construction works include the contracts for the government camp, road relocation and diversion conduit works respectively.

(b) Construction plan

Construction work will generally be done by conventional methods. Excavation will be mostly by the blading and ripping with bulldozers, loading by shovels and haulage 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 130,000 m^3. In the placement of fill materials, impervious core zone will be rolled in 15 cm layer and compacted by sheepsfoot roller. Pervious rock zones are placed in 0,5 m layer with compaction effected by vibrating roller. Core embankment will have almost to be suspended during the wet season, November to April.

Excavation and concrete works for the spillway will be divided in 2 areas, i.e. overflow weir and chuteway-stilling basin areas. Excavation in the overflow weir and upstream part of chuteway will be preceded to supply rock materials to the dam embankment. Concreting in the chuteway will progress intermittently in parallel with the intake, pressure tunnel and powerplant pour works.

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

During the intake excavation and concrete works in the area of El. 119.0,(.; a part of ground must be remained unexcavation to form a cofferdam at an height of El, 127.0.

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

2.1.5. Construction schedule

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

(i) Construction of a diversion conduit (. - 1977 to Apr. 1978).

(ii) Diversion of the 1978 dry season run-off through the diversion conduit. Dam foundation area is dewatered by upstream primary cofferdam and downstream cofferdam. (May to Oct. 1978).

(iii) River diversion throughout the year after the completion of main cofferdam. (Nov. 1978 to Sept.1980).

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

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

The downstream cofferdam will be removed before the spill-out of flow from the spillway.
Construction period of the dam and reservoir work will extend over a period of 5¼ years starting in early 1977 and completing in Mar. 1981. Construction works will proceed through the year, with maintaining 2 working shift except for the peak wet period.

2.2. Irrigation system

2.2.1. Basic consideration

Basic concsideration taken into account for planning of construction method and schedule are presumed as follows.

(1) Workable days, 180 days a year (May - November)

(2) Construction period, total 5 years except preparatory works.

(3) Work division of main canal construction, Dividing into 4 section for the right main canal and construction division will be established as shown below.

Table v-13 Work Division and Sequence of Construction of Main Canal.

Section	Main Canal type	length (m)	Construction year	Related Structure				
				Siphon	Aqueduct	culvert	Turn-out	Bridge
1	Right I	10,450	5 th	4	-	2	6	17
2	" II-III	15,000	3 rd	3	2	-	11	28
3	" IV-VII	19,400	2 nd	5	3	2	14	52
4	" VIII-XII	19,000	1 st	2	7	1	8	48
5	Left I - V	25,550	4 th	2	4	2	10	58

Table v-14 Work Division of Secondary Canal

...tion	Length (m)		
	Secondary C	Rehabilitation C	Total
1	23,900	-	23,900
2	12,700	5,100	17,800
3	30,900	8,700	39,600
4	32,600	17,900	50,500
5	12,100	1,000	13,100

Note : Construction year is same as that of main canal.

(4) Manpower to be employed , 5,000 man-day throughout the construction period.

(5) Allocation of construction force :
Main canal, excavation and embankment;
: 10 % man power
: 90 % mechanical.
Secondary canal excavation : 100 % man power
Farm ditch and drain : 100 % man power

2.2.2. Colo diversion weir

Construction of this weir is scheduled to be started from the 4 th. year taking into account availability of construction plants and equipment used for the Wonogiri dam. After the completion of the Wonogiri dam, the river flood could be decreased considerably and it makes possible to execute the construction work in less risky condition. Before starting the main works at the beginning of 4 th. dry season, necessary preparatory works such as access road, construction of quarters, power and water supply systems etc. will be completed.

Construction of the main works are divided into two stages. In the first stage, the excavation of weir fondation and coffering along the river side will be commenced first, and concreting of the weir body will be followed up. Meanwhile, riprap and bank rivetment in the up - and downstream of the weir will be proceeded.

Metal work and other auxiliary works of the weir will be executed in the succeeding rainy season or the next dry season. In the second stage, the excavation of the approach channel and outlet channel will be executed in parallel with the removal of the coffering and the river flow will be diverted into the new approach channel. The old river channel will be filled back with soil disposed it the site.

2.2.3. Canal

Construction will be started at any place where easy access is obtainable. Excavated soil will be used all for the embankment of road dyke. Materials for embankment part of the canal will be hauled from borrow areas which will be selected near by the construction site.

Construction of the crossing structures over and / or under the tributaries shall be scheduled to complete within dry season to avoid the risk of unexpected high flood. The dowstream end of each canal under construction has to be connected to the nearby tributaries or drainage channel to maintain the canal in dry condition, even in rainy season.

Hauling the embankment material, and spreading and tamping, for the secondary canal, if necessary, will be carried out partly by mechanised execution. The outer slope and the shoulder part at both sides of the canal dyke will be protected by sod facing.

2.3. River improvement

2.3.1. Construction plan

The river section of the project will be divided into three sections. The work section-I is the reach from the cross section No.0 to No.19 including K.Samin, the work section-II is from No.19 to No.31 including K.Brambang, K.Serenan, K.Dengkeng and K.Kupang and the work section-III is from No.31 to No.53 including K. Jlantah.

The major work volumes in each work section are given below.

Work section	I	II	III	Total
Distance includ tributies	13.2	19.8	16.7	49.7
Work volume, Excav	2,484	2,236	1,751	6,351
($1.000\ m^3$) Banking	1,659	1,836	1,328	4,823

Since the inundation area between the confluence with K.Samin and that of K.Jlantah is the largest in the project area, the work section-I , the upstream part of the section-II (and the downstream part of the section-III) should be implemented fisrt from the place needed urgent improvement.

2.3.2. Construction schedule

The construction period is scheduled to extend about 6 years in total from 1978 to 1984, assumed that the possible working days is limited to 180 days ayear, only, during dry sesaon.

2.4. Construction time schedule

Overall time schedule for the construction works of the Wonogiri multipurpose project is presented in Fig v-5 in bar chart.

2.5. Construction plant and equipment

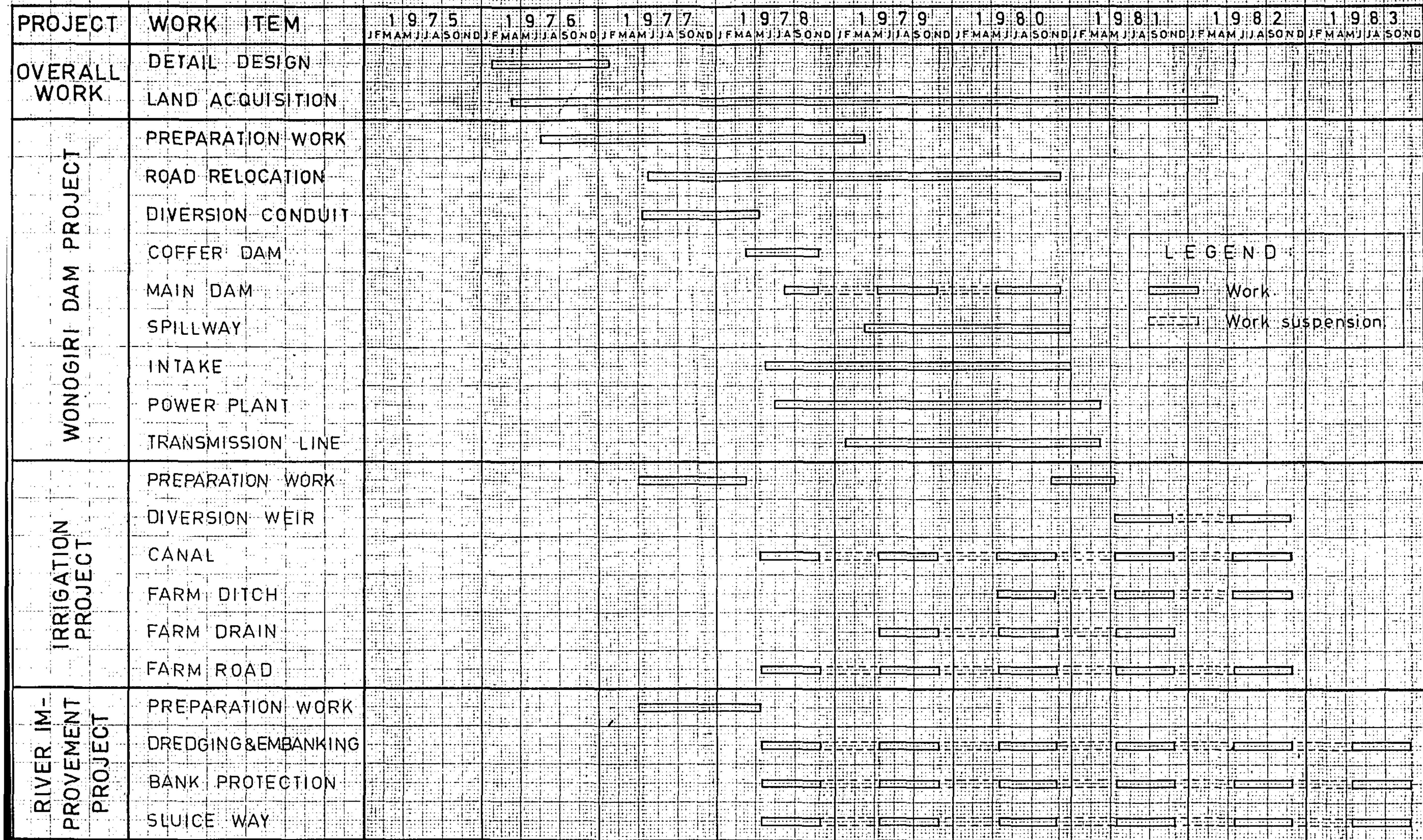
2.5.1. Local availability

Construction plants and equipment necessary for the Wonogiri multipurpose project include wide variations of type, capacity, and number.

There exist no domestic manufacturers and assemblers of such heavy duty machinery at present. Many kinds and number of construction plants and equipment have been imported for the various similar projects and some of them have suitable capacities usable for work execution of Wonogiri project, most of them are fully engaged and not to be transferable to this project. All plants and equipment for this project are, the refore, to have been imported.

WONOGIRI MULTIPURPOSE PROJECT

Fig. V-5 PROPOSED CONSTRUCTION SCHEDULE BY BAR CHART



2.5.2. Wonogiri dam

(1) Construction plant

(a) Aggregate plant

The capacity of the plant must be enough to produce the aggregate of 116,000 tons for concrete volume of 55,000 m^3 in total except concrete for the preparation works.

At daily placing requirement of concrete about 200 m^3, the plant has to process aggregate at the rate of 50 tons per hour assuming the operation of 14 hours a day and working efficiency of 0.6.

The simple type plant consists of a primary crusher, several stages vibrating screens and other accessoiries.

(b) Concrete plant

The average requirement of concreting during the main construction period is estimated at 13 m3/hour. But peak requirement a day will reach to 200 m3 in busiest work stage.

The production capacity of the plant, therefore, must cover this peak requirement of 17 m3/hour in the operation of 14 hours a day and working efficiency at 0.85. A semi-automatic concrete plant of 21 cft. x 2-mixer is adopted.

(c) Water supply system

Required water volume to be used in the project is estimated at 8.4 m3 per minute as shown in the list. The water is pumped up at the upstream of the dam and sent to water pool at arround EL.150 m through a 300 mm dia. water pipe line.

Three units of 200 mm dia. centrifugal pump driven by 75 kw motor will be installed in a pump station including one unit for spare.

Water Requirement List

Item	Requirement
1. Aggregate plant 50 ton/hr	1.5 m3/min.
2. Concrete plant 21 cft. x 2	0.2
3. Repair shop	0.8
4. Saw mill	0.1
5. Stock yard & motor pool	1.0
6. Warehouse	0.1
7. Office	0.1
8. Government living quarter	0.2
9. Contractor's living quarter	0.1
10. Labourer's quarter	0.3
11. Dam site	2.0
12. Diesel generator	1.0
13. Others	1.0
Total	8.4

(d) Power supply system

Electric power generated by 2 units of 500 kw diesel generator is distributed to each site by 20 kv transmission line. The peak requirement of power at every site in the project is totaled to 630 kw assuming the power demand factor of 0.45. In usual case, one generator can supply enough power to the sites.

Power Requirement

Item	Requirement
1. Aggregate plant 50 ton/hr	200
2. Concrete plant 21 cft x 2	50
3. Water supply	225
4. Lighting for road	20
5. Lighting for dam site	30
6. Repair shop	100
7. Saw mill	30
8. Stock yard & motor pool	5
9. Quarter & office	150
10. Dewatering pump	100
11. Welding work for plants	300
12. Others	200
Total	1,410

(e) Fuel supply system

Fuel to be consumed by equipment and mobiles used in the project is estimated at 30.000 litters of light oil and 5.000 litters of gasoline at the peak time in aday.

Fuel will be supplied by fueltanker to the equipment, which can not easily come to the place of fuel supply facility, but other equipment come to the place getting it.

Three stock and supply facilities will be installed. The stock volume of each facility is estimated to be three times of daily consumption.

(1)	Fuel tank on the ground	(light oil)	
	volume	20.000 x 4 tanks.	
(2)	Fuel tank under ground	(light oil)	
	volume............	10.000	x 1 tank
(3)	Fuel tank under ground	(gasoline)	
	volume	15,000	x 1 tank

Fuel tank on the ground will be erected beside diesel generator plant because it is conbinient to directly supply by pipe line to the plant, the biggest consumer.

(2). Construction equipment

On the basis of the items, quantities, period field conditions of the construction works. The numbers and their capacity of the equipment, to be requirement for the works are selected as shown in Table V-15.

2.5.3. Irrigation Project

(1) Construction plant

Concrete structures of the irrigation project can be divided into two kinds of structure. One is the minor structures being not much required the material control and another is the structure of Colo weir being rigidly required the material control. Therefore it is planned to transfer the screeing plant, the concrete plant and other from the dam project for Colo weir of which construction is scheduled after completion of the dam.

Water supply, power supply and fuel supply for the irrigation project are planned only at the Colo weir site. Those necessary for canal construction are provided at each site by portable pumps, generaters and tanks.

(a). Power supply at Colo site

During the construction period of Colo weir, big power to drive the plants transfered from the dam project will be required. For the purpose of supplying the electric power to the plants and after the completion of the project, generated power at the dam project will be sent to the site by 20 kv transmission line. The transmission line will be constructed before the commencement of Colo weir.

(b) Fuel supply

Fuel consumption by the equipment and mobils is estimated at 10.000 litters of light oil and 2.000 litters of gaseline at the peak time a day. Supply method of fuel is the same as that in dam project.

(2) Construction equipment

Major part of the works is shared by the earth moving for canal construction and even in the contruction of the Colo weir. Selection of the equipment is worked out paying attention to combine efficient equipment for earth works.

Necessary equipment for the irrigation project are listed in Table V-16.

2.5.4. River improvement

(1) Construction plants

No particular stationed plants are deemed necessary because most work consists of earth moving in the river channel.

Water, power and fuel supply systems for this work execution are planned following to the canal construction of the irrigation project.

(2) Construction equipment

Since the major parts of the construction work consist of excavation or dredging in the river bed and embankment of the levee extending along the distance of about 32 km, the selection of equipment is worked out from such a point of view as they can use in common and widely for many works. Table V-17 shows the equipment list for the river improvement work.

Table V-15

Construction Plants & Equipment for Dam Project

No.	Equipment	Capacity	Quantity Total	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.	Wheel loader	2.7 m3	6	3	3
7.	Crawler loader	2.0 m3	5	2	3
8.	Power shovel	1.2 m3	3	3	-
9.	Back hoe	0.6 m3	1	1	-
10.	Heavy dump truck	15 ton	15	15	-
11.	Dump truck	8 ton	55	40	15
12.	Agitator truck	3.2 m3	6	6	-
13.	Truck crane	50 ton	1	1	-
14.	- do -	30 ton	1	1	-
15.	Cargo truck	6 ton	15	10	5
16.	Vibration roller	15 ton	1	1	-
17.	Sheep foot roller	20 ton	1	1	-
18.	Road roller	8 ton	4	1	3
19.	Trailer truck	30 ton	1	1	-
20.	Motor grader	3.7 m	3	1	2
21.	Crease car	6 ton	2	1	1
22.	Maintenance car	6 ton	1	1	-
23.	Fuel tanker	8 ton	3	2	1
24.	Water tanker	8 ton	4	2	2
25.	Fork lift	3 ton	1	1	-
26.	Boring machine	max 150 m	6	6	-
27.	Grout mixer & pump	150 l/min	4	4	-
28.	Crawler drill	3 inch bit	3	3	-
29.	Leg drill and shinker	2.7 m3/min.	25	15	10
30.	Pick hammer	1.2 m3/min	25	15	10

No.	Equipment	Capacity	Quantity Total	Quantity Dam	Quantity Road replacement
31.	Portable air compressor	17 m3/min	10	8	2
32.	Concrete pump truck	8 inch	1	1	-
33.	Concrete sprayer	2 inch	1	1	-
34.	Centrifugal pump	8 inch	4	4	-
35.	Submergible	6 inch	6	6	-
36.	- do -	4 inch	6	6	-
37.	Air tamper	hand type	15	15	-
38.	Fuel supply system		1	1	-
39.	Saw mill		1	1	-
40.	Repair shop		1	1	-
41.	Ripper attachment Bull	30 ton	5	3	2
42.	Crane attachment Shovel	1.2 m3	2	2	-
43.	Dragline attachment	- do -	1	1	-
44.	Back hoe attachment	- do -	1	1	-
45.	Miscellaneous		L.S.	L.S.	L.S.

Table V-16

Construction Plants & Equipment for Irrigation Project

No	Equipment	Capacity	Quantity Total	Quantity Purchased	Quantity Transfered from the dam
1.	Bulldozer	20 ton	16	16	-
2.	Crawler loader	2.0 m3	5	5	-
3.	Back hoe	1.2 m3	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 m3	4	4	-
14.	Concrete plant	21 cft x 2	1	-	1
15.	Agitator truck	3.2 m3	3	-	3
16.	Pump w/ engine	4 inch	8	8	-
17.	Road roller	8 ton	2	2	-
18.	Sreening 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 attach ment shovel	1.2 m3	3	3	-
23.	Power shovel attach ment shovel	1.2 m3	3	3	-
24.	Miscellaneous		L.S.	L.S.	-

Table V-17 Construction Plants & Equipment for River Improvement Project

No.	Equipment	Capacity	Quantity
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.	Mator grader	3.7 m	2
7.	Vibrition 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	
		1.2 m^3	3
19.	Repair shop		L.S.
20.	Miscellaneous		L.S.

3. Construction Management and Organization

3.1. Executive agency of 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 project as experienced in many other similar projects in Indonesia. The DGWRD is also entrusted the execution of the power plant construction by The Public Corporation of Electricity (PLN). Meanwhile, the design of the power equipment and construction of power transmission facilities will be executed by the PLN. itself, cooperating with the DGWRD.

As for the resettlement in the reservoir area concerned, the local governor (BUPATI) will take necessary actions under the instruction of the Provincial Governor of Central Java.

3.2. Executive agency at project site

For the execution of construction works in the project area, the existing Central Office of Bengawan Sala Project (PBS PUSAT) will be entrused 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 and control the field operations.

One field office tentatively named (RRO WONOGIRI) as the office of Wonogiri project will be need to be organized under the control of the PBS PUSAT. This field office will carry out day to day field works, such as design and supervising field works, procurement of the necessary materials for construction, maintenance of the plants and equipment, operation of field and laboratory test, and other administrative works.

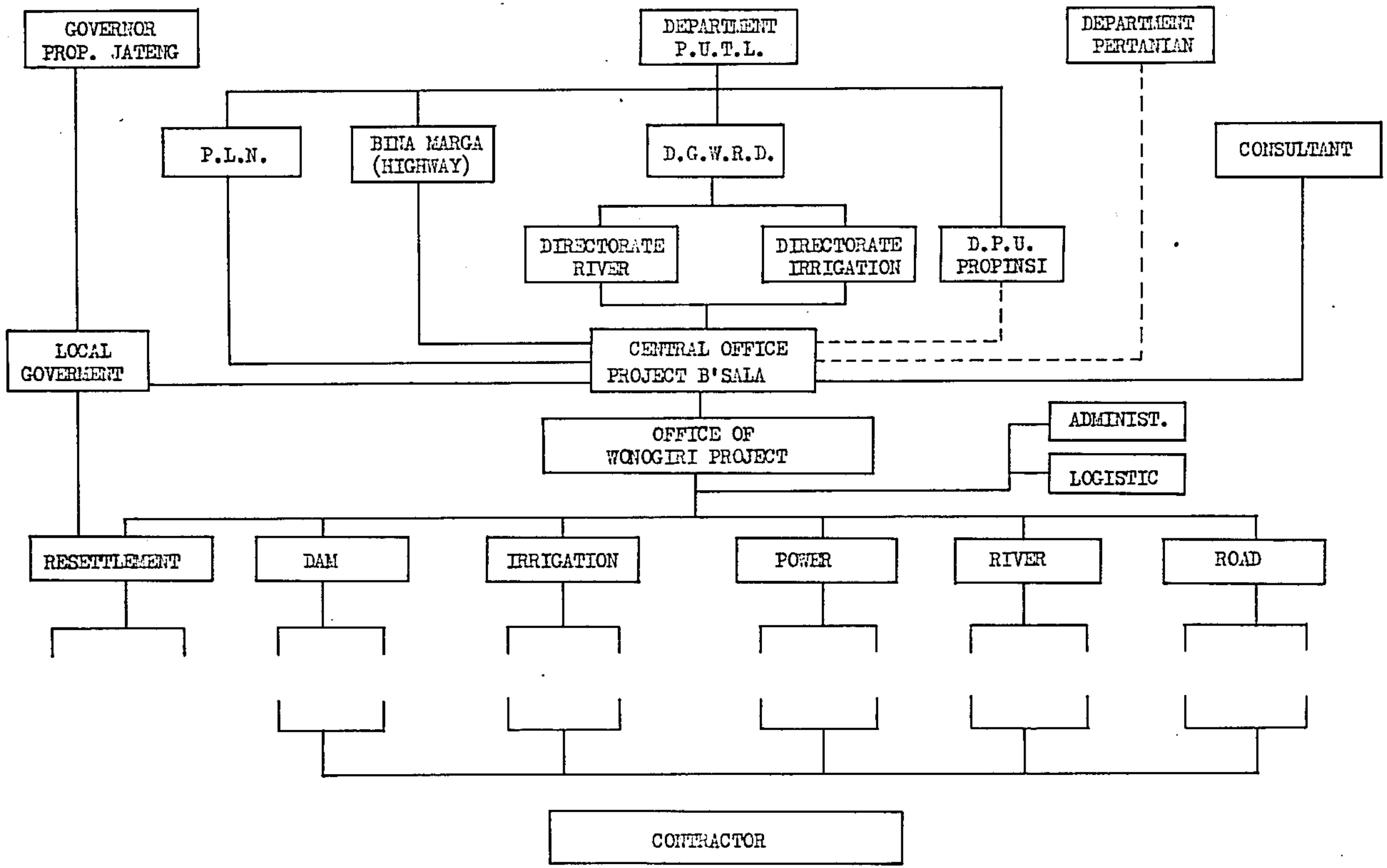
Necessary staff will be appointed to the respective sections. And the daily field operation will be carried out in close operation with local offices of Public Works Development and the local governmental office.

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

Besides, an outside technical assistence by consulting engineers from foreign and/or local should be provided at the PBS PUSAT for accumulating technical knowledge for the construction and operation of the project, and for successful performance of the construction work.

Construction organization chart is presented in Fig. V-6.

Fig. V - 6 Organization Chart.



VI. PROJECT EVALUATION

1. General

The project evaluation in this chapter aims to ascertain the feasibility in view of economic and social considerations. Prior to the economic evaluation, selection of the most optimum scale of the project is conducted through comparative study on the basis of the net present worth which is presented in Appendix.

Economic analysis made for the selected optimum scale of the project using internal rate of return method together with sensitivity analysis concerning the implementation timing of the irrigation facilities and costs fluctuation.

Farm budget is also analysed for confirmation of the feasibility from farmer's economy.

Finaly social impacts of the project are taken into consideration for the project analysis.

The approach and procedure used in this chapter are designed to produce conservative estimate.
It is contemplated that the prices and costs in the analysis reasonably reflects 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" principale.

Costs and benefit are estimated basically in 1974 money value. All conversions from Rupiah to Dollar value are made at an exchange of Rp. 415 = $ 1.

The evaluation is conducted generally for the 50 - year period 1976 - 2025. The projection and evaluation for a period of this length might be rather conservative in relation to the likely economic life of the water storage facilities as weel as the irrigation system.

2. Economic Evaluation

2.1. Project 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.

2.1.1. Primary benefits

Primary bebefits are comprised of irrigation benefit, flood control benefit and hydropower benefit. Negative benefit on the submerged area resulting from the reservoir is also included in the analysis. The summary of the annual primary benefits are presented in the following table.

Table VI-1 Summary of Benefits

(US.$ 1,000)

Benefit	Annual
Irrigation Benefit	13,290
Flood Control Benefit	4,980
Electric Power Benefit	2,200
Negative Benefit	- 820
Total	19,650

For the economic evaluation, the development period of the irrigation benefit is assumed at 5 year after the completion of irrigation facilities.
Flood control benefit is expected to accrue after the coffer dam is completed and contimue to increase stepwise correspoding to the completion of the dam and of river improvement works until 1984.

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

2.1.2. 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 markets 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 increase opportunity for recreation and tourism. The opportunities for recreation in Indonesia at present are limited. However, experience in other countries has shown that, as the standart of living improves, there is proportional increase in the demand for recreation facilities. 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 road network in the irrigation area. This expanded road system will improve the inadequate transportation condition at present and facilitate agricultural activities.

Municipal water supply will be possible to Surakarta city from the Wonogiri Reservoir. Since the quantity of the water now available in the city is not sufficient and the demand will increase with population growth and income increase, it will be necessary to meet 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.

2.2. Project Costs

2.2.1. Construction cost.

The construction cost of the Wonogiri Multipurpose Dam project are estimated on the basis of 1974 price level. The total construction cost will be US$ 110 millions comprising the foreign currency portion of US$ 50.2 millions and local currency portion of US$ 59.8 millions, which includes the construction of dam, land acquisition for reservoir, road relocation, irrigation facilities. These costs are briefly summarized into Table VI-2 by each item. Annual disbursement schedule is also summarized in Table VI-3 for the economic analysis of the project.

Table VI-2 Summary of the Project Costs

(US.$ 1,000)

	Foreign C. Portion	Local C. Portion	Total
I. Dam			
Dam	(12,070)	(6,830)	(18,900)
Road relocation	(800)	(8,200)	(4,000)
Land acquisition	(-)	(15,300)	(15,300)
Sub Total	12,870	25,330	38,200
II. Power	9,370	1,510	10,880
III. Irrigation	12,920	13,680	26,600
IV. River improvement	4,720	10,250	14,970
V. Engineering	3,900	1,100	5,000
VI. Contingencies (15%)	6,420	7,930	14,350
Total	50,200	59,800	110,000

Table VI-3 Disbursement Schedule for the Project Construction

(US $ 1,000)

	1976	1977	1978	1979	1980	1981	1982	1983
I. Dam	830	8,530	12,070	14,070	2,700	-	-	-
	(830)	(4,240)	(8,440)	(9,430)	(2,390)	-	-	-
II. Power	-	-	-	3,270	7,610	-	-	-
				(450)	(1,060)			
III. Irrigation	-	5,610	3,690	4,240	4,310	4,330	4,420	-
		(410)	(2,310)	(2,640)	(2,690)	(2,620)	(3,010)	
IV. River Improvement	-	-	5,520	1,890	1,880	1,890	2,990	800 ∠1
			(1,710)	(1,710)	(1,710)	(1,710)	(1,710)	(1,700)
V. Engineering and Adiministration	50	720	1,030	1,110	1,110	410	410	160
	(50)	(160)	(230)	(230)	(230)	(80)	(90)	(30)
VI. Contingencies	70	2,060	3,130	3,950	2,830	1,000	1,170	140
	(70)	(1,000)	(1,670)	(2,270)	(1,450)	(600)	(770)	(100)
T o t a l	950	16,920	25,440	28,530	20,440	7,630	8,990	1,100 ∠1
	(950)	(5,810)	(14,360)	(16,730)	(9,530)	(5,010)	(5,580)	(1,830)

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

∠1 : Total cost is less than local currency portion due to inclusion of salvage value of the construction machineries.

The land acquisition cost includes the resumption costs of yard, housing quarters and resettlement allowance for the families. The costs for the resumption of sawah and tegal are excluded in the estimated costs, of which value is calculated on the basis of the agricultural outputs and incorporated in the benefit as an annual negative benefit.

Land resumption costs are based on a survey of the reservoir area made by DPUT in 1975 and unit costs estimated from the same data. The resettlement allowances for the displacement are calculated on the basis of the unit price prepared tentively by DPUT.

The summary of the land acquisition cost is presented in the following table.

Table VI-4 Land Acquisition Cost for Wonogiri Reservoir.

	Quantity (ha, Nos.)	Amount (Rp. x 10^3)
Housing 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
Allowance for Resettlement	9,834	2,950,200
Total		6,363,070

(equiv. to US$ 15,300,000)

2.2.2. Operation, maintenance and replacement costs.

The total annual cost for operation , maintenance and replacement of the project is estimated at US$ 0.5 million. The summary of the costs by puposes is presented in the following table.

Table VI-5 Annual Operation, Maintenance and Replecement Cost.

Purpose	Amount (US$ 1,000)
Dam and Reservoir	35
Irrigation	130
River Improvement	20
Power Plant	315
Total	500

2.3. Evaluation

The evaluation of the project is carried out by means of internal rate of return method. Based on the benefits and costs estimated above, the rate of return is estimated at 12,8% for 50-year period which indicates considerable soundness of the project.

Sensitivity analysis

Sensitivity study is made for the analysis of the effect of the construction timing of the irrigation system which is considered to give critical effect on the feasibility of the whole project. The project life is also taken into account for 50 years.

Internal rate of return is estimated in the following cases.

Case I Construction of the irrigation system will complete after 2-year of the dam construction.

Case II Construction of the irrigation system will complete after 5-year of the dam construction.

Case III Construction of the irrigation system will complete after 12-year of the dam construction.

The calculated internal rates of return are as follows :

	Case I	Case II	Case III
Internal Rate of Return	12.8%	11.9%	9.9%

Sensitivity analysis is made also for the fluctuation in the project construction cost.
Internal rates of return are estimated in the following cases.

Case IV   project costs will increase by 5%
Case V   project costs will increase by 10%
Case VI   project costs will decline by 5%.

The calculated internal rates of return are shown in the following table.

	Case IV	Case V	Case VI
Internal Rate of Return	12.3%	11.8%	13.3%

3. 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 River Basin Development ", sample farm survey was carried out for reestimating the typical farm budget in the project area, which includes the investiga tion 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 o.46 ha of sawah and o.o6 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 the 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 VI-6 and Table VI-7

Upon completion of the project, crop income is expected to increase substantially from Rp. 133,410 or US$ 321 to Rp. 304,790 or US $ 734, 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 the resulting net income, which is defined as the difference between farm income and production costs will reach the level of Rp. 246.450 (or US $ 594).

Since the family size is estimated at 4.9 in the project area, percapita income will be well over US $ 120, indicating enough soundness of the project from farmers view point compared with of some US $ 50 without the project.

Annual net reserve or capacity to pay will also grow from Rp. 39.350 or US $ 95 to Rp.138,530 or US$ 334 in spite of the expected increase in living expenses. The increased net reserve indicates sufficient capacity to pay water charge for the irrigation water in the future.

Table VI-6 Typical Farm Budget Without Project

I t e m	Amount (Rp)
I. Farm Income	
Crop Income /1	133,410
Other Income /2	28,740
Total Gross Income	162,150
II. Farm Expenses	
Production Costs	
Crop Production Costs /3	41,530
Other Expenses /4	7,220
(Sub-total)	(48,750)
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)	39,350

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".

Table VI-7 Typical Farm Budget With - Project

	I t e m	Amount (Rp)
I.	Farm Income	
	Crop Income /1	304,790
	Other Income /2	35,900
	Total Gross Income	340,690
II.	Farm Expenses	
	Production Cost	
	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)	138,530

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".

4. Social Impact

The project will have social impact on a great many people and institution.

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, increased job opportunity will no doubt raise the regional income substantially.

Besides, the project will offer considerable opportunities to Indonesian experts for gaining expereience in under-taking the large scale multipurpose dam project.
Through this kind of effect called transfer of knowledge, Indonesia will accumulate sufficient staffs for the execution of development projects under its own responsibility.

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,. Housing quarter will be improved with the additional income.

Healthand sanitation conditions will improve upon completion of the flood control systems including dam and river improvement.

Electrification will be facilitated in the region through the installation of Wonogiri Power Station,which will contribute to the improvement of living condition considerably.

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

5. Conclusion.

The project shows an internal rate of return of 12.8% for a 50-year period. This rate of return is considered to be attractive and justifies the implementation of the project from the economic view point.

Sensitivity analysis indicates that the construction timing of the irrigation facilities affects the overall feasibility of the project considerably , while cost fluctuation gives slight influence on it.

Farm budget analysis also shows the viability of the project from the view point of farmers economy.

Besides the primary benefits, secondary benefits such as from fishery, recreation and tourism are expected, all of which will give favourable socio economic im acts for the country.

It is therefore recomended that the goverment should proceed with the construction of the Wonogiri Multipurpose Project in view of the country's need to attain self-sufficiency in the economy.

VII. RECOMMENDATION FOR FURTHER STUDY

1. Scope of Work

Next to the identification of the viability of project, the detailed engineering works should be followed for preparation of implementation of the construction works. Quicker preparation of implementation program for detailed engineering is, therefore, strongly recommended.

Desirably, the additional field survey, investigations and study, the detailed planning and designs of all the structures, and the preparation of necessary documents for bidding are included in its scope.

With this respect, the scope of work to be rendered to the detailed engineering are explained hereunder in some details.

(1) Review of all the pertinent reports, data, plans and designs, drawings and aerial photo-maps in the project area being newly prepared.

(2) Review of the feasibilty study worked out this time and formulating of the final project concept, design criteria for all the structures and necessary supporting works in the field and laboratory investigations.

(3) Performing of additional ground survey of levelling, traverse and section survey and plane table topographic survey for the structure sites and in the project area.

(4) Additional geological and soil mechanical investigations including auger boring and pitting (canal and transmission line route), machine core drilling, grouting test, blasting test of quarry, laboratory testing.

(5) Additional material investigation including laboratory tests of quarry, borrow areas and aggregate pits.

(6) Inventory survey of the existing facilities including irrigation and drainage canals, roads, railway, bridges, sluices and pumps.

(7) Additional agronomic survey and study including the

existing land use on the basis of new 1:5,000 map, demarcation of irrigation area and cropping pattern.

(8) Assisting and advising the Government in inventory suvey, preparatory undertakings for resettlement in the reservoir area.

(9) Preparation of the detailed project layout, engineering and construction schedules.

(10) Preparation of the final plans, detailed design and drawings, technical specifications and tender documents for all works including;

(a) for Wonogiri dam,
cofferdam, main dam, spillway, diversion conduit, intake and tunnel, penstock and valve, powerhouse and other appurtenant structures, generating equipment, transmission facilities.

(b) for irrigation,
diversion weir, irrigation canals and related structures such as turnouts, diversion and spillways, sluices, culverts, siphons, aqueducts, bridges, and on-farm network such as farm ditches, drains and roads.

(11) Assisting and advising the Government in the preparation of the final plans, detailed design and drawings, technical specification and tender documents for local bidding for preparatory works.

(12) Preparation of cost estimate of the project works and construction time schedule.

(13) Preparation of list of necessary equipment, machineries with spare parts, and materials, and preparation of their specifications and tender documents for procuremnet.

(14) Providing on-the-job training to the counterpart personnel in survey, design including laboratory testing practice.

2. Implementation Period

According to the present schedule for the feasibility study, the final submission of the feasibility report is set at the end of September 1975.

Moreover, the period from Nobember to March is not convenient to carry out the field survey and investigations because of rainy season. The time schedule for the detailed engineering is, therefore, tentatively set out as shown in Fig.VII-1.

3. Required personnel

For the performance of the detailed engineering covering the aforementioned scope of work, a considerable numbers of engineers and specialities of engineers both from the consultant and counterpart of the .Government will be required.

Necessary expertise will have to cover the following specialities; planning and design of dam and related structures, diversion weir and irrigation facilities, powerhouse building, power plant, transmission line and substation, road and bridge, engineering geology, soil mechanic, foundation treatment, agronomy, metal works, plant and equipment, construction and etc. Besides the above engineers, some technical experts will be necessary in ground survey work, and drilling and blasting works.

4. Displacement of Persons from Reservoir Area

Upon completion of the Wonogiri reservoir, approximately 7,000 ha of cultivation land will have to be abandoned and over 47,000 persons will be displaced.

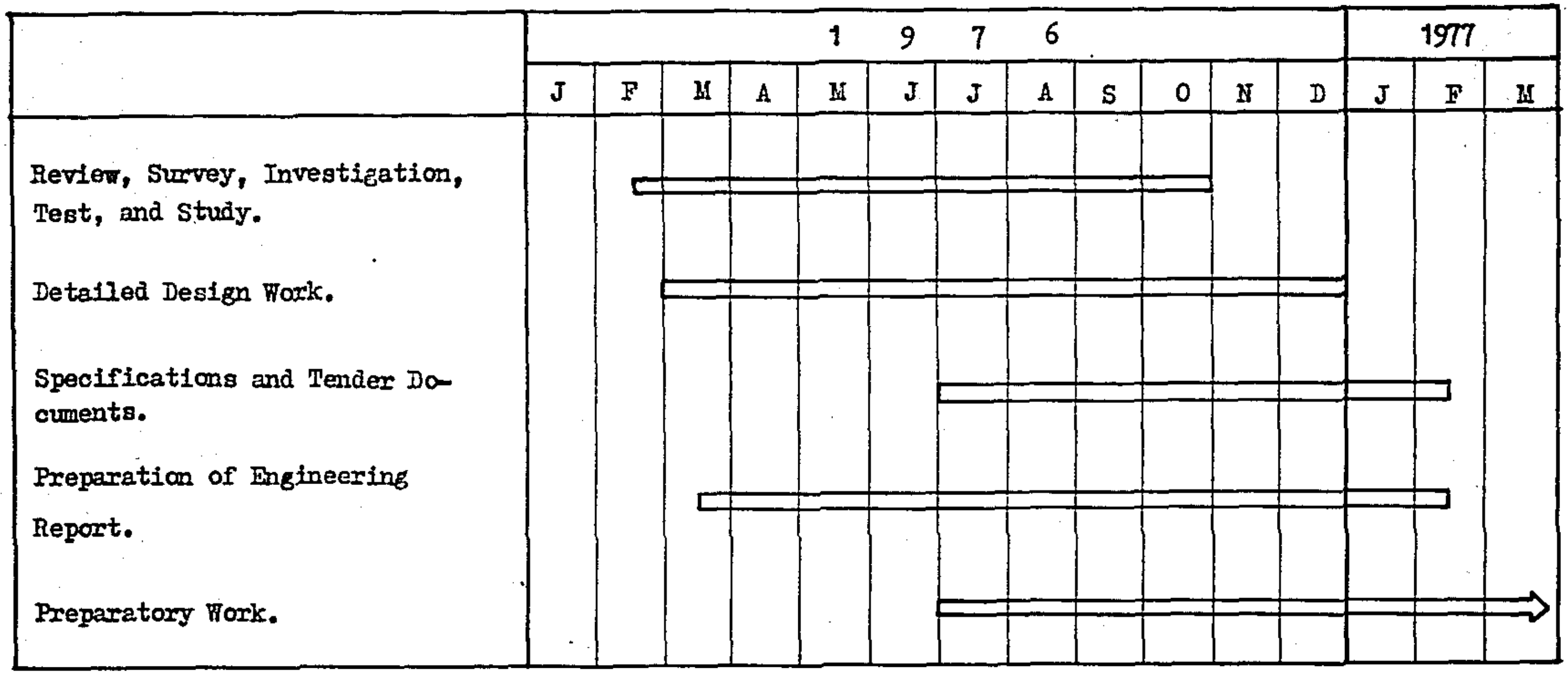
It is therefore contemplated that resettlement of the displaced people and securing alternative employment opportunity for them will be important problem for the successful execution of the project.

At present, a special committee headed by chief of Kabupaten is established to tackle with this problem in colabolation with Gajah 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 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 a initiative step based on the recommendation of the committee for the early implementation of the project.

Basic policies in respect to the resettlement of the people should be formulated as soon as possible in the above mentioned ad-hoc base consulting with the related Ministries and inform to the special committee in Kabupaten so that they can take necessary actions. Important is to give the people enough time evacuating their properties and deciding their future planning. Resettlement must be corporated with arrangement of vocational training for acquiring alternative employment, since most of the people affected are unskilled labour, if in off-farm.

Fig. VII - 1 Tentative Time Schedule for Detatield Engineering.



APPENDIX THE COMPARATIVE STUDY FOR 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)	1,750	1,550	1,330
Reservoir Storage (10^6m^3)	660	536	410
Irrigation Area (ha)	23,600	15,600	8,500
Power			
Installed Capacity (kW)	11,200	13,600	8.400
Yearly Energy (kWh)	27,100	24,400	22,400

The net present worth method is apllied in this study, where the social 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 $)

	Plan A	Plan B	Plan C
Irrig. Benefit	13,290	8,780	4,790
Flood-Control Benefit	4,980	4,980	4,980
Power Benefit	2,200	2,500	1,700
Negative Benefit	- 820	- 740	-660
Total	19,650	15,520	10,810

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 & Power	59,300	58,000	51,400
River Improvement	18,370	18,370	18,370
Irrigation	32,330	21,840	12,750
T o t a l	110,000	98,210	82,520

Summary of Operation, Maintenance and Replacement Costs (US 1,000 $)

	Plan A	Plan B	Plan C
Dam & Power	350	380	320
River Improvement	20	20	20
Irrigation	130	90	50
T o t a l	500	490	390

4. Evaluation

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

(US 1,000 $)

	Plan A	Plan B	Plan C
Net Present Worth	20,356	11,765	2,012

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