BASIC DESIGN STUDY REPORT
ON
THE PUMPING STATION PROJECT
FOR
BENGAWAN SOLO LOWER REACHES
IN
THE REPUBLIC OF INDONESIA

JUNE 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Government of Japan decided to conduct a basic design study on the Pumping Station Project for Bengawan Solo Lower Reaches and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Indonesia a study team headed by Mr. Norifumi Takamura, Deputy Director, Construction Department, Kyushu Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries, from December 4, 1990 to January 17, 1991.

The team held discussions with the officials concerned of the Government of Indonesia, and conducted a field study at the study area. After the team returned to Japan, further studies were made. Then, a mission was sent to Indonesia in order to discuss a draft report and the present report was prepared.

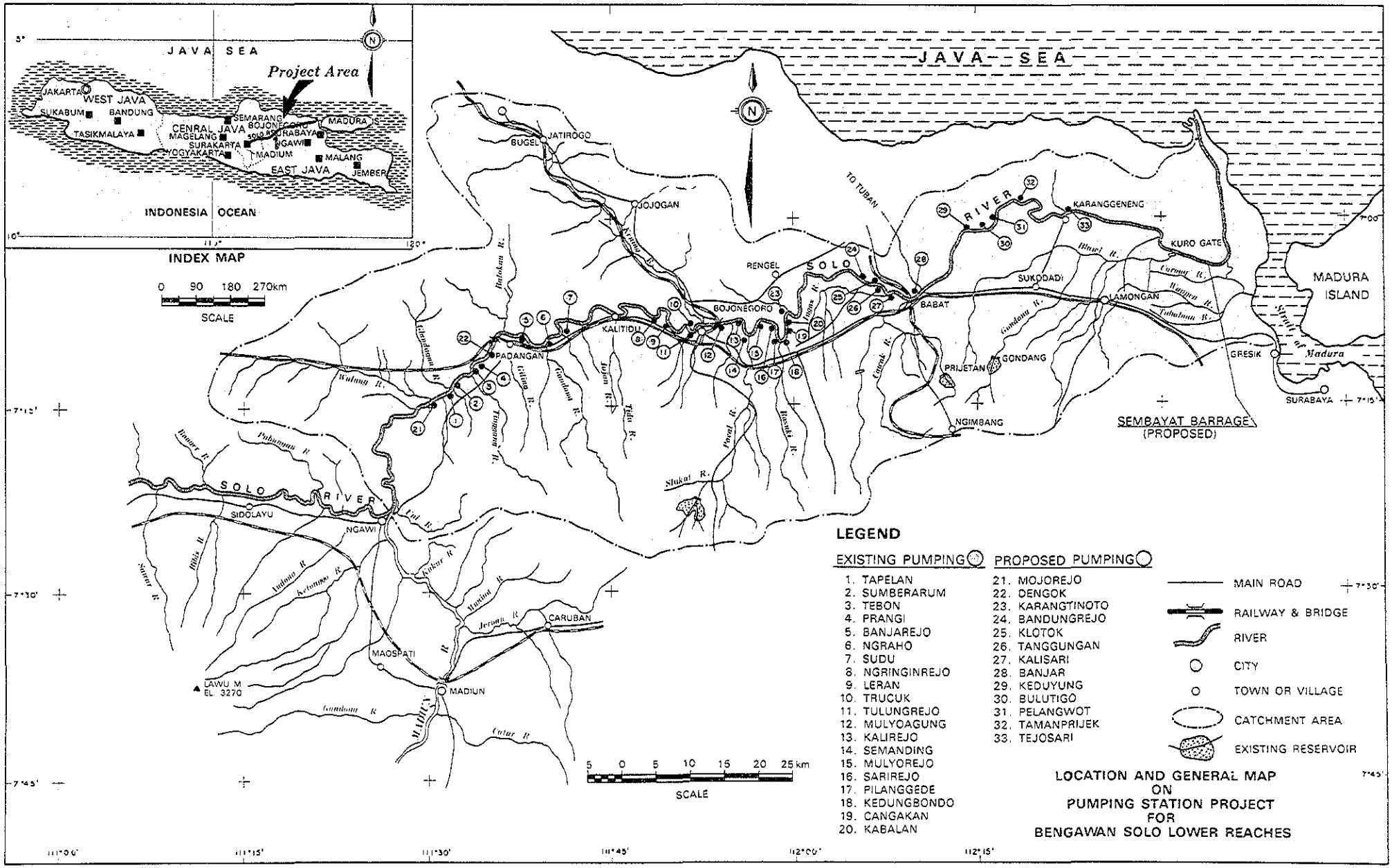
I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of Indonesia for their close cooperation extended to the teams.

June 1991

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency


JAVA SEA
Project Area
JAKARTA
WEST JAVA
SUKABUM
BANDUNG
TASIKMALAYA
CENRAL JAVA
MAGELANG
SEMARANG
BOJONEGORO
SURABAYA
MADURA
SURAKARTA
NGAWI
YOGYAKARTA
MADIUM
MALANG
EAST JAVA
JEMBER
INDONESIA OCEAN
INDEX MAP
0 90 180 270km
SCALE
JAVA SEA
BUGEL
JATIROGO
TO TUBAN
JOJOGAN
RENGEL
SOLO
RIVER
KARANGGENENG
KURO GATE
SUKODADI
LAMONGAN
BABAT
BOJONEGORO
KALITIDU
PADANGAN
PRIJETAN
GONDANG
NGIMBANG
GRESIK
SURABAYA
Strait of Madura
MADURA ISLAND
SEMBAYAT BARRAGE
(PROPOSED)
SIDOLAYU
NGAWI
MAOSPATI
CARUBAN
MADIUN
LAWU M
EL. 3270
5 0 5 10 15 20 25 km
SCALE
LEGEND
EXISTING PUMPING
PROPOSED PUMPING
1. TAPELAN
2. SUMBERARUM
3. TEBON
4. PRANGI
5. BANJAREJO
6. NGRAHO
7. SUDU
8. NGRINGINREJO
9. LERAN
10. TRUCUK
11. TULUNGREJO
12. MULYOAGUNG
13. KALIREJO
14. SEMANDING
15. MULYOREJO
16. SARIREJO
17. PILANGGEDE
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MAIN ROAD
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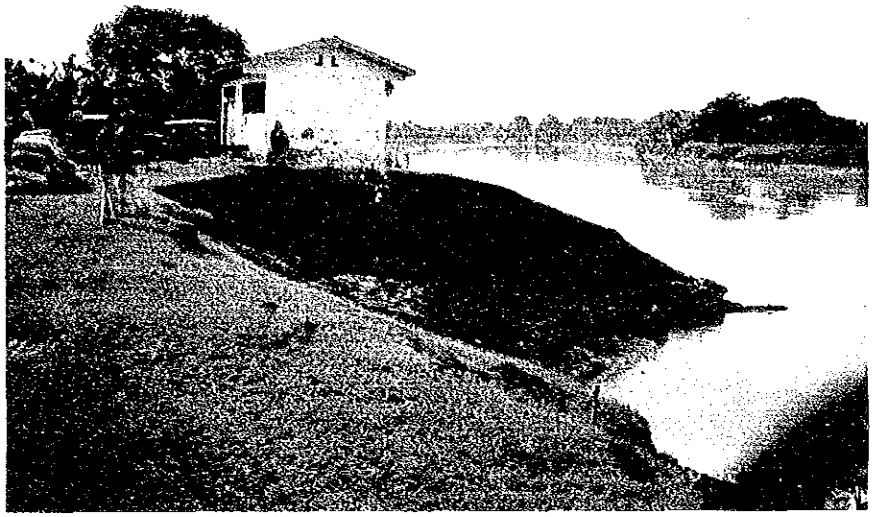
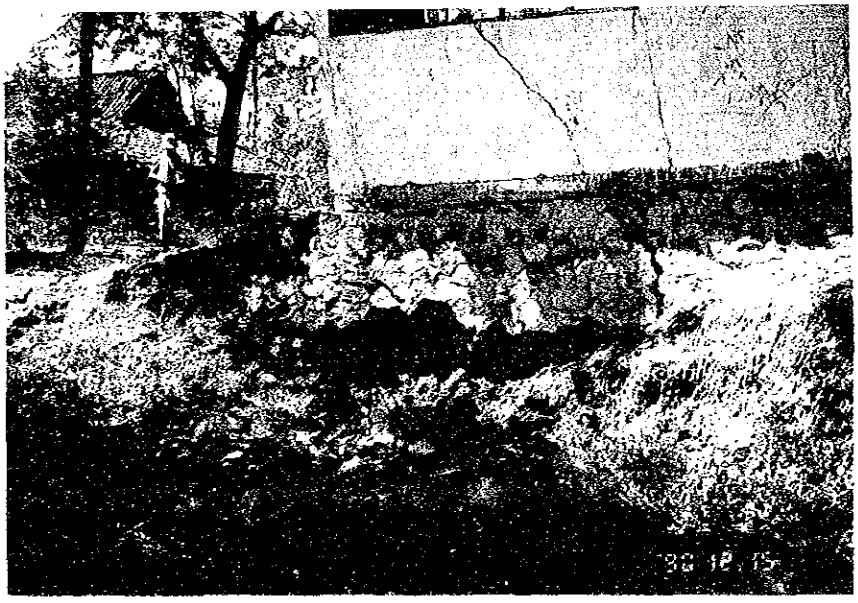
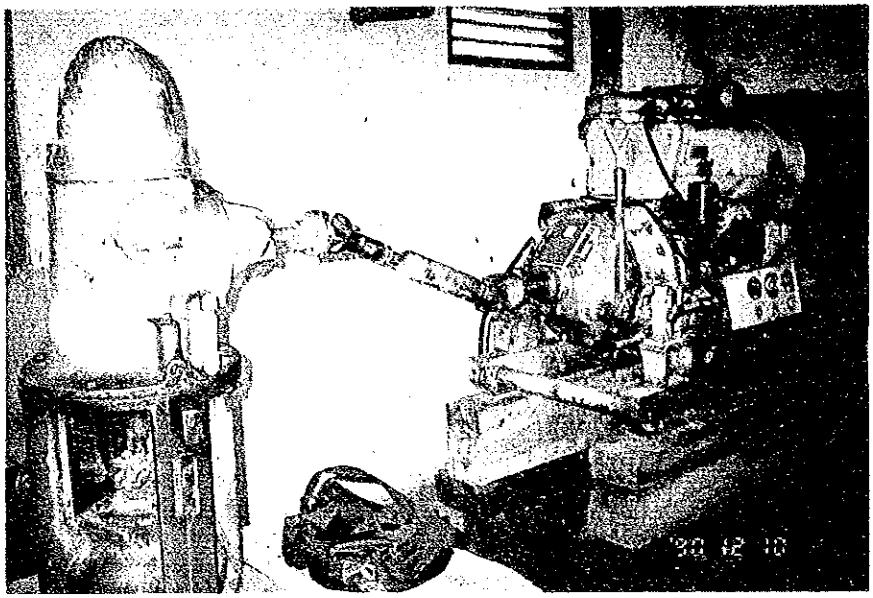
EXISTING RESERVOIR
LOCATION AND GENERAL MAP
ON
PUMPING STATION PROJECT
FOR
BENGAWAN SOLO LOWER REACHES



SARIREJO PUMPING STATION (No. 16) :
An eroded portion of the bank downstream of the pumping station.

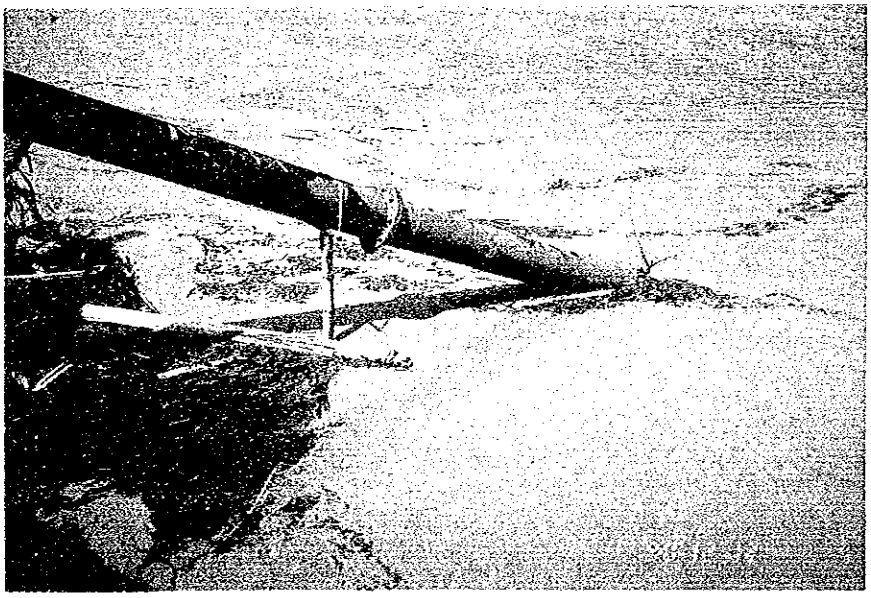


BANJAREJO PUMPING STATION (No. 5) :
Inclined and cracked foundations of the pumping station
because of the erosion.



KABALAN PUMPING STATION (No. 20) :

The pump and engine are not functioning. Settlement of the foundations has caused the joint to be out of line.



LERAN PUMPING STATION (No. 9) :

The suction pipe buried in sediment.

SUDU PUMPING STATION (No. 7) :

Existing main canal.

TANGGUNGAN & KALISARI PUMPING STATIONS (No. 26 & No. 27) :

General view of an area near the proposed pumping station sites.

Private portable pump used for small scale irrigation.

SUMMARY

In the Republic of Indonesia, self-sufficiency of rice production has been achieved in 1984 by improving and strengthening irrigation system in agricultural sector in the fourth five-year national development plan (REPELITA IV, 1984/85 - 1988/89). However, it is necessary to carry out an irrigation development continuously aiming at increasing rice production for growing population (ave. 2 % per annum) and responding the reduction of area for paddy field (20,000 ha per annum reduction in Java island) due to the expanding of housing lot in the skirting part of urbanized area.

Further continuous irrigation development program, therefore, is set up as a important strategy in the fifth five-year national development plan (REPELITA V, 1989/90 - 1993/94). Behind the rapid economic growth, regional imbalance of the level of income has been observed and improvement of living standard of rural areas is also important task to be settled.

Rural area in the East Java has fallen under the mark of economic progress and being identified as the indigent region. This region is listed as one of the important rural areas to be developed. The Government of Indonesia, therefore, has decided to put emphasis on the development of the Solo river which covers the biggest basin of the region. In the lower reach of the Solo river, the following studies or survey have been conducted;

1) Master plan of Solo River Basin Development (1974)
2) Preliminary feasibility study of water and land resources development (1978)
3) Lower Solo River Development Project (1986)

On the other hand, for the upper stream of the Solo river, the following measures also have been taken;

1) Implementation of Wonogiri dam (1982)
2) Colo weir for water intake (completed in 1986)
3) Upper Solo River Improvement Project (under construction)

Upon completion of the Wonogiri dam and Colo weir work, irrigation development has achieved remarkable progress in the upper stream of the Solo river. However, in the lower reaches of the Solo river, though it enjoys fertile alluvial soils, farmers of the concerned region have been suffering without proper water intake facilities and are still depending on rain water only.

As a counter measures for this lower reaches, the Government has installed 20 pumping stations for irrigation in 1981. With these facilities the region enjoyed the developed irrigation system in most economical and effective way. All the operation and maintenance work of these pumping stations have so far been carried out successfully by those farmers themselves under the technical assistance from the Government.

Despite of favors by these 20 pumping stations, after few years operation, most of these pumping stations started malfunctioning such as subsidence of foundation, filling up of pipe with sediment, bank erosion by flooding etc. due to design defects and inaccurate installation. As a result, again the farmers had obliged to cultivate their paddy fully depend on rainfed. The farmers are now depending on privately installed substitute pumping stations with paying very expensive water fee which is approx equivalent to 20 % of their annual yield and still they are managing to continue an agricultural activities.

Under these circumstances, the Government of Indonesia has requested for providing the grant aid by the Government of Japan for rehabilitation of malfunctioned pumping stations and installation of new pumping stations to those unserved area aiming to achieve a stable water supply in the lower reaches of the Solo river. In response to this request, the Government of Japan has decided to implement basic design study on the Pumping Station Project for Bengawan Solo Lower Reaches (hereinafter referred to as " the Project") and in line with the decision, the Japan International Cooperation Agency (JICA) has dispatched a basic design study team (hereinafter referred to as "the Team") to Indonesia for 45 days from December 4, 1990 through January 17, 1991.

The Team held discussions with the officials concerning the Government of Indonesia on the background, objectives, implementation plans, adequacy and scope of cooperation of the Project. In addition, the Team conducted the data collection on the present conditions of related facilities, project site, related infrastructure, construction material cost and other necessary informations, and also executed topo-survey on the Project area. After returning to Japan, the Team has elaborated basic design of necessary facilities and equipment on the

Project by analyzing the result of field survey and based on this analysis, the Team made a draft final report.

In order to explain the contents of the above draft final report to the officials concerning the Government of Indonesia, the JICA has dispatched the Team to Indonesia from May 1 through May 8, 1991 and finalized the contents of the scheme mentioned hereafter.

The Project sites have 33 pumping stations (one station in each village) and are located alongside the lower reaches of the Solo river with total linear length of about 150 km and all the sites are feasible to be developed as pumping irrigation area. Contrary to the Project sites, the Government of Indonesia has initially proposed total 40 sites (existing 20, newly construction 20). However, as a results of survey, 7 sites located in the most lower part of the scheme were excluded with mutual consent of both sides (the Government of Indonesia and JICA) due to upstream of seawater. As a result, total number of the Project sites to be implemented was reduced to 33 stations.

As a component of each site, it was initially proposed by the Government of Indonesia to construct the pumping stations and to carry out bank protection of the Solo river. However, results of survey indicated that most of the beneficial paddy field in the Project area are of highland, and without installation of pipelines to outlet box, effective operation of the Project will be hamper. Therefore the installation of pipeline was decided to be included in the scope of the Project. On the other hand, earth canals after outlet box shall be constructed by the Government of Indonesia and excluded from the scope of the Project.

As for the design of pumping stations, an optimum design is prescribed by reviewing the cause of malfunction taking account of economical operation and maintenance of the pumping station.

Aforementioned 33 pumping stations have same components and are different from each other on the specifications according to water requirement, condition of design parameter such as specification of pump and driving engine, pipe diameter, length of pipeline. The Project component is summarized as follows:

Itemization of the facility per site	Phase I	Phase II	Total
(1) Pumping station	18 sites	15 sites	33 sites
Pumping house (shed)..... 1 lot			
Inlet facility (including bank protection)..... 1 lot			
Pump (ø 150 mm - ø 250 mm) .....2 sets			
Driving engine (12 ps - 25 ps)..... 2 sets			
Suction pipe (ø 150 mm - ø 250 mm) ..... 1 lot			
Discharge pipe (ø 200 mm - ø 400 mm)..... 1 lot			
Valves, fittings, elbow & others ..... 1 lot			
(2) Pipeline	4,200 m	2,050 m	6,250 m
Discharge pipeline (ø 250 mm - ø 400 mm) ..... 1 lot			
Maintenance box ..... 1 lot			
Outlet box ..... 1 pos.			

Executing agency of the Project is Directorate General of Water Resources Development (DGWRD), Ministry of Public Works, the Government of Indonesia and actual executing agency is Solo River Basin Development Project office (PBS) assisted by Solo River Lower Basin Development Project office (PBSH). So far PBS has completed the Wonogiri Dam Project and has been carrying out the rehabilitation work for the Solo river. Through such construction projects, it is believed that PBS has quite experiences and capacity both in technology and management. Taking into above consideration, it can be said that PBS has an ample capacity to execute the Project.

As for the actual implementation, it is rather difficult to supervise all the sites in simultaneous execution of the construction, because of the number of the construction sites scattering alongside of the Solo river within the linear length of 150 km. Furthermore, no direct access is available from one site to the other, and it is necessary to take national road at least once to get to the other site. And it must be considered that during the wet season (Nov. - Apr.), execution of civil work at river side and gabion work of each station will be interrupted by rise of the Solo river water level.

Taking these into consideration, it is rather difficult to implement all 33 sites in one dry season. Therefore, it is practical and adequate to divide the implementation period into two phases.

As each pumping station is independent to the others, it is possible to plan construction schedule for any sites without technical problems. Completion of single pumping station will be immediately beneficial for farmers. Therefore, the Project will be implemented 18 sites under Phase I and the rest 15 sites as Phase II.

When the Project will be implemented through Japan's Grant Aid Program, construction works will take 12 months each for Phase I and Phase II after detailed design, tendering and construction contract.

The amount of the Project cost to be borne by the Government of Indonesia is estimated at about Rp. 2,678.5 million. It consists of Rp. 177.5 million for detailed design of secondary and tertiary canals, Rp. 229.5 million for land acquisition and compensation, Rp. 12 million for replacement of existing stations, Rp. 2,156 million for construction of secondary and tertiary canals, Rp. 91.8 million for office expenses and Rp. 11.5 million for commission for banker.

After completion of the Project, operation and maintenance shall be under the responsibility and control of the East Java Provincial Government. 33 pumping stations are extending over three (3) districts (Bojonegoro, Tuban, Lamongan) and 11 sub districts. The Provincial Government has public works office and agricultural office as implementation bodies of the Project. The public works office is responsible for supervising on the operation and maintenance of irrigation facilities while the agricultural office is proceeding the instruction on agricultural technique and planning of on-farm management. Upon obtaining these assistances from the above mentioned offices, actual operation and maintenance costs shall be borne by the Water Users Association organized by beneficial farmers. Judging from the past performance, the Water Users Association will not face any difficulties for the smooth operation and maintenance of newly installed pumping station.

The Project has a favorable impact on social benefit. Bringing about increase of the beneficial area (from 1,450 to 5,000 ha) in the Project area, the direct effects will result to increment of beneficial families to 6,850 from 2,000 which corresponds to beneficial population of 29,500 peoples, and to be expected 2.3 times of the present major crop yield (paddy) which will increase from 27,300 ton to 63,500 ton. And reduction of the water fee will be also expected. Presently this is approximately equivalent to 20 - 25 % of yield, and after completion of the Project this will be minimized to approximate 5 % of yield. That is

to say, increase of income and decrease of expenditure is obvious due to this multiplicative effect. As a whole result, the Project will surely contribute to raise a living standard of inhabitants in the Project area.

In conclusion, the Project will bring remarkable direct effects to beneficial farmers, and will be expected immediate influence and demonstrative effects to the other areas facing similar problems. Also the Project is in line with the aim of national development plan of Indonesia to reduce the regional economic imbalance. Executing agency or organization for operation and maintenance are verified to be suitable for implementing the Project.

Followings are the recommendations to the Government of Indonesia for more effective and smooth implementation, operation and maintenance of the Project.

1) Secondary and tertiary canals after outlet boxes are surely to be designed and constructed by PBS before completion of the Project.

2) Proper supervision and administration by the public works offices and the agricultural offices in province, district and sub district shall be carried out with respect to the Water Users Association who execute the operation and maintenance of the Project.

3) After completion of the Project, responsible office for operation and maintenance shall be transferred from DGWRD to Provincial Government of East Java. Therefore, effective communication and cooperation shall be preserved by the said two organizations.

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ABBREVIATIONS AND TERMS

BAPPEDA	Badan Pelaksana Pembangunan Daerah (Provincial Development Planning Board)
BAPPENAS	Badan Perencanaan Pembangunan Nasional (National Development Planning Board)
DPU	Departemen Pekerijaan Umum (Department of Public Works)
DGWRD	Directorate General of Water Resources Development
PBS	Proyek Bengawan Solo (Solo River Basin Development Project)
PBSH	Proyek Bengawan Solo Hillir (Solo River Lower Basin Development Project)
JICA	Japan International Cooperation Agency
REPELITA	Rencana Pembangunan Lima Tahun (Five-year Development Plan)
Propinsi	Province
Kotamadya	Municipality
Kabupaten	District
Kacamatan	Sub district
Kelurahan	Group of village
Desa	Village
Gubernur	Governor
Walikota	Mayor
Bupati	Regent
Camat	Sub-regent
Lurah	Chief of kelurahan
Kepala desa	Chief of village
HIPPA	Himpunan Petani Pemakain Air (Water users association)
Padi	A rice grain with the hull or a crop of rice
Padi sawah	Rice cultivated in standing water
Palawija	Secondary crops, dry season food crops grown on sawah
Bantaran	Flood plain along the river bank

CHAPTER 1 INTRODUCTION

The Pumping Station Project for Bengawan Solo Lower Reaches (hereinafter referred to as "the Project") aims to increase food crops production and improve farmers' living standard in the Solo river lower reaches in East Java province by means of rehabilitation and construction of numerous small scale pump irrigation facilities along the Solo river.

The Directorate General of Water Resources Development (DGWRD), Ministry of Public Works, the Government of Indonesia confirmed the high priority of the Project and urgent need of its implementation. The Government of Indonesia requested to grant the financial cooperation on the Project to the Government of Japan on February, 1990. In response to the request, the Government of Japan decided to conduct the Basic Design Study (the Study) on the Project.

The Japan International Cooperation Agency (JICA) sent the Study Team (hereinafter referred to as "the Team") headed by Mr. Norifumi Takamura, Deputy Director, Construction Department, Kyushu Agricultural Administration Office, Ministry of Agriculture, Forestry and Fisheries to justify the Project as the Japan's Grant Aid Program of Japan, for 45 days from December 4, 1990 to January 17, 1991.

Through the Field Survey and succeeding Home Works, necessity and effectiveness of improvement of the pump irrigation scheme in the Project area have been recognized, and proper pump irrigation facilities have been designed by the Team. After a series of the Study, the Draft Final Report on the Project is prepared by the Team.

The JICA sent the Study Team to Indonesia for explanation and discussion on the Report from May 1 to May 8, 1991. After a series of discussions with the Indonesia officials, the basic design proposed in the Report has been agreed in principle. This Basic Design Study Report on the Project has been prepared with refinement and amendment of the Draft Final Report and printed in Japan. (Member list of the Team, survey schedule, member list of persons concerned, and Minutes of Discussion are attached in Appendix.)

CHAPTER 2 BACKGROUND OF THE PROJECT

2.1 Background of the Project

2.1.1 Conditions of Agriculture and Irrigation

In Indonesia, agriculture sector has been the most important one. Rural area has 74 % of total population, and the sector sustains 55 % of economically active population. The sector produces 23.4 % of Gross National Product (GNP).

During the period of the forth five-year development plan (REPELITA IV), the agriculture sector got intensive progress. The irrigation sub-sector also advanced greatly as follows:

-	Rehabilitation of irrigation systems	561,049 ha
-	Construction of new irrigation systems	344,774 ha
-	Reclamation in swamp areas	225,519 ha
-	Flood control	358,980 ha

As the result of such advancements, Indonesia realized the self-sufficiency of rice in the year 1984.

However, food demand has been continuously increasing with the population growth rate of 2 % per annum. Moreover, paddy field around urban area has been converted into residential or other areas in Java island at a rate of 20 thousands hectare (ha) per annum. Therefore, continuous efforts on agricultural and irrigational development are necessary for food self-sufficiency in the country.

In addition, unequal development within regions and sectors is a serious problem in Indonesia. Most farmers in rural area are belong to lower income group, and this is also another reason for further agricultural development.

2.1.2 Outline of Relevant Development Plan

(1) National Development Plan

In the fifth five-year development plan of Indonesia (REPELITA V, 1989/90 - 1993/94), agriculture sector plays a key role for integrated economical development and social stability. Agriculture is also fundamental to industry sector which is rapidly growing these years. The Government of Indonesia aims harmonious development in these two (2) sectors. Furthermore, the Government stresses in the fifth development plan for reduction of regional differences in socio-economical situation and increase of employment opportunity.

Regarding development budget for the fifth five-year development plan, the budget on agriculture and irrigation sector has occupied 16.1 % of total, which is the second largest share. More than half of development budget is planned to be funded by foreign aid.

The main targets of agriculture sector on the fifth five-year development plan are as follows:

1) Strengthening self-sufficiency in food,
2) Improve quantity and quality of food products,
3) Promote farm income as well as living standard of farmers,
4) Expand employment opportunities in rural area, etc.

Most important food crops in the development plan are paddy, maize and soybean.

The main policy on expansion of food production is to promote continuous irrigation development program. This program consists of constructing new irrigation facilities as well as strengthening operation and maintenance of the existing irrigation systems. Other important programs in irrigation development plan are improvement of irrigation efficiency and enhancement of small scale irrigation scheme by farmers.

(2) Regional Development Plan

Each province in Indonesia has its own five-year development plan like the national development plan. East Java province (Propinsi Jawa Timur) currently carries out its fifth five-year development plan (REPELITA V, Jawa Timur 1989/90 - 1993/94). The plan provides targets and measures of provincial development, sectoral development plan, and regency development plan.

The main policy in the provincial development plan is economic growth with the first priority in agriculture sector and the second in industry sector. Besides the plan puts stresses to remedy poverty and to reduce socio-economical gap in region. The provincial plan provides nine (9) development programs, which include expansion of food production with first priority, strengthening operation and maintenance of social infrastructure, and expansion of employment opportunities.

The district development plan of Bojonegoro district, where most of the Project sites are located, has also put more emphasis on agricultural development program, then education, health care and other development programs. The agricultural development program put stresses on the schemes of pump irrigation using river and underground water, and improvement of cropping methods.

The Project aims not only to expansion of food production but also improving living standard of farmers in rural area. From the above points of view, the Project can be considered as a proper scheme along with the national and regional development policies.

2.2 Outline of the Request

(1) Outline of the Request

The Project area is located in the Solo river lower reaches in the province of East Java. The Project area covers a distance of approximately 150 km, and Bojonegoro city is located in the center of the area. In the upper reaches of the Solo river, the Wonogiri dam and relevant irrigation network were

constructed commanding irrigation area of about 24,000 ha in the year 1982 with cooperation of the Government of Japan. As a result, the farm area in the upper reaches of the Solo river become well-developed one. On the other hand, the lower reaches are not tapped yet by a large scale irrigation project. There are no suitable sites for intake facilities due to unfavorable topographical and geological conditions in the lower reaches.

The Ministry of Public Works constructed 20 small scale pumping stations to utilize river water in the lower reaches of the Solo river during the year 1980 to 1981. The Solo river, largest in Java, has enough water for irrigation even during the dry season. These small irrigation systems which only consist of pumping stations and relevant facilities were economically very effective in the area.

However, most of the pumping stations have unfortunately gone out of order within few years after completion. Some still working pumping stations are also not in good condition, facing erosion at river bank. The reasons may be the inadequate design and imperfect implementation of civil works, such as differential settlement at foundations, blockade of suction pipes with sedimentation and damages to embankment by floods, etc.

Therefore, these pumping stations should be rehabilitated as soon as possible, and additional such pumping stations are needed to be constructed at other sites in the Solo river lower reaches, which are presently dominated by rainfed paddy field.

Farmers in the Project area have a great interest in such irrigation schemes. The beneficiaries of existing pumping stations organize water users associations to operate and maintain the facilities by themselves. The Project is expected to be the model to the small scale irrigation projects in Indonesia with enough farmers' participation.

The Project is small in scale but greatly effective in the rural area. Therefore, this can be preferable for the national and regional development policies mentioned above.

Based on the above situation, the Government of Indonesia requested the Japan's Grant Aid Program to the Government of Japan on Pumping Station Project of Bengawan Solo Lower Reaches in the year 1990.

In response to the request, the Government of Japan has decided to send the Basic Design Study Team on the Project under the Japan's Grant Aid Program in order to confirm the possibility and scope of the Project from December 1990 to January 1991.

(2) Components of the Request

The components of the request from the Government of Indonesia are summarized as follows:

- Pumping stations
  1. Rehabilitation of the existing pumping stations : 20 sites
  2. Construction of the new pumping stations : 20 sites

- Specification of pumping station
  1. Pump : vertical turbine type (ø200 mm, 2 sets) diesel engine (2 sets)
  2. Pump house : approximately 17.5 m^2
  3. Valve and pipe : PVC and steel
  4. Concrete outlet box : depend on condition
  5. Bank protection works : depend on condition
  6. Irrigation area : 75 ha in average

CHAPTER 3 OUTLINE OF THE PROJECT AREA

3.1 Location

The location of the Project area is interspersed within the area of 150 km length along the Solo river which is draining the northern part of East Java province. The main city in the Project area is Bojonegoro, from where Solo (Surakarta) city is located 150 km southwestward which takes about three (3) hours by car. In Solo city, office of the Solo River Basin Development Project (PBS), DGWRD, Ministry of Public Works are located, which are the executing agencies of the Project. On the other hand, Surabaya, the second largest city in Indonesia, is located 100 km in the east of Bojonegoro, which takes about three (3) hours by car because of not-fair road conditions.

33 proposed pumping stations of the Project, which consist of 20 rehabilitation and 13 new installation, are located administratively in three (3) districts such as Bojonegoro, Tuban and Lamongan, East Java province (refer to Table A-1 and Fig. A-1). Farm area benefited by the Project is expected to be 5,000 ha in total, and the number of beneficiaries are expected to be about 29,500 persons.

3.2 Natural Condition

(1) Topography and Geology

The Project area is formed as an alluvial plain along the Solo river flowing from west to east. The Solo river is a natural river channel with much meandering, and is subjected to repetitious scouring and sedimentation along the banks whenever flood occurs. On the other hand, swamp areas are studded in the flood-prone area of the river. The Project area is surrounded by the Kapur Utara and Kendeng ranges at the north and south, respectively. The both ranges are relatively low mountain chains having elevation of 300 to 500 m above the sea level.

The Project area is unfavorable to construction of reservoirs due to limestone foundation in general as well as topographic condition. Irrigation using

ground water by deep wells is practiced in highlands adjacent to the Project area.

(2) Meteorology and Hydrology

Climate of the Project area falls under the typical tropical monsoon. Monthly mean temperature varies from 27 °C to 29 °C throughout the year. Annual average rainfall amounts to about 1,850 mm and most of the annual rainfall concentrates in the rainy season from November to April. In the dry season, which lasts from May to October, the amount of rainfall is small and the sunshine hour becomes long. Transition period (dry to rainy season) varies by one (1) month from year to year.

The Solo river is a large one with total river length of about 600 km and is expected to be water source of the Project. The Solo river originates from the southeast portion of Central Java province, then flows through the northern part of East Java province via Solo (Surakarta) city and drains into the Java Sea. Discharges in the rainy season exceed 1,000 m^3/s with the large watershed. In the dry season, the average minimum flow is recorded about 40 m^3/s after construction of the Wonogiri dam.

On the other hand, flood damages occur in the lower reach of the Solo river in every rainy season. Flood prone area in the relating three (3) districts is more than 20,000 ha in total and covers largely the middle portion of the Project area between Bojonegoro and Babat (refer to Fig. A-2). In general, floods occur after every heavy rainfall from January to March and are commonly observed that the inundation period is less than one (1) week.

(3) Soils and Land Use

The Project area is located in the fertile alluvial plain along the Solo river (refer to Fig. A-3). Most of the soils in the area are classified into Vertisols according to the Soil Taxonomy of United States Department of Agriculture (USDA). The parent material of these soils is alluvium from the river. Recent alluvium occurs in the active floodplain, and earlier alluvium occurs at slightly higher elevations on the floodplain (refer to Fig. A-4). These alluviums are composed of marls and limestones or volcanic ash, and these

are well supplied with bases. Major characteristics of weathering process are high temperature throughout the year, dry season of more than four (4) months a year, and poor drainage condition. The soils under such conditions show following characteristics and suitabilities.

Most of the soils in the area are categorized into Heavy Clay having high clay contents of over 50 %. Major soil minerals of the soils are expanding lattice minerals, particularly Smectites. As a result, physical features of the soils fluctuate depending on moisture contents. During the wet season and/or irrigation period the soils become very soft and muddy, but during the dry season the soils become shrink and cracked. From the viewpoint of such physical characteristics and easy cultivation works, the soils are considered to be suitable for paddy cultivation during the wet or irrigation period . In contrary, the soils are not suitable for secondary crops (palawija) cultivation due to hard cultivation works and root growth limitation.

Most of the soils in the area are mostly slight-alkaline with pH value from 7.5 to 8.0. This appear to result from high base saturation of over 80 % and high free lime concentrations in the soils. The availabilities of phosphate and nitrogen are relatively low under such alkaline condition. The chemical characteristics are also unsuitable for secondary crops. However, pH values of the soils under moisture saturation condition become down to neutral (pH 7). This means the soils are suitable for paddy.

Total area of Bojonegoro, Tuban and Lamongan district is about 366,000 ha, and is categorized according to land use. 50.5 % of the total area is categorized as wet land which is mostly utilized as a paddy field. The area of bareland/garden/shifting-cultivation has second largest share of 34.5 %, and the area of house compound and surroundings has the share of 13.9 % (refer to Table A-2). Considering above figures, these three (3) districts of the Solo river lower reaches can be generally termed as the area of cultivable low land. The Project area along the Solo river is categorized into wet land of paddy field (refer to Fig. A-5 and A-6).

3.3 Socio-Economic Condition

(1) Population

Total population of three (3) districts, Bojonegoro, Tuban and Lamongan, was estimated at 3.35 million persons as of 1990, which was equivalent to 1.8% of the total population of the country and 10% of East Java province. The average population density of these districts was 514 person/km^2 which was considerably higher than that of 95 person/km^2 of the country. On the other hand, population growth rate per annum of these districts was about 1 % which was lower than that of about 2.1% of the country. Household size was 4.3 persons and this figure was rather small compared with other areas.

As to the population distribution in East Java province, 23% of that reside in urban area and 77% in rural area. In the area of three (3) districts, population ratio of the rural area is assumed to be slightly increased than the above ratio due to absence of population absorbing urban areas.

(2) Outline of Economic Condition

The Project area falls under low income area in Indonesia. Gross Domestic Product (GDP) per capita of East Java province was Rp. 577 thousand as of 1987, which was equivalent to 79% of the country average of Rp. 733 thousand. Annual growth rate of GDP per capita was 10 to 17% during the year 1984 to 1987. However, the rate of lower income group was high because of disparity in income distribution. Per capita expenditure of East Java province in monthly average was Rp. 40,289 as of 1987, of which less than Rp. 10,000 accounted for 16 % of population and less than Rp. 20,000 reached 67 %. Especially in the rural area, above figures were 20 % and 79 %, respectively. Based on the above data, it can be assumed that the Project area is destitute economically.

Economic structure of East Java province is characterized that the agriculture sector including livestock, forestry and fishery accounts for about 30 % of GDP and is dominant sector of the province. In the agriculture sector, crop production contributes more than 20 % of GDP from which the Project area

can be said to be a granary. The second sector next to the agriculture is trade, hotel and restaurant which accounts to 22 % and the third is manufacturing which accounts to 18 %. Economical activities such as manufacture and commerce in the three (3) districts, where the Project area is located, are not so popular because of their rurality.

(3) Infrastructure

Total length of the major road system in East Java province consists of 1,053 km of national road and 2,476 km of provincial road. In 70 % of provincial road length, road surface condition is not good because of insufficient management. Major road in and around the Project area is the national road with asphalt pavement, which runs along the Solo river from east to west. The provincial road also runs along the Solo river. There are bridges over the Solo river at an interval of 20 to 40 km, through which vehicles can pass. The other rural roads are not paved and are under unsatisfactory maintenance. Especially during the rainy season, it is difficult for vehicles except for four-wheeled drive cars and trucks to pass on the rural roads.

As for telecommunication facilities, private as well as public telephone sets are scarce. However, at the cities such as Bojonegoro and Babat, etc., telephone services are available including international calls. Mail service has not developed well in the rural area. Average number of sending and receiving mail per year per person is only 1.8 and 1.4, respectively, in East Java province.

Electric power is supplied by the public corporation managed by the provincial government. Transmission lines are set up along the major roads and in the cities. However, many rural areas apart from the major roads do not electrified yet.

Domestic water supply and electricity are enjoyed in the city areas, while the rural areas do not. In the rural areas, drinking and miscellaneous water is mostly supplied by wells.

Education is emphasized in the development strategy of the provincial government, and in this respect, schools are constructed in the rural areas. In the three (3) districts, there are 2,161 primary schools with 376,000 pupils; 276 junior high schools with 86,000 pupils; and 133 high schools with 37,000 pupils. In addition to the above public schools under the jurisdiction of the Department of Education and Culture, many private schools are also operated with many pupils. Almost all children are benefited from primary education.

As for medical service facilities, one general hospital functions as a medical center and is available in each district. In addition to this, one special hospital and one private hospital are operated in Tuban and Lamongan, respectively. There are 85 public health centers and 116 sub-public health centers in the three (3) districts, by which social services such as medical treatment, health care and sanitation management,etc. are provided directly to the residents.

3.4 Outline of Agriculture

(1) Outline of Agriculture

The Project area is characterized as a agricultural area producing mainly food crops. Rice and the secondary crops (Palawija) such as maize and soybeans are the predominant crops. Total harvested areas of rice, maize and soybeans are 248 thousand ha, 160 thousand ha and 51 thousand ha, respectively, in the three (3) districts as of 1989 (refer to Table A-3). Other secondary crops are peanuts, cassava, green pea, sorghum and sweet potatoes in descending order in terms of the harvested area. In addition to the above, estate crops, such as tobacco, sugarcane, cotton, vegetables and fruits, are also cultivated in the area. However, in the Project area, rice and secondary crops are only produced because farm area is mainly lowland paddy field.

Provided irrigation facilities and flood protection measures, triple cropping a year would be possible in the Project area. Farming of triple cropping a year is actually practiced in some part of the Project area. Maturation periods of the major crops are 90 to 110 days for paddy, about 90 days for maize and

about 95 days for soybeans. Typical cropping pattern in non-inundated area is: rice crop during the rainy season, rice crop on 30% area and palawija on 70% area during the former dry season and palawija during the latter dry season. At present, two rice crops per year are possible in the area with irrigation facilities, and one rice crop per year without irrigation facilities (refer to Fig. 4-2).

In the Project area, almost all farmers are owner cultivator. Therefore, the farmers need not pay land rental/amortization but pay land tax. Average land holding size per farm household is 0.73 ha in the three (3) districts, Bojonegoro, Tuban and Lamongan. The farmers consume a part of their crop products themselves and sell the rest at market to gain cash. The great portion of the farm households is a full-time farmer. The farmers also earn wages from cooperative farming.

An agricultural cooperative is established in each village, which provides extension services for farmer groups to improve farming methods and farm input materials. On the other hand, a water users association is organized in each irrigation block and manages and operates irrigation facilities. 809 water users associations are working in the relating three (3) districts, which are equivalent to about 70% of villages in number. About a half of the above water users associations seems not to have been well oriented. However, 92 water users associations established in the area function effectively in view of operation and maintenance of irrigation facilities (refer to Table A-6).

(2) Outline of Irrigation

Total area of irrigated paddy field, including the Project area, is 91,552 ha in the three (3) districts, which is 43 % of total paddy field. Irrigated paddy field can be classified into technical, semi technical and non technical according to the technical level of irrigation. Most area of Bojonegoro and Lamongan falls under technical and non-technical level, respectively (refer to Table A-7).

Paddy Field	Area(ha)	Ratio(%)
Irrigated	91,552	43
Technical	31,264	15
Semi Technical	25,478	12
Non Technical(Public)	19,974	9
Non Technical(Private)	14,836	7
Rainfed	119,785	57
Others	619	0
Total	211,956	100

The Project area is not benefited from the large scale irrigation development at present, in spite of the endowments of climate and soils conditions. Construction of the Wonogiri dam was completed in the upper reaches of the Solo river in the year 1982, by which large scale irrigation started from the year 1986. In the lower reaches of the Solo river, 20 pumping stations were constructed along the Solo river because of difficulties in construction of dams and intake weirs from the viewpoint of topography. The original plan was pump irrigation development commanding 1,350 ha with the above pump facilities. However, the majority of pumping stations stopped functioning after several years of operation because of the inadequate design and imperfect construction works as mentioned earlier.

In some areas, because of ill-functioned pumping stations, small scale irrigation is introduced depending on private small pump facilities for lack of an alternative. The rest, i.e., the majority of the farmers, is obliged to depend on rainfed farming and can not plant rice during the dry season. As a result, in the Project area, crop production remains in a low level without complete irrigation facilities.

In the Project area, with the farmers' strong consciousness of ensuring irrigation water, the water users associations manage and operate the existing small irrigation facilities. To the activities of the water users associations, the local Public Works Offices undertake a leading part providing manuals and guidelines. Irrigation canals in the farm are also constructed and maintained by the farmers under the direction of the local Agricultural

Offices. Consequently, farmers' interest in irrigation development is high, and farmers' willingness to participate and cooperate to the Project is very strong in the Project area.

Irrigation fee is collected from the benefited farmers on a fixed rate in the Project area. The rate is about 10% in the case of public irrigation facilities. On the other hand, in the case of private facilities, it is 20 to 25 % and incurring a heavy burden to the farmers.

CHAPTER 4 OUTLINE OF THE PROJECT

4.1 Objectives

The objectives of the Project are to increase food crop production and to improve living standards of farmers through rehabilitation and/or construction of pumping stations in the lower reaches of the Solo river. The Project is expected to be a pilot case for the future irrigation development in the areas of paddy field under the same farming condition. In addition, it is also expected that the Project has a great significance as a model case for areas where farmers can actively carry out the operation and maintenance of irrigation facilities.

4.2 Review of the Request

(1) Feasibility and Necessity of the Project

In the fifth five-year development plan, the strategies of the irrigation sub-sector are to sustain self-sufficiency in rice through the irrigation development and to share the operation and maintenance cost of the irrigation facilities with the benefited farmers. With the Project, enlargement of irrigation area and transformation of rainfed agriculture into multi-cropped irrigated one will be realized in a short time by the rehabilitation of 20 pumping stations and the installation of 13 new pumping stations. Consequently, the financial situation of the farmers will improve by the great increase of agricultural production. Usually, farmer's participation in the irrigation project is scarce in Indonesia due to burden of operation and maintenance cost, etc. However, in the Project area, existing 20 pumping stations are already operated and maintained satisfactorily by the water users associations consisting of farmers. In addition, setting up of new water users associations for the proposed pumping stations has already been started. Therefore, organization for the operation of the Project seems to have no problems. This Project is in line with the fifth five-year development plan and is greatly meaningful to spread its effects to other areas. As to the direct benefits, the irrigation area will be enlarged from 1,457 ha to 5,000 ha from which rice production will increase by 2.3 times, i.e., from 27,300 ton to 63,500 ton. Numbers of households and

population to be benefited by the Project will be 6,850 and 29,500, respectively. Each of pumping station will be small in scale and distributed uniformly (each village will have one pumping station) throughout the Project area, thus the Project area will be benefited uniformly. Farmers will be benefited directly and immediately by the Project due to their ownership of the cultivated land. Hence, the Project is justified to fulfill the conditions which are required for the implementation of the Japan's Grant Aid Program.

(2) Project Implementation and Management

The Project implementation falls within the responsibility of DGWRD, and the actual agencies to carry out the construction works are PBS and PBSH, the subordinate offices of DGWRD. PBS has experienced in the implementation of the Wonogiri Dam Project also with the help of the Government of Japan and the conservancy of the Solo river, etc. Therefore, PBS is reliable both technically and administratively. The number of staffs in DGWRD is about 15,700, that in PBS head office is about 590 and that in PBSH is about 180. The organizations and staffs of the above agencies are judged to have the ability to conduct the implementation of the Project. These agencies have already started to select the personnels who will take charge of the Project.

The system of the Project implementation is shown in Figure 4-1.

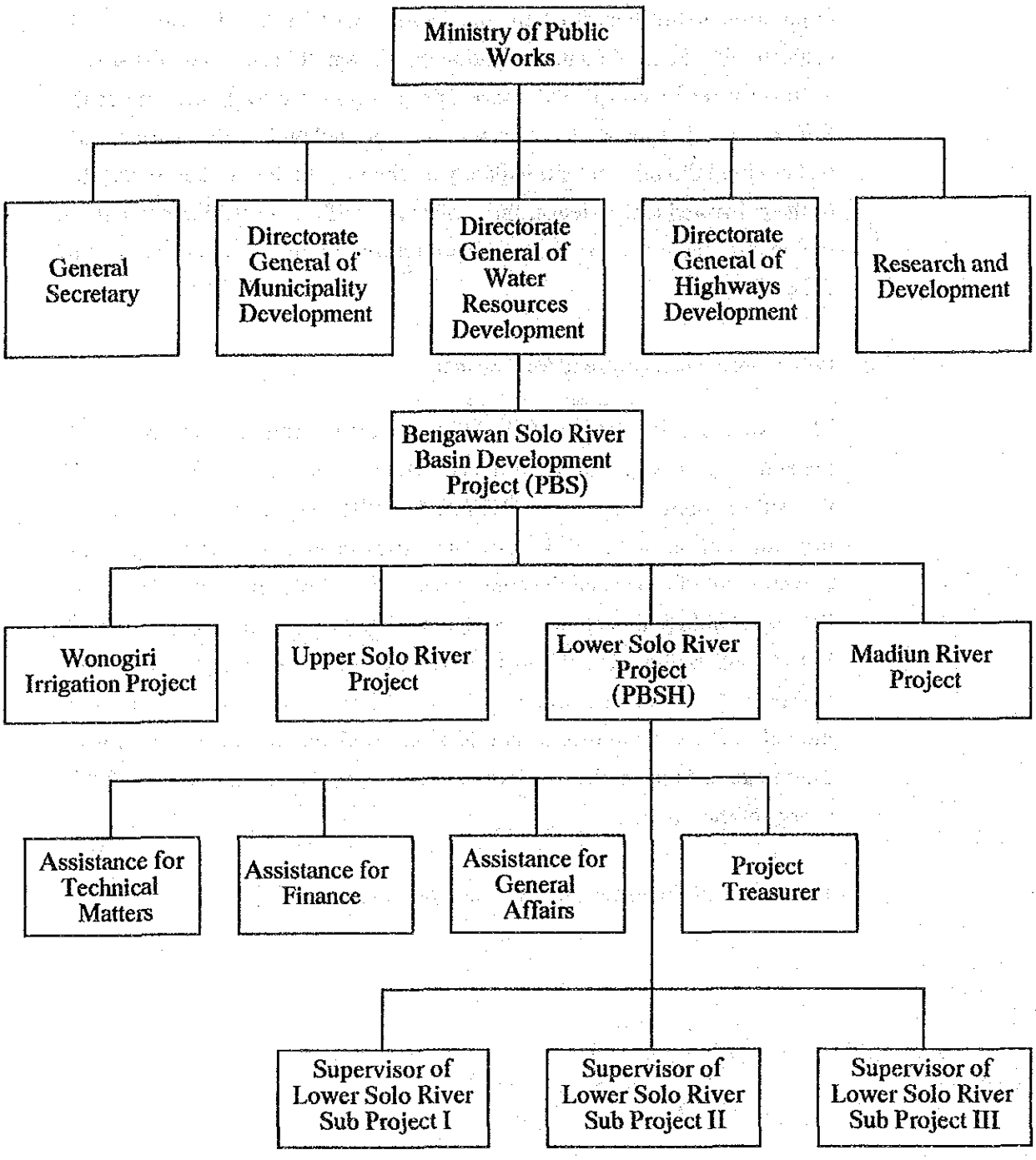


Fig. 4 - 1 Organization Chart of the Project Implementation

(3) Examination for Correlating or Overlapping with Other Similar Plans

The following studies and plannings concerned to agricultural and irrigation development have been conducted in the lower reaches of the Solo river:

Year	Study and Planning	Agency
1974	Master Plan of Solo River Basin Development	OCTA
1978	Preliminary Feasibility Study of Water and Land Resources Development	CIDA
1986	Lower Solo River Development Project	CIDA

OCTA: Overseas Technical Cooperation Agency (Japan)
CIDA: Canadian International Development Agency

"Lower Solo River Development Project (1986)" aimed to conduct feasibility or pre-feasibility study on the irrigation development and flood protection plan. The feasibility study was conducted on the following five (5) components:

a. Rehabilitation of Irrigation,
b. New irrigation,
c. Swamp development,
d. Flood control measures, and
e. Jipang multipurpose dam.

In addition, the following two studies were also carried out as a continuity in more detail by the Government of Indonesia:

a. Development of underground water,
b. Construction of the Sembayat Barrage.

As mentioned above, the projects such as Jipang Dam and Sembayat Barrage were studied in the Project area, and found the area had a high potential for irrigation development. The Government of Indonesia is still making efforts to realize the construction of the Sembayat Barrage. Regarding the flood

protection, the dike construction and drainage improvement on parts of the Solo river are being undertaken by the Overseas Economic Cooperation Fund (OECF) of Japan.

(4) Review of the Request

The request comprises 20 existing pumping stations to be improved and 20 new pumping stations to be installed. However, seven (7) stations out of proposed new pumping stations are excluded because these are located in the area where river water is unsuitable for irrigation due to salt water contamination. The new pumping station proposed originally in the Durikulon area has been converted to the Banjar area for the reason that the three (3) Public Works Offices agreed to locate the new pumping stations uniformly in the three (3) districts. The Banjar area also faces serious water shortage which must be improved preferentially.

The Project components requested originally by the Government of Indonesia are the improvement and construction of pumping stations including their related facilities and structures. However, the results of geographical and other survey in the Project area indicate that pipelines from the pumping stations to the outlet boxes are surely essential to realize practical irrigation farming. Outlet boxes are designed to be located at higher points to expand the beneficial area which consists of paddy fields with relatively high altitude. Consequently, the Government of Indonesia agreed to add the construction of pipeline system to the Project.

It is decided that the on-farm ditches from outlet boxes to each allotments are not included in the Project components because they shall be constructed by the Government of Indonesia.

(5) Basic Policy of the Project Implementation

As the results of the review, it is verified that the effects, necessity and implementing agencies of the Project are appropriate to the Japan's Grant Aid Program. Therefore, the Project is justified in implementing by the Japan's Grant Aid Program. On the basis of this conclusion, the Basic Design Study on the Project is conducted including the planning of the

Project. As for the contents of the Project, the original request is slightly modified as noted in the previous section.

4.3 Outline of the Project

4.3.1 Implementation Agencies and Management System

The control of the pumping stations of the Project is to be transferred to the Provincial Government after completion of the construction. The Water Users Associations composed of beneficial farmers carry out the operation and maintenance of the pumping stations under the guidance of the Public Works Offices of the province, district and sub district levels. The farmers also manage the on-farm ditches which are excluded from the Project. Since the farmers in the Project area are experienced in such management works, they have enough ability to manage the pump irrigation facilities. In the existing irrigation areas, the irrigation fee in kind has been collected, from the harvested crops, independently by the Water Users Association of each pumping station. The details are given in Chapter 7.

4.3.2 Location and Outline of the Project Area

The Project is carried out at 33 sites in the Solo river lower reaches. In this report, the irrigable area bounded according to the geography and soils conditions is defined as the potential area, while the actual irrigation area is defined as the the Project area. The Project area is selected from the potential area according to the followings:

a. To exclude residential areas,
b. To exclude remote areas from each proposed pumping station,
c. To include existing pump irrigation areas,
d. To exclude high altitude areas which are unable to be irrigated by gravity method,
e. To limit the irrigation area of each pumping station up to 200 ha considering to pump capacity.

On the basis of the above terms and additional information, the Project area is delineated in 1/5,000 scale map. Finally, the Project area is settled to the total area

of 5,000 ha, resulting average irrigation area of about 50 ha for each pumping station (refer to Table A-8). The irrigation area per pumping station is double of that when it is requested first.

The Project area includes the paddy field of 1,457 ha irrigated by the existing private pumps. However, most of these are temporary and small in size and are imposing high irrigation fee to farmers. These existing private pumps would be eliminated after the implementation of the Project.

The Project area is divided into 2,023 ha of inundated area and 2,977 ha of non-inundated area. As the inundated area is inundated for a couple of days to a week in every wet season, crops are hardly planted in the wet season. While in the non-inundated area, after the irrigation facilities are improved, cropping will be capable throughout the year.

4.3.3 Outline of the Project

(1) Irrigation

The Project aims to construct 33 pumping stations along the Solo river to irrigate 5,000 ha of paddy field. These pumping stations of the Project are constructed to meet the water shortage problem in the dry season by pumping up water from the Solo river. The Project area is 3.4 times as big to the area of 1,457 ha of the paddy field irrigated by the existing private pumps. The proposed pumping stations are designed to solve the problem of stopping water supply which is caused by the mechanical troubles in the existing private pumps. Therefore, it is expected that crop yields in the dry season will be raised and stabilized by the Project.

A flooding irrigation method is applied to paddy, while a furrow irrigation method is applied to secondary crops. The periods of irrigation are about 80 days for paddy and maize, and about 85 days for soybeans.

(2) Cropping Pattern

The dominant crops in the Project area are rice and secondary crops (maize, soybeans, etc.), of which growing periods are three (3) or four (4) months.

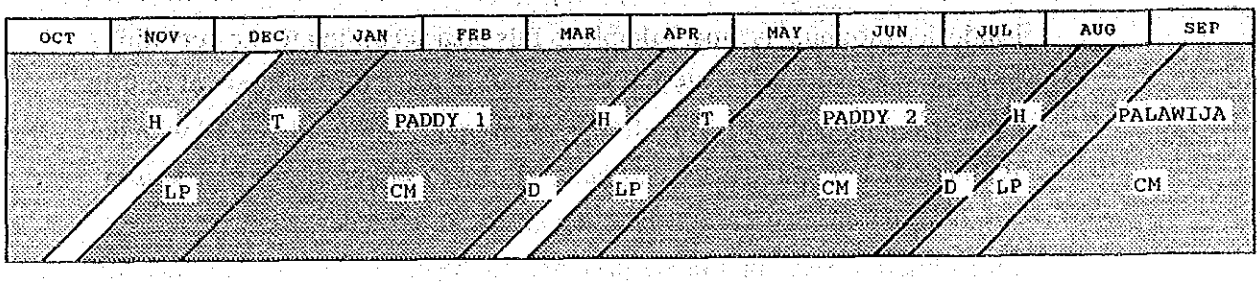
Considering the relatively short implementing period of the Project, it might be safe not to change the existing cropping pattern remarkably. On the other hand, rice cropping is most suitable to this area according to the conditions of geography, climate, soils and so on, and rice has the high rate of return and expanding demand. Therefore, rice cropping will be increased with the Project. In the inundated area, land will be in fallow in the wet season. Triple cropping of rice will be avoided because of degradation of soils, spreading of disease and insect pest etc. In the most dry season, secondary crops will be planted.

Outline of the proposed cropping pattern is shown in Figure 4-2. With this cropping pattern, cropping intensity of rice rises from 130 % to 200 % in the non-inundated area, and from 100 % to 200 % in the inundated area. While that of secondary crops decreases from 170 % to 100 % in the non-inundated area, and from 100% to 0 % in the inundated area. The proposed cropping pattern is summarized as follows (refer to Figure 4-2):

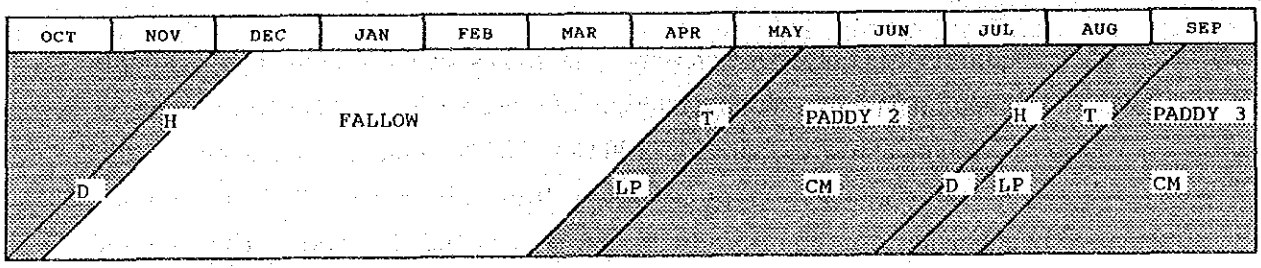
month area	Nov. - Feb. (wet season)	Mar. - Jun. (dry season-1)	Jul. - Oct. (dry season-2)
With Project			
Non-inundated area (2,977 ha)	rice	rice	secondary crops
Inundated area (2,023 ha)	fallow	rice	rice
Without Project			
Non-inundated area (2,977 ha)	rice	rice: 30 % secondary crops: 70 %	secondary crops
Inundated area (2,023 ha)	fallow	rice	secondary crops

WITH PROJECT

NON-INUNDATED AREA

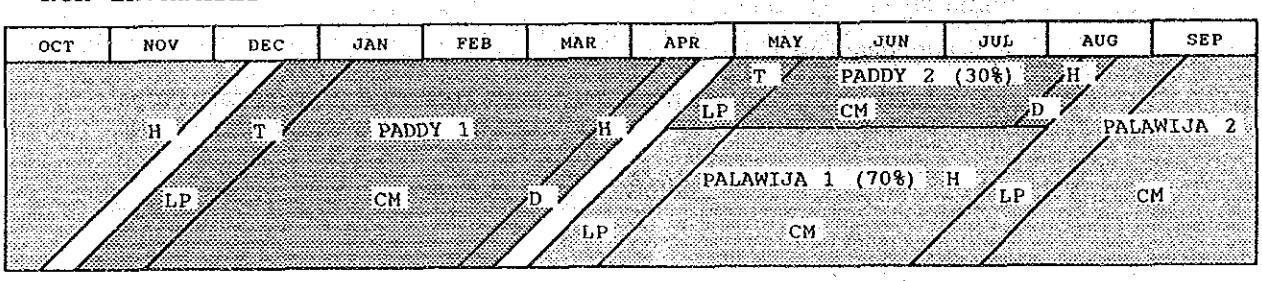


INUNDATED AREA



WITHOUT PROJECT

NON-INUNDATED AREA



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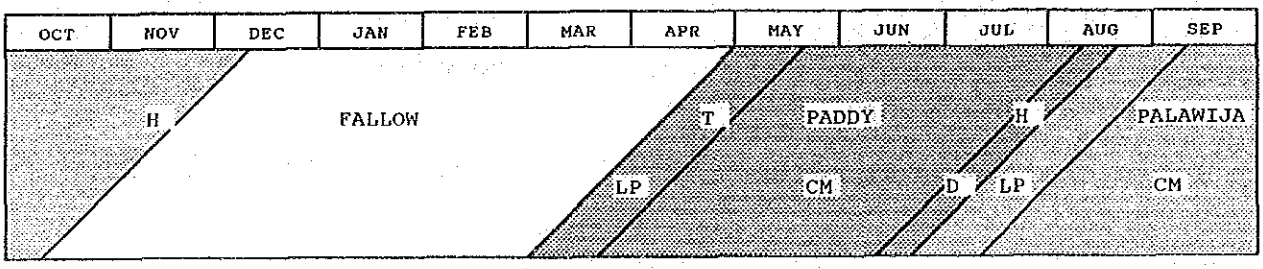


LEGEND

LP : Land Preparation D : Drainage
T : Transplanting H : Harvesting
CM : Crop Management

Fig. 4 - 2 Proposed and Present Cropping Calendar

(3) Crop Production

With the Project, present cropping pattern will be changed as shown above, and crop yields will be increased remarkably. Yields, with and without Project condition, of the major crops such as rice, maize and soybeans are estimated based on the following considerations:

i. Present average yields of technical, non technical irrigation and rainfed areas in Bojonegoro district (refer to Table A-9),

ii. Yield of 14 ton/ha in double cropped paddy field denoted in the report of DGWRD, March 1990,

iii. Paddy yield of 7.47 ton/ha in the Appraisal Report on the Wonogiri Irrigation Project by OECF, January 1989.

Results are indicated in the following table:

Crop	Growing Season	Yield Per Hectare (ton)	
		With Project	Without Project
Rice	wet	6.0	4.0
Rice	dry	6.5	4.0
Maize	dry	3.0	1.0
Soybean	dry	2.0	0.8

The crops out of the secondary crops are assumed to be 80 % of maize and 20 % of soybeans with reference to the actual conditions (refer to Table A-10 and A-11). Based on the above cropping pattern and crop yields, crop production of the Project area is estimated as follows:

Crop	Crop Production (ton)	
	With Project	Without Project
Rice	63,512	27,318
Maize	7,146	8,458
Soybeans	1,190	1,554

In the Project area of 5,000 ha, the rice production will increase up to about 63,500 ton which will be 2.3 times higher than that of the without Project condition. On the other hand, the production of maize and soybeans with Project condition will decrease because parts of these will be replaced by rice in terms of the planting area.

CHAPTER 5 BASIC DESIGN

5.1 Design Policy

The following design policies are adopted in the basic design of the Project:

a. In principle, construction should be carried out using material and equipment which are easily procured around the construction sites. Procurement of construction material and equipment from other countries should be limited as much as possible.

b. As the pumping stations are normally operated and managed by the farmers, manual operation of the pump is adopted as a operation method.

c. Command area by one pumping station should be limited within one village administratively in order to confrontation of water distribution and to make responsibility of management. In addition, each pumping station should be located in the benefited village.

5.2 Design Criteria

Following criteria are adopted for the design on the plan of pump:

a. Design criteria of Indonesia are adopted principally.

b. Standardized structure should be adopted to facilitate the supervision and quality control of the construction because plenty and small similar sized structures are planned, and the construction sites are scattered within the large area of 150 km linear length along the river.

c. The structure to be constructed in the inundated area should be designed taking account a protection from inundated water flow.

d. Simple structure is adopted to facilitate repair.

5.3 Basic Design

5.3.1 Irrigation Water Demand

(1) Design Unit Irrigation Water Requirement

Unit water requirements of paddy and palawija are computed considering land preparation requirement, crop evapotranspiration, percolation, irrigation efficiency and effective rainfall, etc. according to the proposed cropping pattern, as shown in Table A-12. Calculated maximum unit irrigation diversion requirements of non-inundated and inundated area are 0.8 l/s/ha (late in September) and 1.0 l/s/ha (middle and late in September), respectively. The difference of the figures can be explained by the proposed crops in September, palawija in the non-inundated area and paddy in the inundated area (refer to Fig. 4-2). However, in the design of pump and pipeline, the unit requirement of 1.0 l/s/ha is adopted. This value will be able to afford some degree of freedom in the future irrigation plan and can be verified by the survey results of the existing pump capacity.

(2) Planned Irrigation Diversion Requirement

Irrigation area of the proposed 33 pumping stations consists of non-inundated area of 2,977 ha and inundated area of 2,023 ha. The maximum irrigation diversion requirement is estimated to 4.4 m^3/s (late in September) as shown in Table A-13.

5.3.2 Water Source

(1) Flow of the Solo River

Water source of the Project is planned to be the Solo river considering the present conditions of pump operation. The Wonogiri dam was constructed in the upper reach of the Solo river in 1982. Average monthly flow at Babat between 1959 and 1990 is divided into two (2) parts, before 1982 and after 1983 (before and after dam construction), as shown in Table A-16. From the table it can be realized that the annual minimum flow in monthly average before the Wonogiri dam construction ranged from 0.1 m^3/s to 180.5 m^3/s, and after the dam construction the value changes to 20.7 m^3/s to 69.0 m^3/s.

This phenomena indicate that the discharge of the Solo river during the dry season has increased considerably by the operation of the Wonogiri reservoir. Based on the above study, the Solo river is judged as to have satisfactory flow to serve as the water source of the Project compared to the aforementioned maximum irrigation diversion requirement of 4.4 m^3/s.

(2) Water Level of the Solo River

In case of pump up from river flow, water level of the river is an important factor in the design. The water level applied to the design of each pumping station is calculated in proportion to the river length using the water level record at the following four (4) gauging stations (refer to Table A-18). The recorded water level is available for the period of 1983 to 1990, which is after the construction of the Wonogiri dam.

Station	Location
Napel	about 250 km from Solo river mouth
Cepu	about 200 km from Solo river mouth
Bojonegoro	about 140 km from Solo river mouth
Babat	about 90 km from Solo river mouth

Source : PBS

(3) Consistency with the Sembayat Barrage System in the Lower Solo Basin

a. Outline of the Sembayat Barrage Irrigation Project

At present, in the downstream of the Project area, the barrage is under planning at Sembayat site, about 30 km upstream from the mouth of the Solo river. The feasibility study of the above planning is carried out by the Government of Indonesia and is of the stage of preparation of the final report. The planning is to tap 18 m^3/s in total through the construction of the barrage and a water level of 2.00 m high above the sea level can be maintained. Minimum monthly average flow to be compensated for Sembayat Barrage will be 11.5 m^3/s, which is equivalent to 80 % of dependable discharge analyzed by PBS, taking account of the storage effect of Sembayat Barrage.

Domestic and industrial water	7.00 m^3/s
Irrigation water	6.28 m^3/s
Fish pond	2.72 m^3/s
Maintain flow	2.00 m^3/s
Total	18.00 m^3/s

The Solo river is the main water source for the total irrigation area of 22,933 ha of the planning and therefore deficit must be recovered by pumping up from the Solo river. The planning is to be implemented within the year 2000.

b. Consistency with the Sembayat Barrage Irrigation Project

Proposed irrigation area of the Project is 5,000 ha and at present 1,457 ha are operating; therefore, irrigation area is to be increased by 3,543 ha. After the implementation of the Project, the flow at the Sembayat Barrage site is expected to decrease by the incremental amount of the irrigation requirement imputed to the area of 3,543 ha. It can be verified that the Project will not affect the above planning substantially and the decreased flow at the barrage site will exceed the aforementioned planned minimum discharge of 11.5 m^3/s.

Amount of flow decreased at the construction site of Sembayat Barrage can be calculated by deducing present irrigation diversion requirement from the proposed irrigation diversion requirement. The present irrigation diversion requirement is calculated as shown in Table A-14. Amount of decreased flow at the site is calculated based on the above figures as shown in Table A-15. As a result, it is estimated that the amount to be decreased will vary from 3.0 m^3/s (September) to 0.2 m^3/s (January).

The flow at the site of Sembayat Barrage after the implementation of the Project is, then, computed by subtracting the above amount of decrease from the observed flow at the barrage site. However, as

observation of flow has not been carried out at Sembayat, flow data of Babat, located in the upstream of Sembayat, is used in this study as an alternative. In Table A-17, the reduced flow at Babat during the year 1983-1990 is summarized. The minimum monthly average flow at Babat during the above nine years is estimated to be 18.2 m^3/s, which is more than the aforementioned planned minimum discharge of 11.5 m^3/s. Based on the above study, it can be concluded that the Project will not affect the above planning substantially.

5.3.3 Design of Pumping Station

(1) Selection of the Site

Based on the following consideration, the sites of the pumping stations are selected in such a way that water can be pumped up steadily and for long term:

a. Having shorter distance to the higher portion of irrigable land which is advantageous to water distribution in the irrigable area,
b. River course is straight and river bank is stable,
c. Locating at stable water route with short distance from the pumping station,
d. Being near from village to facilitate operation, maintenance and inspection,
e. Hardly effected by direct flow of flood.

Field investigation is carried out based on above points, and the sites of the 33 pumping stations are decided with the advice from the PBS officers and farmers. The decided sites are indicated on the general map of the Project.

(2) Selection of Pumping Station Type

In the selection of pumping station type, the present problems of the existing pumping stations, of which majority does not work, are studied. The pumping station type is selected through the comprehensive alternative study to solve the above problems.

a. Problems of existing pumping stations

Existing pumping stations were designed and constructed by the PBS during the year 1980-1981 (the plan is shown in Figure 5-1). The following problems are identified through the field investigation and studying the existing plan:

- The foundation of engines, which throb considerably, is separated from that of pumps. This brings differential settlement, which is the cause of problems.
- As the foundation of engines is small and placed on sand, liquefaction is easy to occur by throbbing during the rainy season when moisture contents are very high.
- Suction pipes of about 20 cm diameter are set horizontally in the deep of soil. This makes it difficult to operate and maintain them properly.
- Pumping stations are located near bank where is exposed to erosion.
- Exposed portions of the terminals of suction pipes are not protected; accordingly the portions are apt to be damaged by floods.
- The pumps, engines and couplers are imported. Therefore, procurement of spare parts is difficult and satisfactory operation and maintenance are not expected.

b. Selection of pumping station type

In order to solve the above mentioned problems, four (4) alternative plans namely, vertical pump type, floating pump types (floating arm type and floating tower system type) and volute pump type, are studied respectively. The plans are shown in Figures 5-2 to 5-5. The results of studies are summarized in Table 5-1.

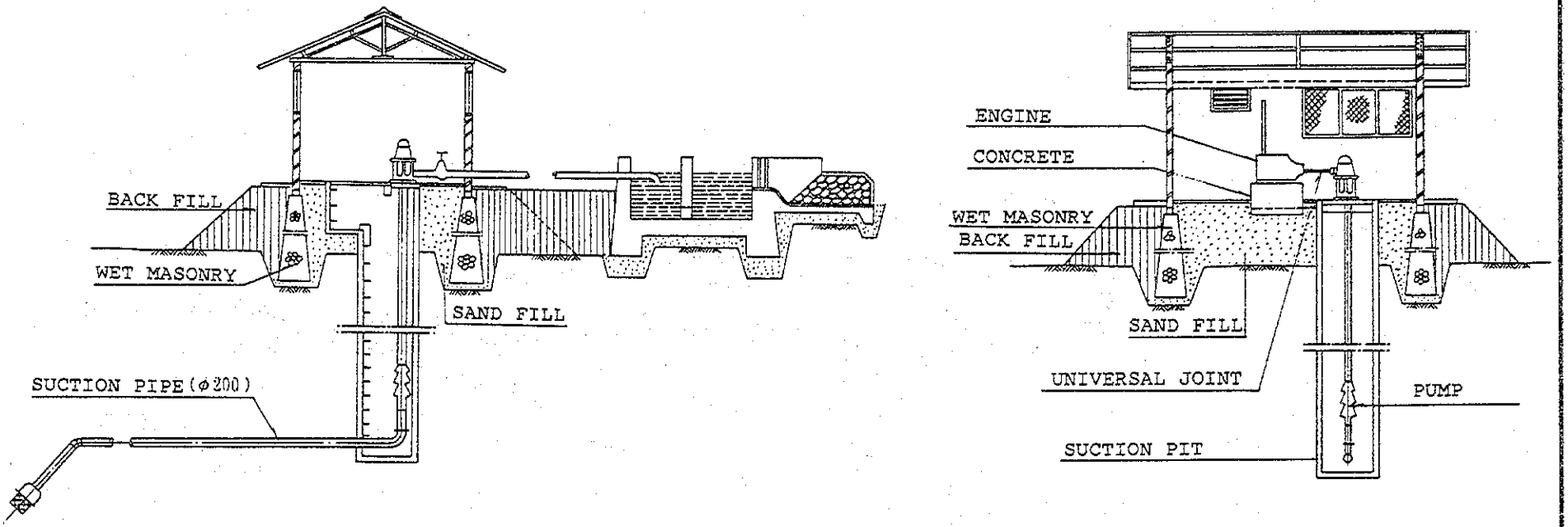


Fig. 5 - 1 Sectional View of Existing Pumping Station

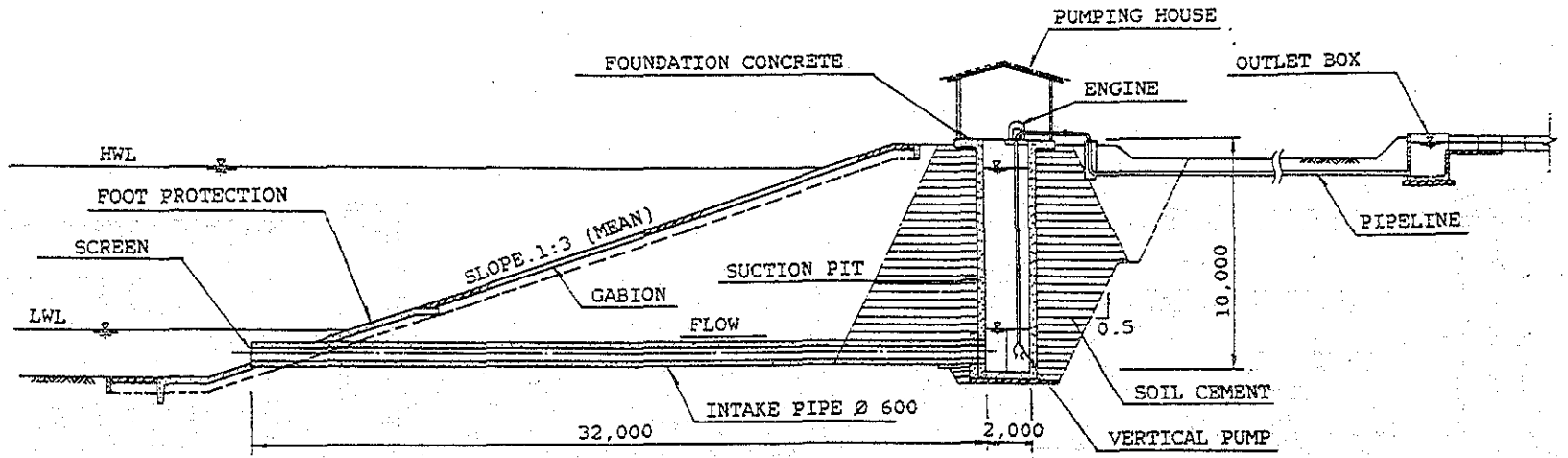


Fig. 5 - 2 Vertical Pump Type
(Plan No. 1)

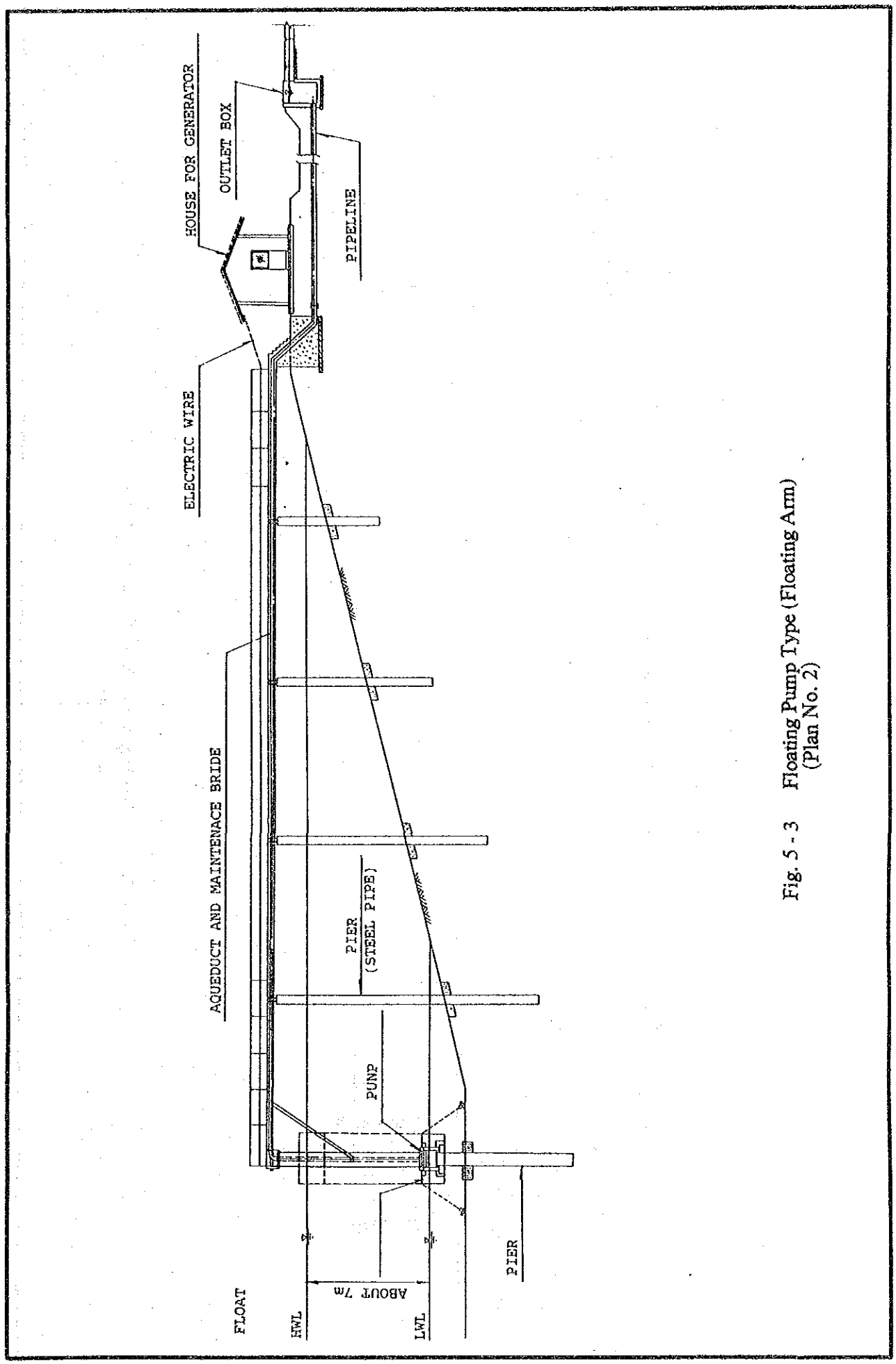


Fig. 5 - 3 Floating Pump Type (Floating Arm)
(Plan No. 2)

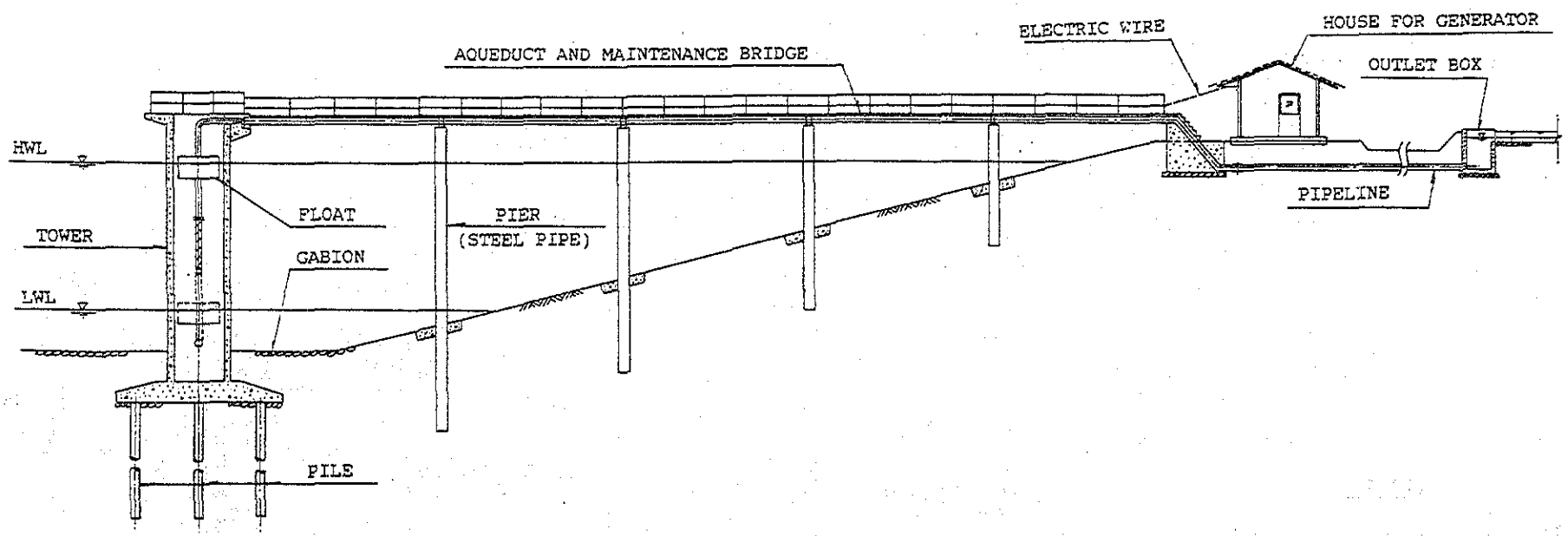


Fig. 5 - 4 Floating Pump Type (Floating Tower System)
(Plan No. 3)

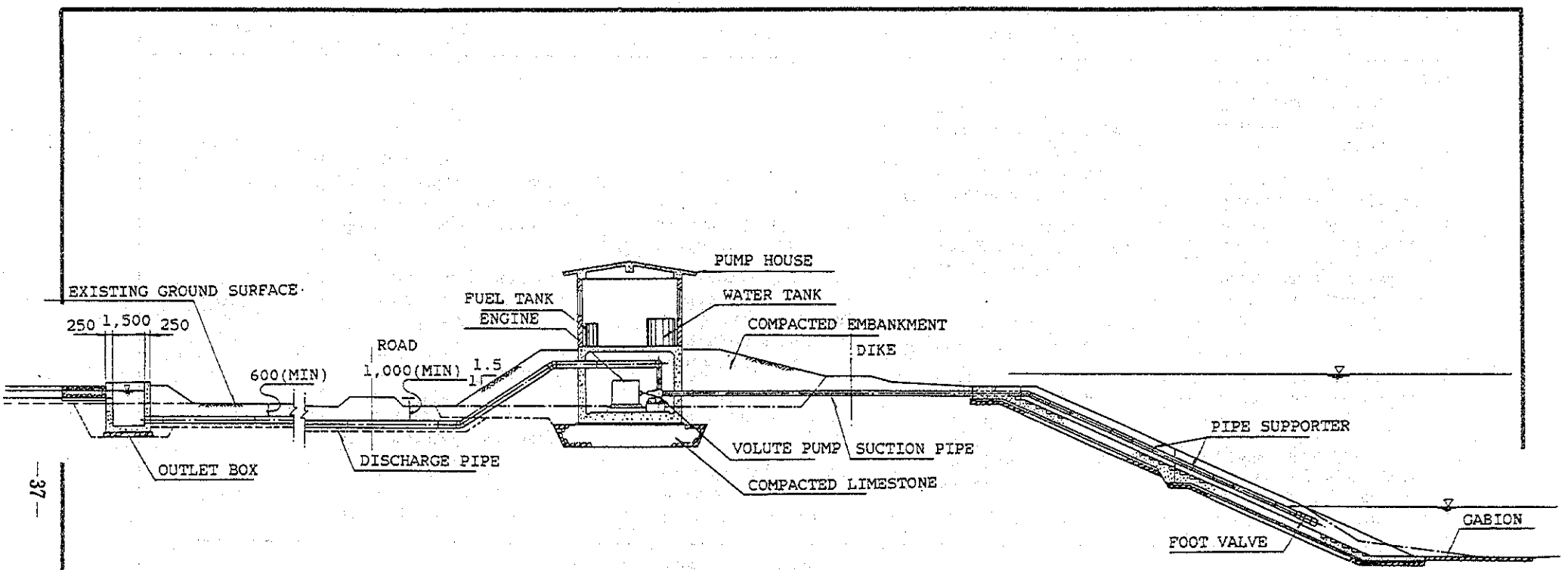


Fig. 5 - 5 Volute Pump Type
(Plan No. 4)

Table 5 - 1 Comparison Table of Pumping Station by Type

◎ Good ● Poor
○ Fair × Not acceptable

	Plan No.1 Vertical pump type	Plan No.2 Floating arm type	Plan No.3 Floating tower system type	Plan No.4 Volute pump type
Construction	Positioned in the proximity of river side, submersible pump set into a deep well slightly below the Lower Water Level (LWL). Horizontal water suction pipe is pierced through the ground to feed water into the well from the river. Impeller is driven by a vertical shaft connected to the engine.	Pillar driven into river bed for setting floating arms with buoy-like segment. This arm allowed to move vertically according to river water level. On this segment, electric powered pump is installed or mounted to which electricity is supplied from an on-shore generator. From top of pillar to the on-shore facility, horizontal pipe bridge is to be installed. This bridge is also utilized for maintaining purpose.	Instead of floating arms, a tower structure, in which the buoy-like segment is enclosed, is to be installed. The other constructions are same as of Plan No. 2.	Volute pump coupled with driving motor is housed in water proofed concrete box to protect from casual flooding. Suction water piping are laid on slant surface of gabion and fixed by metal accessory to protect from water flowing force.
Feature	◎ As pumping-up system adopts thrusting type, hydraulic stability is high. ● Amount of work under the low water level is pretty big. Which result construction & drainage costlier. × Higher possibility of siltation inside horizontal pipe and maintenance is not easy. ● Comparatively, broad revetment work is necessary due to big excavation of river bank.	◎ Height of suction head is constant & not high, provided higher hydraulic stability. ● Pillars in the river interfere the stream. ● Frequent mainte. & checking is necessary for buoy-like segment during flood to protect then from drifting wood & rubbish. ● Special construction machines, like pile driver etc. are mandatory.	◎ Same as of arm type. × Big tower structure in the river considerably interfere river stream resulting complexities in the management of river surface. ● Piling foundation is necessary for heavy tower structure. ● Special construction machines, like pile driver etc. are mandatory. ● Amount of work under the low water level is pretty big. Which result construction & drainage costlier.	● Suction head changes frequently and its maximum value is very big compared to other plan. Also hydraulically unstable. ◎ Simple construction leads to easy maintenance and less cost. ◎ Almost all construction materials & equipments can be procured in Indonesia ◎ Amount of work under the low water level is small, shooter installation period can be expected. ◎ No need to use special construction machine. General tools & equip. are enough to execute.
Judgement	● Poor	○ Fair	× Not acceptable	◎ Good

As indicated in Table 5-1, the volute pump type is evaluated to be superior to others from the following points of view:

- Easy procurement of pump materials in Indonesia,
- Simple structure facilitating operation and maintenance,
- Small construction works around river bank, and
- Possibility of construction by general machinery, etc.

Consequently the volute pump type is selected in the Project.

In case of volute pump type whose location is flood plain along the river bank (Bantaran), it is considered to be constructed under the ground surface (submerged type pump) to prevent the structure from inundated water. However, this idea is discarded by the following reasons:

- Electric power, generated by the diesel engine, is necessary to drive the submerged type pump. Equipments, such as generator and submerged type pump, cause additional cost, which amounts to about 50% of the total cost.
- Fuel cost increases by about 70% because the transmission efficiency is low in comparison to the direct-drive engine type.
- The operation and maintenance cost to be burdened by the farmers increases because of reduction of durable periods accrued from difficult maintenance and incremental operation work required for pumping.

(3) Number of Pumps, Type of Pump and Engine

The number of pumps per station, type of pump and engine are decided as follows.

a Number of pumps

Two (2) pumps of the same type and diameter are decided for each station based on the following reasons.

- Design capacity of a pump is half to the total design irrigation water demand,
- To operate pumps economically in accordance with the seasonal irrigation water demand,
- To eliminate the risk of stoppage of operation during a mechanical trouble, and
- To utilize spare parts each other when necessary.

b. Pump type

Volute pump type is selected considering the following conditions. The volute pump works most effectively among other pump types in the proposed pump site conditions.

- Design capacity per pump ranges from 2 m^3/min to 6 m^3/min.
- Maximum suction head ranges from 3 m to 6 m.
- Total pump head ranges from 8 m to 16 m.

c. Engine

The required capacity of prime mover ranges from 10 ps to 25 ps (from 7.5 kw to 19 kw), thus, diesel engine or electric motor can be used as a prime mover. To compare economical conditions, operation cost per 1,000 hours is calculated for the following two alternatives, i.e. diesel engine or electric motor (20 ps diesel engine is equivalent to 15 kw electric motor). In the calculation, unit cost of light oil and power are evaluated at Rp. 220 per liter and Rp. 122.5 per kwh, respectively:

- Operation cost of diesel engine
  20(ps) x 0.6(load factor) x 0.23(l/ps.hr) x 1,000(hr) x 220(Rp./l)
  = 607,000(Rp.)
- Operation cost of electric motor
  15(kw) x 0.6(load factor) x 1,000(hr) x 122.5(Rp./kw.hr)
  = 1,102,000(Rp.)

By above comparison, it is obvious that the diesel engine is more economical than the electric motor and the operation cost of the electric motor is about double to that of diesel engine. Moreover, base fee needs to be added in the electric fee. Based on the above study, the diesel engine is suitable as a prime mover of the pump in this design.

(4) Design of Pump and Engine Room

Pump and engine room is designed by reinforced concrete box structure with waterproof mortar to protect them from floods. The top elevation of the room is decided by the flood water level of 10-year return period (HHWL) plus freeboard of about 30 cm and total height is to be higher than that of flood water level of 25-year return period.

The height of the pump and engine room is designed at 3.8 m to secure space for pump, engine and pipes in the room. In case of the construction at flood plain (Bantaran), the room is protected by wet masonry.

(5) Design of Intake Structure

Intake structure comprises suction pipes and concrete base structure laid on the river bank. In the design of intake structure, large scale excavation and embankment are not considered in order to maintain the stability of the Solo river bank. The intake structure is to be constructed in such a way that original ground condition can be kept in its original form as much as possible, so as not to disturb river flow. In addition, the intake structure unites a function of a river bank protection work. The suction pipes are fixed to the concrete base structure by metal supporters and steps are provided for the inspection of pipes. Gabion works are designed on the both sides of the concrete base structure at 10 m interval to stable the intake structure firmly to the ground surface. When the gabion is more steeper than 1:3 slope, this portion is to be reinforced by the frame works.

(6) Design of Pump House

The pump house is designed to be built of reinforced concrete beams and brick, taking account of stability against storms and unexpected floods and

stiffness against load of chain block. The chain block is provided for the maintenance of the pumps and engines. The roof is made of reinforced concrete and mortar to make it waterproof. The gable roof is adopted from the scenic point of view.

(7) Design of Pipeline

The pipeline is designed to convey irrigation water by gravity to the higher position in the irrigation area. According to the position of each pumping station, length of the pipeline ranges from 20 m to 820 m with an average of about 200 m.

Asbestos cement pipe is considered mostly without bend pipe portion. The asbestos cement pipe has the following advantages:

- Easy procurement of one made in Indonesia,
- Economical due to less pump head loss caused by low coefficient of roughness, and
- Easy to transport and construction caused by its light weight, etc.

Steel pipes are designed for bend, pump valve joint and portion of pipe buried in concrete.

(8) Design of Appurtenance Structures

The major appurtenance structures comprise outlet boxes of the pipeline and maintenance boxes, attached to the long pipeline, for proper drainage operation and maintenance.

a. Outlet box

The function of the outlet box is to eliminate energy of water (velocity 1.3 - 2.8 m/s) drained from the outlet of the pipeline and to lead it into the next earth canal safely. The box is designed to be of reinforced concrete with the inside volume of 1.5 m x 1.5 m x 1.5 m considering hydraulic and construction conditions.

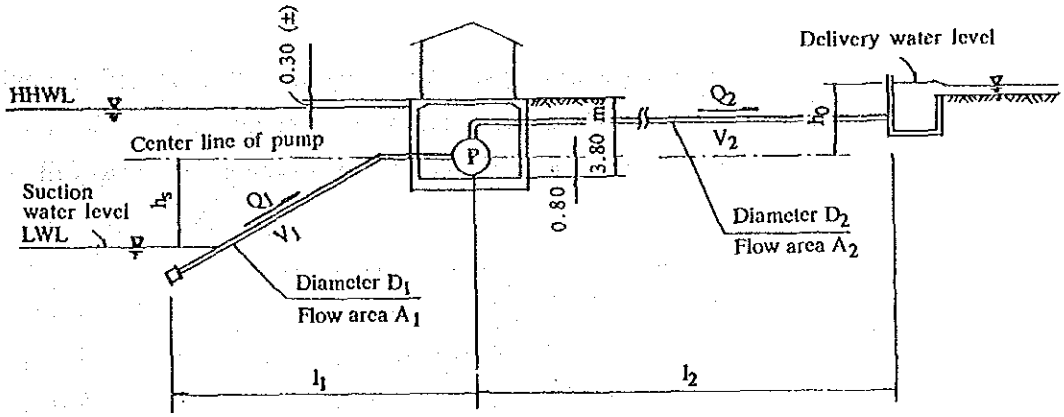
b. Maintenance box

The maintenance box is provided to the long pipeline with an interval of 100 m to 200 m, depends on the condition of pipeline. The box is to be made of reinforced concrete and to be divided into two (2) spaces; one is for valve operation and the other for outlet, where water is drained through the valve and branched pipe of 100 mm diameter.

5.3.4 Dimension of Pumping Station

(1) Hydraulic Calculation

Dimensions of each pumping station, such as diameter of pump, required power of engine, and diameters of pipes, are designed on the basis of following hydraulic calculations. The conditions of hydraulic calculation are shown in followings:



$$Q = 2Q_1 = Q_2, \qquad Q_1 = A_1 \cdot V_1, \qquad Q_2 = A_2 \cdot V_2$$
$$A_1 = \pi D_1^2 / 4, \qquad A_2 = \pi D_2^2 / 4$$

$$H = H_1 + H_2, \qquad H_1 = h_s + h_1, \qquad H_2 = h_0 + h_2$$

$$h_1 = \sum f_1 \cdot \frac{V_1^2}{2g} = 1.50 \cdot f_1 \cdot l_1 = \frac{V_1^2}{2g}, \qquad f_1 = \frac{124.5n_1^2}{D_1^{4/3}}$$

$$h_2 = \sum f_2 \cdot \frac{V_2^2}{2g} = 1.15 \cdot f_2 \cdot l_2 = \frac{V_2^2}{2g}, \qquad f_2 = \frac{124.5n_2^2}{D_2^{4/3}}$$

(Confer above figure for the symbols appeared in the above equations.)

Where,	Q, Q_1, Q_2	Design capacity (m^3/ sec)
	A_1, A_2	Flow area (m^3)
	D_1, D_2	Diameter (m)
	h_s, h_0	Suction and delivery head (m)
	h_1, h_2	Friction head loss on suction and delivery side (m)
	H_1, H_2	Total suction and delivery head (m)
	f_1, f_2	Coefficient of friction loss
	n_1, n_2	Manning's coefficient of roughness
	l_1, l_2	Length of pipe on suction and delivery side (m)

In the design of water level at the outlet box, the elevation of the paddy field, required water head on the ditch (0.5 m per 1 km) and freeboard of 0.3 m are considered. The results of calculation of each station are indicated in Table 5-2.

(2) Dimension of pumping Station

Dimension of each pumping station is determined in accordance with the hydraulic analyses. The salient features of each pumping station are shown in Table 5-3. The volume of the major works is summarized as follows:

- Volute pump ..... 66 nos.
  - ø 150 x 100 (Single suction) ..... 14 nos.
  - ø 200 x 150 (Double suction) ..... 4 nos.
  - ø 200 x 200 (Double suction) ..... 8 nos.
  - ø 250 x 200 (Double suction) ..... 40 nos.

- Diesel engine ..... 66 nos.
  - 12 ps ..... 10 nos.
  - 15 ps ..... 4 nos.
  - 17 ps ..... 16 nos
  - 18 ps ..... 14 nos.
  - 25 ps ..... 22 nos.

- Pipe line (Asbestos cement pipe) ..... 6,250 m
  - ø 200 ..... 280 m

	ø 250	1,100 m
	ø 300	2,910 m
	ø 350	1,310 m
	ø 400	650 m
-	Outlet box	33 nos.
-	Maintenance box.....	30 nos.

Table 5 - 2 Hydraulic Computation for Pumping Stations (No. 1)

No.	Name of Station	Q (m3/sec)	Q1 Q2 (m3/sec)	D1 D2 (m)	A1 A2 (m3)	V1 V2	f1 f2	l1 l2 (m)	∑f1 ∑f2	h1 h2 (m)	hs h0 (m)	H1 H2 (m)	H (m)	1/2 * Q (m3/min)	Pump Diameter (mm)	Engine Power (ps)
1	TAPELAN		0.030	0.15	0.0177	1.69	0.2640	20	7.92	1.15	4.00	5.15			150x100	12
	(60 ha)	0.06	0.060	0.20	0.0314	1.91	0.1064	200	24.47	4.55	4.60	9.15	14.30	1.8	2 sets	2 sets
2	SUMBERARUM		0.075	0.25	0.0491	1.53	0.1336	20	4.01	0.48	3.90	4.38			200x150	25
	(150 ha)	0.15	0.150	0.30	0.0707	2.12	0.0620	250	17.83	4.09	4.70	8.79	13.17	4.5	2 sets	2 sets
3	TEBON		0.025	0.15	0.0177	1.41	0.2640	30	11.88	1.21	3.90	5.11			150x100	12
	(50 ha)	0.05	0.050	0.20	0.0314	1.59	0.1064	80	9.79	1.26	4.00	5.26	10.37	1.5	2 sets	2 sets
4	PERANGI		0.040	0.20	0.0314	1.27	0.1799	30	8.10	0.67	3.90	4.57			150x100	17
	(80 ha)	0.08	0.080	0.25	0.0491	1.63	0.0791	180	16.37	2.22	4.30	6.52	11.09	2.4	2 sets	2 sets
5	BANJAREJO		0.045	0.20	0.0314	1.43	0.1799	30	8.10	0.85	3.80	4.65			150x100	17
	(90 ha)	0.09	0.090	0.25	0.0491	1.83	0.0791	160	14.55	2.49	4.00	6.49	11.14	2.7	2 sets	2 sets
6	NGRAHO		0.080	0.25	0.0491	1.63	0.1336	30	6.01	0.81	3.90	4.71			250x200	25
	(160 ha)	0.16	0.160	0.35	0.0962	1.66	0.0505	350	20.33	2.86	4.30	7.16	11.87	4.8	2 sets	2 sets
7	SUDU		0.100	0.25	0.0491	2.04	0.1336	30	6.01	1.28	3.90	5.18			250x200	18
	(200 ha)	0.20	0.200	0.35	0.0962	2.08	0.0505	40	2.32	0.51	3.30	3.81	8.99	6.0	2 sets	2 sets
8	NGRINGINREJO		0.100	0.25	0.0491	2.04	0.1336	20	4.01	0.85	3.90	4.75			250x200	18
	(200 ha)	0.20	0.200	0.35	0.0962	2.08	0.0505	100	5.81	1.28	2.60	3.88	8.63	6.0	2 sets	2 sets
9	LERAN		0.045	0.20	0.0314	1.43	0.1799	25	6.75	0.70	3.90	4.60			150x100	17
	(90 ha)	0.09	0.090	0.25	0.0491	1.83	0.0791	500	45.48	7.77	3.30	11.07	15.67	2.7	2 sets	2 sets
10	TRUCUK		0.065	0.20	0.0314	2.07	0.1799	20	5.40	1.18	4.00	5.18			200x200	12
	(130 ha)	0.13	0.130	0.25	0.0491	2.65	0.0791	20	1.82	0.65	2.00	2.65	7.83	3.9	2 sets	2 sets
11	TULUNGREJO		0.055	0.20	0.0314	1.75	0.1799	25	6.75	1.05	3.90	4.95			200x200	12
	(110 ha)	0.11	0.110	0.25	0.0491	2.24	0.0791	20	1.82	0.47	1.90	2.37	7.32	3.3	2 sets	2 sets
12	MULYOAGUNG		0.090	0.25	0.0491	1.83	0.1336	25	5.01	0.86	4.00	4.86			250x200	18
	(180 ha)	0.18	0.180	0.30	0.0707	2.55	0.0620	100	7.13	2.37	2.50	4.87	9.73	5.4	2 sets	2 sets
13	KALIREJO		0.080	0.25	0.0491	1.63	0.1336	30	6.01	0.81	4.00	4.81			250x200	17
	(160 ha)	0.16	0.160	0.30	0.0707	2.26	0.0620	80	5.70	1.49	3.60	5.09	9.90	4.8	2 sets	2 sets
14	SEMANDING		0.090	0.25	0.0491	1.83	0.1336	25	5.01	0.86	4.20	5.06			250x200	25
	(180 ha)	0.18	0.180	0.30	0.0707	2.55	0.0620	150	10.70	3.55	2.90	6.45	11.51	5.4	2 sets	2 sets
15	MULYOREJO		0.100	0.25	0.0491	2.04	0.1336	25	5.01	1.06	4.20	5.26			250x200	18
	(200 ha)	0.20	0.200	0.30	0.0707	2.83	0.0620	20	1.43	0.58	2.70	3.28	8.54	6.0	2 sets	2 sets
16	SARIREJO		0.100	0.25	0.0491	2.04	0.1336	25	5.01	1.06	4.20	5.26			250x200	25
	(200 ha)	0.20	0.200	0.40	0.1260	1.59	0.0422	650	31.54	4.07	2.50	6.57	11.83	6.0	2 sets	2 sets
17	PILANGGEDE		0.045	0.20	0.0314	1.43	0.1799	30	8.10	0.85	4.30	5.15			150x100	17
	(90 ha)	0.09	0.090	0.30	0.0707	1.27	0.0620	820	58.47	4.81	3.30	8.11	13.26	2.7	2 sets	2 sets

Table 5 - 2 Hydraulic Computation for Pumping Stations (No. 2)

No.	Name of Station	Q (m3/sec)	Q1 Q2 (m3/sec)	D1 D2 (m)	A1 A2 (m3)	V1 V2	f1 f2	l1 l2 (m)	∑f1 ∑f2	h1 h2 (m)	hs h0 (m)	H1 H2 (m)	H (m)	1/2 * Q (m3/min)	Pump Diameter (mm)	Engine Power (ps)
18	KEDUNGBONDO		0.050	0.20	0.0314	1.59	0.1799	30	8.10	1.04	4.30	5.34			200x150	25
	(100 ha)	0.10	0.100	0.30	0.0707	1.41	0.0620	750	53.48	5.42	5.60	11.02	16.36	3.0	2 sets	2 sets
19	CANGAKAN		0.070	0.25	0.0491	1.43	0.1336	20	4.01	0.42	4.40	4.82			250x200	15
	(140 ha)	0.14	0.140	0.30	0.0707	1.98	0.0620	100	2.13	1.43	3.40	4.83	9.65	4.2	2 sets	2 sets
20	KABALAN		0.085	0.25	0.0491	1.73	0.1336	30	6.01	0.92	4.40	5.32			250x200	25
	(170 ha)	0.17	0.170	0.30	0.0707	2.40	0.0620	150	10.70	3.14	2.20	5.34	10.66	5.1	2 sets	2 sets
21	MOJOREJO		0.075	0.25	0.0491	1.53	0.1336	20	4.01	0.48	4.00	4.48			250x200	25
	(150 ha)	0.15	0.150	0.30	0.0707	2.12	0.0620	150	10.70	2.45	5.60	8.05	12.53	4.5	2 sets	2 sets
22	DENGOK		0.100	0.25	0.0491	2.04	0.1336	20	4.01	0.85	3.80	4.65			250x200	25
	(200 ha)	0.20	0.200	0.30	0.0707	2.83	0.0620	100	7.13	2.91	3.90	6.81	11.46	6.0	2 sets	2 sets
23	KARANGTINOTO		0.100	0.25	0.0491	2.04	0.1336	30	6.01	1.28	4.50	5.78			250x200	25
	(200 ha)	0.20	0.200	0.30	0.0707	2.83	0.0620	20	1.43	0.58	3.30	3.88	9.66	6.0	2 sets	2 sets
24	BANDUNGREJO		0.100	0.25	0.0491	2.04	0.1336	25	5.01	1.06	4.80	5.86			250x200	25
	(200 ha)	0.20	0.200	0.35	0.0962	2.08	0.0505	200	11.62	2.56	0.80	3.36	9.22	6.0	2 sets	2 sets
25	KLOTOK		0.100	0.25	0.0491	2.04	0.1336	30	6.01	1.28	4.80	6.08			250x200	25
	(200 ha)	0.20	0.200	0.35	0.0962	2.08	0.0505	320	18.58	4.10	0.20	4.30	10.38	6.0	2 sets	2 sets
26	TANGGUNGAN		0.060	0.25	0.0491	1.22	0.1336	25	5.01	0.38	4.90	5.28			200x200	15
	(120 ha)	0.12	0.120	0.25	0.0491	2.44	0.0791	100	9.10	2.76	3.20	5.96	11.24	3.6	2 sets	2 sets
27	KALISARI		0.040	0.20	0.0314	1.27	0.1799	25	6.75	0.56	4.90	5.46			150x100	17
	(80 ha)	0.08	0.080	0.25	0.0491	1.63	0.0791	100	9.10	1.23	2.70	3.93	9.39	2.4	2 sets	2 sets
28	BANJAR		0.095	0.25	0.0491	1.93	0.1336	30	6.01	1.14	4.70	5.84			250x200	18
	(190 ha)	0.19	0.190	0.30	0.0707	2.69	0.0620	100	7.13	2.63	0.20	2.83	8.67	5.7	2 sets	2 sets
29	KEDUYUNG		0.100	0.25	0.0491	2.04	0.1336	30	6.01	1.28	3.70	4.98			250x200	17
	(200 ha)	0.20	0.200	0.30	0.0707	2.83	0.0620	20	1.43	0.58	2.20	2.78	7.76	6.0	2 sets	2 sets
30	BULUTIGO		0.100	0.25	0.0491	2.04	0.1336	30	6.01	1.28	3.50	4.78			250x200	18
	(200 ha)	0.20	0.200	0.35	0.0962	2.08	0.0505	200	11.62	2.56	1.00	3.56	8.34	6.0	2 sets	2 sets
31	PELANGWOT		0.100	0.25	0.0491	2.04	0.1336	30	6.01	1.28	3.20	4.48			250x200	17
	(120 ha)	0.20	0.200	0.35	0.0962	2.08	0.0505	100	5.81	1.28	1.90	3.18	7.66	6.0	2 sets	2 sets
32	TAMANPRIJEK		0.060	0.20	0.0314	1.91	0.1799	30	8.10	1.51	2.80	4.31			200x200	12
	(200 ha)	0.12	0.120	0.25	0.0491	2.44	0.0791	20	1.82	0.55	3.10	3.65	7.96	3.6	2 sets	2 sets
33	TEJOASRI		0.100	0.25	0.0491	2.04	0.1336	20	4.01	0.85	2.30	3.15			250x200	18
	(200 ha)	0.20	0.200	0.30	0.0707	2.83	0.0620	100	7.13	2.91	2.50	5.41	8.56	6.0	2 sets	2 sets

Table 5-3 Features of Each Pumping Station

No.	Name of Station	In/Out-side of the Dike	Pump and Engine			Pipeline			
			Pump Size	Engine Power	Nos.	Diameter	Length	Outlet Box	Maintenance Box
1	TAPELAN	Inside	150 ×100 mm	12ps	2sets	200 mm	200 m	1 no.	1 no(s).
2	SUMBERARUM	〃	200 ×150	25	〃	300	250	〃	1
3	TEBON	〃	150 ×100	12	〃	200	80	〃	—
4	PERANGI	〃	〃	17	〃	250	180	〃	1
5	BANJAREJO	〃	〃	〃	〃	〃	160	〃	1
6	NGRAHO	〃	250 ×200	25	〃	350	350	〃	2
7	SUDU	〃	〃	18	〃	〃	40	〃	—
8	NGRINGINREJO	〃	〃	〃	〃	〃	100	〃	—
9	LERAN	〃	150 ×100	17	〃	250	500	〃	3
10	TRUCUK	〃	200 ×200	12	〃	〃	20	〃	—
11	TULUNGREJO	〃	〃	〃	〃	〃	20	〃	—
12	MULYOAGUNG	Outside	250 ×200	18	〃	300	100	〃	—
13	KALIREJO	〃	〃	17	〃	〃	80	〃	—
14	SEMANDING	〃	〃	25	〃	〃	150	〃	1
15	MULYOREJO	Inside	〃	18	〃	〃	20	〃	—
16	SARIREJO	〃	〃	25	〃	400	650	〃	4
17	PILANGGEDE	〃	150 ×100	17	〃	300	820	〃	5
18	KEDUNGBONDO	〃	200 ×150	25	〃	〃	750	〃	5
19	CANGAKAN	〃	250 ×200	15	〃	〃	100	〃	—
20	KABALAN	〃	〃	25	〃	〃	150	〃	1
21	MOJOREJO	〃	〃	〃	〃	〃	〃	〃	1
22	DENGOK	〃	〃	〃	〃	〃	100	〃	—
23	KARANGTINOTO	〃	〃	〃	〃	〃	20	〃	—
24	BANDUNGREJO	〃	〃	〃	〃	350	200	〃	1
25	KLOTOK	Outside	〃	〃	〃	〃	320	〃	2
26	TANGGUNGAN	Inside	200 ×200	15	〃	250	100	〃	—
27	KALISARI	〃	150 ×100	17	〃	〃	〃	〃	—
28	BANJAR	Outside	250 ×200	18	〃	300	〃	〃	—
29	KEDUYUNG	〃	〃	17	〃	〃	20	〃	—
30	BULUTIGO	〃	〃	18	〃	350	200	〃	1
31	PELANGWOT	〃	〃	17	〃	〃	100	〃	—
32	TAMANPRIJEK	Inside	200 ×200	12	〃	250	20	〃	—
33	TEJOASRI	〃	250 ×200	18	〃	300	100	〃	—

CHAPTER 6 IMPLEMENTATION PLAN

6.1 General

In this chapter, implementation plan of the Project is described when it would be carried out under the Japan's Grant Aid Program. The Project is commenced after following procedures.

The Government of Japan and the Government of Indonesia exchange Notes (E/N) on the Project and reach to the conclusion that the Government of Indonesia shall be entered into contract with the Japanese foreign exchange bank to give an authorization to pay (A/P) to the respective consultant and the construction contractor directly. Thereafter the Government of Indonesia selects the Japanese consultant to conduct detailed design and construction supervision, and then the contractor to carry out the construction works.

6.2 Detailed Design

Based on the contract between the Government of Indonesia and the consultant, the consultant conducts detailed design, which consists of topographical survey need for construction works, design works on each pumping station and cost estimation. The scope of the detailed design is intake structure, pumping station, pipeline, and outlet box, according to principle of basic design study. In addition, the consultant provides PBS with informations and advice, such as position and elevation of outlet boxes and designed discharges, for design of secondary and tertiary canals, which is a scope to be executed by the Government of Indonesia.

6.3 Cooperation to Construction Contract

The consultant, after completion of detailed design, cooperates preparation of construction contract under responsibility of the Government of Indonesia. This cooperation includes selection of the construction contractor, determination of contracting method, draft up of the construction contract document, checking of the contents of itemized detail of construction, and attendance and witnessing of construction contract award.

6.4 Plan of Construction Supervision

The consultant, after construction contract, proceeds the construction supervision work of the Project

Actual functions of the construction supervision work are as follows:

1) Cooperation to realize the proper construction contract.
2) Realization of the designing conception.
3) Supervising the construction contractor from the neutral stance so that construction work to be proceeded according to contract.

Following works should be carried out for proper fulfillment of the above.

(1) Evaluation and Approval of the Construction Document

Evaluation and checking of construction drawing, construction material, finished specimen and equipments to be submitted by the construction contractor.

(2) Supervision of the Construction

Evaluation on the construction plan and schedule, supervision for the construction contractor and report on the work progress to the executing agency of the Government of Indonesia.

(3) Cooperation for Smooth Issuance of Authorization of Payment

Cooperation should be made to check the contents of construction bill and its smooth issuance procedure during and end of the construction.

(4) Attendance and Witness for the Inspection

From the commencement to the completion of the construction, checking and technical supervising are made on the amount of work done. After the confirmation of completion of the Project with the fulfillment of contractual obligation, the consultant will present on the occasion of hand over of

contractual objective i.e.; the Project when accepted by the Government of Indonesia, the role of the consultant will then be completed.

6.5 Construction Plan

(1) General

Feature of the Project is that 33 pumping station sites are scattered alongside the Solo river within a total length of 150 km. In view of work efficiency and construction cost, it is recommendable to carry out the work during the dry season because of low river water level. Further, no direct access road is available to move from one site to other. Judging from these circumstances mentioned above, the Project should be implemented in two phases so that sufficient construction management and better work quality will result.

(2) Construction Period

As the proposed construction works are dominated by earth works, the progress would be assumed to be affected by rainfall. Therefore, workability for the construction plan is analyzed with use of rainfall data.

Monthly precipitation and rainy days statistics for nine (9) years at Bojonegoro, approximately located in the center of this Project site, is shown in Table A-19. From the table, following facts can be interpreted.

1) Dry season usually last for six (6) months from May to October.
2) Especially from June to September (four (4) months), it rains scarcely.
3) Lowest water level can be expected in August and September i.e.; at the end of the dry season.
4) Wet season usually last from November to April.
5) 80 % of the yearly precipitation is concentrated in the six (6) months of the wet season. (Precipitation ratio of the wet season = 1,606 / 2,043 = 0.80)
6) Total rainy days during the dry season are 27 days in average.
7) Total rainy days during the wet season are 78 days in average.

Taking above data into consideration, available working days have been computed for the dry and wet season in the following manner. Conventional holidays, the Idul Fithri preceding Ramadan fast for the Moslem peoples are in the wet season (these years), so five days holidays will be counted for this in the wet season; further, particular rainy days which overlap with holidays are calculate as follows;

Dry season $\{ 5 + (365/2) \times (1/7)\} \times \{27/(365/2)\} = 5$ days

Wet season $\{10 + (365/2) \times (1/7)\} \times \{78/(365/2)\} = 15$ days

	Dry Season	Wet Season
(1) Number of Sundays in six months	52 (week/year) / 2 = 26 days	52 (week/year) / 2 = 26 days
(2) Number of religious holidays in six months	10 (day/year) / 2 = 5 days	10 (day/year) / 2 = 5 days
(3) Number of rainy days in six months	27 days	78 days
(4) Number of Idul Fithri holidays	-	5 days
(5) Overlap with rainy days and the other holidays	Δ 5 days	Δ 15 days
Total	53 days	99 days

Therefore, available working days and non-working days for a month will be as follows:

	Dry Season	Wet Season
Non-working Days	53 days / 6 months = 9 days	99 days / 6 months = 17 days
Available working Days	30 days - 9 days = 21 days	30 days - 17 days = 13 days

With above results, it can be anticipated that the available working days for the wet season will be about 60 % (13 / 21 = 0.62) of that of the dry season. If rise of river water also taken into consideration, workability of the wet season will be 50 % of that of the dry season.

(3) Construction Method

a. General

Work volume of one pump house house is not so big, therefore, man power construction is mainly applied for the construction. The construction consists of pump house, intake facilities and pipeline. Those construction methods are described hereinafter.

b. Pump house construction

The pump and engine room is designed as semi submergible type. Main works of the pump house consist of civil works and concrete works. Excavation is done by manpower and the excavated face for foundation must be completed by well compaction by portable compactor. After completion of the excavation, foundation gravel is placed and also compacted. After this, form and reinforced iron bar for concrete shall be installed and concrete shall be placed. As the quality of concrete must be water tight, careful placement with use of vibrator is required and waterproof mortal lining is also required for the face of placed concrete to make pure the waterproof. After completion of pump and engine room, backfilling can be started. The good quality of earth material for backfilling must be used and compacted by manpower with use of compactor.

The pump house shall be constructed after completion of pump and engine room. The frame work is made by concrete and wall portion is made by bricks. These works are also done by manpower.

After this, equipments inside of the pump house such as pump, engine, pipe, fuel tank, and chain block shall be installed.

c. Intake facilities construction

Intake facilities consist of suction pipe, base concrete and river bank protection work. The construction shall be done during low water level of the Solo river in order to avoid the construction from a difficulties caused by high river water. In case of construction during