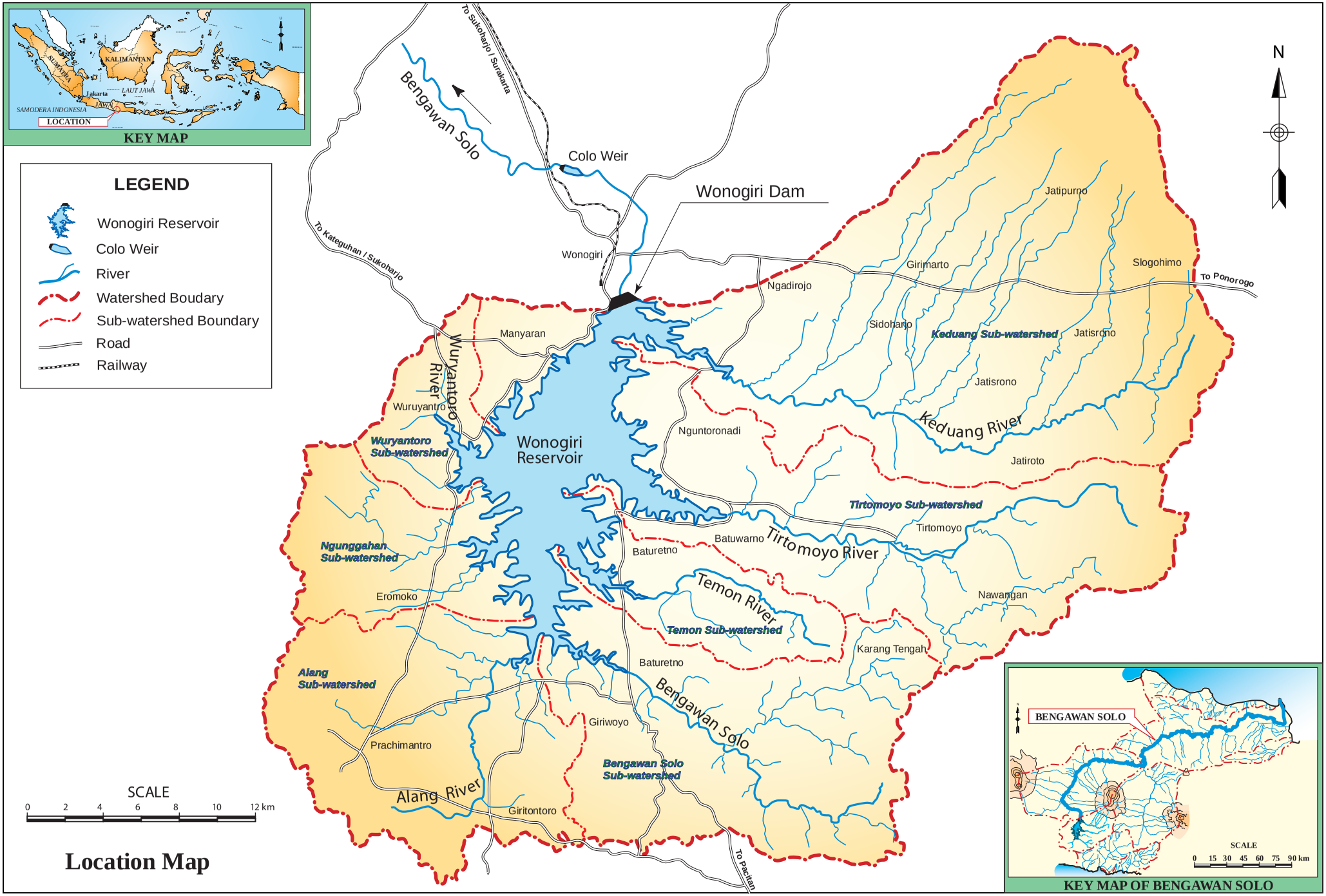
Part II
Feasibility Study


KEY MAP
SUMATERA
KALIMANTAN
Jakarta
LAUT JAWA
JAWA
SAMODERA INDONESIA
LOCATION
LEGEND
Wonogiri Reservoir
Colo Weir
River
Watershed Boudary
Sub-watershed Boundary
Road
Railway
To Sukoharjo / Surakarta
Bengawan Solo
Colo Weir
Wonogiri Dam
To Kateguhan / Sukoharjo
Wonogiri
Jatipurno
Girimarto
Slogohimo
To Ponorogo
Ngadirojo
Sidoharjo
Keduang Sub-watershed
Jatisrono
Manyaran
Wuryantoro River
Wuruyantro
Wuryantoro Sub-watershed
Wonogiri Reservoir
Nguntoronadi
Keduang River
Jatiroto
Tirtomoyo Sub-watershed
Tirtomoyo
Batuwarno
Tirtomoyo River
Ngunggahan Sub-watershed
Baturetno
Eromoko
Temon River
Nawangan
Temon Sub-watershed
Karang Tengah
Alang Sub-watershed
Baturetno
Bengawan Solo
Giriwoyo
Prachimantro
Bengawan Solo Sub-watershed
Alang River
Giritontoro
To Pacitan
N
SCALE
0 2 4 6 8 10 12 km
Location Map
BENGAWAN SOLO
SCALE
0 15 30 45 60 75 90 km
KEY MAP OF BENGAWAN SOLO

THE STUDY ON
COUNTERMEASURES FOR SEDIMENTATION
IN
THE WONOGIRI MULTIPURPOSE DAM RESERVOIR
IN
THE REPUBLIC OF INDONESIA

FINAL REPORT

VOLUME II MAIN REPORT

Part II: Feasibility Study

Table of Contents

List of Tables

List of Figures

Attachments

CHAPTER 1 INTRODUCTION

1.1 Background of the Feasibility Study

The JICA Study Team submitted the Interim Report to Directorate General of Water Resources, Ministry of Public Works at the Steering Committee Meeting in Jakarta on July 4, 2006 in accordance with the Scope of Work of the Study. The Interim Report described the Master Plan of countermeasures for sedimentation problems in the Wonogiri reservoir. Intensive discussions were made between the JICA Study Team and Committee members at the meeting. The conclusion of the Steering Committee was postponed until the next meeting for review by the members, because the Master Plan was of great importance to decide the direction of comprehensive sediment management of the Wonogiri watershed as well as the Wonogiri reservoir.

At the next Steering Committee meeting held on July 19, 2006, the Master Plan tackling for sedimentation issues in the Wonogiri reservoir by means of combination of the structural and non-structural measures was finally approved through a series of discussions. Further at the meeting, the urgent countermeasure proposed in the Master Plan was approved as the priority project that was subject to feasibility study in the Phase II of the Study. The urgent countermeasure (hereinafter referred to as the "Project") comprises three Project components:

i) Sediment storage reservoir with new gates in the Wonogiri reservoir

ii) Watershed conservation in the Keduang River basin, and

iii) Procurement of dredger for periodic maintenance in the intake forebay

1.2 Project Area

The Project Area covers i) the Wonogiri dam and reservoir (reservoir area of 90 km^2), ii) Keduang River basin (catchment area of 421 km^2), and iii) downstream reaches of the Bengawan Solo River from the Wonogiri dam to the confluence with the Madiun River, as shown in a Location Map attached at the beginning of this Part II of the Draft Final Report.

1.3 Feasibility Study Report

The Feasibility Study was commenced in July 2006 as Phase II of the Study in accordance with the work schedule shown in Figure 1.3.1 below. Total duration of the Feasibility Study is scheduled to be 8 months ending in February 2007.

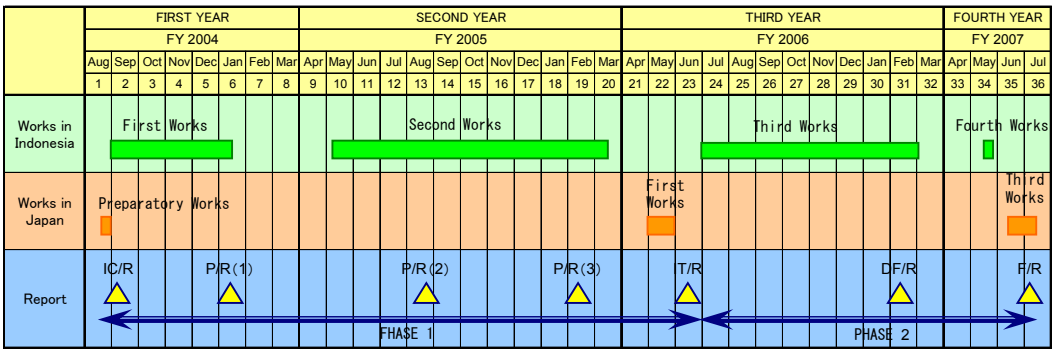


Figure 1.3.1 Overall Schedule of the Study

During the feasibility study, the field investigations; i) topographic survey for the sediment storage reservoir site, ii) geological investigation and laboratory test, iii) land use survey in Keduang River basin, and iv) environmental impact assessment of the Project, were carried out entrusting to the local contractor and university.

This Feasibility Study Report is submitted as the outcome of the Phase II of the Study, describing the whole results of feasibility study on the Project.

CHAPTER 2 THE PROJECT AREA

2.1 Socio-economic Condition

2.1.1 General

The Keduang River basin (Keduang watershed) (about 42,084 ha) was identified as the highest priority area for implementation of the watershed conservation in the Mater Plan Study. As a result, 82 villages as target areas of the planned watershed conservation activities were selected from 98 villages in the Keduang watershed. These target villages are under jurisdiction of 9 kecamatans in Kabupaten Wonogiri. The area extent of the selected villages is about 36,900 ha in total and accounts for 88% of the Keduang watershed. The administrative area covering the selected 82 villages is herein called the Project proposed area.

2.1.2 Administrative Area

The Project proposed area is located all within Wonogiri District, Central Java Province. It has 9 kecamatans, 82 villages and 517 dusuns (small villages) as shown below. An administrative boundary map in the Keduang watershed is shown in Figure 2.1.1.

Table 2.1.1 Administration Divisions of Project Proposed Area in the Keduang Watershed

Province	Kabupaten	Name of Kecamatan	No. of Desa*	No of Dusun**
Central Java	Wonogiri	Girimarto	12	93
		Jatipurno	11	66
		Jatiroto	10	46
		Jatisrono	15	69
		Ngadirojo	6	63
		Nguntoronadi	1	9
		Sidoharjo	12	103
		Slogohimo	14	58
		Wonogiri	1	10
Total			**82**	**517**

Source: *Result of GIS analysis made by JICA Study Team, Nov. 2006
**Statistical year book of Kecamatan ,2004

2.1.3 Population

(1) Number, Growth Rate of Population, and Density

The total population in the Project area is 306,522 in 2004 with an annual population growth rate of 1.26% from 2003 to 2004. The population density is as high as 817/km^2 in 2004. Comparing with Indonesian and Central Java population condition, the rate of population growth and density in the Project area during 2003-2004 is higher than both.

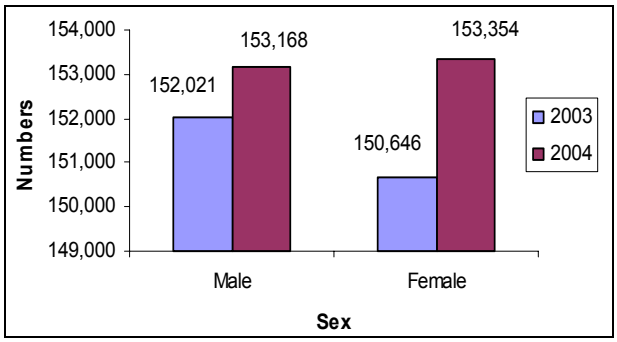
(2) Sex Profile, Household and Family Size

Sex profile in 2003 comparing with 2004, the figures highly difference, such as in 2003, male numbers is higher than female, with sex ratio[1] about 100.91. It means in every 100 female, there are 100.91 male Contrary, female numbers is higher at 2004, with sex ratio about 99.88. It means in every 100 female, there are 99.88 male. The difference of sex ratio in 2003 and 2004 is related with natural population growth (fertility/birth and mortality/dead) and migration (in and out migration). During 2004, male fertility (birth) is

[1] Sex ratio is the ratio of males to females in a given population and year, usually expressed as the number of males for every 100 females. (BPS, Statistical Yearbook of Indonesia, 2004, June 2005:p. 59.)

higher than female, and in contrary female mortality (dead) is higher than male. Similarly with those, there are big different rate of out and in migration between male and female.

Consequently, increasing rate for male and female is quite different. Female increasing is higher than male rate. Male increasing rate from 2003 to 2004 is about 0.75%, and female is about 1.8%. Numbers of each sex and compositions is shown below:



Source: Statistical year book of Kecamatan ,2004

Figure 2.1.2 Sex Profile in Project Proposed Area

The total household in the Project area is about 65,007 and an average family size is 4.72. Household condition refers to quantity of household, density of household per km^2 and family size in such an area. In 2004, household population in project proposed area is 26.60 % from household in kabupaten Wonogiri or 33.84 % of it in Wonogiri catchment's area. But household density in project proposed area is bigger than either in kabupaten or Wonogiri catchment's area. Family size in project area is bigger than in Kabupaten Wonogiri or chacthment area of Wonogiri reservoir, as shown below:

Table 2.1.2 Household, Household Density and Family Size in Project Proposed Area, 2004

Kabupaten	Household (HH)		Family Size	
	2004	**2005**	**2004**	**2005**
Kabupaten Wonogiri	244,386	255,955	4.57	4.38
Wonogiri dam watershed	192,051	201,143	4.57	4.38
Project proposed area	**65,007**		**4.72**	

Source: Statistical year book of Kabupaten Wonogiri 2004 and Kecamatan in 2003 and 2004

(3) Natural Population Growth, Mortality, and Fertility

The height of increasing rate of population and density is related with natural population growth and migration. Hypothetically, it could be said that increase rate of population and density are contributed by natural population growth, decrease of out migration and increase of in migration. These figures are shown below:

Table 2.1.3 Natural Population Growth, Mortality and Fertility in Project Proposed Area

	Natural Population Growth (%)		Fertility		Mortality	
	2003	**2004**	**2003**	**2004**	**2003**	**2004**
Kabupaten Wonogiri	0.62	0.44	11,961	9,113	5,006	4,163
Project proposed area	**0.62**	**0.64**	**3,474**	**3,401**	**1,589**	**1,525**

Source: Statistical year book of Kabupaten Wonogiri 2003 and Kecamatan in 2003 and 2004

(4) Migration

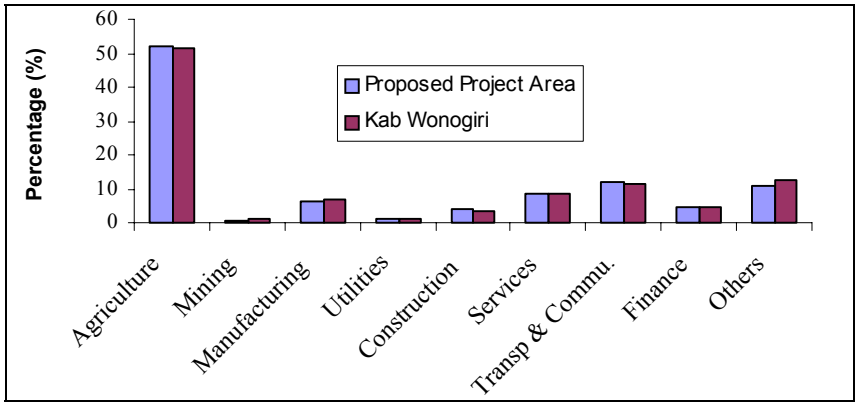
Out migration in the project area is decreasing in 2003-2004, from 2,306 persons (in

2003) decrease about 45.16 % become 1,268 person (in 2004). But, for in migration, it increase about 45.09 % or about 642 persons become 1,995 persons. Those are highly different with increasing rate in Kabupaten Wonogiri and Wonogiri dam watershed, which is increasing on both migrations. Wonogiri people conducted migration for working in other city, such as Jakarta, Surabaya, Surakarta etc.

2.1.4 Economic Profile

(1) Economic Structure

The agricultural sector in Kabupaten Wonogiri is the most dominant sector in terms of contribution to 51% of GRDP of Kabupaten Wonogiri. Major agricultural commodities are 1) seasonal crops such as paddy, polowijoo, chili, etc, 2) perennial crops such as cashew nuts, coconuts, cloves, bananas, chilies, 3) timber's production such as teakwood and Mahagoni and Senokeling and 4) livestock production, followed by transportation & communication, services, manufacturing, etc. The agricultural sector in the Project area also is estimated to contribute to 52 % of RGDP in 2004 and about 44.59% of Kabupaten Wonogiri. RGDP shared by sectors is shown in the figure and tables.



Source: PDRB Kecamatan in 2004; kerjasama BPS & Bappeda Kab. Wonogiri

Figure 2.1.3 RGDP shared by Sector based on Kabupaten Wonogiri and the Project Area

An average of GDP per capita in Project area is estimated to be 2.36 million Rupiah/year/person, or Rp.6,500 (or 0.7$) /day/person, and it is a little below than average in Kabupaten Wonogiri (2.6 million Rupiah). For GDP in project area is 44.59% of GDP of Kabupaten Wonogiri. It seems, the project area is become the most supported GDP to Kabupaten GDP.

Table 2.1.4 Per Capita DGDP in Kabupaten Wonogiri and Project Area in 2004

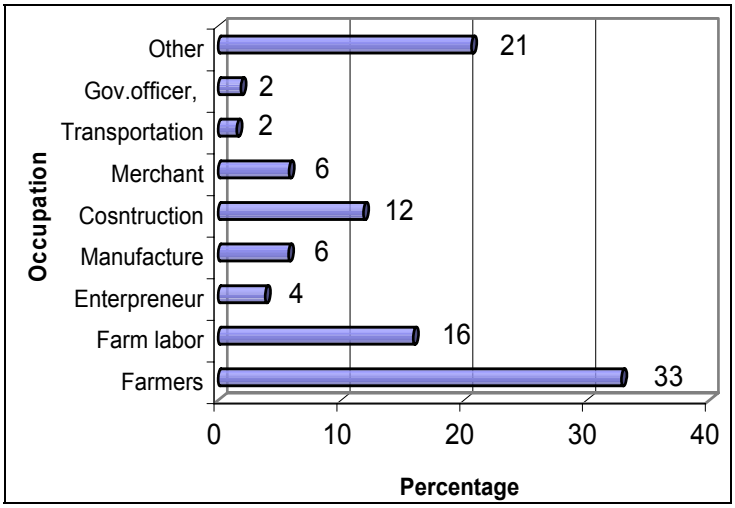
	GDP/capita/year	GDP/year
Unit	Rp.million	Rp.million
Indonesia	2.13	458,401,654
Central Java Province	1.42	45,605,369
Kab. Wonogiri	2.6	2,984,864
Kecamatan in Project Area		
Girimarto	1.9	92,520
Jatipurno	1.7	68,768
Jatiroto	2.0	87,989
Jatisrono	2.3	156,504
Ngadirojo	4.1	245,743
Nguntoronadi	2.8	79,761
Sidoharjo	2.2	105,718

Slogohimo	1.9	103,339
Wonogiri	4.5	390,727
Average in Project Proposed Area	**2.36**	**147,896.6**
Total in Project Area	**23.4**	**1,331,069**

Source: PDRB Kecamatan in 2004; kerjasama BPS & Bappeda Kab. Wonogiri

(2) Labor force / Man Power

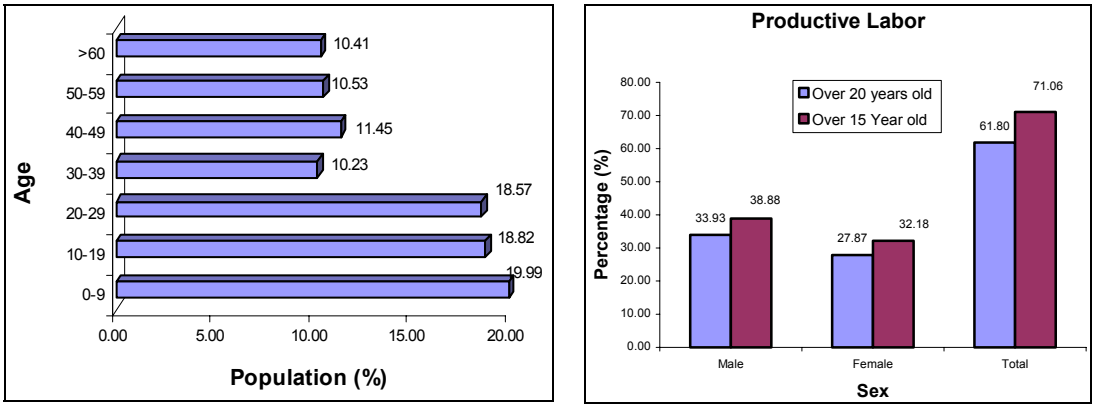
It is estimated based on the village profile, it may be concluded that agricultural sector absorbed about 49% of the total employment in the Project in 2004 as shown below.



Source: Statistical year book of Kecamatan in 2004, Village Profile 2005

Figure 2.1.4 Employment in Project Proposed Area, 2004

Productive labor forces that are supposed to be the persons over 20 years old, is about 182,613 person or about 61.8% of the total population in Project area. On the basis of the Indonesian standard that productive labor force is persons over 15 years old, it is estimated at about 209,593 persons or 71.06% of total population. Dependency ratio[2] of population in Project area is 63. It means that in every 100 population at age 15 up to 60 have to support 63 persons. The detail information is shown below:



Source: Statistical year book in 2004, Village Profile 2005

Figure 2.1.5 Population Classified by Age and Productive Labor Force in Project Area

[2] Dependency ratio means value of load support of every 100 productive (15-60 years old) to unproductive age (below 15 years old and over 60 years old).

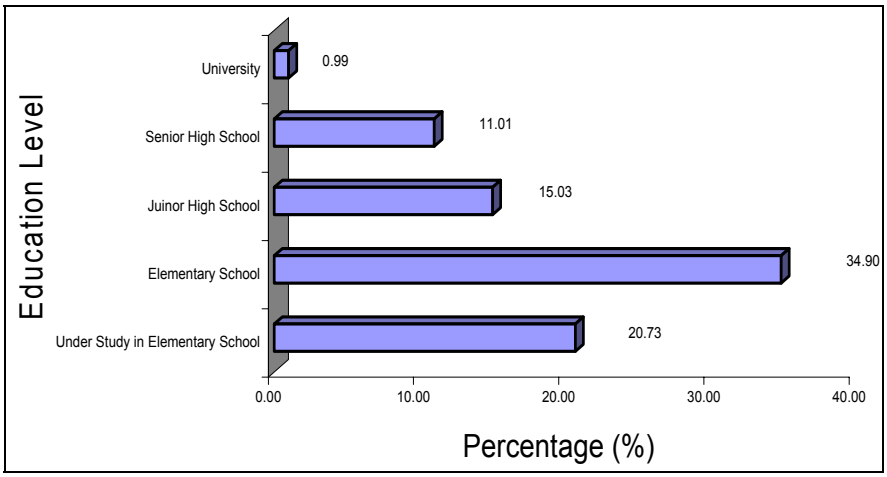
2.1.5 Social Profile

(1) Religion

About ninety eight (98.2)% of the population in the Project area is Moslem, followed by Christians Catholics/Protestant (1.4%); Buddhism (0.4%); and Hind (0.0%).

(2) Education Profile

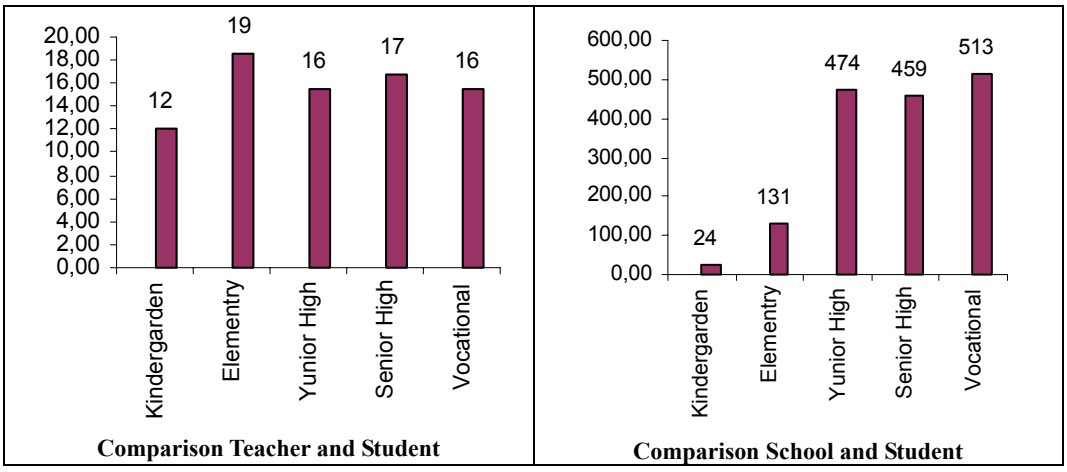
Around 55% of the population in the Project area achieves elementary education. It is dominated by elementary school (34.9%) and under elementary (20.73%). 15.03% of the populations are graduated from Junior High School and remaining 11.01% from tertiary education (Senior High School and University), as shown below:



Source: Statistical year book of Kecamatan in 2004

Figure 2.1.6 Education Achievement

Profile of education in the Project area shows that the numbers of teacher in every level of education are not so different. The ratio of the numbers of students/a teacher ranges from 12 at kindergarten to 19 at elementary school. It seems that the number of students per a facility for junior high schools, senior high schools and vocational schools is insufficient. The summary is shown below:



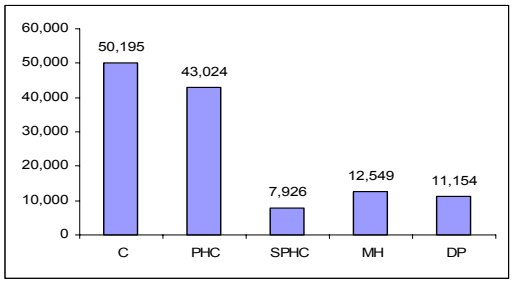
Source: Statistical year book of Kecamatan in 2004, Villages potency 2005.

Figure 2.1.7 Education Profile

(3) Health Profile

Health facilities are insufficiencies in the project area. Every clinic has to provide services

to 50,200 peoples, public health centre to 43,000 peoples and supporting public health center (SPHC) to 7,926 peoples. The numbers of medical care staff are also insufficient in the project area, indicating of the ratio of the number of staff/100 local peoples: 3.7 doctor, 2.63 health advisor, 1.59 nurse and 0.93 traditional nurse. The total number of public health service post (POSYANDU) is about 440 in the Project area, playing an important role in provision of several health advise/services such as maintaining health of mother and child (during pregnancy until under 5 years old). The summary is shown below;

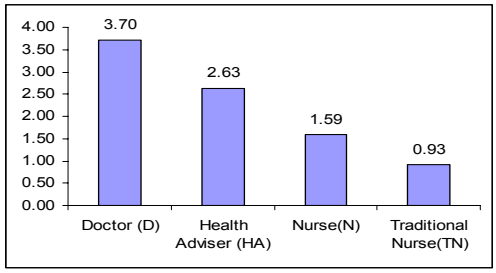


Nos. of Person /Health Facility

Clinic © Midwife House (MH)

Public Health Center (PHC) Doctor Practice (DP)

Supporting Public Health Center (SPHC)



Nos. of Medical Care Staff /100 peoples

Source: Statistical year book of Kecamatan in 2004

Figure 2.1.8 Health Facilities and Medical Care Staff

(4) Poverty

The government determined poverty line for each year in Indonesia on the basis of the standard of poverty line of capita/month/family in 1998. The following table shows that poverty line from 2002 to 2004 in Indonesia and its trend. It is increase 6.36% per year to year in 2002-2003 and 3.35% in 2003-2004 for urban as well as 9.71% per year in 2002/2003 and 2.68% in 2003/2004 at rural community, as shown in table below:

Table 2.1.5 Standard of Poverty Line in Indonesia

	Poverty line (Rp./family)		**Poverty line (Rp/family)**	
	Urban area		**Rural area**	
	Monthly	Yearly	Monthly	Yearly
2002	130,499	1,565,988	96,512	1,158,144
2003	138,803	1,665,636	105,888	1,270,656
2004	143,455	1,721,460	108,725	1,304,700
	Increasing rate		Increasing rate	
2002/2003	6.36	6.36	9.71	9.71
2003/2004	3.35	3.35	2.68	2.68

Source: Statistical year book in Indonesia in 2005

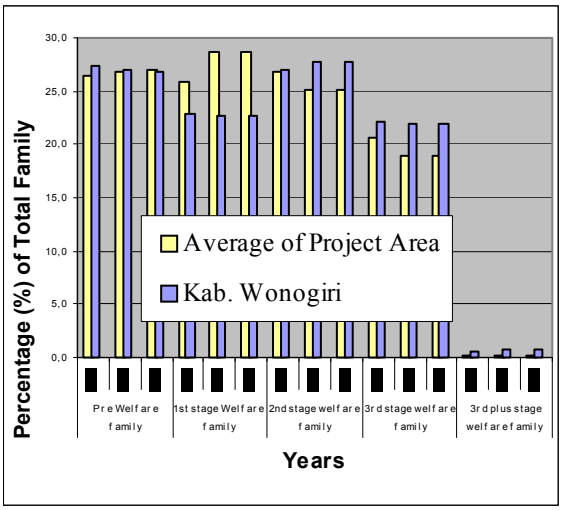
There is no data available about income or expenditure in the Project area. Accordingly, the local government (Kabupaten Wonogiri) uses the classification of the stage of family welfare to specify poverty instead. The classification divides into 5 as shown below:

Table 2.1.6 Classification of Poverty in Kabupaten Wonogiri

Classification	Definition
1. Pre-stage of family welfare	Families which can not fulfill the basic needs.
2. 1st stage of family welfare	Families which can fulfill the basic need, but can not fulfill socio psychological needs.
3. 2nd stage of family welfare	Families which can fulfill basic needs, and socio psychological needs, but can not fulfill entire development needs.
4. 3rd stage of family welfare	Families which can fulfill basic needs, socio psychological needs, and development needs, but can not contribute to society, such as material and financial for social interest.
5. 3rd plus stage of welfare family	Families which can fulfill all needs and sustainable contribution to society.

Source: Petunjuk teknis pendataan keluarga 2006, Vadan kooedinasi Keluarga Berencana National, Propinsi Jawa Tengah , 2005

It is defined that classification of 1st stage of family welfare is poverty line. The peoples within pre-stage and 1st stage of family welfare are classified into the poverty class. As shown in the following figure, over 50% of peoples in both Kabupaten Wonogiri and the Project area belong to the poverty class and the poverty is apt to trend to worsen from 2003 to 2005.



Welfare Condition

Pre Welfare family	2003/2004	1.49
	2004/2005	0.66
Average	2003/2005	1.08
1st stage Welfare family	2003/2004	10.09
	2004/2005	-0.03
Average	2003/2005	5.03
2nd stage welfare family	2003/2004	-6.61
	2004/2005	-0.60
Average	2003/2005	-3.61
3rd stage welfare family	2003/2004	-9.03
	2004/2005	0.11
Average	2003/2005	-4.46
3rd plus stage welfare family	2003/2004	29.86
	2004/2005	-1.38
Average	2003/2005	14.24

Welfare Rate

Source: Statistical year book of Kecamatan in 2004 and 2005

Figure 2.1.9 Increase Rate of Family Welfare Condition, 2003 - 2005

(5) Accessibility and other Facilities

People in the Project area are not isolated. Public's transportation is available in their area. Even, mobilization necessary for agricultural produces is easy to reach markets in kabupaten capital or other cities. The traditional markets in the Project area are in only 6 kecamatans of among 9 kecamatans in the Project area. The animal market is available in each kecamatan except that no data available in Slogohimo. People in the Project area utilize water from spring, shallow and pump well, hydrant, PDAM, river, pipe system and pond for drinking water. Most of people (40.7%) in the Project area utilize pipe system. But, the numbers of water source, shallow well (70.2%) are the most.

Table 2.1.7 Facilities in Project Area

Markets and Number of Transportation Equipment

Facilities	Nos
Public Market	6
Village Market	23
Animal Market	7
Store	745
Mini Bus/Bus	67
Sedan	332
Truck	121
Pic-up	396
Motor Cycle	6626

Drinking Water Supply in The Feasibility Area for Watershed Management

Type	Unit (%)	User (%)
Spring	14.2	28.5
Shalow well	70.2	16.5
Pump well	14.9	4.7
Public hydrant	0.1	1.5
PDAM	0.0	5.4
River	0.6	2.9
Pipe System	0.0	39.7
Pond	0.1	0.8
Total	100	100

Source: Village profiles in 2005

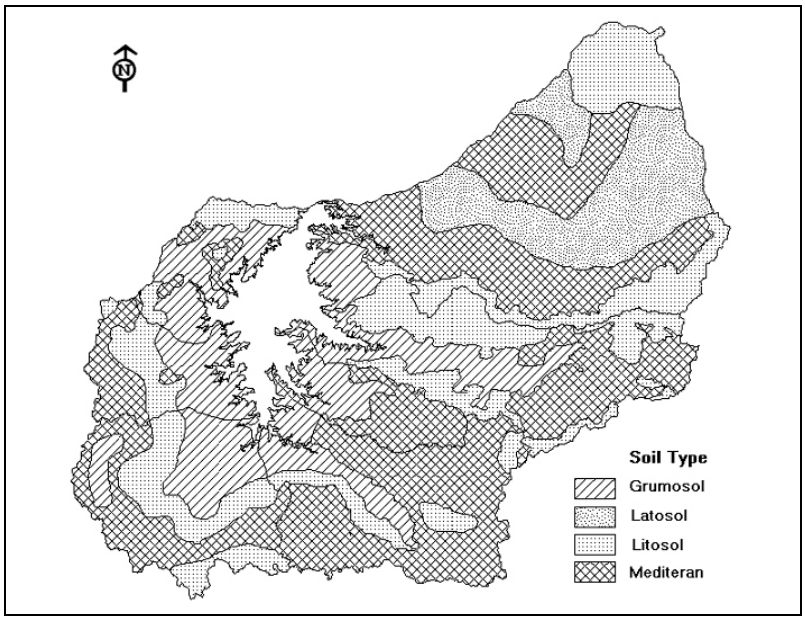
2.2 Soils and Topography

The soils distributed in the Project Area are classified following the old Indonesian classification system, into three soil types of *Mediteran* (Soil Taxonomy: Typic Eutropept/Oxic Dystropept), *Latosol* (Typic Dystropept/Typic Humitropept/Oxic Dystropept) and *Litosol* (Inceptisols). The distribution of the soils over the Wonogiri dam watershed is shown in Figure 2.2.1 and presented below in comparison with the same in the Wonogiri catchment area.

Table 2.2.1 Soil Distribution in Project Area & Wonogiri Catchment

Soil Type	Distribution		
	Keduang		Wonogiri
	(ha)	(%)	(%)
Mediteran	18,489	44	42
Latosol	14,132	34	25
Litosol	9,475	23	12
Grumusol	0	0	21
Project Area Total	42,098	100	100

Source: JICA Study Team



Source: soil map (1/25,000) prepared by SBRLKT, Solo 1985

Figure 2.2.1 Soil Map of Wonogiri Catchment Area

Topographically, the Project area is steep. 53% of the Project area is classified into steepness with over 8% in gradient. The lands are deeply dissected by many tributaries, resulting in slope lands that become very steep.

2.3 Land Use

In the present F/S study, the land use map prepared under the master plan study has been updated through the detail ground truth survey, focused on reviewing land uses classified as paddy field, upland fields and settlement areas. The updated present land use map of the Project Area is shown in Figure 2.3.1.

The land uses in the Area have been classified into land use categories of: i) paddy field, ii) upland field (*tegalan/ladang*), iii) upland field in home settlement (*pekarangan*), iv) housing yard in home settlement, v) forest, orchard & plantation (*hutan & kebun/perkebunan*), vi) State Forest and vii) others. Among the categories, paddy field occupies the largest share followed by home settlement and upland field. The upland fields are areas extensively used for dry land farming. The share of forested area (forest, orchard & plantation) other than the State Forest is rather limited in the Area. The land use features in the Area are shown in comparison with the same in the Wonogiri catchment area as follows;

Table 2.3.1 Present Land Use in the Project Area and Wonogiri Dam Watershed

Land Use Category	Project Area		Wonogiri Dam Watershed	
	Area (ha)	Proportion (%)	Area (ha)	Proportion (%)
(1) Paddy Field	13,042	31	30,495	25
(2) Upland Field	8,491	20	39,761	32
(3) Home Settlement	11,064	26	26,764	22
-Upland field in settlement area	*(7,250)*	*(17)*	*(19,475)*	*(16)*
-Housing yard and garden	*(3,814)*	*(9)*	*(7,289)*	*(6)*
(4) Orchard/Plantation	3,707	9	12,867	10
(5) Dense forest	213	-	281	-
(6) State Forest*	5,027	12	12,779	10
-Dense forest	*(201)*	*(-)*	*(385)*	*(-)*
-Other land use (areas covered with young trees reforested and upland crops in State forest)	*(4,826)*	*(12)*	*(12,394)*	*(10)*
(7) Others (lakes, roads, rivers and other use)	337	1	1,384	1
Total	**41,883****	**100**	**124,331**	**100**

Note; *: Include lands under forest & upland field conditions, **: Difference of areas between M/P and F/S may occur owing to calculation error of GIS. Source: JICA Study Team

The characteristics of major land use categorized are as follows;

(1) Paddy Field

This land use category consists of irrigated paddy field and rainfed paddy field. Lands are mainly distributed in moderately to steeply sloping areas of the Keduang. Irrigated paddy fields are served from the tributaries of the Keduang and springs and commonly used for double cropping of paddy, while in rainfed paddy fields single cropping paddy.

(2) Upland Field

The upland fields in the Keduang are mostly bench-terraced with different protection measures and maintenances and intensively used for seasonal crops. While limited extent of upland field are ridged-terraced or used without terrace construction. Major crops are maize, cassava and beans, and cropping index is dependent on seasonal rainfall distribution. Upland fields are the most serious soil erosion sources in the Project area.

(3) Home Settlement

Lands under this category include housing yards, home gardens and surrounding areas under upland field conditions. The home gardens are used intensively for agricultural purposes and provide an important source of farm income and are commonly planted with variety of crops including vegetables, palawija, fruit trees as mango, banana, rambutan and papaya and even estate crops such as coconut, clove, cashew nut, cacao and *melinjo*. Upland fields accommodated in this land category are used for seasonal crops production with limited soil conservation measures. Upland fields in home settlement are one of the main sources of soil erosion in the area and proper soil conservation measures are essential for the mitigation of the sedimentation problems in the Wonogiri Reservoir.

(4) Forest/Orchard/Plantation

This category of land in the Area practically consists of peoples forests (*hutan rakyat*) and tree crops planted areas (or orchard, *kebun*) since the areas covered with pure stands of estate crops (*perkebunan*) are limited in the area.

A dominant tree planted in the people's forests is teakwood (*Tectona grandis*) and other tree species include *sonokeling* (*Darbegia grandis*), mahogany (*Swietenia machopylia*), *Sengon* (*Albizia falcata*) and Eucalyptus (*Eucalyptus degluputa*). The forests are used under an agro-forestry system (*tumpansari*) and crops tolerant or suitable for shade such as medical crops (ginger & turmeric) are intercropped beneath the canopies of trees. In orchard, various kinds of fruits trees are sparsely planted.

(5) State Forest

The Forest is under the management and control of KPH Surakarta (*Kesatuan Pemangkuan Hutan*/Forest Administration Unit) of Perum Perhutani (State Forestry Company). The state forests in the area are classified into the protected forests and production forests. The protected forests are established in the piedmont areas of Mt. Lawu. The production forests are mostly developed in hilly to mountainous areas. Major trees planted in the forests are merkusi pine (*Pinus merksi*) and other species include *sonokeling* (*Darbegia grandis*), teakwood (*Tectona grandis*), mahogany (*Swietenia machopylia*) and Eucalyptus (*Eucalyptus degluputa*).

However, based on the interpretation of satellite images taken in 2003, the current status of the Forest is identified as follows;

Dense forest	201ha (4%)
Areas interpreted as not in forest conditions	4,878ha (96%)

Most of the areas interpreted as "not in forest conditions" could be regarded as newly reforested areas based on the information provided by the State Forestry Company.

2.4 Agriculture

2.4.1 Land Holding

Access to land holding data at village level is limited to less accurate figures indicated in the Statistical year book in 2004 and Village potential in 2005 of the selected villages. To provide rough features on land holding status, land holding of farm land in the selected villages are summarized below.

Table 2.4.1 Distribution of Farm Households by Holding Size in Selected Villages

Holding Size of Food Crops Field	Range	Average
- Land less	0 ~ 91%	26%
- < 0.5 ha	0 ~ 100%	40%
- 0.5 - < 1.0 ha	0 ~ 100%	27%
- > 1.0 ha	0 ~ 56%	8%

Source: Statistical year book in 2004 & Village potential of selected villages in 2005

As shown in the table, holding size of food crops field of about 70% of farm households in the selected villages are less than 0.5 ha and those having more than 1.0 ha is limited to 8% as a whole. However, the distribution of farm households by holding size largely differs among villages.

2.4.2 Crop Production

(1) Overall Features

Crop sub-sector agricultural activities in the selected villages are characterized by food crops production in paddy field (wet land farming) and food and limited scale horticulture & tree crops production in dry land (dry land farming). The wet land farming is practiced mainly in rice terraces constructed on sloping lands. The dry land farming is practiced in terraced fields constructed on moderate to steep sloping lands. The primary crop in the wet land farming is paddy (wet land rice), while in the dry land farming maize and cassava is dominant followed by groundnuts and cultivation of other upland crops is rather limited in extent. The subject crop sub-sector activities of the present Study are the dry land farming practiced for production of seasonal and tree crops.

(2) Wet Land Farming

Paddy production is by far the most important farming activity in the wet land farming, however, palawija production in rotation with paddy is also intensively practiced in off-season(s) or season(s) restricted from water availability. Major palawija in paddy fields in the selected villages is maize followed by groundnut and limited extent of soybeans.

Wet land farming is almost exclusively carried out in irrigated paddy fields. According to the present land use, the area extents of paddy fields in the selected villages are estimated at 11,643 ha or 89% of the total paddy field in Keduang watershed. From the statistical data, it could be assumed that about 70 % of the paddy fields are under irrigated.

(3) Dry Land Farming

Upland field (*tegal*), upland field in home settlement (*pekarangan*) and, where farming operations are practiced under rainfed conditions (dry land farming), are defined as dry farmland in the present Study. The extent of the dry farming land in the selected villages is estimated at 13,939 ha or about 90% of the total farm land of 15,752 ha in the Keduang watershed based on the present land use. The ratio of dry farm land/(dry farmland +paddy) shows about 60%. Dry land farming can be characterized with its instability and is extensively practiced in the entire sub-catchment area because of limitation in wet land (paddy field) where more stable farming activities is operated.

The dry farmlands are developed in moderate to steep sloping lands distributing in the area and currently terraces of different protection measures and maintenance conditions are constructed almost in the entire dry farmlands. Land resources of the area are exposed to danger of soil erosion if sufficient vegetative covers are not provided.

Use of dry farmland under multi cropping system (*tumpansari*) composed of maize and cassava is a prevailing farming system in the area, while monoculture of maize and multiple cropping consisting of maize, cassava and groundnut is also practiced in the area. Tree crops are generally planted as components of the multi cropping system and monoculture of the same is seldom recognized. Therefore, accurate features on tree crops planted areas appear are impossible to estimate.

(4) Seasonal Crop Production

For providing rough indicators on crop productions in the selected villages, crop production data from 2001 to 2003 in the major kecamatans in the Project Area are summarized below.

Table 2.4.2 Production Features of Seasonal Crops in Major Project Kecamatans

Crop	Cropped Area (ha)	Production (ton)	Crop	Cropped Area (ha)	Production (ton)
Paddy	2,025	10,993	Groundnut	1,953	2,288
Upland Rice	57,606	241,666	Soybeans	119	129
Maize	57,606	241,666	Cassava	2,406	34,423

Source: Wonogiri Agriculture Services Office

(5) Fruits & Estate Crops

Major fruits and estate crops grown in the selected villages include mango, coconut, citrus and cashew nut.

2.4.3 Livestock

The livestock sub-sector is providing important income sources for farm economy in the selected villages, especially for the same of dry land farmers. The average holding sizes of livestock per household in 2004 are estimated as summarized in the following table.

Table 2.4.3 Holding Sizes of Livestock per Household in the Selected Villages

	Cow/Cattle	Goat/Sheep	Poultry
Holding Size per Household (No.)	0.3	1.0	8

Source: Statistical year book in 2004 & Village potential in 2005

Farmers basically raise livestock not for commercial purpose, but animals as assets and draft power and fowls for family consumption. Marketing of animals are made generally through animal markets established at kecamatan level and the rest are traded directly through animal traders at village or kecamatan level.

2.5 Forestry

Forest areas in the sub-catchment area are categorized into the state forest (*hutan negara*) and peoples forest (*hutan rakyat*). The state forest is managed and controlled by State Forest Company (*Perum Perhutani*) and the peoples forest is under the control of individual land owners. In the peoples forest, community based forestry development activities are promoted by forestry agencies.

(1) State Forest

The state forest in the Wonogiri dam watershed is under the management and control of KPH Surakarta (*Kesatuan Pemangkuan Hutan*/Forest Administration Unit). The kabupaten/ kecamatan level operations of KPH are executed through BKPH (*Bagian Kesatuan Pemangkuan Hutan*/ Forest Administration Sub-unit) established at watershed levels and field level operations are carried out by RPH (*Resort Pemangkuan Hutan*/Field

Unit of KPH). In the Keduang watershed area, the state forests extend in the northern and southern fringe of the area.

(2) People's Forest (Hutan Rakyat)

The people's forests (*hutan rakyat*) are defined as forest areas owned and operated by individuals (villagers/farmers)[3]. The people's forests in the Wonogiri catchment area are classified into two types of: i) forests established under government subsidy or projects (*swadaya perbantu*) and ii) forests established by owners self-help efforts (*swadaya murni*). Majority of the peoples forests in the area are developed by the latter self-help activities.

All the peoples forests in the sub-catchment area are foretasted forests and a greater part of them are managed under an agro-forestry system called tumpansari where multiple planting of trees and seasonal crops are practiced. Dominant tree in the forests is teakwood. Other tree species planted include: *sengon* (*Albizia falcata*), mahogany, acacia (*Acacia auriculiformis*) and Eucalyptus (*Eucalyotus degluputa*). Predominant accompanying seasonal crops include maize, cassava, beans and medical crops.

The target areas of teakwood forest development under Peoples Forest Program of Gerhan (National Movement for Forest & Land Rehabilitation/*Gerakan Nasional Rehabilitasi Hutan dan Lahan*) in the sub-catchment area are 1,250ha, 1,125ha and 200ha in 2003, 2004 and 2005, respectively. Field observations on the target areas of the program indicate, however, the over density of teakwood reforestation because farmers tend to plant free seedlings supplied by the program in fields already planted with teakwood. In addition, withering of seedlings due to drought is problem of the program yet to be solved.

2.6 Watershed Conservation Activities in the Selected Villages

2.6.1 Past Watershed Conservation Activities in the Selected Villages

The past watershed conservation activities in the selected villages are represented by the activities under the IBRD Project (Upper Solo Watershed Protection Project; 1988/89–1994/95). The activities of the Project in the selected villages are summarized below.

Table 2.6.1 Programs Implemented in the Selected Villages under IBRD Project

Programs	Programs Implemented in Selected Villages						
	88/89	89/90	90/91	91/92	92/93	93/94	Total
Terrace formation (ha)	495	1,002	1,263	1,806	723	-	5,288
Small gull plug (Nos.)	181	259	212	304	-	-	956
Gully head structure (Nos.)	25	49	51	58	-	-	183
Big gully plug (Nos.)	41	39	12	9	-	-	101
Check dam	8	10	0	2	-	-	20
Sloping grass (m^2)	24,723	38,265	19,430	26,703	-	-	109,121
Road side protection (m^2)	0	22,079	7,525	0	0	0	29,604
River bank protection (m^2)	391	910	0	0	0	0	1,301

Source: files of the Governor office

2.6.2 Current Watershed Conservation Activities in the Selected Villages

The current watershed conservation activities in the selected villages are represented by the activities under Gerhan (National Movement for Forest & Land Rehabilitation; 2003 -

[3] Reported that no customary or traditionally owned communal forests exist in the Wonogiri dam watershed.

2007). The Gerhan activities in the selected villages from 2003 to 2006 are summarized below.

Table 2.6.2 GERHAN Programs Implemented in Keduang Watershed from 2003 to 2005

Programs	Programs Implemented in Selected villages			
	2003	2004	2005	Total
Peoples Forest	1,250 ha	1,125 ha	200 ha	2,575 ha
Check Dam	-	1 unit	2 units	3 units
Gully Plug	21 units	-	10 units	31 units
Small Gully Plug			25 units	25 units
Absorption Well	27 units	4 units	40 units	71 units
Small Reservoir	-	1 unit	-	1 unit

Source: LHKP Wonogiri

As the Keduang sub-catchment area was selected as a priority area of the project for mitigating sedimentation in the Wonogiri Reservoir, a larger proportion of programs were implemented in the area.

2.7 Site Geology on the Proposed Sediment Storage Reservoir

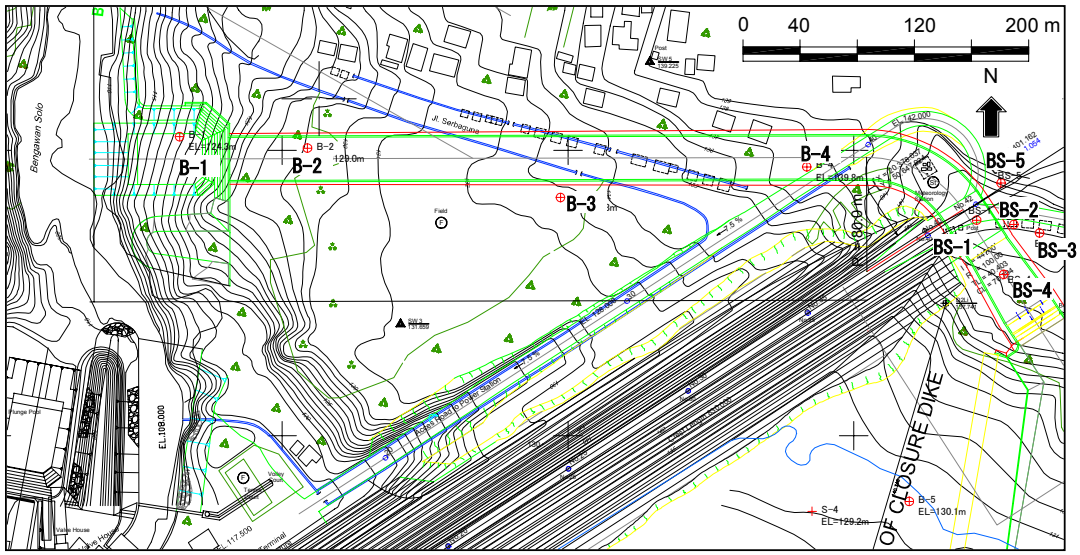
The proposed sediment storage reservoir structurally comprises:

i) Gate structure for sediment release
ii) Spillway structure (Waterway and stilling basin)
iii) Closure dike
iv) Overflow dike

The spillway with new gates is planned on the gentle hill of the right abutment of the Wonogiri dam. Geological investigation and laboratory test was carried out in September to December, 2006. The respective geological conditions from engineering geology viewpoints are described below.

2.7.1 Gate Structure for Sediment Release

Location map of the drill holes is shown in Figure 2.7.1 below.



Source: JICA Study Team

Figure 2.7.1 Location Map of Drilling Points for the Proposed Spillway and Gates

Results of drilling works and the laboratory tests using drilling core samples are

summarized in Tables 2.7.1 and 2.7.2 respectively.

Table 2.7.1 Results of Drilling Survey at the Proposed Gates Location

Drilling No	Length (m)	Ground Water Level (m)	Geological Condition (m)				
			Organic Soil	Lapilli tuff	Sandy tuff	Tuff Breccia	
				D class (CL class)	D class	D class	CL class
BS-1	30	11.5	0.0-0.7	0.7-9.8 (6.0-9.8)	9.8-15.2	15.2-19.0	19.0-
BS-2	30	12.1	0.0-0.2	0.2-9.5	9.5-15.0	15.0-19.0	19.0-
BS-3	30	11.3	0.0-0.8	0.8-10.0	10.0-14.8	14.8-18.0	18.0-
BS-4	30	11.2	0.0-0.2	0.2-11.0	11.0-14.5	14.5-19.0	19.0-
BS-5	30	11.2	0.0-0.8	0.8-10.8 (6.6-10.8)	10.8-14.5	14.5-17.0	17.0-

Source: JICA Study Team

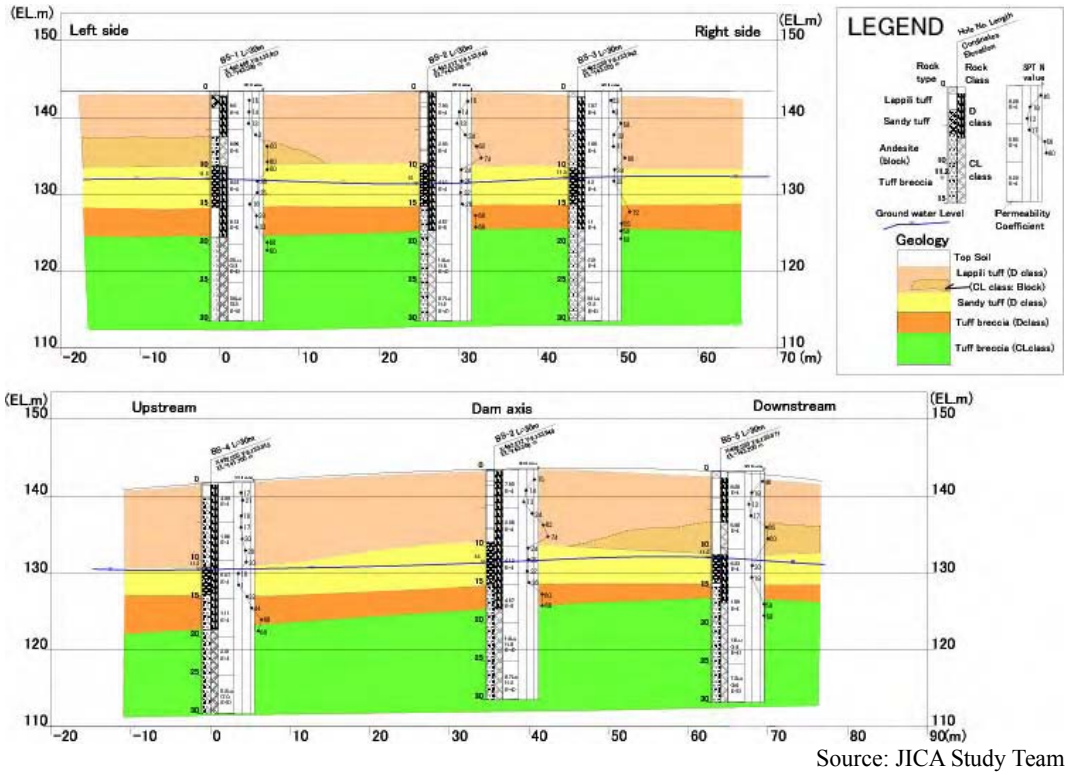
Table 2.7.2 Summary of Laboratory Test for Rock Core Sample (CL class)

Hole No.	Depth (m)	Density (g/cm^3)	Unconfined Compressive Strength (kgf/cm^2)	Axial Strain (%)	Specific gravity			Absorption (%)
					Dry	Saturated Surface-Dry	Apparent	
BS-1	7.20 - 7.50	1.587	31.92	2.51	1.838	2.117	2.548	15.14
BS-1	28.70 - 29.00	2.008	31.19	4.07	1.847	2.123	2.552	14.95
BS-2	18.20 - 18.50	1.973	171.13	1.19	2.018	2.244	2.605	11.16
BS-4	27.60 - 27.80	1.666	18.93	2.74	1.717	2.010	2.430	17.10
BS-4	28.15 - 28.35	1.975	68.21	2.30	1.891	2.138	2.511	13.07
BS-5	10.50 - 10.70	1.694	38.67	2.20	1.810	2.085	2.498	15.23
Average		1.817	60.008	2.50	1.854	2.120	2.524	14.44
Max		2.008	171.130	4.07	2.018	2.244	2.605	17.10
Min		1.587	18.930	1.19	1.717	2.010	2.430	11.16

Source: JICA Study Team

This area consists of lapilli tuff, sandy tuff and tuff breccia in descendant order and completely weathered from the surface to 17-19 m deep (D class), except for moderately hard lapilli tuff block (CL class) at the depth of 6-10 m of the leftward and downstream side of the proposed site.

The base rock of the gates location is moderately hard tuff breccia (CL class) (see Figure 2.7.2 below).



Source: JICA Study Team

Figure 2.7.2 Geological Profile of Proposed Gates Location

The physical and mechanical properties of the bedrock are estimated as shown in Table 2.7.3 based on field tests and laboratory tests. Moderately hard tuff breccia (CL class) has bearing capacity adequate for the foundation of the proposed gate structures.

Table 2.7.3 Basic Properties of Bedrock at the Gates Location

Facies	Depth (m)	SPT N Value	Unconfined Compressive Strength (kgf/cm2)	Bulk Density (g/cm3)	Estimated Strength C= Φ=	Estimated Permeability Coefficient (cm/s)
Lappili tuff	0-6	12-50 (23)				5 E-4
	6-10	31-74 (40)				5 E-4
Sandy tuff	10-15	11-35 (24)				5 E-4
Tuff Breccia (D class)	15-19	32-72 (51)				1E-4
Tuff breccia (CL class)	19-		19-171 (60)	1.6-2.0 (1.8)	3 kgf/cm2 35 degrees	1E-4

Source: JICA Study Team
Note: Parenthetic numbers show average of the test results.

2.7.2 Spillway Structure

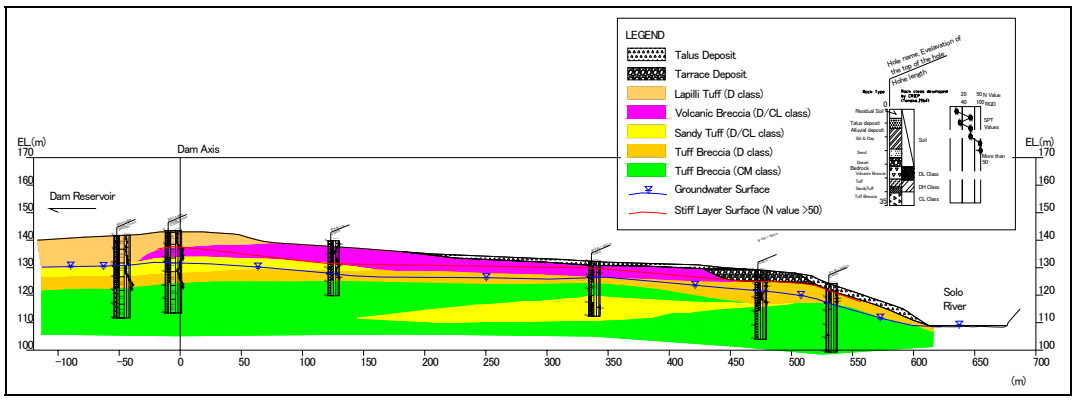
Location map of the drill holes is shown in Figure 2.7.1. Results of drilling works carried out at proposed spillway alignment are summarized in Table 2.7.4 below.

Table 2.7.4 Results of Drilling Survey along the Proposed Spillway Alignment

Drilling No	Length (m)	Ground Water Level (m)	Depth (m) / Geology	Depth (m) / Rock Condition
B-1	25	7.2	0.0-2.5 Talus deposits/Embankment 2.5-25.0 Tuff breccia (18.6-19.0 Sandy tuff)	0.0-2.5 Soil 2.5-7.0 D class 7.0-25.0 CL class
B-2	25	5.3	0.0-3.8 Terrace deposit/Embankment 3.8-12.0 Tuff breccia 12.0-13.0 Tuff 13.0-25.0 Tuff breccia	0.0-3.8 Soil 3.8-14.5 D class (3.8-12.0 DL class, 12-14.5 DH class) 14.5-25.0 CL class
B-3	20	6.0	0.0-1.5 Talus deposit/Embankment 1.5-12.7 Volcanic breccia 12.7-20.0 Tuff breccia	0.0-1.5 Soil 1.5-7.6 D class (1.5-6.0 DL class, 6.0-7.6 DH class) 7.6-15.0 CL class 15.0-20.0 D class (DH)
B-4	20	12.0	0.0-0.2 Residual Soil 0.2-8.35 Volcanic Breccia 8.35-9.5 Tuff breccia 9.5-10.5 Tuff 10.5-20.0 Tuff breccia	0.0-0.2 Soil 0.2-14.3 D class (DL class 0.2-8.35, 8.35-14.3 DH class) 14.3-20.0 CL class
Total	90			

Source: JICA Study Team

This area is underlain by lapilli tuff, volcanic breccia, sandy tuff and tuff breccia in descendant order and a relative soft sandy tuff layer is intercalated by tuff breccia as shown in Figure 2.7.3. The depth of ground water surface is 6 -12 m. Very stiff layers (SPTN Value>50), which is suitable for the foundation of spillway channel, will be encountered at the depth of 2.5 -8 m.

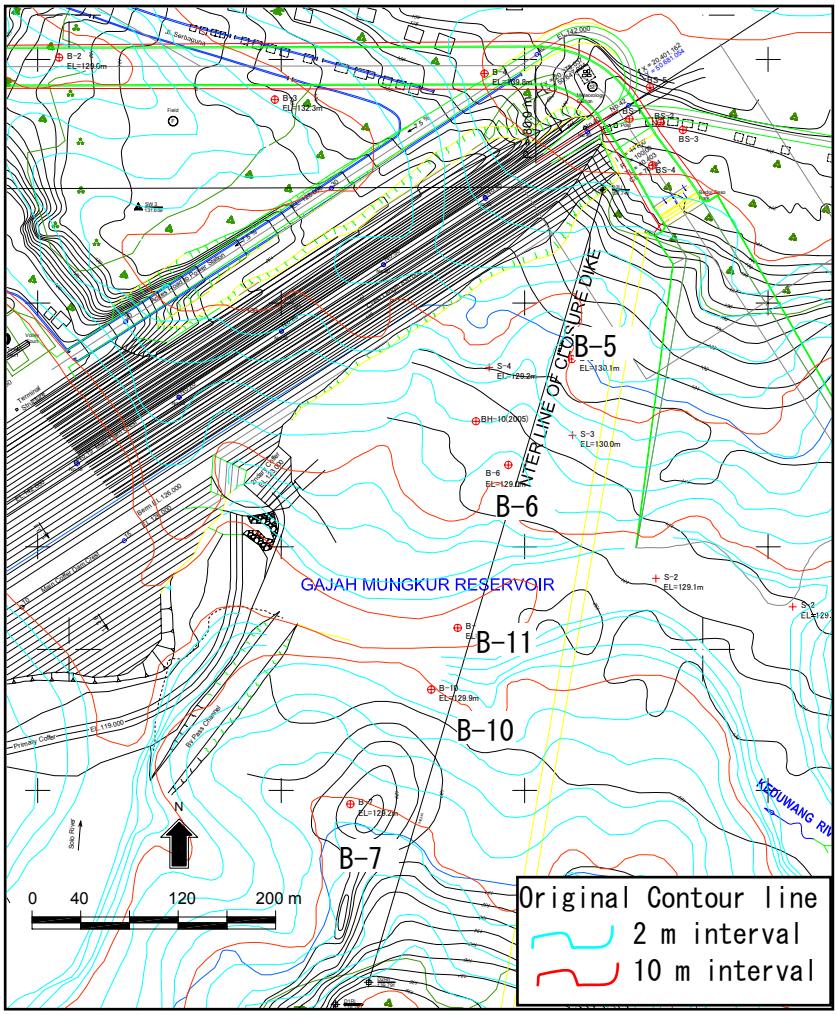


Source: JICA Study Team

Figure 2.7.3 Geological Profile of Proposed Spillway Alignment

2.7.3 Closure Dike

Location Map of drilling points is shown in Figure 2.7.4. The original Keduang River is supposed to have flowed westward around the drilling point B-11(about 370 m S17W from bench mark D2L1).



Source: JICA Study Team
Note: Original topographic feature is based on 10,000 scale map by PBS in 1982.

Figure 2.7.4 Location Map of Drilling Points for the Proposed Closure Dike

Results of drilling works are summarized in Table 2.7.5.

Table 2.7.5 Results of Drilling Survey for the Proposed Closure Dike

Drilling No	Length (m)	Ground Water Level (m)	Depth (m) / Geology	Depth(m) / Soil or Rock Condition (SPT N value)
B-5	20	1.5	0.0-1.55 clay 1.55-1.60 sandy clay 1.60-15.0 tuff breccia 15.0-17.0 sandy tuff 17.0-20.0 tuff breccia	0.0-1.60 very soft (N <1) 1.6- 4.50 very stiff 4.5-6.0 hard (N>50) 6.0-20.0 rock
B-6	20	0.0	0.0-0.5 clay 0.5-1.0 sand 1.0-1.6 clay 1.6-3.2 sandy clay 3.2-7.0 clay 7.0-20.0 tuff breccia (10.7-10.9 tuff)	0.0-7.0 very soft (N <1) 7.0-8.5 very stiff (N=36) 8.5-9.5 hard (N>50) 9.5-20.0 rock
B-7	20	0.0	0.0-2.6 clay 2.6-5.0 tuff breccia 5.0-12.2 tuff 12.2-20.0 tuff breccia	0.0-2.6 very soft (N <1) 2.6-5.0 stiff (N =13) 5.0-11.2 hard (N>50) 11.2-20.0 rock
B-10	20	0.0	0.0-1.85 clay 1.85-2.0 sand 2.0-4.2 clay 4.2-5.0 clayey sand	0.0-9.9 very soft (N<1) 9.9-10.0 soft 10.0-13.0 very stiff (N=24-50) 13.0-20.0 hard (N>50)

Drilling No	Length (m)	Ground Water Level (m)	Depth (m) / Geology	Depth(m) / Soil or Rock Condition (SPT N value)
			5.0-7.0 clay 7.0-7.4 clayey sand 7.4-9.9 clay 9.9-20.0 tuff breccia	
B-11	23	0.0	0.0-10.0 clayey sand (0.3-0.5, 0.8-1.8, 2.0-2.3, 2.32-2.45, 2.46-3.2, 4.0-4.5, 4.7-5.0, 5.5-6.8 and 9.5-9.7 clay layer) 10.0-21.0 clay 21.0-23.0 volcanic conglomerate	0-21 very soft (N<1) 21-23 hard (N>50)
Total	103			

Source: JICA Study Team
Note: Groundwater data were obtained immediately after drilling work.

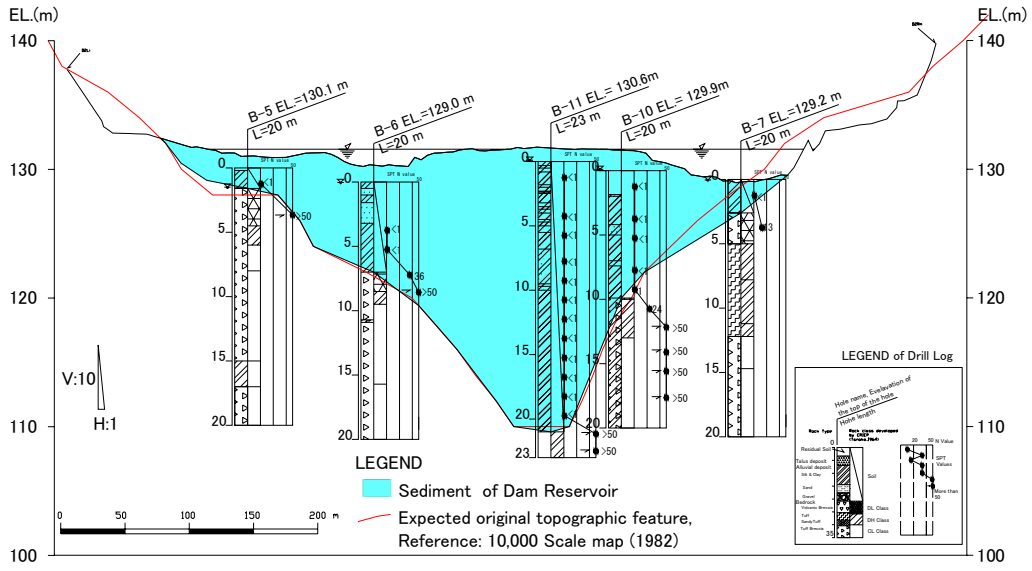
At the closure dike site, very soft sediments in the reservoir (SPTN value <1) cover near-horizontal strata of tuff breccia and volcanic breccia, which formed meandering and narrow valleys of Keduang River before Wonogiri Multipurpose Dam construction (see Figure 2.7.5).

Sediment deposits, reaching 21 m in thickness at the middle of the reservoir, consist mainly of clay. Relatively thin sand strata are sometimes intercalated in some portions of the sediments, which are expected to have been river traces.

Tuff breccia underlying soft reservoir sediments is suitable for the foundation of closure dike except for surface weak zone.

Sediment deposits are consist mainly of very soft clay (classified into MH by the Unified Soil Classification System of ASTM D-2487), and often includes detritus of crops, bamboo and plastic sheet especially in surface zone or along the recent course of Keduang River according to drilling core and test pit observation. Therefore, sediment deposits in the reservoir are not suitable for embankment materials.

Excavation of the completely weathered tuff breccia in the reservoir shore instead of the reservoir sediments would contribute both to embank materials acquisition and to the reservoir rehabilitation.

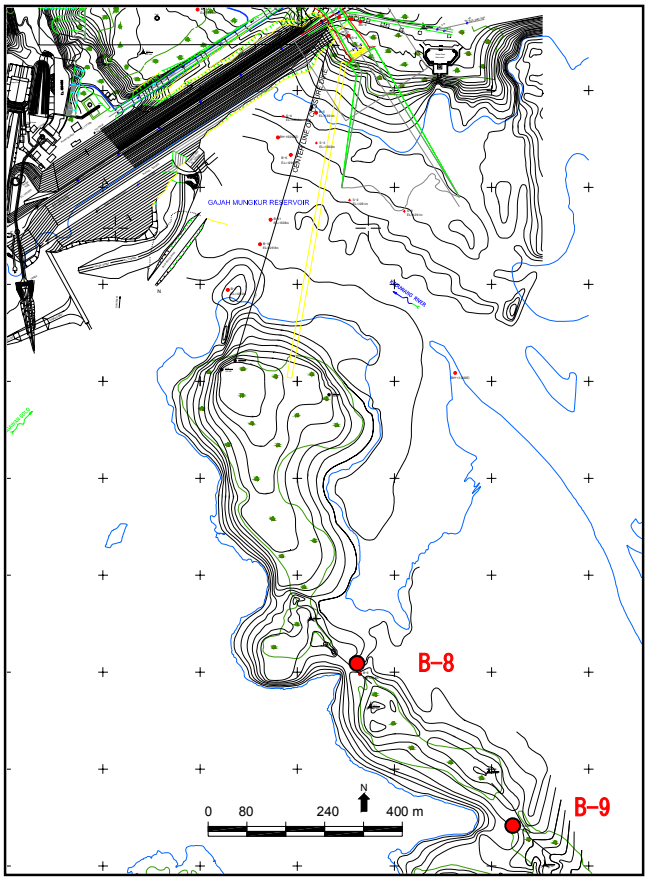


Source: JICA Study Team

Figure 2.7.5 Geological Profile of Closure Dike

2.7.4 Overflow Dike

Location Map of drilling points is shown in Figure 2.7.6. Results of drilling works are summarized in Table 2.7.6.



Source: JICA Study Team

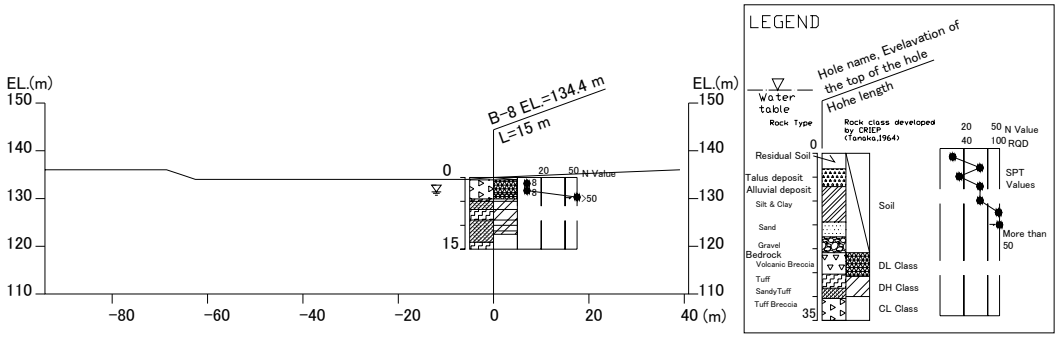
Figure 2.7.6 Location Map of Drilling Points for the Proposed Overflow Dike

Table 2.7.6 Results of Drilling Survey for Closure Dike

Drilling No	Length (m)	Ground Water Level (m)	Depth (m) / Geology	Depth(m) / Soil or Rock Condition (SPT N value)
B-8	15	3.0	0.0-0.5 residual soil 0.5-4.5 tuff breccia 4.5-5.0 tuff 6.5-6.7 sandy tuff 6.7-8.9 tuff 8.9-13.55 sandy tuff 13.55-15.0 tuff breccia	0.0-0.5 very soft-soft 0.5- 4.5 firm (N=8) 4.5-11.0 hard (N>50) 11.0-20.0 rock
B-9	15	2.6	0.0-1.0 residual soil 1.0-7.5 volcanic breccia 7.5-9.0 tuff 9.0-15.0 sandy clay	0.0-1.0 very soft-soft 1.0-6.5 firm-stiff (N=9~20) 6.5-11.0 stiff-very stiff (N=13~50) 11.0-15.0 rock
Total	30			

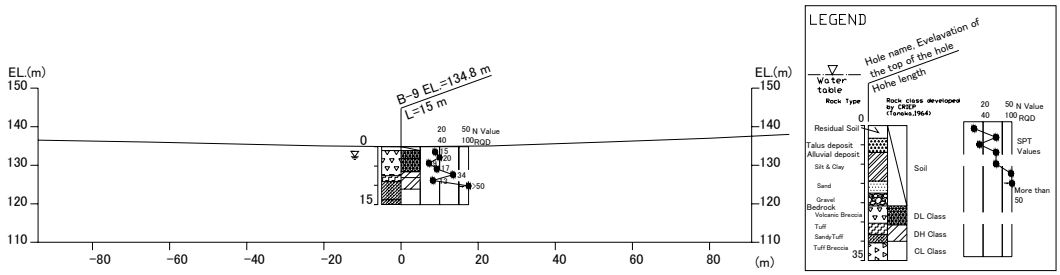
Source: JICA Study Team

This area is underlain by near-horizontal strata of volcanic breccia, tuff breccia, tuff, and sandy tuff in descendant order. After removal of surface residual soil including plant detritus etc, embankment dike and small structures of 2-3 m in height can be founded on the base rock (see Figures 2.7.7 and 2.7.8)



Source: JICA Study Team

Figure 2.7.7 Geological Profile of Overflow Weir (Drill hole B-8)



Source: JICA Study Team

Figure 2.7.8 Geological Profile of Overflow Weir (Drill hole B-9)

2.7.5 Construction Material for Concrete Aggregates

The quarry site exploited for the construction of the Wonogiri Multipurpose dam is located behind Wonogiri town approximately 2 km to the west from the dam site. The site, underlain by andesite and well-cemented volcanic breccia, is suitable for concrete source in both quantitative and qualitative aspects.

2.8 Meteorology and Hydrology

2.8.1 Basin Mean Rainfall

Figure 2.8.1 shows an isohyetal map of mean annual rainfall over the Wonogiri catchment for the period from 1983 to 2005. Table 2.8.1 presents the estimated mean monthly basin rainfall for the five major tributaries. The table shows that annual rainfalls in the two tributary basins, the Keduang and Tirtomoyo River basins, are considerably higher than those in other three tributary basins.

Table 2.8.1 Mean Monthly Basin Rainfall by Major Tributary in the Wonogiri Dam Catchment (1976-2005)

(Unit : mm)

Tributary Basin	Month												Annual
	J	F	M	A	M	J	J	A	S	O	N	D	
Keduang	393	353	326	215	90	62	32	22	30	104	236	287	2,148
Tirtomoyo	394	374	340	229	90	72	32	13	22	72	205	282	2,124
Temon	339	326	289	181	75	57	21	10	14	61	160	274	1,807
Bengawan Solo	340	317	276	170	84	61	22	12	19	58	155	243	1,757
Alang	326	289	256	154	66	61	24	10	18	51	159	237	1,671
Remaining Area	341	315	283	181	85	61	32	15	17	77	167	236	1,812
Whole Catchment	369	336	307	201	89	64	31	16	24	82	198	274	1,990

Source: JICA Study Team

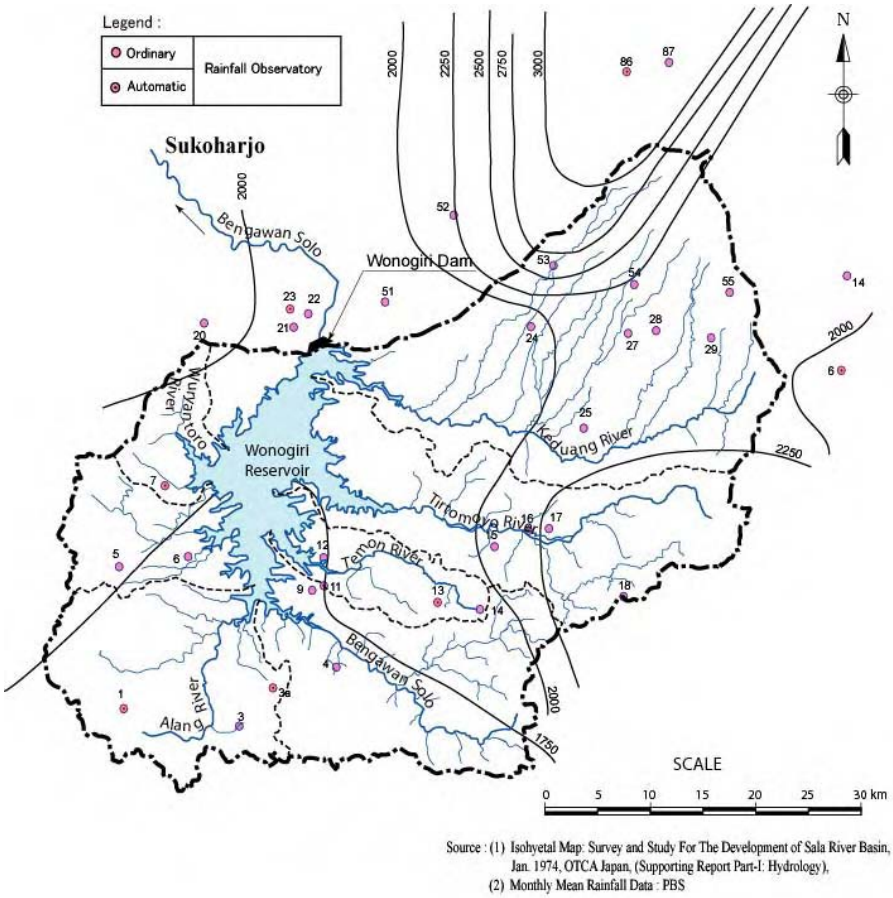
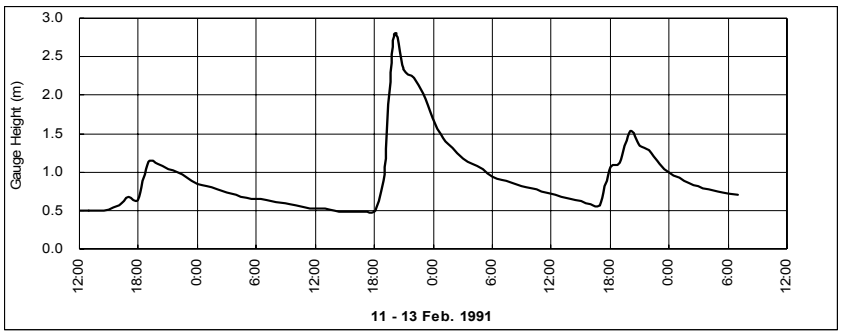


Figure 2.8.1 Isohyetal Map of Annual Rainfall for the Wonogiri Dam Catchment

2.8.2 Floods from the Keduang River

The hourly water level at Ngadipiro on the Keduang River in February 1991 is shown in Figure 2.8.2 below. The February 1991 flood is one of large floods in the year. The flood records indicate that the February 1991 flood with duration of about 24 hours is a typical flood pattern in the tributary basin. Besides, the flood concentration time is generally as short as 2 to 3 hours.



Source:PBS

Figure 2.8.2 Hourly Water Level Hydrograph at Ngadipiro on the Keduang River in February 1991

2.8.3 Reservoir inflow from the Keduang River

Hourly reservoir inflows from five major tributaries in 1993-2005 were estimated based on the reservoir operation records. Hourly discharge records at major tributaries that were observed under the Study were available only the wet season from November 2004 to

May 2005. In other period for 1993-2004, simulated hourly discharges as well as hourly reservoir operation records were used. Table below shows the estimated mean monthly inflows from major tributaries on the hydrological year basis in 1993-2005.

Table 2.8.2 Estimated Mean Monthly Dam Inflow from 5 Major Tributaries and Remnant Area (Nov. 1993 – Jun. 2005)

(Unit : 10^6 m^3)

Tributary Basin	N	D	J	F	M	A	M	J	J	A	S	O	Annual
Keduang	22.9	38.7	50.0	81.1	82.6	44.6	10.7	7.5	5.0	2.2	3.2	5.9	354.3
Tirtomoyo	11.6	26.7	29.9	49.0	48.5	26.9	6.3	4.4	3.4	0.6	0.3	2.8	210.4
Temon	2.2	5.0	6.7	10.3	9.7	5.1	1.1	0.8	0.5	0.0	0.1	0.5	41.9
Bengawan Solo	8.1	17.7	22.2	36.0	34.9	16.4	3.8	3.0	2.0	0.2	0.3	1.8	146.4
Alang	7.8	15.2	18.7	27.4	30.0	12.3	3.0	2.4	1.0	0.1	0.2	1.7	119.8
Remaining Area	7.0	13.6	16.5	25.5	25.0	13.7	3.5	2.5	1.7	0.4	0.6	1.8	111.7
Whole Catchment	59.6	116.9	144.1	229.3	230.6	119.0	28.3	20.5	13.6	3.6	4.7	14.3	984.4

Source: JICA Study Team

2.9 Garbage from the Keduang River

2.9.1 Blocking of the Intake

Considerable quantity of garbage (mainly vegetative debris) from the Keduang River washes into and deposits the intake forebay at the beginning of wet season. Partial blockage of the power intake has already frequently occurred. In October 2006, the power generation was shut down due to blocking of trash rack screens of the intake. Urgent removal works to remove garbage and sediment deposits at the intake was carried out by PJT I Bengawan Solo (see photos below).

Garbage removing by divers

Garbage removed from the intake

Excavation of sediment deposits at the intake by a dragline in October 2006

2.9.2 Garbage Survey in the Keduang River

In the Study, garbage survey was carried out to estimate the garbage volume conveyed from the Keduang River in the period of November 2006 to February 2007. The garbage trap made of bamboo was installed on the existing check dam on the Keduang River.

The volume of trapped garbage is 36 m^3 in November, 120 m^3 in December, 97 m^3 in January, and 438 m^3 in February (as of 18th day). Totally 655 m^3 of garbage was trapped. Floods at the beginning of wet season convey larger quantity garbage into the Wonogiri reservoir. As the reservoir water level is the lowest at the beginning of wet season, garbage from the Keduang River is likely to reach the intake forebay.

Installation of garbage trap by bamboos

Broken garbage trap by flood

Garbage taking

Garbage burning after volume measurement