

Chapter 4
Rehabilitation Works for Hydropower Stations

CHAPTER 4 REHABILITATION WORKS FOR HYDROPOWER STATIONS

4.1 Sutami and Wlingi Hydropower Stations

4.1.1 Basic Concept for Rehabilitation Works

According to the results of the site investigation, the civil structures in Sutami and Wlingi do not require the rehabilitation works at the moment. On the other hand, in order to achieve a sustainable operation of the power stations, the hydro-mechanical equipment and generating equipment are recommended to be rehabilitated considering the following concepts.

(1) Hydro-mechanical Equipment (Gates and Penstocks)

Neither serious damage nor deterioration of hydro-mechanical equipment was observed to cause the reduction of power generation. No remarkable defect was found during this study. However, local control cabinets for intake gates at Sutami are obsolete and do not comply with the present safety codes for electrical appliances. Further, a few colored glasses on the indicator light have been broken. The rehabilitation works are recommended to be made for the control cabinets which do not comply with the safety codes for electrical appliances.

On the other hand, no rehabilitation work is required for the hydro-mechanical equipment at Wlingi.

(2) Generating Equipment (Water Turbine, Generators and Control System)

The existing generating equipment was designed based on the technology and practice in the 1970's, and major components such as turbine runner, generator stator windings and control and protection panel have not yet been rehabilitated to date. Under such situation, some damage/deterioration can be possibly identified even if no severe problems have been observed so far. In addition, spare parts for the original equipment are difficult to find in the market.

According to "IEC 62256 - Hydraulic turbines, storage pumps and pump-turbines - Rehabilitation and performance improvement", the opportune time for starting rehabilitation should be prior to the equipment experiencing frequent and severe problems with its major components such as for example: generator winding failures, major runner cracking, cavitations or particle erosion damage, bearing failures and/or equipment alignment problems due to foundation or substructure movement or distortion. To avoid long term stoppage due to a severe problem and/or non availability of spare parts for damaged components in the near future, rehabilitation work is recommended to restore at least the original performance and reliability to maintain continuous long time operation. This can be achieved by adopting advanced and modern technology for the major components. Upon

renovating the major components, each power station is expected to have an extended life of another 40 years.

(3) Methods of Rehabilitation

As a scope of the rehabilitation work, partial or entire replacement of the component is considerable, but it is not recommended to adopt a partial replacement because the components were very old and designed in the 1970's practice and therefore the partial replacement is very difficult in procurement of parts and may cause a limited tender only by the original manufacturer. Therefore the entire replacement of the component is recommended to make a competitive tender.

4.1.2 Rehabilitation Works

(1) Hydro-mechanical Equipment (Gates and Penstocks)

The gate leaf and structure of the hydro-mechanical equipment in Sutami are working in good condition and no serious problems have been observed. Therefore, only three (3) sets of local and remote control cabinets for intake gates have been considered for rehabilitation. It is recommended to design, to fabricate and install the new control cabinets in accordance with the latest codes for electric appliances.

(2) Generating Equipment (Water Turbine, Generators and Control System)

The generating equipment is composed of various components and Table 4.1.2-1 shows major components with their functions and possible problem/trouble.

Table 4.1.2-1 Major Components of Generating Equipment

Component	Part	Function	Possible problem/trouble
1 Water Turbine	-Turbine runner	-Convert hydraulic energy to mechanical energy	-cavitations -corrosion
	-Spiral casing	-Embedded water passage to runner	-crack and corrosion
	-Guide vane	-Adjust water volume to runner	-crack due to cavitations -corrosion
	-Inlet valve	-Open and close water passage to water turbine	-water leakage
	-Turbine bearing	-Support turbine shaft	-vibration -high temperature
	-Governor	-Adjust speed and load of water turbine	-non control of speed and load
2 Generator	-Stator	-Generate voltage	-short circuit of windings -earth fault of windings
	-Rotor	-Convert mechanical energy to electrical energy	-short circuit of windings -earth fault of windings
	-Thrust bearing	-Support rotor and generator shaft	-vibration -high temperature
	-AVR	-Adjust generator voltage	-non control of voltage
3 Control and Protection	-Control panel	-Operate and control machines -Record events and status	-non control of machines
	-Protection panel	-Protect machines from trouble	-malfunction of protection
4 Transformer	-Main transformer	-Step-up generator voltage to high voltage	-high temperature -oil leakage

(Prepared by JICA Study Team)

These are classified as major components since any problem or trouble in any of these will cause a significant damage to the hydropower station, resulting in forced long term stoppage.

Based on the data collected during the site investigation, evaluation for the major components was made to clarify a scope of rehabilitation works. Results of the evaluation was made in three (3) statuses, namely,

- A: Deterioration is remarkable and replacement is urgently required,
- B: Deterioration is going and repair and/or replacement at annual inspection (AI) or major overhaul (MO) is recommended, and
- C: Deterioration has not yet been appeared but observation in the regular maintenance is recommended.

It is noted that the evaluation in this study was carried out based on visual inspection and collected data, but not based on non-destructive inspection.

For Sutami Hydropower Station

Results of evaluation for the existing generating equipment are shown in Table 4.1.2-2 and considerations for the results for key parts such as turbine runner, generator stator windings and control and protection panel are described below.

Table 4.1.2-2 Evaluation of Major Components of Generating Equipment (Sutami)

Component	Part	Evaluation			Observation	
		A	B	C		
1	Water Turbine	-Turbine runner	○			Spare runner is changed by other unit runner. The used runner had cavitations damage and repaired by welding, but depth of cavitations was very deep. Maximum use of repaired runner could be less than 3 times.
		-Spiral casing			○	Spiral casing was embedded and then inspection was not carried out in this study.
		-Guide vane		○		Inspection was not carried out in this study, but there could be corrosion because of about 40 year of operation.
		-Inlet valve		○		Continuous water leakage was observed.
		-Turbine bearing		○		Bearing temperature is maintained within the allowance.
		-Governor	○		Type is very old mechanical type and spare parts are not available in the market.	
2	Generator	-Stator	○			Breaking voltage has dropped and residual life was evaluated at 2 years in the examination conducted in 2004.
		-Rotor		○		Taking the examination results of stator into consideration, the deterioration is the same as that of the stator.
		-Thrust bearing	○			Bearing temperature is maintained within the allowance, but about 7 degrees increased above the initial temperature.
		-AVR	○			Type is very old analog type and spare parts are not available in the market.
3	Control and Protection	-Control panel	○			Type is very old analog type and spare parts are not available in the market. Automatic data logger to record operating status is not equipped.
		-Protection panel	○			Protection relays are old mechanical type and spare parts are not available in the market.
4	Transformer	-Main transformer			○	Temperatures of winding and oil are maintained within the allowance.

(Prepared by JICA Study Team)

1) Evaluation of Turbine Runner

Turbine runner of unit 1 was inspected during the examination carried out in 2004 and cavitations corrosion on the surface of the turbine blades were measured in terms of length, width and depth. The results are shown in Appendix D. The measured depth of corrosions ranges from 2.5 mm to 8 mm. The photograph of the corrosion is shown below. As seen in the photos, corrosion was considered serious because of its substantial depth. Turbine runner is usually evaluated whether the depth of corrosion exceeds 1 mm or not, if it exceeds, it is judged whether repair by welding or replace depend on the degree. However, the number of repair by welding is recommended to be less than 3 times to avoid deterioration due to welding stress. The damaged turbine runner of Sutami was repaired by welding and used for the other unit. Taking such deep cavitations corrosion into consideration, it is recommended to replace with new runners to avoid a serious problem causing the turbine runner to crack.



Cavitations Corrosion at Outlet Side
(on Blade No. 11)



Detail of Cavitations Corrosion
(Size of Corrosion: 40L x 10W x 8.0D mm)

2) Evaluation of Generator (Stator Windings)

Comparing with the commissioning test records in 1973, the air cooler inlet air temperature at full load (35 MW) increased by more than 10 °C and the air cooler outlet air temperature reached to 45 °C which is a very high value for the cooling air of the generator. (Generally, the temperature of cooling air entering into the generator should not be higher than 40 °C.) As a result, the stator winding temperatures increased by about 10 °C. However, the cause of this temperature increase has not been examined yet.

In 2004, the diagnostic tests were carried out to make an assessment of the residual life of the stator winding. Consequently, the residual life of the stator windings is estimated at two or three years by the following study.

For safe continuous operation of the generator, it is required that the breakdown voltage of the stator winding should be higher than the safety operational level, which is obtained by the formula: $2E + 1$ kV where E is the normal operating voltage. In case of Sutami, the safety operation level is calculated at 23 kV (as $E=11$ kV).

The breakdown voltage of the stator winding of Sutami was estimated at 26.9 kV by the measured values referring to the criteria of the Central Research Institute of Electric Power Industry in Japan. According to the relationship between stator winding breakdown voltage and operation year (Reference: Central Research Institute of Electric Power Industry in Japan), it is estimated that the stator winding breakdown voltage of 26.9 kV will drop to 23 kV in two years.

3) Evaluation of Control and Protection Panel

Control and protection panel was designed by the 1970's technology and no computer system was applied to the panels. Therefore, all operating control is made by manual operations and all protection relays are mechanical type. Operating staff read and write down the data by hand and then the operating data are input in a personal computer for logging. Selection switch of temperature measurement in the control desk was repaired and control numbers of the operation knob were worn and then the operator can not read the numbers, which may cause a safety problem such as mal-operation. Therefore, the existing control and protection panel is recommended to replace entirely with new system. Modern control and protection panel is computerized system with redundant system to achieve a reliable operation and automatic data logger is equipped in the system.

Moreover, PJB has a plan to replace the existing control and protection panels of 12 hydropower stations in the Brantas River basin under control by them including Sutami and Wlingi with new system to control and manage all the hydropower stations from the head office of PJB. Therefore, needs for replacement of the control and protection panel is very high.

4) Recommended Scope of Rehabilitation Work

The scope of the rehabilitation work was studied based on the above evaluation. The recommended scope involves replacements of the major component which was evaluated as "A". However, guide vanes and turbine bearings are also included in the scope since both parts are closely related to design of the new turbine runner for improvement of turbine performance. In order to maximize the performance and reliability of the new turbine runner, these parts are also recommended to be replaced with a new design even they are evaluated as "B".

The recommended rehabilitation scope is shown as follows and illustrated in Figure 4.1.2-1.

i) For Water Turbine:

- Replacement of Turbine Runner, Guide Vane and Turbine Bearing
- Replacement of Inlet Valve
- Replacement of Governor

ii) For Generator:

- Replacement of Stator and Rotor

- Replacement of Thrust Bearing
- Replacement of AVR
- iii) For Control and Protection Panel:
 - Replacement of Control Panel and Operation Desk
 - Replacement of Protection Panel

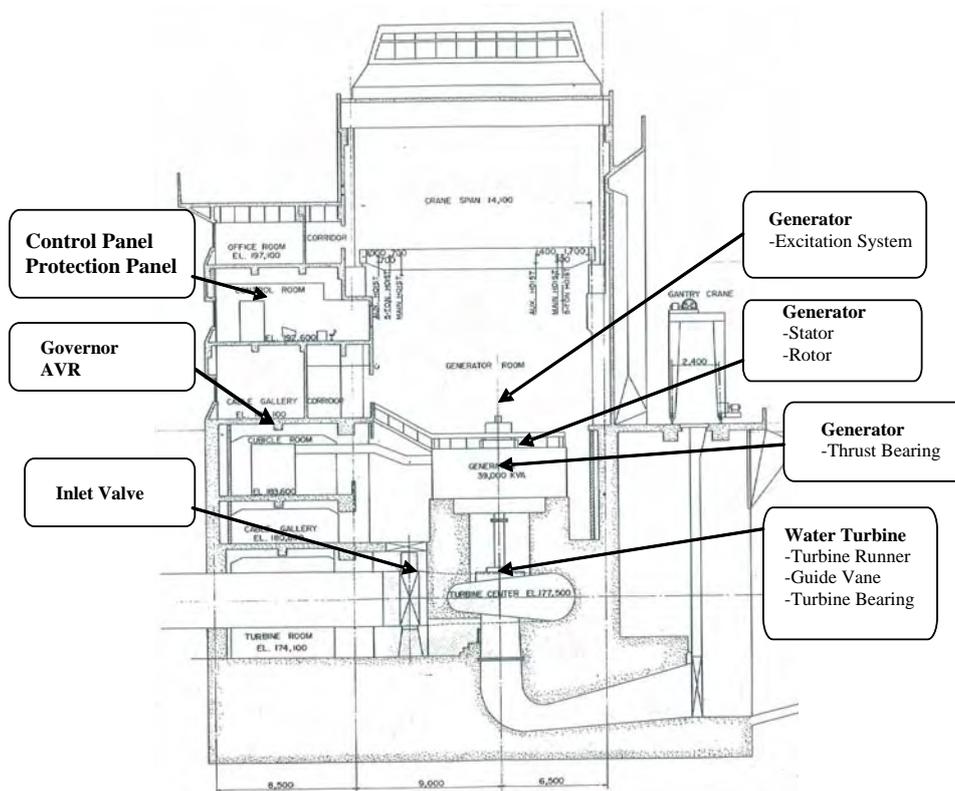


Figure 4.1.2-1 Scope of Rehabilitation Works for Sutami Hydropower Station
(Prepared by JICA Study Team)

Concepts for introduction of new technology under the rehabilitation are described as follows.

Turbine Runner

Turbine runner and guide-vanes including facing plates and wearing ring for three units are replaced with new ones. New runner is designed using modern computational fluid dynamics (CFD) technology and the performance is verified through model test. Guide vane is designed to make a smooth water passage in combination with the newly designed runner to increase efficiency and performance of water turbine. Oil-less lubricating bushing for guide vanes operating mechanism is recommended for easy maintenance. The outline of the existing stay ring, which is a part of the embedded spiral case, is modified during installation work to match the design of the new runner. Turbine guide bearing is also changed from the existing cylinder type to the segment type.

Inlet Valve

The existing inlet valve is of the butterfly type and continuous water leakage from the seals is observed. Inlet valve is changed into the through flow type which has less water loss than the original type, to increase the water turbine efficiency.

Governor

The existing governor is of the mechanical type and no production has been made by any manufacturer. The entire governor system is replaced with a modern digital governor with proportional, integral and derivative (PID) computing functions to achieve quick response and stable control. Main processor and power supply unit is recommended to be redundant in hot-standby arrangement to achieve high reliability.

Generator Stator and Rotor

Stator and rotor are essential parts of the generator which convert mechanical energy to electrical energy. Electrical insulation is required to be maintained in good conditions throughout the operation. However, it is noted that the electrical insulation tends to deteriorate proportionally with operating hours due to heat or vibration stress. Damage of stator and/or rotor windings due to less electrical insulation is the most serious accident that could occur, causing the machines to trip and long term stoppage is forced. Thus, stator windings are recommended to be replaced with new ones. At the same time, stator frame, rotor windings and air cooler is redesigned in order to realize the optimum performance of the generator.

Thrust Bearing

Considering that the temperature of the existing thrust bearing has increased from the initial stage, thrust bearing is recommended to be replaced with non-metallic material to provide low friction coefficient, less wear resistance and reduction of loss. In order to avoid oil vapor leakage from the thrust bearing, an advanced new technology of brush seal is also applied.

AVR

The existing AVR is of the analog type and no similar model has been made by any manufacturer. The whole AVR system is replaced with a modern digital AVR to achieve high speed computation, high control precision and stability and easy maintenance. Main processor and power supply unit is recommended to be redundant in hot-standby arrangement to achieve high reliability.

Control and Protection Panel

The existing control and protection panel is of the analog type with mechanical protection relays and no similar production has been made by any manufacturer. The whole control system is replaced with new distributed control system (DCS) with programmable logic controller to perform automatic control, indications, protection and alarm management for water turbine, generator, station service circuit with advanced technology including

control/monitoring desk, supervisory and control panel. Digital type electrical protective relays are also used to achieve quick response, wide applications, wide setting ranges and compact space. The electrical protective relays for the generating equipment are arranged in dual configuration to enhance high reliability. Supervisory control and data acquisition (SCADA) system is introduced to perform supervisory control of the whole components, data trending, data logging, event recording and compiling of daily and monthly reports. The SCADA system mitigates the operator's daily duty and also be useful to check and analyze the operating status of the whole power station. At the same time, the AC/DC power supply system is recommended to be replaced with a new one to coordinate the new control and protection system.

For Wlingi Hydropower Station

Results of evaluation for the existing generating equipment are shown in Table 4.1.2-3 and considerations for the results for key parts such as turbine runner, stator windings, control and protection panel etc. are described below.

Table 4.1.2-3 Evaluation of Major Components of Generating Equipment (Wlingi)

Component	Part	Evaluation			Observation	
		A	B	C		
1	Water Turbine	-Turbine runner	○			No Spare runner is provided. The used runner had cavitations damage and repaired by welding. Maximum use of repaired runner could be less than 3 times.
		-Spiral casing			○	Spiral casing was embedded and then inspection did not carry out in this study.
		-Guide vane		○		Inspection did not carry out in this study, but there could be corrosion because of more than 30 year operation.
		-Turbine bearing		○		Bearing temperature is maintained within the allowance.
		-Governor	○			Type is very old mechanical type and spare parts are not available in the market.
2	Generator	-Stator	○			Insulation resistance is measured and the values are plotted in a wide range from small to large. It is recommended to examine the breaking voltage of windings.
		-Rotor		○		Detail examination is recommended as the same as stator windings.
		-Thrust bearing		○		Bearing temperature is maintained within the allowance.
		-AVR	○			Type is very old analog type and spare parts are not available in the market.
3	Control and Protection	-Control panel	○			Type is very old analog type and spare parts are not available in the market. Automatic data logger to record operating status is not equipped.
		-Protection panel	○			Protection relays are old mechanical type and spare parts are not available in the market.
4	Transformer	-Main transformer			○	Temperatures of winding and oil are maintained within the allowance.

(Prepared by JICA Study Team)

1) Evaluation of Turbine Runner

Turbine runner is of Kaplan type, which is applied for lower head turbine, and the turbine blades can be moved by pressure oil to adjust water volume. Therefore, runner blades are

important and sensitive part for speed and load control against the power network fluctuation. Taking long term operation more than 30 years into consideration, details examination including pressured oil operating system for the runner blades is recommended.

2) Evaluation of Generator (Stator Windings)

The insulation resistances were plotted in the range between 235 M-ohm and 1.03 G-ohm for stator windings and between 253 M-Ohm and 1.74 G-ohm for rotor windings according to data of MO carried out by PJB in 2008. The measured values were randomly plotted in a wide range from a small one to large one, which is considerable to have tendency of potential insulation problem inside stator and rotor windings. Thus, the insulation resistance values might indicate a sign of deteriorating electrical insulation.

3) Evaluation of Control and Protection Panel

Control and protection panel was designed by the 1970's technology and no computer system was applied to the panels. Therefore, all operating control is made by manual operations and all protection relays are mechanical type. Operating staff read and write down the data by hand and then the operating data are input in a personal computer for logging. Control numbers of the operation knob were worn and then the operator can not read the numbers, which may cause a safety problem such as mal-operation. Therefore, the existing control and protection panel is recommended to replace entirely with new system. Modern control and protection panel is computerized system with redundant system to achieve a reliable operation and automatic data logger is equipped in the system.

4) Recommended Scope of Rehabilitation Work

Scope of the rehabilitation work was studied based on the above evaluation and the recommended scope was considered that replacement of major components which are evaluated as "A". However, guide vanes and turbine bearings are also included in the scope since both parts are closely related to design of new turbine runner and it is quite effective to improve the performance of water turbine. In order to maximize the performance and reliability of new turbine runner, those parts are also recommended to be replaced with new design even they were evaluated as "B".

On the other hand, AVR is excluded in the scope because the existing AVR is scheduled to be replaced with new one with PJB fund.

Recommended rehabilitation scope is listed as follows and illustrated in Figure 4.1.2-2.

i) For Water Turbine:

- Replacement of Turbine Runner, Guide Vane and Turbine Bearing
- Replacement of Governor

ii) For Generator:

- Replacement of Stator and Rotor

- Replacement of Thrust Bearing
- iii) For Control and Protection Panel:
 - Replacement of Control Panel and Operation Desk
 - Replacement of Protection Panel

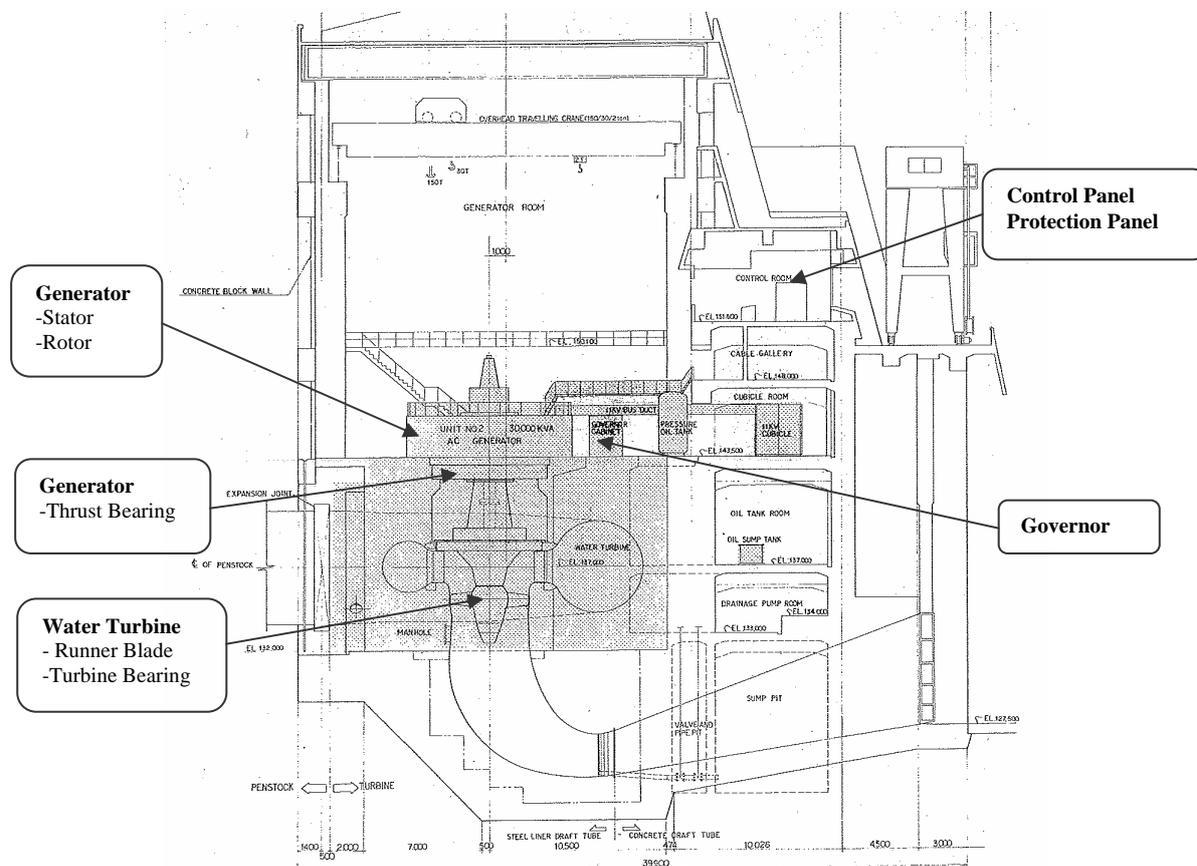


Figure 4.1.2-2 Scope of Rehabilitation Works for Wlingi Hydropower Station
(Prepared by JICA Study Team)

Concepts for introduction of new technology under the rehabilitation are described as follows.

Turbine Runner, Guide Vane and Turbine Bearing

Turbine runner and guide-vanes with facing plates and wearing ring for two units are replaced with new ones. New runner is designed using modern computational fluid dynamics (CFD) technology and the performance is verified through model test. Guide vane is designed to make a smooth water passage in combination with the newly designed runner to increase efficiency and performance of water turbine. Oil-less lubricating bushing for guide vanes operating mechanism is recommended for easy maintenance. The outline of the existing stay ring, which is a part of the embedded spiral case, is modified during installation work to match the design of the new runner. Turbine guide bearing is also changed from the existing cylinder type to the segment type.

Since the existing Kaplan runner is the oil filled type inside the runner hub, it is recommended to change to the water filled type so that the runner blade operating mechanism is immersed in water with anti-rust liquid instead of only water.

Governor

As the same as Sutami, the existing governor is of the mechanical type and no production has been made by any manufacturer. The entire governor system is replaced with a modern digital governor with proportional, integral and derivative (PID) computing functions to achieve quick response and stable control. Main processor and power supply unit is recommended to be redundant in hot-standby arrangement to achieve high reliability.

Stator and Rotor

Stator and rotor are essential parts of the generator which convert mechanical energy to electrical energy. Electrical insulation is required to be maintained in good conditions throughout the operation. However, it is noted that electrical insulation tends to deteriorate proportionally with operating hours due to heat or vibration stress. Damage of stator and/or rotor windings due to less electrical insulation is the most serious accident that could occur, causing the machines to trip and long term stoppage is forced. Stator windings are recommended to be replaced with new ones. At the same time, stator frame, rotor windings and air cooler should be redesigned in order to realize the optimum performance of the generator.

Thrust Bearing

Although temperatures of the existing thrust bearing are within tolerances, thrust bearing is recommended to be replaced with non-metallic material to provide low friction coefficient, less wear resistance and reduction of loss. In order to avoid oil vapor leakage from the thrust bearing, an advanced new technology of brush seal is also applied.

Control and Protection Panel

The existing control and protection panel is of the analog type with mechanical protection relays and no similar production has been made by any manufacturer. The whole control system is replaced with new DCS with programmable logic controller to perform automatic control, indications, protection and alarm management for water turbine, generator, station service circuit with advanced technology including control/monitoring desk and supervisory and control panel. Digital type electrical protective relays are also used to achieve quick response, wide applications, wide setting ranges and compact space. The electrical protective relays for the generating equipment are arranged in dual configuration to enhance high reliability. SCADA system is introduced to perform supervisory control of the whole components, data trending, data logging, event recording and compiling of daily and monthly reports. The SCADA system mitigates the operator's daily duty and also be useful to check and analyze the operating status of the whole power station. At the same time, the AC/DC

power supply system is recommended to be replaced with a new one to coordinate the new control and protection system.

4.1.3 Effectiveness of the Rehabilitation Works

(1) Stable and Reliable Power Supply in the Regional Area

Figure 4.1.3-1 shows the daily load curves in East Java in March 2010. During weekday (March 3, 2010 Wednesday), night time peak has reached 3,510.4 MW, which is about 400 MW higher than the day time demand of about 3,100 MW. This night time peak demand is mainly covered by hydropower generations and diesel power generations. Sutami and Wlingi with total capacity of 159 MW share approximately 40% of the increased peak demand in the night time of 400MW.

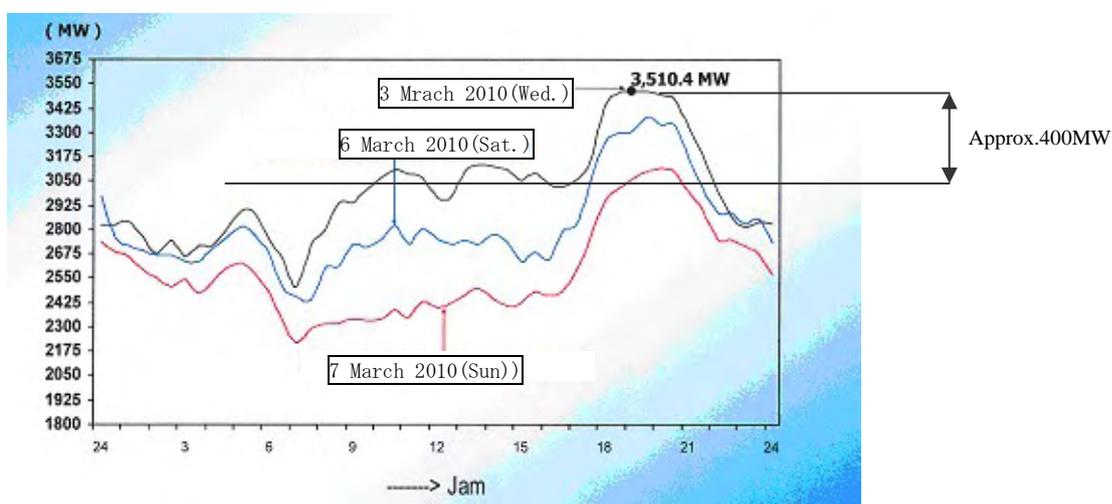


Figure 4.1.3-1 Daily Load Curve in East Java

(Source: P3B)

Sutami and Wlingi are operating under close cooperation with each other. Under cooperative and effective operations, their regional role has been definite and distinctive as a peak power station in the region. Figure 4.1.3-2 demonstrates the basic operational pattern of Sutami during rainy and dry seasons in 2008.

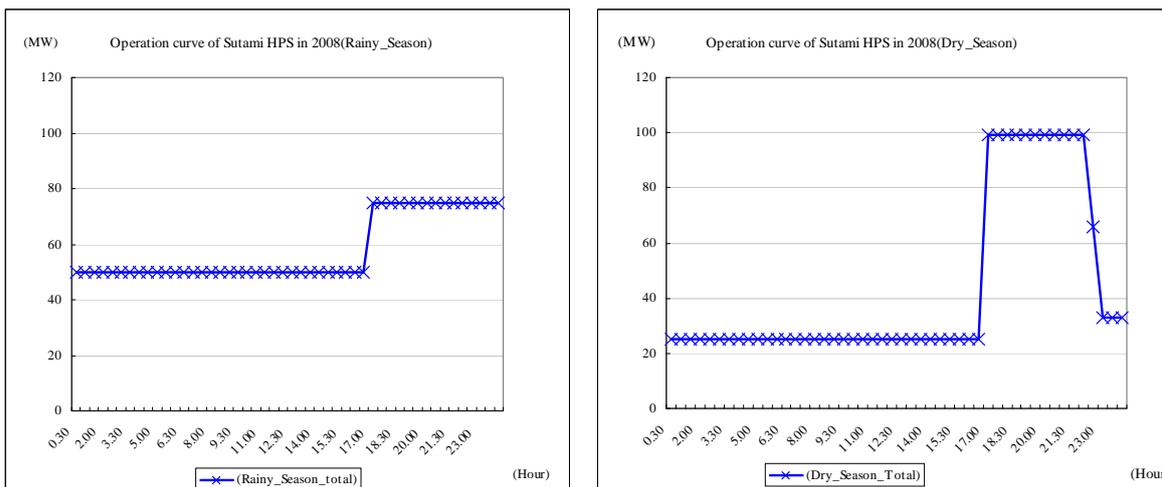


Figure 4.1.3-2 Operational Pattern Curve of Sutami Hydropower Station in 2008 (Source: PJB)

Based on the reservoir operational plan, the night time peak power supply primarily takes control during both rainy and dry seasons. Moreover, during the rainy season except for night time peak two generator units are basically operated with as much water as available to generate power during daytime. During dry season, only one unit is essentially operated.

The adjustment for the night time peak demand is significantly large during the dry season. From around 5 p.m., all of the three units are fully operated. At around this same time, Wlingi is also fully operated in collaboration with Sutami in order to supply peak power.

Figure 4.1.3-3 demonstrates the operational pattern curves of the combined outputs of Sutami and Wlingi during rainy and dry seasons in 2008.

This figure clarifies that both hydropower stations were operated so as to cover their respective outputs. In particular, both stations have adjusted to the night time peak demand at the same time.

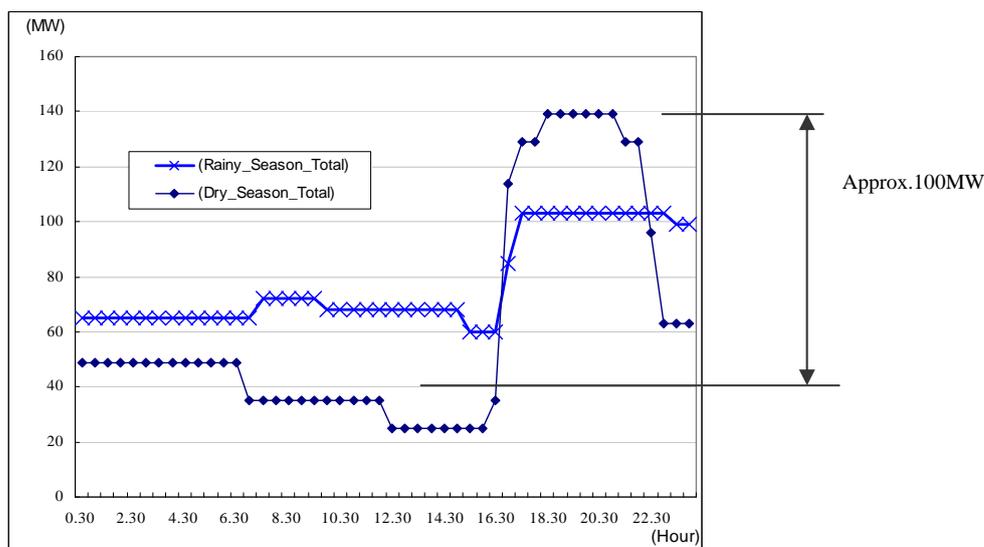


Figure 4.1.3-3 Operational Pattern Curve of Sutami and Wlingi hydro power stations in 2008 (Source: PJB)

According to the records in the dry season, the output of Sutami and Wlingi was increased by 100MW as much as possible in order to catch up with the night time peak, which accounts 25% of the increase of night time peak in the whole East java. Judging from this fact, Sutami and Wlingi are inevitable power stations in terms of night time peak-adjustment in the region.

Furthermore, it is important to ensure the best allocation of power supply in accordance with daily load in terms of maintaining stable and reliable power supply considering the characteristic of power sources. Sutami and Wlingi hydropower station are functioning as power stations which supply the power for peak and middle loads. At present, the power supply from thermal power stations are confined in the region due to interruption of 150kV transmission line, which means that the supplying power for base load has to be strengthened. It is required that both stations are functioning so as to supplement portion of base load in addition to the power supply of middle and peak loads. Thus, the rehabilitation works will highly contribute to maintain a stable and reliable power supply to the regional area.

In addition, Sutami has a function of black start of Paiton thermal power station. When a power plant starts operation, the electricity from its own power source (i.e., diesel engine generator) or from external power source is required. The large scale thermal plant such as Paiton requires a huge amount of electricity for starting. The existence of Sutami is justified being a power source to Paiton for the starting. Therefore, Sutami contributes significantly to the reliability and stability of the 500 kV Java-Bali power transmission network.

(2) Performance Improvement

As a performance improvement of the generating equipment by the rehabilitation works, increase of efficiency of the water turbine is expected. Water turbine is composed of spiral casing, guide vanes and turbine runner, which formulate a water passage. Usually, efficiency of the water turbine is gradually decreasing by increase of friction loss due to corrossions of the water passage, and corrossions of the turbine runner is most effective to the efficiency since it directly convert the hydro energy to the mechanical energy. Potential efficiency gains expected by turbine runner replacement are guided by IEC 62256 depending on the age of unit as shown in Table 4.1.3-1.

Table 4.1.3-1 Potential Total Gain in Efficiency from the Replacement of a Francis Runner

Francis Turbine Potential Runner Efficiency Gains			
Age of unit	60 years	40 years	20 years
1.Profile improvement	2.2	1.0	0.5
2.Restoration of surface condition	1.0	0.5	0.25
3.Reduction of seal loss	1.0	0.75	0.5
Total potential gain	4.2	2.25	1.25

(Source: IEC 62256)

Both Sutami and Wlingi are nearly 40 years old. Thus, 2.25% gain can be expected by the runner

replacement. In addition, according to IEC 62256, potential additional efficiency improvement by replacement of guide vanes is about 0.2 to 1.0 %. Taking these potential gains into consideration, total turbine efficiency is expected to increase by about 3%.

On the other hand, increase of the generator efficiency is not so expected by replacement of stator and rotor windings since the electrical insulation is only expected to be improved by the replacement.

(3) Power Generation Benefit

Dependable Output and Power Generation

After completion of the rehabilitation work, life time of the generating equipment is expected to extend and the efficiency is also increased by the performance improvement. In order to estimate the power generation benefit after the rehabilitation work, the dependable output and the power generation were calculated respectively in accordance with data of runoff inflow to Sutami Reservoir from 2004 to 2009.

For comparison of the benefit, calculations for ‘Without Project (without rehabilitation)’ and ‘With Project (with rehabilitation)’ have been carried out and details of the calculation are shown in Appendix E. In this study, ‘Without Project’ and ‘With Project’ are considered with the following assumptions.

Without Project

‘Without Project’ means that the rehabilitation works are not implemented and the generating equipment stop its operation at the expected life period, that is, 44 years¹ is assumed after the initial operation. In addition, the following two cases are considered for “Without Project”

Case-1: The existing generating equipment stop due to a severe problem on the major components, e.g., short circuit of generator stator windings or cracking of turbine runner, after 44 years from the initial operation, namely, unit 1 in 2017 and the other 2 units in 2020 and they are no longer operated.

Case-2: The existing generating equipment stop due to a severe problem on the major components, e.g., short circuit of generator stator windings or cracking of turbine runner, after 44 years from the initial operation, namely, unit 1 in 2017 and the other 2 units in 2020. The damaged components will be rehabilitated after the accident and for this study at least 5 years outage is assumed to be required for the rehabilitation including financial procurement, design, tender, equipment procurement, transportation and installation, which means total 8 years is required for the recovery of the whole 3 units (unit 1 restart in 2022 and the other units restart in 2024).

¹ 44 years is assumed by taking twice of the legal life time of 22 years and referring IEC 62256 in which expected life time for Francis turbine is described in between 30 to 50 years.

With Project

‘With Project’ means that the rehabilitation work start in 2011 with the financial assistance of Japanese ODA and total implementation period is assumed in 5 years for three units including consultancy services, tender, design, equipment procurement, transportation and installation. The installation work of the first unit will start in 2014 and complete replacements of three units in 2017.²

The operation pattern for ‘Without Project’ and ‘With Project’ is shown in Table 4.1.3-2.

Table 4.1.3-2 Combination of Operated Generating Equipment

Year	Without Project				With Project	
	Case 1		Case 2		Existing unit	New unit.
	Existing unit	New unit	Existing unit	New unit		
2014	3	-	3	-	2	-
2015	3	-	3	-	1	1
2016	3	-	3	-	-	2
2017	2	-	2	-	-	3
2018	2	-	2	-	-	3
2019	2	-	2	-	-	3
2020	-	-	-	-	-	3
2021	-	-	-	-	-	3
2022	-	-	-	1	-	3
2023	-	-	-	1	-	3
2024	-	-	-	1	-	3
2025	-	-	-	3	-	3
2026	-	-	-	3	-	3
.....	-	-	-	3	-	3
2060	-	-	-	3	-	3

(Prepared by JICA Study Team)

The results of the calculation for the dependable output and the power generation for ‘Without Project’ and ‘With Project’ scenario are shown in Table 4.1.3-3. The calculations under ‘With Project’ and ‘Without Project-Case 2’ are considered using total efficiency with 3% increase after the completion of rehabilitation works. Figure 4.1.3-4 shows comparison of the power generation for ‘Without Project’ and ‘With Project’.

² For economic and financial analysis purpose, it is assumed that each unit will be returned to service every year after the rehabilitation.

Table 4.1.3-3 Power Generation Simulation Results in Sutami

Year	Without Project								With Project			
	Case 1				Case 2							
	Dependable Output (MW)	Power Generation (GWh)			Dep. Output. (MW)	Power Generation (GWh)			Dep. Output. (MW)	Power Generation (GWh)		
Primary		Secondary	Total	Prm.		Sec.	Tot.	Prm.		Sec.	Tot.	
1976	80.0	215	210	425					-	-	-	-
.....
2014	71.2	202	225	427	71.2	202	225	427	67.9	159	255	414
2015	71.1	202	225	427	71.1	202	225	427	68.9	161	259	420
2016	71.0	202	225	427	71.0	202	225	427	69.9	164	263	427
2017	67.9	159	255	414	67.9	159	255	414	72.9	208	232	440
2018	67.9	159	255	414	67.9	159	255	414	72.9	207	233	440
2019	67.9	159	255	414	67.9	159	255	414	72.6	207	233	440
2020	-	-	-	-	-	-	-	-	72.5	207	233	440
2021	-	-	-	-	-	-	-	-	72.5	207	233	440
2022	-	-	-	-	37.2	84	223	307	72.3	207	233	440
2023	-	-	-	-	37.2	84	223	307	72.0	206	234	440
2024	-	-	-	-	37.2	84	223	307	72.0	206	234	440
2025	-	-	-	-	71.8	206	234	440	71.8	206	234	440
2026	-	-	-	-	71.7	206	234	440	71.7	206	234	440
.....
2060	-	-	-	-	67.3	201	240	440	67.3	201	240	440

(Prepared by JICA Study Team)

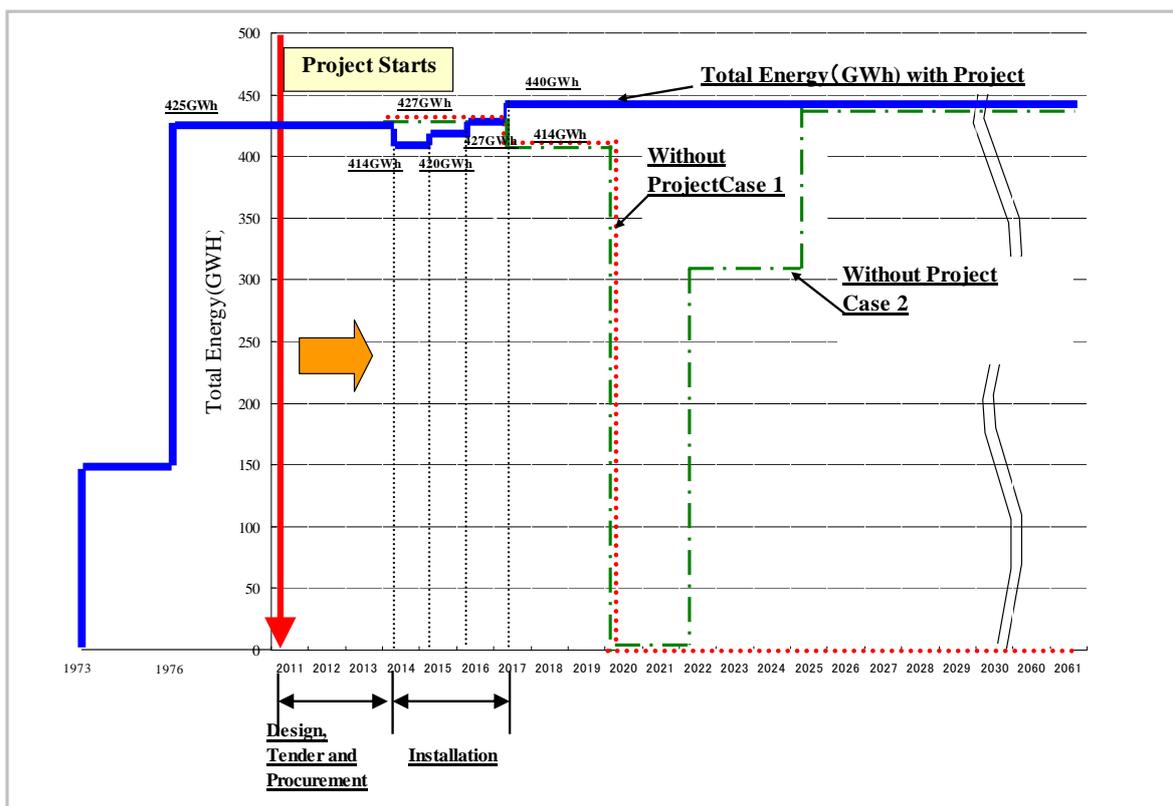


Figure 4.1.3-4 Power Generation for Without Project and With Project in Sutami

(Prepared by JICA Study Team)

As seen in the above table and figure, it can be said that the power generation in ‘With Project’ during the rehabilitation work is reduced by only 13 GWh (427 GWh-414 GWh) because the

available water for generation is nearly same even two or three units operation.

The power generation benefit of Case-1 is much higher than Case-2 since the expected power generation (440 GWh) after the rehabilitation work account as benefit during the whole period of new life time.

On the other hand, in case of Case-2, the power generation benefit is differences of the power generations in the period of rehabilitation work of damaged components between 2017 and 2024, because the power generation in 'Without Project' can be restored after the rehabilitation.

4.1.4 Project Financial Cost

The project financial cost for the recommended rehabilitation works is estimated with the direct cost and the indirect cost, and those are estimated with the following considerations.

(1) Direct Cost

The equipment cost for each component to be rehabilitated for Sutami and Wlingi was estimated based on the estimated cost submitted by the manufacturer at the time of application for the JBIC export credit line in 2004. The cost was reviewed for this study taking into account for recent similar hydropower project and international tendering. In addition to the equipment cost, costs for foreign supervisors during the site installation works and site erection work were included in the direct cost. The erection work is estimated as 10% of the total equipment cost.

(2) Indirect Cost

The indirect cost is estimated in the following assumptions:

- 1) The engineering services (E/S) is 8 % of the direct cost.
- 2) Project administration cost is 3 % of the direct cost.
- 3) Physical contingency is 15 % of the direct cost, engineering services and project administration cost in the indirect cost.
- 4) Price contingencies is estimated referring to the similar projects in Indonesia as follows:
Foreign currency (FC) is 1.3 % per annum, local currency (LC) is 3.2 % per annum

(3) Project Financial Cost

The estimated project financial cost for Sutami and Wlingi is shown in Table 4.1.4-1 and summarized as follows with the exchange rate of 1US\$=94.07 JPY and 1Rp.=0.01143 JPY (as of April 30, 2010).

1) For Sutami hydropower station

FC: JPY 3,335x10⁶, LC: Rp. 30,059 x10⁶

Equivalent total: JPY 3,679x10⁶

2) For Wlingi hydropower station

FC: JPY 2,561x10⁶, LC: Rp. 22,742 x10⁶Equivalent total: JPY 2,821x10⁶

3) For Sutami and Wlingi hydropower stations

FC: JPY 5,896x10⁶, LC: Rp. 52,801 x10⁶Equivalent total: JPY 6,500x10⁶

Table 4.1.4-1 Estimated Project Financial Cost for Sutami and Wlingi

		1Rp.=		0.01143					
1.Sutami	Category	Item to be Rehabilitated	Quantity	Unit	Unit Cost		Cost		Remarks
					FC(JPY)	LC(IDR)	FC(JPY)	LC(IDR)	
1.Direct Cost									
1	Hydromechanical Equipment	Local control cabinets	3	Sets	750,000		2,250,000		
		Remote control cabinets	1	Sets	500,000		500,000		
		Demolishing and installation	1	LS				87,489,000	
	Sub-total 01						2,750,000	87,489,000	
2	Generating Equipment	Turbine	3	Sets	164,000,000		492,000,000		
		Inlet valve	3	Sets	110,000,000		330,000,000		
		Governor	3	Sets	54,000,000		162,000,000		
		Generator	3	Sets	337,000,000		1,011,000,000		
		Exciter System	3	Sets	44,000,000		132,000,000		
		Control, Protection and Monitoring Sy	3	Sets	118,000,000		354,000,000		
		Necessary Parts for Overhaul	3	sets	6,000,000		18,000,000		
		Supervising for Rehabilitation	1	Lot			48,000,000		
		Site Erection Work	1	LS			0	21,863,000,000	
	Sub-total 02						2,547,000,000	21,863,000,000	
3	Transmission and Substation	Disconnecting Switch(PJB)	3	Sets	4,000,000		12,000,000		
		Disconnecting Switch(P3B)	9	Sets	4,000,000		36,000,000		
		Control equipment	1	Lot			5,000,000		
		Site Erection Work	1	LS				463,692,000	
	Sub-total 03						53,000,000	463,692,000	
4	Civil	N/A							
	Total 1						2,602,750,000	22,414,181,000	
							2,858,944,000		
2. Indirect Cost									
1	Engineering services			LS			208,220,000	1,793,134,000	8 % of Total 1
2	Project administration			LS					
3	Physical contingencies			LS			421,646,000	3,631,097,000	15 % of Total 1 and 01.02 of Indirect Cos
4	Price contingencies			LS			102,833,000	2,221,352,000	FC: 1.3 %, LC: 3.2 %
	Total 2						732,699,000	7,645,583,000	
							820,088,000		
	Grand Total						3,335,449,000	30,059,764,000	
							3,679,032,000		
2. Wlingi									
1.Direct Cost	Category	Item to be Rehabilitated	Quantity	Unit	Unit Cost		Cost		Remarks
					FC(JPY)	LC(IDR)	FC(JPY)	LC(IDR)	
1	Generating Equipment	Turbine	2	Sets	309,000,000		618,000,000		
		Governor	2	Sets	60,000,000		120,000,000		
		Generator	2	Sets	370,000,000		740,000,000		
		Control, Protection and Monitoring Sy	2	Sets	220,000,000		440,000,000		
		Necessary Parts for Overhaul	1	Lot			20,000,000		
		Supervising for Rehabilitation	2	Sets	16,000,000		32,000,000		
		Site Erection Work	1	LS				16,955,000,000	
	Sub-total 01						1,970,000,000	16,955,000,000	
2	Transmission and Substation	Disconnecting Switch(PJB)	2	Sets	4,000,000		8,000,000		
		Disconnecting Switch(P3B)	4	Sets	4,000,000		16,000,000		
		Control Equipment	1	Lot			5,000,000		
		Site Erection Work	1	LS				290,000	
	Sub-total 02						29,000,000	2,900,000	
3	Civil	N/A							
	Total 1						1,999,000,000	16,957,900,000	
							2,192,829,000		
2. Indirect Cost									
1	Engineering services			LS			159,920,000	1,356,632,000	8 % of Total 1
2	Project administration			LS					
3	Physical contingencies			LS			323,838,000	2,747,180,000	15 % of Total 1 and 01.02 of Indirect Cos
4	Price contingencies			LS			78,979,000	1,680,609,000	FC: 1.3 %, LC: 3.2 %
	Total 2						562,737,000	5,784,421,000	
							628,853,000		
	Grand Total						2,561,737,000	22,742,321,000	
							2,821,682,000		

(Prepared by JICA Study Team)

4.1.5 Implementation of Rehabilitation Works

(1) Implementation Schedule of the Rehabilitation Works

Schedule of the rehabilitation works is proposed as shown in Figure 4.1.5-1.

Items		1st Year (2011)	2nd Year (2012)	3rd Year (2013)	4th Year (2014)	5th Year (2015)
1.	Consultancy Services					
1.1	Tendering for Consultant (ICB)	■				
1.2	Design and Preparation of Tender Documents	■	■			
1.3	Construction Supervision				■	■
2.	Rehabilitation Works					
2.1	Tendering for Contractor (ICB)		■			
2.2	Design and Manufacturing			■	■	
2.3	Transportation				■	
2.4	Unit 1 Rehabilitation for Sutami				■	■
2.5	Unit 2 Rehabilitation for Sutami					■
2.6	Unit 3 Rehabilitation for Sutami					■
2.7	Unit 1 Rehabilitation for Wlingi				■	■
2.8	Unit 2 Rehabilitation for Wlingi					■

Figure 4.1.5-1 Implementation Schedule for Rehabilitation Works for Sutami and Wlingi
(Prepared by JICA Study Team)

The implementation period is estimated at five (5) years in total including the consultancy service and the international competitive bidding (ICB) for the rehabilitation works.

Procurement of equipment including design, model test, manufacturing, factory test and transportation will take around 18 months from the date of contractual commencement. Site rehabilitation works including dismantling the existing equipment, installation of new equipment and commissioning test is estimated to take around 6 months for each unit. The rehabilitation works is recommended to carry out unit by unit to minimize the power generation loss during the works, therefore total 18 months are taken for the whole site works. For the execution of site works, the installation work is proposed to be done by the power station personnel of PJB while the manufacturer provide necessary technical supervisors for the smooth execution of the rehabilitation works.

The rehabilitation works for Wlingi is recommended to carry out at the same time as Sutami in order to shorten the period of the rehabilitation works and also minimize outage periods due to the rehabilitation works.

(2) Implementation Agencies

Sutami and Wlingi hydropower stations are operated and maintained by PJB at the moment. Therefore, the implementation agency for the rehabilitation works could be PJB under management of PLN.

4.2 Soedirman (Mrica) Hydropower Station

4.2.1 General

Soedirman (Mrica) Hydropower Station is located on the Serayu River flowing near Banjarnegara City in the Central Java province. The principal features and the general layout of the facilities are shown in Appendix B



Soedirman (Mrica) Hydropower Station
(Source: Indonesia Power)

(1) Present Situation of Reservoir Sedimentation

The previous study report as shown in ANNEX C concluded that 80% of the gross storage volume of the Mrica reservoir will be filled with sediment by 2014 considering an annual sediment trapping volume of 4.2 MCM/year. According to the simple

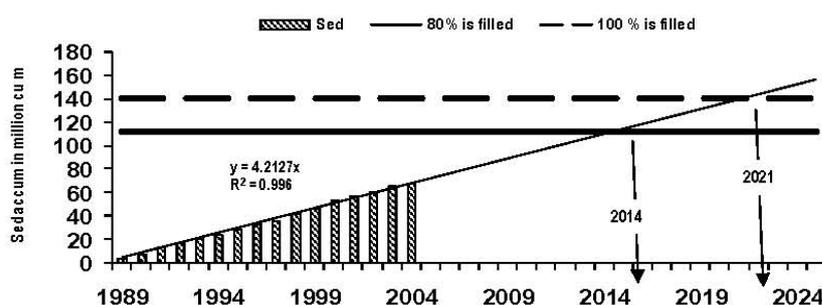


Figure 4.2.1-1 Prediction of Remaining Useful Life of Mrica Reservoir

(Source: Sedimentation Control: Part II. Intensive Measures inside of the Mrica Reservoir, Central Java)

prediction, the reservoir will also be filled up to the high water level (HWL) in 2021. If so, irrigation water supply to the downstream area (10,000 ha) which is the primary purpose of the reservoir, and power generation will become difficult. Further, securing the dam safety will become questionable. Under the above circumstances, it is very urgent to mitigate the sedimentation problems in the Mrica reservoir from the regional as well as the national perspectives.

Differences between initial storage volume and current volume in the Mrica Reservoir in each are

shown in Table 4.2.2-1.

Table 4.2.1-1 Difference Ratio between Initial Storage Volume and Current Volume in Mrica Reservoir

Storage Volume	Initial in 1989	Observed in 2010	Observed /Initial	Note
Dead Storage Volume (m3)	101.99	23.90	23%	Below EL.214.50
Effective Storage Volume(m3)	46.30	32.00	69%	EL.214.50 to 231.00
Flood Storage Volume(m3)	35.47	35.47	100%	EL.231.00 to 234.50

(Source of data: Indonesia Power)

(2) Present Countermeasures against Reservoir Sedimentation

IP and the local government have carried out several activities related to the sediment problem in the Serayu River basin. The on-going countermeasures by IP and the local government are described below.

Long-term Countermeasure

- Greenery program: Greenery program was initiated in 1996 and green-belt surrounding the reservoir in the Meraw and Serayu watersheds has been carried out.
- Elucidation to farmers : The local government of Wonosobo promotes various elucidations to farmers, propose reforestation policy and cultivation program of mini papaya “carica” at the plateau and surrounding areas. In November 2009, IP conducted a “field course” which aimed to thoroughly educate farmers on sprouting method, proper land plowing cultivation practice, and plant preservation, up to harvesting. Through this course, about 6,000 seedlings of coffee and albazia trees were provided to farmers.
- Introduction of new practices on potato field cultivation: One of the main reasons of sediment production in the upper reach of the Serayu and Merawu river basins is that potatoes are cultivated on the hill side area without terracing. The local government has carried out numerous studies and researchers and introduced new practices on potato field cultivation.

Medium-term Countermeasure

- Sabo dam construction: In order to trap produced sediment in the Serayu, Merawu and other small river basins, sabo dam construction has been proposed by the Center for Water Research and Development, Sabo Center Yogyakarta. The sabo dam construction project is on-going. Six sabo dams have been constructed and another 15 are being planned.

Short-term Countermeasure

- Small scale dredging work: IP has carried out dredging work about 0.05 to 0.1 MCM/year. Dredged material has been utilized as the construction material by the local residents.
- Sediment flushing operation: The Mrica Dam is equipped with drawdown culvert so as to flush

sediment from the reservoir and to lower the water level during emergency case. The profile of the drawdown culvert intake is shown in Figure 4.2.1-2. IP has carried out sediment flushing operation through the drawdown culvert from 1996 up to now. Annual average volume of sediment flushing is about 75,000 m³. Yearly sediment flushing volume from the drawdown culvert is shown in Table 4.2.1-2. According to the IP’s estimation, sediment flushing volume will drastically increase from 2010 to 2014, since IP assumed that the toe of the sediment deposit slope will reach the drawdown culvert by 2014.

Table 4.2.1-2 Sediment Flushing Volume

Year	Sediment Flushing Volume (MCM)	Note
1996	7,733	Observed
1997		
1998		
1999	24,628	
2000	33,954	
2001	66,658	
2002	17,884	
2003	16,783	
2004	403,819	
2005	80,119	
2006	34,098	
2007	54,501	
2008	58,385	
2009	94,842	
2010	750,000	Planned
2011	1,250,000	
2012	2,000,000	
2013	3,000,000	
2014	4,200,000	

(Source: Indonesia Power)

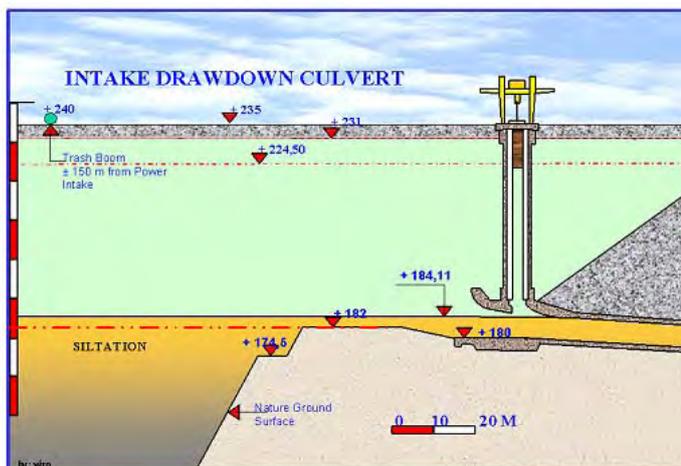


Figure 4.2.1-2 Profile of Drawdown Culvert Intake
(Source: Indonesia Power)

- Modification of reservoir operation: IP has modified the reservoir operation rule of the Mrica reservoir. The operation rule established the water level restriction during the rainy season from December to April so as to minimize the spill out discharge from the reservoir and to prevent sedimentation above EL.228.00 m.

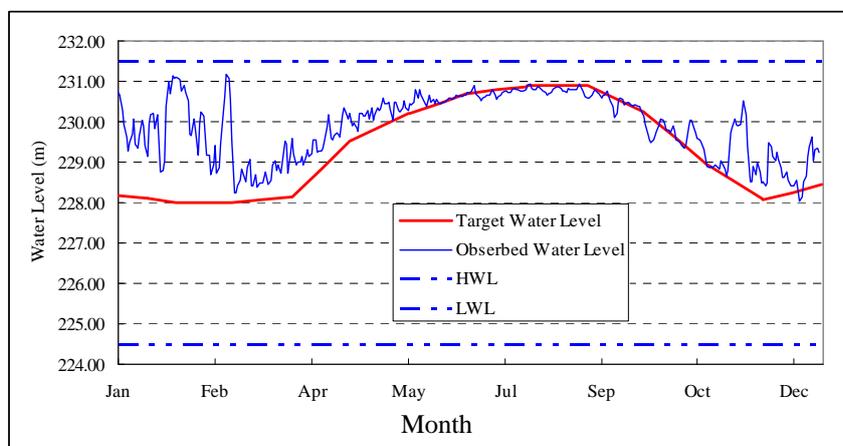


Figure 4.2.1-3 Target Water Level and Observed Water Level
(Prepared by JICA Study Team based on observation record and estimation results by IP)

The above countermeasures are basically appropriate. However, there are some difficulties in getting the expected results to address the sedimentation problems. The major reasons for such difficulties are as described below;

Difficulty in Reforestation and Introduction of New Cultivation Program

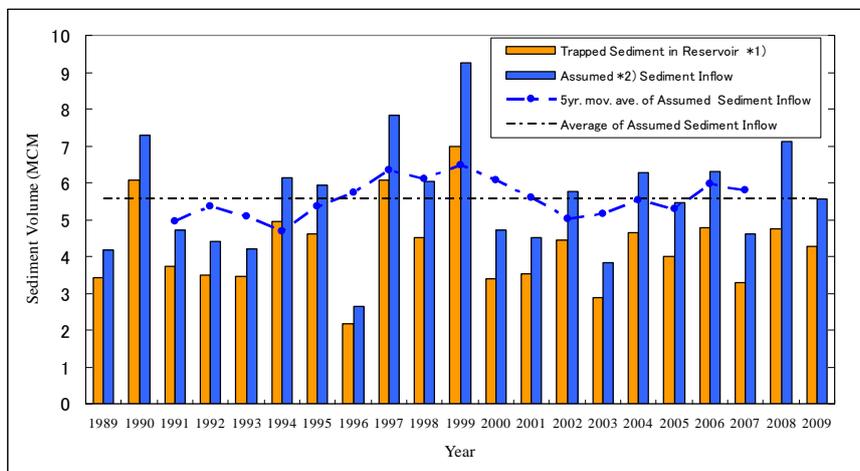


Figure 4.2.1-4 Trapped Sediment Record and Assumed Sediment Inflow in the Reservoir

(Prepared by JICA Study Team based on observation record by IP)

*1): Based on observed record by Indonesia Power

*2): Assumed by Brunei's middle curve formula. Calculation of sediment inflow is as described in Table BA1.1 of Annex B.

As shown in Figure 4.2.1-2, the sediment inflow to the reservoir has not been reduced greatly by means of the above-described long-term countermeasures. The main reason is as listed below:

- The high sediment production in the Serayu River basin has been triggered by large scale deforestation for developing cultivation area. In order to reduce sediment production, drastic reforestation program should be required with new job creation for the local farmers utilizing the cultivation area. However, it is difficult for the local government and IP to perform the program.
- It takes time to introduce new practices on potato field cultivation instead of the traditional practice due to cultural and economical reasons of the local farmers.

Low Progress and Low Trapping Capacity of the Sabo Dam

- Due to financial reasons of the local government and IP, the sabo dam construction has been delayed.
- The developed sabo dam storage capacity (less than 0.5 MCM) is less than 10% of the assumed annual sediment production (5.6 MCM, as described in Table BA1.1 of Annex B) in the watershed.

Low Effectiveness of Sediment Flushing Operation

The effectiveness of the above countermeasure is too small to recover the storage volume or to

extend the storage life period due to the following reasons:

- Dredging volume is less than 5% of the annual trapped sediment volume. More large scale dredging work is required. However, IP cannot carry out the dredging work due to financial restriction.
- In order to carry out effective sediment flushing operation for recovering the storage volume, most of the water in the reservoir should be discharged prior to the flushing operation. However, for the irrigation water supply, the Mrica reservoir cannot draw down the reservoir water level below the low water level (LWL) of EL.224.50 m. As shown in Figure 4.2.1-5, since the tractive force of the flowing water is reduced under the water filled condition of the reservoir, sediment flushing volume is too small to recover the storage volume.

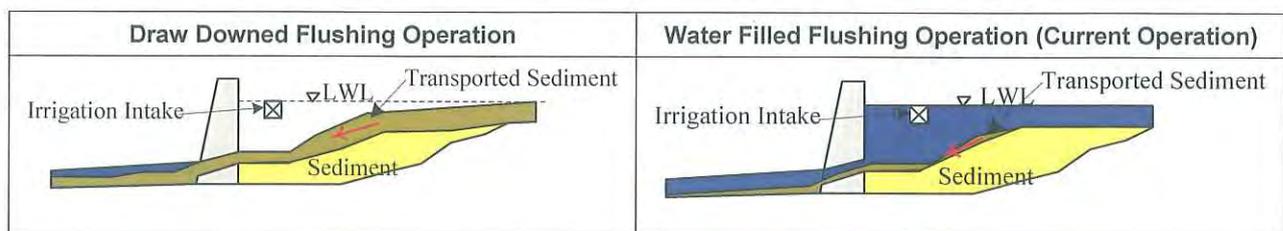


Figure 4.2.1-5 Image of Sediment Flushing Operation

(Prepared by JICA Study Team)

(3) Consideration of the Present Countermeasures

As described above, IP and the local government have performed appropriate countermeasure for sediment control in the Serayu River basin. However, due to their limited competence and funding, the scale of the countermeasures is too small to get effective results on the sediment issues.

IP and the local government understand the above described issues and they concluded that the following measures should be carried out to mitigate the sediment issues in the Serayu River basin.

- To mitigate large scale sediment production and sedimentation in the Mrica reservoir, integrated watershed sediment management shall be performed and managed.
- The watershed sediment management should deal not only with the technical aspect but also socio-economic and cultural aspects so as to improve the cultivation practice of the local farmers.
- To execute and maintain the watershed sediment management, not only IP and the local government but also the Government of Indonesia (GoI) and stakeholders in the Serayu River basin shall cooperate on the plan.
- To execute the large scale dredging work by IP for recovering the effective volume of the Mrica reservoir, financial assistance shall be required. IP has requested the assistance from the GoI; however, it is still pending.

- To execute prompt construction and effective management of the sabo dam, IP considers that the assistance of the Ministry of the Public Works is required.

As described the above, sedimentation problem in the Mrica Reservoir is related to the sediment management in the Serayu River basin closely. Hence the sedimentation countermeasure in the reservoir should be carried out as part of the Watershed sediment management in the basin. In addition to the above findings, it is recommended to execute the following measures in order to achieve sustainable watershed sediment management in the Serayu River basin.

- The riverbed of the Serayu River at the bridge, located about 60 km downstream of the Mrica dam, has been degraded by around 5 m as shown in Figure 4.2.1-6. The degradation has been caused by the sediment trapping at the Mrica Dam. To achieve sustainable watershed sediment management in the Serayu river basin, comprehensive sediment balance study and management plan shall be conducted taking into consideration of environmental, social aspect, technical, and economical aspects.
- To perform effective sediment control and to maintain the sustainable watershed sediment management, a special organization of the Serayu watershed management, which consists of GoI, the local government, IP, and stakeholders along the river basin, shall be established.
- To execute the sustainable watershed sediment management and to obtain stakeholder's consent, the sediment management should aim to achieve comprehensive benefit over the watershed.



Figure 4.2.1-6 Degradation of the Riverbed at Downstream of Mrica Dam

(Prepared by JICA Study Team based on pictures provided by IP)

4.2.2 Sustainable Watershed Sediment Management

(1) Strategy for Watershed Sediment Management

Based on the considerations as described in Sub-clause 4.2.1, the sedimentation problems of the Mrica Reservoir shall be solved in terms of the sediment management over the Serayu River basin. This section describes the strategy of the sustainable watershed sediment management over the Serayu River basin.

The objectives of watershed sediment management over the Serayu River basin are: 1) to restore normal function of the watershed by means of balancing the sediment flow between upstream and downstream of the reservoir, 2) to achieve sustainable water utilization of reservoir by means of recovering and keeping storage capacity, and 3) to keep the safety of the dam by means of preventing intake plugging due to sediment.

As a commonly practiced in the world in recent years, the watershed sediment management is classified into three methods, namely: **1) to reduce sediment inflow to the reservoir, 2) to pass the sediment inflow directly to the downstream of the reservoir, and 3) to recover storage volume**. So as to achieve the above-described objectives, all the sediment management methods shall be required over the Serayu River basin.

The watershed sediment management shall be executed to **minimize the negative impact due to sediment discharge to the downstream watershed area and to maximize positive impact** through sediment balance over the watershed.

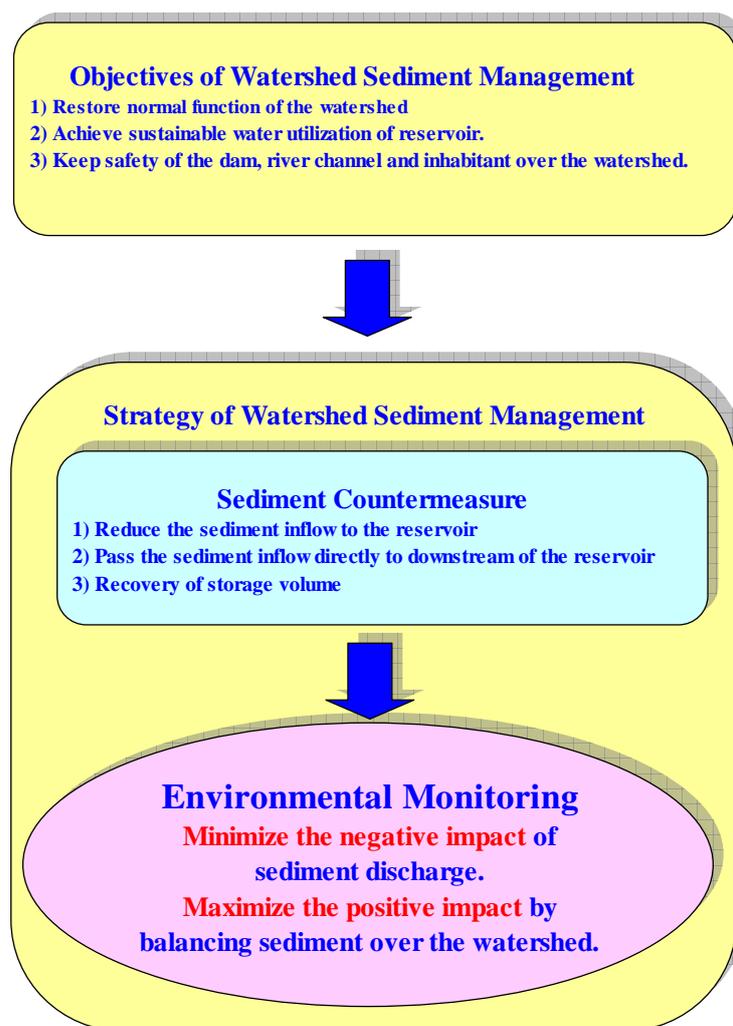


Figure 4.2.2-1 Strategy of Watershed Sediment Management of Serayu River Basin
(Prepared by JICA Study Team)

(2) Final Target of Watershed Sediment Management

Appropriate sediment management shall be performed for each area of the Serayu River basin and the countermeasures shall be managed to achieve overall benefit over the Serayu River basin.

Current sediment problems over the Serayu River basin are categorized into three areas, namely: 1) high sediment production in the upstream basin area, 2) large amount of trapped sediment in the Mrica reservoir area, and 3) serious riverbed degradation and serious coast retreat in the down stream basin area. Outline of the current status of sediment problems over the basin is shown in Figure 4.2.2-2.

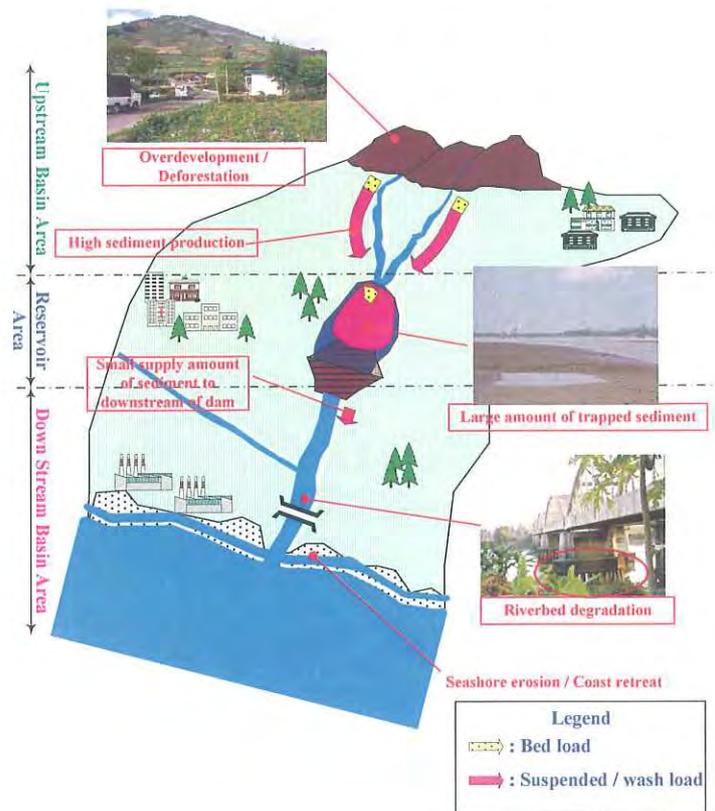


Figure 4.2.2-2 Current Status of Sediment Problems over the Serayu River Basin

(Prepared by JICA Study Team)

The problems over the Serayu River basin are similar to those of the Japanese example in many aspects but can be settled in accordance with the above explained strategy. Thus, the final target of the Serayu watershed sediment management plan will be established in accordance with the Japanese practice of the sediment management.

The actual countermeasures for each basin area are summarized below. The final target of the sustainable watershed sediment management plan over the Serayu River basin is as illustrated in Figure 4.2.2-3.

<u>Upstream Basin Area</u>	: Reduction of sediment inflow,
<u>Reservoir Area</u>	: Passing sediment directly to the downstream of reservoir, : Recovery of the storage volume, and
<u>Downstream Basin Area</u>	: Environmental monitoring of the sediment management.

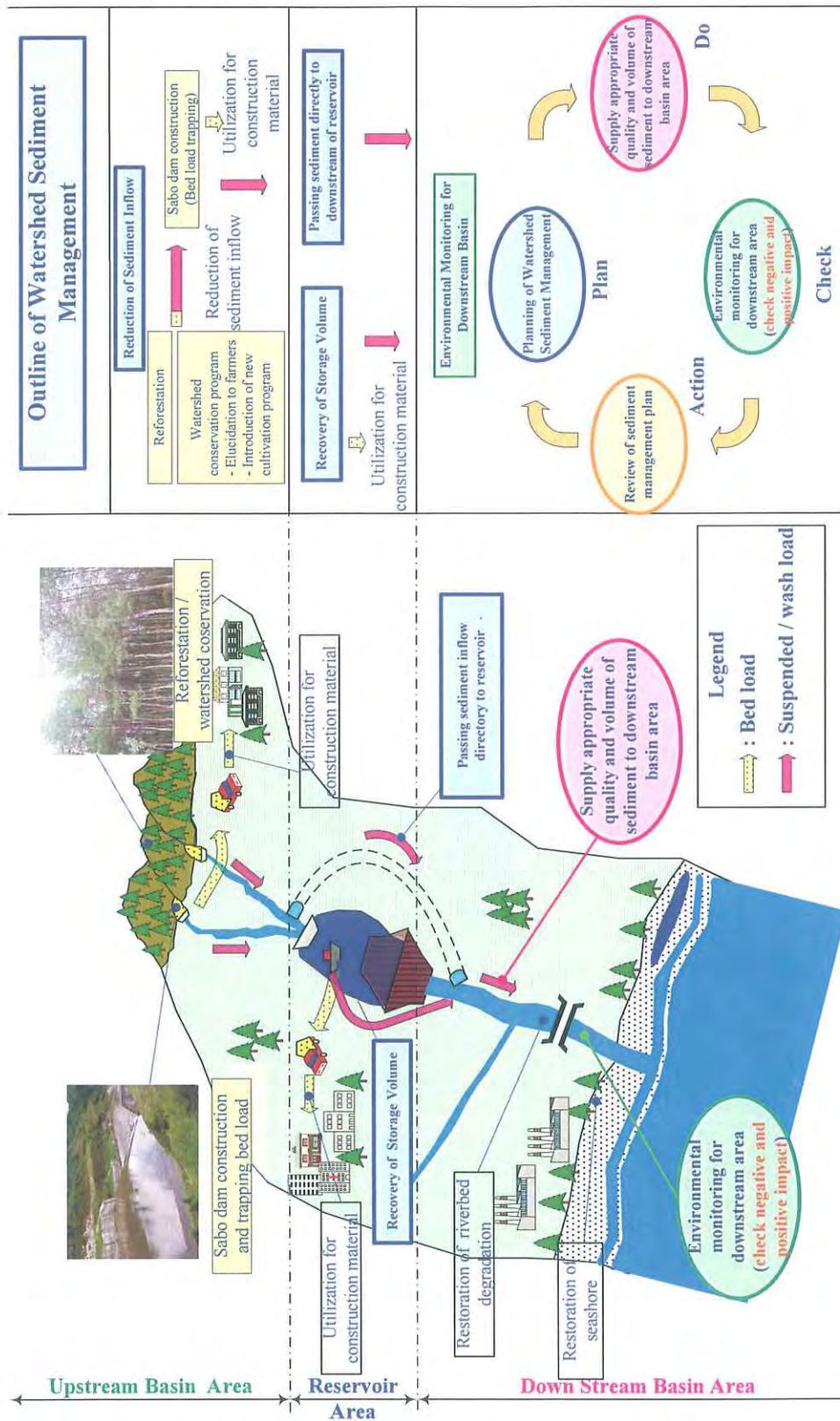


Figure 4.2.2-3 Final Target of Watershed Sediment Management in the Serayu River Basin
(Prepared by JICA Study Team based on pictures provided by IP)

(3) Implementation Policy of Watershed Sediment Management

Implementation policy (preliminary level) of the watershed sediment management has been established to achieve the final target of the management with the following considerations:

- Implementation policy shall be prepared considering the basin area and the target time frame,
- Current and on-going countermeasures shall be utilized as much as possible, and
- Target of each basin area and each time frame shall be clearly defined.

The implementation policy is proposed by the JICA Study Team based on the current and on-going countermeasures and as shown in Table 4.2.2-1. According to the policy, the sediment countermeasures in the reservoir area and the monitoring plan for the downstream basin area have not been studied yet by the local government and IP. Hence, the JICA Study Team will carry out the remaining studies preliminarily initially and finalize the implementation policy in Sub-clause 4.2.3.

Table 4.2.2-1 Implementation Policy of Watershed Sediment Management

Area		Target Period		
		Sort-term	Medium-term	Long-term
Upstream Basin Area	Target of sediment management	Prevention of increasing sediment production	Trapping of bed load material	Reduction of Sediment Product
	Conceivable Countermeasure	- Restriction of deforestation	- Sabo dam construction	- Reforestation - Introduction of watershed conservation program (Elucidation to farmers, introduction of new cultivation program)
	Current status	on-going	on-going	on-going
	Implementing agency at present	Local government and Indonesia Power		
Reservoir Area	Target of sediment management	Maintain intake function	Passing the sediment inflow directly to downstream of the reservoir	Recovery of effective storage volume
	Conceivable Countermeasure	- Improvement of reservoir operation rule - Sediment flushing operation	- to be determined	- to be determined
	Current status	on-going	Not yet studied	Not yet studied
	Implementing agency at present	Indonesia Power		
Downstream Basin Area	Target of sediment management	Protection against riverbed degradation and coastal encroachment	Improve sediment balance	Minimize negative impact and maximize positive impact
	Conceivable Countermeasure / Monitoring	- Riverbed protection, - Bridge replacement - Coastal protection	- Monitoring quality and volume of sediment	- PDCA management for the watershed sediment management
	Current status	on-going	Not yet studied	Not yet studied
	Implementing agency at present	Ministry of Public Works		

(Prepared by JICA Study Team)

4.2.3 Supplementary Study on Sediment Countermeasures

This section describes the additional sediment countermeasures to reinforce the watershed sediment management over the Serayu River basin.

(1) Countermeasure for Passing Sediment Inflow Directly to the Downstream of the Reservoir (Sediment Routing)

The countermeasure aims to achieve natural sediment balance over the Serayu River basin by means of passing the sediment inflow directly to the downstream of the Mrica reservoir. Basic concept of the countermeasure is listed below.

- In principle, sediment inflow shall not be trapped in the reservoir as much as possible,
- Bed load (over 1.0 mm) cannot pass through the reservoir. The material shall be trapped by the sabo dams constructed in the upstream basin area,
- Only suspended load (0.1 to 1.0 mm) and wash load (below 0.1 mm) material can pass directly to the downstream of the reservoir,
- Reservoir water level shall not be lowered below the low water level of EL224.50 m in order to maintain irrigation water supply throughout the year.

There are two conceivable countermeasures for the sediment routing operation as shown in the Table 4.2.3-1. The sediment sluicing operation requires the reservoir to draw down below the low water level. This is not acceptable because the Mrica Reservoir is supposed to maintain the irrigation water supply. On the other hand, sediment inflow can be diverted by the bypass tunnel regardless the reservoir water level.

The sediment bypass tunnel is only one countermeasure to meet the above requirements. Hence, the bypass tunnel has been selected for the sediment routing countermeasure.

Table 4.2.3-1 Comparison of Sediment Routing Countermeasure

	Sediment Bypass Tunnel	Sediment Sluicing Gate *1)
Figure		
Outline	- The sediment inflow is diverted directly to the downstream by the sediment bypass tunnel.	- The sediment inflow is sluiced out by the sluice gate of the main dam.
Merit	- Sediment bypass operation can be executed regardless of the reservoir water level. - Spill out volume for the sediment flushing is smaller than for the sluicing operation.	- Existing facility of the draw down culvert can be utilized as the sluice gate.
Demerit	- Expensive construction cost is required. - Natural and social environmental impact due to the weir and tunnel construction works shall be mitigated.	- Reservoir water level shall be reduced. - Large amount of reservoir water spill out will be required. - Dredging works is required so as to execute the sluicing operation due to large amount of trapped sediment.
Application to the Site	- Sediment flushing operation can be executed regardless of the reservoir water level. Applicable	- Due to irrigation water supply, reservoir water level cannot be drawn down below the LWL. Not Applicable

Note *1) Sediment sluicing and sediment flushing requires physically same facility. Sediment sluicing operation is passing the sediment inflow directly to the downstream. Sediment flushing is discharging the trapped sediment from the reservoir.

(Prepared by JICA Study Team)

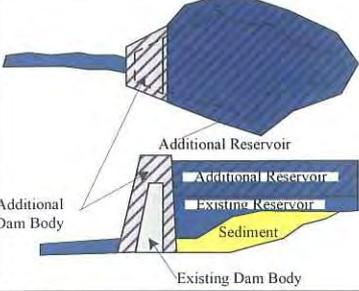
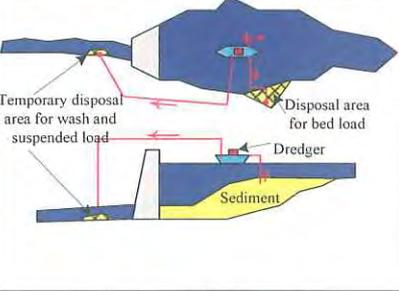
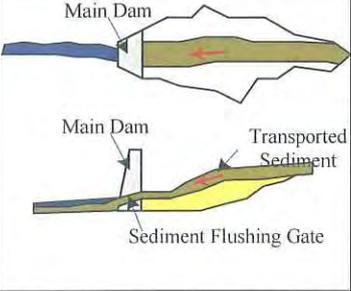
(2) Countermeasure for Recovery of Effective Storage Volume

The countermeasure aims to recover storage function of the reservoir and ensure dam safety. There are three conceivable countermeasures as shown in Table 4.2.3-2. The dredging work has been selected as countermeasure due to following reasons:

- Only dredging work can recover the storage volume while keeping the reservoir water level above the LWL of EL.224.50 m,
- Environmental impact to the downstream area due to dredging work can be minimized by means of controlling the quality and volume of the sediment,
- The dam crest raising measure causes large environmental impact and,
- The sediment flushing measure can recover limited storage volume.

In addition to the dredging work, the existing drawdown culvert has still an important function to flush the sediment around the power intake.

Table 4.2.3-2 Comparison on Methods of Recovering of Effective Storage Volume

	Increase Storage Volume		Removal of Sediment	
	Dam Crest Raising	Dredging (including Gravity Suction Method)	Sediment Flushing	
Figure				
Outline	-Increasing reservoir volume by raising dam crest level.	-Recovering effective volume by sediment dredging or suction utilizing reservoir water pressure.	- Recovering effective volume by sediment flushing.	
Application for Dam in Japan	-Okawa Dam, Shirakawa Dam, Sannowkai Dam	-Miwa Dam, - Koshibu Dam, -Sakuma Dam, -Akiba Dam, -Nagashima Dam.	-Dashi Daira Dam, Unazuki Dam	
Technical Merit	-Disposal of trapped sediment can be minimized.	-Dredging can be executed regardless of the reservoir water level. -Volume of dredging can be controlled depending on monitoring results.	-Existing facility of the draw down culvert can be utilized as the flushing gate.	
Technical Demerit	-Wide area of land acquisition is required. -Water supply for irrigation and power generation shall be interrupted during the construction. -Existing power house, spillway and intake cannot be re-utilized due to limitation of layout space. -Huge construction cost.	-High operation and maintenance cost. -It takes long time to recover the effective storage volume.	-Reservoir water level shall be reduced below the LWL. -Dredging works are required to execute the flushing operation due to the large amount of trapped sediment.	
Environmental Impact	-Resettlement due to newly created reservoir area. -Impact of land utilization and natural environment on reservoir area. -Demolishing the structure will cause large amount of disposal. Large Impact	-Occurrence of muddy water in the reservoir. -Impact of natural environment and water utilization along the downstream river due to sediment discharge. -Impact of land utilization of disposal area. Medium Impact	- Impact of natural environment and water utilization along the downstream river due to flushing operation. -Flushing high density and large amount of muddy water during flushing operation. Medium Impact	
Evaluation	Huge scale construction work and large environmental impact are expected. Not Applicable	Negative impact can be minimized by controlling the sediment discharge volume. Only the countermeasure can be executed regardless of the reservoir water level Applicable	Sediment flushing can be allowed only for keeping the intake function. Not Applicable	

(Prepared by JICA Study Team)

(3) Disposal Method for Dredging Work

There are three conceivable disposal methods as shown in Table 4.2.3-3. Each method has some merits and demerits. However, it is not ideal to select only one method for the sediment disposal. Therefore, integration of the methods has been proposed for the dredging work with the following considerations:

- Bed load material shall be disposed to the disposal area,
- The bed load material shall be utilized as construction material as much as possible,
- Only the suspended load and the wash load materials shall be discharged to the downstream of the reservoir, and
- Quality and quantity of the discharged sediment materials shall be controlled based on the monitoring results in the downstream river basin.

Table 4.2.3-3 Disposal Method for Dredging Work

	Disposal Area	Discharge to Downstream of Reservoir	
		Temporary Placing + Wash out	Dredging + Sediment Flushing
Outline	Transport the dredged sediment material to the disposal area. Bed load will be utilized as construction material.	Place the dredged sediment at the downstream of the reservoir and wash out by the power generation discharge, or spill out discharge.	Move the trapped sediment close to the flushing gate by the dredger and flush out the sediment.
Application for Dam in Japan	Sakuma Dam, Miwa Dam, Koshib Dam	Nagashima Dam, Akiba Dam	Sakuma Dam (sediment movement only), Akiba Dam (sediment movement only)
Applicable Material	Bed load, suspended load and wash load	Suspended load and wash load	Suspended load and wash load
Merit	-Bed load material can be disposed.	-Large amount of sediment can be disposed.	-Transportation cost is not required.
Demerit	-Only small quantity can be disposed due to limitation of available disposal area.	-Bed load material cannot be washed out to minimize environmental impact. -Quality of the sediment shall be controlled.	-Bed load material cannot be washed out to minimize environmental impact. -Large amount of spill out water will be required. -Quality of the sediment shall be controlled.
Environmental Impact	-Impact on land utilization and natural environment of disposal area. -Social impact caused by noise, vibration, exhaust fume, and dust due to the truck transport.	-Impact on natural environment and water utilization along the downstream river due to sediment discharge. -Impact on underwater environment due to river bed fluctuation.	-Impact on natural environment and water utilization along the downstream river due to sediment discharge. -Impact on underwater environment due to river bed fluctuation.
Cost	High	Medium	Low (Disposal cost only)
Evaluation	Applicable for small quantity	Applicable for suspended load and wash load. However, quality and quantity shall be controlled.	

(Prepared by JICA Study Team)

(4) Monitoring Plan for Downstream River Basin Area

In order to achieve the sustainable sediment management in the Serayu River basin, environmental monitoring shall be carried out to meet the target in each time frame. The medium-term and long-term targets of the environmental monitoring plan have been proposed based on the implementation policy of the watershed sediment management plan as shown in Table 4.2.2-1.

Medium-term target: Achieve sediment balance in the Serayu River basin

Long-term target: Minimize negative impact and maximize positive impact

Conceivable monitoring measures in the downstream river basin are as follows:

- Impact on water utilization such as irrigation water supply and domestic water supply,
- Impact on aquatic organism (mainly fish), aquatic plant,
- Impact on riverbed and seashore topography and landscape, and
- Impact on river and coastal structural due to topographic change.

Based on the above monitoring, quality and volume of the sediment discharge from the reservoir shall be controlled appropriately.

Finally, the monitoring system should be carried out by Plan, Do, Check and Action (PDCA) quantity control system. The environmental management system to achieve the long-term target is illustrated below:

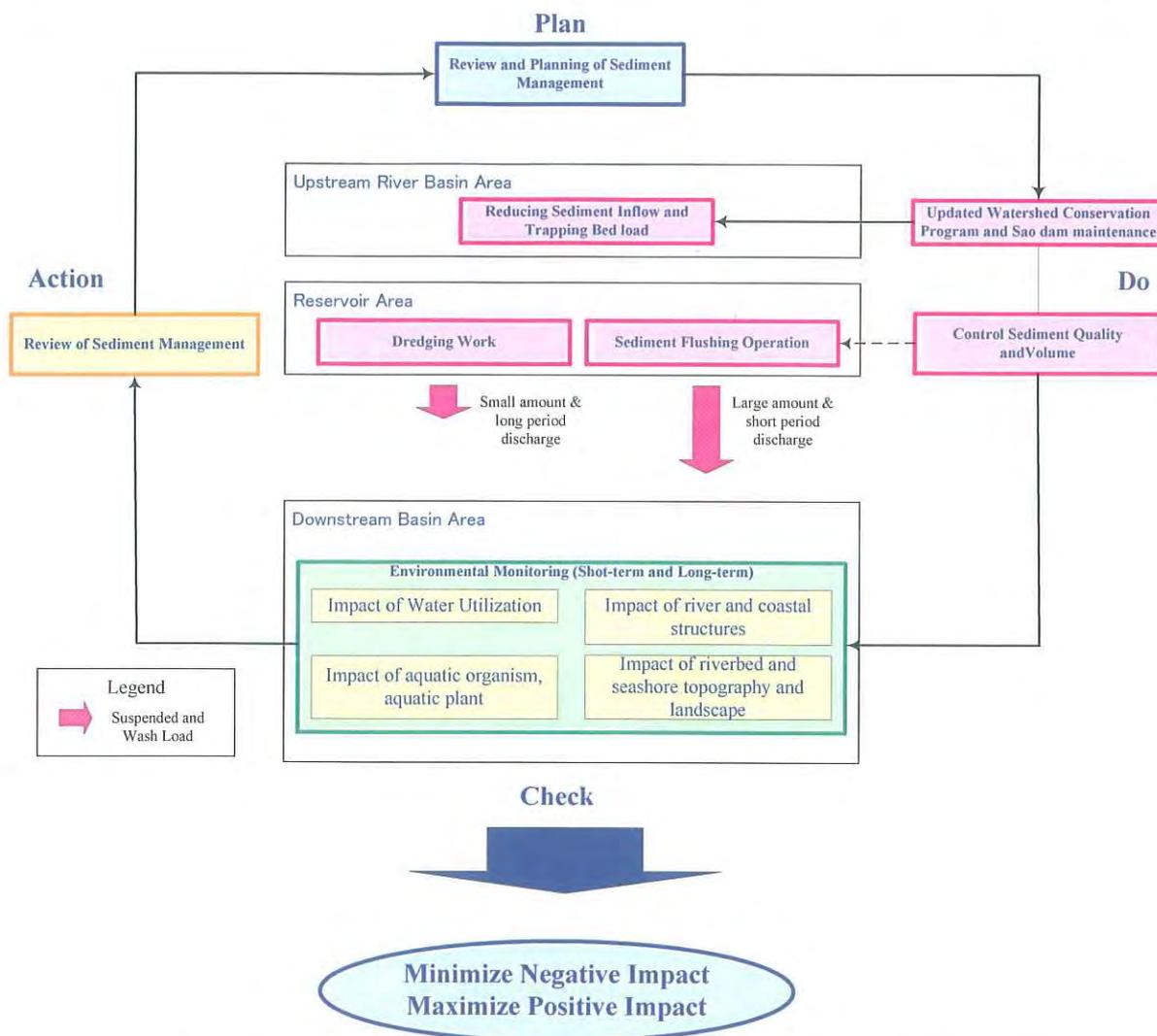


Figure 4.2.3-1 Environmental Management System for Watershed Sediment Management (Prepared by JICA Study Team)

4.2.4 Conclusion

In order to settle the serious sediment problems in the Serayu River basin as well as the Mrica Reservoir, the local government and IP have carried out several examination and countermeasures so far. However, as explained through this chapter, there is no progress in getting the expected results to address the sediment problems. Taking into account of such current situation, while, referring to the actual examples of the sediment countermeasures in Japan, the study has examined the sediment countermeasures in whole of the Serayu River basin, including sedimentation countermeasure in the Mrica Reservoir, from the sustainable sediment management point of view. The conclusion is discussed below.

(1) Technical Aspect

1) Establishment of Target of Sediment Management by River Basin Area and Time Frame

The fundamental approach of the river basin sediment management is to separate the river

basin into the upstream river basin area, reservoir area and downstream river basin area by fixing boundaries; establish the target of the sediment management; and to definite the required countermeasures and monitoring plan for each river basin area.

Since the manifestations of the expected effectiveness and implementation progress depends on the type of the sediment countermeasure, the target of the sediment management in terms of time frame, such as short-term, medium-term and long-term, shall also be established in target set for each river basin area.

2) Improvement of Sediment Balance

The sediment countermeasures carried out by the local government and IP have been analyzed and compared with the watershed sediment management in Japan. In order to execute the sustainable sediment management, the sediment countermeasure that has been carried out so far should be continued and reinforced. Moreover, the sediment imbalance, which has been caused by the large amount of trapped sediment in the Mrica reservoir, shall be improved.

In order to improve the above sediment imbalance, the sediment diversion weir and the bypass tunnel for the sediment bypass are recommended. However, adjustment of the quality and volume of the sediment to be supplied to the downstream is required. This shall be examined based on the detailed investigation results to be executed in a further study.

3) Recovery of the Reservoir Storage Volume

The effective reservoir storage volume which will be totally reduced in the near future shall be recovered to secure not only the water utilization and flood control functions of the reservoir but also the dam safety by plugging the power intake.

As a result of the examination, the dredging in the reservoir shall be effective for the recovery of the reservoir storage volume. However, as to the dredging volume and the disposal method of the dredged material, the appropriate scale and method shall be examined based on the detailed investigation in a further study.

4) Execution of Environmental Monitoring in the Downstream Area and the Realization of the Sustainable Watershed Sediment Management

In order to execute the sustainable watershed sediment management, environmental monitoring in the downstream area is absolutely imperative. Following the improvement of the watershed sediment balance, main items to be monitored are as follows:

- Impact on the water utilization in the downstream,
- Impact on the aquatic life (in particular, fishes) and aquatic plant,
- Impact on topography of the river such as the river bed fluctuation and the coastal retreat, and
- Impact on the structures of the river.

It is important that the watershed sediment balance management and the required

countermeasures shall be timely improved considering the above influence. Finally, the sustainable river basin sediment management shall require the PDCA cycle.

5) Future Vision of the Watershed Sediment Management

Based on the examination results in Section 4.2, the future vision of the sustainable sediment management in the Serayu River basin (i.e., long-term target) is summarized below.

Table 4.2.4-1 Future Vision of River Basin Sediment Management

Area	Target of the Sediment Management	Countermeasures to be Implemented / Operation and Maintenance
Up-stream Basin Area	-Trapping of bed load -Reduction of sediment inflow	-Sabo dams construction and the maintenance -Revival of forest -River basin conservation countermeasure
Reservoir Area	-Passing the sediment inflow -Recovery of the reservoir storage volume	-Construction of sediment bypass tunnel and appropriate operation and maintenance -Execution of dredging in the reservoir and appropriate disposal of the dredged material
Downstream Basin Area	-Improvement of sediment balance -Minimizing the negative impact in the downstream area and maximizing the positive impact on whole benefit of the watershed.	Execution of the environmental monitoring Execution of the sustainable sediment monitoring through the PDCA cycle

(Prepared by JICA Study Team)

6) Comprehensive Master Plan for the Watershed Sediment Management and Urgent Countermeasure

In order to solve the serious sedimentation problems in the Mrica reservoir and to execute the sustainable sediment management, the comprehensive master plan for the watershed sediment management shall be prepared first. Further, the road map for the appropriate sediment balance planning including the downstream area of the reservoir, and the sedimentation countermeasures / O&M planning shall be prepared.

Based on the master plan, the survey/investigation, design and implementation for the urgent sediment countermeasures in the Serayu River basin shall be executed in order to solve the serious sediment problems.

In this preliminary study, based on the limited information, study period and the bold assumptions, the urgent sedimentation countermeasures in the reservoir area are examined for reference. The components are shown below and in Annex B.

- Sand bypass tunnel: Length=7,500 m, Width/Height= 5.8 m / 6.4 m
- Diversion weir: Type: Full face slicing gated type.
- Dredging work to be conducted by cutter suction type dredger: 1,300 PS, 3 nos.

The above countermeasure is prepared only for considering the sediment balance in the upstream basin of the Serayu River and Mrica reservoir area as well as the economic benefit of the irrigation water supply and power generation at the Mrica reservoir. This countermeasure

however can be considered only for reference. Optimization study of the countermeasure based on the detailed survey and study results through the proposed master plan shall be performed.

(2) Organization of Implementation and O&M for River Basin Sediment Management

In order to execute a sustainable sediment management in the Serayu River basin, the watershed sediment management shall be planned and executed aiming not only to maximize of the irrigation and power generation benefits but also to maximize the whole benefit in the Serayu River basin. From this point of view, the organization of the implementation and the O&M for the watershed sediment management is recommended as follows:

1) Establishment of the Organization for the Watershed Sediment Management

Each organization has carried out the implementation and O&M of the sediment countermeasures in the Serayu River basin without cooperating with the other organization so far. However, to execute a sustainable sediment management effectively, proper coordination with other organizations is absolutely necessary. Moreover, the management plan and O&M plan aimed at maximizing the whole benefit in the river basin are essential. Therefore, it is recommended that the implementation organization for the watershed sediment management consisting of the local government, IP, Ministry of Public Works and users within the river basin shall be established in the Serayu River basin.

2) Participation of the Residents in Decision Making, Planning and O&M

The participation of the residents in the Serayu River basin in the decision making, river basin conservation countermeasures and in the planning and operation of the sediment management is recommended from the sustainable watershed sediment management point of view. Following the above establishment of the organization for the river basin sediment management, the watershed sediment management method with the participation of the residents in the Serayu River basin shall be executed.

3) Initiation of Watershed Sediment Management with Financial Support

IP and the local government have performed appropriate countermeasure for sediment control in the Serayu River basin. However, due to their limited competence and funding, the scale of the countermeasures is too small to get effective results on the sediment issues.

Therefore, it is strongly recommended that the watershed sediment management measure in the Serayu River basin as well as countermeasure for the Mrica reservoir should be initiated as a practical solution with definite financial support.

Chapter 5
Economic and Financial Analysis

CHAPTER 5 ECONOMIC AND FINANCIAL ANALYSIS

5.1 Economic and Financial Analysis of the Rehabilitation Work for Sutami

5.1.1 Economic Analysis

(1) Methodology

In conducting economic analysis of the rehabilitation work for Sutami Hydropower Station, the economic effect brought by the project is evaluated from the viewpoint of national economy. Here, the economic value of cost and benefit expressed by a discounted cash flow are compared. The economic internal rate of return (EIRR), net present value (NPV) and benefit cost ratio (B/C) are employed as key indicators in the evaluation. NPV can be expressed by the following formula:

$$NPV = \sum_{n=0}^n \left\{ \frac{B_n}{(1+r)^n} \right\} - \sum_{n=0}^n \left\{ \frac{C_n}{(1+r)^n} \right\}$$

Here, n = number of year in the future, B_n = benefit in n year, C_n = cost in n year, r = discount rate, while IRR is the value of "r" with which the value of NPV becomes 0, as denoted below.

(2) Basic Assumption

With reference to other examples in the Indonesian power sector, the analysis is conducted with the following basic assumptions:

1) Opportunity Cost of Capital (Social Discount Rate)

The opportunity cost of capital adopted as the reference value for EIRR in most cases is between 10% and 12%. Here, it is assumed to be 10% as it is commonly applied in power sector projects in Indonesia..

2) Standard Conversion Factor (SCF)

In the economic analysis, the local currency portion of the construction and indirect costs, which are calculated based on local market prices, need to be converted into economic price using an appropriate SCF. In this study, the SCF is assumed to be 0.9 with reference to other relevant examples.

3) Period Subject to Evaluation

The period subject to evaluation is 45 years including 40 years of expected lifetime (economic life) and 5 years of construction period.

4) Starting Point of the Project

The starting point of the project is the year 2011.

5) Price Escalation

Inflation rate is excluded from the calculation, and the constant price of 2010 is adopted.

6) Handling of Tax

All taxes including VAT and customs duty tariff are considered as transfer account to be excluded.

7) Handling of Interest on Loan

As this analysis is conducted mainly for the purpose of calculating the IRR on gross capital, interest on loan is also excluded.

8) Exchange Rate

The following exchange rates are adopted as of April 30, 2010:

1 US\$ = 94.07 Yen, 1 Rp. = 0.01143 Yen

(3) Economic Cost

The economic cost of the rehabilitation work is based on the result of the quality survey in the previous chapter. The cost consists of construction cost, indirect cost and annual O&M cost. To calculate the economic cost, in addition to the exclusion of transfer account like tax and subsidy, the local currency portion of the cost is adjusted using the aforementioned value of SCF.

1) Capital Cost (Initial Investment Cost)

Major items of capital cost adjusted to economic price are indicated in the following table:

Table 5.1.1-1 Capital Cost (Economic Price) (Unit: million Rp.)

Category	Total	1st year	2nd year	3rd year	4th year	5th year	6th year	
		(2011)	(2012)	(2013)	(2014)	(2015)	(2016)	
1. Construction Cost								
Hydromechanical Equipment	FC	241	-	-	-	80	80	80
	LC	79	-	-	-	26	26	26
Generating Equipment	FC	222,835	-	-	-	74,278	74,278	74,278
	LC	19,677	-	-	-	6,559	6,559	6,559
Transmission and Substation	FC	4,637	-	-	-	1,546	1,546	1,546
	LC	417	-	-	-	139	139	139
Sub-total 1	FC	227,712				75,904	75,904	75,904
	LC	20,173				6,724	6,724	6,724
2. Indirect Cost								
Engineering services	FC	18,217	3,036	3,036	3,036	3,036	3,036	3,036
	LC	1,614	269	269	269	269	269	269
Physical contingencies	FC	36,889	-	-	-	12,296	12,296	12,296
	LC	3,268	-	-	-	1,089	1,089	1,089
Sub-total 2	FC	55,106	3,036	3,036	3,036	15,333	15,333	15,333
	LC	4,882	269	269	269	1,358	1,358	1,358
Total	FC	282,819	3,036	3,036	3,036	91,237	91,237	91,237
	LC	25,055	269	269	269	8,083	8,083	8,083
Grand Total	FC+LC	307,873	3,305	3,305	3,305	99,319	99,319	99,319

(Prepared by JICA Study Team)

2) O&M Cost

Annual O&M cost is expected to come up during the start of operation of equipment installed for this project. However, it should be noted that in the case of a rehabilitation project, the O&M cost refers only to the net increase of cost under the ‘With Project’ case as compared to the ‘Without Project’ case. With regard to the Sutami Project, two possible cases are assumed. It is also worth pointing out that the negative values of the O&M cost can be understood as the benefit resulting from the savings in O&M cost with the implementation of the project.

i) Case 1

O&M cost in the ‘With Project’ case is expected to decline by 20% starting from 2017 following the completion of the construction work. On the other hand, O&M cost in the ‘Without Project’ scenario is supposed to remain at the same level until 2020, when the operation of the aging machines will come to a total stop and the O&M cost will become 0.

ii) Case 2

O&M cost in the ‘With Project’ case is expected to be the same as in Case 1 but in the ‘Without Project’ case, it is supposed to return to the same level in 2019 when the rusty machines have been repaired one way or another.

Table 5.1.1-2 Net Increase of O&M Cost over the Project Period (Case 1) (Unit: million Rp)

Year	Without Project				With Project				Net Increase of O&M Cost
	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	
2011	136	136	136	409	136	136	136	409	0
.....	136	136	136	409	136	136	136	409	0
2016	136	136	136	409	136	136	136	409	0
2017	136	136	136	409	109	109	109	327	-82
2018	136	136	136	409	109	109	109	327	-82
2019	136	136	136	409	109	109	109	327	-82
2020~	0	0	0	0	109	109	109	327	327

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of Annual O&M cost for one turbine in Sutami power station in the past 6 years.

Table 5.1.1-3 Net Increase of O&M Cost over the Project Period (Case 2) (Unit: million Rp)

Year	Without Project				With Project				Net Increase of O&M Cost
	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	
2011	136	136	136	409	136	136	136	409	0
.....	136	136	136	409	136	136	136	409	0
2016	136	136	136	409	136	136	136	409	0
2017	136	136	136	409	109	109	109	327	-82
2018	136	136	136	409	109	109	109	327	-82
2019	136	136	136	409	109	109	109	327	-82
2020	0	0	0	0	109	109	109	327	327
2021	0	0	0	0	109	109	109	327	327
2022	136	0	0	136	109	109	109	327	191
2023	136	136	0	273	109	109	109	327	55
2024~	136	136	136	409	109	109	109	327	-82

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of Annual O&M cost for one turbine in Sutami Power Station in the past 6 years.

(4) Economic Benefit

The benefit of this project is estimated by calculating the net increase of benefit resulting from the difference between the 'With Project' and 'Without Project' cases. In the economic analysis, the economic benefit is reflected by the value of capacity benefit (kW value) and energy benefit (kWh value), which can be derived from the kW value and kWh value when introducing alternative power supply in the case of the 'Without Project' scenario. Moreover, the saving in O&M cost and the value of CO₂ emission reduction are also considered as benefits of this project.

1) Annual Power Benefit

The capacity benefit expressed by the difference of power capacity between 'With Project' and 'Without Project' cases could be understood as the annual average kW value of construction cost and constant cost of a new gas turbine plant, as the existing hydropower station is intended mainly for peak load. As for the energy benefit, it could be calculated using the kWh value of gas turbine plant (for peak load) and coal steam plant (for base load) and the difference of energy produced between 'With Project' and 'Without Project' cases.

i) Unit Value of Capacity (kW Value) and Unit Value of Energy (kWh Value)

The unit values of capacity and energy for alternative power supply in the case of the 'Without Project' case are shown in the table below. As far as Sutami Project (as well as Wlingi Project to be dealt with later) is concerned, the unit value of capacity in the case of high seed diesel gas turbine plant should be relevant. With regard to the unit value of energy, data of both the high speed diesel gas turbine plant and the coal steam turbine plant are utilized.

Table 5.1.1-4 Unit Values of Capacity and Energy for Alternative Power Plants

Name of Data	Type of Power Plant	Rate in US\$	Rate in Rp
Unit value of capacity	High speed diesel gas turbine	63.49 US\$/kW/year	522,523 Rp/kW/year
	Coal steam Turbine	216.95 US\$/kW/year	1,785,499 Rp/kW/year
Unit value of energy	High speed diesel gas turbine	0.106 US\$/kWh	872 Rp/kWh
	Coal steam Turbine	0.02028 US\$/kWh	167 Rp/kWh

(Source: Prepared by JICA Study Team based on PLN Rencana Usaha Penyediaan Tenaga Listrik 2006 - 2015)

ii) Calculation of Annual Power Benefit

By using the abovementioned kW value and kWh value, the annual power benefit including capacity benefit and energy benefit are derived as shown in the following two tables, which respectively reflect two cases that are different only in the 'Without Project' case.

Table 5.1.1-5 Annual Energy and Capacity Benefit (Case 1)

Item	Unit	Without Project		With Project		Net
		Primary Energy	Secondary Energy	Primary Energy	Secondary Energy	
Annual Energy						
2014	GWh	202	225	159	251	-17
2015	GWh	202	225	162	255	-10
2016	GWh	202	225	164	259	-4
2017	GWh	159	255	208	232	26
2018	GWh	159	255	208	232	26
2019	GWh	159	255	208	232	26
2020~	GWh	0	0	208	232	440
Dependable Capacity						
2014	MW	71.2		67.9		-3.3
2015	MW	71.1		68.9		-2.2
2016	MW	71.0		69.9		-1.1
2017	MW	67.9		72.9		5
2018	MW	67.9		72.9		5
2019	MW	67.9		72.9		5
2020~	MW	0		72.9		72.9
Energy Benefit: kWh Value						
2014	Rp million	192,320		162,465		-29,855
2015	Rp million	192,320		165,420		-26,900
2016	Rp million	192,320		167,590		-24,730
2017	Rp million	163,065		198,080		35,015
2018	Rp million	163,065		198,080		35,015
2019	Rp million	163,065		198,080		35,015
2020~	Rp million	0-		198,080		198,080
Capacity Benefit: kW Value						
2014	Rp million	33,483		31,931		-1,552
2015	Rp million	33,436		32,402		-1,035
2016	Rp million	33,389		32,872		-517
2017	Rp million	31,931		34,283		2,351
2018	Rp million	31,931		34,283		2,351
2019	Rp million	31,931		34,283		2,351
2020~	Rp million	0		34,283		34,283
Total Annual Benefit						
2014	Rp million	225,803		194,396		-31,407
2015	Rp million	225,756		197,822		-27,935
2016	Rp million	225,709		200,462		-25,247
2017	Rp million	194,996		232,363		37,366
2018	Rp million	194,996		232,363		37,366
2019	Rp million	194,996		232,363		37,366
2020~	Rp million	0-		232,363		232,363

(Prepared by JICA Study Team)

Table 5.1.1-6 Annual Energy and Capacity Benefit (Case 2)

Item	Unit	Without Project		With Project		Net
		Primary Energy	Secondary Energy	Primary Energy	Secondary Energy	
Annual Energy						
2014	GWh	202	225	159	251	-17
2015	GWh	202	225	162	255	-10
2016	GWh	202	225	164	259	-4
2017	GWh	159	255	208	232	26
2018	GWh	159	255	208	232	26
2020	GWh	0	0	208	232	440
2022	GWh	84	223	208	232	133
2025~	GWh	208	232	208	232	0
Dependable Capacity						
2014	MW		71.2		67.9	-3.3
2015	MW		71.1		68.9	-2.2
2016	MW		71.0		69.9	-1.1
2017	MW		67.9		72.9	5
2018	MW		67.9		72.9	5
2020	MW		0		72.9	72.9
2022	MW		37.2		72.9	35.7
2025~	MW		72.9		72.9	0
Energy Benefit: kWh Value						
2014	Rp million		192,320		162,465	- 29,855
2015	Rp million		192,320		165,420	- 26,900
2016	Rp million		192,320		167,590	- 24,730
2017	Rp million		163,065		198,080	35,015
2018	Rp million		163,065		198,080	35,015
2020	Rp million		0		198,080	198,080
2022	Rp million		99,390		198,080	98,690
2025~	Rp million		198,080		198,080	0
Capacity Benefit: kW Value						
2014	Rp million		33,483		31,931	- 1,552
2015	Rp million		33,436		32,402	- 1,035
2016	Rp million		33,389		32,872	- 517
2017	Rp million		31,931		34,283	2,351
2018	Rp million		31,931		34,283	2,351
2020	Rp million		0		34,283	34,283
2022	Rp million		17,494		34,283	16,789
2025~	Rp million		34,283		34,283	0
Total Annual Benefit						
2014	Rp million		225,803		194,396	- 31,407
2015	Rp million		225,756		197,822	- 27,935
2016	Rp million		225,709		200,462	- 25,247
2017	Rp million		194,996		232,363	37,366
2018	Rp million		194,996		232,363	37,366
2020	Rp million		0		232,363	232,363
2022	Rp million		116,884		232,363	115,479
2025~	Rp million		232,363		232,363	0

(Prepared by JICA Study Team)

Both Case 1 and Case 2 are assumed to have the same schedule for the installation and operation of new plants and old plants in the case of the ‘With Project’ scenario, as shown in the following table.

Table 5.1.1-7 Schedule for Installation and Operation of New Plants and Old Plants

Year	New Plant		Old Plant	
	Installation	Operation	Installation	Operation
2014	1			2
2015	1	1		1
2016	1	2		
2017		3		

(Prepared by JICA Study Team)

As for the ‘Without Project’ case, power capacity and energy are assumed to fall around 30% in 2007 and to 0 after 2020 in Case 1. Meanwhile, Case 2 expects that the capacity and energy will recover up to 30% in 2022, and then return to the former level from 2025 onwards.

2) Reduction of O&M Cost

As denoted in Table 5.1.1-2 and 5.1.1-3, the negative values of net O&M cost suggest the positive effect of this project, and should be counted as benefit items.

3) Reduction of CO₂ Emission

The benefit of CO₂ emission reduction is assumed to be the net increase of energy achieved by the project converted into money value. The CO₂ conversion factor and emissions trading rate indicated below are adopted for the calculation. The CO₂ emissions trading rate in EU market as of May 26, 2010 is Euro 15.2 /t-CO₂.

Table 5.1.1-8 CO₂ Conversion Factor and Emissions Trading Rate

CO ₂ Conversion Factor	CO ₂ Emissions Trading Rate	¥/Euro	Rp/¥
0.644 t-CO ₂ /MWh	15.2 Euro/t-CO ₂	114	87

(Source: 1. CO₂ Conversion Factor :

2. CO₂ Emissions Trading Rate: Website Point Carbon (www.pointcarbon.com/news/1.1447431))

(5) Calculation of EIRR

The values of EIRR in both Case 1 and Case 2 are calculated by first disregarding the benefit of CO₂ reduction as seen in Case 1 (1) and Case 2 (1) and then considering this benefit as reflected in Case 1 (2) and Case 2 (2). Additionally, economic net present value (ENPV) and Benefit-Cost Ratio (B/C) worked out here as well as all the values of ENPV, FNPV (financial net present value) and B/C to be mentioned in the rest of this report are discounted at the rate of 10.0%. The respective cash flow tables are shown in the Appendix and the results are seen in Table 5.1.1-9.

Table 5.1.1-9 Major Results of Economic Analysis

Case		EIRR	ENPV	B/C
CO ₂ Reduction Benefit Excluded	1(1)	26%	Rp. 760,852 million	4.9
	2(1)	15%	Rp. 77,325 million	1.4
CO ₂ Reduction Benefit Included	1(2)	28%	Rp.938,928 million	5.8
	2(2)	18%	Rp121,776million	1.6

(Prepared by JICA Study Team)

The results show that whether the benefit of CO₂ reduction is considered or not, EIRR values of both Case 1 and Case 2 are expected to exceed the Indonesian social discount rate of 10%. The economic effect of Case 1 is better than Case 2 mainly because the net increase of power benefit (including energy benefit and capacity benefit) in Case 1 is much greater.

(6) Sensitivity Analysis

1) Assumptions for Analysis

Here, the sensitivity analysis is conducted with the purpose of verifying how the change of previous assumptions for the project will affect the results of the evaluation. The analysis is focused on Case 1(1) and Case 2(1) where the benefit of CO₂ reduction is not considered. Three scenarios are assumed as follows:

- Scenario 1: Construction cost rises by 10% and 20%. (Scenario 1a and 1b)
- Scenario 2: Fuel cost for alternative power supply decreases by 10% and 20%. (Scenario 2a and 2b)
- Scenario 3: Construction cost rises by 20% concurrently with the decline of fuel cost by 20% for alternative power supply.

2) Results of Analysis

The results of sensitivity analysis are indicated in the following two tables.

For case 1(1), with the change of previous assumptions for the project, the value of EIRR is expected to vary from 22% to 25%. However, the results of all the cases assumed here are well above the level of 10%, and even under the strictest conditions assumed in Scenario 3, the project is still economically feasible.

Table 5.1.1-10 Results of Sensitivity Analysis for Case 1(1)

Scenario	1a	1b	2a	2b	3
EIRR	25%	24%	25%	24%	22%
ENPV(million Rp)	745,413	729,9754	679,932	599,141	568,264
B/C	4.5	4.2	4.5	4.1	3.5

(Prepared by JICA Study Team)

Regarding Case 2(1), the value of EIRR is expected to vary between 10% and 14%. Even under the strictest conditions assumed in Scenario 3, the project is still economically feasible.

Table 5.1.1-11 Results of Sensitivity Analysis for Case 2(1)

Scenario	1a	1b	2a	2b	3
EIRR	14%	13%	14%	12%	10%
ENPV(million Rp)	61,886	46,447	54,460	31,712	666
B/C	1.3	1.2	1.3	1.2	1.0

(Prepared by JICA Study Team)

5.1.2 Financial Analysis

(1) Methodology

With regard to the financial analysis of the rehabilitation work for Sutami Hydropower Station, the point of evaluation is the financial profitability of the project. Here, the basic assumptions for analysis in terms of the period subject to evaluation, starting point of the project, price escalation, handling of tax and interest on loan are the same with those of the economic analysis.

(2) Financial Cost

The financial cost of the rehabilitation work consists of the initial capital investment already estimated in the previous chapter and O&M cost. The O&M cost is calculated based on the values denoted in the economic analysis dealt with in the previous section.

1) Capital Cost

Major items of the capital cost are denoted by the following table:

Table 5.1.2-1 Capital Cost (Unit: million Rp.)

Category	Total	1st year	2nd year	3rd year	4th year	5th year	6th year	
		(2011)	(2012)	(2013)	(2014)	(2015)	(2016)	
1. Construction Cost								
Hydromechanical Equipment	FC	241	-	-	-	80	80	80
	LC	87	-	-	-	29	29	29
Generating Equipment	FC	222,835	-	-	-	74,278	74,278	74,278
	LC	21,863	-	-	-	7,288	7,288	7,288
Transmission and Substation	FC	4,637	-	-	-	1,546	1,546	1,546
	LC	464	-	-	-	155	155	155
Sub-total 1	FC	227,712				75,904	75,904	75,904
	LC	22,414				7,471	7,471	7,471
2. Indirect Cost								
Engineering services	FC	18,217	3,036	3,036	3,036	3,036	3,036	3,036
	LC	1,793	299	299	299	299	299	299
Physical contingencies	FC	36,889	-	-	-	12,296	12,296	12,296
	LC	3,631	-	-	-	1,210	1,210	1,210
Sub-total 2	FC	55,106	3,036	3,036	3,036	15,333	15,333	15,333
	LC	5,424	299	299	299	1,509	1,509	1,509
Total	FC	282,819	3,036	3,036	3,036	91,237	91,237	91,237
	LC	27,838	299	299	299	8,981	8,981	8,981
Grand Total	FC+LC	310,657	3,335	3,335	3,335	100,217	100,217	100,217

(Prepared by JICA Study Team)

2) O&M Cost

The values of annual O&M cost are calculated in the same way as in the economic analysis. The only difference is that while the values of O&M cost need to be adjusted into the economic price using the SCF in the economic analysis, the financial analysis does not require such adjustment. Values of O&M cost in Case 1 and Case 2 are shown in the following two tables.

Table 5.1.2-2 Net Increase of O&M Cost over the Project Period (Case 1) (Unit: million Rp.)

Year	Without Project				With Project				Net Increase of O&M Cost
	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	
2011	151	151	151	454	151	151	151	454	0
.....	151	151	151	454	151	151	151	454	0
2016	151	151	151	454	151	151	151	454	0
2017	151	151	151	454	121	121	121	364	-91
2018	151	151	151	454	121	121	121	364	-91
2019	151	151	151	454	121	121	121	364	-91
2020~	0	0	0	0	121	121	121	364	364

(Prepared by JICA Study Team)

Note: The value of annual O&M cost for one turbine is estimated based on the average value of Annual O&M cost for one turbine in Sutami power station in the past 6 years.

Table 5.1.2-3 Net Increase of O&M Cost over the Project Period (Case 2) (Unit: million Rp.)

Year	Without Project				With Project				Net Increase of O&M Cost
	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	Turbine #1	Turbine #2	Turbine #3	Total O&M Cost	
2011	151	151	151	454	151	151	151	454	0
.....	151	151	151	454	151	151	151	454	0
2016	151	151	151	454	151	151	151	454	0
2017	151	151	151	454	121	121	121	364	-91
2018	151	151	151	454	121	121	121	364	-91
2019	151	151	151	454	121	121	121	364	-91
2020	0	0	0	0	121	121	121	364	364
2021	0	0	0	0	121	121	121	364	364
2022	151	0	0	151	121	121	121	364	212
2023	151	151	0	303	121	121	121	364	61
2024~	151	151	151	454	121	121	121	364	-91

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of Annual O&M cost for one turbine in Sutami power station in the past 6 years.

(3) Financial Benefit

With regard to the financial benefit, values of net increase of tariff revenue resulting from the net increase of energy produced and reduction of O&M cost are calculated.

1) Increase of Electric Tariff Revenue

The values of net increase in electric tariff revenue are derived from the net increase of energy with the project (With Project – Without Project) and the average electric tariff, which is worked out based on the present electric tariff of Rp 740/kWh (as of 2010) with annual escalation of 1.5% . Values of annual net increase of energy over the project period are presumed to be as follows (Case 1 and Case 2): (The reasons for the assumption of Case 1 and Case 2 are already explained in the section on economic analysis.)

Table 5.1.2-4 Annual Net Increase of Energy Produced (Unit: GWh)

year	Case 1			Case 2		
	Without P	With Pro.	Net Increase	Without Pro.	With Pro.	Net Increase
2014	427	410	- 17	427	410	- 17
2015	427	417	- 10	427	417	- 10
2016	427	423	- 4	427	423	- 4
2017	414	440	26	414	440	26
2018	414	440	26	414	440	26
2019	414	440	26	414	440	26
2020	0	440	440	0	440	440
2021	0	440	440	0	440	440
2022	0	440	440	307	440	133
2023	0	440	440	307	440	133
2024	0	440	440	307	440	133
2025	0	440	440	440	440	-
.....	0	440	440	440	440	-
2060	0	440	440	440	440	-

(Prepared by JICA Study Team)

2) Reduction of O&M Cost

As denoted in the previous section, the negative values of net O&M cost suggest the positive effect of this project, and should be counted as benefit items.

(4) Calculation of FIRR

FIRR is calculated using the values of financial cost and benefit, which are arranged in the cash flow table as shown in the Appendix. Major results are as follows:

Table 5.1.2-5 Major Results of Financial Analysis

Case	FIRR	FNPV	B/C
1	35%	Rp1,606,755 million	9.2
2	23%	Rp. 203,117 million	2.0

(Prepared by JICA Study Team)

The results show that FIRR values of both Case 1 and Case 2 exceed the Indonesian social discount rate of 10% by a large margin, FNPV values appear as positive values, and values of B/C are far larger than 1. The financial effect of Case 1 is better than Case 2 mainly because the net increase of power benefit (including energy benefit and capacity benefit) in Case 1 is much greater.

(5) Sensitivity Analysis

1) Assumptions for Analysis

The sensitivity analysis is conducted with the purpose of verifying how the change of previous assumptions for the project will affect the results of the evaluation. Three scenarios for both Case 1 and Case2 are assumed as follows:

- Scenario 1: Construction cost rises by 10% and 20%. (Scenario 1a and 1b)
- Scenario 2: Electric tariff decreases by 10% and 20%. (Scenario 2a and 2b)
- Scenario 3: Construction cost rises by 20% concurrently with the decline of electric tariff by 20%.

2) Results of Analysis

The results of sensitivity analysis are revealed in the following two tables.

For case 1, with the change of previous assumptions for the project, the value of FIRR is expected to vary between 30% and 34%. The results of all the cases assumed here are well above the level of 10%. Even under the strictest conditions assumed in Scenario 3, the project is still far better than what is required.

Table 5.1.2-6 Results of Sensitivity Analysis for Case 1

Scenario	1a	1b	2a	2b	3
FIRR	34%	33%	34%	32%	30%
FNPV(million Rp)	1,591,177	1,575,600	1,429,677	1,245,992	1,214,836
B/C	8.5	7.9	8.3	7.3	6.3

(Prepared by JICA Study Team)

Regarding Case 2, the value of FIRR is expected to vary from 16% to 21%. Although Case 2 does not seem as profitable as Case 1, it is still far better than what is required.

Table 5.1.2-7 Results of Sensitivity Analysis for Case 2

Scenario	1a	1b	2a	2b	3
FIRR	21%	20%	21%	19%	16%
FNPV(million Rp)	187,539	171,962	166,542	123,391	92,236
B/C	1.9	1.8	1.9	1.6	1.4

(Prepared by JICA Study Team)

5.2 Economic and Financial Analysis of Rehabilitation Work for Wlingi

5.2.1 Economic Analysis

(1) Methodology and Basic Assumption

The economic analysis of the rehabilitation work for Wlingi Hydropower Station is conducted using the same methodology and basic assumptions as those for the Sutami project.

(2) Economic Cost

1) Capital Cost (Initial Investment Cost)

Table 5.2.1-1 Capital Cost (Economic Price) (Unit: million Rp.)

Category	Total		1st year	2nd year	3rd year	4th year	5th year	6th year
			(2011)	(2012)	(2013)	(2014)	(2015)	(2016)
1. Construction Cost								
Generating Equipment	FC	172,353	-	-	-	57,451	57,451	57,451
	LC	15,260	-	-	-	5,087	5,087	5,087
Transmission and Substation	FC	2,537	-	-	-	846	846	846
	LC	3	-	-	-	1	1	1
Sub-total 1	FC	174,891	0	0	0	58,297	58,297	58,297
	LC	15,262	0	0	0	5,087	5,087	5,087
2. Indirect Cost								
Engineering services	FC	13,991	2,332	2,332	2,332	2,332	2,332	2,332
	LC	1,221	203	203	203	203	203	203
Physical contingencies	FC	28,332	-	-	-	9,444	9,444	9,444
	LC	2,472	-	-	-	824	824	824
Sub-total 2	FC	42,324	2,332	2,332	2,332	11,776	11,776	11,776
	LC	3,693	203	203	203	1,028	1,028	1,028
Total	FC	217,214	2,332	2,332	2,332	70,073	70,073	70,073
	LC	18,956	203	203	203	6,115	6,115	6,115
Grand Total	FC+LC	236,170	2,535	2,535	2,535	76,188	76,188	76,188

(Prepared by JICA Study Team)

2) Annual O&M Cost

i) Case 1

Regarding Case 1, the O&M cost in the 'With Project' case is expected to decline by 20% starting from 2017 following the completion of the construction work. On the other hand, the O&M cost in the 'Without Project' scenario is supposed to remain at the same level until 2022, when the operation of the aging machines will come to a total stop and the O&M cost will become 0.

ii) Case 2

As for Case 2, O&M cost in the 'With Project' case is expected to be the same as in Case 1. In the 'Without Project' case, however, it is supposed to come up again to around half of the normal level starting from 2024 and will reach this level from 2027 onwards when the rusty machines have been repaired one way or another.

Table 5.2.1-2 Net Increase of O&M Cost over the Project Period (Case 1) (Unit: million Rp.)

Year	Without Project			With Project			Net Increase of O&M Cost
	Turbine #1	Turbine #2	Total O&M Cost	Turbine #1	Turbine #2	Total O&M Cost	
2011	80	80	160	80	80	160	0
.....	80	80	160	80	80	160	0
2017	80	80	160	64	64	128	-32
.....	80	80	160	64	64	128	-32
2022~	0	0	0	64	64	128	128

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of Annual O&M cost for one turbine in Wlingi Power Station in the past 6 years

Table 5.2.1-3 Net Increase of O&M Cost over the Project Period (Case 2) (Unit: million Rp.)

Year	Without Project			With Project			Net Increase of O&M Cost
	Turbine #1	Turbine #2	Total O&M Cost	Turbine #1	Turbine #2	Total O&M Cost	
2011	80	80	160	80	80	160	0
.....	80	80	160	80	80	160	0
2017	80	80	160	64	64	128	-32
.....	80	80	160	64	64	128	-32
2022	0	0	0	64	64	128	128
2023	0	0	0	64	64	128	128
2024~	40	40	80	64	64	128	48
.....	40	40	80	64	64	128	48
2027~	80	80	160	64	64	128	-32

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of Annual O&M cost for one turbine in Wlingi Power Station in the past 6 years.

(4) Economic Benefit

1) Annual Power Benefit

Regarding the Wlingi project, owing to the lack of reliable output data, the capacity benefit expressed by the difference of power capacity between the 'With Project' and 'Without Project' cases is neglected. Accordingly, the annual power benefit here refers only to the values of energy benefit, which are calculated using the kWh value of gas turbine plant (for peak load) and coal steam plant (for base load), and the difference of energy produced between 'With Project' and 'Without Project' cases.

By using the kWh value mentioned in the section on Sutami project, the values of annual energy benefit are derived as denoted in the following table, which reflect the two cases that are different only under the 'Without Project' case.

Table 5.2.1-4 Net Increase of Energy Benefit (Unit: GWh)

Year	Case 1			Case 2		
	Without Project	With Project	Net Increase	Without Project	With Project	Net Increase
2011	140	140	0	140	140	0
.....	140	140	0	140	140	0
2016	140	140	0	140	140	0
2017	140	144	4	140	144	4
.....	140	144	4	140	144	4
2021	140	144	4	140	144	4
2022	0	144	144	0	144	144
2023	0	144	144	0	144	144
2024	0	144	144	70	144	74
2025	0	144	144	70	144	74
2026	0	144	144	70	144	74
2027~	0	144	144	140	144	4

(Prepared by JICA Study Team)

With regard to the ‘Without Project’ case, the values of power generated are assumed to fall to 0 from 2022 with the shutdown of the aging equipment in Case 1, while it is assumed that the power generated would partially restored starting in 2024 and fully restored from 2027 onwards.

2) Reduction of O&M Cost

The negative values of net O&M cost denoted in Table 5.2.1-2 and 5.2.1-3 are to be counted as benefit items.

3) Reduction of CO₂ Emission

The benefit of CO₂ emission reduction is estimated using the same methodology and assumptions as those for the Sutami project.

(5) Calculation of EIRR

As what have been done in the analysis of the Sutami project, the values of EIRR in both Case 1 and Case 2 of the Wlingi project are calculated first by disregarding the benefit of CO₂ reduction and then considering this benefit. The respective cash flow tables are shown in the Appendix, and major results are as follows:

Table 5.2.1-5 Major Results of Economic Analysis

Case		EIRR	ENPV	B/C
CO ₂ Reduction Benefit Excluded	1(1)	13%	Rp.82,539 million	1.6
	2(1)	2%	Rp. -74,924 million	0.5
CO ₂ Reduction Benefit Included	1(2)	15%	Rp. 130,801 million	1.9
	2(2)	4%	Rp. -59,561 million	0.6

(Prepared by JICA Study Team)

The results show that the EIRR value of Case 1 is expected to pass the Indonesian social discount rate requirement even when the CO₂ reduction benefit is excluded. As for Case 2, the EIRR value is expected to fall to 2% if the CO₂ reduction benefit is disregarded and will remain far below the level of the social discount rate even if the benefit of CO₂ reduction is taken into account. Therefore, Case 2 is economically unfeasible whether the benefit of CO₂ reduction is considered or not.

(6) Sensitivity Analysis

1) Assumptions for Analysis

The sensitivity analysis here focuses on Case 1(1) which disregards the effect of CO₂ reduction benefit. Three scenarios are assumed as follows:

- Scenario 1: Construction cost rises by 10%. (Scenario 1a and 1b)
- Scenario 2: Fuel cost for alternative power supply decreases by 10% and 20%. (Scenario 2a and 2b)
- Scenario 3: Construction cost rises by 20% concurrently with the decline of fuel cost by 20% for alternative power supply.

2) Results of Analysis

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

For case 1(1), with the change of previous assumptions for the project, the value of EIRR is expected to vary between 11% and 13%, but, even under the strictest conditions assumed in Scenario 3, EIRR value will remain above the level of social discount rate.

Table 5.2.1-6 Results of Sensitivity Analysis for Case 1(1)

Scenario	1a	1b	2a	2b	3
EIRR	13%	12%	12%	12%	11%
ENPV (million Rp.)	70,697	58,853	59,507	36,475	12,789
B/C	1.4	1.3	1.4	1.2	1.1

(Prepared by JICA Study Team)

5.2.2 Financial Analysis

(1) Methodology and Basic Assumptions

The methodology and basic assumptions for the financial analysis of the Wlingi project are the same as what have been adopted in the case of the Sutami project.

(2) Financial Cost

1) Capital Cost

Major items of the capital cost are indicated in the following table:

Table 5.2.2-1 Capital Cost (Unit: million Rp.)

Category	Total	1st year	2nd year	3rd year	4th year	5th year	6th year	
		(2011)	(2012)	(2013)	(2014)	(2015)	(2016)	
1. Construction Cost								
Generating Equipment	FC	172,353	-	-	-	57,451	57,451	57,451
	LC	16,955	-	-	-	5,652	5,652	5,652
Transmission and Substation	FC	2,537	-	-	-	846	846	846
	LC	3	-	-	-	1	1	1
Sub-total 1	FC	174,891	0	0	0	58,297	58,297	58,297
	LC	16,958	0	0	0	5,653	5,653	5,653
2. Indirect Cost								
Engineering services	FC	13,991	2,332	2,332	2,332	2,332	2,332	2,332
	LC	1,357	226	226	226	226	226	226
Physical contingencies	FC	28,332	-	-	-	9,444	9,444	9,444
	LC	2,747	-	-	-	916	916	916
Sub-total 2	FC	42,324	2,332	2,332	2,332	11,776	11,776	11,776
	LC	4,104	226	226	226	1,142	1,142	1,142
Total	FC	217,214	2,332	2,332	2,332	70,073	70,073	70,073
	LC	21,062	226	226	226	6,794	6,794	6,794
Grand Total	FC+LC	238,276	2,558	2,558	2,558	76,867	76,867	76,867

(Prepared by JICA Study Team)

2) O&M Cost

Values of O&M cost in Case 1 and Case 2 are shown in the following two tables.

Table 5.2.2-2 Net Increase of O&M Cost over the Project Period (Case 1) (Unit: million Rp.)

Year	Without Project			With Project			Net Increase of O&M Cost
	Turbine #1	Turbine #2	Total O&M Cost	Turbine #1	Turbine #2	Total O&M Cost	
2011	89	89	178	89	89	178	0
.....	89	89	178	89	89	178	0
2017	89	89	178	71	71	143	-36
.....	89	89	178	71	71	143	-36
2022~	0	0	0	71	71	143	143

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of annual O&M cost for one turbine in Wlingi Power Station in the past 6 years.

Table 5.2.2-3 Net Increase of O&M Cost over the Project Period (Case 2) (Unit: million Rp.)

Year	Without Project			With Project			Net Increase of O&M Cost
	Turbine #1	Turbine #2	Total O&M Cost	Turbine #1	Turbine #2	Total O&M Cost	
2011	89	89	178	89	89	178	0
.....	89	89	178	89	89	178	0
2017	89	89	178	71	71	143	-36
.....	89	89	178	71	71	143	-36
2022	0	0	0	71	71	143	143
2023	0	0	0	71	71	143	143
2024	45	45	89	71	71	143	53
.....	45	45	89	71	71	143	53
2027~	89	89	178	71	71	143	-36

(Prepared by JICA Study Team)

Note: The value of Annual O&M cost for one turbine is estimated based on the average value of annual O&M cost for one turbine in Wlingi Power Station in the past 6 years.

(3) Financial Benefit

With regard to the financial benefit, values of net increase of tariff revenue resulting from the net increase of energy produced and reduction of O&M cost are calculated.

1) Increase of Electric Tariff Revenue

The values of net increase in electric tariff revenue are derived from the net increase of energy with the project (With Project – Without Project) and the average electric tariff, worked out in the same way as what has been done in the section of Sutami. Values of annual net increase of energy over the project period are the same as what have been revealed in Table 5.2.1-4 under the economic analysis.

2) Reduction of O&M Cost

As denoted in the previous section, the negative values of net O&M cost suggest the positive effect of this project, and should be counted as benefit items.

(4) Calculation of FIRR

FIRR is calculated using the values of financial cost and benefit, which are arranged in the cash flow table as shown in the Appendix. Major results are as follows:

Table 5.2.2-4 Major Results of Economic Analysis

Case	FIRR	FNPV	B/C
1	14%	Rp. 218,062 million	1.8
2	3%	Rp. -138,696 million	0.5

(Prepared by JICA Study Team)

The results show that the FIRR value of Case 1 exceeds the Indonesian social discount rate of 10%.

In Case 2, however, FIRR value comes out as 3%, FNPV value appears to be a negative value, and the B/C value is less than 1. Accordingly, Case 2 is financially unfeasible.

(5) Sensitivity Analysis

1) Assumptions for Analysis

Three scenarios for Case 1 are assumed as follows:

- Scenario 1: Construction cost rises by 10% and 20%. (Scenario 1a and 1b)
- Scenario 2: Electric tariff decreases by 10% and 20%. (Scenario 2a and 2b)
- Scenario 3: Construction cost rises by 20% concurrently with the decline of electric tariff by 20%.

2) Results of Analysis

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

With the change of previous assumptions, the value of FIRR is expected to vary from 12% to 14%. Even under the strictest conditions assumed in Scenario 3, EIRR value will remain above the level of social discount rate.

Table 5.2.2-5 Results of Sensitivity Analysis for Case 1

Scenario	1a	1b	2a	2b	3
FIRR	14%	14%	13%	12%	12%
FNPV (million Rp.)	206,113	194,165	168,420	118,310	94,413
B/C	1.7	1.6	1.6	1.4	1.3

(Prepared by JICA Study Team)

5.3 Economic and Financial Analysis of Rehabilitation Work for Sutami and Wlingi

5.3.1 Calculation of EIRR

(1) Results of EIRR

When the rehabilitation works in Sutami and Wlingi are combined into a single project, the results of EIRR calculation for Case 1 and Case 2, both considering and disregarding the CO₂ reduction effect, are derived as follows:

Table 5.3.1-1 Major Results of Economic Analysis

Case		EIRR	ENPV	B/C
CO ₂ Reduction Benefit Excluded	1(1)	22%	Rp.843,391 million	3.5
	2(1)	10%	Rp.2,401 million	1.0
CO ₂ Reduction Benefit Included	1(2)	24%	Rp. 1,069,730 million	4.1
	2(2)	12%	Rp.62,215 million	1.2

(Prepared by JICA Study Team)

The results show that EIRR values of both Case 1 and Case 2 will exceed the Indonesian social discount rate of 10% whether the CO₂ reduction effect is considered or not. The economic effect of Case 1 is better than Case 2 mainly because the net increase of power benefit in Case 1 is much greater. It is worth noting that even in the economically unfeasible Case 2 for Wlingi project, it will become feasible when implemented together with Sutami project.

(2) Sensitivity Analysis

1) Assumptions for Analysis

Three scenarios for Case 1(1) and Case 2(2) are assumed as follows:

- Scenario 1: Construction cost rises by 10% (Scenario 1a and 1b)
- Scenario 2: Fuel cost for alternative power supply decreases by 10% and 20%. (Scenario 2a and 2b)
- Scenario 3: Construction cost rises by 20% concurrently with the decline of fuel cost by 20% for alternative power supply.

2) Results of Analysis

The results of the sensitivity analysis are revealed in the following tables.

Regarding Case 1(1), the value of EIRR is expected to vary between 18% and 21%. Even under the strictest conditions assumed in Scenario 3, the project is still economically feasible.

Table 5.3.1-2 Results of Sensitivity Analysis for Case 1(1)

Scenario	1a	1b	2a	2b	3
EIRR	21%	20%	21%	20%	18%
ENPV (million Rp.)	816,907	789,626	740,236	6,536,413	581,851
B/C	3.2	3.0	3.2	2.9	2.5

(Prepared by JICA Study Team)

As for Case 2(2), the value of EIRR will be from 8% to 11%, and it will slip to the level below 10% only when in the strictest Scenario 3. But it is worth noting that Case 2(2) takes into account the benefit of CO₂ reduction, so the result could be worse when this item is excluded.

Table 5.3.1-3 Results of Sensitivity Analysis for Case 2(2)

Scenario	1a	1b	2a	2b	3
EIRR	11%	10%	11%	10%	8%
ENPV (million Rp.)	34,935	7,654	32,020	1,771	-52,790
B/C	1.1	1.0	1.1	1.0	0.9

(Prepared by JICA Study Team)

5.3.2 Calculation of FIRR

(1) Results of FIRR

FIRR is calculated using the values of financial cost and benefit, which are arranged in the cash flow table as shown in the Appendix. Major results are as follows:

Table 5.3.2-1 Major Results of Financial Analysis

Case	FIRR	FNPV	B/C
1	25%	Rp. 1,824,815 million	4.8
2	12%	Rp. 64,422 million	1.1

(Prepared by JICA Study Team)

The results show that both Case 1 and Case 2 are financially sound with their values of FIRR exceeding the social discount rate, FNPV coming out as positive figures and B/C higher than 1.

(2) Sensitivity Analysis

1) Assumptions for the Analysis

Three scenarios for Case 1 and Case 2 are assumed as follows:

- Scenario 1: Construction cost rises by 10% and 20%. (Scenario 1a and 1b)
- Scenario 2: Electric tariff decreases by 10% and 20%. (Scenario 2a and 2b)
- Scenario 3: Construction cost rises by 20% concurrently with the decline of electric tariff by 20%.

2) Results of Analysis

The results of the sensitivity analysis are revealed in the following tables.

Regarding Case 1, the value of FIRR is expected to vary between 21% and 25%, but will remain well above the level of the social discount rate even under the strictest conditions assumed in Scenario 3.

Table 5.3.2-2 Results of Sensitivity Analysis for Case 1

Scenario	1a	1b	2a	2b	3
FIRR	25%	24%	24%	23%	21%
FNPV (million Rp.)	1,797,287	1,769,762	1,594,724	1,364,244	1,309,275
B/C	4.5	4.3	4.3	3.8	3.4

(Prepared by JICA Study Team)

As for Case 2, when electric tariff is cut down by 20%, the value of FIRR is expected to fall to 9%, and if the 20% cut of electric tariff occurs concurrently with a 20% rise in construction cost, the value of FIRR is will further slip down to 7%.

Table 5.3.2-3 Results of Sensitivity Analysis for Case 2

Scenario	1a	1b	2a	2b	3
FIRR	11%	10%	10%	9%	7%
FNPV (million Rp.)	36,895	9,369	10,205	-43,991	-99,044
B/C	1.1	1.0	1.0	0.9	0.8

(Prepared by JICA Study Team)

Chapter 6
Environmental and Social Considerations

CHAPTER 6 ENVIRONMENTAL AND SOCIAL CONSIDERATIONS

6.1 Basic Information

6.1.1 Objectives

The purpose of environmental and social considerations in this Study is to confirm issues for the implementation of rehabilitation project of Sutami and Wlingi hydropower stations and countermeasures for sedimentation of Mrica Reservoir selected as the results of screening of the existing hydropower stations.

In addition, examinations for the current environmental condition at the Brantas River basin, in where Sutami and Wlingi are located, were conducted and the study results were described based on the collected data and information in Section 6.5.

6.1.2 Regulations and Administrative Framework

(1) Relevant Regulations

Table 6.1-1 shows the relevant regulations in Indonesia related to environmental and social considerations as referred to in this study.

Table 6.1-1 Relevant Environmental Regulations

Regulation No.	Regulation Title
Law No. 5/1990	Conservation of living natural resources and its ecosystem
Law No. 24/1992	Spatial Design
Law No. 23/1997	Management of living environment
Presidential Decree No. 32/1990	Management of protected area
Government Regulation No. 10/1993	Protection of cultural heritage
Decree of Ministry of Environment No. 48/MENLH/11/1996	Noise standards
Decree of Ministry of Environment No. 49/MENLH/11/1996	Vibration standards
Decree of Ministry of Environment No. 50/MENLH/11/1996	Odor standards
Government Regulation No.7/1999	Protection of plant and animal species
Government Regulation No. 19/1999	Seawater pollution control
Government Regulation No. 41/1999	Air quality management and pollution control
Government Regulation No. 82/2001	Water quality management and water quality control
Government regulation No. 74	Hazardous waste material management
Presidential Decree No. 36/2005	Provision of land for development in public interest

(Prepared by JICA Study Team)

(2) AMDAL Approval Procedure

Relevant regulations on environmental impact assessment in Indonesia (AMDAL: Analysis

Mengenai Dampak Lingkuar Hidup) are listed in Table 6.1-2.

Table 6.1-2 Relevant Regulations on AMDAL

Regulation No.	Regulation Title
Decree of State Minister of Environment No. 56/1996	Criteria on significant environmental impact
Decree of Head of BAPEDAL No. KEP299/11/1996	Guideline on the social aspect in AMDAL
Decree of Head of BAPEDAL No. KP124/12/1997	Guideline on public health aspect in AMDAL
Governmental Regulation No. 27/1999	Environmental Impact Analysis (AMDAL)
Presidential Decree No. 10/2000	Environmental Impact Management Agency (BAPEDAL)
Decree of Minister of Environment No. 2/MENLH/02/2000	Guideline on AMDAL document evaluation
Decree of Ministry of Environment No. 4/MENLH/02/2000	Guideline on preparing the AMDAL document for integrated residential development activity
Decree of Ministry of Environment No. 5/MENLH/2000	Guideline on preparing the AMDAL document for development activity in wetland area
Decree of Ministry of Environment No. 8/MENLH/02/2000	Public involvement and information release on the analytical process concerning AMDAL
Decree of Ministry of Environment No. 9/MENLH/02/2000	Designing guideline of environmental impact assessment
Decree of Ministry of Environment No. 17/2001	Type and size of business and/or activities requiring AMDAL document
Decree of Ministry of Environment No. 40/2000	About the Guideline Administration Commission of Assessor for Environmental Impact Analysis. (AMDAL)
Decree of Ministry of Environment No. 41/2000	Guideline in Forming the Commission of Assessor for Environmental Impact Analysis (AMDAL).
Decree of Ministry of Environment No. 42/2000	Formation of Membership of Commission of Technical Team and Assessor of AMDAL.

(Prepared by JICA Study Team)

AMDAL approval procedure is shown in Figure 6.1-1 and outlined below.

A project executer submits the prepared terms of reference (TOR) to the AMDAL committee for appraisal. After appraisal, an environmental study is implemented. The environmental assessment report (ANDAL: Analisis Dampak Lingkungan), environmental management plan (RKL: Rencana Pengelolaan Lingkungan) and environmental monitoring plan (RPL: Rencana Pemantauan Lingkungan) are then prepared and appraised by the AMDAL committee. The result of the appraisal is reported by the AMDAL committee to the designated ministry responsible for the project. Information about environmental approval is announced within 75 days after obtaining the appraisal result from the AMDAL committee.

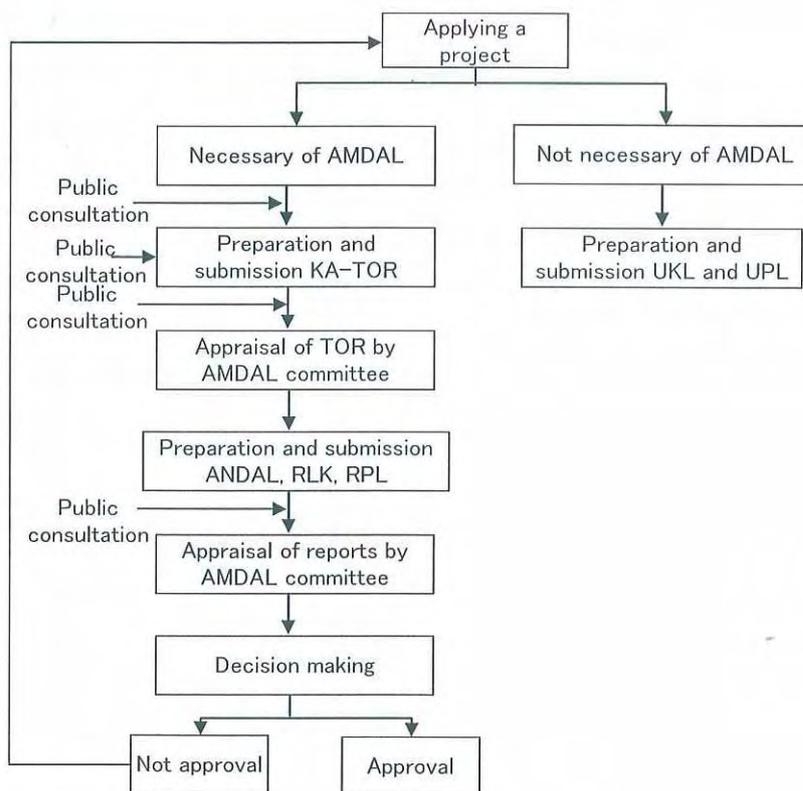


Figure 6.1-1 AMDAL Approval Procedure
(Prepared by JICA Study Team)

6.2 Environmental Considerations for Rehabilitation Activities at Sutami and Wlingi

Section 4.1 proposes rehabilitation project for Sutami and Wlingi hydropower stations in order to improve facility functions. Environmental and social considerations for the project are therefore examined, and the expected impacts are shown in Table 6.2-1. The environmental checklist from Japan Bank for International Cooperation Guideline for Confirmation of Environmental and Social Considerations issued in April 2002 (the JBIC Guideline) for proposed activities is shown in Table 6.4-1.

Table 6.2-1 Expected Impact and Examination Points for Rehabilitation Activities at Sutami and Wlingi

Power Stations	Rehabilitation Activities	Expected Impact	Examination Points
Sutami and Wlingi	Rehabilitation for generating equipment (Water Turbine, Inlet Valves, Governor, AVR, Generator, Control/Protection System) ¹	[During Construction] Oil pollution Treatment of wastes (oil, concrete, iron) Noise and vibration [Operation and Maintenance] Oil pollution due to operation and maintenance work	[During Construction] Establishment of risk management Setting sheet or frame to prevent oil leakage Announcement to local residents in advance [Operation and Maintenance] Establishment of risk management Setting sheet or frame to prevent oil leakage. Safety education of workers

(Prepared by JICA Study Team)

¹ As for Wlingi power station, rehabilitation activities are proposed for Water Turbine, Governor, Generator, Control/Protection System.

6.3 Environmental Considerations for Mrica Reservoir

6.3.1 Current Condition

(1) Situation of Environmental Impact Assessment

The ANDAL report was prepared in 1993. However, its existence was not confirmed according to the environmental department of IP. RKL and RPL were also prepared and kept by IP, and outline of them is shown below.

1) RLK

It was considered in RLK that optimum environmental management of Mrica reservoir might be possible through several approaches such as technical, economic and institutional approaches. The outline of these approaches is described below.

a) Technical Approach

- Installation of warning system such as radio announcement
- Installation of protection in a garbage dumping place in the upstream to prevent flowing garbage into the river basin
- Cleaning aquatic weed and garbage in the reservoir, and utilizing aquatic weed for domestic animal feed
- Relocation of infrastructure and public facilities
- Development of the reservoir area in order to utilize labor force from the agriculture sector
- Securing landslide around the reservoir area, and utilizing open area effectively where construction activities occupied

b) Economic Approach

- Providing priority to local residents for construction labors
- Providing opportunities to local residents to take advantages of existing social facilities
- Using local resources for development and operation of the project including socio-economic condition

c) Institutional Approach

- Handling natural and social environmental issues with relevant authorities by establishing a special team
- Establishing a special team to control inundation chaired by the deputy governor

of Central Java province

- Establishing a rescue team for an accident due to water from the reservoir and establishing a health unit at the time of inundation or filling of water
- Establishing a technical unit of transportation of the lake and the river

Expected impacts and mitigation measures were highlighted in Table 6.3-1.

Table 6.3-1 Outline of RLK for Mrica Reservoir

Stage	Factor	Expected Impact	Mitigation Measures
Pre-Construction	Land Acquisition	10 villages accounting for 2,550 households were project affected people who were requested resettlement, and there was difficulty on negotiation of compensation amount.	PLN provided compensation amount according to discussion with the project affected people.
Construction	1. Transportation <ul style="list-style-type: none"> - Road & Bridge - Public health and safety 2. Land <ul style="list-style-type: none"> - Hydrology - Flora and Fauna 	1. Transportation <ul style="list-style-type: none"> - Degradation of road condition due to transportation of construction machines. - Negative impact to public health and safety due to increasing of transportation of construction machines 2. Land <ul style="list-style-type: none"> - Increasing the risk of run off and erosion - Disruption of ecological balance due to loss of vegetation and habitat 	1. Transportation <ul style="list-style-type: none"> - Maintenance and repair of road and bridge regularly - Installation of traffic signal - Spraying water - Plantation trees and preparation of wall 2. Land <ul style="list-style-type: none"> - Creating greenbelt around the reservoir by planting perennial plants
Operation	1. Inundation <ul style="list-style-type: none"> - Displacement - Loss of Public Facility - Public Health - Discharging Water - Safety at downstream area - Safety at reservoir area 3. Water Quality <ul style="list-style-type: none"> - Degradation of water quality in reservoir 	1. Inundation <ul style="list-style-type: none"> - Unrest of displaced people - Loss of public facilities - Some accidents during inundation - Unhealthy condition due to weed growing and garbage flowing 2. Discharging Water <ul style="list-style-type: none"> - Risk of people who used river water at downstream - Unstabilization of slop around reservoir area - Impact to irrigation at downstream due to lack of nutrition 3. Water Quality <ul style="list-style-type: none"> - Stratification of water temperature - Impact to aquatic flora and fauna in the reservoir 4. Dislocation <ul style="list-style-type: none"> - Risk of dislocation due to the scale of the reservoir and geological feature 	1. Inundation <ul style="list-style-type: none"> - No clear description about mitigation measures of people displacement - Relocation and rebuild of public facilities - Preparation of rescue team for filling water - Cleaning water to prevent growing weed and providing medication for employees at the power station - Clearing the land before inundation 2. Discharging Water <ul style="list-style-type: none"> - Installing radio announcement system of discharging water - Applying the best technical method such as surface drainage, slope treatment, sub-drainage, rock-fill, earth-fill, etc. - Appropriate water quality treatment by considering the water quality standard 3. Water Quality <ul style="list-style-type: none"> - Conducting turnover of water in the reservoir 4. Dislocation <ul style="list-style-type: none"> - Consultation with communities around the reservoir - Cooperation with regional geological office

(Source: Prepared by JICA Study Team based on RLK for Mrica Reservoir)

With respect to institutional arrangement on implement environmental management plan, RKL defines to cooperate with provincial government and relevant authorities.

2) RPL

RPL described to monitor the parameters defined in RPL shown in Table 6.3-2.

Table 6.3-2 Outline of RPL for Mrica Reservoir

Parameters	Expected Impact	Monitoring	Frequency/ Monitoring Structure
Land use	- Changing land use due to new settlement from inundation area	- Monitoring through observation, assessment data, and map of land use comparing before and after the project including improvement of regional development activities	Once a year during operational phase
Geology	- Dislocation due to the size of the reservoir and geological nature - Slope un-stabilization	- Monitoring of earthquake from two stations - Monitoring of slide from two stations	- Monitoring every day - Reporting month to PLN and relevant governorate authorities
Hydrology	- Changing groundwater level due to inundation, and fluctuation of surface water in the reservoir and downstream - Sedimentation	- Monitoring of sedimentation	- Monitoring cooperated with relevant authorities
Water Quality	- Eutrophication - Turnover	- Monitoring of TSS, TDS, SiO ₂ , pH, DO, CO ₂ , No ₂ -N, NH ₃ -N, NoO ₃ -N, H ₂ S, N-total, P-total, pesticide, heavy metal, plankton, benthos, bacteria - Analyzed water quality by the standard method (APHA, 1980) - Analyzing plankton by the Simpson method (Odum, 1975), and analyzing benthos by the method of Shannon & Wiener (Lee at al, 1978)	- Monitoring cooperated with Research center
Aquatic weed	- Changing aquatic environment and impact to hydropower facility by rapid growth of aquatic weed	- Monitoring density, frequency and dominance of aquatic weed	- Monitoring cooperated with Research center
Micro climate change	- Changing temperature, humidity, air circulation and rainfall condition	- Monitoring rainfall, rain pH, temperature air, humidity, solar radiation, wind speed and direction - Using recording devices, p meters, thermometers, hydrometers	- Conducted by PLN Mrica in cooperation with BMG (meteorological and geological agency)
Public health	- Raising a risk of disease by habitation changing due to land and aquatic environment changing	- Monitoring malaria and other infectious diseases existing in society	- Implemented at the district health service such as clinic
Flora and fauna	- Changing of ecosystem around the reservoir area though protected species might not be affected	- Inventory of species diversity, density - Comparing inventory result between pre-project and after project	- Monitoring cooperated with the district office of natural conservation authority

(Source: Prepared by JICA Study Team based on RPL for Mrica Reservoir)

Regarding reporting system, RPL defines to report the monitoring result to Regional Environmental Agency (BKLH), regional planning department (BAPPEDA) and relevant authorities.

3) Current Situation of Implementation of RKL and RPL

According to the environmental department in Mrica reservoir, land use, water quality and flora and fauna were monitored though only water quality monitoring record was confirmed. Further confirmation and examination of monitoring result is necessary. With respect to reporting system, it was observed that reporting was done according to the defined system in a timely manner.

(2) Pollution Control

IP is conducting regular water quality monitoring with an external partner. Monitoring is being conducted at nine locations in the reservoir, considering 30 parameters.

According to the latest water quality monitoring report compiled in September 2009, most of the parameters except BOD and cadmium at nine locations met the standard levels. The monitoring result is shown in Table 6.3-3.

Table 6-3-3 Result of Water Pollution Monitoring at Mrica Reservoir

Parameter	Unit	Depth (m)		Standard
		0.2	5.0	
Temp	°C	25.0	25.5	
TDS	mg/l	90.0	78.0	1000
TSS	mg/l	180.0	125.0	400
pH	-	7.9	7.9	6-9
BOD	mg/l	8.1	6.3	6.0
COD	mg/l	27.80	18.88	50.0
T-P	mg/l	0.150	0.067	1.0
NO3	mg/l	7.460	3.120	20.0
As	mg/l	<0.001	<0.001	1.00
B	mg/l	<0.001	<0.001	1.00
Co	mg/l	<0.001	<0.001	0.2
Se	mg/l	<0.001	<0.001	0.05
Cd	mg/l	0.0015	0.0040	0.01
chrome hexavalent	mg/l	0.009	0.001	0.05
Cu	mg/l	0.0014	0.0020	0.02
Pb	mg/l	0.007	0.001	0.03
Hg	mg/l	<0.001	<0.001	0.002
Zn	mg/l	0.026	0.008	0.05
Cn	mg/l	0.017	0.001	0.02
F	mg/l	0.689	0.172	1.5
N	mg/l	0.0015	0.0030	0.06
Cl2	mg/l	45.89	20.46	-
H2S	mg/l	0.00	0.00	0.002
NH3-N	mg/l	0.290	0.175	-
Fe	mg/l	0.511	0.072	-
Cl	mg/l	0.00	0.00	0.03

(Prepared by JICA Study Team based on monitoring report Penelitian Kualitas Air in September 2009)

With respect to BOD at nine locations, all monitoring points recorded values ranging from 6.33 mg/l to 9.09 mg/l. These exceed the standard limit of 6 mg/l. As for cadmium, values recorded at eight locations range from 0.11 mg/l to 0.02 mg/l, exceeding the standard of 0.001 mg/l. The report considered that the possible reasons for exceeding the BOD levels are agriculture, fish carcasses and garbage.

Domestic garbage that flow into Mrica Reservoir was collected by IP daily², and disposed to a public place by a garbage collection service.

Every six months, IP conducted water quality monitoring in the reservoir, and sediment and greenbelt monitoring. Monitoring results were compiled in a report, and submitted to IP and PLN every three months. In addition, the results were reported to the environmental department in the governorate and to the governor every six months. Water quality monitoring was conducted through an external partner, while sediment and greenbelt monitoring were conducted by IP.

(3) Natural Environment

It was ascertained that the reservoir area did not include protected area, but habitation of vulnerable species was not confirmed due to less information available. According to information from the regional office of the Ministry of Forest in Semarang, the following species defined in Law No. 7/1999 were observed in the Central Java province as shown in Table 6.3-4. Classification of IUCN and CITES are also described in the table.

Table 6.3-4 Vulnerable Species in Central Java Province

Indonesian Name	Scientific name	IUCN	CITES
Mammal			
Menjangan, Rusa, Sambar	Cervus spp.	-	-
Landak	Hystrix Brachyura	-	-
Bajing Terbang Ekor Merah	Iomys Horsifieldi	-	-
Trenggiling, Peusing	Manis Javanica	ED	Appendices II
Kidang, Muncak	Muntiacus Muntjak	LC	-
Malu-malu	Nycticebus Councang	-	-
Lumba-lunba Air Tawar, Pesut	Orcaella Brevirostris	VU	-
Kuskus	Phalanger spp.	*1	-
Kancil, Pelanduk, Napu	Tragulus spp. Tragulus Javanicus	DD	-
Birds			
Burung Alap-alap, Elang	Accipitridae	*2	Appendices II
Burung Udang, Raja Udang	Alcedinidae	-	-
Pecuk Ular	Anhinga Melanogaster	NT	-
Kuntul, Bangau Putih	Bubulcus Ibis	LC	-
Kuntul, Bangau Putih	Egretta spp.	LC	-
Burung Alap-alap, Elang	Falconidae	-	Appendices II
Tulung Tumpuk, Bultok Java	Megalaima Javanesis	-	-
Plant			
Kantong Semar	Nepenthes spp.	-	-

Remarks : ED stands for "Endangered", LC stands for "Least Concern", VU stands for "Vulnerable", DD stands for "Data

² Contract with garbage collector was renewed every 6 months.

deficient”, NT stands for “Near Threatened”, according to IUCN classification.

*1) Although habitation in Indonesia is confirmed according to information of IUCN, habitation in Central Java is not confirmed.

*2) *Accipiter cirrocephalus*, *Accipiter Ervthrauchen*, etc are classified into LC according to the classification at IUCN.

(Source: Jenis-Jenis Tumbuhan Dan Satwa Yang Dilindungi Lingkup Provinsi Jawa Tengah and IUCN Red List)

(4) Social Environment

About 10,000 ha irrigation area is located downstream of Soedirman hydropower station. However, any impacts to agriculture or fishery at said location were not reported so far.

6.3.2 Recognition of Problems

IP and the local government focused on sediment treatment, and made utmost efforts to address the problem by instructing farmers to change crops within a limited budget since agriculture extending along the river contributed to erosion. IP and the local government recognize the seriousness of sediment problems since their activities and outcomes were limited.

6.3.3 Suggestions for Next Stage

Implementation of sediment flushing, reservoir dredging work, construction of diversion weir and sediment bypass tunnel are recommended as countermeasures on sedimentation in the reservoir. Environmental and social considerations for implementing these countermeasures are summarized as follows by referring to previous similar studies in Indonesia, Japan and Europe. In addition, the environmental checklist for constructing weir and sand bypass channel in the JBIC Guidelines is shown in Table 6.4-2.

(1) Expected Impacts from Flushing through Sand Bypass Tunnel and Diversion Weir

As mentioned in Section 4.2, most of the components in sediment flushing are suspended load and wash load. Therefore, the experience at Miwa dam in Japan is referred to as a similar example, and expected impacts and items to be considered are further highlighted.

Three times of trial flushing operation were carried out at Miwa Dam in Japan in March 2008 after completion of construction of the bypass tunnel and diversion weir in 2001. The bypass tunnel and diversion weir were constructed as countermeasure on sedimentation problem at Miwa Dam. Cross-grained sediment is caught at sediment storage dam or diversion weir prior to flushing, and therefore, only wash load flow through according to the flushing record at Miwa Dam. Regular monitoring on turbidity and habitation of aquatic fauna was conducted at Takato Dam located downstream of Miwa Dam after the trial flushing operation. However, any turbidity or impact to water use downstream was not observed.

In the case of Mrica Reservoir, wash load and suspended load are planned to be discharged to downstream by flushing operation, although its scale was small. Considering the current situation of Mrica Dam (i.e., no impact at downstream water use) and experience at said location, conceivable impacts from conducting countermeasures using bypass tunnel and diversion weir is

summarized as follows:

- Degradation of water quality due to decreasing water flow into Mrica Reservoir
- Short period turbidity at downstream area
- Impact to aquatic flora and fauna due to turbidity
- Changing aquatic environment due to the increase in river bed level

(2) Expected Impacts from Sediment Flushing Operation

With respect to sediment flushing, the experience at Dashidaira Dam in Japan and study result from “Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project,” conducted under JBIC loan No.IP-510 in 2005 is useful references in examining the impacts at Serayu River basin.

At Dashidaira Dam, the first sediment flushing operation was conducted in 1985, six years after operation started. Organic substances changed its nature in an anaerobic condition for six years, which caused turbidity with offensive odor at downstream after the flushing operation. Meanwhile, study results from “Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project”, revealed the outcomes of flushing as summarized below.

- A few days of offensive odor; however, its impact was not serious;
- Increasing the level of turbidity, BOC, COD, SS by approximately 10 times the usual condition; and
- Many dead fishes after several days of flushing operation.

Although flushing and dredging have been carried out at Mrica Dam, its scale of 0.1 MCM/year is considered small. There are no records on impacts at downstream of the dam so far. However, BOD level is higher than the standard level according to the monitoring result. Based on such condition, it is considered that there is a possibility of causing offensive odor and turbidity at downstream when flushing operation is conducted at the dam, although its impact is not as serious as in Dashidaira Dam. In addition, impact to aquatic flora and fauna and fisheries is expected based on the findings from “Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project”. Expected impacts are summarized below.

- Short period offensive odor in downstream river basin
- Short period turbidity in downstream river
- Short to middle period of impact to aquatic flora and fauna due to wash load
- Impact to fisheries along downstream river

(3) Expected Impacts from Dredging Operation

Flushing dredged sediment to downstream and disposing dredged sediment at the dead area in the reservoir site is proposed. Regarding flushing of dredged sediment to downstream, dredged sediments, divided into wash load/suspended load, should be flushed while the bed load to be

disposed at the dead area in the reservoir area or spoil bank. Some of the disposed soil will be utilized as construction materials. Wash load and suspended load are temporarily kept at the downstream area, and are flushed at the time of flood and discharged during power generation. As for disposing dredged sediment at the dead area in the reservoir, land acquisition is not necessary. Therefore, social impact caused by land acquisition is not expected. However, impact on fisheries is expected due to increase in turbidity. Conceivable impacts are summarized below.

- Short period turbidity due to wash load
- Short period impacts to aquatic flora and fauna caused by wash load
- Impact on fisheries
- Increasing riverbed level

Outline of conceivable impact caused by sedimentation countermeasures proposed by this study is shown in Table 6.3-5.

Table 6.3-5 Outline of Conceivable Impacts due to Sedimentation Countermeasures

Countermeasures	Expected Impact	Magnitude	Range of Impact	Period of Impact
Bypass tunnel and diversion weir	Increasing river bed level	B	Direct downstream	Long period (until the time when discharging soil from upstream and amount of bed load transport at downstream become equal)
	Recession of ground water due to tunnel construction	C	Tunnel construction area	During tunnel construction period
	Water quality degradation in the reservoir	B	Inside the reservoir and downstream	Long period (permanently unless countermeasures of delusion is taken)
Flushing	Offensive odor	B	Direct downstream	Short period (several days)
	Turbidity	B	Direct downstream to wide area at downstream	Short period (several days)
	Increase river bed level	B	Direct downstream to wide area at downstream	Short period (several days)
	Increase BOD/COD/SS level	B	Direct downstream to wide area at downstream	Short period (several days)
Dredging	Turbidity	B	Direct downstream to wide area at downstream	Short to middle period (several days to a few weeks)
	Increase river bed level	B	Direct downstream to wide area at downstream	Long period (until the time when discharging soil from upstream and amount of bed load transport at downstream become equal)
	Increase BOD/COD/SS level	B	Direct downstream to wide area at downstream	Short to middle period (several days to a few weeks)

Remarks:

Rating of magnitude is shown below.

A: Serious impact is expected.

B: Moderate impact is expected.

C: Minor impact is expected.

D: No impact is expected.

(Prepared by JICA Study Team)

6.3.4 Items to be examined Further

Outline of items to be examined further for conducting countermeasure activities on sedimentation in Mrica Reservoir is shown in Tables 6.3-6, 6.3-7, 6.3-8 and 6.3-9.

(1) Sediment Flushing through Bypass Tunnel and Diversion Weir

Table 6.3-6 Items to be examined for Sediment Flushing through Bypass Tunnel and Diversion Weir

Item	Conceivable Impact	Items to be Examined Further
Before Construction		
Land acquisition	Possibility of land acquisition for construction of bypass tunnel and diversion weir	<ul style="list-style-type: none"> - Conducting consultation with land owners at appropriate timing - Appropriate compensation to be offered
	Possibility of involuntary resettlement due to land acquisition	<ul style="list-style-type: none"> - Conducting consultation with land owners at appropriate timing - Preparation of resettlement action plan by referring to the result of consultation with project affected people - Appropriate measures for ethnic groups or indigenous groups if they are affected
During Construction		
Air quality	Dust due to operation of construction vehicles and machines	<ul style="list-style-type: none"> - Preparation and implementation of environmental management plan and environmental monitoring plan
Water quality	Turbidity due to construction work	<ul style="list-style-type: none"> - Installing gate or sheet pile to prevent water pollution - Constructing embankment dike - Establishment of system for announcing flushing to downstream
Ground water	Recession of groundwater due to tunnel construction	<ul style="list-style-type: none"> - Confirmation of groundwater use - Confirmation of tunnel alignment
Noise and vibration	Noise and vibration due to operation of construction vehicles and machines	<ul style="list-style-type: none"> - Appropriate construction plan
Impact to downstream	Impact to agriculture and fisheries due to turbidity	<ul style="list-style-type: none"> - Establishment of system for announcing flushing to downstream - Appropriate compensation to be offered to fishermen and farmers
Operation and Maintenance		
Water quality	Degradation of water quality due to decreasing water flow to the reservoir	<ul style="list-style-type: none"> - Securing sufficient quantity of dilution water
Impact to downstream	Changing aquatic environment due to increase of river bed level (e.g., loss of place for laying eggs)	<ul style="list-style-type: none"> - Implementation of flushing by utilizing natural conditions such as floods

(Prepared by JICA Study Team)

(2) Implementation of Sediment Flushing

Table 6.3-7 Items to be examined for Sediment Flushing

Item	Expected Impact	Items to be Examined Further
Before implementation		
No impact is expected		
During implementation		
Water quality	Temporary turbidity due to wash load	- Impact to water use at downstream - Impact to land use at downstream
Impact to downstream	Impact to aquatic flora and fauna	- Confirmation of fishery at downstream
After implementation		
Water quality	Temporary turbidity due to wash load	- Impact to water use at downstream - Securing sufficient quantity of dilution water
Increase river bed level	Impact to aquatic environment	- Impact to aquatic biodiversity
	Impact to infrastructure	- Impact to infrastructure such as bridges and bank protection
Impact to downstream	Impact to fishery due to impact to aquatic flora and fauna	- Impact to water use at downstream
	Offensive odor	- Confirmation of water and sediment condition

(Prepared by JICA Study Team)

(3) Disposal of Dredged Sediment from Reservoir Dredging Works

Table 6.3-8 Items to be examined Further for Dredging and Disposal of Bed Load at Spoil Bank

Items	Expected Impact	Items to be Examined Further
Before Implementation		
No impact is expected		
During Implementation		
Water quality	Temporary turbidity due to dredging work	- Impact to water use at downstream - Impact to land use at downstream - Confirmation of sediment condition - Confirmation of sediment amount in the reservoir
After Implementation		
Water quality and soil condition	Soil pollution around the disposal area due to piling bed load	- Confirmation of sediment condition

(Prepared by JICA Study Team)

Table 6.3-9 Items to be examined Further for Flushing Wash and Suspended Loads to Downstream

Items	Expected Impact	Items to be Examined Further
Before Implementation		
No impact is expected		
During Implementation		
Water quality	Temporary turbidity due to wash load flushing	- Impact to water use at downstream - Impact to land use at downstream
Impact to downstream	Impact to aquatic flora and fauna	- Confirmation of fishery at downstream area
After Implementation		
Water quality	Temporary turbidity due to wash load	- Impact to water use at downstream
Increase river bed level	Impact to aquatic environment	- Impact to aquatic biodiversity
	Impact to infrastructure	- Impact to infrastructure such as bridges and bank protection
Impact to downstream	Impact to fisheries due to affected aquatic flora and fauna	- Impact to water use at downstream

(Prepared by JICA Study Team)

(4) Common Issues to be examined for the Implementation of Sediment Countermeasures

The following items need to be examined as common issues for the implementation of sediment countermeasures mentioned in above (1) to (3).

- Preparation and implementation of appropriate environmental management plan and environmental monitoring plan
- Establishment of an organization to implement environmental management plan and environmental monitoring plan
- Establishment of a framework for reporting environmental monitoring result

(5) Items to be examined for the Implementation of Comprehensive Sedimentation Countermeasures

Due to urgency in implementing sedimentation countermeasures, this Study proposes at (1) and (2) in Section 4.2.3 to conduct several countermeasures comprehensively, namely: i) flushing through sand bypass tunnel and diversion weir, ii) flushing, and iii) dredging. Expected impacts for each countermeasure are examined in Section 6.3.3. When each countermeasure is implemented comprehensively, the degree of impact is expected to increase. For instance, degradation of water quality worsens when a diversion weir is constructed since quantity of water inflow to Mrica Reservoir seemed decreasing. By conducting flushing operation with the degraded condition of water quality, impact to environment is considered to be much serious compared with flushing operation during usual condition. Accordingly, examination of an appropriate plan for conducting sediment countermeasure activities is necessary in addition to examination of mitigation measures against the expected environmental impact.

(7) Other Issues to be examined

AMDAL approval is necessary depending on the length of tunnel and dredging amount. Thus, confirmation with the local environmental authority on the necessity of AMDAL is important when the tunnel length and amount of sediment flushing is examined in detail. In addition, impact caused by implementing activities related to the sedimentation measures needs to be examined further.

6.4 Environmental Checklist in the JBIC Guidelines

The environmental checklist as per the JBIC Guidelines for the proposed rehabilitation activities at Sutami and Wlingi hydropower stations and the countermeasures for sedimentation of Mrica Reservoir are shown in Tables 6.4-1 and 6.4-2, respectively.

6.5 Environmental and Social Issues of Brantas River Basin and Saguling Reservoir

6.5.1 Current Condition of the Brantas River Basin

(1) General

During the site investigation related to Sutami and Wlingi hydropower stations, examinations for environmental and social conditions of Brantas River basin including Sutami and Wlingi Reservoirs as well as briefly examination of the Sengguruh Reservoir³ was conducted. Because of the limited period, confirmation was done through interviews with the environmental departments at each reservoir and by reviewing existing water quality conditions presented in the water quality monitoring report.

(2) Situation of Environmental Assessment at the Existing Reservoirs

Environmental impact assessment was not conducted for the Sutami and Wlingi Reservoirs since they were constructed before the AMDAL relevant regulations were enforced. However, environmental study was conducted for said reservoirs in 2004 with the purpose of initiating internal confirmation of the current environmental situation around both reservoirs. The report on the study result was prepared and submitted to the Ministry of Environment. This however was not considered as an official report. Therefore, there was no approved ANDAL/ RKL/ RPL for both reservoirs, and no comments were received from the AMDAL committee.

Apart from the report and as a part of Corporate Social Responsibilities (CSR), PJB has conducted regular public consultations (i.e., once a year) with neighboring communities to obtain information on the condition of the reservoir and power station. However, detailed information and results of regular public consultations were not described in the report regarding CSR namely “Laporan Lealissi Program CSR/ Community Development, PT PJB Brantas (Tahun 2009)”.

As a part of CSR, plantation at the greenbelt area has also been conducted in order to enhance nature conservation around the reservoir area.

(3) Pollution Control

1) Result of water quality monitoring

PJB conducted monitoring (mainly machine maintenance) every three months, while water quality monitoring was conducted once a year by an external partner.

At the reservoirs in Brantas River basin, PJT I also regularly conducted water quality monitoring at the reservoirs and rivers. The monitoring parameters included temperature, TDS, TSS, pH, BOD, COD, DO, TP, NO₃, NH₃, F, NO₂, oil and grease, although only BOD, COD and DO levels were publicized in the monitoring report, Pemantauan Kualitas Air Di Das

³ The Sengguruh Reservoir locates just upstream of the Sutami Reservoir and functions sediment and garbage storage dam for the Sutami Dam. (Refer to Section 3.4)

kali Brantas Tahun 2008.

i) Sutami Reservoir

Water quality monitoring was conducted at three locations by manual sampling and one location by automatic sampling in Sutami Reservoir. Both BOD and DO levels almost met the standard, while COD was beyond the normal value. The monitoring result is shown in Table 6.5-1.

ii) Wlingi Reservoir

Water quality monitoring was conducted at one location by automatic sampling point in Wlingi Reservoir. Water quality monitoring was conducted every four months, and most of the parameters met the standard level except for COD measured in April. The Monitoring result is shown in Table 6.5-1.

2) Implementation structure of water quality monitoring

The results of both monitoring by PJB and PJT I were compiled and reported to PJB Jakarta office via PJB Surabaya office.

Regarding water quality monitoring conducted by PJT I, monitoring parameters and frequency were set for each river. Meanwhile, the laboratory of PJT I conducted water quality monitoring by themselves. The monitoring results were compiled in the annual report, and distributed to all stakeholders including the environmental department in a municipality.

3) Structure of environmental management at Brantas River basin

Current environmental management structure is formulated with the environmental department in Malang Region and PJT I. When the environmental department received inquiries from the public, they explained the condition based on the report from PJT I. They were only in a position to coordinate between the public and PJT I. However, PJT I request the environmental department could have responsibility in managing environmental conditions in the Brantas River basin not only the coordination. Hence, the environmental management structure was not yet established firmly.

Table 6-5-1 Result of Water Pollution Monitoring at Sengguruh, Sutami and Wlingi Reservoir

	Location	Parameter	Standard	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Sengguruh	Bridge	BOD	6.0	2.1			3.0			3.0				4.0	
		COD	50.0	4.4			22.1			4.0				8.4	
		DO		5.8			7.2			6.6				6.7	
	Upstream of Sutami Reservoir	BOD	6.0	3.8	3.2	2.9	2.3	3.3	5.1	3.4	2.6	2.5	4.0	5.4	3.4
		COD	50.0	12.3	20.6	11.0	8.9	11.2	31.1	7.7	9.0	10.0	18.2	14.5	9.9
		DO		5.3	6.5	8.1	6.1	5.5	9.4	5.5	6.7	5.1	6.6	7.3	4.9
Sutami	Middle of Sutami Reservoir	BOD	6.0	3.5	3.8	3.4	7.2	12.8	3.4	4.2	5.5	4.1	4.3	6.1	4.6
		COD	50.0	13.4	11.8	7.7	32.4	18.7	19.9	15.8	18.8	16.4	8.9	27.4	15.3
		DO		5.4	5.8	6.5	5.8	6.0	6.2	6.4	3.7	7.1	6.3	7.2	4.9
	Downstream of Sutami Reservoir	BOD	6.0	2.9	1.8	2.1	8.9	20.6	5.4	5.5	6.0	6.9	6.9	4.1	5.6
		COD	50.0	4.9	6.5	5.3	27.4	11.3	34.7	23.8	27.8	21.8	27.6	7.2	22.3
		DO		5.7	4.4	5.3	5.9	6.1	7.2	6.9	3.6	9.7	5.5	4.6	4.6
	Ferry Bridge	BOD	6.0	2.3	2.3	2.1	2.9	1.9	4.9	2.4	1.6	3.4	1.7	2.2	3.2
		COD	50.0	4.3	14.5	4.2	12.2	17.6	6.5	3.9	2.9	3.7	3.4	4.2	8.7
		DO		2.2	2.1	2.9	6.2	2.0	1.5	4.3	4.5	7.6	4.3	3.9	3.6
	Kasamben Ferry	BOD	6.0	2.8			2.2			4.6				4.4	
		COD	50.0	4.7			10.2			6.0				4.6	
		DO		4.9			6.4			4.8				7.2	
	Wlingi Reservoir D/S	BOD	6.0	2.5			2.2			4.2				3.5	
		COD	50.0	10.2			9.5			7.9				8.3	
		DO		8.6			7.8			6.3				5.0	
Wlingi	Lodoyo Reservoir D/S	BOD	6.0	2.6			2.1			2.9				6.4	
		COD	50.0	6.3			13.5			4.0				7.4	
		DO		6.6			7.0			5.0				8.1	

(Source: Prepared by JICA Study Team based on Pemantauan Kualitas Air Di Das kali Brantas Tahun 2008)

(4) Natural Environment

It was confirmed from the existing reports that both Sutami and Wlingi reservoirs do not include any protected area although there were no descriptions about protected areas in the review of the ANDAL report. It is noted however that there is a nature conservation forest called Grand Forest Park R. Soerjo, which consist of pine natural forest, savanna, and mountain rainforest. Grand Forest Park R. Soerjo locates approximately 30km south from Sutami Reservoir.

The following flora and fauna were observed around both reservoirs although these were not included in the list of protected species in Law No.7/1999 as well as CITES. The Internal Union for Conservation of Nature (IUCN) red list meanwhile includes the species as shown in Tables 6.5-2, 6.5-3 and 6.5-4.

Table 6.5-2 Flora at Sutami Reservoir

Indonesian Name	Scientific Name	IUCN
Akasia	Acacia Avriabiformis	-
Albasia	Albizzia Falcataria	-
Flamboyan	Delonya Regia	-
Bungur	LagestromiaPtecocarpus	-
Angasana	Indicus	-
Mahoni	Switenia Mahagoni	-
Beringin	Ficus Benyamina	-
Waru	Hibicus Tiliaceus	-
Pinus	Pinus Merkusii	VN (*1)

Remarks : VN stands for "Vulnerable" according to the definition of IUCN.

*1) Habitation of Pinus Merkusii was mentioned at Sumatra Island, according to IUCN.

(Source: Review ANDAL, Sutami Reservoir 2004, IUCN and IUCN Red List)

Table 6.5-3 Fauna at Sutami Reservoir

	Indonesian Name	Scientific Name	IUCN
1.Mamala			
	Musang	Paradoxurus Hermaphoditus	-
	Kelelawar	Pteropus Vampirus	-
	Codot	Hyposideras sp	-
2.Birds			
	Pipit	Lonchura lecogastoides	-
	Gereja	Passer montanus	LC
	Kutilang	Pycnonotus Caver	-
	Bercet	Cisticola spp	LC (*1)
	Pcikrak	Prinia familiaris	-
	Perkutut	Gopelia striata	-
	Tekukur	Straptopelia chinensis	-
	Layang-layang	Hirundo rustica	-

3. Reptiles			
	Katak daun	Hyela parasitica	-
	Katak sawah	Rana cancrivora	LC (*2)
	Katak darat	Bufo melanostotus	-
4. Amphibians			
	Kadal	Mabuia multifasciata	-
	Bunglon	Draco lineatus	-
	Biawak	Varanus sylvator	-
	Ular air	Natrix piscator	-

Remarks : LC stands for the classification of "Least Concern", according to IUCN.

*1) *Cisticola juncidis* is classified into LC, according to IUCN.

*2) *Fejervarya cancrivora* is classified into LC, according to IUCN.

(Source: Review ANDAL, Sutami Reservoir 2004 and IUCN Red List)

Table 6.5-4 Fish at Sutami Reservoir

Indonesian Name	Scientific Name	IUCN
Wakkai, Jendi, Jambai	Pangatiu Micronema	-
Keprek	Puntius Binaculata	-
Palung	Hamoala Macrolepidota	-
Tawes	Puntius Javanicus	-
Baderbang	Puntius Bramoides	-
Gabus	Ophiocephalus Striatus	-
Tombro	Cyprianus Carpio	-
Gurami	Osprhonemus Gouramy	-
Mujair	Tilapia Mosambica	-
Nila	Osteochilus Nilaticus	-
Lele	Clarias Batrocus	-

(Source: Review ANDAL, Sutami Reservoir 2004 and IUCN)

In addition to the above tables, several species, as enumerated in Table 6.5-5, were confirmed at Wlingi Reservoir.

Table 6.5-5 Additional Species Confirmed at Wlingi Reservoir

	Indonesian Name	Scientific name	IUCN
1	Birds		
	Puyuh	Tumix Susciator	
	Elang Ruuk, Egreta Garzeta (Kuntul Kecil)	Spilornis Cheela	LC
	Tilil	Triaga sp	
	Copsychus Saularis	Aur	LC
	Heleyon Cloris	Raja undang biru	
2	Amphibians		
	Ular belang	Bungarus candidus	
3	Fishes		
	Labepbarbus sp	Sengkaleng	

(Source: Review ANDAL, Wlingi Reservoir 2004)

(5) Social Environment

Social environmental issues, caused by the reservoir after its operation, are considered as impacts to land use and water use in the downstream area. According to the environmental department in PJB, there were no claims on land use or water use such as agriculture or fishery.

(6) Current Condition at Sengguruh Reservoir

1) General

The “Engineering Study for the Brantas River and Bengawan Solo River Basin” finalized in February 2005 explained that the pulp factory or tapioca factory in Malang City as well as along Lesti and Juwok Rivers are the pollution sources of Sengguruh Reservoir. The reservoir located just upstream of the Sutami Reservoir functions as sediment and garbage storage dam for the Sutami Dam, as described in Section 3.4. During the site reconnaissance in this Study, conducted on April 2010, it was found that the condition has not improved, and that wastewater and garbage continue to flow into the reservoir. Sediments mixed with sand and garbage was temporarily piled near the reservoir, causing offensive odor. It was confirmed that a master plan has not yet been prepared for the water and garbage management in Malang City, except for the planning of an industrial area.

2) Result of water quality monitoring

Manual sampling at one location and automatic sampling at another location were conducted at Sengguruh Reservoir. Although the BOD and DO almost met the standard levels, COD exceeded the acceptable value. The monitoring result is shown in Table 6.5-1.

(7) Current Condition of Natural and Social Considerations in Conducting Sediment Treatment in the Brantas River Basin

Construction of a sediment bypass channel as the sediment countermeasure for the Wlingi Reservoir is on-going at the time of this Study. AMDAL relevant regulations define the necessity to obtain AMDAL approval depending on the length of the channel. Environmental impact assessment was separately conducted by University of Brawijaya in 1995, and by Sinotech Engineering Consultants Inc. in 1996. However, actual mitigation measures were not confirmed during the Study.

PJT I and Besar Balley Willya Sungai (BBWS) have been conducting sediment countermeasures such as dredging, sediment flushing operations and sabo-dam construction works as part of their job description⁵, although the responsible party for such countermeasures is the Ministry of the

⁵ According to the study result of the “Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project, December 2005”, BAPEPEDAL requested PJR I to prepare RKL and RPL although AMDAL approval was not necessary.

Public Works. A spoil bank was established at a vacant space in Wlingi Reservoir⁶. However, the environmental condition around the spoil bank was not confirmed prior to the piling of sediment soil.

6.5.2 Recognition of Problems

PJT I, the responsible authority for the operation and maintenance of reservoirs in the Brantas River basin, has strategies on watershed management in the river basin for the short term (i.e., regular dredging), medium term (i.e., construction of sabo dam) and long term (i.e., conducting rehabilitation programs in the entire basin). In addition, they understood the importance of conducting environmental impact assessment and preparing mitigation measures at the time of implementing these strategies. Moreover, they are also concerned with the necessity to cooperate with other authorities in order to realize these strategies.

With respect to the prevention of troubles with neighbors due to the dredging treatment, PJT I paid attention to the social environment of said neighbors such as establishing a system to rent the spoil bank as the agriculture land, or considering advance announcement to neighbors, including farmers and fishermen, regarding the dredging to be implemented.

6.5.3 Suggestions for the Next Stage

Establishment of the framework discussed below is recommended to be considered as the next stage.

(1) Pollution Control

Although wastewater and garbage from Malang City is considered as one of the reasons for the water pollution at Brantas River, there was no master plan related to wastewater and garbage management. Preparation of such plan is necessary as soon as possible.

(2) Establishment of Cooperation Mechanism for Water Quality Improvement

It was confirmed from interview survey that demarcation or cooperation among relevant authorities for the management of Brantas River was vague. Confirmation of the role and responsibility on river environmental management is necessary within relevant parties such as the environmental department in a municipality or region. Moreover, cooperation among relevant parties for water quality improvement and enhancement of river environmental management are necessary to be examined.

The “Basin Coordination Committee” for the Brantas River basin has been established consisting of members such as the deputy mayor as the committee leader, and staff from each relevant

6 According to the study result of the “Water Resources Existing Facilities Rehabilitation and Capacity Improvement Project, December 2005”, the land for three spoil banks around Sutami Reservoir and Wling Reservoir was property of PJT I. Regarding spoil bank around Sutami Reservoir, it was used by local residents as cultivated area.

authority in a province⁷. However, it does not work effectively. Therefore, reviewing the structure of the committee is necessary to ensure comprehensive management of the Brantas River basin.

(3) Establishment of Checking Function on Management of the Brantas River Basin

It is necessary to monitor the environmental administration for sound river basin management. Therefore, establishment of a committee to monitor river basin management is considered as necessary in the future.

In Japan and Europe, the monitoring on environmental and social considerations is conducted by a committee, which involves academic people. Said committee is established to examine the impacts caused by the maintenance of reservoir and conducting sediment treatment. In order to effectively conduct river basin management at Brantas River, involvement of academic people in the Basin Coordination Committee is important. In addition, participation of the committee in environmental and social monitoring is essential.

⁷ According to “Brantas River Case Study Indonesia (Dr. Kikkeri V. Pamu, P.E., December 2004)” NGOs and academic people were not included in the committee as of December 2004.

Table 6.4-1 Environmental Checklist for Sutami and Wlingi Power Stations (1/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1 Permits and Explanation	(1) EIA and Environmental Permits	<p>① Have EIA reports been officially completed?</p> <p>② Have EIA reports been approved by authorities of the host country's government?</p> <p>③ Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?</p> <p>④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?</p>	①-④ Necessity to prepare EIA report is not expected though confirmation to prepare environmental management plan and environmental monitoring plan to local environmental agency is necessary.
	(2) Explanation to the Public	<p>① Are contents of the project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public?</p> <p>② Are proper responses made to comments from the public and regulatory authorities?</p>	①-② Explanation of the rehabilitation activities to public is necessary prior to conducting activities.
2 Mitigation Measures	(1) Air Quality	① Do air pollutants, such as sulfur oxides (SOx), nitrogen oxides (NOx), and soot and dust, and dioxins emitted from various sources, such as incinerators, and vehicles used for waste collection and transportation comply with the country's emission standards and ambient air quality standards?	① Appropriate vehicle operation according to Indonesian regulations and standards is necessary.
	(2) Water Quality	<p>① Do effluents from various facilities comply with the country's effluent standards and ambient water quality standards?</p> <p>② Does the water quality of leachates from the waste disposal sites comply with the country's effluent standards and ambient water quality standards?</p> <p>③ Are adequate measures taken to prevent contamination of surface water and groundwater by these effluents and leachates?</p>	<p>① Effluent from power station is almost met the Indonesian standard though some parameters exceeded it.</p> <p>②-③ Wastes generated from proposed rehabilitation activities are expected to be disposed at an existing waste treatment plant which meets the Indonesian standard for waste management. Therefore, leachate quality is expected to meet the Indonesian standard accordingly.</p>
	(3) Wastes	<p>① Are wastes, such as treatment residues, cinder, and fly ash generated from crushing and segregation processes, and diverted wastes from composting process properly treated and disposed of in accordance with the country's standards?</p> <p>② Are hazardous and dangerous wastes properly segregated from other wastes, stabilized, treated, and disposed of in accordance with the country's standards?</p>	①-② Wastes generated from proposed rehabilitation activities are expected to be treated at an existing waste treatment plant which meet the Indonesian standards.
	(4) Soil Contamination	① Are adequate measures taken to prevent contamination of soil and groundwater by leachates from the waste disposal sites?	① Wastes generated from proposed rehabilitation activities are expected to be disposed at an existing waste treatment plant which meets the Indonesian standard for waste management. Therefore, countermeasures for leachate is expected to be conducted by an existing waste treatment plant according to the Indonesian standards.
	(5) Noise and Vibration	① Do noise and vibrations generated by the facility operations (especially incinerators, waste segregation and crushing facilities), and vehicle traffic for waste collection and transportation comply with the country's standards?	① Rehabilitation activities proposed in this Study does not include impact noise and vibration generated by facility operations. Regarding noise and vibration due to vehicle transportation, it will be accord with the Indonesian standards.
	(6) Odor	① Are there any odor sources? Are adequate odor control measures taken?	① Any odor sources are not expected.

Table 6.4-1 Environmental Checklist for Sutami and Wlingi Power Stations (2/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
3 Natural Environment	(1) Protected Areas	① Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?	① The project site does not include protected areas.
	(2) Ecosystem	① Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)? ② Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions? ③ If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem? ④ Is there a possibility that the project will adversely affect aquatic organisms? If impacts are anticipated, are adequate measures taken to reduce the impacts on aquatic organisms? ⑤ Is there a possibility that the project will adversely affect vegetation and wildlife? If impacts are anticipated, are adequate measures taken to reduce the impacts on vegetation and wildlife?	① The project site does not encompass primeval forests, tropical rain forest or ecologically valuable habitats. ② It is found that a species classified in vulnerable on IUCN red list is said to be located around the Sutami power station according to ANDAL report. ③ Significant ecological impact is not expected by conducting proposed rehabilitation activities. ④ Proposed rehabilitation activities is not expected to affect adverse impact to aquatic organisms. ⑤ Proposed rehabilitation activities is not expected to affect adverse impact to vegetation and wildlife.
	(3) Management of Abandoned Sites	① Are environmental protection and restoration plans (such as landfill gas and leachate collection and treatment systems, prevention of illegal dumping, and reforestation) after facility closure considered? ② Is a sustainable management framework for the abandoned sites established? ③ Are adequate financial provisions secured to manage the abandoned sites?	①-③ Proposed rehabilitation activities does not include construction of new waste treatment plan, therefore impacts from ①-③ are not expected.
4 Social Environment	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? ④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	①-⑦ Involuntary resettlement is not expected.

Table 6.4-1 Environmental Checklist for Sutami and Wlingi Power Stations (3/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
4 Social Environment	(2) Living and Livelihood	① Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? ② Are considerations given to the existing recovery systems, including waste pickers? ③ Is there a possibility that waste transportation will adversely affect the regional traffic? ④ Is there a possibility that effluents from the project and leachates from the waste disposal sites will adversely affect fisheries and other water uses by local inhabitants (especially drinking water)? ⑤ Is there a possibility that pathologic insects or other disease vectors will breed as a result of the project?	① Although some impact on noise and vibration due to proposed rehabilitation activities are expected, serious impact is not expected since Sutami and Wlingi power stations locate away from residential area. ② Impact to existing recovery systems including waste pickers is not expected. ③ Some impact due to transportation of construction vehicles and machines are expected, it will be mitigated by preparing appropriate vehicle operation plan. ④ Regarding effluent from power stations, any adverse impact to water use from downstream of Sutami and Wlingi power stations are not reported so far. In addition, water quality degradation due to conducting proposed rehabilitation activities is not expected. As for leachates from waste treatment plant, it is expected to be treated according to the Indonesian standards. ⑤ Serious impact due to pathologic insects or other disease vectors is not expected.
	(3) Heritage	① Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	① Further confirmation is necessary.
	(4) Landscape	① Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	① Rehabilitation activities will not affect to local landscape adversely.
	(5) Ethnic Minorities and Indigenous Peoples	① Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples? ② Are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous peoples?	① There is no specific regulations on ethnic minorities and indigenous people. ② Although further confirmation is requested, impact to especially ethnic minorities and indigenous people is not expected.
	(1) Impacts during Construction	① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)? ② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts? ③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts? ④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?	① Further examination to the points mentioned in the section 6.2.4 is necessary for expected impact. ② Serious impact to natural environment is not expected since proposed rehabilitation activities do not include construction activities. ③ Further examination to the points mentioned in the section 6.2.4 is necessary for expected impact. ④ Since health and safety education to workers is provided according to interview, it is also provided in the proposed rehabilitation activities.

Table 6.4-1 Environmental Checklist for Sutami and Wlingi Power Stations (4/4)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
5 Others	(2) Monitoring	① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts? ② Are the items, methods and frequencies included in the monitoring program judged to be appropriate? ③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)? ④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?	①-④ Further examination is necessary since adequate monitoring and report of monitoring result are indispensable.
6 Note	Reference to Checklist of Other Sectors	① Where necessary, pertinent items described in the Forestry Projects checklist should also be checked (e.g., projects including large areas of deforestation).	① Proposed rehabilitation activities does not include construction of new waste treatment plant.
	Note on Using Environmental Checklist	① If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	① Impact to transboundary or global issues is not expected.

1) Regarding the term “Country’s Standards” mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are made, if necessary.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan' experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Table 6.4-2 Environmental Checklist for Mrica Reservoir (1/3)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
1 Permits and Explanation	(1) EIA and Environmental Permits	<p>① Have EIA reports been officially completed?</p> <p>② Have EIA reports been approved by authorities of the host country's government?</p> <p>③ Have EIA reports been unconditionally approved? If conditions are imposed on the approval of EIA reports, are the conditions satisfied?</p> <p>④ In addition to the above approvals, have other required environmental permits been obtained from the appropriate regulatory authorities of the host country's government?</p>	<p>① It is necessary to confirm necessity of AMDAL approval with a local environmental agency since AMDAL approval is requested to channel construction according to its length and sediment volume.</p> <p>② It is also necessary to confirm necessity of AMDAL approval regarding construction of weir since it is planned to be constructed in a reservoir.</p>
	(2) Explanation to the Public	<p>① Are contents of the project and the potential impacts adequately explained to the public based on appropriate procedures, including information disclosure? Is understanding obtained from the public?</p> <p>② Are proper responses made to comments from the public and regulatory authorities?</p>	<p>①-② It is expected that explanation to the public will be done in a process of AMDAL study if it is necessary. Even though AMDAL approval is not necessary, appropriate explanation to public is requested to be carried out.</p>
2 Mitigation Measures	(1) Water Quality	<p>① Is there a possibility that changes in river flow downstream (mainly water level drawdown) due to the project will cause areas that do not comply with the country's ambient water quality standards?</p>	<p>① Changes in river flow downstream will not be expected due to construction of sand bypass tunnel and diversion weir.</p>
	(2) Wastes	<p>① In the case of that large volumes of excavated/dredged materials are generated, are the excavated/dredged materials properly treated and disposed of in accordance with the country's standards?</p>	<p>① Generated waste will be treated and disposed properly according to Indonesian regulation.</p>
	(3) Subsidence	<p>① Is there a possibility that the excavation of waterways will cause groundwater level drawdown or subsidence? Are adequate measures taken, if necessary?</p>	<p>① It is expected that groundwater level will be drawdown due to project though its impact will be limited. Therefore, possibility of subsidence is considered as low. Countermeasures will be examined accordingly.</p>
3 Natural Environment	(1) Protected Areas	<p>① Is the project site located in protected areas designated by the country's laws or international treaties and conventions? Is there a possibility that the project will affect the protected areas?</p>	<p>① Impact to protected area is not expected.</p>
	(2) Ecosystem	<p>① Does the project site encompass primeval forests, tropical rain forests, ecologically valuable habitats (e.g., coral reefs, mangroves, or tidal flats)?</p> <p>② Does the project site encompass the protected habitats of endangered species designated by the country's laws or international treaties and conventions?</p> <p>③ If significant ecological impacts are anticipated, are adequate protection measures taken to reduce the impacts on the ecosystem?</p> <p>④ Is there a possibility that hydrologic changes, such as reduction of the river flow, and seawater intrusion up the river will adversely affect downstream aquatic organisms, animals, vegetation, and ecosystems?</p> <p>⑤ Is there a possibility that the changes in water flows due to the project will adversely affect aquatic environments in the river? Are adequate measures taken to reduce the impacts on aquatic environments, such as aquatic organisms?</p>	<p>①-② Since the protected area does not locate near the project site, habitation of protected species is not expected. However, further examination is necessary.</p> <p>③-④ Since decreasing volume of water inflow to the reservoir is expected, water quality degradation of the reservoir and impact to downstream area are expected.</p> <p>⑤ Further examination of mitigation measures on aquatic environment mentioned in the section 6.4.4 in the report is necessary.</p>

Table 6.4-2 Environmental Checklist for Mrica Reservoir (2/3)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
3 Natural Environment	(3) Hydrology	① Is there a possibility that hydrologic changes due to the project will adversely affect surface water and groundwater flows?	① Sand bypass is planned to cross groundwater at some sections of branch downstream. However, impact will be limited if it will be caused.
	(4) Topography and Geology	① Is there a possibility that excavation of rivers and channels will cause a large-scale alteration of the topographic features and geologic structures in the surrounding areas?	① Alternation of topographic features and geologic structure in the surrounding area is not expected.
4 Social Environment	(1) Resettlement	① Is involuntary resettlement caused by project implementation? If involuntary resettlement is caused, are efforts made to minimize the impacts caused by the resettlement? ② Is adequate explanation on relocation and compensation given to affected persons prior to resettlement? ③ Is the resettlement plan, including proper compensation, restoration of livelihoods and living standards developed based on socioeconomic studies on resettlement? ④ Does the resettlement plan pay particular attention to vulnerable groups or persons, including women, children, the elderly, people below the poverty line, ethnic minorities, and indigenous peoples? ⑤ Are agreements with the affected persons obtained prior to resettlement? ⑥ Is the organizational framework established to properly implement resettlement? Are the capacity and budget secured to implement the plan? ⑦ Is a plan developed to monitor the impacts of resettlement?	① Involuntary resettlement is not expected. However, there is a possibility of land acquisition with involuntary resettlement when design is studied in detail.
	(2) Living and Livelihood	① Is there a possibility that the project will adversely affect the living conditions of inhabitants? Are adequate measures considered to reduce the impacts, if necessary? ② Is there a possibility that the amount of water (e.g., surface water, groundwater) used by the project will adversely affect the downstream fisheries and other water uses? ③ Is there a possibility that water-borne or water-related diseases (e.g., schistosomiasis, malaria, filariasis) will be introduced?	① Temporal impact on noise and traffic congestion are expected, and further examination to the points raised in the section 6.4.4 is necessary. ② There is a risk of water quality degradation at downstream area, and therefore further examination to the points raised in the section 6.4.4 in the report is necessary. ③ According to information from Ministry of Health in Indonesia, reservoir area is regarded as "middle risk" of malaria. Therefore, a risk of water-related diseases will be expected, and examination of mitigation measures is necessary.
	(3) Heritage	① Is there a possibility that the project will damage the local archeological, historical, cultural, and religious heritage sites? Are adequate measures considered to protect these sites in accordance with the country's laws?	① Further confirmation is necessary.
	(4) Landscape	① Is there a possibility that the project will adversely affect the local landscape? Are necessary measures taken?	① Impact to local landscape is not expected.

Table 6.4-2 Environmental Checklist for Mrica Reservoir (3/3)

Category	Environmental Item	Main Check Items	Confirmation of Environmental Considerations
	(5) Ethnic Minorities and Indigenous Peoples	<p>① Does the project comply with the country's laws for rights of ethnic minorities and indigenous peoples?</p> <p>② Are considerations given to reduce the impacts on culture and lifestyle of ethnic minorities and indigenous peoples?</p>	<p>① There is no specific regulations on ethnic minorities and indigenous people. However, consideration of human rights stipulated by the Indonesian regulation is necessary.</p> <p>② Although further confirmation is requested, impact to especially ethnic minorities and indigenous people is not expected.</p>
5 Others	(1) Impacts during Construction	<p>① Are adequate measures considered to reduce impacts during construction (e.g., noise, vibrations, turbid water, dust, exhaust gases, and wastes)?</p> <p>② If construction activities adversely affect the natural environment (ecosystem), are adequate measures considered to reduce impacts?</p> <p>③ If construction activities adversely affect the social environment, are adequate measures considered to reduce impacts?</p> <p>④ If necessary, is health and safety education (e.g., traffic safety, public health) provided for project personnel, including workers?</p>	<p>①-③ Examination to the points raised in the section 6.4.4 is necessary.</p> <p>④ Health and safety education is necessary to be conducted during construction.</p>
	(2) Monitoring	<p>① Does the proponent develop and implement monitoring program for the environmental items that are considered to have potential impacts?</p> <p>② Are the items, methods and frequencies included in the monitoring program judged to be appropriate?</p> <p>③ Does the proponent establish an adequate monitoring framework (organization, personnel, equipment, and adequate budget to sustain the monitoring framework)?</p> <p>④ Are any regulatory requirements pertaining to the monitoring report system identified, such as the format and frequency of reports from the proponent to the regulatory authorities?</p>	<p>① Although detailed examination is necessary, it is requested to conduct continuous monitoring on the items which are expected to cause impact.</p> <p>② It was confirmed from interview to relevant parties that monitoring items, frequency and method were appropriate.</p> <p>③ It was confirmed from interview to relevant parties that adequate monitoring framework is established in the proponent.</p> <p>④ Monitoring report system is not exactly described, but it is considered that such system is already established through a routine work.</p>
6 Note	Note on Using Environmental Checklist	If necessary, the impacts to transboundary or global issues should be confirmed (e.g., the project includes factors that may cause problems, such as transboundary waste treatment, acid rain, destruction of the ozone layer, or global warming).	Impact to transboundary or global issues is not expected.

1) Regarding the term "Country's Standards" mentioned in the above table, in the event that environmental standards in the country where the project is located diverge significantly from international standards, appropriate environmental considerations are made, if necessary.

In cases where local environmental regulations are yet to be established in some areas, considerations should be made based on comparisons with appropriate standards of other countries (including Japan' experience).

2) Environmental checklist provides general environmental items to be checked. It may be necessary to add or delete an item taking into account the characteristics of the project and the particular circumstances of the country and locality in which it is located.

Chapter 7
Conclusion and Recommendation

CHAPTER 7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

(1) Needs for Effective Use of Hydropower Stations

The installed capacity of generating facilities owned by PLN is 25,594 MW as of 2008. Out of this capacity, the thermal power shares 72 % (as the total of steam at 33%, combined cycle at 29% and gas at 10%), while hydropower has 14 % and diesel has 12%. Major role of hydropower in the power network is for peak load operation, but they are forced to operate for base load operation as long as water is available, to reduce fuel cost for thermal power plants. Java Bali power system has higher priority on power development over the other systems since it shares 72% of the whole power system in Indonesia with the biggest demand center of Jakarta. To cope with the growing power demand estimated at 9.8% per year, the first crash program has been implemented with a total of 10,000 MW coal-fired thermal power plants. Further, the second crash program is on-going. The second program incorporates the development of hydropower and geothermal power in addition to coal-fired power plants. Hydropower has a remarkable benefit in terms of environmental and economical aspects because it uses renewable energy, and has low operation cost.

Under such circumstance, the necessity of effective use of the existing hydropower stations has been increasing not only to strengthen the power supply capacity through new development but also to immediately realize a present energy consumption structure based on non-fossil fuels that can ultimately contribute to the from reduction of greenhouse gas emissions.

(2) Sedimentation of Hydropower Stations

Sedimentation problem in the reservoir is one of the serious problems in the operation of hydropower stations. The reservoir-type power station suffers from the decrease of dependable power output due to reducing the effective storage volume and from the difficulty of utilizing smooth intake water due to sedimentation around the intake. The run-of-river type power station that has no storage volume also suffers from the intake problem as described above.

The geology of the Java Island in Indonesia consists mainly of erupted volcanic materials which are easily eroded. Moreover, the watershed of the reservoir has considerable population and its crop agriculture is flourishing.

Hence, from the geological and social environmental points of view, the sedimentation problems are likely to occur in the reservoir located in Java Island.

On the other hand, even if there are sedimentation problems in the reservoirs located in the Sulawesi, the Kalimantan and the Sumatra islands, they can be considered not overly serious comparing with the geological and social aspects in Java Island.

(3) Screening of Hydropower Stations

Four hydropower stations located in Java Island (i.e. Saguling in West Java, Soedirman in Central Java and Sutami & Wlingi in East Java) were selected for further site investigations at the second screening with high priority given based on the following criteria: i) regional effectiveness, ii) degree of deterioration, iii) degree of sedimentation, iv) expected effect of rehabilitation, and iv) urgency. The results of the site investigations for the four hydropower stations are as follows:

1) Sutami Hydropower Station (105 MW)

Sutami commenced the operation in 1973 and has been operating for over 36 years. The generating equipment has been maintained well by power station staffs and severe damage or heavy accident causing stoppage of the machines has not been recorded so far. Moreover, major components such as turbine runner, generator, governor, AVR and control system have not been rehabilitated since the commencement of its operation. Sutami places high priority not only for power distribution to the regional area and also for black start of Paiton thermal power plant. After the interruption of 150 kV transmission lines due to the eruption of Mud Volcano in 2006, Sutami contributes more reliable and stable power supply to the regional area than before.

2) Wlingi Hydropower Station (54 MW)

Wlingi has been operating for over 31 years as a cascade power station of Sutami since 1978. Wlingi has the same function as Sutami, but major components such as turbine runner, generator, governor, and control system have not been rehabilitated since its commencement of operation.

3) Sedimentation Problems in Brantas River Basin

Sengguruh Dam, the Sutami Dam, Lahor Dam, Wlingi Dam and the Lodoyo Weir exist in the Brantas River basin in the East Java province. Except Lahor Dam, these dams have hydropower stations in the downstream. These dams have been constructed in the 1970s and they have suffered from sedimentation problems. In particular, the Wlingi Reservoir was almost filled with volcanic ashes due to the eruption of Mt. Kelud several times in the past. At the moment, the dredging works at each dam above is carried out. In addition, sediment bypass channel construction to divert sediment inflow from upstream to downstream of the Wling Dam and sabo dam construction in the watersheds of Sengguruh Dam and Wlingi Dam are on-going under the financial assistance of Japanese ODA and own fund of GoI by PJT I and BBWS, through the Ministry of the Public Works.

According to PJB, the service life of Sutami Dam will be prolonged until around 2055 after the

above works have been completed as scheduled. Meanwhile, operation of the Wlingi Dam is expected to be extended depending on the effective operation of the above sabo dams and sediment bypass channel.

4) Soedirman Hydropower Station (180.9 MW)

Soedirman has been operating for 21 years since 1988 and is well maintained by power station staff. The reservoir is facing a serious sedimentation problem, but the power generation is not affected at the moment. The control system was replaced with a computerized system with automatic data logger in 2006.

5) Sedimentation Problems of Soedirman (Mrica) Reservoir

Since the Soedirman (Mrica) dam was constructed, sediment inflow into the reservoir, which is more than expected, has been experienced. IP has predicted that in 2014, 80% (118.6 MCM) of the gross reservoir capacity will be buried and sedimentation will reach up to the HWL in 2021. Under these circumstances, IP, in cooperation with the local government and other agencies, is now executing watershed management such as construction of sabo dams and campaign to residents on the present growing crop conversion, etc. so as to maintain the reservoir function. However, because the annual sedimentation to the reservoir is very huge and around 4.2 MCM, it is very questionable whether watershed management countermeasures alone can solve the sedimentation problems or not.

The Soedirman (Mrica) Reservoir is utilized for downstream irrigation water supply (10,000 ha) and flood control besides power generation. Implementation of the radical countermeasures to solve the sedimentation problems should be carried out not only to keep function of water utilization but also to ensure flood control function of the Soedirman (Mrica) Reservoir.

6) Saguling Hydropower Station (700 MW)

Saguling has been operating for 24 years since 1985 and is well maintained by power station staffs. The generated power is directly connected to Java-Bali 500 kV transmission line network. Saguling has an important function of LFC to stabilize the power system in addition to peak and base load operations. Major components have not been rehabilitated so far. Due to water quality and chemical contents, the cooling water system is damaged and has suffered from frequent cleaning of filters. Thus, replacement of the existing governor system and embedded cooling water pipes has been contracted under the financial assistance of JBIC export credit line. It is being progressed now and just awaiting the effectiveness of the contract.

7) Sedimentation Problems of Saguling Reservoir

Saguling Dam has a gross reservoir capacity of 875 MCM. According to IP, the annual sedimentation to the reservoir is observed at around 4 MCM. However, since the reservoir capacity is very big, and it can still be functional for around 30 years from now. The

problems at the moment are the reservoir water pollution and intruded waste materials from households. They are caused by large volume of sewage/ waste materials from households and factories in Bandung City which is located in the watershed of the Saguling Reservoir and has a population of 2,500,000. The solution to these problems is an urgent matter in this region. The study for the water resources management plan in the Citram River basin including the Saguling Reservoir watershed is now on-going under the ADB. The water quality and the sediment problems in the Saguling Reservoir shall be solved as one of the main components in the ADB study.

As a result of the evaluation after the site investigation, the following two (2) rehabilitation works are proposed.

- i) Rehabilitation works for the generating equipment in Sutami Hydropower Station
- ii) Countermeasure for sedimentation in Soedirman (Mrica) Reservoir

The rehabilitation work at Sutami is proposed to be combined with the rehabilitation works at Wlingi to enhance effectiveness because the both power stations were constructed in the 1970's as cascade power stations in the Brantas River.

(4) Rehabilitation Works in Sutami and Wlingi Hydropower Stations

1) Based on the following evaluation of major components of generating equipment, the outline of recommended rehabilitation work is summarized below.

- Turbine runner: Corrosions of deep cavitations pitting are observed.
- Inlet valve: Water leakage is continuously observed.
- Generator: Residual life of stator coils has been evaluated as 2~3 years by examination carried out in 2004, and temperature of thrust bearing is increased by more than 10 degree against that for initial stage.
- Governor & AVR: Mechanical and analog type and no spare parts are available in the market.
- Control and protection panel: Old fashion type (analog and mechanical relays) and no spare parts are available in the market, and no automatic data logger is equipped with.

2) Scope of Rehabilitation Works

For Sutami Hydropower Station

Replacement of turbine runner, guide vanes, turbine bearing, inlet valve, governor, generator stator and rotor windings, thrust bearing, AVR and control and protection panels

For Wlingi Hydropower Station

Replacement of runner blade, runner hub, guide vanes, turbine bearing, governor, generator stator and rotor windings, thrust bearing and control and protection panels

3) Construction Period

Overall: 5 years

- Consultancy services: 1.5 years (including Consultant Tender, Design and Preparation of Tender Documents)
- Tender for rehabilitation work: 0.5 years
- Manufacturing and delivery of equipment: 1.5 years
- Rehabilitation work at site: 1.5 years (unit by unit for three units)

4) Preliminary Project Cost

	FC (x10 ⁶ JPY)	LC (x10 ⁶ Rp)	Equivalent (x10 ⁶ JPY)
1.Sutami hydropower station	3,335	30,059	3,679
2.Wlingi hydropower station	2,561	22,742	2,821
3.Total	5,896	52,801	6,500

(Prepared by JICA Study Team)

5) Economic and Financial Analysis

The economic and financial analysis was made in 2cases as Case-1 and Case-2 and the results are shown in the following tables. Rehabilitation work for Sutami is both economically and financially feasible while rehabilitation work for Wlingi alone is not feasible in Case-2. However, it will be more feasible to execute the rehabilitation project for Sutami and Wlingi as one package.

Table 7.1-1 Economic Indices for Cases-1 & 2

	Case-1			Case-2		
	EIRR(%)	NPV(x10 ⁶ Rp.)	B/C	EIRR(%)	NPV(x10 ⁶ Rp.)	B/C
1.Sutami	28	938,928	5.8	18	121,776	1.6
2.Wlingi	15	130,801	1.9	4	-59,561	0.6
3.Sutami and Wlingi	24	1,069,730	4.1	12	62,215	1.2

Table 7.1-2 Financial Indices for Cases-1 & 2

	Case-1			Case-2		
	FIRR(%)	NPV(x10 ⁶ Rp.)	B/C	FIRR(%)	NPV(x10 ⁶ Rp.)	B/C
1.Sutami	35	1,606,755	9.2	23	203,117	2.0
2.Wlingi	14	218,062	1.8	3	-138,696	0.5
3.Sutami and Wlingi	25	1,824,815	4.8	12	64,422	1.1

Note 1: Case 1: The operation of the existing machines will come to a total stop in 2019 and no longer operated..

Case 2: The operation of the existing machines will come to a total stop in 2019 and return to the service after the rectification in 2024.

Note 2: EIRR include benefit of CO2 reduction, while FIRR exclude.

(Prepared by JICA Study Team)

6) Expected Effect of Rehabilitation

Sutami and Wlingi place high priority not only for power distribution to the regional area, but

also for power supply of black start of Paiton thermal power plant located in East Java. Upon renovating the major components, Sutami and Wlingi are expected to have an extended life of another 40 years, and thus Sutami and Wlingi continue to play an important function for reliable and stable power supply in the regional area.

(5) Preliminary Study for Sediment Countermeasure for Soedirman (Mrica) Reservoir

In order to solve the serious sedimentation problems in the Serayu River basin, the local government and IP have carried out lots of examination and countermeasures so far. Referring to actual examples of sedimentation countermeasures in Japan, the Study has examined the sedimentation countermeasures in the Serayu River basin from the sustainable sediment management point of view. Results of the study are summarized as follows:

1) Establishment of Target of Sediment Management by River Basin Area and Time Frame

In order to achieve effective sediment management, the target shall be set in terms of each river basin area (upstream river basin area, reservoir area, and downstream river basin area) and time frame (short-term, medium-term, and long-term).

2) Improvement of Sediment Balance

For sustainable sediment management, sediment imbalance due to the large amount of trapped sediment in the Soedirman (Mrica) Reservoir shall be improved. Through this preliminary study, the sediment diversion weir and sediment bypass tunnel are recommended as an effective countermeasure to recover the reservoir storage volume. Capacity and layout of the structures shall be examined based on the detailed investigation results to be executed in a further study.

3) Recovery of the Reservoir Storage Volume

As a result of this study, dredging in the reservoir is effective for the recovery of the reservoir storage volume. However, as regards the dredging volume and disposal method of the dredged materials, the appropriate scale and method shall be examined based on detailed investigation.

4) Execution of Environmental Monitoring in the Downstream Area and the Realization of the Sustainable Watershed Sediment Management

In order to execute the sustainable river basin sediment management, monitoring the environment in the downstream area is very necessary. Following the improvement of the river basin sediment balance, the main items to be executed are as follows:

- Impacts on water utilization in the downstream area,
- Impacts on the aquatic life (in particular, fishes) and aquatic plant,
- Impacts on topography of the river and seashore such as riverbed fluctuation and coastal encroachment, and
- Influence on the structures of the river and seashore.

Finally, the sustainable river basin sediment management shall adopt the PDCA cycle.

5) Future Vision of the Watershed Sediment Management

Based on the examination results in Section 4.2, the future vision of the sustainable sediment management in the Serayu River basin (i.e., long-term target) is summarized in Table 7.1-3.

Table 7.1-3 Future Vision of River Basin Sediment Management

Area	Target of the Sediment Management	Countermeasures to be Implemented / Operation and Maintenance
Up-stream Basin Area	<ul style="list-style-type: none"> - Trapping of bed load - Reduction of sediment inflow 	<ul style="list-style-type: none"> - Sabo dams construction and the maintenance - Revival of forest - River basin conservation countermeasure
Reservoir Area	<ul style="list-style-type: none"> - Passing the sediment inflow - Recovery of the reservoir storage volume 	<ul style="list-style-type: none"> - Construction of sediment bypass tunnel and appropriate operation and maintenance - Execution of dredging in the reservoir and appropriate disposal of the dredged material
Downstream Basin Area	<ul style="list-style-type: none"> - Improvement of sediment balance - Minimizing the negative impact in the downstream area and maximizing the positive impact in the whole area 	<ul style="list-style-type: none"> - Execution of the environmental monitoring - Execution of the sustainable sediment monitoring through the PDCA cycle

(Prepared JICA Study Team)

6) Comprehensive Master Plan for the Watershed Sediment Management and Urgent Countermeasure

The comprehensive master plan for the watershed sediment management shall be performed first. Further, the road map for the appropriate sediment balance planning, sedimentation countermeasures, and O&M planning shall be prepared.

Based on the master plan, the urgent sedimentation countermeasures in the Serayu River basin shall be executed.

(6) Environment

1) Current Environmental Condition at Each Reservoir

i) Pollution Control

According to the defined framework in PJB or IP, water quality monitoring is regularly conducted at each reservoir. It was found that eutrophication is progressing at Sutami, Wlingi and Saguling reservoirs. The major reasons of eutrophication were considered as domestic garbage, wastewater and agricultural activities at the river basin area. With respect to Soedirman (Mrica) reservoir, COD and Cd exceeded the Indonesian standard.

ii) Natural and Social Environment

The project area at each reservoir is not classified as the protected area according to existing information and interviews with relevant parties. However, there are several

species classified as endangered or vulnerable based on IUCN definition and species classified in Appendices II on cities around the Sutami, Wlingi and Soedirman (Mrica) reservoirs. Although cultivated area has expanded downstream of each reservoir, no impact to water use or land use was reported by local residents.

2) Necessary Steps for Environmental Management for Sutami and Wlingi Reservoir

In order to tackle the water pollution faced by Sutami and Wlingi reservoirs, establishment of the following framework is recommended to be examined further:

- Preparation of master plan for waste management at Marang City,
- Review of the function of Basin Coordination Committee at the Brantas River for appropriate environmental management at the river basin, and
- Involvement of academic person in the Basin Coordination Committee to perform appropriate environmental monitoring as well as examination of environmental and social considerations

3) Expected Impact of Rehabilitation Work at Sutami and Wlingi Hydropower Stations

In order to conduct the rehabilitation activities at Sutami and Wlingi hydropower stations, the following impacts are mainly expected. Thus, further examination of the expected impacts is necessary.

Table 7.1-4 Expected Impact of Rehabilitation Work at Sutami and Wlingi Hydropower Stations

Expected Impact	Issues to be Considered Further
Oil leakage during rehabilitation work	Appropriate monitoring during operation
Waste (e.g., oil, concrete, steel, mud, etc)	Appropriate treatment according to Indonesian regulations
Noise and vibration, dust	Preparation of environmental management plan and environmental monitoring plan

(Prepared JICA the Study Team)

4) Expected Impact of Sediment Countermeasure at Mrica Reservoir and Serayu River Basin

In order to conduct watershed sediment management in the Serayu River basin and countermeasures at Soedirman (Mrica) Reservoir, the following impacts are mainly expected. Thus, further examination of the expected impacts is necessary.

Table 7.1-5 Expected Impact of Sediment Countermeasure at Mrica Reservoir and Serayu River Basin

Expected Impact	Issues to be Considered Further
Impact on water use at downstream area	Confirmation of water use and land use at downstream area
Impact on aquatic environment	Examination of impact on fishery at downstream area
Possibility of land acquisition and involuntary resettlement due to construction of weir	Conduct of appropriate consultation with land owners
Impact on existing infrastructure due to change of river bed level	Examination of impact on existing infrastructure such as bridges or banks

(Prepared by JICA Study Team)

7.2 Recommendations

7.2.1 Rehabilitation Works at Sutami and Wlingi Hydropower Stations

(1) Timing of Rehabilitation Works

The reliable life of hydropower plant prior to major rehabilitation is typically estimated between 30 and 50 years according to IEC 62256 depending on type of unit, design, and severity of service. Sutami and Wlingi hydropower stations were constructed in the 1970's and their operating years nearly reach their reliable lives. It is considered that their reliable and stable operations are subject to high risks even if their equipment is maintained in good conditions. According to the inspection carried out in 2004, the estimated residual life of the generator stator windings was assessed at two years based on the calculated braking voltage of stator windings. In addition, spare parts for the original equipment are no longer available in the market. Therefore, it is recommended that the appropriate time for rehabilitation shall be initiated prior to the machines experiencing severe problems with its major components such as water turbine, generator, and governor etc. to avoid significant loss of revenue due to long term outage.

(2) Maintenance and Inspection of Generating Equipment

The maintenance work of hydropower generating equipment was previously carried out under time based maintenance (TBM) through annual inspection, general inspection every three years and major overhaul every six years. Recently, however, TBM is modified to condition based maintenance (CBM) in order to reduce the maintenance cost. Therefore, it is required to monitor and record the conditions and status of equipment in a more precise manner to correctly judge the degree of damage. The inspection items being conducted so far are not fully covered for such purpose due to non-availability of testing apparatus, e.g., testing equipment for measurement of breaking down voltage of generator windings. Procurement of testing equipment and tools especially for electrical equipment, such as generator windings, governor and excitation equipment is recommended.

(3) Recommended Scheme for Rehabilitation Work

To accelerate the implementation of rehabilitation project at Sutami and Wlingi Hydropower Stations, the executing agency is recommended to secure the fund financed by international donors. For that purpose, a feasibility study for the project including the following contents has to be carried out as the next step.

1) Detailed Site Survey for each Hydropower Station

To grasp and analyze the conditions of generating equipment, detailed inspections are to be carried out under the complete shutdown of the equipment.

2) Determination of Rehabilitation Scope

Based on the result of the detailed site survey, needs for the rehabilitation work are to be confirmed again and scope of the work, target equipment for replacement, including several alternatives are to be determined.

3) Determination of Specifications and Quantities of the Equipment

Specifications and quantities of the target equipment are to be determined.

4) Formulation of Work Program

To minimize the power outage period, work program, which can be realize short-term and efficient replacement work is to be formulated.

5) Cost Estimate

Based on the specifications, quantities and work program, detailed project costs are to be estimated considering the equipment price levels and the trends of material price fluctuations at the time of the feasibility study.

6) Economic and Financial Analysis

Based on the cost estimate, economic and financial analyses including sensitivity analysis are to be carried out.

7) Necessity of IEE or EIA

Since the major components of the project is rehabilitation work, it is considered that implementation of the project will hardly affect to the environment. However, IEE or EIA including environmental monitoring program for noise, vibration, dusts, wastes, soil pollution by leakage oil during the work is to be carried out, if necessary.

8) Others

- Possibility for CDM application
- TOR for the consulting services, etc.

The executing agency of Indonesia is recommended to make a request for the above feasibility study to international donors.

For your reference, in January 2008, the Government of Japan established new official development assistance (ODA) scheme, called “Climate Change Program Loan (“Cool Earth Loan”)", as part of the Cool Earth Partnership to provide ODA loan with special interest rates for the purpose of supporting implementation of recipients’ programs to address global warming. The Government of Japan has already provided the loan to the Government of Indonesia since 2008 to support Indonesia’s efforts to address climate change issues under its National Action Plan Addressing Climate Change.

Since this rehabilitation project has little environmental load and avoids development of new thermal power plants that produce lots of greenhouse effect gas, it is recommended to accelerate

the project utilizing such ODA scheme more effectively after completion of the feasibility study.

7.2.2 Watershed Sediment Management for Serayu River Basin

For the sustainable sediment management in the Serayu River basin, the watershed sediment management shall be planned and executed to maximize the whole benefit in the Serayu River basin. From this point of view, organization of the implementation and O&M for the watershed sediment management is recommended as follows:

1) Establishment of the Organization for the Watershed Sediment Management

For executing the sustainable sediment management effectively, proper coordination with other organizations is absolutely imperative. Therefore, it is recommended that the implementation organization of the watershed sediment management consisting of the local government, IP, the Ministry of Public Works and the users within the river basin shall be established for the Serayu River basin.

2) Participation of the Residents in Decision Making, Planning, O&M

Participation of residents in the Serayu River basin in the decision making, the river basin conservation countermeasures, and planning and operation of the sediment management are recommended from the sustainable watershed sediment management point of view.

3) Initiation of Watershed Sediment Management with Financial Support

IP and the local government have performed appropriate countermeasure for sediment control in the Serayu River basin. However, due to their limited competence and funding, the scale of the countermeasures is too small to get effective results on the sediment issues.

Therefore, it is strongly recommended that the watershed sediment management measure in the Serayu River basin as well as countermeasure for the Mrica reservoir should be initiated as a practical solution with definite financial support.

4) Implementation Procedure and Study Items of the Master Plan for Watershed Sediment Management in Serayu River Basin.

As reference, the required study items to be conducted during master plan stage for the sediment management plan and the implementation procedure so as to execute the sustainable watershed management plan are respectively shown in Table 7.2-1 and Figure 7.2.-1.

Table 7.2-1 Required Study Items of the Master Plan

No.	Investigation / Survey and Study	Explanation
1	Production volume of land collapse/sliding material	1) Identification of possible land collapse/sliding areas in the Soedirman (Mrica) Dam watershed 2) Estimation of the potential land collapse/sliding material volume
2	Sediment transport volume	1) Riverbed fluctuation analysis from the upstream of the Soedirman (Mrica) Dam to the downstream of the Serayu River 2) Prediction of existing and future situations in the Serayu River 3) After actual flood or release test of the sediment, examination of effect of transport of sediment material to the surrounding coastal area
3	Water utility in the downstream of the river	Identification of the water intake location and grasp of total water utility volume in the Serayu River
4	Water quality	1) Investigate the existing water quality in the Serayu River 2) Estimation of the effect to the water quality due to the sediment diversion and release to the downstream
5	Release test of the sediment	1) Release test of the sediment shall be executed using the low level river outlet of the Soedirman (Mrica) Dam Prior to the above test, the deposited sediment in the reservoir shall be moved to near the river outlet using the dredgers, etc. 2) Monitoring sediment transport volume, river bed fluctuation in the Serayu River, effect to the water quality in the downstream
6	Natural and social environment consideration in the Serayu River	Environmental assessment on the natural and social impact shall be executed based on the above Item No. 5.
7	Grasp of sabo dam construction in the upstream watershed of the Mrica Dam by the local government	Evaluation of the on-going sedimentation problem countermeasure by the local government
8	Constitution of the sediment balance in the Serayu River	After the construction, this shall be the fundamental concept for the preparation of the Soedirman (Mrica) Reservoir sedimentation problem countermeasure.
9	Establishment of the implementation policy	Based on the sediment balance study, implementation policy to meet short-term, medium-term and long-term targets, as proposed by this JICA study, shall be updated.
10	Comparison of the alternative measures	The best suited countermeasure for the sedimentation problem shall be selected. The countermeasure shall consist of the technical measure and non-technical measures.
11	Environment monitoring plan	The construction/execution of environment monitoring plan during construction and after construction shall be made.
12	Selection of urgent countermeasure	In accordance with the implementation policy described in Item No. 9, urgent countermeasure to be implemented shall be selected from the selected measures in Item No.10.

(Prepared by JICA Study Team)

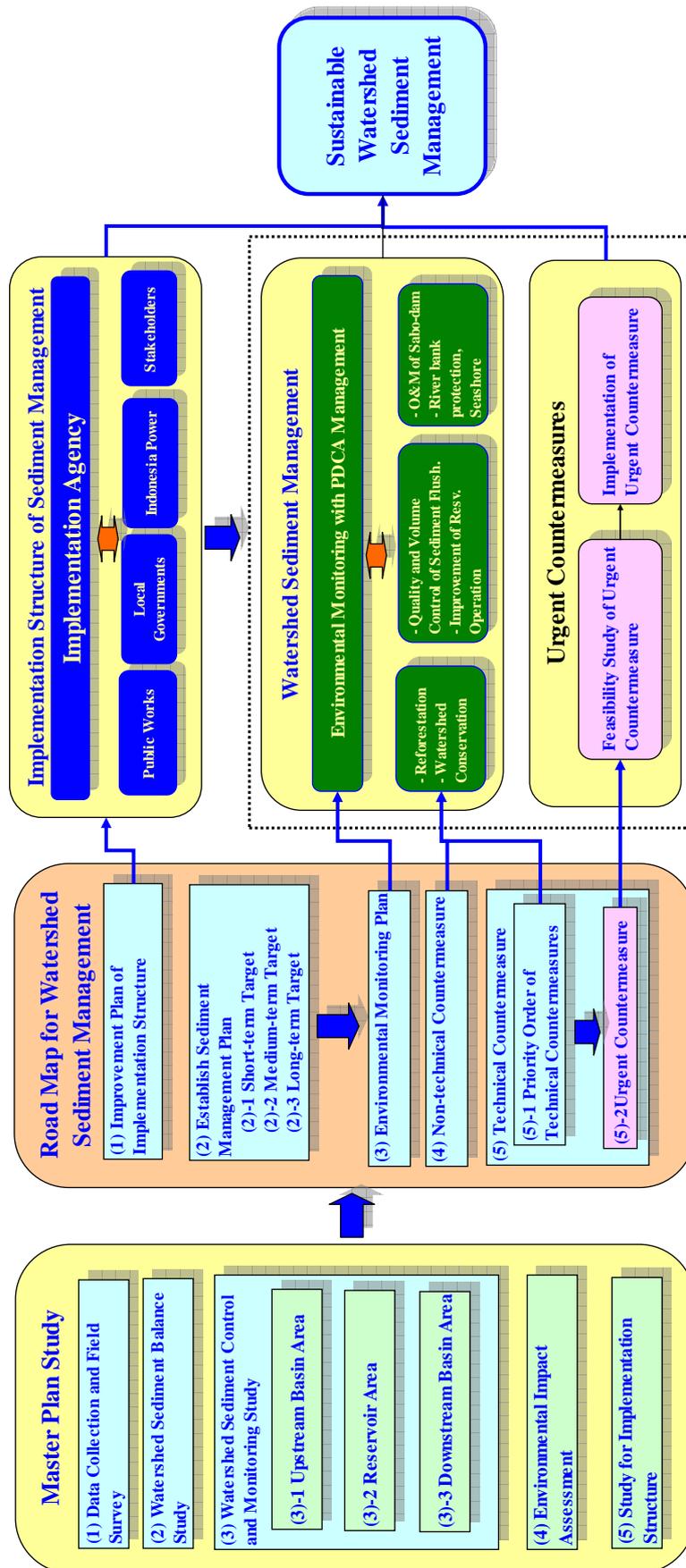


Figure 7.2-1 Proposed Implementation Procedure

(Prepared by JICA Study Team)