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OUTLINE AND EFFECTS OF PERMANET SEDIMENT MANAGEMENT MEASURES FOR MIWA DAM

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ABSTRACT

This paper reports on the outline and effect of the flood bypass tunnel (sand discharge bypass), the first permanent sedimentation measures adopted for multipurpose dams in Japan, and is consisted of the following parts.

1) Background of Miwa Dam redevelopment project and outline of the permanent sedimentation measures

2) Operation and effect of the tunnel in flood events that occurred in 2006

3) Future development

Keywords: Sedimentation Bypass Specified Multi Purpose Dam Wash Load Consecutive Observation Environmental Research

1. INTRODUCTION

As a redevelopment project for Miwa Dam in Japan, the Mibu River Comprehensive Development Construction Office has been conducting excavation of the deposited sediment for recovering the reservoir capacity, promoting permanent sediment management measures for controlling sedimentation in the reservoir. The permanent sediment management measures involve the “flood bypass tunnel” for controlling the inflow of wash load into the reservoir, as well as “intra-reservoir sediment management facilities” that discharge the wash load included in the turbid waters flowing into the reservoir, which are led into it without bypassing for the purpose of water level recovery or flood control in connection with water utilization.

This paper summarizes the project outline and trial run of the flood bypass tunnel that was completed in May 2005.

2. OUTLINE OF MIBU RIVER BASIN

Mibu River originates from Mt. Senjogatake and is the largest tributary of Tenryu River, with the total stream length of 60 km and the basin area of 481 km^2. It flows into Tenryu River in Ina City at 40 km downstream from Lake Suwa.

Mibu River has a complex stream profile due to the complicated surrounding geography along the median tectonic line. The average bed slope at its downstream is 1/100, steeper than Tenryu River, exhibiting a typical fan delta profile.

Due to the rough terrain as exemplified by the South Alps mountains and complicated geological features along the median tectonic line as mentioned above, there are a number of landslide scars in upstream areas, producing a large amount of soil.

The Mibu River basin is located in Ina City. Fig1 shows the basin of Tenryu River.

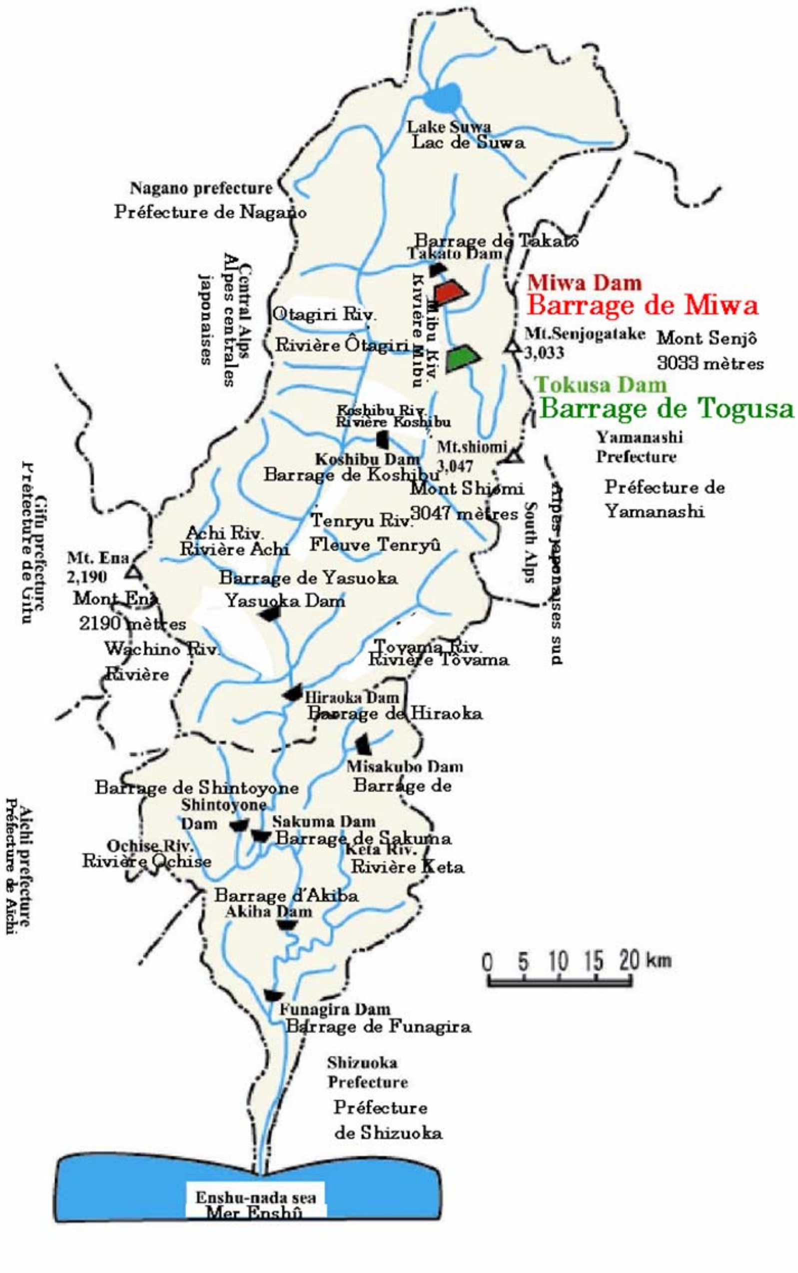


Figure1 Tenryu River Basin

3. BACKGROUND OF MIWA DAM REDEVELOPMENT PROJECT

The flood control plan at the time of constructing Miwa Dam assumed the maximum inflow for 100-year probable flood to be 1,200 m^3/s and the maximum outflow to be 300m^3/s. Also, for the purpose of flood prevention of Mibu River and Tenryu River, sediment capacity of about 6.6 million m^3 was planned and secured, which corresponds to a 40-year sediment level. In August 1959, however, right before the completion of construction, a heavy flood which recorded flood discharge that almost reached the design high water discharge with a maximum flow of 1,182 m^3/s, occurred. Within 3 years starting from this event to the "Showa 36 (1961) Disaster," one of the most destructive floods in Ina Valley's history, a total of about 6.8 million m^3 of soil flowed in the reservoir, and this already exceeded the design sediment capacity. In 1982, the largest flood of Mibu River that recorded the flood discharge of 1,321 m^3/s exceeding the design high water discharge at the Miwa Dam occurred, resulting in about 4.3 m^3 new sediment only within this year, and the succeeding flood in 1983 delivered of about 1.6 million m^3 sediment.

Such repeated floods have brought an enormous quantity of soil into the Miwa Dam reservoir, which has amounted up to about 20 million m^3 since the completion of the dam.

During this period, emergency measures such as excavation and removal of sediment have been carried out in the reservoir, but they have proved insufficient for a large amount of soil flowing in. Therefore, drastic solutions have been necessary. Fig. 2 shows the transition in sediment volume, while Fig. 3 indicates the longitudinal changes of sedimentation.

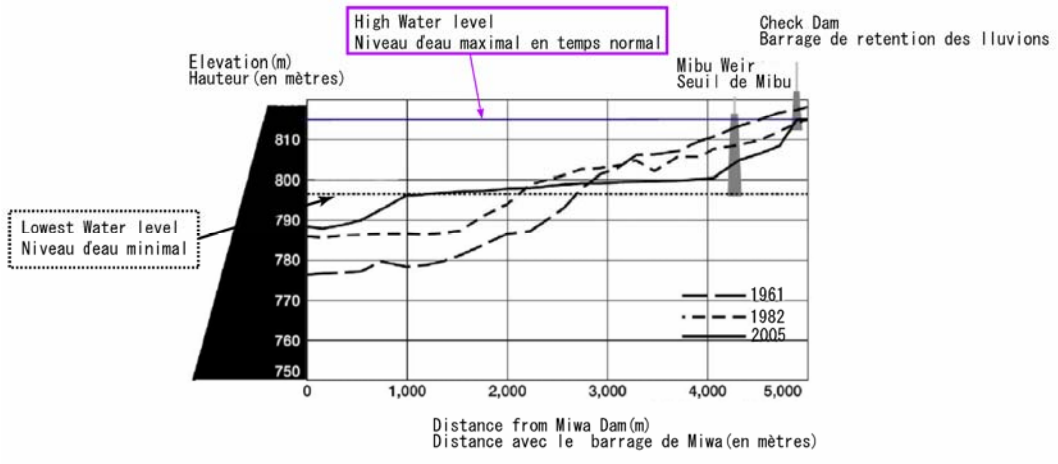


Figure2 Transition in Sedimentation Status in Dam Reservoir

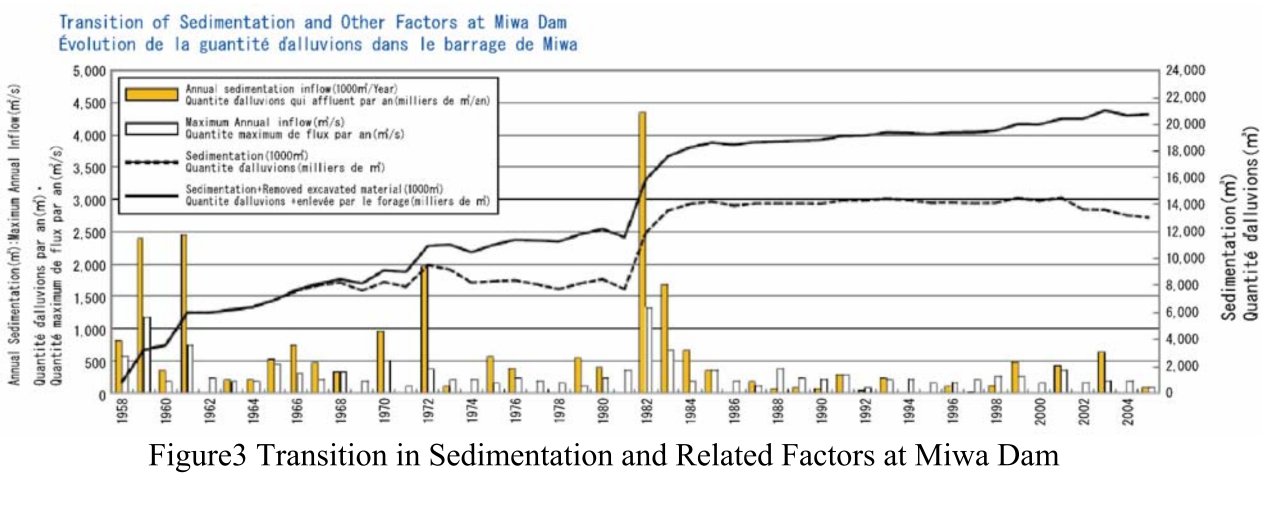


Figure3 Transition in Sedimentation and Related Factors at Miwa Dam

4. HISTORY OF MIWA DAM REDEVELOPMENT PROJECT

Since 1981, consideration had been independently given to Miwa Dam Redevelopment Project until 1988 when it was adopted as a new construction project and named as Mibu River Comprehensive Development Project jointly with another construction project for Tokusa Dam located upstream of Miwa Dam that had been already in commission. In 1994, the check dam was completed as a tentative facility of Miwa Dam, and the excavation of the reservoir sediment started in 2000. In 2001, construction of the permanent sediment management facilities was commenced. In 2005, a flood bypass tunnel and a diversion weir were completed.

5. OUTLINE OF MIWA DAM REDEVELOPMENT PROJECT

5.1 SEDIMENT EXCAVATION

Sediment excavation is conducted for maintaining the existing flood control and water utilization functions of Miwa Dam by removing the sediment in the reservoir. In the beginning, slurry transport was mainly considered, but the actual excavation was planned to be carried out when the reservoir's water level gets lower, aiming at the low cost of land excavation and transportation by dump trucks. Before, about 2 million m^3 has been excavated and the removed material was effectively reused for improving local agricultural fields.

5.2 PERMANENT SEDIMENT MANAGEMENT MEASURE

In the redevelopment project, consideration was given to the inflow volume of soil as well as such physical characteristics as grain size based on the obtained data after completion of Miwa Dam. About three fourths of sediment is fine sand called wash load with an average grain diameter of 0.017 mm which usually flows in a floating state in the water during floods. Consequently a measure was considered to discharge wash load to the downstream of Miwa Dam during flood while avoiding sedimentation at Takato Dam located downstream.

Permanent sediment management measure consisted of the construction of a "flood bypass tunnel" designed to reduce inflow of wash load into the reservoir, and "intra-reservoir sediment management facilities" for discharging wash load after sedimentation when the flood water is led into the reservoir without bypassing for the purpose of water level recovery and flood control in connection with water utilization.

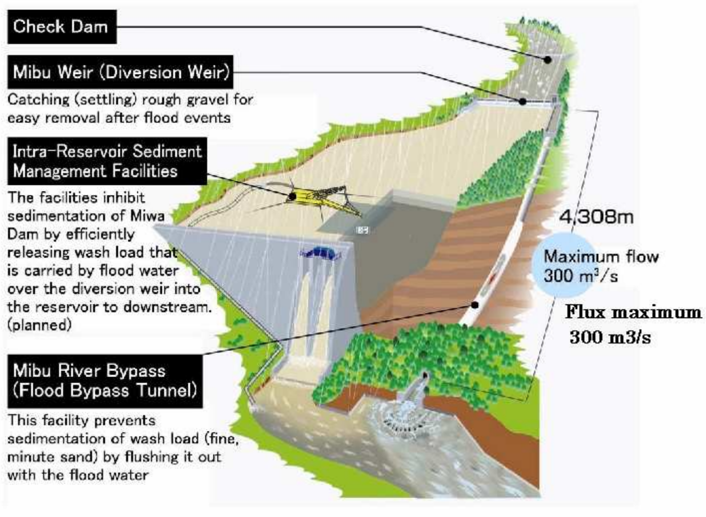


Figure4 Image of Miwa Dam Permanent Sedimentation Management Measure

5.3 FLOOD BYPASS TUNNEL

5.3.1 Outline of Flood Bypass Tunnel

Before flood bypassing, rough gravel carried in the flood water is trapped at the check dam at first, and finer sand are let flow downstream.

Next, the diversion weir diverts the fine sand (wash load) flowing from the check dam at into the bypass tunnel together with the flood water. On the upstream side of the diversion weir, a trap weir (submerged dike), installed under water, in front of the gate, captures rough objects passing over the check dam to prevent them from flowing into the bypass tunnel. The gate set at the bypass tunnel inlet adjusts the outflow to allow the flood water to flow at maximum of 300 m^3/s.

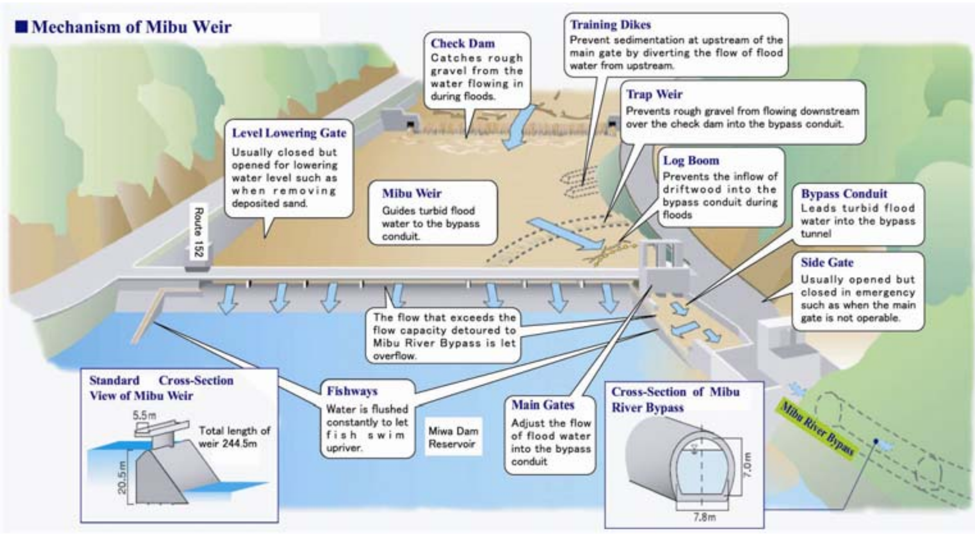


Figure5 Mechanism of Permanent Sediment Management Measure

5.3.2 Sediment Balance Plan

Of the annual average of 685,000 m^3 of the sediment flowing into Miwa Dam, an annual average of 160,000m^3 of larger particles (bed load and suspended load) are trapped at the check dam, which has a capacity of about 200,000m^3, and removed by excavation to be effectively utilized as construction materials. In case a large flood occurs and the check dam is up to the capacity, the diversion weir located downstream having a capacity of about 500,000 m^3 prevents the inflow of sand and gravel into Miwa Dam to the possible extent.

Consequently, the 525,000 m^3 of wash load reaching the diversion weir consists only of fine particles, of which an annual average of 399,000 m^3 is discharged through the flood bypass tunnel that has a discharge capacity of 300 m^3/s, an amount that corresponds to the design effluent flow of Miwa Dam. For such water utilization purposes as water level recovery and flood control, an annual average of 126,000 m^3 of wash load flows into the dam's reservoir over the diversion weir when floods occur. Of this, a total of 105,000 m^3 is planned to be discharged, of which 21,000 m^3 is discharged from the spillway on the dam body and 79,000 m^3 by the intra-reservoir sediment management facilities, which will be mentioned later in this paper. Furthermore, the 26,000 m^3 deposited in the reservoir is to be managed by the sediment storage capacity.

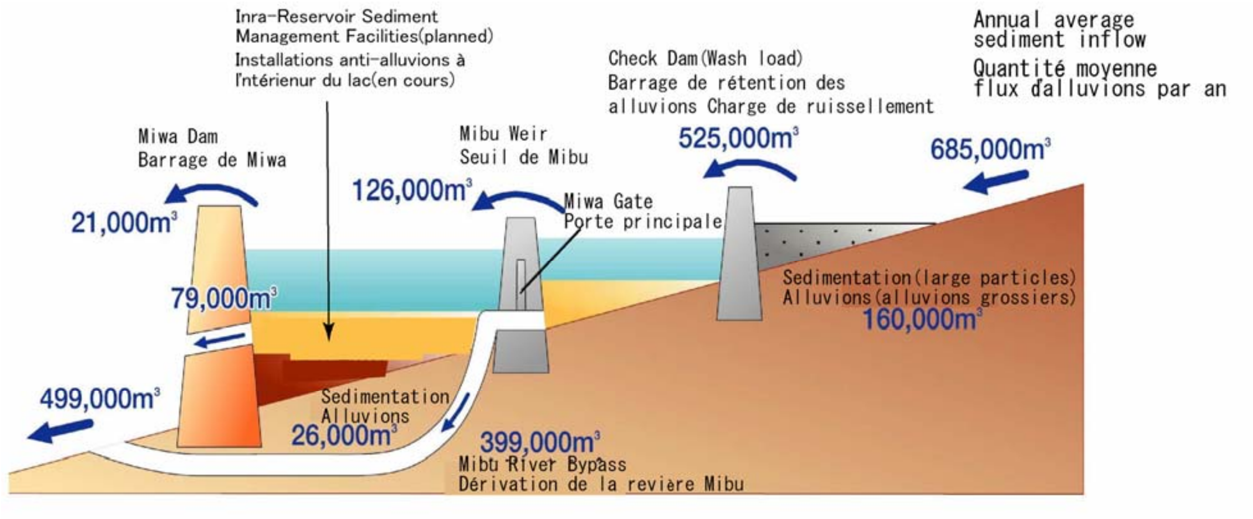


Figure6 Schematic of Sediment Management Measure

5.3.3 Operation of Flood Bypass Tunnel

The operation of the flood bypass tunnel will be conducted in coordination with the flood control of Miwa Dam. When the inflow is expected to exceed 100 m^3/s after the water level of Miwa Dam recovers to the normal level, the water is discharged through the bypass at the maximum rate of 300 m^3/s and terminated when the inflow after the peak period goes under 100m^3/s. In this case, setting the power generation discharge as a base line, priority is given to bypass discharge rather than dam discharge as illustrated in Fig. 8.

However, it is necessary to formulate the most effective plan for such operations as commencing of bypass discharge or operation ending flow rate, etc by analyzing and feeding back the monitoring results obtained from trial run.

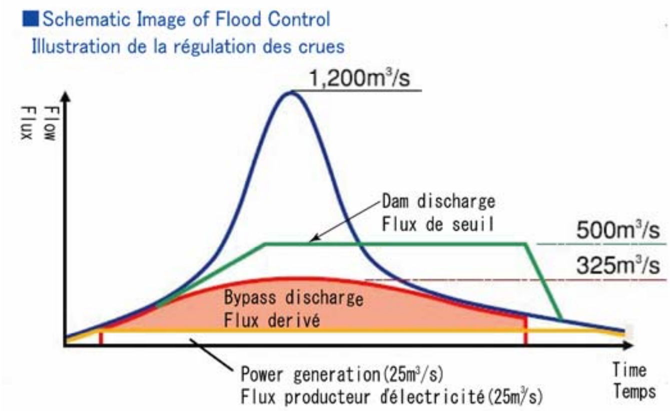


Figure7 Image of Flood Control

5.4 INTRA-RESERVOIR SEDIMENT MANAGEMENT FACILITIES

The intra-reservoir sediment management facilities are designed to collect sediment to one place during normal water-level periods, suck it during flood through the sand discharge pipe by using water-level difference, and flush it down to downstream. (Table2,Fig9)

Starting from FY2005, discussions have been held by the Designing VE Panel for considering optimal construction methods including the one jointly developed with private sectors.

The deliberations by the Chubu Regional Development Bureau VE Review Committee approved the setting up of the VE Panel and participation of designing advisors who provide “technical suggestions and advice for optimal methods from the standpoint of life cycle cost, including maintenance and management cost while ensuring the functions and performance.” In this way, further reduction of life cycle cost is being promoted against the basic designing.

Table1 Procedure of Intra-Reservoir Sediment Manegement

Non-Flood Period	Collection	Collect sediment
	Transport	Transfer sediment
	Piling	Pile up sediment
Flood Period	Suction	Suck up sediment
	Discharge	Discharge to downstream

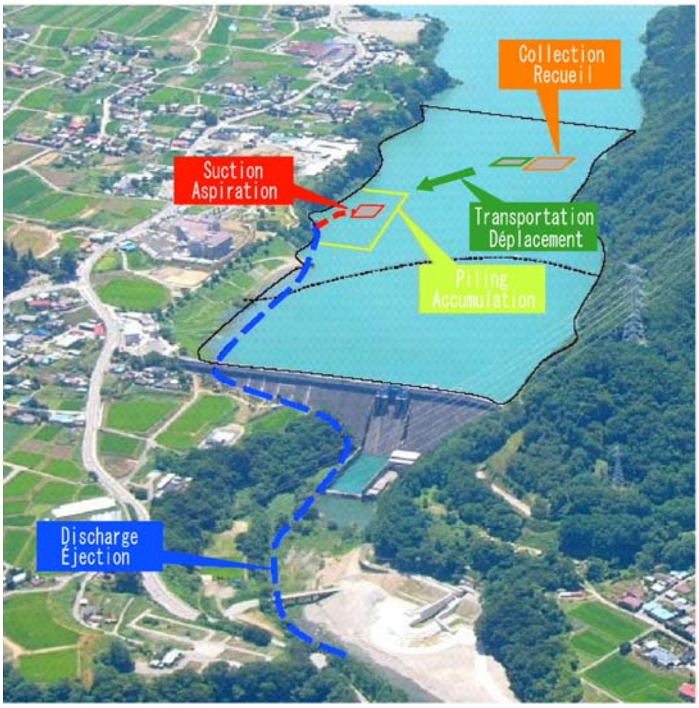


Figure8 Image of Intra-Reservoir Sediment Manegement Facilities

6. MONITORING OF PERMANENT SEDIMENT MANAGEMENT MEASURES

6.1 MONITORING ITEMS

During the trial run, the following items were checked with a view to verifying the sand discharge effect and evaluating the influence on downstream environments.

6.1.1 Sediment Balance Plan

Evaluation will be carried out on the plan's validity through comparing the measured and estimated results of the following four items:

- Quantity of wash load flowing into Miwa Dam
- Catching status of sand and gravel in the diversion weir and check dam
- Status of sedimentation in the Miwa Dam reservoir
- Status of sedimentation of the Takato Dam reservoir, located downstream of Miwa Dam

6.1.2 Tunnel Structure

The diversion performance of the diversion weir and the status of sedimentation, wear, etc. of the flood bypass tunnel are checked..

6.1.3 Turbidity of Discharge Water

The bypass discharge is expected to let out water with higher turbidity to downstream compared to the conventional gate discharge via the reservoir. On the other hand, it is designed to lessen the turbidity in the reservoir and reduce prolonged turbidity of discharge after the flood. These items are to be evaluated.

6.1.4 Influence to Natural Habitats

The significance on living organisms living in the downstream areas in connection with the change in turbidity of dam discharge.

Approximately a duration of 5 years from the commencement of trial run is planned as the monitoring period, where the frequency or items to be monitored shall be reviewed as needed. Moreover, pre-operation monitoring has been conducted since 2004, a year before the trial run, to have the Chubu Regional Dam and Estuary Barrage Management Follow-Up Committee, organized by the Chubu Regional Development Bureau, conduct scientific and objective evaluation of the acquired data by comparing it to the monitored results after the trial run.

6.2 Outline of Trial Run in FY 2006

In July 2006, heavy rain that caused considerable damages on a nation-wide scale took place, and these left a lot of damaging scars to Lake Suwa and the areas along Tenryu River. Test descharge was carried out by the use of the flood bypass tunnel under trial run from 18th to 20th of July, 2006

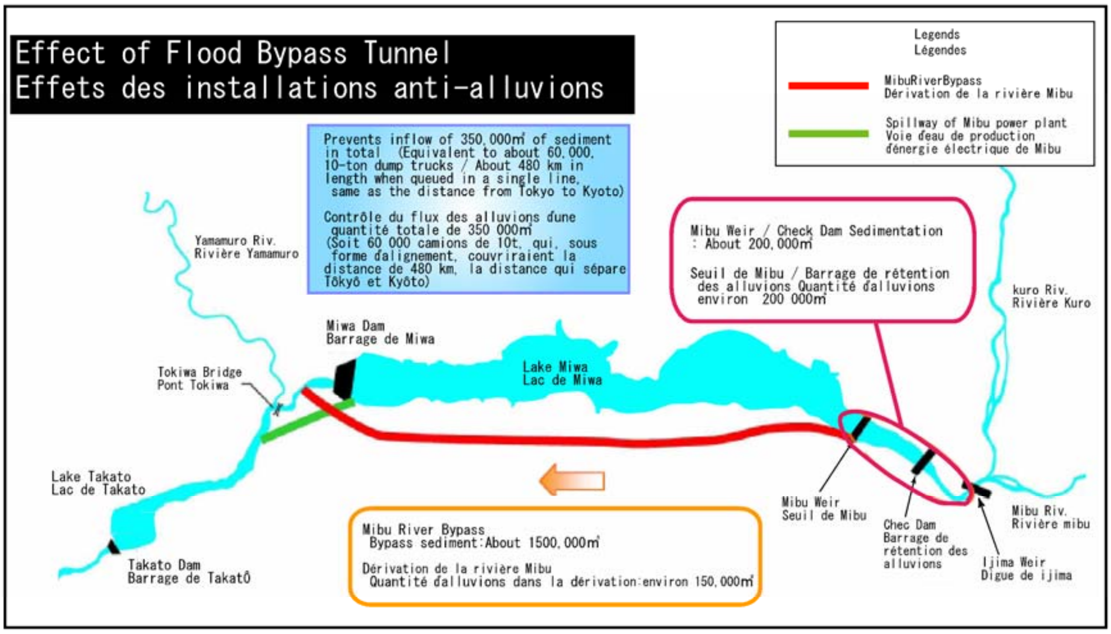
6.2.1 Status of Flood

In the Miwa Dam area, a total area-wide average rainfall of 253.3 mm was recorded from 15:00 on 17th to 18:00 on the 20th in July, 2006, resulting in a flood of maximum inflow of 366 m^3/s. During this rainfall, for about 47 hours from 15:00 on 18th to 14:00 on the 20th, the flood bypass tunnel released up to a maximum of 242 m^3/s.

Of the total inflow of about 33 million m^3, during the test discharge period of 47 hours, about 23 million m^3 was discharged, bypassing approximately 70% of the turbid water from the upstream areas to downstream of the dam.

6.2.2 Effect of Sedimentation Measures

During the test discharge period of 47 hours, about 150,000 m^3 of wash load was bypassed to downstream. In addition, about 200,000 m^3 of gravel and sand was caught at the check dam and diversion weir. Such sand and gravel used to be flowing into the Miwa Dam reservoir before the bypass tunnel was completed, and therefore the inflow of a total of about 350,000 m^3 of sand and gravel was prevented, thus helping sediment volume in the Miwa Dam reduce.



Note) The bypassed sediment was estimated from the SS and flow rate obtained at each measuring point.
La quantité d'alluvions qui est passée est calculée par rapport aux données MES mesurées à chaque emplacementet les données de mesure du flux

Figure9 Effect of Flood Bypass Tunnel

6.2.3 Status of Tunnel

After the test discharge, no deformation or displacement in the tunnel's lining or outlet as well as in Mibu Weir was observed. No signs of wear were found in the gate as well, and these results confirmed the tunnel's soundness.

Status Inside Mibu River Bypass
(Shortly after discharge on July 20)

Status of Mibu River Bypass Tunnel Outlet
(On August 17, one month after discharge)

Status of Bypass Main Gate
(On August 20, one month after discharge)

Photo1 Inside Tunnel, Energy Dissipater, and Main Gate

7. CONCLUSION

The flood bypass tunnel of Miwa Dam was able to detour 150,000 m^3 of sand and gravel to the dam's downstream in the test discharge during the floods in July 2006. The results of this test discharge were reported to the FY 2006 Management Follow-Up Committee for dam facilities, and a favorable evaluation was given regarding verification of the facilities' functions. For this year, the results of test discharges that will be conducted in July and September will be analyzed together, and the results of the sediment balance verification as well as investigation on environmental effect on the downstream areas will be reported for evaluation.

Also, the designing of the intra-reservoir sediment management facilities, an integral supplement to the flood bypass tunnel, will be promoted. This unit of facilities will be designed to further contribute to prevent sediment from accumulating by discharging it through a siphonic principle for flood control related purposes.

As discussed above, the fact that the first flood bypass system for a multi-purpose dam demonstrated its effectiveness can be a valid advance case for other dams facing a similar sedimentation issue. Expectations for utilizing the information provided herein constitute the conclusion of the paper.

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