Key Issue:
4- Reservoir Sedimentation


(Photo by the KANSAI Electric Power Co., Inc.)

Climate Zone:
Cf: Temperate Humid Climate

Subjects:
- Sediment Flushing of Reservoir by Large-scale Flashing Facilities
- Method of Forming Reasonable Consensus of Local Community Concerning Sediment Flushing

Effects:
- Long-term Removal and Reduction of Sediment in Reservoir
- Forming of Consensus Concerning Way of Sustainable Sediment Flushing

Project Name: Dashidaira Dam
Country: Toyama Prefecture, Japan (Asia) (N 36°50', E 137°40')

Implementing Party & Period
- Project: the KANSAI Electric Power Co., Inc.
1985 (Completion of construction) -
- Good Practice: the KANSAI Electric Power Co., Inc.
1995 (Commencement of improved operation) -

Key Words:
Sediment Flushing, Consensus of Local Community, Environmental Impact

Abstract:
The watershed of the Kurobe River Basin yields a lot of sediment and the Dashidaira Dam constructed in 1985 is equipped with sediment flushing gates. Through the precise prediction of environmental impact and the meeting with stakeholders including local residents and technical experts, appropriate mitigations for environmental impact has been established.

1. Outline of the Project

The Dashidaira Dam was constructed by the Kansai Electric Power Co. (KEPCO) on the midstream stretch of the Kurobe River (approximately 26 km from the river mouth) for the regulating reservoir of the Otozawa Power Station, and is the first dam in Japan equipped with large-scale sediment flushing facilities.

Streams of the Kurobe River Basin have extremely heavy sediment loads and a major concern when planning construction of the Dashidaira Dam was how to solve the sedimentation problem as there were strong demands from the local community for prevention of coastal erosion. In general, measures against sedimentation at a dam consist of installing sediment storage weirs, dredging, etc. At the Dashidaira Dam, however, 1) a very large volume of sediment is brought down from the upstream catchment area, 2) even if dredging were to be done, transportation of dredged sediment would be difficult because of the constraints imposed by the site consisting of a gorge, and 3) conventional methods such as dredging would be unable to solve problems of degradation in the downstream area and erosion of the coastline. KEPCO, noting the importance of mitigating riverbed degradation and coastal erosion, decided to adopt a flushing method whereby sediment would be discharged downstream to the same extent as before construction of the dam.

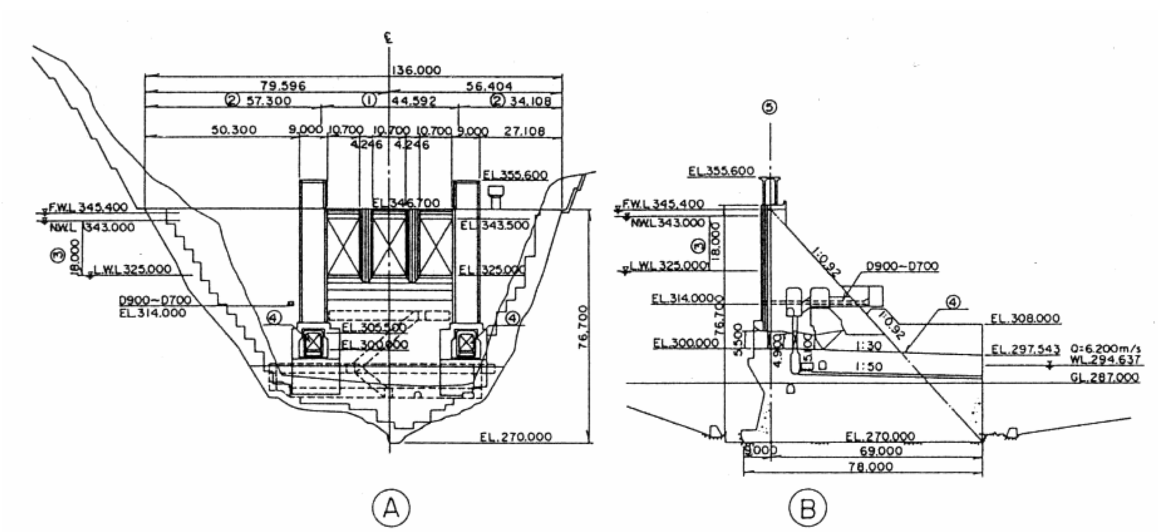
Specifications in outline of the dam and the sediment flushing facilities are given in Table-1 while an outline view of the Dashidaira Dam is shown in Fig.-1. The Dashidaira Dam has two large-scale

sediment flushing tunnels in its body. Their structures are that when it is desired to release sediment downstream the water level at the dam is lowered for free flow of water inside the reservoir so that accumulated sediment will be discharged.
The construction of the Otozawa Power Station was begun in 1982 and operation was started in 1985.

Table-1 Specifications of Dashidaira Dam

Item	Specification	
River system	Kurobe River, Kurobe River System	
Catchment area	461.18 km^2	
Power station	Name	Otozawa Power Station
	Max. output	124 MW
	Max. discharge	74.0 m^3/s
	Effective head	193.5 m
Dam	Type	Concrete gravity
	Height	76.7 m
	Crest length	136.0 m
	Volume	203,000 m^3
Reservoir	Gross storage capacity	* 9.01x10^6 m^3
	Effective storage capacity	* 1.66x10^6 m^3
	Available depth	18 m
Flushing channel	Quantity	2 lines (steel lined)
	Dimensions	5.0×5.0 m
Sediment flushing gate	Upstream side	Slide gate
	Intermediate	Roller gate
	Downstream side	Radial gate

*:when constructed



①Overflow section ②Non-overflow section ③Drawdown range ④Flushing channel ⑤Dam Axis

Fig.-1 Outline view of Dashidaira Dam (source: Ref. 1)

2. Features of the Project Area

The Kurobe River springs from the Northern Alps Mountain Range in the Chubu Sangaku National Park, runs down from mountainland of elevation from 2,000 to 3,000 m cutting steeply graded, deep gorges before dropping into the Sea of Japan. The catchment area is 682.5 km^2, and with a length of 86.0 km, that is, the Kurobe is one of the swiftest rivers even in Japan. The river basin has an annual mean precipitation of approximately 4,000 mm to make it one of the most rainy and snowy areas in the country, and there is an abundant flow of water throughout the year.

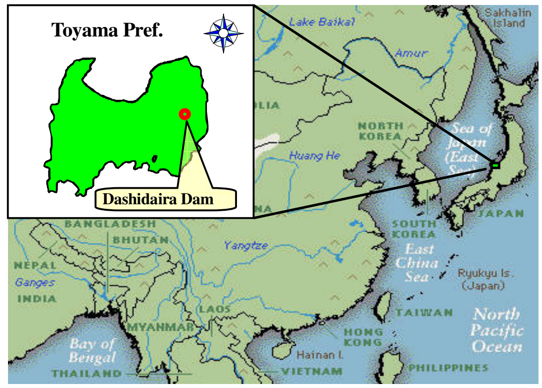


Fig.-2 Dashidaira Dam location

The entire catchment of the Kurobe River consists of new and old granites which are low in water retention capacity, and the runoff ratio is extremely high. There are approximately 7,000 collapse areas totaling 31 km^2 out of the 667 km^2 of mountainland in its catchment area. It means that this area is characterized by heavy sediment load extremely.

The mountainland part of the Kurobe Basin is designated a special area of the Chubu Sangaku National Park and a pure natural state is maintained. The Kurobe River, with its abundant water is looked upon as a rich source of electric power and a stable fountain of domestic and agricultural water supply. It also contributes greatly to the local economy as a tourism resource.

3. Major Impacts

As of June 2000, sediment flushing had been carried out a total of eight times at the Dashidaira Dam. Annual sediment discharges and the cumulative discharge are shown in Fig.-3.

In December of 1991, six years after completion of the dam in 1985, the sediment accumulated had reached approximately 3 million m^3, making it possible for discharge to be done from the gates, and the first flushing was carried out. The result, contrary to expectations, was that turbid water of a dark gray color and with a putrid odor was discharged, and moreover, this turbid water spread out into the sea area and discharge was discontinued at the request of the local community.

A committee including local representatives and knowledgeable persons was organized in order to study the impacts and suitable methods of the sediment discharge. The committee carried out investigations of the impacts on fisheries and agriculture, and of the impacts on the environment, and also conducted sediment-flushing tests (February 1993). It was learned that organic matter had become degenerated by long-term deposition of sediment in the dam reservoir, and this had affected the downstream environment when the sediment was discharged. Consequently, comparisons were made with alternatives such as 1) leaving sediment untouched instead of removing it (for example, removing the dam and returning the river to its original state), 2) discharging sediment without using sediment flushing gates (for example, preventing sediment from entering Dashidaira Reservoir), and the final conclusion was that to discharge sediment using sediment flushing gates would be the most suitable measure for dealing with sedimentation at the dam. Table-2 gives the environmental impact items investigated.

Table-2 Environmental impacts investigated

Items Investigated	Site investigated			Contents of investigation
	Dam	River	Sea	
Water quality	●	●	●	Water temperature, pH, SS, Turbidity, BOD, COD, T-N, T-P, etc.
Bottom material (sediment)	●	●	●	Appearance, Mud temperature, Smell, pH, COD, Ignition loss, T-N, T-P, Grainsize distribution, etc.
Aquatic organism	—	●	●	Fish, Attached algae, Chlorophyll-a, Benthic organisms, Zoo/ Phytoplankton, etc.
Sedimentation condition	●	●	—	Cross sectioning

4. Mitigation Measures

The method of discharging sediment from the Dashidaira Dam is to temporarily lower the water level of the reservoir and wash out deposited sediment by free flow of river water. The previously-mentioned committee recommended that in order to minimize impacts on the downstream environment, discharge should be done during floods when the volume of river flow is large so that the discharge of sediment from the dam would be close to natural conditions, and sediment flushing was done during floods according to the committee recommendation.

Approximately 3.4 million m3 of sediment were newly deposited at the Dashidaira Dam by severe local rain in 1995 so that the stability of the dam was endangered, so that it was decided that emergency flushing for disaster recovery should be carried out over three years (1995-1997). These emergency discharges were also carried out during floods in accordance with recommendations of the committee.

5. Results of the Mitigation Measures

As of June 2000, sediment flushing had been carried out a total of eight times at the Dashidaira Dam. Annual sediment discharges and the cumulative discharge are shown in Fig.-3.

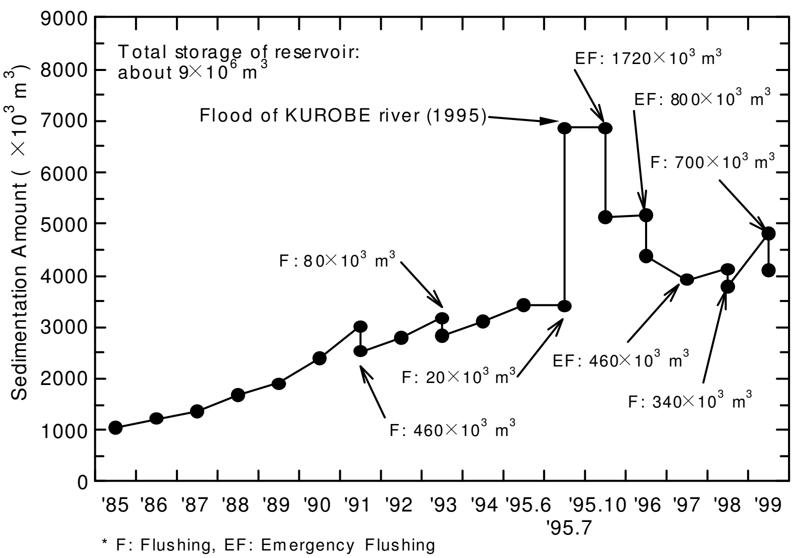


Fig.-3 Temporal change of reservoir sedimentation

The sediment flushing facilities of the Dashidaira Dam produced results as expected in the aspect of flushing sediment out of the reservoir. As a result of adopting the procedure of releasing sediment to coincide with flood discharge, it became possible to carry out sustainable sediment flushing without causing any great problem in the downstream area. It was found on investigating sediment flushing records and the environment when flushing that 1) the sediment flushing facility of the Dashidaira Dam is effective as a means of discharging sediment from within the reservoir, 2) the sediment flushing carried out to coincide with flooding is effective as a measure for mitigating the impact on the downstream environment, and 3) if a proper sediment flushing method is adopted, the environment is not greatly affected even when large-volume sediment flushing is hurriedly done. Flushing has since been done annually at the same time as flooding in accordance with the advice of the committee.

Meanwhile, in order to ascertain the environmental impacts, KEPCO has carried out investigations on the river and sea area downstream of the dam.

The results of the investigations may be summarized as follows:

1) In water quality investigations of the river, turbidity conditions of the downstream river are showing improvement year by year, and prominent impacts due to sediment flushing are not seen.
2) In water quality investigations of the sea area, indices of turbidity and organic matter were temporarily high in the vicinity of the river's mouth during sediment flushing, but in investigations one day after flushing, the conditions were seen to have returned more or less to normal.
3) In bottom material investigations, changes in conditions before and after sediment flushing were not seen and impacts on bottom materials were not detected.
4) Regarding aquatic organisms (benthic animals), as a whole, there were reductions in populations immediately after sediment flushing, but in investigations one month later, the situation had returned more or less to the condition before sediment flushing and close to a natural flood condition.

Table-3 Results of sediment flushing impact investigations (water quality-SS measurements)

(Unit: mg/L)

			Immediately below dam	Shimokurobe Bridge (near estuary)	Point C (sea area)	Point A (sea area)
1995 emergency flushing	Before flushing		23	230	490	4
	During flushing	Max. observation	103,500	26,000	1,000	31
		Average	18,000	7,500	—	—
	After flushing	1 day after	30	193	6	3
1996 emergency flushing	Before flushing		764	1,520	1,500	31
	During flushing	Max. observation	56,800	6,770	1,200	52
		Average	10,000	2,900	—	—
	After flushing	1 day after	194	879	76	7
		1 month after	8	6	5	3
1997 emergency flushing	Before flushing		4	8	3	1
	During flushing	Max. observation	93,200	4,330	3,500	24
		Average	10,000	2,200	—	—
	After flushing	1 day after	108	757	86	14
		1 month after	35	22	6	6

Note: Maximum observations of turbidity and SS at Point C in 1997 emergency flushing being higher than for previous two emergency flushings are because in 1996 emergency flushing, rough weather during peak of turbidity of river made sea area investigations impossible.

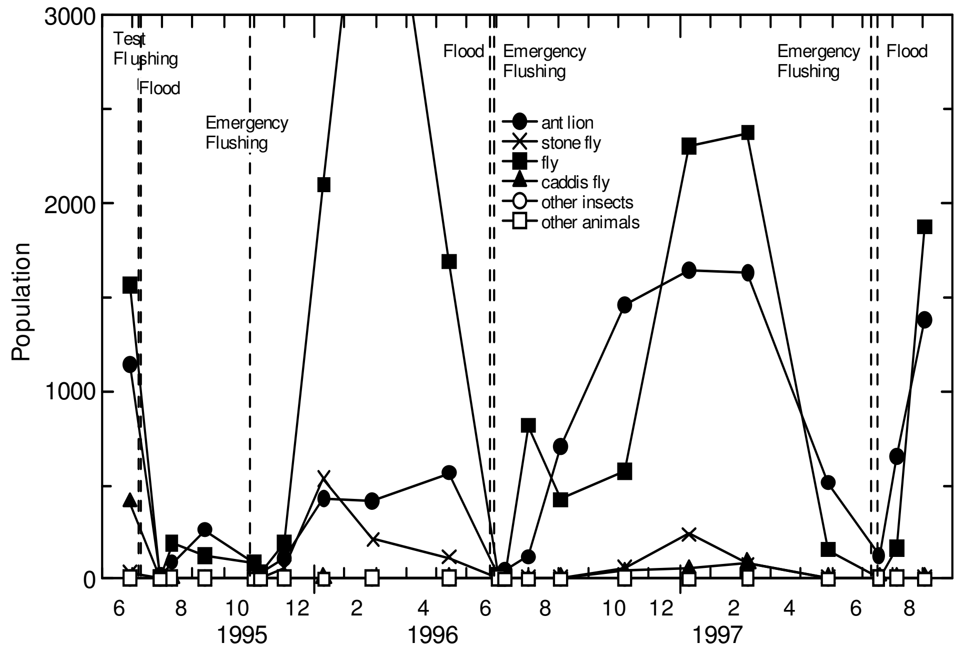


Fig.-4 Results of sediment flushing impact investigations
(benthic animal investigations)

As examples of investigation results, Table-3 shows values of SS measurements in the river and sea area, and Fig.-4 the transitions in the population of benthic organisms. This population was calculated taking six locations downstream of the dam, counting the population of organisms living in an area of 0.5 m^2 at each location, and totaling the counts of the six.

6. Reasons for Success

The following may be cited as reasons for success:

1) Study of Sediment Flushing Operation Scheme Considering Environmental Impacts
   In order to minimize impacts on the downstream environment, a mode of operation was adopted in which sediment flushing was made to coincide with flooding so that sediment would be discharged in a condition close to natural floods.
2) Consultation with scientists, experts, stakeholders, etc.
   A committee to study the impacts of sediment flushing composed of knowledgeable persons and representatives of local government, fisheries and agricultural organizations was formed, measures to deal with sedimentation at the Dashidaira Dam were examined from various angles, a study of the possibility of sediment flushing from the dam giving consideration to environmental aspects was made, and a consensus was reached with the local community.
3) Establishment of Prediction Method for Environmental Impact by Sediment Flushing
   Numerical simulations were made of items such as SS and DO in the downstream part of the river and in the sea area when flushing sediment from the dam, enabling prediction to some extent of impacts on the environment when sediment flushing was done, and this made it possible to plan a better method of operation through utilization of the prediction results.

7. Outside Comments

1) Kurobe river disaster restoration related committees' joint meeting, Results of emergency flushing Report (Nov. 17, 1997)

"Sediment flushing process was improved and verified through a test flushing that was conducted in February 1994, experimental flushing in July 1995 and three emergency flushings conducted after 1995. Now the process for sediment flushing at times of flood that enables sediments to be flushes in a form closer to natural system has almost been established."

8. Further Information

8.1 References

1) Tetsuya KOKUBO, Masakazu ITAKURA, Minoru HARADA: Predicting Method and Actual Results on Flushing of Accumulated Deposits from Dashidaira Reservoir, ICOLD 19th Q74.R47, 1997
2) Masanobu TEZUKA, Hidemitsu DAITO, Masahiro KATO: Design and Operational Results of Sediment Flushing Facilities, ICOLD 20th, 2000
3) Committee for Study of Environmental Impacts of Sediment Flushing from Dashidaira Dam on the Kurobe River: Report on Results of Studies and Recommendations (Japanese), April 1995

8.2 Inquiries

the KANSAI Electric Power Co., Inc.

URL : http://www.kepco.co.jp/english/index.html

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