一庫ダム Hitokura Dam

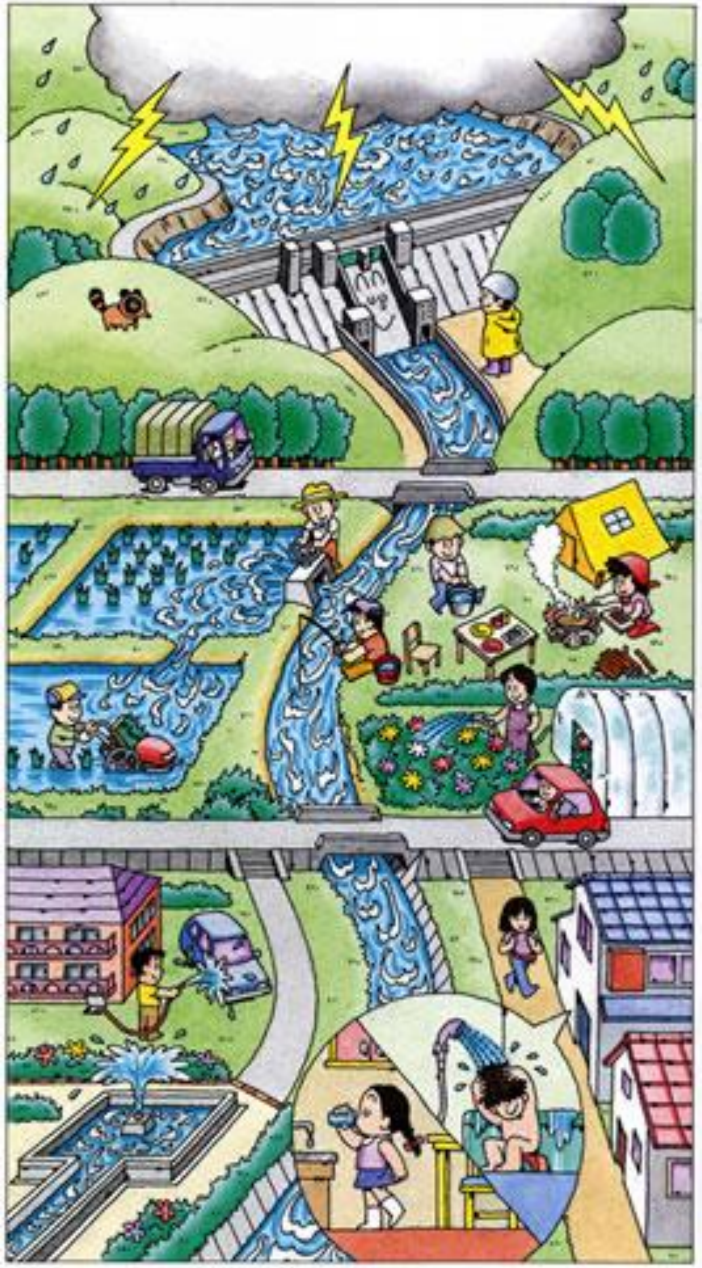
- The cities of Amagasaki, Itami, Toyonaka, Kawanishi, Takarazuka, Ikeda and Mino are all located in the surrounds of the Ina River. Thanks to its economic growth from 1960 onward, this region rapidly developed as the center of Kansai, resulting in ballooning of the population of the region involving associated areas, reaching about 1.6 million, and giving rise to a serious water shortage problem.

- Moreover, frequent major flooding from the Ina River in the past inflicted serious damage on residents living on its shores. Even now, residents on the shores of the river still have vivid memories of the horrors of events such as the major floods centered on Kobe in 1938 and serious flooding throughout the entire Kinki region caused by the typhoon No. 13 in 1953.

- To address these issues, a plan was formed to construct a multi-purpose dam with floodwater regulating functions and channel improvement of the Ina River implemented to mitigate damage from flooding, so that water could be supplied from the dam during periods of drought for agricultural and waterworks use and sufficient additional municipal water produced for between 500 and 600 thousand more people.

- Subsequently, at the massive cost of 63.8 billion yen, the Hitokura Dam was completed over a period of 16 years from August 1, 1968, when the survey center was inaugurated, to March 1984.

Roles of the Dam



■ Floodwater Regulation

To mitigate damage caused by flooding, the dam provides regulating functions that prevent too much water from flowing into the river when massive amounts of water are produced by events such as typhoons or torrential rainfall, thus reducing the amount of floodwater downstream.

■ Maintenance of Normal Waterflow Function

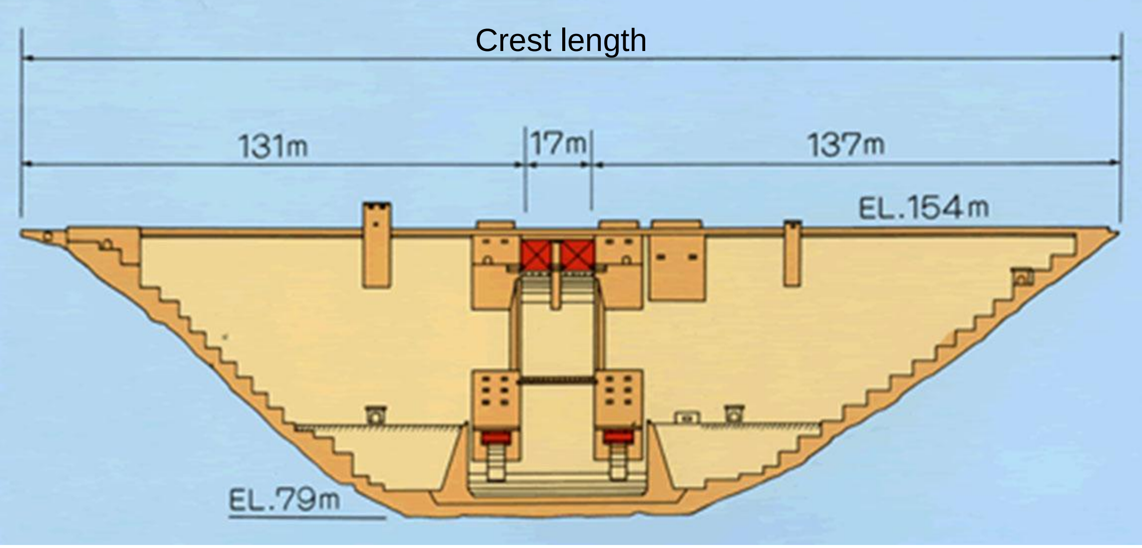
Water is supplied from the dam when there is a shortage of water in the Ina River to stabilize the river flow and ensure sufficient supply of water for irrigation of existing agricultural land on the shores of the river and waterworks intake.

■ Supply of Water for Waterworks

Water supply from the dam ensures sufficient city water for between about 500 and 600 thousand more people.

Dam Structure and Specifications

■ Frontal View of the Dam (Downstream part)



■ Standard Cross Section Drawing (Overflow part)

■ Dam Specifications

Location	Karamatsu, Hitokura-aza, Kawanishi-shi, Hyogo Prefecture
River name	Yodo River system, Ina River tributary, Hitokura Oroji River
Type	Concrete gravity dam
Total water storage capacity	33,300,000m³
Floodwater regulation capacity	17,500,000m³
Surcharge capacity	4,000,000m³
Effective water storage capacity	30,800,000m³
Irrigation capacity	13,300,000m³
Sedimentation capacity	2,500,000m³
Embankment height	75m
Crest length	285m
Dam volume	441,000m³
Height of crest above sea level	EL. 154.0m
Basin area	115.1km²
Reservoir area	1.4km²
Irrigation water depth	44.0m
Surcharge level	EL. 152.0m
Constant reservoir level	EL. 149.0m
Water level limit during flooding	EL. 135.3m
Minimum level	EL. 108.0m
Planned high water discharge	790m³/s
Regulated flow rate	640m³/s
Planned maximum discharge	150m³/s
Design floodwater flow rate	1,730m³/s

Hitokura Dam Discharge Equipment

○ The dam is furnished with crest spillway gate, emergency spillway gate and low-water management discharge equipment, each of which is operated to discharge water matched to discharge requirements at the time. These gates can all be opened and closed remotely from the management office.

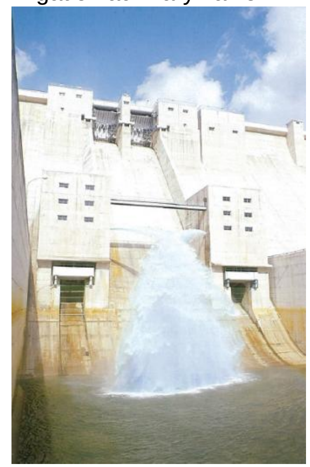
Discharge Equipment		
Crest spillway gate	Type	I-type discharge pipe
	Discharge pipe	Two 4.4 m (W) x 4.4 m (H) pipes
	Gate	Two high-pressure radial gates Two coaster gates
	Discharge capacity	Q=650 m³/s at water level limit level during flooding of 135.3 m
Emergency spillway gate	Type	Crest overflow
	Gate	Two 8.5 m (W) x 9.3 m (H) radial gates
	Discharge capacity	Q=890 m³/s at design floodwater level of EL.152.5 m
Low-water management discharge equipment	Type	Intake tower
	Selective water intake	Discharge pipe
	7-stage round gate	950 m/m branching at less than φ1,400 m/m
	Gate	Jet flow gate, etc.
	Discharge capacity	Q=9.0 m³/s at minimum irrigation water level of EL.108.0 m

Crest spillway gate

This is a floodwater regulating gate and water is discharged from all sluice gates until a flood on a scale that occurs only roughly once every hundred years occurs.

Low-water management discharge equipment

Discharge from the irrigation auxiliary valve

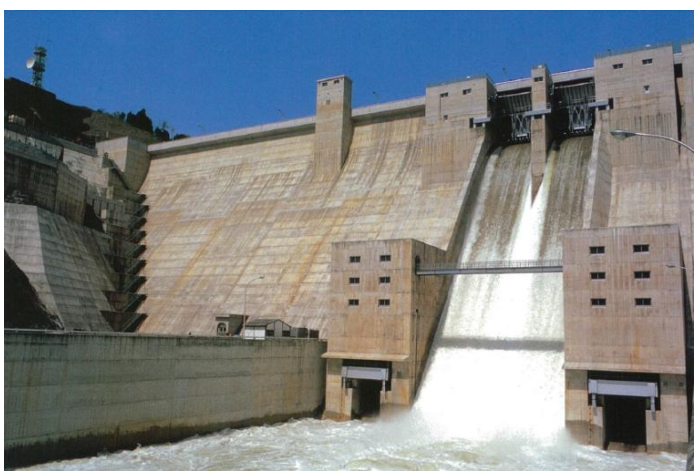


When water is discharged downstream from the dam to maintain normal city water and waterflow functions, water taken from selective water intake gates is discharged from facilities such as discharge valves or hydroelectric power generation equipment for management use.

Selective water intake gate opening and closing equipment

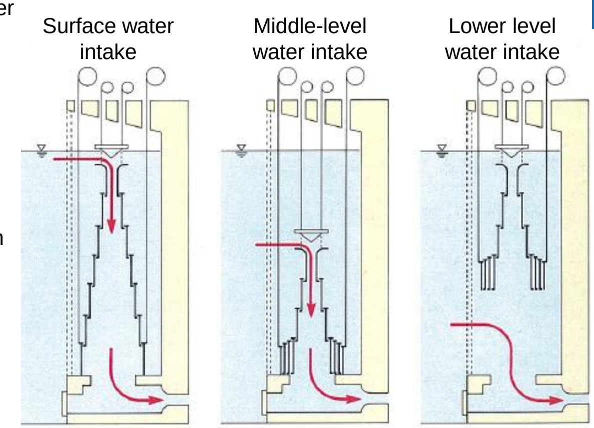
Emergency spillway gate

This is an emergency gate that prevents overflow at the dam crest when massive amounts of floodwater that cannot be handled by the crest spillway gate alone are caused by a flood on a scale that occurs only roughly every hundred years.



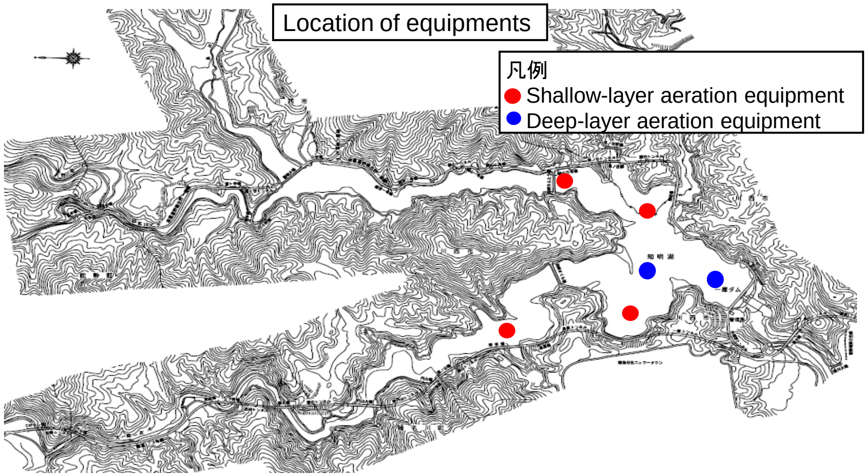
About selective water intake

During the period from spring to autumn, the upper level of water in the reservoir is warm, and the lower level cold. Normally, only water from the upper level is taken in and discharged downstream from the dam.
However, when, for example, abnormal growth of phytoplankton on the upper level degrades the water quality, relatively clean water is taken from the middle level and discharged.

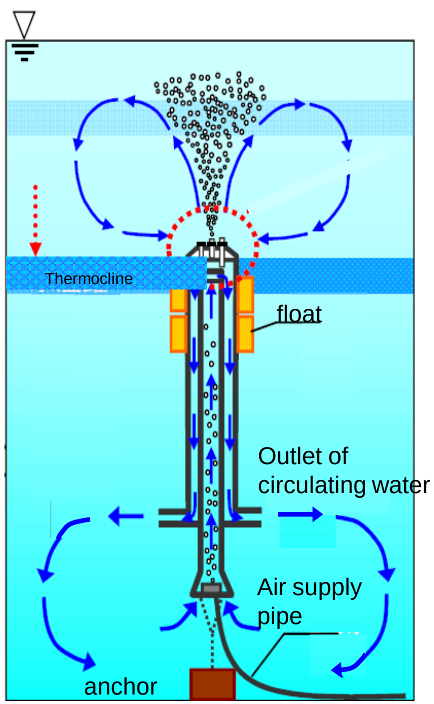


Aeration equipments and hydroelectric power plant

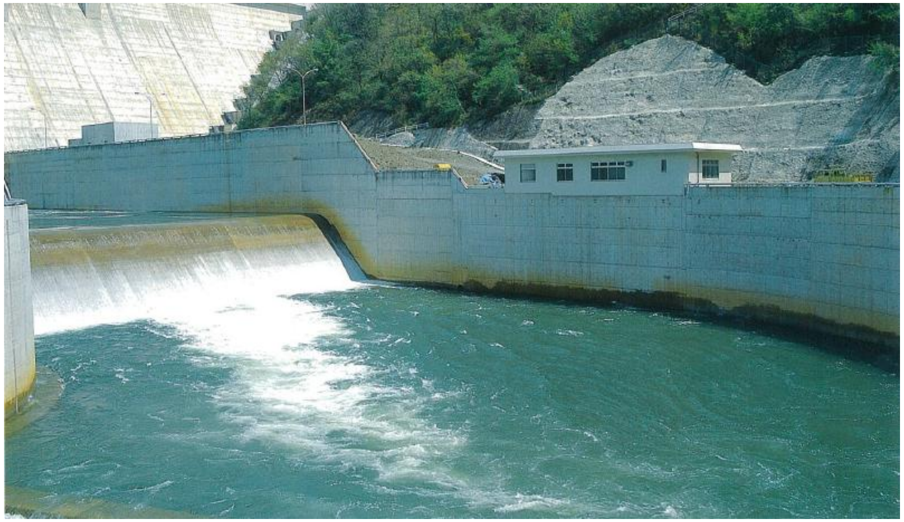
Aeration equipments for water quality improvement



There are six aeration equipments in the reservoir to improve water quality. Two of them is deep-layer aeration equipments, which also works as shallow aeration equipment and the rest is shallow-layer aerations.
A deep-layer aeration equipment sends oxygen to the bottom of the reservoir to control the creation of hydrogen sulfide, inorganic phosphorus and also hydrogen sulfide odor cased by discharge from the gates.
A shallow-layer aeration equipment circulates the water in the reservoir using bubbles generated in the depth of about 15 to 20 m in the reservoir to control the unusual huge scale of emergences of algae such as water bloom.



Hydroelectric power plant for daily dam management and maintenance works



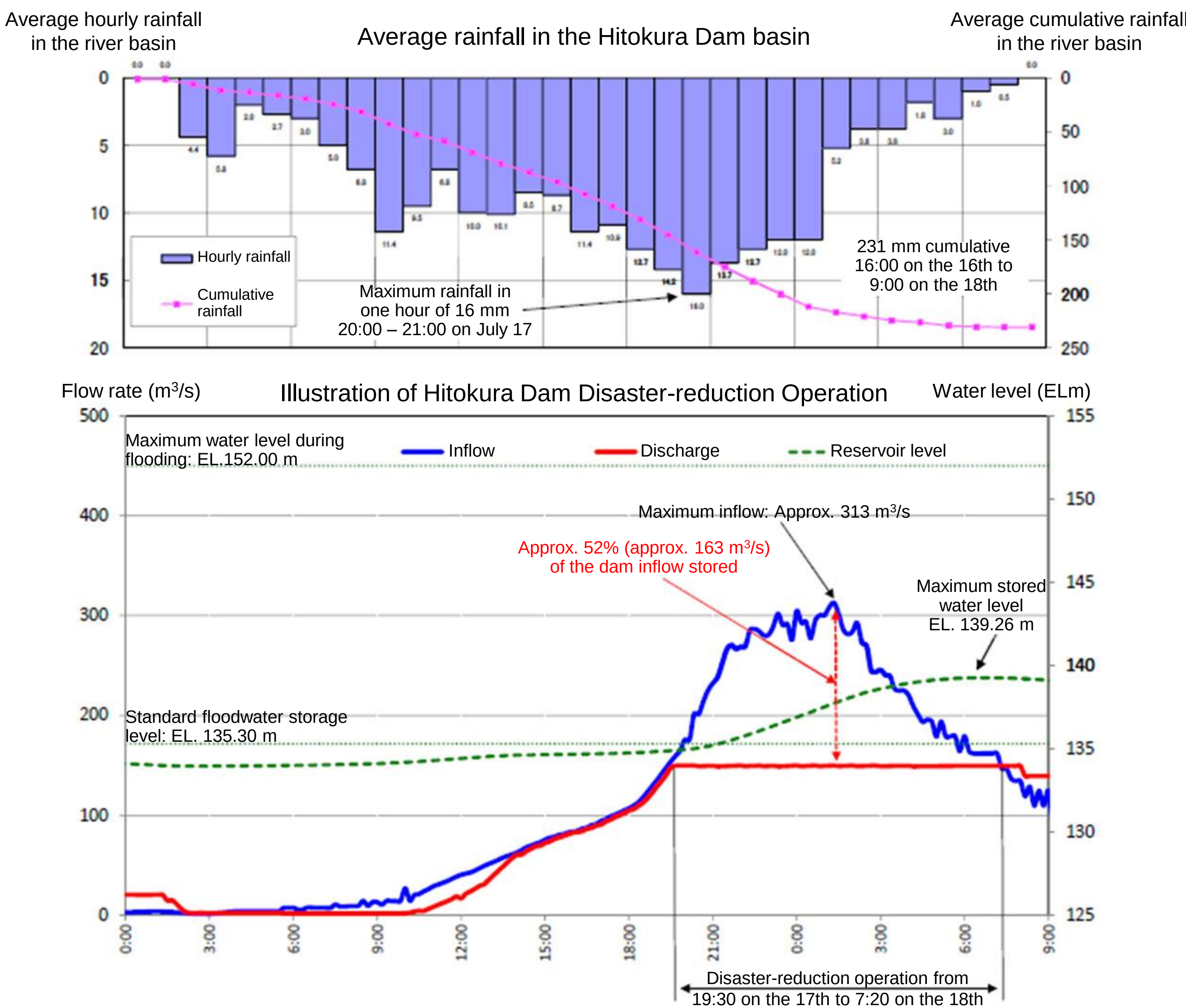
The hydroelectric power plant can generate 1,900 kW electricity at maximum using discharged water from the dam. The generated electricity is used for daily dam management and maintenance works. The surplus electricity is sold to Kansai Electric Power Company, so the management and maintenance costs can be saved.

Water-wheel and generator specifications

Water wheel specifications		Generator specifications	
Type	Horizontal-shaft Francis Turbine	Type	3-phase synchronous generator
Maximum output	2,100 KW	Maximum output	1,900 KW
Maximum head	59.0 m	Voltage	6,600 V
Maximum flow rate	4.2 m^2/s	Frequency	60 Hz
Rotation speed	720 rpm		

Floodwater Regulation when Typhoon Number 11 struck in 2015 – 1/2

Regarding Hitokura Dam Disaster-reduction Operation during rainfall produced by Typhoon Number 11



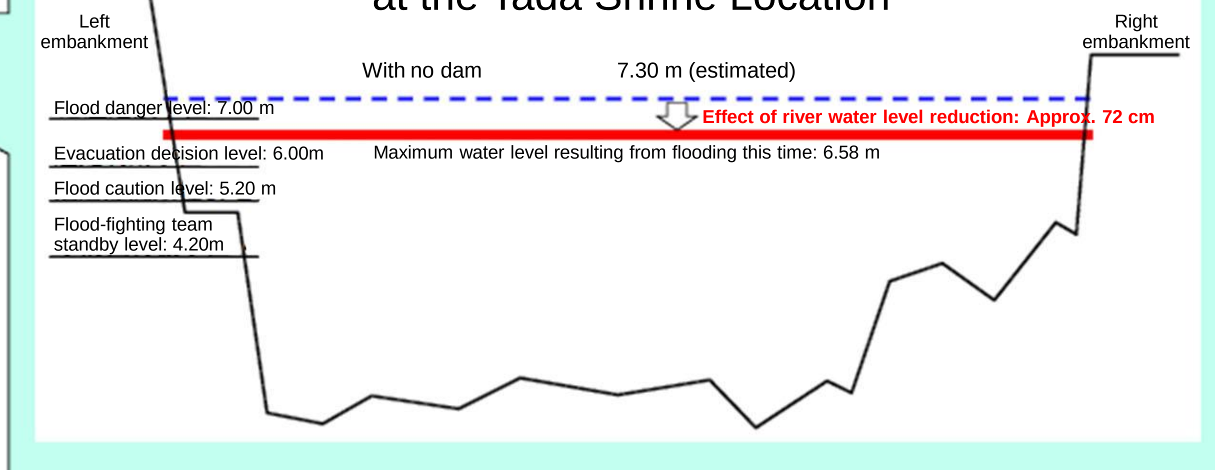
Floodwater Regulation when Typhoon Number 11 struck in 2015 – 2/2

Floodwater equivalent to approximately three times the size of the Kyocera Dome Osaka was stored and the water level downstream from the dam reduced by a maximum of 72 cm.

Maximum inflow (313 m^3/s) was recorded when rainfall caused by Typhoon Number 11 increased inflow to the dam. Floodwater equivalent to approximately three times the size of the Kyocera Dome Osaka (approx. 3.56 million cubic meters) was stored in the Hitokura Dam and it is estimated that the water level at the Tada Shrine location downstream from the dam was reduced by 72 cm. (The size of Kyocera Dome Osaka is calculated to be 1.20 million m^3.)

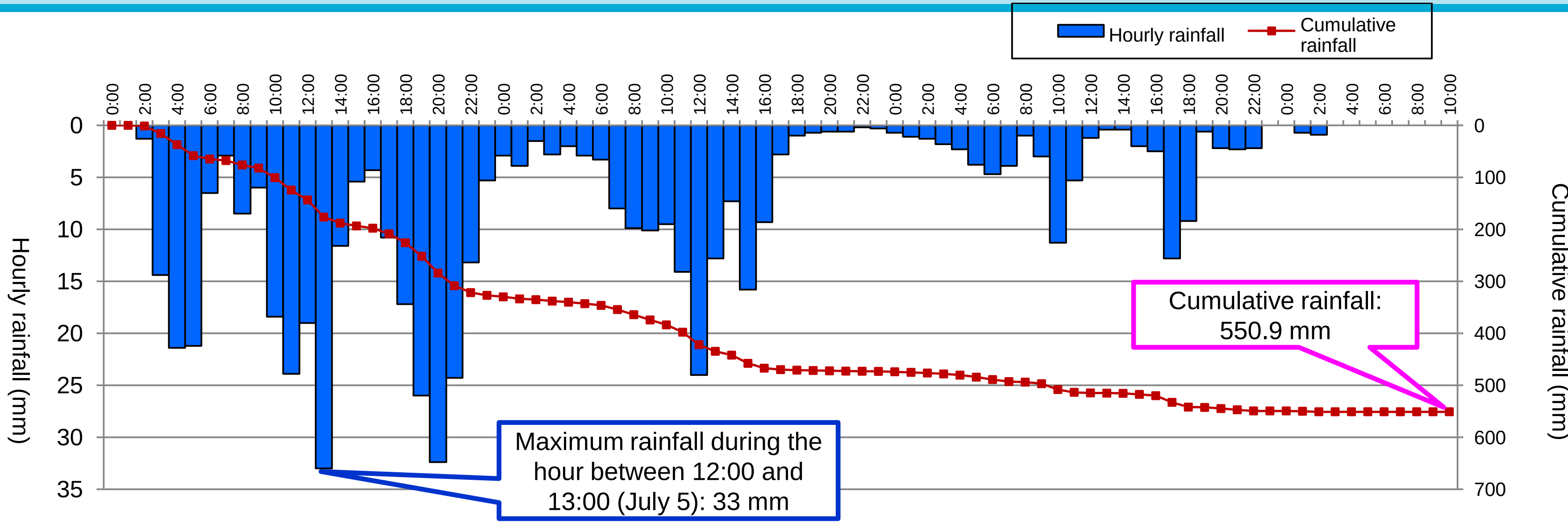
Ina River Basin Diagram

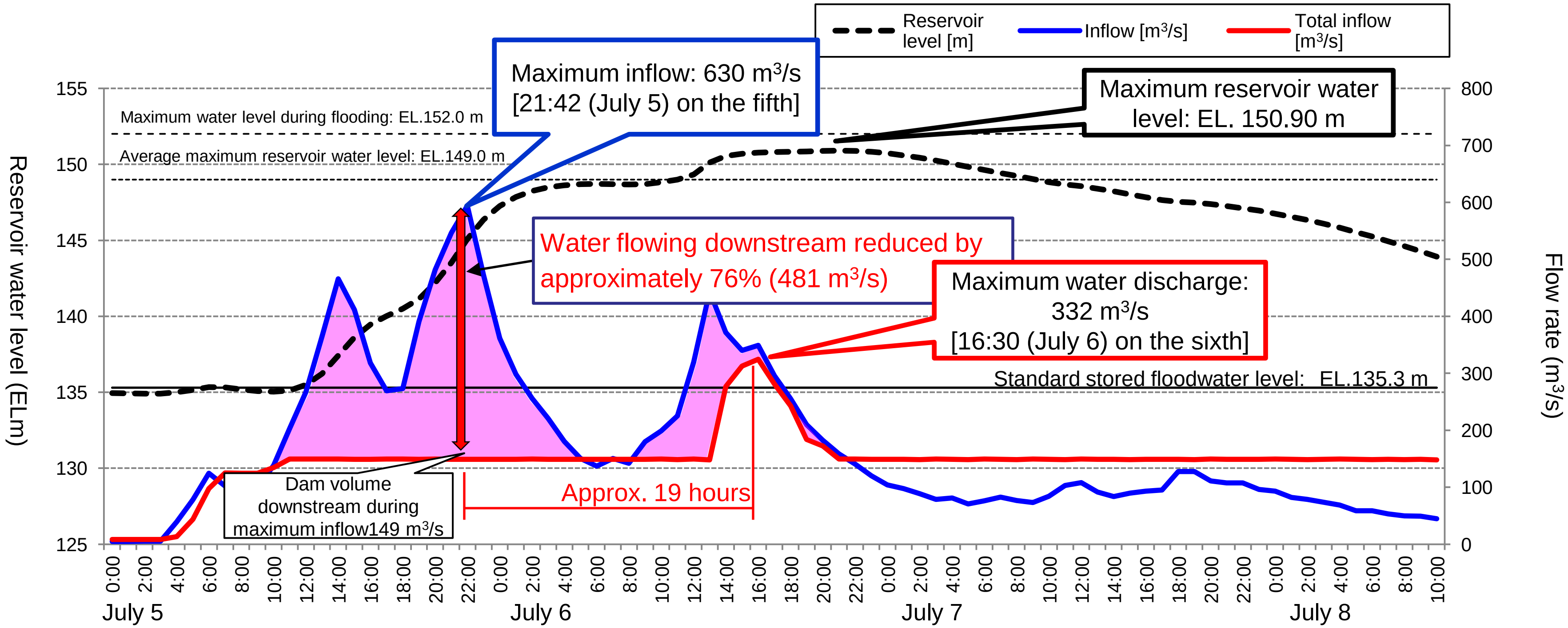
Effects of Water Level Reduction at the Tada Shrine Location



*This presentation shows preliminary figures which may change through future close investigation.

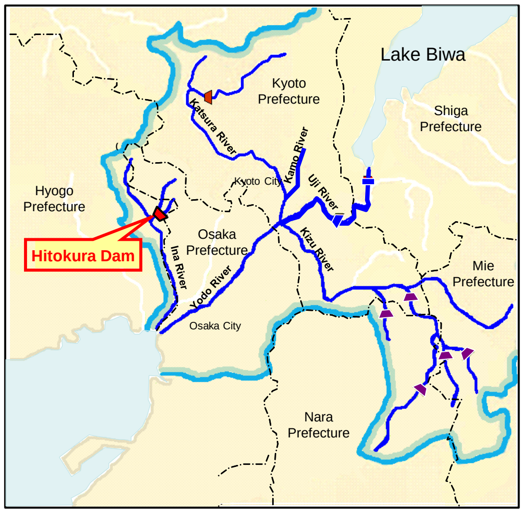
Floodwater Regulation during the Torrential Rainfall of July 2018 – 1/2





Floodwater Regulation during the Torrential Rainfall of July 2018 – 2/2

- Record rainfall totaling 550.9 mm from the onset of rain caused by a stationary active seasonal rain front was observed in the Ina River Hitokura Dam basin in the Yodo River system. Although a maximum inflow to the dam of 630 cubic meters per second was recorded during the rainfall, attempts to reduce the river water level downstream from the dam were made by implementing disaster-reduction operation, resulting in reduction of the inflow by approximately 76% (481 cubic meters per second).
- If there had been no dam, it is estimated that the water level at the Tada Shrine location would have risen 8.26 m above the height of the embankment, resulting in floodwater overflowing the embankment and causing flood damage.



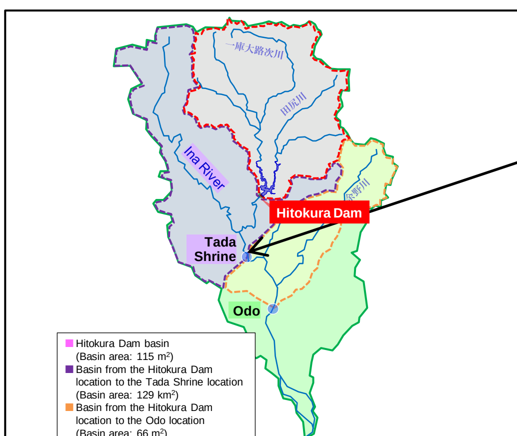
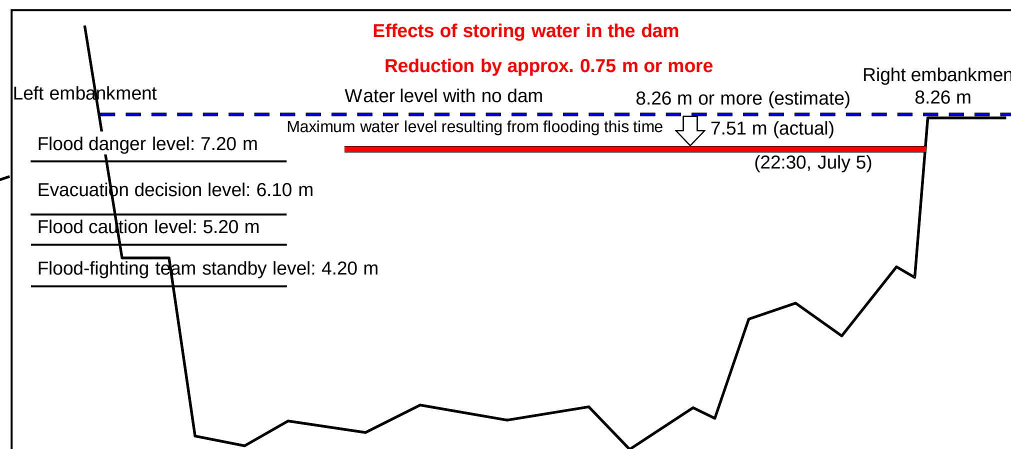


Illustration of the Ina River Basin

State of the reservoir before the start of floodwater storage
(Approx. 10:00 on July 2: EL.135.84 m)

State of the reservoir with water approaching the maximum level during flooding
(Approx. 17:00 on July 6: EL.150.81 m (water continuing to rise)

Effects of Water Level Reduction at the Tada Shrine Location



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