# Advanced Technologies to Upgrade Dams under Operation

## *can reduce the*
## *COST,*
## *CONSTRUCTION PERIOD and*
## *SOCIAL & ENVIRONMENTAL IMPACTS.*

**Upgrading 60-year-old Katsurazawa Dam**


Japan Commission on Large Dams

Japan Dam Foundation

Japan Dam Engineering Center

Japan Association of Dam & Weir Equipment Engineering

Water resources Environment Center

Japan Water Agency

Public Works Research Institute

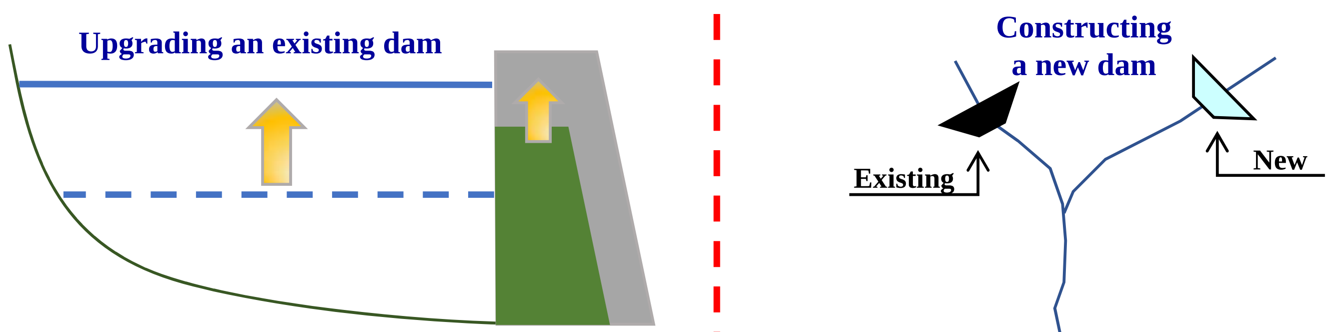
Water and Disaster Management Bureau
Ministry of Land, Infrastructure, Transport and Tourism
Government of Japan

# MLIT's comprehensive water management policies:

| | |
|---|---|
| *Planning* | Formulate long-term strategies and mid-term plans on flood risk management and water resource management. |
| *Coordinating* | Enhance coordination among water-related stakeholders. |
| *Implementing* | Implement water-related infrastructure construction and improvement projects including dam upgrading under operation. |
| *Accumulating* | Accumulate water-related knowledge in cooperation with relevant research institutions such as National Institute for Land and Infrastructure Management (NILIM) and Public Works Research Institute (PWRI). |

# Why upgrade dams under operation ?

Dam upgrade projects have less impact on the environment and local community than new dam construction projects.




| | Upgrading an existing dam | | | Constructing a new dam | | |
|---|---|---|---|---|---|---|
| **Social impact** | **Comparatively small impact** | Newly inundated land | **Less** | **Severe impact by rebuilding the local community** | Newly inundated land | **Significant** |
| | | Shifted roads | **Less** | | Shifted roads | **Significant** |
| | | Cost | **Low** | | Cost | **High** |

**Dam upgrading achieves expected benefits with reducing negative environmental impacts with lower project cost and with shorter construction period.**

| | Upgrading an existing dam | | | Constructing a new dam | | |
|---|---|---|---|---|---|---|
| **Environmental impact** | **Less impact on the ecosystem** | Interruption of the river flow | **None** | **Need mitigation measures for the impact on ecosystems** | Interruption of the river flow | **Significant** |
| | | Disturbance of the river habitat | **Low** | | Disturbance of the river habitat | **Significant** |

# Technologies to upgrade dams under operation

# 1. Technologies to increase the reservoir volume

## 1-1 Raising the dam body

Increasing the reservoir volume to improve the ability for the flood control and/or power generation.

- New Katsurazawa Dam in Hokkaido Pref.（Fig.1-1a)
- Kasabori Dam in Niigata Pref.(Fig.1-1b)
- New Maruyama Dam in Gifu Pref. etc.

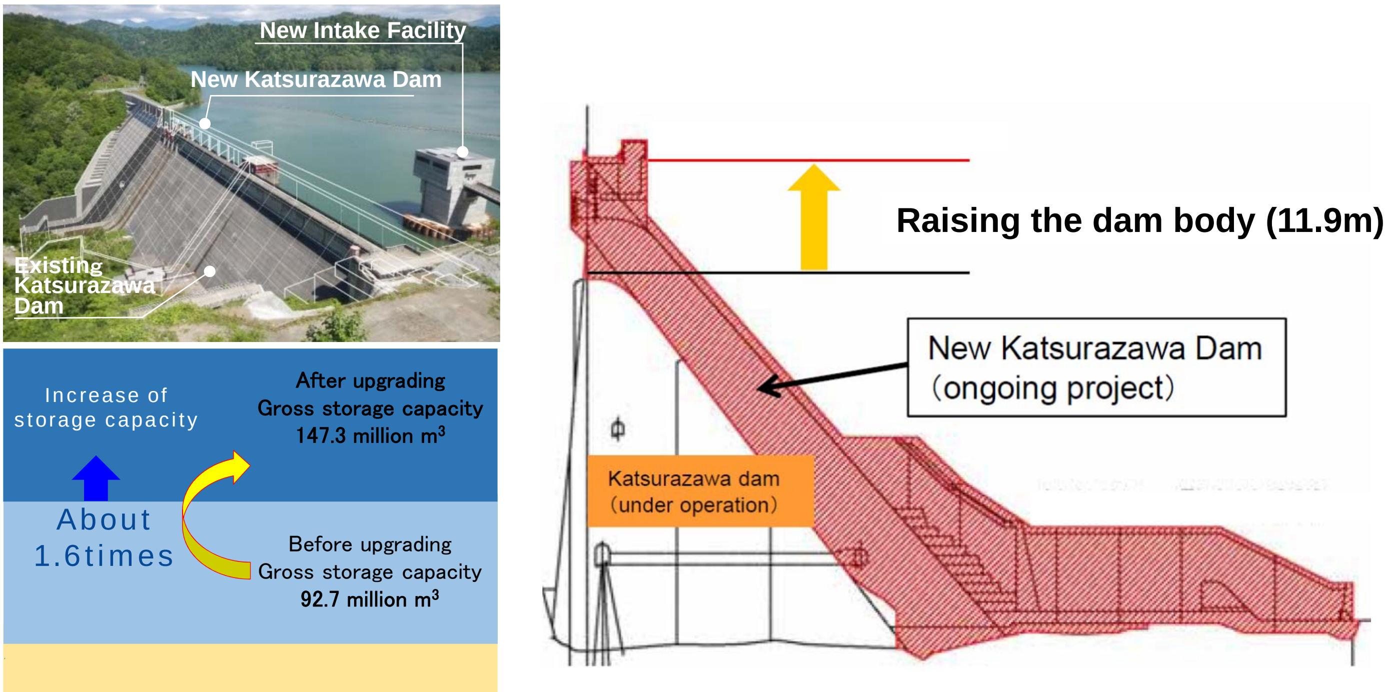



**Fig.1-1a New Katsurazawa Dam（large-scale project）**

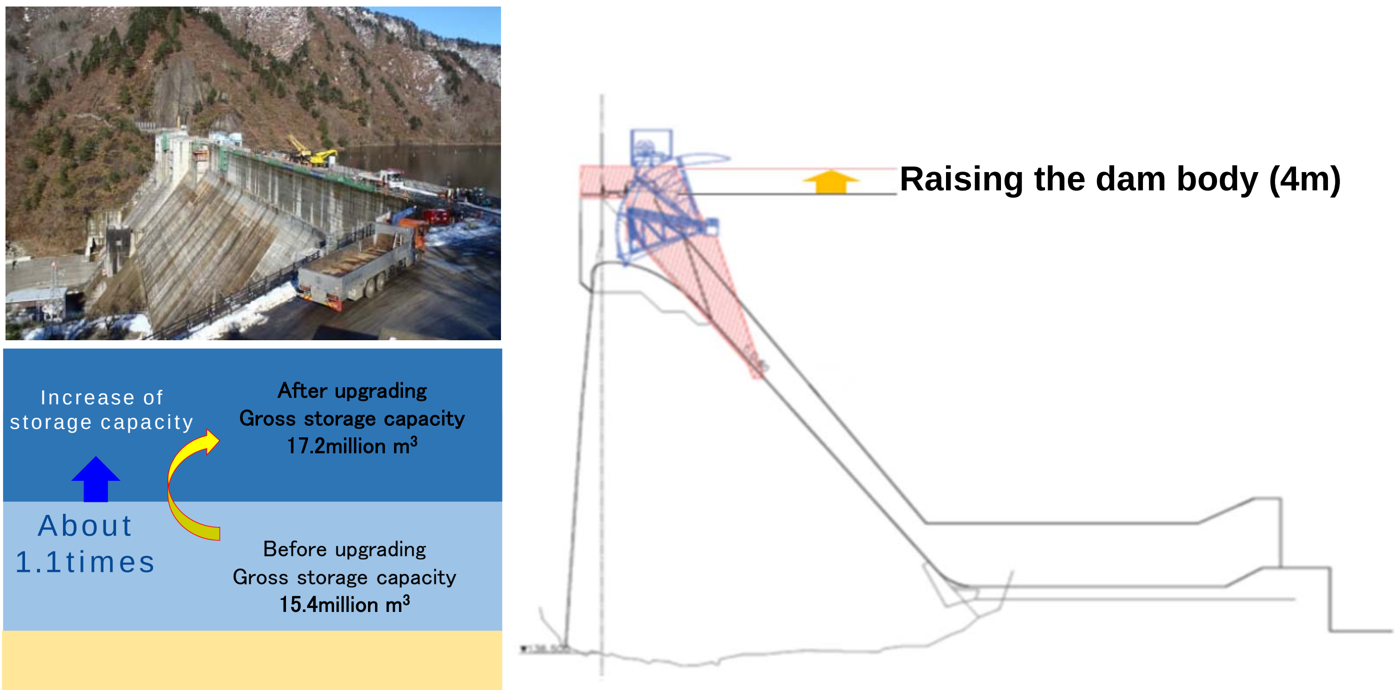
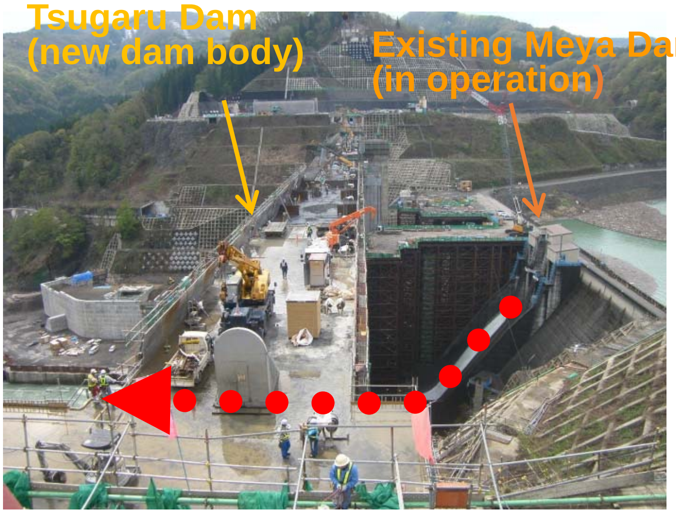



**Fig.1-1b Kasabori Dam (small-scale project)**

## 1-2 Constructing a new dam just downstream from the existing dam without stream diversion

Upgrading the dam body without interruption on the operation of the existing dam.
・Tsugaru Dam in Aomori Pref.（Fig.1-2）
・Yubarishuparo Dam in Hokkaido Pref. etc.



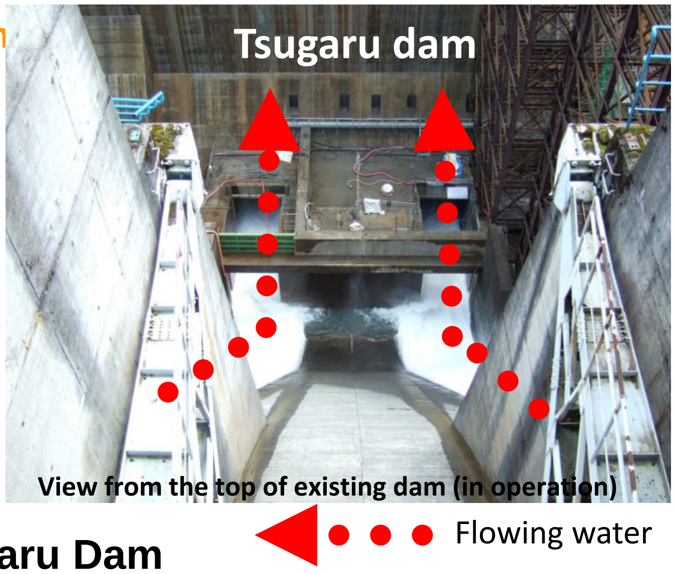
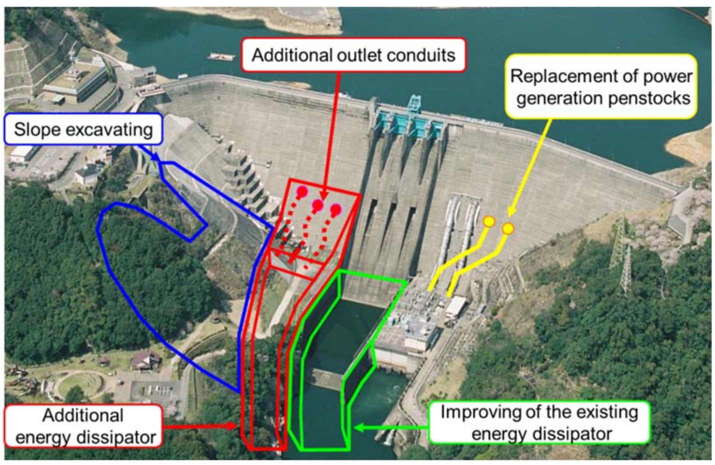




**Fig.1-2 Tsugaru Dam**

## 1-3 Constructing structures in deep reservoir

Installing deep-water structures for re-arrange the active storage capacities without the restriction on the operational function of the existing dam.
・Tsuruda Dam in Kagoshima Pref. (Fig.1-3)
・New Katsurazawa Dam in Hokkaido Pref. etc.



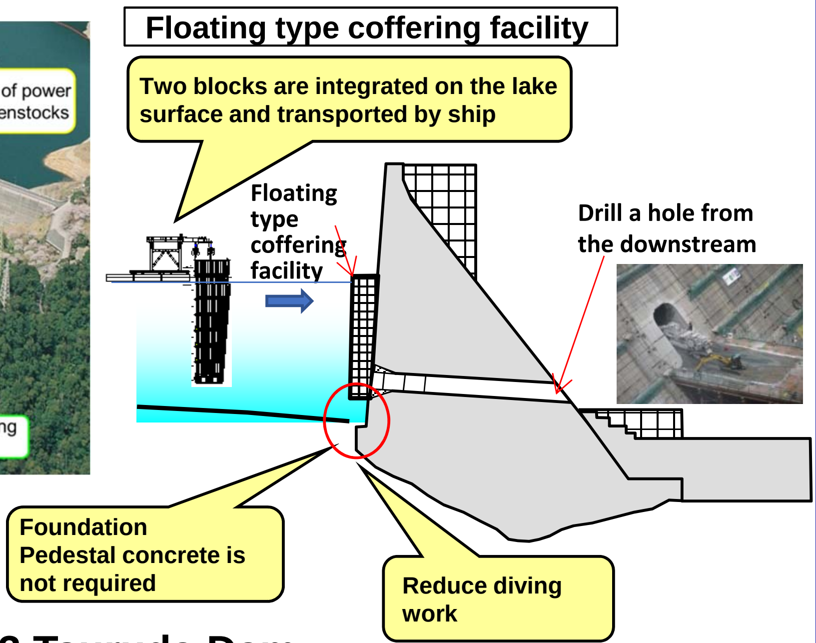
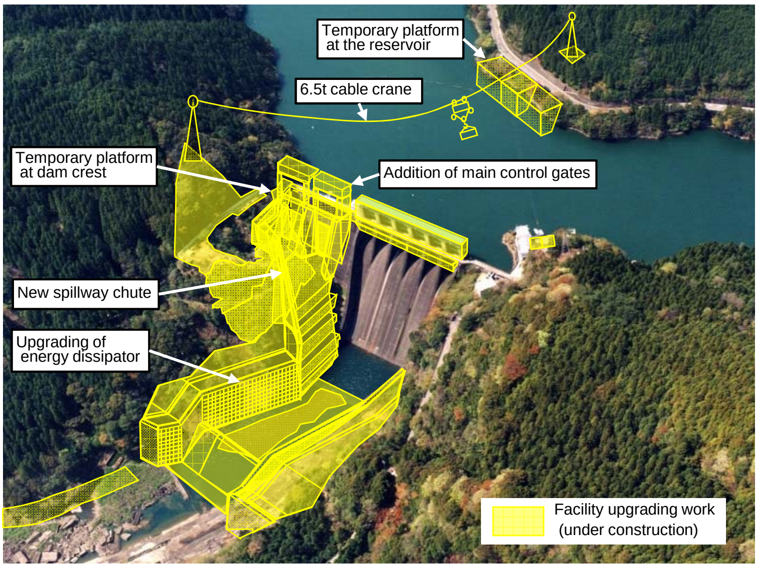




**Fig.1-3 Tsuruda Dam**

## 2. Technologies to increase the discharge capacity

### 2-1 Constructing additional crest gates

Installing the additional gate to optimize the operation for flood control.
・Nagayasuguchi Dam in Tokushima Pref.(Fig.2-1)
・Houri Dam in Miyazaki Pref. etc.

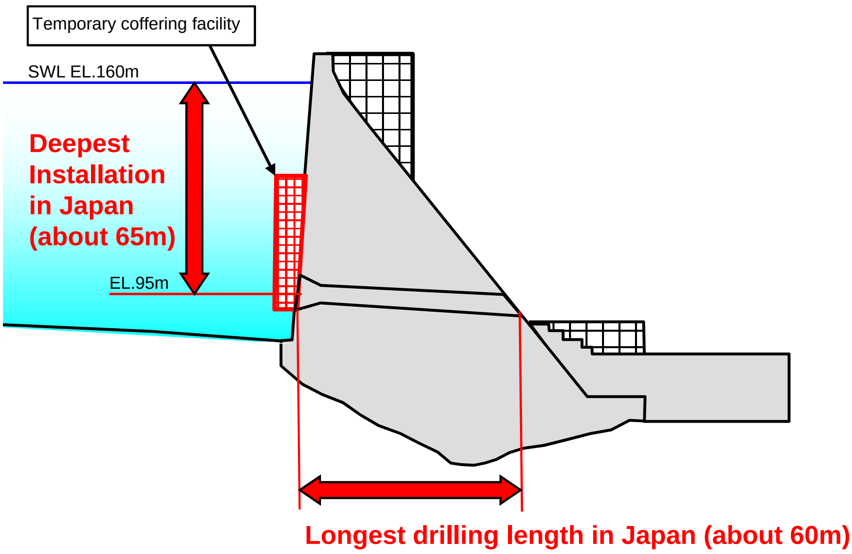



Construction situation

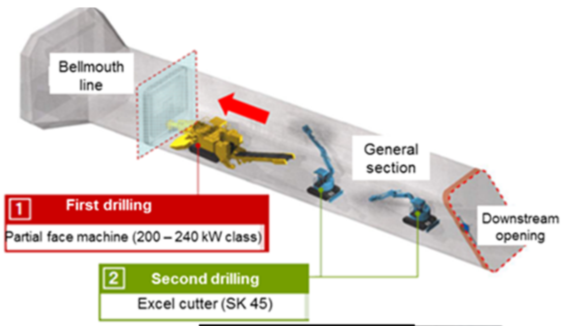
**Fig.2-1 Nagayasuguchi Dam**

### 2-2 Drilling the existing dam body from downstream

Constructing new discharge tunnel through the dam body to optimize the operation.
・Tsuruda Dam in Kagoshima Pref.(Fig.2-2)
・Tase Dam in Iwate Pref. etc.




**Drilling method in the dam body**




Case from other dam

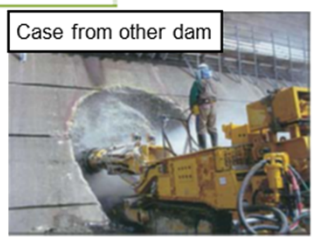
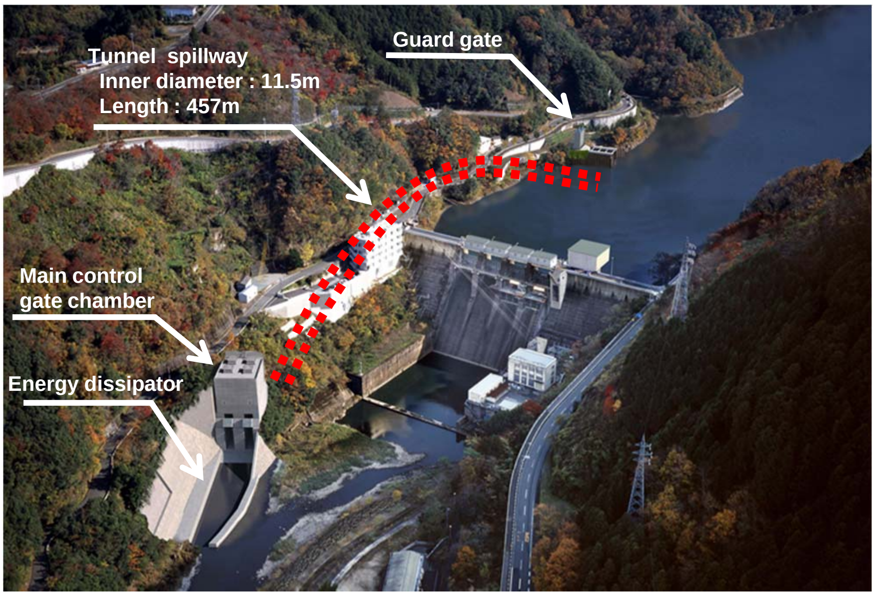


**Fig.2-2 Tsuruda Dam**

## 2-3 Constructing new spillways

Installing new spillway to optimize the operation without affecting the dam body.
- Kanogawa Dam in Ehime Pref.(Fig.2-3)
- Amagase Dam in Kyoto Pref. etc.




Steel penstock pipes of 11.5 m diameter, as the world's largest, were installed.

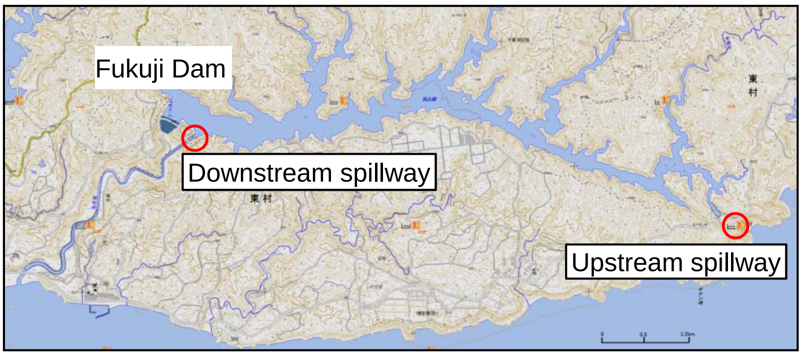
**Fig.2-3 Kanogawa Dam**

## 2-4 Upgrading existing spillways

Upgrading the existing spillway to optimize the operation without affecting the dam body.
- Fukuji Dam in Okinawa Pref.(Fig.2-4)
- Sabaishigawa Dam in Niigata Pref. etc.

(1) Downstream spillway before upgrading (Normal and emergency uses)

(2) Downstream spillway after upgrading (Drum gates installed) (Normal and emergency uses)





(1) Upstream spillway before upgrading (Emergency use)

(2) Upstream spillway after upgrading (Normal and emergency uses)

**Fig.2-4 Fukuji Dam**

# 3. Technologies to improve the structural stability

## 3-1 Improving the structural stability of the existing dam to resist earthquakes damage

Improving the seismic resistance while installing the additional flood control capacity simultaneously.

・Sayamaike Dam in Osaka Pref.(Fig.3-1)

・Hongochi-Teibu Dam in Nagasaki Pref. etc.

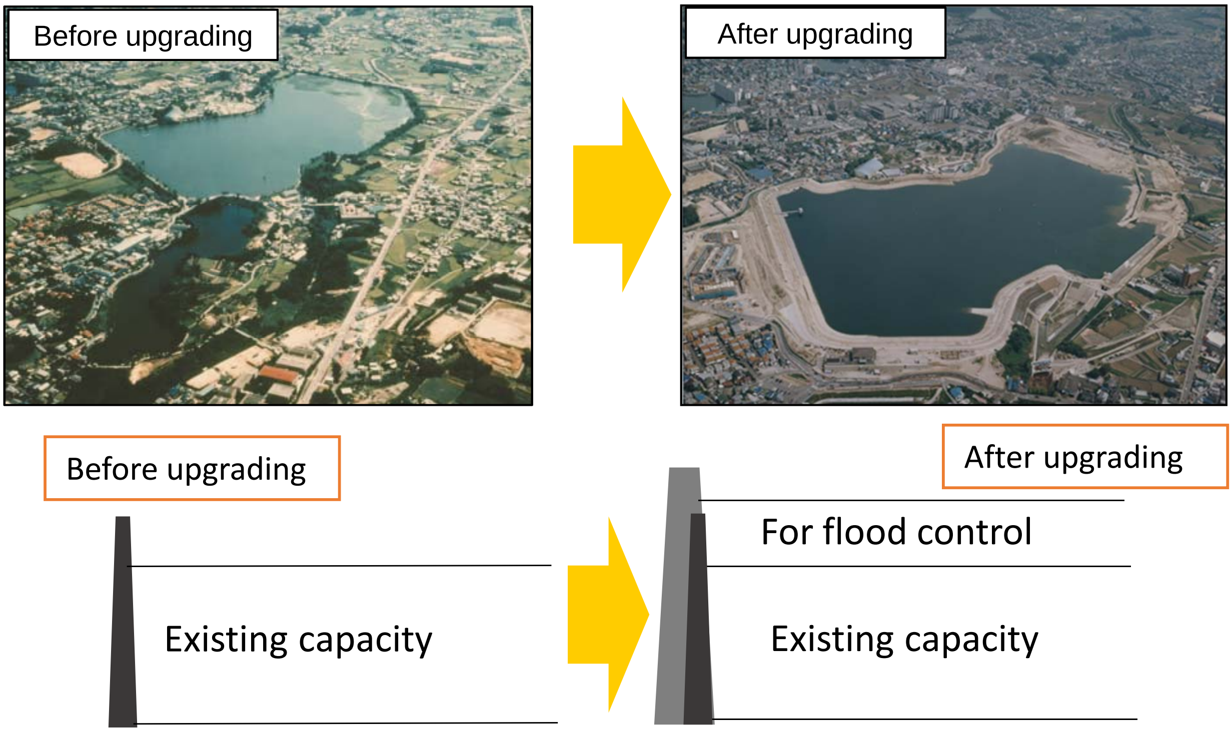



**Fig.3-1 Sayamaike Dam (Oldest dam in Japan, more than 1,300 years old)**

## 3-2 Controlling the seepage through the dam body and/or its foundation

Implementing an appropriate combination of the countermeasures for controlling the seepage with a limited budget.

・Kin Dam in Okinawa Pref.(Fig.3-2)

・Chubetsu Dam in Hokkaido Pref. etc.

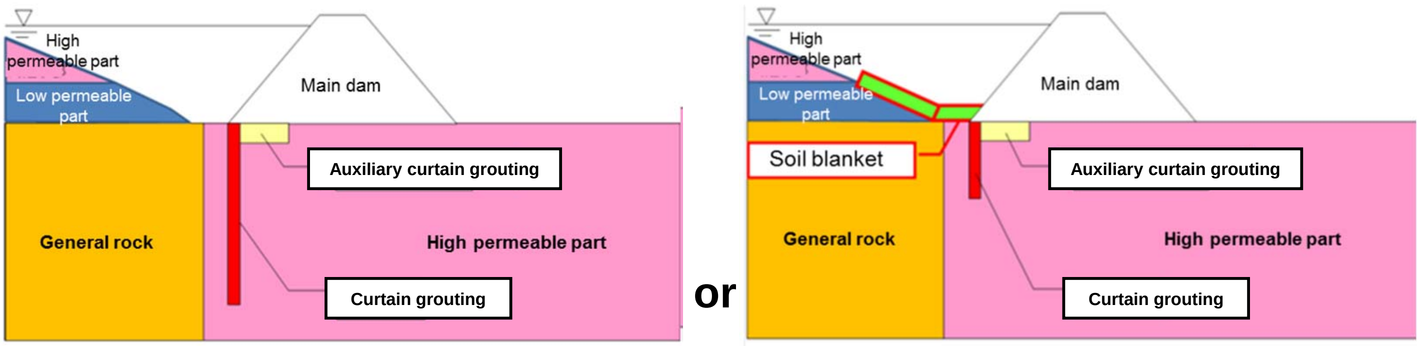



**Fig.3-2 Kin Dam**

## 3-3 Improving the stability of the downstream structures

Reinforcing the energy dissipator to improve the structural stability of the facilities in the downstream.

・Tsuruda Dam in Kagoshima Pref.(Fig.3-3)
・Nagayasuguchi Dam in Tokushima Pref. etc.

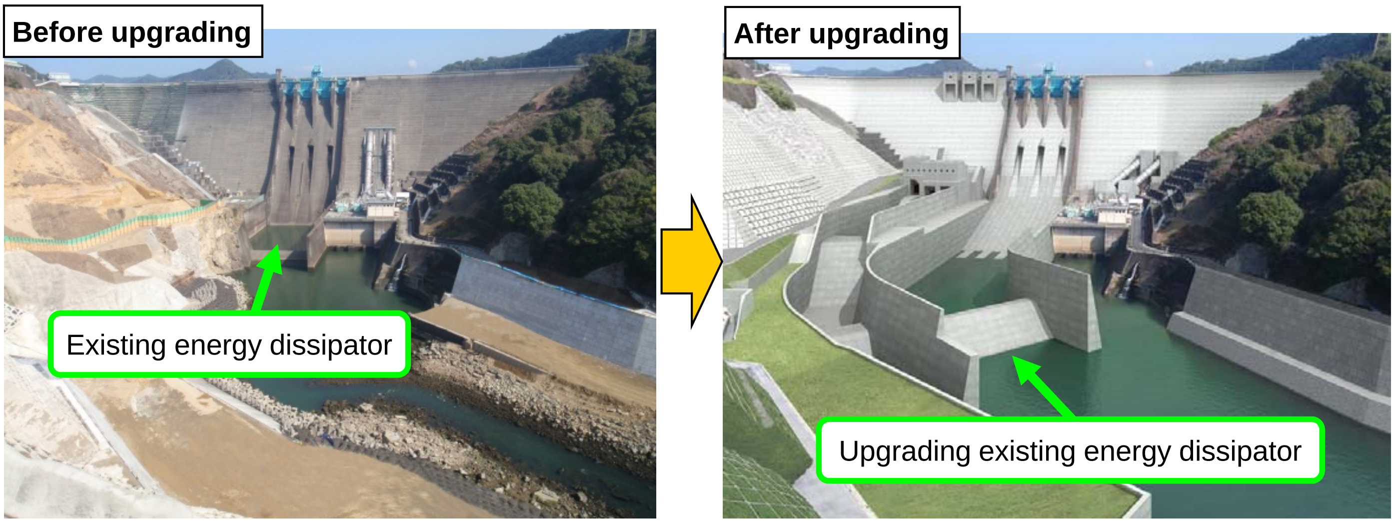



**Fig.3-3 Tsuruda Dam**

## 3-4 Inspecting the structural stability to resist catastrophic earthquakes

Ensuring the good seismic performance of a new or the existing dam (Fig.3-4).

Design (Level1)

**<u>Seismic design standard based on the seismic coefficient method to resist the design seismic force (Level 1)</u>**

• Seismic design for seismic force according to the following
-dam type (concrete gravity, concrete arch, rockfill dams)
-area classification with earthquake motion records

Check (Level2)

**<u>Guidelines for Seismic Performance Evaluation of Dams During Large Earthquakes (Level 2)</u>**

Required to satisfy the following two seismic performances despite damage at the time of Level 2 earthquake motion:

(1) The water storage function must be retained

(2) Damage must remain recoverable

**Fig.3-4 Seismic Design Standard and Seismic Performance Evaluation Guidelines**

# 4. Technologies to improve the operation

## 4-1 Maximizing the function through the coordination among multiple dams in a river basin

Carrying out the integrated operation for effective water resource management.
- Shorenji, Hinachi and Murou Dams in the Yodo river basin (Fig.4-1)
- Ikari and Kawaji Dams in the Tone river basin. etc.

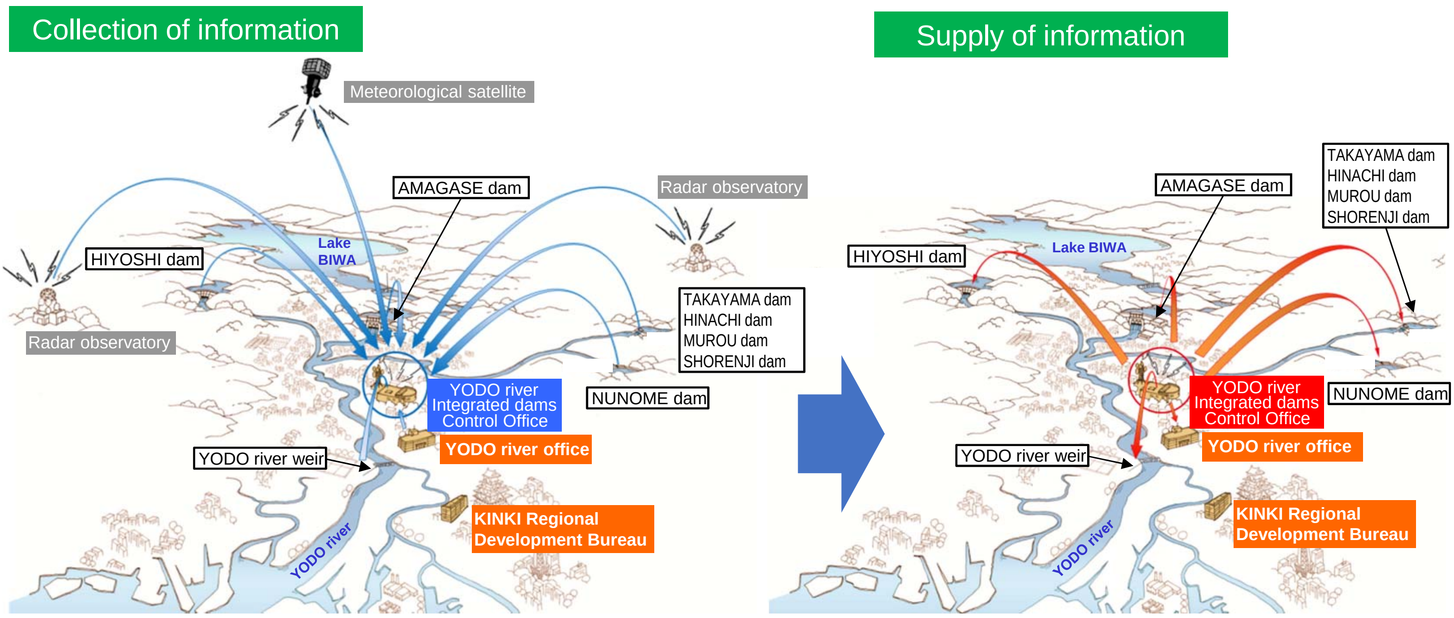



**Fig.4-1 The Yodo river basin**

## 4-2 Implementing the flexible and timely operation on the flood discharge

Implementing the real time rainfall forecasting system based on the radar equipment for improving the efficiency of the flood control operation.
- Sarutani Dam in Nara Pref.(Fig.4-2)
- Miharu Dam in Fukushima Pref. etc.

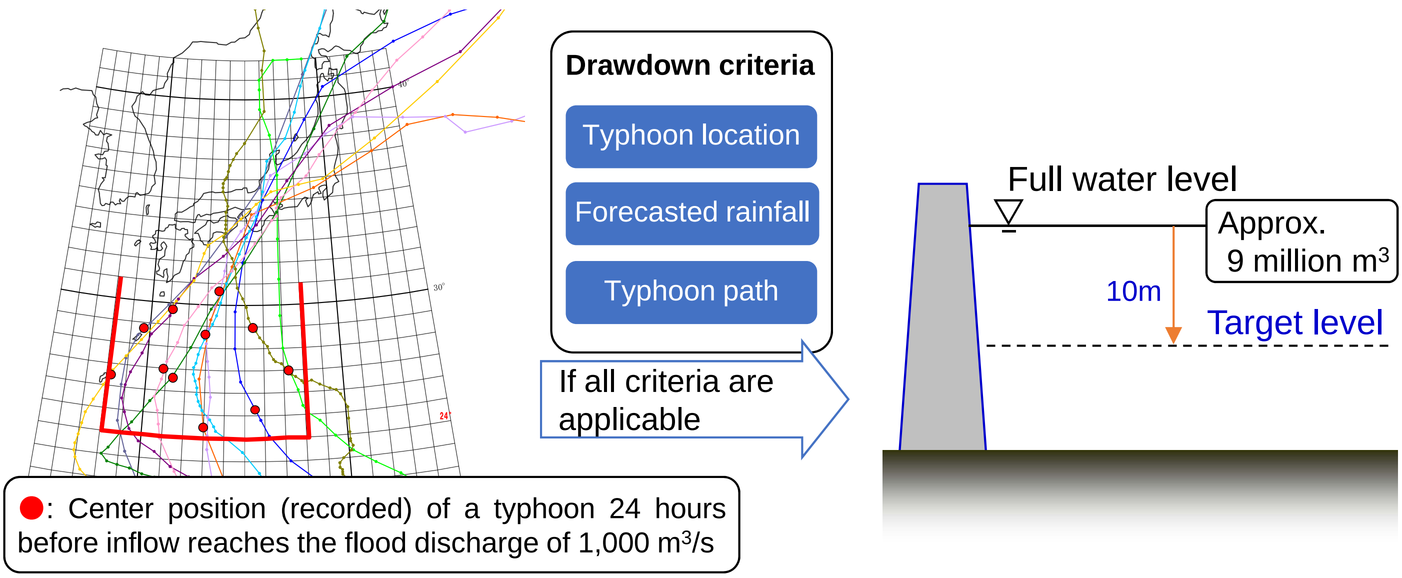
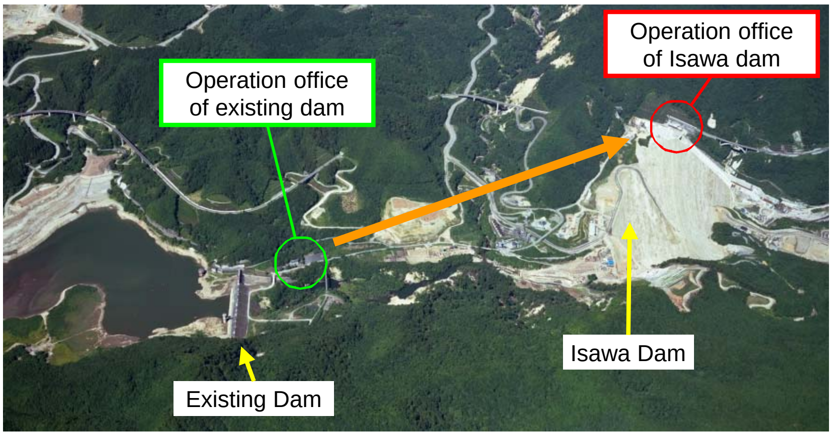
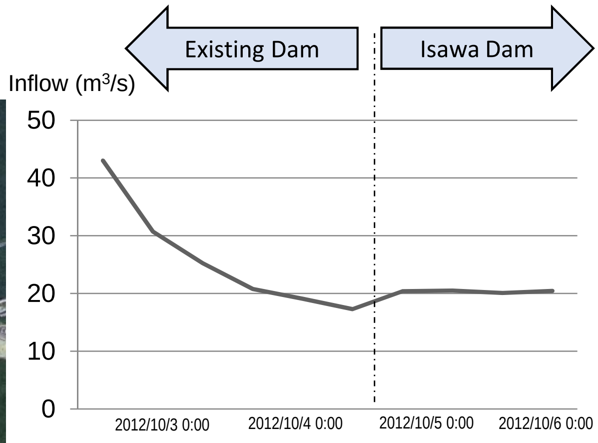



**Fig.4-2 Sarutani Dam**

# 4-3 Installing a new system without interrupting the operation

Enabling the continuous operation during the dam upgrading project.
- Isawa Dam in Iwate Pref.(Fig.4-3)
- Uchinomi Dam in Kagawa Pref. etc.




Gathering data on a continuously operating dam

**Fig.4-3 Isawa Dam**

# 4-4 Installing or upgrading the power generating facility

Installing the power generating facility under high water pressure conditions.
- Murou Dam in Nara Pref.(Fig.4-4)
- Terayama Dam in Tochigi Pref. etc.

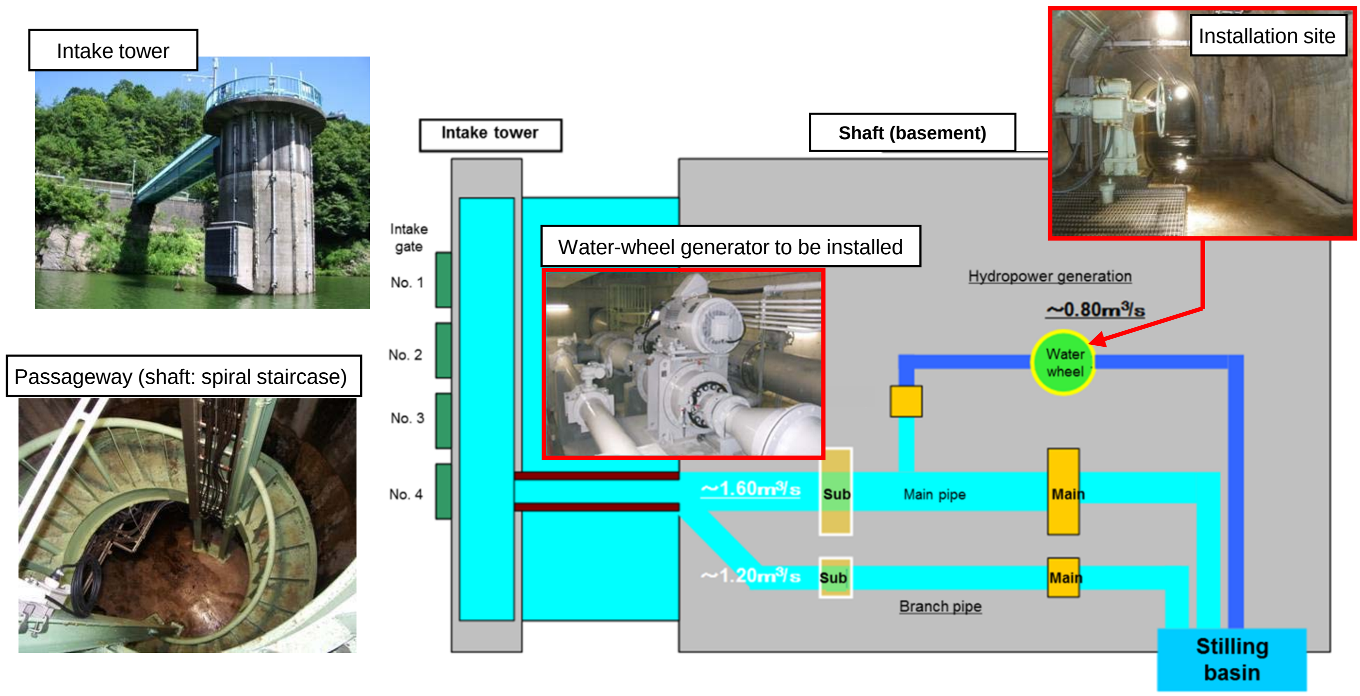



**Fig.4-4 Murou Dam**

# 5. Technologies to control the sediment

## 5-1 Controlling the sediment by the bypass tunnel

Extending the lifetime of the dam by improving the stability of the riverbed.
・Koshibu Dam in Nagano Pref.(Fig.5-1)
・Miwa Dam in Nagano Pref. etc.

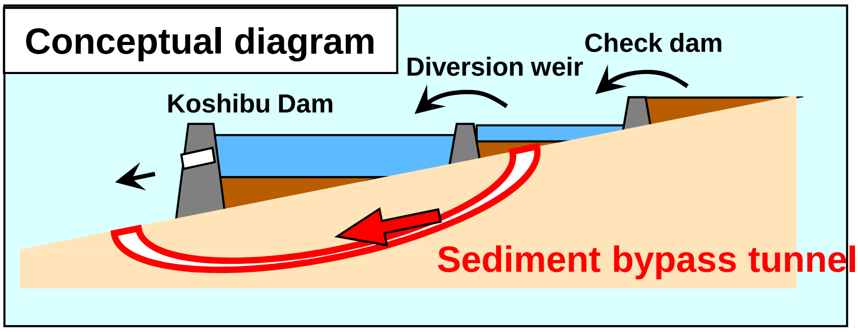





**Fig.5-1 Koshibu Dam**

## 5-2 Excavating and transporting the sediment

Reusing the sediment as aggregate after the excavation.
・Shichikashuku Dam in Miyagi Pref.(Fig.5-2)
・Yokoyama Dam in Gifu Pref. etc.

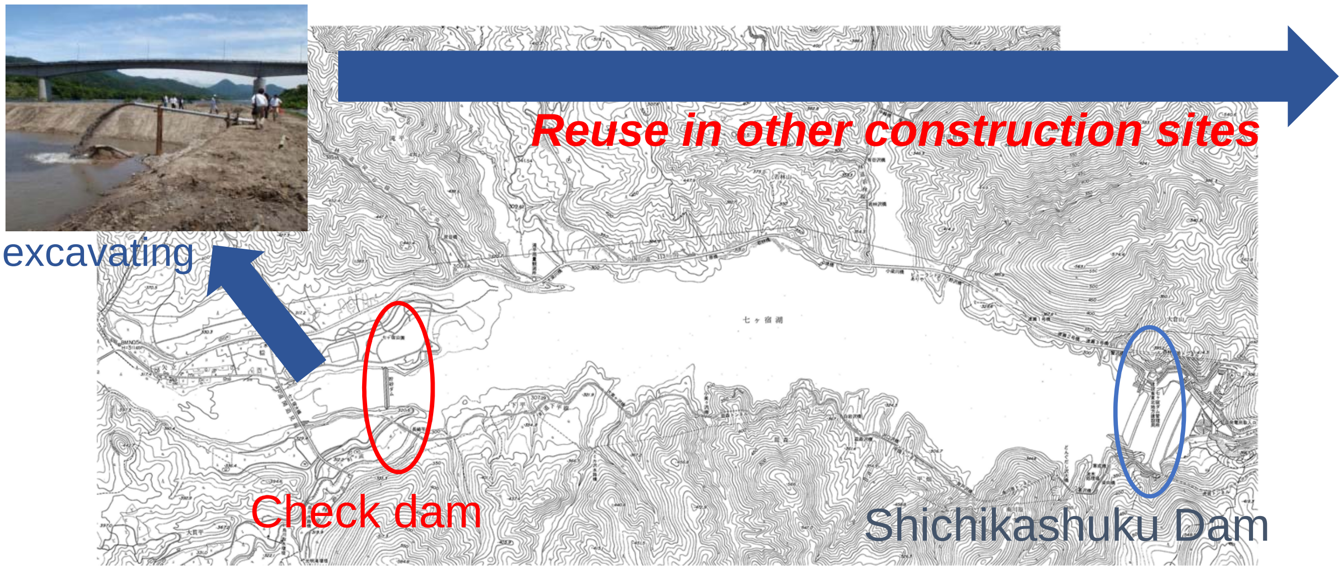



**Fig.5-2 Shichikashuku Dam**

## 5-3 Constructing a check dam to control the sediment

Extending the lifetime of the dam by controlling the sediment on the riverbed.

・Yuda Dam in Iwate Pref.(Fig.5-3)

・Miharu Dam in Fukushima Pref. etc.

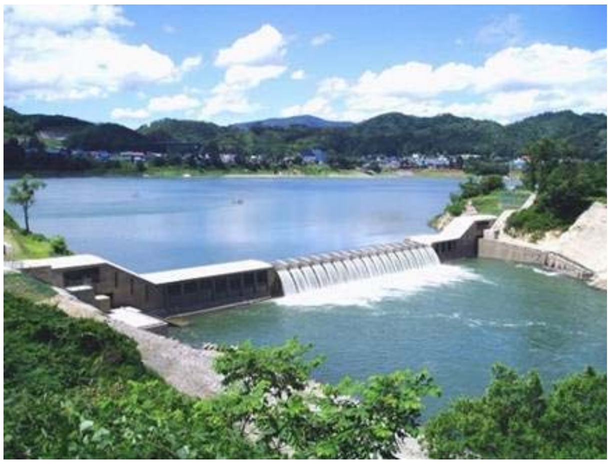



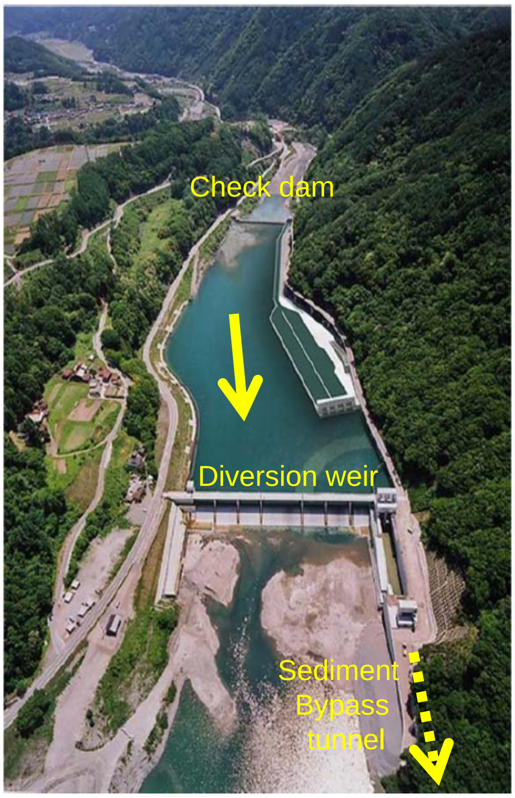
**Fig.5-3 Yuda Dam**

## 5-4 Combining several sediment removal methods

Implementing an appropriate combination of the countermeasures for controlling the sediment with a limited budget .

・Miwa Dam in Nagano Pref.(Fig.5-4)

・Sakuma Dam in Shizuoka Pref. etc.



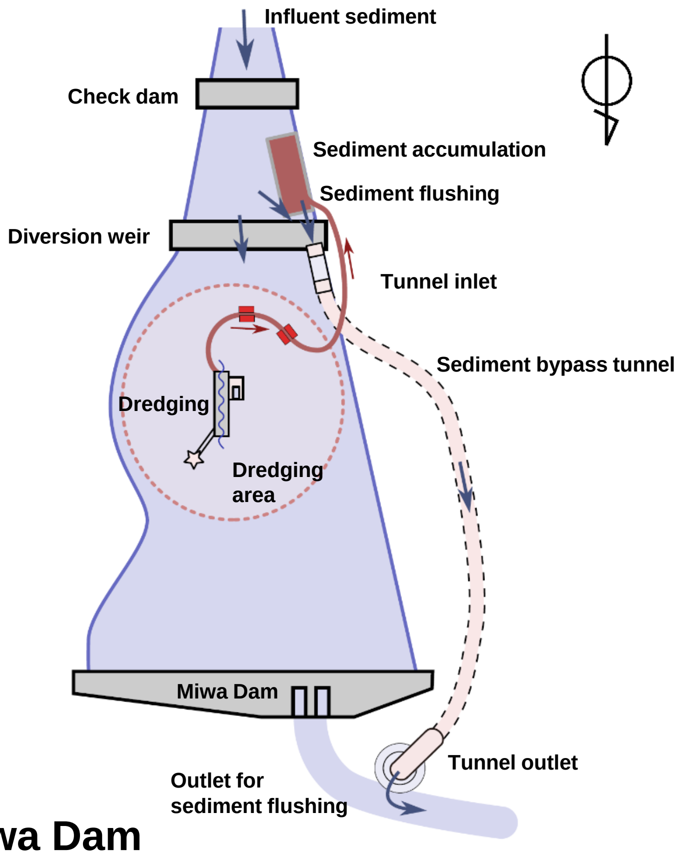




**Fig.5-4 Miwa Dam**

# 6. Technologies to improve the environment

## 6-1 Adopting the selective water intake facility

Controlling the water temperature in the downstream to preserve biodiversity and agricultural effectiveness.

・Yokoyama Dam in Gifu Pref.(Fig.6-1)

・Benoki Dam in Okinawa Pref. etc.

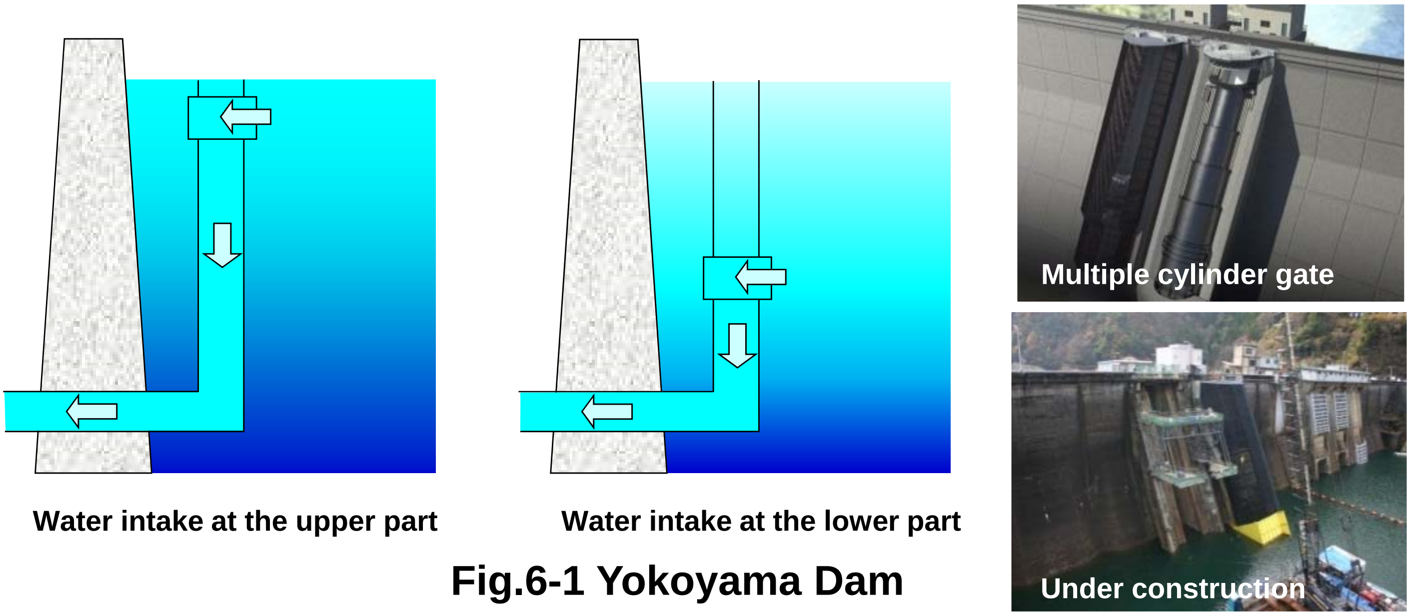



**Fig.6-1 Yokoyama Dam**

## 6-2 Bypassing the fresh water directly from the upstream to the downstream

Maintaining the downstream water environment, even when the reservoir environment is temporarily degraded.

・Urayama Dam in Saitama Pref.(Fig.6-2)

・Miharu Dam in Fukushima Pref. etc.

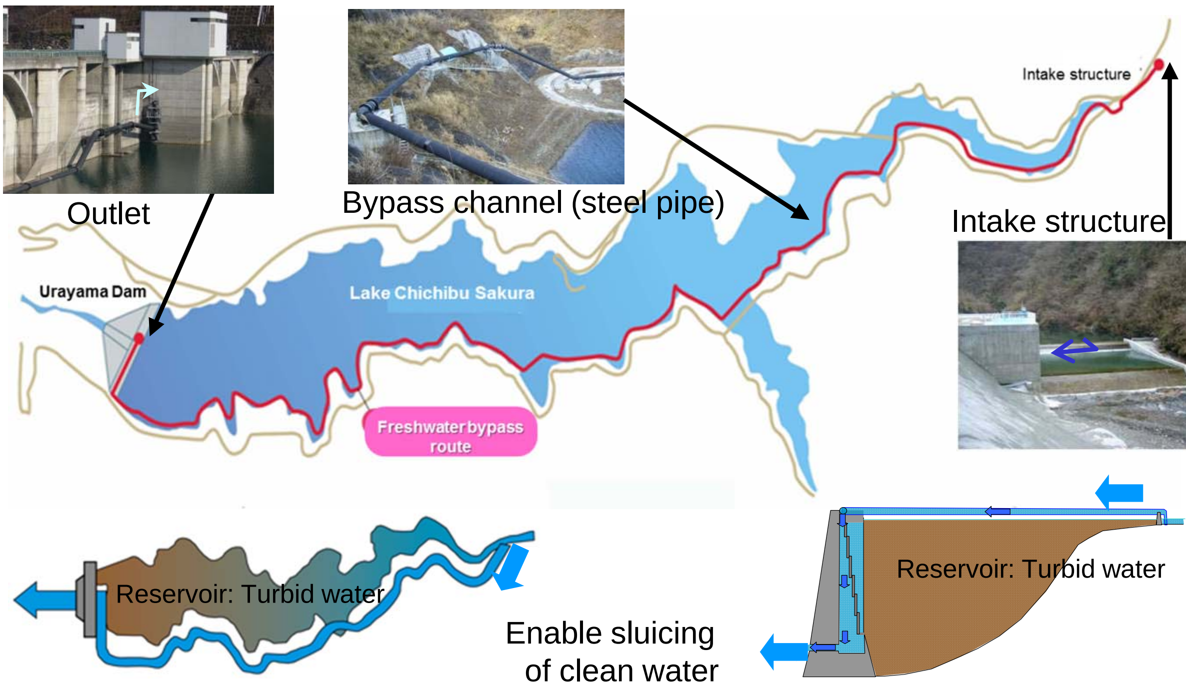



**Fig.6-2 Urayama Dam**

## 6-3 Adding aerator

Reducing the amount of blue-green algae in the reservoir by the aeration.
- Urayama Dam in Saitama Pref.(Fig.6-3)
- Kamafusa Dam in Miyagi Pref. etc.

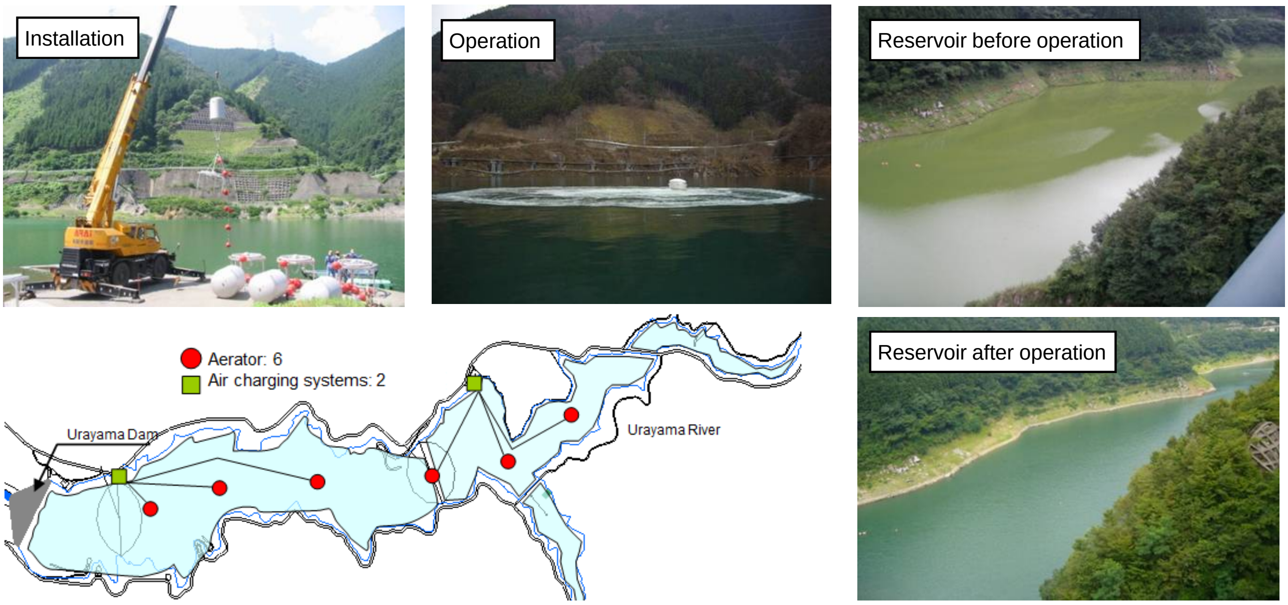



**Fig.6-3 Urayama Dam**

## 6-4 Adding facilities to conserve the ecosystem such as the fish way

Guiding the fish to pass-by the dam reservoir via the fish way.
- Pirika Dam in Hokkaido Pref. (Fig.6-4)
- Samani Dam in Hokkaido Pref. etc.


**Fig.6-4 Pirika Dam**

# 7. Cooperative operation of multiple dams

## 7-1 Capacity restructuring between dams

Efficient utilization of multiple reservoirs by water transmission.(Fig.7-1)

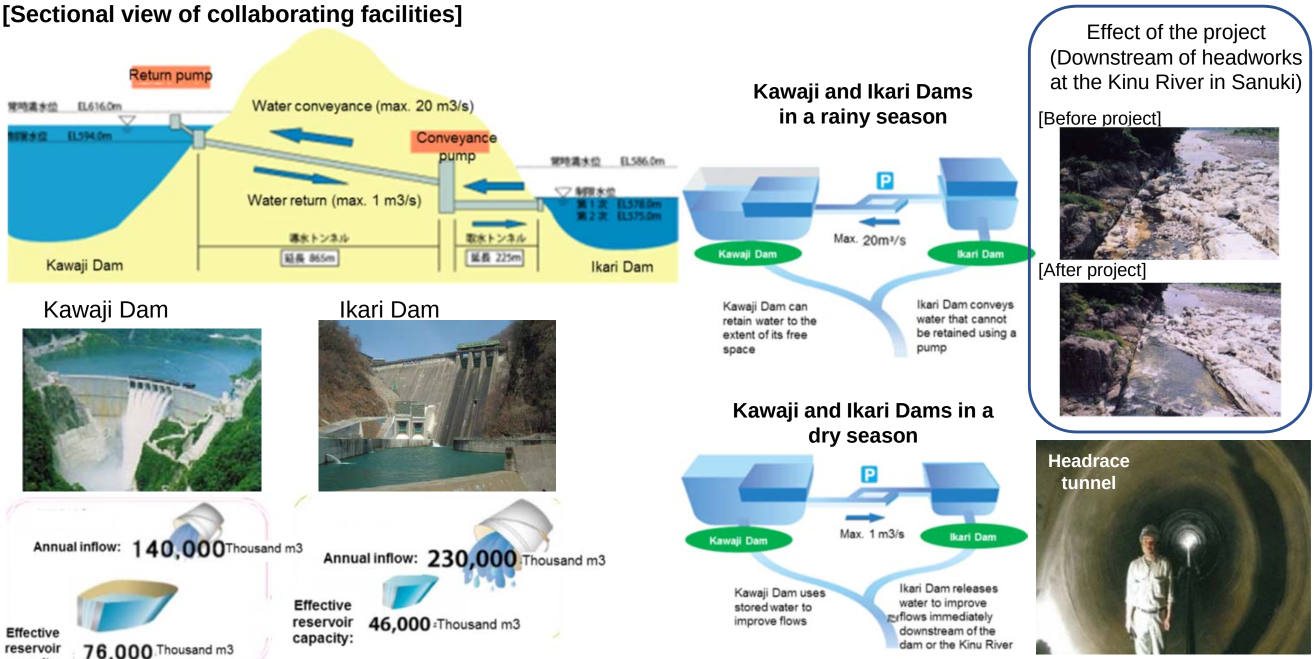
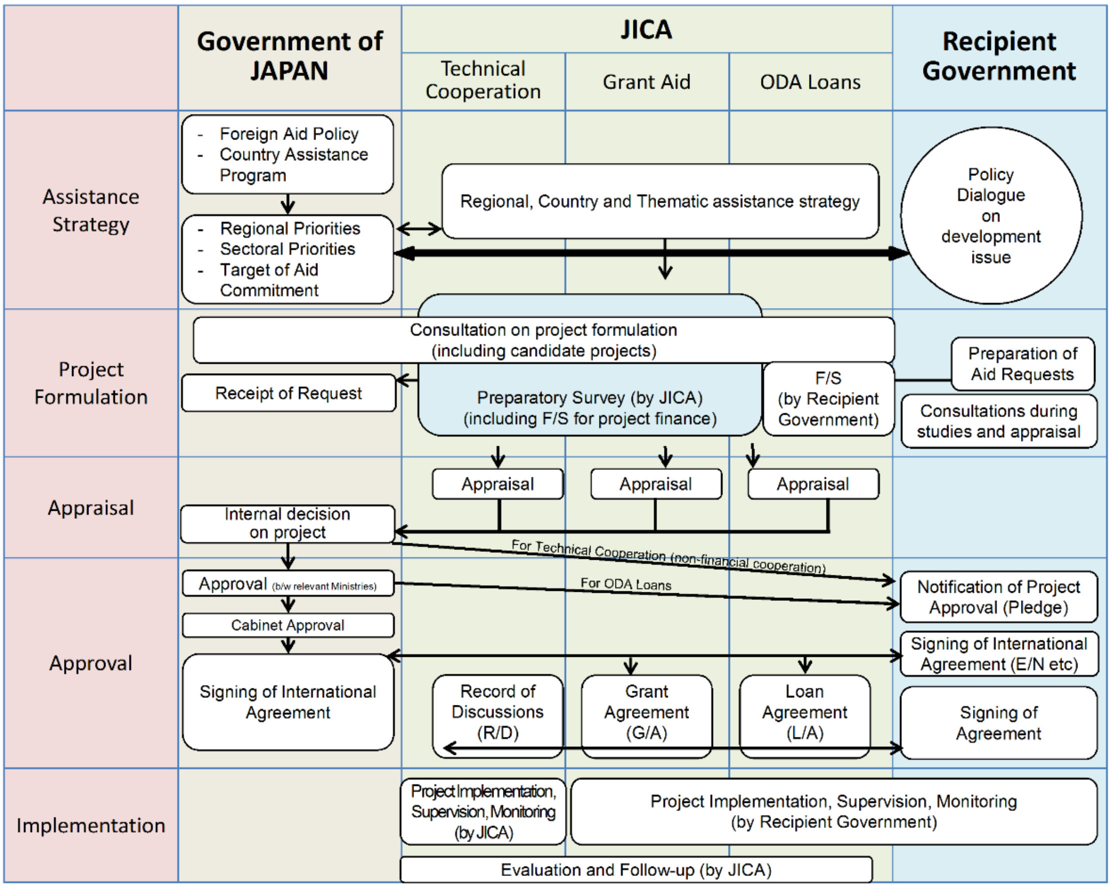
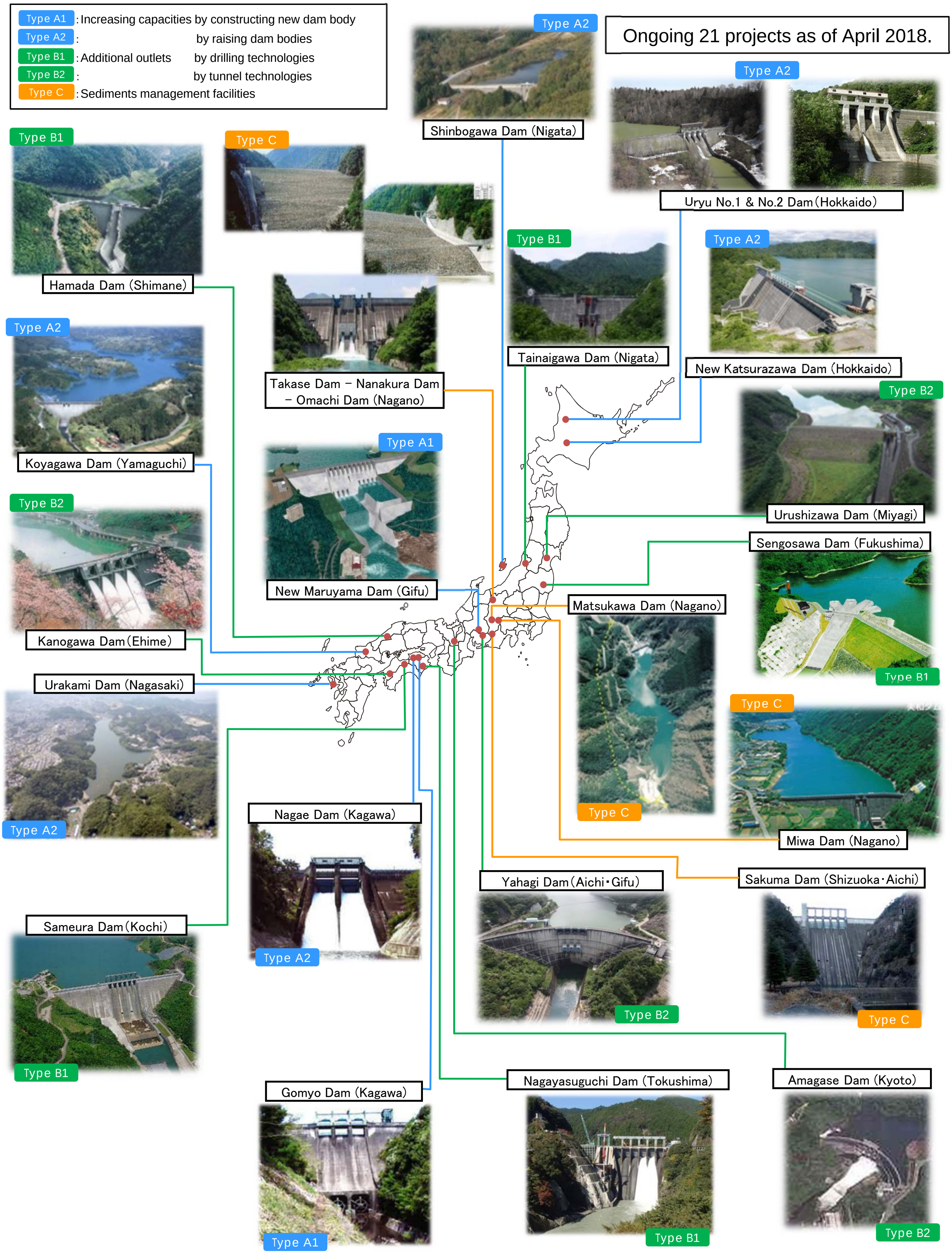



**Fig.7-1 Kawaji and Ikari Dams**

## Project Flow Chart (Overseas Assistance)



# Upgrading of operating dams
## (Ongoing major projects)



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