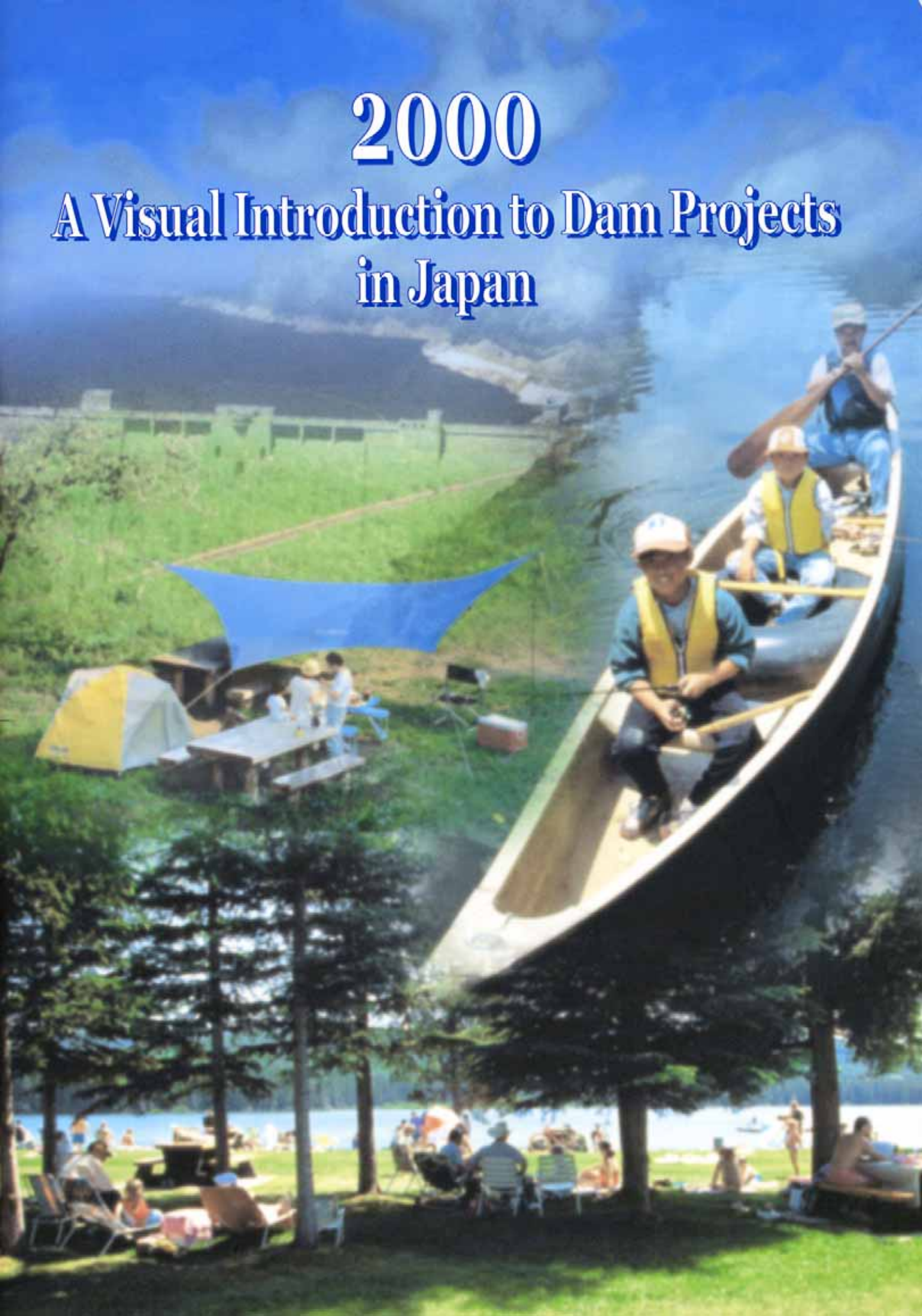
2000

A Visual Introduction to Dam Projects in Japan

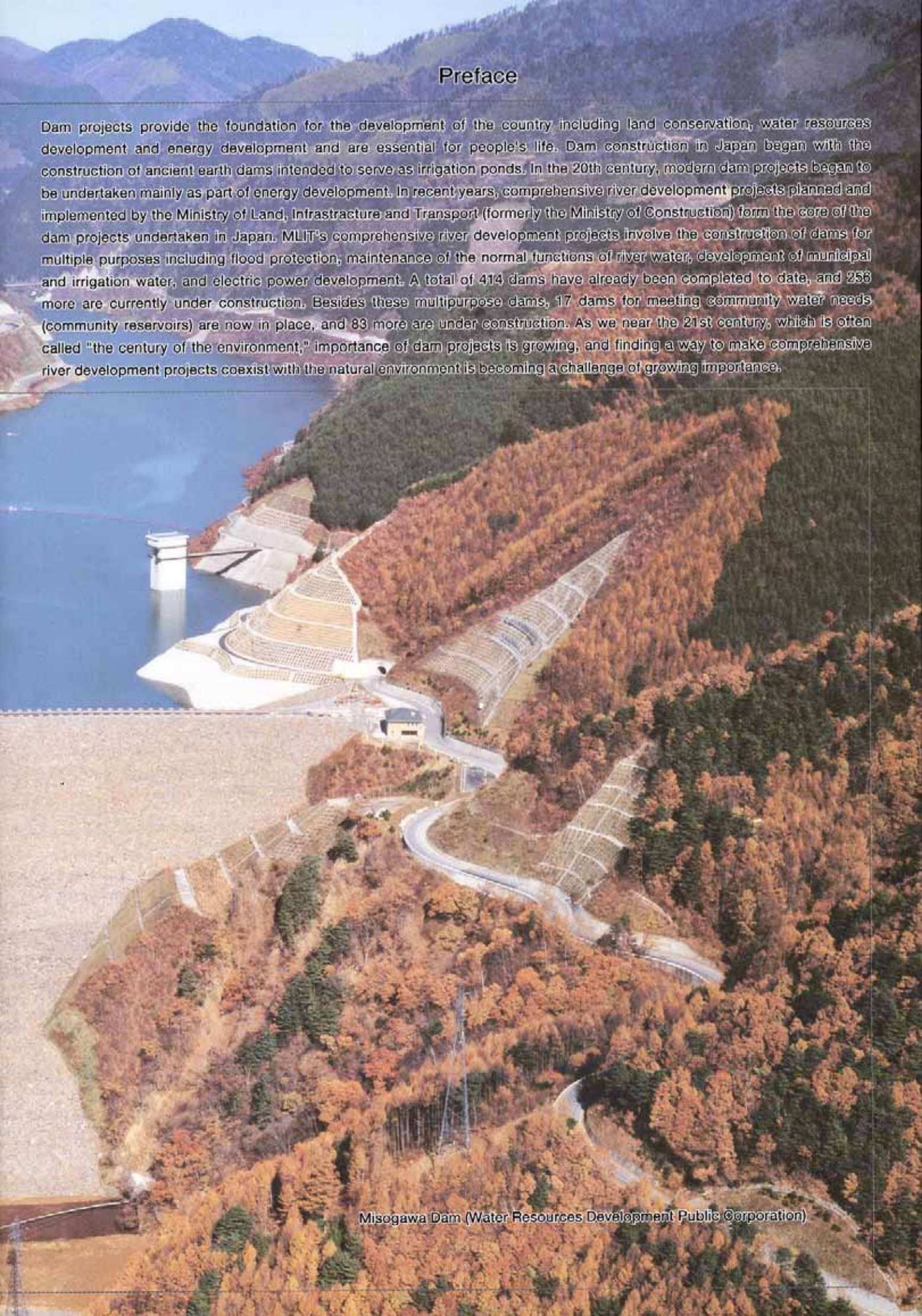


WATER REVOLUTION

CONTENTS

Preface

Dam projects provide the foundation for the development of the country including land conservation, water resources development and energy development and are essential for people's life. Dam construction in Japan began with the construction of ancient earth dams intended to serve as irrigation ponds. In the 20th century, modern dam projects began to be undertaken mainly as part of energy development. In recent years, comprehensive river development projects planned and implemented by the Ministry of Land, Infrastracture and Transport (formerly the Ministry of Construction) form the core of the dam projects undertaken in Japan. MLIT's comprehensive river development projects involve the construction of dams for multiple purposes including flood protection, maintenance of the normal functions of river water, development of municipal and irrigation water, and electric power development. A total of 414 dams have already been completed to date, and 256 more are currently under construction. Besides these multipurpose dams, 17 dams for meeting community water needs (community reservoirs) are now in place, and 83 more are under construction. As we near the 21st century, which is often called "the century of the environment," importance of dam projects is growing, and finding a way to make comprehensive river development projects coexist with the natural environment is becoming a challenge of growing importance.



Misogawa Dam (Water Resources Development Public Corporation)

1 Japan: A Country Vulneable to Floods

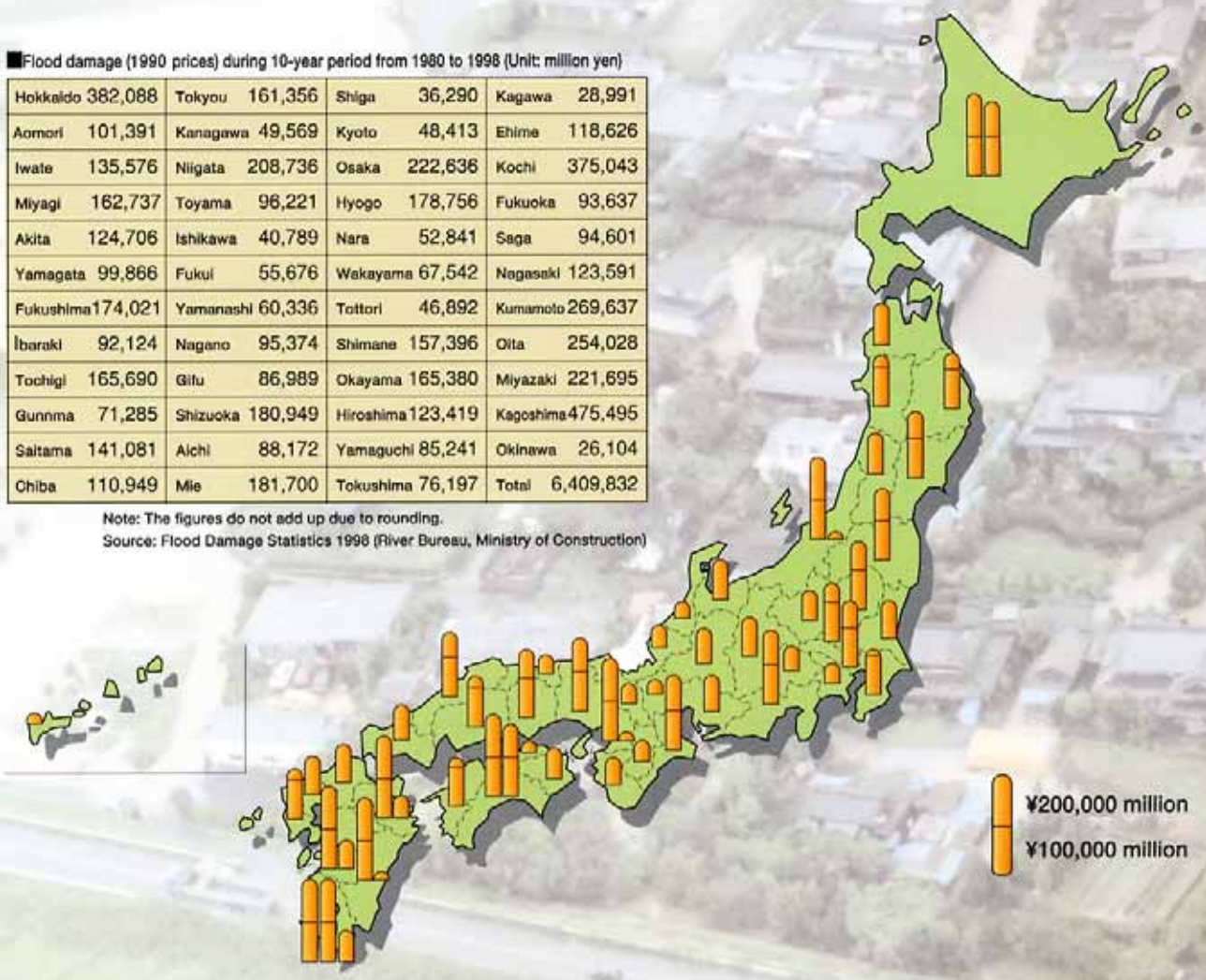
1 Flood damage in Japan

Natural and social conditions in Japan make the entire country vulnerable to floods.

■Flood damage (1990 prices) during 10-year period from 1980 to 1998 (Unit: million yen)

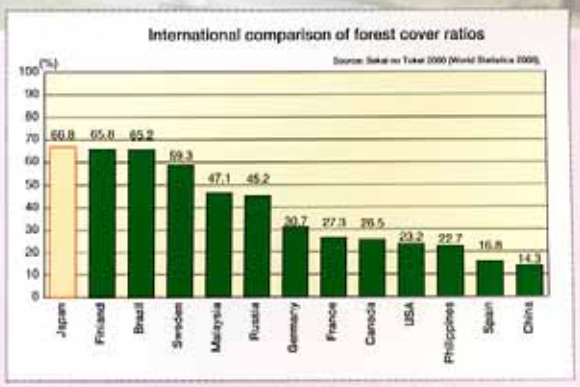
Hokkaido	382,088	Tokyou	161,356	Shiga	36,290	Kagawa	28,991
Aomori	101,391	Kanagawa	49,569	Kyoto	48,413	Ehime	118,626
Iwate	135,576	Niigata	208,736	Osaka	222,636	Kochi	375,043
Miyagi	162,737	Toyama	96,221	Hyogo	178,756	Fukuoka	93,637
Akita	124,706	Ishikawa	40,789	Nara	52,841	Saga	94,601
Yamagata	99,866	Fukui	55,676	Wakayama	67,542	Nagasaki	123,591
Fukushima	174,021	Yamanashi	60,336	Tottori	46,892	Kumamoto	269,637
Ibaraki	92,124	Nagano	95,374	Shimane	157,396	Oita	254,028
Tochigi	165,690	Gifu	86,989	Okayama	165,380	Miyazaki	221,695
Gunnma	71,285	Shizuoka	180,949	Hiroshima	123,419	Kagoshima	475,495
Saitama	141,081	Aichi	88,172	Yamaguchi	85,241	Okinawa	26,104
Chiba	110,949	Mie	181,700	Tokushima	76,197	Total	6,409,832

Note: The figures do not add up due to rounding.
Source: Flood Damage Statistics 1998 (River Bureau, Ministry of Construction)



Q: Doesn't afforestation make dams unnecessary?

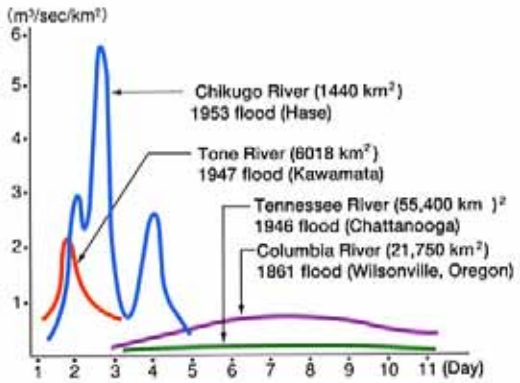
A: Forests are often called "green dams" because forests reduce runoff into rivers by letting rainwater infiltrate the forest soil and letting it flow away slowly during nonflood periods. The belief that "green dams" make human-made dams unnecessary is a misunderstanding. This is evident from the fact that floods and droughts occur in Japan every year although Japan is one of the most forested countries in the world. Under the influence of changing weather conditions, forests do not necessary act for the benefit of human beings. When saturated as a result of a long or heavy rain, the forest soil cannot be expected to mitigate flooding. In the event of drought, the amount of water that flows into rivers decreases because forests absorb soil water for their own growth. It is necessary, therefore, to mitigate flood and drought damage by making both forests, or "natural dams," and human-made dams function effectively.



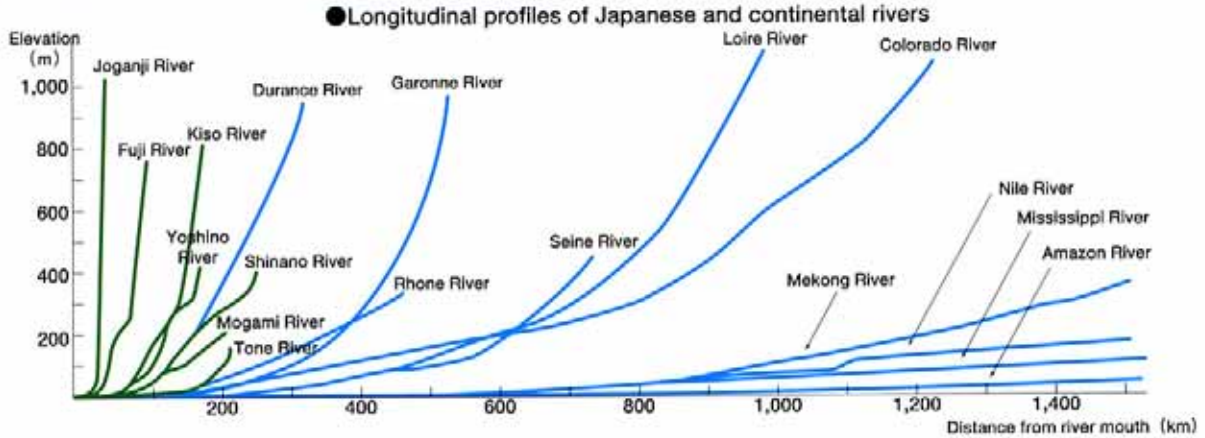
2 Natural conditions

Topography of Japan is steep, and rivers in the country generally run fast and energetic because of their steepness. The climate in Japan is characterized by concentration of rainfall occurring mainly in the tsuyu (=baiu) and typhoon seasons and by large differences between streamflows under ordinary weather conditions and those during heavy rain.

●Flood duration and flood discharge per unit drainage area



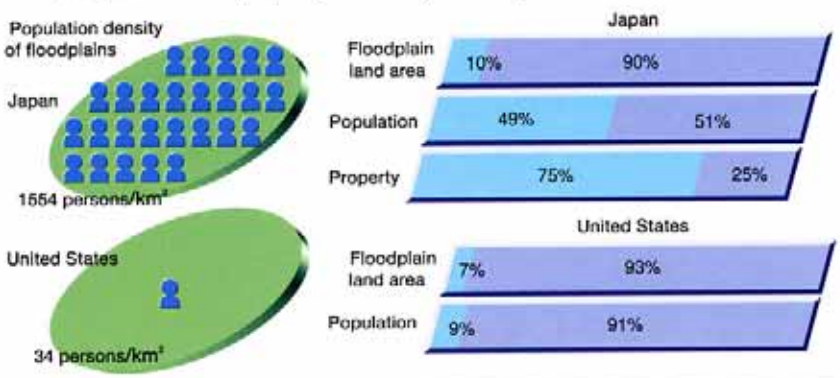
●Longitudinal profiles of Japanese and continental rivers



3 Social conditions

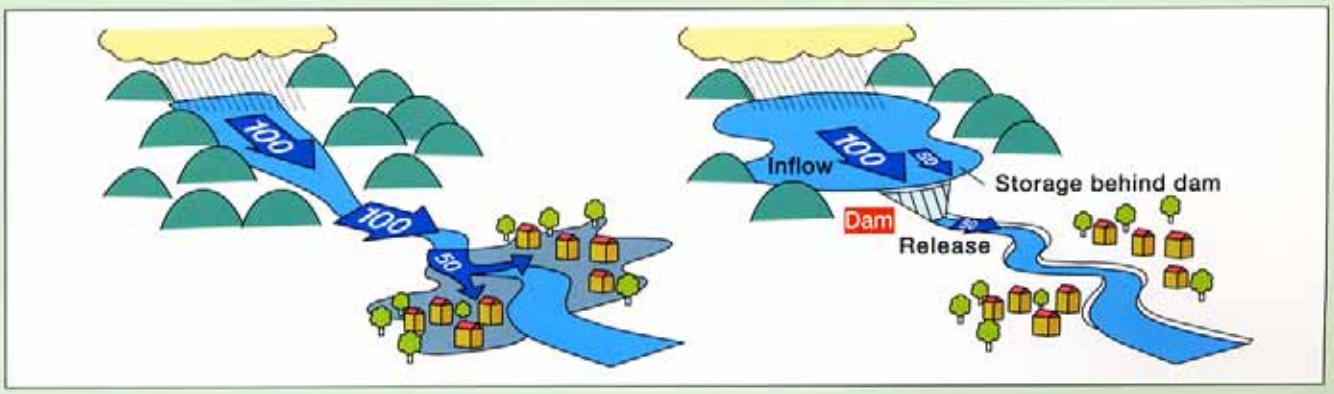
Population and property in Japan are highly concentrated in flood-prone areas. Flooding in these areas can cause tremendous damage.

●Population and property on floodplains: Japan vs. United States



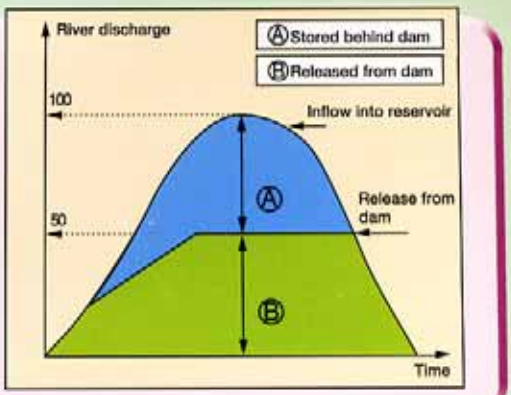
2 Role of Dams in Flood Control

One of the most important roles is to regulate river discharge in times of flood to reduce discharge downstream and mitigate flood damage. Flood regulation by means of dams, along with river improvement works downstream, is a very effective means of flood mitigation



Q: Doesn't a dam cause a flood, instead of preventing it?

A: Dams reduce flood damage downstream by storing part of flood flows in river channels. When a major flood exceeding the storage capacity of a dam flows into the dam's reservoir, the dam lets it pass downstream as is for the sake of safety. If this occurs, the stage of the river downstream may rise sharply. Even in cases like this, however, a dam does not release a flow greater than the flood flow entering the reservoir. Flood damage, therefore, will not be increased by a dam.



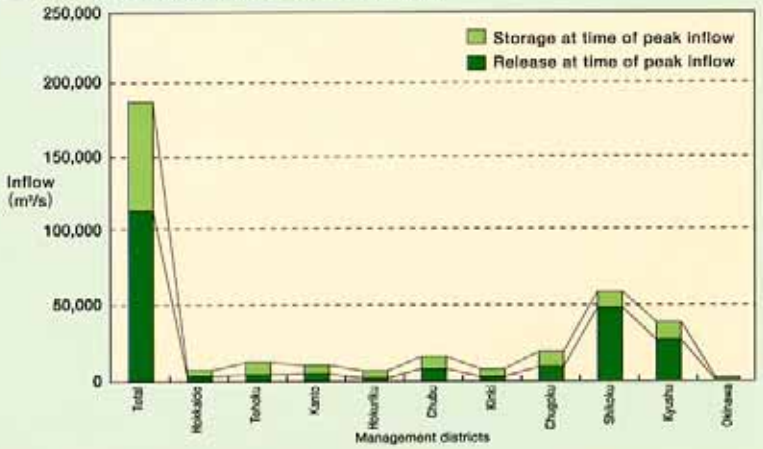
3 Flood Control Effect of Dams

A total of 584 flood control operations were performed in 1999 at dams under the jurisdiction of the Ministry of Construction. Through these operations, about 50 percent of the flood flows that entered the reservoirs was stored behind the dams to reduce flood damage downstream.

■ Peak flood discharge reductions attained in 1999 (by 584 control operations)

a) Total flood peak inflow	Approx.187,000m^3/s
b) Release from dam at time of peak inflow	Approx.115,000m^3/s
c) Reduction in flood flow downstream (a - b)	Approx. 72,000m^3/s
d) Flow control ratio (c/a×100)	Approx. 39%

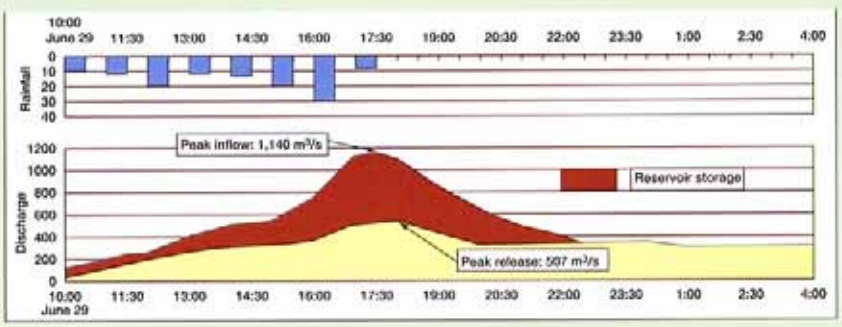
■ Flood control dam operations in 1999



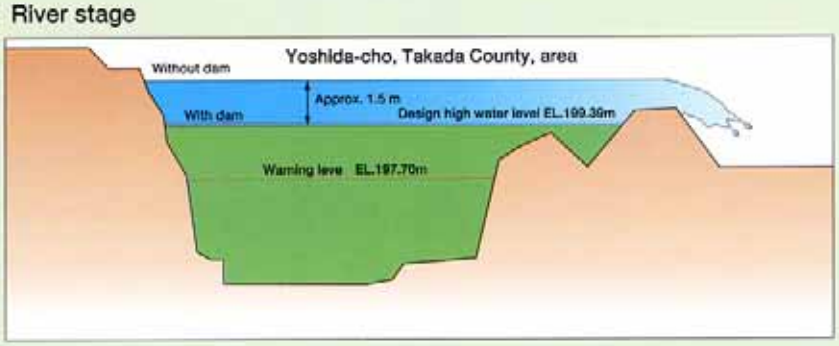
■ Example of flood control dam operation (Haji Dam, Gono River, baiu front rain on June 29 and 30, 1999)

A heavy rain brought about by an active baiu (summer rainy season) front hovering over western Japan caused major damage to the Chugoku region.
On June 29, the peak inflow at Haji Dam reached 1,140 m^3/s. According to the dam operation rules, about 55 percent of this flood flow was regulated and releases were made at a rate of 507 m^3/s in order to reduce damage downstream.
Later during the rain, the design high water level was exceeded at the Yoshida gauging station (Yoshida-cho, Takada County, Hiroshima Prefecture) downstream of the dam. In view of the possibility of serious damage, therefore, the flood control storage was increased by about 200 m^3/s so that releases were made at 300 m^3/s, in order to prevent flood damage from spreading.

Flood control diagram



River stage



Dam data

Name of Dam	Haji Dam
Name of river	Gono River(Gono River System)
Type	Gravity concrete dam
Height	50.0m
Length	300.0m
Effective storage capacity	41,100,000m^3
Flood control storage capacity	31,500,000m^3
Year completed	March,1974

4 Japan:A Country Vulnerable to Droughts

1 Past droughts in Japan

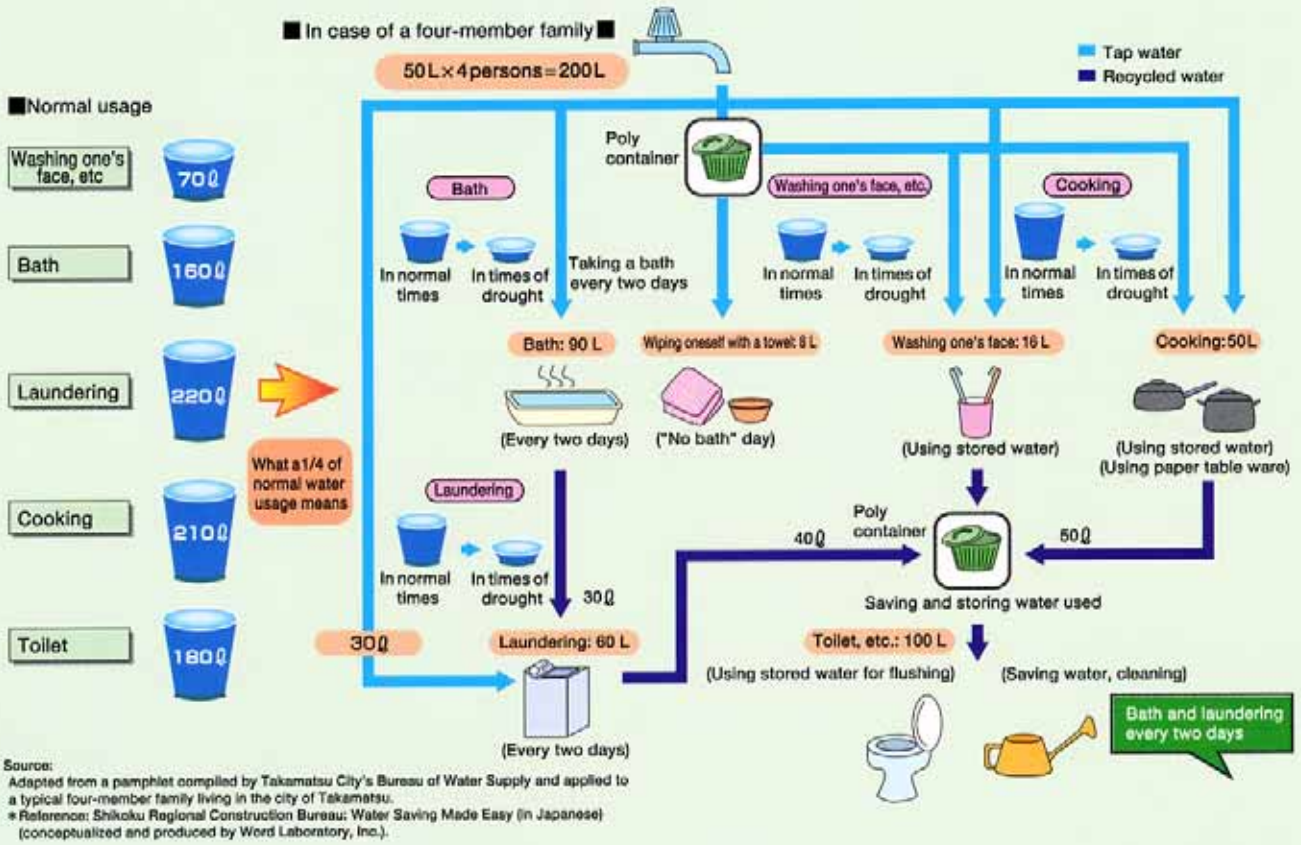
Water trucking
(Drought of 1994, Matsuyama City)

Reservoir bottom exposed during drought (Drought of 1990, Yagisawa Dam)

Reservoir bottom exposed during drought
(Drought of 1994, Sameura Dam)

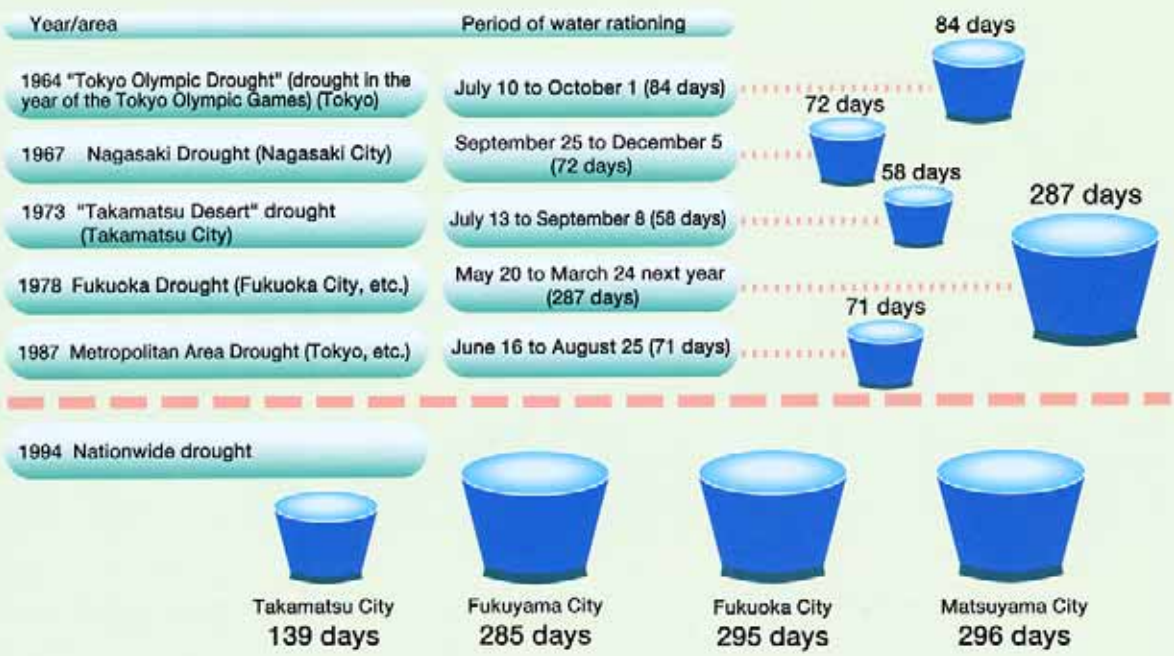
Source: Data compiled by National Land Agency (Water Resources in Japan 1999 (in Japanese)).
Note: The above map shows the number of years in which drinking water supply was interrupted or restricted in the 10 years from 1979.

2 Influence of drought on everyday life



Source:
Adapted from a pamphlet compiled by Takamatsu City's Bureau of Water Supply and applied to a typical four-member family living in the city of Takamatsu.
* Reference: Shikoku Regional Construction Bureau: Water Saving Made Easy (in Japanese) (conceptualized and produced by Word Laboratory, Inc.).

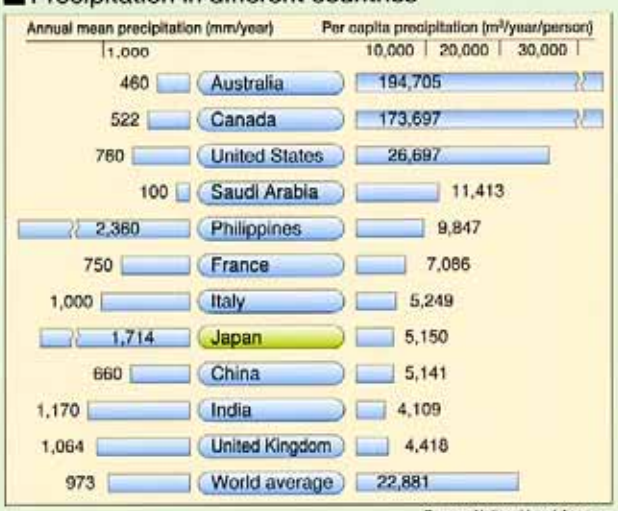
3 Major historical droughts



5 Overview of Water Resources in Japan

Japan is located in the Asian monsoon zone, one of the most rainy regions of the world. Annual mean precipitation of about 1,710 mm is nearly twice as high as the world average of about 970 mm. Since, however, Japan is a densely-populated small country whose per capita precipitation is as low as about one-fourth of the world average, the country is by no means blessed with water. In addition, the concentration of rainfall in the rainy and typhoon seasons makes river How regimes unstable, making water utilization difficult.

■ Precipitation in different countries

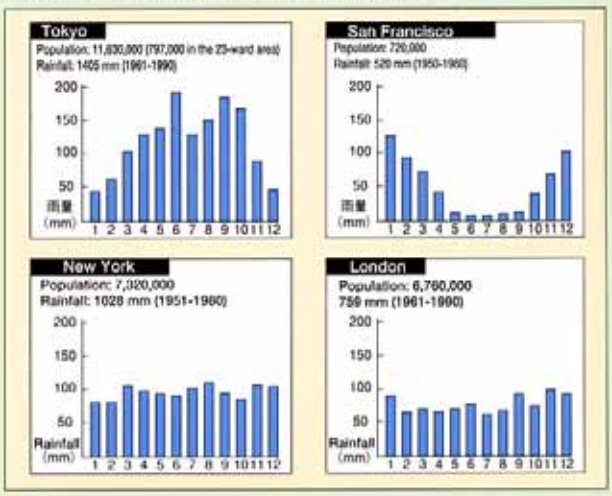


Source: National Land Agency

The volume of water stored behind dams in the Tokyo metropolitan area is only one-tenth of the reservoir storage in New York.

■ Reservoir storage (per capita) in major cities of the world

■ Urban population and annual precipitation

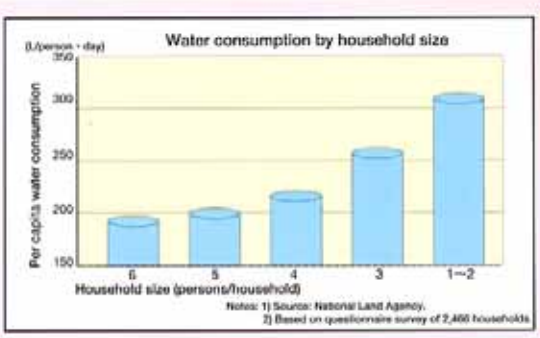


On average, the volume of water taken by Tokyo from the Tone River, a source of water for the Tokyo area, runs short once in three years. Considering the fact that in major cities in other countries, water shortage occurs about once in 10 years, there is an urgent need to implement water resources development projects. Cities in Europe and the United States usually use as their goals the severest drought on record or a 50-year drought, while Japan uses a 10-year drought. Measures need to be taken, therefore, against extreme droughts such as the construction of low-flow augmentation reservoirs.

Name of city	Drought frequency	Goal
Tokyo	Once in 3 years	10-year drought
San Francisco	Once in 11 years	Severest drought on record
New York	Once in 7 years	Severest drought on record
London	Once in 15 years	50-year drought

Q: Why are they building dams when water demand is not increasing?

A: People often believe erroneously that water demand will decrease as the population decreases. In reality, however, per capita water consumption is currently increasing as the living environment changes (e.g., increase of nuclear families, increase of flush toilets), and water demand is actually on the increase. Drier-than-usual weather in recent years has also caused water demand to grow. If this tendency continues, water demand will continue to grow and ensuring that such demand is met will become important.



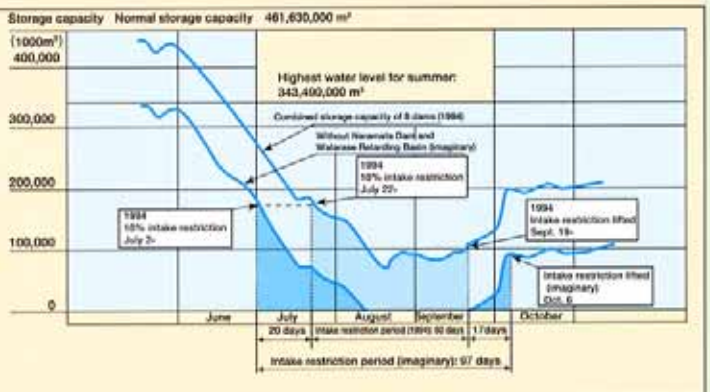
6 Examples of Effective Dam Operations against Drought

1 Effect of Naramata Dam and Watarase Retarding Basin

The year 1994 saw 40% to 70% higher than usual rainfalls in the months of April to August and a nationwide water shortage. The Tone River system was no exception, and restriction was imposed on water intake from 22nd of September.
If it had not been Naramata Dam (completed in 1990) and Watarase Retarding Basin (completed substantially in 1989), the restriction on water intake would have lasted for more than a month and the impact on people's lives would have been even more serious.

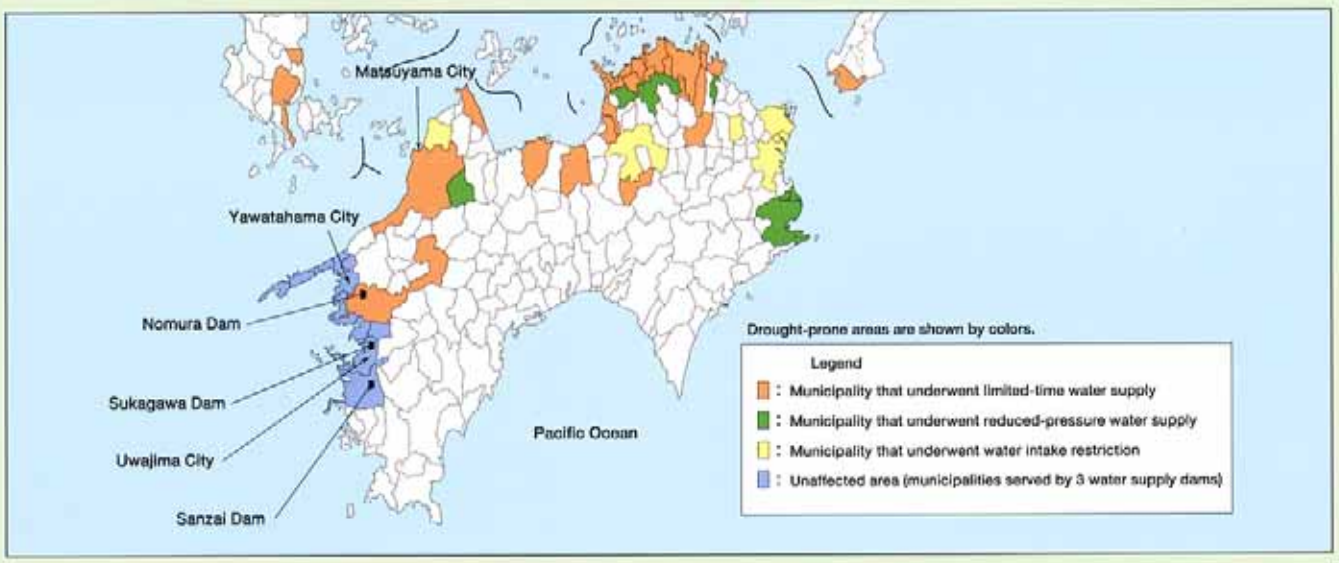
■Water control structures in Tone River system

■Lower-than-usual rainfall in 1994 and effect of Naramata Dam and Watarase Retarding Basin



2 Effect of dam development in southern Ehime region

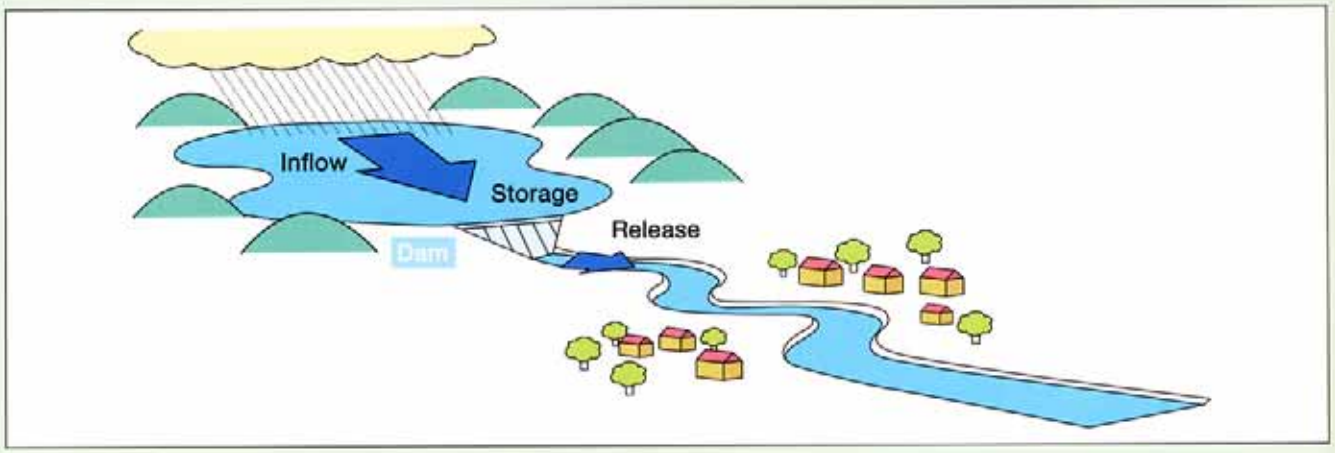
Since the coastal area of Ehime Prefecture's Nanyo region, which includes Uwajima, Yawatahama and other cities, lacks major rivers, the area suffers from water shortage almost every year. Impact of the severe drought in 1967 was particularly serious: almost all water supplies were shut down or restricted, and citrus, which is a major agricultural product in the area, withered.
With the completion of Nomura (1981), Sukagawa (1976) and Sanzai (1980) dams, the area became less vulnerable to drought and, during the drought of 1994, suffered no damage even though the drought was as dry as the 1967 drought.



7 Purpose of Comprehensive River Development Projects

1 Flood control

Flood discharge and therefore flood damage downstream are reduced by controlling flood flow with a dam.



2 Maintaining normal functions of river

During periods of drought, dams augment low flow conditions to maintain the normal function of rivers (providing secure water supplies for existing water uses, navigation, fishery, tourism, prevention of saltwater intrusion, prevention of river mouth blockage, protection of river management facilities, protection of wildlife, keeping river water clean).

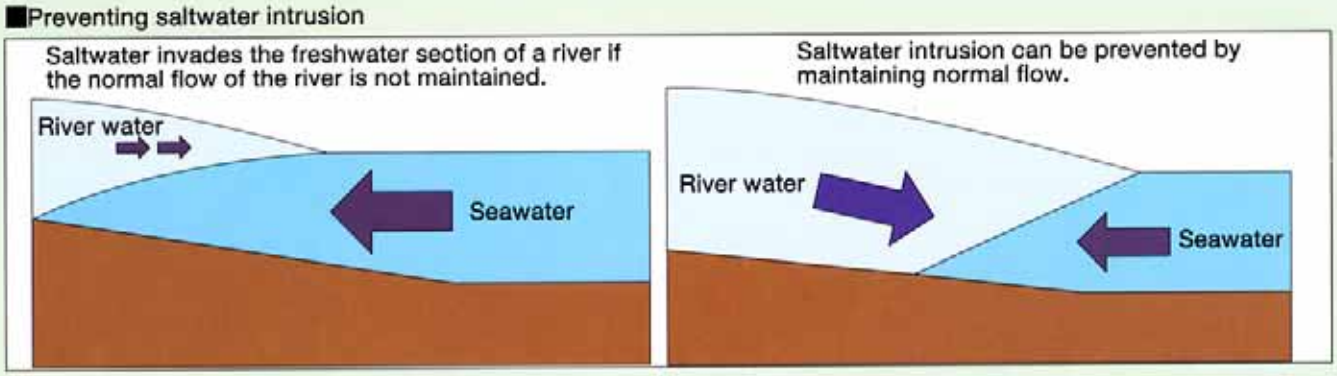

Providing a secure water supply for existing irrigation uses


Navigation

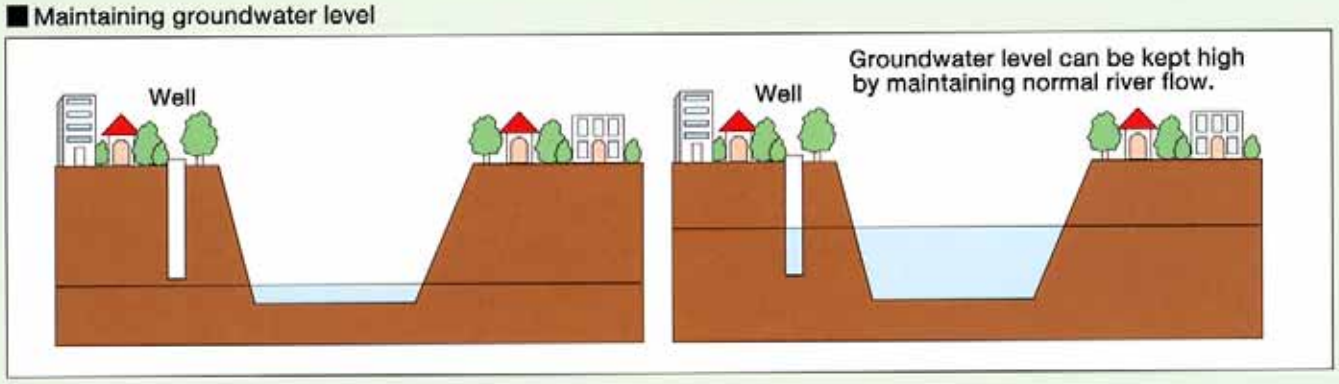

Fishery


Tourism

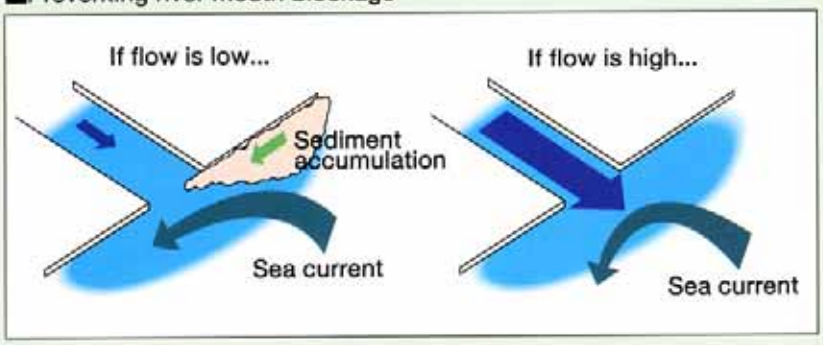
■Preventing saltwater intrusion



■ Maintaining groundwater level



■Preventing river mouth blockage



Protecting river management facilities

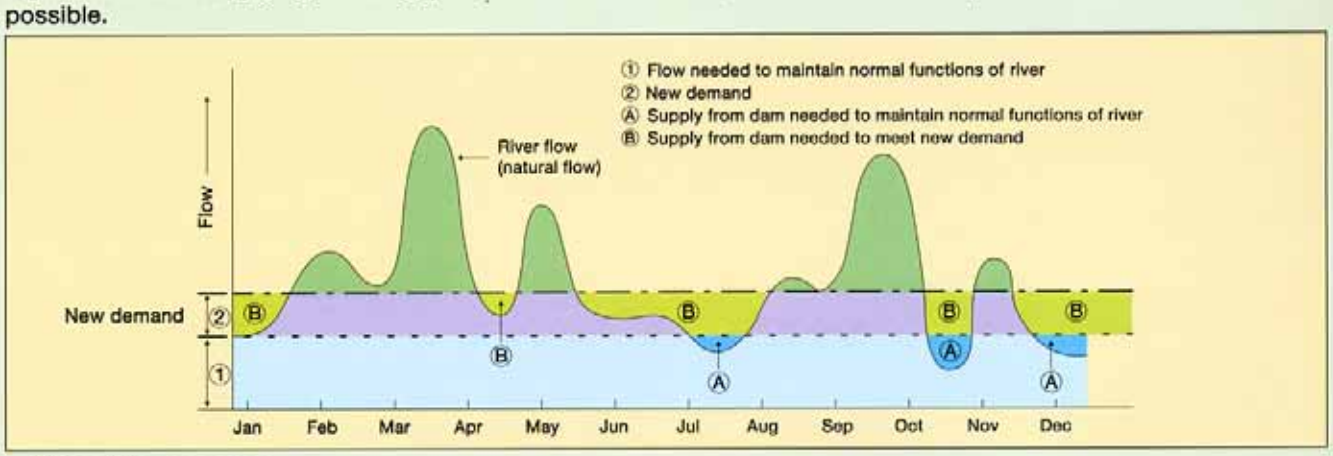
Protecting wildlife

Keeping running water clean

7. Purpose of Comprehensive River Development Projects

3 Development and municipal and irrigation water and power generation

The purpose of comprehensive river development projects is to meet the growing demand for supply municipal and other water supplies and to produce hydroelectric power, a type of clean energy, in order to meet the energy demand.
Dams can increase river flows that are available dependably throughout the year by storing water during periods of higher flow and supplying it during periods of low flow. Thus, dams make development of new water resources possible.



■ Municipal water

Domestic water

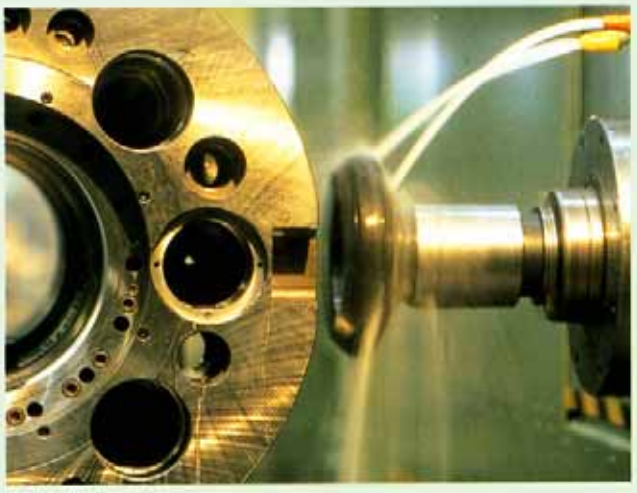
Flush toilet

Swimming pool

Domestic water

■Municipal water

Plant



Industrial water

■ Irrigation

Agricultural water

Agricultural water

■ Power generation

Power generation

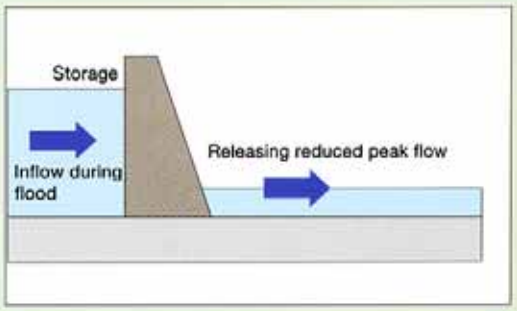
8 Concept of Comprehensive River Development Project

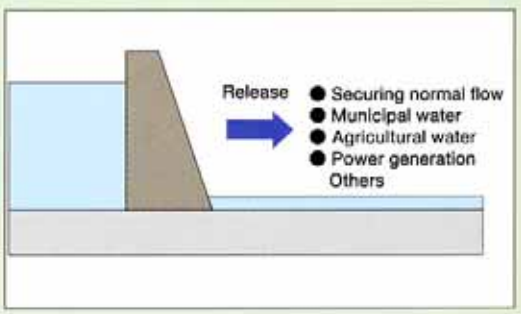
9 Comprehensive River Development Projects and Mechanisms for Flood Control and Water Utilization

1 Multipurpose dam construction projects

Multipurpose dam construction projects aim to provide downstream flood protection by securing the capacity needed to retain flood flow and reducing peak flood flows. By use of this capacity, multipurpose dams stabilize streamflow for water supply downstream by storing river water during periods of higher flow and releasing stored water during periods of low flow

Origawa Dam (Chubu Regional Construction Bureau)

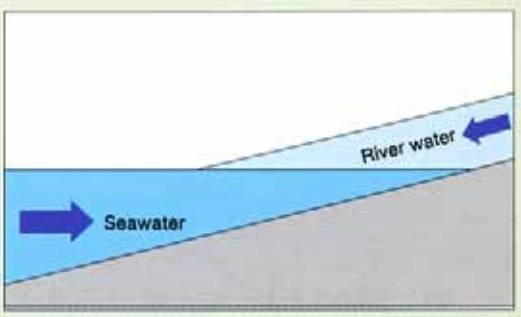


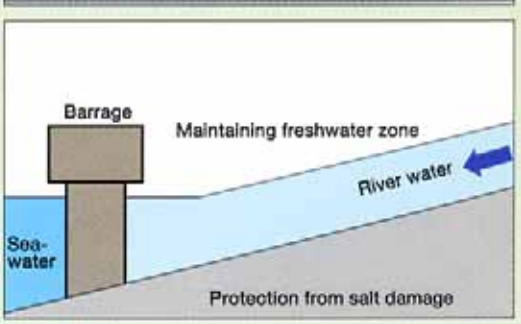


2 Estuary barrage construction projects

The purpose of estuary barrage construction is not to store flood flows, but to pass flood flows safely. There are cases where stable water supply is made by possible by securing the capacity to store river water, as in the case of dams, and there are also cases where it is made possible by preventing saltwater intrusion to create a freshwater zone. Choice between these methods is made according to such factors as barrage location.

Nagaragawa River Estuary Barrage (Water Resources Development Public Corporation)

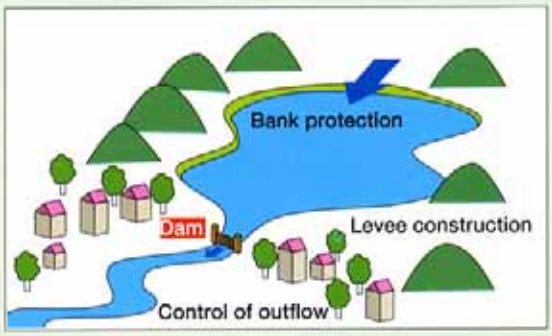




3 Lake development projects

The purpose of lake development projects is develop new water resources by protecting the areas around and downstream of lakes and controlling outflows from lakes with structures such as lake shore levees, weirs and bank protection works.

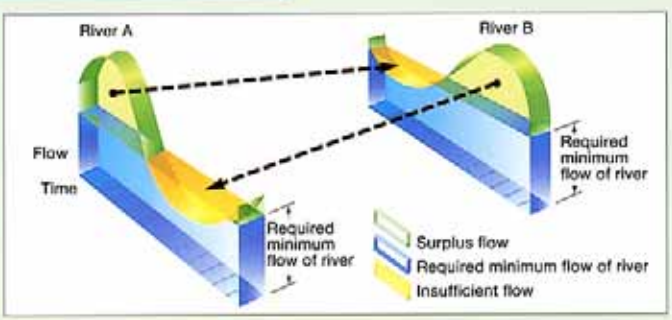
Development of Lake Kasumigaura(Water Resources Development Public Corporation)



Lake shore levee (Lake Kasumigaura Development, Water Resources Development Public Corporation)

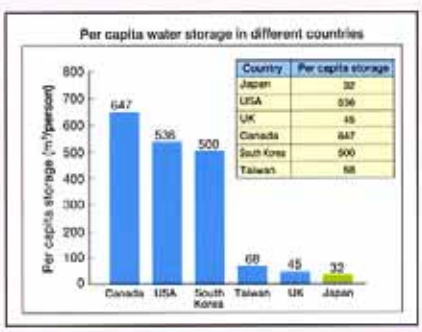
4 Water conveyance channel

Water conveyance channel projects involve controlling the flow regimes of rivers by, for example, divert water from a higher-flow river to lower-flow river. The aims of these measures are development of new water resources, replenishment of water for unspecified use, and flood control such as interior drainage for smaller rivers.



Q: I hear that the age of dams has ended in the United States. Is it true?

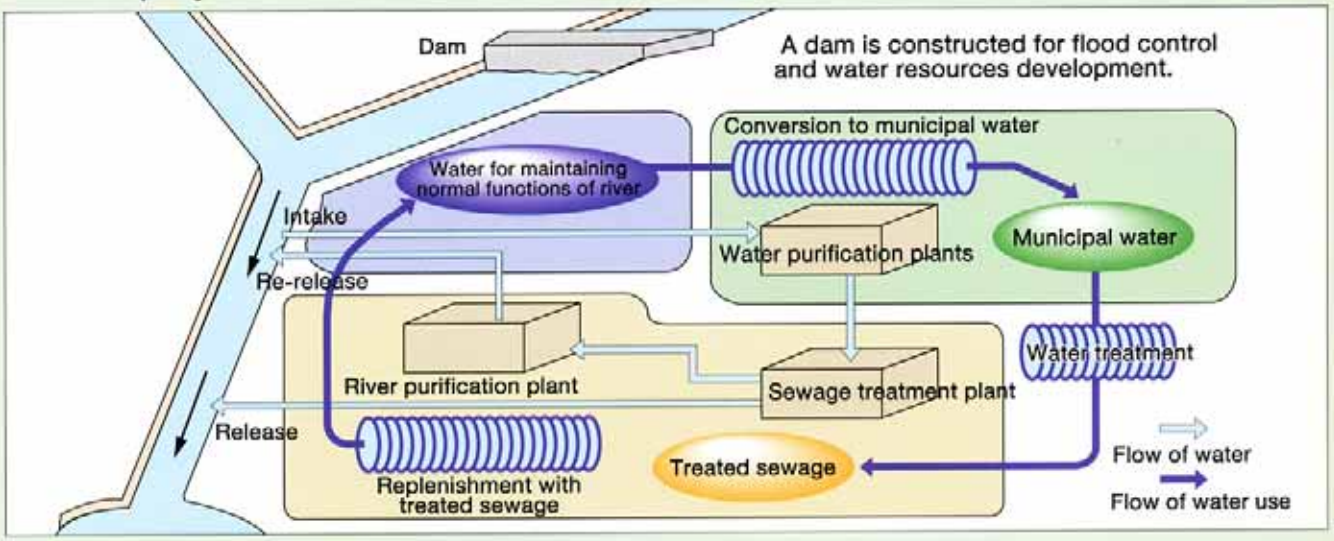
A: Direct comparison of the water resource situations in the United States and Japan is not possible because of considerable differences in meteorological, geographical, social, economic and other conditions between the two countries. As one indicator, per capita reservoir storage in the United States is more than about 17 times that in Japan. Under these circumstances, in the United States, new dam construction is no longer very active, and the maintenance and reconstruction of existing dams have become the major activities. It was in view of these conditions that Mr. Daniel P. Beard, then Commissioner of the Bureau of Reclamation, said, "The dam-building era in the United States is now over" at The International Commission on Irrigation and Drainage(ICID) Since, however, a total of 36 dams (dams higher than 15 m) are currently under construction in the United States, the proclamation "The dam-building era in the United States is now over." is by no means true.



9. Comprehensive River Development Projects and Mechanisms for Flood Control and Water Utilization

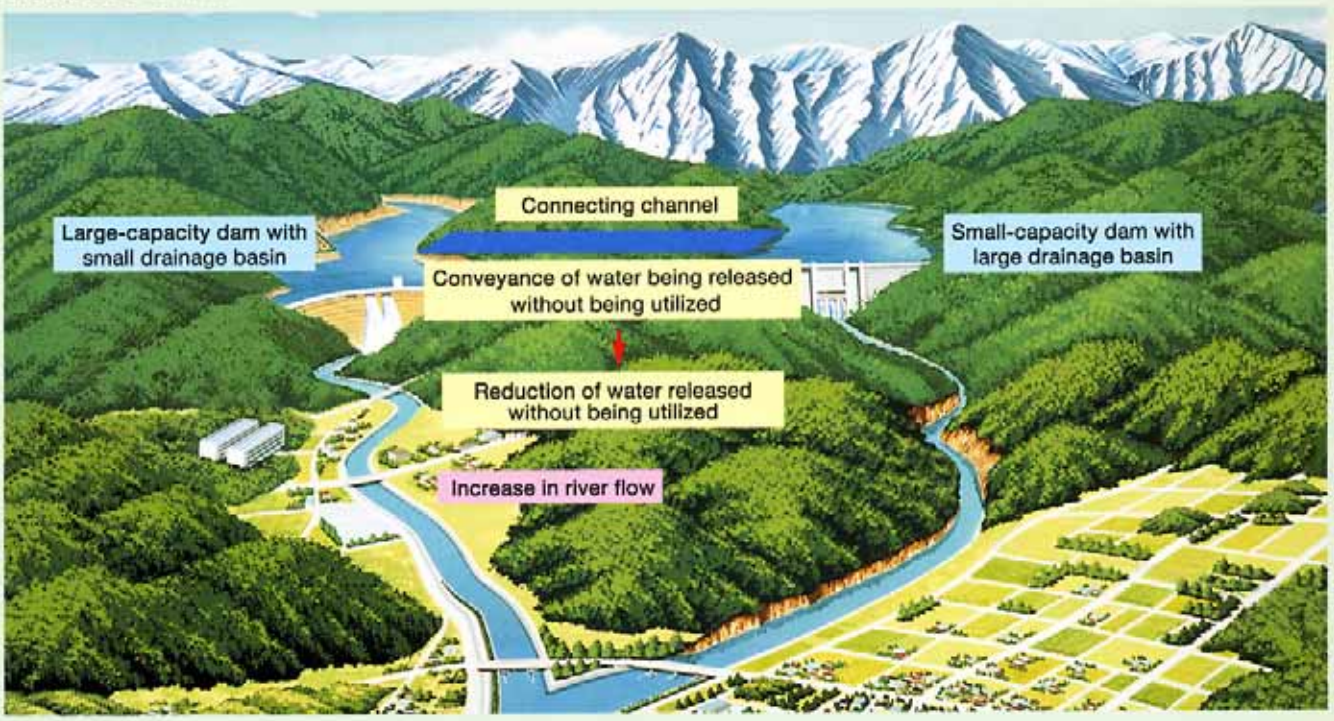
5 Water use efficiency improvement projects

During periods of low flow, treated sewage is subjected to advanced treatment, and advanced-treated sewage is released into rivers to maintain the normal functions of rivers and thereby develop new water resources and improve river water quality.



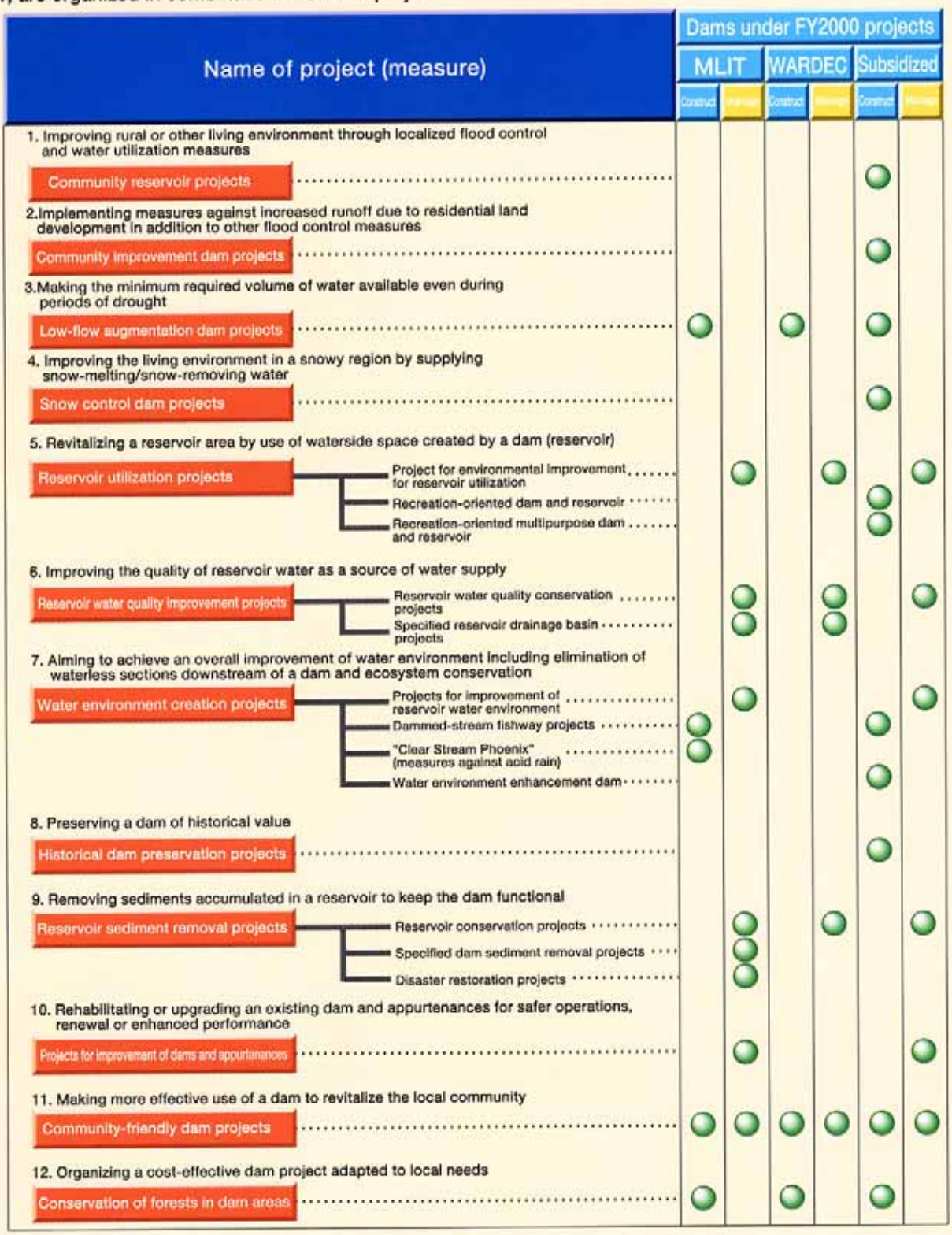
6 Dam tie-up projects

By connecting, by water channels, large-capacity dams (reservoirs) with low inflows from small drainage basins and small-capacity dams (reservoirs) with high inflows from large drainage basins, water being released without being utilized is stored behind other dams. Thus, with a view to securing the required streamflow during periods of low flow and improving the river environment, effective use is made of existing dams to develop water resources in a short period of time.



10 Outline of Comprehensive River Development Project for Meeting Diverse Needs

A comprehensive river development project includes various construction projects aimed at wide-area flood control and water utilization, such as dam construction, estuary barrage construction, lake development and flow regime control river projects, and management projects aimed at making proper use of completed structures.
To meet diverse needs of different communities, various projects for meeting area-specific needs, as described below, are organized in combination with main projects.



10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

1 Community reservoir projects

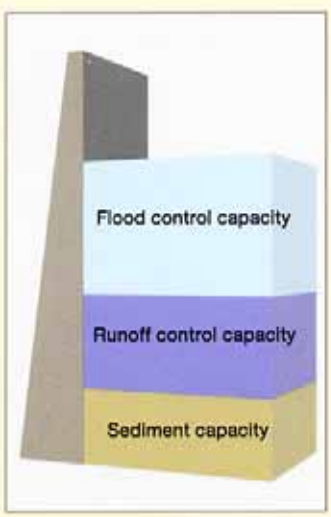
Local water demand in mountain regions and peninsulas and on islands may be as small as several hundred liters per day, and most of these areas depend on wells and small streams. These water sources may pose problems associated with water security during periods of drought or water quality. Since these areas are also vulnerable to floods, there is an urgent need for food control and water utilization measures.
The purpose of a community reservoir project is to build a community reservoir to meet local flood control and water utilization needs associated with a small local stream.

Ryorigawa Community Reservoir (Iwate Prefecture)

Kanabara Community Reservoir (Nagano Prefecture)

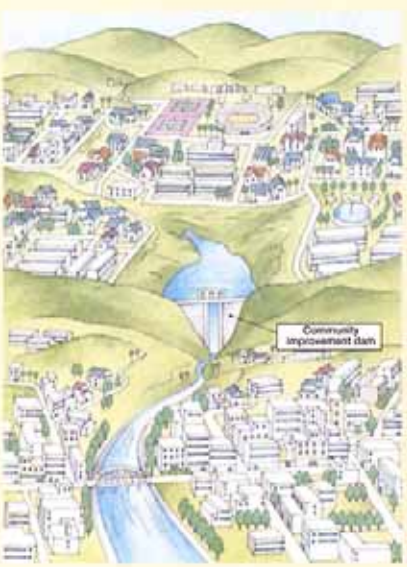
2 Community improvement dam projects

A community improvement dam project involves the implementation of measures against increased runoff resulting from residential land development and the construction of a flood control dam. The purpose of these measures is to achieve flood control goals while promoting development projects.



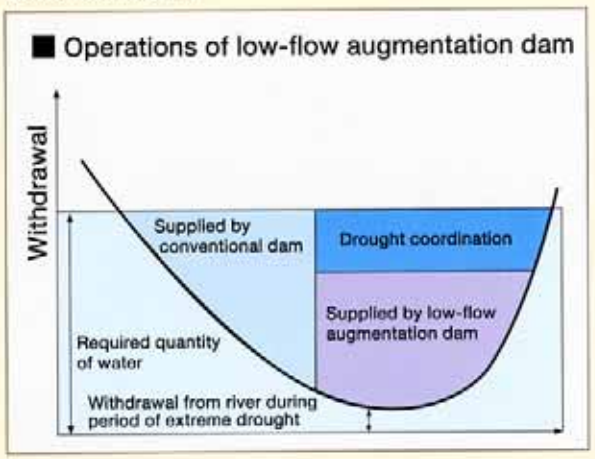
Without a community improvement dam

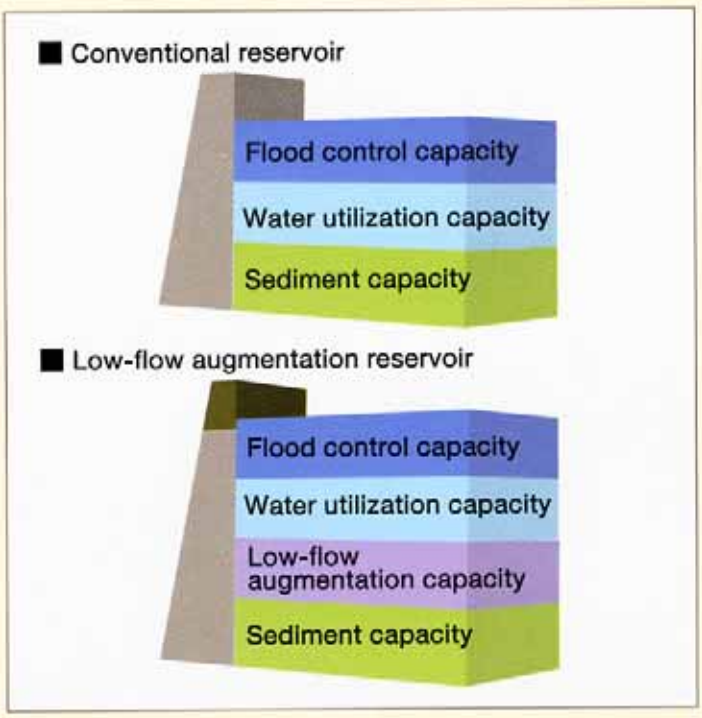
With a community improvement dam



3 Low-flow augmentation dam projects

Areas particularly vulnerable to drought, such as large cities, require drought control measures so that people's lives, economic activities and the city's functions are not interrupted even during periods of extreme drought. Under a low-flow augmentation dam project, a dam (reservoir) is constructed, therefore, to secure the minimum required quantity of water even during periods of extreme drought.





4 Snow control dam projects

The goal of a snow control dam project is to improve the living environment in a snowy area by developing snow-melting or snow-removing water and supplying it during winter.

Making snow-melting or snow-removing water available

10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

5 Reservoir utilization projects

1 Projects for environmental improvement for reservoir utilization (1994-)*

At a dam under the jurisdiction of the Ministry of Land,Infrabtracture and Trasport environmental measures are taken in the reservoir area to induce proper land uses in the reservoir area, thereby contributing to smooth dam management. The reservoir area is also provided as a place for rest and relaxation, and the reservoir itself is enhanced as a recreational resource, in order to activate the local the reservoir area.

＊Instituted through integration of dam area environmental improvement projects (1975-) and reservoir utilization promotion projects (1988-).

Wind surfing

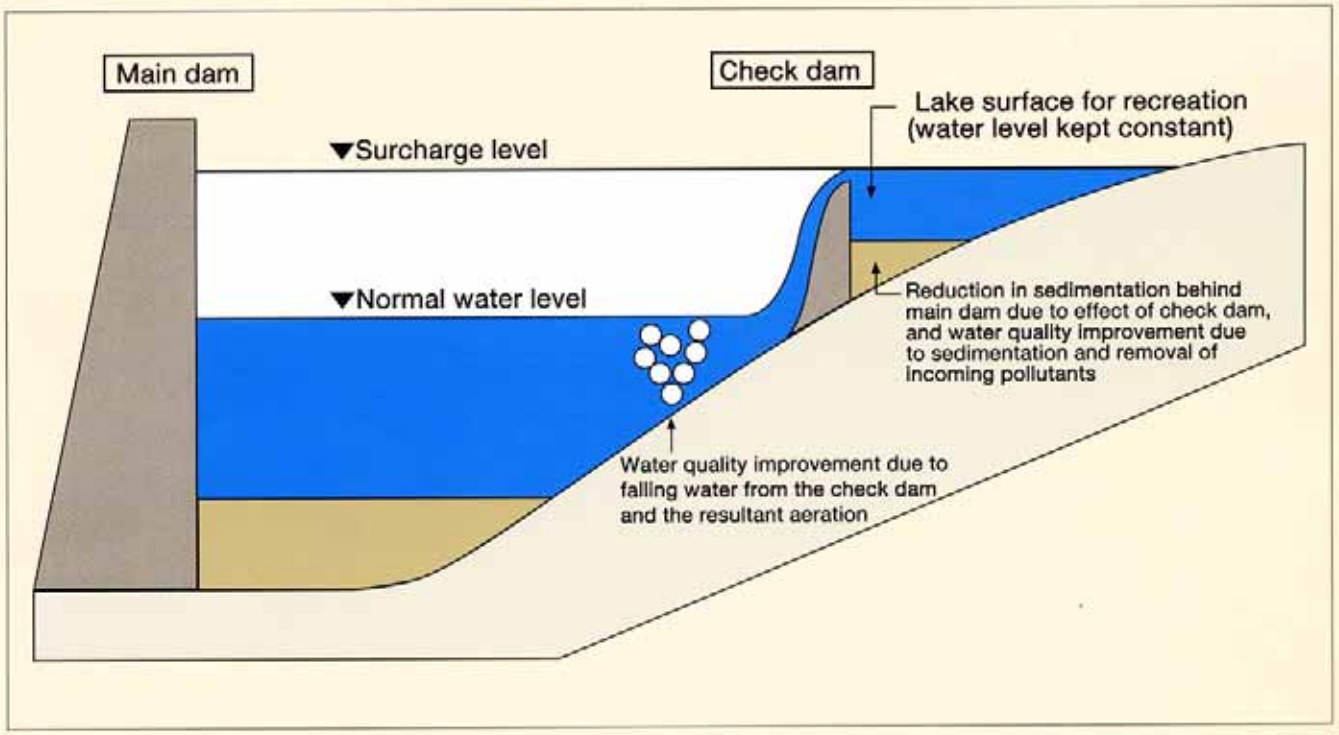
Blossom viewing at a waterside park
(Haji Dam, Chugoku Regional Development Bureau)

10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

5 Reservoir utilization projects

2 Recreation-oriented reservoirs (1989-)

In addition to a main dam, a check dam to form a reservoir whose water level always remains the same is built while maintaining harmony with the natural environment of the reservoir area. By enhancing accessibility of the reservoir, these measures help revitalize the local community.



3 Recreation-oriented multipurpose dams (1990-)

A dam project jointly implemented with a local public body, "third-sector" or other entity for the construction and installation of recreation facilities utilizing the dam structure and the reservoir, such as restaurants, camping grounds and multipurpose halls, is undertaken to help promote leisure time activities.

Activities in close contact with water on water surface formed by check dam

6 Reservoir water quality improvement projects

1 Reservoir water quality improvement projects (1993-)

Urbanization of the drainage basin of a dam and devastation of mountains in a dam area cause long-term turbidity of reservoir water and eutrophication. To prevent or mitigate such problems as turbidity and eutrophication, an assortment of measures for water quality preservation:

■Dredging, aeration, shallow water aeration, algae removal, etc.

■Construction and installation of ponds and phosphorus-absorbing materials; and feeder stream measures to be implemented as part of both a dam project and a sewerage project, such as advanced treatment, taken for the purpose of nutrient removal

■Slope protection works for turbidity prevention, such as revetment, board fencing, planting, sodding, as turbidity prevention measures. If necessary, an expanse of land is acquired as an environmental conservation zone for water quality preservation.

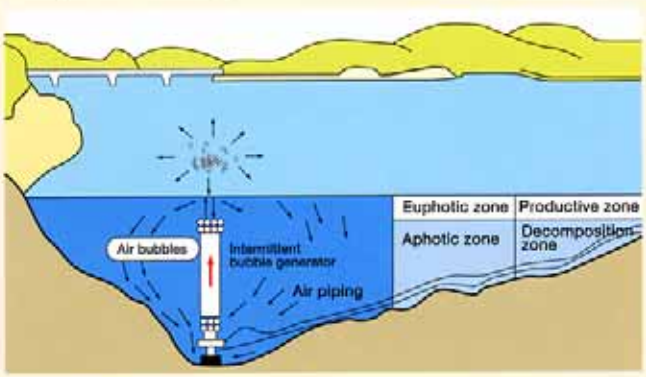
■A tree zone (lakeside grove) is created to prevent sediments and turbid water from entering the reservoir.

Greening of lakeside slope

Blooms in a reservoir

Phosphorus-absorbing materials laid in a tributary channe

Creation of a tree zone



Aeration mechanism

Shallow water aeration in reservoir

10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

6 Reservoir water quality improvement projects

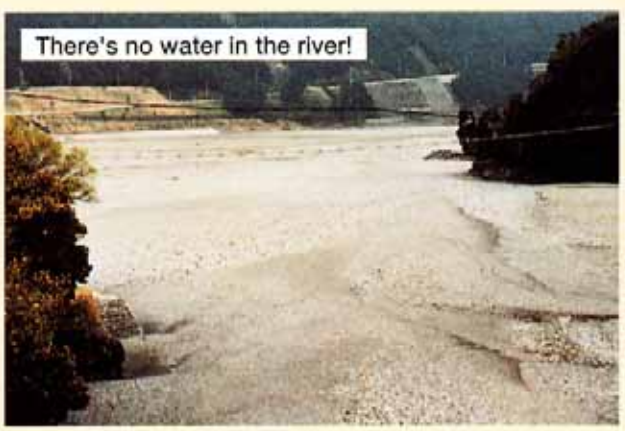
2 Specified reservoir drainage basin projects (Type II Green Belt) (1987-, institutionally expanded in 1994)
Various water quality control measures are taken to cope with deterioration of reservoir water quality caused mainly by domestic wastewater influent from the reservoir drainage basin and wasting of the surrounding woodland.
■To control turbid water inflow, vegetative cover is created by such means as tree planting in an area in the dam area where sediment inflow needs to be controlled.
■To prevent eutrophication of the reservoir, nutrients (e.g., nitrogen, phosphorus) are removed from the reservoir drainage basin.

Bare land in a reservoir area upon completion of planting

Bare land in a reservoir area two years after planing

7 Water environment creation projects

1 Projects for improvement of reservoir water environment (1993-)
With the growing public demand for comfortable living, people are beginning to reconsider the multi-faceted value of water and recognize the need to create an ecosystem-friendly environment.
Various measures to improve the riverrine water environment, such as development of fish-friendly streams, are currently underway. As part of such effort, active measures are taken to improve the types of river-crossing structures listed below and install environmental conservation facilities in order to improve the overall water environment of reservoirs and downstream areas.



●Outlet facilities for releasing environmental flows
Structures for releasing water for environmental flows to eliminate waterless sections downstream.

●Fishways
Facilities for enabling migratory fish to pass through a dam. A fishway is installed on a channel that meet the following requirements:
■Migratory fish already existed before dam construction and continues to inhabit the river section in the dam area.
■Construction of a fishway can be expected to considerably improve the environment for migratory fish species.
■Fishway construction is technically possible.

●Released water treatment plant
Plant for treating water released from a dam that is installed in cases where water released from a dam is posing a water quality problem (e.g., odor) downstream and is hampering river utilization at, for example, river parks, scenic spots or camping grounds.

●Spawning grounds
Spawning grounds or similar facilities provided to improve the habitat of fish in the sections upstream and downstream of the dam.

●Others
Facilities, other than those mentioned above, designed to improve the water environment upstream and downstream of the dam.

2 Dammed-stream fishway projects (1993-)
A fishway is installed at a relatively low fishwayless dam or weir that is under construction in a middle or lower reach of a river and that is adversely affecting the riverine environment extending over a long river section by hampering fish migration.

Fishway at Meboro Dam (Nagasaki Prefecture)

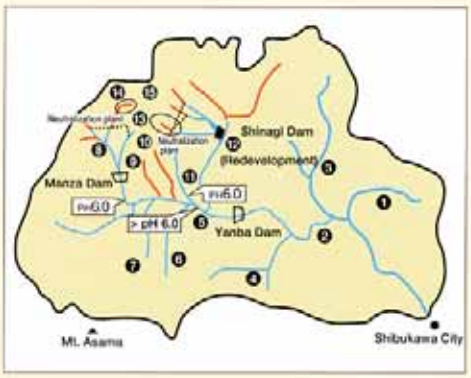
10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

7 Water environment creation projects

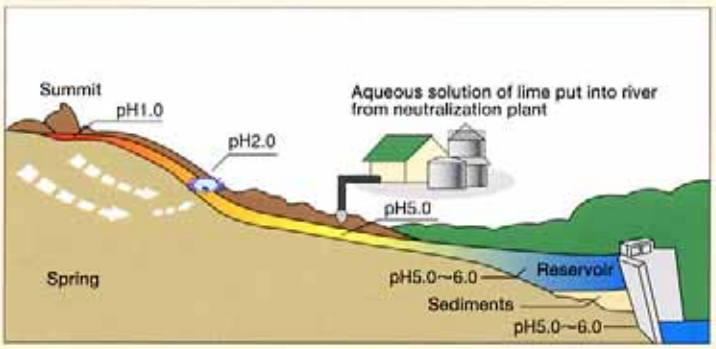
3 "Clear Stream Phoenix" Projects (acidity control measures) (1991-)

The quality of river water is declining because of wastewater that enters the rivers from their drainage basins. There are even rivers that are strongly acidic. These rivers have had a considerable impact not only on people's lives but also on the riverine ecosystem. The aim of a Clear Stream Phoenix Project, which is organized concurrently with dam construction, is to restore a sound nature-rich river-improve river water quality, makes a river inhabitable for fish again and makes river water usable-by installing neutralization plants.

Before



After

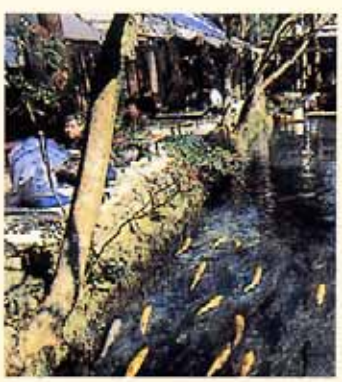


Shinagi Dam (Kanto Regional Construction Bureau)

4 Water environment enhancement dam (1988-)

As a solution to the problem of declining environmental functions of urban rivers resulting from urbanization, river flows for environmental purposes, such as dilution flows, are made available, and suburban recreation spaces to promote human-water contact are provided.

Dilution water in castle moast



Running water as landscaping element

Playing with water in suburban recreation space

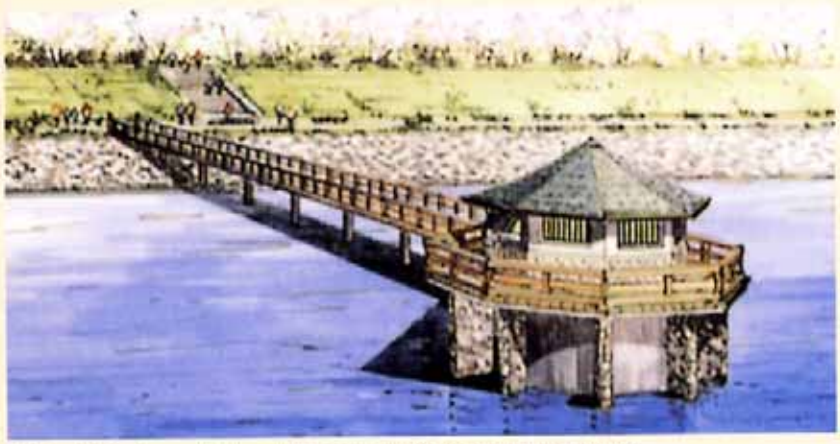
8 Historical dam preservation projects

Historical dam preservation project (1990-)
Dams of historical value are preserved, and at the same time their flood control and water utilization functions are enhanced.

●Restoration and redevelopment of dam structures
The functions of an aging dam are restored, and new flood control and water utilization functions are developed.

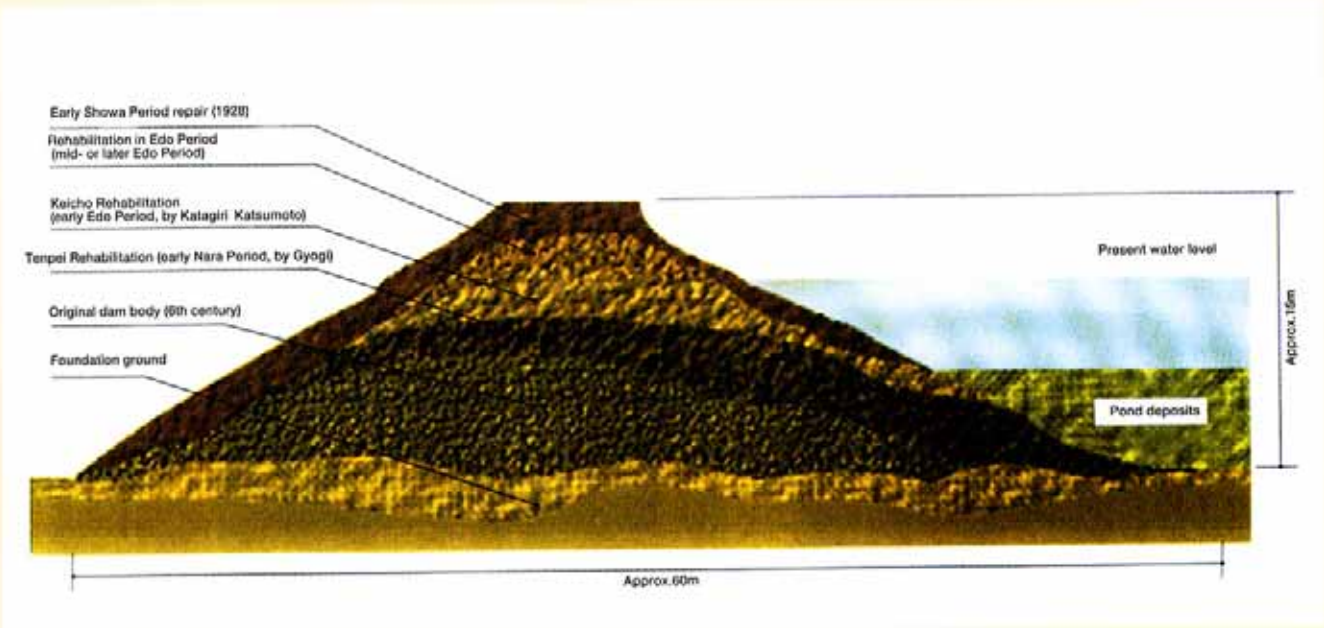
●Preservation of historical landscape
Civil engineering structures associated with a historical dam such as a dam body, intake structures and bridges are preserved or restored, and a historical dam environment is created, giving consideration to the aesthetic design of surrounding structures.

●Providing a place for dam history education
Dam-related documents and memorabilia are preserved and put on exhibit to provide a place for education.



Water intake tower designed to go well with historical landscape

Sayama Pond mentioned in the Emperor Suinin section of Kojiki (Record of Ancient Matters)



Cross section of Sayamaike Dam

10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

9 Reservoir sediment removal projects

As one of the measures to be taken against reservoir sedimentation, sediment accumulated in a reservoir is removed to restore the reservoir's storage capacity.

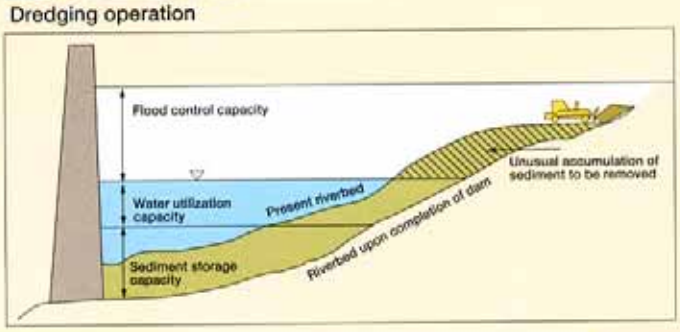
1 Reservoir conservation projects (1979-)
As a measure to be taken in connection with reservoir sedimentation, check dams or other structures are constructed to keep the reservoir functional and make effective use of dredged material as concrete aggregate.

Check dam

2 Specified dam sediment removal projects (1987-)
At a dam whose design sediment storage capacity has already been exceeded by the volume of sediment actually accumulated in the reservoir, that part of the sediment that is reducing the effective storage capacity is dredged and permanent sediment control works such as flush pipes are provided. These measures are taken to restore flood control and water utilization functions early and to increase storage capacity.

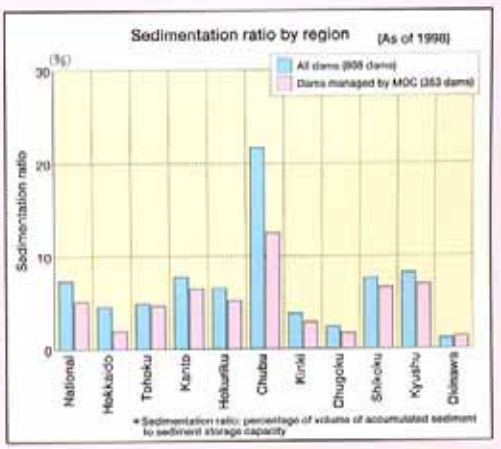
Dredging operation

3 Disaster restoration projects (1992-)
If a volume of sediment far exceeding the design storage capacity of a reservoir has flowed into the reservoir and that sediment accumulation in the reservoir has encroached on its storage capacity to the extent of diminishing flood control capacity to a certain degree, a disaster restoration project is undertaken to remove the sediment encroaching on flood control capacity.



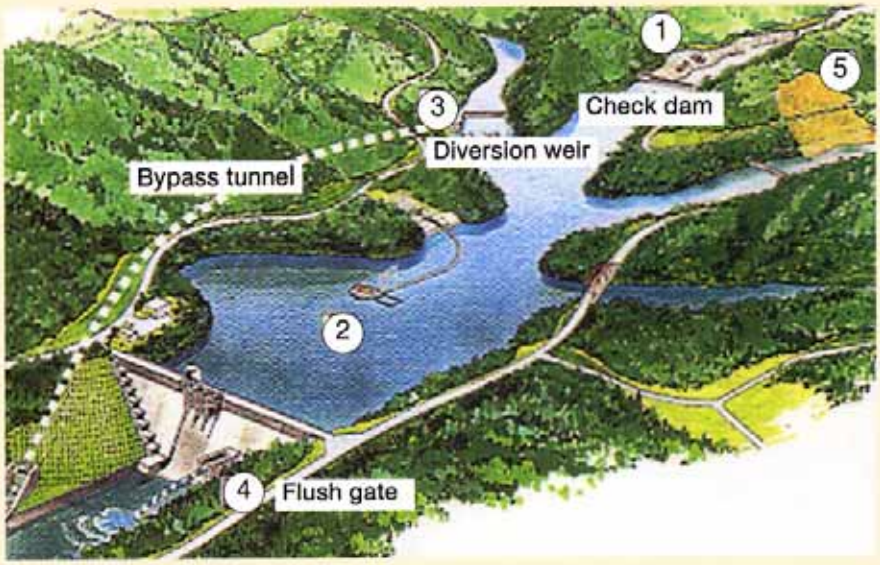
Q: Dams are eventually made unusable by sediment accumulation, aren't they?

A: Since a newly constructed dam usually has enough capacity to store the volume of sediment that can be expected to accumulate in 100 years, sediment accumulation usually does not pose a problem. The average sedimentation ratio for dams in Japan in 1997 was 7.0%, and although the some dams in the Chubu region show high sedimentation ratios, they are by no means unusable. However, in preparation for possible future accumulation of greater-than-expected volumes of sediment due to development in upstream areas or extreme floods, which may hamper the functioning of reservoirs, various measures (see the next page) are being taken to reduce sediment inflow into reservoirs and remove accumulated sediment. With the recent recognition of the need to supply a certain amount of sediment to the rivers downstream for environmental purposes, attempts are being made in some rivers at releasing part of the sediment accumulated in reservoirs into the channels downstream.

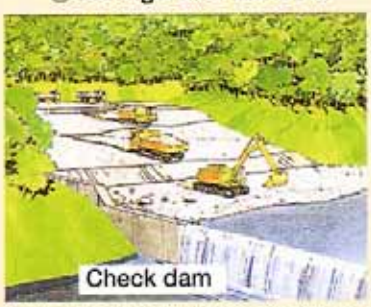


Measures against reservoir sedimentation

According to such factors as the nature of sediment being accumulated in each reservoir, various measures are being taken against ongoing or future reservoir sedi-9mentation.



①Storage and removal



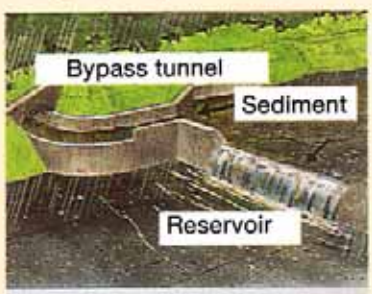
Sediment is caught at the reservoir entrance and removed.

②Dredging

Dredgers and other equipment are used to remove sediment accumulated on the bottom of the reservoir.

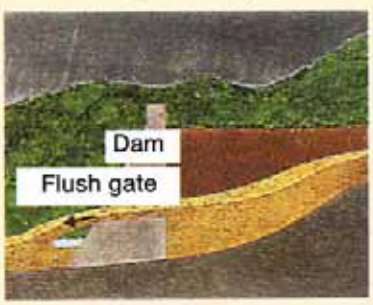
Removed material is utilized as concrete aggregate and embankment material.

③Passing downstream



In times of flood, sediment is let to flow on downstream via a bypass tunnel.

④Flushing



In times of flood, force of water is used to flush out accumulated sediment.

⑤ Planting for erosion control

10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

10 Projects for improvement of dams and appurtenances

In-service dams are screened to identify dams and appurtenances that are not functioning well or are functionally inadequate because of aging or by other reasons. The dams and appurtenances thus identified are improved extensively and urgently to enhance their performance.

■Improvement or construction of spillways, gates and other flood control outlet facilities and low flow outlet facilities; sediment control using bypass tunnels, etc.; extensive slope stabilization works around dam body

■ Example of an upgraded outlet structure

Tase Dam (Tohoku Regional Development Bureau)

Improvement or construction of spillways, gates and other facilities

Aging and failing outlet facility


Dam
Diversion weir
Sediment control through bypass tunnel, etc.
Extensive slope stabilization works around dam body
Bypass tunnel
Improvement and construction of energy dissipator
Improvement and construction of low flow outlet facilities

10. Outline of Comprehensive River Development Project for Meeting Diverse Needs

11 Dam projects open to local communities

With the growing public demand for opportunities to enjoy nature and recreations, dams, reservoirs and the surrounding areas are being expected to play an important role in activate local communities by providing open spaces rich in water and greenery, promoting their utilization and conserving the environment.
To meet such demand, effort is being made to reflect the creativity of local communities, make dams more comfortable to stay at and more open to local communities, and revitalize local communities.

Image of a dam open to local community

Examples of specified-dam projects

Dam body and plaza opened to the public for upstream-downstream exchanges (Hiyoshi Dam, Water Resources Development Public Corporation)

Dam designed to well with surrounding landscape (Miharu Dam, Tohoku Regional Development Bureau)

Internal space opened to the public

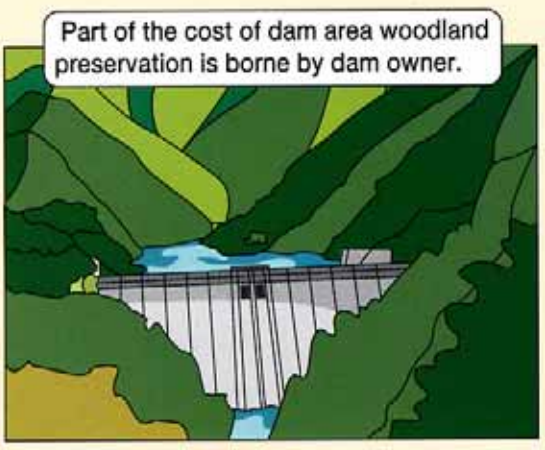
Lakeside camping site

12 Dam area woodland preservation system

There are cases where a local public body or other entity acquires and manages the woodland around a dam on condition that the dam owner does not pay for the relocation of an existing road. Under this system, part of the cost of acquisition and management is borne by the dam owner within the limit of the cost of road relocation, with a view to implementing the dam project in a way suitable for the local economic and social conditions

Conventional method

Newly instituted method



(Effect of new system)
- Project cost reduction
- Preservation of woodland around the dam

11 Revitalization of Reservoir

Measures for reservoir area development

Various measures for reservoir area development are taken to mitigate the impact of dam construction on the reservoir area and revitalize the local community.

Making land and housing available

Housing development

Stimulating industries

Development of agricultural infrastructure

Building public facilities

Road construction

Park construction

Activate the reservoir area

The construction site of a dam is opened to the public as a place for out-of-classroom education and for communication between visitors and the local community.

A pavilion built at a construction site, where visitors can learn about the dam and flood control, as well as nature, industries, history and culture of the area. (Otaki Dam, Kinki Regional Development Bureau)

In the pavilion, visitors can experience the heaviest rain in Japan or in the world to learn the horrors of flooding and the blessings of rain. (Otaki Dam, Kinki Regional Development Bureau)

Using dams for various events

In reservoir areas, dams are used for a variety of events to revitalize local communities and promote communication between the reservoir area communities and beneficiary communities downstream.

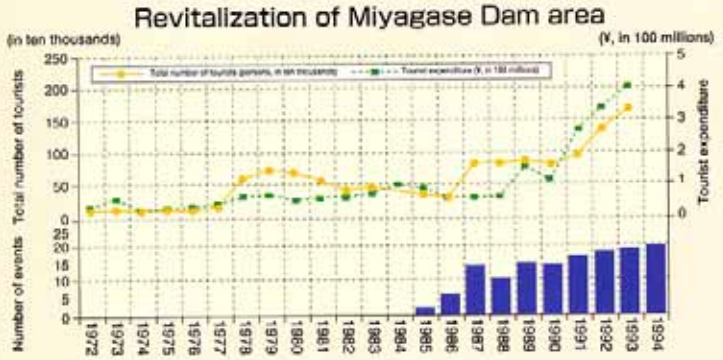
Releasing carp (Kyuragi Dam, Kyushu Regional Development Bureau)

Carp streamers flown over lake at Dam Festival (Nomura Dam, Shikoku Regional Dvelopment Bureau)

Water Festival at Lake Sameura (Sameura Dam, Water Resources Development Public Corporation)

Event held inside a hollow gravity dam (Yokoyama Dam, Chubu Regional Development Bureau)

Revitalization of Miyagase Dam area



Christmas event

One of the communities designated as "Mizu-no-sato" (villages of water)

12 Conserving and Creating Natural Environment

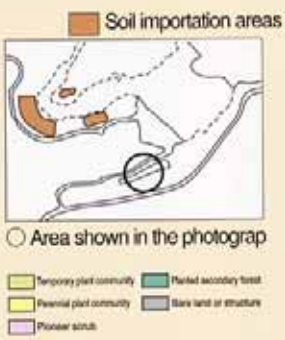
In planning and implementing a comprehensive river development project aimed at protecting people from floods and securing drinking water supply, the Ministry of Land, Infrastructure and Transport makes creative efforts to minimize impact on the natural environment and create a new, sound natural environment.

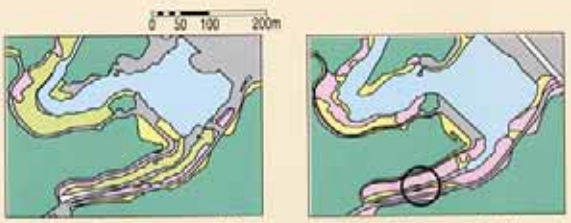
1 Environmental conservation

■Greening of lakeshore slopes-Minoogawa Dam (Osaka prefecture)
At the site of Minoogawa Dam located in Meijinomori Quasi-national Park, thorough research and studies on the natural environment were conducted because the construction work was to be carried out at a site blessed with nature. According to the findings thus obtained, various environmental conservation and restoration work was carried out.
One of the nature conservation/restoration projects adopted as part of this effort was the greening of the lakeside slopes. In the project, surface soil taken from the forest area to be submerged was spread over the lakeside slopes so as to form green slopes as early as possible. A follow-up study conducted five years after completion of the dam confirmed the progress of nature recovery, indicated by the ongoing recovery of vegetative cover and the increase in insect population.
These pre- and post-construction efforts for conservation of the natural environment at Minoogawa Dam were recognized with the Environment Award sponsored by the Environment Agency in June 1993.

Lakeside slope 10 years after completion of the dam (1993)

Lakeside slope covered with imported soil (1983)





6 months before completion of dam (1982)

5 years after completion of dam (1988)

Changes in vegetation from 1982 to 1988. In the soil importation areas, communities of temporary plants such as Polygonum thunbergii were replaced by pioneer scrub (communities of Rubus hirsutus and Aralia elata).

■Man-made stream of ayu-Lake Biwako (Shiga Prefecture)
Young ayu (Plecoglossus altivelis) produced in Lake Biwa are an important fisheries resource that accounts for 70% of all seeds released into streams in Japan. There had been concern about the possibility that lake level changes caused by comprehensive development of Lake Biwa might hamper ayu's migration up natural streams pouring into the lake. Effort was made, therefore, to develop aquaculture technology for maintaining the population of the fisheries resource, and a man-made river for spawning and hatching was constructed at the mouths of the Ado and Ane rivers. Young of ayu that migrate downriver from these man-made rivers have increased dramatically, by far exceeding the number of sea-going young from natural streams in recent years.

Adult ayu in spawning bed of man-made river

Man-made section of the Ado River

Man-made section of the Ane River

A man-made river consists of a channel whose bed is covered with a 20 cm thick layer of gravel to serve as a spawing bed, a pump station that pumps up water from Lake Biwa, and a stocking pond for parent fish equipped with lighting equipment that is used to control the spawning season.

2 Creation of nature-rich environment

■For waterbirds and fishes-Iida Dam (Ibaraki Prefecture)

"Shoals of Waterbirds and Fish" at Iida Dam have various features specifically designed for waterbirds and fish, such as wando (small inlet-shaped pools), log piles, nesting cliff and marches. There is also an "observation wall" (hiding wall with observation windows) from behind which visitors can observe wild birds. There are other sanctuaries for waterbirds and fish, such as Fish and Omurasaki Paradise (omurasaki is a butterfly species called "great purple emperor") and Floating Island of Waterbirds, distributed over the Lake Kasama area.

Fish and Omurasaki Paradise

Shoals of Waterbirds and Fish

Shoals of Waterbirds and Fish

Floating Island of Waterbirds

Observation wall from which to observe wild birds (Shoals of Waterbirds and Fish)

3 Harmony with nature

■ Lakeshore landscape-Uryu Daiichi Dam (Hokkaido)

The reservoir formed by Uryu Daiichi Dam has the largest reservoir area (2373 ha) in Japan. Lake Shumarinai (reservoir), which was completed in 1943, offers splendid views of landscapes in harmony with nature in Hokkaido. In 1973, the lake area was designated as Shumarinai Prefectural Natural Park. The lake has a ria-coast-like shoreline, and there are a total of 15 islets of various sizes on the lake.

Lakeside camping site

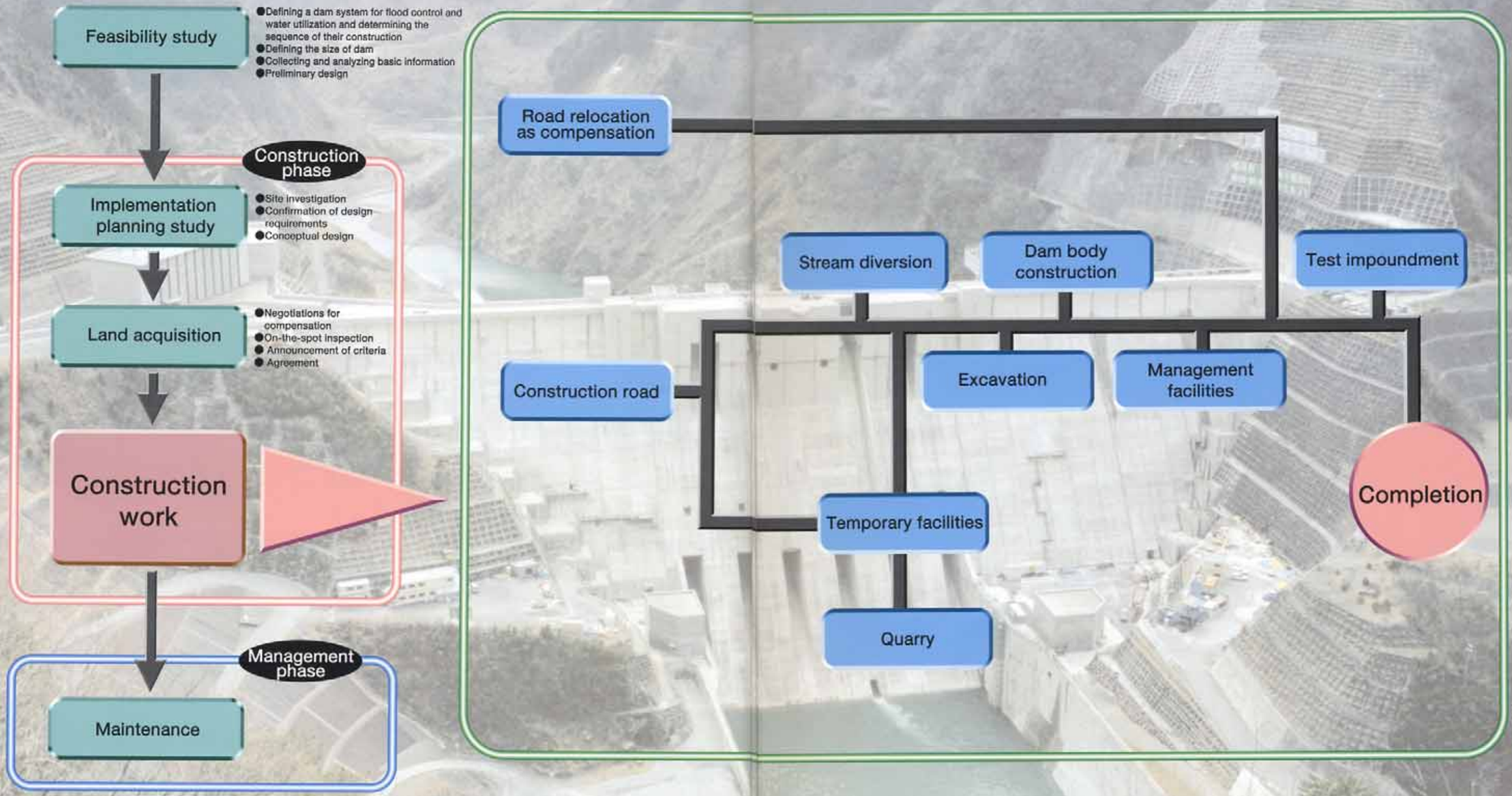
View of Lake Shumarinai. The lake offers scenic views that change with the seasons.

Ria-coast-like shoreline and islets of various sizes

Benten Island, one of the islets floating on the lake

13 Dam Project: From Inception to Post-construction Management

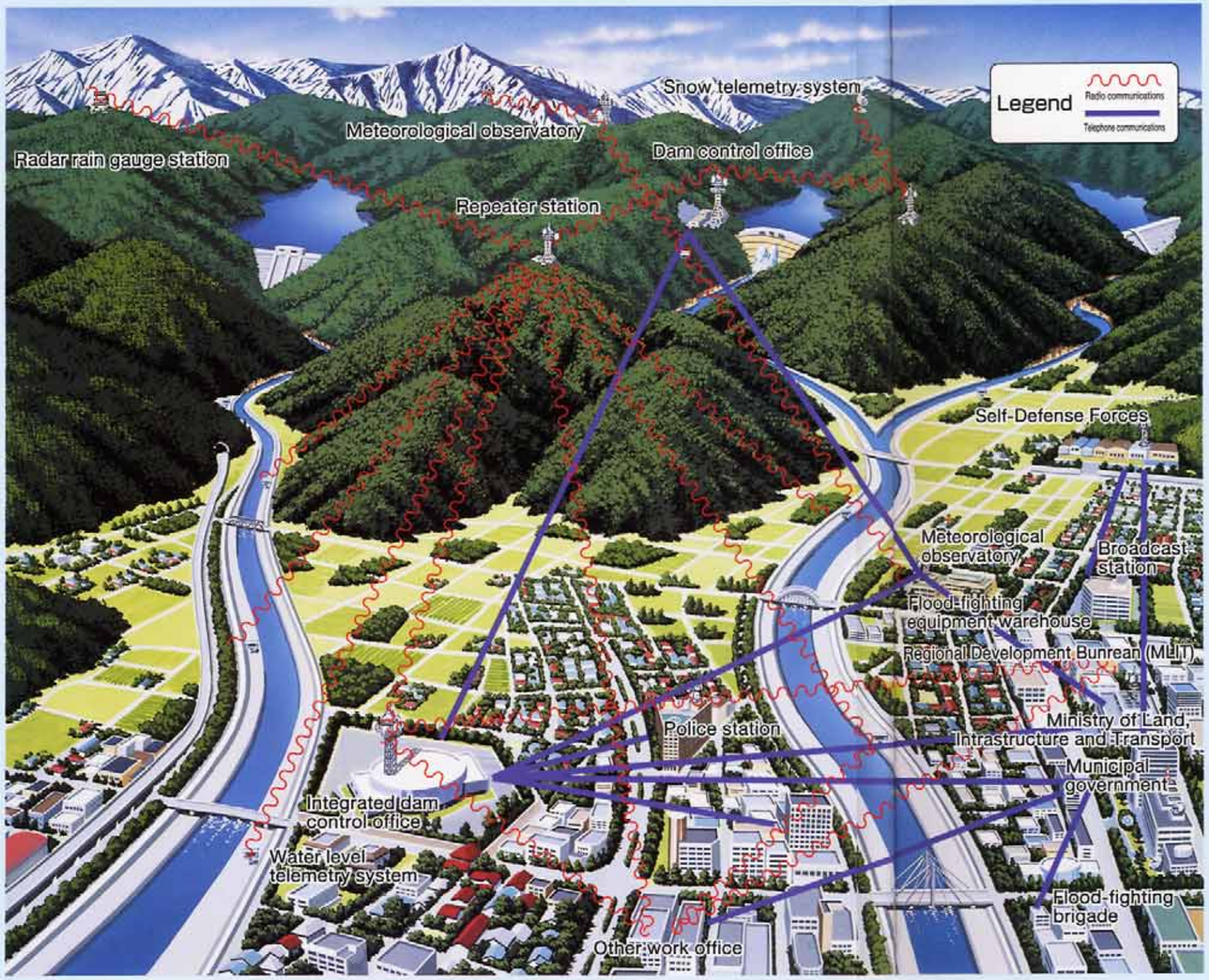
The process of a typical dam project from inception to post-construction management is illustrated below. Depending on the size of dam and other factors, the whole process takes 10 to 20 years.



Nagashima Dam (Chubu Regional Development Bureau)

14 Dam Management

Dam management refers to all actions taken to properly maintain and operate a constructed dam in order to achieve the goal of the dam project. Dam management activities include facilities management, which involves inspection, maintenance, rehabilitation and other tasks performed to ensure safety of the dam structure and the reservoir area and keep various facilities functional, and functional management, which involves observation, control, operation and other tasks carried out to attain the goals of the dam such as flood control and water supply.




Radar rain gauge station

Release warning


Yodogawa dam Integrated Control Office


Dam data processing system

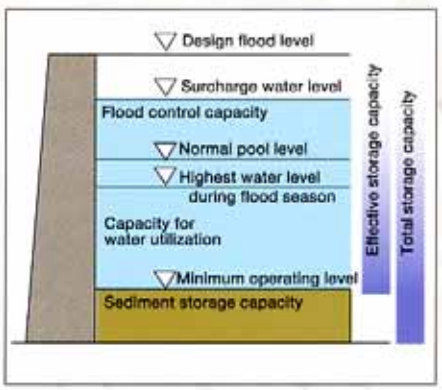
15 Glossary of Dam-related Terms

Reservoir level

(1) Design flood level: highest water level in a reservoir in the case where the design flood discharge* for the dam flows down from the dam
(2) Surcharge water level: highest water level of flowing water in times of flood to be temporarily retained in a reservoir
(3) Normal pool level: highest water level of flowing water to be retained by a dam in ordinary times (during nonflood periods)
(4) Minimum operating level: water level at the level of the lowest sill of the intake from which to take in water from the reservoir. Usually, water below the minimum operating level cannot be used
(5) Highest water level during flood season: highest water level during a flood season in cases where normal pool level is lowered to increase flood control capacity
* Maximum flood discharge that, from the standpoint of engineering, is likely to occur at the dam site

Reservoir capacity

(1) Total storage capacity: total of sediment storage capacity, dead storage, capacity for water utilization and flood control capacity
(2) Effective storage capacity: total storage capacity of a reservoir minus sediment storage capacity and dead storage capacity
(3) Flood control capacity: capacity of the space between normal pool level (or highest water level during flood season) and surcharge water level
(4) Capacity for water utilization: storage capacity of the space between minimum operating level
(5) Sediment storage capacity: capacity for sediment that is likely to accumulate in a reservoir in a certain period of time (usually 100 years)
(6) Dead storage: capacity of the space (if any), in a reservoir for hydropower generation or for other purposes, between the highest level of sediment storage zone and minimum operating level



Normal discharge

Normal discharge is a minimum streamflow that is needed to maintain the normal functions of river water and that satisfies both a specified minimum discharge needed to be maintained even during periods of drought (minimum acceptable flow) for purposes such as navigation, fishery, landscaping, salt damage prevention, protection of river management facilities, maintenance of groundwater level, protection of plants and animals and maintenance of cleanness of river water and a minimum discharge needed for downstream uses and specified for proper river management.

Examples of environmental measures during construction

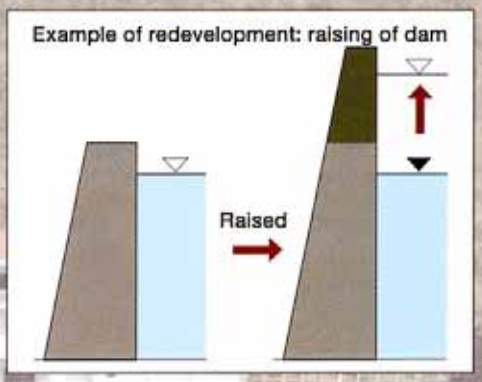
Turbid water treatment: Dam construction produces a large volume of wastewater including water used to wash concrete aggregate, water used to wash the dam body during construction, and water used to wash temporary equipment such as concrete mixers and buckets. In order to prevent adverse impacts on the environment, wastewater thus produced is chemically treated so that treated water, which satisfies the specified water quality requirements, can be used again or be disposed of.
Noise control: Dam construction often involves the use of large construction equipment. If necessary, such as when there are houses near the construction site, measures such as using low-noise equipment, restricting the use of large machinery to certain hours, imposing speed limits and installing noise reduction systems are taken to prevent noise problems.

Test impoundment

Since impoundment is the most important task to be performed to make the most of the functions of a reservoir, it is important to fully confirm its safety. In a dam construction project, test impoundment is carried out after completion of the dam body, and only after safety of the dam body, outlet facilities and the reservoir area has been confirmed, normal dam operations are initiated.

Redevelopment of dams

While it has become increasingly difficult to find good sites for dam construction in recent years, demand for flood control and water utilization continue to grow. Under these circumstances, work is underway to make more effective use of existing dams or redevelop them besides constructing new dams. There are basically two methods for redevelopment of existing dams: increasing reservoir capacity (by, for example, making the dam higher or excavating the reservoir) and changing the way an existing reservoir is operated (making operational changes through construction or modification of intake facilities, outlet facilities, etc.).



Water quality standards for reservoirs

In the classification for environmental quality standards set for the protection of the living environment, reservoirs are classified either as rivers (excluding lakes) or lakes (natural lakes, and man-made lakes with a storage capacity exceeding 10,000,000 m^3).

【Rivers (excluding lakes)】

Type	pH	BOD	SS	DO	Coliform count
AA	6.5~8.5	< 1 mg/L	< 25 mg/L	> 7.5 mg/L	< 50 MPN/100 mL
A	6.5~8.5	< 2 mg/L	< 25 mg/L	> 7.5 mg/L	< 1000 MPN/100 mL
B	6.5~8.5	< 3 mg/L	< 25 mg/L	> 5 mg/L	< 5000 MPN/100 mL
C	6.5~8.5	< 5 mg/L	< 50 mg/L	> 5 mg/L	
D	6.0~8.5	< 8 mg/L	< 100 mg/L	> 2 mg/L	
E	6.0~8.5	< 10 mg/L	No visible suspended solids	> 2 mg/L	

●All values are daily averages.

【Lakes (natural lakes, and man-made lakes with a capacity exceeding 10,000,000 m^3)】

Type	pH	COD	SS	DO	Coliform count
AA	6.5~8.5	< 1 mg/L	< 1 mg/L	> 7.5 mg/L	< 50 MPN/100 mg/L
A	6.5~8.5	< 3 mg/L	< 5 mg/L	> 7.5 mg/L	< 1000 MPN/100 mg/L
B	6.5~8.5	< 5 mg/L	< 15 mg/L	> 5 mg/L	
C	6.0~8.5	< 8 mg/L	No visible suspended solids	> 2 mg/L	

●All values are daily averages.
●Environmental quality standards for total nitrogen and total phosphorus have also been set for some water bodies.

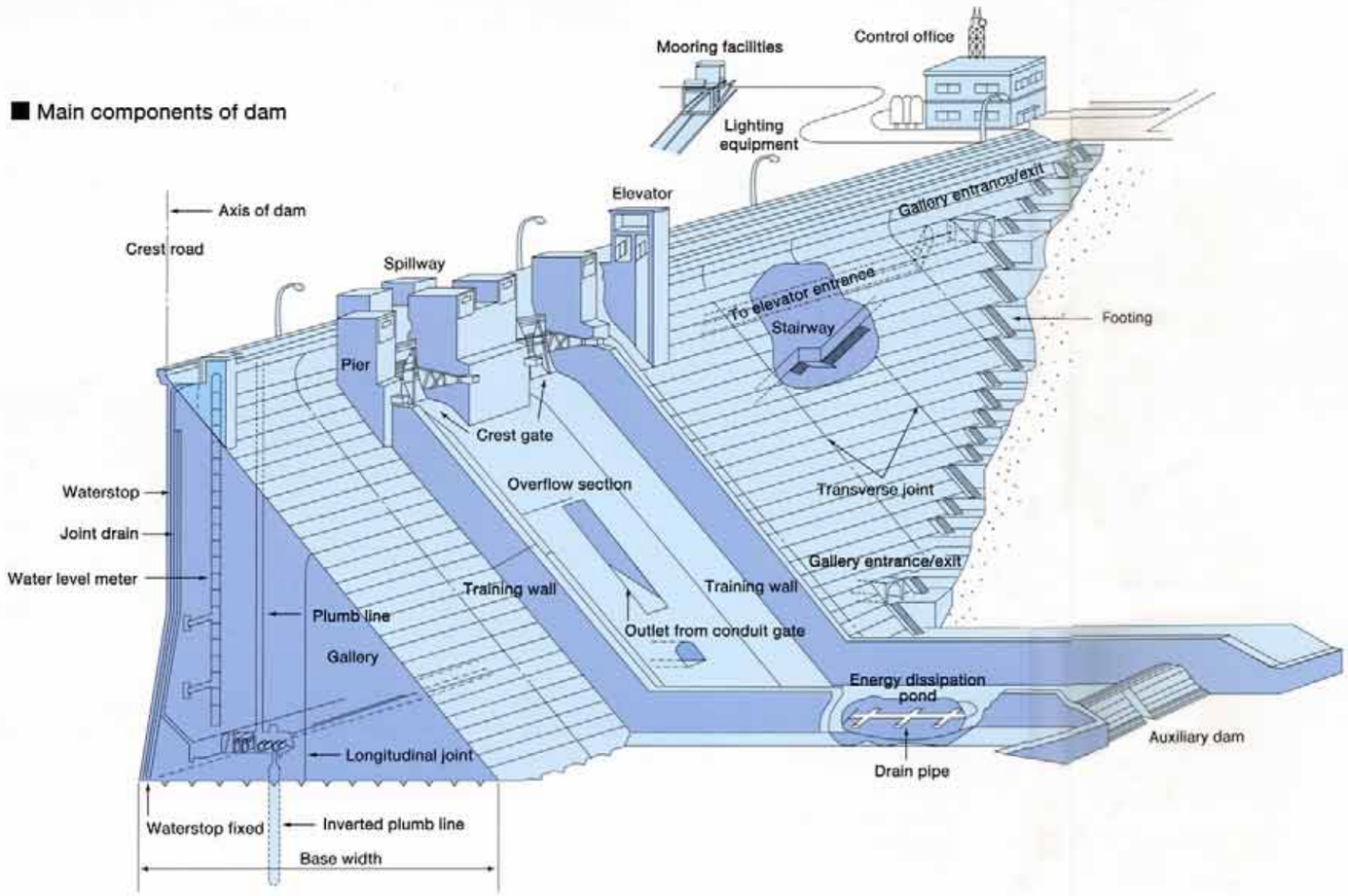
Notes

pH (hydrogen ion concentration): Values smaller than 7 indicate acidity, and values greater than 7, alkalinity.
BOD (biochemical oxygen demand): The amount of oxygen consumed by aerobic microorganisms. BOD increases as the amount of organic matter increases.
COD (chemical oxygen demand): The amount of oxygen consumed by chemical processes. COD increases as the amount of organic matter increases.
SS (suspended solids): Insoluble solid particles ranging in size from about 2 mm to 1 μm in suspension in water.
DO (dissolved oxygen): The amount of oxygen dissolved in water. Clear water has a high DO value.

Chiya Dam (Okayama Prefecture)

16 Dam Basics

■ Main components of dam



Heavy construction equipment used at dam site


Bulldozer (60 t)


Dump truck (77 t)


Concrete bucket (6 m³, 20 t)


Crawler-mounted vibrator used for compaction

Dams in Japan: Height & Capacity Ranking

Rank	Height (m)	Name of dam	Type	Location (prefecture)	Owner	Year completed
1	186.0	Kurobe	A	Toyama	Kansai Electric Power Co., Inc.	1963
2	176.0	Takase	R	Nagano	Tokyo Electric Power Company	1981
3	158.0	Naramata	R	Gunma	Water Resources Development Public Corporation	1990
4	157.0	Okutadami	G	Fukushima	Electric Power Development Co., Ltd.	1961
5	156.0	Urayama	G	Saitama	Water Resources Development Public Corporation	1998
6	155.5	Sakuma	G	Shizuoka	Electric Power Development Co., Ltd.	1956
7	155.0	Nagawado	A	Nagano	Tokyo Electric Power Company	1969
8	153.0	Tedorigawa	R	Ishikawa	Electric Power Development Co., Ltd. MLIT, Ishikawa Prefecture	1979
9	149.0	Ogochi	G	Tokyo	Tokyo Prefecture	1957
10	145.0	Tagokura	G	Fukushima	Electric Power Development Co., Ltd.	1959
11	140.0	Arimine	G	Toyama	Hokuriku Electric Power Company	1959
11	140.0	Kusaki	G	Gunma	Water Resources Development Public Corporation	1976
11	140.0	Kawaji	A	Tochigi	Kanto Regional Development, MLIT Bureau	1983
11	140.0	Misogawa	R	Nagano	Water Resources Development Public Corporation	1996

Rank	Total capacity (m³, in millions)	Name of dam	Type	Location (prefecture)	Owner	Year completed
1	601	Okutadami	G	Fukushima	Electric Power Development Co., Ltd.	1961
2	494	Tagokura	G	Fukushima	Electric Power Development Co., Ltd.	1959
3	370	Miboro	R	Gifu	Electric Power Development Co., Ltd.	1961
4	353	Kuzuryu	R	Fukui	Electric Power Development Co., Ltd., Ministry of Construction	1968
5	338	Ikehara	A	Nara	Electric Power Development Co., Ltd.	1964
6	327	Sakuma	G	Shizuoka	Electric Power Development Co., Ltd.	1956
7	316	Sameura	G	Kochi	Water Resources Development Public Corporation	1977
8	261	Hitotsuse	A	Miyazaki	Kyushu Electric Power Co., Inc.	1963
9	254	Tamagawa	G	Akita	Tohoku Regional Development Bureau	1990
10	231	Tedorigawa	R	Ishikawa	Electric Power Development Co., Ltd. MLIT, Ishikawa Prefecture	1979

■ Types of dam A: arch dam R: rockfill dam E: earth dam G: concrete gravity dam

As of end of 1998

Dams in the world: Height & Capacity Ranking

Rank	Height (m)	Name of da	Type	Country	Year completed
1	300	Nurek	E	Russia	1980
2	285	Grande Dixence	G	Switzerland	1961
3	272	Inguri	A	Russia	1980
4	262	Vajont	A	Italy	1961
5	261	Chicoasén	E/R	Mexico	1980
6	250	Mauvoisin	A	Switzerland	1957
6	250	Guavio	E/R	Columbia	1990
8	245	Sayano-Shushensk	A/G	Russia	1989
8	245	Ertan	A	China	(2000)
10	242	Mica	E/R	Canada	1973

Rank	Total capacity (m³, in millions)	Name of dam	Type	Country	Year completed
1	*2700000	Owen Falls	G	Uganda	1954
2	182000	Kakhovskaya	E/G	Russia	1955
3	180600	Kariba	A	Zimbabwe/Zambia	1959
4	169270	Bratsk	E/G	Russia	1964
5	168900	Aswan High	E/R	Egypt	1970
6	153000	Akosombo	E/R	Ghana	1965
7	141852	Daniel Johnson	A	Canada	1968
8	135000	Guri	E/R	Venezuela	1986
9	73300	Krasnoyarsk	G	Russia	1967
10	70309	W.A.C.Bennett	E	Canada	1967

■Types of dam A: arch dam R: rockfill dam E: earth dam G: gravity dam

※-The year in parentheses is an estimated year of completion.

-An asterisk (*) indicates storage capacity including the capacity of a natural lake.

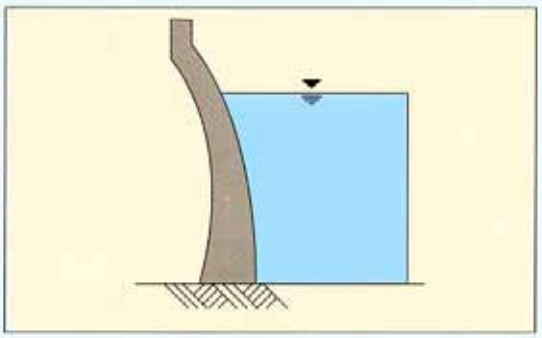
Source: Water Power & Dam Construction Year Book 2000

17 Types of Dam

Dams can be classified into a number of types according to materials used, type of structure and other characteristics. Representative dam types in Japan are shown below.

Arch dam

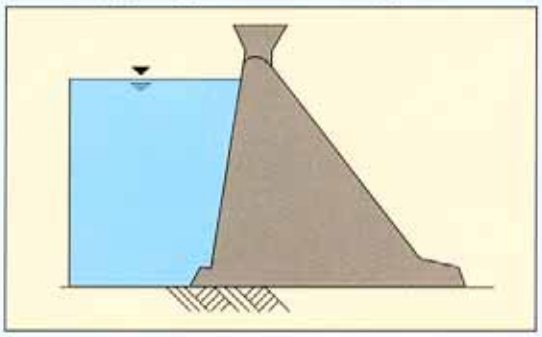
An arch dam is a dam designed to resist water pressures and other external forces by the arch action of the structure. The horizontal cross section of an arch dam is in the shape of an arc or parabola.



Shorenji Dam (Water Resources Development Public Corporation)

Concrete gravity dam

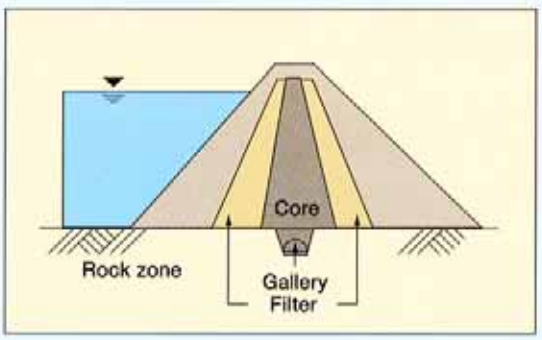
A concrete gravity dam is a dam built to resist water pressures and other external forces by its own weight. Concrete gravity dams are usually linear in shape, and its cross section is basically a triangle.



Tamagawa Dam (Tohoku Regional Development Bureau)

Fill dam

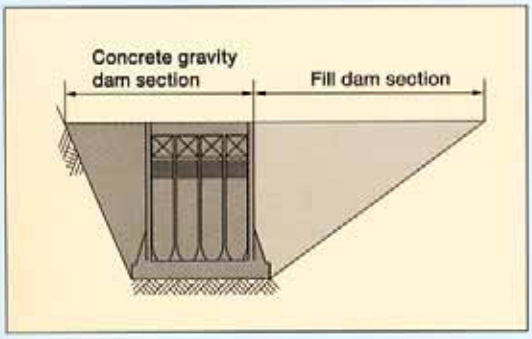
A fill dam is made of rocks, gravel, sand and/or soil. Belonging to this category are zoned fill dams, homogeneous fill dams, and fill dams with impermeable facing.



Naramata Dam (Water Resources Development Public Corporation)

Hybrid dam

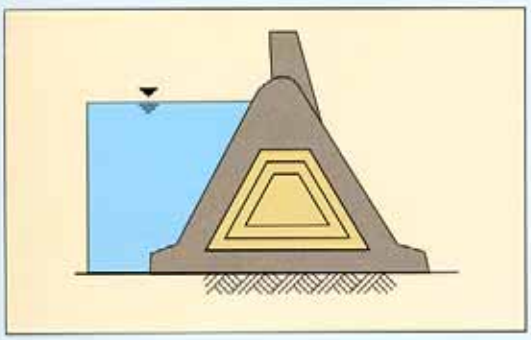
A hybrid dam is a combination of a concrete gravity dam and a fill dam.



Gosho Dam (Tohoku Regional Development Bureau)

Hollow gravity dam

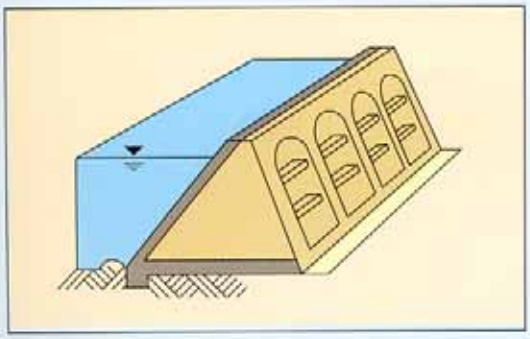
A hollow gravity dam is a type of concrete gravity dam that has a hollow structure.



Kanayama Dam (Hokkaido Development Bureau)

Buttress dam

A buttress dam consists of a reinforced-concrete upstream face and a series of walls called buttresses.



Sasanagare Dam (Hakodate City)

18 Construction Methods

To rationalize construction by achieving such goals as improved economy and shorter construction periods, various construction methods have been developed in recent years.

1 Columnar block placement method (conventional method)

In the columnar block placement method, dam concrete is placed in a number of columnlike blocks.

Nagashima Dam (Chubu Regional Development Bureau)

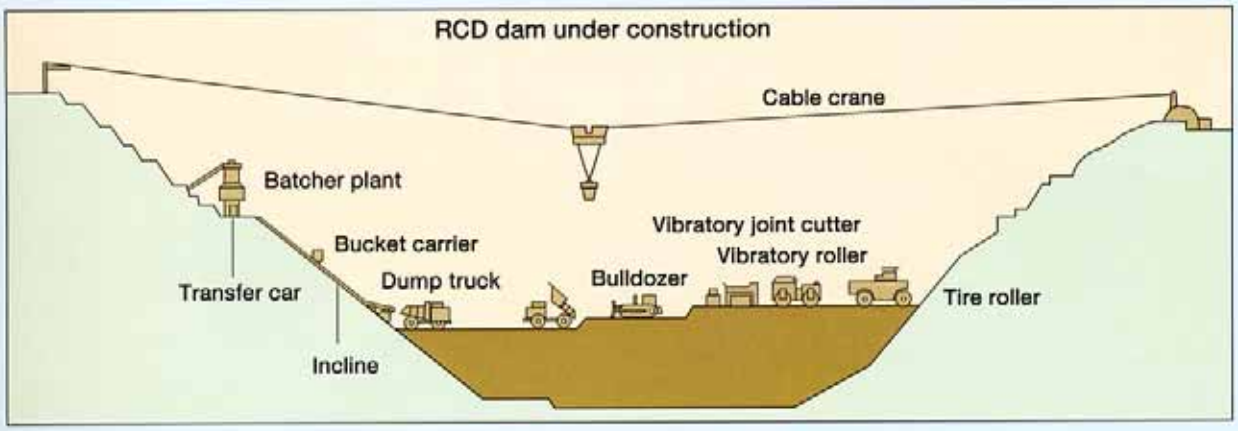
2 ELCM (rationalized construction method)

In the Extended Layer Construction Method (ELCM), a number of blocks are placed concurrently without making steps as in the pillor-shoped block placement method.

Hinati Dam (Water Resources Development Public Corporation)

3 RCD Method (rationalized construction method)

The Roller Compacted Dam-concrete (RCD) Method is a rationalized method of construction. The RCD Method is an innovative construction method utilizing the advantages of the fill dam construction method, which uses equipment such as trucks, bulldozers, vibratory rollers and tire rollers.



(1) Direct delivery to dump trucks by inclines

Miyagase Dam
(Kanto Regional Development Bureau)

(2) Direct delivery of concrete by belt conveyors

Gassan Dam
(Tohoku Regional Development Bureau)

(3) Tower crane and bucket method of concrete deliver

Satunaigawa Dam
(Hokkaido Development Bureau)

19 Reducing the Cost of Dam Construction

In their meeting in April 1997, the cabinet ministers approved the Action Guidelines on Measures for Reducing Public Works Construction Costs. At the meeting, it was decided to take every action to reduce public works construction costs by more than 10 percent by the end of fiscal year 1999.
In fiscal year 1994, leading the efforts in the government, the Ministry of Construction (currently the Ministry of L.I.T)began its all-out effort to reduce the cost of public works including dam construction.

■Example of work flow in cost reduction effort

Work flow in cost reduction effort (FY1998)

Surikamigawa Dam (Fukushima Prefecture), Tohoku Regional Development Bureau

Surikamigawa Dam Work Office (technical personnel)

Surikamigawa Dam technical committee

Develops an agenda associated with the dam construction project as a whole and explores ways to reduce the project cost with a view to attaining the goals described in the action plan for construction cost reduction in public works projects.

- Rationalization
- Labor saving
- Review of current design
- Construction method
- Temporary works plan
- Construction schedule

Project team

Early dissolution of pending problems

- Quarry
- Embankment
- Concrete
- Boring and grouting
- Intake and outlet facilities
- Management facilities
- Environmental measures
- Road relocation

Dam construction joint venture

Surikamigawa Dam Construction Project Rationalization Committee

Explores possibilities of cost reduction in all aspects of the Surikamigawa Dam construction project and develops an agenda

- Dam body
- Relocated road
- Intake and outlet facilities
- Management facilities

Decision making organization

Surikamigawa Dam Construction Project Cost Reduction Committee

Work office

- Personnel (technical managers and above)

Joint venture

- Senior dam manager & engineer
- General manager or equivalent (head office)

- Item-by-item evaluation
- Making decisions associated with construction
- Screening of agenda items
- Preliminary coordination
- Applicability of new technologies/materials
- Economy of design and construction

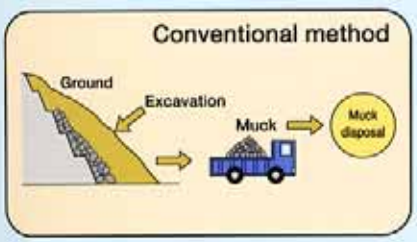
Working groups

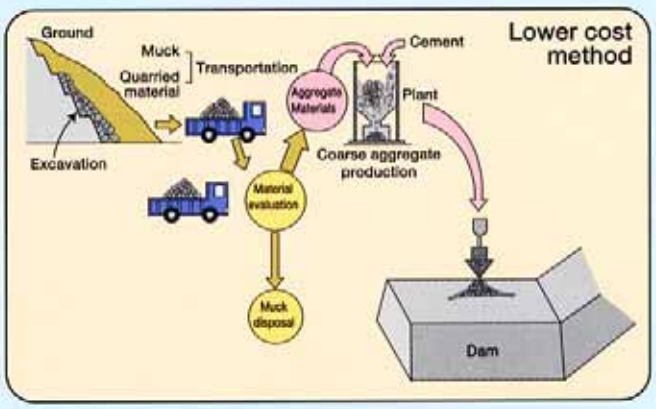
(1) Dam structure working group
(2) Road relocation working group
(3) Construction facilities working group

■Examples of cost reduction measures

Using excavated material as concrete aggregate　Ootaki Dam (Nara Prefecture), Kinki Regional Development Bureau

By using higher-quality portions of muck produced from excavation for the dam body as concrete aggregate, quarrying requirements as well as muck disposal cost were reduced.





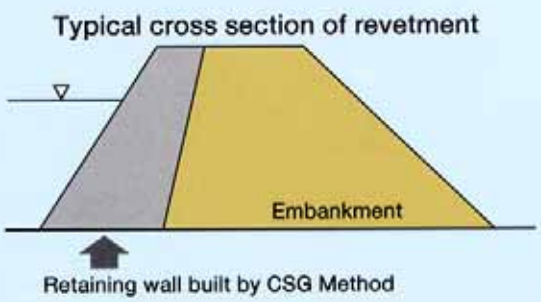
Cost reduction of about 11%

*Muck: material produced as a result of excavation

Using CSG Method for revetment work　Tokuyama Dam (Gifu Prefecture), Water Resources Development Public Corporation

In view of the site conditions including the work yard conditions and locally available materials (riverbed sand and gravel), the CSG Method* was employed for revetment work.

Full view of completed revetment



Cost reduction of about 17%

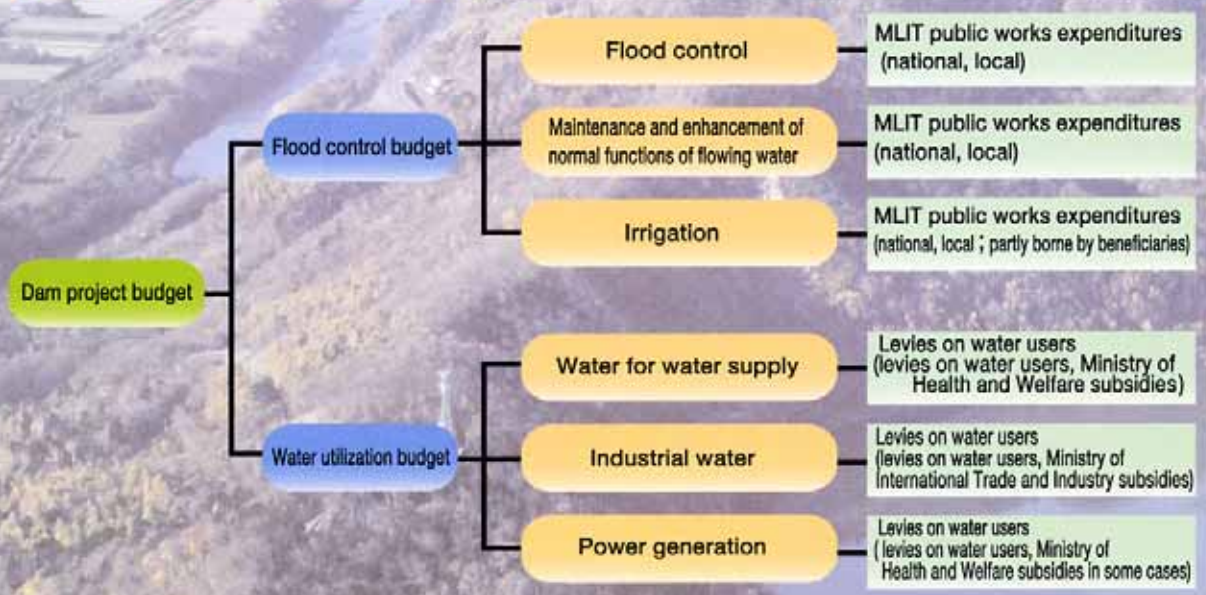
Conventional method	Tokuyama Dam
Locally produced material (riverbed sand and gravel) → Revetment construction using reinforced gabions	Locally produced materials (riverbed sand and gravel) → CSG Method → Mixed with cement → Used for revetment construction (Boulders) → Used as embankment material

- Use of locally produced materials makes for effective use of resources.
- A shorter construction period can be achieved.

*CSG Method (Cemented Sand and Gravel Method): a construction method in which locally produced sand and gravel are mixed with cement, and mixtures thus obtained are compacted to build structures.

20 Outline of Budgeting System for Comprehensive River Development Projects

1 Budgeting system



2 Legal framework and implementing bodie

■ Dam-related legal framework and implementing bodies

Category	Type	Law name	Implementing body
MOC	Specified multipurpose dams	Specified Multipurpose Dam Act	Ministry of Land,Intrstrucion and Transport (MLIT)
	Comprehensive river development project	River Law	
	Flow regime control rivers	River Law	
WARDEC	Facilities developed by WARDEC (specified facilities)	Water Resources Development Promotion Act	Water Resources Development Public Corporation (WARDEC)
		Water Resources Development Public Corporation Act	
Subsidized	Multipurpose dams	River Law	Prefectural governments
	Flood control dams	River Law	

■ Legal framework for promotion of dam construction

Act on Special Measures for the Reservoir Area Development

3 Budget frameworks

Project name	Applicable law concerning national funding/subsidizing	National fund/subsidy ratio	Year instituted
■MLIT projects ●Specified multipurpose dam construction projects	Art. 59, Art 60 Para. 1 and Art. 96 of the River Law; Art. 8 of the Specified Multipurpose Dam Act; Art.7 Para. 4 of the Special Measures Law for Development of Okinawa	Large-scale projects[1] 7/10 Other projects[2] 2/3	1957
●MLIT comprehensive river development projects	Art. 59, Art. 60 Para. 1 and Art. 96 of the River Law; Art. 7 Para. 4of the Special Measures Law for Development of Okinawa	Large-scale projects[1] 7/10 Other projects[2] : 2/3	1951
●MLIT flow regime control river projects	Art. 59, Art. 60 Para. 1 and Art. 96 of the River Law; Art. 7 Para. 4 of the Special Measures Law for Development of Okinawa	Large-scale projects[1] 7/10 Other projects[2] : 2/3	1972
●MLIT dam maintenance projects	Art. 59, Art. 60 Para. 1 and Art. 96 of the River Law; Art. 7 Para. 8 of the Special Measures Law for Development of Okinawa	5.5/10[3]	1957
●MLIT dam facilities improvement projects	Art. 59 and Art. 60 Para. 1 of the River Law	2/3	1994
●MLIT dam environment improvement projects	Art. 59 and Art. 60 Para. 1 of the River Law	1/2	1993
■ WARDEC projects ● Construction projects	Art. 26 Para. 1 of the Water Resources Development Public Corporation Act	Large-scale projects[1] 7/10 Other projects[2] : 2/3	1962 1967
● Management projects	Art. 27 Para. 1 of the Water Resources Development Public Corporation Act	5.5/10	
■Subsidized projects ●Subsidized multipurpose dam construction projects	Art. 60 Para. 2, Art. 62 and Art. 96 of the River Law; Art. 5 Para. 1 of the Special Measures Law for Development of Okinawa	(Class A river)[4] Large-scale projects 5.5/10 Other projects 1/2 (Class B river)	1940[9]
●Subsidized flood control dam construction projects	Art. 60 Para. 2, Art. 62 and Art. 96 of the River Law; Art. 5 Para. 1 of the Special Measures Law for Development of Okinawa	1/2[5]	1967 1972
●Subsidized dam improvement projects	Art. 16 of the Local Finance Law	4/10[6] 1/3[7]	
●Subsidized dam rehabilitation projects	Art. 61 of the River Law; Art. 16 of the Local Finance Law	1/2[8] 1/3	Class A river 1965 Class B river 1977
●Subsidized dam environment improvement projects	Art. 16 of the Local Finance Law	1/3	1975

● : Construction project ● : Management project

Notes:
1) Large-scale project: a project that amounts to more than ¥12,000 million in public works expenditure and that falls within one of the categories shown in the table below.
2) 8.5/10 for Hokkaido and 9.5/10 for Okinawa
3) 7/10 for Hokkaido and 9.5/10 for Okinawa
4) In Hokkaido, 7/10 for large-scale projects and 2/3 for other projects
5) 5.5/10 for Hokkaido, 6/10 for Amami Islands and 9/10 for Okinawa
6) Projects to which subsidy ratio of 4/10 is applicable: dam improvement projects, projects for installation of hydropower generation plant for dam management, disaster restoration projects for current fiscal year
7) Projects to which subsidy ratio of 1/3 is applicable: river channel improvement projects, reservoir conservation projects
8) Projects to which subsidy ratio of 1/2 is applicable: dam facilities improvement projects
9) Implemented as "river water control projects" until 1950

Category	Criteria
Dam	Total storage capacity of more than 8,000,000 m³
Lake water level control facility	All facilities
Headrace, floodway or cut-off channel	Length of more than 750 m
Retarding basin	Area of more than 150 ha (overall)
Weir or groundsill	Length of more than 150 m

Fixed ratios of 8.5/10 and 9.5/10 are applied to Hokkaido and Okinawa, respectively.

Takisato Dam (Hokkaido Development Bureau)

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