ACTIONS TO CONSERVE THE ENVIRONMENT AT OYAMA DAM

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1. Overview of Oyama Dam construction project

Oyama Dam, which is now under construction on the Akaishi River of the Chikugo River System in Kyushu in south- western Japan by Japan Water Agency, is a multi-purpose dam intended for control flood, maintaining normal function of river flow（stable water supply for vested water right, conserving river environment）, and providing new water supply. Total construction cost of the dam is about 1.2 billion dollars and it is scheduled to be completed in March 2013. Figure 1 shows the location of Oyama Dam. The dam specifications are: concrete gravity dam with dam height of 94.0m, dam body volume of 550,000m3, submerged area of 0.6km2, catchment basin area of 33.6km2, and total reservoir capacity of 19,600,000m3. Work on the dam body began in April 2007. Figure 2 is a photomontage of the completed dam.

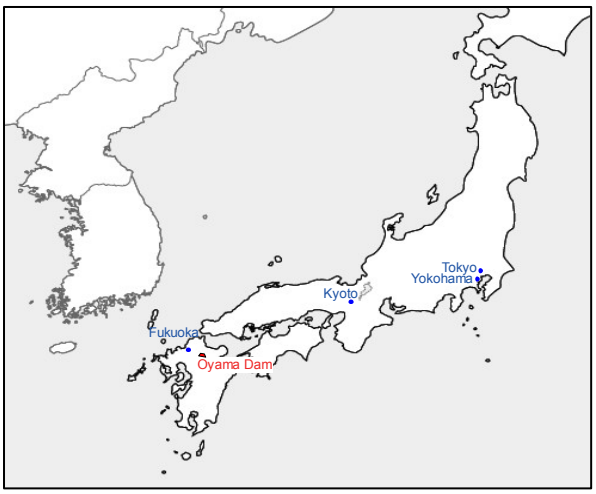

Figure 1. Location of Oyama Dam

Figure 2. Photomontage of Completed Dam

The Chikugo River is a Class A river (river managed by the national government) with a drainage basin of 2,860km^2 and total main channel length of 143km. The average annual rainfall in the Chikugo River basin is about 2,050mm. About 40% of this rainfall is concentrated in the rainy season from June to July, and a total of 60% of annual rainfall is this rainy season rainfall in addition to rainfall during the August to September typhoon season.

The Chikugo River basin has contributed to the economic development of the region since ancient times by supplying irrigation water, river transport routes, hydroelectric power, etc., but once it is struck by extremely heavy rainfall, the river is transformed into a raging torrent, which has caused frequent flood damage in the past. The massive flood of June 1953 was a particularly severe disaster that took the lives of 147 people and created a total of 540,000

victims. Around Fukuoka City and in southern Fukuoka Prefecture that are regions using water supplied by Oyama Dam, droughts are frequent. Especially in 1978, continuing light rainfall forced restrictions on the water supply in Fukuoka City for 287 days from May 20, 1978 to March 24, 1979. A drought in 1994 was far more severe than the one in 1978, resulting in a 295 day period of restricted water use extending from August 4, 1994 to May 31, 1995. Oyama Dam was constructed as part of comprehensive development including flood control and water use on the Chikugo River under these circumstances. Photo 1 is a view of the flood in 1953 and photo 2 is a view of the Fukuoka City drought in 1978.

Photo 1. Chikugo River Flood in 1953

Photo 2. Fukuoka City Drought in 1978

2. Actions to conserve the environment

2.1 Background to actions to conserve the environment

The submerged 60 hectares in area of Oyama Dam are smaller than 200 hectares established in the Environment Impact Assessment Implementation Rules enacted by the Cabinet in 1984. But in order to prevent or mitigate impacts of dam construction on the environment, a survey of the natural environment in and surrounding the dam project district began in 1985, giving an overview of the natural environment and clarification of the state of habitats of rare plant and animal life.

Later in 1994, the Oyama Dam Environmental Measures Council was formed by scholars, experts on the environment and representatives of concerned organizations active mainly in the local district. The environmental survey and studies of conservation measures were conducted with the guidance and advice of this council in order that the dam project will be completed in harmony with the local environment and that it will have the agreement with the local people. Photo 3 is a view of a meeting of the Oyama Dam Environmental Measures Council.

Environmental conservation measures are now being taken in conjunction with progress on the work, and a study to develop even better conservation measures is being carried out with the guidance and advice of experts.

Photo 3. Meeting of the Oyama Dam Environmental Measures Council

2.2. Basic environmental conservation policies

At Oyama Dam, actions are being taken to minimize the impacts on the environment by the project under the following policies in order to conserve environment of habitation and the growth of the animals and plants for diverse plant and animal life and abundant ecosystems

in the project district and its surroundings. The impacts of noise, vibration, and dust on water quality, animals, plants, ecosystems, scenery, and other items will be predicted to assess environmental impacts under the environmental impact assessment system. And conservation measures will be planned to deal with the predicted impacts.

1) Advance survey and predictions as well as monitoring surveys

Conservation measures will be taken based on the results of predictions of the impact by the project clarified by environmental surveys of the project district and its surroundings. And before the execution of each work, an environmental patrol on the work site will be carried out, and after conservation measures have been taken, monitoring surveys will be carried out to assess the effectiveness of the conservation measures.

2) Adoption of design and construction methods that conserve habitats for plant and animal life

The design of road diversion and temporary roads will be done by planning the road alignment and adopting the reinforced earth wall method etc. to absolutely minimize the change of the land by the work. The quarrying work will be done by making actions to use aggregate effectively and by purchasing the aggregate from outside quarry to minimize topographical change caused by excavation.

3) Restoration of the environment of habitation of temporary facility yard

Bare land created by the work on slopes will be quickly restored by seeding and planting by native species. Rich forest environments will be restored on quarried land and on disposal area by covering it with topsoil and planting trees.

4) Taking measures to reduce the impact of permanently changed land

Important species impacted by construction work, such as rare Salamander(*hynobius neavius*), Calanthes, Orchidaceae (*Cephalanthera falcate*), will be moved to or transplanted outside the region changed. Impacts on the Great Purple Emperor (*Sasakia charonda*) will be reduced by moving and transplanting nettle trees that are sources of nourishment for its larvae.

5) Provision of guidance and advice and seminars by experts to ensure effectiveness of conservation measures

In order that environmental surveys and predictions and conservation measures are effective, the Oyama Dam Environmental Measures Council will meet regularly and obtain guidance and advice from experts. Environment seminars will be held for JWA employees and people involved in the works to provide them with knowledge and increased awareness necessary to conserve the environment.

3. Environmental conservation measures

3.1 Atmospheric environment

Predictions of the impact of noise, vibration, and dust produced by the work at Oyama Dam have

Photo 4. Installation of Noise Barriers (Top: before installation, Bottom: after installation)

revealed that although the noise of the construction machinery will have a small impact, some areas will be impacted by the noise of work vehicles, so noise barriers shown in Photo 4 are installed as an environmental conservation measure. And actions will be taken to reduce noise produced by the work, by not operating work vehicles that pass through hamlets late at night and early in the morning. It is predicted that the work will have little vibration and dust impact, but to protect the environment, low noise type or construction machinery equipped to reduce noise will be used, and dust will be controlled by cleaning or regularly spraying water on the temporary roads.

3.2 Water quality

3.2.1 State of the catchment basin

Approximately 1,100 people who rear approximately 300 head of cattele populate Oyama Dam catchment. And 90% of the catchment is forested and there are hardly any large employers.

The flow rate at the dam site has been an average of about $3m^3/s$ per year since observations began in 1988, and the maximum flow rate observed during this period was $365m^3/s$ (July 2, 1990).

Regarding the water quality at the dam site and in the inflowing river, turbidity of the water caused by sediment and dissolved oxygen are both below environmental standards※, but items related to eutrophication, namely total nitrogen and total phosphorus are about 0.5mg/L and 0.03mg/L respectively, values which undeniably indicate the possibility of eutrophication after completion of the dam.

※ The Akaishi River where Oyama Dam will be constructed has not been categorized for water quality related environmental standards, so these values are compared with those for a Class A river under environmental standards applied to the convergence of the Oyama River (Chikugo River) and the Akaishi River.

3.2.2 Water quality during construction

The turbid water treatment plant shown in Photo 5 is installed to treat turbid water generated by dam body construction work. And to reduce the turbidity of turbid water generated on bare land such as slopes, setting pond will be installed to treat this water at work sites where bare land above a certain level will be created.

Photo 5. Installation of Turbid Water Treatment Plant

3.2.3 Water quality after completion of the dam

The prediction of water quality after dam completion shows that problems related to dissolved oxygen or prolonged turbidity will not occur, but there may be water temperature (discharge of warm water) or eutrophication problems, so selective intake equipment and aeration equipment will be installed.

1) Dissolved oxygen

This value is approximately 10mg/L, and it is predicted that even after dam construction, environmental standards (Class A River category) of 7.5mg/L will be expected.

2) Turbidity of water by sediment

It is predicted that after construction, the number of days per year when the SS (suspended sediments) exceeds 5mg/L will decrease from 41 days to 29 days, and the number of days per year when it is 25mg/L (environmental standard: Class A river category) will decrease from 11 days to 3 days.

3) Water temperature

It is predicted that operating selective intake equipment to take in water from the same temperature layer as that of inflow water can

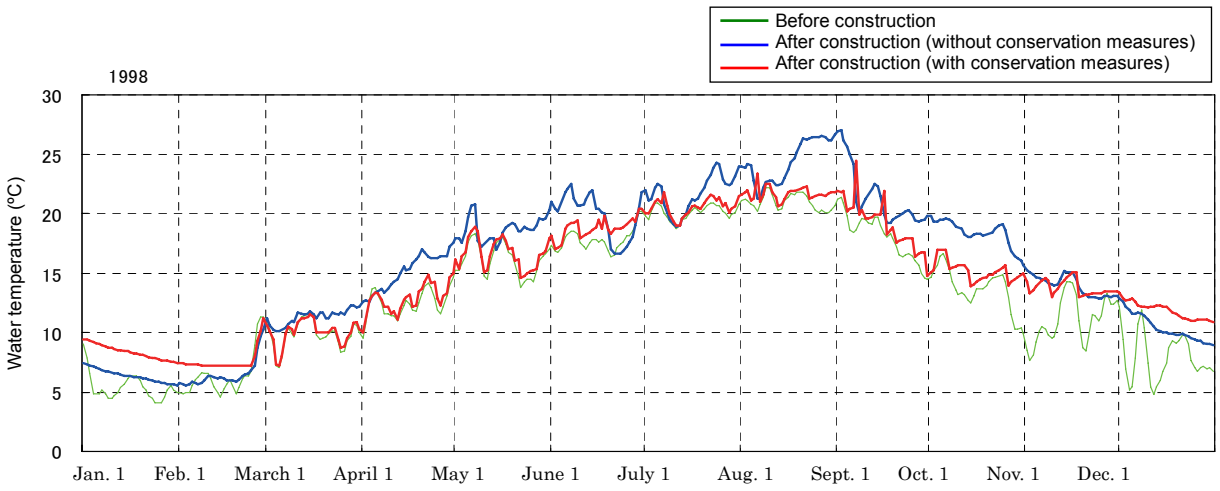

Figure 3. Results of Prediction of Discharged Water Temperature

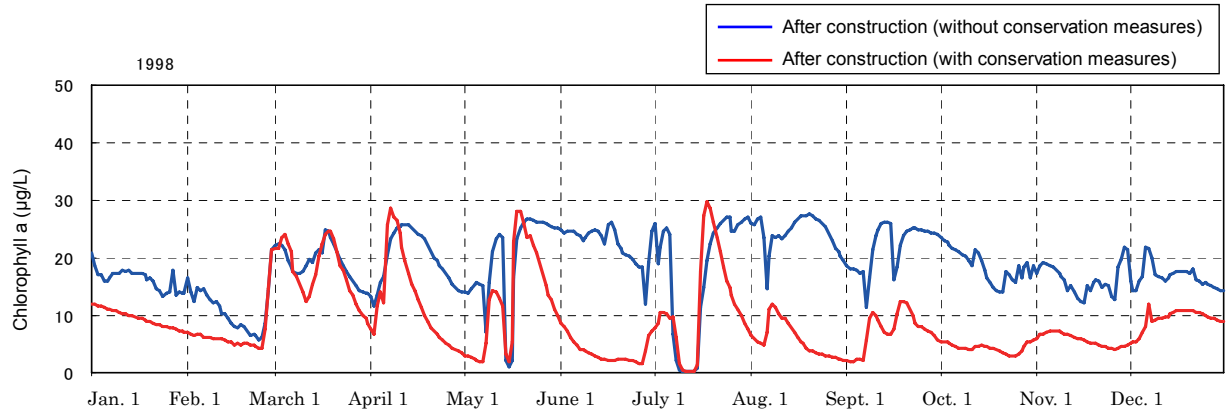

Figure 4. Results of Prediction of Chlorophyll a Concentration (Discharged Water Quality)

substantially reduce discharge of warm water, but the tendency to discharge water at a warmer temperature than that before dam is constructed during the fall and winter will continue. Figure 3 shows predicted temperature of discharged water.

4) Eutrophication

There will be cases where the chlorophyll a concentration will temporarily rise, but it is expected that the operation of aeration equipment will be able to bring it back to low densities. A comparison based on annual average values shows the density will be reduced to 9.6 μg/L from 19.2 μg/L, which it would be without environmental conservation measures. It is also predicted that it will be possible to discharge water with BOD (Biological Oxygen Demand) close to the water quality before dam construction. Figure 4 shows the results of a prediction of chlorophyll a concentration (discharged water quality).

3.3 Animals

In order to protect the rich natural environment surrounding Oyama Dam, important species considered to be rare etc. were, with the guidance and advice of the Oyama Dam Environmental Measures Council, selected from among species confirmed by a survey of the state of distribution and habitats of plants and animals in the region surrounding the project site and a study of relevant documents. Table 1 shows the number of confirmed species of animals and the number of important species.

These important species were superimposed on places impacted by Oyama Dam construction project (places submerged by the reservoir or where new roads are constructed) by organizing

the confirmation points and habitat environments, and the degree of impact on each species was studied. Figure 5 is an image of identifying the habitat environments with the project plan.

Table 1. Numbers of Confirmed Species and Important Species of Animals

Taxon	Species confirmed by the field survey			Number of important species
Mammalian	7th	10 families	21 species	4 species
Birds	13th	36 families	111 species	25 species
Reptilian	1st	5 families	9 species	None
Amphibian	2nd	6 families	12 species	3 species
Fish	5th	9 families	20 species	3 species
Land insects	22nd	240 families	1,498 species	30 species
Benthos insects	18th	80 families	171 species	1 species

The results of the prediction show that the project will have only a little impact on most of the important species, but many confirmation points and important habitat environments of two species, rare Salamander (*hynobius neavius*) and Great purple emperor (*Sasakia charonda*) are distributed in the region that is supposed to be changed by digging and excavating, and since it is considered that the two species will be exposed to the impacts of the project, environmental conservation measures will be taken in response to progress of the work.

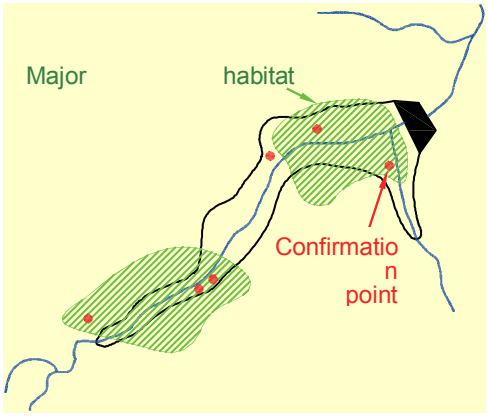

Figure 5. Project Plan Superimposed on Habitat Environment

Photo 6. rare Salamander

Photo 7. Great purple emperor

1) Rare Salamander(*hynobius neavius*) conservation measures

It was necessary to change the land near a marsh to build a diversion road, but after execution, local rock and topsoil were used to restore the marsh environment (vegetation on and around the riverbed, etc.). Photo 8 shows the restoration of the marsh environment. And trees were planted and topsoil was applied to restore the forest, and hynobius neavius larvae were relocated.

2) Great purple emperor conservation measures

Nettle trees and *Celtis jessoensis* which are trees eaten by the larvae of the Great purple emperor were moved and transplanted and seeds collected from nettle trees now growing in the reservoir were used to grow seedlings. And after the nettle trees were transplanted, the larvae of the Great purple emperor were relocated.

Photo 8. Restoration of a Marsh Environment (Top: immediately after execution, Bottom: restoration)

Photo 9. Nettle Tree Seedlings

3.4 Plants

As in the case of animals, important species of plants were selected, their confirmation points and habitat environments were organized, and identified with the project plan to study whether or not they would be impacted by the project. Table 2 shows the numbers of confirmed species and important species of plants.

The results of the prediction show that the project will have only a little impact on many important species, but the confirmation points and important habitat environments of 11 species of plants including calanthe, *Cephalanthera falcate*, *Deinanthe bifida Maxim.*, and *Vigna vexillata*, etc. are widely distributed in the areas that will be changed. Therefore, they will be impacted by the project, so relocation and other environmental conservation measures will be taken in response to progress of the work.

Table 2. Numbers of Confirmed Species and Important Species of Plants

Category	Number of species confirmed by the field survey		Number of important species
Seed plants/ Pteridophyta	143 families	929 species	29 species
Periphyton	22 families	123 species	None
Bryophyta	–	–	1 species

1) *Cephalanthera falcate* conservation measures
Transplanting *Cephalanthera falcate* has been considered difficult, because of its unique habitat morphology: its symbiosis with a fungus called mycorrhizal fungus. So at Oyama Dam, a transplanting method was studied to prepare specialized transplanting equipment which was used to transplant *Cephalanthera falcate* along with its surrounding soil. Photo 10 shows the transplanting of *Cephalanthera falcate*.

2) *Vigna vexillata* conservation measures
Vigna vexillata, which is an important species that grows at only two confirmed locations in Oita Prefecture, was transplanted and sowed at Oyama Dam site. Research on conserving *Vigna vexillata* began with a study of seeding methods, and in 2008, seeding was started based on a method with a good germination rate. Photo 11 shows transplanting and seeding of *Vigna vexillata*.

3.5 The ecosystem

The ecosystem was studied from the three perspectives of dominance, typicality, and

Photo 10. Transplanting Cephalanthera falcate
(top: Cephalanthera falcate, bottom: transplanting)

specificity to examine the impacts on species or biotic communities of noteworthy plants and animals and environment of habitation of them, etc.

① Dominance: Species in an upper level of the ecological food chain and its habitat environment.

② Typicality: Biotic communities and environment of habitation which typify the characteristics of the ecosystem of a region.

③ Specificity: Biotic communities and environment of habitation, which are indices of special environments difficult to grasp applying typicality.

A survey of state of habitats and range of activity of the Mountain hawk-eagle (*Spizaetus nipalensis*) which was selected as the species to indicate dominance has confirmed that there are six pairs of Mountain hawk-eagle in the area around the project district, and the activity range of one pair (core area) overlaps with the project

Photo 11. Transplanting and Seeding *Vigna vexillata*
(Top: *Vigna vexillata*, Middle: transplanting, bottom: seeding)

area. But because many nesting and hunting areas will remain unchanged, it was predicted that this pair will continue to inhabit and breed in the district.

The cedar/cypress forests and the sawtooth oak (Quercus acutissima) forests occupy most of the catchment basin and have been maintained for a long time, and which have been selected as biotic communities and environment of

habitation to be indices of typicality (land-based). Predictions of the changing degree of the environment of, and impacts on species which inhabit and which grow and develop in these forests has shown that most of the forests will remain and sustain these typical environments after completion of the dam.

Predictions of the degree of change of environment of, and impacts on species which inhabit and which grow and develop in three forms of river morphology—rivers flowing through mountain hamlets, mountain streams, and riverhead—can be seen in the area around the dam. And they have been selected as environments which are indices of typicality (river areas). Also they have shown that although there may be change in the environment of habitation of living organisms under change of the flow regime etc. The impacts in a river flowing through mountain hamlets downstream from the dam will be small. And there will be some change along mountain streams and riverhead upstream from the reservoir and tributaries after the project.

3.6 Other environments

In addition to the matters discussed above, an environmental survey and a prediction of impacts were carried out concerning, "topography and geology", "scenery", and "places for activities bringing humans and nature together". The project would have either zero or only a little impact on these matters. And regarding "waste materials", the production of construction by-product will bet a load on environment, so reusing as much as possible of by-products to take environmental conservation measures will be promoted.

4. More aggressive environmental conservation initiatives and information dissemination

In preparation for the construction of Oyama Dam, environmental conservation measures were studied based on the results of the advance surveys and predictions described above. In addition to these environmental conservation measures, design and construction were done to help conserve the environment. And enlightenment activities directed at people participating in the work and JWA employees to strengthen their awareness and knowledge of the environment. Also other initiatives were undertaken to help conserve the environment, and active actions made to disseminate information throughout the region. The contents of these initiatives are described below.

○ Initiatives to lower the project's load on the environment (to obtain ISO14001 certification).
○ Holding environmental seminars for JWA employees and construction worker in order to provide them with knowledge and boost their awareness of environmental conservation.
○ Preparing and using the Plant and Animal Handbook as a portable text containing photographs and characteristics of valuable plants and animals near Oyama Dam.
○ Establishing the Oyama Dam Environmental Conservation Promotion Council to perform environmental patrols in order for JWA employees and people participating in the work to work together to conserve the environment.
○ Appointment of environmental conservation managers for large-scale works.
○ Actively using pamphlets, environmental reports, or web sites to disclose and disseminate information concerning initiatives to conserve the environment at Oyama Dam site.
○ Periodically issuing notifications and updating a web site concerning Oyama Dam by the Publicity Committee and Web Site Committee, formed horizontally linking sections of the dam office.
○ Dissemination of information by billboards or an information center on the dam observation plaza.
○ Holding gatherings to bring together residents of the regions upstream and downstream of Oyama Dam

5. Summary

Undertaking giant public projects such as dam

construction while taking care to protect the surrounding environment has come to be considered an extremely natural approach, regardless of the scale of each project. Environmental conservation measures vary for each project depending on its content, the local environment, social background etc., but each is taken by devising fresh and innovative approaches with reference to experience of other projects, the guidance and advice of scholars, and the views and experiences of the local people.

Japan Water Agency has prepared the Environmental Action Guidelines (Four volumes: Basic Concepts of Environmental Measures, Natural Environment Conservation, Water Quality, and Monitoring). This improves JWA employees' awareness of and clarifies their attitudes toward environmental conservation at the same time as they undertake organized and systematic environmental conservation.

At Oyama Dam, the goal is to obtain the views of outsiders to create a dam that is in harmony with its natural setting and is viewed positively by the local people, by making aggressive initiatives to conserve the environment and disseminating information about these initiatives.

Photo 13. Environment Report and Environmental Pamphlet

Photo 12. Plant and Animal Handbook