23 kilometers from the mouth of the River over a 14-year period from 1979 to 1992. The data show that the toxicity levels related to public health (cadmium, total cyanide, lead, etc.) were below the detection limits for all items monitored and, thus, environmental standards were met. Monitoring of biological values covered pH, hydrogen ion concentration, biochemical oxygen demand (BOD), suspended solids (SS), dissolved oxygen (DO), and coliform bacteria. Evaluating the BOD content as one of the most characteristic pollution indices, it can be seen that the environmental standard (3.0 mg/liter maximum) was met each year. The year-by-year changes in the monitored data indicate that the values for BOD, total phosphorus (P), surface-dissolved oxygen (DO) and total nitrogen remained virtually level.

(2) FISH AND SHELLFISH VARIETIES (FISH, CONCHES, AND CRUSTACEANS)

Extensive environmental studies have confirmed that there are 15 orders, 43 families and 104 species of fish inhabiting the Nagara waters. The *deep-bodied bitterling* has been identified as one of the fish species of special interest in the River. It is a fish species designated as a "Natural Monument." Another fish species singled out by the Environment Agency's Basic Plan for Environmental Conservation (referred to herein as the Natural Environment Survey) as a species of special interest is the *Four-spine sculpin. The three-spine stickleback* and the *Nippon Baratanago* (*Rhodeus ocellatus smithii*), two other species of special interest, also have been confirmed as existing in the River by interviews with the local population in the context of this survey. Also, it was possible to identify the trout species, *Oncorhynchus masou macrostomus*, listed in the Red Databook as an Endangered Species.

The survey showed evidence of 6 orders, 14 families and 26 families of conches and 6 orders, 23 families and 48 species of crustaceans present in the river. Apart from those previously described, none of the others include a species of special interest.

(3) BIRDS AND OTHER ANIMALS (BIRDS, MAMMALS, REPTILES, AMPHIBIANS, AND INSECTS)

The area's identified bird population comprises 16 orders, 36 families, and 145 species. The bird species designated as "Natural Monuments" include the white-fronted goose and the bean goose, while species of particular noteworthiness include the goshawk and peregrine falcon. All of these species have been identified as existing in the Nagara River area. The following species, listed in the Natural Environment Survey as species of special interest, have been identified as being present in the area: the great-crested grebe, the common cormorant, the Baikai teal, the falcated teal, the osprey, the marsh harrier, the kestrel, the lapwing, the kingfisher, Latham's snipe, and the Indian Pratincole. The Red Databook of the Environment Agency lists the intermediate egret, the whistling swan, the sparrow hawk, the little tern, and the mandarin duck as "Rare Species." The survey has shown that all of these species can be found in the area.

The mammalian varieties present in the area include 5 orders, 8 families and 14 species. The Natural Environment Survey verified that the Japanese macaque is a species of special interest. Herds of this simian species have been reported in the Survey as being distributed in the area, including the area of the lower reaches of the Nagara River. Yet, there was no evidence of this species within the target range of the Study.

By reviewing the presence of various forms of flora and flora located along the river channels and on the Tokai Plain, one can consider all of the species that generally inhabit the area. Medium size mammals, such as the badger and fox, have been discovered in the vicinity of the levee separating the Kiso and Nagara rivers. It is apparent that a rural ecology exists in the area.

The survey showed that 1 order, 3 families and 7 species of amphibians and 2 orders, 3 families and 8 species of reptiles are present in the area. No species of special priorities of amphibians or reptiles were identified.

Insects that were identified as existing in this area included 13 orders, 178 families and 837 species of terrestrial insects and 5 orders, 21 families and 69 species of aquatic insects. The *Mortonagrion hirosei*, designated as an "Endangered Species" in the Red Databook of the Environment Agency, is an existing species of special interest.

(4) PLANTS

Plants typically growing in roughly a 30-kilometer range of the mouth of the Nagara River include reed and *miscanthus sacchariflorus* and willow woods. Shrub plants, such as *mugwort*, the *miscanthus*

variety of *eulalia*, and many other indigenous plants are confirmed on the soil-blanket zone and in other areas.

A total of 91 families and 549 species of terrestrial plants have been confirmed as growing in the area. A plant species of special interest among them is the *Eupatorium fortunei ("Fujibakama")*, a plant designated as an "Endangered Species" by the Nature Conservation-Society of Japan and the World-Wildlife Fund for Nature Japan (WWF Japan) in its "Report on the Current Status of Important Plant Species in Need of Protection in Japan." The report also include the *Penthorum chinensis ("Takanoashi")* and the *Carex rugulosa (Okugu)*, two species designated as "Vulnerable."

The survey demonstrated that there are 22 families and 54 species of large aquatic plants in the area. They include the *Monochoria Korsakowii,* the *Caldesia parnassifolia* and the *Salvia plebeia,* species that are classed as "Vulnerable" in the "Report on the Current Status of Important Plant Species in Need of Protection in Japan."

Within the survey range, it has been possible to detect 318 species of attached algae. None of these, however, is of special interest or particularly noteworthy.

4. BASIC PRINCIPLES OF THE FLOOD CONTROL PLAN [1) 6)]

(1) STANDARD PROJECT FLOOD DISCHARGE

As already stated in Section 2, the Three Major Showa Floods -- as they are known -- caused devastating damage to the region, and the discharge volumes during these disasters substantially exceeded the flood control plans that had been in operation to that point. It was, therefore, recognized that a review of the flood control plans was an urgent necessity. The result was that the present Flood Control Plan was initiated in 1963.

The Standard Project Flood Discharge (or the design flood calculated without regulation) for the Chusetsu reference point is set at 8,000 cubic meters per second. This calculation corresponds to the peak discharge recorded in the August 1960 Flood (as the maximum discharge calculated to have been released into the lower reaches on the assumption that there was no inundation in the upper reaches) and represents a magnitude of flooding liable to occur at a 90-year return period.

The project scales for the principal rivers of Japan as a whole have been reviewed since around 1975. These project scales are designed to cope with floods likely to occur at a return period ranging from 150 to 200 years. (Table 4.1) The population vulnerable to flood damage in the Nagara River area is estimated at approximately 670,000 people, and property damage estimates are 3.8 trillion yen. It is, therefore, a matter of urgency to promote flood mitigation measures based on the present flood control plan and to enlarge the project scale in, and for, the future.

(2) DESIGN FLOOD DISCHARGE

Under the current plan, the Standard Project Flood Discharge is equal to the maximum flood discharge on record, as has been described earlier. On this basis, the Flood Discharge design for the river channel has been conceived at 7,500 cubic meters.

In the case of the Nagara River, there are few suitable locations for dam sites in the upper reaches, so the flood control volume secured by the dams is extremely small in relation to the peak discharge of the Standard Flood Discharge. Consequently, the design flood discharge of the river channel is proportionately high (Table 4.1). Thus, the river channel plays an extremely major role in the flood control plan for the Nagara.

Table 4.1 Standard Project Flood Discharge Allocation Percentages for Principal River Channels in Japan

River	Reference Point for Flood Control Planning	Standard Project Flood Discharge (A) (m^3/s)	Design Flood Discharge (B) (m^3/s)	Regulation Capacity of Dams (A-B) (m^3/s)	Allocation Percentages for River Channel (B/A) (%)	Project Scale (Return period in years)
Nagara	Chusetsu	8,000	7,500	500	93.8	90
Ishikari	Ishikari-Ohashi	18,000	14,000	4,000	77.8	150
Kitakami	Kosenji	13,000	8,500	4,500	65.4	150
Tone	Yatajima	22,000	16,000	6,000	72.7	200
Arakawa	Iwabuchi	14,800	7,000	7,800	47.3	200
Tama	Ishihara	8,700	6,500	2,200	74.7	200
Shinano	Ojiya	13,500	11,000	2,500	81.5	150
Tenryu	Kashima	19,000	14,000	5,000	73.7	150
Toyo	Ishida	7,100	4,100	3,000	57.7	150
Yahagi	Iwatsu	8,100	6,400	1,700	79.0	150
Kiso	Inuyama	16,000	12,500	3,500	78.1	100
Ibi	Mangoku	6,300	3,900	2,400	61.9	100
Yodo	Hirakata	17,000	12,000	5,000	70.6	200
Ota	Tamamura	12,000	7,500	4,500	62.5	200
Yoshino	Iwatsu	24,000	18,000	6,000	75.0	150
Chikugo	Arase	10,000	6,000	4,000	60.0	150

Data source "Technical Report of the Nagara River Estuary Barrage"

(3) RIVER IMPROVEMENT MEASURES

After the design flood discharge has been determined for the river channel, the next step is to establish practical plans for the river channel by defining improvement measures appropriate to the conditions of the particular river, including the backward displacement of levees, the raising of the levee height, river dredging, and the excavation of diversion channels to create floodways.

On the Nagara River, it could be extremely hazardous to increase the design high-water level. It would also be difficult to widen the River to any significant extent because of the low-lying hinterland, which is one of Japan's largest sub-seawater level plains and because of the significant number of private dwellings adjacent to the river. For these reasons, it was decided to adopt an improvement policy consisting of large-scale riverbed dredging without extending the river width to let the flood water run off at the lowest possible water level. The dredging scheme would result in lowering the water level, and this effect would impact a range of more than 45 kilometers upstream from the river mouth, reaching a maximum of 1.5 meters in the vicinity of the Nanno-Ohashi Bridge located at the 28-kilometer point.

Lowering the Nagara River water level will bring about favorable effects in conduction of flood control to the tributaries whose flood water levels will, accordingly, be lowered. It is therefore possible to enhance the effectiveness of flood control not only for the Nagara River but also for the tributaries including the Sakai and Arata rivers Additionally, effective pump operation can be expected when the land-side inundation water is drained into the Nagara River by pumps.

(4) HIGH-TIDE PROJECT

Downstream of the JR Kansai Line Bridge (located at the 7.2-kilometer point), levee construction for high-tide protection is underway on the Nagara River as a measure against excessive outward pressure resulting from the rising high-tide water level, which can exceed the flood water level. At present, the high-tide levee has a height of T.P. (Tokyo Peil) +7.0 meters at the river mouth and T.P.+5.3 meters at the location of the barrage. Even if there were a recurrence of a major typhoon, like the Ise Bay Typhoon, the heights of these levees would be adequate to withstand the rise in water level. As further protection, the

levees have been reinforced with a concrete-lined embankment structure. To enhance the safety factor against high-tide conditions still further, a riverside berm with a water dissipating capability (levee reinforcement and water dissipating structure) was created in front of the present levee, which was constructed as part of the restoration work after the Ise Bay Typhoon, in order to assure greater water-dissipation. At the same time, the high-tide levee was raised (parapet construction) by making use of a riverside berm.

5. THE NAGARA RIVER ESTUARY BARRAGE PROJECT [6) 7) 8) 9)]

(1) OUTLINE OF THE NAGARA RIVER ESTUARY BARRAGE PROJECT

Built at a point 5.4 kilometers from the mouth of the Nagara River (at Nagashima Town in Mie Prefecture on the left bank and Kuwana City in Mie Prefecture on the right bank), the Nagara River Estuary Barrage is equipped with movable gates and has a total length of 661 meters, crossing the river channel. (Photo. 5.1)

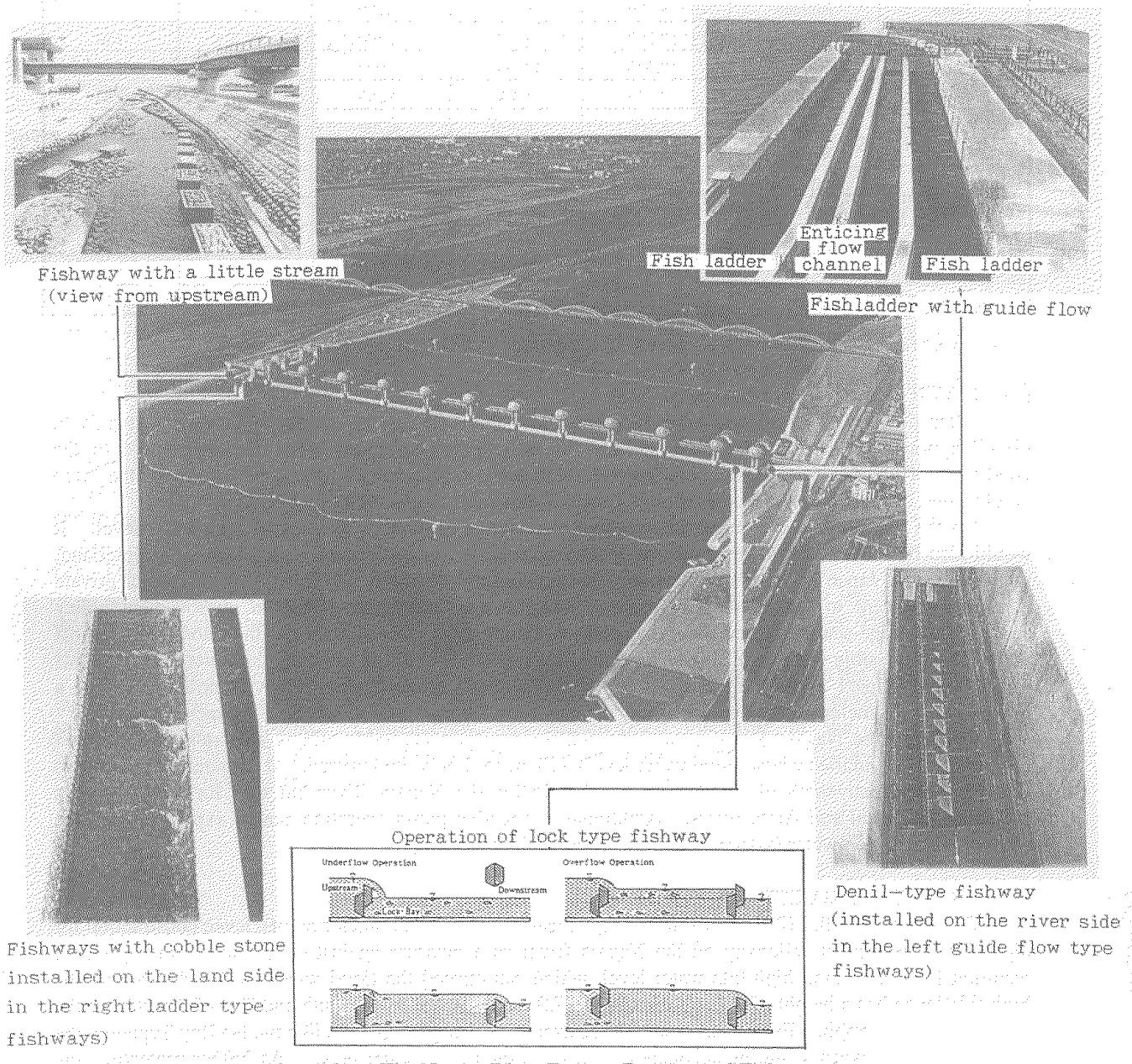

Photo. 5.1 The Nagara River Estuary Barrage and Fishways