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Flood Control and Environmental Considerations of the Nagara River

Tatsuo Hamaguchi
Director of River Division, Chubu Regional Construction Bureau,
Ministry of Construction, Japan
Sannomaru 2-5-1, Naka-ku, Nagoya 460

1. INTRODUCTION

The Nagara River, a part of the Kiso-Sansen Tripotamia River System, has flooded and fertilized the Nobi Plain since ancient times. This large river has influenced and sustained the life and culture of inhabitants along the river for centuries. At times, however, it also has inflicted severe flood disasters upon the region, threatening and imperiling the lives of those who have dwelled along the Nagara. The destruction caused by raging floods led to valiant attempts to keep the river at bay through such noteworthy major projects as the famous Horeki Flood Control Works and the Meiji Riparian Improvement Project. Although the river system has undergone various modifications conceived by mankind, the river known as the "Sei-Ryu" (Pure Stream) has retained its rich natural environment. The course of the river in the vicinity of the levee separating the Kiso and Nagara rivers is a classic example of the co-existence of man and nature. The region is renown for its unique natural beauty; yet, an important feature of the area is a man-made structure, the Meiji Improvement Project, which was constructed about 100 years ago. The Nagara River estuary barrage (artificial barrier in a water course) was completed in 1995, becoming a new landmark in the area. Dredging work on a mound in the Nagara River commenced in 1995 and, coupled with the estuary barrage, has ushered in a new era for the River.

This Report presents an historic perspective of flood control measures and highlights the natural environment of the Nagara River by providing a general overview of the development of the river system.

2. HISTORY OF FLOOD DAMAGE CAUSED BY, AND FLOOD CONTROL WORK ON, THE NAGARA RIVER [1) 2) 3) 4)]

(1) GENERAL STATUS OF THE RIVER BASIN

The Nagara River springs from the Daimichitake (elevation: 1,709m), a cliff located in the village of Takasu, Gujo-Gun, Gifu Prefecture. From there it flows in a southeasterly direction along the neighboring ravines to merge with the Yoshida and Kibishima rivers near the village of Hachiman in Gujo-Gun. The Nagara then joins the Itadori River at Mino City to enter the Nobi Plain, flowing southwesterly. After merging with the Tsubo, Mugi, and Ijira rivers, the enlarged river flows southward, parallel to and separated from, the Kiso River by a levee. In Kuwana City, Mie Prefecture, it merges with the Ibi river and empties into Ise Bay to form a river with a total river length of 166 kilometers and a river basin area of 1,985 square kilometers. (Fig. 2.1)

The Nobi Plain formed by the Kiso-Sansen Tripotamia System (consisting of the Kiso, Nagara and Ibi Rivers) is one of the largest alluvial plains in Japan and has a surface area of 1,485 square kilometers. Of great historical significance, the area is situated near the center of the country where Japan's eastern and western cultures have merged. The city of Nagoya is located in the southeastern part of the Nobi Plain. One of three major metropolitan areas in Japan, the Chukyo metropolitan area has developed significant commercial and industrial activities in the hub city of Nagoya, as well as in satellite cities throughout the region. The region's economy is bolstered further by substantial agricultural endeavors in the suburban areas of Nagoya.

(2) FLOOD CONTROL MEASURES PRIOR TO THE MEIJI ERA

As a result of the topological and morphological characteristics of the basin and the rainfall pattern, the Kiso-Sansen Tripotamia System traversing the Nobi Plain tends to be inundated first by the Ibi River in times of flooding. Subsequently, the plain is flooded by the Nagara River and, finally, by the Kiso River. Locally, this phenomenon traditionally has been described as the Sequence of the Fourth, Eighth, and

Twelfth Watches. (A watch is a period of two hours.) At present, the three rivers --- the Kiso, Nagara, and Ibi --- flow separately. Prior to the "Horeki Flood Control Works (1751-1764)," however, the Kiso-Sansen Tripotamia System in the Edo Era (1600-1867) was connected by a web of many tributaries. In those days, flooding occurred throughout the Nobi Plain in sequences, with time lags from place to place in which the flood waters hit according to the elaborate meandering of the three rivers and their various tributaries. Apart from the net-shaped appearance of the river system, the topography includes a high elevation in the east and a low elevation in the west. As a result of these factors, the Ibi River swells during periods of heavy rainfall. When the Ibi River overflows, the water level of the Nagara River rises, and finally, after it has risen, the Kiso River rises. The combined effect of the three rivers flooding in tandem tends to cause continued flooding for long periods of time. This phenomenon also accounts for irregular flow patterns, with the river course changing somewhat each time the plain flooded.

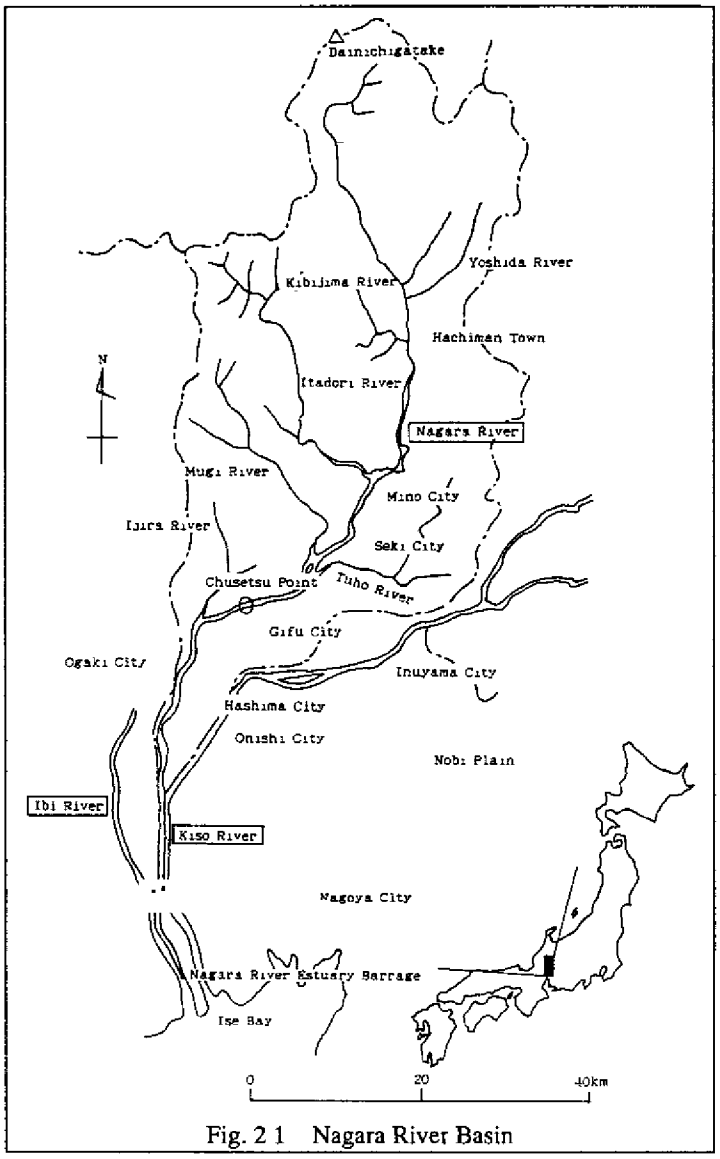

Fig. 2 1 Nagara River Basin

The people living in this region constructed dams, or levees, area by area to encircle the entire region in order to protect their hamlets and farming lands from floods. There are many such "ring levees" in the Nobi Plain, and the ring levees are a unique, nationally recognized, feature of the region The areas surrounded by ring levees formed a Waju (encircled enclave), a social unit whose development as a close-knit village community was predicated on the necessity of cohesive group interaction to protect the community against floods.

The formation of such "enclaves" was inspired by the Okakoi Tsutsumi levee (a ring levee) built in the early Edo period. From 1608 to the following year, ring levees were constructed on the left bank of the Kiso River over a length of about 50 kilometers from Mount Inuyama to Yatomi. Although the "project" had the military objective of protecting the Related Clan of Owari and the Tokugawa Family, it also played a major role in protecting the Owari land from floods. A restriction was placed, however, that required "... the levees on the opposite bank of Mino to be lower than the Okakoi Tsutsumi by about 91 centimeters " This requirement meant that the construction of a proper levee system was not permitted. As a result, the land of Mino was frequently assailed by flood disasters so that "enclaves encircled by ring levees" were developed also in the upstream parts of the basin not previously subject to water damage. These ring levees were constructed mainly in the low wet land of Nishi-Nanno. At one time there were more than 80 of these levees

These ring levees were unable to provide sufficient protection against flooding, and the fact remains

that the area still continued to suffer from flood damage occasionally. In December 1753, the Shogun issued a Civil Construction Support Order to the Satsuma Clan for the construction of the Kiso-Sansen Tripotamia Flood Control Works (known as the Horeki Flood Control Works) at the then enormous cost of about 400,000 ryo (more than double the Satsuma clan's annual revenue). The main purpose of the Horeki Flood Control Works was to separate the river system of the Kiso-Sansen Tripotamia. The works mainly consisted of river channel coffering and construction of fixed dams, and was executed under the strict supervision of the then Shogun, with the minister of the Satsuma Clan, Yukie Hirata, acting as the General Magistrate or Prefect.

The "Flood Control Shrine" built in Aburajima enshrines the ancestral spirit of Yukie Hirata and commemorates the significant achievements of the Horeki Flood Control Works. The "Senbon Matsubara Pine Woodland" is said to have been planted on the cofferdam by the Samurai of the Satsuma Clan in commemoration of the completion of the construction work, and this woodland also serves as a reminder of Hirata's great achievement.

Yet, despite the flood control projects that have stood the test of time, the area continues to be deluged by periodic floods. The circumstances associated with the region's flooding are reflected in a local folk saying: Be grateful for a harvest every five years; consider it a blessing if you reap a harvest every three years. (In other words, conversely, if the area residents could escape the misfortune of floods for a couple of years, they felt very lucky indeed.)

(3) THE MEIJI AND TAISHO IMPROVEMENTS

Some 130 years after the Horeki Flood Control Works, the Meiji government embarked on a full-scale flood control project (Improvement Works Project) Aimed at mitigating flood damage in the region, this Project initiated the complete separation of the river flows of the Kiso-Sansen Tripotamia System, a feat which the Horeki Flood Control Works had not been able to achieve.

In those days Holland was regarded as one of the most advanced countries in civil engineering construction, so the Meiji government invited a group of Dutch civil engineers to address the issues of flood mitigation Johannis de Rijke, a member of this group, conducted a survey of the Kiso-Sansen Tripotamia Basin and proposed the complete separation of the rivers by widening the river channel in the lower reaches of the Kiso-Sansen Tripotamia and by erecting separation levees to separate the Kiso and Nagara rivers. Based on this project proposal, the improvement plans for the lower reaches of the Kiso river were prepared for the execution of Japan's first Comprehensive River Channel Improvement Project.

The cost of this major project, the Meiji Riparian Improvement Project, amounted to a grand total of 9.74 million yen, a substantial cost burden in light of the fact that the national budget during this period was approximately 80 million yen. The project was completed in the 45th year of the Meiji Era, that is, 1912 (the last year of Meiji) The Flood Control Program, an essential part of the Meiji Riparian Improvement Project, covered a design flood discharge of approximately 4,170 cubic meters per second. The main construction work consisted of widening the river channels, dredging and levee dam construction, as well as the diversion work of the Tripotamia System with the erection of the levee separation system (to separate the Kiso and Nagara rivers), the building of the Sentohira lock, and the guide levee at the mouth of the Kiso and Ibi rivers.

Although the Meiji River Improvement Project generally has been effective in alleviating flood damage in the lower reaches of the Kiso-Sansen Tripotamia System, it has not been able to control flood disasters in the upper reaches of the river system. As the upriver areas continued to be vulnerable to flood damage following the project, a major improvement project for the upper reaches was undertaken in the ensuing dynasty, the Taisho Era, starting in the year 1921. Named for the era, this work is known as the Taisho Riparian Improvement Project.

The main construction tasks undertaken in the context of this project consisted of widening the river channels, construction of levee dams, excavation work, coffering the effluents of the Furukawa and of the Furufurukawa rivers, and closing the confluence of the Furukawa River. As the construction work on the upper reaches of the Kiso river proceeded, improvement work also was carried out on its branches.

(4) THE THREE MAJOR SHOWA FLOODS

As described, in spite of the mitigating effects of the Meiji Riparian Improvement Project, the inhabitants around the Kiso-Sansen Tripotamia System frequently suffered from flood disasters of major proportions. Thus, in 1936, a reinforcement project to strengthen the improvement works in the lower

reaches of the Kiso-Sansen Tripotamia System was initiated. For this expanded flood control program, which included reinforcement of the levee dam and further river channel excavation, the Nagara River's design flood discharge was augmented to 4,500 cubic meters per second from the roughly 4,170 cubic meters per second capacity of the previous Meiji Riparian Improvement Project.

Nonetheless, three major flood disasters -- the floods of September 1959, August 1960, and June 1961 -- devastated the area. Each of the three major Showa floods, as they are known, was due to breaches of the levees because the extent of the floods exceeded the design flood discharge (4,500 m^3/s) and went beyond the capacity extended for the high water level. (Table 2.1)

Table-2.1 Flood Status of the Nagara River

Flood	Experienced Max. Water Level			Discharge at Chusetsu		Rainfall [2]	Flood Damage [3]	
	Naruto (24.0km) (m)	Sunomata (39.2km) (m)	Chusetsu (50.2km) (m)	Observed (m^3/s)	Adjusted [1] (m^3/s)	(Gifu Meteorological Station)	Fatalities	Submerged Houses (nos.)
September 1959 Flood	T.P. 7.80	T.P. 11.96	T.P. 18.06	5,560	7,400	232.5 (198.4)	431	7,900
August 1960 Flood	T.P. 8.11	T.P. 11.63	T.P. 18.26	6,713	8,000	274.4 (194.0)	0	7,500
June 1961 Flood	T.P. 8.35	T.P. 11.74	T.P. 18.06	6,268	6,700	625.9 (361.2)	2	29,200
September 1976 Flood	T.P. 7.70	T.P. 11.62	T.P. 18.11	6,386	—	839.0 (420.5)	7	59,500

Note: 1) Adjusted figures present the values estimated on the assumption of no inundation in the upper reaches.
2) Upper figures present total rainfall, and figures in parentheses present amounts of 2-day sequential rainfall.
3) Flood damage covers municipalities in Gifu Prefecture in the Nagara basin. The August 1960 flood includes Nagashima Town and Tatuta Village.

Data source: "History of Annual Disaster Restoration Works" (Gifu Prefecture), "History of Restoration Works for Ise Bay Typhoon," "Statistics of Flood Damage," "The Record of the September 1976 Flood" (Chubu Regional Construction Bureau)

a) The September 1959 Flood In terms of the scale of the damage, the three major Showa flood disasters are unparalleled in the history of flood damage in Japan. The 1959 disaster was caused by the Ise Bay Typhoon which resulted in a record high tides, claiming a heavy toll of nearly 5,000 victims in the three Tokai prefectures. The Nagara River basin recorded a total rainfall of around 100 - 500 mm, and as the typhoon approached, the hourly rainfall was recorded at 60 - 80 mm with a significant amount of rain unleashed in a very short time. At Akutami upstream of Gifu City and at Hotojima in Seki City, the levees burst and the River rose above its banks near the Nagara Bridge in Gifu City.

The disaster caused by the Ise Bay Typhoon was due almost entirely to high tides. The levees at the mouth of the Kiso-Sansen Tripotamia System burst in a total of 26 places. The height of the levees at that time was around T.P. (Tokyo Peil) +4m. The maximum high-tide level in the Bay of Nagoya, however, was recorded as T.P.+3.89m, so it can be assumed that the water rose virtually to the crest of the levee and surged over the levees, lashed by the violent storms. Though the levees had been fortified with revetments in parts of the River, structurally they consisted essentially of earth. As flood protection engineering at that time did not have the strength of design we now take for granted -- concrete slopeface embankments and concrete lined structures to prevent overtopping -- it is understandable that levee breaches occurred in so many locations.

Immediately after the typhoon, a High-Tide Protection Plan was established for the Ise Bay area to prevent the repetition of flood disasters resulting from major typhoons. The restoration work was completed during (fiscal) 1962. As a result of progressive land subsidence that has occurred since 1962, however, effectiveness of the high-tide protection has deteriorated significantly. Reinforcement on the levees is underway presently as part of a high-tide control project. (Section 4.)

b) The August 1960 Flood The flood disaster of 1960 went down in the history of the Nagara River as the worst inundation the region had experienced to that point. Catastrophic rainfall was brought ashore by typhoons Nos. 11 and 12, raging from August 10 to 12. The total rainfall in the Nagara River basin

amounted to record-breaking levels of about 250 - 800 mm.

Again, as in the previous year, the levees burst at Akutami and Hotojima in Seki City, with devastating results. The engorged Nagara River overflowed its banks around the area of the Nagara Bridge.

c) The June 1961 Flood The third in a series of floods assailing the same area came in the wake of a huge storm, the 1961 Torrential Rain at the Rainy Season Front, as it was called by meteorologists. The rainy season front, in conjunction with typhoon No. 6, raged from June 24 through 27 -- a torrential downpour. The total rainfall recorded in the Nagara basin was around 500 - 800 mm; the scale of the overflow was similar to that of the September 1959 disaster Again, Akutami and Hotojima in Seki City were the sites of levee breaches, similar to those of August 1960.

(5) THE SEPTEMBER 1976 DISASTER

The typhoon and its front in September 1976 brought record-breaking rainfall of 1,000 mm pelting the Kiso-Sansen Tripotamia basin, leaving a trail of major destruction behind. Naturally, the storm severely impacted the Nagara River This catastrophic flood lasted for several days, with the peak of the flood waves rising to a high water level at five mountains. Around 10:30 a.m. on September 12, the right bank of the Nagara River levee burst at the Omori area of Ampachi Town, Ampachi-Gun, Gifu Prefecture, resulting in a major disaster. The breach in this levee submerged an area of about 17 square kilometers, causing more than 90% of the surface area of the towns of Ampachi and Sunomata to be underwater. This deluge caused substantial damage, with some 3,500 houses destroyed or damaged. The maximum inundation depth was recorded at around 3 meters.

Most of roughly 2000 victims of this flood were inundated by water surging over the burst levee. Allegations were made that the levee break disaster was caused by defects in construction and management of the levee. Legal action was instituted against the Japanese government, Ministry of Construction, as the managing authority of the levee with claims for damages pursuant to Section 2, Paragraph 1, of the State Tort Liability Act (Writ served by the Nagara River Tribunal -- Ampachi and Sunomata). This writ was filed in 1977 by the residents of Ampachi Town (Ampachi Writ) and the residents of Sunomata Town (Sunomata Writ). Litigation lasted about 17 years. It was not until February 1990 that a verdict was reached on the second claim by the Nagoya High Court. The Court found in favor of the State.

Initially, the Ampachi Writ (the first claim) was deliberated in the Gifu District Court which ruled against the State by recognizing fault in the management of the river. An appeal was lodged against the verdict, and the outcome of the Supreme Court proceedings was, therefore, awaited with intense interest. The Final Appeals Court passed judgment in a session held at the Supreme Court's No.1 Petty Court on October 27, 1994 The court found in favor of the defendant (the State) and rejected the plaintiffs' claims against the State. The verdict reached by the final appeals court was a judgment based on the general assessment of conditions surrounding the case by citing the usual criteria for assessing failure to exercise the proper level of care, that is, action constituting a tort Citing the January 1984 Daito Judicial Precedents of the Supreme Court, it was stated as follows: "River management is of an essentially different nature from the management of other structures, such as roads, and that it is, therefore, subject to various financial, technical and social limitations " According to the Supreme Court, the question as to whether or not there has been a defect in river management "...ought to be assessed by the criteria as to whether it can be ascertained that safety has been, and can be demonstrated to have been, assured by taking into consideration factors such as the scale of flood disasters in the past, the frequency of such disasters, the causal factors of disasters, the nature of the damage, the prevailing rainfall conditions, the topology of the river basin and other natural conditions, the patterns of land use and other social conditions, the presence or absence and the extent of emergencies requiring urgent repair, and other conditions in general, and by comparison with the general standards and socially accepted ideas of river management for rivers corresponding to the same scale and same extent on the basis of the restrictions referred to above." The Final Appeals Court ruling thus supported the Verdict pronounced in the Court of Second Instance and denied that there had been a defect in the river management on the part of the government on the grounds that ". .the levees concerned had the height and width required for protection against floods due to high water levels of a magnitude equivalent to the water level anticipated in the project and that the levees were in a condition capable of exhibiting their effect of preventing the occurrence of such disasters as can be foreseen from the normal behavior of the river basin in flood situations on a scale foreseen in the Master Plan; wherefore, it is reasonable to assert that, compared to general standards and the socially accepted

ideas of river management for rivers of the same scale and same extent, on the basis of the restrictions arising from the particular nature of river management, safety had been, and can be demonstrated to have been, assured."

The Final Appeals Court passed two separate verdicts in response to the writs by the inhabitants of Ampachi and Sunomata Towns. However, the Court's ruling on both cases essentially was identical in content.

When the levee on the Nagara River burst it was possible to confirm that the flood waters were restricted by the Jurenbo Ring Levee located downstream of the levee breach point and that the secondary levee (an earthfill structure with a flood spread control function, constructed in addition to the Nagara River levees) was effective in preventing an extension of the flood (Photo. 2.1).

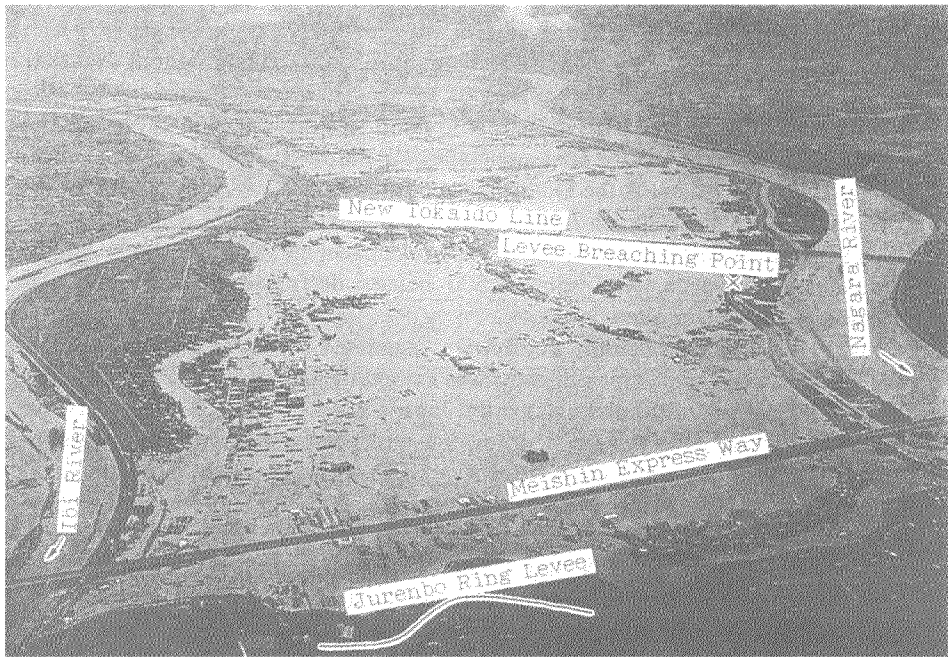

Photo. 2.1 Prevention of Flood Water Expansion by Jurenbo Ring Levee
(Flooding by the burst levees of the Nagara River in September 1976)

3. THE NAGARA RIVER'S NATURAL ENVIRONMENT [5) 6)]

Subsection 3.(1) deals with water quantity and quality of the Nagara River, while Subsections 3.(2)-3.(4) present the ecological conditions -- including fish and shellfish varieties, birds and other animals, and plants inhabiting in the Nagara River from the river mouth to the 30-kilometer point -- identified by environmental studies conducted from 1963 to January 1992. (A comprehensive study on environmental impacts was executed by a group of specialists, called the Kiso-Sansen Survey Team (KST) over four years from 1963. Studies on terrestrial fauna and flora also covered areas on the Kiso River side of the levee separating the Nagara and Kiso Rivers, and on the Ibi River side of the levee separating the Nagara and Ibi Rivers.)

(1) WATER QUANTITY AND QUALITY

The river regime or discharge records, reflecting Chusetsu as one of the reference points of the Nagara River, cover a 37-year period from 1954 to 1994 (missing measurements in 1961 and for 1965-1967). The records demonstrate maximum flow volume of 6,713.10 cubic meters per second in 1960 and a minimum flow volume of 6.24 cubic meters per second, making an average flow of 114.78 cubic meters per second. The Chusetsu records also indicate that the high-water flow averaged 122.29 cubic meters per second, constituting a medium flow of 65.99 cubic meters per second, a low flow 40.98 cubic meters per second, and a drought-level flow of 23.05 cubic meters per second.

The river water quality was monitored at the Tokai-Ohashi Bridge situated at a point approximately