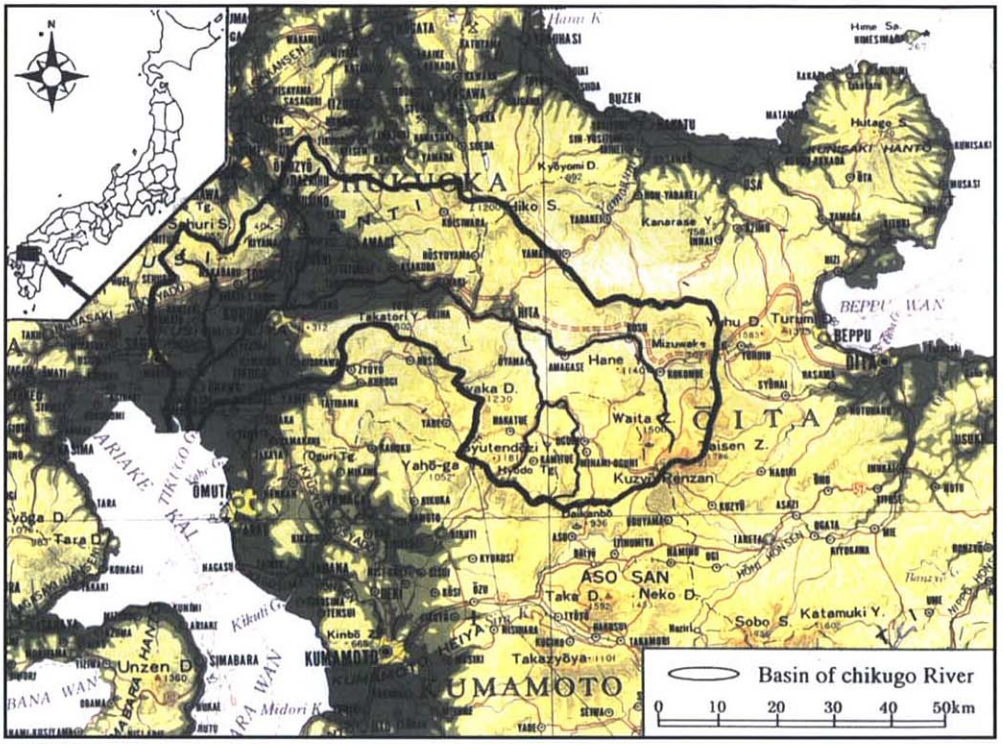
# Chikugo-gawa

## Map of River

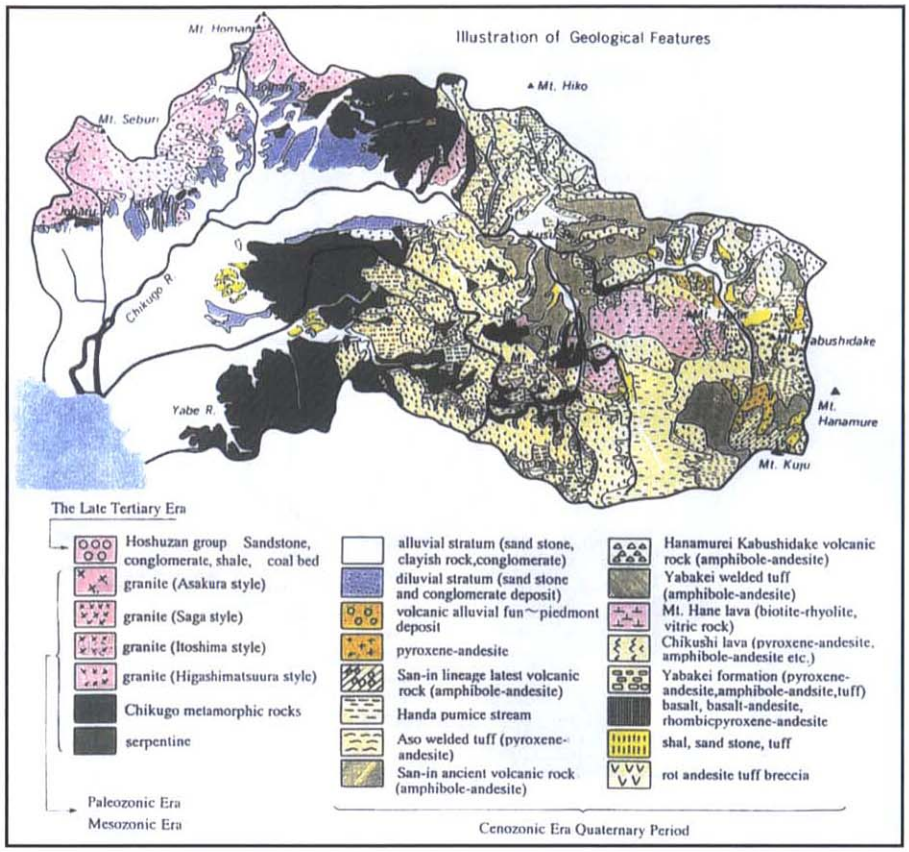



## Table of Basic Data

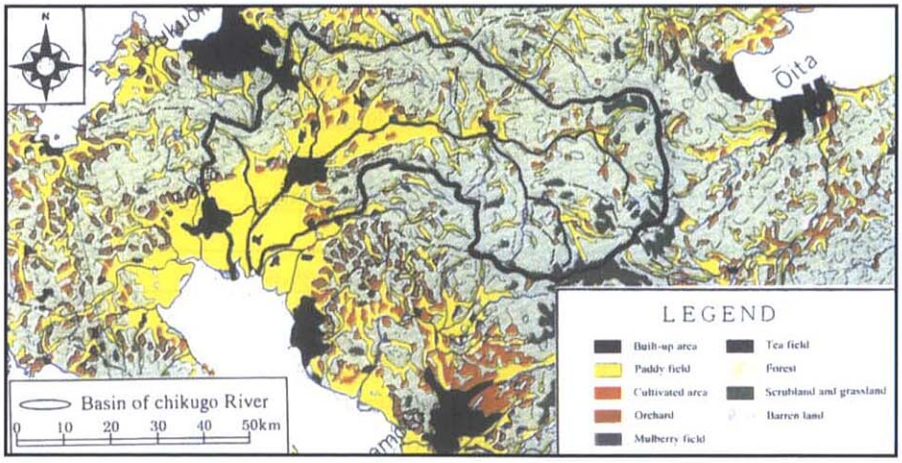
| | | |
|---|---|---|
| **Name:** Chikugo River | | **Serial No.:** Japan-4 |
| **Location:** Kyushu Island, Japan | N 32° 59′ 00″ ~ 33° 33′ 10″ | E 130° 16′ 30″ ~ 131° 18′ 30″ |
| **Area:** 2,860 km$^2$ | **Length of main stream:** 143 km | |
| **Origin:** Outer rim of Mt. Aso | **Highest point:** Mt. Kujyu (1,791 m) | |
| **Outlet:** Sea of Ariake , Sea of Eastern China | **Lowest point:** River mouth (0 m) | |
| **Main geological features:** Cenozoic era (tuff, lava, andesite), Paleozonic era (granite) | | |
| **Main tributaries:** Kusu River (530 km$^2$), Homan River (260 km$^2$), Sagae River (143 km$^2$) | | |
| **Main lakes:** None | | |
| **Main reservoirs:** Matsubara Reservoir (55x10$^6$m$^3$, 1972) Shimouke Reservoir (59x10$^6$m$^3$, 1972) | | |
| **Mean annual precipitation:** 2,168 mm (1961~ 1990) (basin average) | | |
| **Mean annual runoff:** 114.7m$^3$/s at Senoshita (2,315 km$^2$) (1950~1994) | | |
| **Population:** 1,079,000 (1990) | **Main cities:** Kurume, Saga, Hita | |
| **Land use:** Forest (49.7%), Rice paddy (22.1%), Other agriculture (10.8%), Urban (15.3%) (1990) | | |

# 2. Geographical Information

## 2.1 Geological Map




## 2.2 Land Use Map



# 1. General Description

The source of the Chikugo River is on the outside of the Aso caldron. It has tributaries in the mountains around Aso. It passes through the narrow valley along the lower stream of the Hita basin, named Yoake Ravine, where it is joined by the Kusu River which originates in the Kuju mountain range. At Hita City it gathers many tributaries and continues to flow through the fertile Chikushi Plain. The river finally flows out into the Ariake Sea, which is famous for land reclamation works and high tidal range.

The length of the main stream of Chikugo River is 143 km and the catchment area is 2,860 $km^2$, spreading over 4 prefectures, 12 cities, 37 towns and 7 villages. About 70% of the basin is made up of mountain ranges while the remaining 30% is plains, forming the Chikushi Plain, one of the largest rice producing areas in Japan. The population in the basin in 1990 was 1,079,000. The catchment receives an average annual precipitation of 2,168 mm (1961~1990), while the average discharge at Senoshita has been 115 $m^3/s$ (5.0 $m^3/s/km^2$) (1950~1994).

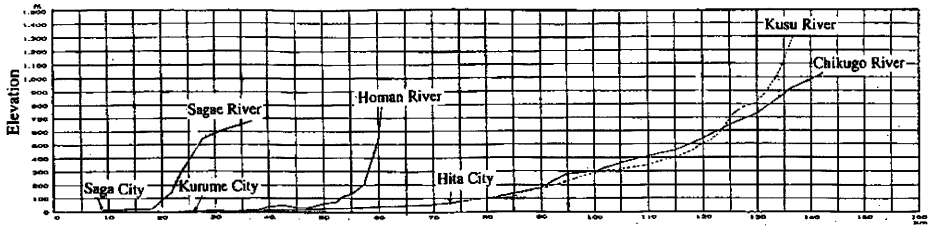
The main industries of the Chikugo River basin are forestry and lumber cutting around the upper stream, and agricultural activities such as rice and fruit production, food processing and fermentation and manufacturing of rubber products, along the middle and lower stream. In the brackish water area downstream, a well-known local specialty known as "Etsu fishing" is quite popular. At the seashore of the Ariake Sea, there is a prosperous seaweed cultivation area. There are many places to visit around the basin. Many national, quasi-national and prefectural parks, such as Aso-Kuju National Park, are located upstream. Besides, there are many hot springs, such as Amagase, Tsuetate, Harazuru, etc. in the basin. The presence of hot springs can be attributed to the active volcano, Mt. Aso, and the Kuju mountain range close to the basin.

## 2.3 Characteristics of River and Main Tributaries

| No | Name of river | Length [km]<br>Catchment area [$km^2$] | Highest point [m]<br>Lowest point [m] | Main Cities<br>population [1990] | Land use<br>[%] |
|---|---|---|---|---|---|
| 1 | **Chikugo**<br>(Main river) | 143<br>2,860 | Outer rim of Mt. Aso<br>1,028<br>0 | Hita City, Kurume City<br>(1,079,000) | A(10.8)<br>F (49.7)<br>L(2.1)<br>P(22.1)<br>U(15.3) |
| 2 | **Kusu**<br>(Tributary) | 56<br>530 | Mt. Kuju 1,791<br>95 | Hita City<br>(41,140) | |
| 3 | **Homan**<br>(Tributary) | 35<br>260 | Mt. Sangun 935<br>6 | Tosu City<br>(168,119) | |
| 4 | **Sagae**<br>(Tributary) | 29<br>143 | Mt. Seburi 1,055<br>6 | Saga City<br>(105,626) | |

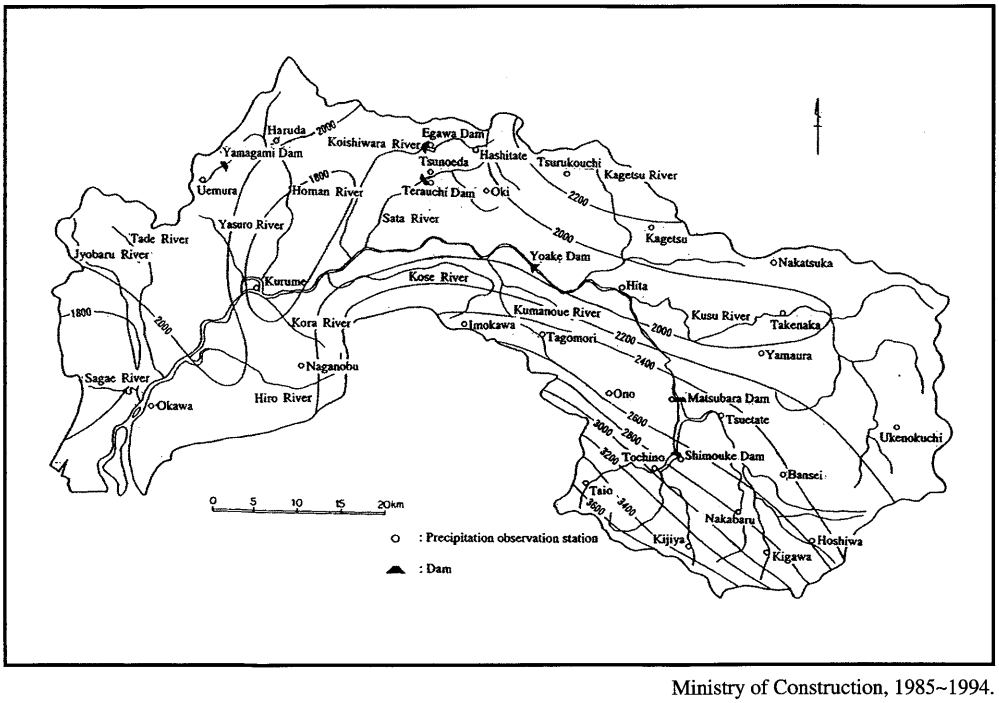
A : Other agricultural field ; F : Forest; L : Lake, River, and Marsh ; P : Paddy field; U : Urban

## 2.4 Longitudinal Profiles




# 3. Climatological Information

## 3.1 Annual Isohyetal Map and Observation Stations




Ministry of Construction, 1985~1994.

## 3.2 List of Meteorological Observation Stations

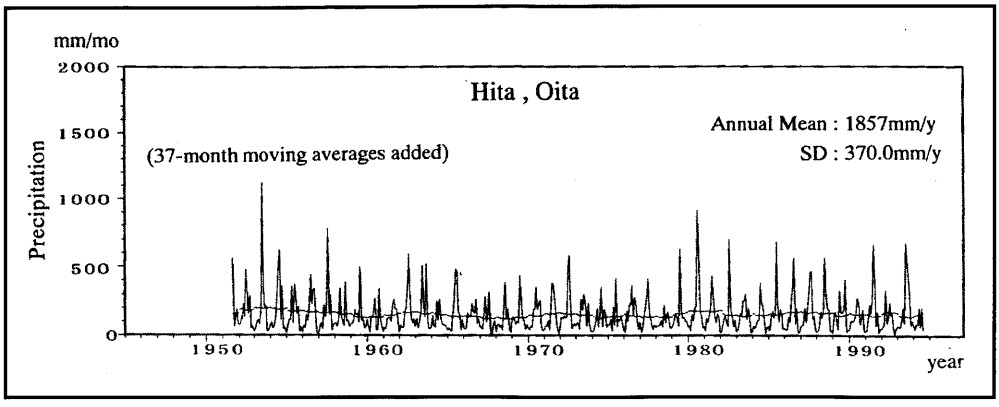
| No.* | Station | Elevation [m] | Location | Observation period | Mean annual precipitation [1] [mm] | Mean annual evaporation | Observation items |
|---|---|---|---|---|---|---|---|
| 90502 | Kigawa | 740 | N 33°02′40″<br>E 131°04′40″ | 1960~1994 | 2,782 | N | P |
| 90503 | Kurokawa | 660 | N 33°04′27″<br>E 131°08′32″ | 1960~1994 | 2,362 | N | P |
| 90508 | Tsuetate | 290 | N 33°00′40″<br>E 131°02′10″ | 1967~1994 | 2,395 | N | P |
| 90509 | Taio | 500 | N 33°07′40″<br>E 131°52′50″ | 1959~1994 | 3,335 | N | P |
| 90515 | Teratoko | 755 | N 33°11′15″<br>E 131°16′20″ | 1971~1994 | 2,338 | N | P |
| 90516 | Nogami | 450 | N 33°11′16″<br>E 131°12′22″ | 1958~1994 | 2,043 | N | P |
| 90517 | Mori | 322 | N 33°09′00″<br>E 131°17′03″ | 1946~1994 | 1,901 | N | P |
| 90521 | Yokohata | 180 | N 33°19′40″<br>E 131°02′00″ | 1959~1994 | 1,891 | N | P |
| 90528 | Haruda | 20 | N 33°27′40″<br>E 130°33′25″ | 1960~1994 | 1 988 | N | P |
| ** | Hita | 4 | N 33°15′00″<br>E 130°18′00″ | 1893~1994 | 1,805[2] | N | P |

* Serial number by River Bureau, Ministry of Construction.
** Meteorological Observatory, Japan Meteorological Agency.
N : no data
P : Precipitation;
1) Period for the mean is from the beginning of the observation period to 1994.
2) Annual mean (1965~1994) in Hita.

## 3.3 Monthly Climate Data

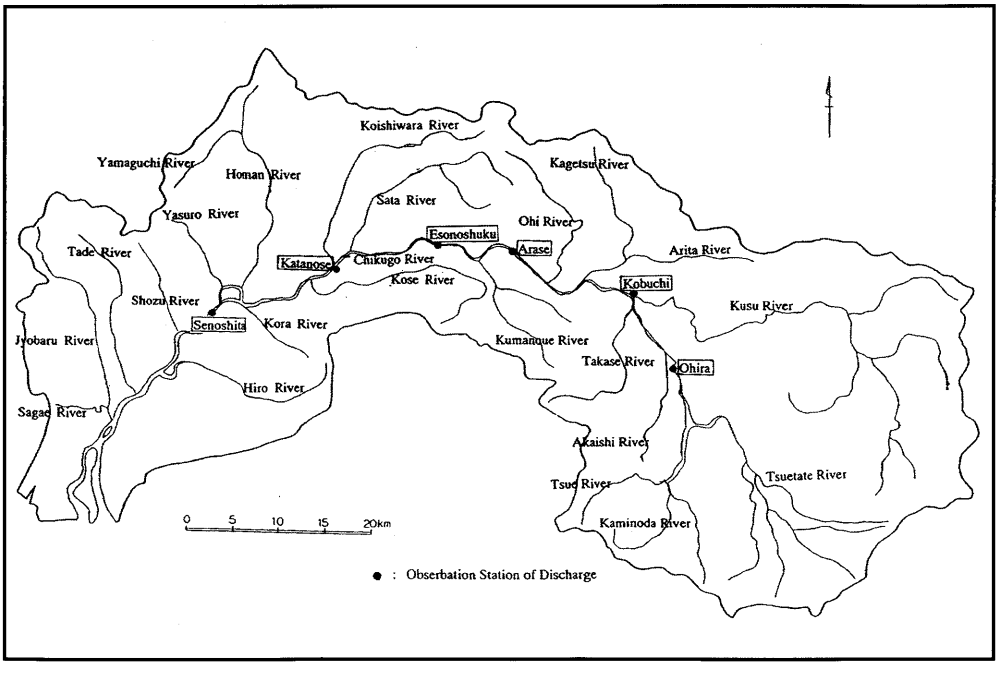
| Observation item | Observation station | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual | Period for the mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Temperature [°C] | Hita | 3.5 | 4.6 | 8.1 | 13.7 | 18.1 | 22.0 | 26.2 | 26.5 | 22.5 | 16.2 | 10.6 | 5.4 | 14.8 | 1950~1995 |
| Precipitation [mm] | Hita | 70.2 | 84.6 | 119.2 | 160.2 | 173.1 | 348.0 | 329.9 | 187.6 | 183.2 | 82.7 | 65.9 | 52.3 | 1,856.9 | 1950~1995 |
| Solar radiation [MJ/m$^2$/d] | Saga | 7.9 | 10.1 | 12.4 | 15.8 | 16.9 | 15.5 | 17.2 | 18.1 | 14.2 | 12.5 | 9.1 | 7.5 | 13.1 | 1981~1995 |
| Duration of sunshine[hr] | Hita | 111.0 | 119.7 | 155.1 | 170.2 | 187.7 | 150.8 | 172.5 | 202.2 | 152.9 | 162.1 | 133.1 | 116.0 | 1,833 | 1950~1995 |

## 3.4 Long-term Variation of Monthly Precipitation




# 4. Hydrological Information

## 4.1 Map of Streamflow Observation Stations



## 4.2 List of Hydrological Observation Stations

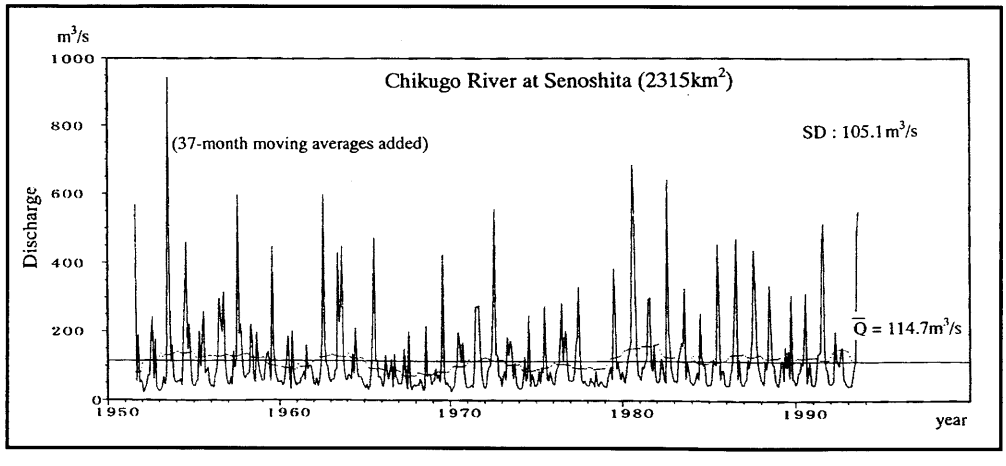
| No. * | Station | Location [km] from river mouth | Catchment area A [km$^2$] | Observation period | Observation items [1] [frequency] |
|---|---|---|---|---|---|
| **90504** | **Ohira** | 84.6 | 533 | 1958 ~ present | Q (h) |
| **90505** | **Kobuchi** | 76.6 | 1,137 | 1955 ~ present | Q (h) |
| **90510** | **Arase** | 62.0 | 1,443 | 1976 ~ present | Q (h) |
| **90515** | **Esonoshuku** | 53.0 | 1,546 | 1953 ~ present | Q (h) |
| **90519** | **Katanose** | 41.3 | 1,727 | 1956 ~ present | Q (h) |
| **90526** | **Senoshita** | 25.9 | 2,315 | 1950 ~ present | Q (h)WQ (m) |

* Serial number used by River Bureau, Ministry of Construction.
1) Q : Discharge; WQ : Water quality; h : Hourly; m : Monthly

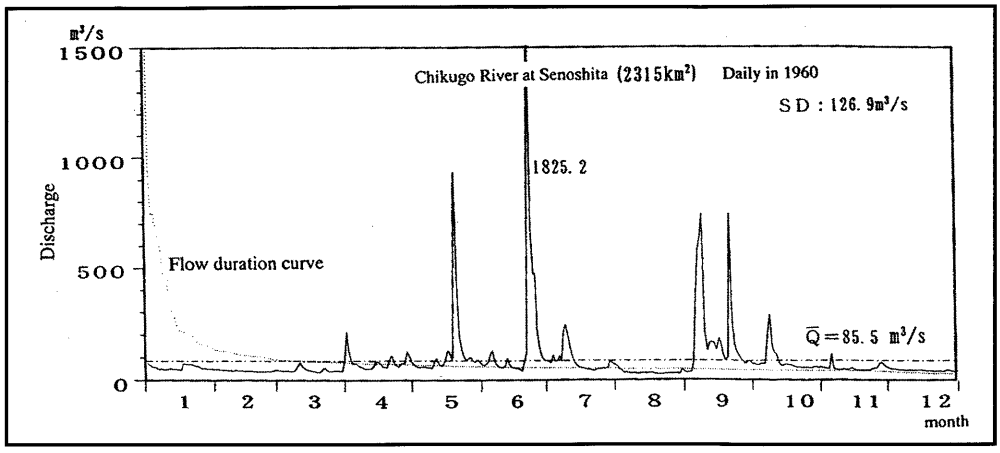
| No. | $\overline{Q}$ [2) [m$^3$/s] | Q max[3) [m$^3$/s] | $\overline{Q}$ max[4) [m$^3$/s] | $\overline{Q}$ min[5) [m$^3$/s] | $\overline{Q}$ /A [m$^3$/s/100km$^2$] | Q max/A [m$^3$/s/100km$^2$] | Period of Statistics |
|---|---|---|---|---|---|---|---|
| **90504** | 13.7 | 2,256 | 965 | 1.1 | 2.57 | 423 | 1958~1994 |
| **90505** | 59.3 | 3,879 | 1,928 | 13.5 | 5.22 | 341 | 1955~~1994 |
| **90510** | 83.3 | 4,529 | 2,526 | 19.9 | 5.77 | 314 | 1976~~1994 |
| **90515** | 78.8 | 6,225 | 2,356 | 13.2 | 5.10 | 403 | 1953~~1994 |
| **90519** | 84.1 | 5,785 | 2,402 | 12.6 | 4.87 | 335 | 1956~~1994 |
| **90526** | 114.7 | 6,070 | 2,744 | 22.0 | 4.95 | 262 | 1950~~1994 |

2) Mean annual discharge
3) Maximum discharge
4) Mean annual maximum discharge
5) Mean annual minimum discharge

## 4.3 Long-term Variation of Monthly Discharge



## 4.4 Annual Pattern of Discharge




## 4.5 Unique Hydrological Features

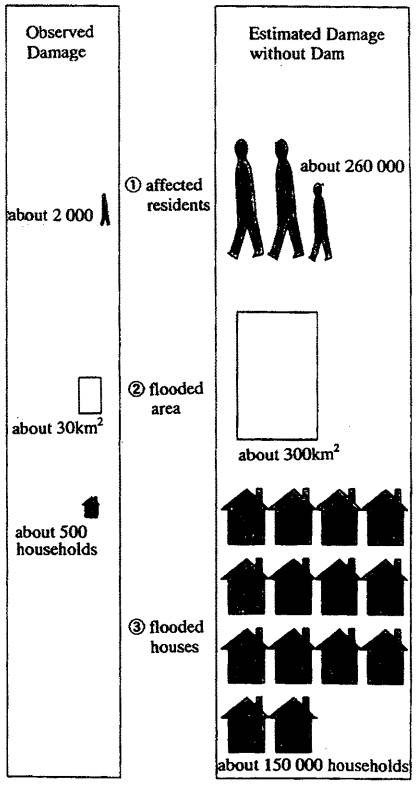
The mean annual precipitation of the Chikugo River basin is 2,168 mm, some 40% of which comes during the rainy season from June to July. The rainy season and the typhoon season from August to September account for about 65%. According to observation data at Senoshita, Reference Point of the Chikugo River (Ministry of Construction), the average annual total discharge has been approximately $36 \times 10^8$ $m^3$ from 1951 to 1994, while the mean daily discharge has been nearly $10^7$ $m^3$/day on average. From the long-term variation of annual mean discharge from 1975~1994, the minimum annual mean discharge is 52.4 $m^3$/s (1978) and the maximum is 209.7 $m^3$/s (1980), four times as much as the minimum.

As the figures above show, the Chikugo River is an unstable river difficult for control and utilization of water.

The Chikugo River flooded in July 1982, and calamity was avoided as a result of flood control by Mastsubara Dam and Shimouke Dam built in 1972. If there were no dams, the flooded area would have been 10 times larger, and the number of people affected would have been more than 100 times. This makes clear how effective the flood control was.

There are three flood diversion channels in the middle reach of the Chikugo River. One is Oishi Diversion Channel built in the feudal age in Japan (pre~1868), another is Chitose Diversion Channel built in the Meiji Era (1868~1912), and the other is Harazuru Diversion Channel conpleted in 1979 in the wake of a devastating flood that occurred in the Chikugo River basin in 1953. These have been useful in flood control, and are used as open spaces with water and greenery.

The effect of the flood control by Mastsubara Dam and Shimouke Dam in 1982.



## 4.6 Annual Maximum and Minimum Discharges

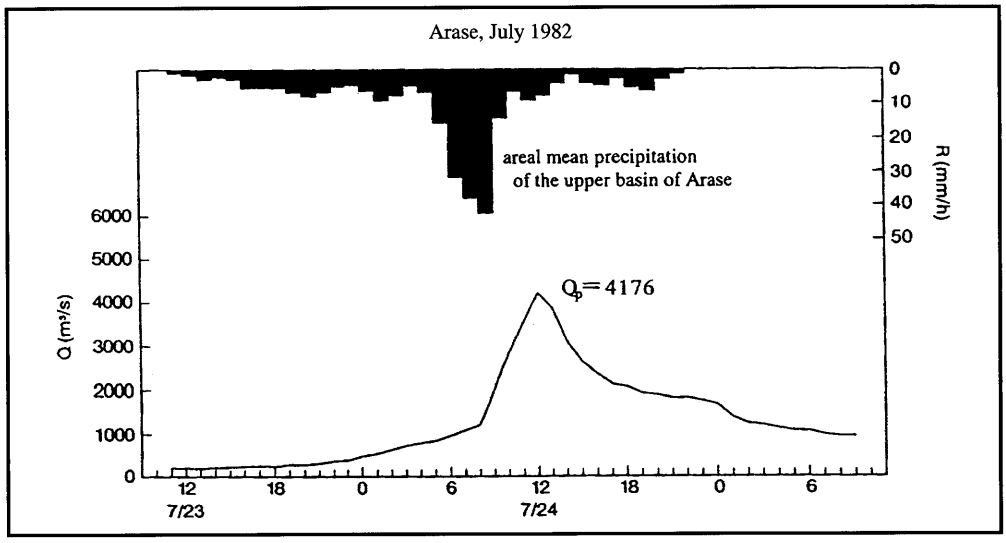
**At Senoshita (2,315 km²)**

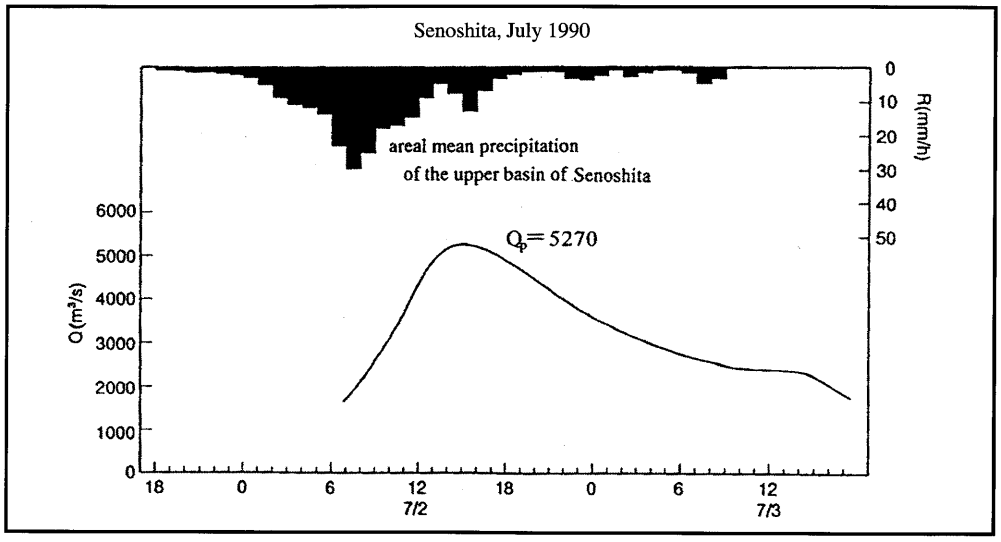
| Year | Maximum [1] | | Minimum [2] | | Year | Maximum [1] | | Minimum [2] | |
|---|---|---|---|---|---|---|---|---|---|
| | Date | [m³/s] | Date | [m³/s] | | Date | [m³/s] | Date | [m³/s] |
| **1975** | 6.21 | 2,284 | 8. 5 | 20.7 | **1985** | 6.28 | 4,118 | 3.22 | 26.5 |
| **1976** | 6.23 | 2,300 | 1. 1 | 35.4 | **1986** | 7. 8 | 3,273 | 6.13 | 33.1 |
| **1977** | 6.16 | 1,656 | 9.21 | 35.1 | **1987** | 7.19 | 2,834 | 1. 2 | 38.4 |
| **1978** | 6.11 | 702 | 6.19 | 10.1 | **1988** | 6.24 | 3,341 | 2.17 | 32.9 |
| **1979** | 6.29 | 5,055 | 6.17 | 20.2 | **1989** | 9. 3 | 3,082 | 8.13 | 35.1 |
| **1980** | 8.30 | 4,007 | 2.13 | 42.3 | **1990** | 7. 2 | 5,270 | 6.14 | 32.6 |
| **1981** | 6.27 | 2,562 | 6.19 | 21.9 | **1991** | 7. 1 | 3,547 | 1.23 | 39.9 |
| **1982** | 7.24 | 5,127 | 7. 2 | 18.1 | **1992** | 8. 8 | 1,061 | 6.19 | 11.0 |
| **1983** | 7. 5 | 2,670 | 2.23 | 34.4 | **1993** | 9. 4 | 4,248 | 6.12 | 33.4 |
| **1984** | 6.27 | 1,553 | 8.19 | 34.1 | **1994** | 6.18 | 583 | 8. 6 | 12.8 |

1) , 2) Instantaneous observation by recording chart

## 4.7 Hyetographs and Hydrographs of Major Floods

**Arase, July 1982**






# 5. Water Resources

## 5.1 General Description

In the past, the Chikugo River water has been used for irrigation since the four weirs, Fukurono, Oishi, Yamada and Eri were constructed during the 1,600s. Nowadays river water is used for power generation, industrial needs, domestic needs among others.

To cope with these demands for water, a plan for water resources development has been executed since Chikugo River was designated as one of the systems based on the Water Resources Development Promotion Act in 1964. Chikugo River was the third to be designated as such following the Tone and the Yodo rivers.

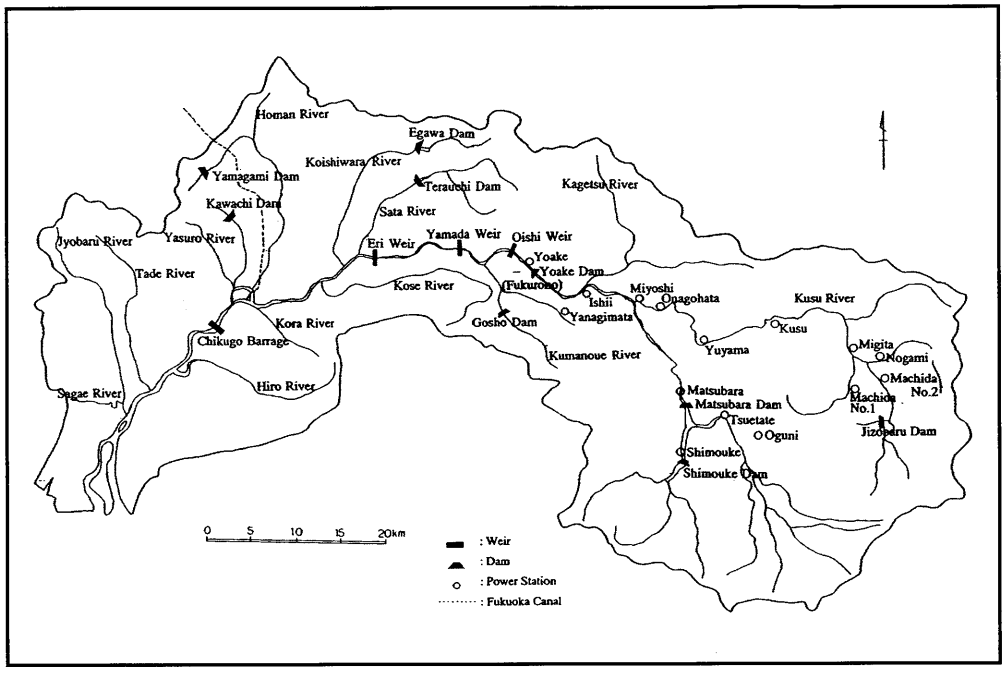
In terms of agricultural use, Chikugo water has been used to irrigate one of the largest rice-producing areas of Japan, about 52,000 ha of the river basin. Farmers take water from weirs or by pumps. Around the river mouth, irrigation water is abstracted by "Ao Intake", making use of the tidal oscillation peculiar to the Ariake Sea and Creek.

The Chikugo River has generated hydroelectric-power since the beginning of this century. Since Ishii Power Station at Hita City started operating in 1907, many hydropower stations have been built upstream of the Chikugo River or along the Kusu River. Twenty-two power plants such as the one at Onagohata generate a total of about 216 MW (installed capacity).

As for municipal water supply (domestic and industrial), Kurume City was the first to utilize river water in 1930. Afterward its use spread to every municipality in the basin. In industrial usage, water has been used for rubber and food industries among others.

One very important point of water use in the Chikugo River is that the water has been conveyed outside the basin. The development of the Japanese economy after World War II, as well as the urbanization around Fukuoka City and the improvement of the standard of living, caused increased water demand in the municipal sector. To deal with this problem, a Master Plan for Water Resources Development of the Chikugo River was established by the national government and water resource management facilities (Chikugo Barrage, Fukuoka Canal, etc.) were built.

## 5.2 Map of Water Resources Systems



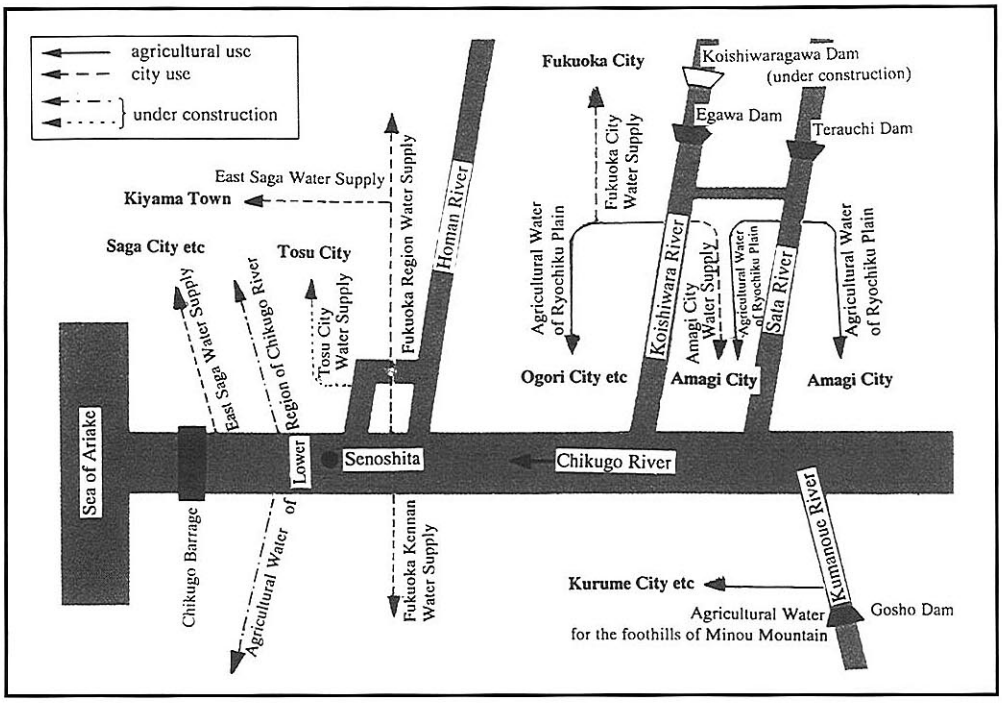

## 5.3 List of Major Water Resources Facilities

### Major Reservoirs

| Name of river | Name of dam | Catchment area [$km^2$] | Gross capacity [$10^6 m^3$] | Effective capacity [$10^6 m^3$] | Purpose [1] | Year of completion |
|---|---|---|---|---|---|---|
| Chikugo | Matsubara | 491.0 | 54,600 | 47,100 | F,N,P,W | 1972 |
| | Yoake | 1,440.0 | 4,050 | 790 | P | 1954 |
| | Chikugo Barrage | 2,315.0 | 5,500 | 930 | F,N,W | 1984 |
| Tsue | Shimouke | 185.0 | 59,300 | 52,300 | F,N,P,W | 1972 |
| Jizobaru | Jizobaru | 6.1 | 1,858 | 1,846 | P | 1922 |
| Kumanoue | Gosho | 42.0 | 7,660 | 6,700 | A,W | 1990 |
| Sata | Terauchi | 51.0 | 18,000 | 16,000 | F,N,A,W | 1979 |
| Koishiwara | Egawa | 30.0 | 25,326 | 24,054 | A,W,I | 1972 |
| Yamaguchi | Yamagami | 9.1 | 2,980 | 2,800 | F,N,W | 1979 |
| Yasuro | Kawachi | 4.5 | 1, 995 | 1, 102 | F,A | 1968 |

1) A: Agricultural use; F: Flood control; I: Industrial use; N: Maintenance of normal flows
P: Hydro-power; W: Municipal water supply

**Major Interbasin Transfer**




## 5.4 Major Floods and Droughts

**Major Floods at Senoshita [ 2,315 km$^2$**

| Date | Peak discharge [m$^3$/s] | Rainfall [mm] Duration | Meteorological cause | Dead and Missing | Major damages (Districts affected) |
|---|---|---|---|---|---|
| **1953.6** | not available | 122.5<br>6.24 ~ 6.28 | Baiu Front | 147 | entire basin |
| **1979.6** | 5,055 | 1,119.6<br>6.25 ~ 6.29 | Baiu Front | 0 | lower stream |
| **1980.8** | 4,007 | 663.0<br>8.28 ~ 8.30 | Autumn rain | 0 | Saga City |
| **1982.7** | 5,127 | 480.5<br>7.22 ~ 7.24 | Baiu Front | 0 | Oguni Town |
| **1985.6** | 4,118 | 1,164.7<br>6.21~ 6.28 | Baiu Front | 0 | lower stream |
| **1990.7** | 5,270 | 486.5<br>6.29 ~ 7.2 | Baiu Front | 0 | Saga City |

**Major Droughts**

| Period | Precipitation | Number of days of restricted water supply (Fukuoka City) |
|---|---|---|
| 1978 | 1,331.7 mm (61.4%) [1] | 287 days |
| 1994 | 1,055.0 mm (48.7%) [1] | 295 days |

1) The ratio to the average annual precipitation (1961~1990) at Senoshita upstream (CA = 2, 315 km$^2$).

## 5.5 Groundwater and River Water Quality

**River Water Quality[1] Senoshita[2] in 1992**

| Date | Jan 7 | Feb 12 | Mar 3 | Apr 23 | May 12 | Jun 9 | Jul 8 | Aug 6 | Sep 8 | Oct 8 | Nov 6 | Dec 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| pH | 7.4 | 7.6 | 7.3 | 7.7 | 7.6 | 7.4 | 7.2 | 7.4 | 7.7 | 7.3 | 7.4 | 7.7 |
| BOD[mg/l] | 1.1 | 1.1 | 2.2 | 1.8 | 0.9 | 1.7 | 1.1 | 1.7 | 2.4 | 1.1 | 1.0 | 0.9 |
| COD[mg/l] | 3.1 | 1.9 | 4.3 | 3.2 | 2.6 | 3.4 | 3.4 | 4.3 | 5.0 | 2.5 | 2.4 | 3.0 |
| SS[mg/l] | 6 | 5 | 24 | 14 | 12 | 10 | 11 | 9 | 8 | 8 | 7 | 7 |
| Coliform group[3] [MPN/100ml] | 1.3x10$^6$ | 7.9x10$^5$ | 7.0x10$^5$ | 7.0x10$^5$ | 3.3x10$^5$ | 4.9x10$^5$ | 7.9x10$^6$ | 1.3x10$^6$ | 3.3x10$^5$ | 3.3x10$^5$ | 7.9x10$^5$ | 1.7x10$^6$ |
| Discharge[4] [m$^3$/s] | 65.45 | 57.50 | 107.10 | 108.62 | 131.59 | 64.55 | 95.90 | 55.90 | 59.35 | 58.41 | 41.25 | 57.86 |

1) Observed once a month after several dry days.
2) Located near Kurume City 25.9 km upstream from the river mouth.
3) Measurement method: BGLB(brilliant green lactose bile) culture MPN (most probable number)method.
4) Discharge on the water quality observation date.

## 5.6 Other Notable Features of Water Resources

The tidal amplitude in the Ariake Sea is very high (about 6 m). When flood tide reaches Kurume City (25 km upstream of the estuary), it pushes the wedge of fresh water upstream. The lower reach of the Chikugo River consists of low, flat land 0-5 m above sea level, which was formed by sedimentation of the Chikugo River and reclamation. Farmers in these districts have used these special features for irrigation since olden times. They take in fresh water pushed up by the tide and store it in creeks to irrigate paddy fields. They call it "Ao Intake". There are facilities such as pumps, sluice pipes and sluice gates, etc. to take in fresh water. They are used to take in a great deal of water in a short time, limited by tidal level or salinity. There are innumerable creeks in these districts. This has brought about problems such as poor drainage or restrictions of land use, and has become a retarding factor in the improvement of agricultural productivity, community development and so on. A project which will convey agricultural water from the Chikugo Great Weir to Ao Intake districts in order to eliminate the reliance on unstable intake methods is being arranged or is in progress.

In September 1991, typhoon No.19 hit Kyushu Island, passing through the northern coast of Saga and Fukuoka prefectures, then engulfing the entire north in a storm zone. At Mt. Aso, the maximum instantaneous wind speed reached 60.9 m/s, and many other weather stations reported winds as strong. Mountain forests were terribly damaged with "Futoboku" (trees blown down by typhoons). The total damaged area in Fukuoka, Saga, Kumakoto and Oita prefectures was 37,000 ha, and the total number of Futoboku was about 15 million. In June 1993, a flood caused by the record-breaking Baiu front brought in a large number of floodwoods to the river, yet the storage capacity for an anticipated 77,000 m$^3$ of floodwoods at Matsubara and Shimouke Dams prevented damage downstream.

# 6. Socio-culturalical Characteristics

There are a lot of archaic remains in Kyushu Island, especially concentrated in the north, which is close to continental Asia and known as the birthplace of the rice crop kingdom in Japan, which is also related to water. Many remains are spread along the Chikugo River. One of them, the Yayoi Era Yoshinogari remains which consisted of many burial articles were found in May 1986 in the hilly regions adjacent to the Tade River, which is a tributary on the right bank of the Chikugo lower stream. It was one of the most important archeological findings in Japan. Suitengu Shrine, the head Suitengu Shrine in Japan, is the main cultural legacy of the basin, located in the middle reach of the river. It is said that it is propitious for easy delivery of babies or for the guardian angel of children and for protection against water imps.

The Chikugo River has about 30 weirs to irrigate the Chikugo Plain, which is rich in rice production. Among them, the Oishi, Yamada and Eri weirs are known as " the Three Great Weirs" because they are historical structures, built in the feudal ages of Japan. Three water wheels connected together can also be found on the right bank of the Hori River, which receives water from Yamada weir. This has been designated as a national historic site and a folk cultural asset of the prefecture for being the greatest set of waterwheels in existence. The elevated railway bridge across the lower stream of the river is the longest railway bridge in East Asia, completed in 1935 and later converted to a pedestrian overpass.

# 7. References, Databooks and Bibliography (In Japanese)

Geographical Survey Institute (1994): *The national atlas of Japan*, Ministry of Construction.(2.1,2.2)
Geographical Survey Institute (1993): *Millionth international map*, (NI-52/53/54, NJ-52,53,54), Ministry of Construction.(front page).
Japan Association of Dams (1994): *Damu nenkan* (Yearbook of dams).(5.3)
Kyushu Regional Construction Bureau (1994): *Suiri suimon kansokusho ichiranhyo* (List of hydraulic and hydrological measurement stations), River Division, Ministry of Construction. (4.2)
Kyushu Regional Construction Bureau (1988): *Chikugo gawa*, Ministry of Construction.(1, 2.1, 4.5, 5.1)
National Astronomical Observatory (1992): *Rika nenpyo* (Science yearbook), vol. 65, Maruzen Inc.,Tokyo .(3.3)
River Bureau (1950-1994): *Ryuryo nenpyo* (Streamflow yearbook), vol. 347, 1950-1994, Japan River Association, Ministry of Construction. (4.1, 4.2, 4.3, 4.4, 4.6)
River Bureau (1992): *Suishitsu nenpyo* (River water quality yearbook), vol. 33, Ministry of Construction.(5.5)
River Bureau (1946-1994): *Uryo nenpyo* (Rainfall yearbook), vol. 142, Ministry of Construction. (3.1, 3.2, 3.4)