

Mogami-gawa

Map of River

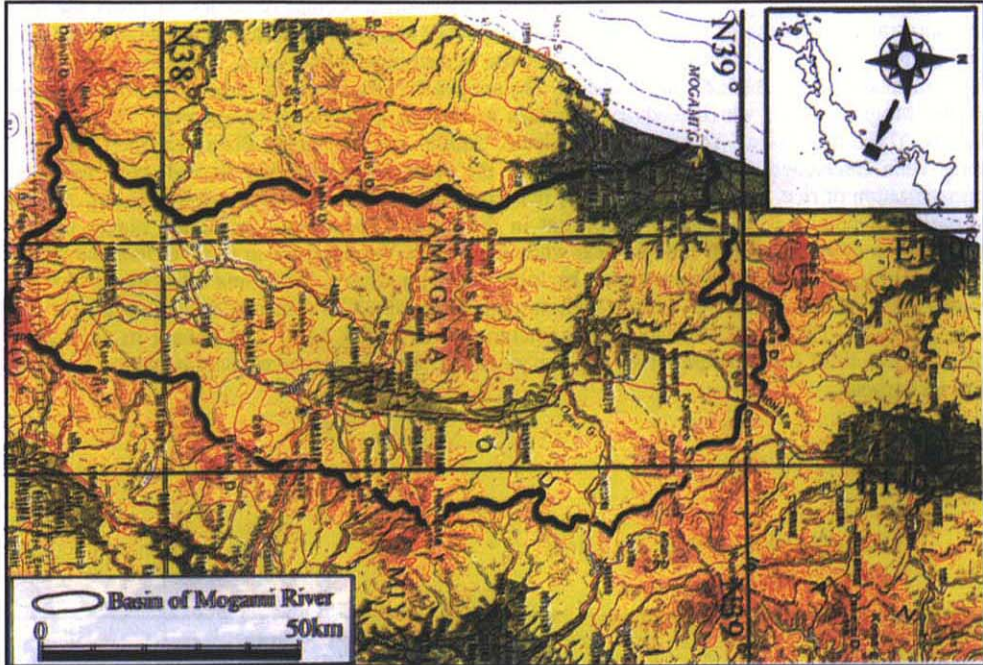


Table of Basic Data

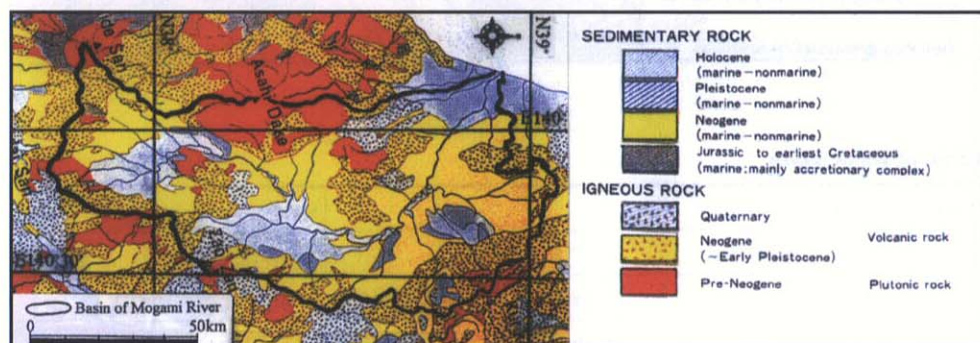
| | | |
|--|---|----------------------------|
| Name: Mogami River | | Serial No.: Japan-3 |
| Location: Northern Honshu, Japan | N 37° 44' ~ 38° 54' | E 139° 50' ~ 140° 38' |
| Area: 7 040 km ² | Length of main stream: 229 km | |
| Origin: Mt. Nishiazuma (2 035 m) | Highest point: Mt. Iide (2 105 m) | |
| Outlet: Sea of Japan | Lowest point: River mouth (0 m) | |
| Main geological features: (Upper basin) Neogene Tuffaceous family; (Lower basin) Quaternary | | |
| Main tributaries: Su River (681 km ²), Sagae River (478 km ²), Sake River (869 km ²) | | |
| Main lakes: None | | |
| Main reservoirs: Shirakawa Reservoir (50 x 10 ⁶ m ³ , 1980), Gassan Reservoir (109 x 10 ⁶ m ³ , 1990) | | |
| Mean annual precipitation: 2 151 mm (1943~1992) at Hirayama | | |
| Mean annual runoff: 174.0 m ³ /s at Shimono (3 534.3 km ²) (1964~90) | | |
| Population: 1 004 730 (1985) | Main cities: Yamagata, Sakata, Shinjyo, Yonezawa | |
| Land use: Forest (76.4%), Water surface (1.8%), Paddy field (11.6%), Vegetable field (3.6%), Urban (0.8%) (1985) | | |

1. General Description

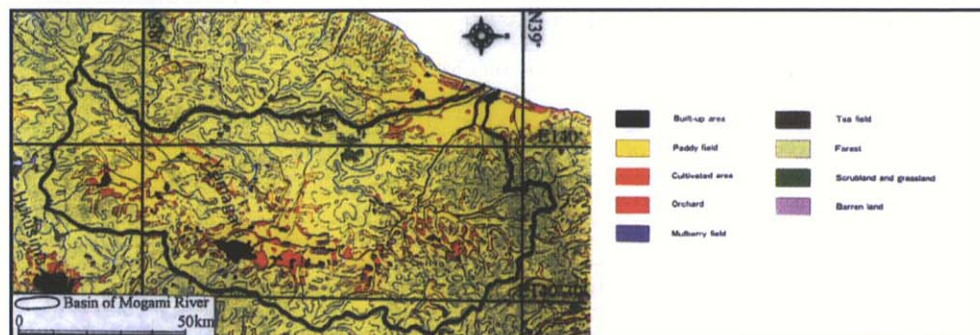
The Mogami River, 229 km long and draining an area of 7 040 km², flows through the important rice producing areas of the northern Honshu Island. It originates from Mt. Nishiazuma and flows to the north. Passing through a series of basins, each separated by narrow valleys, it turns to the west and flows into the Sea of Japan at Sakata. The narrow valleys often become obstacles for flows and tend to cause floods. The basin is part of the world's heaviest snowfall areas due to the winter monsoon from Siberia. The snow depth reaches 5-6 m in the western mountain ranges. The heavy snowfall in Yonezawa and Shinjo Basins is also notable. The snowmelt is therefore the major source of discharge of the Mogami River, which feeds rice paddies as well as generates hydro-power. The series of basins, Yonezawa, Nagai, Yamagata (Murayama), Shinjo, and the Shonai Plain near the coast have long been developed for producing rice, and the river navigation has served as a mode of transportation of rice. Sakata was the major rice exporting harbour to Osaka area in Edo era. Spatial variation of precipitation is quite significant in the basin. The western mountain ranges receive precipitation more than 3 000 mm per year while the middle Yamagata Basin receives less than 1 500 mm per year. Because it is surrounded by high mountain ranges, the basins often experience the Faehn phenomena. As a result, Japan's highest temperature 40.8°C was recorded at Yamagata City on July 25, 1933. The Aka River which has a catchment area of 856.7 km² used to have its confluence near the mouth of the Mogami River, but was separated in 1935 to prevent sedimentation from the Sakata harbour.

2. Geographical Information

2.1 Geological Map



2.2 Land Use Map

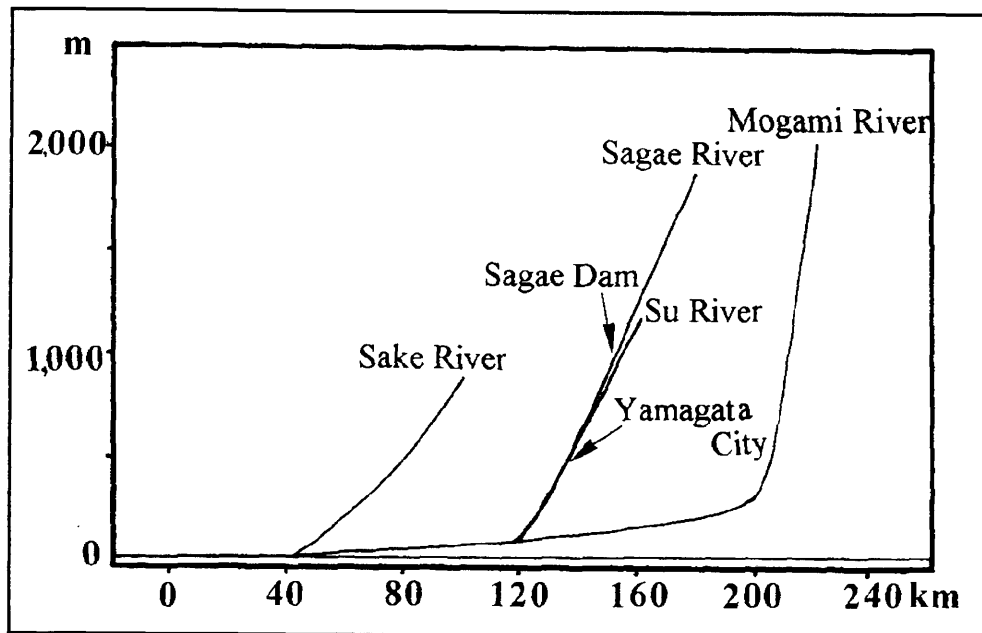


2.3 Characteristics of River and Main Tributaries

| Name of river | Length [km] Catchment area [km ²] | Highest peak [m] Lowest point [m] | Cities Population (1985) | Land use [%] (1985) |
|------------------------|--|--|-------------------------------------|------------------------|
| Mogami (Main river) | 229 7 040 | Mt. Nishi-azuma, 2 035 River mouth, 0 | Yamagata, Sakata, etc. 1 004 730 | A (3.6) F (76.4) |
| Sagae (Tributary) | 59.2 478.4 | Mt.Oasahi-dake, 1 870 82.1 | Sagae, etc. 18 067 | L (1.8) P (11.6) |
| Sake (Tributary) | 55.5 869.7 | Mt. Mizunashi-omori, 911 28.5 | Shinjo, etc. 68 859 | U (0.8) Other (5.8) |
| Su (Tributary) | 42.8 681.8 | Mt. Funabiki, 1 172 85.1 | Yamagata, etc. 308 007 | |

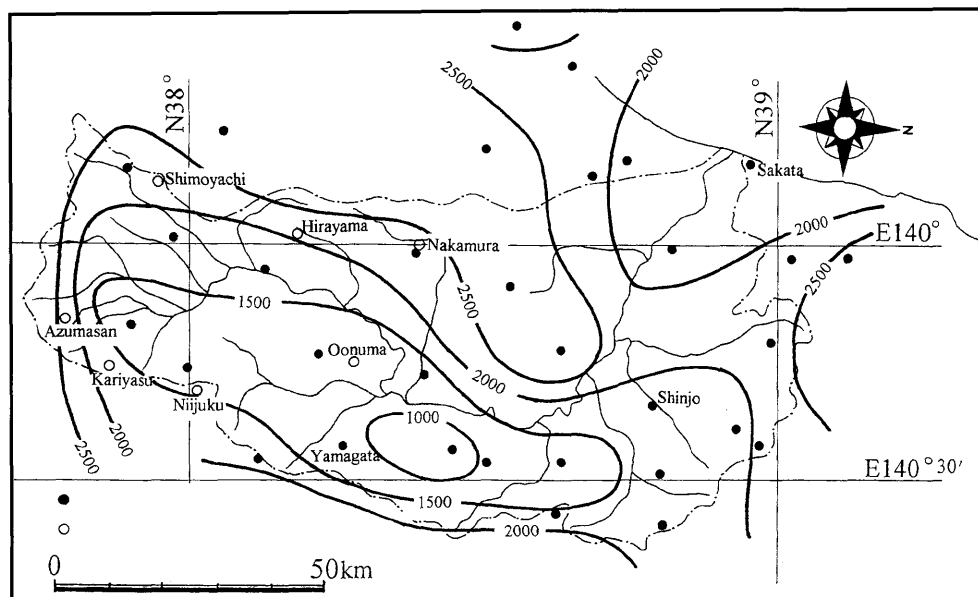
A: Other agricultural field (vegetable) F: Forest L: Lake, River, Marsh P: Paddy field U: Urban

2.4 Longitudinal Profiles



3. Climatological Information

3.1 Annual Isohyetal Map and Precipitation Observation Stations



3.2 List of Meteorological Observation Stations

| No. | Station | Elevation [m] | Location | Observation period | Mean annual precipitation [mm] | Mean annual evaporation [mm] | Observation items ¹⁾ |
|--------|------------|---------------|---------------------------------|--------------------|--------------------------------|------------------------------|---------------------------------|
| 20502* | Azumasan | 820 | N 37° 46' 34" E 140° 07' 23" | 1940~ present | 1 831.5 1940~1991 | - | P |
| 20505* | Nijuku | 290 | N 38° 00' 57" E 140° 15' 41" | 1955~ present | 1 445.1 1955~1992 | - | P |
| 20507* | Shimoyachi | 370 | N 37° 35' 00" E 139° 52' 07" | 1938~ present | 2 298.2 1938~1992 | - | P |
| 20512* | Hirayama | 220 | N 38° 05' 30" E 139° 59' 37" | 1943~ present | 2 150.8 1943~1992 | - | P |
| 20519* | Nakamura | 450 | N 38° 23' 05" E 139° 59' 44" | 1938~ present | 2 719.7 1938~1991 | - | P |
| 47588# | Yamagata | 152 | N 38° 15' 12" E 140° 20' 54" | 1889~ present | 1 126.3 1961~1990 | - | DS, P, SR |
| 47520# | Shinjo | 105 | N 38° 45' 12" E 140° 18' 54" | 1949~ present | 1 655.8 1961~1990 | - | DS, P |
| 47587# | Sakata | 3 | N 38° 54' 24" E 139° 50' 48" | 1936~ present | 1 857.0 1961~1990 | - | DS, P, SR |

*: Serial number used in Streamflow Yearbook, River Bureau, Ministry of Construction.

#: Serial number used by Meteorological Observatory, Japan Meteorological Agency.

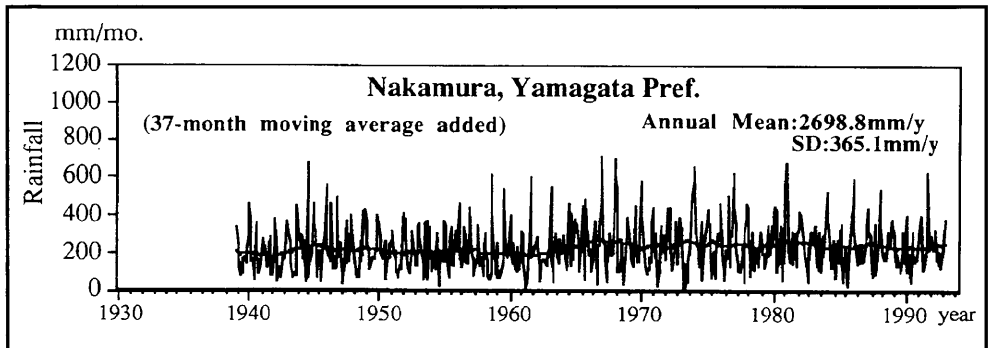
1) P: Precipitation, SR: Solar radiation, DS: Duration of sunshine.

3.3 Monthly Climate Data

Station: Yamagata

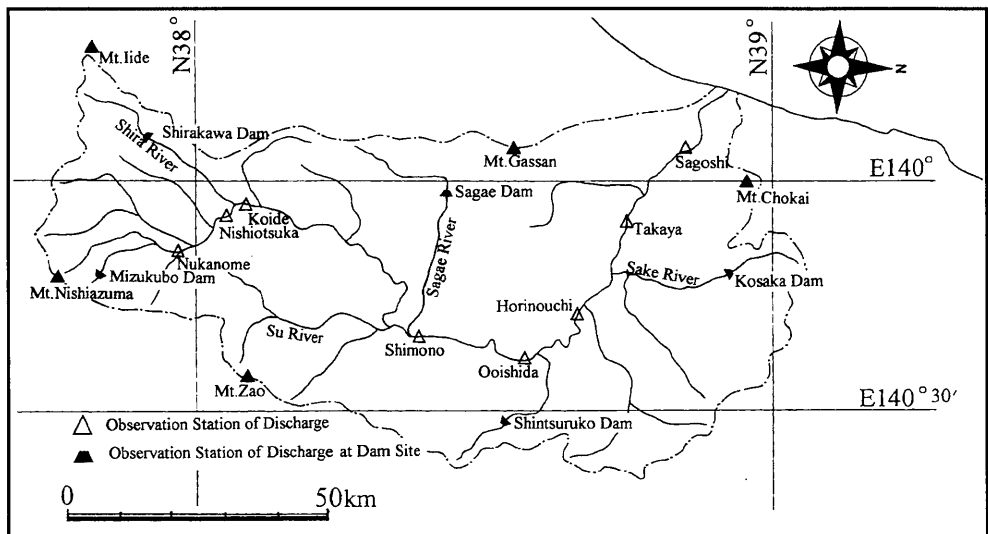
| Observation item | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Annual | Period for the mean |
|--|------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|--------|---------------------|
| Temperature [°C] | -0.9 | -0.6 | 2.6 | 9.6 | 15.4 | 19.4 | 23.1 | 24.6 | 19.4 | 12.7 | 6.9 | 2.1 | 11.2 | 1961~90 |
| Precipitation [mm] | 86.5 | 74.1 | 65.5 | 66.2 | 75.8 | 100.3 | 143.8 | 138.8 | 126.9 | 80.8 | 83.2 | 84.4 | 1126.3 | 1961~90 |
| Solar radiation (MJ/m ² /d) | 6.8 | 9.2 | 12.5 | 15.9 | 18.2 | 17.1 | 16.4 | 16.6 | 12.1 | 9.6 | 6.5 | 5.6 | 12.2 | - |
| Duration of sunshine (hr) | 88.1 | 101.2 | 149.5 | 183.7 | 206.4 | 161.1 | 156.8 | 186.4 | 127.6 | 127.7 | 96.7 | 81.8 | 1667.0 | - |

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

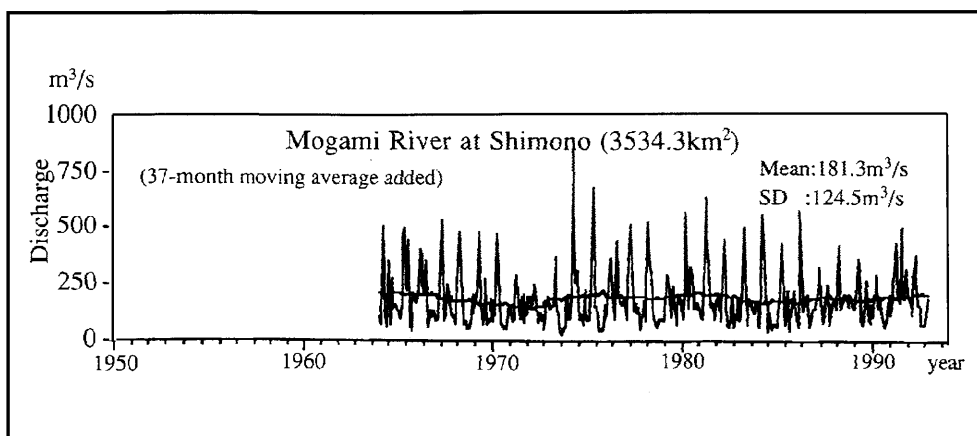
| No.* | Station | Location from the river mouth [km] | Elevation [m] | Catchment area (A) [km ²] | Observation period | Observation items ¹⁾ (frequency) |
|-------|--------------|------------------------------------|---------------|---------------------------------------|--------------------|---|
| 20503 | Nukanome | 198.7 | 201.31 | 359.1 | 1975~present | H1, Q(h) |
| 20509 | Nishi-Otsuka | 185.5 | 190.00 | 1 018 | 1960~present | H1, Q(h) |
| 20513 | Koide | 179.2 | 182.70 | 1 350 | 1951~present | H1, Q(h) |
| 20520 | Nagasaki | 126.2 | 77.80 | 2 147 | 1977~present | H1, Q(h) |
| 20528 | Shimono | 114.5 | 69.72 | 3 534 | 1964~present | H1, Q(h) |
| 20533 | Oishida | 86.65 | 47.52 | 3 963 | 1958~present | H1, Q(h) |
| 20535 | Horiuchi | 62.84 | 42.44 | 4 516 | 1957~present | H1, Q(h) |
| 20548 | Takaya | 32.60 | 22.26 | 6 271 | 1959~present | H1, Q(h) |
| 20553 | Sagoshi | 11.00 | 0.00 | 6 497 | 1967~present | H1, Q(h) |

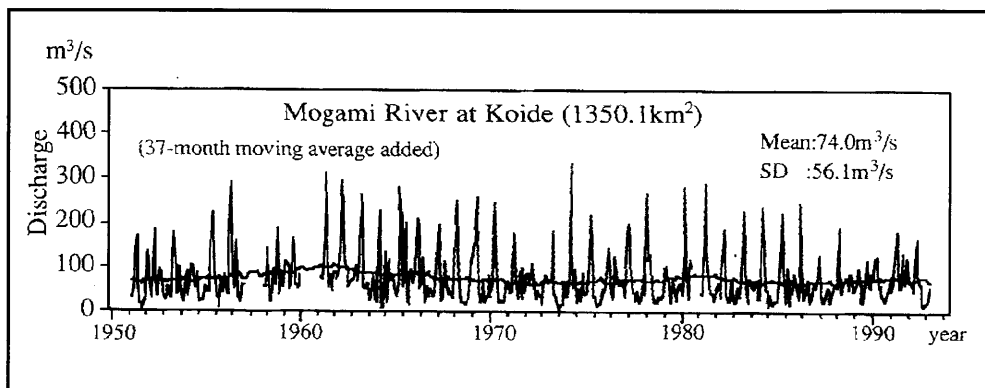
| No.* | \bar{Q} ²⁾ [m ³ /s] | Q max ³⁾ [m ³ /s] | \bar{Q} max ⁴⁾ [m ³ /s] | \bar{Q} min ⁵⁾ [m ³ /s] | \bar{Q} / A [m ³ /s/100km ²] | Q max / A [m ³ /s/100km ²] | Period of statistics |
|-------|---|---|---|---|---|---|----------------------|
| 20503 | 36.0 | 822.8 | 377.1 | 1.65 | 10.0 | 229.1 | 1975~1990 |
| 20509 | 45.2 | 1 818 | 615.9 | 4.09 | 4.44 | 178.6 | 1961~1990 |
| 20513 | 73.1 | 2 596 | 786.5 | 7.09 | 5.41 | 192.3 | 1961~1990 |
| 20520 | 111.8 | 2 358 | 1 237 | 14.9 | 5.21 | 109.8 | 1977~1990 |
| 20528 | 174.0 | 3 807 | 1 929 | 25.6 | 4.92 | 107.7 | 1964~1990 |
| 20533 | 204.7 | 3 557 | 1 765 | 33.9 | 5.17 | 89.76 | 1961~1990 |
| 20535 | 218.6 | 3 386 | 1 873 | 37.8 | 4.84 | 74.98 | 1961~1990 |
| 20548 | 316.3 | 6 061 | 3 111 | 53.7 | 5.76 | 96.5 | 1961~1988 |
| 20553 | 390.2 | 6 327 | 3 323 | 50.3 | 5.54 | 97.38 | 1967~1990 |

* Serial number used in Streamflow Yearbook, River Bureau, Ministry of Construction.

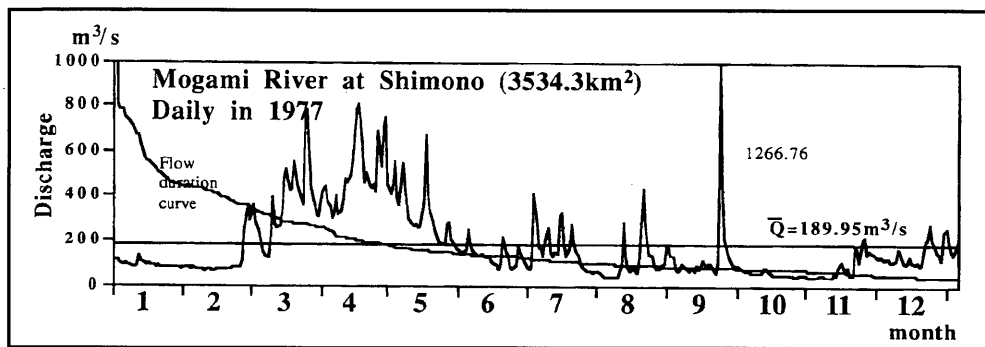
- 1) H1: Water level in recording chart,
Q: Discharge, (including the use of H-Q curve),
h: Hourly.
- 2) Mean annual discharge.
3) Maximum discharge.
4) Mean annual maximum discharge.
5) Mean annual minimum discharge.

4.3 Long-term Variation of Monthly Discharge



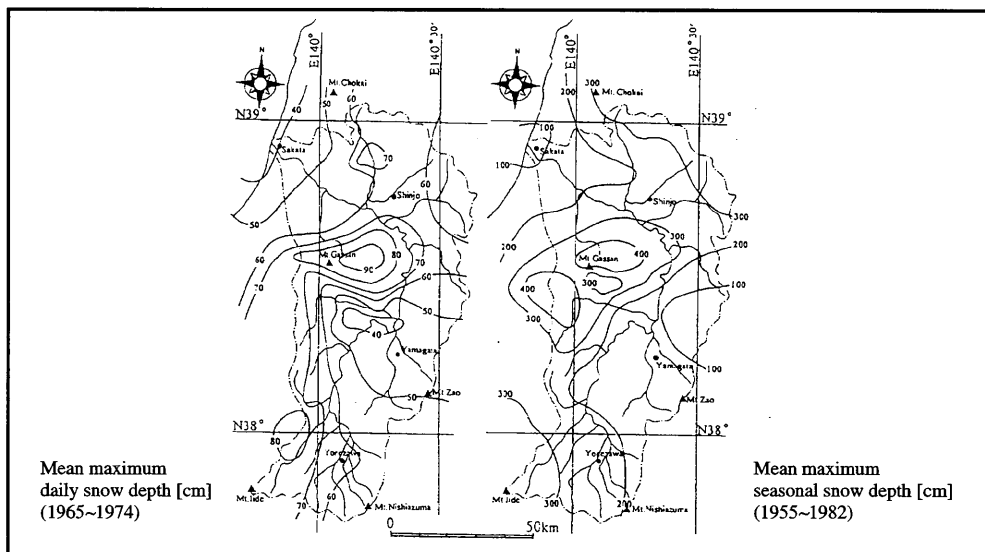


4.4 Annual Pattern of Discharge



4.5 Unique Hydrological Features

The Mogami River Basin receives heavy snowfall particularly in the western mountain ranges. The mean maximum daily and seasonal snow depths are illustrated below:



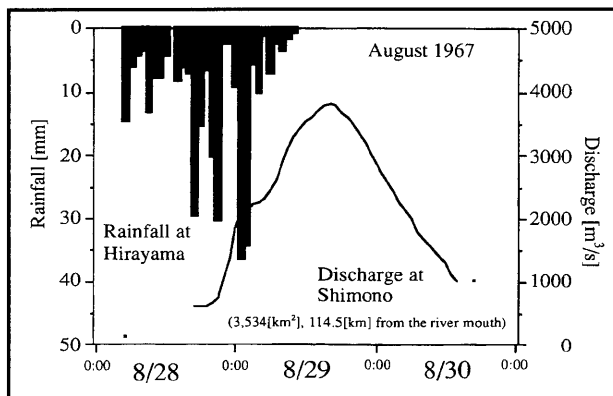
4.6 Annual Maximum and Minimum Discharges

At Shimono [3 534.3 km²]

| Year | Maximum ¹⁾ | | Minimum ²⁾ | | Year | Maximum ¹⁾ | | Minimum ²⁾ | |
|------|-----------------------|---------------------|-----------------------|---------------------|------|-----------------------|---------------------|-----------------------|---------------------|
| | Date | [m ³ /s] | Date | [m ³ /s] | | Date | [m ³ /s] | Date | [m ³ /s] |
| 1964 | 7.13 | 2 148 | 8.20 | 29 | 1979 | 7.29 | 1 927 | 9.21 | 40 |
| 1965 | 7.18 | 2 521 | 8.31 | 27 | 1980 | 4.07 | 1 831 | 10.12 | 44 |
| 1966 | 7.18 | 2 458 | 8.25 | 22 | 1981 | 6.23 | 2 900 | 8.18 | 27 |
| 1967 | 8.29 | 3 807 | 8.09 | 21 | 1982 | 9.13 | 2 186 | 7.16 | 30 |
| 1968 | 3.31 | 1 006 | 8.02 | 21 | 1983 | 5.17 | 1 228 | 6.28 | 38 |
| 1969 | 8.08 | 3 253 | 7.26 | 26 | 1984 | 4.06 | 1 360 | 8.21 | 23 |
| 1970 | 4.18 | 968 | 7.28 | 22 | 1985 | 7.04 | 1 204 | 8.25 | 25 |
| 1971 | 7.16 | 1 451 | 8.07 | 22 | 1986 | 8.05 | 3 186 | 8.03 | 19 |
| 1972 | 3.21 | 1 146 | 8.11 | 25 | 1987 | 8.29 | 1 797 | 7.11 | 26 |
| 1973 | 4.17 | 805 | 8.16 | 5 | 1988 | 8.05 | 1 069 | 7.27 | 53 |
| 1974 | 4.15 | 1 740 | 8.21 | 36 | 1989 | 8.07 | 1 589 | 7.31 | 28 |
| 1975 | 4.09 | 1 524 | 8.19 | 6 | 1990 | 6.27 | 1 987 | 9.03 | 34 |
| 1976 | 8.06 | 3 382 | 8.02 | 19 | 1991 | 10.13 | 2 401 | 8.28 | 55 |
| 1977 | 9.20 | 1 569 | 8.04 | 39 | 1992 | 5.08 | 802 | 8.18 | 45 |
| 1978 | 6.26 | 2 037 | 8.06 | 13 | 1993 | 8.28 | 2 811 | 10.23 | 57 |

1), 2) Instantaneous observation by recording chart

4.7 Hyetographs and Hydrographs of Major Floods

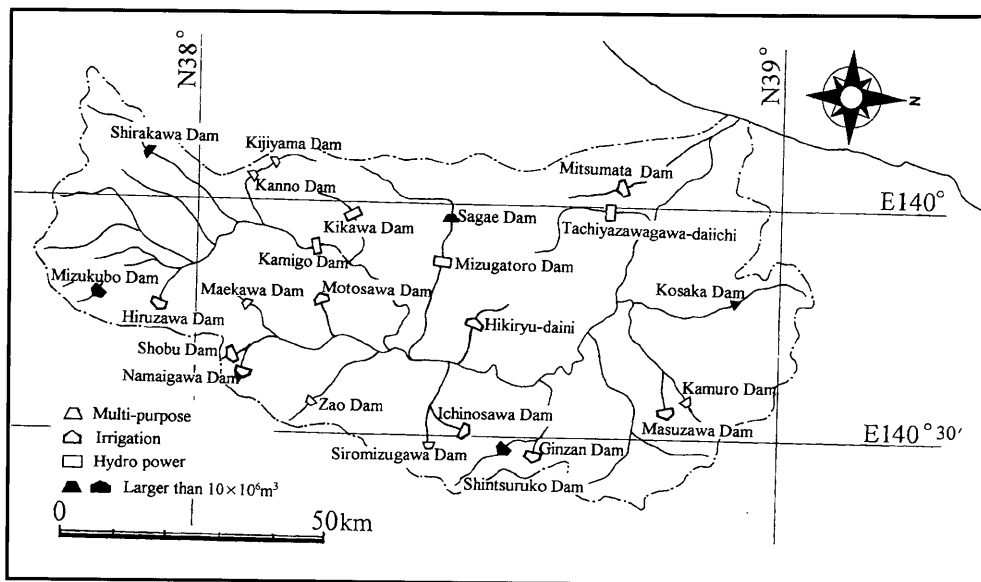


5. Water Resources

5.1 General Description

The main industry of the Mogami River Basin is rice production. There are more than 4 300 intakes for paddy field irrigation. The largest intakes are the Mogami-gawa Intake Gate and the Kusanagi Head Works for the irrigation of some 14 200 ha in the Shonai Plain. The municipal and industrial water uses are not much yet but expected to increase in Yamagata, Sakata and other cities. The water pollution is increasing around Yamagata City, but the middle and downstreams are still free from contamination. There are 21 hydro-power stations with a total capacity of about 197 MW (1992). The largest reservoir in the basin is the Gassan multi-purpose reservoir (built in 1990) with a capacity of $109 \times 10^6 \text{ m}^3$ with the second one being the Shirakawa reservoir (built in 1981) which has a capacity of $50 \times 10^6 \text{ m}^3$. The basin is rich in ground water, the reserve being estimated to be about $1 500 \times 10^6 \text{ m}^3$ in the whole basin in 1973 and its use was $700 \text{ m}^3/\text{day}$ in 1977. It is used for domestic, industrial, irrigation and in winter for snow-melting purposes. Rapid water level depletion and land subsidence are already occurring where extensive withdrawals are made as in Yonezawa basin. During years of heavy snowfall, 4-10 m depletions occur in Yonezawa basin aquifer.

5.2 Map of Water Resources Systems



5.3 List of Major Water Resources Facilities

Major Reservoirs

| Name of river | Name of dam (reservoir) | Catchment area [km ²] | Gross capacity [10 ⁶ m ³] | Effective capacity [10 ⁶ m ³] | Purpose ¹⁾ | Year of completion |
|---------------|-------------------------|-----------------------------------|--|--|-----------------------|--------------------|
| Shira | Shira-kawa | 205.0 | 50.00 | 41.00 | A, F, I, P | 1981 |
| Sagae | Sagae (Gassan) | 231.0 | 109.00 | 98.00 | A, F, P, W | 1990 |
| Okitamano | Kijiyama | 63.0 | 8.20 | 6.40 | F, P | 1960 |
| Sake | Takasaka | 68.2 | 19.05 | 12.75 | F, P | 1967 |
| Mamigasaki | Zao | 21.0 | 7.30 | 5.20 | F, W | 1969 |
| Shiramizu | Shiramizu-gawa | 15.2 | 5.30 | 4.60 | A, F | 1990 |
| Kanayama | Kamuro | 22.5 | 7.40 | 5.80 | F, W | 1993 |
| Niu | Shintsuruko | 56.0 | 31.50 | 29.96 | A | 1988 |
| Kariyasu | Mizukubo | 31.0 | 31.00 | 29.00 | A, W | 1974 |
| Masuzawa | Masuzawa | 3.8 | 6.81 | 6.75 | A | 1964 |
| Mogami | Kamigou | 1,810.0 | 7.66 | 1.89 | P | 1962 |

1) A: Agricultural use F: Flood control I: Industrial use P: Hydro-power W: Municipal water supply

5.4 Major Floods and Droughts

Major Floods

A number of flood records are available since the 17th century. However, records with any appreciable hydrological information are available only after 1913. The records used for the current flood control design are those of 1913, 1944, 1967 and 1969. Old flood records include the large ones in 1648, 1658 and 1757.

| Date | Station Catchment area [km ²] | Peak discharge [m ³ /s] | Rainfall [mm] ¹⁾ Duration | Meteorological cause | Dead and missing | Major damages (Districts affected) |
|------------|---|--|---|-------------------------|------------------------|---------------------------------------|
| 1913. 8.29 | - | - | - - | Frontal (Typhoon) | - | - |
| 1944. 7.19 | - | - | 126.8 7.19~7.21 | Frontal (Baiu) | 7 | Sakata, Shinjo |
| 1965. 7.18 | Shimono (3 534) Takaya (6 271) | 2 520 3 054 | 157.9 7.15~7.18 | Frontal (Baiu) | 6 | Yonezawa, Nagai |
| 1967. 8.28 | Shimono (3 534) Takaya (6 271) | 3 806 3 452 | 203.0 8.26~8.29 | Low pressure | 8 | Nagai |
| 1969. 8.08 | Shimono (3 534) Takaya (6 271) | 3 253 6 060 | 50.5 8.07~8.08 | Low pressure, Front | 2 | Shinjo |
| 1971. 7.16 | Shimono (3 534) Takaya (6 271) | 1 451 3 921 | 23.0 - | Frontal (Baiu) | 4 | Shinjo |
| 1975. 8.06 | Shimono (3 534) Takaya (6 271) | 576 2 795 | 34.1 8.06~8.07 | Cold front | 5 | Shinjo |
| 1981. 6.23 | Shimono (3 534) Takaya (6 271) | 2 900 4 204 | 87.0 8.21~8.23 | Frontal (Baiu) | 0 | Yamagata |
| 1986. 8.05 | Shimono (3 534) Takaya (6 271) | 3 185 3 547 | 166.0 8.05~8.06 | Typhoon | 0 | Yamagata |
| 1993. 8.27 | Shimono (3 534) Takaya (6 271) | 2 810 2 440 | 291 8.26~8.27 | Typhoon | 0 | Nanyo |

1) Measured at Mt. Azuma Station

5.5 Groundwater and Water Quality

River Water Quality ¹⁾ at Shimono ²⁾ in 1993

| Date | Jan 9 | Feb 1 | Mar 1 | Apr 19 | May 10 | Jun 7 | Jul 5 | Aug 2 | Sep 11 | Oct 4 | Nov 8 | Dec 6 |
|---|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|--------------------------|
| pH | 6.7 | 6.8 | 6.7 | 6.9 | 6.8 | 7.1 | 7.1 | 6.7 | 7.0 | 6.7 | 6.6 | 6.9 |
| BOD [mg/l] | 0.6 | 1.3 | 3.6 | 0.9 | 0.9 | 1.5 | 1.7 | 2.3 | 1.6 | 1.3 | 1.7 | 1.1 |
| COD _{Mn} [mg/l] | 3.0 | 3.0 | 12.0 | 2.9 | 3.2 | 4.2 | 3.6 | 5.7 | 3.1 | 1.7 | 2.2 | 2.1 |
| SS [mg/l] | 9 | 17 | 392 | 46 | 15 | 12 | 15 | 40 | 22 | 16 | 14 | 20 |
| Coliform group ³⁾ [MPN/100ml] | 3.3 x 10 ² | 3.3 x 10 ³ | 4.9 x 10 ³ | 1.7 x 10 ³ | 4.9 x 10 ³ | 3.3 x 10 ³ | 1.3 x 10 ⁴ | 1.1 x 10 ⁴ | 4.9 x 10 ³ | 3.3 x 10 ³ | 2.3 x 10 ² | 2.4 x 10 ³ |
| Discharge ⁴⁾ [m ³ /s] | 121.1 | 111.3 | 453.5 | 410.8 | 194.6 | 101.9 | 68.6 | 74.3 | 220.8 | 84.4 | 57.8 | 176.1 |

Annual changes of Water Quality (BOD 75% value)⁵⁾

| | 1984 | 1985 | 1986 | 1987 | 1988 | 1989 | 1990 | 1991 | 1992 | 1993 |
|-----------|------|------|------|------|------|------|------|------|------|------|
| Kaminitta | 5.3 | 4.6 | 3.9 | 3.3 | 2.5 | 3.9 | 3.9 | 3.9 | 3.4 | 3.2 |
| Nukanome | 2.6 | 2.5 | 2.2 | 2.2 | 1.8 | 2.6 | 2.6 | 2.5 | 2.6 | 2.3 |
| Shimono | 1.4 | 1.0 | 1.4 | 1.4 | 1.2 | 1.7 | 1.2 | 1.4 | 1.4 | 1.3 |
| Takaya | 1.0 | 1.3 | 1.3 | 1.1 | 1.3 | 1.5 | 1.2 | 1.0 | 1.2 | 1.0 |

- 1) Criteria of selecting observation date: Usually every Wednesday; during normal flow condition.
- 2) Location of the station: 114.5 km from 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) The value with nonexceedance probability being 75%.

5.6 Other Notable Features of Water Resources

In the Mogami River Basin, the cultivation of rice paddy has a long history, relying upon the abundant discharge of snowmelt in early spring. In the early stage of the development, diversion dams for irrigation were constructed in the relatively small tributary rivers since flood flows could not be controlled in the main rivers. It was after World War II that a number of large diversion dams were built along the main channel of the river using modern construction technologies. Although it is remotely located from the major large cities of central Japan, this basin has been famous for rich agricultural production of rice. Especially the Shonai Plain is one of the richest "Kome-dokoro" (place of rice growing) in Japan.

6. Socio-cultural Characteristics

The Mogami River was historically used for navigation to export rice, Benibana oil and others from the basin to Kyoto and Osaka area, while in return, importing advanced civilisation and culture. But the river, especially its steep reaches between Murayama and Obanazawa, was difficult for navigation and was historically designated as one of the three rapids of Japan. The navigation was opened around the year 1600 after difficult construction works. Many poets and artists made pieces after the Mogami River. One of the famous ones is the Haiku poem by Matsuo Basho of Edo era, "Samidarewo Atsumete Hayashi Mogami-gawa" (The Mogami River runs fast collecting spring rain of May). A Waka poem relating to rice is "Mogami-gawa Noboreba Kудару Inafuneno Inaniwa Arazu Konotsukibakari" (Rice transporting boats go up and down along the Mogami River. I love you (inaniwa arazu) but not this month). The three mountains, so called "Dewa-sanzan", Mt. Gassan, Haguro and Yudono are the places of pilgrimage of Japanese native shamanism. The river down-boating through the rapids is a popular recreation activity in the basin. The boatman's folksong "Mogami-gawa Funauta" is also well known.

7. References, Databooks and Bibliography (In Japanese)

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