DX-based Water-related Disaster Risk Reduction in Urban Areas

International Training Workshop on Smart Cities in Asia and the Pacific

"Building safe, resilient, inclusive, livable and sustainable cities and communities"

Session 4: Smart City: Water-related Disaster Risk Reduction

14 May 2025

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CLIMATE CHANGE AND BASIN-WIDE FLOOD RISK REDUCTION

Cities below flood water levels

MLIT
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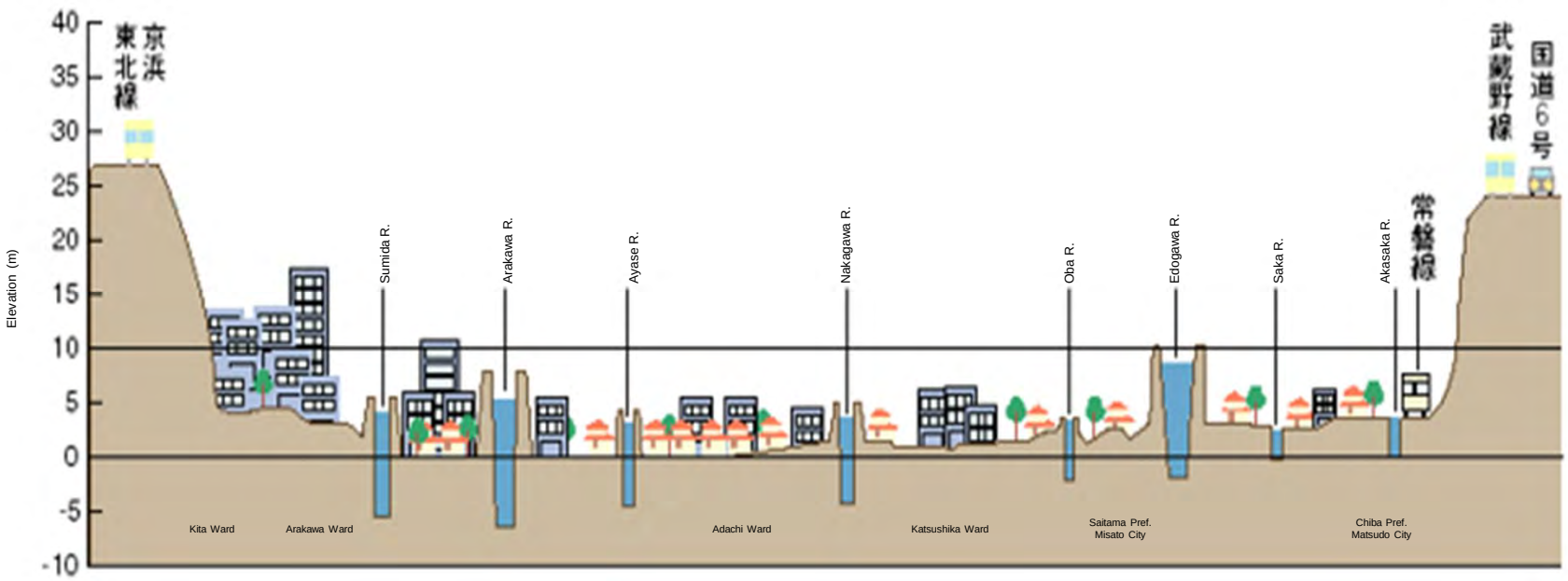
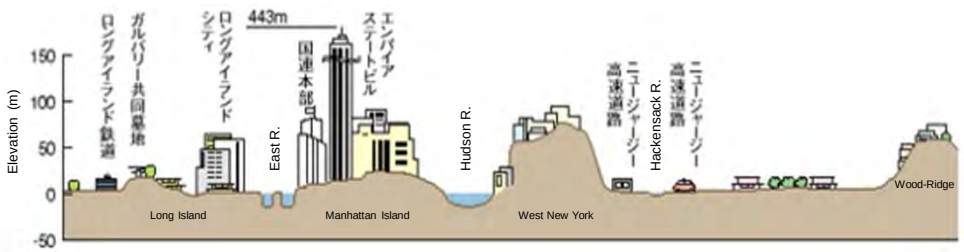
- Many cities are located in places that are lower than the water level of rivers.

Tokyo



New York



London

* Source: MLIT

Cities below flood water levels

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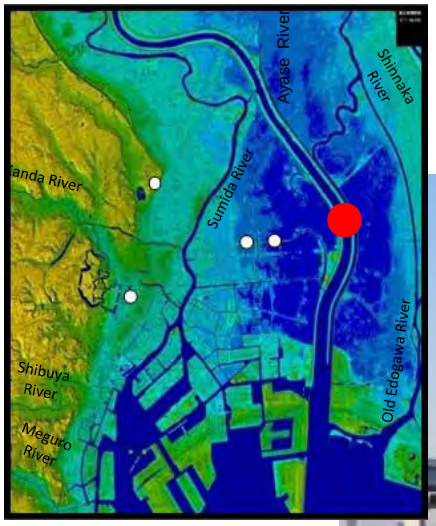
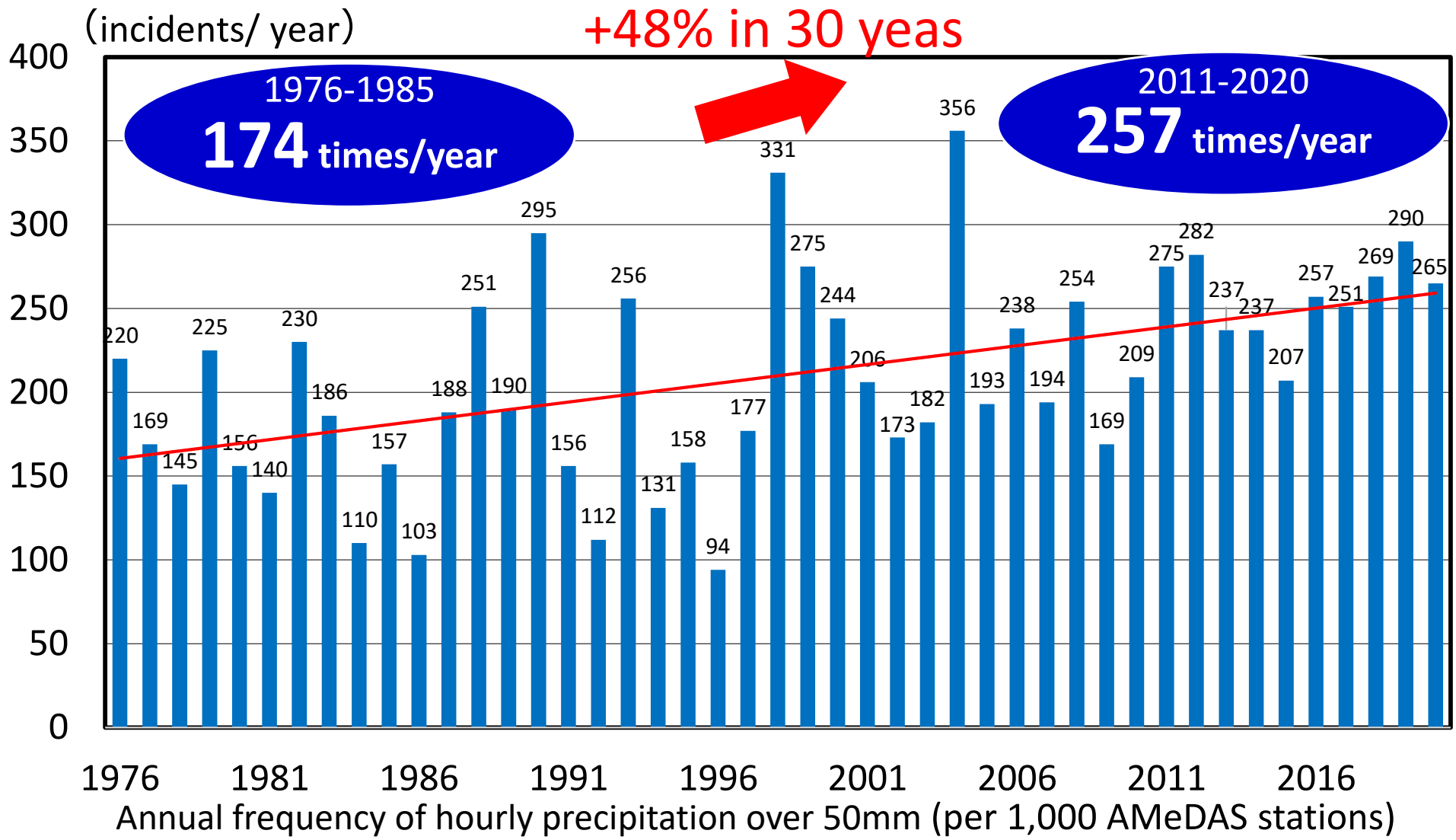
- In Tokyo, many people live and work below the water level of the rivers.



* Source: MLIT

Increasing heavy rainfalls

- The frequency of short duration heavy rainfall (over 50 mm/hour) has increased by about 1.4 times in 30 years.



- Addition of previous year's data is in January each year
- There were originally around 800 AMeDAS stations in 1976. The number increased to about 1,300 in 2016. To remove the effect of the difference in the number of stations between years, the comparison is made after conversion to frequency per 1,000 stations.
- Excludes radio-robotic rain gauge stations that were used in mountainous areas but later removed.

* Source: MLIT

Recent Severe Flood Disaster in Japan

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Ibaraki, September 2015

Fukushima, October 2019

Okayama, Jule 2018

Kumamoto, July 2020

Source: MLIT

Quantitative Impact Assessment of Global Warming

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- The Meteorological Research Institute of the Japan Meteorological Agency and the Ministry of the Environment have conducted a quantitative assessment of the impact of global warming on precipitation.
- At present, the total rainfall is calculated to have increased by about 6.5% to 16% due to the effects of global warming.
- In the future, it is possible that the total rainfall increases further by 4.4% to 19.8% compared to the current level.

Global warming that has already occurred → **Global warming that will occur in the future**

Flood disaster (torrential rain event)	**Present time** Impacts of temperature rise and sea surface temperature rise due to warming since 1980	**Future** Future climate conditions relative to the current climate (2°C rise scenario to 4°C rise scenario)
Heavy rain in July 2018	Total precipitation increased by **about 6.5 %** (1)	-
2019 East Japan Typhoon	Total precipitation increased by **about 11%** (1)	In the future, the total precipitation will further increase by **4.4% to 19.8%** (2)
Heavy rain in July 2020	Total precipitation increased by **about 15%** (1)	-
Heavy rainfall from June to early July 2023	Total precipitation increased by **about 16%** Total number of linear precipitation zones increased by **about 15%** (1)	-

Notes:
*Prepared by the Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism, based on the respective sources. ((1): Published by the Meteorological Research Institute, JMA; (2): Published by the Ministry of the Environment)
*After faithfully reproducing actual heavy rainfall phenomena using numerical simulations of the atmosphere, the effects of global warming have been quantitatively evaluated by removing the temperature increase associated with global warming, or by increasing the temperature based on further warming scenarios, and then performing numerical simulations of the atmosphere again.
*The rate of increase in total rainfall for the heavy rainfall in July 2020 is based on an evaluation of only the linear precipitation zones that occurred near the Kuma River basin.
*The rate of increase in total rainfall for the heavy rainfall from June to early July 2023 is based on an evaluation of the heavy rainfall in northern Kyushu that occurred from July 9 to 10, 2023. The rate of increase in the total number of linear precipitation zones is evaluated for the period of heavy rainfall from June to early July 2023.

Change in the amount of rainfall and frequency of flooding due to climate change

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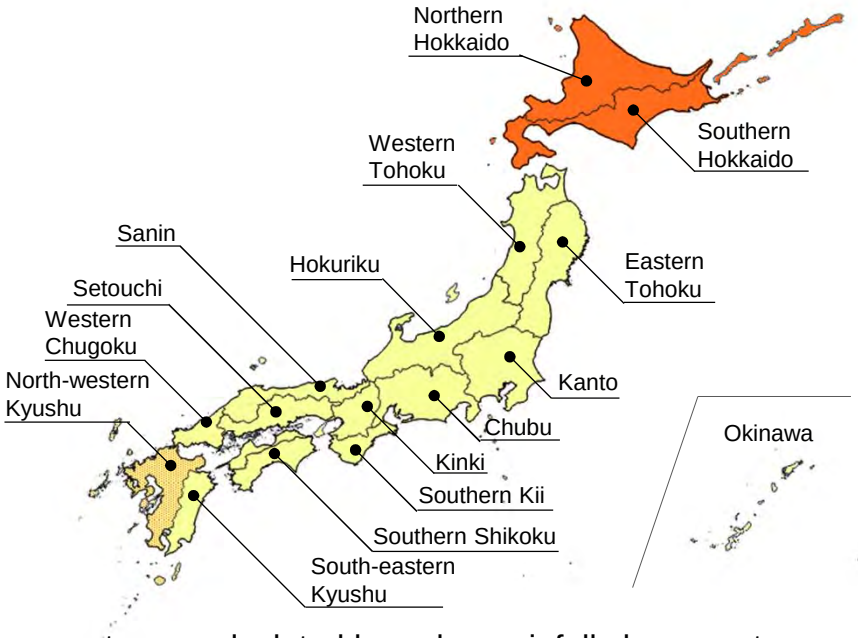
○ The future rainfall change rate is calculated for each region with similar rainfall characteristics, and the rainfall change rate is set based on an evaluation of the breadth of the future sea surface temperature distribution and average values etc.
○ The rainfall change rate for a rise of 2˚C is 1.15 times for Hokkaido and 1.1 times for other areas (including Okinawa), and the precipitation change rate for a rise of 4˚C is 1.4 times for Hokkaido and North-western Kyushu and 1.2 times for other areas (including Okinawa).
○ When temperatures rise by 4˚C, there is a significant impact on small basins and short-term rainfall, so change of rainfall rate is set separately.

<Rainfall change rate for each region>

Area classification	2˚C rise	4˚C rise	
			Short time
Northern and Southern Hokkaido	1.15	1.4	1.5
North-western Kyushu	1.1	1.4	1.5
Other areas (including Okinawa)	1.1	1.2	1.3

*Of the rate of change in rainfall from a rise of 4˚C, the short time means that the duration of rainfall is 3 hours or more and less than 12 hours and cannot be applied to rainfall of less than 3 hours.
*Applies to rainfall areas of 100 km² or more. However, even where less than 100 km², can be applied if keeping in mind that the rainfall change rate may be larger than this value set.
*Applies to a planned scale of 1/200 or more annual excess probability (more frequent).



<Reference> National average changes in flow rate and flood frequency in class A river systems, calculated based on rainfall change rate

Climate change scenario	Rainfall	Flow rate	Flood frequency
Rise of 2˚C	Approx. 1.1 times	Approx. 1.2 times	Approx. 2 times
Rise of 4˚C	Approx. 1.3 times	Approx. 1.4 times	Approx. 4 times

*The rate of change in rainfall for rises of 2˚C, 4˚C, is calculated from a simulation model of global rises of 2˚C, 4˚C in average global temperatures in comparison with pre-industrial levels
*The rate of change of the flow rate is calculated from the rainfall multiplied by the rainfall change rate, and is the average change of flow rate for the target scale of class A flood control plans(1/100-1/200)
*The rate of change of flood frequency is the average change rate of the current and future frequency of rainfall of the target scale of class A flood control plans (1/100-1/200)
(For example, if the frequency of a certain amount of rainfall is currently 1/100, if the frequency in the future will be 1/50 this means that the flood frequency change will be 2 times)

Revising Plans to Consider Climate Change

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- Revise plans considering the future impacts of climate change

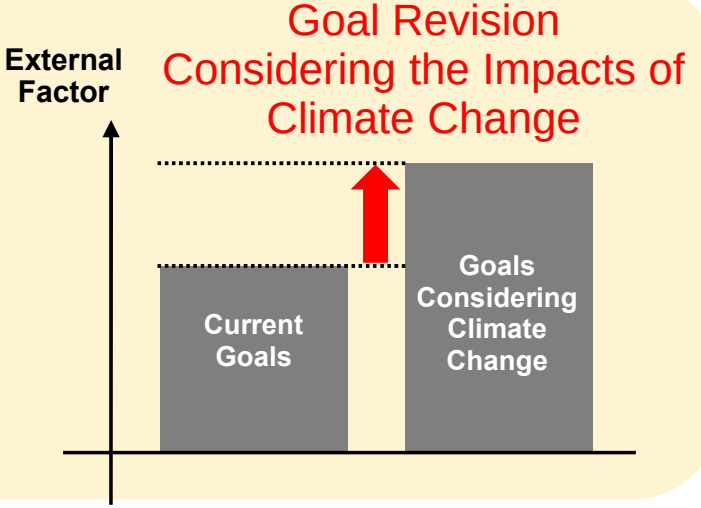
Plan Revision

The current defense plans against floods, inland floods, landslides, storm surges, and high tides were developed based on **past records of precipitation and tide levels**

However,
they may not be able to secure safety considering the impacts of climate change, such as increased rainfall and rising sea levels

For the future,
revise plans to **consider the impacts of climate change such as increased rainfall* and rising sea levels**

* In the scenario, hold global average temperature increase to well below 2°C (the target scenario of the Paris Agreement on Climate Change), precipitation is likely to increase by a factor of 1.1



River Basin Disaster Resilience and Sustainability by All

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- Flood control with the cooperation of all the stakeholders around basins
- Upgrade flood control plans with consideration for climate change impacts
- Promote the following integrated and multi-layered measures: 1) Flood Prevention, 2) Exposure Reduction, and 3) Disaster Resilience

1) Flood Prevention

Basins

- Improve rainwater storage functions

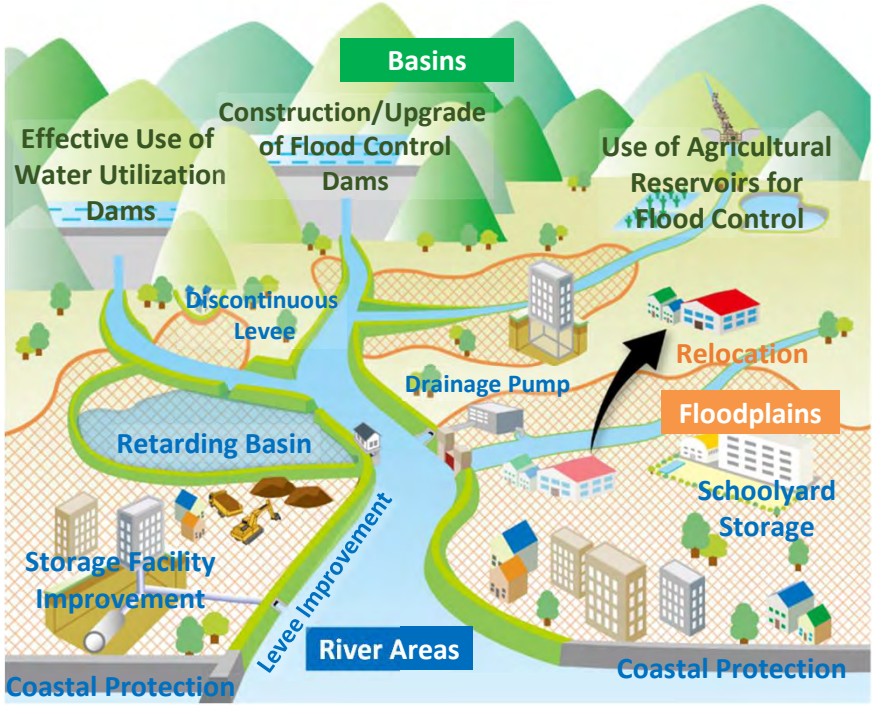
River Areas

- Store flood water through construction, upgrade, and effective use of dams.
- Ensure and improve the discharge capacity of river channels
- Reduce overflow
- Improve Levees

2) Exposure Reduction

Floodplains

- Guide residents to lower risk areas
- Promote safer ways of living
- Localize inundation areas



3) Disaster Resilience

Floodplains

- Improve land risk information
- Reinforce evacuation systems
- Minimize economic damages
- Promote safer ways of living
- Improve support systems for affected local governments
- Eliminate inundation promptly

* Source: MLIT

FLOOD RISK MEASURES IN URBAN AREAS

Urban Flood Storage: Koshigaya Lake-town

- The Koshigaya Lake-town, a major development project covering 225.6 ha and with a planned population of 22,400, has also developed flood storage with a capacity of 1.2 million m3 to compensate for the increase in run-off caused by urban development.

* Source: Koshigaya City Office (https://www.city.koshigaya.saitama.jp/kurashi_shisei/kurashi/sumai/reikutaun/laketown.html)

Multi-Purpose Flood Storage : Tsurumi-River

- The Tsurumi River Multi-Purpose Detention Basin, an area of 84 ha with a storage capacity of 3.9 million m^3, is located on the outskirts of Yokohama City.
- This area is managed as an urban park and the Nissan Stadium, while storing floodwater during heavy floods.

Before the development (1982)

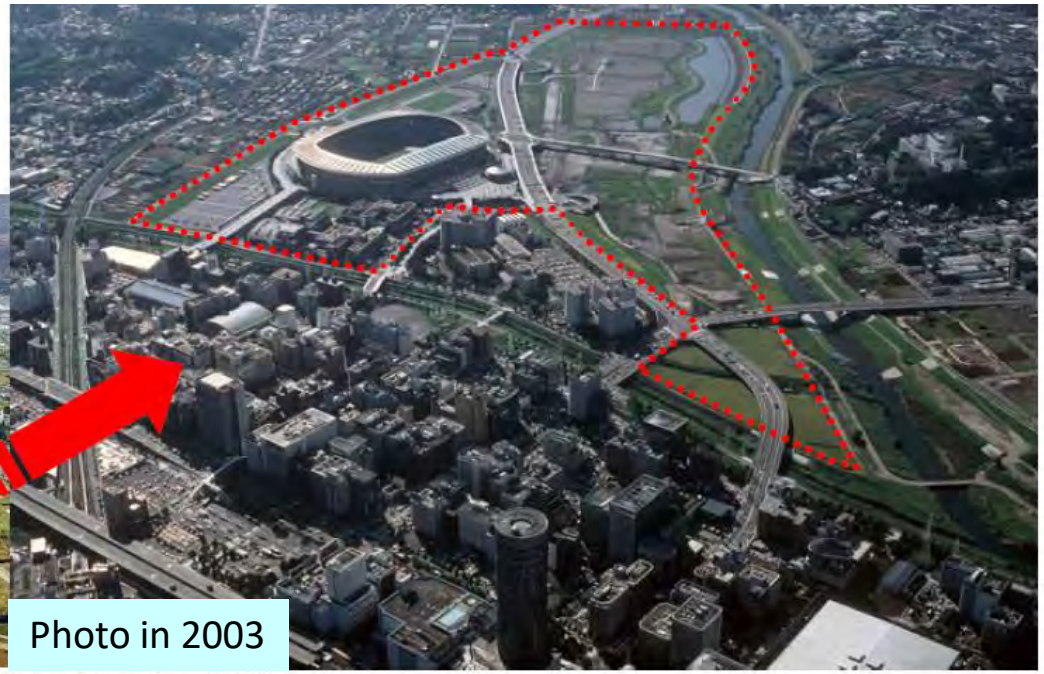
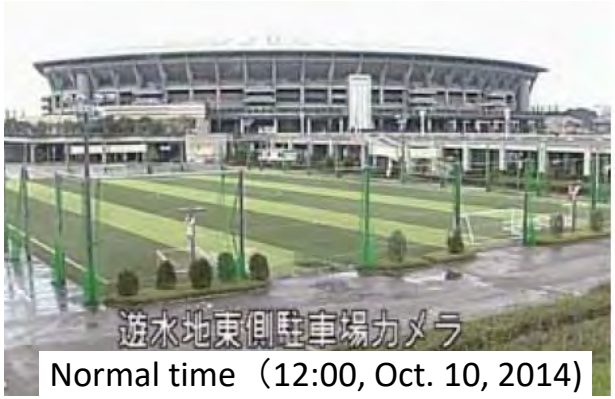
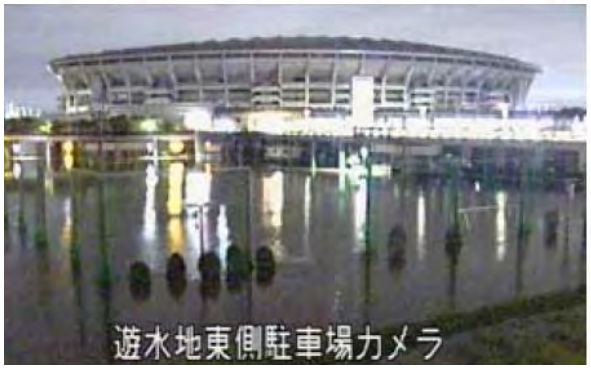


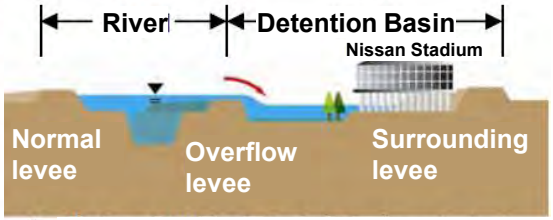
Photo in 2003



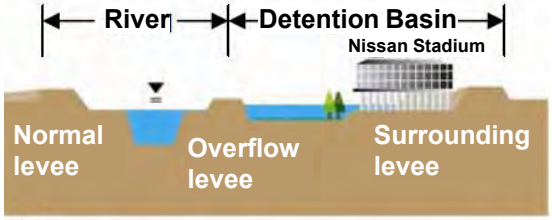
Normal time （12:00, Oct. 10, 2014）



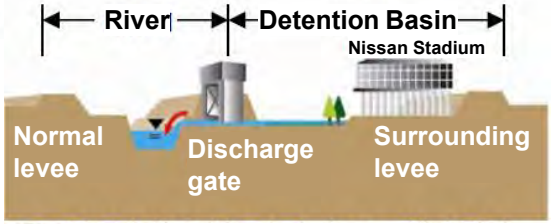
Storing floodwater(23:00, Oct. 9, 2014)



1 Overflow levee is designed to divert floodwater into the storage.



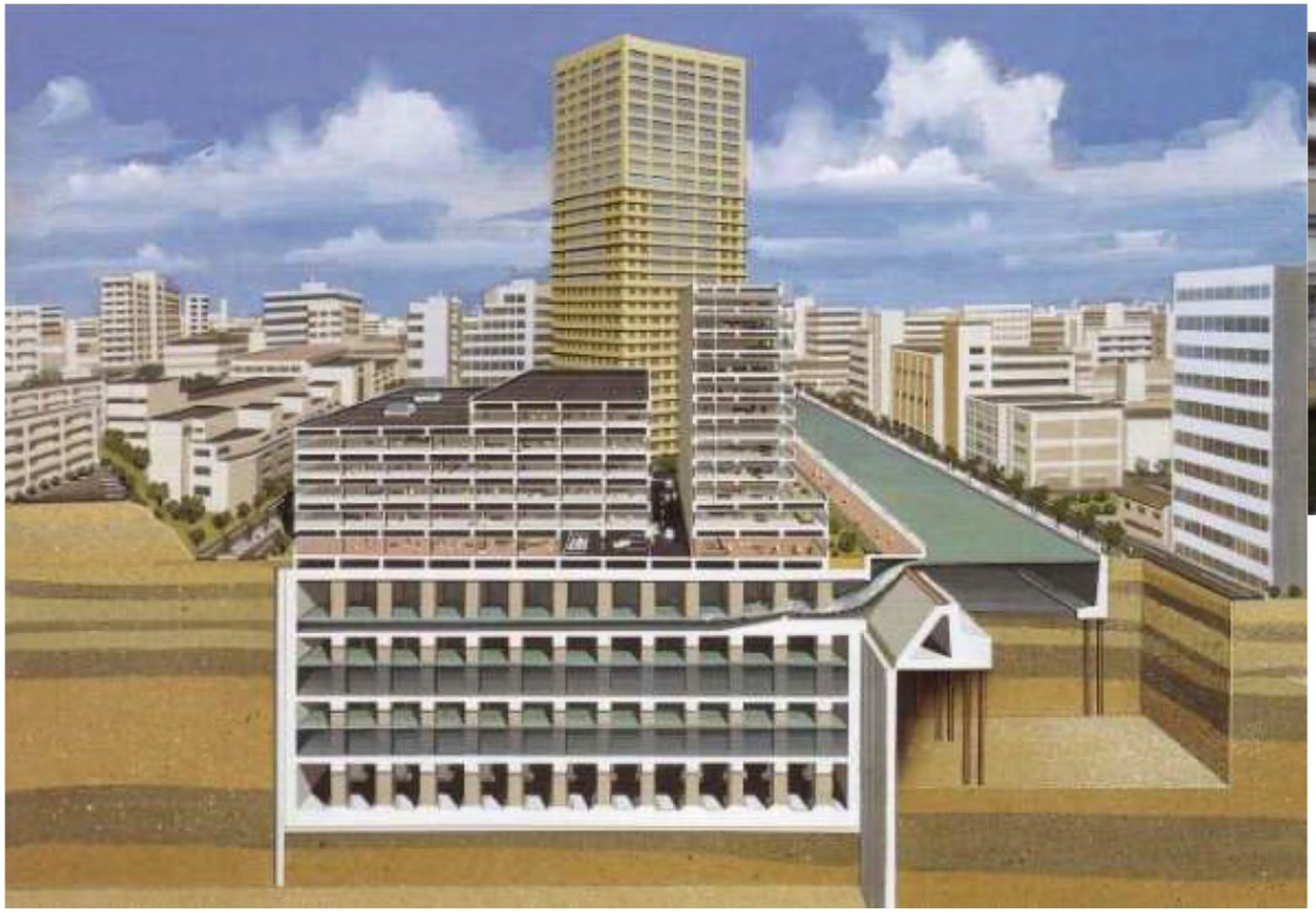
2 Floodwater is stored during floods.

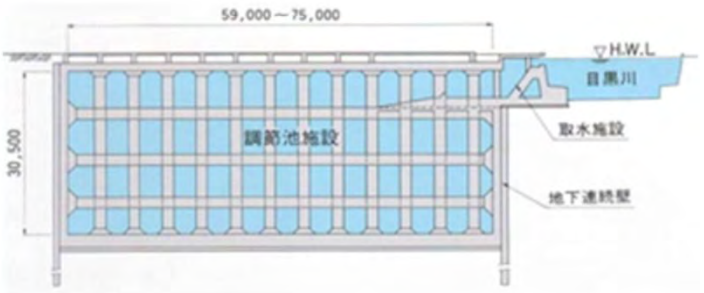


3 The stored water is released after the flood event.

Multi-Purpose Flood Storage : Ebara Storage

- The Ebara Flood Storage Tank, with a capacity of 200,000 m3 on an area of 1 ha, is located in the centre of Tokyo.
- The building above the tank is used for residential and public purposes.





* Source: Tokyo Metropolitan Office (https://www.kensetsu.metro.tokyo.lg.jp/content/000046135.pdf)

Comprehensive flood management in Shizuoka City

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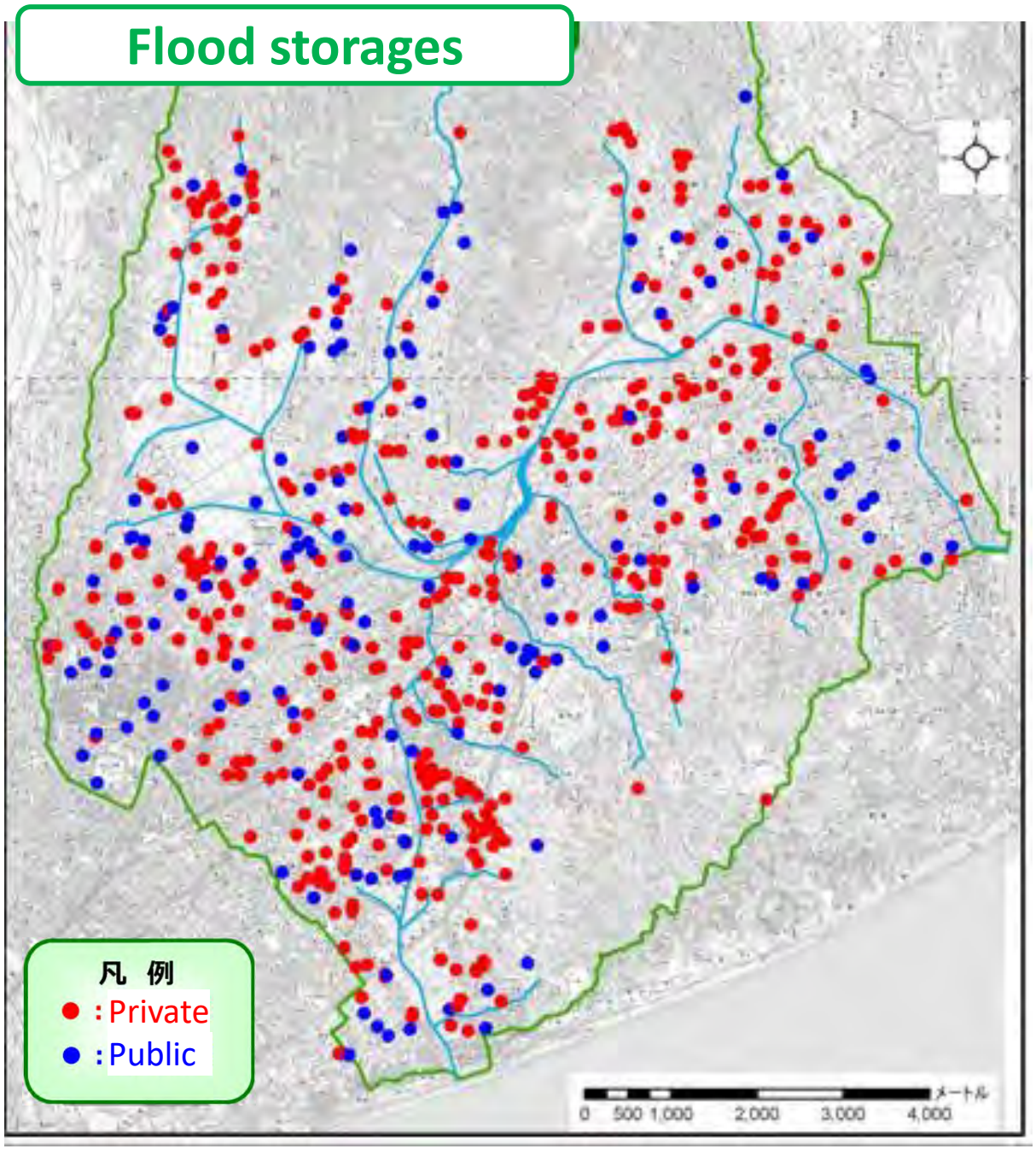
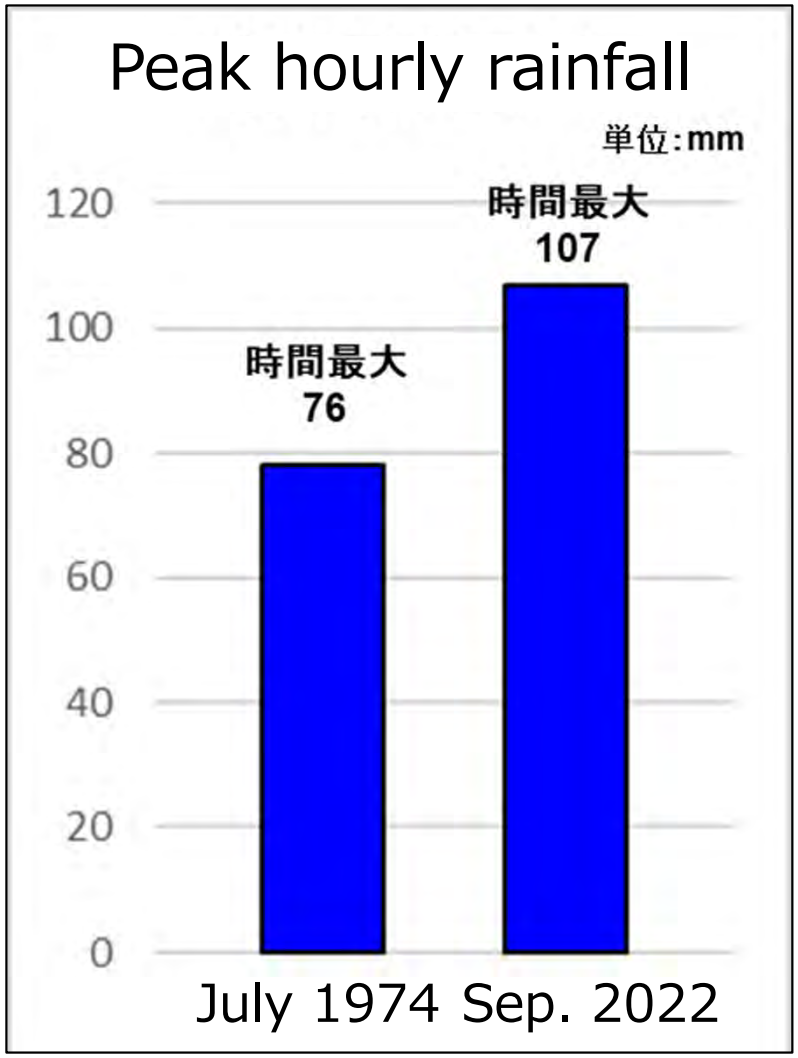


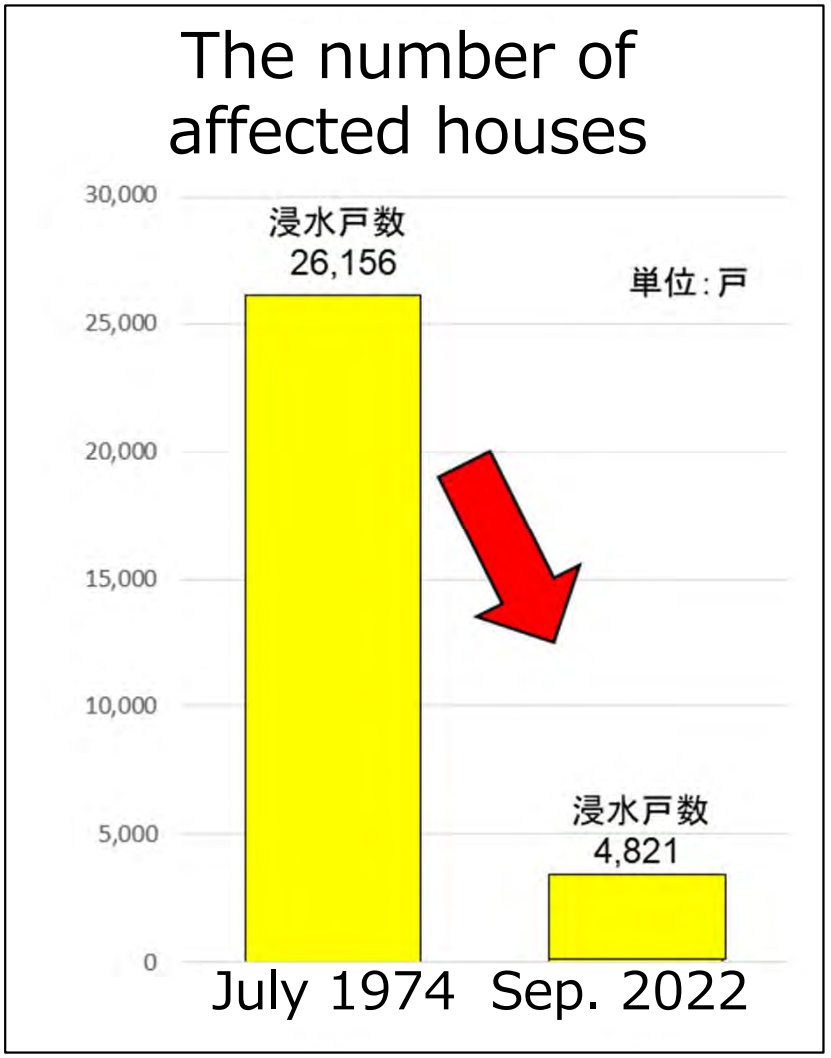
690,000 m^3 of storage has been developed by the public and private sectors in Shizuoka City.

* Source: MLIT

Comprehensive flood management in Shizuoka City

- The number of homes affected was drastically reduced from 26,156 to 4,821, despite the heavier rainfall.





*based on a report as of 17 Feb. 2023

* Source: MLIT

Metropolitan Outer Area Underground Discharge Channel

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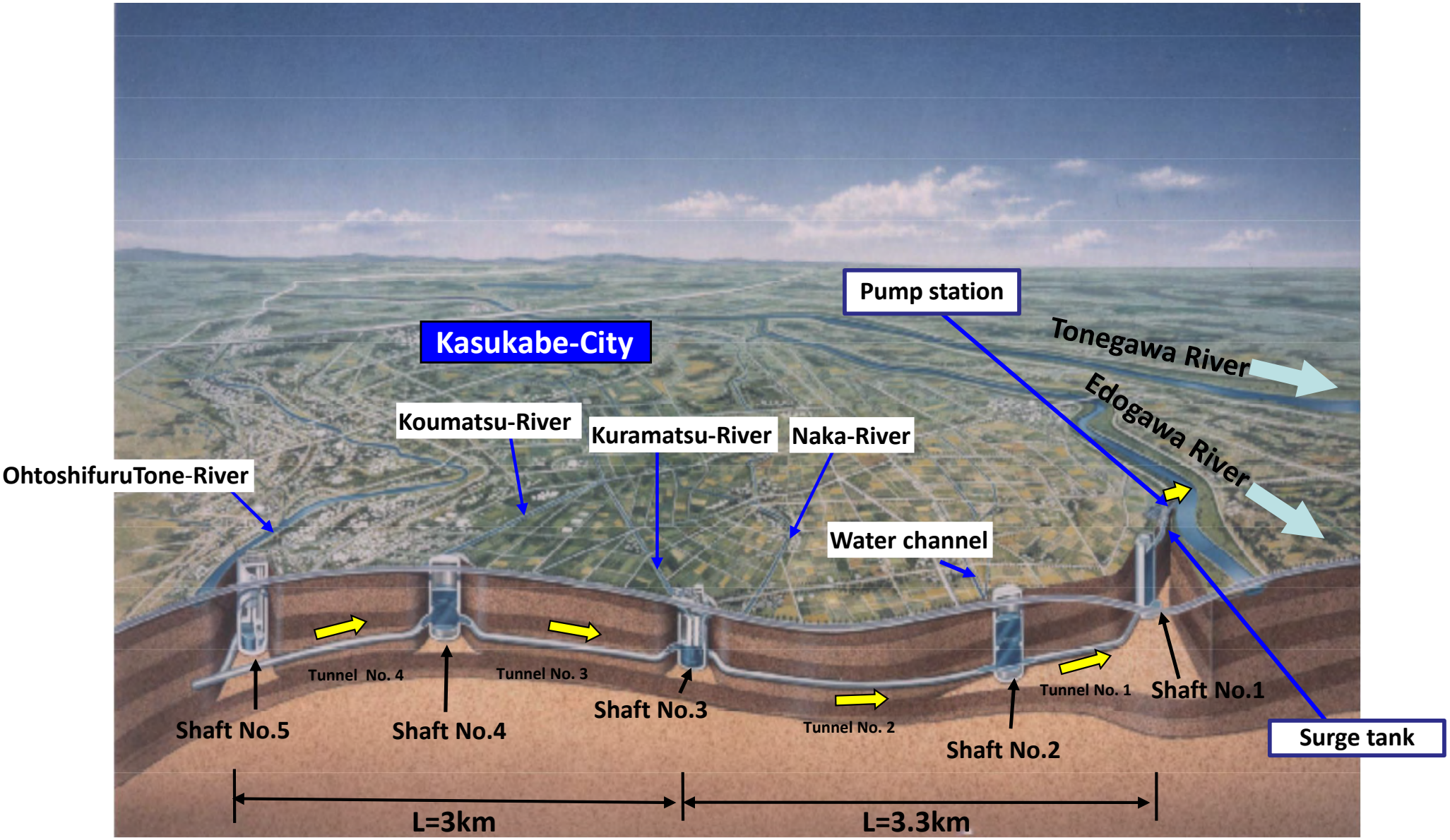
Take in floods of some rivers and discharge them into large River.



Metropolitan Outer Area Underground Discharge Channel

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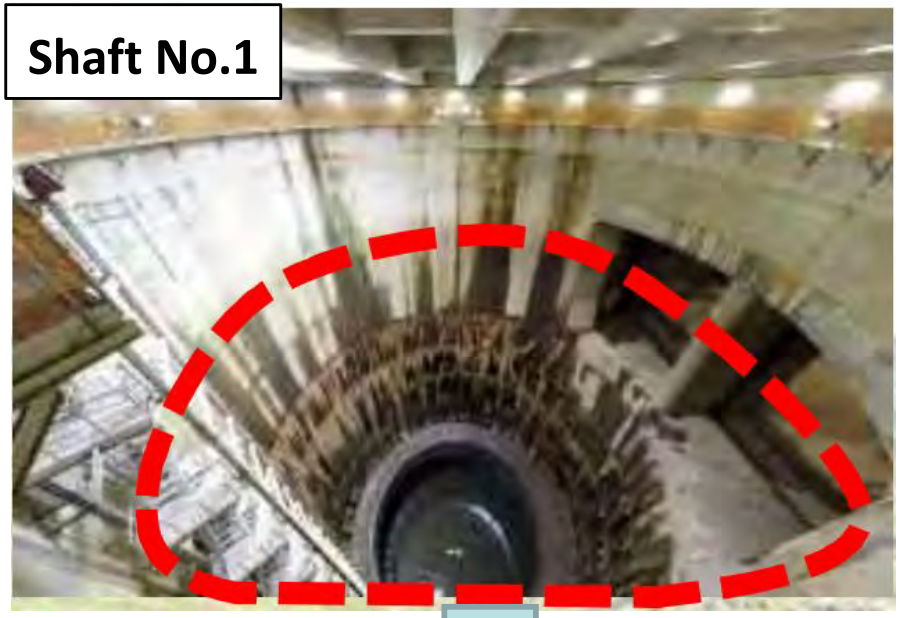

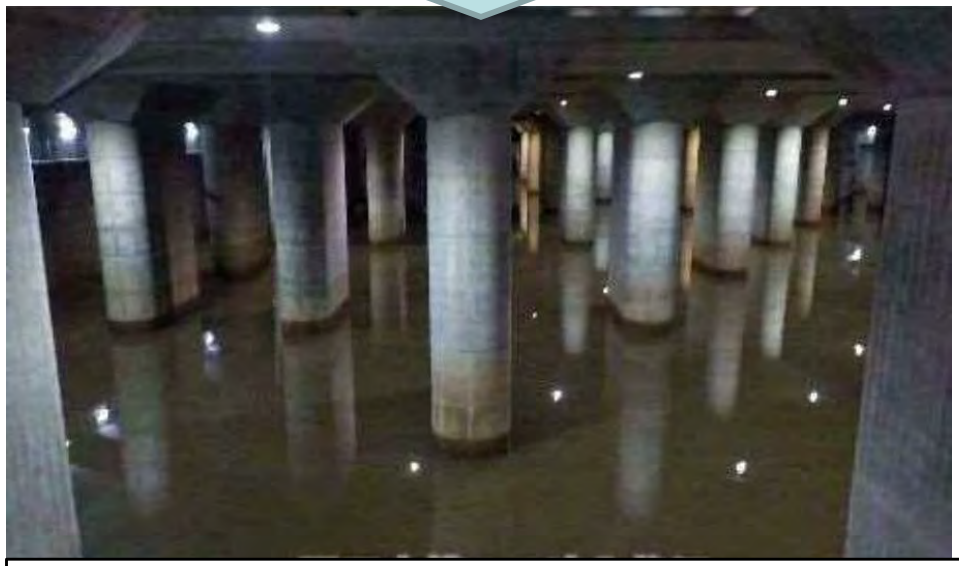

12 million stored (Oct. 14, 2019 Typhoon Hagibis)

FLOOD DISASTER EARLY WARNINGS

Warnings and Evacuation

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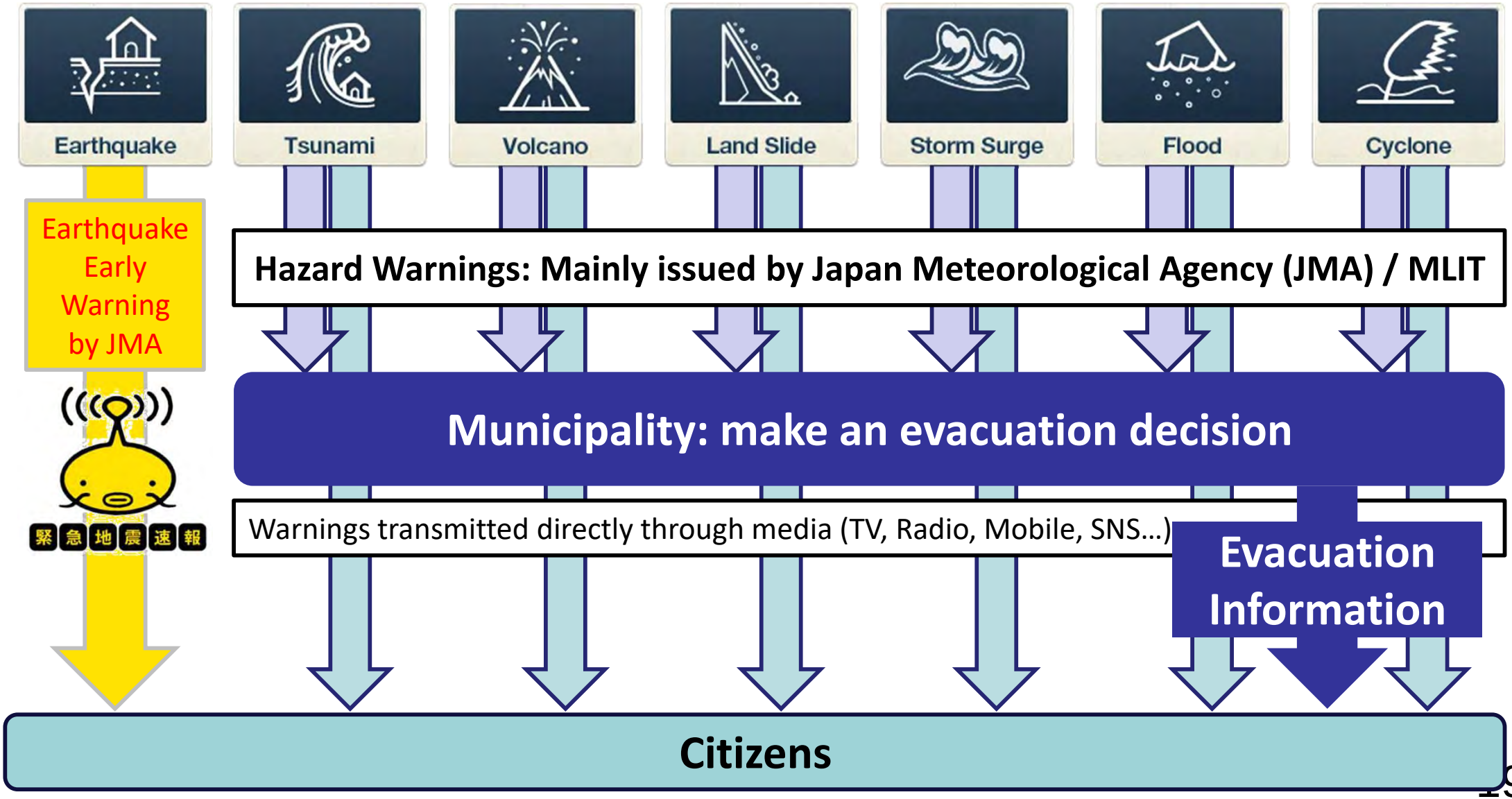
■ The Japanese government prepares various types of multi-hazard early warnings, which are shared with municipalities to support the issuance of evacuation information, and also shared directly with citizens. Earthquake EW will be quickly transmitted to citizens.



Source of the icons: Bosai Solution Map, Japan Bosai Platform (https://www.bosai-jp.org/en/solution)

Various Types of Disaster Warnings in Japan

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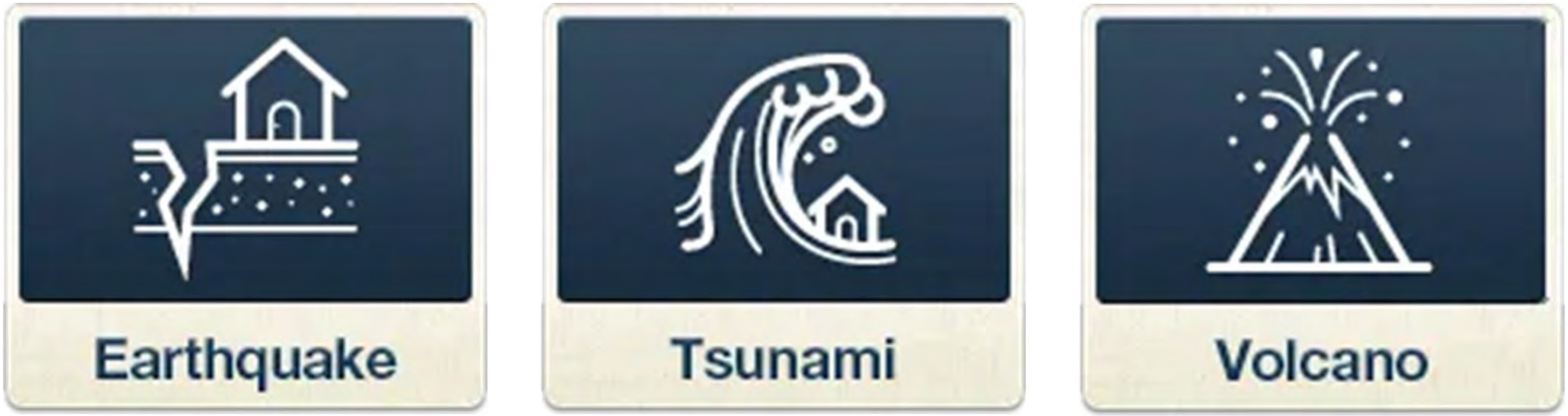
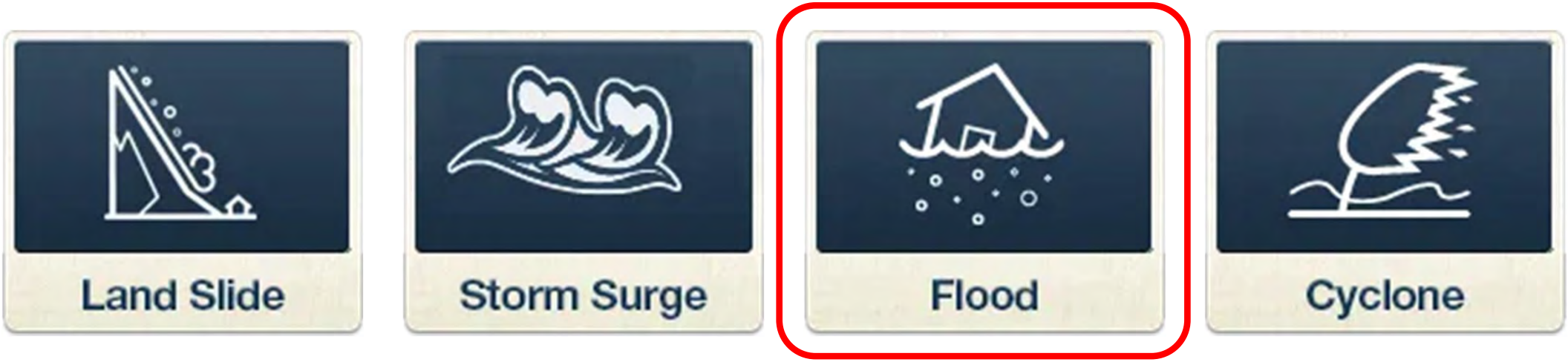
Geophysical hazards



Hydrometeological hazards



Source of the icons: Bosai Solution Map, Japan Bosai Platform (https://www.bosai-jp.org/en/solution)

Overview of Flood Disaster EW in Japan

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■ Japan's flood EW consists of **6 types** of services including **2 hydrological flood forecasts**, **2 meteorological-index-based warnings**, with **2 map-based complementary** information services.

	Flood information services				Rainfall and inundation Warning	
	Flood forecast		Flood Warning			
	Large rivers	Medium rivers	Complementary information			Complementary information
Target area	429 rivers	1,747 rivers	>22,000 rivers		All areas	All areas
Range	River section			Municipality		1km-mesh on map
Analysis	Based on hydrological forecasts			Based on meteorological index		
Service	Flood forecast	Water-level warning	Map-based information per section	Flood warning per area	Heavy Rain Warning per area	Map-based Information per 1km mesh
Target event	• Flooding				• Inundation	
Trigger	Level 2-4: Water-level (observed / forecasted) Level 5: Actual event	Level 2-4: Water-level (observed) Level 5: Actual event	Small rivers: Indicators based Large and medium rivers: Water-level	Indicators based on analysis or forecasts		

*This is a basic standard with some exceptions.

Structure of Water Level Forecast

- Flood forecasts are made based on rainfall observation and forecast by JMA, and water level observation and facility operation data by river managers (MLIT or prefectures).
- The run-off model and river model are shared between the JMA and the river managers.

気象庁
Japan Meteorological Agency

River Managers
(National offices for major rivers / Prefectural offices for others)

Rainfall Observation

Rainfall Prediction

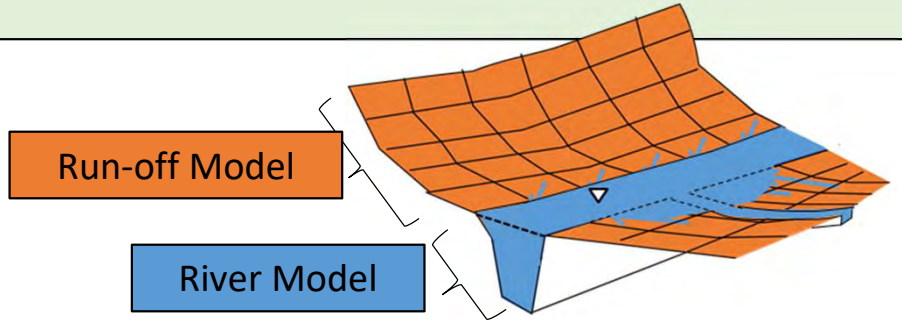
Flood forecasting model

Water level observation

Operation of dams and other facilities

- **Run-off Model**
  Calculate the amount of water flowing into rivers based on topographical data and predict the amount of runoff into rivers.
- **River Model**
  Calculate river water flow based on river channel topography data to predict water levels and flow rates

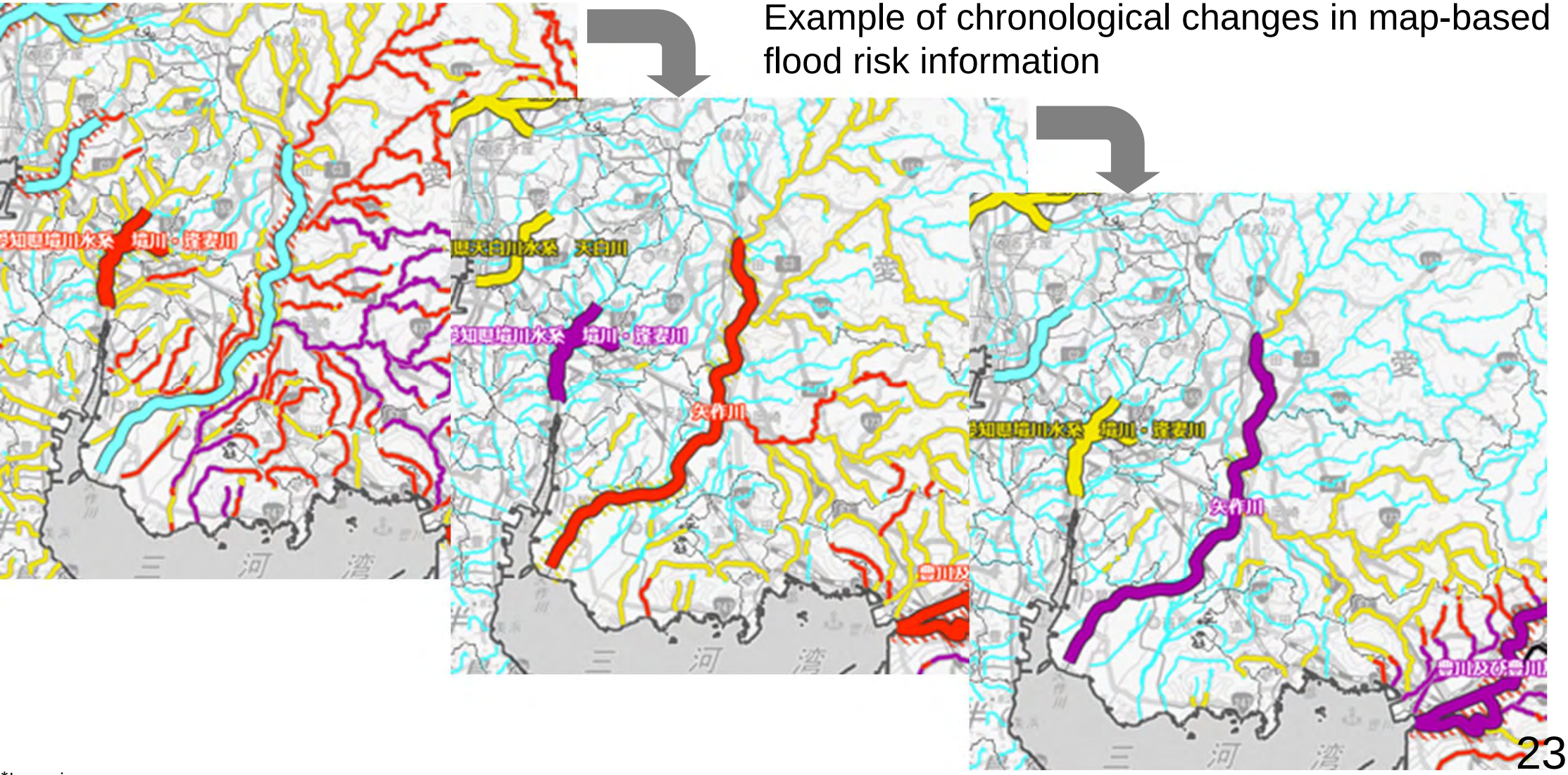
Water level and river flow forecast information



Map-based Flood Risk Information

- For smaller rivers, even without an individual flood forecast, flood risk information is provided for **each river section** by simple hydrometeorological estimation.
- The information is combined with flood forecast data for larger rivers and **displayed on a single map**.

Example of chronological changes in map-based flood risk information



*Large rivers are….

Flood and Rainfall Warnings

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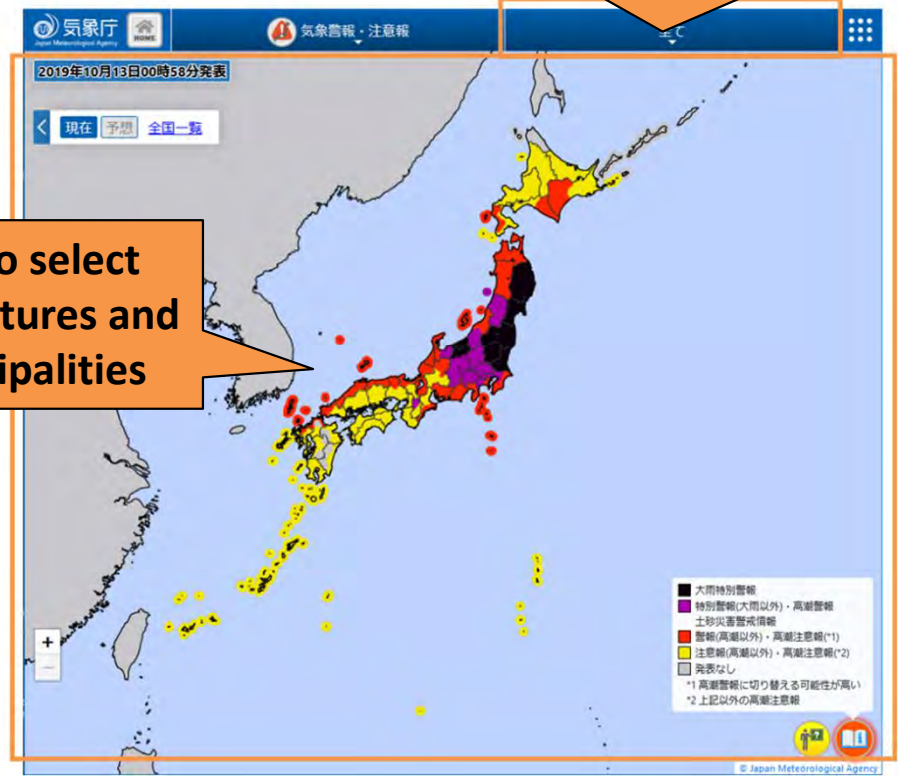
■ JMA provides multi-hazard are-based warning information through its website.

Categories of the warnings



Click to select prefectures and municipalities

Prefectural scale map

Municipal scale information:

a) Displays a summary of warning/caution events expected within the selected municipality and prefecture.

b) The type of 'Emergency Warning', 'Warning' or 'Advisory' currently being announced is displayed.

c) The progress of events every three hours, in terms of warnings and advisories issued.

Source: JMA Website (https://www.data.jma.go.jp/multi/warn/)

FLOOD HAZARD MAPS

MLIT Hazard Map Portal Site

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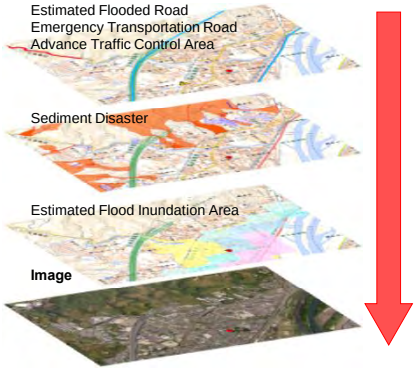
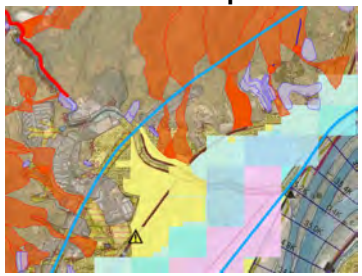
○ Make useful information public about disaster evacuations and disaster prevention measures to take in advance.
○ Various nationwide disaster prevention information can be viewed on one map.

Overlay Hazard maps

Information that is useful for the prevention of various disasters from around the country can be browsed and overlaid on one map.



Browse by superimposing on 1 map



Local Hazard Maps

Hazard maps for municipalities nationwide can be seen.

Flood Hazard Map, Chiyoda Ward, Tokyo

Tsunami Hazard Map, Fujisawa City

Various information on disaster prevention is available, making it useful for evacuation and prevention planning.

Search Evacuation Routes

Flood countermeasures

Earthquake resistance measures

Liquefaction countermeasures

Know the risks of your current location.

MLIT Hazard map Portal Site http://disaportal.gsi.go.jp/

Hazard Maps Search

Universal design of “overlay hazard maps”

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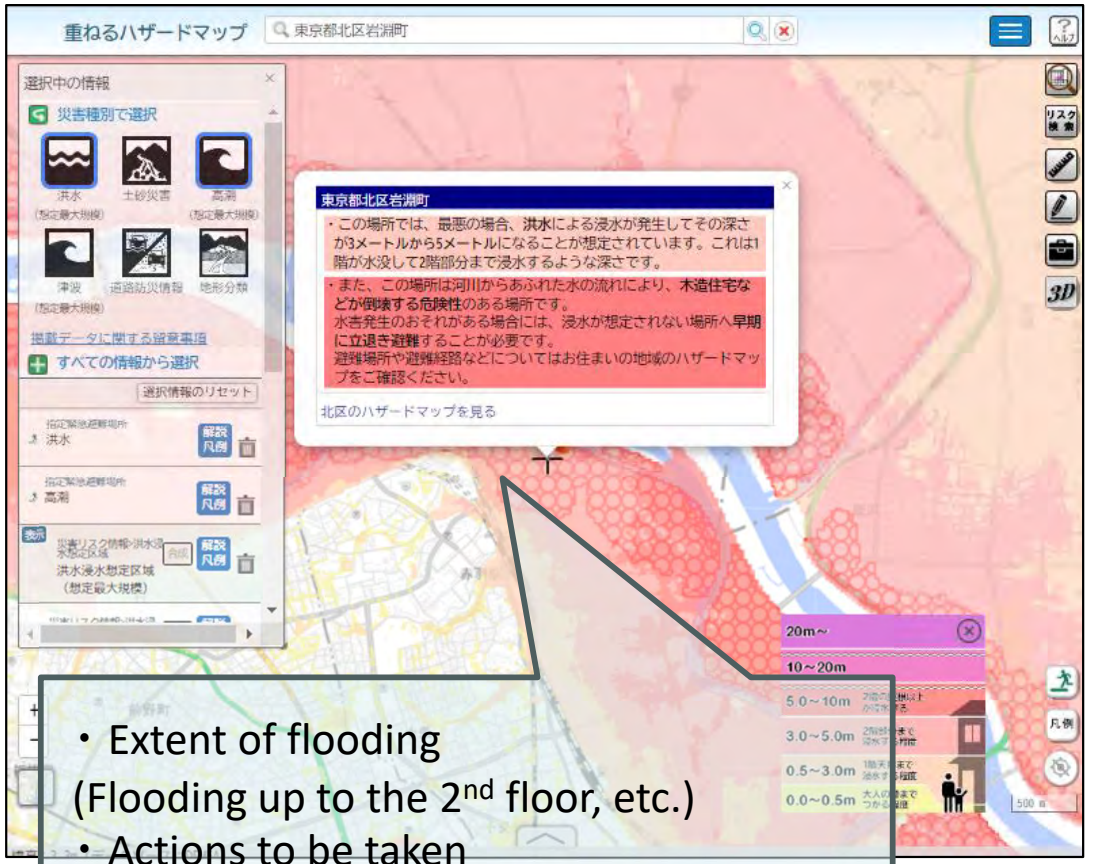
○ A new function has been added that allows users to simply enter an address or search for their current location without having to click on an icon or map; the disaster risk at that location and the actions to be taken in the event of a disaster will automatically be displayed in text.

Top Page

・Enter address
・Search current location

Explanation of disaster risk



・Extent of flooding
(Flooding up to the 2nd floor, etc.)
・Actions to be taken
(necessity of evacuation, etc.)

Flood Risk / Frequency Map

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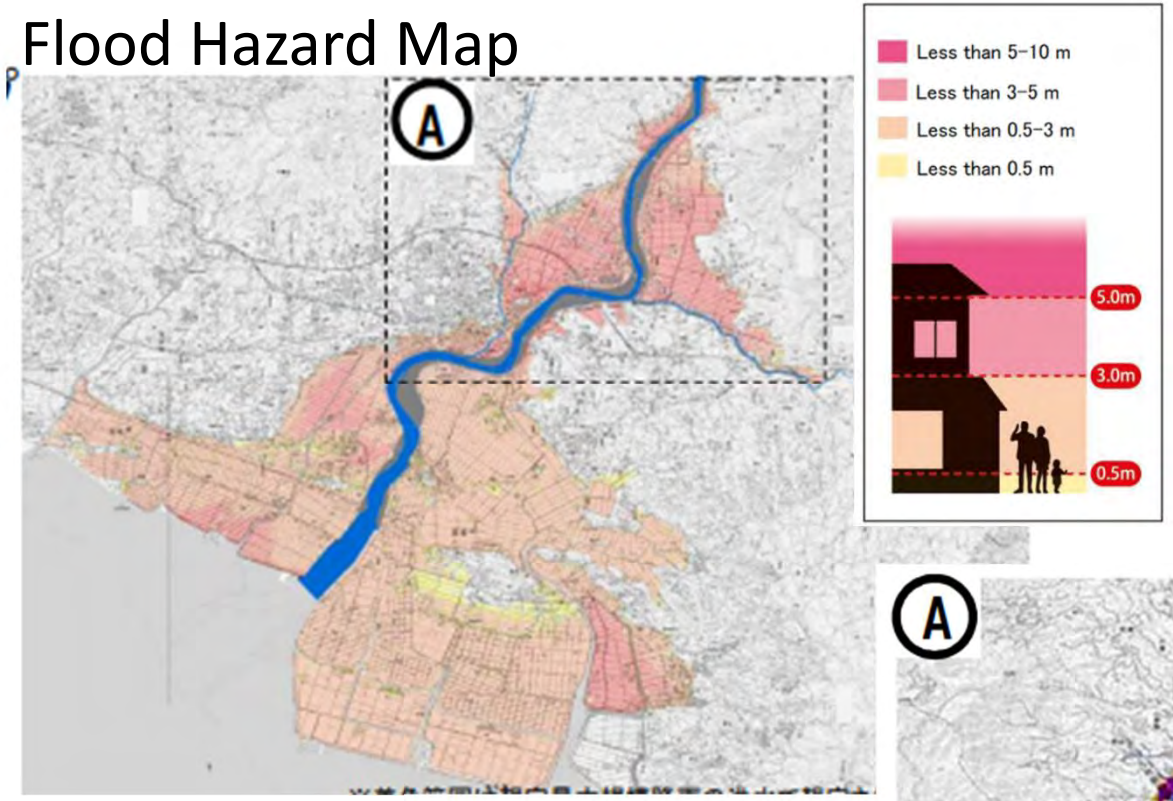
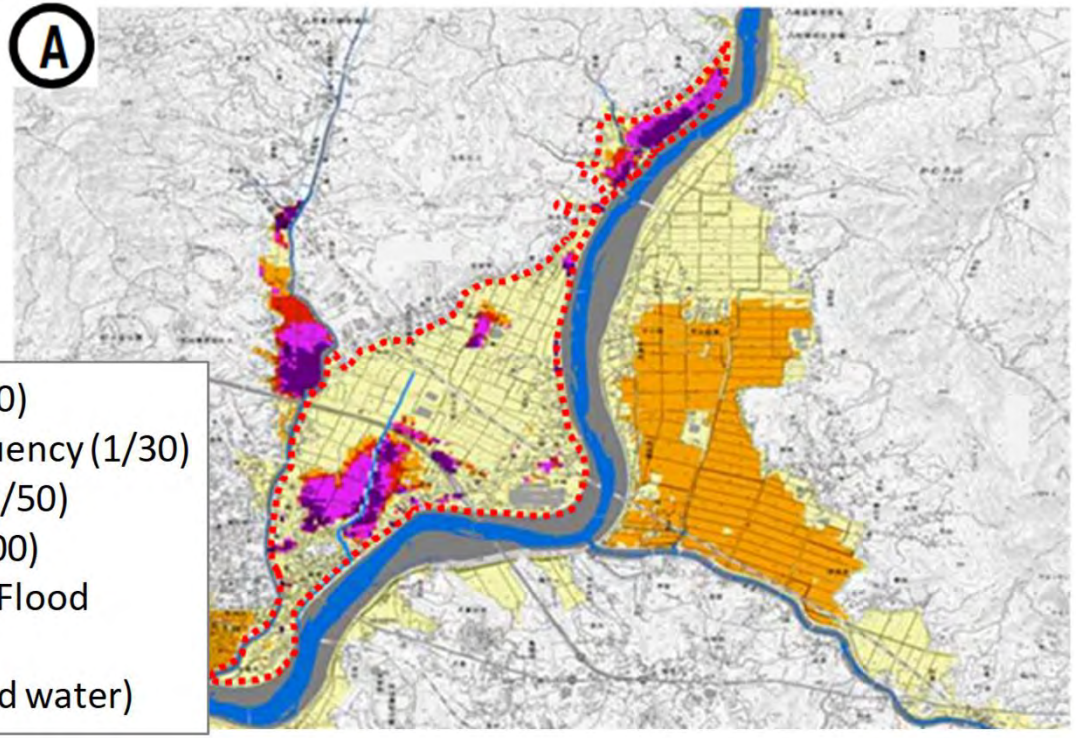
Flood Hazard Map



Flood Frequency Map

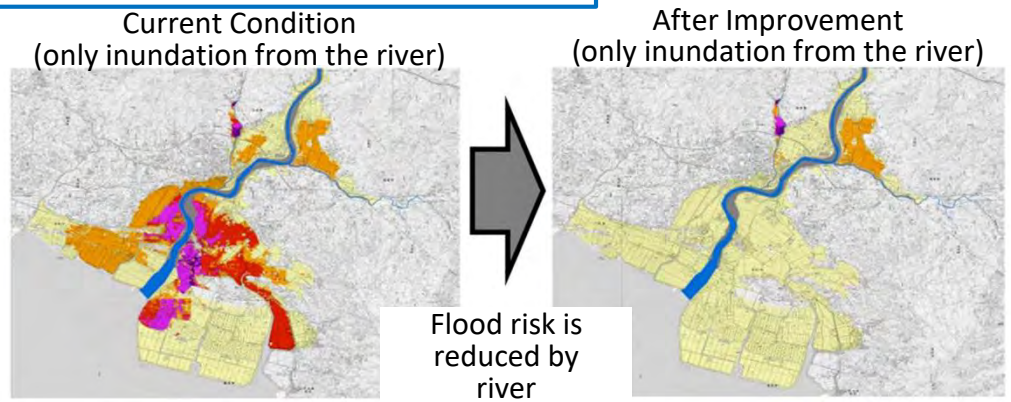


High Frequency (1/10)
High & Middle Frequency (1/30)
Middle Frequency (1/50)
Low Frequency (1/100)
Probable Maximum Flood
Analysis area
(Inundation by Inland water)

Utilization of Flood Risk Assessment Results

- Visualize the effects of damage mitigation by organizing damage data (extent of inundation, number of fatalities, amount of damage, etc.) in response to various external forces, and study damage mitigation measures based on the information.

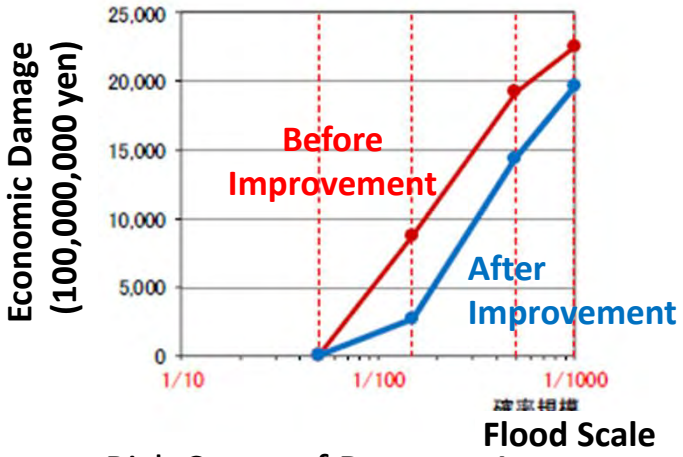
Method of Flood Risk Assessment



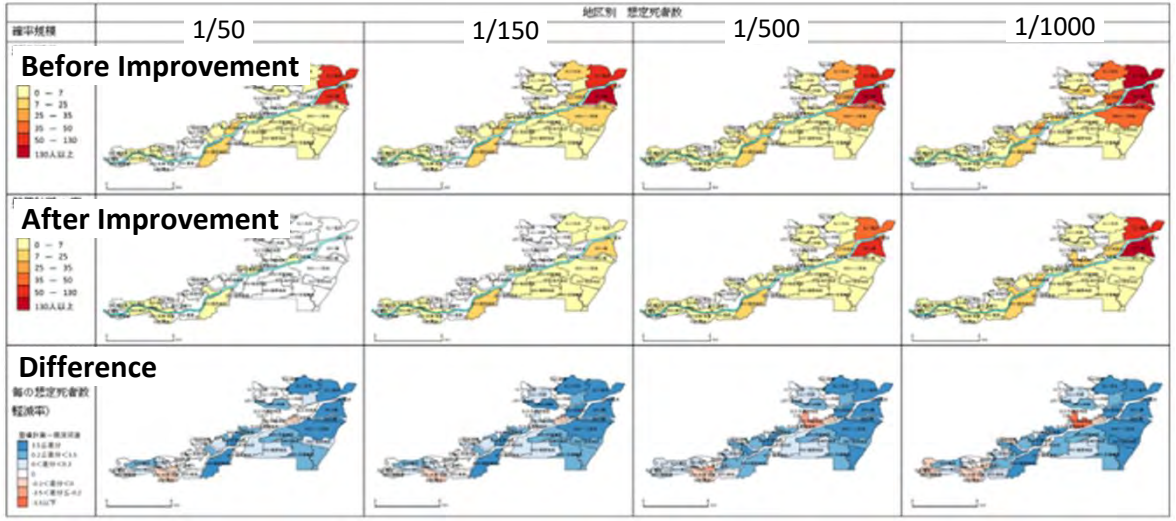
Flood Risk Map (before and after river improvement)

- ✓ To clearly indicate the changes in flood risk based on current and future inundation analysis and helps to visualize the effects of countermeasures such as infrastructure development.
- ✓ This can lead to appropriate disaster prevention planning.

Whole River Basin



Risk Curve of Damage Amount



Assumed number of fatalities and distribution of mitigation effects

Land Use Management

MLIT Ministry of Land, Infrastructure, Transport and Tourism

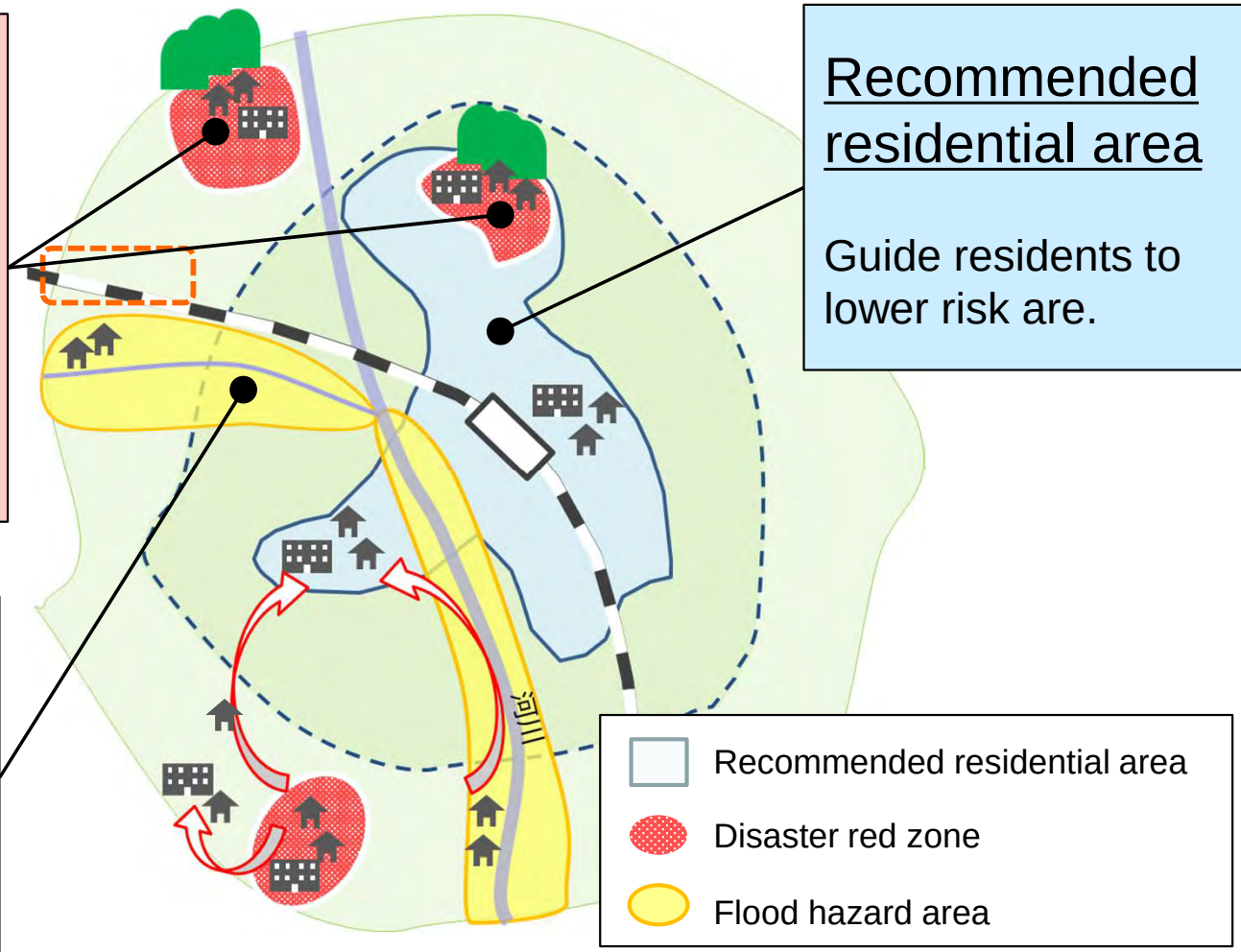
○ Guide residents to lower risk areas
○ Mandatory to present a hazard map during real estate transactions and provide information on the location of the property concerned, etc.

[Disaster red zone]
No permission for new developments(*) in principle

(*)Housing and business building(store, hospital, social welfare facility, hotel, factory, etc.)

[Flood hazard area]
Conditional permission(*) for new developments

(*)with condition of safety and evacuation measures

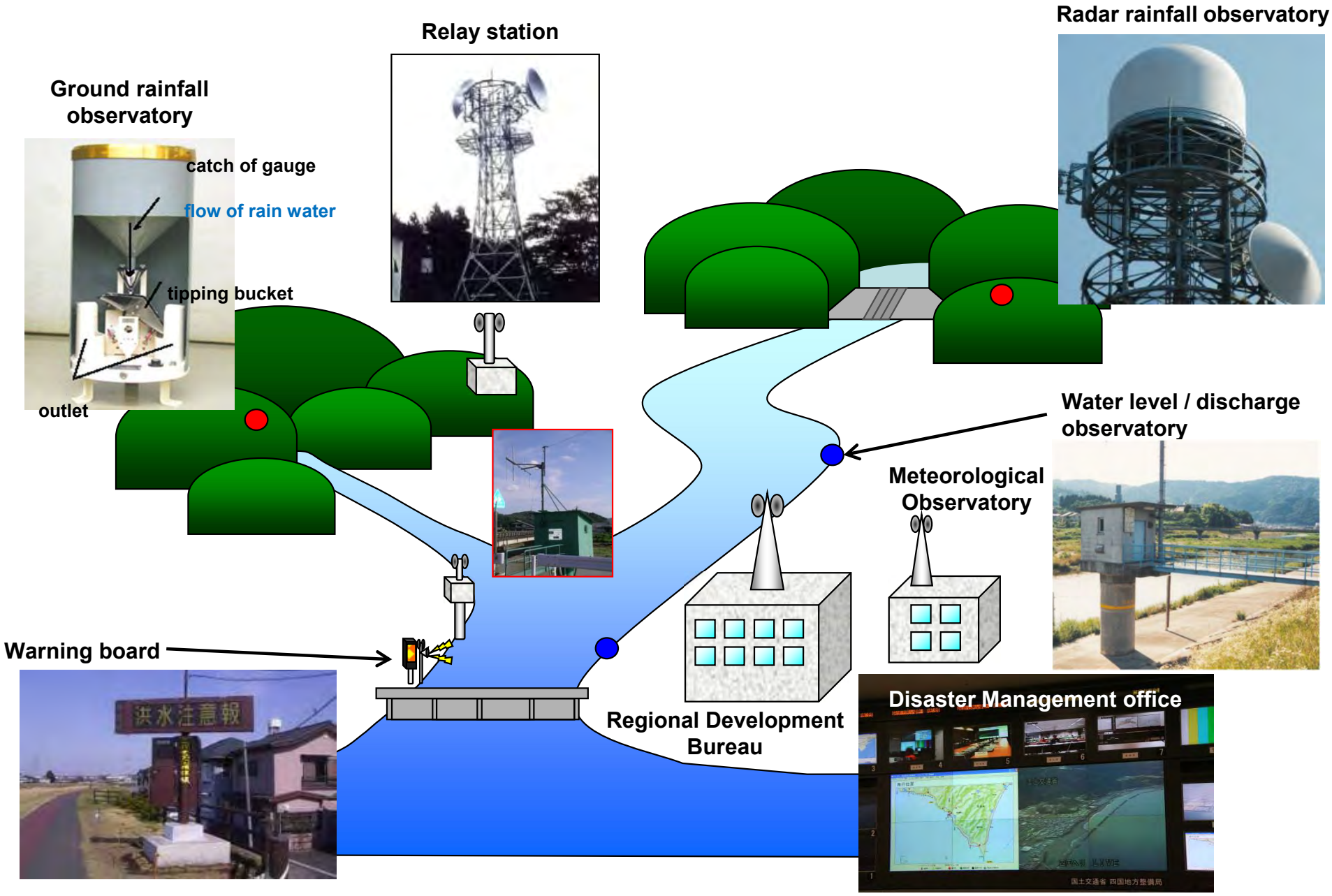


Recommended residential area

Guide residents to lower risk are.

OBSERVATION NETWORKS

Hydrological observatory network in Japan



Hydrological Observation System

- Hydrological observatories are developed for providing basic data necessary for flood control, irrigation, and environmental purposes in river planning, river improvement and maintenance.
- 8,728 rain-gauges, 14,986 water-gauges, and 65 rainfall radars have been developed by JMA/MLIT.

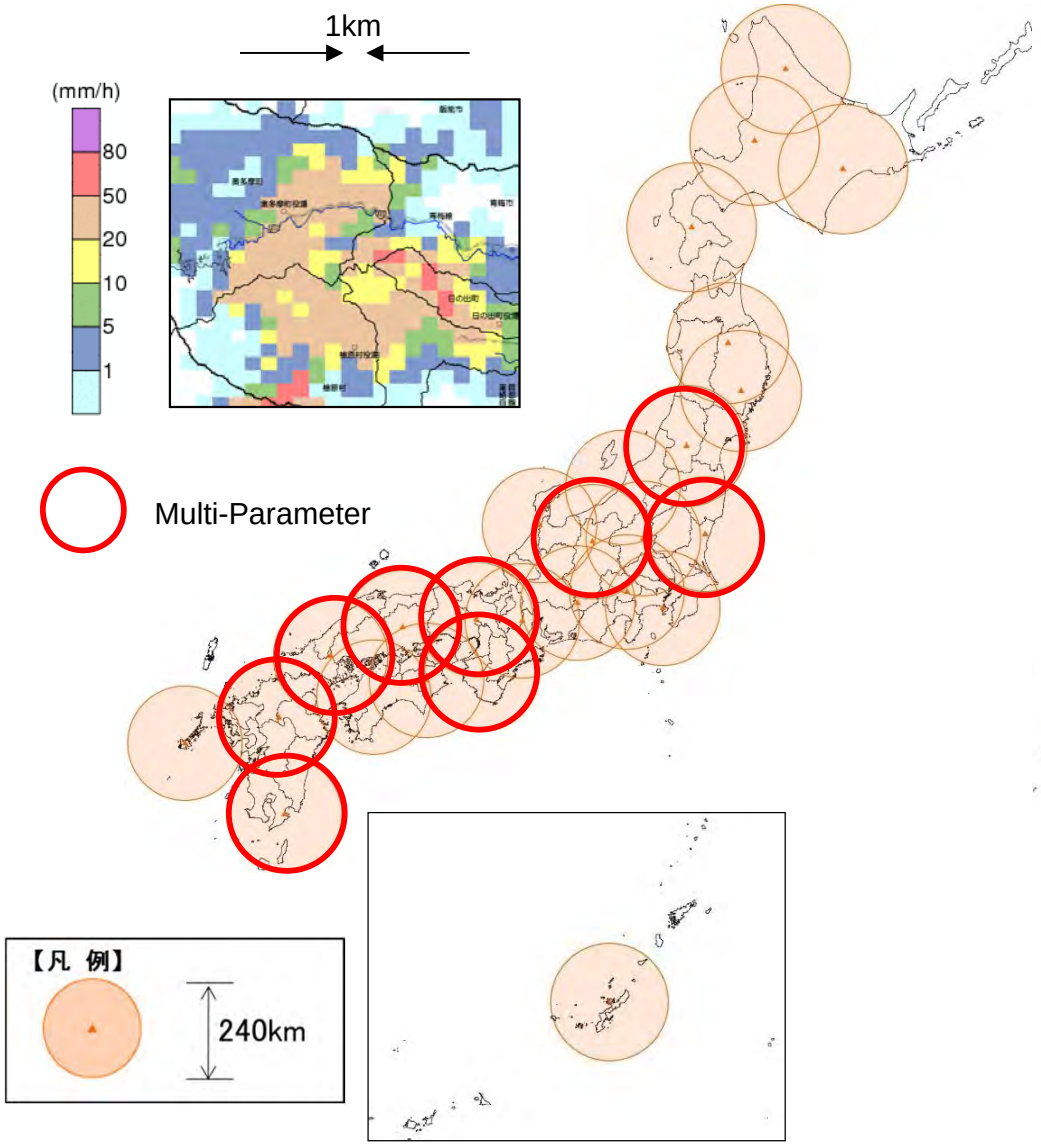
Administrator	Rain gauge station	Water gauge station		
		Regular	Simplified	Total
Water and disaster management bureau, MLIT	2,404	2,078	2,722	4,850
Japan Meteorological Agency	1,286	-	-	-
Prefectures and Japan Water Agency	5,038	4,892	5,244	10,135
Total	8,728	6,970	8,016	14,986

(as of 2024.2)

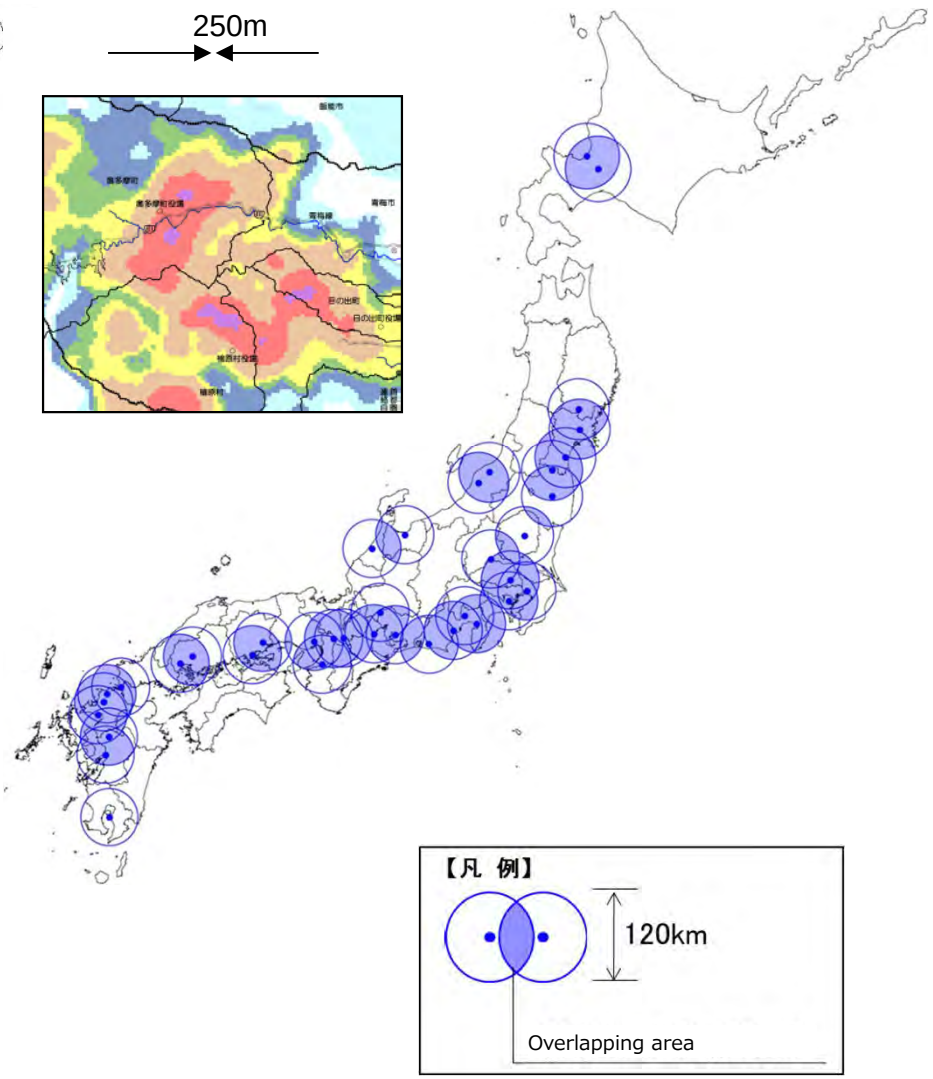
Type	Frequency	Location of observatory
Rain gauge station	▪ hourly ▪ 10 min (flood time, etc.)	▪ 1 observation post in each region displaying uniform rainfall conditions ▪ 1 observation post roughly every 50 km^2
Rainfall radar	▪ C-band：5 min to 10 min ▪ X-band：1 min to 2 min	▪ C-band (26): quantitative observation range radius of 120 km ▪ X-band (39): quantitative observation range radius of 60 km
Water gauge station	▪ hourly ▪ 10 min (flood time, etc.)	▪ Locations where permanent observation is necessary to create reference points for river improvement projects and water resource development projects ▪ Locations where necessary for flood forecasting and flood protection warnings ▪ Locations where important for understanding river discharge characteristics
Discharge observatory	▪ Low flow measurement: 36+ times / yr ▪ Flood flow measurement: 10 floods / yr	▪ 1 observation post in each region displaying uniform rainfall conditions ▪ 1 observation post roughly every 50 km^2

Rainfall Observation

C-Band Radar (26 units)



X-Band MP Radar (39 units)



CCTVs

- Inexpensive and easy-to-install cameras with limited zoom and swivel functions
- Installation in areas with high flood risks where residential buildings and important facilities are located
- Encourage appropriate evacuation decisions by sharing real flooding situations as images with residents, in addition to water level information

Easy outdoor installation

- Neither a power supply nor communication cables are required for wireless types (wireless, solar batteries, etc.)

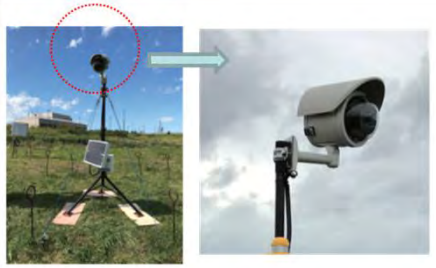
Reduction in costs by limiting functions

- No zoom or swivel functions
- Main device priced at around 300,000 yen/unit

Image gathering via the Internet

- Combine water level gauge data with risk control functions and provide it to the general public

[Comparison with the conventional type]

	Conventional CCTV cameras	Simplified river monitoring cameras
Photographic image		
Image	Video (HD)	Stll images (HD)
Communication method	Wired (optical fiber)	Wireless (LTE, etc.)
Power supply	Commercial power supply	Solar battery, etc.
Other information	Swivel and zoom functionality With screen wiper	Transmits a still image every five minutes

No. of announcements of river safety information (as of the end of Mar. 2024)	Conventional CCTV cameras	Simplified river monitoring cameras	Total
MLIT	4,278	2,060	6,338
Prefectures, etc.	666	3,685	4,351
Total	4,944	5,745	10,689

River water level information website

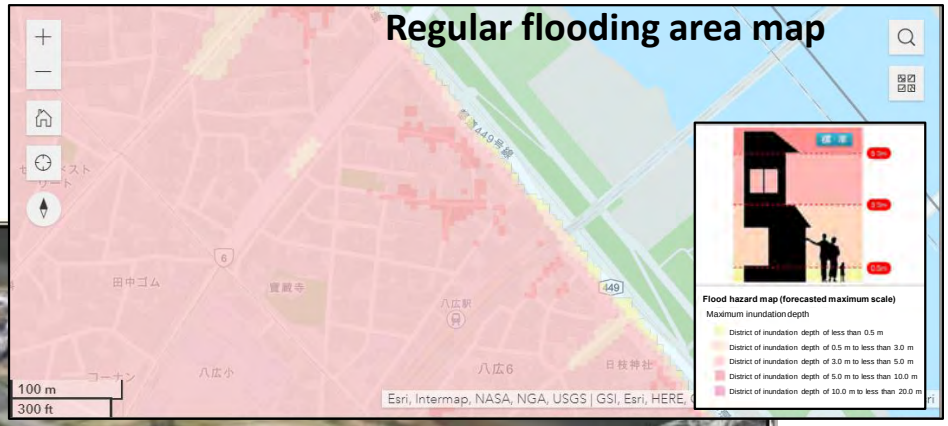
NEW TECHNOLOGIES

Promotion of 3D Displays of Flood Risk Information

MLIT Ministry of Land, Infrastructure, Transport and Tourism

3D flooding area map (example of Arakawa River)

- 3D displays are effective as risk communication tools, as they make it easy to see the risk of inundation around homes.

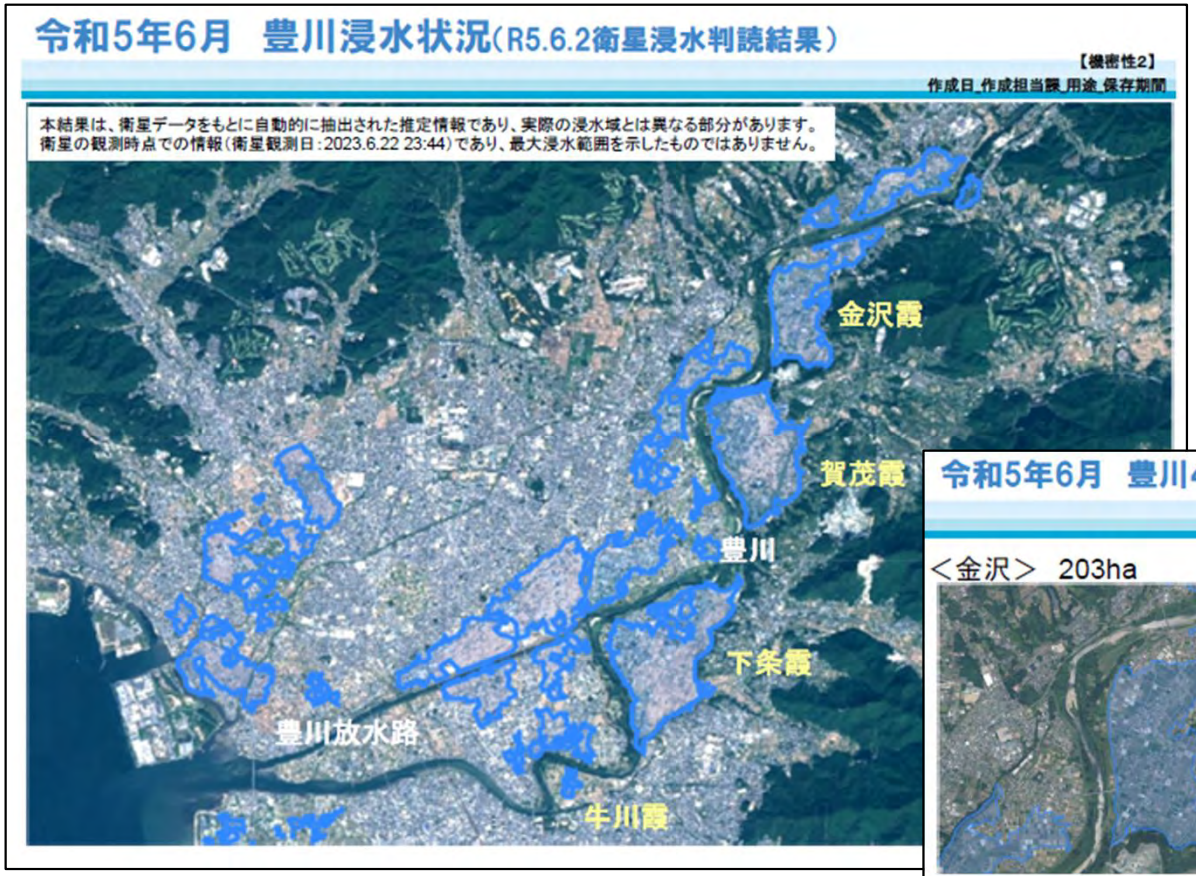


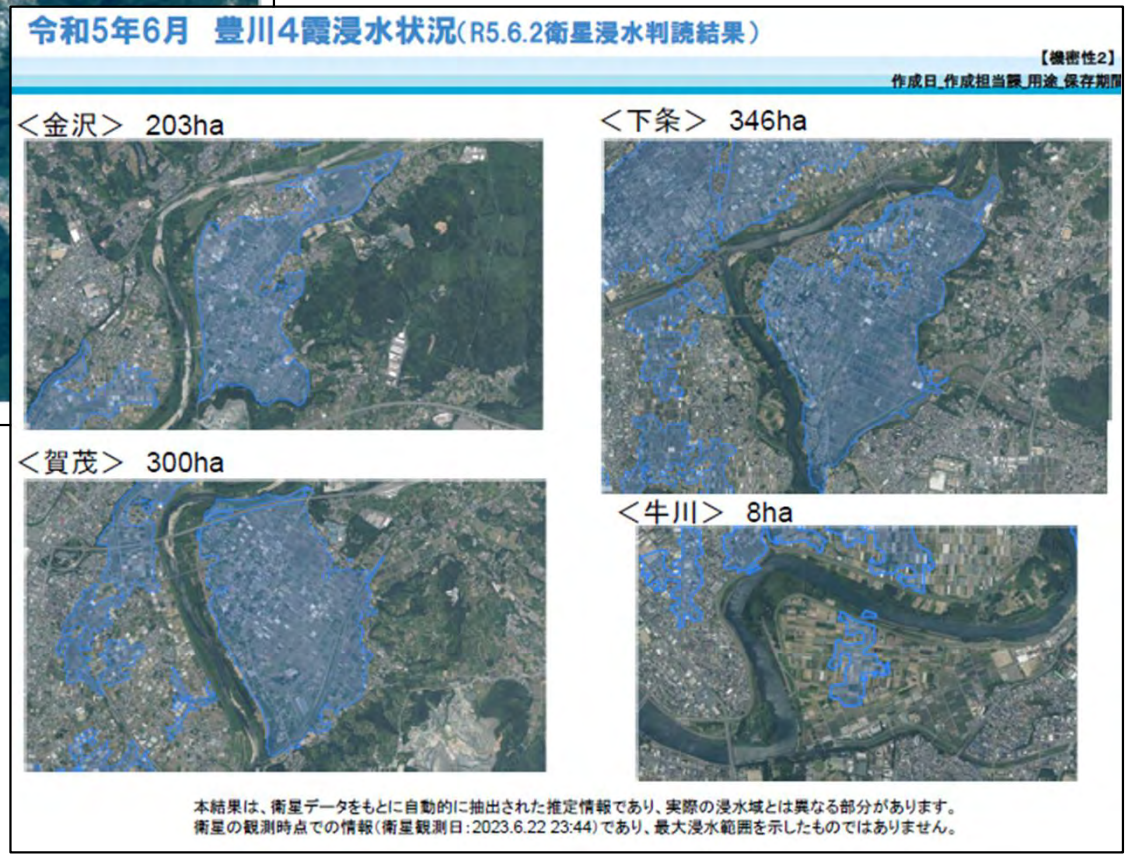
Arakawa 3D flooding area map URL https://experience.arcgis.com/experience/a14b9a7cee8943889babc2096f5a5fe7/page/page_0/?views=view_1

Utilization of Satellite Data for Inundation Analysis

MLIT Ministry of Land, Infrastructure, Transport and Tourism

➢ **Preliminary damage report just after the inundation event**





Utilization of Satellite Data for Inundation Analysis

MLIT Ministry of Land, Infrastructure, Transport and Tourism

- **Rough estimate of flood volume to assist in planning the use of pump-equipped vehicles**

排水施設	設置場所	規格	排水開始	排水完了
小坂井排水機場	同左	約8m3/s	2023/6/2 12:43	2023/6/3 20:20
排水ポンプ車(庄内川)	小坂井排水機場周辺	30m3/min	2023/6/3 10:35	2023/6/3 23:00
排水ポンプ車(豊橋)	同上	30m3/min	2023/6/3 10:45	2023/6/3 23:00
排水ポンプ車(中部技術)	小坂井高校周辺	30m3/min	2023/6/3 16:00	2023/6/3 18:00

One-coin flood sensors

MLIT Ministry of Land, Infrastructure, Transport and Tourism

Inundation damage identification

Helicopter survey

Real-time
- Unable to perform the survey in bad weather and at night

Trace survey

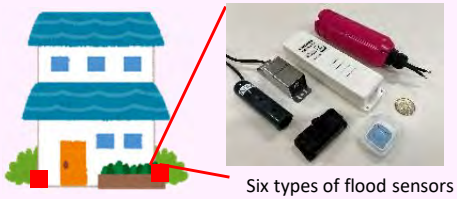
Mobility
- Unable to survey a wide area
- Need manpower
- Need technical experts

Existing technologies

One-coin flood sensor

Characteristics

Compact, inexpensive, durable flood sensors for installation at multiple sites on levees and in river basins

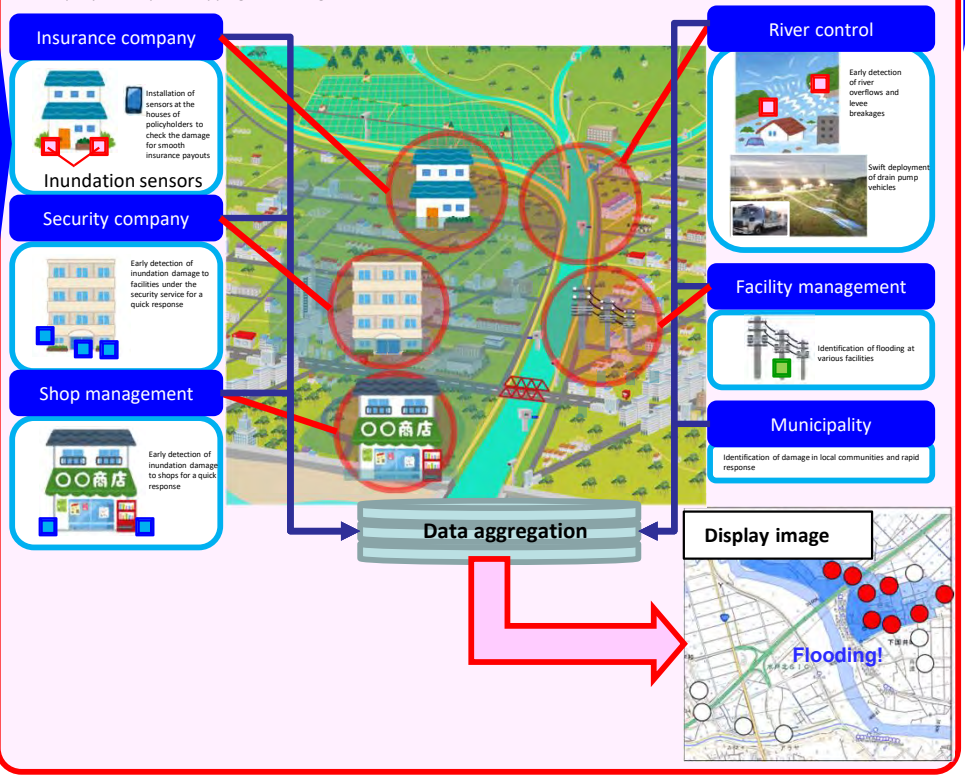


- Compact
- Low cost
- Long life

Six types of flood sensors used during the demonstration experiment

Image of inundation area identification under the public-private partnership

Establish an information-gathering mechanism by installing flood sensors in partnership with companies and local governments to rapidly identify overtopping or breakages of levees and inundation conditions in local communities



Technology development

Utilization image

During a disaster
- Early staffing
  (Road closures due to flooding
  Shelters opening, etc.)
- Consideration of pump vehicle deployment

During the restoration phase
- Simplification and acceleration of disaster certification (by municipalities, etc.)
- Early insurance payouts
- Early response for restoration

etc.

Schedule

FY2021
- Held a preparatory meeting for a demonstration experiment
- Considered and decided on sensor specifications and the contents of the demonstration experiment

FY2022
- The government, municipalities, private companies, etc., installed a total of 10 sensors in 5 model municipalities to start the demonstration experiment

FY2023
- Expanded the model municipalities to 58, with the government, municipalities, private companies, etc., installing a total of 26 sensors to continue the demonstration experiment
- Expand the area as necessary

(As of Jan. 4, 2024)

One-coin flood sensors

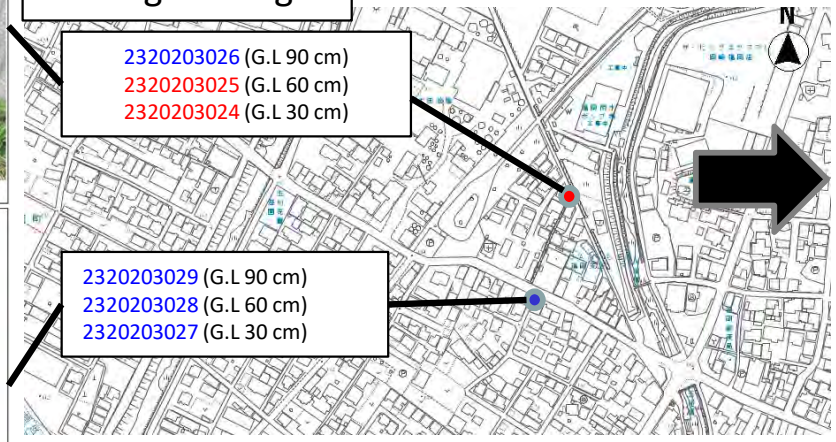
MLIT Ministry of Land, Infrastructure, Transport and Tourism

In 2022, inundation due to Typhoon No. 15 (TALAS) was detected by the flood sensors installed in Okazaki City (from 15:00 to 24:00, Sept. 23, 2022)

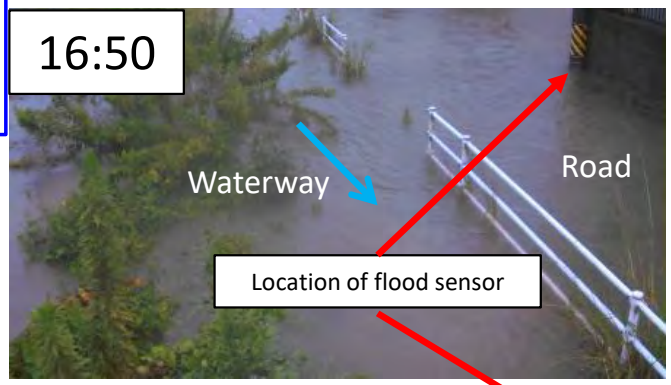
Sensors installed in the Fukuoka school district in Okazaki City

Two flood sensors installed at one site out of six installed at two sites in the Fukuoka school district detected the inundation from the late afternoon to the early evening on Sept. 23, 2022.

Enlarged image



Detection
No detection



Time of detection

Sensor ID	15:00	15:30	16:00	16:30	17:00	17:30	18:00	18:30	19:00	19:30	20:00	20:30	21:00	21:30	22:00	22:30	23:00	23:30	24:00
2320203025																			
2320203024																			

Inundation detection time

Sensor type: RIPRO Corporation

15:25
The Okazaki municipal disaster control headquarters was established following the announcement of a heavy rain warning (landslides and flooding) and flood warning.

18:06
The emergency deployment system changed from an alert to primary emergency deployment.

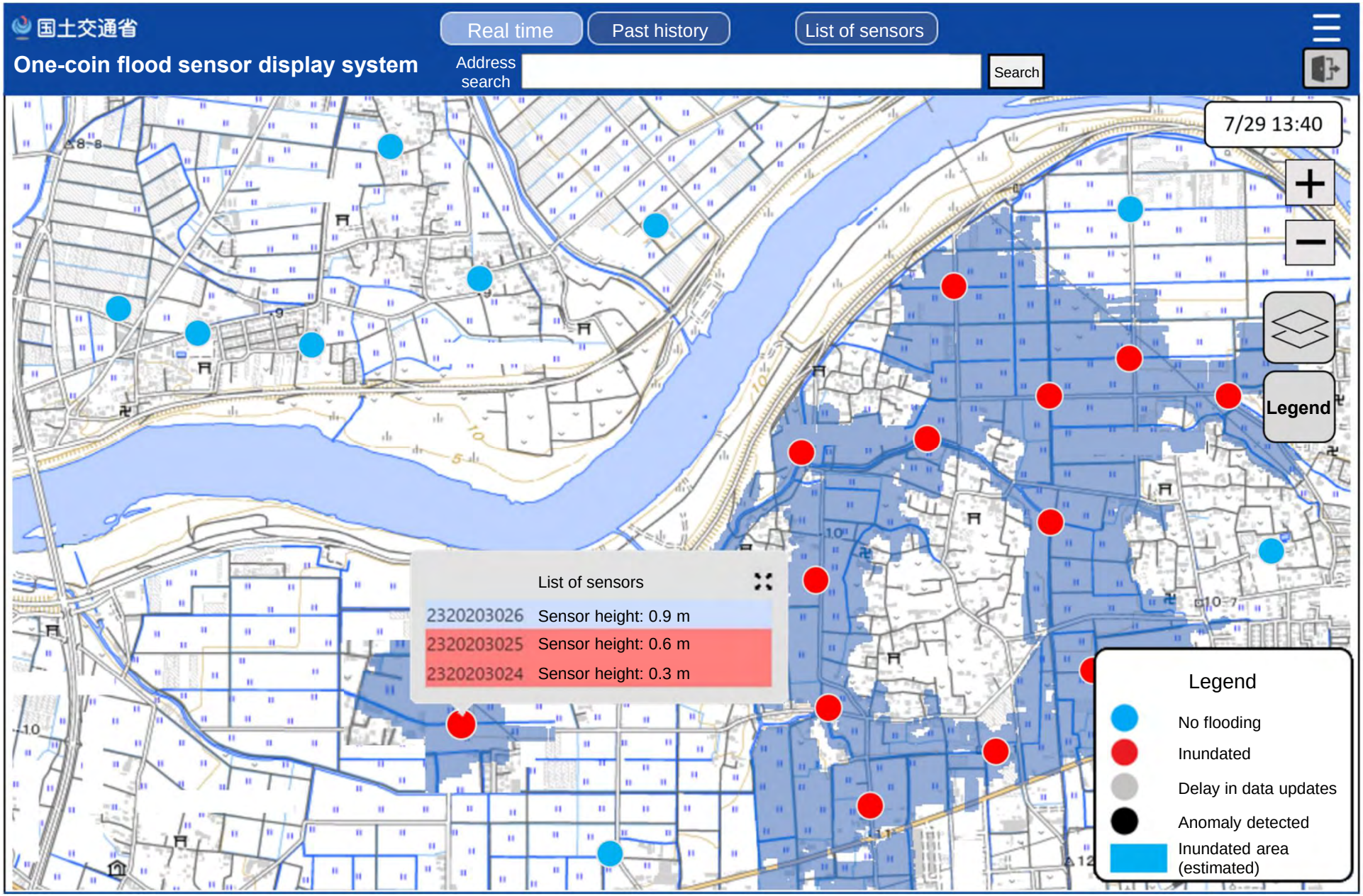
20:57
The heavy rain warning (landslides and flooding) was lifted. The emergency deployment system changed from primary emergency deployment back to an alert.

22:46
The flood warning was lifted.
The Okazaki municipal disaster control headquarters was dissolved.

- **The sensor manufacturer confirmed the arrival of inundation detection information from the sensors to its server.**
- **Okazaki City confirmed the inundation information on the website for the manufacturer's viewing system.**

One-coin flood sensors

Detection status of the flood sensors (image)



THANK YOU !!