Various measures against water-related disasters in Japan

～Case studies based on risks and river basins～

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2. Case studies of Tone River and Arakawa River

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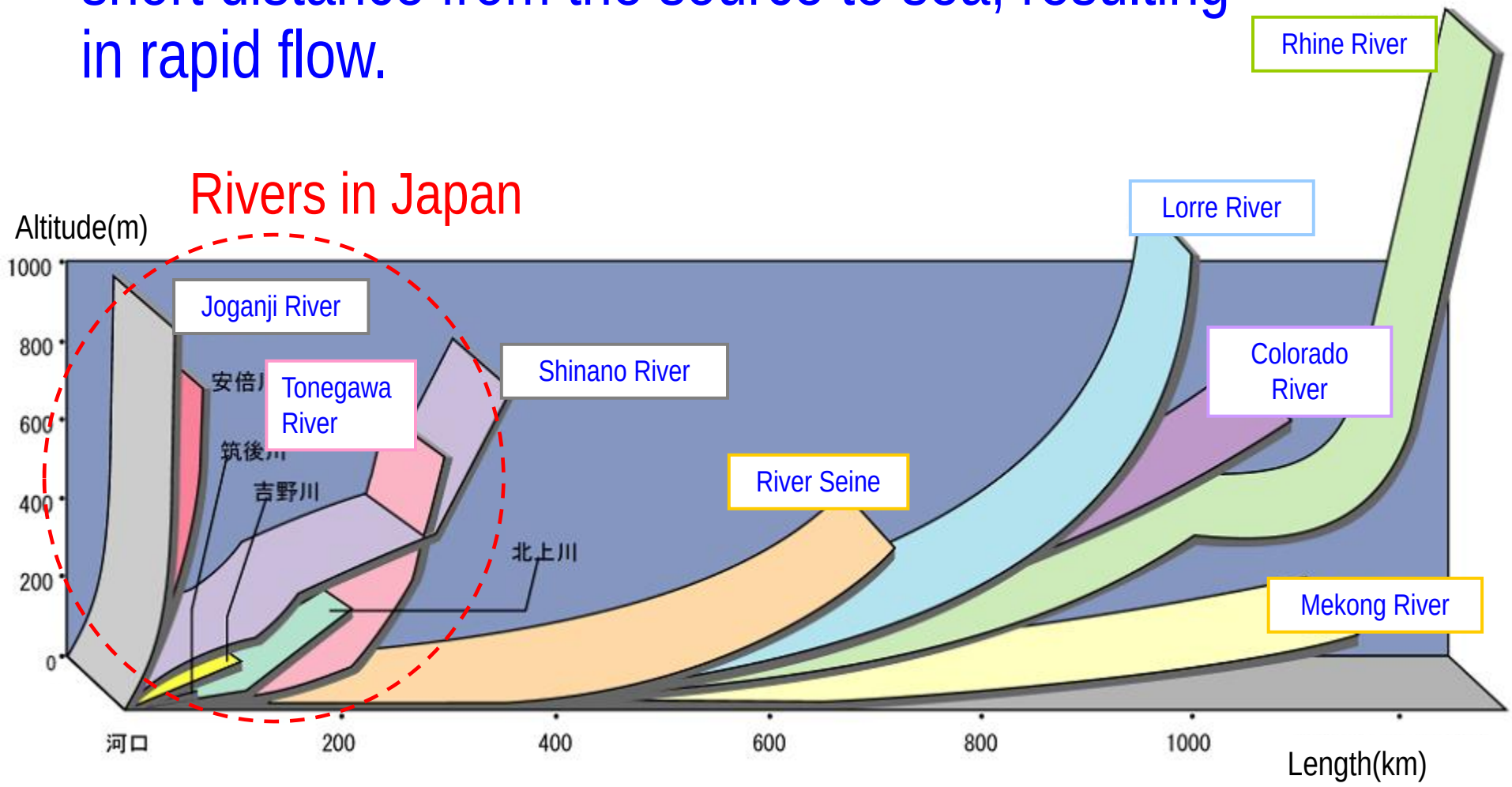
4. Lessons Learned

Various measures against water-related disasters in Japan

Contents

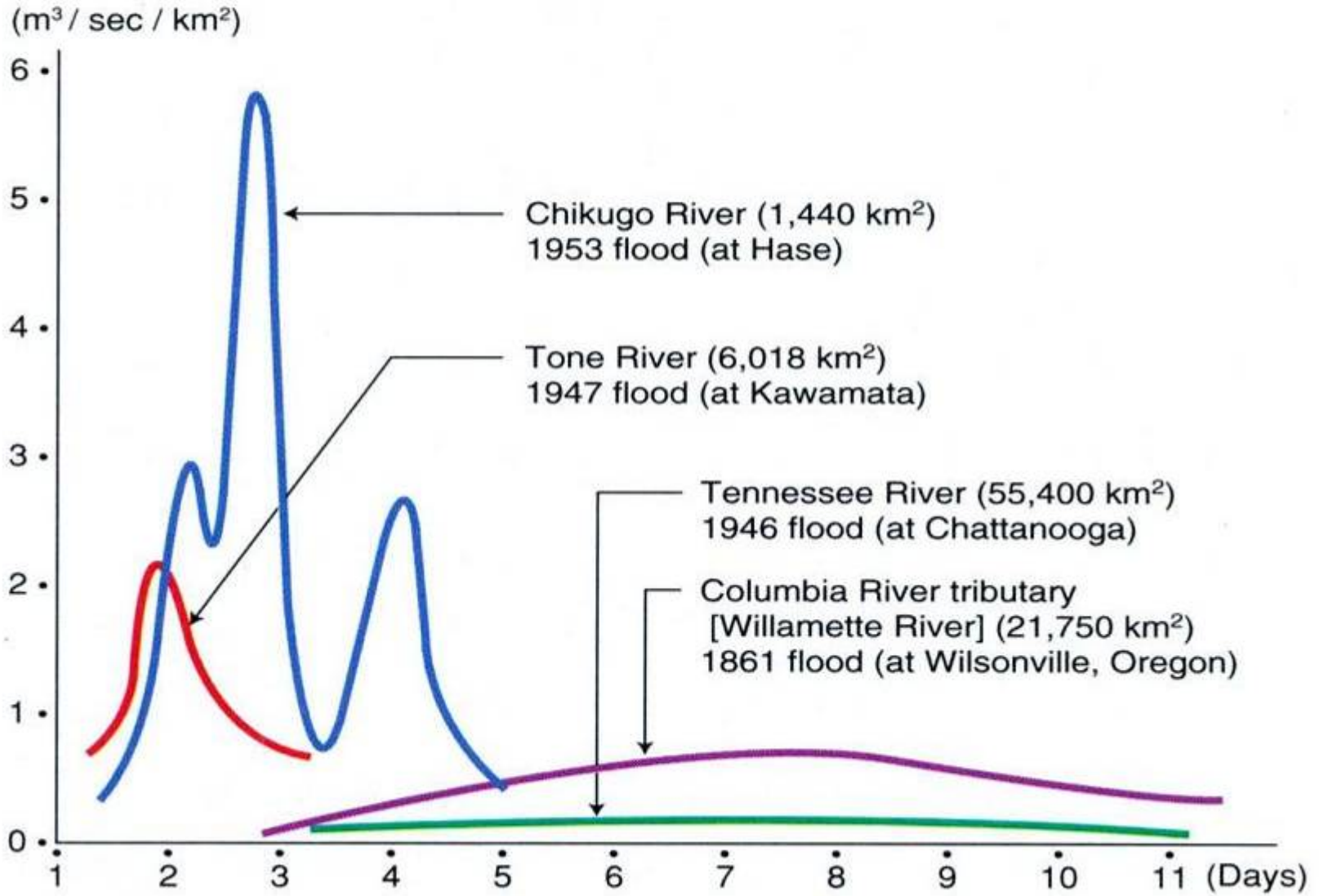
Rivers in Japan are very steep

Many rivers in Japan are very steep with a short distance from the source to sea, resulting in rapid flow.

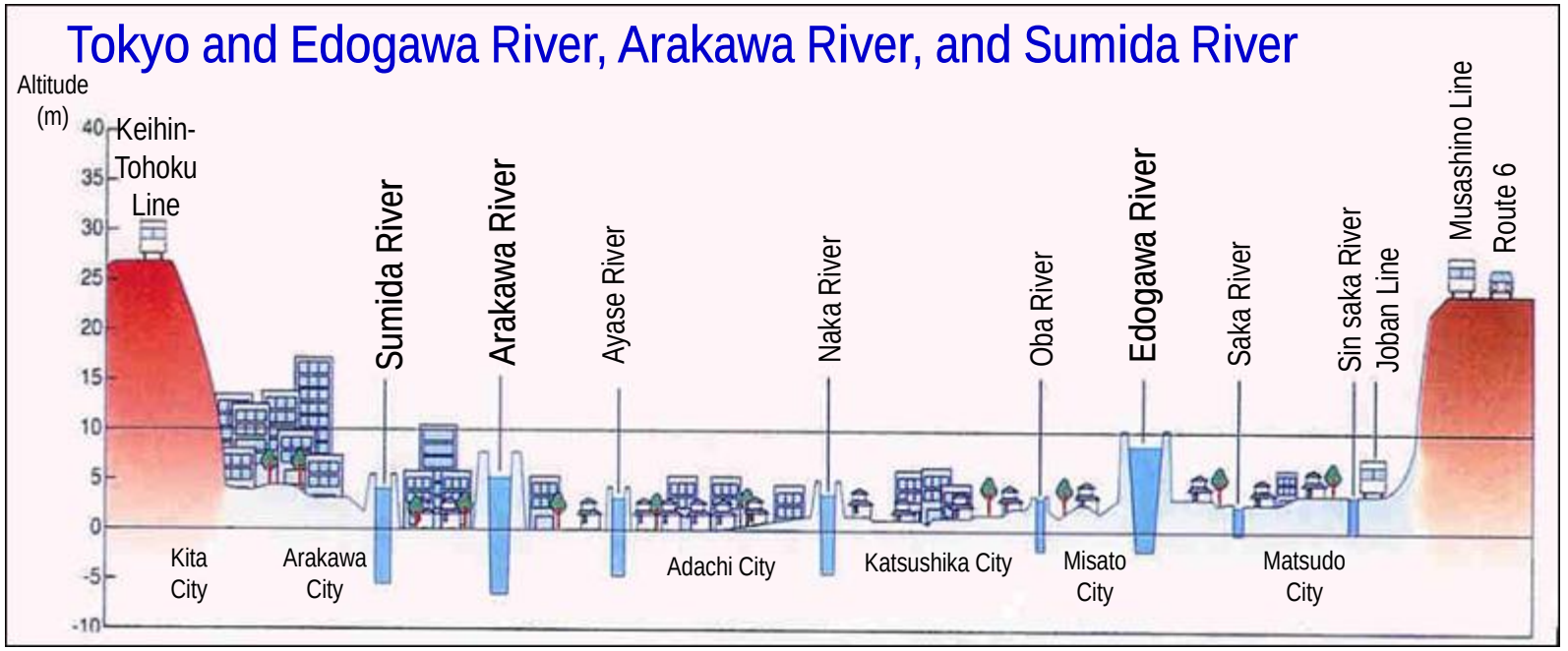


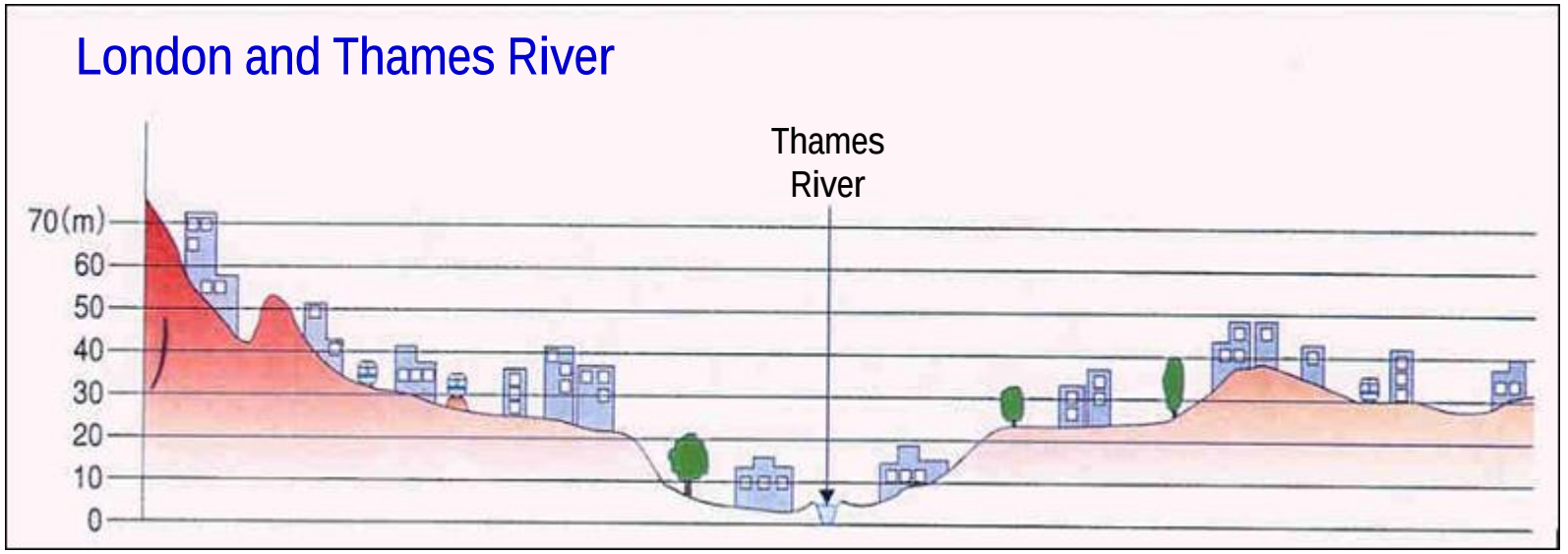
Rapid water level increase of river in Japan

Ratio of flood duration to flood discharge per unit area of catchment discharge. ($m^3/sec/km^2$)

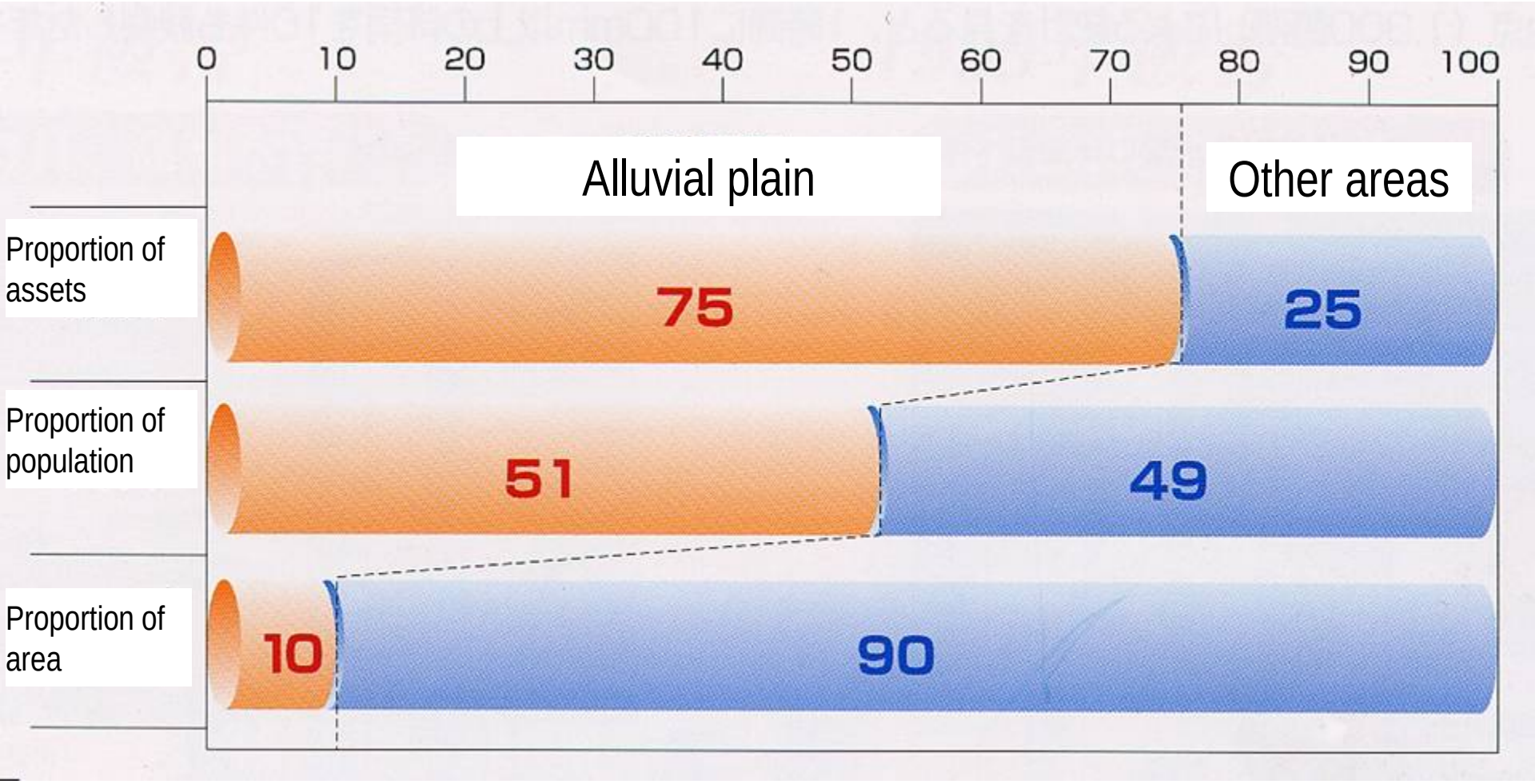


River level in downtown Tokyo and London





Concentration of assets and population in alluvial plain



Floods caused by Typhoon Kathleen killed more than 1,100 people and submerged over 300,000 houses in 6 prefectures in the Kanto region.

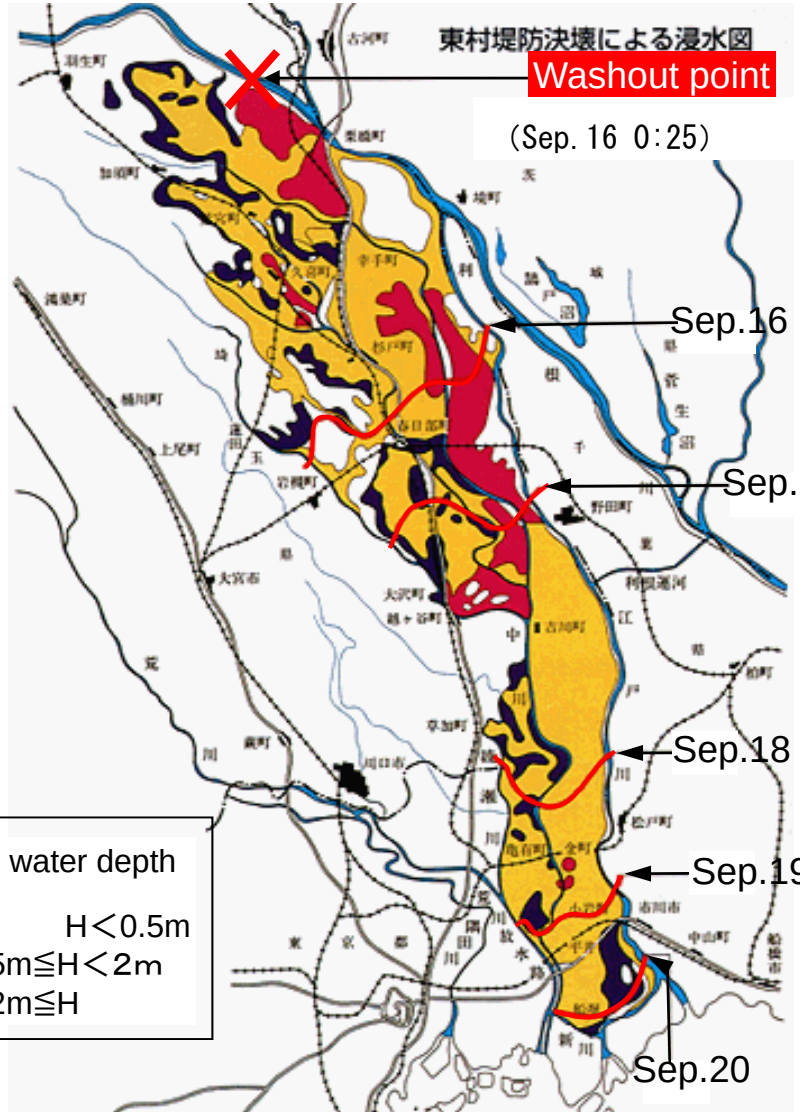
Typhoon Kathleen, which struck the Kanto region in September 1947, caused dikes of Tone River to collapse, and floods reached as far as Tokyo. It was a major disaster that claimed a toll of over 1,100 lives in 6 prefectures (Tokyo, Chiba, Saitama, Gunma, Ibaraki, and Tochigi) in the Kanto region.

Damage caused by Typhoon Kathleen (September 1947)

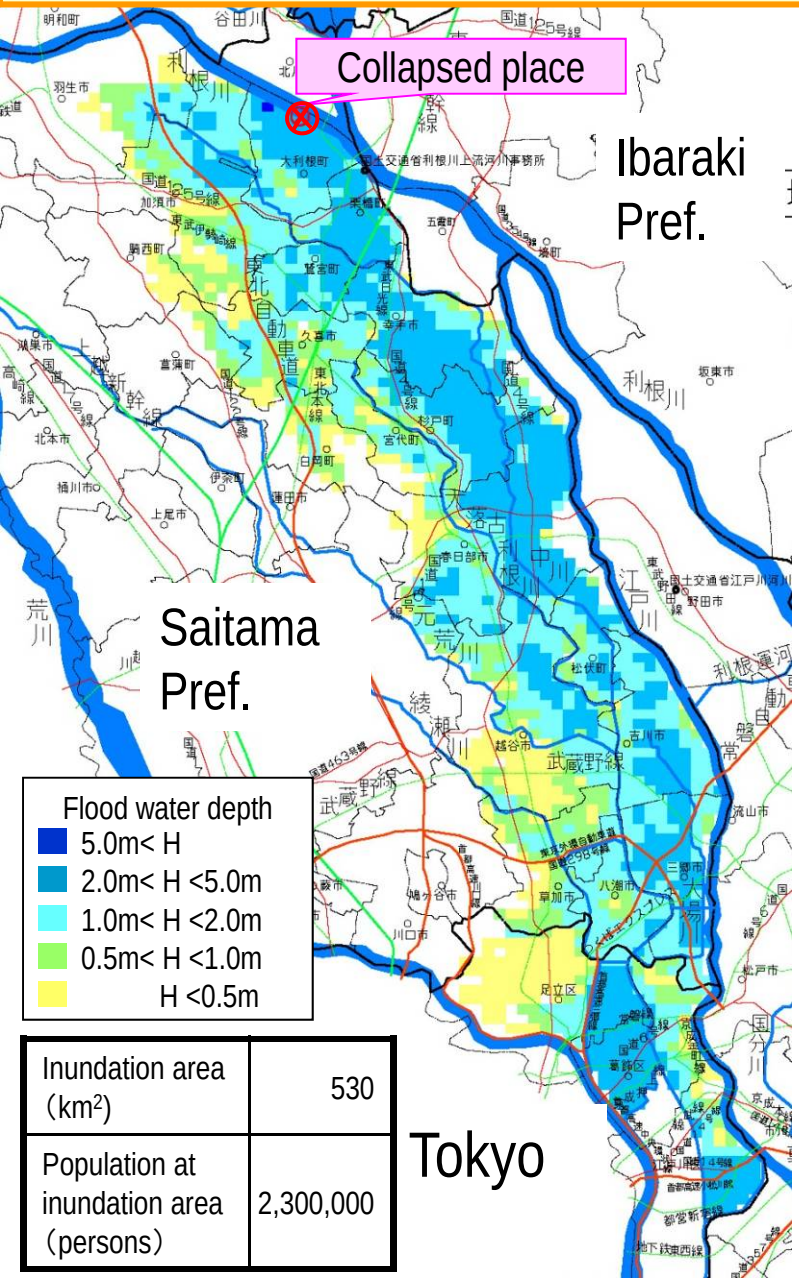
Collapse of dikes of Tone River in the Tone River system [134.5k]

Katsushika City in Tokyo

Areas inundated by Typhoon Kathleen (September 1947)



If typhoon Kathleen hit again and broke dikes of Tone River, the estimated victims is 2.3million



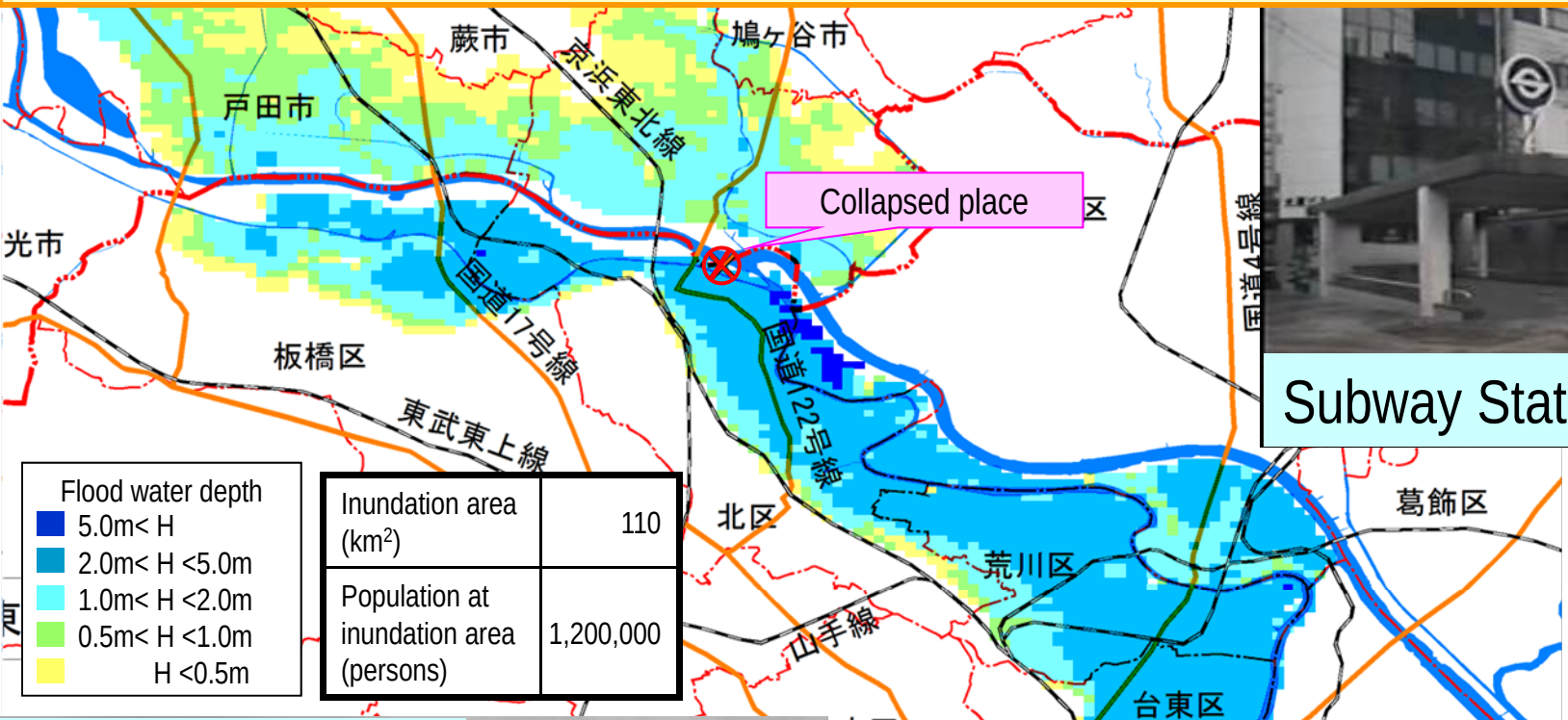
Inundation area (km²)	530
Population at inundation area (persons)	2,300,000

Image of inundation of loop route No.7 (Katsushika City)

Normal

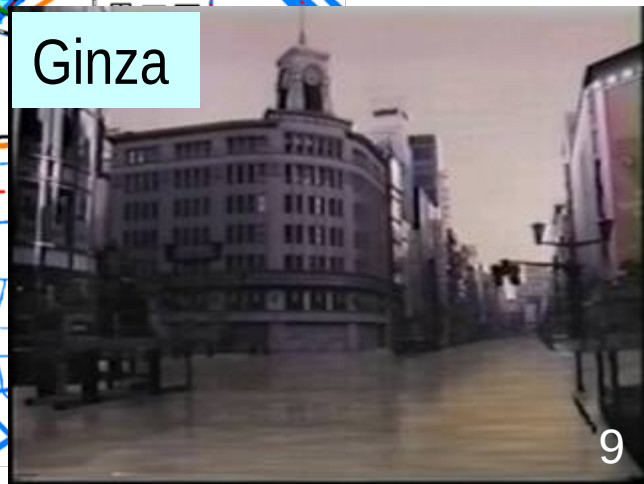
Dike break

If typhoon Kathleen hit again and broke dikes of Arakawa River, the center of Tokyo would be submerged.



Subway Station

Tokyo Station

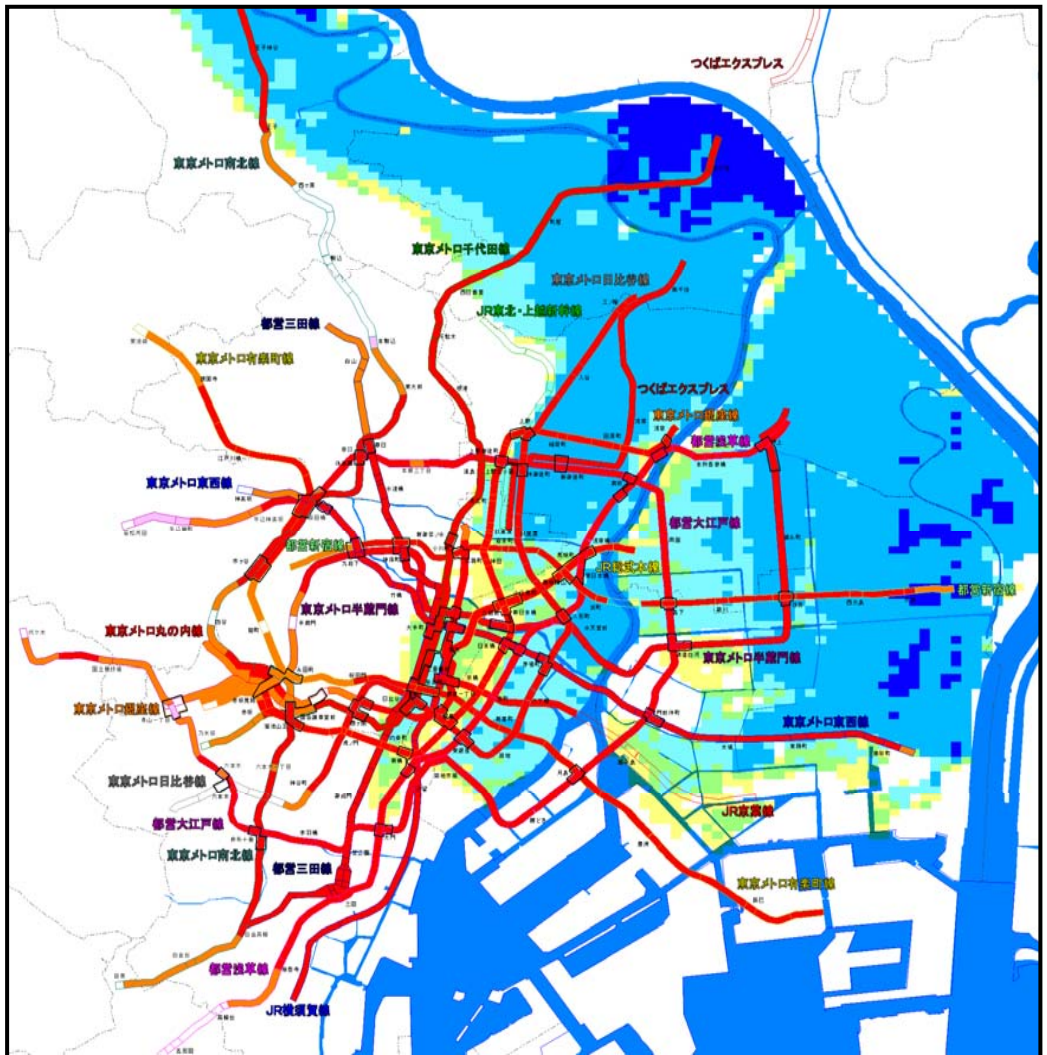


Ginza

Expansion of inundation through subway tunnels

- Underground shopping areas and buildings' underground are inundated from subway tunnels
- The inundation starts earlier than / without on the ground

Inundated area in case of the right dike of Arakawa River broken



depth of inundation

- 1mm or more – less than 0.5m
- 0.5m or more – less than 1.0m
- 1.0m or more – less than 2.0m
- 2.0m or more – less than 5.0m
- 5.0m or more

Inundation of subways

- Full (water reaches the ceilings)
- Inundation (water is higher than 2m)
- Inundation(water is higher than 5cm)
- No inundation

- No pump operation
- Conditions of Water-stop Board is 1m high from gateway floor
- No in & out flow from ventilation shaft

Heavy rain incidents : total rainfall more than 1000mm

Frequent water & sediment related disasters by heavy rain more than 1000mm

Year 2004

Fukui Downpour Disaster
* fatality : 4
* flooded up to the floorboard : 4,052

Typhoon 23nd
* fatality : 43
* flooded up to the floorboard : 13,041

・Heavy rain the total of which is more than 1000mm (Tokushima Prefecture)
・Dike breach and inundation along Yura River and Maruyama River caused by Typhoon 23nd

Inundation of Yura River (Maizuru City, Kyoto Pref.)

Year 2005

Typhoon 14th
<Chugoku region>
* fatality : 4
* flooded up to the floorboard : 1,678
<Kyushu Region>
* fatality : 19
* flooded up to the floorboard : 3,960

・Total rainfall by Typhoon 14th was more than1,000mm (southern part of Kyushu)
・Inundation along Oyodo River & Gokase River

Inundation belong along Oyodo River (Miyazaki City, Miyazaki Pref.

Debris flow in Kami-shiiba area (Shiibara Vil., Miyazaki Pref.)

Year 2006

July Flood
* fatality : 5
* flooded up to the floorboard : 899

・Total Rainfall was more than 1,200mm in July Flood in 2006.
・Inundations occurred along Sendai River & Yonenotsu RIver

Debris flow in Shimote-Nakama area (Hishikari Town, Kagoshima Pref.)

Inundated houses (Satsuma town, Kagoshima Pref.)

Year 2007

Typhoon 4th
* fatality : 3
* flooded up to the floorboard : 1,152

・Total Rainfall was more than 1,000mm by Typhoon 4th.
・Inundations occurred along Midori River.

Inundation belong along Midori River (Kosa Town, Kumamoto Pref.

Inundation belong Tributary of Midori River (Kosa Town, Kumamoto Pref.

Recently, floods occurred in various places by localized heavy rain, 100mm/h and more over

Localized torrential rain, hourly rainfall over 100mm, suffered in nationwide, and the flood damage occurred in various places in 2008

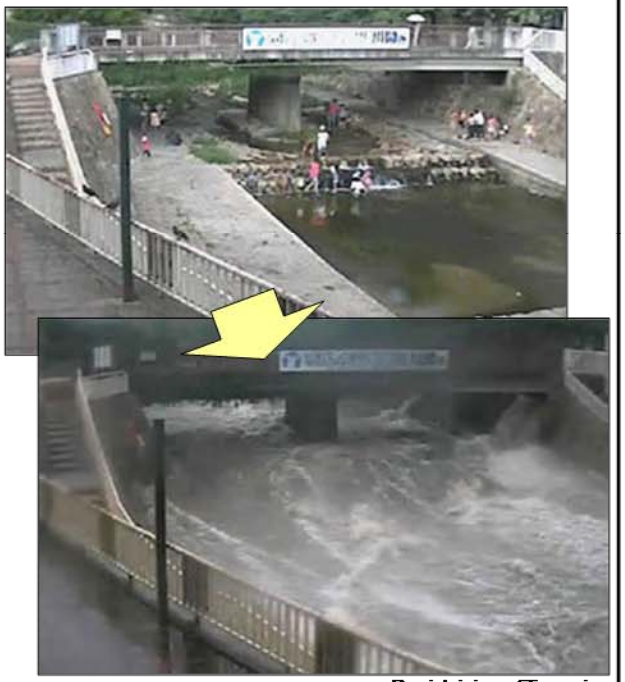
July, Flood in Asanogawa, Ishikawa and Nanto city, Toyama

Hourly rainfall 132mm in Nanto city,
Hourly rainfall 114mm in Kanazawa city

500 houses were flooded above floor level
1,476 houses were flooded up to the floorboards
20 houses were destroyed by debris flow.

July, Flood in Togagawa, Hyogo

The rainfall 21mm in ten minutes and the rainfall 17mm in ten minutes were recorded in Togagawa in Kobe City



Rapid rising of Toga river

Five people including three children were killed by flush flood, water raising of 134cm in ten minutes.

August, Flood in Okazaki, Aichi

The rainfall 146.5mm

Hourly rainfall 120mm in Ichinomiya City.

Flood situation of Okazaki City

620 houses were flooded above floor level

705 houses were flooded up to the floorboards in Okazaki City.

Recent Water & Sediment Related Disasters (Year 2009)

Downpour over 100mm/h across the nation caused Water & Sediment Related Disasters

Damaged situations in Chugoku & Kyushu Region July 2009 Disasters

・116mm/h (Hakata City, Fukuoka Pref.)
・72.5mm/h (Hofu City, Yamaguchi Pref.)

Immense damage occurred in Northern Kyushu and Chugoku Region

<Chugoku & Northern Kyushu region>
* fatality : 30
* flooded up to the floorboard : 2,067

Stricken area in Fukuoka Pref.
(Kyushu Jukan Highway)

Nursing Home stricken by debris flow
(Hofu City, Yamaguchi Pref.)

Damaged situations by Typhoon 9th

・100.5mm/h (Naka Town, Tokushima Pref.)
・89mm/h (Sayo Town, Hyogo Pref.)

Huge area, from Kyushu to Tohoku, was damaged

* fatality & missing: 26
* flooded up to the floorboard : 1,917

Damaged area along Sayo River
(Sayo Town, Hyogo Pref.)

Damaged area along Hikihara River
(Anaguri City, Tokushima Pref.)

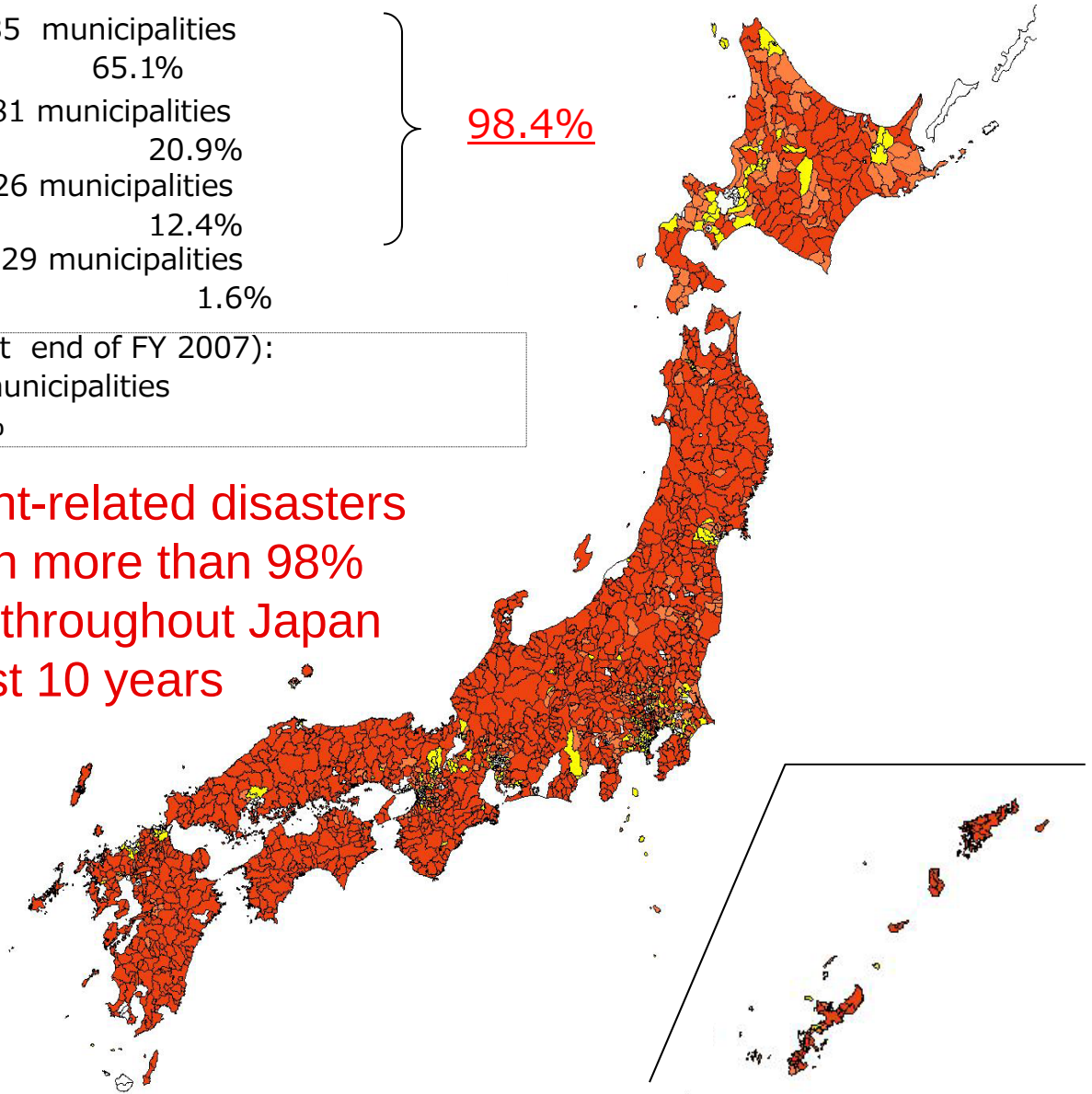
A number of local governments have experienced water-related disaster's damage

10 times or more	: 1,185 municipalities	65.1%
5 to 9 times	: 381 municipalities	20.9%
1 to 4 times	: 226 municipalities	12.4%
0 times	: 29 municipalities	1.6%

98.4%

(total number of municipalities at end of FY 2007):
1,821 municipalities
100.0%

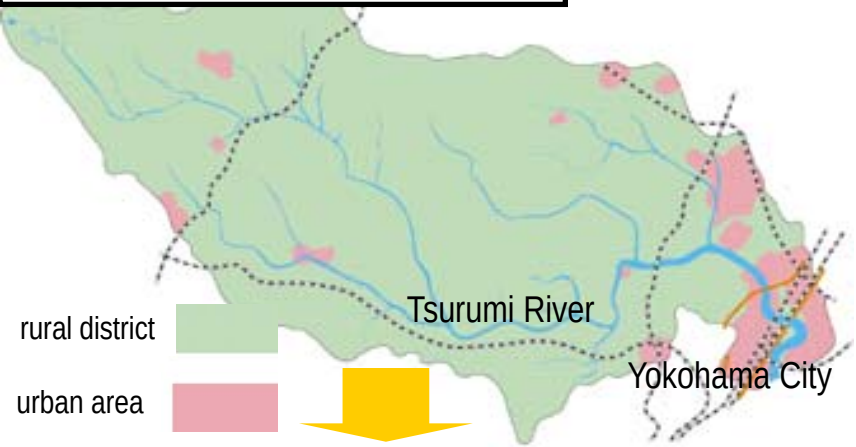
Flood and sediment-related disasters have occurred in more than 98% of municipalities throughout Japan in the past 10 years



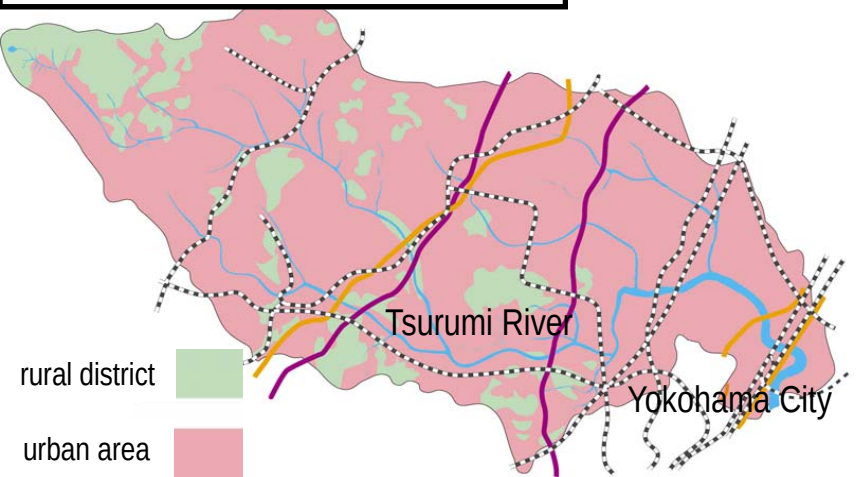
Influences of Urbanization on Floods

Tsurumi River

1958
Urbanization rate: About10%
Population: About 450,000



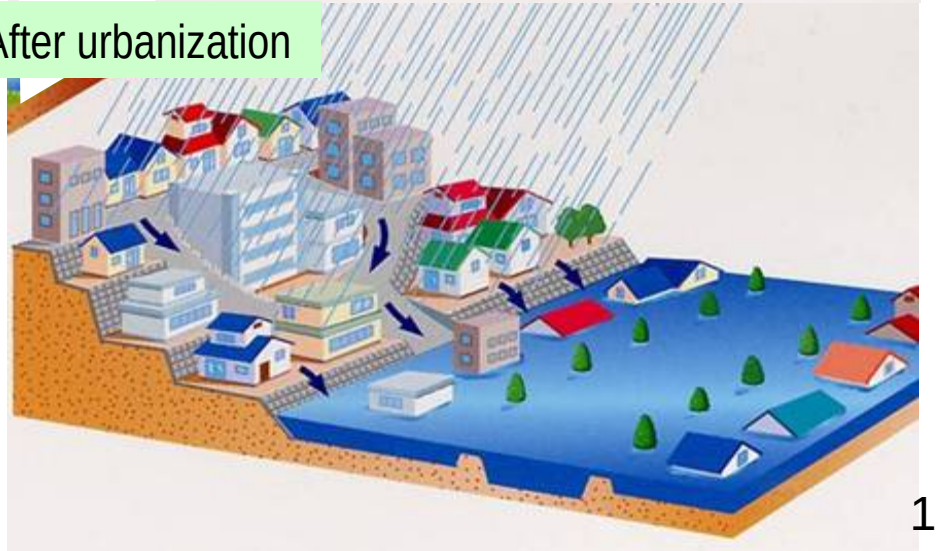
2004
Urbanization rate: About 85%
Population: About 1.88million



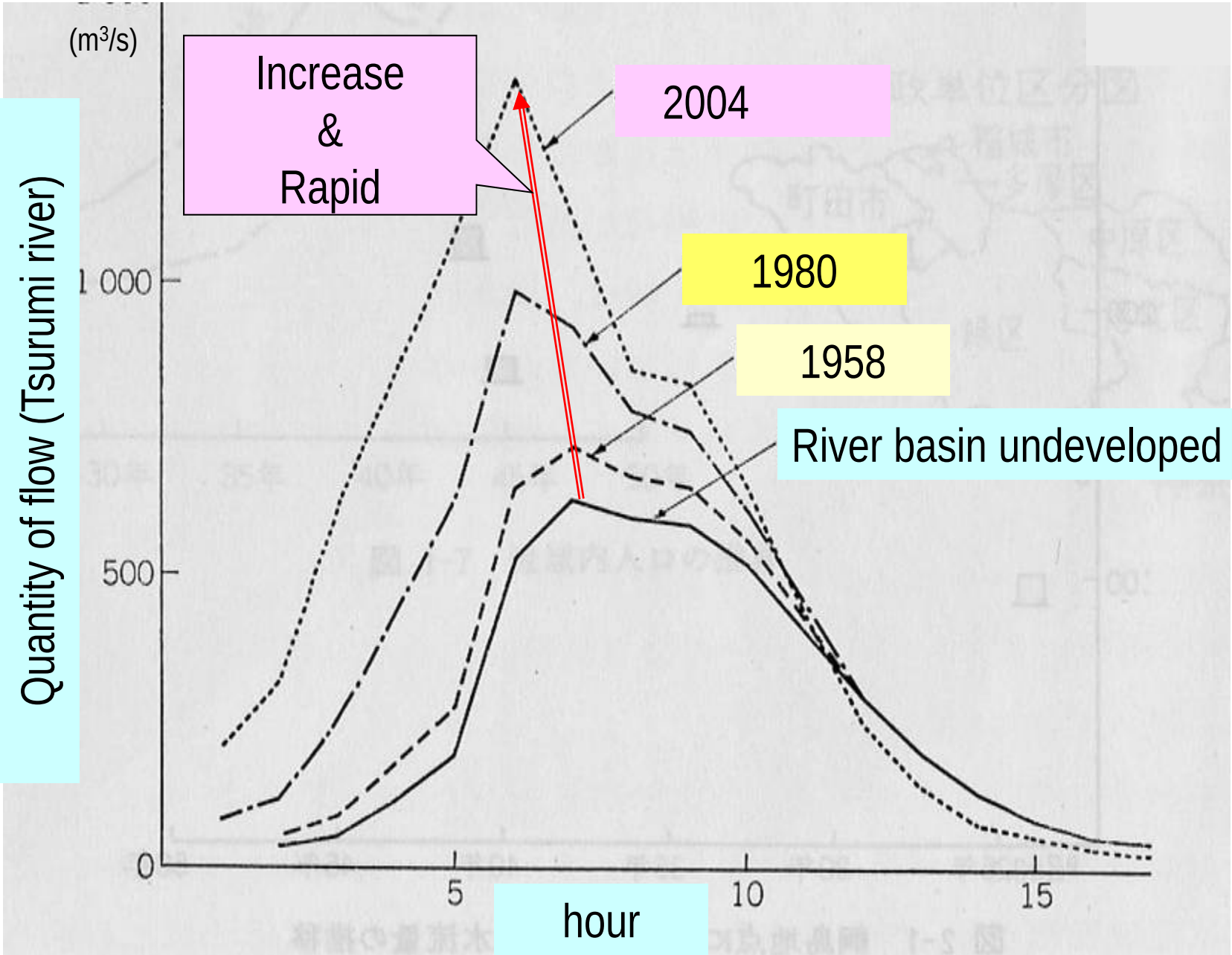
Rapid urbanization has resulted in the elimination of rice fields and forests that naturally serve to hold rainwater and absorb it into the ground. There has thus been an increase in the amount of surface runoff flowing into the river, increasing the chances of flooding.

Before urbanization

After urbanization



Effects of Urbanization on Floods



Submergence at the underground facilities in urban areas

Oct.2004

Azabujuban Sta. of Tokyo subway line

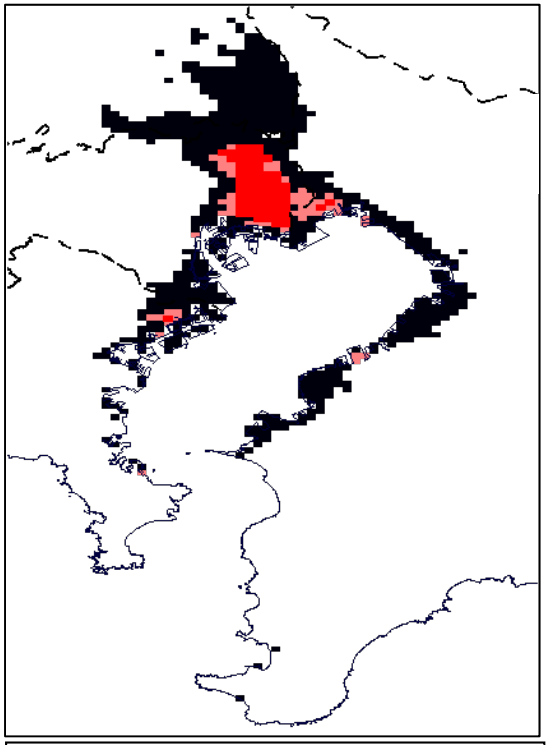
Jul. 2003

Fukuoka municipal subway

About 1.76 million people live in an area below sea level (zero-meter zone; about 116-km^2) along Tokyo Bay (from Yokohama City to Chiba City).
If sea level rises by about 60 cm, the zero-meter zone would increase by about 2.1 times (about 244 km^2), and the population in this area would grow by 1.5 times (about 2.7 million).

＊面積、人口は朔望平均満潮位以下の数値

The zero-meter zone that extends along Tokyo Bay (from Yokohama City to Chiba City)

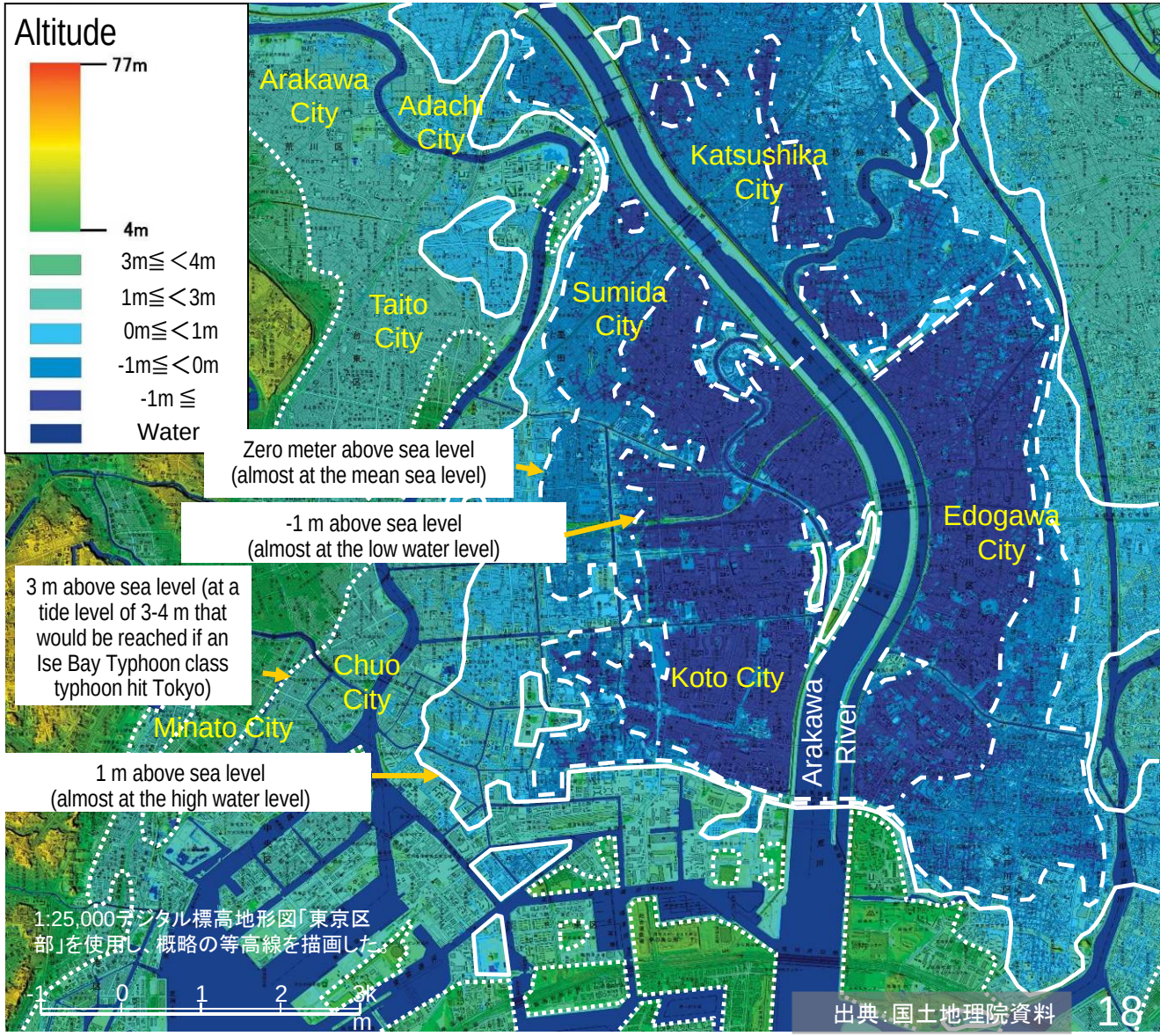


■ : Areas of Tokyo peil of ±0 or lower
■ : Areas at the high water level or lower
■ : Areas at the highest high water level (HHWL) or lower

※No areas of surfaces of rivers or lakes are included.
※based on the national land-use digital information
Shown are the areas at elevations lower than sea level shown in a threedimensional mesh (1 km x 1 km). Total area and population are based on three-dimensional data.

出典：国土地理院地図を基に国土交通省作成

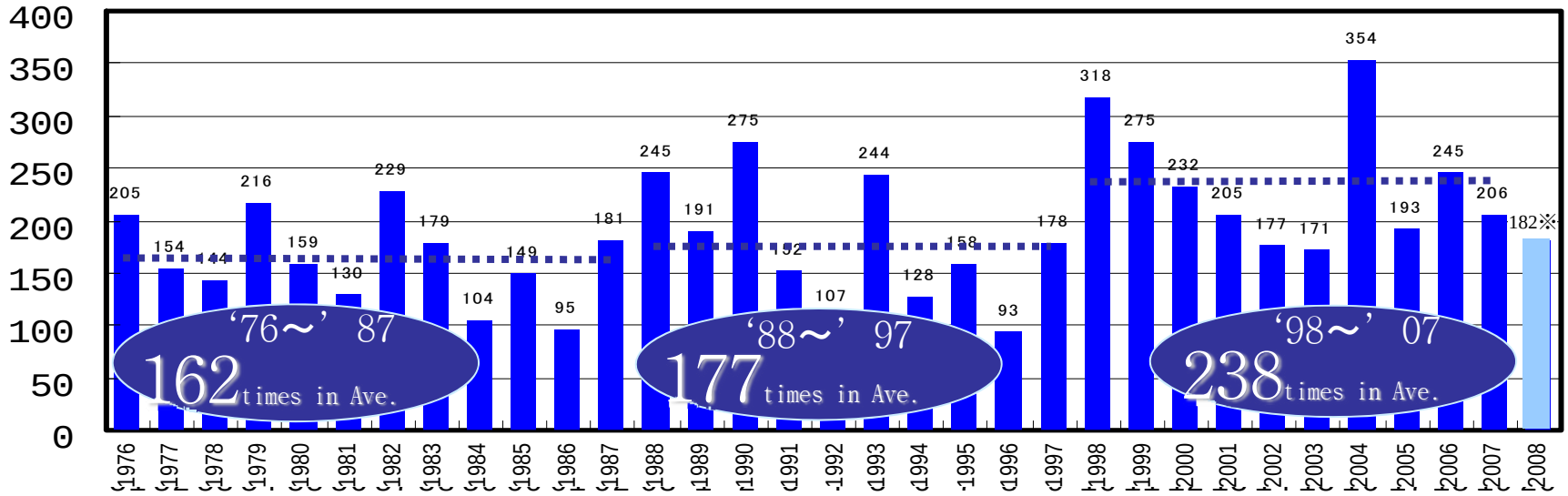
The zero-meter zone that extends in City of Tokyo



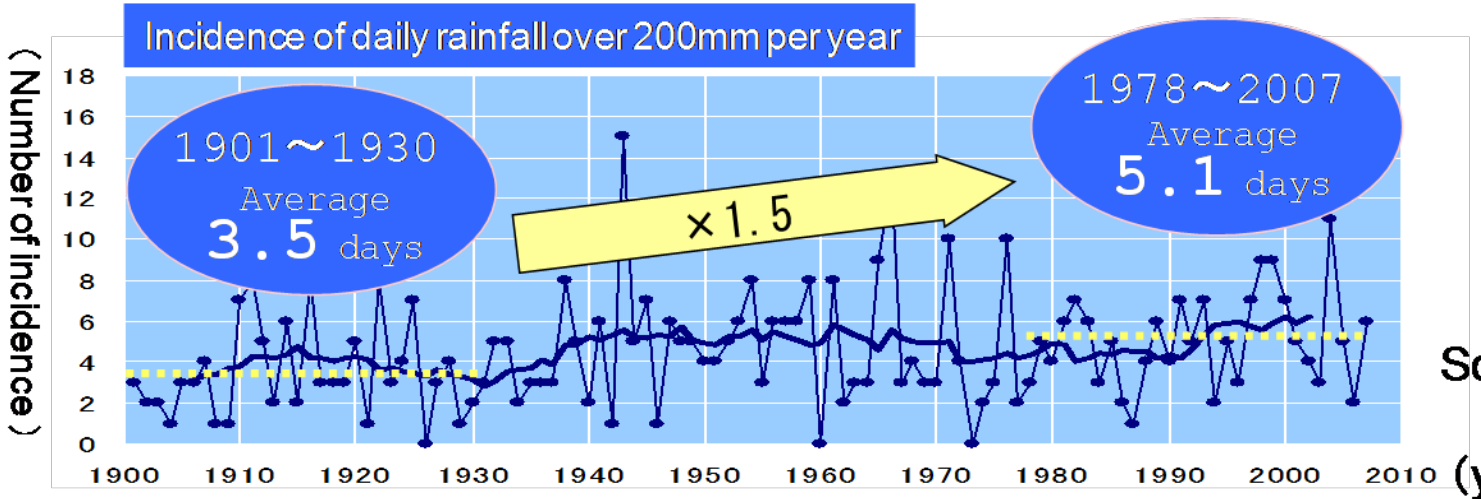
出典：国土地理院資料

Heavily concentrated rainfalls are on the increasing trend.

Hourly rainfall over 50 mm is significantly increasing



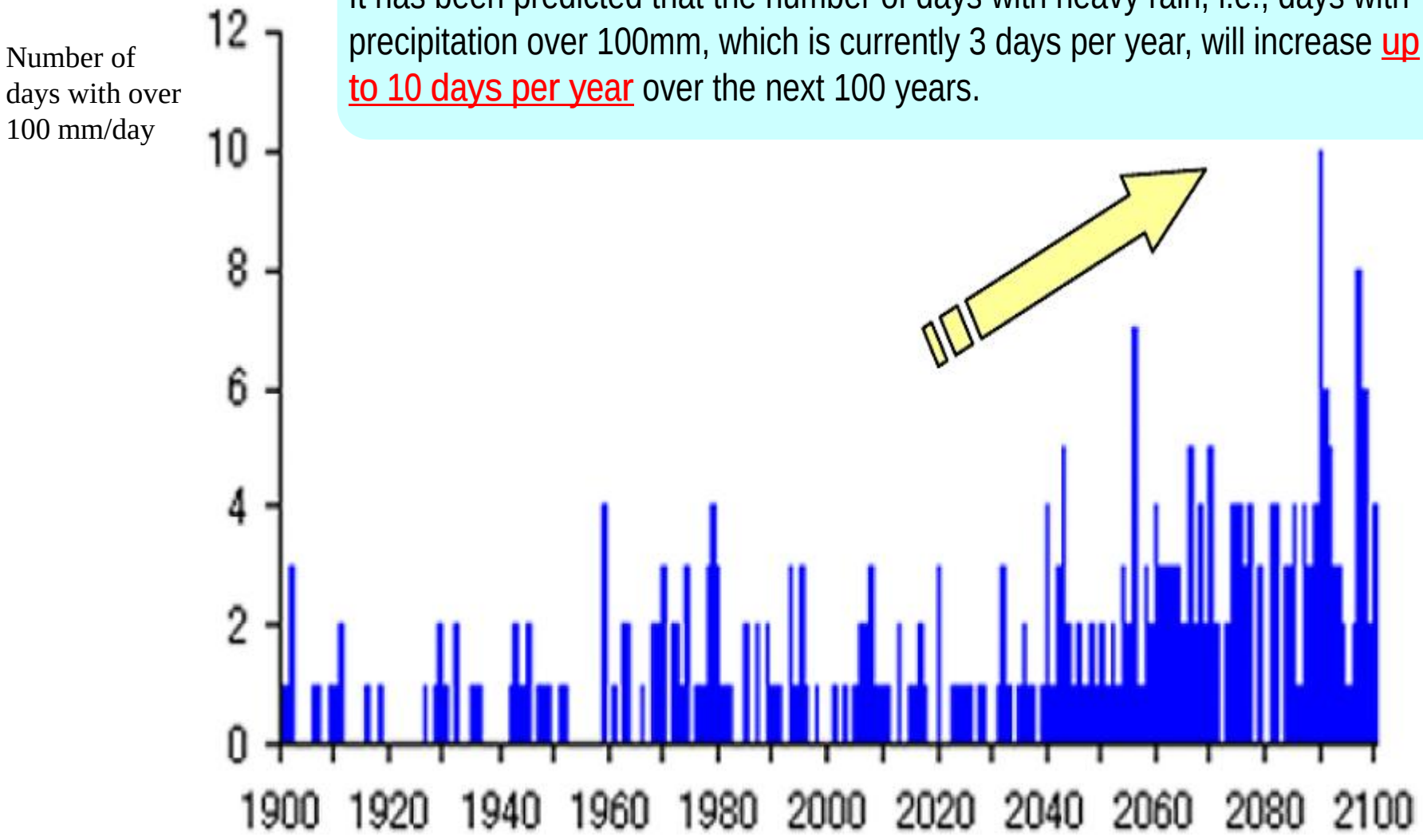
Daily rainfall over 200 mm is increasing



Source: JMA

Precipitation in summer will increase over the next 100 years.

It has been predicted that the number of days with heavy rain, i.e., days with precipitation over 100mm, which is currently 3 days per year, will increase up to 10 days per year over the next 100 years.



出典：平成16年9月16日報道発表資料（東京大学気候システム研究センター、国立環境研究所、海洋研究開発機構地球環境フロンティア研究センター）

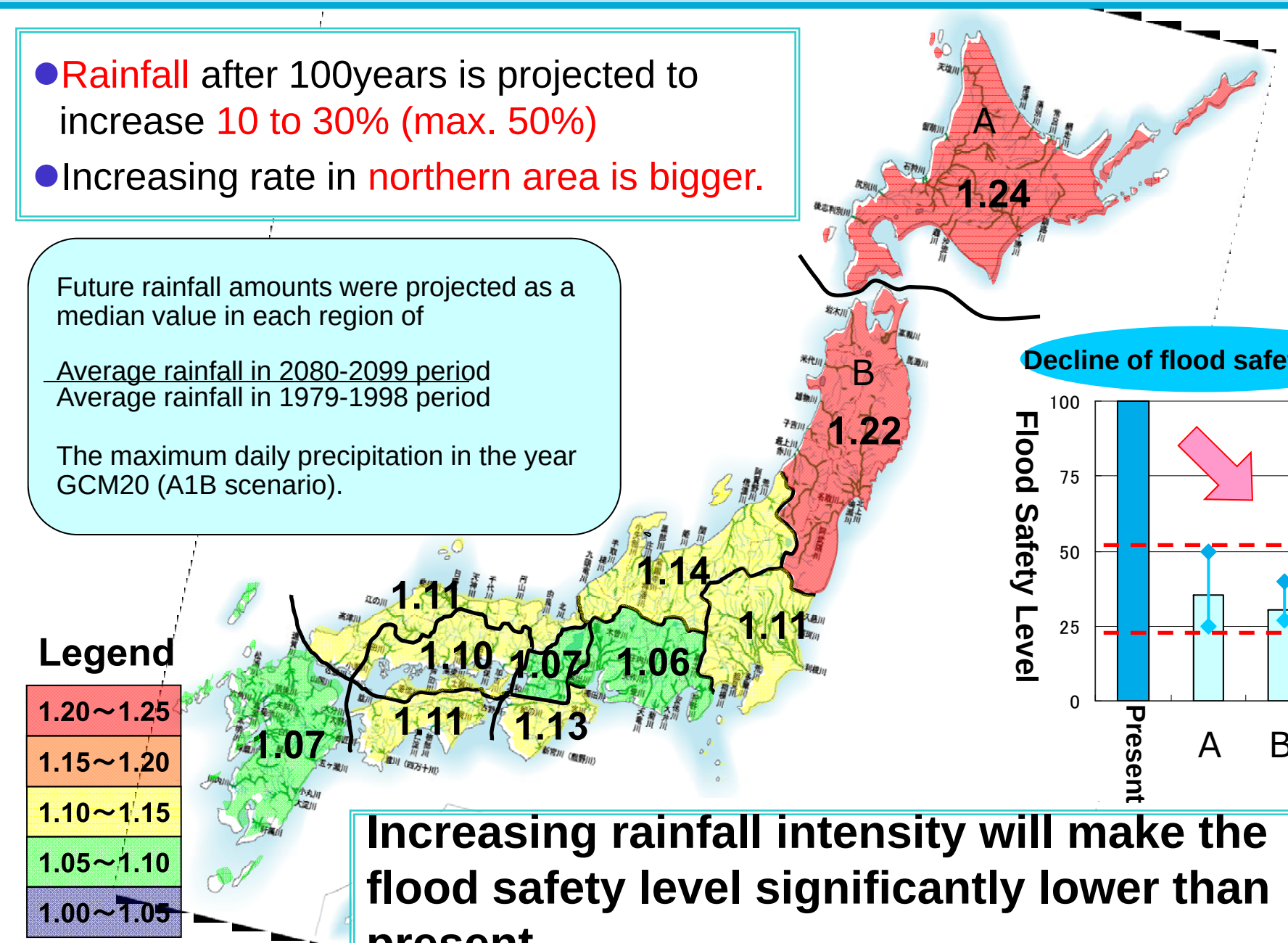
Projection of future climate

- Rainfall after 100years is projected to increase 10 to 30% (max. 50%)
- Increasing rate in northern area is bigger.

Future rainfall amounts were projected as a median value in each region of

$$\frac{\text{Average rainfall in 2080-2099 period}}{\text{Average rainfall in 1979-1998 period}}$$

The maximum daily precipitation in the year GCM20 (A1B scenario).



Increasing rainfall intensity will make the flood safety level significantly lower than present

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4. Lessons Learned

Comprehensive flood control measures

1)River improvement

- River channel improvement
- Construction of dams, retarding basins and discharge channels etc.

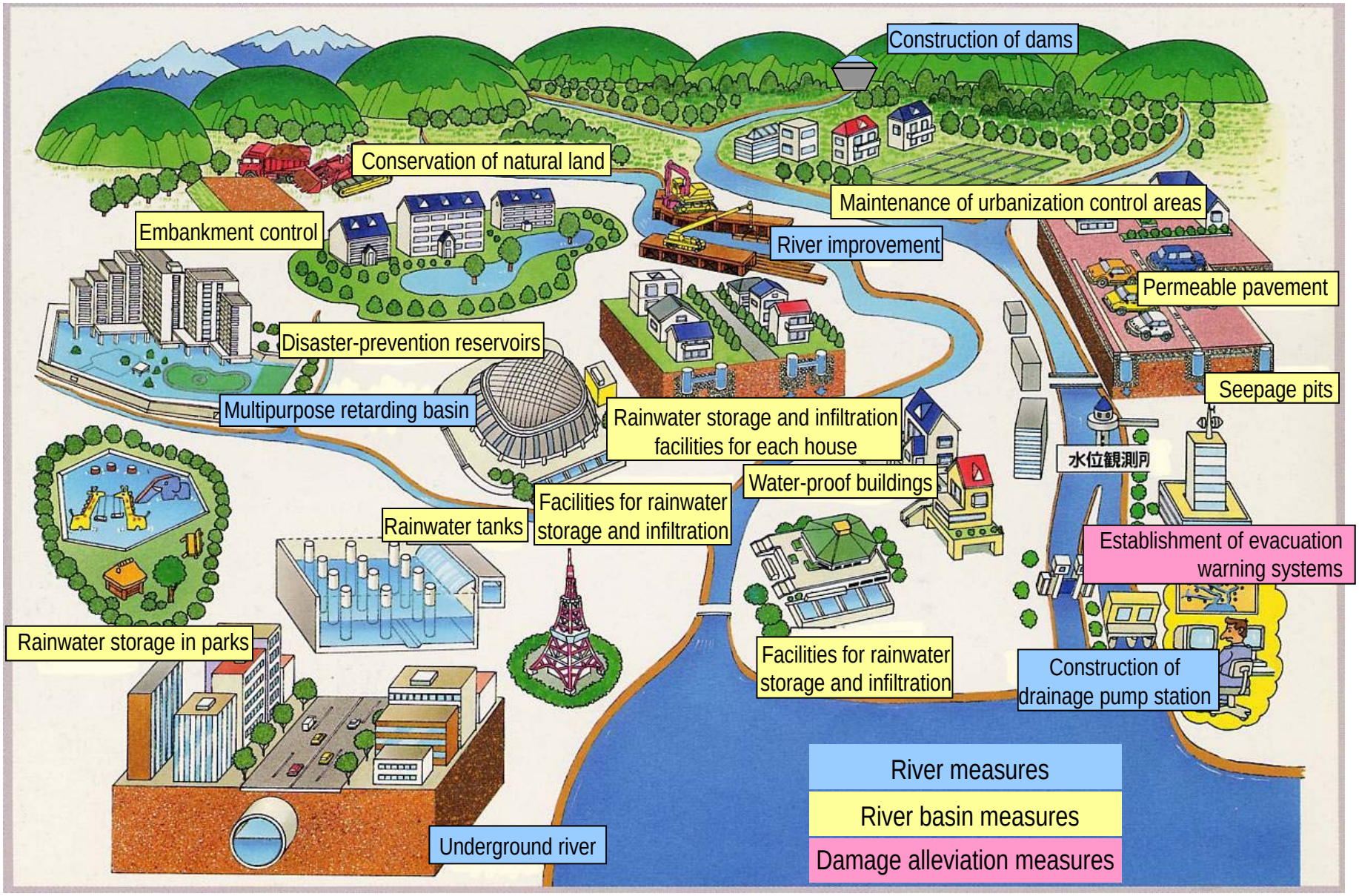
2)Measures for river basins

- Maintaining urbanization control areas
- Conservation of fields
- Constructing reservoirs
- Constructing rainwater tanks
- Constructing permeable pavements and seepage pits

3)Measures to alleviate damage

- Establishing the evacuation warning systems
- Upgrading flood diffence systems
- Promoting awareness of local residents

Comprehensive Flood Control Measures

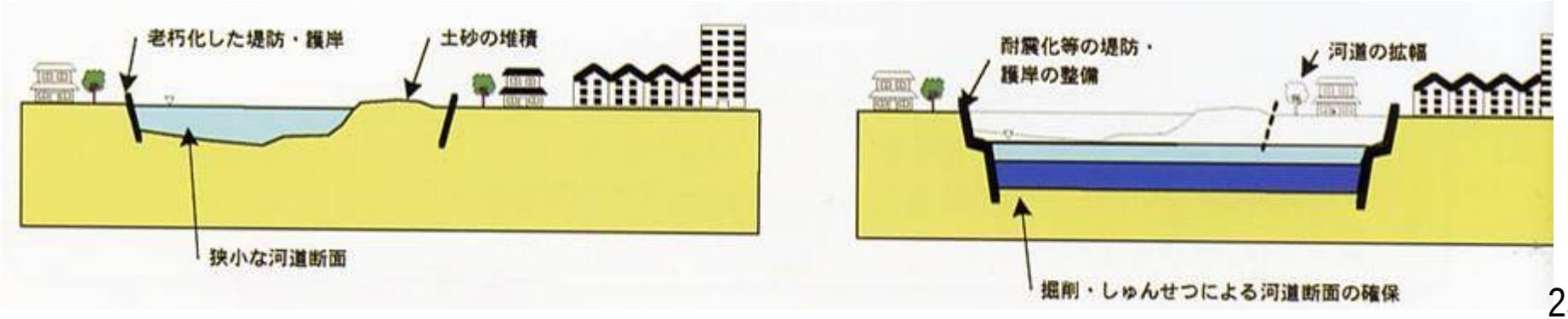


River channel improvement

Widen and dredge rivers

before

after



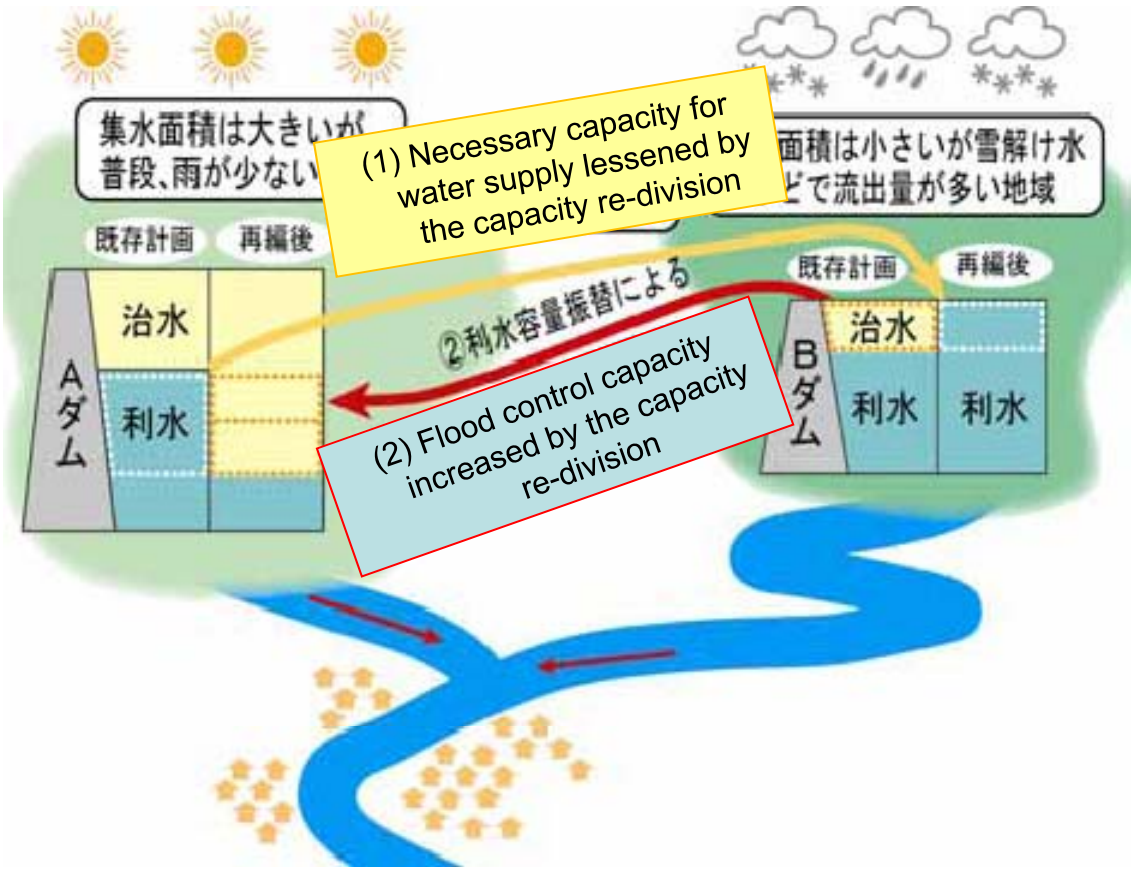
Improvement of dikes

Building and strengthening of dikes

Construction & Operation Improvement of Dams

Integrated operation of existing dams

Optimum capacity re-division of related dams based on present situations of dam operation, precipitation and flow characteristic of each river basin



Construction of retarding basins

Arakawa River First Retarding Basin

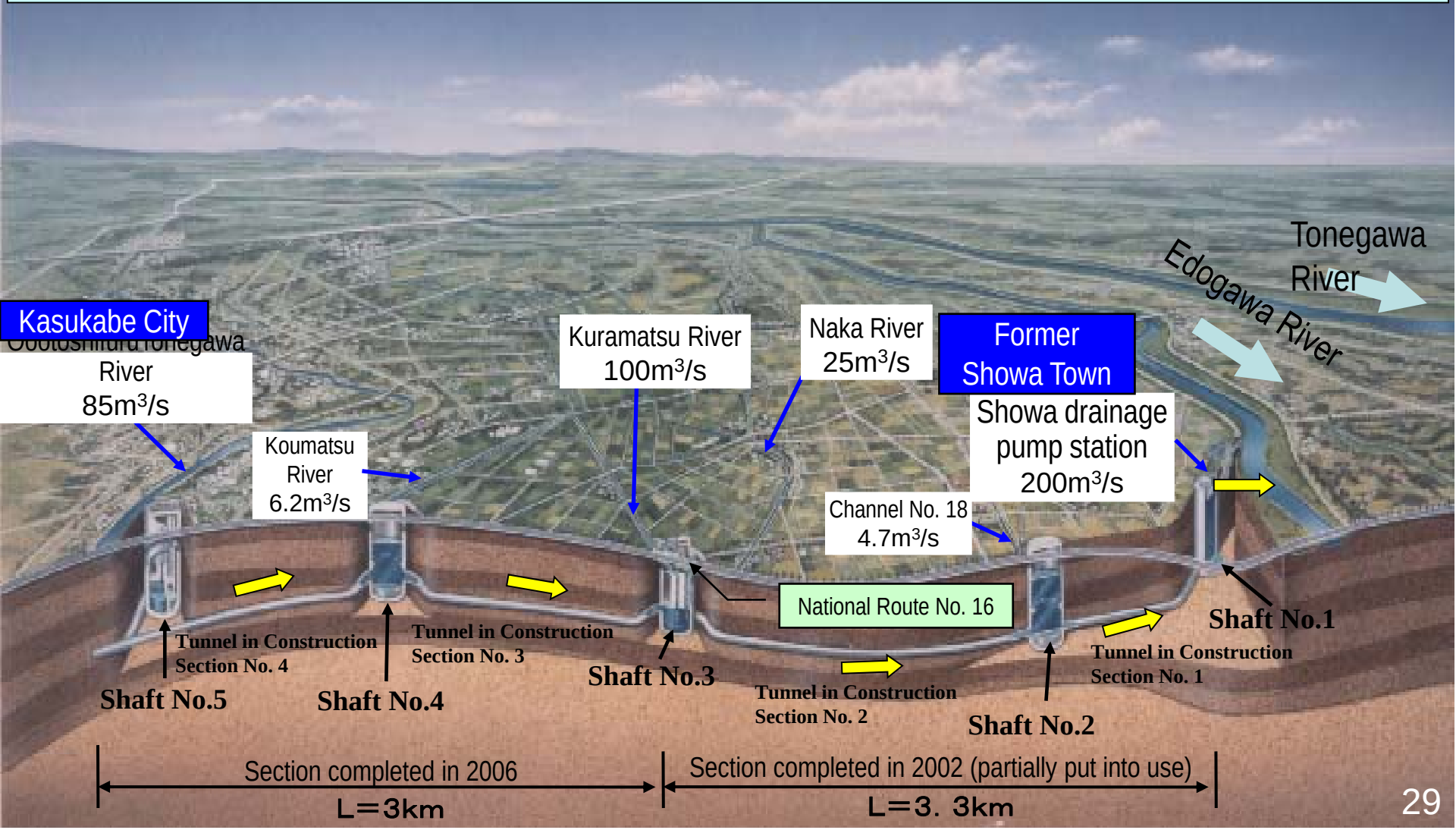
- location : Saitama City & Toda City, Saitama Pref.
  (28.8 – 37.2km from estuary of Arakawa river)
- Operation Start : Year 2003
- Area of Reservoir : 580 ha
- Total Capacity for Flood Control : 39 mil. m^3
- Valid Capacity : 10.6 mil. m^3
- Control volume : 850m^3/sec

Photo by Arakawa Upstream River Office

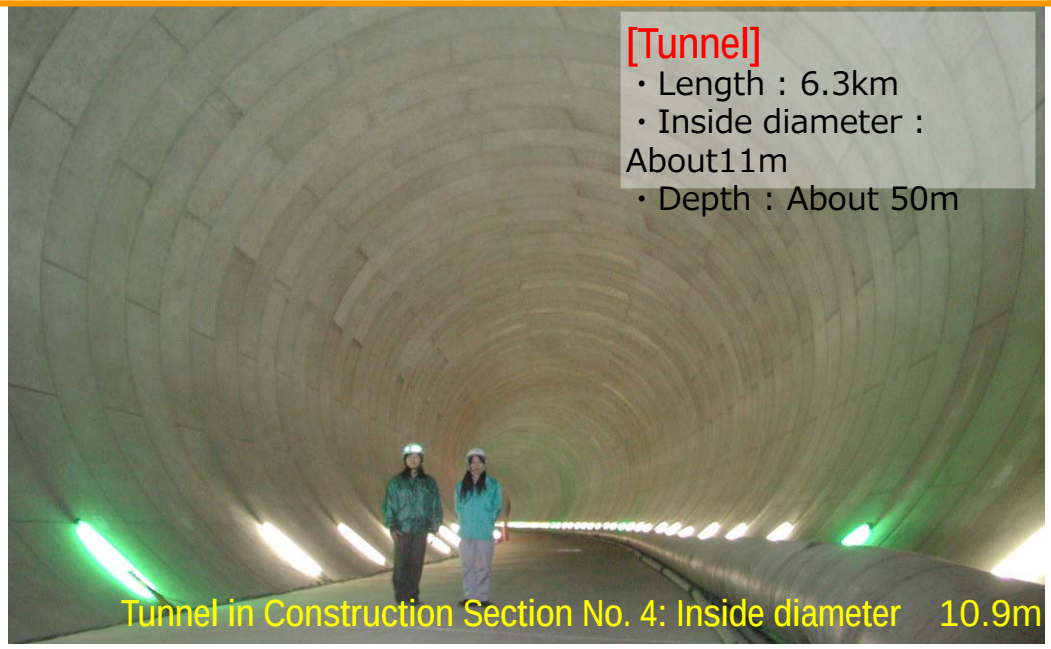
Condition of outer discharge channels in the Tokyo metropolitan area

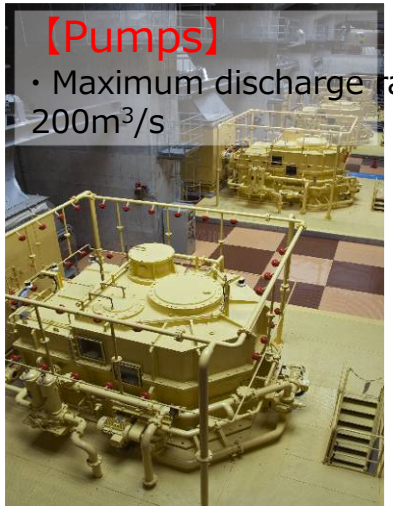
[Purpose]

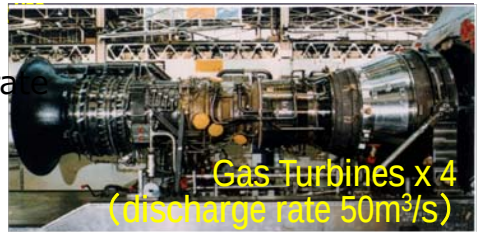
In order to alleviate flood damage to the Naka River basin, which frequently suffers such damage due to its level terrain and rapid urbanization, the external canal takes in floods of Naka River, Kuramatsu River, OootoshifuruTonegawa River, and other rivers and discharges them into Edogawa River.



Condition of outer discharge channels in the Tokyo metropolitan area







写真：江戸川河川事務所提供

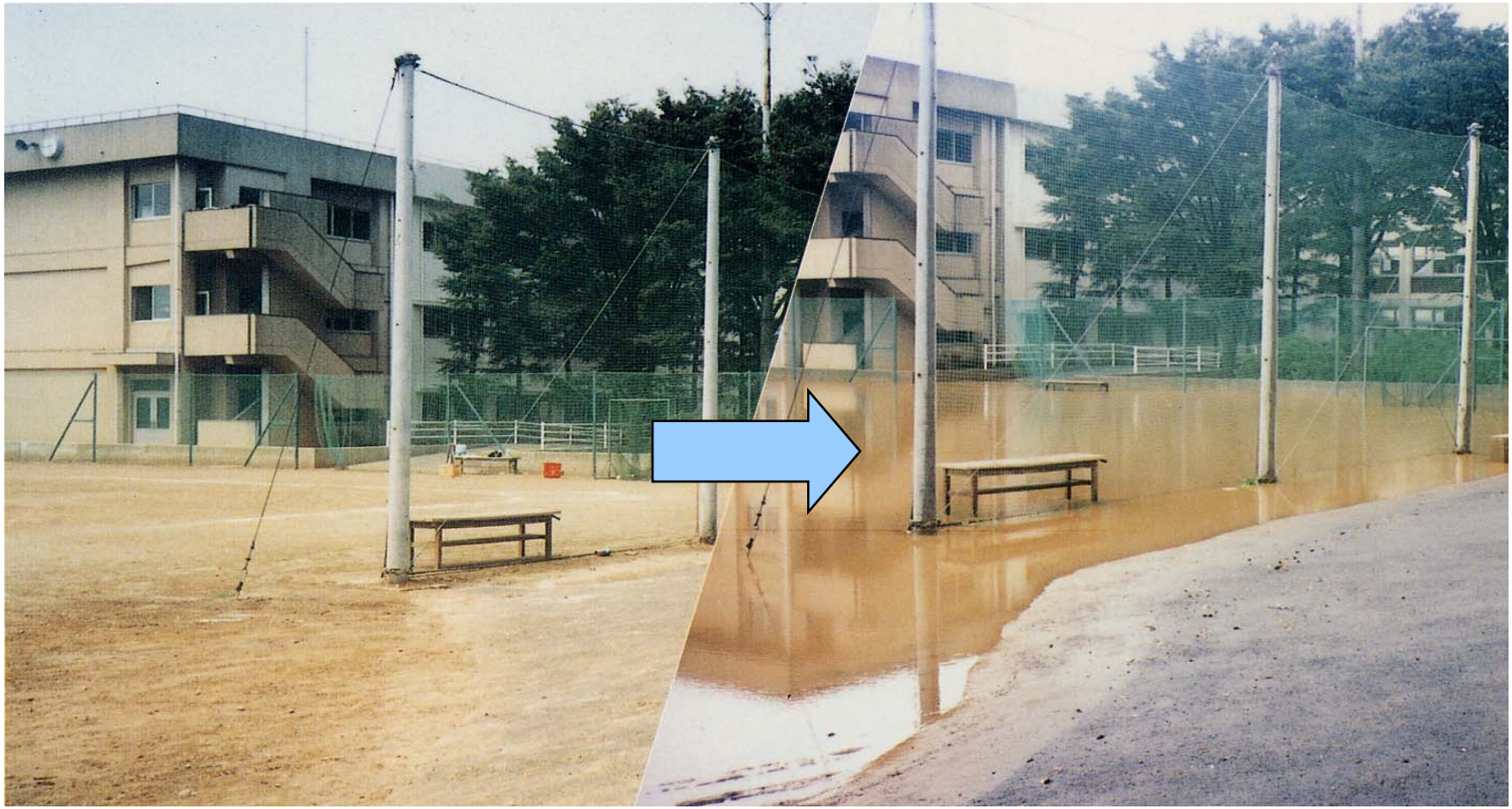
Constructing flood control pond

Flood control pond temporarily stores rainfall so that it does not inundate rivers all at once .

Kirigaoka reservoirs

Development of rainwater storage facilities

Storing rainwater in a schoolyard



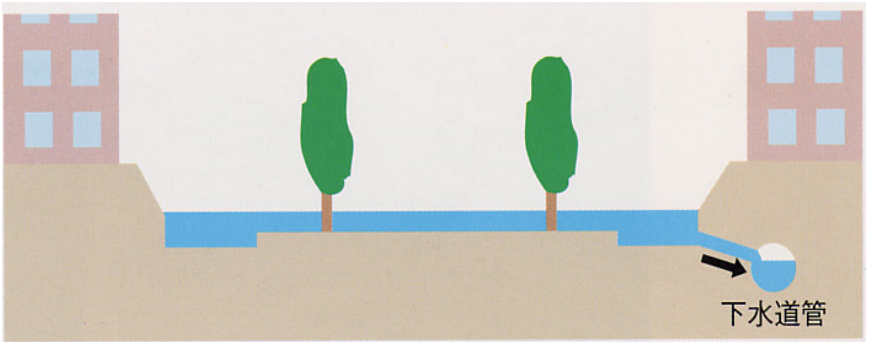
Constructing permeable pavements

permeable pavement

permeable tile pavement

Tokyo

Constructing rainwater tanks and seepage pits between buildings

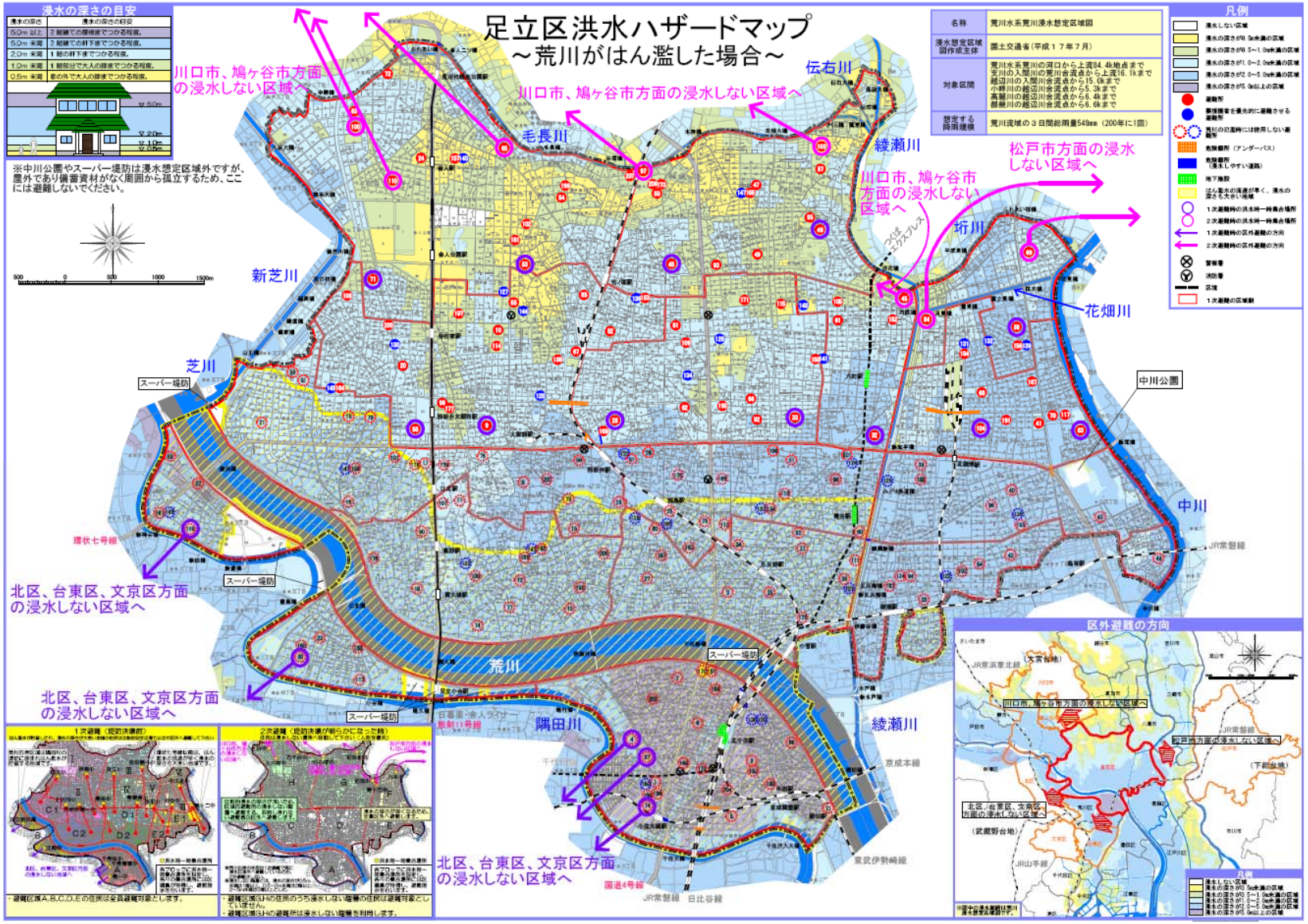


Infiltration facilities improvement

Seepage pits・Seepage trench

Publication of flood hazard maps

It is also important to promote software measures in parallel with the implementation of hardware measures.



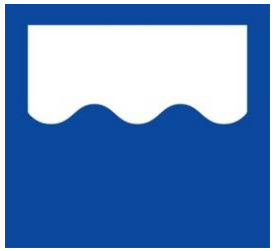
The assumed flood water depth and other information are indicated in town (1)

- Information on the assumed flood water depth, evacuation sites, etc. is indicated in town in order to allow residents to escape safely and smoothly when a flood occurs.

[Flood-related symbols]

JIS規格（案内用図記号）Z8210:2006

[Flood]



This symbol indicates that the area concerned may be affected by floods.

[Evacuation site (building)]

This symbol shows a safe building that provides a shelter when a disaster occurs.

Examples of flood-related signs installed

Information on the assumed flood water depth, evacuation sites, etc. is indicated on electric poles and the walls of public facilities.

※現在、東京都北区（荒川）、兵庫県豊岡市（円山川）に設置

The assumed flood water depth and other information are indicated in town (2)

The assumed flood water depth is indicated using a tape.

QRコード

Provision of River information by mobile phone

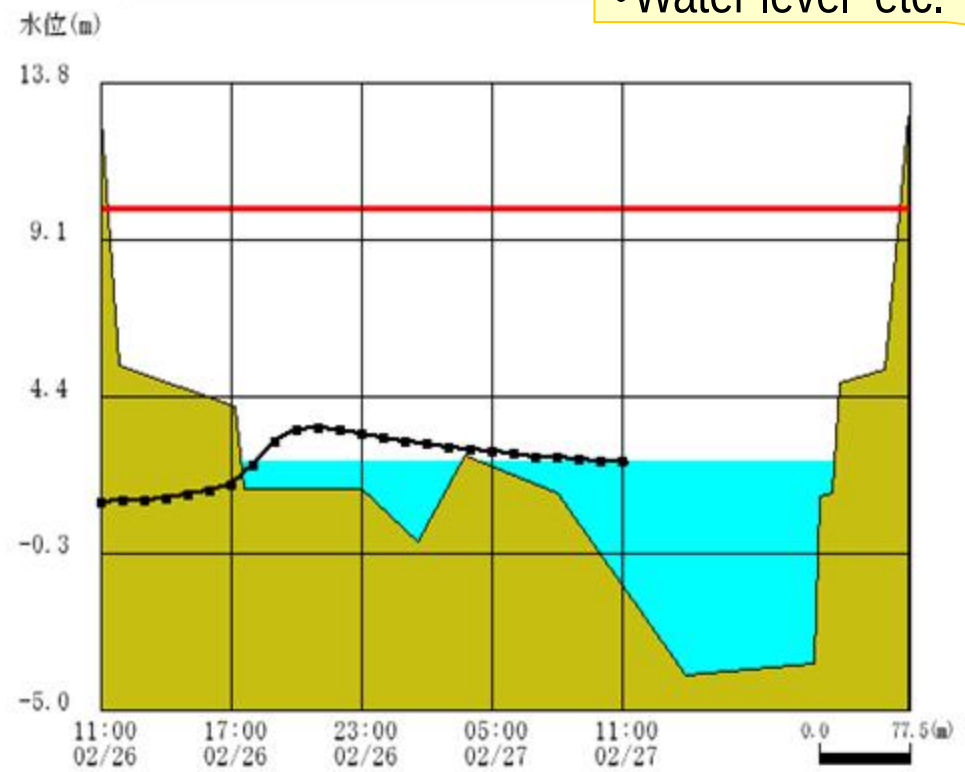
Information provided on the internet

観測所別水位グラフ

計画高水位	10.0
危険水位	—
特別警戒水位	—
警戒水位	—
指定水位	—

年月日時分	水位(m)
2006/02/27 11:00	**
10:00	**
09:00	**
08:00	**
07:00	**
06:00	**
05:00	**
04:00	**
03:00	**
02:00	**
01:00	**
2006/02/26 24:00	**
23:00	**
22:00	**
21:00	**
20:00	**
19:00	**
18:00	**
17:00	**
16:00	**

水系名	吉野川
河川名	吉野川
観測所名	高瀬橋
所在地	徳島県名西郡石井町藍畑



※この情報は速報値であり 検定済データではありません。

Information provided to mobile phones

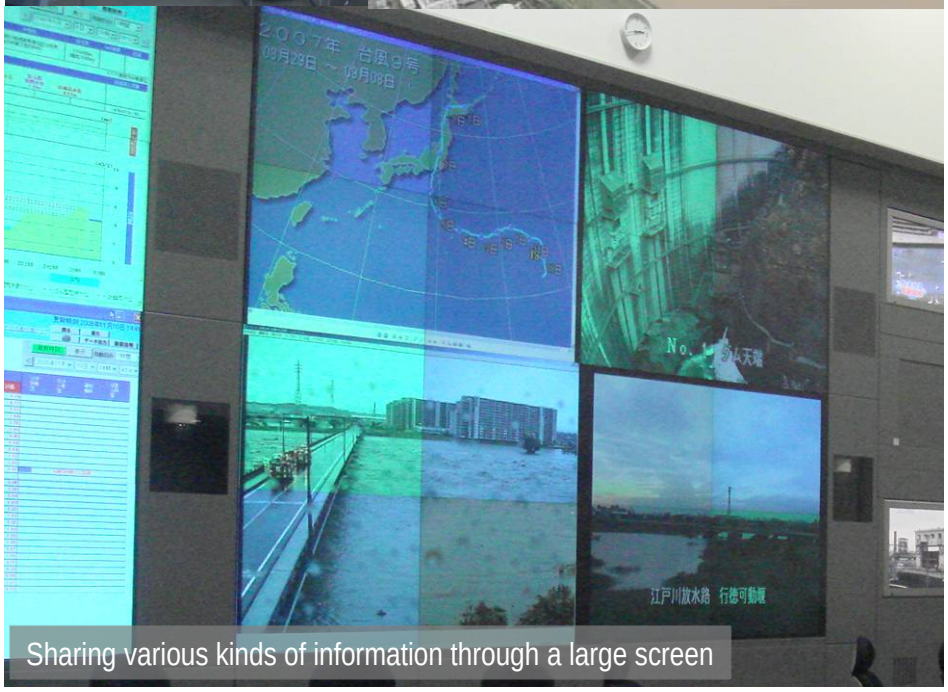
Contents
- Precipitaion by hyeto meter
- Precipitaion by rader rain gages
- Water level etc.

Establishing stronger systems to gather and analyze information

- When a disaster occurs, bases are established to collect information and respond to the disaster.
- It is necessary to establish systems to gather, analyze, and share various kinds of information such as water levels, flow rates, and precipitation.

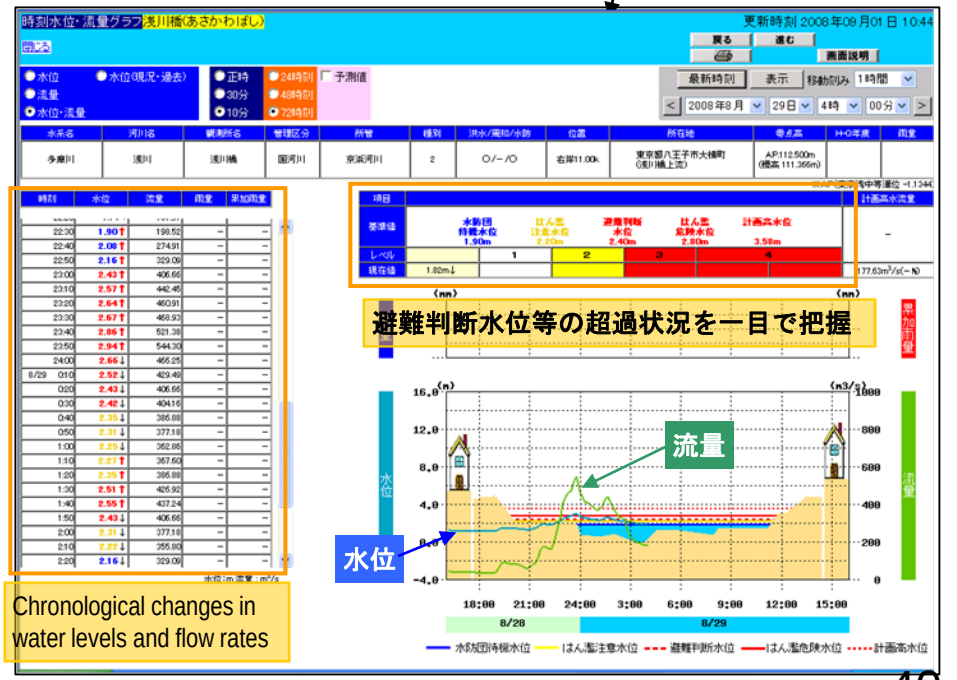

Response to disaster

Images of affected areas sent by helicopters



Sharing various kinds of information through a large screen


River information system

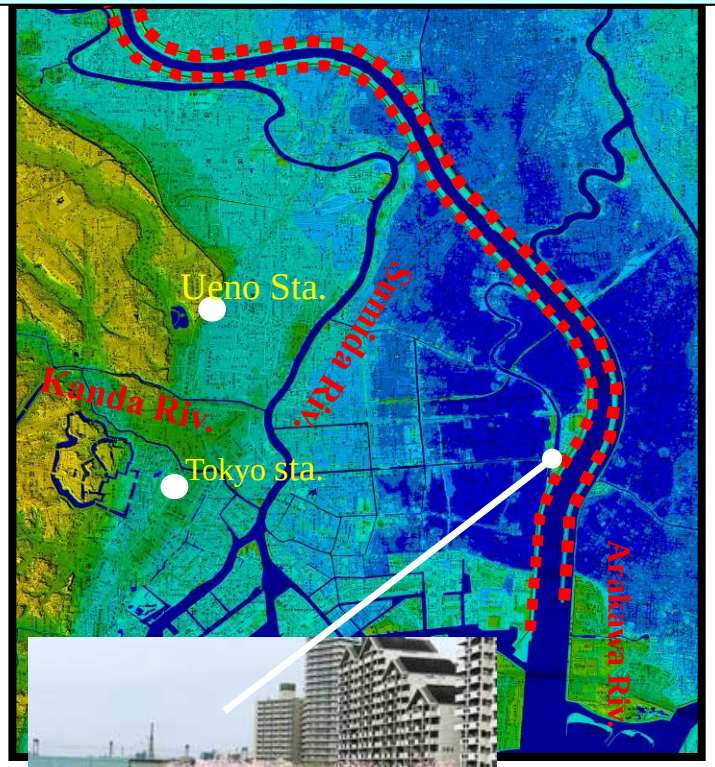


Chronological changes in water levels and flow rates

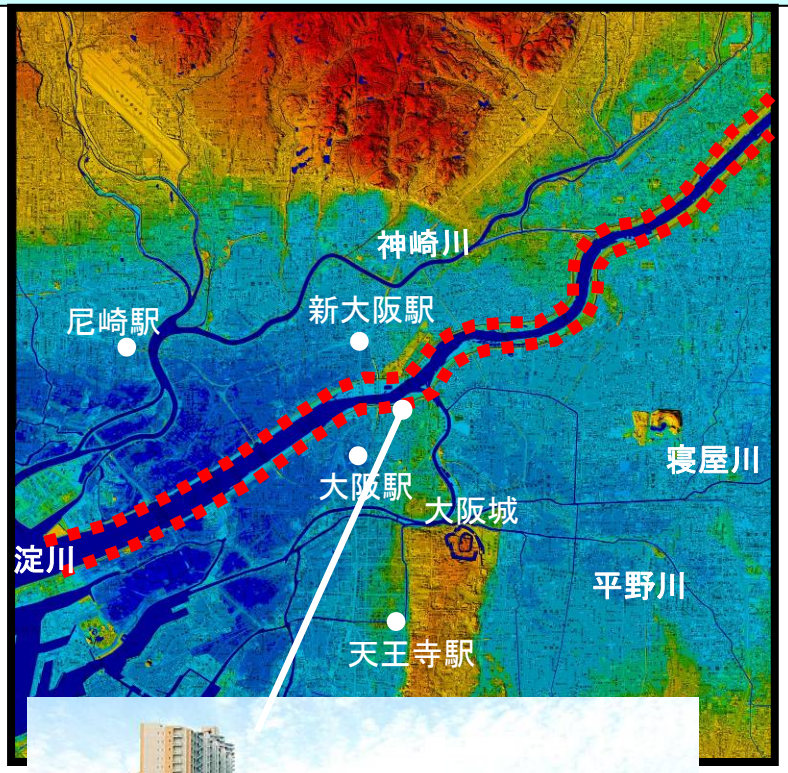
写真：国土交通省関東地方整備局

Prevention from Catastrophic Damage

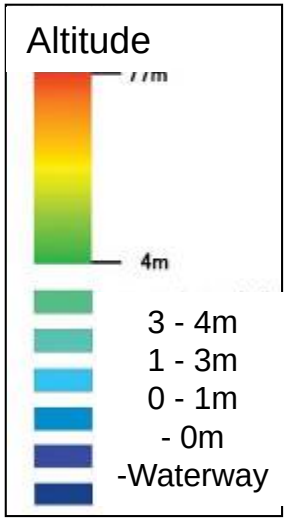
High-standard embankment, which has excellent durability against seepage and overtopping during flood, is constructed, in order to prevent low level terrain areas of high urbanized large cities, such as Tokyo and Osaka, from catastrophic damages, in case of rapid flooding with dyke breach.

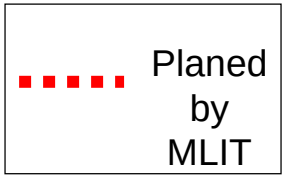


Komatugawa Area, Arakawa



Iganishi Towmk Yodo





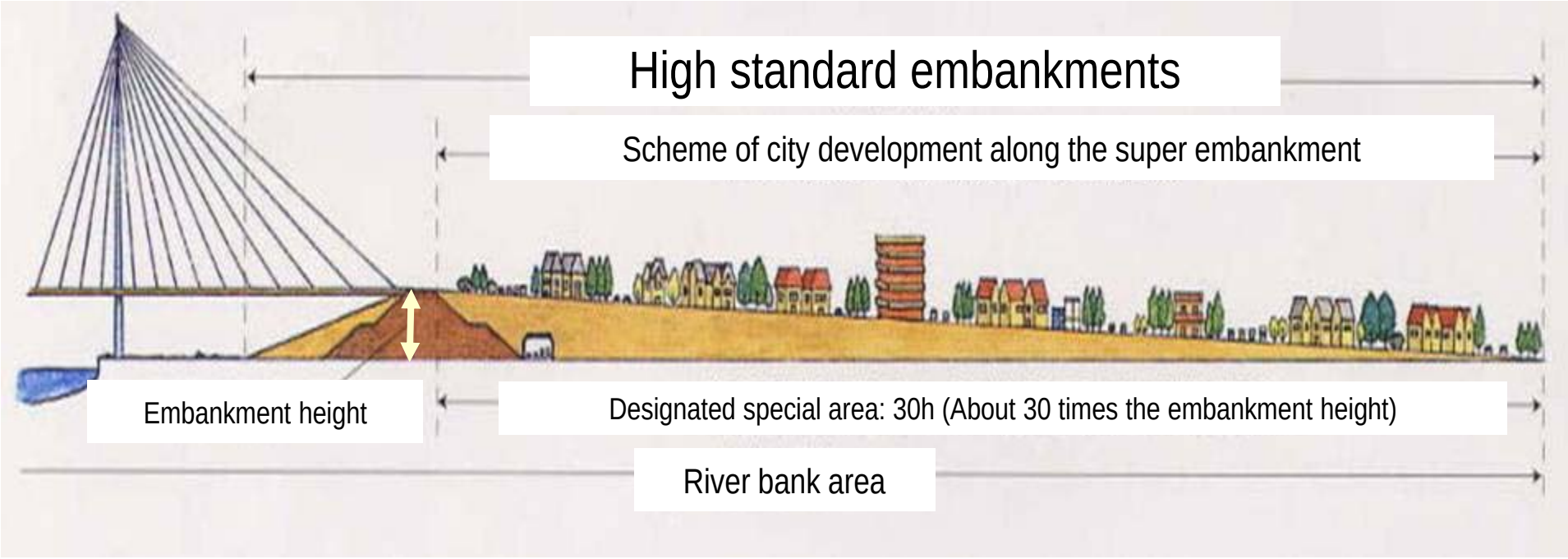
6 rivers of 5 river system (Tone, Arakawa, Edogawa, Tama, Yodo, Yamato) selected

High-standard Embankments (a.k.a. Super Embankments)

- Super embankments have mounding in more extensive urban areas than existing embankments. The advantages of super embankments are:

1) no collapse at floods,
2) no collapse against inundation, and
3) earthquake-resistant.

- River bank land development is strictly restricted pursuant to the River Law. However, the whole slopes at the back of super embankments are designated as the special areas, for which land development is deregulated.



High-standard Embankments (a.k.a. Super Embankments)

In order to prevent devastating damage caused by the destruction of dikes even when water infiltrates or overflows due to floods, embankment with a safer structure are being built (high-standard embankments).

Prior to embankment

After embankment

Arakawa River and Shinden districts in Adachi City

写真：荒川下流河川事務所提供

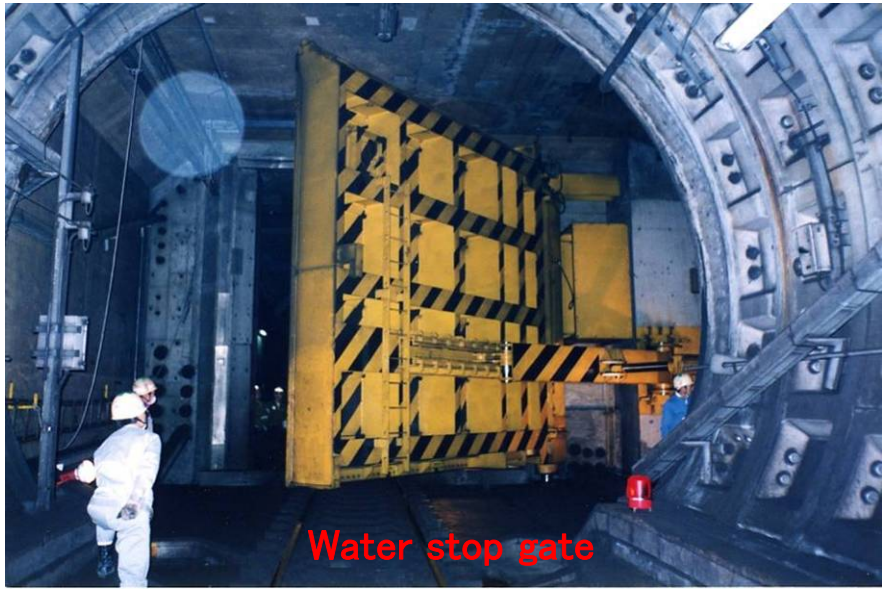
Measures taken for subways to cope with floods

1) Installation of water stop boards at the entrance to subway stations

2) Installation or elevation of water stop doors at the entrance of subway stations

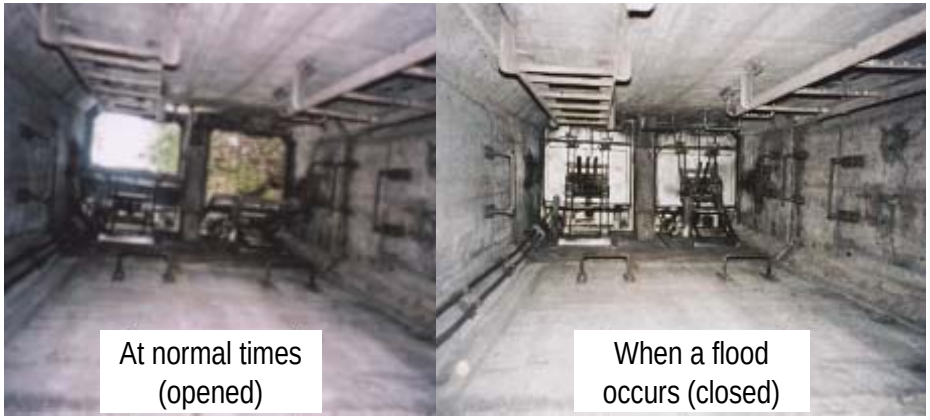
Entrance to a subway station on Tozai Line (Koto City)
The installation standard is to prevent floods at T.P. 1.0 m or higher.

3) Measures to protect tunnels from floods



4) Measures to prevent floods from air vents

Machines for preventing floods



* These pictures were taken from underground in the air vent, looking up to the ground surface.

Various measures against water-related disasters in Japan

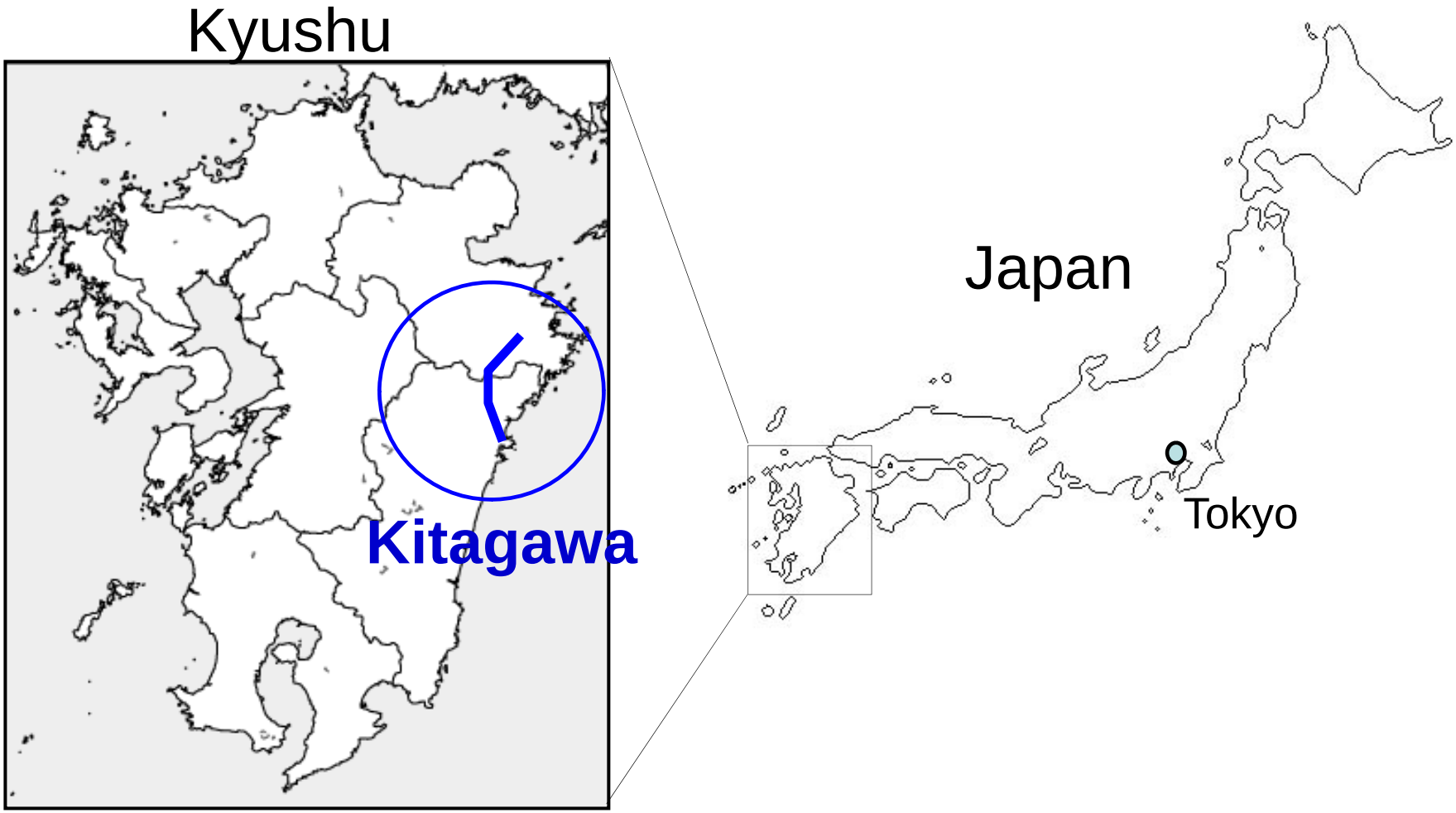
Contents

1. Characteristics of rivers and river basins in Japan

2. Case studies of Tone River and Arakawa River

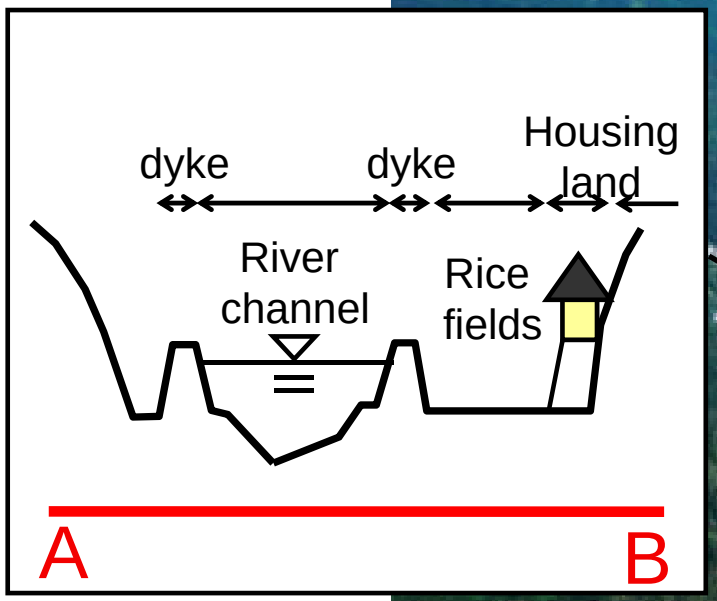
3. Case studies of Kitagawa River

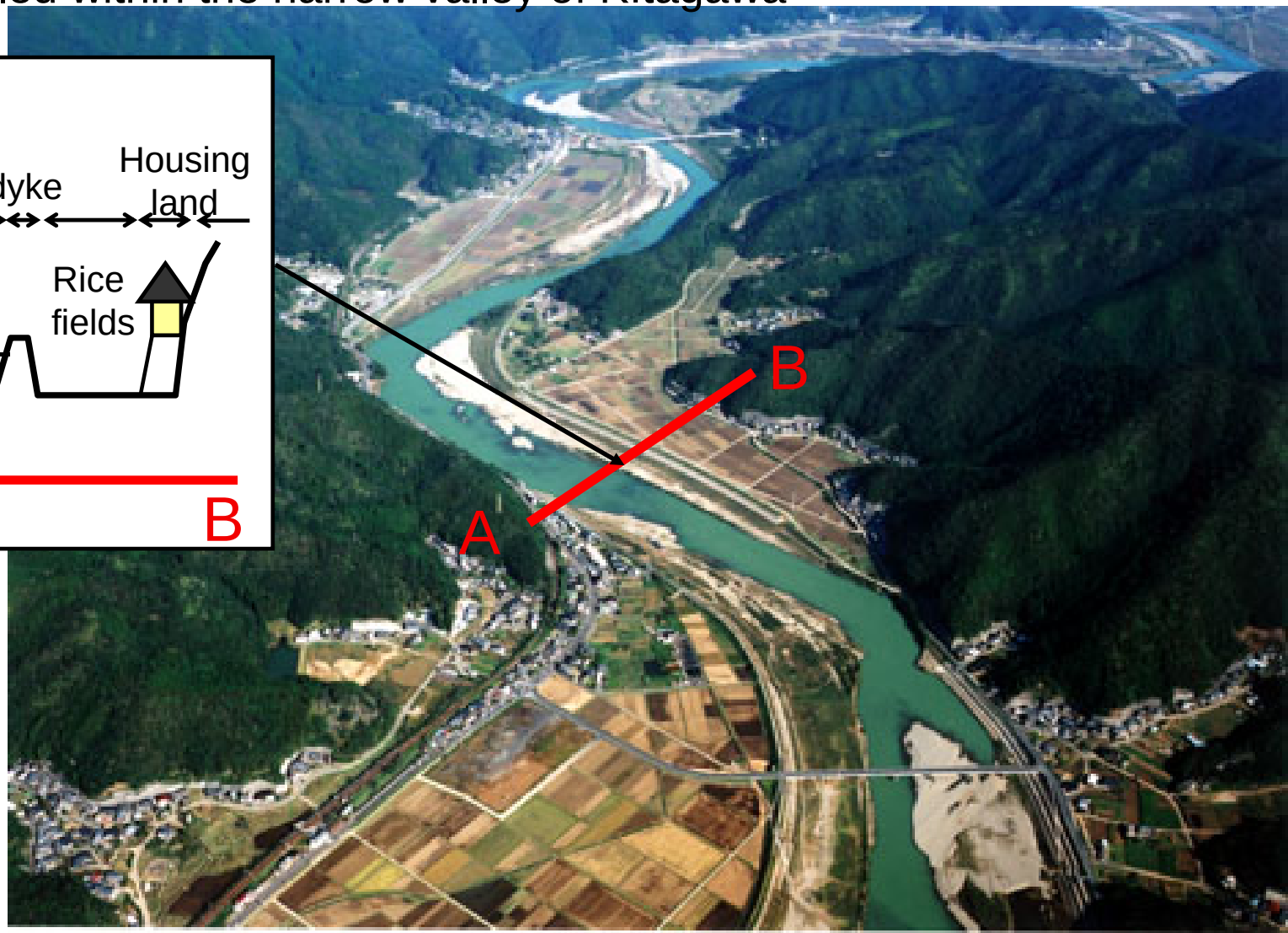
4. Lessons Learned


Kyushu
Kitagawa
Japan
Tokyo

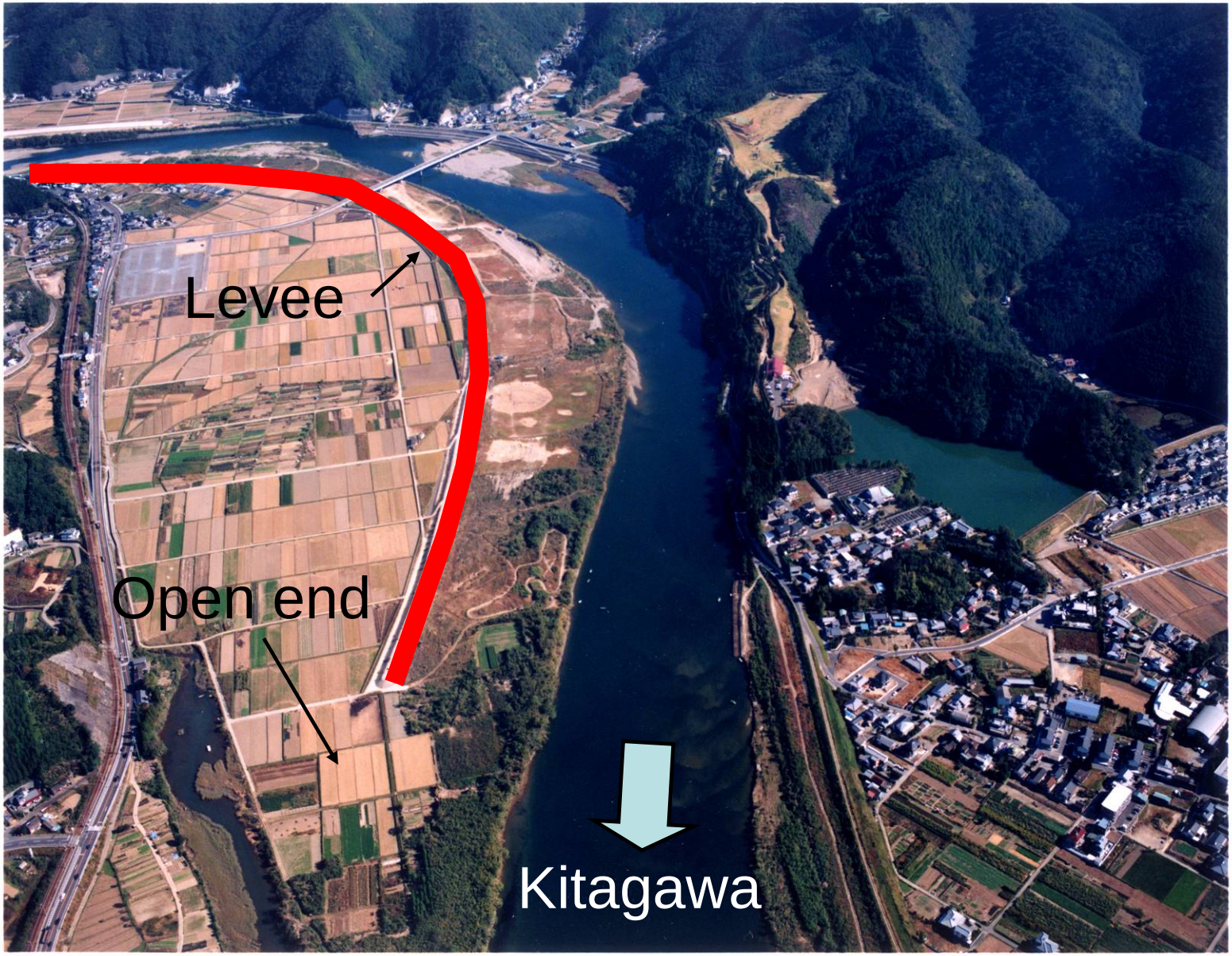
Kitagawa river meanders through flat areas in the valley floor, mainly used for rice fields. Housing land locates higher area along the foot of mountains.

A river channel, which has enough capacity for the recorded flood discharge, cannot be installed within the narrow valley of KItagawa





Traditional Japanese *Kasumi-tei*, or “Open Levee”



Typhoon 19th in 1997 made flood discharge up to 5,000 m^3/s, much more than design discharge 4,000m^3/s, and cased serious inundation damages along Kitagawa.

1,900 houses of whole area of valley floor was inundated.

Flood control measure with “*Kasumi-tei*”

Continuous levees and excavation cannot secure the discharge for recorded flood.

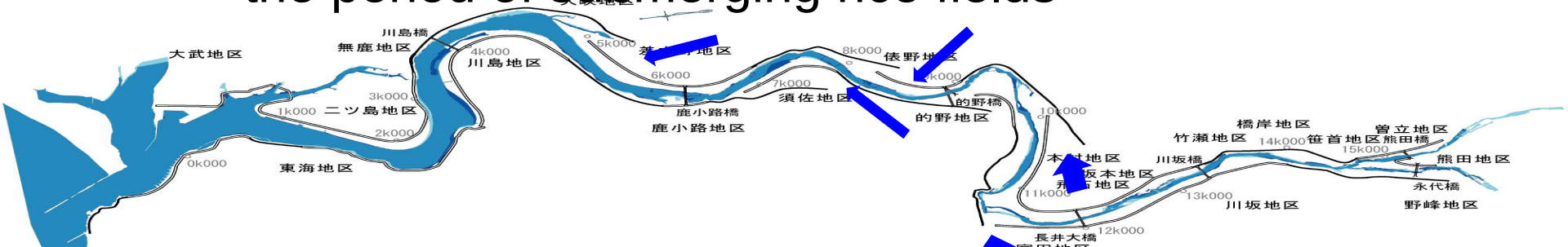
=> In case of dyke breach, catastrophic damage may occur because of flood flow impacts.

The risks in the inundation areas could be reduced, by keeping the end of the levee open to allow the inundation from downstream side and make the flood flow slower.

=> ・flood flow from the downstream

> reduce the flood flow velocity to prevent the rice plants from falling down.

> rapid drainage around the end of inundation to shorten the period of submerging rice fields



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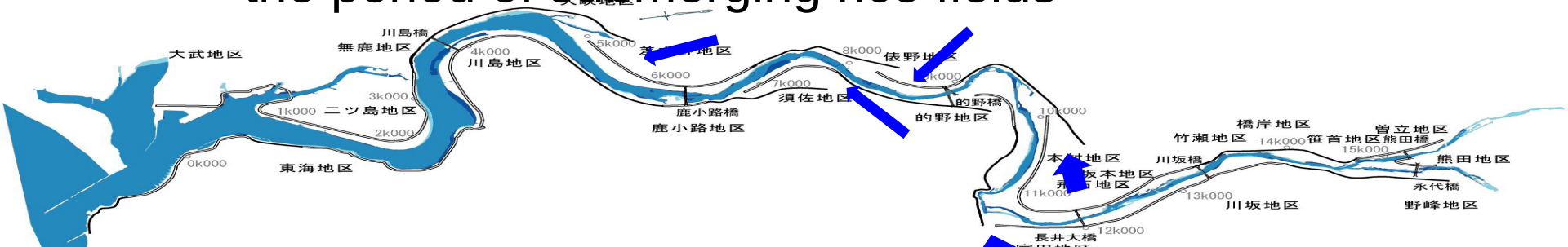
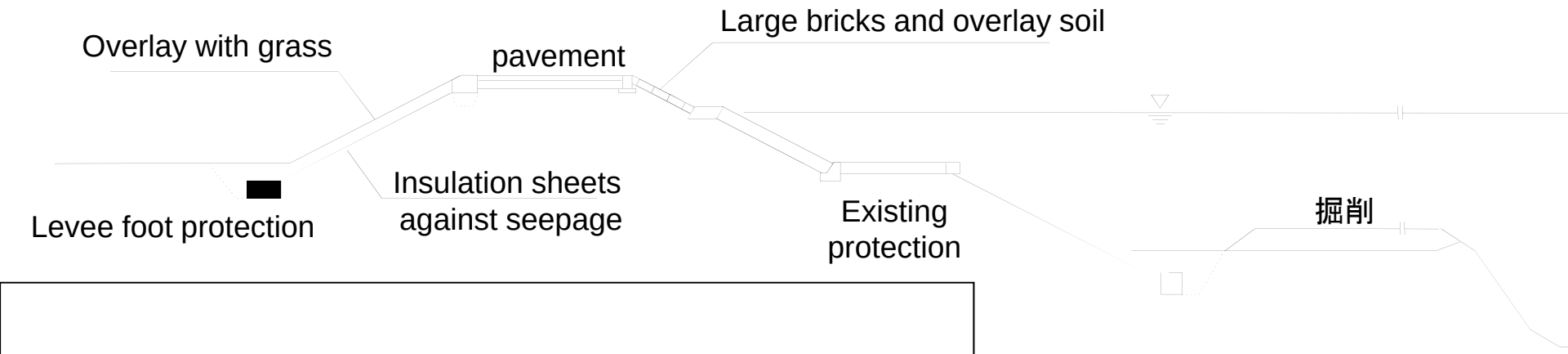
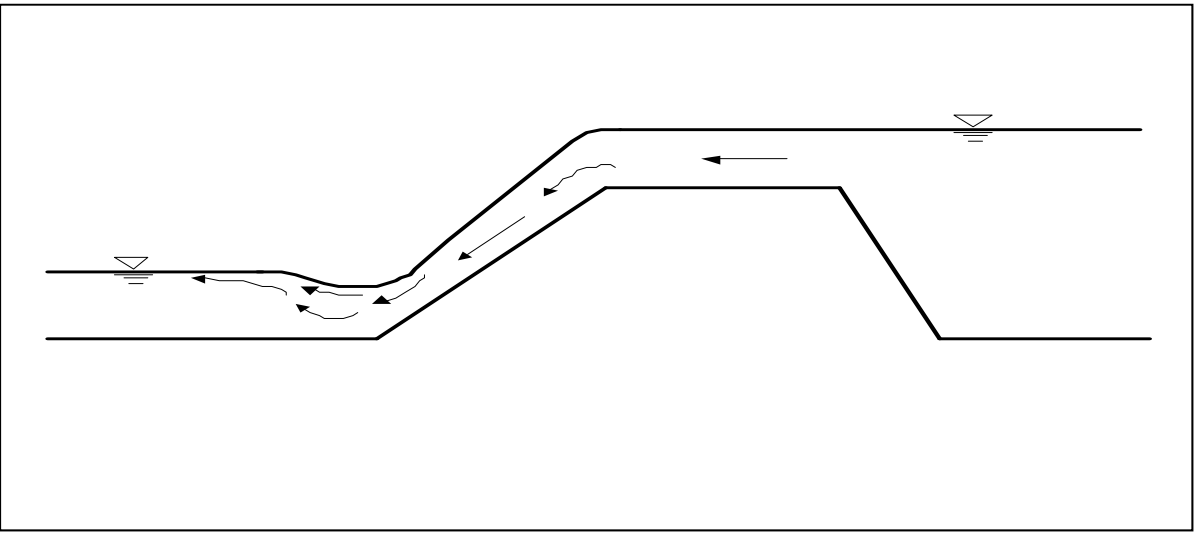


Excavation and felling trees, as a part of the flood control measures including the open end levees, were carried out for increase in the discharge capacity to lower the flood water level.

Strengthen Levee against over topping



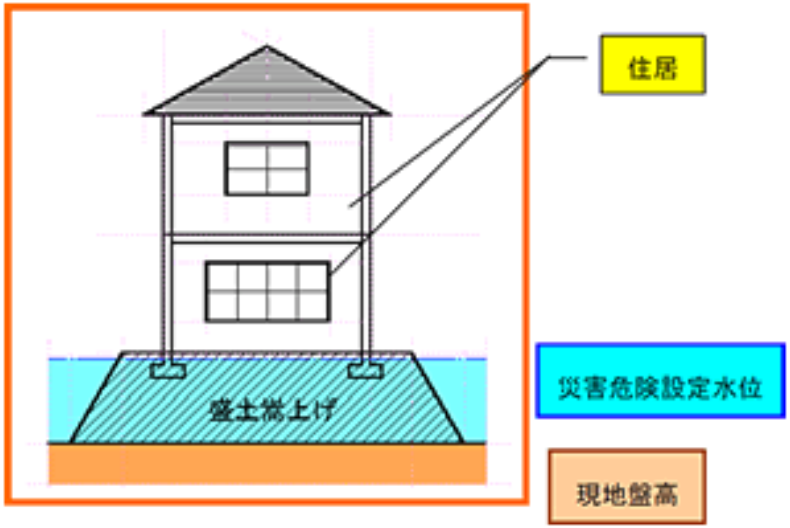


inundation water protect the levee foot against erosion caused by over topping flow.

Building regulations and a subsidies for heightening houses are carried out to reduce the damage from inundation.

Heightening Houses

“High risk area of disaster”
The heightening is regulated



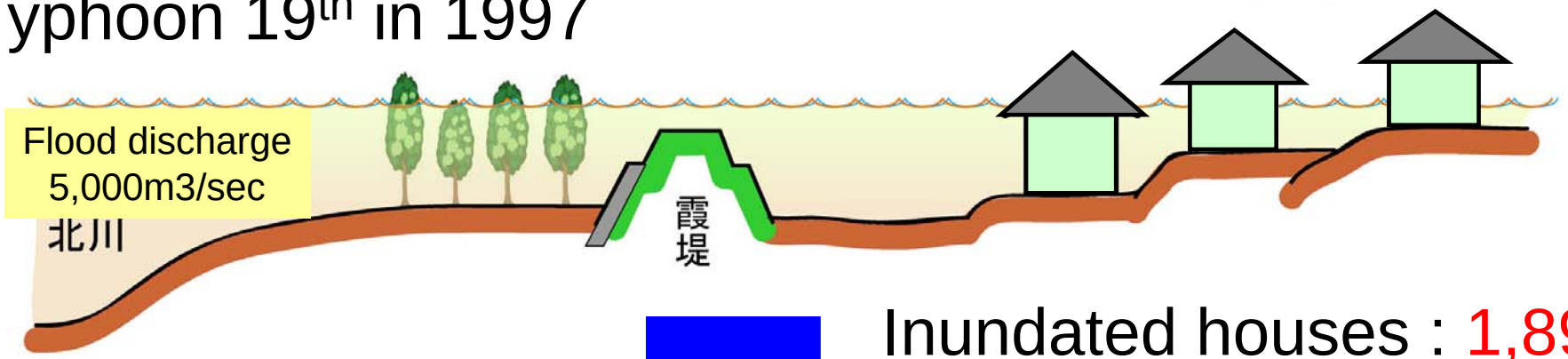
The series of measures are accepted with the background as follows…

1. The self defense against flood has been carried out in this area.
2. Flood flow control with open end levee, “Kasumi-tei” has

Successful results of the measures.

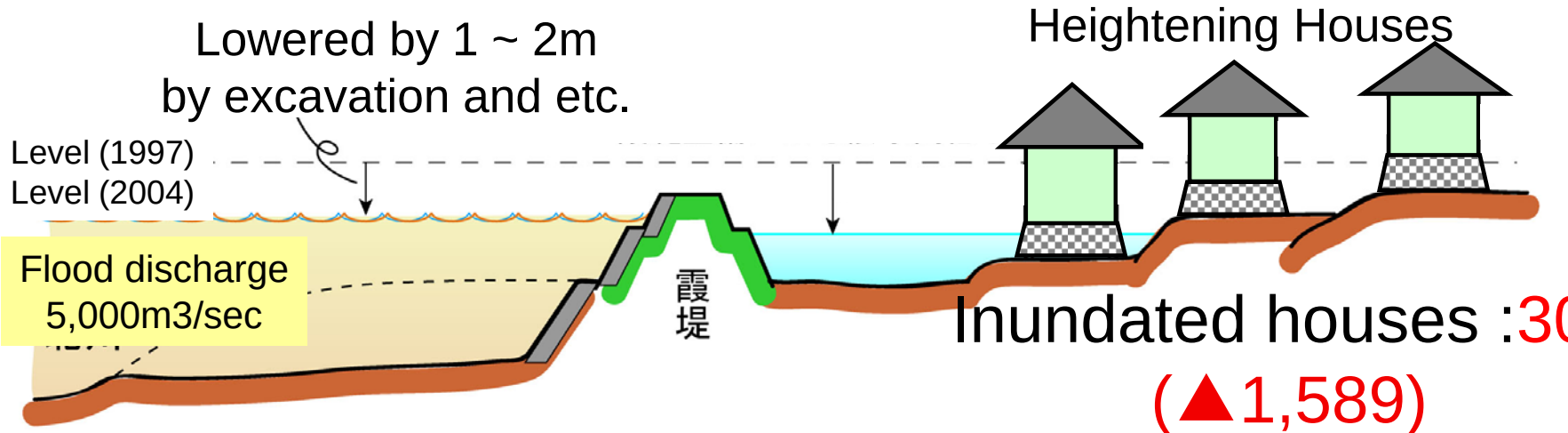
> Inundation damage was reduced remarkably in case of the same magnitude flooding.

Typhoon 19th in 1997



Inundated houses : 1,894

Typhoon 23rd in 2004



Inundated houses :305
(▲1,589)

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Lessons Learned (1)

- Various and multilayered measures have been implemented in the cases above, in consideration of the characteristics of each river basin and its risks of water-related disaster.

Tone and Arakawa river (Tokyo metropolitan area):
Socio-economic damage of inundation is huge and serious.
> Main target of the measures is the reduction of the magnitude of inundation, which would make a fatal damage to the nation.

Kitagawa river:
Socio-economic damages of inundation is limited within the area.
> Main target of the measures is the reduction of the damage based on the characteristics, land use, historical flood control measure, which would allow the inundation.

Lessons Learned (2)

- The measures to enlarge the resilience against various magnitude of disasters is required because the increase in the hazard of water-related disasters is projected in future.

  > The combination of multilayered measures will provide an optimal solution for preventing serious damage from occurring in the future.

Thank you very much for you attention.