The Effects of Future Increases in Heavy Rain on Measure for the Prevention of Inundation in Urban Areas

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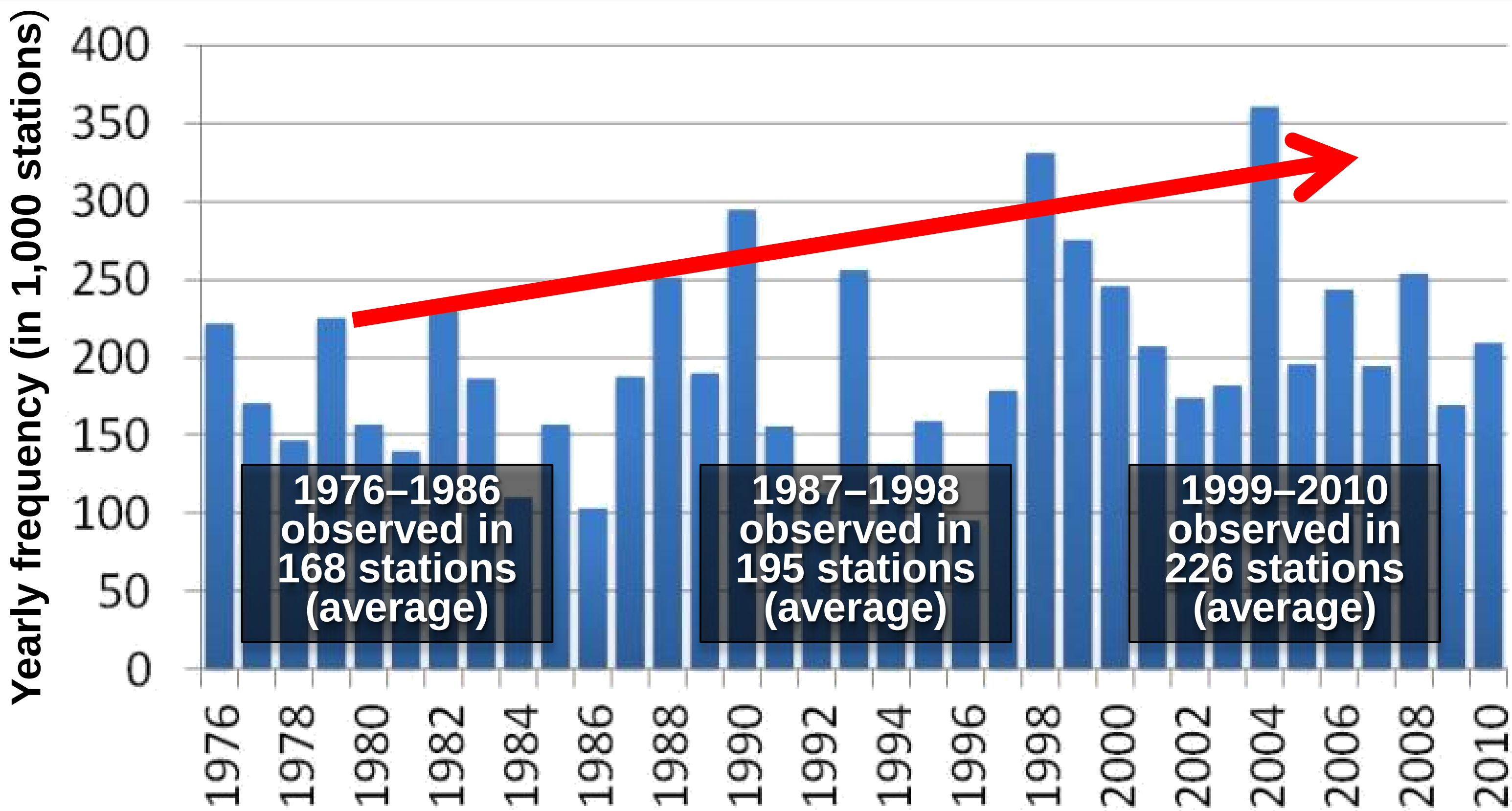
Background

Frequency of rainfall exceeded 50 mm/h observed in 1,000 stations per year for recent 35 years



Reference: Japan Meteorological Agency

- In recent years, rainfall exceeded 50 mm/h has occurred frequently in Japan.

Background

Reference: http://www.mlit.go.jp/mizukokudo/sewerage/crd_sewerage_tk_000117.html

- Present inundation countermeasures need to be improved against heavy rain.

Today's Topic

1. Increasing rate of heavy rain
2. Case studies about increase of heavy rain
3. Examples of stormwater storage systems
4. Effective use of stormwater

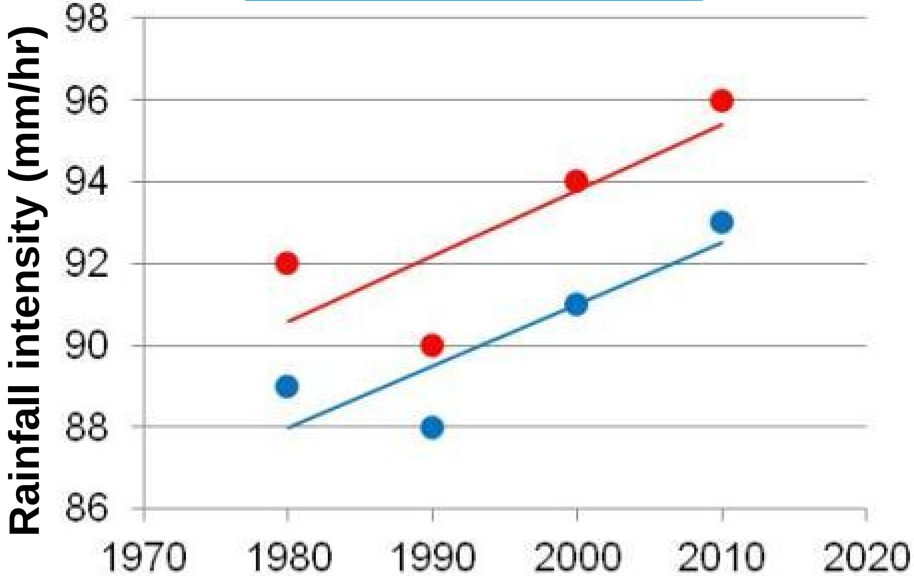
1. Increasing rate of heavy rain

Is heavy rain occurring more frequently?

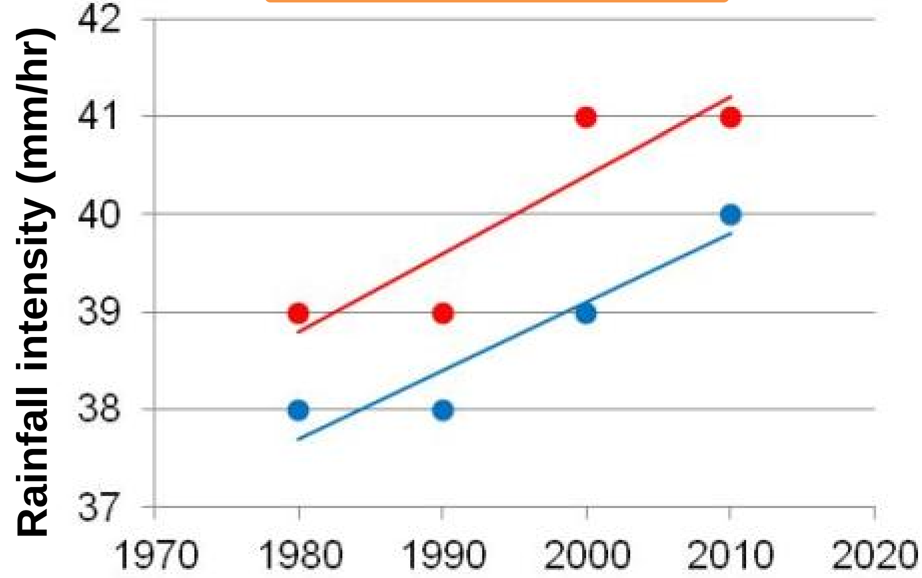
- Analysis data from Japan Meteorological Agency
- ✓ Annual maximum 10-minute rainfall intensity
- ✓ Annual maximum 60-minute rainfall intensity
- ✓ For 50 years (1960–2009)
- ✓ 57 meteorological observatories

1. Increasing rate of heavy rain

10 minutes



60 minutes



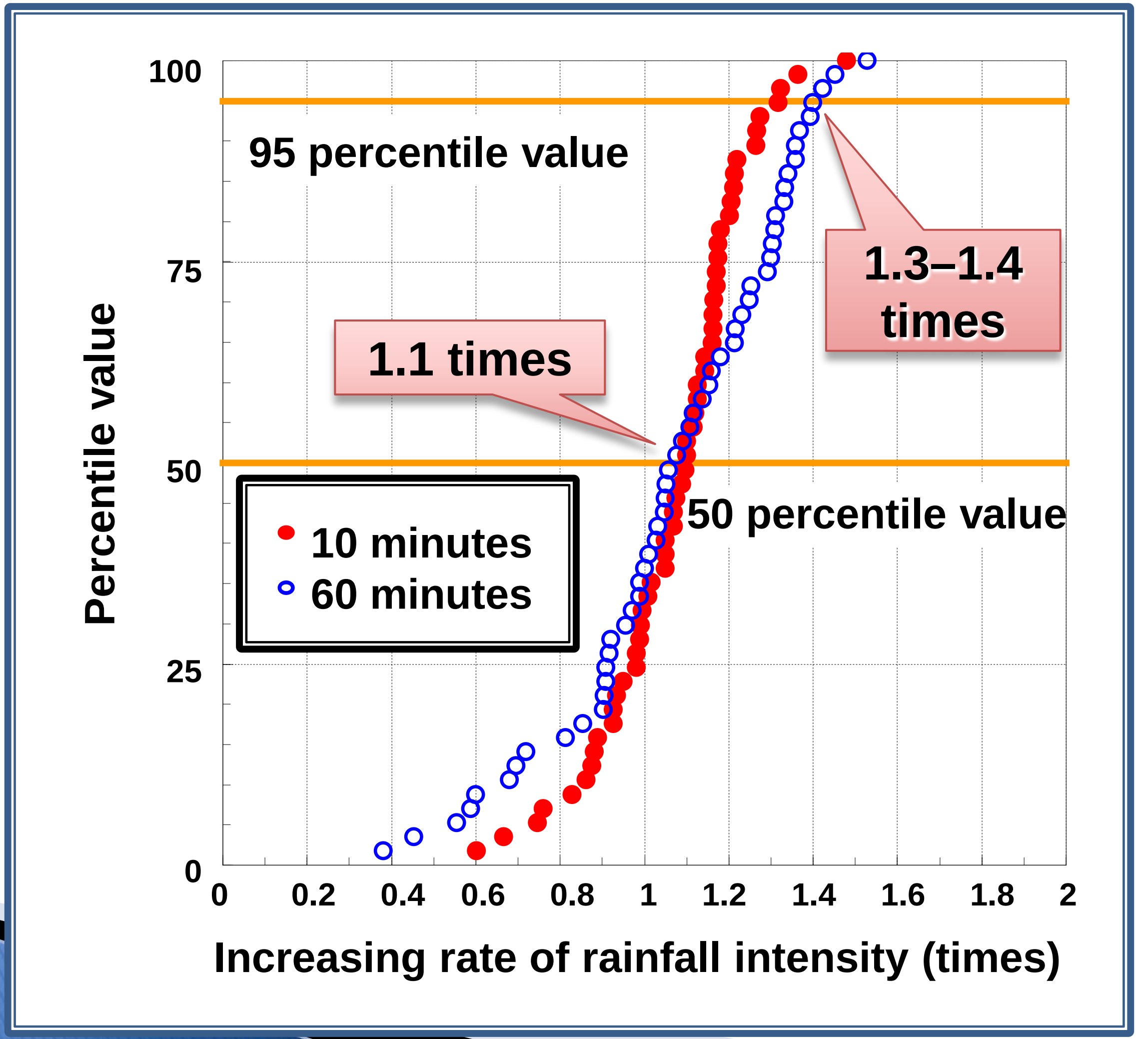
- 5-year probability
  Increasing rate for 50 years : 8%
- 10-year probability
  Increasing rate for 50 years : 8%

- 5-year probability
  Increasing rate for 50 years : 9%
- 10-year probability
  Increasing rate for 50 years : 10%

- Calculated by the Thomas plot method

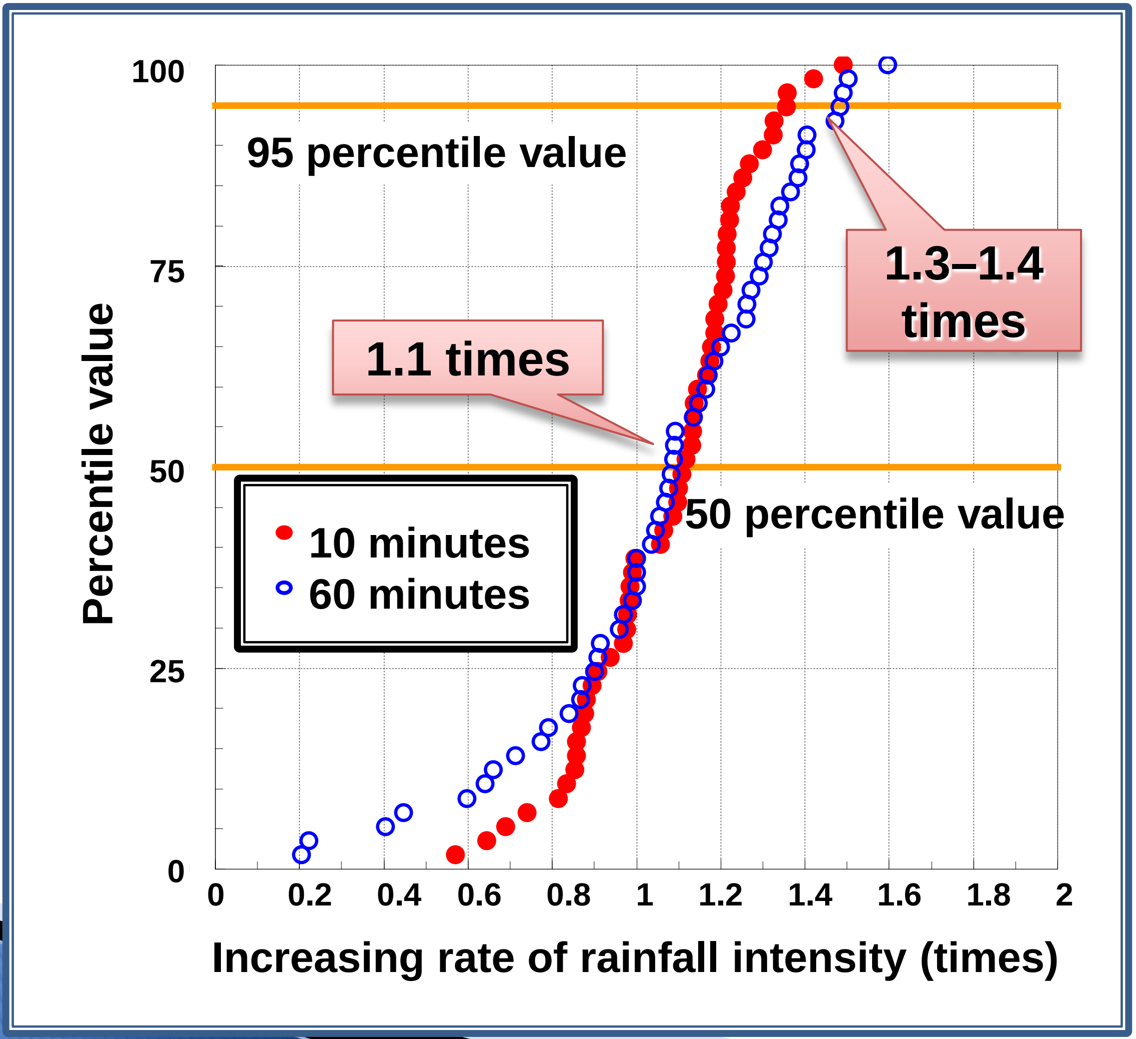
1. Increasing rate of heavy rain

- Increasing rate of **5-year probable rainfall intensity** for 50 years
- 57 meteorological observatories



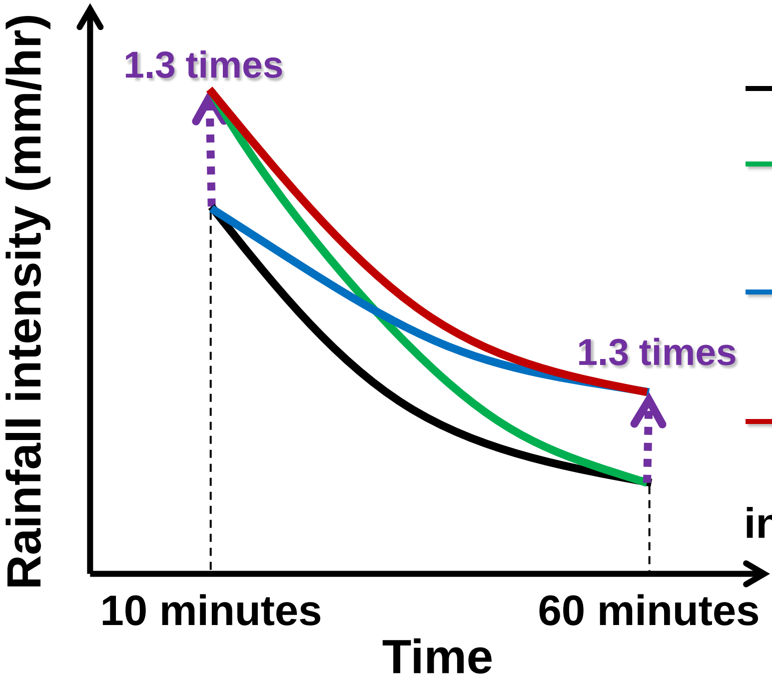
1. Increasing rate of heavy rain

- Increasing rate of **10-year probable rainfall intensity** for 50 years
- 57 meteorological observatories



2. Case studies about increase of heavy rain

- Image of Scenario Pattern



— **Conventional planned rainfall intensities**

— **Scenario A**
(1.3 times Increase of 10-minute rainfall intensity)

— **Scenario B**
(1.3 times Increase of 60-minute rainfall intensity)

— **Scenario C**
(1.3 times Increases both of 10-minute rainfall intensity and 60-minute rainfall intensity)

- Object districts

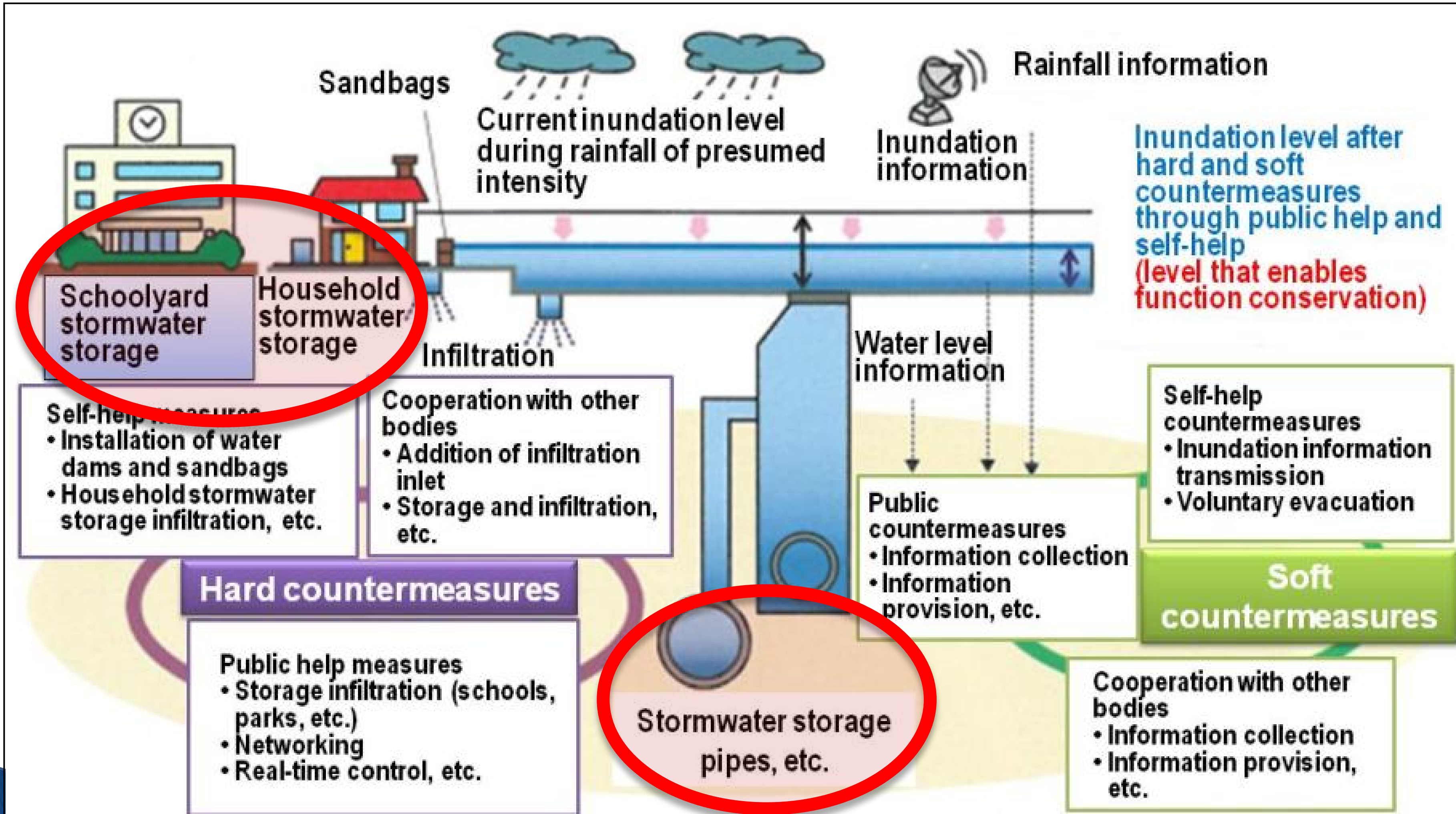
	District X	District Y	District Z
Area of drainage district (10^4 m^2)	**3,350**	**62**	**1,900**

2. Case studies about increase of heavy rain

District name		District X	District Y	District Z
Area of drainage district (10^4 m^2)		3,350	62	1,900
Scenario A (Increase of 10-minute rainfall intensity)	Increasing rate of inundation area* (inundation depth over 0.2 m)	0.7%	**6%**	0.4%
	Main region of inundation	-	Upstream	-
Scenario B (Increase of 60-minute rainfall intensity)	Increasing rate of inundation area* (inundation depth over 0.2 m)	**7%**	0%	**7%**
	Main region of inundation	Midstream	-	Overall
Scenario C	Increasing rate of			

- ✓ In regards to small catchment areas, it is important to consider the impact of short periods of rainfall.
- ✓ As for large catchment areas, improving the level of drainage over a wide area is effective.

Comprehensive inundation countermeasures



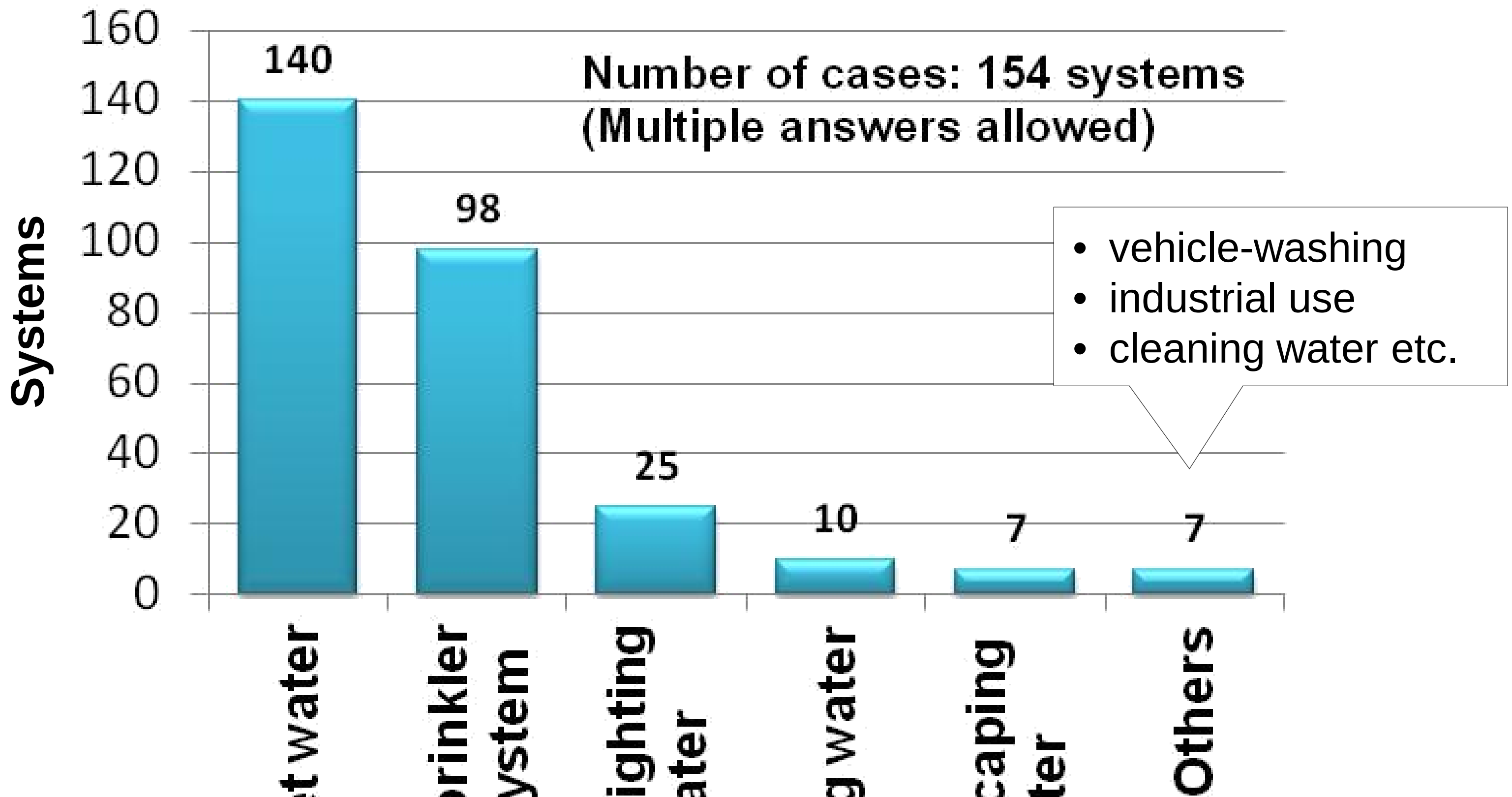
Reference: Sewage Works in Japan 2009(Japan Sewage Works Association)

3. Examples of stormwater storage systems

In recent years, **effective use of stormwater storage** is increasing in Japan.

4. Effective use of stormwater

- 154 stormwater utilization systems of 9 local governments



✓ Consideration of stormwater use like this figure is important in the efficient use of water resources.

Conclusions

1. Increasing rate of heavy rain

- 10-minute rainfall intensity and 60-minute rainfall intensity of 5 or 10 year probability are likely to increase, and the increasing rates are estimated 1.3 or 1.4 times in 50 years at most.

2. Case studies about increase of heavy rain

- In regards to small catchment areas, it is important to consider the impact of short periods of rainfall.
- As for large catchment areas, improving the level of drainage over a wide area is effective.

Conclusions

3. Examples of stormwater storage systems

- Underground pipes, underground ponds, surface in the parks, and in paddy fields as stormwater storage is increasingly effective in Japan.

4. Effective use of stormwater

- The major use of stormwater is toilet water, followed by sprinkler system, etc.
- Consideration of stormwater use is important in the efficient use of water resources.

Thank you for your attention.

Acknowledgement

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Trends of rainfall in the world

- Extremely heavy rain is increasing in Europe, North America and South America.*

- In the long term, total amount of rainfall is increasing in the Southern Hemisphere, but it's not changing significantly in worldwide.**

Reference: Japan Meteorological Agency

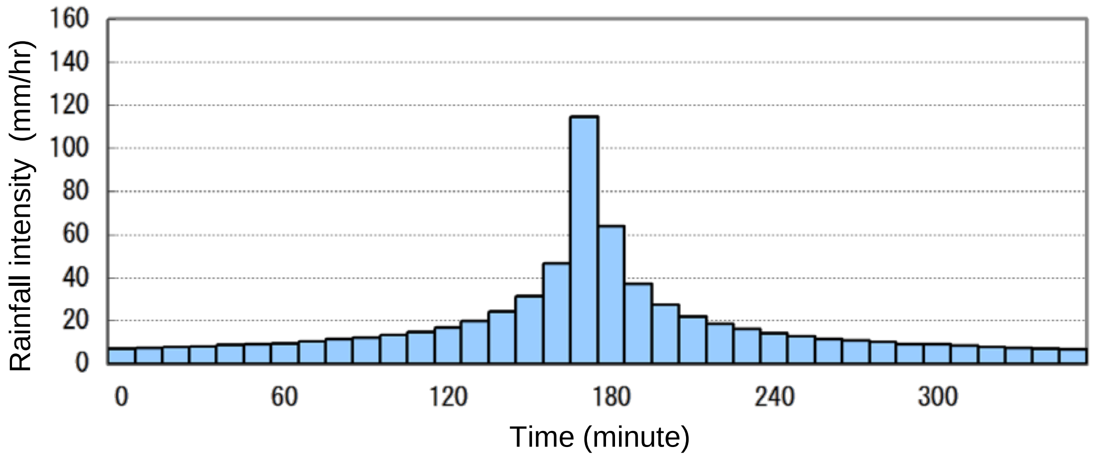
*http://www.data.kishou.go.jp/climate/cpdinfo/climate_change/2005/1.3.3.html

**http://www.data.kishou.go.jp/climate/cpdinfo/climate_change/2005/pdf/2005_2-1.pdf

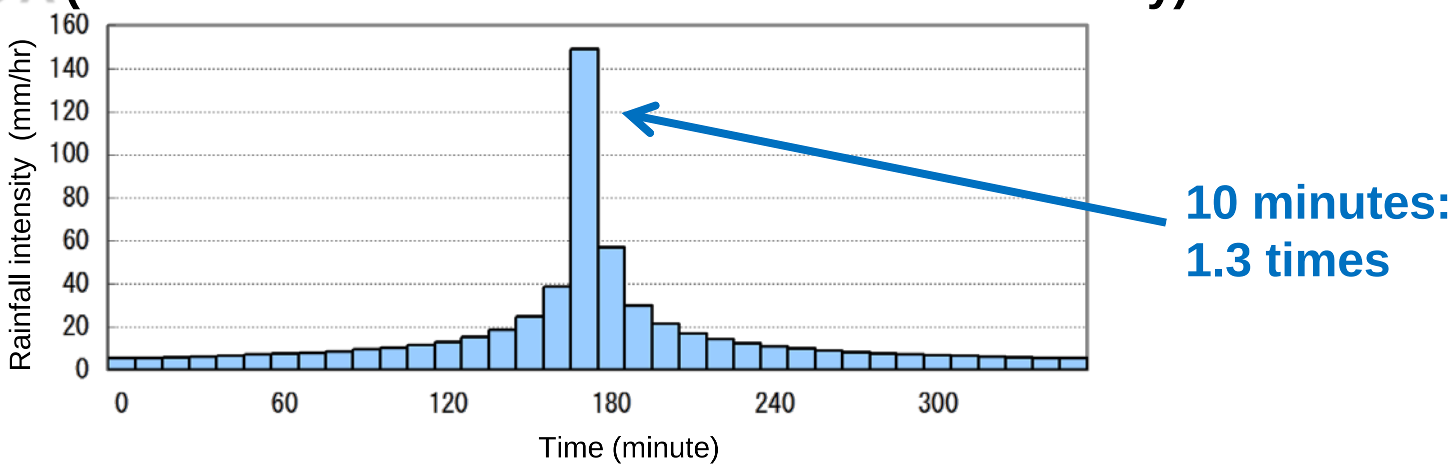
Scenario patterns of rainfall intensity

Rainfall Intensity was calculated by the formula which can calculate rainfall intensity only from 10-minute rainfall and 60-minute rainfall.

✓ **Conventional planned rainfall intensities**

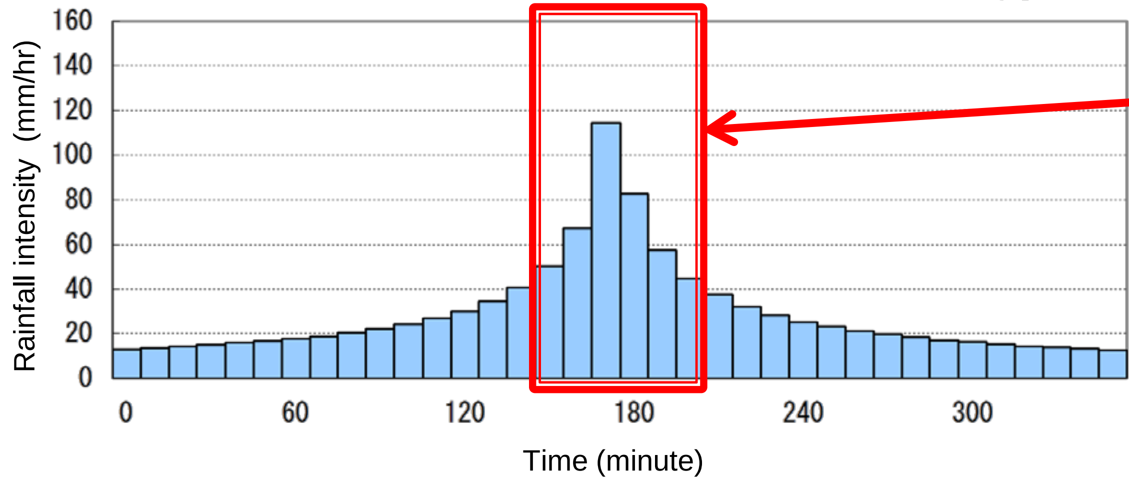


✓ **Scenario A (1.3 times Increase of 10-minute rainfall intensity)**



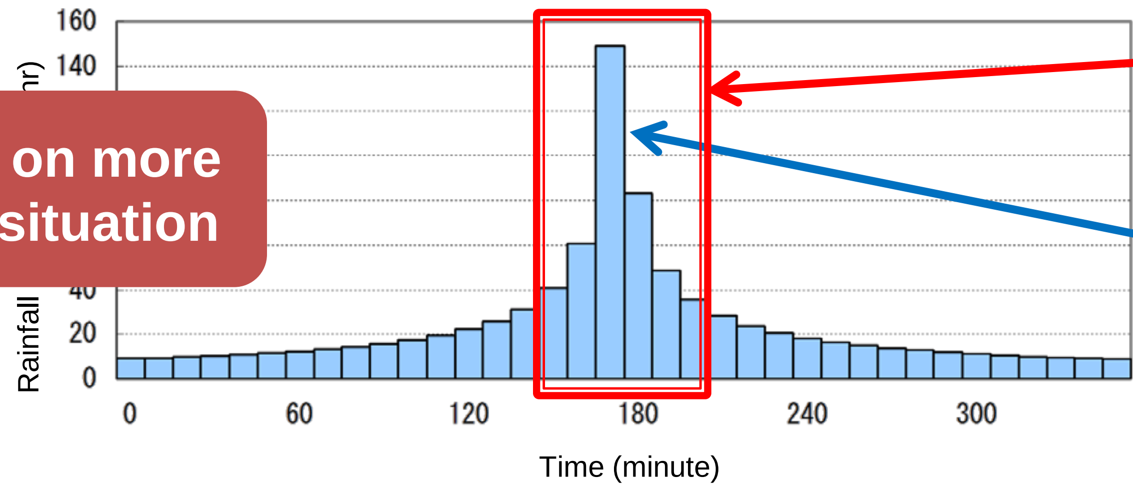
Scenario patterns of rainfall intensity

✓ **Scenario B (1.3 times Increase of 60-minute rainfall intensity)**



60 minutes: 1.3 times

✓ **Scenario C (1.3 times Increases of 10-minute and 60-minute rainfall intensity)**



60 minutes: 1.3 times

10 minutes: 1.3 times

To evaluate on more dangerous situation

Object districts of the case studies

- In order to compare the results of a large catchment area and a small catchment area, we chose three districts.

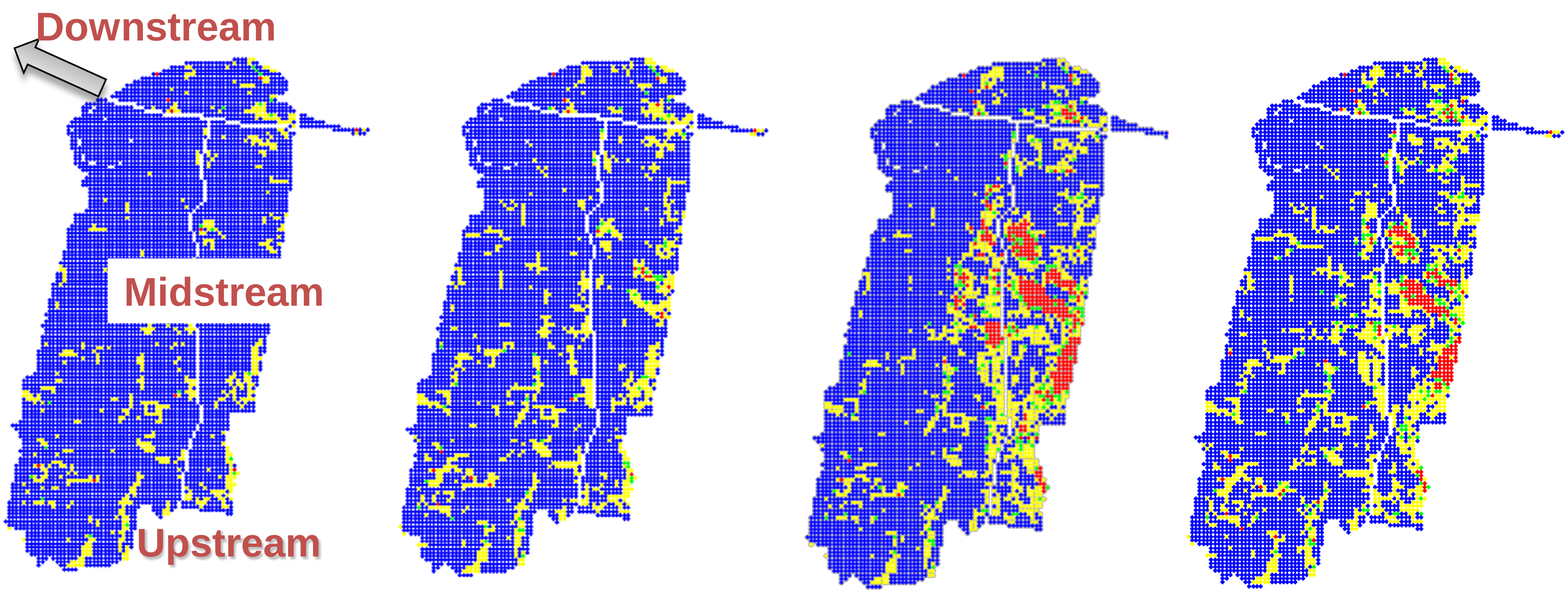
District name		District X	District Y	District Z
Drainage method		Combined	Separate	Combined
Area of drainage district (10^4 m^2)		**3,350**	**62**	**1,900**
Runoff coefficient		0.45	0.60	0.82
Rainfall simulated	60-minute rainfall intensity (mm/hr)	34.3	50.0	53.4
	10-minute rainfall intensity (mm/hr)	87.1	109.5	114.6
Minimum diameter of sewer pipe simulated (mm)		1,000	300	500
Software used for the simulations*		MOUSE	MOUSE	InfoWorks

* The model which each city was using for formulation of sewer plans

- ✓ Different characteristics of geographic and rainfall
- ✓ Adequate data for inundation simulation

Examples of simulation results (District Z)

Conventional planned **Scenario A** **Scenario B** **Scenario C**



Inundation depth (m)
- 0
- 0–0.2
- 0.2–0.3
- 0.3–

- ✓ Main region of inundation depends on size of catchment areas.
- ✓ However, it's not clear only from this result. <u>It is necessary to simulate in other districts.</u>

Suitable countermeasures for each district considered from this research result

Small catchment area (District Y)

In regards to small catchment areas, it is important to consider the impact of short periods of rainfall.

↓

So, peak cut type countermeasures are effective.

Large catchment area (District X, District Z)

As for large catchment areas, improving the level of drainage over a wide area is effective.

↓

So, improvement in drainage capacity is effective.
For example, it's the network of large-scale sewer pipes.

Examples of stormwater storage systems

Underground storage pipes

Reference: http://www.city.kawasaki.jp/53/53kense/home/usui_choryuukan/usui_choryuukan.htm

Underground storage ponds

Reference: http://www.city.fukuoka.lg.jp/data/open/cnt/3/29121/1/Sannou_StormwaterReservoir.pdf

Underground storage pipes and underground storage ponds have benefit that large quantity for storage was ensured. However, construction of these takes high cost and long period.

Surface storage in parks

Reference: http://www.city.yokohama.lg.jp/doro/kasenkeikaku/menu/chisui/sogochisui.html

Storage in paddy fields

Reference: http://www.city.anjo.aichi.jp/shisei/joreikeikaku/usuimasterplan/suiden/documents/suidentyoryu-taihu2gou.pdf

Surface storage in parks and storage in paddy fields are cheaper than large storage systems, but require approval of the park manager or owner of paddy fields.

Examples of stormwater use

Institution kind	Storage capacity (m^3)	Time started to use	Purpose of use	Amount of annual use (m^3)
Public office	1,095	Feb., 1990	Toilet water, Sprinkler system[*1]	10,000
Public office	86	Oct., 2009	Toilet water, Sprinkler system	744
Public office	1,200	Jun., 2003	Cooling water[*2], Landscaping water[*3]	2,634
School	365.4	Apr., 1998	Toilet water, Sprinkler system	3,565
Communal facility	2,000	May., 1999	Toilet water	35,158
Tourist facility	500	Dec., 2000	Toilet water	6,000–7,000
…	…	…	…	…

[*1] Sprinkler system: Watering a tennis court, a garden, a road, etc.
[*2] Cooling water: Cooling an air conditioner, etc.
[*3] Landscaping water: Creating a artificial river, a artificial pond , etc.

Ongoing study

Increase of heavy rain

- By conducting other simulations and investigations, the countermeasures which have effects in each district are found out.

Effective use of stormwater

- We will visualize data on a map and exhibit the map on the Internet. By doing so, we promote effective use of stoemwater.

Effective use of stoemwater in storage systems is increasing, but the area is still restricted. For example, it is an area with few water resources.