Waterworks damage

Yasuko Kuwata
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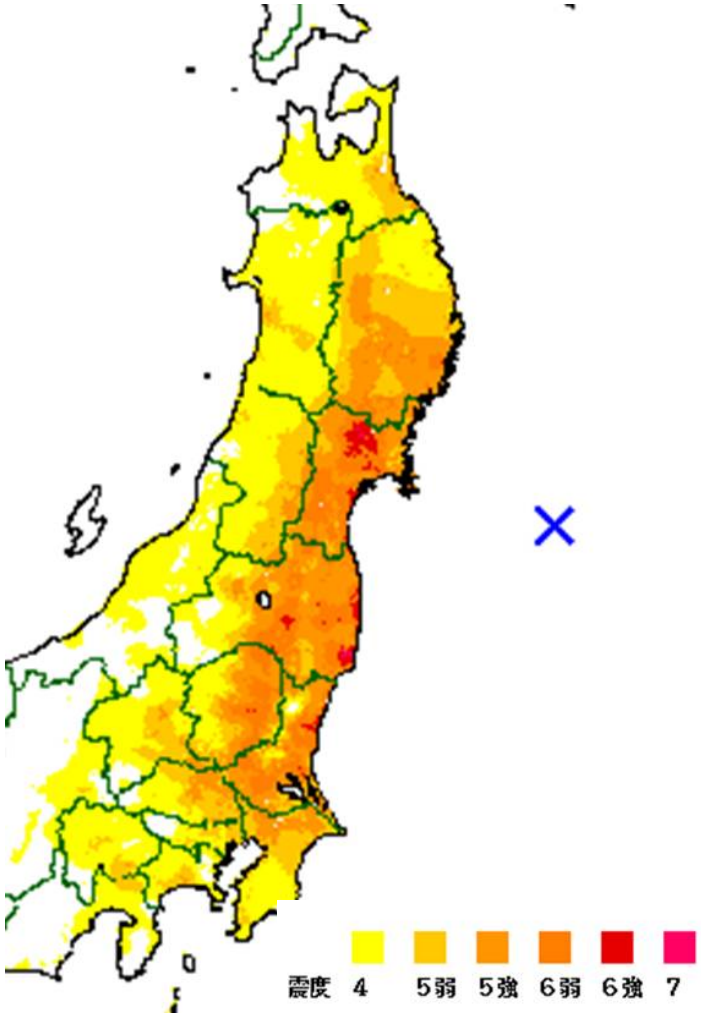
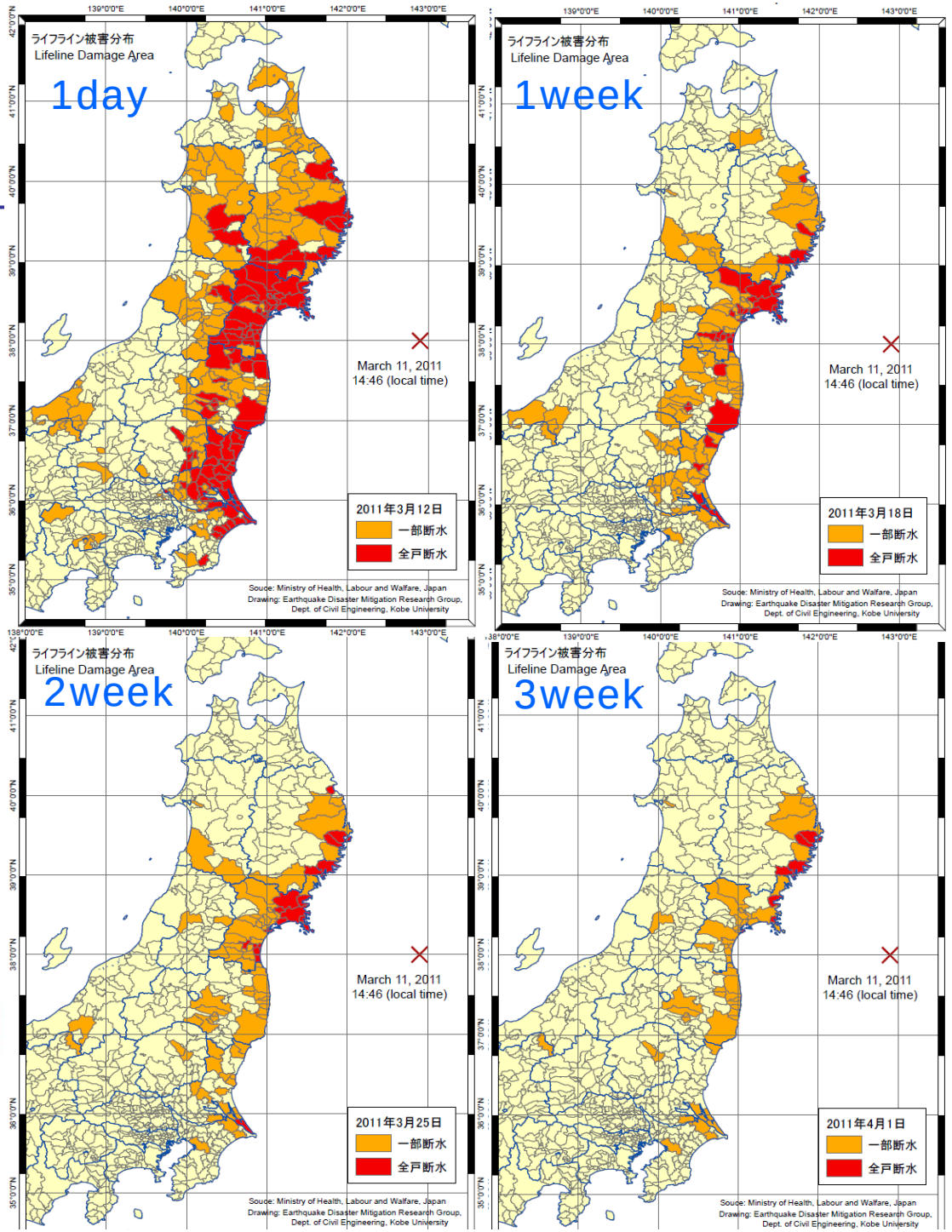
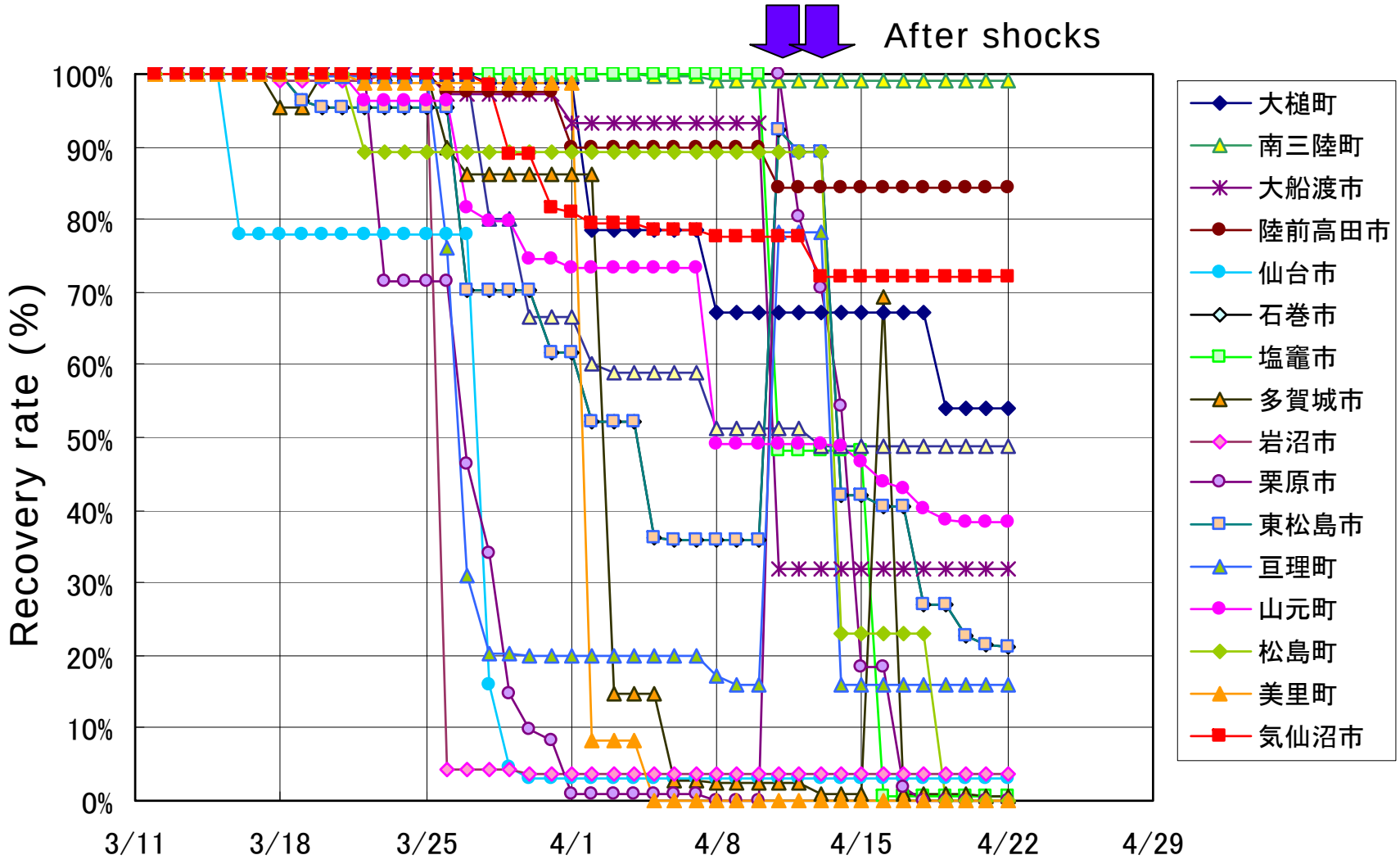
Ground motion and water outage



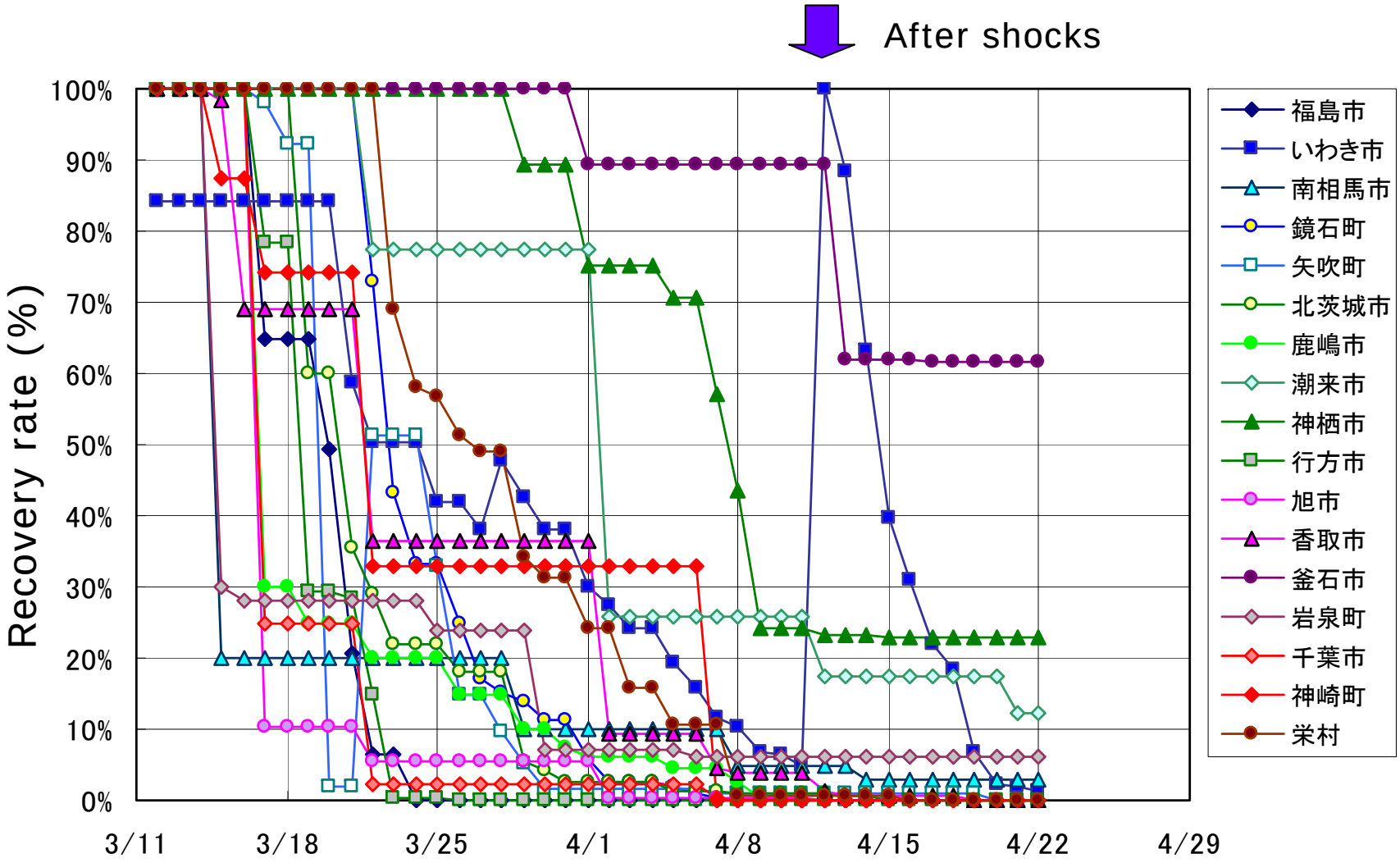
Seismic intensity（JMA）



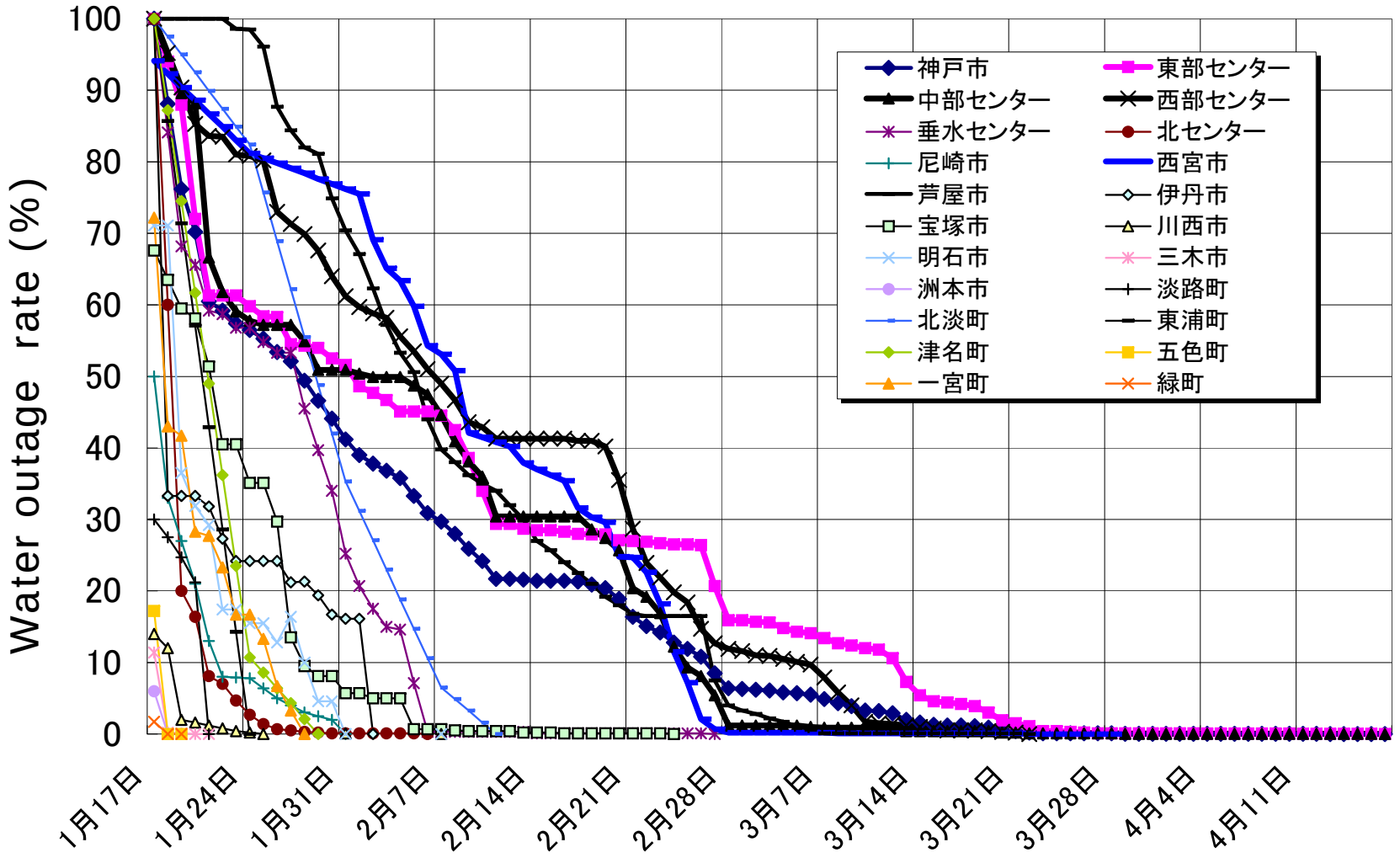
Restoration process (Miyagi Pref.)



Restoration process (except Miyagi Pref.)

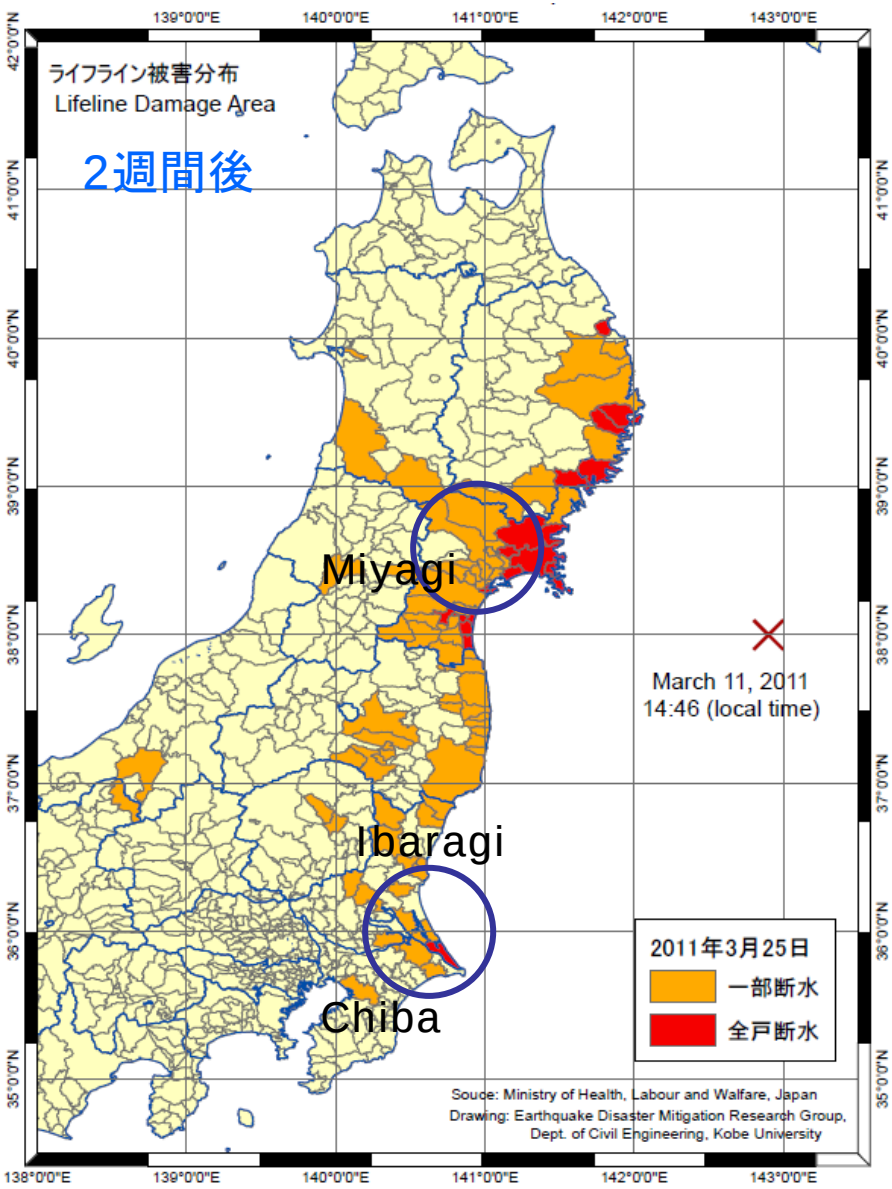


Restoration process in the Kobe EQ



Damage pattern and regional characteristic

- Tohoku area (Miyagi Pref.)
  - Destructive tsunami damage at coastal area
  - Large diameter pipe damage
  - Local damage due to liquefaction
  - Minor damage to small diameter pipeline
- Kanto area (Chiba/Ibaraki Pref.)
  - Moderate seismic intensity
  - Wide-area liquefaction damage



Damage to water supply facility Miyagi pref.

Destructive tsunami damage at coastal area

Large diameter pipe damage

Local damage due to liquefaction

Minor damage to small diameter pipeline

Large diameter pipe damage/ Shiraishi

River under-passing
transmission pipeline SPϕ2400

Lateral sliding 70 cm

Large diameter pipe damage/ Shiraishi

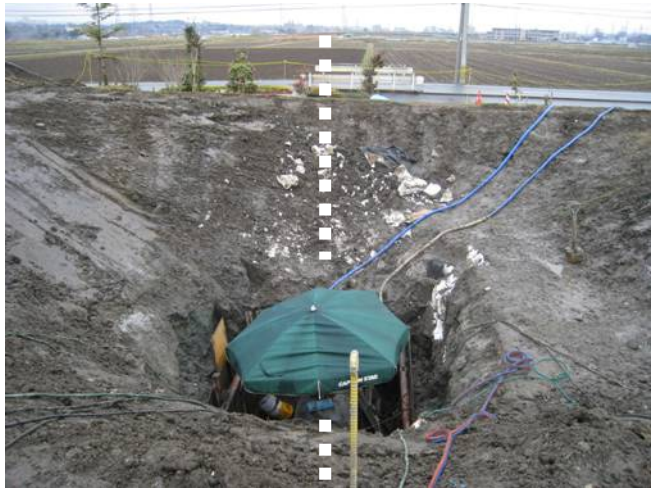
(March 28, Google Earth)

River under-passing transmission pipeline SPφ2400

Large diameter pipe damage/ Shiraishi

Joint at SPϕ1200, damaged by April 7, aftershock

Large diameter pipe damage/ Sendai

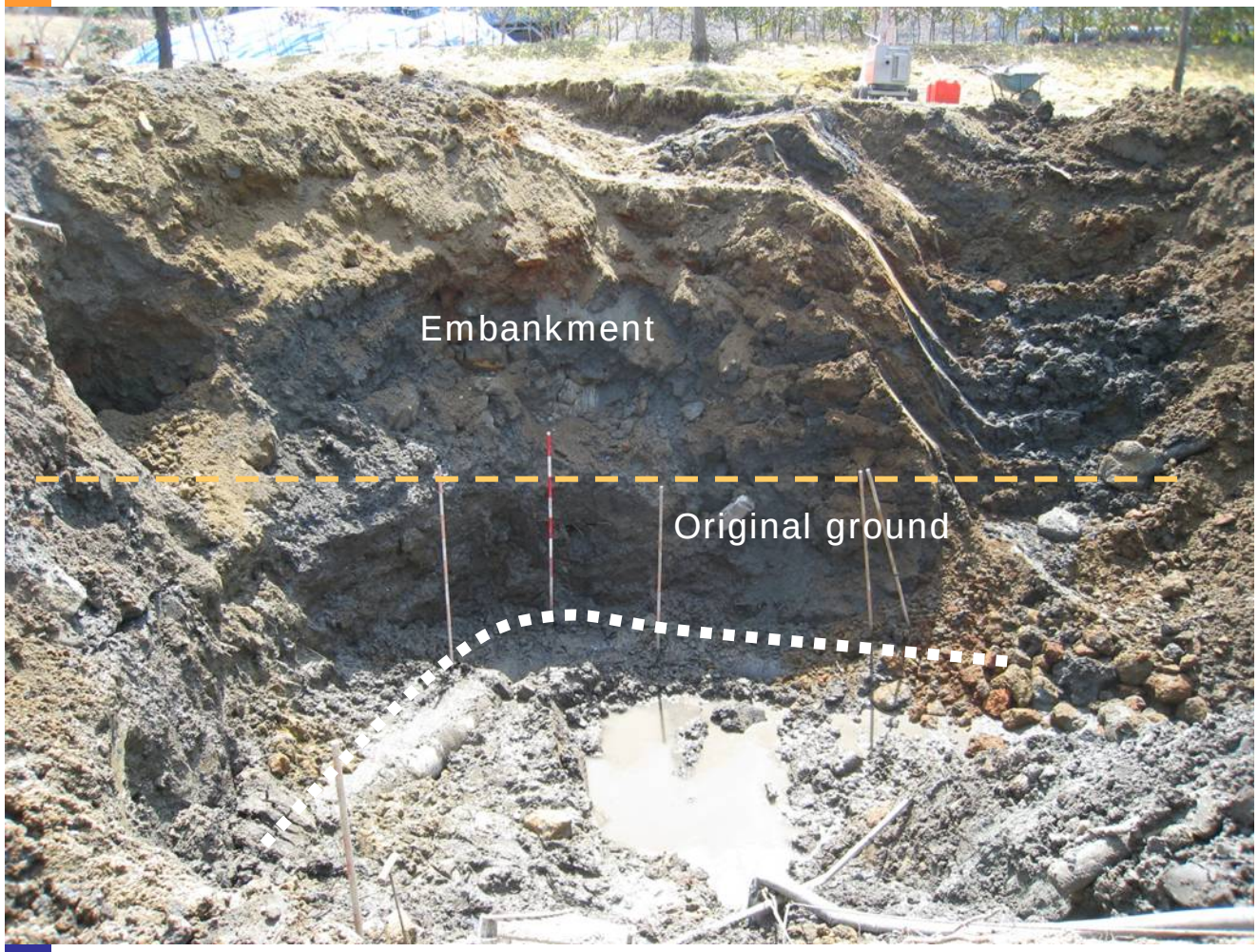


Water leak at welded part of steel pipe, Sendai: SPϕ700 damaged by April 7, aftershock

Large diameter pipe damage/ Sendai

Water leak at welded part of steel pipe, Sendai: SPφ700 damaged by April 7, aftershock

Large diameter pipe damage/ Osaki



Water leak from joints at bending part DIPϕ500, damaged by April 7 aftershock

Pipe bridge damage/ Misato

Eai river right side

Eai river left side

Water leak from joint

Slide of embankment at water pipe bridge (ϕ500) and water leak from flexible joint, after April 4 aftershock

Pipe damage, Natori

DIP ϕ300, damaged by April 7 aftershock

Before April 7

Crack on pipe body

Pipeline damage due to ground deformation


Midorigaoka, Sendai


Oritate, Sendai

Land deformation at hill-side land development


Furukawa, Osaki

Liquefaction


Sakuragaoka, Sendai

Sakuragaoka, Sendai

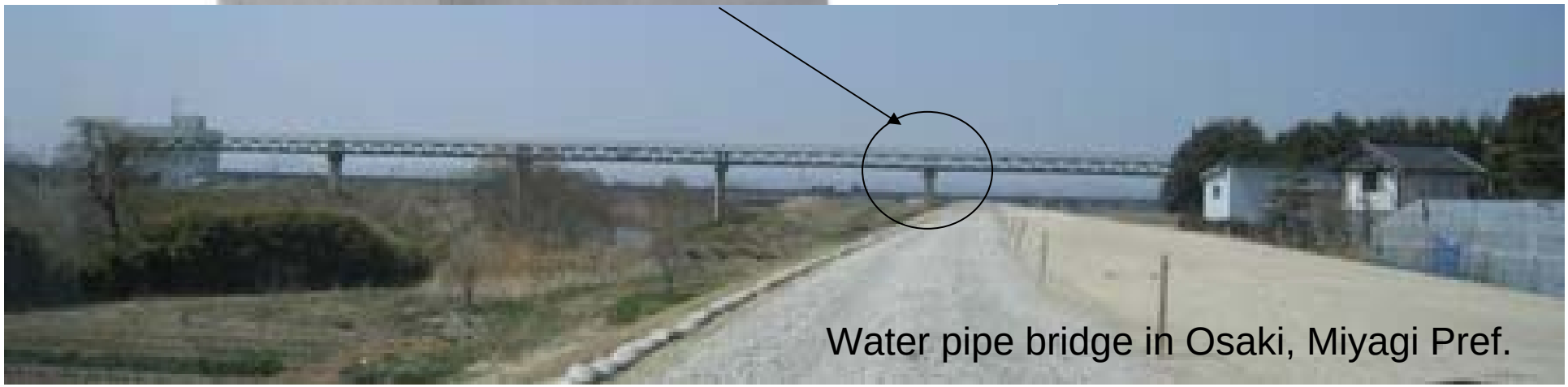

Furukawa, Osaki

Temporal repair of water pipe bridge.

How much performance is required in temporary repair?

Speed? Or performance?

Consideration for strong aftershocks



Water pipe bridge in Osaki, Miyagi Pref.

Water pipe bridge/ adjusted pipe

Bearing of water pipe bridge Osaki

Minami sanriku

Sendai

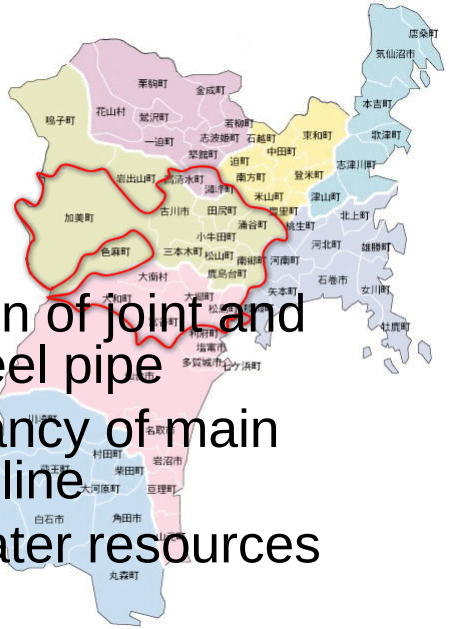
Kesennuma

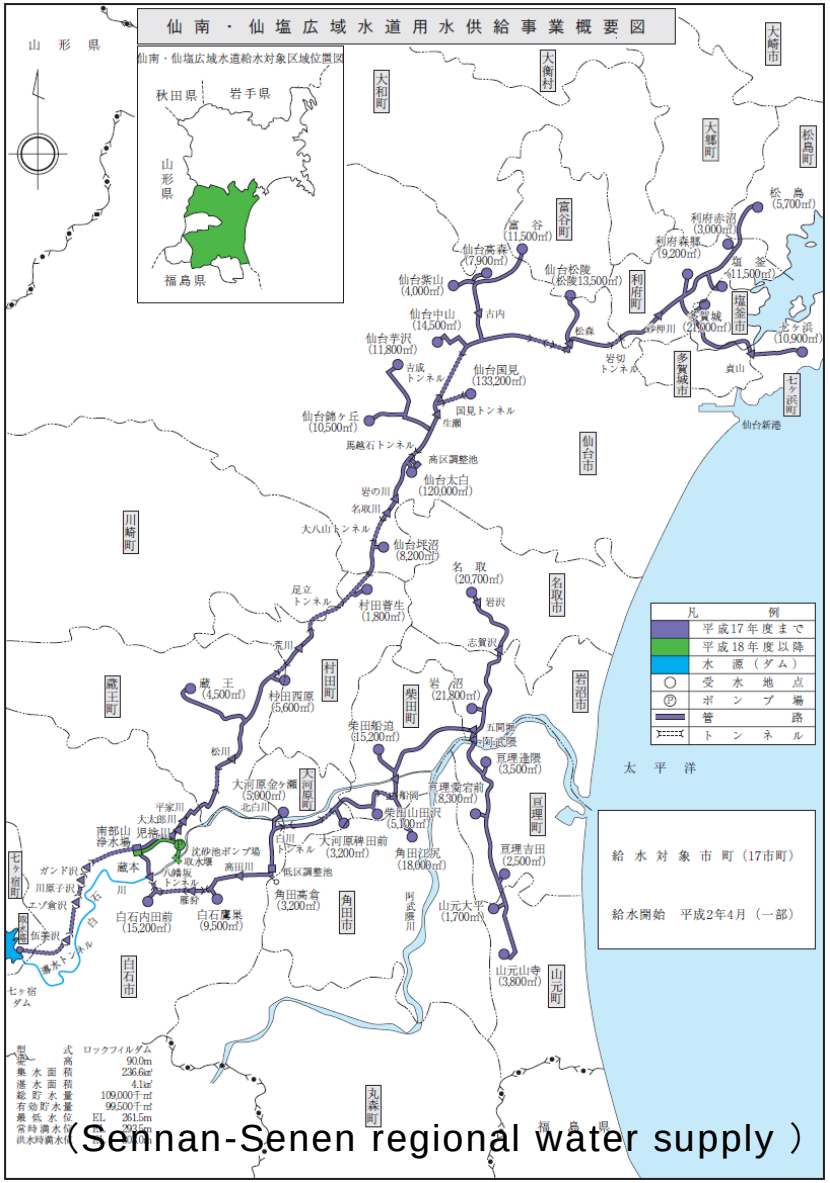
Why does it take long restoration in Miyagi?

- Minor damage/ Purification plant and distribution plant
- Regional water transmission supply
  - Sennan-Senen regional water supply / 17 cities and towns
  - Osaki regional water supply
- Less redundancy of large-diameter transmission pipe
- No or few water resources in each city

//ISSUE//

- Seismic evaluation of joint and welded part of steel pipe
- Securing redundancy of main transmission pipeline
- Securing multi-water resources





（Sennan-Senen regional water supply ）

Damage to water supply facility Ibaraki/ Chiba prefs.

Moderate seismic ground motion

Wide-area liquefaction damage to facility and pipeline


Kasum
igaura
Kita
ura
Pacific
sea
Kashima, Ibaraki
Itako, Ibaraki
Wanigawa river
Kashima
port
Tonegawa river
Sawara(Katori),
Chiba
Hitachi-
tonegawa
river
Kamisu, Ibaraki
Omigawa
(Katori),
Chiba
Data © 2011 MIRC/JHA
Google
画像取得日: 2011 年 3 月 29 日 35° 54'32.74" N 140° 35'42.20" E 標高 0 m
高度 19.99 km

Liquefied area around Kamisu/ Kashima

(March 12, Google Earth)

Wanigawa purification plant

(March 12, Google Earth)

Damage at Wanigawa purification plant

Liquefaction surrounding pump facility

Damage at Wanigawa purification plant

Liquefaction damage

Common duct 50 cm lift up

Surround ground 50 cm subsidence

Pipe connection to facility

Damage to flexible joint, DIPϕ600, by subsidence due to liquefaction at the connection to the facility

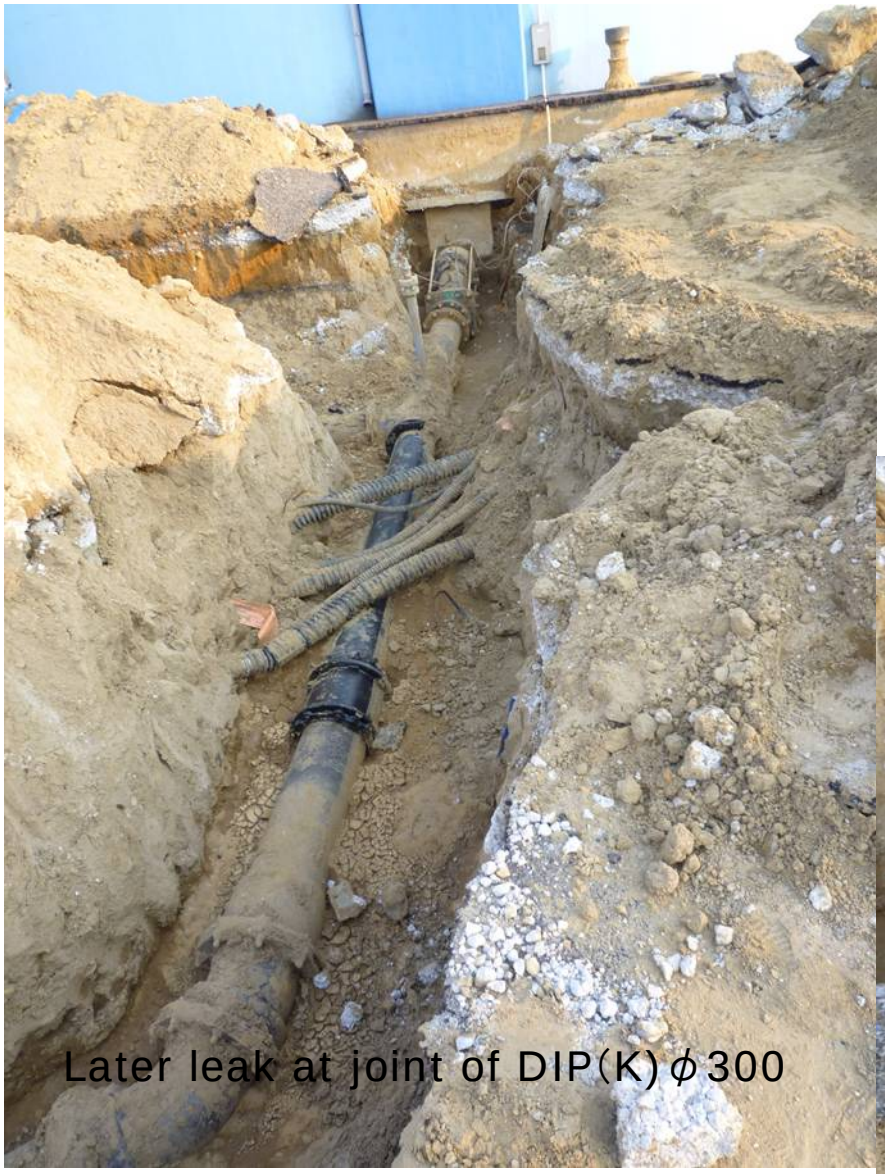
Subsicence/ No subsidence

Intake pipe

Surrounding facility

Foundation of Electric power

Distribution reservoir

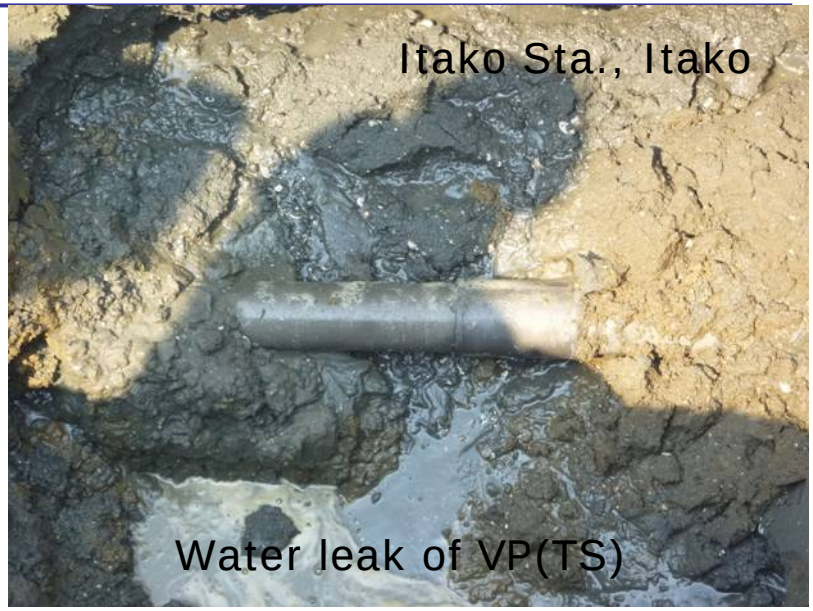


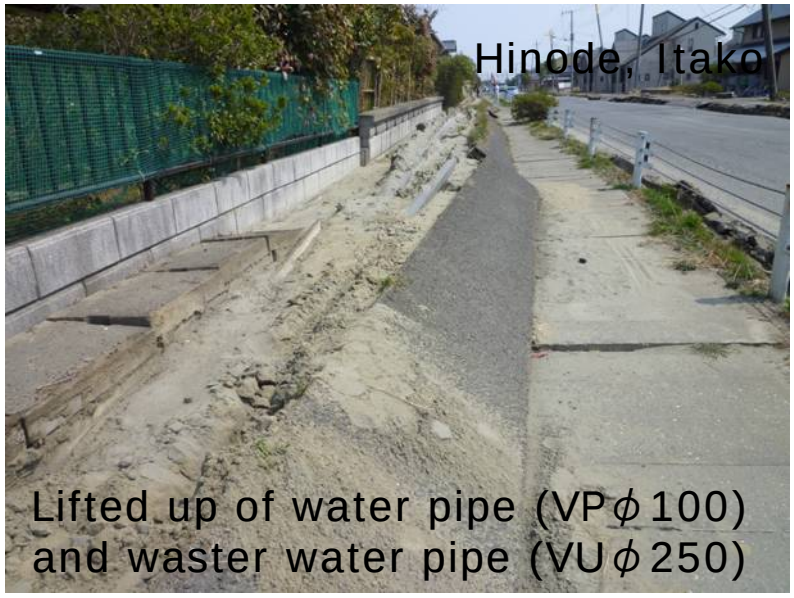
Later leak at joint of DIP(K)φ300

Crack and subsidence due to liquefaction

Water leak from bellow's type flexible joint

Pipeline damage due to wide-area liquefaction/ Itako, Ibaraki





Pipeline damage due to wide-area liquefaction/ Kamisu, Ibaraki


Horiwari, Kamisu


Horiwari, Kamisu

Lifted water drain


Horiwari, Kamisu

Scoring around embankment


Horiwari, Kamisu

Temporal transmission pipeline
SGPϕ400

Pipeline damage due to wide-area liquefaction/ Katori, Chiba

Lift up of water storage tank by liquefaction

Storage tank was constructed for disaster

Water storage tank 100m^3, Urayasu, Chiba

Other damage in Ibaraki/ Chiba areas

Water storage 100m³/ Urayasu

Firefighting water storage 40m³/ Asahi

Asahi

Uplifted tanks in liquefied ground

Hitachi

Leak of SPφ250

Pipe at sliding bearing of pipe beam bridge hit at walls

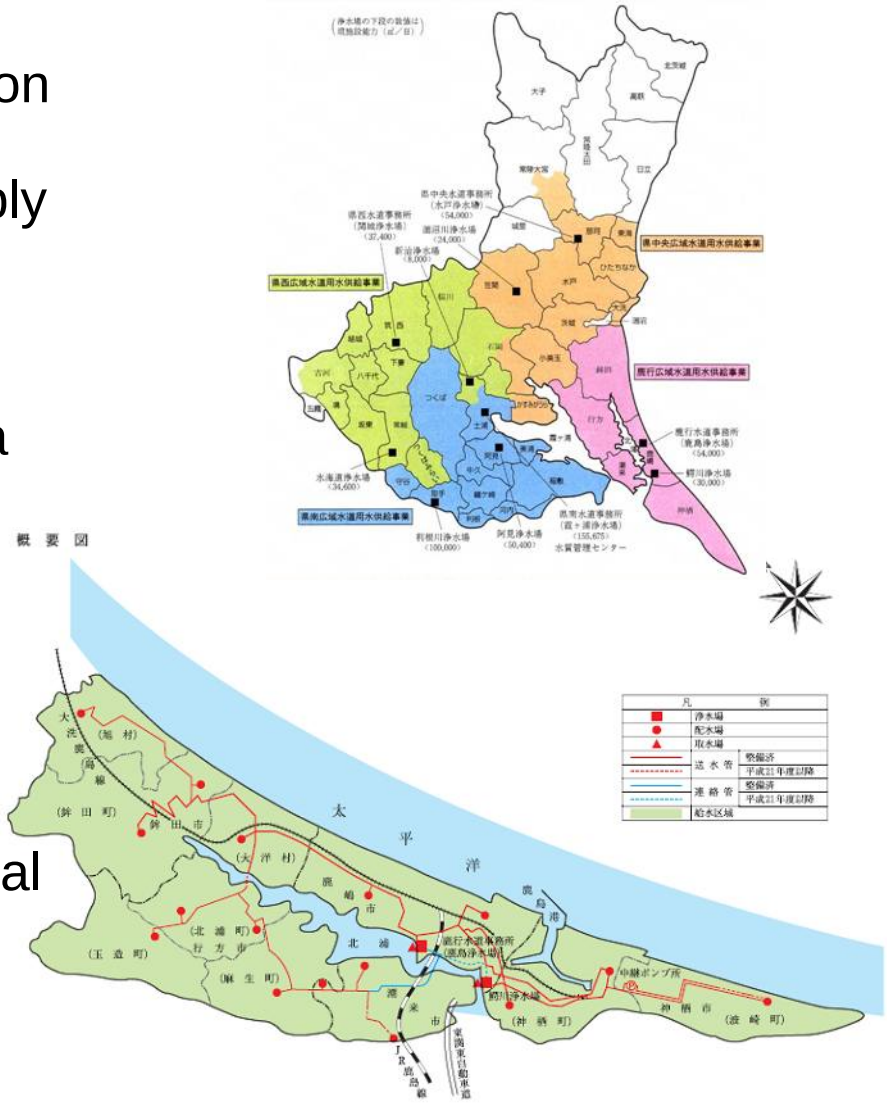
Other pipeline damage

Pipeline damage,DIPϕ150, due to landslide

Pipeline damage, DIP(A)ϕ350, due to raised ground surrounding underpass of highway embankment

Why does it take long restoration in Ibaraki?

- Interruption of water transmission because of liquefaction of purification plant and distribution plant
- Wide-area water transmission supply
  - Rokko wide water supply
- Less redundancy of large-diameter transmission pipe
- Difficulty of pipe repair at wide-area liquefaction



Rokko wide water supply

//ISSUE//

- Revaluation of liquefaction at coastal area
- Install of flexible pipe at developed land of residence

Future tasks on structural problem

- Seismic measures of large-diameter pipe
  - Seismic performance of welded part and joint of large-diameter pipe
  - Seismic behavior of underpass, curve, fixed parts of pipeline
  - Seismic performance of water pipe bridge
- Wide-area liquefaction mechanism and its measures
  - Peak ground motion plus duration of ground motion
  - Evaluation of important facilities against long-period ground motion
    - Intake structure of embankment
    - Subsidence surrounding facilities
    - Uplift measures of common duct and drain
    - Pipe connecting to facilitate
  - Flexible pipe install at liquefaction area
  - Uplift measures of water tanks
- High-level aftershock measures
  - Damaged earth structures, temporal repaired structures

Future tasks on functional problem

- Black out measures
  - A few days black-out causes delay of water supply (damage identification, filling water in reservoir and large-diameter pipeline.
- Redundancy of transmission and delivery main pipeline
  - Wide-area water transmission system with less redundancy
  - Two systems (regional and local)
  - Multi water resources
  - No enhancement of small and old systems
- Water storing by shut-off valves
  - Saving water by automatically or manually
- Emergency connection pipelines between cities
  - Not efficient in this event, because wide-area disaster

Future tasks on recovery in wide earthquake disaster

- Suffered water department staffs
  - Half of staffs was Isolated in the sea for a night
- Early response of emergency water delivery
  - Lessons from recent earthquakes.
  - Dispatched from JWWA, other cities.
  - Malfunction of information management by chief government in Tohoku, Kanto district
- Recovered by local workers, not dispatched workers
- Securing supply-chain of materials
  - Pipe, equipment, fuel, vehicle, roadway
- Decision making of recovery strategy in liquefaction zone
  - Repair/ Install with above pipeline
- Lack of engineers in local government
  - Reducing engineers in last decade.

Thank you for your attention!!!