Water Quality Risk Management in Emergency

Water & Waste Eng.
2020/05/29

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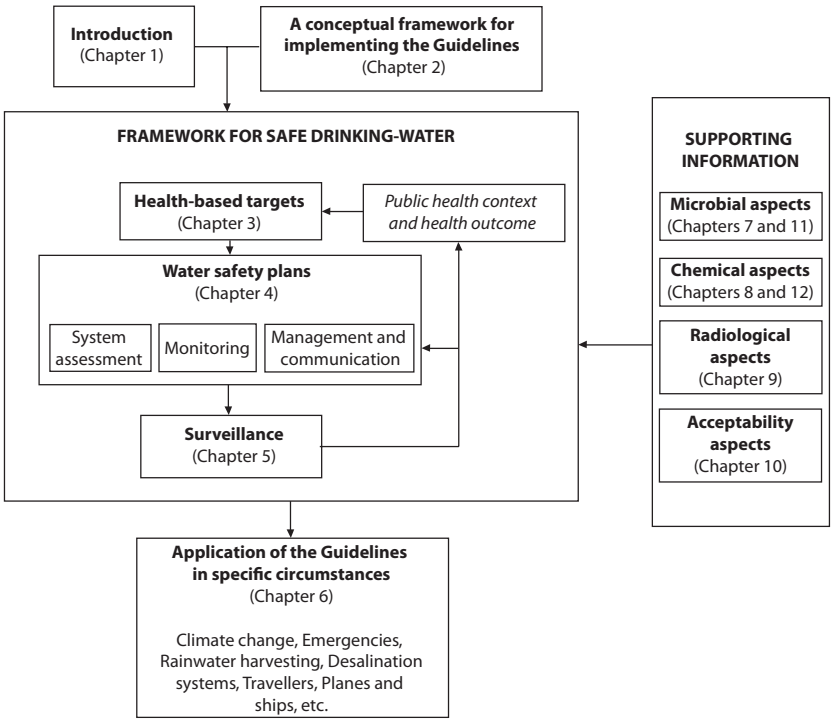
Framework for safe drinking water



©Guidelines for Drinking-water Quality - 4th ed., WHO, 2011

HACCP
Hazard analysis and critical control points

- a systematic preventive approach to food safety from biological, chemical, and physical hazards in production processes
- to design measurements to reduce these risks to a safe level.
  - The HACCP system can be used at all stages of a food chain, from food production and preparation processes including packaging, distribution, etc.

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Principles

- Conduct a hazard analysis
- Identify critical control points
- Establish critical limits for each critical control point
- Establish critical control point monitoring requirements
- Establish corrective actions
- Establish procedures for ensuring the HACCP system is working as intended
- Establish record keeping procedures

Water quality management

- **The use of HACCP for water quality management** was first proposed nearly 20 years ago.
- a number of water quality initiatives applied HACCP principles and steps to the control of infectious disease from water, and provided the basis for the Water Safety Plan
- Water Safety Plan is a way of adapting the HACCP approach to drinking water systems

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Current management approaches

- aimed at assuring the safety of drinking water
- preventing pollution of source waters
- selective water harvesting
- controlled storage
- treatment prior to distribution
- protection during distribution
- safe storage within the home and in some circumstances, treatment at the point of use

The basis for water safety

- Know your catchment
- Know your source water quality
- Control the treatment
- Protect your distribution
- Safe drinking water

©Medema et al. , 2003

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Health-based targets

- Health outcome targets: the specification of water quality targets
- Water quality targets: a health risk from long-term exposure, guideline values (concentrations) of the chemicals of concern
- Performance targets: short-term exposure represent public health risk, required reduction of the substance of the concern or effectiveness in preventing contamination
- Specified technology targets:

Water safety plan

- To prevent contamination of source waters
- To treat the water to reduce or remove contamination that could be present to the extent necessary to meet the water quality targets
- To prevent re-contamination during storage, distribution and handling of drinking-water

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Development of a water safety plan

- system assessment
- operational monitoring
- management plans
- documentation and communication

Disinfection

- **Disinfection**
  - chemical agents designed to inactivate or destroy microorganisms
  - Chlorine, Ozone, UV (Ultra Violet)
- **Sterilization**
  - any process that eliminates, removes, kills, or deactivates all forms of life
  - steam, dry heat, flaming, incineration, chemicals (Ethylene oxide, Nitrogen dioxide, Ozone)

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Chlorine reaction

- **Free residual chlorine:** $HOCl$, OCl^-
- **Combined residua chlorine:** NH_2Cl, $NHCl_2$, NCl_3
- **When we put chlorine into water;**

$$Cl_2 + H_2O \rightleftarrows HOCl + H^+ + Cl^-$$

$$HOCl \rightleftarrows + H^+ + OCl^-$$

- **The existence form of chlorine depends upon pH.**
  - pH < 5 almost $HOCl$, pH7 80% of $HOCl$, pH9 almost OCl^-

Chlorine reaction (with ammonia)

- The chlorine reaction with ammonia results in combined residual chlorine; monochloramine, dichloramine and nitrogen trichloride

$$NH_3 + HOCl \rightleftarrows NH_2Cl + H_2O$$

$$NH_2Cl + HOCl \rightleftarrows NHCl_2 + H_2O$$

$$NHCl_2 + HOCl \rightleftarrows NCl_3 + H_2O$$

- Furthermore, combined available chlorine decreases when we add chlorine

$$NH_2Cl + NHCl_2 \rightleftarrows N_2\uparrow + 3H^+ + 3Cl^-$$

$$NH_2Cl + NHCl_2 + HOCl \rightleftarrows N_2O\uparrow + 4H^+ + 4Cl^-$$

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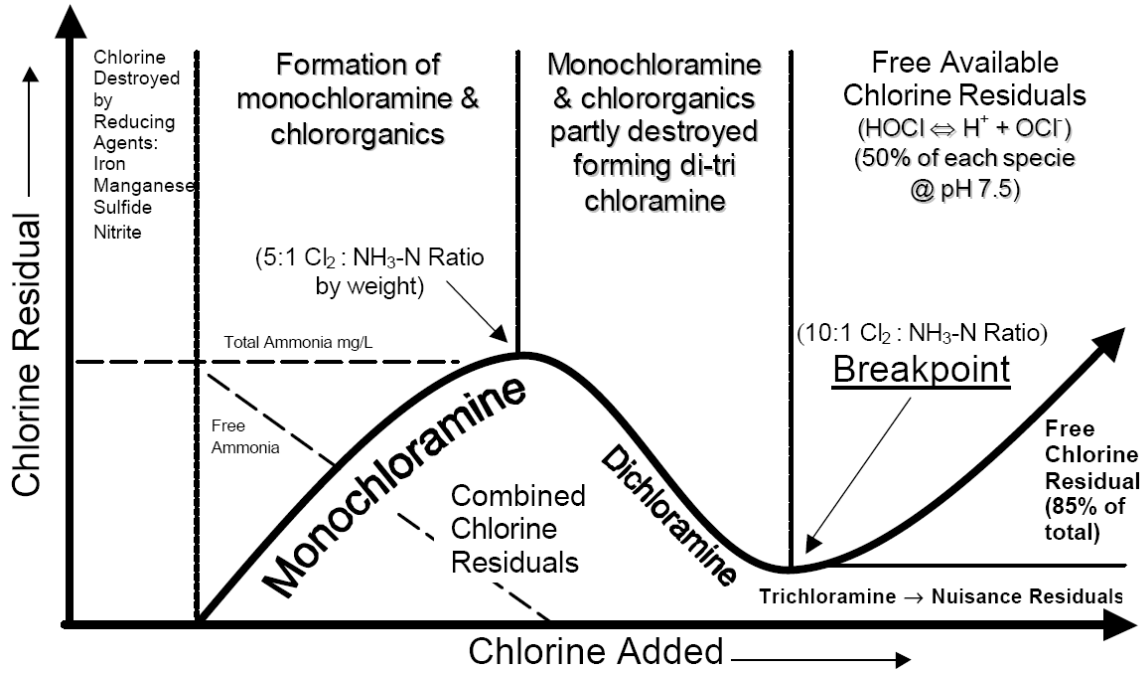
Breakpoint Chlorination Curve



Drinking water quality management in Emergency

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Boil water advisory/notice/order

- a public health advisory or directive given by government or health authorities to consumers when a community's drinking water is, or could be, contaminated by pathogens.
- Under a boil-water advisory (BWA), the Centers for Disease Control and Prevention recommends that water be brought to a rolling boil for one minute before it is consumed in order to kill protozoa, bacteria and viruses.

Portland, Oregon issues boiled water notice for entire city, May 23, 2014

- The Portland Water Bureau issued a city-wide boil notice on Friday morning, May 23, 2014, after water staffers detected E. coli in three separate tests during the past three days.
- The State of Oregon Health Authority's Drinking Water Program has required the City of Portland to issue a Boil Water Notice for all Portland Water Bureau customers and some regional water providers.
- Until further notice, all Portland Water Bureau customers and those in the affected areas should boil all tap water used for drinking, food preparation, tooth brushing and ice for at least one minute. Ice or any beverages prepared with un-boiled tap water on or after May 20 should be discarded. Detailed maps, fact sheets and additional information can be found on the Water Bureau's website

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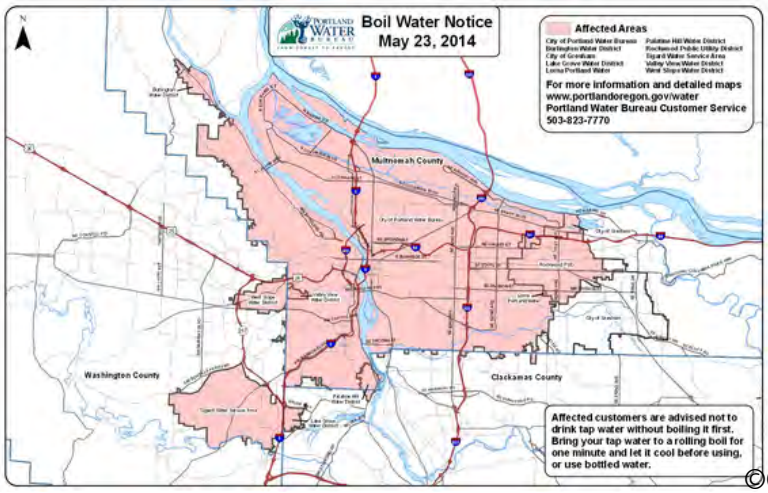
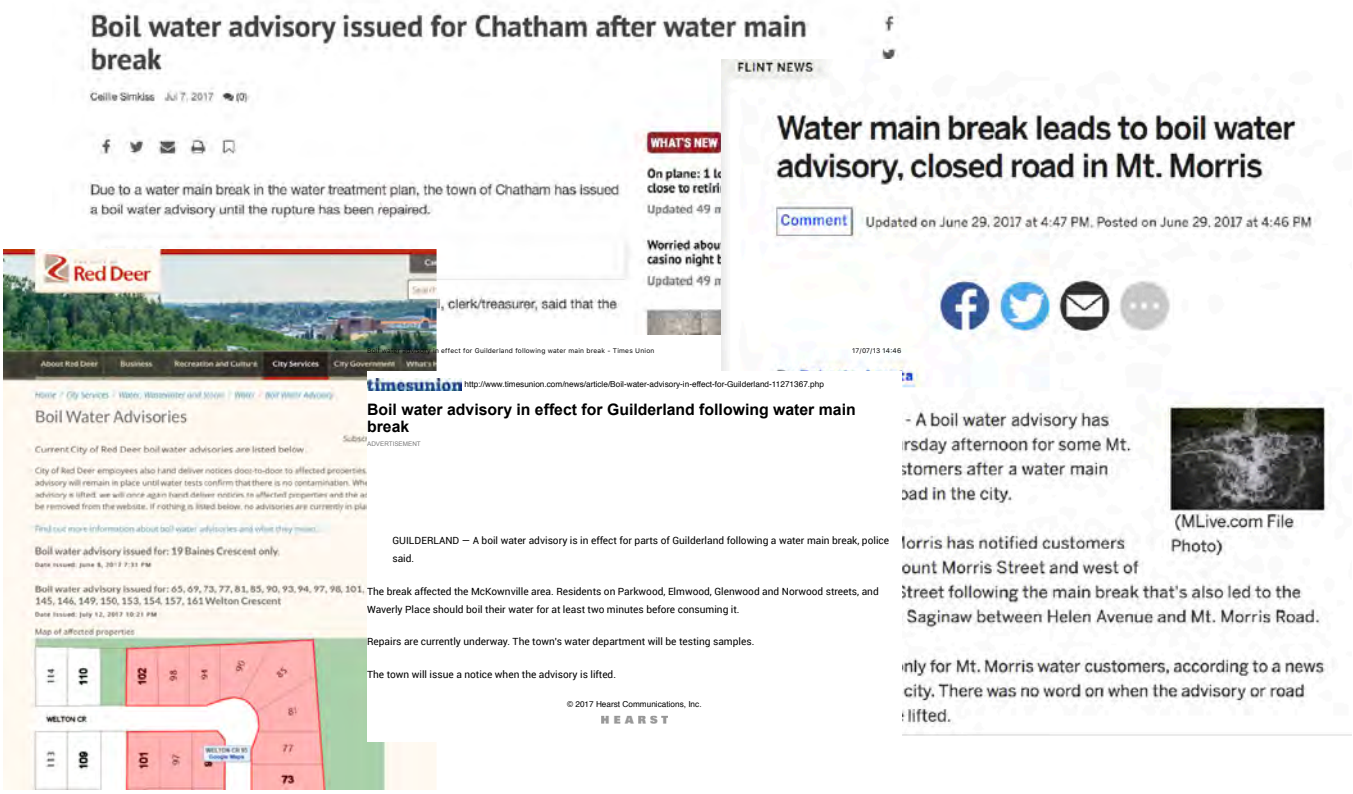
Boiled Water Notice

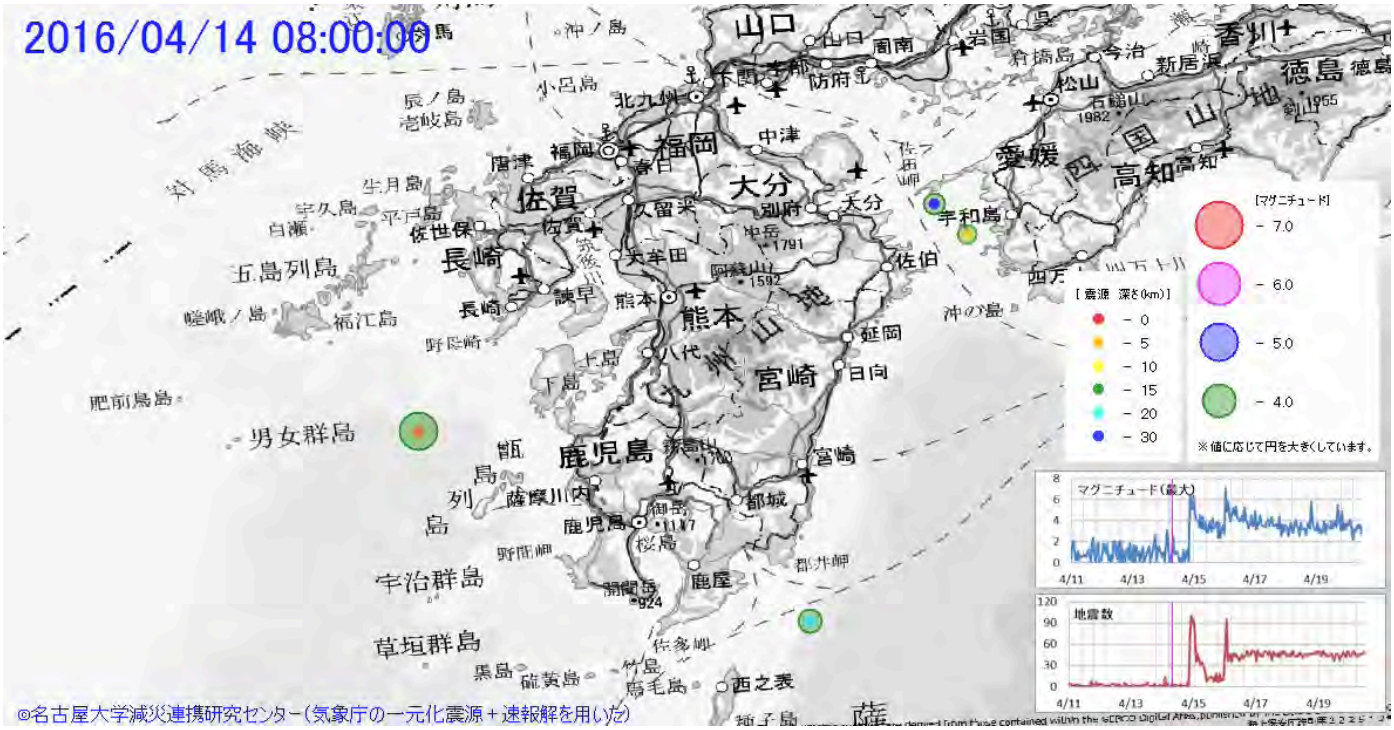
- In three separate incidents from May 20 to May 23, repeat water samples confirmed the presence of total coliform and E. coli in routine drinking water samples. The water samples that tested positive for bacteria were collected at the outlets of Mt. Tabor Reservoirs 1 and 5, and at the SE 2nd Avenue and Salmon Street wate offline.



Boil water notice/advisory



2016 Kumamoto earthquake



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1995 Kobe and 2016 Kumamoto earthquake

	2016 Kumamoto	1995 Kobe
Fault Activity	Hinaku & Nutagawa	Nojima
Time & Date	April 16, 2016, 1:25	January 17, 1995, 5:46
Magnitude	Mj 7.3	Mj 7.3
Earthquake type	Intra-plate earthquake	Intra-plate earthquake
Death	272 【50】	6,434 【5,500】
Damaged municipal gov.	Kumamoto	Hyogo and Osaka
Damaged housing	8,640	104,906
Evacuation	180K	320K
Cause of death	relevant to the earthquake	crushing and/or suffocation by building collapse
Disaster debris	3.02 millions ton	14.50 millions ton

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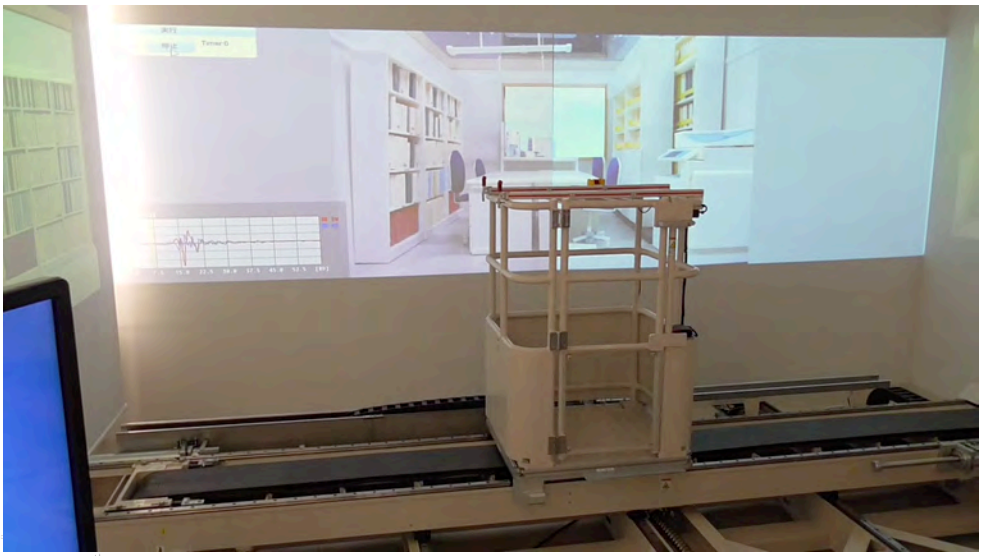
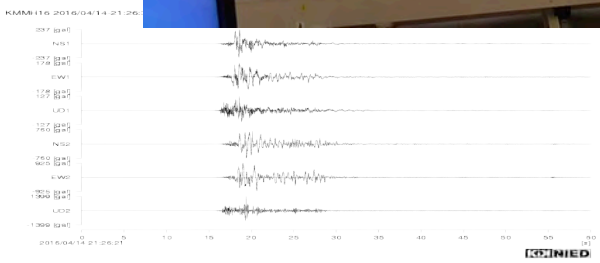
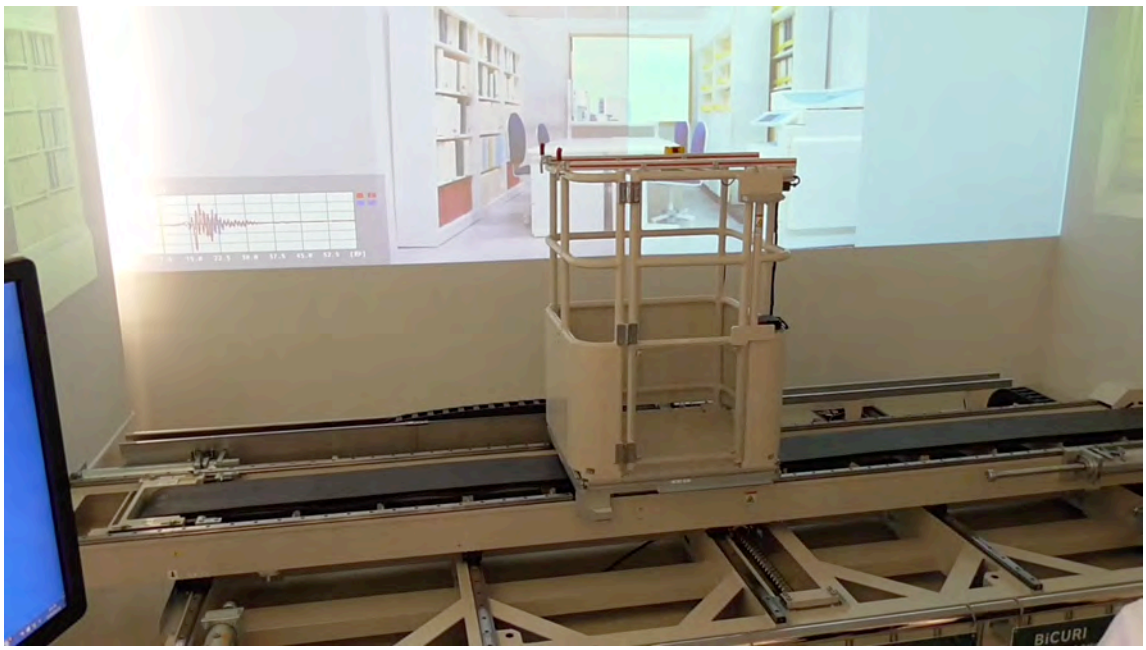
1995 Kobe Earthquake Mj7.3 Japanese Seismic Scale 7

2016 Kumamoto Earthquake, Mashiki Town KiK-net Mashiki, Japanese Seismic Scale 7





Motion of Wooden Housing 2nd Floor, in Mashiki Town at 2016 Kumamoto Earthquake



Damage to Water Facility in Nishihara, 2016 Kumamoto Earthquake

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Pipeline Damage

Pipeline Damage

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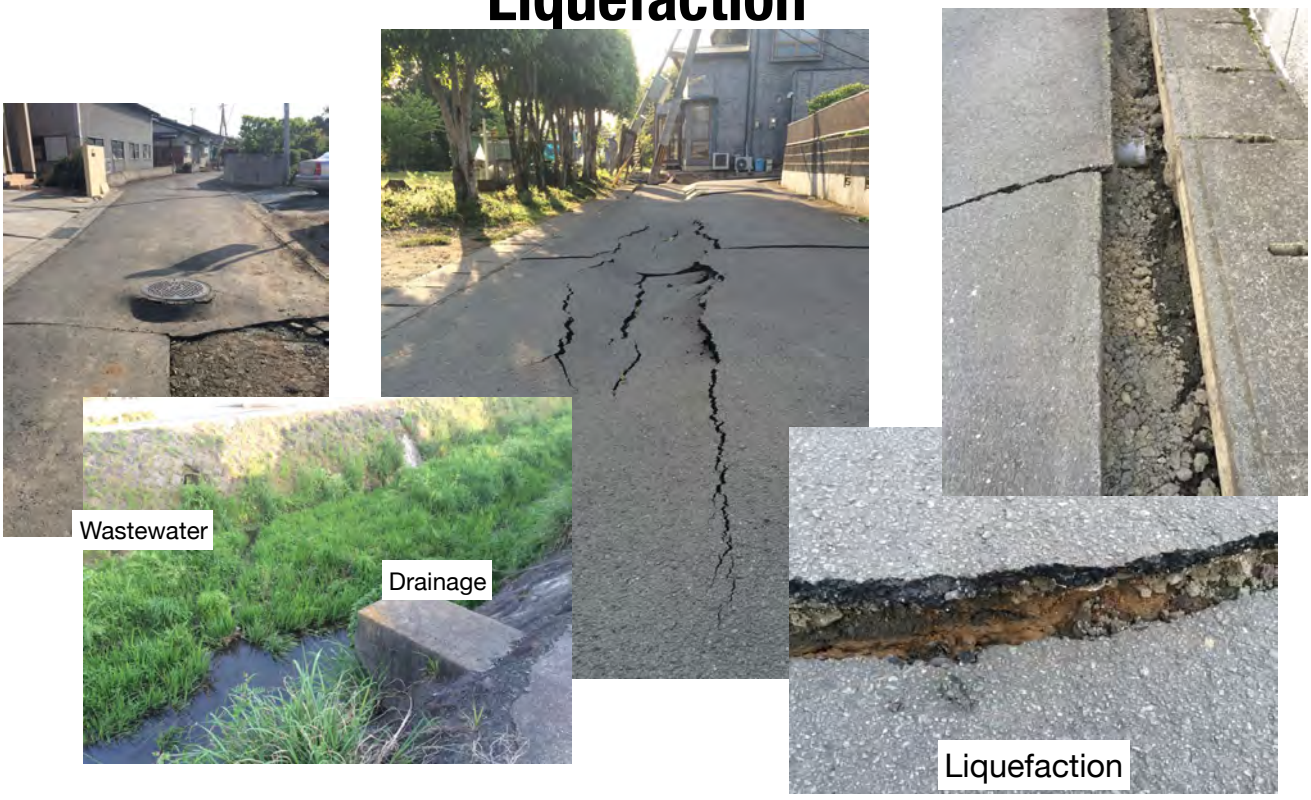
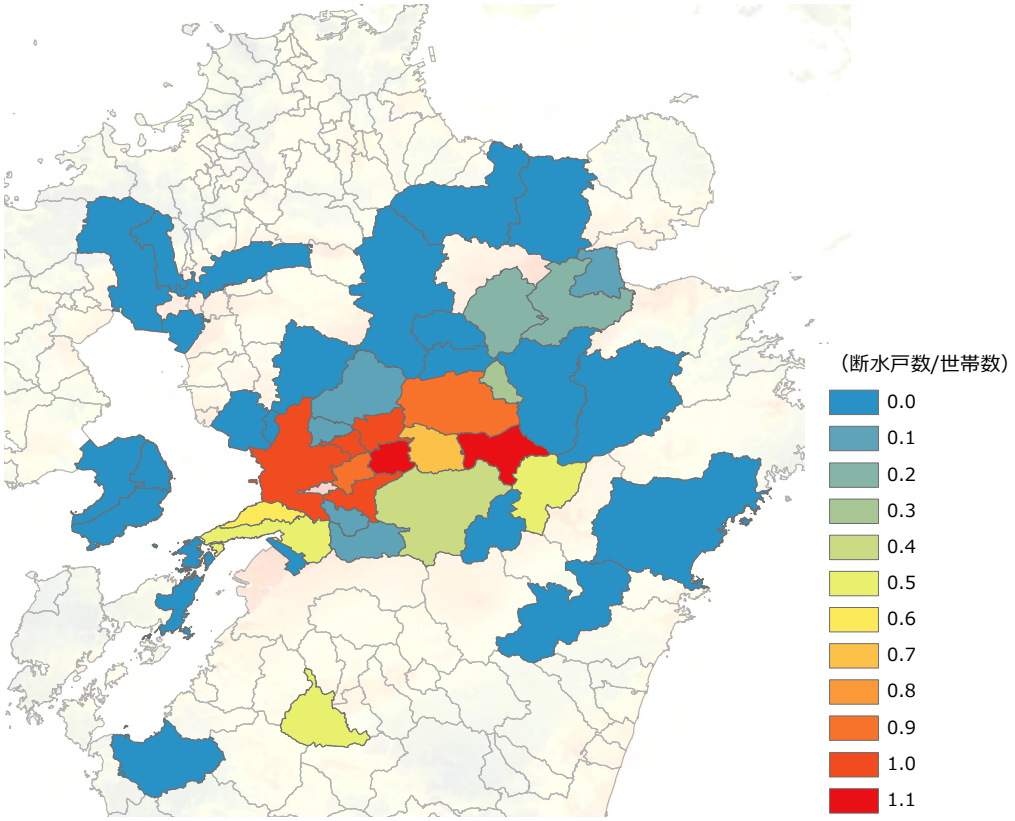
Damage to Wastewater & Drainage System due to Liquefaction



Ratio of no water service consumer



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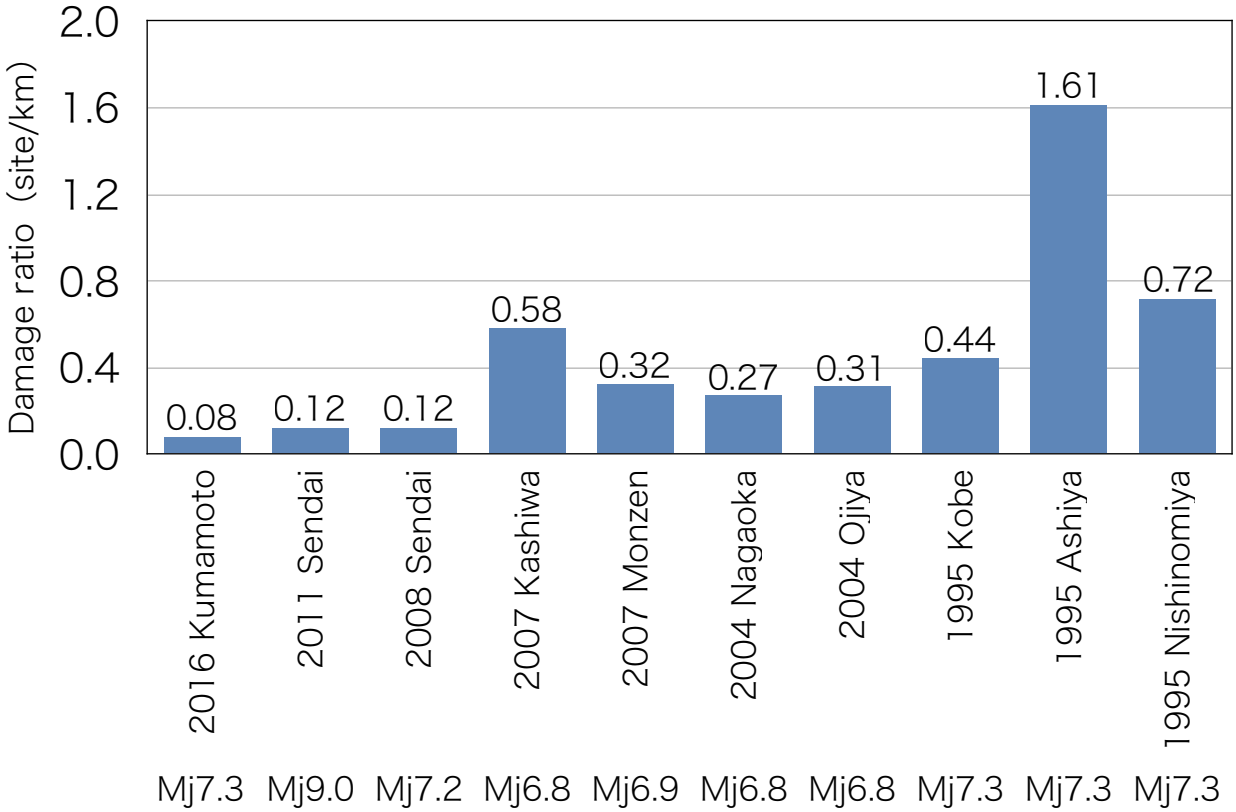
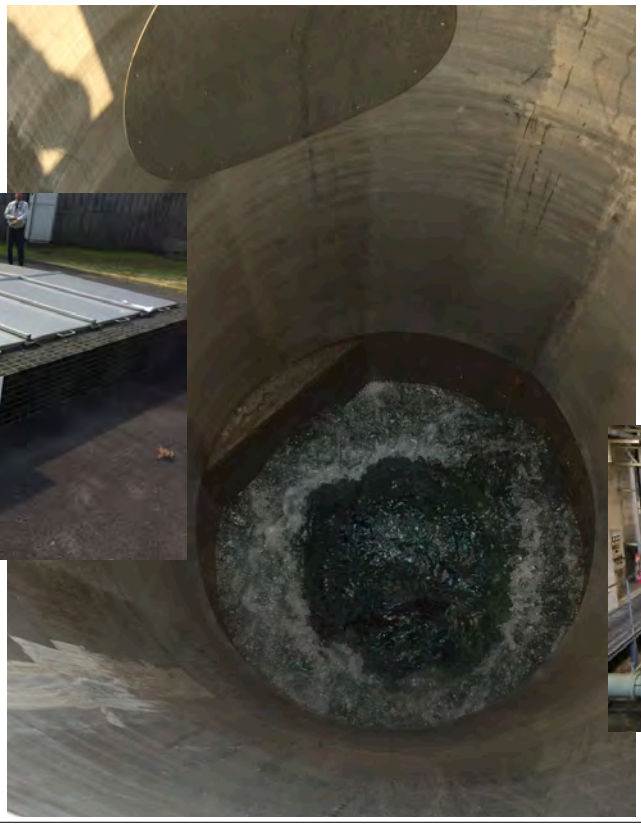
Damage ratio of pipeline



Water system in Kumamoto

Emergency shut-down valve



Pump station

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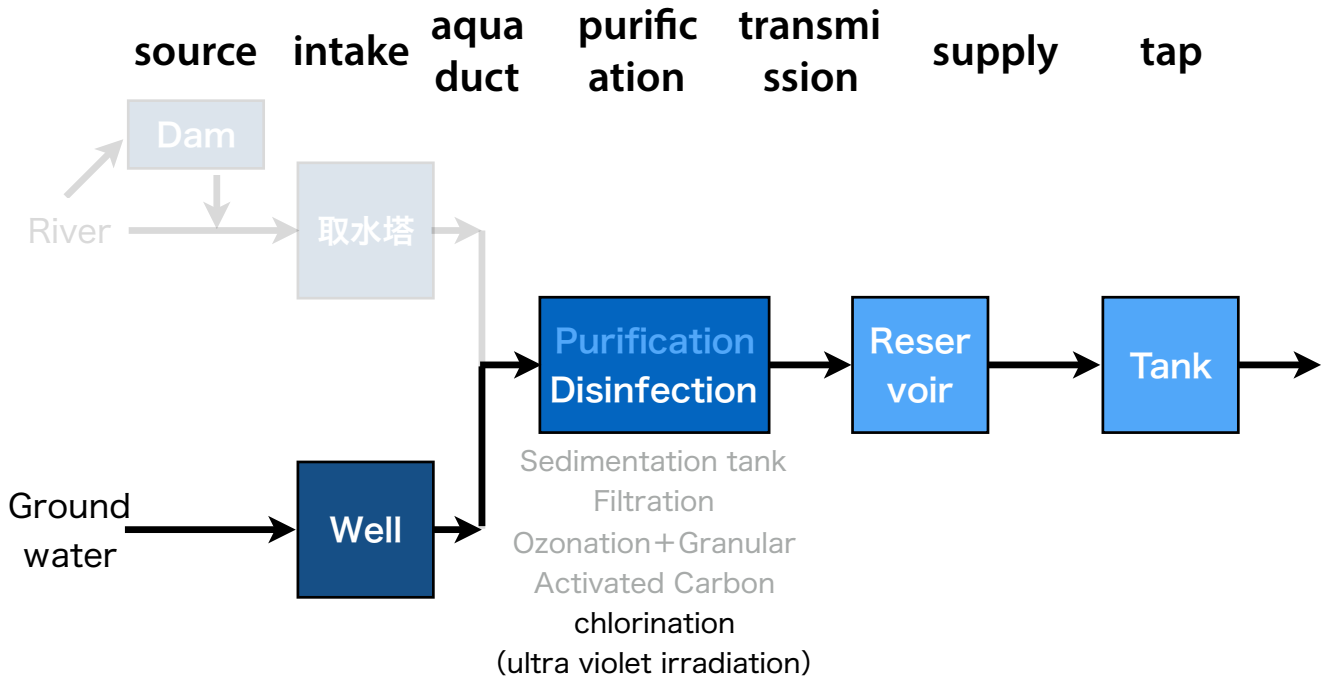
Water system in Kumamoto region



Supply drinking water with limit intake notice in emergency

- Advisory of manager of water supply section, Ministry of Labour, health, and welfare on 31 March, 2016.
- Suspension of drinking water supply, water act 23
  - ✓ harmful immediately
  - ✓ directly affect to human body
- **CANNOT** meet water quality standard
- continue to supply drinking water with limit intake notice

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Your choice…

You are executive director of the water works bureau.

You have a responsibility on decision making on suspension of drinking water supply.

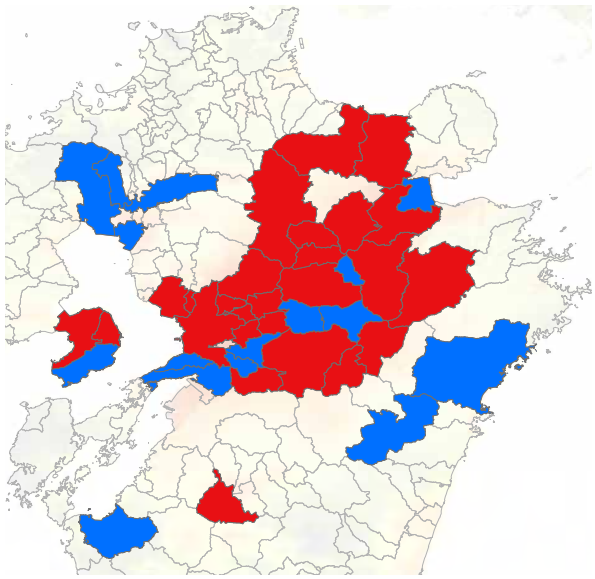
After an earthquake disaster, treated water in your water utility can not meet the drinking water quality standard because of elevated turbidity.

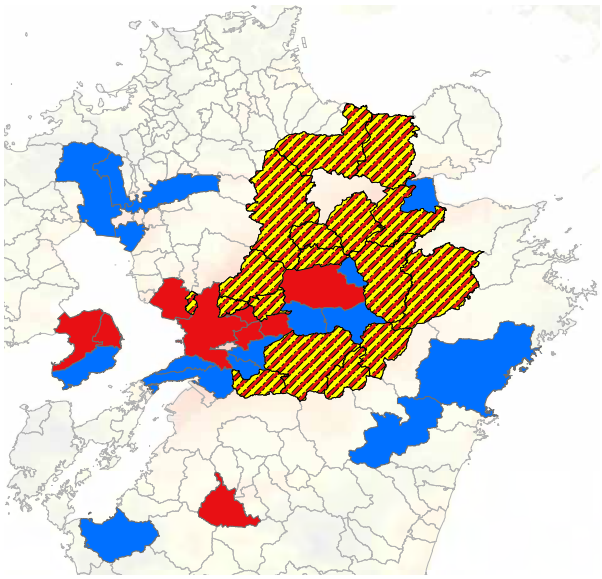
A. Suspension of drinking water supply

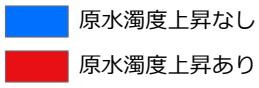
B. Continue to drinking water supply with intake limitation

Elevated turbidity of water source and intake limitation

turbidity of water source







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Los Angeles City Department of Water and Power

— LADWP Overview

- ✓ Largest municipal utility in United States
- ✓ Founded 1902
- ✓ Serves 4.1 million people
- ✓ 712,000 service connections
- ✓ 775 square kilometer service area
- ✓ Receives water from 4 aqueducts, local wells
- ✓ LADWP owns and operates the water and power systems

1994 Northridge Earthquake

- January 17, 1994
- Magnitude 6.7 (Mw)
- Thrust Fault (blind/buried)
- Epicenter in Northern Los Angeles
  - ✓ Urban San Fernando Valley
- Millions of people impacted by strong shaking
- 670,000 residents in LA without water
- Another 180,000 people in LA had reduced pressure

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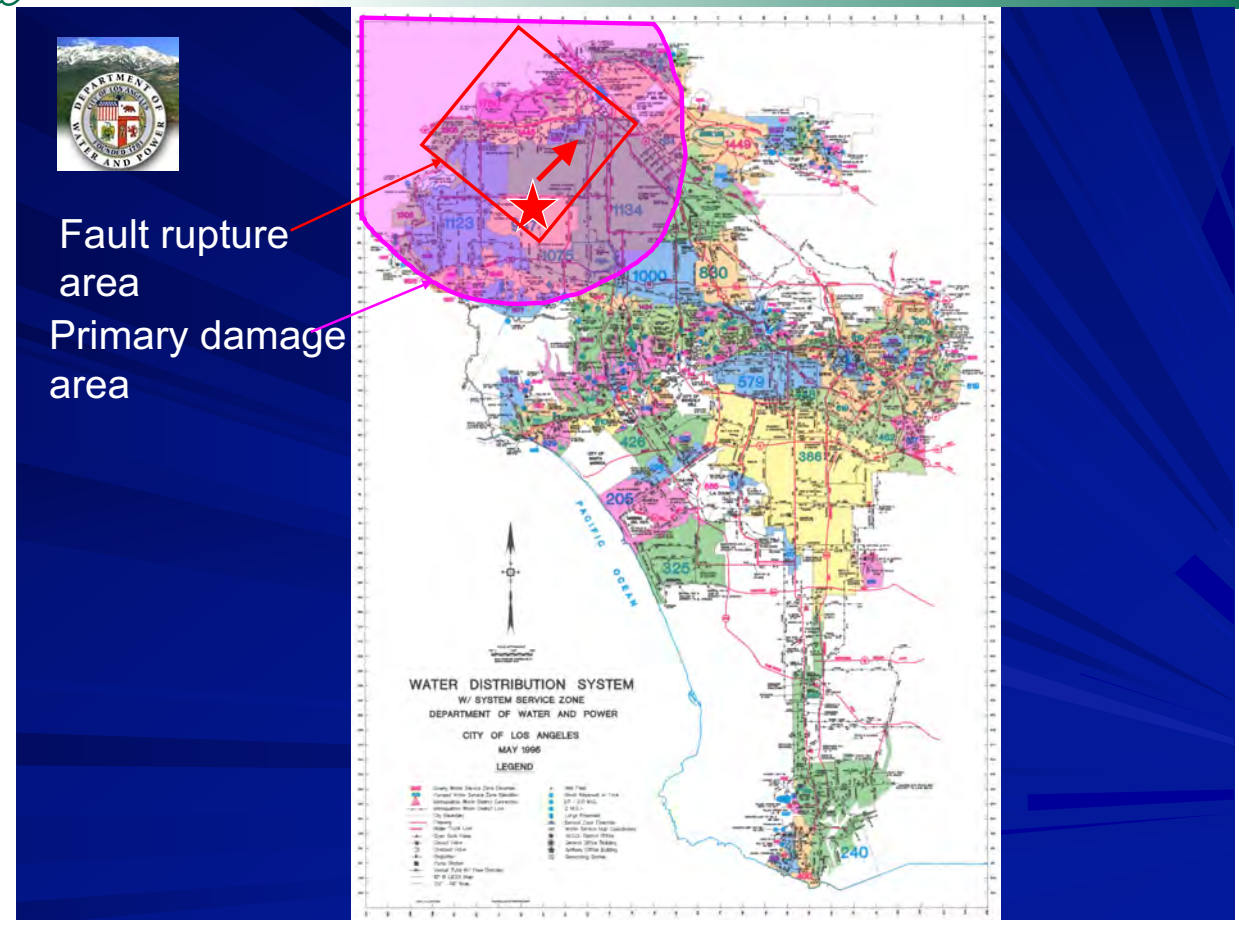

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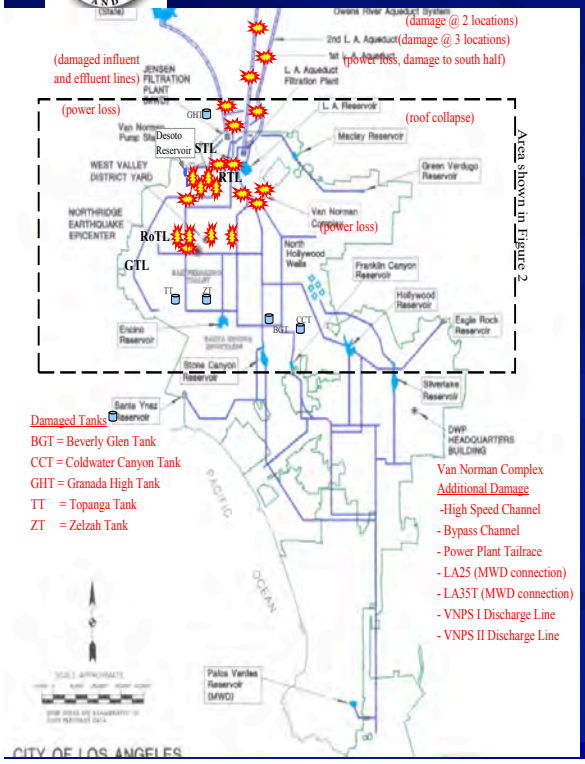
LA Water System Damages



- 14 repairs to raw water pipes
- 60 repairs transmission pipes
- 1013 repairs distribution pipes
- 200 service connection repairs
- 7 damaged reservoirs
- 1/2 treatment plant out of service
- Lost power up to 27 hrs
- No outage at pump and chlorine stations

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Customer Impacts
Service outage

- No water service
- Reduced fire protection capability
- Flooded streets restricted access
- Commerce and economics impacted for most industrial and restaurant businesses
- More bottled water used
- LADWP supplied emergency water in sanitized tanker trucks (15 locations)
- Beverage companies supplied bottled water

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Water Purification Advisory

- Issued throughout system on Jan. 17
- Concern: Potential for contamination from pipe breaks
- Lifted advisory in areas after water testing
- Longest in epicenter area
- Water purification advisory lasted up to 12 days
  - ✓ longer than service outage

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Customer Impacts Water Purification Advisory

- Boil or disinfect before using
- Customer concern with water quality
- More bottled water used
- Restaurants
  - ✓ Impacted serving and cooking food
  - ✓ Impacted cleaning
- Los Angeles Airport
  - ✓ Commercial airlines threatened to be grounded
- Flush pipes and water heaters in buildings following advisory removal