World Bank Disaster Risk Management Hub, Tokyo

Resilient Water Supply and Sanitation Services

The Case of Japan

Solutions Brief

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Photo Credit: Kyodo News

Japan has built the resilience of its water supply and sanitation services through an adaptive approach based on lessons learned from past natural disasters. This experience offers key insights for low- and middle-income countries seeking to reduce their vulnerabilities in essential service provision.

Sustainability of essential WSS services at risk

Natural disasters have increasingly damaged water supply and sanitation (WSS) facilities and infrastructure, leaving entire communities without safe and reliable drinking water and the safe disposal of wastewater. These emergency events could arise from inundation of facilities, loss of electricity, and exposure and disruption of infrastructures. Less-severe impacts can arise from increased siltation of reservoirs and slow-onset events such as droughts, thus having longer-term effects on the resilience and reliability of services. Although more investment is urgently needed to improve basic WSS access in low- and middle-income countries, building the resilience of new and existing infrastructure is also critical for sustainable development.

Legal and institutional frameworks for resilient WSS services in Japan

Rapid urbanization and population growth as well as a cholera outbreak led Japan to rapidly develop water resources and wastewater services under the 1957 Waterworks Act and 1958 Sewerage Act. WSS services are delegated to the municipalities from the Ministry of Health, Labor and Welfare (MHLW) for water supply and from the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) for sewerage. Based on the 1961 Disaster Countermeasures Basic Act, WSS utilities made considerable efforts to enhance their disaster risk management (DRM) capabilities to plan and implement risk mitigation investments as well as emergency response procedures—all of which are iteratively improved based on lessons learned from past natural disasters.

In addition, the Japan Water Works Association and the Japan Sewage Works Association develop guidelines and establish a mutual support network of member utilities in case of disasters. Also, to help utilities invest in risk reduction or recover from disasters, MLIT and MHLW provide a range of subsidies.

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Urban WSS utilities' best practices and lessons learned

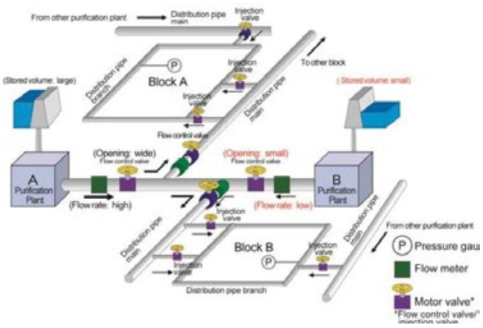
Utilities in Japan offer insightful lessons based on their accumulated experience of natural disasters. It is recommended to conduct risk assessment and cost-benefit analysis to prioritize and implement economically and technically viable resilience measures. Each best practice listed below pertains to one or more stages of infrastructure life cycle—systems planning, engineering design and materials, asset management, and contingency programming—as designated within brackets in each listed practice.

Fukuoka City: Building drought resilience and enhancing drainage capacity against urban floods

The Fukuoka Waterworks Bureau supplies water to 1.48 million residents, with an NRW level of 3.8 percent in 2014. In 1978 and 1994, the utility experienced severe droughts that necessitated water rationing for approximately 300 days each. As a result of numerous drought countermeasures implemented from source to tap, including the following, the utility did not need to ration water during the 2005 drought (when the annual rainfall dropped to the third-lowest level):

- **Water resources development and conservation** [systems planning]: Diversification of water sources including development of an intake facility at Chikugo River in 1983 and a seawater desalination plant in 2005; enforcement of a regulation to use nonpotable water (for example, reclaimed water or rainwater) for buildings, sanitary facilities, and tree or plant watering
- **Efficient water distribution control system** [systems planning]: Establishment of Japan's first Water Distribution Control Center in 1981 to monitor and remotely control water quality, flows, and pressures by operating 177 motor valves based on an analysis of data collected from the flow meters and pressure gauges installed throughout the 21-block water distribution pipe network (Figure 1)

Figure 1. Water Distribution Control System, Fukuoka City



Source: ©Fukuoka Waterworks Bureau (FWB). Reproduced, with permission, from FWB; further permission required for reuse

- **Portfolio risk management for leakage prevention** [asset management]: Regular leakage inspection and implementation of preventive or corrective measures (for example, replacement of aging service pipes) based on the results of risk assessments conducted every year in high-risk areas every two years in medium-risk areas, and every four years in low-risk areas.

Hiroshima City: Enhancing water supply continuity against extreme rainfalls and landslides

The Hiroshima City Waterworks Bureau supplies water to 1.2 million residents and two neighboring towns, with an NRW level of 6.9 percent as of 2014. Multiple precipitation-induced landslides in August 2014 extensively damaged the city's water distribution networks and other facilities, causing approximately 3,500 households to lose access to water (photo 1). The heavy rains also posed a challenge to water treatment because of an unprecedented increase in turbidity. The utility's rapid restoration was enabled by implementation of structural and nonstructural measures, including the following:

- **Installation of redundant emergency networks of water supply** [systems planning] [contingency programming]: Installation in 2005 of a network of interconnecting pipelines to enhance the backup water supply capacity, which enabled 80 percent of the households to receive emergency water from another primary water treatment plant (WTP)
- **Emergency preparedness at pumping stations, reservoirs, and storage tanks** [contingency programming] [engineering design and materials]: Installation of uninterruptible power supply at pumping stations to prevent service disruption during a blackout; installation of emergency shutoff valves at the primary reservoirs; and, with support from the city's Fire Services Bureau, seismic reinforcement of more than 30 underground emergency water storage tanks. Seismic-resistant tanks and pipes were also effective in minimizing impacts of landslides.

Photo 1. Exposed Distribution Mains after 2014 Landslides in Hiroshima

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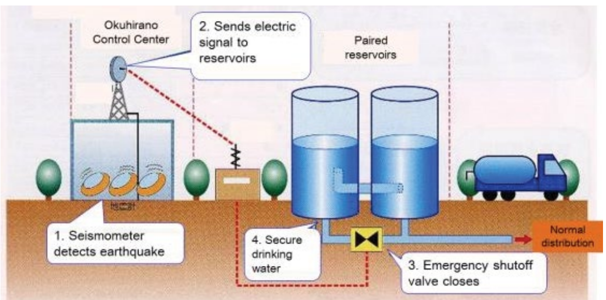
Kobe City: Enhancing resilience of water supply based on lessons learned from the 1995 Earthquake

The Kobe City Waterworks Bureau supplies water to 1.53 million residents, with an NRW level of 7.4 percent as of 2014. The 1995 Hanshin-Awaji Earthquake (magnitude 7.3) took the lives of 4,571 people and severely damaged the infrastructure; it took 10 weeks to restore piped water supply. Based on the lessons learned, the utility set several recovery time objectives (RTOs): (a) 3 liters per person within the first three days postdisaster, (b) 20 liters per person within seven days, (c) 100 liters per person within 11 days, and (d) 250 liters per person within 28 days. To achieve these RTOs, the utility implemented a master plan comprising the following elements:

- **Seismic retrofitting of distribution pipes** [engineering design and materials]: The 1995 earthquake did not affect the pipes with seismic-resistant joints. The seismic retrofitting prioritized the pipelines connected to hospitals and schools.
- **Emergency water storage system** [contingency programming]: When the seismometers detect an earthquake, the utility's Control Center remotely operates emergency shutoff valves at 37 pairs of reservoirs. The system will shut off one of the two storage reservoirs for seven-day emergency use, while the other reservoir will continue distributing water for the unaffected districts and firefighting (Figure 2).
- **Building redundancy through a multifunctional transmission pipeline** [systems planning] [contingency programming]: The utility has completed a 20-year project to install a 13-kilometer transmission pipeline that can provide emergency water storage through six intake points. The pipeline is connected to a distribution network, which allows the pipeline to also act as an emergency distribution pipeline.

Figure 2. Okuhirano Control Center's Emergency Water Storage System, Kobe City



Kumamoto City: Enabling rapid earthquake recovery through risk-informed investments

The Kumamoto City Waterworks and Sewerage Bureau provides services to about 700,000 residents, with an NRW level of 10.3 percent in 2014. In April 2016, two earthquakes of magnitudes 6.5 and 7.3 caused all residents to lose access to water. However, the utility restored water supply within two weeks, owing to the following measures:

- **Seismic risk assessment and reinforcement of WSS assets** [engineering design and materials]: Before the earthquakes, the utility has prioritized and implemented seismic reinforcement of pipelines, distribution reservoirs, pumping stations, and wastewater treatment plants (WwTPs) based on a risk assessment taking into account the pipe age, materials, soil conditions, and impacts in case of failure. No damages were observed in the reinforced assets during the 2016 earthquakes.
- **Framework agreements with the private sector and mutual assistance from other utilities** [contingency programming]: The utility commissioned the Kumamoto City Pipe Construction Cooperative to identify and fix pipe failures and leakage at the outset of the response period. The Japan Water Works Association coordinated with the utility to deploy personnel from other utilities for emergency water supply activities and to identify pipe failures and repair works.

Sendai City: Integrating business continuity and asset management after Great East Japan Earthquake

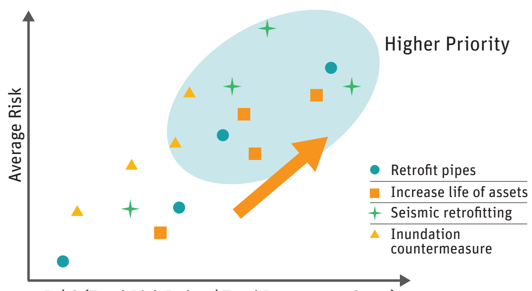
The Sendai Waterworks Bureau and Construction Bureau provide services to 1.05 million residents, with an NRW level of 5.8 percent in 2014. The 2011 Great East Japan Earthquake (GEJE) of magnitude 9.0 led to a loss of water access among up to 500,000 residents, and the city's primary WwTP was completely submerged by tsunami. Best practices and lessons learned from GEJE include the following:

- **Building redundancy and seismic reinforcement of water supply assets** [systems planning] [engineering design and materials]: The utility has divided the water supply distribution network into approximately 120 small blocks and built redundancy to increase backup capacity in addition to seismic reinforcement of assets including pipes and valves. This has enabled the utility to operate the seismic-resistant pipelines that were not physically affected by the GEJE.
- **Sanitation business continuity planning** [contingency programming]: The utility was in the process of developing a business continuity plan (BCP). Based

on the draft BCP, the utility successfully switched to a simple gravity-fed treatment process and opened an emergency discharge gate, which enabled it to continue treating sewage despite the reduced treatment capacity. As a result, the utility managed to prevent sewage overflows after the GEJE.

- **Mutually reinforcing and integrating a sanitation BCP and an asset management (AM) system** [asset management] [contingency programming]: A geographic information system (GIS) database of assets enabled the utility to quickly identify the location and investigate the extent of pipe failures. SCB plans to improve its BCP, including postdisaster emergency inspection, based on the results of seismic and inundation risk assessment conducted as part of the AM system. The utility will also adopt the prioritization and investment decision-making process established under the AM system for emergency repair and reconstruction works (Figure 3). The utility plans to improve regular inspection procedures based on the lessons learned from its pipe damage assessment during GEJE.

Figure 3. Risk-informed Investment Decision Making, Sendai City



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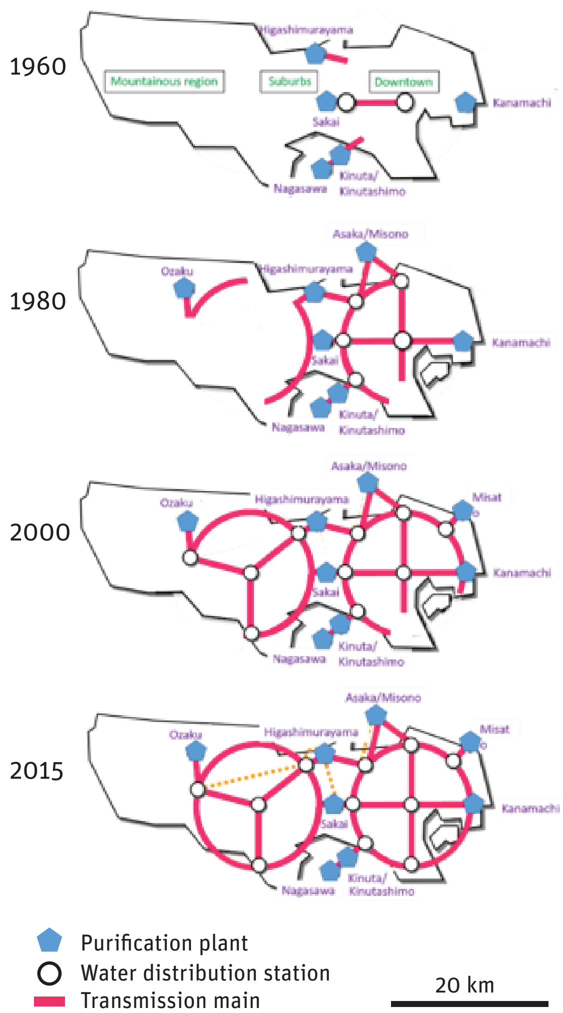
Tokyo: Enhancing seismic resilience to ensure continuity of WSS services for 13 million residents

The Bureau of Waterworks of the Tokyo Metropolitan Government is the largest utility in Japan, with an NRW level of 4.1 percent as of 2014. Although Tokyo has not been affected by large earthquakes since the 1923 Great Kantō Earthquake, the utility has been building resilience in the following ways, based on historical data, estimated scenarios, and lessons learned from other utilities:

- **Increasing interconnectivity between WTPs and between WwTPs** [systems planning]: The utility has interconnected the WTPs and WwTPs to build a backup capacity in case some of the plants are physically affected by a natural hazard (Figure 4).
- **Iterative improvement of disaster risk reduction and emergency preparedness and response planning** [contingency programming]: The utility developed its first Water Supply Seismic Disaster Prevention Plan in 1973, corresponding to a Prefectural Seismic Disaster Prevention Plan. Later, in 1982, the utility separated the plan into two primary plans, which are regularly reviewed and improved: the Earthquake Countermeasures Development Plan for risk reduction infrastructure investments and the Earthquake Emergency Response Plan. Each department and division of the utility has developed standard operating procedures and operation manuals to smoothly implement specific emergency tasks.

Figure 4. Interconnections of Water Treatment Plants with Pipelines, Tokyo, 1960–2000



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