Redefining Emergency Water Supply in Large-Scale Disasters

— The Effectiveness of Water-Circulation Systems Demonstrated by the Noto Peninsula Earthquake, and the Road Ahead —

(Source: Commissioned research by the National Institute for Land and Infrastructure Management, Ministry of Land, Infrastructure, Transport and Tourism, 'Study on the Integrated Operation of Emergency Water Purification and Emergency Water Supply in Disasters')

Summary

In the 2024 Noto Peninsula Earthquake, prolonged and wide-area water outages occurred, severely affecting evacuees' living conditions. While emergency water supply measures secured drinking water, domestic water—needed for bathing, handwashing, and the like, in volumes 10 to 100 times greater than drinking water—was in severe short supply, laying bare the limits of the conventional emergency water-supply approach centered on water trucks.

In light of this experience, the government is strengthening efforts to secure domestic water. The Cabinet Office has revised disaster-response policy and, in its guidelines on conditions during evacuation, explicitly called for ensuring bathing opportunities in line with the Sphere standards. The National Resilience Implementation Mid-term Plan likewise sets a goal of stockpiling, in all municipalities by 2030, supplies sufficient to meet the Sphere standards. However, there is no social consensus on either the quantities of domestic water required or the means of securing it, and current measures remain inadequate.

This paper explains effectiveness testing of emergency water supply using water-circulation (recycling) systems and portable water-purification units, conducted under a commissioned study from the National Institute for Land and Infrastructure Management titled "Integrated Operation of Emergency Water Purification and Emergency Water Supply in Disasters" carried out by a joint research body comprising NJS Co., Ltd., METAWATER Co., Ltd., and WOTA Corp. In an estimate using Suzu City, Ishikawa Prefecture—which experienced a long, city-wide outage during the Noto earthquake—as a model, the results indicated that:

1. The volume of water required to maintain evacuee hygiene could be reduced to about 40% of the pre-introduction level through a water-circulation system, enabling demand to be met even under outage conditions; and

2. The time needed to satisfy evacuees' water demand could be shortened from 142 days after the disaster with conventional methods to 10 days,

suggesting that sanitary conditions at evacuation shelters could be maintained even during a water outage.

Going forward, it will be necessary to visualize evacuees' water-demand volumes with outage risk in mind and build social consensus around practical emergency water-supply methods. On that basis, it is important to determine the required quantities of household-water equipment and materials—including water-circulation systems—nationwide, pre-position supplies to cover any shortfalls, standardize operations, and thereby ensure feasibility.

Chapter 1: The Reality of Domestic (Non-Drinking) Water Use in the Noto Peninsula Earthquake

In the Noto Peninsula Earthquake that struck on January 1, 2024, the core water-supply facilities in the Oku-Noto area suffered devastating damage. Coupled with severed road networks and the peninsula's unique geographic conditions, the time required to restore water service extended to as long as five months[1]. The damage was also wide-ranging: the outage covered the entirety of Suzu City and Wajima City, among other areas.

In this paper, "restoration of water service" refers to restoration up to the water meter. In the actual disaster areas, however, many households continued to face severe daily constraints for an even longer period because earthquake damage to in-house plumbing meant no water came out of the tap. In addition, because evacuation life continued for an extended period, the functions required of emergency water supply changed depending on the number of days since the disaster.

Amid this widespread and prolonged outage, while drinking water was secured early on through supplies of bottled water and conventional water-tanker trucks, domestic water—which requires roughly 10 to 100 times the volume of drinking water—was in severe short supply.

To visualize the purposes, targets, and on-the-ground reality of emergency water supply under such wide-area and long-term outages, the A-JUMP survey report first defined phases of emergency water supply[2] and then organized the necessary uses and water volumes for disaster victims during outages (Table 1). In doing so, it (i) reflected the actual conditions of the Noto Peninsula Earthquake[3], (ii) considered demand not merely on a per-capita basis but by each use of water, and (iii) took into account existing standards and research such as the Sphere standards.

What Are the Sphere Standards?

- The Sphere standards are international standards established to ensure that disaster-affected people can maintain minimum living conditions during humanitarian assistance in disasters and conflicts. Developed under the "Sphere Project," launched in 1997 by NGOs and international organizations, they are currently compiled in the "Sphere Handbook." Minimum standards are presented for sectors such as water and sanitation, food, shelter, and health, and the standards serve as a common language for international humanitarian operations.
- In Japan, prompted by the Noto Peninsula Earthquake, the Cabinet Office revised its "Guidelines for Efforts to Ensure a Favorable Living Environment During Evacuation Life" in December 2024, explicitly stating the development of evacuation-living environments in line with the Sphere standards. For example, for bathing facilities, a quantitative benchmark such as "one facility per 50 people, provided separately for men and women" is indicated.

[1] Excluding areas where early restoration was difficult

[2] In the A-JUMP survey report, four target phases were set with reference to prior research. Phases 1–3 are those to be pursued under water-outage conditions through emergency water supply, while Phase 4 is to be achieved by restoration of water service. In addition, because water use was expected to differ between evacuees in shelters and those sheltering at home, Phase 3 distinguishes shelter evacuees from at-home evacuees.

- Phase 1 – Ensuring Survival: A stage for preserving life with the bare minimum amount of water.
- Phase 2 – Ensuring Sanitary Conditions: A stage for securing hygiene to prevent infectious disease and deterioration of health due to poor conditions.
- Phase 3 – Ensuring a Sound Living Environment: A stage for securing a sound living environment at a level evacuees can tolerate even during prolonged evacuation.
- Phase 4 – Restoring Everyday Living Conditions: A stage for restoring the everyday living environment that existed before the disaster.

[3] Bathing: Some at-home evacuees visited shelters to bathe.
Cooking: Cooking at shelters during water outages was rarely observed; meals appear to have been provided mainly via boxed lunches, food trucks, and a central-kitchen model.

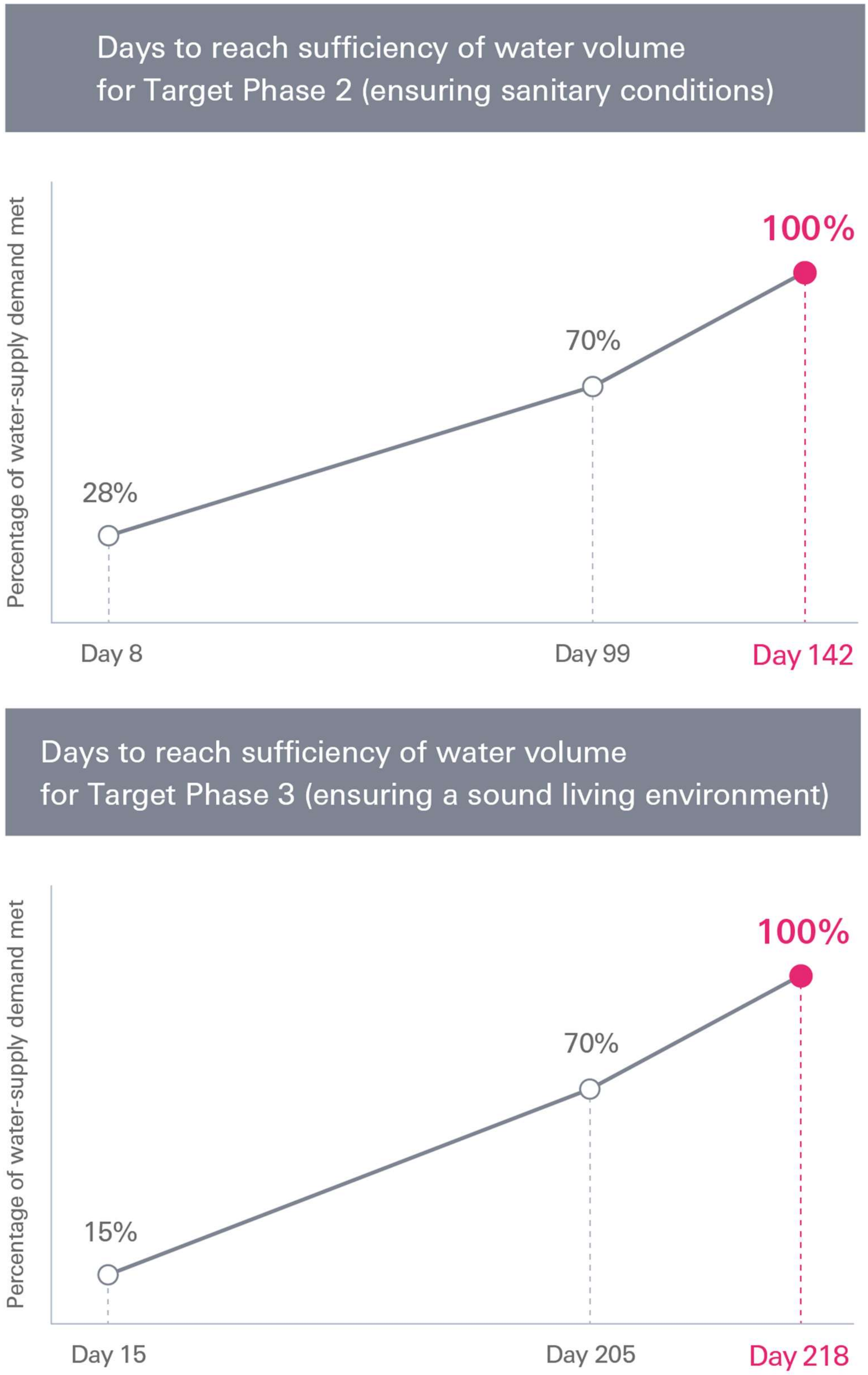
Table 1: Per-Capita Daily Water Requirement (L/day) by Phase and Use

Classification		Emergency water supply during outages				Accelerated restoration of piped service
Target Phases		Target Phase 1	Target Phase 2	Target Phase 3		Target Phases 4
		Securing life (at shelters, etc.)	Securing sanitary conditions (at shelters, etc.)	Securing a sound living environment (at shelters, etc.)	Home: Securing a sound living environment (at home, etc.)	Securing ordinary (pre-disaster) living conditions
Definition		At shelters, secure life with the bare minimum amount of water.	At shelters, secure sanitary conditions to curb deterioration of health due to infectious disease and poor environments.	At shelters, secure a sound living environment at a level evacuees can tolerate.	At home, secure a sound living environment at a level evacuees can tolerate.	At home, secure a water supply equivalent to that before the disaster.
Anticipated Duration		~7 days	8–14 days	15 days and beyond (shelters / home)	15 days and beyond	—
Per-capita daily water requirement		3L	26L	63L	34 L (*68 L if shelter showers are counted*)	250L
	Drinking[4]	3L: water intake essential for sustaining life (all phases)	3L: water intake essential for sustaining life (all phases)	3L: water intake essential for sustaining life (all phases)	3L: water intake essential for sustaining life (all phases)	—
	Face washing[5]	0L: mouthwash	1L: gargling, tooth-brushing	1L: gargling, tooth-brushing	1L: gargling, tooth-brushing	
	Handwashing[5]	0L: alcohol	5L: minimum handwashing	5L: minimum handwashing	5L: minimum handwashing	
	Bathing[6]	0L: alcohol wipes, etc.	11L: occasional shower—about once every three days, private booth	34L: daily shower, private booth	0L: *※use shelter showers*	
	Toilet[7]	0L: portable toilet	6L: temporary toilets	20L: flush-type temporary toilets	0L: portable toilet	
	Cooking[8]	0L: emergency rations	0L: distribution of emergency rations; food trucks	0L: boxed-meal distribution; food trucks	20L: simple cooking + purchase of prepared foods	
	Laundry[9]	0L: Do not do laundry (accept)	0L: Send laundry out of the city	0L: Send laundry out of the city	5L: Hand-wash part of it	

[4] Drinking water was set based on the Sphere standards for minimum survival water intake, 2.5–3 L per person per day.
[5] Handwashing and face-washing, etc., were set based on Miyara et al. (2010), Nakakubo et al. (2019), and the Sphere standard of 2–6 L for basic hygiene practices. While previous studies treat handwashing and face-washing as a single category, we distinguish between them here because the required water quality differs.
[6] Bathing volumes were set, together with bathing frequency, based on Miyara et al. (2010), Nakakubo et al. (2019), and Shimatani et al. (1997). Note that the Sphere standards do not specify a water volume for bathing; instead, they stipulate service conditions such as a maximum facility throughput of 50 users and separate provision for men and women.
[7] Toilet water volumes were set according to the anticipated toilet types, based on Miyara et al. (2010), Nakakubo et al. (2019), and the Sphere guideline figures for public toilets (pour-flush: 3–5 L; sewer-connected flush toilets: 20–40 L).
[8] Cooking water was set by place of use: for shelters, figures reflect the meal-provision methods observed during the Noto Peninsula earthquake (distribution of supplies and boxed meals, food trucks); for households, values were set based on Miyara et al. (2010) and Nakakubo et al. (2019).
[9] Laundry water was set by place of use: for shelters, figures reflect laundry practices during the Noto Peninsula earthquake (use of laundromats and cleaning services outside the outage area); for households, values were set based on Nakakubo et al. (2019).

In the A-JUMP survey report, using Suzu City during the Noto Peninsula Earthquake as a case, we estimated and compared the city's total water demand with the actual volume supplied through emergency water supply, and visualized how well demand was met at each target phase.
The results show that with conventional emergency water-supply methods it was difficult to meet demand: Target Phase 2 (ensuring sanitary conditions) was not satisfied until Day 142 after the disaster, and Target Phase 3 (ensuring a sound living environment) not until Day 218. This suggests that, during this period, evacuees were compelled to live under restrictions on water use (Figure 1).

Figure 1: Case Study of the Noto Peninsula Earthquake (Conventional Emergency Water-Supply Methods)



Chapter 2: Bottlenecks in Conventional Emergency Water Supply

In emergency water supply, it is necessary to ensure three processes:
(1) **Purification**: producing usable water from the source;
(2) **Distribution**: transporting the purified water to points of use;
(3) **Drainage**: properly treating and discharging the water after use.

During the Noto Peninsula Earthquake, when restoration of water service in the Oku-Noto area dragged on, problems arose in all three processes above. First, insufficient purification capacity became an issue. For example, at Hōryū Water Purification Plant—the core plant serving Suzu City, one of the hardest-hit municipalities—water could not be supplied until more than two months after the disaster, when work such as laying raw-water conveyance pipes and installing portable purification units at the plant had finally made supply possible.

Next, distribution of large volumes of domestic-use water became problematic. In Suzu City, even in Target Phase 2—beginning one week after the disaster, when the need for domestic-use water becomes greater—the entire city area still had no running water. As a result, emergency water supply had to cover not only drinking water but also domestic-use water for all evacuees. Distribution by water tank trucks has inherent limits, which led to shortfalls in supply. In addition, until the core purification plant was restored, emergency water was brought in over long distances using purification plants in other municipalities as supply bases; until portable purification units were set up at farm ponds within Suzu City, transport efficiency was particularly poor.

At the same time, treatment of wastewater from domestic use posed challenges. In Suzu City, as with the waterworks, both the sewer system and on-site septic tanks suffered severe damage. Out of concern for drainage, disaster victims limited water use at home to small amounts such as handwashing and face-washing, while uses that generate large volumes of wastewater—such as bathing and laundry—were centered at evacuation shelters. However, even shelters were unable to treat wastewater for an extended period, so people were asked to be mindful of drainage and to use water in ways that produced as little wastewater as possible.

Given these realities in the Noto Peninsula Earthquake, when a wide-area, long-term water outage occurs, it is clear that emergency water supply by conventional means (water trucks and bottled water) alone cannot meet needs for domestic-use water. The structural issues of the conventional approach can be summarized as follows:

● **Insufficient purification capacity**

If purification facilities are damaged, the volume of water that can be purified within the disaster area is inadequate.

● **Insufficient distribution volume**

If pipelines are damaged, distribution must rely on water trucks; the number of trucks is limited, and in a wide-area outage it is often impossible to secure nearby supply bases, causing transport efficiency to drop sharply. Even if purification is possible nearby, transporting the large quantities needed—including domestic-use water—is difficult, resulting in insufficient volumes delivered to each shelter.

● **Constraints on wastewater treatment**

If sewers or on-site septic tanks are damaged, wastewater cannot be treated, restricting uses of domestic water that generate large volumes of discharge (toilets, bathing, laundry, etc.).

Chapter 3: Solving Structural Issues with Water-Recirculation Systems

A solution that fundamentally removes these bottlenecks is a new emergency water-supply approach that combines water-recirculation systems with portable water-purification units. This makes it possible to overcome the three challenges—purification, distribution, and drainage—at the same time.

- **Portable water-purification units**
  - Devices that purify directly from usable sources within the disaster area, such as river water or swimming-pool water.
  - Various portable types exist (with differing capacities), including vehicle-mounted and helicopter-deployable models.
- **Water-recirculation systems**
  - Systems that collect wastewater and reuse it after treatment, enabling extensive water use with only a small amount of priming (feed) water.
  - Systems are available for uses such as bathing and handwashing.

By combining these two, the issues with the conventional approach described earlier can be resolved as follows.

- **Securing purification capacity**

  Using portable purification units allows direct purification from water sources inside the disaster zone. As a result, purification can begin quickly without waiting for damaged treatment plants to be restored. It also eliminates the need to haul in large volumes of water from outside the area and increases the number of potential supply bases, which in turn improves the efficiency of distribution by water trucks, etc.

- **Securing distribution volume**

  Deploying water-recirculation systems at shelters and similar sites lets a small amount of priming water be reused repeatedly, drastically reducing the net quantity that must be delivered to each shelter. This prevents shortages of domestic-use water at shelters even when distribution is limited to a small fleet of water trucks.

- **Securing wastewater treatment**

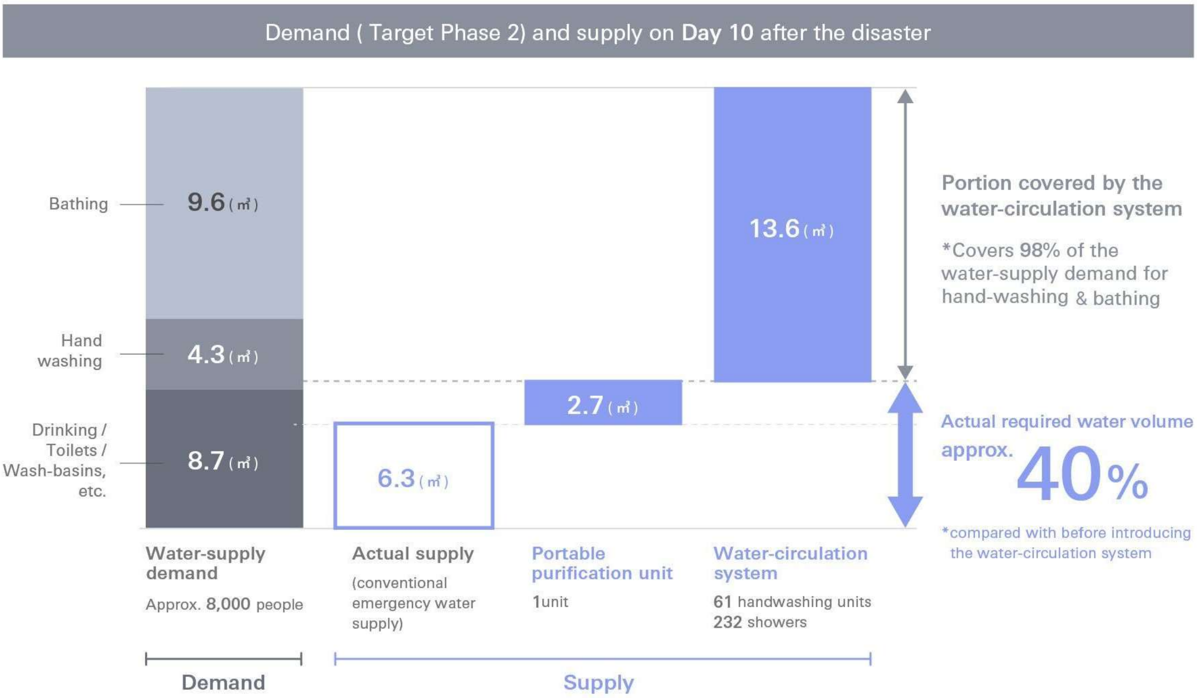
  Because water-recirculation systems collect, purify, and reuse the water used, they enable domestic uses that generate large volumes of wastewater—such as toilets, bathing, and laundry—even when sewers or on-site septic tanks are damaged, thereby maintaining sanitary conditions.

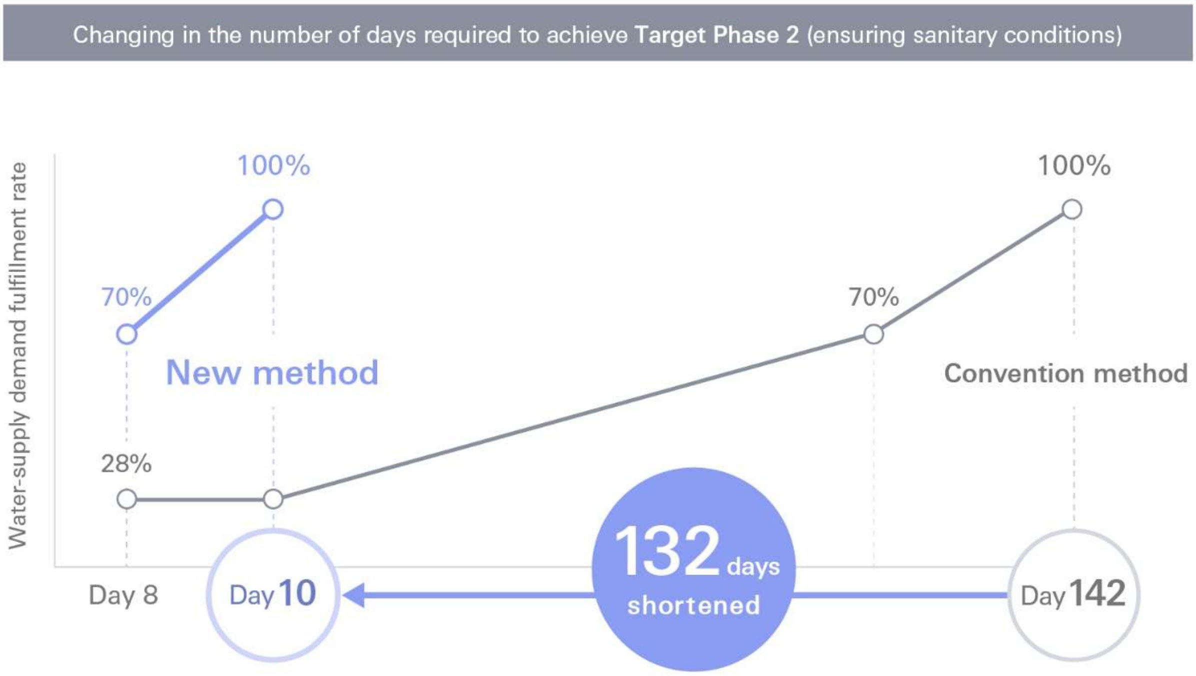
Figure 2. Functions of the Water Circulation System and Portable Water Purification Unit

In the A-JUMP survey report's estimates using Suzu City as a case, it was confirmed that if portable water-purification units and handwashing/bathing water-recirculation systems were deployed sufficiently[10], the effective volume of water required to meet the demand for Target Phase 2 (ensuring sanitary conditions) could be reduced to about 40% of the pre-recirculation level, enabling sufficiency by Day 10 after the disaster—a shortening of roughly 130 days (Figure 3)

[10] Taking distribution efficiency into account, seven portable water-purification units are installed near the shelters (with the assumption that one unit has begun operating by Day 10).
For the water-recirculation systems, the number of units is set in line with the Sphere standards, based on the number of evacuees by town immediately after the disaster (a total of 11,000 people): handwashing stations—61 units (at 1 per 250 people), and showers—232 units (at 1 per 50 people). These are installed at all shelters, excluding temporary facilities open for one week or less.

Figure 3. Case Study of the Noto Peninsula Earthquake
(New Method: Including Water Circulation System and Portable Water Purification Unit)





Chapter 4: Challenges and Responses Toward Implementation

Spurred by the Noto Peninsula Earthquake, the government is accelerating full-scale efforts to secure domestic water during service interruptions. In June 2024, the Cabinet Office established the "Working Group to Review Disaster Response Based on the 2024 Noto Peninsula Earthquake," which indicated the need for measures to secure alternative water sources for domestic use and to ensure usable environments for toilets, laundry, bathing, and the like. In response, December 2024 saw revisions to the "Guidelines for Efforts to Ensure a Good Living Environment During Evacuation" and the "Guidelines (Checklist) for Supporting the Management of Evacuation Facilities and Evacuee Life," explicitly stating that evacuation living environments should be ensured in line with the Sphere standards. Furthermore, the "First Mid-Term Plan for Building National Resilience," approved by Cabinet decision in June 2025, positions various initiatives aimed at a fundamental improvement of evacuation-shelter environments—based on the Sphere standards and similar benchmarks—as priority policies to be promoted. As a government target, the plan sets the proportion of municipalities that stockpile disaster supplies and equipment—such as toilets and beds—necessary to set up shelters that meet the Sphere standards at 100% by 2030.

Going forward, it will be necessary to visualize evacuees' water-supply demand in light of water-outage risks and to build social consensus around realistic emergency water-supply methods. On that basis, it is important to determine, nationwide, the quantities of **materials and equipment needed to secure domestic water—including water-recirculation systems—**to meet water demand, and to promote pre-positioning to cover shortfalls and the standardization of operations, so as to ensure feasibility.

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