
Implementation Model of Disaster Prevention Drill Utilizing PDCA Cycle in Capital of Tokyo

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Abstract: In recent years, the Tokyo Metropolitan Government (TMG) faces threats including terrorism and natural disasters like earthquakes. In response, Tokyo Metropolitan Government Bureau of Waterworks (hereinafter referred to as the Waterworks Bureau) created its own implementation model for disaster prevention drills utilizing a PDCA cycle to improve staff's crisis response capabilities in disaster situations. The drill implementation model utilized by the Waterworks Bureau in the past serves as a helpful resource for waterworks utilities around the world that are studying how to improve their response capabilities when faced with threats including earthquakes, terrorism, storm and flood damage, and emerging infectious diseases. In this paper, we describe the specific process of the Waterworks Bureau's disaster prevention drill PDCA cycle, and we propose a drill implementation model for waterworks utilities.

Keywords: Drill, crisis response capabilities, earthquake countermeasures, anti-terrorism measures

1. Introduction

Japan is one the world's most earthquake-prone countries. Even in the Tokyo capital area, experts observe there to be a 70% probability of an M7-class earthquake striking directly under Tokyo within the next 30 years. Moreover, Tokyo faces other threats including terrorism aimed at the Olympic and Paralympic Games, and new strains of influenza and other emerging contagious diseases. To address these threats, Tokyo Waterworks is engaged in building up "tangible" infrastructure to minimize damage as much as possible, such as by making facilities more earthquake-resistant. Yet as natural disasters and other phenomena occur at scales that exceed expectations, it is essential to pursue not only tangible but "intangible" measures as well.

Manpower is a crucial part of such intangible measures, but efficiency improvements in waterworks administration have resulted in the present total number of Waterworks Bureau staff dropping to less than half of its peak level. Thus, the Waterworks Bureau plans and implements systematic, comprehensive drills (Photos 1-2, Table 1) throughout the year to deepen the disaster-response knowledge of each and every staff member, as well as to improve organizational response capabilities to

achieve the maximum possible response when a disaster does occur. Moreover, after each drill is complete, we study performance, determine issues for improvement, and consider means of improvement before then revising our manuals and planning drills for the next fiscal year. For drill implementation, we have built a drill implementation model that uses a unique Waterworks Bureau PDCA cycle (Figure 1) to strengthen crisis response capabilities across the entire organization.

The PDCA cycle process implemented by the Waterworks Bureau can serve as a helpful resource for other waterworks utilities in improving their own crisis response capabilities. In this paper, we propose an implementation model for disaster prevention drills at major metropolitan waterworks utilities.

Various drills implemented by the Waterworks Bureau



Photo 1: Emergency restoration drill



Photo 2: Joint emergency water-supply drill in collaboration with other municipal waterworks utilities

Drill scenario	Implementation scale	Description of drill	Frequency and timing	Number of participants (planned)
Hypothetical natural disasters	Bureau-wide drill	Response drill for a disaster occurring on a weekday	One time in the first half of the year	1,800 people
		Response drill for a disaster occurring on a holidays	One time in the first half of the year	1,300 people
		Assembly drill for a disaster occurring on a holiday	One time in the first half of the year	3,900 people
		Safety check / assembly check system drill	Twice per year	3,600 people each
	Individual drills for each location	Emergency water-supply drill involving collaboration by multiple entities	One time in the first half of the year	3,700 people (incl. residents, etc.)
		Priority Hub Water Supply Drill for Essential Personnel	One time in the first half of the year	
		Drill for securing water supply routes for central agencies, etc.	Year-round	Total of more than 1,000 facilities
	Joint drill with other water utility companies	Information office initial response drill	Once per month	10 people each
		Liaison and Coordination Water Utility / Intermediary Water Utility Collaborative Drill	September	Joint implementation by 3 organizations (Tokyo Waterworks Bureau, Sendai City Waterworks Bureau, Ibaraki Prefectural Government Public Enterprise Bureau)
		Joint supply drill using connecting pipes	Held in sequence	Implemented with water utilities utilizing connecting pipes
		General disaster-preparedness drills in wards, cities, and towns	Held in sequence	Participation in general disaster-preparedness drills for cities in the Tokyo Metropolitan Area
Hypothetical disaster outside of Tokyo "Tokyowater Rescue dispatch"	Dispatches to the Kanto region	JWWA Kanto Regional Branch (North Kanto Block) joint disaster-preparedness drill (Host: Hitachi City Public Enterprise Bureau)	Once per year	Participation by at least 15 waterworks utilities
		JWWA Kanto Regional Branch (South Kanto Block) joint disaster-preparedness drill (Host: Chiba Prefectural Waterworks Bureau)	Once per year	
	Dispatches to respective distant locations	Kansai regional joint disaster-preparedness drill (joint drill between host utilities and utilities dispatching relief/rescue teams to the Kansai region, based on a hypothetical Nankai megathrust earthquake)	Once per year	Joint implementation by 4 organizations (Tokyo Waterworks Bureau, Osaka City Waterworks Bureau, Kobe City Waterworks Bureau, Fukuoka City Waterworks Bureau)
		JWWA drill for a nationwide earthquake or other emergency (information transmission drill)	Once per month	All water utilities in Japan are participants (Host: Japan Water Works Association)
Hypothetical terrorist attack	Bureau-wide drill	Waterworks Bureau terrorism response drill (collaborative with police and fire department)	Once per year	500 people
	Individual drills for each location	Joint drills at water treatment plants with police and fire departments	Held in sequence	10 water treatment facilities
Hypothetical spread of emerging infectious disease	Bureau-wide drill	Waterworks Bureau new influenza strain outbreak response drill	Once per year	300 people

Table 1: FY 2017 Drill Plan

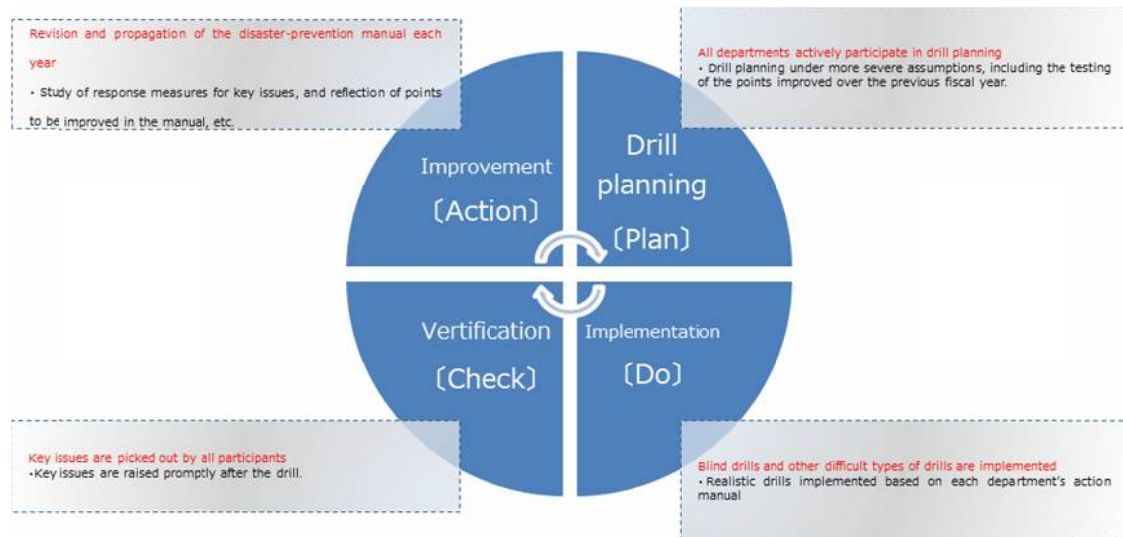


Figure 1: Tokyo Waterworks disaster prevention PDCA cycle

2. Tokyo Waterworks implementation model for disaster prevention drills

Of the various drills implemented by the Waterworks Bureau, this paper will showcase implementation models for two: the “assembly drill for a disaster occurring on a holiday” and the “response drill for a disaster occurring on a holiday,” both of which hypothesize an earthquake striking on a holiday.

Assembly drill for a disaster occurring on a holiday

(1) Plan: All staff participate in drills and create an assembly plan

The “assembly drill for a disaster occurring on a holiday” hypothesizes a scenario in which a disaster occurs on a holiday and all public transportation has been brought to a halt. All personnel physically walk their routes to the assembly site, i.e. their workplace. The aim of this drill is to help achieve safe and efficient assembly in the event of disasters occurring on holidays or at night, and to aid in the study of how to establish a rapid initial response framework with an understanding of the circumstances under which assembly is taking place for each office. As a general principle, all staff participate in this drill, and drill participants create assembly plans in advance of the drill to ensure that they can travel safely and efficiently. These assembly plans are made to take account of the possibility that public transportation could be brought to a halt by the earthquake, that it could be impossible to reach one’s assigned workplace, and that one may need to assemble at the bureau office nearest to one’s home.

(2) Do: Travel on foot while checking on objects that may be dangerous, etc.

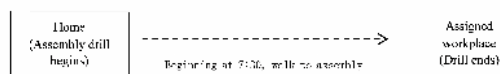
This drill hypothesizes a *shindo* 7-class earthquake occurring directly underneath Tokyo at 7 AM on a holiday, bringing public transport to a halt. Drill participants living 20 km or more from their assigned workplace assemble instead

at the bureau office closest to their home. Additionally, as per the assembly patterns for the “assembly drill for a disaster occurring on a holiday” (Figure 2), it is assumed that public transportation will be operational part of the way to assembly sites and that drill participants will walk a maximum of around 10 km. During the drill itself, participants will travel by foot and, as they walk, note objects along the route that may be dangerous when walking to the assembly site, such as old buildings and signs facing the road, in addition to noting the locations of convenience stores, gasoline stands, and other buildings that may contain toilets, food, or other necessities.

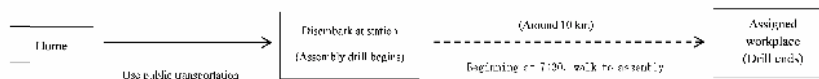
Assembly patterns for the “assembly drill for a disaster occurring on a holiday”

1. Staff who live within 20 km of their assigned workplace (assembly location = workplace)

(1) Staff who live within 10 km of their assigned workplace

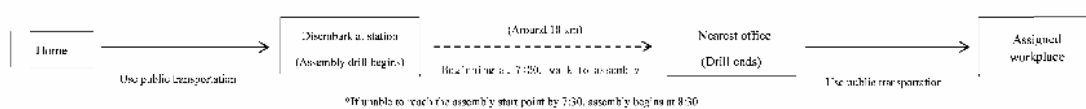


(2) Staff who live at least 10 km but less than 20 km from their assigned workplace



2. Staff who live at least 20 km from their assigned workplace (assembly location = nearest office)

(1) Staff who live at least 20 km from their assigned workplace, and at least 10 km from the nearest office



(2) Staff who live at least 20 km from their assigned workplace, and within 10 km of the nearest office

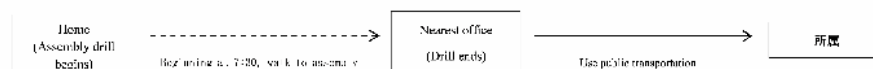


Figure 2: Assembly patterns in “assembly drills for disasters occurring on holidays”

(3) Check: Create staff assembly simulations for holiday disaster situations

After drills, we created a “Simulation of staff assembly in a holiday disaster situation (Figure 3)” to study how to establish a rapid initial response framework with an understanding of the circumstances under which assembly is taking place on holidays for each office. The conditions of the simulation of staff assembly and the result (the rate of staff assembly) carried out based on the result of the “assembly drills for disasters occurring on holidays” are as follows.

- Staff assembling at their assigned workplace on the day of the disaster (Staff who live within 20 km of their assigned workplace) : 57%
- Staff assembling at a bureau office near their home on the day of the disaster (Staff who live at least 20 km from their assigned workplace but within 20 km of their closest bureau office) : 24%
- Staff assembling at their assigned workplace on the day after the disaster (Management-level staff and similar who live at least 20 km from their assigned workplace / staff who will serve as directors of disaster response) : 10%
- Staff assembling at a bureau office near their home on the day after the disaster or later (Staff who live at least 20 km from their assigned workplace and at least

20 km from their nearest bureau office) : 9%

This “simulation of staff assembly in a holiday disaster situation” shows that, viewing the Waterworks Bureau as a whole, it is possible for at least half of staff to assemble at their assigned workplace on the day of the disaster. On the other hand, the simulation also shows that “for many offices in the downtown Tokyo area, half or fewer staff are able to assemble at their assigned workplace on the day of the disaster”; and that “many staff assemble at offices to which they are not assigned in the northeastern region outside of the downtown Tokyo area, to an extent heavily exceeding the number of assigned staff at those facilities.”

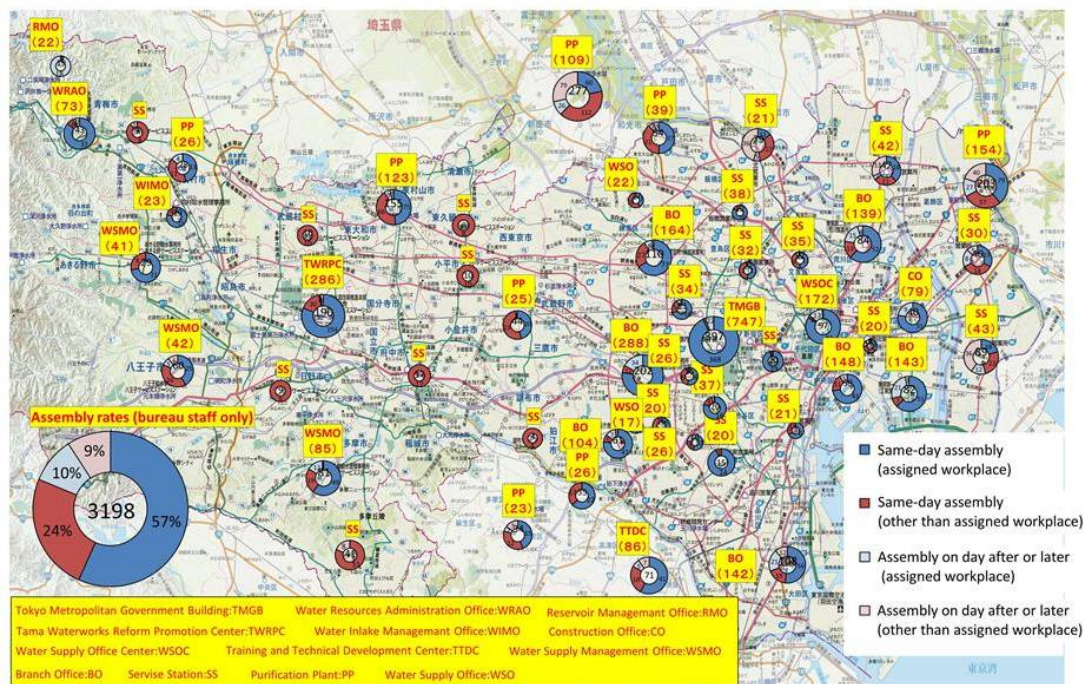


Figure 3: Simulation of staff assembly in a holiday disaster situation

(4) Action: Consideration of activities for staff assembling at offices to which they are not assigned after a disaster

When a challenge or issue is discovered during a drill, the Waterworks Bureau ensures that it studies potential countermeasures to address that challenge or issue. In the drill above, many staff in disaster situations assembled at bureau offices other than the workplaces to which they were assigned. Therefore, each office studied what activities these non-assigned staff ought to engage in when assembling there. These considerations took into account the assembled staff members' occupation types with respect to administrative and technical tasks.

Additionally, for offices in the northeast area outside of downtown Tokyo at which large numbers of non-assigned staff would assemble, studies also prioritized having the non-assigned staff understand the office to which they had assembled and where in the office necessary emergency supplies are located in a disaster situation, in addition to other similar information.

In this way, the Waterworks Bureau conducts drill planning and implementation using the PDCA cycle, as well as post-drill testing and improvements. Building on the “assembly drill for a disaster occurring on a holiday,” the next drill conducted afterwards was the “response drill for a disaster occurring on a holiday.” This drill is described below.

Response drill for a disaster occurring on a holiday

(1) Plan: All departments participate from the planning stage

A “response drill for a disaster occurring on a holiday” is conducted on an actual holiday when government offices are closed. The aim of the drill is to improve the practical response capabilities of staff in a holiday or nighttime post-disaster context in which they must act to respond with limited numbers.

First, hypothetical damage estimates used in the drill are typically created by the same department that conducted planning for the drill. However, at the Waterworks Bureau, hypothetical damage estimates are instead created by each respective department themselves. This is so that each department can finely tune improvements to their response capabilities vis-à-vis the specific weaknesses that they recognize they will face in a disaster situation. Additionally, although this drill is a practical field drill beginning with initial response to a disaster, each department created in advance the scenario used in their drill from the immediate post-disaster situation to the end of the drill. The purpose of this is to improve immediate disaster response capabilities through the act of hypothesizing beforehand, as much as possible, the conditions of a rapidly changing disaster situation.

(2) Do: Highly difficult “blind” drills

In order to improve participants’ practical response capabilities, drills are “blind,” meaning that the department executing the drill is not notified of the drill’s scenario beforehand. Building on the results of the “assembly drill for a disaster occurring on a holiday,” staff assembling at the bureau office nearest to their home in a disaster actually participate in the drills conducted at their nearest bureau office. The primary contents of these drills are wide-ranging in nature, including drills for surveying and restoration in a disaster-affected area, drills for receiving relief and rescue teams from other cities, drills for response headquarters deliberation, and drills for collecting and utilizing damage information from SNS and other sources (Photos 3-4). During drills, evaluators are dispatched to objectively check whether participants are using their manuals and performing their activities properly.

Drill photos



Photo 3: Drill for Water Supply Response
HQ deliberation at the Tokyo Government Office



Photo 4: Facility inspection (incl.
participants not assigned to the office)

(3) Check: After drills, ensure that issues are extracted, verified, and tested

After a drill has been completed, time is always set aside for drill recap and overview in which participants share information about shortcomings and methods of improvement. If there is not enough time for this, a questionnaire is distributed among all drill participants to extract key issues.

For reference, opinions collected after the last drill included the following: “When sharing information on whiteboards, in addition to using black and red markers, differently colored Post-it Notes should be used to make priority and importance obvious at a glance”; and “To better help cross-team collaboration, responsible parties need to set aside time to come together when necessary to confirm progress with one another.”

Regarding the participation in drills of staff who works at other offices, issues mentioned included the following: “Some non-assigned staff assembling from other offices knew almost nothing about the work done at the site where they were assembling. Because it is difficult to learn about the assembling office’s operations in such a short amount of time, they were only able to do basic administrative work”; and “There were more non-assigned staff from other offices than staff assigned to this workplace, and thus there were problems finding space, etc., for people to work.”

(4) Action: Reflect points of improvement in the manual every year, and propagate that knowledge among staff

The Waterworks Bureau establishes a period of time in our annual schedule for the propagation and revision of the content of our disaster preparedness manual before the distribution of the manual, such that issues identified in drills can be reliably reflected in the manual (Figure 4). At the beginning of the fiscal year, we communicate the content of the manual and that revisions will be made based on testing. Through this, when testing via drills, we are presented with more concrete issues, challenges, and solutions to those issues and challenges with a focus on revising the manual. The actual revisions to the manual take place near the end of the fiscal year after all of the year’s drills have been concluded.

The content of the new, revised manual is propagated among all staff at the beginning of the next fiscal year after personnel transfers have been conducted, such that staff can quickly get an understanding of their roles and other information.

April to May	June to November	December to March
Propagate content of disaster preparedness manual to all staff	Disaster preparedness drill implementation period (systematic implementation of drills in Table 1)	Manual revision period

Figure 4: Annual schedule

3. Conclusion

As discussed above, the Tokyo Waterworks Bureau has created a framework for enabling personnel to promptly assemble on holidays and at nighttime through “assembly drills for disasters occurring on holidays.” Additionally, we also create a “simulation of staff assembly in a holiday disaster situation” to identify distinctive features and challenges involved in the assembly under such circumstances. Finally, we conduct “response drills for disasters occurring on holidays” based on issues, challenges, and solutions discovered through previous work. Through this series of initiatives, we were able to improve the effectiveness of the initial response that is so important in disaster situations by effectively utilizing the staff who assemble at the offices nearest to their homes, even in their potentially limited numbers.

We have conducted many necessary disaster preparedness drills in the past, but by reliably executing this cycle of drill planning, execution, and testing, which leads to improvements that are then utilized in further drills, each and every staff member has improved their awareness and understanding of both the drills and disaster response. Moreover, by executing the PDCA cycle and continually brushing up the latest manual, we are able to achieve effective emergency response in disaster situations.

The “implementation model for drills using a PDCA cycle” that was introduced in this paper is thought to be useful not only for earthquake disaster response drills but for flood or terrorism response drills as well. In the future, by planning and executing drills of an even more practical nature, and then by testing and improving those drills, we will increase our response capabilities with regard to all types of disasters, thereby fulfilling our mission as an essential core utility sustaining the lifestyles of Tokyo residents and the urban activities of the capital city of Tokyo.

Bibliography

“Damage estimates and countermeasures for an earthquake originating directly underneath Tokyo (Final report)”. (Dec. 2013 Cabinet Office Central Disaster Prevention Council).