Rapid Emergency Repairs of Water Pipes through the Construction of a Leakage Information Collection System (Leakage Information Collection Using Social Media in Disaster Situations)

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Abstract
A large-scale earthquake disaster will cause massive damage to water pipes, and a lack of personnel as well as congested regular telecommunications lines due to the disaster may greatly diminish organizations' abilities to collect damage information and communicate.
In earthquakes of recent years, there have been cases in which leakage information provided via social media by local residents and others has been successfully used to achieve efficient water pipe restoration and repairs.
To act on this, the Bureau of Waterworks Tokyo Metropolitan Government (hereinafter referred to as, "the Bureau") has built a Leakage Information Collection System that uses leakage information provided by residents via social media to identify rapidly the locations and scale of leaks, leading to quick restoration and repair.

Keywords
Earthquake disaster countermeasures, leakage information from residents, rapid pipe restoration, social media

INTRODUCTION (Background to building the Leakage Information Collection System)

There is forecast that a 70% probability of a magnitude-7 earthquake will strike directly beneath Tokyo, the capital of Japan, within the next 30 years.
If this earthquake were to occur directly beneath Tokyo, it is predicted that damage to water pipes and similar infrastructure would result in water outages in 30-40% of Tokyo, causing major damage to Tokyo's capital-city functionality and residents' lifestyles.
Therefore, the Bureau is systematically proceeding with the installation of earthquake-resistant joint pipes that are less likely to come loose in earthquakes. As of March 2018, 43% of joint pipes have been replaced into earthquake-resistant.

However, it would require a substantial amount of time and funding to earthquake resistant distribution pipes in Tokyo, which is long enough to circle two-thirds around the Earth (27,126 km as of March 2018). If an earthquake occurs directly beneath Tokyo at the present stage, there would be significant water outages, as shown above.
In the aftermath of major earthquakes occurring in Japan in recent years (the M9 Great East Japan Earthquake on March 11, 2011; and the M7 Kumamoto earthquake of April 14 and 16, 2016; etc.), the full restoration of damaged pipes required as much as one to five months (Figs. 1).
For this reason, there is a need to discover and confirm leak sites as well as restore water service as rapidly and efficiently as possible.
In the Kumamoto earthquake, core pipelines were damaged and water outages were widespread. In addition, there were also numerous water outages in feeder pipes supplying households. As many as 1,000 personnel, including local and dispatched support staff and contractors, were involved in restoration-related construction work.

Fig. 1: Damage to water supplies caused by recent earthquakes

Ministry of Health, Labour and Welfare
Edited for Kumamoto earthquake materials

Earthquake name	Date of occurrence	Earthquake magnitude (M)	Number of households with water outages	Max. length of water outages
Great Hanshin Earthquake	Jan. 17, 1995	7.3	Approx. 1,300,000 households	Approx. 3 months
Niigata Prefecture Chuetsu Earthquake	Oct. 23, 2004	6.8	Approx. 130,000 households	Approx. 1 month
Great East Japan Earthquake	Mar. 11, 2011	9	Approx. 2,567,000 households	Approx. 5 months
Kumamoto Earthquake	Apr. 14, 2016	7.3	Approx. 446,000 households	Approx. 3.5 months

In the event of an earthquake, it is highly likely that the Bureau’s call center will be flooded with calls, tying up phone lines and causing confusion due to a welter of information. Hence, it is highly likely that there will be impediments to the Bureau’ s ability to perform its role of collecting and communicating information on pipelines’ damage situation and others.
Meanwhile, in large-scale earthquakes such as those above that resulted in a large number of leaks, leakage information from residents and others was used to restore water service in an efficient manner.
In the Kumamoto earthquake, the mayor of Kumamoto City used his own social media (Twitter) to request that residents submit and share information on damage in their local areas. This request was retweeted and resulted in thousands of pieces of information being shared both in the replies and by telephone.
According to S. Villegas (2013)’, social media is the most efficient way to understand consumers’ needs and the best way to get real-time feedback.
Although some information provided by residents over social media may include misinformation and groundless rumor, much of the information is useful. Actively collecting this sort of information leads to quicker, more appropriate disaster response.

The Bureau’s earthquake response plan involves forming search groups to go to the disaster site and conduct on-site surveys of damage however, there has never before been a mechanism for conducting emergency repairs with the efficient use of information from residents.
To this end, the Bureau has created a Leakage Information Collection System that uses leakage information provided by residents over social media as an earthquake disaster countermeasure. The Bureau is able to promptly identify leak locations and sizes, and leading to rapid pipe restoration.

METHOD (About the Leakage Information Collection System)

Immediately after a disaster, phone lines are heavily congested by both landlines and mobile phones, resulting in restriction for around 90% of phone calls. Damage to internet connection lines (telecommunication lines) results in a partial inability to access the internet; however, major providers have begun introducing earthquake and power outage countermeasures at data centers as well as decentralizing server placement, thereby generally enabling continuation of service. Thus, information collection via social media is an effective tool in earthquake disaster situations.
Moreover, information communicated via social media is up-to-date and vivid, sometimes being sent from nearby damaged locations in real-time or immediately after a disaster has occurred. It is also possible to post photographs, enabling others to visually confirm the magnitude of the damage.
Drawing on the above sorts of advantages offered by social media, we expect that information sent over social media can be efficiently collected and analysed to more efficiently conduct emergency repairs of leaks.

Leakage information collection mechanism

In order to collect a large amount of leakage information in the event of an earthquake, the Bureau has selected Twitter as our information collection tool due to the large number of followers (61,300 as of January 2019) on our official Bureau account and the service's information propagation functionality.

The Bureau's method of collecting information is to first transmit (tweet) a request on the Bureau's official account for information on specific leak (etc.) locations and on-site photos, as well as a request for propagation of the tweet and information. To simplify information collection, the text of the tweet should give specific examples of how to write out information. (1 – Specific location [Names of municipality and town including *Chome (block number)], 2 – Photo of the location or a landmark.)

By having followers and others propagate (retweet) the Bureau's request for information, the tweet reaches a large number of non-following users, enabling the information to reach a broader base of people (Fig. 2).

Users provide information in the form of replies to the Bureau's tweet, and this centralization of information in the reply section helps to make information collection more efficient. By continuously and repeatedly tweeting, the Bureau is able to collect the most up-to-date information from a larger number of people.

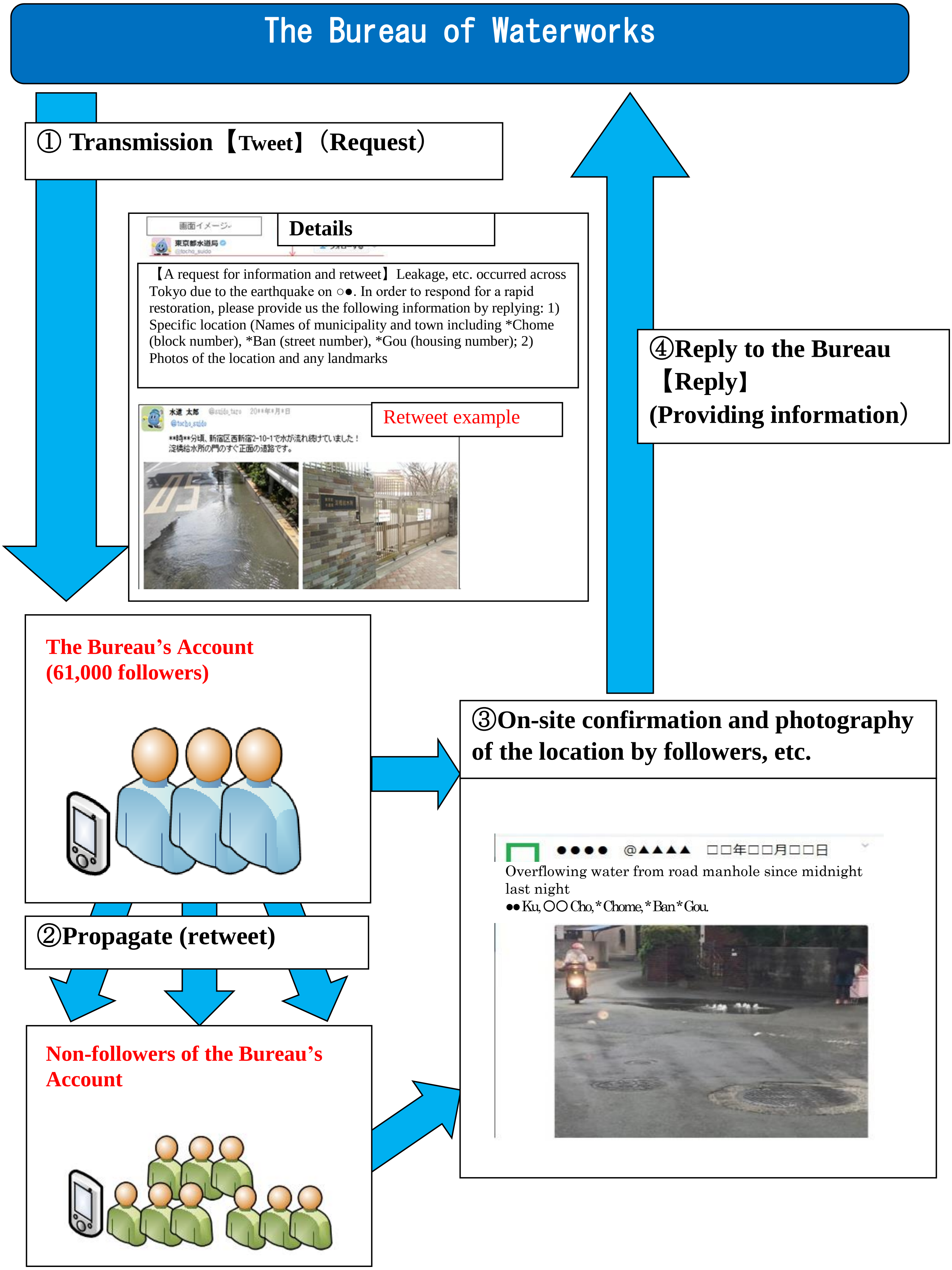

Fig. 2: Requesting and collecting information with social media

Use of leakage information

In order to efficiently collect a vast amount of information, analyze it, and use it for rapid pipeline restoration, the Bureau's personnel input leakage information collected via social media into the GIS database (Fig. 3).

Fig. 3: Inputting leakage information into the GIS database

Input leakage data is aggregated there and stored as markers on the map.
Reported information, which was registered under the same address, will be displayed as overlapping markers for up to ten results. If there are two or more reports, a number will display the total number of reports for that location (Fig. 4).
Through this, all personnel are able to visually perceive leak locations and the number of reports.
This information aggregation method makes it clear if multiple leak reports are actually regarding the same location.

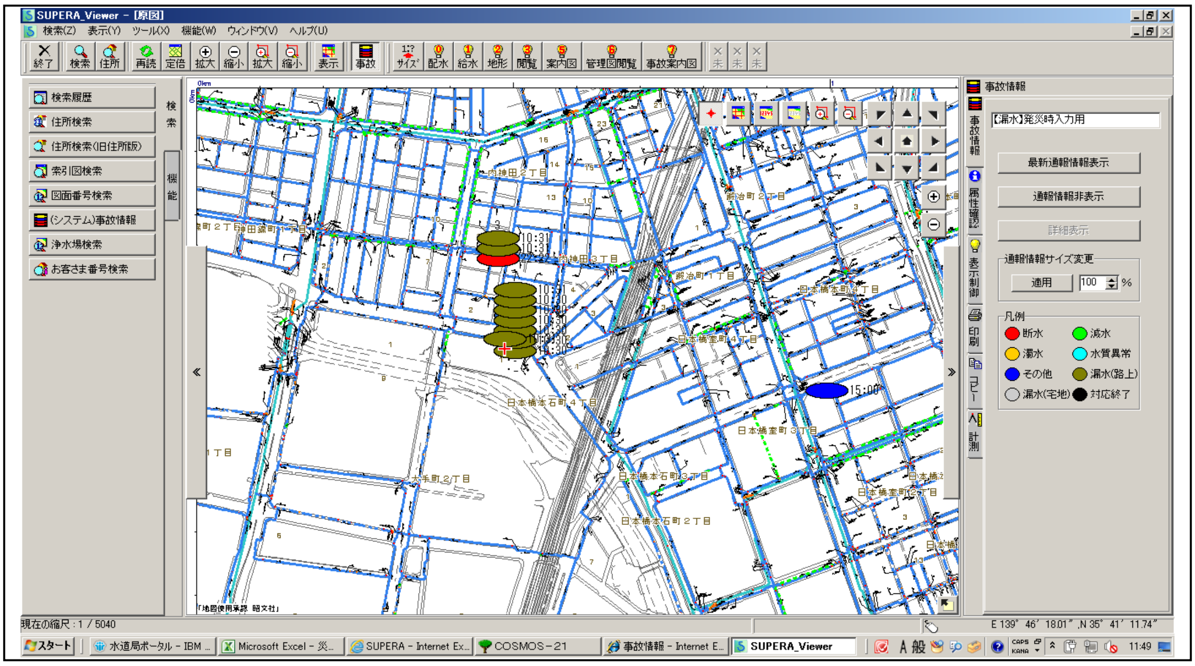

Fig. 4: **Displaying leakage information in the GIS database**

If a leak has been completed to, enter an already registered address and select “Response complete” on the menu screen to display a black marker on the very top of the report markers (Fig. 5).

Fig. 5: Response complete (black marker)

Report data can be output converted into Excel format and viewed as a table (Fig. 6).

通報コード	時間帯コード	作成日	作成者	作成所属	区	町名	番地	号数	内容	他部所連絡	備考
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□		不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□		不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	停電による断水	不要	SNS
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□		不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	管理会社を案内済	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	漏水	不要	SNS写真3
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	漏水	不要	SNS写真4
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	断水	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	宅地内漏水	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	停電による断水	不要	SNS
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	断水	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	濁水	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	濁水	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	断水	不要	
▲▲▲▲	2016・・・・・	2016/□/□	●●●●	△△△	○○区	■■	▲	□	断水	不要	

Fig. 6: Report data list (Excel table)

Collected site photos are saved in a shared folder on the Bureau server where it can be viewed by all personnel (Fig. 7).

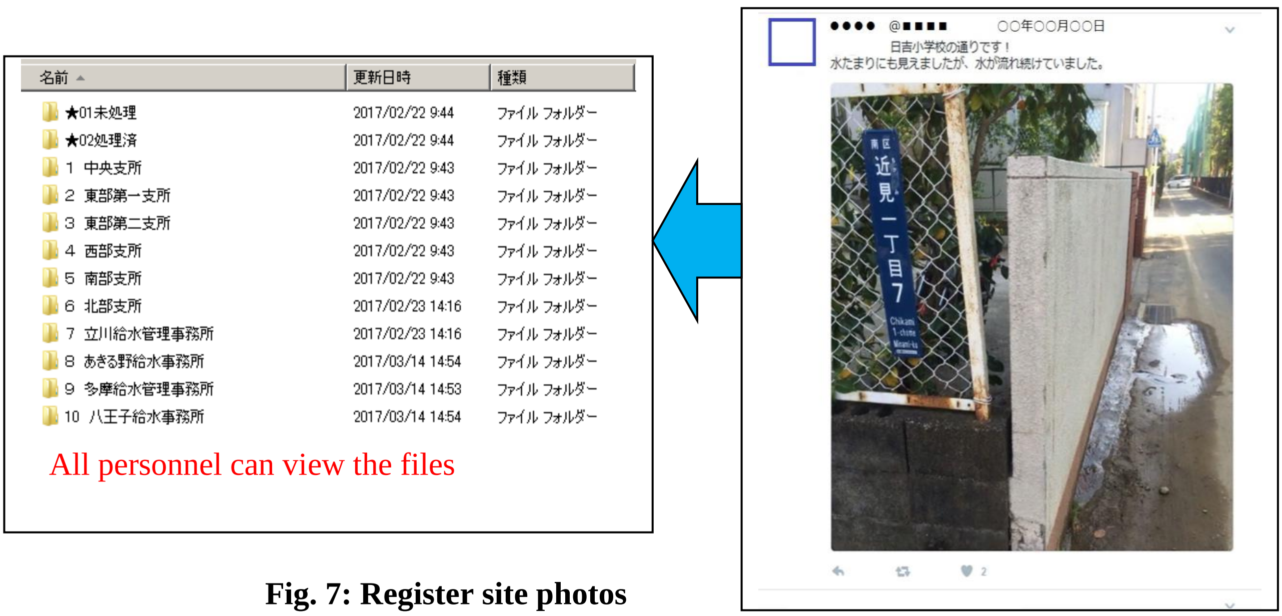

Fig. 7: Register site photos

Based on the number of reports, their content, and the site photos in the database, it is possible for the department performing to emergency restoration to infer the scale of damage.

Combining multiple collected data together improves accuracy, and it is possible to efficiently conduct surveys of pipe damage as well as assign restoration and repair priorities.

According to reports by local inspection teams to the Kumamoto earthquakes in April 2016, there was a huge number of redundancies in leakage reports from residents. Once they visited a site based on information they were given, they would sometimes find that another contractor who was already working on the problem or even that repairs were already completed. There was such confusion in the information collection process. There were also numerous errors in the addresses on the aggregated table of damage data, leading to problems with aggregation and responding to residents' inquiries.
In this regard, the visual representations of leakage data, repair status, and other information input into the Bureau's GIS database as well as the collection of site photos are effective means of avoiding redundancy at the Bureau.

Inputting data into the system
The Bureau has reflected this usage of the Leakage Information Collection System in its earthquake emergency response plan, and we conduct drills that make use of social media information (inputting data, dispatching to sites based on reported information, etc.).
As a general rule, information based on tweets from which only partial addresses can be determined is not input into the system to avoid confusion. However, if a store name or other landmark is included, that landmark can be looked up on the internet to determine the address and input it into the system.
In addition, personnel working on this process are divided into two types: those who collect reports and those who input data into the system. The system input work requires more time; thus, the Bureau assigns more personnel to that task to handle efficiently even large amounts of information. In the Bureau's "drill scenarios" in disaster training, it is assumed that five personnel will form a group. The two groups (10 personnel) will handle around 2,000 reports for 10 hours per day, or they will handle around 6,000 reports over three days after a disaster occurrence. In actual drills, we tested this by inputting around 800 reports in total at each department.
As a result, processing the information per one report via social media require half the time of conventional phone-based collection methods (which required around 10 minutes per report). This enables personnel to efficiently process more leakage information.
Moreover, in the past, personnel being dispatched to disaster sites would manually search for and prepare maps (GIS system or residential maps) needed for on-site surveys, based on telephone reports. Although this was inefficient, the introduction of the current system massive improved efficiency.

CONCLUSION
Social media are convenient, used by a large number of people, and offer immediacy and wide influence. In disaster situations, social media can be a useful way of efficiently collecting and analyzing information on leaks and other topics.
As described, this Leakage Information Collection System that uses social media is already employed in drills. It has drastically reduced processing times compared to conventional telephone-based reporting, and this is expected to greatly increase the number of leakage reports that can be handled.
Also, in pipeline restoration work, the collecting a large quantity of leakage information with attached photos can be expected to enable departments responsible for emergency repairs to promptly and accurately grasp the situation, likely making it a useful part of pipe restoration plans. This use of information from residents via social media is not only useful in leakage data collection after disasters, but also can be applied to understand the situation on the front lines in a variety of scenarios, including water supply and outage status information at emergency water supply hubs and evacuation shelters
In this way, the use of social media helps to push disaster response forward to a more advanced stage.

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