

Electronic supplementary material (ESM1) – Hydrogeology Journal

Report on questionnaire survey on Disaster Emergency Wells

(Disaster Emergency Well registrants in the city of Kumamoto, Kumamoto Prefecture, Japan)

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1. Background

This survey was supported by the “Efficient Securing of Water Resources” project under the Enhancement of National Resilience against Natural Disaster, Cross-ministerial Strategic Innovation Promotion Program, controlled by the Cabinet Office of the Government of Japan (Project leader: Professor OKI Taikan, University of Tokyo). This research project was launched within the context of frequent occurrence of natural disasters in Japan. The overall aim is to construct a “groundwater utilization system for emergency situations” by investigating the availability of groundwater resources in times of crisis, without causing substantial negative impacts on the environment and by considering the institutional arrangements that underpin such a system.

The purpose of this questionnaire survey is to collect information on how groundwater was actually used following occurrence of an earthquake. The research target is registrants of Disaster Emergency Wells (DEWs) in the city of Kumamoto, Kumamoto Prefecture, Japan. The city of Kumamoto was struck by the Kumamoto Earthquake in 2016.

A DEW is a local well registered with the local government that could be used as a supplementary water supply in the event of occurrence of an earthquake. While some wells are constructed by the local government, most are privately owned by local factories and shopping malls. Registered DEWs are supposed to be accessible by the local population as a source of water for drinking or other domestic purposes in an emergency. However, it is not mandatory and accessibility is at the discretion of well owners. Although Kumamoto did not have DEWs in operation at the time of the Kumamoto Earthquake (DEWs were registered the year following the earthquake), private wells were used as a source of water supply.

This survey was conducted in conjunction with a second survey whose research target was the welfare facilities for aged people in the city of Kumamoto. The objective of this initial survey was to reveal how groundwater was used following occurrence of an earthquake by focusing on the behavior of those who supplied the groundwater. The objective of the second survey is to establish how groundwater was used by focusing on the actions of those who were in need of water. Integration of the results obtained from these two surveys enables more comprehensive understanding of groundwater utilization following occurrence of an earthquake.

2. Method

2-1. Research target

The research target comprised DEW registrants in the city of Kumamoto. The DEW registrants in the city of Kumamoto comprised 91 organizations as of 9 March 2020. The full list can be obtained at the following address:

https://www.city.kumamoto.jp/common/UploadFileDsp.aspx?c_id=5&id=15906&sub_id=15&flid=247378 (accessed on 22 January 2021).

2-2. Questionnaire survey method

An online questionnaire survey was used.

2-3. Timespan

The questionnaire was distributed on 10 February 2021 and the deadline for response was set as 1 March 2021.

2-4. Results of replies

Replies were obtained from 57 of 91 registrants (reply rate: 62.6%).

3. Questions and answers

Q1 Please write organization name and location

Replies to this question are omitted.

Q2 Did any trouble take place at the well? Please select one of the following answer choices. If you select [1], please then move to question 3. If you select [2] or [3], please then move to question 5.

Answer Choices	Responses	
1. Trouble took place.	33.33%	19
2. Trouble did not take place.	59.65%	34
3. Not sure if trouble took place.	7.02%	4
Answered		57
Skipped		0

Q3 Only those who selected [1. Trouble took place] at question 2 should answer this question. What type of trouble took place? Please select from the following choices. Selection of multiple answer choices is allowed.

Answer Choices	Responses	
1. Pump came to a halt owing to cutoff electricity supply.	26.32%	5
2. Electricity was available but pump was destroyed.	0.00%	0
3. Groundwater was unavailable owing to water table decline.	5.26%	1
4. Groundwater became muddy.	47.37%	9
5. Other (free descriptive answer).	31.58%	6
Answered		19
Skipped		38

Q4 How many days did it take for all the troubles selected at question 3 to be solved? Please select one from the following answer choices.

Answer Choices	Responses	
1. Troubles were solved on the day of earthquake occurrence.	22.22%	4
2. Troubles were solved within 6 days.	44.44%	8
3. Troubles were solved from 7–13 days.	5.56%	1
4. Troubles were solved from 14 days to less than 1 month.	11.11%	2
5. Troubles were solved after 1 month or longer.	16.67%	3
Answered		18
Skipped		39

Q5 After occurrence of the earthquake, did you conduct an inspection of water quality before using groundwater again? Please select one from the following answer choices. If your selection is [1]–[3], please then move to question 6. If you select [4] or [5], please then move to question 7.

Answer Choices	Responses	
1. Inspection was conducted personally.	5.26%	3
2. Inspection was conducted by an external organization.	50.88%	29
3. Inspection was conducted personally and by an external organization.	8.77%	5
4. Inspection was not conducted.	24.56%	14
5. Not sure if inspection was conducted or not.	10.53%	6
Answered		57
Skipped		0

Q6 Only those who selected [1. Inspection was conducted personally], [2. Inspection was conducted by an external organization], or [3. Inspection was conducted personally and by an external organization] at question 5 should answer this question. How many days did it take to get the results of the water quality inspection? Please select one from the following answer choices.

Answer Choices	Responses	
1. 0 (day of earthquake occurrence) to 1 day after earthquake occurrence.	5.88%	2
2. 2–6 days after earthquake occurrence.	23.53%	8
3. 7–13 days after earthquake occurrence.	38.24%	13
4. 14 days or more after earthquake occurrence.	32.35%	11
Answered		34
Skipped		23

Q7 Did you provide groundwater to the local population? Please select one from the following answer choices. If you select [1], please then move to question 8. If you choose [2], please then move to question 16.

Answer Choices	Responses	
1. Provided.	52.63%	30
2. Did not provide.	47.37%	27
Answered		57
Skipped		0

Q8 Only those who selected [1. Provided] at question 7 should answer this question. To whom did you provide groundwater? Please select from the following answer choices. Selection of multiple answer choices is allowed.

Answer Choices	Responses	
1. Individuals.	83.33%	25
2. Residents' associations.	26.67%	8
3. Other firms.	30.00%	9
4. Shelters.	6.67%	2
5. Hospital.	6.67%	2
6. City government.	0.00%	0
7. Fire station.	0.00%	0
8. Fire corps volunteers.	0.00%	0
9. Not sure to whom groundwater was provided.	3.33%	1
10. Other (free descriptive answer).	13.33%	4
Answered		30
Skipped		27

Q9 Only those who selected [1. Provided] at question 7 should answer this question. For what purposes did you provide groundwater? Please select one from the following answer choices.

Answer Choices	Responses	
1. Drinking purposes (including cooking purposes).	3.33%	1
2. Domestic purposes (toilet, laundry, and bathing).	63.33%	19
3. Fire protection.	0.00%	0
4. Drinking and domestic purposes.	23.33%	7
5. Drinking and fire protection purposes.	0.00%	0
6. Domestic and fire protection purposes.	3.33%	1
7. Drinking, domestic, and fire protection purposes.	0.00%	0
8. Other (free descriptive answer).	6.67%	2
Answered		30
Skipped		27

Q10 Only those who selected [1. Provided] at question 7 should answer this question. When did you start to provide groundwater? Please select one from the following answer choices.

Answer Choices	Responses	
1. 0 (day of earthquake occurrence) to 1 day after earthquake occurrence.	46.67%	14
2. 2–6 days after earthquake occurrence.	46.67%	14
3. 7–13 days after earthquake occurrence.	3.33%	1
4. 14 days or more after earthquake occurrence.	3.33%	1
Answered		30
Skipped		27

Q11 Only those who selected [1. Provided] at question 7 should answer this question. For how long in a day did you provide groundwater at longest? Please select one from the following answer choices.

Answer Choices	Responses	
1. A part of daytime.	43.33%	13
2. Daytime.	20.00%	6
3. A part of nighttime.	0.00%	0
4. Nighttime.	0.00%	0
5. An entire day (24 h).	36.67%	11
Answered		30
Skipped		27

Q12 Only those who selected [1. Provided] at question 7 should answer this question. Why did you provide groundwater to the local population? Please select one from the following answer choices.

Answer Choices	Responses	
1. Because providing water was a requirement of DEW registration.	6.67%	2
2. Because there was a request from the city government, even though we were not a DEW registrant when the earthquake occurred.	3.33%	1
3. Because there was a request from residents, even though we were not a DEW registrant when the earthquake occurred.	13.33%	4
4. We provided groundwater without any requests, even though we were not a DEW registrant when earthquake occurred.	60.00%	18
5. Not sure of the reason.	6.67%	2
6. Other (free descriptive answer).	10.00%	3
Answered		30
Skipped		27

Q13 Only those who selected [1. Provided] at question 7 should answer this question. Was there a manual for providing groundwater to the local population (e.g., showing how to pump groundwater, rules for water allocation per person, and timespan in a day for groundwater provision)? Please select one from the following answer choices.

Answer Choices	Responses	
1. There was an original manual.	0.00%	0
2. There was a manual provided by the city government.	0.00%	0
3. There was no manual.	100.00%	30
Answered		30
Skipped		27

Q14 Only those who selected [1. Provided] at question 7 should answer this question. How did you publicize that the well was available? Please select from the following answer choices. Selection of multiple answer choices is allowed.

Answer Choices	Responses	
1. Original public relations (e.g., poster, signboard, social media, and homepage).	20.00%	6
2. Public relations by the city government (e.g., poster, social media, homepage, and bulletin).	3.33%	1
3. Hazard map produced by the city government.	0.00%	0
4. Newspaper.	0.00%	0
5. Radio.	0.00%	0
6. Television.	0.00%	0
7. We did not publicize the information.	73.33%	22
8. Other (free descriptive answer).	13.33%	4
	Answered	30
	Skipped	27

Q15 Only those who selected [1. Provided] at question 7 should answer this question. We suppose the well that was used for groundwater provision was drilled before occurrence of the earthquake. When the well was drilled, was the well subject to regulation of law or ordinance? Please select one from the following answer choices. After answering this question, please then move to question 17.

Answer Choices	Responses	
1. It was subject to regulation of Industrial Water Law of the national government.	0.00%	0
2. It was subject to regulation of prefectural ordinance.	50.00%	14
3. It was subject to regulation of city ordinance.	10.71%	3
4. It was not subject to regulation of any law or ordinance.	17.86%	5
5. Not sure if it was subject to regulation of law or ordinance.	21.43%	6
	Answered	28
	Skipped	29

Q16 Only those who selected [2. Did not provide] at question 7 should answer this question. Why did you not provide groundwater to the local population? Please select from the following answer choices. Selection of multiple answer choices is allowed.

Answer Choices	Responses	
1. Because we were not a DEW registrant when the earthquake occurred.	59.26%	16
2. Because a procedure for groundwater provision was not set up.	3.70%	1
3. Because there was no request from the city government.	33.33%	9
4. Because there was no request from local residents.	33.33%	9
5. Because there was concern regarding groundwater quality.	7.41%	2
6. Because the pump was destroyed by the earthquake.	3.70%	1
7. Because the pump came to halt owing to cutoff of electricity supply.	7.41%	2
8. Because access to the premises was restricted.	3.70%	1
9. Because water delivery apparatus such as taps and hoses were lacking.	3.70%	1
10. Other (free descriptive answer).	14.81%	4
	Answered	27
	Skipped	30

Q17 From here, we would like to ask about efforts following the earthquake. Was there a change in well management after the earthquake? Please select one from the following answer choices. If you select [1], please then move to question 18. If you select [2], please then move to question 19.

Answer Choices	Responses	
1. There was a change.	45.61%	26
2. There was no change.	54.39%	31
	Answered	57
	Skipped	0

Q18 Only those who selected [1. There was a change] at question 17 should answer this question. What was the nature of the change? Please select from the following answer choices. Selection of multiple answer choices is allowed. After answering this question, please then move to question 20.

Answer Choices	Responses	
1. Purchased emergency power generator.	3.85%	1
2. Made contract regarding groundwater quality inspection with an external organization.	0.00%	0
3. Produced instruction manual regarding groundwater provision to local population.	0.00%	0
4. Prepared equipment for water delivery (e.g., taps and hoses).	11.54%	3
5. Registered well in the Disaster Emergency Well system.	84.62%	22
6. Demolished well after the earthquake.	3.85%	1
7. Other (free descriptive answer).	11.54%	3
	Answered	26
	Skipped	31

Q19 Only those who selected [2. There was no change] at question 17 should answer this question. What are the reasons for not making any changes? Please select from the following answer choices. Selection of multiple answer choices is allowed.

Answer Choices	Responses	
1. Because the well worked as usual even after the earthquake and it was not necessary to take countermeasures.	93.10%	27
2. Because equipment for well management (e.g., emergency power generator) is too expensive.	0.00%	0
3. Because the city government's water trucks were available and it was not necessary to take countermeasures.	3.45%	1
4. Because there are too many other things to do and there is no spare time to reconsider well management.	0.00%	0
5. Other (free descriptive answer).	6.90%	2
	Answered	29
	Skipped	28

Q20 What type of policies do you think are necessary to enhance the effectiveness of groundwater utilization following occurrence of an earthquake? Please let us know your expectation for local government. Please select from the following answer choices. Selection of multiple answer choices is allowed.

Answer Choices	Responses	
1. Deregulation on well drilling.	7.02%	4
2. Subsidy for well drilling and purchase of emergency power generator.	24.56%	14
3. Execution of emergency drilling that includes utilization of wells.	5.26%	3
4. Preparation of rules regarding groundwater provision.	33.33%	19
5. Publication of hazard map that includes information on well locations.	35.09%	20
6. Strengthening of rapid inspection of groundwater quality following occurrence of an earthquake.	35.09%	20
7. No particular policy requests.	15.79%	9
8. Other (free descriptive answer).	7.02%	4
	Answered	57
	Skipped	0

Q21 Please let us know if you have any comments regarding groundwater utilization following occurrence of an earthquake (free descriptive answer).

Replies to this question are omitted.